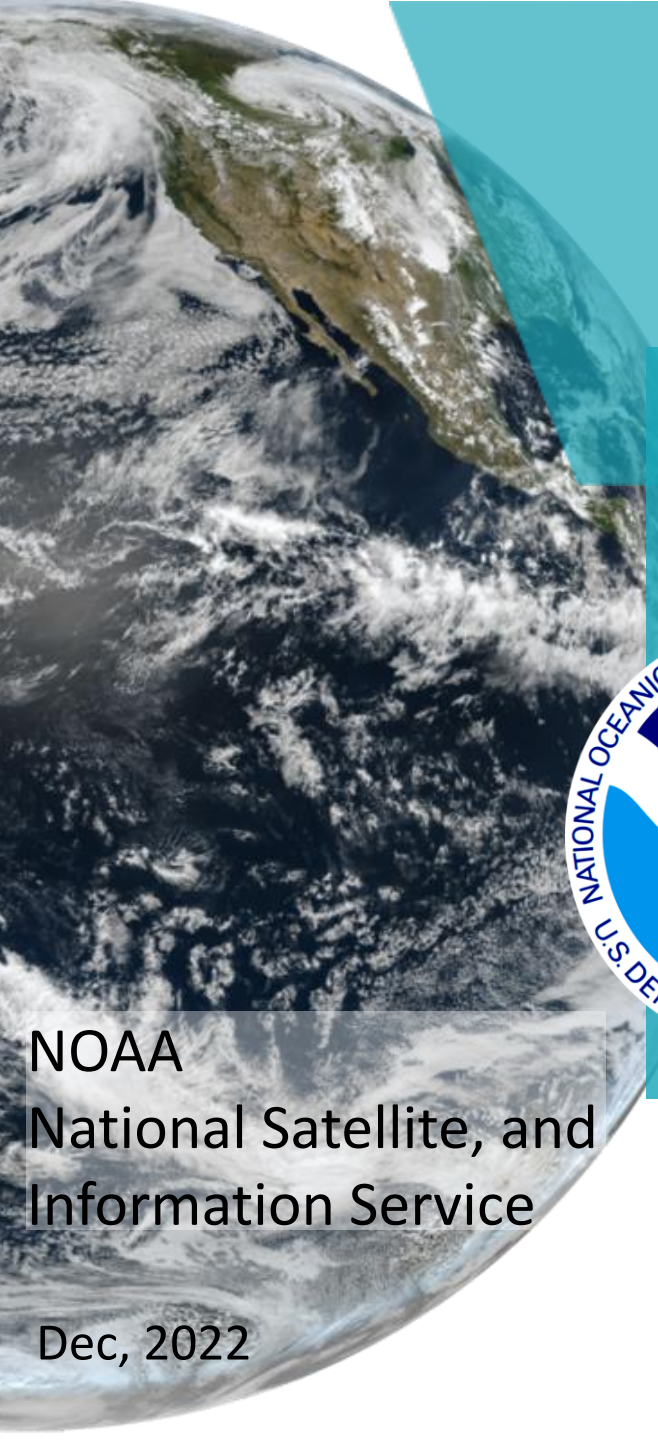
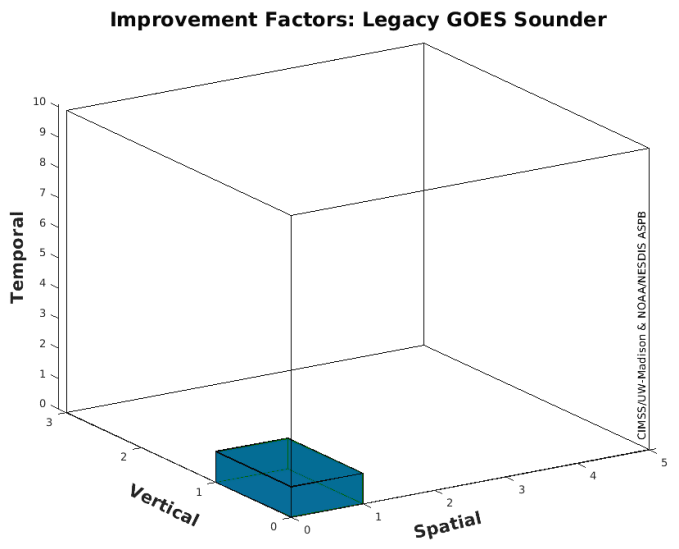




