



# Update on GEO Hyperspectral Sounders: GIFTS and GeoMetWatch “Storm”



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**University of Wisconsin - Madison  
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**WMO Commission for Atmospheric Sciences  
Thorpe ICSC, DAOS Working Group 5<sup>th</sup> Meeting  
UW-Madison, Union South, 19-20 September 2012**

# *Perspective from recent talk at IRS*



## **Status of High Spectral Resolution IR for Advancing Atmospheric State Characterization (Sounding) and Climate Trend Benchmarking:**

**A Period of Both Opportunity Realized and Squandered**

**Squan·der, verb, *skwändər***

- 1. Waste in a reckless and foolish manner**
- 2. Allow (an opportunity) to pass or be lost**

International Radiation Symposium 2012, IRS2012-587  
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

# Summary from IRS

- ① **LEO Operational Wx:** AIRS, IASI, & CrIS **Realized**, but plan needed for **CrIS upgrades**
- ② **GEO Severe Wx:** GIFTS/ HES for GOES-R **Squandered\*** (in US), but **GeoMetWatch offers a Fix**
- ③ **Ground-based Wx Networks:** AERI **Not Realized**—Have great **Promise**
- ④ **Climate Benchmark & Intercal:** CLARREO **Squandered\*\*** (CLARREO delayed indefinitely), but Earth Venture Instrument Proposals (e.g. **Zeus**) and international collaborations could provide a path

*\*should be in orbit, removed from plans \*\*delayed indefinitely*



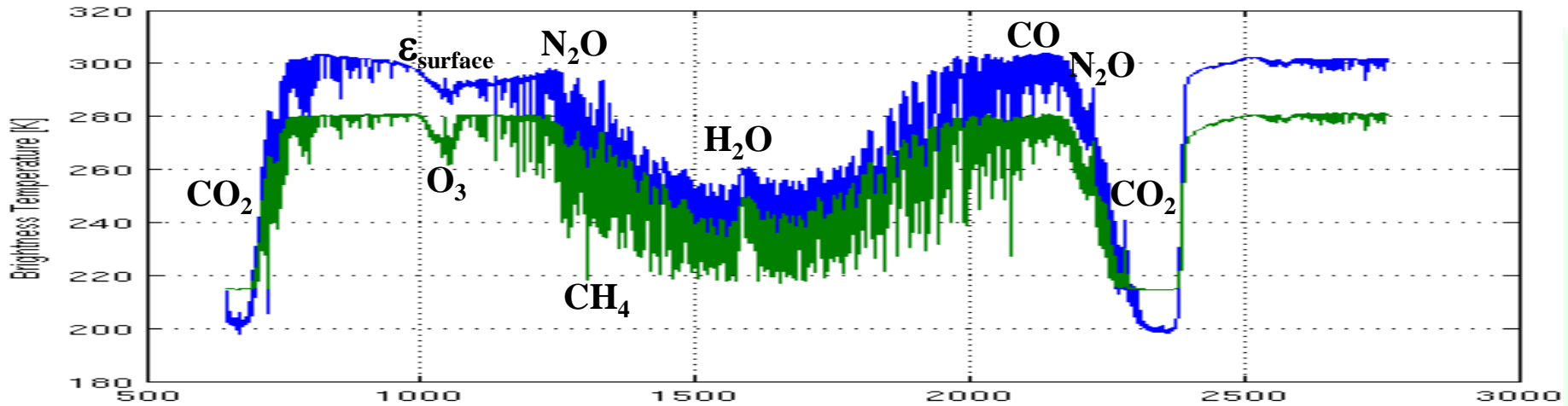
# Topics

- ◆ **Hyperspectral Sounding Background**
- ◆ **GIFTS: Cancelled in 2006, followed by cancellation of the GOES-R Sounder but IRS proceeding for MTG in 2019 & Chinese advanced sounder planned for 2015**
- ◆ **GeoMetWatch: A US Company planning to sell advanced sounder data from “STORM”, a GIFTS-like, privately funded sensor**

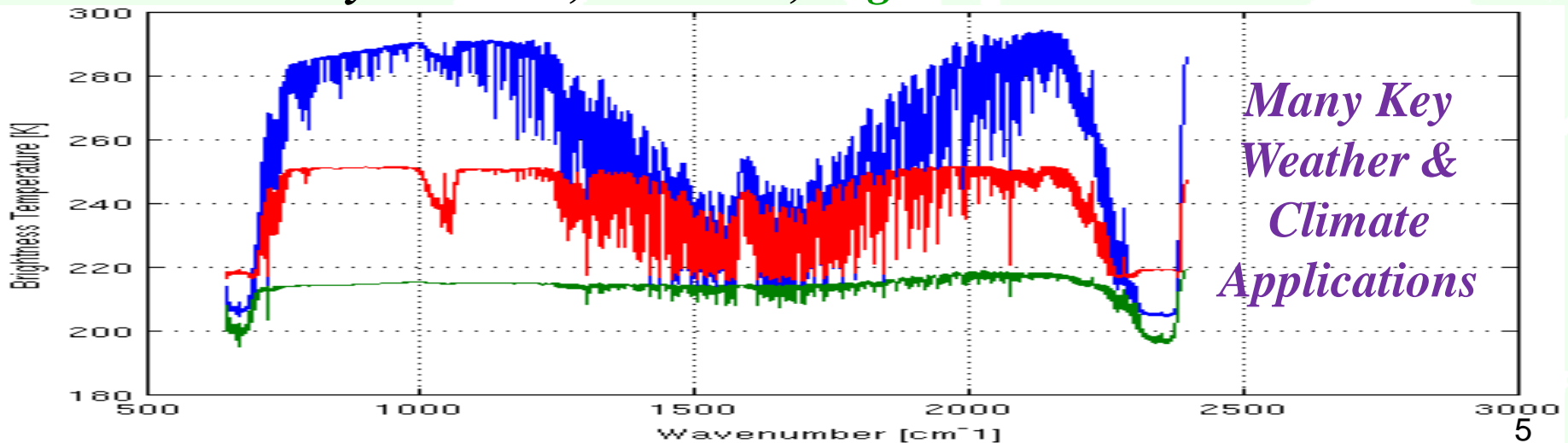
# ① Hyperspectral Sounding Background

## High Information Content

*Clear: Ocean and Desert*



*Cloudy: Thin ice, Mid-level, High black*



# High Spectral Resolution IR

*Proven developments in Radiative Transfer & Inter-Calibration form a solid foundation for sounding, GSICS & climate benchmarking*

1986: HIS  $\Rightarrow$  LBLRTM/GENLN2

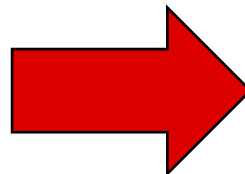
1990: HIS  $\Rightarrow$  AERI (UW/DOE ground-based)

1990s: AERI  $\Leftrightarrow$  NIST  $\Rightarrow$  LBLRTM

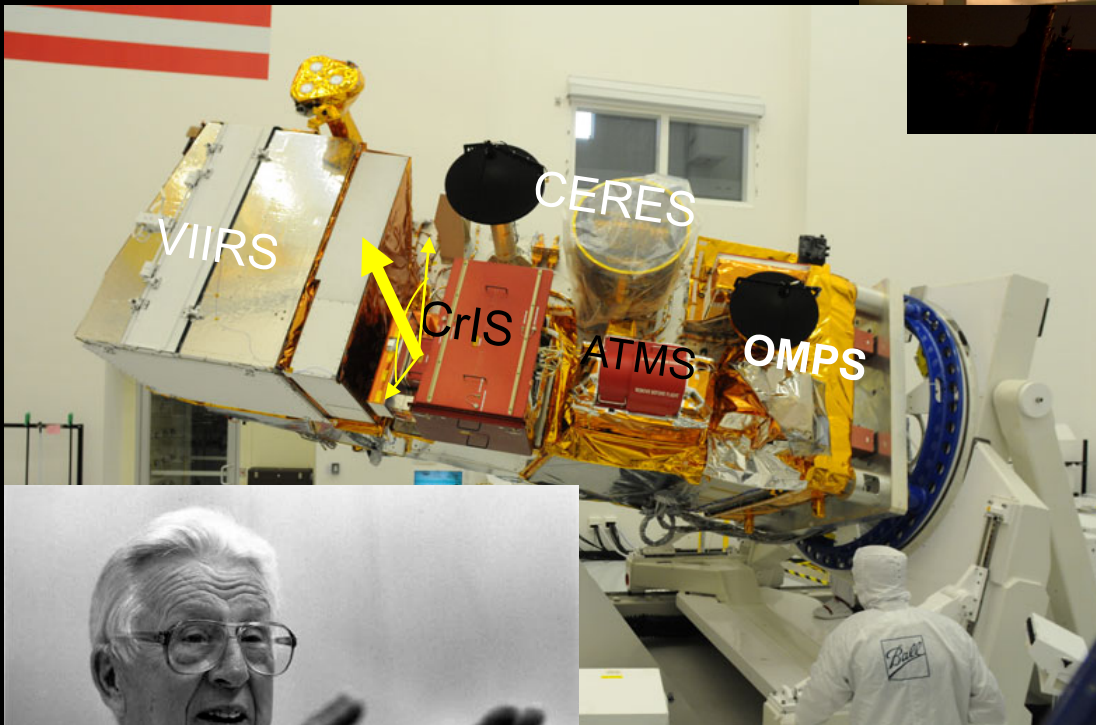
2002+: Scanning HIS  $\Leftrightarrow$  NIST  $\Leftrightarrow$  AIRS  $\Rightarrow$  kCARTA/LBLRTM  
AIRS  $\Rightarrow$  MODIS, GOES, HIRS

2006: Scanning HIS  $\Rightarrow$  NAST  $\Rightarrow$  IASI  $\Rightarrow$  LBLRTM/kCARTA  
IASI  $\Rightarrow$  MODIS, AIRS, ...

2012: Scanning HIS  $\Rightarrow$  NAST  $\Rightarrow$  CrIS  $\Rightarrow$  LBLRTM/kCARTA  
CrIS  $\Rightarrow$  VIIRS, GOES...  
 $\Leftrightarrow$  AIRS  
 $\Leftrightarrow$  IASI



# CrIS launched on Suomi NPP Initiating JPSS with EUMETSAT



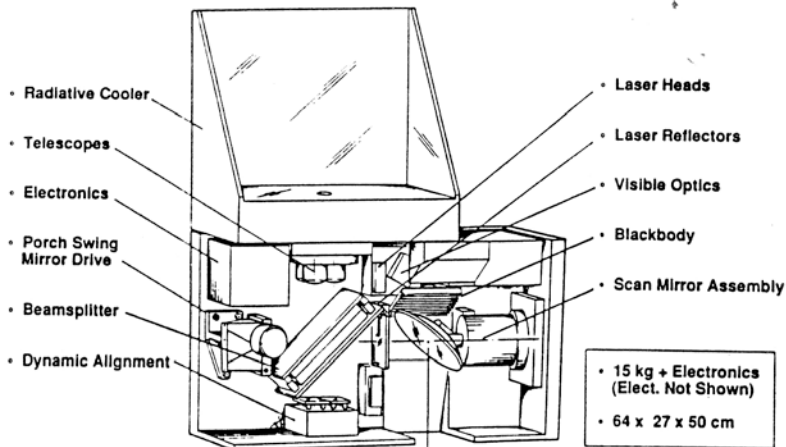
*Verner E. Suomi*  
1915-1995



# CrIS: 1990/91

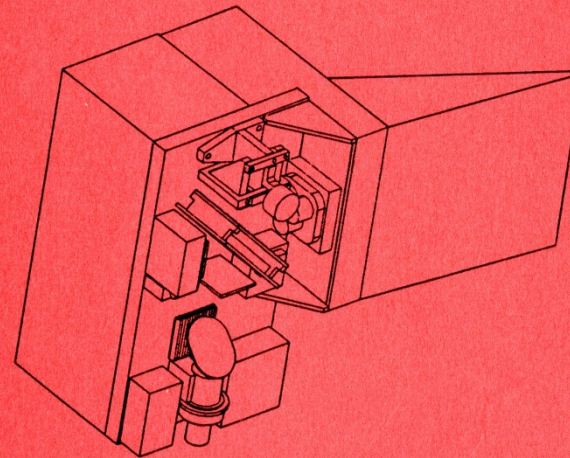
## Historical Roots

- *EUMETSAT (John Morgan) sponsorship*
- *Originated by Bill Smith, in residence at EUMETSAT*
- *UW-Madison/SSEC prime, Hank Revercomb, PI*
- *Detailed design by SBRC, Bomem DA interferometer Still Chase, Henry Buijs*



