# Going for Knowledge: GOES Geosynchronus Satellites

Mr. Timothy J. Schmit

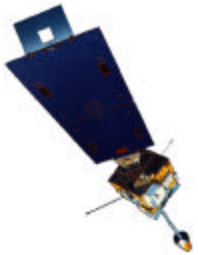
NOAA/NESDIS (National Oceanic and Atmospheric Administration/National Environmental Satellite, Data, and Information Service)

SaTellite Applications and Research (STAR)

Advanced Satellite Products Team (ASPT)

in collaboration with the

Cooperative Institute for Meteorological Satellite Studies (CIMSS)



*Madison, WI*
*11 March 2003*

UW-Madison

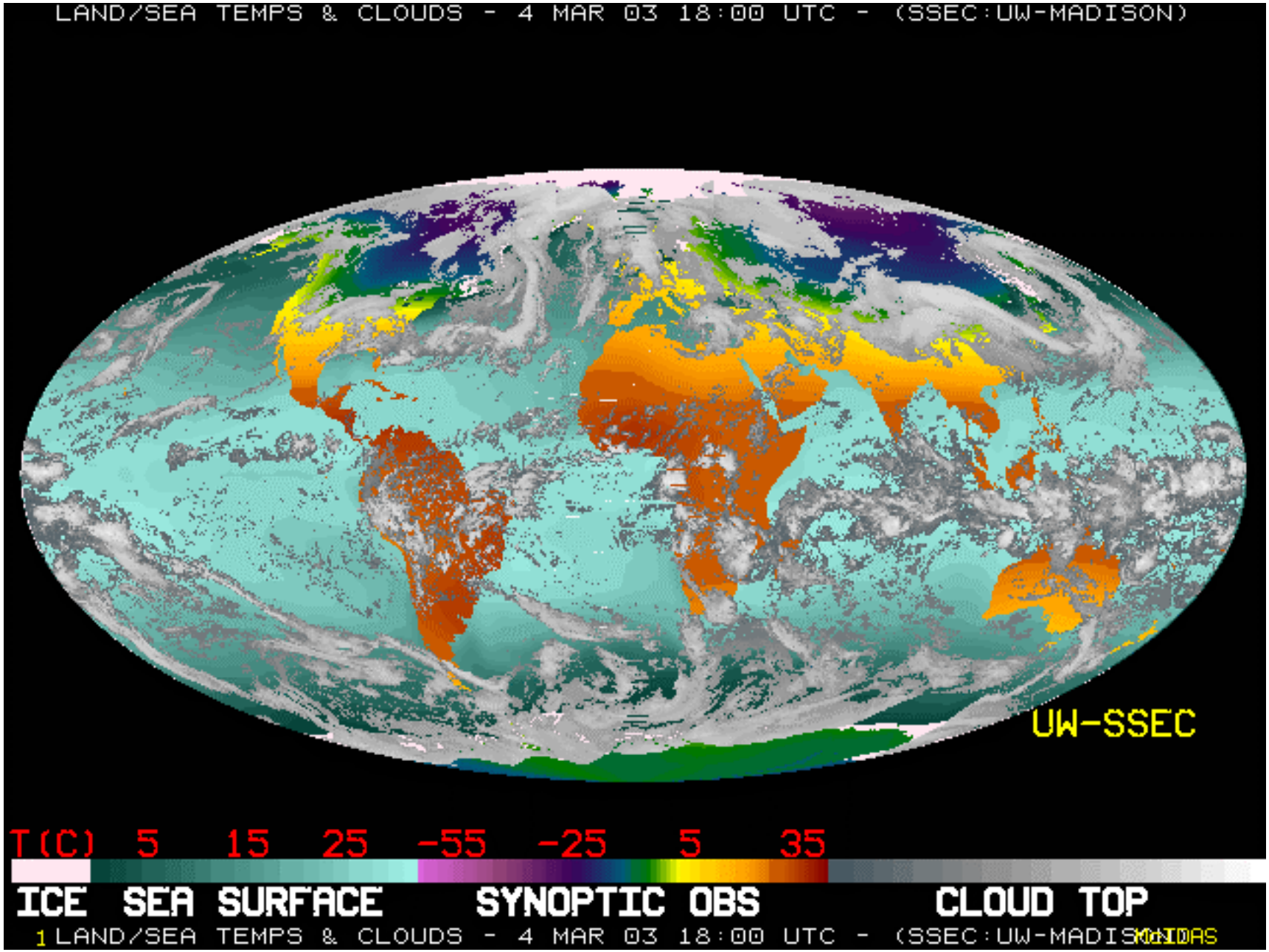
Wisconsin has a long history with the development and continued improvements of the geostationary satellites.

These space-based satellites are the backbone for observing atmospheric changes on fine time and space scales.

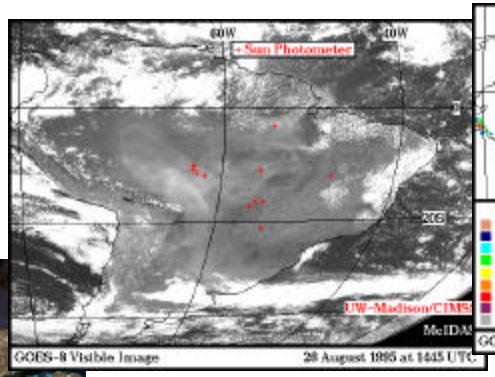
What is a GOES satellite and what does it do?

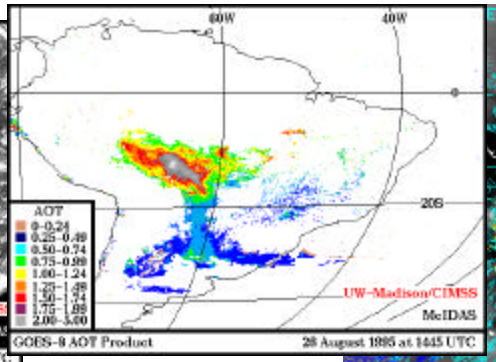
Sample images and products of clouds, fog, severe weather storms, snow, etc.

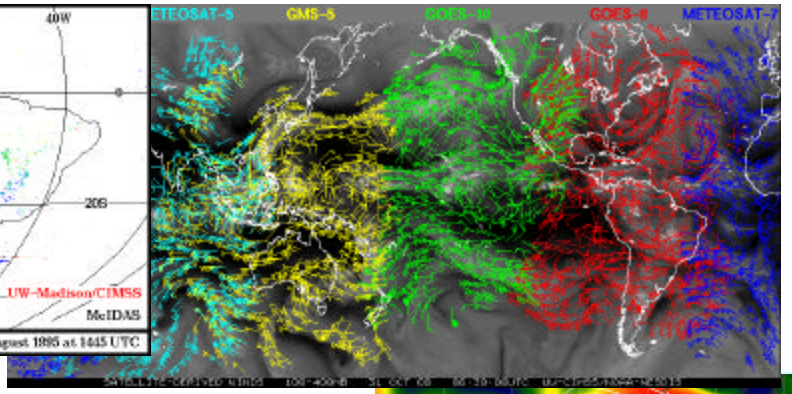
Future geostationary capabilities.




Global image -- combination of satellite and ground-based observations.




