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Prediction of Asian summer monsoon onset using the new JMA global model

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सार – जापान मौसम वैज्ञानिक एजेंसी के नए परिचालन ग्लोबल मॉडल का प्रयोग करते हुए 1979 और 1986 मानसून प्रारम्भ के लिए कुछ प्रागुक्ति प्रयोग किए गए थे। 1988 के प्रारम्भ के लिए परिचालन मॉडल पूर्वानुमान के परिणामों का भी परीक्षण किया गया था। इन पूर्वानुमानों में, पूर्व-प्रारम्भ आरम्भिक स्थितियों से आरम्भ होते वास्तविक दक्षिणी-पश्चिमी मानसून प्रवाह विकसित होते हैं। अधिकतर स्थितियों में सिनॉप्टिक विक्षोभों की रचना और विकास जैसे कि प्रारम्भ भ्रमिल और मानसून अवदाबों की प्रागुक्ति भी इस मॉडल से की गई है। किन्तु इन विक्षोभों की प्रागुक्ति की विशुद्धता प्रत्येक मामले में भिन्न होती है।

ABSTRACT. Using the new JMA operational global model, some prediction experiments were carried out for 1979 and 1986 monsoon onsets. The results of the operational model forecasts for 1988 onset were also examined. In these forecasts, realistic southwesterly monsoon flows developed starting from the pre-onset initial conditions. In most cases, formation and development of synoptic disturbances such as onset vortex and monsoon depressions were also predicted by the model. The accuracy of the prediction of these disturbances, however, varies among the cases.

1. Introduction

There have been many numerical prediction studies of the Asian summer monsoon onset. WGNE selected the 1979 onset as one of the cases for the forecast inter-comparison experiments (Temperton and Krishnamurti *et al.* 1983). Among the seven models participated the experiments, only the FSU model reasonably well reproduced the onset vortex, showing the difficulty of the forecast of monsoon onset. Kershaw (1984) conducted some experiments on the same case and showed the importance of initial analysis. Kershaw (1985) further showed the sensitivity of the prediction of onset vortex to the sea surface temperature of the Arabian Sea. At JMA, Kanamitsu (1982) also took the same case and carried out prediction experiment. In his experiment, global aspects of the monsoon onset were predicted well, while the local aspects such as the formation of onset vortex were not well predicted. More recently, Kuma (1988) studied the 1986 onset, and revealed the important role of the convective heating over the western Pacific region on the development and westward shift of the Tibetan high.

Using the new JMA operational global model, some more prediction experiments were carried out for the 1979 and 1986 onset. In this paper, the results of these experiment are presented and discussed. The results of the operational global model for the 1988 onset period are also discussed.

2. Model and data

In March 1988, JMA's operational prediction models were renewed. The new global model is a spectral model with T_{63} horizontal resolution and 16 vertical levels. Along with the increase of the resolution, all the physical process parameterizations were renewed. By these changes, the new model, compared with the old model, has much stronger radiative cooling more precipitation and more intense tropical circulations. The outline of the new JMA operational global model is shown in Table 1.

JMA Global spectral model

Integration domain : Globe

Horizontal resolution	: Triangular truncation at wave-number 63
Grid	: 96 Gaussian latitudes and 192 longitudes
Vertical levels	: 16
Time integration	: Semi-implicit scheme
Forecast time	: 72 hr for 00 GMT initial, 192 hr for 12 GMT initial
Orography	: Included. Small scale smoothed
Initialization	: Nonlinear normal mode initialization with physics
Earth surface	: Monthly averaged albedo, soil moisture, ice cover specified geographically

Sea surface temperature : Daily analyzed value

Physical parameterizations

(1) Surface exchanges : Louis's scheme for surface fluxes and level 2 closure model for vertical diffusion

(2) Convection : Kuo's scheme and shallow convection

(3) Large scale condensation

(4) Orographic gravity wave drag

(5) Radiation : Long wave cooling and solar heating with interactive cloud. Diurnal variation included

(6) Soil temperature calculated using force restore method

The data used in the experiment for initial condition and verification are the JMA objective analyses. FGGE IIIb data compiled at ECMWF is used for the 1979 onset case. It should be noted here that objective analyses are quite dependent on the forecast models used to produce the first guess field for the optimum interpolation analysis in the data sparse region. As the region of Asian summer monsoon includes the data sparse area such as Indian Ocean and Himalayas, the objective analysis of this region is quite dependent on the forecast model.

