October 15-16, 2015

Second International Symposium on Climate and Earth System Modeling

HOST/ORGANIZER:

Earth System Modeling Center,
Nanjing University of Information
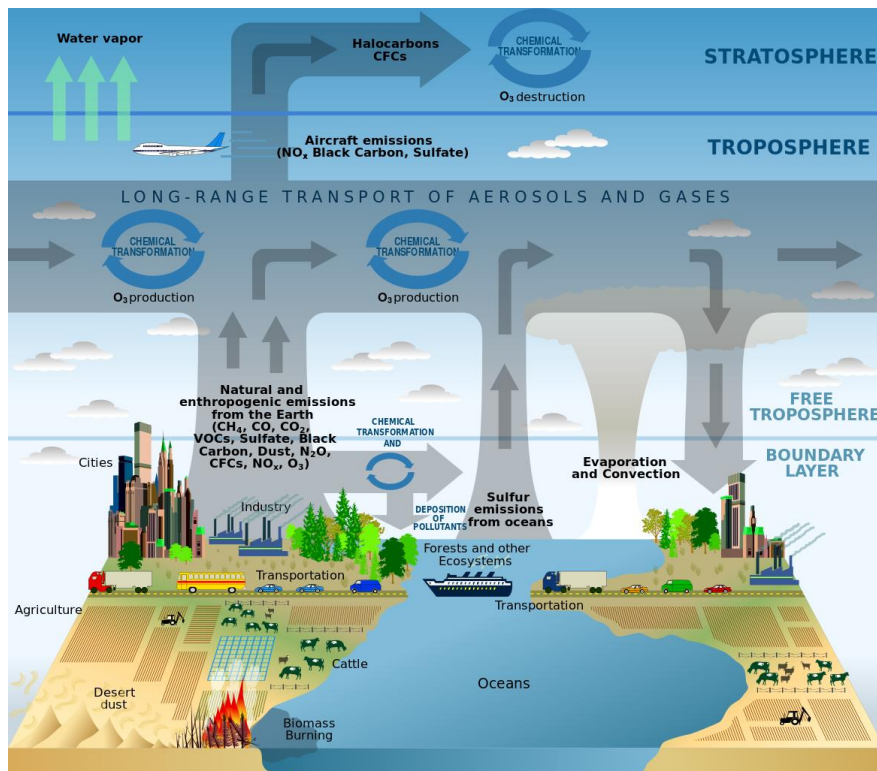Science and Technology

TIME: October 15-16, 2015

VENUE:

Lecture Hall (1st Floor),
Meteorology Building,
Nanjing University of Information
Science and Technology

About ESMC

The Earth System Modeling Center (ESMC) of Nanjing University of Information Science and Technology (NUIST) was initiated in the summer of 2012 and formally established in May 2013.

The ESMCaims at developing world-class climate and earth system models to meet the multiple needs for 1) seamless climate prediction from subseasonal to decadal time scale, 2) future projection of the earth climate and environmental changes, and 3) modeling and prediction of highly impactful weather and climate events, and 4)better understanding of underlying physical processes of complex climate variability. The ESMC serves as an international scientific research platform to promote frontier research on global changes and interdisciplinary research on Earth System Science, as well as to nurture a team of young generation talents.

Agenda

October 15, 2015(Thursday)	
08:30-09:00	**Opening Ceremony**
09:00-09:15	**Photo**
09:15-12:00	**Session I –1 Model Development** **Chair: Xiuqun Yang/Hong Liao**
09:15-09:40	AGCM with Cloud Microphysics In-Sik Kang (Seoul National University)
09:40-10:05	GFDL's Unified Weather-Climate Model Developments Shian-Jiann Lin (GFDL/NOAA, UCAR)
10:05-10:25	Development of TaiESM Chein-Jung Shiu (RCEC, Academia Sinica, Taiwan)
10:25-10:45	Convective Parameterization in the High Resolution Modeling Era Guangjun Zhang (Tsinghua University & Scripps Institution of Oceanography)
10:45-11:05	A Brief Introduction to an ESM+CEM Model Wenjie Dong (Beijing Normal University)
11:05-11:25	Revisiting the Double ITCZ Problem in Coupled Climate Models Baoqiang Xiang (GFDL/NOAA, UCAR)
11:25-11:45	Finite-volume Atmospheric Model of the IAP/LASG (FAMIL) Qing Bao (IAP, Chinese Academy of Sciences)
11:45-12:00	FIO-ESM: the Earth System Model with Surface Gravity Waves Zhenya Song (First Institute of Oceanography, SOA)
12:10	**Lunch**
14:00-15:30	**Special Session - ESMC Reports** **Chair: Tim Li**
14:00-14:20	The Progress of the NUIST Model Development Bin Wang (University of Hawaii/NUIST)
14:20-14:30	Understanding of Tropical Cyclone Climate Change over the Western North Pacific Liguang Wu (NUIST)
14:30-14:40	An Atmospheric Origin of the Multi-decadal Bipolar Seesaw Zhaomin Wang (NUIST)
14:40-14:50	Can the Tibetan Plateau Snow Cover Influence the Interannual Variations of Eurasian Heat Wave Frequency? Zhiwei Wu (NUIST)

Agenda

October 15, 2015(Thursday)	
14:50-15:00	Climate Variability and Future Projection Pang-chi Hsu (NUIST)
15:00-15:10	Analysis of Seasonal Ozone Budget in the Boundary Layer of the Asia-Pacific Region Xuewei Hou (NUIST)
15:10-15:20	Size-resolved Aerosol Module: Model Development and Climatic Effect Xiaoyan Ma (NUIST)
15:20-15:30	Some Advances in Paleoclimate Simulation and Analysis of NUIST Earth System Model Fei Liu (NUIST)
15:30-15:40	**Coffee Break**
15:40-18:10	**Session II –1 Model Application** **Chair: Wenjie Dong/Zhiwei Wu**
15:40-16:05	Prospects for Prediction of Sub-seasonal to Seasonal Climate James L. Kinter III (George Mason University)
16:05-16:30	Preliminary Results of Global Monsoon Modeling Intercomparison Project Tianjun Zhou (IAP,Chinese Academy of Sciences)
16:30-16:50	Arctic Sea Ice Simulation and Projection: How Credible Are the State-Of-The-Art Climate Models? Xiangdong Zhang (IARC, University of Alaska Fairbanks)
16:50-17:10	Transient Response of an Atmospheric GCM to External Forcings Laurent Li (CNRS, UPMC)
17:10-17:30	Using Satellite Data to Represent Multi-scale Ocean-Atmosphere Processes for Improved Climate Modeling Ronghua Zhang (IOCAS, Chinese Academy of Sciences)
17:30-17:50	Future Projection of the Extreme Rainfall Frequency of Taiwan Mei-Yu Downscaled from the CMIP3 and CMIP5 Models Mong-Ming Lu (Central Weather Bureau, Taiwan)
17:50-18:10	Arctic Sea Ice in CMIP5 Climate Model Projections and Their Seasonality Variabilities Fei Huang (Ocean University of China)
18:20	**Reception**

Agenda

October 16, 2015(Friday)	
08:30-12:00	**Session I-2 Model Development** **Chair: Zhaoming Wang/Xiaoyan Ma**
08:30-08:55	Climate Modeling in Japan Masahide Kimoto (University of Tokyo)
08:55-09:20	Deconstructing Recent Regional Climate Change: Is CO2 a Sufficient Driver? Hans Von Storch (Institute of Coastal Reseach/HZG, Hamburg University and Ocean University of China)
09:20-09:40	A New Normal in Land Surface Modeling Zongliang Yang (University of Texas at Austin)
09:40-10:00	Importance of Bitwise Identical Reproducibility in Earth System Modeling and Status Report Li Liu (Tsinghua University)
10:00-10:20	Development of the Online Aerosol Module in GCM Tie Dai (IAP, Chinese Academy of Sciences)
10:20-10:40	**Coffee Break**
10:40-11:00	Fast and Slow Response of the Climate System Long Cao (Zhejiang University)
11:00-11:20	Chemical-dynamical-radiative Feedbacks in the Stratosphere in Chemistry-climate Models Wenshou Tian (Lanzhou University)
11:20-11:40	Schwarz-Christoffel Conformal Mapping Based Grid Generation for Ocean General Circulation Models Shiming Xu (Tsinghua University)
11:40-12:00	Simulation on the Melt Pond of Arctic Jie Su (Ocean University of China)
12:10	**Lunch**
14:00-18:10	**Session II–2 Model Application** **Chair: Pang-chi Hsu/Hua Chen**
14:00-14:25	Extreme Precipitation and Tropical Cyclones in a Warming Climate Simulated by CAM Julio Bacmeister (NCAR Earth System Laboratory)
14:25-14:50	Applications of Climate System Models: Target Observations for High-impact Ocean-Atmospheric Environmental Events Mu Mu (IOCAS, Chinese Academy of Sciences)

