The effect of zonal gradients of sea surface temperature on the Indian Ocean winter monsoon[1]

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Cohen (1981) discussed the results of several global climate simulations by the 7-layer, 8 x 10 GISS climate model (Hansen et. al., 1980) that were designed to test the contributions of various surface boundary conditions to the global climate. The model was run with the sun fixed at a perpetual January. In a comparison of run #5, in which realistic January surface boundary conditions were used, with run #4, which was the same except that a zonally symmetric climatological January sea surface temperature (SST) field was used, one of the results was that run #5 provided a better simulation of the Indian Ocean monsoon. This report presents a further comparison of the wind fields over the Indian Ocean that were generated by these two model runs.

Saha (1970) described a possible effect of zonal anomalies of SST in the Indian Ocean on the monsoon circulation. Numerical experiments (e.g. Washington et. al., 1977) have tested this relationship for the summer monsoon.

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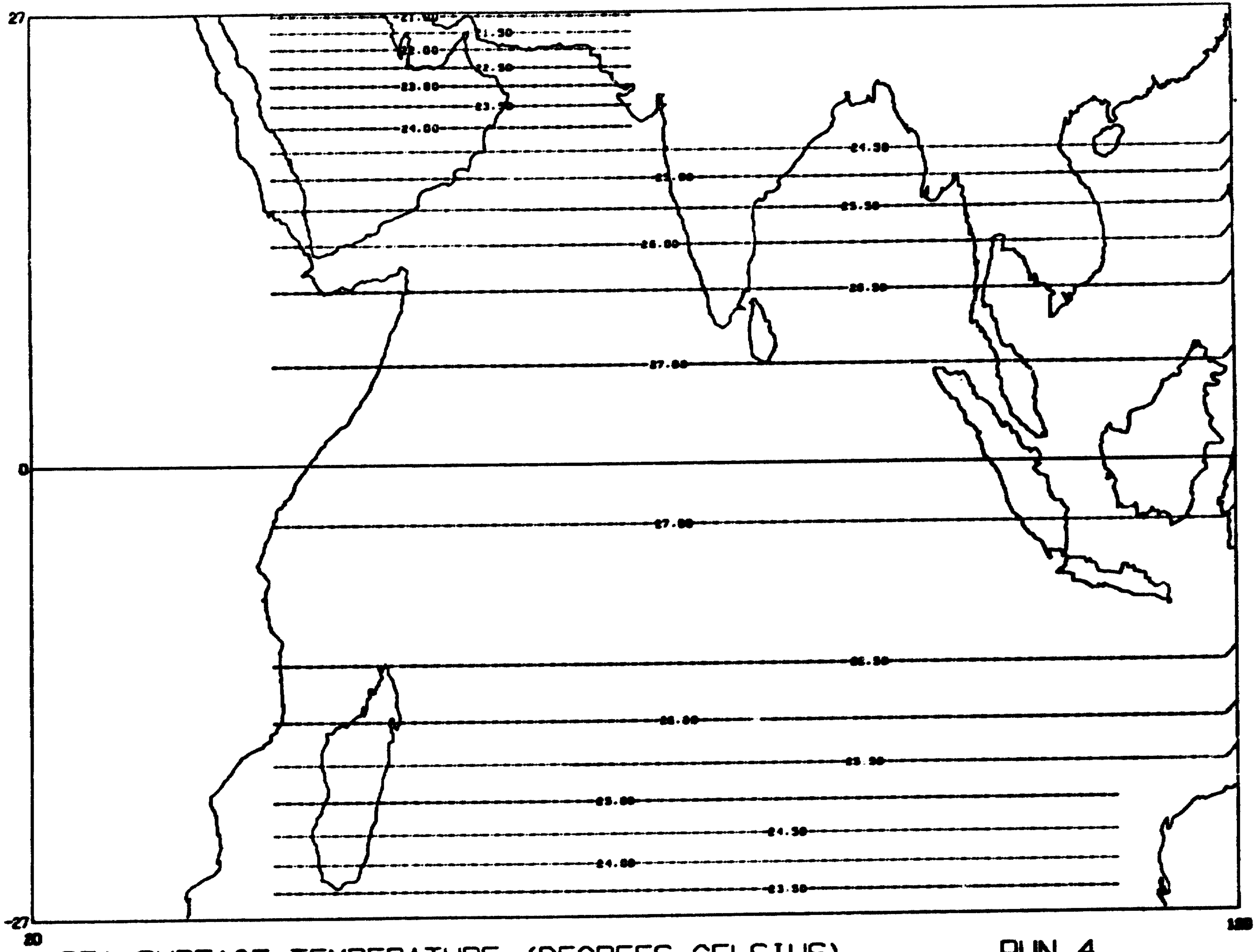
In run *4 of the present experiment, zonally symmetric SST's were used over the entire globe; fig. 1 shows these temperatures for the Indian Ocean. Fig. 2 is a regional map of the global realistic SST field used in run *5. The warmest area, at 28 C, is just south of the equator in the eastern part of the Indian Ocean, and isotherms are generally oriented in a southwest-northeast direction except for the colder water at the west coasts of the continents. The map of the difference between the two SST fields (fig. 3) shows colder areas in run *5 surrounding the Somali Peninsula, in the South China Sea, and northwest of Australia. Water is warmer by 2 degrees in run *5 southwest of Madagascar, with a warm tongue extending northeastward towards Malaysia and the Bay of Bengal.