3. Experimental results

3.1. *The* 1986 *onset*

(a) *Prediction of Tibetan high*

Kuma (1988) discussed the impotant role of the convective heating over the western Pacific region on the intensification and westward shift of the Tibetan high corresponding to the onset of monsoon. He showed by numerical experiment that the use of the observed heating rate (estimated from satellite cloud temperature) in place of the model forecast convective heating rate significantly improved the forecast of Tibetan high. As the new JMA model has in general much stronger convective activity than the old model, the improvement of the forecast of Tibetan high is expected in the new model and was found to be much better than in the old model forecast. Fig. 1 shows that the forecast precipitation of the new model is close to the observed (estimated from satellite cloud) rain, while the old model significantly underestimated the rain.

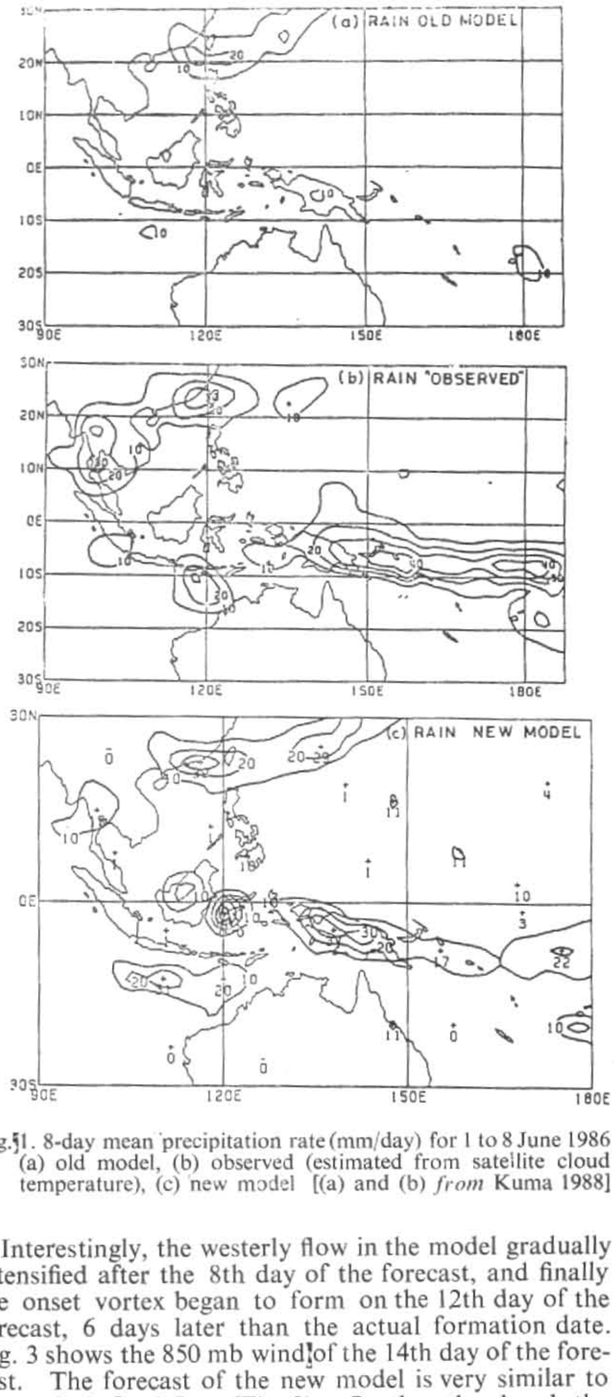

Fig. 1. 8-day mean precipitation rate (mm/day) for 1 to 8 June 1986 (a) old model, (b) observed (estimated from satellite cloud temperature), (c) new model [(a) and (b) *from* Kuma 1988]

(b) *Prediction of low level flows*

Monsoon onset is characterized by the intensification of low level southwesterly flow over the Arabian Sea, and onset vortex often forms on the west coast of India. In 1986 monsoon onset, according to the JMA objective analyses, the onset vortex formed on 7 June. A prediction experiment is carried out starting from the initial field at 12 GMT of 1 June 1986.

As the Tibetan high was predicted by the new model fairly well, the development of the low level monsoon flow was also expected to be predicted well. However, the intensification of the low level southwesterly flow and the fomation of the onset vortex were not properly predicted by the model. Fig. 2 shows the JMA objective analysis of 850 mb wind for 12 GMT of 9 June 1986 and the corresponding 8-day forecast from 1 June. In the forecast, the southwesterly current correctly reached the southern part of India but the wind speed over the Arabian Sea is much less than the observed. The model failed to predict the onset vortex which is clear in the analysis in Fig. 2.

