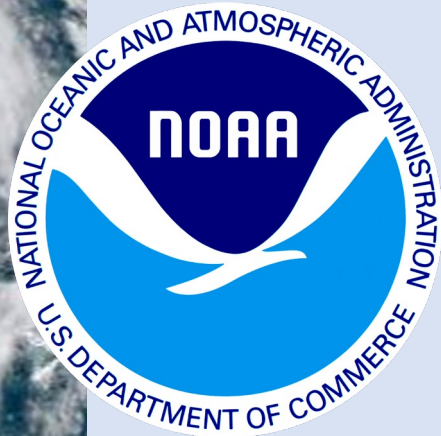


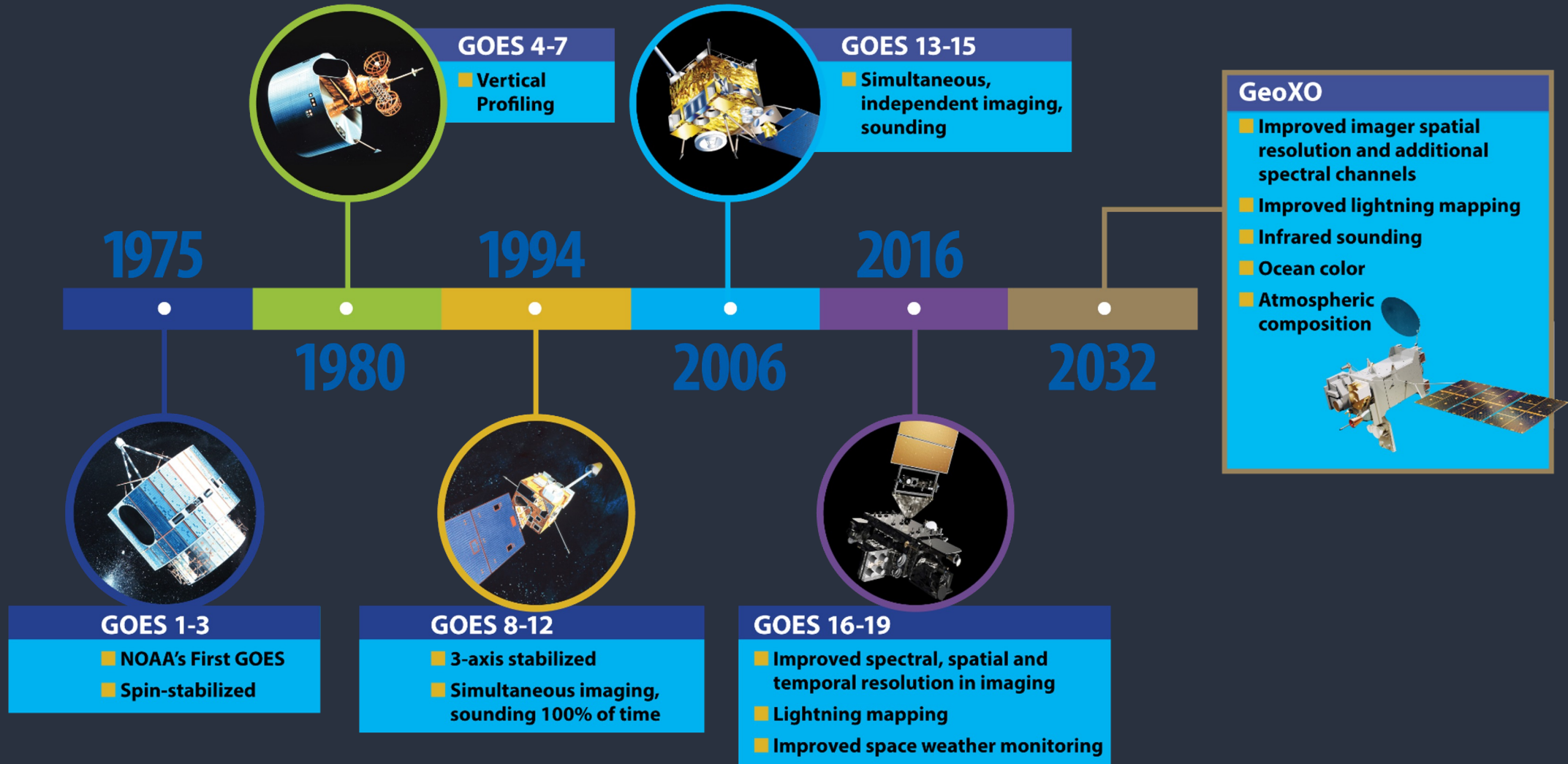


GeoXO and its Sounder Update

NOAA
**National Environmental Satellite,
Data, and Information Service**

Andrew Heidinger GEO Senior Scientist
Ed Grigsby, GEO Program Director
Dan Lindsey GOES-R Program Scientist
Erica McGrath-Spangler, NASA-GMAO
Zhenglong Li, UW-CIMSS

Evolution of GOES



GeoXO Current Baseline



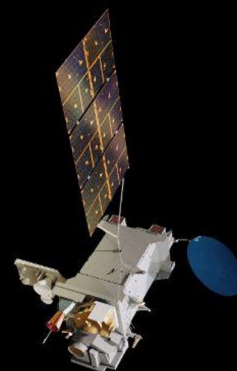
GEO-West

**Visible/Infrared Imager
Lightning Mapper
Ocean Color**



GEO-Center

**Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload**



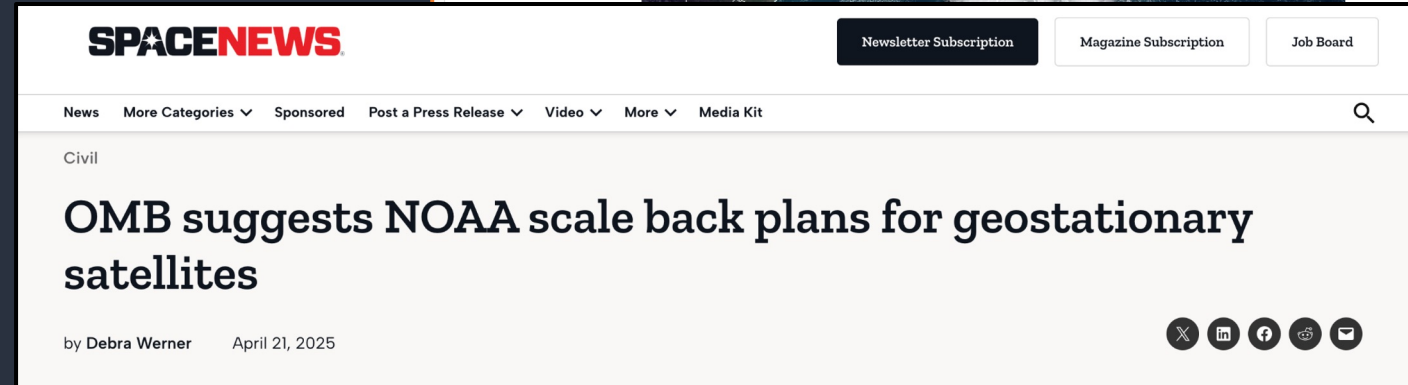
GEO-East

**Visible/Infrared Imager
Lightning Mapper
Ocean Color**



GeoXO Future is Uncertain

- GeoXO Program is being reviewed.
- Final decisions are unknown.
- We expect GeoXO to be more focused on the weather mission and to have a larger commercial role.
- We hope that a sounder will remain a part of the program.
- Stay tuned.



