Annual Report 2009

Nansen-Zhu International Research Centre
Beijing, China

Report from the Advisory Board

Vision

The overarching goal of the Nansen-Zhu International Research Center (*NZC*) is to become an internationally acknowledged climate research and training centre with emphasis on tropical and high-latitude regions, and the interactions between these regions, for past, present and future climate.

Organization

The Nansen-Zhu Centre is a non-profit joint venture located at the Institute of Atmospheric Physics under the Chinese Academy of Sciences (IAP/CAS) in Beijing, China.

NZC has five founders: IAP/CAS; the Nansen Environmental and Remote Sensing Center (NERSC), Bergen, Norway; the University of Bergen (UoB), Bergen, Norway; the Bjerknes Centre for Climate Research (BCCR), Bergen, Norway; and the Peking University (PKU), Beijing, China. A revised agreement was signed on November 4th 2008 in the witness of Norwegian Minister of Research and Higher Education, HE Tora Aasland, and the Vice President of Chinese Academy of Sciences, Prof. Zhongli Ding, where also the Nanjing University, Nanjing, China, was included as a new partner represented by Prof. Xiuqun Yang.

Background

Representatives from the Chinese and Norwegian authorities formally opened the Nansen-Zhu Centre on 4 November 2003. The center is based on an Agreement of Understanding between IAP/CAS, NERSC and UoB of 7 August 2001, and a Memorandum of understanding between IAP/CAS, NERSC, UoB and PKU of 5 November 2002.

NZC is set up based on the desire to run an attractive and focussed cutting edge climate research network bridging scientists from China, Norway and abroad.

Particularly, NZC aims to:

- Exchange scientists and graduate students between the founding partners
- Initiate and develop joint research projects between the founding partners
- Co-ordinate and facilitate joint research proposals to be submitted to national and international funding bodies

Founding Partners

- Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), Beijing, China
- Nansen Environmental and Remote Sensing Center (NERSC), Bergen, Norway
- University of Bergen (UoB), Bergen, Norway
- Peking University (PKU), Beijing, China
- Bjerknes Centre for Climate Research (BCCR), Bergen, Norway
- Nanjing University (NJU), Nanjing, China

Leader Team

- Director Professor Huijun Wang, IAP/CAS
- Co-Deputy Director Professor Zifa Wang, IAP/CAS
- Co-Deputy Director Professor Yongqi Gao, NERSC/IAP
- Research school leader, Professor Tore Furevik, UoB

The Advisory Board

- Professor Ola M. Johannessen, Director NERSC, Co-chairman
- Professor Huijun Wang, Director IAP/CAS, Co-chairman
- Professor Peter M. Haugan, Director Geophisical Institute/UoB
- Professor Benkui Tan, Dep. Director, PKU
- Professor Eystein Jansen, Director BCCR
- Professor Xiuqun Yang, Director of School of Atmospheric Sciences, NJU

NZC

http://nzc.iap.ac.cn

- Stimulate and support joint publications in international peer-reviewed journals
- Develop co-operation in education and research programs

Research Areas

NZC's strategy is to integrate field observations, remote sensing products, theory and numerical modelling to develop cutting-edge research within eight prioritised topics:

- Reconstruction of past climate and climate variability based on low- and high-latitude paleo-environmental reconstructions from tree rings, marine and lake sediments, mountain glaciers, ice cores and by use of modelling (*Co-heads: Eystein Jansen, UNIFOB Klima AS and Huijuan Wang, NZC/IAP)*.
- Study the natural and anthropogenic variability of selected glaciers at high and low latitudes and their potential interrelationships, including the study of the Greenland ice sheet and mountain glaciers and their contributions to the past, present and future sea-level changes (*Co-heads: Atle Nesje, UoB/UNIFOB, Meixue Yang, Chinese Academy of Sciences)*.
- Development and evaluation of seasonal, inter-annual and decadal time scale climate predictability systems, and identification of low- and high-latitude teleconnection patterns and mechanisms (*Co-heads: Tore Furevik, UoB/UNIFOB and Shuanglin Li, NZC)*.
- Model and assess long-term climate and air quality effects of regional to global scale atmospheric events like aerosol variability, dust storms and pollution emissions (*Co-heads: Igor Esau, NERSC and Zifa Wang, NZC)*.
- Assess sources and sinks of carbon dioxide on seasonal to interdecadal time scales based on integrated use of observations and modelling (*Co-heads: Christoph Heinze, UoB/UNIFOB and Yongfu Xu from IAP)*.
- Model and analyze the ocean circulation by means of advanced data assimilation methods (*-heads: Laurent Bertino, NERSC and Jiang Zhu from IAP)*.
- Development of satellite-based, multidisciplinary, spatially- and temporally-harmonized and stable long time series of Essential Climate Variables for environmental and climate change monitoring and research (*Co-heads: Johnny A. Johannessen, NERSC/UoB and Pucai Wang from IAP)*.
- Collaboration on module development, validation and applications of Earth system models (*-heads: Mats Bentsen, NERSC and Yongqi Gao from NZC)*.