Interestingly, the westerly flow in the model gradually intensified after the 8th day of the forecast, and finally the onset vortex began to form on the 12th day of the forecast, 6 days later than the actual formation date. Fig. 3 shows the 850 mb wind of the 14th day of the forecast. The forecast of the new model is very similar to the analysis for 9 June (Fig. 2). On the other hand, the old model completely failed to reproduce the monsoon flow. It should be noted, however, when we continued the integration of the old model, the southwesterly flow started to intensify at around the 20th day of the forecast, and on the 30th day, the forecast monsoon flow was quite realistic (Fig. 4).

3.2. *The* 1979 *and* 1988 *onsets*

In spite of the improvement of the model, in the 1979 case, the onset vortex was not formed in the forecast, although the intensification of the southwesterly current was reasonably well predicted. A monsoon depression on the 10th day of the forecast was correctly predicted.

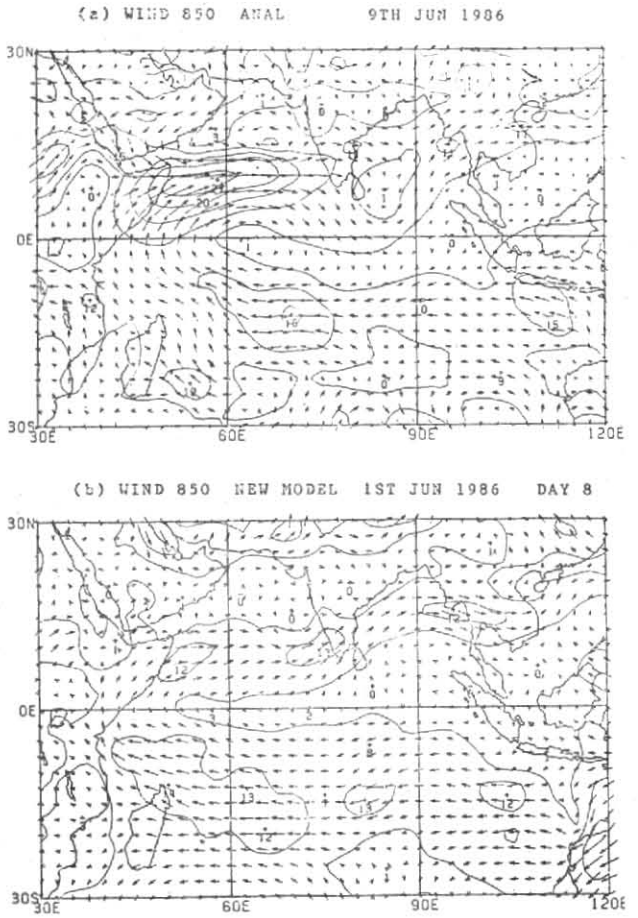

Fig. 2. 850 mb wind field (thin lines denote isotach) for 9 June 1986 (a) Analysis & (b) 8-day forecast from 1 June

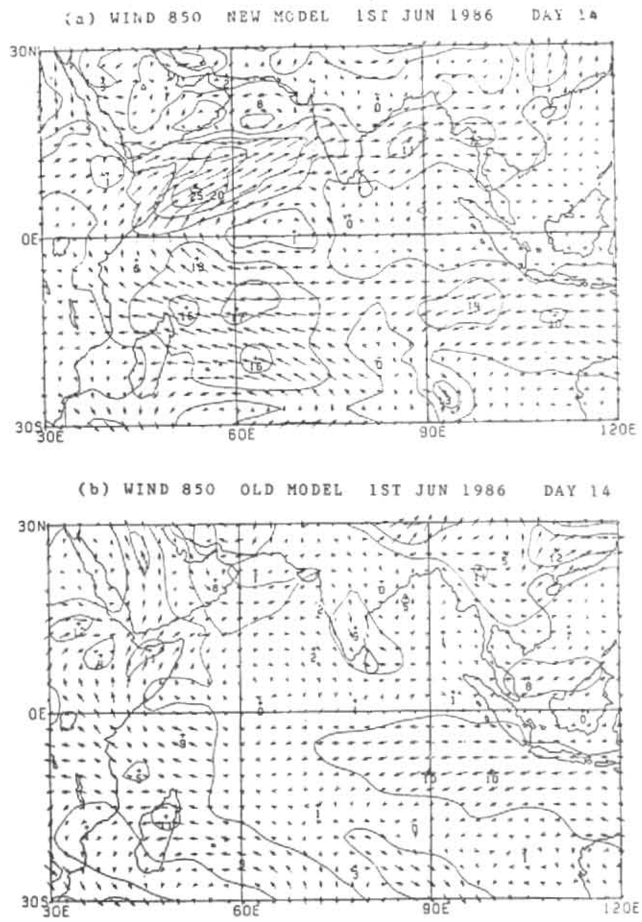

Fig. 3. 850 mb wind field of 14-day forecasts from 1 June 1986 (a) new model and (b) old model