## INTERFEROMETER THERMAL SOUNDER (ITS)

FEASIBILITY STUDY  
FINAL REPORT



DECEMBER 20, 1991

PREPARED FOR  
EUMETSAT

PROPRIETARY

University of Wisconsin  
Space Science and Engineering Center



**HUGHES**  
SANTA BARBARA RESEARCH CENTER  
a subsidiary





## AIRS

Atmospheric InfraRed Sounder

Grating spectrometer

166 kg, 256 W

13.5 km FOV at nadir, contiguous

Launched on NASA Aqua in 2002

## IASI

*930 JPSS orbit*

Infrared Atmospheric Sounding Interferometer

Michelson interferometer

236 kg, 210 W

2x2 12 km FOVs at nadir, non-contiguous

Launched on Metop-A in 2006



*Full scale model at 2010 IASI meeting*



## CrIS *1330 JPSS orbit*

Cross-track Infrared Sounder

Michelson interferometer

146\* kg, 110 W

3x3 14 km FOVs at nadir, contiguous

Launched on Suomi NPP, 28 Oct 2011

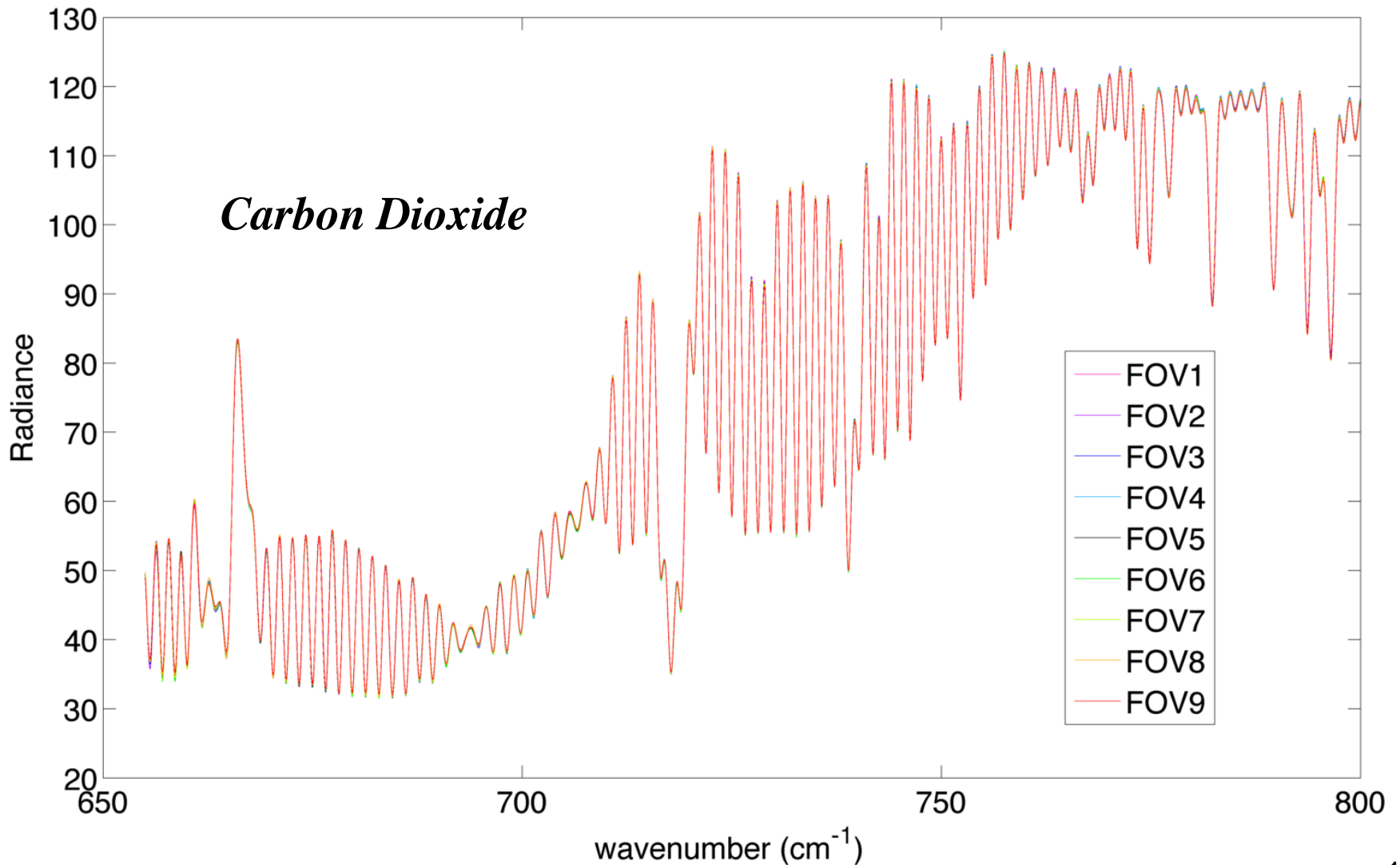
\* with vibration isolation that was not deployed

**CrIS ~  
the size  
of HIRS**

*Exelis(ITT)/ABB(Bomem)*

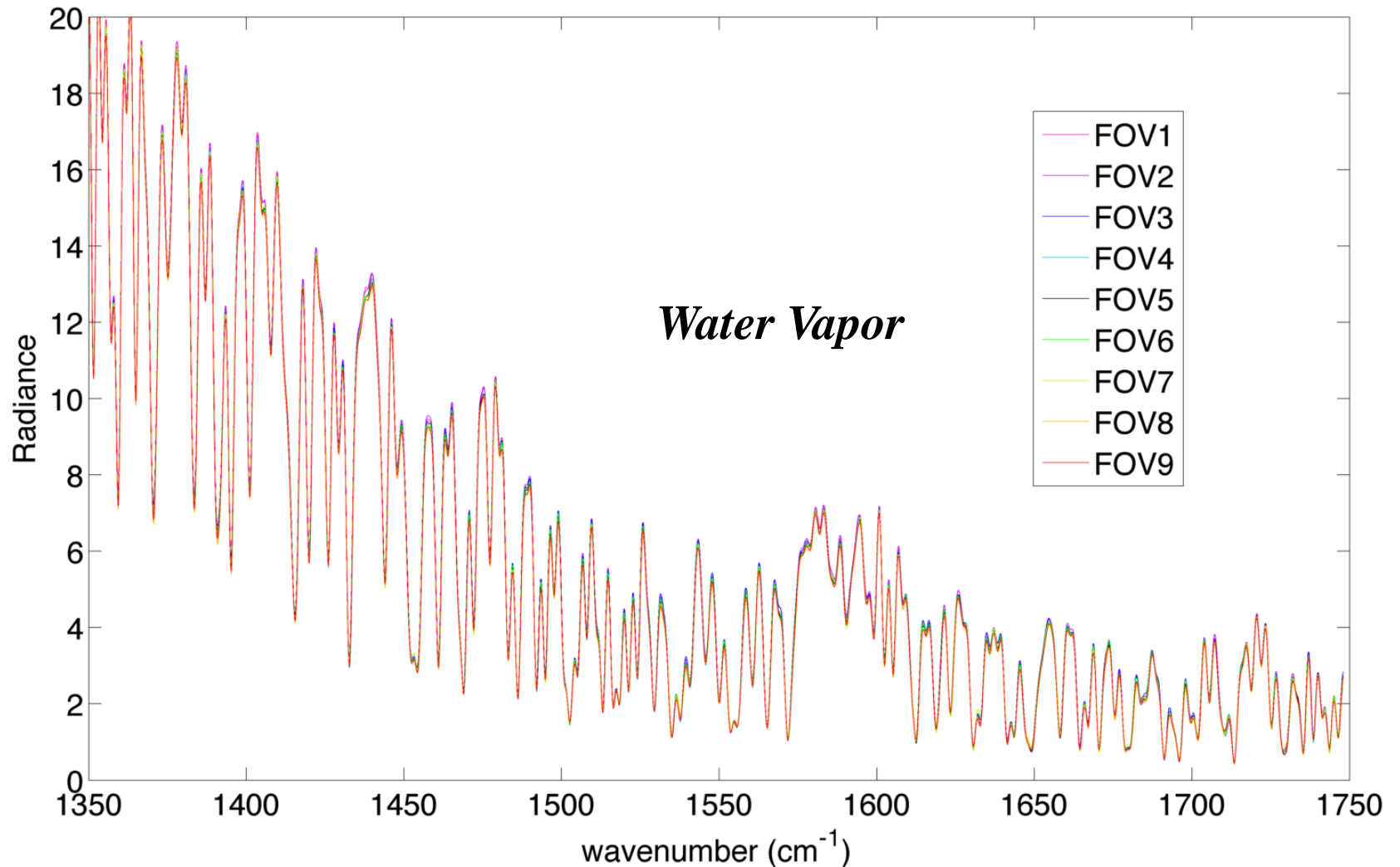
# Sample “1<sup>st</sup> Light” spectra (20 January)

## Overlays for a uniform 3x3 FOR



# Sample “1<sup>st</sup> Light” spectra (20 January)

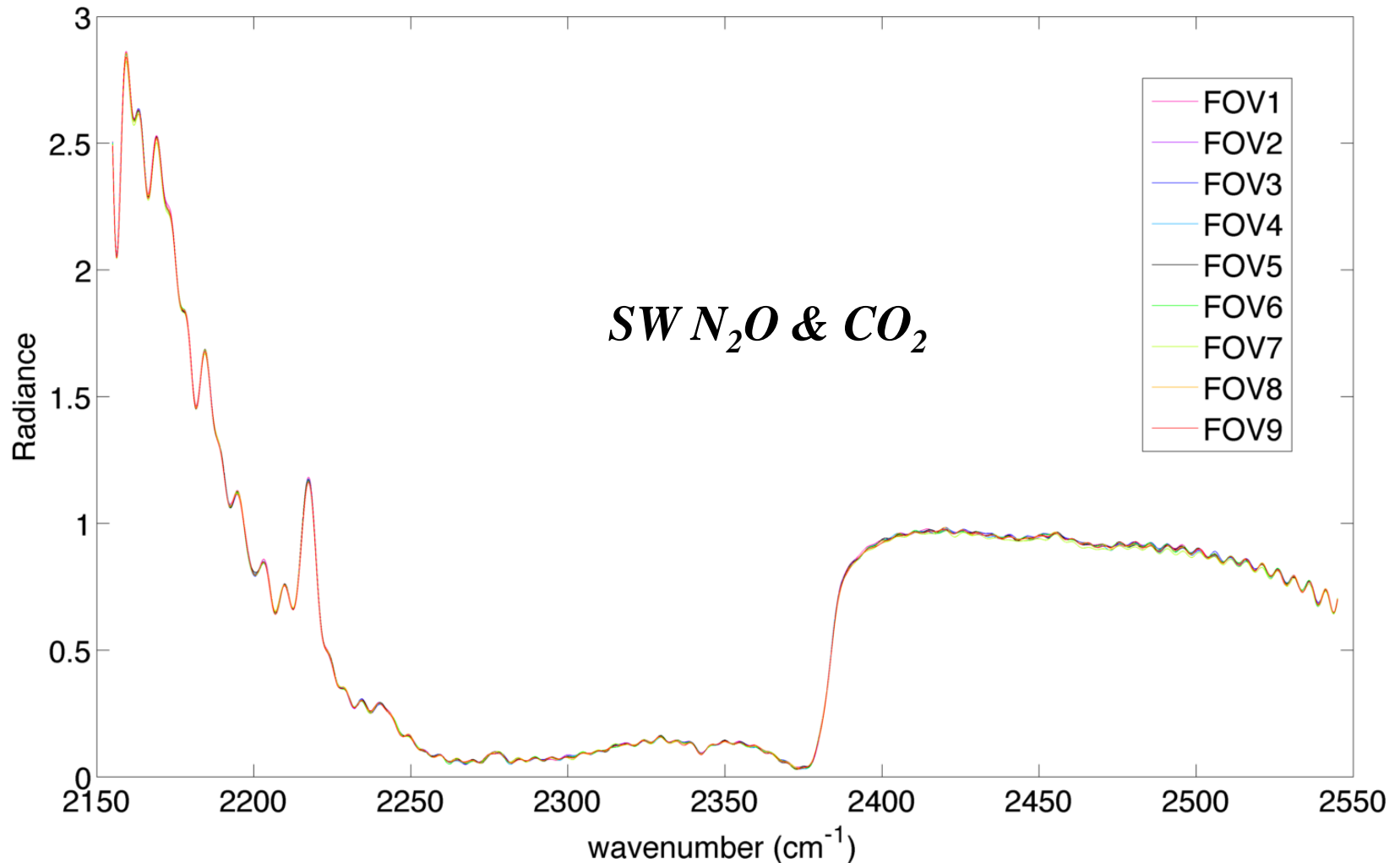
## Overlays for a uniform 3x3 FOR





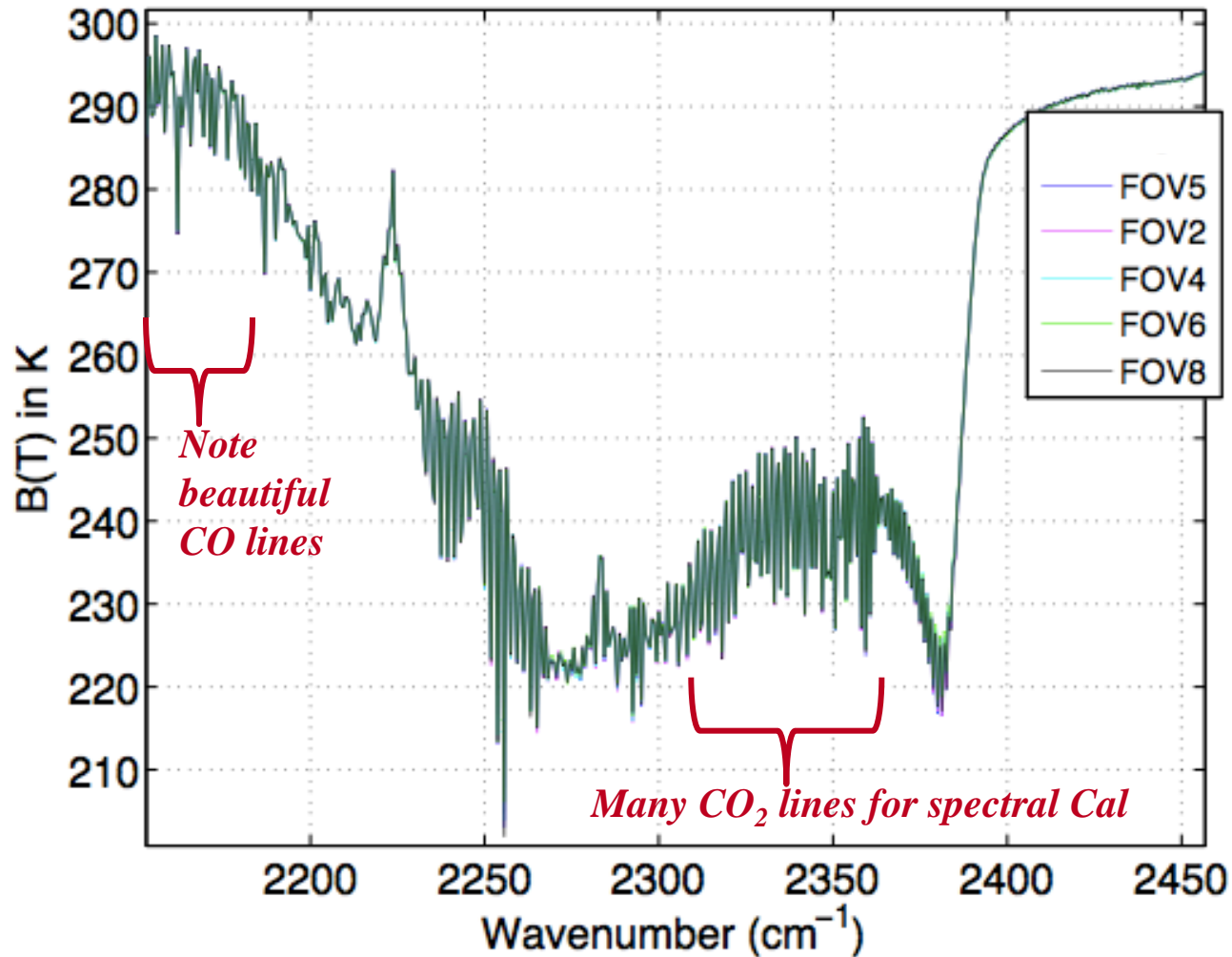
# Sample “1<sup>st</sup> Light” spectra (20 January)