Staff

At the end of 2009, NZC has a total staff of 93 persons. The staffs consist of 16 full-time members with 15 research scientists and 1 administration staff, 7 part-time research scientist, 16 associated research scientists, 1 joint member and 2 post doc, 25 PhD students and 26 master students.

Publications

In 2009, the NZC staff published 45 papers in international referee journals. Of these papers, 29 were published in Scientific Citation Index (SCI) journals, 2 in SCI-Extended journals and 14 in other journals.

Doctoral Dissertations

Six PhD-students defended their theses at IAP/CAS during November 2008 to October 2009:

- Wenyuan Chang: An Investigation of the Impacts between Air Pollution and Climate Change by CATUS Model (Dec. 9, 2008)
- Xu Yue: Simulation of dust global transport and its direct radiative effect (Dec. 13, 2008)
- Yali Zhu: Study on the influences of mid-high latitude major atmospheric modes on Asian-Australian monsoon system (Dec. 13, 2008)
- Ying Zhang: Study on the possible impacts of global warming on background fields related to tropical cyclone activities over western North Pacific (May 22, 2009).
- Jianjian Fu: Impact of Global SST on the interdecadal variability of East Asian Summer monsoon and interannual variability of East Asian Winter monsoon. (June 8, 2009)
- Yanming Wang: Response of Asian monsoonal climate to the Atlantic Multidecadal Oscillation(AMO)-observations and multi-model simulations (June 8, 2009).

Awards

NZC staff has received 4 awards in 2009:

- Dabang Jiang: Scientific Innovation Award by the IAP/CAS.
- Xu Yue： "Xue Du Feng Zheng" Excellent Dissertation
- Yanming Wang： "Xue Du Feng Zheng" Excellent Dissertation.
- Jianqi Sun, Second class of the Xie-Yi-Bing Award for Young Scientists

Bilateral Visits

NZC has close collaboration and frequent project-dependent exchange with students and researchers from NERSC, BCCR and UoB.

Chinese visits to Norway;

Dong Guo, Dec.5, 2008-Feb.28. 2009

Jiping Xie, Apr.1-Jun. 1, Jul.15-Sep.15, 2009

Lei Yu, Oct.5-Dec.29, 2009

Linling Chen, Sep.9, 2008-present

Yanchun He, Nov. 20-Feb.13, Aug.4-Oct.31, 2009

Norwegian visits to China Oct.12-17, 2009;

Ola M. Johannessen, Bente Johannessen, Eystein Jansen, Tore Furevik, Atle Nesje, Nils Gunnar Kvamstoe, Birgit Falch, Odd Helge Otteraa and Juergen Balder.

Joint Project

One bilateral climate research project "Exploring Decadal to Century Scale Variability and Changes in the East Asian Climate during the last Millennium (DecCen)" has been approved by Norwegian Research Council in 2009 with Chinese partners and other institutions involved. The kick-off meeting of DecCen was held at NZC during October 12-14.

Economy

NZC receives funding partly from the Chinese and Norwegian partners, including the Nansen Scientific Society in Bergen, Norway, and partly from national and international funding agencies. NZC received 6010 kRMB (596 kEURO) in 2009.

Prospects for 2010

The Board expects more research activities with focus on "Water and energy cycle in East Asia under global warming" and "Decadal scale Climate variability in East Asia" in 2010. This is partly due to the received top research program supported by the Ministry of Science and Technology (MOST) in China and partly due to the stable support from Norwegian partners and more funding possibilities from the National Sciences Foundation of China (NSFC), the Research Council of Norway (RCN), the Ministry of Science and Technology (MOST), the Chinese Academy of Sciences (CAS), and the Nansen Scientific Society in Bergen, Norway.

Beijing, 15 October. 2009

Huijun Wang (Co-chairman)

Ola M. Johannessen (Co-chairman)

Peter Haugan — Benkui Tan

Eystein Jansen — Xiuqun Yang

Staff Members

By the end of 2009, the different staff categories are:

Full-time (16 persons)

Huijun Wang (Dir.)

Zifa Wang (Co-Dep. Dir.)

Shuanglin Li

Dabang Jiang

Ke Fan

Xiquan Wang

Lixia Ju

Jianqi Sun

Fuying Xie

Aihui Wang

Lei Yu

Jie Li

Yali Zhu

Ying Zhang

Jianjian Fu

Huili Huang (admin.)

Jointly (1)

Yongqi Gao (Co-dep. Dir.)