algorithms

INFORMATION

theory
modeling

DATA

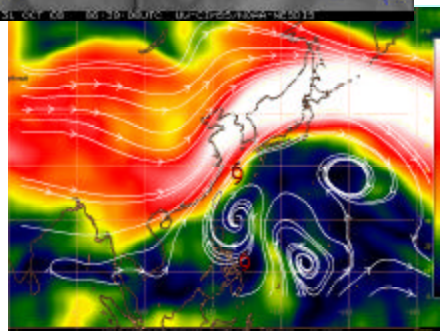
EDUCATION

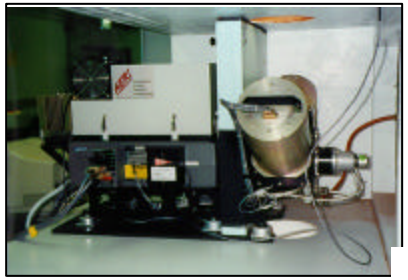
KNOWLEDGE

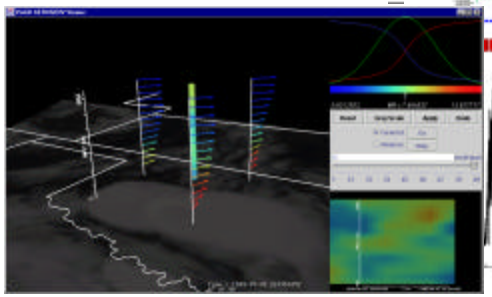
new instruments

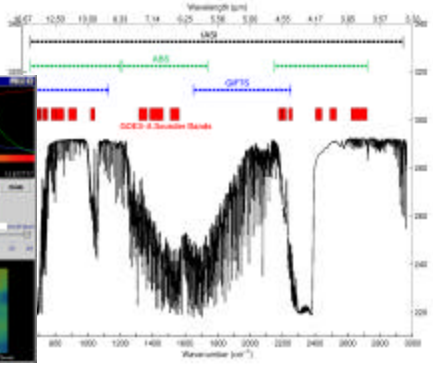
ACTION

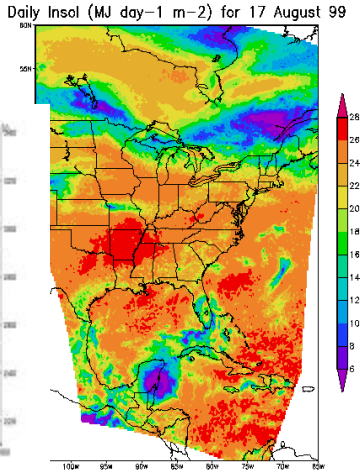
applications

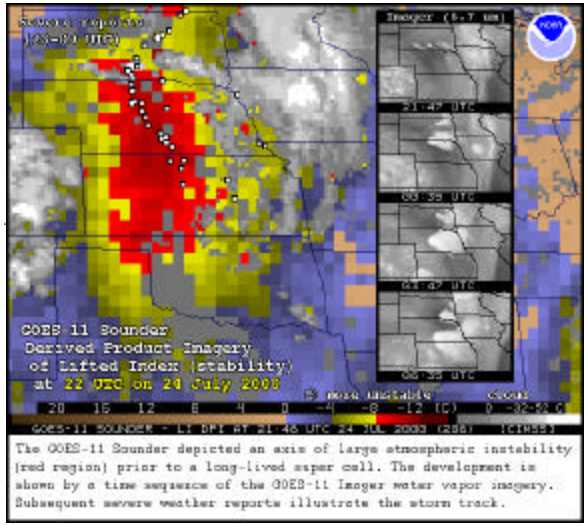




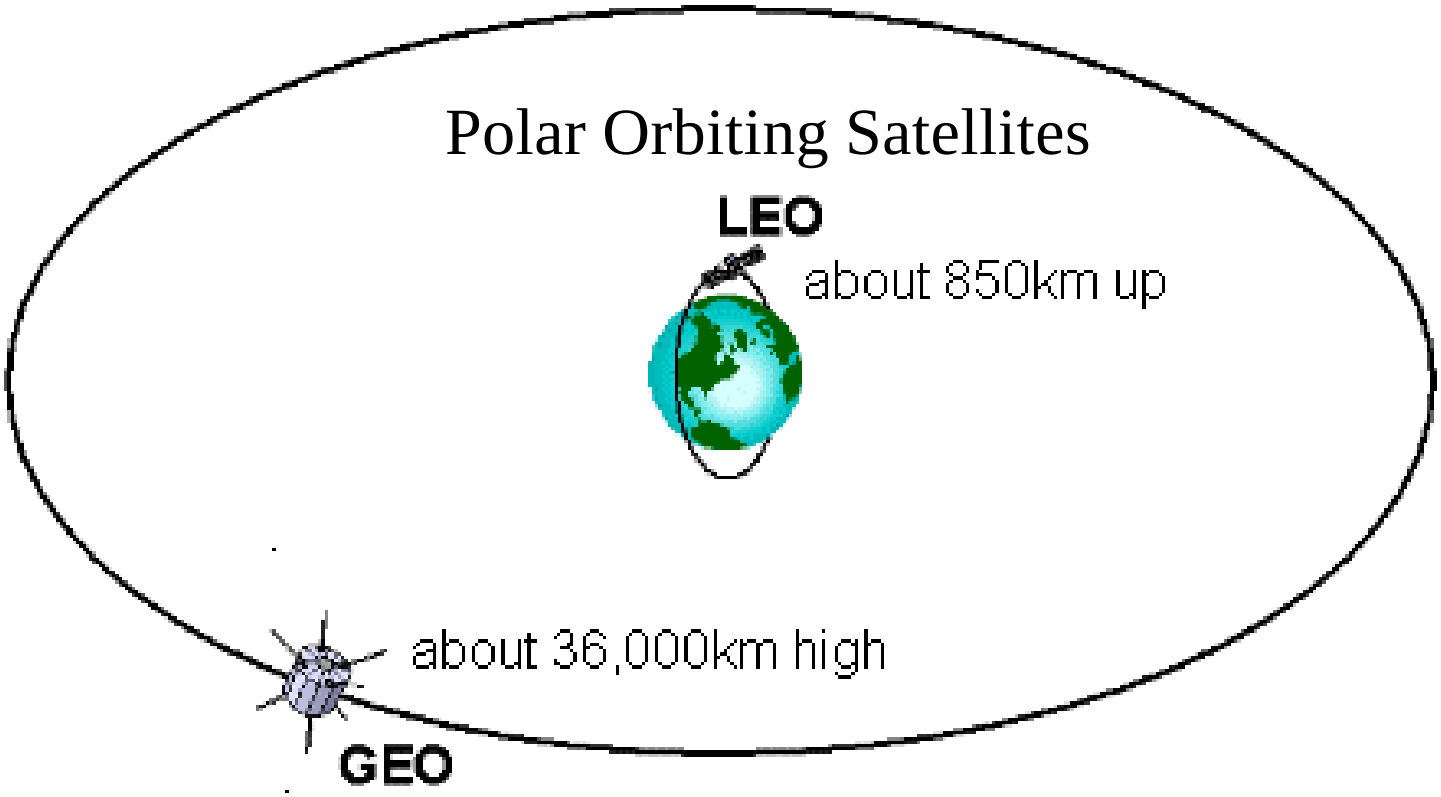






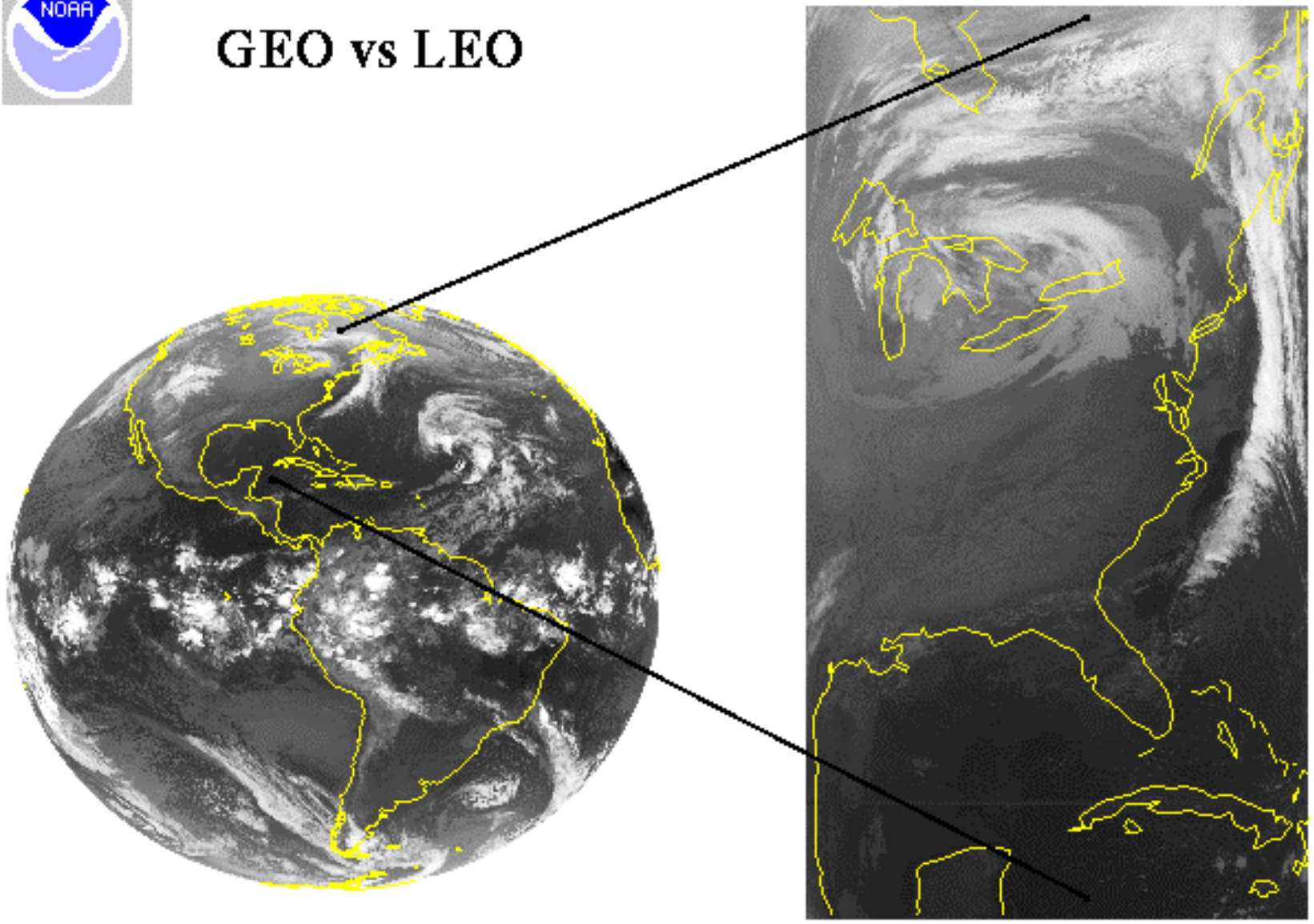



# LEO and GEO orbit elevations




Geostationary Satellites

# GEO vs LEO

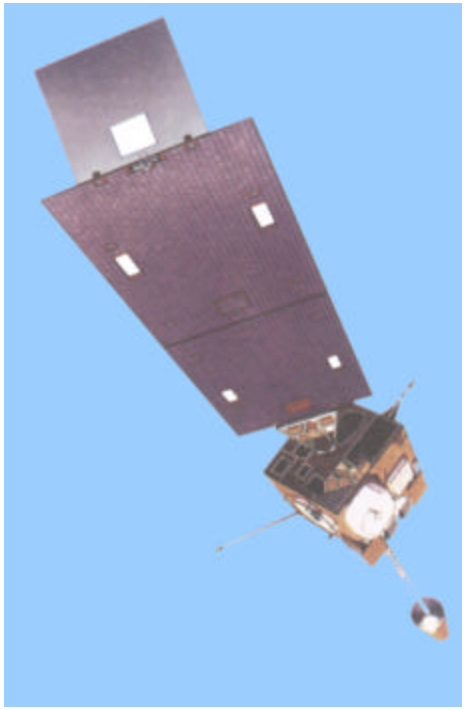


GOES-8 IMAGER 12UTC 02APR98

NOAA-12 AVHRR 12UTC 02APR98

**G**eostationary
**O**perational
**E**nvironmental
**S**atellite

# Geostationary Satellites

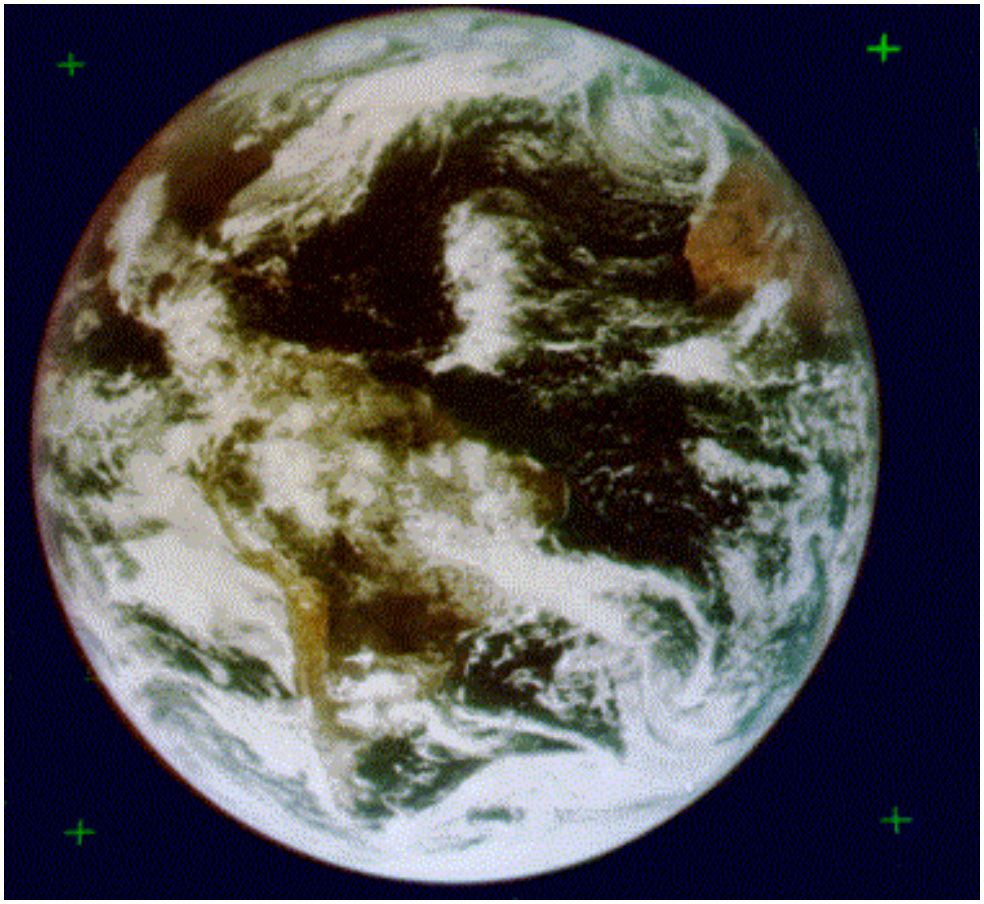


- Warnings to U.S. Public -- Detect, track and characterize
  - Hurricanes
  - Severe or possibly tornadic storms
  - Flash flood producing weather systems
- Imagery/soundings for weather forecasting
- Information for aviation and numerical models
- Environmental data collection – Platforms including buoys, rain gauges…
- First operational Solar X-Ray Imager

# Introduction of Geostationary Satellites

- On December 6, 1966, "a stellar day" in satellite meteorology, the first Application Technology Satellite (ATS-1) was launched.

  ATS-1's spin scan cloud camera (Suomi and Parent 1968) provided full disk visible images of the earth and its cloud cover every 20 minutes. The spin scan camera on ATS-1 occurred because of an extraordinary effort by Verner Suomi and Homer Newell, when the satellite was already well into its fabrication.



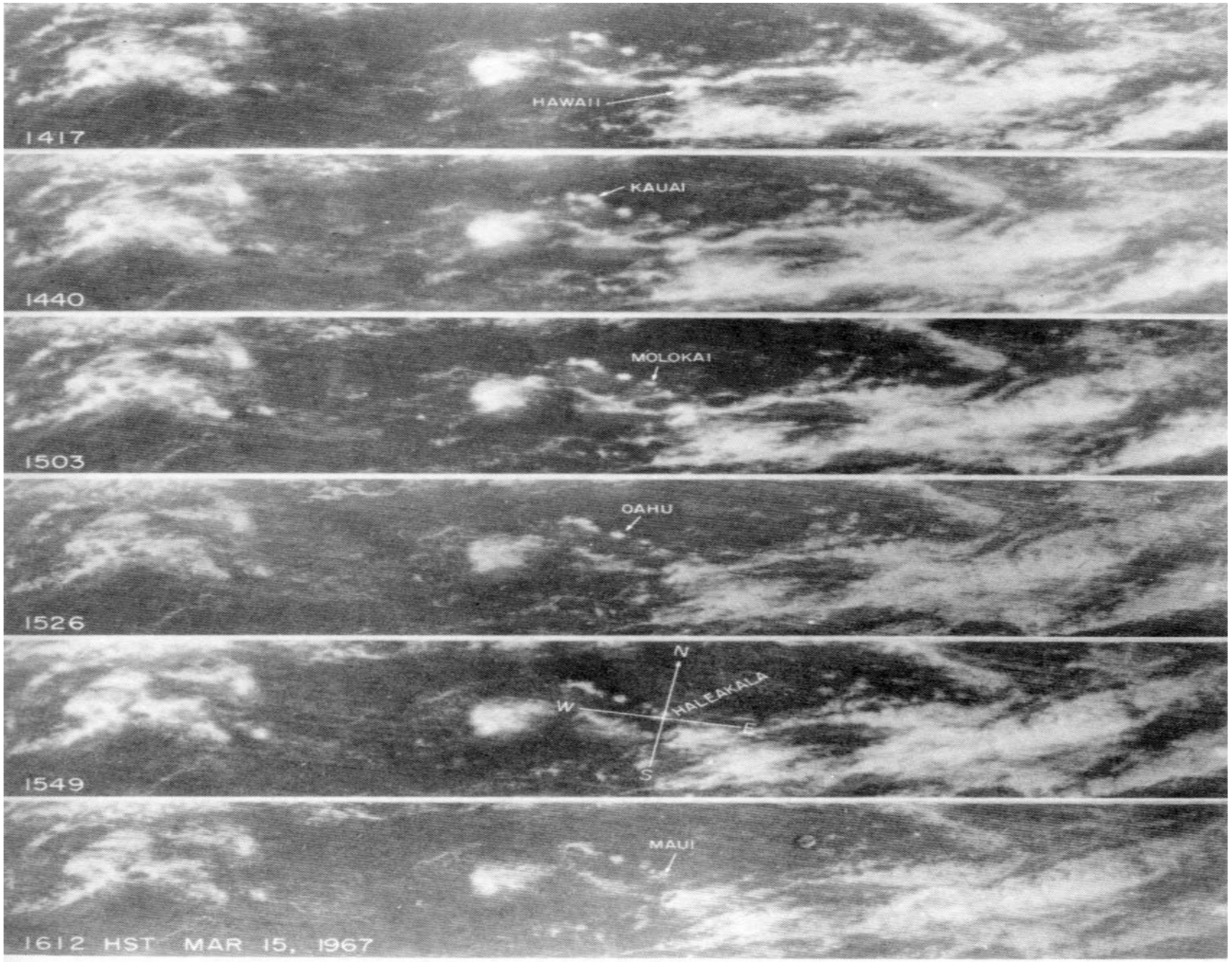
**ATS-3 (color)**

**“the clouds moved - not the satellite”**

**Verner Suomi**

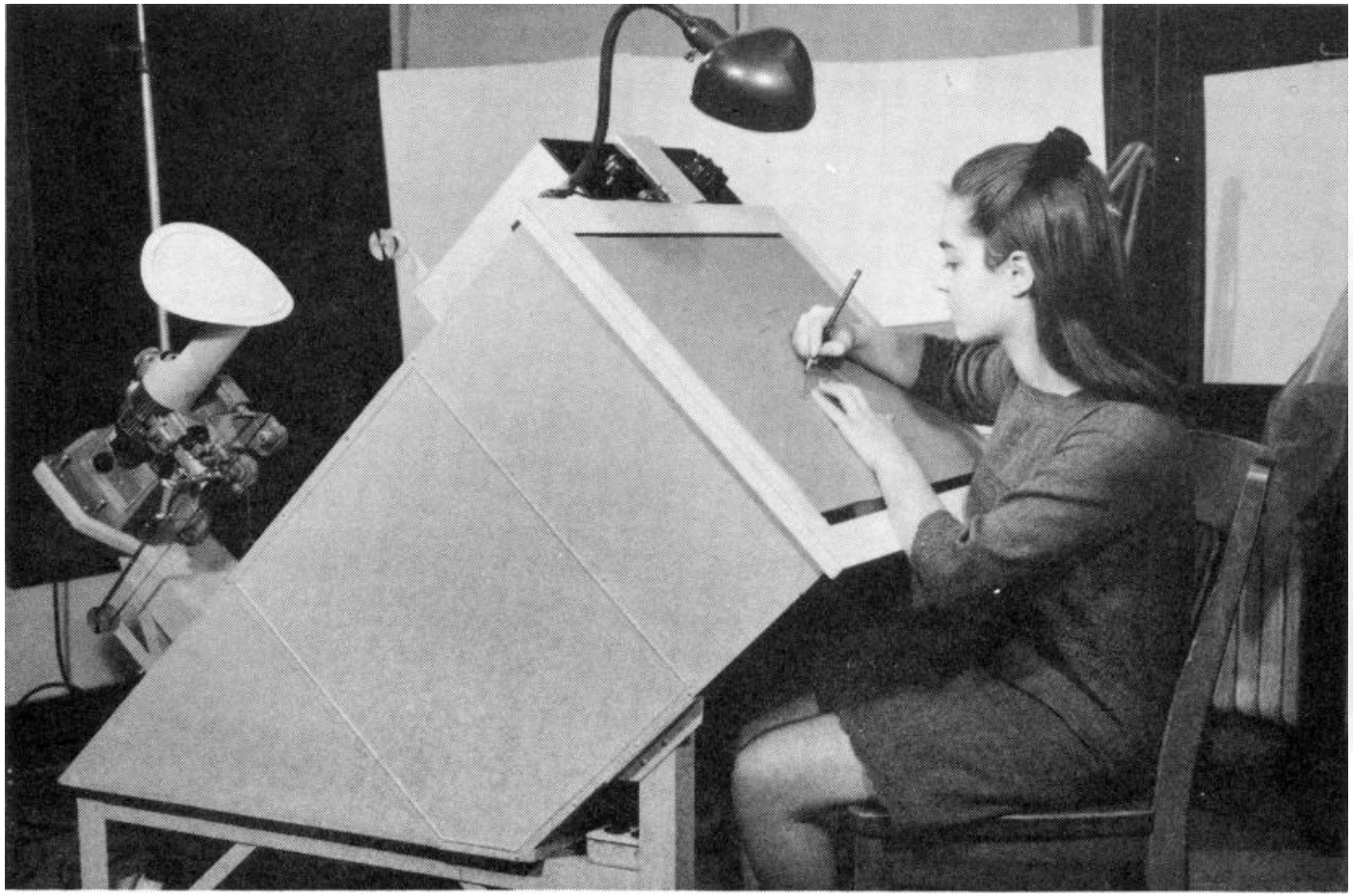
**From 6 Dec 1966, ATS-1's geostationary spin scan cloud camera provided full disk visible images of the earth and its cloud cover every 20 minutes**

# Verner E. Suomi and Robert J. Parent




ATS-1 pictures started at 1417, 1440, 1503, 1526, 1549, and 1612 Hawaii Standard Time.

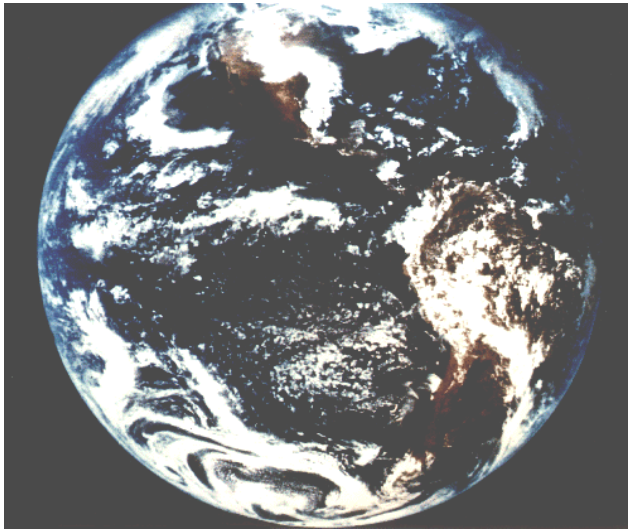
# A loop projector constructed by Ted Fujita for study of ATS cloud motions



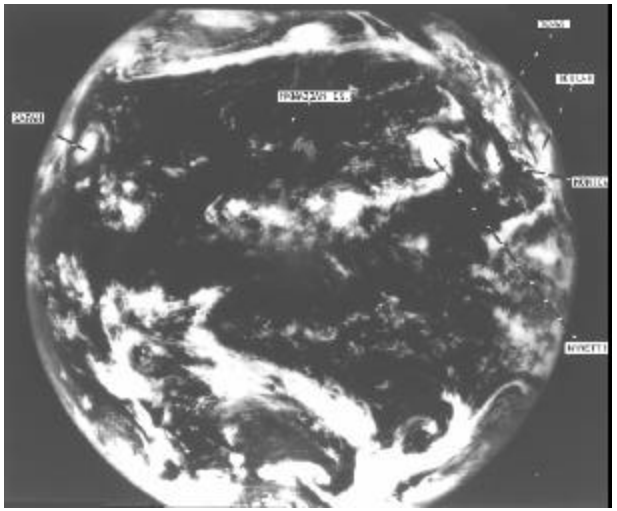
# NOAA - NASA

## have been working together on GEOs for many years

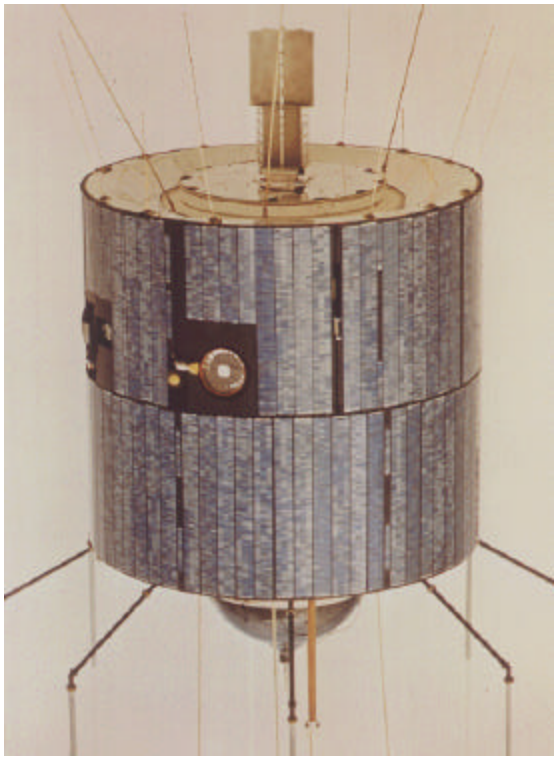
## ATS-1 was soon followed by a color version, ATS-3



