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OBSERVATIONAL STUDY OF THE REMOTE FORCING OF PACIFIC SUBTROPICAL HIGHS

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1. BACKGROUND

We show preliminary investigations of remote forcing mechanisms of the Pacific subtropical highs. To streamline the discussion, the Northern and Southern Hemisphere surface subtropical highs will be called the “NP high” and the “SP high” respectively. Three remote forcing views are considered:

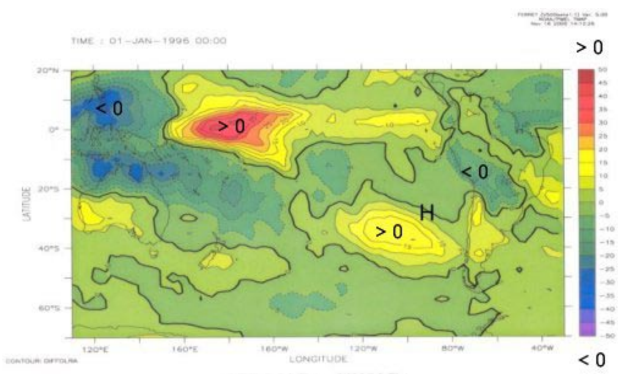
Current view: (e.g. Hoskins et al. 1999) rising motion and diabatic heating (precipitation) eastward and equatorward of the NP high creates sinking and surface equatorward motion on the E side of the high.

Classical view: (e.g. Grotjahn, 1993) diabatic heating that is mainly equatorward (“Hadley cell”) and/or westward (“Walker cell”) of the subtropical high maintains a divergent circulation having sinking over the subtropical high. A divergent circulation may connect Amazonian rainfall with the SP high overlapping with the current view. Such overlap is much weaker for the NP high.

Extratropical forcing view: Transient eddies interact with the subtropical highs in several different ways. The nature of the main interactions is unclear. So, we use two opposing working hypotheses to guide the initial research: 1) the extratropical cyclone storm track suppresses the areal extent of the subtropical high and 2) extratropical cyclones have local circulations that enhance the subtropical high. These are testable by examining terms in governing equations as well as the divergent circulation driven by eddy fluxes.

2. PRELIMINARY EVIDENCE

Some simple analyses justify opening the discussion of these 3 views. We first use monthly-averaged NCEP/NCAR reanalysis data so *nothing can be said about cause and effect*, only coincident activity. While precipitation (P) data is often criticized, this monthly P is presumably adequate here since we emphasize relative changes at each grid point.



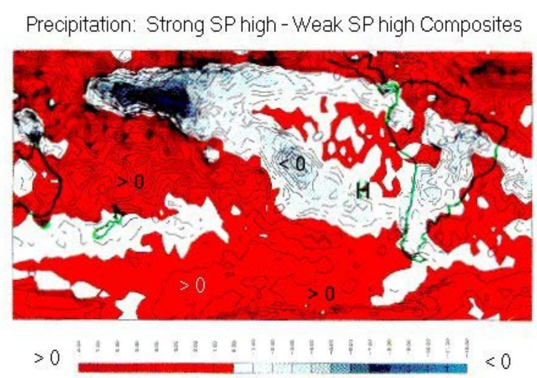


Fig. 1. Comparison of OLR and P composites for SH summer. The data record differs: JFM months from 1980-1999 for left plot and DJF from 1980-1994 at right. The months selected differ for the two plots. Yet, the major features are quite similar. Prominent in each figure is a shift of greater P (lesser OLR) over Papua New Guinea and the opposite in the western Pacific ICZ. H marks the location of peak SLP. Lat/lon ranges differ between figs.

Work with OLR data was halted due to lack of funds. However, simple composites (**Fig. 1**) are similar for OLR and P data. Correlations mentioned are those passing 5% significance tests. Color plots of figures 1 and 2 can be found at this website:
http://www-atm.ucdavis.edu/~grotjahn/Subhi
Also included are other figures plus a color version of this manuscript.

