HM-1

Stationary Wave Responses to Global Climate Change in CMIP II Models

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The stationary wave responses to 1% increase in carbon dioxide concentration and sulfate aerosols in the atmosphere in five state-of-the-art coupled ocean atmospheric models within the CMIP II framework are examined in this study. These models include the GFDL R30 spectral model, the NCAR CSM, the UK Met Office HadCM3, the Canadian climate model CCCM, and the Department of Energy Parallel Climate Model (PCM). The models were chosen since they are participants of the CMIP2 Plus project, for which model history archives were available. All models show significant stationary wave responses to global climate change. The detailed dynamics of the model responses differ greatly. Some resembles that of an El Nino response, while others are driven more by the zonal mean flow changes. We are currently in the process of diagnosing the maintenance mechanisms of the model stationary wave responses using a linear stationary wave model. Detailed results will be presented at the conference.

HM-2

Mean and Uncertainty of Arctic Sea-Ice Change and Their Connection with Arctic Climate Change in CMIP2 Simulations

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In this work, we analyze the 2-D distribution of mean and uncertainty of Arctic sea-ice and climate changes at time of CO2 doubling and their connection using the simulations of the second phase of the Coupled Model Intercomparison Project (CMIP2). Comparison with observations shows that the ensemble mean of CMIP2 models simulates the observed sea-ice climatology reasonable well. Arctic surface warming at the time of CO2 doubling is not evenly-distributed and ranges from 1 to 5ºC. The

intermodel spread is pronounced in the Arctic Ocean, particularly in the Barents Sea. Reduction of sea-ice thickness is in the range 0.3-1.8 m and mainly appears in the Greenland-Barents Seas. Meanwhile, sea-ice concentrations decrease more than 10 % in most regions of the Arctic Ocean. The sensitivity of Arctic surface air temperature change with respect to sea-ice area change is model dependent. For some models, the sensitivity is different even in different periods of the transient integration. Values of the sensitivity vary from -2.0 to -0.5 $C/10^6$ km^2 for most CMIP2 models. Furthermore, colder (warmer) Arctic climate may favor higher (lower) sensitivity.

Simulated mean and intermodel spread patterns of surface air temperature change are similar to those of sea-ice thickness and sea level pressure changes, implying that the mean and uncertainty of projected Arctic climate change may be largely determined by the interaction between sea-ice and the atmosphere. Both sea-ice thickness and sea-ice concentration are sensitive to the increase in greenhouse gas concentrations, and are connected with surface air temperature and sea level pressure changes in the Arctic. The average of all model simulations indicates that a positive phase of the Arctic Oscillation is stronger and/or occurs more often at the time of CO2 doubling. Both the mean and intermodel spread patterns show considerable differences between models with and without flux adjustment in some regions.

HM-3

The Role of Natural Variability in a CMIP2 Ensemble with the Bergen Climate Model (BCM)

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Results from a six-member ensemble of the standard CMIP2-type of integrations performed with BCM are presented. The different members are initiated from maximum, minimum, increasing and decreasing strengths of the Atlantic Meridional Overturning Circulation (AMOC) from a 300 years control integration.

Even though the ensembles are run with the same transient changes in CO2 they show a large spread in their regional response to the greenhose forcing, emphasising the role natural variability. The spread was especially pronounced in the Arctic. Highlighting the role of strong feedback mechanisms, which amplify variability in this region. The spread in the trends tend to be propotional to the ensemble mean response giving the largest spread over land during wintertime.

Results show that the the zonal mean temperature trends in the different ensembles converge with increasing sampling time. This reduces the spread by 80-90% by increasing the sampling time from 20 to 75 years. This is not the general case for precipitation, in some regions and seasons the trends tend to diverge more with

increased sampling time. If and how fast the trends converge for different seasons and latitudes are investigated.

The results suggests that the divergence of multimodel ensembles from a single solution should be seen as a manifestation of both the influence of internal variability and real intermodel differences.

HM-4

The Impact of Convective Parameterization Schemes on Climate Sensitivity

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Over the past 30 years, climate model equilibrium global mean temperature responses to a doubling of CO2 have continued to lie in a wide range from 1.5°C to 4.5°C. This high level of uncertainty in the impact of climate change remains, despite substantial progress in the parameterization of climate processes in the models. A key factor in the different model estimates of climate sensitivity to the doubling of CO2 is the parameterization of clouds and convection. A major difficulty in estimating the role of convective parameterization in climate sensitivity has been that most climate models differ not only in their convection schemes, but also in many other aspects of their physical parameterizations.

This presentation addresses specifically the role of moist convective parameterization scheme in determining a model's climate sensitivity. A new global coupled atmosphere-ocean climate model has been developed and is known as HIRES. It has two choices of numerical schemes and a variety of cumulus parameterizations. The atmospheric model resolution is 1.8 degrees, and the ocean resolution is 1 degree, increasing to 0.5 degrees in the tropics. A series of 110-year simulations (1990-2100) has been carried out with increasing CO2 concentrations based on the IS92a scenario, in addition to a parallel "control" series with fixed CO2. Each series is comprised of six ensemble members generated from the two numerical schemes (high order conserving Eulerian and Lagrangian schemes) and three moist convection parameterization schemes (moist convective adjustment, Betts-Miller; and simplified Arakawa-Schubert). All the control runs give reasonable simulations of the mean climate and its inter-annual variability. The climate change simulations are relatively insensitive to the choice of numerical scheme. However, there are different climate sensitivities in the simulations generated by the three convection schemes.

Here, we concentrate on the Transient Climate Response (TCR), and not the equilibrium climate sensitivity, as the model simulations have not yet been run to equilibrium. The global mean temperature change at the time of CO2 doubling (around 2070) is the key measure of the magnitude of the TCR. There is clear dependence of TCR on the convective parameterization scheme used. As expected, the global mean precipitation change is also dependent on the parameterization scheme.

The continental scale patterns of temperature change are not sensitive to the convective parameterization scheme, whereas the magnitudes vary considerably. The

patterns of precipitation change are more sensitive to the choice of convection scheme, particularly in the tropics.

HM-5

Climateprediction.net

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Since the middle of last year, climateprediction.net has been using volunteered PCs to carry out a large perturbed physics ensemble with a complex climate model. Several experiments are envisaged within the project but to date the experiment has focused on exploring parameter space by carrying out simulations to quantify model responses to doubling levels of CO2 (details of the experiment can be found at: http://www.climateprediction.net/science/strategy.php).
Results from the first year of the experiment will be presented, as well as details of plans for future developments.

HM-6

Large-Scale Tropospheric and Stratospheric Climate Variations in Radiosonde and Satellite Temperature Datasets and Implications for Climate Monitoring

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Among the climate variables considered in climate change detection and attribution studies, the vertical profile of temperature has received considerable attention, in part because models suggest it responds sensitively to different combinations of imposed anthropogenic and natural climate forcings. Therefore, it is important to understand and quantify surface, tropospheric and stratospheric temperature variations and long-term change, including their uncertainty. This poster will explore two aspects of global and regional temperature change.

First, we examine long-term (multi-decadal to centennial) temperature change and suggest that simple linear trends are an overly simplistic way of modeling and quantifying the changes. Because global temperature anomaly time series exhibit steplike changes, we propose three other simple statistical models that incorporate breakpoints. We find that a "sloped-steps" model, with piecewise linear segments separated by abrupt step changes, explains considerably more of the total temperature variability than the others, including the simple linear slope model. This is the case in surface data for 1900-2002, in radiosonde data for 1958-2001 in both the troposphere (850-300 hPa) and stratosphere (100-50 hPa), and in stratospheric data for 1979-2001 from channel 4 of the satellite-borne Microwave Sounding Unit.

Second, we explore the uncertainty in signals of climate variations and change, based on examination of eight upper-air temperature datasets. We quantify both the magnitude and uncertainty of various climate signals, including: the stratospheric quasibiennial oscillation, tropospheric El Nino-Southern Oscillation signals; stratospheric warming following three major volcanic eruptions; the abrupt tropospheric warming of 1976-77; and multi-decadal linear temperature trends. Uncertainty estimates are based both on the spread among signal estimates from the different observational datasets, and on the sampling errors of the signal in any individual dataset.

