Sub-seasonal prediction at JMA

Yuhei Takaya

Japan Meteorological Agency

Climate Prediction Division

Acknowledgements: S. Matsueda, S. Maeda, T. Kanehama and R. Sekiguchi

ECMWF Workshop on Subseasonal Predictability, 3 Nov. 2015, Reading UK

Outline

- Early history of sub-seasonal prediction
- Introduction of JMA sub-seasonal prediction
- Sub-seasonal extreme weather prediction
  - Products [EFI, probability of extremes, warning map]
  - Relationship between MJO and extreme weather

Pioneers in subseasonal predictions

Pioneering and challenging work of Miyakoda et al. (1983), Spar et al. (1976), Shukla (1981) opened the door for subseasonal predictions.

Dr. Kikuro Miyakoda
Source: Princeton Univ. webpage

These studies

- explored the predictability at a subseasonal time-scale (beyond deterministic predictable limit),
- recognized that the subseasonal prediction can be seen as an initial value problem with external forcings (boundary value problem).

"Predictability In the Midst of Chaos" Shukla (1998), Palmer (1993)

Miyakoda et at. (1983) Simulation of a blooking event in January 1977. MWR
Spar et al. (1976) Monthly mean forecast experiments with the GISS model. MWR
Spar et al. (1978) An initial state perturbation experiment with the GISS model. MWR
Shukla (1981) Predictability of time averages. Part I. Dynamical predictability of monthly means. JAS

January 1977

Thousands in U.S. kept home by cold

Story on 2A

THE MIAMI NEWS

Miami, Florida, Wednesday afternoon, January 19, 1977 38 Pages

FINAL HOME EDITION

Souvenir edition:
The day that couldn't happen

Snow in Miami!

Growers fear big loss from killer freeze

Freeze warnings tonight for Dade

Picture Courtesy of Charles Trainor/Miami Herald

Source: NOAA/NWS
http://www.srh.noaa.gov/images/mfl/news/SnowSouthFlorida35th.pdf

January 1977

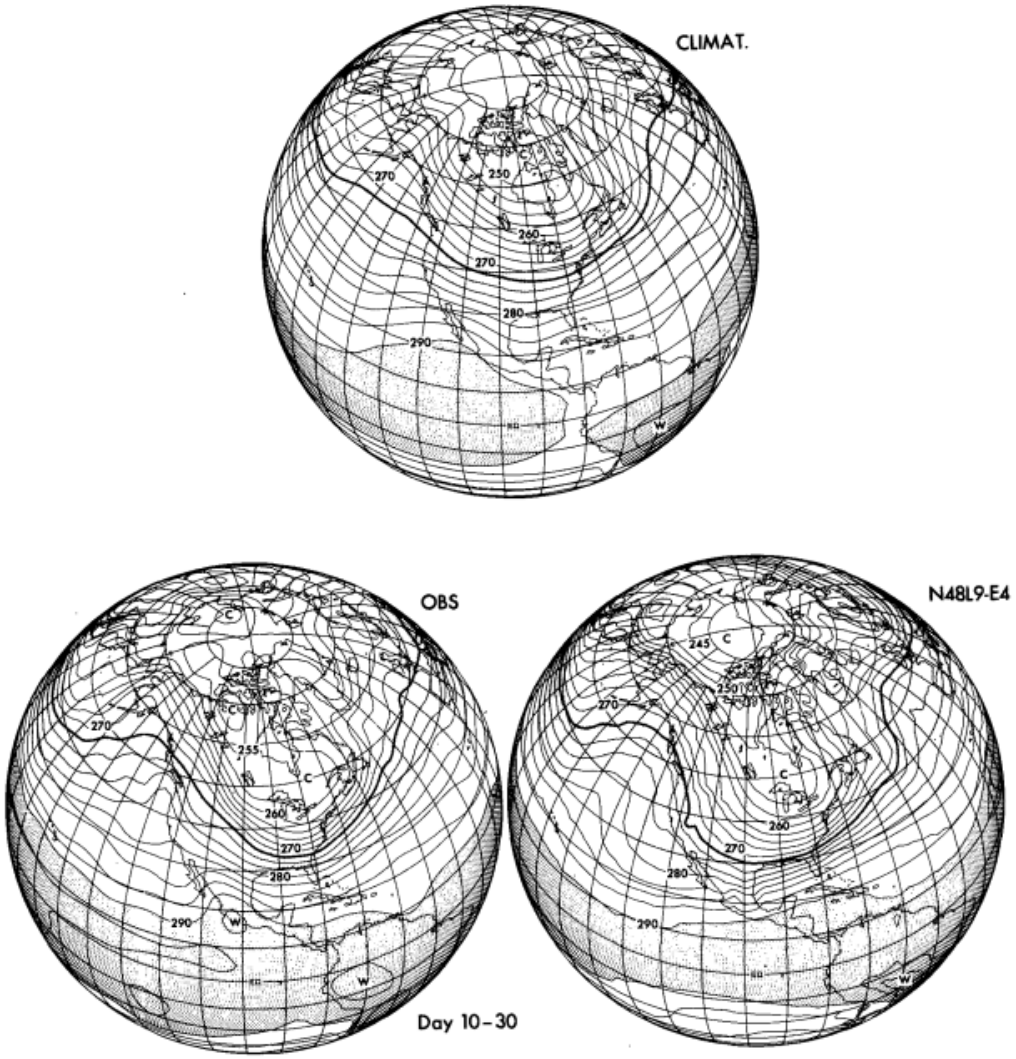
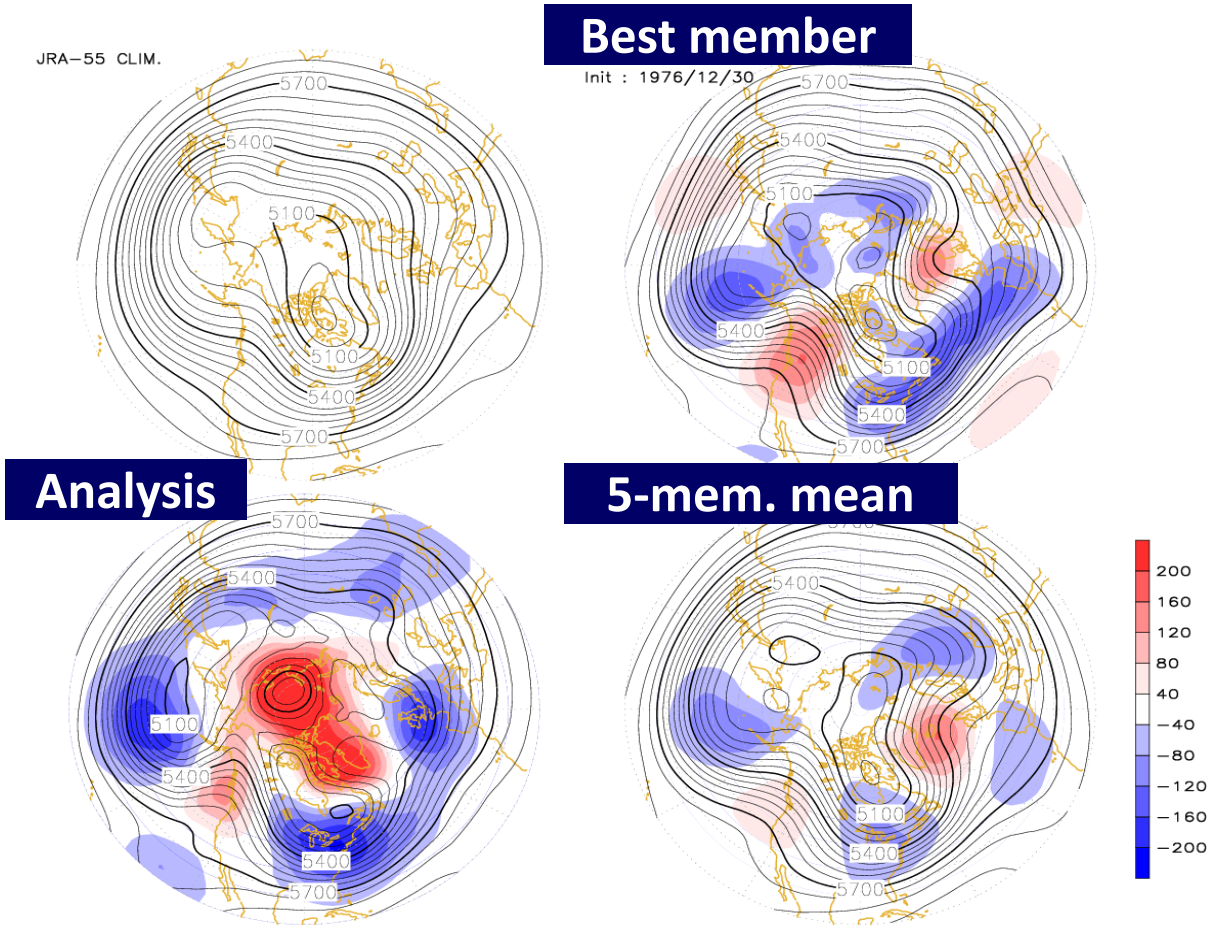


