Seasonal-interannual prediction of sea surface height using an ocean-atmosphere dynamical model "SINTEX-F"

Takeshi Doi, Masami Nonaka, Swadhin K. Behera
(APL/VAiG/JAMSTEC)

PICES2019

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Skillful seasonal-interannual forecast is necessary to reduce the risks!

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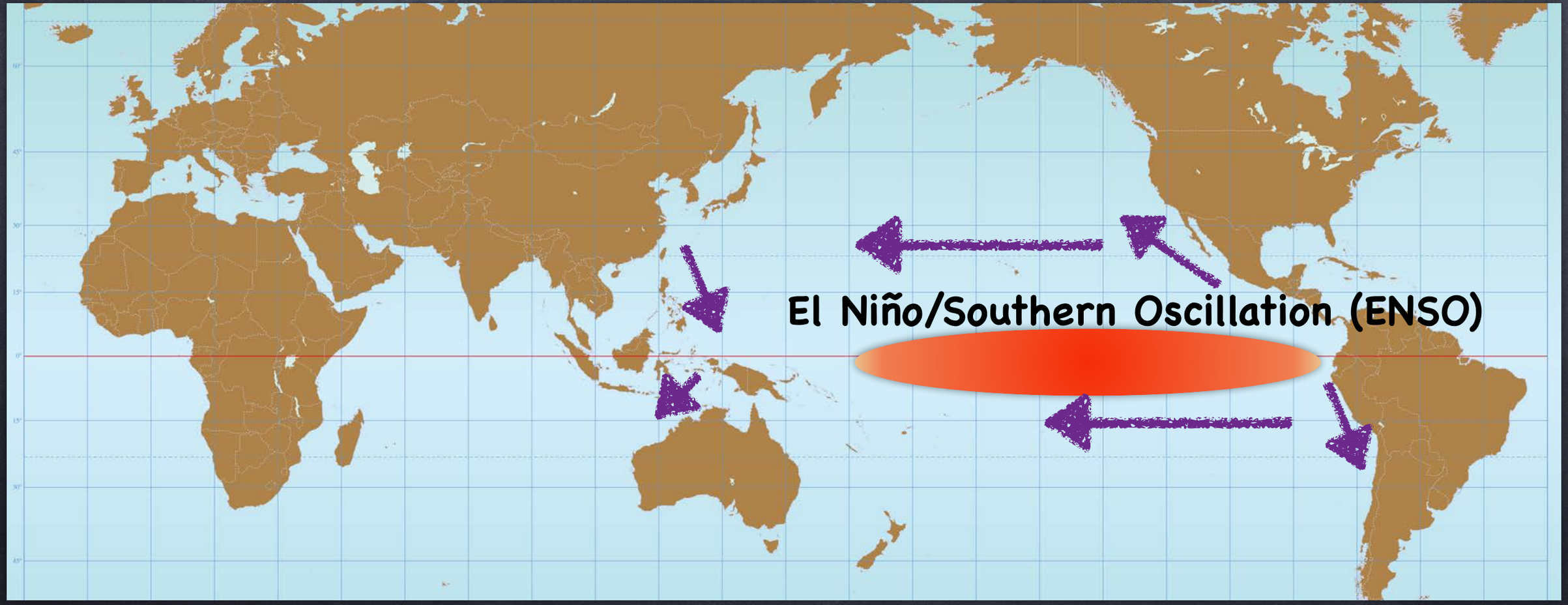

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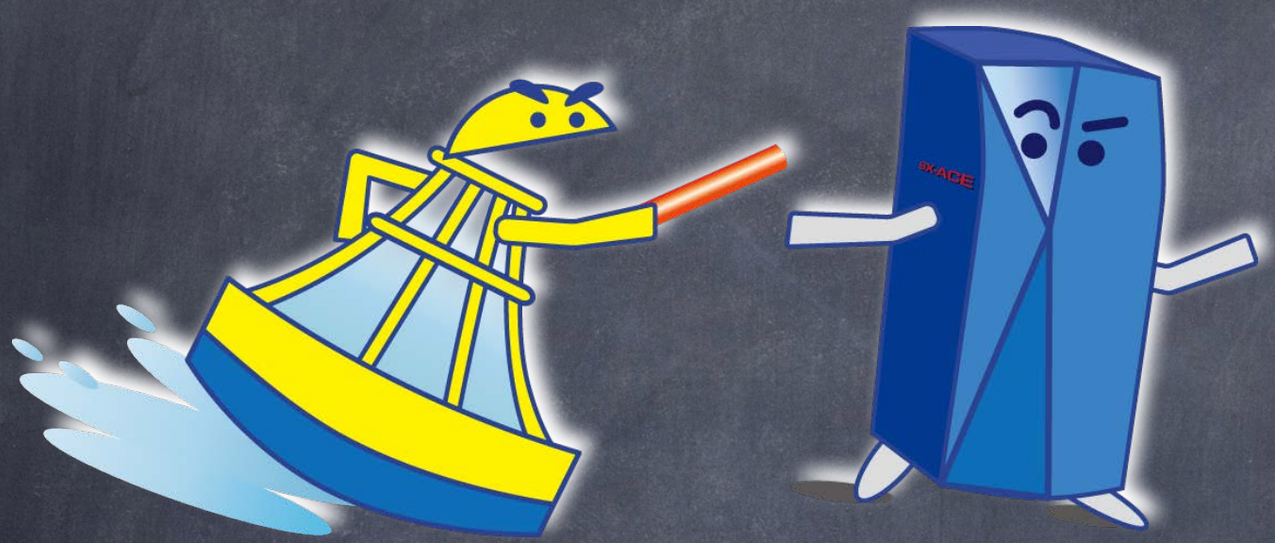

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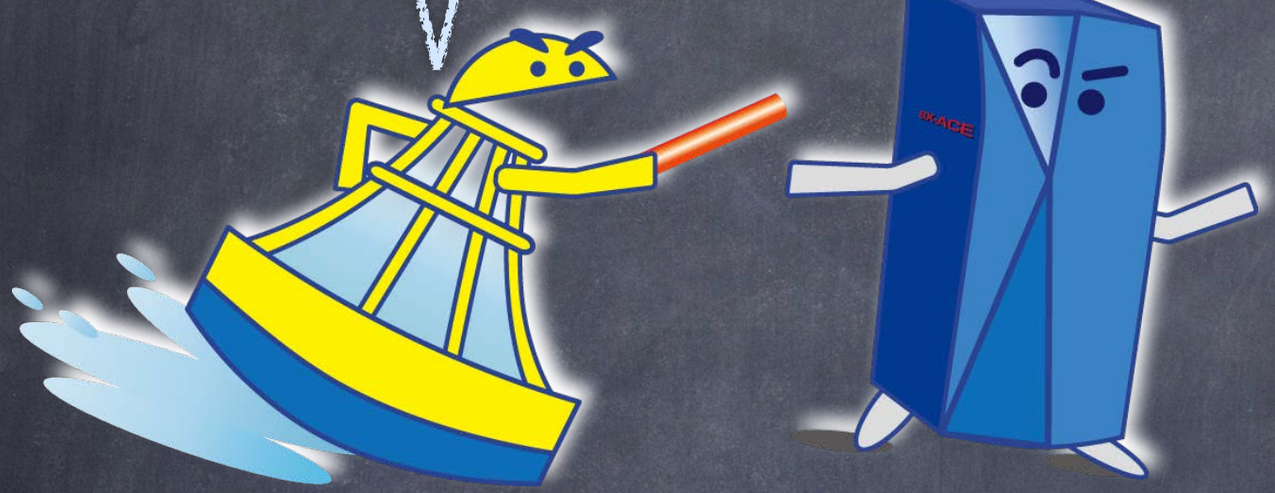

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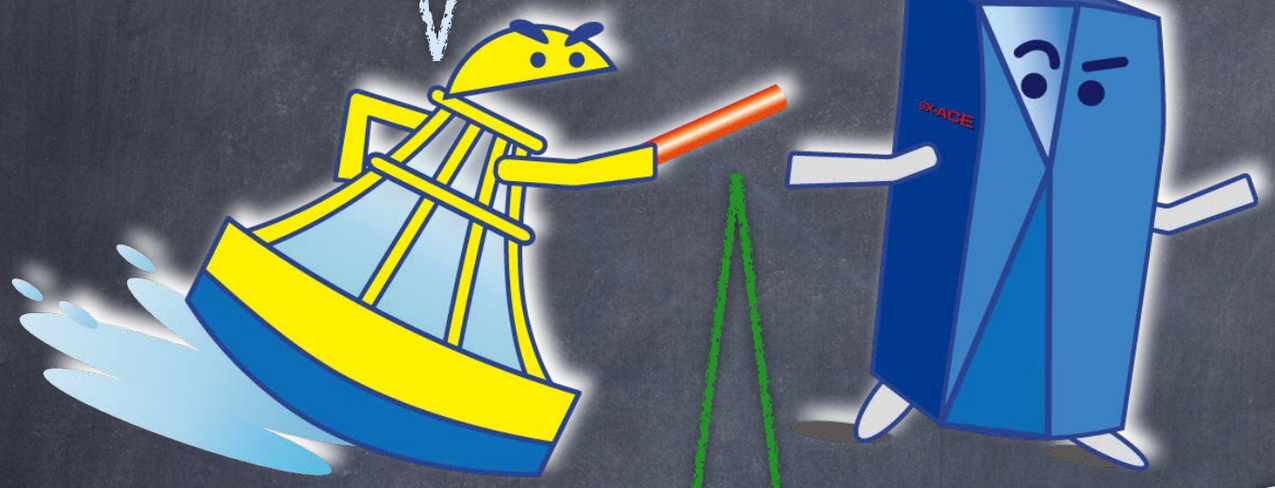

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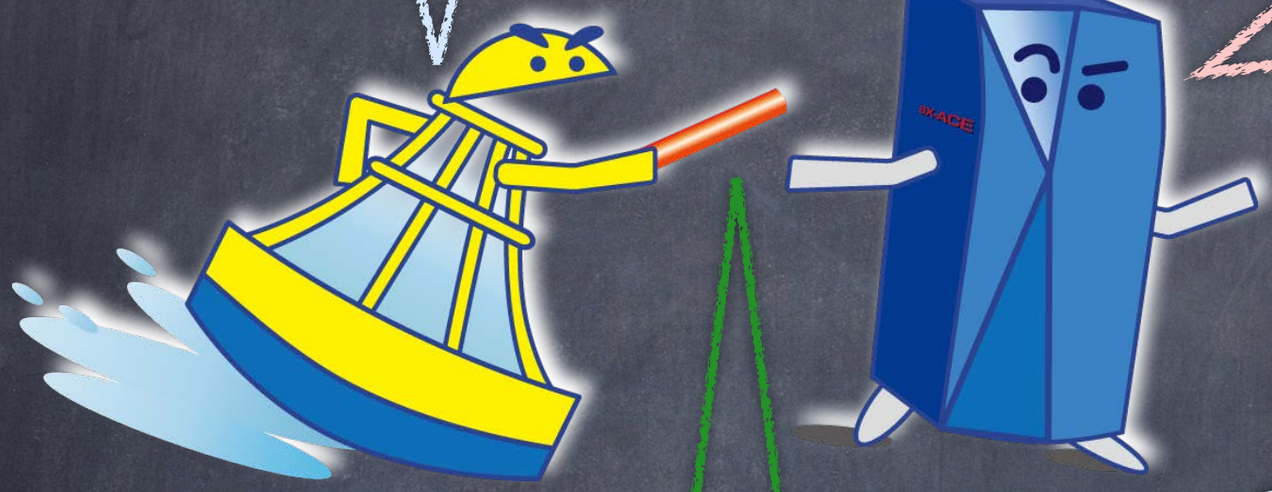

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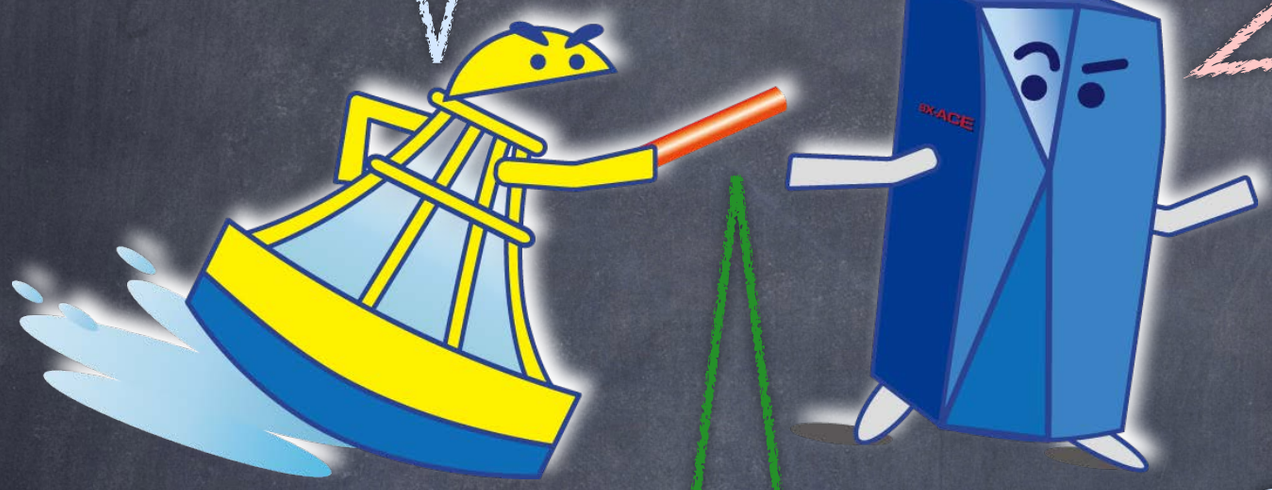

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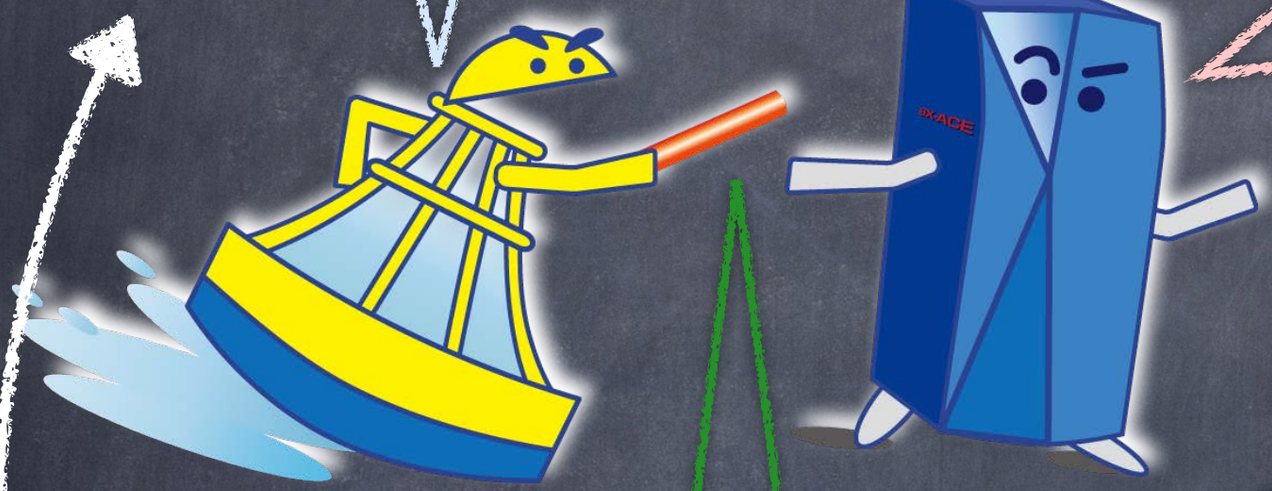

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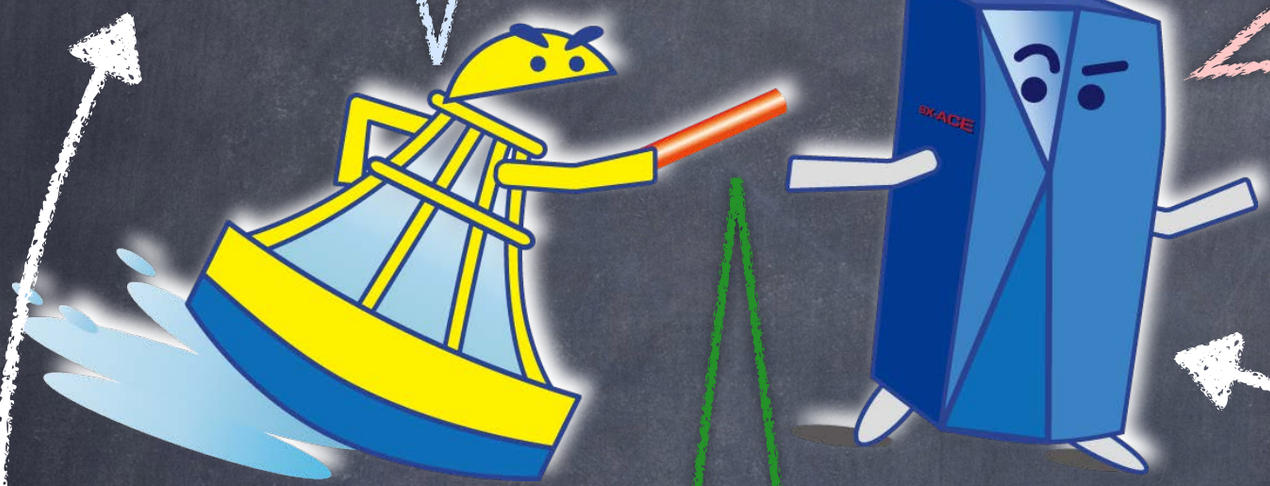

