Updates on sub-seasonal to decadal prediction research in Japan

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Research & development highlights

- The new JMA seasonal prediction system (JMA/MRI-CPS3) is under development. (due in operation by 2022)
- Large ensemble experiment presents some preponderance for ENSO and IOD prediction. (SINTEX-F2)
- Seasonal-to-decadal prediction research using MIROC6 (model for CMIP6, Tatebe et al. 2018 GMD)

Next generation of the JMA Seasonal Ensemble Prediction System (JMA/MRI-CPS3)

Specifications of JMA/MRI-CPS3

	JMA/MRI-CPS2 ***(operational since 2015)***	***JMA/MRI-CPS3*** ***(due in operation by 2022)***
Atmosphere (JMA-AGCM)	*TL159L60* , ~110km, Up to *0.1hPa* Stochastic Tendency Perturbation *GHG forcing* in RCP4.5 scenario	***TL319L100*** , ***~55km***, Up to ***0.01hPa*** Stochastic Tendency Perturbation *GHG forcing in SSP2-4.5 A1 scenario*
Ocean (MRI.COM) (Tsujino et al 2010)	1.0º (lon) x 0.3-0.5º (lat) L52+BBL Global Ocean with Tripolar Grids Sea-ice model	***0.25º*** (lon) x ***0.25º*** (lat) L60 Global Ocean with Tripolar Grids Sea-ice model
Initial Condition	Atmosphere: JRA-55 Land: JRA-55 land analysis Ocean: MOVE/MRI.COM-G2 T, S & SSH Sea-ice model	Atmosphere: ***JRA-3Q*** Land: ***JRA-3Q land analysis*** Ocean: **MOVE/MRI.COM-G3** **4DVAR** at low + IAU at full res. ***Sea-ice assimilation***
Ensemble Size	51 (13 BGMs, 4 days with 5-day LAF)	51 (3-5 members per day, 11-17-day LAF, TBD)

