Southwest and Northeast Monsoon Season of India During 2004 as Seen by JRA25 and the General Circulation Model 'T80'

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INTRODUCTION

The Indian summer monsoon of the year 2004 was intriguing. All the three phases of the monsoon, namely the onset phase, the established phase and the withdrawal phase, were considerably different from long-term averages. Most noteworthy feature of 2004 is the recent case of abnormally low Indian monsoon rainfall. Here we present the evolution of some of the important circulation features associated with the Indian summer monsoon and explore the various relationships between anomalies by using two atmospheric general circulation models of different resolutions. The findings of this paper with respect to this monsoon are related to: early onset, prolonged stagnation in the advancement, the deficient mean July rainfall, the model prediction capability of the mid-latitude westerly, movement of few synoptic systems, seasonal mean rainfall, the strength of the cross equatorial flow, delay in the withdrawal phase etc., The correlation coefficient between the analysis and prediction of the models are also computed separately. In India the period of October to December is referred to as post-monsoon season. In total, the post-monsoon season rainfall was normal in the year 2004. In this post-monsoon season the intense cyclo-genesis over the Indian seas was very much subdued. Another noteworthy feature is that no cyclone had landfall as all of them weakened over the sea itself. Is the normal (scanty) northeast monsoon is followed by normal (scanty) southwest monsoon and/or vice versa?

Through various monsoonal projects, our understanding of the Indian monsoon has substantially improved. However, research from these projects also reveals that the inter-annual, seasonal and/or daily forecasts of monsoon rainfall is still not satisfactory, and unpredicted floods and/or droughts occur in many places year after year in the Indian monsoon region. Recently the Coordinated Enhanced Observing Period (CEOP) an element of the world climate research programme has provided this opportunity to study the energy and water cycle over this monsoonal region. The most important weather events during the CEOP's Enhanced Observing Period-4 (EOP-4), extending from 01 October 2003 to 31 December 2004, is the Indian boreal summer monsoon and Indian winter monsoon. The prime CEOP scientific objective (Koike, 2004, 2006) is quote as "to document the seasonal march of the monsoon systems, assess their driving mechanisms, and investigate their possible physical connections"

For this study, the global general circulation models with the resolutions of (i) Triangular truncation with 80 waves in horizontal and 18 Layers (sigma) in vertical denoted as 'T80L18', and (ii) Triangular truncation with 106 waves in horizontal and 40 Layers in vertical denoted as 'T106L40'/JRA25 are used.

ONSET OF SOUTHWEST MONSOON

The arrival of the summer monsoon over the Kerala coast is found to be reasonably punctual. In this year, the onset occurred over south Kerala as a week current on 18 May, about two weeks ahead of the long term mean date (Taniguchi K et al 2006) 01 June. Does this early onset of monsoon provide any clue to the subsequent rainfall (Dhar et al, 1980) during the monsoon season? The present study gives no clue. The progress of the monsoon was, however, slow and after two periods of prolonged stagnation, monsoon current covered the whole of the country by 18 July, thus taking about two months from onset over Kerala instead of the usual one month period from 01 June.

BREAK CONDITION

Weak zonal flow in the westerly indicates movement of troughs through the area under consideration. Such a trough, when weak or moderate in strength and not followed by another within a short time, may lead to increase in rainfall over northwest India. Incursion of an intense trough, or repeated incursions of weak to moderate troughs, often leads to the 'break in monsoon' with shift of the monsoon trough to the foothills of the Himalayas accompanied by heavy rainfall there and an increase in rainfall over the peninsula.

THE STRENGTH OF CROSS-EQUATORIAL FLOW

During summer the mean angle at which the Sun ray reaches the surface of the earth is small and near the perpendicular incidence leads to large value of insolation and higher surface temperature. Since air expands at higher temperature, there is transport of mass from the warmer summer hemisphere to the cooler winter hemisphere and the mean surface pressure decreases (increases) over the summer (winter) hemisphere. The mass transport, however, is not unidirectional throughout the troposphere. Near the surface, air flows into the summer hemisphere across the equator in response to the lowering of the mean surface pressure in that hemisphere. This winter to summer hemispheric transport of mass is more than compensated by the reverse transport at higher levels, especially in the upper troposphere where anticyclone develops due to presence of warmer air present at the lower levels. A reverse Hadley cell develops as the low level flow moving towards the summer pole lifts up over the monsoon regime and connects with the upper airflow moving towards equator where it sinks to complete the full circuit. The mean meridional wind speed is taken as an indictor of the cross-equatorial flow over the Arabian Sea. It is noted that in 2004 the cross-equatorial flow had already established at the beginning of June starting probably sometime in May. It remains almost steady in the mean till the end of August and decreases in magnitude thereafter. Magnitudes of the cross-equatorial flow in the observed and forecasts are similar except in September when the cross-equatorial flow is weakened in the model T80L18.

LOCATION AND STRENGTH OF THE TIBETAN HIGH

The Tibetan plateau with an average elevation of 4 km above the mean sea level is the most prominent terrain influencing the Asian monsoon system in general, exerting dominating influence over the Indian summer monsoon system. The CEOP community (Koike.T 2004, 2006) has collected a wealth of information over this area form 01 October 2001 to 31 December 2004 using their different mechanisms of data collection procedure. With the arrival of the summer monsoon over India, an anticyclone is established over the Tibetan plateau at the upper troposphere, being most prominent at the 200 hPa level. This anticyclone in the wind field or high in the geo-potential field migrates from the Indonesian area where it returns after the summer monsoon season comes to an end over India.

