GeoXO

GeoXO hyperspectral infrared and microwave simulations for forecast performance assessment

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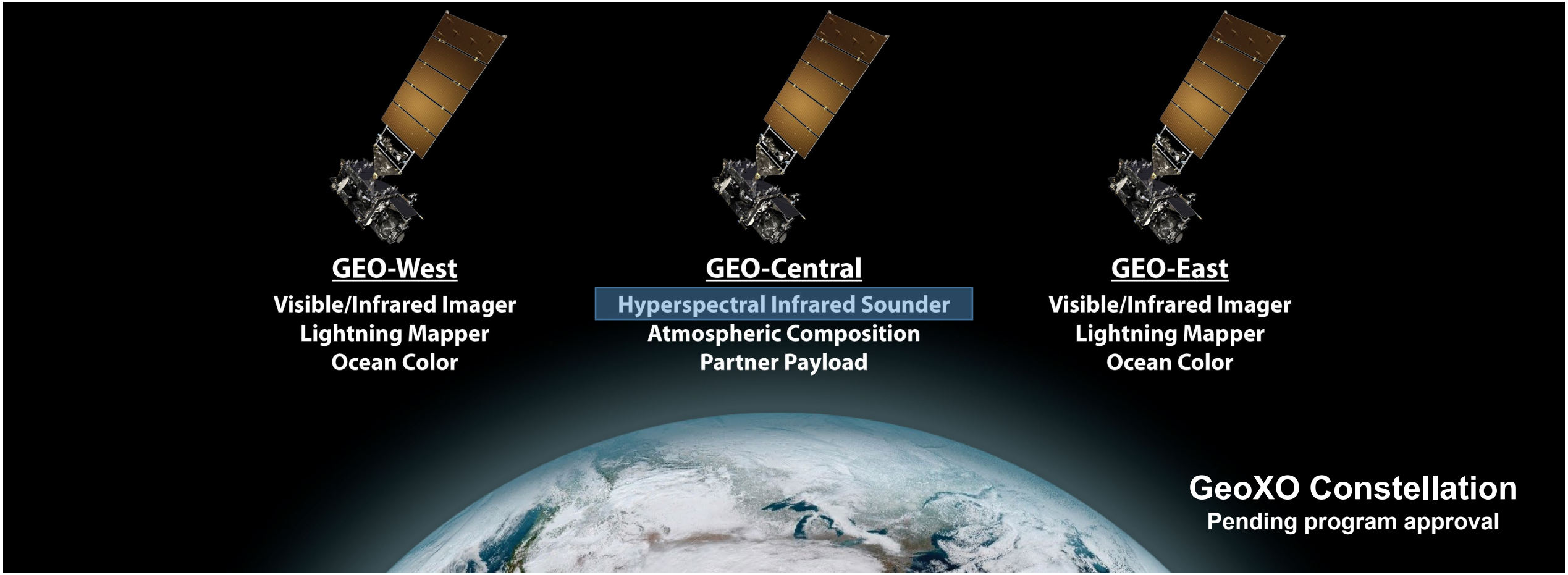
GeoXO


GEO-West
Visible/Infrared Imager
Lightning Mapper
Ocean Color
GEO-Central
Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload
GEO-East
Visible/Infrared Imager
Lightning Mapper
Ocean Color
GeoXO Constellation
Pending program approval

Summary of IR and MW experiments

Infrared Experiment

- How will a GXS-like instrument compare with impact of other satellite sensors on NWP improvement?
- *Quick answer:* The observations are beneficial for the first 24-48 hours and GXS provides the highest relative impact for CONUS 24-hour FSOI

Microwave Experiment

- How does impact of GEO microwave observations compare to GEO infrared observations?
- *Quick answer:* IR and MW in GOES-E, GOES-W slots showed similar impact, but all-sky assimilation not considered for MW.

