

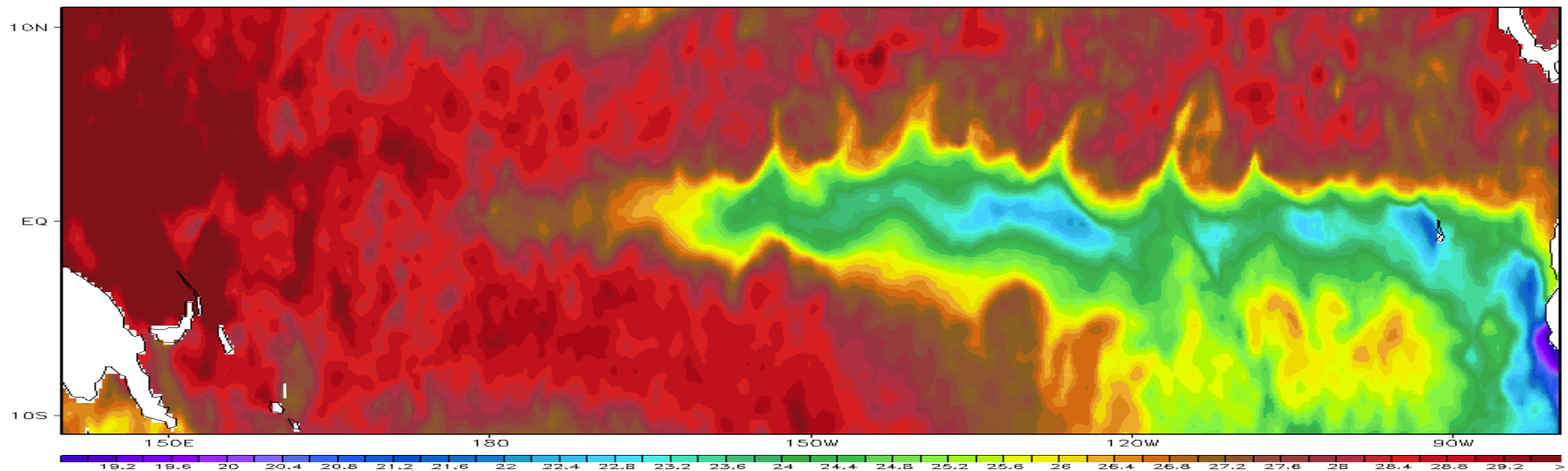
Improvement of Seasonal Forecasts with Inclusion of Tropical Instability Waves on Initial Conditions

Yoo-Geun Ham

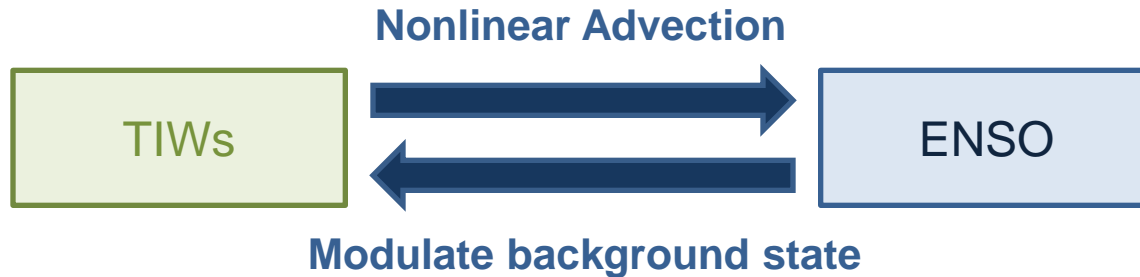
Global Modeling and Assimilation Office, NASA/GSFC

Daily mean SST at July 1st, 1998

Daily mean ERSST (0.25°x0.25° resolution)



Tropical Instability Waves (TIWs) :
Is it ignorable for seasonal prediction?

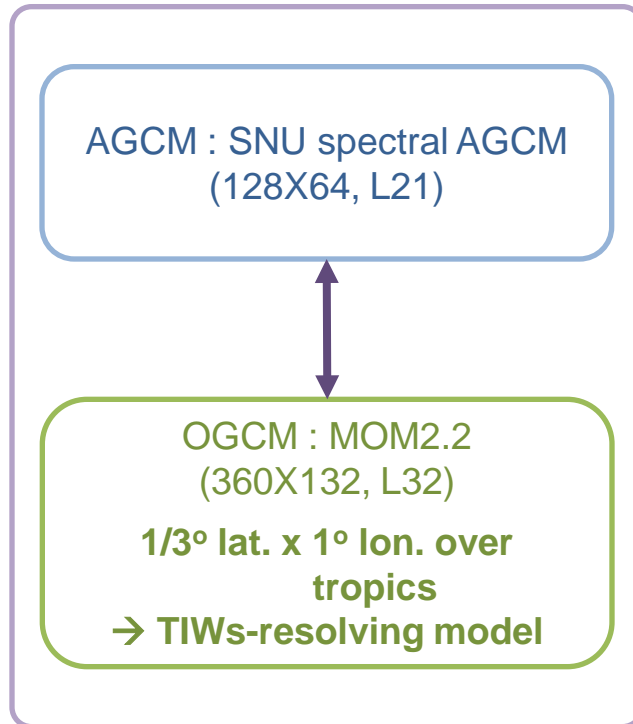


Relationship between TIWs and ENSO

- There is negative relationship between ENSO and TIW variability (Philander, 1990; Jochum and Murtugudde, 2004)
- TIWs on ENSO can cause El Nino-La Nina asymmetry through a nonlinear temperature advection generated by TIWs (An 2008)

Description of CGCM

The Resolution of CGCM



AGCM description

- SAS cumulus convection
- 2-stream k-distribution radiation
- Bonan (1996) land surface
- Convective momentum transport
- Tokioka constraint ($\alpha=0.1$)
- Auto conversion time scale modification

OGCM description

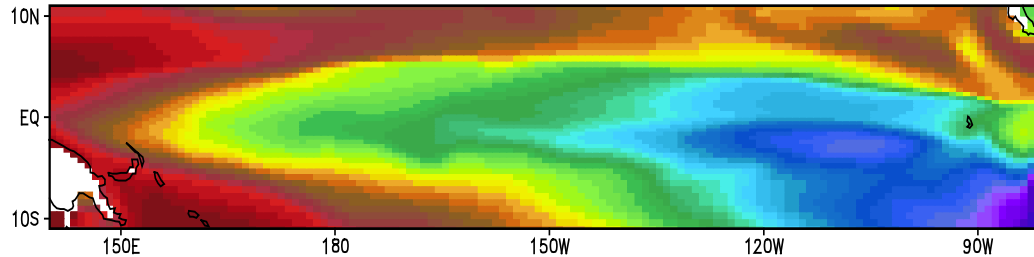
- Diurnal coupling (coupling frequency : 2-hour)
- Noh mixing scheme

