ATMO 352
Severe Weather and Mesoscale Forecasting
Spring 2007

Laboratory #6: Introduction to GOES, GOES image data, and the Enhanced-V severe weather signature

Section 502, Friday
2-23-07
Due: By beginning of next lab session (3-2-07)

Introduction: The purpose of this laboratory assignment is to introduce you to operational meteorological satellites, basic data interpretation, and severe weather indicators. We will focus specifically on NOAA's Geostationary Operational Environmental Satellites (GOES) and GOES imager products and interpretation, including visible, (long-wave) infrared, and water vapor channels.

Background: GOES satellites provide the continuous monitoring necessary for CONUS (CONtinental United States)-wide real-time weather forecasting. They circle the Earth in a geosynchronous orbit. In other words, they orbit Earth's equator at a speed matching the Earth's rotation, allowing them to remain continuously at about 35,800 km (22,300 miles) above a fixed location on the surface of the Earth. From this perspective, the GOES has a full-disc view of the Earth. Because they stay above a fixed location, they provide continuous monitoring of atmospheric "triggers" of severe and significant weather. GOES are able to monitor the pre-convective environment for these triggers and then track storm movements once they develop.

Table 1. GOES imager instrument characteristics. Source: http://www.oso.noaa.gov/goes/

GOES Imager Instrument Characteristics					
Channel number:	**1 (Visible)**	2 (Shortwave Infrared or IR)	**3 (Moisture or Water Vapor)**	**4 (Long Wave IR 1)**	5 (Long Wave IR 2)
Wavelength range (μm)	**0.55 - 0.75**	3.80 - 4.00	**6.50 - 7.00**	**10.20 - 11.20**	11.50 - 12.50
Instantaneous Geographic Field of View (IGFOV) at nadir	**1 km**	4 km	**8 km (GOES-11)** **4 km (GOES-12)**	**4 km**	4 km

The GOES Imager is a five channel (one visible, four infrared) imaging radiometer designed to sense radiant (i.e., emitted) and solar reflected energy (Table 1). In this class, we will focus on channels 1 (Visible), 3 (Water Vapor), and 4 (IR – longwave). There are two primary GOES for operational forecasting: 1) GOES – CONUS EAST (GOES-12 centered over 75° W longitude) and 2) GOES – CONUS WEST (GOES-11 centered over 135° W longitude). GOES-10 is also operational serving its mission over South America. GOES-9 currently serves as back-up. Depending on your location of interest over CONUS, you may wish to analyze data from one or both GOES-EAST and GOES-WEST satellites.

There are three operational imaging modes for GOES. The modes are 1) Routine Operations, 2) Rapid Scan Operations (RSO), and 3) Super Rapid Scan Operations (SRSO). Tables 2 and 3 below provide information on the coverage, scan duration and scan times for GOES-EAST and GOES-WEST, respectively, during Routine Operational mode.

Table 2. GOES-EAST Imager Scan Sectors in Routine Mode.

Frame Name	**Boundaries**	**Duration (mm:ss)**	**Scan Times (UTC)**
Full Earth	Earth Edge	26:16	0245, 0545, etc
Extended N Hemisphere	20S-66N/45-120W	14:16	xx15, xx45
Southern Hemisphere	20-50S/30-120W	4:53	xx10, xx40
CONUS	14-60N/60-125W	4:45	xx00, xx30

Source: http://www.class.ncdc.noaa.gov/release/data_available/goes/index.htm

Table 3. GOES-WEST Imager Scan Sectors in Routine Mode.

Frame Name	**Boundaries**	**Duration (mm:ss)**	**Scan Times (UTC)**
Full Earth	Earth Edge	26:10	0000, 0300, etc
Northern Hemisphere	0-66N/90W-170E	9:00	xx00, xx30
Southern Hemisphere	0-45S/115W-170E	7:00	xx22, xx52
PACUS	12-60N/90-175W	5:00	xx15, xx45

Source: http://www.class.ncdc.noaa.gov/release/data_available/goes/index.htm

During Rapid Scan Operations (RSO) and Super Rapid Scan Operations (SRSO), imagery is collected more frequently over increasingly reduced areas. During GOES RSO, four views of CONUS are provided at approximately 7.5 minute intervals in a 30 minute period. A northern hemisphere scan for both GOES-EAST and GOES-WEST is also included in each 30 minute cycle. This schedule yields eight views of the continental U.S. per hour for RSO. RSO is a special imaging schedule that can be activated by any National Weather Service (NWS) Weather Forecast Office (WFO) for any operational situation it deems necessary.