Planned GeoXO Weather Capabilities

Continuity of Weather and Hydrological Services	Enhancements for Weather and Hydrological Services
• Visible/Infrared Imager • Lightning Mapper (LM) • Receipt/relay of signals from Data Collection System (DCS) platforms and relay of commands to them • Data rebroadcast using commercial services for High Rate Information Transmission, Emergency Managers Weather Info Network, Imagery	• Hyperspectral IR Sounder • Spatial and spectral resolution improvements for Imager • Spatial resolution improvement for Lightning Mapper • 2X the channels for DCS relay

pending final approval



GeoXO Will Underpin Broad Swath of NOAA's Weather Mission

Volcanoes

GXI detects eruptions and tracks ash plumes

Wildfires

GXI detects hotspot formation and evolution and helps track smoke plumes

LMX detects continuing-current lightning strikes

Monitors pyrocumulonimbus clouds and fire-generated lightning

Aviation

GXI detects cloud and vapor patterns of turbulence and other risks

LMX detects lightning threat

GXS detects conditions where icing is likely to occur

Drought

GXS and **GXI** improve drought analysis and forecasting; benefits agricultural planning and management

Tornadoes, Thunderstorms and Floods

GXS senses pre-storm environment; predicts storms before development

GXI detects cloud patterns before and during storm formation; monitors flooding

LMX detects lightning; improves severe storm warnings

Blizzards and Lake Effect Snow

GXS improves forecasts

GXI improves storm monitoring

Nor'easters and Open Ocean Storms

GXS improves forecasts

GXI improves storm monitoring and tracking

Hurricanes

GXI and **LMX** provide minute-by-minute monitoring

GXS improves hurricane track

GeoXO
Weather
Sensors

GXI = Imager **LMX** = Lightning Mapper **GXS** = IR Sounder



GeoXO Sounder Activities



Planned GeoXO Sounder Activities

- Generation of GXS Proxy Data and prototype profile retrievals for other applications.
- IRS Readiness for NOAA and NASA models (GFS, RRFS and GEOS).
- GeoXO sounder RRFS OSSE with NOAA/OAR/QOSAP
- Inclusion of GEO sounder data in NOAA/OAR/NSSL Warn on Forecast.
- Studying methods for 3D Winds.



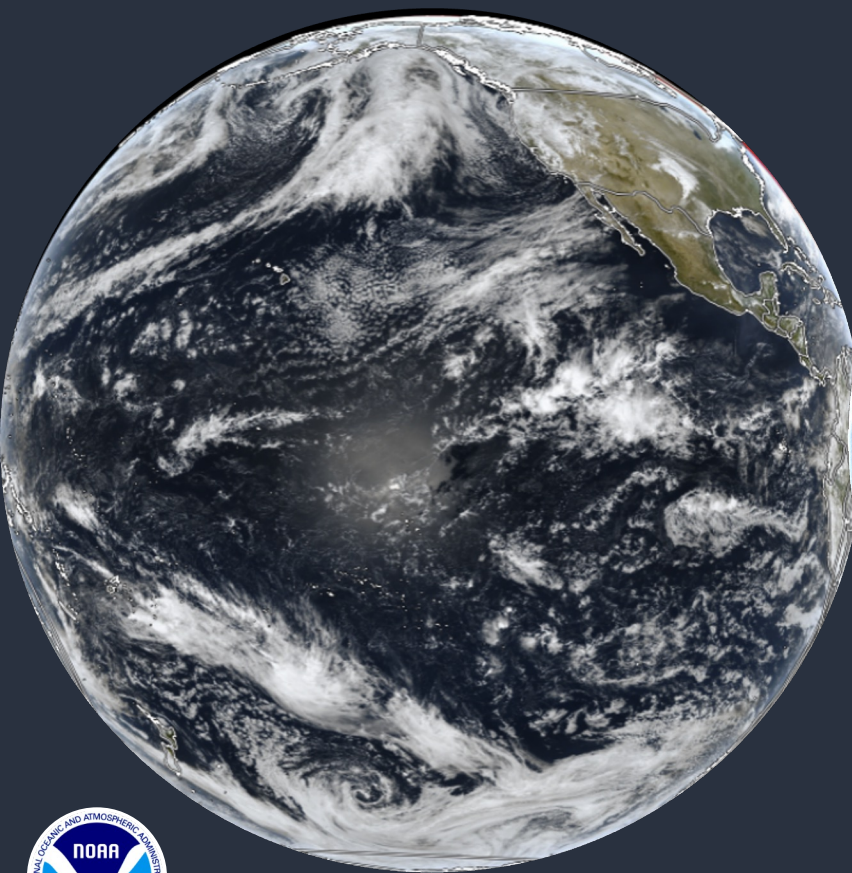
Open Questions about the GeoXO Sounder

- The GeoXO imager has 4 IR and 1 solar H₂O Channels and channels with O₃ and CO₂ sensitivity. What is the optimal method inclusion of these imager observations in the sounder applications?
- Is there a desire to make profiles and applications from the GEO-Ring of sounder from algorithms with similar approaches and performance? If so, can ITSC provide guidance?
- Does the sounder radiance community want similar PCA formats from each agency?
- Is 105W the optimal position of the GeoXO sounder?
- Optimal configuration of the NOAA LEO and GEO (and GEO-Ring) sounders are still discussed.