*Initialization for seasonal prediction

: **Nudging the GODAS with 5-day rescaling time-scale**

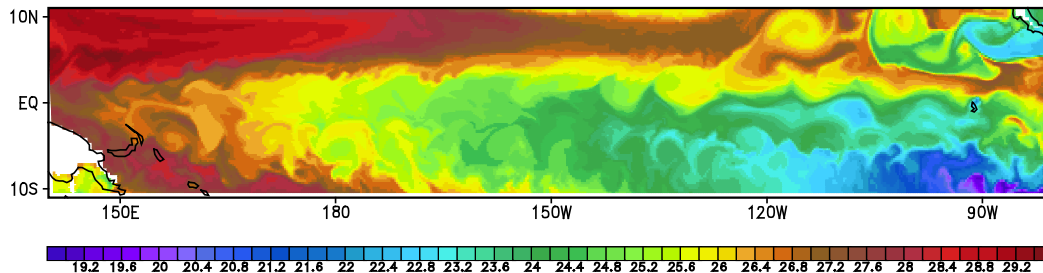
Initializing eddy-resolving ocean model

Smoothed reanalysis



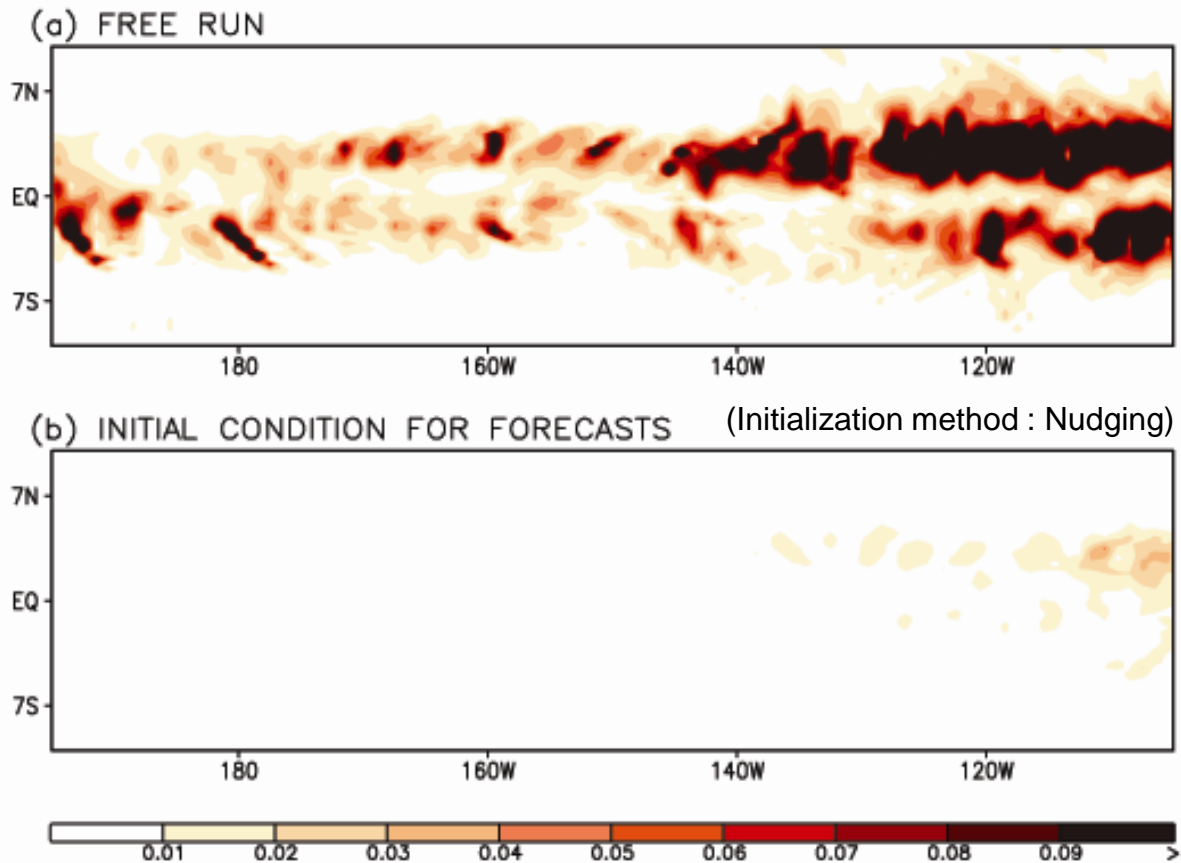
Initialization (using Nudging method)

Eddy-resolving ocean model



Due to coarse observations and deficiencies in initialization methods, TIW variability is hard to be resolved

20-year averaged TIW variability



TIWs is underestimated in initial conditions

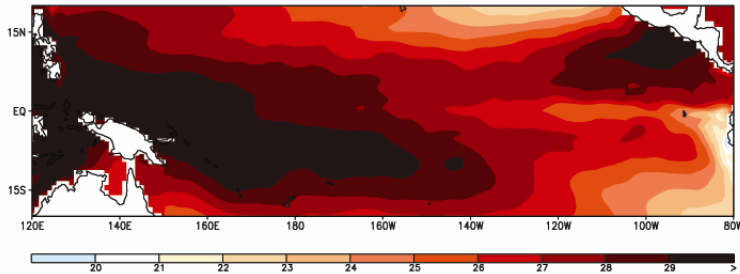
Seasonal Forecast experiments

Seasonal Forecast experiments

- SNU CGCM ($1^{\circ} \times 0.3^{\circ}$ resolution over equator \rightarrow Eddy resolving model)
- 20 year hindcast (1981-2000)
- Start from May 1st (Summer season)
- 4-month lead forecast
- 4 Ensemble members using LAF

CNTL run (Nudged IC)

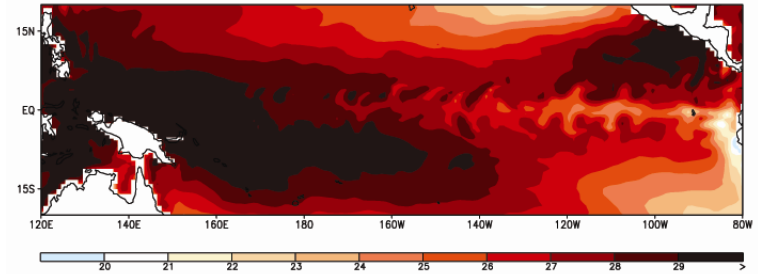
Initial condition of CNTL run : May 1st 1989



VS

EDDY run (Nudged IC + TIWs perturbation)

Initial condition of EDDY run : May 1st 1989



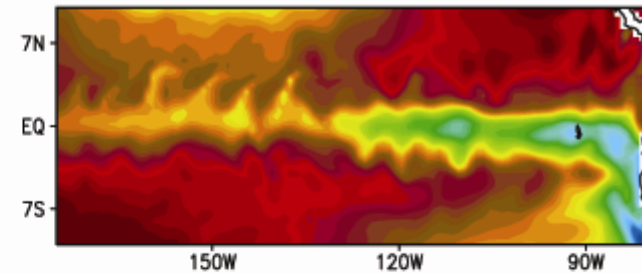
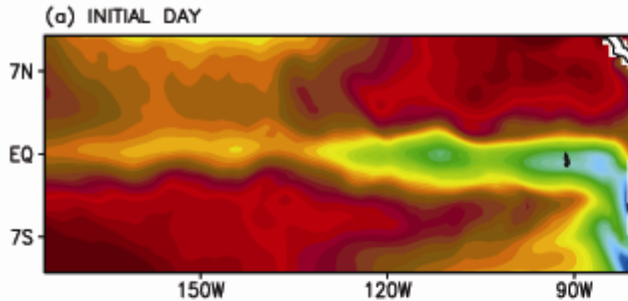
- Shape of perturbation : Fixed
 \rightarrow Obtained from long-run simulation
- Magnitude of perturbation
 \rightarrow Proportional to (Warm pool SST – Cold tongue SST) of each year

