MS-1

Globally Unified Monsoon Onset and Retreat Indexes

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Different criteria have been used in the past to define the monsoon onset and retreat over different monsoon regions and even over different parts of the same monsoon region. Here we propose an objective criterion to define, for the first time, globally unified summer monsoon onset (or retreat) dates using a single meteorological variable (i.e., the global daily 1 deg by 1 deg normalized precipitable water data) with the threshold value being the Golden Ratio (0.618). Results are found to be consistent with those determined using long-term rainfall data over most monsoon regions. The precipitable water data have also been used to refine the definition of monsoon regions on a grid-cell-by-cell basis.The objective definitions of these basic monsoon characteristics would provide one of the necessary foundations for global monsoon research. They, along with the onset/retreat data over a ten-year period (1988 - 1997), would also facilitate the diagnostics and validation of global monsoon simulations.

MS-2

Climatological Mid-Summer Droughts in Monsoon Regions

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In several subtropical regions around the world, the annual march of rainfall is characterized by wet summers (loosely defining "monsoonal" for present purposes) with dry spells in the middle. Examples include East Asia, Central America, and populous regions in Brazil. We illustrate these examples and the similarities among their settings, show the observed corresponding circulation changes, and examine simulations by several global models for their fidelity in reproducing the feature. Based on the results, we offer deductions and hypotheses about the climate dynamics involved and the likely source regions for interannual variations.

MS-3

The Impacts of Land-Sea Contrast to the Formation of the Subtropical Anticyclone

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Monthly mean reanalysis data and numerical experiments based on a climate model are employed to investigate the relative impacts of different diabatic heating and their synthetic effects on the formation of the summertime subtropical anticyclones. Results show that the strong land-surface sensible heating (SE) on the west and condensation heating (CO) on the east over each continent generate cyclones in the lower layers and anticyclones in the upper layers, whereas radiative cooling over oceans generates the lower layer anticyclone and upper layer cyclone circulations. Such circulation patterns are interpreted in terms of the atmospheric adaptation to diabatic heating through a PV-ThetaT view. A Sverdrup balance is used to explain the zonally asymmetric configuration of the surface subtropical anticyclones. The strong deep CO that is maximized in the upper troposphere over the eastern continent and the adjacent ocean is accompanied with upper tropospheric equatorward flow and weaker lower tropospheric poleward flow, whereas the very strong longwave radiative cooling (LO) that is maximized near the top of the planetary boundary layer over the eastern ocean is accompanied with strong surface equatorward flow and weaker upper layer poleward flow. The center of the surface subtropical anticyclone is then shifted towards the eastern ocean, and its zonal asymmetry is induced. This study concludes that in the summer subtropics over each continent and its adjacent oceans, LO, SE, CO and of a double-dominant heating (D) from west to east compose a LOSECOD heating quadruplet. A specific zonal asymmetric circulation pattern is then formed in response to the LOSECOD quadruplet heating. The global summer subtropical heating and circulation can then be viewed as 'mosaics'of such a quadruplet heating and circulation patterns, respectively.

IMS-4

Detection and Attribution of 20th Century African Monsoon Changes

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A key unresolved question is how regional patterns of climate will respond to anthropogenic and natural forcings during the 21st Century. A diagnosis and attribution for the regional changes that have already been witnessed during the 20th Century is one prerequisite for gaining insights on this problem.

Among the regional 20th Century changes documented in the Third Assessment Report (TAR) of the IPCC (2001) has been notable wintertime drying of the Mediterranean region, and the drying of the African monsoon regions. The latter has

included the subtropical drying during boreal summer over sub-Saharan Africa, and the subtropical drying during austral summer over southern Africa.

This study explores the extent to which recent African multi-decadal drying trends result from dynamical feedbacks involving atmospheric responses to ocean changes. A focus is placed on the role of sea surface temperatures (SSTs) over the tropics. These too have strongly warmed during the 20th Century, and their interannual fluctuations (e.g., those related to the El Niño/Southern Oscillation phenomenon) have also become more intense.

The basis for this attribution research is large, ensemble suites of climate simulations of the period 1950-1999 employing atmospheric general circulation models. The models are forced with the observed history of monthly SST variations, and also with idealizations of that history. These integrations provide evidence that recent drying over both the Sub-Saharan and southern African monsoon systems have been strongly determined by the 20th century trajectory of SSTs. The role of specific ocean regions is assessed, and the attribution of those ocean changes is further pursued using "historical" integrations with coupled ocean-atmosphere climate models forced by increasing greenhouse gases.

MS-5

Oceanic Forcing of the African Monsoon in the NSIPP1 AGCM

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When forced only with the observed record of sea surface temperature (SST) over 1930-2000, the NSIPP1 AGCM - version 1 of the atmospheric model developed at NASA's Goddard Space Flight Center in the framework of NASA' Seasonal to Interannual Prediction Project - exhibits unprecedented skill at reproducing the observed variability of northern summer precipitation over tropical Africa.

The two leading patterns of July-to-September rainfall obtained from Principal Component Analysis represent variability at the meridional edges of the African summer monsoon. The first pattern represents variability at the southern edge of the climatological precipitation pattern, along the Gulf of Guinea. The second pattern represents variability at the northern edge, across the Sahel. These patterns are statistically and dynamically separate. Gulf of Guinea rainfall is controlled by eastern equatorial Atlantic SSTs. Sahel rainfall is sensitive to global, tropical SSTs. Tropical Pacific SSTs, e.g. the El Nino/Southern Oscillation phenomenon, contribute to variability on the interannual time scale in the Sahel, while the warming of the oceans around Africa, Indian as well as Atlantic, is shown to be statistically related to the drying trend of the 1970s and 1980s.

While the contribution of global warming to the recent warming of the oceans around Africa remains to be clarified, the skillful simulation of year-to-year variability of the northern summer African rains provides a measure of the limits to predictability, and sets the stage for the exploitation of seasonal climate prediction in the region.

MS-6

Antropogenic Changes of the West African Monsoon

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A large ensemble of 62 integrations with the NCAR CSM 1.4 climate model has been used for examining the antropogenic changes in precipitation. The integrations have been carried out within the Dutch Challenge Project (see accompanying poster). The integration period is 1940-2080. From 2000 onwards the greenhouse gas concentrations were varied according the SRES A1 scenario. Due to the large number of ensembles stable statistics can be obtained. The predictability of the antropogenic changes in precipitation appears to be regionally dependent. For many regions the large inter-ensemble variability serious limits the predictability. Other regions, however, do reveal a significant signal. An example is the precipitation in the West African monsoon region. The differential response of the circulation over the adjacent oceans and land masses to the increase in greenhouse gases modify the position and intensity of the West African monsoon.

MS-7

Influence of ENSO on the Onset, Withdrawal and Intensity of Tanzanian Rainfall

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This study examines the influence of ENSO on the onset, withdrawal and intensity of the rainy seasons over coastal Tanzania and interactions with intraseasonal signals propagating in the Indian Ocean / East African region. El Niño appears to be associated with above average rainfall while La Niña is associated with below average rainfall over the Tanzanian coast. Increased rainfall during El Niño years tends to be due to a longer than average rainfall season associated with early onset while reduced rainfall during La Niña years is associated with late onset and hence shorter than average rainfall season. The atmospheric circulations indicate that the wet conditions during El Niño years were associated with enhanced convection and low-level easterly anomalies over the equatorial western Indian Ocean implying enhanced advection of moisture from the Indian Ocean while the reverse is true for La Niña years. While the north coast shows ENSO impacts similar to equatorial East Africa, the south coast appears to be a transition zone between this response and the opposite signed

response that tends to occur in southern Africa. Thus, the ENSO signals over the south coast are similar to the north coast and those in Kenya during the early season (OND) but are mixed during the late season.

Hovmöller plots of OLR and zonal wind at 850hPa and 200hPa show both eastward and westward propagating features as well as stationary patterns over the Indian Ocean. It was observed that the propagating features were absent during strong El Niño years. It is also found that the areas of large negative OLR anomalies (strong convection) couple well with areas of strong westerly anomalies in lower levels with strong easterly anomalies in upper levels. It is shown that these convective oscillations over the Tanzanian coast have some of the characteristic features of intraseasonal oscillations observed elsewhere in the tropics.

MS-8

The Role of the Meridional Temperature Gradient in the West African Monsoon Circulation

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The study examines regional climate model (RCM) simulations of the mean June-September climate and the implications of the mean temperature distribution for the model representation of the African Easterly Jet and African wave disturbances (AWD). Two simulations are made with assigned invariant ground temperatures (Tg). Experiment 1 uses an unrealistically reduced meridional gradient where Tg are some 5-6°C too warm within a swath along the Gulf of Guinea coast, but are otherwise reasonable. Experiment 2 tests the response to cooler, more realistic Tg within the same swath. Experiment 3 was made with a fully interactive land surface process model, which computed a realistic mean distribution of Tg, with realistic diurnal variations. Results show a rather acute sensitivity of the mean circulation to the Tg meridional gradient, and by implication, to land surface processes. The more realistic meridional temperature gradient created by the cooler, coastal Tg (Exp 2) increased the vertical wind shear over West Africa and eliminated spurious westerly circulation at 700 mb. AWD composites were transformed from intense closed cyclonic circulations with copious rainfall to more realistic open waves that organized more moderate precipitation maxima. Lower vorticity variances in Experiment 2 imply that the open waves were characterized by more moderate vorticity extremes. Corresponding spectral amplitudes for 3-6 day periodicities of the 700 mb meridional wind were 40-80% of Experiment 1 values within the swath of maximum AWD activity. From among the three simulations, the simulation with the interactive land surface model achieved seasonal mean precipitation, temperature, energy flux and circulation distributions that, despite some unrealistic features, were closest to observational evidence. Experiment 3 AWD were much less intense and favored slightly longer periods. Results demonstrate that discrepancies in modeled ground temperatures can have far- reaching consequences for

the simulation of both the mean summer climate and individual synoptic disturbances. The study implies that the cooling along the Gulf of Guinea coast prevents AWD from developing into more intense storms.

MS-9

Seasonal Evolution and Variability Within the West African Monsoon System

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In this study, we investigate the seasonal variations in surface rainfall and associated large-scale processes in the tropical eastern Atlantic and West African region. The 5-yr (1998-2002) high-quality TRMM rainfall, sea surface temperature (SST), water vapor and cloud liquid water observations are applied along with the NCEP/NCAR reanalysis wind components and a 3-yr (2000-2002) QuickScat satellite-observed surface wind product.

Major mean rainfall over West Africa tends to be concentrated in two regions and is observed in two different seasons, manifesting an abrupt shift of the mean rainfall zone during June-July. (i) Near the Gulf of Guinea (about 5N), intense convection and rainfall are seen during April-June and roughly follow the seasonality of SST in the tropical eastern Atlantic. (ii) Along the latitudes of about 10N over the interior West African continent, a second intense rain belt begins to develop from July and remains there during the later summer season.

This belt co-exists with a northward-moved African Easterly Jet (AEJ) and its accompanying horizonal and vertical shear zones, the appearance and intensification of an upper tropospheric Tropical Easterly Jet (TEJ), and a strong low-level westerly flow. Westward-propagating wave signals [i.e., African easterly waves (AEWs)] dominate the synoptic-scale variability during July-September, in contrast to the evident eastward-propagating wave signals during May-June.

The abrupt shift of mean rainfall zone thus turns out to be a combination of two different physical processes: (i) Evident seasonal cycles in the tropical eastern Atlantic ocean which modulate convection and rainfall in the Gulf of Guinea by means of SST thermal forcing and SST-related meridional gradient; (ii) The interaction among the AEJ, TEJ, low-level westerly flow, moist convection and AEWs during July-September which modulates rainfall variability in the interior West Africa, primarily within the ITCZ rain is shown to be a good evidence for this seasonal evolution.

MS-10

African Monsoon Multidisciplinary Analysis (AMMA): An International Research Project and Field Campaign

AMMA International Science Committee
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The interannual and interdecadal variability of the West African monsoon (WAM) is well documented and has motivated considerable research in this area. The dramatic change from wet conditions in the 50s and 60s to much drier conditions in the 70s, 80s and 90s over the whole region represents one of the strongest inter-decadal signals on the planet in the 20th century. Superimposed on this, marked interannual variations in recent decades have resulted in extremely dry years with devastating environmental and socio-economic consequences. Vulnerability of West African societies to climate variability is likely to increase in the next decades as demands on resources increase in association with one of the World's most rapidly growing populations. Vulnerability may be further increased in association with the effects of climate change.

Based on a French initiative, an regionally integrated project has been built. AMMA is now an international project supported by many national agencies and has received endorsement from both CLIVAR and GEWEX.

Recognising the societal need to develop strategies that reduce the socioeconomic impacts of the variability of the WAM, AMMA wants to facilitate the multidisciplinary research required to provide improved predictions of the WAM and its impacts on daily-to-decadal timescales. It promotes international coordination of relevant ongoing activities, necessary basic research and a multi-year field campaign over West Africa and the tropical Atlantic to support this research.

Motivated by the science and societal issues the AMMA project has three overarching aims:

(1) To improve our understanding of the WAM and its influence on the physical, chemical and biological environment regionally and globally.

(2) To provide the underpinning science that relates climate variability to issues of health, water resources and food security for West African nations and defining relevant monitoring strategies.

(3) To ensure that the multidisciplinary research is effectively integrated with prediction and decision making activity

To achieve these aims a multiscale approach to the study of the WAM has been designed. AMMA promotes research on the WAM around 4 interacting spatial scales: (i) global scale where consideration is given to how the WAM interacts with the globe, (ii) regional scale where monsoon processes are emphasized including scale interactions and the coupled land-ocean-atmosphere system, (iii) mesoscale where mesoscale convective systems and processes operating at the catchment scale are emphasized and (iv) local scale where hydrology and links with applications including agriculture are emphasized.

AMMA is planned to be a multi-year project and will involve 3 nested observing periods: the LOP or Long term Observing Period at interannual-to-decadal scale (unarchived historical and additional (2002-2010)); the EOP or Enhanced Observing Period at the seasonal scale (2004-2006); the SOP or Special Observing Period during summer of 2006. To address the objectives of AMMA, a synergistic approach cutting across disciplines and across spatial and temporal scales is necessary. Numerical modeling and assimilation will be with satellite observations the main tool. Particular attention is brought to evaluate and improve numerical prediction of weather and climate over the West African region. AMMA is developping close partnerships between those

involved in basic research of the WAM and its impacts, operational forecasting centres and decision makers. It promotes the development of blended training and education activities for African research and technical institutions.

IMS-11

Some Recent Studies of the Characteristics of Weather Systems (Including the Monsoon Systems) of West Africa Using Satellite Data

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This study utilizes some recently available satellite data in Nigeria to examine the characteristics and consequences of ocean-atmospheric interactions and their consequences for the weather systems, and with special emphasis on the monsoon systems during the rainy season. The study was carried out with respect to (a) the beginning of the rainy season (b) the middle of the rainy season (c) the little dry season and (d) the end of the rainy season. The paper first discusses the main factors usually associated with the characteristics and consequences of the weather systems, including the intertropical discontinuity (ITD) and the ocean factor, the characteristics of the winds, topography, land and sea contrasts, which are especially significant for local scale systems and the characteristics and consequences of the disturbances during the period of study. The paper then discusses the various characteristics and consequences of the weather systems as they relate to meso and micro scale systems in West Africa, and the significance of the dynamic controls, particularly the relative significance of topography and land and sea contrasts as major factors in the potential predictability of the monsoonal systems, and developing forecasting and prediction models for West Africa.

The results of the study show that (a) although the ITD and the ocean factor are significant for inducing significant changes in the characteristics and patterns of change in the air-sea interactions, it is becoming clearer that (a) the influence of topography and micro-scale land and sea contrasts are very significant factors influencing and initiating and evolution of the weather systems, while the ocean and other factors influence the changes in the patterns of movement of the weather systems and (b) the characteristics of the variations and change in the patterns of movement of the weather systems are also significantly affected by the weather systems in other parts of the world and especially by the European weather. The implications of the results for improving forecasting and prediction of weather and climate in West Africa are then discussed, particularly as regards (a) the need for consideration and inclusion of most of the significant factors in developing models for the region (b) the need for adequate considerations of the three scales of operations of weather and climate systems, namely macro, meso, and micro-scales, in developing such regional models and (c) the need for continued acquiring of the satellite and other data and information for continuous monitoring of the weather systems and the implications of weather and climate in the region.

MS-12

Rainfall Variability in West Africa Using the NCEP Coupled Forecast System Model (CFS03)

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This study examines the rainfall variability in West Africa using global climate model. The GCM used for this study is a global coupled atmosphere-ocean forecast system model (CFS03), recently developed at the National Centers for Environmental Prediction (NCEP). CFS03 consists of a T62L64 version of the operational NCEP Atmospheric Global Forecast System model (GFS03) and the Geophysical Fluid Dynamics Laboratory (GFDL) Modular Ocean Model version 3 (MOM3). A free run of more than 32 years has been conducted. Preliminary diagnoses indicate that CFS03 realistically simulated ENSO variability, with amplitude and frequency comparable to that observed.

In this study, we present the CFS03 free-run results with focus on the rainfall variability in the Sahelian region of West Africa. Annual and seasonal cycle of rainfall in this region simulated in the CFS03 run will be discussed and the spatial patterns of SST associated with wet and dry episodes will be examined. In addition, the associations between rainfall pattern and ENSO episodes will be examined. Composite analysis will be used to compare the ENSO events that resulted in suppressed rainfall with those that do not. Characteristics of rainfall variability and the rainfall-ENSO relationship in the Sahelian region (as a whole and divided into three sectors: West Coast, Sahel, and Guinea) will be discussed.

MS-13

West African Monsoon: Is the August Break Breaking?

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In July, heating of the continents in the Northern Hemisphere results in strengthened monsoon systems which bring rains to West Africa. In Nigeria, the annual rainfall total decreases from over 3,800mm at Forcados on the coast to under 650mm at Maiduguri in the north-east of the country. June, July, August and September are the rainiest months throughout the country. In many parts of the south, however, there is a slight break in the rains for some two to three weeks in late July and early August or the "August break". In this study, we are underscoring the obvious that climate is changing.

The rainfall data for 1960-2000 analysed between the months of July - August for some sites in the south of Nigeria shows that the "August break" may indeed "be breaking". We have discussed wholistic approaches to climate change research in this monsoon region.

MS-14

Interactions of the Tropical Oceans in Forcing Anomalous Sub-Saharan West African Rainfall

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Two large-scale rainfall anomaly patterns describe most of the summer rainfall variability over sub-Saharan West Africa. One is an out-of-phase distribution between Sahel and Guinea Coast summer rainfall anomalies and the second one is characterized by anomalies of the same sign over these two areas. Observations and atmospheric model experiments show that these patterns can be induced by simultaneous sea surface temperatures anomalies (SSTAs) in the tropical Indian Ocean and in the eastern tropical Atlantic. Since the SST anomalies in both ocean basins are predictable, the variability in sub-Saharan West African rainfall may also be predictable at least one season ahead.

MS-15

Interaction of the Atlantic Equatorial Cold Tongue and African Monsoon

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The seasonal cycle of equatorial Atlantic sea surface temperature (SST) is characterized by a rapid cooling from April to July, coinciding with the African monsoon onset, then followed by a slow warming that lasts three times longer. Two sets of ensemble simulations are carried out with an atmospheric general circulation model to investigate the mechanisms for the wind changes that cause the rapid seasonal cooling and the feedback of this equatorial cooling onto the African monsoon. In the control simulation, SST is prescribed in its full climatological seasonal cycle globally. In the second simulation, equatorial Atlantic SST is held constant in time from April 15 onward.