Agenda

October 16, 2015(Friday)	
14:50-15:10	Probabilistic versus Deterministic Skill in Predicting the Western North Pacific-East Asian Summer Monsoon Variability with Multi-Model Ensembles Xiuqun Yang (Nanjing University)
15:10-15:30	What Causes the Divergent Projections of ENSO Amplitude Changes under Global Warming Tim Li (University of Hawaii)
15:30-15:50	The Most Disturbing Tendency Error of Zebiak-Cane Model Associated with El Nino Predictions and Its Implications WansuoDuan (IAP,Chinese Academy of Sciences)
15:50-16:10	Impact of Biogenic Emissions on Climate Change Feng Liu (University of Illinois at Urbana-Champaign)
16:10-16:20	**Coffee Break**
16:20-16:40	The Simulation of Past and Future Changes in Tropospheric Ozone and Aerosols in China Hong Liao (IAP, Chinese Academy of Sciences)
16:40-17:00	Land Surface Model Calibration at Grid-scale trough Mcrowave Data Assimilation for Improving Soil Moisture Simulations Kun Yang (ITP, Chinese Academy of Sciences)
17:00-17:20	Paleoclimate: ESM Used in Understanding Geological Questions Zhongshi Zhang (IAP, Chinese Academy of Sciences)
17:20-17:40	China's Air Pollution: New Perspectives on Global Sources and Transport Jintai Lin (Peking University)
17:40-18:00	Unrealistic Treatment of Detrained Water Substance in FGOALS-s2 and its Influence on the Model's Climate Sensitivity Bian He (IAP, Chinese Academy of Sciences)
18:00-18:10	**Closing Remarks**
18:20	**Banquet**

Abstract

AGCM with Cloud Microphysics

In-Sik Kang

School of Earth Environment Sciences, Seoul National University, Seoul, Korea

The present study demonstrates that a general circulation model (GCM) requires a full representation of cloud microphysics to simulate the extreme precipitation frequency close to the observation. GCMs with conventional convective parameterizations produce common bias in precipitation frequency: they overestimate light precipitation and underestimate heavy precipitation with respect to observed values. This frequency shift toward light precipitation is attributed here to a lack of consideration of cloud microphysical processes related to heavy precipitation. The budget study of cloud microphysical processes using a cloud-resolving model shows that the melting of graupel and accretion of cloud water by graupel and rainwaterare important processes in the generation of heavy precipitation. However, those processes are not expressed explicitly in conventional GCMs with convective parameterizations. In the present study, the cloud microphysics is modified to allow its implementation into a GCM with a horizontal resolution of 50 km. This coarse-resolution GCM with cloud microphysics requires an additional vertical mixing process in the lower troposphere. The newly developed GCM, which includes explicit cloud microphysics and additional vertical mixing, produces more heavy precipitation and less light precipitation than conventional GCMs, thus simulating a precipitation frequency that is closer to the observed.

Abstract

GFDL's Unified Weather-climate Model Developments

Shian-Jiann Lin

Geophysical Fluid Dynamics Laboratory

The NOAA/Geophysical Fluid Dynamics Laboratory has been developing a unified regional-global modeling system with variable resolution capabilities that can be used for severe weather predictions (e.g., tornado outbreak events and cat-5 hurricanes) and ultra-high-resolution (1-km) regional climate simulations within a consistent global modeling framework. The foundation of this flexible modeling system is the non-hydrostatic extension of the vertically Lagrangian dynamical core (Lin 2004, Monthly Weather Review) known in the community as FV3 (finite-volume on the cubed-sphere). Because of its flexability and computational efficiency, the FV3 is one of the final candidates of NOAA's Next Generation Global Prediction System (NGGPS). We have built into the modeling system a stretched (single) grid capability, a two-way (regional-global) nested grid capability, and the combination of the stretched and two-way nests, so as to make sub 1-km resolution regional climate simulation within a consistent global modeling system feasible using today High Performance Computing System.

One of our main scientific goals is to enable simulations of high impact weather phenomena (such as tornadoes, thunderstorms, category-5 hurricanes) within an IPCC-class climate modeling system previously regarded as impossible. In this presentation I will demonstrate that it is computationally feasible to simulate not only super-cell thunderstorms, but also the subsequent genesis of tornadoes using a global model that was originally designed for century long climate simulations. As a unified weather-climate modeling system, we evaluated the performance of the model with horizontal resolution ranging from 1 km to as low as 200 km. In particular, for down-scaling studies, we have developed various tests to ensure that the large-scale circulation within the global variable resolution modeling system is well simulated while the small-scale can also be accurately simulated with the targeted high resolution region.

Abstract

Development of TaiESM

Huang-Hsiung Hsu, Wei-Liang Lee, Chein-Jung Shiu*, Yi-Chi Wang, I-Chun Tsai, Min-Hui Lo,
Chao-An Chen, and Yung-Yao Lan

Research Center for Environmental Changes, Academia Sinica

* Corresponding author: cjshiu@gate.sinica.edu.tw

Many efforts are devoted to building a new earth system model i.e.,Taiwan Earth System Model (TaiESM) which is developed based on Community Earth System Model (CESM) from NCAR. To better simulate small-scale and short-term variability, we have implemented the deep convection, shallow convection, and planetary boundary layer schemes from NCEP Global Forecast System Model into CESM and TaiESM. In addition, a new cloud fraction scheme based on triangle probability distribution function of total water is used to replace that with assumption of critical relative humidity. Implementation of these new moist processes is able to improve simulations in the weather-scale, such as the diurnal cycle and intensity of extreme precipitation. A parameterization for the 3-D topography effect on surface solar radiation is also implemented to evaluate the shading and reflection of sunlight in mountainous areas. This effect can enhance snowmelt in the sunward side of mountains. We have integrated an ocean mixed layer model with a very high vertical resolution in CESM to simulate fast changes in sea surface temperature (SST), and it can significantly improve simulations for Madden-Julian Oscillation. Furthermore, a new three-moment aerosol parameterization is also implemented into TaiESM to have seamless coupling with a full two-moment bulk cloud in the near future. For land model, a surface irrigation scheme is also implemented into TaiESM. In the presentation, we will demonstrate some improvements corresponding to individual implementation of physical processes as well as some promising preliminary global model results of TaiESM both from short-term prescribed SST and fully coupled global simulations.

Abstract

Convective Parameterization in the High Resolution Modeling Era

Guangjun Zhang

Center for Earth System Science, Tsinghua University

&Scripps Institution of OceanographyLa Jolla, CA 92093-0221

Convective parameterization schemes were originally developed for use in general circulation models (GCMs) with spatial resolutions on the order of several hundred kilometers. Later it was also used in numerical weather prediction (NWP) models with higher resolutions. Today, GCMs typically have spatial resolutions of about 100 km and NWP models have spatial resolutions of 20 to 50 km. Yet, the same old convective parameterization schemes are used. Are fundamental assumptions that were used in convective parameterization development still valid at high resolutions? As the computing power increases dramatically in recent years, high-resolution cloud models can be run globally. Is convective parameterization coming to an end?

In this talk, recent developments in convection simulation in GCMs will be briefly reviewed, followed by the analysis of cloud model simulation for use in the development of scale-aware convective parameterization schemes. In particular, I will focus on the closure issue. Closure is an importantcomponent of convective parameterization schemes and it determines the amount of convection with the aid of large-scale variables. Different types of closures exist in current convective parameterization schemes, from convective quasi-equilibrium, CAPE removal to moisture convergence and boundary layer control. I will examine the relationship between commonly used coarse-grained closure variables and convection for a range of GCM horizontal resolutions. Cloud resolving model simulations of tropical convective systems from the ARM TWP-ICE field experiment are used to create domain averages representing different GCM horizontal resolutions. I will show that moisture convergence and large-scale CAPE generation (dCAPE)-based closures workwell. Other closures, such as CAPE and PBL turbulent kinetic energy (TKE)-based closures do not capture the variation of convection with the large-scale fields. It is found that the correlation between moisture convergence and convective precipitation is largest when moisture convergence leads convection. This correlation weakens as the subdomain size decreases to 8 km or smaller. Although convective precipitation and mass flux increase with moisture convergence or CAPE generation by GCM grid-scale circulation at a given subdomain size, as the subdomain size increases, the rate at which they increase becomes smaller. It suggests that moisture convergence and dCAPE-based closures should scale down the predicted convective precipitation as GCM resolution increases, implying that scale-awareness should be factored into convective parameterization closures as GCM resolution increases.