FIG. 6. The widespread record coldness over the United States for January 1977 is displayed by a 10–30 day mean temperature map at the 850 mb level. The predicted temperature shown is for the last 20 days of a one-month forecast (lower right) by the N48L9–E4 model, the observed temperature for the same period (lower left) and the January climatology (top). Units are deg. K, and the contour interval is 2.5 K.

T850 Forecast (Day10-30)

Miyakoda et al. 1983

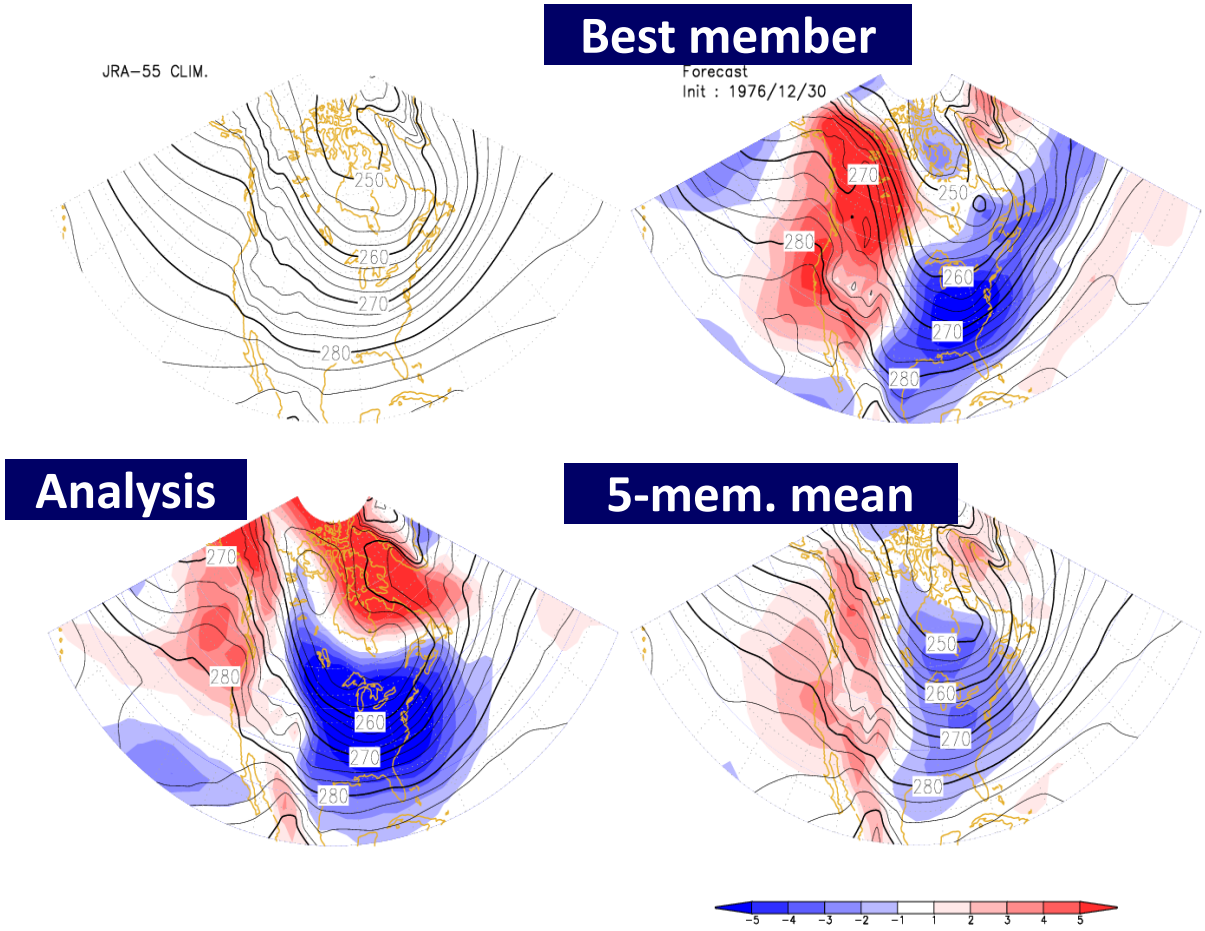
Retrospective forecast for January 1977



Z500 Forecast (Day10-30)

Courtesy T. Kanehama and R. Sekiguchi (CPD)

Retrospective forecast for January 1977



T850 Forecast (Day10-30)

Courtesy T. Kanehama and R. Sekiguchi (CPD)

Once upon a time…, and since then

According to a **WMO survey in 1979**,

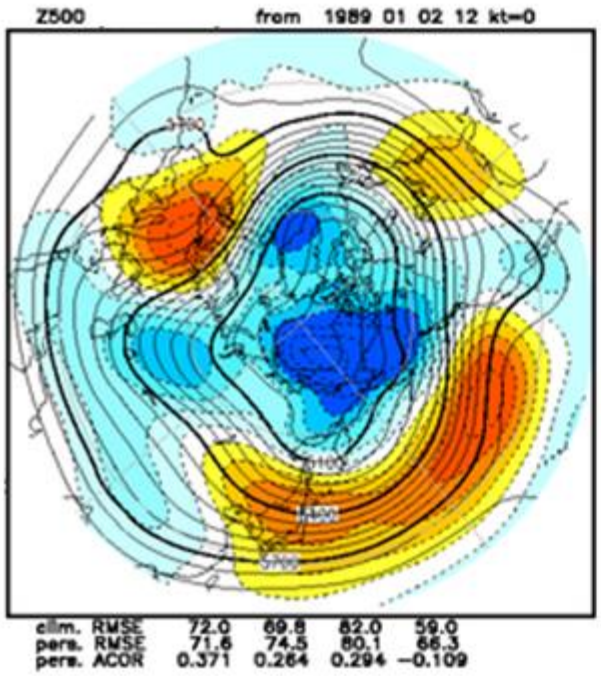
- **At least 32** national meteorological services are **interested in the long-range forecast** (beyond the limit of deterministic prediction),
- **15 issued monthly forecasts**, 32 issued seasonal outlook at that time (based on statistical methods).