Comparison of these simulations indicates that the equatorial cooling exerts a significant influence on the African monsoon, intensifying the southerly winds in the Gulf of Guinea and pushing the continental rain band inland away from the Guinean coast. The intensification of the cross-equatorial southerlies associated with the onset of the African monsoon, in turn, triggers the oceanic cooling in the east. The equatorial

easterlies are also important for the seasonal cooling by inducing local upwelling and raising the thermocline in the east.

Three mechanisms are identified for the easterly acceleration in the equatorial Atlantic in boreal summer. First, the monsoon rainfall distribution is such that it induces zonal sea-level pressure gradients and easterly anomalies in the eastern Atlantic. Second, the strong cross-equatorial southerlies advect the easterly momentum from the south into the equator. Finally, zonal pressure gradients associated with the equatorial ocean cooling accelerate surface easterly winds in the middle and western Atlantic. This interaction of equatorial SST and zonal wind causes their westward co-propagation and is a key ingredient of the equatorial annual cycle, in analogy to that in the equatorial Pacific.□

MS-16

The Impact of Mediterranean SSTs on the Sahelian Rainfall Season

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A variety of regional and global sea surface temperature (SST) patterns are known to affect interannual to decadal variations of summer rainfall over the Sahel, and for most of these patterns considerable progress has been made towards understanding their influence. However, a possible link between Mediterranean SSTs and Sahelian rainfall has so far received little attention, and so the aim of this paper is to use observational and atmospheric general circulation model (AGCM) data to confirm and understand this relationship.

In years when the Mediterranean is warmer than average, it is shown that the Sahel tends to be wetter then normal, whereas in cool Mediterranean years it tends to be drier. The observed data also demonstrates that during the last five decades (1947-96) the strength of this impact has been roughly equal to that of Pacific SSTs, and a little less than that of the tropical Atlantic. Moreover it is most apparent on timescales of a decade or more, although it does also exert some influence at shorter timescales. It is also speculated that the Mediterranean may partly explain the impact of an interhemispheric pattern of SST anomalies found in earlier studies.

Analysis of the AGCM data provides the most convincing evidence that the observed relationship is indeed due to an influence of the Mediterranean on the Sahel. In particular, a pair of idealised experiments forced by warmer/colder than average SSTs in the Mediterranean, and climatological SSTs elsewhere, produce a clear and significant summer rainfall response over the Sahel. Data from these experiments are then used to explain this impact. If SSTs in the Mediterranean are warmer than average, then local evaporation is enhanced, and the moisture content of the lower troposphere increases. This additional moisture is advected southwards across the eastern Sahara by the mean flow, leading to enhanced low-level moisture convergence over the Sahel, which feeds enhanced rainfall. This is then amplified by four positive feedback mechanisms: a more rapid influx of moisture from the tropical Atlantic triggered by enhanced convective heating; a reduced outflow of moisture from the mid-level African

easterly jet; an enhanced hydrological cycle; and a larger rainfall contribution from African easterly waves.

MS-17

Mechanisms Associated with the June-September 2003 Sahel Rainfall

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The Sahel receives approximately 90% of its mean annual rainfall during the June-September period. This rainfall pattern is closely related to the north-south movement of the ITCZ, which starts its northward movement in March and reaches its northernmost position in August. In this study, we use gridded rainfall data and NCEP-NCAR reanalysis to diagnose the mechanisms associated with the 2003 Sahel rainfall, which we consider as the second wettest year since 1990. Accompanying the wet condition of the Sahel rainfall in Jun-Sep 2003, there was an enhanced monsoon activity associated with a low-level south-westerly flow that featured strong westerly velocity convergence across the Gulf of Guinea region and a penetration of moist and unstable air into the Sahel. This low level monsoonal flow was most enhanced across central Sahel at 925 hPa, but an even deeper penetration of moisture across the entire Sahel region associated with a strengthening of the St. Helen high pressure system was evident at 850 hPa. This strong monsoonal flow was further amplified by an anomalous cyclonic circulation that covered northern and central Sahel. Further physical evidence linking the 2003 Sahel rainfall to the multi-decaldal variability in the atmosphere will be discussed.

MS-18

North China and North Africa Drought in Global Viewpoint

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1 Introduction

The research indicates that there is a climate jump around 1965 in the summer rainfall of North China. After 1965,the summer rainfall decreases obviously and the trend of drought is also evident. This trend is very similar with that of Sahel and should be considered as global scale climate phenomenon. In the research on the global change we emphasize the sensitive zone where many kinds of large scale environmental elements have transition feature. Typical example are the climate change in Sahel and North China.

Considering from the atmospheric circulation pattern, these regions are located in the north boundary of the influence from the summer monsoon and the anomalous monsoon also influence largely the local precipitation. Considering from the distribution of vegetation, these regions are located in the interlacing area between forest and

grassland. Considering from the human activity, these regions belong to the interlacing area between agriculture and animal husbandry. Furthermore, considering from the geographical background these regions are located in the area which belongs to the monsoon region in one side and the subtropical and inland desert in other side.

Therefore we choose North China and Sahel as the focus of our research.

2 Data and Methods:

Using the monthly data from 1949 to 2003 reanalysed by NCAR/NCEP, and the data of rainfall and temperature at 160 stations in China from 1951 to 2003, by the method of statistical correlation, composite analysis and the analysis of maximum entropy spectrum, we examine the relationship between the 500hPa geopotential height anomalies in East Asia and drought or flood caused in the eastern part of China in summer. Special attention is paid to the following region: North China.

3 Conclusions:

1 The temperature difference between the southern and northern hemisphere provide the global scale climatic background for the drought in North China and Sahel.

2 In this temperature difference background, the East Asian summer monsoon and the African monsoon shift northward or southward, then the precipitation of North China and Sahel located in the north boundary experience periods of above normal or below normal.

IMS-19

An Alternate Perspective of the Asian Monsoon Onset and Its Predictability

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The surface of the ridgeline of the subtropical anticyclone separates the westerlies in mid- latitudes from the easterlies in tropics. Subject to the thermal wind relation, this ridge surface tilts towards warmer area with increasing height. In the boreal winter, it tilts southward and is zonal located with its 500hPa ridgeline near 12N. In summer while its tilting keeps unchanged over other longitudes, it tilts northward over the region ranging from East Africa to the western Pacific because the Asian Continent is warmer than the surface Indian Ocean. Therefore the ridgelines of the subtropical anticyclone in the lower troposphere are broken over this region. As a result, the prevailing tropical easterlies in winter over this region are reversed to southwesterlies in the lower troposphere, accompanied with the development of intense convective rainfall. This region is known as the Asian monsoon region. At the time when the tilting of the ridge surface is transferring from southward to northward, the in situ ridge surface becomes perpendicular to the surface, which is in accord with the reversal from winter to summer of the meridional temperature gradient and the prevailing wind. This is the time of the monsoon onset. A 'monsoon onset axis' is then defined as the axis at the ridge surface of the subtropical anticyclone that is perpendicular to the earth's surface. It is

shown, based on the NCEP/NCAR analysis data, that this monsoon onset axis appears firstly over the eastern Bay of Bengal (BOB) in early May, indicating the early start of the Asian monsoon. It then propagates gradually eastward, passing South China Sea (SCS) around May 20 and reaching the western Pacific in early June. Only after the Indian monsoon onset appears in early June, the whole process of the Asian monsoon onset is completed, and the summertime general circulation pattern is established. Therefore, the configuration evolution of the ridge surface of the subtropical anticyclone can be considered as an alternate perspective of the Asian monsoon onset.

Based on these, the time series of the Asian monsoon onset are constructed and correlated with meteorological variables. Particular efforts are made in understanding the impacts on the seasonal transition in the area of the atmospheric thermal status over the Tibetan Plateau to the north and the sea surface temperature on the tropical BOB to the south. Results show that the BOB monsoon onset is well correlated with the ENSO events and the thermal status over the Tibetan Plateau. The predictability of the BOB monsoon onset is investigated. Results show that the BOB monsoon onset can be qualitatively predicted based on linear trend estimates, and its quantitative prediction requires the understanding and consideration of the atmospheric low frequency variability.

MS-20

The Annual Cycle of Zonal Wind, Water Vapor and Potential Temperature Anomalies over Indian Ocean and Pacific

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The purpose of this paper is to show the dynamic coupling between large-scale zonal wind, moisture and potential temperature anomalies in the troposphere over equatorial region of Indian Ocean and Pacific during dry and wet Indian monsoon years. For this goal the height – longitude distributions of the zonally averaged parameters were analysed. The choice of Indian summer monsoon season as the starting point for the annual cycle to follow agrees with Yasunari (1991) who proposed the concept of 'monsoon year' as a unit year of climatic anomalies in the tropics.

The study based on composite means, were calculated for dry (1951, 1965, 1968, 1972, 1982, 1986 1987) years with weak summer All-Indian rainfall and warm events of ENSO during following fall and winter season and wet (1955, 1964, 1970, 1975, 1988) years with strong rainfall and cold events.

A study had shown, that the changes in the field of zonal wind anomalies, providing convergence and divergence anomalies in the troposphere during the annual cycle, as in dry and wet years, are consistent with the changes of specific humidity and potential temperature anomalies. The maximum positive (negative) moisture anomalies is observed in the convergence (divergence) regions. The maximum of the warm (cold) potential temperature anomalies is observed over maximum positive (negative) specific humidity anomalies.

The pattern of anomalies in equatorial region during every calendar season of dry composite year is opposite to the pattern of anomalies in wet year. The maximum of specific humidity anomalies over maritime continent (negative in dry years and positive in wet years) is observed during fall and accompanied by maximum of zonal wind anomalies in the troposphere, from surface to 400 mb. The zonal wind anomalies may be main reason of moisture anomalies in the troposphere in this region.

The maximum of specific humidity and potential temperature anomalies over Western Indian ocean and Pacific is observed in following boreal winter season with maximum sea surface temperature anomalies in these regions. It is interesting to note the development of two maximums of the moisture anomalies over equatorial Pacific – in the low and middle troposphere. The reason of high maximum may be the vertical structure of zonal wind anomalies, that provides convergence (in dry years) and divergence (in wet years) in middle troposphere between zonal wind anomalies of low level and zonal wind anomalies of high level of troposphere.

MS-21

Chinese Monsoon Flooding Situation in 1990's and Its Relation to El Nino Event

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China is a significant monsoon climate area with the most outstanding features, concentrated heavy rains in the Central China, the middle-lower reaches of Yangtze River in June-July, so-called Mei-yu rainy season.

Based on 50 years (1951-2000) data statistics, the average rainfall in June-July of 1990's was the most abundant comparing to other 4 decades. In the 50 years, there were altogether 8 times of extremely severe flooding (ESF) while 4 of them occurred in 1990's.

In this paper, ESF in 1998 is analyzed detailedly. All the atmospheric factors were favorable to severe Mei-yu rains in June-July, 1998. Following it, 5 times of extensive heavy rains occurred in higher reaches of Yangtze River during 1-29, August. It made the mainstream of Yangtze River a very high water level lasted as long as 2 months with many stations breaking historical highest record. As a result, it caused the most severe flooding disaster of economic loss as large as USD 25 billions.

There exists close relation between El Nino event and flooding in Yangtze River.Altogether 9 El Nino events occurred in 1951-1990. 7 of them started in spring-summer, and flooding appeared in same year with only one exception, the normal year. Other 2 events started in autumn, and flooding appeared in next summer. It was especially true in 1990's. Very frequent 4 El Nino events took place in 1991, 1993, autumn of 1994, and 1997-1998, the strongest one in past 100 year. Correspondingly, 4 times of ESF and other 2 times of flooding occurred. Obviously, El Nino event is an important factor making very heavy rainfall in Yangtze River.

In this paper, mechanism of impact of El Nino on atmospheric circulation is also studied. El Nino gives a significant impact on global, especially tropical atmospheric circulation resulted in subtropical high weaker and more south. Then, the large-heavy rain belt lies continuously in Yangtze River to form a severe flooding.

After the ESF disaster in 1998, China government made an investment of about USD 3.5 billions to build and reinforce dyke of Yangtze River. As a result, another ESF occurred in 2002, but without any burst of dyke and severe disaster.

IMS-22

Long Memory of East-Asian Monsoon and its Implication for Climate Prediction

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The predictability of the climate system is associated with its memory, which can be represented with an auto-correlation of an observed series. In order to understand the long time memory of the East-Asian monsoon, the detrended fluctuation analysis (DFA) is applied to the time series x(i) (i=1,..., N) of East-Asian monsoon. A power law scaling of long time memory is revealed. On the basis of the analysis for the observations of the East-Asian monsoon a time series model for interannual prediction has been established.

The departure series xx(i) of x(i) are calculated and the xx(i) with increasing i are integrated and denoted as y(k).Then y(k) is divided into segments of equal length s and the least-square line fitting the data in each segment, yn(k), is calculated. The series y(k) is detrended by subtracting the local trend yn(k), and the root-mean square fluctuations F(s) of the detrended series are computed. F(s) is computed for all "segment-size" s. If log F(s) increases linearly with log s, then the slope of the line relating F(s) and s in a log-log scale gives the scaling exponent a.

According to the random walk theory, the fluctuations F(s) in a given time segment of length s are related to the autocorrelation function C(s). For the long time power law correlations show a power spectra: C(s): sEXP(-g), the fluctuations F(s) increase as a power law: F(s): sEXP(a). We have computed the East-Asian monsoon indices with the DFA, The results show that the East-Asian monsoon exhibits a long time memory; it means the East-Asian monsoon has significant persistence in the yearly series. For winter monsoon, a=0.55, g=0.9; but for summer monsoon, a=0.73, g=0.54. It is shown that the difference between long time memories of monsoons in winter and summer is remarkable. The weather and climate in China is extremely impacted by East-Asian monsoon in summer, such as Meiyu weather over Yangtze River in June, July. So predicting the intensity and duration of summer East-Asian monsoon is important task for Chinese meteorologist. The good long time memory of the East-Asian monsoon provides a theoretical basis for its prediction.

In regard to monsoon prediction, we have established a data-based self memory (DASM) model, a newly-developed time series technique, for the yearly series for 1873-2000.The hindcast for 1990-2000 for the interannual change in the East-Asian monsoon

with the DASM model shows its prediction score is better than the AR (Auto-Regressive) model in the time series analysis.

MS-23

The Asian Summer Monsoon Wind During the Past Millennium

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Reconstructing the Asian summer monsoon during the past millennium has relevance to process-oriented studies as well as efforts to predict future climate change. We reconstructed the Asian summer monsoon winds for the last 1,000 years using fossil Globigerina bulloides abundance in box cores from the Arabian Sea. The Arabian Sea sediments are nannofossil-rich foraminifer oozes, and the low oxygen content of the Arabian Sea minimizes the bioturbation that would otherwise smooth the record. The composite record based on two cores shares several similarities with the time series of northern-hemisphere warming, namely weaker winds between 1000-1600 AD with a brief increase 1200-1400, a minimum around 1600, and an increase during the past 4 centuries. This is not surprising because both model and observation-based studies reveal a link between cooling/ increased snow cover over Eurasia, and a weaker monsoon the following summer. Alternately, the forcing implicated in the recent warming trend (volcanic aerosols, solar output, greenhouse gases) may directly affect the monsoon. Either interpretation is consistent with the hypothesis that the SW monsoon strength will increase during the coming century as greenhouse gas concentrations continue to rise and northern latitudes continue to warm. Preliminary study of the longer Holocene interval indicates 8 intervals of weaker monsoon winds that are correlated with cooling events in the North Atlantic. We infer that the observed link between Eurasian warmth/ snow cover and the SW monsoon persists on the millennial scale.

MS-24

Interdecadal Variations of the East Asian Summer Monsoon and Its Relation to East Tropical Pacific SSTs

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The East Asian Summer Monsoon is closely related to the severe flood and drought events in the region, and is distinct from the Indian Monsoon. The interdecadal variations of the East Asian Summer Monsoon and its relationship with the east tropical

Pacific SSTs and atmospheric circulation systems are studied using different data from CMA, Met. Office U.K. and NCEP for 1900-2000.

It is shown that there are two cycles of East Asian Summer Monsoon in last century. The variations of the second cycle of East Asian Summer Monsoon in last century are carefully studied. It is pointed that the stronger period of East Asian Summer Monsoon are from 1952 to 1966, the weaker from 1977 to 2000. It seems that the period of 1967-1977 is transition period. The geopotential height and sea level pressure anomaly patterns during summer season change sign from 1951-1961 to 1977-2000. The SST anomaly patterns in east tropical Pacific also change sign from stronger to weaker period. Further analysis shows that the relationship between East Asian Summer Monsoon and SSTs in east tropical Pacific are changeable.

MS-25

The Optimal Coupling of an AGCM with a Land Surface Scheme and Its Effect on the Simulation of East Asian Climate

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In order to implement vegetation effects on turbulent exchanges between land surface and the atmosphere, the Biosphere-Atmosphere Transfer Scheme (BATS) was coupled to an atmospheric general circulation model (AGCM) which had used bucket scheme as a land surface model. In this study, we have adopted the maintenance of energy balance and the closure of water cycle as the principal constraints for successful coupling.

After many try and errors, it was shown that the simulation results with the BATS did not deteriorate the long-term averaged global energy and water budget. The global water budget expressed as globally averaged evaporation minus precipitation was merely about 0.005mm/day. This imbalance was sufficiently small within an acceptable margin of truncation error in calculating. It was also found that atmospheric imbalance represented by the difference between energy budget at the top and at the surface of the model over the entire globe was about 7.2W/m*m which was improved as much as 0.6W/m*m compared with the existing result. Moreover, we have found that whether the call to land surface scheme is before or after vertical diffusion parameterization might cause atmospheric energy imbalance.

To initialize soil moisture after coupling of the AGCM to the BATS, spin-up integration was executed using climatological sea surface temperature (SST) as lower

boundary conditions. It took about 50-60 years to reach equilibrium for total soil moisture which had been excessively prescribed at initial state in the BATS.

Finally, we will present some of the salient results on AMIP II standrad experiments in which our AGCM runs with bucket and new land surface model. In particular, the sensitivity of the East Asian summertime climate to the coupling of the BATS will be examined in terms of continental scale water and energy budget.

MS-26

Summer Monsoon Onset over South Asia and the Intra-Seasonal Oscilation

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Two Intra Seasonal Oscillation (ISO) cycles are needed to complete the Asian Summer Monsoon onset process. Studying a composite of 9 years, in each year of which the ISO has a period of 35 +/- 5 days, it is found that at the end of the first ISO (pentad –8), a spatially large area of deep convection gets established over the equatorial Indian Ocean south of the Bay of Bengal. This area of deep convection moves to Southeast Asia and the South China Sea monsoon onset takes place (during pentads –5 to –4). At pentad –3, a spatially large convective heat source with maximum convection south of the Arabian sea near the equator and an associated Low Level Jetstream (LLJ) crossing the equator close to the east African coast forms. This convective heat source grows in area and intensity and slowly moves north and the associated LLJ grows steadily in strength. At the onset of monsoon over India (Kerala), as defined by the India Meteorological Department, at 0-pentad, this heat source and the LLJ become very strong. The axis of the heat source then passes through Kerala then and the LLJ axis is just south of Kerala. The monsoon onset as defined by Fassulo and Webster (2003), based on the hydrologic cycle, is a few days later when the already strong LLJ moves to the centre of peninsular India.

