Evaluation, application and development of ESM in China

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Outline

- Preliminary evaluations on CMIP5
- Important applications
- Progress in coupling techniques
- Future development for AR6

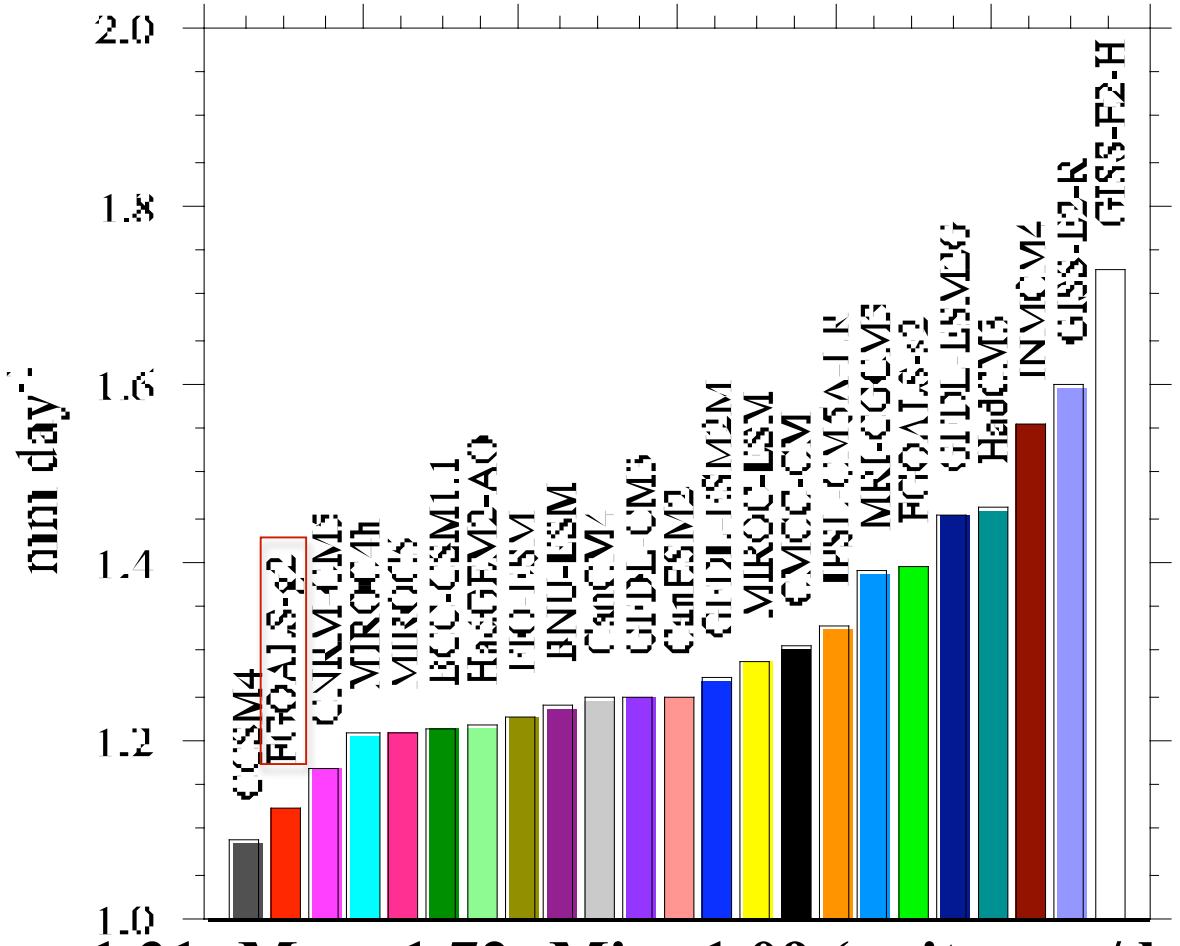
CMIP5 models in China

Group Name	Institution	Model Name
LASG-CESS	Institute of Atmospheric Physics, Chinese Academy of Sciences; Tsinghua University	**FGOALS-g2**
LASG	Institute of Atmospheric Physics, Chinese Academy of Sciences	**FGOALS-s2**
BNU	Beijing Normal University	**BNU-ESM**
BCC	Beijing Climate Center	**BCC-CSM 1.1**
FIO	First Institute of Oceanography	**FIO-ESM1.0**

Main Variables Evaluated

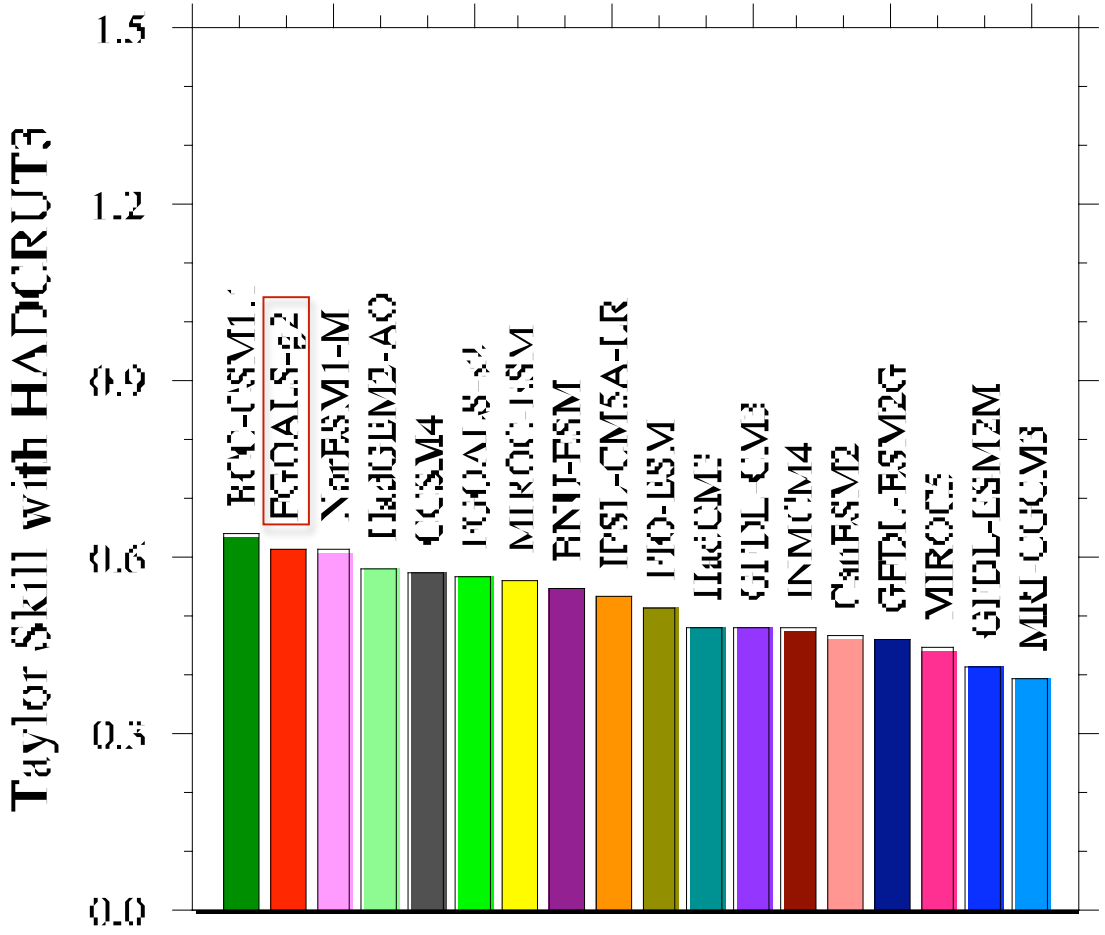
Variable name	Component	Evaluation Method
Precipitation	Globe	Root Mean Square Error
Global mean SAT anomaly (SATA)	Detrend of SATA	Taylor skill (Taylor, 2001)
Tropic SSTA annual cycle	Pacific	Pattern Correlation
Warm extremes	1980-1999, 21 regions	Relative RMS
Asian Monsoon	JJAS mean, annual cycle index	Pattern Correlation
ENSO	SD, variance annual cycle, amplitude, zonal wind stress	Direct comparison or correlation with observation

Global area-weighted mean RMSE of Precipitation (1980-2005)(OBS: GPCP)



Mean: 1.31; Max: 1.72; Min: 1.09 (unit: mm/day)