The large spread among trend estimates suggests that using multiple datasets to characterize large-scale upper-air temperature trends gives a more complete characterization of their uncertainty than reliance on a single dataset. For other climate signals, there is value in using more than one dataset, since signal strengths vary, but the purely statistical uncertainty of the signal in individual datasets is large enough to effectively encompass the spread among datasets. This result supports the notion of an eleventh climate monitoring principle, augmenting the ten principles that have now been generally accepted (although not generally implemented) by the climate community. This eleventh principle calls for monitoring key climate variables with multiple, independent observing systems for measuring the variable, and multiple, independent groups analyzing the data.

HM-7

Precipitation and Temperature Trends in the Past 50 years in Relation to the General Atmospheric Circulation

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Daily precipitation and temperature time-series for the period from 1951-2000 are available for 75 Italian stations. All stations have been carefully cross-checked and homogenized. Trend analysis underlines possible changes in magnitude and variability of climate fluctuations on decadal timescale. Particular emphasis is given to extreme events.

Seasonal average trend are calculated in order to detect redistribution of climate events within the annual cycle. Principal Component Analysis (PCA) is employed to identify sub-regions within the Italian domain; the presence of trends and changes in variability of climate events in each region is evaluated.

Variations of general circulation indexes in the past 50 years are considered in order to relate climate changes over the Italian peninsula and its sub-regions to the atmospheric circulation. Pressure patterns, occurring in concomitance to severe droughts/precipitations and warm/cold events, are identified and weather regimes, if any, are discussed.

The present work can be easily extended to larger domains, where sufficient data are available. Regions affected by large-scale low-frequency climate fluctuations are particularly suitable for this kind of analysis. It is the case of the Mediterranean region, affected by the AO/NAO, and the western USA, influenced by ENSO and PDO.

Keywords: Extreme events, Trend analysis, Atmospheric circulation, Circulation indexes.

HM-8

Gridding of Global Precipitation Observations from 1951 to 2000 with Respect of Homogeneity

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Reliable globally gridded precipitation data based on observations are an essential basis for many challenges of today's climate research. The analysis of the global water and energy budget, the adjustment of satellite data as well as the calibration and verification of global circulation models are among them.

However, the quality of estimated gridded precipitation fields depends on many influencing variables. Important factors are the reliability of the station-meta data as well as the observed precipitation data but also the station-density. In order to provide gridded data-sets that enable climate variation studies on multidecadal and even longer time-scales it is of special importance to ensure the temporal homogeneity of the data-

base, in particular for statistical analysis with regard to human impact on global climate change.

Within the framework of a DEKLIM (German Climate Research Program) funded project at the Global Precipitation Climatology Centre (GPCC) a new globally gridded monthly precipitation data-set is created. It covers the period from 1951 to 2000 at a spatial resolution of 0.5°x0.5°. The underlying data base of observations is a subset of nearly 5.000 Stations extracted from the GPCC database which itself consists of up to 50.000 stations derived from several large global data bases (CRU - Climatic Research Unit, GHCN - Global Historical Climatology Network, FAO - Food and Agriculture Organization of the UN) and national meteorological, hydrological and agricultural agencies.

All the data are thoroughly quality controlled with respect to outliers, wrong or inconsistent values and erroneous station-meta data. Only station time series (which are partly merged from several different sources) that cover a main fraction (90% and more) of the period of interest and pass all quality checks enter into the approved interpolation procedure according to Shepard and Willmott. Thus only about ten percent of all available stations are used to create the gridded data set in order to ensure the temporal homogeneity of the data coverage.

HM-9

Comparison of Monthly Mean Station and NNR Surface Temperature Anomalies with Respect to Their Annual Cycles for Selected Stations in Argentina

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It is generally accepted that the two most important anthropogenic forcings leading to climate change are the increase of greenhouse gases, commonly referred to as "global warming", and changes in land use, such as urbanization, agriculture, etc. Unfortunately, their impacts on climate change have been very difficult to separate because they both tend to produce surface warming. The impact of urbanization on surface warming has been estimated by comparing observations in cities with those in surrounding rural areas, but these estimations have considerable uncertainty.

Here we used the difference between trends in observed temperatures in Argentina and the corresponding trends in the reconstruction of surface temperatures determined from a reanalysis of global weather over the past 50 years, which is insensitive to surface observations, to estimate the impact of land use changes on surface warming. Kalnay and Cai (2003) developed this method, using the property that NCEP-NCAR Reanalysis (NNR) is insensitive to land surface properties, but it is

sensitive to atmospheric climate changes. The difference of observation minus reanalysis surface temperature trends is at least partly attributable to changes in land surface use, including both urbanization and agricultural practices. An advantage of the method is that climate changes associated with changes in atmospheric circulation with decadal time scales are filtered out from the trend because they are also present in the reanalysis.

For the surface observations, we use the daily surface maximum and minimum surface stations temperatures from the National Weather Service of Argentina over mostly the Argentinean provinces for 1961-2000. For the NNR, we use the global daily surface maximum and minimum temperatures Gaussian distributed, also for the period 1961-2000.

Preliminary results for stations situated in four regions of Argentina (Humid Pampas, Litoral, North and Patagonia) agree with the previous results shown in Kalnay and Cai (2003), with good agreement between the reanalysis and the station data. Over the last two decades the differences between the observations and the reanalysis show an increase of 0.5C/decade, at least partly attributable to land-use changes.

HM-10

General Empirical-Statistical Model for Space-Time Fluctuations and Its Application for Monitoring and Prediction

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All space-time fluctuations of the most meteorological characteristics can be represented as 3-dimentional array with the following main axes:
- seasonal fluctuation inside each year and at each station,
- inter-annual long-term fluctuations of different time scales on each station,
- space fluctuations of each year during long-term period and for all stations over the area.

Development of general space-time model includes three main consecutive phases of aggregation and disaggregation of information:

- stage 1: aggregation inside of intra-annual time interval in different forms: averaging, summarizing, parameters of seasonal function, etc;
- stage 2: modelling over the long-term period for each point (station) including the decomposition and extraction of homogeneous components of different time scale (interannual, decadal, centural) and determination of time model in stochastic (distribution function) or deterministic-stochastic (for example, autoregression model) forms;
- stage 3: regionalization and spatial modelling inside of homogeneous regions.

Regionalization is based on the indexes of classification or similarity. In modern changing conditions such indexes of spatial classification can be the dynamic properties of the extracted climate tendencies: their statistical significance, direction, form of tendency, its contribution, etc. Time series with the same main properties of climate tendencies can be combined into homogeneous region. Modelling inside of such homogeneous region can be realized in one of the following forms: averaging, isolines, parameters of space model.

The particular methods have been developed for the realization of each stage of the simulation. Model of seasonal function has been developed for the first stage of intra-annual aggregation. This model has linear structure, connects the conditions of each year with the average historical conditions and represent all intra-year fluctuations as two coefficients connected with amplitude and level of the function and one parameter is represented as standard deviation of remainders of each-year seasonal function, which characterises an intensity of synoptic and macro-synoptic processes. Statistical methods of decomposition and extraction of homogeneous components of different time scales have been developed for realization of the second stage of the modelling. Suggested methods are the most robust in comparison with the wellknown methods such as spectral analysis and averaging of different kind (weights, smoothing, etc). Principle of a regionalization on the basis of the same tendencies of climate change has been developed and structure of a spatial model with three parameters has been suggested, which characterize an amplitude and a level of field and intra-field fluctuations.

Application of developed approach and methods has been given for modeling of air temperature in Europe. For this purposes about 120 the longest time series of monthly air temperature have been selected. Time series of parameters of seasonal function as well as annual temperature have been obtained and climate change components were extracted. On the basis structure of these components homogeneous regions have obtained and in each region the spatial model has been developed. The results of the tendencies in time series of the parameters of spatial models are discussed. The second example connects with the extraction of different time scale components in the longest time series of precipitation and air temperature over the world and analysis of general regular properties of their periods and amplitudes of cycles for climatic variability of interannual and decadal time scales as well as the contribution of centural climate changes. The third example devotes to assessment of predictability of decadal and centural climate change components for the longest time series of air temperature in the Paris station.