Ocean 4DVAR Analysis

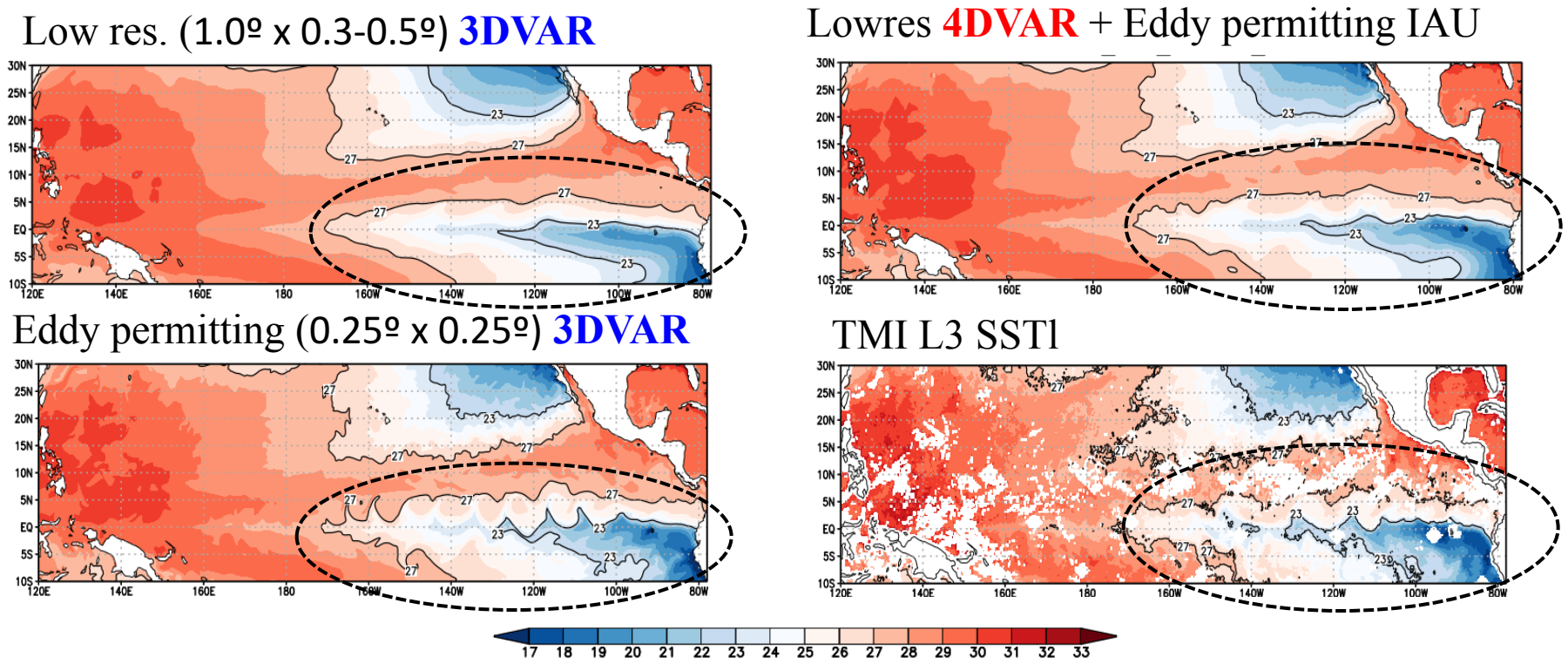
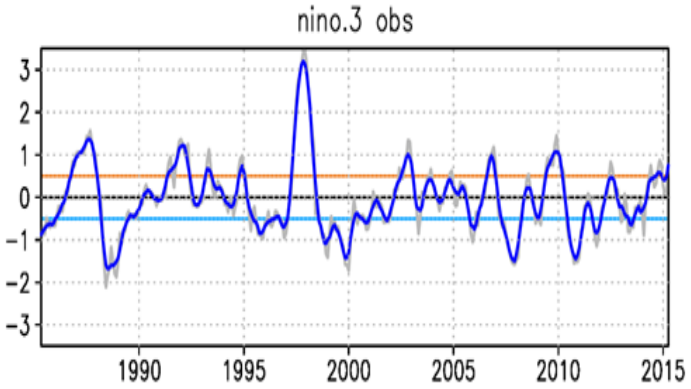


Fig. SST in degrees Celsius at 30th July, 2010.

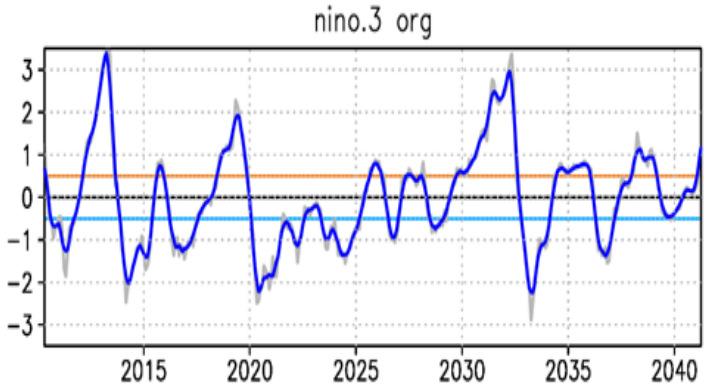
- 4DVAR+IAU gives better initial conditions over 3DVAR for seasonal EPS.
- Preliminary experiments have found positive impacts on ENSO forecast.
- Pilot ocean reanalysis (1990-) is on going to accommodate further tests.