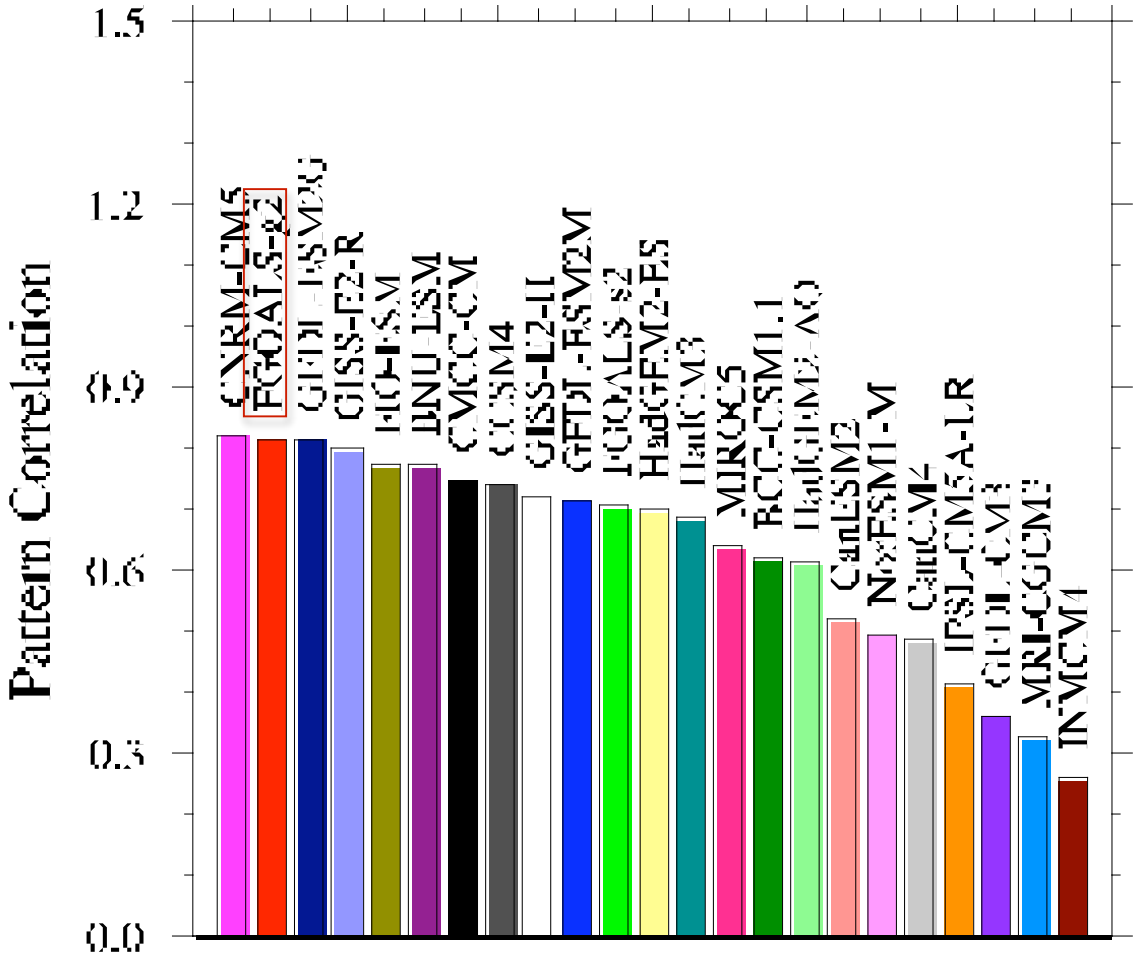
20th Century SAT Variation (1870-2005)



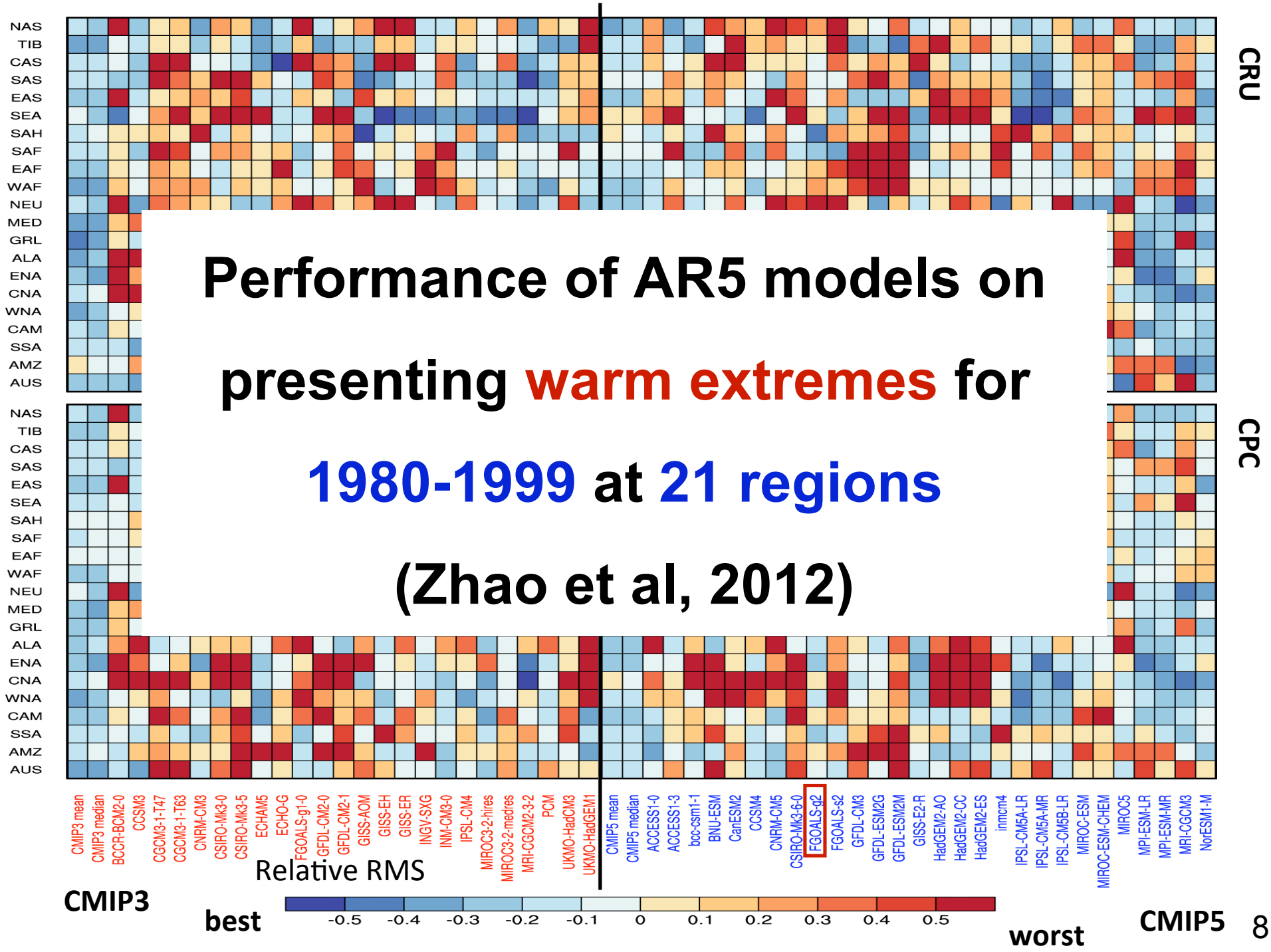
Mean: 0.52; Max: 0.64; Min: 0.39

Tropic Pacific Annual Cycle

(2^{o}S-2^{o}N, 120^{o}E-80^{o}W)

