NTU INTERNATIONAL SCIENCE CONFERENCE ON CLIMATE CHANGE: MULTIDECADAL AND BEYOND

WORKSHOPS

理論科學研究中心
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Central-Pacific El Nino: Dynamics, Climate Impacts, and Its Recent Emergence

Prof. Jin-Yi Yu

Statistical analyses, numerical experiments, and case studies were conducted to suggest an extra-tropical forcing mechanism for the generation of the Central-Pacific El Nino-Southern Oscillation (ENSO), to contrast its distinct impact on North America Climate from the conventional type of ENSO, and to postulate its increasing occurrence in the recent two decades.

For material related to this talk, click here.

Estimating Multi-decadal Trends in ENSO: A Case Study Using Darwin SLP

Prof. Andy Chiodi

The task of identifying which aspects of climate are undergoing very long term trends from anthropogenic climate change or natural processes has received increased attention in recent decades. High quality, very long climate records are few. Recent improvements to the climate observing system have increased the information available in recent decades, but because geophysical spectra tend to have considerable variance at low frequencies (they are "red") as well as much shorter frequencies, it is unclear whether reliable estimates of long term trends can be made from multi-decadal or shorter time series.

We use the long (135yr) high quality record of sea level pressure (SLP) at Darwin, Australia, which is a very good proxy for the state of the El Nino-Southern Oscillation (ENSO), to determine the prospects for using shorter multi-decadal records to estimate longer term trends in ENSO. We have found that the distribution of 20 or 30 year sub-segments is evenly split among positive and negative trends and that the long term trend is not statistically significant. Despite this, multi-decadal (20-60 year) trends pass statistical significance tests surprisingly often when they are based on fits to autoregressive models or done via bootstrap calculations. For Darwin SLP, multi-decadal records are not long enough to reliably determine century-scale trends. The recent use of satellite-based observations and the increased sampling of the world's oceans since the 1950s have provided a wider range of climatically relevant information in recent decades than was available previously. But we suggest caution is needed when imputing meaning to trends found in these recent multi-decadal or shorter geophysical time series. The Darwin record illustrates that a multi-decadal trend may not be a good indicator of longer term behavior.

For material related to this talk, click here.

Global-Scale Decadal Hyper Modes

Prof. Dietmar Dommenget

The article discusses the idea of global-scale multi-decadal hyper modes. In this simple stochastic model it is illustrated that multi-decadal climate variability is globally linked via the tropical regions by atmospheric teleconnections. The persistence of higher latitudes SST variability with an exponentially decreasing mixing into the deeper oceans leads to a power spectrum with a lowfrequency tail and different slope compared to a red noise power spectrum. The main elements of this stochastic model do not involve any ocean dynamics beyond local vertical mixing.

For material related to this talk, click here.

Atlantic Meridional Overturning Circulation and Climate

Dr. Rong Zhang

This chapter reviews the global and regional scale climate impacts of the Atlantic Meridional Overturning Circulation (AMOC) on paleo and modern climate. It also discusses the tropical and extra-tropical AMOC fingerprints and the origin of the multidecadal North Atlantic sea surface temperature (NASST) variations, meridional coherence and propagation of AMOC variations, the anthropogenically forced AMOC changes in the 21st century, and the impacts of the Nordic Sea overflow on the AMOC and large scale North Atlantic ocean circulation.

For material related to this talk, click here.

North Atlantic Decadal-to-Multidecadal Variability - Mechanism and Predictability

Prof. Noel Keenlyside

TBA

For material related to this talk, click here.

Centennial Variability: Dynamics and Global Impacts

Prof. Mojib Latif

It is well established that centennial climate variability can be externally forced by e.g. variations of the solar constant or varying atmospheric aerosol concentrations. Climate models suggest that pronounced centennial variability can be also produced internally. However, different mechanisms were proposed. This paper deals primarily with the internal centennial climate variability in the Southern Hemisphere. The latter featured some rather unexpected trends during the recent trends, e. g. a lack of surface warming in contrast to the Northern Hemisphere which did strongly warm. The decadal trends in the Southern Hemisphere are explained as part of a longer-term centennial variability of the Southern Ocean circulation. The long timescale originates from the slow accumulation of North Atlantic Deep Water (NADW) in the Weddell Sea at mid-depth, which destabilizes the water column from below and eventually stimulates deep convection there. The heat accumulation during the non-convective regime and its subsequent release to the atmosphere during the convective regime can be viewed as a non-linear recharge oscillator.

The Southern Ocean centennial variability has global climate impacts. In particular, the Atlantic Meridional Overturning Circulation (AMOC) responds with a time delay of several decades to a century to the variations in the Southern Ocean.