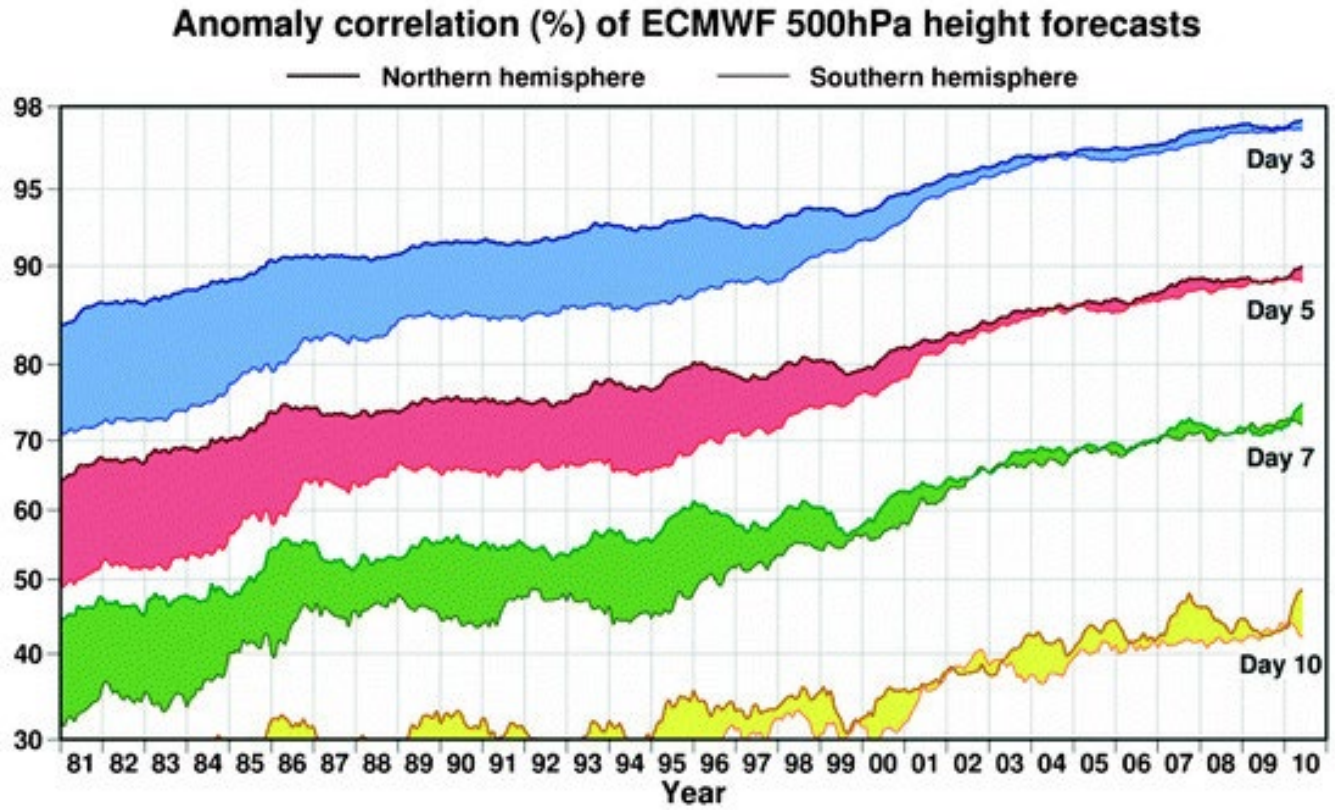
Importance of Satellite observations in NWP

- Goal of weather prediction is to enable better decision-making
  - Requires a good forecast, which benefits from good observations of the atmosphere and its processes
- NWP systems benefit from conventional and satellite observations combined with a global model through data assimilation to initialize forward in time forecasts
- Conventional observations (e.g. radiosondes, ground-based stations) are spatially irregular
- Satellite data essential to filling data voids globally
  - The largest impacts are seen from new information content

Forecast skill vs. Time

The assimilation of satellite observations allows SH forecasts to be as skillful as those in the NH by providing global coverage

- Width of the lines indicates forecast skill gap between hemispheres
- Gap shrinks significantly circa 2000
  - Radiance assimilation
  - ATOVS (AMSU-A + AMSU-B/MHS)
  - AIRS



OSSEs

Combining “observations” with mathematical models

- Using Observing System Simulation Experiments (OSSEs) to test proposed instruments within the context of numerical weather prediction before the investment of building and deploying

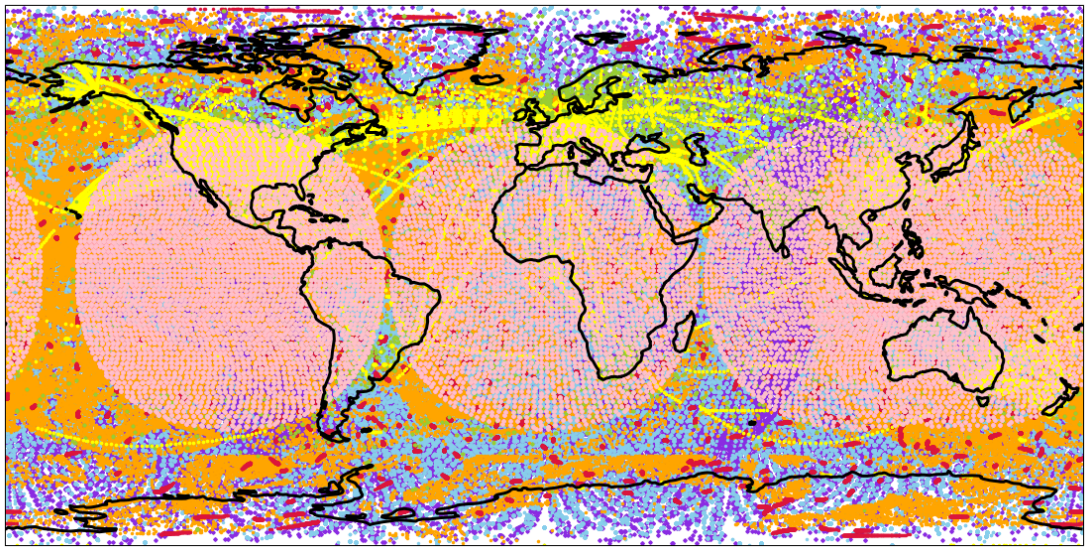
- Requires 3 parts:
  - A nature run – long simulation to represent the real world
  - Global observations simulated from the nature run to resemble and statistically imitate real observations
  - A data assimilation system used for testing