Part-time (7)

Botao Zhou; Hui Gao; Jingzhi Su; Jinping Han; Wenyue Chang; Xianmei Lang; Xu Yue;

Affiliated (16)

Eystein Jansen, Gan Luo; Haijun Yang; Helge Drange; Jiang Zhu; Mats Bentsen; Meixue Yang; Odd Helge Otterå; Ola M. Johannessen; Pucai Wang; Tianjun Zhou; Tore Furevik; Weiwei Fu; Xiuqun Yang; Yongfu Xu; Zhongshi Zhang

Post Doc (2)

Gbaguidi Alex Enagnon; Ning Shi

PhD Students (25)

Baozhu Ge; Dong Guo; Donglin Guo; Entao Yu; Fengyun Wang; Huopo Chen; Jianbin Wu; Jiangping Huang; Jun Wang; Limin Cai; Linling Chen; Meijing Lin; Qizhong Wu; Rashed Mahmood; Shuzhou Wang; Tao Wang; Ting Yang; Wei Wang; Weiling Xiang; Xiao Tang; Xiaole Pan; Yanchun He; Ping zhong Yan; Ying Liu; Yuhong Guo

Master Students (26)

Dong Chen; Fei Li; Feifei Luo; Fen Dong; Hang Su; Huansheng Chen; Jianghua Wan; Jie Bian; Jiehua Ma; Jinfeng Yao; Jingjing Xu; Minghong Zhang; Na Liu; Peishu Zong; Qing Yan; Shan Liu; Shengping He; Xiaoting Chen; Xuedong Cui; Xueshun Chen; Ya Gao; Yanyan Huang; Yufei Zou; Zhe Wang; Zhiping Tian, Zhuolei Qian

SCIENTIFIC HIGHLIGHTS

1 CLIMATE RESEARCH

Variability of Northeast China River Break-up Date (Wang and Sun, 2009)

This paper investigates the variability of the break-up dates of the rivers in Northeast China from their icebound states for the period of 1957–2005 and explores some potential explanatory mechanisms. Results show that the break-up of the two major rivers (the Heilongjiang River and Songhuajiang River) was about four days earlier (Fig.1), and their freeze-up was about 4–7 days delayed, during 1989–2005 as compared to 1971–1987. This interdecadal variation is evidently associated with the warming trend over the past 50 years. In addition, the break-up and freeze-up dates have large interannual variability, with a standard deviation of about 10–15 days. The break-up date is primarily determined by the January–February–March mean surface air temperature over the Siberian-Northeast China region, via changes in the melting rate, ice thickness, and snow cover over the ice cover. The interannual variability of the break-up date is also significantly connected with the Northern Annular Mode (NAM), with a correlation coefficient of 0.35–0.55 based on the data from four stations along the two rivers. This relationship is attributed to the fact that the NAM can modulate the East Asian winter monsoon circulation and Siberian-Northeast China surface air temperature in January–February–March.

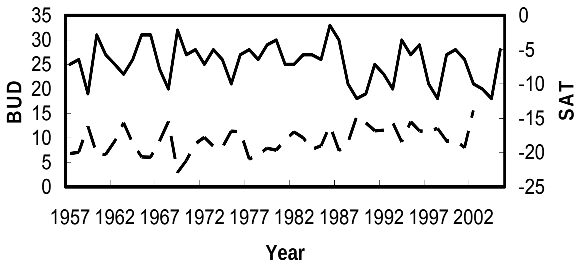

Fig.1 Time series for the break-up date (days after 31 March) of Qike during 1957–2005 (solid line) and the mean JFM SAT (◦C) averaged for the region 47.25◦–52.25◦N, 125.25◦–130.25◦E during 1957–2002 (dashed line).

A New Scheme for Improving the Seasonal Prediction of Summer Precipitation Anomalies (Wang and Fan, 2009)

A new scheme is developed to improve the seasonal prediction of summer precipitation in the East Asian and western Pacific region. The scheme is applied to the Development of a European Multimodel Ensemble System for Seasonal to Interannual Prediction (DEMETER) results. The new scheme is designed to consider both model predictions and observed spatial patterns of historical ''analog years.'' In this paper, the anomaly pattern correlation coefficient (ACC) between the prediction and the observation, as well as the root-mean square error, is used to measure the prediction skill. For the prediction of summer precipitation in East Asia and the western Pacific (08–40°N, 80°–130°E), the prediction skill for the six models ensemble hindcasts for the years of 1979–2001 was increased to 0.22 by using the new scheme from 0.12 for the original scheme (Fig.2). All models were initiated in May and were composed of nine member predictions, and all showed improvement when applying the new scheme. The skill levels (ACC) of the predictions for the six models increased from 0.08, 0.08, 0.01, 0.14, 20.07, and 0.07 for the original scheme to 0.11, 0.14, 0.10, 0.22, 0.04, and 0.13, respectively, for the new scheme.

