Analysis of Hurricane Catarina (2004)

Ron M^{c}Taggart-Cowan
Department of Earth and Atmospheric Sciences,
University at Albany

Lance F. Bosart
Department of Earth and Atmospheric Sciences,
University at Albany

Christopher A. Davis
National Center for Atmospheric Research

Eyad H. Atallah
Department of Atmospheric and Oceanic Sciences,
McGill University

John R. Gyakum
Department of Atmospheric and Oceanic Science,
McGill University

May 9, 2005

The development of Hurricane Catarina over the western South Atlantic Ocean in March 2004 marks the first time that the existence of a hurricane has been confirmed by satellite imagery in the South Atlantic basin. The storm undergoes a complex lifecycle, beginning as the extratropical precursor moves east-southeastward off the Brazilian coast and towards the mid-latitudes. Its eastward progress is halted and the system is steered back westward towards the Brazilian coast as it encounters a strengthening dipole

(Rex 1950) blocking structure east of the South American continent. Figure 1 shows a conceptual schematic of the interaction between the block and the evolving vortex. The strengthening of the anticyclonic blocking component (Fig. 2) results in the reorientation of the steering flow and a reduction in the vertical shear over a large area above the storm. Entering this weak shear region, Catarina begins a tropical transition process (Davis and Bosart 2004) over anomalously cool 25°C ocean waters (Fig. 3). As the convective outflow from the developing tropical system reinforces the ridge component of the dipole block (Fig. 2 as expected from the conceptual model shown in Fig. 1), the storm is accelerated westward towards the Santa Catarina province of Brazil and makes landfall there as a nominal Category 1 hurricane.

The complex evolution of the system is analyzed using a suite of diagnostic tools and a conceptual model (Fig. 1) of the tropical transition and steering processes in the presence of a dipole block is developed. Once the essential properties of the upper-level flow are established, an analog study is undertaken to investigate lower-atmospheric responses to similar blocking regimes. Persistent dipole blocking structures are found to be rare east of South America; however, the evolution of systems occurring during these periods is shown to be complex and to possess varying degrees of subtropical development modes.

References

Davis, C. A., and L. F. Bosart, 2004: The TT problem. *Bull. Amer. Meteor. Soc.*, **85,** 1657–1662.

Rex, D. F., 1950: Blocking action in the middle troposphere and its effect upon regional climate. I. An aerological study of blocking action. *Tellus*, **2,** 196–211.