US Plans for Geostationary Hyper-spectral Infrared Sounders

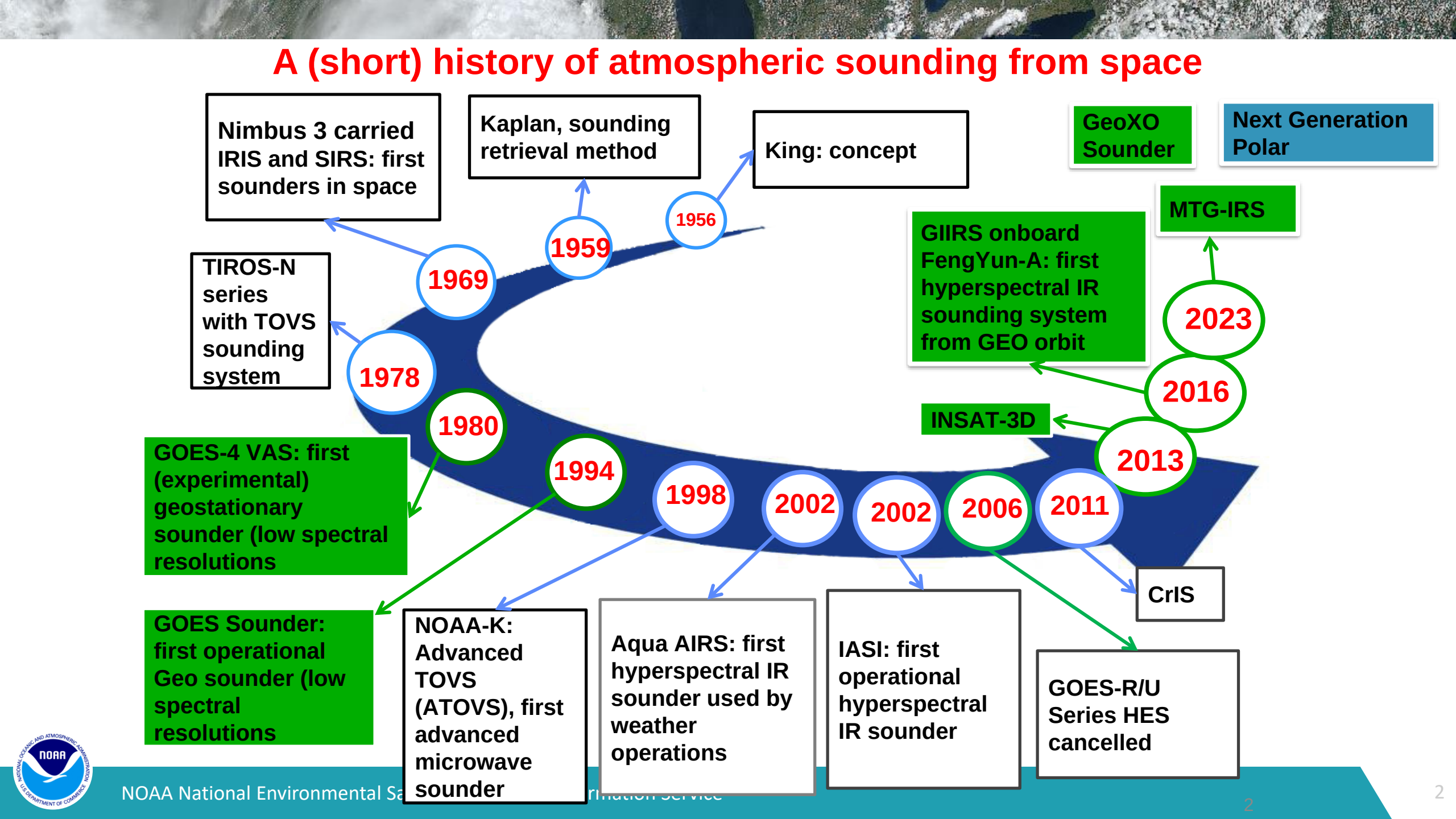
GXS 101

Tim Schmit, NOAA NESDIS STAR CoRP ASPB
And many, many others ……

NOAA
National Satellite, and Information Service

Dec, 2022

A (short) history of atmospheric sounding from space



History

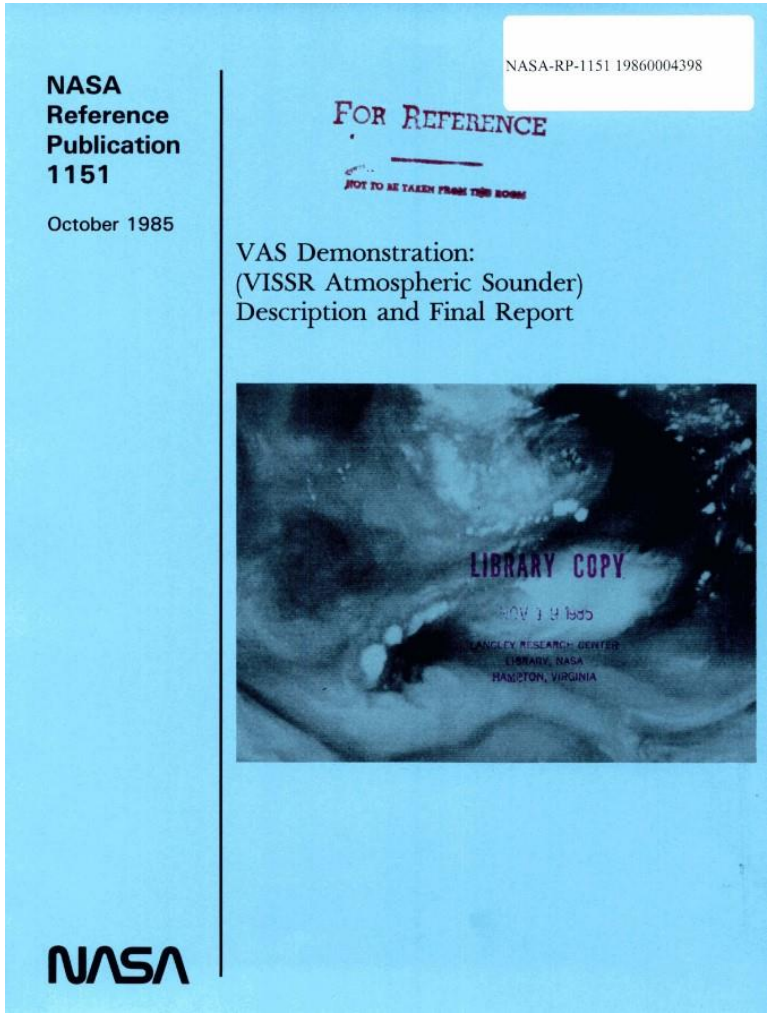
FOREWORD

What about the future?

