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2001-2003 REAL-TIME USE OF CYCLONE PHASE DIAGRAMS TO IMPROVE STRUCTURAL DIAGNOSIS & FORECASTING

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1. Introduction

Since summer 2001, cyclone phase diagrams (Hart 2003) have been made available in real-time at the URL http://moe.met.fsu.edu/cyclonephase. These diagrams have been used both experimentally and operationally by various tropical cyclone forecast centers in the United States and Canada. Initially, the diagrams were being used exclusively for forecasting extratropical transition (ET) of tropical cyclones (Evans and Hart 2003); however, in the past two years, the diagrams have been increasingly used for structural forecasting of subtropical cyclones and cold-core to warm-core evolution. The lifecycle evolution of several cases will be examined demonstrating how the cyclone phase diagrams aided the forecast process for structural evolution and forecast uncertainty estimation.

2. Methodology

1° NCEP AVN, 1° Canadian CMC, 1° U.S. Navy NOGAPS, and 0.56x0.83° UKMO UKMET model data are used for synoptic analyses, and also are the grids upon which the cyclone phase diagrams are based (both analysis and forecast).

3. Updated Objective N. Atl. ET Geography

The distribution of ET completion points in the period 1997-2003, as defined by Evans and Hart (2003), is shown in Fig. 1 for AVN and NGP-based cyclone phase diagrams. Their distribution is much more uniform than the NHC-based partially-subjective diagnosis, which tends to cluster along the southeast U.S. coast, and east of the Maritimes.

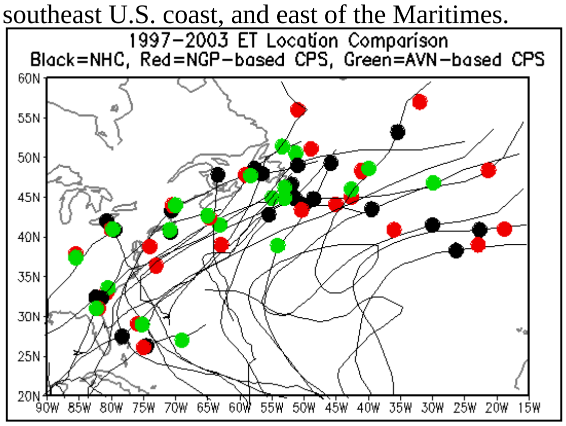

Figure 1: Distribution of ET completion location for 20 (34) storms 1997-2003 based on AVN, NGP data.

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4. May 2001

Out of a band of disorganized cloudiness (Fig. 2a), the operational models initialized on 3 May 2001 unanimously forecast a cyclone to develop. The nature of the development was in question, with the AVN predicting a cold-core baroclinic evolution (Fig. 3a, 4a), and the CMC (not shown) & NGP a warm-core evolution (Fig. 3b, 4b). The nature of forecast evolution is not apparent from either the MSLP or 500hPa height field alone, but is revealed clearly when examined from a cyclone phase perspective (Fig. 3). Based upon recent model performance, the AVN-based forecast was accepted and indeed the verifying cyclone evolution was asymmetric cold-core (not shown, but see Fig. 2b).

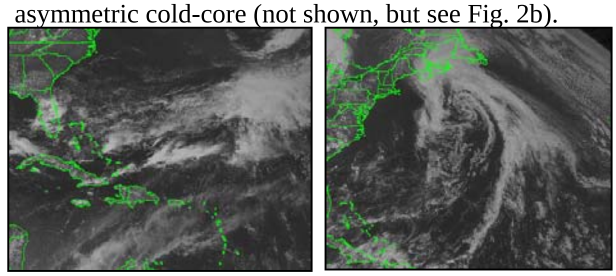

Figure 2: Visible satellite imagery at a) 1800 UTC 3 May 2001 and b) 1800 UTC 9 May 2001.

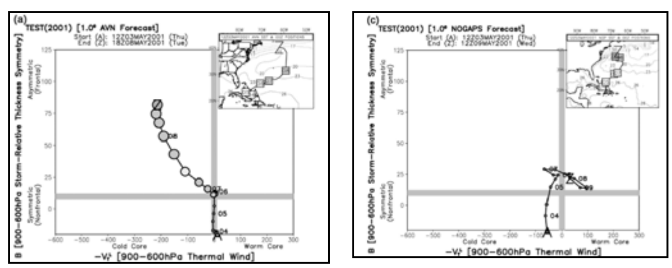

Figure 3: Model-forecast cyclone phase diagrams of forecast cyclone evolution for a) AVN and b) NOGAPS, both initialized at 1200 UTC 3 May 2001.

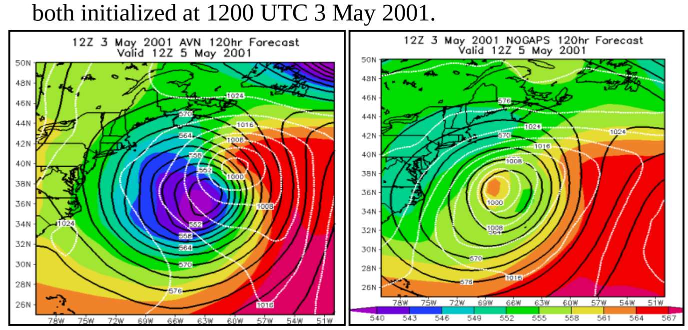

Figure 4: 120-hr model forecast 500hPa height (black contour), 1000-500hPa thickness (shaded), and MSLP (white contour) valid 1200 UTC 5 May 2001.