ATS-3 (color)

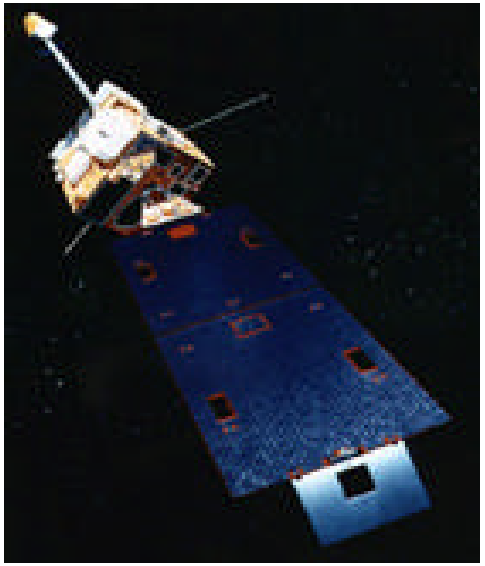


ATS-1 (B/W)



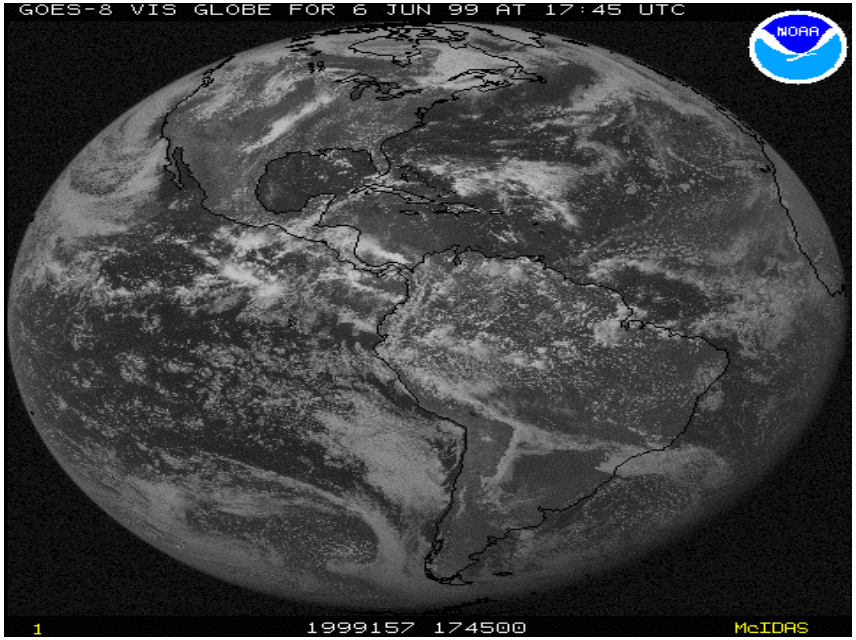
ATS-3

**In 1994, the GOES was launched on a three axis stable platform (enabling better signal to noise in the measurements) and expanded to separate imaging and sounding instruments (allowing operational soundings for the first time).**

What a long tail!

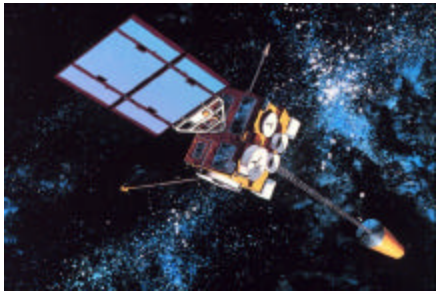
GOES-8 is almost 8 yrs old



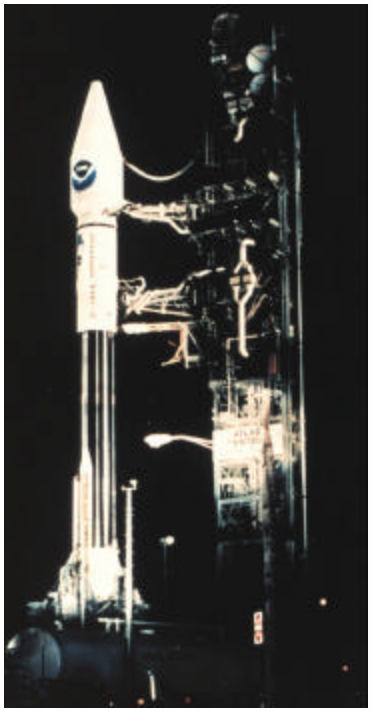

13 Apr 94

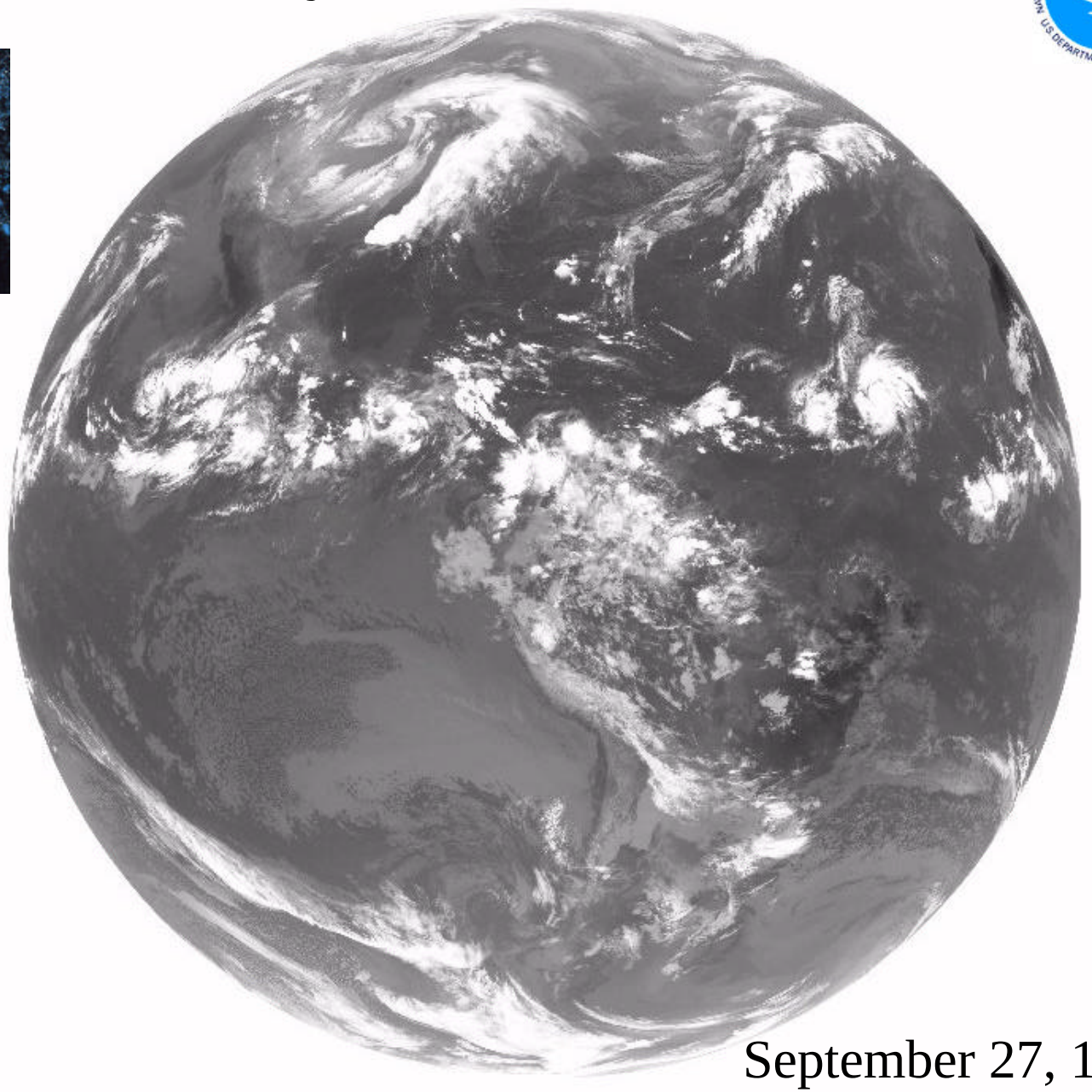
# Geostationary Weather Satellite

The satellite:



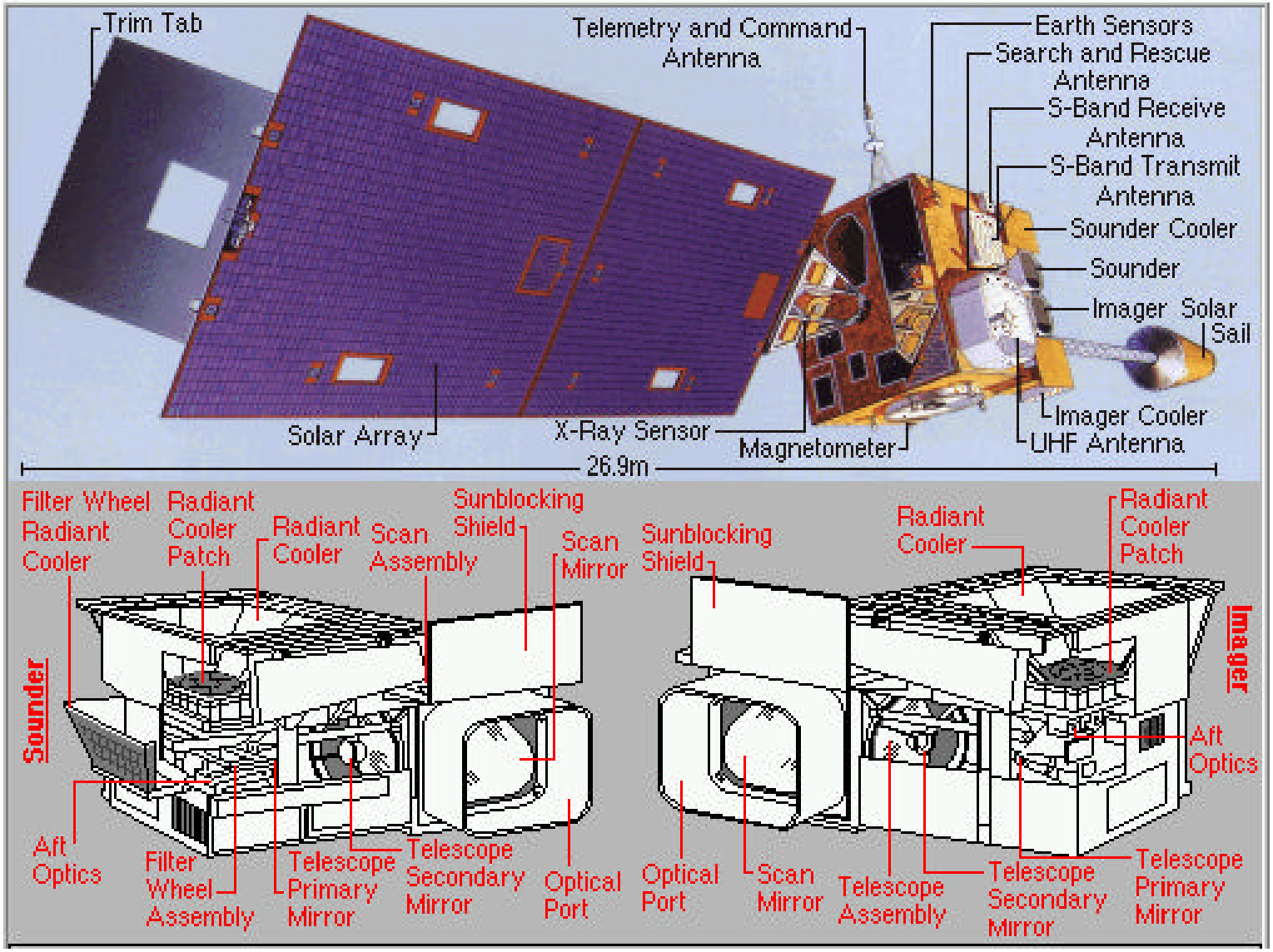
The rocket:



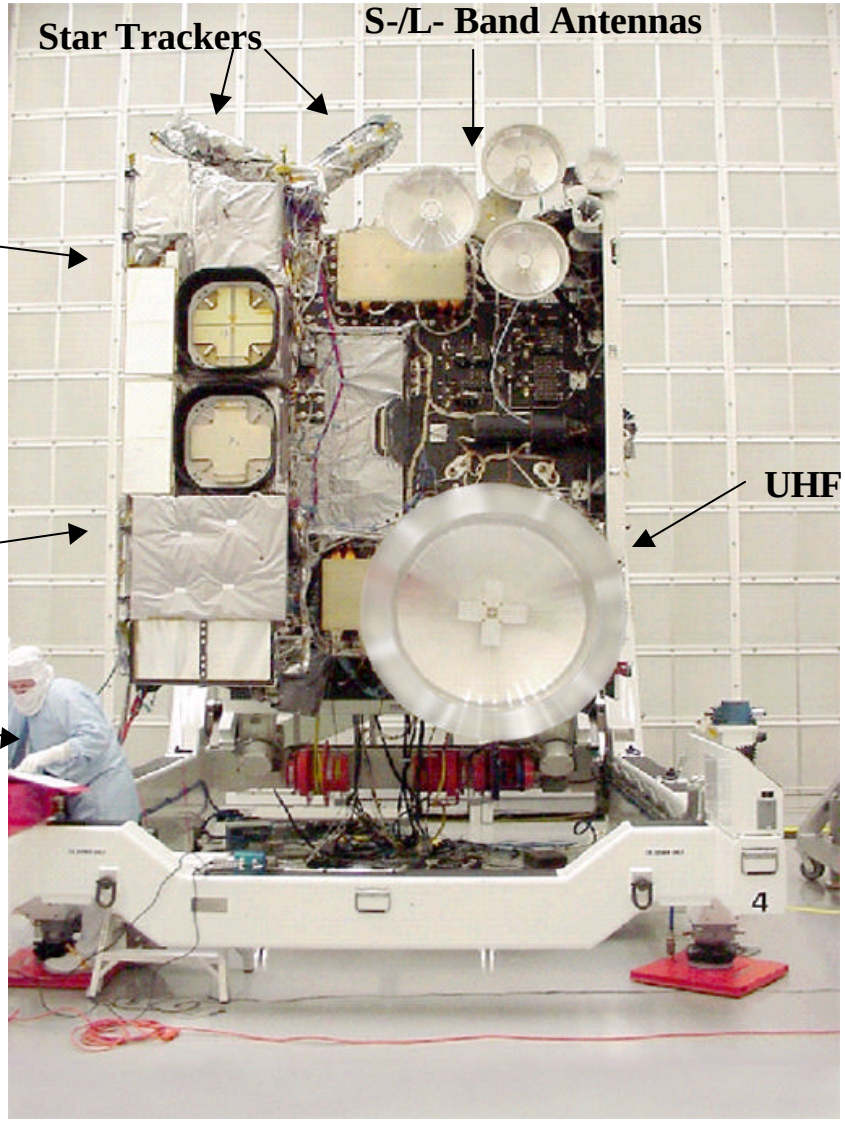


September 27, 1995

# GOES-8/12

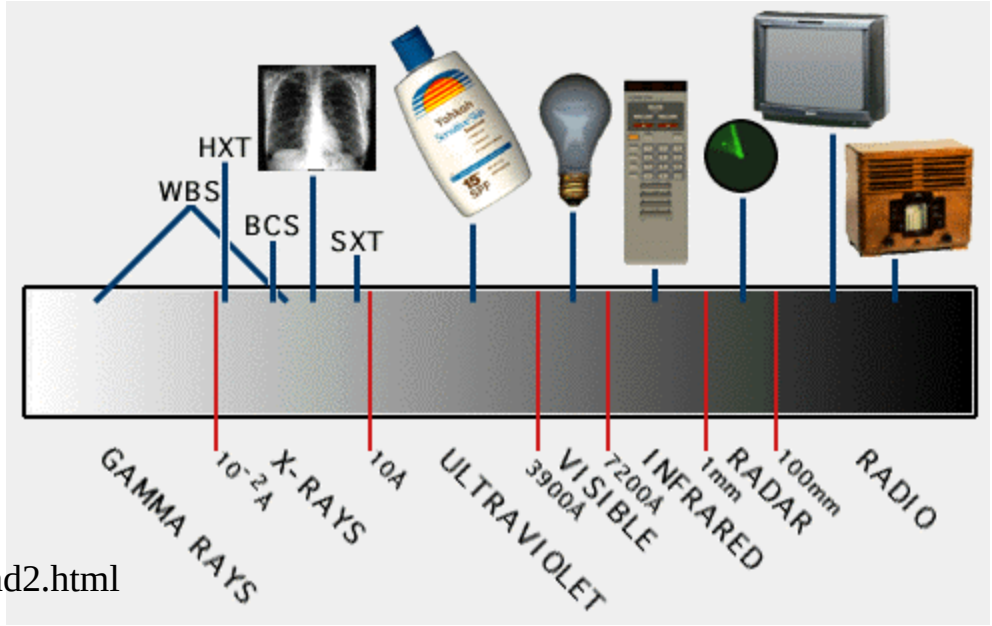

Trim Tab
Telemetry and Command Antenna
Earth Sensors
Search and Rescue Antenna
S-Band Receive Antenna
S-Band Transmit Antenna
Sounder Cooler
Sounder
Imager Solar Sail
Imager Cooler
UHF Antenna
Magnetometer
X-Ray Sensor
Solar Array
26.9m
Filter Wheel Radiant Cooler
Radiant Cooler Patch
Radiant Cooler
Scan Assembly
Sunblocking Shield
Scan Mirror
Sounder
Aft Optics
Filter Wheel Assembly
Telescope Primary Mirror
Telescope Secondary Mirror
Optical Port
Sunblocking Shield
Radiant Cooler
Radiant Cooler Patch
Imager
Aft Optics
Optical Port
Scan Mirror
Telescope Assembly
Telescope Secondary Mirror
Telescope Primary Mirror

