Mausam, (1990), **41**, 2, 189-192

551.511.13 : 551.553.21

30-50 day oscillation of monsoon : Some simple mechanisms

R. N. KESHAVAMURTY, S. V. KASTURE and V. KRISHNAKUMAR

Physical Research Laboratory, Ahmedabad

सार – विभिन्न दिशाओं, मौसम प्राचलों और अनेक स्तरों पर ग्रीष्म मानसून में पाये गये 30-50 दिन के दोलन के आकार-विज्ञान पर विचार विमर्श किया गया है। इस शोधपत्र में समीकरणों और उनके समाधानों की प्रणाली द्वारा, इन दोलनों के निदर्श अध्ययनों और भारतीय क्षेत्र में उनके उत्तराभिमुख गति पर विचार विमर्श किया गया है।

ABSTRACT. Morphology of 30-50 day oscillation found in summer monsoon in different directions, different weather parameters and at various levels has been discussed. Model studies of these oscillations and their northward movement in the Indian region are described in this paper by a system of equations and their solutions.

1. Introduction

A 30-50 day oscillation was first found in the equatorial region by Madden and Julian (1971). The structure of this oscillation was east-west overturnings in the equatorial longitude-height plane and this oscillation moved slowly eastwards. Dakshinamurti and Keshavamurty (1976) found large power around the period of one month in the zonal component of wind over India. Yasunari (1980) and Sikka and Gadgil (1980) have found similar northward movement in satellite cloudiness. Krishnamurti and Subrahmanyam (1982) found a 30-50 day oscillation and its northward movement in the zonal component of wind in the Indian region. Similar eastward propagation has been found in satellite OLR data by Lau and Chan (1986 a). Kasture and Keshavamurty (1987) studied the 30-50 day oscillation and found that it extends throughout the troposphere and has a slow northward movement and also has some interannual variability. Knutson *et al.* (1986) have also studied the 30-50 day oscillation with satellite OLR data and 200 mb winds.

In Webster and Chou's (1980) simple model shorter period active and break cycles have been reproduced but not the longer 30-50 day oscillation. Chang (1977) using linear theory and large damping suggested that this oscillation may be an atmospheric Kelvin wave. Lau and Peng (1987) have given a linear theory of the eastward moving 30-50 day mode and explained that it is due to mobile wave-CISK. Keshavamurty (1986) introduced an equatorial heat source in a 5-level adiabatic global spectral model. They obtained a fast eastward moving Kelvin wave with a 2-layer structure but with a period of 9 days. However, when the model output was low pass filtered they obtained low frequency oscillations in the time scale of 25-50 days. Kasture *et al.* (1988) introducted Lau's wave-CISK formulation in this model and found an eastward propagating moist Kelvin wave with a scale of wave number one and with a period of 25 days. This has a two-layer structure in the vertical and resembles the observed 30-50 day mode. Keshavamurty *et al.* (1986, 1988) also studied the northward propagation of the 30-50 day mode in the Indian region using simplified equations and semi-analytical techniques.

Hendon (1988) obtained low frequency eastward moving wave in a two-level model including wave-CISK. Several other authors have also studied this oscillation with simpler models.

2. Morphology of the 30-50 day oscillation

The low frequency subseasonal variability can be seen in the time series of rainfall over central India as in 1965 and 1967 (*from* Fig. 4, Kasture and Keshavamurty 1987). The long period of poor rainfall during 2-18 August 1965 is a typical break monsoon epoch. The time series of vorticity over east central India also show similar features (*from* Fig. 5, Kasture and Keshavamurty 1987). There is a good correspondence between the time series of vorticity and rainfall. Periods of small or negative vorticity correspond to periods of poor rainfall or breaks. Periods of large positive vorticity correspond to periods of active monsoon or higher than normal rainfall.

Composite pentad anomalies during active monsoon and during breaks also bring out this low frequency variability. During active monsoon we see an anomaly east-west trough forming over Peninsular India and marching slowly northwards. During breaks, on the other hand, we have an east-west anomaly ridge forming over Peninsular India (and eastwards) and moving slowly northwards.

