Decadal prediction using a recent series of MIROC global climate models

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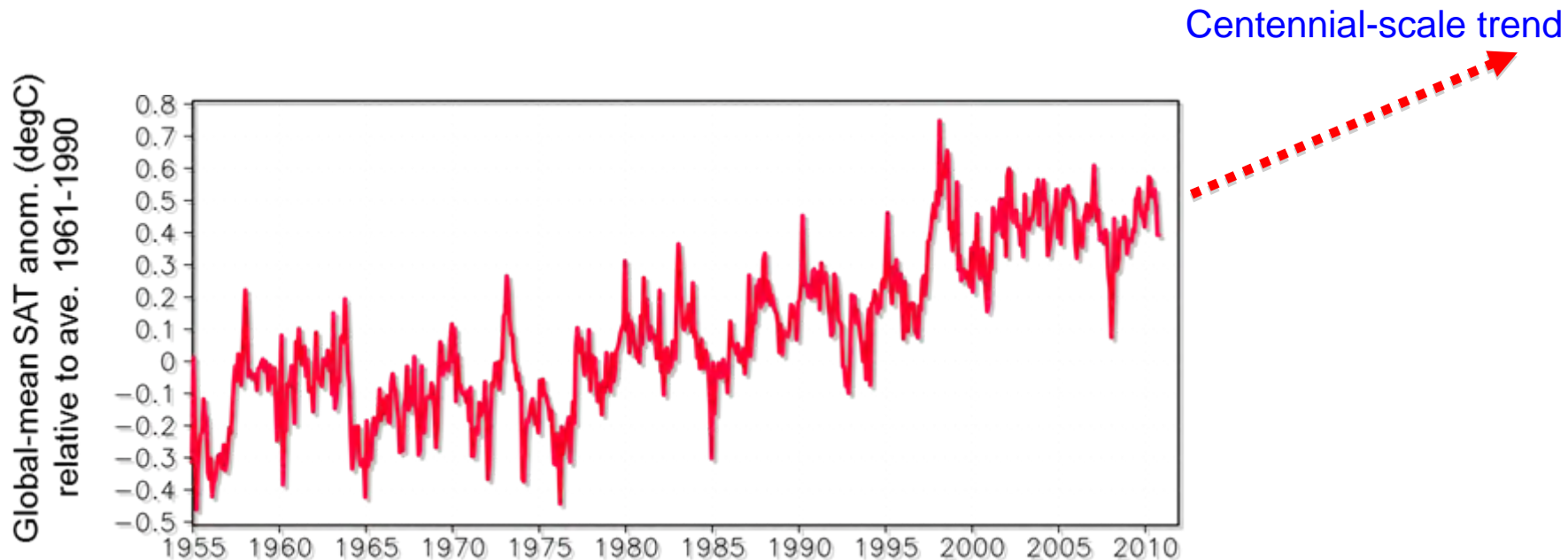
M. Ishii (JAMSTEC / MRI, JMA)

H. Tatebe, Y. Komuro, T. T. Sakamoto (JAMSTEC)

and Members of SPAM (System for **P**rediction and **A**ssimilation by **M**IROC)

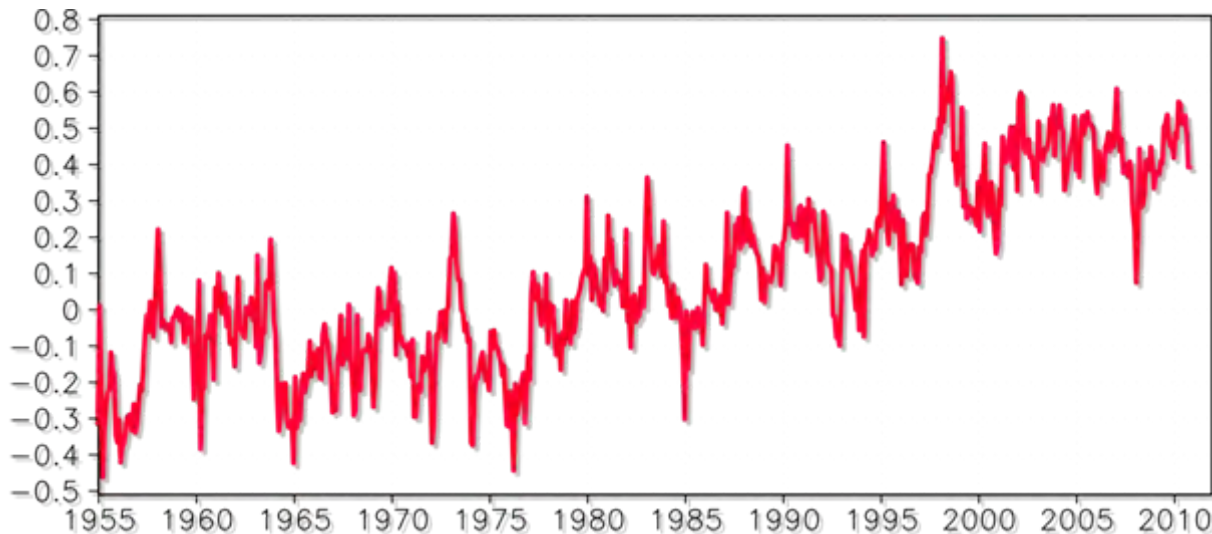# Long-term (100-300yrs) & Near-term (10-30yrs) toward IPCC-AR5 & CMIP5

● **Long-term** climate projection (**centennial** timescales)
   ● **Externally-forced variations** (e.g., CO_2, volcano, solar cycle, …)
      -> model responses, climate sensitivity of models

● **Near-term** climate prediction (**decadal** timescales)
   ● **Internally-generated** (and externally-forced) **variations** (e.g., PDO, IPO, NPGO, …)
      -> initialization of climate states

Centennial-scale trend

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Centennial-scale trend

Decadal modulation & regional changes due to internal variations (e.g., PDO, IPO NPGO,…)

Summary

We performed ensembles of initialized decadal hindcasts (predictions) using a recent series of MIROC global climate models;

    Mochizuki et al. (2010), published in *Proc. Natl. Acad. Sci. USA.*

        MIROC3m   for IPCC-AR4)

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        MIROC4h   high resolution

        MIROC5   new and/or improved physics parameterizations)

        To be available to the public towards contribution to the assessment and process studies in IPCC-AR5 & CMIP5.