# GOES-N Satellite

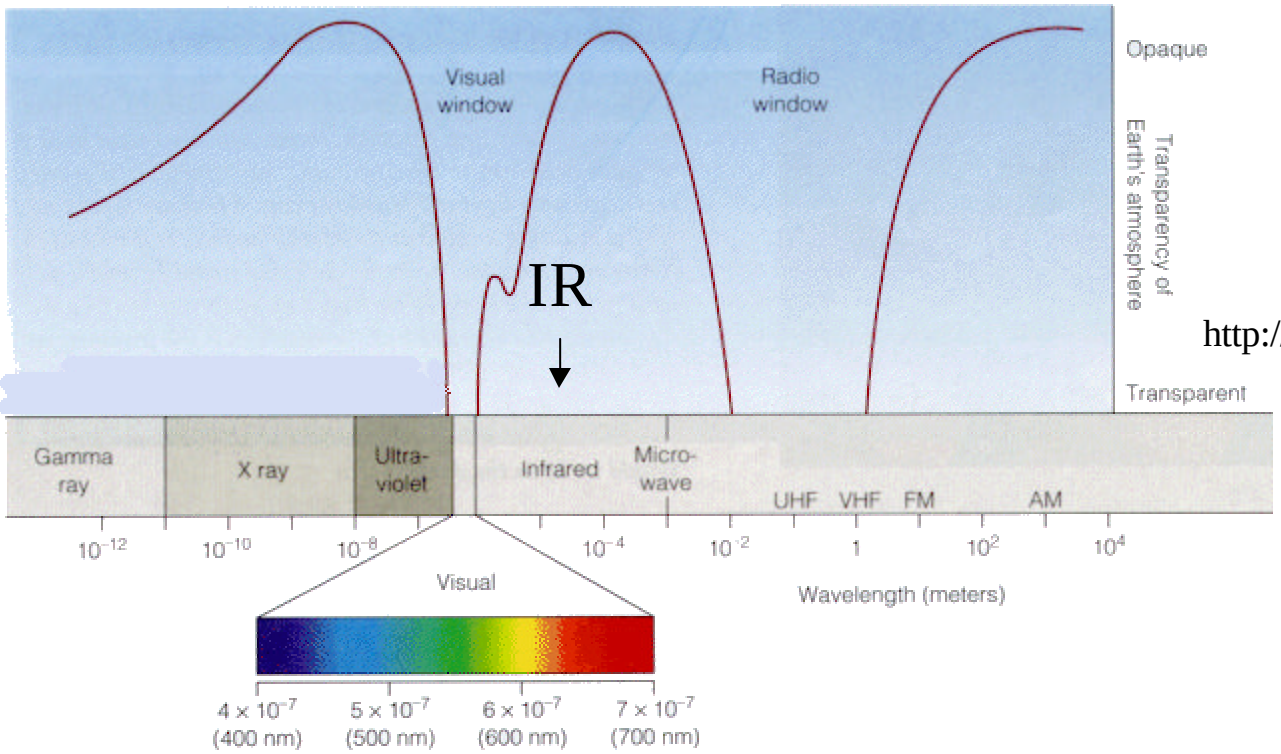



GOES-N (S/N08)

# Electromagnetic Spectrum

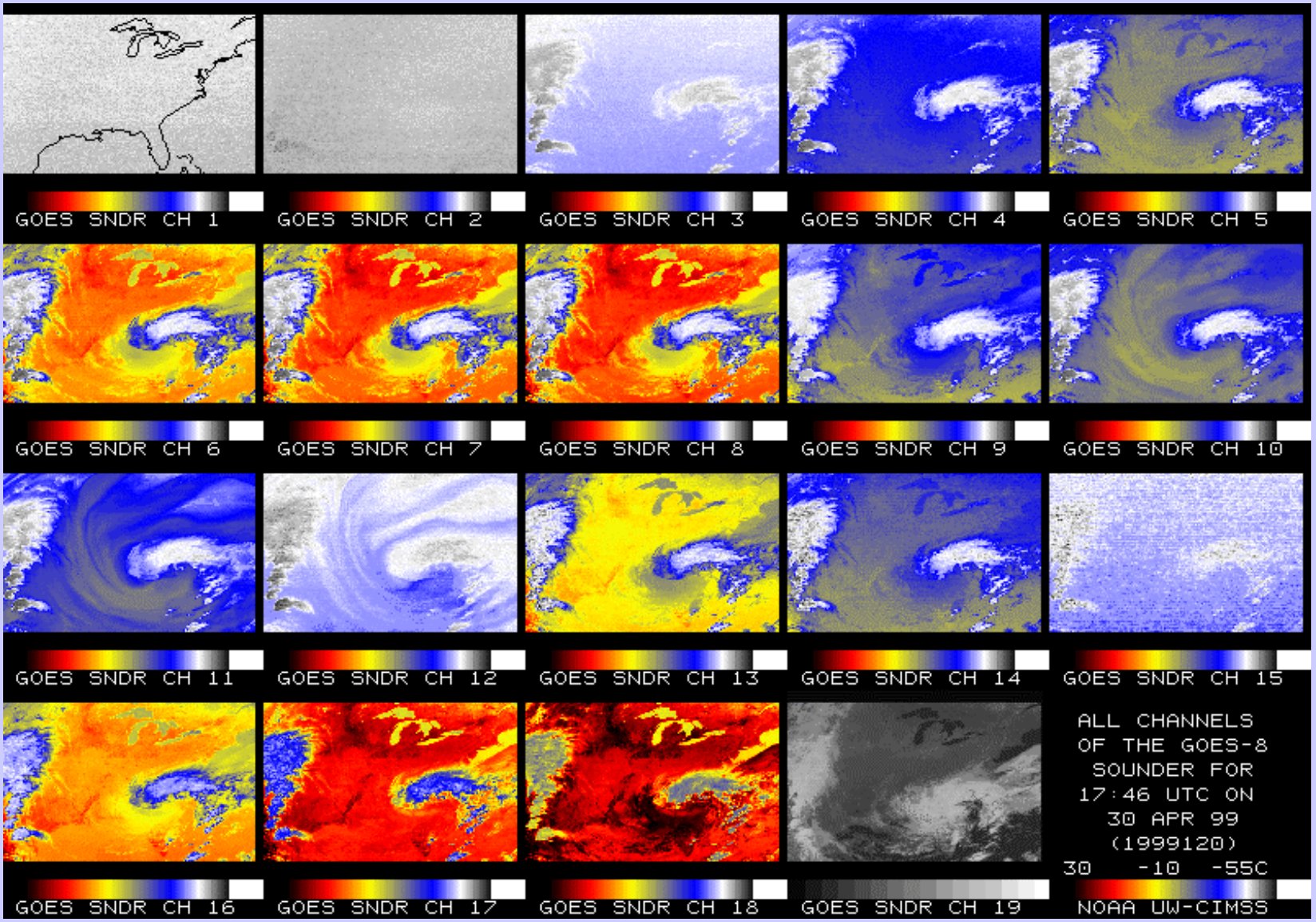



http://flare25.solar.isas.ac.jp/english/yohkoh_background2.html



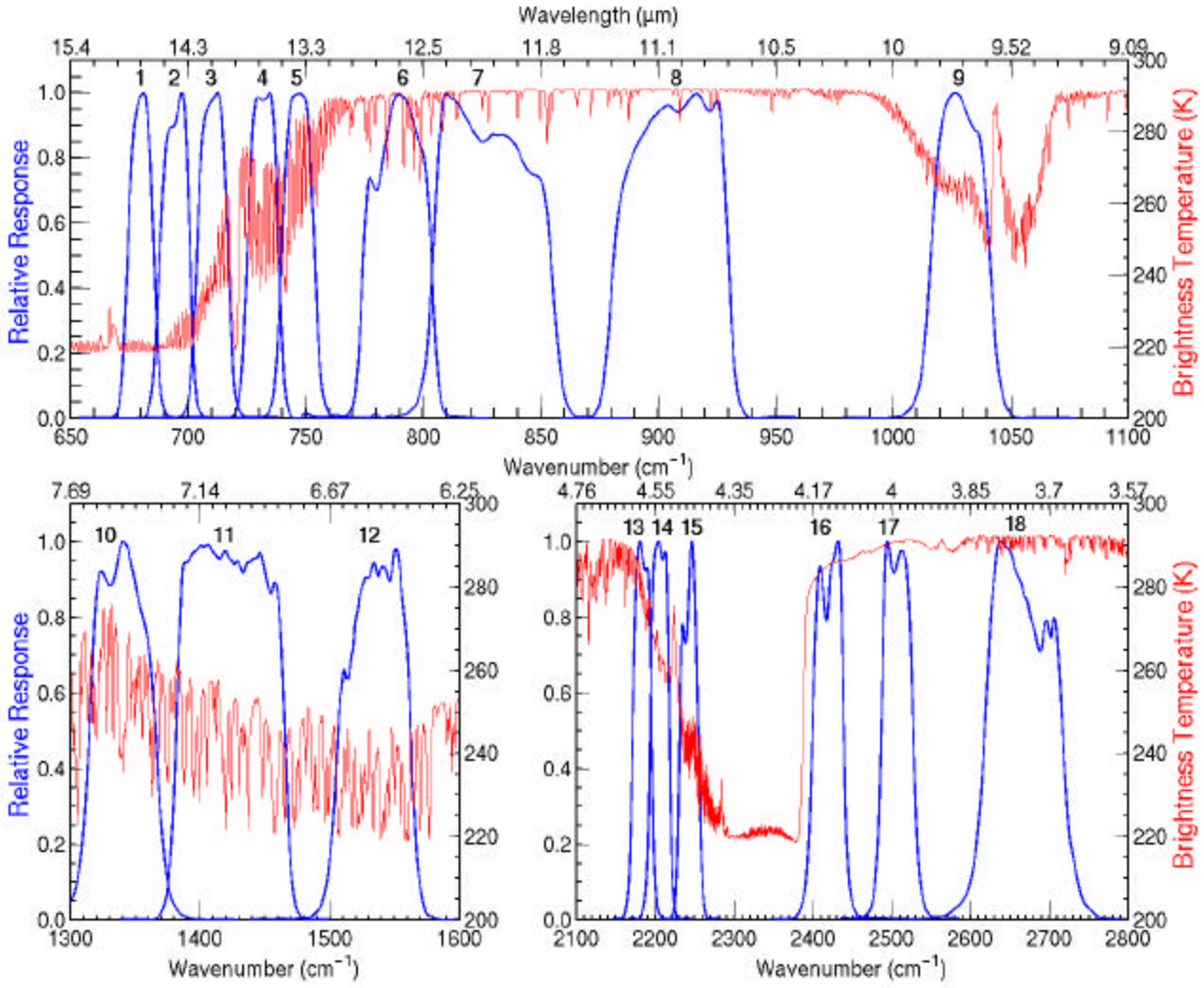

http://junior.apk.net/~matto/rastrain.htm

# GOES Sounder Spectral Bands: 14.7 to 3.7 um & Vis



# GOES Sounder Spectral Coverage

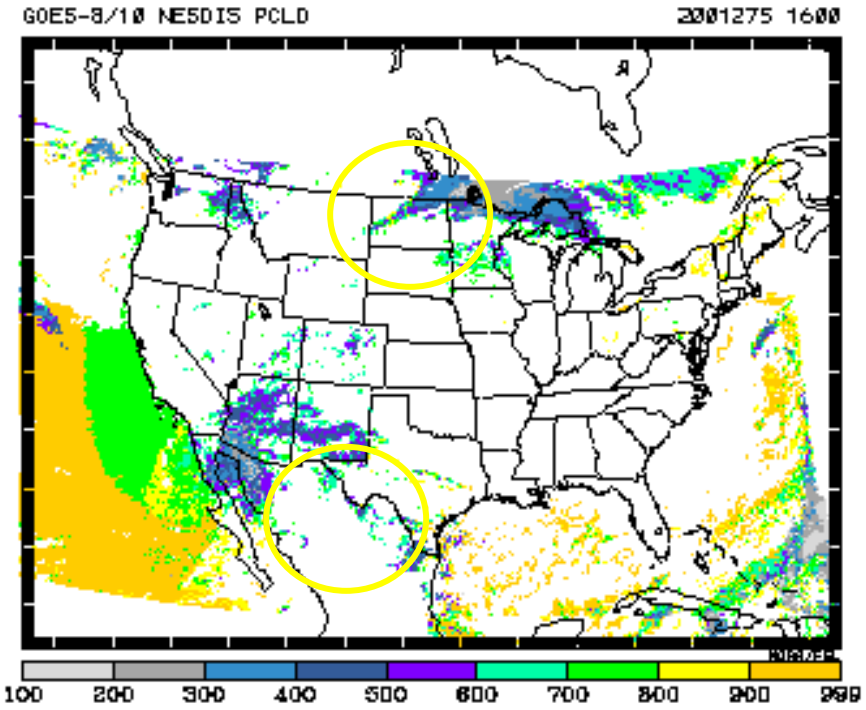
Current instrument has 18 infrared bands.



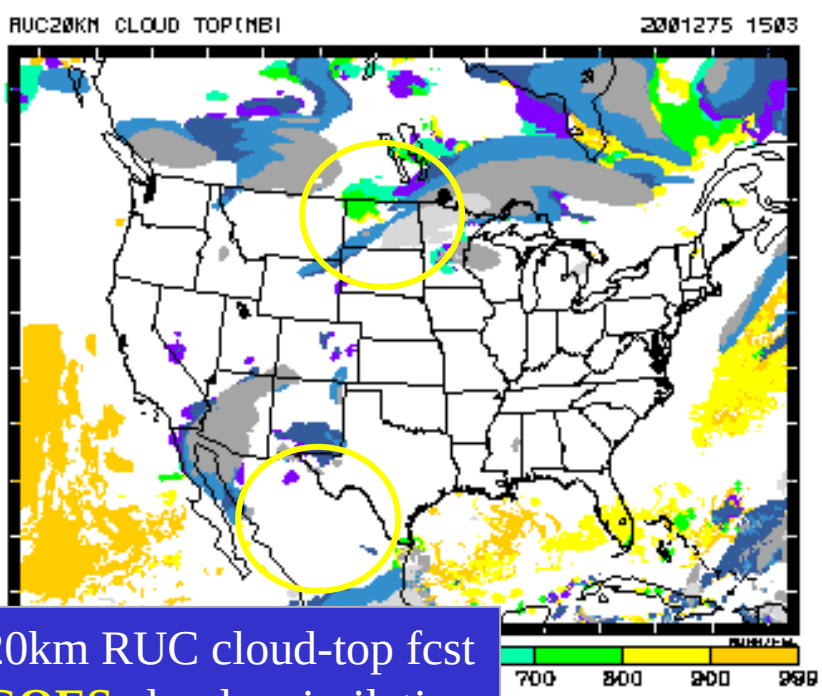
# GOES in NWP, routine and experimental:

| Model | GOES Data |
|---|---|
| NCEP Global | Sounder Radiance, Imager Winds, Imager Radiances |
| Eta Model | Sounder Radiance, Sounder PW, Imager Winds, Data for LandDataAssimilationScheme, Sounder Clouds |
| FSL's RUC | Sounder TPW, Sounder Clouds, rapid-scan winds |
| CIMSS CRAS | Sounder PW, Sounder Clouds |
| Australia (LAPS) | Imager Winds |
| ECMWF | Imager Winds, Imager Radiances |
| GFDL (experimental) | Imager Winds |
| NOGAPS | Imager Winds, Sounder Winds |
| NAAPS | Imager Biomass Fire Product |
| CSU RAMS | Imager Biomass Fire Product |
| UW ALEXI | Change of Sounder Skin Temperature, Imager insolation |