Abstract

A Brief Introduction to an ESM (Earth System Model) +CEM(Climate Economy Model) Model

Wenjie Dong[1,2], Jieming Chou[1,2], Shili Yang[1,2], Wenping Yuan[1,2], Zhigang Wei[1,2], Xiaodong Yan[1,2], Yan Guo[1,2], Xian Zhu[1,2], Haiqing Huang[1,2], Juan Chen[2], Xing Wei[2], Wen Shi[1,2], Zhiguo Zhang[2], Song Yang[2,3], Zhiping Wen[2,3], Guoling Feng[2,4], Yundi Jiang[2,4], Hui Ling[2,5], Ming Chen[2,5], Yuping Guan[2,6], Juan Dong[2,7], Yexing Li[2,7], Zhongkui Wu[2], and Deliang Chen[2,8]

1State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875,China;2 Zhuhai Joint Innovative Center for Climate-Environment-Ecosystem, Future Earth Research Institute, Beijing Normal University, Zhuhai 519087, China; 3 Department of Atmospheric Physics, SUN YAT-SEN UNIVERSITY, Guangzhou 510275,China;4National Climate Center, China Meteorological Administration, Beijing 100086, China;5Institute of Space and Earth Information Science, The Chinese University of Hong Kong, HKSAR, China;6South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou510301, China; 7 Zhuhai Meteorological Bureau, Zhuhai 519000, China;8Department of Earth Sciences, University of Gothenburg, Box 460, S-405 30 Gothenburg, Swede

Corresponding E-mail: dongwj@bnu.edu.cn; yangsl@mail.bnu.edu.cn

This study first reviews the concept and methods of Orderly Human Activities proposed by Prof. Y.E. Du-Zheng et al in 2003, and then its practice and Feasibility in the coupled climate economy model and earth system model in current research needs. Moreover, the advantages and limitations of the coupled earth system model and integrated assessment models in the application of global change research are discussed. Finally, the approach and the latest preliminary progress in earth system model +climate economy model and coupling system are briefly introduced. In order to build up such an earth system + human society system model, a joint effort from social economic science, natural science, and other research community, even from policy makers and end usersis required. This research could also be used to promote the development of innovative talent and teamswith multiple disciplines. Hopefully, in the near future, significant progress will be made in the coupling of these two models for successful use in the research of Orderly Human Activities.

Abstract

Revisiting the Spurious Double ITCZ Problem in Coupled Climate Models

Baoqiang Xiang

Geophysical Fluid Dynamics Laboratory

As a long standing issue, many coupled climate models suffers the spurious double Inter-tropical Convergence Zone (ITCZ) (DI) problem while the corresponding AMIP runs usually do not. This study aims to investigate the mechanisms responsible for the formation of DI by examining 20 CMIP5 models and a series of sensitivity experiments using a Geophysical Fluid Dynamics Laboratory (GFDL) model. Results demonstrate that the DI is mainly originating from the tropics (insufficient tropical meridional SST bias) while the remote forcing from extra-tropical bias is secondary. The zonal pattern of SST bias does not contribute to the global DI but is critical in modulating the precipitation pattern as well as regional DI.The tight linkage between DI and the SST bias in the region with relative high low-cloud fraction suggests that the underrepresentation of low-cloud in atmospheric model is likely the major source for tropical SST bias as well as the DI problem.
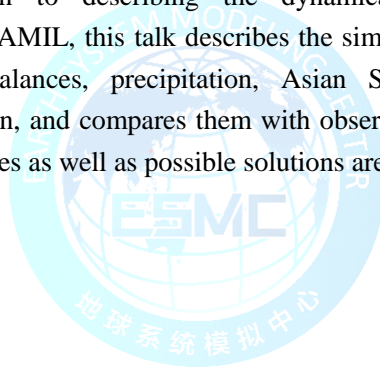
Abstract

Finite-volume Atmospheric Model of the IAP/LASG (FAMIL)

Qing Bao

Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

The Finite-volume Atmospheric Model of the IAP/LASG (FAMIL) is introduced in this work. FAMIL has the flexible horizontal and vertical resolutions up to 25km and 1Pa respectively, which currently running on the "Tianhe 1A&2" supercomputers. FAMIL is the atmospheric component of the third-generation Flexible Global Ocean–Atmosphere–Land climate System model (FGOALS3) which will participate in the Coupled Model Intercomparison Project Phase 6 (CMIP6). In addition to describing the dynamical core and physical parameterizations of FAMIL, this talk describes the simulated characteristics of energy and water balances, precipitation, Asian Summer Monsoon and stratospheric circulation, and compares them with observational/reanalysis data. Finally, the model biases as well as possible solutions are discussed.

Abstract

FIO-ESM: the Earth System Model with Surface Gravity Waves

Zhenya Song[1,2], Fangli Qiao[1,2], and Ying Bao[1,2]

1 First Institute of Oceanography, SOA, Qingdao 266061, China

2 Laboratory for Regional Oceanography and Numerical Modeling, Qingdao National Laboratory for

Marine Science and Technology, Qingdao, 266237, China

The critical role of oceanic surface waves in climate system is receiving more and more attention. We set up an Earth System Model (ESM) in 2013, which is the first climate model with surface gravity waves and named as the First Institute of Oceanography-Earth System Model (FIO-ESM), composed of a coupled physical climate model and a coupled carbon cycle model. In the coupled physical climate model, a surface wave model is introduced through coupler by including the non-breaking wave-induced vertical mixing into the ocean circulation model. Surface waves can improve the performance of climate model especially in the simulation of upper ocean mixed layer depth in the southern ocean, and in the reduction of tropical biases. The FIO-ESM version 1.0 was employed to conduct Coupled Model Intercomparison Project Phase 5 (CMIP5) experiments. Now, the new version of FIO-ESM (FIO-ESM version 2) is under development. Its framework is similar to FIO-ESM version 1, but the model components, physical processes and resolution will be much improved. It will be employed to take part in CMIP6.

Abstract

Prospects for Prediction of Sub-seasonal to Seasonal Climate

James L. Kinter III

Center for Ocean-Land-Atmosphere Studies, George Mason University, Fairfax, Virginia, USA

Substantial progress has been made over the past several decades in numerical weather prediction (NWP), due to advances in atmospheric observing systems, atmospheric models, high-end computing, and data assimilation methods. Climate simulations have likewise benefited from advances in computing and Earth system observations (such as moored buoys and drifting profiling floats in the global ocean), as well as increasingly realistic representations of the interactions between the atmosphere, ocean and land surface in coupled climate models. Advances in climate prediction have also been driven by our improving understanding of the sources of seasonal to annual predictability, including El Niño and the Southern Oscillation (ENSO), soil moisture anomalies in transition regions and seasons, and the secular temperature trend associated with global climate change. The net result has been that model-based prediction systems can now provide credible predictions of the global climate up to one year in advance.

Between the time scales of NWP and seasonal climate predictions, there is a gap at the subseasonal to seasonal (S2S) time scale. This gap has been identified as a high priority for both the research and operational prediction communities. Hoskins (2013) has noted that there is predictive potential at all time scales, including S2S, because of processes such as (i) persistent blocking states, (ii) interactions between the tropics and extratropics expressed, for example, in the dispersion of Rossby waves in response to tropical tropospheric heating, (iii) persistent ocean anomalies in both the tropics and extratropics, and (iv) persistent soil moisture anomalies that alter surface fluxes and atmospheric boundary layer stability. Considerable research on the Madden-Julian Oscillation (MJO) has demonstrated S2S predictability beyond NWP time scales. There is also evidence that predictive information can be obtained from the state of the North Atlantic Oscillation (NAO), and the influence of the stratosphere.

There are very few operational forecast products at this time scale, and the problem of subseasonal prediction in particular has only recently garnered attention. The demand for S2S predictions arises from a diverse set of information requirements in agriculture, transportation, energy resource management, and other sectors. The presentation will summarize recent advances in prediction of sub-seasonal to seasonal climate variations and indicate areas for research that are needed to reach a state of maturity for forecasting at these time scales.