● We validated a few-years-long predictive skills of the PDO (in addition to the global warming trend and the AMO) in the initialized hindcasts; Major predictable variations in these initialized hindcasts are the global warming trend, the PDO and the AMO.

●Regionally, In addition, we found large impacts of initialization (i.e., longer predictability than in the so-called global warming simulations) over the mid- and high latitudes of the North Pacific and the high latitudes of the North Atlantic.

● Note that it may not be easy to hold fully significant discussions due to the small number of ensembles particularly in MIROC4h case (i.e., three) at this stage.
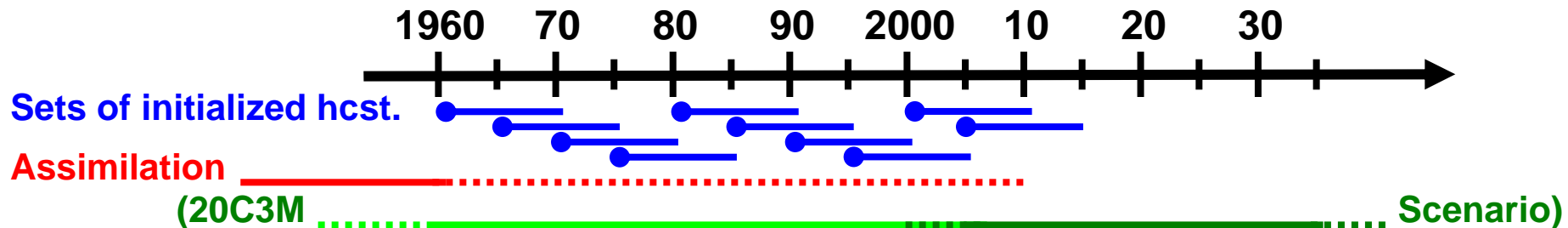
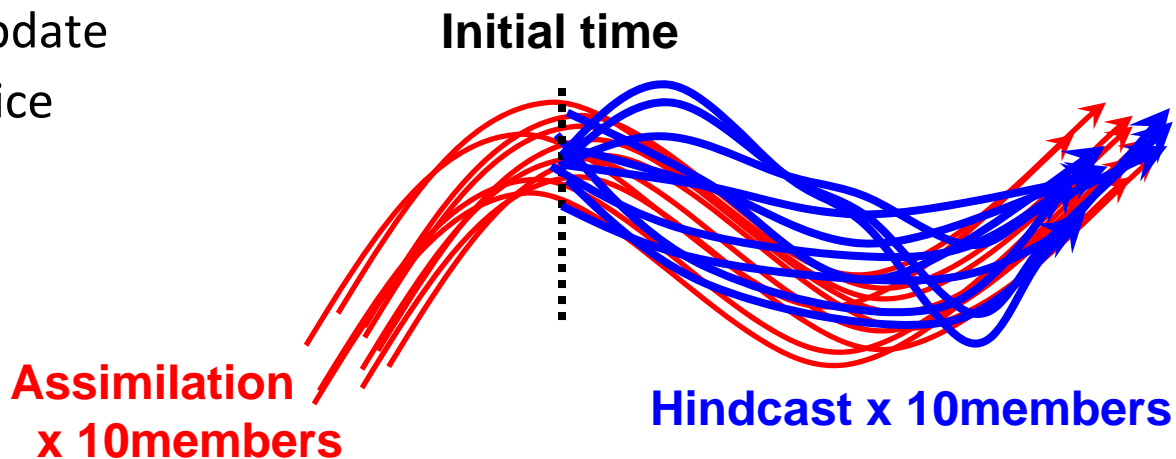# Series of MIROC global climate model
(**M**odel for **I**nterdisciplinary **R**esearch **O**n **C**limate)

|		Atmosphere	Ocean
AR4	**MIROC3m**	T42 (128× 64, ~2.8°), L20	1.4°× (0.5°–1.4°), L43+BBL 0-layer EVP sea ice
	MIROC3h	T106 (320× 160, ~1.2°), L56	0.28125°× 0.1875°, L47+BBL 0-layer EVP sea ice
AR5 (near-term prediction)	**MIROC4h** (Sakamoto et al. 2011)	T213 (640× 320, ~0.6°), L56	0.28125°× 0.1875°, L47+BBL 0-layer EVP sea ice
	MIROC5 (Watanabe et al. 2010)	T85 (256× 192, ~1.4°), L40 new physics	1.4°× (0.5°–1.4°), L49+BBL multi-category sea ice

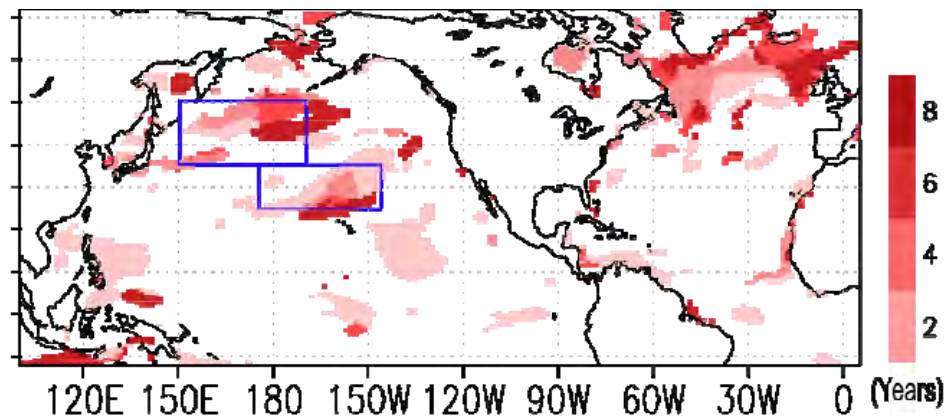# Decadal Hincasts using old version (MIROC3m)

- 10 ensemble assimilation & sets of 10 ensemble decadal hindcasts
- Design of assimilation experiments
    - Objective analysis of T/S (Ishii et al. 2003, 2006 2009)
    - Anomaly assimilation relative to averages during 1961-1990
    - Interpolated from monthly means
    - Upper 700m depth
    - Incremental Analysis Update
    - No assimilation for sea ice

