Decadal Climate Prediction : A Challenge

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and

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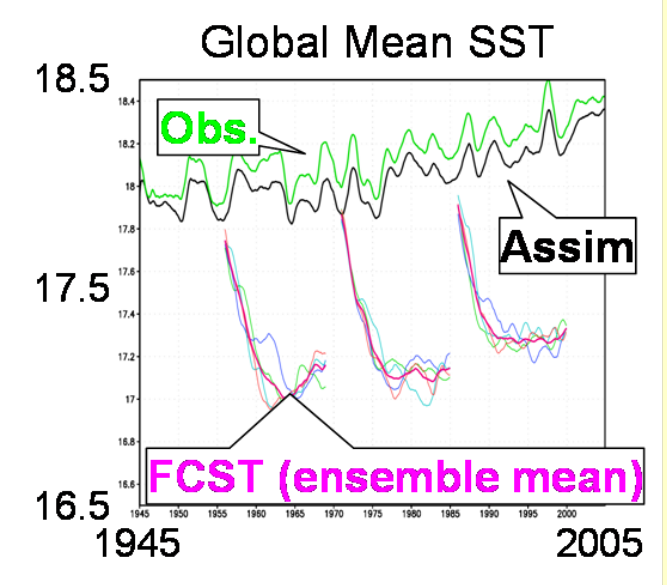
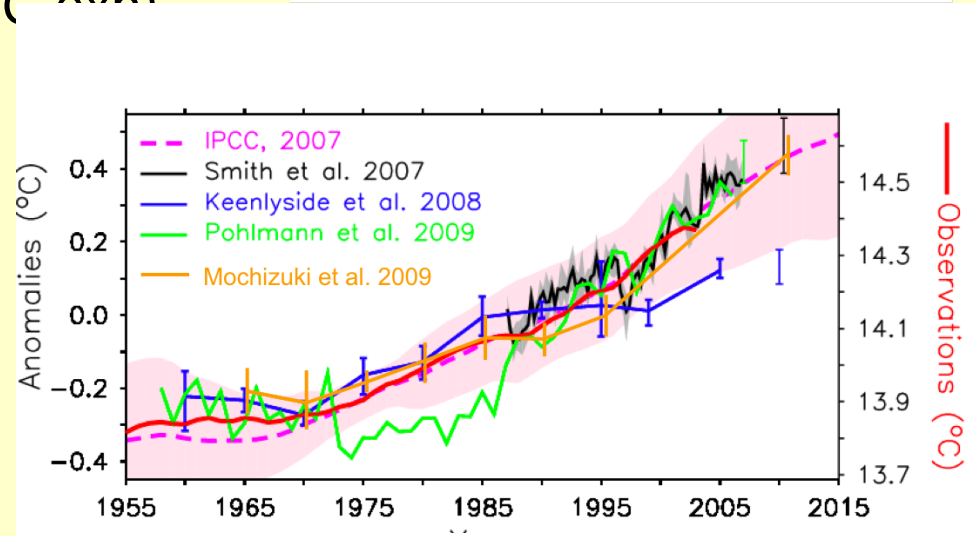
3: National Institute for Environmental Studies (NIES)

4: Kyoto Univ.

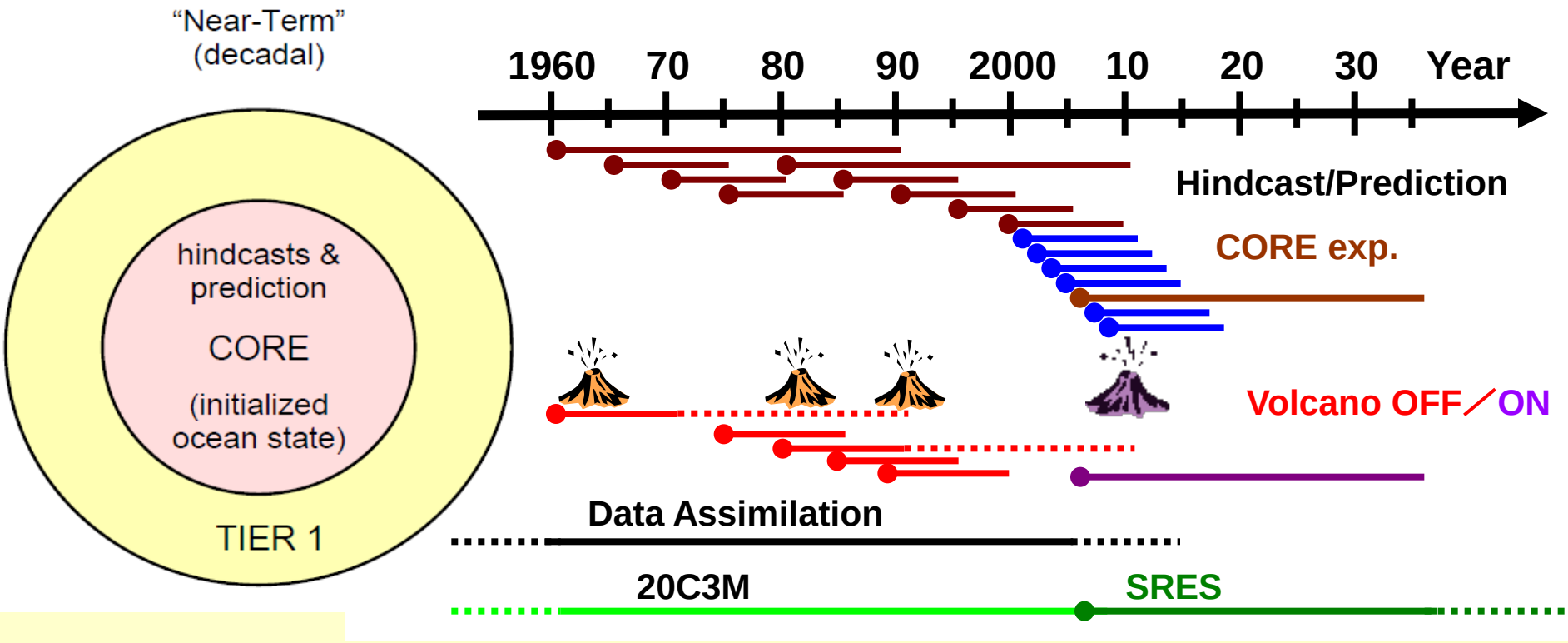
Near-Term Projection: Issues

- Societal needs
- Regional details vs. Uncertainty
  i.e., Resolution vs. Ensemble
- Near-term uncertainty:
  Natural variability
  >> Socio-economic scenario
  → Mixed Initial-Boundary value problem
  → (a new category of CMIP/IPCC exp)
- Initialization? How?
- Drift?
- Decadal predictability?
- Models good enough?
- Chemistry? Aerosols?
- Volcanoes?



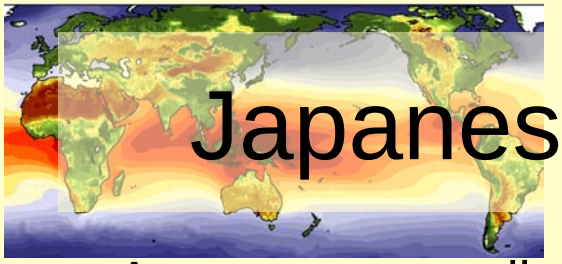


CMIP5 Experimental Design



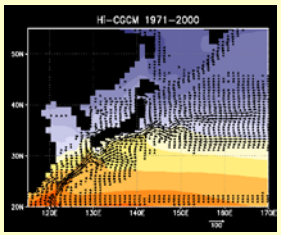
Taylor et al. (2008)

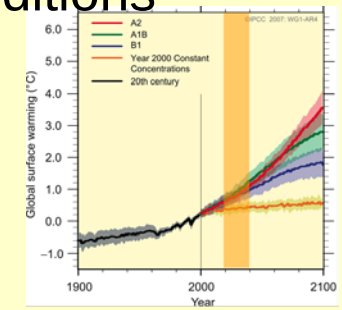
5000-Year Integration
for 10 member ensemble,

