

Monsoon Oscillations of the Findlater Jet and Coastal Winds of India

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ABSTRACT

Intraseasonal variability (ISV) of the Low Level Jet (LLJ) and its effects on coastal winds during the Indian summer monsoon are examined using National Centre for Environmental Prediction / National Centre for Atmospheric Research (NCEP) reanalyses winds and India Meteorological Department (IMD) wind observations along 11 coastal stations of India. The active-phase "peninsular-path" of the LLJ and its "branching-out" during break-phase are well reproduced by NCEP 850 mb winds. Though the foot-prints of the LLJ are visible in NCEP surface winds in the oceanic region, over land, it is not traceable. The ISV of the LLJ is found to have significant bearing on the coastal winds to affect the forcing on coastal circulation of India. During active phase, the south-westerly wind anomalies (~ 1.5 m/s) in the south-east coast (Chennai/Tuticorin) favor upwelling in this region. During break phase, the ISV of the LLJ favors upwelling off Goa in the west coast and opposes upwelling off Tuticorin/Chennai in the east coast. Though NCEP surface winds do not carry the ISV of the LLJ over land, it captures the observed variability of coastal winds. Wavelet analysis on IMD coastal winds (10 m) for the 11 stations and the co-located 850 mb NCEP winds show 10-20 day and 30 -60 day modes of ISV. While the amplitude of the 30-60 day mode, associated with the variability of the LLJ is 6 m/s, for IMD coastal winds it is ~2 m/s.

INTRODUCTION

A Low Level Jet (LLJ), also known as the Findlater jet, exists over the Indian Ocean and peninsular India during summer monsoon, June to September (Joseph and Raman, 1966; Findlater, 1969). The LLJ is best manifested at 850 mb (nearly 1.5 km) with a core speed of 20-30 m/sec. It emanates from the Mascarene high, crosses the equator hugging the East African high lands and then turns to the Arabian Sea and extends further eastwards crossing India. Though the jet axis is nearly stable in the western Indian Ocean, over India and the eastern Indian Ocean, the LLJ is subjected to north-south oscillations. Displacement of convective heating zones are responsible for the latitudinal oscillations of the LLJ and associated active/break spells in the monsoon circulation and precipitation (Sikka and Gadgil, 1980). During active monsoon, the jet passes through the peninsular India and this region gets more precipitation compared to rest of India. However, during break monsoon, the jet branches out over the Eastern Arabian Sea; one heading towards north-east (into the monsoon trough) and the other turning towards south-east, into another convective zone formed in the equatorial region (Joseph et al. 2001). Since the core of the jet is

located within the Planetary Boundary Layer (PBL), where the atmosphere-ocean coupling takes place, the jet induced variability should be seen in the surface winds. Therefore, when we consider the coastal waters of India, the latitudinal displacements of the LLJ cause differential forcing of wind and fresh water in the coastal region. The objective of the present study is to know the Intraseasonal Variability (ISV) of the jet and its degree of manifestation in surface/coastal winds along the east and west coast of India. ISV of coastal winds should contribute towards ISV of circulation along the east and west coast of India.

DATA AND METHODOLOGY

The study uses daily zonal (u) and meridional (v) winds at surface and 850 mb derived from the NCEP/NCAR reanalysis for the period 1976 to 1985 (Kalnay et al 1996).

India Meteorological Department (IMD) routinely observes surface meteorological parameters from the coastal stations of India. Daily wind data from 11 stations, located along the east and west coast (Fig. 1) for the period 1976 -1985 forms the second data set for this study. Since the highest ISV occurs

during active and break phases of summer monsoon, ISV of the jet and coastal winds are analysed based on the active/break composites. The active and break days are identified based on the IMD definitions.