Data Assimilation -- GOES radiances and products have a major role




Verification
Cloud-top pressure
based on NESDIS product



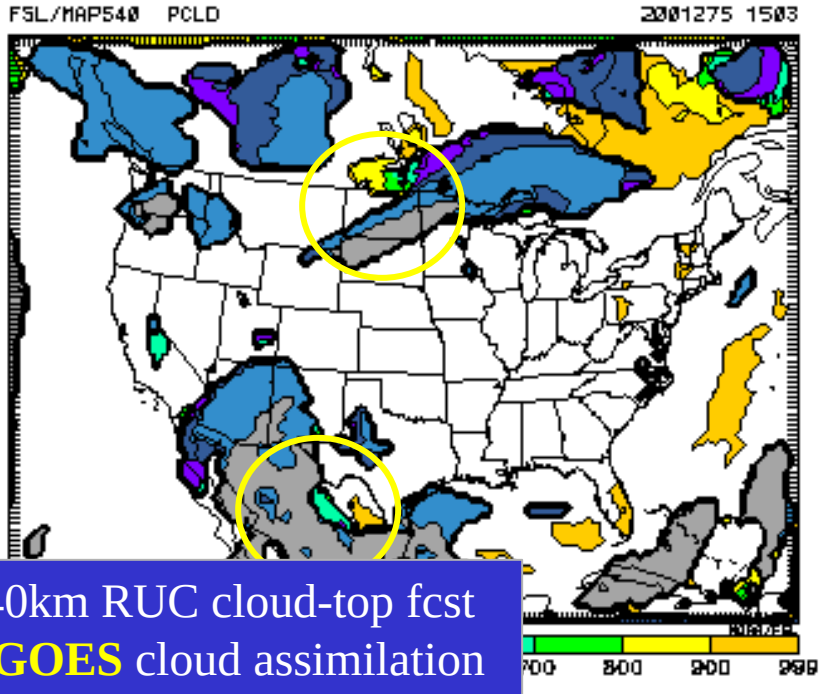

3h 20km RUC cloud-top fcst
**w/ GOES** cloud assimilation

# Effect of GOES (sounder cloud) data on 3-h RUC cloud **forecasts**

*"much improved cloud forecasts"*

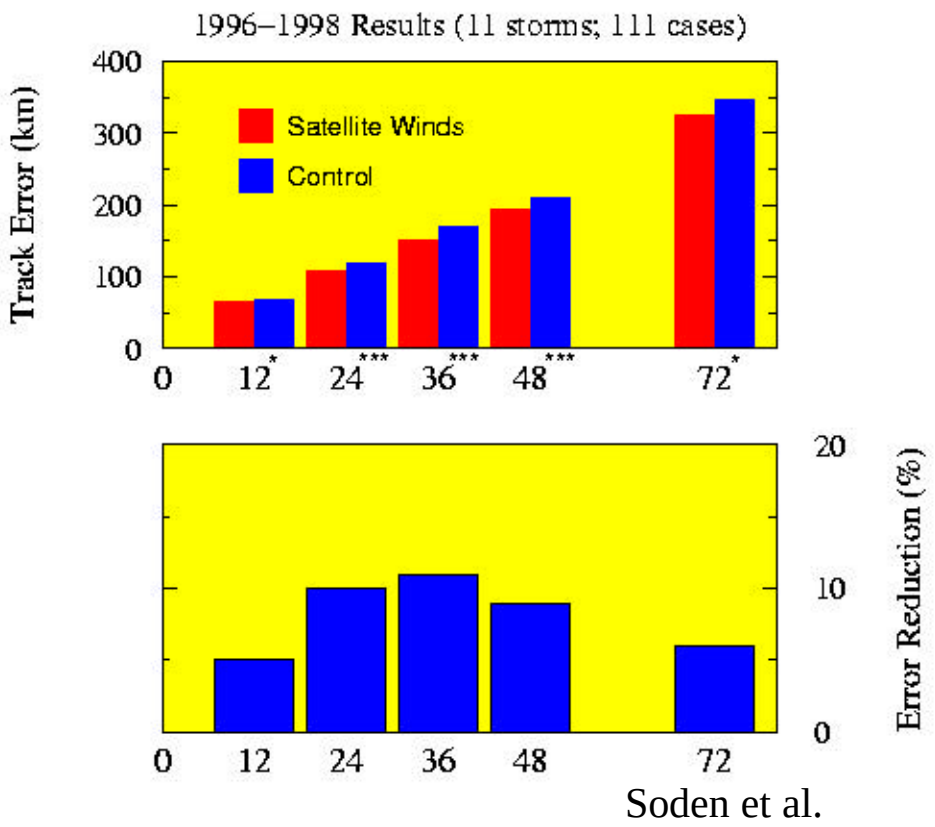
Stan Benjamin – NOAA/FSL

1800 UTC
Tues 2 Oct 2001

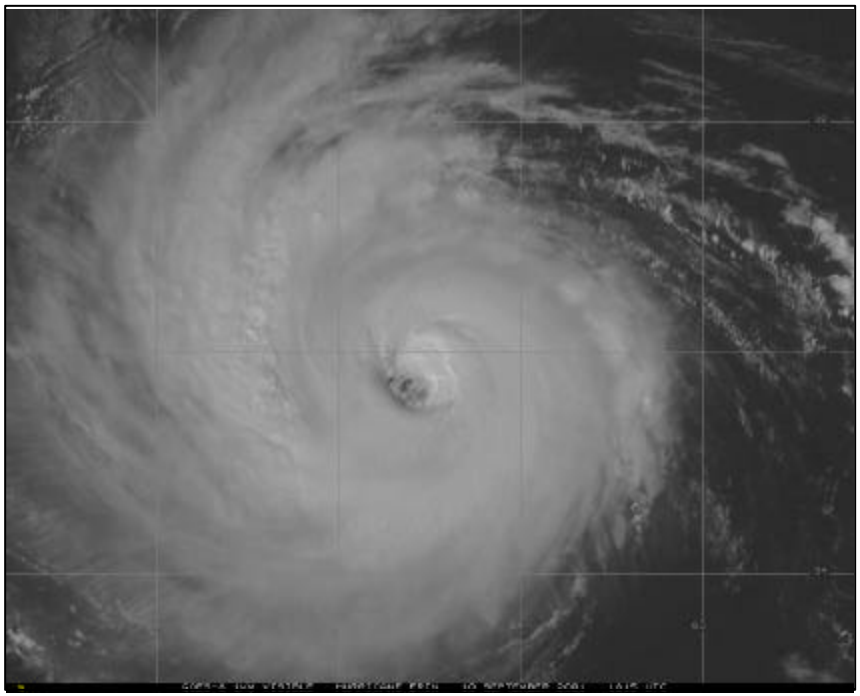



3h 40km RUC cloud-top fcst
**No GOES** cloud assimilation

# Satellite winds on GFDL Forecasts




Soden et al.

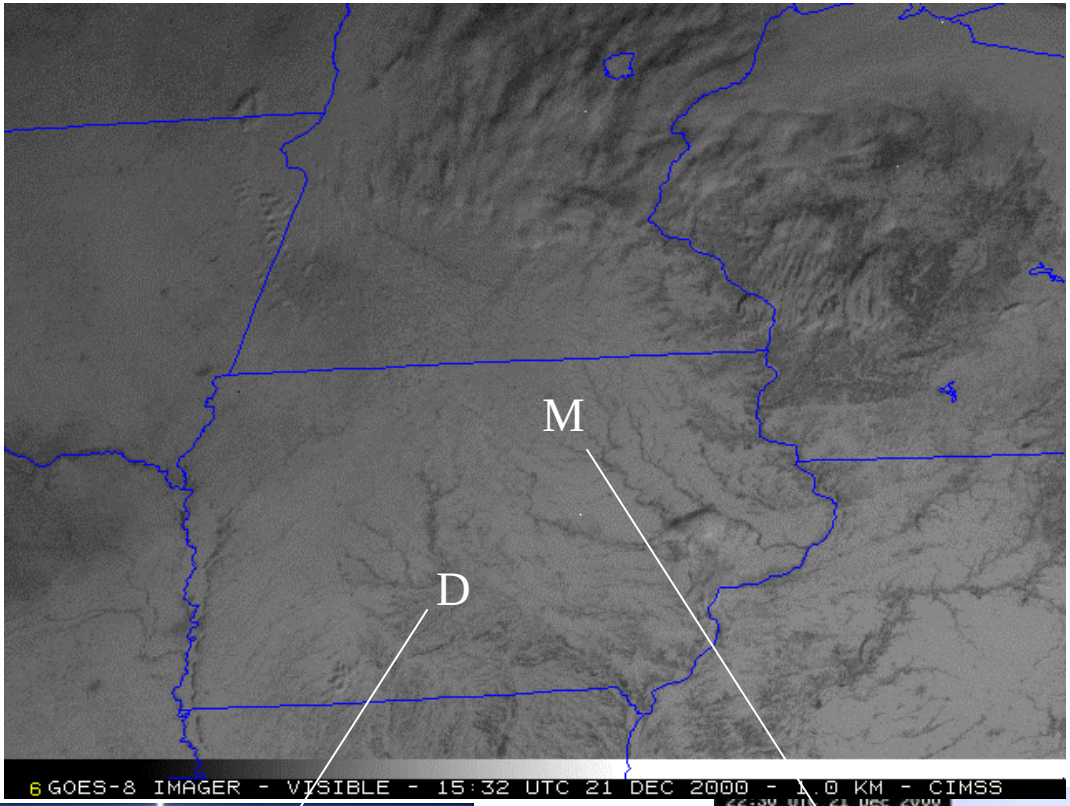


GOES-8 1km visible

Former National Hurricane Center director Robert Sheets once said that if he had only one tool to do his forecasting job, it would be the geostationary weather satellite.

http://www.usatoday.com/weather/news/2000/w330satann.htm

# Snow: 21 December 2000 | Blowing Snow Across Iowa



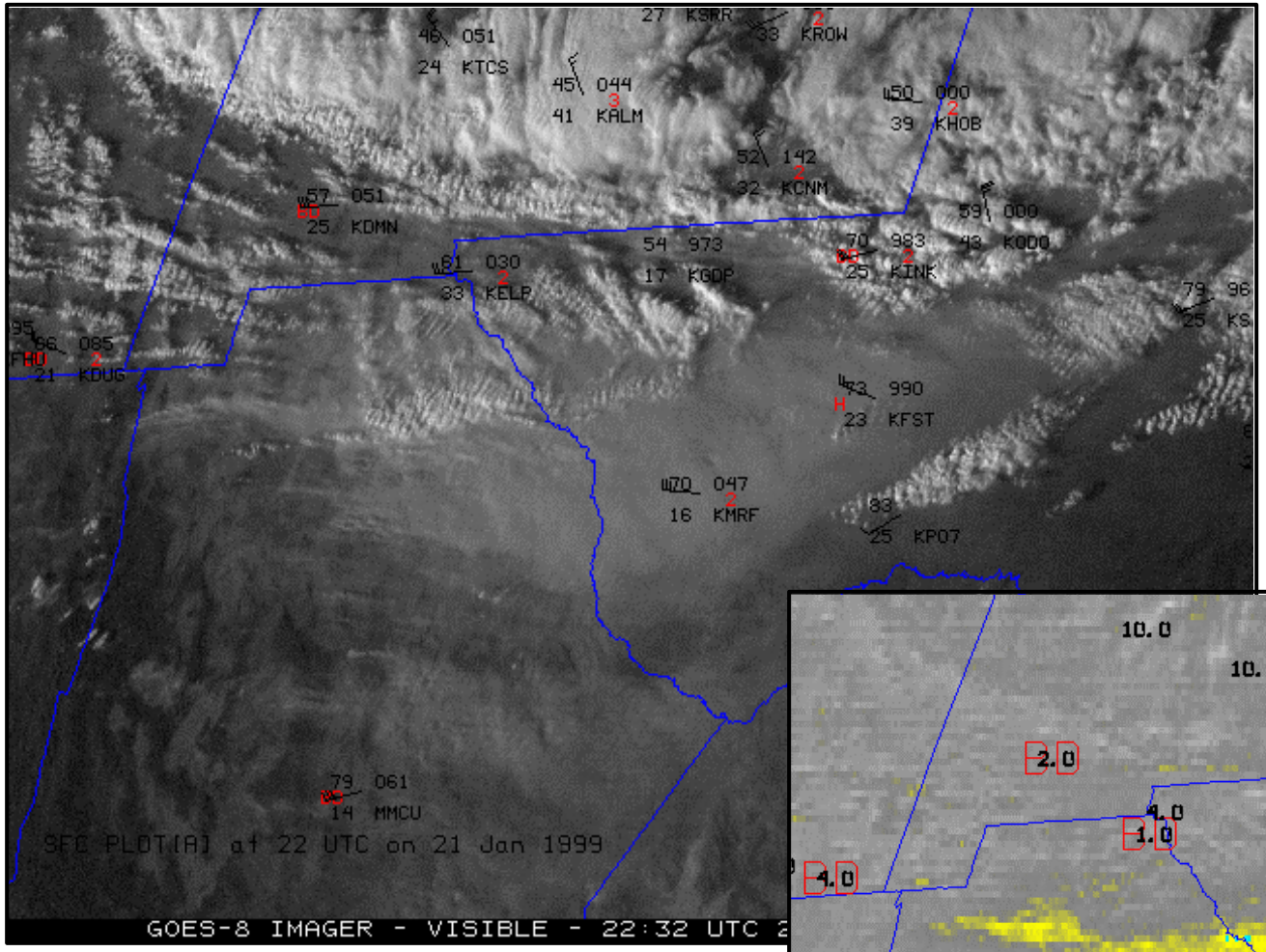


“Sundogs” (refraction off ice crystals)

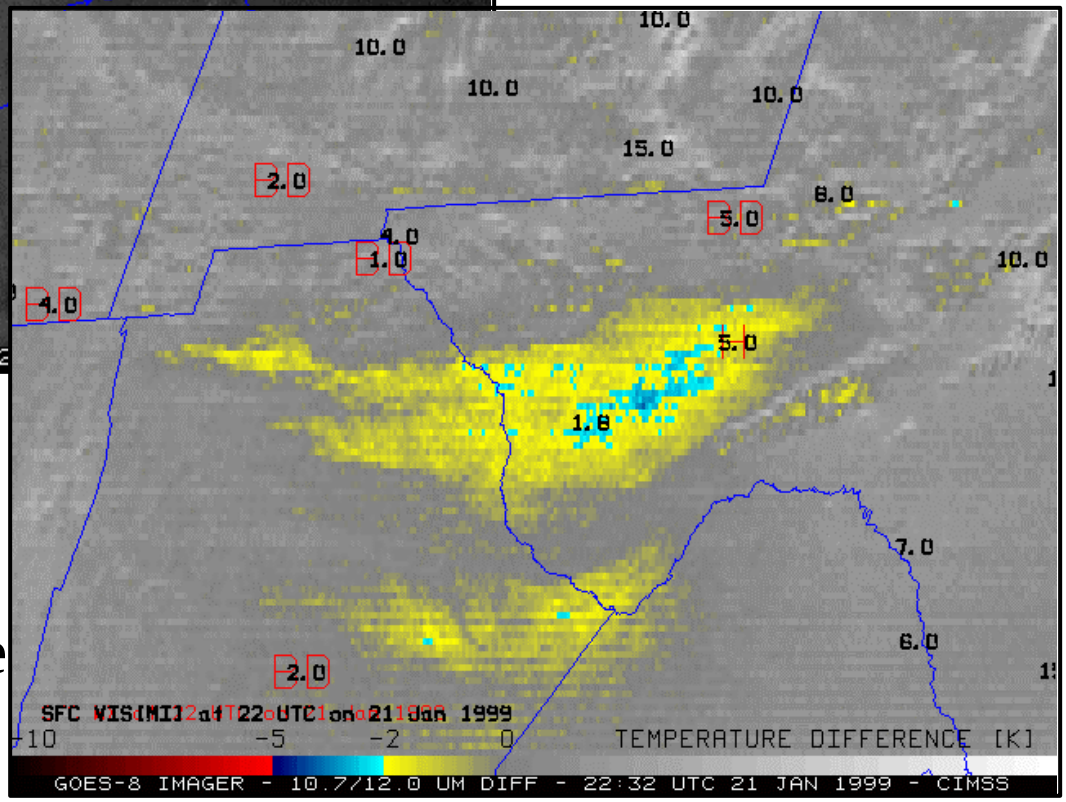
http://cimss.ssec.wisc.edu/goes/misc/001221.html

Dust Detection

GOES Visible

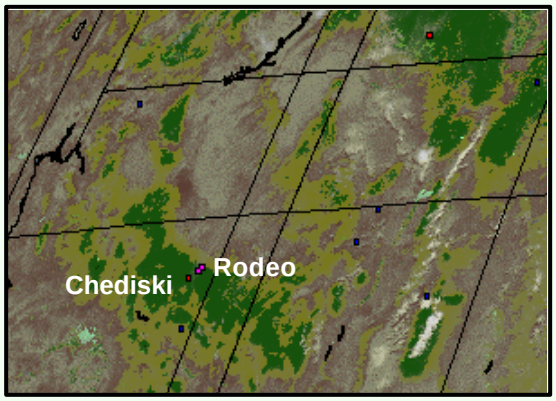



GOES Split-window Difference
(10.7 µm - 12 µm)