## Overlays for a uniform 3x3 FOR



# Full Resolution SW band from CrIS

*Early 2013 Downlink planned*



*Calibrated with UW/UMBC CCAST—thanks to Larrabee Strow*

# LEO Operational W<sub>x</sub>: AIRS, IASI, & CrIS

**AIRS: 2002-**

L1B: > 1200  
Resolving Power  
9 FOV/50km square

**IASI: 2006-**

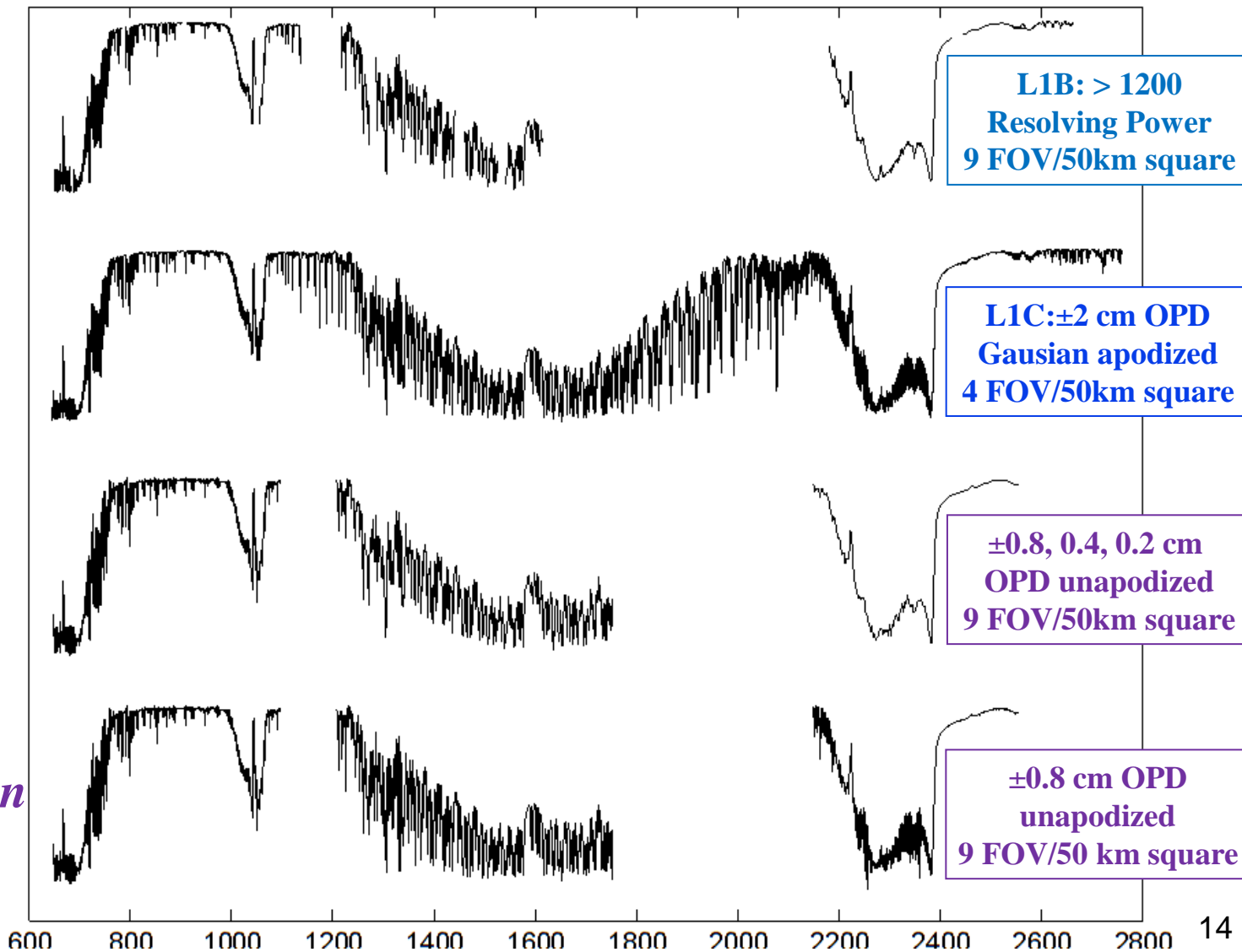
L1C: ±2 cm OPD  
Gaussian apodized  
4 FOV/50km square

**CrIS: 2011-**

±0.8, 0.4, 0.2 cm  
OPD unapodized  
9 FOV/50km square

**CrIS: 2011-  
Full Resolution  
starting 2013**

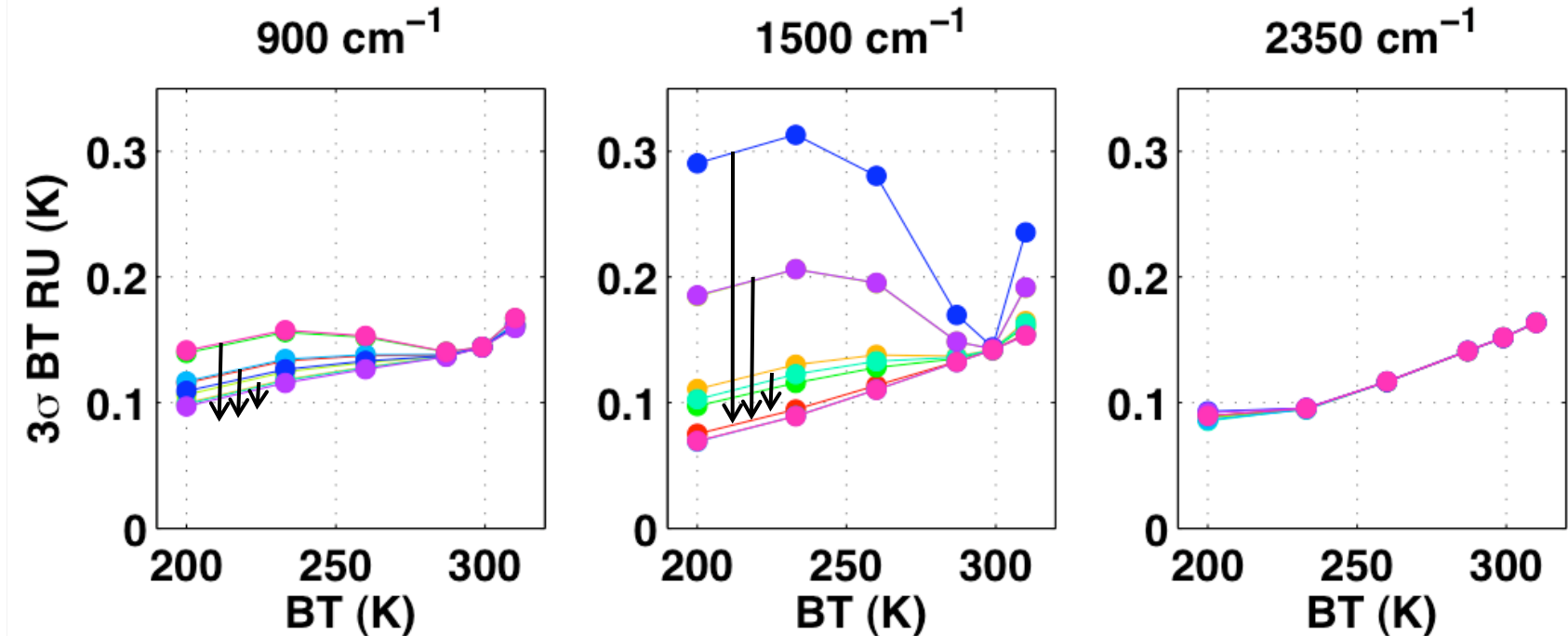
±0.8 cm OPD  
unapodized  
9 FOV/50 km square





# Expected Radiometric Uncertainty

Shown versus scene temperature for all FOVs for ~mid-band spectral channels

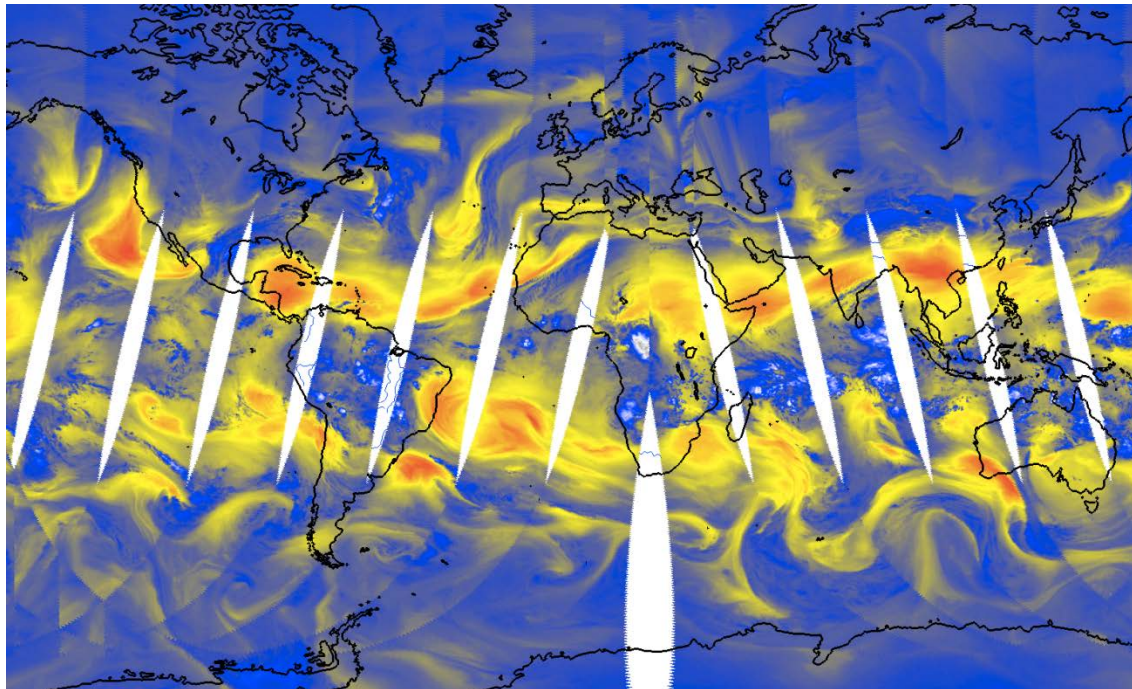


*FOV to FOV spread in LW and especially MW is due to non-linearity*

***Final inflight uncertainty far better than spec!***  
*(< 0.2K 3-sigma, after inflight non-linearity refinement)*

# CrIS on Suomi NPP

- ◆ CrIS instrument performance is exceptional
  - Very low noise
  - Very stable and accurate
  - Provides excellent baseline for future upgrades providing
    - ◆ Contiguous spectral coverage
    - ◆ Higher spatial resolution

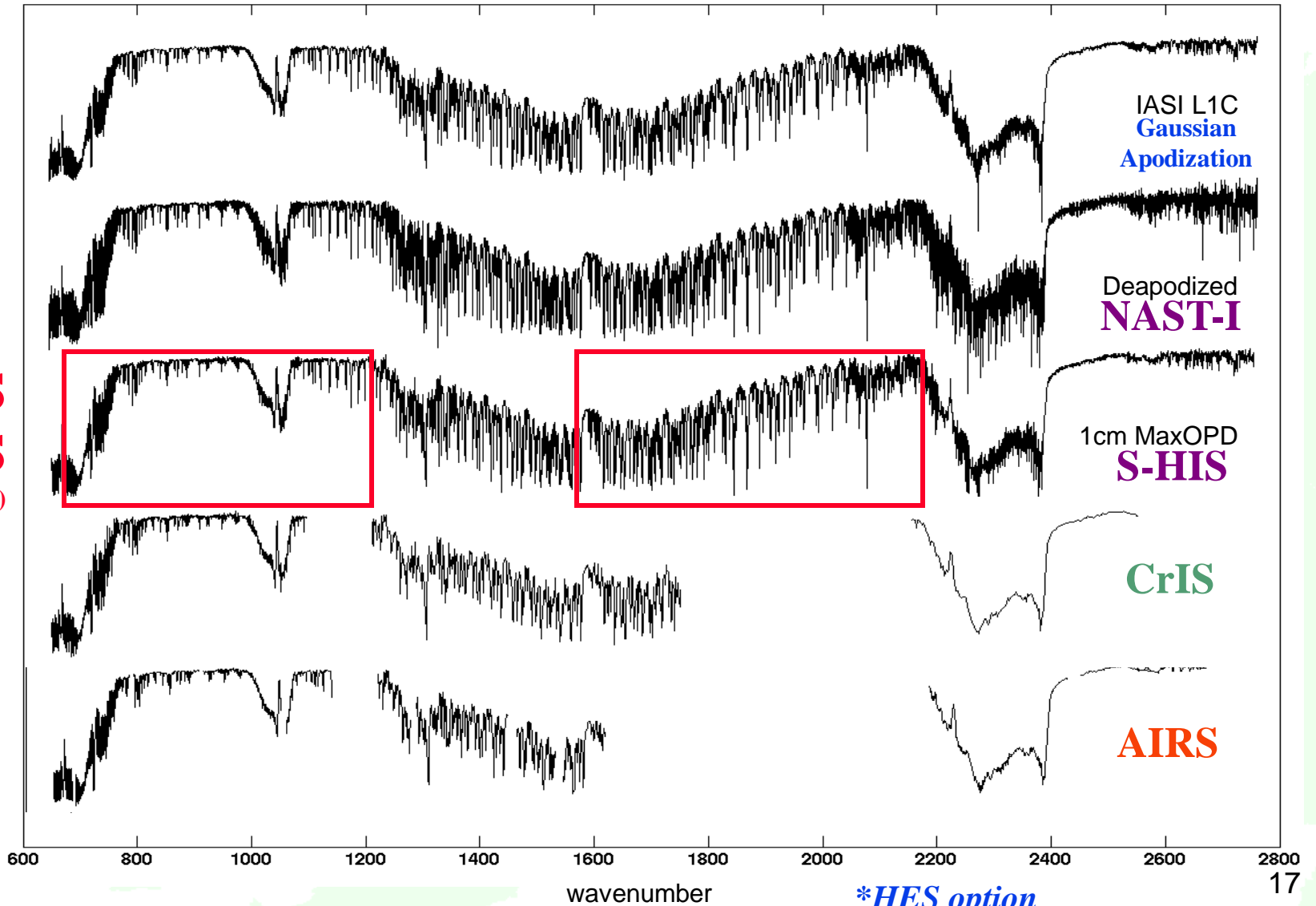


*Water Vapor  
24 February,  
1580  $\text{cm}^{-1}$*

*CrIS on Suomi NPP a fitting tribute to Verner Suomi*

# ② GIFTS

(Geostationary Imaging Fourier Transform Spectrometer)