HM-11

Detection of Climate Change and Attribution of Causes Based on ERA-40

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Changes over the last four decades of the energy of different regions of the Earth system are monitored. Throughout ERA-40 analyses and the discretization of the ECMWF IFS model are used. The different regions considered are the tropics, the mid latitudes, and the polar latitudes in four zonal sectors. For each of these twenty regions we consider separately averaged values over land and ocean points and for each of these integrals over the stratosphere, the upper troposphere, the lower troposphere, and over the land points averaged values of the energy in the surface and soil layers of the model. For the atmosphere we consider both kinetic energy and total potential energy. The energy quantities computed are used to set up energy budgets as a function of time, for the different regions and for the whole Earth system. In order to try to explain the changes in the temperature dependent part of the total potential energy (the heat

energy) we insert every 6 hour an ERA-40 analysis into the IFS model (with the full ERA-40 resolution) and compute an initial heat-energy tendency (IHT). We separate out the different contributions to this tendency which may explain the observed changes in the heat energy. The external radiative forcings considered explicitly are those related to changes in solar irradiance (prescribed), in well mixed greenhouse gases (prescribed), and in ozone (model determined / analyzed). In addition we calculate the radiative forcings due to internal variations, possibly due to feed back processes. Namely, forcing related to specific humidity (analyzed), cloud cover (model determined) and surface albedo (due to analyzed changes in snow and ice cover). Finally we consider the variations in the contributions to the heat energy tendencies from dynamic processes (e.g. advection), phase changes of water, and diffusion processes. The total systematic (i.e. monthly mean values of the) initial heat energy tendency (SIHT), as well as each individual contribution to it, are compared to the corresponding “observed” (i.e. analyzed) monthly changes of the heat energy in order to try to explain the causes of the “observed” changes. Any deviation between a SIHT and the corresponding “observed” change (i.e. the SIHT error, SIHTE) must be due to model errors or analysis errors, or a combination of both. By a comparison with available GCM derived patterns of aerosol forcing it will be estimated to what extend the SIHTEs can be explained by various kinds of aerosol forcing.

HM-12

Towards Probabilistic Climate Change Prediction

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There are currently large uncertainties in both global mean and regional spatial patterns of climate change produced by coupled GCMs. These uncertainties must be accounted for if we are to provide quantitative information for objective risk assessment by policy makers. Here we present a study in which uncertainty in the GCM response to increasing greenhouse gases and other radiatively active substances is quantified by varying poorly-constrained parameters in the model parameterisation schemes. Firstly, a O(100) ensemble of control and 2xCO2 parameter perturbation experiments are performed with version 3 of the Hadley Centre GCM coupled to a slab ocean to estimate the range of responses to doubled CO2 arising from uncertainties in atmospheric parameters. Secondly, a smaller number of fully coupled atmosphere-ocean ensemble members are run by carefully selecting parameter combinations from the slab-model ensemble that produce models that have both realistic climatologies and span the range of possible responses. Thirdly, these coupled experiments are compared with their slab model counterparts to develop statistical relationships required to infer the transient response of climate from the equilibrium response to doubled CO2. Finally, these scaling relationships are used to infer likelihood-weighted probability distributions of transient changes from the large ensemble of slab model experiments, under a number of different emissions scenarios. Preliminary results will be presented and future directions discussed.

HM-13

Climate Change Experiments with LOVECLIM, a Three-Dimensional Model of the Earth System

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A three-dimensional global model of the Earth system suitable for studying the long-term evolution of climate (LOVECLIM) has been recently developed. This model is made up of a coarse-resolution three-dimensional atmosphere–sea-ice–ocean model (ECBILT–CLIO), a dynamical model of the continental biosphere (VECODE), a comprehensive model of the oceanic carbon cycle (LOCH), and a high-resolution thermomechanical model of the Greenland and Antarctic ice sheets (AGISM). The atmospheric component has the big advantage that it has been simplified to a level that makes runs on a multi-century time-scale computationaly feasible, while at the time, producing results that, on the whole, are comparable to those of atmospheric general circulation models. The performance of the coupled model is evaluated by performing ensemble simulations over the period 1500–2000 and by comparing the model results to climate reconstructions available. In these simulations, the following forcings are taken into consideration: the variations in solar irradiance, the volcanic activity, the anthropogenic emissions of CO2, and the changes in concentration of other greenhouse gases and sulphate aerosols resulting from human activities. In the future, the model will be used to investigate the evolution of climate and sea level over the third millennium.□

HM-14

The "DCM" Atmospheric GCM at a High Horizontal Resolution of T159: First Simulations

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The DCM atmospheric GCM is a new climate model, which has been set up at the Danish Meteorological Institute in Copenhagen. It combines the dynamical core of the ARPÈGE/IFS numerical weather prediction model (cycle 18) developed by Météo-France in Toulouse and the European Centre for Medium Range Weather Forecasts in Reading with the physical parameterisations of the ECHAM atmospheric GCM (version 5) from the Max Planck Institute for Meteorology in Hamburg. The DCM atmospheric GCM can be run at a variety of horizontal resolutions, i.e., T63 (standard resolution), T106, T159, etc., and at two vertical resolutions, i.e., with 31 (standard resolution) or 60 vertical levels in hybrid vertical coordinates, with the uppermost level at 10 hPa and at 0.1 hPa, respectively.Here, the DCM atmospheric GCM is run at a high horizontal resolution, i.e., at a triangular spectral truncation of zonal wavenumber 159 (T159), and with 31 vertical levels. That is, the model's prognostic variables, i.e., the temperature, divergence and vorticity, and specific humidity at the 31 levels and the surface pressure are given in spectral coordinates, while the other variables are given on the corresponding linear reduced Gaussian grid, with 320 grid points along a parallel of latitude at low latitudes and a decreasing number of grid points at higher latitudes. In combination with the advanced numerical scheme, which allows for a relatively long time step, this particular geometry considerably reduces the computing time of the model, so that with this model also extended simulations can be performed at a high horizontal resolution of T159. We, therefore, are able to perform two 30-year simulations: one for the recent climate (1961-1990), where the model is forced with observed values of the sea surface temperatures and sea ice conditions, and one for the future climate (2071-2100), where the model is forced with sea surface temperatures and sea ice conditions originating from a transient climate change simulation (SRES-scenario) with a coupled climate model. We will present results from these first simulations, considering both the quality of the model by comparing the simulation of the recent climate to the 40-year re-analyses from the European Centre for Medium Range Weather Forecasts and the possible future change in climate by comparing the simulations of the future and the recent climate with each other.

HM-15

Development of Super High Resolution Global and Regional Climate Models on the Earth Simulator for the Projection of Global Warming

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We are conducting a five-year research project "Development of super high resolution global and regional climate models" funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to develop a global climate (atmospheric) model with a horizontal resolution of 20 km realistically simulating such phenomena as typhoons and Baiu front globally, and cloud resolving non hydrostatic regional models (NHMs) with a horizontal resolution of a few km simulating meso-scale

phenomena such as heavy rainfall and heavy snowfall. These models are utilized to investigate the effects of global warming on these phenomena through time-slice numerical experiments. The models have been implemented on and optimized to the Earth Simulator. The time integration of the global model has been further accelerated by introducing a semi-Lagrangian scheme. The present version of a horizontal resolution TL959 (20km mesh) with 60 vertical layers attains 44 hours for one year integration using 60 nodes (480 8Gflops-CPUs) on the Earth Simulator. Test runs in climate mode (no re-initialization during multi-year simulation periods) as well as in forecast mode (short-term forecasts initialized with analyses) show that the model simulates the eyes and spiral band of typhoons very well. The cloud resolving NHMs have been tested with horizontal resolutions from 1 km to 5 km and about 1000 x 1000 x 38 grid domain around Japan. A 1-km mesh model has successfully reproduced heavy rainfalls associated with a typhoon, and clouds bands associated with heavy snowfalls over Japan Sea in winter. The spectral boundary coupling method is introduced to perform a long-term integration of the NHM multi-nested in the global model. A 70-day integration has been stably performed with reproducing the observed climatology of precipitation. Preliminary results from long-term integrations with the global model and the NHMs will be presented in poster to show the model performance.

