Recent Progress of Climate-related Researches at JMA

Shingo Yamada

Tokyo Climate Center

Japan Meteorological Agency

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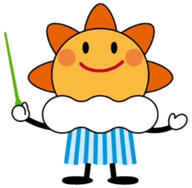
4. Development of the Next Generation El Niño Prediction System (Unified Coupled Ocean-Atmosphere GCM)

Brief introduction of the JRA-25 data

JRA-25 Overview



- Joint research project of JMA and CRIEPI
- Period：1979.1 - 2004.12 (26 years)

  (followed by JCDAS 2005.1-present)
- Resolution : T106L40 (~120km grid size: top 0.4hPa)
- Assimilation Scheme : 3D-Var

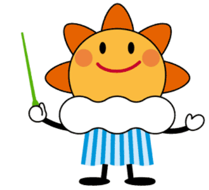
  based on the JMA operational system as of April 2004
- Original or firstly used observational data

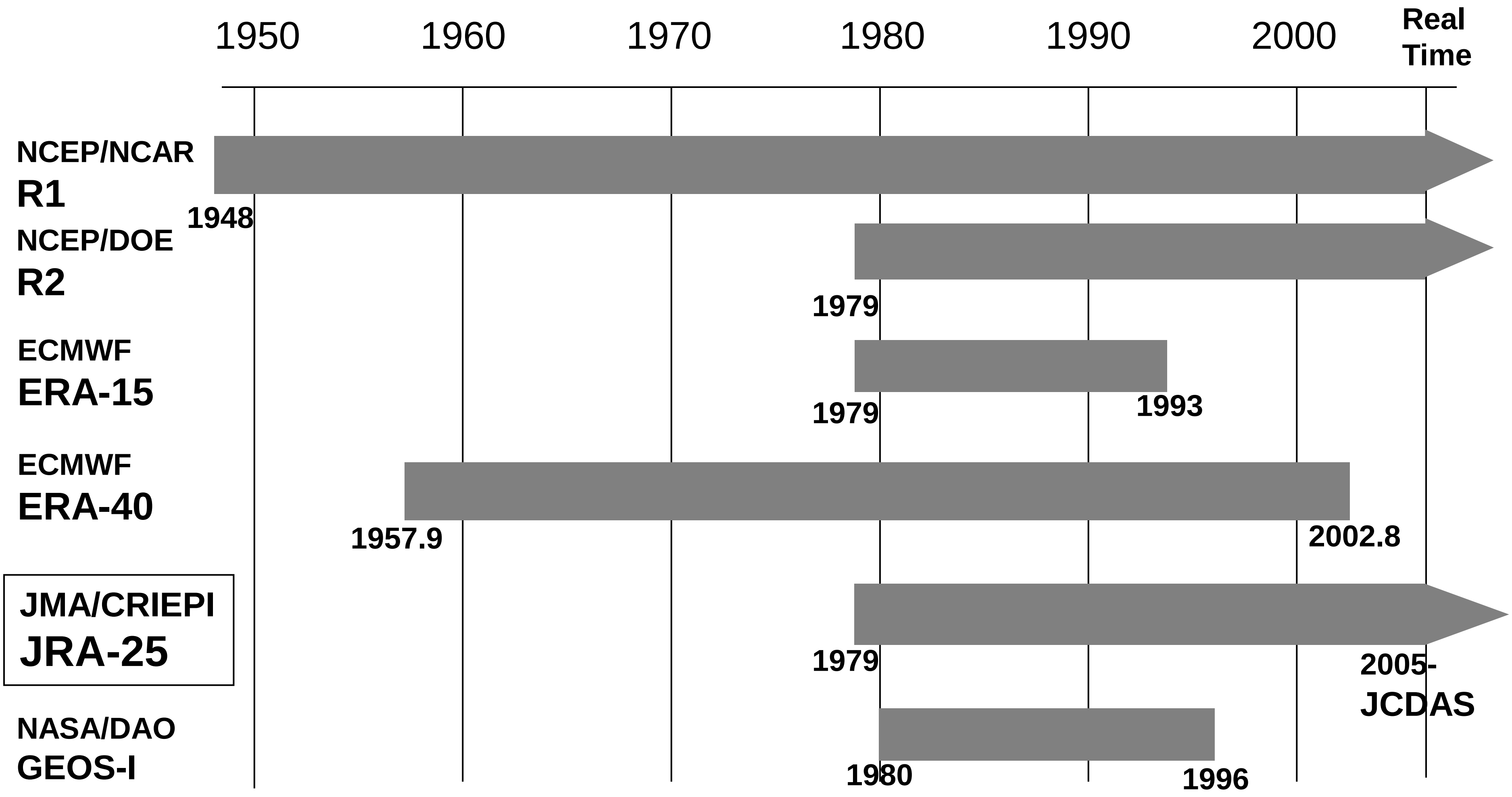
  Tropical Cyclone Retrievals, SSM/I snow coverage, digitized Chinese snow depth, reprocessed GMS-AMV
- Unique boundary/forcing data

  Daily COBE SST and sea ice (Ishii 2005, IJC)

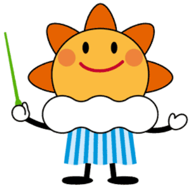
  Daily 3D-ozone profile produced with a chemical transport model

Comparison with the Existing Re-analyses



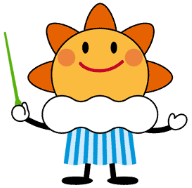


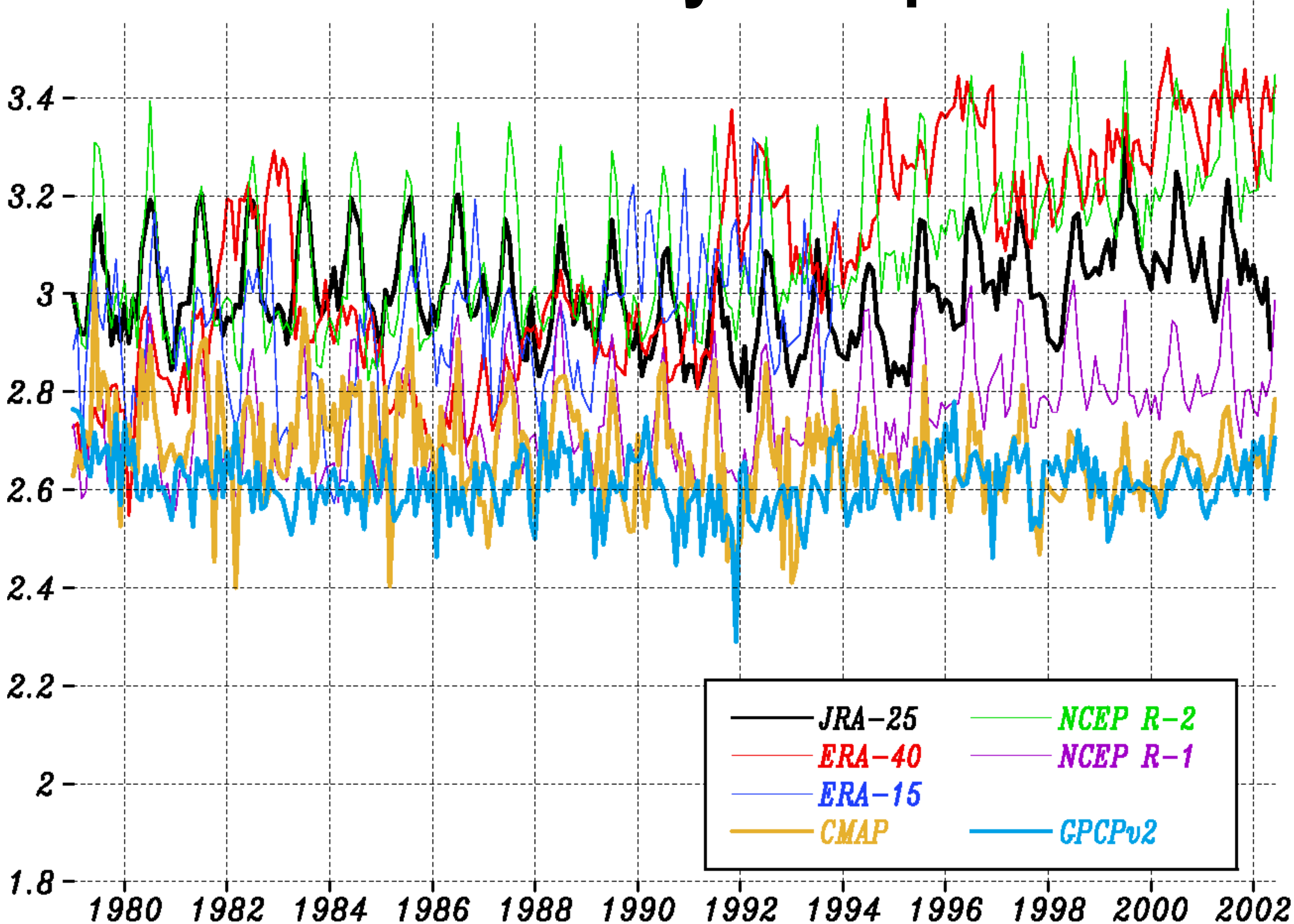
Outstanding Features of JRA-25 Data



- Good representation of global precipitation
  owing to the assimilation of satellite data (mainly SSM/I)
- Good representation of tropical cyclones
  by assimilating Dr. Fiorino's TCR data
- Good representation of surface temperature trend
  compared with the ERA-40 and CRU (Jones)
- JRA can be used to study localized severe weather
  by providing initial and/or boundary conditions to high-resolution limited area models
- However, some cautions are also noted
  - Jumps in time series (temperature …) are often found mainly in the stratosphere due to changes of satellites in the biased model background
  - Unrealistic aridification is seen over Amazon River basin

Global Mean Monthly Precipitation

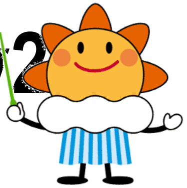


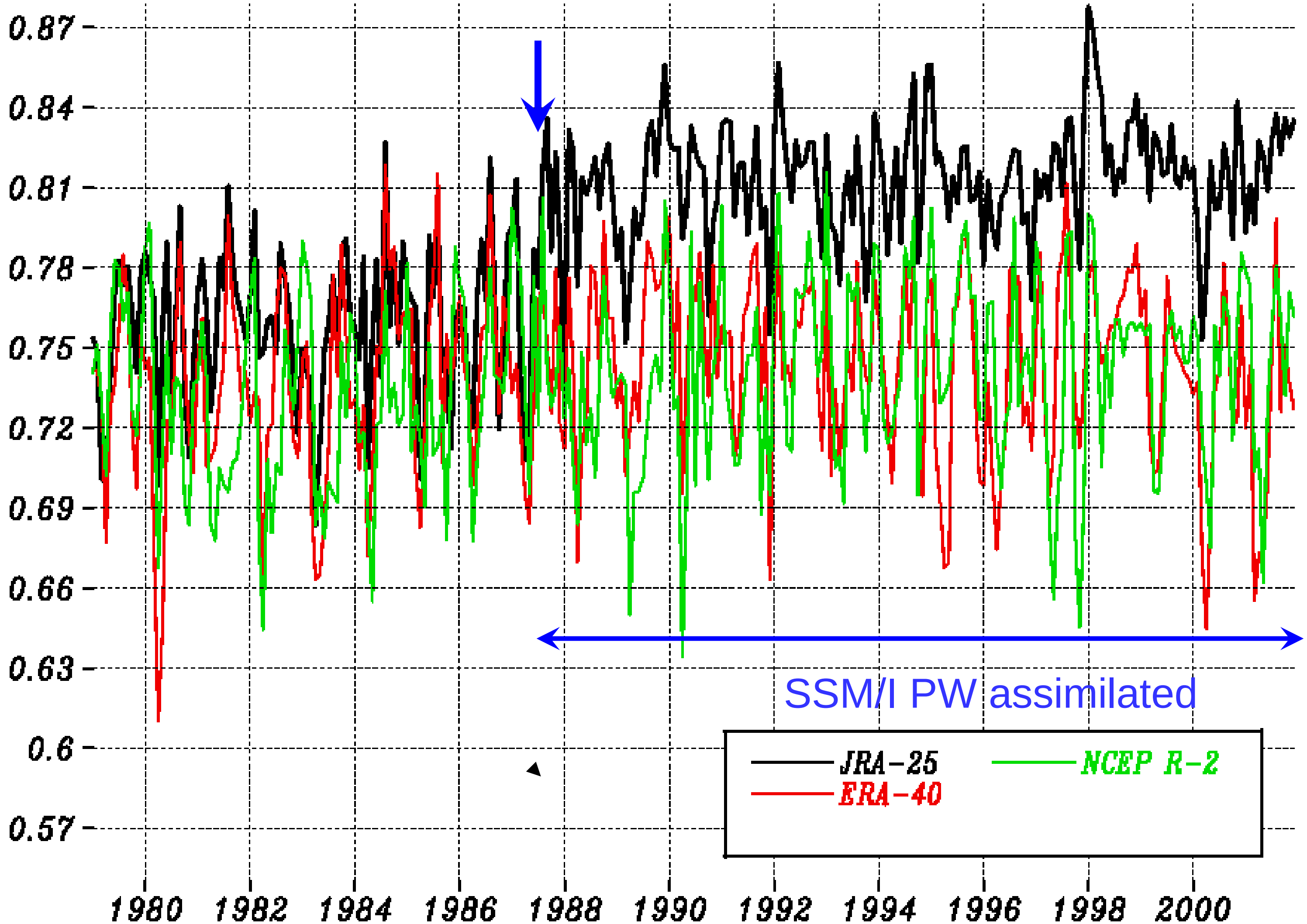


Courtesy: H. Koide

Global mean precipitation is most stable in the re-analyses without evident increase in the recent years nor suffering by volcanic eruptions, while the amount is larger than 'observational' precipitation data GPCP and CMAP.