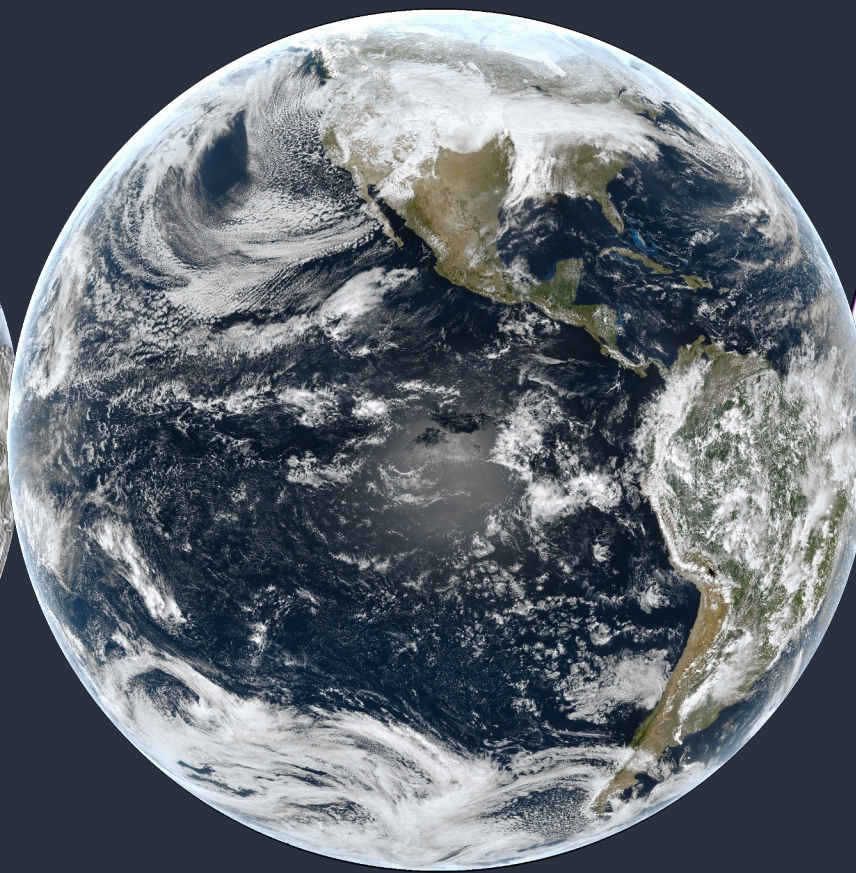


GOES Views

GOES West 137W



GOES Central 105W



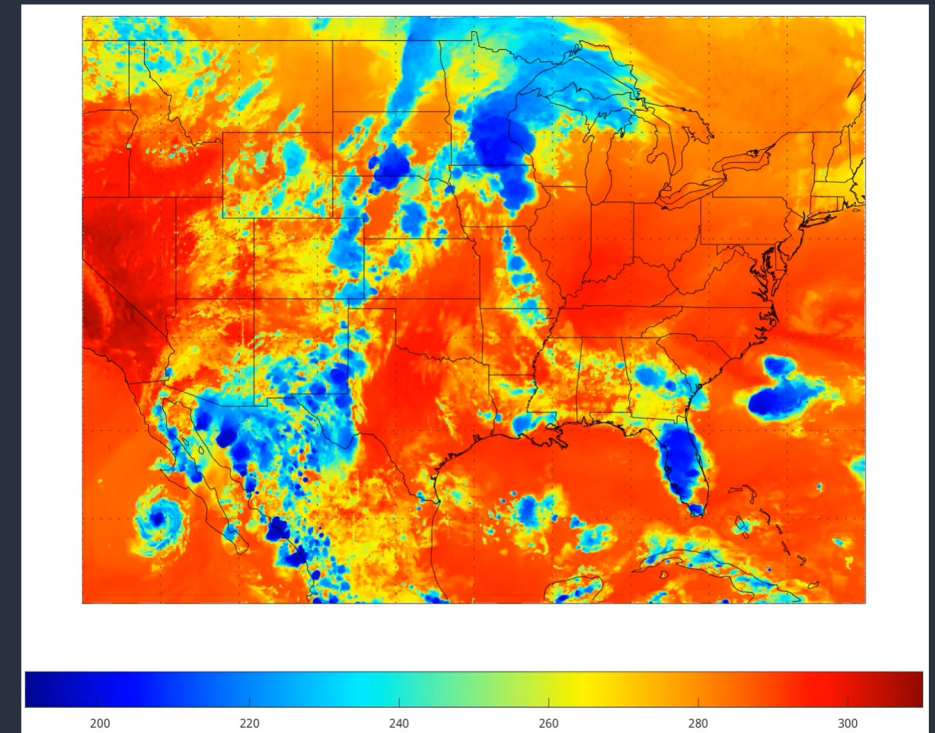
GOES East 75W



GeoXO Sounder Proxy Datasets

- Two versions of GeoXO sounder proxy datasets have been created and are ready for community use:
 - V1 for FTS and V2 for grating system
 - Contain radiance/T/Q/U/V/Ts/Emis
- The high resolution (1km) ECMWF nature run (XNR1K) used to provide the atmosphere and surface conditions
- The UW-Madison Pressure-Layer Fast Algorithm for Atmospheric Transmittance (PFAAST) coupled with Texas A&M cloudy model to simulate all sky radiances
- The sounder is assumed to have a spatial resolution of 4km, a temporal resolution of 15 minutes, satellite longitude of 105W
- Both continental US (CONUS) and sounding disk
- Possible applications: sounding profile retrievals, nowcasting, 3D winds

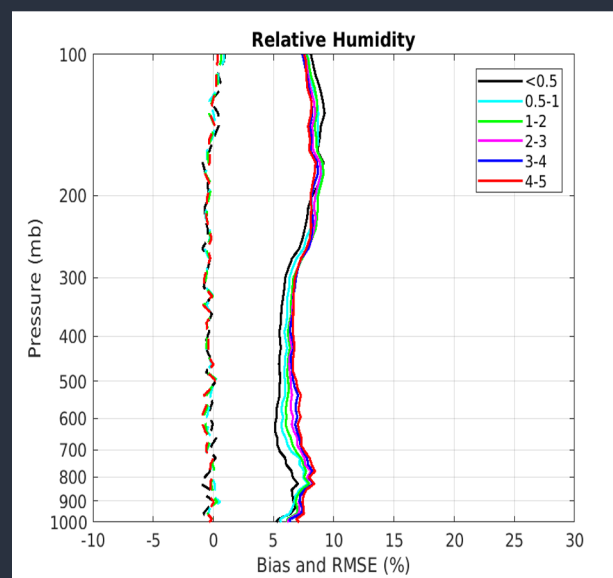
V2 BT(K) of 909.2302 cm^{-1}



Prototype Profile Retrievals

- A Deep Neural Network (DNN) used to develop a GeoXO sounder profile retrieval algorithm.
- Use 100 PCA coefficients derived from radiances of all 2402 channels.
- Technique shows a robustness to the presence of cloud. Scene had only 34% clear-skies, but retrievals worked for 71%.
- Temperature and relative humidity quality are only slightly affected by increased cloud impact
- large negative values of LI indicate areas that could support severe storm outbreaks and development.
- This data will be used to test improvement in severe storm nowcasting skills with NWS.