HM-16

Regional Changes in the Northern Eurasia during the 21st Century from Simulations with the IAP RAS Climate Model of Intermediate Complexity

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Regional changes in the northern Eurasia from transient runs of the IAP RAS climate model of intermediate complexity (IAP RAS CM) in comparison with simulations of coupled general circulation models for the period from the middle 19th century till the end of the 21st century under different scenarios for changes in greenhouse gases atmospheric content are analyzed.

In general model results show an increase of mean values and variances of regional precipitation in the Ob, Yenisei, Lena and Volga rivers basins and rivers runoffs to the Arctic Ocean and to the Caspian Sea in the XXI century relative to the 20th century. The probability of exceeding in the 21st century of the 20th century maximum runoff is analyzed also for different rivers. The correlation of regional precipitation and rivers discharge with Arctic Oscillation and North Atlantic Oscillation and with characteristics of Atmospheric Centers of Action from observations and model simulations is studied. Geographical distribution of permafrost is diagnosed using an integral permafrost model and climatic characteristics simulated by IAP RAS CM. According to those estimations permafrost covered area can decrease to the end of the 21st century remarkably. More detailed analysis is performed for selected regions. In

particular, for the Yakutsk and Tiksi regions the permafrost thawing depth (TD) changes are estimated using both differential and integral permafrost models forced by the climate scenarios computed by IAP RAS CM. Intermodel scatter is relatively small till the late 21st century when the differential model simulate that talik-effect can be formed. For the analyzed regions permafrost models simulate the present day TD value reasonable well and predict its increase during the 21st century.

HM-17

On the Formation of Tropical Night near the Mountainous Coastal Sea

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A non-hydrostatic grid point model in a complex terrain-following coordinate (x, y, z*) was adopted for a 48 hour numerical experiment from 0600LST, August 13 to 0600LST, August 15, 1995, by Hitachi super computer at Japan Meteorological Research Institute. Two different domains consist of 50 x 50 grid points with a uniform horizontal interval as 20km in a coarse-mesh model and 5km in a fine-mesh for one-way double nesting, respectively. 16 levels in the vertical coordinate were divided from 10 m into 6 km. 12 hourly global meteorological analysis data made by Japan Meteorological Agency and National Oceanic and Atmospheric Administration satellite pictures were horizontally and vertically interpolated for initial data in the coarse domain. As synoptic scale westerly wind blowing over a high steep mountain in the west of a city toward the eastern sea is interrupted by upslope wind combined with valley wind and easterly sea breeze from the sea, two different wind regimes confront near the mid of the eastern slope of the mountain and go up to the 1700 m height over the ground, becoming a westerly return flow in the upper level over the sea. Convective boundary layer (CBL) with a 1km depth is developed over the ground surface of the inland basin in the west of the mountain, while a depth of thermal internal boundary layer (TIBL) like CBL shrunken by relatively cool easterly sea-breeze is less than 150 m from the coast along the eastern slope of the mountain. As the convergence of sensible heat flux from the ground surface of mountain (or inland coast) toward upper level atmosphere is much greater than the flux on the coastal sea, sensible heat flux should be accumulated inside thermal internal boundary layer along the eastern slope of the mountain and convective boundary layer over the top of the mountain. Then, accumulated sensible heat flux under the influence of sea breeze returning from the mountain top toward the coast was transported into the coast, resulting in high air temperature. Under nocturnal cooling of ground surface after sunset, mountain wind with the daytime existed westerly wind to be an intensified westerly downslope wind and it further combined with land breeze, becoming strong wind. No sensible heat flux divergence or very small flux divergence occurs in the coast and coastal sea, but the flux divergences are much greater at the top of the mountain and along its eastern slope than over the coastal inland and sea surfaces. Much more cooling down of the mountain surface than the coastal surface and heat transfer from warm pool over the coast toward the coast resulted in tropical night.

Characterisation of Extreme Events on the Multi-Annual Timescale Using a High-Resolution Coupled Global Circulation Model

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Investigations of initial attempts to extend the seasonal forecasts to multi-annual timescales by using a high-resolution coupled global circulation model are presented. The objective of this study is twofold. Firstly, we briefly quantify and interpret model errors which arise as as consequence of both the coupling shock as well as the tendency of models to drift away from reality. Secondly, and more importantly for this session on ``Human influence on climate'', we evaluate how the probability distribution functions (PDFs) of particularly relevant physical variables such as precipitation and surface temperature vary under different forcing regimes. More specifically, perturbations to green-house-gases, aerosols, ozone as well as impact of modified oceanic initial conditions are applied in order to generate an ensemble of realisations of the climate system. These realisations allow us to study how the PDFs' behaviour is affected. Post-processing procedures aimed at removing the drift, with reference to observations, are also discussed. Early results seem to indicate an increase of the probability of occurrences of extreme precipitation over Europe and Africa associated to increased green-house-gases.

Extreme Temperature Events over Southern South America

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Weather and Climate extremes can be serious and damaging effects on human society and infrastructure. There are some indications from observations concerning how climate extremes may have changed in the past. One of the major concerns with a potential change in climate is that an increase in extreme events will occur. High quality data is the indispensable resource that is required to quantitatively assess changes in extremes. Over South America there is no an homogenized regional database, nor monthly, nor daily, unless some regional intents have been initiating among researchers of different countries. With a greatly controlled 40-yr daily database over Argentina, and in order to capture the temporal patterns of observed temperature change, this work studies the trends of the Maximum (MaxT) and Minimum (MinT) daily temperatures mean, standard deviation and extremes on Argentina. Extreme temperatures were defined by the number of ‘cold nights’ (‘days’) and ‘warm nights’ (‘days’) per season, by comparing values to the 5th and 95th MinT (MaxT) percentiles limits. The strongest (positive) changes over time occurred in summer MinT, whereas their standard deviation

decreases. Mean MaxT mostly decrease over time in summer over northern Argentina but they increase in Patagonia (southern Argentina). Generally negative trends were obtained in the number of cold nights and warm days per summer, while the number of warm nights and cold days has increased at certain locations. Patagonia shows many stations with increasing number of warm days and nights in winter and decreasing number of cold days and nights in summer. Summer mean temperature is more sensitive to extremes than the winter one. In summer, the increase in mean temperature is more strongly related to the increase in the number of warm days and nights than to a decrease in the number of cold days and nights. In winter the region with the highest correlation was found in Patagonia while in the most productive area (La Pampa) very little or non-significant association exists between mean temperature and the occurrence of warm or cold days. Therefore, under the supposition of a warming climate, the response of the extreme values of the climatic system can be very various.

HM-20

Spatial Distribution of Precipitation and Temperature Extremes over Europe and Its Coupling with the Large-Scale Atmospheric Circulation

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The goal of this study is to identify, characterize and investigate the leading modes of the coupled variability between temperature and rainfall extremes over Europe vs. atmospheric circulation. How this coupling could change in a greenhouse gas-driving climate change is also addressed. As far as climate extremes and their impacts are concerned, the exceedance probabilities of the daily rainfall and of the daily maximum and minimum temperatures, as well as the fields themselves, are analyzed. All the analyses are performed separately for winter (December-February) and for summer (June-August).

The analysis employed data provided by the NCEP/NCAR (National Centre for Environmental Prediction/ National Centre for Atmospheric Research) reanalysis project. Additionally, data simulated by the Hadley Centre Coupled Model - 3rd generation (HadCM3) for the common period (1961-89) and for the period 2070-2099 under the B2 and A2 SRES (Synthesis Report on Emission Scenarios; Emission Scenarios - IPCC Special Report, 2000) scenarios was also used. A validation of the HadCM3 is also included.