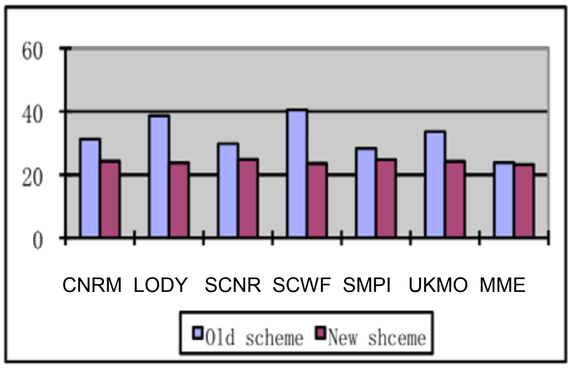

Fig.2. Spatial mean RMSEs for the six individual models and the MME prediction, expressed as the percentile of the multiyear precipitation climatology for East Asia (08–408N, 808–1308E).

How the "Best" Models Project the Future Precipitation Change in China (Chen and Sun, 2009)

Projected changes in summer precipitation characteristics in China during the 21st century are assessed using the monthly precipitation outputs of the ensemble of three "best" models under the Special Report on Emissions Scenarios (SRES) A1B, A2, and B1 scenarios. The excellent reproducibility of the models both in spatial and temporal patterns for the precipitation in China makes the projected summer precipitation change more believable for the future 100 years. All the three scenarios experiments indicate a consistent enhancement of summer precipitation in China in the 21st century. However, the projected summer precipitation in China demonstrates large variability among the sub-regions (Fig. 3). The projected increase in precipitation in South China is significant and persistent, as well as in North China. Meanwhile, in the early period of the 21st century, the region of Northeast China is projected to be much drier than the present. But, this situation changes and the precipitation intensifies later, with a precipitation anomaly increase of 12.4%–20.4% at the end of the 21st century. The region of the Xinjiang Province probably undergoes a drying trend in the future 100 years, and is projected to decrease by 1.7%–3.6% at the end of the 21st century. There is no significant long-term change of the projected summer precipitation in the lower reaches of the Yangtze River valley (figure not shown). A high level of agreement of the ensemble of the regional precipitation change in some parts of China is found across scenarios but smaller changes are projected for the B1 scenario and slightly larger changes for the A2 scenario.

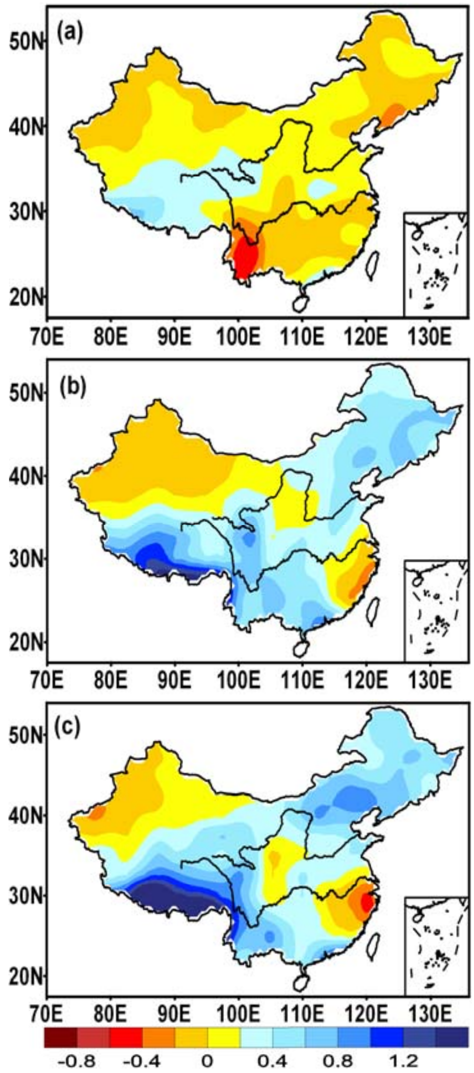

Fig.3 Spatial distribution of the difference of the mean climate state of the summer precipitation in the IPCC scenario A1B for the time period: (a) 2010-2029, (b) 2040-2059, and (c) 2080-2099 with the reference period from 1980-1999. Units: mm d^{-1}.