Decadal Hincasts using old version (MIROC3m)
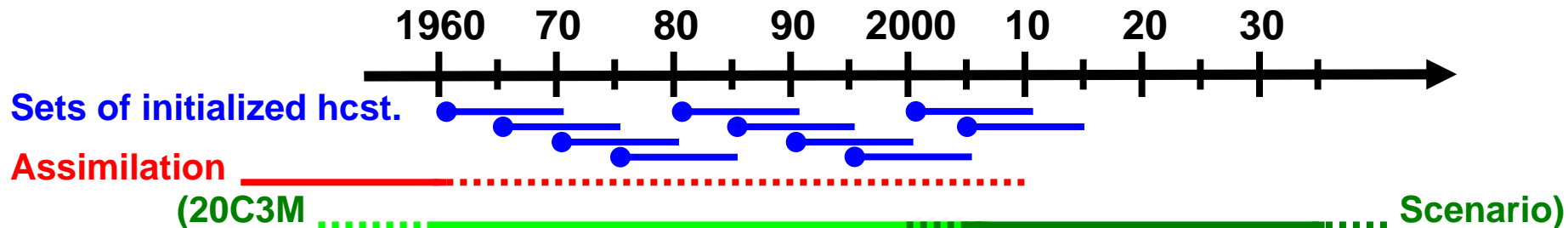
1960   70   80   90   2000   10   20   30

Sets of initialized hcst.

Assimilation

(20C3M ....   **Scenario)**

- ➤ 10 ensemble assimilation & sets of 10 ensemble decadal hindcasts
- ➤ Design of assimilation experiments
  - ➤ Objective analysis of T/S (Ishii et al. 2003, 2006 2009)
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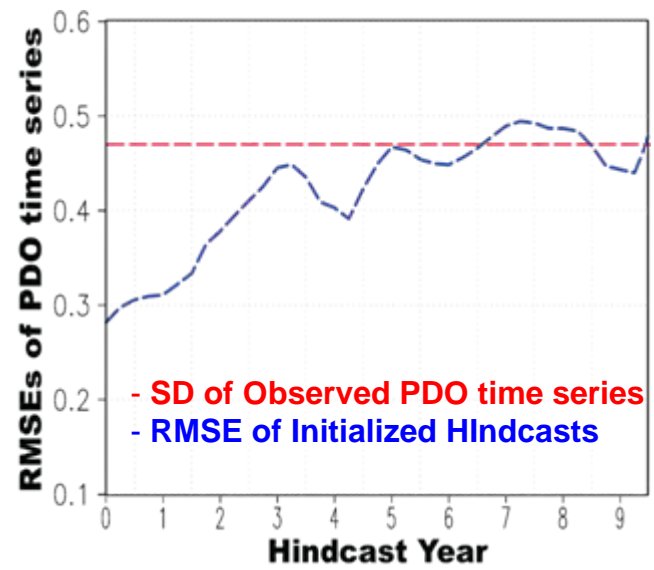 - ➤ No assimilation for sea ice

Predictable regions for 5-yr mean VAT300 (vertically averaged ocean temperature upper 300m) at specific hindcast years.
(Anomaly Correlation Coefficient > 90% significance levels)

PDO Hincasts using old version (MIROC3m)
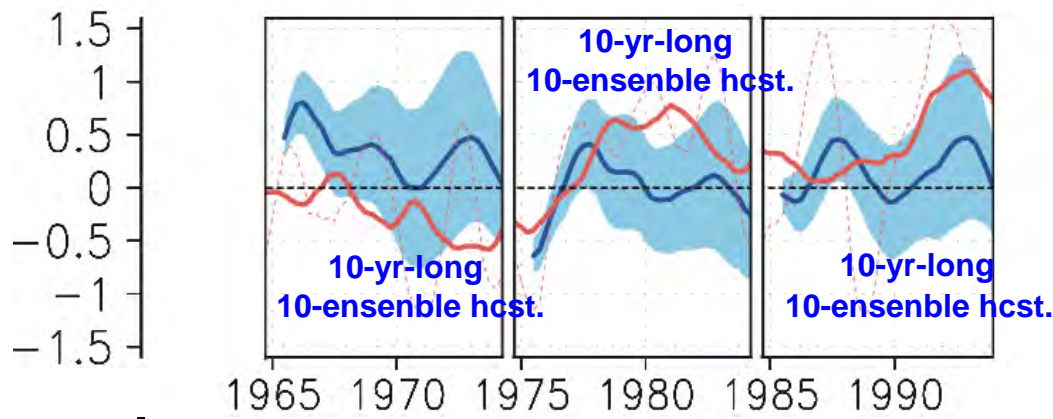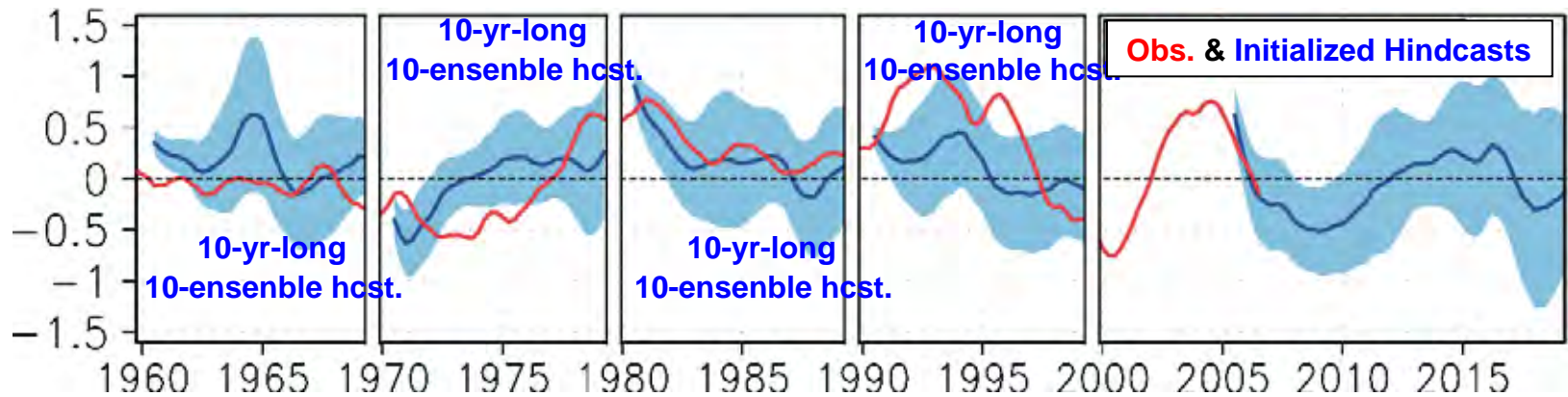
PDO index (i.e., projection onto the modeled EOF1 of the North Pacific VAT300) is obtained by an EOF analysis to internal variations of the model, that are defined using a signal-to-noise maximizing EOF of 10-ensemble 20C3M simulations.