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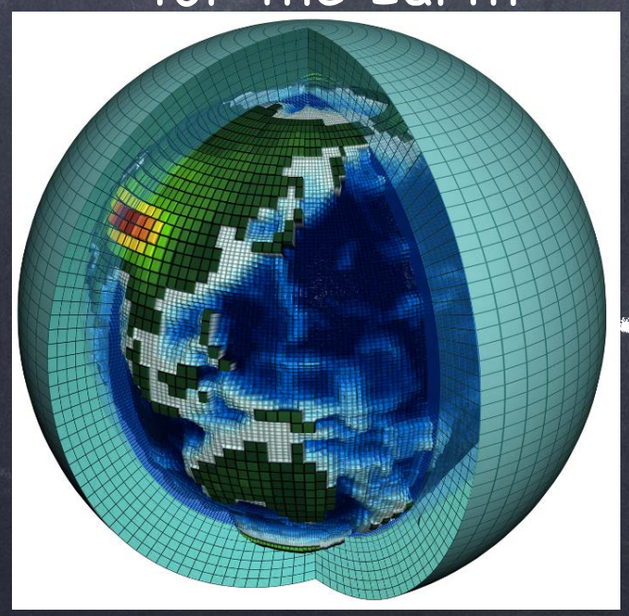
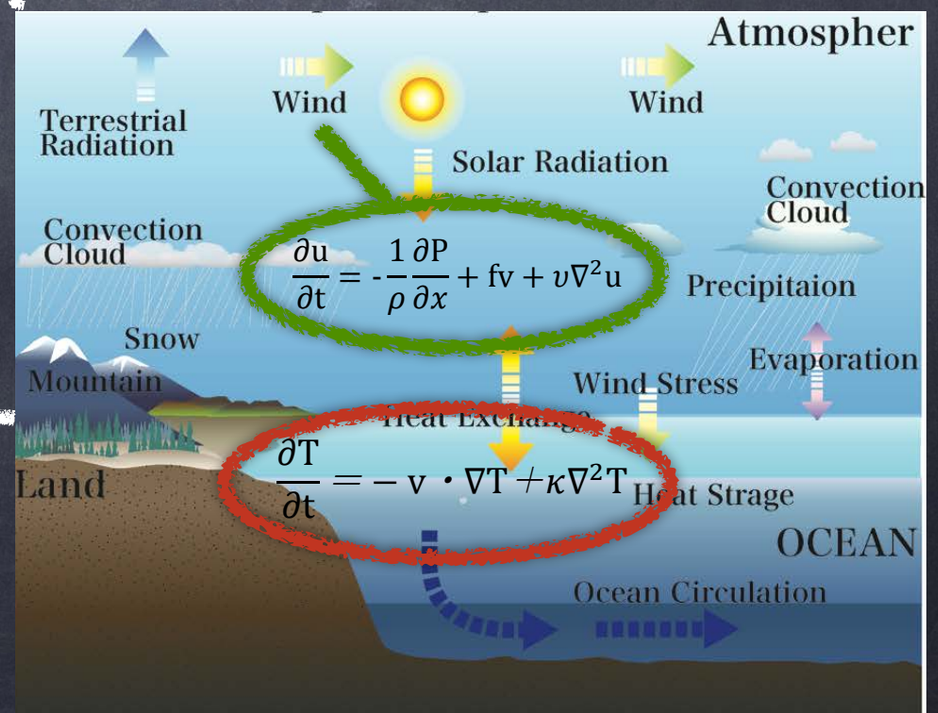
Calculate partial differential eq.

Use grids of "cell" for the Earth





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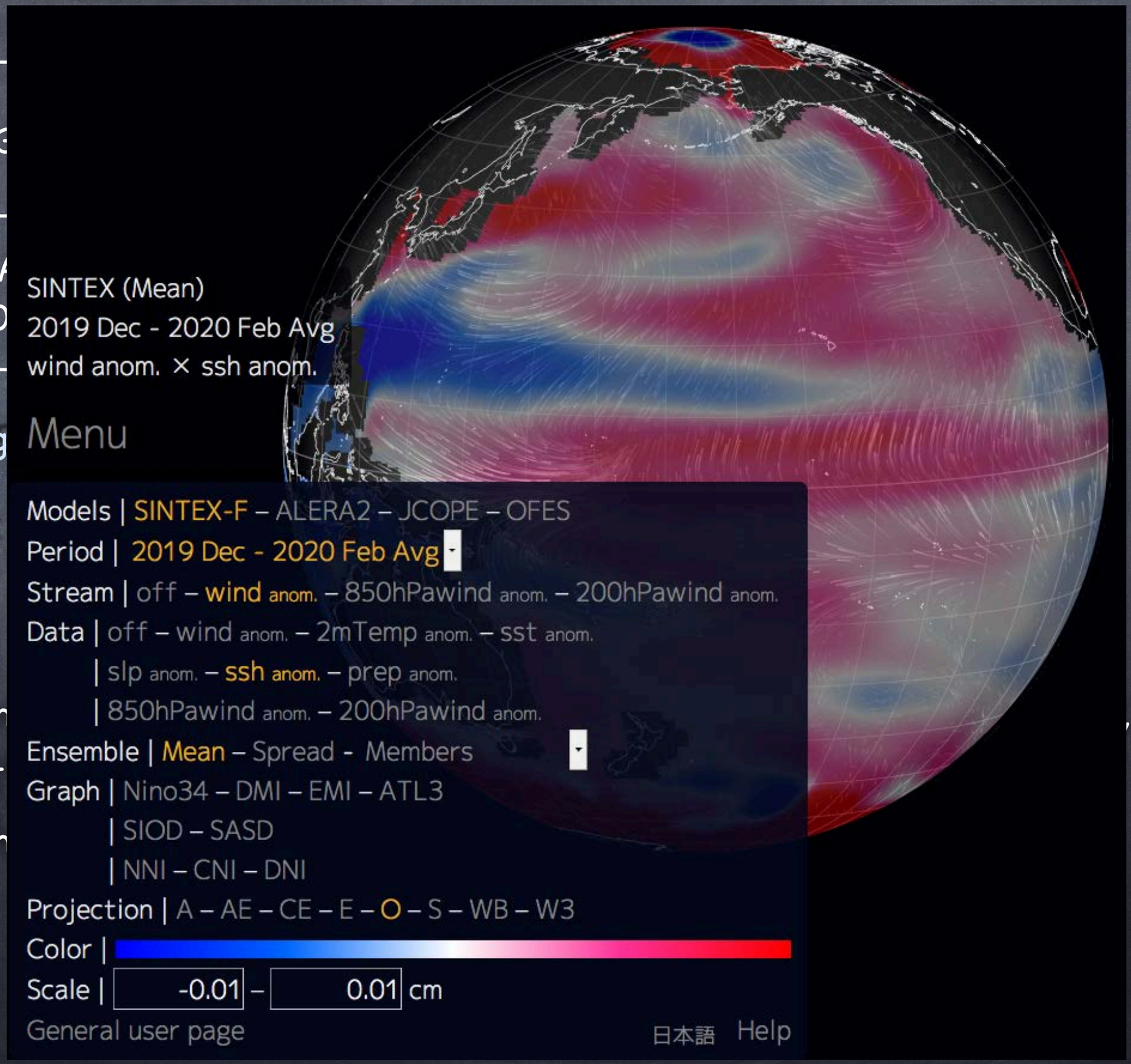


Skill assessment is

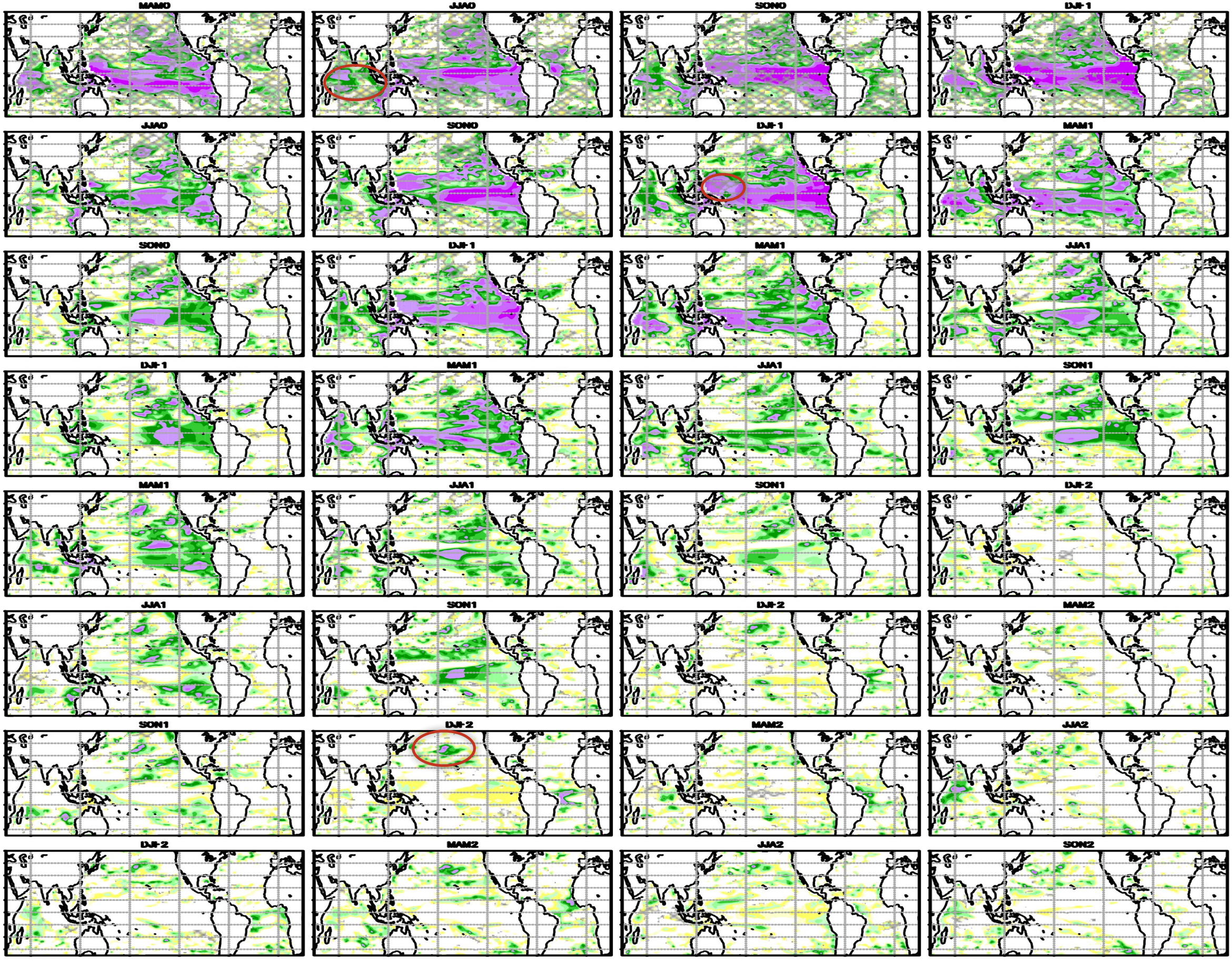
- Based on anomaly correlation coefficient (ACC) between obs. and re-forecast output.
- Re-forecast period: issued of the first date of every month in years 1993-2010
- Reference data: AVISO+ data in 1993-2010
- Monthly climatology in 1993-2009
- Anomaly (deviation from monthly climatology) is linearly detrended

ACC for SSH prediction

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

(a) Mar. 1st ini. (b) Jun. 1st ini. (c) Sep. 1st ini. (d) Dec. 1st ini.

Lead month (1.5~22.5 month)



ACC for SST prediction

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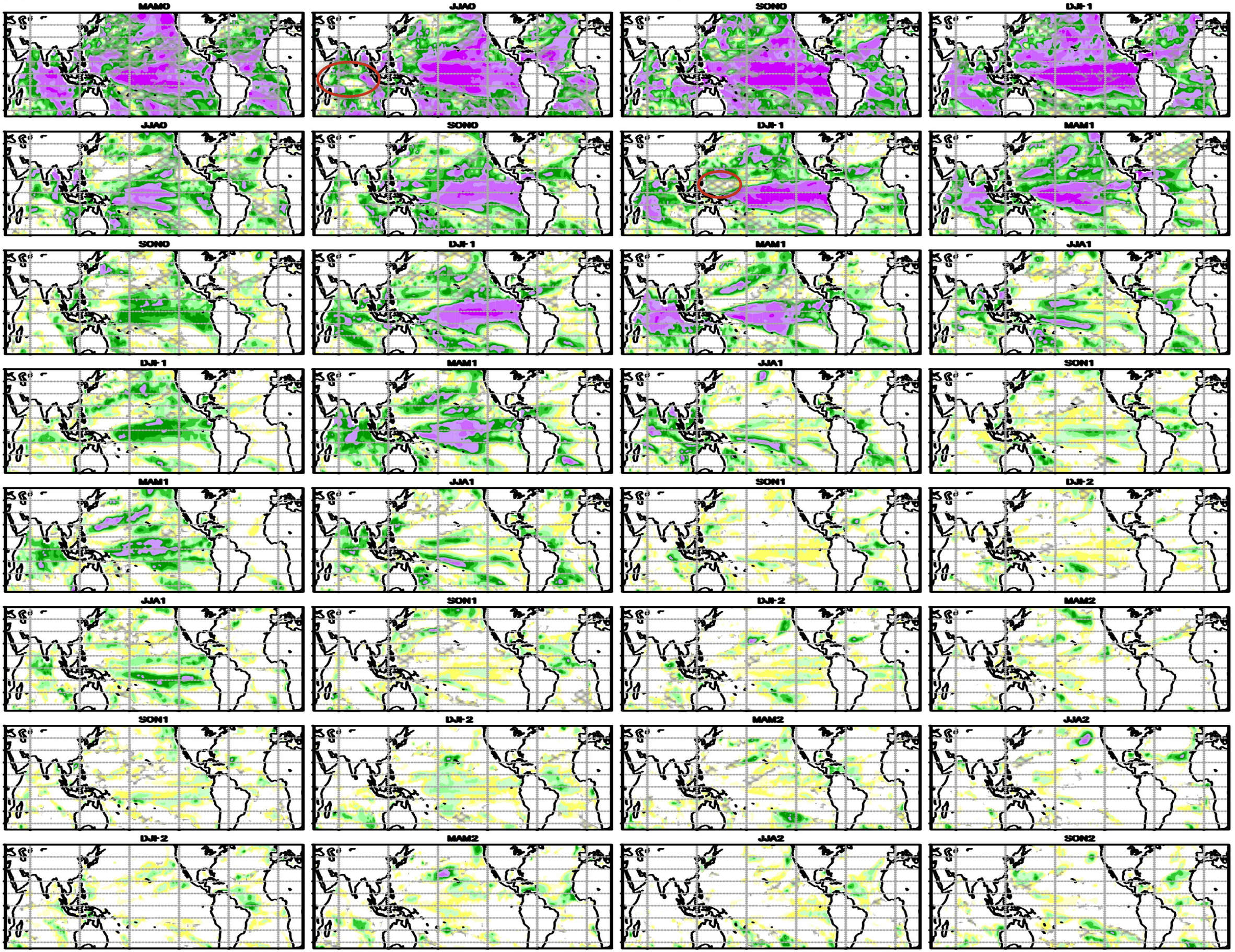

Diffrence in ACC between SSH and SST predictions

−0.8 −0.6 −0.4 −0.2 0.2 0.4 0.6 0.8

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MAM0	JJA0	SON0	DJF-1
JJA0	SON0	DJF-1	MAM1
SON0	DJF-1	MAM1	JJA1
DJF-1	MAM1	JJA1	SON1
MAM1	JJA1	SON1	DJF-2
JJA1	SON1	DJF-2	MAM2
SON1	DJF-2	MAM2	JJA2
DJF-2	MAM2	JJA2	SON2

Maskout for low skill of SSH (ACC<0.5)