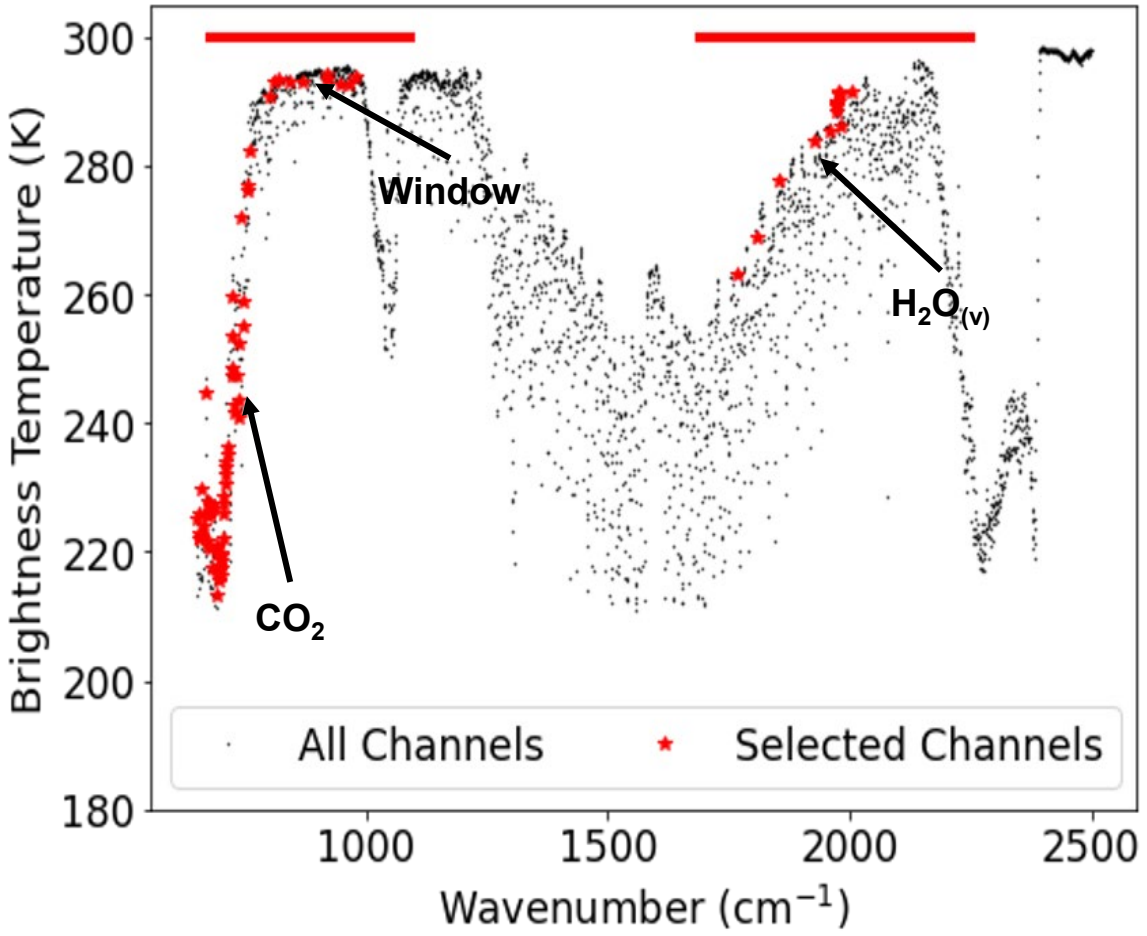
Infrared experiment: GeoXO GXS impact

CONTROL: Baseline observations

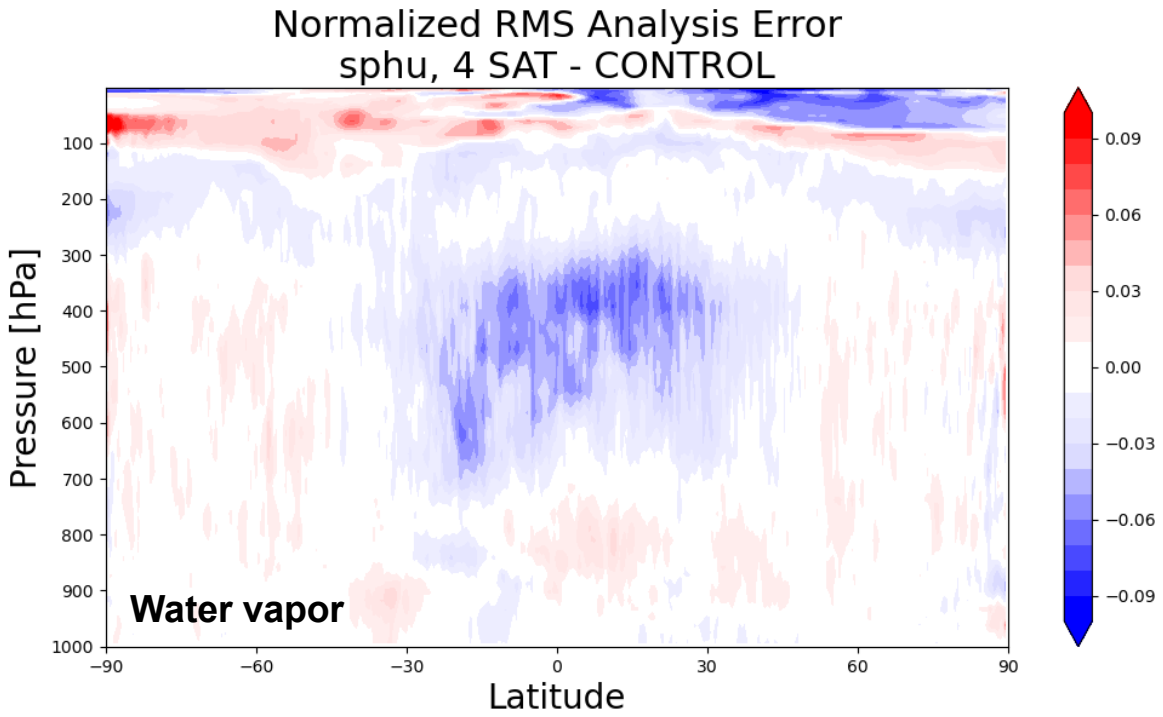
4 SAT: Control + 4 GEO infrared sounders