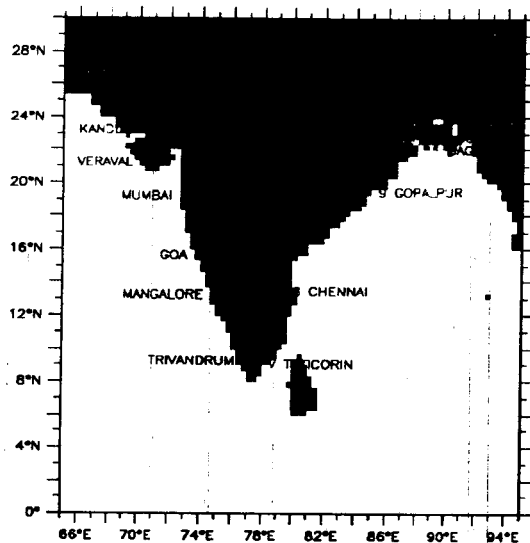


Fig. 1: IMD coastal stations.

RESULTS AND DISCUSSION

The LLJ course during active and break monsoon is shown in Fig.2. Upper panel shows the 850 mb composite winds during active monsoon and the lower panel shows the same but for break monsoon. The active-phase "*peninsular-path*" and the "*branching-out*" during break-phase are well depicted in the composites. Though the foot prints of the jet during active/break could be seen in the composites of surface winds in the oceanic region, over land, it is not traceable (Fig.3). The active and break composites of wind anomaly at 850 mb are given in fig.4. During active monsoon, 850 mb wind anomaly is high in the north eastern India (easterly wind anomaly) and south western Bay of Bengal (westerly wind anomaly). During active monsoon, since the '*peninsular-path*' gets more activated and the '*northern-branch*' heading to the foot-hill of the Himalaya is absent, the spatial structure (high wind anomalies in north-east India and south-west Bay of Bengal) and directions of wind anomalies are consistent with ISV of the LLJ. During break, the wind anomalies reverse their directions. The south-westerly anomalies are associated with the activated '*northern-branch*' of the jet. The north-easterly anomaly (centered in the peninsular India) represents the weakened '*peninsular-path*'. During active as well as break monsoon, the anomalous wind peaks to 5-6 m/s.

Composite wind-anomalies at the surface during active and break monsoon are given in fig. 5. Though the direction of the NCEP surface wind

anomalies during active/break period is similar to that at 850 mb, its spatial structure (especially, the high wind anomaly regions) is significantly modified. One of the obvious changes during break monsoon is the shift in the core of the high anomaly winds from the peninsular India to the central-eastern Arabian Sea. When we consider the coastal stations, NCEP surface wind anomalies are higher (~ 2 -m/s) at Goa in the west coast and at Tuticorin/Chennai in the east coast. During break, the north-easterly anomalies in the coastal waters off Goa promote upwelling and the former in the south-east coast of India opposes upwelling. The reverse is true during active period.

Composite wind anomalies for zonal(u) and meridional (v) of the IMD wind vectors along with the mean winds are shown in fig.5. The ISV of the IMD coastal winds are consistent with the NCEP surface winds anomalies along the coast. The highest anomaly of about 1.5 m/s is found to occur at station Goa, in the west coast and at Tuticorin/Chennai (1 m/s) in the east coast.

Results of the wavelet analysis on IMD coastal winds (surface) for the 11 stations and the co-located 850 mb NCEP winds show 10-20 day and 30-60 day modes of ISV (Fig. 6). Goswami et al. 1998 observed 10-20 day and 30-60 day modes in NCEP surface winds and suggested that the synoptic structure of the 30-60 day mode is intimately related to the active/break phases of the Indian summer monsoon. While the amplitude of the 30-60 day mode, associated with the variability of the jet (NCEP winds at 850 mb) shows 6 m/s, for IMD surface winds it is ~ 2 m/s.

ACKNOWLEDGEMENT

The first author is grateful to Prof. Yasuhiro Sugimori, Professor, CReS, Chiba University for supporting this work under the COE program of Ministry of Education, Japan.