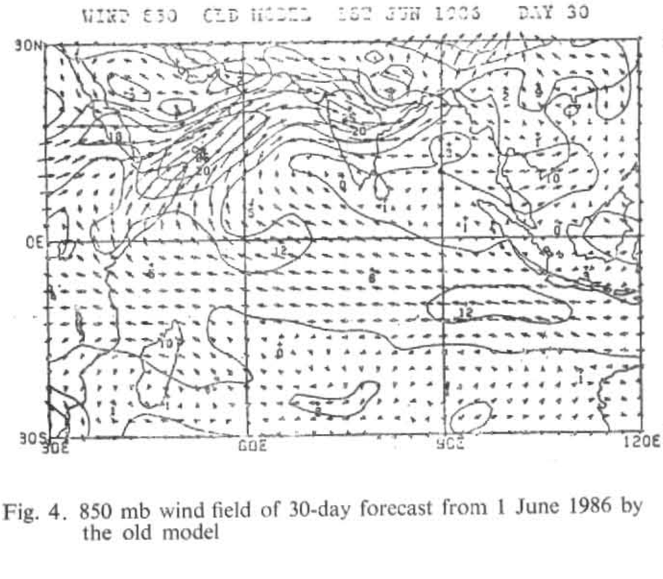

Fig. 4. 850 mb wind field of 30-day forecast from 1 June 1986 by the old model

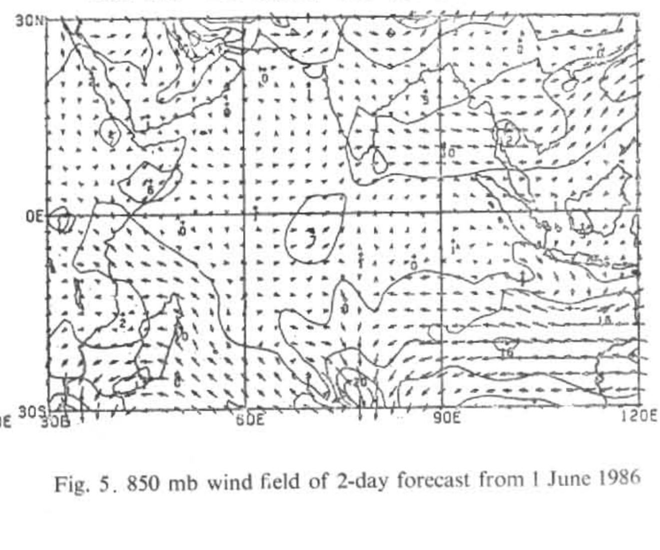

Fig. 5. 850 mb wind field of 2-day forecast from 1 June 1986

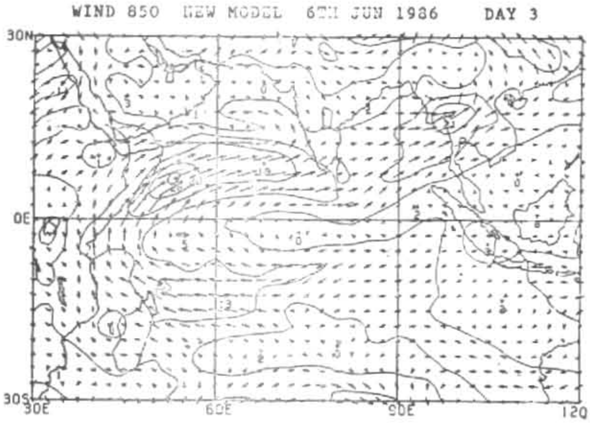

Fig. 6. 850 mb wind field of 3-day forecasts from 6 June 1986 (*see* Fig. 4a for corresponding analysis)

The operational forecasts by the new JMA global model were examined for the 1988 onset period. In 1988, the onset vortex formed on 7 June at the southwest coast of India. On the same day another vortex is located at the north of Bay of Bengal. In the global model forecasts, these vortices were not necessarily predicted well, although the maintenance or the intensification of the southwesterly flows were predicted well. For example, in the 8-day forecast from 4 June, the west coast vortex is correctly predicted to form on 7 June but the Bay of Bengal depression was missing. Later in the forecast, the west coast vortex over-developed and wrongly moved to the east and then north, while the actual vortex moved northnorthwestward. In the case of 15-day forecast from 27 May, single vortex formed on 7 June, on the correct date, but at the wrong place, at the southeast coast of India.