Surface winds in run *4 (fig. 4) are generally from the northeast, east, or southeast, except for a strong onshore wind at the west coast of India. Cross equatorial flow is mostly from south to north.

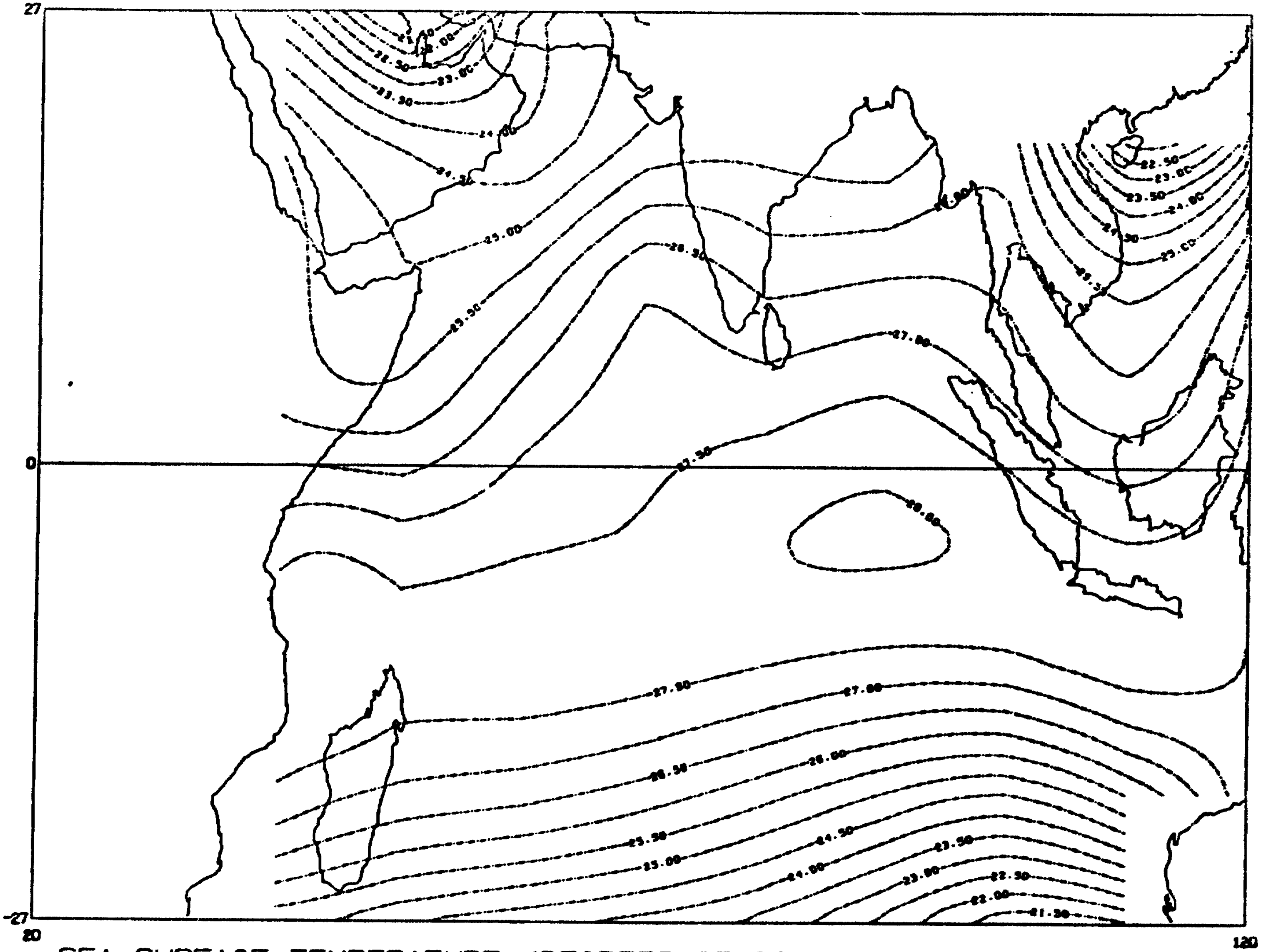
In run *5 (fig. 5) cross equatorial flow is reversed, flowing from north to south, in agreement with observation (fig. 6). The map of differences of the surface winds between run *5 and run *4 (fig. 7) shows the generally northerly cross equatorial flow and an increased westerly and northwesterly flow at 8 S. Exceptions are the increased southerly flow in run *5 crossing the equator at the eastern and western borders of the Indian Ocean.