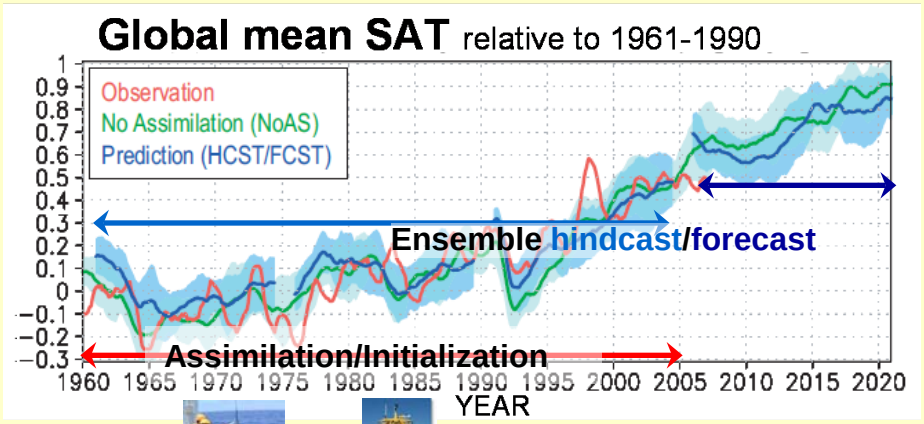


Japanese CLIMATE 2030 Project

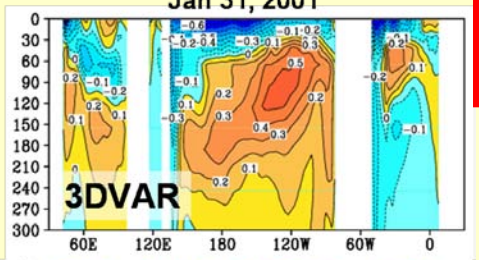
- A near-term prediction up to 2030 with a high-resolution coupled AOGCM
  - 60km Atmos + 20x30km Ocean
  - w/ updated cloud PDF scheme, PBL, etc
  - advanced aerosol/chemistry
- Estimate of uncertainty due to initial conditions
  - Initialization & ensemble generation
  - For impact applications
    - water risk assessment system
    - impacts on marine ecosystems
    - etc.
- Test run w/ 20km AOGCM (in 2011)

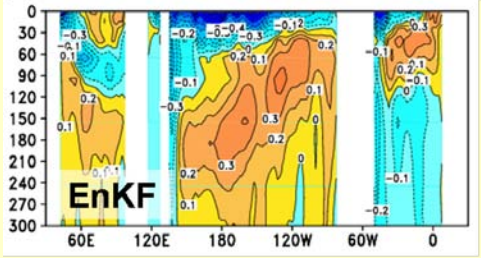




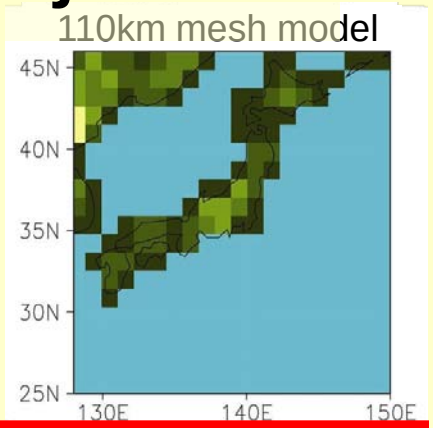


Equatorial X-section Zonal Current
Jan 31, 2001

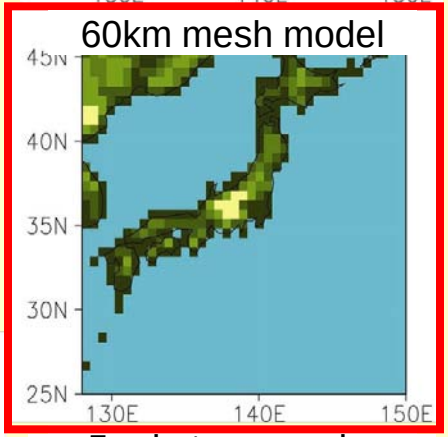




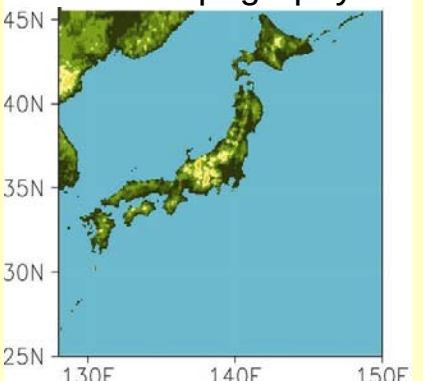
110km mesh model



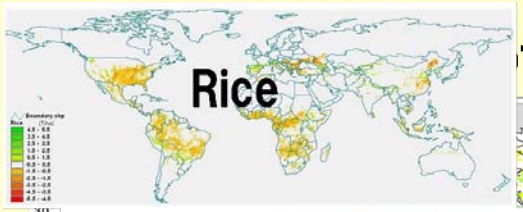
60km mesh model



5-min topography



Impact assessment



fca centennial

Changes in crop yields

in 2070-2100

from 1975-2005

Oki et al. (2007)

Floods of a centennial

Yang et al. (2007)

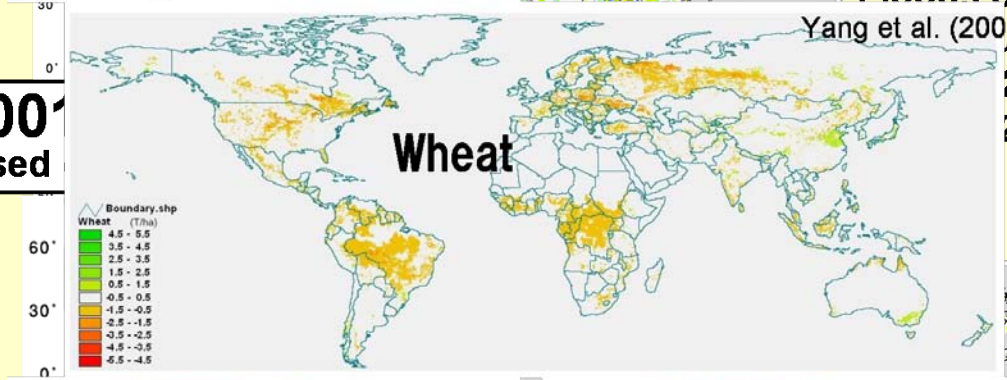
ir

20-40 yrs

2030.

200

based



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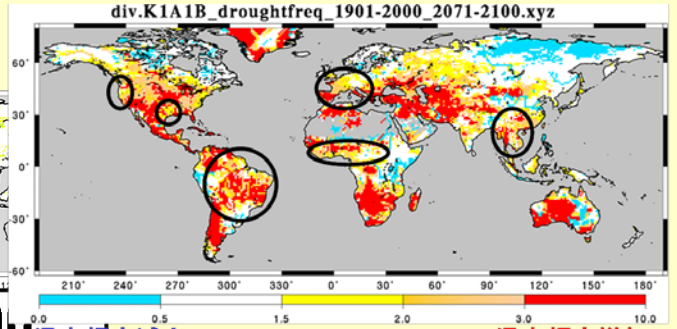
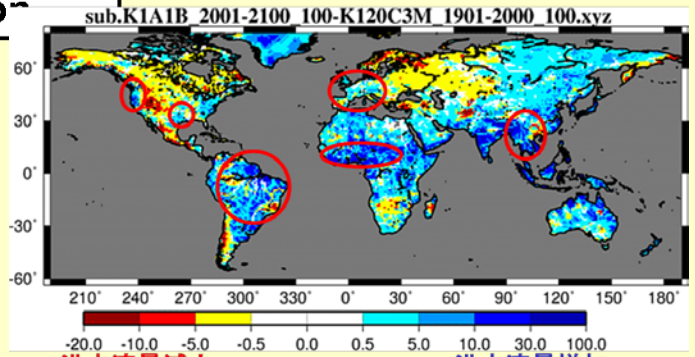
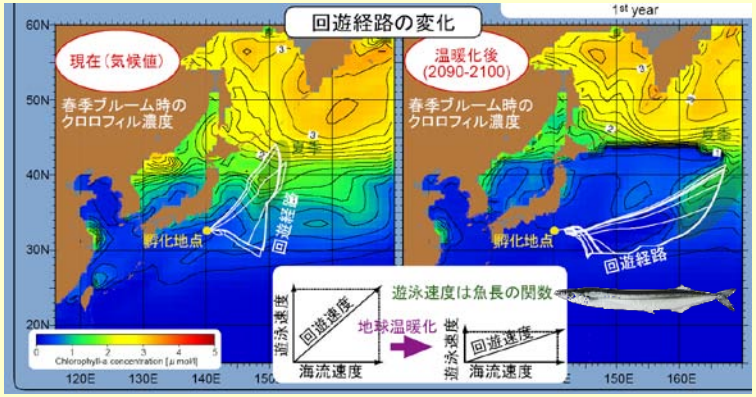


