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INTERHEMISPHERIC INTERACTION — A CASE STUDY

With the positioning of Indian geostationary satellite INSAT-1B along 74°E, the scope of research has widened from regional to intercontinental scale. INSAT-1B full disc cloud imageries which give an overview of the cloud systems in the two hemispheres between 50° S-50° N and 10° E-150°E, together with the INOSHAC (Indian Ocean & Southern Hemisphere Analysis Centre) extended charts prepared for different levels twice daily at 00 UTC and 12 UTC have given an unique opportunity for meteorologists to study the inter-hemispheric interaction in their true perspective. Such interactions, of course, are not always obvious. However, there are occasions when they are most pronounced and meteorologists can easily identify them. The present paper is a case study of one such occasion when the interaction between the tropics of southern hemisphere and the middle latitudes of northern hemisphere was most pronounced on 24 January 1985.

INSAT-1B satellite cloud imageries for 09 UTC of 24 January 1985 (Fig. 1) depict pronounced interaction between the tropics of southern hemisphere (SH) with the middle latitudes of northern hemisphere (NH) through cloudiness in the south-north channel 20°E-50° E. The INOSHAC charts of different levels prepared for 12 UTC of 24 January (Fig. 2) are compared and the systems present along the channel 20°E-50°E, linked with the cloudiness observed. Cloud imageries and charts of 23 January are also consulted for the sake of comparison.

A consultation of cloud imageries and the conventional surface charts indicate the presence of two equatorial troughs (ETs) on either side of the equator during winter. On 24 January 1985, the NHET encircled most of the hemisphere and was located along 2°-3°N over Indian Ocean. The SHET was located approximately along 10°S between 50° E and 150°E. Over African region the NHET extends to 5°N between 20°E and 40°E and SHET extends to 18°S between 20°E and 25°E. The entire longitudinal belt from 20°E to 50°E running across Africa and Saudi Arabia forms a north-south pressure trough zone between 30°N and 30°S (tropics of both the hemispheres). On the satellite imagery we have an extensive channel of convective activity between 25°E & 50°E extending from 20°S to 25°N. Since January is a summer month for SH, convection is more pronounced in the SHET than in the NHET. The two ETs interact and the maximum interaction is observed over the land mass of east Africa. The convection extends from SH tropics to 5°N between 10° E & 40°E through equator. It narrows down to strip like zone of medium and high clouds along 35°E longitude. From the large scale *cu*-convection in the equatorial region warm and moist air in the middle tropospheric levels streams towards northern latitudes, producing thick layered sheets of medium clouds on its way. The *ci* clouds are the outflow from the embedded *cb* clouds. Another extension of cloudiness from SH to NH takes place between 60° E & 70° E. The medium cloudiness between Eq-10° N and 50° E-60°E and between 15° N & 25° N and 55° E & 65° E (IR-imagery) appear to be from this source. In the middle latitudes of NH we observe convection over the Arabian peninsula, multiple layers of clouds over Iraq and Iran and high clouds over Tibet and China. In the east, convection is observed to be pronounced on either side of the equator over Malaysia and Indonesian Islands, wherefrom, the medium and *ci* clouds extend northward in a 10° wide channel from equator to 10°N along 100° E and then northeastward up to 110° E.

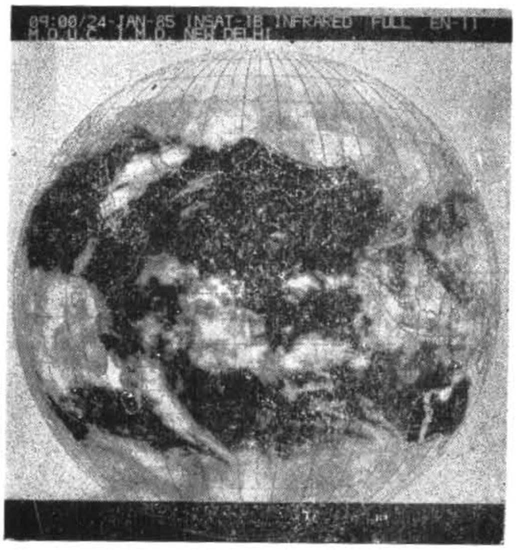

Fig. 1. INSAT-1B satellite cloud imageries for 09 UTC of 24 January 1985

At 850 hPa the sub-tropical ridge is located approximately along 20° N between 65° E and 150° E. It is displaced to 30° N between 20° E and 60° E. This northward displacement may be inferred as due to the extension of equatorial trough over land in the northern hemisphere. The sub-tropical zone consists of