A New Approach to Forecasting Typhoon Frequency over the Western North Pacific (Fan and Wang, 2009)

This paper presents a new approach for forecasting the typhoon frequency of the western North Pacific (WNP). The year-to-year increase or decrease in typhoon frequency is first forecasted to yield a net typhoon frequency prediction. Five key predictors for the year-to-year increment in the number of typhoons in the WNP have been identified, and a forecast model is established using a multi-linear regression method based on data taken from 1965-2001. Using the forecast model, we made a hindcast of the typhoon frequency of the WNP during 2002-2007. The model exhibited a reasonably close fit for the period of 1965-2007, including the larger anomalies in 1997 and 1998. It also accounted for the smaller variability of the typhoon frequency of the WNP during the validation period 2002-2007, with an average root mean square error of 1.3 (2.85) during 2002-2007(1965-2001). The cross-validation test of the prediction model shows that the new approach and the prediction model (M-DY_{31})has better prediction skill, as compared to the models established based on the typhoon frequency itself rather than typhoon frequency increment (M-Y_{31}) (Fig.4), with SS of 0.17, correlation coefficient, RMSE, MAE of 0.76 (58% of variance), 2.4, 2 for M-DY_{31y}, respectively, of 0.64 (41% of variance), 2.9, 3.8 for M-Y_{31y}. Thus, this new approach has the potential to improve the operational forecasting skill for typhoon frequency in the western North Pacific.

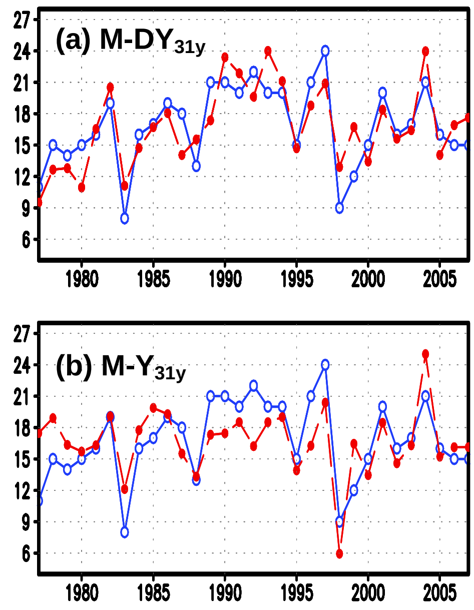

Fig.4 The time series of predicted WNPTF (dashed) using the cross-validation and observed (solid) WNPTF during 1977-2007.(a) M-DY_{31y}; (b) M-Y_{31y}

Asymmetric Response of Asian Monsoonal Climate to Opposite AMO Phases (Wang et al., 2009)

With experiments with the NCEP atmospheric general circulation model, the Asian monsoonal climate response to a warming or cooling of the North Atlantic SST anomalies are investigated. The results suggest that the positive-phase AMO induces intensified Indian rainfall, but the impact on Indian rainfall is insignificant when the AMO is in negative phase (Fig.5). Asymmetric response in surface air temperature is also found (Fig.6).

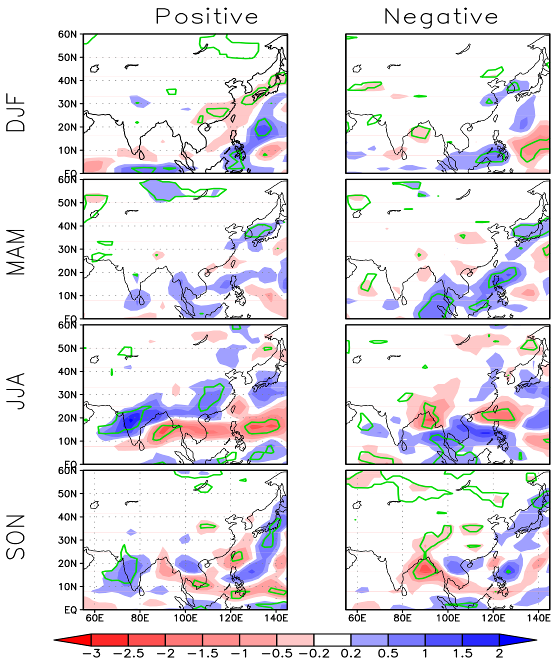

Fig.5 Modelled precipitation responses to two opposite AMO phases in four seasons. Left panels are for the positive phase, while the right panels are for the cold phase. Unit: mm/day.