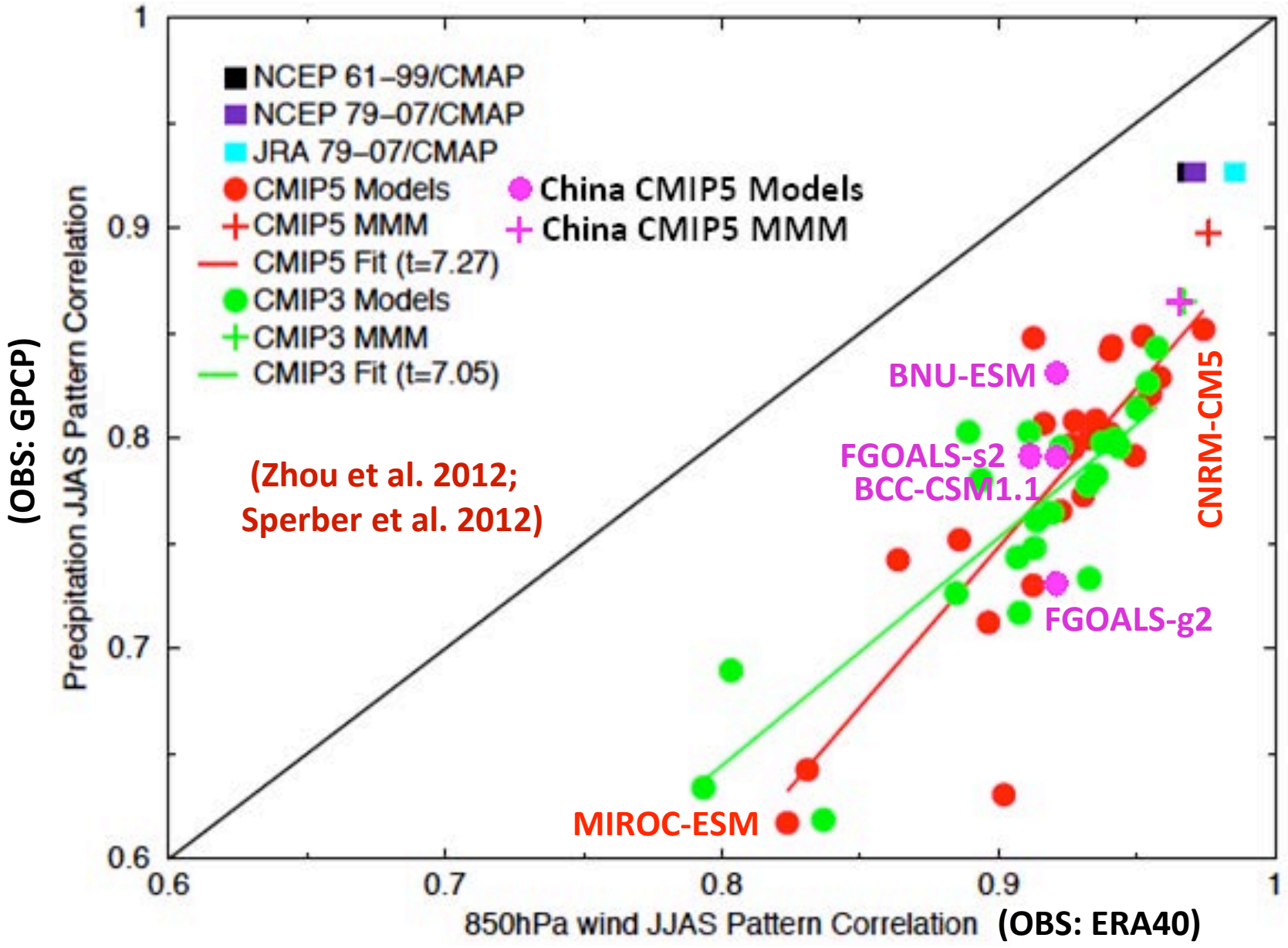


Mean: 0.63; Max: 0.82; Min: 0.26



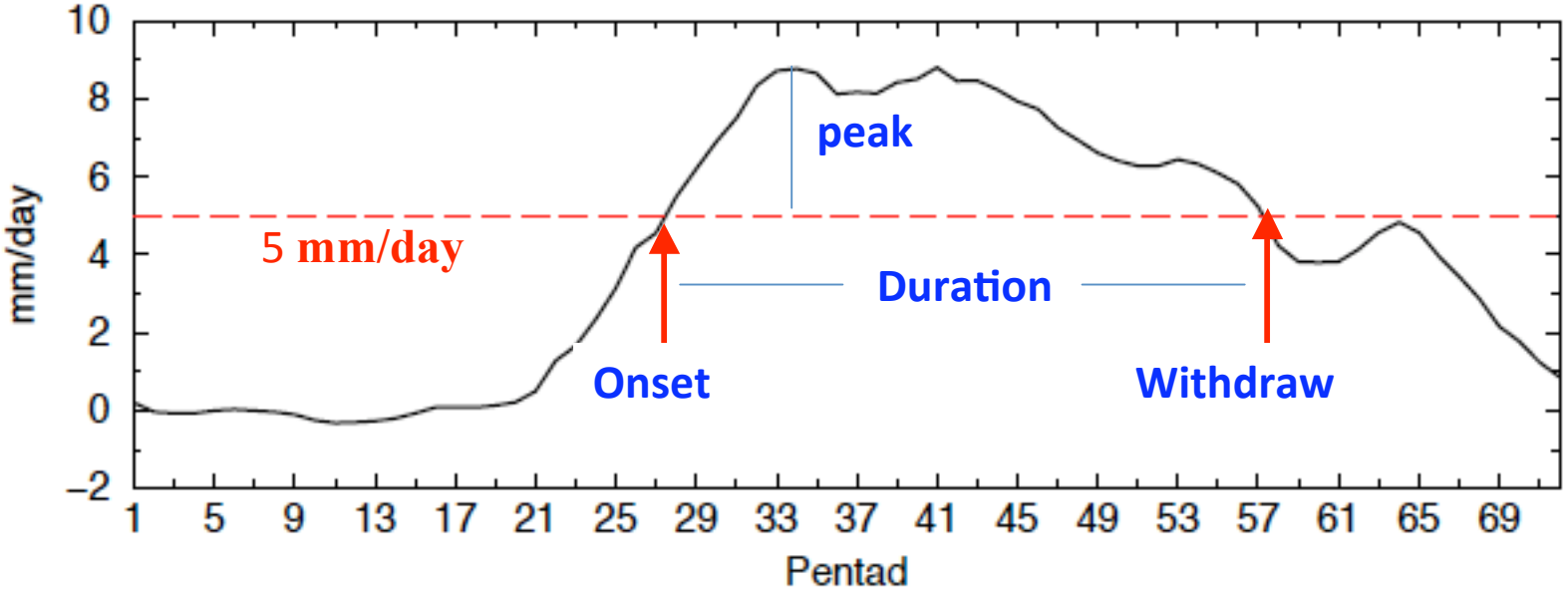
Performance of AR5 models on presenting warm extremes for 1980-1999 at 21 regions (Zhao et al, 2012)

Skills of CMIP Models on JJAS Asian Precipitation and Wind



Summer monsoon annual cycle index

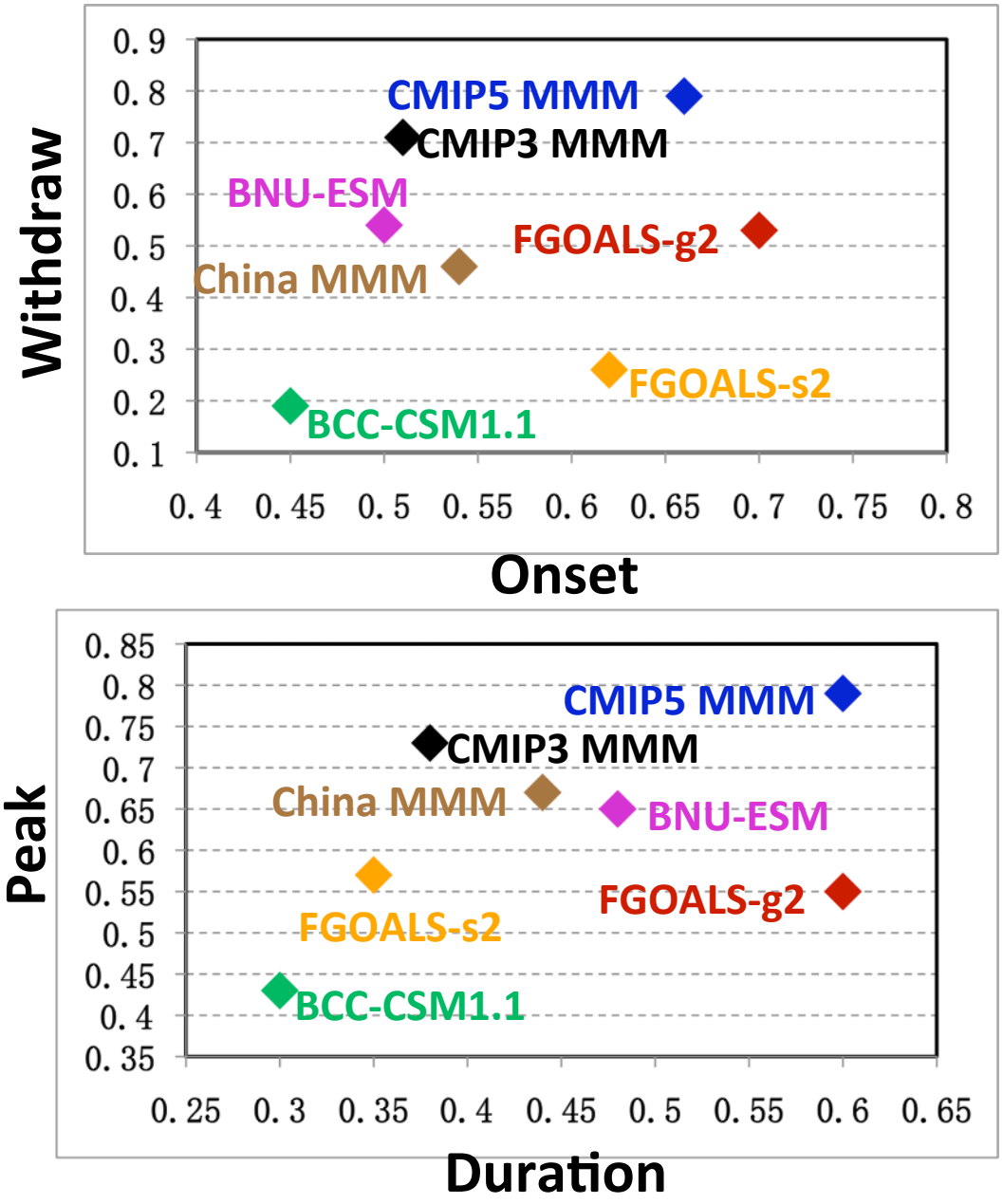
Relative rainfall rate in the Bengal Bay region



(Sperber et al. 2012)

Asian summer monsoon

(Zhou et al. 2012; Sperber et al. 2012)



1) Comparing with CMIP3 models, CMIP5 models improve the Asian summer monsoon significantly;