As in Cohen (1981), the Student's t-test is used to compute statistical significance. Fig. 8, showing the difference between the surface winds of run *5 and run *4, is a reproduction of fig. 7, except that wind vectors are drawn only where the differences between the zonal wind



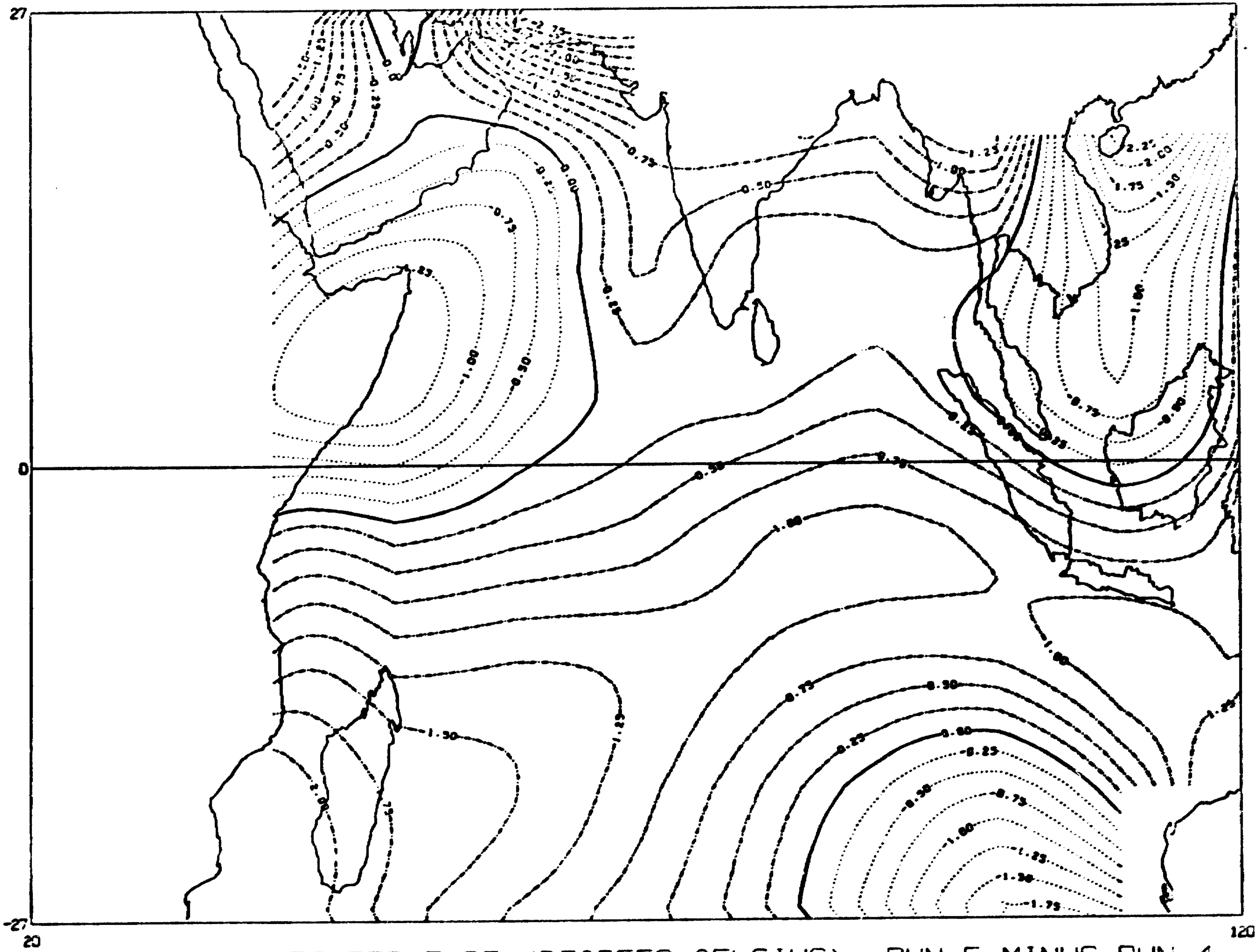
SEA SURFACE TEMPERATURE (DEGREES CELSIUS) RUN 4