Correlation of Monthly Precipitation with GPCPv2

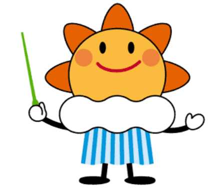




Courtesy: H. Koide

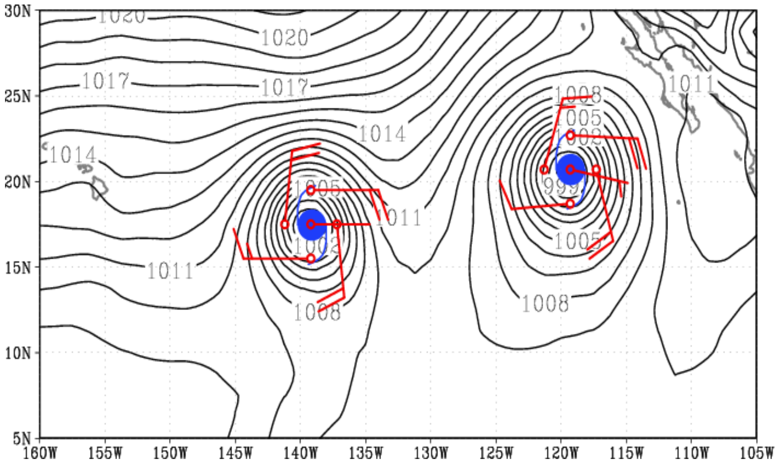
Globally averaged correlation of monthly precipitation with the 'observed' precipitation (GPCP) is good (around 0.8), especially after the precipitable water content data (SSM/I) are assimilated.

Impact of Dr. Fiorino’s TC Wind Data

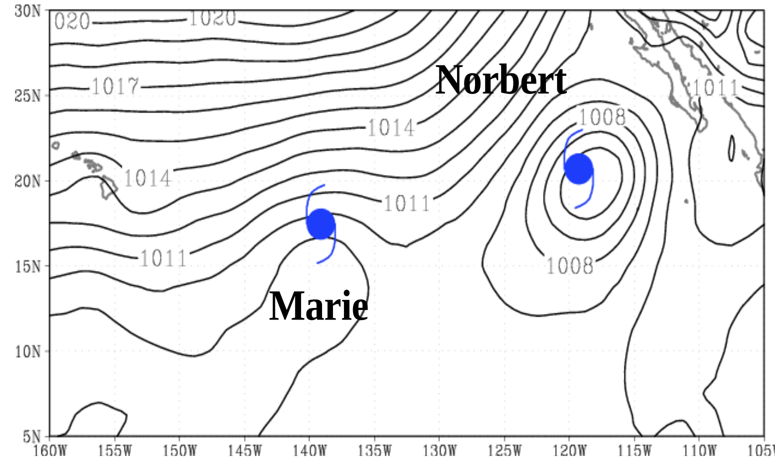


1200 UTC 15 September 1990 in the eastern North Pacific

JRA-25

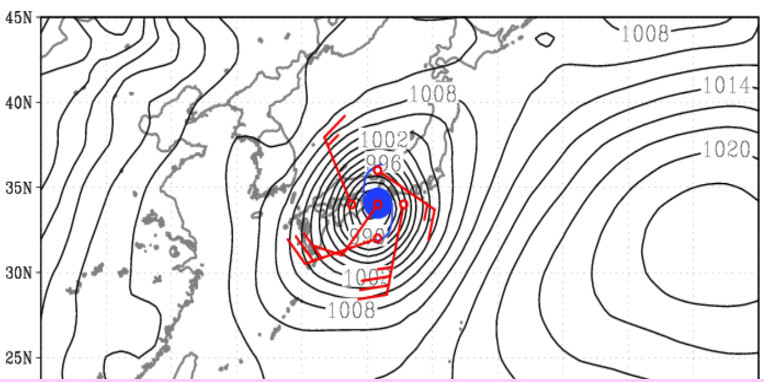


Control

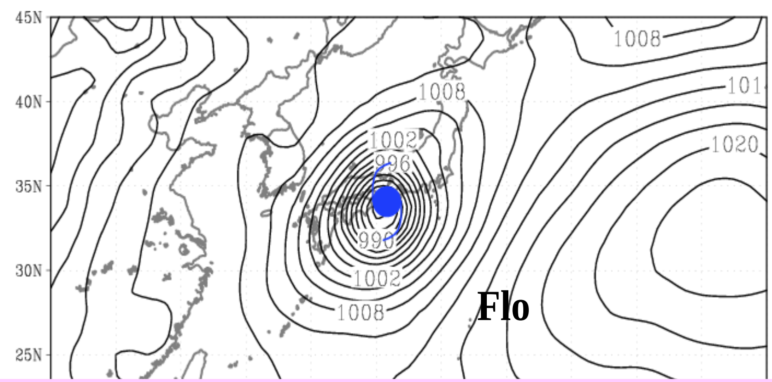


1800 UTC 19 September 1990 in the western North Pacific

JRA-25

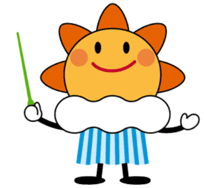


Control



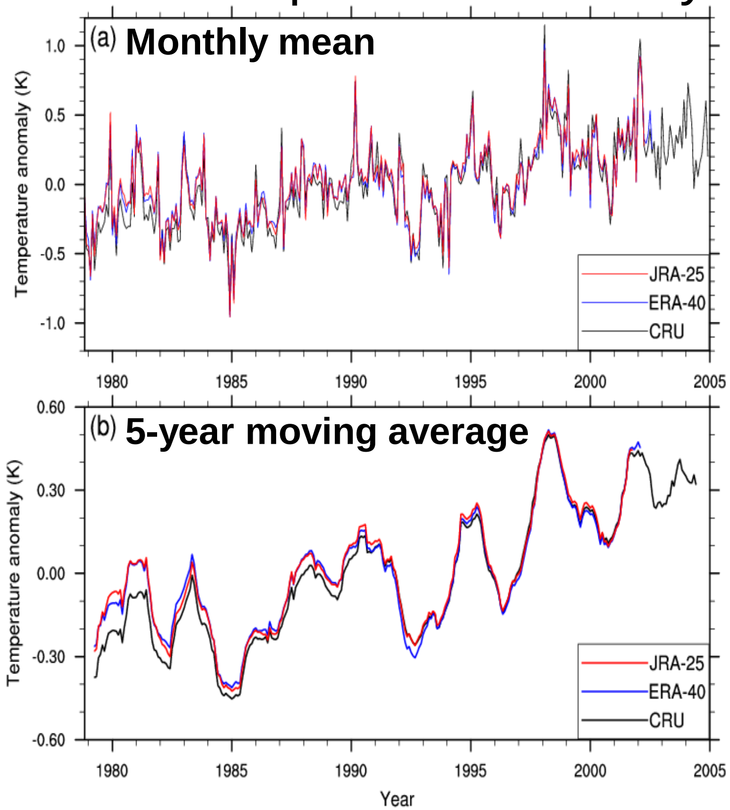
The impact of the TC wind data is clear over the eastern North Pacific. For the control, the assimilation system fails to reproduce not only wind-field around the two TCs but also the locations of their centers.

Long-term Trend of Surface Temperature



Comparison between JRA-25, ERA-40 and CRU (Jones)

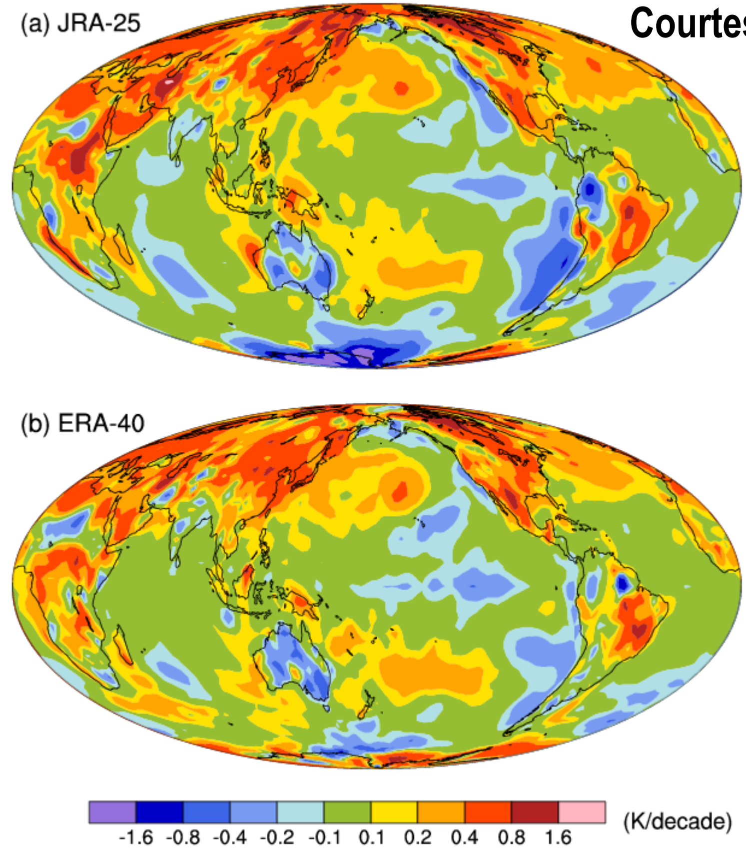
Global Temperature Anomaly



JRA-25, ERA-40, CRU(Jones)

Distribution of tendency (K/decade)

Courtesy: J. Tsutsui



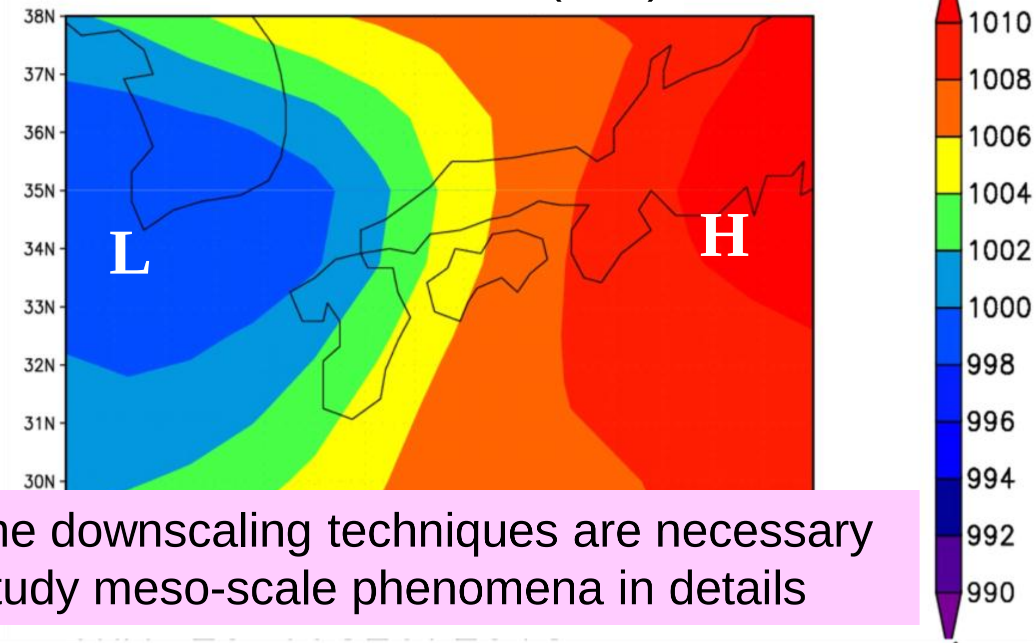
The JRA-25 dataset includes a set of analyses at reference heights near the surface. The JRA-25 surface analysis employs a two-dimensional optimum interpolation scheme, which is similar to the one in ERA-40. The CRU dataset contains surface air temperature anomalies in 5-deg by 5-deg grid boxes used in climate change studies. It is verified that these three datasets have similar spatial and temporal distributions.