Sea Surface Temperature (SST) data with spatial resolution of about 25 kilometres taken from TRMM Microwave Imager (TMI) show that SST over the tropical Indian and west Pacific oceans and the monsoon onset process are closely related. At pentad –8, in years with ISO period close to 40 days, the active convection over the equatorial Indian Ocean is associated with the centre of the Indian Ocean Warm Pool (IOWP) located over the Bay of Bengal. The centre of the IOWP shifts to the east Arabian Sea prior to the monsoon onset over Kerala. At pentad –8 in the Bay of Bengal and at pentad –3 in the Arabian sea, the central regions of the areas of convection are located in the areas of large SST gradient near the equator and not over the centres of the IOWP (maximum SST). This is consistent with the current knowledge on convection – SST relationships. In 1998 the ISO had a period of only 20 days as shown by an analysis of the vertically integrated moisture and also convection. In 1998, two ISO cycles totaling 40 days complete the monsoon onset process.

MS-27

Predictability Studies of the Intraseasonal Oscillation in ECHAM

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The active and break events of the Asian summer monsoon are associated with the transition of the intraseasonal oscillation (ISO). The present study analyzes the predictability of the Northern Hemisphere summer ISO, as it is simulated by the ECHAM5 GCM forced with climatological SSTs. The model's resolution is T63 with 31 vertical layers.

Daily values of Northern Hemisphere summer precipitation from a 10-year integration are used to validate the ISO simulation with CMAP observations. Extended EOFs over the time-longitude domain are calculated. Since the predictability is expected to be different at different phases of the ISO, four different phases of the ISO are determined by creating principal component time series of the positive and negative maps of the first and second EEOF. The two highest amplitudes of the principal component time series of the positive first EEOF are selected to identify the two strongest ISO events. These dates and the following maxima of the other three phases are the starting dates of perturbation experiments. Fourteen ensemble experiments are integrated for each date using the breeding method (Toth and Kalnay, 1993). Its advantage is the growth of large model uncertainties and the damping of small uncertainties. The breeding method requires a short perturbed model integration after which the prognostic variables at the new time step are scaled down to the order of a rescaling mask. This new perturbation is added to the control experiment at the new time step and the model is again integrated for a short time. This process is repeated for four times, until the final perturbation is nearly independent of the initial perturbation at the timestep four integrations ago.

The short integration period is five days to obtain the intraseasonal variability. 90-day forecasts are produced and appended to the previous 120 days of the control experiment. The signal-to-noise ratio of these 210-day datasets is analyzed over a region, which covers the Asian summer monsoon activity. Predictability of up to more than 30 days is found for the two simulated ISO events. This potential predictability is considerably higher than in numerical weather forecasts indicating that useful forecasts of monsoon active and break periods may be possible with lead times of at least two to three weeks. Additional work will include the analysis of more events and the use of observed initial conditions to conduct hindcast experiments.

MS-28

Exploring the Dynamics Linking Indian and Pacific Ocean Coupled Variability in a CGCM

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The links between Indian Ocean dipole (IOD), the El Niño-Southern Oscillation (ENSO), and Indian monsoon variability have been the subject of a number of studies, climatological and numerical, with interpretation of the links between the dynamical systems varying.

We here report on a series of experiments with a coupled general circulation model (CGCM), in which the dynamics linking the variability in the tropical Indian and Pacific basins is explored. A long (200 year) simulation from the Sintex CGCM is compared with simulations of the same model that have had the variability in either the tropical Pacific or tropical Indian Oceans damped.

One major focus has been the link between the IOD and ENSO. We find that the IOD can exist in the absence of ENSO. Two different triggering events for the IOD are found. The first is well-known, and linked with an anomalous Walker circulation during a developing El Niño. The second, and the only trigger found in the absence of ENSO, is associated with an anomalous Hadley circulation driven by a strengthened meridional sea surface temperature gradient, an early start of a component of the Indian monsoon.

In a complimentary experiment in which the tropical Indian Ocean variability is damped, we find that the amplitude of ENSO variability in the equatorial Pacific remains virtually unchanged, but that changes occur elsewhere in the Pacific and in the southern Indian Ocean.

MS-29

Ocean Roles in the Transitions Between Indian and Australian Monsoons

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This study uses a series of CGCM (coupled atmosphere-ocean general circulation model) experiments to examine the roles of the Indian and Pacific Oceans in the transition phases of the biennial Indian-Australian monsoon tendency. In each of the three CGCM experiments, air-sea interactions are restricted to a certain portion of the Indo-Pacific Ocean by including only that portion of the ocean in the ocean model component of the CGCM.

The results show that the in-phase transition from a strong (weak) Indian summer monsoon to a strong (weak) Australian summer monsoon occurs more often in the CGCM experiments that include an interactive Pacific Ocean. The out-of-phase transition from a strong (weak) Australian summer monsoon to a weak (strong) Indian

summer monsoon occurs more often in the CGCM experiments that include an interactive Indian Ocean.

It is found that the Indian Ocean and the Pacific Ocean repond differently to the Indian and Australin monsoons. These different ocean responses allow these two oceans to play different roles in the transition phases of the biennial tendency in the Indian-Australian monsoon system.

MS-30

Role of Indian Ocean Salinity in Monsoon Simulations and El Nino Forecasts

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Our results are based on observations and simulations of the Indian and tropical Pacific oceans/atmosphere over the period 1980-2000. First, we demonstrate with the Indian Ocean model that it is crucial to simulate salinity and force the model with observed rainfall including their interannual anomaliesin order to make the simulations of the SST anomalies driven by the wind agree with data. Second and third steps of the demonstration are performed with a quasi-equilibrium tropical atmosphere model which is forced by the observed land conditions and SSTs over the Pacific and Atlantic oceans, and by the model SSTs over the Indian Ocean.

The Indian SSTs are found crucial to simulate the strong wind and rainfall anomalies observed in 1994 and 1997 over the Indian Ocean. Over the Pacific, the atmosphere model reproduces the fluctuations of the trade winds in the central Pacific in very good agreement with data regardless of the Indian SSTs, but the latter have a significant impact on the model winds in the western Pacific.

Finally, a tropical Pacific ocean model coupled to the atmosphere is used to demonstrate that the changes of the winds in the western Pacific can play a role as important as the trade winds in forecasting El Nino events.

MS-31

Dominant Mode of Asian-Australian Monsoon Variability

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The dominant mode of the Asian-Australian monsoon (A-AM) interannual variability is season-dependent and has a biennial tendency. This mode coincides with turnabouts of El Nino (La Nina) events. Its evolution from one summer to the next is characterized by two anomalous surface anticyclones dominating, respectively, the South Indian Ocean (SIO) and western North Pacific (WNP). The SIO anticyclone occurs during development of El Niño and the WNP anticyclone attains maximum intensity during mature and decay of El Niño. The anomalous rainfall in India, Africa, Australia-Indonesia and East Asia are associated with these two anomalous anticyclones.

A widely held view is that El Nino/La Nina and warm-pool SST anomalies primarily force A-AM anomalies. In contrast to this view, we show that the warm pool SST anomalies are largely a result of anomalous monsoon and cannot be regarded as a cause to A-AM variation; furthermore, while the remote El Nino forcing alone explains neither the extraordinary amplification of the SIO anticyclone nor the maintenance of the WNP anticyclone.

We propose that the interannual variability of A-AM is attributed to three factors: the remote ENSO forcing, the local monsoon-warm ocean interaction, and the annual cycle of monsoon circulations. The atmosphere-ocean conditions in SIO and WNP are similar, namely, an east-west anomalous SST dipole with cold water to the east and warm water to the west of the anticyclone centers. These conditions result from a positive feedback between the anomalous descending atmospheric Rossby waves and SST dipole. The air-sea interaction in the two regions share common wind-evaporation/entrainment and cloud-radiation feedbacks but differ in the roles of oceanic dynamics in SST variability. Numerical experimentations with coupled ECHAM AGCM-WLF ocean model demonstrate that the monsoon-ocean interaction plays an important role. In addition to the monsoon-ocean interaction and ENSO forcing, the seasonal march of the background flows also plays a critical role. It controls the nature of the monsoon-ocean feedback and can remarkably modify the atmospheric response to remote forcing. During the summer of El Niño development, a tilted anticyclonic ridge originates from the maritime continent and extends to southern India. This considerable equatorial asymmetry results from the effects of monsoon easterly vertical shear on Rossby waves.

The understanding obtained from this study leads to a new paradigm for TBO.

IMS-32

Monsoon Variability over South and East Asia Vis-a-vis Indian Ocean Dipole Mode

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The influence of the Indian Ocean Dipole Mode on the summer monsoon rainfall over South Asia (India) and East Asia (China, Korea, Japan) has been investigated. While the observed rainfall data are used as a measure of monsoon intensity, the sea surface temperature (SST) difference over the western and southeastern Indian Ocean (IO) constitutes the dipole index. The NCEP-NCAR Reanalysis data are used to examine the dynamics and the physical processes by which the dipole and monsoon variability are connected. The methodology adopted is correlation and composite analysis. The anomalous circulation features associated with the extreme monsoon and

dipole phases are determined to draw inferences. The data used covers the period 1960-2000.

Results reveal that the positive phase (anomalous warm west and cool east IO) of the dipole during autumn is favorable for rainfall activity over India and China, but is unfavorable for monsoon activity over Korea and Japan during the following summer. The relationships are more consistent and stronger for the remote Korean and Japan regions, rather than for the near IO region. While the monsoon variability over East Asia appears to have no impact on the dipole variability, an extreme Indian monsoon affects the dipole mode variability. In fact the impact of the Indian monsoon on dipole is much stronger than vice versa.

The anomalous 500 hPa geopotential height and the 850 hPa vector wind patterns clearly suggests that the warm SSTs and strong convection over the western IO associated with the positive phase induces a zonal Rossby wave train over the northern hemisphere mid-latitudes of Eurasia propagating eastwards and displacing the North Pacific Subtropical High (NPSH) over northeast Asia. This weakens the low-level jet reducing the moisture supply over the Korean-Japan peninsula. On the other hand, the warming over the eastern IO / west Pacific associated with the negative phase of the dipole supports the southwestward extension of the NPSH, intensifying the low-level jet and the moisture supply. Thus the origin for the displacement of the NPSH, whose location, shape and strength play a dominant role in the monsoon variability over East Asia, appears to be in the IO associated with the extreme dipole phases.

The impact of the Pacific Ocean is perhaps more on monsoon variability over South Asia, however, the impact of the Indian Ocean appears to be more on monsoon over East Asia, in particular the Korean-Japan peninsula.

□ *MS-33*

Responses of East Asian Winter Monsoon to Extra-Tropical and Tropical Pacific SSTAs in Autumn and Winter: Observations and Modelling

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Observational studies suggest that both the surface temperature anomalies (SSTAs), in Tropical and Extra-Tropical Pacific in autumn and winter, bear intiminate relationships to the anomalous East Asian winter monsoon (EAWM). It is well-known that the SSTAs in both regions are correlated closely, so it is very necessary to investigate the roles of Tropical and Extra-Tropical Pacific SSTAs on EAWM respectively. Based on the observations, numerical experiments are designed to investigate the responses of EAWM to autumn/winter SSTAs in the equatorial east-central and mid-latitude Pacific by using NCAR CCM2. Results show that EAWM responds to the winter/autumn SSTAs in both the mid-latitude and equatorial east-central Pacific to a certain extent, but the anomalous characteristics of the atmospheric response to SSTAs are various with the season and the sea area where the SSTA occurs. In autumn, the significant response of EAWM to SSTA occurs in the mid-latitude

Pacific. The persistent autumn SSTA in the mid-latitude Pacific can lead to the anomalous general circulation of atmosphere over Eurasian Continent and North America, inducing the atmospheric EU and PNA wave train patterns. The cooler (warmer) autumn SST in the mid-latitude Pacific is favorable to the occurrence of a stronger (weaker) EAWM. But in winter, EAWM is affected by SSTAs in both the equatorial east-central Pacific and the mid-latitude Pacific. The forcing from the SSTAs over those two regions results in the anomaly of winter general circulation accompanied by the PNA and WP wave train patterns. As a result, the positive (negative) SSTA in the east-central Pacific and the negative (positive) SSTA in the mid-latitude Pacific are favorable to the occurrence of a weaker (stronger) EAWM.

IMS-34

Climate Change and Monsoon Circulation Systems: Variability and Predictability with Reference to Indian Monsoon System

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The monsoon regions of the globe also appear to exhibit variability on times scales ranging from intraseasonal to interannual. It has long been noticed that these variations may be predictable elements within the context of a coupled ocean-atmosphere-land system of the Indian monsoon circulation in relation to Asian-Australian monsoon system, either inherently associated with the coupled monsoon system or from external influences (e.g., ENSO, Eurasian hydrology). It is also focused that there is some evidence that the variability in the monsoon influences ENSO. The present study has been attempted on the precept that, based on the knowledge that inferences have been drawn in the last decade towards understanding the variability of the Indian or Asiatic monsoon and exploiting that knowledge to making useful forecasts of variability. The present study also probes in to the decadal variation in the monsoon circulation patterns and its variability in relation to the precipitation pattern over the Indian subcontinent. The study also investigates the intraseasonal to interannual variability in the Monsoon circulation with a view to identify the factors that influence predictability and circulation patterns. A common circulation pattern which links rainfall variability over India on sub seasonal and interannual timescales have been identified and used as a base for the predictability of the seasonal mean monsoon behaviour that requires only the effects of the slowly varying components of the climate system. Thus the study emphasizes its importance in studying the spatial and temporal variability of Indian Monsoon system for intraseasonal, interannual and decadal times scales, El Nino and ENSO connections with the Monsoon circulation and decadal oscillation pattern and its behaviour, seasonal oscillations, ocean-land surface processes coupling with the Monsoon dynamics and the circulation patterns related to its predictability. The study was carried out with the available data and case studies available at its best to examine the Monsoon circulation patterns to observe circulation systems, variability and predictability in relation to spatial variation in precipitation pattern over the subcontinents. Forecasts of seasonal rainfall anomalies are feasible to the extent that these anomalies are related to predictable shifts in boundary conditions such as land surface conditions and sea surface temperature. Using an ensemble of seasonal forecasts, the influence of

Eurasian land surface conditions (specifically springtime snow anomalies) on Indian monsoon variability has been demonstrated which has implications for the future development of seasonal prediction for India.

IMS-35

Response of the Asian Summer Monsoon to Changes in ENSO Properties

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Diagnostics from observed precipitation and NCEP-NCAR reanalysis products reveal that after the 1976-77 climate shift in the Pacific there was a dramatic change in the response of the Indian Summer Monsoon (ISM) to El Niño, particularly during July-August. Based on 1950-1975 (PRE76), and 1977-2001 (POST76) El Niño composites we note that the Western North Pacific Monsoon (WNPM) was stronger than normal in both epochs, while the ISM was weaker than normal during the entire monsoon season during PRE76 but only during the onset and withdrawal phases in POST76 period. The major difference between the two epochs, in terms of observed SST during July-August, is the presence of cold SST anomalies over the Indo-Pacific warm pool whose effect on the ISM is investigated from a suite of experiments with an Atmospheric General Circulation Model (AGCM) that has realistic monsoon precipitation climatology.

Using the AGCM, 10-member ensemble simulations, separately for PRE76 and POST76 El Niño events, and cases where SST anomalies inserted over (i) tropical Indo-Pacific-TIP, (ii) tropical Pacific only-TPO, and (iii) tropical Indian Ocean only-TIO, are conducted. Qualitatively, TPO solutions reproduce the observed monsoon response in both epochs. Specifically, during July-August of POST76, the cold SST anomalies in conjunction with remote subsidence suppress the precipitation (3-5 mm/day) over the Maritime Continent-equatorial central Indian Ocean. TIP solutions indicate that inclusion of Indian Ocean SST anomalies further amplifies the negative precipitation anomalies extending into the equatorial eastern Indian Ocean. The low-level anti-cyclonic circulation anomalies that develop as a Rossby wave response to these convective anomalies increase the westerlies over the northern Indian Ocean to favor a stronger ISM and WNPM. During PRE76, absence of such cold SST anomalies over the warm pool had an opposite effect on the monsoon. A simple linear model is employed to confirm the processes identified from the AGCM.

In sharp contrast, when SST anomalies only in the Indian Ocean are preserved, TIO solutions reveal weaker than normal ISM during July- August of POST76. However, in both epochs the Indian Ocean SST exerts significant impact on the WNPM variations. The implications of the model solutions on the seasonal prediction of the monsoon are discussed.

IMS-36

Impacts of the Indian Ocean on the Indian Summer Monsoon-ENSO Relationship

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This study investigates the impacts of the Indian Ocean on the relationship between the Indian summer monsoon and the El Niño-Southern Oscillation (ENSO) through numerical simulations with a coupled atmosphere-ocean general circulation model and atmospheric general circulation model (AGCM) experiments with specified sea surface temperature (SST) and surface heat flux (SHF) forcing. Previous studies have shown that this particular coupled model captures many aspects of the observed Indian summer monsoon-ENSO relationship. However, it is found that when the Indian Ocean is decoupled from the atmosphere the Indian monsoon-ENSO relationship reverses. This change is linked to the relationships between surface evaporation, surface wind, and SST in the North Indian Ocean. In the coupled case, surface evaporation anomalies are positively correlated with surface wind anomalies during April-June and are of the same sign as SST anomalies during July-September. In the decoupled Indian Ocean case, surface evaporation anomalies are of the same sign as surface wind anomalies during the entire April-September period. Numerical experiments with an AGCM were performed with SST or SHF anomalies specified in the tropical Indian-Pacific Ocean, tropical Pacific Ocean only, and tropical Indian Ocean only. These experiments confirm the importance of local coupled air-sea feedback in the Indian Ocean for a proper simulation of the Indian monsoon-ENSO relationship.

IMS-37

The Dominant Modes of Indian Ocean SST and Their Climate Effect

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In this study we show that the basic features of IO SST variability and its dominant modes using EOF analysis. Based on this result, we investigate the relationship between the dominant modes of IO SST and their climate effect focused on

the monsoon, ENSO, IO dipole mode, and others. Also we discuss the time evolution and potential predictibility associated with SST, monsoon, and others.

MS-38

Study of Indian Winter Monsoon Rainfall Variability and Atmospheric Circulation Changes

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In this paper an attempt is made to examine the influence of Sea Surface Temperatures(SSTs) of the Pacific and the Indian Oceans on winter monsoon rainfall variability, which accounts for upto 60% of yearly total rainfall during October through December over South peninsular India. The datasets relating to Indian winter monsoon rainfall, SSTs and Southern Oscillation Index (SOI) of the Pacific and SSTs over western Indian Ocean are used in this study from 1946-1997.Linear correlation and sliding correlation analyses show relation between two different parameters and stationarity of the relationship.

Year-to-year variations of winter monsoon rainfall are related with the Pacific Ocean and atmospheric parameters like SOI and SSTs over Nino-4 region.Above analyses reveal that SOI and SSTs in April and May show statistically significant inverse and positive relationships respectively with the rainfall in the recent four decades. Further, 20-year sliding correlation between winter monsoon rainfall and the SOI /SSTs over Nino-4 region reveals significant relationship greater than 5% level. Secondly the influence of SSTs over the western Indian Ocean during April through June on winter monsoon is also examined and it is interesting to note that there is a significant positive relationship between above two parameters and their 20-year sliding correlation coefficients show that this relationship is stronger in the recent three decades.

Finally, the NCEP/NCAR Reanalysis datasets are used to examine the strength and extent of Walker and Hadley cell circulations around the winter monsoon study region which are highly influenced by the Pacific and the Indian Ocean temperatures in the case of extreme events.These anamalous circulation changes throw light on the variability of Indian winter monsoon rainfall over south peninsular India.

