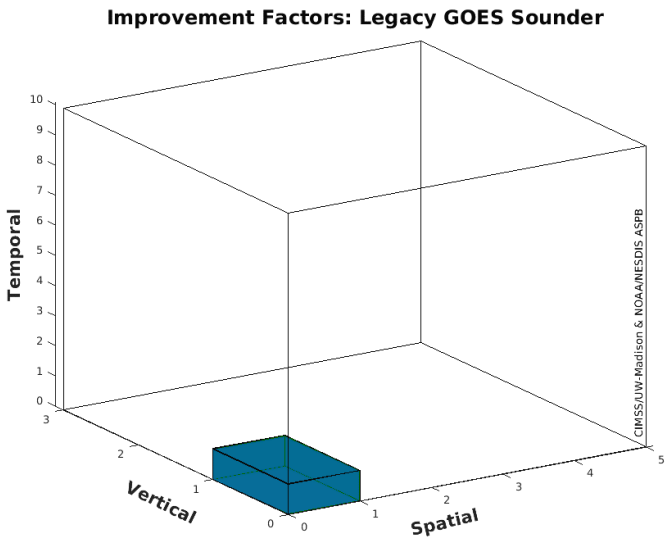


GOES-8 Class Sounders

GOES-8/15

NOAA
National Satellite, and
Information Service

Oct 2021

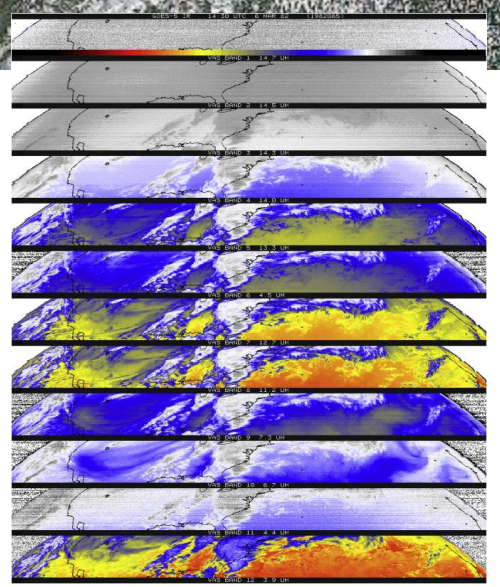
Tim Schmit NOAA NESDIS STAR COPR ASPB, Madison, WI
(AWG Legacy Atmospheric Profile Team Lead and GXS Products)
With help from many others (Paul Menzel, Mat Gunshor, UW/CIMSS)

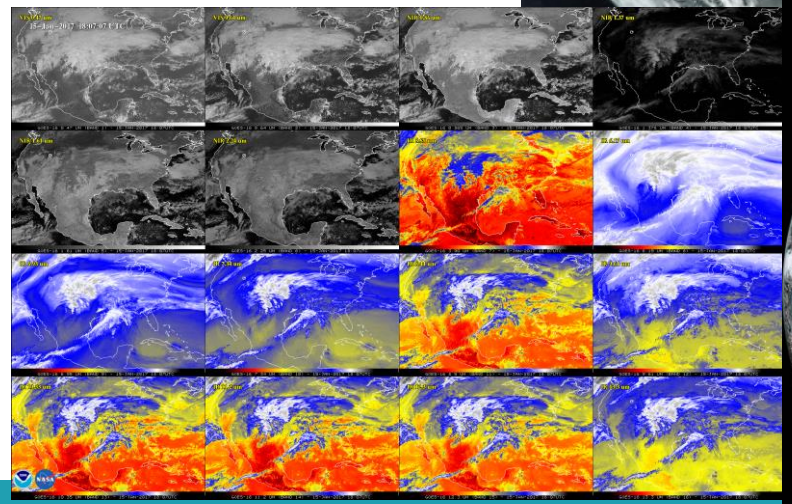
U.S. Geostationary Game-changers

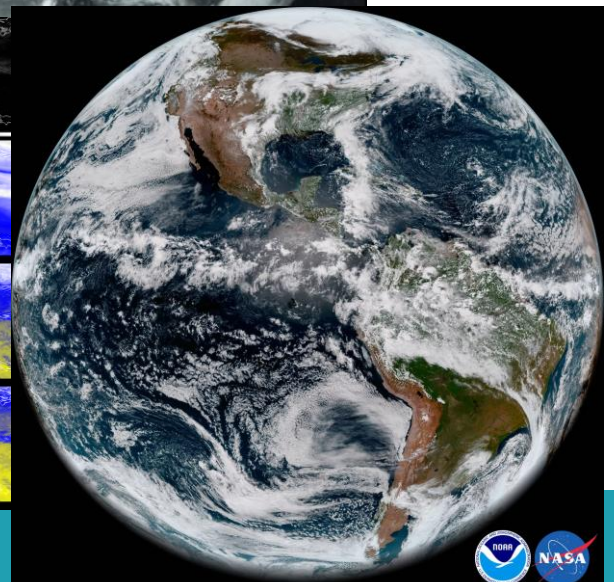
Item	Imagery	Sounding
First of it's kind (experimental)	ATS-1 (1966)	VAS (1980)
First Operational	GOES-1 (1975)	GOES-8 (1994)
Orders of magnitude improvements	GOES-R series (2016)	High-spectral IR (203?)

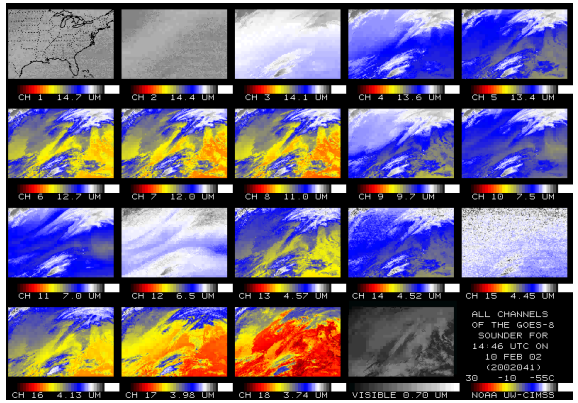
GOES-R series included the first geostationary lightning mapper

Item
First of it’s kind (experimental)
First Operational
Orders of magnitude improvements









?