**GIFTS  
& IRS  
(EUMETSAT)**

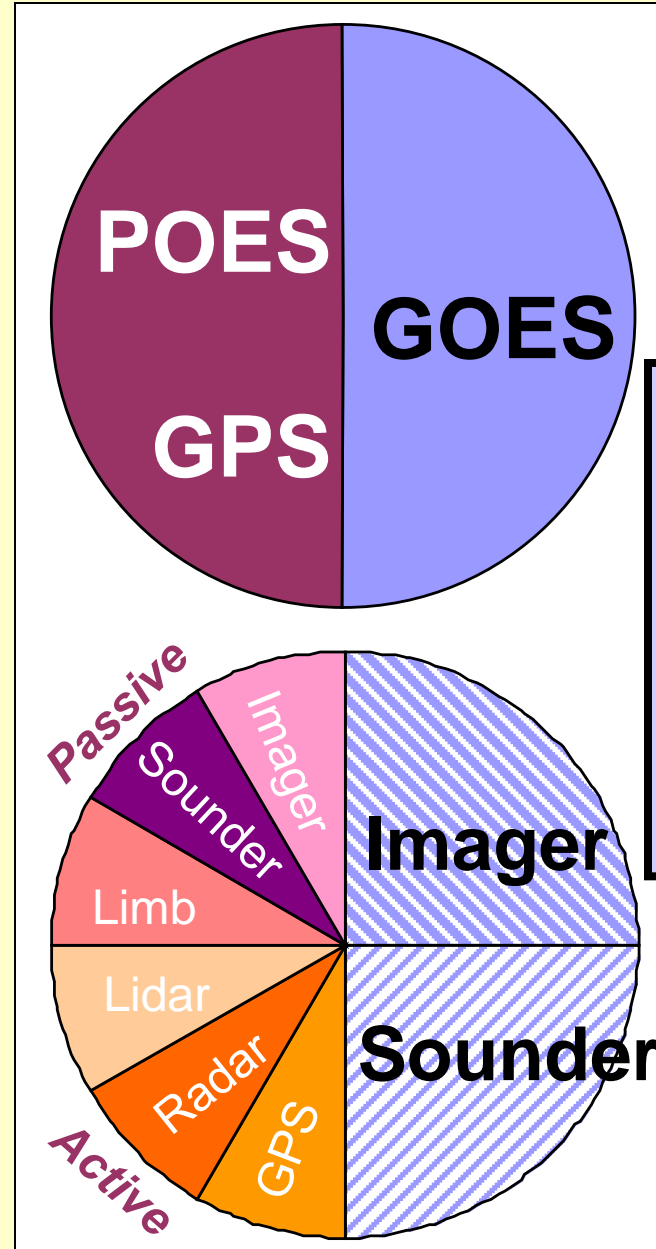
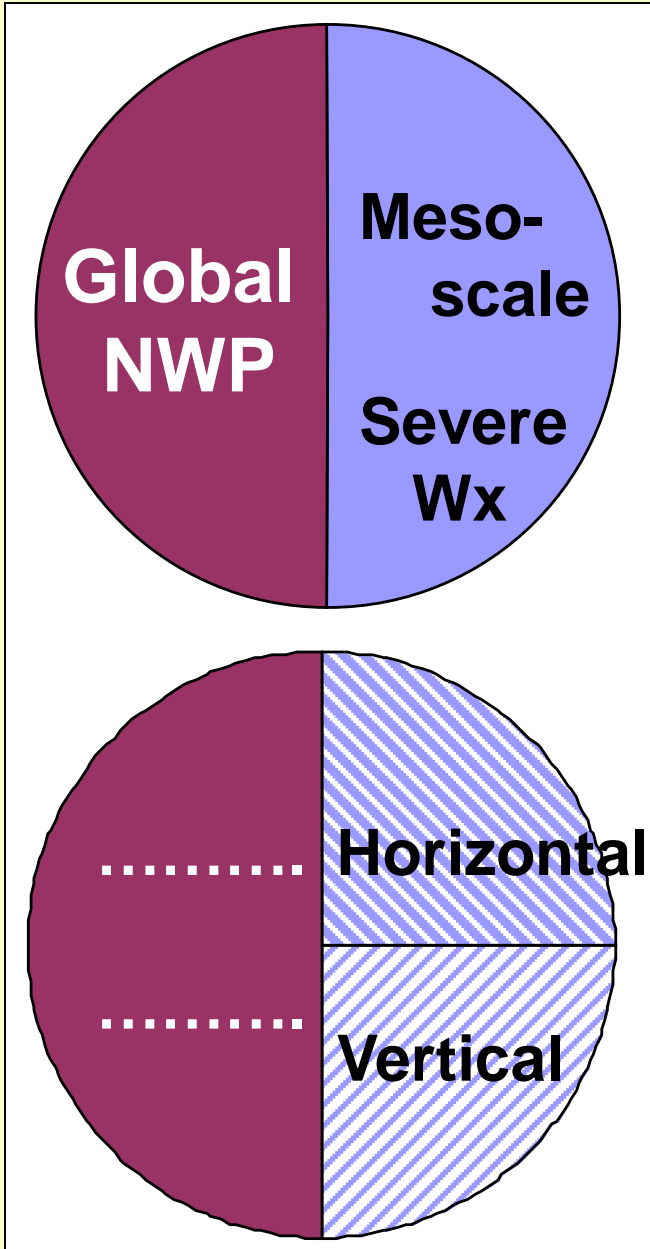
*\*HES option*



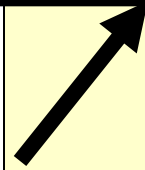
# Operational Weather Satellites

## ROLE

## APPROACH



**GOES  
Sounder**  
= 1/4 Wx Sat.  
role  
= 1/2 Severe  
Wx Sat. role



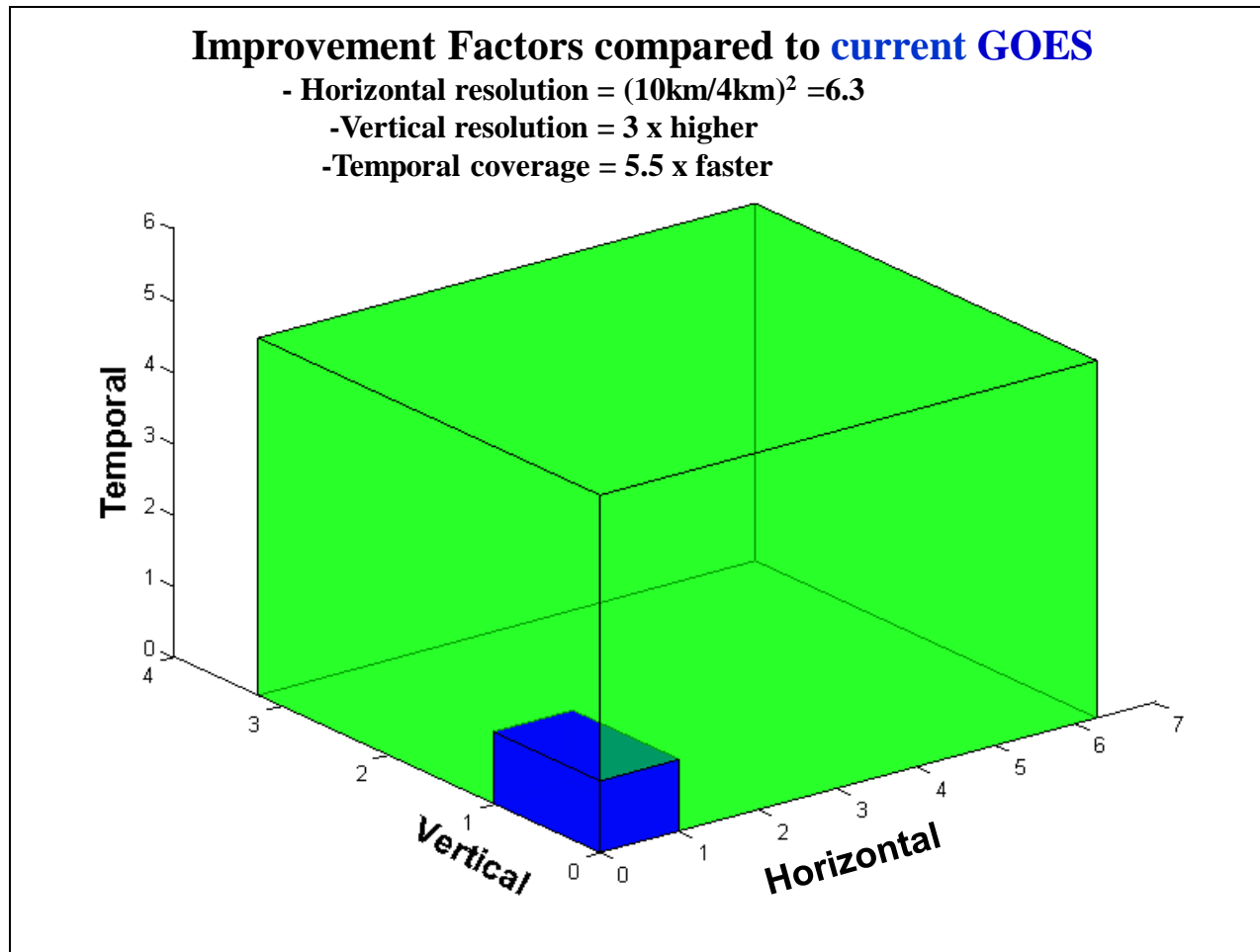
**Not just one  
in a long list!**

# **GEO IR Imaging Sounder capability is unique**

- **Polar Sounders:**  
Inadequate temporal coverage
- **GPS:** Inadequate spatial resolution and temporal coverage
- **Current GEO Sounder:**  
Vertical resolution 2-3 times lower
- **ABI Imager:**  
Inadequate vertical resolution
- **GEO Microwave:**  
Vertical resolution 2-3 times lower

# GIFTS offered 2 orders of magnitude temporal/spatial resolution improvement

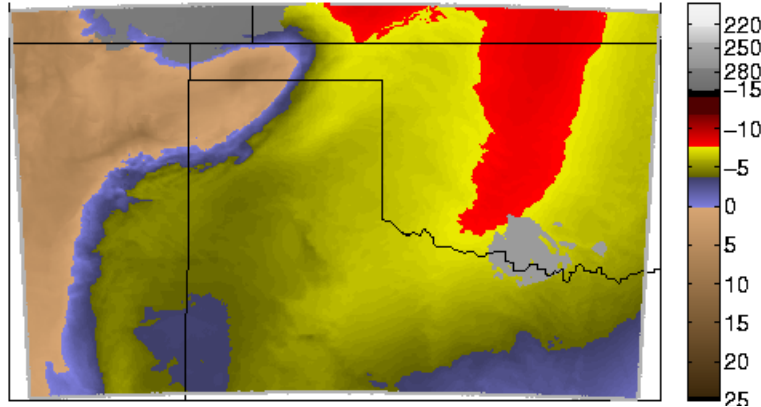
*OSSE shows 4-5 hours extra warning of severe wx*



# OSSE of GEO advanced IR sounder for storm Nearcasting

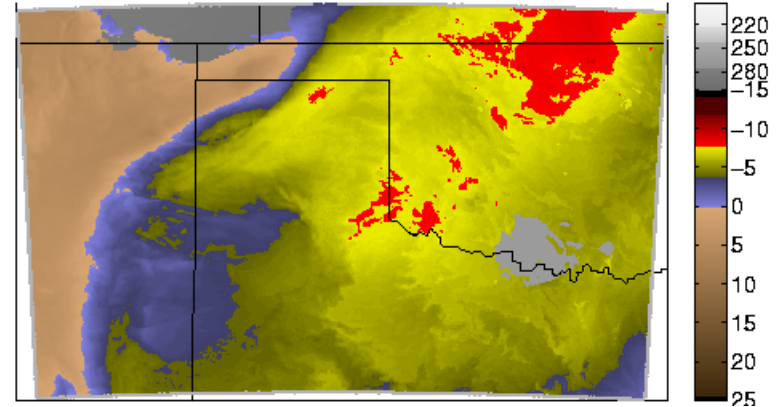
**True**

06-12-2002, 1200 UTC  
Lifted Index [°C]



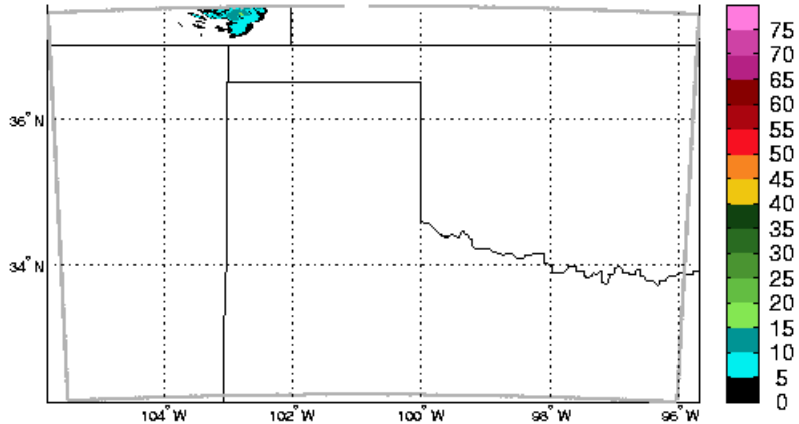
**GIFTS/HES/IRS**

06-12-2002, 1200 UTC  
Lifted Index [°C]