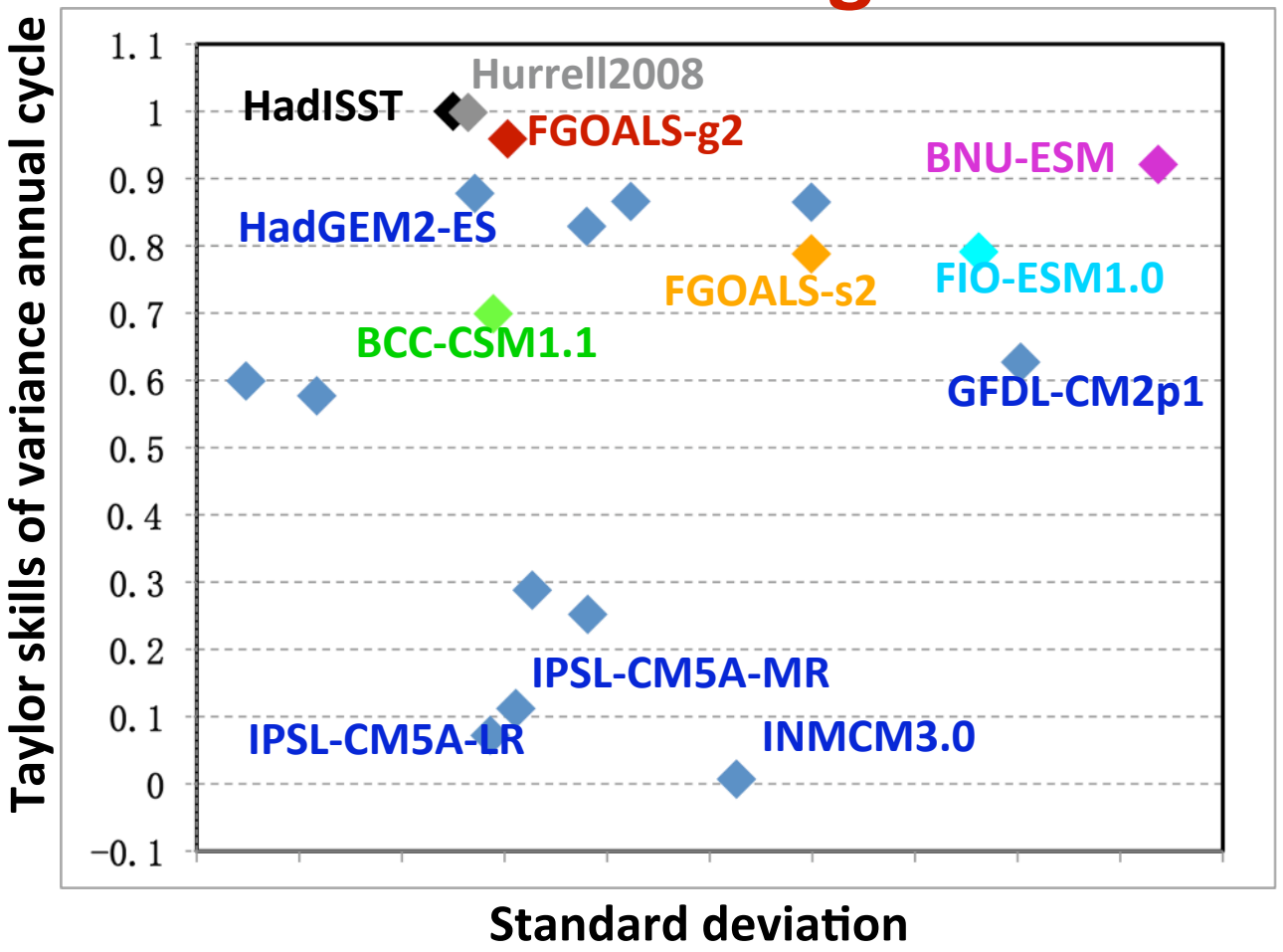
2) China MMM performs better than CMIP3 MMM on onset and duration, but worse on withdraw and peak;

3) FGOALS-g2 presents better onset and duration but worse withdraw and peak than both CMIP3 MMM and CMIP5 MMM;

4) FGOALS-g2 presents better onset, withdraw and duration but worse peak than China MMM.

(OBS: GPCP)

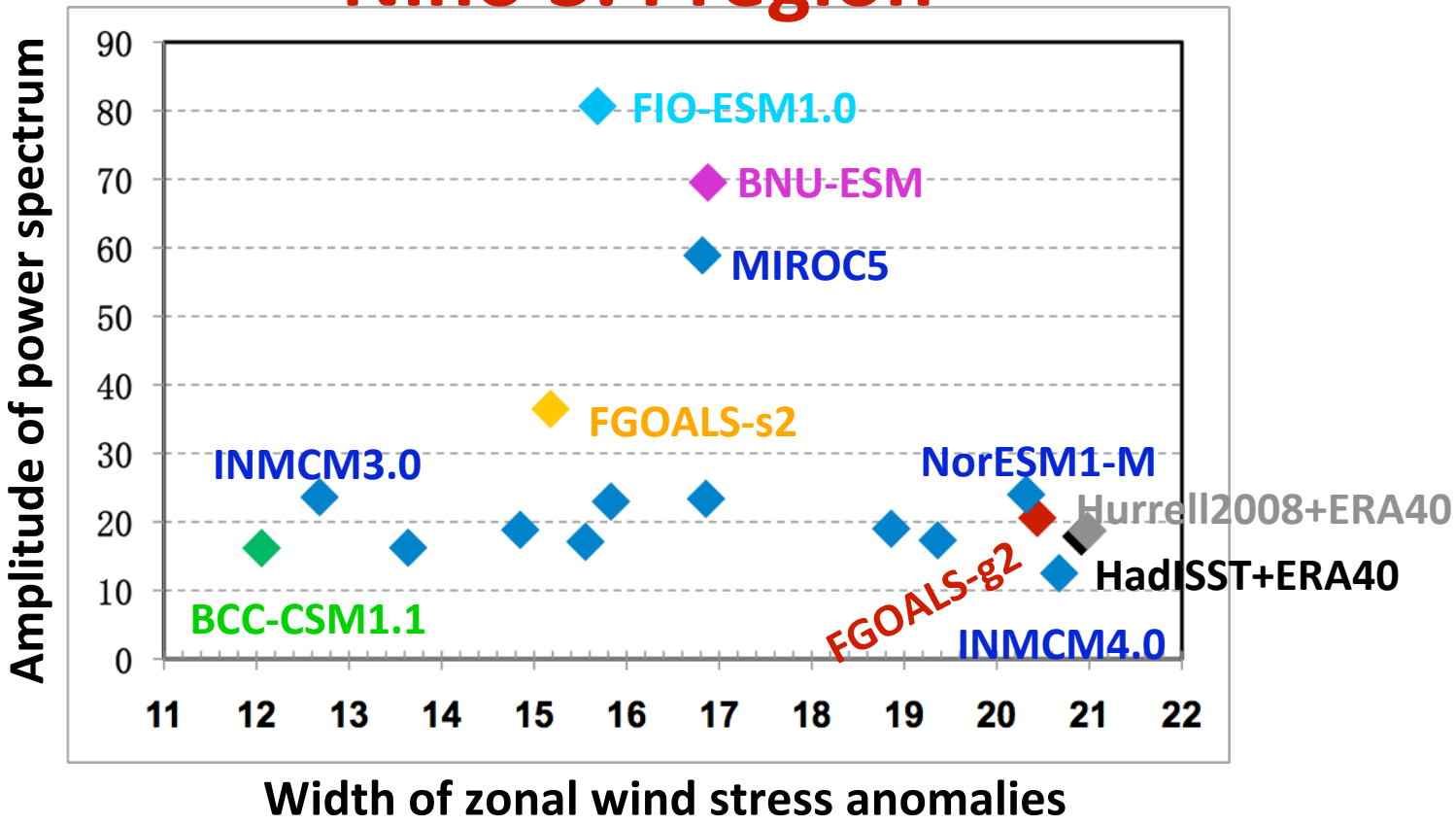
Nino 3.4 region



Other models: CNRM-CM5, INMCM4.0, MIROC5, MIROC-ESM, MPI-ESM-LR, NorESM1-M

(Huang et al, 2012)

Nino 3.4 region



Other models: CNRM-CM5, HadGEM2-ES, IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM, MPI-ESM-LR

(Huang et al, 2012)