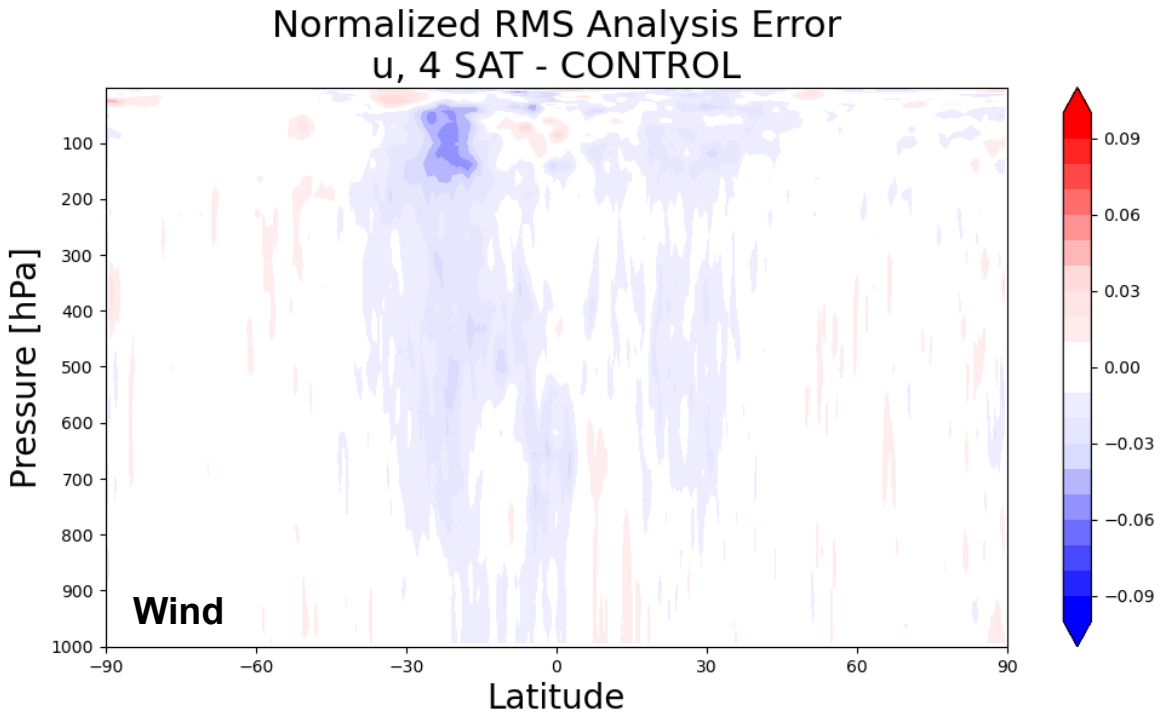
- 0° -- Meteosat Third Generation
- 140.7° -- Himawari
- 105° -- FY-4A
- -105° -- GeoXO Sounder





