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Development of Climate Prediction System at IAP/CAS

Zhaohui LIN

ICCES, Institute of Atmospheric Physics, Chinese Academy of Sciences

lzh@mail.iap.ac.cn

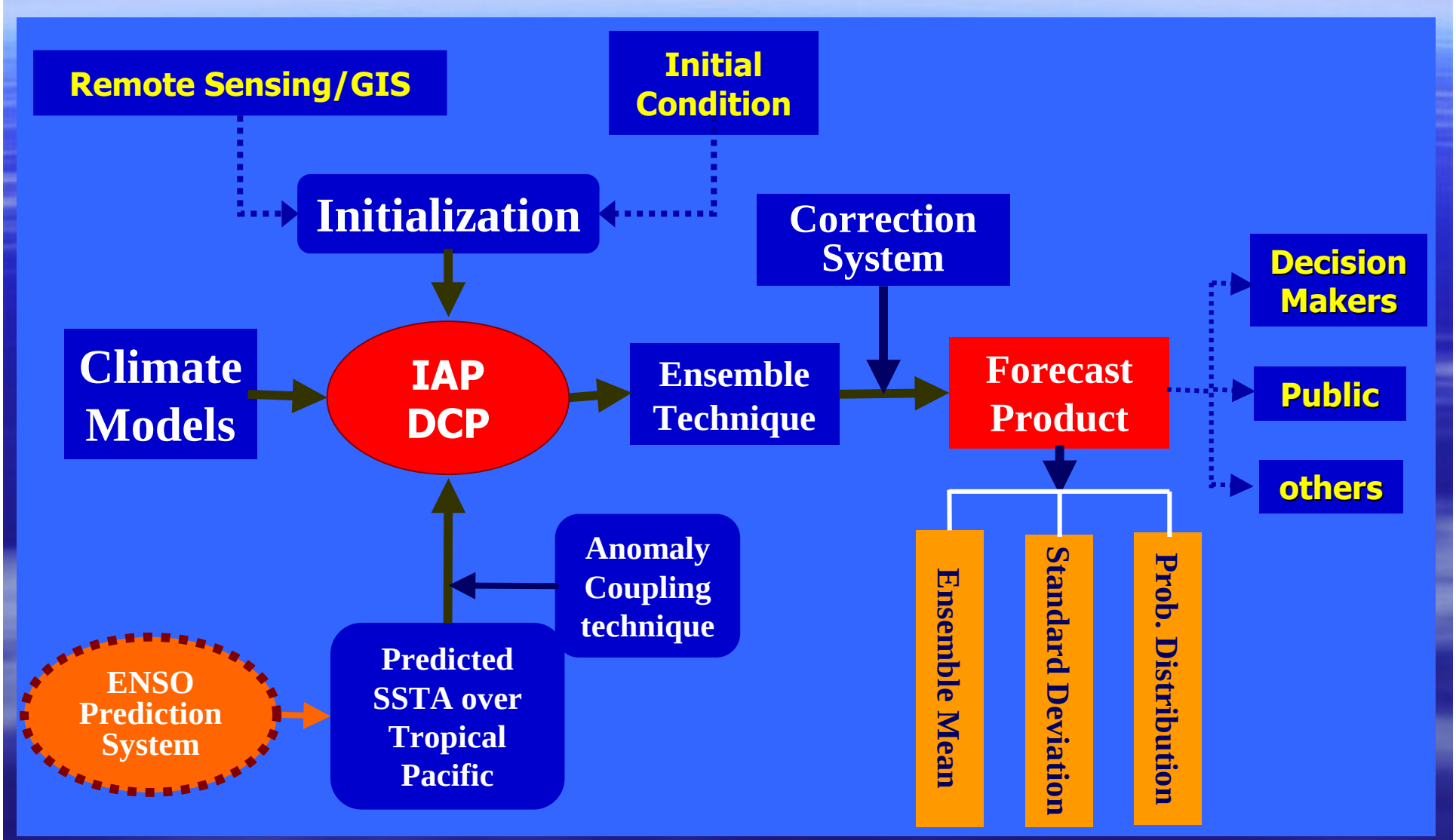
Collaborator: Dr. Yanling ZHAN, Fei ZHENG, He ZHANG,