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- Important applications
- Progress in coupling techniques
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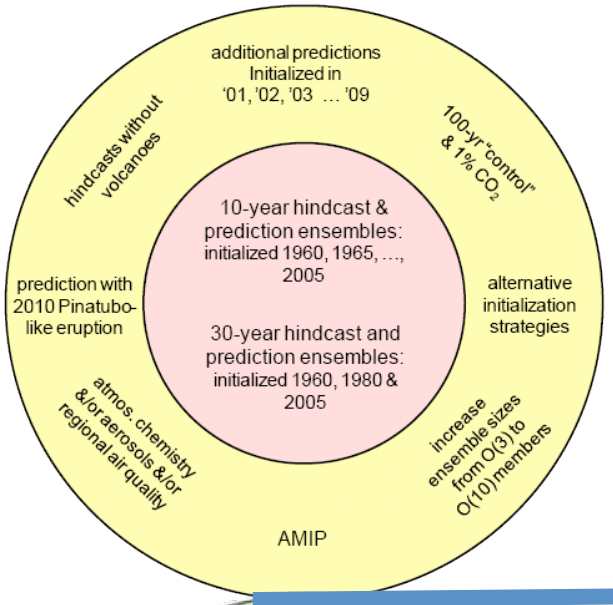
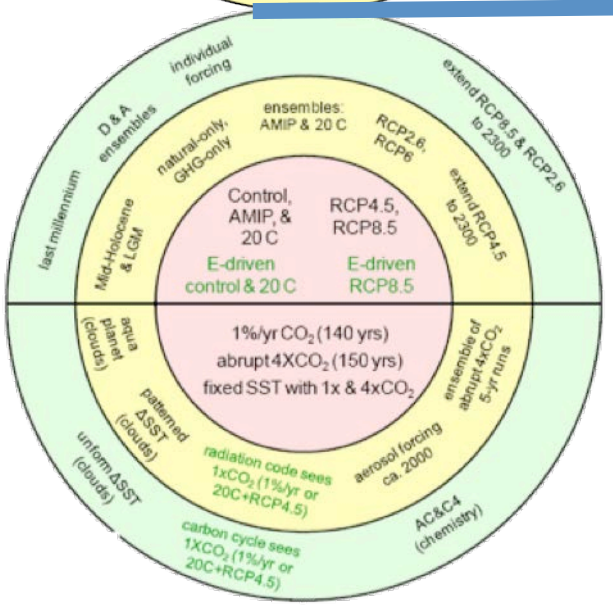
Attribution, Centurial Projection and Decadal Prediction





Modeling scheme courtesy of Dong, 2010
http://114.255.218.74/index.jsp

CMIP5 models

- **CESM**
- **BNU-ESM**
- **FGOALS**
- **FIO-ESM**
- **BCC-CSM**

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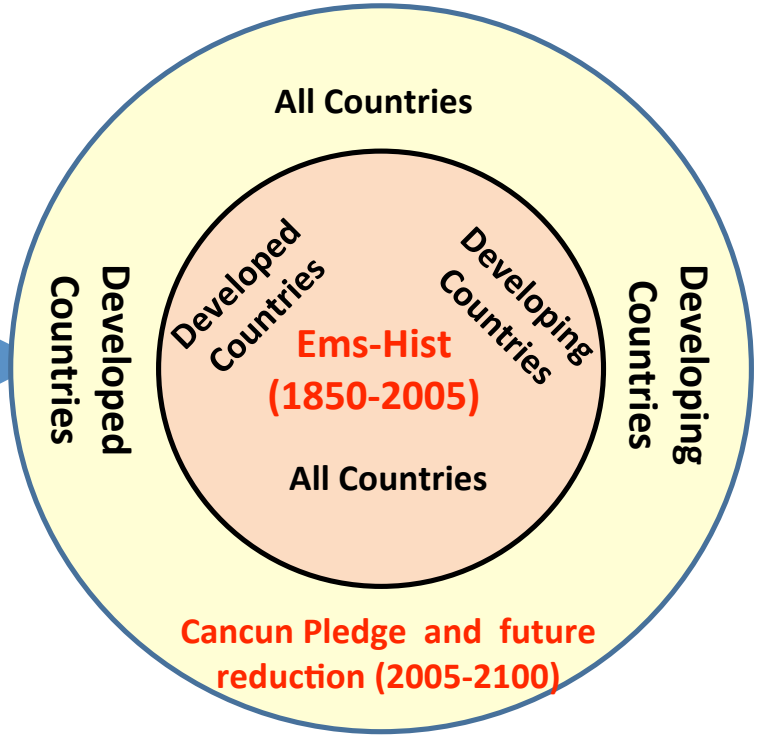
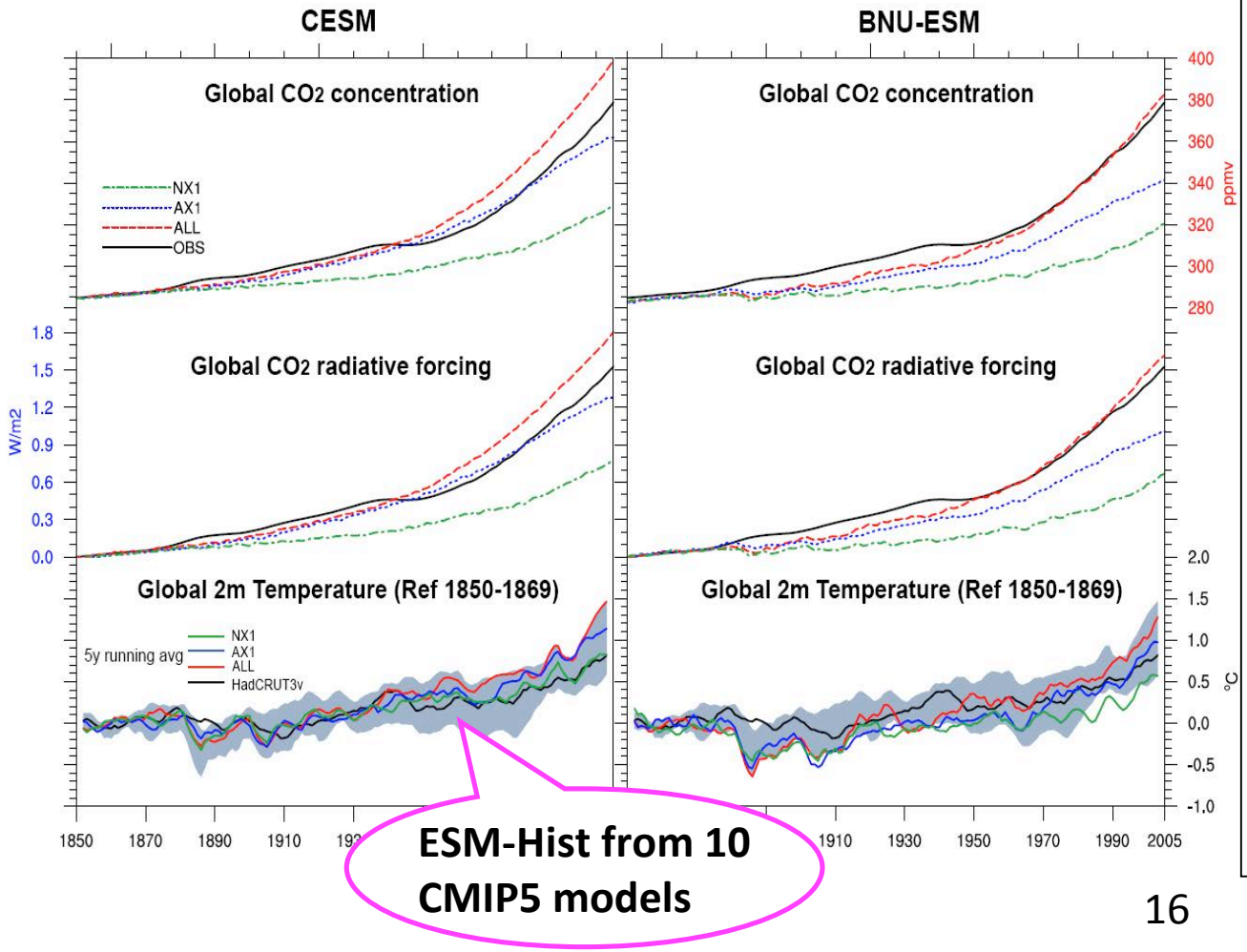
Projections



Developed and developing world responsibilities for historical climate change

ALL = All countries' emission= =AX1+NX1
AX1= developed countries' emissions ;
NX1= developing countries' emissions;



- CO_2 concentration :

Developed: 61% and 71%;

Developing: 39% and 29%;

- CO_2 radiative forcing:

Developed: 53% and 62%;

Developing: 47% and 38%;

- Air temperature:

Developed: 60% and 64%

Developing: 40% and 36%

Wei et al., 2012, PNAS

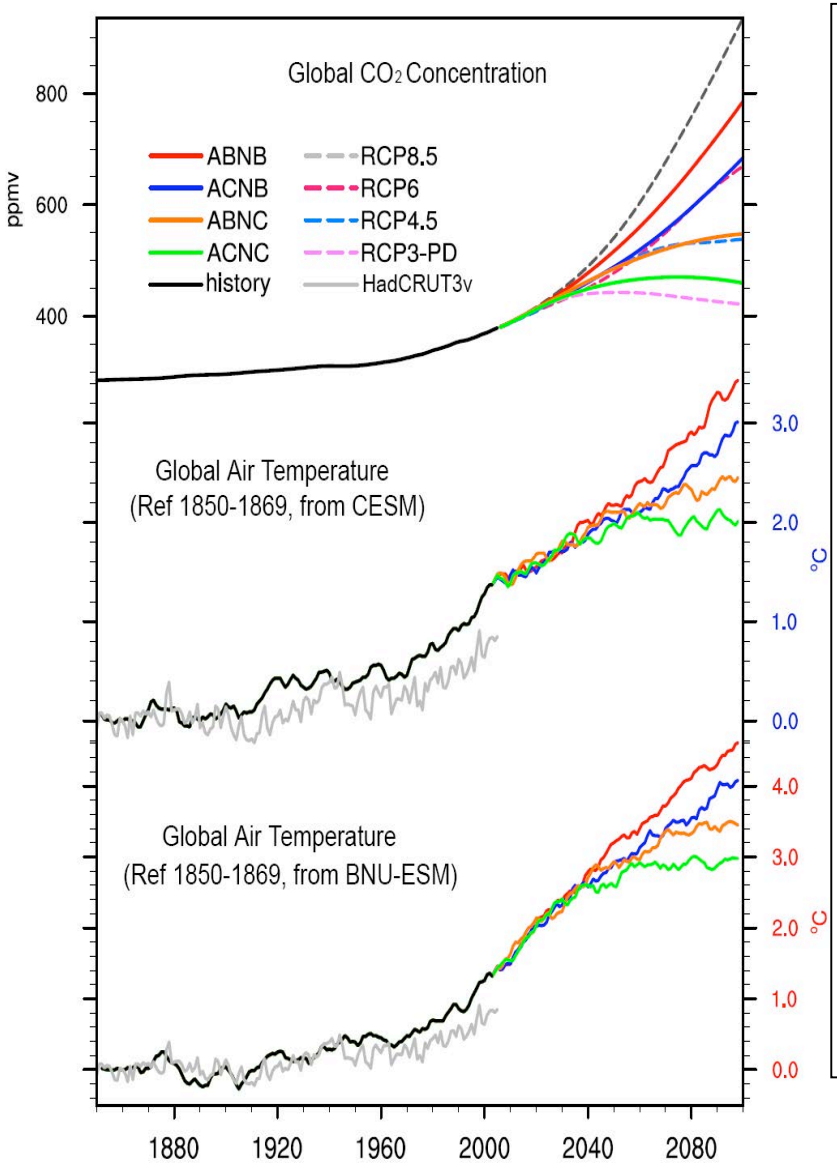
Developed and developing world responsibilities for CO_2 mitigation

ABNB =all countries non-mitigation;

ACNB =only developed countries follow Cancun (2006-2020)+ 80% reductions by 2050 and zero emissions by 2100;

ABNC =only developing countries follow Cancun (2006-2020)+ 50% reductions by 2050 and zero emissions by 2100;

ACNC =all countries mitigation



- **Contributions to reduction of global warming:**

Developed: 33% and 35%

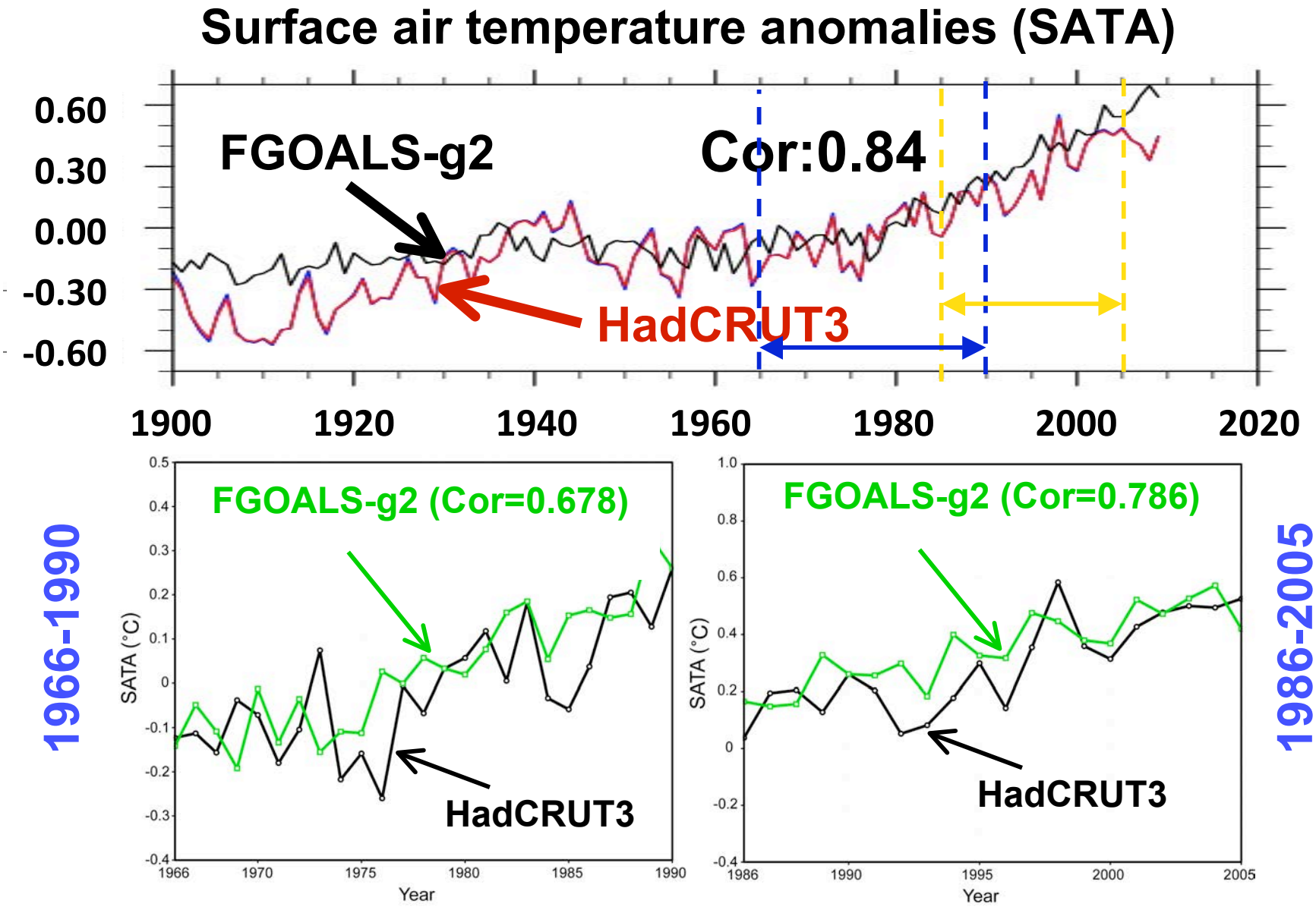
Developing: 67% and 65%

- **Mitigation goal:**

Current mitigation cannot control rising temperature within 2℃ in 2100. It is necessary to fill the gap with more ambitious mitigation efforts.

Wei et al., 2012, PNAS

Surface Air Temperature Anomalies by FGOALS-g2 (2nd sample of historical run)



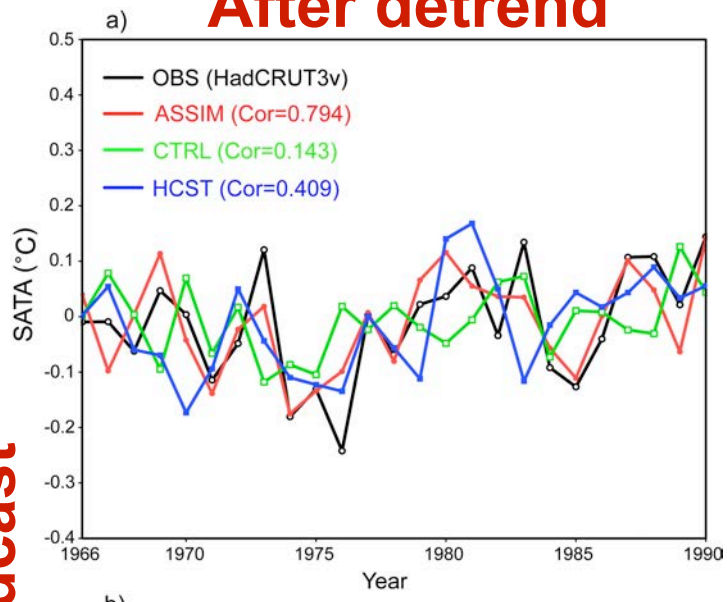
30-year predictions of SATA by FGOALS-g2