The winter rainfall extremes throughout Europe are mainly governed by the North Atlantic Oscillation, which corresponds to a largely dominant leading coupled mode. The daily rainfall is also strongly connected to the North Atlantic Oscillation. The HadCM3 is particularly skillful in reproducing the observed links between rainfall and large-scale atmospheric flow. An increase in the frequencies of occurrence of rainfall extremes was found in both the A2 and the B2 scenarios in agreement with the changes in large-scale

atmospheric forcing. In both emission scenarios a slight northward drift and a zonality increase in the large-scale forcing over winter rainfall are also apparent. The observed temperatures over Europe are closely connected to the North Atlantic Oscillation through the first coupled mode. The HadCM3 is able to reliably reproduce the coupled variability. A very strong warming over Northeastern Europe might be expected, while an increase in the occurrence of temperature extremes is detected. The summer rainfall appears to be much more complex than its winter counterpart. In fact, its relation with the large-scale circulation is much weaker and controlled by local or regional effects. A significant drying during the European summer is clearly identified, with a major exception over Northeastern Europe. In summer a very intense warming over Southern Europe is detected. This is thought to be a result of the enhancement of the leading mode.

HM-21

Drought Tendency Investigations Based on Homogeneous Database and Drought Sensitivity in the Hungarian Drought Strategy Plan

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Hungary is located in Central Europe, in the Carpathian basin. Drought is a returning natural phenomenon and disaster also here. During history several severe drought events have been recorded for each century. From the view-point of drought frequency the period since 1983 is the most unusual: severe drought and water scarcity became almost universal.

As far as the future tendencies are concerned an analysis of climatic data on long-term observations demonstrates that there is a significant increasing of the temperature and a decreasing tendency of the precipitation amounts and the soil moisture content. Drought, as a complex phenomena depends on many parameters, which has usually inhomogeneous time series. Therefore, the real long-term climatological research has to be esteblished on homogeneous series. Unfortunately, only few applied homogenization methods have well established mathematical basis (especially for rain series and daily data), although most of the drought indices are sensitive to one or more climatological parameters.

Our poster shows the influence of the data quality on the long-term drought tendency research. We will evidence, that big differences can occur within small distances in the characteristics of drought events, e.g. different regions of Hungary behave on different way.

Another aim of the poster to show the regional drought sensitivity of the country. We took into consideration the orography (slope, direction of slopes), soil characteristics (organic matter content, depth of the soil layer, etc.), land use and climatological parameters. We will present an attempt to describe the temporal variability of drought sensitivity.

All this information is included in the Hungarian Drought Strategy Plan, recently finished and discussed by the wide expert community of the country. The Plan contains the past, present and future processes, events and activity in connection with the

drought in Hungary. It will be accepted by the government in 2004. The poster discusses the main structure and tasks of this Plan.

*HM-22

Causes of Future Summer Drying over Central Europe

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Global circulation models (GCMs) consistently predict that one of the effects of enhanced concentrations of atmospheric greenhouse gases may be a reduction in mean summertime precipitation over much of central and southern Europe. If this becomes a reality, significant stress on water resources and agriculture is likely to result, and thus it is important to assess the reliability of such projections.

The majority of studies to date have suggested that the primary driver of this reduced summertime precipitation is a springtime reduction in soil moisture content, mainly due to enhanced evaporation and reduced snowmelt in a warmer climate. However, two other possibilities which have received less attention are as follows: (1) changes in large-scale circulation driven by climate change in remote regions, and (2) the impact of regional variations in the pattern of local warming and an associated reduction in relative humidity over land.

An analysis of projected climate change for the latter part of the twenty-first century, using a high-resolution atmospheric GCM, HadAM3P, provides evidence that all three of the above drivers may be causing the summer drying. However, in order to assess the reliability of this projected drying, it is necessary to be able to at least roughly quantify the relative importance of these local and remote mechanisms. Yet this cannot be achieved using the same global GCM data.

We have therefore designed a suite of sensitivity experiments which utilise a regional (European) version of HadAM3P. The relative contribution of each potential driver of summer drying is explored by altering the matrix of inputs to this model, so that in any one integration, some inputs are representative of the future climate state, and others are representative of the present climate state. Inputs that are altered in this way are: various components of the lateral boundary forcing, greenhouse gas and aerosol concentrations, SSTs, and soil moisture content. This enables us to assess whether future summer drying over Europe is predominantly caused by: regional variations in the local warming; remote circulation changes (divergence and/or storm track anomalies); or spring soil moisture anomalies. Furthermore, the role of positive feedbacks induced by evaporative anomalies over land is also assessed.

The analysis of these experiments will be presented, and their implications for an assessment of the reliability of projections of future summer drying over central Europe will be discussed.

HM-23

Dynamic Analysis of an Extreme Precipitation Episode Simulated by HIRHAM4 Model, for Central Europe

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The most recent studies produced with the precipitation fields simulated by DMI's HIRHAM4 regional climate model, based on the analyses of extreme precipitation events show that, in Central Europe, there is an increase in the frequency of intense events as well as in the rainfall amounts during their occurrence, in a future period (2071-2100), under the A2 emission scenario (Nature, Feb 2003, vol. 421) relative to reference period 1961-1990. Selecting first the most intense precipitation episodes occurred in both the reference and future periods, the atmospheric dynamics simulated by HIRHAM4 is analysed during those events, aiming to elucidate the main physical mechanisms behind their development. To perform this analysis, HIRHAM4 six hourly data is used in the calculus of specific dynamic variables, and their behaviour during the occurrence of the extreme episodes is presented and discussed. The study focuses on individual developments responsible for the most severe events and contributes to assess the realism of the model's performance.

HM-24

Estimates of the Regional Distribution of Sea-Level Rise over the 1950 to 2000 Period

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TOPEX/Poseidon satellite altimeter data are used to estimate global empirical orthogonal functions that are then combined with historical tide gauge data to estimate monthly distributions of large-scale sea-level variability and change over the period 1950 to 2000. The reconstruction is an attempt to narrow the current broad range of sea-level rise estimates reported in the Intergovernmental Panel on Climate Change Third Assessment Report, to identify any pattern of regional sea-level rise, and to determine any variation in the rate of sea-level rise over the 51 year period. The computed rate of global averaged sea-level rise from the reconstructed monthly time series is 1.8 ± 0.2 mm yr-1. Decadal variability in sea level is observed but there is no detectable secular increase in the rate of sea-level rise over the period 1950 to 2000. A clear regional pattern of sea-level rise is identified. The maximum sea-level rise is in the eastern off-equatorial Pacific and there is a minimum along the equator, in the western Pacific and eastern Indian Ocean. A greater rate of sea-level rise on the eastern north American coast compared with the United Kingdom and the Scandinavian Peninsula is also found.

The major sources of uncertainty are the inadequate historical distribution of tide gauges, particularly in the southern hemisphere, inadequate information on tide gauge datum movements (vertical land motion from post glacial rebound and tectonic activity) and the short satellite altimeter record to estimate global sea-level covariance functions. The results clearly demonstrate that tide gauge records will continue to complement satellite altimeter records for observing and understanding sea-level change.

HM-25

Annual and Interannual Variations and Long-term Trend of Sea Level Along China Coast

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Based on about 40 years data from the 44 tidal gauges along China coast and the meteorological and hydrographic data of costal area, the annual and interannual variations and long-term trend of sea surface level (SSL) corresponding to the Bohai Sea, the Yellow Sea, the East China Sea, and the South China Sea are analyzed. It is found that the annual variations of SSL are closely related to local monsoon features of the China Seas, such as the seasonal rainfall, the runoffs from the land into the seas, the sea temperature, and the sea surface wind-direction reversal. In addition, the annual variations of SSL have obviously latitudinal variability. In other words, the annual amplitude of SSL in the northern seas i.e. the Bohai Sea and the Yellow Sea is much greater than in the southern seas, and the monthly mean SSL in the north has much quicker response to the monsoon forcing than in the south where the SSL variation lags a few months behind the annual variation of monsoon. The latitudinal variability can be attributed to the trend and configuration of the China coastline and it will cause more water to accumulate along the northern shoreline and intensify the impact given to the north by storm surges in summer. Beside the annual variations of SSL, interannual variation can also be found. The monthly mean SSL is abnormally decreased in an ENSO year, for example, in 1972, 1976, 1982-1983, 1986-1987, and 1991, especially in the south of China.

A long-term SSL trend can also be found by different analysis methods. Generally speaking, a similar tendency toward SSL increase can be detected although the analysis methods are various. The estimation of the annual rising rate of SSL has a range from 0.48 mm/year to 1.92 mm/year at all the tide gauge locations but two. The one is decreased at a rate -0.72 mm/year and the another is rising too quick at a rate 3.8 mm/year, which might be caused by the ground sinking where the tide gauge is located.