Prof. Jiang ZHU

Outlines

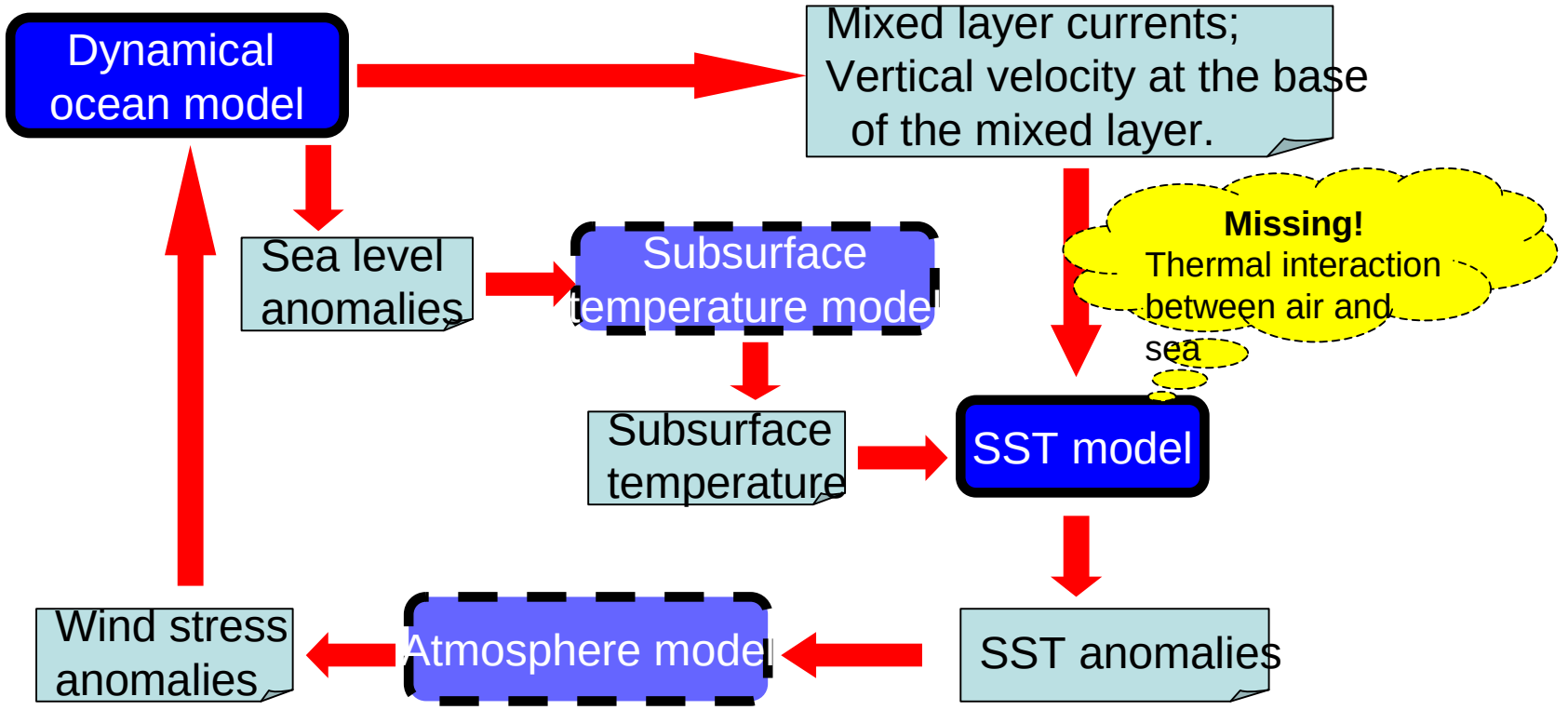
- New IAP ENSO Ensemble Prediction System
- Development of IAP Earth System Model
- Land surface Initialization scheme for IAP seasonal prediction system

IAP Dynamical Climate Prediction System



An ENSO Ensemble Prediction System Based on an Intermediated Coupled Model

The basic intermediate coupled model (ICM) has been developed by *Keenlyside and Kleeman* [2002,JGR] and *Zhang et al*. [2005,MWR]. It mainly includes an ocean dynamical model and a statistical atmospheric model, and a SST model is also coupled within the ICM.

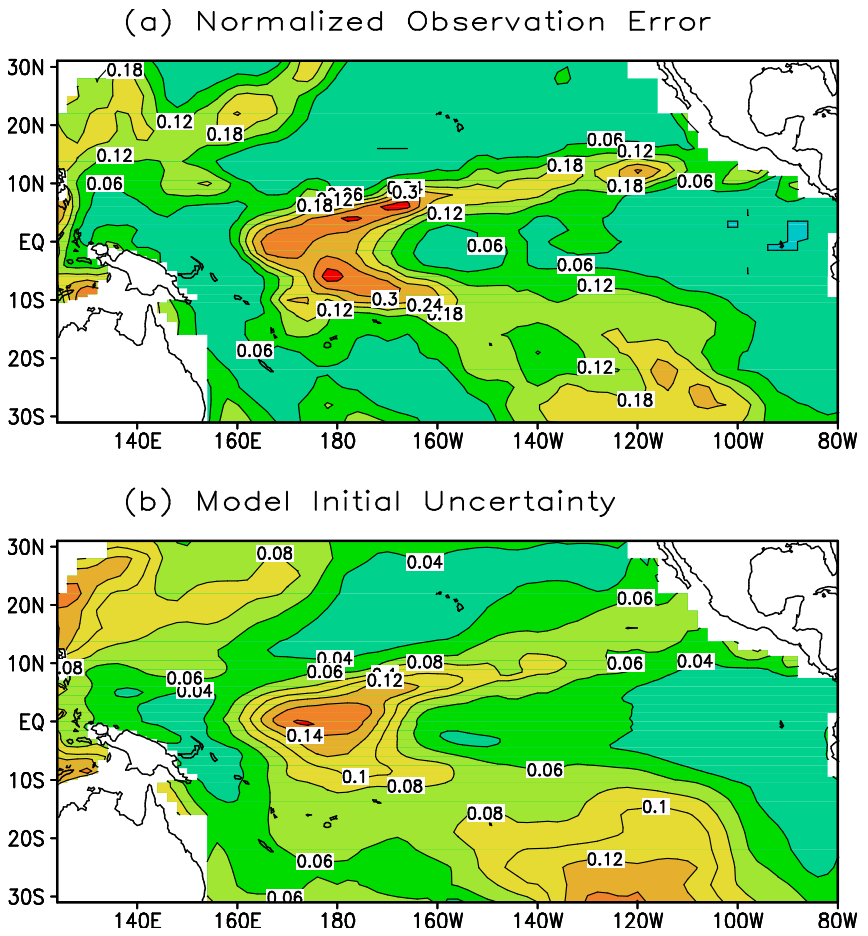


Illustrating of model coupling

Initial ensemble condition

- The initial ensemble conditions are provided by the EnKF [e.g., *Evensen*, 2003] data assimilation approach through assimilating all available observations into the model with 100 ensemble members [*Zheng et al.*, 2007, GRL; *Zheng and Zhu*, 2008, JGR].
- This ensemble initialization approach not only can generate the accurate and dynamical consistent initial ensemble members, but also can provide reasonable initial stochastic uncertainties for the EPS by combining both background and observation errors during the assimilation cycles.