These results are the foundation for future satellites. The VAS experience suggests that extension into the microwave region, and **increased spectral resolution in the infrared region,** are essential so that we can obtain soundings through persistent clouds and **with improved vertical resolution**. Geostationary microwave instruments and high spectral resolution infrared interferometers are **feasible and would be highly useful**.

The administrative mechanisms of interagency cooperation must be put into motion as soon as possible to accomplish this. **We must not lose the momentum ....**

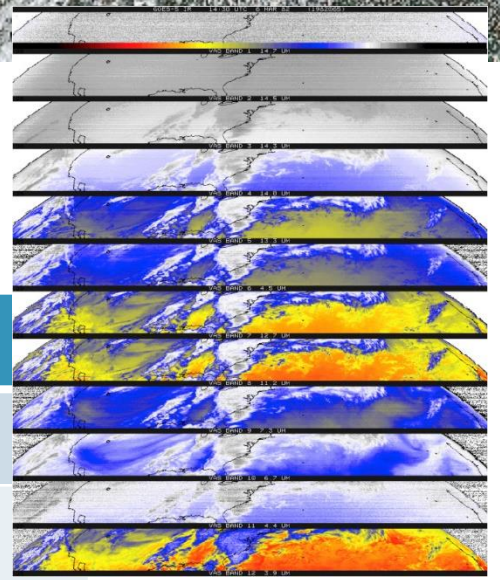
Professor Verner E. Suomi
Director
Space Science and Engineering Center
University of Wisconsin-Madison
1985

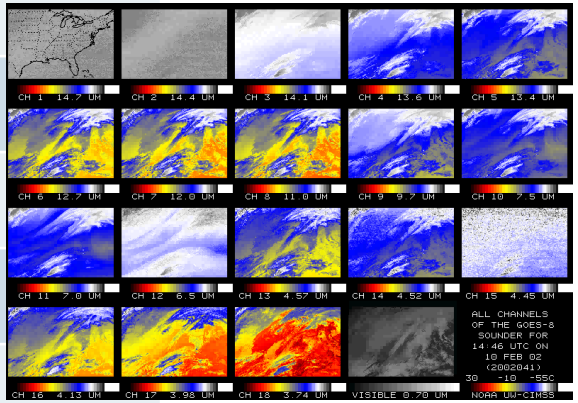


[**Bold** highlights added]

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?)

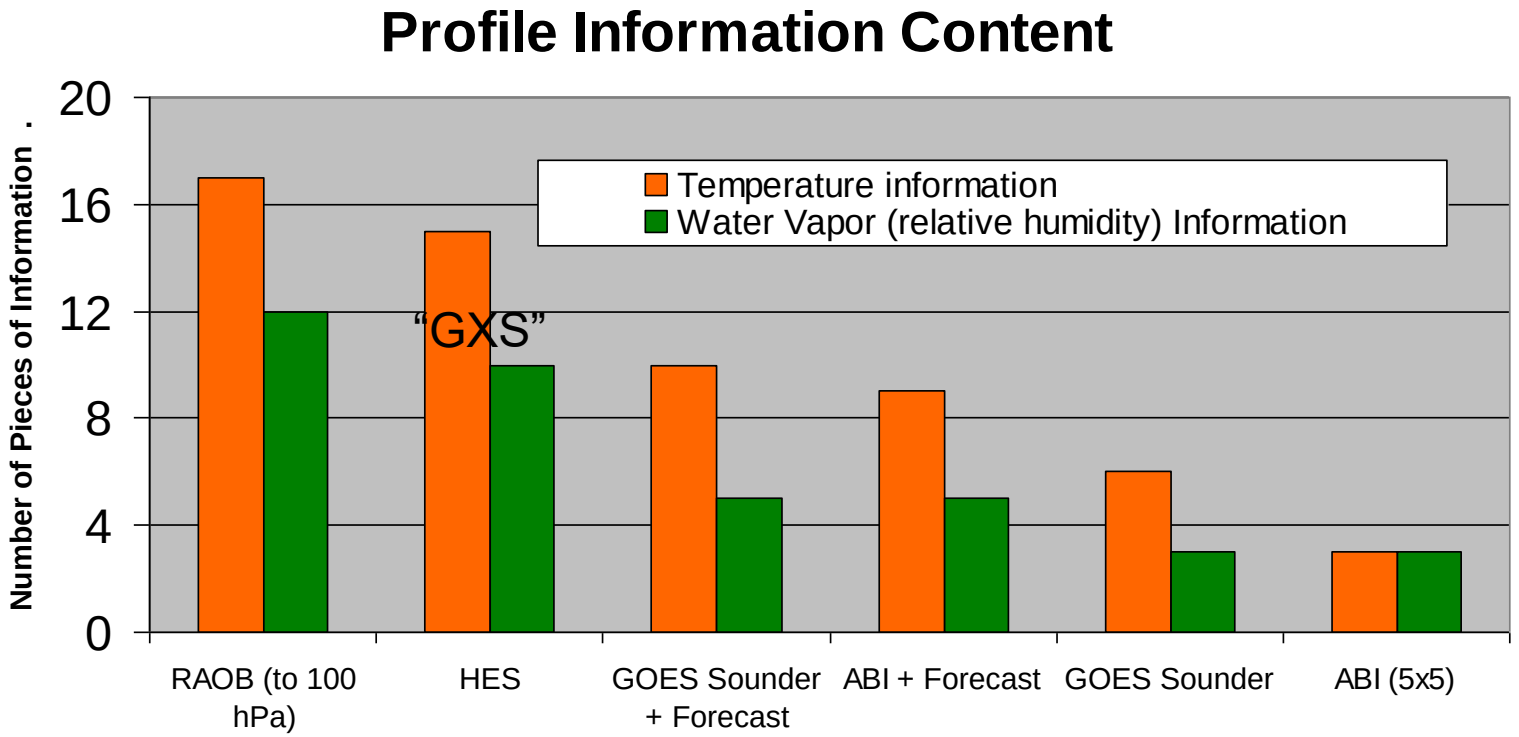




?

