The analysis in terms of the cospectrum function permits the examination of the roles of eddies of frequencies as high as 4 cycles per day. An interesting feature is that whereas the mass and momentum fluxes due to transient eddies arise predominantly from long period eddies, significant contributions to heat fluxes result from shorter periods.

ACKNOWLEDGMENT

This paper is published by the permission of the Director of the Commonwealth Bureau of Meteorology.

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In his recent paper on the dynamics of the Inter-Tropical Convergence Zone (ITCZ), Bates (1970) assumes that the available moisture for condensational heating is that at the top of the Ekman boundary layer. Since the specific humidity decreases approximately linearly with height in the low levels and the Ekman layer depth varies with latitude, $\phi$, as $(\sin \phi)^{-1}$, the moisture factor in Bates's Eq. (24) for this heating is made to vary partially as $(\sin \phi)^{2}$. One implicit, striking result of this approach is that there is absolutely no available moisture at the Equator.

It would seem more realistic to take the humidity at cloud base, rather than that at the top of an Ekman layer which has little physical meaning in very low latitudes, when computing condensational heating in an idealized ITCZ model. Since the height of cloud base varies little over the range of tropical latitudes, and in particular is well inside the Ekman layer near the Equator, the available moisture would then be proportional to the specific humidity of the surface air. The condensation of this moisture would, of course, be dependent on the field of vertical motion.

Such a modification of Bates's theory might bring his calculated ITCZ closer to the Equator. Note that his Fig. 3 indicates a dry ITCZ directly on the Equator, a weak moist ICTZ at latitude 3° and a strong moist ITCZ at 14°; as the importance of condensational heating increases in Bates's model, the farther away from the Equator is the ITCZ. This result is physically curious but is clearly related to the parameterization of available moisture.
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Reference

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Reply

By J. R. Bates

It is true, as pointed out by Dr. Pike, that the condensational heating term in my ITCZ study varies as (sin $\phi$)$^{-1}$ and is thus zero at the Equator. The $(\sin \phi)^{-1}$ variation of the boundary layer depth, suggested by Ekman theory, is not without some observational support in low latitudes—see, for instance, Palmén (1963), Fig. 4, where the Equatorward mass flow at low levels is seen to be contained within a layer whose depth varies, with good approximation, as $(\sin \phi)^{-1}$.

There is little doubt that making the available moisture proportional to the specific humidity of the surface air, as suggested by Pike, would bring the ITCZ closer to the Equator. Alternatively, introducing a factor in the heating term to allow for the effect of latitudinally varying sea surface temperature, the importance of which has been emphasized by Pike's own studies (Pike 1971), could have the same effect. But even without incorporating any of these changes, there is a degree of degeneracy in the boundary layer model which allows a quasi-steady ITCZ to become established at different latitudes from the Equator up to about 15°, for the same physical parameters but with different initial conditions (see Charney 1968). In my paper, attention was concentrated on a case where there was a quasi-steady ITCZ well removed from the Equator, as being the most suitable basic state for studying the effect of zonally asymmetric disturbances.

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23 March 1971.