For material related to this talk, click here.

Attribution of Climate Change in the Presence of Internally-Generated Variability

Prof. Mike Wallace

Many questions concerning the nature and causes of climate variability on the interdecadal time scale are still unresolved. For example, there is no consensus within the scientific community as to whether time-varying forcing associated with aerosols or whether variations in the Atlantic Meridional Overturning Circulation were responsible for the mid-20th century hiatus and the recent (post-1998) slowdown in the rate of global warming. Nor is it clear why the Arctic has experienced rapid warming during the past decade while surface air temperatures over the Northern Hemisphere as a whole have warmed very little or why, during the late 20th century; wintertime temperatures over the Northern Hemisphere continents poleward of 40°N warmed three times as rapidly as global-mean (land plus ocean) annual-mean surface air temperature during the same interval. These spatial and temporal differences in the rate of warming stem from the fact that the climate system is varying on the interdecadal time scale in response to its own internal variability as well as to a variety of natural and anthropogenic forcings. Detection, attribution and projection of human-induced climate change on the decade-to-decade time scale is problematical, and in some cases it is even difficult to distinguish between low frequency climate variability and climate change. These ambiguities can be expected to persist until the signature of human-induced climate change becomes large enough to stand out clearly above the natural “background variability”, as is projected to occur in the second half of this century.

In the world of models, the distinction between climate change and climate variability is clear. Climate change in response to the buildup of greenhouse gases and other anthropogenic forcings can be determined from a suite of simulations in which each member is started from a different set of initial conditions and run with the same prescribed, time-varying external forcings. Provided that the number of individual realizations is large enough to ensure a high level of statistical significance, the ensemble-mean climate can be identified with the human-induced climate change “signal” and the departures of the trajectories in the individual realizations from the ensemble mean trajectory are attributable to the internal variability of the simulated climate system. The same ensemble runs can be used to generate probabilistic projections of climate change over the next few decades.

Just how applicable the results derived from the model world are to the real world depends upon how well the models are able to simulate the internally generated low frequency variability of the climate system. With only one observed climate trajectory that can be used as a basis for validating the models, this question cannot be answered definitively, but it can be assessed in a probabilistic way. Generating a robust characterization of the low frequency variability in the historical climate record with which the statistics derived from the model runs can be compared is a prerequisite for assessing the internally generated variability. Just what such a characterization should include has not yet been fully agreed upon in the climate diagnostics community.

It seems reasonable that a robust characterization of the variability in the historical record should include variance and covariance statistics. Given only one realization, such statistics must be based on temporal, as opposed to run-to-run variances and covariances. To obtain a robust characterization of the variability (i.e., a characterization with a sufficient number of statistical degrees of freedom to be considered reliable) it is necessary to restrict the analysis to frequencies 10-30 times higher than one cycle over the length of the historical record , e.g., through the application of a high pass filter. Attribution of variability with frequencies lower than this cutoff frequency is inherently ambiguous. It is amenable to probabilistic statements based on comparisons with statistics derived from ensembles of runs, but there is no way of knowing with certainty whether it is natural or human-induced. Given that the historical record of global observations of surface air temperature and precipitation is only a ~100-years long, it is inevitable that decadal variability falls within this "twilight zone" in which attribution can be performed only in a probabilistic way.

Another factor that limits our ability to diagnose the decadal-scale variability in the climate record is the fact that inherently stochastic variability on the interannual time scale associated, for example, with the ENSO cycle or with large excursions of the Northern and Southern Hemisphere annular modes is capable of inducing a substantial sampling variability on the interdecadal time scale. For example, it has been questioned whether the so-called Pacific Decadal Oscillation (PDO) is merely a manifestation of such stochastic, sampling variability. It has also been suggested that anthropogenic forcing could also be responsible for some of the observed circulation changes on the multidecadal time scale. For example, the more rapid warming of the continental interiors relative to the surrounding oceans due to the much lower heat capacity of the underlying surface could serve to weaken the wintertime planetary waves .

Regardless of the mechanisms that give rise to it, decadal scale climate variability mediates the rate of rise of global-mean temperature. Performing a "dynamical adjustment" to remove (or at least reduce) the contribution of these circulation changes to the rise in global-mean temperature simplifies the space-time structure of the surface air temperature record and renders it more spatially and seasonally coherent.

In this presentation we will summarize the state of our knowledge of internally generated interdecadal variability of the climate system. We will show how the interplay free and forced climate variability complicates the attribution of global warming, regional climate impacts and extreme events and we will demonstrate how performing a dynamical adjustment can simplify the representation of climate change in the historical record.

For material related to this talk, click here.