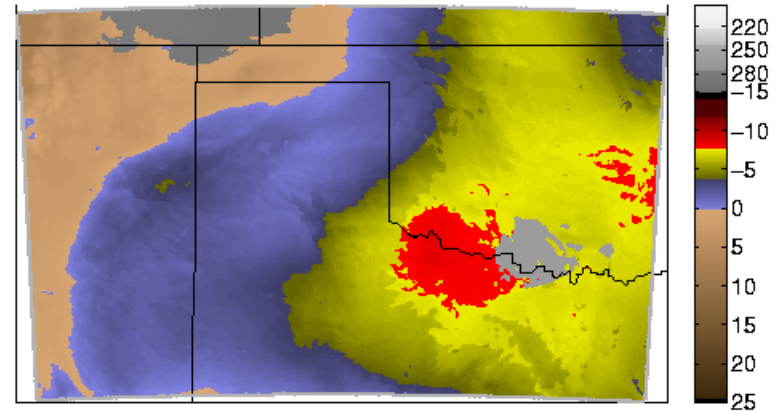
*Red = extreme instability*

06-12-2002, 1200 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1200 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

UW/CIMSS

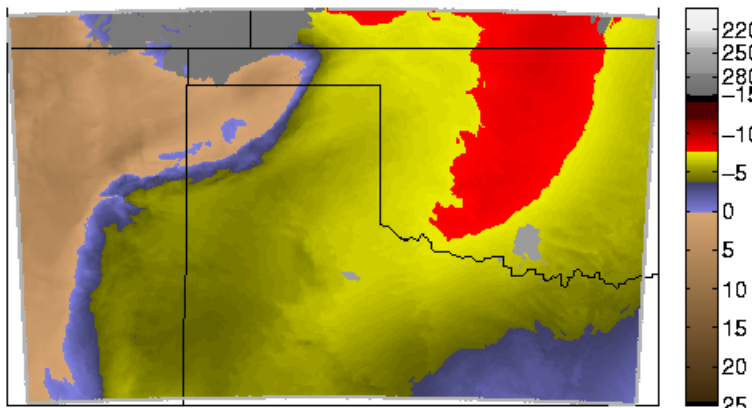
**Jun Li, Jinlong Li, Jason Otkin, and Tim Schmit**



# OSSE of GEO advanced IR sounder for storm Nearcasting

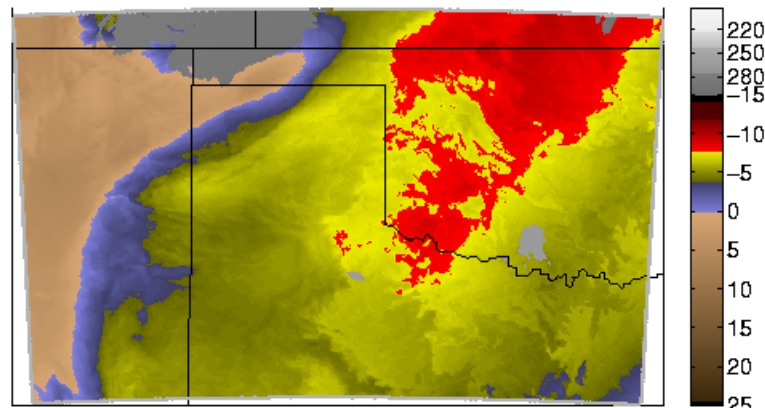
**True**

06-12-2002, 1300 UTC  
Lifted Index [°C]



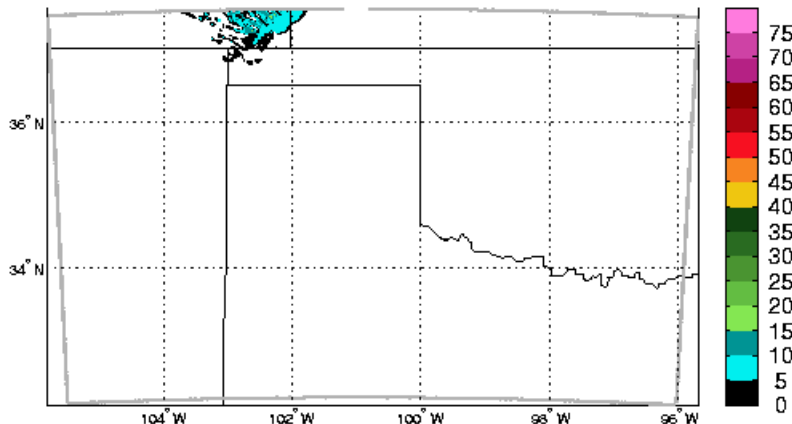
**GIFTS/HES/IRS**

06-12-2002, 1300 UTC  
Lifted Index [°C]



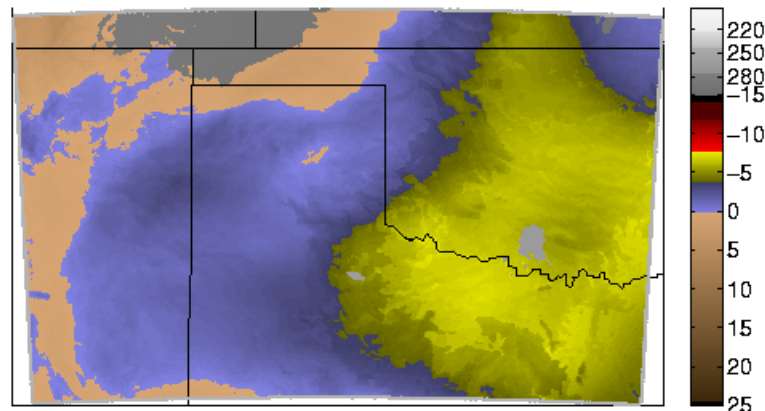
*Extreme instability indicated*

06-12-2002, 1300 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1300 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

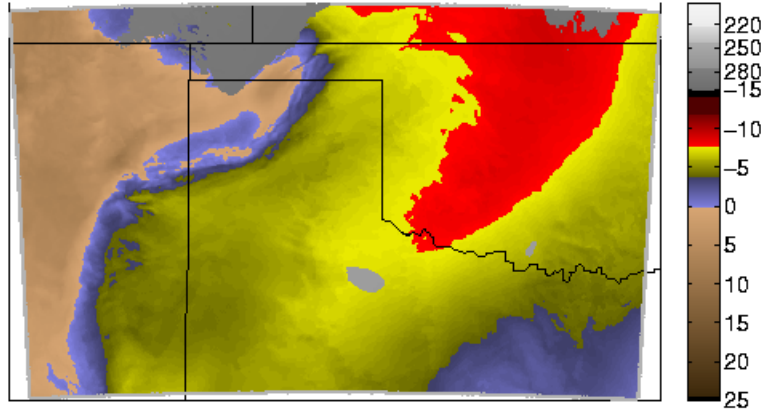
UW/CIMSS

*1300 UTC*

# OSSE of GEO advanced IR sounder for storm Nearcasting

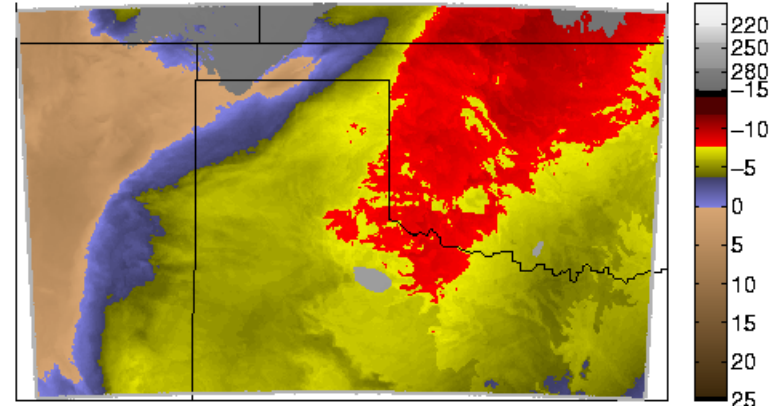
**True**

06-12-2002, 1400 UTC  
Lifted Index [°C]

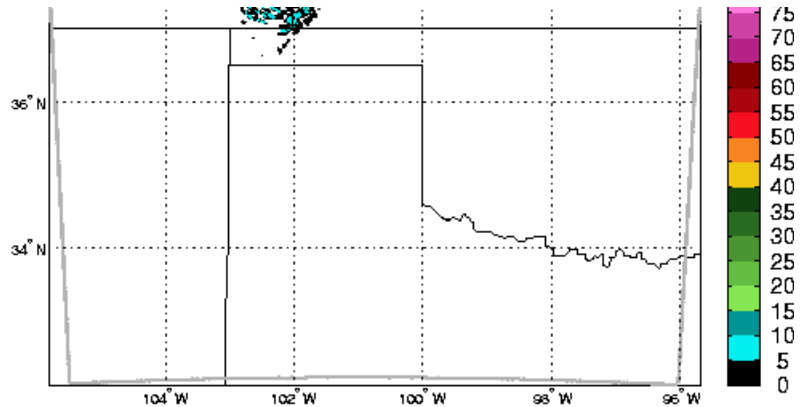


**GIFTS/HES/IRS**

06-12-2002, 1400 UTC  
Lifted Index [°C]

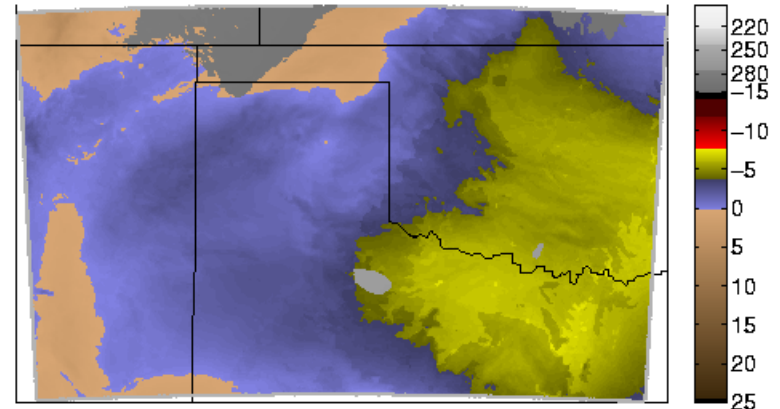


UW/CIMSS



**Simulated Radar**

06-12-2002, 1400 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

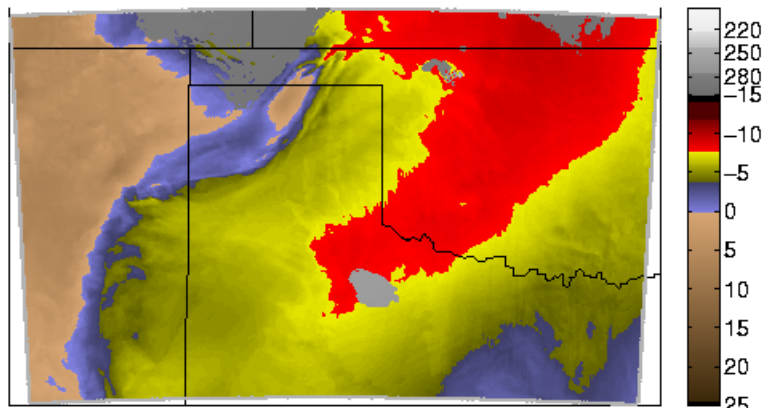
UW/CIMSS

**1400 UTC**

# OSSE of GEO advanced IR sounder for storm Nearcasting

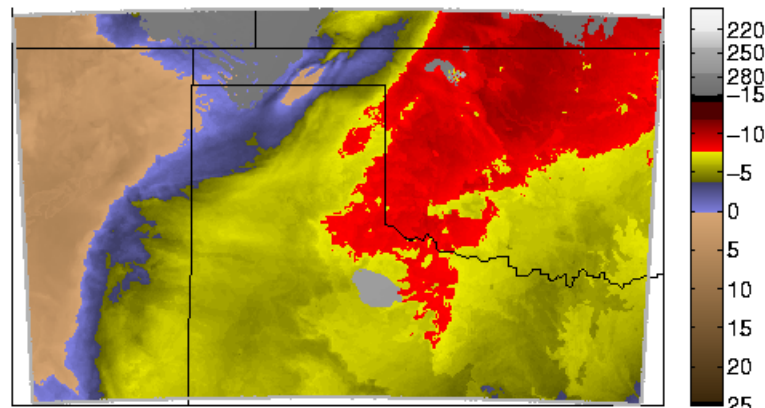
**True**

06-12-2002, 1500 UTC  
Lifted Index [°C]

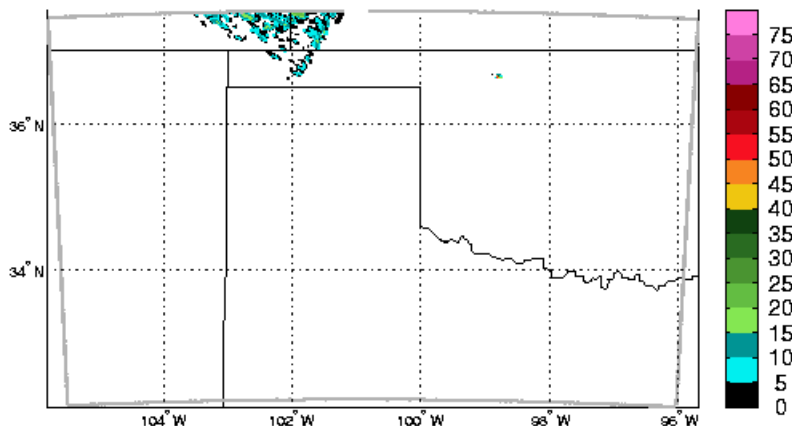


**GIFTS/HES/IRS**

06-12-2002, 1500 UTC  
Lifted Index [°C]