Fig. 1



SEA SURFACE TEMPERATURE (DEGREES CELSIUS) RUN 5

Fig. 2



SEA SURFACE TEMPERATURE (DEGREES CELSIUS) RUN 5 MINUS RUN 4

Fig. 3

SURFACE WIND RUN 4 THE AVERAGE OF 20 MONTHS

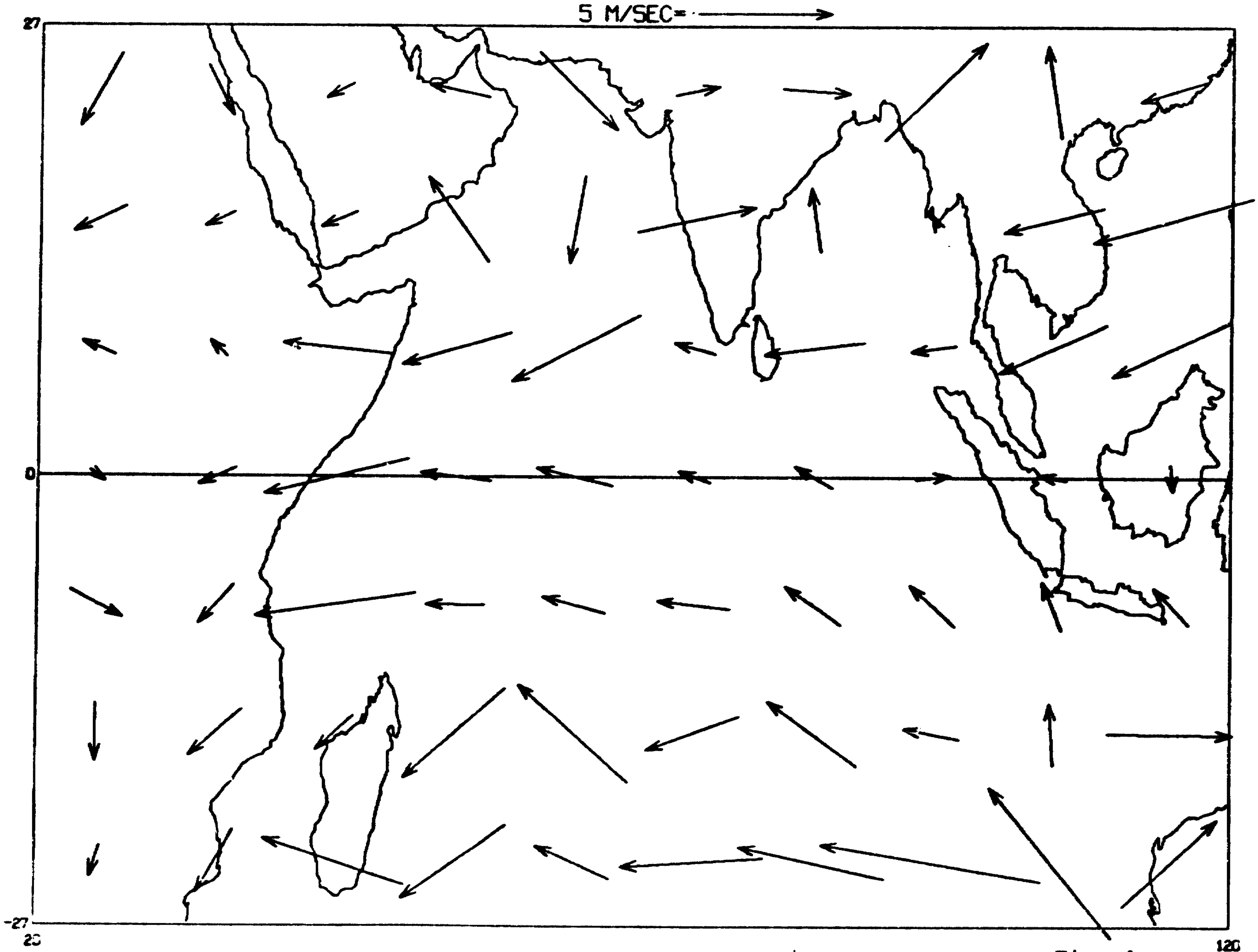


Fig. 4