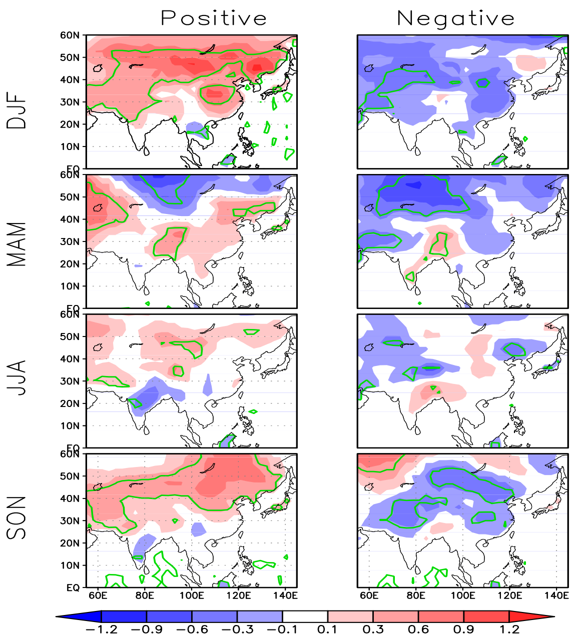

Fig. 6, as Fig. 5, but for surface air temperature. Unit: °C

Somali Jet Changes under the Global Warming (Lin et al., 2009)

The Somali Jet Index under the climate change of Scenario A2 (SRESA2) for the period 2005-2099 in JJA (June-July-August) is calculated. The results show that 18 IPCC-AR4 models have performed better in describing the climatological features of Somali Jet in the present climate simulations. Analysis of Somali Jet intensity changes from the multi-model ensemble results for the period 2005-2099 shows a weakened Somali Jet in the early 21st century (2010-2040), the strongest Somali Jet in the middle 21st century (2050-2060) as well as the weakest Somali Jet at the end of the 21st century (2070-2090). Compared with the period 1976-1999, the intensity of Somali Jet is weakening in general, and it becomes the weakest in the end of the 21st century. Considering the important role of Somali Jet in the Indian monsoon and East Asian monsoon and climate of China, the variability of Somali Jet and its evolvement under the present climate or future climate changes need to be further clarified (Fig.7).

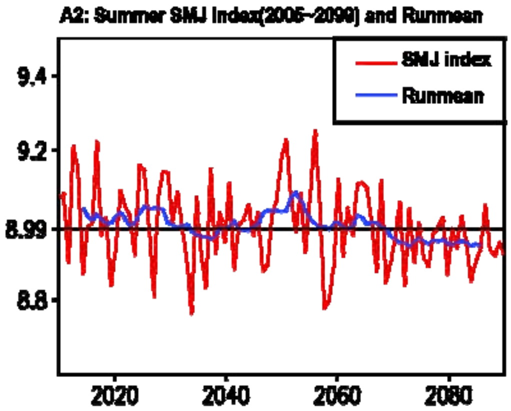

Fig.7 18-model ensemble time series of the Somali Jet index (unit : m s^{-1}) under the climate change of Scenario A2 (SRESA2) for the period 2005-2099 with a 11 year running mean. The thick solid line represents the average value for the period 2005-2099

Contribution of the Sea Surface Temperature over the Mediterranean-Black Sea to the Decadal Shift of the Summer North Atlantic Oscillation (Sun and Yuan, 2009)

Recent observational study has shown that the southern center of the summer North Atlantic Oscillation (SNAO) was located farther eastward after the late 1970s as compared to before. In this study, the cause for this phenomenon is explored. The result shows that the eastward shift of the SNAO southern center after the late 1970s is related to the variability of the Mediterranean-Black Sea (MBS) SST, as shown in Fig.8. A warm MBS SST can heat and moisten its overlying atmosphere, consequently producing a negative sea level pressure (SLP) departure over the MBS region. Because the MBS SST is negatively correlated with the SNAO, the negative SLP departure can enhance the eastern part of the negative-phase of the SNAO southern center, consequently producing an eastward SNAO southern center shift. Similarly, a cold MBS SST produces an eastward positive-phase SNAO southern center shift.

The reason for why the MBS SST has an impact on the SNAO after the late 1970s but why it is not the case beforehand is also discussed. It is found that this instable relationship is likely to be attributed to the change of the variability of the MBS SST on the decadal time-scale. In 1951–1975, the variability of the MBS SST is quite weak, but in 1978–2002, it becomes more active. The active SST can enhance the interaction between the sea and its overlying atmosphere, thus strengthening the connection between the MBS SST and the SNAO after the late 1970s. The above observational analysis results are further confirmed by sensitivity experiments.