ENSO asymmetry and ENSO feedbacks

Analysis



Model Free run

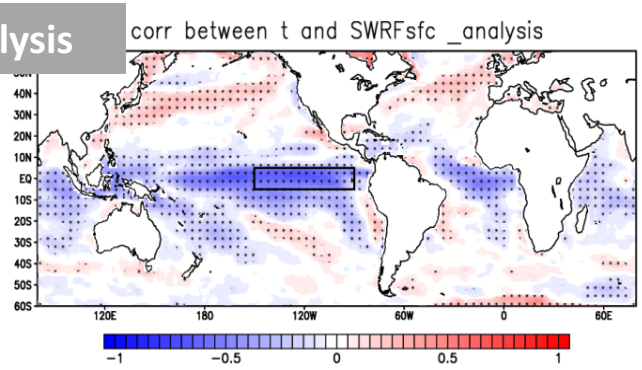


NINO.3 SST

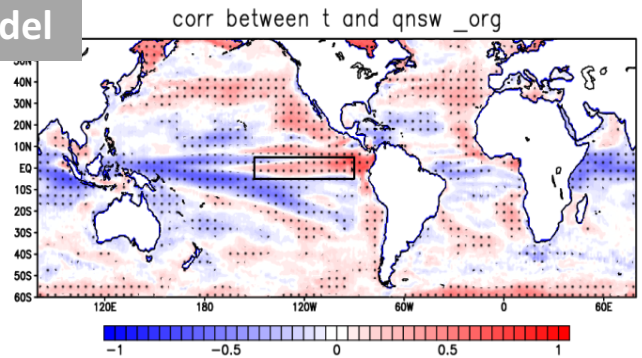
- The model fails to reproduce ENSO asymmetry
- "too" regular and strong ENSO, suggesting severe lack of negative feedbacks during the events.

Shortwave radiation feedback in ENSO

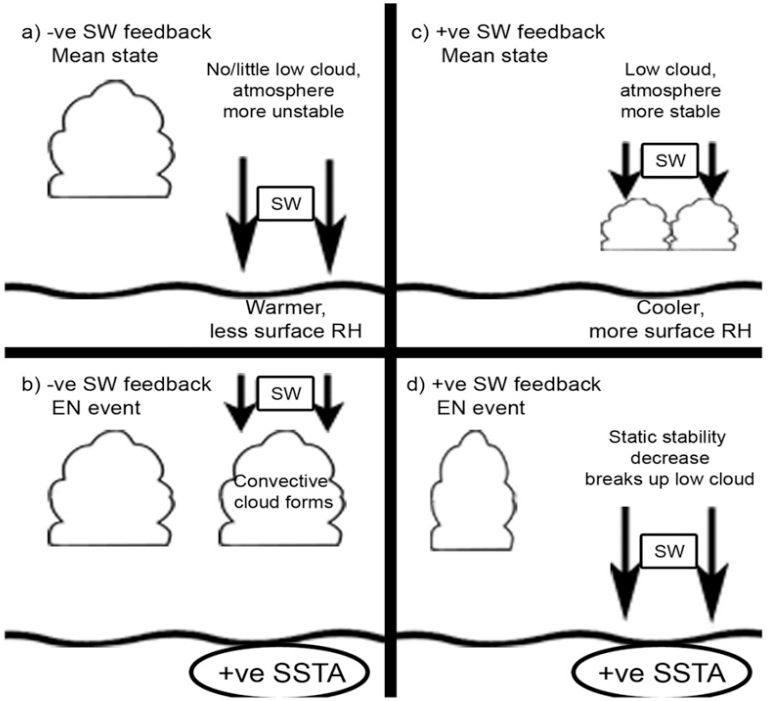
Analysis



Model



Correlation between SST and net downward shortwave radiation flux at the surface

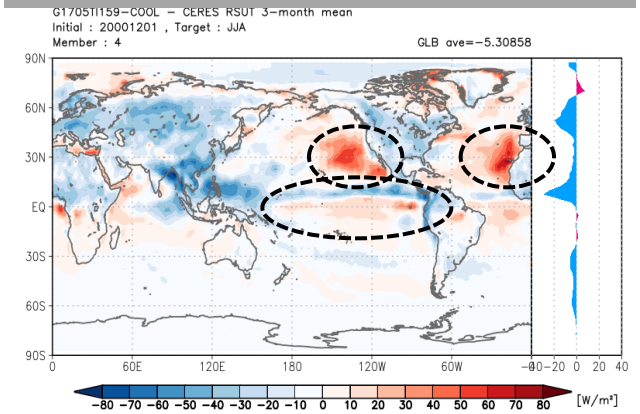


Ferret and Collins (2018) : *J. Climate*, **31**, 1315-1335.