Fig. 1 shows the power spectra of u-component of wind at Nagpur at the standard levels during the monsoon season of 1975 (*from* Kasture and Keshavamurty 1987). We see large power in the period range of 30-40 days. Fig. 2 (*from* Kasture and Keshavamurty 1987) shows

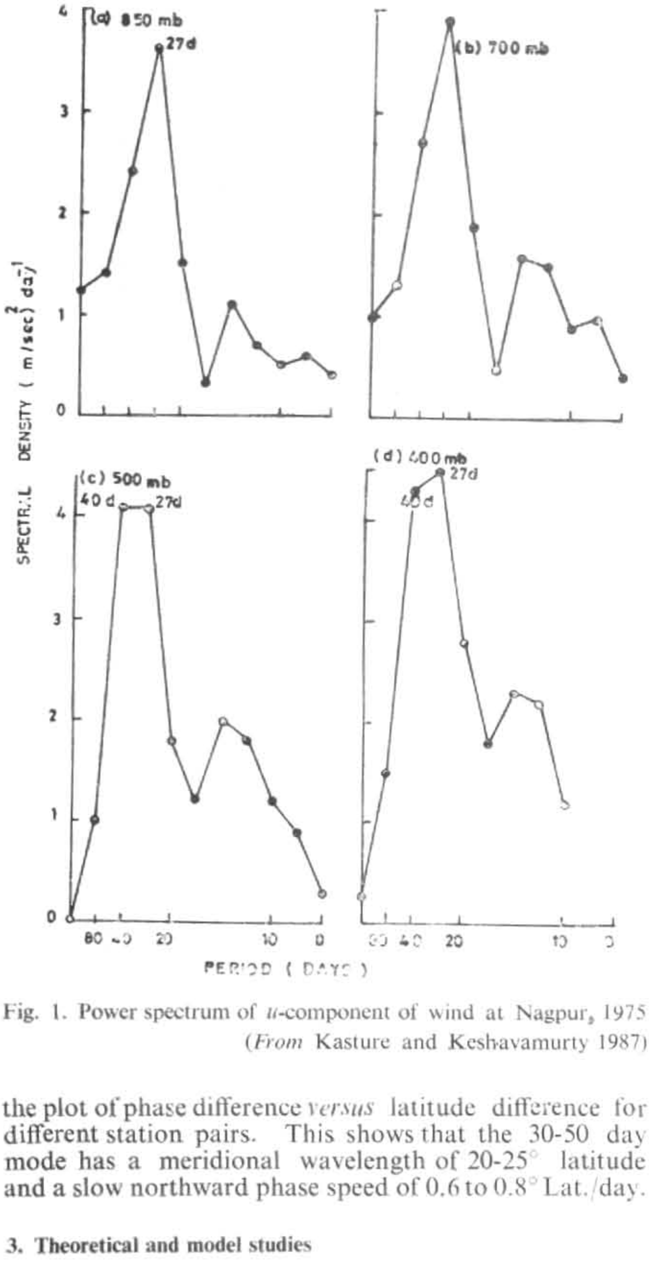

Fig. 1. Power spectrum of *u*-component of wind at Nagpur, 1975 (*From* Kasture and Keshavamurty 1987)

the plot of phase difference *versus* latitude difference for different station pairs. This shows that the 30-50 day mode has a meridional wavelength of 20-25° latitude and a slow northward phase speed of 0.6 to 0.8° Lat./day.

3. Theoretical and model studies

There have been several theoretical and model studies to understand :

(*i*) the 30-50 day period,

(*ii*) the northward movement in the Indian monsoon region. Many of these studies have been referred to in the introduction. In this section we shall briefly summarize our studies in this field.

3.1. *30-50 day period*

Keshavamurty *et al.* (1986) studied the problem with a global spectral model. They introduced a weak symmetric equatorial heat source in an adiabatic global spectral model. The heating had a vertical profile of the type sin ($\pi\ p/p_0$). The model had 5 levels in the vertical and rhomboidal truncation at 10 waves. The model was integrated for 120 days. There was no basic flow. A fast eastward moving Kelvin wave with a two-layer structure but with a period of 9 days was generated. However, when the model output was low pass filtered small low frequency oscillations in the period range 25-50 days remained.