AMO-like Interdecadal Variability in the CMIP5 - Are Models Oversensitive to Prescribed Forcing?

Prof. Huang-Hsiung Hsu

The Atlantic Multidecadal Oscillation (AMO), which fluctuates in a period of 60-70 years and has been found connected with many observed climate fluctuations, is one of the most explored interdecadal phenomena in recent years (e.g., Kushnir 1994, Schlesinger and Ramankutty 1994, Kerr 2000). Considering the significant impacts of the AMO on regional climate, which will be briefly reviewed in this presentation, whether the phenomenon is reasonably simulated by the current state-of-art climate model is an important issue for climate change research. Studies based on the third phase of Climate Model Intercomparison Project (CMIP3, Meehl et al. 2007) simulations found limited model capability (e.g., Kravtsov and Spannagle 2008, Knight 2009) in simulating AMO. This study revisited this issue by analyzing the CMIP5 data to firstly evaluate the model capability in the pre-industrial simulations. A reasonable model should simulate the AMO-like variability to a certain degree, if internal variability is the major reason for the existence of the AMO. Whether the AMO-like variability is enhanced or suppressed in the historical simulations were also examined through a comparison with the pre-industrial simulation. Both pre-industrial and historical simulations were started with the same initial condition. The former was simulated with constant CO_2 concentration in 1850 and no any other observed forcing, while the latter was forced by prescribing "observed" (both natural and anthropogenic) forcings (Taylor et al. 2012 for details). The systematic differences between two sets of experiments were most likely due to the prescribed forcings in the historical simulations. In order to explore the model sensitivity to the prescribed forcing, interdecadal variability in the future projection is also briefly touched upon. Present study reveals the current status of our capability in simulating AMO-like interdecadal variability and provides further information for the interpretation of observed AMO variation in recent few decades.

For material related to this talk, click here.

An Observational Analysis of Oceanic and Atmospheric Structure of Global-Scale Multidecadal Variability

Prof. Peng Liu

We aim to identify the multi-decadal variability relative to the global warming trend in available observation data. First we apply the Hilbert-Huang Transform (HHT) method to the global mean surface temperature (ST_gm) data to obtain a centennial global warming trend. Then the associated signals to the global warming trend are removed from three sets of climate variables including SST, ocean temperature from surface to 700 m, and the NCEP and ERA40 reanalysis, respectively. All detrended variables are low-pass filtered. Through three independent EOF analyses of the filtered variables, all consistently show two dominant modes with their respective temporal variability resembles the Pacific Decadal Oscillation/Inter-decadal Pacific Oscillation (PDO/IPO) and the Atlantic Multi-decadal Oscillation (AMO). The spatial structure of PDO-like mode is characterized by an ENSO-like structure and hemispheric symmetric features. The eigenvectors of AMO-like mode feature overall warm SST anomalies in the Atlantic and Pacific basin north of 100S. The atmospheric structure associated with the AMO-like mode also exhibits hemispheric asymmetric features with anomalous warm air in Eurasia, and cold air over southern oceans. In the past 30 years, the evolution of PDO-like and AMO-like oscillations gives rise to strong temperature trends resembling negative-phase PDO mode in Pacific, and positive-phase AMO mode in Atlantic. Globally, the two multi-decadal oscillations contribute an important part of the ST_gm warming. The two oscillations are expected to slow down the global warming trends in the next decade.

For material related to this talk, click here.

Dynamic Transitions in Climate Dynamics

Prof. Shouhong Wang

The main objective of this article is to develop a systematic dynamic transition theory for low frequency variability of the large-scale atmospheric and oceanic flows. The primary goal of this proposed effort is to document, through careful theoretical and numerical studies, the presence of climate low frequency variability, to verify the robustness of this variability's characteristics to changes in model parameters, and to help explain its physical mechanisms. The main focus is on a few typical sources of atmospheric and oceanic variability, including in particular the wind driven ocean circulation, the thermohaline circulation (THC) and the tropical atmosphere-ocean modes associated with the El Nino Southern Oscillations (ENSO). The wind-driven circulation plays a role mostly in the oceans' subannual-to-interannual variability, while the THC is most important in decadal-to-millenial variability.

There are two types of nonlinear systems in nature: conservative and dissipative. A systematic dynamic transition theory for dissipative systems is established recently by the authors. The key philosophy of the theory is to search for the full set of transition states, giving a complete characterization of stability and transition. The set of transition states is represented by a local attractor near or away from the basic state. The central theme of the theory is to establish a general principle that transitions for all dissipative systems consists of only three types: continuous, catastrophic, and mixed (random).