SURFACE WIND RUN 5 THE AVERAGE OF 20 MONTHS

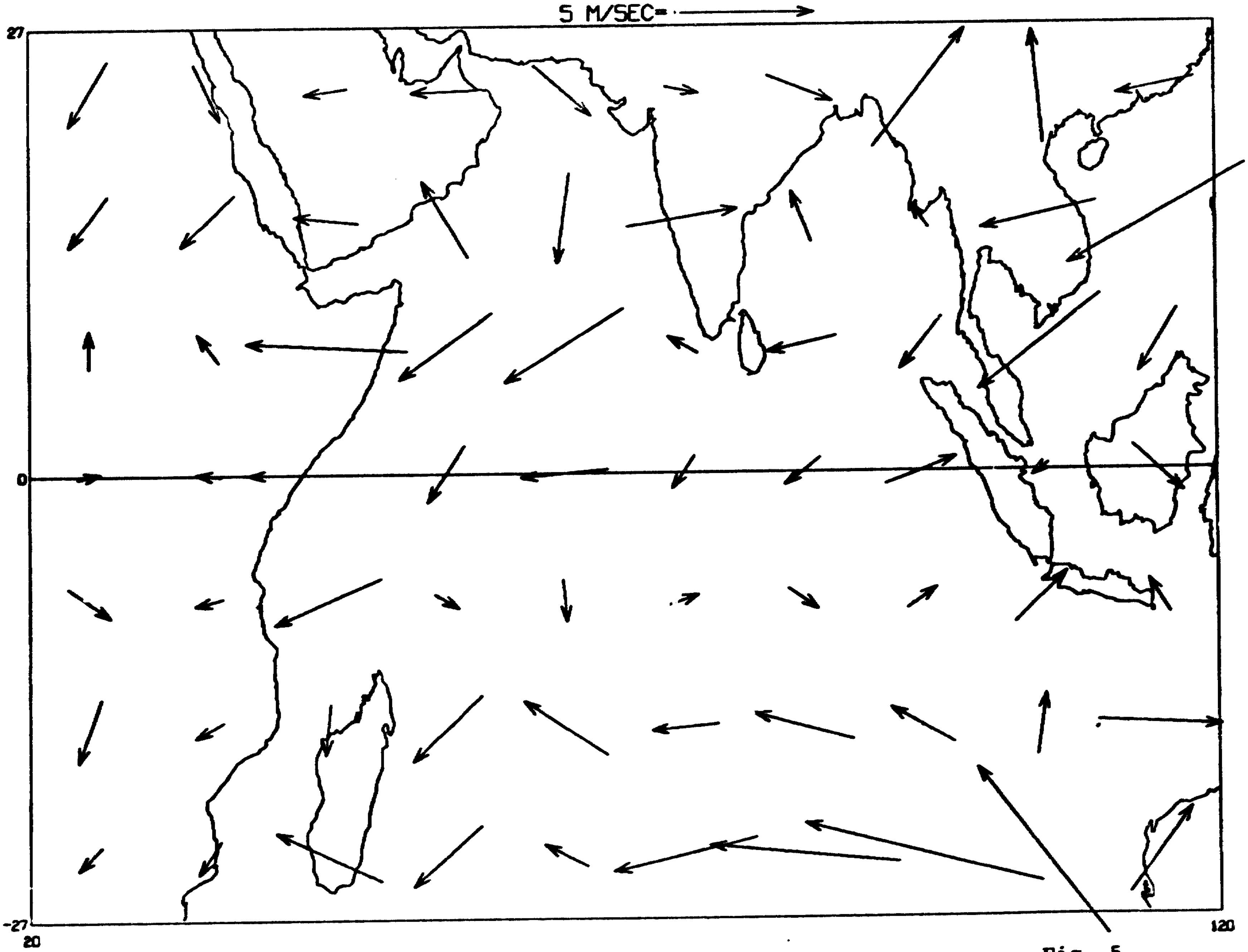


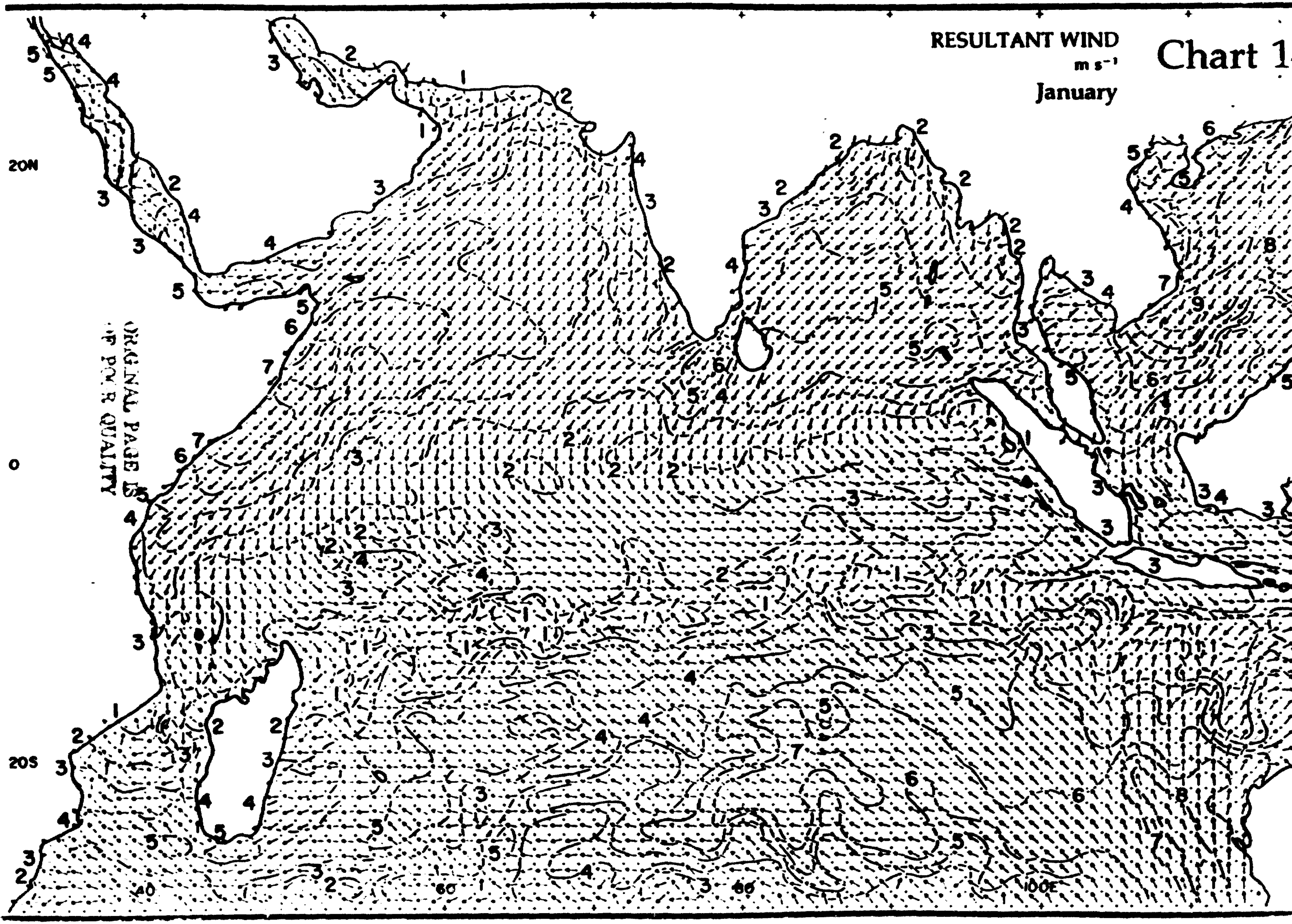
Fig. 5

Chart 1

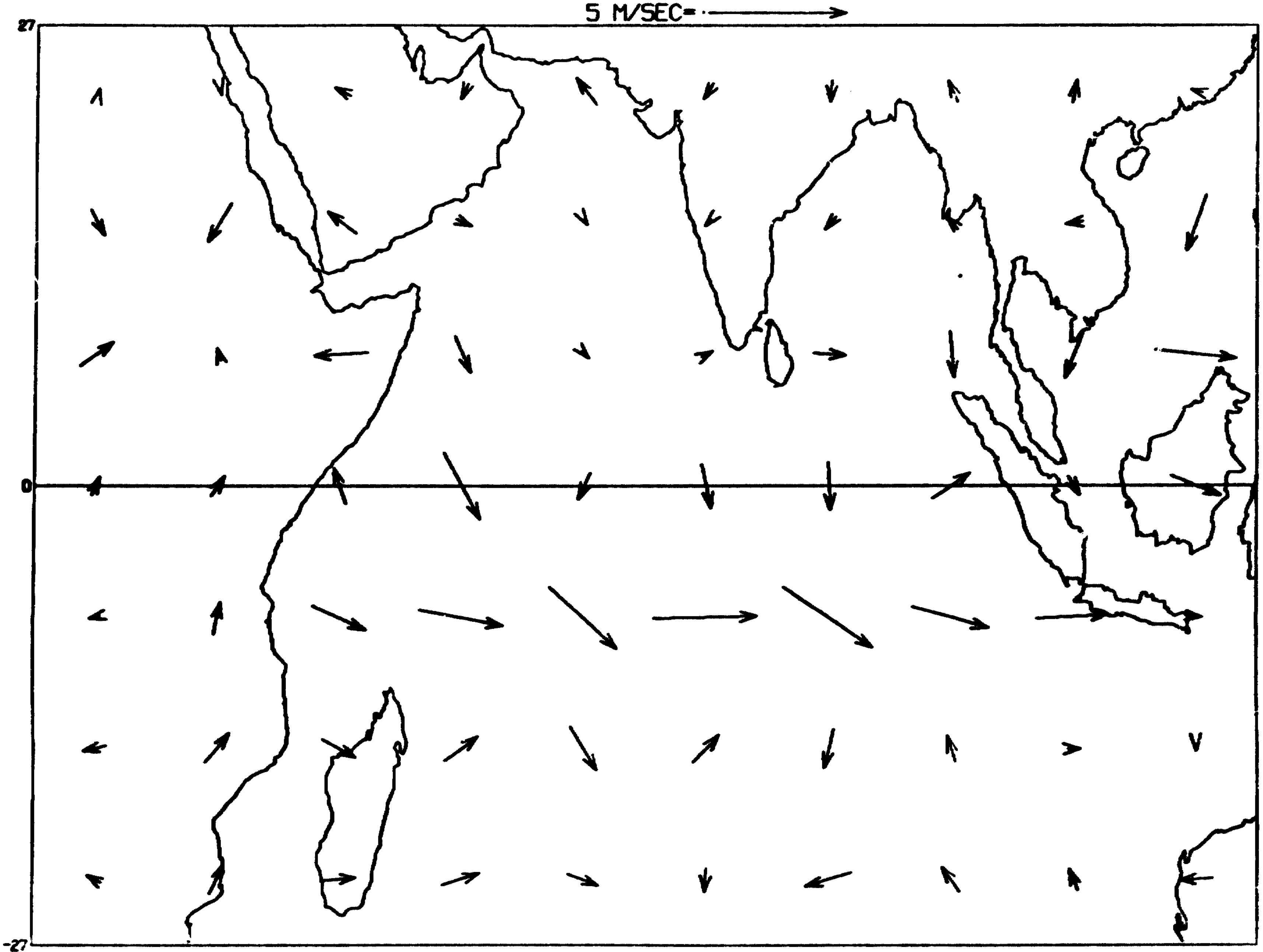
RESULTANT WIND

m s^{-1}

January



SURFACE WIND RUN 5 MINUS RUN 4 THE AVERAGE OF 20 MONTHS



components are significant at the 5% level. Similarly, fig. 9 shows the wind vectors only where the differences between the meridional components are significant at the 5% level.