GeoXO GXS impact - Global



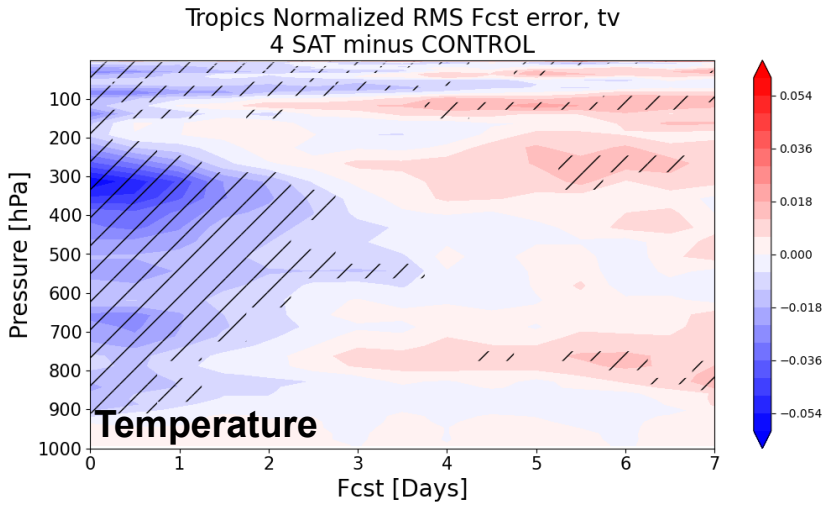


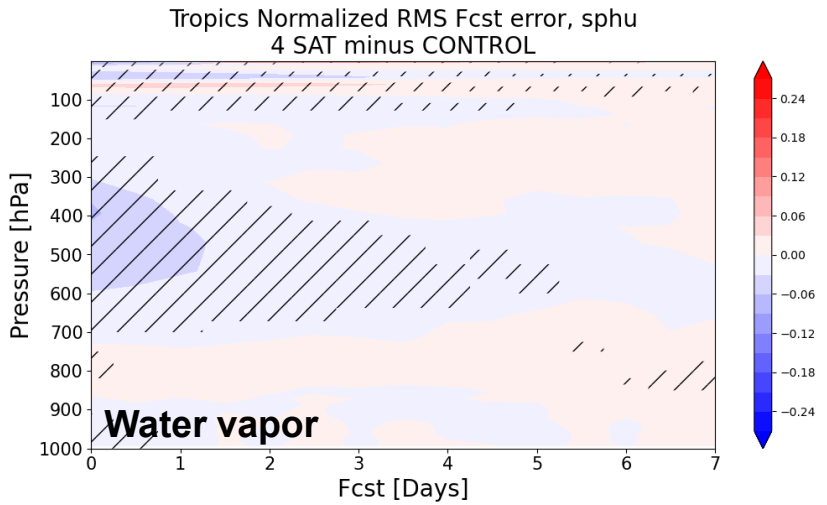
Largest impacts seen in water vapor and wind

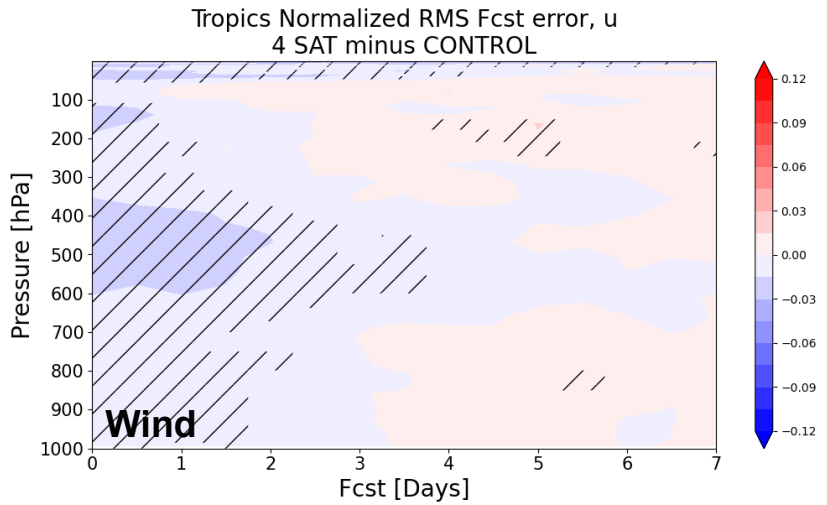
- Water vapor improved, particularly in free troposphere & tropics
- Wind improvement, particularly in tropics and through column
- New information content! GXS will have TEMPORAL INFORMATION

Blue: Improvement
Red: Degradation

GeoXO GXS impact - Tropics







Blue: Improvement
Red: Degradation

Forecast skills in the Tropics illustrate middle-tropospheric impact; also show largest impact

- Middle tropospheric data void again an important factor
- More temperature & wind impact; important due to tropical decoupling of mass and wind
- Degradation towards medium range (3+ days) potentially due to disconnect between GEOS ADAS & G5 Nature Run microphysics
  - Systematic differences in climatology will appear in the tropics as time evolve

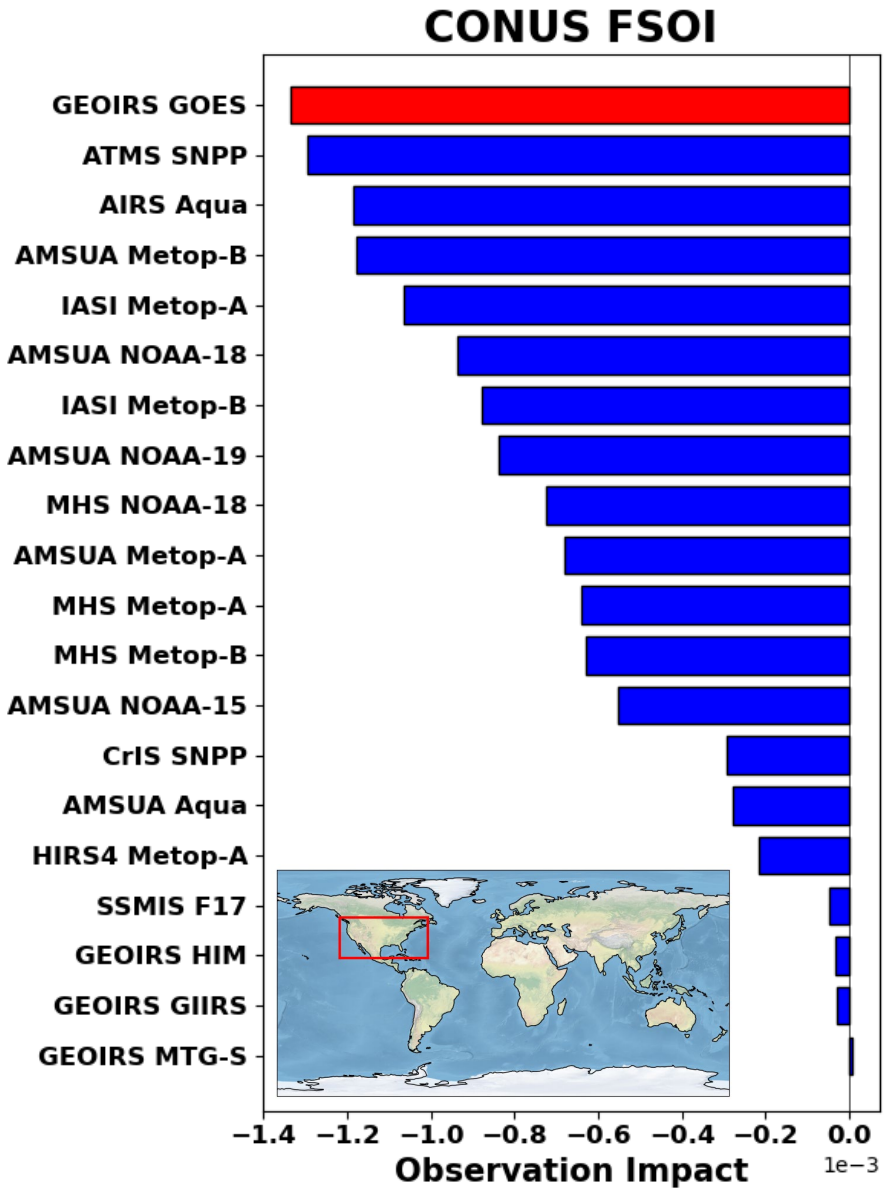
GeoXO GXS FSOI – Continental United States