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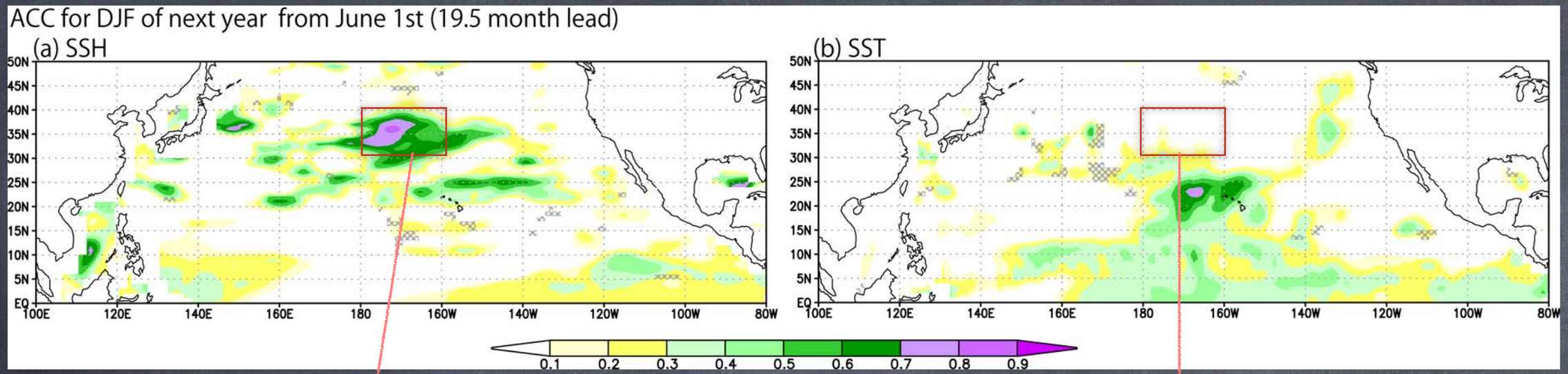
Some preliminary analysis


ACC for DJF of next year from June 1st (19.5 month lead)
(a) SSH
(b) SST
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
100E
120E
140E
160E
180
160W
140W
120W
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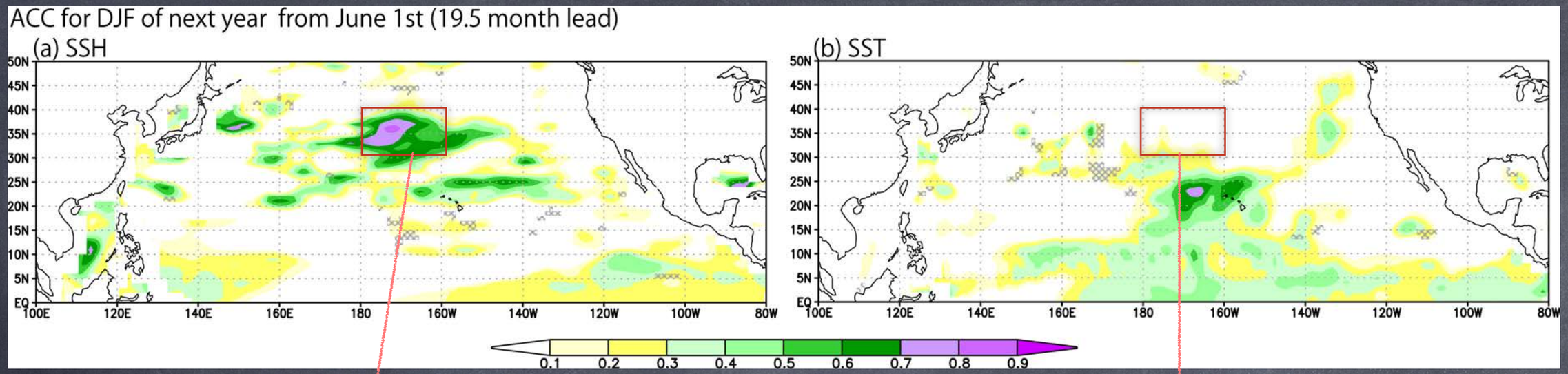
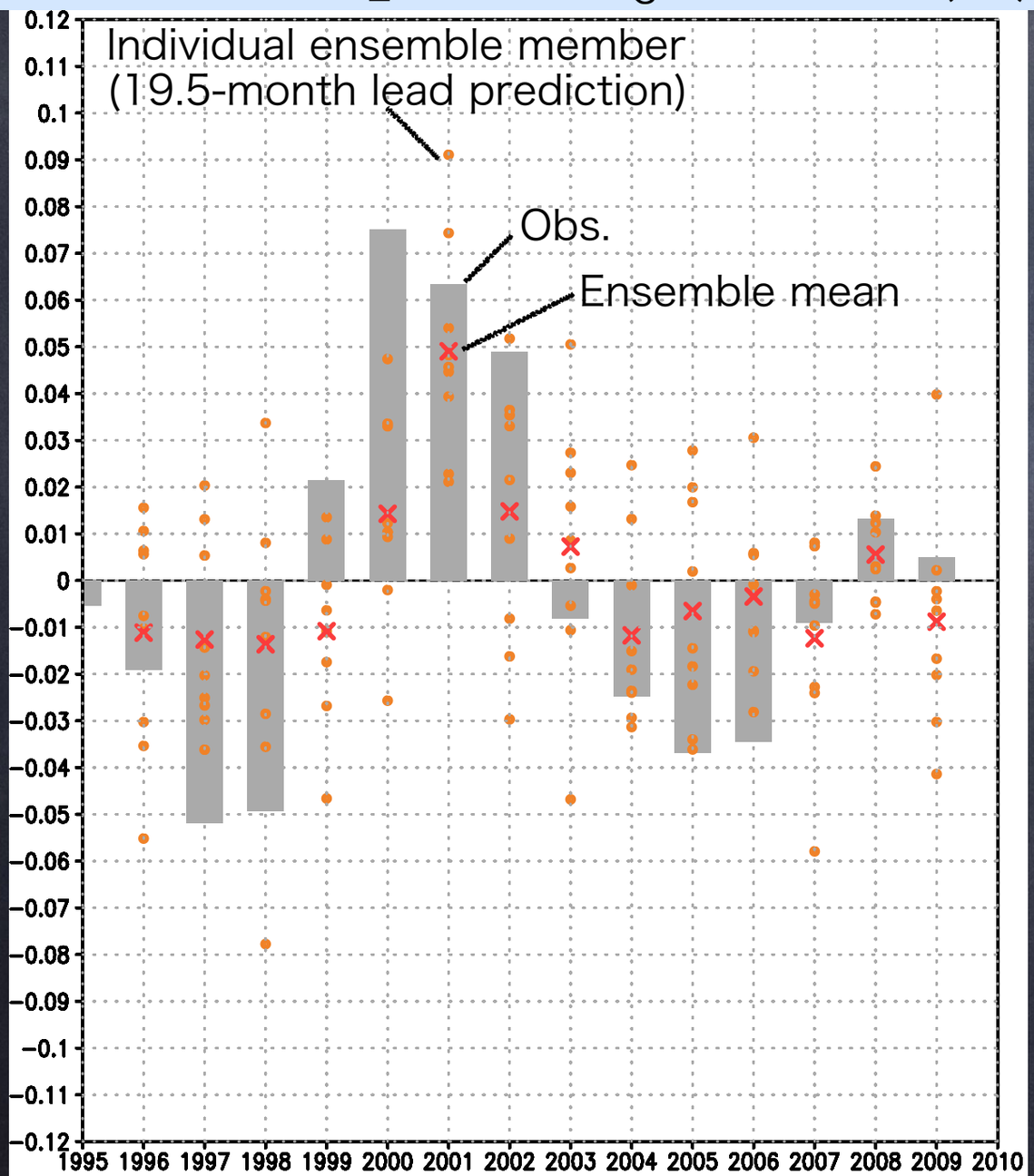


Time series of DJF_SSHA averaged in the box (cm)



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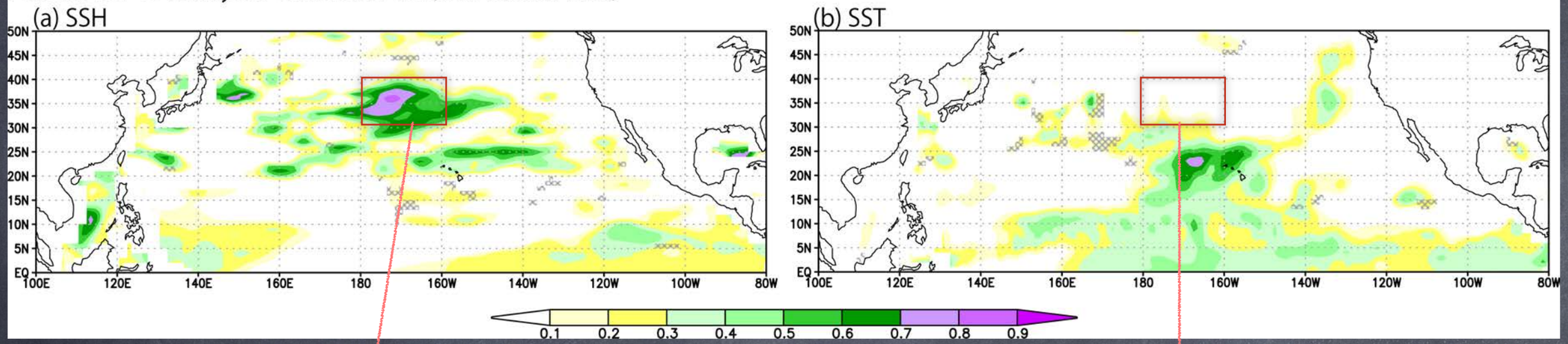

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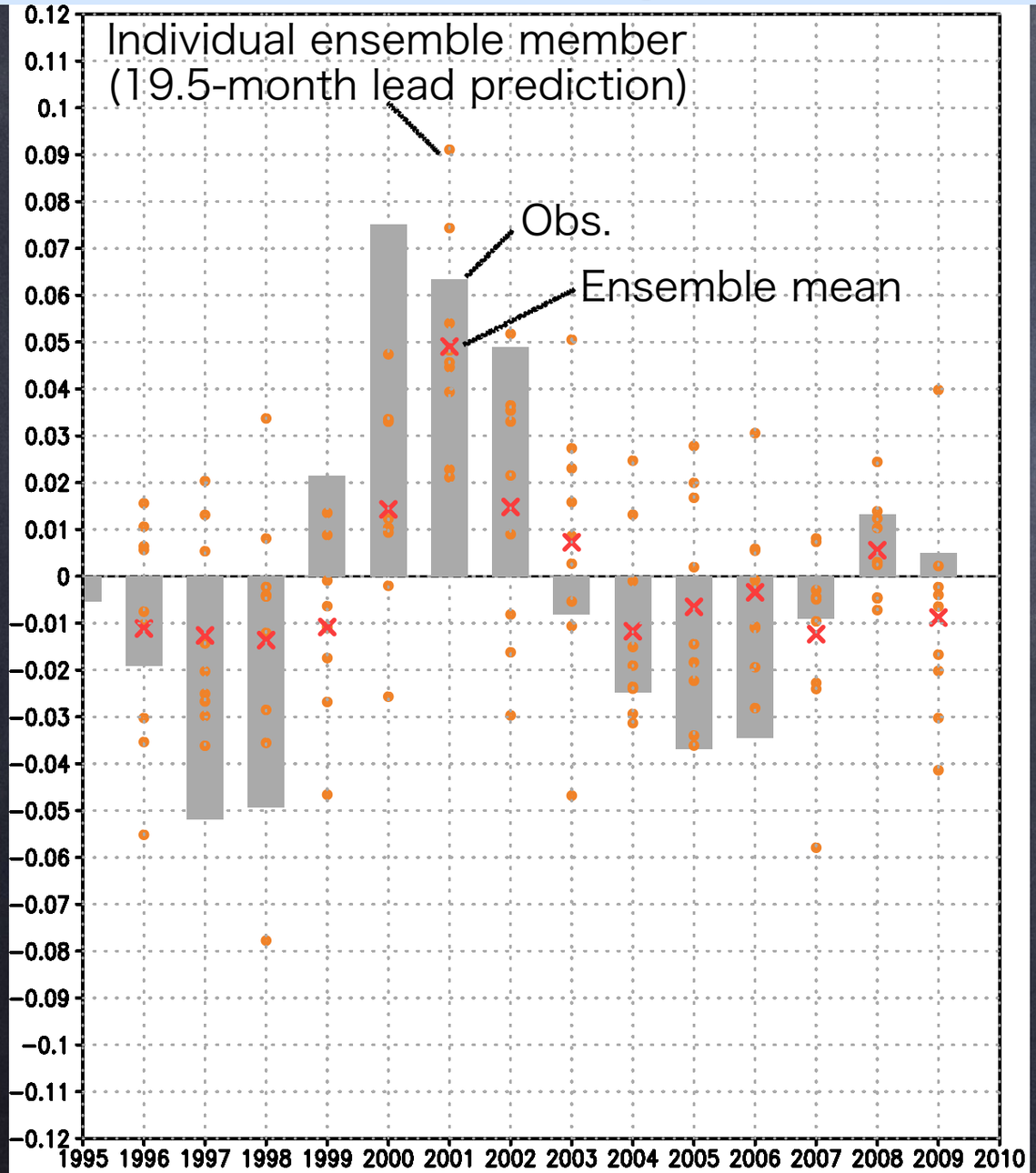
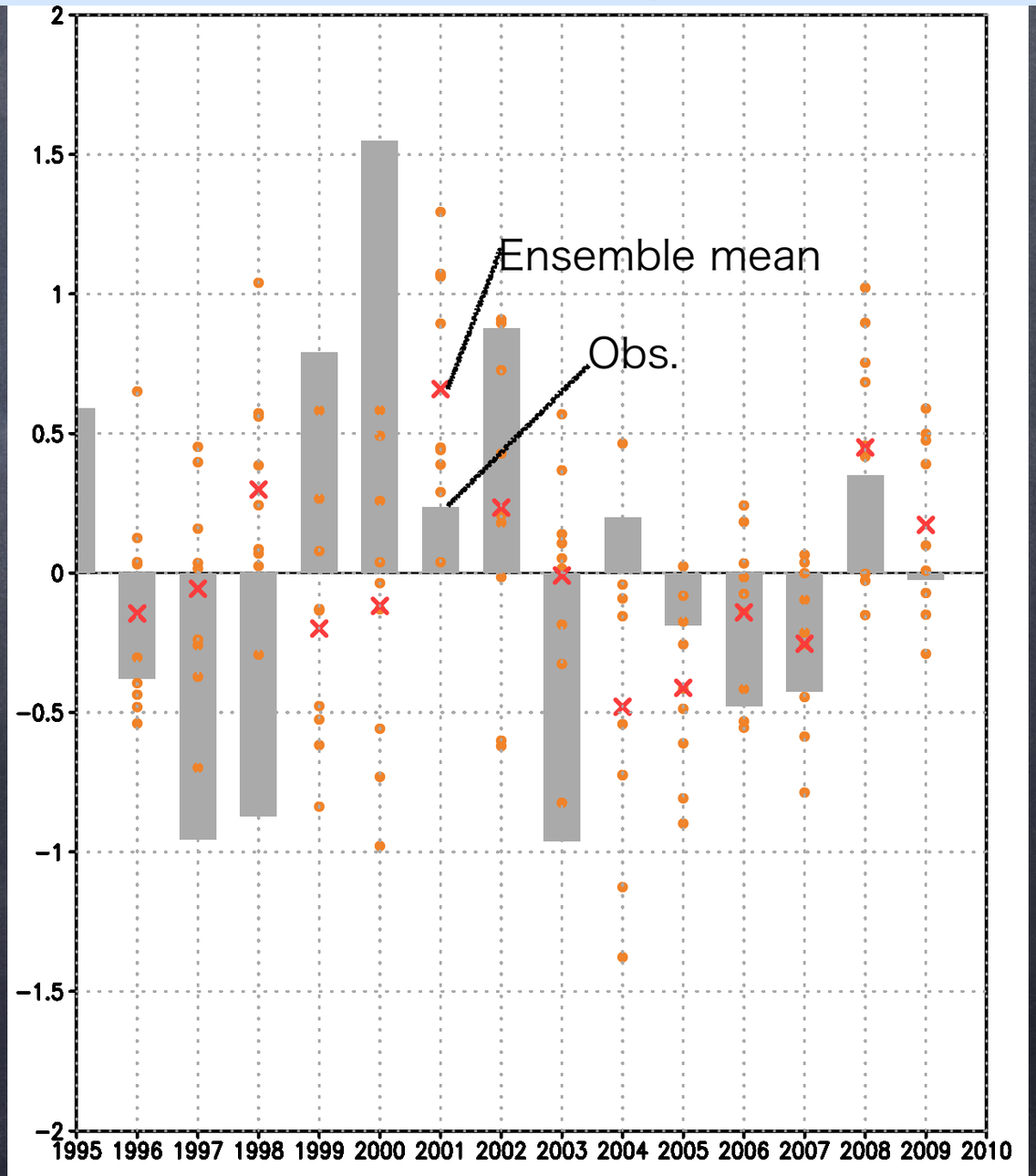
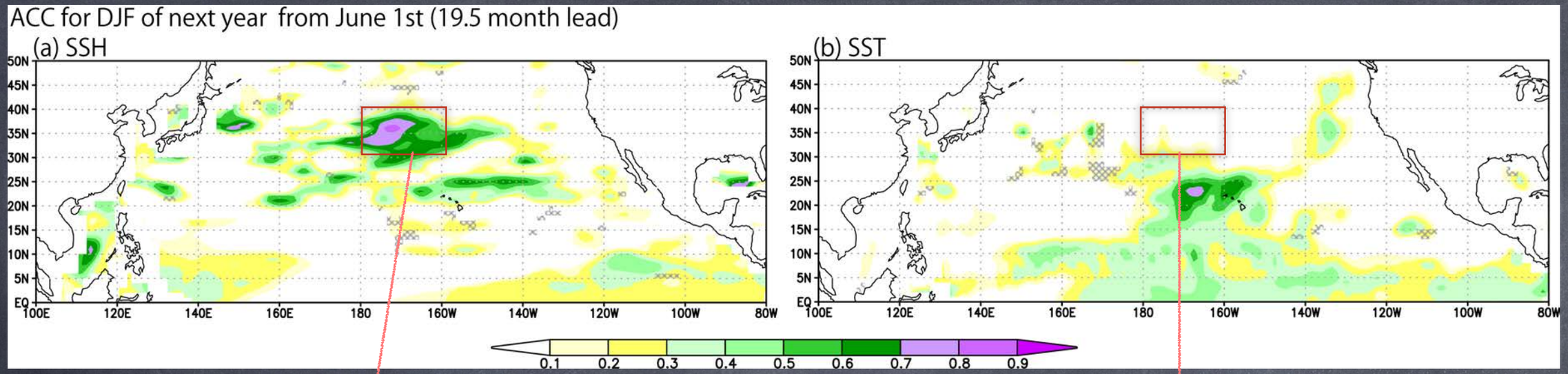