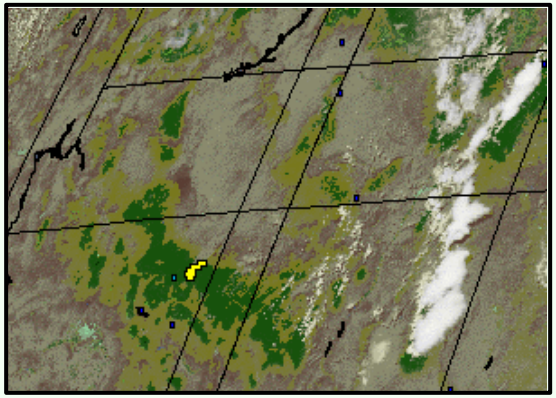


# GOES WFABBA Monitors Rapid Intensification of Wildfires

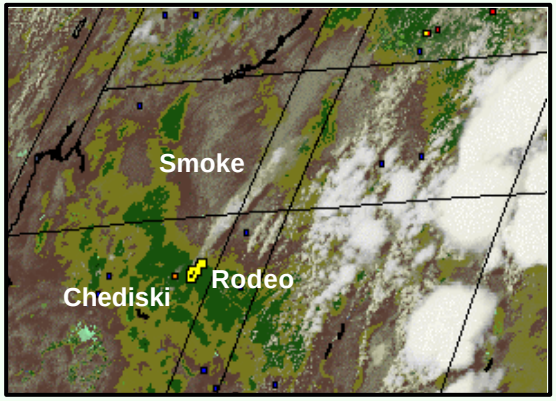
## Arizona




20 June 2002 16:15 UTC

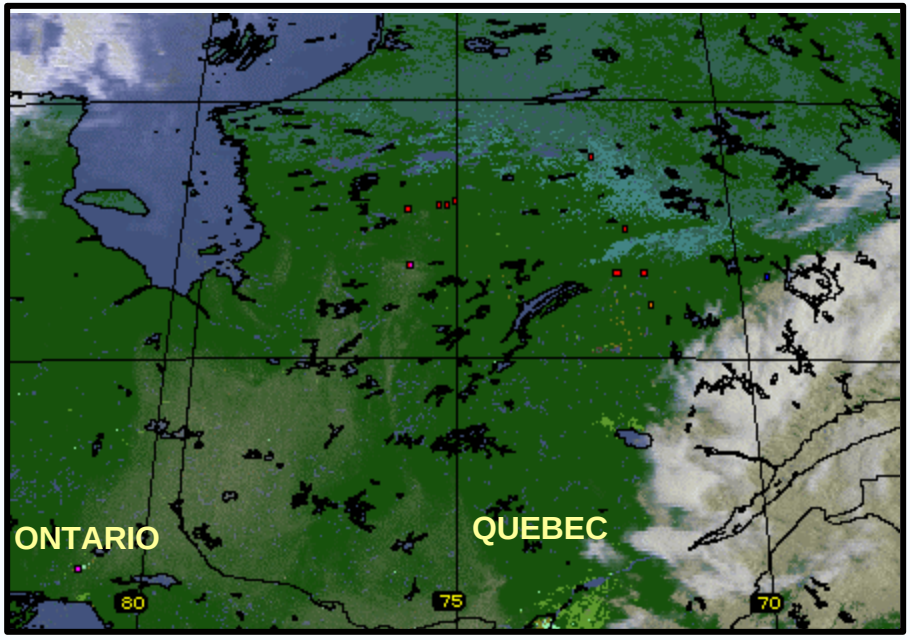


18:15 UTC

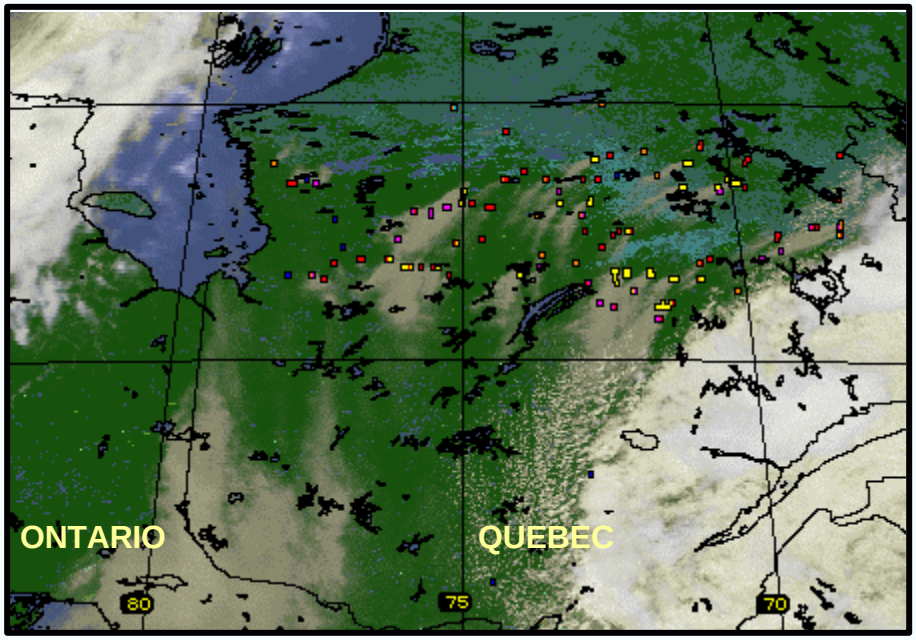



21:15 UTC

## Quebec




6 July 2002 11:45 UTC

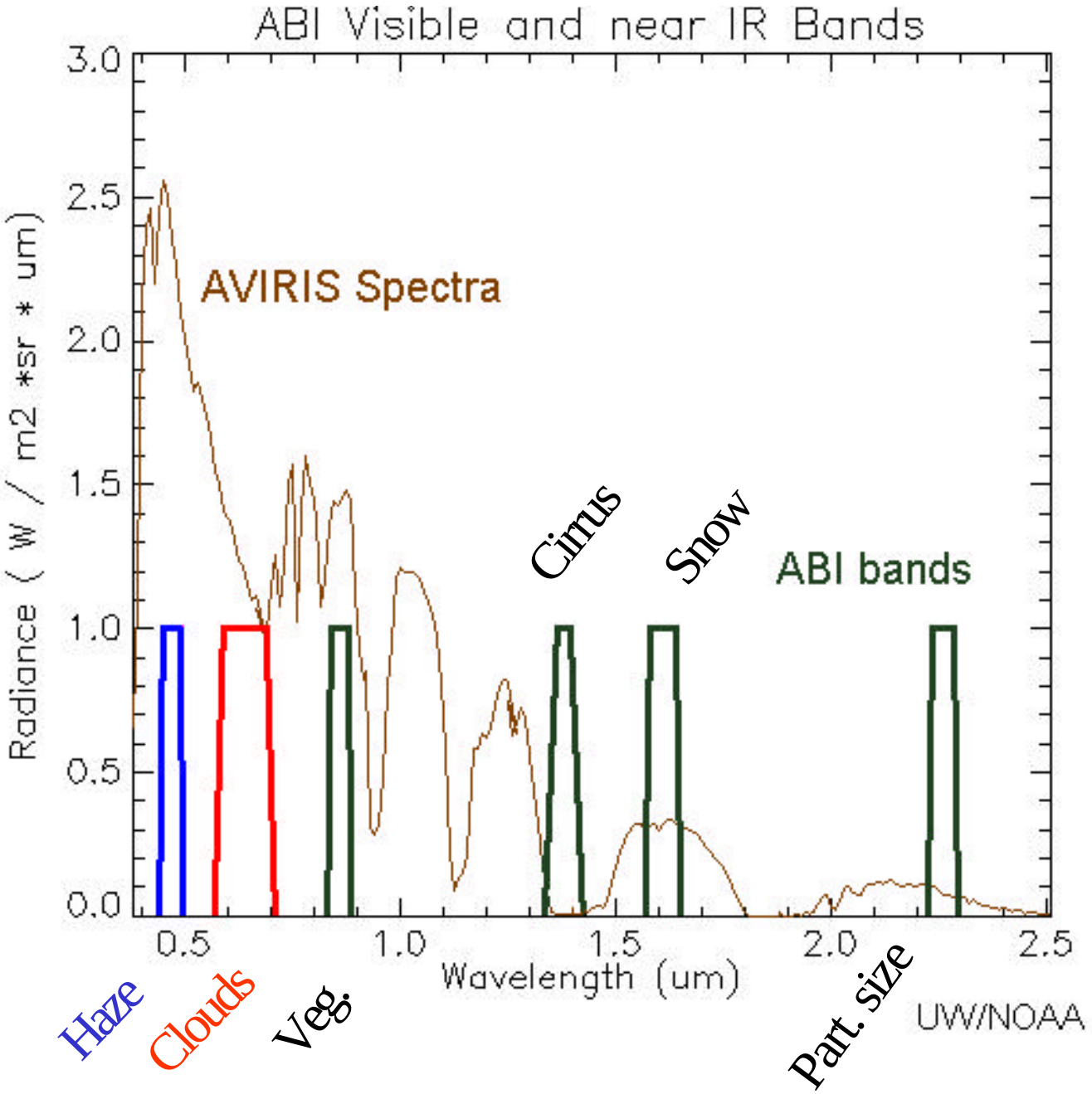



17:45 UTC

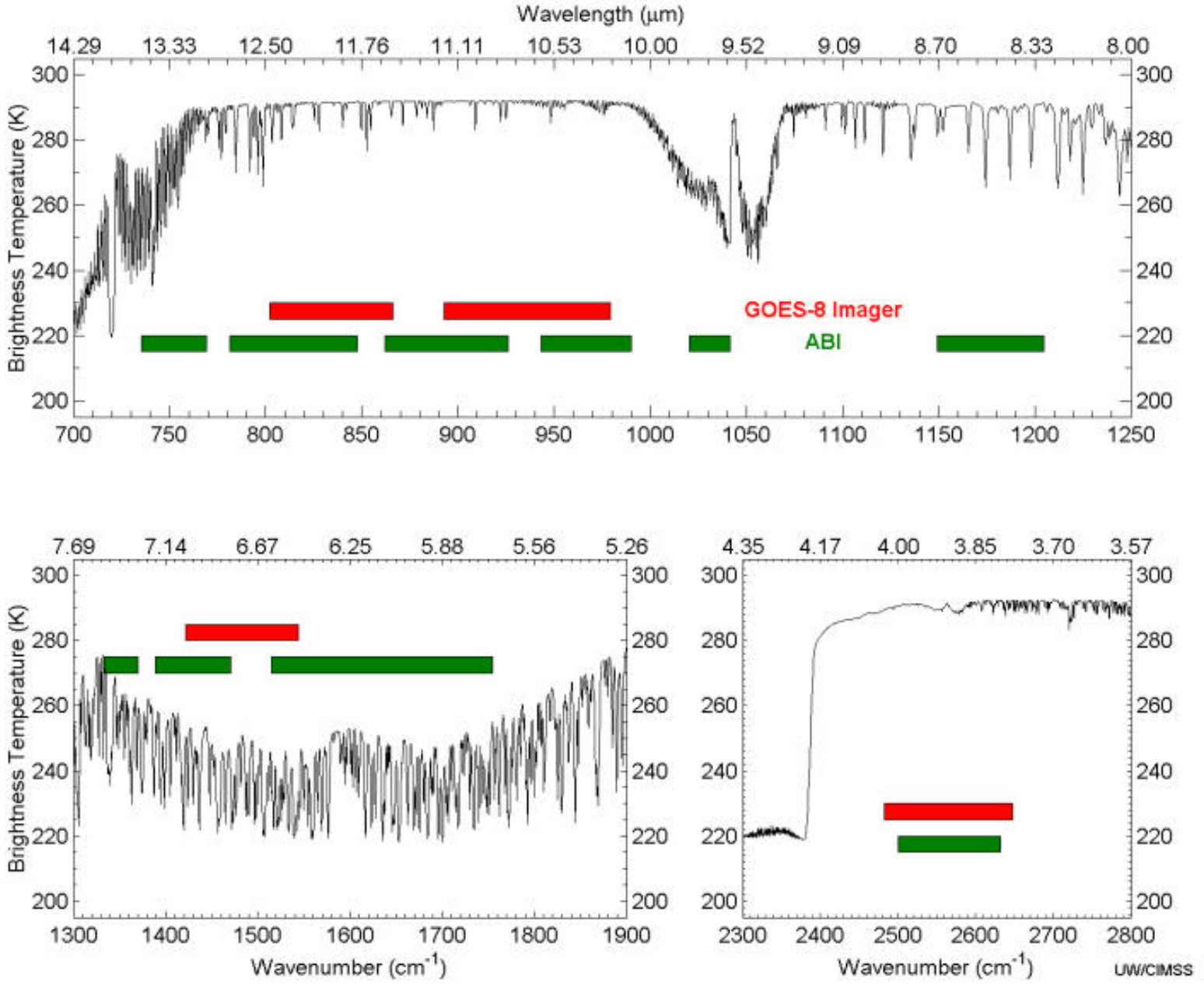
# The Advance Baseline Imager:

| | ABI | Current |
|---|---|---|
| **Spatial resolution** | | |
| 0.64 μm Visible | 0.5 km | Approx. 1 km |
| Other Visible | 1.0 km | n/a |
| IR bands | 2 km | Approx. 4 km |
| **Spatial coverage** | | |
| Full disk | 4 per hour | Every 3 hours |
| CONUS | 12 per hour | 4 per hour |
| **Operation during eclipse** | | |
| | Yes | No |
| **Spectral Coverage** | | |
| | 15/16 bands | 5 bands |

# Visible and near-IR channels on the ABI



# IR channels on the current GOES and on the ABI



# ABI Bands

| Band No. | Wavelength Microns | Bandpass microns | Primary Purpose |
|---|---|---|---|
| 1 | **0.47** | 0.45-0.49 | Daytime aerosol-on-land/coastal water mapping, vis. |
| 2 | **0.64** | 0.59-0.69 | Daytime clouds fog, insolation, winds |
| 3 | **0.86** | 0.84-0.88 | Daytime vegetation & aerosol-on-water, winds |
| 4 | **1.38** | 1.365-1.395 | Daytime cirrus cloud |
| 5 | **1.61** | 1.58-1.64 | Daytime cloud water, snow |
| 6* | **2.26** | 2.235 - 2.285 | Daytime land/cloud properties, particle size, vegetation |
| 7 | **3.90** | 3.80-4.00 | sfc. & cloud/fog at night, fire |
| 8 | **6.15** | 5.7-6.6 | High-level water, flow |
| 9 | **7.0** | 6.8-7.2 | mid-level water, flow |
| 10 | **7.4** | 7.3-7.5 | Lower-level water & SO2 |
| 11 | **8.5** | 8.3-8.7 | total water for stability, cloud phase, dust, SO2 |
| 12 | **9.7** | 9.6-9.8 | total ozone, turbulence, winds |
| 13 | **10.35** | 10.1-10.6 | sfc. & cloud, ice part size |
| 14 | **11.2** | 10.8-11.6 | total water for SST, clouds, rainfall |
| 15 | **12.3** | 11.8-12.8 | total water & ash, SST |
| 16 | **13.3** | 13.0-13.6 | air temp & cloud heights and amounts |

Current GOES Imagers

MSG or Sounder

MODIS or MTG, etc

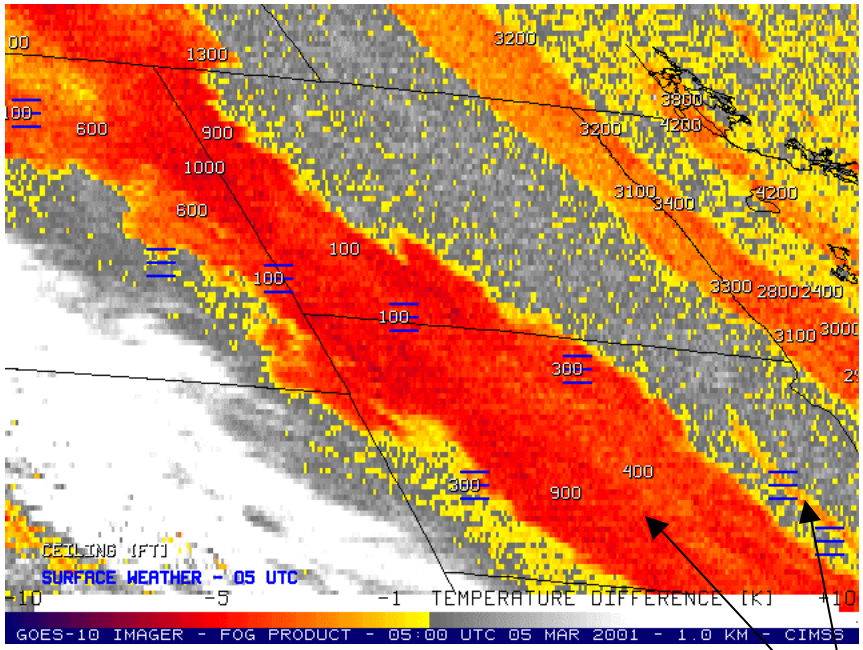
# ABI (3.9 μm)

Based on GOES Imager Ch 2

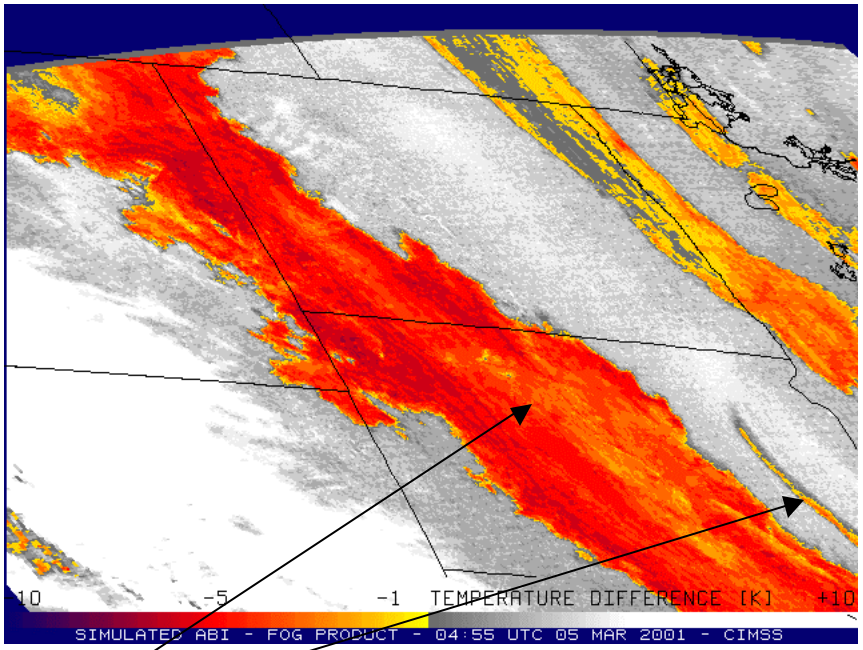
useful for fog, snow, cloud, and fire detection

## 5 March 2001 - Nocturnal Fog/Stratus Over the Northern Plains

GOES-10 4 minus 11 μm Difference




ABI 4 minus 11 μm Difference




Both images are shown in the GOES projection.