[Miyakoda and Chao 1982 JMSJ]

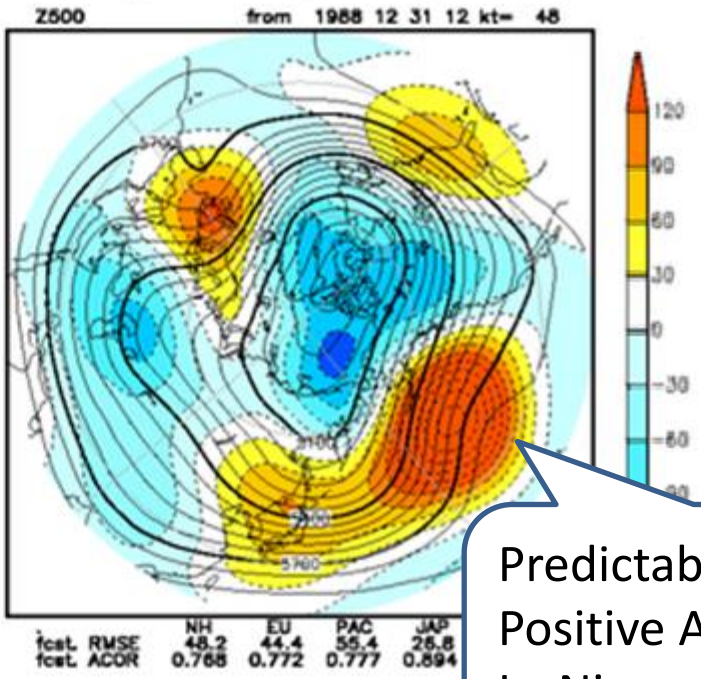
JMA celebrated the **70th anniversary of long-range forecasts in Nov. 2012**, and will mark the **20th anniversary of the operational dynamical one-month ensemble prediction in March next year.**

Dawn of operational dynamical one-month prediction

Z500(JRA-55)



Z500(GSM1403C)



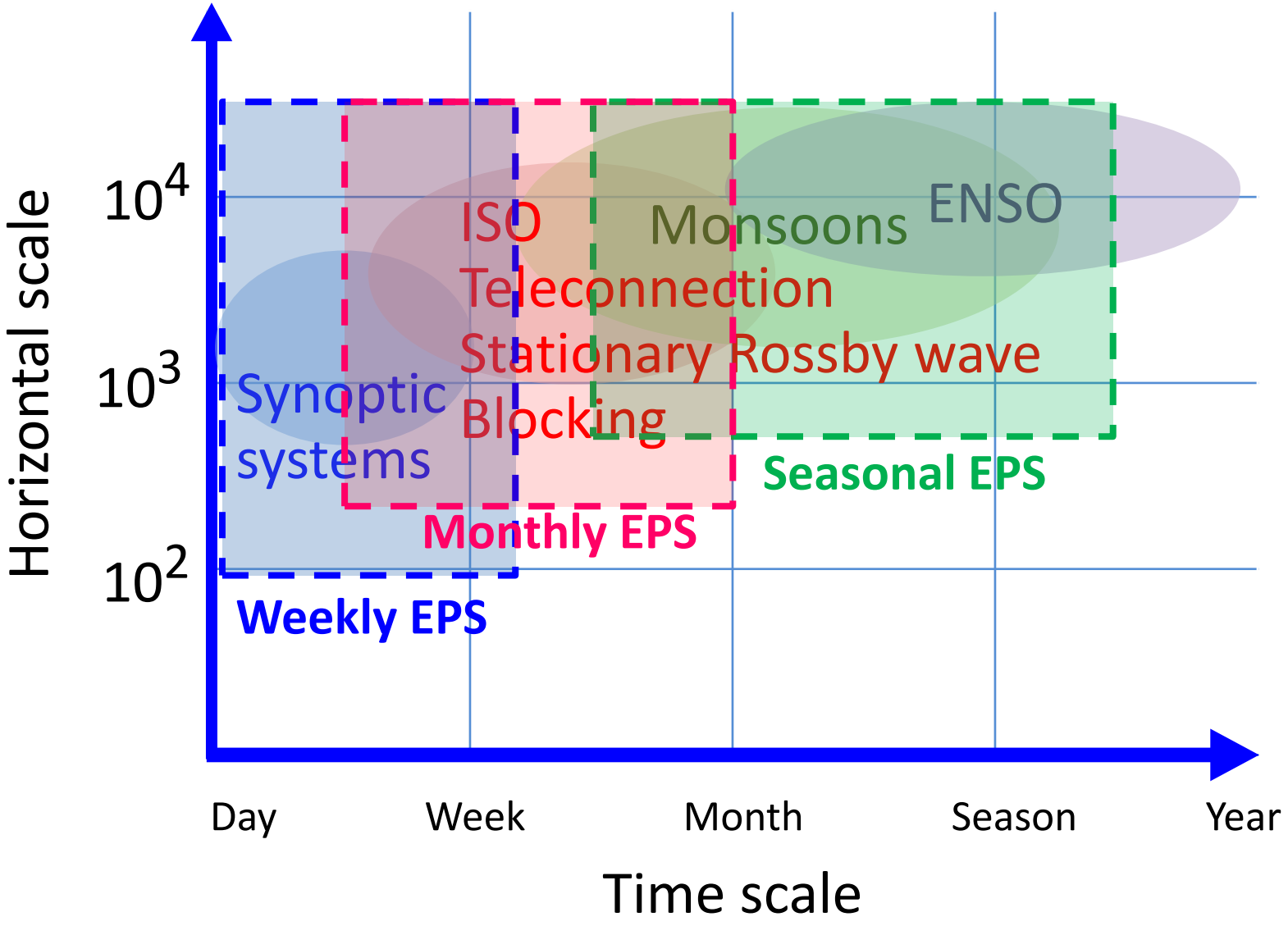
Predictable case
Positive AO phase,
La Nina
Takaya and Minami (2014)

Initial date: 31 Dec. 1988
4-week average of Z500 (5-member ensemble mean)