Series of **MIROC** global climate model
(**M**odel for **I**nterdisciplinary **R**esearch **O**n **C**limate)

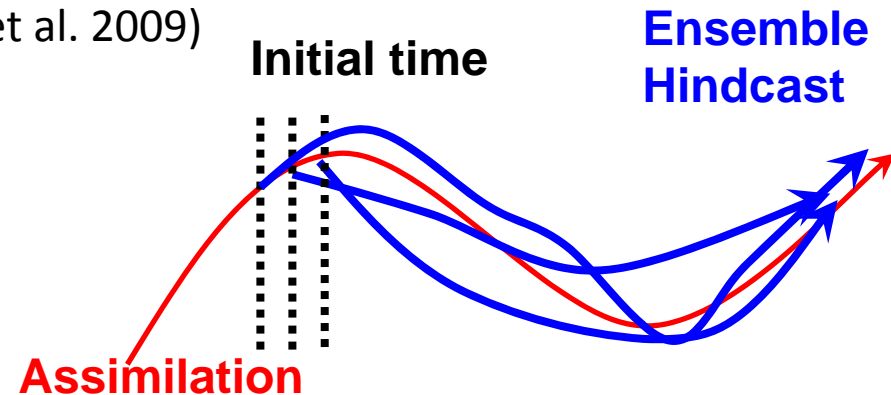|		Atmosphere	Ocean
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Decadal Hindcasts officially toward IPCC-AR5 & CMIP5
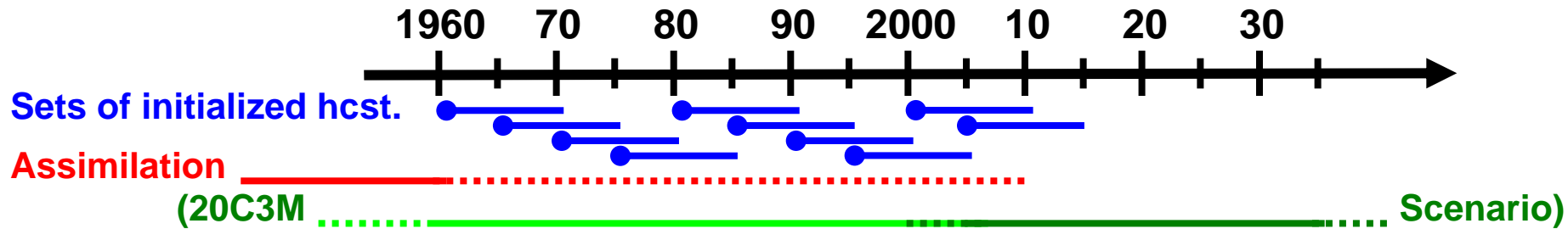
- ➤ **MIROC4h:** Assimilation: 1 ensemble, Hindcasts: 3 ensembles
- ➤ **MIROC5:** Assimilation: 2 ensembles, Hindcasts: 2x3 ensembles
  - ➤ Lagged Average Forecast (LAF) with 3-month intervals

    (e.g., For hindcast from 01Jan1971 -> IC:01Jul1970, 01Oct1970, 01Jan1971)

- ➤ **Assimilation**
  - ➤ *Updated* objective analysis of T/S (Ishii et al. 2009)
  - ➤ Anomaly assimilation

    relative to averages during 1971-2000
  - ➤ Upper 3000m depth
  - ➤ Interpolated from monthly mean values
  - ➤ Incremental Analysis Update (IAU)
  - ➤ No assimilation for sea ice
  - ➤ *Spatially-smoothed analysis increments* to assimilate only large-scale variations

Singular vectors of the leading SVD modes in **4-yr-mean** global SST **in the hindcast years 2-5 (lead time = 3yr).**

