Forecasting Winter Cyclogenesis

This article will focus on some remote sensing capabilities related to forecasting winter cyclogenesis.

The predictability of winter-season cyclogenesis has long been one of the most challenging aspects of winter weather. Certainly, the typical key forecast parameters are foundational to the event onset, precipitation types and durations, and the post-event conditions (e.g., freezing, melting, re-freezing, avalanche). We often look to the jet stream pattern, both at analysis time and forecast by various models. In the CONUS, it's possible to have two very active jet streams in various stages of their lifecycle interacting with each other. Typically, amplified flow will bring cold/dry or warm/moist large scale air flows into these systems.

One of the most useful satellite image loops during the winter season is the so-called "water vapor" imagery. This imagery, available from the NOAA Geostationary Operational Environmental Satellites (GOES) and other GOES-like satellites globally, offers the meteorologist a view of the water vapor depth as seen from outer space. Typically, in areas with thunderstorms and opaque cirrus shields, the height of the water vapor being sensed is very high in the atmosphere. In the remaining areas, the imagery shows the variation in water vapor in a layer centered around 400 mb. In the days and hours before a major cyclogenesis event is forecast, the water vapor imagery can be used to provide some key clues related to the existence, evolution or formation of shortwaves, their origins, and their likely paths toward a synoptic or even meso-scale cyclogenesis event.

Shown below are a series of three GOES water vapor images. The first image (Figure 1) shows a jet streak/short wave trough which will lead to a major cyclogenesis event and snowstorm for the east coastal areas of the mid-Atlantic. Figure 2), showing more amplification of the longwave trough, now also depicts a key satellite signature of cyclogenesis. This key signature is known as a "baroclinic leaf" and can be seen in the blue/green cold cloud tops over AL, western GA, and western FL. Finally, in the third image (Figures 3), the full-scale cyclogenesis has occurred and becomes evident by the large area of subsidence shown in the peach color. Note the deformation zone located from coastal Maine to central Ohio. Also shown are areas of convection near the center of the cyclone and in the cirrus shield ahead of the cold front.

In closing, you might wonder, is that the state-of-the-art ? Good question. The answer can now be found on the National Weather Service Advanced Weather Interactive Processing System (AWIPS) and other data systems which process and display the GOES Sounder data. By making images of the GOES sounder data, water vapor images at 300 mb (6.5 um), 500 mb (7 um), and 700 mb (7.4 um) can be displayed to show jet streaks/shortwave troughs at three additional different layers in the atmosphere. In the case shown below, a northern jet stream shortwave (shown) combines with a southern-jet stream shortwave (not shown) earlier in time to produce a very large scale rapid cyclogenesis event. GOES sounder images are shown in images 4 and 5 below (Figures 4 and 5).

For more information, animations, and examples, visit the Virtual Institute for Satellite Integration Training (VISIT) website at:
http://rammb.cira.colostate.edu/visit/modelinit/title.asp
http://rammb.cira.colostate.edu/visit/cyclo.html

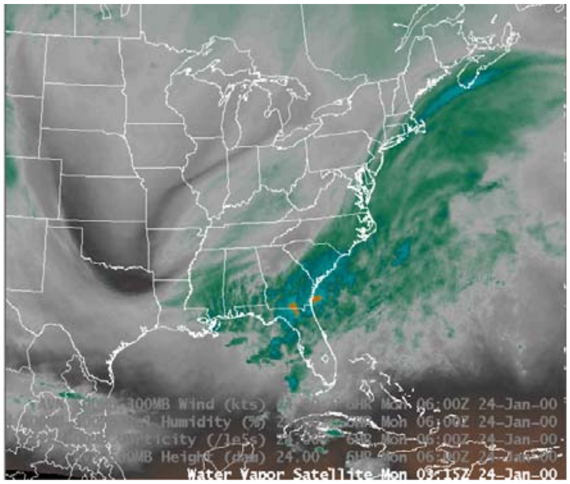

Figure 1: GOES-8 Imager 8km Water Vapor valid at 3:15 UTC, 24 January 2000. Shown in the darker colors in northeast Texas is the northern stream shortwave which will produce underforecasted or unforecast cyclogenesis. You may recall this event became nicknamed the "no surprise" snowstorm. The middle of the layer being sensed by the GOES imager in areas where opaque cirrus exists is about 400 mb.