MS-39

Moisture Transport from the Ocean and Precipitation in India

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A method has been developed to provide high-resolution vertical integrated moisture transport (IMT) in the atmosphere by combining the observations by spacebased scatterometers and microwave radiometers. The method is able to capture both high and low frequency variations of IMT, as validated with time series of global radiosonde stations. The IMT fields over the tropical and subtropical oceans have been

computed between 1989 and 2003, using data from QuikSCAT and the Tropical Rain Measuring Mission (TRMM). The geographical distribution and the annual variation of IMT in the Indian Ocean will be discussed. The temporal variations of the net influx of moisture from the ocean and the precipitation over the Indian subcontinent (from TRMM) are compared. An observed delay in the onset of summer monsoon indicated by both continental precipitation and IMT across the coastline was observed in 2002. Possible remote factors, as indicated through analysis of IMT field, particularly intraseasonal processes, will be presented.

IMS-40

Variability and Extremes of Daily Rainfall during the Indian Summer Monsoon

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In this study the variability and extremes of daily rainfall events during the Indian summer monsoon is investigated on the basis of a long observational record for the period 1901-1989, originating from the Indian Meteorological Department. The data are daily averages for 52 blocks, extending 2.5° in the meridional and in the zonal direction, except for the blocks on the Indian west coast with a width of 1°. The characteristics of the variability and of extremes of daily rainfall will be described by various means. Among others, extreme daily rainfall events are investigated by means of various theoretical extreme value distributions, i.e., the Generalized Extreme Value distribution (GEV) and the Generalized Pareto distribution (GPA), each with a number of different assumptions for the daily data entering the fist to the theoretical distributions are based. This allows for assessing the suitability of the different kinds of theoretical extreme value distributions for describing extreme daily rainfall events during the Indian summer monsoon.

The spatial distribution of the rainfall intensity on wet days during the Indian summer monsoon is very similar to the distribution of the overall monsoon rainfall, with maxima on the west coast of the Indian peninsula and in Assam and a small amount of precipitation in northwest India and in the southeastern part of the Indian peninsula. The day-to-day variability of the rainfall on wet days, on the other hand, is relatively strong in the northwestern and southeastern parts of the Indian peninsula. The gamma distribution is suitable for characterizing the time series of daily rainfall during the Indian summer monsoon by two parameters, i.e., the scale parameter â and the shape parameter á. A substantial amount of precipitation in association with heavy rainfall events is not only found on the west coast of the Indian peninsula and in Assam, where the maxima of the rainfall intensity are located, but also in Gujarat. The GPA distribution is better suited for describing the behaviour of the heavy rainfall events during the Indian summer monsoon than the GEV distribution. This deficiency is related to the substantial temporal variability of daily rainfall during the Indian summer monsoon on sub-seasonal as well as on interannual time scales.

MS-41

Clustering of Synoptic Activity by Indian Summer Monsoon Intraseasonal Oscillations

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Active and break phases of the Indian summer monsoon are characterized by enhancement and decrease of precipitation over the monsoon trough region. Using genesis data of monsoon low pressure systems (LPS) and circulation data for the period 1954 to 1993, it is shown that the frequency of occurrence of LPS is nearly 3.5 times higher in the active phase of monsoon as compared to the break phase. In addition, the tracks of these synoptic systems are also strongly spatially clustered along the monsoon trough during the active phase of the monsoon. The enhanced (decreased) frequency of occurrence of LPS during active (break) phases is due to modulation of meridional shear of zonal winds and cyclonic vorticity along the monsoon trough by the intraseasonal oscillations (ISO).

MS-42

Behaviour of Synoptic Scale Monsoon Systems over Indian Seas Prior to the Onset Phase of Southwest Monsoon

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The Indian monsoons are part of large planetary scale Asian monsoons which are the most dominant systems of the world. The summer monsoon system is extremely important scientific problem. It is the major component of the global atmospheric general circulation. Summer monsoon is the only regular phenomenon in the sense that it comes every year. But its activity has intraseasonal as well as interannual variability. As the onset date varies, atmospheric circulation pattern also differs from year to year. Occurrence of synoptic scale monsoon systems in the Arabian Sea and Bay of Bengal during early May to early June may play significant role in the actual onset date and total rainfall of the monsoon season. Though it is already known that total number of depressions and cyclonic storms occurring in the Arabian sea and Bay of Bengal have no direct relation with total seasonal rainfall of India, it is still not clear whether the number of synoptic systems in the pre-monsoon system have any relation with seasonal rainfall of India. In the last decade, except the year 2002, rest of the years, Indian

southwest monsoon rainfall is found to be good. It is interesting to note that during the year 2002, a cyclonic storm in the Arabian sea is observed for the period 6-10 May. But for the year 2000, not a single system is observed prior to onset of southwest monsoon. Therefore, it is intend to study behaviour of various synoptic scale lower tropospheric monsoon system observed in the Arabian Sea and Bay of Bengal from 1st week of May to 1st week of June i.e. prior to the onset of southwest monsoon for the last ten years and to determine their possible relation if any, with southwest monsoon rainfall. For this purpose NCMRWF (National Centre for Medium Range Weather Forecast, N.Delhi, India) analysed daily winds, temperature and humidity parameters at 1.5o x 1.5o resolution throughout in the troposphere over the region, EQ-25.5N and 49.5E-100E are considered. Dynamics and Physics is responsible for the behaviour of the system will be discussed. The role of dynamic instability in the onset phase of southwest monsoon will be studied.

IMS-43

Studies on the Land-Ocean-Atmosphere Interactions in the Summer Monsoon Climate System Over India

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The large scale variability of summer monsoon over India owes its existence due to surface boundary conditions (soil moisture, snow cover and sea surface temperature) was well established during the MONEX-79 (Monsoon Experiment) and TOGA (Tropical Ocean Global Atmosphere). Recent research has also shown that the inter-annual fluctuations in the complex monsoon system are influenced not only by the surface boundary conditions but also by the internal intra-seasonal variability on the low frequency scale. In order to understand the role of land-ocean-atmosphere processes in the low frequency variability of the `Monsoon Climate System over India? organised major field programs. These observational studies are well known as MONTBLEX (Monsoon Trough Boundary Layer Experiment-1990), LASPEX (Land Surface Processes Experiment over Sabarmati river basin-1997), BOBMEX (Bay of Bengal Monsoon Experiment-1999) and ARMEX (Arabian Sea Monsoon Experiment-2002-2003). Conventional and special observational systems were deployed to collect data on different spatio temporal scales as per the design strategy of these experiments. Efforts were made to quality control and archive these observational data sets. The data are available to the scientific community for research and validation of their modelling studies on the Indian monsoon. The paper would present the salient features of these observational programmes, highlight the major scientific results and integrate new findings of each of these programmes. An attempt will be made to bring out the insight provided in understanding the monsoon climate variability by implementing the new observational and modeling studies carried out in India.

MS-44

Multiscalar Spatio-Temporal Variability of the Indian Summer Monsoon as Observed from the Frequency of Cyclogensis in the Monsoon Trough Zone

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Fluctuations in the performance of the summer monsoon during the season over India are known to dominantly dependent on two important factors viz.

a) the north-south oscillations in the regional monsoon trough and

b) the frequency of formation of the synoptic scale (3-5 day) weather disturbances like the monsoon lows and depressions

The intra-seasonal active-break cyclone of the monsoon and the overlapping formation of the monsoon lows/depressions or prolonged absence of the cyclogensis for a period of 15-30 days are influenced by the intra-seasonal oscillation of the monsoon on 30-50 day scale, This study has examined the following aspects of the multi-scalar spatio-temporal variability of the monsoon using the database of the frequency of formation of lows and depressions during the last 25 years (1979-2003) thus extending the database of Mooley and Shukla to 100 years. Besides the day to day position of the monsoon trough are collected to study the following:

(i) Inter-annual variations in the latitudinal position of the monsoon trough and its linkage with active-break cycle and frequency of cyclogesis in the last 25 years.

(ii) Large scale regional fluctuations in the lower tropospheric monsoon flow as produced in the NCEP analysis.

(iii) Frequency of cyclogensis, the life span and tracks of the lows/depressions on year to year basis in relation to drought / excess monsoon years, the secular change, if any, in them, prolonged break monsoon incidence and their possible linkages with low-frequency ISO:

(iv) Decadal scale fluctuations in the frequency of cyclogensis, life spans and tracks of monsoon disturbances based on 100 years of database:

(v) Role of ENSO cycle and secular variations in the El Nino monsoon connections on the monsoon cyclogensis.

The above database and the study would help monsoon modelling community to assess the strength and weakness of the model generated monsoon in multi-decadal simulations available with them.

MS-45

Intraseasonal Variability of the Indian Monsoon Rainfall

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The life cycles of active and break phases of the Indian monsoon rainfall have been studied using a 70-year long gridded daily rainfall data set. By performing a multi-channel singular spectrum analysis (MSSA), two oscillatory modes with periods of about 45 and 20 days have been identified. These two modes show the rainfall anomalies moving from central India to the foothills of the Himalyas and correspond well to the lagged composites of the rainfall based on active and break periods. These two intraseasonal modes, however, do not contribute much to the seasonal mean rainfall. The components corresponding to three other EOFs of the MSSA contribute considerably to the seasonal mean rainfall. The analysis lends support to the hypothesis that the Indian monsoon rainfall variability consists of a component with seasonal signature and a component varying on intraseasonal time scale. The circulation features corresponding to these modes have been examined. Similar MSSA has been carried out on daily OLR to find the relation between the active and break periods of the monsoon and the convection zones over the Indian Ocean. This study has also investigated the question of whether there is a northward propagation of the convection in establishing active and break phases of the rainfall over India.

IMS-46

Role of Intra-Seasonal Oscillations in Seasonal Monsoon Strength: Contrasting Indian Monsoon of 2002 And 2003

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The June through September summer monsoon rainfall for India as a whole was 81 (102) % during 2002 (2003) of its long period average. While the southwest monsoon of 2002 was a severe all-India drought, monsoon 2003 was marked by near-normal rainfall over the country. During the last 5 monsoons (1999-2003), 2002 (2003) was the worst (best) monsoon in terms of quantum of rainfall.

The daily time series of observed precipitation for 2002 is marked by a prolonged break during July; rainfall was deficient by about 50%, unprecedented in the last hundred years. Except during the last week of June and second week of August, no clear active periods are noticed. Conversely during 2003 summer season, no well-defined break periods are discernible. Instead the precipitation time series is marked by relatively steady rainfall from one day to the next. Some distinct active periods prevail during third week of June, mid July, end of July, and first and last week of September. This intermittent behavior of rainfall is associated with a hierarchy of quasi-periods, namely the 3-7 days, associated with the oscillation of the monsoon trough; 10-20 days associated with the westward moving waves and the 30-60 days, characterized by northward moving convective zones.

To get a better insight into the daily rainfall time series, techniques of Band-pass filter and Wavelet Analysis are applied. Results reveal that while the monsoon 2002 was dominated by the slower 30-60 days mode, monsoon 2003 was dominated by the faster 10-20 days and the 3-7 days modes. Even within a monsoon season, a change from active to weak spell clearly shows the period of oscillation increasing from less than 20 days to more than 50 days. This was very obvious during the long dry spell of July 2002. In contrast a change from weak to active spell show periodicity length decreasing.

Further the active (break) spells are strengthened when the positive (negative) phases of both these oscillations appear simultaneously ie they are phase-locked. While the monsoon 2002 reveals one northward progression associated with the 30-60 days mode, no meridional progressions are visible during monsoon 2003.

Thus, besides the surface boundary forcing, the seasonal monsoon strength also depends on the frequency of active or break periods associated with these intra-seasonal oscillations. This inverse (direct) relationship of the Indian monsoon strength with the 30-60 (10-20) days mode has some implications for forecasting. During the season it is possible to foreshadow the subsequent behavior of these oscillations, and serve as a guiding tool for medium and extended range forecasting.

MS-47

VHF Radar Observations During Indian Summer Monsoon

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Indian summer monsoon is associated with torrential rains and strong winds. It is characterized by heavy convection and occasional depressions in the Bay of Bengal and Arabian Sea. Indian summer monsoon usually starts in the month of May or June and it retreats from the country by September. MST radars are powerful tool for studying the atmospheric dynamics. During the summer monsoon period, experiments were carried out using the Indian MST Radar located at Gadanki (13.5°N, 79.2°E). From MST Radars we get the three components of wind with high time and altitude resolution. The wind characteristics during the time of active monsoon, onset and withdrawal of monsoon are studied. The movement of tropical easterly jet stream is studied in detail. The wave generation during the monsoon is also studied. These results will be presented in detail at the conference.

MS-48

Effect of Tibetan Snow Depth on Indian Summer Monsoon: Results of a Regional Model

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It is known that the Tibetan plateau has mechanical as well as thermal effects on the atmospheric circulation pattern, especially over the summer monsoon circulation of the region. With the availability of sophisticated regional models, it is very essential to examine the effect of slowly varying surface boundary conditions such as the Tibetan snow on the Indian summer monsoon circulation and associated rainfall. Although RegCM3 has been used widely for various mesoscale studies, it has not been tested to study the characteristics of Indian summer monsoon features and associated rainfall so

far. In this paper, RegCM3 has been integrated over the Indian region to (i) examine some of the salient features of monthly mean monsoon circulation and rainfall using different convection schemes and to (ii) conduct sensitivity experiments with snow depth over Tibet during the spring season as the boundary condition in the model to see its effect on the subsequent summer monsoon circulations and rainfall over India.

RegCM3 has been integrated from April to September in the years 1993 to 1996 and the mean monsoon circulation features and rainfall simulated by the model at 55km resolution have been studied for the monsoon season (June, July, August and September). Characteristics of wind at 850 hPa and 200 hPa, temperature at 500 hPa, surface pressure, rainfall and snow depth simulated by the model at resolution 55km have been examined for both the convective schemes Kuo and Grell with Arakawa-Schubert as the closure scheme. The monsoon circulation features have been compared with those of NCEP/NCAR reanalysis and the rainfall with those of India Meteorological Department (IMD) observational rainfall data. The maximum strength of JJAS mean Somali jet at 850 hPa in the control run is 14m/s for Kuo and 16m/s for Grell convection scheme. The corresponding NCEP/NCAR reanalysis JJAS mean value is 16m/s. Similarly, the maximum strength of wind at 200 hPa over the Indian Ocean is 14m/s for Kuo and 18m/s for Grell schemes.

Based on model simulations, it is inferred that Tibetan snow in April decreases the rainfall over India in the following monsoon season. The influence of Tibetan snow depth on monsoon circulation features and subsequent summer monsoon rainfall over India has also been examined in detail by using NIMBUS-7 SMMR snow depth data as the boundary condition in RegCM3. The difference fields of mean monsoon circulation simulated in the control as well as sensitivity experiments are examined in detail in order to study the influence of Tibetan high snow on Indian monsoon circulation and its associated rainfall. Model simulations confirm that All India rainfall is reduced by 30% in the high Tibetan snow experiment than in the control (no snow) experiment. High snow over Tibet also results in weak lower level monsoon westerlies and upper level easterlies.

MS-49

Climate Effects of the Deep Continental Stratus Clouds Generated by Tibetan Plateau

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Evidence is presented to show that the annual mean cloud optical depth in the leeside of the Tibetan Plateau exhibits a global maximum between 60oS and 60oN. This large cloud optical depth is due to the persistence of deep stratus clouds (primarily the nimbostratus and altostratus) during winter and spring. These deep stratus clouds are generated and maintained by the frictional and blocking effects of the Tibetan Plateau. The plateau slows down the over-flow, inducing downstream mid-level divergence; meanwhile it forces the low-level surrounding-flows to converge downstream, generating sustained large scale lifting and stable stratification that maintains the thick stratus clouds.

This stratus clouds produce extremely strong cloud radiative forcing at the top of the atmosphere, which fundamentally influences the local energy balance and climate change. Analysis of the long-term meteorological station observation reveals that the monthly mean anomalous cloudiness and surface temperature vary in tendon. In addition, the surface warming leads to destabilization and desaturation in the boundary layer. These evidences suggest positive feedbacks between the continental stratus clouds and surface temperature through changing lower-tropospheric relative humidity and stratification. It is shown that the positive feedback mechanism is more robust during the period of the surface cooling than during the period of surface warming. It is suggested that the positive climate feedback of the continental stratus cloud may be instrumental in understanding the long-term climatic trend and variation over the East Asia.□

MS-50

O-18 Ratios in Precipitation along Three Vapor Transport Paths

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Three sampling cross-sections along the south path starting from the tropics through the vapor passage in Yunnan-Guizhou Plateau to the middle-low reaches of Yangtze River, the north path from west China, via north China, to Japan under the westerlies and the plateau path from South Asia over the Himalayas to the northern Tibetan Plateau, are set up, based on the IAEA/WMO global survey network and sampling sites on the Tibetan Plateau. The variations, and the relationship with precipitation and temperature, of the O-18 ratios in precipitation along the three cross-sections are analyzed and compared. Along the south path, the seasonal differences of mean O-18 ratios in precipitation are small at the stations located in tropics, but increase markedly from Bangkok towards the north, with the O-18 ratios in the rainy season smaller than that in the dry season. The O-18 ratios in precipitation fluctuate on the whole, which shows that the different vapor sources. Along the north path, the seasonal differences of the mean O-18 ratios in precipitation for the stations in the west of Zhengzhou are all greater than that in the east of Zhengzhou. During the cold half-year, the mean O-18 ratio in precipitation reaches its minimum in Urumqi with the lowest temperature owing to the wide Cold-High Pressure over the Mongolia, then increases gradually with longitude, and keeps at a roughly same level at the stations eastward from Zhengzhou. During the warm half-year, the O-18 ratios in precipitation are lower in the east than in the west, influencing by the summer monsoon over East Asia markedly.

Along the plateau path, the mean O-18 ratios in precipitation in the rainy season are correspondingly high in the south parts of the India Subcontinent, and then decrease gradually with latitude. A sharp depletion of the stable isotopic compositions in precipitation takes place due to the very strong rainout of the stable isotopic compositions in vapor in the process of the lifting on the southern slope of the Himalayas. The low level of the O-18 ratios in precipitation is from Nyalam to the Tanggula Mountains during the rainy season all the while, but O-18 ratio increases with increasing latitude persistently from the Tanggula Mountains to the northern Tibetan Plateau because of the replenishment of vapor with the relative heavy stable isotopic compositions originating from the inner Plateau. During the dry season, the mean O-18 ratios in precipitation decrease basically along the path from the south to the north. Generally, the mean O-18 ratios in precipitation during the rainy season are lower than those in the dry season for the regions controlled by the monsoons over South Asia or the Plateau, on the contrary for the regions without monsoon or by weak monsoon.

Key words: stable isotope; vapor transport path; temperature; precipitation

IMS-51

Meridional Propagation of the MJO and Off Equatorial Monsoon Variability

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In this study we examine the links between tropical heating, the Madden Julian Oscillation (MJO)/Intraseasonal Oscillation (ISO), and the off-equatorial monsoon development. We examine both observations and idealized "MJO heating" experiments employing the NASA Seasonal-Interannual Prediction Project (NSIPP) atmospheric general circulation model (AGCM). In the simulations, the model is forced by climatological SST and an idealized eastward propagating heating profile that is meant to mimic the canonical heating associated with the MJO in the Indian Ocean and western Pacific.

