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TITLE: The Effect of Latent Heat Release on Synoptic-to-Planetary Scale Wave Interactions and Implications for Satellite Observations: Observational Study

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SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

We have continued our diagnostic studies of observed atmospheric phenomena in which latent heat release may influence the interaction between synoptic and planetary-scale circulations. We have also extended this work to include diagnostic studies of forecasts of these interactions by the Community Climate Model (CCM) at the National Center for Atmospheric Research (NCAR).

Our previous work has identified an indirect role of latent heat release (inferred from satellite data) in one case of synoptic-planetary scale interaction studied, i.e. in the formation of a large blocking pattern following the landfall of Hurricane Juan (1985). Specifically, latent heat released in the Hurricane's rainfall modified the temperature field in such a way that 500 mb height rises forced by warm air advection and associated with the block development were larger than they would have been without the latent heat release.

The rate at which the 500 mb anticyclone in the blocking pattern intensified, in part due to the latent heat enhanced warm air advection, was significantly larger than the average intensification rate of 500 mb anticyclones in a large sample we have studied. We have termed this process rapid 500 mb anticyclogenesis, and have constructed a synoptic climatology of this phenomenon as well as of rapid 500 mb cyclogenesis. Most such anticyclones are observed north of the 500 mb westerlies and thus may be regarded as cutoff or blocking systems. Many are observed downstream of rapidly intensifying surface cyclones. In a separate case study, we have diagnosed the contributions to 500 mb height rises in one such anticyclone and found them to be due almost exclusively to warm air advection downstream of an intense oceanic surface cyclone. Since it is well known that latent heat release is an important physical process in these rapidly intensifying surface cyclones, as in hurricanes, then we hypothesize that the released heat is enhancing the warm air advection in the same way as found in the Hurricane Juan case. However, we need to diagnose this possibility with satellite data.

We have found that operational short-range forecasting models underpredict rapid 500 mb anticyclogenesis, as well as associated upstream surface cyclones. We hypothesize that misforecast latent heat release in the cyclones leads to the 500 mb anticyclone's forecast error.

The accuracy with which Atlantic Ocean surface cyclones are forecast at short and medium range by the NCAR CCM depends, in the sample studied, upon the initial conditions. Initial states with faster than normal 500 mb geostrophic westerlies over the western Atlantic Ocean are followed in time by intense and poorly predicted oceanic surface cyclones. Hemispheric forecast skill deteriorates rapidly in these cases. In one such case studied, the synoptic-planetary scale wave interactions are poorly forecast at short and medium range at 500 mb over the Atlantic Ocean. Initial states with weaker than normal westerlies over the western Atlantic are followed in time by relatively weak and better forecast oceanic surface cyclones. Hemispheric forecast skill is maintained in these cases through the medium range, on average, and skillful 30-day forecasts was occasionally noted. One such diagnosed case revealed that synoptic-to-planetary scale interaction at 500 mb over the Atlantic Ocean was well-forecast through the medium range. It is hypothesized that skillful extended-range forecasts of surface cyclones and that this may in turn depend upon the initial conditions. Forecasts of intense oceanic surface cyclones for which latent heat release is known to be important could potentially be improved by incorporating satellite information into the initial conditions.

FOCUS OF CURRENT RESEARCH:

We have been exploring alternative methods to facilitate the prediction of rapidly intensifying surface cyclones. Recognizing that synoptic-scale systems, such as these cyclones, are less predictable at medium range and beyond than are planetary-scale circulations, we propose that the planetary-scale environment for explosive cyclogenesis could be better predicted than the cyclones themselves. We have therefore constructed a planetary-scale climatology of explosive cyclogenesis by compositing together filtered 500 mb height fields (retaining planetary waves only) corresponding to a large sample of rapidly intensifying surface cyclones, stratified geographically and according to the direction of 500 mb geostrophic flow (southwesterly, northwesterly or westerly) over the cyclone center. The composites are calculated from five days preceding to five days following each rapid cyclogenesis event, and have climatology subtracted so that the evolution of planetary-scale anomalies before and after cyclogenesis can be followed. Whether the anomalies are distinct from background variability and thus provide predictive value is now being evaluated.

Following explosive cyclogenesis over which the filtered 500 mb flow is southwesterly, there appear in the composites large positive 500 mb height anomalies downstream. In some cases, these anomalies are associated with blocking patterns. Whether the objectively-defined blocking patterns in the data set are preceded by upstream intense surface cyclone activity is being investigated.

Finally, the contribution of synoptic-scale processes, notably warm air advection, to planetary-scale height rises during a block formation following an explosive cyclogenesis event is being diagnosed. We hope to eventually evaluate the impact of satellite derived latent heat release upon the warm air advection in this case.

PLANS FOR NEXT YEAR:

We wish to explore the possibility that incorporating satellite-derived latent heat release into the initial fields of an extended-range forecast may improve the forecast accuracy. To accomplish this, we plan to perform forecast experiments with the NCAR CCM. In these experiments, the CCM initial latent heating (forecast from other variables) will be replaced with satellite-derived estimates of the heating, using Dr. Pete Robertson's precipitation algorithm. The cases to be selected will feature forecasts of explosive surface cyclogenesis at different times after the initial time. The purpose of these experiments will be to assess the impact of the satellite-modified initial conditions upon forecasts of cyclones early in the forecast cycle, and upon forecasts of the background planetary-scale environment preceding later cyclones. The initial time will be moved forward in a set of experiments designed to assess the utility of updating an extended-range forecast cycle with satellite information.

MANUSCRIPTS PREPARED IN THE PAST YEAR:

Alberta, T.L., S.J. Colucci and J.C. Davenport: Rapid 500 mb cyclogenesis and anticyclogensis. (submitted to Monthly Weather Review).

Colucci, S.J. and D.P. Baumhefner: Initial weather regimes as predictors of numerical long-range forecast accuracy. (submitted to the Journal of the Atmospheric Sciences).