In comparing fig. 8 with fig. 7 it can be seen that all of the difference vectors for which the zonal component is not statistically significant have an almost negligible zonal component. A comparison of fig. 9 and fig. 7 yields a similar conclusion regarding meridional wind components.

Summary

The GISS climate model was run in a perpetual January mode with a realistic SST field, and again with a zonally symmetric SST field. With zonally symmetric SST, cross equatorial flow at the surface of the Indian Ocean is mostly from south to north; when a realistic SST field is used, cross equatorial flow is reversed over most of the Indian Ocean, indicating that SST is an important factor in generating the Indian Ocean winter monsoon circulation.

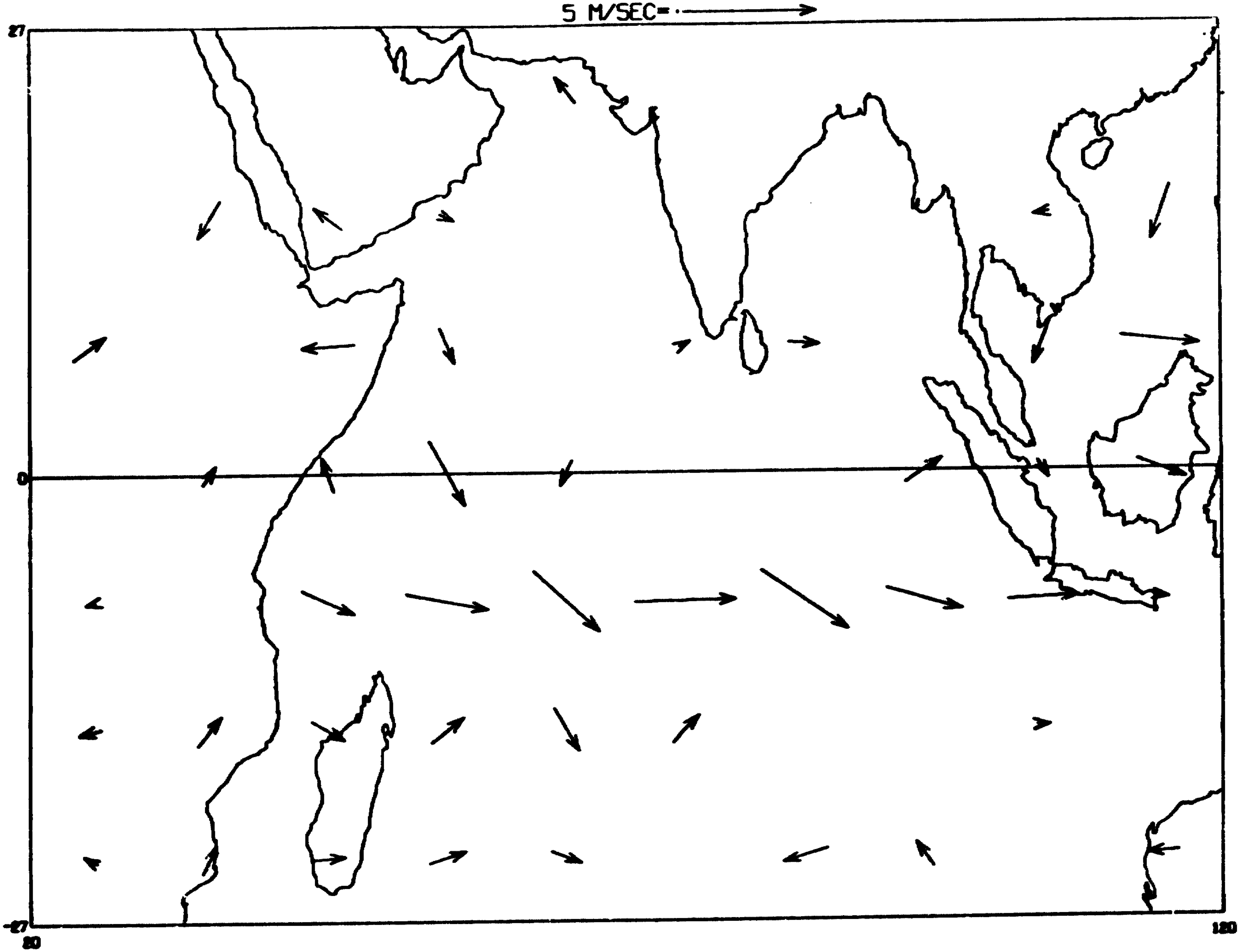


Fig. 8 Surface wind, run 5 minus run 4. Wind vectors are drawn only where the difference between the zonal components is significant at the 5% level.