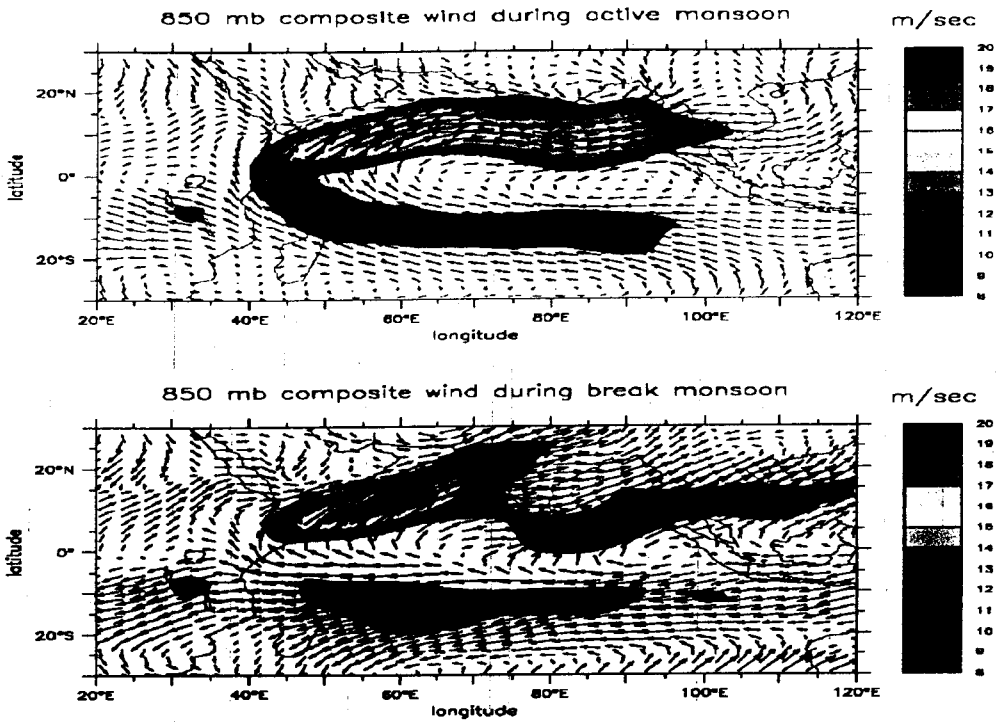


Fig.2: NCEP 850 mb composite winds during active (upper) and break(lower) monsoon.