OBS error vs. Initial uncertainty

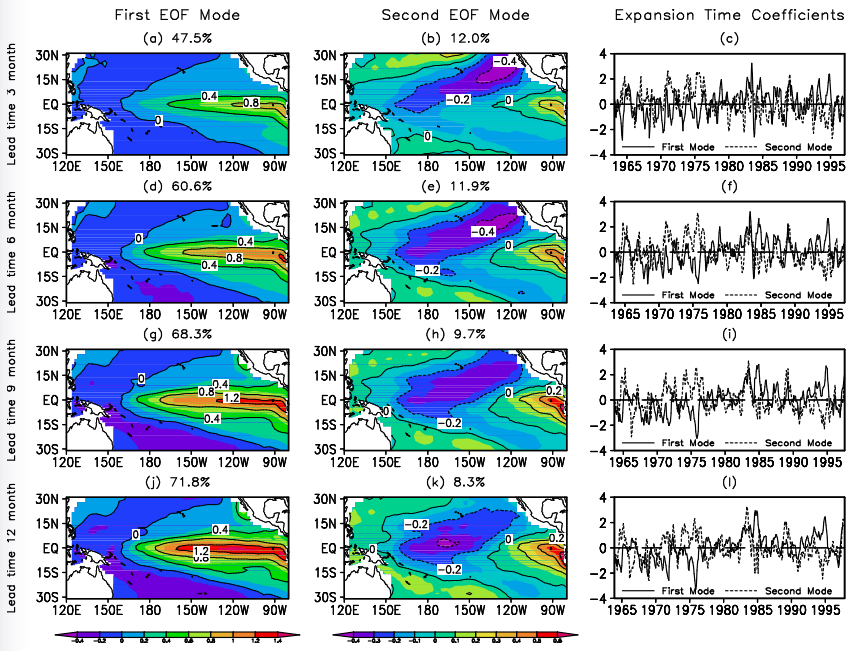


A case at Jan. 1998

Model error perturbation

Model error model

$$\begin{cases} Q_j^{(t)} = \sum_{i=1}^{M} \lambda_i^{(t)} \times \Psi_{i,j} + \xi_j^{(t)} \\ \lambda_i^{(t)} = \alpha_{i,j} \times \lambda_i^{(t-1)} + \sqrt{1-\alpha_{i,j}^2} \times v_i^{(t)} \end{cases}$$

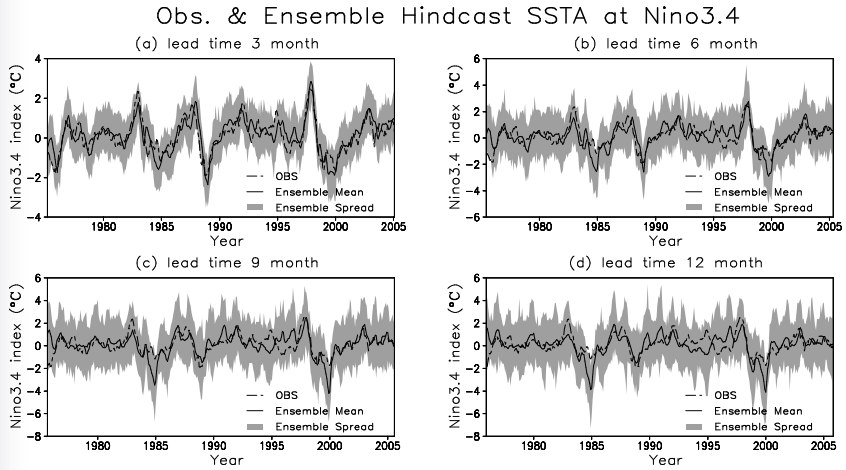


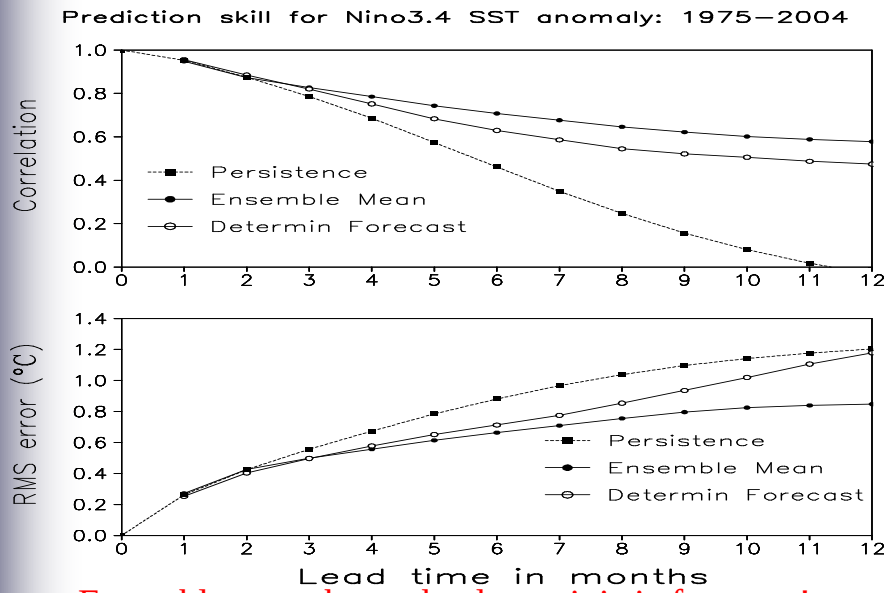
Spatial patterns of the first and second EOF modes, and their associated normalized time coefficients for model errors at 3-, 6-, 9-, and 12-month lead times.

- Due to the deficiency of simulating the coupled air-sea interactions and subsurface thermal effects in the SST model, a linear, first-order Markov stochastic model is developed and embedded within the SST model of the ICM to represent the model uncertainties of forecasted SST anomaly fields during the forecast process [*Zheng et al.*, 2006, GRL; 2009, AAS].
- This perturbation method has been verified to be capable of effectively simulating the time evolutions of model uncertainties during the ensemble forecasting procedures [*Zheng et al.*, 2009 CSB].