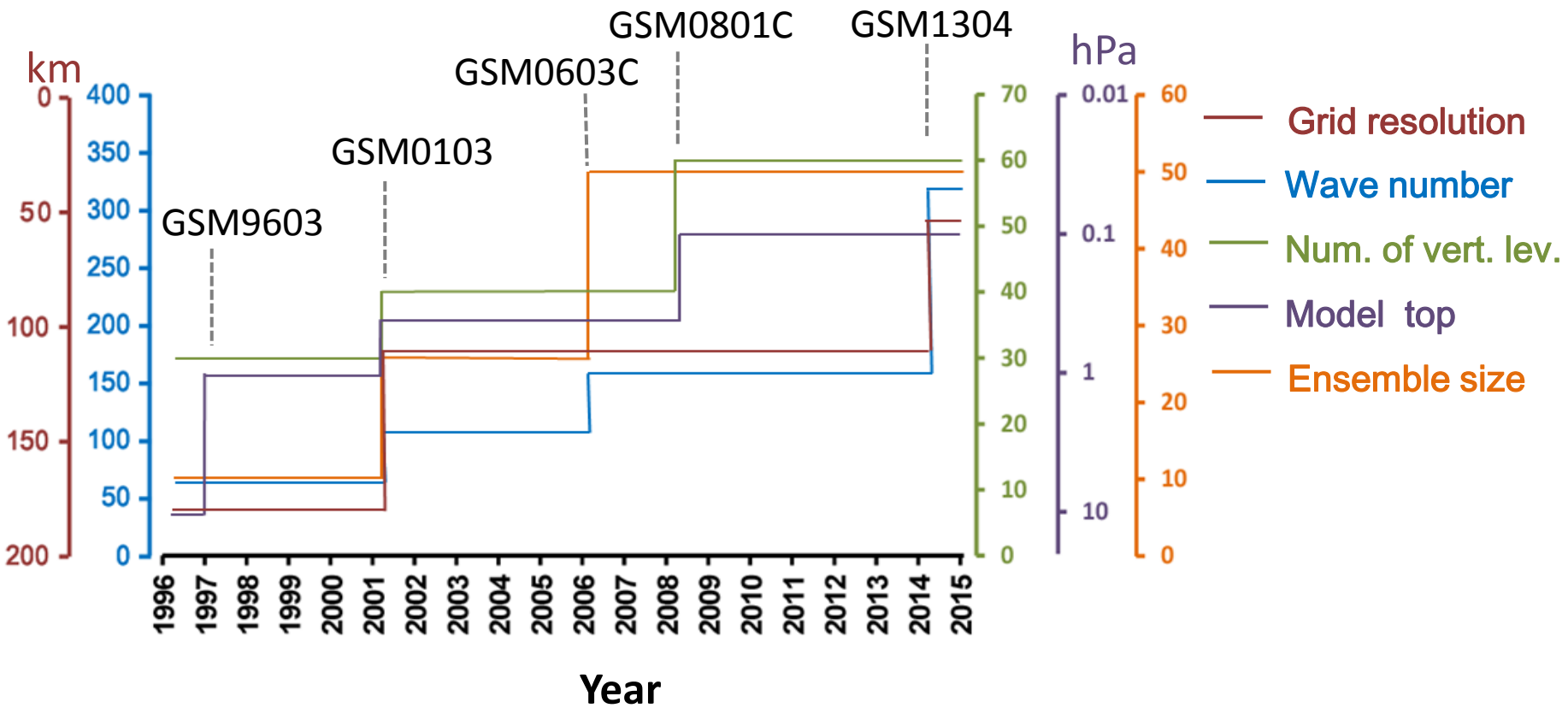
Yamada S., S. Maeda, T. Kudo, T. Iwasaki and T. Tsuyuki (1991) JMSJ

8-member ensemble with using JMA GSM8911

Coverage of EPSs



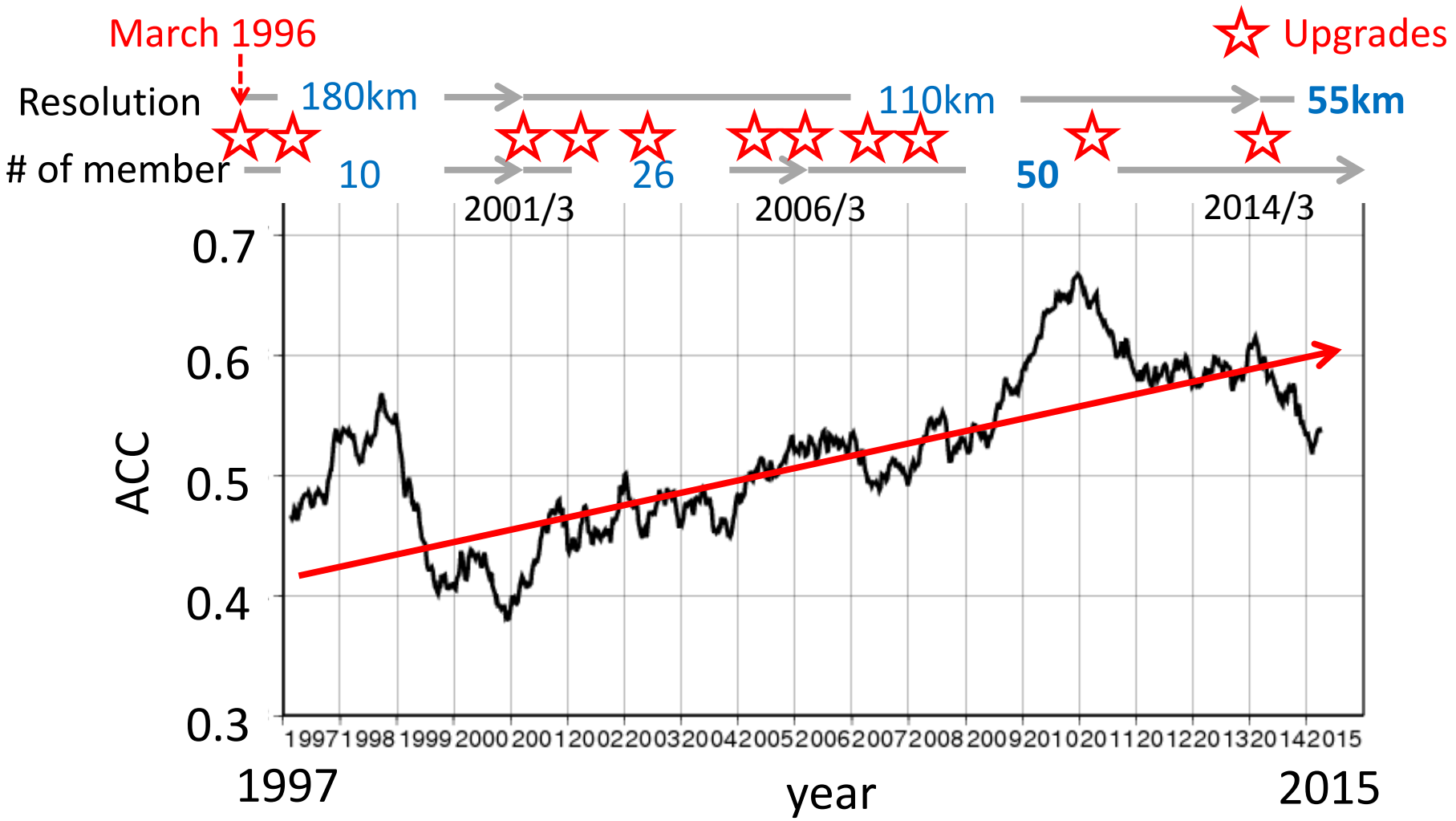
Resolutions of One-month EPS



x3 horizontal resolution, **x1.5** vertical levels, **x5** ensemble size

* Indicates changes with resolution/ensemble size upgrades, only

ACC of NH 500-hPa height



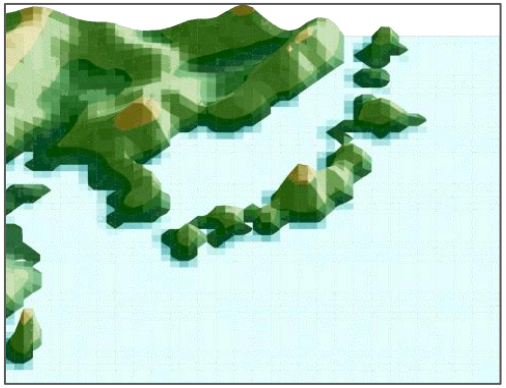
500hPa height ACCs of JMA One-month EPS in NH（20˚N～90˚N）

Scores of 28-day (4-week) average (day2-29) shown, 1-year runnning mean was applied.
(Averages of 1 year before were plotted.)