For ENSO, we derive a new mechanism of the ENSO, as a self-organizing and self-excitation system, with two highly coupled processes. The first is the oscillation between the two metastable warm (El Ni\~no phase) and cold events (La Nina phase), and the second is the spatiotemporal oscillation of the sea surface temperature (SST) field. The interplay between these two processes gives rises the climate variability associated with the ENSO, leads to both the random and deterministic features of the ENSO, and defines a new natural feedback mechanism, which drives the sporadic oscillation of the ENSO. The randomness is closely related to the uncertainty/fluctuations of the initial data between the narrow basins of attractions of the corresponding metastable events, and the deterministic feature is represented by a deterministic coupled atmospheric and oceanic model predicting the basins of attraction and the sea-surface temperature (SST). It is hoped this mechanism based on a rigorous mathematical theory could lead to a better understanding and prediction of the ENSO phenomena.

For the THC, a mathematical theory is derived. In particular, we obtain a general transition and stability theory for the Boussinesq system, governing the motion and states of the large-scale ocean circulation. First, it is shown that the first transition is either to multiple steady states or to oscillations (periodic solutions), determined by the sign of a nondimensional parameter K, depending on the geometry of the physical domain and the thermal and saline Rayleigh numbers. Second, for both the multiple equilibria and periodic solutions transitions, both Type-I (continuous) and Type-II (jump) transitions can occur, and precise criteria are derived in terms of two computable nondimensional parameters b_1 and b_2. Associated with Type-II transitions are the hysteresis phenomena, and the physical reality is represented by either metastable states or by a local attractor away from the basic solution, showing more complex dynamical behavior. Third, a convection scale law is introduced, leading to an introduction of proper friction terms in the model in order to derive the correct circulation length scale. In particular, the dynamic transitions of the model with the derived friction terms suggest that the THC favors the continuous transitions to stable multiple equilibria.

For material related to this talk, click here.

Evidence for a Multi-decadal Oscillation in Global Temperature and Its Impact on the Deduced Anthropogenic Warming Trend: A Review

Prof. Ka-Kit Tung

Our work was inspired by the paper of Wu et al. [2011] , who showed, using the novel method of Ensemble Empirical Mode Decomposition (Wu and Huang [2009]; Huang et al. [1998]), that there exists, in the 150-year global mean surface temperature record, a multi-decal oscillation. With an estimated period of 65 years, 2.5 cycles of such an oscillation was found in that global record. They further argued that it is related to the Atlantic Multi-decadal Oscillation (AMO) and, if this oscillation is separated out, a monotonic trend emerges in the global mean temperature, with little acceleration of warming. Given the importance of this last implication on the recent anthropogenic global warming, it is quite natural that the scientific community is demanding more evidence that this oscillation is real, recurrent and natural, and in particular evidence that it is not a response to time varying anthropogenic forcing that happens to look like an oscillation.

For material related to this talk, click here.

Fluctuation-dissipation Theorem with Application to Climate Change Studies

Prof. Xiaoming Wang

We survey recent results on fluctuation-dissipation theorem with application to climate change studies. In particular, we will present recent linear response formulas for unperturbed chaotic (stochastic) complex dynamical systems with time periodic coefficients developed by Andrew Majda and the author. Such time periodic systems arise naturally in climate change studies due to the diurnal and seasonal cycle. These response formulas are developed through the mathematical interplay between statistical solutions for the time-periodic dynamical systems and the related skew-product system. This interplay is utilized to develop new systematic quasi-Gaussian and adjoint algorithms for calculating the climate response in such time-periodic systems. New linear response formulas are also developed here for general time-dependent statistical ensembles arising in ensemble prediction including the effects of deterministic model errors, initial ensembles, and model noise perturbations simultaneously. An information theoretic perspective is developed in calculating those model perturbations which yield the largest information deficit for the unperturbed system both for climate response and finite ensemble predictions.

For material related to this talk, click here.

Rapid Increase of High Ocean Heat Content Regions in the Western North Pacific Ocean for Supertyphoons

Prof. I-I Lin

Category-5 tropical cyclones (TCs), Hurricane Katrina (2005) and supertyphoon Megi (2010) for example, are the most intense and devastating cyclones on earth. The majority (~ 70%) of these 'super' cyclones are formed in the western North Pacific Ocean (WNPO), imposing threats to nearly a billion people living in the Asian coasts. As understood from existing knowledge, the ocean condition required for reaching the extraordinary intensity of category-5 over the WNPO is not trivial. In addition to warm sea surface temperature (SST) of ~ 29 degrees Celsius or above, a sufficiently-thick layer of subsurface warm water beneath sea surface is also needed. Typically warm layer thickness, as characterized by high upper ocean heat content (UOHC),of more than 100 kj cm2 for a typhoon travels in moderate speed, is required. During typhoon season (July-October), meeting the warm SST requirement is usually possible. Due to strong solar radiation in summer, most part of the WNPO is characterized by uniformly warm SST of ≧ 29 degrees Celsius. However, it is more difficult to meet the subsurface requirements, since regions with such thick subsurface warm layer are more limited. Using 2 decades of satellite observations, we examine the long-term variability of the ocean condition in the MDR region. As will be presented, our results suggest that regions satisfying ocean's subsurface condition for supertyphoons have increased significantly, a worrisome situation requires attention.