Time series of DJF_SSTA averaged in the box (ºC)





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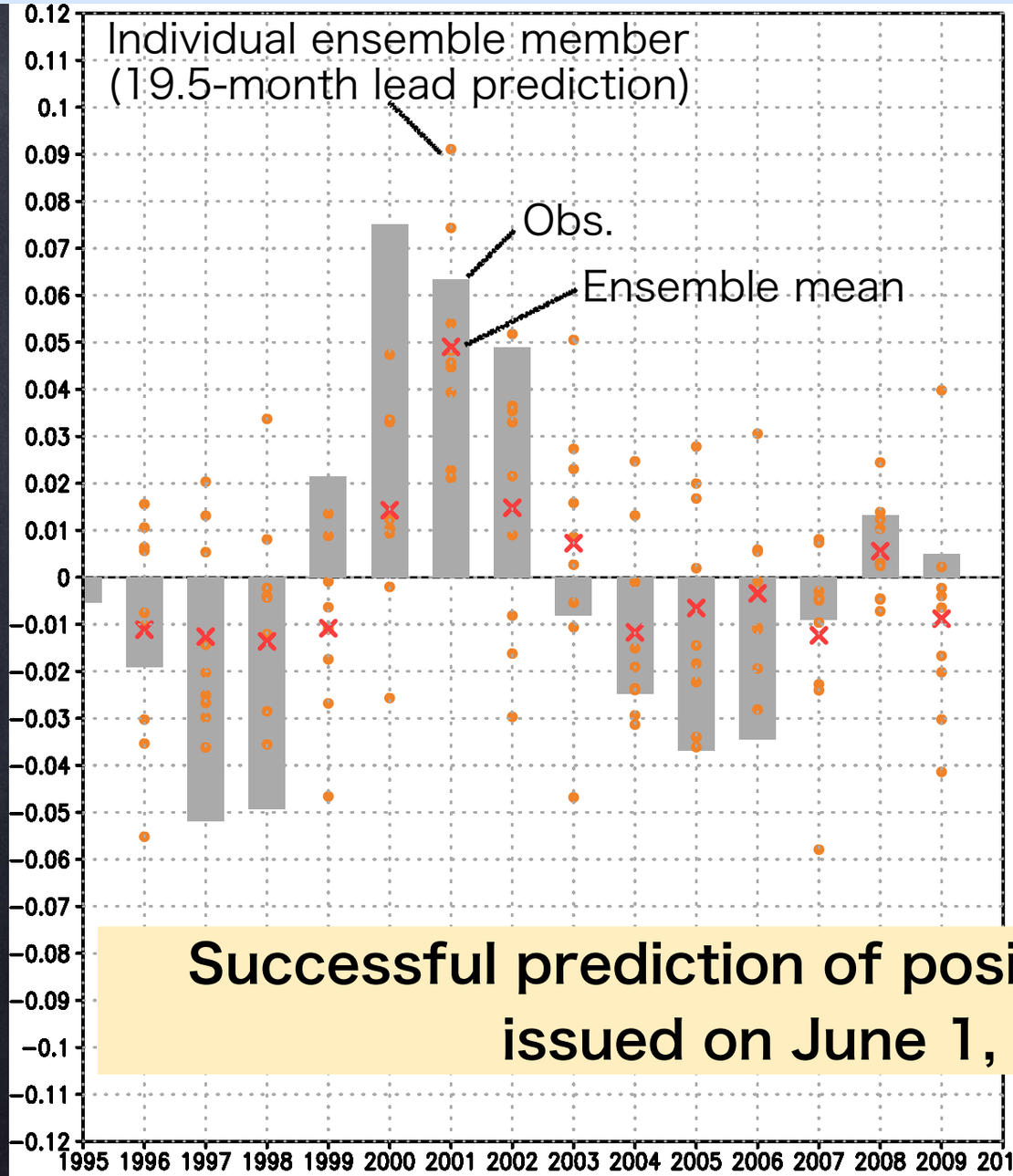

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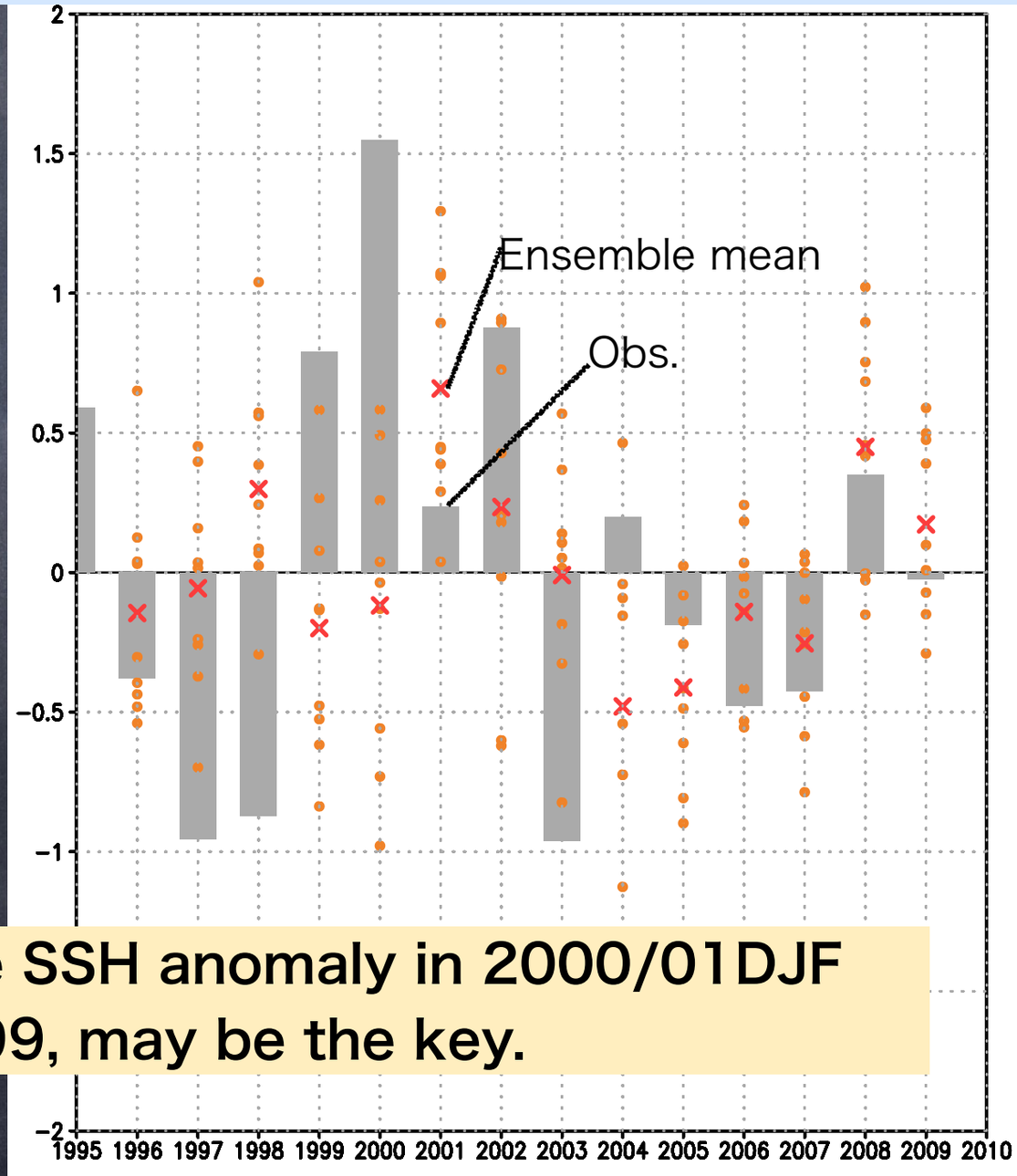
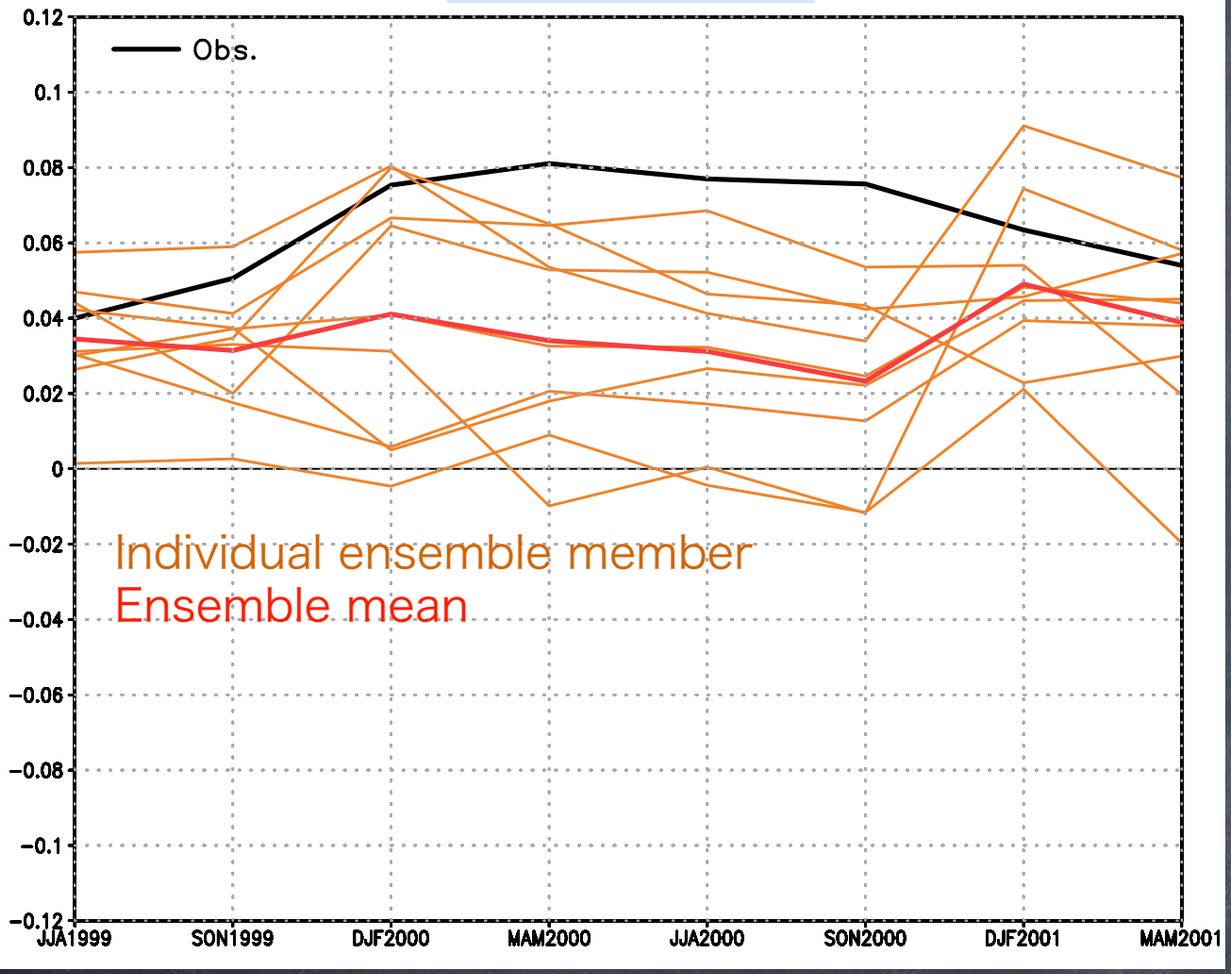


Successful prediction of positive SSH anomaly in 2000/01DJF issued on June 1, 1999, may be the key.

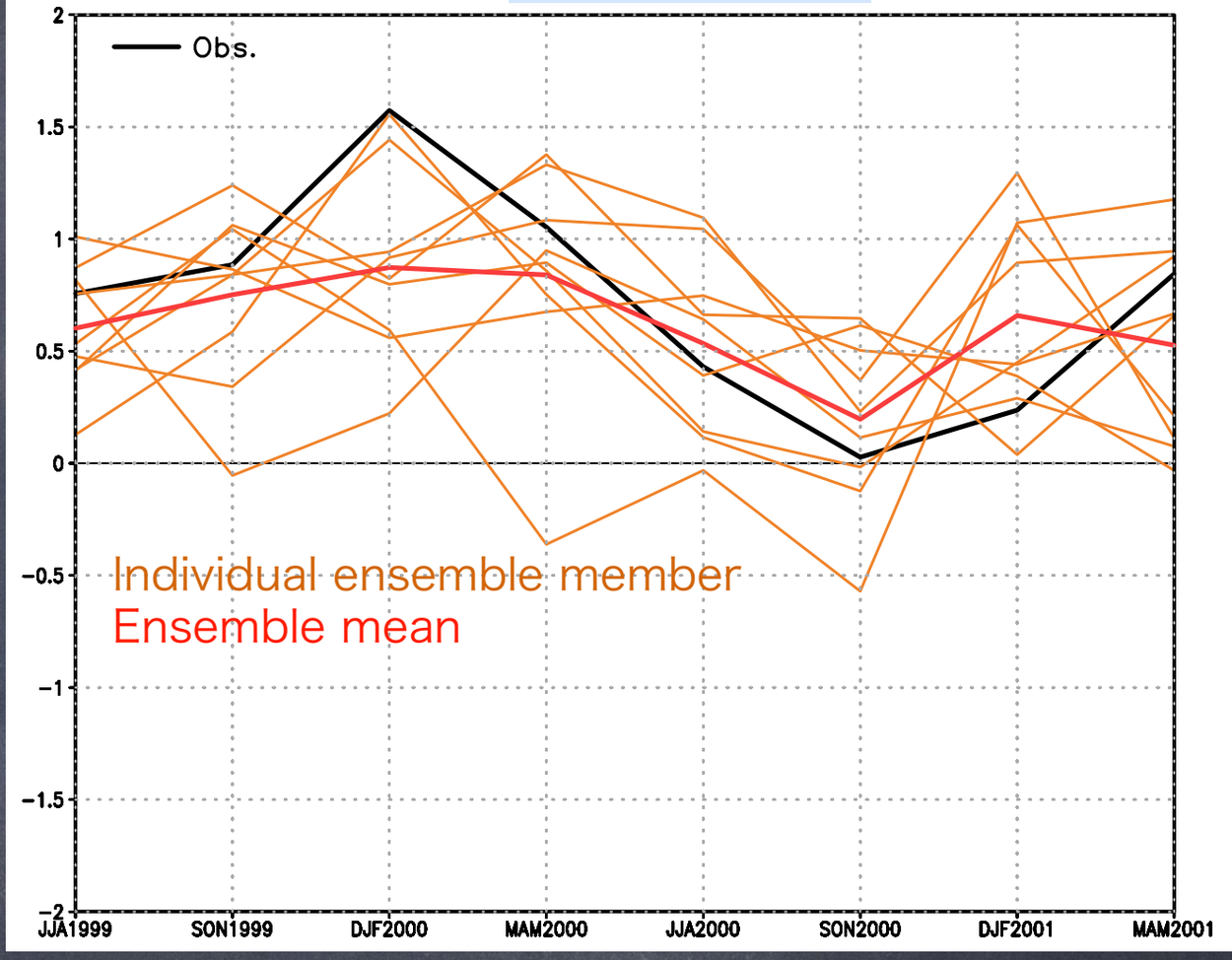
Regional anomaly (in 30-40N, 180W-160W) plumes from JJA1999 to MAM2001 (prediction issued on June 1, 1999)

SSH (cm)



The positive anomaly persisted to SON2000, and recovered to DJF2000/01

SST (ºC)

