Statistical Downscaling Based on Dynamical Models: Application to Seasonal Temperature/Precipitation in China

CHEN Lijuan

Beijing Climate Center, CMA

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Outline

- Motivation: why downscaling
- Downscaling Methods and Data
- Step 1: Predictability of temperature/ precipitation in winter
- Step 2: Downscaling Skill of temperature/precipitation by using hindcast/predict result of CGCM/BCC
- Discussion and Summary

Why downscaling of GCM output? (1)

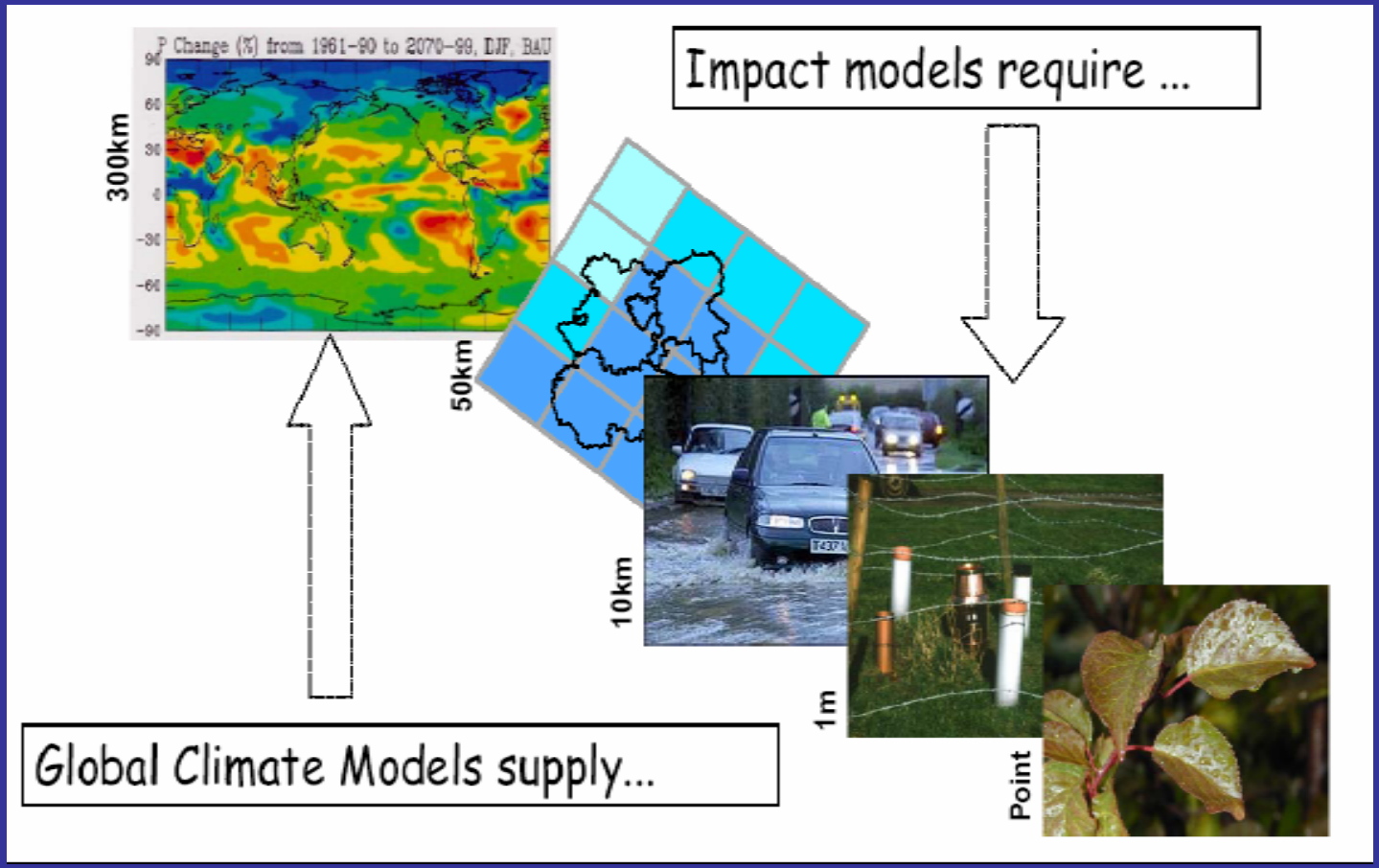
- There are important differences between the real world and its model representation
- Variables may not be represented explicitly by the GCM
- GCMs are not perfect and their forecasts are subject to error (i.e., parameterization)

Why downscaling of GCM output? (2)

- Spatial biases: GCM climatology may have rainfall maximum displaced
- Temporal biases: GCM climatology may have seasonal cycle wrong
- Small-scale affects (such as topography) important to local climate could be poorly represented in the GCM

Why downscaling of GCM output? (3)

Global climate models often do not provide what is needed in impact studies!



What is downscaling?

- A set of techniques that relate local and regional-scale climate variables to the larger-scale atmospheric forcing

  (Hewitson & Crane 1996)

Downscaling approches

- Dynamical downscaling (process-based method)

  Regional Climate Models (RCM), Limited Area Models (LAM)