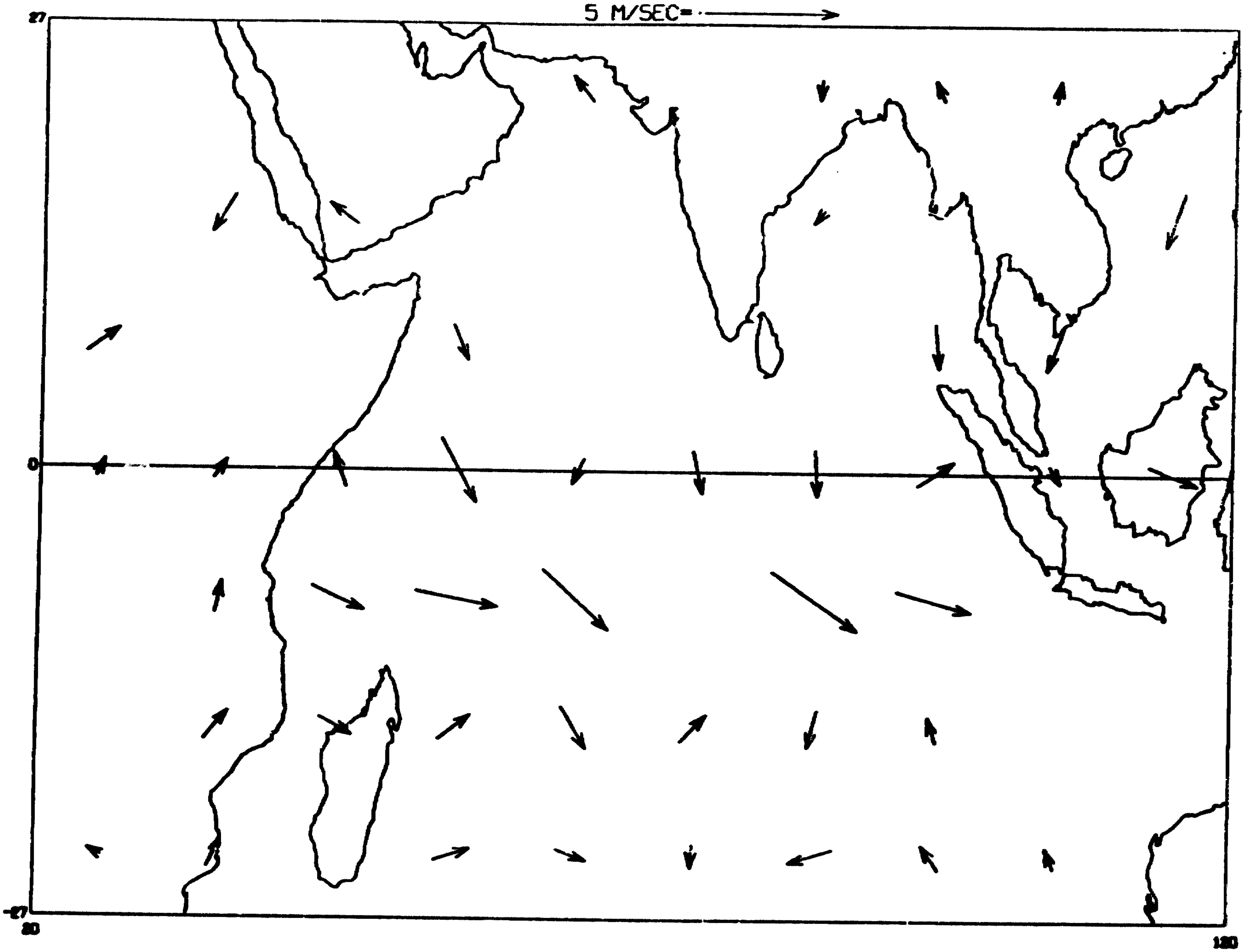


Fig. 9 Surface wind, run 5 minus run 4. Wind vectors are drawn only where the difference between the meridional components is significant at the 5% level.

References

Cohen, C., 1981: The effect of surface boundary conditions on the climate generated by a coarse-mesh general circulation model. NASA, Goddard Institute for Space Studies, Goddard Space Flight Center, New York, N. Y. 10025.

Hansen, J., G. Russell, D. Rind, P. Stone, A. Lacis, L. Travis, S. Lebedeff, and R. Ruedy, 1980: An efficient three-dimensional global model for climate studies. I. Model I. NASA, Goddard Institute for Space Studies, Goddard Space Flight Center, New York, N. Y. 10025.

Hastenrath, S. and P. J. Lamb, 1979: Climatic atlas of the Indian Ocean. Part I: Surface climate and Atmospheric circulation. The University of Wisconsin Press.

Saha, K., 1970: Zonal anomaly of sea surface temperature in equatorial Indian Ocean and its possible effect upon monsoon circulation. Tellus, 22, 403-409.

Washington, W. M., R. M. Chervin and G. V. Rao, 1977: Effects of a variety of Indian Ocean surface temperature anomaly patterns on the summer monsoon circulation: experiments with the NCAR general circulation model. PAGEOPH, 115, 1335-1356. Also appears in T. N. Krishnamurti, ed., Monsoon Dynamics, Birkhauser Verlag.