True/False on GOES-8/15 Class Sounders

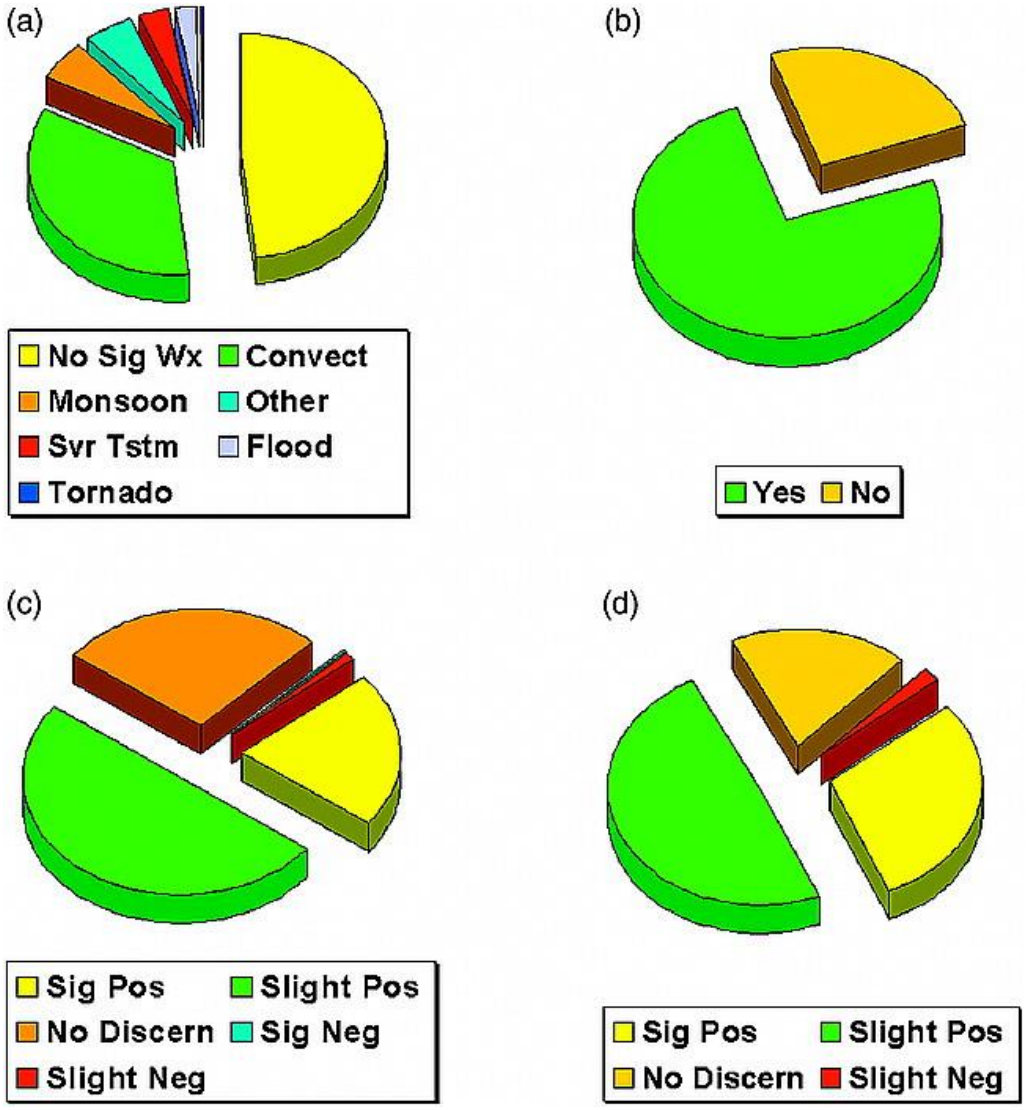
- F - No one used the GOES-I (8) class sounders
- F – HES was cancelled due to lack of needed data
- F - the ABI is a sounder
- F - we have enough vertical moisture and motion information; there's no NWS support for high spectral IR observations
- F - NWP was fully prepared to assimilate GOES Sounder radiances
- T - the limited vertical resolution of the GOES-I class sounders severely limited some applications; we need high spectral IR to add the vertical information
- T - the GOES-I sounders had 3 scan modes: slow, slower, slowest (FD coverage in about 7 hours).
- T- the GOES-I sounders were 1970s (HIRS) science, designed in the 1980s, flown first in the 1990s.
- T - the ABI was designed to work in concert with the ABS (high spectral IR sensor)
- T – GXS/Legacy Sounder > ABI/Imager

No one used the GOES-I/P class sounder: **False**

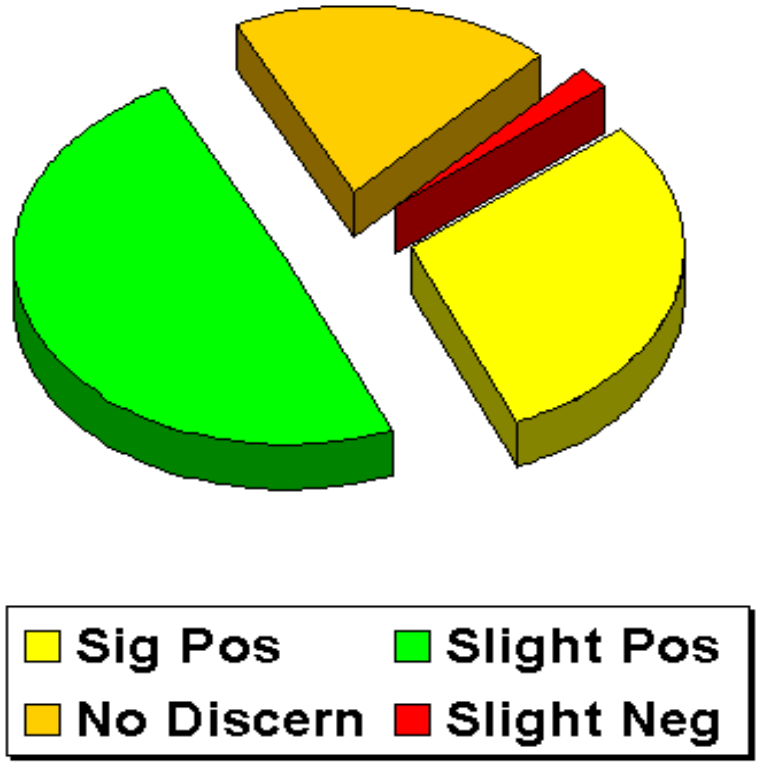
Operational Uses over many years:

- ASOS Clouds,
  - Hourly roundups
- Moisture winds,
- TPW/Lifted Index by WFOs in AWIPS,
- Layer PW in NCEP model
  - The operational NCEP Eta Model system first began assimilating retrieved layers of moisture from the GOES-8 sounder in October 1997. [*until the Eta switched to NAM*]
  - Also TPW in the Rapid Update Cycle (RUC)

NWP: assimilated sounder clouds in the Rapid Update Cycle (RUC) (hourly)