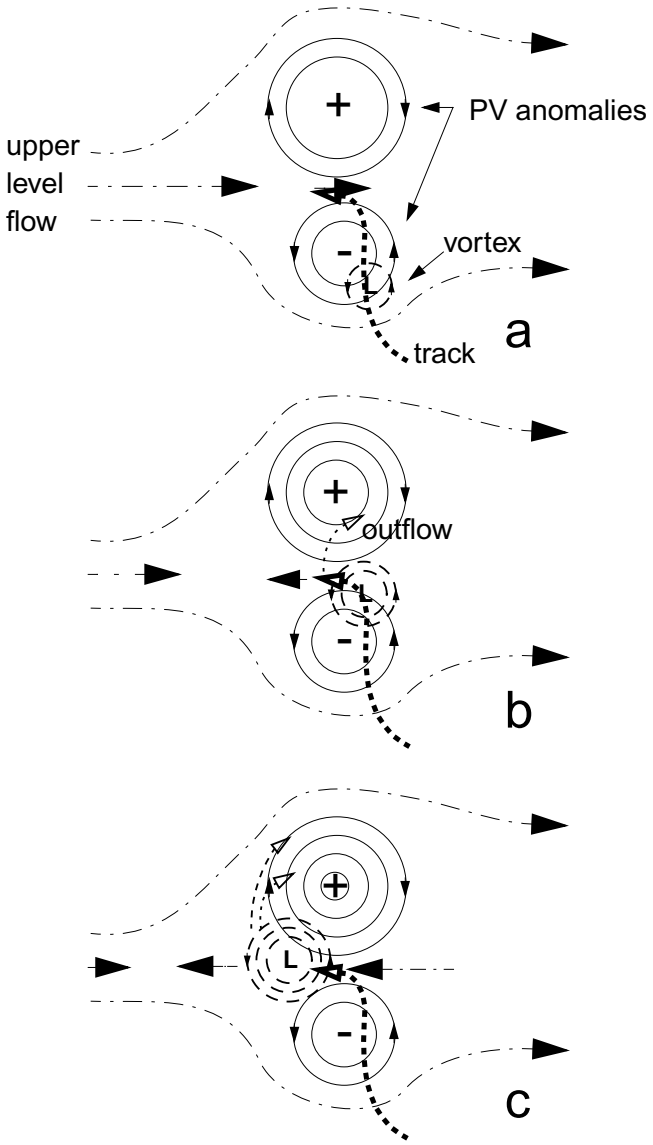

Figure 1: Conceptual model of a TT in a dipole blocking environment. The blocking component PV anomalies are signed as indicated, with relative magnitudes proportional to the number of concentric rings surrounding the feature. The direction of the upper-level flow is represented by the dash-dot vectors in all panels and labeled in (a). The track of the precursor and hurricane vortex is indicated by the heavy dotted line and open arrow. The lower-level circulation itself is represented by an "L" and is surrounded by a number concentric circles that increases with increasing storm intensity. The outflow from the system as it undergoes TT is indicated by a thin dashed line and open arrows in (b) and (c).