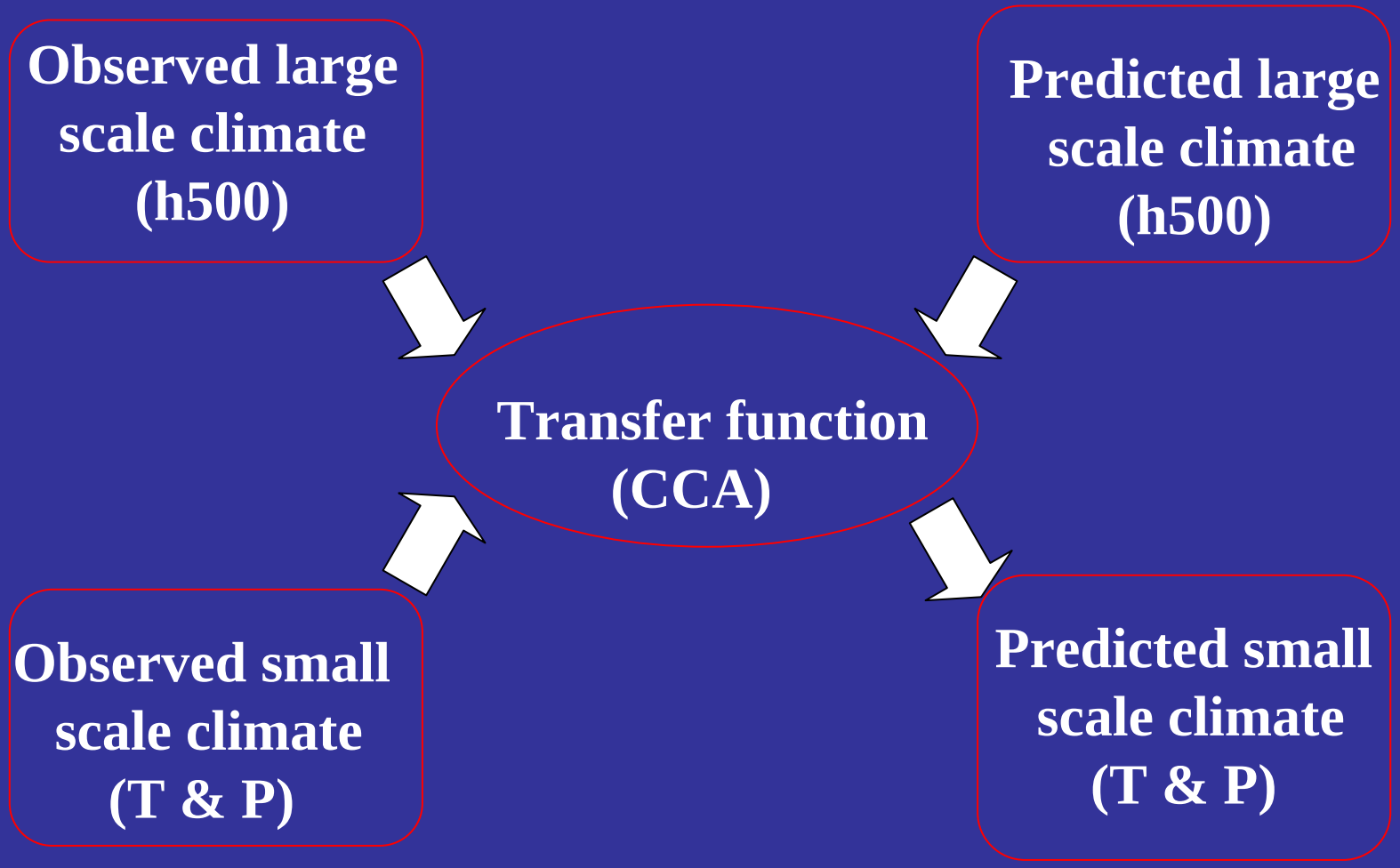
- Statistical/empirical downscaling

  statistical relationship between local values and large-scale averages of surface or free troposphere variables

- Statistical/dynamical downscaling

  has features of both methods

Statistical downscaling



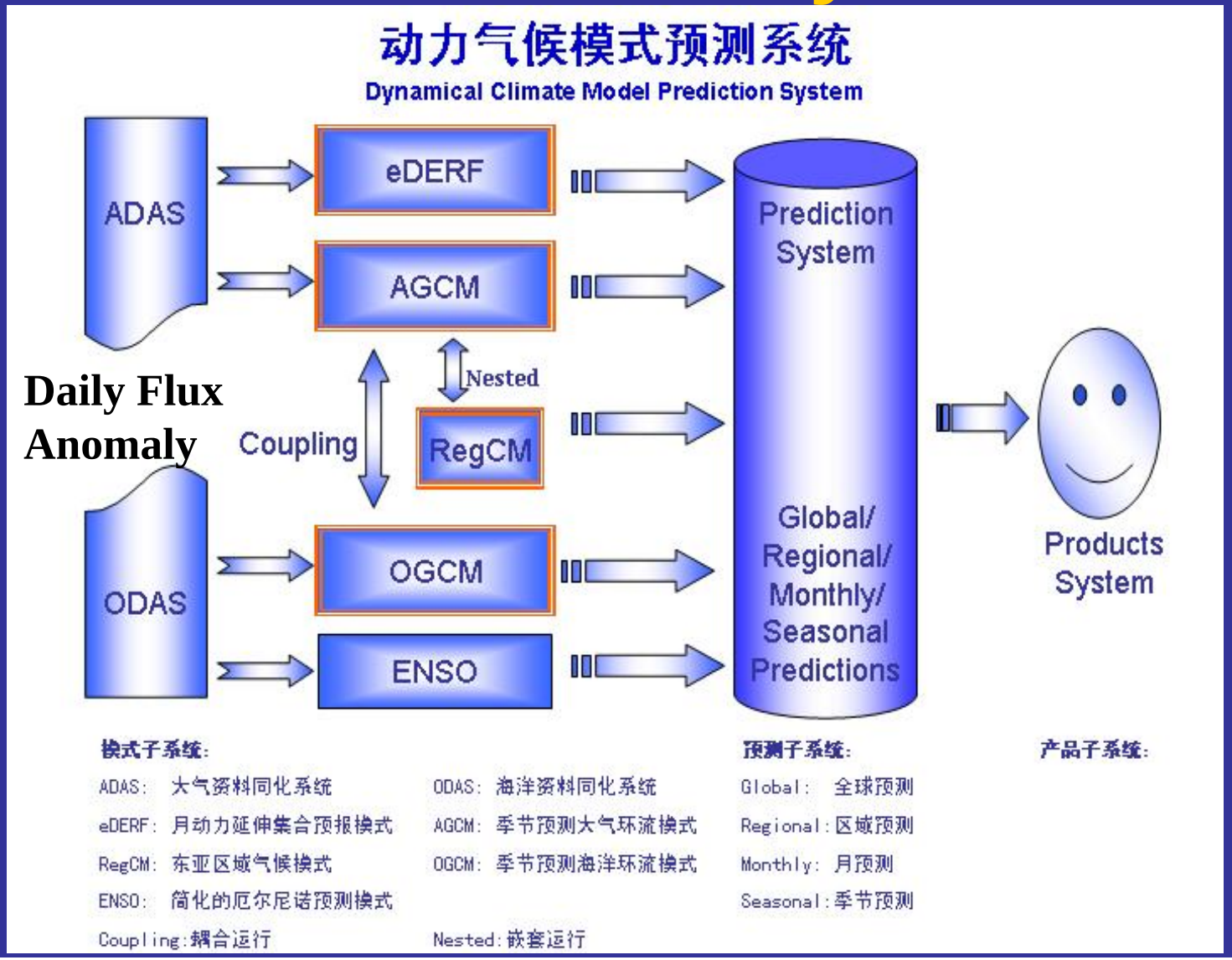
Transfer function: CCA

- CCA has the main advantage of selecting pairs of spatial patterns that are optimally correlated, making a physical interpretation of connection between predictands and predictors possible.
- Prior to the CCA, the original data are projected onto their EOFs to reduce noise (small-scale features) and to reduce the dimension of the data. Only a limited number of them are retained, explaining most of the total variance.
- As the time coefficients are normalized to unity, the canonical correlation patterns represent the typical strength of the signal. The 1st CCA pair gives the maximum correlation between the two parameters, followed by the 2nd CCA pair and so on.