The SVD analyses are applied to the hindcasts (hatch; absolute values > 0.02) and the corresponding observations (shade).
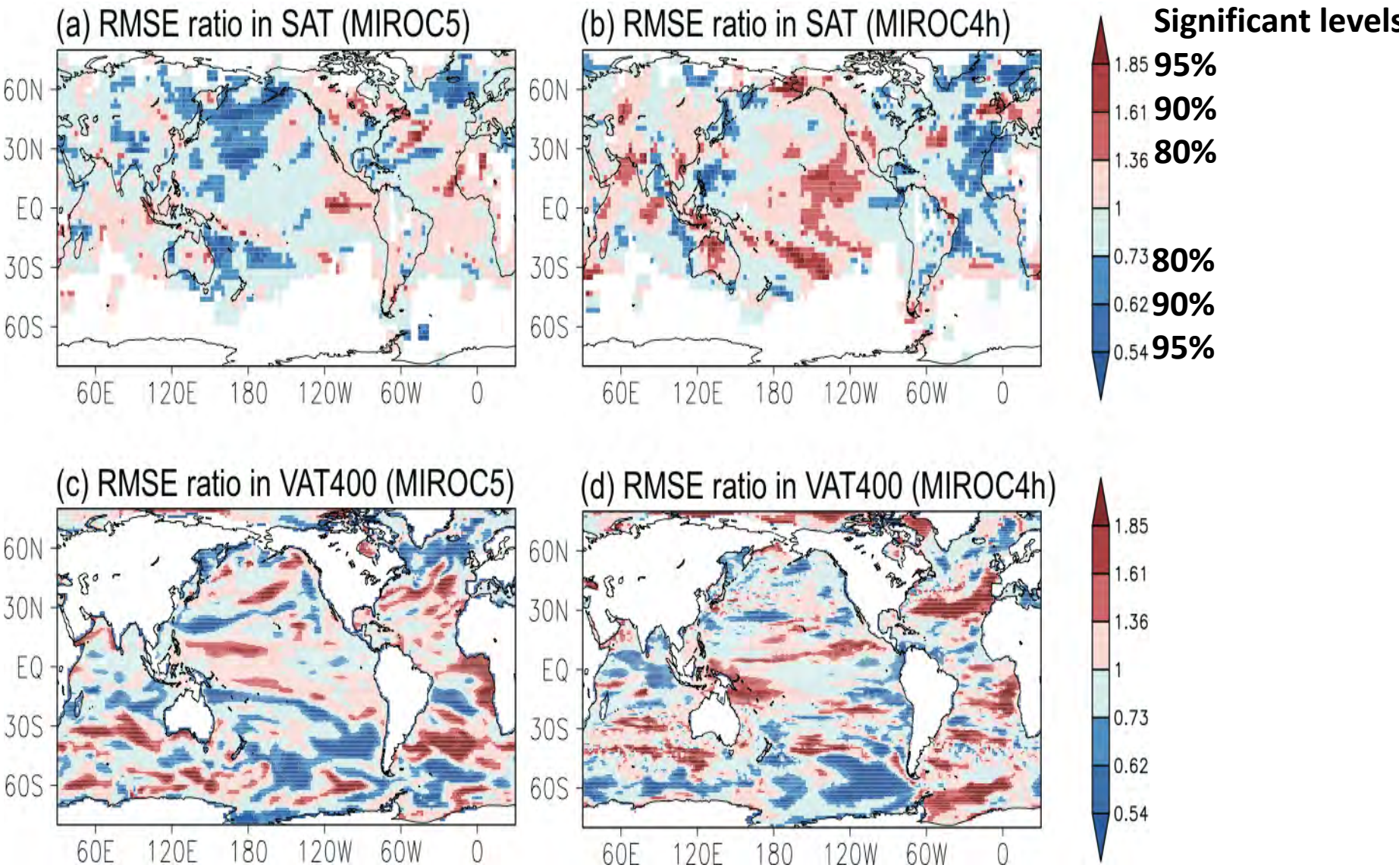
Predictable variations in SST (SVD modes; obs. & hcst.)
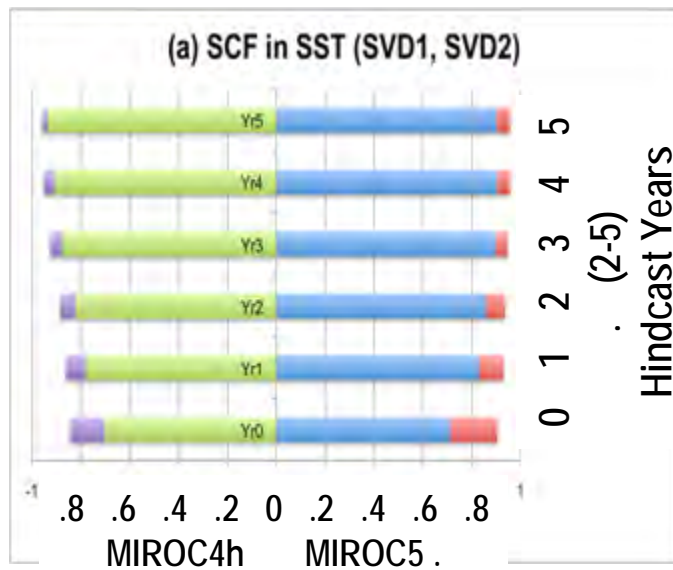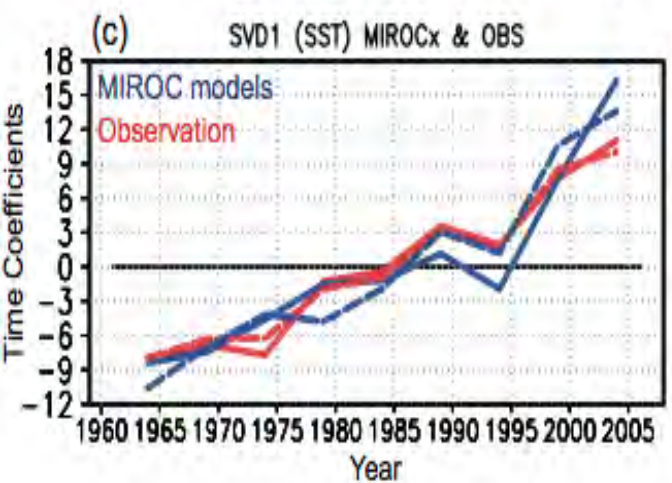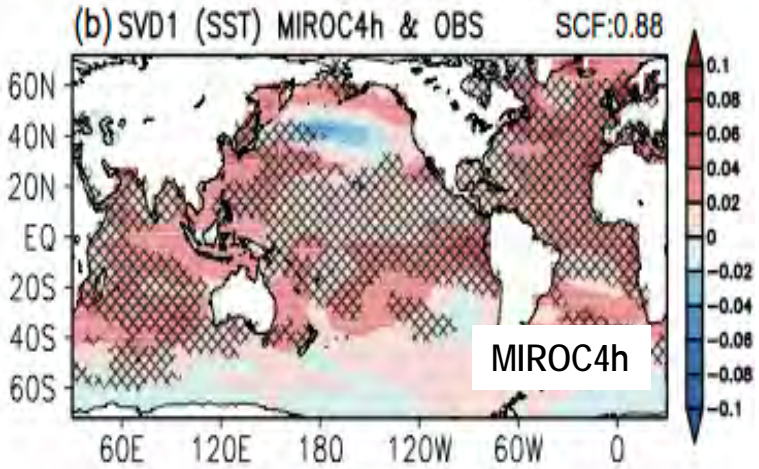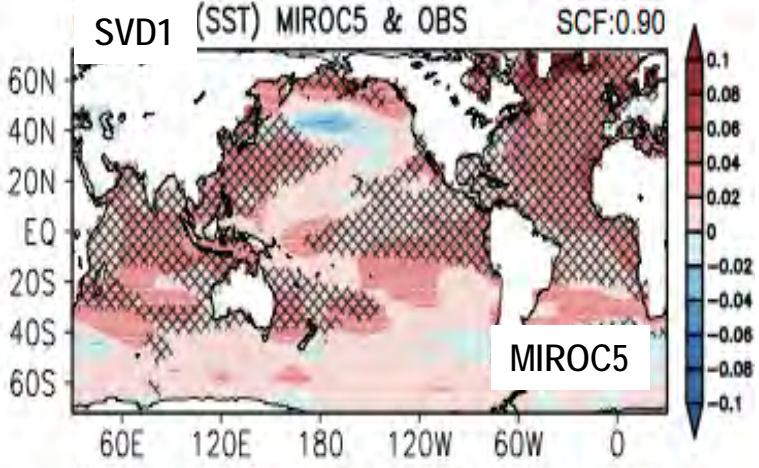
- Values of SCF of the SVD1 and SVD2 at specific hindcast years.