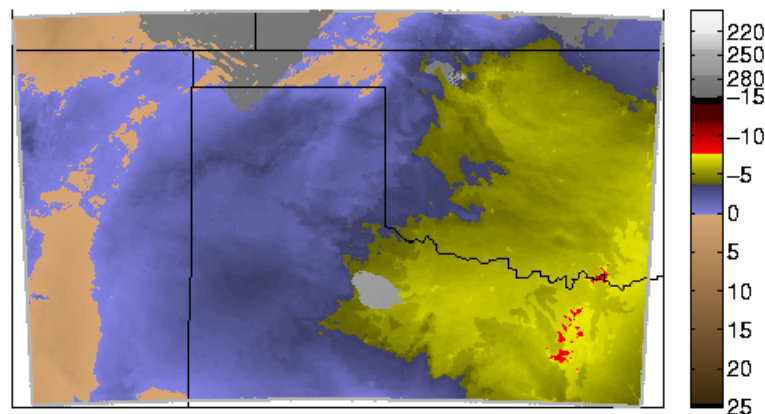


06-12-2002, 1500 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1500 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

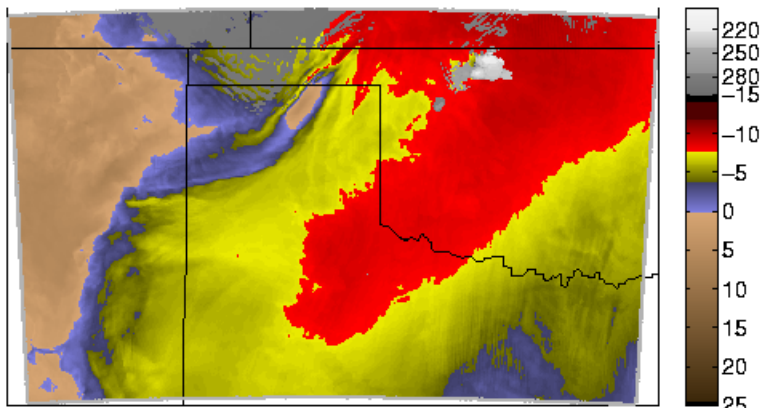
UW/CIMSS

*1500 UTC*

# OSSE of GEO advanced IR sounder for storm Nearcasting

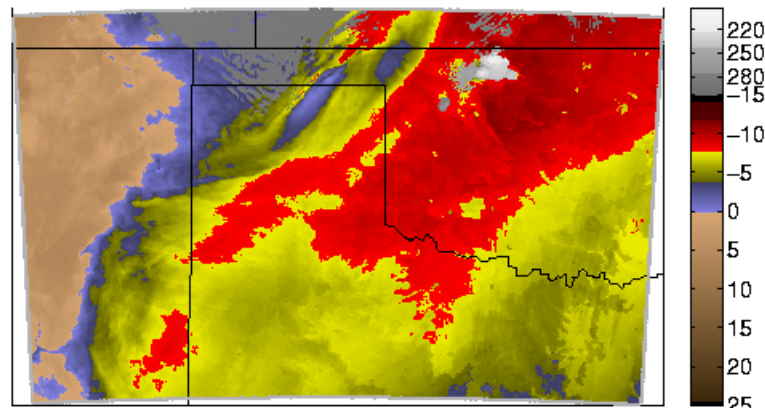
**True**

06-12-2002, 1600 UTC  
Lifted Index [°C]

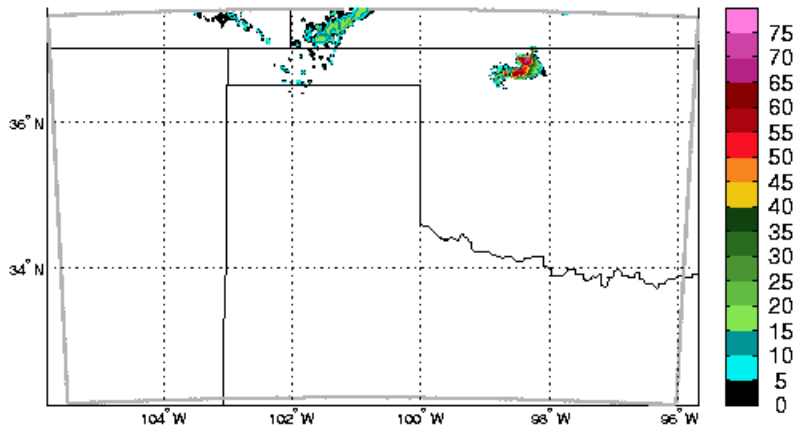


**GIFTS/HES/IRS**

06-12-2002, 1600 UTC  
Lifted Index [°C]

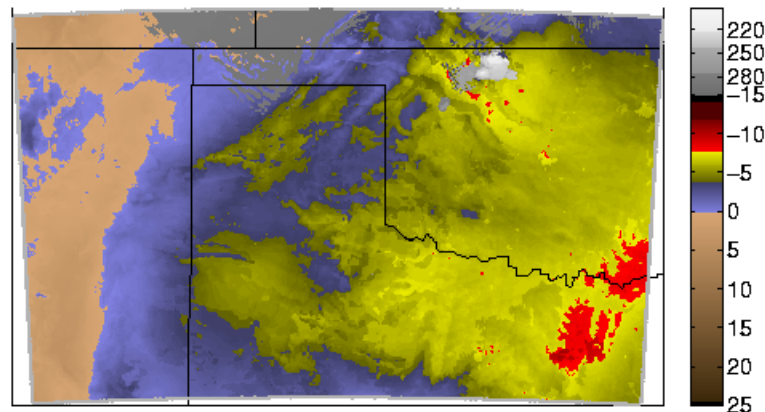


06-12-2002, 1600 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1600 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

UW/CIMSS

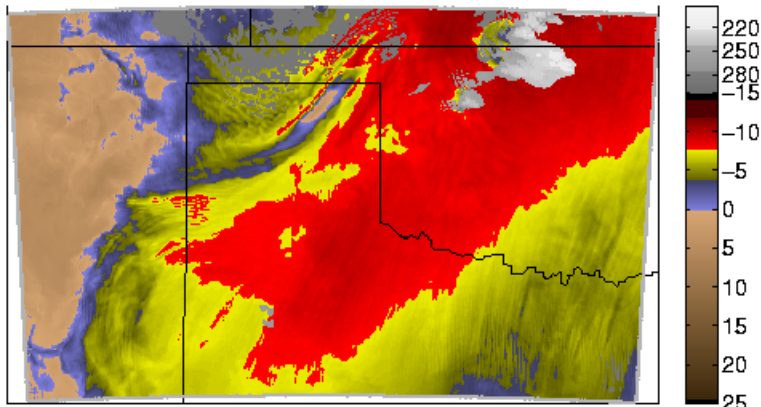
*1600 UTC*



# OSSE of GEO advanced IR sounder for storm Nearcasting

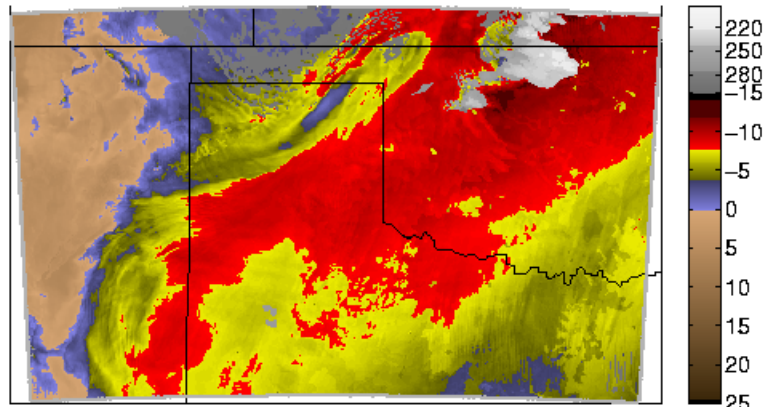
**True**

06-12-2002, 1700 UTC  
Lifted Index [°C]

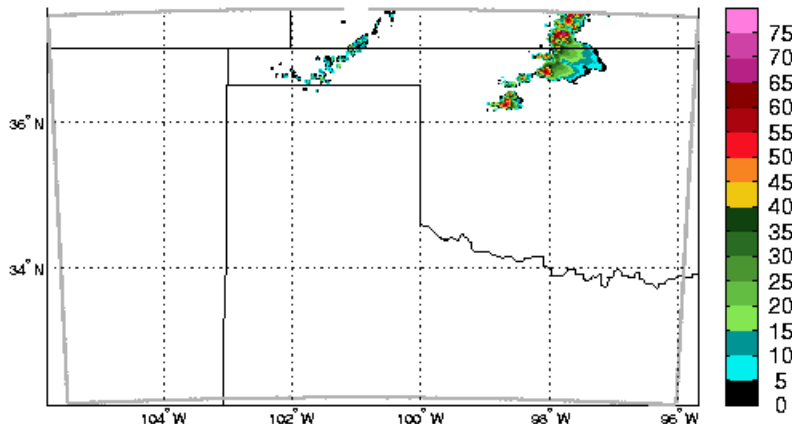


**GIFTS/HES/IRS**

06-12-2002, 1700 UTC  
Lifted Index [°C]

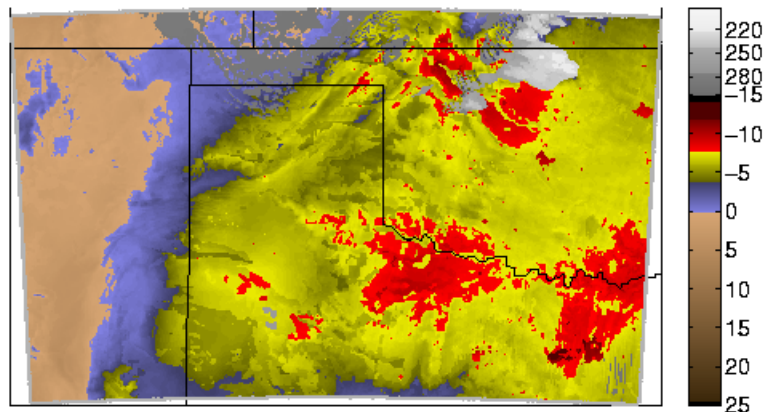


06-12-2002, 1700 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1700 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

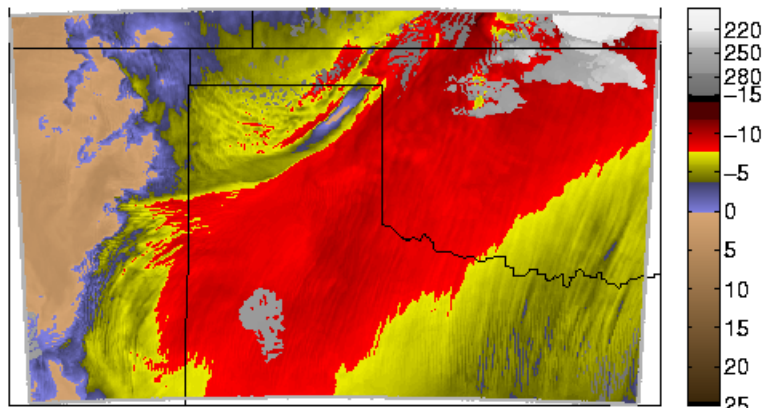
UW/CIMSS

*Start to see extreme instability*  
*1700 UTC in GOES 4 hours later*

# OSSE of GEO advanced IR sounder for storm Nearcasting

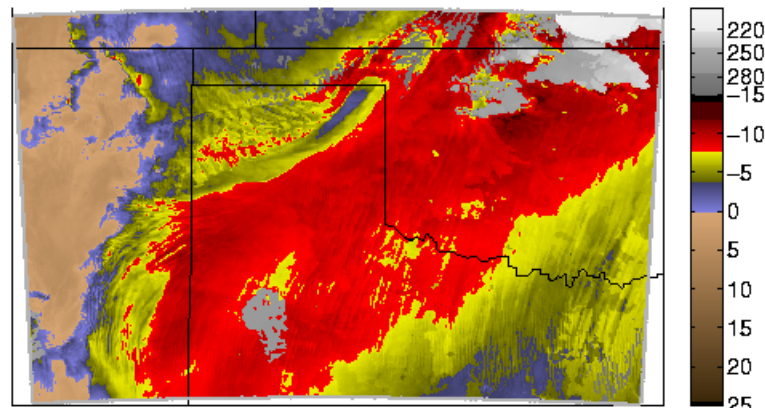
**True**

06-12-2002, 1800 UTC  
Lifted Index [°C]

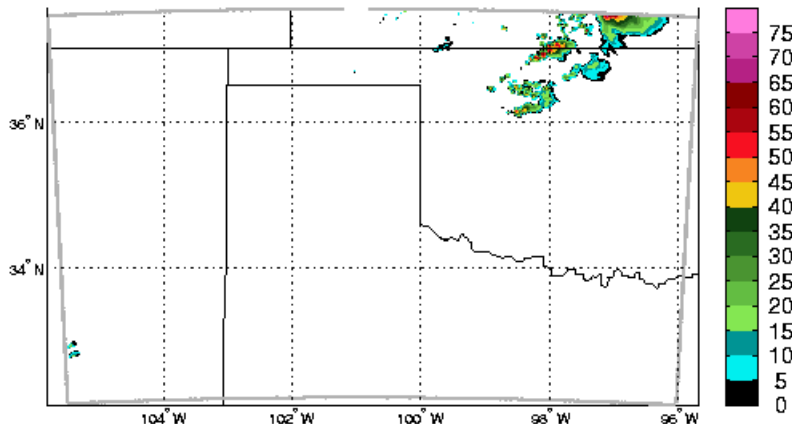


**GIFTS/HES/IRS**

06-12-2002, 1800 UTC  
Lifted Index [°C]