The anticyclone over Tibet in the upper troposphere is the result of heating in the atmospheric layer between the plateau and the 300 hPa level. The reason for the heating is different for the eastern part of the plateau where convection releases diabatic heating below 300 hPa and the western part of the plateau where excess insolation reaching the elevated land surface produces sensible heating near the surface. This difference in mechanism of heating – sensible versus latent, is due to the fact that the western part of Tibet, along with the adjacent (Leh) part of the Jammu and Kashmir in India, is actually very dry as all the moisture carried by the westerly winds precipitates over the windward side of the various mountain ranges to the west of this region. The eastern region of Tibet gets moisture from the Bay of Bengal carried by the southerly winds passing through north-south oriented mountain ranges at the extreme end of the northeast India.

The location of the Tibetan high is also important as occasionally the centre of the anticyclone shifts, mainly along a east-west direction, thus shifting the region of upward and downward motions from east to west or vice versa. Prolonged residence of the Tibetan high to the west of its usual position may indicate deficit precipitation over the eastern India and the central plains. In the seasonal average there are two centers of Tibetan high located climatologically near 65°E and 85°E as seen by JRA25 datasets.

LOW LEVEL FLOW

Experiments with numerical models (Xue et al, 2003) have shown that with the intensification of Mascerene high, the Somali Low-Level Westerly Jet (LLWJ) is significantly enhanced together with the summer monsoon circulation in the tropical Asia. In fact the strengthening of the Somali LLWJ is taken to be an indicator of enhanced rainfall over the west coast of India. The LLWJ, however, is not only affected by the flux of air from the southern hemisphere but also by the land-sea temperature contrast near the Somali coast.

PRECIPITATION

The India Meteorological Department (IMD, 2004, 2005) prepares a special monsoon bulletin for each day of the monsoon season and posts it in real time in its website. There is considerable inter-annual variability in all phases of Indian summer monsoon but for rainfall statistics the IMD will declare the monsoon season (Basu, 2005) to have fixed duration of 122 days from 01 June to 30 September irrespective of their onset dates. This bulletin includes all rainfall observations of amounts more than 1 cm and received in real time. For this study these observations are used. During the monsoon season of 2004, both July and August recorded below normal rainfall except for the weeks ending on 4 to 11 August 2004. The direst July 2004 is clearly recorded here.

To provide the most temporally extensive estimates of atmospheric hydrologic fields, the NCEP/NCAR reanalysis (Kalnay et al, 1996, Kistler et al, 2001) is used for this study The NCEP reanalysis precipitation is referred for verification of T80L18, T106L40 models predicted precipitation for the monsoon season of 2004. The NCEP precipitation is the best near real time observation available to the authors at the time of this study. From this study it is concluded that the areas that received more than 100 cm of rain during the season are the west coast strip in the windward side of the north-south oriented hill ranges (Western Ghats), the extreme north-eastern part of the country and a region in the east adjoining the Bay of Bengal.

The first two of the above three regions, receive large amounts of seasonal total rainfall due to the barrier effect of topography seen by the T106L40, while the third one receive large amount of rain due to the dynamical effect of the monsoon trough that leads to periodic cyclogenesis over the Bay of Bengal and associated convergence of moist air from the sea.

SALIENT FEATURES OF POST-MONSOON SEASON

The post-monsoon season is the major period of rainfall activity over south peninsula, particularly in the Andhra Pradesh, Rayalaseema, Tamilnadu and Pondicherry. In the Indian context this post-monsoon season is some times named as northeast monsoon or retreating monsoon or winter monsoon or cyclonic storm season. The beginning of the post-monsoon season in this year 2004, in a way behaved complimentary to the southwest monsoon season, in terms of rainfall. As far as the rainfall is concerned, the southwest monsoon's withdrawal phase provided plenty of rain in the beginning of October. Southwest monsoon withdrew from the entire country on 18 October, and simultaneously the post-monsoon rains commenced over Tamilnadu, Kerala and adjoining parts of Karnataka using the general circulation model T106L40. During 2004 the post-monsoon arrived over the Tamilnadu coast on 18 October the same day for the year 1994. The year 1994 has experienced the normal southwest and normal northeast monsoons.

Though the principal rainy season for Karnataka, Kerala, Tamilnadu, is the southwest monsoon season, rainfall continues till December in these areas, the period northeast monsoon contributing about 20 % of the annual total. The rainfall over south peninsula towards the end of southwest monsoon season is mainly in the interior districts and it generally occurs in the afternoon, evening or early part of the night. As the season advances, the rainfall is mainly in the coastal districts with the interior districts getting less rain. Thus the northeast monsoon 2004 is normal succeeded by the normal southwest monsoon 2005.

During this post-monsoon season only a Depression (D), a Deep Depression (DD) and a Severe Cyclonic Storm (SCS) formed. Warm oceans with surface temperature of 26°C or higher provide the fuel for the tropical cyclone. During this cyclonic storm season the intense cyclo-genesis over the Indian seas is very much subdued and another noteworthy feature is no cyclone had landfall as they weakened over the sea itself as seen by JRA25 datasets.

CONCLUDING REMARKS

From the above study it can be concluded that: The summer monsoon of the year 2004 was unusual over India in various aspects. The onset occurred over the south Kerala as weak current on 18 May, two weeks ahead of the normal date. This early onset of southwest monsoon 2004 does not provide any clue to subsequent rainfall during the season. The advance phase has been delayed, thus it took about two months time to cover the entire country instead of usual one month's time. During the month of June and July the heat low is almost remain stationary. The intensification of heat low in the forecast continues with the forecast length. The forecast central pressures corresponding to the synoptic systems during the southwest monsoon season are mostly lower than the observed ones.

During the post-monsoon season the location of the system, total rainfall predictions obtained from the atmospheric model is in good agreement with the observations. There is no rainfall amount relationship between the southwest monsoon and the northeast monsoon of the current year and/or preceding/succeeding year.

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