- Convective clouds during El Nino reflect downwelling shortwave flux back to space, serving as a negative feedback to SST.
- In the model, excessive low-level clouds disappear during ENSO as sea surface warms up, bringing a positive feedback to SST.

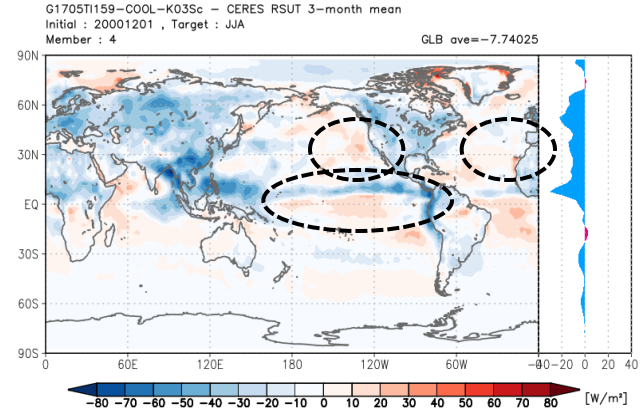
Stratocumulus scheme update

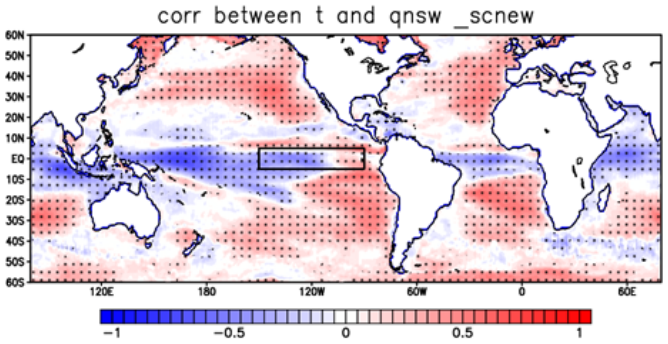
Current St. scheme (Kawai, 2006)



TOA upward shortwave radiation flux bias

New St. scheme (Kawai et al. 2013)





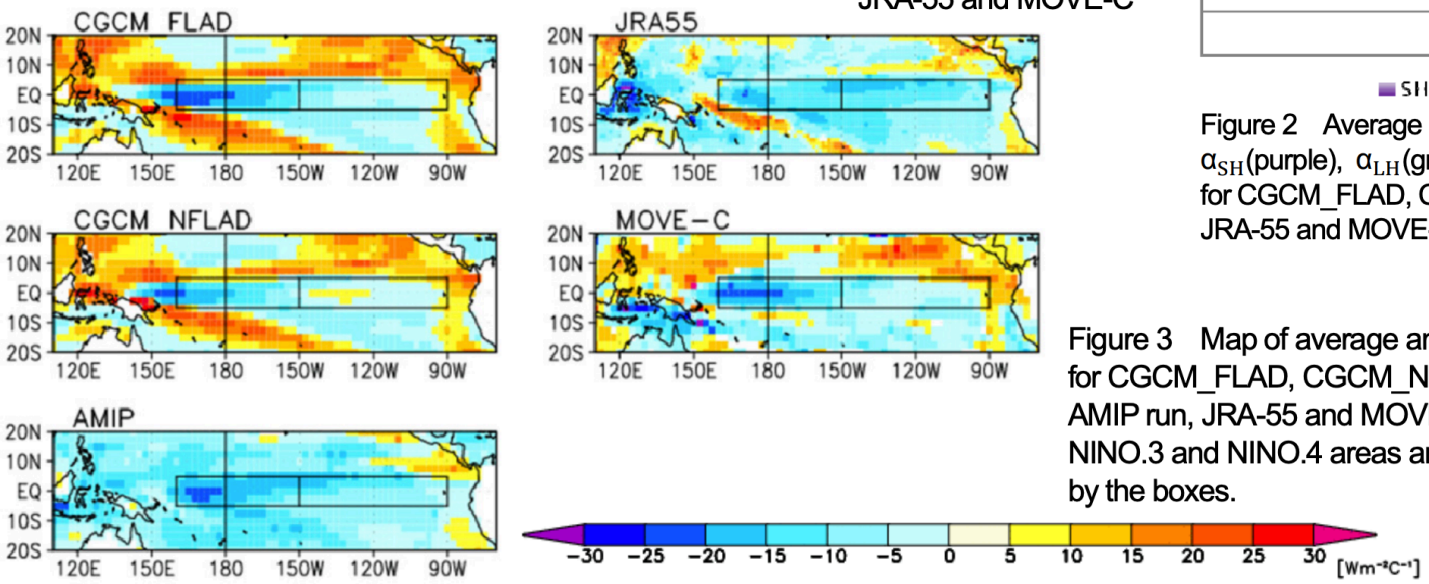
- Kawai et al. (2017) introduces an improved index to measure favorable conditions for stratocumulus to develop.
- With the index implemented in the st. scheme, the model now suppresses thick low-level cloud in NINO.3 and reproduces the negative shortwave radiation feedback.