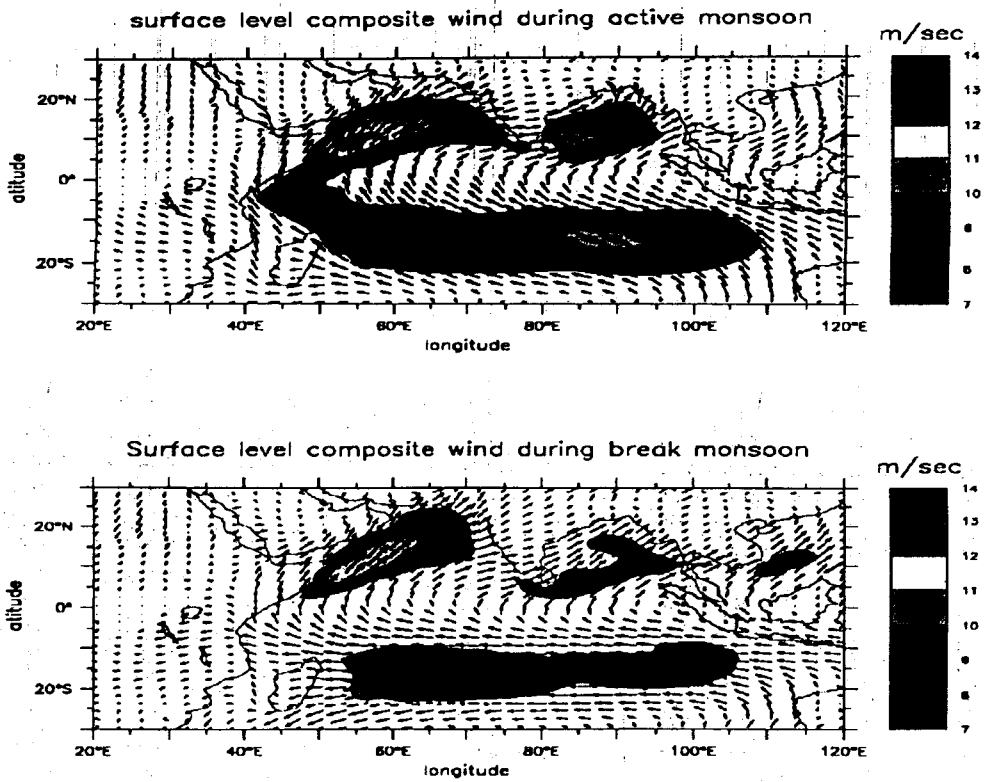


Fig.3: NCEP 10 m composite winds during active (upper) and break(lower) monsoon.

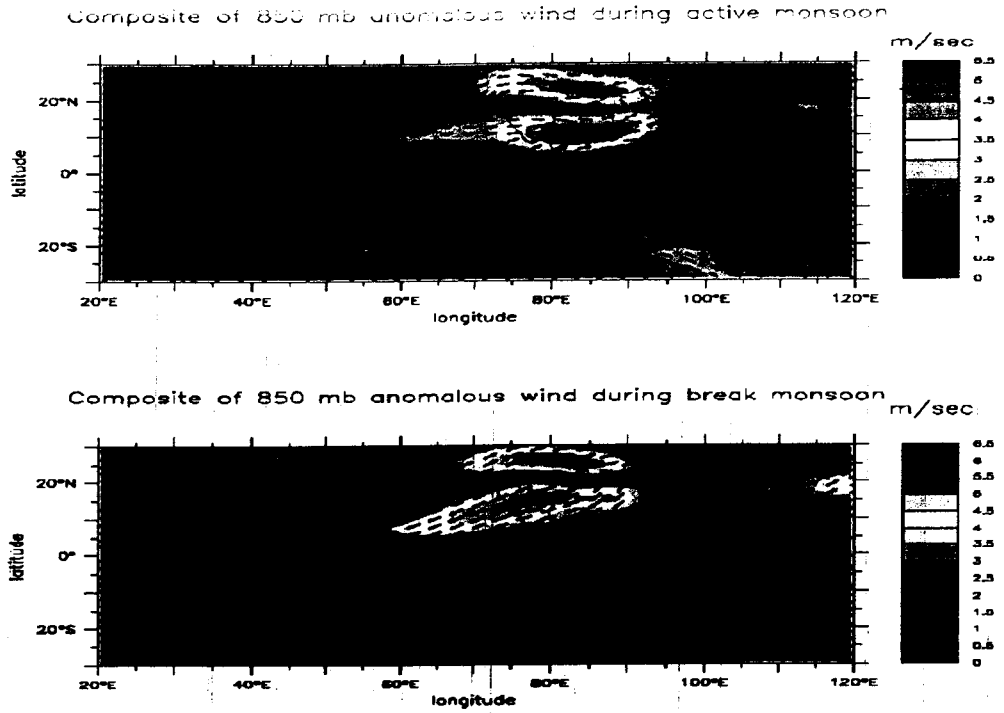


Fig.3: NCEP- 850 mb wind anomaly composites for active (upper) and break(lower).