Heavy Rain event
- Nagasaki Gou -

1982. 7.24. 03JST

Surface Weather Chart

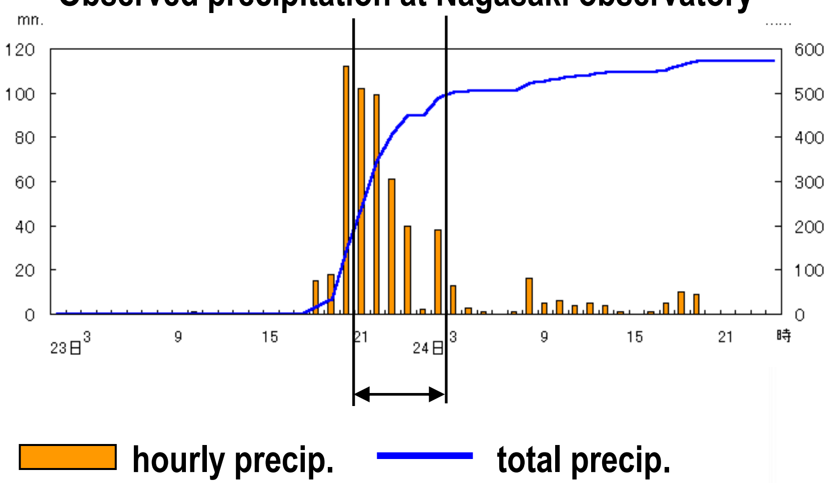
JRA-25 MSLP (hPa)



Some downscaling techniques are necessary to study meso-scale phenomena in details

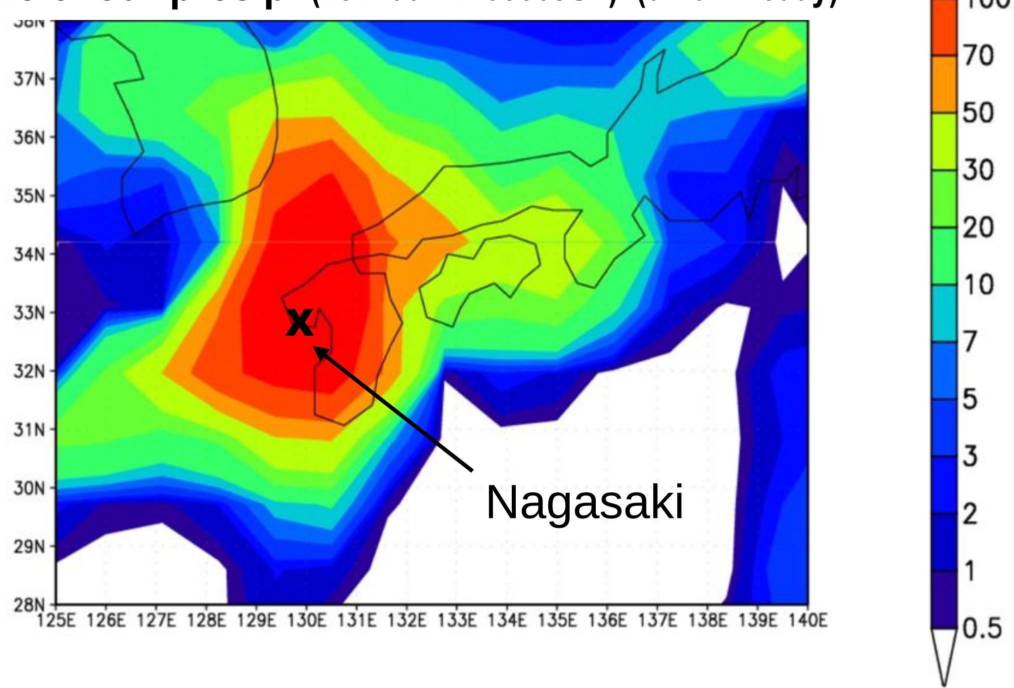
Synoptic fields are properly analyzed, although resolution is not sufficient.

Observed precipitation at Nagasaki observatory

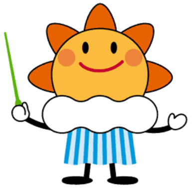


299 persons died.

JRA-25 6hour precip. (232100 - 240300JST) (unit:mm/day)



Possible application areas of JRA+JCDAS for operation and research



JRA-25+JCDAS

Monitoring global climate system

Monitoring climate system and detect anomalous events worldwide

Monitoring the Earth's Environment

Carbon cycle, reference data for ozone analysis

Forcing data for a chemical transport model

Climatology

Time series at a point

JRA-25 climatology atlas

Seasonal Prediction

Consistent initial and verification data of atmosphere, land surface and ocean for seasonal hindcast experiments

Atmospheric forcing data for driving ocean models

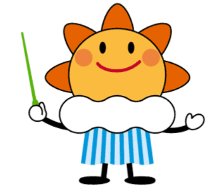
Climate and environmental research

Extreme events, climate change, development and improvement of seasonal prediction model

Analysis of Energy and water cycle.

Study of severe weather events using fine-mesh limited area models

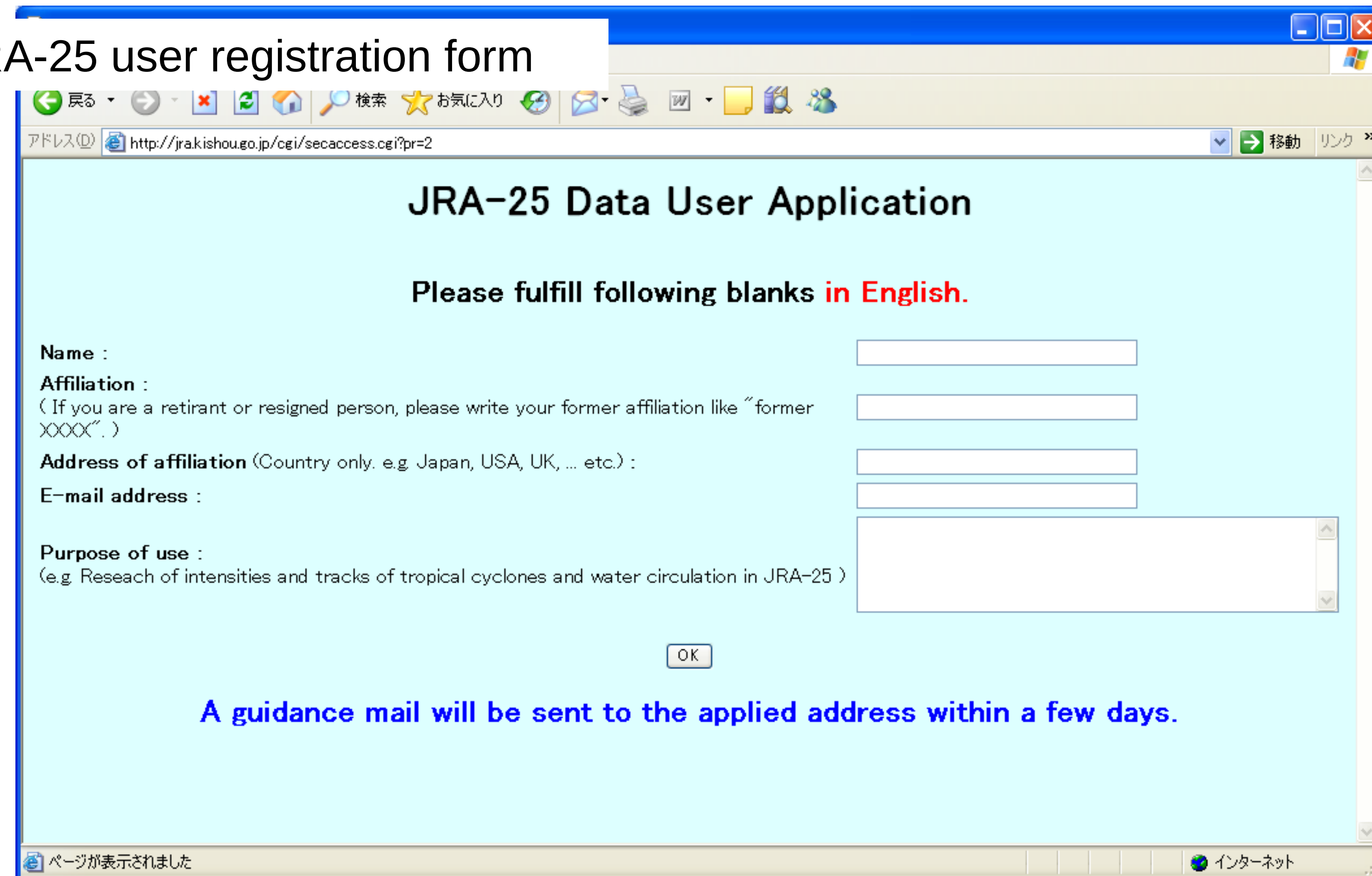
By providing proper initial and boundary data to perform numerical experiments for severe events in the past.



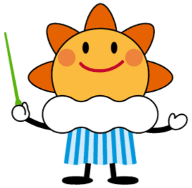
JRA-25 official data and near-real-time JCDAS data are now available via Internet

- JRA-25 official website : http://jra.kishou.go.jp/
- Registration is necessary for downloading the data

JRA-25 user registration form



Statistical relationship between the NINO SSTs and the climate over the globe using the JRA and COBE-SST data

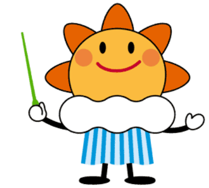


Examination of the statistical relationship between the NINO SSTs and the surface climate anomalies in the world

- Analyzed Period：1949 - 2004 (56 years)
- Data used in this study (JMA:2006)
  - SST : COBE SST (Ishii 2005, IJC) : Monthly
    - NINO.3 : 5N-5S, 150W-90W = New definition of El Niño/ La Niña event
  - Surface temperature and precipitation : Monthly
    NCDC/WDC + NCAR + APN + CLIMAT report via GTS

These figures will be available via TCC web site:

http://okdk.kishou.go.jp/products/climate/ENSO/

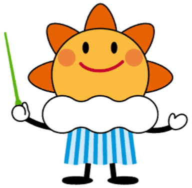


Newly defined El Niño / La Niña Periods

(Black circle) (White circle)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1949							○	○	○	○	○	○
1950	○	○	○	○	○	○	○					
1951					●	●	●	●	●	●	●	●
1952	●	●										
1953				●	●	●	●	●	●	●	●	
1954				○	○	○	○	○	○	○	○	○
1955	○	○	○	○	○	○	○	○	○	○	○	○
1956	○	○										
1957				●	●	●	●	●	●	●	●	●
1958	●	●	●	●								
1959												
1960												
1961												
1962												
1963						●	●	●	●	●	●	●
1964	●			○	○	○	○	○	○	○	○	○
1965	○				●	●	●	●	●	●	●	●
1966	●	●										
1967									○	○	○	○
1968	○	○	○	○					●	●	●	●
1969	●	●	●	●	●	●	●	●	●	●	●	●
1970	●	●			○	○	○	○	○	○	○	○
1971	○	○	○	○	○	○	○	○	○	○	○	○
1972					●	●	●	●	●	●	●	●
1973	●	●	●			○	○	○	○	○	○	○
1974	○	○	○									
1975				○	○	○	○	○	○	○	○	○
1976	○	○	○			●	●	●	●	●	●	●
1977	●	●	●									
1978												