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A sampling of 1-point correlation data is given in **Fig. 2** using 6 different grid points surrounding the location of peak SLP for the NP high. Local summer conditions shown. Rank correlations are used because P data are skewed and single-signed. Generally, it is harder to pass a significance test with a rank correlation (2 tests used). A general property is that SLP on different sides of the NP high have associations with different remote phenomena, usually those on the same side. Two important exceptions are for the E and SE correlation points. There is **no** significant increased Central American P

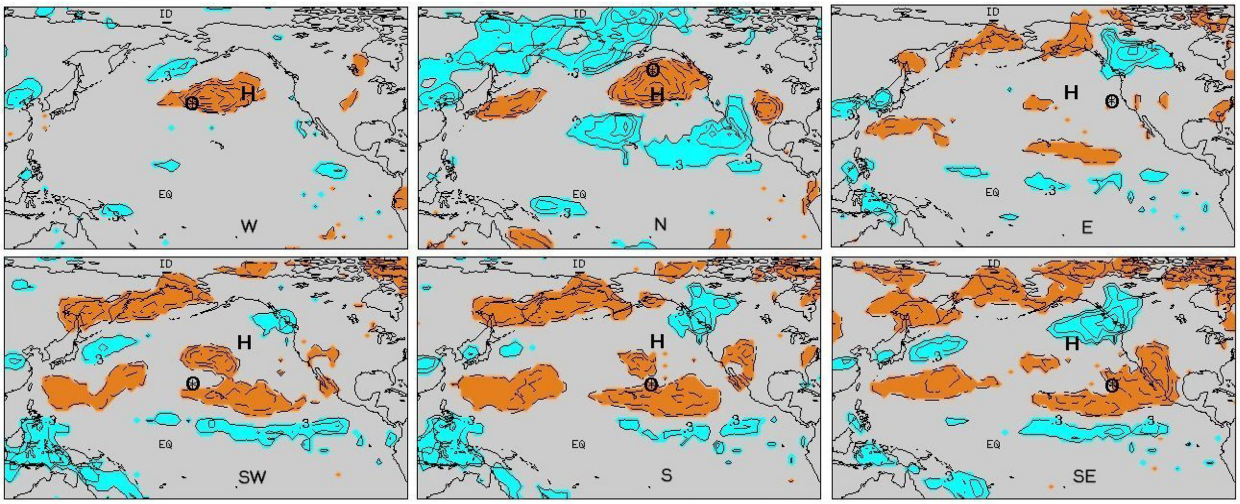

Fig. 2. 1-point correlations for the NP high during 15 summers (JJA). Shaded areas have correlation greater than 0.3 (magnitude) and also exceed 95% significance tests. H indicates the climatological location of maximum SLP for the NP high. O is centered at the correlation grid point. Cyan areas indicate more precipitation, brown indicate less. Locations are W, N, E of peak SLP (top row) and SW, S, SE of the peak SLP (bottom row, left to right). If figure is not in color for the W grid point panel: H is in a darker (brown) area and almost all other N Pacific areas are lighter (cyan).

associated with increased P on the east side of the high possibly contradicting the current view. The large area of significant correlation near and W of Central America is for **de**creased P, not increased as forecast by the current view. *Peak* correlations exceed 0.6 in most panels; for the S correlation point peak values are –0.74 and +0.67 for the storm track and +/-0.6 for the ICZ. **Fig. 2** also illustrates a limitation of the technique. Dipolar patterns appear (e.g. along the ICZ, along the midlatitude storm track) consistent with a shift of the band of P. Each panel in the bottom row shows a southward shift of the ICZ. Is the shift caused by higher SLP at the correlation points on the S side of the NP high? Or, does an ICZ shift southward lead to stronger SLP at these points? One could make a simple argument in support of each option; lag/lead: composites and correlations should resolve the issue.

For the SP high, correlations are not quite as high: latitudinal shifts of the ICZ (to the north) have correlation magnitudes ~0.5 for higher SLP on the N side of the SP high. Similar dipole correlations are seen for correlation points to the W, SW, and S of the SP high in apparent association with SPCZ and frontal cyclone track shifts away from the SP high center. (Please see the website for figures.) It is noteworthy that points to the W and E of the SP high peak location have **no** significant correlation with Amazonian P again contrary to the current view. Note: composite data (**Fig. 1**) have lower OLR but not high P over western S. America; but the months used differ.

3. PRELIMINARY CONCLUSIONS

If the current view describes the dominant process that enlarges the summer subtropical high, then evidence for that view should be prominent in the crude analyses above. An anomaly in P to the east should correlate with some anomalous property of the SLP. That is not seen. Instead, these experiments show that the issue is much more complex. There is evidence for remote forcing by the classical and extratropical forcing views. However, cause and effect cannot be discerned from monthly mean data. Additional work using other fields and techniques such as: lag/lead composites and correlations, numerical modeling (mainly to fill data voids) and Ertel PV tendency evaluation are pending adequate funding.

4. REFERENCES

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Hoskins, B., R. Neale, M. Rodwell, G.-Y. Yang, 1999: Aspects of the large-scale tropical atmospheric circulation. *Tellus*, **51A-B**, 33-44.