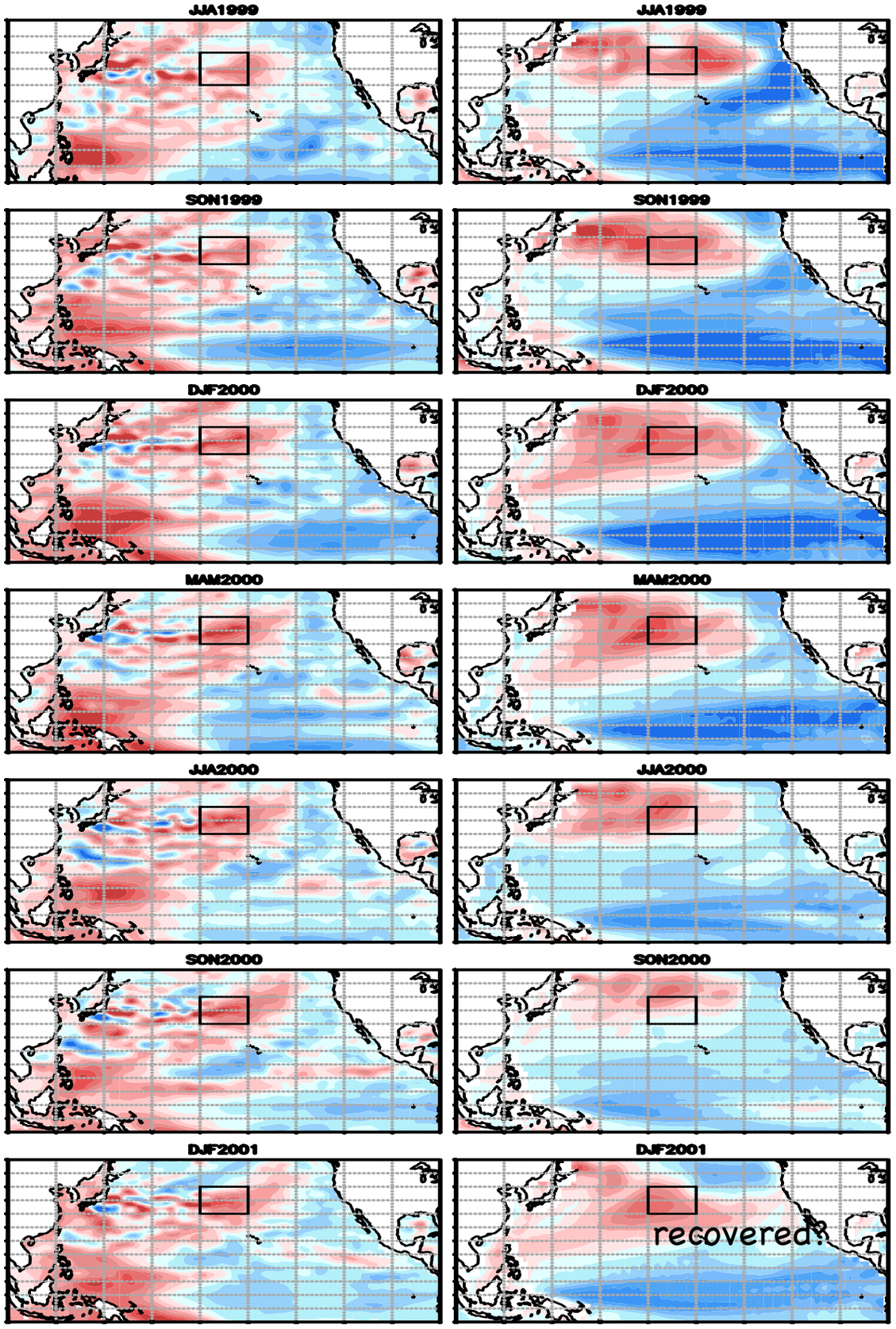


The positive anomaly disappeared in SON2000

SSH anom. (1×10^{-1} cm)

Obs.

Prediction issued on June 1, 1999



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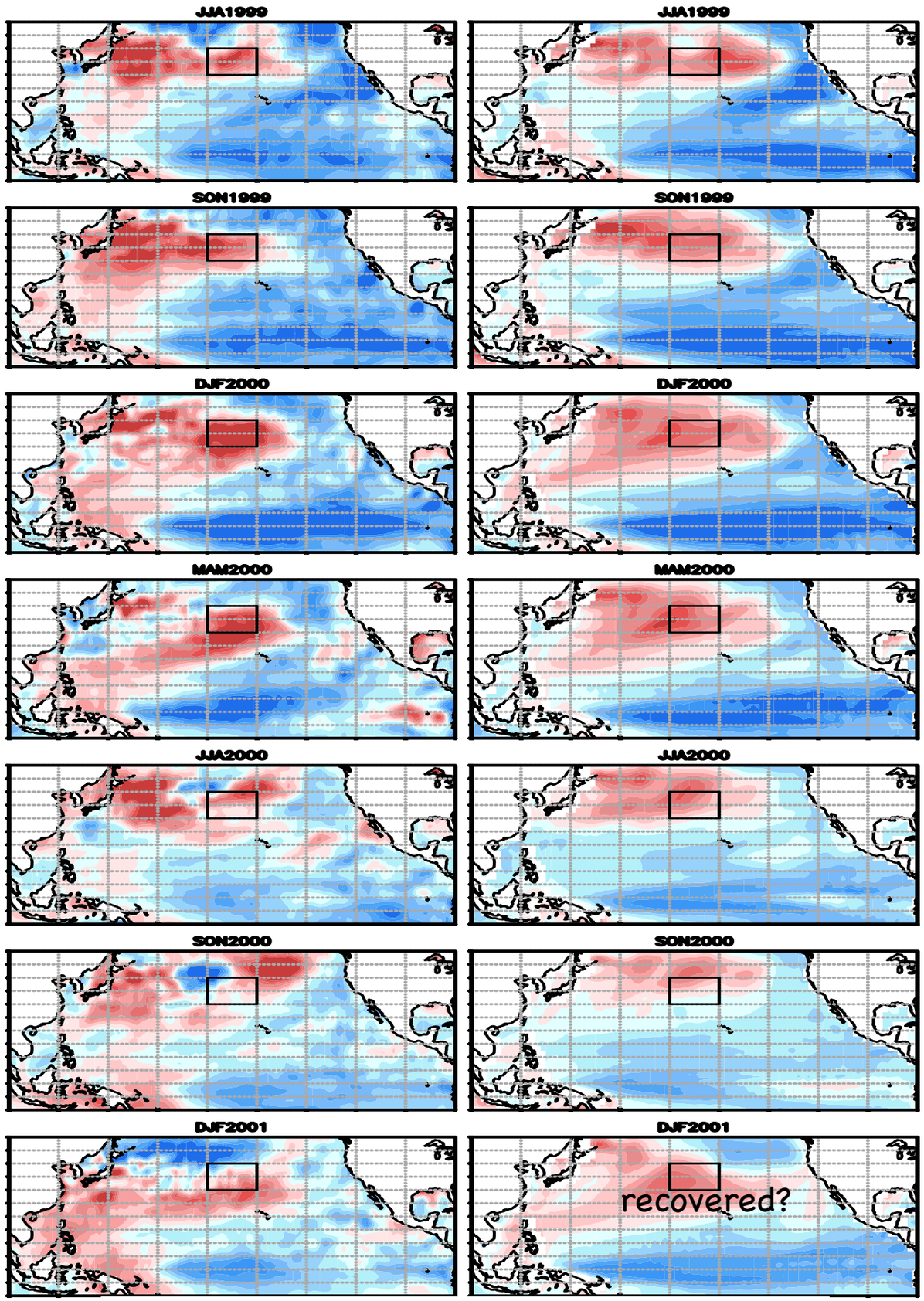
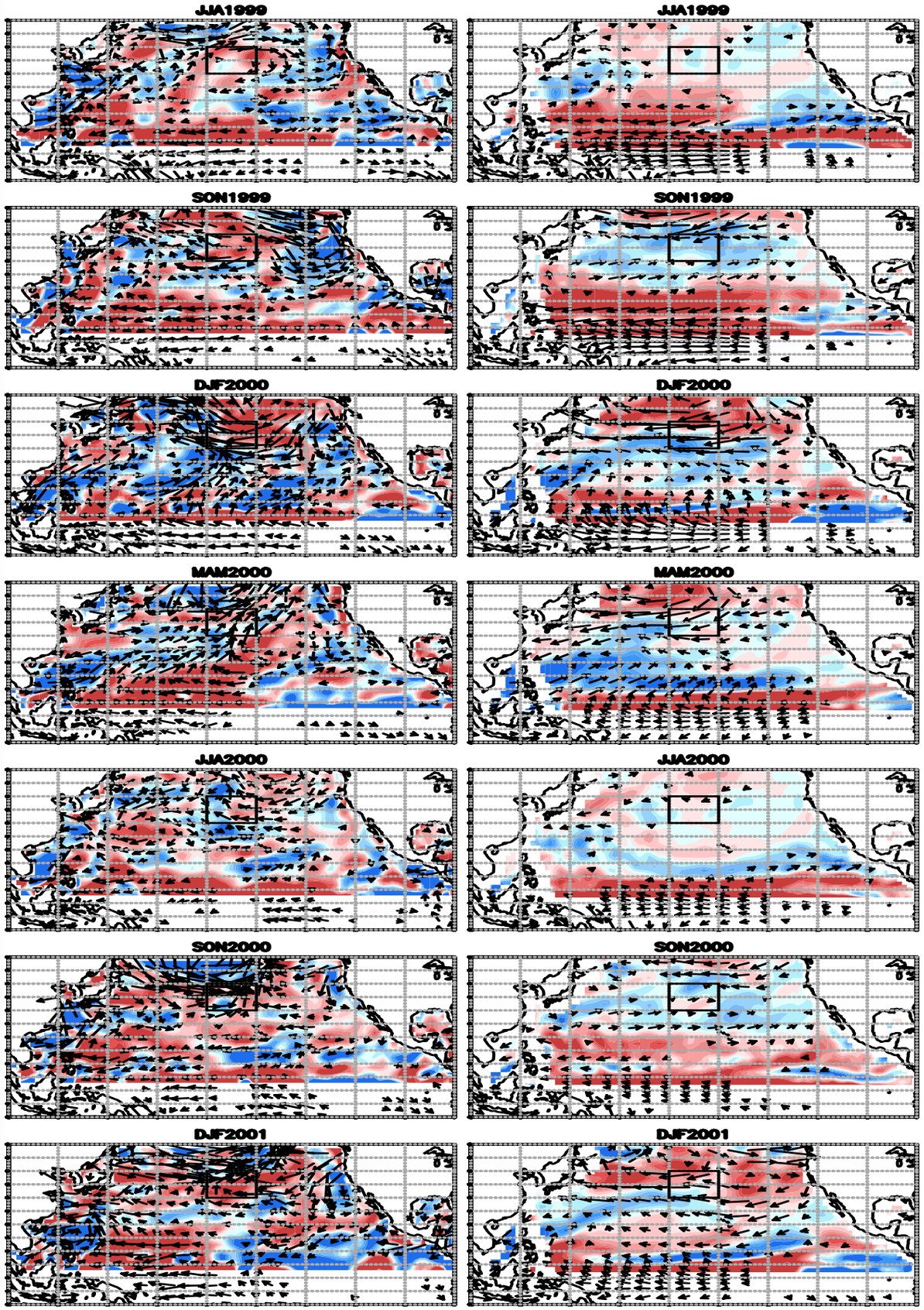


Ekman upwelling anom. (1×10^{-6} m/s)

Reanalysis

Prediction issued on June 1, 1999



Net heat flux anon (W m^{-2})

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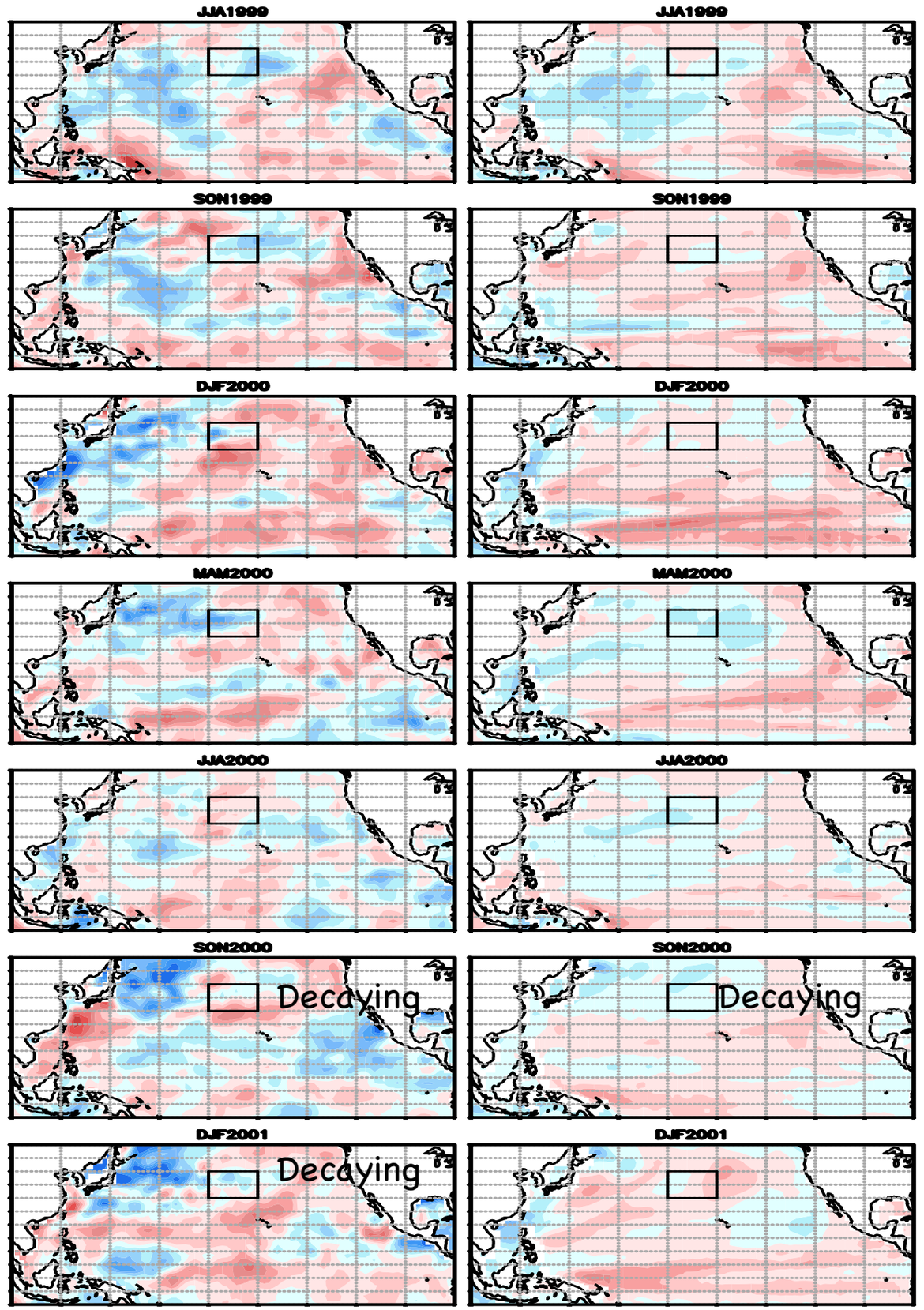

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Introduce new prediction system (SINTEX-F2)

Schematic of numerical seasonal prediction: "baton pass"

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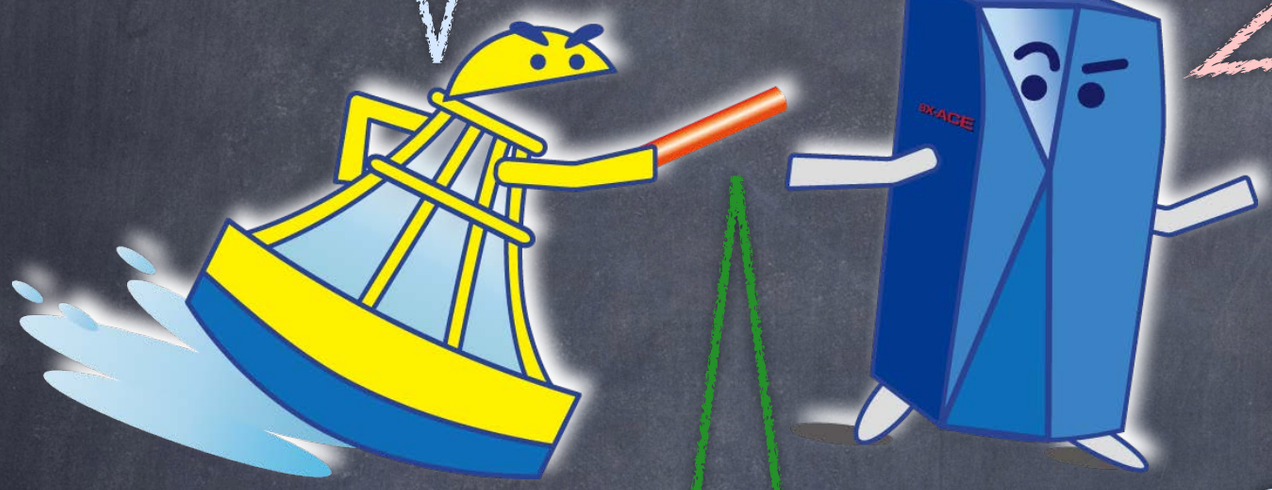