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1979												
1980												
1981												
1982				●	●	●	●	●	●	●	●	●
1983	●	●	●	●	●	●	●	●				
1984							○	○	○	○	○	○
1985	○	○	○	○	○	○	○	○	○			
1986									●	●	●	●
1987	●	●	●	●	●	●	●	●	●	●	●	●
1988	●			○	○	○	○	○	○	○	○	○
1989	○	○	○	○	○							
1990												
1991				●	●	●	●	●	●	●	●	●
1992	●	●	●	●	●	●	●					
1993												
1994												
1995							○	○	○	○	○	○
1996	○	○										
1997				●	●	●	●	●	●	●	●	●
1998	●	●	●	●	●			○	○	○	○	○
1999	○	○	○	○	○	○	○	○	○	○	○	○
2000	○	○	○	○								
2001												
2002						●	●	●	●	●	●	●
2003	●	●										
2004												
ElNino	14	12	8	11	13	15	15	14	15	15	15	14
LaNina	13	12	10	12	11	11	14	14	15	14	14	14
Neutral	29	32	38	33	32	30	27	28	26	27	27	28



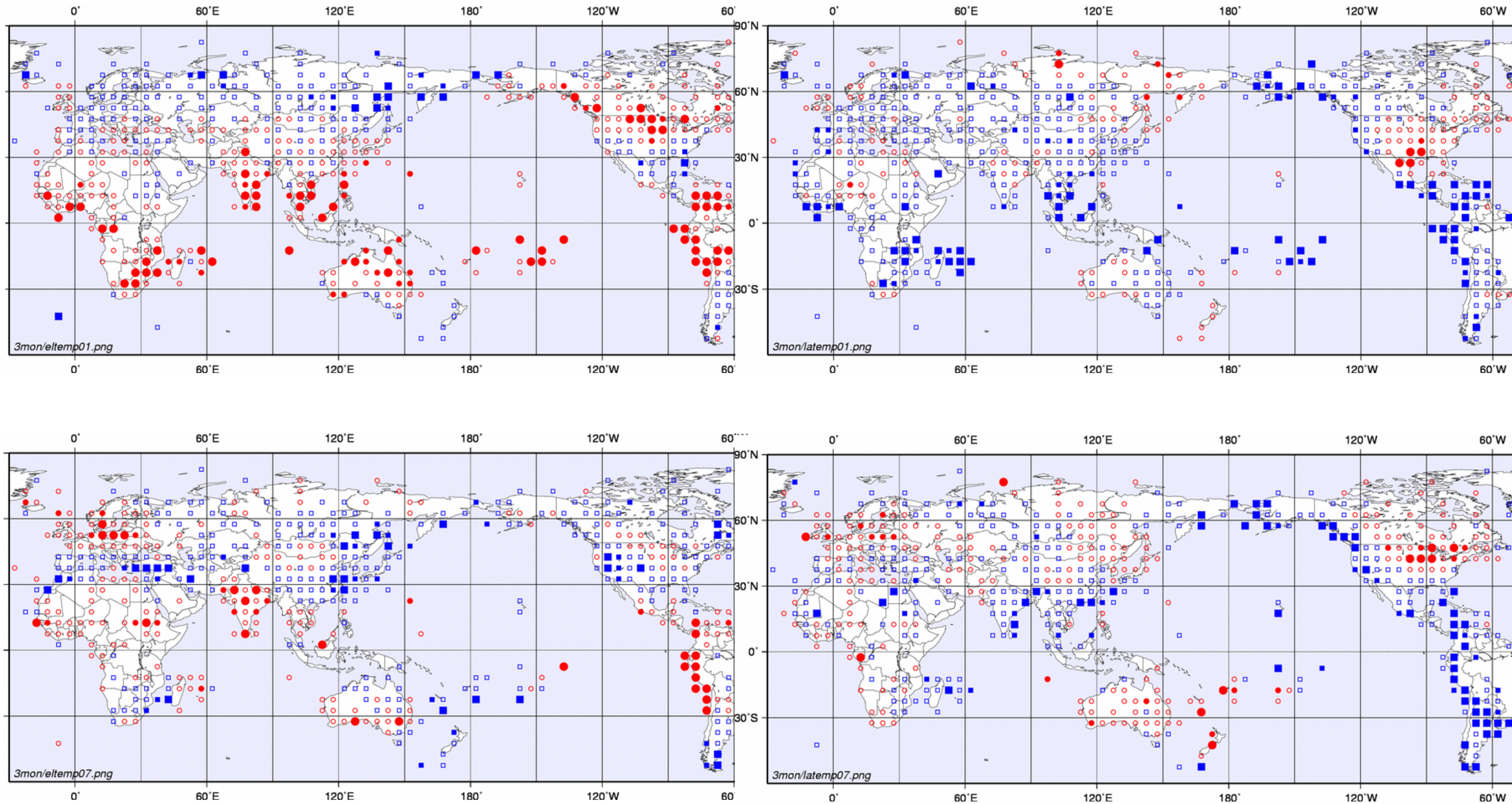
Significance of Temperature Anomalies
against Neutral cases using t-test

Red : warm
Blue : cool

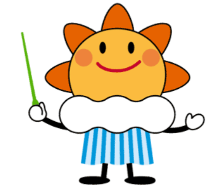
El Niño year   La Niña year

Winter (DJF)

Summer (JJA)



Filled circle/square : 5% significance   Open circle/square : 10% significance



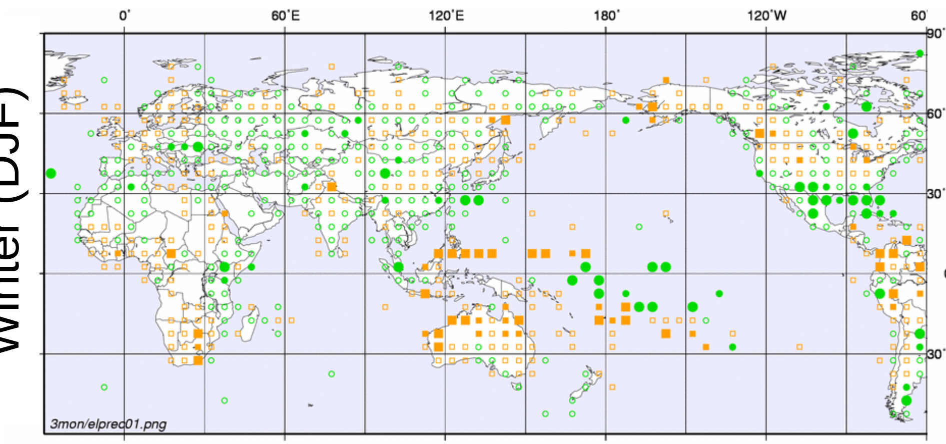
Significance of Precipitation Ratio against Neutral cases using t-test

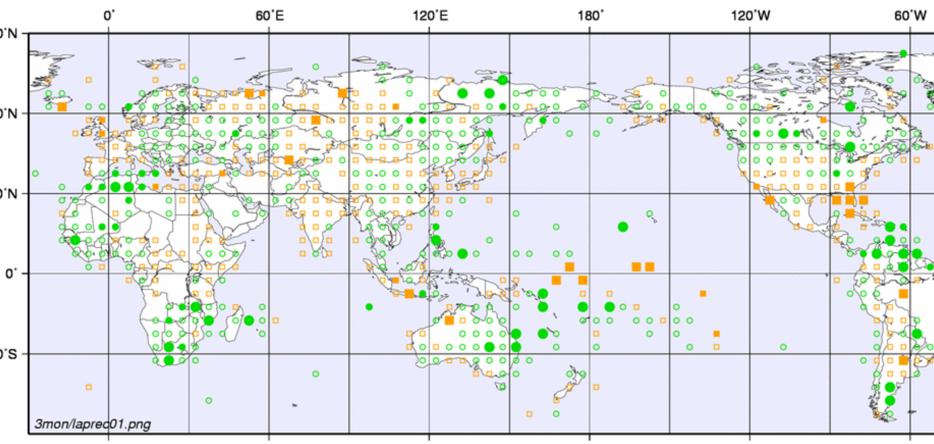
Green : wet

Orange : dry

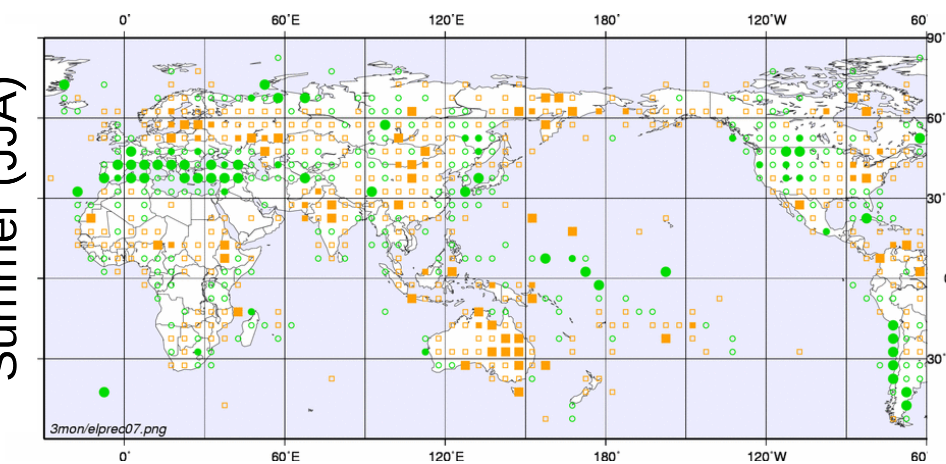
El Niño year | La Niña year

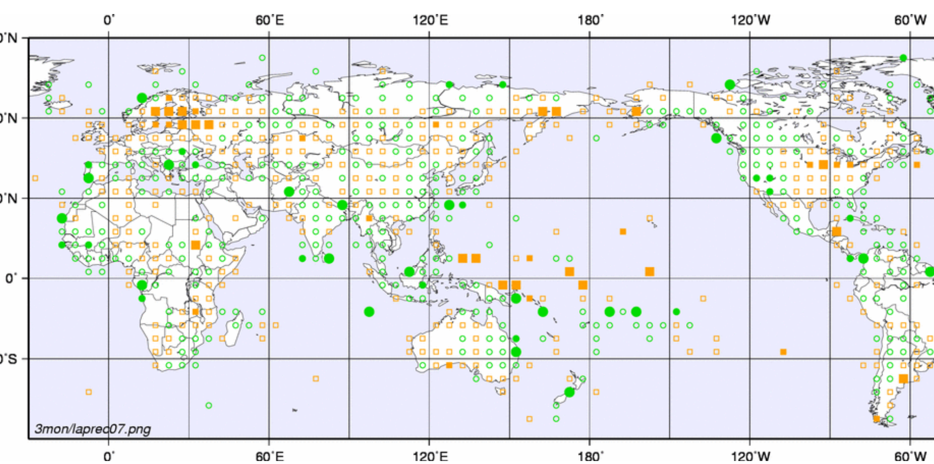
Winter (DJF)





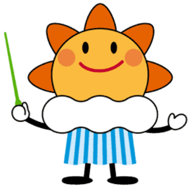
Summer (JJA)