SST evolutions at summer 1984

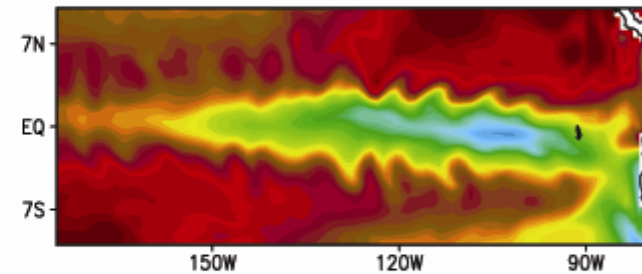
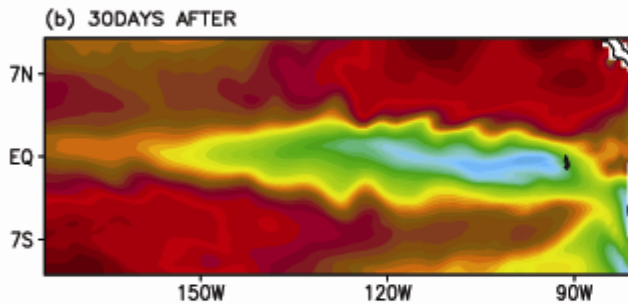
CNTL

EDDY

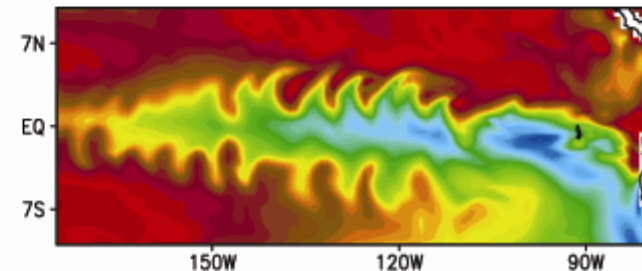
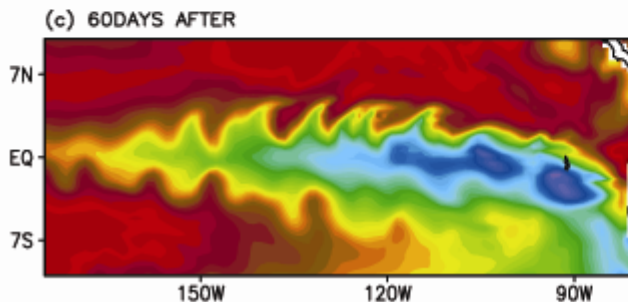
Initial day