NWS Forecast Office Assessment of GOES Sounder Atmospheric Instability



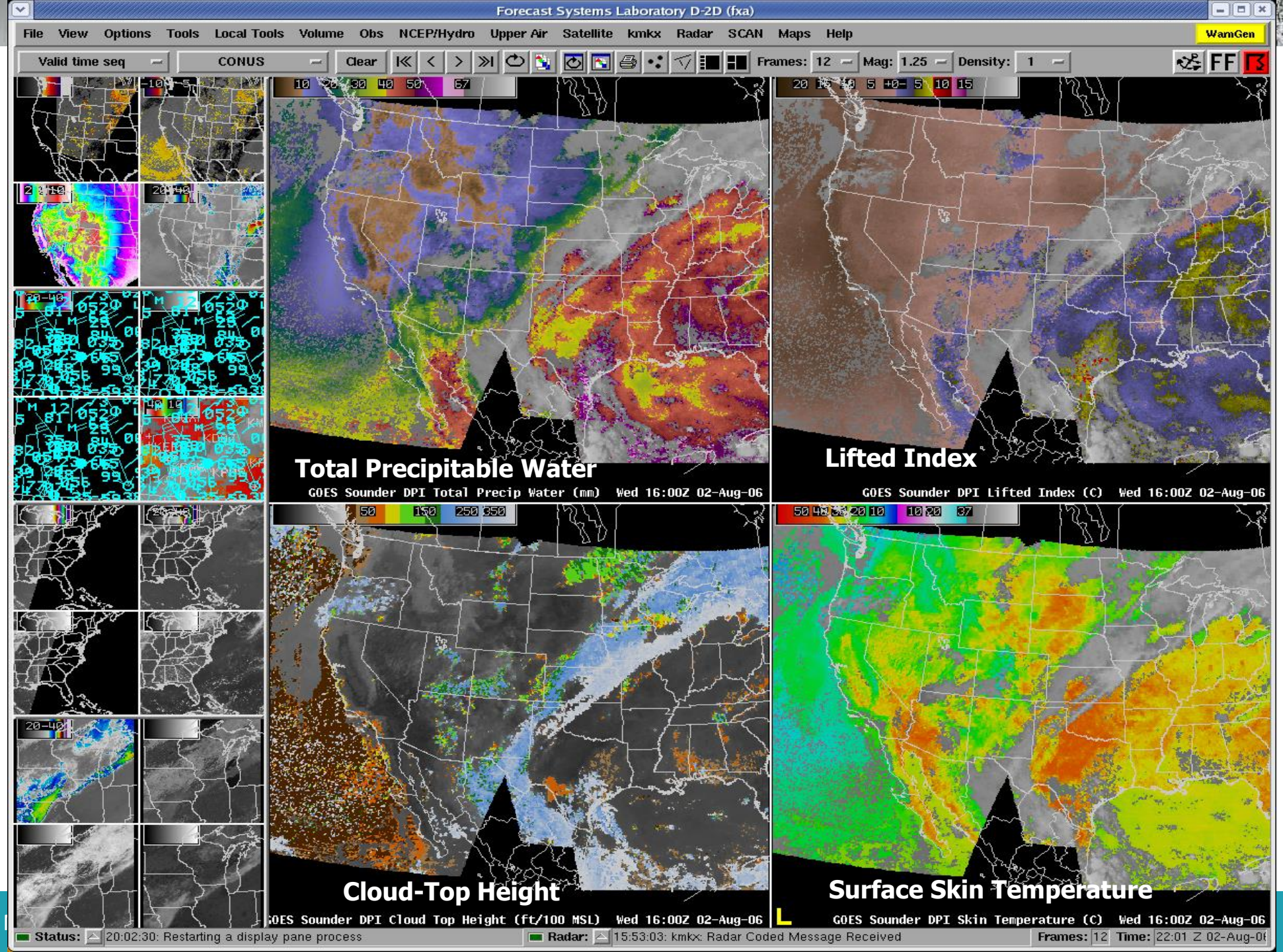
Summer 1999 Forecaster assessment of usefulness of changes in hourly LI, CAPE, & CINH product for predicting location/timing of thunderstorms

Out of 248 valid weather cases:

- Significant Positive Impact (30%)
- Slight Positive Impact (49%)
- No Discernible Impact (19%)
- Slight Negative Impact (2%)
- Significant Negative Impact (0)

Figure from the National Weather Service, Office of Services

GOES Sounder Product	Operational Use within the NWS
Clear-sky Radiances	**Assimilation into** NCEP operational regional & global NWP models over water
Layer & Total Precipitable Water	**Assimilation into** NCEP operational regional & global NWP models; **display and animation within** NWS AWIPS for use by forecasters at NWS WFOs & National Centers in forecasting precipitation and severe weather
Cloud-top retrievals (pressure, temperature, cloud amount)	**Assimilation into** NCEP operational regional NWP models; **display and animation within** NWS AWIPS for use by forecasters at NWS WFOs; **supplement to** NWS/ASOS cloud measurements for generation of total cloud cover product at NWS/ASOS sites
Surface skin temperature	**Image display and animation within** NWS AWIPS for use by forecasters at NWS WFOs
Profiles of temp & moisture	**Display (SKEW-Ts) within** NWS AWIPS for use by forecasters at NWS WFOs in forecasting precipitation and severe weather
Atmospheric stability indices	**Image display and animation within** NWS AWIPS for use by forecasters at NWS WFOs in forecasting precipitation and severe weather
Water Vapor Winds	**Image display and animation within** NWS AWIPS for use by forecasters at NWS WFOs


Forecast Systems Laboratory D-2D (fxa)
File View Options Tools Local Tools Volume Obs NCEP/Hydro Upper Air Satellite kmkx Radar SCAN Maps Help
WarnGen
Valid time seq
CONUS
Clear
Frames: 12
Mag: 1.25
Density: 1
FF
Total Precipitable Water
GOES Sounder DPI Total Precip Water (mm) Wed 16:00Z 02-Aug-06
Lifted Index
GOES Sounder DPI Lifted Index (C) Wed 16:00Z 02-Aug-06
Cloud-Top Height
GOES Sounder DPI Cloud Top Height (ft/100 MSL) Wed 16:00Z 02-Aug-06
Surface Skin Temperature
GOES Sounder DPI Skin Temperature (C) Wed 16:00Z 02-Aug-06
Status: 20:02:30: Restarting a display pane process
Radar: 15:53:03: kmkx: Radar Coded Message Received
Frames: 12 Time: 22:01 Z 02-Aug-06

AWIPS
2006

GOES Sounder Data and Products

Some Non-Operational Products

- **DPI Products (Not available on AWIPS, but via web pages,etc)**
  - **Downburst potential product**
    - Aids in monitoring and situational awareness in pre-convective environments
    - Assessment and short term forecasting of severe convective storm and downburst wind gust potential
  - **Convective Available Potential Energy (CAPE) DPI**
    - Aids in monitoring and situational awareness in pre-convective environments
  - **Convective Inhibition (CINH) DPI**
    - Aids in monitoring and situational awareness in pre-convective environments
  - **Layer Precipitable Water (PW) DPI**
    - Useful in tracking SW monsoon moisture
  - **700-500 MB Temperature Lapse Rate DPI**
    - Used to identify areas of elevated instability
- **Other Products**
  - **Ozone**
  - **Outgoing Longwave Radiation (OLR)**

Plus, helped prepare for the ABI (and SEVIRI) in many ways, included elevated mixed layers.