For material related to this talk, click here.

On Noise, Cycle and Trend in Climate Data

Prof. Norden E. Huang

Ever since Fourier introduced the eponymous transform people tends to think everything in terms of simple harmonic waves. Powerful as it is, the Fourier analysis is a mathematical tool that decomposes any signal into components consisting of sinusoidal functions. In simple example, the Fourier analysis can consistently separate a signal into its constituent components, but for complex signal from physical phenomena whether those harmonic components represents any physical significance is a totally different question. As Fourier analysis is based on linear stationary assumption, but not all the phenomena are indeed linear and stationary. For a nonstationary, the trend in the signal is another important property of the process we want to define and quantify. Here, the Fourier analysis would be of limited use. Furthermore, data from all physical processes contain noise from all different sources covering natural processes to measuring devices. To separate the noise from the signal is a challenging problem where Fourier analysis could offer limited information. Take the climate change as an example, to find the cycle and trend is the goal of climate study.

But climate data are full of noise from all kind of sources. Therefore, to find a method to apply to climate study is an urgent problem. Here we will introduce a new method, the Empirical Mode Decomposition (EMD), to separate noise form signal and also identify the cycles of change from the trend. A better way to define cycle is through frequency. With a proper frequency definition, the trend and noise could be easily identified. To define frequency, we have to decompose the data into the constituent component, each one would have to be a 'mono-component' function, or an Intrinsic Mode Function (IMF) through EMD.

For material related to this talk, click here.

Mathematical Theory of Climate Sensitivity

Prof. Michael Ghil

Recent estimates of climate evolution over the coming century still differ by several degrees. This uncertainty motivates the work presented here. There are two basic approaches to apprehend the complexity of climate change: deterministically nonlinear and stochastically linear, i.e. the Lorenz and the Hasselmann approach. The "grand unification" of these two approaches relies on the theory of random dynamical systems. We apply this theory to study the random attractors of nonlinear, stochastically perturbed climate models. Doing so allows one to examine the interaction of internal climate variability with the forcing, whether natural or anthropogenic, and to take into account the climate system's non-equilibrium behavior in determining climate sensitivity.

This non-equilibrium behavior is due to a combination of nonlinear and random effects. We give here a unified treatment of such effects from the point of view of the theory of dynamical systems and of their bifurcations. Energy balance models are used to illustrate multiple equilibria, while multi-decadal oscillations in the thermohaline circulation illustrate the transition from steady states to periodic behavior. Random effects are introduced in the setting of random dynamical systems, which permit a unified treatment of both nonlinearity and stochasticity. The combined treatment of nonlinear and random effects is applied to a stochastically perturbed version of the classical Lorenz convection model.

Climate sensitivity is then defined mathematically as the derivative of an appropriate functional or other function of the system's state with respect to the bifurcation parameter.

For material related to this talk, click here.

Pacific and Atlantic Decadal Variability Reflected by the Winter Temperature in Taiwan During the Period 1911-2010

Prof. Mong-Ming Lu

One hundred years of temperature data at six Taiwan stations are decomposed using the data adaptive method Ensemble Empirical Mode Decomposition (EEMD) to five intrinsic mode functions (IMFs) and a centennial secular trend (ST). Significant multi-decadal modes (period > 40 years) in winter and the associated warm (1930s and 1940s) and cold (1970s and 1980s) decades are identified. The decades from early 1950s to mid-1970s are the transition years from warm to cold, while the recent decades since 1990 are the transition from cold to warm. The ST shows much larger warming rate than the linearly regressed trend. The multi-decadal modes of Taiwan temperature are in-phase with the AMO and global mean temperatures. The termination of the warm (cold) regime is associated with the weakening (strengthening) of the North Pacific subtropical gyre. The rapid warming after 1990s can be resulted from the combined effect of negative PDO and positive NPGO, although anthropogenic influence cannot be ruled out.

For material related to this talk, click here.