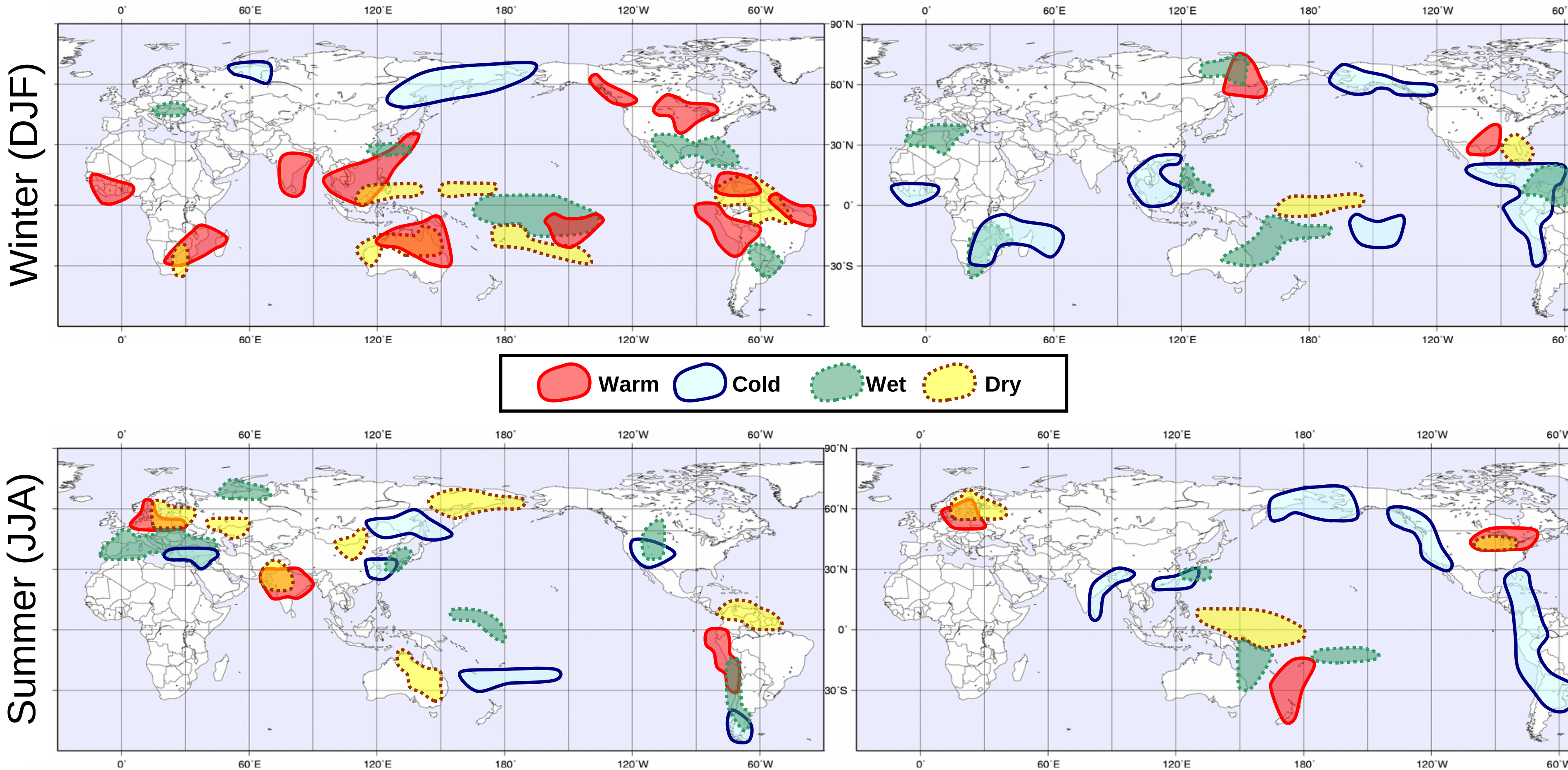


Filled circle/square : 5% significance   Open circle/square : 10% significance

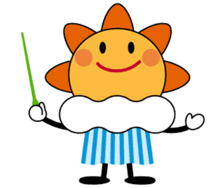
Schematic Features of Climate Anomalies



El Niño year   La Niña year



During El Niño events, Japan except its northern part is likely to experience warm in winter and spring, while cool in autumn together with the Korean Peninsula and northeastern China. Southeast Asia tends to experience warm and dry throughout the year except summer.



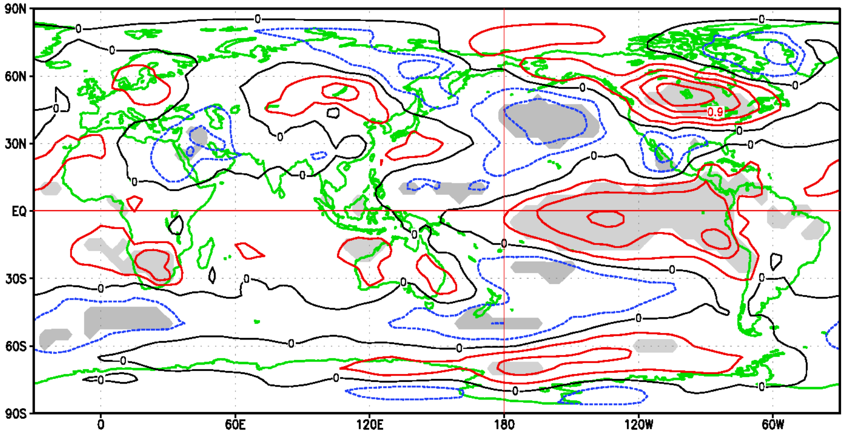
Re-examination of the statistical relationship between the NINO SSTs and the circulation anomalies over the globe

- Analyzed Period：1979.1 - 2004.12 (26 years)
- Data used in this study
  - SST : COBE SST (Ishii 2005, IJC)
    - NINO.3 : 5N-5S, 150W-90W = New definition of El Niño/ La Niña event
  - Atmospheric elements : JRA-25
    - (Geopotential height, Sea level pressure, Temperature, Wind vector, Stream function)
- Data used in former study (JMA:2003) 1979-2001
  - SST : GLBSST (Marine Division/JMA)
    - Region B : 4N-4S, 150W-90W = Old definition of El Niño/ La Niña event
  - Atmospheric elements : ERA-15 (ECMWF) (1979-1993)
    & GANAL (NPD/JMA) (1994-2001)

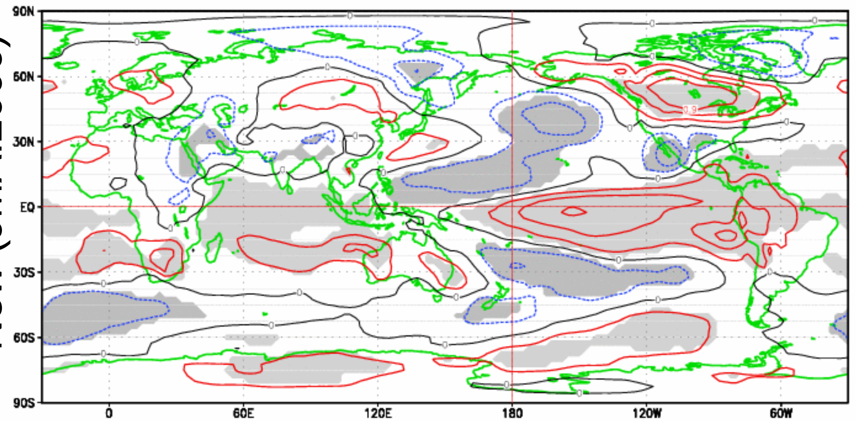
These figures are available via TCC web site:
http://okdk.kishou.go.jp/products/clisys/REGR/

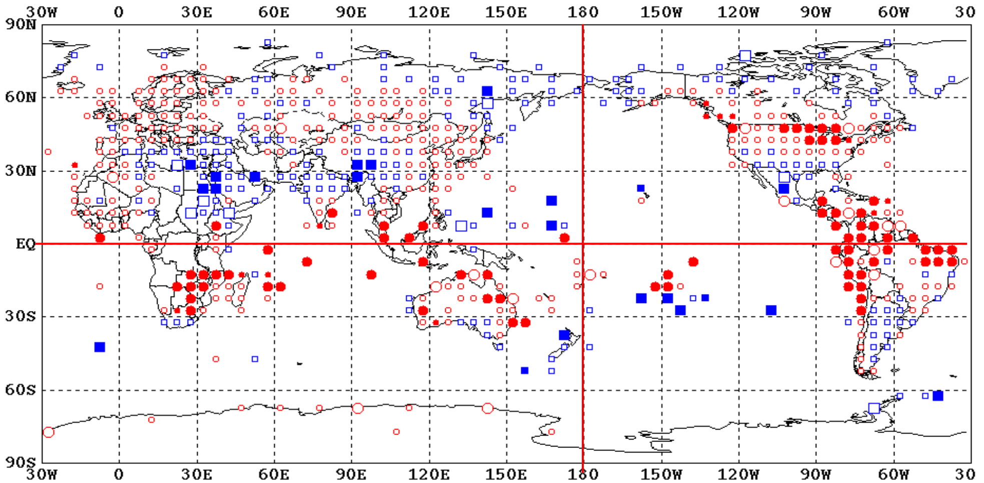
Linear Regression coefficient maps between NINO.3 and T850 in winter (DJF)

Former (JMA:2003)



New (JMA:2006)





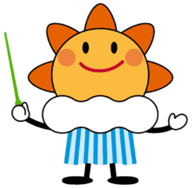
↑Regression between NINO.3 and Surface Observation Temperature (DJF)

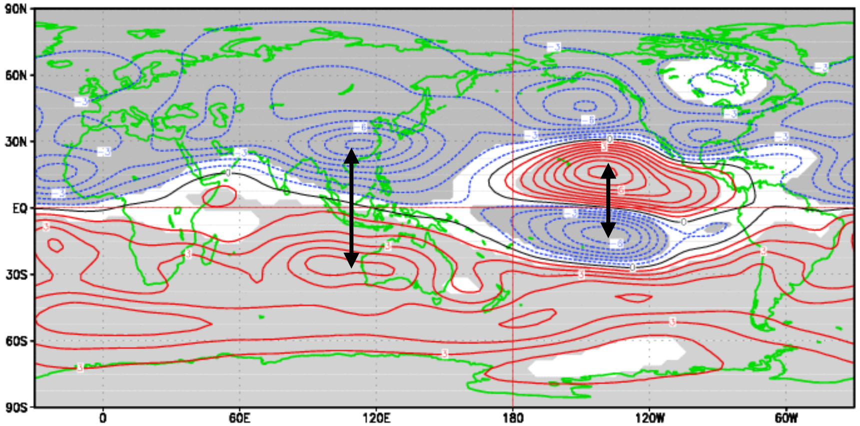
Blue/red mark shows positive/ negative temperature anomaly. Filled-mark shows 95% confidence level.

← Contour interval is 0.5Cdegree. Shading shows 95% confidence level based on F-test.

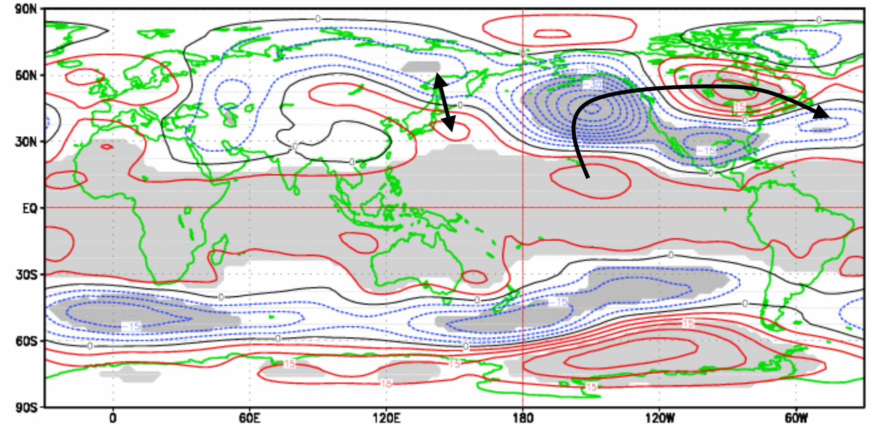
The areas of the 5% significance level in the new analysis (left lower panel) are much wider than in the former analysis (left upper panel).
These significant regions in the new analysis are more similar to the ones of observation surface temperature data (right panel), compared to former one.