Abstract

Overview of Global Monsoons Modeling Inter-comparison Project (GMMIP)

Tianjun Zhou

Institute of Atmospheric Physics, Chinese Academy of Sciences, China (zhoutj@lasg.iap.ac.cn)

Monsoons occur in various regions around the world. Prediction of the monsoon rainfall change in the coming decades is of deep societal concern and vital for infrastructural planning, water resource management, and sustainable economic development. Climate models are useful tools in climate variability and climate change studies. However, the performance of the current state-of-the-art climate models is very poor and needs to be greatly improved over the monsoon domains. The Global Monsoons Modelling Inter-comparison Project (hereafter **GMMIP**) aims to improve our understanding of physical processes in global monsoon systems and to better simulate the mean state, interannual variability and long-term change of global monsoons by performing multi-model inter-comparisons. The contributions of internal variability (IPO-Interdecadal Pacific Oscillation, AMO-Atlantic Multidecadal Oscillation) and external anthropogenic forcing to the historical evolution of global monsoons in the 20th and 21st century will be addressed. This talk will present an overview of GMMIP project and show some preliminary results of GMMIP Tier-1 and Tier-2 Experiments.

Abstract

**Arctic Sea Ice Simulation and Projection:
How Credible Are the State-Of-The-Art Climate Models?**

Xiangdong Zhang

International Arctic Research Center and Department of Atmospheric Sciences, University of Alaska

Fairbanks, Fairbanks, AK 99775, USA

Rapid changes have occurred in the Arctic climate system, representatively evidenced by the decade-long acceleration of sea ice reduction and the extreme sea ice loss in the summers of 2007 and 2012. However, the phase 3 and 5 of Coupled Model Intercomparison Project (CMIP3 and CMIP5) climate models continually exhibit substantially large uncertainties in simulating and projecting Arctic climate change and variability. To better understand the uncertainties and enhance credibility of climate change projections, we evaluate performance of sea ice simulations in these models against observations, and identify sources of model discrepancies and uncertainties. To this end, we introduced and employed a transient climate sensitivity analysis approach. The result suggests that the model uncertainties result from the large range of sensitivities involved in the simulation of sea ice mass balance. Perturbations in model initialization can also cause different feedback strength in the ensemble runs. Finally, the results demonstrate that the transient climate sensitivity approach can help constrain diversity of model results, and obviously reduce spread of Arctic sea ice and surface air temperature predictions and projections from decadal to century time scales.

Abstract

Transient Response of an Atmospheric GCM to External Forcings

Zhaoxin Laurent Li (laurent.li@lmd.jussieu.fr)

Laboratoire de meteorology dynamique (LMD),

IPSL/CNRS, University Pierre and Marie Curie,

Paris, France

Atmospheric responses to an external forcing may manifest at different time scales, from an almost immediate response to a delay of a few tens of days. The immediate response is generally direct and linear, but the delayed response is often indirect and resulted from complex non-linear processes in the atmosphere. An experimental protocol is proposed to assess these different responses within an atmospheric general circulation model. It consists of running the model in a transient manner and examining the temporal evolution of the response. However due to the chaotic behavior of the atmospheric flow, the noise quickly surpasses the signal. It thus needs an ensemble approach. Two examples will be shown to study how atmospheric circulation evolves with time as responses to SST anomalies in the north Atlantic and the Mediterranean Sea, respectively. Both sectors experience typical mid-latitude transient circulations. In both cases, a baroclinic response is quickly formed over the anomalous-SST area. A few days later, equivalent barotropic structures can be observed all through the globe. These results are helpful to understand physical mechanisms of atmospheric teleconnections and the multi-scale characteristics of ocean-atmosphere interaction. The experimental protocol can also be applied to tropical SST anomalies and perturbations in land surface properties.

Abstract

Using Satellite Data to Represent Ocean Biology-induced Negative Feedbackon ENSO in a Hybrid Coupled Model of the Tropical Pacific

Rong-Hua Zhang

Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology,

Chinese Academy of Sciences, Qingdao, 266071

Biological conditions in the tropical Pacific Ocean (e.g., phytoplankton biomass) are strongly regulated by physical changes associated with the El Niño-Southern Oscillation (ENSO). The existence and variation of phytoplankton biomass, in turn, act to modulate the vertical penetration of the incoming sunlight in the upper ocean, presenting an ocean biology-induced heating (OBH) effect on the climate system. Previously, a penetration depth of solar radiation in the upper ocean (H_p) is defined to describe the related bio-climate connections. Parameterized in terms of its relationship with the sea surface temperature (SST) in the tropical Pacific, an empirical model for interannual H_p variability has been derived from remotely sensed ocean color data, which is incorporated into a hybrid coupled model (HCM) to represent OBH effects. In this work, various HCM experiments are performed to demonstrate the bio-feedback onto ENSO, including a climatological H_p run (in which H_p is prescribed as seasonally varying only), interannual H_p runs (with different intensities of interannually varying OBH effects), and a run in which the sign of the OBH effect is artificially reversed. Significant modulating impacts on interannual variability are found in the HCM, characterized by a negative feedback between ocean biology and the climate system in the tropical Pacific: the stronger the OBH feedback, the weaker the interannual variability. Processes involved in the feedback are analyzed; it is illustrated that the SST is modulated indirectly by ocean dynamical processes induced by OBH. The significance and implication of the OBH effects are discussed for their roles in ENSO variability and model biases in the tropical Pacific.

Abstract

Future Projection of the Extreme Rainfall Frequency of Taiwan Mei-Yu Downscaled from the CMIP3 and CMIP5 Models

Mong-Ming Lu* and Yin-Ming Cho

Central Weather Bureau, Taipei, Taiwan

*Email: lu@rdc.cwb.gov.tw

The large-scale circulation condition favorable to the extreme Taiwan Mei-yu rainfall event was identified using 64 years of daily precipitation data at 10 meteorological stations and the 850-hPa winds of the NCEP/NCAR reanalysis data set during the period of 1951-2014. An extreme event is identified when the daily rainfall total is larger than a threshold value determined on the station basis. The result shows that the circulation pattern of a cyclonic flow over southern part of China and Taiwan and an anticyclonic flow over the South China Sea and the Philippine Sea, that induces strong westerly winds at the area with strong vorticity gradient, is favorable to the occurrence of the extreme event. A southwesterly flow index (SWFI) was defined to describe the circulation and strong southwesterly wind condition. The SWFI can capture the above and below normal variations with above 60% hit rate for the prediction period. The SWFI is proved as a useful downscaling approach by applying it to six CMIP3 and ten CMIP5 models to project how Taiwan extreme Mei-yu rainfall frequency changes under different global warming scenarios. The same downscaling approach can also be used in the S2S prediction of the frequency of extreme rainfall events in Taiwan Mei-yu season.

Abstract

Arctic Sea Ice in CMIP5 Climate Model Projections and Their Seasonality Variabilities

FeiHuang, HongWangand Xiao Zhou

Physical Oceanography Laboratory and Key Laboratory of Ocean-Atmospheric Interaction and Climate in
Universities of Shandong, Ocean University of China, Qingdao 266100, China

This paper focus on the seasonality change of Arctic sea ice extent (SIE) from 1979 to 2100 using newly available simulations from the Coupled Model Intercomparison Project Phase 5(CMIP5). A new approach to compare the simulation metric of Arctic SIE between observation and 31 CMIP5 models was established. The approach is based onfour factors including the climatological average, linear trend of SIE, span of melting season and annual range of SIE. It is more objective and can be popularized to other comparison of models. Six best models (GFDL-CM3, CESM1-BGC, MPI-ESM-LR, ACCESS-1.0, HadGEM2-CC and HadGEM2-AO in turn)were found which meet the criterion closely based on above approach. Based on ensamble mean of the six models, we found that the Arctic sea ice will continue declining in each season and firstly drop below 1 million km^2 (defined as the ice-free state) on September in 2065 under RCP4.5 scenario and on September in 2053 under RCP8.5 scenario.We also focused on the annual cycle of the Arctic SIE and found out the duration of Arctic summer (melting season) will increase by about 100 days under RCP4.5 scenario and about 200 days under RCP8.5 scenario relative to current circumstance by the end of the 21st century. Annual range of SIE (seasonal melting ice extent) will increase almost linearly in the near future 30-40 years before the Arctic appears ice-free ocean, indicating the more ice melting in summer, the more ice freezing in winter, which may cause more extreme weather events in both winter and summer in the future years. The Arctic sea ice spatial patterns of annual and semi-annual cycle modes from history to future under different scenarios were also compared.