Specifications of latest system GSM1304

Model version	GSM1304
Horizontal res.	T_L319 (~55km)
Vert. level	60 levels (top 0.1hPa)
Forecast length	34 days
Atmospheric I.C.	JMA global analysis (4D Var)
Land I.C.	Off-line land analysis
SST	Persisted anomaly
Sea Ice	Statistically prescribed
Ensemble generation	BGM method (TRP+ NH) ＋Stochastic physics ＋LAF (1 day)
Ensemble size	50 (25 × 2 initial dates)
Frequency	Once a week (Tue. Wed.)

Orography and grid of GSM1304

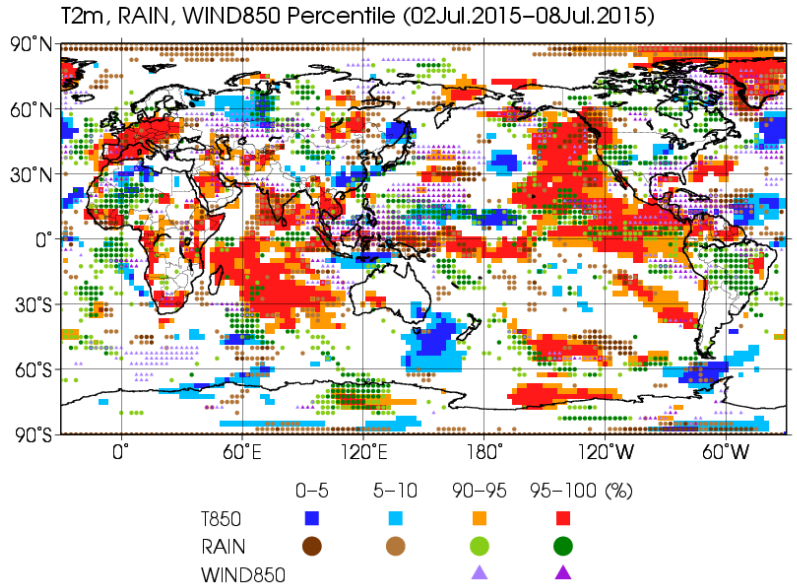


Sub-seasonal extreme weather prediction

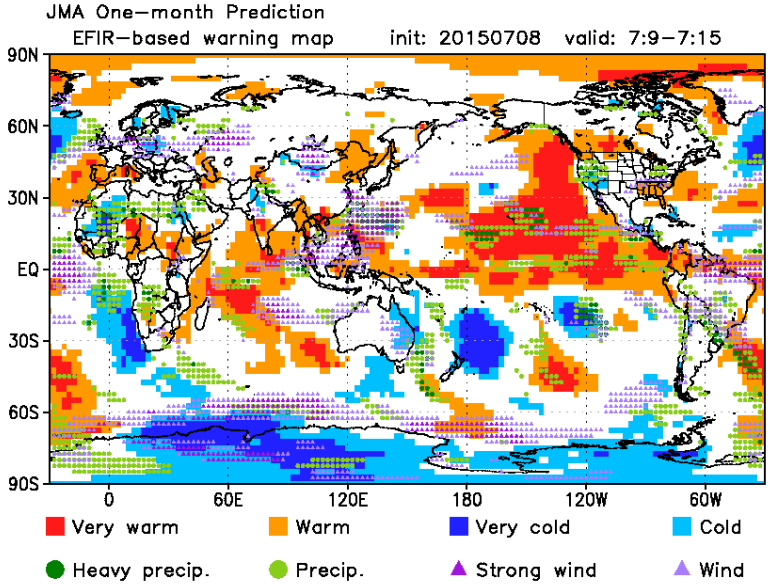
Monitoring and Forecasting extreme weather

Both monitoring and forecasting extreme weather enforce better climate services.

Monitoring (past)



Prediction (future)



