

# Geostationary Imaging Fourier Transform Spectrometer

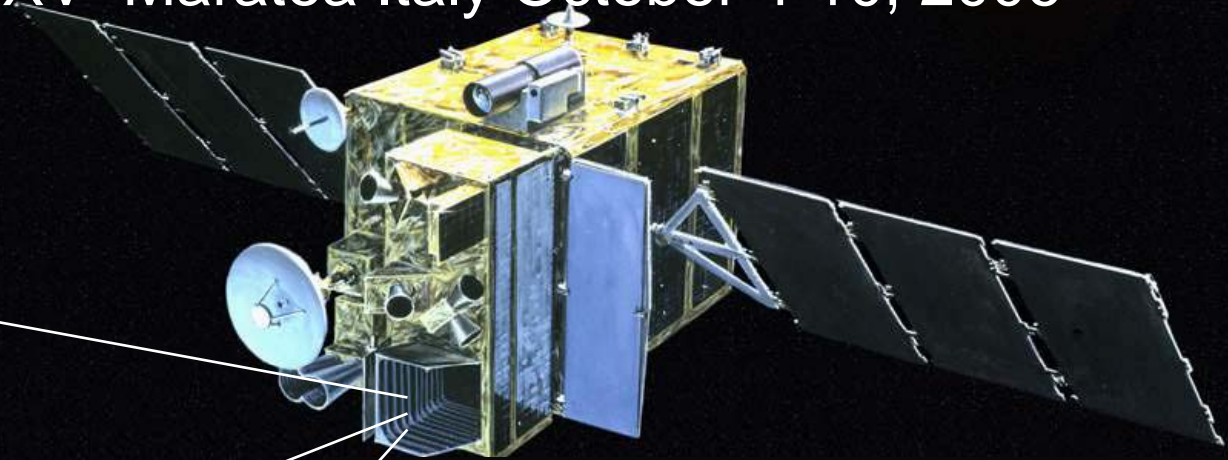
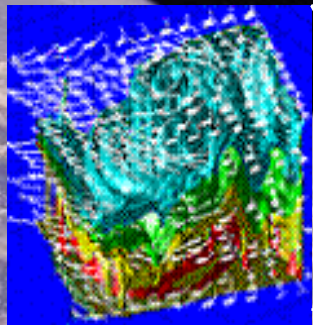
New Technology for Atmospheric Temperature, Moisture, Chemistry, & **Winds**

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ITSC-XV Maratea Italy October 4-10, 2006

*“GIFTS”*



**4-d Digital Camera:**

**Horizontal:** Large area format Focal Plane detector Arrays

**Vertical:** Fourier Transform Spectrometer

**Time:** Geostationary Satellite

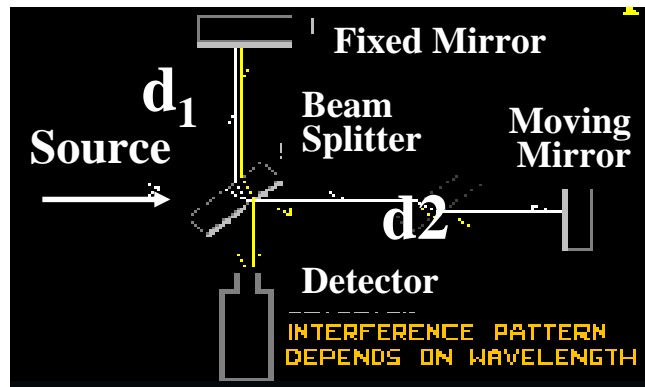
# Geosynchronous Imaging Fourier Transform Spectrometer - GIFTS

- *GIFTS is an infrared and visible **digital movie camera***
- *GIFTS will provide a revolutionary four dimensional view of the Earth's atmosphere (**80,000 vertical profiles with 4 km spacing every minute**)*
- *Measures the **distribution, change, and movement** of atmospheric moisture, temperature, and certain pollutant gases, such as carbon monoxide and ozone*
- *Observation of the convergence of invisible water vapor, and the change of atmospheric temperature, will provide meteorologists with the observations needed to **predict where, and when, severe thunderstorms and tornados are likely to occur before they are visible on radar or in satellite cloud imagery***
- *Observation the motion of moisture and clouds at different altitudes enables **atmospheric winds** to be derived over vast, and otherwise data sparse, oceanic regions of the globe*
- *GIFTS wind profile observations provide the means to **improve the forecast of where tropical storms and hurricanes** will move and where and when they will come ashore (i.e., their landfall position and time)*

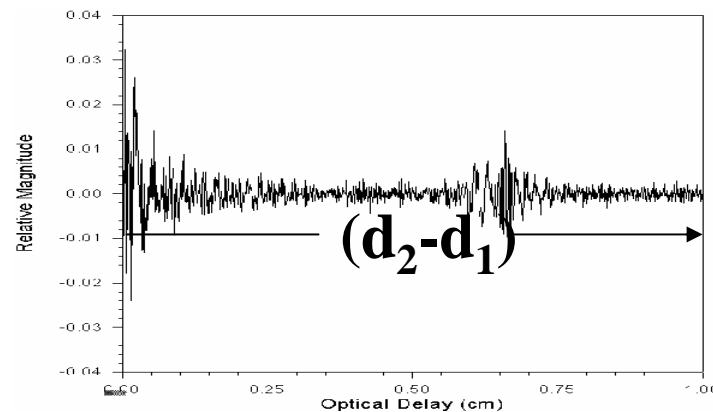
**GIFTS will provide Nations, with the capability to better protect their citizens against the loss of their lives and property, as a result of the violent nature of severe storms**

# Interferometer Measurements to Soundings

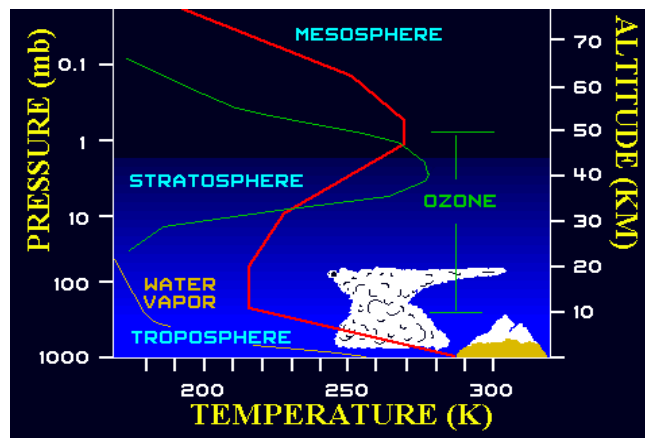
## Michelson Interferometer (FTS)



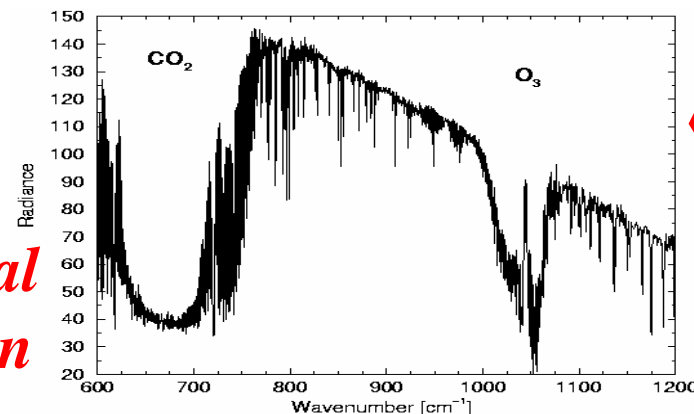
## Interferogram



*Fourier Transformation*



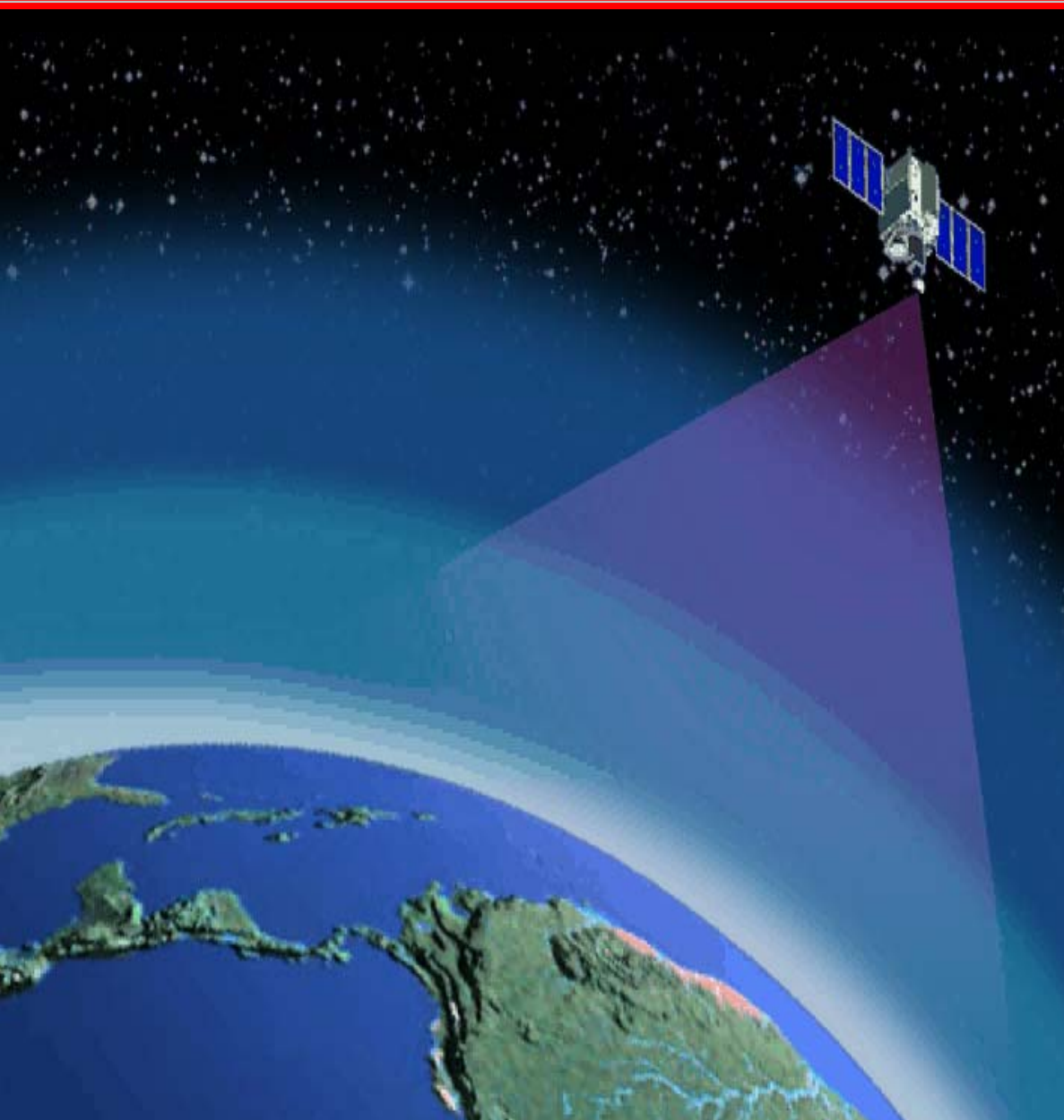
Vertical Sounding



Radiance Spectrum

**Radiance spectrum measured with a single detector element  
GIFTS is equivalent to 16,384 spectrometers in parallel operation**