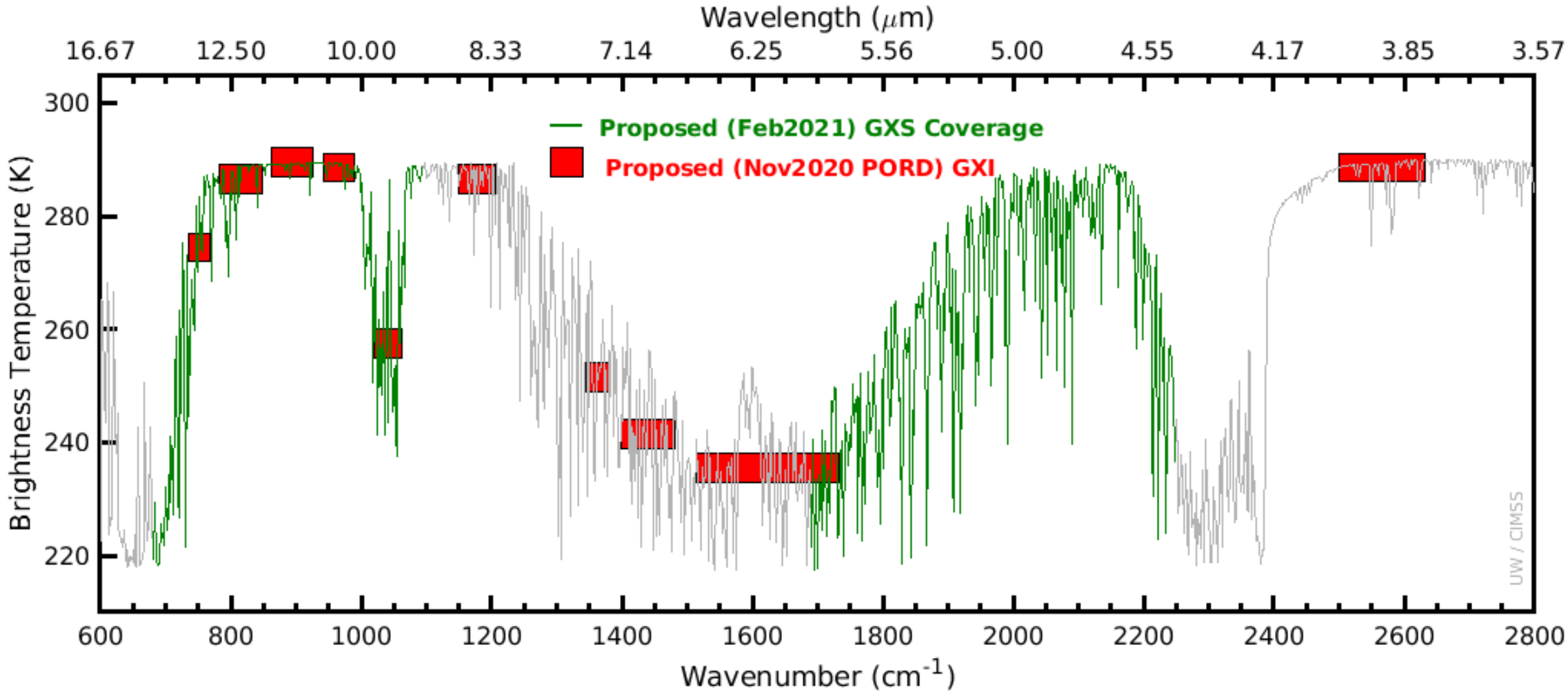
GOES-R series included the first geostationary lightning mapper

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.