Seamless information for disaster preparedness

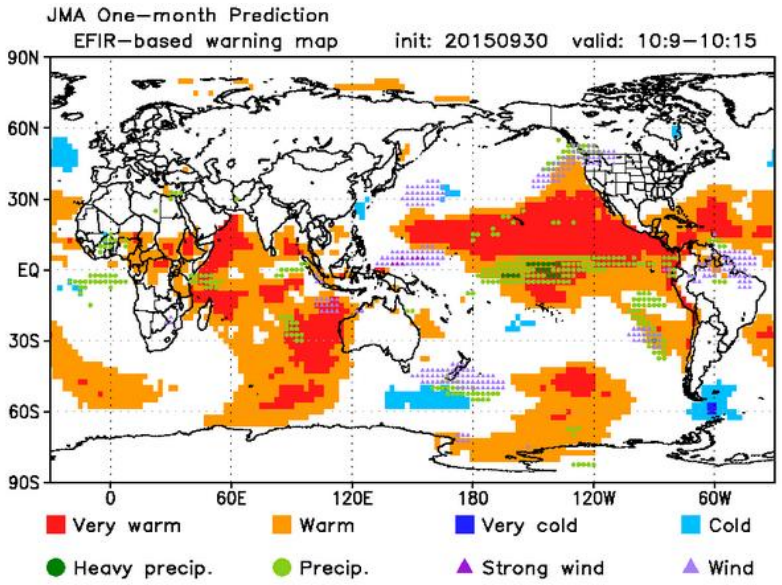
→ Analysis-prediction

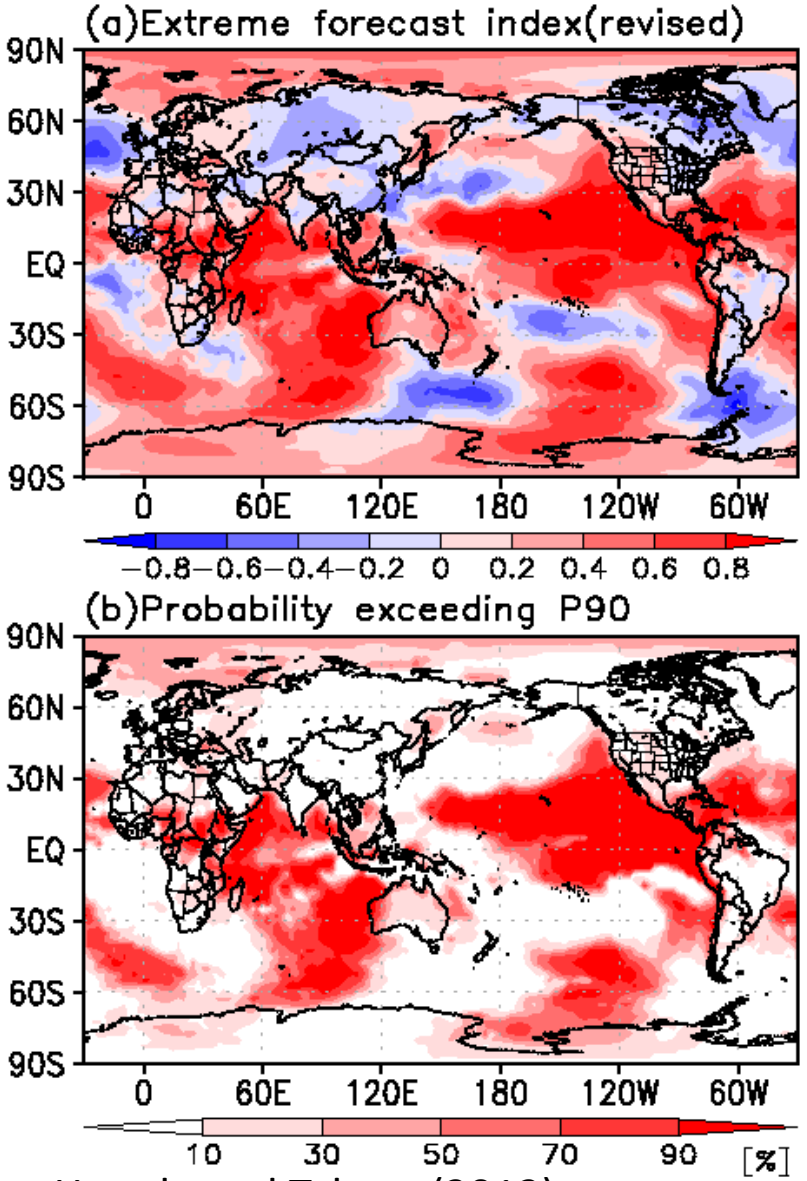
Forecast products in support of early warnings for extreme weather events

(a) Extreme Forecast Index (EFI) maps

(b) Probability (>90%, <10%)

(c) Warning map (EFI>0.8)





Access is allowed for RCCs, NMHSs, RCOFs,

http://ds.data.jma.go.jp/tcc/tcc/products/model/index.html

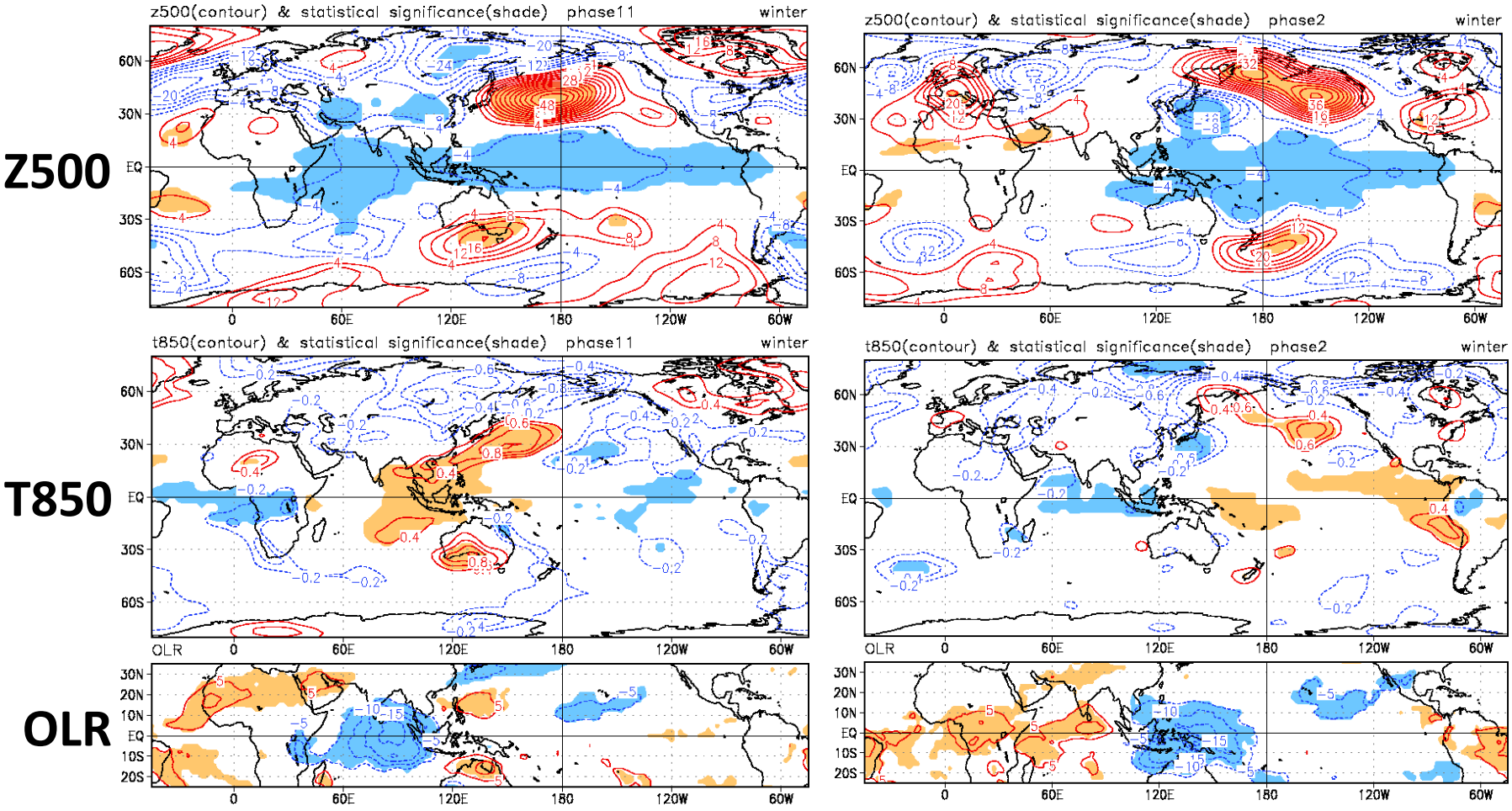
Harada and Takaya (2012) WGNE Blue book

Sources of the predictability for extreme weather events

- Quasi-stationary Rossby wave
- Blockings
- Tropical influence via teleconnections (e.g., ENSO, MJO etc.)
- Land, Stratosphere, Sea-ice…

Review: MJO and extratropics

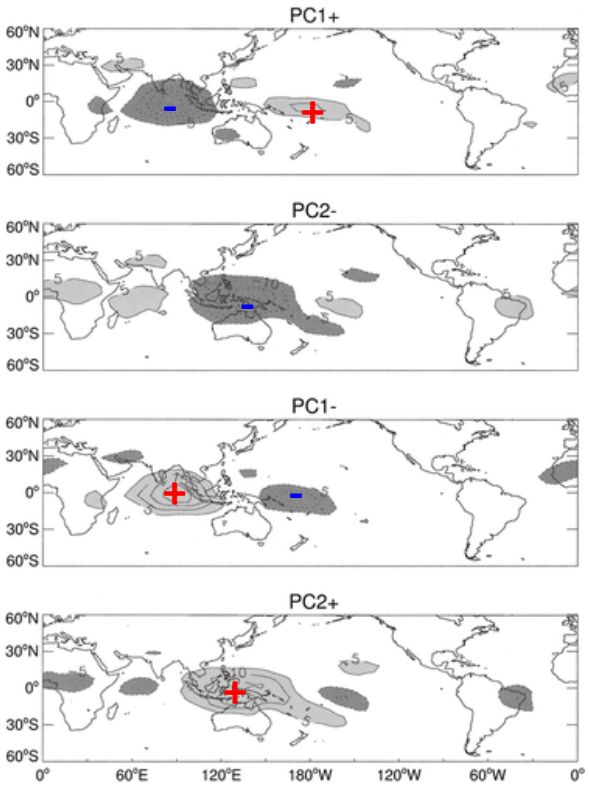
- MJO influences extratropical circulations and weather.