Cloud impact on RH retrievals

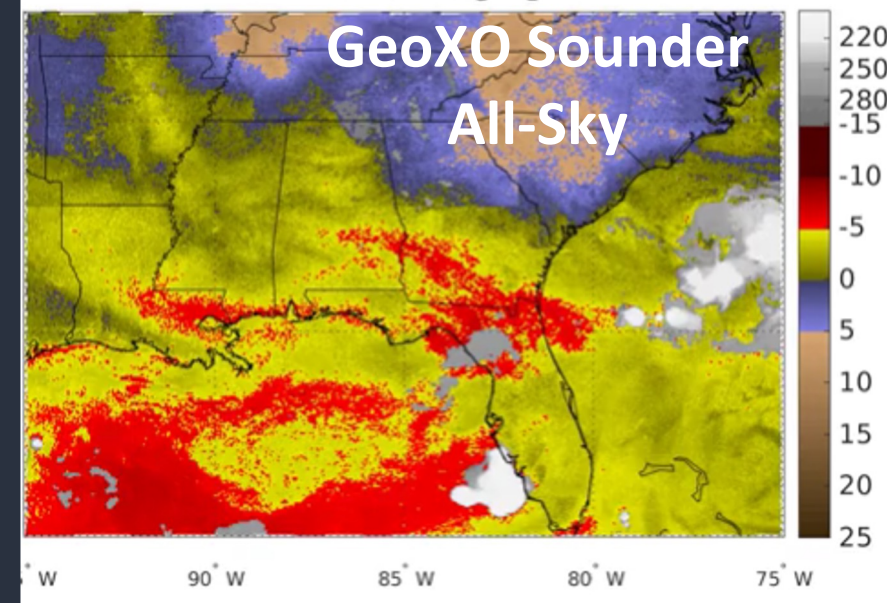


Different colors represent different levels of cloud impact (BT difference (K) between the clear and cloudy for $5.1\mu\text{m}$)

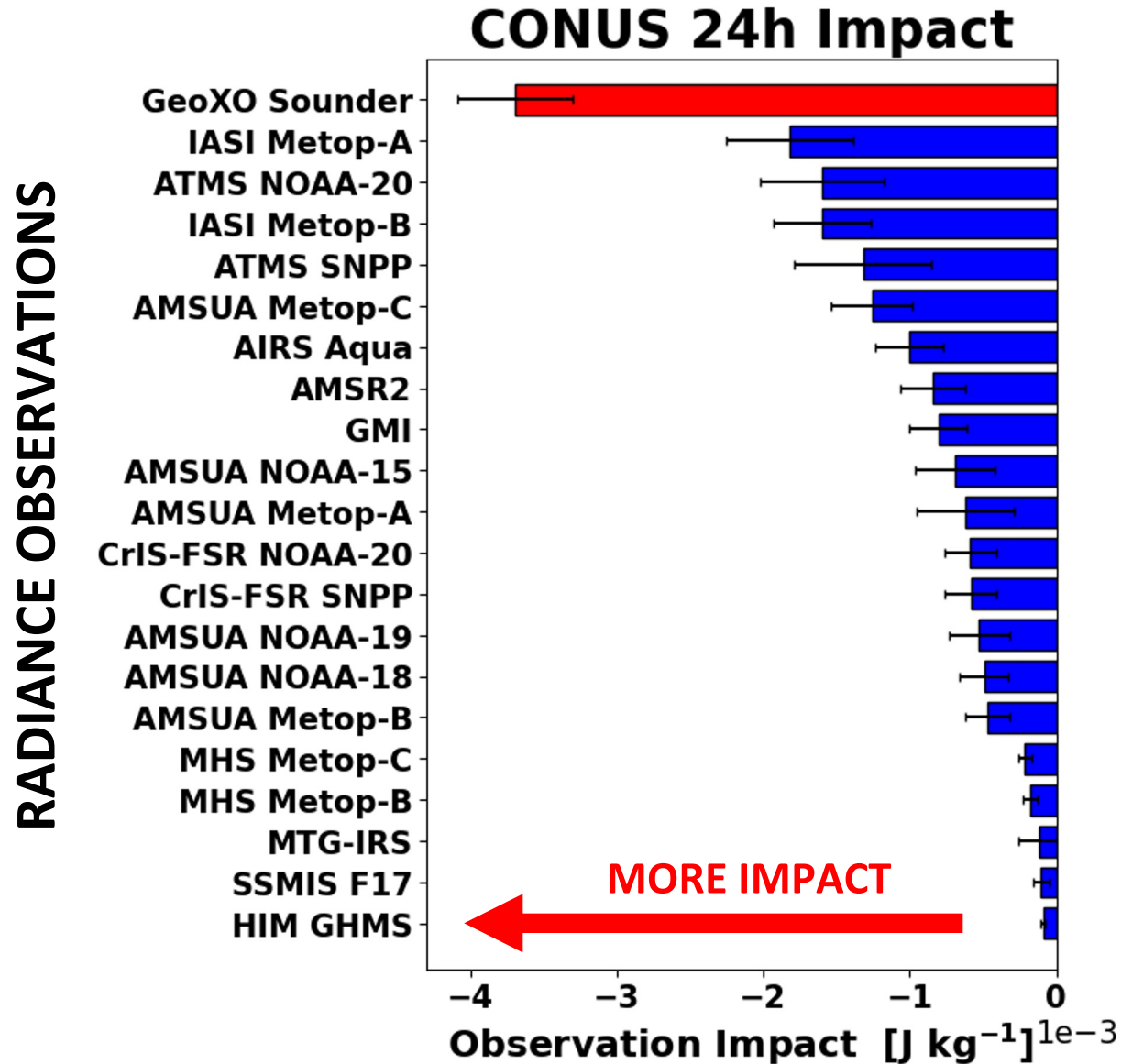
Truth

2019-09-06, 1200 UTC
Lifted Index [$^{\circ}\text{C}$]