5. Hurricane Michelle (2001)

Michelle underwent extratropical transition at the lowest latitude on record, approximately 23° (compare to Hart and Evans 2001). However, model forecasts of the structural evolution varied from model to model, and from one initialization time to the next (Fig. 5). Early model runs (blue/green) forecast a very intense ET event, with an upper trough interacting directly with the TC. However, subsequent runs (orange/red) changed the timing of interaction with the trough, leading to forecasts of absorption of the cyclone before ET would complete. Thus, this example represents an excellent case of the relationship between cyclone/trough interaction and structural forecasting. Verification of model-analysis and forecast cyclone structure has begun using AMSU-based cyclone phase diagnostics (Fig. 6).

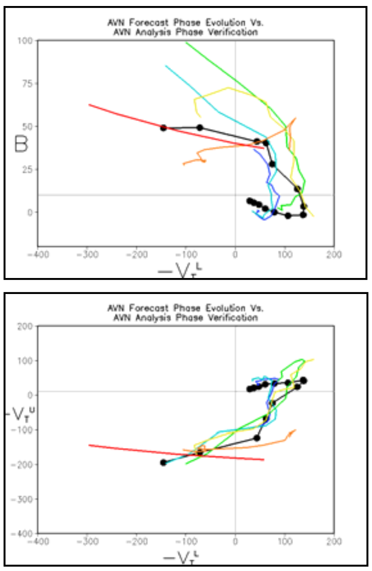

Figure 5: 1-6 November 2001 AVN spaghetti plot of consecutive model-forecast cyclone phase trajectories (colorized) and model-analysis verifying phase trajectory (black, with marks) for a) B vs. $-V_T^L$ and b) $-V_T^L$ vs $-V_T^U$. Cold colors indicate earlier initialization times and warm colors indicate later over the six day period.

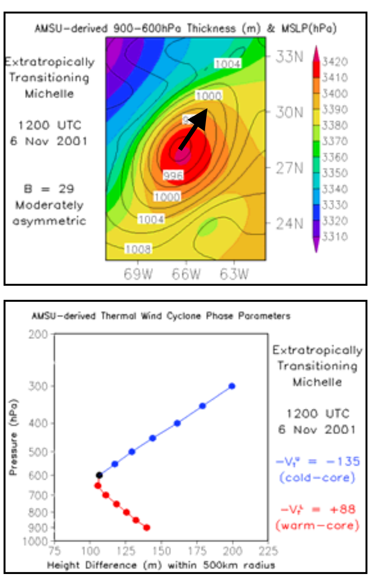

Figure 6: Example of preliminary cyclone structural diagnosis and model verification using AMSU-based cyclone phase parameters. a) Derivation of phase parameter B from the AMSU-based 900-600hPa thickness and storm motion. b) Derivation of phase parameters $-V_T^L$ and $-V_T^U$. These values can be compared to Fig 5 for validation.

6. (Sub)Tropical Ana (2003)

Five to six days in advance of Ana's development, numerical guidance was indicating (as evidenced in the CPS diagrams) that the development of a subtropical low was likely. Diagnostics from conventional analyses (not shown) did not provide such clear indication of warm-core development at so early in the year (April). For a short period of time after reaching subtropical status, Ana became a strong tropical storm (Fig. 8b), and then underwent extratropical transition--also well-anticipated by later model runs' phase diagrams (not shown). Ana represents a classic case where the phase diagrams provide a more insightful perspective on the nature of impending cyclone development than was possible prior to their implementation.

7. Acknowledgments

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8. References

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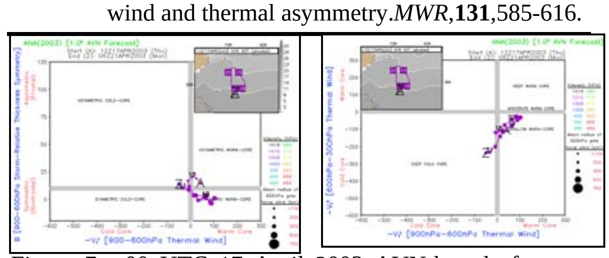

Figure 7: 00 UTC 17 April 2003 AVN-based forecast cyclone phase evolution. The development of an increasingly warm-core, symmetric cyclone from an open wave (Figure 8a) is illustrated.

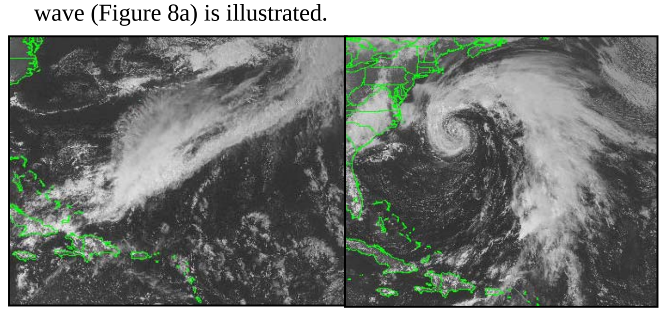

Figure 8: Visitible satellite imagery at a) 1800 UTC 14 April 2003 and b) 1800 UTC 19 April 2003.