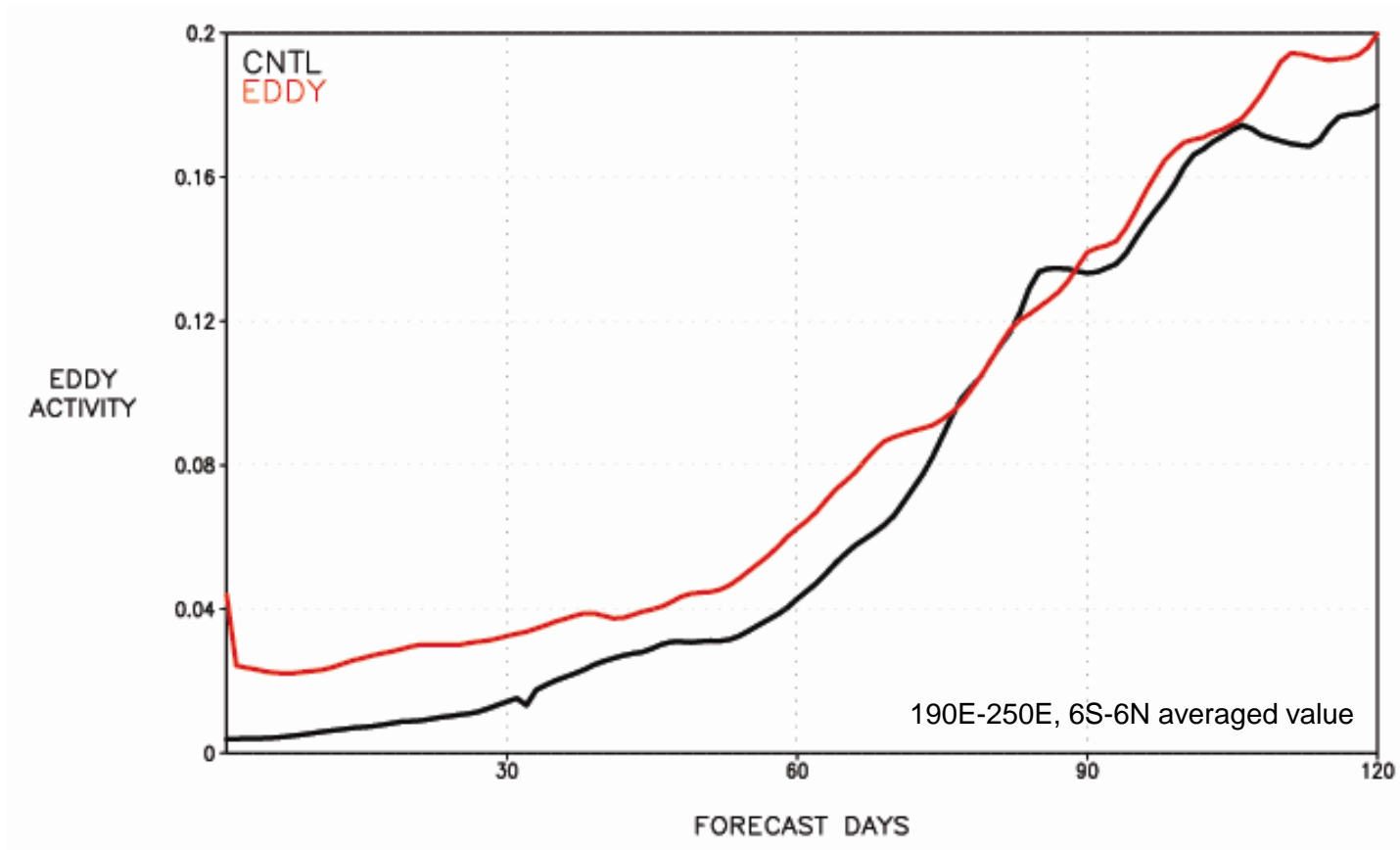
30days after



60days after



Eddy activity 20year average

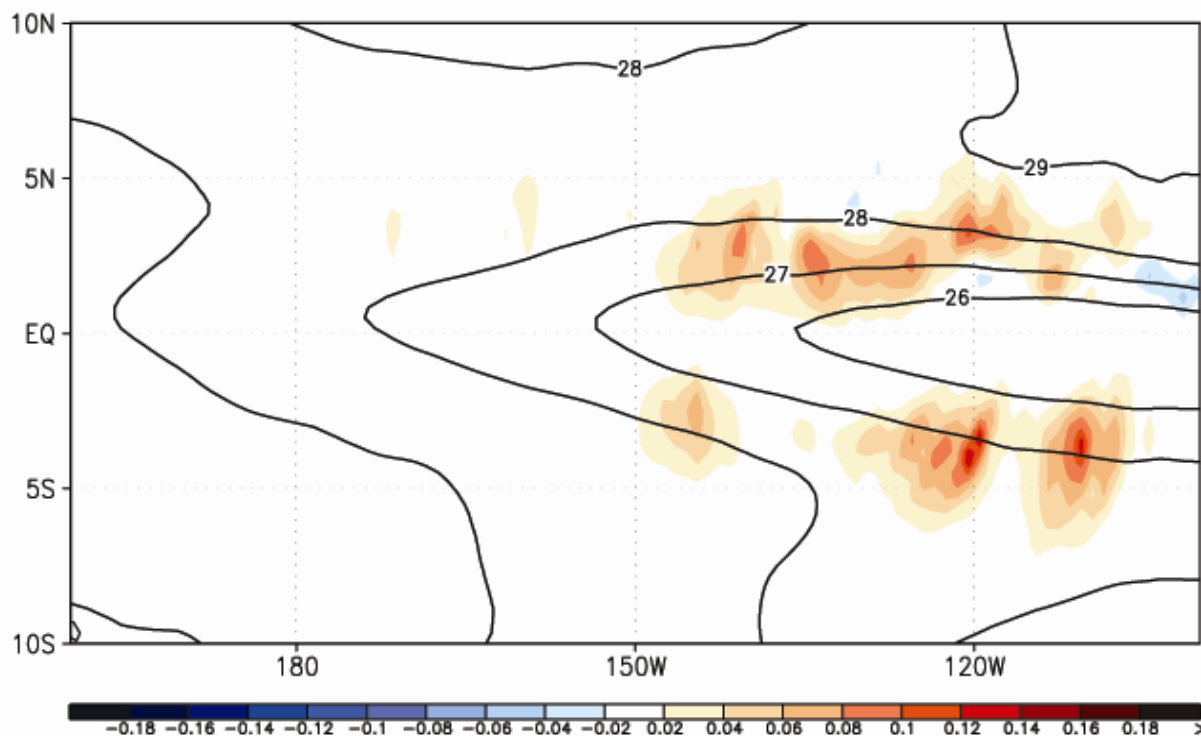


TIWs perturbation in initial condition
enhance eddy activity on seasonal time scale

Eddy activity difference (EDDY-CNTL) 20year average

2 month average (01May-30June)

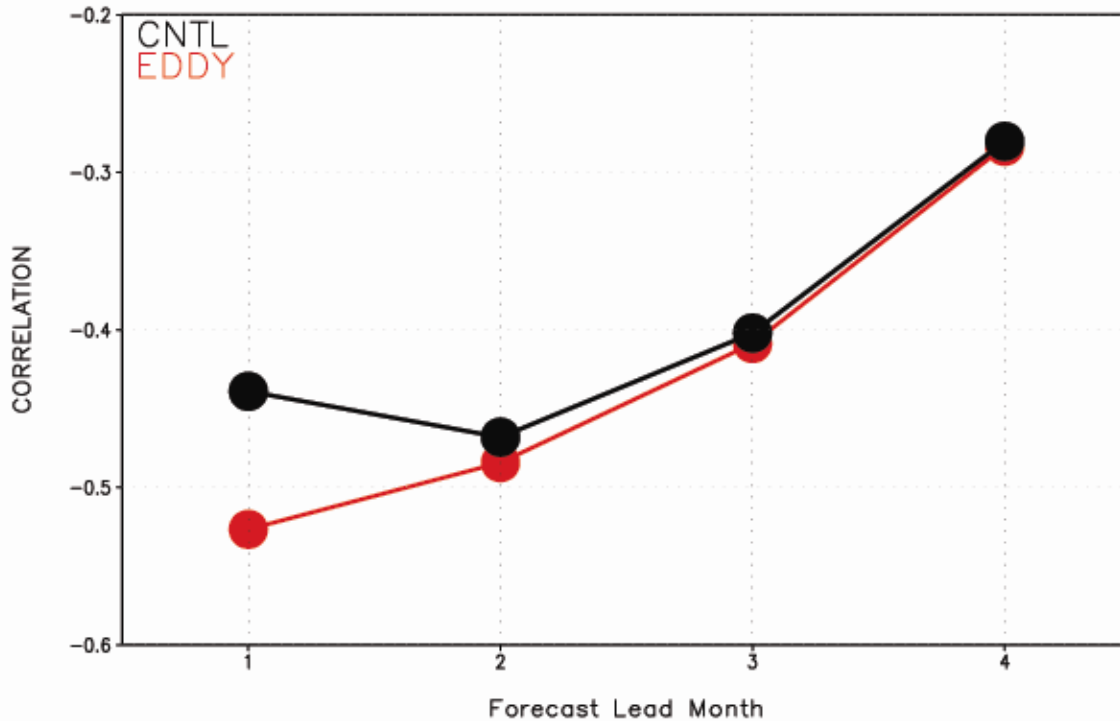
Eddy : zonal-scale is smaller than 10° from daily snapshot



Enhanced TIW activity due to eddy-seeding impact
is robust over large SST gradient region

Negative relationship between ENSO and TIWs

Correlation coefficient between nonlinear TIWs advection and NINO3.4 index



El Nino

La Nina



Nonlinear advection due to TIWs
long cold tongue

$$-\int_{x=170^{\circ}W}^{120^{\circ}W} \int_{y=3^{\circ}S}^{3^{\circ}N} \int_{z=50m}^{0m} \left[u' \frac{dT'}{dx} + v' \frac{dT'}{dy} + w \frac{dT'}{dz} \right] dx dy dz$$