Data

- NCEP/NCAR reanalysis data : 500hPa geopotential height (1951-2006)
- CGCM/BCC hindcast and predicted data: 500hPa geopotential height , temperature, precipitation (1983-2006)
- Station data: seasonal temperature/precipitation of 160 stations over China (1951-2006)
- Region of 500hPa: East Asia（70-150^{o}E，10-60^{o}N）

Dynamical Climate Model Prediction System



AGCM (T63L16)

OGCM (T63L30)

Initial Field Information

Atmosphere	The assimilated data at 00 GMT of the end 8 days of Sept.
ocean	6 instantaneous field derived from the end of day of Sept. by GODAS_NCC （salinity、sst、wind stress et al）
ensemble number	8×6＝48
integration	11 months (here use the result of winter time: 3-5months)

Approach

- Standardize the data including predictant and predictor data
- EOF + CCA : from experiment to define the optimal EOF truncations and CCA patterns
- The skill of the model is checked with cross-validation: All data except one sample, which is to be used for validation, are used to develop the model. This procedure is repeated until each sample has a chance to be used to validate the model.

Cross-validation of CCA reconstructed using NCEP 500hPa geopotential height with observed temperature/precipitation in winter

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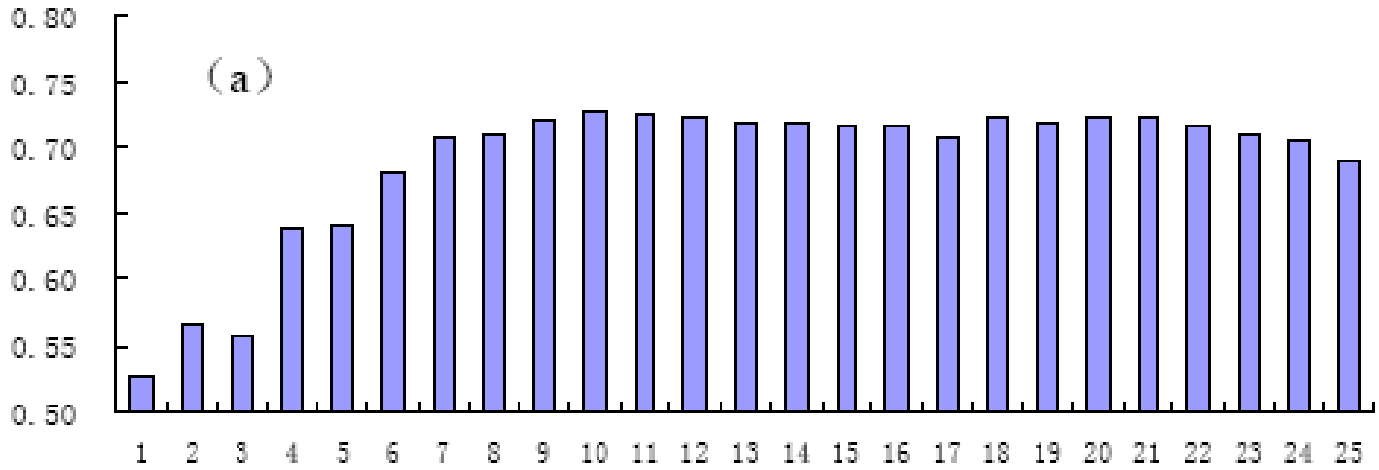

X-axis: EOF number; y-axis: ACC

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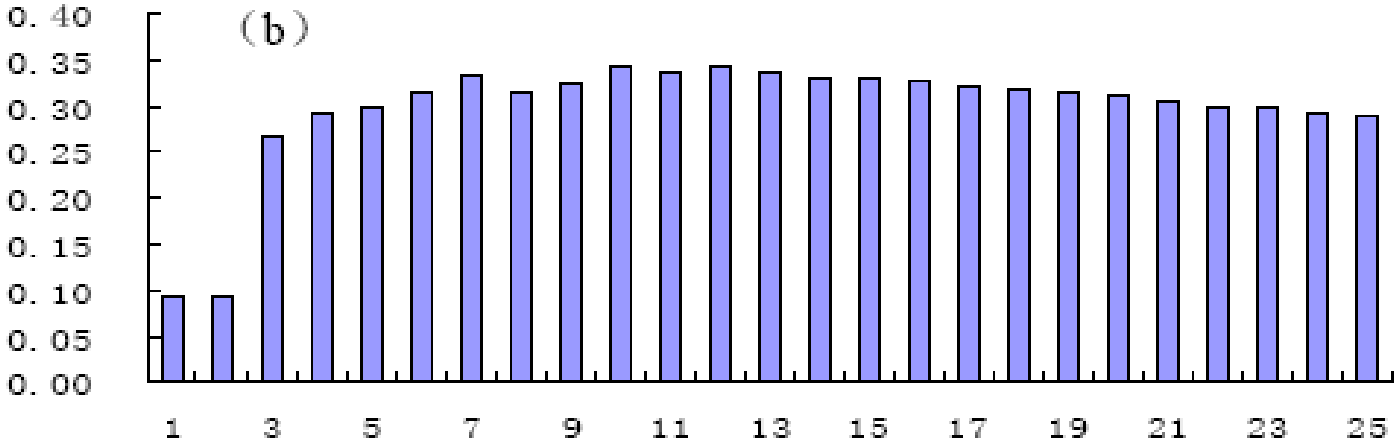

Cross-validation of CCA reconstruction using NCEP 500hPa geopotential height with observed temperature/precipitation in winter

when different numbers of CCA patterns are used.