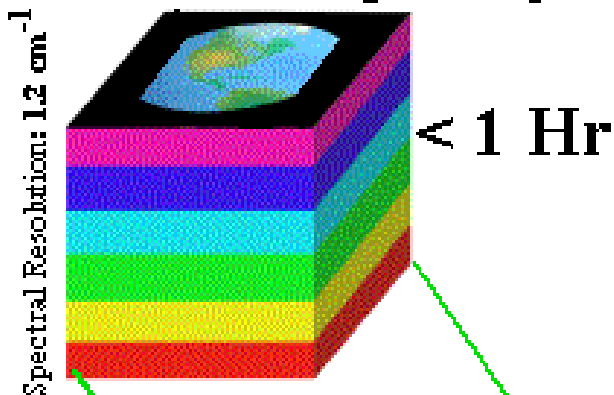
# GIFTS Sampling Characteristics



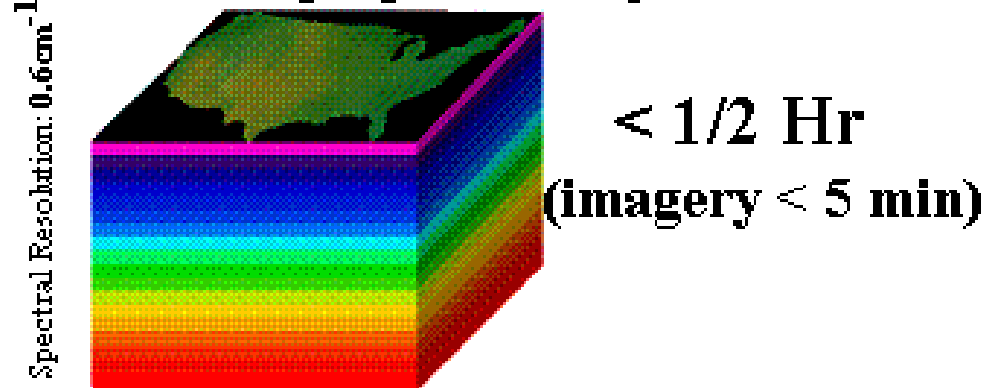
- Two 128x 128 Infrared focal plane detector arrays with 4 km footprint size
- A 512 x 512 Visible focal plane detector arrays with 1 km footprint size
- Field of Regard 512 km x 512 km at satellite sub-point
- Ten second full spectral resolution integration time per Field of Regard
- ~ 80,000 Atmospheric Soundings every minute

# Example GIFTS Operating Modes

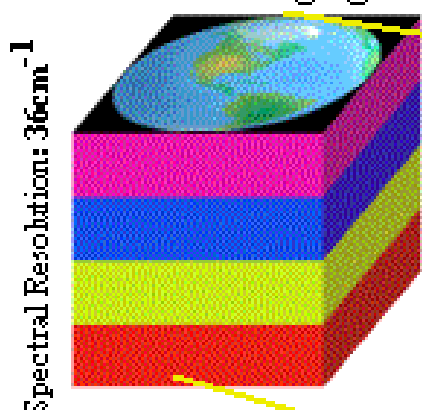
Global Disk Sounding: 300 Steps



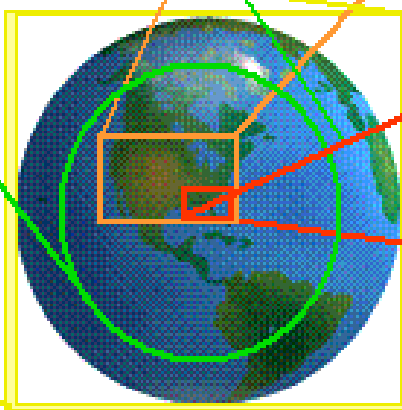
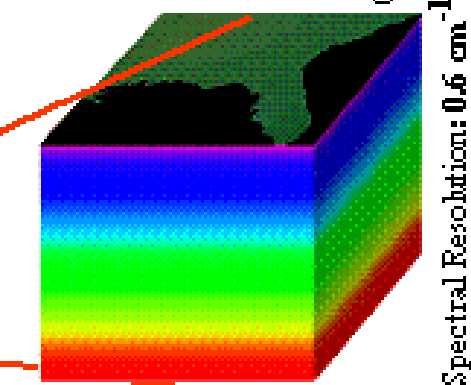
Sounding Regional: 144 Steps



Global Disk Imaging: 422 Steps

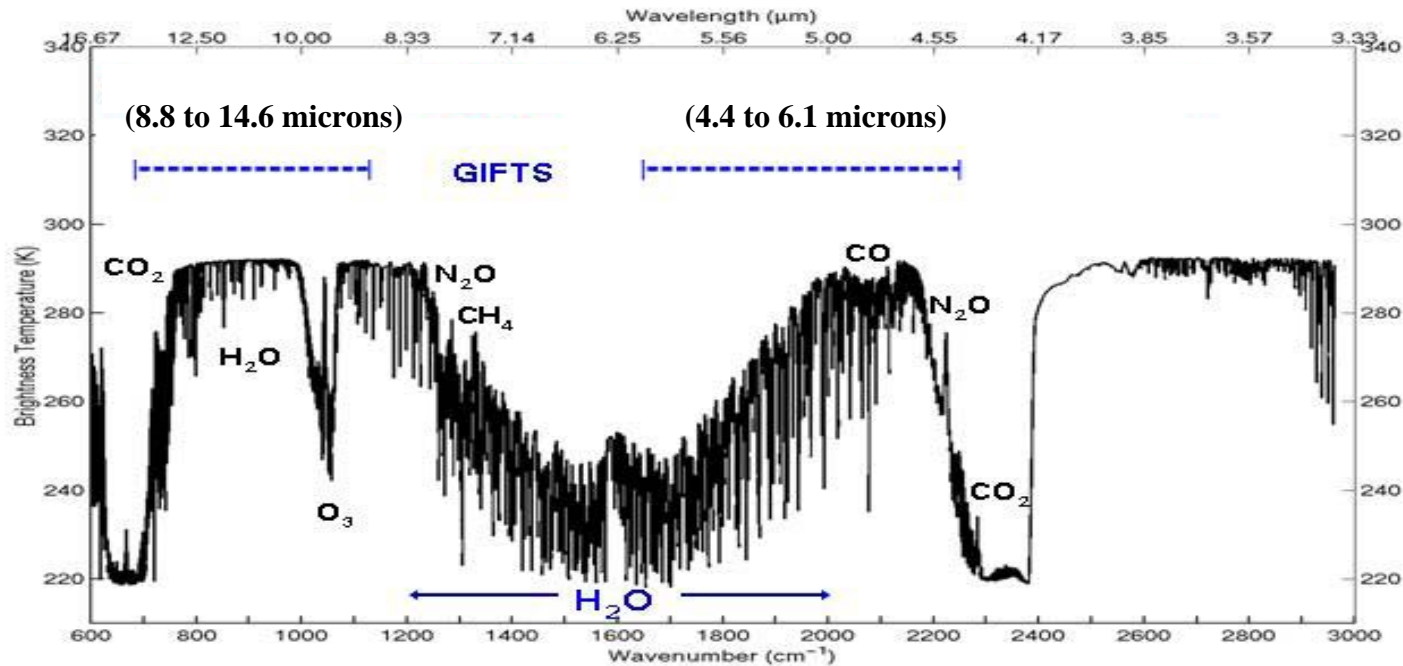


Mesoscale Sounding: 36 Steps





# GIFTS IR Measurements and Products



## Products:

**Water vapor** (soundings, fluxes, winds);  $\epsilon < 20\%$  / 1-2 km layers

**Temperature** (sounding, stability);  $\epsilon < 1^\circ\text{K}$  / 1-2 km layers

**Wind Velocity**;  $\epsilon < 4$  m/s / 2 km layers

**Carbon monoxide concentration** (2 Layers);  $\epsilon < 10\%$  / 5 km layers

**Ozone concentration** (4 Layers);  $\epsilon < 10\%$  / 8 km layers

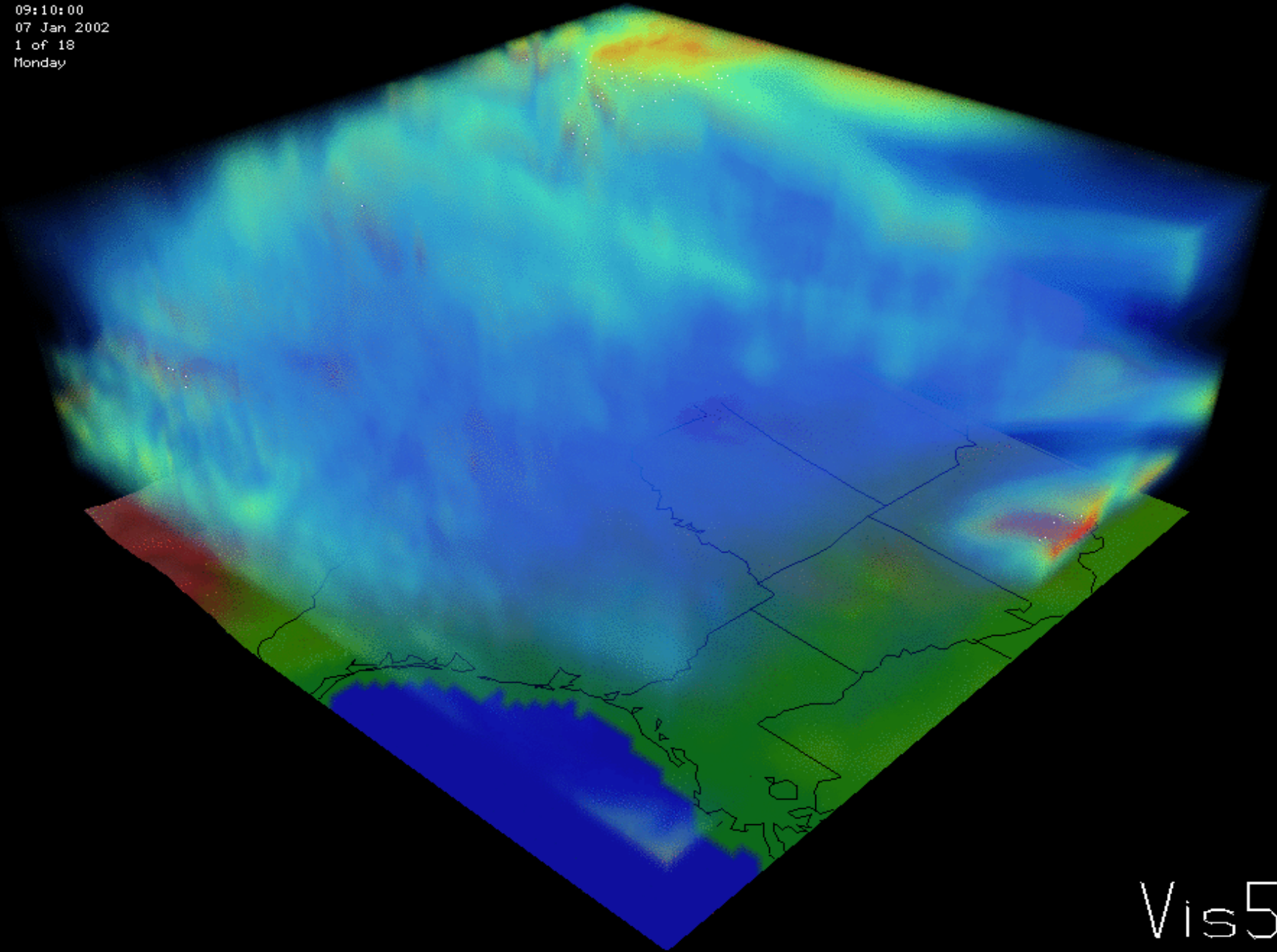
**Surface Temperature**;  $\epsilon < 0.3^\circ\text{K}$  for sea,  $\epsilon < 1^\circ\text{K}$  for land