Keywords: Arctic; Arctic sea ice; CMIP5; seasonality; annual cycle
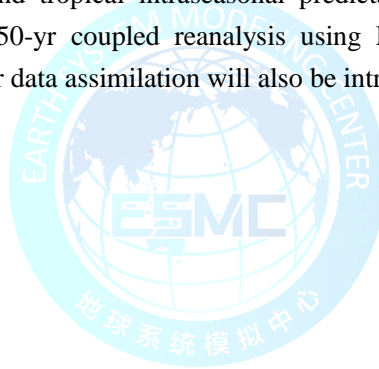
Abstract

Climate Modeling in Japan

Masahide Kimoto

Atmosphere and Ocean Research Institute,

The University of Tokyo

An overview of recent activities on climate modeling in Japan will be given together with some science results with models such as a coupled atmosphere-ocean model, MIROC, its earth system model version, MIROC-ESM, and a global cloud-system resolving model, NICAM. Following topics will be covered: multi-year prediction by MIROC, carbon cycle modeling with MIROC-ESM, and tropical intraseasonal predictability by NICAM. An initial attempt at a 150-yr coupled reanalysis using MIROC and a coupled ensemble Kalman filter data assimilation will also be introduced.

Abstract

Deconstructing Recent Regional Climate Change: Is CO2 a Sufficient Driver?

Hans von Storch

Institute of Coastal Reseach/HZG, Hamburg University and Ocean University of China

Regional and global climate conditions undergo permanent variations; in the past this was due to the ubiquitous natural variability of the high-dimensional, multiply chaotic weather system; additionally slow natural factors had an imprint. To this complex mix of drivers causing the climate system to exhibit variations of the weather statistics (i.e., its climate), humans are now adding factors which act on time scales of decades – namely foremost greenhouse gas emissions, but also contributions to more, or less, aerosol loads and changing surface conditions. For responding properly to these changing conditions it is useful if one would know if ongoing changes will prevail for a long time and will possibly even become stronger, or if they will persist for a limited time (such as an ENSO event or the impact of volcanoes). For sorting this out, a methodology has been developed, named "detection and attribution", which allows to first identify changes beyond the range of natural variations, and then determine which mix of causes is most plausible in dynamically explain the changes. Here, simulations with climate models play a key role, namely in estimating the level of natural variations, and in suggesting the space/time patterns, which are supposedly characteristic for which driver.

In the past the methodology has been mostly used on the global and on continental scales. We have now used the methodology for examining ongoing climate change in sub-continental parts of Europe (Baltic Sea Basin and Mediterranean Region). We found changes beyond the range of natural variations, so that external drivers are needed for explanation. While greenhouse gases turned out to provide plausible explanations in some seasons, in others they were insufficient, and additional other drivers are needed. Such drivers could be the reduction of aerosols in the regional atmosphere.

Abstract

The New Normal in Land Surface Modeling

Dr. Zong-Liang Yang (liang@jsg.utexas.edu),Professor and Jackson Chair

Director, Center for Integrated Earth System Science, Jackson School of Geosciences

University of Texas at Austin, Austin, Texas USA 78712-0254

The rapid development of land surface models (LSMs) over the past three decades has reached a point that these LSMs can adequately represent the surface energy, water, and carbon balances spanning a wide range of space and time scales, as judged by comparison with a wealth of surface and remote sensing datasets. LSMs have been used in various weather forecasting and climate change studies, such as assessing the coupling strength between the land surface and the atmosphere, understanding climate and carbon interaction and feedbacks, and quantifying the impacts of land use and land cover change on climate change. Recently, LSMs are being merged with other types of models including surface hydrology (river flows with implications for flooding and drought, soil chemistry, nutrient transport, and freshwater inflow to coastal zones), groundwater (aquifers, irrigation, and human withdrawals), ecology (vegetation growth and health, crop yield, wetlands, and riverine ecosystems), air quality (biogenic emissions, dust emissions, aerosols, urban canopy layer, and dry/wet deposition), and urban flood early warning. New data assimilation methods are being explored to take advantage of remote sensing products, surface flux network measurements, and aircraft datasets to improve LSMs' predictive skills. Multi-physics (or multi-parameterization) frameworks have been incorporated in LSMs to allow for multi-hypothesis testing and uncertainty quantification. Hyperresolution modeling at scales of O(100 m) is being proposed to take advantage of the emerging petascale computational resources. Therefore, next-generation LSMs are becoming more complex as we are facing unprecedented challenges to understand variability and change on all time and space scales, and to quantify the climatic impacts on energy and water resources, agriculture, ecosystems, and environmental conditions for decision-making. As a result, the new development of these LSMs demands much more coordinated and integrated efforts from multi-disciplinary groups.

Abstract

Importance of Bitwise Identical Reproducibility in Earth System Modeling and Status Report

L. Liu[1,2], S. Peng[1], C. Zhang[3], R. Li[3], B. Wang[1,2,4], C. Sun[1], Q. Liu[1], L. Dong[4], L. Li[4], Y. Shi[1], Y. He[1], W. Zhao[1], and G. Yang[3,1,2]

[1]Ministry of Education Key Laboratory for Earth system modeling, Center for Earth System Science (CESS), Tsinghua University, Beijing, China.

[2]Joint Center for Global Change Studies (JCGCS), Beijing, 100875

[3]Department of Computer Science and Technology, Tsinghua University, Beijing, China.

[4]State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China.

Correspondence to: L. Liu (liuli-cess@tsinghua.edu.cn), B. Wang (wab@tsinghua.edu.cn), G. Yang (ygw@tsinghua.edu.cn)

Reproducibility is a fundamental principle of scientific research. Bitwise identical reproducibility, i.e., bitwise computational results can be reproduced, guarantees the reproduction of exactly the same results. Here we show the importance of bitwiseidentical reproducibility to Earth system modeling but the importance has not yet been widely recognized. Modeled mean climate states, variability and trends at different scales may be significantly changed or even lead to opposing results due to a slight change in the original simulation setting during a reproduction. Out of the large body of Earth system modeling publications, few thoroughly describe the whole original simulation setting. As a result, the reproduction of a particular simulation experiment by fellow scientists heavily depends on the interaction withthe original authors, which is often inconvenient or even impossible. We anticipate bitwise identical reproducibility to be promoted as a worldwide standard, to guarantee the independent reproduction of simulation results and to further improve model development and scientific research.

Abstract

Development of the Online Aerosol Module in GCM

Tie Dai[1], Xiaofei Wu[1], Qing Bao[1], Daisuke Goto[2],Guangyu Shi[1], Teruyuki Nakajima[2]

1State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid

Dynamics, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

2National Institute for Environmental Studies, Tsukuba, Japan

3Earth Observation Research Center, Japan Aerospace Exploration Agency, Tsukuba, Japan

There are still large uncertainties to simulate the aerosol composition and its associated optical properties with aerosol module coupled with GCM. The aerosol optical properties simulated by a flexible high resolution global to regional climate model (NICAM-Chem) are evaluated using the space-based and ground-based observations. For each aerosol species, the mean AOT is within the range of the AeroCom models. For the 3-year mean AODs and AEs for all sites show the correlations between model and AERONET of 0.753 and 0.735, respectively, and 82.1% of the modeled AODs agree within a factor of two with the retrieved AODs. The primary model deficiency is an underestimation of fine mode aerosol AOD and a corresponding underestimation of AE over pollution region. The effects of cloud on aerosol model evaluation are also considered with the MODIS cloud observations. The differences between clear-sky and all-sky AODs are larger over polluted regions. The aerosol processes over East Asia including emission, transport, and deposition are compared between multiple aerosol models, and the general similarities and differences are found. The similar aerosol module are coupling with the LASGGCM model, our preliminary results indicate the natural aerosol component emissions are estimated well including the seasonal variations. After the comparisons, the aerosol assimilation system for the NICAM-Chem is further developed to improve the model performances. Assimilation leads to significantly positive effect on the simulated AOD field, improving agreement with all of the 12 AERONET sites over the Eastern Asia based on both the correlation coefficient and the root mean square difference (assimilation efficiency). Meanwhile, better agreement of the Ångström Exponent (AE) field is achieved for 8 of the 12 sites due to the assimilation of AOD only.