Low clouds play a leading role in the relationship between clouds and surface temperature variability, amplifying ENSO-induced surface temperature anomalies through thermodynamically driven changes in the shortwave CRE. c.f. Lutsko (2018) GRL

ENSO-feedback diagnostics in previous system

ENSO thermal feedback

$$Q' = \alpha T'.$$



JRA-55 and MOVE-C

Figure 3 Map of average annual α_{SW}, for CGCM_FLAD, CGCM_NFLAD, AMIP run, JRA-55 and MOVE-C. The NINO.3 and NINO.4 areas are shown by the boxes.

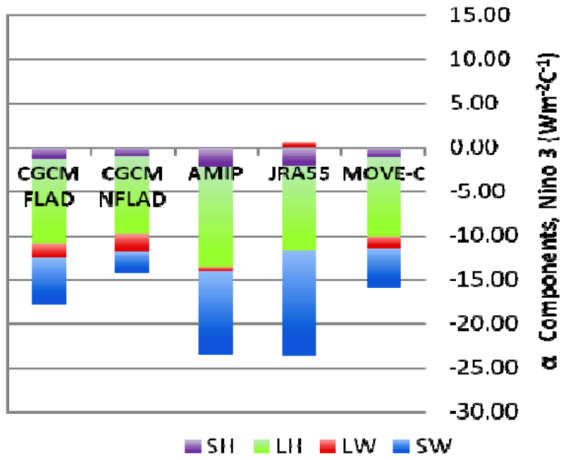


Figure 2 Average annual α components: α_{SH}(purple), α_{LH}(green), α_{LW}(red) and α_{SW}(blue) for CGCM_FLAD, CGCM_NFLAD, AMIP run, JRA-55 and MOVE-C

Matsueda and Takaya (2013, WGNE Blue book)