Annual Temperature Reconstruction in the Eastern Part of the Northeast China Since A.D. 1765 Based on Tree-ring Width Data

Dr. Hong Yin

Understanding of past climatic variability over the Northeast China is limited because of the lack of long-term climatic records. Here we reconstruct the annual mean temperature since A.D. 1765 based on tree-ring data in the Eastern part of the Northeast China. The reconstruction series can account for 45.8% of the annual temperature variance in the instrumental period (1959 to 2002).Six cold periods and five warm periods were identified based the 11-year moving average of reconstructed annual temperature series. The periods of 5.6-year and 3.8-year are found significant with a 99% confidence based on the power spectrum method. Significant abrupt changes with a 99% confidence are observed for around 1817,1839,1867,1913 and 1937with a 30-year moving T-test. Comparisons with other paleoclimatic proxies show that some cold and warm periods coincide with Siberia, Japan, China and Northern Hemisphere temperature. After strong volcanic eruptions in 1815, 1883, 1902, 1912 and 1991, the reconstruction temperature are on a low side. Especially after the 1912 volcanic eruption, the duration of the cooling period is longest from 1912 to 1921.

For material related to this talk, click here.

Interhemispheric Thermal Gradients and Multidecadal Variations in the Tropical Climate over the 20th Century

Prof. John Chiang

Several lines of evidence – paleoclimate observations, model simulations, and theory - suggest that cooling originating over the northern extratropics have a profound effect on tropical rainfall, by generating an interhemispheric thermal gradient that shifts the latitudinal position of the Intertropical Convergence Zone southward, and weaken rainfall over Northern Hemisphere summer monsoon regions. This change is associated with an altered cross-equatorial atmospheric energy transport induced by hemispheric differences in surface and top-of-atmosphere energy flux. In this talk, I highlight a few cases where this framework may be usefully applied to understanding multidecadal and longer-timescale forced changes in tropical rainfall over the 20th century, focusing on two cases: a southward trend in the tropical Atlantic ITCZ, and the late 1960's abrupt weakening in the North African and Asian monsoons.

For material related to this talk, click here.

The South-Flood North-Drought Pattern Over Eastern China and the Drying of the Gangetic Plain

Prof. Sumant Nigam

The Indo-Gangetic Plain and the lowlands/plains eastward of the Tibetan Plateau exhibit substantial – at times, precarious – trends in summer precipitation since the mid-twentieth century. These include declining rainfall over the northern Gangetic Plain, and a meridional dipole over eastern China that is commonly referred as the South-Flood North-Drought (SFND) pattern in the region. The trends have been attributed to increased aerosol/dust loadings, significant land-use land-cover change, and increased greenhouse gas emissions, among others. Interestingly, multidecadal natural variability is not a commonly cited cause. The presence of oppositely-signed (i.e., increasing) rainfall trends in the first-half of the 20th century in some of the same regions prompted this reassessment of the role of multidecadal SST variability in generating summer rainfall trends over large parts of monsoon Asia.

Multi-decadal Variability in Indian Summer Monsoon Rainfall: Some New Perspectives

Prof. B. N. Goswami

Based on the observational data for the 1871-2000 period the Indian Summer Monsoon Rainfall (ISMR) exhibited neither a significant trend nor any impact of climate change, but a quasi-60-year periodicity with alternate epochs (~30 years) of above and below normal rainfall. However, the recent decade of 2001-2010 has changed this scenario significantly. While the ISMR displays a weak decreasing trend for the entire observational data period (1871-2011), the last 6 decades show a strong decreasing trend significant at 99% confidence level. Thus, the existence of a quasi-60-year periodicity is not a robust feature limiting the predictability of multi-decadal variability of ISMR. Possible drivers for the multi-decadal variability of ISMR are explored with special emphasis on understanding the drivers for the recent decreasing trend in the ISMR.

For material related to this talk, click here.

Interdecadal Variability of Intense Tropical Cyclone Activity in the Southern Hemisphere

Prof. Kevin Cheung

The variability of intense tropical cyclone (TCs) in the Southern Hemisphere and its relation with large-scale environmental parameters using principal component analysis (PCA) are examined. The results show that there was a shift from low intense TC activity during 1976/77- 1987/88 (period 1) to high activity during 1988/89-2007/08 (period 2), which is related to more occurrences of intense TCs in the southwestern Indian Ocean (SWIO) and northwestern Australian region during period 2. There are distinct sea surface temperature anomaly (SSTA) dominating patterns based on T-mode PCA in period 1 and period 2, with the five dominating ones in period 2 having higher SSTA in the TC development regions. The temporal variability of the vertical wind shear (VWS) over IO is also examined through S-mode PCA. The second mode shows high VWS during the 1970s to early 1980s, followed by low VWS afterward during period 2, which may be responsible for the shift in intense TC activity over the IO. Linear correlative analysis shows that this VWS mode of variability is significantly related to the subtropical dipole events in the southern IO, which critical in determining the large-scale atmospheric and oceanic conditions for intense TCs to develop over the basin.