We show that the variability of the Asian-Australian summer monsoons is closely linked to the tropical MJO/ISO activity and heating. The MJO/ISO variability includes a well-known meridional propagation that affects the summer monsoons of both hemispheres. The AGCM experiments with idealized eastward propagation MJO-like heating reproduce the observed meridional propagation including the observed seasonal differences. The results suggest that the winter/summer differences associated with the MJO are auxiliary features that depend on the MJO's environment (basic state and SST) and are not the results of fundamental differences in the MJO itself.

MS-52

Summertime MJO Activity in the Eastern Pacific Ocean and the North American Monsoon System

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The summertime (Jul-Sep) activity of the Madden Julian Oscillation (MJO) has a local maximum in the tropical eastern Pacific Ocean, just off the west coast of southern Mexico. During this season, vigorous monsoon-like precipitation develops in northwestern Mexico with links to regional-scale changes in precipitation and atmospheric circulation across North America--the North American Monsoon System. 20 years of daily precipitation data for stations across Central and North America are used to examine the influence of the MJO activity in the eastern Pacific and linkages to the monsoon system. The predictive potential for precipitation related to the influence of the MJO activity is also examined out to 21-day lead times.

An index of MJO activity is constructed by averaging the Wheeler et al. estimate of the MJO over (120W-100W,10-15N). The index varies smoothly in time and the phase is estimated from the sign and slope of the index. Compositing the daily station data based on the phase of the eastern Pacific MJO divided into four parts shows a notable influence throughout Central and North America. The largest percentage changes in precipitation are along southwestern Mexico / northwestern Central America as well as along the west coast of the U.S. In both regions, precipitation during one of the quarter-cycles of the MJO differs from the long-term mean by 45% or more. This large difference is realized at individual stations. Precipitation is also influenced less strongly in other regions such as the gulf coast of the U.S. At different phases in the MJO evolution, the large-scale patterns of variability associated with the MJO have considerable similarities to variability associated with the North American Monsoon System. These similarities are examined in terms of precipitation anomalies and low- and upper-level winds.

As a initial assessment of predictability, a very simple scheme is considered: the phase of the MJO is predicted by assuming it advances at its average rate, and this predicted phase is then used to anticipate whether precipitation at a given lead time will be suppressed or enhanced. Two versions of the MJO estimate are considered: a diagnostic one that is more accurate but not available in real-time, and a real-time estimate. With the simple scheme applied to the diagnostic estimate for a subset of stations in the focus regions previously mentioned, useful predictive information exists out to 21 days; using the real-time estimate, there is predictability out to at least 14 days.

MS-53

Spatial Coherence of Southwest U.S. Rainfall on Intraseasonal and Interannual Timescales

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The southwestern U. S. is particularly sensitive to variability in climate, and management of water resources in this arid region of growing population presents a formidable challenge. Improved knowledge of hydroclimatic variability is a first step in better planning and management of systems which are both directly and indirectly climate dependent.

Precipitation is produced by a complex combination of interacting processes operating over a wide range of space and timescales. Southwestern U.S. precipitation regimes experience climate variability on a wide range of potentially interacting timescales ranging from intraseasonal to decadal. It is therefore important to identify and isolate various mechanisms responsible for these fluctuations in space and time. Some possible forcings are introduced by natural modes of atmospheric circulation associated with large-scale processes such as ENSO and MJO, along with changes in intraseasonal wave activity emanating out the North Pacific. The challenge facing the climate community is to develop and implement a capacity to forecast these variations.

In this contribution, we examine spatial coherence of Southwest U.S. rainfall patterns, utilizing wavelet analysis (WT) and empirical orthogonal function (EOF) analysis to describe the space-time behavior of Southwest U. S. rainfall and adjacent Mexico. WT applied to time-series allows not only detection of the periodic fluctuation in frequency space, but also their temporal localization. Hence, the combination of WT Analysis with EOF allows us to examine these characteristics over one region.

We analyze daily precipitation data from station and reanalysis data for the years 1958-2002 in order to identify dominant modes of variability of precipitation and coherence with large scale circulation. Preliminary analyses reveal that summer rainfall in the southwestern U. S. is modulated by large-scale, low- frequency (20-50 day) dynamics. Improved understanding of these interactions could lead to more accurate seasonal to subseasonal forecasting of precipitation.

MS-54

Structure of Subseasonal Disturbances over the North American Monsoon Region

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Intraseasonal precipitation variability over the southwestern U.S., Central America, and adjacent ITCZ regions is analyzed during the monsoon season (July-August) using surface station observations, along with radiosonde, Outgoing Longwave Radiation, and NCEP/NCAR reanalysis data. Over much of Mexico, active periods of monsoon precipitation are most commonly associated with "easterly wave" type disturbances which propagate into the region from the Atlantic. Similar to classical easterly waves, these disturbances tilt strongly to the east with height through the troposphere, and precipitation is concentrated in the low level southerly wind perturbation behind the low level trough. Farther north, episodes of widespread

convection over the southwest U.S. also tend to occur in southerly flow anomalies, but the circulations which predominate here have a more nearly equivalent barotropic structure, with little tilt and amplitudes that increase rapidly with height. These perturbations are accompanied by eastward shifts of the mean subtropical ridge to a position over the southeastern U.S. and Gulf of Mexico, resulting in moisture advection northward at mid-tropospheric levels from the source region over Mexico. This shift is frequently associated with a systematic pattern of Rossby wave activity propagating into North America from the North Pacific, as shown by an E Vector analysis.

For convective episodes over the low terrain of the southwest U.S. there is a statistical relationship to Gulf of California moisture "surges", characterized by bursts of low level southerly winds in the Gulf that bring near surface moisture into the deserts. Although heavy rainfall events are frequently accompanied by these surges, we show that low level moisture is neither a necessary or sufficient condition for such events. Farther north over the higher terrain of the Colorado Plateau mid-level moisture advection by anomalous southerly flow is generally present during widespread precipitation episodes.

Both the easterly waves and the Rossby wave activity originating over the Pacific show highly statistically significant signals up to two weeks prior to the convective outbreaks over North America, which may be useful for predictive purposes. In addition, the submonthly activity itself is modulated by lower frequency intraseasonal changes in the circulation, a small portion of which appears to related to the Madden-Julian Oscillation. However, the bulk of this variability does not appear to be forced directly from the tropics, but may simply be due to other sources of internal variability such as wave-mean flow interaction which cause changes in the large scale circulation.

□

MS-55

Climate of Atmospheric Water Budget Parameters over the North American Monsoon Region

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The paper is an overview of the work on atmospheric water budget evaluations over the North American Monsoon (NAM) domain at the NOAA Climate Prediction Center. Information on the observational and model-based datasets, their availability and features, and also on the technique involved will be discussed. Upper air radiosonde and surface observations over Mexico, Central America and the U.S. are used to evaluatethe water budget parameters over the North American Monsoon region. The results which are based on about thirty year time series of atmospheric water budget components (i.e. precipitable water, water vapor fluxes, precipitation) include analyses and initialize discussions about time series, mean annual cycles, anomalies, long-term variations, and possibilities of closing water budgets over the NAM area.

Relationship Between Antecedent Land and Sea Surface Conditions, Warm Season Precipitation in the North American Monsoon Region over 1916-2001

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The North American Monsoon (NAM) is the dominant source of precipitation in parts of the U.S. Southwest. Possible improvements in the ability to predict NAMS precipitation could have important economic and social impacts on the region. We explore links between the NAM seasonal (Jun-Jul-Aug-Sep) precipitation in this region and the antecedent pre-monsoon (previous autumn, winter, and spring) land surface conditions (precipitation, surface air temperature, soil moisture, snow cover) , oceanic conditions (sea surface temperature) and atmospheric circulation (500mb geopotential height, Z500). In this study, we focus on western Arizona and eastern New Mexico which have a strong monsoon signal. Land surface data for the study were monthly aggregates from the extended retrospective Land Data Assimilation System (LDAS) archive over North America for the period 1916 to 2001. The retrospective LDAS archive includes gridded (at one-eighth degree spatial resolution) precipitation (P), mean surface air temperature (Ts), and Variable Infiltration Capacity (VIC) land surface model-derived soil moisture (Sm), and snow water equivalent (SWE). Our preliminary results for 1950-1999 indicate that the relationship between previous winter's precipitation and the strength of NAMS precipitation are not stable in time, in contrast to the implication of past studies. Over the period 1965-1999, the relationship is strong, but weak in other periods. Also, while the land surface memory of the previous winter's precipitation can persist through spring, and in some cases even into June, this land memory contributes little to the magnitude of NAMS (summer) precipitation. In particular, the pre-monsoon (June) surface temperature over the U.S. Southwest desert shows a negative relationship with monsoon precipitation, which is the reverse of what we expect based on the monsoon driving force concept of land-sea temperature contrasts. The apparent reason is the June upper-tropospheric atmospheric circulation pattern: the June 500 mb anticyclone in dry years induces an increase in surface temperature in the U.S. Southwest, and vice versa. The atmospheric circulation anomaly map also suggests that winter and summer atmospheric circulation correlation may be the main cause for previous winter precipitation – a negative relationship with the strength of the summer's monsoon. These relationships have been inferred from preliminary analysis of the 1950-99 period, which we here extend to most of the 20th century. We also assess the relative importance of land surface feedback, sea surface conditions and atmospheric conditions

to NAMS and their robustness, with the eventual goal of improving the predictability of monsoon warm season precipitation.

MS-57

Eastern Pacific Tropical Cyclone Development and the North American Monsoon System

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We describe the preliminary results of an investigation of the role of eastern Pacific tropical cyclone activity in the North American Monsoon System (NAMS). Tropical cyclones and their remnants account for a significant fraction of summer rainfall across parts of the NAMS domain. The goals of this project are to (1) assess the capabilities of a high-resolution regional model (MM5) for simulating tropical cyclones in the context of the monsoon circulation, (2) assess the interannual variability of eastern Pacific tropical cyclones and their tracks in the observational record, relating such variability to monsoon precipitation indices, and (3) use the model to examine sources of potential predictability of cyclone activity on seasonal/interannual time scales.

The initial simulations illustrate the sensitivity of model-simulated cyclone development and total precipitation (over the ocean and the continent) to model parameterizations of physical processes and the location of prescribed lateral boundary conditions. Results of these sensitivities will be shown and an initial assessment of MM5 to accurately predict important features of the NAMS will be discussed.

MS-58

Numerical Simulation of the Large-Scale North American Monsoon Water Sources

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A general circulation model (GCM) that includes water vapor tracer (WVT) diagnostics is used to delineate the dominant sources of water vapor for precipitation during the North American monsoon. A 15-year model simulation carried out with one-degree horizontal resolution and time varying sea surface temperature is able to produce reasonable large-scale features of the monsoon precipitation. Within the core of the Mexican monsoon, continental sources provide much of the water for precipitation. Away from the Mexican monsoon (eastern Mexico and Texas), continental sources generally decrease with monsoon onset. Tropical Atlantic Ocean sources of water gain influence in the southern Great Plains states where the total precipitation decreases during the monsoon onset. Pacific ocean sources do contribute to the monsoon, but tend to be weaker after onset. Evaluating the development of the monsoons, soil water and surface

evaporation prior to monsoon onset do not correlate with the eventual monsoon intensity. However, the most intense monsoons do use more local sources of water than the least intense monsoons, but only after the onset. This suggests that precipitation recycling is an important factor in monsoon intensity.

MS-59

Low-level Winds, SSTs and Precipitation in the North American Monsoon

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Five years of QuickScat winds, AVHRR SSTs and a high resolution satellite derived precipitation dataset are used to investigate the interplay between the low-level winds and SSTs over the Gulf of California (GoC) and the patterns of precipitation known as the North American Monsoon.

We find that the onset of the summer monsoon season is accompanied by a decoupling of the flow along the GoC from the flow over the North East Pacific, with the establishment of a time-mean southerly flow over the entire gulf. Such a dynamical decoupling, which is coupled to a profound seasonality in the SSTs, is not evident in the winds from the reanalysis products.

A PDF analysis of the winds is used to identify transient events, namely Gulf Surges. Our results are compared to those obtained by traditional methods of surge identification based on surface observations at Yuma, Arizona (at the northern mouth of the Gulf). The validity of the two methods are compared and discussed; in addition, the relative contribution to the total moisture transport by the time mean flow and transient eddies is estimated.

Overall, our results seem to reinforce the importance of the unique geography of the Gulf of California in the monsoon development and raise the question of to what degree models that poorly resolve such complex topography can indeed reproduce the distinctive features of the North American Monsoon precipitation regime.

MS-60

Rainfall in the North American Monsoon Experiment Domain: A Perspective from the TRMM Satellite and Rain Gauge Networks

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One of the objectives of the North American Monsoon Experiment (NAME) is to document the vertical and horizontal structure (including rainfall characteristics) of precipitation features over the Sierra Madre Occidental (SMO) and adjacent Gulf of California (GOC) region. A number of previous studies have shown that large-scale feedbacks from the North American Monsoon System (NAMS), including rainfall patterns in the southwestern United States, are sensitive to the intensity and spatial distribution of rainfall within the core of the NAME region. Because of the lack of in situ measurements in NW Mexico, accurate satellite estimates of rainfall are critical for validation of numerical forecast models. However, until now, ground validation datasets of satellite rainfall estimates (i.e., spatially dense research quality rain gauges or calibrated ground radars) in the NAME region have prevented detailed validation of both rain estimates and numerical models. This is especially true in the complex terrain of the SMO, where operational gauge locations tend to be biased towards low elevations.

NAME is planned for summer 2004 and will take place in an area where Tropical Rainfall Measuring Mission (TRMM) satellite rainfall estimates from spaceborne radar and passive microwave sensors differ by more than 100 percent in both directions depending on location relative to the terrain of the SMO. The varying regimes of rainfall observed in the NAME domain (varying from the extremes of continental to oceanic rain types) challenges the satellite rainfall algorithms due to the complex terrain and surface properties and varying environmental forcings for rainfall systems. Detailed observations from the NAME field campaign radars and rain gauges will allow future evaluation of satellite rain estimates performance in the region.

This study will examine the multi-year climatology of rainfall systems in the NAME region as observed by the TRMM satellite, exploiting TRMM's multi-sensor approach to deduce the rainfall, convective intensity, and lightning characteristics of precipitating systems. TRMM rainfall climatologies as well as early results from the NAME high resolution gauge network as a preliminary investigation of rainfall variability and algorithm deficiencies in the region.

MS-61

Enhancement of the Daily Raingauge Network in Mexico in Support of NAME

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The activities described in this poster are directly responsive to the stated priorities of the FY2004 NOAA PACS/GAPP NAME-2004 Field Program and are a critical contribution to the PACS/GAPP North American Warm Season Precipitation

Initiative, which is focused on variability and predictability of summer climate over the North American monsoon region. Specifically, we have installed and are maintaining a cooperative network of ~1100 simple rain gauges in poorly sampled areas of Northwest and Northcentral Mexico. Daily data are collected, digitized, quality controlled, analyzed and disseminated. Improved daily precipitation analyses for Mexico will be generated by merging the new data with an existing database available at the Climate Prediction Center both during and after the NAME 2004 campaign. The improved analyses will resolve details of the daily precipitation pattern that are critical to the objectives of NAME and facilitate related PACS/GAPP diagnostic and modeling studies in the core monsoon region (e.g. relationships between precipitation and topography), on the regional scale (e.g. relationships between moisture surges and precipitation) and on the continental scale (e.g the out-of-phase relationship between precipitation in SW North America and the U.S. Great Plains). Following NAME 2004, the SMN will continue to manage the network towards an improved official climatic database for Mexico.

MS-62

Precipitation, Precipitable Water, and Monsoons

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With the development in satellite observations and retrieval techniques, precipitable water (W) has become a conventional meteorological quantity. It has recently been applied to determine the monsoon onset and retreat, but traditionally precipitation (P) is used for the purpose. In this study, the relationship between these two hydrologic parameters is physically clarified for different temporal components by using observed ten-year daily data over the conterminous United States and Mexico.

It is revealed that the mean annual cycles of P and W are continentally controlled by different factors, and thus, exhibit different spatial characteristics. The annual cycle of W over the entire US-Mexico region, similar to surface temperature, shows a high spatial correlation with maximal W in summer and minimal in winter. Theoretical analysis shows that the annual cycle of W over land is dominated by surface temperature due to its large annual range regardless of how the relative humidity changes annually. In contrast, the annual cycle of P over land is mainly influenced by atmospheric circulation, and thus has significant local characteristics. Over the North American monsoon region, the annual P is in a pattern with maxima in summer and minima in winter. Over the non-monsoon regions, the annual P is mainly in patterns with maxima in winter and minima in summer, or with P changing little during the year. The daily deviations of P and W to their mean annual cycles have significant positive correlation over the entire US-Mexico region.

It is therefore concluded that, because of the significant positive correlation between the mean annual cycles of P and W over the monsoon region, W can be reasonably used to determine the monsoon onset and retreat which were originally determined by P. The interannual variations of the monsoon onset and retreat can also be properly reflected by W since the daily deviations of P and W to their mean annual cycles have high positive correlation over the monsoon region. Over the non-monsoon region, there is no positive correlation between the mean annual cycles of P and W, and this explains why the global monsoon regions could not be fully distinguished from the

non-monsoon regions in our previous work in which a globally unified monsoon onset and retreat index was proposed by using the single parameter of W.

MS-63

Interannual Variability of Warm-Season Rainfall over the US Great Plains in NCAR/CAM and NASA/NSIPP Simulations: Intercomparisons for NAME

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Interannual variability of summer rainfall and moisture fluxes from two state-of-the-art atmospheric model simulations are analyzed over the US Great Plains in order to advance the goals of the North American Monsoon Intercomparison Project (NAMIP). The NCAR simulation was obtained using the Community Atmospheric Model (CAM, Version 2.0) while the NASA one was generated from the ARIES atmospheric model developed for NASA's Seasonal-to-Interannual Prediction Program (NSIPP); both models serve as the atmospheric component of their center's climate system model. The simulations were produced using the observed 1950-998 lower boundary conditions (sea-surface temperature, sea-ice, etc.).

The retrospective U.S. and Mexican precipitation data set, and the NCEP and ECMWF reanalysis are used as targets for the simulations. The simulations are in some disagreement with each other and with nature in the spatio-temporal portrayal of rainfall variability over the US Great Plains and associated rainfall teleconnections over southern United States and Mexico. Notable Great Plains precipitation anomalies are linked with vertically integrated, stationary moisture flux anomalies from the Gulf of Mexico in nature, but not in simulations. Models do produce significant rainfall anomalies over central U.S. but these are likely generated from other processes (e.g., local evaporation). The simulations also exhibit rather different linkages between Great Plains precipitation and the Pacific SSTs, with the NCAR/CAM producing a linkage structure that is closer to the observed pattern.

MS-64

An Analysis of the Warm Season Diurnal Cycle Over the Continental United States and Northern Mexico in General Circulation Models

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In this presentation we report on our progress in analyzing and improving the warm season diurnal cycle over the United States and northern Mexico in three different AGCMs (from NASA, GFDL and NCEP). Our strategy involves a coordinated analysis approach in which we examine the impact of resolution and various convective and related processes (e.g. development of CAPE, interactions with the land surface, and the role of clouds), with a particular focus on the diurnal cycle of precipitation. We also assess the influence of both regional (e.g. land/sea circulations, sloping/complex terrain)and larger scale (e.g. low level jets, the North American monsoon system) controls and feedbacks on the evolving diurnal cycle. All findings are tested and evaluated within the models of all three groups to ensure that the results are not model specific. The analysis includes an assessment of the limitations imposed by an inadequate observing system, and the improvements that are anticipated with the advent of the NAME 2004 field campaign.