Mochizuki et al. (2012) *J. Meteor. Soc. Japan.*

Predictable variations in VAT400 (SVD modes; obs. & hcst.)
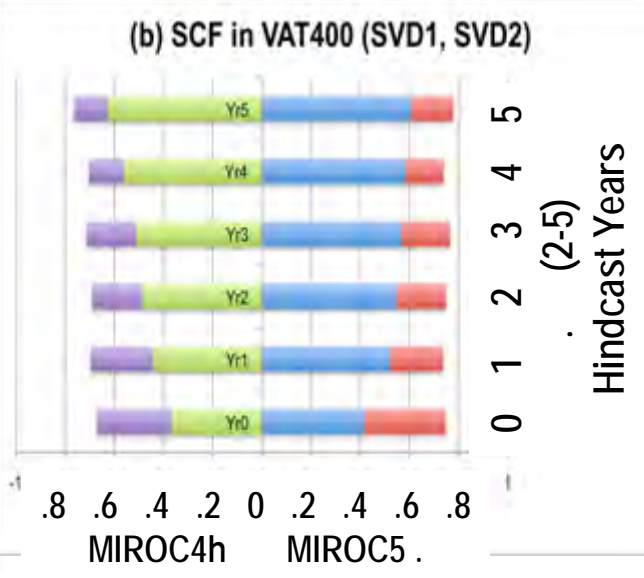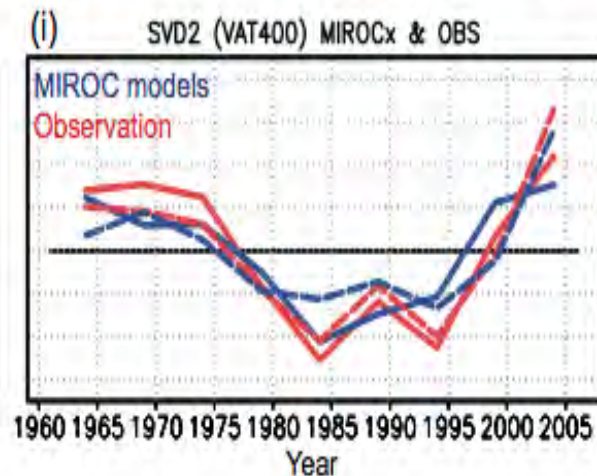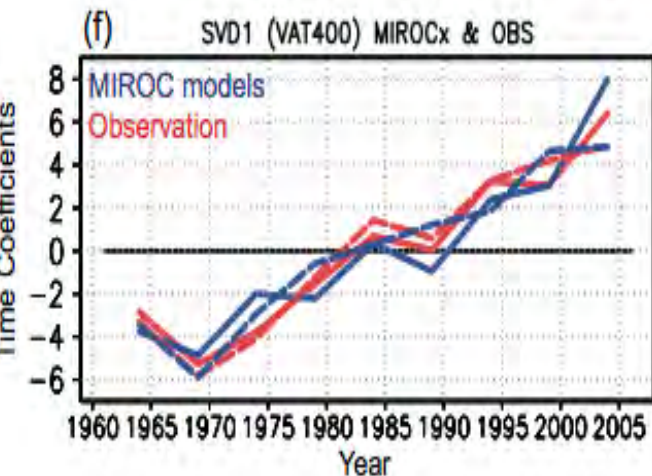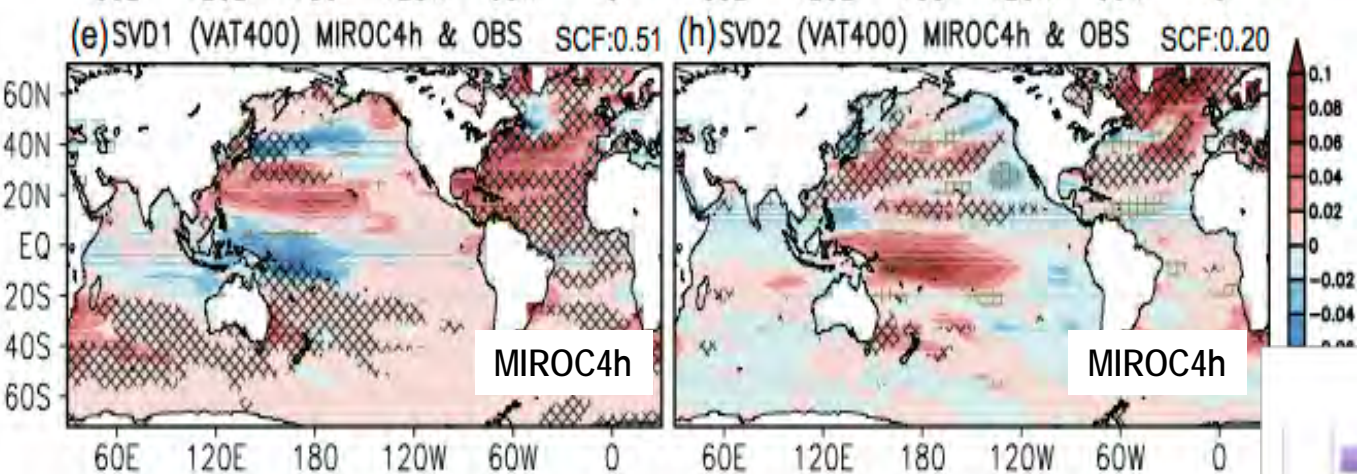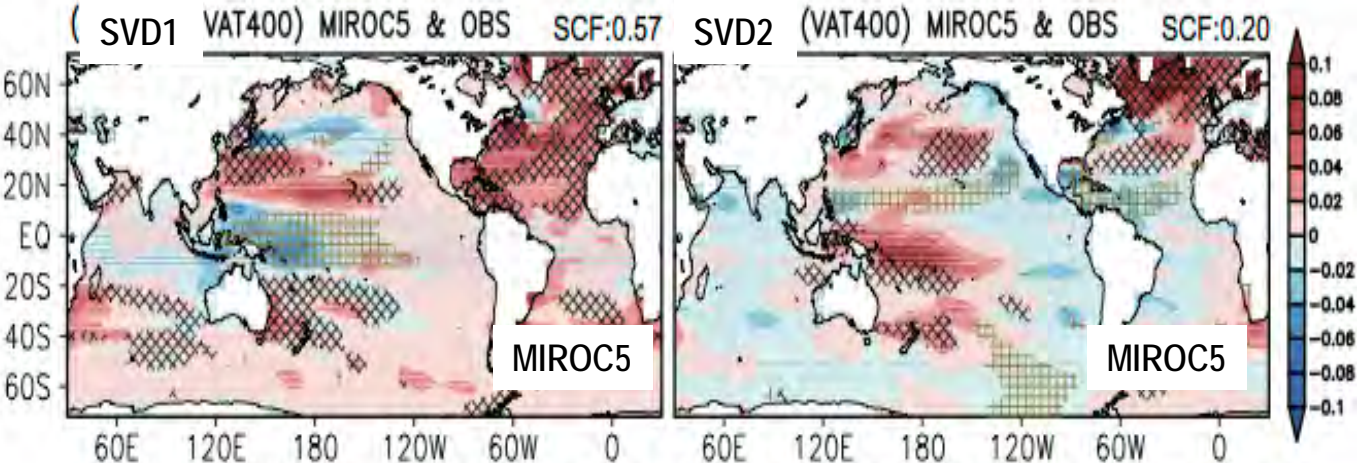
Impact of initialization in 2-5yr hindcasts
RMSE ratio (hcst. with init. / hcst. without init.)