Abstract

Using the Framework of Fast Response and Slow Feedback to Understand Climate Change

Long Cao

School of Earth Sciences, Zhejiang University, Hangzhou, China

A key issue in projection of future climate change is to understand the response of climate system to external forcings, such as changes in greenhouse gas and aerosol concentrations. Traditionally, climate response to a change in external forcing is analyzed in terms of equilibrium response of the climate system or climate evolution on different timescales ranging from years to centuries. Over the past decade, the framework of fast response and slow feedback has emerged as a useful paradigm for understanding climate change. Fast response refers to rapid climate adjustment to a change in external forcing that occurs before substantial change in global mean surface temperature, and slow feedback refers to climate response that is associated with the change in surface temperature.

In this study I will show some examples that utilize the conceptual response-feedback framework to understand climate change in response to external forcings. First, the different characteristics of climate response to CO_2 forcing and solar forcing are investigated using the framework of fast response and slow feedback; Second, model-simulated climate response to solar geoengineering is analyzed in the context of the response-feedback framework; Third, utility and limitation of the linear response-feedback paradigm in representing total climate change is discussed. It is shown that the response-feedback framework provides new insight into the understanding of the behavior the climate system.

Key words: climate change, fast response, slow feedback, climate modeling

Abstract

Chemical-dynamical-radiative Feedbacks in the Stratosphere in Chemistry-climate Models

Wenshou Tian

College of Atmospheric Sciences, Lanzhou University, China

Developing chemistry-climate models to understand chemical-dynamical-radiative feedbacks in the atmosphere is a hot topic in recent years. Some previous modeling and observational studies have showed that the chemical-dynamical-radiative feedbacks in the atmosphere play an important role in climate system. Our chemistry-climate simulations reveal that the stratospheric ozone, nitrous oxide, methane and water changes can cause significant temperature and circulation changes both in the stratosphere and troposphere, while the effects of those tracer gas changes on the climate are largely modulated by CO_2, SST changes and solar variations. The stratospheric ozone, which has undergone a declining trend since 1980s and then an expected recovery in the future, is particularly important in various chemical-dynamical-radiative feedbacks in the atmosphere and may lead to potential climate changes in the future. These results also imply that a better understanding of climate changes requires fully interactive chemistry-climate models in which the stratospheric processes, particularly, chemical processes should be properly coupled, otherwise, the effects of human activities on the earth's climate could be misevaluated.

Abstract

Schwarz-Christoffel Conformal Mapping Based Grid Generation for Ocean General Circulation Models

Shiming Xu

Tsinghua University

We propose two new grid generation algorithms for ocean general circulation models (OGCMs). Contrary to conventional, analytical forms based dipolar or tripolar grids, these new methods are based on Schwarz-Christoffel conformal mappings which map regions of user-specified irregular boundaries to regularly shaped regions (i.e., disks, slits, etc.). The conventional grid design objectives such as pole relocation are addressed, as well as more advanced issues, including: (1) the enlargement of latitudinal-longitudinal portion of the grid, and (2) the new perspectives arisen from high-resolution and multi-scale modeling. The generated grids could potentially achieve the alignment of grid lines to coastlines, enhanced spatial resolution in coastal regions, and easier computational load balance. Due to that the grids are orthogonal curvilinear, they can be easily utilized by the majority of OGCMs which assume grid orthogonality. The proposed grid generation algorithms can also be applied to regional ocean modeling when complex land-sea distribution is present.

Abstract

Simulation on the Melt Pond of Arctic

Jie Su[1], Chuanyin Wang[1], Hongjie Liang[1], and Matti Leppäranta[2]

1 Ocean University of China, Qingdao, China

2 Helsinky University, Helsinky, Finish

During melt season, melt pond is significant phenomena on the sea ice surface. The accuracy of melt pond fraction simulation is important to understand the heat budget of the atmosphere-ice-ocean system. Melt water sources from melting snow, ice and liquid precipitation. In CICE 5.0+ model, three melt pond parameterization schemes have different processes on the melt pond's generation, melt water distribution and frozen. In numerical simulation based on CICE model, the simulation results of 'topo' scheme, when use the freezing conditions as that of 'cesm' scheme, have tendency of more matching MODIS retrieval results data than the other two schemes in the aspect of the inter-annual variability of spatial averaged melt pond fractions of Arctic, melt ponds coverage extent, the length of maximum melt season and its amplitude of interannual variation. Snow infiltration effect is introduced in 'topo' scheme in our study which leads to a more reasonable spatial evolution of melt pond. But in the current simulation, the melt pond coverage extent as well as the melt pond fraction snow infiltration is too small on the multiyear ice. The loss of melt water volume is also analyzed in our study.

Abstract

Extreme Precipitation and Tropical Cyclones in a Warming Climate Simulated by CAM

Julio Bacmeister

National Center for Atmospheric Research

Projections for future tropical cyclone activity are made with the Community Atmosphere model at 28km horizontal resolution. Future SSTs are constructed from coupled runs using a bias correction technique based on present day coupled model biases. Results for RCP4.5 and RCP8.5 warming scenarios are compared. The impact of different future SSTs is also explored. We find substantial decreases in overall N Atlantic TC activity, but increases in the frequency of major storms in the NW Pacific. While these results are relatively robust in terms of general character we find important sensitivities to the future SSTs used. Changes in TC related precipitation are also examined. We find large increases in extreme precipitation frequency for all future SSTs. Mitigation to RCP4.5 is seen to significantly reduce the risk of extreme TC precipitation.

Abstract

Applications of Climate System Models: Target Observations for High-impact Ocean-Atmospheric Environmental Events

Mu Mu[1], Wansuo Duan[2] and Rong Feng[2]

[1]Institute of Oceanology, Chinese Academy of Sciences, Qingdao266071

[2]LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

High-impact ocean-atmospheric environmental events, such as El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), tropical cyclone (TC), and the Kuroshio large meander (KLM), etc. are defined asthe oceanic, weather or climate events that often induce aggressively large economic and societal loss on regional or global scales. Sufficient observations are required to properly determine the initial fields for skillful predictions of these events. A strategy called "target observation" has been developed since 1990s. In this presentation, we will review some progresses of the authors' group in target observation of ENSO and IOD.

First, to investigate the sensitive area for ENSO forecasting, we applied the conditional nonlinear optimal perturbation (CNOP), by using the Zebiak-Cane model, to determine the most sensitive patterns for El Niño forecasting. Furthermore, it is shown that these sensitive patterns of initial errors also exist in the initial analysis fields of the ENSO hindcasts generated by FGOALS-g and LDEO5 models. The largest values of CNOP-type errors are found in the eastern equatorial Pacific, indicating that the initial errors in this region make the largest contribution to the errors at the prediction time and therefore can be considered a sensitive area for El Niño forecasting.

Then, we present the results for IOD, by using Geophysical Fluid Dynamics Laboratory Climate Model version 2p1 (GFDL CM2p1). It is found that the initial errors with an east-west dipole pattern are more likely to result in a significant winter predictability barrier (WPB) than special distributed random initial errors; the areas where the large values of the dipole pattern initial errors are located have great effect on the prediction uncertainties and provide useful information for targeting. Further, the prediction uncertainties in winter are more sensitive to the initial errors in the subsurface sensitive areas than to those in the surface ones.

Abstract

What Controls the Divergent Projection ofENSO Amplitude Change under Global Warming?

Tim Li, Lin Chen andYongqiang Yu*

University of Hawaii and NUIST

*Institute of Atmospheric Physics, Chinese Academy of Sciences

An important issue facing the climate community is how ENSO amplitude will change under global warming. Diagnosis of 20 CMIP5 models shows that these models projected a divergent future ENSO amplitude change under global warming (GW). Some models projected a statistically significant increase in ENSO amplitude, whereas others projected a statistically significant decrease. The spread among the CMIP5 models is in a way similar to that in the CMIP3 models. Given that the same set of the CMIP5 models projected a consistent mean state change (e.g., a greater polar warming than a tropical warming and an El Nino like wamring in the equatorial Pacific), one may wonder why the ENSO projection is so divergent, and what are key factors that control the ENSO amplitude change across these CMIP5 models?