**Clouds** (altitude, optical depth, microphysical properties, “winds”)

**Aerosol Concentration and Depth**;  $\epsilon < \text{TBD}$

# Water Vapor Flux (3 x 3 GIFTS Cubes)

09:10:00  
07 Jan 2002  
1 of 18  
Monday



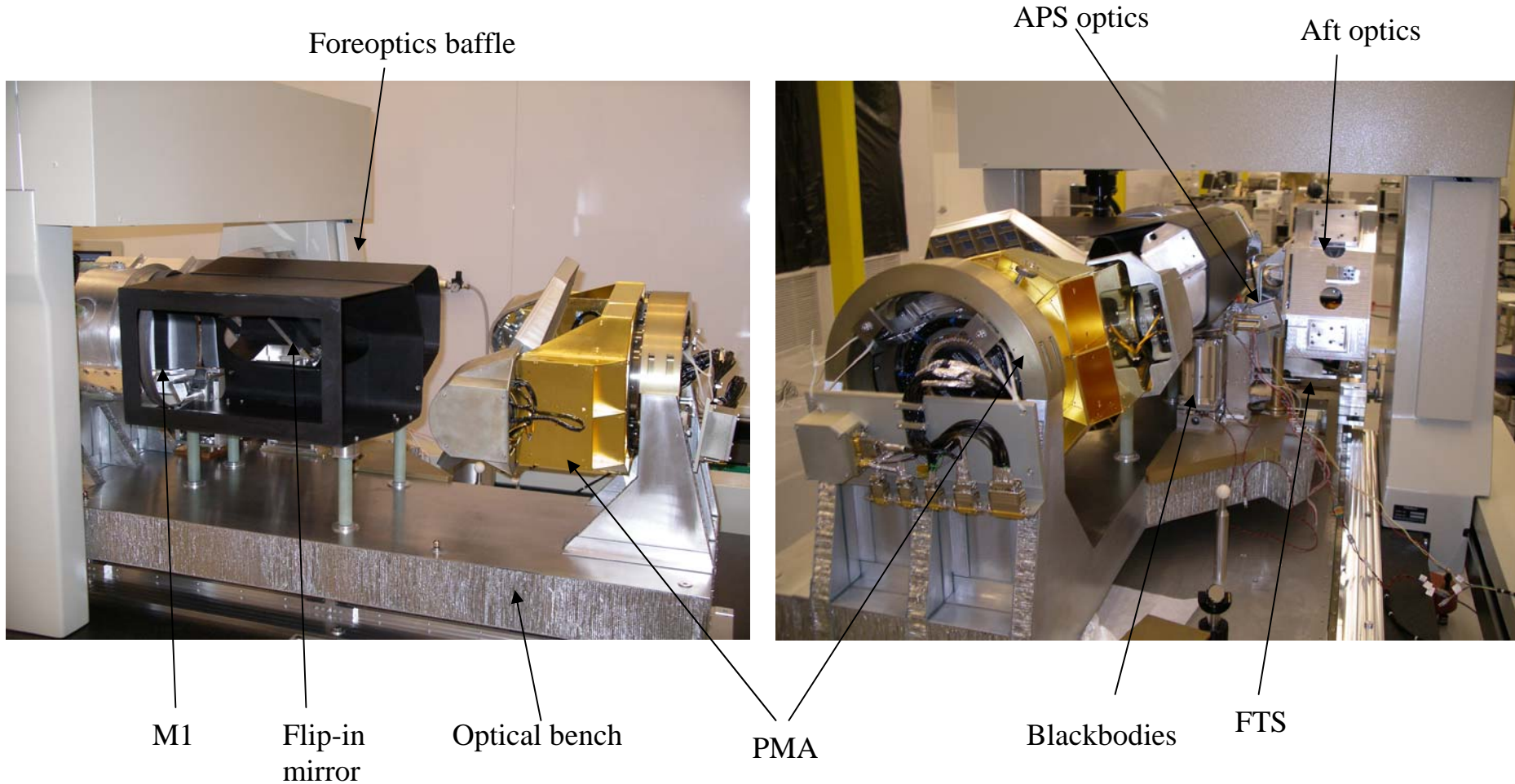
Vis5D

# GIFTS - Background

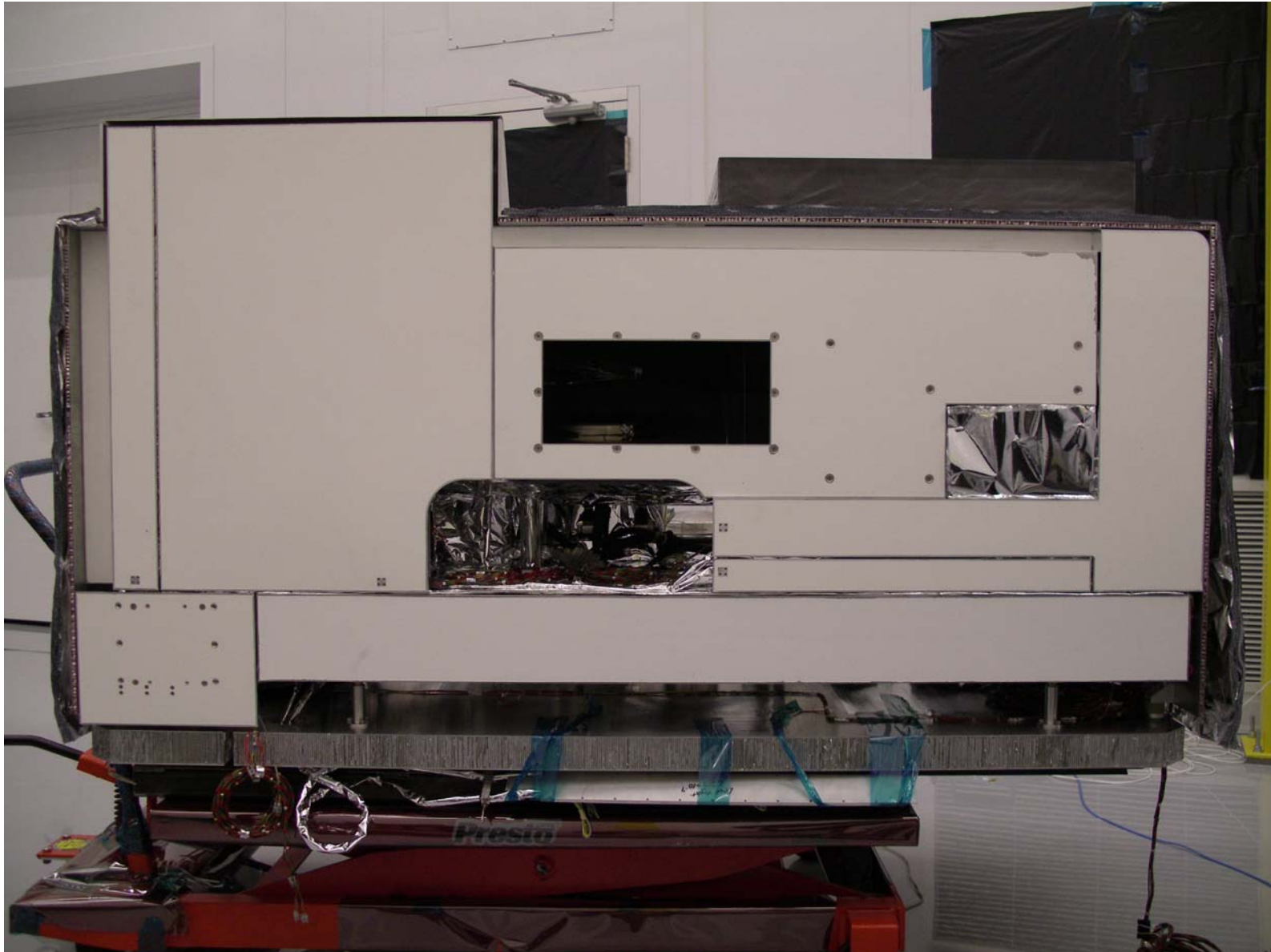
- **1998:** As a result of the NASA Advanced Geosynchronous Studies (AGS) program, **GIFTS is proposed** by NASA/LaRC, UW/SSEC, and USU/SDL for NASA's New Millennium Program (NMP) EO-3 Mission. NMP was to be used to transition from AGS paper studies into a geo-satellite hardware demonstration.
- **1999:** The **GIFTS proposal was selected for the NMP EO-3 mission**. The Navy and NOAA partnered with NASA to fund the space mission. The Navy was to provide the spacecraft and the USAF was to provide launch services. NOAA was to provide the ground processing system and to conduct a "demonstration of operational utility" as a GOES risk reduction activity. NASA/LaRC funded the Space Dynamics Laboratory at Utah State Univ. to build the GIFTS instrument and the University of Wisconsin's Space Science & Engineering Center (SSEC) to develop the in-flight calibration hardware/software system and to conduct the "measurement concept validation". NASA/LaRC manages the program and leads the science team in the development of the science applications of the data. After a one year research demonstration of utility for weather and chemistry applications over CONUS, GIFTS was to become a Navy operational system positioned over the Indian Ocean.
- **2000:** GIFTS advanced **technology development began**.
- **2002:** GIFTS was **de-manifested from USAF launch schedule** due to a FY-03 Navy budget shortfall.
- **2003:** **NASA and NOAA continued to fund the GIFTS** instrument and ground system development.
- **2004:** The **NMP EO-3 space mission was cancelled**. NASA and NOAA agree to complete the GIFTS instrument as an Engineering Demonstration Unit (EDU) as risk reduction for GOES-R. Recognizing the importance of GIFTS for the World Weather Watch (WWW), the World Meteorological Organization (WMO) initiates an International Geostationary satellite Laboratory (IGeoLab) program for flying GIFTS.
- **2005:** The **GIFTS EDU was completed and successfully ground tested** in a space chamber.
- **2006:** The GIFTS EDU was calibrated and **atmospheric measurements were obtained** by sky viewing from the ground. **NASA requests a proposal from the GIFTS team** (LaRC, HU, UW, USU) for a space qualified instrument, in preparation for a response to anticipated Decadal Survey Recommendations.