Linear Regression coefficient maps between NINO.3 and Stream function

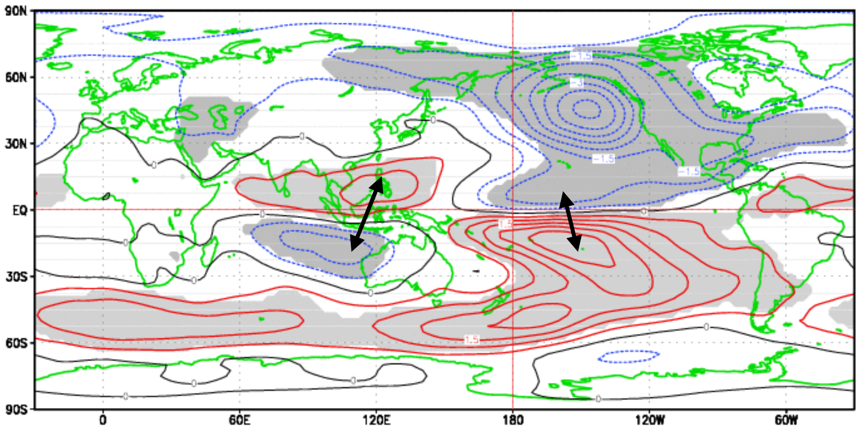




200 hPa Stream Function for winter (DJF).



500 hPa Height for winter (DJF).



850 hPa Stream Function for winter (DJF).

-500 hPa height:
Positive (negative) anomalies are seen around Japan (eastern Siberia). This anomaly pair is similar to so called Western Pacific pattern. Tropical/Northern Hemisphere pattern is found around North America.

A couple of cyclonic (anti-cyclonic) anomalies on both sides of the equator are seen over the eastern Pacific (Southeast Asia and Australia) at 200hPa with opposite sign anomalies underneath. Those patterns are consistent with the response to the typical equatorial heating anomalies.

Verification of the JMA's Seasonal Ensemble Prediction based on the Long-term Hindcasts

Specification of 4-month EPS Experiment (Hindcast)

Model : JMA AGCM (TL95L40)

Target years : 1983 to 2003, 21 years

Target months : All months (initial date is the 10th of every month)

Integration time : Four months (120 days)

Atmospheric initial condition

: ERA-15 from 1983 to 1993, and
JMA's operational global analyses from 1994 to 2003

Land surface initial condition

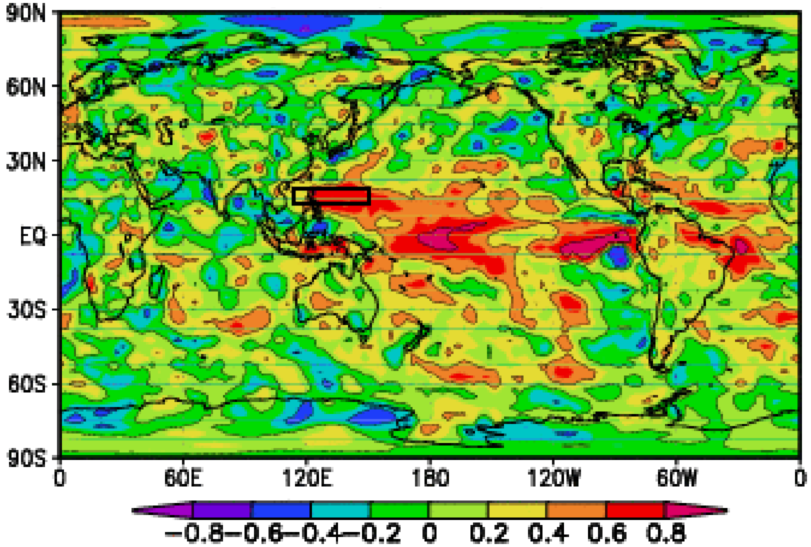
: Output from SiB
forced by ERA-15 from 1983 to 1993, and
10-year average of them for 1994 to 2003

SST : Two-tiered method ; Combination of persisted anomaly, climate and prediction by CGCM

Ensemble size : 5 members

Forecast Skills of Precipitation (Summer : JJA)

Distribution of anomaly correlation coefficient

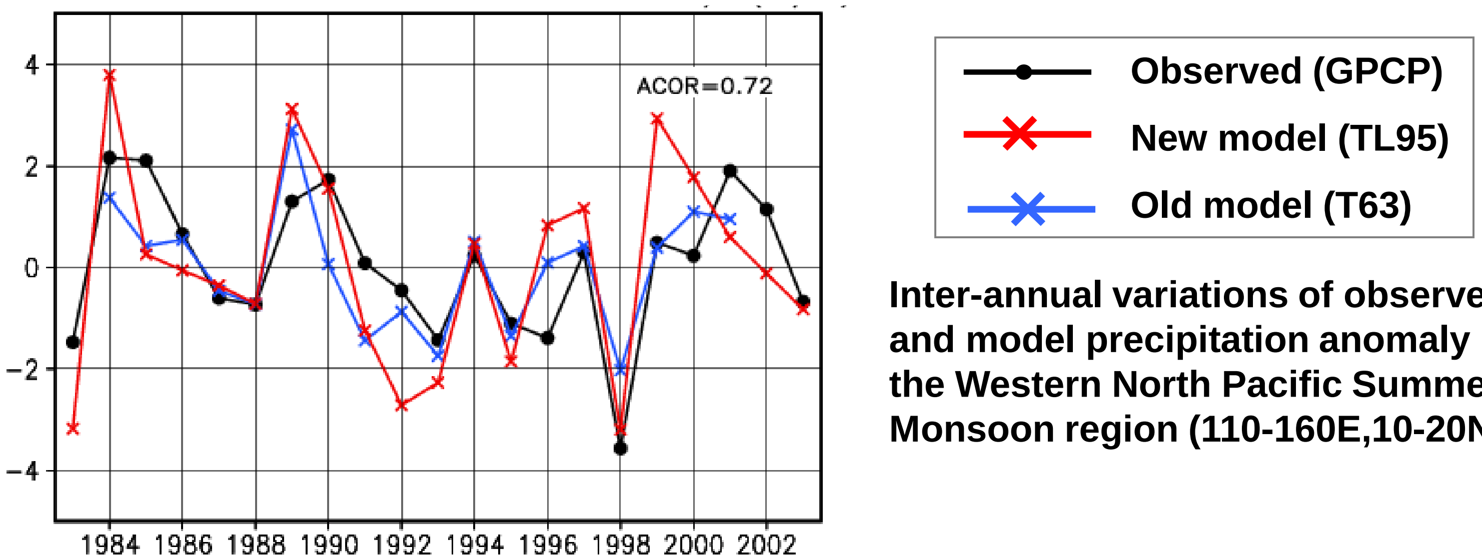


Distribution of inter-annual temporal correlation between observed(CMAP) and model ensemble average forecast precipitation for 21 years (1983-2003)

Initial : 10 May

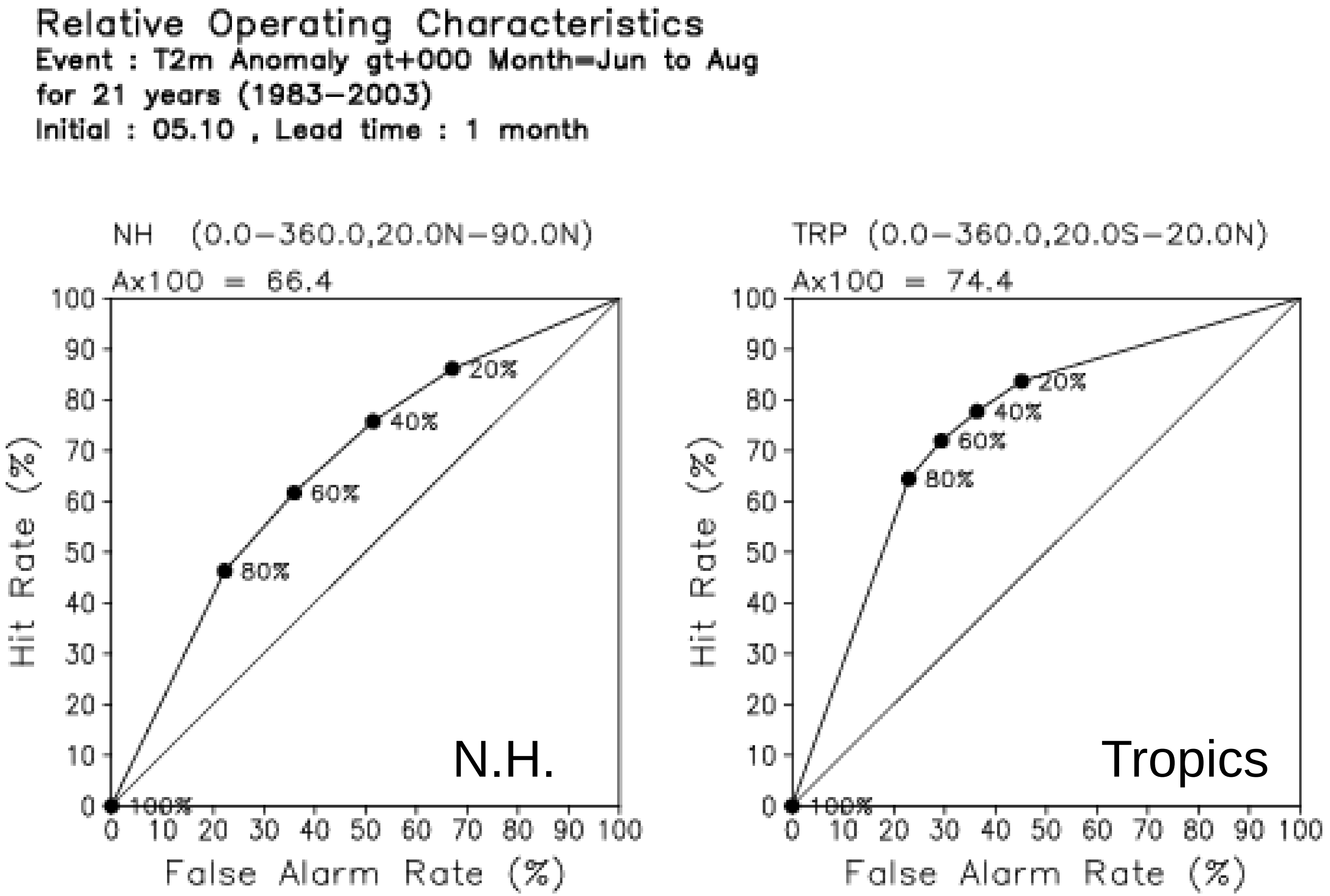
Forecast range: 21-110day (90day mean)