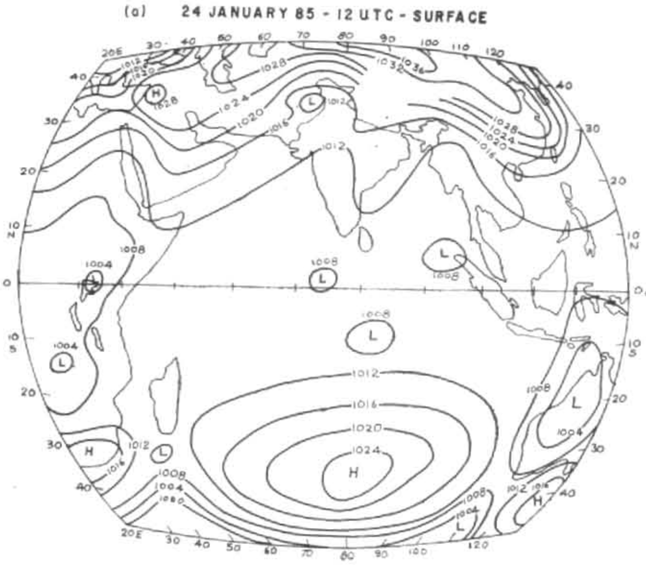

Fig. 2(a). Analysed chart for surface at 12 UTC of 24 January 1985

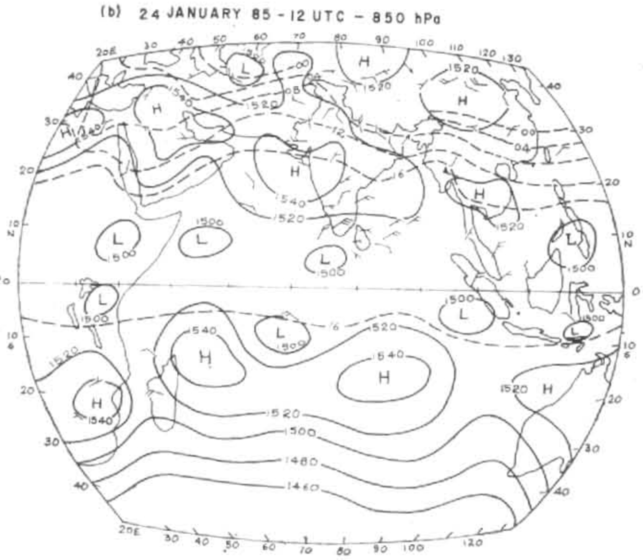

Fig. 2(b). Analysed chart for 850 hPa at 12 UTC of 24 January 1985

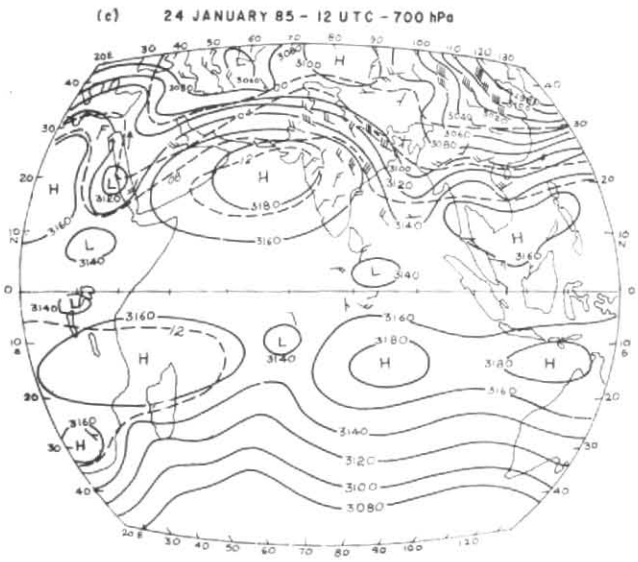

Fig. 2(c). Analysed chart for 700 hPa at 12 UTC of 24 January 1985

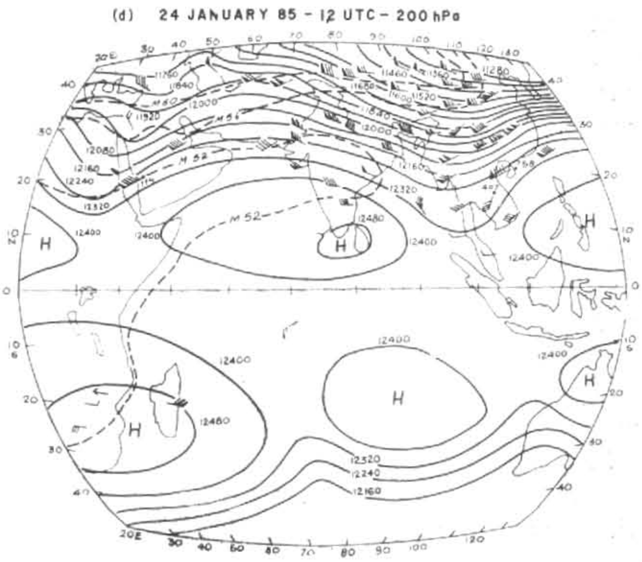

Fig. 2(d). Analysed chart for 200 hPa at 12 UTC of 24 January 1985 anticyclone cells separated from each other by the easterly/westerly troughs to their south/north. The extensive convection between 17°N & 30°N and 40°E & 50°E on the western side of the Arabian Sea anticyclone coincides with such an easterly trough at 850 hPa level. The easterlies in the equatorial region of Malaysia and Indonesian Islands are from the return current around the subtropical anticyclone extending over Western Pacific. These easterlies have gradually picked up moisture while approaching the warm equatorial waters and get destabilized. Moisture is also advected upward by *cu* formation. Large *cu* and *cb* clouds build-up on the two sides of the equator, while the medium and *ci* clouds are advected to the northern/southern latitudes. This is the cloudiness observed between 10°N-20°N and 100°E-110°E in NH.

In mid-tropospheric levels the medium type clouds extending from equatorial Africa northeastward in the satellite pictures coincide with the southerlies in the forward sector of the westerly trough along 35°E at 700 hPa and 500 hPa. This is also the region where isotherms bunch together at these levels. The middle latitude cloudiness over Saudi Arabia, Iraq and Iran is associated with the deep westerly troughs with embedded cyclonic circulation in them. By an examination of the 12 UTC charts of 23 January, it is evident that these westerly troughs moved from the west and intensified on 24 January in response to the heat and moisture advection from the south. Similarly the activity on the eastern side intensified in response to the happenings on the western side.

The processes that go on in tropics and their interaction with the middle latitudes can be well visualized in upper tropospheric levels. The middle latitude westerly troughs and the associated temperature gradients of mid-tropospheric level extend to 300 hPa. 200 hPa forms the level of outflow *ci* from the *cb* clouds embedded in the equatorial trough. In the present case the outflow *ci* along 35°E have maintained continuity up to 17°N, 43°E. In the eastern sector, the *ci* outflow maintains its continuity from equator to 20°N. This outflow from the *cb* clouds strengthens the upper tropospheric winds in the northern latitudes, owing to the conservation of angular momentum. Following Ranjit Singh (1987), winds over the stations 41114 (18°N, 43°E), 48407 (15°N, 105°E) and 59758 (20°N, 110.5°E) have been computed and found to agree reasonably well with the observed values as given in Table 1.

TABLE 1