渇水頻度減少　渇水頻度増加



洪水流量減少　洪水流量増加



Hirabayashi et al. (2006)

Analysis and Ensemble Options

SPAM:
System for
Prediction and
Assimilation by
MIROC

- **Applicable to hi-res models**
- **Coupled/Anomaly Assimilation**
- **Heat/Water(salinity) conservation**
- ***LF Assimilation***

Cost ↓

	Data Assimilation	Ensemble Generation
梅	Gridded SST, subsfc T&S*(off-line) + IAU	LAF, Ensemble Assimilation, AIP
竹	3DVAR* + IAU	LAF, Ensemble Assimilation
松	Ensemble Kalman Filter (EnKF)	EnKF

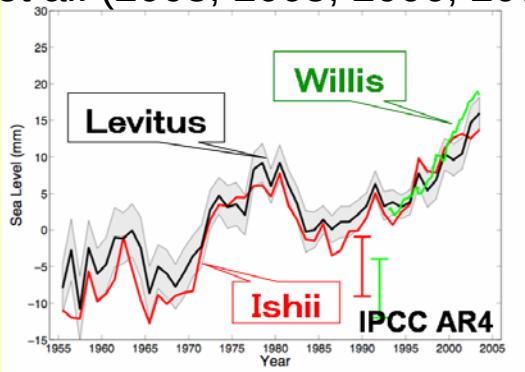
LAF: Lagged Average Forecast

IAU: Incremental Analysis Update

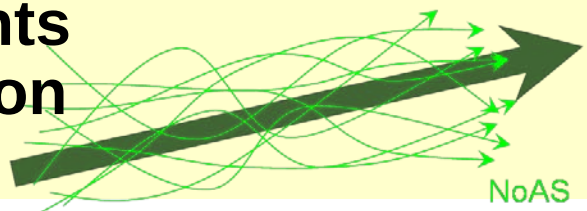
$$\frac{dT}{dt} = Q + \frac{T_a(t_k) - T(t_k)}{\tau}$$

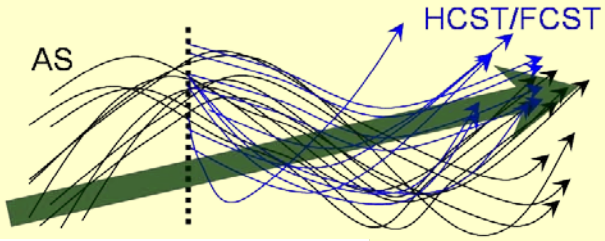
AIP: Analysis Increment Perturbation

*Ishii et al. (2003, 2005, 2006, 2009)

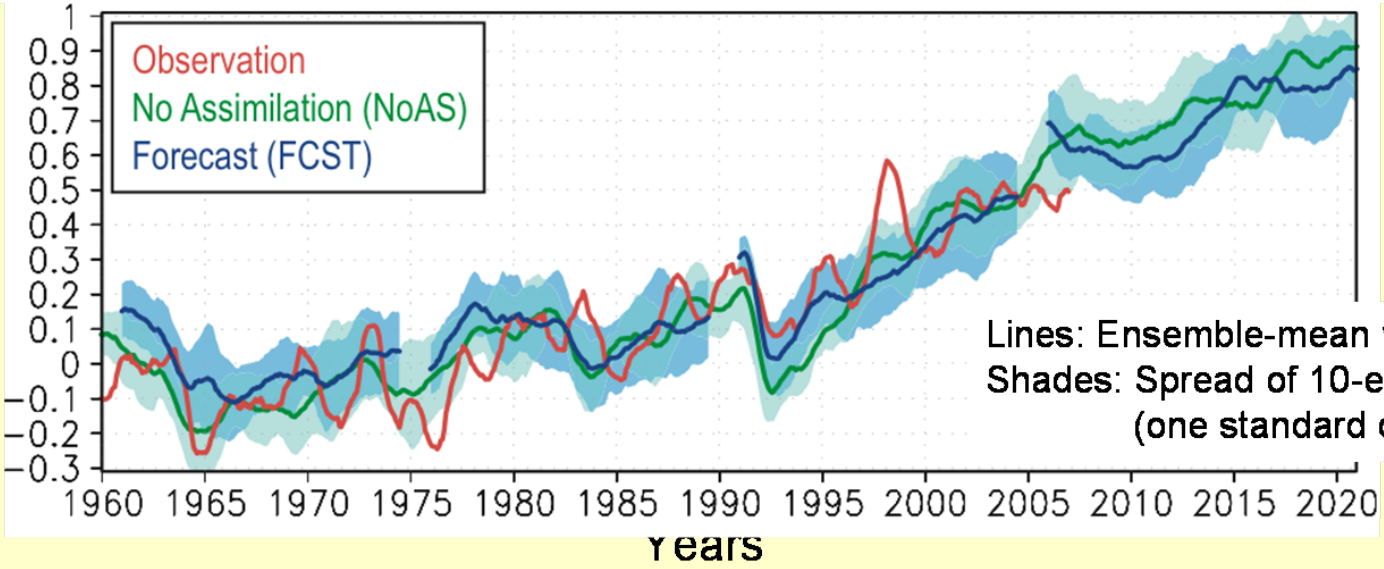


Prediction Experiments w/o and w/ initialization





Global-mean Surface Air Temperature (SAT) anomaly relative to ave. 1961-1990



Linear trend: Response to external forcing (based on a scenario)

0.085 degC/10yr (OBS)

0.080 degC/10yr (NoAS)

Decadal-scale modulation: Internal variability

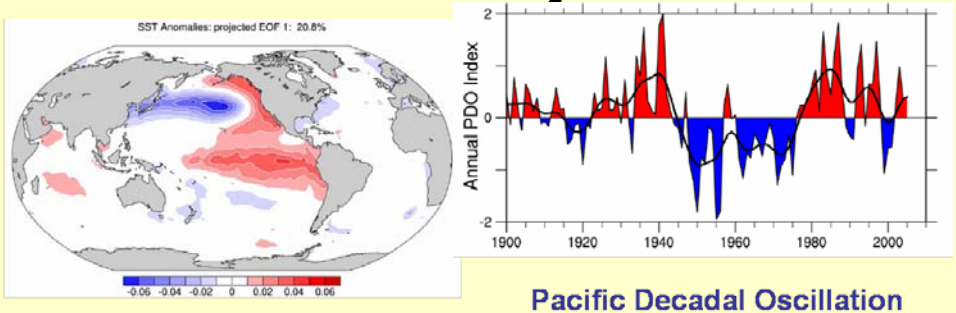
Difference(71-78)-(79-86): 0.149 degC (OBS)

Difference(71-78)-(79-86): 0.091 degC (NoAS)

standard deviation of NoAS's 10 ensembles: 0.078 degC

Mochizuki et al. (2009)