# GIFTS EDU Assembly



# GIFTS - Fully Assembled

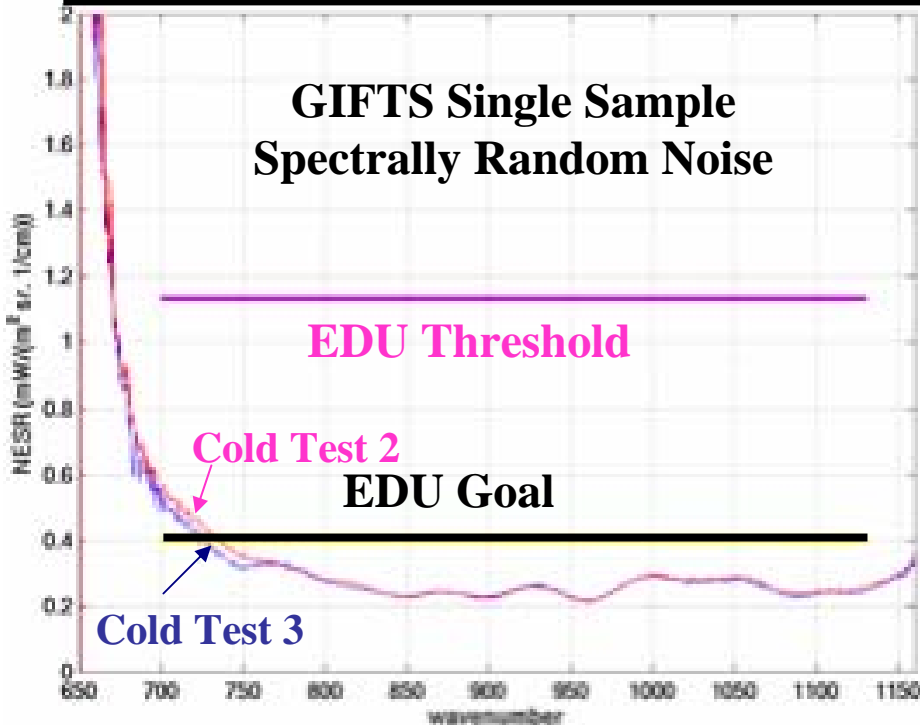




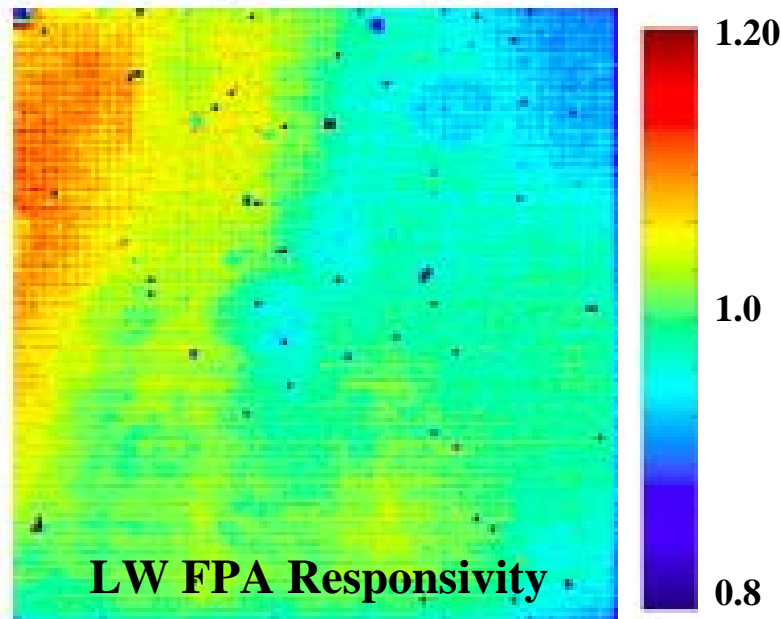
# GIFTS: Wrapped up for Thermal Vacuum Testing at SDL



# GIFTS T-V Tests Show That HES LW Band Measurements With Required S/N & High Operability Are Achievable



## LW FPA Operability



Pixels with responsivity in range 80%-120% of mean	98.2%
Pixels with noise less than 3X mean noise	96.3%
Active pixels (those that meet both responsivity & noise criteria)	95.9%

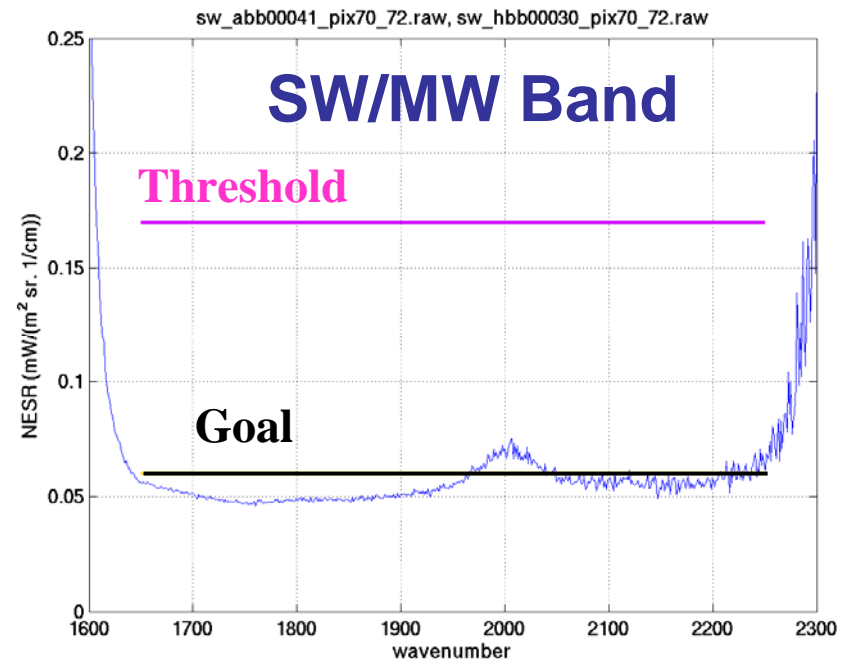
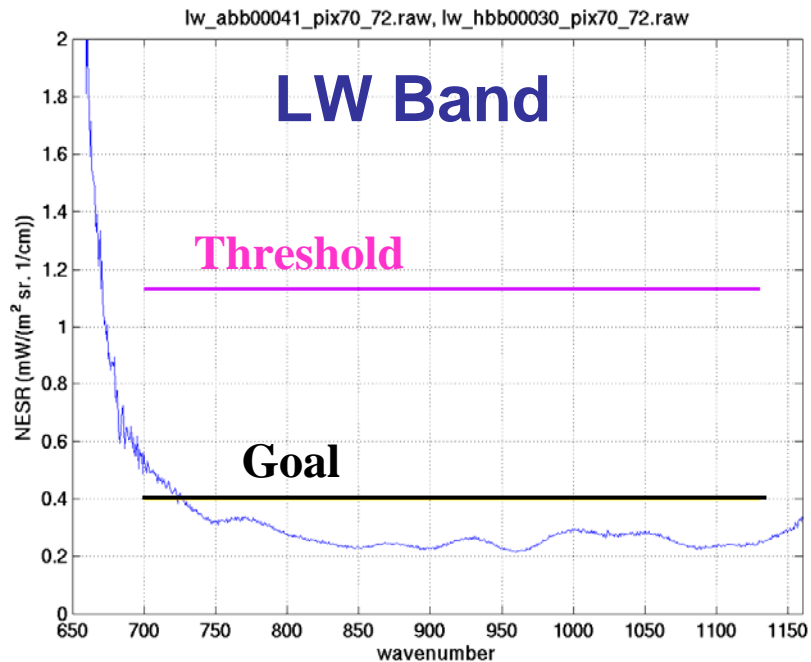
### Significance:

- Can achieve AIRS-like radiometric performance for 4 km spatial footprints covering 500x500 km field every 12 seconds.
- Coverage about 40 x faster than GOES, 5-6 times faster at full spectral resolution, all with spatial footprints that are 4 times smaller in area and contiguous.



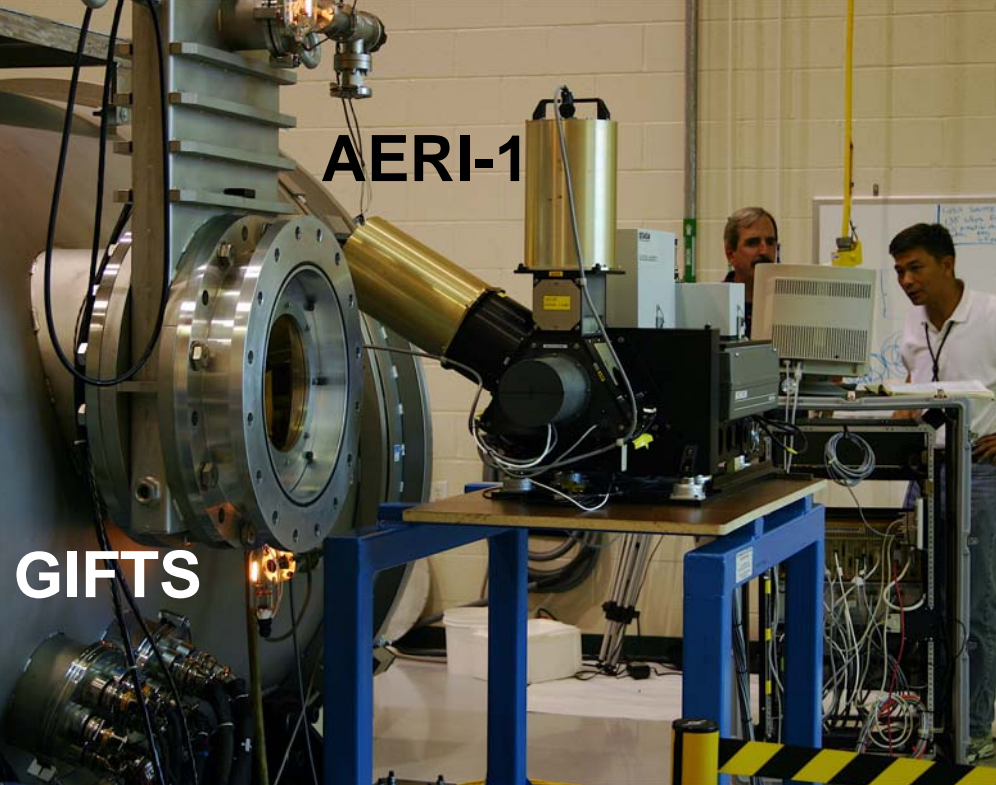


# GIFTS NESR- Exceeds the EDU Performance Goal Over Most of the Two Bands



# Sky View Test

- GIFTS (in chamber) & AERI-1 viewing sky through a common scene mirror
- AERI-2 outside to account for the air path between chamber and outside scene mirror & the scene mirror reflectivity/emissivity