For material related to this talk, click here.

Multidecadal Trends of Tropical Cyclone and China Summer Monsoon Extreme Rainfall and Taiwan Typhoon Rain Intensity

Prof. Chih-Pei Chang

Interpretations of extreme rainfall trends in the Asian monsoon regions are complicated by tropical cyclones (TCs) from tropical oceans, whose rainfall trend may be different from the local monsoon (non-TC) rain. In the last half century the trends over the China summer monsoon region have been distorted by western North Pacific typhoons with the TC-related extreme rainfall trend smaller than monsoon-related extreme rainfall. The net impact underestimates the increasing trend in monsoon extreme rainfall over most areas. The largest underestimate occurs in Hainan Island, while an opposite case occurs in Taiwan whose extreme rainfall trend is hugely inflated by local increases in TC rainfall in the last decade. The increases are due to slowly-moving modest TCs and small variations of their tracks relative to the high mountains. If the terrain factors are taken into account, the apparent large increase in TC-related rainfall before and after landfall disappears. The remaining increase due to stronger TC - monsoon interactions becomes apparent only after the typhoon center exits Taiwan; and the preliminary analysis of a century-long record.

suggests this may reflect multidecadal variations. These regional and local variations also highlight the importance of considering different mechanisms of rainfall systems in order to differentiate regional and global drivers in the attribution of extreme rainfall trends.

For material related to this talk, click here

Variations of Western North Pacific Tropical Cyclone Activity on Decadal Time Scales and Longer

Prof. Johnny Chan

This paper presents an examination of the variations of tropical cyclone activity in the western North Pacific Ocean on time scales of a decade or longer. It is shown that the number, intensity, tracks and landfall locations of TCs have substantial variations on time scales from multi-decadal to centennial, together with longer trends. Many of these variations can be explained by similar variations in the atmospheric and/or oceanographic environments in which these TCs are embedded.

For material related to this talk, click here.

North Atlantic Hurricane Activity: Past, Present and Future

Prof. Rym Msadek

We review past, present and future North Atlantic hurricane activity from the revisited analysis of observational record and models projections. When adjusted for likely missed tropical storms, the observational record does not show any significant increase or decrease of North Atlantic hurricane activity. Some model projections of late 21st century hurricane activity indicate an increase in frequency of the strongest storms (category 4-5 hurricanes). The projected increase is substantial (+100% per century) in the CMIP3 ensemble model downscaling, but much smaller (+40%) and not statistically distinguishable from zero in the CMIP5 ensemble model downscaling. Rainfall rates for hurricanes are projected to increase and downscaling results for most CMIP5 models show a decrease in overall frequency of tropical storms and hurricanes. The largest source of uncertainty to predict changes in hurricane frequency in the Atlantic for the coming decades arises from the internal variability of the climate system. The predictability of hurricane frequency on multiyear timescales is investigated. Initial encouraging results suggest that skill may be achievable beyond the seasonal time scales. However the short record and the changing observational system limits our ability to confidently predict North Atlantic hurricane activity for now.

For material related to this talk, click here.

Applications of Conditional Nonlinear Optimal Perturbations to the Studies of ENSO and THC

Prof. Mu Mu

This report reviews the applications of conditional nonlinear optimal perturbations (CNOPs) to the “spring predictability barrier” (SPB) problem in El Niño-Southern Oscillation (ENSO) predictions and the decadal variabilities of thermohaline circulation (THC) problem. First we briefly introduce the approach of CNOP, and then the results obtained by CNOP on SPB problem will be given. Finally we discuss the stability and decadal variability problems of THC by using CNOP approach.

For material related to this talk, click here.

Decadal variability of summer rainfall over China: obsevation vs. a1000-year control simulation of HadCM3

Dr. Yonghui Lei

For material related to this talk, click here.

Multi-year Prediction and Predictability

Prof. Tim DelSole

This talk presents an overview of our current understanding and accomplishments in predicting the climate on multi-year time scales. There is clear evidence from coupled atmosphere-ocean general circulation models that the climate system can be predicted on multi-year time scales based on changes in greenhouse gas concentration, aerosol concentration, and solar insolation, and based on initial condition information primarily from the ocean subsurface. New statistical optimization techniques have substantially clarified the space-time structure of both forms of predictability on multi-year time scales. These techniques reveal not only predictability of ocean quantities, but also predictability of temperature and precipitation over land on multi-year time scales. To validate these results from climate model studies, we present a new prediction system which, for the first time, is verified to have skill on multi-year time scales over the entire twentieth century observational record.