Merits of a 108-Member Ensemble System in ENSO and IOD Predictions

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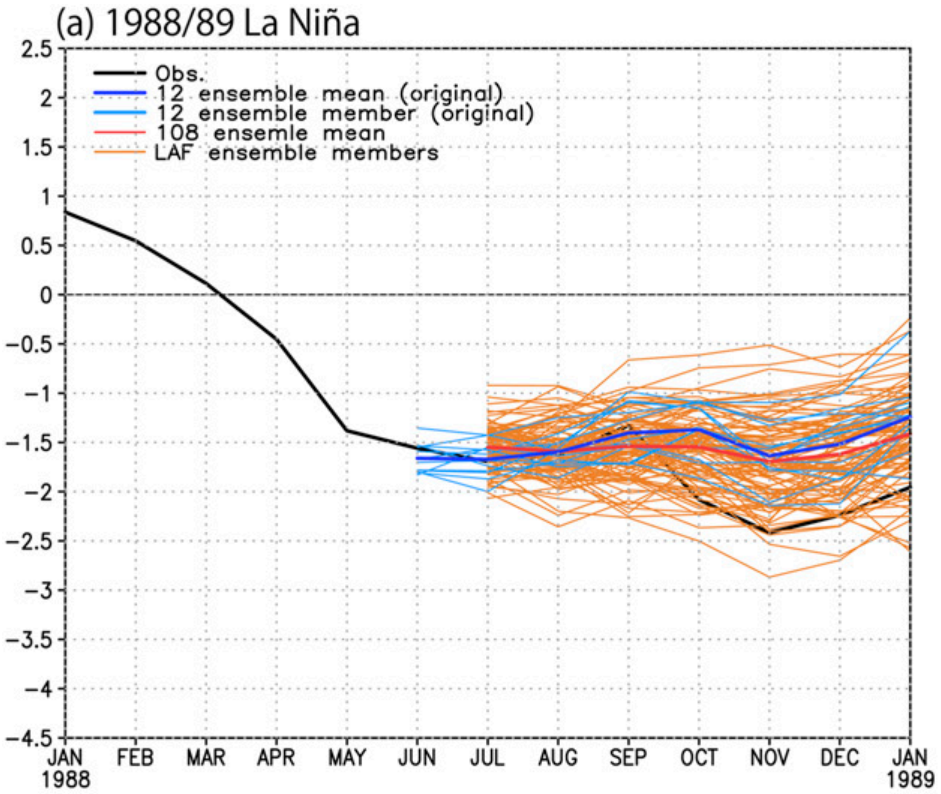
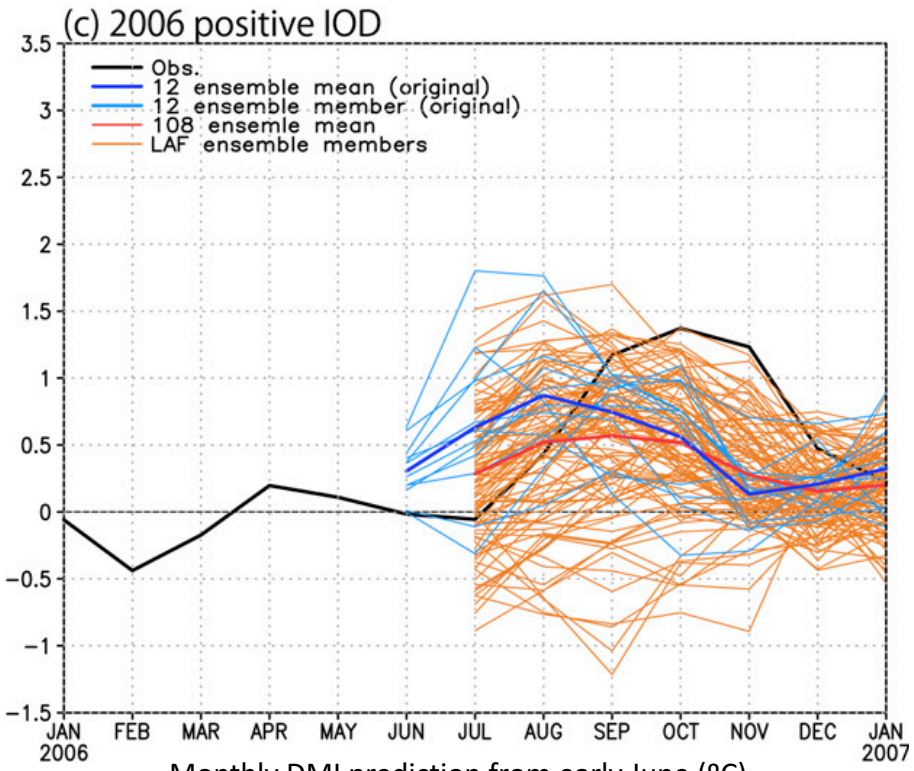
(Doi et al. 2019, J.Climate)