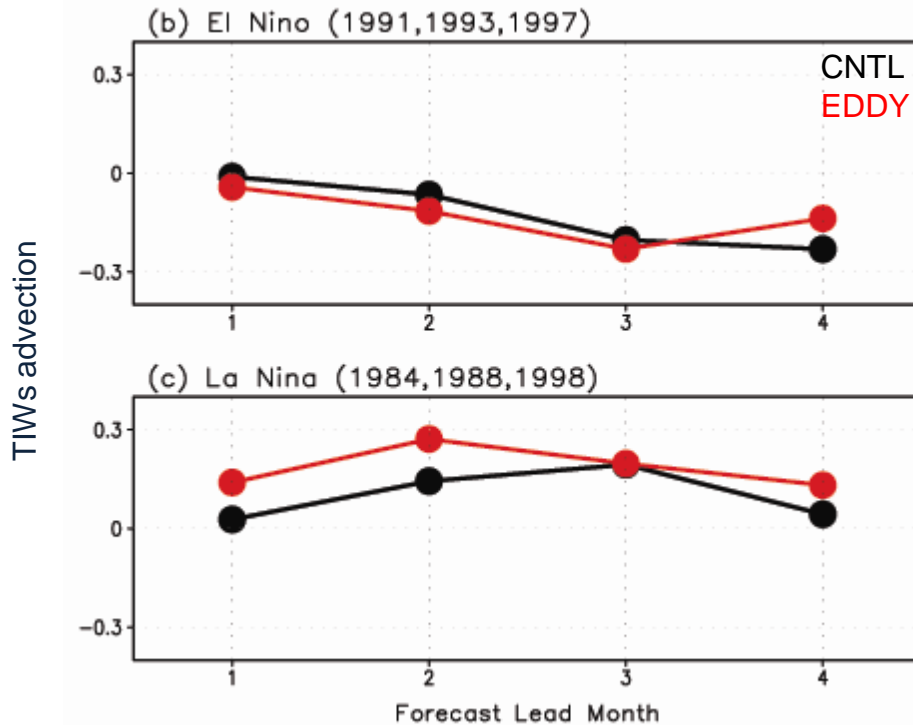
Enhanced
sub-scale SST gradient

- Prime : small-scale components whose zonal scale is less than 10 degree

enhanced mixing due to eddies
strong La Nina damping

Asymmetry of NINO3.4

Nonlinear TIWs temperature advection over NINO3.4



Asymmetry of NINO3.4
($m^3/m^2^{1/2}$)