During GOES Super Rapid Scan Operations (SRSO), approximately 10 one-minute interval scans are provided every 30 minutes over specially prescribed 1000 km x 1000 km sectors. The remaining time in the half hour cycle is devoted to scans of the northern hemisphere and CONUS (or sub-CONUS for GOES-WEST). When GOES RSO or SRSO is utilized, most of the southern hemisphere is not scanned.

Reading: To complete this lab, you should first carefully read “Satellite Meteorology: Online Remote Sensing Guide” by the University of Illinois WW2010 Project at the following internet web site: http://ww2010.atmos.uiuc.edu/(Gh)/guides/rs/sat/home.rxml. A more detailed and up-to-date description of the current GOES along with real time image data can be found at http://www.oso.noaa.gov/goes/. More online GOES image data can be found at "some useful weather links" accessible via our class web page at http://www.met.tamu.edu/class/atmo352/.

The Enhanced-V Cloud Top Signature: A Satellite IR Indicator of Severe Storms

Background:
Since the 1980's (e.g., McCann 1983, Monthly Weather Review), operational forecasters have used the "**enhanced-V**" cloud top feature found in enhanced IR GOES imagery as a signature of imminent or ongoing severe weather (e.g., tornado or large hail). The enhanced-V signature is essentially a v-shaped structure of colder (enhanced) IR cloud top temperatures accompanied by a downwind warm spot (or warm wake) in the IR cloud top temperature. The enhanced-V is formed when strong upper-level winds are diverted around an overshooting thunderstorm top. The warm spot downwind of the overshooting top is associated with either 1) subsiding (and hence warming) air downwind of the updraft core or 2) upward rising air downwind of the updraft (that is due to a hydrodynamic pressure gradient and) that enters the stratosphere where it mixes with the warmer air. An example of three simultaneous enhanced-V's during a tornadic event over Texas is shown below in Figure 1.