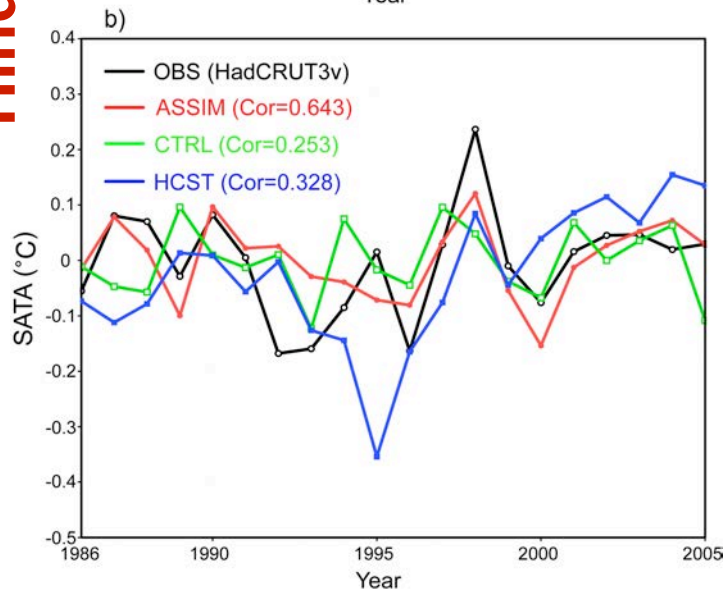
After detrend

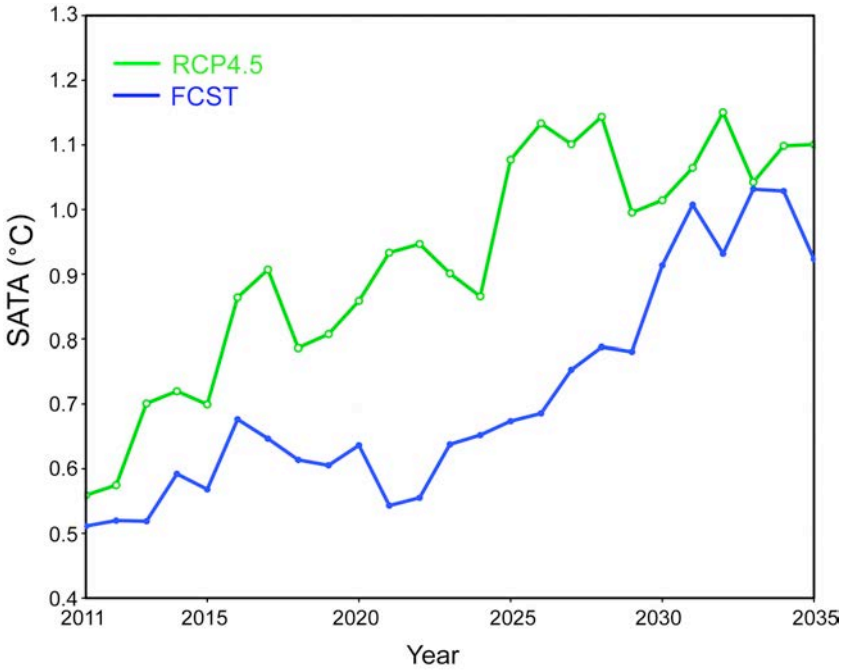
Hindcast

1966-1990

1986-2005







2011-2035
(Forecast)

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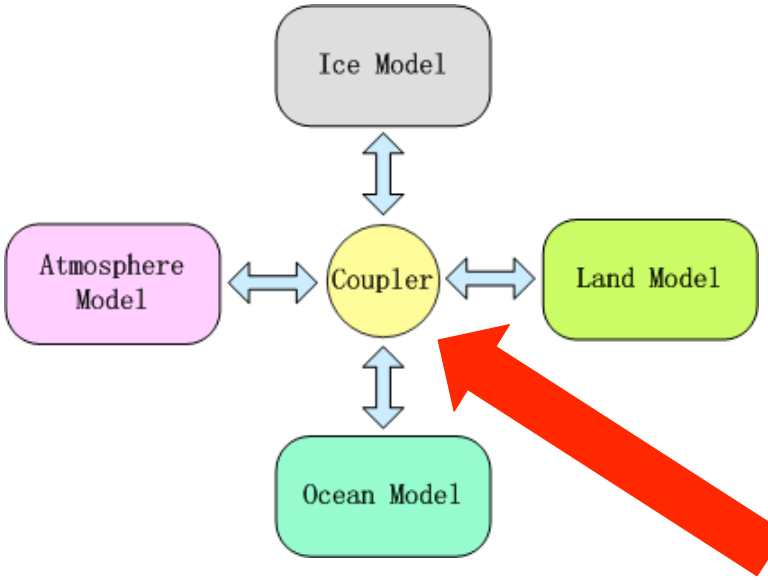
Lack of direct flux exchange in available couplers

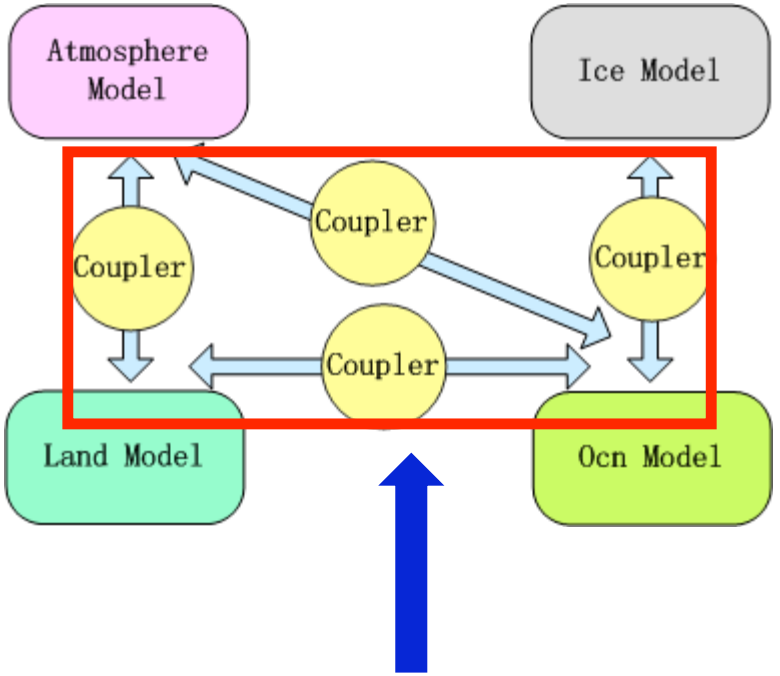
NCAR Coupler



Centralized flux coupler
without direct flux exchange

(Liu et al, 2011)

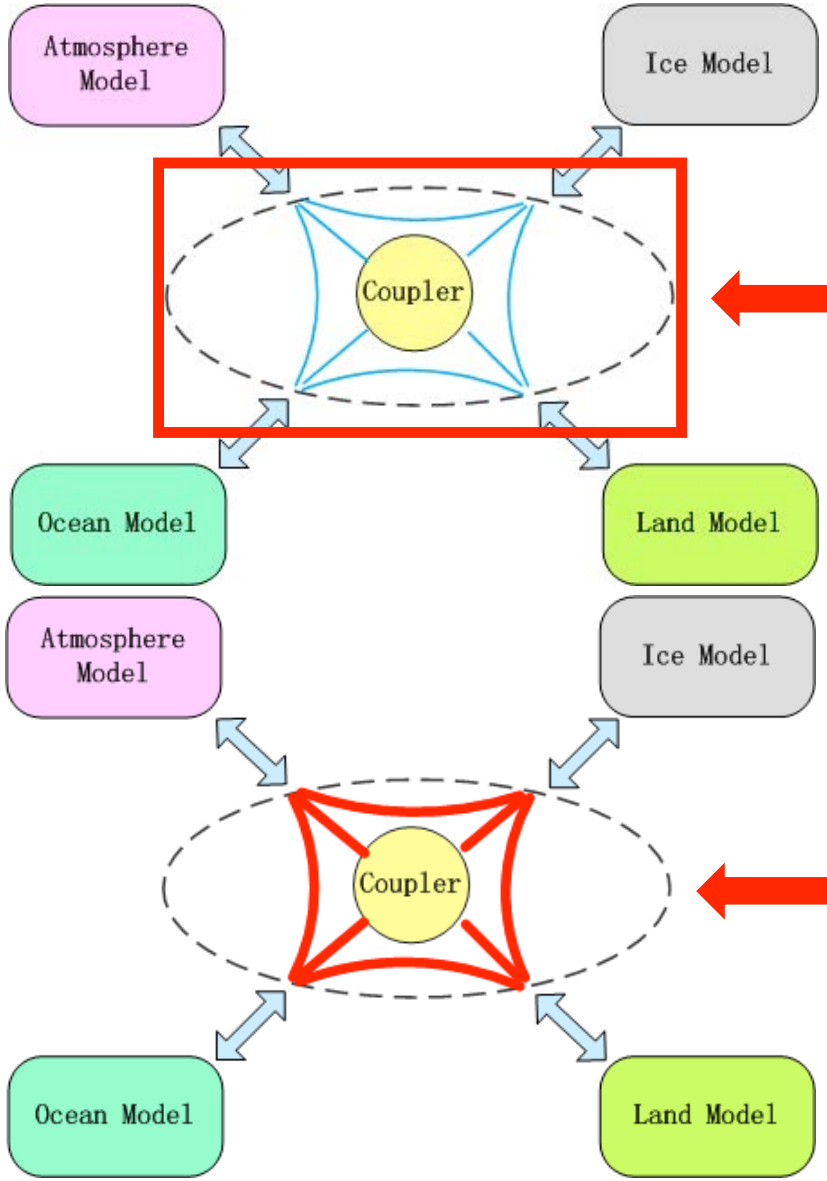
OASIS Coupler



Decentralized non-flux coupler without direct flux exchange

C-Coupler: to overcome the imperfection

(the first coupler developed by Chinese scientists)