4. Discussion and conclusions

In the 1986 onset case, the forecast onset was delayed as long as 6 days. This delay of the forecast onset could be understood, if we look at the first several days of the forecast. During the first several days of the forecast from 1 June, the southwesterly current over the Arabian Sea significantly weakened, while the initial strength was maintained in the analyses. Fig. 5 shows the 850 mb wind field of the 2nd day of the forecast. There is almost no flow over the Arabian Sea. If there were not this initial stage deterioration of the forecast, the onset vortex might have been predicted at correct time. Indeed, in the forecast from 6 June 1988, there was no initial weakening of the southwesterly flow and the onset vortex was correctly formed on the first day of the forecast. Subsequent development and northwestward movement were correctly predicted up to 9 June (Fig. 6), although further development and westward movement beyond 9 June were not predicted well.

The quality of the initial analysis was suspected as the reason for the weakening of the southwesterly flow, since the JMA analysis used for the experiment is dependent on the old model. To examine this possibility, analysis-forecast cycle was performed using the new model for 10 days starting from 22 May 1986. The reanalyzed initial field of 850 mb wind is shown in Fig. 1(b). In the forecast starting from the new analysis, the onset vortex formed on the 9th day of the forecast, 3 days earlier than the forecast from the old analysis but still 3 days later than the actual formation date. The initial weakening of the southwesterly flow, however, was not improved by the reanalysis.

The reason for the weakening of the southwesterly flow in the forecast from 1 June 1986 is not yet clear at present. No initial weakening of the southwesterly flows was experienced in the other cases. Pearce and Mohanty (1984) pointed out that the onset period consists of two phases : (1) a moisture build up over the Arabian Sea and (2) a rapid intensification of the Arabian Sea winds. According to them, during the first phase of onset, the heating due to subsidence of the air over the continental region between Egypt and the west coast of India is important for the establishment and maintenance of the Somali jet. The weakening of the southwesterly flow in the forecast from 1 June 1986 may be linked to this process of maintenance of Somali jet.

According to the results of the experimental forecasts for the 1979 and 1986 onsets and the operational forecasts for the 1988 onset, the JMA new global model is capable of developing realistic monsoon flows starting from pre-onset initial conditions. Realistic synoptic disturbances such as onset vortices and monsoon depressions are also predicted by the model, but the accuracy of the prediction varies among the cases. Realistic monsoon flows were simulated by GCMs more than several years ago (*e.g.*, Gilchrist 1981). However, the prediction of the onset of monsoon seems to be a different matter. Krishnamurti and Ramanathan (1982) showed by numerical experiment that the rapid intensification of the southwesterly monsoon flow in the model occurs when a post-onset field of differential heating is used. In the real atmosphere, however, at some time during the period of onset, there should be a transition from pre-onset heating to post-onset heating, and once the post onset type heating starts it should develop rapidly by some positive feedback process involving latent heat release. The key to the prediction of onset, therefore, may be the prediction of this transition and probably more accurate prediction of synoptic scale disturbances is needed. Further improvement of the model and initial data is necessary, particularly the improvement of observation seems to be essential.

References

Gilchrist, A., 1981, Simulation of Asian summer monsoon by an 11-layer general circulation model, *Monsoon Dynamics*, M.J. Lighthill and R.P. Pearce, (Eds.), Cambridge University Press.

Kanamitsu, M., 1982, Numerical forecast of the onset of summer monsoon. Regional Scientific Conf. on Tropical Met. Tsukuba, Japan, 18-22 October 1982.

Kershaw, R., 1984, Numerical experimentation at U. K. Met. Office—Forecast and analysis of the onset of the southwest monsoon, GARP Special Rep. No. 44, IV 60-77.

Kershaw, R., 1985, Onset of southwest monsoon and sea-surface temperature anomalies in the Arabian Sea, *Nature*, **315**, 561-563.

Krishnamurti, T.N. and Ramanathan, Y., 1982, Sensitivity of the monsoon onset to differential heating, *J. atmos. Sci.*, **39**, 1290-1306.

Kuma, K., 1988, The role of equatorial heat sources in the western Pacific Ocean on the onset of the Asian summer monsoons of 1986, *J. met. Soc. Japan*, **66**, 399-417.

Pearce, R.P. and Mohanty, U.C., 1984, Onset of the Asian summer monsoon 1979-82, *J. atmos. Sci.*, **41**, 1620-1639.

Temperton, C., Krishnamurti, T.N., Pasch, R. and Kitade, T., 1983, WGNE Forecast Comparison Experiments, WCRP Rep. No. 6.