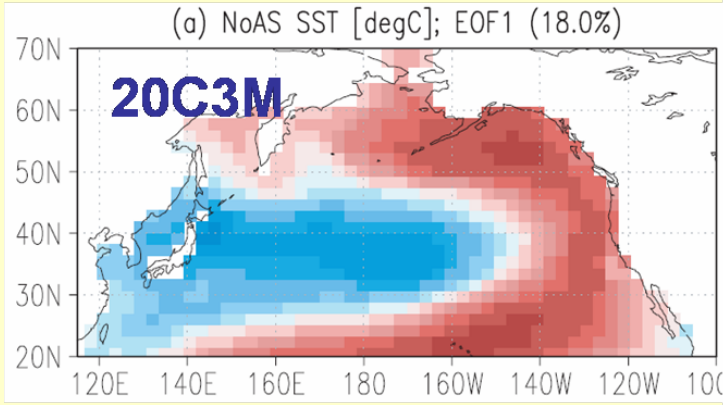
Predictability of PDO: Impact of initialization

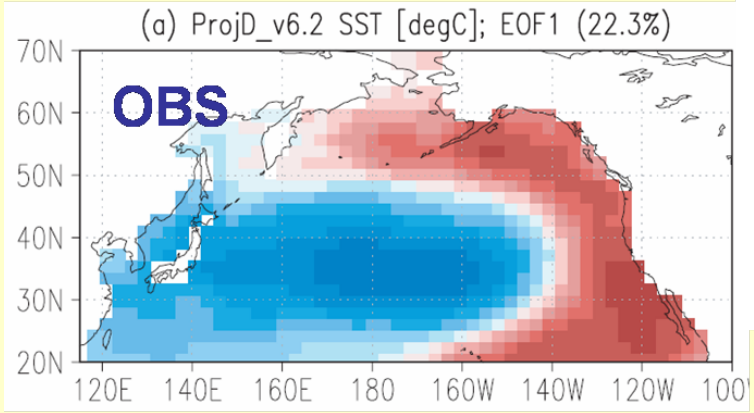


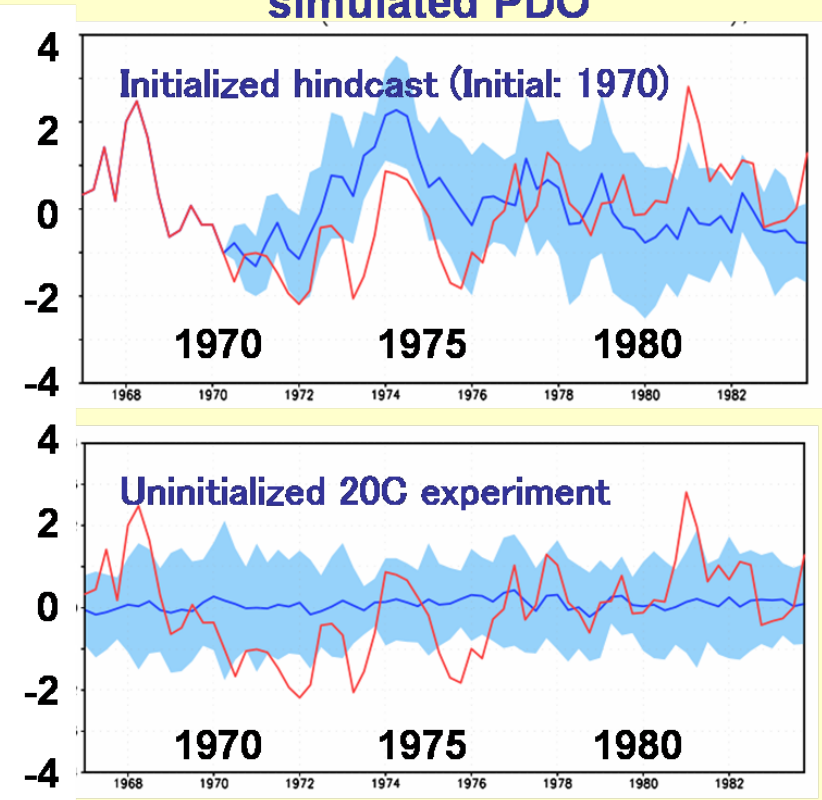
Pacific Decadal Oscillation

SST EOF1 PDO

Time series projected on to simulated PDO







Observation

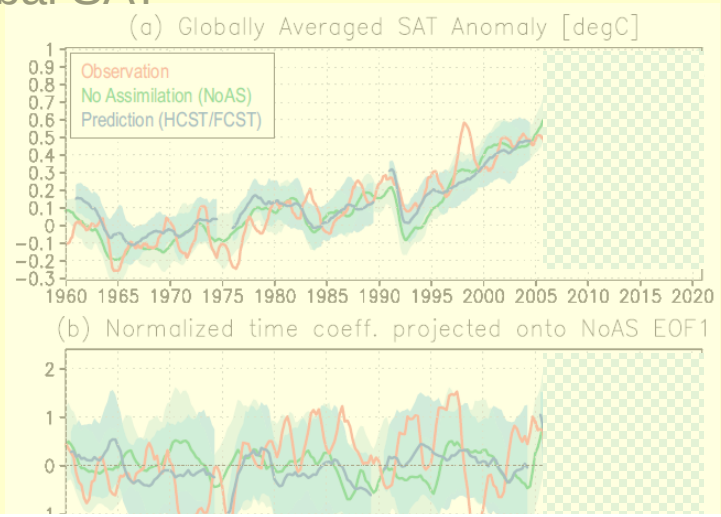
Hindcast & spread

Mochizuki et al. (2009, submitted)

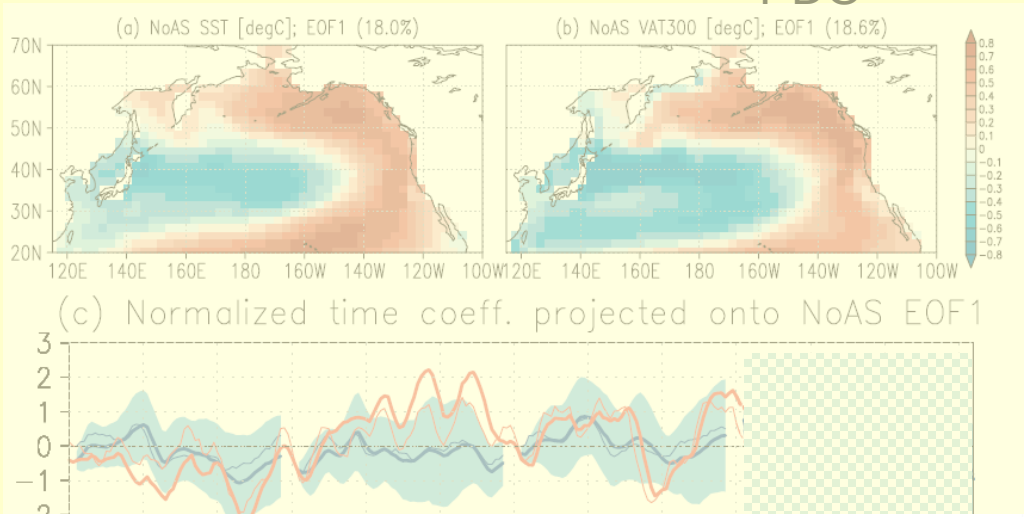
Decadal Predictability?