Prediction verification – Prediction skills (1975-2004)

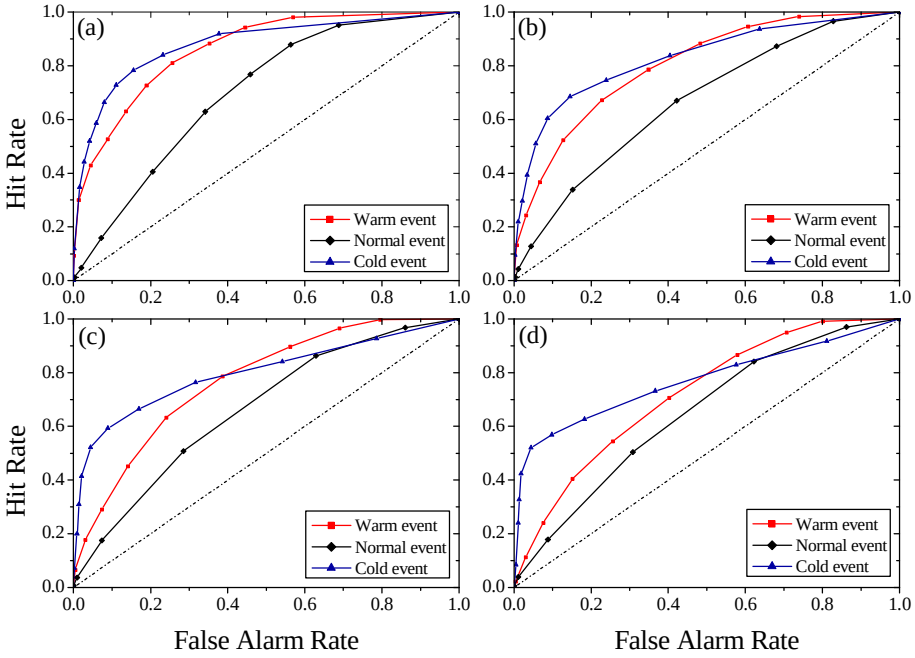
Obs & predicted SSTA over Niño3.4 region





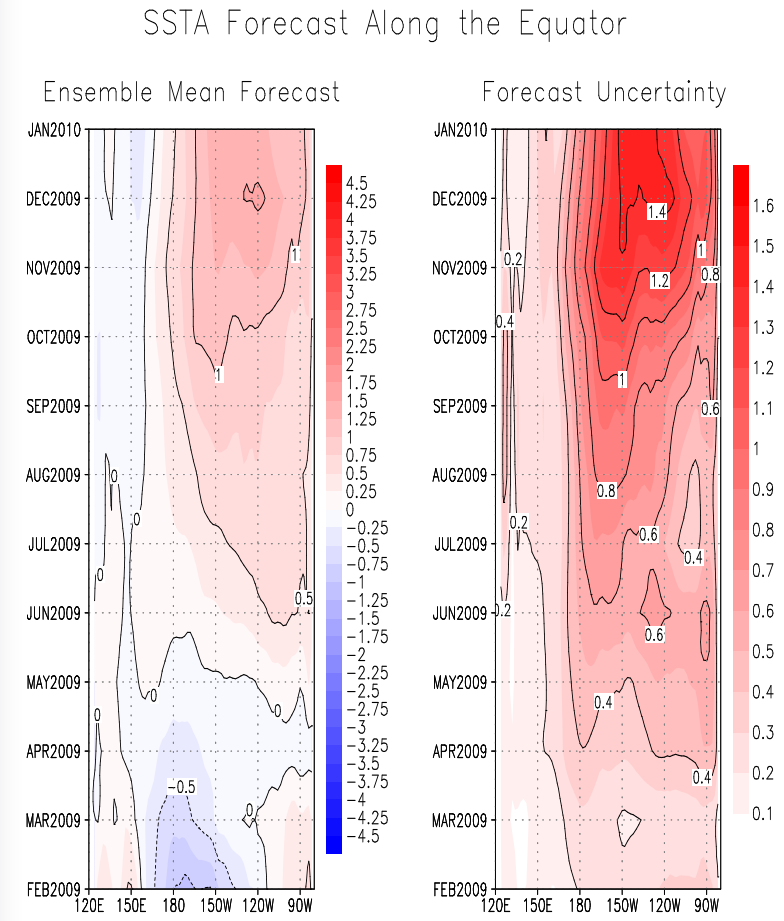
Ensemble mean beats the deterministic forecast !

Probabilistic prediction skill



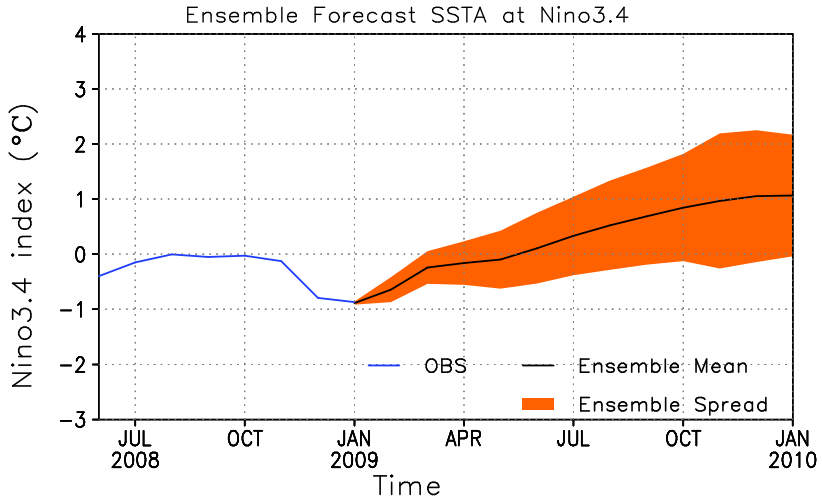
The ROC curves for the three events at different lead times all lie in the top-left corner. These mean that the EPS has reasonable and relative high probabilistic prediction skill.