Spectral

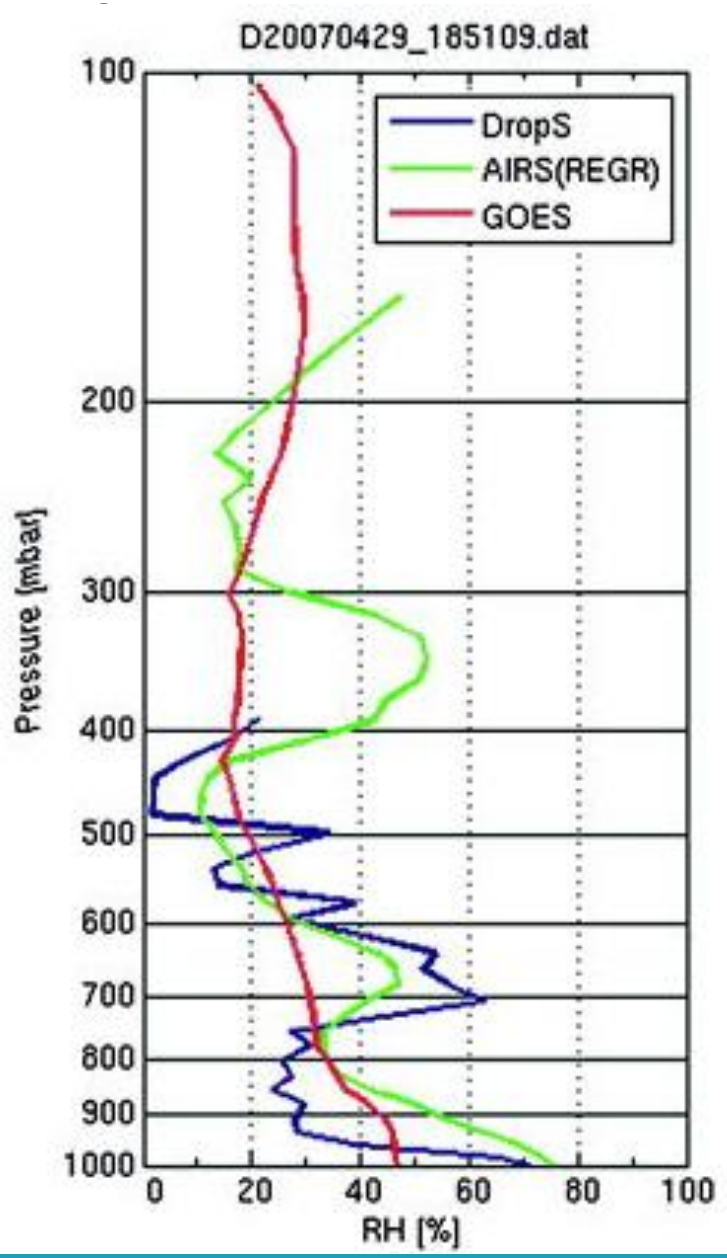

Wavelength (μm)
16.67
12.50
10.00
8.33
7.14
6.25
5.56
5.00
4.55
4.17
3.85
3.57
Proposed (Feb2021) GXS Coverage
Proposed (Nov2020 PORD) GXI
Brightness Temperature (K)
300
280
260
240
220
UW / CIMSS
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
Wavenumber (cm-1)

Improved Vertical

Three RH soundings:

- Although legacy GOES Sounder [similar to ABI or GXI] (red) has reasonable men accuracy in general, it lacks vertical structures when compared with dropsonde (blue).
- The high-spectral-resolution observations of AIRS SFOV sounding (green) better depicts the fine structures in this case, which are close to those from the dropsonde.

Retrieval performance has improved over the last more than a decade.



Applications in forecasting

- **The improved vertical resolution** allows for the critical vertical distribution of moisture to be monitoring (in clear skies)

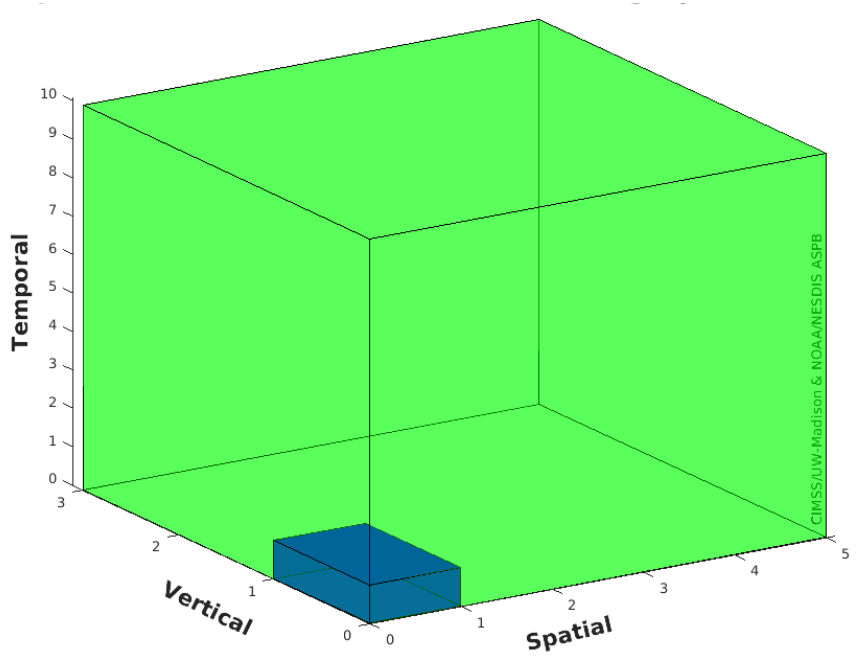
- NWS and other forecasters **have been using hyperspectral sounder data from LEO satellites for years** via the Hazardous Weather Testbed and NOAA Unique Combined Atmospheric Processing System (NUCAPS)

- However, a LEO sounder has a revisit time of 12 hours for a spot over the equator compared to the **GEO sounder that can revisit the same location in about 30 minutes**
  - The intrinsic nature of the geostationary orbit permits longer integration time of the detector over the same Earth scene and continuous data downlink. As a result, a GEO hyperspectral sounder can achieve a footprint on the Earth surface of 4 km
    - Doubling the clear-sky yields, comparted to LEO

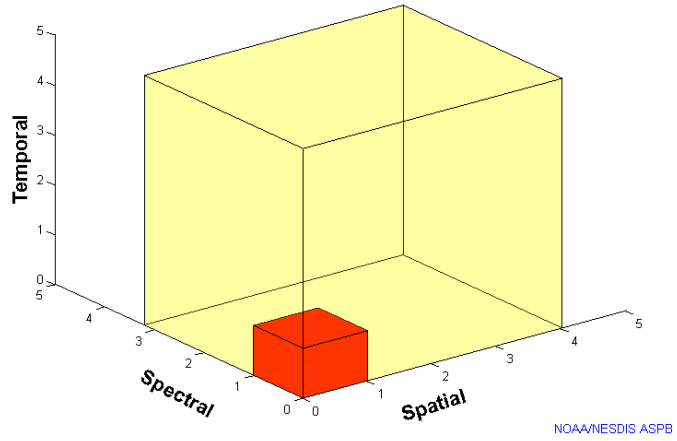
GXS/Legacy GOES Sounder > ABI/Legacy Imager

- GeoXO Sounder could be something like 3, 5 and 10 times improved (vertical, spatial and temporal) over the legacy geo sounder! (The legacy sounder had many operational uses.)
- "Everyone" knows about the ABI being 3, 4 and 5 times (spectral, spatial and temporal) improved over the legacy geo imager.