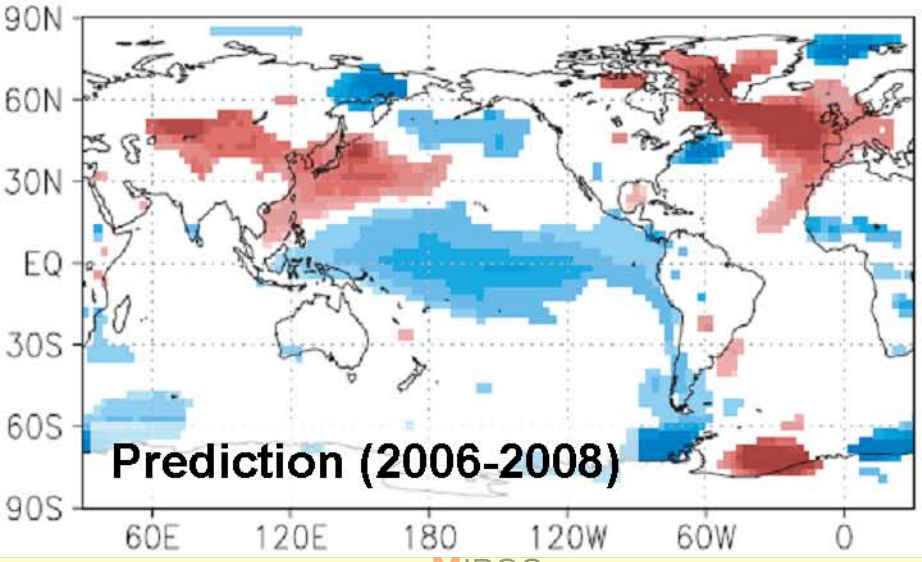
Assimilation vs. Hindcasts w/ & w/o initialization

Global SAT

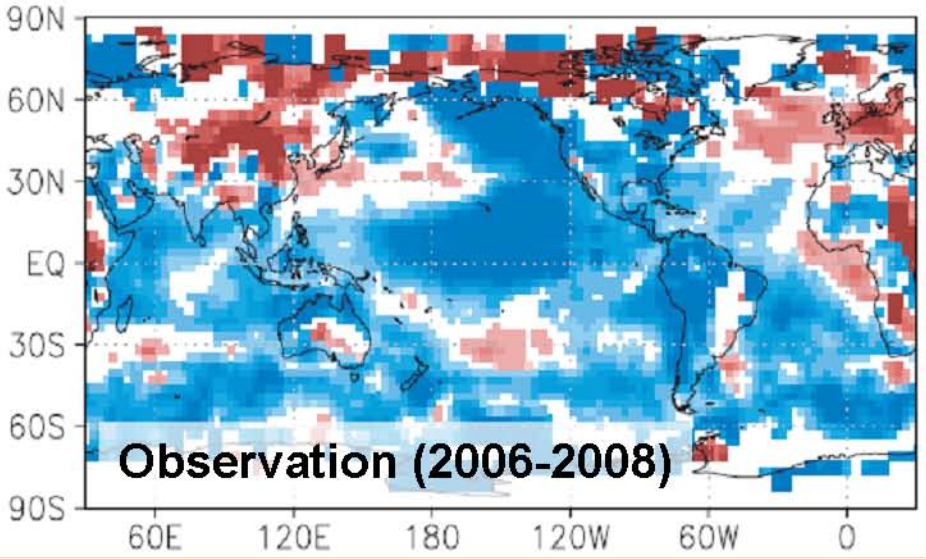


PDO





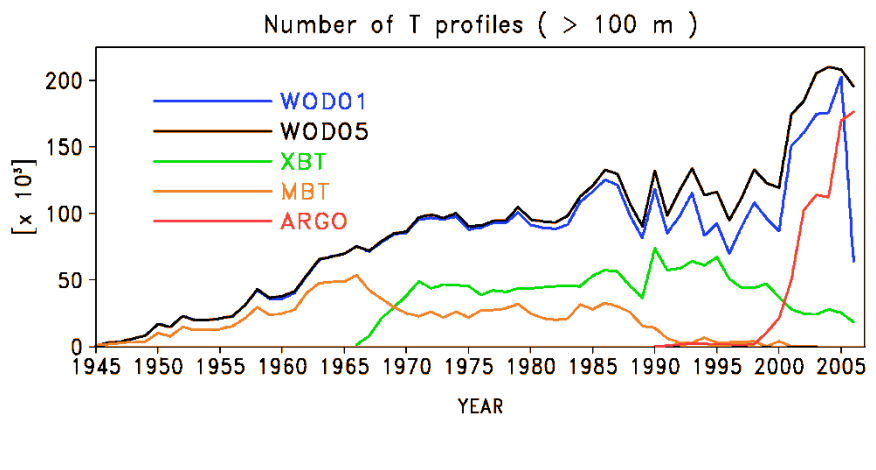
MIROC

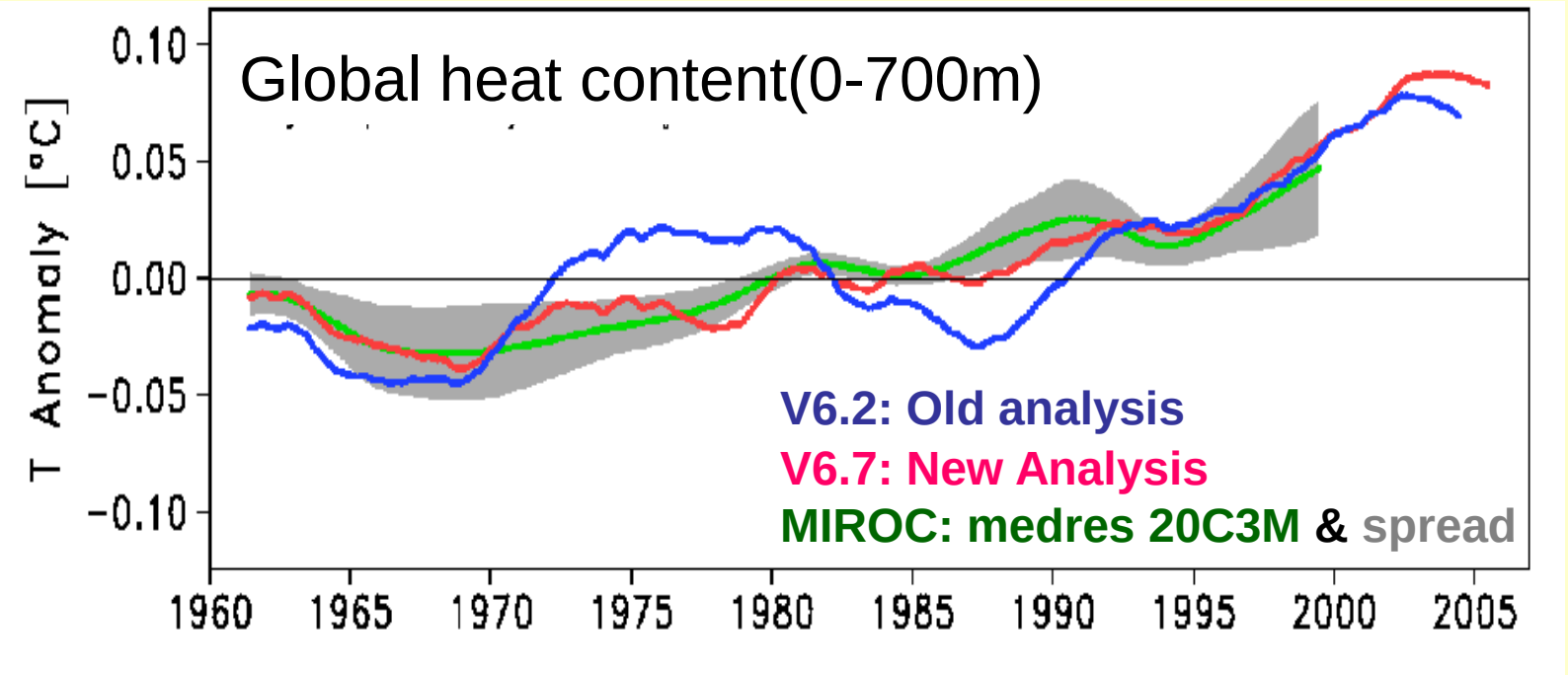


Mochizuki et al. (2009)