GeoXO Sounder
All-Sky



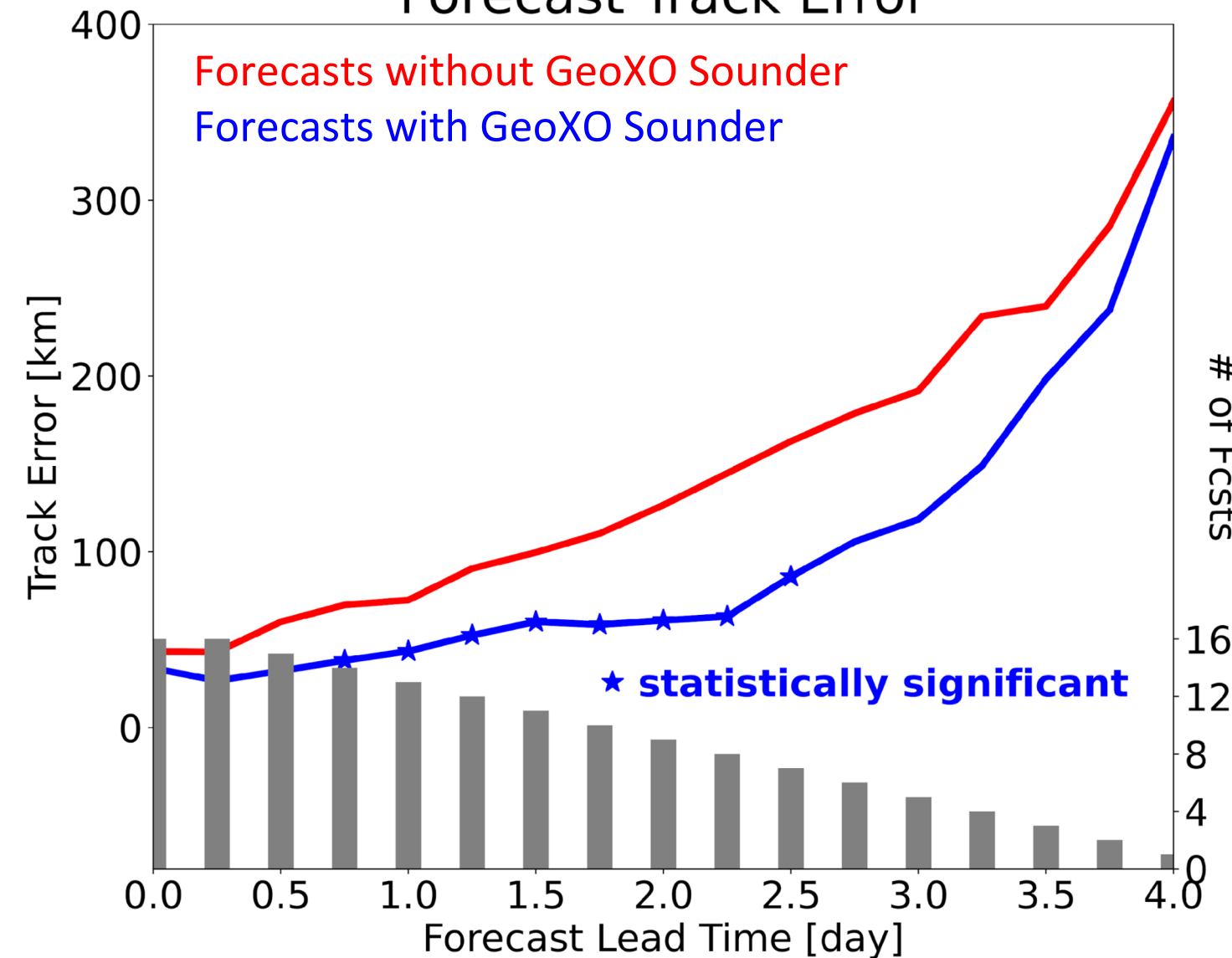
The retrieved lifted index animation provides useful information on instability tendency for storm outbreak and development



GeoXO OSSE Impacts

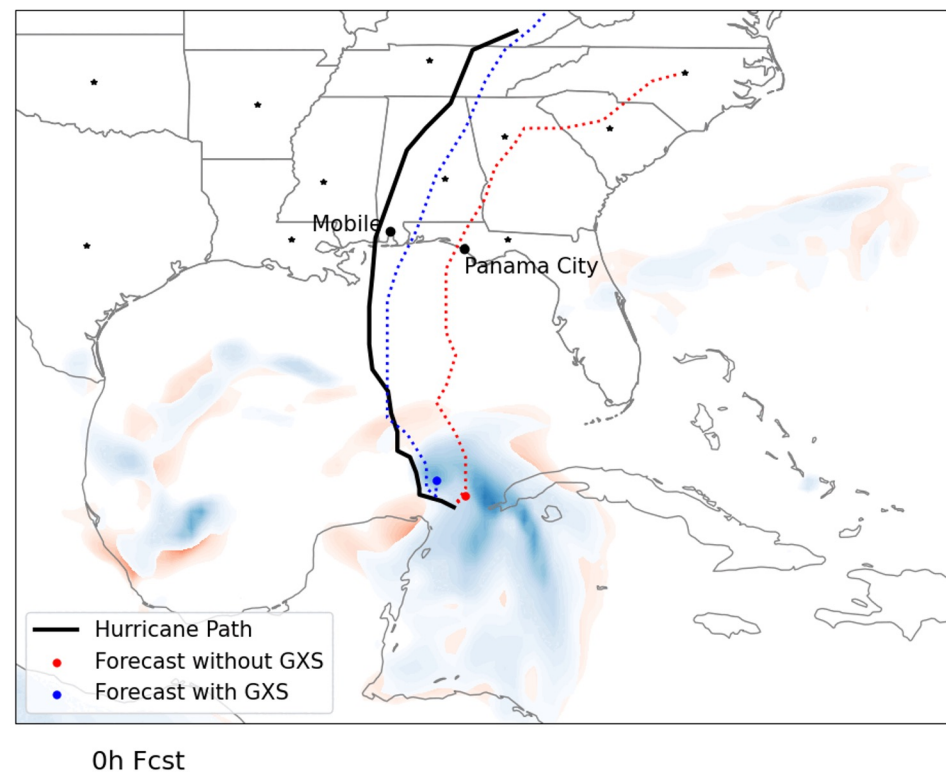
- Largest radiance impact over CONUS
- High temporal frequency
- Constant spatial coverage

Forecast Track Error



8 hurricanes studied

Overall improvement to forecast track



McGrath-Spangler et al. (2024)

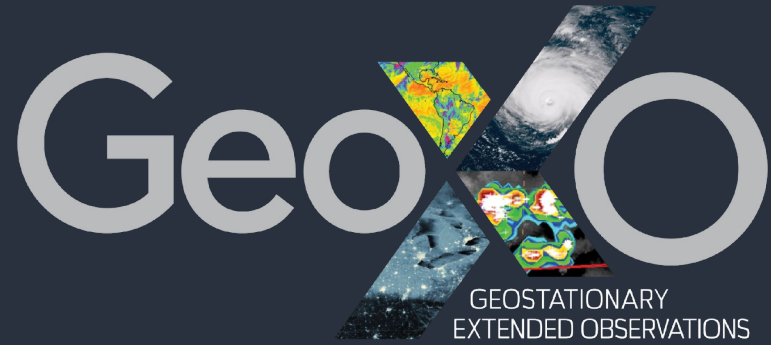
Ongoing / Planned Data Assimilation Work For GeoXO