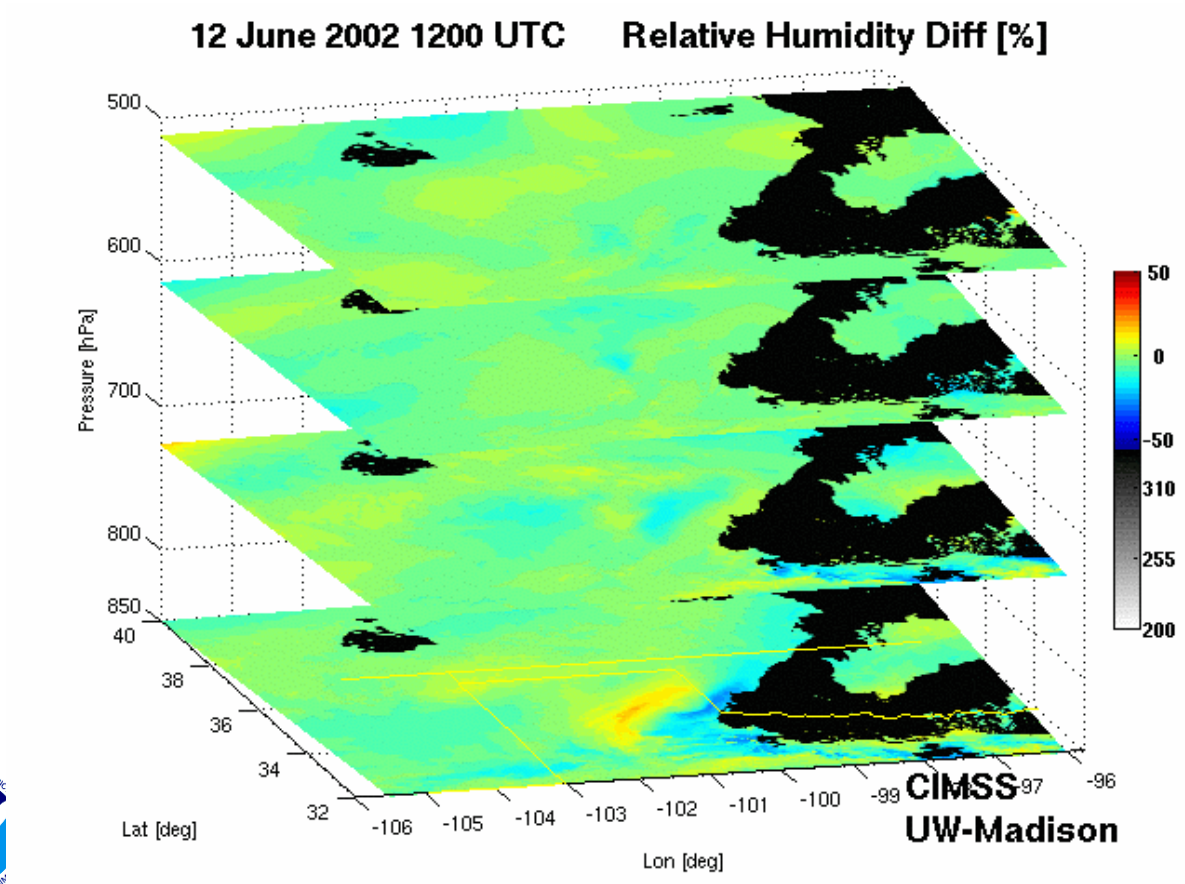
HES was cancelled due to lack of needed data: False

- My understanding that HES was cancelled in part to NPOESS cost over-runs, very large processing estimates and a more complex instrument (married with the Coastal Waters).
- WMO's implementation plan for evolution of space and surface-based sub-systems of the GOS 2005 (WMO/TD No. 1267): GEO Sounders – All meteorological geostationary satellites should be equipped with hyper-spectral infrared sensors for frequent temperature/humidity sounding as well as tracer wind profiling with adequately high resolution (horizontal, vertical and time).
- Consistent with Decadal study recommendations.
- Needed as part of the global constellation
- COURL requirements remain

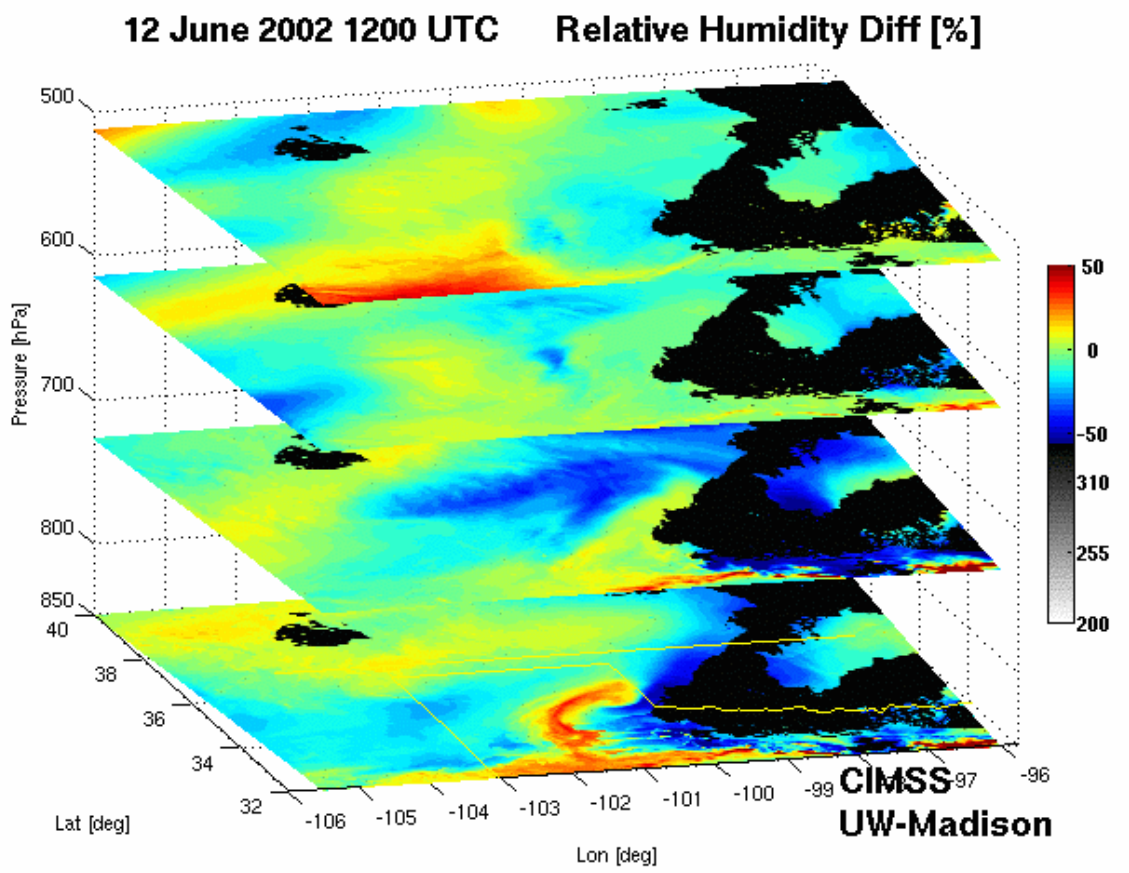
The ABI is a sounder: **False**

- Needed to relax HES requirements, so the ABI (with a lot of help from the initial T/q profiles) could meet the new GOES-R series requirements.