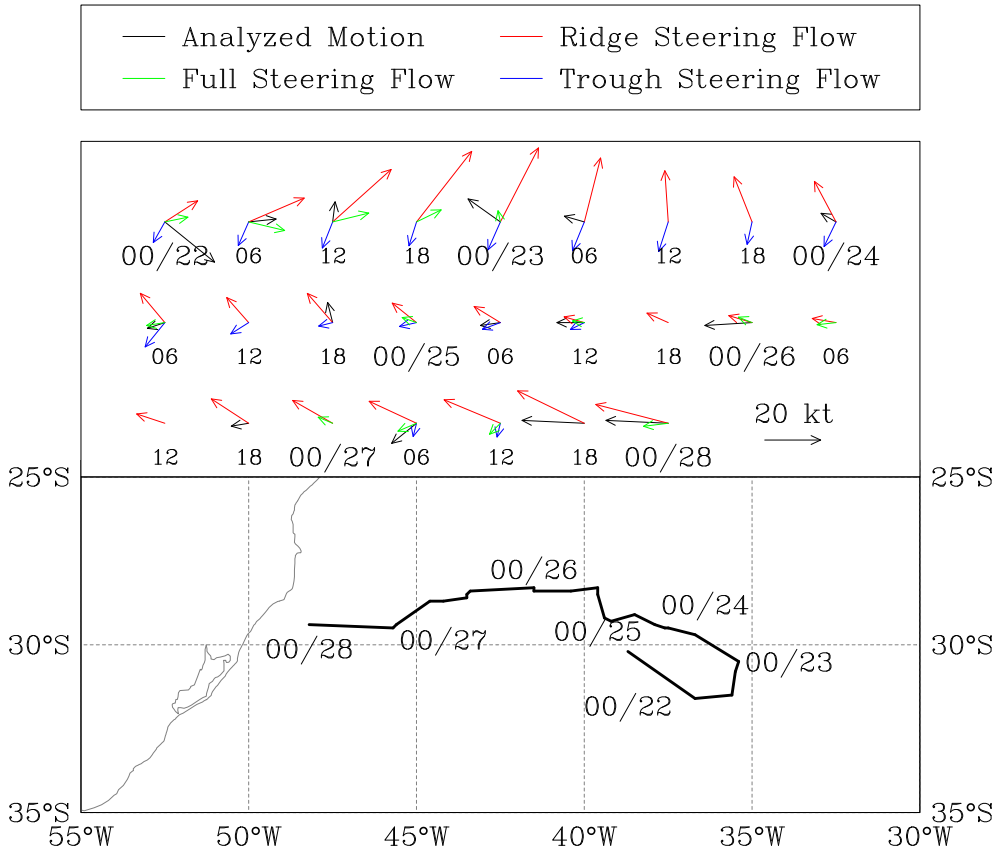

Figure 2: Steering flow diagnosis for Hurricane Catarina's full lifecycle. Catarina's track is shown in the bottom half of the plot, with instantaneous storm locations indicated by the date stamps. The vectors in the top half of the plot are color coded as indicated in the legend and represent the analyzed storm motion vector (black), the full steering flow (green), the steering flow contribution from the ridge component of the dipole block (red) and the steering flow contribution from the trough component of the block (blue). Steering and motion vectors are plotted at 6 h intervals as indicated by their associated date stamps and represent both the magnitude (scaled against the reference vector in the lower-right corner of the panel) and the direction of the component forcing.

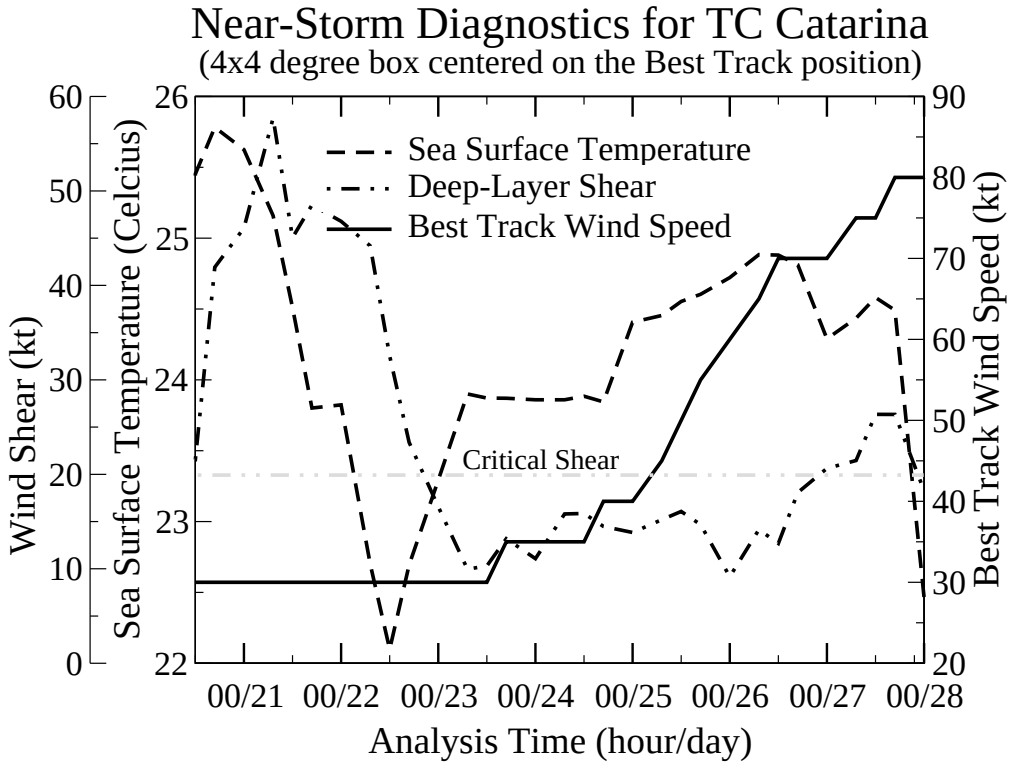

Figure 3: Near storm time series of sea surface temperature (dashed line), deep layer shear (dynamic tropopause to 850 hPa, dash-dotted line) and Best Track wind speed (compiled by Roger Edson). The approximate threshold shear value of 20 kt is shown with a grey dash-dotted line. The $4^\circ \times 4^\circ$ box follows the storm center at 6 h intervals.