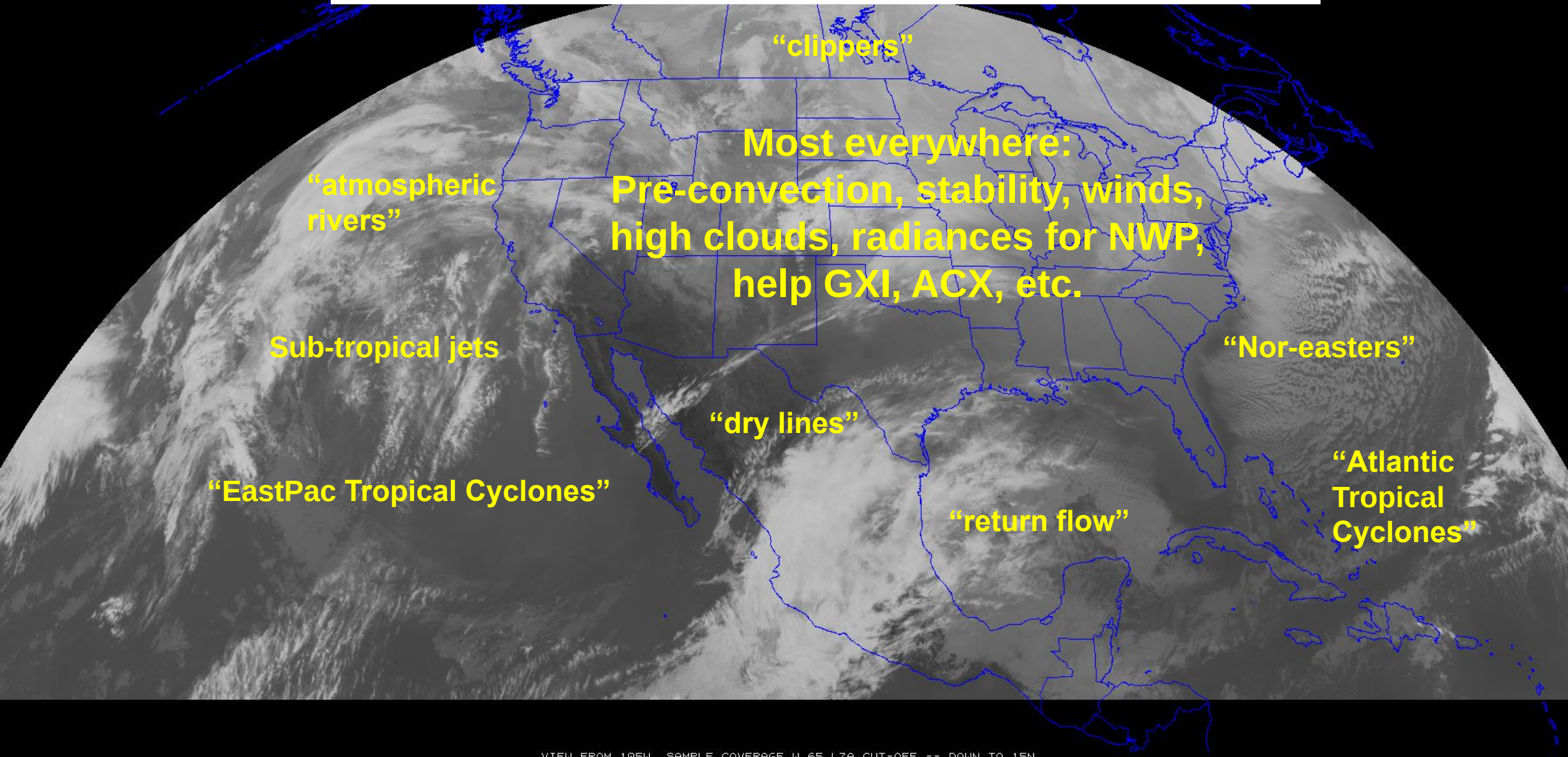
Improvement Factors: GeoXO Sounder and Legacy geo Sounders



Improvement Factors: ABI and Legacy geo Imagers



Sample GeoXO Sounder Uses



Need for high spectral and temporal observations

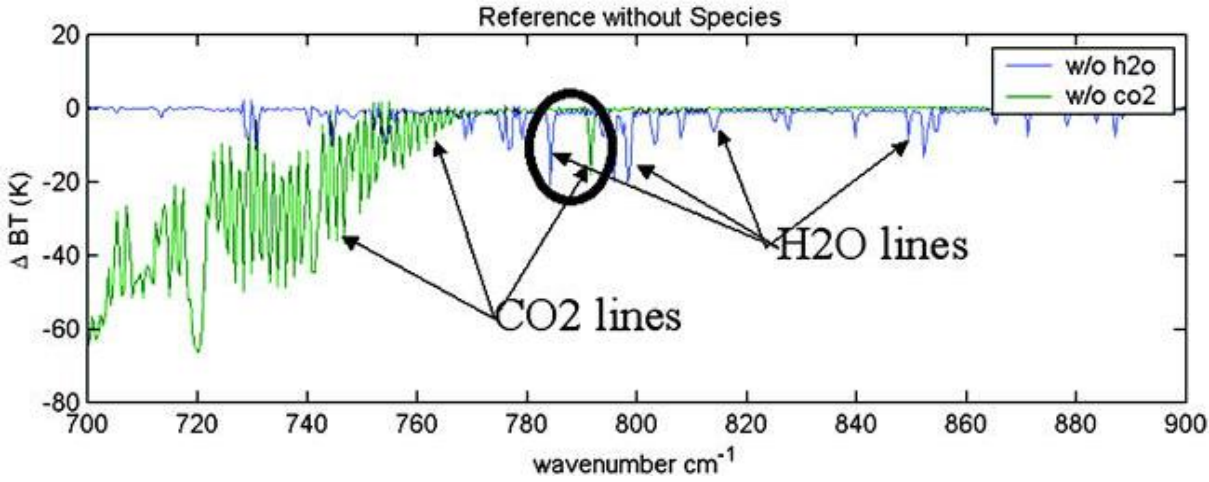
- **High-spectral-resolution observations provide much more information**
  - Imagers average out important vertical information.
  - LEO has shown the many benefits, especially on the global scale, lacks time resolution
- Forecasting Applications – fill in critical gaps wrt vertical moisture, wind and temperature
  - **Nowcasting** and **Numerical weather prediction**, especially on the regional/mesoscales
- Additional applications
  - High-spectral-resolution sounder observations would also **improve derived products with only advanced imager data** (and or with polar-orbiter and other data)
    - volcanic ash, cloud detection, cloud-top properties, atmospheric motion vectors, dust detection, land and sea surface temperatures.
  - **New areas**
    - Moisture flux, capping inversion, surface emissivity, trace gases and climate
- **Economic impacts** (“billions and billions”…) More with the benefits of 4dvar analysis …
- Critical Component of the **Global Constellation**