For material related to this talk, click here..

The Aerosol-Monsoon Climate System of Asia

Prof. William K.M. Lau

In Asian monsoon countries such as China and India, human health and safety problems caused by air-pollution are worsening due to the increased loading of atmospheric pollutants stemming from rising energy demand associated with the rapid pace of industrialization and modernization. Many studies have demonstrated that aerosols can strongly interact with the monsoon water cycle. Because of complexity of the dynamics of the monsoon systems, aerosol monsoon interactions must be studied and understood in relation to changes in fundamental driving forces of the monsoon climate system (e.g. sea surface temperature, land-sea contrast etc.) on time scales from synoptic to intraseasonal variability (~days-weeks) to climate change (~ multi-decades). Indeed, because of the key contributions of aerosols to the global and regional energy balance of the atmosphere and earth surface, and possible effects of the microphysics of clouds and precipitation, a better understanding of the response to climate change in Asian monsoon regions requires that aerosols be considered as an integral component of a fully coupled aerosol-monsoon system on all time scales.

For material related to this talk, click here.

Variability of Sea Ice Over Decadal and Longer Timescales

Prof. John Walsh

Recent syntheses of sea ice and related proxy information have provided an improved picture of Arctic sea ice variability over decadal and longer timescales. A spectrum of variability is superimposed on a recent decrease of Arctic sea ice. An outstanding feature is the correspondence with the Atlantic Multidecadal Oscillation, which has timescales of 50–120 years. The linkage appears to arise through the inflow of Atlantic Water to the Arctic Ocean. Less robust, and by all indications non-stationary, associations with atmospheric modes such as the North Atlantic Oscillation have also been documented, primarily in recent decades. One possible reason for the nonstationarity of such associations is that the centers of action of major atmospheric modes may change over the timescale of centuries or even less. Observational information on Antarctic sea ice variability is virtually nonexistent beyond the past 100–150 years, so proxy information provides the only clues to longer-term Antarctic sea ice variability. Such information obtained from ice cores suggests that wintertime ice extent in the East Antarctic sector has decreased by about 20% since 1950, and that multicentury variations also characterize Antarctic ice extent.

For material related to this talk, click here.

Multi-year Predictability of Temperature and Precipitation over Land

Dr. Liwei Jia

This study provides a basis for multi-year predictions over land by explicitly identifying patterns in multiple climate models that are predictable on multi-year time scales. The patterns are identified by maximizing the Average Predictability Time (APT) of surface air temperature and precipitation in pre-industrial control simulations. Because the patterns are identified from control runs, the predictability arises from internal dynamics that occur in the absence of interannual variations of anthropogenic and natural forcing. The leading two most predictable components of surface air temperature are verified to be significantly predictable for 2-20 years, with one component deriving predictability from the persistence of temperature over the oceans, and the other deriving predictability from evolving ENSO patterns. Global annual mean land precipitation is shown to be significantly predictable for 2-4 years in multiple models. These results contradict the widely held belief that temperature and precipitation is unpredictable beyond seasonal time scales.

For material related to this talk, click here.

Stochasticity and Memort Effects in Multi-level Dynamical Systems: Connecting the Ruelle Response Theory and the Mori-Zwanzig Approach

Prof. Valerio Lucarini

We consider the problem of disentangling multi-level systems by connecting the seemingly unrelated approaches of the Mori-Zwanzig projection operator technique and of the Ruelle response theory, for which we propose a new derivation. We show that by using the Ruelle response theory on a weakly coupled system it is possible to construct a surrogate dynamics for the slow variables, such that the expectation value of any observable agrees, up to second order in the coupling strength, to its expectation evaluated on the full dynamics, where both slow and fast variables are involved. The impact of the fast variables onto the slow variables is parametrized in the surrogate dynamics as the sum of a deterministic contribution, a stochastic forcing, and a memory term. Then, using a Dyson expansion, we show that such surrogate dynamics agrees up to second order to the effective dynamics one can derive by expanding perturbatively the Mori-Zwanzing projection operator, which creates, instead, an accurate representation of the trajectories of the slow variables. In the case of e.g. geophysical fluid dynamics, this implies that the parametrizations of unresolved

processes suited for prediction (numerical weather forecast) and those suited for the representation of long term statistical properties (climate) are closely related, if one takes into account, in addition to the widely adopted stochastic forcing, the usually neglected memory effects. This bears relevance for the current trend of aiming at seamless prediction.

For material related to this talk, click here.