Lau and Peng (1987) did a linear analysis and explained the 30-50 day oscillation as due to mobile wave-CISK. We introduced the same wave-CISK type of heating in the 5-level spectral model. We also introduced a linear drag of 5 days. We obtained an eastward moving moist Kelvin wave of period 25 days. Fig. 3 (*from* Kasture *et al.* 1988) shows the longitude line section of *u*-component of wind at 300 mb which clearly brings out the 25-day period. Figs. 4 (a&b) (*from* Kasture *et al.* 1988) shows the *u*-component field on day 10 at 900 and 300 mb bringing out the 180° phase difference indicating a two-layer structure. This has a large resemblance with observations.

3.2. *Northward movement in the Indian region*

Keshavamurty *et al.* (1986) used simplified zonally symmetric equations to understand the northward movement. They used symmetric perturbations superposed on basic flow $U\ (y, p)$ typical of the monsoon region. They used a two-level model and a highly simplified parameterization of cumulus heating. Substituting oscillatory solution they could reduce the system of equations to the form :

$$\frac{d^2V}{dy^2} + n^2\,(y)\,V = 0$$

where,

$$n^2 = \frac{\dfrac{i\omega f}{\triangle p}\left(\dfrac{\partial}{\partial y}\ (U_1 + U_3) - 2f\right)}{K\left(\dfrac{\partial U_3}{\partial y} - f\right) + i\,\omega\,\sigma \triangle p}$$

Here V is the meridional wind; ω is frequency; f coriolis parameter; U_1, U_3, basic zonal winds over the monsoon region during July at 200 and 700 mb; $K = H\ \sigma\ g\ \rho\ \sin 2\alpha\ \sqrt{K_e/2f_0}$, where $H = 1.5$; $\alpha = 22\frac{1}{2}$ deg; K_e = coefficient of eddy viscosity; f_0 at 10° N; ρ = density of air; σ=static stability. They computed $n^2\,(y)$ and $n\,(y)$ and found that they were complex indicating a possibility of northward propagation.

More recently, Keshavamurty *et al.* (1988) have used a more simplified system of equations :

$$\frac{\partial u_3'}{\partial t} + \left(\frac{\partial U_3}{\partial y} - f\right) v_3' = -\,ku_3'$$

$$\frac{\partial v_3'}{\partial t} + f u_3' = -\frac{\partial \phi_3'}{\partial y} - kv_3'$$

and

$$\sigma\omega_2' = K\,\frac{\partial u_3'}{\partial y}$$

where, u_3', v_3' are the perturbation zonal and meridional components of wind, ϕ_3' perturbation geopotential, k linear drag, $\omega_2 = dp/dt$. In this case, they are able