FSOI is a measure of 24 hour forecast error reduction projected into observation space

- A negative value equates a reduction in error, so NEGATIVE = GOOD

Regional FSOI targeting CONUS shows how each satellite reduces the 24-hour forecast error over CONUS

- GOES instrument has largest impact compared to other GEO sounders
- Results from 00, 06, 12, and 18 UTC cycles
  - Important to consider all four cycles as polar orbiters vary in coverage by synoptic time
- Interesting question – How to improve even more?
  - Better use over land
  - Better QC/methods in marine stratocumulus regions off west coast



Microwave experiment

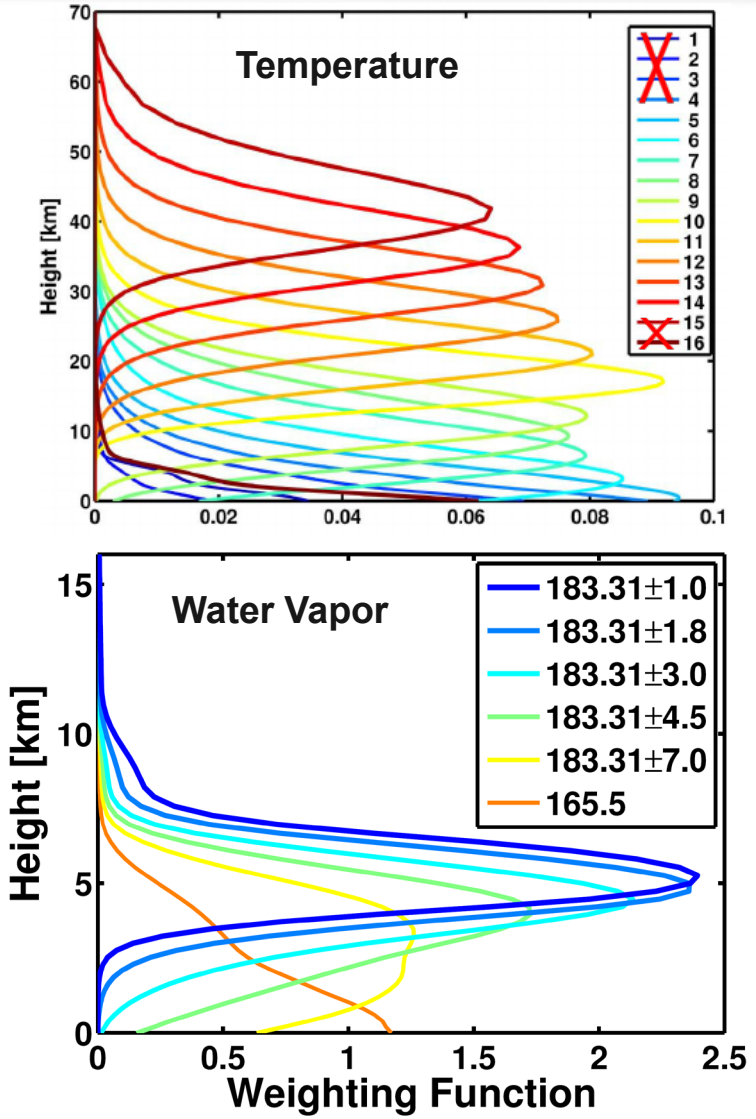
MW configuration: ATMS in GEO Orbit

Spectral

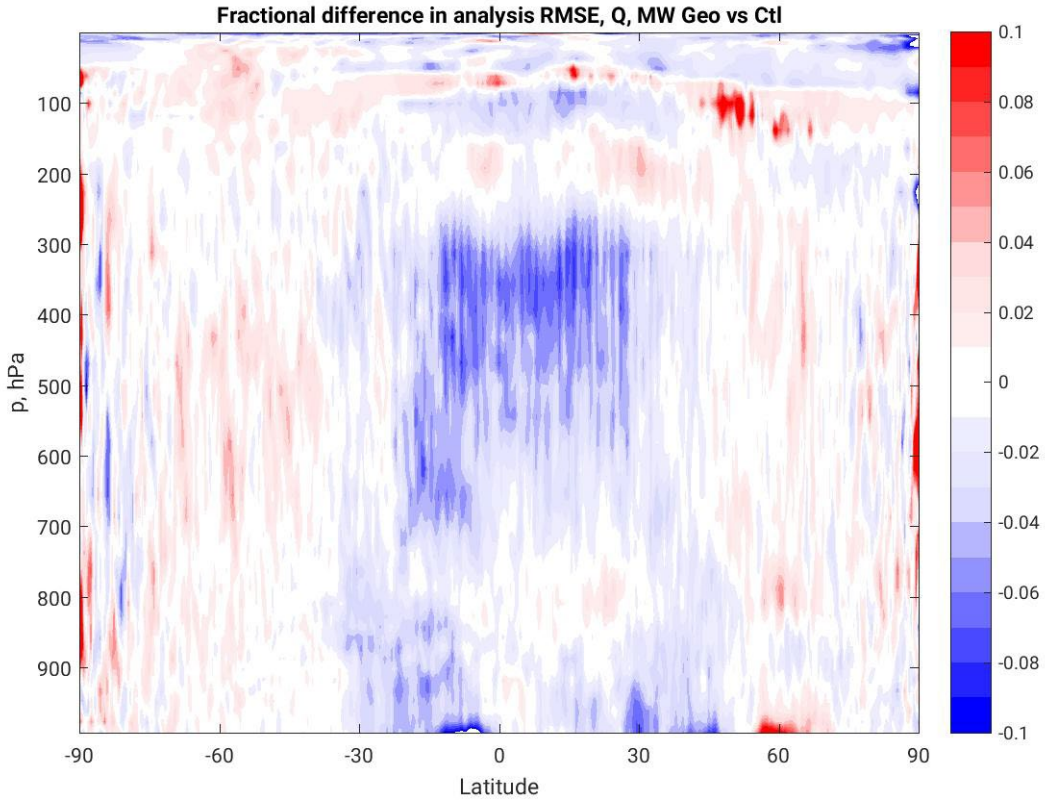
- Low (60 GHz) Frequency Temperature
  - 11 channels
  - Follows existing ATMS methodology
    - Avoids window/surface sensitive channels
  - Does not use channel 15
    - Different than POES ATMS methodology
    - Mesospheric sensitivity can impose strong model biases into observation space
- High Frequency (165/183 GHz) Water Vapor
  - 6 channels

Thinning parameters same w/ IR & MW

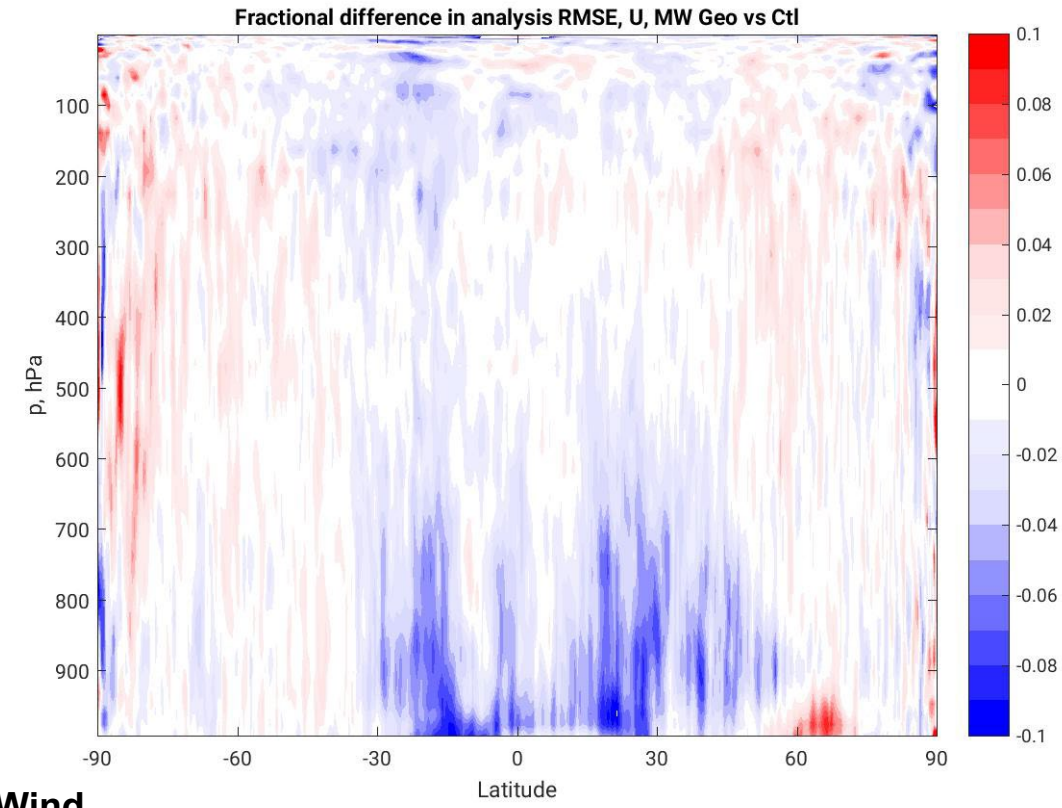
- 180 km spatial thinning
- Hourly cadence