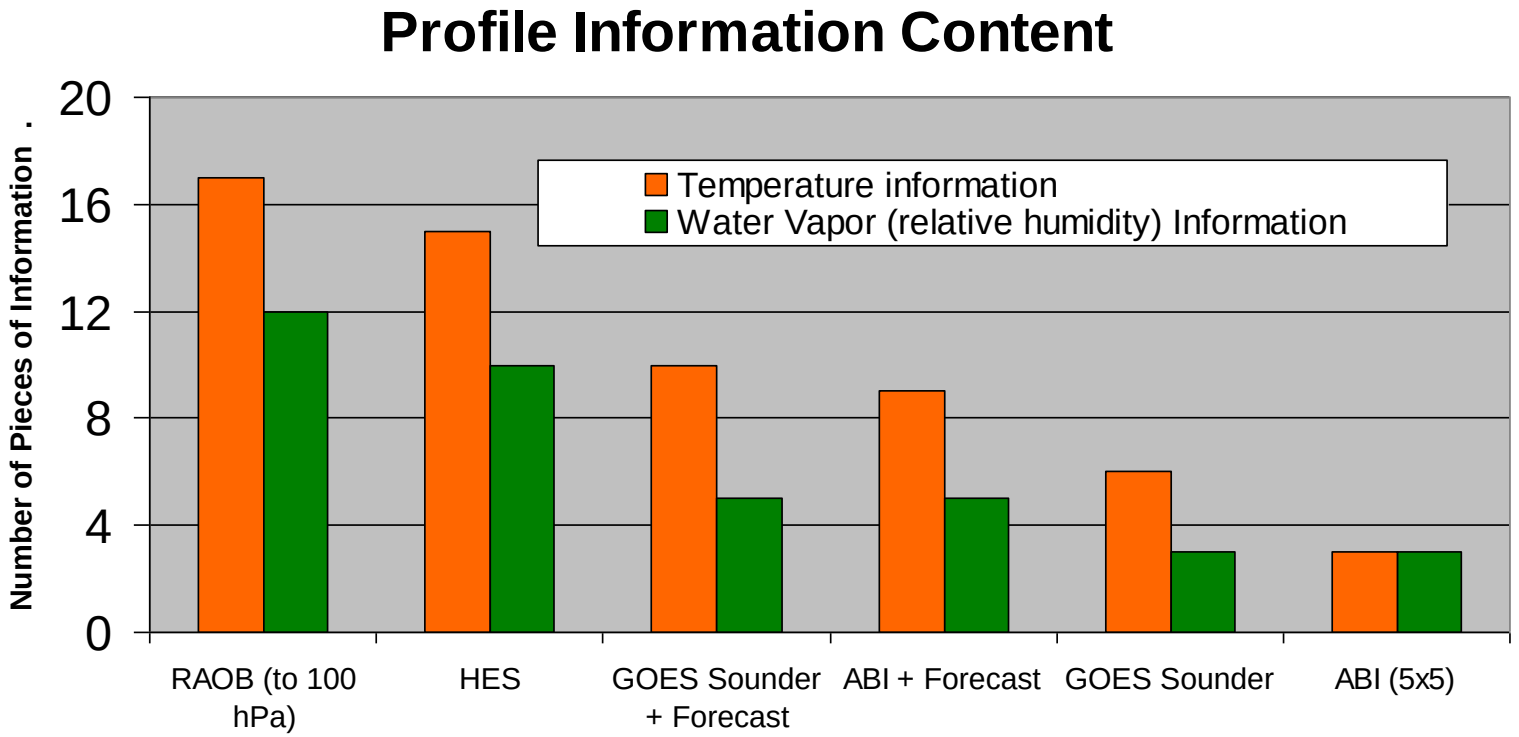
GEO Advanced Sounder minus truth



Simulated GOES-R ABI minus truth



ABI is not an advanced sounder!

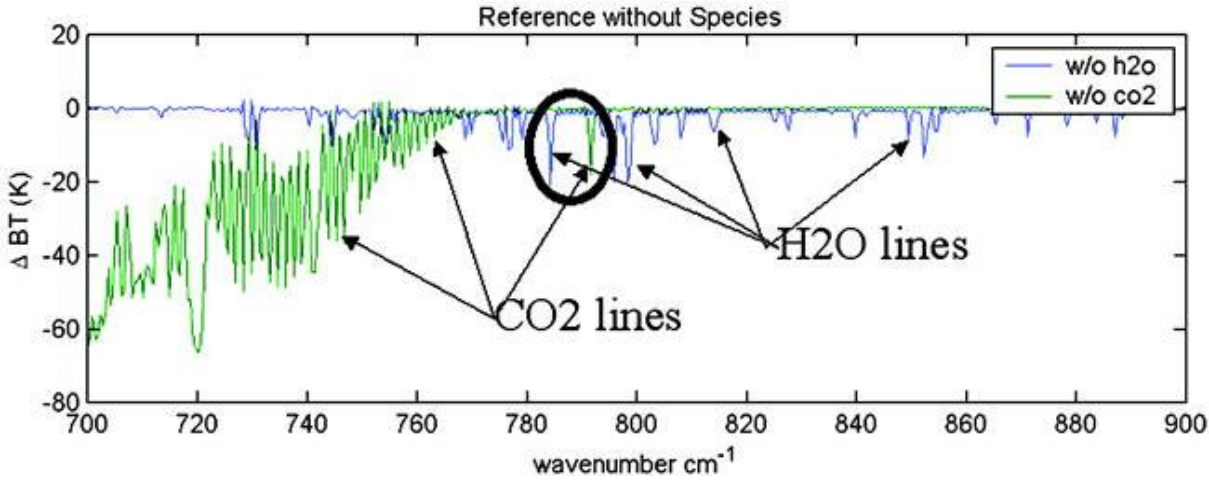


The relative vertical number of independent pieces of information is shown. The *moisture* content is similar between the ABI and the current GOES Sounder. The Sounder does show more *temperature* information than the ABI. The ABI is not close to the information content of a high-spectral sensor.