Average Precipitation in WNPSM region

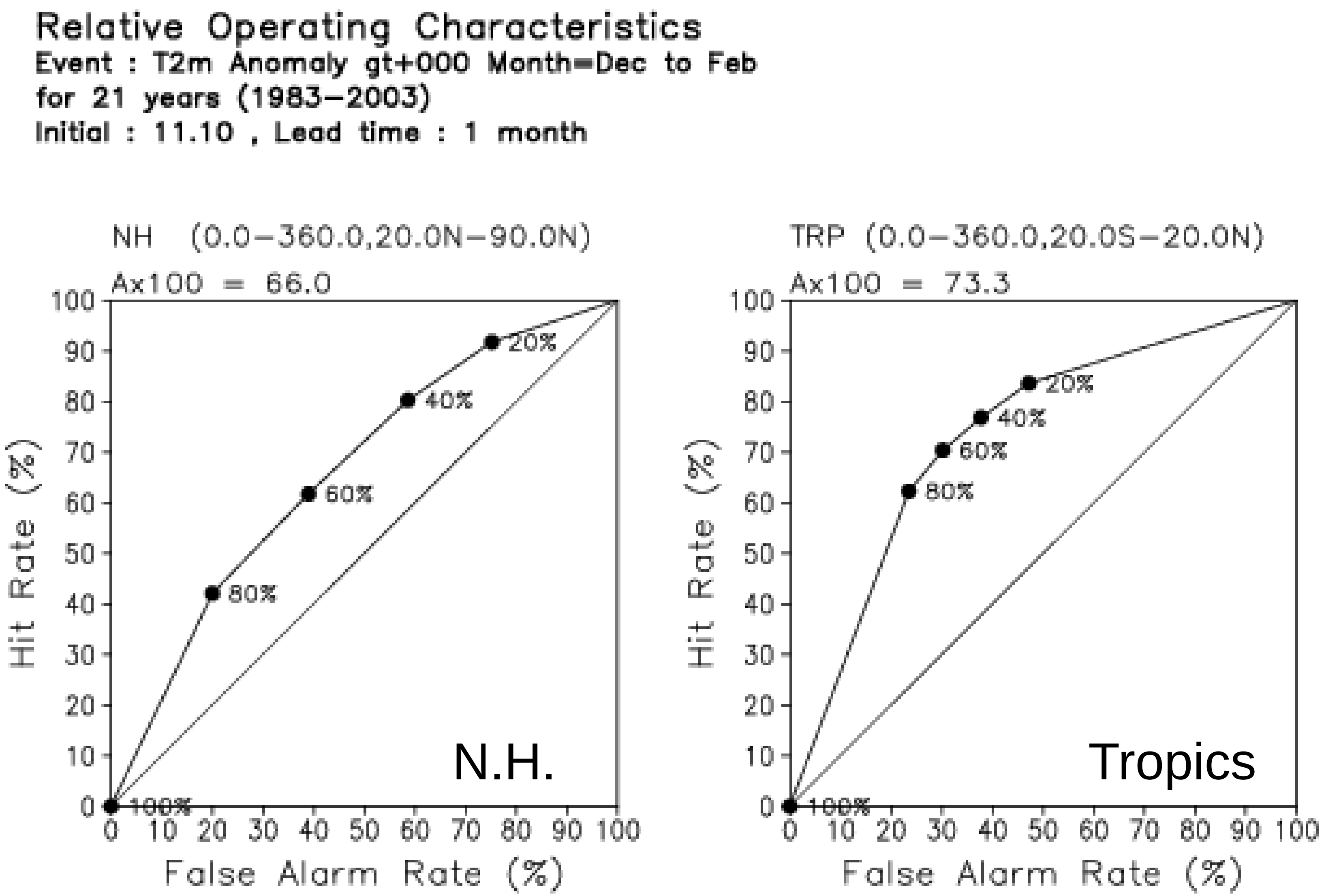


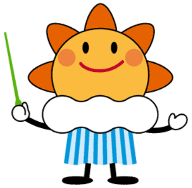
Inter-annual variations of observed and model precipitation anomaly in the Western North Pacific Summer Monsoon region (110-160E,10-20N)

ROC score（T2m:JJA）

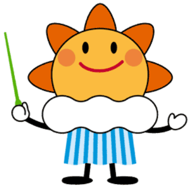


ROC score（T2m:DJF)





Summary for Probabilistic Verification



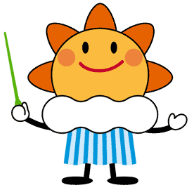
3-month mean ROC score

T2m	N.H.	Tropics	S.H.
JJA（Initial : 10 May）	66.4	74.4	68.2
DJF（Initial : 10 Nov）	66.0	73.3	60.4

Precipitation	N.H.	Tropics	S.H.
JJA（Initial : 10 May）	53.5	62.2	53.9
DJF（Initial : 10 Nov）	55.6	61.6	53.9

Summary

1 Forecast skill in temperature is significant.
2 Forecast skill in precipitation is marginal (slightly positive).
3 Forecast skills are better in ENSO years.
4 Forecast skill in precipitation in WNPSM region is good.



Development of the Next Generation El Niño Prediction System (Unified Coupled Ocean-Atmosphere GCM)

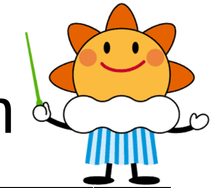
A new system for forecasting SST in the equatorial Pacific using a coupled atmosphere-ocean model has been developed at MRI/JMA.

System Components

a) the TL95L40 version of the JMA atmospheric model
b) the new MRI Community Ocean Model (MRI.COM)
c) the new Ocean Data Assimilation System “Multivariate Ocean Variational Estimation System (MOVE)” developed in MRI

We are now continuing to develop this system, which will replace the current JMA operational system in 2008.

CGCM Components and Ocean Data Assimilation System



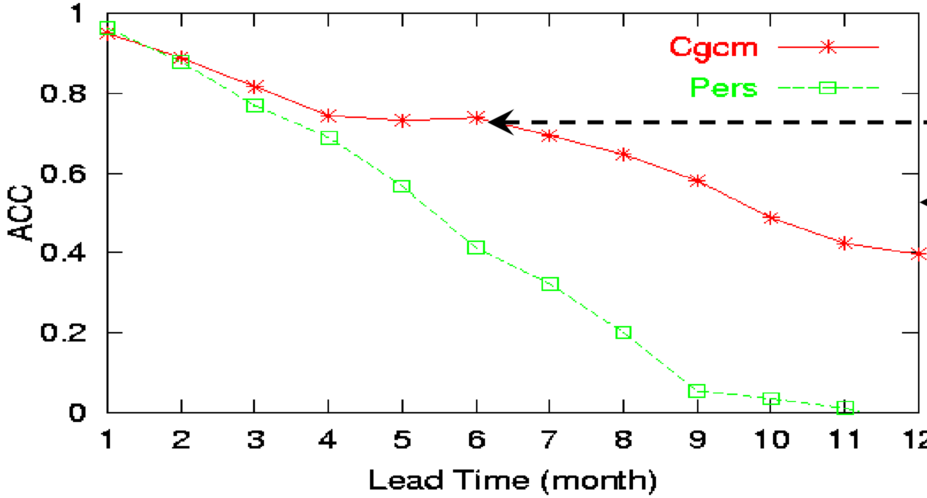
	JMA Operational Model (JMA-CGCM2)	MRI/JMA-CGCM3
AGCM	T42L20	TL95L40 (same as the current seasonal prediction model)
OGCM	JMA-OGCM ▪zonal: **2.5deg** ▪meridional: **0.5-2.0deg** ▪vertical: **20 levels**	MRI.COM ▪zonal: **1.0deg** ▪meridional: **0.3-1.0deg** ▪vertical: **50 levels**
Coupling	▪Coupling time: **24 hours** ▪Momentum and heat fluxes adjustment	▪Coupling time: **1 hour** ▪Momentum and heat fluxes adjustment
Ocean Data Assimilation System	JMA-ODAS ▪3D-VAR(T,S) ▪Observation: T, S on GTS, COBE-SST, SSH ▪IAU* : **1 day** ▪Error statistics: **univariate** ▪**Linear constraints**	MOVE/MRI.COM ▪3D-VAR(T,S) ▪Observation: T, S on GTS, COBE-SST, SSH ▪IAU :**10 days** ▪Error statistics: **multivariate** ▪**Nonlinear constraints**

IAU* (Incremental Analysis Update)

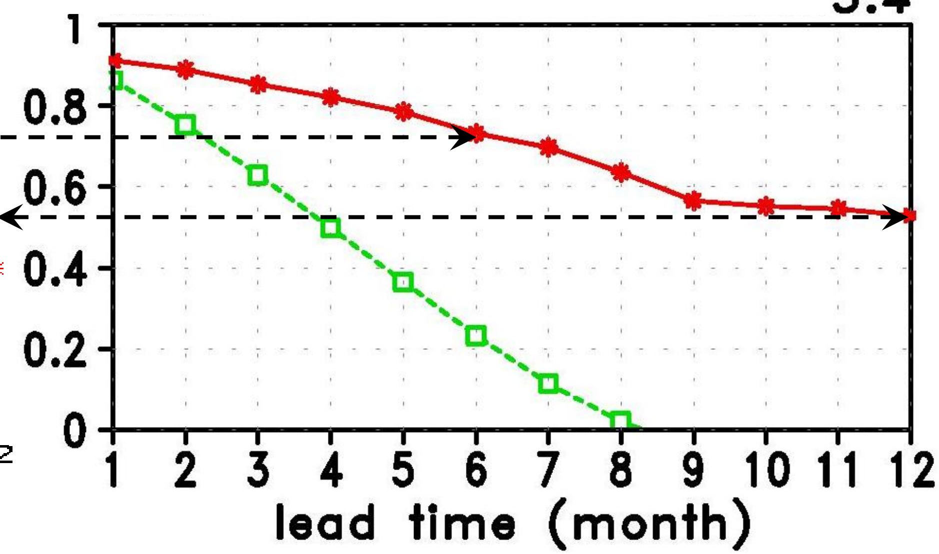
Hindcast Skill: NINO3.4 SST for 1990-1999

Anomaly Correlation

JMA Operational Model

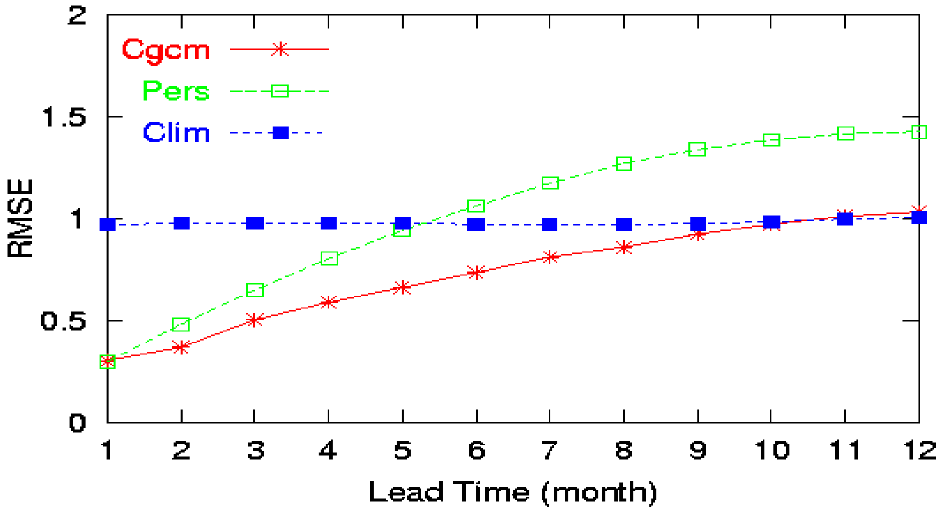


New MRI/JMA CGCM

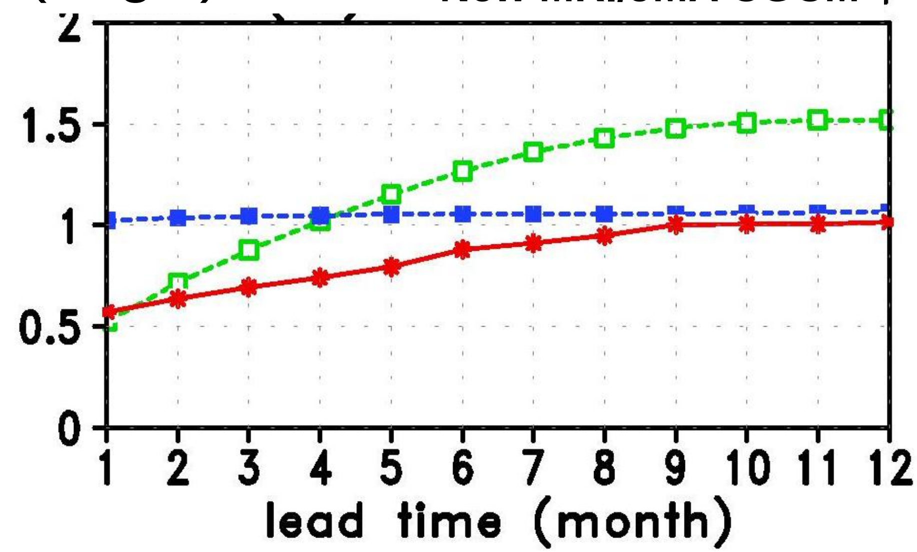


RMSE (degC)