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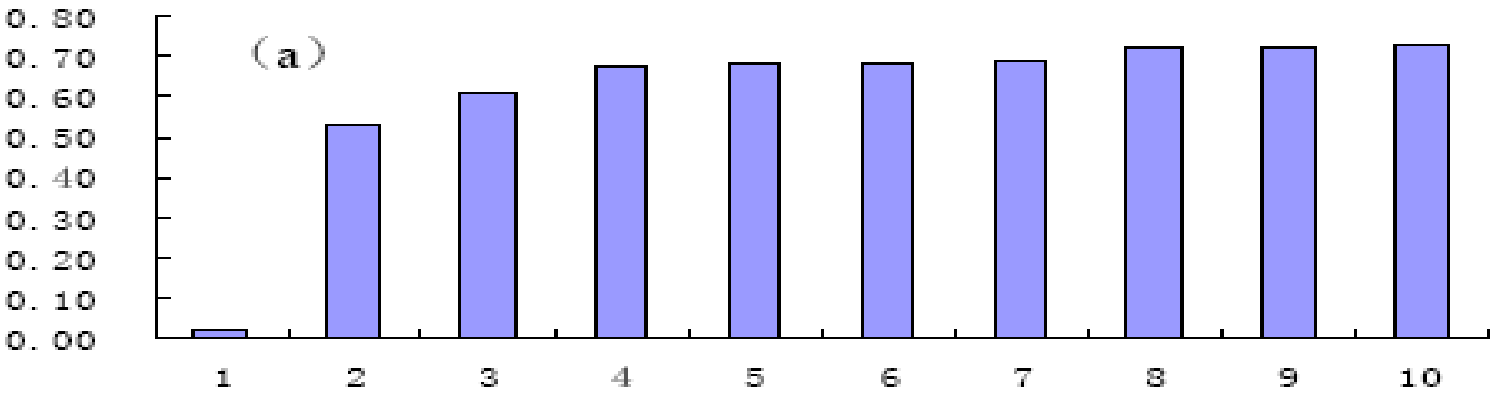

X-axis: CCA number; y-axis: ACC;

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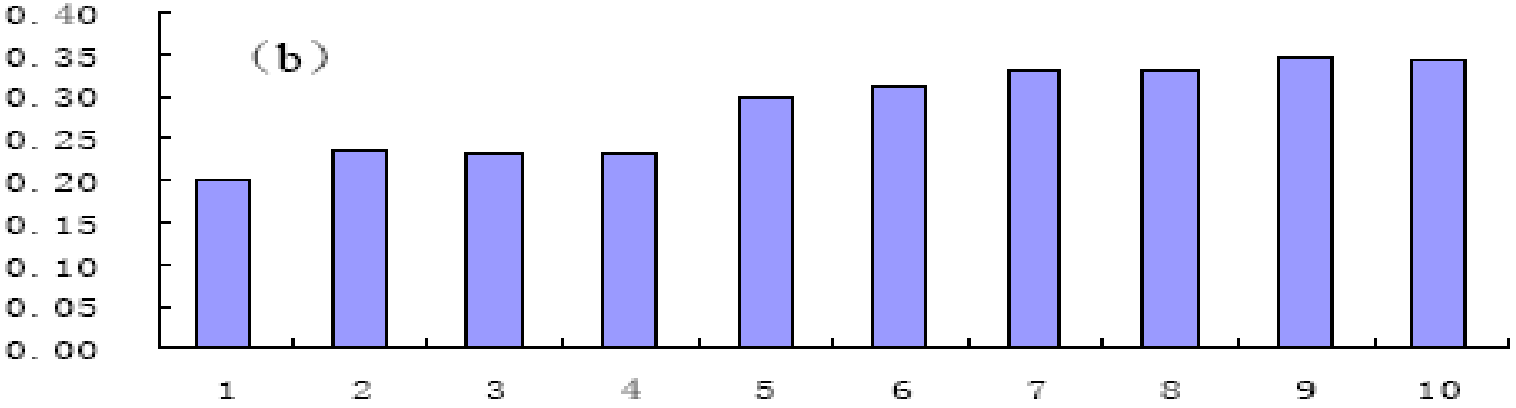


Downscaling skill by using Reanalysis data (500hPa)