Initial wind speed (m/sec)	Lat. of wind maxima (°N)	Additional zonal vel. (m/sec)	Computed wind maxima (m/sec)	Observed wind maxima (°/m/sec)
Zero	18	46.4	46.4	240°/46
—12.5	20	57.9	45.4	240°/45
—12.5	15	32.2	19.7	230°/18

Day and time of INSAT-1B satellite observation : 24 January 1985, 09 UTC

Latitude of the emergence of outflow : Equator

During NH winter there is a cross-equatorial flow from NH to SH in the lower troposphere in Malaysia-Indonesian Islands region. Here the build-up of convection takes place on both sides of the equator. It is followed up by the build-up of intermittently spaced cloud clusters in NHET and SHET. This occurs from the *in situ* development due to propagation of gravity waves as well as wave CISK effect (Stevens and Lindzen 1978, Stalie *et al.* 1983). Over African landmass the interaction becomes more pronounced. Moisture is transported to mid-tropospheric levels by the large-scale equatorial *cu* convection (Ogura 1982). This is steadily carried to the middle-latitudes of northern hemisphere by the disturbances in tropical easterlies (Ludlam 1982). In the western sector this has been observed along two longitudinal channels between 30°E-40°E and 50°E-60°E in the form of medium cloudiness. The areas with medium cloudiness form warmer zones with rising motions. The approaching westerly troughs, therefore, deepen and the formation of closed cyclonic circulations takes place in them. These mid-tropospheric cyclonic circulations are associated with convergence and air may, therefore, rise above them and subside below. The subsidence may warm the air underneath which also later acquires the characteristic of rising motion and then the cyclonic circulations may descend to lower tropospheric and ground level (Ramage 1971, Koteswaram *et al.* 1987). The medium cloudiness, therefore, gets organised into convective cloudiness by this process taking place on synoptic scale. In the upper troposphere this interaction may be observed in the form of cross-equatorial flow of easterlies from the summer hemisphere to winter hemisphere where westerly component is added up to the air stream in its subsequent poleward journey. In the present case study we have shown the strengthening of middle latitude westerlies by the outflow *ci* which is taking place from the tops of *cb* clouds along equator. The upper air westerly trough and the jet stream so formed may provide outflow channel and divergence to lower tropospheric convection, thus, interacting with the lower tropospheric levels. The disturbances located to the northeast and eastward also get accentuated during the process. On the eastern sector the interaction is noticed in the form of return current from middle latitudes to equatorial region of Malaysia and Indonesian Islands leading to build-up of convection there. In turn, the outflow from *cb* clouds strengthens the subtropical westerly jet stream over Japan region.

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