IMS-65

NAMAP: An Assessment of Regional and Global Model Simulations of the North American Monsoon

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We summarize results from the North American Monsoon Experiment Model Assessment Project, known as NAMAP. The analysis is based on a set of six model simulations of the 1990 summer climate across southwestern North America, carried out independently following a common format. The simulations are designed to provide a set of comparable control runs for a single season in order to assess the state of the art of standard regional and global models in simulating the seasonal evolution and diurnal cycle of atmospheric circulation, hydrometeorology, and land surface flux fields across the domain of the North American Monsoon system. All the models are driven by the same prescribed time-varying SST fields, so differences between models are associated with land surface characterization and internal model dynamics (including resolution). Two models are global and four are nested regional models, so the analysis also shows differences associated with the imposition of prescribed lateral atmospheric boundary conditions for the regional models. Despite significant cross-model differences, all the models simulate the basic seasonal evolution from pre-onset dry conditions through a summer seasonal precipitation maximum. However both global models exhibit delays in monsoon onset compared to observations or the regional models. Precipitation amounts vary significantly in core regions of the monsoon throughout the diurnal cycle, suggesting that monsoonal precipitation is sensitive to the onset and magnitude of late afternoon deep convection, as well as in the nocturnal propagation and persistence of

convective systems. Large cross-model differences in surface turbulent fluxes are found, motivating future model development and validation efforts that would enhance the simulation of atmosphere-land surface feedbacks.

MS-66

Diurnal Cycle of Precipitation Associated with the North American Moonson System: A Case Study for 2003 Using the CMORPH Data Set

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The diurnal cycle of precipitation associated with the North American Monsoon System (NAMS) has been examined for 2003 using the newly available CMORPH satellite-based precipitation data set (Joyce et al. 2004). The CMORPH technique combines spatially incomplete precipitation estimates derived from space borne passive microwave observations with infrared imagery to create spatially complete half-hourly precipitation fields on a 8km x 8km grid over the globe from 60S to 60N.

In this study, 3-hourly mean precipitation fields are computed on a 0.25 deg lat/lon over the NAME domain for the 6-month period from May - October 2003. A diagnostic study is then performed to describe the temporal-spatial structure of the mean state and diurnal cycle of the NAMS precipitation over the period. Our preliminary results are:

1) Precipitation associated with the North American Moonsoon System is influenced significantly by topography such that the precipitation increases sharply as the system moves inland and reaches its maximum about 50km west of the mountain ridge;

2) Precipitation variations over the NAMS domain are dominated by the diurnal cycle which experiences its minimum and maximum at 10 LST and 19 LST, respectively;

3) The phase of the diurnal cycle is relatively stable on a daily basis throughout the period, while the magnitude varies on synoptic and intra-seasonal time scales;

4) The diurnal cycle of the NAMS precipitation is coupled with, and out of phase with, precipitation over the eastern Pacific ITCZ and the Gulf of Mexico.

Futher work is underway to examine the diurnal cycle of clouds and to investigate the relationship with large-scale circulation and moisture fields. Detailed results will be reported at the conference.

☒ *MS-67*

Diurnal, Intraseasonal and Interannual Variability of Precipitation and Cloudiness Associated with the North American Monsoon System

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Improved understanding of the large diurnal variability of precipitation associated with the North American Monsoon System (NAMS) is crucial to improving efforts to model and predict climate variability in the Western U.S. In this poster we will describe the mean annual cycle and interannual variations of precipitation and cold cloud in the NAMS region over the period 1987-1997. Our data sources will be the CPC Merged Analysis of Precipitation (CMAP), together with histograms of IR-derived equivalent black body temperature averaged over 5-day periods with 3-hourly diurnal resolution. The mean annual cycle and interannual variations of the diurnal cycle in cold cloud using a variety of temperature thresholds will be examined using harmonic and wavelet analysis, as well as simple inspection of sequences of figures. The observed variability will be compared to observed diurnal variability in precipitation measured by recording gauges and the spatial and temporal characteristics of the relationship will be described. The observed diurnal cycle will be compared to the results from regional model experiments conducted as a part of the North American Monsoon Experiment (NAME) Model Assessment Program.

☐ *MS-68*

Dendrochemistry of a High Elevation Tropical Pine Forest for Isotopic Analysis and Reconstruction of the North American Monsoon System: Nevado De Colima, Mexico

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The area watered by the North American Monsoon encompasses a vast geographic region, from tropical Mexico to the deserts of the Great Basin. The system is ultimately driven by tropical ocean-atmosphere interactions, which in turn orchestrate global climate variability over a range of timescales. Instrumental observations at the end points of the system span only the past few decades in the tropical south and are limited to only a few decades more in the desert north. At both locations, high-resolution proxy records of climate can supplement existing data. The Mexican mountain pine (Pinus

hartwegii) has been shown to hold a paleoclimate record at a high elevation site in tropical Mexico. Warm-season precipitation regime is the dominant year-to-year signal in a 400-year tree-ring chronology from Nevado de Colima, Mexico, where an automated weather station and a range of automatic tree growth sensors (phytograms, point and band dendrometers) have been installed at 3770 m (12,370 ft) elevation. Co-measuring tree growth and climate over a three-year period, has contributed to a better understanding of the complex response of low latitude, high elevation trees to changing environmental conditions. This characterization is supplemented a reconstruction of the stable isotopic record of Monsoon fluctuation as recorded by the trees. Stable isotopic characterization of the source waters has been traced through the atmosphere/ soil/ plant continuum and characterized before and after the Monsoon. Additional isotopic analysis of tree ring cellulose is underway. Preliminary results show a strong seasonal isotopic signal and the potential for reconstruction of relative humidity, drought and monsoon intensity.

MS-69

Relationships Between Gulf of California Moisture Surges and Precipitation in the Southwestern United States

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Relationships between Gulf of California moisture surges and precipitation in the southwestern United States are examined. Standard surface observations are used to identify gulf surge events at Yuma, Arizona for a multi-year (July-August 1977-2001) period, and Climate Prediction Center precipitation analyses and NCEP/NCAR Reanalysis data are used to relate the gulf surge events to the precipitation and atmospheric circulation patterns, respectively. Emphasis is placed on the relative differences in the precipitation and circulation patterns for several categories of surge events, including those that are relatively strong (weak) and those that are associated with relatively wet (dry) conditions in Arizona and New Mexico after onset. The extent to which these patterns are influenced by a phasing of tropical easterly waves and mid-latitude westerly waves is also considered. Results indicate that a significant fraction of the events in all categories are related to the passage of tropical easterly waves (TEWs) across western Mexico, but that the strength and location of upper tropospheric anti-cyclonic circulation features in mid-latitudes strongly influence whether a given surge will be associated be anomalously wet (dry) conditions in Arizona and New Mexico.

We have also investigated relationships between surge events and other types of synoptic disturbances (e.g. tropical storms moving northward/westward, middle/upper level inverted troughs, etc.) that may influence the evolution of the surges.

MS-70

VAMOS Programs Data Archives

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The University Corporation for Atmospheric Research/Joint Office for Science Support (UCAR/JOSS) supports data management activities for a variety of climate-related projects and field campaigns around the globe since the mid 1990s. These include the Pan American Climate Studies (PACS), Variability of the American Monsoon Systems (VAMOS), East Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System 2001 (EPIC-2001), The South American Low Level Jet Experiment (SALLJEX) and the upcoming North American Monsoon Experiment (NAME). To support these projects, UCAR/JOSS conducts a variety of data management activities ranging from the planning and preparation of data management documents, to the data collection, processing, quality assurance, archival, and dissemination to support project researchers. JOSS operates an interactive relational database catalog to search and distribute project data sets. In addition, UCAR/JOSS is providing support to the World Climate Research Programme (WCRP) Coordinated Enhanced Observing Period (CEOP) project. One of CEOP's scientific objectives is to document the seasonal march of the monsoon systems, assess their driving mechanisms, and investigate their possible physical connections. To support this objective CEOP has identified a number of well instrumented reference sites in tropical regions. UCAR/JOSS takes the data from each of these reference sites and develops a quality assured hourly resolution composite data set in a uniform format. The initial data set for CEOP covers the period from 1 July to 30 September 2001 and three additional annual cycle data sets are planned to follow over the period from October 2001 to September 2004. This poster will summarize data management activities and provide an overview of these various databases.

IMS-71

WCRP/CLIVAR/VAMOS/South American Low-Level Jet Field Campaign: General Overview

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The South American low-level jet (SALLJ) east of the Andes is part of a continental-scale gyre that transports moisture from the tropical Atlantic Ocean, first westward across the Amazon Basin, and then southward to the extratropics of South America. Although this gyre has continental scale, it displays a regional intensification just to the east of the Andes mountains, with strongest winds apparently near Santa Cruz, Bolivia. The relatively small spatial scale (compared with the density of the sounding network) of this intensification of the winds has limited the understanding of any variations in the LLJ intensity and structure, to downstream rainfall variability over southeastern South America. In that sense, CLIVAR/VAMOS has implemented the SALLJ international program, to contribute to the understanding of the role of SALLJ in

moisture and energy exchange between the tropics and extratropics and related aspects of regional hydrology, climate and climate variability.

The SALLJ field campaign (SALLJEX) was performed with great success between 15 Nov 2002 and 15 Feb 2003 in Bolivia, Paraguay, central and northern Argentina, western Brazil, and Peru. Scientists, collaborators, students, NWS personnel and local volunteers from all the countries in the region and USA participated in SALLJEX activities in an unprecedented way. SALLJEX had three major components: i) Enhanced upper-air network, by incrementing both radiosonde and pibal observations was needed to quantify the variability of the LLJ over different spatial scales; describe the spatial variability of the diurnal cycle; and to describe the Chaco heat low. ii) Enhanced raingauge daily observations were essential to determinate wet and dry periods during the experiment and their relationship with SALLJ events; provide ground truth estimates for comparison with a hierarchy of numerical rainfall simulations and determine the accuracy of satellite-rainfall estimates over the region. iii) The NOAA/P-3 missions gave from around 120 hours of flights, a detailed representation of the structure and variability of the LLJ east of the Andes and of the relationship between MCS activity and the LLJ.

SALLJEX observations provide a unique opportunity for numerical model validations and sensitivity studies that attempt to reproduce the structure of the jet and its variability as well as the related precipitation. Such validations as well as data assimilation experiments are currently undergoing. Some of the SALLJEX related investigations are also presented in this Conference. Further information about SALLJEX is available at

http://www.salljex.at.fcen.uba.ar/ or http://www.joss.ucar.edu/salljex/.

□

MS-72

Mesoscale Convective Systems Activity during SALLJEX and the Relationship with SALLJ Events

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Many previous studies have shown the precipitation over La Plata Basin is produced by large Mesoscale convective systems (MCSs). During the international field campaign SALLJEX conducted during November 15, 2002 to February 15 2003, enhanced pibals and radiosoundings have been performed in a South American region enclosing the low level jet (LLJ) domain. IR brightness temperature available at http://lake.nascom.nasa.gov/ every half an hour was used to localize the position and stage of every MCSs during SALLJEX using the program FORTRACC (Machado et al 98). This enhanced upper-air network and the availability of higher resolution data allowed addressing the relationship between the timing and intensity of the low-level jet and the MCSs. SALLJEX period shows the presence of 112 MCS over Southeastern

South America (SESA, 20-40S – 44-64W), with the most intense and large systems located between 54 – 64W.

The MCSs characteristics studied include initiation time, duration, maximum extension time and size. The initiation time displays a maximum at late afternoon and evening hours, showing highest frequency on the region located in 20-30S – 44-54W. The MCSs mature stage occurrence shows two maxima, the most important occurs at 08 UTC (around 5 local time) and the other one since 20 UTC up to midnight (17 to 21 local time). The mature stage size attains huge values during spring with areas higher than 400.000 km2 in the 30 % of the cases, while in summer these cases are less frequent.

SALLJEX wind data in case studies denote the presence of a strong convergence during the initiation and mature stage while during dissipation dominates cyclonic vorticity related to horizontal wind shear. The MCSs environmental conditions have been composited over 20-30S – 54-64W domain during nocturnal hours using GDAS analysis.

The signal of a favorable environment to develop intense convection around 30S, represented by a strong moisture flux along the eastern slope of the Andes is present the day before the MCS attains its mature stage. The LLJ is weaker during the MCSs mature stage time and the convergence region moves toward the MCS location. Further analysis will be performed composing the environment related to MCSs over the remaining subregions and different maximum extension times.

IMS-73

Model Intercomparison During SALLJEX

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The South American Low level jet experiment (SALLJEX) provided a unique framework to assess model performance over the region. During this period, a set of six regional models (ETA model at the Univ. of Maryland, ETA model at CPTEC/INPE – Brazil-, MM5 model at Univ. of Chile and at CIMA/Univ. of Buenos Aires, RAMS model at CIMA/Univ. of Buenos Aires and at Univ. of Sao Paulo) and two global models (COLA/CPTEC, Brazil and Utah Global model at Univ. of Utah) provided daily short range forecasts (up to 72 hours).

The overall models performance has been analyzed during SALLJEX Special Observing Period (from January 8, 2003 to February 10, 2003), while a set of individual cases has been selected for detailed assessment of model performance under different boundary and initial conditions. In order to achieve this objective, a series of coordinated experiments have been carried out after SALLJEX period. The selection of the individual cases provided insight into the particular issues that characterize the short to medium range prediction over the area of interest, which were stated in SALLJ scientific objectives. One key aspect was to assess the degree of dispersion between forecasts generated with identical initial and boundary conditions, and very similar domain and horizontal resolution settings. For a particular case characterized by the occurrence of heavy precipitation over northeastern Argentina, it is shown that, even providing the same initial and boundary conditions from the GDAS analysis (i.e. running the regional models with the analyses instead of using any global model forecast) the dispersion between the members of the ensemble is large, and starts from the very beginning, after the first 6-hr forecast. All the models failed to provide a reasonably good precipitation estimate, and strong discrepancies between model's low level circulations have been also found. It is considered that the absence of an organized larger scale forcing could be the main responsible of these models failure in this particular case. Also a lack of an adequate representation of the initial state has been detected. For this reason, a new set of experiments is being carried out, to analyze the impact of the inclusion of SALLJEX data both, in the initial field and in the boundary conditions for regional models.

IMS-74

Data Assimilation at CPTEC/INPE During the Period of the SALLJEX

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The assimilation system at CPTEC is performed using the Physical-space Statistical Analysis System (PSAS), both in the Atmospheric Global Circulation Model and the Regional Model. This scheme solves analysis equations globally. This eliminates the local approximation and data selection of the optimal interpolation (OI) schemes. PSAS is comparable to the global variational spectral analysis system, but

unlike spectral analysis schemes, it works directly in physical space. It minimises an objective function with the control variable defined in observation space. During the SALLJEX (South American Low-level Jet Experiment) experiment, six radiosonde data were added to the normal dataset which comprises the GTS, ATOVS, TPW and quikScat data. These radiosondes were operating in an area which was not covered by the normal measures, the area of the Low Level Jet occurrence. The objective was to show the impact of assimilating these additional data in the analysis system during the SALLJEX, and to show features associated with the LLJ occurrence. Satellite images had shown periods of CCM development during the period, and the previous analyses had shown the occurrence of the LLJ associated with these developments. In this study, the AGCM CPTEC/COLA is applied with the PSAS scheme, to do a reanalysis of January 2003. The results show that there is an intensification of the LLJ and a small shifting of its center towards west and an increase of the humidity in the area of the LLJ.

IMS-75

Simulating a Low-Level Jet Observed during the SALLJEX with RAMS

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A major objective of the South American low-level jet experiment (SALLJEX) was to describe from observations the detailed structure of the strong flow often found to the east of the Andes. With reliable observations, the fidelity of numerical simulations can be assessed to evaluate the performance of modeling efforts to reproduce the jet. This study describes a moderately intense LLJ with strongest winds over southern Bolivia and western Paraguay on 06 February, 2003 which we chose to simulate with the Regional Atmospheric Modeling System (RAMS) version 4.3. The LLJ event persisted for several days, and was subject of an intensive observation period during the SALLJEX that extended from Feb 4th through February 9th. The RAMS model run was initialized at 12 UTC 05 February. Initial and boundary conditions were provided by the GDAS analyses (1º horizontal resolution) every 6 hour. Two-way nesting capability of the model was used, with two grids, with 80 km and 20 km resolution. Special observations made by the NOAA P-3 flight mission on February 6th are presented to show the observed structure of the jet approximately 24-30 hours after the model initialization time. A maximum wind speed of about 25 m/s is found in the 800 hPa - 750 hPa over northwestern Paraguay. A second maximum was observed near Santa Cruz, Bolivia before the aircraft landed. Comparison between aircraft data and model simulations shows that the simulated fields are reasonable in describing the general northwesterly flow, but underestimate the intensity. There are differences between the observations and simulations near the Andean foothills and also in the flatter terrain over eastern Bolivia, where the effects of

grid-scale convection appears to perturb the wind field more than the observations indicate.

IMS-76

Daily Precipitation Monitoring Over South America: Experience During SALLJEX

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Investigations on regional extreme events occurrence, climate model validations as well as evaluations of model skills in simulating climate trends and changes in extreme event frequency over South America have been limited by lack of high-quality daily climate database for temperature and precipitation. The climate observing system over South America exhibits serious deficiencies in terms of both its spatial and temporal resolution. In that sense, one of the main components of the CLIVAR/VAMOS/South American Low Level Jet Experiment (SALLJEX) was the enhancement of the current daily rainfall network over southeastern South America (SESA). SALLJEX activities were concentrated over Argentina, Bolivia, Paraguay, Peru and Uruguay and the resulting daily precipitation database not only included the observations from the new raingauge stations installed by SALLJEX but also the data from networks owned by local cooperatives and institutions that kindly accepted to participate in the experiment. Details of the SALLJEX daily precipitation database will be given at the Conference.

Although SALLJEX was only held during the austral warm season of 2002-2003, it has been very useful because the observations collected give a unique opportunity for validation of numerical simulation sensitivity studies that attempt to reproduce the structure of the jet and its variability as well as the related precipitation. In particular, the purpose of the SALLJEX daily precipitation network was to provide ground truth estimates for a) determining wet and dry periods during the experiment and their relationship with SALLJ events; b) comparison with a hierarchy of numerical simulations

of rainfall in the region and c) determining the accuracy of satellite-rainfall estimates over the region.

SALLJEX efforts have shown that there is a considerable amount of historical daily rainfall observations owned by local institutions and organizations that can be potentially rescued in order to improve the current deficient climatic database over SESA. Future plans for daily precipitation data rescue over SESA will also be discussed.

MS-77

Feedback Between the Low Level Jet and Convection: A Case Study During SALLJEX

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The RAMS model (Regional Atmospheric Mesoscale Model) is used to simulate the environmental conditions associated with the development of a mesoscale convective system (MCS) located in central Argentina during the South America Low-Level Jet Experiment (SALLJEX). This MCS developed at the exit region of a strong low-level jet which met Bonner criterion over a large region encompassing northern Argentina, Paraguay and Bolivia. Evaluation of model results during a 36-h period indicates that the model successfully reproduces most principal features of this event, including the low-level jet diurnal cycle, strength and distribution of precipitation at the exit region. In order to better understand the interaction between this low level jet and the latent heat release at the exit region associated with the MCS activity, a sensitivity experiment was performed. This experiment essentially differs from the control in that the water vapor was treated as a passive tracer (NO-LH). The hypothesis underlying this experiment is that the feedback between convection and the low level jet tends to reinforce the latter, accelerating the ageostrophic poleward component of the low level wind. This mechanism has been suggested as the main responsible for the southward increased penetration of these particular low level jet events in previous works.