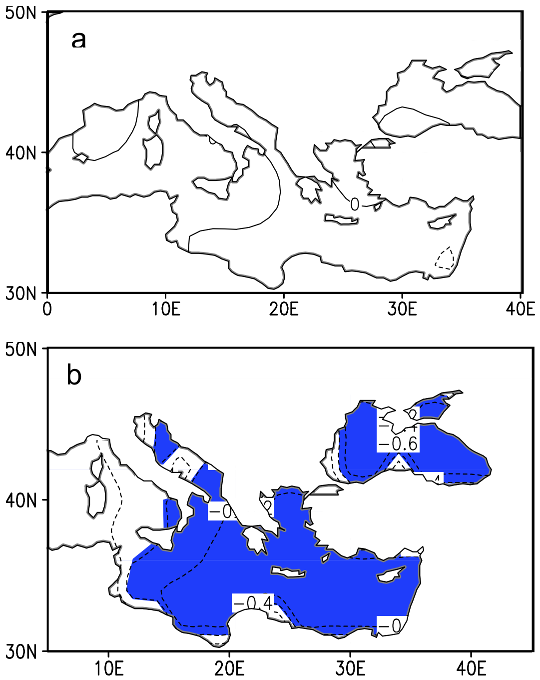

Fig.8 Geographical distributions of the correlation coefficients between the SNAO and MBS SST over the periods of (a) 1951–1975 and (b) 1978–2002. Blue shading shows areas where the SST correlates negatively with the SNAO index at the 0.05 significance level.

Simulation of Dust Aerosol Radiative Feedback using the Global Transport Model: Dust Cycle and Validation (Yue et al., 2009)

We have developed a Global Transport Model of Dust (GMOD) within a general circulation model, using comprehensive parameterizations of the emission and deposition processes from Wang et al. (2000). These parameterizations are modified to match the surface conditions and meteorological fields of the climate model. A 20-year simulation from the dust model predicts an average dust emission of 1935 ± 51 Tg yr^{-1} and a global dust burden of 27.8 ± 0.8 Tg for particles whose radii are smaller than 10 μm (Table 1). Comparisons with observations show that the GMOD reproduces reasonably well dust concentrations, total deposition, and aerosol optical thickness. The simulated dust particle size distribution is consistent with observations; both have a volume median radius in the range 1.0–4.0 μm. We examine the temporal variation of dust transport on different timescales. The simulated interannual variability is small, but the seasonal variation is quite large in the Sahara Desert and central Asia. We pay special attention to the diurnal variation of dust; both observations and simulations show that dust mobilization is more active during the local daytime than night-time (Fig.9). Such variation is attributed to the diurnal alteration of surface meteorological fields, such as relative humidity and wind friction velocity.

Table 1. Global dust budget.

Radius (μm)	Effective R (μm)	Uplift ($Tg\ a^{-1}$)	Dry ($Tg\ a^{-1}$)	Wet ($Tg\ a^{-1}$)	Burden (Tg)	Lifetime (days)
0.1–1.0	0.39	97	1	95	5.5	20.9
1.0–2.0	1.44	213	24	189	8.4	14.5
2.0–5.0	3.27	600	313	287	10.8	6.6
5.0–10.0	7.21	1025	967	58	3.0	1.1
0.1–10.0	2.15	1935	1305	629	27.8	5.2

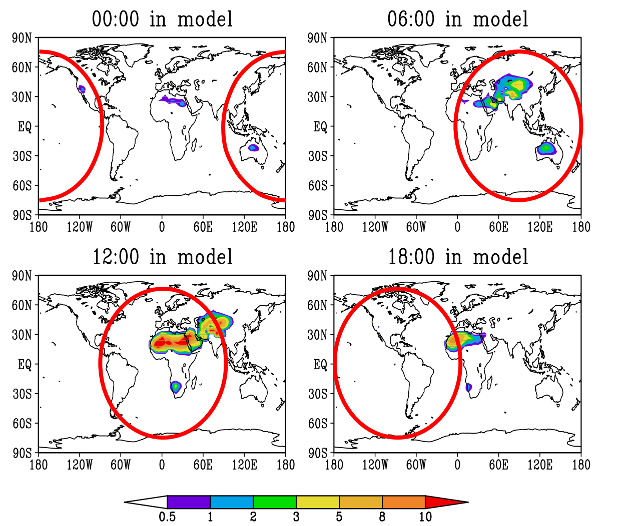

Fig.9 Dust uplift at 00:00, 06:00, 12:00, 18:00 model hours. Units: μg m^{-2} s^{-1}. The red circle represents the domain of insolation in the GCM.

Improving Treatment of the Vertical Snow Burial Fraction over Short Vegetation in the NCAR CLM3 (Wang and Zeng, 2009)

Through extensive investigation, we found one deficiency of the NCAR Community Land Model (CLM3) is the disappearance of simulated snow even in the middle of winter over a boreal grassland site due to unrealistically modeled high downward turbulentfluxes. The problem is caused by the inappropriate treatment of the vertical snow burial fraction for short vegetation. In CLM3, snow burial fraction is defined as a linear function of time invariant parameters (i.e., vegetation top and bottom height). Our model studies over the boreal forest and grassland found that the treatment of snow in the model was suitable for trees, but it produced unrealistic rapid snow depletion in midwinter over the grassland site. To solve this model deficiency, we proposed a new snow burial fraction formulation for short vegetation and then evaluated it using *in situ* observations. This modification in the CLM3 largely removes the unrealistic surface turbulent fluxes, leading to a more reasonable snowmelt process, and improves the snow water equivalent (SWE) simulation over boreal grassland in winter.