In this study we develop a step-by-step approach to address the above questions. Given that ENSO development undergoes various positive and negative feedback processes, the first question we address is what feedback process is most critical for the divergent ENSO amplitude change.Our results show that the Bjerknes thermocline and zonal advective feedbacks are the major drivers for the divergent projection of ENSO amplitude change.

The second question is, given that both the Bjerknes and zonal advective feedbacks involve the mean state and perturbation changes, what are their relative roles?Our diagnosis shows that the perturbation change is critical. Thirdly, given that the Bjerknes feedback involves the following three processes, atmospheric wind response to SSTA forcing, ocean thermocline response to wind forcing, and ocean subsurface temperature response to thermocline change, which of the above processes is critical? Our diagnosis shows that the ocean thermocline response to the wind forcing plays the most important role. Fourthly, given the same Niño4wind stress forcing, why somemodels generate a stronger thermocline response while others generate a weaker response? The answer is that it is attributed to the divergent change of ENSO meridional structure, which is further controlled by the change of climatologic subtropical cell (STC) in the Pacific. Finally a strategy is developed to project future ENSO amplitude change based on both the robust mean state projection and the physics-based ENSO amplitude - mean STC relationship.

Abstract

The Most Disturbing Tendency Error of Zebiak-Cane Model Associated with El Nino Predictions and its Implications

WansuoDuan and Peng Zhao

(Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China)

The nonlinear forcing singular vector (NFSV) is used to identify the most disturbing tendency error of the Zebiak-Cane model associated with El Nino predictions. The results show that only one NFSV exists for each of the predictions for the given El Niño events. These NFSVs cause the largest prediction error for the El Nino event. It is found that the NFSVs often present large-scale zonal dipolar structures and are dependent on the prediction periods. The NFSVs associated with the predictions crossing through the growth phase of El Niño tend to exhibit a zonal dipolar pattern with positive anomalies in the equatorial central-western Pacific and negative anomalies in the equatorial eastern Pacific (denoted as "NFSV1"). Meanwhile, those associated with the predictions through the decaying phase of El Niño are inclined to present another zonal dipolar pattern (denoted as "NFSV2"), which is almost opposite to the NFSV1. Similarly, the linear forcing singular vectors (FSVs), which are computed based on tangent linear model, can also be classified into two types "FSV1" and "FSV2". We find that both FSV1 and NFSV1 often cause negative prediction errors for Niño-3 SSTA of the El Niño events, while the FSV2 and NFSV2 usually yield positive prediction errors. However, due to the effect of nonlinearities, the NFSVs usually have the western pole of the zonal dipolar pattern much farther west, and covering much broader region. The nonlinearities have a suppression effect on the growth of the prediction errors caused by the FSVs and the particular structure of the NFSVs tends to reduce such suppression effect of nonlinearities, finally making the NFSV-type tendency error yield much large prediction error for Niño-3 SSTA of El Niño events. The NFSVs, compared to the FSVs, are more applicable in describing the most disturbing tendency error of the Zebiak–Cane model since they consider the effect of nonlinearities. The NFSV-type tendency errors may provide information concerning the sensitive areas where the model errors are much more likely to yield large prediction errors for El Niño events.

Abstract

Land Surface Model Calibration through Microwave Data Assimilation for Improving Soil Moisture Simulations

Kun Yang (yangk@itpcas.ac.cn)

Institute of Tibetan Plateau Research, Chinese Academy of Sciences

CAS Center for Excellence in Tibetan Plateau Earth Sciences

Soil moisture is a key variable in climate system, and its accurate simulation needs effective soil parameter values. Conventional approaches may obtain soil parameter values at point scale, but they are costly and not efficient at grid scale (~10 km) of current climate models. This study explores the possibility to estimate soil parameter values by assimilating microwave brightness temperature (TB) data. In the assimilation system, the TB is simulated by the coupled system of a land surface model (LSM) and a radiative transfer model (RTM), and the simulation errors highly depend on parameters in both the LSM and the RTM. Thus, sensitive soil parameters may be inversely estimated through minimizing the TB errors. The effectiveness of the estimated parameter values is evaluated against intensive measurements of soil parameters and soil moisture in three grasslands of the Tibetan Plateau and the Mongolian Plateau. The results indicate that LSM simulations with the estimated parameter values reasonably reproduce the measured soil moisture. This demonstrates it is feasible to calibrate LSMs for soil moisture simulations at grid scale by assimilating microwave satellite data, although more efforts are expected to improve the robustness of the model calibration.

Abstract

Paleoclimate: ESM Used in Understanding Geological Questions

Zhongshi Zhang

Department of atmospheric science, China University of Geosciences, 430074 Wuhan, China

Uni Research Climate and Bjerknes Centre for Climate Research, 5007 Bergen, Norway

Nansen-Zhu International Research Centre, IAP, Chinese Academy of Sciences, 100029 Beijing, China

Paleoclimate studies are often carried out on three different time scales, sub-orbital, orbital and tectonic time scales. On the sub-orbital scale, climate changes for hundreds or thousands of years are considered. On the orbital time, climate changes for tens or hundreds of thousand years are considered. On the tectonic time scales, climate changes for million years are considered. Therefore, on the longer time scales, the crossing between climate science and geological science becomes more obvious.

How modern climate comes into being? This is a basic scientific question on the tectonic time scales. In this talk, based on the modelling with an ESM, I will use one simple example to show how desert climate comes into being in north Africa.

It is widely believed that the Sahara desert is no more than ~2–3 million years (Myr) old, with geological evidence showing a remarkable aridification of north Africa at the onset of the Quaternary ice ages. Before that time, north African aridity was mainly controlled by the African summer monsoon (ASM), which oscillated with Earth's orbital precession cycles. Afterwards, the Northern Hemisphere glaciation added an ice volume forcing on the ASM, which additionally oscillated with glacial–interglacial cycles. These findings led to the idea that the Sahara desert came into existence when the Northern Hemisphere glaciated ~2–3 Myr ago. The later discovery, however, of aeolian dune deposits ~7 Myr old suggested a much older age, although this interpretation is hotly challenged and there is no clear mechanism for aridification around this time. Here we use climate model simulations to identify the Tortonian stage (~7–11 Myr ago) of the Late Miocene epoch as the pivotal period for triggering north African aridity and creating the Sahara desert. Through a set of experiments with the Norwegian Earth System Model and the Community Atmosphere Model, we demonstrate that the African summer monsoon was drastically weakened by the Tethys Sea shrinkage during the Tortonian, allowing arid, desert conditions to expand across north Africa. Not only did the Tethys shrinkage alter the mean climate of the region, it also enhanced the sensitivity of the African monsoon to orbital forcing, which subsequently became the major driver of Sahara extent fluctuations. These important climatic changes probably caused the shifts in Asian and African flora and fauna observed during the same period, with possible links to the emergence of early hominins in north Africa.

Abstract

China's Air Pollution: New Perspectives on Global Sources and Transport

Jintai Lin

Peking University

China has become the world's top emitter of anthropogenic aerosol and gaseous pollution. The severity of China's pollution not only has caused dramatic domestic environmental problems, but has also raised concerns of long-range pollution transport to downwind regions. China is also the world's top trading country, and it manufactures and exports large amounts of industrial products to supply foreign consumption. This means significant implicit pollution transport from foreign countries to China through international trade. China's domestic pollution is further complicated by inter-provincial trade that supplies both Chinese and foreign consumption. In this study, we will analyze China's pollution sources and transport by combining satellite measurements, chemical transport modeling, emission calculation, and economic analysis. We will demonstrate that China's pollution is connected to other countries via both atmospheric and economic mechanisms. Solving global pollution problems needs interdisciplinary and comprehensive thinking.

Abstract

Unrealistic Treatment of Detrained Water Substance in FGOALS-s2 and its Influence on the Model's Climate Sensitivity

Bian He

State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics,

Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

Key Laboratory of Meteorological Disaster of Ministry of Education, Nanjing University of Information

Science and Technology, Nanjing 210044

Based on a series of aqua-planet and air-sea coupled experiments, the influence of unrealistic treatment of water substance in FGOALS-s2 on the model's climate sensitivityis investigated in this paper. Because the model do not adopt an explicit microphysics scheme, the detrained water substance from the convection scheme has been converted back to the humidity. This procedure could lead to an additional increase of water vapor in the atmosphere which could strengthen the model's climate sensitivity. Further sensitive experiments confirm this deduction. After removing the water vapor which converted from the detrained water substance, the water vapor reduced significantly in the upper troposphere and the high clouds also reduced. Quantitative calculations show that the water vapor almost reduced 10% of the total water vapor and 50% at 150hPa when the detrained water substance is removed, contribute to the 30% of the Atmospheric Surface Temperature (AST) increasing. This study calls for an explicitmicrophysics scheme should be introduced to the model in order to handle the detrained water vapor to improve the model's simulation skill.