It has been found that the low-level jet resulting from the NO-LH run is significantly weaker than the observed and than the simulated in the control experiment. The more significant differences between both runs are observed after 24-h of simulation over northeastern and central Argentina, ahead of the MCS and coinciding with the time when the precipitation rates are strongest over central Argentina in the control run, partially confirming the hypothesis. Nevertheless, it has been also found strong sensitivity to latent heat release at the entrance region of the low level jet (around 17ºS) where the low level wind response is of the opposite sign, thus suggesting some kind of compensation along the current. The areal dependence of the sensitivity motivated an additional set of experiments that are designed to isolate the effect over both regions: the entrance (close to the Amazon) and the exit of the low level jet (around the La Plata basin). This study strongly reinforces the idea of the central rol that the LLJ has upon the hydrological balance South America.

MS-78

Description of the Chaco Low Characteristics Using SALLJEX Special Observations

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A low pressure system is commonly observed over Northwestern Argentina (locally known as the Northwestern Argentinean Low, NAL, but more widely referred to as the Chaco low) near the Andean slopes. Previous studies characterized the NAL as a thermal-orographic system, being much more frequent during summer than in winter. Through modeling studies it has been demonstrated that the summer NAL has a significant diurnal cycle and its existence is mostly explained by the sustained surface warming that results from the previous day's circulation. Nevertheless, all the mentioned work, since no upper air-data is available over the region of the NAL, does not have an observational basis and/or can not be verified against any observation On the other hand, several studies related to the South American Low level jet (SALLJ), identified the relationship between the deepening of this low pressure system and the intensification of the northerly low level jet.. For this reason, special attention was given to this thermal low during SALLJEX, and in particular a NOAA-P3 flight mission (February 1st , 2003) has been dedicated to the observation of this feature. This work compiles all the data provided through the enhanced upper air observations and the NOAA-P3 profiles, in order to describe the three dimensional structure of the NAL episode that started by January 29, 2003 and ended by February 3, 2003.

From the radiosonde station at Santiago del Estero, Argentina (located near the low center) it could be detected an impressive warming (reaching above 40ºC at 3 PM local time) and a very deep mixed layer, reaching up to 700 hPa, where a subsidence inversion avoids further penetration of the mixing. Northerly winds dominated the circulation at Santiago del Estero on Februay 1 st . From the radiosondes and the circulation obtained with the P3, it could be confirmed that the thermal low exhibits a closed circulation, even at 700 hPa. They also show that this system is surrounded by very deep mixing layers that reach up to 650 hPa over the warmer surfaces. The depth of the mixing layers shows an increase towards the low level pressure center. This rather unique stratification of the system has been identified for the first time. Further information from the flight observations, (soon available) will be added to improve the characterization of the horizontal and vertical structure at the core.

Variability of the South American Low Level Jet (SALLJ) in Various Time and Spatial Scales

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Variability of the structure and spatial extension of the SALLJ is studies using a combination of various data sets (global reanalyses, PACS-SONET observations, OLR) and the data generated during the SALLJEX field experiment during the austral summer of 2003.

On the circulation characteristics, SALLJ composites during the warm season show the enhanced low-level meridional moisture transport coming from equatorial South America as well as an upper level wave train emanating from the West Pacific propagating towards South America. The intensification of the warm season SALLJ obeys to the establishment of an upper-level ridge over southern Brazil and a trough over most of Argentina. The circulation anomalies at upper and lower levels suggest that the intensification of the SALLJ would lead to an intensification of the South Atlantic Convergence Zone SACZ later on, and to a penetration of cold fronts with an area of enhanced convection ahead at the exit region of the SALLJ.

Regarding the time variability, SALLJ seems to occur all year long, with the SALLJs bringing tropical moist air masses from the Amazon into southern Brazil-Northern Argentina more frequent in the warm season, and the SALLJs bringing tropical maritime air less humid than the tropical air masses coming from the Subtropical Atlantic High more frequent during the cold season. SALLJs are detected mostly during the warm season to the North of ~20S, while to the south the SALLJs seem to occur all year long. The diurnal cycle shows that SALLJs are more frequent and intense between 06 and 12 Z for the warm season north of 20 S, while at the region downstream the maximum is detected between 00 and 06 Z. during the cold season. At interannual time scales, even though there is a weak tendency for stronger and more frequent warm season SALLJ episodes in years with anomalously warm surface waters in the tropical Pacific, we cannot affirm with large degree of certainty that there is a strong relationship between the occurrence of El Niño events and the number and/or intensity of SALLJ episodes. However, the El Nino 1998 featured more frequent and intense warm season jet episodes than during La Nina 1999, and this has been demonstrated by the reanalyses, the available PACS-SONET upper-air observations and by other studies using independent data sets and regional modeling.

Diurnal Wind Cycle of the South American Low-Level Jet

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The South American Low-level jet (SALLJ) is a moist corridor that promotes exchange of atmospheric water vapor from low to mid-latitudes and consequently modulates the spring and summer rainfall events over the La Plata river basin. A three-month international field experiment (SALLJEX) has been conducted under VAMOS/CLIVAR during which enhanced pibals and radiosoundings have been launched over a region enclosing the SALLJ domain.

A study has been performed in order to characterize the lower troposphere wind diurnal cycle during SALLJEX in terms of wind speed, wind direction and altitude of the maximum wind as one of the specific objectives of this experiment. Hodographs at most SALLJEX sites reveal the oscillation in direction over the diurnal cycle with transitions between different time intervals instead of a regular progression. The observed behavior is consistent with a simple theoretical model that includes inertial oscillation, a subsynoptic pressure gradient related to mountain-valley differential diurnal heating/cooling and the interaction of a dominant meridional northerly component with the subsynoptic circulation. Diurnal rotation is weaker in the northern part of the network increasing toward the south where synoptic variability is stronger. Maximum speed altitude varies between less than 500 m and 3 km with a tendency to rise during daytime hours, consistent with a mixed layer growth.

The preliminary analysis of spatial variability in the time of wind speed maximum is not clear in SALLJEX data. The SALLJEX wind data has been divided in three different samples and composited to look for signals in the diurnal cycle using the NCEP operative analyses: days without evidence of SALLJ (NSALLJ), days characterized by SALLJ occurrence penetrating to subtropical latitudes (Chaco-SALLJ events, denoted CJE) and non-Chaco SALLJ events (NCJE). At northern sites within the network the jet signal is very weak but it becomes stronger during SALLJ events with a maximum at 9 UTC. At Santa Cruz, Bolivia, the wind speed vertical profile shows a strong (~15 m/s) and high maximum present at all the available hours (except 21 UTC) during SALLJ events. Over Paraguay the strongest jets (>20 m/s) and the maximum amplitude in diurnal oscillation occur during CJEs from 6 to 12 UTC. Near the mountains over Argentina another shallow LLJ is present during NSALLJ cases while eastward (at Resistencia) a jet is evident only during CJEs and more to the south the SALLJ signal weakens determining the southern limit of SALLJ.

On the Characteristics and Time Variability of the Low Level Jet East of the Andes and the South American Monsoon System

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There are some observational evidences as well as modeling studies that show that the Low Level Jet East of the Andes (hereafter, LLJ) is responsible for most of the moisture and energy transport between these two basins, and the LLJ is a components of the South American Monsoon System. Studies using reanalises and other observational data sets have started to show some characteristics of the LLJ. A field experiment was implemented during the austral summer of 2003 to perform high resolution observations in the characteristics of the LLJ. A science team involving scientists from Brazil, USA, Bolivia, Argentina, Paraguay and Peru is working on the analysis of series of detailed and high resolution surface, upper-air and remote sensing observation, in order to answer this science question:

What is the role of the LLJ on the moisture transport from the Amazon to the La Plata basins? More specific science issues include: the synoptic variability of the LLJ; the spatial structure and time variability from diurnal to intraseasonal time scales; the role of the of the LLJ in the intraseasonal variability of precipitation along the South Atlantic Convergence Zone; the role of the LLJ in the dynamics of the Mesoscale Convective Complexes over the La Plata Basin; the interannual variability of the LLJ; the dependence of the LLJ in relation to SST anomalies in the Pacific and Atlantic; the representation of the LLJ in atmospheric models; and the coupling between the occurrence or not of LLJ episodes and rainfall in the Andean region, east of the Andes, and southern Brazil-northern Argentina.

The extension and upgrading of the current observational network will allow for better and more frequent surface and upper-air directed towards a better understanding of the LLJ, based on a combination of observation and monitoring of circulation and fluxes associated to the LLJ, complemented by regional and global models. Using observations from this field experiment as well as the NCEP reanslyses and SST anomalies from NCEP we studied case studies, seasonal variability as well as interannual and interdecadal variability of the LLJ and its characteristics.

MS-82

Relationship Between the Occurrence of South American Low Level Jet and Daily Precipitation and Temperature Extreme Events

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Summer precipitation over northeastern Argentina is influenced, among other features, by the moisture transport. This could be from the tropical North Atlantic into the Amazon Basin and then towards the southern Brazil-Northern Argentina region or from the tropical South Atlantic both converging into the South American Low Level Jet (SALLJ). This circulation could also influence Maximum (MaxT) and Minimum (MinT) Temperatures in the affected region.

This study introduces climatology of daily precipitation and daily MaxT and MinT associated with SALLJ episodes, classified in ChacoLLJ, no Chaco LLJ and no LLJ, during the warm semester (September to February) in Argentina (northern of 40°S). The daily quintiles of MaxT, MinT and rainfall for each month in a climatological period (1959-1998) was calculated. The daily quintiles of rainfall were calculated without considering the zero rainfall.

In general there are little intraseasonal differences, considering the temperatures probability patterns. During Chaco LLJ days, there is very low probability of having a cold extreme temperature over the North, and a high probability of having a cold extreme MaxT or MinT (1st quintile) over the central region. The opposite pattern occurs for high Temperatures (5th Quintile). The cases of NO LLJ are opposite to the Chaco LLJ and the cases of no Chaco LLJ are intermediate. MinT is stronger related to the occurrence of Chaco LLJ than MaxT, with probabilities less than 5% of having extremely cold temperatures and higher than 50% of having extremely warm temperatures if it is a Chaco LLJ day.

During the No Chaco LLJ, the monthly pattern of the conditional probabilities, taking into account only the rainy days, presents more intraseasonal variability than the temperatures. If there is a Chaco LLJ day, the probability patterns show a N-S or NW-SE gradient. In the northeastern region, low probability of having low rainfall amount or high probability of having high rainfall amount is associated. The opposite pattern occurs during the cases of No Chaco LLJ. Taking into account every day of the months, including the zeros, the probability of having No Rain is higher (greater than 80%) during No LLJ than during Chaco LLJ (lower than 50%).

MS-83

Regional Climate Model 2 (RegCM2) Simulations of the Low Level Jet East of the Andes

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During the 1998 Austral summer (January-February) there was a great number of Mesoscale Convective Systems (MCS) in Northern Argentina and Paraguay (near 20~30S). From the literature, it is known that there is a strong association between low level jet (LLJ) east of Andes activity and MCS formation in this region and consequent anomalous precipitation. This work presents an analysis of the presence of LLJ in a climatic simulation for January 1998 with the RegCM2 (Regional Climate Model version 2).

The RegCM2 is a compressible, finite difference model with hydrostatic balance and vertical sigma coordinates. The model included the Biosphere-Atmosphere Transfer Scheme (BATS) for surface process representation and the radiative transfer scheme from NCAR Community Climate Model (CCM) version 2. The simulation used horizontal resolution of 75 km, 14 sigma levels, cumulus scheme of Grell and explicit moisture scheme that include a prognostic equation for cloud water. The initial and boundaries values were obtained from NCEP reanalyzes. In order to identify the LLJ along the day (00:00, 06:00, 12:00 and 18:00 UTC) the following criterion was used: speed of the north wind component in 850 hPa lower than -8 m/s and minimum vertical shear of 2 m/s between 850 and 700 hPa which was applied to the data obtained from the simulation. The LLJ composites allowed the discussion of the predominant characteristics and associated anomalies.

The numerical results indicated that the LLJ begins its formation in the north part of South America at 18:00 UTC and in the subsequent times it expands the activity area up to 12:00 UTC. Through the application of the above criterion, the number of LLJ occurrence detected at two distinct points: (I) 23.3S-62.5W, (altitude ~ 300 m) and (II) 18.7S-63.9W (altitude ~ 800 m), were 66 and 75, respectively, with a minimum number of occurrence during 18:00 UTC and maximum at 00:00 UTC. At point I there was also a maximum at 06:00 UTC. The vertical composite of the meridional wind component for the LLJ events showed velocities of 14 m/s at 850 hPa and vertical shear above 5m/s between 850 and 700 hPa. The simulated intensities of the LLJ are reasonably in agreement with observational data analyses. The January precipitation in the Northern Argentina and Southern Brazil associated with the LLJ periods corresponds to around 60% of the total. This result is also in agreement with the observational analyses.

Despite of only using one month of climate simulation, the preliminary results suggested the importance of the LLJ establishment in the generation of the precipitation anomaly downstream of the LLJ formation region, as documented in previous climatological studies. The above normal precipitation over South Brazil and Northeast Argentina during January 1998 was fairly reproduced by the RegCM2 simulations.

Further sensitivity test with the new version of the model (RegCM3) is currently in progress and the results will be presented elsewhere.

MS-84

The Low Level Jet and the South America Monsoon Variability

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The variability of meridional wind in the LLJ and the occurrence of typical summer systems during a period of the SALLJEX are discussed. January 2003 was a very active month with occurrence of the South Atlantic Convergence Zone (SACZ), Upper Level Cyclonic Vortex (ULCV), displacement of frontal systems over South America, short wave disturbances and Mesoscale Convective Systems (MCS). Low level northerly winds over the LLJ area occurred when there was development of a short wave disturbance and MCSs over northern Argentina, and southerly winds were observed in that area in cases of frontal systems displacements northwards and SACZ occurrences. It is shown that the synoptic conditions associated with the synoptic systems and the meridional wind variability were well forecasted by the CPTEC global and regional models. However the mesoscale features in the LLJ area were not well obtained at that time. Daily reanalysis using the assimilation system of PSAS, with and without the additional radiosonde data from the SALLJEX show the improvements in the mesoscale features and the correction in the vertical structure of the LLJ. The atmospheric characteristics associated with the synoptic and mesoscale systems and the relation between low level meridional wind over northern Argentina and convection over Southeast Brazil are analysed during January 2003 in the CPTEC reanalyses data. This variability in the meridional wind and aspects of the SACZ are also analysed in a climate simulation results of the CPTEC/COLA AGCM. Intraseasonal anomalies obtained from filtered model results data of 10 S.H. summer months were similar to observations. The area of northern Argentina and Paraguay, which is affected by MCS, has an opposite relation with the SACZ area in terms of intraseasonal convective activity identified in OLR anomaly analysis. Correlation analysis between OLR anomalies in this area and high level meridional wind over the Southern Hemisphere show wavetrains over South Pacific and a trough over northern Argentina associated with convective activity. Correlation analysis of OLR in the SACZ area and high level meridional wind in other grid points, show also a wavetrain over Pacific, but the trough is located over southern Brazil, to the south of the SACZ. Therefore, the position of the low frequency high level trough and the direction of the low level meridional wind in the LLJ area seems to be important in the development of the MCS and in the monsoon variability.

MS-85

Observed Mean Meridional Circulation in Southern South America East Andes Using Radiosonde Data: Their Influence Humidity Transports

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The main goal of this paper is to characterize, spatial and temporally, the mean meridional circulation east Andes and determinate the influence on humidity distribution in southern South America, using radiosonde data. A statistical analysis was carried out with 25 years of data from 10 stations in Argentina during 1958-1982 period. Zonal and meridional wind components and water vapor fluxes were calculated. The data set used in this study, is the more complete one for the region.

Intra-seasonal variation of the regional meridional circulation is analyzed by mean of meridional wind component vertical cross sections at each radiosonde location. Also meridional and zonal cross sections of meridional wind component are used to study monthly and seasonal pole to equator displacement of the cell circulations. Over subtropical and central east region, the most important feature is the establishment of the Ferrel cell during the whole year except at the beginning of spring, when the whole subtropical troposphere is dominated by an enhanced northerly circulation. During July, northerly circulation in mean and lower troposphere, also reaches the central Argentina between 31ºS and 38ºS. Southerly circulation penetrate into Central region west of 64º W (Santa Rosa location, 36,4ºS, 64.1ºW) during fall and early winter (from March to June) extending in the whole troposphere. At the same time a weakness of the southerly circulation is observed near Andes over Mendoza (32.9ºS; 68.9ºW) and Neuquen (38.6ºS; 67.6ºW) and an enhanced northerly branch anticyclonic circulation domain in lower levels mainly from April to July.

In the Central region the subtropical and polar air mass convergence zone is clearly settled over the 64º West meridian between Cordoba (31.2ºS; 64.1ºW) and Santa Rosa locations. During January and July, the Ferrel and direct polar cells met in the area with the northerly (southerly) branch in lower (upper) levels for the Ferrel (polar) cell and the southerly (northerly) branch in lower (upper) levels for the polar cell. From May to August an intensification of the northerly circulation is clearly observed in the subtropical area over Resistencia (27.3ºS; 59ºW) (the warm branch in the front waves). Humidity fluxes from northwest at lower level are more intensive during winter (monsoon ?)

The reverse of meridional circulation (from North to South) can be appreciated in a 30º south zonal cross section located over Ezeiza (the cold branch in the front waves). This fact means that the mean position of cold fronts associated with the subpolar lows displacement, is located in the littoral area, neighborhood of Resistencia and Ezeiza (34.4ºS; 58.3ºW) locations, during the above mentioned period.

MS-86

Regional Forecast Sensitivity to Local and Remote Targetting

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Prediction of weather and short-range climate evolution over South America is characterized by different challenges than those that arise for North America. This presentation focusses upon special challenges posed by observation gaps in the southern atmosphere. The operational observing network of land radiosondes is much more sparce here than over the northern hemisphere, while the southern oceans may be observed almost as well by satellites as are the northern oceans. It is consequently unclear whether data sparce regions of the oceans or continents represent the most strongly limiting components of the southern observing system. We study the relative importance of initial state detail over South America and detail external to South America with a set of experiments using a variable resolution global model designed to assess impact of initial state changes upon regional predictablity. The approach is to first initialize the model with coarse-resolution analyses in a control integration, and to subsequently replace these coarse analyses with higher-resolution analyses. The higher resolution initial state transplants are performed globally, and in separate experiments that target the South American sector as well as all regions outside South America.

The study has been concentrated in two particular events corresponding to the Intensive Observing Period during SALLJEX (South American Low level jet experiment). For these dates, also the impact of SALLJEX data will be assessed through the use of initial fields that include these data. The lower troposphere carries particular significance through its role in water vapor transport in the summer wet season. Present experiments suggest that forecasts of lower-troposphere winds are strongly influenced by detail of the initial state specification over South America through the first five days of prediction. On the other hand, marked sensitivity of uncertainty impact is found for different synoptic situations used for the initialization. These preliminary results imply an important role for in-situ observations for both the description and prediction of the regional and continental-scale hydrologic cycle.