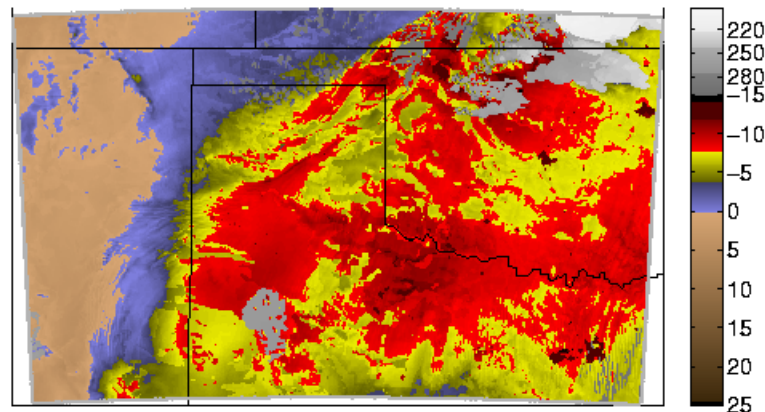


06-12-2002, 1800 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1800 UTC  
Lifted Index [°C]



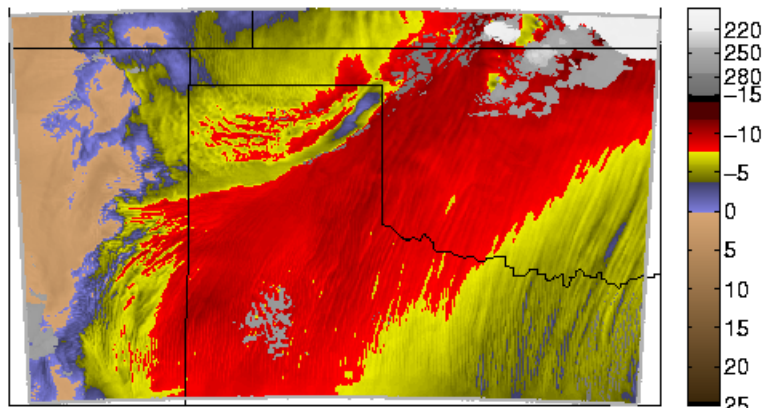
**ABI/GOES Sounder like**

UW/CIMSS  
*GOES shows extreme instability  
1800 UTC  
5 hours later, but note false alarms*  
UW/CIMSS

# OSSE of GEO advanced IR sounder for storm Nearcasting

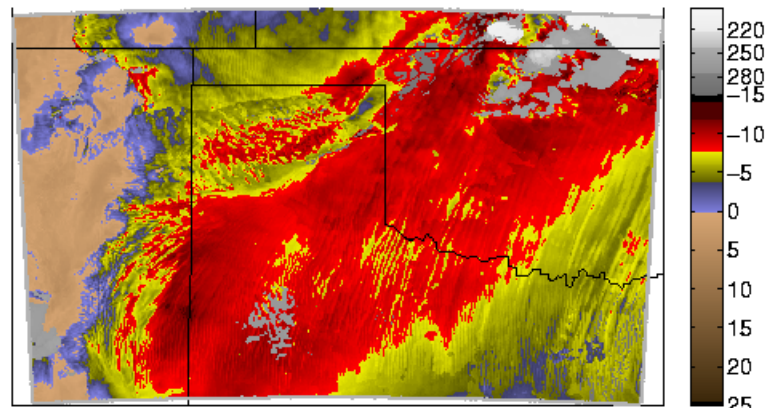
**True**

06-12-2002, 1900 UTC  
Lifted Index [°C]

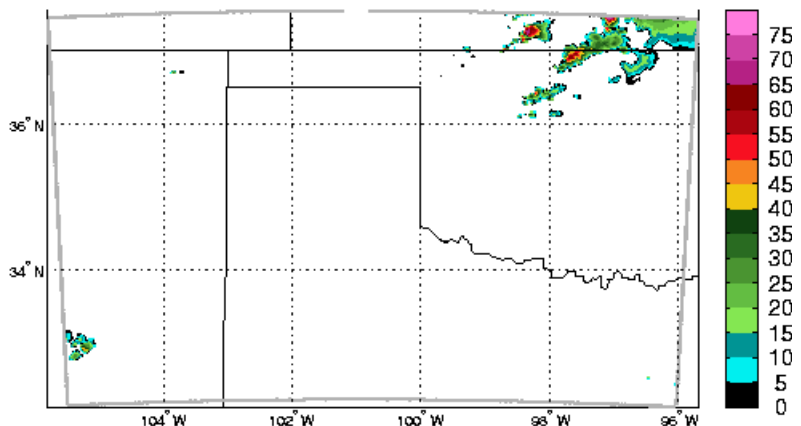


**GIFTS/HES/IRS**

06-12-2002, 1900 UTC  
Lifted Index [°C]

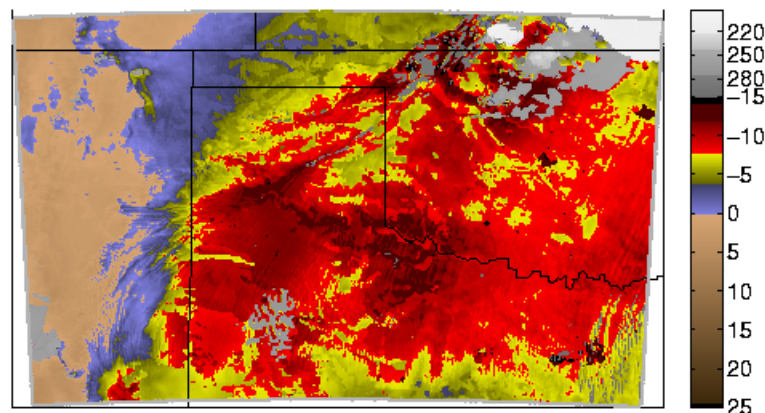


06-12-2002, 1900 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 1900 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

UW/CIMSS

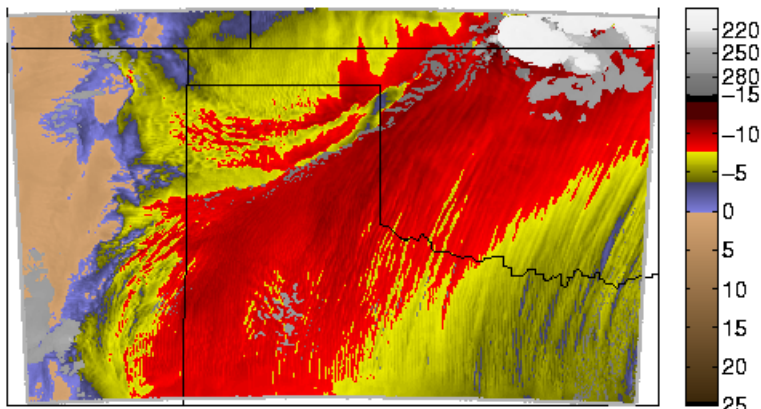
*1900 UTC*



# OSSE of GEO advanced IR sounder for storm Nearcasting

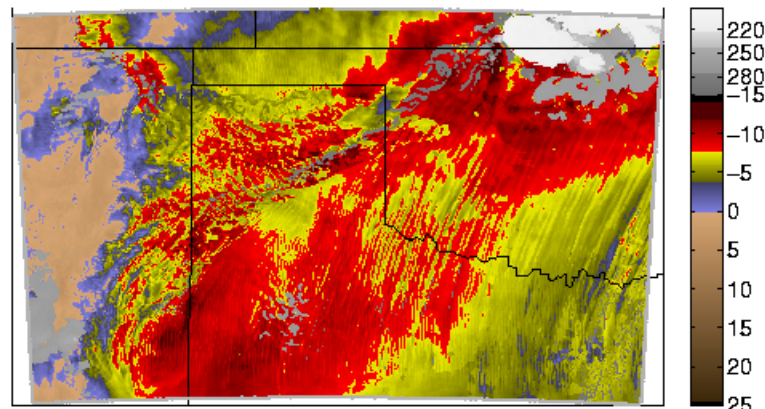
**True**

06-12-2002, 2000 UTC  
Lifted Index [°C]

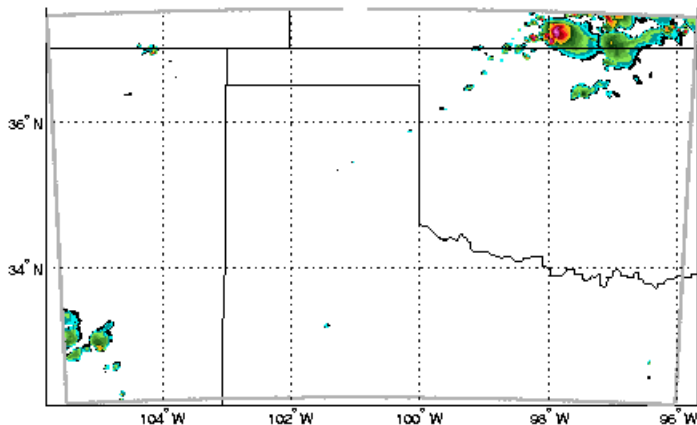


**GIFTS/HES/IRS**

06-12-2002, 2000 UTC  
Lifted Index [°C]

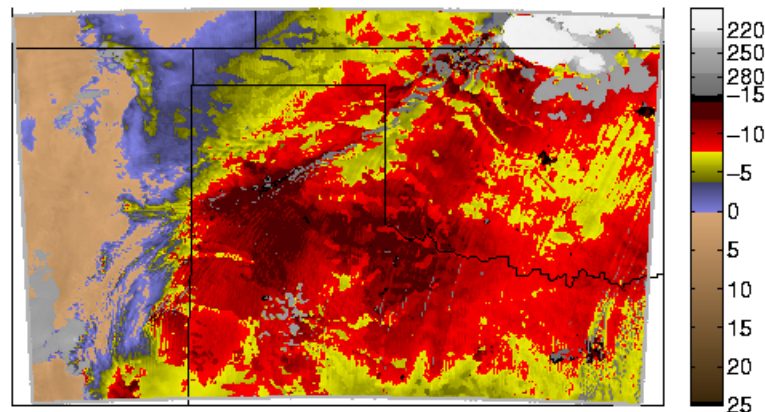


06-12-2002, 2000 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 2000 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

UW/CIMSS

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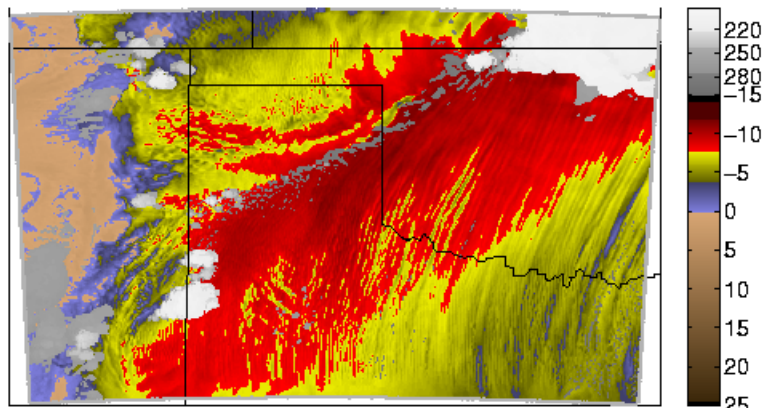
*2000 UTC*



# OSSE of GEO advanced IR sounder for storm Nearcasting

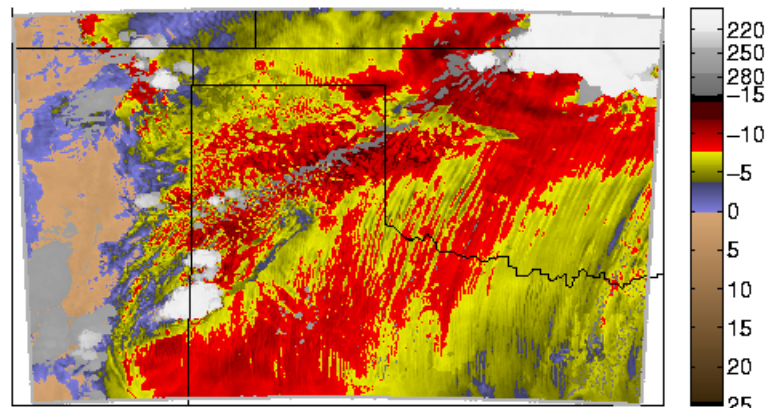
**True**

06-12-2002, 2100 UTC  
Lifted Index [°C]

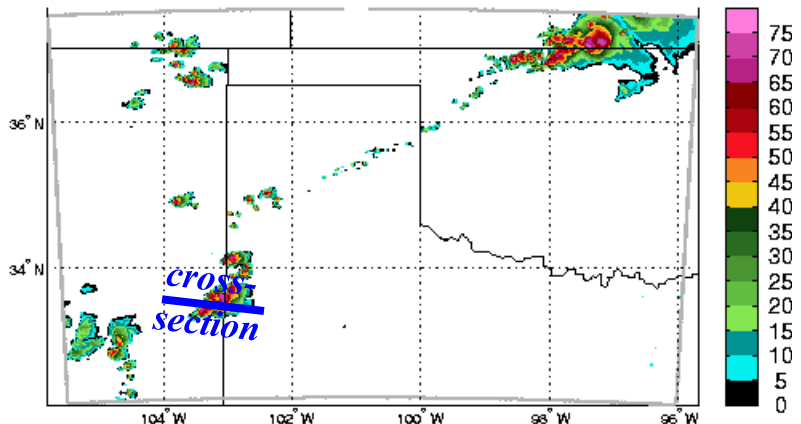


**GIFTS/HES/IRS**

06-12-2002, 2100 UTC  
Lifted Index [°C]