2. Initialization (assimilation)

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Prediction of future

$$x(t_0) + \Delta t \times M = X(t_0 + \Delta t)$$

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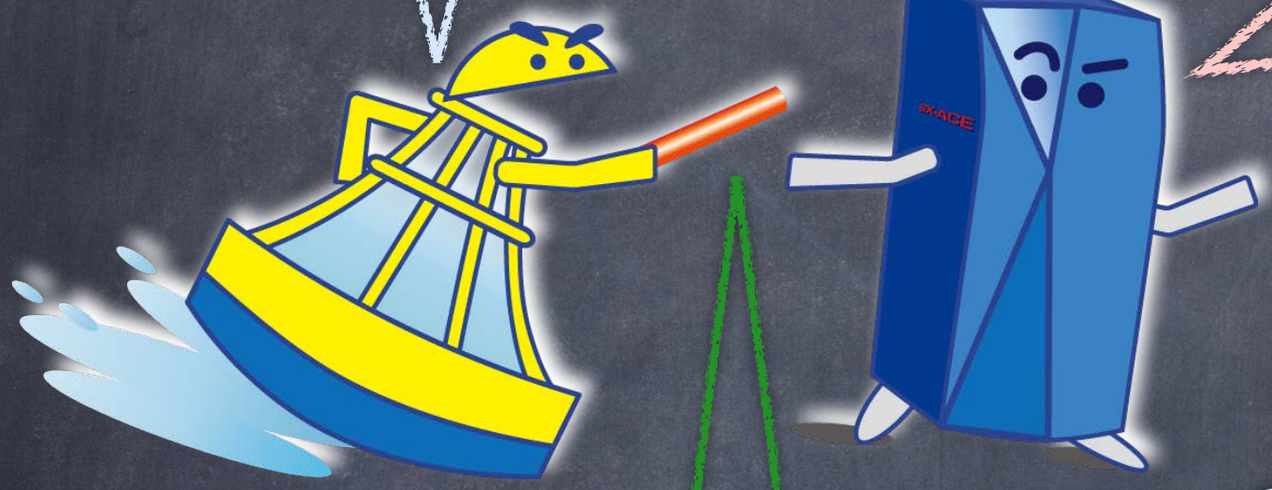

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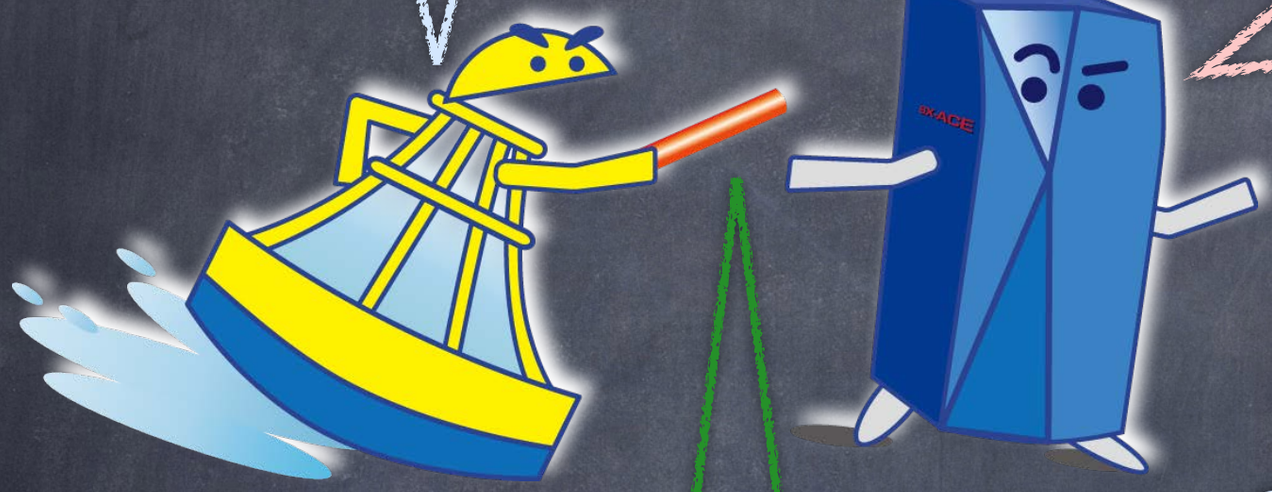

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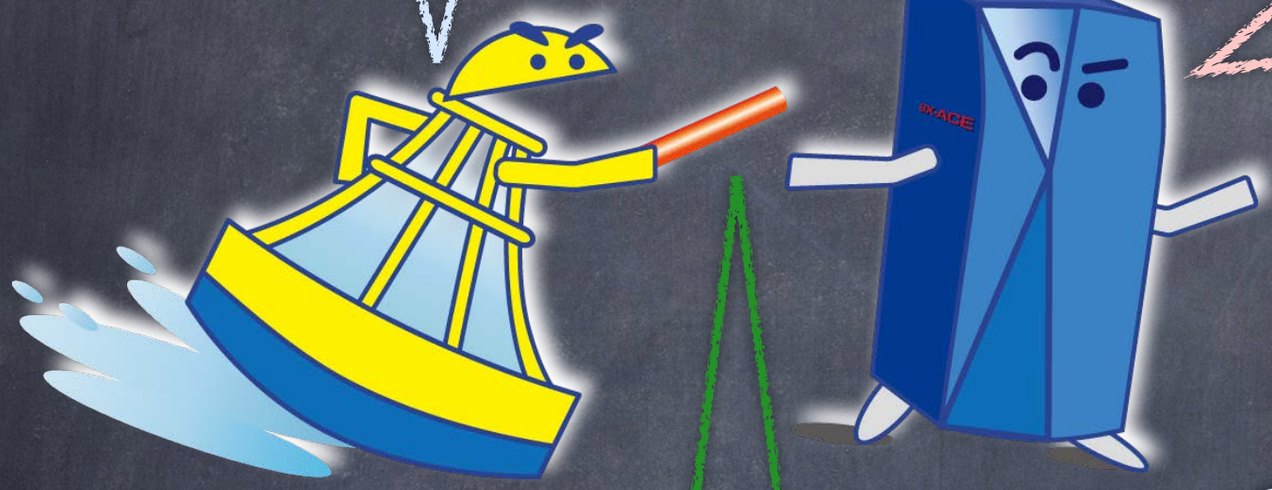

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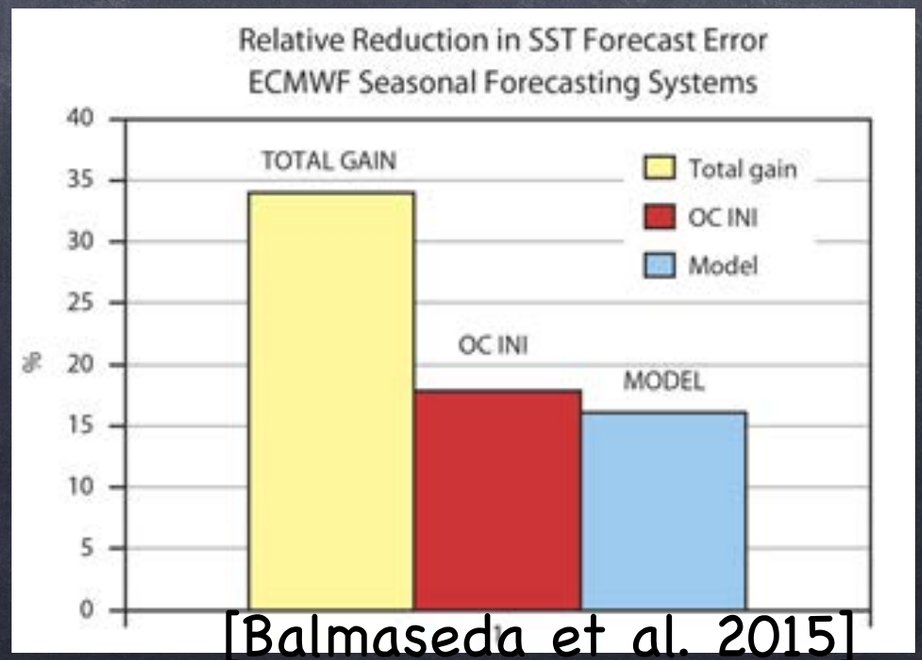

[Balmaseda et al. 2015]

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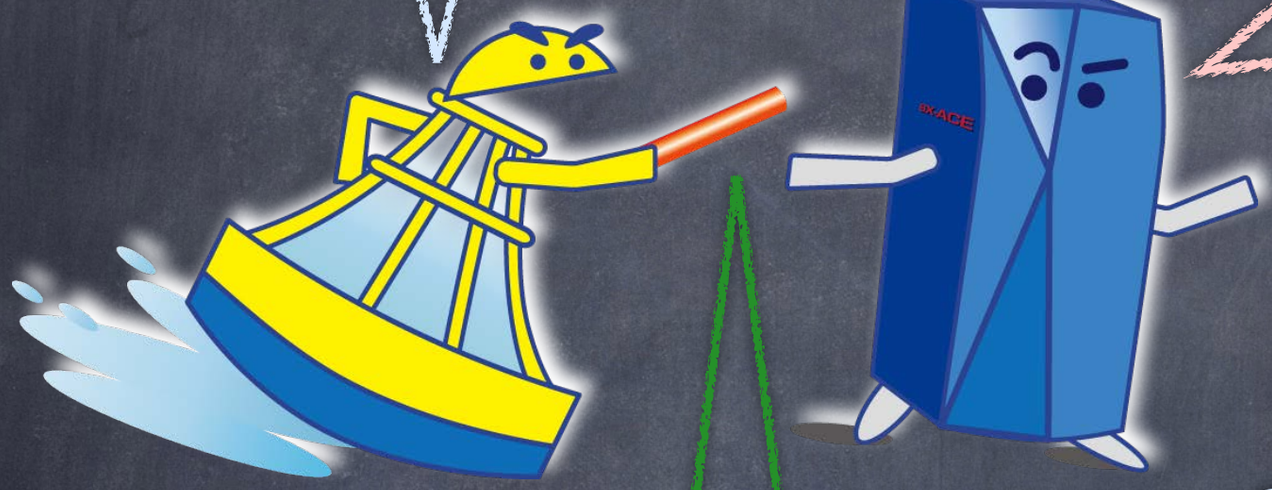

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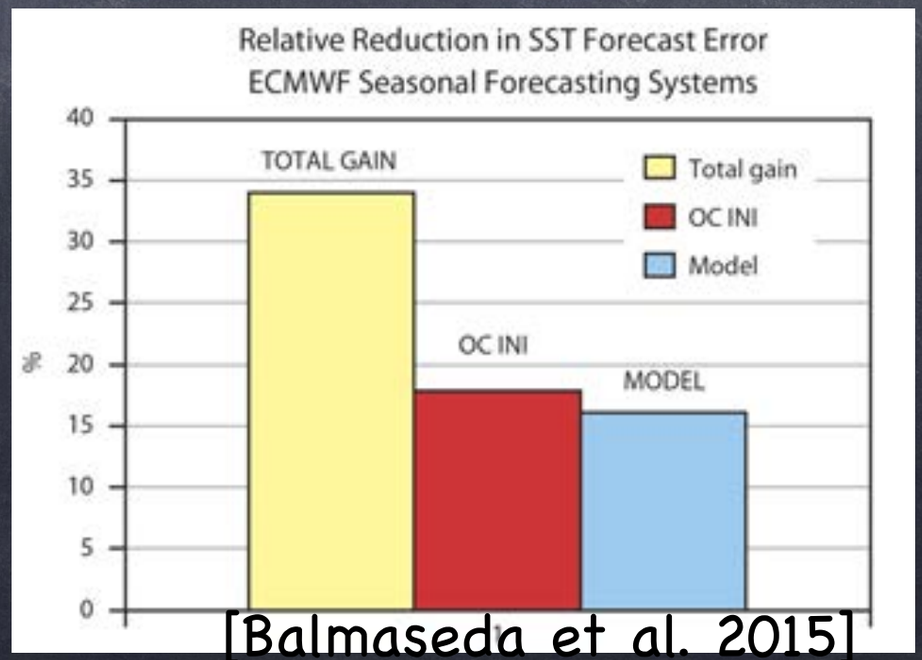
Some previous works (e.g. ECMWF system) suggest that #1 model development and #2 ocean initialization are equally important for improving seasonal prediction skill.



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How to improve the seasonal prediction system

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Strategy 2: Ocean Initialization (Doi et al. 2017, JC)

From SST-nudging to
three dimensional variational scheme (3DVAR)
using 3D profile data of Temperature and Salinity

Strategy 1: Model development (Doi et al. 2016, JAMES)

	AGCM	OGCM	Coupling	Sea Ice
SINTEX-F1 (Luo et al. 2005)	ECHAM4 T106L19	OPA8 2×(0.5-2) L31	Every 2 hour No flux correction	restoring obs. climatology
SINTEX-F2 (Masson et al. 2012; Sasaki et al. 2013)	ECHAM5 T106L31	NEMO(OPA9) 0.5×0.5 L31	Same as F1	LIM2

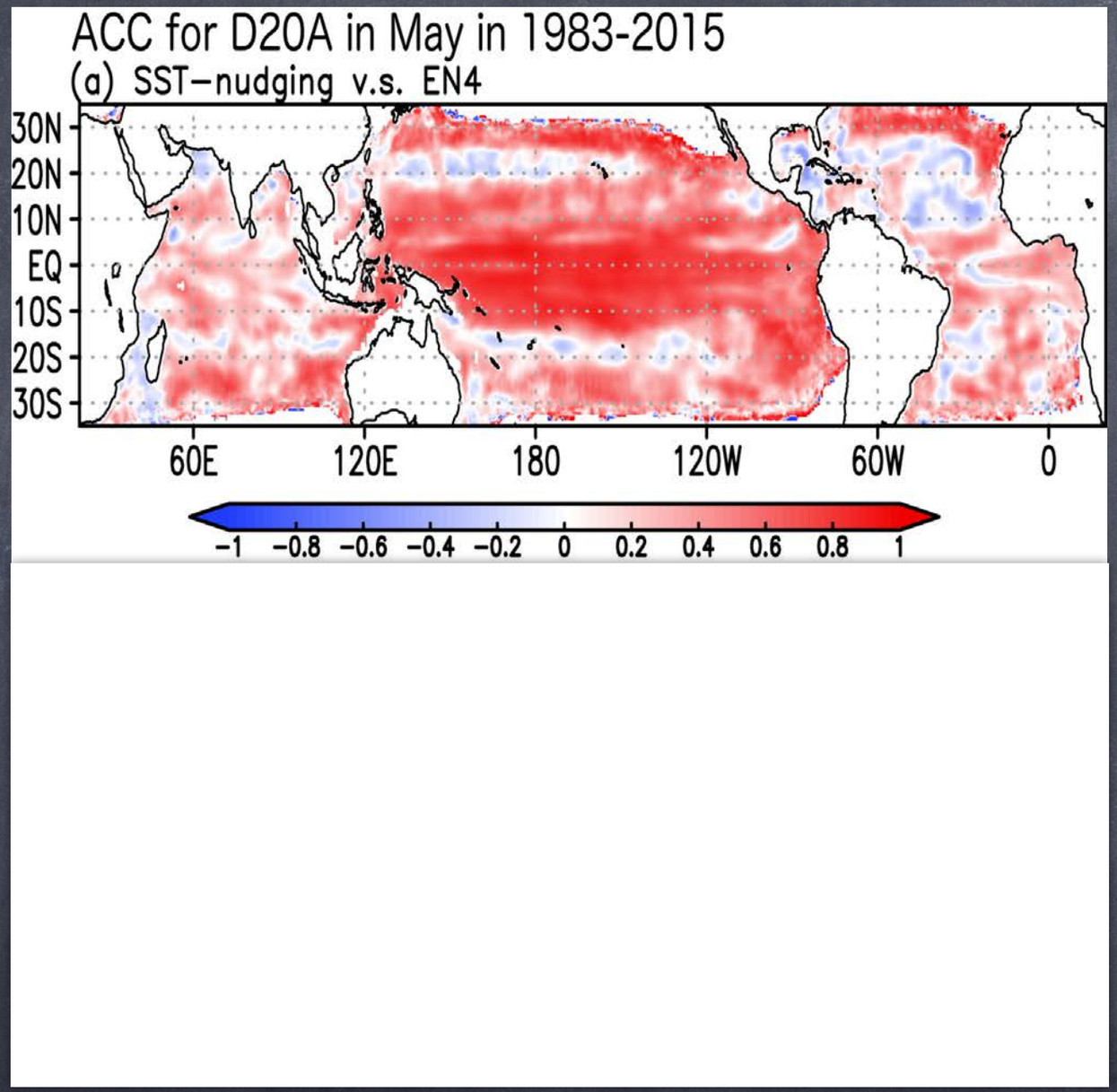
- Initialization: SST-nudging scheme
- 12 ensemble members

{2 sst data (1ºweekly, 025ºdaily) × 3 nudging strengths
× 2 physical schemes for SVS ocean mixing (Sasaki et al. 2012)}

"A high-resolution with a dynamical sea-ice model" may improve the coastal climate phenomena and the mid, high-latitude climate.

