9.3 **MECHANISMS THAT PROPAGATE POLAR SATELLITE-DERIVED ATMOSPHERIC MOTION VECTOR INFORMATION INTO LOWER LATITUDES**

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1. INTRODUCTION

The use of Atmospheric Motion Vectors (AMVs) in NWP (Numerical Weather Prediction) models continues to be an important source of information in data sparse regions. These AMVs are derived from a time-sequence of images from geostationary and polar orbiting satellites. NWP centers have documented positive impact on model forecasts not only in regions where the AMVs are measured, but elsewhere as well. One example is the effect of the Moderate Resolution Imaging Spectroradiometer (MODIS) polar winds on forecasts in the middle and subtropical latitudes (Key et al, 2003).

Using a pre-operational version of the National Centers for Environmental Prediction's (NCEP) Global Forecast System (GFS), a side-by-side experiment was run for a six week period, with and without the MODIS polar winds. This experiment began on 10 Aug 2004. Several cases within this period have been examined to determine how winds in the polar regions may affect the height and wind fields in lower latitudes. Two basic possibilities are investigated: a) An adjustment in the mass field by the three-dimensional variational (3DVAR) assimilation system and b) Dynamical considerations in the vicinity of the polar jet stream.

By using a combination of model analyses and forecasts, with sophisticated visualization techniques, an attempt is made to separate and quantify the relative importance of each effect.

2. 3DVAR CONSIDERATIONS

To determine the effect of the 3DVAR assimilation, analyses early in the experiment are examined to see if adding data in the polar regions affects the model fields in other areas.

The first two figures depict the speed difference at 800 hPa between the model run with and without the MODIS winds. These are a global images with the dateline in the middle. North and South America are regions on the right hand side with little difference (relatively flat). The yellow is close to zero difference; the brown to black is up to a +7 m s^{-1} difference; the green to blue is from -1 to -6 m s^{-1} difference. A positive difference indicates the model run with MODIS winds has higher wind speeds at that location. The contours are 800 hPa geopotential heights.

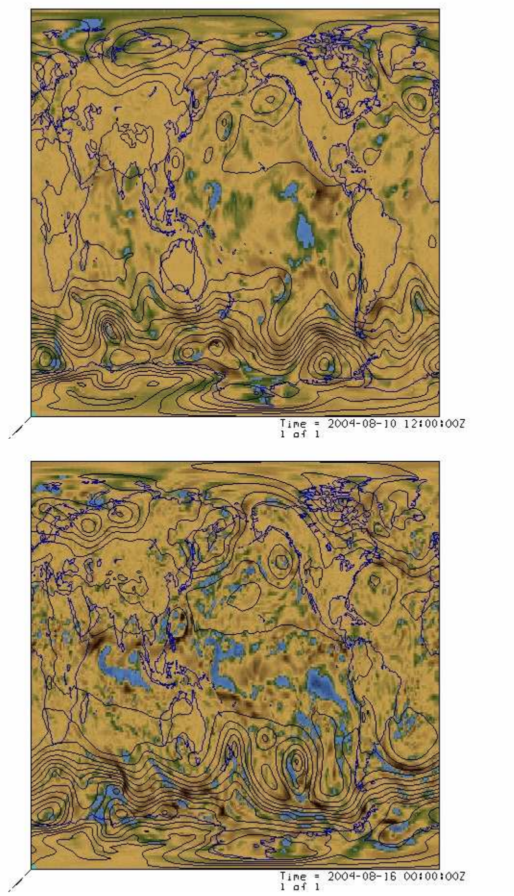

Figure 1: Speed difference (shaded) at 800 hPa with 800 hPa geopotential height contours. (a) 12 hours into the experiment. (b) 6 days into the experiment.

Figure 1a is the speed difference in the analysis 12 hours into the experiment at 800 hPa. Even though this is only 12 hours into the model run, significant differences are found from the polar regions to the tropics. Because of the adjustments to observations in a 3DVAR, the effects of the MODIS winds can be found in regions away from the actual measurements and more immediate than normal propagation would suggest. The biggest effect is in regions where there is no observations, most notably the lack of radiosondes. Note that there is little difference over the land regions. Figure 1b is from 6 days into the model run. There is finer-scale structure to the

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differences with the largest differences in the Roaring 40s and in the ITCZ across the Pacific and into the Indian Ocean.

3. DYNAMICAL EFFECTS

The majority of the MODIS AMVs are from tracking clear-sky water vapor features just below the tropopause, in the 300 to 500 hPa (5 to 9 km) layer north of the polar jet.

Figure 2 is from Palmén and Newton (1969) showing a vertical cross-section from the equator to the pole. It shows that parcels originating north of the polar front (labeled PFJ) near the tropopause, may eventually be found in the lower troposphere in the subtropics: “cold air sinks and spreads out in the lower troposphere as it moves equatorward (Palmén and Newton, 1969).” Since the MODIS winds are derived in this region north of the PFJ, we would expect trajectories to show this equatorward motion.