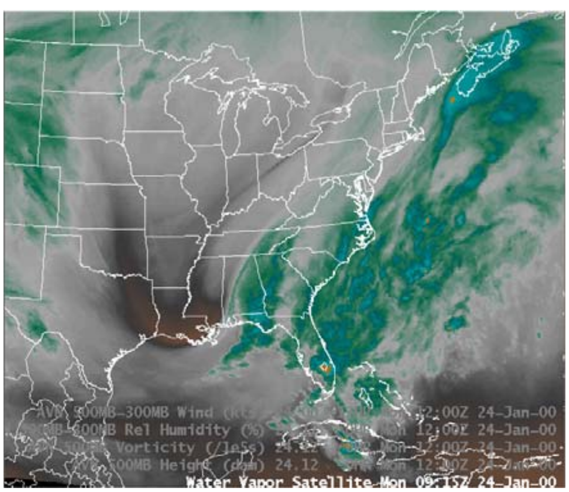

Figure 2. GOES-8 Imager 8km Water Vapor valid at 9:15 UTC, 24 January 2000. Shown in the dark and peach colored area centered on LA is the much more pronounced signature of the northern and southern stream shortwaves and the related initial cyclogenesis and baroclinic leaf signature.

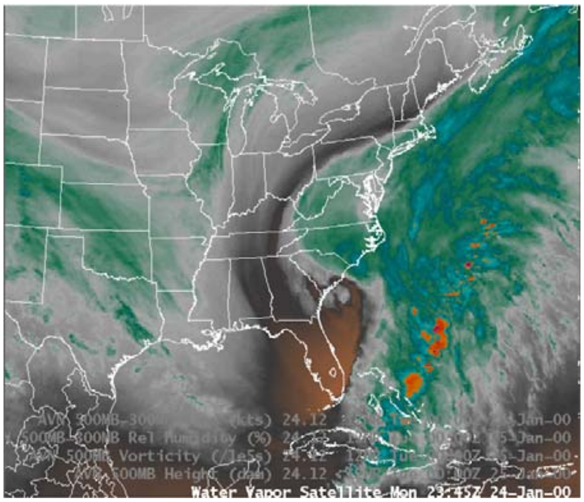

Figure 3. GOES-8 Imager 8km Water Vapor valid at 23:45 UTC, 24 January 2000. Cyclogenesis and further intensification are shown with the classic synoptic scale features of a low pressure system. Note the cyclone center, close to the coast of South Carolina indicated by convection developing near the center of the circulation. The warm/moist and cold/dry air flows (conveyor belts) are now evident. This image also shows the deformation zone along the northern extent of the cirrus shield from Ohio to Maine.

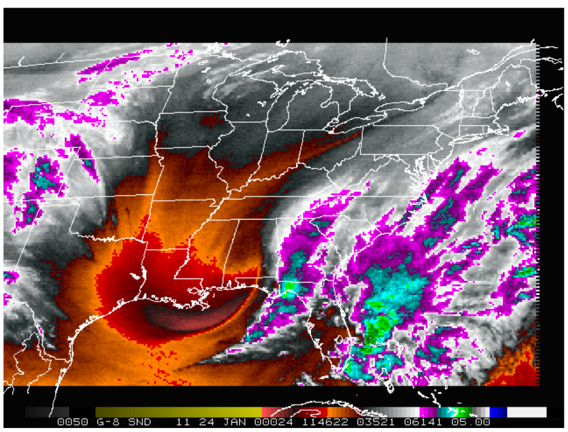

Figure 4. GOES-8 Sounder 10km Water Vapor valid at 11:46 UTC, 24 January 2000. This water vapor channel senses moisture in the layer from 500 mb to 900 mb with the greatest contribution coming from about 700 mb. Notice the differences and similarities with the imager water vapor in the areas without cirrus and where thin or middle clouds are present.

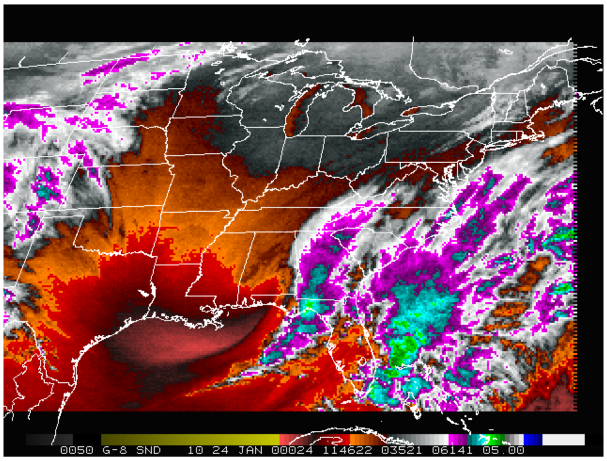

Figure 5. GOES-8 Sounder 10km Water Vapor valid at 11:46 UTC, 24 January 2000. This water vapor channel senses moisture in the layer from 300 mb to 700 mb with the greatest contribution coming from about 500 mb. The structures of the opaque cirrus regions versus the areas where "vapor" can be seen show the higher-level view of the shortwave and the surrounding airflows. A third, higher layer water vapor channel, is also available.

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