160Sta

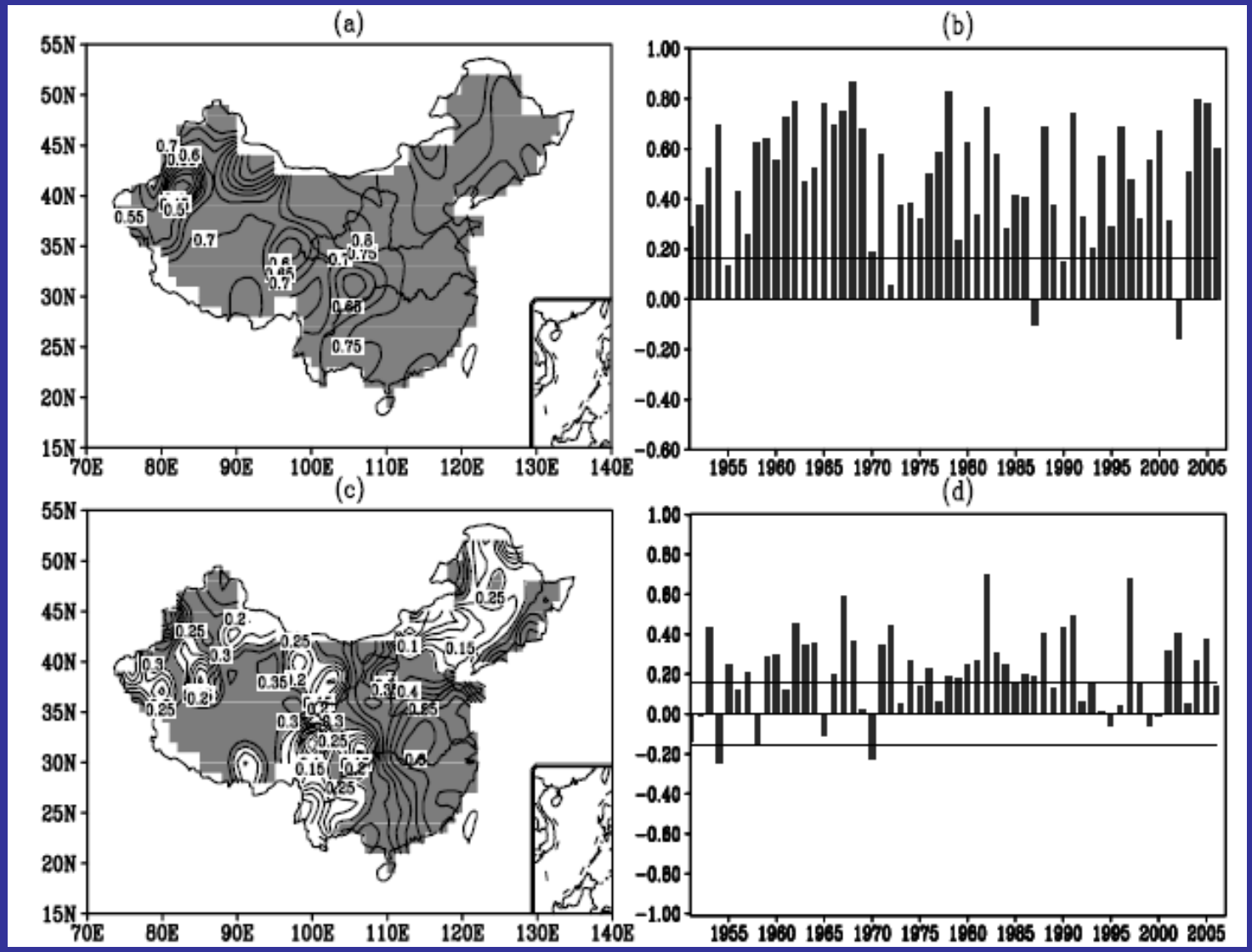
51a

5%

106Sta

35a

5%



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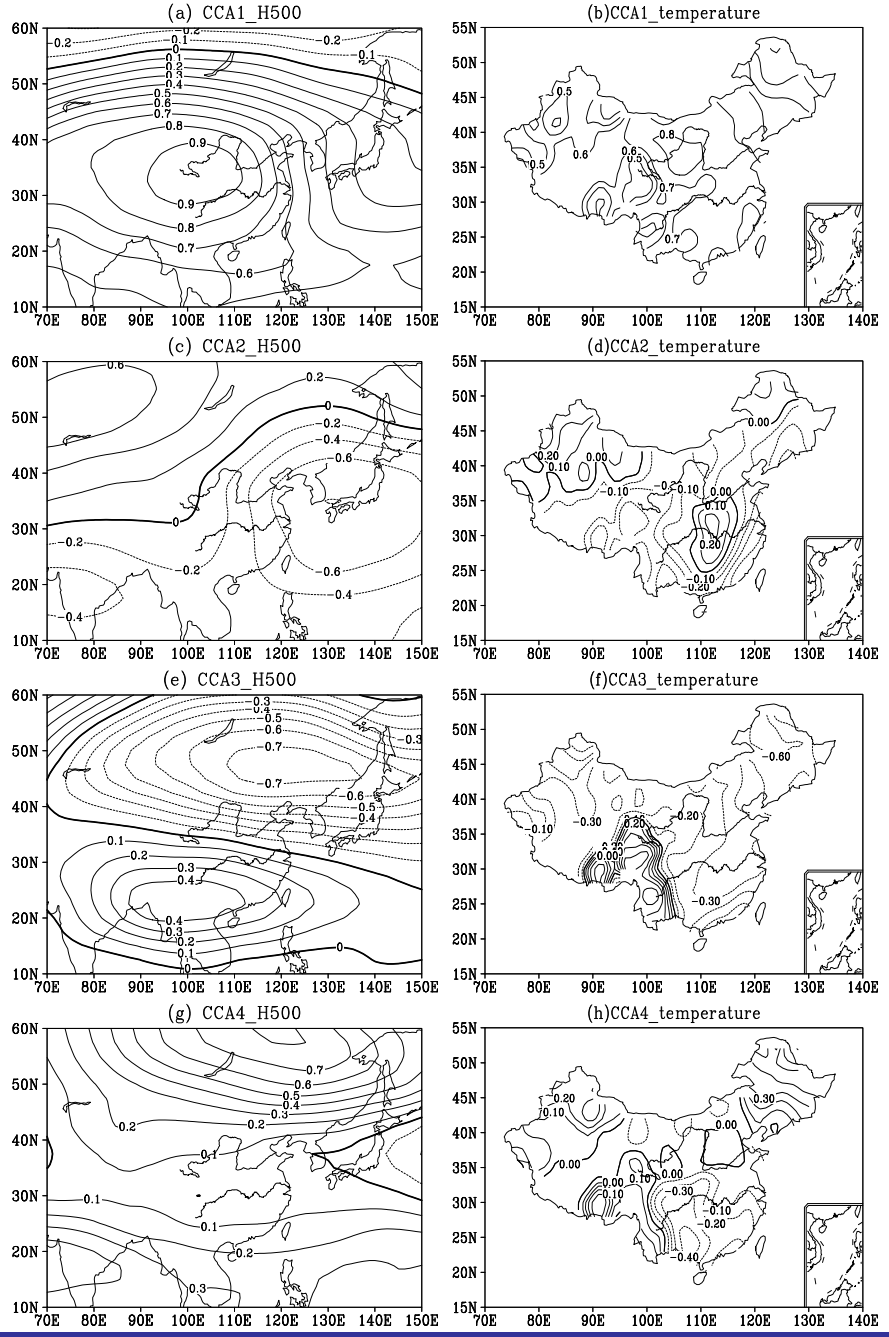
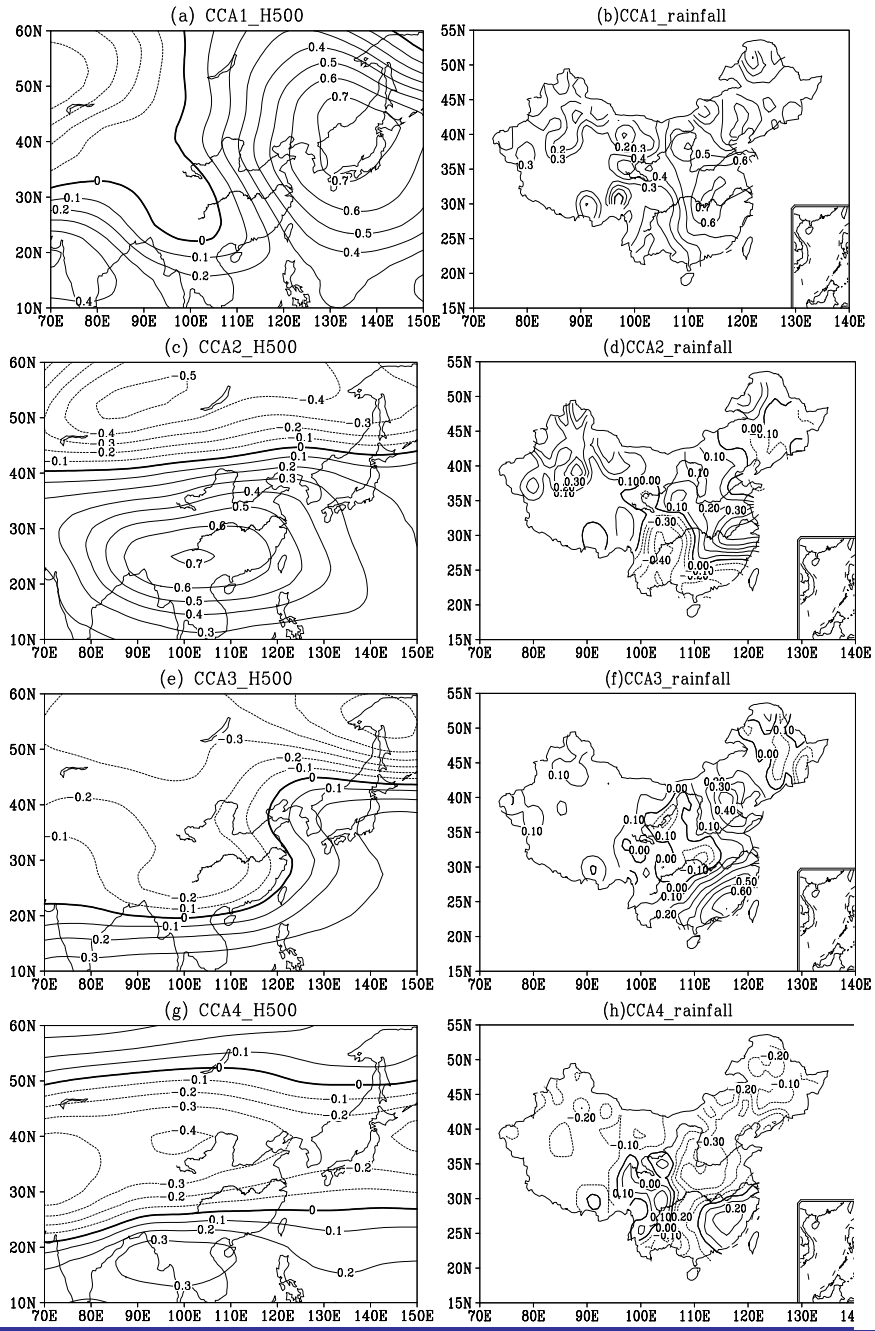
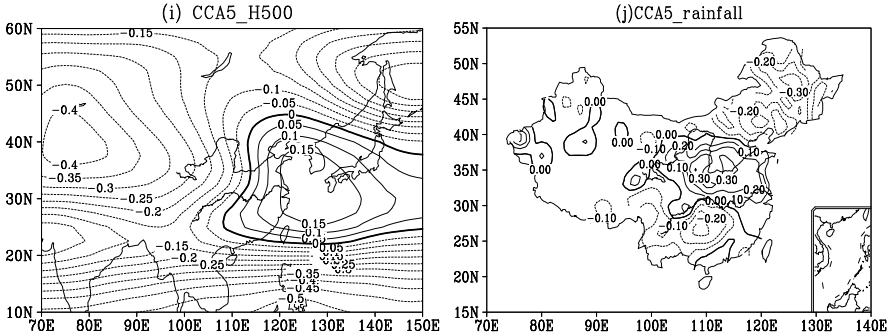