(a) RMSE ratio in SAT (MIROC5)

(b) RMSE ratio in SAT (MIROC4h)

Significant levels

1.85	**95%**
1.61	**90%**
1.36	**80%**
1	
0.73	**80%**
0.62	**90%**
0.54	**95%**

(c) RMSE ratio in VAT400 (MIROC5)

(d) RMSE ratio in VAT400 (MIROC4h)

(a) Global-mean SAT yr2-5 [degC]

MIROC5 R:0.97, RMSE:0.058[degC]
MIROC4h R:0.99, RMSE:0.046[degC]
Observed SD: 0.204[degC]

(c) AMO yr2-5 [degC]

MIROC5 R:0.81, RMSE:0.179[degC]
MIROC4h R:0.81, RMSE:0.192[degC]
Observed SD: 0.306[degC]

(e) PDO yr2-5

MIROC5 R: 0.51, RMSE:2.01
MIROC4h R:-0.13, RMSE:2.89
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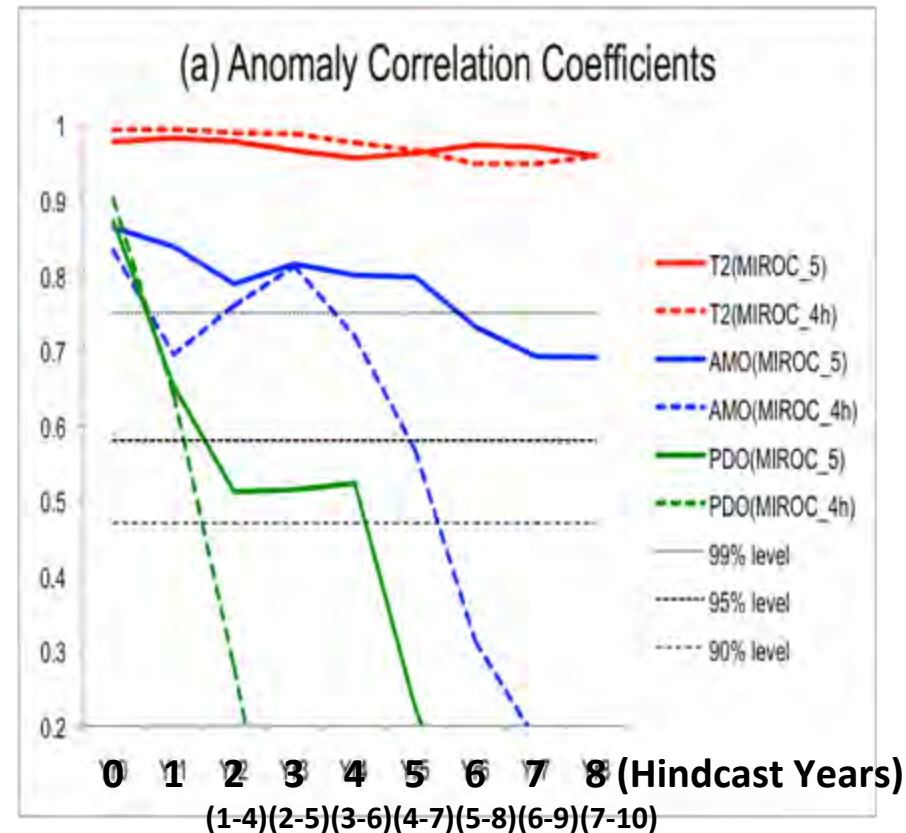# Hindcasted and observed time series of major predictable variations (e.g., Global mean, AMO, PDO)
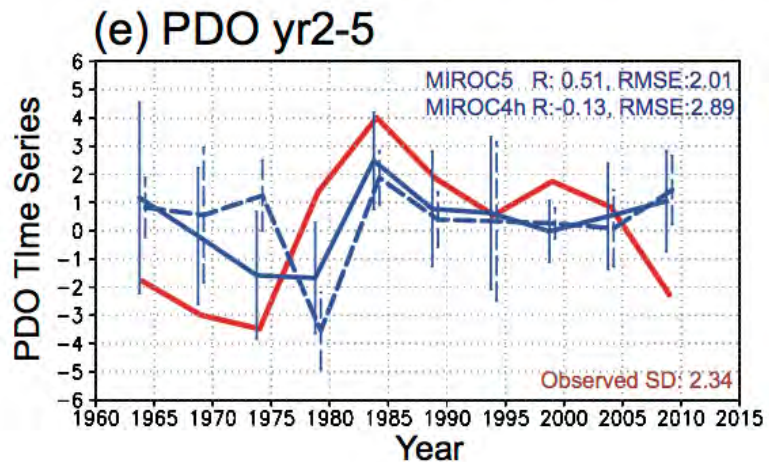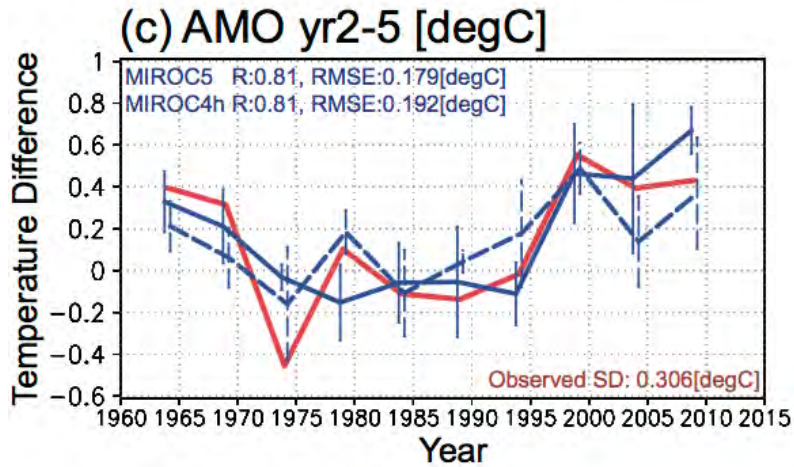
AMO time series =
Area- averaged SST differences 60W-10W, 40N-60N minus 30W-10E, 10S-40S.
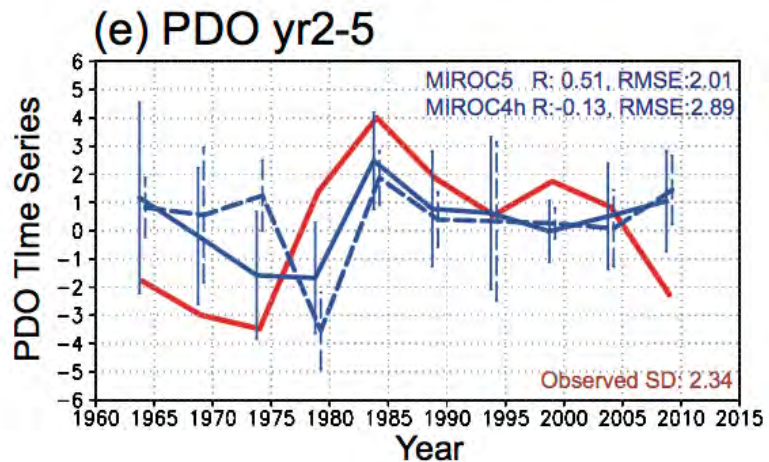
PDO time series =
Projection onto the leading EOF of detrended VAT400 observation.