We have enough vertical moisture and motion information; there's no NWS support for high spectral IR observations: False

- Geo hyperspectral IR sounder is the only way to measure boundary layers moisture changes on spatial and temporal resolution needed for the weather ready nation" (*Sieglaff et al 2009 and others*)

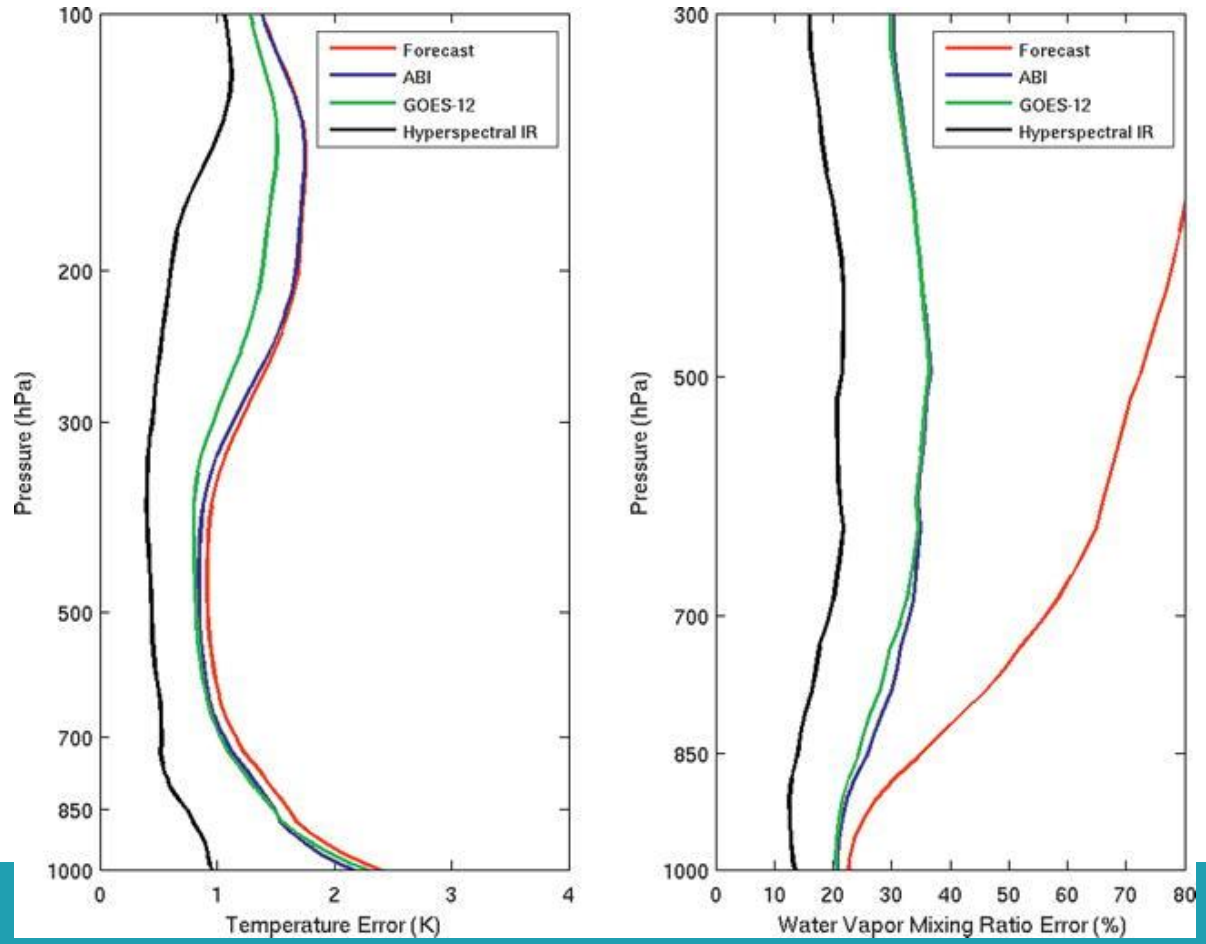
- The Assessment of Alternatives concluded that there were not other sensors that could fill the void of the HES with respect to vertical moisture.
  - 1999: NWS ORD "Goal of 2km for sounder spatial res"
  - 2010: NWS memo "Sounder on GOES-U" top geo item
  - 2019: NWS Director "Geo Sounder the next big thing"



NWP was fully prepared to assimilate GOES Sounder radiances: **False**

- The assimilation of AIRS, IASI, CrIS consumed the NWS efforts in the 2000s and showed very positive impact.
- Absence of 4DVAR and effort slowed preparation and enthusiasm for GHIS, HES, or GIFTS.
  - Assimilation times of only every 6 or 12 hours limited the use of hourly data.
- 4DVAR showing good promise with Geo data
  - FY-4A GIIRS and Tropical Cyclone intensity and track improvements.

The limited vertical resolution of the legacy GOES sounder severely limited some applications; we need high spectral IR: **True**