Reevaluation of historical upper-ocean heat content

- **Depth correction for historical XBT & MBT (Ishii and Kimoto, 2009)**

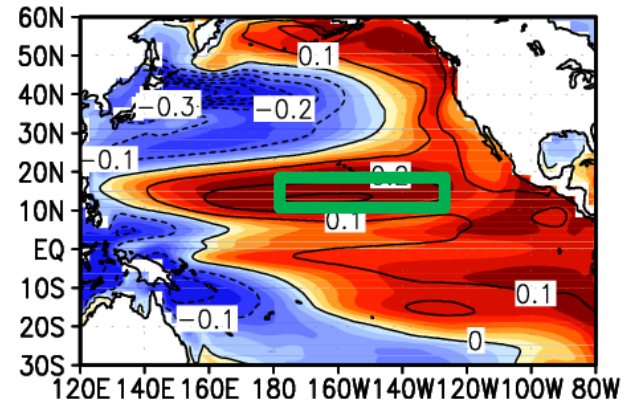


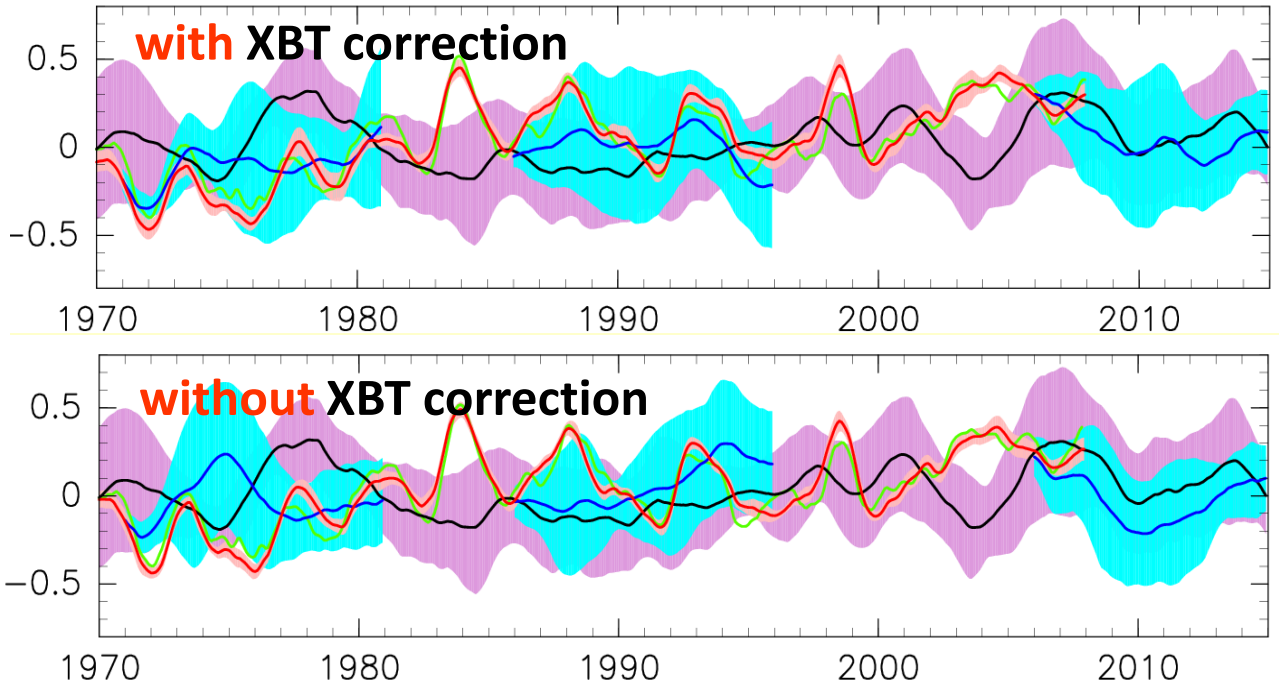


Impact of XBT correction

Obs Assim HCST 20c3m/SRES

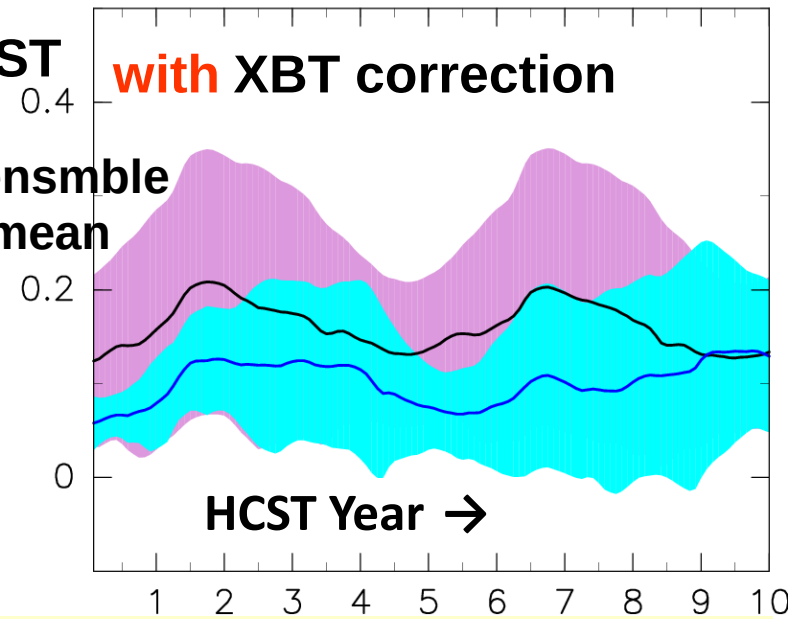
VAT300 EOF 1

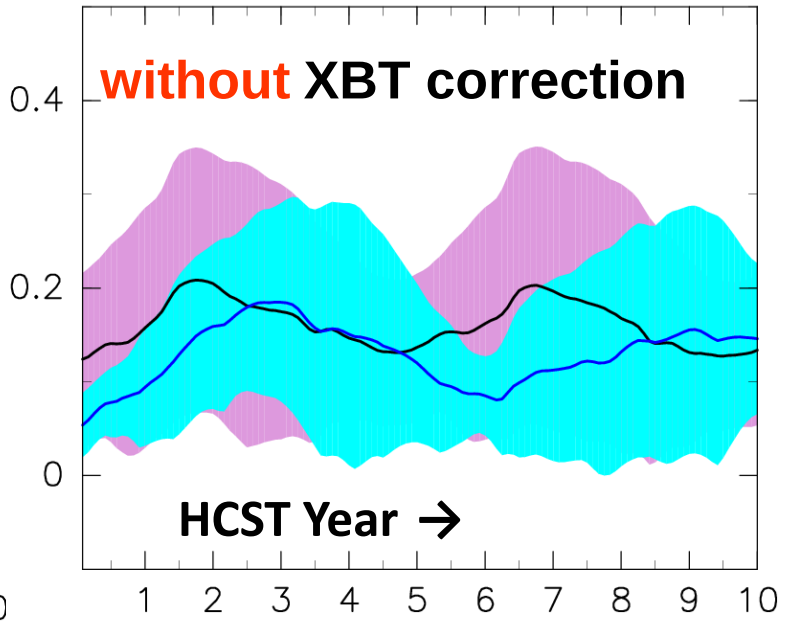




RMSE of HCST

- **7 ICs**
- **10 member ensmble**
- **3yr running mean**





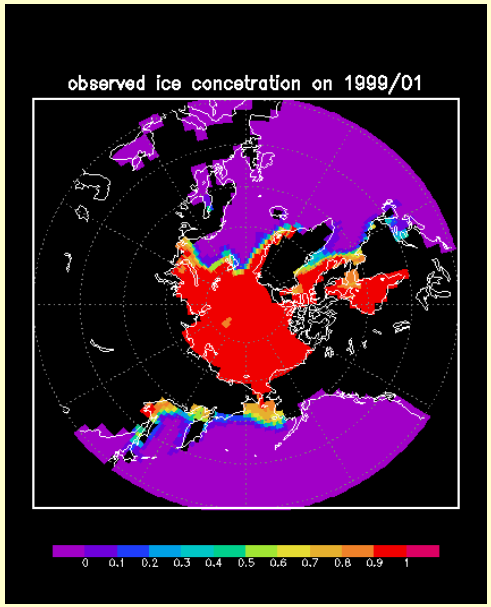
(Yasunaka)