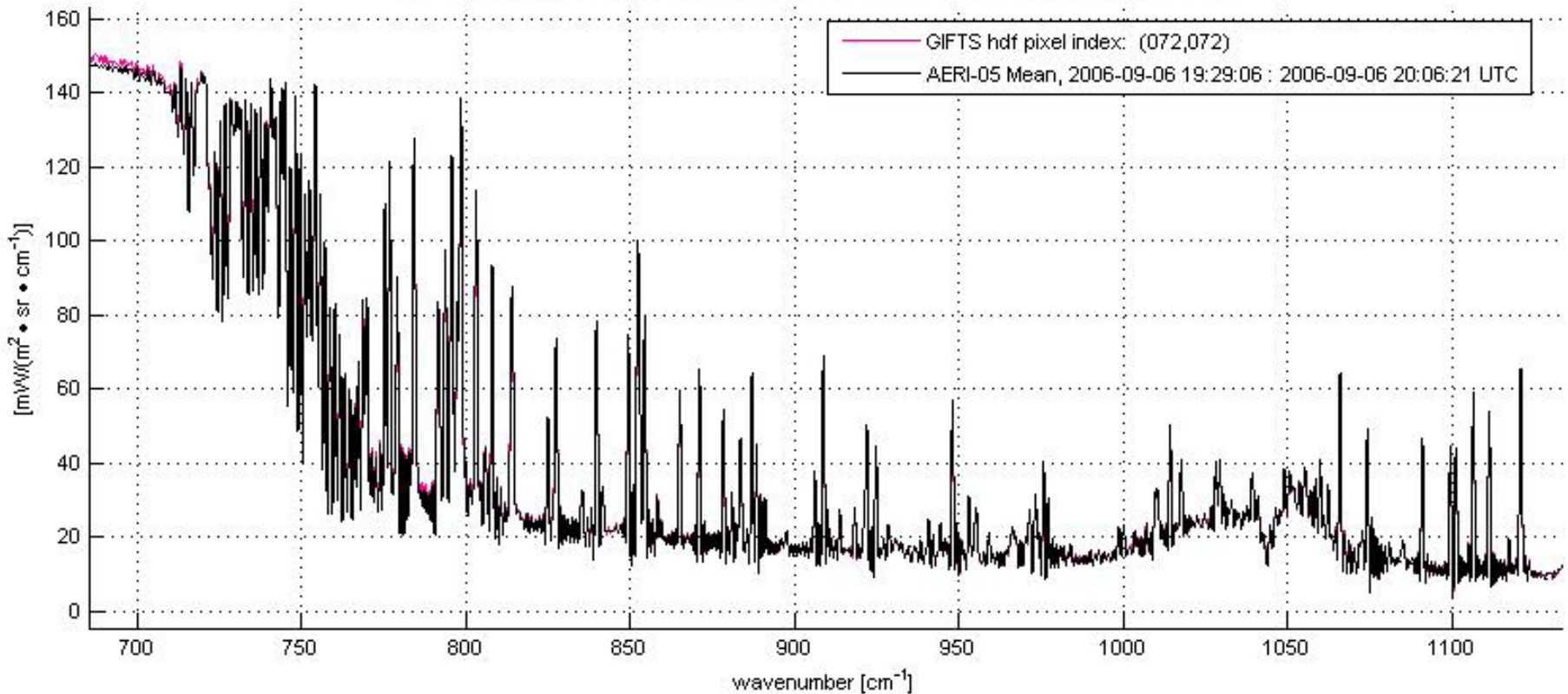


# GIFTS and AERI Viewing Sky



# LW, GIFTS-AERI05, pixel 72,72

LW Calibrated Spectral Radiance; Scan Direction: 0  
Scene: CCE00005 : CCE00009; Cold Cal Ref: EXT00349 (79.5K); Hot Cal Ref: EXT00359 (286.1K)  
GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC

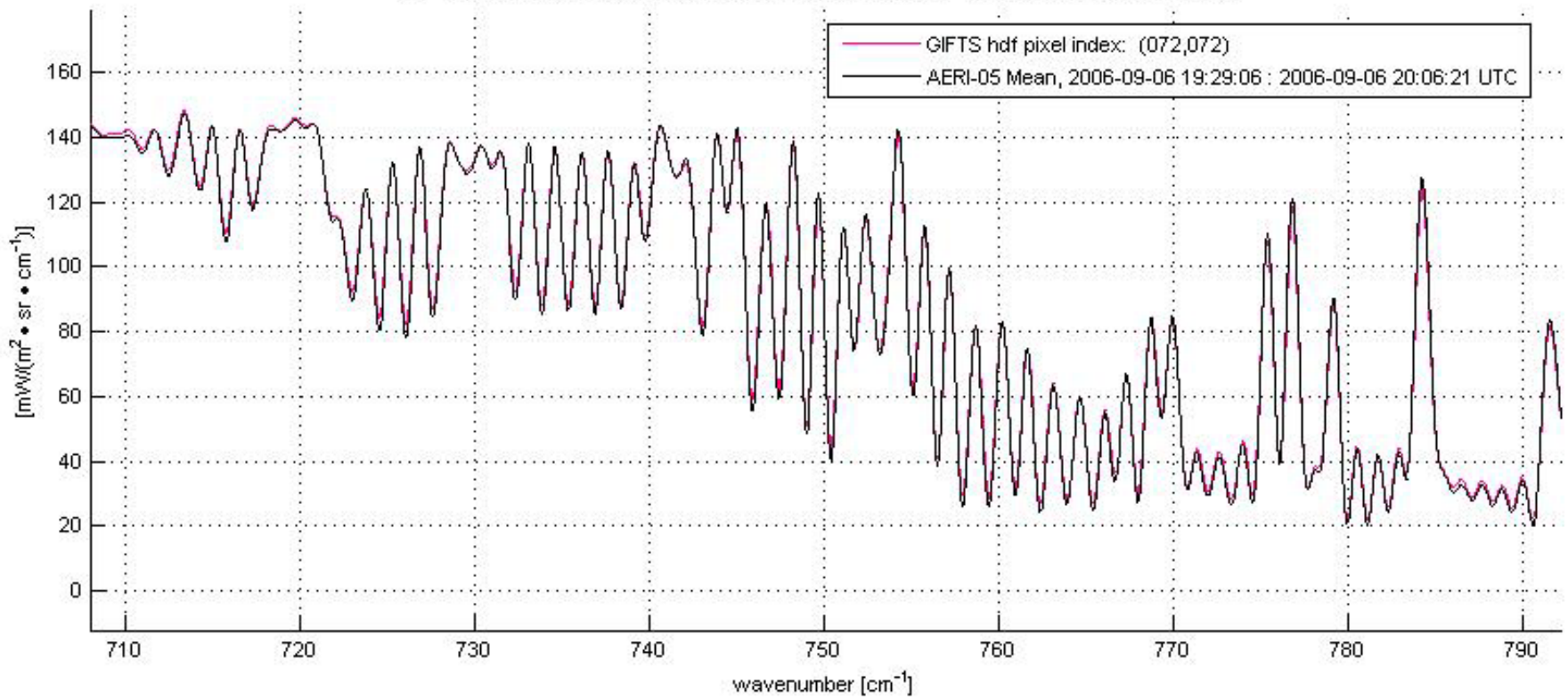


**GIFTS LW Band shows very good agreement,  
even without non-linearity correction**



# LW, GIFTS-AERI05, pixel 72,72

LW Calibrated Spectral Radiance; Scan Direction: 0  
Scene: CCE00005 : CCE00009; Cold Cal Ref: EXT00349 (79.5K); Hot Cal Ref: EXT00359 (286.1K)  
GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC



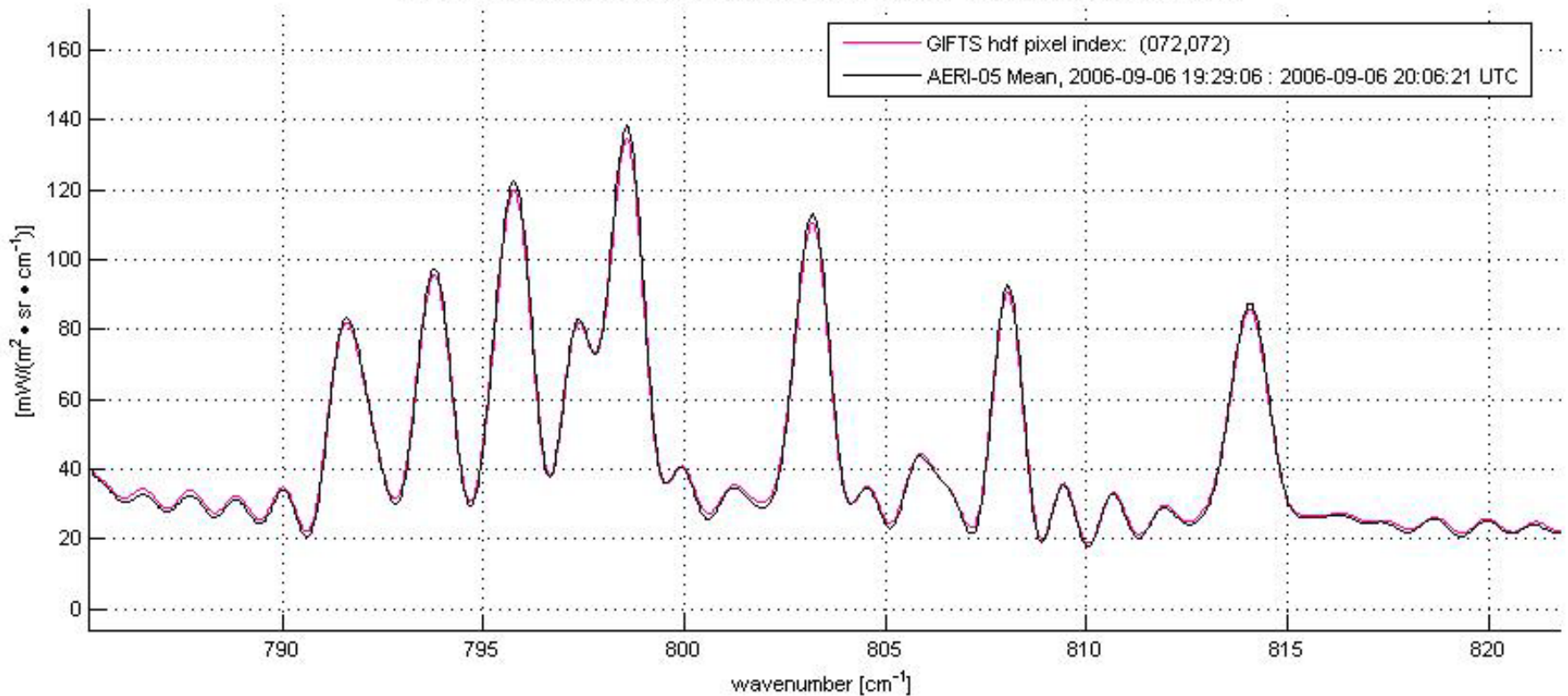
**708-792  $cm^{-1}$ , 15 micron  $CO_2$  band**

# LW, GIFTS-AERI05, pixel 72,72

LW Calibrated Spectral Radiance; Scan Direction: 0

Scene: CCE00005 : CCE00009; Cold Cal Ref. EXT00349 (79.5K); Hot Cal Ref. EXT00359 (286.1K)

GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC



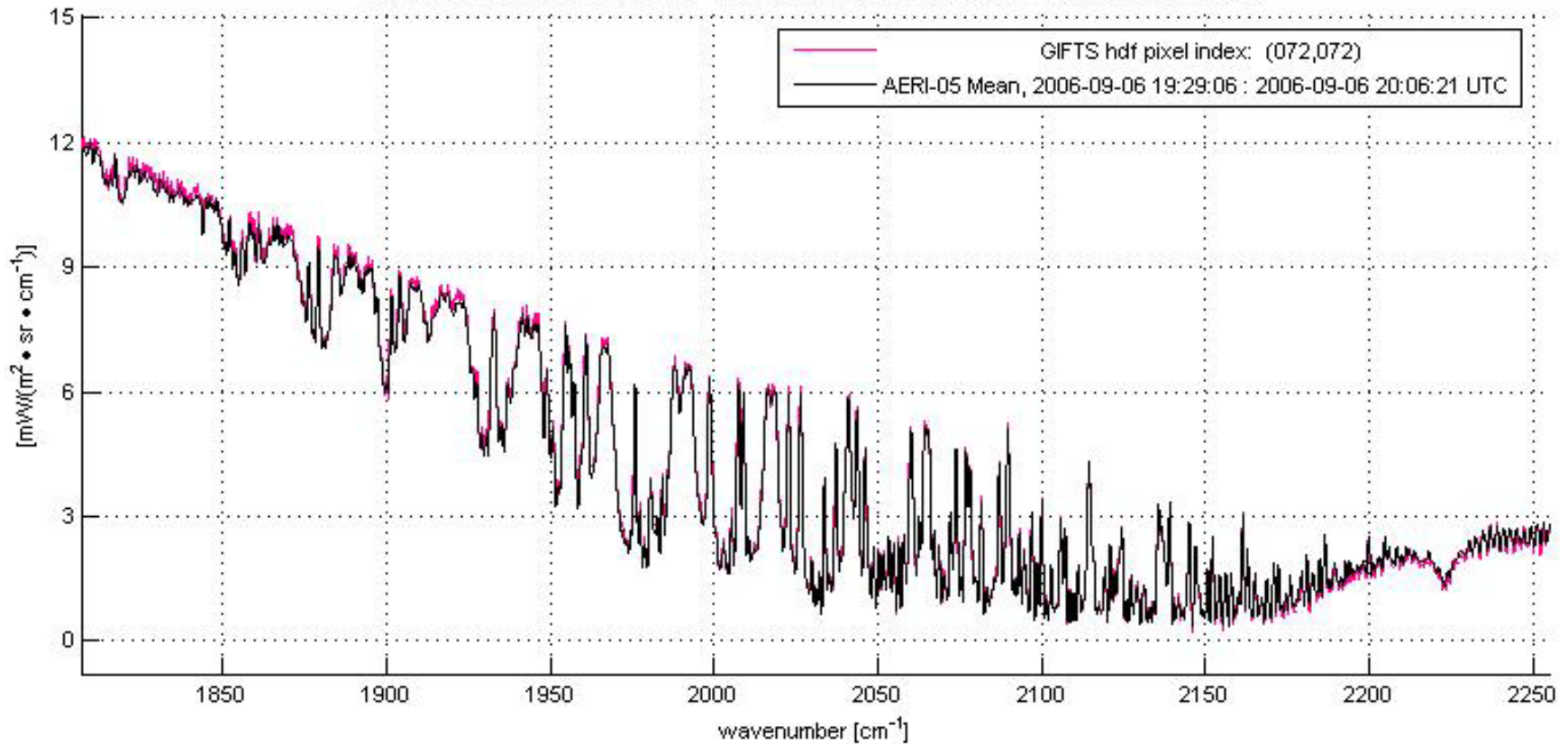
**786-822  $cm^{-1}$ , Weak WV and 792  $CO_2$  Q branch**

# SW, GIFTS-AERI05, pixel 72,72

SW Calibrated Spectral Radiance; Scan Direction: 0

Scene: CCE00005 : CCE00009; Cold Cal Ref. EXT00349 (79.5K); Hot Cal Ref. EXT00359 (286.1K)

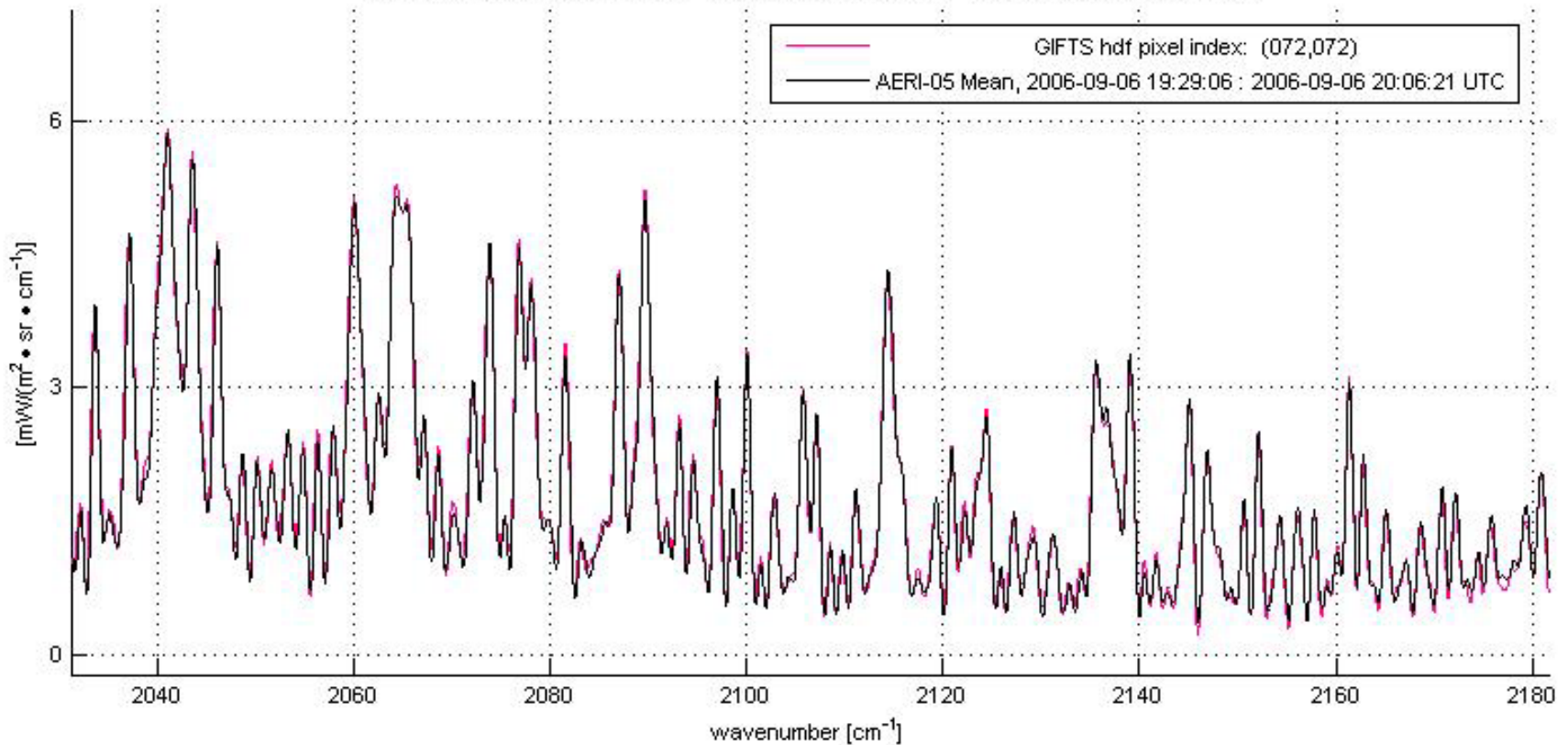
GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC



**GIFTS SW Band agreement is also good**

# SW, GIFTS-AERI05, pixel 72,72

SW Calibrated Spectral Radiance; Scan Direction: 0  
Scene: CCE00005 : CCE00009; Cold Cal Ref: EXT00349 (79.5K); Hot Cal Ref: EXT00359 (286.1K)  
GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC

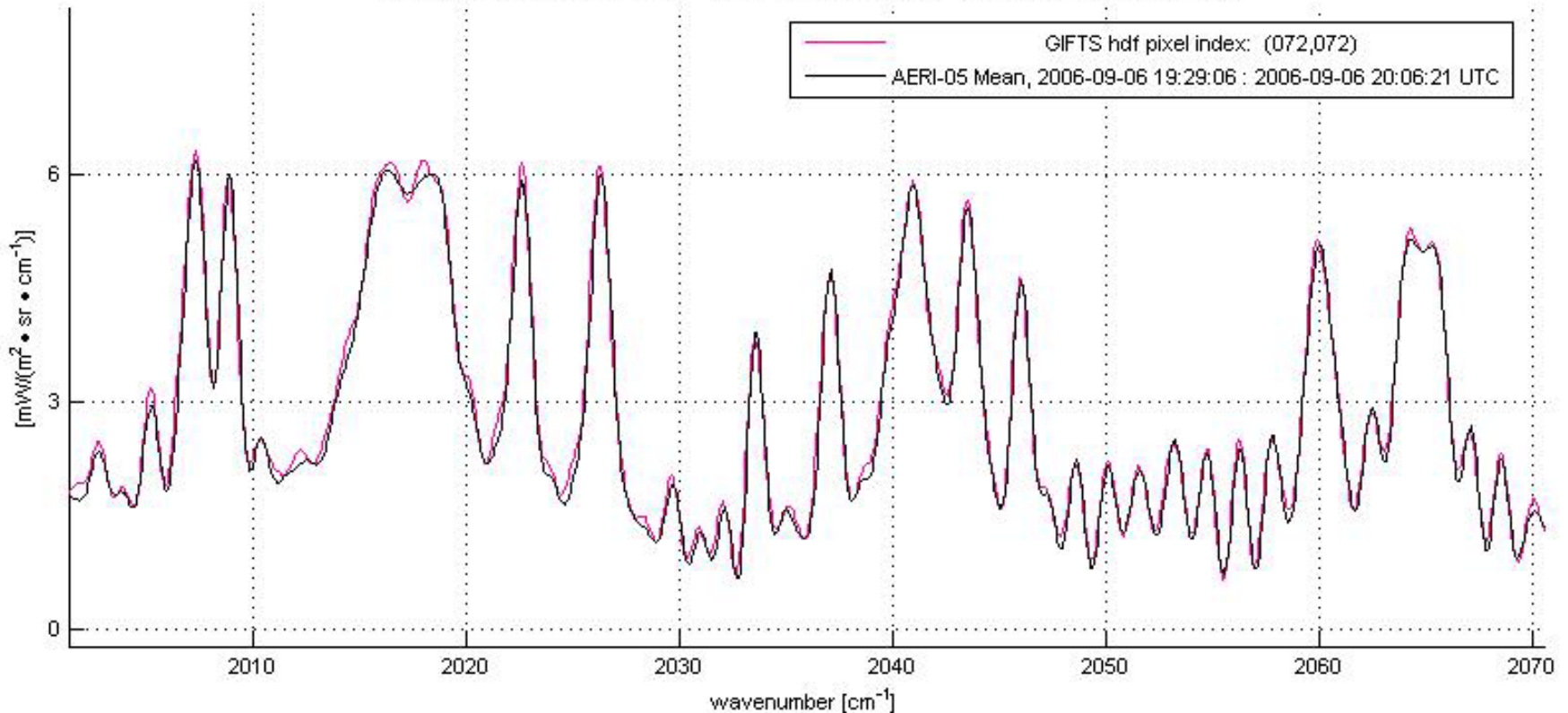


**2030-2180  $cm^{-1}$ , mainly Water vapor**



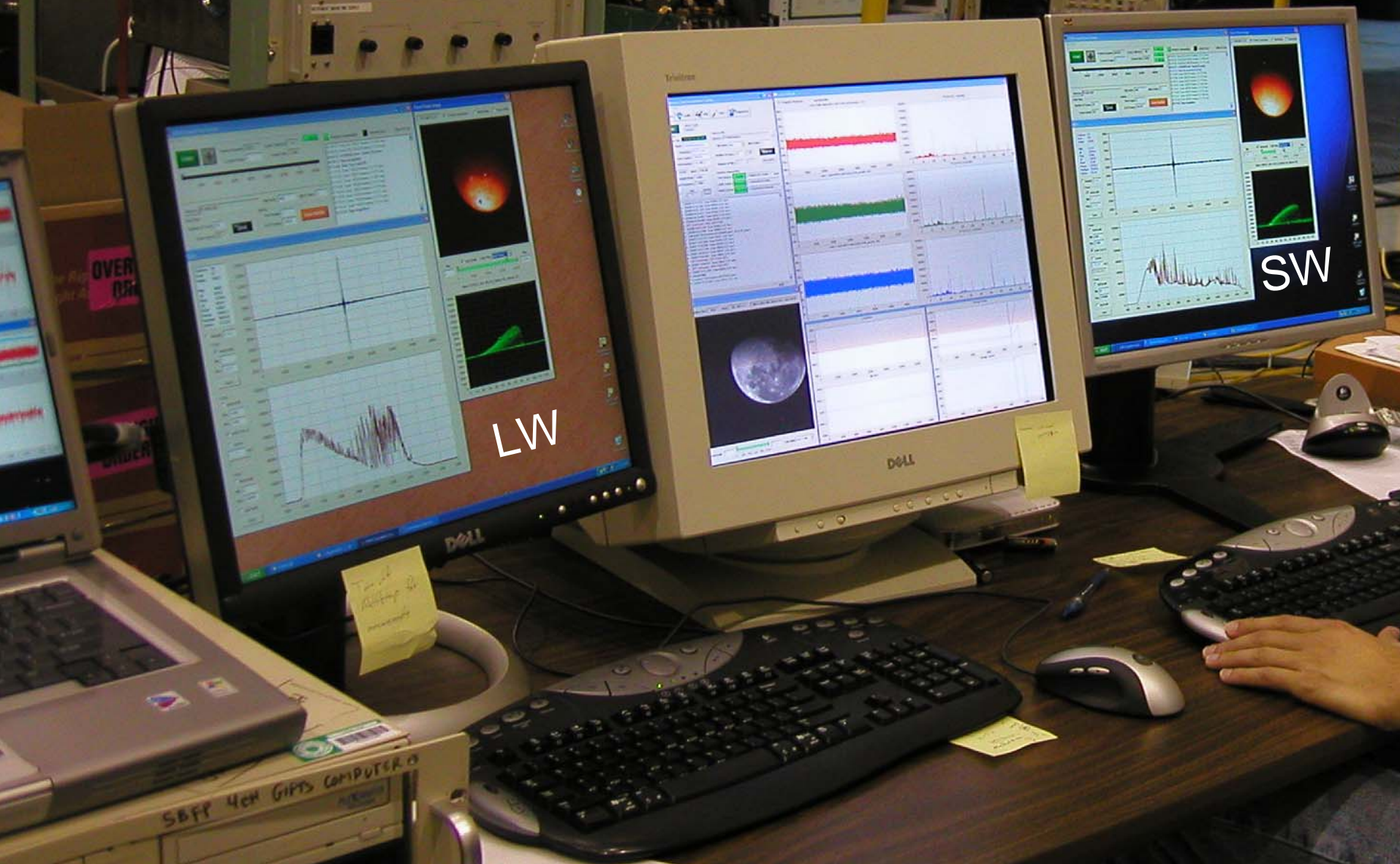
# SW, GIFTS-AERI05, pixel 72,72

SW Calibrated Spectral Radiance; Scan Direction: 0  
Scene: CCE00005 : CCE00009; Cold Cal Ref. EXT00349 (79.5K); Hot Cal Ref. EXT00359 (286.1K)  
GIFTS Data Collection Period: 2006-09-06 19:28:15 - 2006-09-06 20:08:10 UTC