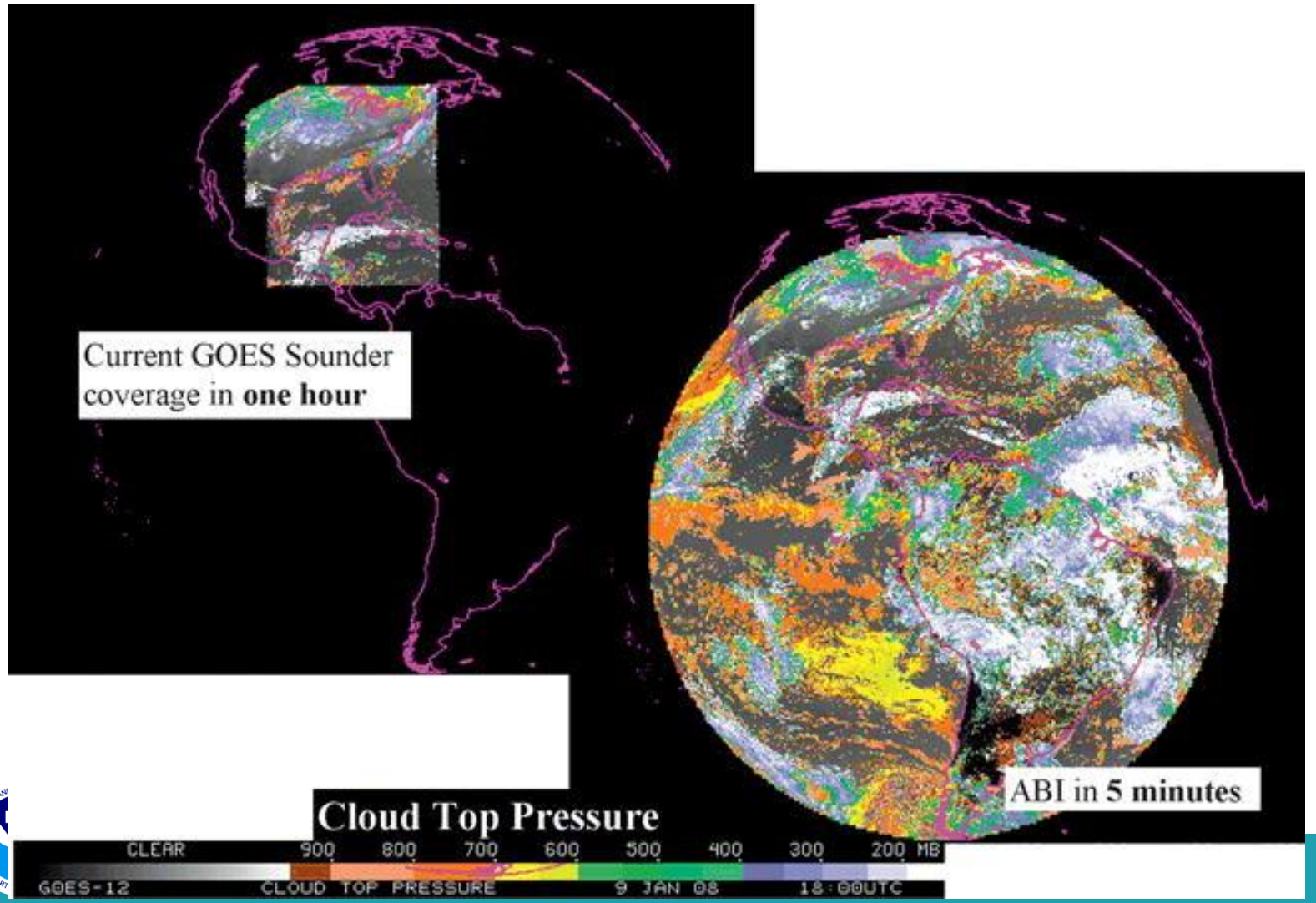


ABI has very limited vertical information, but similar to what the legacy GOES Sounders had (for moisture).

This doesn't mean ABI are good sounders, but the legacy GOES were poor sounders

- yet still used in their day

The GOES-I sounders had 3 scan modes: slow, slower, slowest: **True**



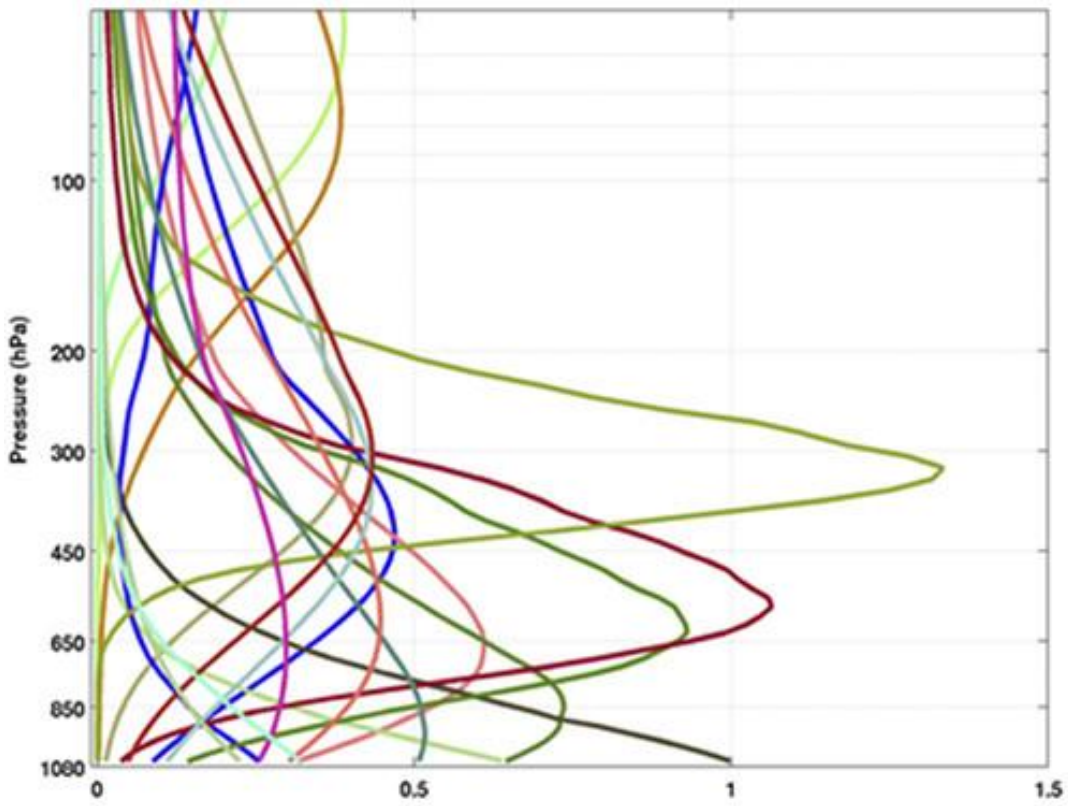
The slow coverage rate limited impact in global models and limited regions to scan

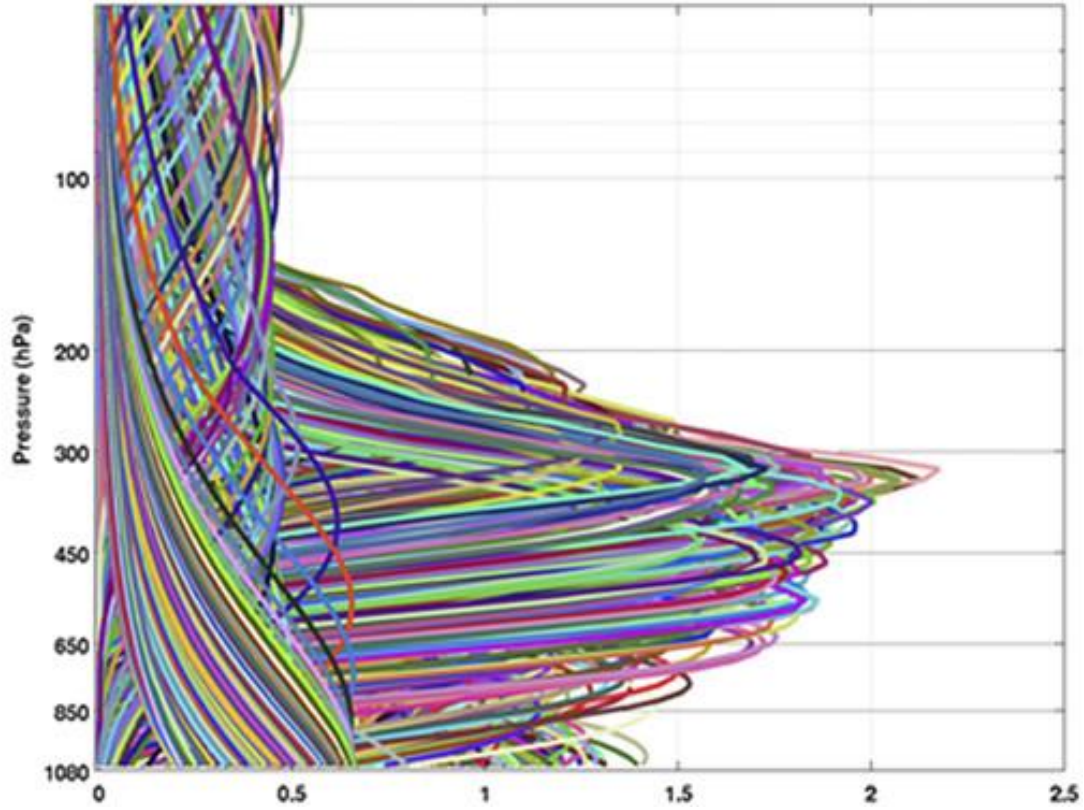
Legacy GOES Sounder FD coverage in about ~7 hours

The GOES-I sounders were 1970s (HIRS) science, designed in the 1980s, flown in the 1990s: **True**

- Early on the science showed that improved vertical resolution was needed, although the GOES-8/15 sounders were still broad-band sensors.
- Planned efforts to evolve the GOES-8/15 sounders did not materialize
- There were detailed issues that were not properly addressed.
  - For example, the observations from the 4 detectors varied, yet the SRF wasn't broken out by detector, nor was the detector information easy available to the modelers. Or truly understanding the observation over the view angles, etc.