- **Assimilate MTG/IRS radiance**
 - Radiance data preprocess (e.g. Bufr to IODA format etc)
 - Collaborate CRTM application for MTG/IRS with JCSDA and other labs and centers
 - Develop JEDI MTG/IRS assimilation capability
- **Refine satellite DA configuration**
 - Quality control and variational bias correction
 - Add more satellite sensors
 - Test data impacts (satellite and conventional observations)
- **Develop cycled MPAS/JEDI system**
 - Phase 1 with 3DVar assimilation using global uniform 15km grid
 - Integrate satellite rad data assimilation capability into workflow
 - Coordinate this work with the RRFSv2 development team
- **Forecast Sensitivity and Data Impact Study:**
 - Further spatial and temporal analysis of data impact analysis for RRFSv1 (FV3-GSI based)
 - Expand the preliminary data impact analysis for RRFSv2 (MPAS-JEDI based)

Conclusions

- GeoXO is going through a period of uncertainty and we don't know the outcome.
- We continue to hope that a sounder will be part of our program.
- We are working with a large community in the USA to get ready for a GEO sounder over the Western Hemisphere and look forward to MTG/IRS.
- We appreciate all of the coordination and guidance from the ITWG.





Thank You



Backup



IRS channel selections

- The test dataset has 245 LWIR channels and 55 MWIR channels.

```
required_channels_lw =
  1   2   3   4   5   6   7   8   9  10
 11  12  13  14  15  16  17  18  19  20
 21  22  23  24  25  26  27  28  29  30
 31  32  33  34  35  36  37  38  39  40
 41  43  44  45  46  47  49  52  54  56
 57  58  59  60  63  64  65  66  67  68
 69  70  73  82  83  84  85  86  87  90
 91  92  95  96  97 101 102 103 104 105
106 108 109 111 114 115 116 121 122 124
125 126 127 129 131 141 147 149 152 160
161 162 166 169 173 174 175 176 187 188
189 190 192 194 195 197 198 199 200 202
204 206 207 208 210 214 222 224 242 245
267 268 281 284 286 287 288 289 320 331
345 377 388 439 514 529 531 533 536 538
540 542 543 544 548 549 550 556 561 562
568 569 570 572 573 574 576 577 578 579
580 581 582 583 584 586 587 588 589 590
592 593 594 595 596 597 598 599 600 601
602 606 609 611 614 615 616 617 618 619
620 621 623 624 625 626 627 628 629 630
631 632 633 634 635 636 637 638 639 640
641 642 643 656 683 691 709 713 717 733
746 757 761 784 806 820 821 822 823 825
841 842 844 859 862
required_channels_mw =
  5   9  11  15  17  19  20  27  28  30
 31  39  40  42  43  45  46  47  51  57
 58  59  60  61  62  65  70  73  74  75
 76  79  80  81  85  87  91  93 106 110
111 115 118 126 141 159 160 173 176 177
194 783 919 1049 1068
```