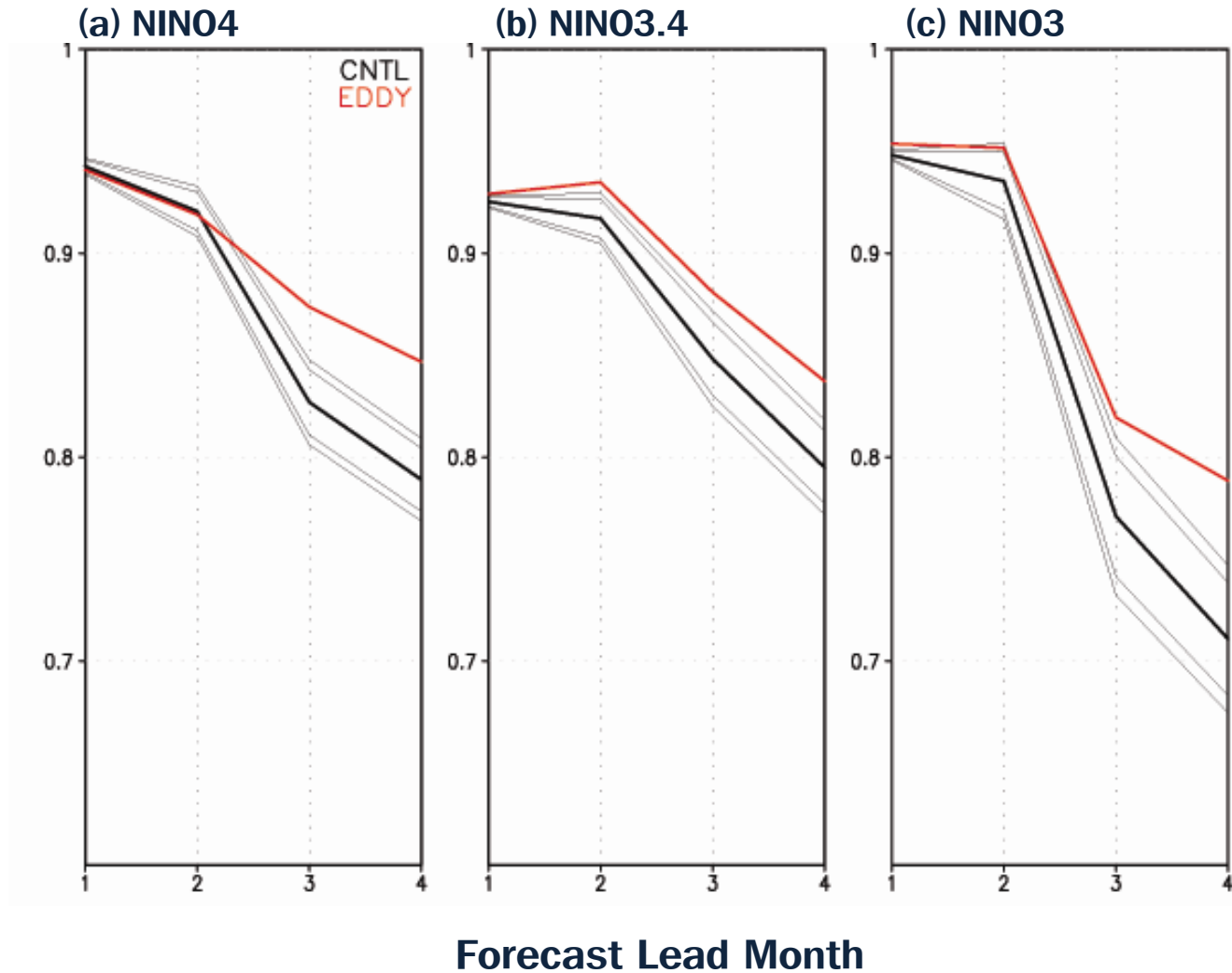


Role of TIWs on ENSO :
El Niño damping \ll La Niña damping

Forecast skill of NINO indices

OBS : ERSST

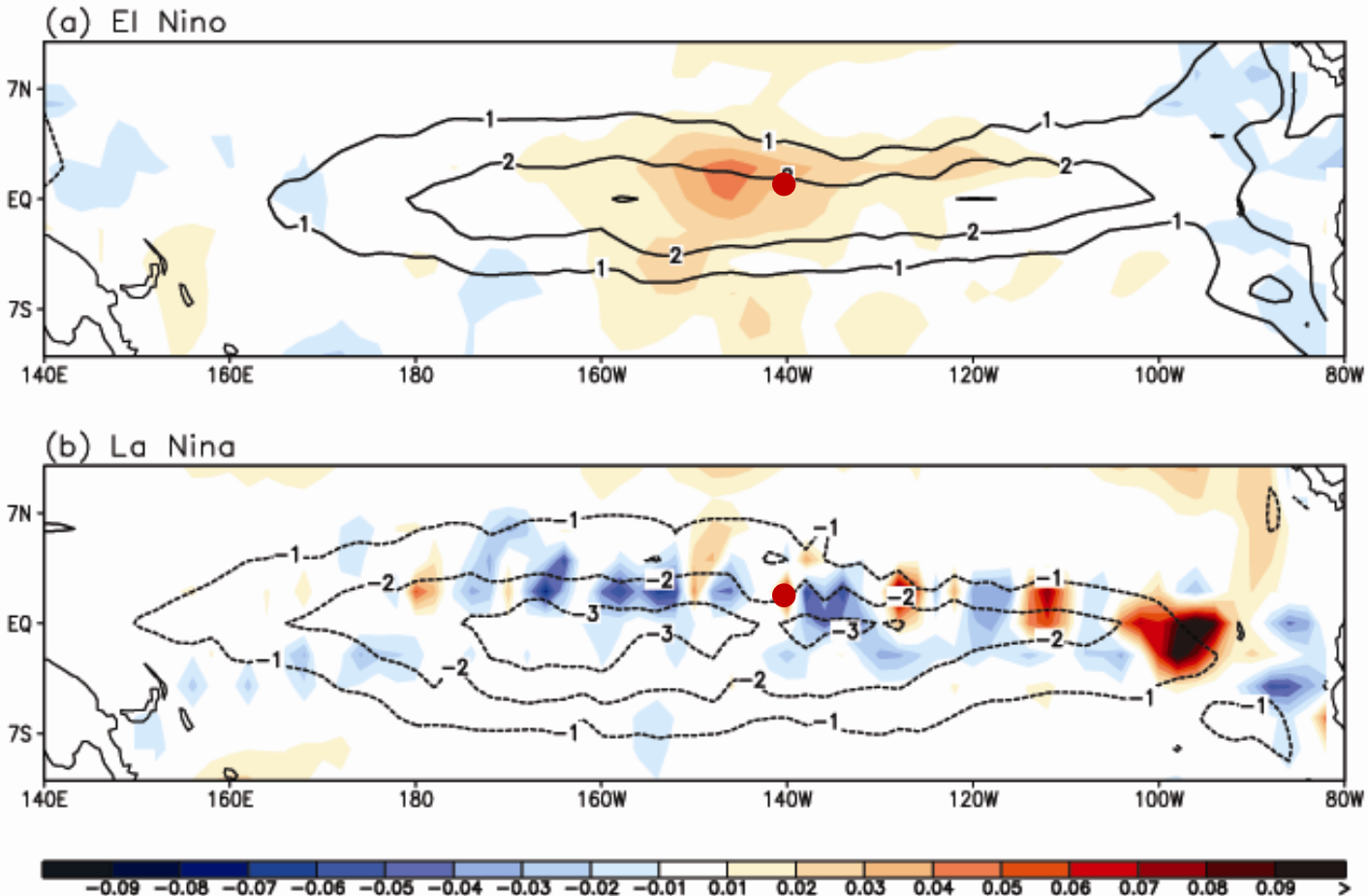
Correlation
skill



Summary and conclusion

- Due to coarse observational networks and deficiencies in widely-used initialization methods (e.g. 3DVAR or OI methods), TIW variability in oceanic initial conditions is excessively suppressed
- Through 20-yr ensemble forecast experiments, it is shown that seasonal TIWV with TIWs-seeded initial conditions is significantly stronger until 2-month lead time.
- Enhanced TIWV amplifies nonlinear relationship between TIWs and ENSO, which leads realistic simulation of the El Nino-La Nina asymmetry

Ensemble covariance of SST at 140W, 2N



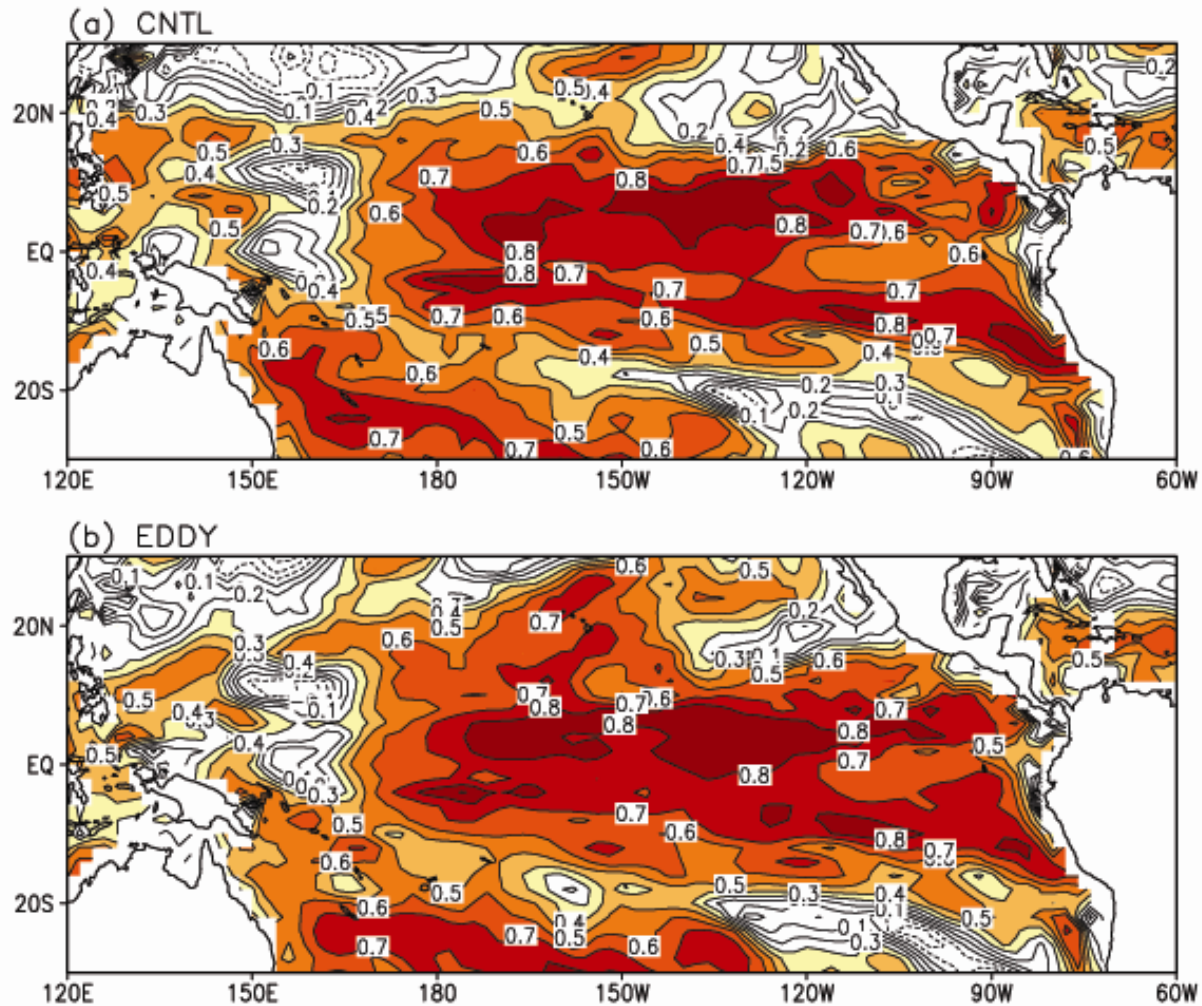
Error statistics between El Nino & La Nina is much different
→ El Nino : Nearly Gaussian, La Nina : small-scale feature