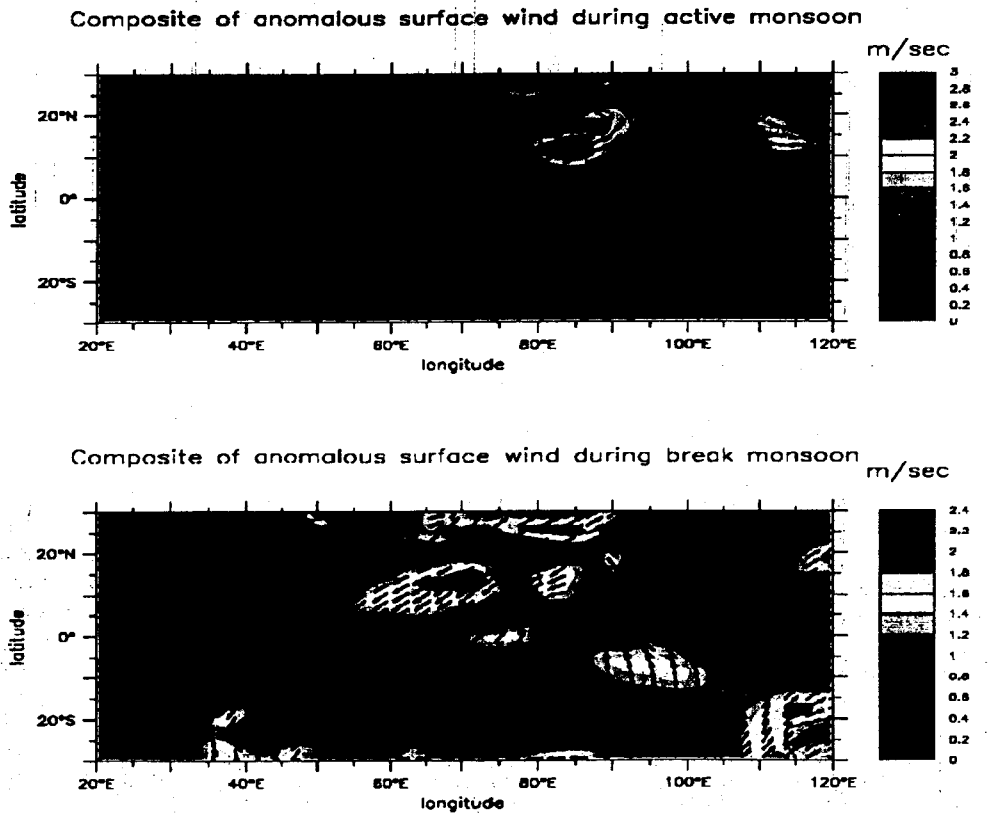


Fig.4: NCEP- 10 m wind anomaly composites for active (upper) and break(lower).