HM-26

Relations of Antarctic Sea Ice with El Nino Event and Global Sea Level Change

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As a large scale heat sink, the Antarctic sea ice give a great impact on global climate change. In this paper, two relations of Antarctic sea ice with El Nino event and global sea level change are studied.

In two ends of South Pacific Ocean, Antarctic sea ice closely relates to sea surface temperature anomaly (SSTa) in the equatorial Pacific. It is especially true in ¨C18--+24 months stage with a significant negative correlation. The maximum correlation coefficient of -0.58 appears in SSTa 2 months lag with a significant level of 99.99%. It is called as Southern (Pacific) Oceanic Oscillation (SOO). This kind of “seesaw” phenomenon in meridional direction is comparable to the famous Southern Oscillation in zonal direction both in intensity and duration.

There is an estimate that, if all the Antarctic continental ice cover is melted, global sea level would raise about 60 m. Many coastal countries and cities would be inundated by sea water. In this paper, relation between inter-decade variation of Antarctic sea ice and global sea level raising (SLR) is studied. Because sea ice data started from 1973, we use data in 1973-82 as 1970s, and 1983-92 as 1980s.

In the Pacific Antarctic region, sea ice decreased from 1970s to 1980s, warmer sea water was brought by South Ocean Current to the South America continent and turns northward to form a warmer Peru Cold Current. As a result, sea level out of west coast of South America was commonly higher in 1980s. In the Antarctic Atlantic region, sea ice increased in 1980s. Sea temperature of Benguela Current should be colder, and sea level out of west coast of Africa should be descent in 1980s. It coincided with the actual SLR distribution from 1970s to 1980s.

HM-27

Climate Changes in the California Current System

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We investigate the effects of greenhouse gases, incorporated into the forcing fields of an eddy-resolving regional ocean model (ROMS), on several oceanographic variables of the California Current System. This is done by carrying out a series of equilibrium runs in which the climatological trend, between the 1990's and the 2040's, and as obtained from a coupled model experiment, is used. The effect of greenhouse gases is assessed both, separately among wind stress, surface heat flux and open boundary conditions in three different runs, and jointly in one single run. When excluding the greenhouse gases effect from any of these forcing fields, its values are set to climatological ones. Preliminary results show that the effect of greenhouse gases in the wind stress field lead to a warmer coastal ocean off central and southern California, especially at the surface during summer and fall and north of Point Conception. This

change is accompanied by an increased sea level. Offshore, in the California Current, SSTs get colder. The Southern California Bight shows warmer and saltier waters, which is accompanied by higher sea level and deeper isopycnal depths in general. The largest changes in the wind field climatology take place in the coastal ocean north of Point Conception for the wind stress curl and offshore (~800km) for the wind stress fields.

HM-28

The Response of Climate Variability and Mean State to Climate Change: Preliminary Results From

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The response of the mean state and modes of climate variability to climate change forcings is one of the most important issues in climate research. This issue is particularly relevant for Australia, where a highly variable climate, often characterised by severe floods and drought, is strongly influenced by the El Niño-Southern Oscillation (ENSO), north-south variations in the midlatitude high-pressure belt position (Pittock, 1973), and, possibly, Indian Ocean sea surface temperature (SST) variations (e.g., Nicholls, 1989). A change in the properties of such modes may result in significant changes to Australian rainfall variability. Further, global warming signals may project onto these modes, contributing to secular trends in rainfall climatology. Trends towards lower rainfall in some regions suggested by global climate models would compound with rising temperatures and potential evaporation to exacerbate the strain on future water resources.

Several of the above aspects have been examined using the CSIRO Mark 2 model, including whether the Pacific warming pattern is El Niño-like or La Niña-like (Cai and Whetton, 2000; 2001) and whether an observed rising trend in mean sea level pressure (MSLP) at southern midlatitudes (Cai et al., 2003a) can be at least partially attributed to global warming. The Mark 2 model studies are, however, limited by low resolution of the model and the fact that the model ENSO is too weak, with an amplitude of about one third of the observed. Thus the issue of ENSO response to climate change could not be addressed.

A greatly improved, non-flux adjusted, higher-resolution model, referred to as the CSIRO Mark 3 model, has since been established. This model has resolution of 1.85 degree longitude, and 1.85 or 0.93 degree latitude for the atmospheric and oceanic components, respectively. More details can be found in Gordon et al. (2002). One control and two climate change experiments with the Mark 3 model have been carried out, providing an opportunity to revisit some of the issues discussed above. Here we present some preliminary results. In particular, we focus on processes that potentially control changes in Australian climate variability and rainfall patterns.

Change Due to Global Warming of Atmospheric Circulation in the Northern Hemisphere and Oceanic Circulation in the North Pacific

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Change of the atmospheric circulation in the Northern Hemisphere due to global warming is investigated using a medium resolution (T42 for the atmosphere and 2.5 by 2 degree for the ocean) climate model (MRI-CGCM2.2) and a response to the change in the atmospheric field of the oceanic circulation in the western North Pacific, which affect the climate in the Northeast Asia, is investigated using a high-resolution (1/4 by 1/6 degree) OGCM.

The historical run of the climate model is performed from 1850 to 1990 and it is extended to 2100 using a global warming scenario IPCC-SRES-A2. In the model, the globally averaged surface atmospheric temperature rises by about 0.9 [degC] from 1850 to present and by about 1.9 [degC] from present to 2100 The spatial pattern of the trend of the sea-level pressure in the Northern Hemisphere shows an annular pattern similar to the Arctic Oscillation (AO) with decreasing trend in the Arctic regio and increasing trend in the mid-latitudes. This indicates that the anti-cyclonic atmospheric circulation is intensified over the mid-latitude North Pacific due to the global warming. To clarify the effect of this change on the oceanic circulation near Japan, we performed time-slice runs for the present state (1991-2010) and for the future state (2041-2080) using a high resolution OGCM forced by the simulated atmospheric fields. The last 20-year data of each run is used for analysis. In the present state, the model succeeds in simulating the path of the Kuroshio with the straight path south of Japan and the separation off the east coast of Japan. In the future state, the Kuroshio tends to take meandering paths south of Japan and warm core eddies that pinch off from the Kuroshio Extension tend to appear more frequently off the east coast of Japan, which leads to the warming trend of SST there. Thus, the change in the atmospheric fields mentioned above causes the northward shift of the boundary between the wind-driven oceanic subtropical and subpolar gyres, where the path of the Kuroshio Extension exists. The sea level rise during the 70 years (from 2000 to 2070) estimated from the calculated result is 12 - 18 cm at the grid points around Japan.

□

HM-30

Past and Projected Temperature Changes in Hong Kong

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Hong Kong is densely populated with a sizeable economy in an urban setting thus making the identification of climate change of importance. This study examined the secular temperature change characteristics in Hong Kong over the past 118 years and its relationship with global warming and urbanization. Future temperature projections for Hong Kong and its nearby areas up to 2100 was estimated based on IPCC climate model forecasts.

Trend and wavelet analyses were applied to temperature data collected by the Hong Kong Observatory to identify long-term trend and periodic variation. Results showed that Hong Kong has been warming up in the past, in line with the warming trend in Mainland China and the globe. In the recent decade, the rural areas of Hong Kong have been warming up at about 0.2°C per decade, similar in magnitude to the global average. In urban areas, the corresponding rise was about 0.6°C per decade. The difference of 0.4°C per decade between urban and rural areas of Hong Kong can be attributed to the urban heat island effect. Apart from long-term trend, strong signals also existed on the inter-annual and inter-decadal time scales. These variations are closely related to the changes in East Asian monsoon circulation and the El-Nino Southern Oscillation. Seasonally, temperatures after World War II were rising for all the seasons with the largest rate of increase in winter.

Gridded temperature projections up to 2100 under the IS92a GG scenario were extracted from IPCC's seven global climate models. Various statistical downscaling techniques were applied and results from all models suggested that the temperature for Hong Kong will continue to rise and its magnitude close to the global average. The temperature rise indicated by the CCCma model is among the largest. Temperature anomaly relative to the 1961-1990 normal near Hong Kong, discounting urbanization effect, may reach 6°C by 2100, slightly lower than that for Mainland China.