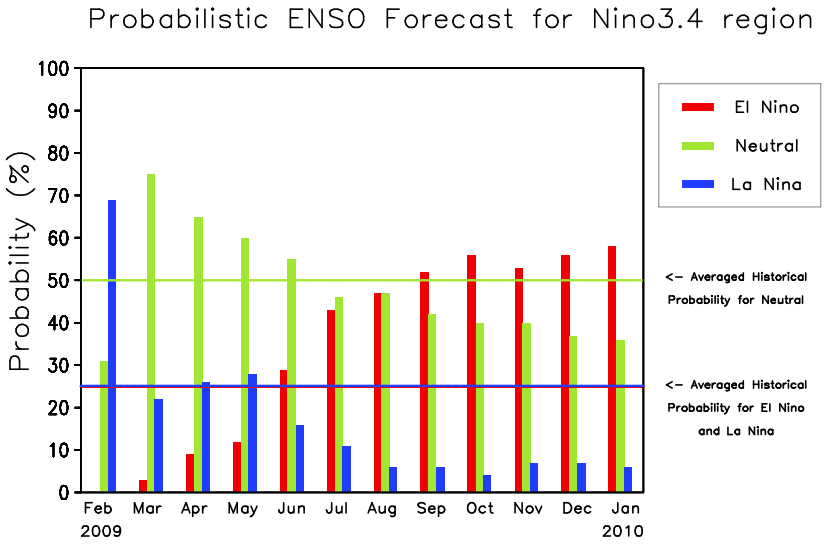
2009 forecast – Started from Feb. 2009



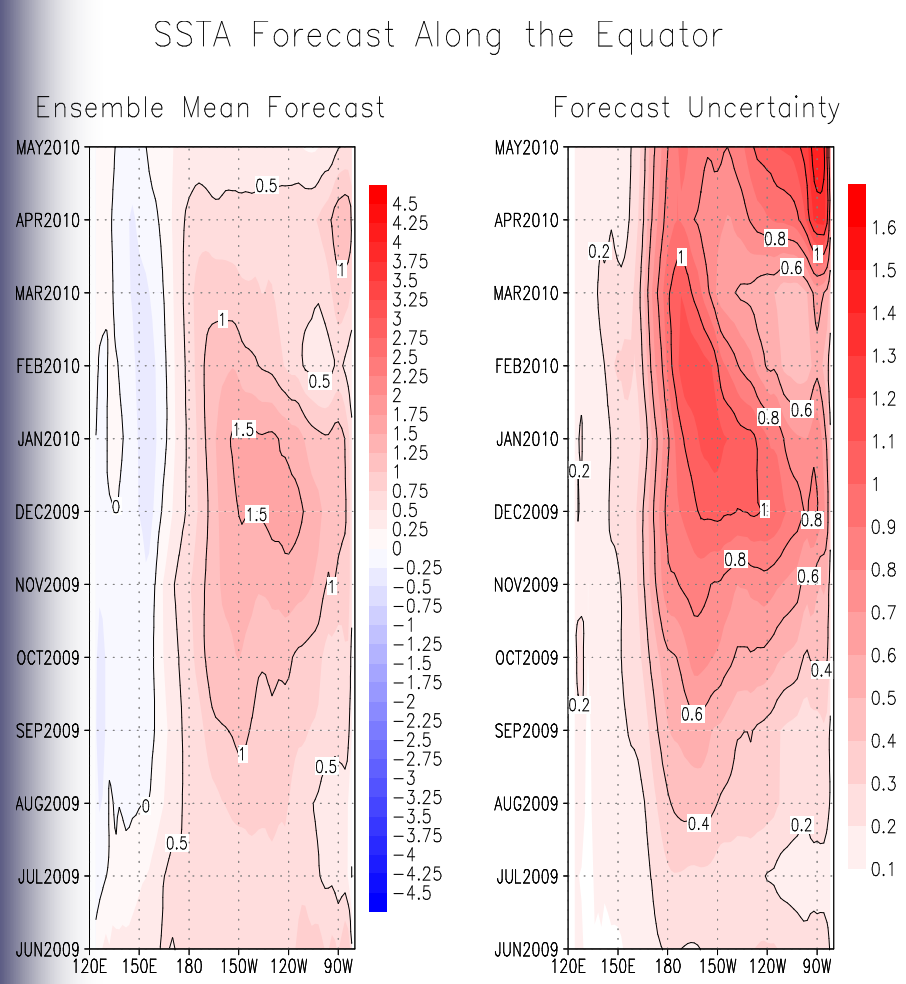
Ensemble-mean forecast

Forecast uncertainty



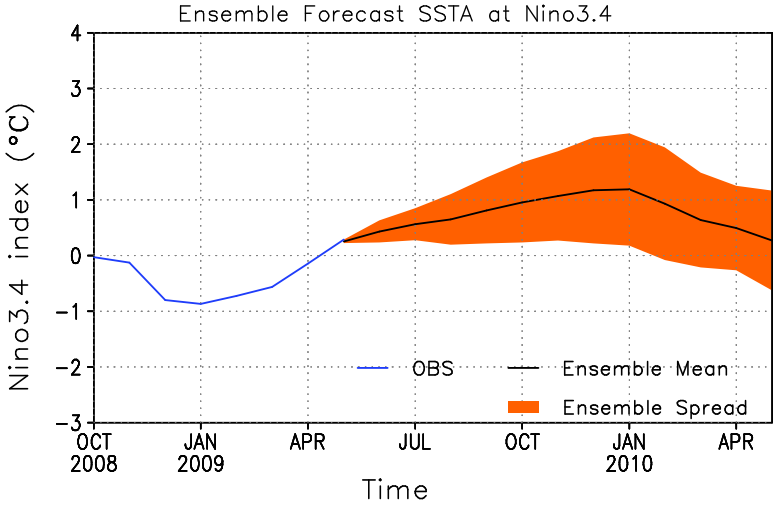


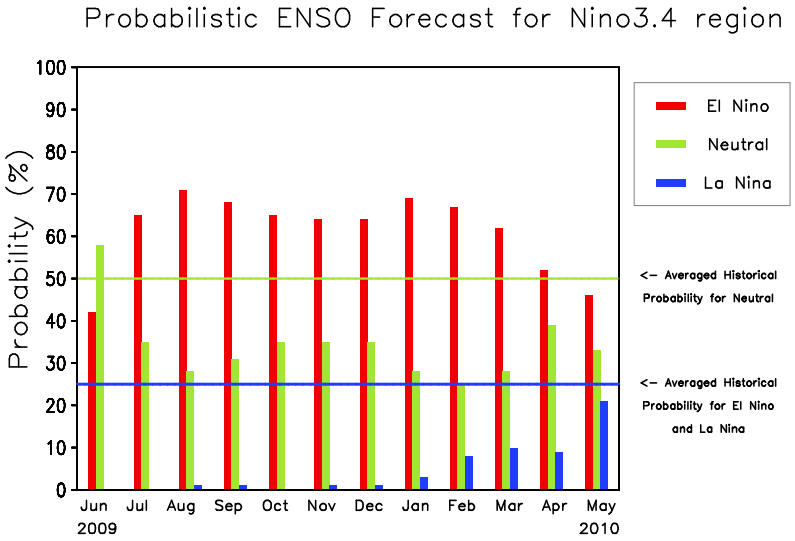
2009 forecast – Started from Jun. 2009



Ensemble-mean forecast

Forecast uncertainty





IAP Earth System Model Development

- CAS Key program “Development of Earth System Dynamic Model” has been Initiated since 2007, with the support by The Chinese Academy of Sciences
- Phase I: 2007.8-2010.12,
- Total budget for Phase I:
  - ~1.5 Million USD (10 Million Chinese Yuan)

- Further support by CAS, MOST in the next 10 years

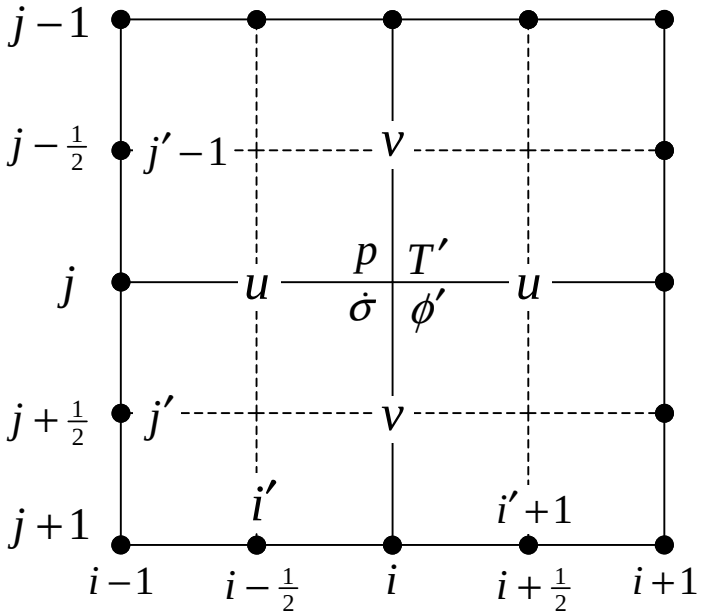
Components of IAP Earth System Model