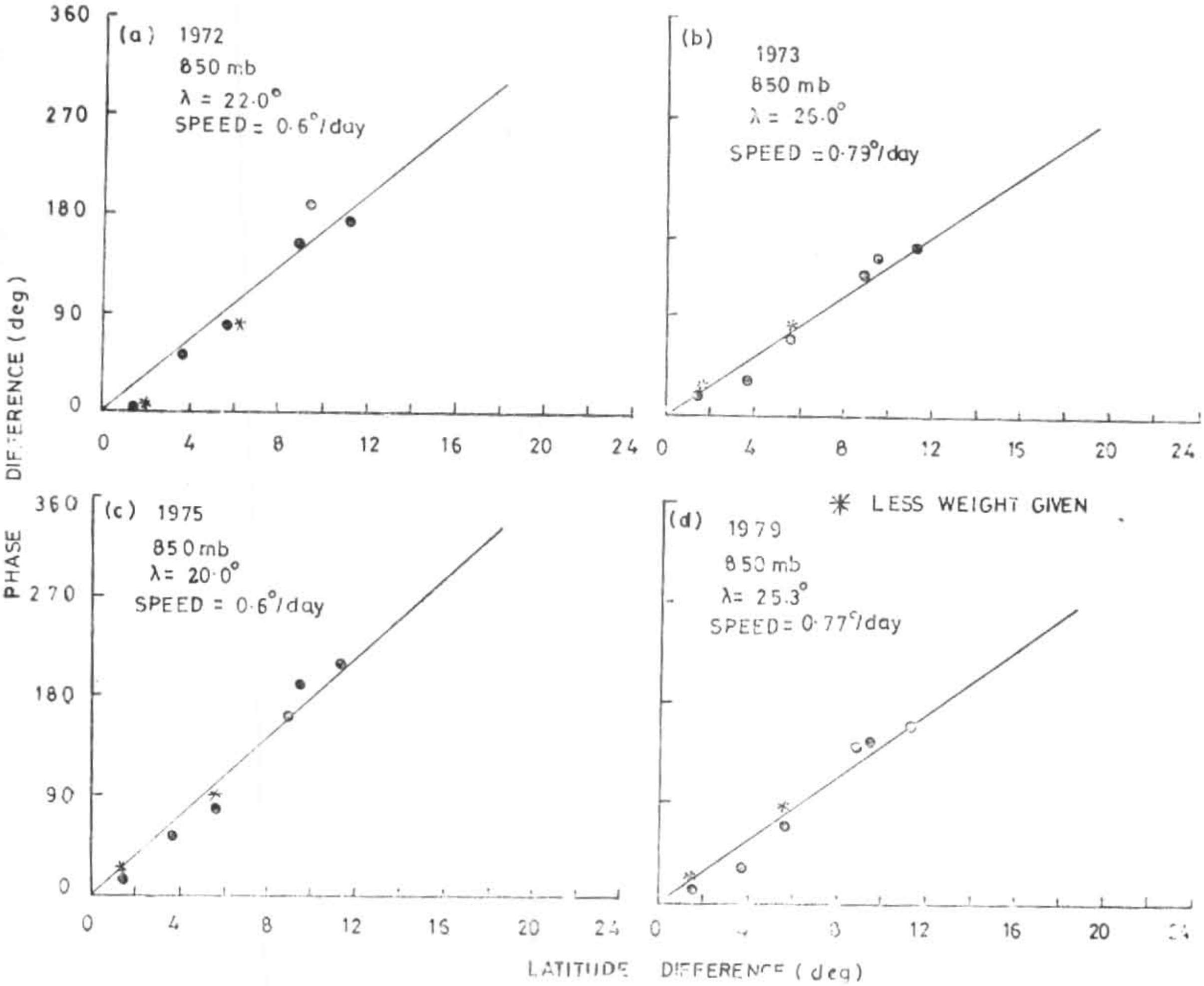

Fig. 2. A plot of phase difference *versus* latitude difference — 850 mb
(*From* Kasture and Keshavamurty 1987)

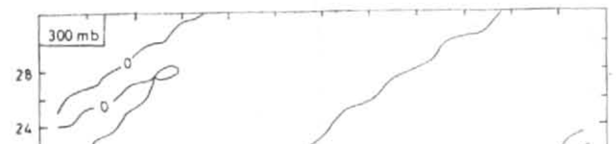

Fig. 3. Zonal component of wind at 300 mb (m sec^{-1})
(*From* Kasture *et al.* 1988)

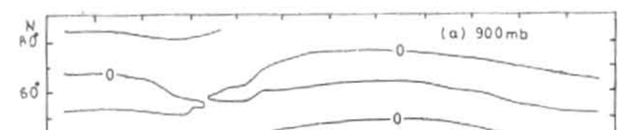

Fig. 4(a). Zonal component of wind at 900 mb, 10 days (m sec^{-1})
(*From* Kasture *at al.* 1988)

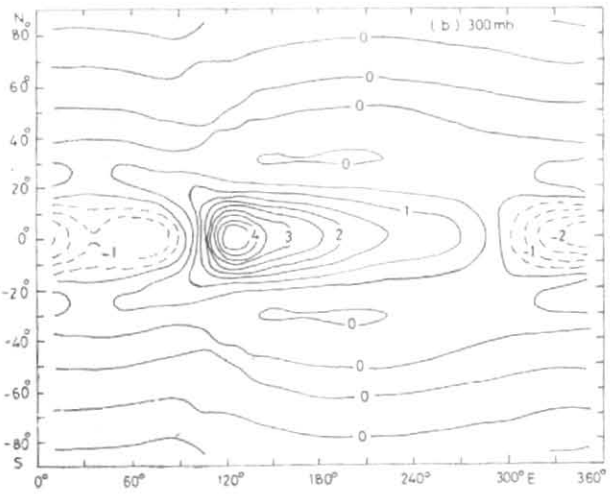

Fig. 4 (b). Zonal component of wind at 300 mb, 10 days (m sec^{-1})
(*From* Kasture *et al.* 1988)