The first four temperature (right fig.) CCA patterns corresponding to CCA patterns of 500hPa potential height (left fig.) with 10 EOF truncation



The first five Precipitation (right fig.) CCA patterns corresponding to CCA patterns of 500hPa potential height (left fig.) with 10 EOF truncation



Downscaling result by using CGCM/BCC 500 hPa height

CGCM output

Downscaling result

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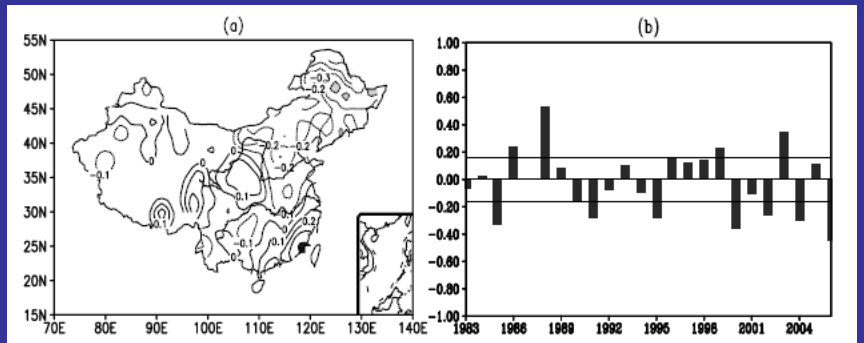