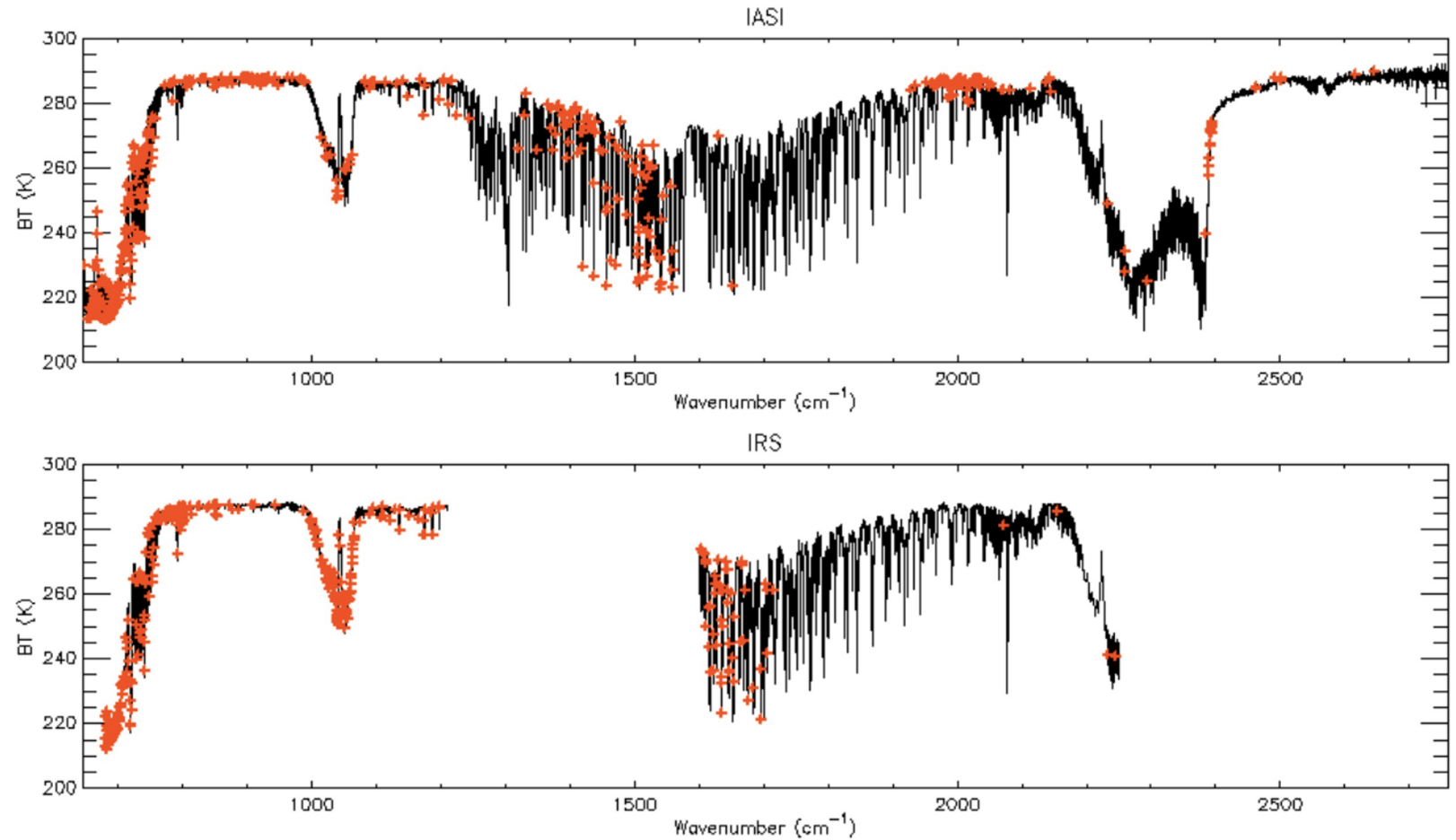


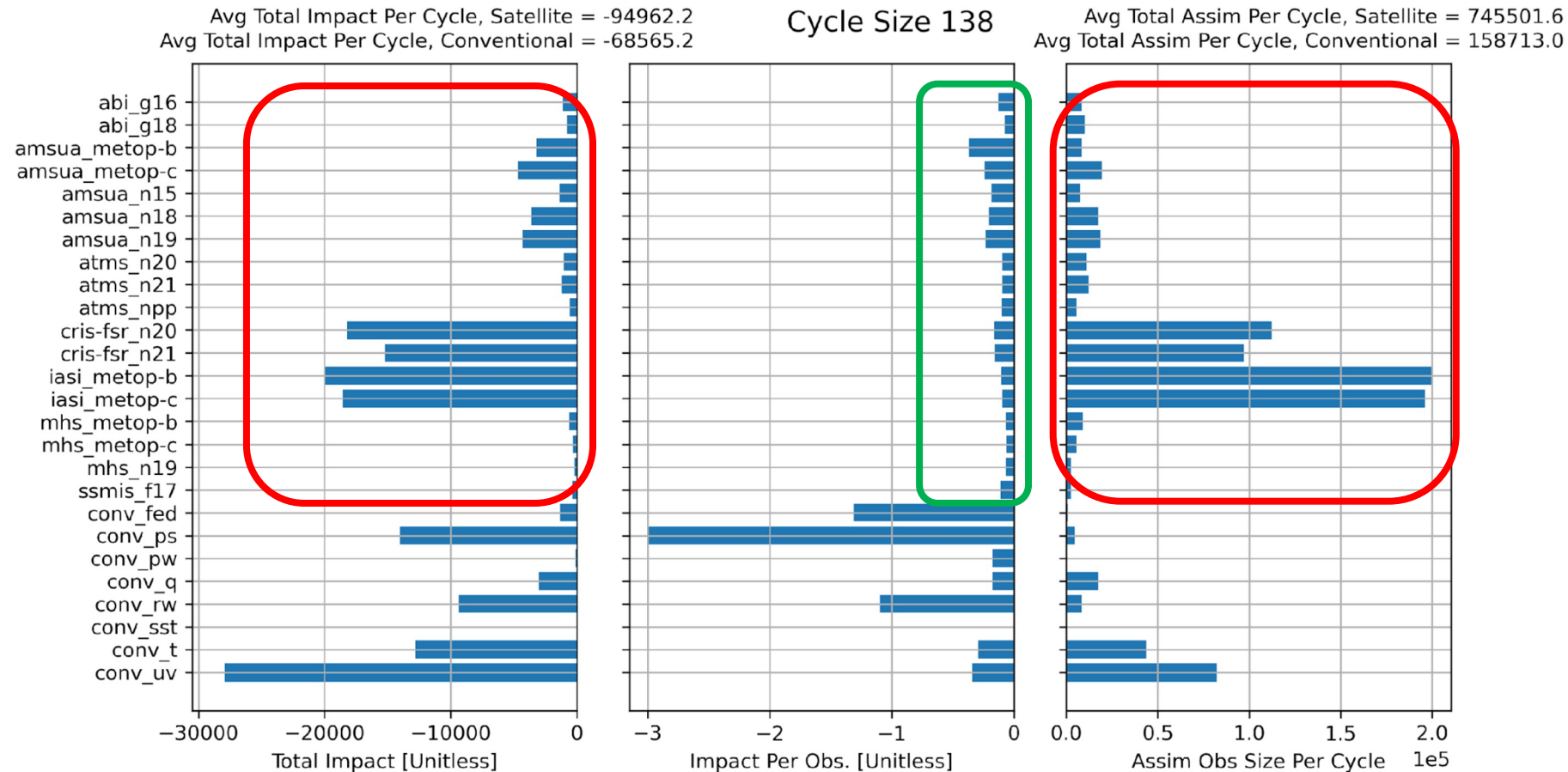
Figure 6: Top: typical IASI spectrum with 500 selected channels marked by red crosses. Bottom: the equivalent IRS spectrum, with 300 channels from Coopmann (2022) marked by red crosses.

Total Data Impact (Full Domain)