- Atmospheric General Circulation Model (AGCM)
- Oceanic General Circulation Model (OGCM)
- Land Surface Model (LSM)
- Dynamic Global Vegetation Model (DGVM)
- Aerosol and Atmospheric Chemistry Model (AACHEM)
- Oceanic Bio-Geo-chemistry Model (OBGM)
- Regional Bio-Geo-chemistry Model (RBGM)

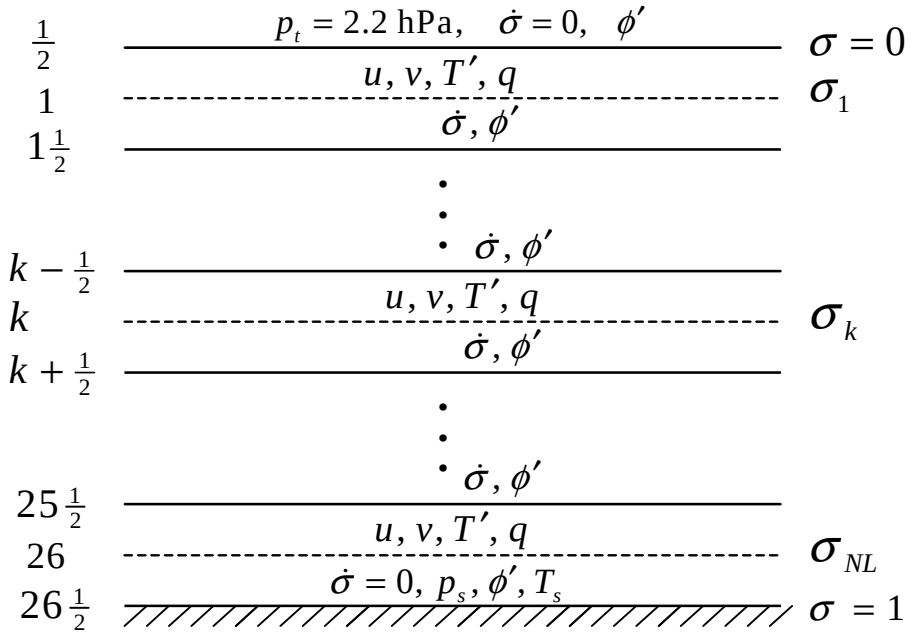
IAP Atmospheric GCM4.0 (IAP AGCM4.0)

Model description

- **Finite-difference scheme (including poles)**



Horizontal staggered C-grid system



Vertical staggered grid system

1.4°(lat)×1.4°(lon)×26L with the top at 2.2 hPa

Model physics

- **Clouds (**Rasch et al., 1998; Zhang et al., 2003**)**

  Prognostic cloud condensate with diagnotic cloud amount

- **Convection**

  deep convection (Zhang and McFarlane, 1995)
  shallow convection (Hack, 1994)