Sea Ice Data Assimilation

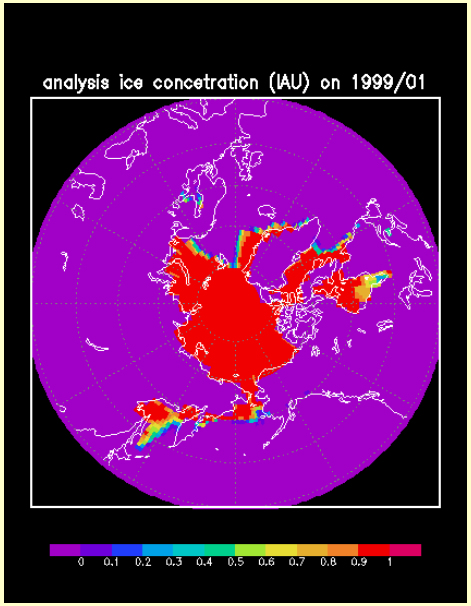
- SIC data assimilation by IAU
- Free from T, S constraints near SI.
- Water (salinity) conserved

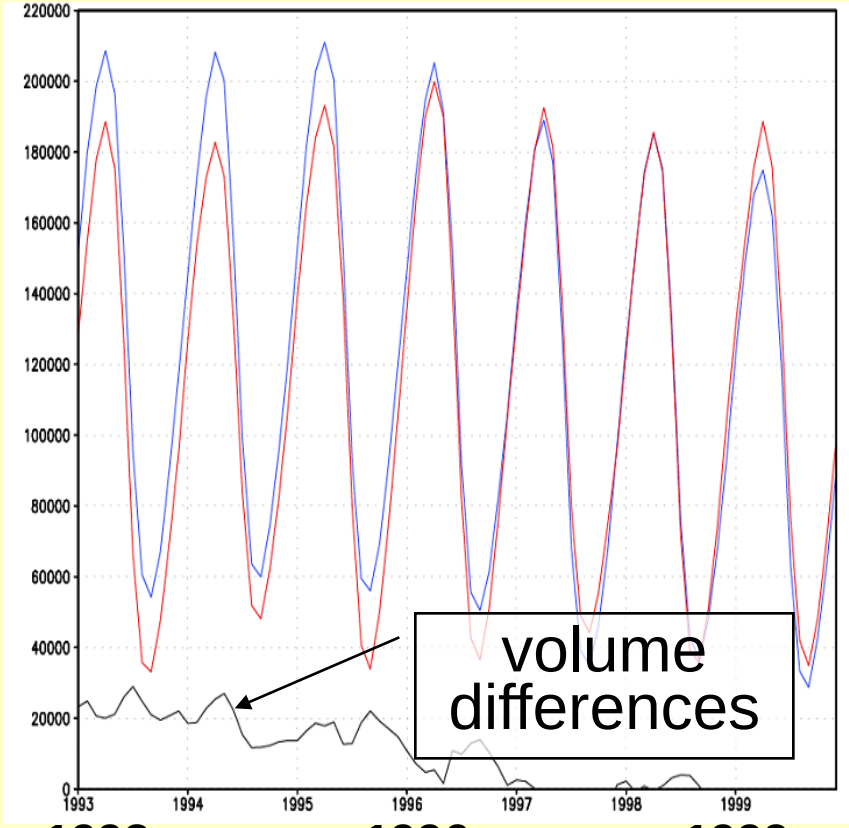
Arctic Sea Ice Concentration

Observed



Assimilated



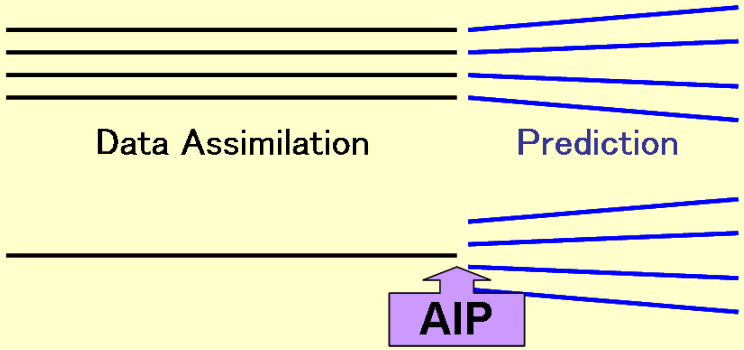


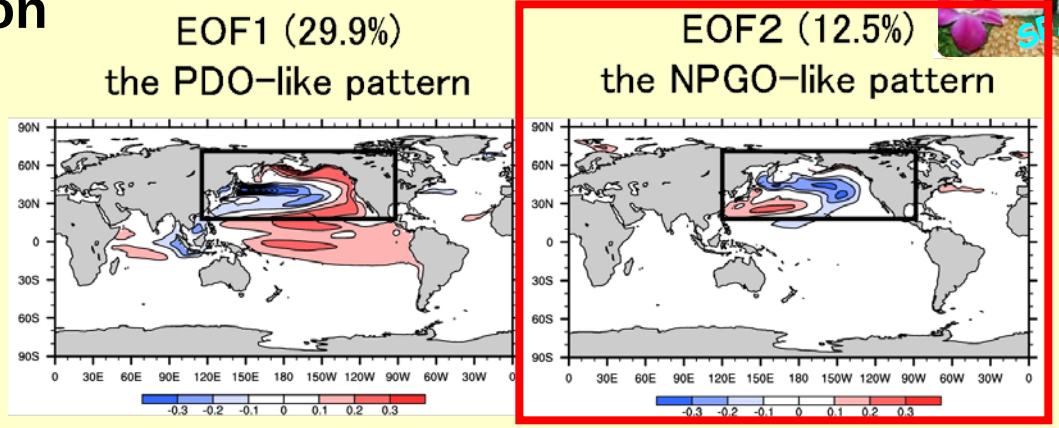
1993 **1996** **1999**

Predicted SI volume

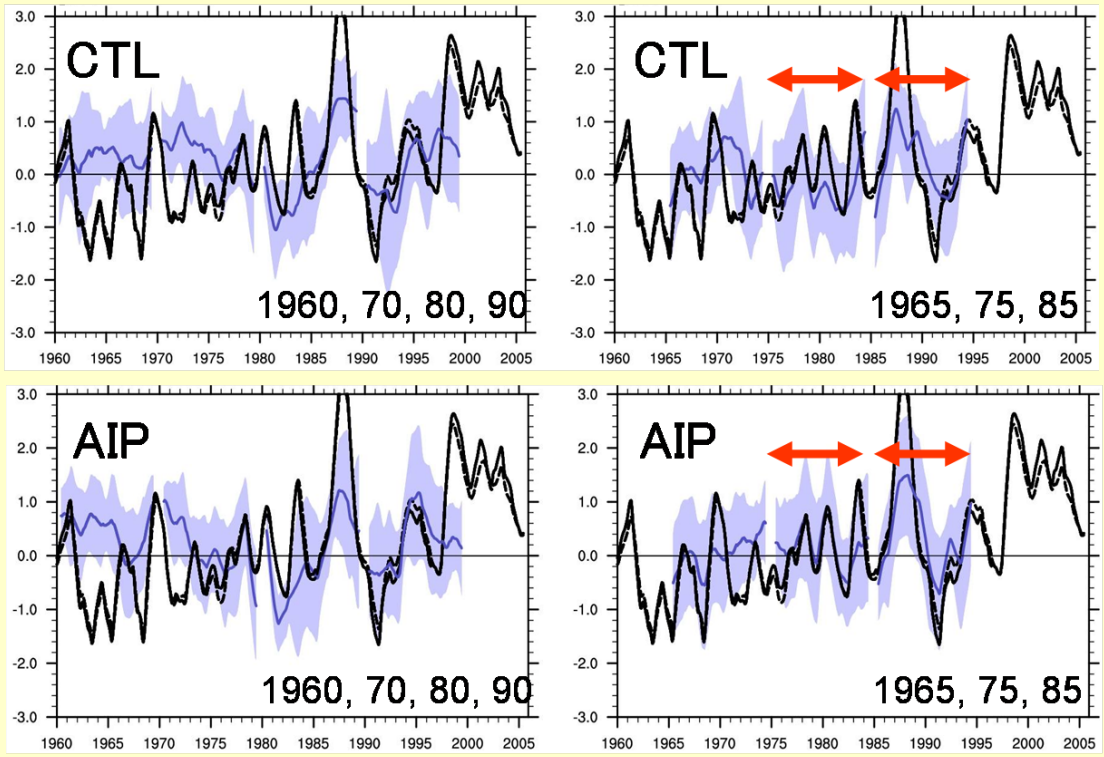
w/ and **w/o** SI data assim

Analysis Increment Perturbation (AIP)