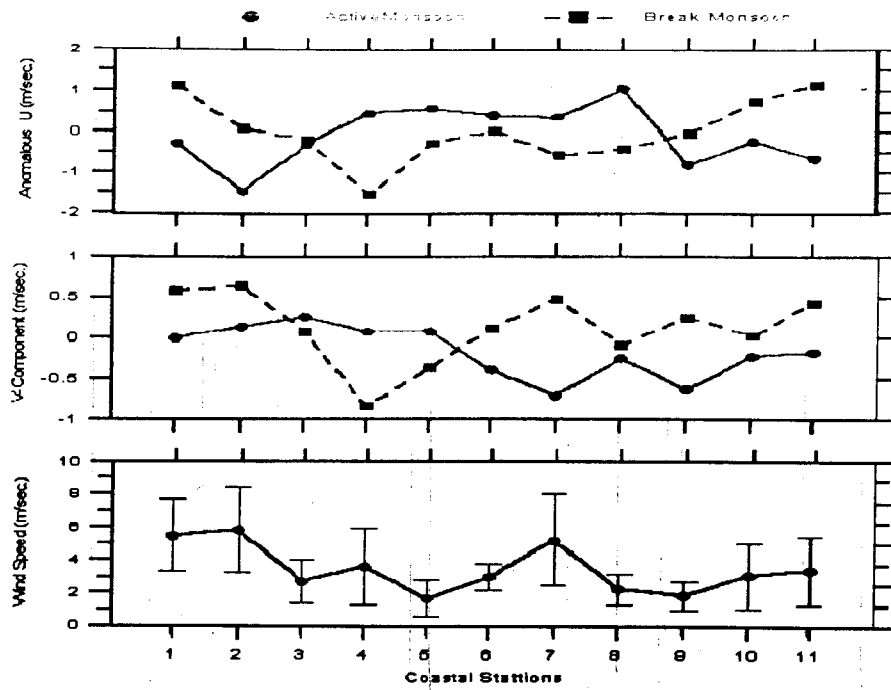


Fig.5: Active-break composites of u-v component wind anomaly at 11 IMD stations with the mean and standard deviations of the wind speed.

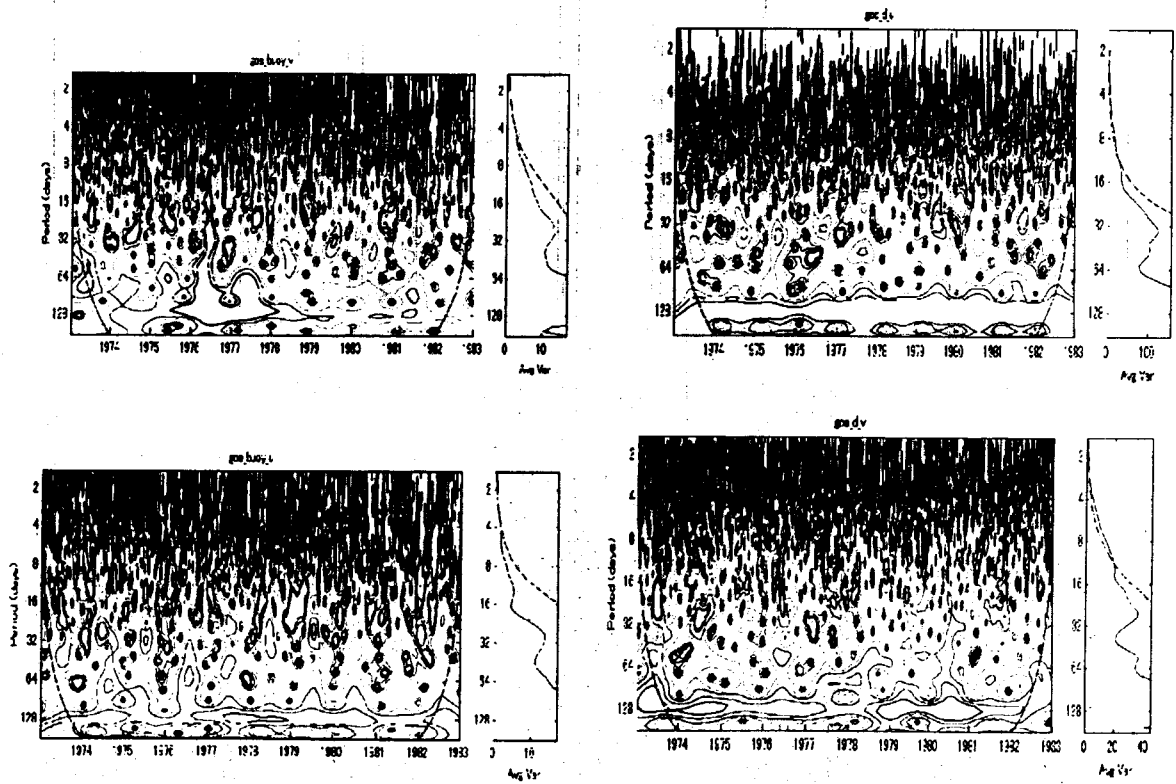


Fig.6: Wavelet analyses for U-wind of IMD (upper left), U-wind of NCEP (upper-right), V- wind of IMD (lower-left) and V- wind of NCEP(lower-right) for station Goa.

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