Seasonal Forecast System of Japan Meteorological Agency: Physical Basis of Seasonal Forecasting in the Asian Region

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Introduction

Seasonal forecasting in the Asian monsoon remains one of the most demanding tasks. Climate in Asia is influenced by ENSO and the Asian monsoon. Therefore it is vital to better predict these two major variabilities for seasonal forecasting in this area. The advent of atmosphere-ocean coupled seasonal forecast models has significantly improved forecast skill in the Asian region. The Japan Meteorological Agency (JMA) and the Meteorological Research Institute (MRI) developed an atmosphere-ocean coupled seasonal forecast system (Yasuda et al. 2007). The system has been in operational use for seasonal forecasting at the JMA since February 2010. In this presentation, the physical basis of the seasonal forecast in Asia is presented using a full set of hindcasts and real-time forecasts.

JMA seasonal forecast system (2010.2-present)

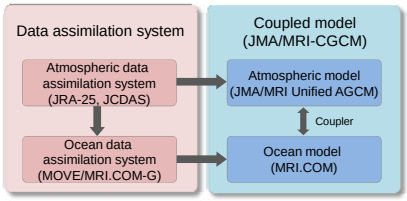

Fig. 1 Schematic of JMA seasonal forecast system

The new JMA seasonal forecast system consists of an atmosphere-ocean coupled model and atmosphere/ocean data assimilation systems. Details are listed in the right tables (Tabs. 1 and 2).

Operational setups of real-time forecasts are illustrated in Fig. 2. JMA issues the seasonal forecast based on its 50-member ensemble forecast. Hindcasts were carried out for the sufficiently long period (1979-2008, 30 years) to verify the forecast skill and to calibrate its real-time forecasts. The real-time forecasts and verification are available at JMA web site: http://ds.data.jma.go.jp/tcc/tcc/products/model/.

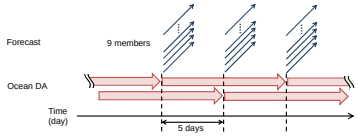

Fig. 2 Schedule of the operational forecast system

Tab. 1 Data assimilation and initial perturbations

Atmosphere DA	JRA-25/JCDAS Onogi *et al.* 2007
Ocean DA	MOVE-MRI.COM /G Usui *et al.* (2006) 75S-75N, 0-360E resolution: 1° × 0.3-1° 50 levels (23 levels in the upper 200m)
Initial Perturbation	Bred Vectors for extratropics and tropics (Chikamoto et al. 2007). Ensemble ocean data assimilation with atmospheric perturbations.

Tab. 2 Coupled model (JMA/MRI-CGCM)

AGCM	JMA/MRI Unified AGCM resolution: T_L95L40 (~ 180km)
OGCM	MRI.COM Tsujino *et al.* (2009) 75S-75N, 0-360E resolution: 1° × 0.3-1° 50 levels (23 levels in the upper 200 m)
Coupler	coupling interval : 1 hour Flux adjustment for heat and momentum fluxes

See also Yasuda *et al.* (2007), Takaya *et al.* (2010)

Link between East Asian climate and the western North Pacific

The relationship between conditions (e.g., precipitation, circulations, sea surface temperature) in the western North Pacific and East Asia is of special importance in predicting East Asian climate. In particular, the teleconnection between convective activity in the Western North Pacific and the circulation in East Asia is corroborative for the predictability in East Asia (e.g., Kosaka and Nakamura, 2008; Kosaka and Nakamura 2009; Nitta 1987; Sun et al. 2010).

It was reported that state-of-the-art coupled models can represent aforementioned major variability in East Asia (Chowdary et al. 2010). The full set of hindcasts with the JMA seasonal forecast system shows significantly higher skill in predicting the major variability than an old system using an atmospheric model (Yasuda et al. 2007). This suggests that superior ability of coupled models in predicting the East Asian monsoon system. The reason is that couple models would be able to well predict the Asian Monsoon variability, which is essentially an atmosphere-ocean coupled system through the air-sea interaction and influenced by remote conditions such as the Indian Ocean and tropical Pacific and even tropical Atlantic. Furthermore the feasibility of prediction of convective activity in the Western North Pacific support the feasibility of the typhoon potential forecast on a seasonal time scale (Takaya et al. 2010).

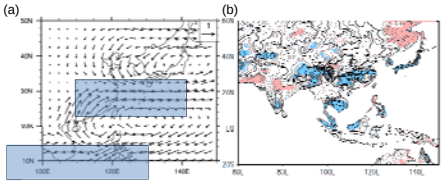

Fig. 3 Major mode in East Asia
(a) 850-hPa wind. Boxes show areas for Wang and Fang Index (U850 (5-15N,90-130E) – U850 (22.5-32.5N,110-140E)).
(b) Correlation between the major mode and precipitation. Ligh blue (pink) shadings indicate much (less) precipitation corresponding to the major mode.
Figures from Sun et al. (2010).

