NOTES AND CORRESPONDENCE

Comments on "Further Evidence of Global-Scale, 5-Day Pressure Waves"

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In a recent article in this journal, Madden and Julian (1972) report on an analysis of long time-series of station pressure data from both hemispheres, which they say provides "Further Evidence of Global-Scale, 5-Day Pressure Waves." The question as to whether the traveling planetary-scale waves in the two hemispheres are parts of global-scale waves that extend across the equator, or are separately generated in their respective hemispheres and propagate mainly zonally with relatively little influence across the equator, is of considerable practical importance for forecasting models, for instance. Careful interpretation of statistical results is therefore very important. Examination of Madden and Julian's methods indicates that they do not provide evidence of inter-hemispheric connections, for the reasons discussed in this note.

After removal of fluctuations of periods longer $\gtrsim 10$ days, Madden and Julian have made a type of superposed-epoch analysis using the day on which a negative anomaly of the latitudinally averaged pressure in the tropics from 25S to 25N first appears at the Greenwich meridian as the key day. They then conclude, from their Fig. 4, that there is a "composite wave" apparently extending from about 60S to 60N. Among other aspects Fig. 4 shows that middle latitudes in both hemispheres have positive anomalies when the equatorial region does, and that the middle latitude anomalies propagate westward in phase with those in the equatorial region, thus appearing to extend across the equator in a manner similar to the theoretical mode represented in their Fig. 5.

Expressed in statistical terms, the observations in Fig. 4 show that the average value of the pressure in middle latitudes, both north and south, given an equatorial value, is approximately proportional to that equatorial value, or

$$E\{P_N | P_E; w(P_E)\} \approx \alpha_N P_E$$
$$E\{P_S | P_E; w(P_E)\} \approx \alpha_S P_E,$$

(1)

Madden and Julian have included only those time periods when the equatorial wave appeared to move all the way around the earth without interruption. This can be expressed as an additional condition, i.e.,

$$E\{P_N | P_E; w(P_E)\} \approx \beta_N P_N,$$
$$E\{P_S | P_E; w(P_E)\} \approx \beta_S P_S,$$

where $w(P_E)$ represents the equatorial wave condition.

Similar results would be obtained if the equatorial waves were extensions of waves in the respective hemispheres, of similar speeds (periods) but independent phases. Results of statistical analysis of the SIRS Nimbus 3 radiance data (Deland, 1973) indicate such influences on the equatorial region by waves in middle latitudes, in the stratosphere. We may hypothesize that the equatorial influence of either hemisphere is predominant during part of the time, due either to usually large amplitude in middle latitudes or conditions suitable for propagation into the tropics. Let us say that during the period $T_N$ under consideration, the Northern Hemisphere influences the tropics during $T_N$ and the Southern Hemisphere during $T_S$. During $T_N$, $P_N$ will thus be proportional to $P_N$ on the average, i.e.,

$$E\{P_E | P_N; \{T \subset T_N\}\} \approx \beta_N P_N,$$

so that

$$E\{P_N | P_E; w(P_E), \{T \subset T_N\}\} \approx P_E/\beta_N; \quad (2)$$

but since $P_E \approx P_N/\beta_N$ and $P_S$ is not correlated with $P_N$ during $T_N$

$$E\{P_S | P_E; w(P_E), \{T \subset T_N\}\} \approx 0.$$

Similarly,

$$E\{P_S | P_E; w(P_E), \{T \subset T_S\}\} \approx P_E/\beta_S,$$

and

$$E\{P_N | P_E; w(P_E), \{T \subset T_S\}\} \approx 0.$$

The overall averages of $P_N$ and $P_S$, conditional only on the value of $P_E$ and the wave condition $w(P_E)$, are then the same as the conditional averages above [Eq. (2)], corrected for the proportions of time that the equatorial
region is influenced by the respective hemispheres, i.e.,

\[
E(P_N | P_E; w(P_E)) \approx (P_E/\beta_N)(T_N/T) \\
E(P_S | P_E; w(P_E)) \approx (P_E/\beta_S)(T_S/T)
\]

which agrees with the observed relationships (1).

The principal effect of the equatorial wave condition \( w(P_E) \), in terms of our model, appears to be the exclusion of transition periods when influences of the two hemispheres are approximately equal and (by chance) approximately out of phase.

The results of Madden and Julian on coherence and phase angles between equatorial and extratropical latitudes are consistent with the above model, for the influence of the other hemisphere on the equatorial pressure is simply incoherent noise, which, in the mean, reduces coherence but does not change the phase.

It therefore appears that the results reported by Madden and Julian can be explained in terms of a simple model of middle latitude waves that extend into the tropics, and do not indicate any significant influences across the equator.

It would be worthwhile to repeat the analysis using, for example, key days based on the average pressure in the 30-50N latitude band. Any "global" traveling waves should appear in the results if examined as in Madden and Julian's Fig. 4.

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REFERENCES