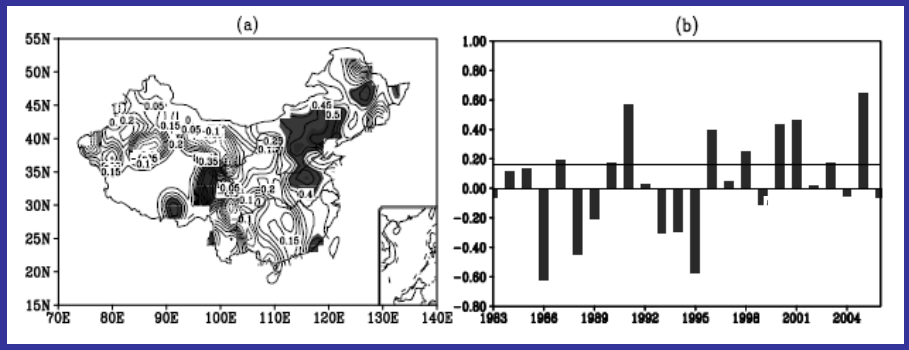

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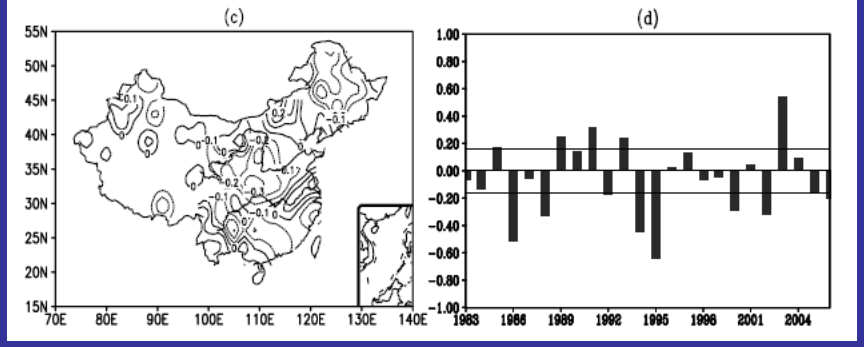
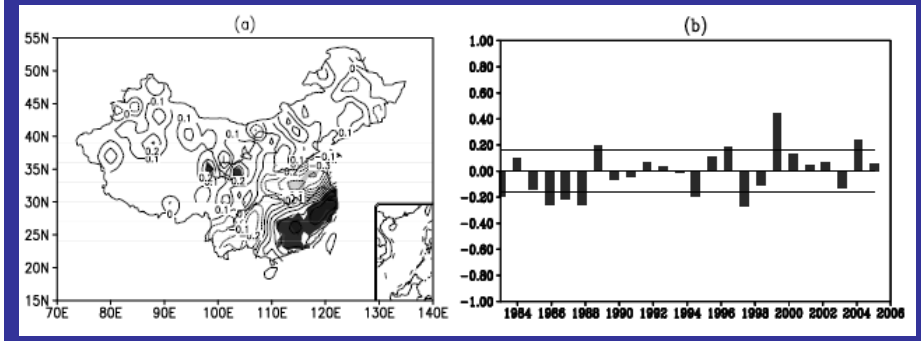
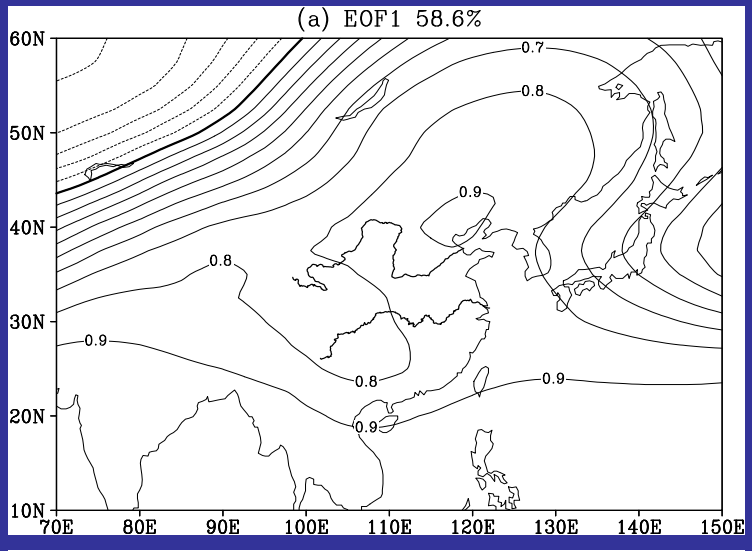


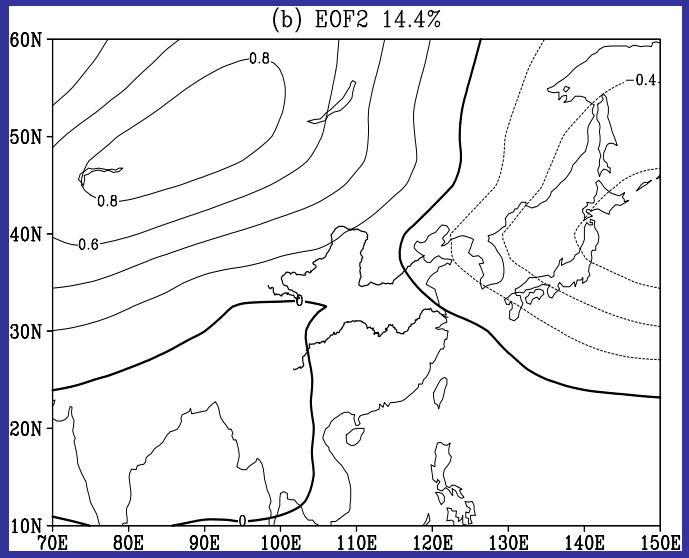


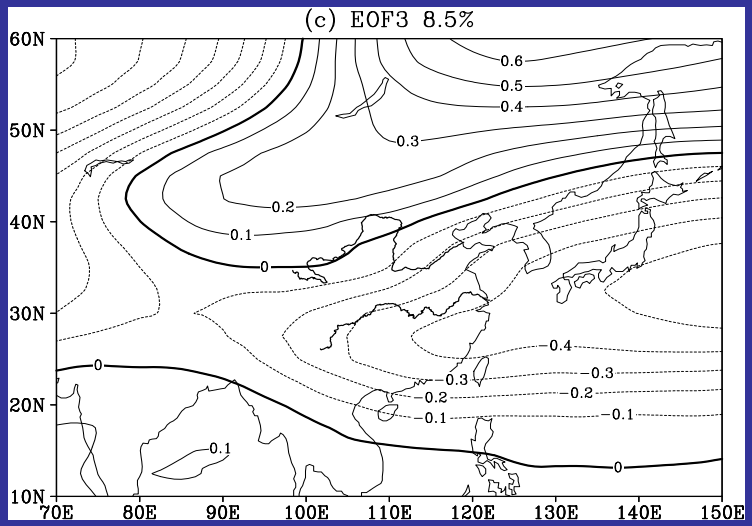
ACC distributions and spatial correlation of predicted temperature and precipitation of 160 stations by CGCM/NCC