Keywords: FGOALS-s2, climate sensitivity, cloud radiation, global warming

Abstract

Uncertainty in Model Climate Sensitivity Traced to Representations of Cumulus Precipitation Microphysics

Ming Zhao

Geophysical Fluid Dynamics Laboratory

Uncertainty in equilibrium climate sensitivity impedes accurate future climate projections. While the spread across climate models is known to arise primarily from model differences in cloud feedback, the exact processes responsible for the spread across models remain unclear. Here we show that model estimates of climate sensitivity are strongly affected by the manner through which cumulus cloud condensate is converted into precipitation in a model's convection parameterization, processes that are only crudely accounted for in GCMs. Using a developmental version of the next generation Geophysical Fluid Dynamics Laboratory GCM, we demonstrate that two commonly used methods for converting cumulus condensate into precipitation (threshold versus fractional removal and associated treatment in mixed- and ice-phased cloud precipitation) can lead to drastically different climate sensitivity, as estimated here with an atmosphere/land model by increasing sea surface temperatures uniformly and examining the response in the top-of-atmosphere energy balance. The effect can be quantified through a bulk convective detrainment efficiency, which measures the ability of cumulus convection to generate clouds and moisten the free troposphere per unit precipitation. Given current uncertainties in representing convective precipitation microphysics, this study suggests that one can engineer climate sensitivity in a GCM without impacting the quality of the simulation of the climate appreciably. In the absence of clear observational constraints on these processes, the implications of having this ability to engineer climate sensitivity needs to be considered when estimating the uncertainty in climate projections.

Abstract

Influence of Latent Heating over Southern Asia on Sahel Summer Rainfall

Shan He, Song Yang, and Zhenning Li

Department of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, Guangdong, China

The summer rainfall in the Sahel region shows an apparent decreasing trend since the 1950s. This decreasing rainfall trend is related to variations of global summer sea surface temperature (SST) including an increase of SST in the Asian monsoon region (AMR). Analysis also indicates that the anomalous rising motion over AMR and anomalous sinking motion over the Sahel region are associated with the decrease in the African rainfall since the 1970s.

The U.S. NCAR Community Atmospheric Model version 4 is applied to investigate the influence of latent heating anomaly associated with the Asian summer monsoon on the Sahel summer rainfall. When the condensation latent heating rate of deep convection over AMR in summer is increased to 1.1 folds, the response of the model to the heating anomaly matches the general features of circulation anomalies that have been observed. The model features of anomalous rainfall in the Sahel region are also similar to those observed. Hence, it is concluded that the teleconnection between the increase in summer SST over AMR and the decrease in summer rainfall in the Sahel region is resulted from the positive condensation latent heating anomaly of deep convection over AMR under the global warming background.

Abstract

Scheme Development of Convection and Cloud Processes of TaiESM

Yi-Chi Wang*, Chein-Jung Shiu, Hua-Lu Pan, Jen-Ping Chen and Huang-Hsiung Hsu

Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan

*Correspondence to: yichiwang@gate.sinica.edu.tw

As convection and cloud processes continue to be major challenges for earth system models, our group in the Research Center for Environmental Changes, Academia Sinica, has especially devoted to the development of the model physics of convection and clouds for the Taiwan Earth System Model (TaiESM).

The major developments of convection and cloud processes of TaiESM include (1) improvement of convective triggering of the deep convection scheme, (2) development of PDF-consistent macrophysics scheme, and (3) implementation of a full two-moment microphysics scheme.

Currently, the first two developments will be included in the first version of TaiESM, while the development of microphysics scheme would be included in the later version of TaiESM. The cloud microphysical scheme used is based on CLR (Chen and Liu, 2004; Cheng et al., 2007, 2010). This scheme is capable of simulating aerosol-cloud interactions through detailed coupling between cloud and aerosol microphysical processes. This work describes the developments of convection and cloud processes of TaiESM and their impacts on climate simulations in contrast to the Community Earth System Model developed by NCAR, which is the base model of TaiESM.

Simulations driven by climatological sea surface temperature with TaiESM show the observed diurnal to synoptic scales of rainfall variability are better reproduced over the coastal and land regions due to improved convective triggering. In the meantime, with the modified cloud scheme, the TaiESM-simulated cloud fields show better consistency with humidity, and associated biases of shortwave and longwave cloud radiative forcing are reduced in the tropics.

Abstract

Changes and Influences of Latent Heating Released by Deep Convection over the South China Sea and the Philippine Sea during Boreal Spring under the Background of Global Warming

Zhenning Li and Song Yang

Department of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, Guangdong, China

Long-term trends of several climate variables during boreal spring in the last 3 decades are investigated. For precipitation, both Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) and Global Precipitation Climatology Project (GPCP) datasets show significant increasing trends over the South China Sea (SCS) and the Philippine Sea (PS, 0^0-15^0N, 110^0E-155^0E) during boreal spring. In the NCEP Climate Forecast System Reanalysis (CFSR) datasets, the significant increasing trend of latent heating released from deep convections is also found over this region. The latent heating has intensified in the whole column of the atmosphere, especially among 600-300hPa level. The maximum heating level has been lifted about 50hPa/30yr in the last 30 years during spring. Meanwhile, significant decreasing trend of spring-time rainfall is found over southern China.

In order to figure out the influences of latent heating changes over the SCS and the PS, and to capture the possible linkage between the spring-time rainfall over this region and southern China, a series of fully-coupled earth system model experiments are conducted using the NCAR Community Earth System Model (CESM). Results indicate that the spring-time latent heating over the SCS and the PS have a strong link to the rainfall over southern China. Specifically, the climate system response over southern China to the latent heating changes over the SCS and the PS is very similar with the observed long-term trend, corresponding to significantly less precipitation in southern China and much more precipitation over the SCS and the PS. The increased latent heating causes an anomalous cyclone over the SCS and the PS, resulting in in-situ convergence and intensified deep convection. Northwestern part of the anomalous cyclone weakens the seasonal mean southwesterly over southern China, which causes less moisture transported to southern China and suppresses the spring-time rainfall.

Convenience Information

- **Transportation**

(a) Nanjing Lukou International Airport:

1. Metro:

Nanjing Lukou International Airport—>Line S1 or Shuttle Bus Line 2—>Nanjing South Station —>Line 3—>Taifenglu —>Line S8—>NUIST—>NUSIT Hotel

Nanjing Lukou International Airport—>Line S1 or Shuttle Bus Line 2—>Nanjing South Station —>Line 3—>Taifenglu —>Line S8—>Dachang—>Jinling New Town Hotel

2. Taxi:

It takes about one hour from the airport to the two hotels by taxi and may cost about $40-$50 (300 YUAN).

Convenience Information

- **Transportation**

  (b) Nanjing South Station:

  1. Metro:

  Nanjing South Station—>Line 3—>Taifenglu—>Line S8—>NUIST—>NUSIT Hotel

  Nanjing South Station—>Line 3—>Taifenglu —>Line S8—>Dachang—>Jinling New Town Hotel

  2. Taxi:

  It takes about 40 min from the railway station to the two hotels by taxi and may cost about $25 (150 YUAN).

- **Hotel Information**

  (a) NUIST hotel (Nanqi Hotel):

  No.219, Ningliu Road, Pukou District, Nanjing

  500m from the Conference Hall of NUIST

  (b) Jinling New Town Hotel:

  No. 488, Yuanxi Road, Dachang, Liuhe District, Nanjing

  6km from the Conference Hall of NUIST; shuttle bus will be provided.

- **Weather**

  Average minimum temperature 13 ℃, average maximum temperature 22 ℃, and monthly average rainfall 54 mm.

- **Currency**

  The currency in Nanjing is the Chinese Yuan. Foreign currency and traveler's checks can be exchanged into Chinese Yuan at foreign exchange banks or Jinling New Town Hotel. Exchange rates are subject to market fluctuations, but as of date, 1 USD = 6.2 Yuan approximately.

- **Local Organizing Committee**

  Dr. Weiyu Pan: +86-25-58695723/13913831176, apan@nuist.edu.cn

  Ms. Ying Han: 15996371050, ying.han@nuist.edu.cn