Low vs High IR Spectral Resolution



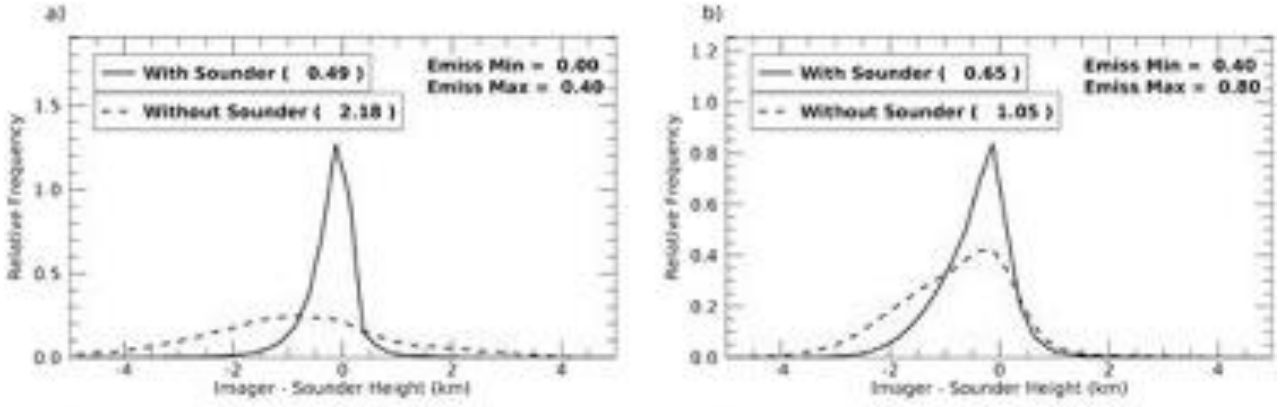


- Weighting or (Contribution) Functions

The ABI was designed to work in concert with the ABS: **True**

- Higher resolution imagery within a sounder FOV was just one of the ways the ABI and ABS (Advanced Baseline Sounder) could help each other.
  - Combined ozone retrievals where another

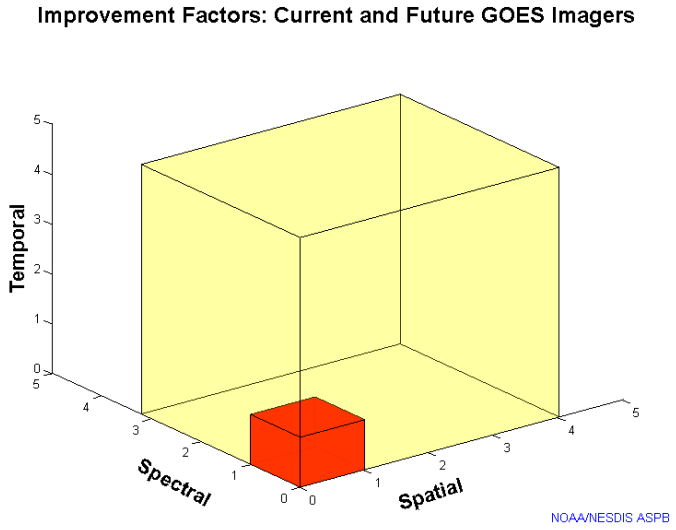
Using Sounder Data to Improve Cirrus Cloud Height Estimation from Satellite Imagers by Heidinger, et al., 2019



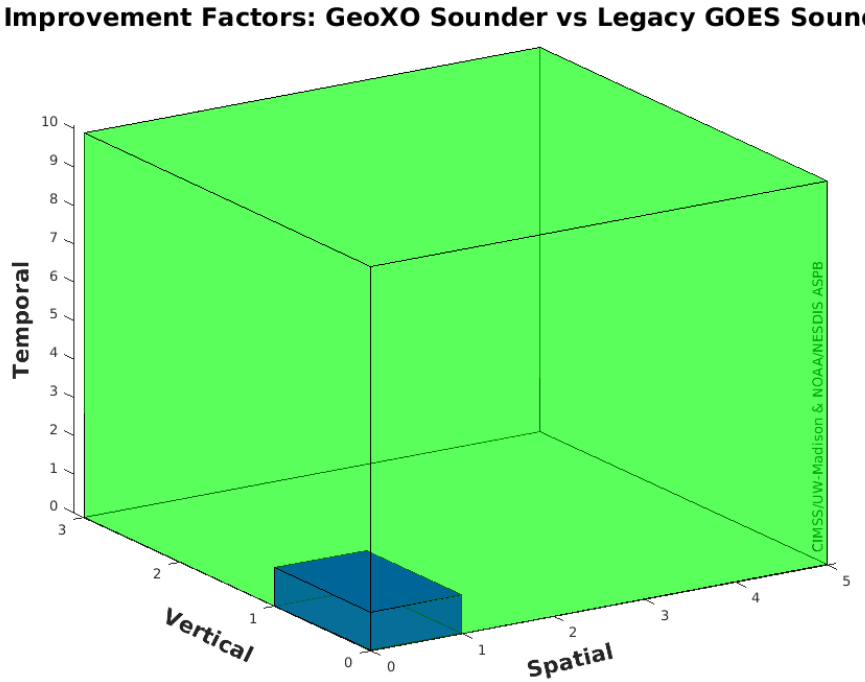
"… resulting cloud height data preserved both the accuracy of the sounder information and the resolution offered by the imager. Comparisons with *CALIPSO* showed that the imager plus sounder heights more closely matched the sounder heights, and agreed better with *CALIPSO* than the imager products."
https://doi.org/10.1175/JTECH-D-18-0079.1

GXS/Legacy Sounder > ABI/Imager: **True**

- "Everyone" knows about the ABI being 3, 4 and 5 times (spectral, spatial and temporal) improved over the legacy geo imager.



- GXS would be something like 3, 5 and 10 times improved (vertical, spatial and temporal) over the legacy geo sounder!



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Summary

While the legacy GOES (-8/15) sounders were used operational in many ways, including both nearcasting (TPW, atmospheric instability, clouds, and winds) and NWP (global and regional)…

The information content (spectral, temporal, spatial) on future advanced geo sounders will be so large compared to legacy (broad band) geo IR sounders, that it dwarfs the capability of the legacy operationally used sounders