Projected time coefficients onto EOF2

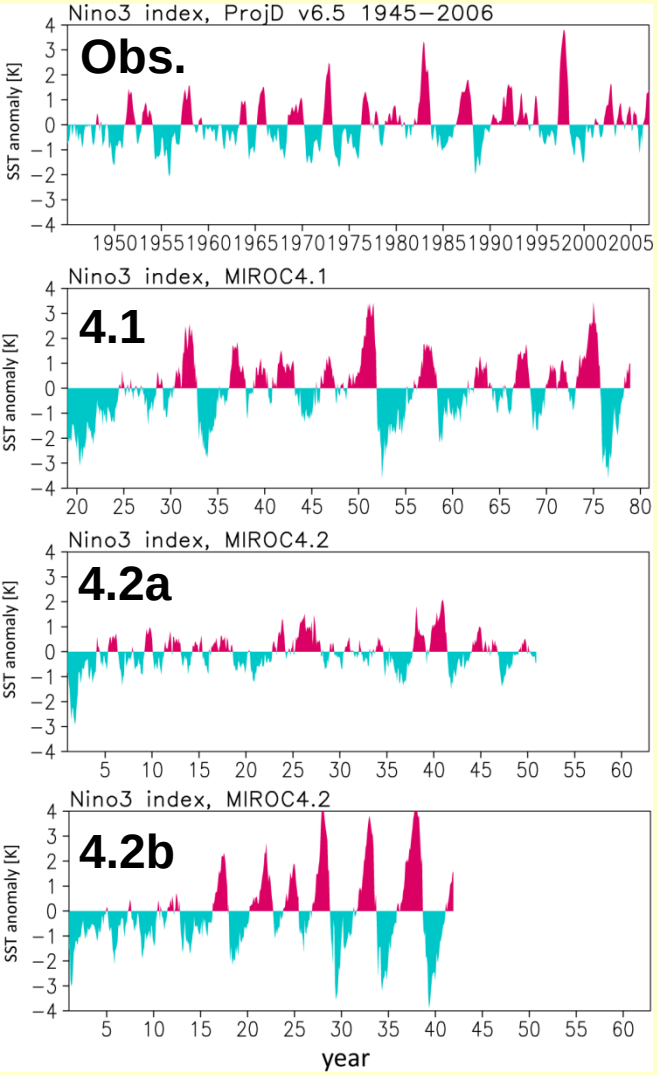


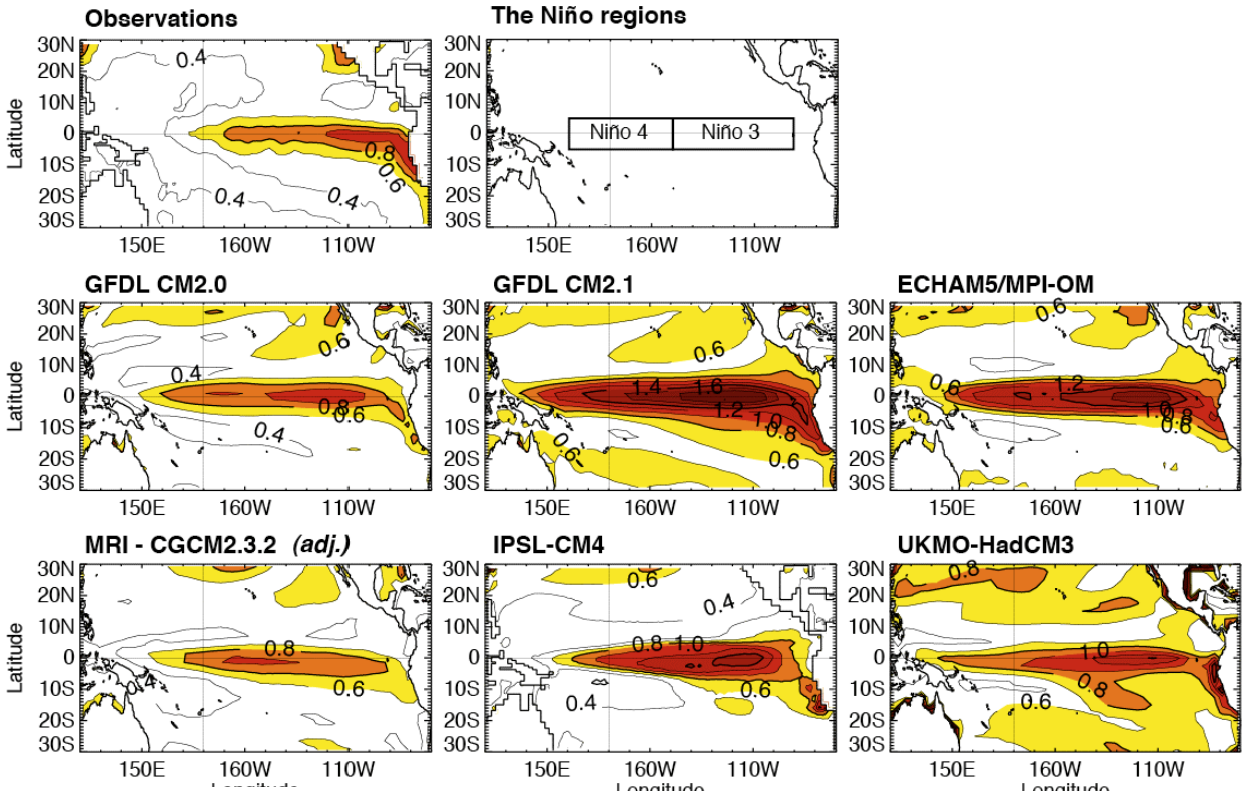
※12-mon running mean

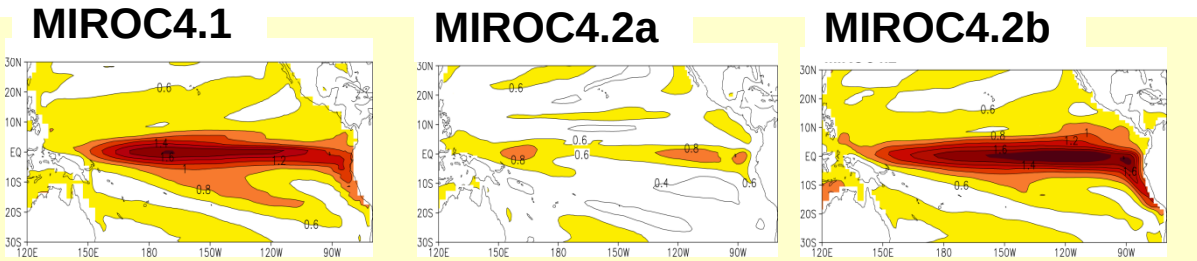
—Obs. - - -Assim. —Pred.

Chikamoto et al. (2009, in preparation)

ENSO







1) Same AGCM in 4.1 / 4.2

2) Only downdraft parameter is difeerent in 4.2a and 4.2b

Guilyardi et al. (2008,in press.)