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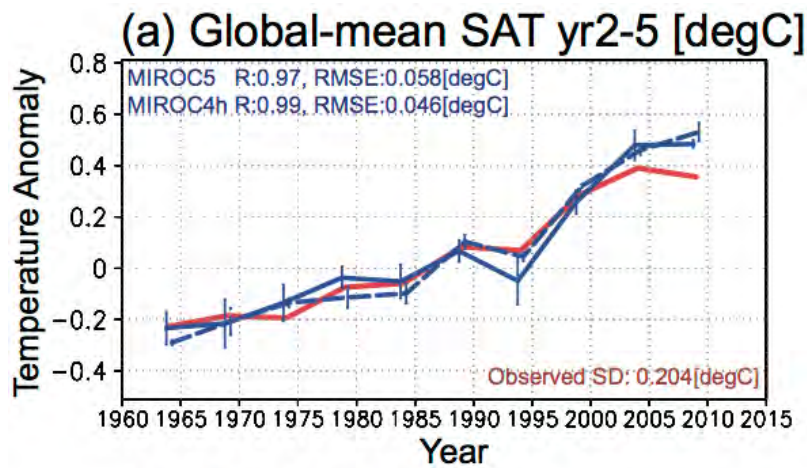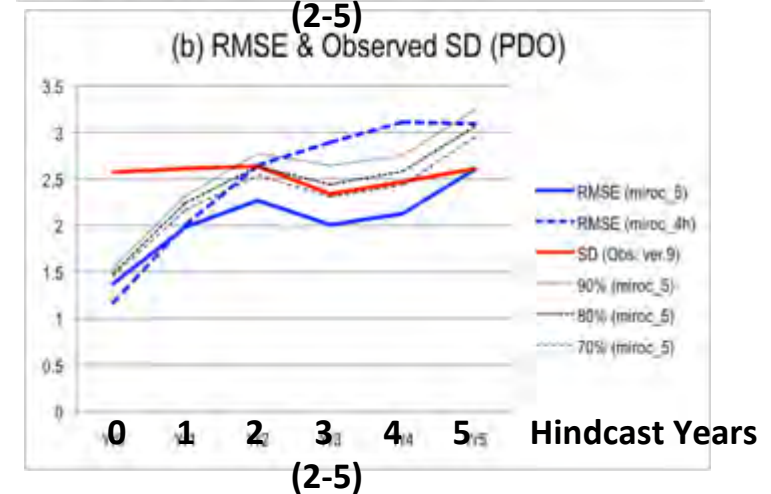# Hindcasted and observed time series of major predictable variations (e.g., Global mean, AMO, PDO)

MIROC5: solid, MIROC4h: broken

(a) Anomaly Correlation Coefficients

- T2(MIROC_5)
- T2(MIROC_4h)
- AMO(MIROC_5)
- AMO(MIROC_4h)
- PDO(MIROC_5)
- PDO(MIROC_4h)
- 99% level
- 95% level
- 90% level

0 1 2 3 4 5 6 7 8 (Hindcast Years)
(1-4)(2-5)(3-6)(4-7)(5-8)(6-9)(7-10)

Mochizuki et al. (2012), *J. Meteor. Soc. Japan.*

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MIROC4h high resolution

MIROC5 new and/or improved physics parameterizations)

To be available to the public towards contribution to the assessment and process studies in IPCC-AR5 & CMIP5.

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