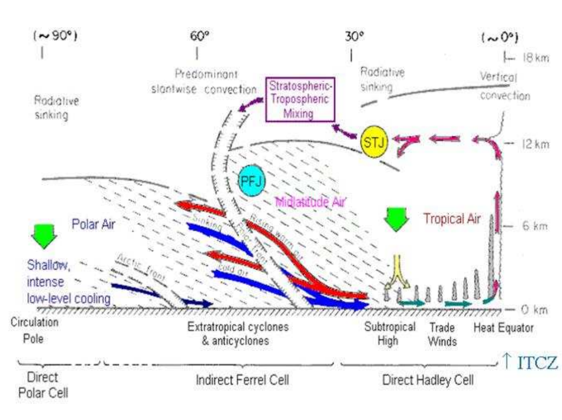

Figure 2: Vertical cross-section from the equator to the pole. This is from Palmén and Newton (1969).

Figures 3a (view from the top) and 3b (edge-on looking northward) show trajectories originating in Siberia make their way to the western US in about 48 hours, descending from about 8-9km to the surface. This is consistent with Figure 3.

Even though these mechanisms propagate information into the lower latitudes, the largest differences in the forecasts appear in the polar jet region. Figure 4 is a visualization of GFS model output over North America from an 84 hour forecast, valid 20 Sep 2004 at 1200 GMT, using the Integrated Data Viewer (IDV). The cyan contours are the 400 hPa geopotential height field. The green isosurfaces represent differences greater than 25 gpm in the height field between a model run using the MODIS winds and a control run. These green volumes are where the MODIS winds had an effect of raising the height field. If the isosurface is centered on a trough or ridge, that indicates a stronger ridge (for example, over Hudson Bay) or weaker trough. If the isosurface is displaced from the trough center, that indicates a phase shift in the trough location (for example, the region in the Pacific Northwest). As expected, the largest differences in the height field are in the vicinity of the polar jet. These differences are smaller in the early forecast periods and grow over time as the forecast fields diverge. This example is about one month into the MODIS winds assimilation experiment.

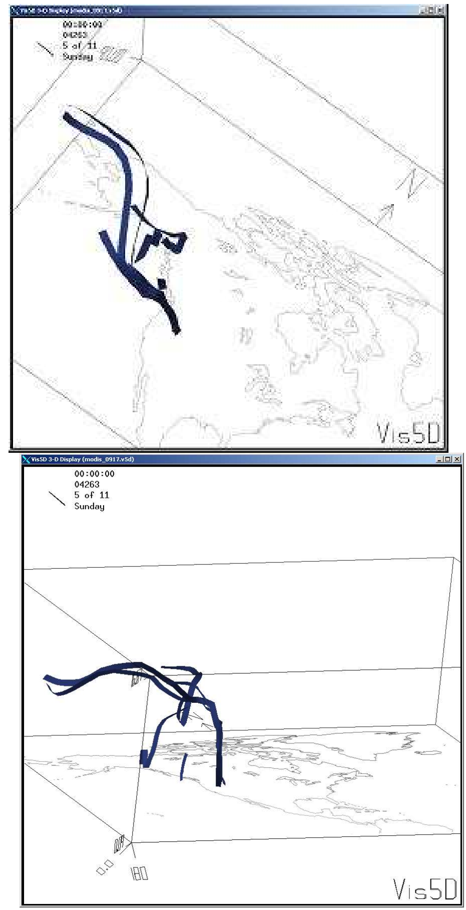

Figure 3: Forecast parcel trajectories from the GFS model over a 48 hour period, ending at 0000 GMT on 20 Sep 2004.

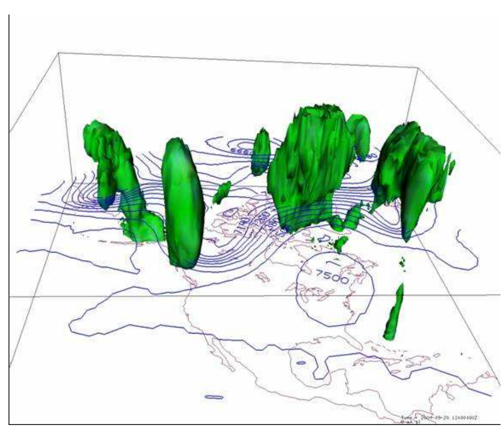

Figure 4: GFS model output from an 84 hour forecast valid at 1200 GMT on 20 Sep 2004.

4. SUMMARY

This is still early in the research, but there is evidence that the 3DVAR assimilation and dynamics in the vicinity of the polar jet both contribute to propagating information from polar-derived AMVs into the mid- and lower-latitudes. The status will be presented at the conference.

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5. REFERENCES

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Palmén, E., and C. W. Newton, 1969: *Atmospheric Circulation Systems: Their Structure and Physical Interpretation*. Academic Press, 603 pp.