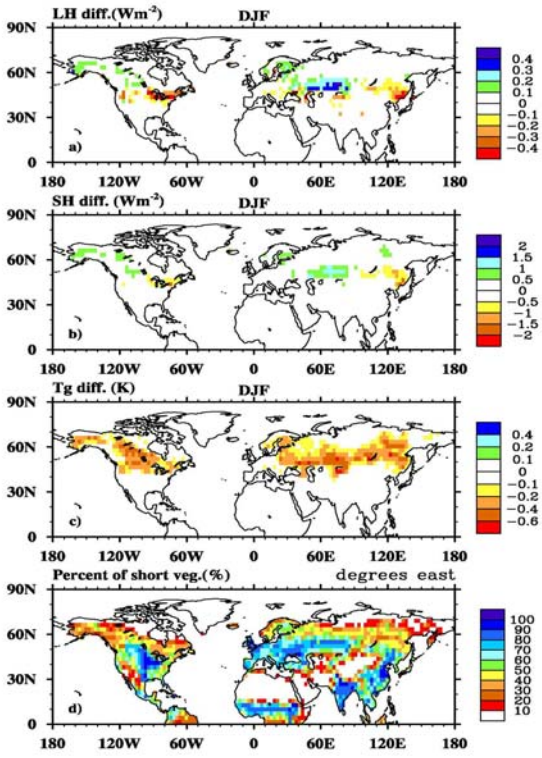

Fig.10 Ten-year (1995-2004) averaged DJF differences between global offline simulations using CLM3 with new formulation versus the standard CLM3. a) latent heat (LH) difference, b) sensible heat (SH) difference, c) ground temperature (Tg), and (d) percentage of short vegetation (grass and crop) coverage over the Northern Hemisphere.

Moreover, global offline simulations show that the proposed formulation decreases sensible and latent heat fluxes as well as the ground temperature during the snowmelt season over short vegetation dominant regions (Fig.10). Correspondingly, the SWE is enhanced, leading to the increase in snowmelt-induced runoff during the same period. Furthermore, sensitivity tests indicate that these improvements are insensitive to the exact functional form or parameter values in the proposed formulation.

2. Environmental Research

The Integrated Forecasting System in Gulf of Aden

The integrated forecasting system in Gulf of Aden has been developed in 2009. The system can be used to forecast weather situation and meteorological conditions in future three days, and also can put out sea currents (Fig.11) and wave height in Gulf of Aden. That system provided a strong support for convoy of Chinese navy in the Gulf of Aden.

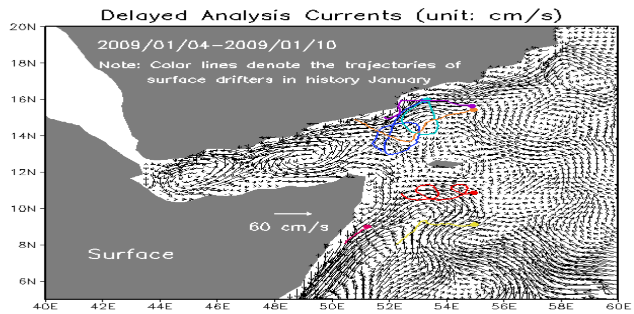

Fig.11 Sea currents forecast

Development of an Urban Dense-gas Transport and Dispersion Model for Emergency Response

There is much research underway on flow and dispersion in urban areas, spurred by environmental issues and by the need to estimate the effects of consequences of the accidental releases of chemical hazardous materials.

In response to the need for emergency response, a Urban dense-gas transport and dispersion model for emergency response is developed. The model is based on concepts originally for air entrainment into and gravity spread of a heavy gas cloud, further development of this model is accounting for the specification of the turbulence and wind profile in the urban canopy.

The performance characteristics of this model are used for comparisons with the Salt Lake City

Urban 2000 data set. The Predictions of the model are shown to agree with the observations from the Urban 2000 experimental trials within a factor of about two. These performance measures satisfy previously established acceptance criteria for dense-than-air vapour cloud dispersion models.

LIST OF PUBLICATIONS IN 2009

SCI INDEXED (29)

Chen H. P., and **J. Q. Sun** (2009): How the "Best" Models Project the Future Precipitation Change in China. *Adv. Atmos. Sci.*, 26(4), 773-782.

Fan K, **M. J. Lin**, Y. Z.Gao (2009): Forecasting the summer rainfall in North China using the year-to-year increment approach. *Sci. China. Ser. D-Earth Sci.*, 52 (4), 532-539.

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