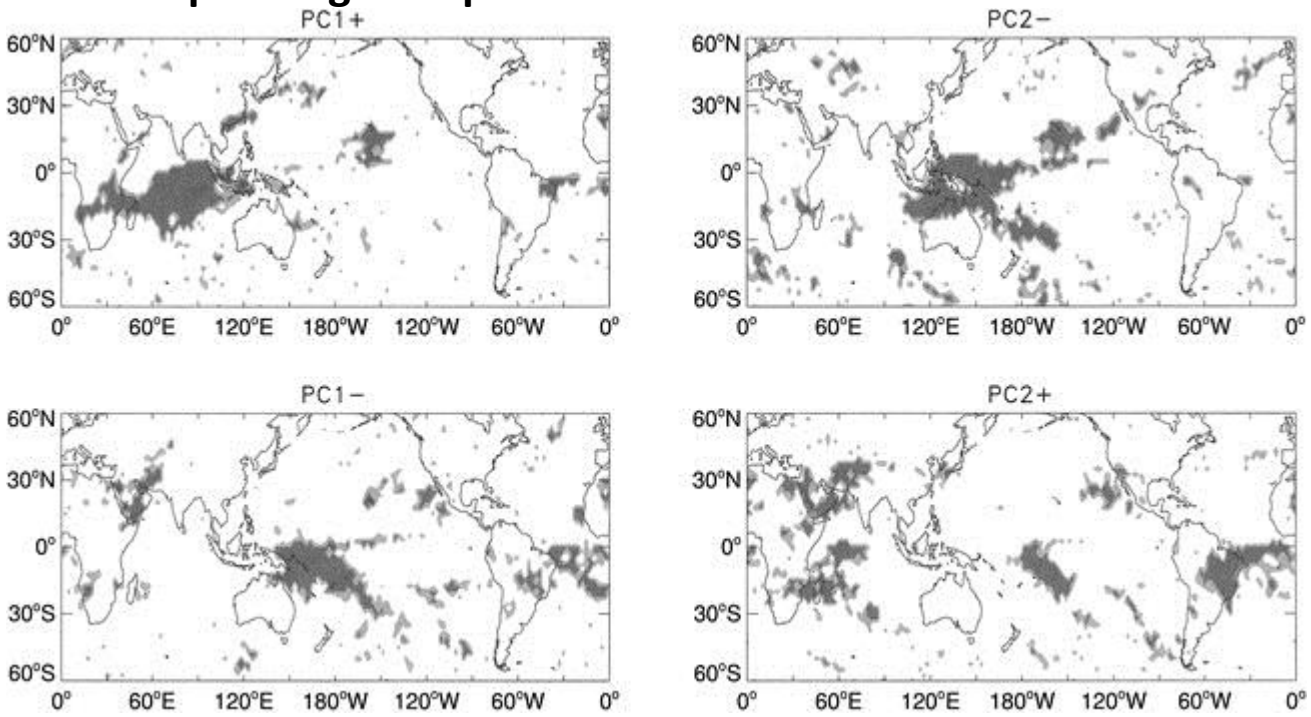
Endo and Harada (2008) Tenki in Japanese

Extreme precipitation events and MJO

Composites of 20–90-day OLR anomalies



Regions where extreme precipitation is more frequent in the Corresponding MJO phases



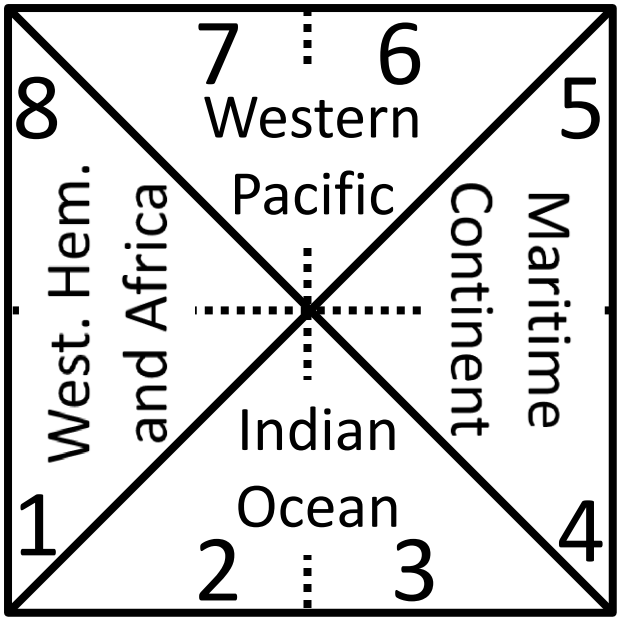
Light (heavy) shading indicates regions statistically significant at the 90% (95%) level

The extreme event was defined as when the GPCP pentad precipitation exceeds the 75th percentile of the gamma pdf

Jones et al. (2004) J. Clim.

Extreme temperature and MJO

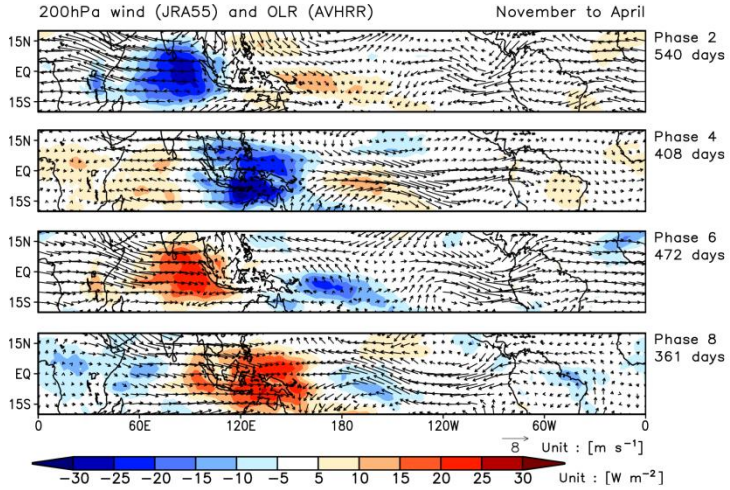
- An extreme event is defined as occurring when 7-day mean analysis field exceeds or falls below the 95th or 5th climatological percentiles estimated from the period 1981 to 2010.
- The MJO index is computed from OLR and zonal wind (U850 and U200) daily data, following Wheeler and Hendon (2004).
- Analysis data is from JRA-55 (Kobayashi et al. 2014), except for OLR data from NOAA (Liebmann and Smith 1996).