Thank you

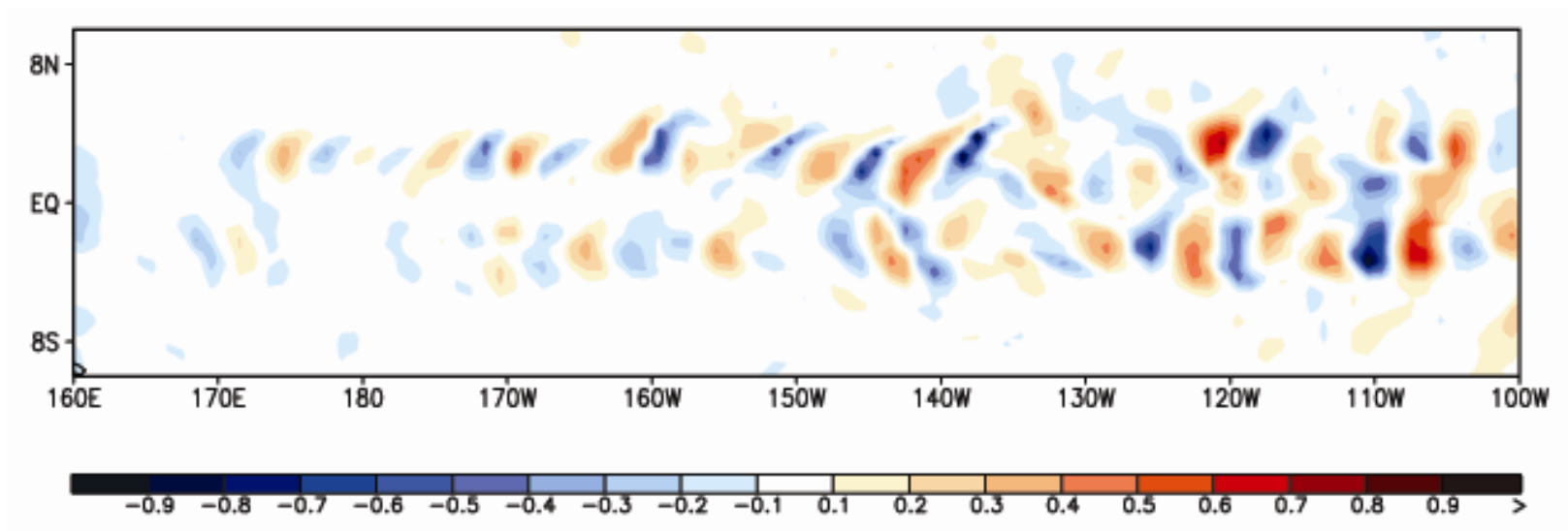


Forecast skill of august SST

4ensemble, OBS : ERSST



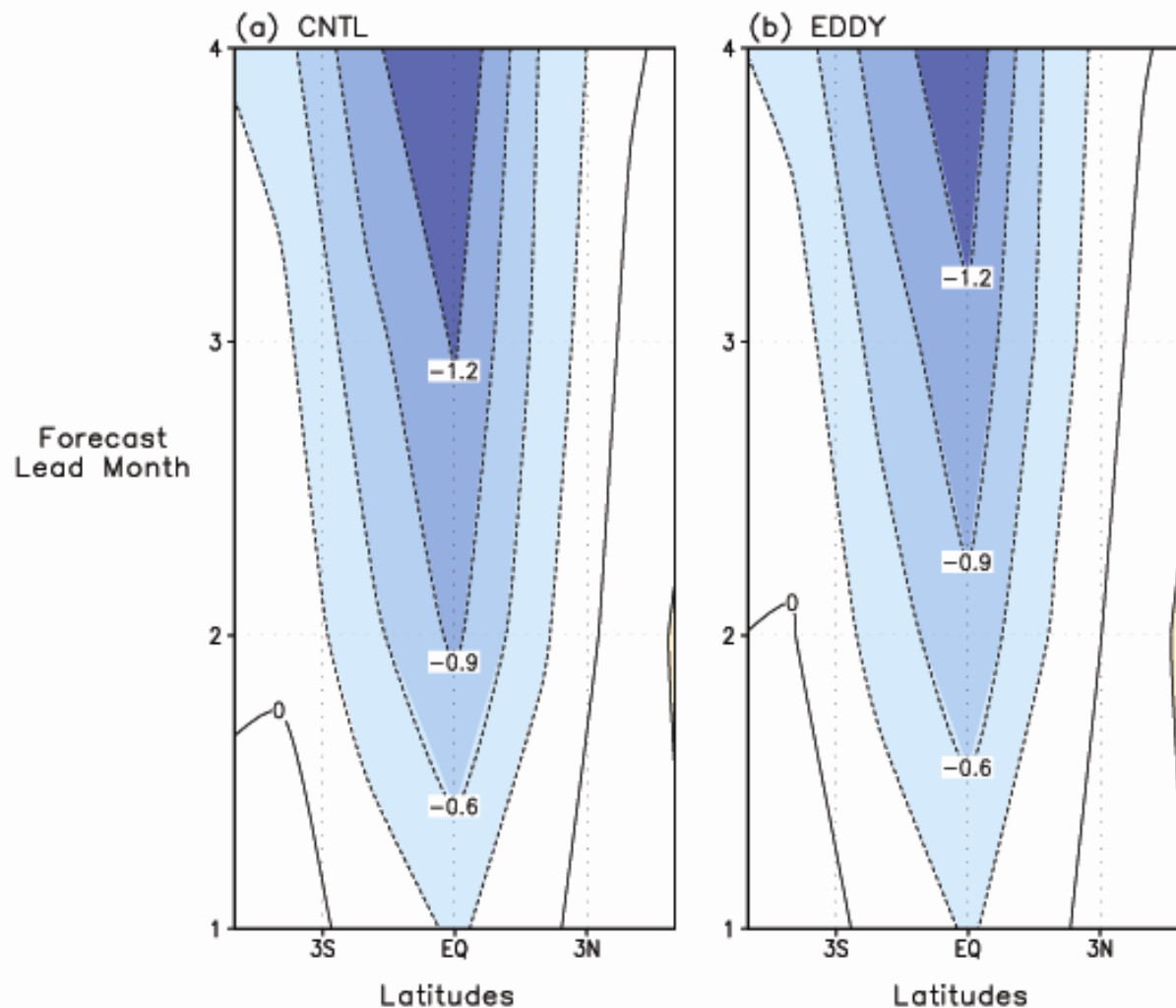
Oceanic eddy pattern in SNU CGCM



Eddy : zonal-scale is smaller than 10° from daily snapshot
Snap shot at May 1st during La Nina