Monthly Niño-3.4 prediction from early June (ºC)



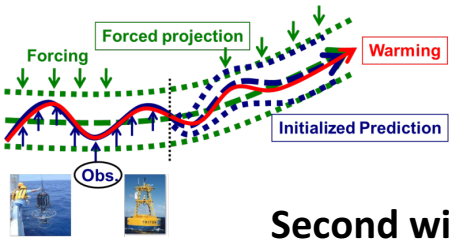
Monthly DMI prediction from early June (ºC)

Probability prediction of extremely strong ENSO and the Indian Ocean dipole (IOD) events is significantly improved in the larger ensemble.

Note: 108 ensemble members: 12 Burst (SINTEX-F2-3DVAR, Doi et al. 2017) ＊ 9 days LAF

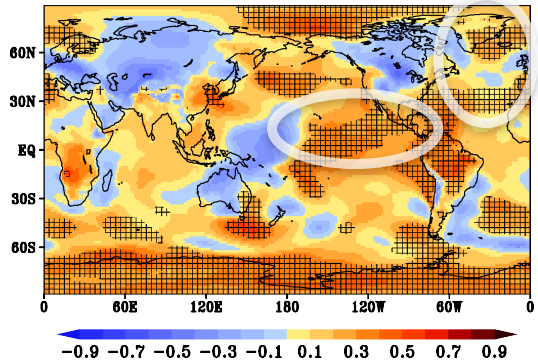
Seasonal-to-decadal predictions by MIROC6

Seasonal-to-decadal predictions by MIROC6



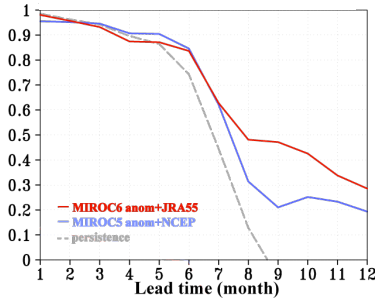
- Simple nudging-like initialization of ocean anomaly state (0-3000m: to, so, & sea-ice)

Second winter SLP



[hatch: significant at 95%]

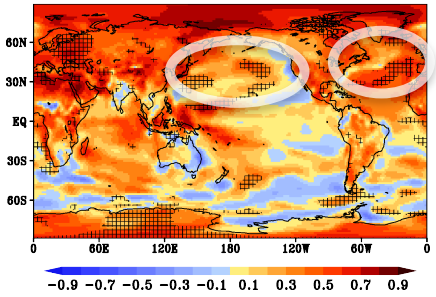
ACC: Niño3.4



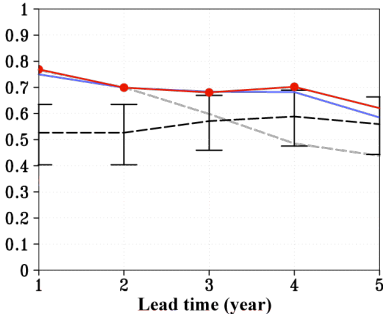
- Seasonal predictions including skills of Niño3.4 are improved from MIROC5 (CMIP5).

- Significant skills are seen within limited regions such as the North Pacific and North Atlantic at lead year 5.

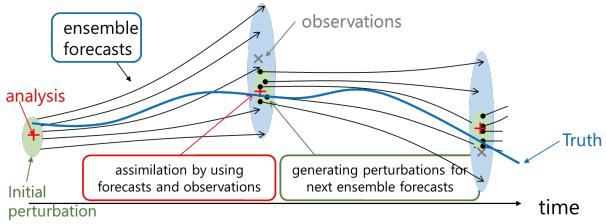
SAT ACC (Yr5)



ACC: AMV index



MIROC6 Anom+JRA55
MIROC5 Anom+NCEP
MIROC6 Hist
persistence



- Initialization system with LETKF has been continuously developed as well.