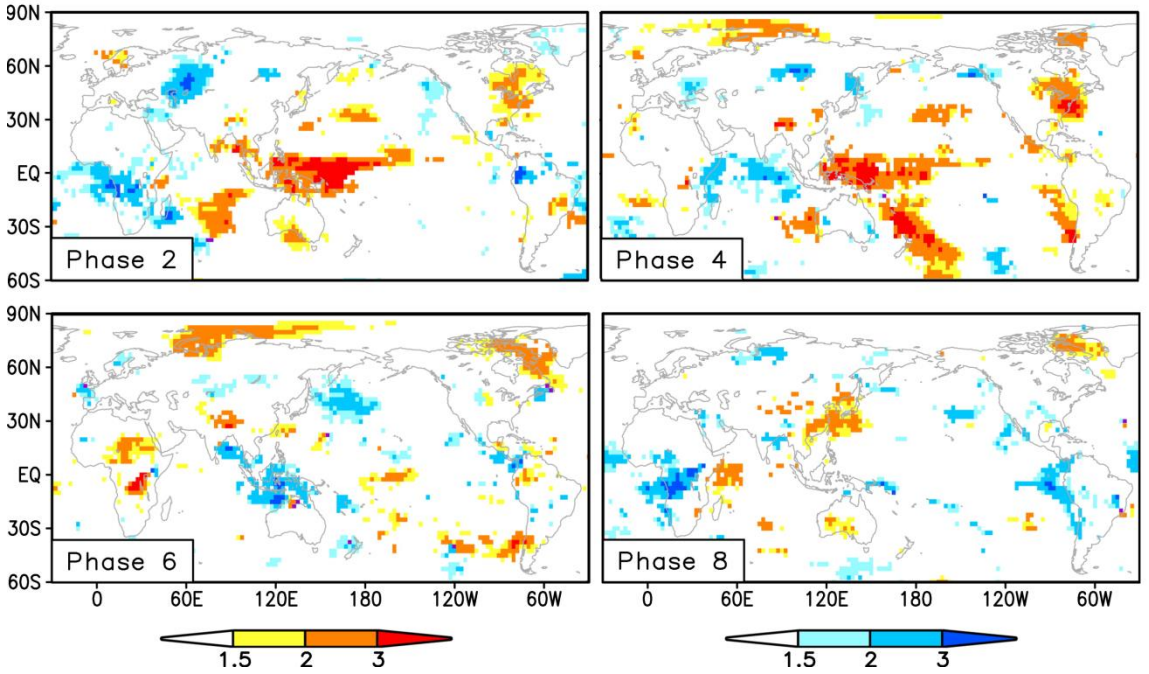
Matsueda and Takaya (2015) J. Clim.

Extreme temperature events and MJO

Composites of OLR and 200-hPa wind anomalies



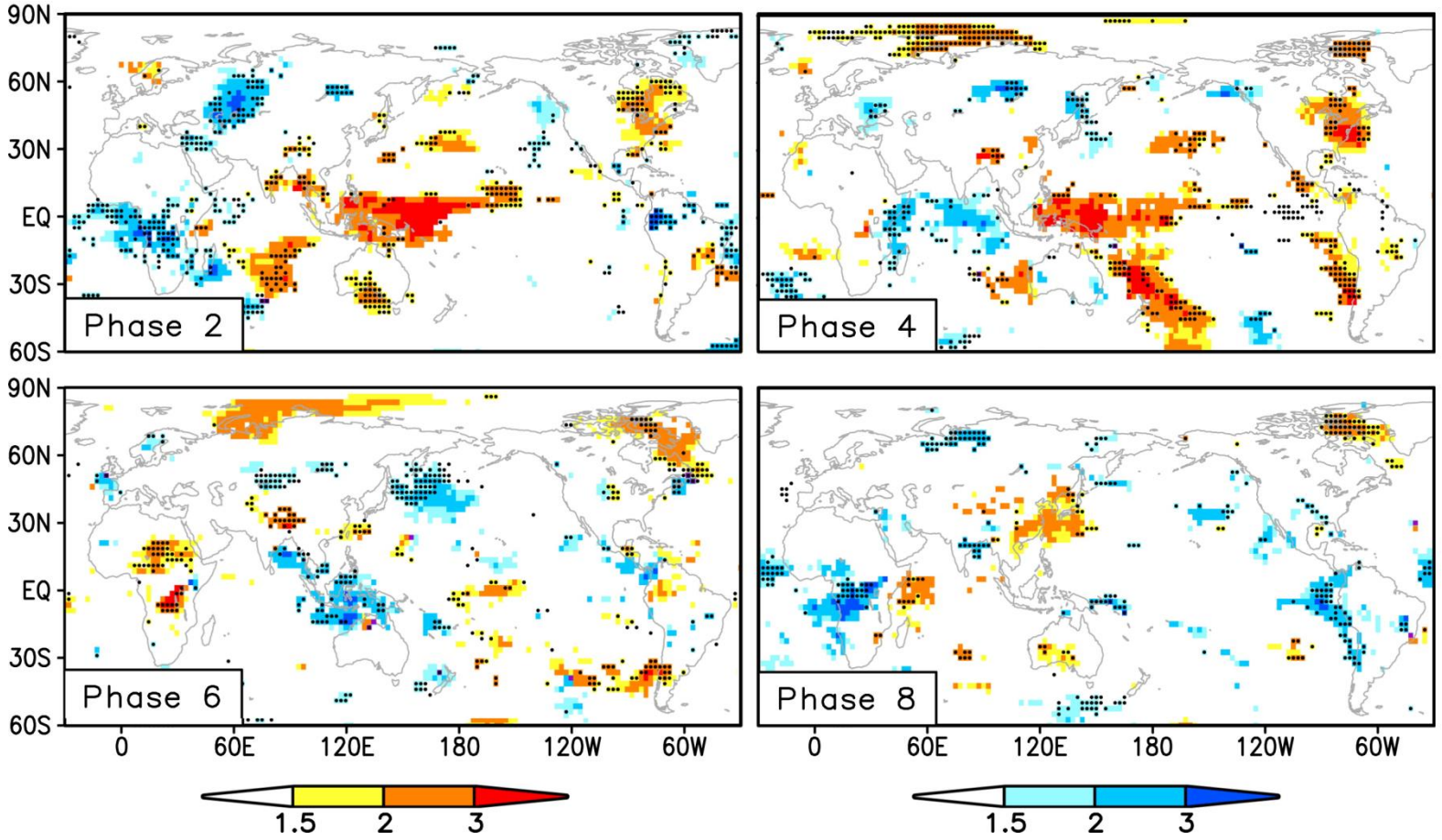
Ratios of the occurrence frequency of T850 extreme warm and cold events following active MJOs to those following inactive MJOs with a 3–9-day lag.



The ratios are plotted only in areas where the frequency increases following active MJOs were significant at the 95% confidence level.

Matsueda and Takaya (2015) J. Clim.

Predictive skill of EWE, ECE and its relation to MJO



Black dots indicate where the forecast skill (hit rate) of T850 extreme warm or cold events with a lead time of 8 days during the active MJOs **was better than it was during inactive MJOs (no significance test).**

Summary

- JMA One-month EPS has been improved in the last 2 decades.
- JMA provides operational sub-seasonal (One-month) prediction and some special products in support of early warnings for extreme weather events.
- Relationship between MJO and extreme temperature events are shortly reviewed.
- MJO is a source of the predictability for extreme weather events.
- Improvement of representations of MJO in the JMA model may result in better predictions of extreme events.