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ROLE OF TROPICAL CYCLONES IN LARGE-SCALE MOMENTUM, HEAT, AND MOISTURE BUDGETS

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1. INTRODUCTION

Standard calculations of eddy contributions to the zonal mean heat, moisture and momentum budgets use global meteorological analyses that poorly represent tropical cyclones (TCs). These calculations may greatly underestimate any storm-related eddy transports. Can the contributions from TCs to eddy transports be ignored? If the storms are important in the global heat, moisture, and momentum budgets, then it will be necessary to adequately represent their effect (by parameterization) in modest-resolution global models that can be applied to climate sensitivity problems. Here we will attempt to characterize the eddy transports associated with TCs in a controlled integration with an ultra-fine resolution global atmospheric general circulation model (GCM).

2. DATA AND METHODS

The GFDL "SKYHI" GCM has been integrated with a horizontal resolution of 0.33 degrees (N270) and a vertical resolution of 40 levels. In a single simulated Northern Hemisphere tropical cyclone season, this model produced at least 30 identifiable TCs, all in the western Pacific, including some very intense ones (Hamilton and Hemler, 1997). Output for the month of July is the focus of this study. There were seven typhoons in the model output for this month, including two super typhoons.

This study focuses on the longitude bands from 10-29N. A spatial smoothing function is applied to the SKYHI output to degrade the resolution from N270 to roughly N25 (3.6 degrees), which largely removes the signature of tropical cyclones. The spatial smoothing function follows the work of Sardeshmukh and Hoskins (1984). Total eddy transports are calculated from the full model output using 12 hour snapshots, and are compared with transports computed with the smoothed output over the entire domain. In order to isolate the effect of typhoons on the eddy flux, a smaller region directly around the location of the typhoons are smoothed, and compared with the unsmoothed full model output.

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3. RESULTS

3.1 EDDY MOMENTUM FLUX

The total eddy meridional flux of westerly momentum calculated with the full model output reach values of 35 m^2s^{-2} (Fig. 1). When the full model output are compared with the data smoothed over the full data set, total fluxes are decreased by 5 m^2s^{-2} (~10%) (Fig. 2).

When these calculations are extended to employ a processing that smoothes only in the vicinity of intense TCs, the contributions to eddy transports from the TCs can be isolated. All the TCs that occurred during the month were located within the longitude band from 120-150E. This is 1/12 of the total longitude band, yet it accounts for 1/5 of the total fluxes in the momentum fields (Fig. 3). The greatest effect appears to occur in the lower latitiudes.

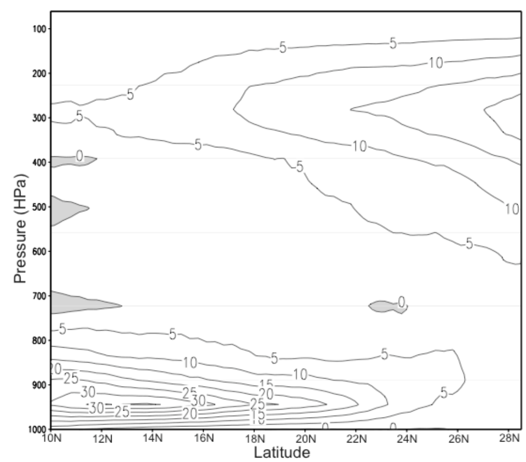

Fig. 1. Eddy momentum flux calculated from the full model output. Contour interval is 5 m^2s^{-2}.

3.2 EDDY HEAT FLUX

Smoothing over the entire domain, values of eddy heat flux decrease by an average of ~10%. When the smaller area surrounding the TCs was smoothed, there appears to be a large influence of the storms on eddy heat flux south of 20N. The eddy heat flux for the storms contributes to 50% of the heat flux that was smoothed over the entire domain in the 800-600hPa levels in the latitude band from 12-18N. This value is also ~10% of the total heat flux calculated from the unsmoothed full model results. The effect of the TCs becomes less important north of 20N and accounts for only 1% of the overall eddy heat flux. Similar to the eddy momentum flux, the TCs effect on eddy heat flux appears to be largest in the lower latitudes.

3.3 EDDY MOISTURE FLUX

The eddy moisture flux is most prominent in the lower levels below ~720Hpa. When the whole data set is smoothed, the eddy moisture flux decreases by 10-25%. When the smoothed range is decreased to cover just the area of the TCs, the fluxes are 15-30% less than the fluxes calculated with the entire domain smoothed. This value is 10% of the total fluxes in the latitudes south of 15N, and has a large drop off in the latitudes from 15-29N (< 1%). The largest impact on eddy moisture fluxes are seen further south, and decrease to the north.

4. DISCUSSION

When the signature of the TCs are removed, the greatest decrease in the eddy momentum, heat and moisture flux is seen the longitude bands south of 20N. It appears as if small scale fluxes are enhanced in this region as a result of TC activity. These results indicate that the influence of TCs may have an effect on the global eddy heat, momentum, and moisture fluxes, and may need to be included in future circulation models.

5. FUTURE WORK

In order to test the importance of this northwest Pacific region on the overall fluxes, longitudinal bands will also be calculated in the other 12 sectors for comparison (eg. 0-30E, 30-60E, etc.). Additionally, calculations will be made to determine how much of the flux are due to stationary fluxes and how much are due to transient fluxes.

6. REFERENCES

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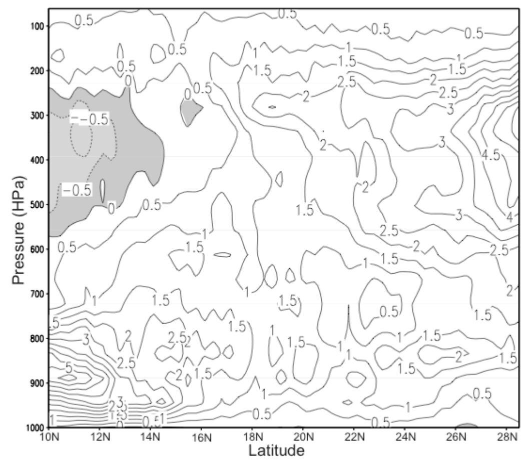

Fig. 2. Mean monthly eddy momentum flux calculated from the full model output minus the eddy momentum flux calculated from the smoothed output. Contour interval is .5 $m^2 s^{-2}$.

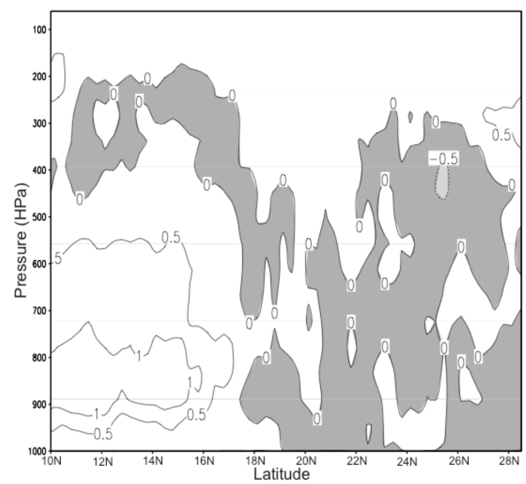

Fig. 3. Mean monthly eddy momentum flux calculated from the full model output minus the eddy momentum flux calculated with the smoothing applied to the region around the TCs . Contour interval is .5 $m^2 s^{-2}$.