**2000-2070  $cm^{-1}$ , mainly Water vapor**

# GIFTS Real-time DATA Display



LW

SW

SBFF 4CH GIFTS COMPUTER 2

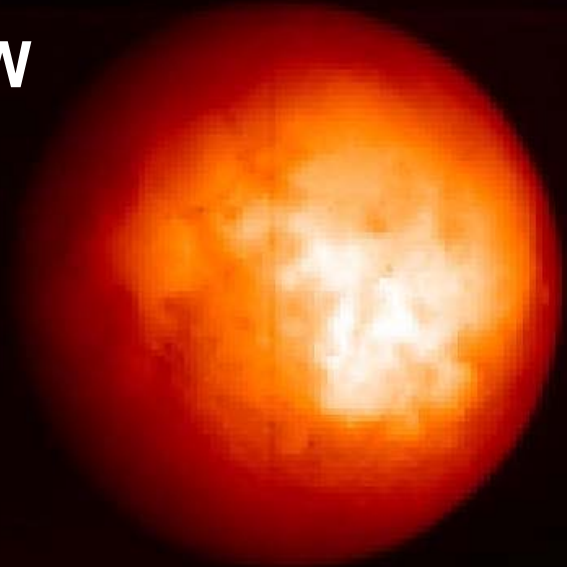


# GIFTS- Lunar Images

SW/MW



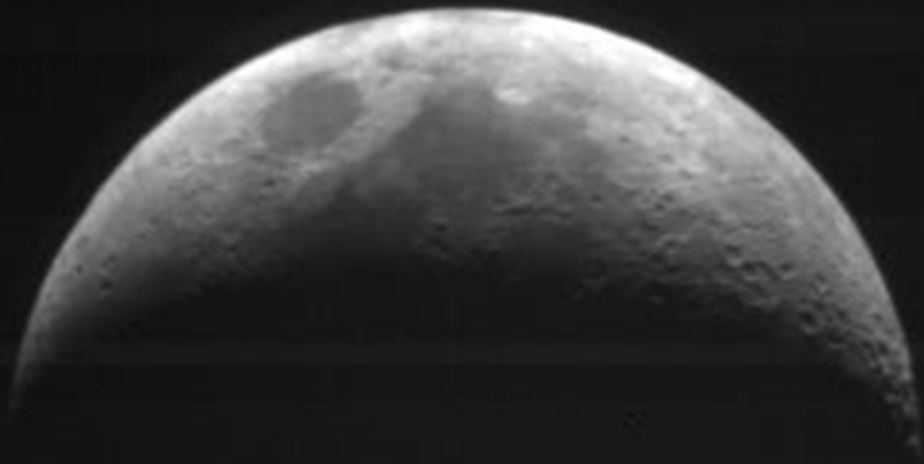
LW



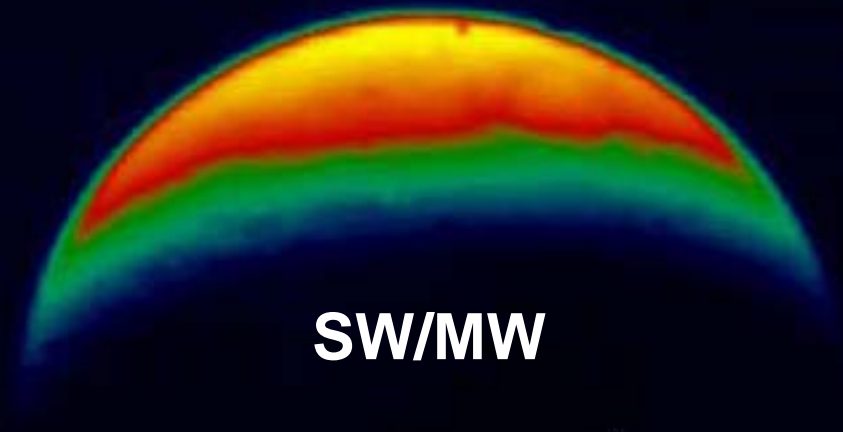
Visible

# GIFTS- Lunar Images

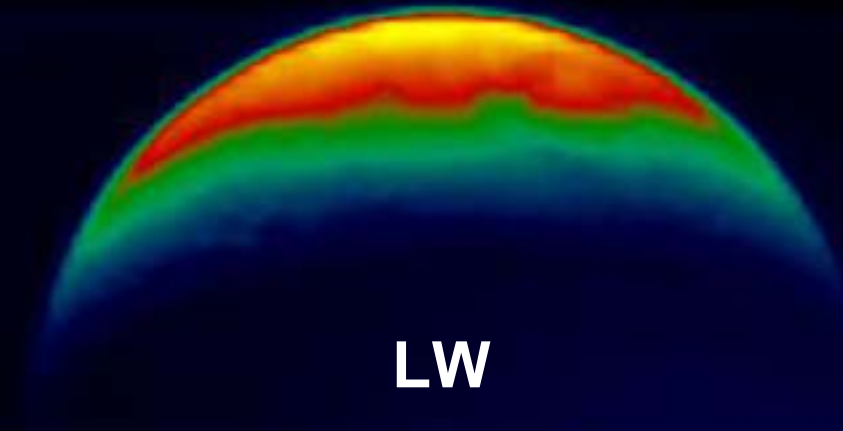
Visible



SW/MW



LW





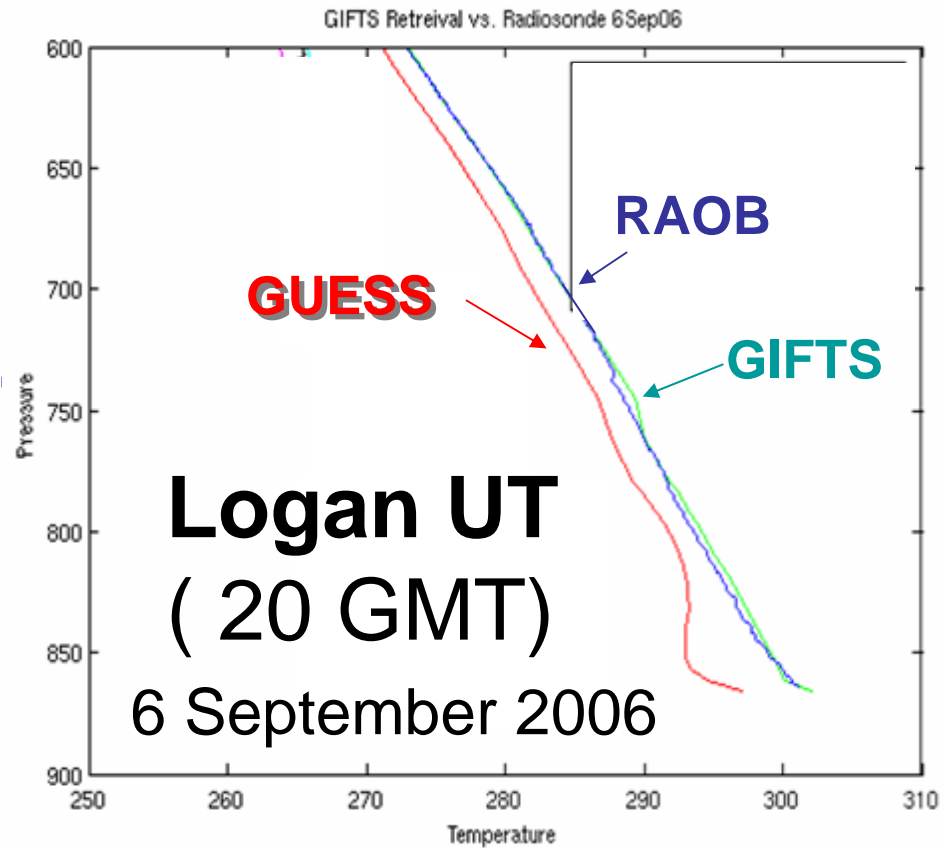
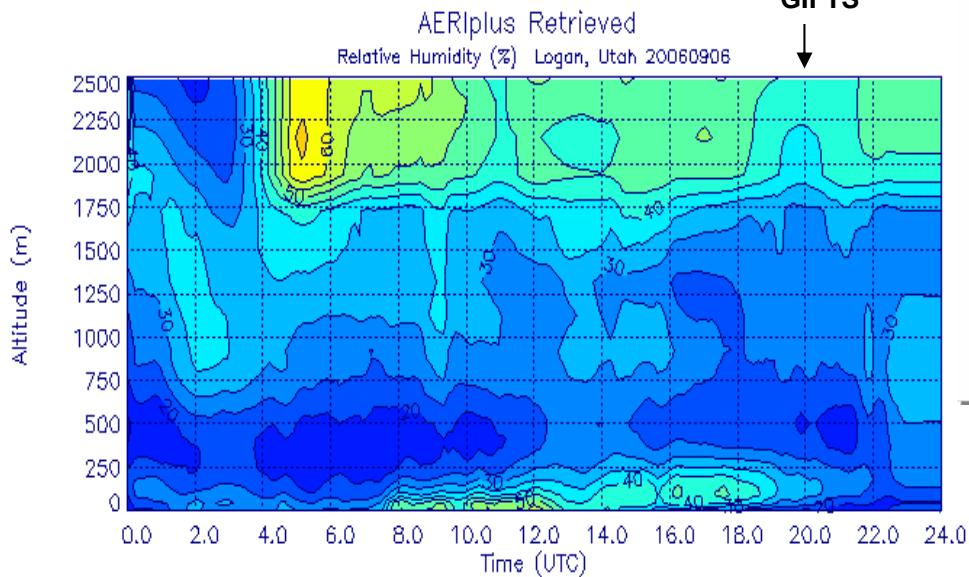
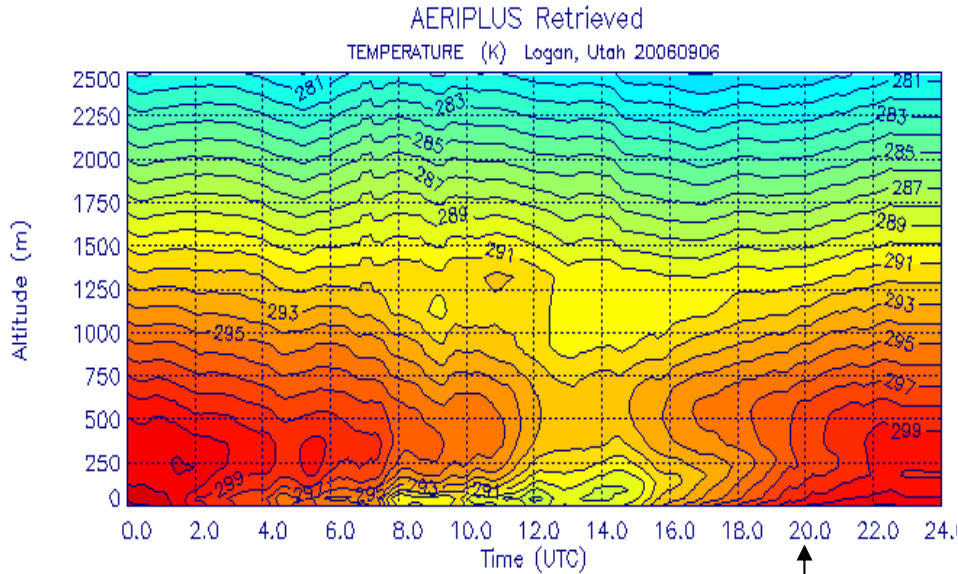
# Interferogram Scan Movie

DC output of the LW  
detector array during  
one 66,276 point  
interferogram scan  
(11 sec)

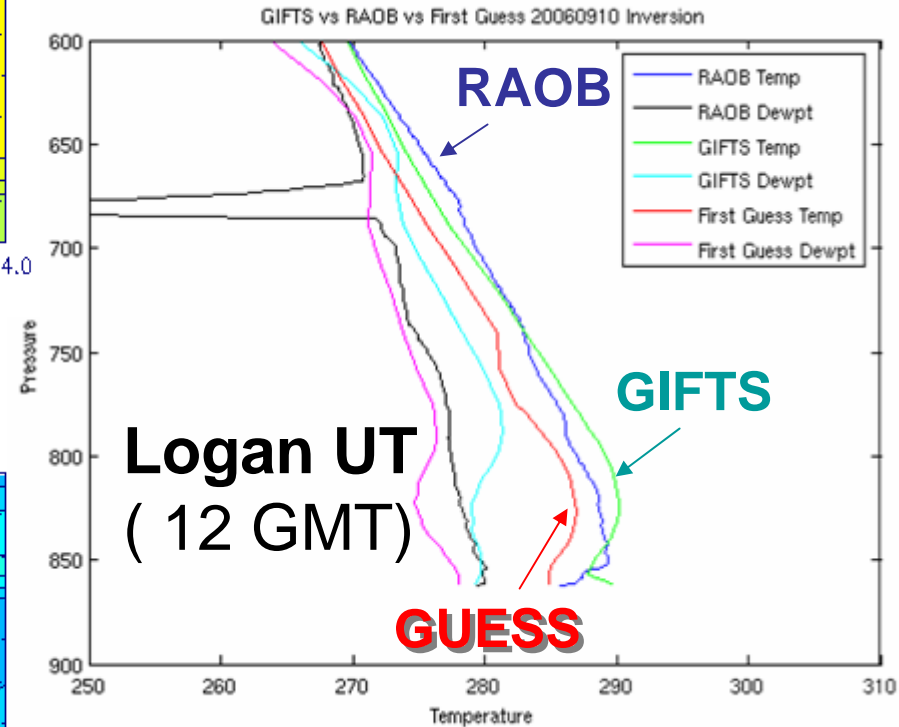
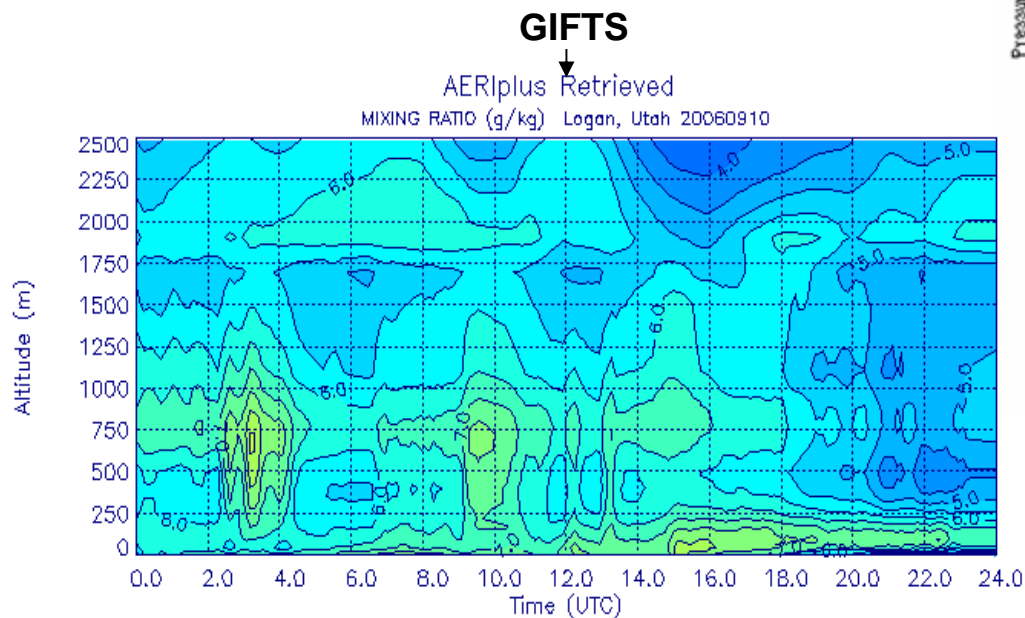
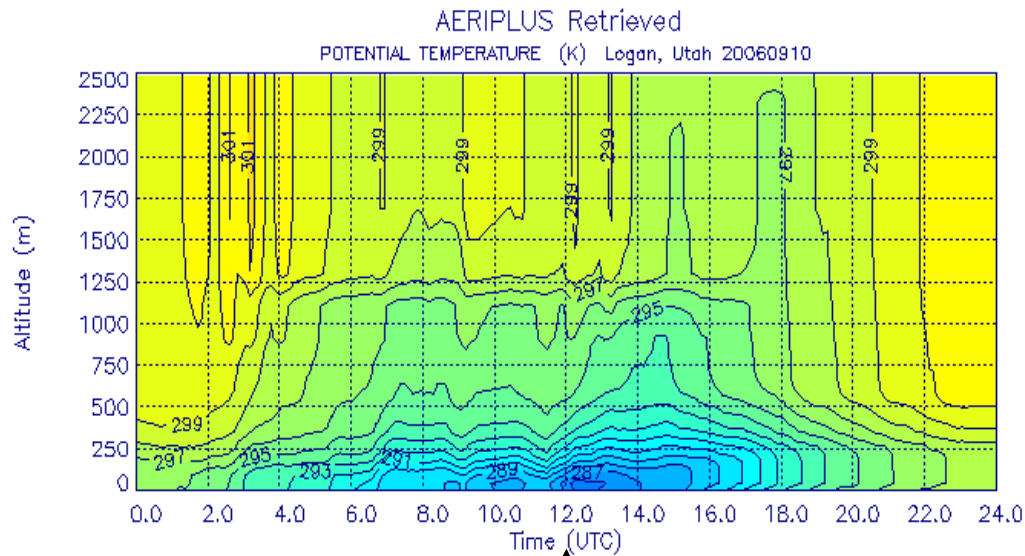
Movie made from  
a sequence of every  
50<sup>th</sup> Frame  
(1325 frames)

← 135 meters @ 10 km altitude →

# GIFTS- Profile Retrievals (9-6-06)



# GIFTS- Profile Retrievals (9-10-06)



# **GIFTS- A Technical Success**

- **All technologies successfully integrated to create a revolutionary Geostationary Satellite Imaging Spectrometer, fully tested and characterized in a space (T/V) chamber**
- **Accurate radiometric data demonstrated through direct comparisons with AERI**
- **High resolution temperature and moisture sounding capability demonstrated through ground-based sky viewing measurements**



# Conclusion

**We need to get  
GIFTS into Space  
As Soon As  
Possible !**

**Thank you for your continued support of the GIFTS**

International TOVS Study Conference, 15<sup>th</sup>, ITSC-15, Maratea, Italy, 4-10 October 2006  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2006.