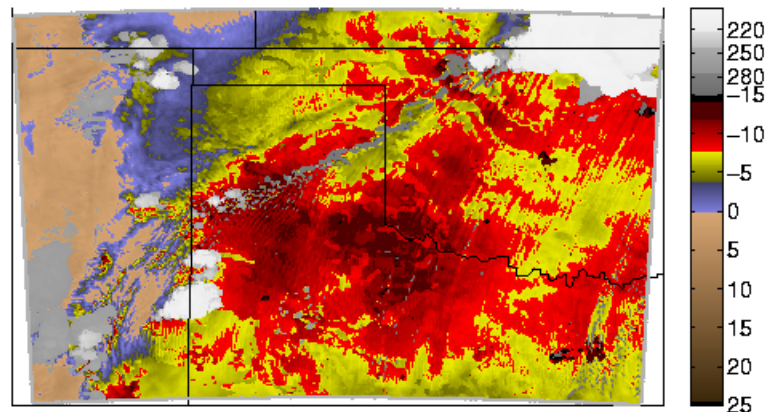


06-12-2002, 2100 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

06-12-2002, 2100 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

*Rain line shows in  
radar 8 hours later*

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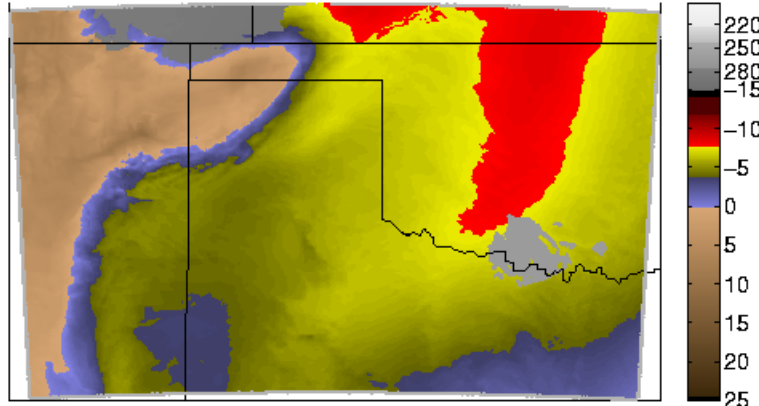
**2100 UTC**

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# OSSE of GEO advanced IR sounder for storm Nearcasting

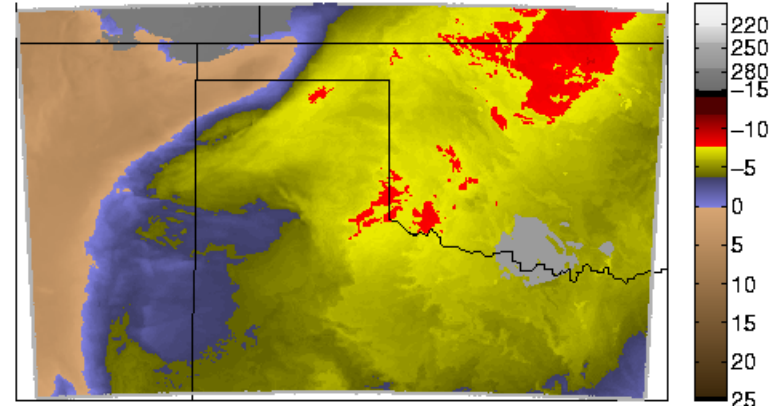
**True**

06-12-2002, 1200 UTC  
Lifted Index [°C]



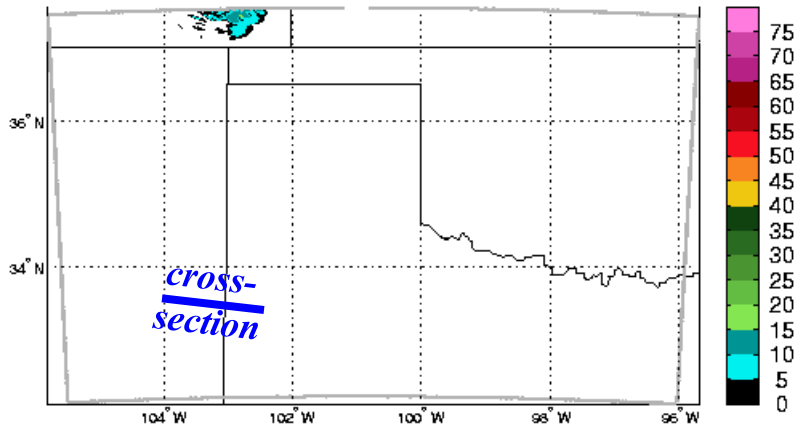
**GIFTS/HES/IRS**

06-12-2002, 1200 UTC  
Lifted Index [°C]



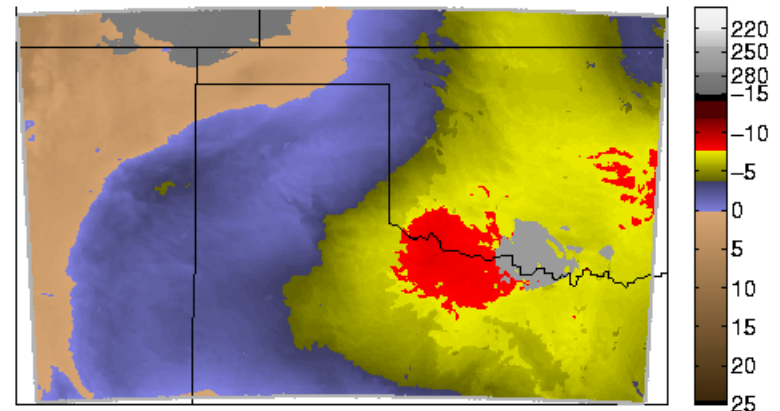
*Red = extreme instability*

06-12-2002, 1200 UTC  
Radar reflectivity [DBZ]



**Simulated Radar**

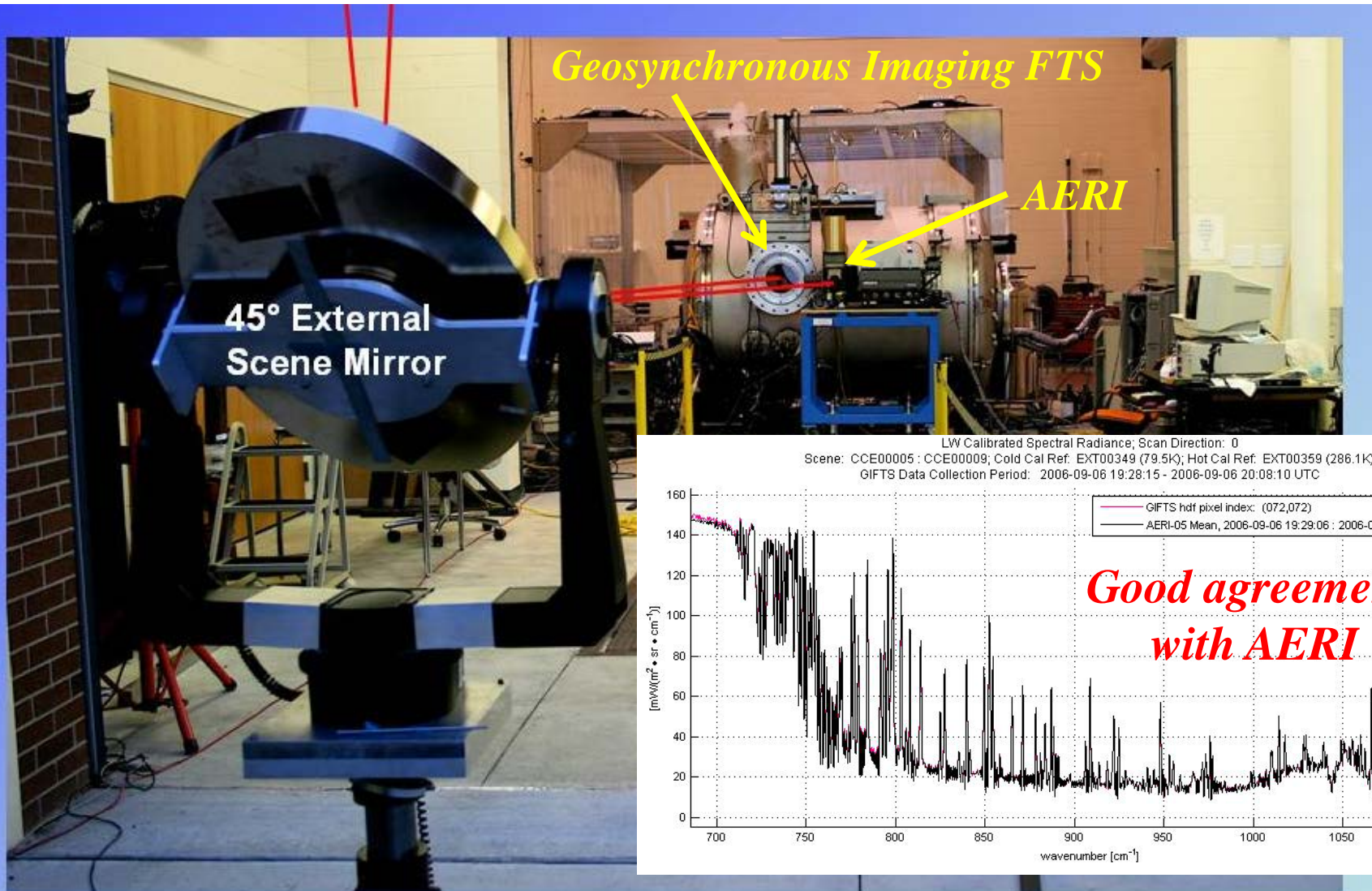
06-12-2002, 1200 UTC  
Lifted Index [°C]



**ABI/GOES Sounder like**

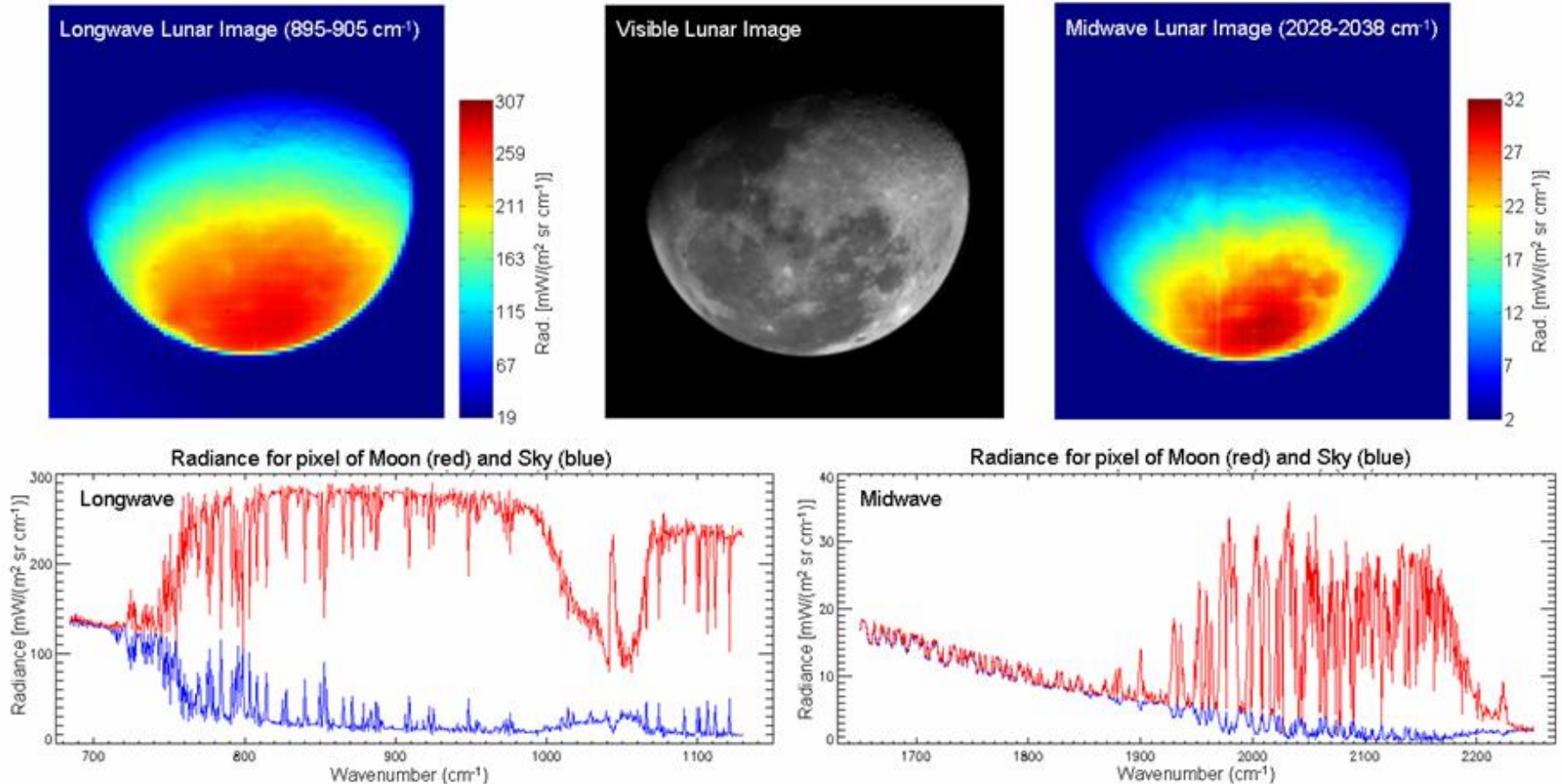
**GIFTS/HES/IRS provides needed instability and warning information hours earlier than current GOES Sounder (+4-5 hrs) and Radar (+8 hrs)**

# 2006! GIFTS Engineering Model Viewed Atmosphere from T/V chamber at Space Dynamics Lab





# Lunar Views Demonstrated GIFTS Imaging Capability



Results from a single interferometer scan of the moon, viewed in the visible, mid-wave IR, and long-wave IR. Also the spectral intensities of two selected pixels from the IR images, one viewing the moon, the other the clear sky background.



## ③ GeoMetWatch, a US Company



- ◆ Privately owned commercial data provider offers **“STORM”** *leveraging GIFTS technology development*
- ◆ Oct 2010: Licensed by US Dept. of Commerce for hyper-spectral data collection at *6 sites around the world* (under the US Remote Sensing Act of 2003)
- ◆ Promises to restore critical data for severe weather forecasting cancelled from GOES-R and much more *at a fraction of the cost, in record time!*
- ◆ Potential Customers: US, top sovereign governments world-wide, and & commercial enterprises

# GeoMetWatch Partnership



**Space Dynamics Laboratory  
Utah State University**



**Space Science & Engineering Center  
University of Wisconsin**

**"STORM" SENSOR**

**DATA CENTER**

**Users**

*Unprecedented  
Severe Weather Disaster  
Mitigation Capability*

# Summary

- ◆ **GeoMetWatch is moving ahead with the concept of a privately funded advanced sounder named “Storm”**
- ◆ **Flight during 2016 is still possible**
- ◆ **Populating 6 orbital locations is ultimately envisioned**