JMA Operational Model

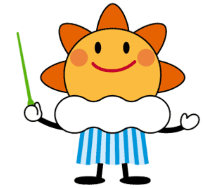


New MRI/JMA CGCM



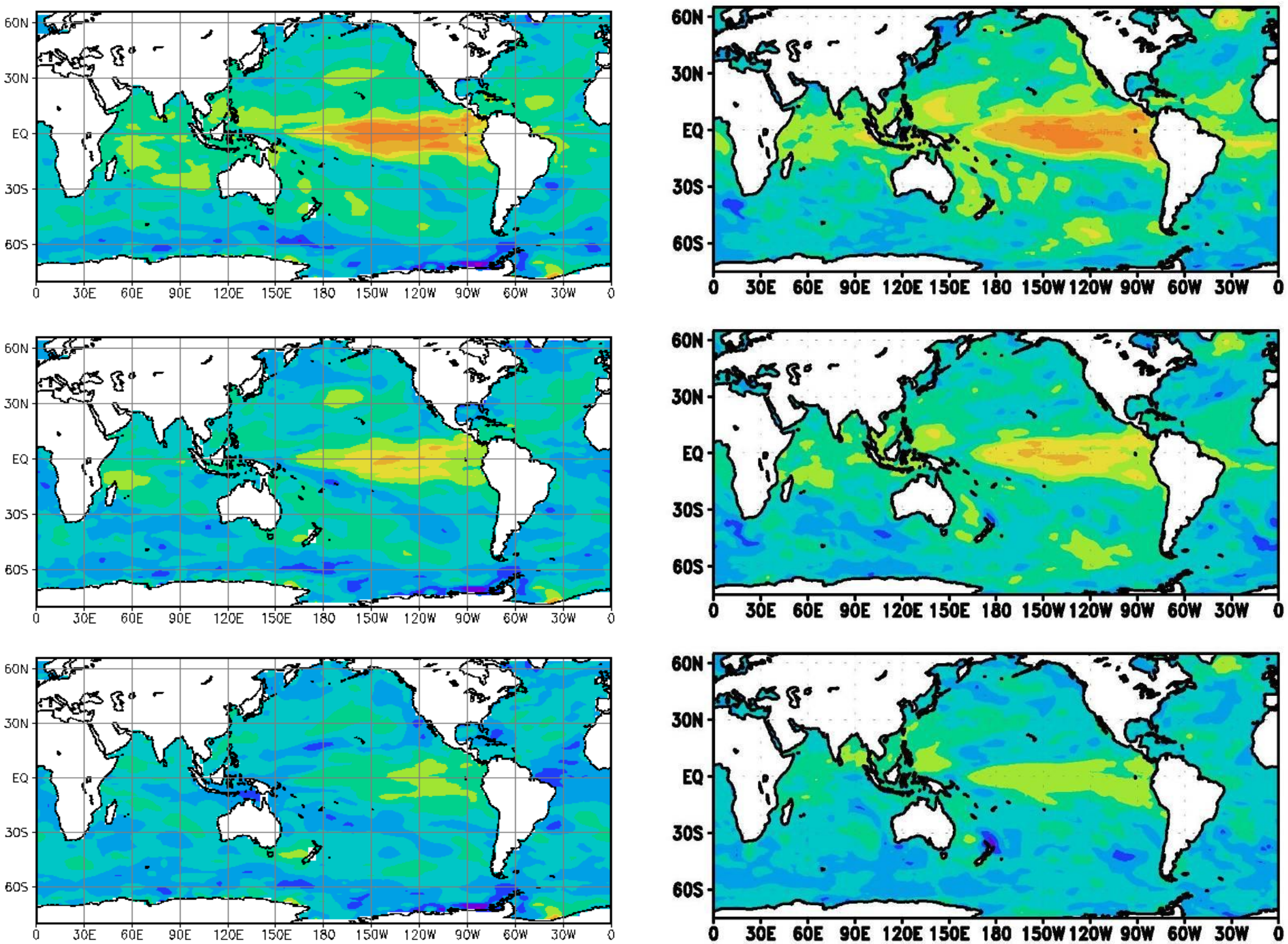
large & persistent skill after 10-month lead time

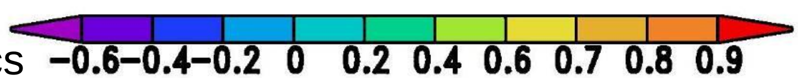
Hindcast Anomaly Correlation : SST for 1990-1999



JMA Operational Model | **New MRI/JMA CGCM**

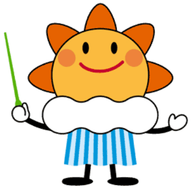
Lead time





large & persistent skill in the tropics

Hindcast RMSE (degC) : SST for 1990-1999



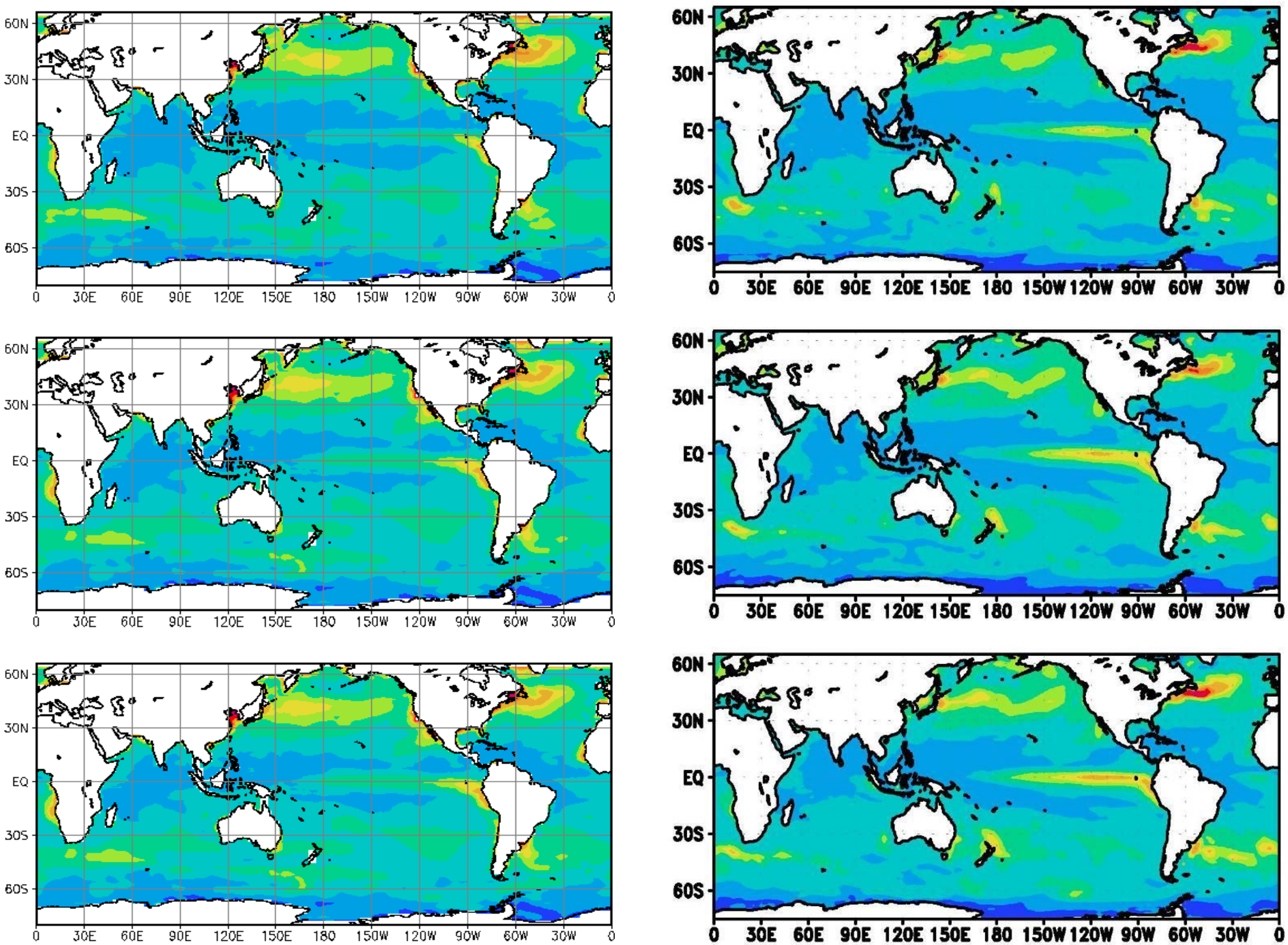
JMA Operational Model | **New MRI/JMA CGCM**

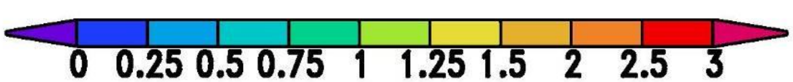
Lead time

3 month

6 month

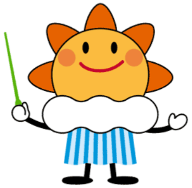
12 month

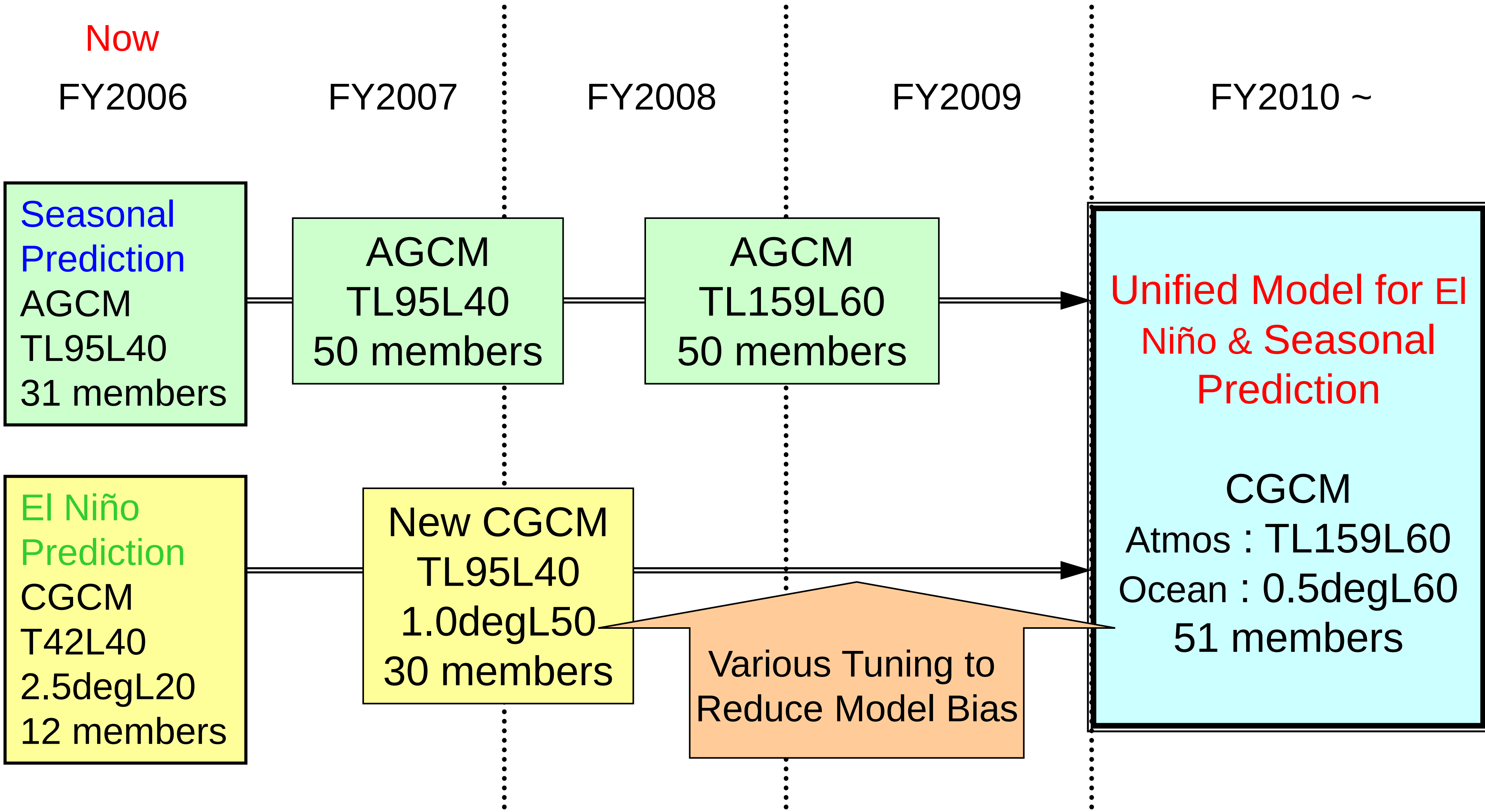




A little larger error in the eastern equatorial Pacific

Time Schedule





Seasonal Forecast with Coupled Model (CGCM) after 2010

Thank you
for your attention.