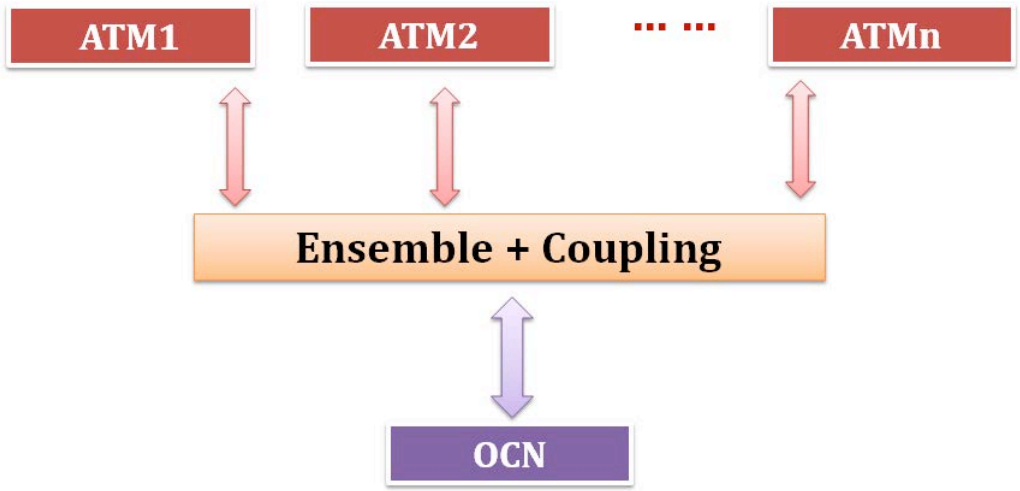
Centralized flux coupler for modularization and standardization

Direct flux exchange for better parallel efficiency of high-resolution models

(Liu et al, 2011)

Ensemble coupling software framework

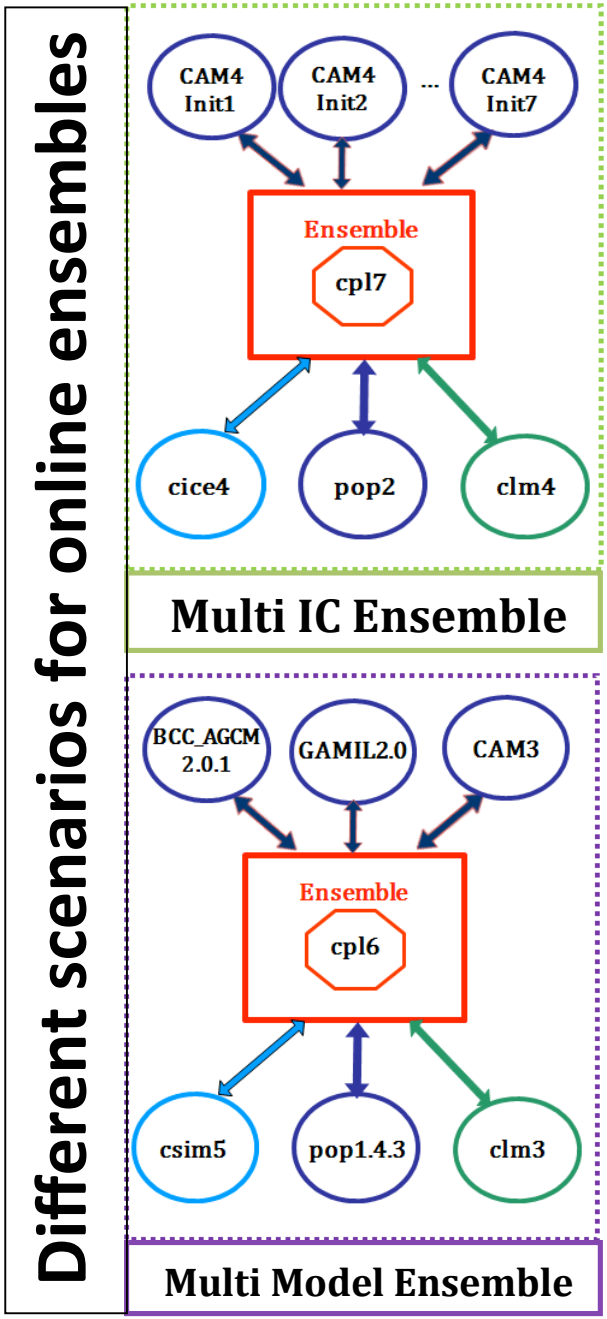
Online ensemble tool for coupled climate model



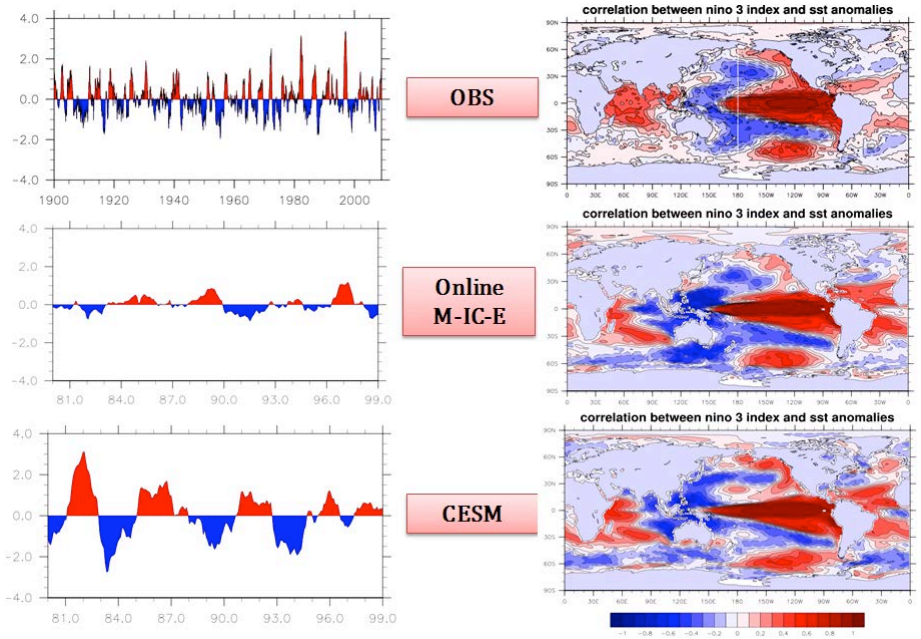
Motivation

How **weather noise / atmospheric model uncertainty** impacts the climate response?

(Xue et al, 2011)



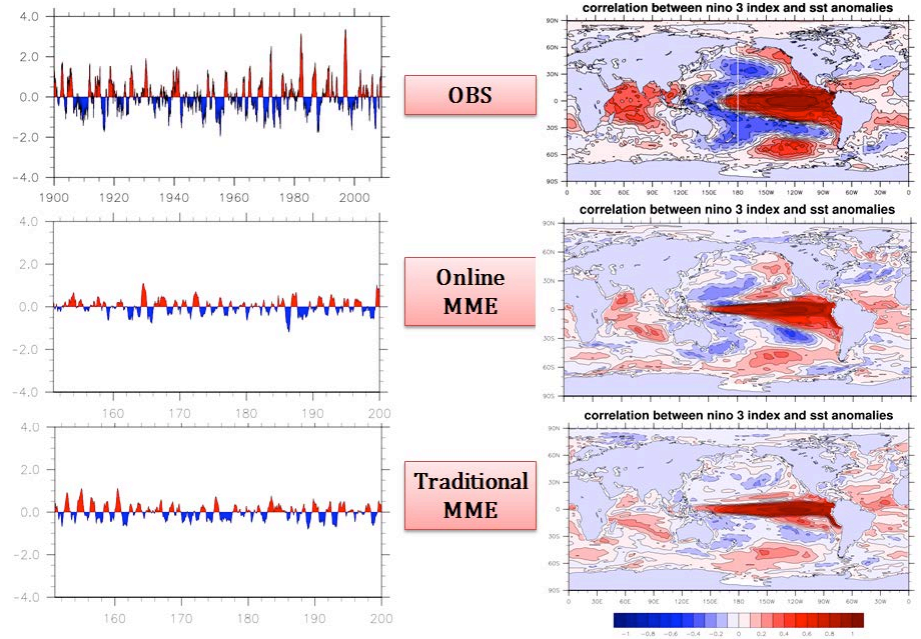
ENSO



(Xue et al, 2012)

Online Multi-initial condition ensemble

Single initial condition



Online Multi-model ensemble

Offline Multi-model ensemble

(Xue et al, 2011)

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Future Plan for AR6

- Further evaluation of China CMIP5 models and other CMIP5 models for understanding of uncertainties in these models;
- Development of high-resolution AGCM and OGCM (0.5^0-0.1^0 in horizontal and 50 layers in vertical within 5 years);
- Development of earth system model based on our own coupler: C-Coupler;
- Improvements of online ensemble coupling framework and ensemble coupling strategies;
- Improvements of dynamical cores, physical parameterizations, and carbon cycle processes.

Thank you