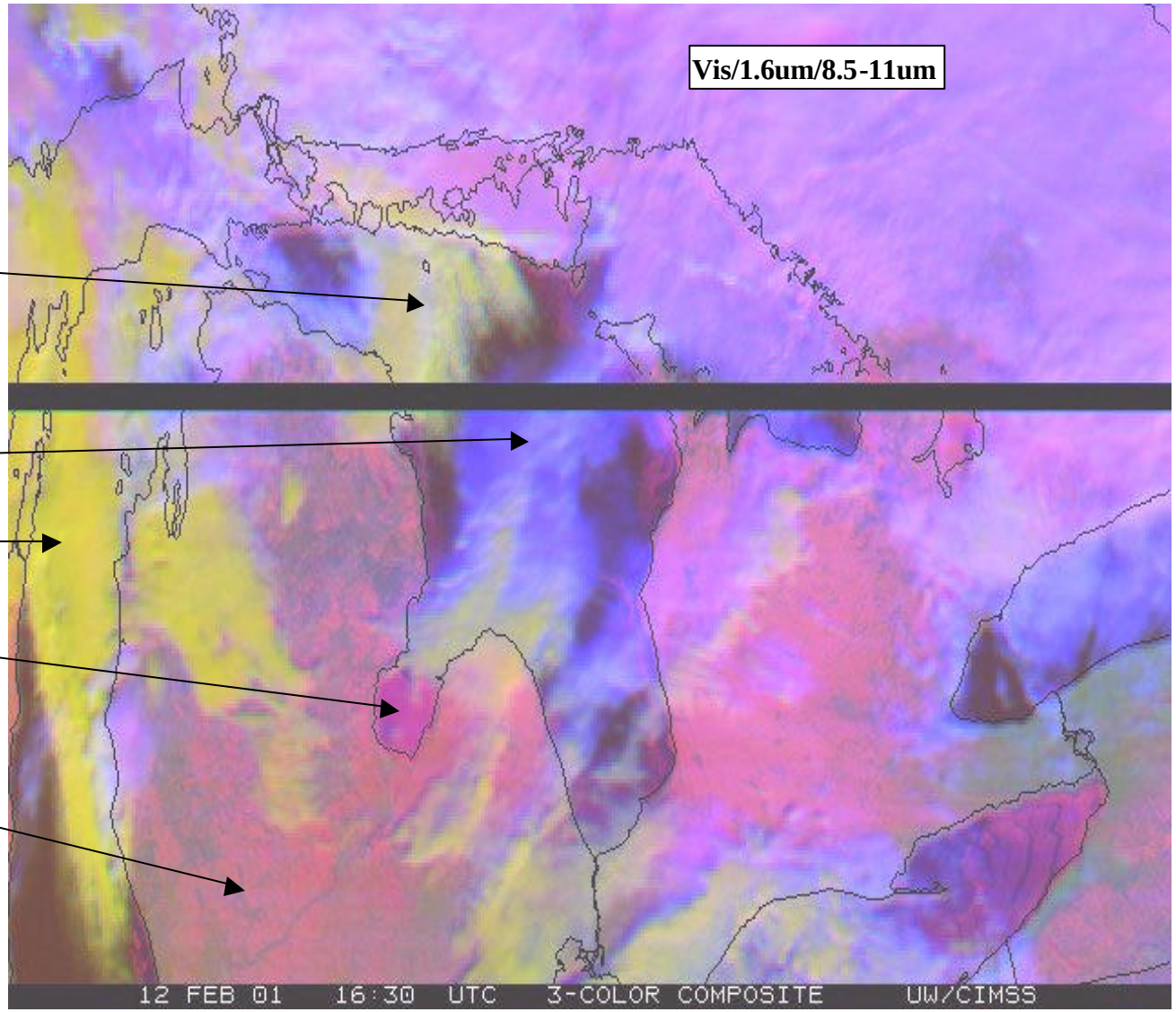
Fog

UW/CIMSS

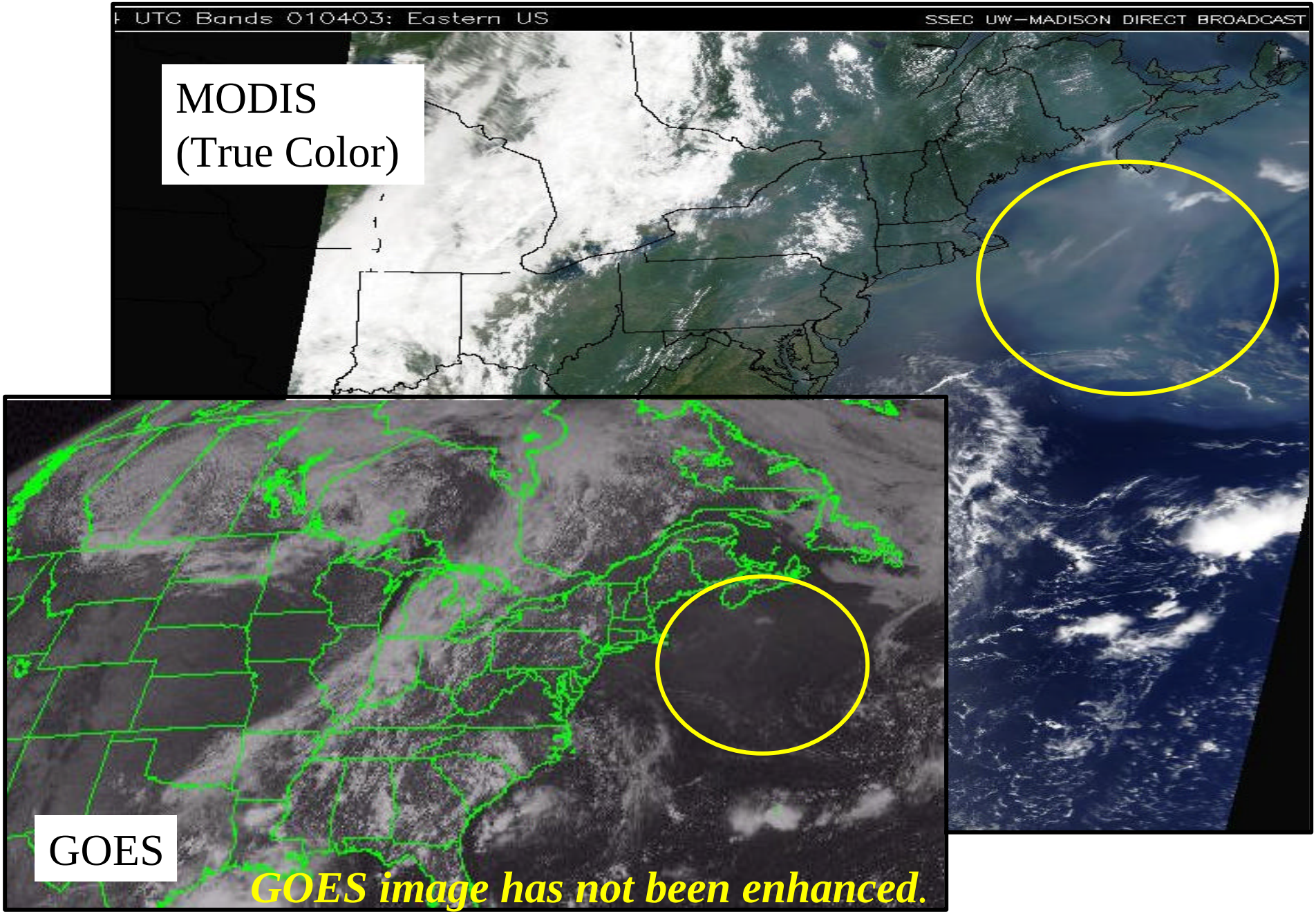
ABI image (from MODIS) shows greater detail in structure of fog.

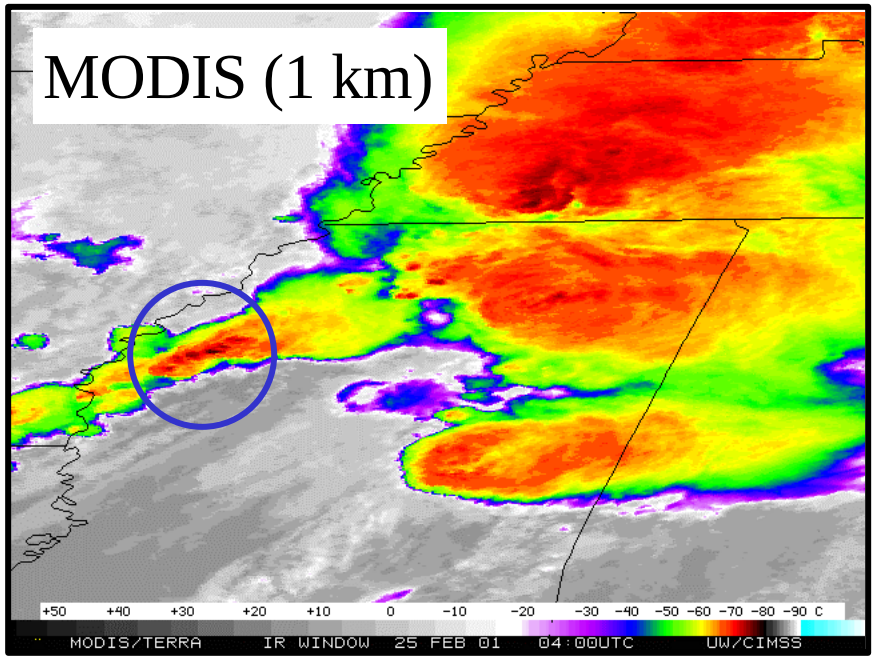
# Water/Ice Clouds and Snow/Lake Ice

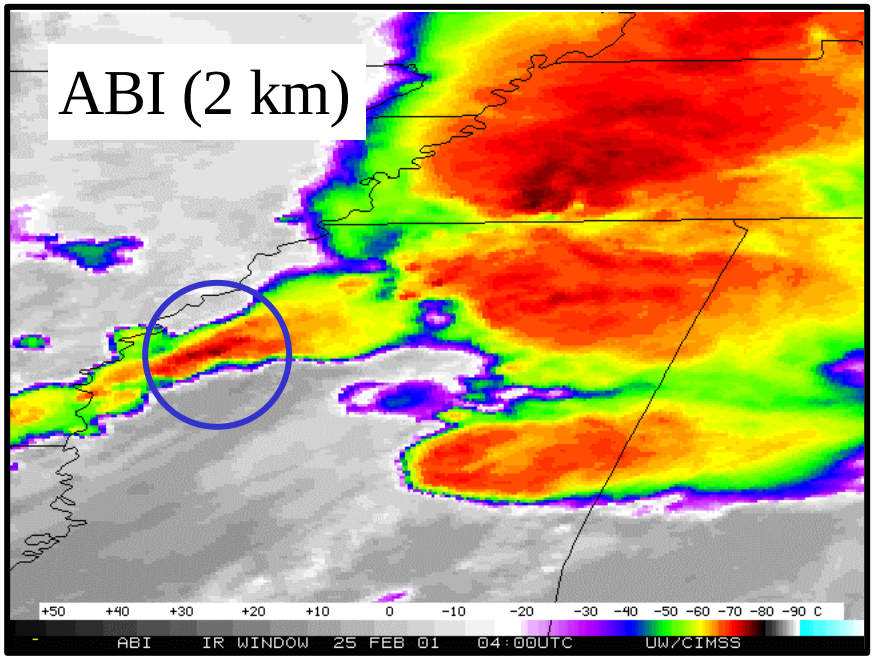
## ABI Simulations (from MODIS data)
## 3-color composite (Visible/1.6 µm/8.5-11 µm)
## 12 February 2001; 1627 UTC



# Haze Detection





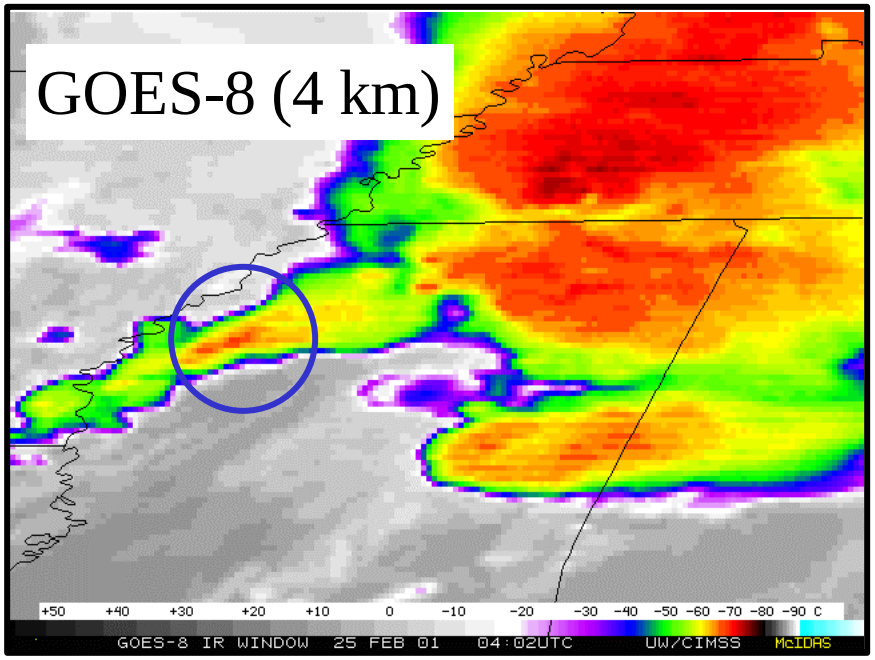

**Severe convection:**

**IR windows**

**25 February 2001**

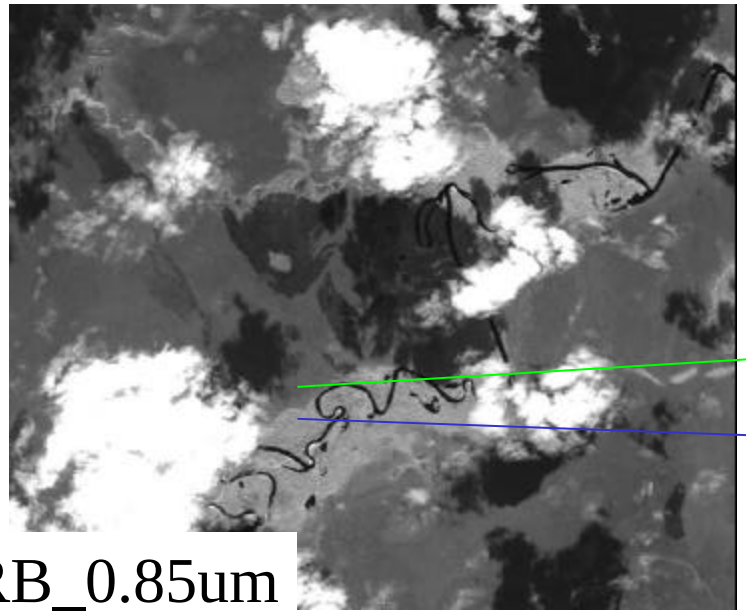
The simulated ABI clearly captures the over-shooting (cold) cloud tops, while the current GOES Imager does not.

Images shown in GOES projection.

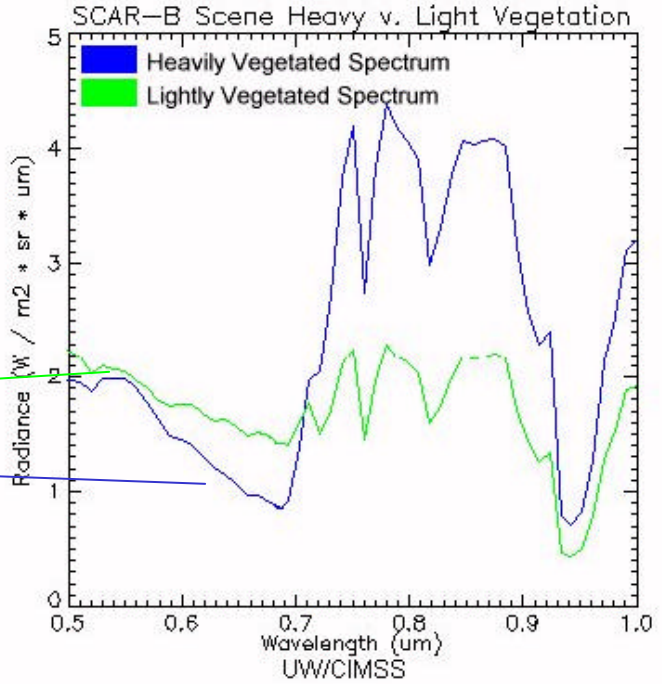


# Utility of the 0.86 mm band

- Helps in determining vegetation amount, aerosols and for ocean/land studies.
- Enables localized vegetation stress monitoring, fire danger monitoring, and albedo retrieval.
- Provides synergy with the AVHRR/3.