Similar downscaling was applied to the IS92a GS and various SRES scenarios. All model projections under the scenarios indicated temperature rise near Hong Kong. In general, the rise is highest under the fossil intensive A1FI scenario. In the vicinity of Hong Kong, the future temperature rise over the land area is found to be higher than the sea. In this study, the relative merits of different statistical downscaling techniques and model performance were discussed. An attempt was also made to project the temperature change due to urbanization.

HM-31

Change Detection and Attribution in Climate - Anthropogenic Causes in India

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The study of natural changes, provides a means for assessing the relative significance of anthropogenic perturbations, as compared with natural variations. The major controls of long-term changes(1000 to 10000 years) in geomorphic systems are climate change, sea level, and tectonic changes. One important question is whether or not human impacts are significant compared to natural changes, at these time scales.

Although good evidence exists for significant human impact on geomorphic systems during recent historic times, evidence of significant prehistoric human impacts is less clear. Climate change is one of the important controls of long-term change in the natural environment, and at some time scales it is the dominant control. Climatic change is a change in average atmospheric conditions at a particular place or in a particular region. It is often difficult to distinguish from climatic variability, especially in strongly seasonal climates. An understanding of climatic variations is therefore basic to understanding and assessing environmental change.

Climatic variations influence the variations in vegetation patterns and associations at periods greater than 1000 years; at shorter time scales, other factors such as human activities become important. In some areas, for example India, human activities have influenced the vegetation for thousands of years. Landform development is controlled by climatic and geologic factors at temporal scales greater than 1000 years, and by human actions at shorter time scales. Human impacts on the physical landscape may be more serious and long-lived than the one on the atmosphere and biosphere. Climatic change in India (regional scale) is resulted from two widespread processes – overgrazing, and deforestation. Overgrazing was the cause of the expansion of the Rajasthan Desert of India. Several thousand years ago this region was the site of Indus Valley civilization. At that time the climate was arid but not as dry as today. The present day aridity is caused by subsidence in the atmosphere and is augmented by the radiative cooling of suspended dust, the presence of which is caused by sparsity of vegetation as a result overgrazing. Also studies indicate that increases of albedo due to overgrazing or unwise cultivation in arid areas cause increased subsidence thereby suppressing precipitation. Another important contributor to climatic change is the land use/cover change and the concomitant deforestation. In India, every conceivable hectare of scrub, pasture, or fallow has been a candidate for more intensive use. An intensive study (FAO, 1999) over the past century shows expansion of arable land. Between 1940 and 1990 years, total cultivated land has increased by 34 million hectares. A considerable proportion of this expansion was driven by new irrigation projects that converted semiarid grasslands/scrub woodlands to grain cultivation. A reduction of the vegetation cover has resulted in decrease of precipitation.

HM-32

Impact of Climate Change Scenarios for 2100 on the Biomes of South America

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The IPCC scenarios of climate change for two SRES emissions scenarios (A2 and B2) from an array of Global Climate Models available at the IPCC Data and Distribution Center (DDC) are used to study the potential redistribution and changes of biomes in South America for 2100. Earlier studies indicated various degrees of sensitivity of biomes to climate change in South America. An extreme case (Cox et al.,Nature, 2000) indicated an Amazon forest die-back. For this study, we use the CPTEC Potential Vegetation Model (Oyama and Nobre, GRL, 2003) forced by climatic fields of 10 global climate models for the two above-mentioned SRES emissions scenarios. The ensemble of cases encompasses an envelope of plausible climate changes for this century. The results indicate that for the A2 emissions scenarios substantial biome redistribution can be expected. Large portions of the Amazon tropical forest would be replaced by tropical savannas and the semi-arid vegetation of Northeast Brazil could be replaced by semi-desert vegetation. Even for the more moderate B2 emissions scenarios, some biome redistribution can be expected, though of less impact. The ecological, social and economic implications of those projected impacts are discussed.

HM-33

The Role of Modelled Ocean-Sea Ice-Atmosphere Interactions in Shaping XXIst Century Climate Change Scenarios

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Trying to assess climate changes during the XXIst century is a real challenge. On the one hand they depend on which so-called scenario (e.g. IPCC-SRES)is chosen, but also on the coupled model that is used.

Several scenario experiments were already run at Meteo-France with a first version of the coupled model consisting of ARPEGE-Climat (climate model, including ISBA SVAT), OPA (OGCM), Gelato (sea ice) and MOBIDIC for stratospheric ozone. Slightly different parameterizations were used for running SRES-B2 scenarios with this non-relaxed model on the period 1950-2100, and this led in some cases to similar, but noticeably different modelled climates, particularly for the end of the XXIst century.

First, the model was run with and without homogeneous and heterogeneous chemistry. Apart from a lack of ozone hole over the poles, no significant difference on climate appeared between the two experiments. Then the coupled model was run in its standard version (i.e. with chemistry) and river routing was added (TRIP, run on a 1x1 deg. hydrological mesh). This led to a modification of the water cycle in the Arctic and to a change in sea ice regime there, with significant impacts on modelled climate change in the arctic and subarctic regions, particularly at the end of the XXIst century. In all these experiments, the simulated climate was globally comparable to observations on the

period 1950-2000, except in the Antarctic due to rapid, unrealistic sea ice depletion mainly caused by biased ocean-atmosphere interactions.

These biases were dramatically reduced in the second version of the coupled model, which yields a much more stable and realistic climate in the Antarctic, as well as a more stable thermohaline circulation. This new simulation, which can be considered as another sensitivity experiment was also compared with the previous ones. It showed a more realistic simulated climate on the global scale for the period 1950-2000, which allows to be more confident in simulated climate change for the XXIst century.

HM-34

Climate Variability and Change in Aral Sea Region

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Aral Sea, a large salty lake located in Kazakhstan and Uzbekistan, Central Asia, was once the fourth largest inland water body on the Earth. As known, presently the Aral sea has lost about 75% of its surface area and 90% of its volume, and has become an environmental disaster area, as a result of human impact in the basins of its river tributaries. It is generally believed that the Aral Sea desiccation has had a significant impact on the weather and climate in the surrounding areas.

The objective of the present work is to investigate the long-term climate variability in the Aral sea region and verify if the air temperature changes that have occured during the last few decades be attributed to the Aral sea desiccation, or do they reflect some natural larger scale climate variability. The structure of the air temperature trends at surface and at different isobaric levels was investigated using NCAR/NCEP reanalysis data, CARDS aerological data, data collected at Kazakhstan and Uzbekistan meteorological stations. Five groups of stations are identified in the study region using an objective classification algorithm. Analysis of following parameters: sea level pressure, surface air temperature, zonal and meridional wind velocities demonstrated that the character of the climatic variability is different for different groups. The reanalysis data for the Aral sea region are first validated against the observational data. Was shown that in the study region, the NCAR/NCEP reanalysis data coincide well with the in-situ air temperature data. We examined the trends of temperature separately for three different periods, namely for the period before the Aral sea shallowing onset; the desiccation period, and the entire period from 1951 through 2000. The trends and the standard deviations of the trend slope coefficients for all periods were calculated and the comparative analysis was then performed. The wavelet analysis is used to investigate the frequency structure of the air temperature and precipitation data. Estimates of monthly-mean troposphere and stratospheric temperature trends over the past twenty years in Aral sea region, from three hydrodynamical models (INM, RHMC, HADCM3) are compared both with each other and with the observed trend analyses using aerological observations. The modeled temperature trends are driven by changes in carbon dioxide and without any forcing.

In summary, the results indicate that the climate change possibly associated with the Aral sea desiccation was particularly pronounced in the area south and southwest

from the sea. Considerable long-term changes have occurred not only in the near-surface layer, but also up to 700 mb levels in the southwestern part of Aral sea region, which may point towards some large scale processes involved.