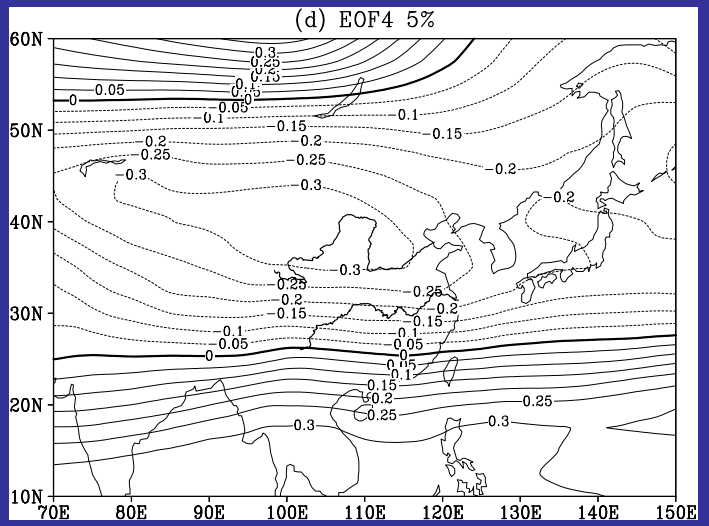
Cross-validation of predicted temperature and precipitation of 160 stations using CGCM/NCC 500 hPa height data based on the optimal CCA model.

The leading four EOF patterns of the winter normalized 500hPa geopotential height predicted by CGCM/BCC



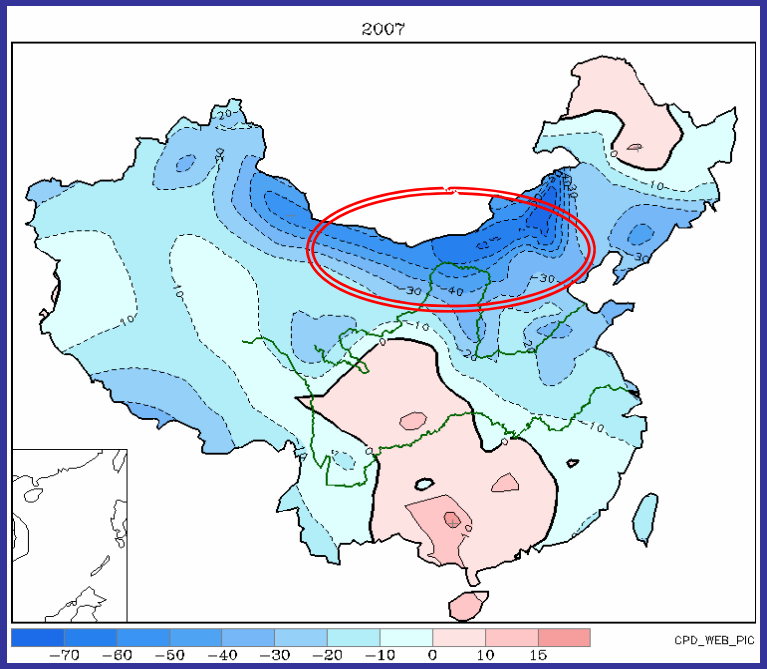




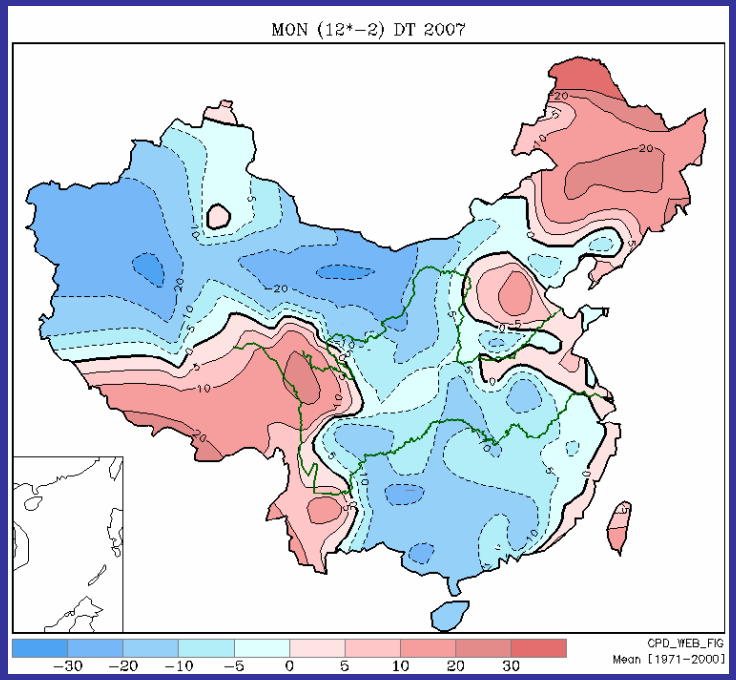


Real time prediction experiment: Temperature Prediction in 2007-2008 winter

Temperature prediction for 2007/2008 winter



Observation in 2007/2008 winter



Leadtime: 2 months

Discussion and Summary (1)

- Based on the established 500hPa circulation in East Asia in winter by cross validation and the optimum downscale model for the abnormal temperature and precipitation in China in winter, the application of CCA method has good result for the forecast of temperature and precipitation. If use 500hPa large-scale circulation to interpret the temperature and precipitation, the average ACC of the predictability of the winter temperature is 0.7 or so, the highest number can be 0.9; the average ACC of the predictability of precipitation is 0.3 or so, the highest number can be 0.7. The predictability of temperature is far higher than that of precipitation. There is obvious regional difference for the predictability level for temperature and precipitation.

Discussion and Summary (2)

- The abnormal 500hPa circulation in East Asia in winter has close relations with the abnormal temperature and precipitation in winter. The CCA method has revealed that there is clear physical meaning between the large-scale circulation and temperature/precipitation. The first 4-5 of CCA patterns have revealed the main influence relation by the large-scale circulation in East Asia in winter for temperature and precipitation in winter. Among them, East Asia trough , Siberian high and West Pacific subtropical high are the most important system influencing the temperature and precipitation in winter.

Discussion and Summary (3)

- The downscaling forecast result for temperature and precipitation by CGCM/BCC large-scale circulation is obviously higher than the result of the direct output of the model. The improvement for the temperature is higher than that for precipitation. The predictability for the downscaling forecast skill stems from the simulation of the large-scale circulation and this is one of the source of achieving better results from downscaling forecast models.

Thanks a lot !

The leading four EOF patterns of the winter normalized 500hPa geo-potential height from NCEP data