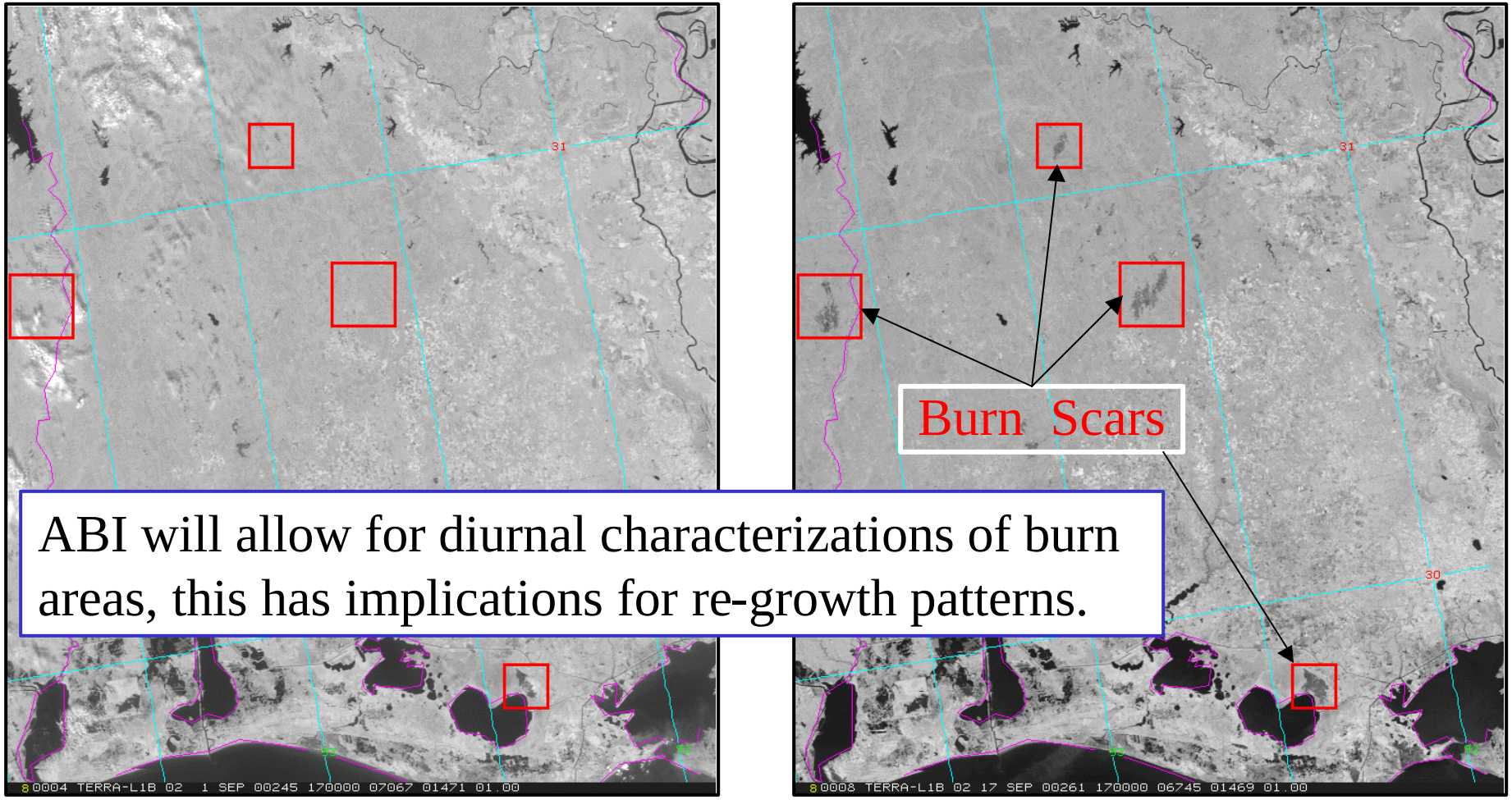
SCARB_0.85um



# MODIS Detects Burn Scars in Louisiana

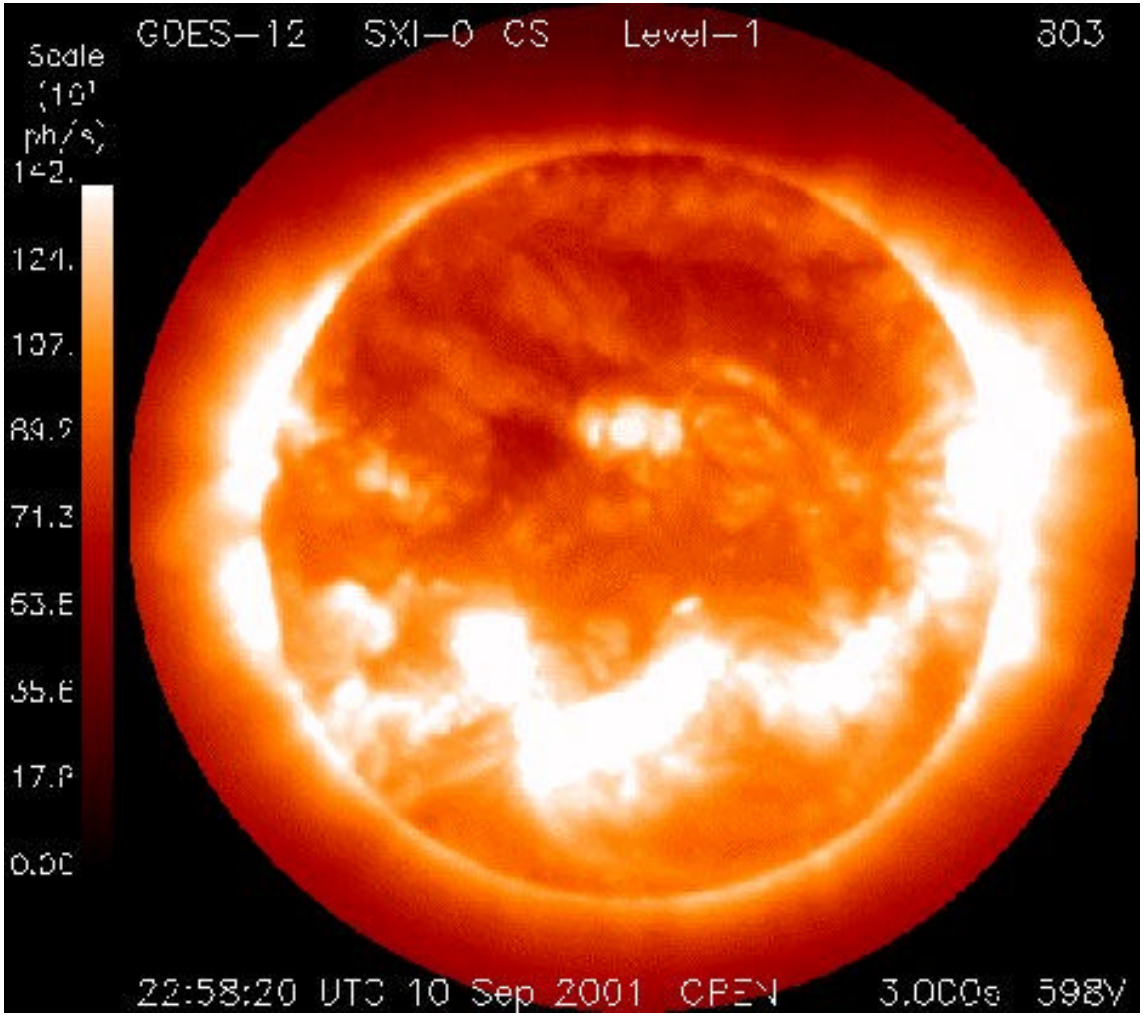
01 September 2000-- Pre-burning

17 September 2000-- Post-burning



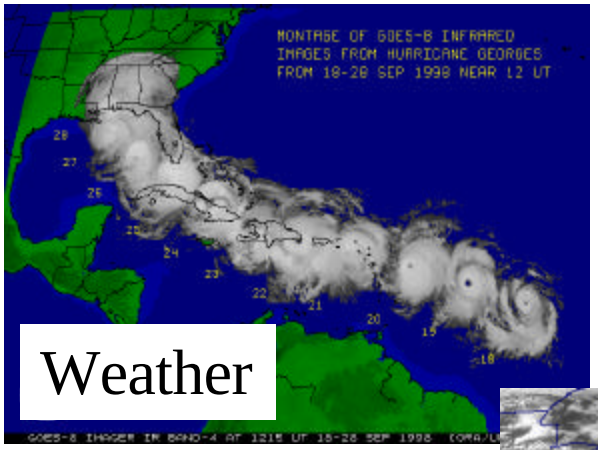

ABI will allow for diurnal characterizations of burn areas, this has implications for re-growth patterns.

Scars (dark regions) caused by biomass burning in early September are evident in MODIS 250 m NIR channel 2 (0.85 μm) imagery on the 17th.

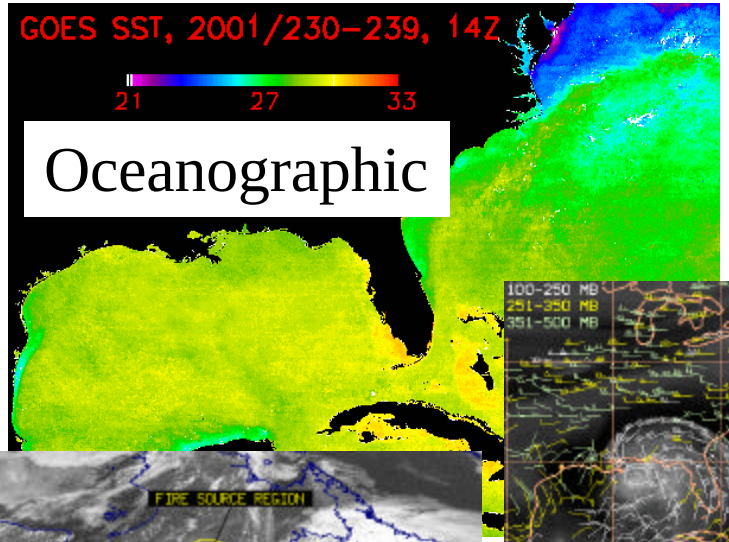



Solar X-Ray Imager on GOES-12

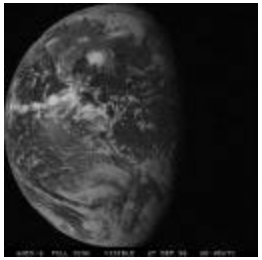
# Current GOES Imagers -- a wide variety of Applications

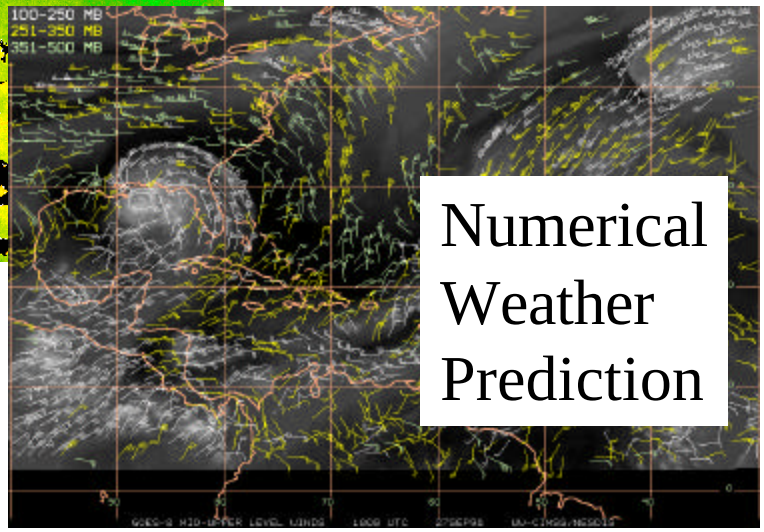



Weather

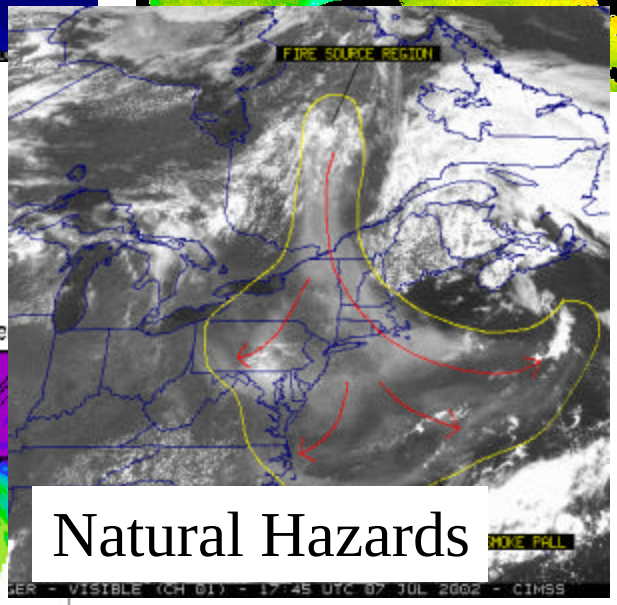



Oceanographic

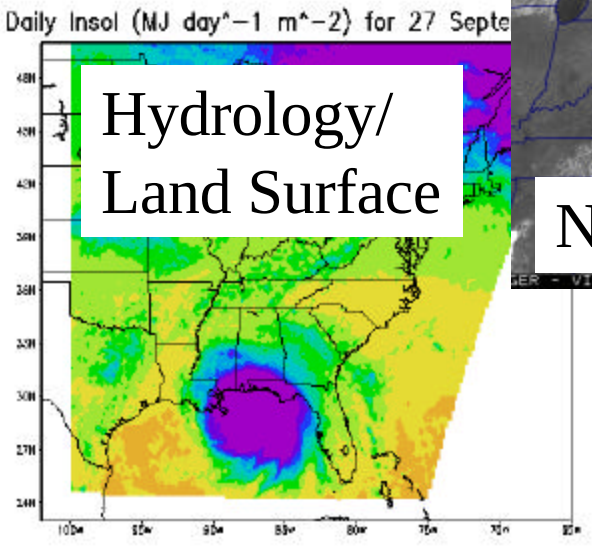




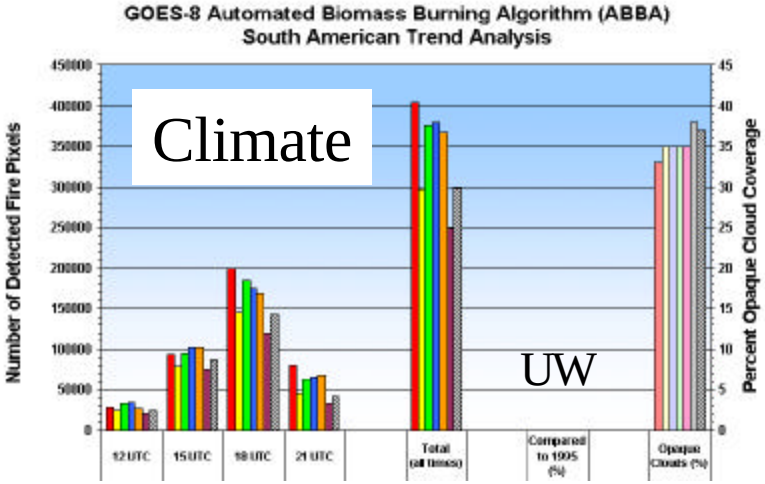

Numerical Weather Prediction




Natural Hazards




Hydrology/ Land Surface




Climate

UW

## Web sites which feature interesting Space imagery:

- **Planetary Images** from SSEC Outreach at the University of Wisconsin - Madison
- **X-ray images of the Sun** from the NOAA Space Environment Center
- **PhotoJournal of the Planets** from NASA JPL
- **Solar system simulator** from NASA JPL
- **Space Place information** from University of Wisconsin - Madison

## Web sites which feature interesting Earth imagery:

- **Real-time satellite images** from SSEC at the University of Wisconsin - Madison
- **Real-time satellite global composites** from SSEC at the University of Wisconsin - Madison
- **Real-time GOES products** from CIMSS at the University of Wisconsin - Madison
- **Real-time satellite images** from NASA GHCC
- **Historical GOES images** from the National Climatic Data Center
- **Operational Significant Events Imagery** from the NOAA/NESDIS Satellite Services Division

## Other interesting sites:

- **GOES rocket launches** from the NASA Glenn Research Center
- **Useful teaching applets** from T. Whittaker
- **Verner E. Suomi Virtual Museum** from SSEC/CIMSS
- **Information on next generation GOES imager** from NOAA and CIMSS
- **Misc. animations** from various sources

**http://cimss.ssec.wisc.edu/goes/links/space_links.html**