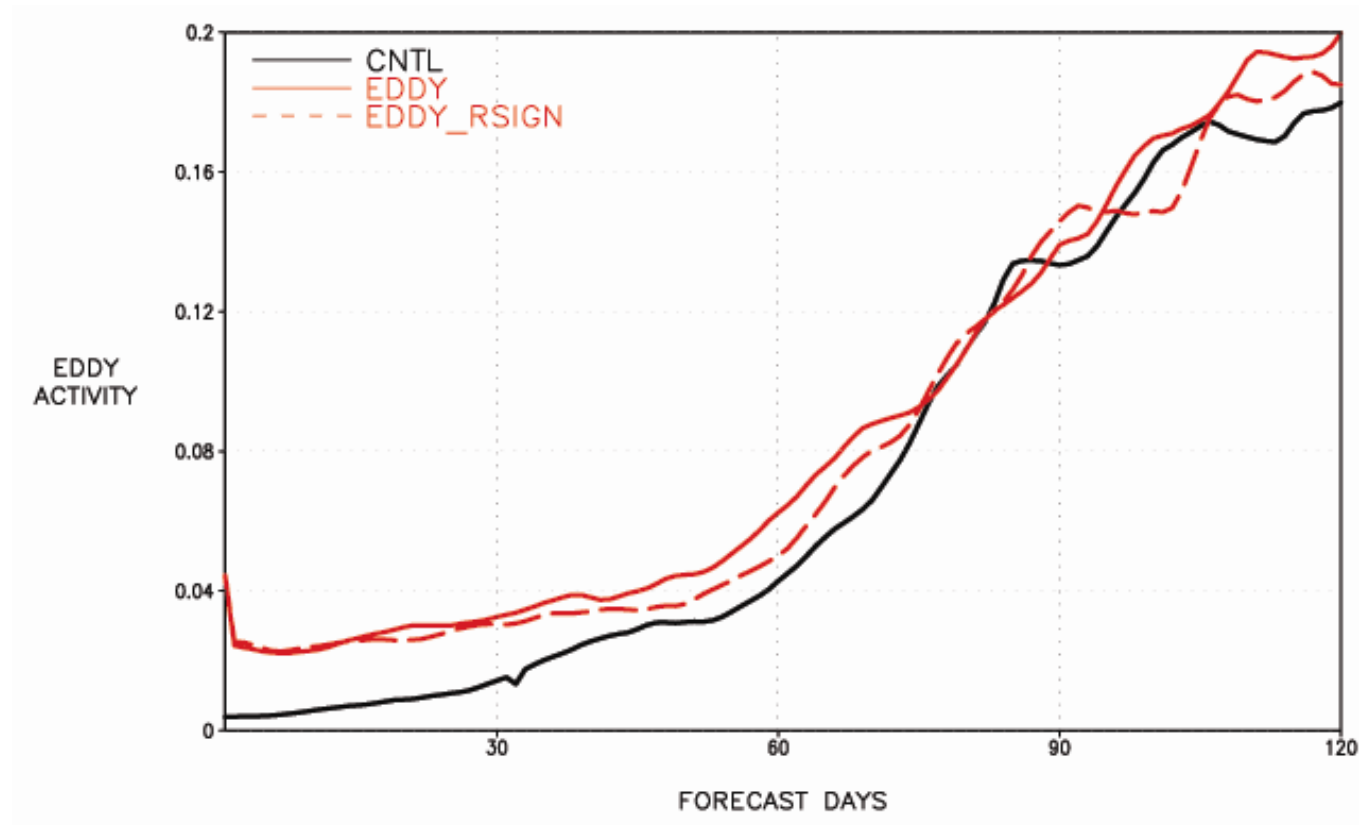
Climatological SST bias

4ensemble, OBS : GODAS



190E-240E average
Unit : K

Eddy activity 20year average



TIWs perturbation in initial condition
enhance eddy activity on seasonal time scale

Magnitude of Cold tongue SST (MCSST) = (ECSST-EPSSST) +
(OESST-EPSSST)

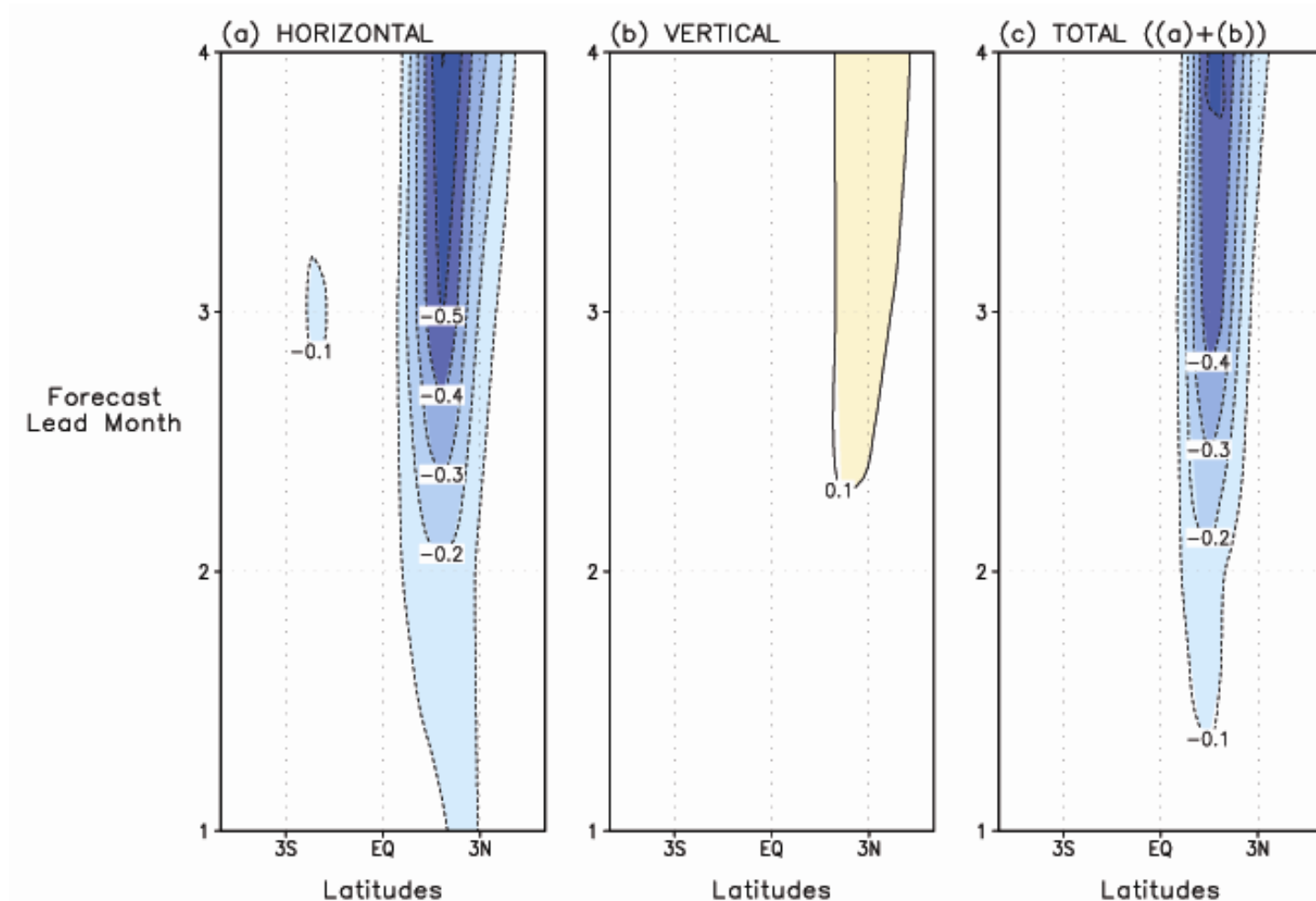
EPSSST: 170°W-120°W, 2°S-
2°N

ECSST: 150°E-180°E, 2°S-
2°N

OESST: 170°W-120°W, 2°N-
5°N

$$\text{TIW perturbations of year } Y = \frac{\text{MCSST}_{\text{IC of } Y}}{\text{MCSST}_{\text{Free}}} \cdot \text{TIWs}_{\text{Free}}(x, y, z)$$

TIW advection during ENSO : Horizontal vs Vertical



Results in EDDY run
Regressed value onto NINO3.4 index
Unit : K/month