IMS-87

Impact of South Atlantic SST Anomalies on the Hydrologic Cycle of La Plata Basin in South America

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The effect of South Atlantic SST anomalies on hydrometeorological processes in the Southeastern South America (SESA) during the warm season is investigated using seasonal simulations with the Eta regional model. Simulations consisted of control runs and integrations with anomalies that follow the main modes of SST variability in the Atlantic Ocean. The first mode of interest has a north-south dipole structure with a warmer center of 0.9 C around 15 S-15 W and a cold center of 1.2 C around 32 S-30 W, and it corresponds to the leading mode that maximizes the co-variability between precipitation over SESA and the South Atlantic SST.

Our results show that the Eta model provides a satisfactory simulation of the evolution and propagation of synoptic and mesoscale features, first moving eastward in the tropics then, a small portion of them moving southward along the eastern slopes of the Andes and then propagating westward offshore to the subtropical South Atlantic. Analysis of the average of the last two months of the integrations indicates that the warm pole in the tropics induces a southward shift of the Atlantic ITCZ, increasing the low-level moisture that is advected inland into the Amazon River basin, enhancing the amount of precipitation in SESA; a cold pole in the tropics induces opposite results with less amount of precipitation in SESA. The increase of precipitation in the La Plata River Basin, located in the subtropical South America, appears not directly connected with the southward advection of moisture but to a more complex situation involving a weak convergence of the low-level Jet east of the Andes and a circulation induced by the pole in the subtropical South America.

IMS-88

On the Character of Intense Precipitation Events over the Central La Plata Basin

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The character of intense precipitation events associated with the main mode of variability over the central La Plata basin was investigated using ETA model products. In order to assess the ability of the ETA model to reproduce the temporal variability of precipitation over Southeastern South America (SESA), comparisons between the 12-36 h forecast precipitation and observed precipitation data were made for the austral winters (May-September) and the summers (November-March) during the period 2001-2003. Results show good agreement between the two data sets, in terms of magnitude and frequency.

Composites of upper-level and lower-level circulation features were prepared for the largest precipitation events (wet periods) in the SESA region. Results for summertime show that wet periods are associated with a stronger-than average subtropical jet stream over SESA and the western Atlantic; the band of greatest precipitation is found near the jet`s left entrance region. Also, strong northwesterly flow at low levels (low-level jet) extends from the southwestern Amazon Basin southeastward across eastern Bolivia and southern Brazil. This low level jet produces a strong transport of moisture from the Amazon toward southern Brazil, and increases the atmospheric water content and convective instability (as estimated from the equivalent potential

temperature) over SESA. In addition, the increase of regional precipitation results in a large increase of model forecast river runoff over southern Brazil and Paraguay.

The wet composites for winter show many similarities and some differences with the wet composites for summer. The more relevant differences are the enhanced cyclonic circulation over northern Argentina, and an anticyclonic circulation center over the western Atlantic during the winter period, suggesting an amplified mid-latitude wave pattern with the enhanced rainfall occurring just east of the cyclonic circulation center.

MS-89

Interannual Variability of Precipitation in the Humid Subtropics of South-America

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Monthly averages of raingauge data averaged for the region (22-28ºS and 64-66ºW) east of the Andes mountains (1928-2001), sea surface temperatures and NCEP/NCAR reanalyses starting in 1951 are used to document and describe the interannual component of precipitation variability over the Argentine North-West (NWA). The area exhibits marked gradients of precipitation, with a humid region flanked by semiarid areas to the East and South. Precipitation variability in the region is modulated by moisture flux from the north-east and it is therefore dependent on processes that influence the strength of low level winds. The presentation explores relationships between NWA rainfall and regional processes such as moisture re-cycling and upstream acceleration of low level currents and remote sea-surface temperature controls.

MS-90

An Avaliation of the Applicability of West-Central Brazil Summer Monsoon Indexes

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The West-Central Brazil (WCB) region contains the western portion of the Brazilian Planalto and the headwaters of major rivers, such as Araguaia and Paraguay, which flow into the Amazon and La Plata basins, respectively. It includes a portion of the summertime rainfall maximum where the mean annual cycle of circulation is highly related to the South America monsoon system. The WCB has some monsoon

characteristics such as upper level anticiclonic circulation, low-level depression and a temperature maximum. However, the wind reverse does not happen as in Asian monsoon, just the zonal wind changes its direction.

Several criteria for determining rainy season onset and demise dates have been applied to the monsoon regions of the world, based on rainfall, winds and cloudiness, among others. The aim here is evaluate the applicability of some monsoon indexes to identify the onset and demise dates and the quality of the rainy season in the WCB. The indexes used are OLR (OI), precipitation and 850-hPa zonal wind (PZWI), vertical shear of meridional wind (SMWI) and vertical shear of zonal wind (SZWI).

The data used in this study are pentad of OLR, daily averaged fields of wind from the NCEP/NCAR reanalysis and gridded daily precipitation analyses for Brazil, from the Climate Prediction Center. The period used in all dataset is July/1979-June/1997.

The SMWI and SZWI are defined by the difference of 850- and 200-hPa meridional wind in the point 10oS-40oW and the zonal wind in 25oS-55oW point, respectively. These points are selected because the correlation between the precipitation and the shear component wind was higher. Using the PZWI we define the onset (demise) of the rainy season as the first occurrence of 850-hPa westerly (easterly) winds along 60ºW in the band 10ºS-20ºS together with rainfall rates greater (less) than 4 mmd-1 for at least 75% of the subsequent 8 pentads. By OI we define onset (demise) when the OLR mean in the WCB area (10oS-20oS; 50oW-60oW) is less (more) than 235Wm-2 at least 6 of the subsequent 8 pentad.

Preliminary results show that the OI and PZWI can be used to identify the onset and demise dates. The SMWI in shows a good relationship with the onset and demise of the some rainy seasons studied and the SZWI did not show good results. Others discussions are also made about the applicability of these indexes in the predictability of the rainy season quality.

IMS-91

The Autumn Rainy Regime over the Eastern Amazon/Northeast Brazil: Rainfall-Producing Atmospheric Mechanisms on Intraseasonal and Submonthly Timescales

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The regional precipitation variability within the autumn rainy regime (March to May) over the eastern Amazon (EAM) and northeast Brazil (NEB) is diagnosed by using raingauge-based weekly data from 1982 to 2001. This rainy regime is remarkably modulated by the combined effect of the Pacific and Atlantic SST anomalies. Thus, two extreme and contrasting large-scale climatic scenarios are considered in this study: the unfavorable - UNFAV (favorable - FAV) scenario defined by the simultaneous manifestations of the El Niño (La Niña) in the Pacific and northward (southward) SST gradient in the intertropical Atlantic. UNFAV (FAV) composites for unfiltered data showed remarkable changes in both the Walker and the Hadley cells associated with the

Atlantic ITCZ anomalously weakened (enhanced) which in consequence yields deficient (abundant) autumn rainy regime in most of the EAM/NEB. In the context of these scenarios, we have objectively identified the pluviometric variability using empirical orthogonal functions (EOF) analyses performed on the (30-70 day) intraseasonal and (£ 21 day) submonthly filtered weekly precipitation anomalies for 18 autumn seasons (1983 to 2000). Only the leading EOF mode for these timescales is presented. Strong pluviometric oscillations for both scales during UNFAV and FAV years revealed that, even under extreme climatic conditions prevailing simultaneously in the tropical Pacific and Atlantic, events with anomalously deficient and abundant precipitation over the EAM/NEB occur alternately. Composites based on events with anomalously increased precipitation (selected from principal component series) on intraseasonal and submonthly scales were analyzed separately for the UNFAV and FAV years. It is attempted to isolate and identify the main rainfall-producing atmospheric mechanisms for these scales and regions. These analyses corroborate that during both scenarios UNFAV and FAV the more important rainfall-producing atmospheric mechanism over the EAM/NEB on intraseasonal scale consists in the establishment of deep convective bands organized during sporadic passages of the frontal systems over the northeast Brazil. Such a regional pattern is embedded in large-scale dynamical environment related to the propagation of the MJO convection-active phase over the tropical South America. On the other hand, the main rainfall-producing atmospheric mechanism over the same regions on submonthly scale is the Atlantic ITCZ during FAV years. However, during UNFAV years were observed that the equatorial Atlantic ITCZ activity may be forced by meridionally elongated midlatitude wave trains at upper troposphere.

MS-92

Monitoring the Variability of Atmospheric Circulations in Latin America with the Pan American Climate Studies Sounding Network

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The relatively recent availability of the global NCEP reanalyses has stimulated a relatively large number of studies of climate and climate variability. It has become apparent that in-situ measurements are needed to validate some of these studies. The Pan American Climate Studies (PACS) Sounding Network (SONET) has evolved in response to the perceived lack of in-situ atmospheric soundings over the inter-American region to adequately support these climate research studies. Since depending on the individual efforts of each country in the region to enhance their own sounding networks was not viewed as a proactive solution to the lack of sounding data, NOAA's Office of Global Programs (OGP) in 1997 supported an initial effort to establish a temporary

network of pilot balloon stations to monitor the windfield in parts of Central and northern South America. This has, over the succeeding 6 years, become what is now called the PACS-SONET (http://www.nssl.noaa.gov/projects/pacs/).

At the present time the PACS-SONET involves pilot balloon observations at some 21 sites in 8 countries in Latin America. Seven sites are operated in Mexico, six in Bolivia, followed by two sites each in Paraguay, Venezuela and Peru, and one each in Ecuador, Colombia and Nicaragua. Observations are made daily, near 1200 UTC, except in Mexico, where twice-daily observations are made, and in Piura, Peru where frequent morning cloudiness required afternoon soundings. Each site has a specific contribution to the overall scientific objectives of the project, which have in the past several years focused on supporting longer-term monitoring aspects of the two CLIVAR/VAMOS monsoon experiments, the South American Low-Level Jet Experiment (SALLJEX, January-February 2003) and the upcoming North American Monsoon Experiment (NAME, summer 2004).

This poster will describe, in addition to the basic aspects of the SONET, the special observations that have focussed on the North America Monsoon circulation. The observations from two SONET sites along the Gulf of California show, when combined with radiosonde observations from the region, the lower-tropospheric flow reversal associated with the monsoonal circulation over the Gulf of California. The pilot balloon observations are particularly useful because they are made twice-daily, unlike current radiosonde observations, in this region where the amplitude of the diurnal cycle in the windfield is comparable or larger than the magnitude of the mean flow.

Finally, some of the future directions of the PACS-SONET are described. These include establishing more sites and incorporating special radiosonde-type observations into key sites of the network.

IMS-93

Anomaly Nesting: A Methodology to Downscale the South American Summer Monsoon from an AGCM

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In this paper a methodology is proposed to downscale coarse resolution Atmospheric General Circulation Model (AGCM) seasonal simulations. Anomaly nesting involves replacing the climatology of the driving AGCM with observed (in this case the National Centers for Environmental Prediction reanalysis) climatology at the lateral boundaries of the nested regional climate model (the Regional Spectral Model). In this study the methodology is tested over South American and the neigboring Ocean basins. A comparison of the austral summer seasonal simulation with the conventional way of nesting, namely driving the regional model with full AGCM forcing, reveals that substantial gains in the deterministic skill are realized through anomaly nesting. It is also shown that the high frequency variance (at 3-30 day and 30-40 day time scales) is more realistic from the anomaly nesting procedure.

MS-94

Topographic Modulation of American Precipitation Patterns

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Historical data sets reveal strong inter-annual signals of observed precipitation over both North and South America. These signals are consistent with orographic modulation of regional atmospheric circulations associated with larger-scale index cycle variability. We describe correlations of regional index cycles with regional cyclonic activity and precipitation for both winter and summer, and attempt to provide a theoretical explanation of the observations. The theory also suggests an alternative mechanism for the seasonal reversals observed in monsoonal regimes. This mechanism emphasizes mechanical deflection of ambient flow rather than local heating and proposes that the observed seasonal reversals from wintertime anticyclonic conditions to summertime cyclonic conditions in some monsoonal regions are strongly influenced by the changing ambient zonal flow from winter to summer.

MS-95

The Influence of SST on the South American Monsoon System

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Rotated Empirical Orthogonal Function (REOF) analysis was applied over Chen precipitation data set in order to find a mode that explains the low frequency variability of austral Summer precipitation related to the modulation of South Atlantic Convergence Zone (SACZ) and its relationship with sea surface temperature (SST) anomalies. The REOF 3, which explains about 7.5% of the total variance, consists of positive loading over SACZ region and negative loading over northern Argentina. This mode was used to identify seven years with enhanced activity of SACZ during the Summer season (1950, 1957, 1962, 1965, 1967, 1988, 1991) and nine years with inhibited manifestation of this system (1973, 1975, 1976, 1977, 1981, 1984, 2000, 2001, 2002). In years with increased activity of SACZ during the Summer (here defined from January to March), a low level anomalous cyclonic circulation centered at southeastern Brazil enhanced the moisture transport from the tropics to the SACZ region, inhibiting the occurrence of precipitation over La Plata Basin. A dipole structure consisting of an anticyclonic center over the tropics and a cyclonic center over the subtropics was observed over the continent at high levels. In these years negative SST anomalies were observed close to southeastern South America and positive anomalies were found over eastern South Atlantic. A SST dipole structure was also observed over Indian basin, presenting negative anomalies to the west of the basin and positive in the east side. On the other hand, years with inhibited activity of SACZ presented a low level anomalous anticyclonic circulation over eastern Brazil that enhanced the deviation of moisture transport which

usually occurs from the Amazon basin to Southeastern Brazil during the Summer. Moreover, an anomalous low level northerly moisture flux was observed over La Plata Basin and positive precipitation anomalies were seen over this region. A high level anomalous anticyclonic circulation was configured over the subtropical South America. Positive SST anomalies were observed over South Pacific and western Equatorial Pacific. An observational and numerical case study using a ten-members ensemble technique applied to the Community Climate Model 3.6 General Circulation Model for the 2001 Summer drought observed over eastern Brazil was performed. The results confirmed the combined influence of South Pacific and Equatorial Pacific oceans over the inhibition of SACZ activity.

IMS-96

Intraseasonal Variability During Summer in South America

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The austral summer (DJF) is the rainy season over most of Brazil and South America (Argentina, Paraguay and Uruguay). The knowledge of the intraseasonal oscillations of the summer precipitation with alternating dry and wet phases is important for some applications and can indicate procedures that allow its prognostic.

Many studies have shown that the summer precipitation exhibits a large intraseasonal variability, indicated by the analysis of the outgoing longwave radiation (OLR). In general, theseworks emphasize that the intraseasonal variations in the Madden Julian Oscillation (MJO) time scales, over the region of the South Atlantic Convergence Zone (SACZ), exhibit a dipole pattern where enhanced precipitation over the SACZ is accompanied by decreased rainfall in southern South America.

The present study examines the intraseasonal variability of the observed summer precipitation (for November to March). EOF analysis was performed on daily precipitation data filtered to retain periods in the ranges of 20-30 and 30-70 days, in order to obtain the modes that most contribute to the variability in each of these ranges. The results shows a mode of variability with strong anomalies concentrated in Southeast South America with reversed signal in South America. The lag composite analyses suggest that the signal associated with 20-30 days mode and the 30-70 days mode seems to be originated over the subtropical Pacific Ocean. The vertically integrated moisture flux, in both cases, present a strong westerly moisture flux from the Amazon region towards the Southeast South America. Numerical experiments using a primitive equations model are also been running in order to investigated the role of heating sources over this region.

MS-97

The Diurnal Cycle of Precipitation over South America Based on CMORPH

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The diurnal cycle of precipitation over South America is studied using the CMORPH analysis technique. Satellite precipitation estimates from passive microwave (PMW) sensors provide better estimates of precipitation than those based on IR. However, the PMW satellites (polar-orbiters) have a poorer temporal resolution that the IR satellites (geostationary). CMORPH takes advantage of the better precipitation estimates provided by the PMW satellites and the better temporal resolution of the geostationary satellites to provide precipitation analyses.CMORPH provides high spatial (maximum 8 km) and temporal (30 minutes) resolution precipitation analyses that are ideal for documenting the diurnal cycle of precipitation. The focus of this investigation is on the diurnal cycle of precipitation associated with the South American monsoon. Major features depicted by CMORPH include an afternoon maximum in precipitation over the Andes and the high terrain in central and eastern Brazil, and a nocturnal maximum in precipitation over areas just east of the Andes (western Argentina, central Bolivia and western Paraguay). A remarkable diurnal cycle in precipitation occurs in coastal areas of northern and northeastern South America. With the daytime heating, precipitation rapidly forms along and just inland from the coast. This precipitation advances westward and southward, producing a nocturnal maximum in areas approximately 500 km inland from the coast. A nocturnal maximum also occurs along the immediate coast and offshore in the vicinity of the ITCZ. A nocturnal maximum is also evident over the Atlantic in the vicinity of the South Atlantic Convergence Zone during the southern summer.

MS-98

Uncertainties in Estimating Moisture Fluxes in the Intra-Americas Sea

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We use atmospheric observations and model analyses in and around the Intra-Americas Sea (i.e. Gulf of Mexico plus Caribbean Sea) to evaluate uncertainties in calculating moisture flux divergences in that region. The main dataset used is an archive of regional analysis fields from the Eta regional analyses for April 2002 - December 2003. The Eta analyses are 4-times daily and have a resolution of about 32 km. The water vapor fluxes from the Eta analyses compare well with sounding

estimates. We verify our Eta flux divergence estimates by applying the Gauss theorem and comparing estimates from boundary values with estimates from interior values. We estimate the uncertainties in the moisture flux divergence calculations due to the coarser space and time sampling resolution of the global NCEP/NCAR reanalyses. The estimates of the moisture flux divergence do not change much when the Eta analyses are decimated to the coarser global reanalysis grid. However the monthly estimates from the actual global reanalysis and the Eta analysis are quite different. The water vapor flux analysis is also performed separately for the Gulf of Mexico and the Caribbean Sea. The flux divergences show large differences from month to month and are generally divergent (evaporation exceeds precipitation) during the warm seasons of 2002-2003. Interannual differences between the moisture flux divergences of 2002 and 2003 are also investigated. The ultimate goal of our project is to explore the connection among the warm pool of the Intra-Americas Sea, its moisture budget, moisture transport from the Intra-Americas Sea into North America, and warm-season precipitation over North America. Understanding these issues is essential for improving climate predictability over the land regions surrounding the Intra-Americas Sea.

MS-99

An Analysis of the Effect of Monsoon Winds on Precipitation on the Mexican South Pacific Coastline: A Methodological Proposal

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In the West Pacific region between Central America and the meridian 120°W, during the summer rainy season, at the level 1000 hPa, a change appears in the dominant circulation, consisting of a flow of equatorial winds from the west. These winds reach the coasts of America, as far as approx. 20ºN, and are in agreement with the description of Webster et al. (1998), who stated that the majority of monsoon descriptions emphasize that monsoon winds cross the equator.

In this work we propose the use of a logistical regression model in order to explain the connection between the summer rains in the coast of the states of Jalisco, Colima, Michoacán, Guerrero, Oaxaca and Chiapas and the monsoon winds which reach the above region. The model allows us to describe the systematic variations of quantities of interest in terms of co-variables which interact in a common medium. Considering the available databases, the co-variables used are: time, in relation to the periods of rain and dryness; the wind direction and velocity on the coast and in a marine sector; the surface temperature of the sea; the atmospheric humidity and the presence of tropical cyclones.

The analysis confirms the existence of an intermittent monsoon flow, well defined, above all in the August-October period, and we call it the South Mexican-Central American Monsoon. It was also found that the presence of these monsoon winds provokes a reduction in the precipitation on the coastline and an increase in the interior zones, from the state of Colima to the south, while Jalisco acts as a transition zone between the region of the known North American Monsoon and the region covered by this study.