GeoXO : GXS Summary (What and Why)

Attribute	What	Why
Coverage	Sounding Disk as seen from both GOES-East and –West positions	The Atlantic for hurricane development and model initializations, CONUS for the pre-convective environment monitoring and the Pacific for both upstream weather and monitoring moisture (and winds) over the huge area with little conventional data.
Spatial Resolution	4 km (at the satellite subpoint)	Doubling the clear-sky yields, comparted to LEO, for a given time. Also for finer moisture gradients to be monitored.
Temporal Resolution	Sounding Disks (60 min), CONUS (~30 min) and mesoscale (5 min)	Sounding Disk upstream information and hurricane monitoring, CONUS for pre-convective monitoring and the targeted (or mesoscale) for regions of extremely active weather. Also, also for clouds to move out and less get more clear sky information.
Spectral Coverage / Resolution	680- 1095 cm-1 14.7 – 9.13 μm 1689 – 2250 cm-1 5.92 – 4.44 μm) @ ~0.6 cm-1	Spectral with information related to temperature, moisture and support select atmospheric compositions (ozone, NH3, isoprene, HNO3, N20 and CO). Need to resolve, not average out, the critical on/off spectral lines.
Other	Evolution of the radiances	Provides critical vertical information on atmospheric winds for both nowcasting and NWP applications.

More vertical moisture and motion information; NWS support for high spectral IR observations

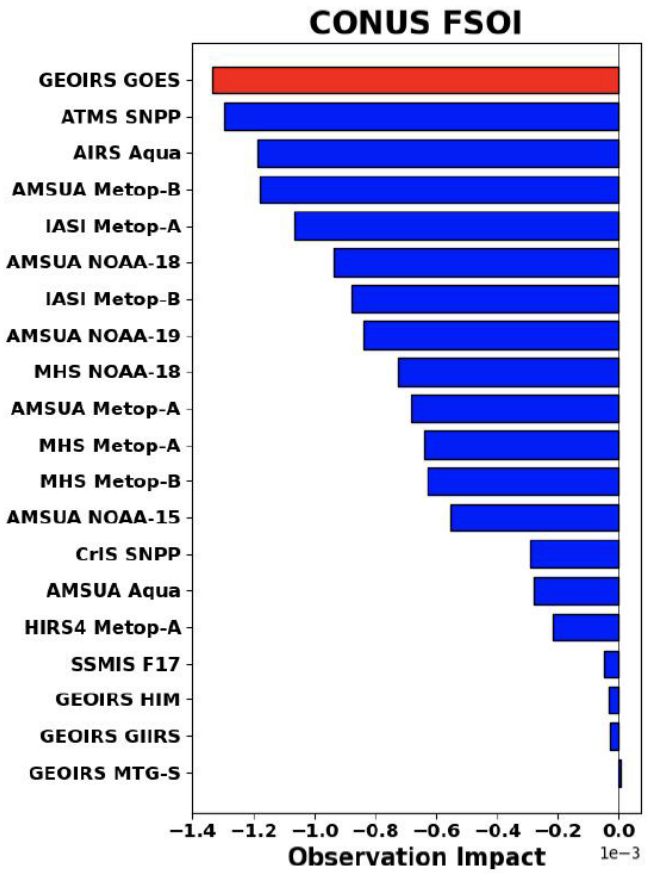
- Geo hyperspectral IR sounder is the only way to measure boundary layers moisture changes on spatial and temporal resolution needed for the weather ready nation (*Sieglaff et al 2009 and others*)
- The Assessment of Alternatives concluded that there were not other sensors that could fill the void of 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”



More info

- Hyperspectral infrared (IR) sounders
  - https://www.ssec.wisc.edu/geo-ir-sounder
- NOAA NESDIS Tech Report: Geostationary Extended Observations (GeoXO) Hyperspectral InfraRed Sounder Value Assessment Report
  - https://repository.library.noaa.gov/view/noaa/32921
- GeoXO
  - https://www.nesdis.noaa.gov/next-generation-satellites/geostationary-extended-observations-geoxo

- Computer simulation of 24-hr Forecast Sensitivity Observation Impact ... for CONUS, for the four cycles:



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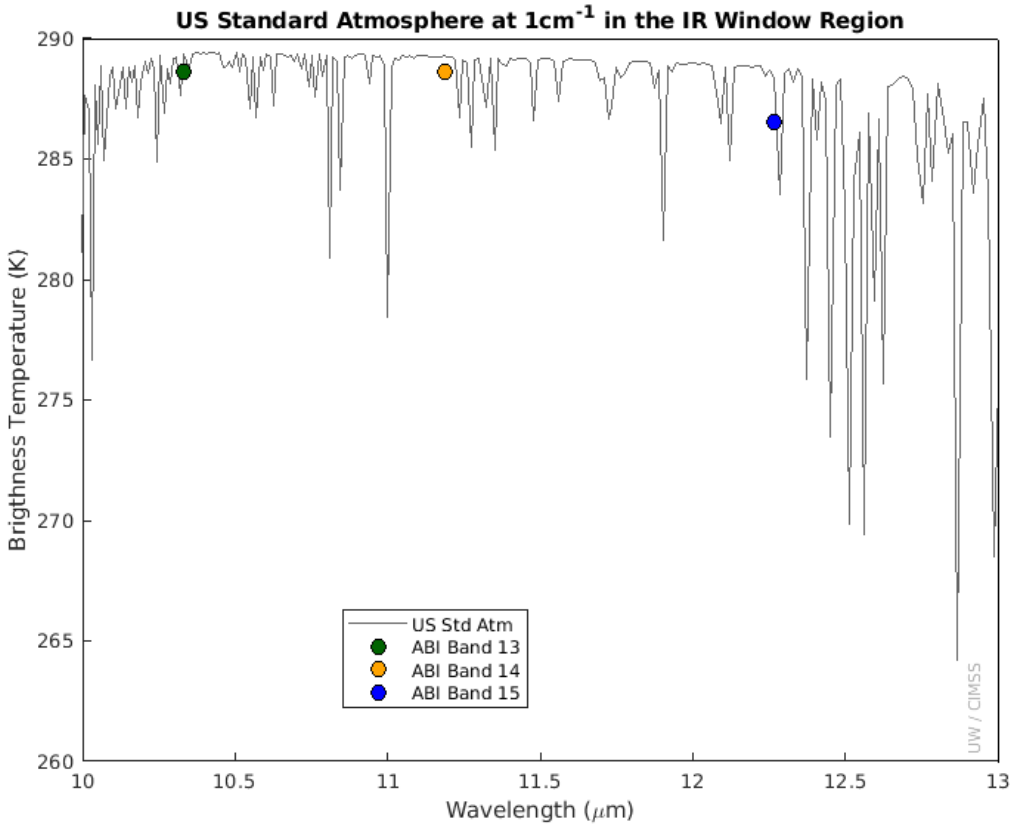
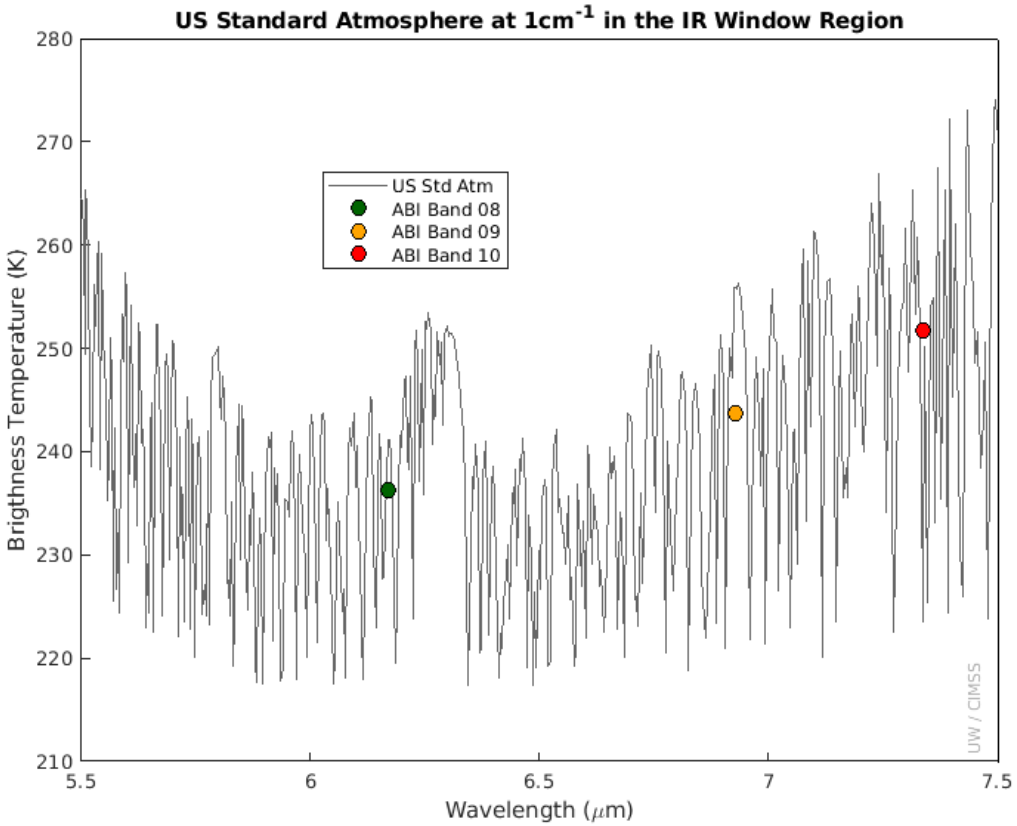
Questions ?





Advanced sounders have much more temperature and moisture vertical information (Images: Mat Gunshor, CIMSS)

Thanks to many who have contributed, especially Ed Grigsby and the geoXO Hyperspectral InfraRed Sounder value assessment team and the geoXO sounder working group