Strategy 2: Ocean Initialization (Doi et al. 2017, JC)

The initialization skill of subsurface ocean



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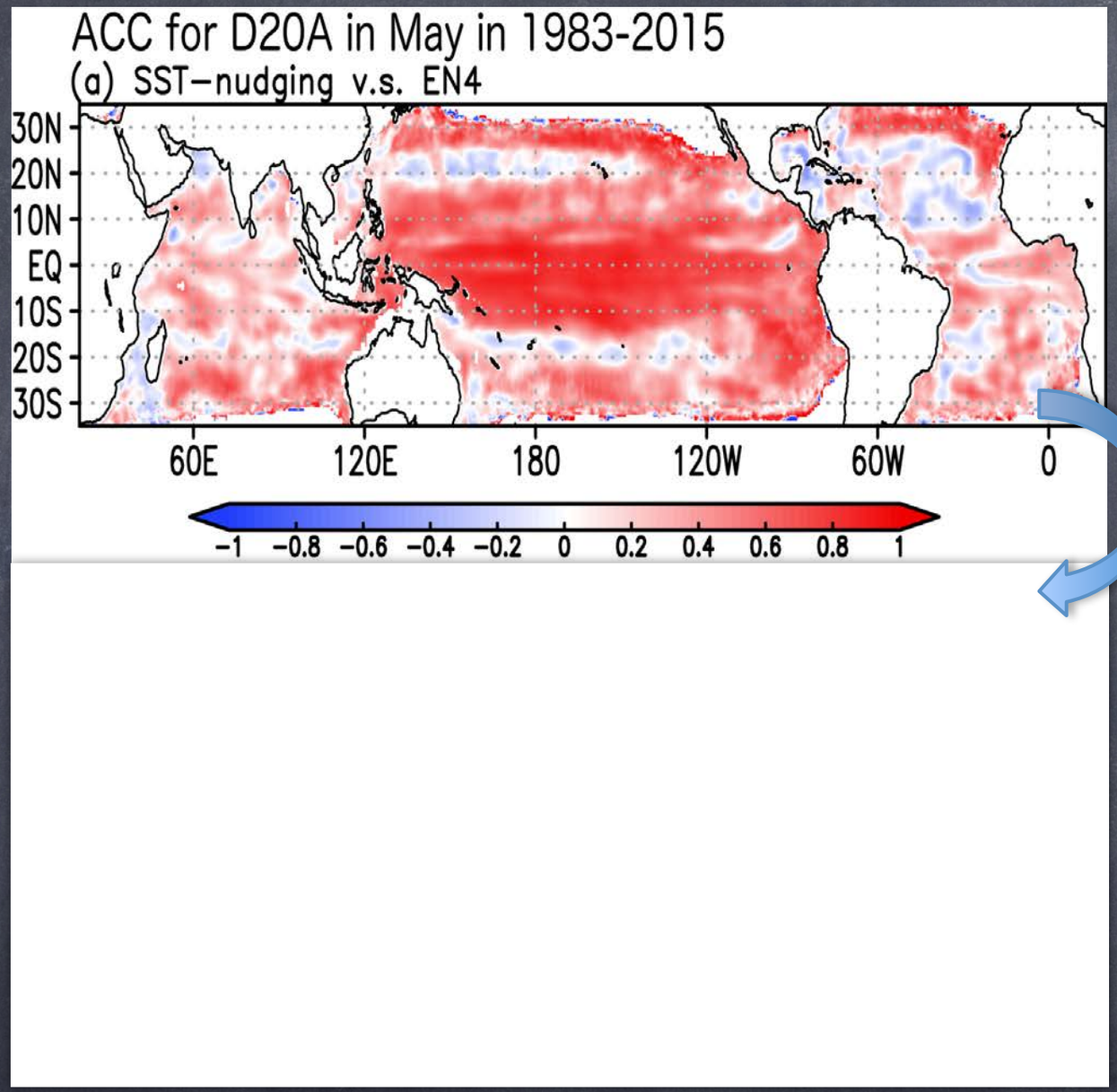

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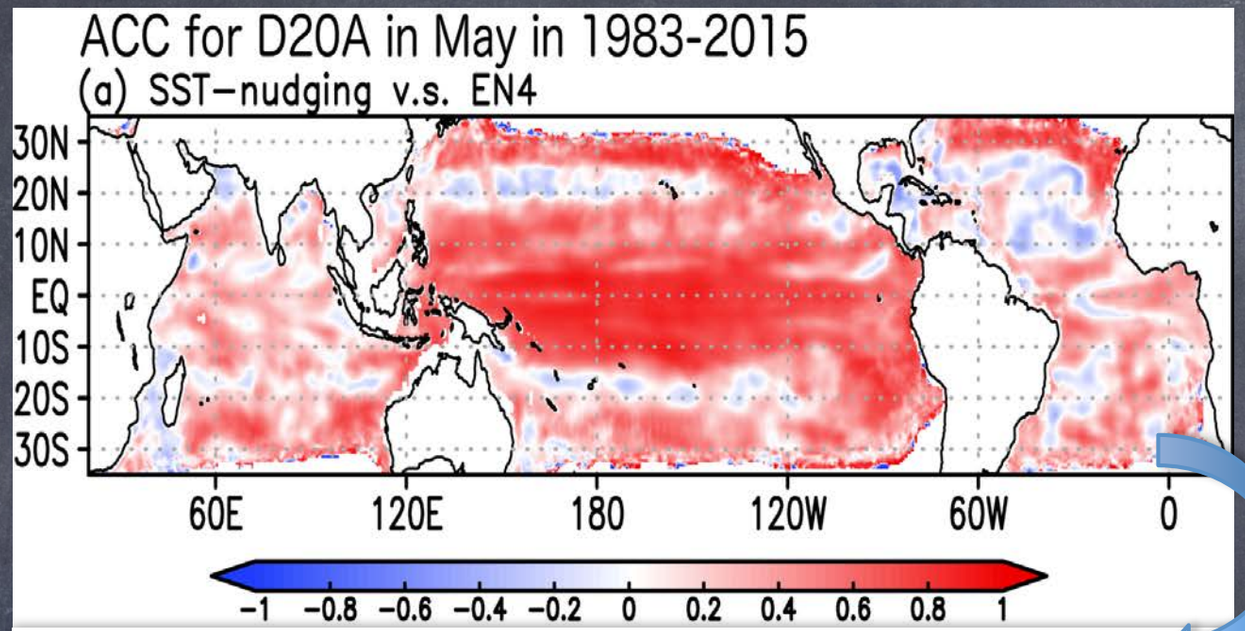

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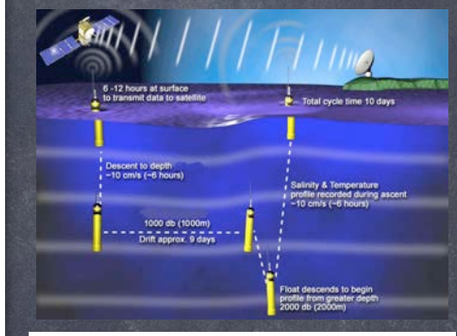

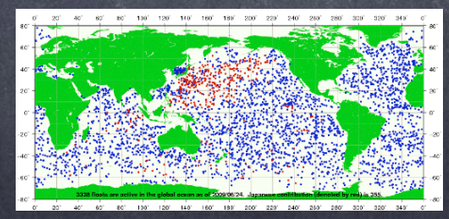

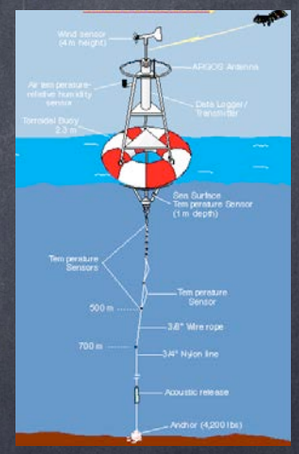

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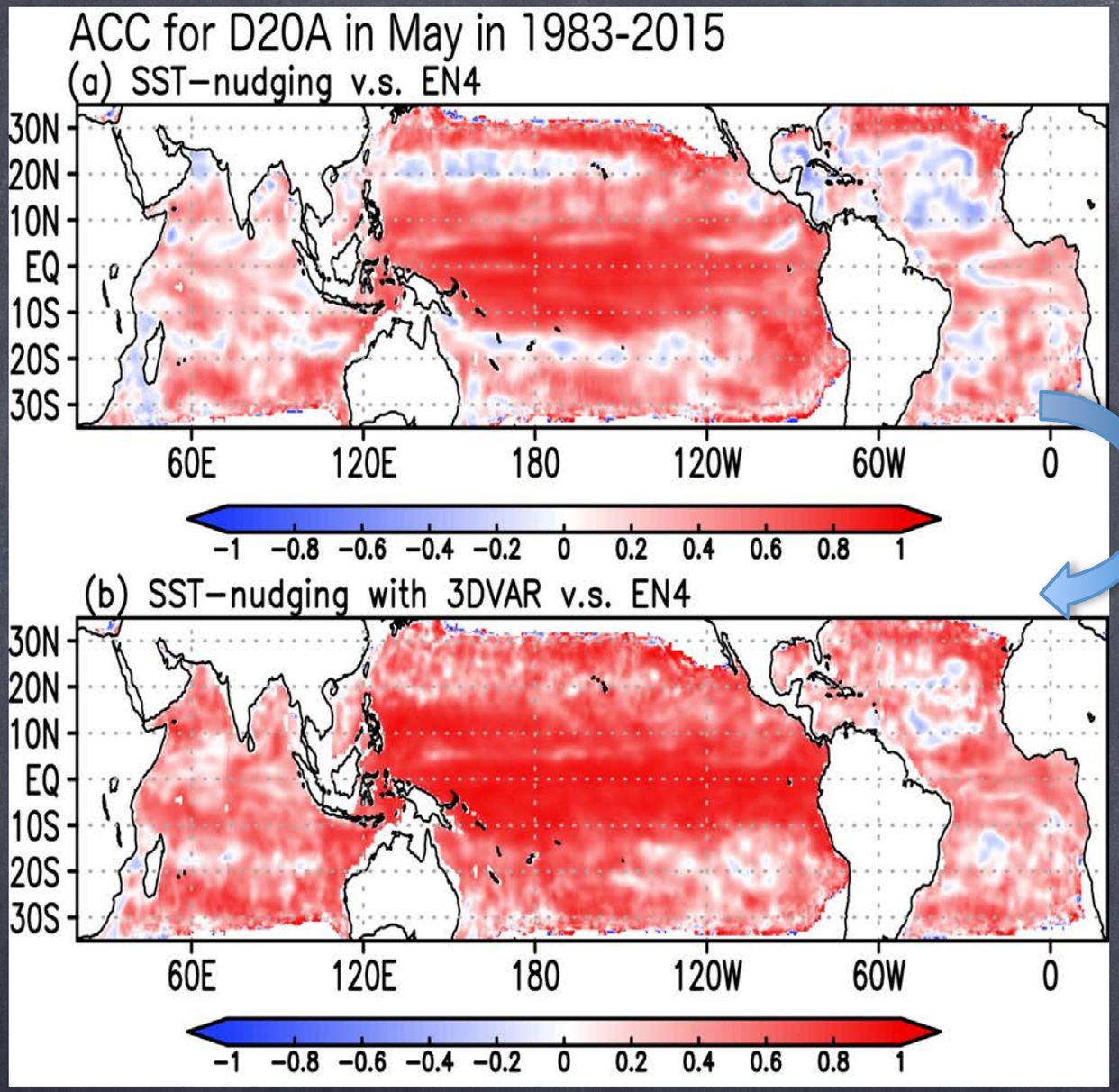

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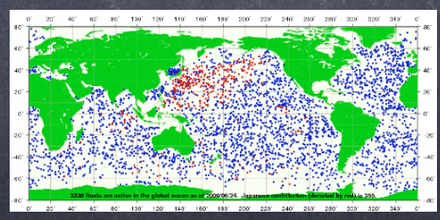

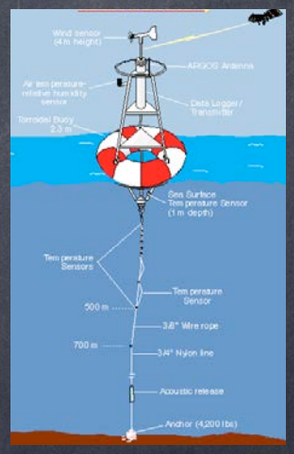

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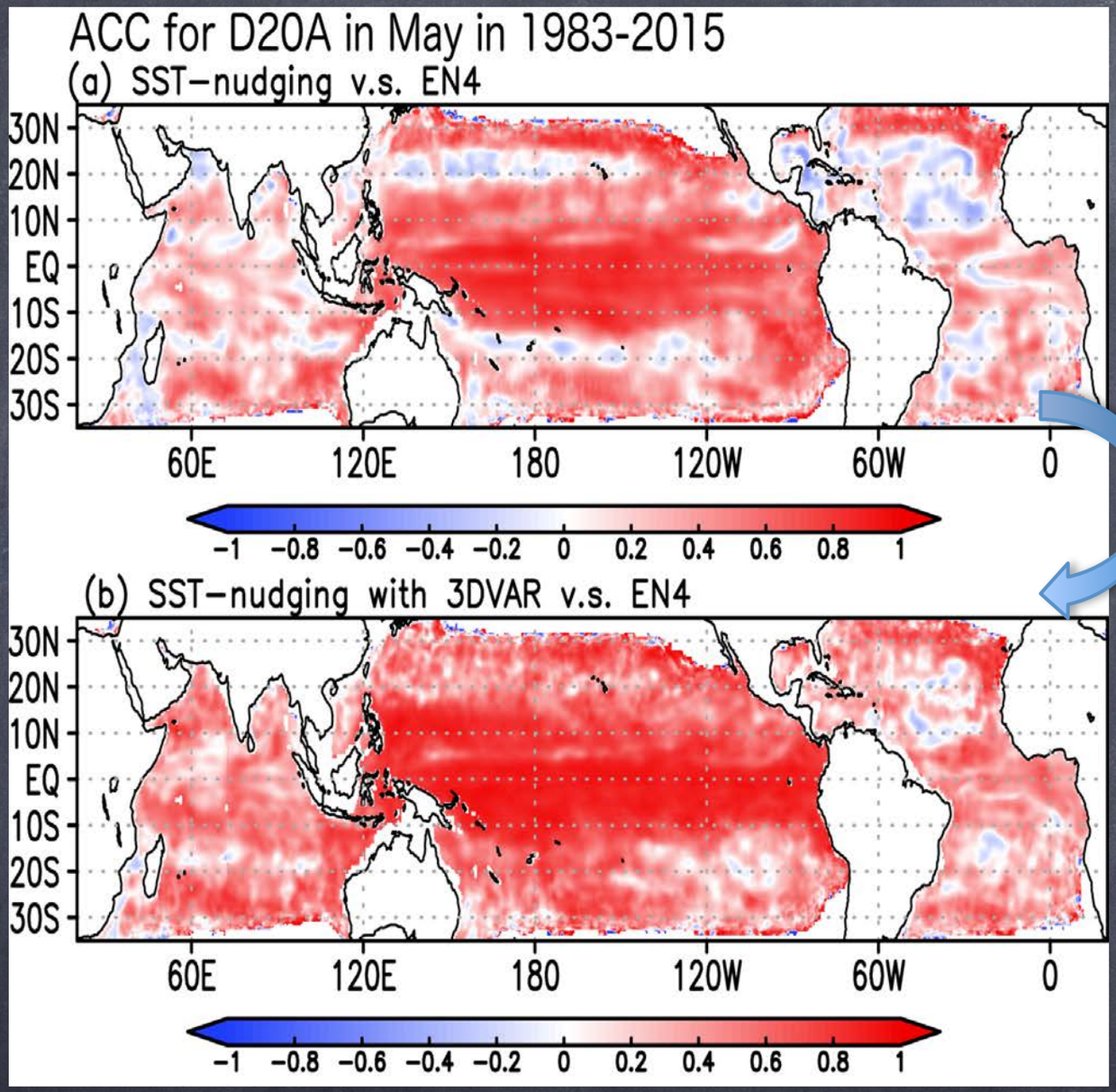

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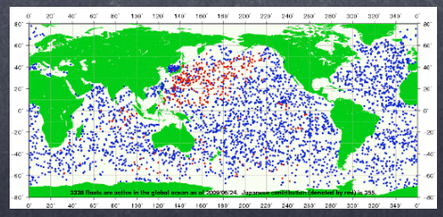
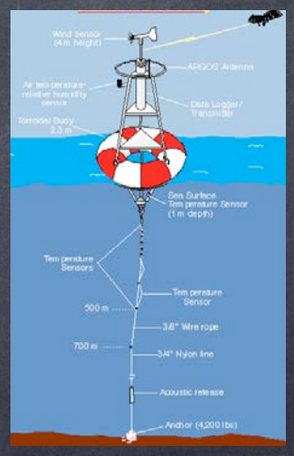
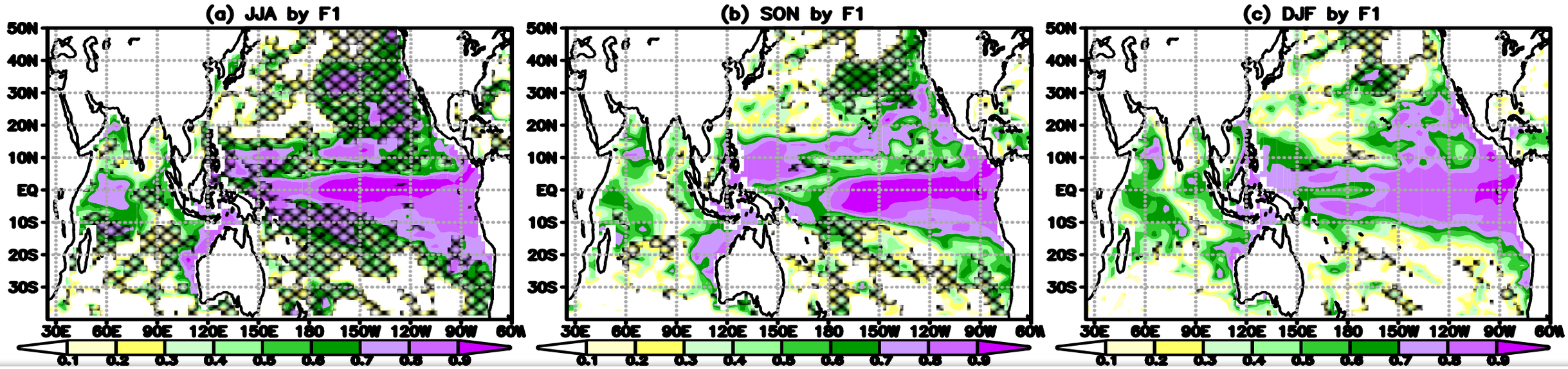




Initial state of subsurface ocean in the tropical Indian Ocean and the tropical Atlantic, and the mid-latitude is closer to the observation by the new initialization scheme.