- **Boundary layer (**Holtslag et al., 1993; Boville et al., 2003**)**

  Non-local atmospheric bounday layer scheme

- **Radiation**

  Kiehl et al., 1998; Collins, 2001; Collins et al., 2002

- **Aerosol (including atmospheric chemistry)**

  Barth et al., 2000; Rasch et al., 2000

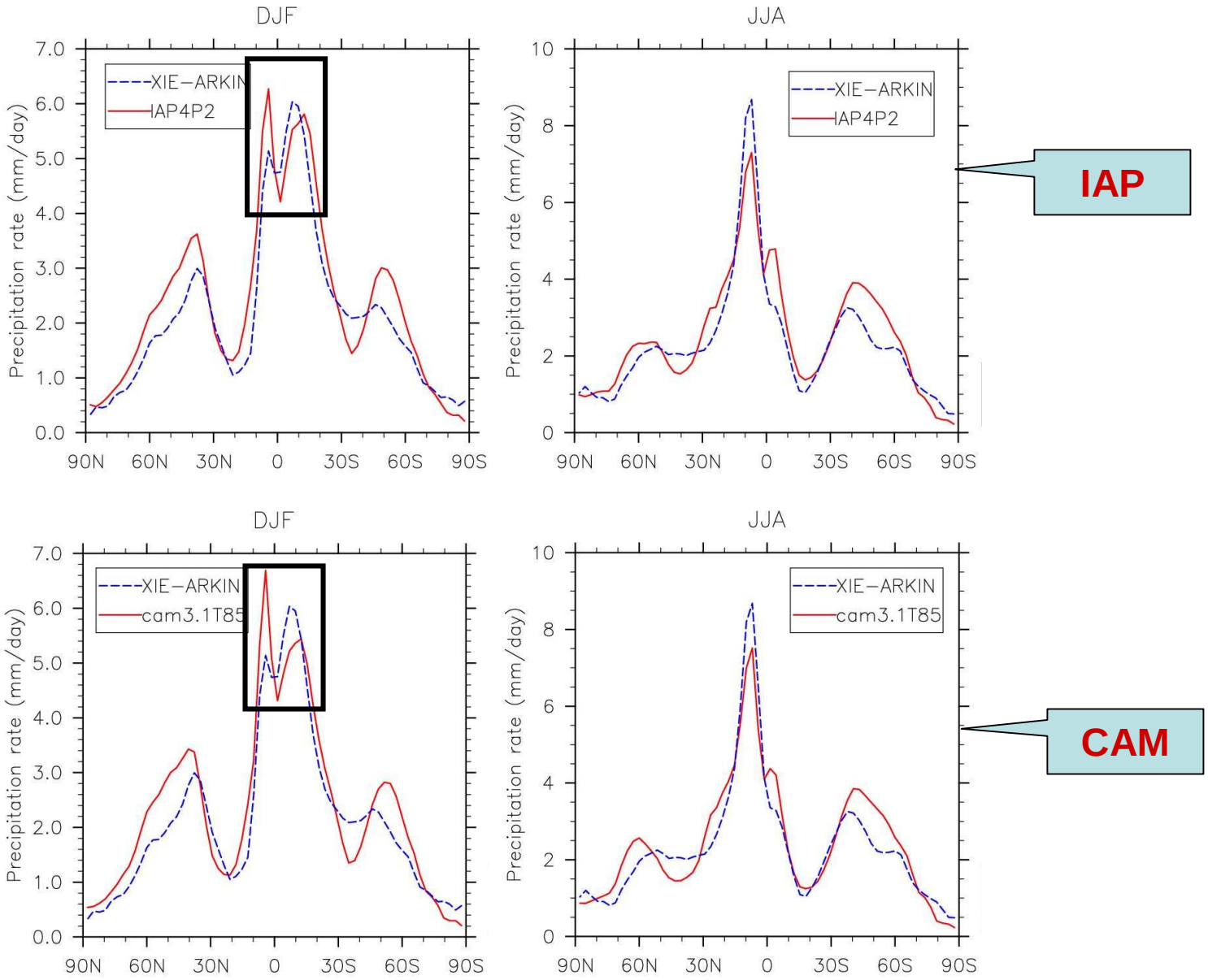
- **Land**

  CLM2 (Bonan et al., 2002)