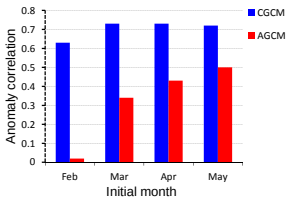

Fig. 4 Anomaly correlations of Wang and Fan (1999) index.
The 3-month mean Wang and Fan indices of forecasts starting from February to March during 1979-2004 are verified. The graph shows scores of current foreacast system (blue) and an old system with an atmospheric model (red).

Presented at the WCRP Open Science Conference, Denver, USA, 24-28 October 2011

Summary

The outline of the JMA operational seasonal forecast system was presented. Introduction of the atmosphere-ocean coupled model offers significant improvements for the operational seasonal forecast especially for the summer Asian monsoon, which prediction was relatively poor with the old uncoupled atmospheric model. The improvement of the Asian monsoon prediction with the coupled model opened a future for seasonal forecasting in the Asian region.

On the other hand, studies investigating mechanisms of the atmosphere-ocean variability in the Asia were flourished in recent years. These studies revealed that the Indian Ocean and tropical Pacific have substantial contribution to the Asian climate in many ways. The analyses would underpin the capability of the seasonal forecast in the Asian region if these processes are represented well in coupled models.

In summer 2010, the severe conditions including the 2010 Chinese flood and extremely hot summer in Japan happened and massive damage was caused. The JMA system successfully predicted these conditions as well as other operational centers' models, however, the extremely hot condition in Northern Japan was underestimated in the JMA forecast. The new system is now under development in order to ameliorate the forecast skill in the higher latitude.

East Asian forecast for summer 2010

The summer 2010 was affected by extreme conditions including devastating Chinese and Pakistan floods extreme heat wave in Russia, East Asia and North America. The JMA seasonal forecast system relatively well predicted these anomalous conditions as well as other centers' (Fig. 5). The East Asian circulations would be related to suppressed convection influenced by variability of the Indian-Pacific oceans (namely so-called "Indian Capacitor Effect" (Yang et al. 2007, Xie et al. 2009)). A companion poster (Session C25:W70A, Yasuda et al.) discusses mechanisms and contributing factors in detail. This example demonstrates the feasibility of prediction in East Asia with coupled models.

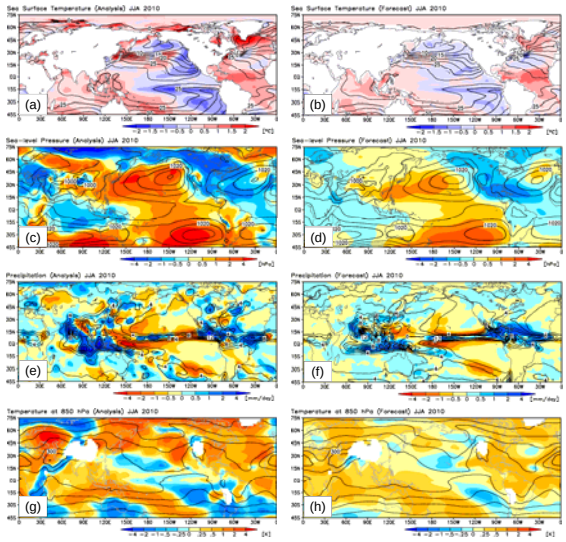

Fig. 5 Analyzed and predicted 3-month mean (Jun.-Aug. 2010) fields

(left) Analyses (a) COBE-SST (Ishii et al. 2005), (c) JRA-25/JCDAS, (e) GPCP V2.2, (g) JRA-25/JCDAS

(right) Predictions with JMA seasonal forecast system started from the end of May.

Shading indicates anomalies from 1979-2004 climatology of the analysis and model.

Plans for next JMA seasonal forecast system

● Upgrades of model resolution and domain
The model resolution of atmospheric model will be upgraded to TL159L60 (~110 km, model top 0.1 hPa) . The ocean model domain will cover the global ocean with 1° × 1-0.5° resolution (tripolar grid).

● Inclusion of dynamical sea-ice model
A dynamical sea-ice model will be tested for the seasonal forecast. Initial conditions for sea-ice are produced in the ocean data assimilation including the sea-ice model by correcting temperature and salinity.

● New physical parameterization scheme
A new cloud overlap scheme (simplified ICA, Collins, 2001), stochastic physics, new sea-surface module including Monin-Obkhov formulation and prognostic skin SST (Takaya et al. 2010) will be planned to be adopted to the new coupled model.

● Other future developments
Future developments required to further improve the JMA seasonal forecast system were discussed at the International Workshop on "Development of Atmosphere-Ocean Coupled Models towards Improvement of Long-Range Forecast", Tokyo, Japan, 8-10 December 2010. Proceedings and presentations can be accessed at : http://www.jma.go.jp/jma/en/Activities/cgcm_2010/cgcm_ws_2010.html.

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