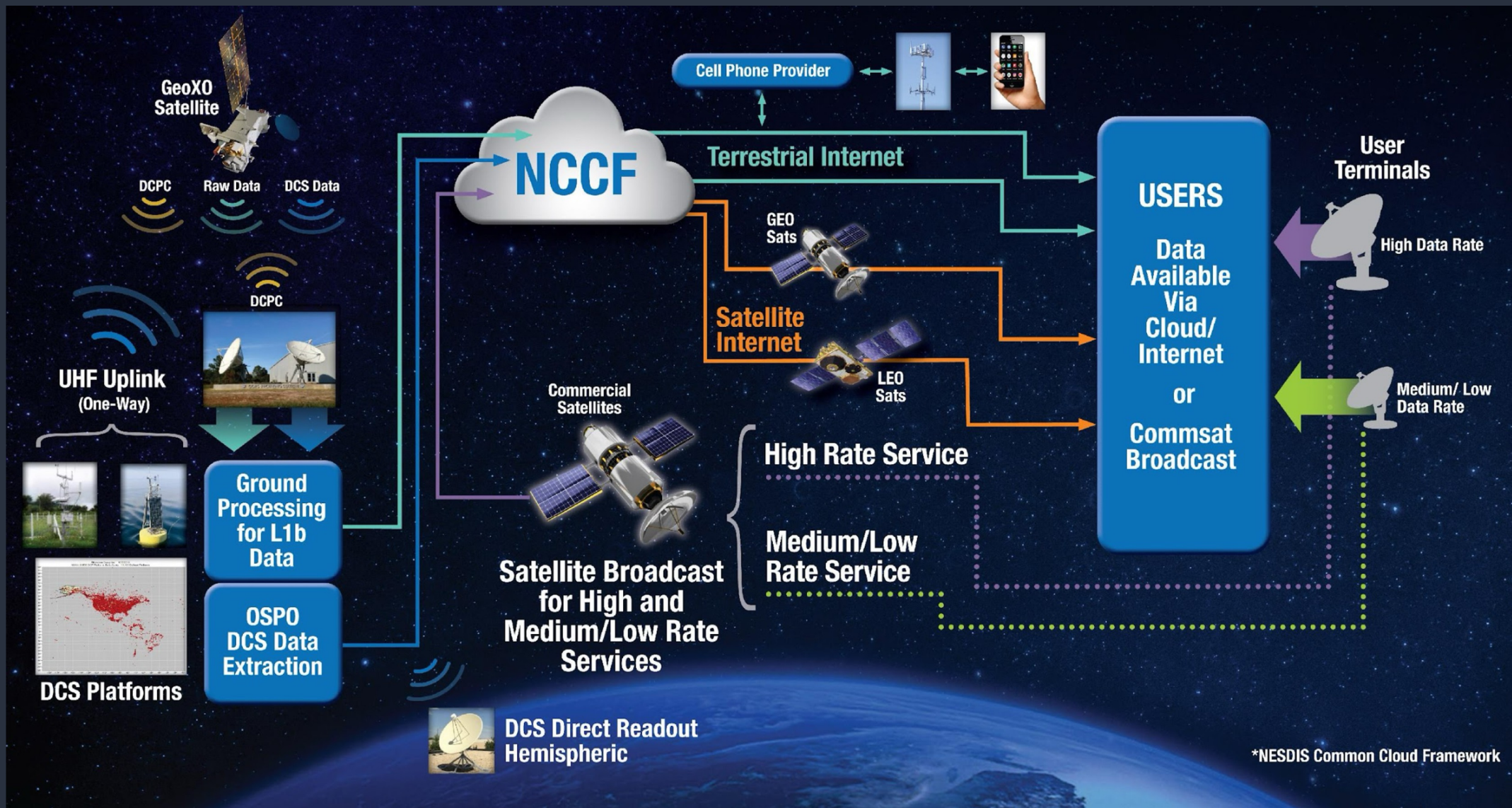
Findings

Between Satellite Sensors:

- IR data show much larger total impacts than microwave data, mainly due to size difference
- In terms of impact per obs., microwave data shows stronger impacts than the IR data.

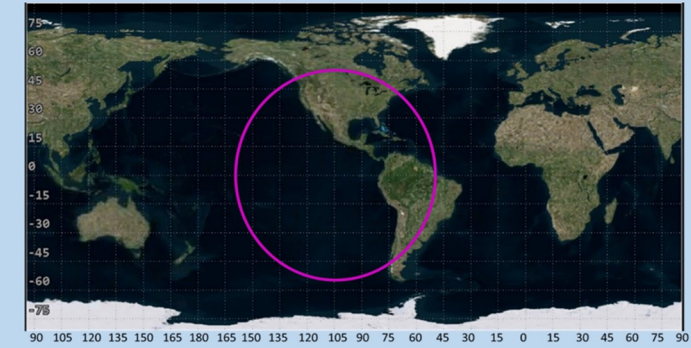


GeoXO Data Delivery

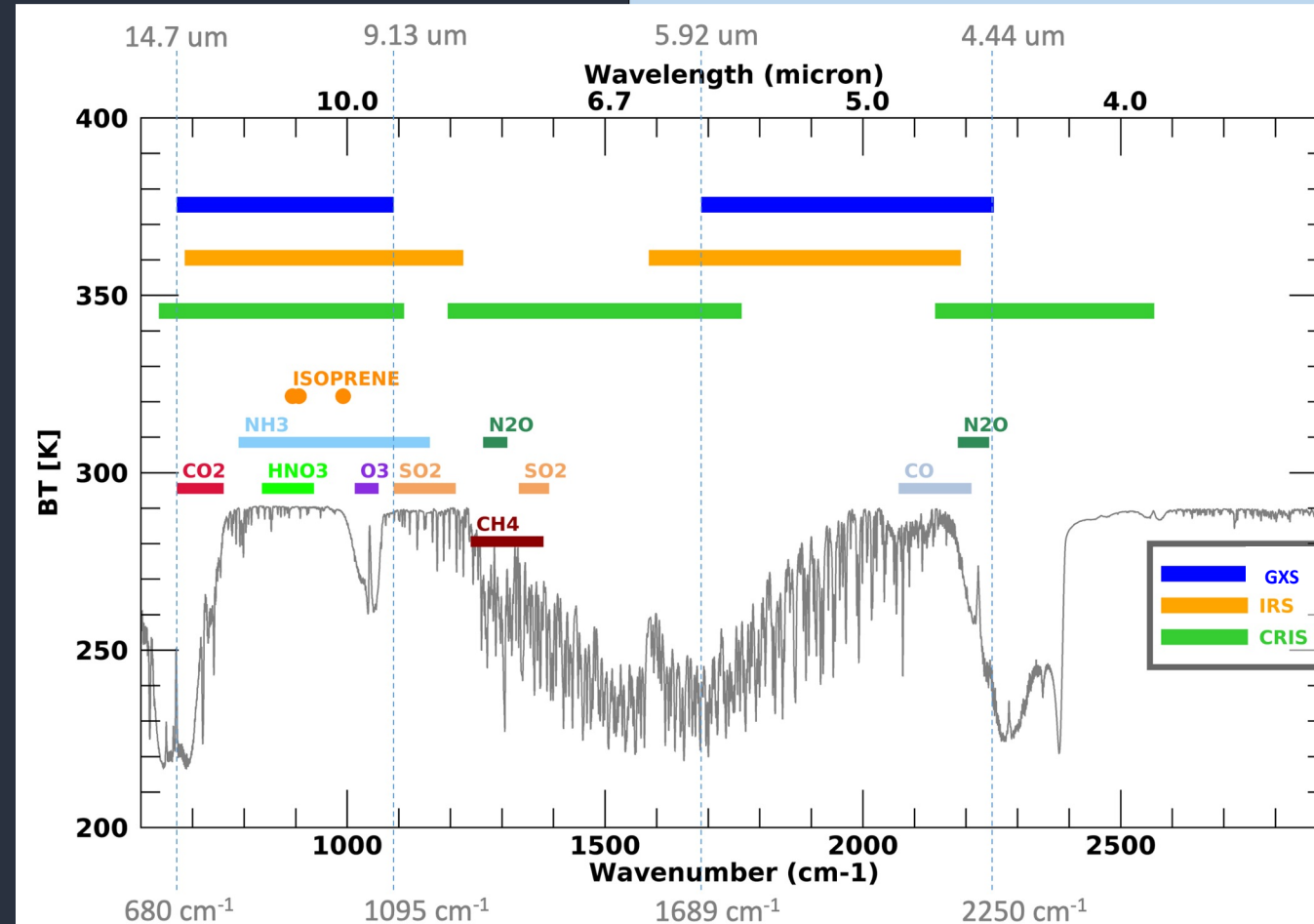


Baseline Requirements: IR Sounder(GXS)

GeoXO Sounder (GXS) coverage from 105 W



Baseline Requirements	
GSD	4 km (<i>Same as GOES-13 Imager IR</i>)
Coverage Area	Sounding Disk (SD) defined by a 62° zenith angle centered at 105W
Revisit Time	60 minutes
Spectral Coverage	4.44-5.92μm, 9.13-14.7μm
Spectral Resolution	0.625 cm ⁻¹
Signal:Noise	NEdN requirements are comparable to those of other IR hyperspectral sounders



GeoXO Timeline