HM-35

Climatology of 3D-Dust Distribution over the Mediterranean

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Within the framework of the NASA-Israeli MEIDEX project the averaged 3D-dust distribution over the whole Sahara and vicinity regions was estimated and analyzed. This averaged distribution was based on the 3-year database of 48-hour dust forecasts produced by the dust prediction system, which had been developed earlier at the University of Athens and subsequently modified in Tel Aviv University. Vertical distributions of dust reflect differences between the Atlantic and the Mediterranean dust transport. As a whole, the Mediterranean dust is found to be within a wider range of altitudes, penetrating rather higher into the troposphere. On average, dust over the Atlantic penetrates up to < 5 km while over the Mediterranean up to < 8 km. The characteristic feature of dust vertical profiles over the main Saharan dust source near Lake Chad is its maximum concentration near the surface. From April to June averaged profiles over the Chad basin in the Sahara are restricted below the level of ~4.5 km. In the winter months and in March, dust concentration over the Chad basin is closer to the surface, under 1.5 km. Dust also maximizes near the surface over another dust source, which is the major one in summer, located in West Africa. The model results are found to be consistent with dust-layer altitude ranges from present-day lidar soundings. Besides, the results are in accordance with general synoptic knowledge of the mechanism of dust transport to the Mediterranean. In order to validate the TAU dust model, a quantitative comparison of model vertical profiles against lidar soundings over Rome (Italy) was made. Positive results of this comparison indicate that the model performance is sufficiently good and appropriate for regular dust forecasting. The knowledge of 3D-dust distribution is a pre-requisite for the inclusion of the aerosol forcing in climate models.

HM-36

Climate Response to Tropospheric Absorbing Aerosol in an Intermediate General Circulation Model

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This study uses idealised aerosol distributions with the Reading Intermediate General Circulation Model to assess and explain the climate response in that model to absorbing tropospheric aerosol. We find that the sign of the direct aerosol radiative forcing is not a good indication of the sign of the resulting global and annual mean surface temperature change. The climate sensitivity parameter for aerosols which absorb some solar radiation is much larger than that for CO2 or solar experiments with the same model.

Reasons for the enhanced surface temperature response in the presence of aerosol are examined. Significant changes in cloud amount occur, some of which appear most influenced by the change in surface temperature and may be generic to any mechanism that warms the surface. A reduction in low cloud amount occurs when the aerosol single-scattering albedo is less than 0.95; the so-called "semi-direct" effect of aerosols is clearly evident in this model. We suggest that this aerosol-cloud feedback is present in all GCMs which include absorbing tropospheric aerosol but remains largely undiagnosed. Comparisons with a previous study and further sensitivity tests suggest that the magnitude of this effect and the mechanisms behind it are strongly dependent on the cloud scheme employed.

☐*HM-37*

Human Activity and Climate

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In brief, climate could be considered as how hot or cold a place or region could be. Many factors determine the climatic conditions of a place. Among these facrors, human influence has been noted to have a remarkable influence on climate. Climate change in some usage has been referred to as any change in climate over time, whether due to natural variability or as a result of human activity. Some schools of thought rightly hold that climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

If we are looking at this change in climate in the light of human influence or human activity, we will have many things to take into account. We will examine natural variability which encompasses human activity; the role of greenhouses and their effect on the ozone thereto partaining; atmospheric aerosols; with anthropogenic changes in land surface condition on climate trends and variability.

In the greater part of this research work we have dwelt much on the influence of human activity on climate. It is agreed that changes in climate come about as a result of both internal variability within the climate system and external factors: both natural and anthropogenic. Influence on climate is highly noticed as a result of radiative forcing. This is supposed to be the measure of influence a factor has in altering the balance of incoming energy in the earth atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive radiation especially like those produced by increasing concentrations of greenhouse gases, tend to warm the

surface. A negative radiation forcing which can arise from an increase in some types of aerosols: microscopic airborne particles tends to cool the surface.

Due to the limitation in the number of words that this abstract has to contained, more elaboration will be done in the full paper.

HM-38

Human Influence on Climate: A Study with Reference to Climate Change Prediction and Emission of Green House Gas Emissions in India and Identification of Major Dimensions

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Humankind has become a forceful component in the functioning of the earth system. Human activities were largely responsible for a continuous increase in a atmospheric CO2 concentration and greenhouse gases emission. The airborne content of CO2 reflects a fraction of the CO2 (45%) attributed mainly from anthropogenic sources studies (tracer and modeling) indicate that the oceans cannot account for the imbalances in a global carbon budget. Studies revealed that the terrestrial ecosystem as a major source of CO2 in many of the countries around Indian ocean have witnessed substantive landuse changes in view of the population pressure since 1990. Man made impacts in atmospheric composition of greenhouses gases are evident by way of analyzing the alarming changes that takes place in the climate system of India. The countrywide mean maximum temperature has risen by 0.6ºC, and the mean minimum temperature has decreased by 0.1ºC. However, as the result from mean minimum temperature is not statistically significant, they concluded that most of the increases in mean surface air temperature over India is due to the increase in daytime temperature. The present study is an attempt to analyze the human influence on climate change in India with reference to man-made impact on greenhouse gas emissions owing to the influence of various human activities. The study thus analyzes the greenhouse gas emissions with reference to carbon dioxide emissions and its impacts in global change scenario of Indian subcontinent in relation to human dimensions such as landuse changes and its various human activities in relation to energy consumption and .to identify the major dimensions that resulted in green house emissions and warming as a result of changing composition of atmosphere both in rural and urban areas and finally with the help of conceptualization of findings an attempt is also made to build a framework and Plan for a Adaptation and Mitigation strategy to plan for a sustainable development for India and Developing countries. The study was based on the secondary data collected at various levels including the case studies carried out extensively on the impact of greenhouse gases including CO2 on global climate change at all levels Factor analysis, a multivariate statistical technique used to identify the major dimensions for selected variables such as land use changes and various human activities resulting in the release of carbon dioxide emissions from various sectors of economic activities such as agriculture, industry, transport and power.

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HM-39

Desertification during the 20th Century and the Global Warming as Its Cause

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In this study, we use the Koeppen's climate classification in order to find an evidence of the desertification during the 20th century. By constructing ten normal climates from the decadal means of the global precipitation and surface air temperature, we classify global land into 11-category subregions and analyzed the decadal trends of areal change of 5 major climate regions. Especially, dry climate regions are divided into steppe(BS) and desert(BW) regions.

As a consequence, it is clarified that the tropical and dry climate regions were rapidly extended during the most recent 20-30 years. On the other hand, the polar and arctic climate regions experienced rapid reduction in their areas during the longer period. Both the expansion of warmer climate region and the reduction of colder climate region may be considered as a direct result of the global warming. Area of the dry climate region focused in this study was gradually decreased from 1930s to 1960s, and then showed significant increase in the rate of about 0.6%/decade up to the 1990s. It is revealed that this trend was directly correlated with the trend of precipitation change during the 20th century, and also that the expanding trend in recent 30 years was highly relevant to the global warming.

Desertification in the 20th century, defined as the expansion of desert climate regions in this study, could be explained by the land degradation of steppe climate regions nearly without exception(more than 98%). In addition to the well-known fact, we find that the largest portion in the increase of BS area was from the reduction of desert area. This new fact implies that the systematic antidesertification also occurred during the last century as well as the desertification. In order to speculate the desertification on regional scale, we select five main arid regions including Sahara, and investigate the change of BS and BW area for each region. The results demonstrate that regional trend of the change in the 20th century is considerably distinct each other. As well known, desertification in the central Asia was most serious 1950s. Finally, we can find that the global scale desertification may be explained more or less from the expected overall intensification of subtropical highs and the increase of low-level wind divergence in those regions induced by the global warming. However, this linear inference is not valid on the regional scale.

HM-40

Impact of Land-Use Change and Urbanization on Climate

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We estimated the portion of the surface temperature warming trend over US surface stations below 500m that can be attributed to changes in land-use including agriculture and urbanization, by comparing the surface temperature trends with the trends obtained from the NCEP/NCAR Reanalysis, which does not use surface observations and is insensitive to land use changes (Kalnay and Cai, Nature, 423, 528-531).

We will discuss these results, including the seasonal cycle, the impact of using Historical Climatological Data adjusted for changes in station location and time of the day and further results shedding light on the possible use of reanalysis for climate trends. □

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