to get an analytical solution for V_3, the meridional wind amplitude at 700 mb as :

$$V_3 = \left[V_{30} \Big/ \sqrt{\left\{ K\left(\frac{\partial U_3}{\partial y} - f\right) + k\,\sigma\,\triangle p \right\}^2 + \omega^2\sigma^2\triangle p^2} \right] \times \exp\left[i \tan^{-1}\left[\left\{ K\left(\frac{\partial U_3}{\partial y} - f\right) + k\,\sigma\,\triangle p \right\} \Big/ \omega\,\sigma\,\triangle p \right] \right]$$

and a rough expression for the meridional speed of propagation. They obtained a northward phase speed of a few metres per second north of 10° N.

References

Chang, C.P., 1977, Viscous internal gravity waves and low frequency oscillations in the tropics, *J. atmos. Sci.*, **34**, pp. 901-910.

Dakshinamurti, J. and Keshavamurty, R.N., 1976, On oscillation of period around one month in the Indian summer mosoon, *Indian J. Met. Hydrol. Geophys.*, **27**, pp. 201-208.

Hendon, H.H., 1988, A simple model of the 40-50 day oscillation, *J. atmos. Sci.*, **45**, 569-584.

Kasture, S.V. and Keshavamurty, R.N., 1987, Some aspects of the 30-50 day oscillation, *Proc. Indian Acad. Sci.* (Earth Planet. Sci.), **96**, 49-58.

Kasture, S.V., Lau, K.M. and Keshavamurty, R.N., A model study of the 30-50 day oscillation in the tropical atmosphere (In preparation).

Keshavamurty, R.N., Kasture, S.V. and Krishnakumar, V., 1986, 30-50 day oscillation of the monsoon : A new theory, *Beitr. Phys. Atmos.*, **49**, 443-454.

Keshavamurty, R.N., Krishnakumar, V. and Kasture, S.V., 1988, Northward propagation of the 30-50 day mode in the Indian monsoon region. Accepted for publication in *Proc. Indian Acad. Sci.* (Earth Planet. Sci.).

Knutson, T.R., Weickmann, K.M. and Kutzbach, J.E., 1986, Global scale intraseasonal oscillations of outgoing long wave radiation and 250 mb zonal wind during the northern hemisphere summer, *Mon. Weath. Rev.*, **114**, 605-623.

Krishnamurti, T. N. and Subrahmanyam, D., 1982, The 30-50 day mode at 850 mb during MONEX, *J. atmos. Sci.*, **39**, 2088-2095.

Lau K.M., and Chan, P.H., 1986, Aspects of the 40-50 day oscillation during the northern summer as inferred from outgoing long wave radiation, *Mon. Weath. Rev.*, **44**, 1354-1367.

Lau, K.M. and Peng, L., 1987, Origin of low-frequency (Intraseasonal) oscillations in the tropical atmosphere—Part I : Basic Theory, *J. atmos. Sci.*, **44**, 950-970.

Madden, R.A. and Julian, P.R., 1971, Detection of a 40-50 day oscillation in the zonal wind in the tropical Pacific, *J. atmos. Sci.*, **28**, 702-708.

Sikka, D.R. and Gadgil, S., 1980, On the maximum cloud zone and the ITCZ over Indian longitude during southwest monsoon, *Mon. Weath. Rev.*, **108**, 1840-1853.

Webster, P.J. and Chou, L., 1980, Low frequency transients of simple monsoon system, *J. atmos. Sci.*, **37**, 368-381.

Yasunari, T., 1980, A quasi-stationary appearance of 30-40 day period in the cloudiness fluctuations during the summer monsoon over India, *J. met. Soc. Japan*, **58**, 225-229.