ACC of SSH prediction from June 1st



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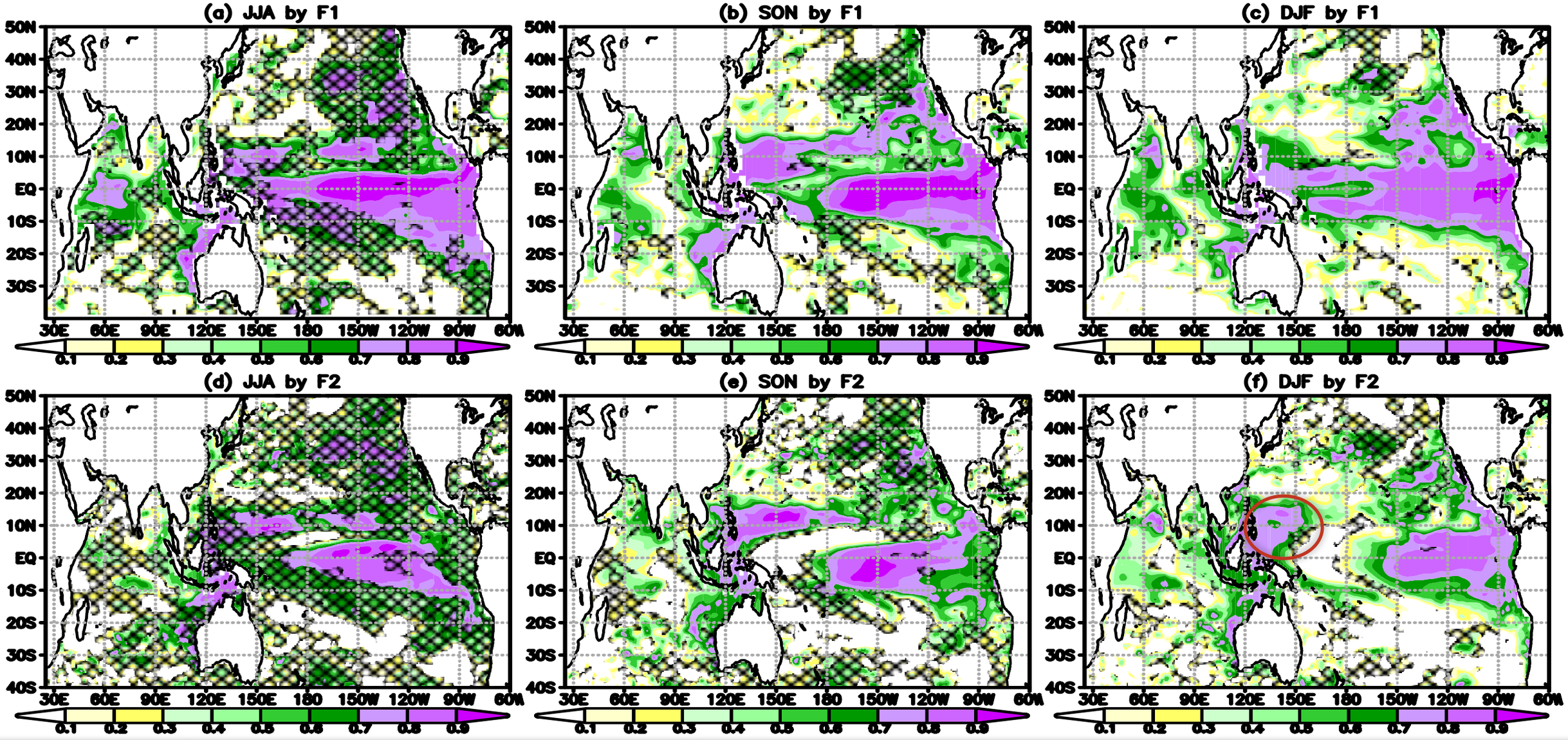

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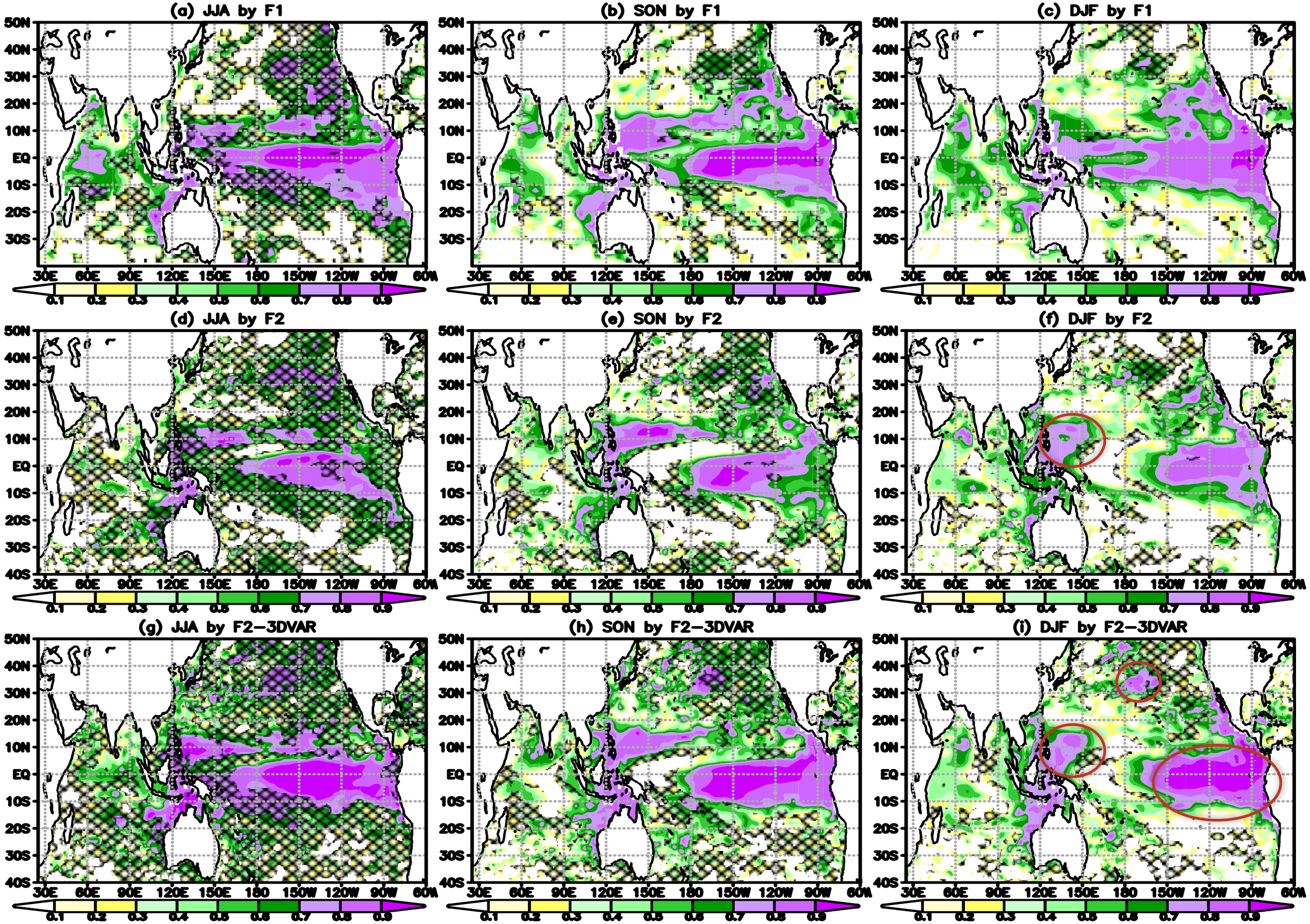
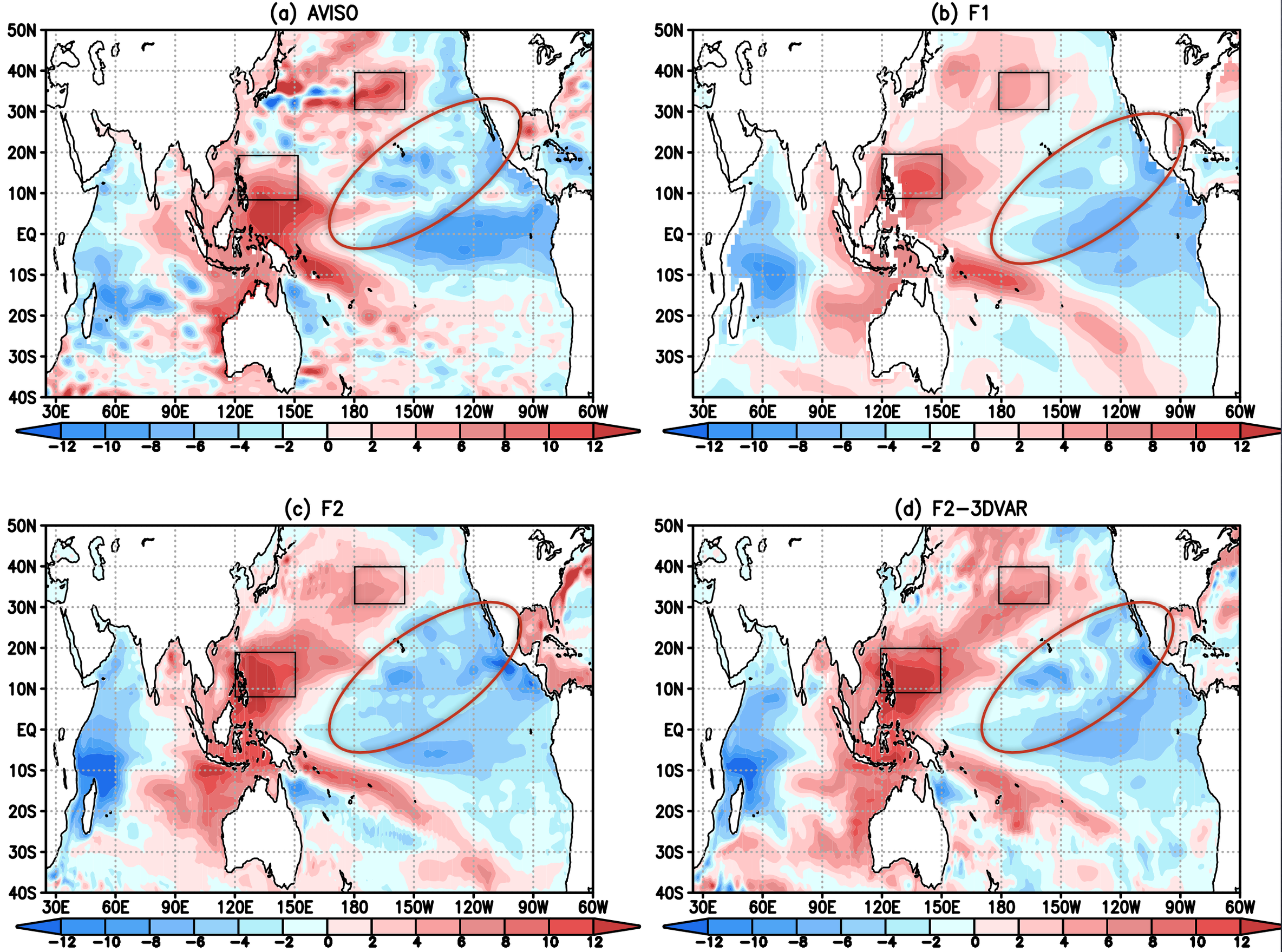


Prediction of SSH anom. in DJF2000/01 issued on June 1, 2000(1×10^{-1} cm)

Before ARGO



Prediction of SSH anom. in DJF2004/05 issued on June 1, 2004(1×10^{-1} cm)

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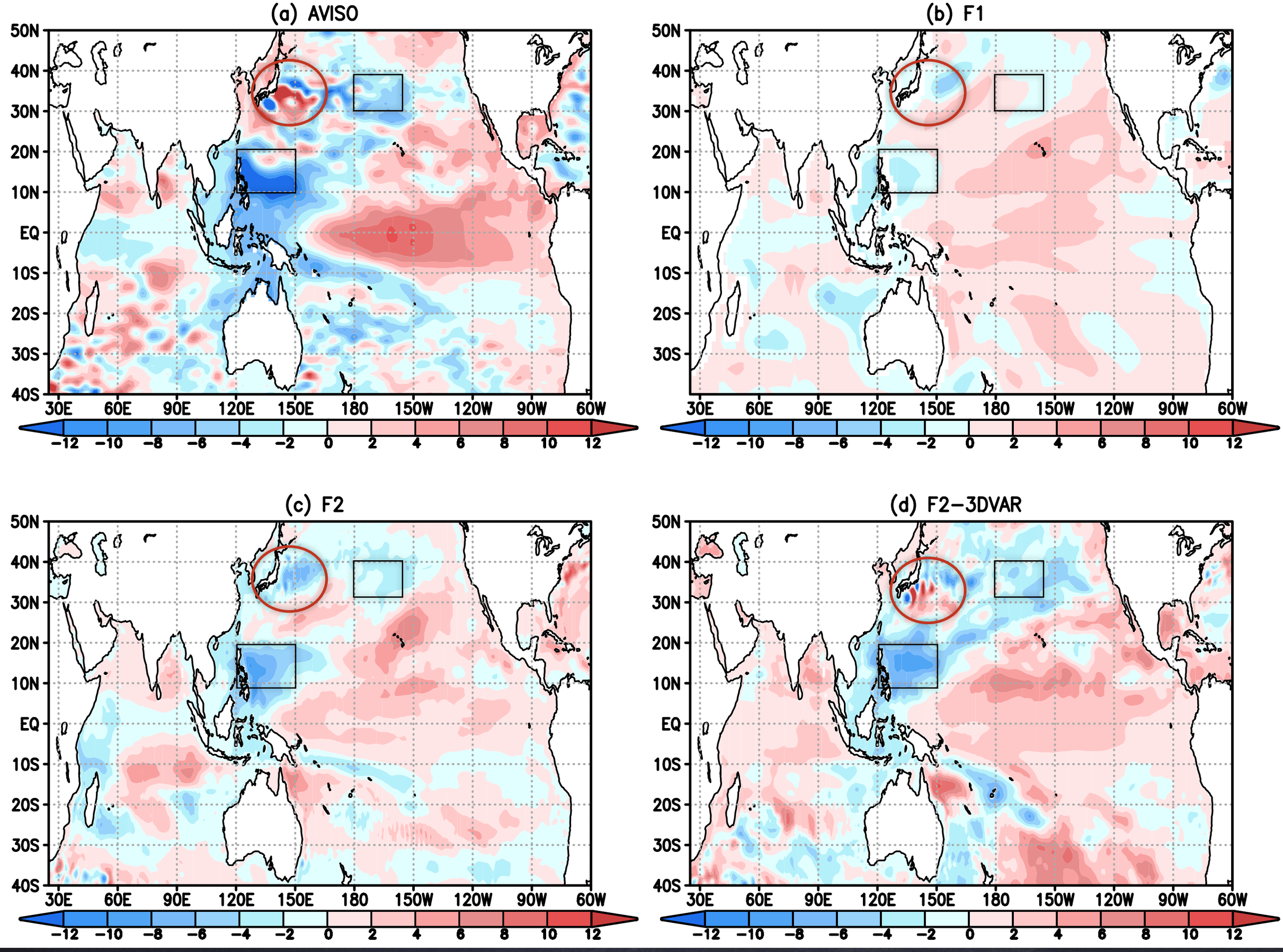

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- We hope that those information is helpful for prediction beyond ocean physical variables (e.g. chl-α)

End