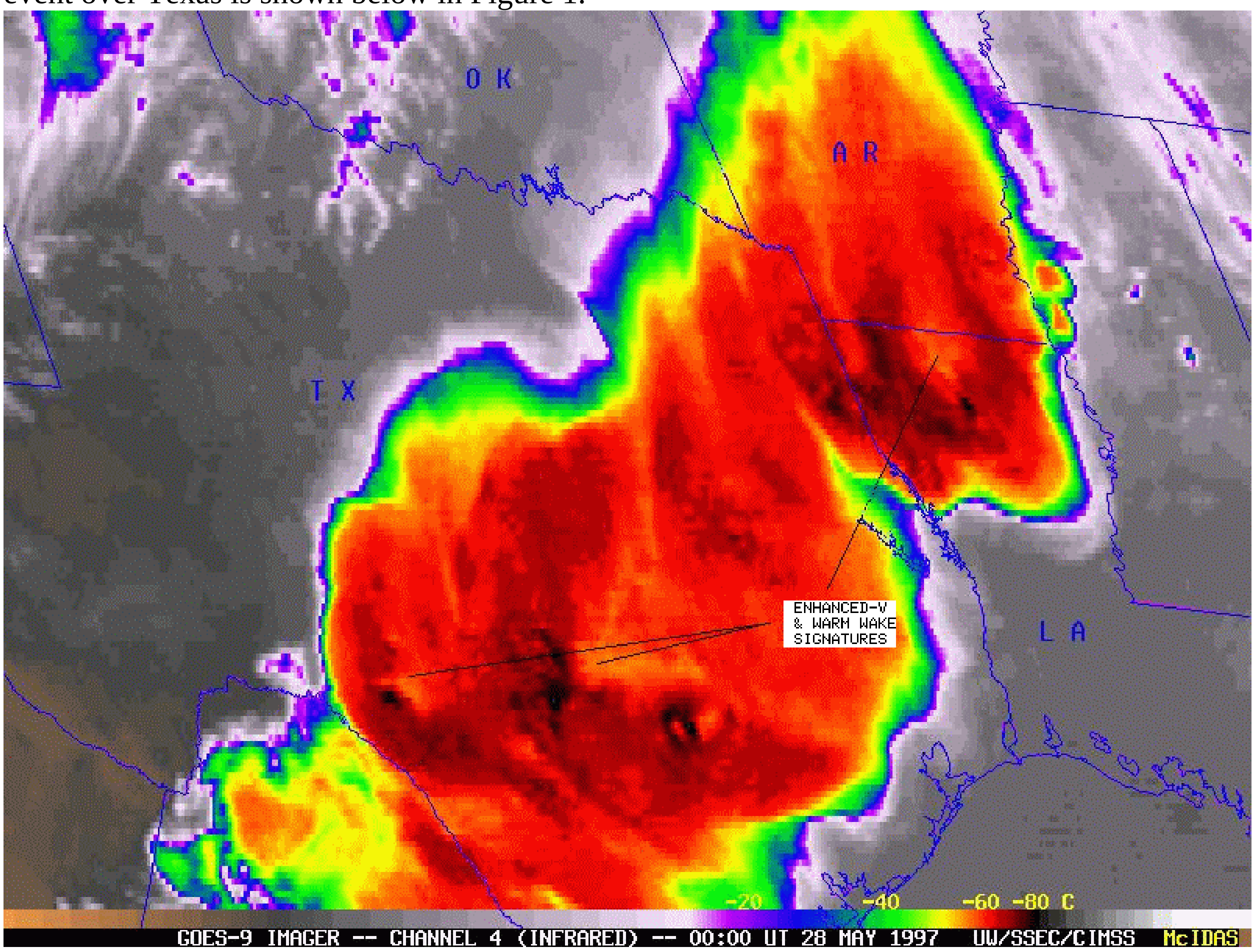

Figure 1. Example of enhanced-V and associated warm-wake satellite (enhanced) IR signatures of severe weather from the Jarrell, Texas tornadic supercell of 27 May 1997. The IR (Channel 4) GOES-9 image (28/00z) is courtesy of http://cimss.ssec.wisc.edu/goes/misc/970527.html.

The signature is typically associated with growing and intense convection. Research has shown median lead-times of 31 minutes from first enhanced-v/warm wake to severe weather. The features typically last for about 1 hour (median value). Unfortunately, there is a low probability of detection (POD) (20%-25%) of severe weather for this signature. In other words, not all severe weather is associated with an enhanced-V. Interestingly, the POD increases to about 50% in tornadic storms of F2 strength or stronger on the Fujita-damage scale. Fortunately, the false alarm ratio (FAR) is low, meaning that a storm that exhibits an enhanced-V/warm wake signature has a high probability of producing severe weather.

Data: Archived GARP GOES and WSR-88D data for the 1998 Spencer, SD ("Spencer") and 1999 Oklahoma City, OK ("OKmay3") tornado cases.

Exercises: (50 points)

1. (*22 points*) We will now identify the time and location of enhanced-V/warm wake signature in the Oklahoma City, OK tornadic case of 3 May 1999 and determine its relationship to WSR-88D radar structure.

a) (*12 points*) The first F3 tornado for the 3 May 1999 OKC tornado outbreak occurred at about 2220 Z. Type in "OKmay3" and enter. Run garp. Bring up GOES-8 (actually found under GOES-10) Garp IR 4-km imagery and focus in on the Oklahoma region. Usually, *enhanced* IR imagery (like Fig. 1 above) is required to identify the enhanced-V and warm wake signatures. In GARP, select "options" then "enhancement." Change the satellite color IR enhancement to "sabir." Loop all available times. *Find the IR time of occurrence, cloud top temperature (°C), latitude and longitude of the apex of the enhanced-V and warm wake signatures found in any of the available images*. From all of these signatures, *estimate a "typical" (numerical or eyeball average) temperature difference (°C) between the enhanced-V (e.g., coldest temperature) and the nearby warm wake (e.g., warmest temperature).*

b) (*10 points*) Using OKC NIDS radar reflectivity and velocity data, *describe the relationship between the satellite signatures and radar inferred supercell structure*.

2. (22 points) Repeat questions #1a,b above for the 30 May 1998 Spencer, SD tornado case.

a) (*12 points*) Repeat 1a) for the 30 May 1998 Spencer tornado. Type in "Spencer" and then run garp. The peak damage for the Spencer tornado occurred at about 31/0144 Z.

b) (*10 points*) Repeat 1b) for the Spencer tornado using FSD radar reflectivity and velocity data, which you are already familiar with from Lab #5.

3. (*6 points*) *What lead times did you get from the first occurrence of the satellite signature and the tornado in each case*? (Keep in mind our archive has reduced temporal resolution data so reality would likely be better).