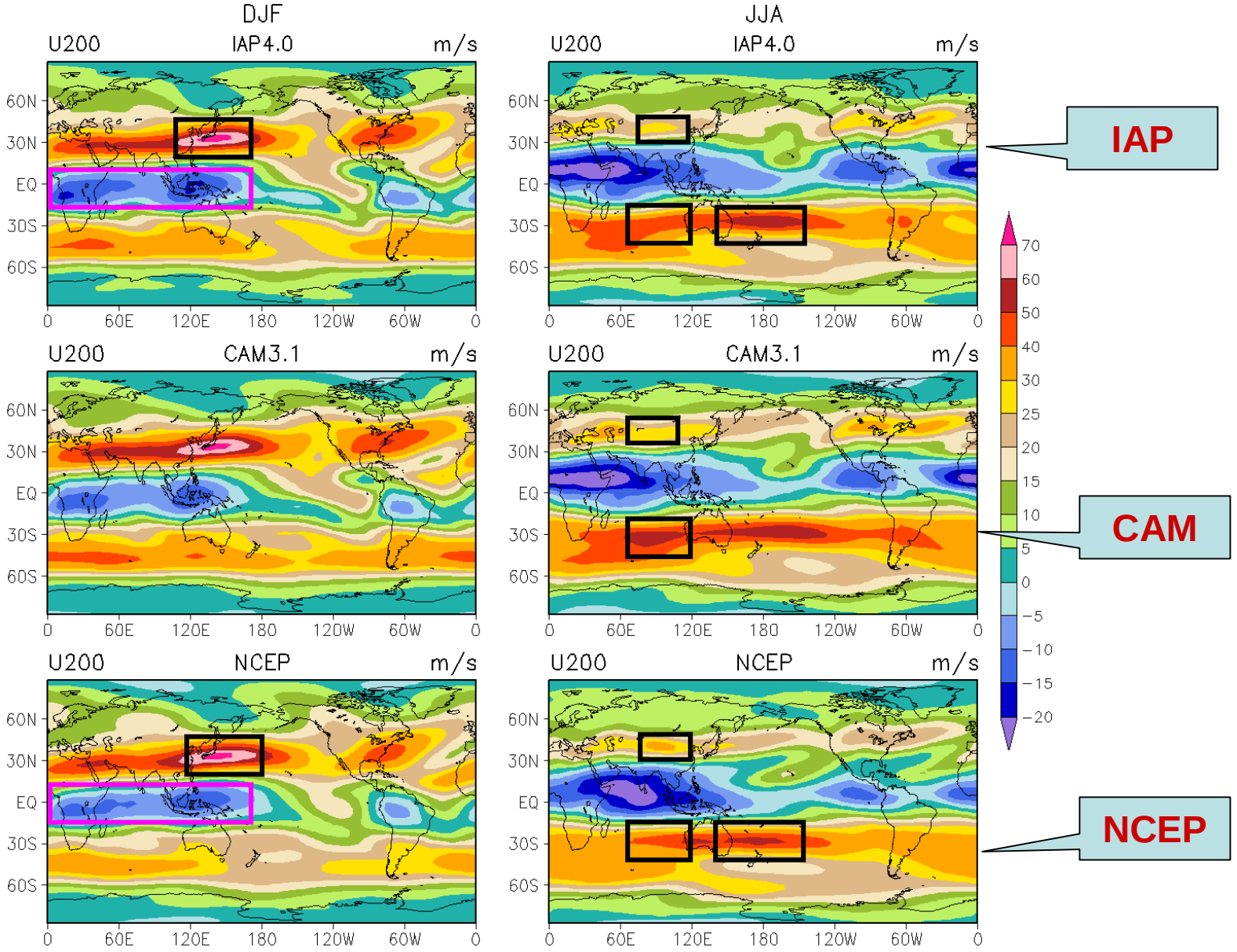
- **Ocean**

  bulk formulas to determine the turbulent fluxes

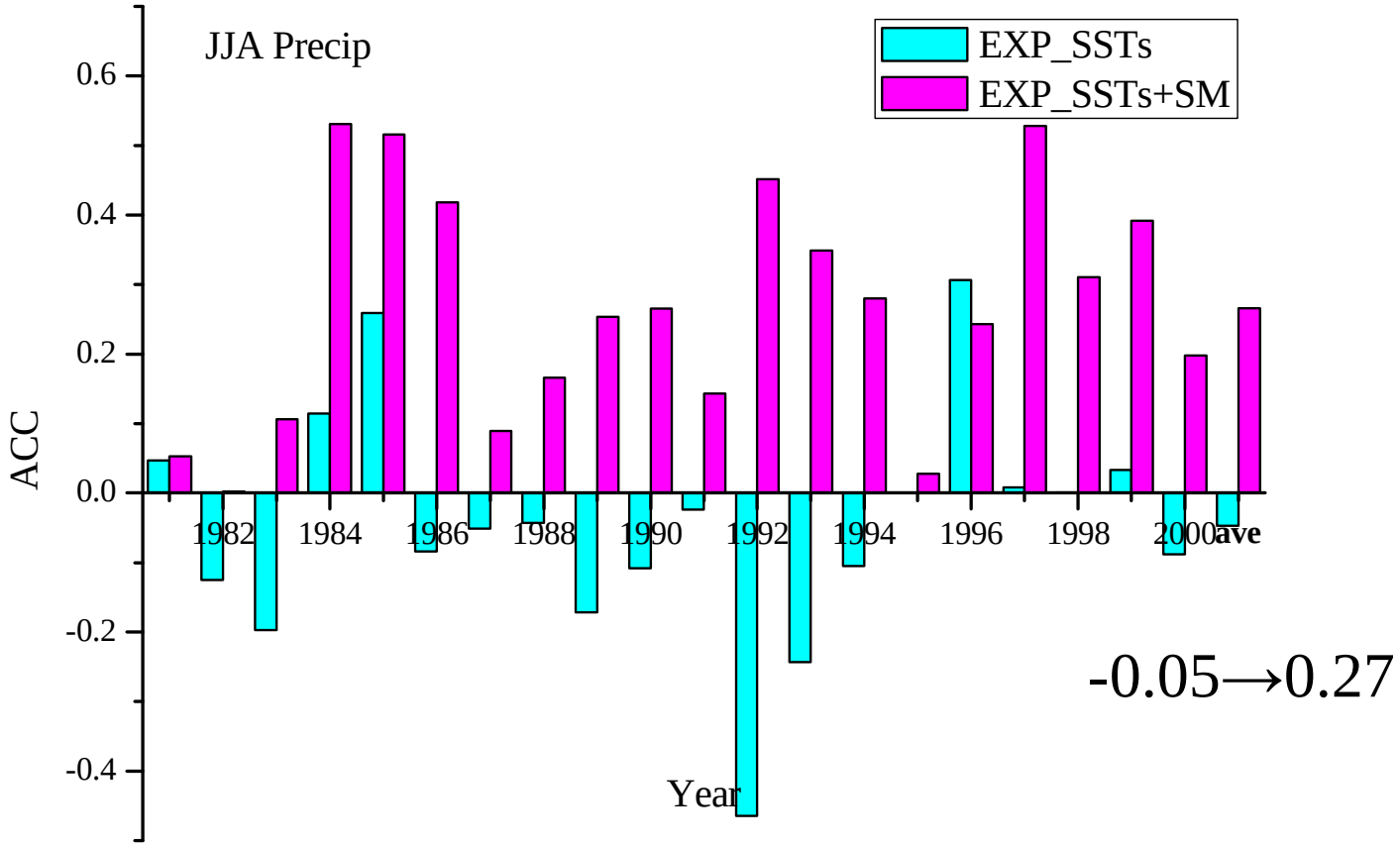
results — zonal mean precipitation



results — zonal wind at 200 hPa



Anomaly Correlation Coefficients of precipitation over East Asia in JJA (From IAP AGCM2.0_CoLM)



Better land surface conditions can improve the seasonal prediction skill of summer precipitation anomalies over East Asian

Next step

1. **Historical Forecast:**
   - **Duration: 1975- present**
   - **SSTA prediction: IAP-EPS ENSO prediction system**
2. **Coupled IAP AGCM4.0 with IAP Oceanic GCM (Expected in mid-2010)**
   - **Run for CHFP**
3. **Initialization scheme for Land surface conditions**