Microwave results - Analysis



Water vapor

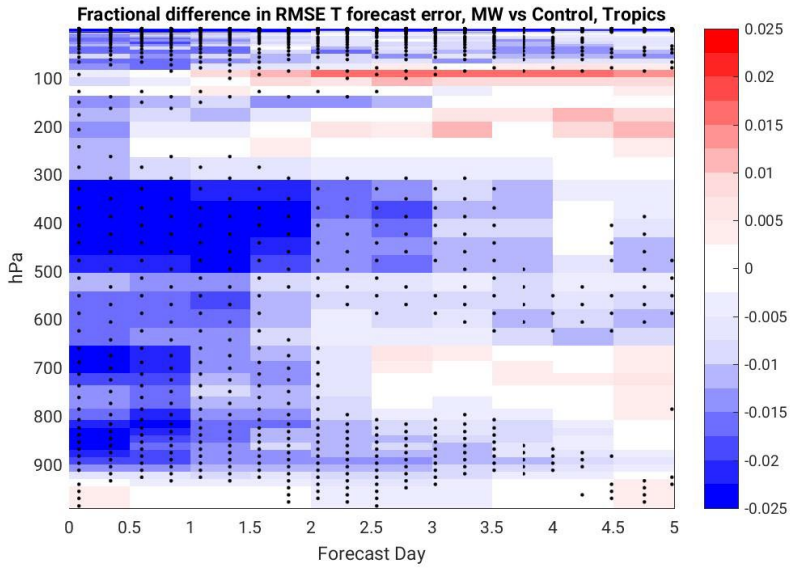


Wind

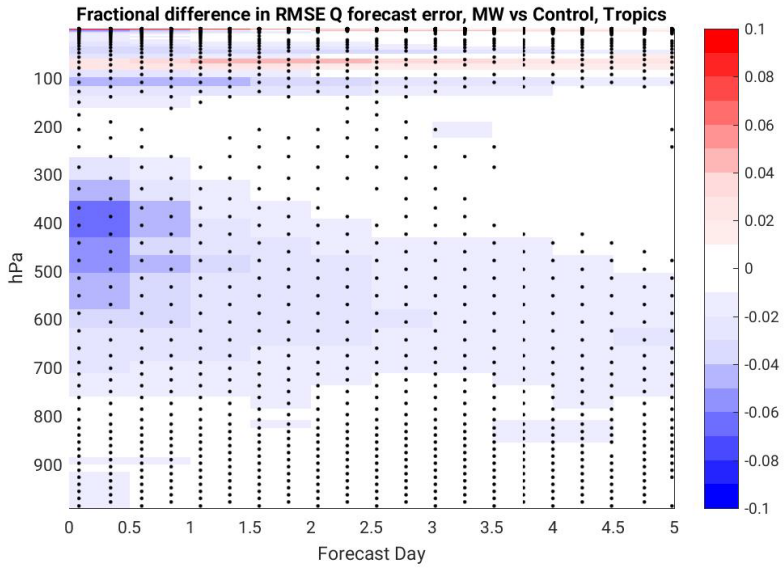
Blue: Improvement
Red: Degradation

- Analysis impacts for MW similar to IR in general
  - Zonal wind error improvements focused in lower troposphere

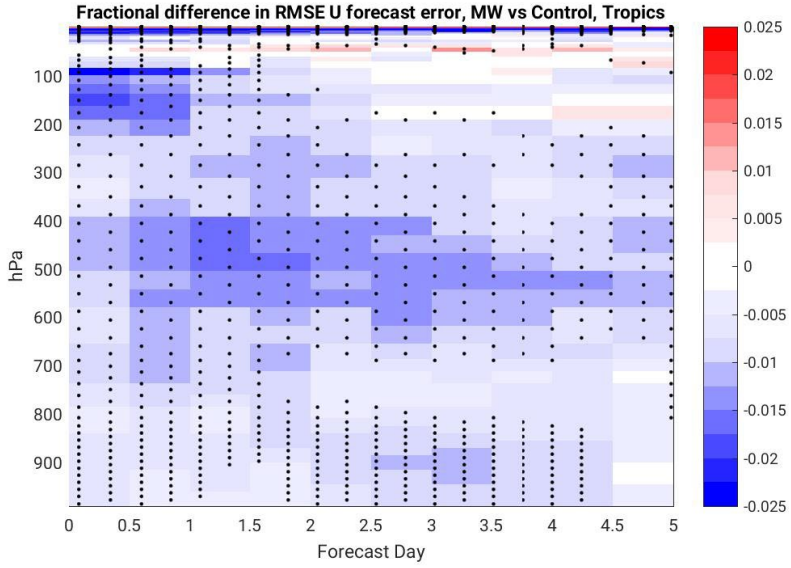
Microwave results – Tropics Forecast



Temperature



Water vapor



Wind

Blue: Improvement
Red: Degradation

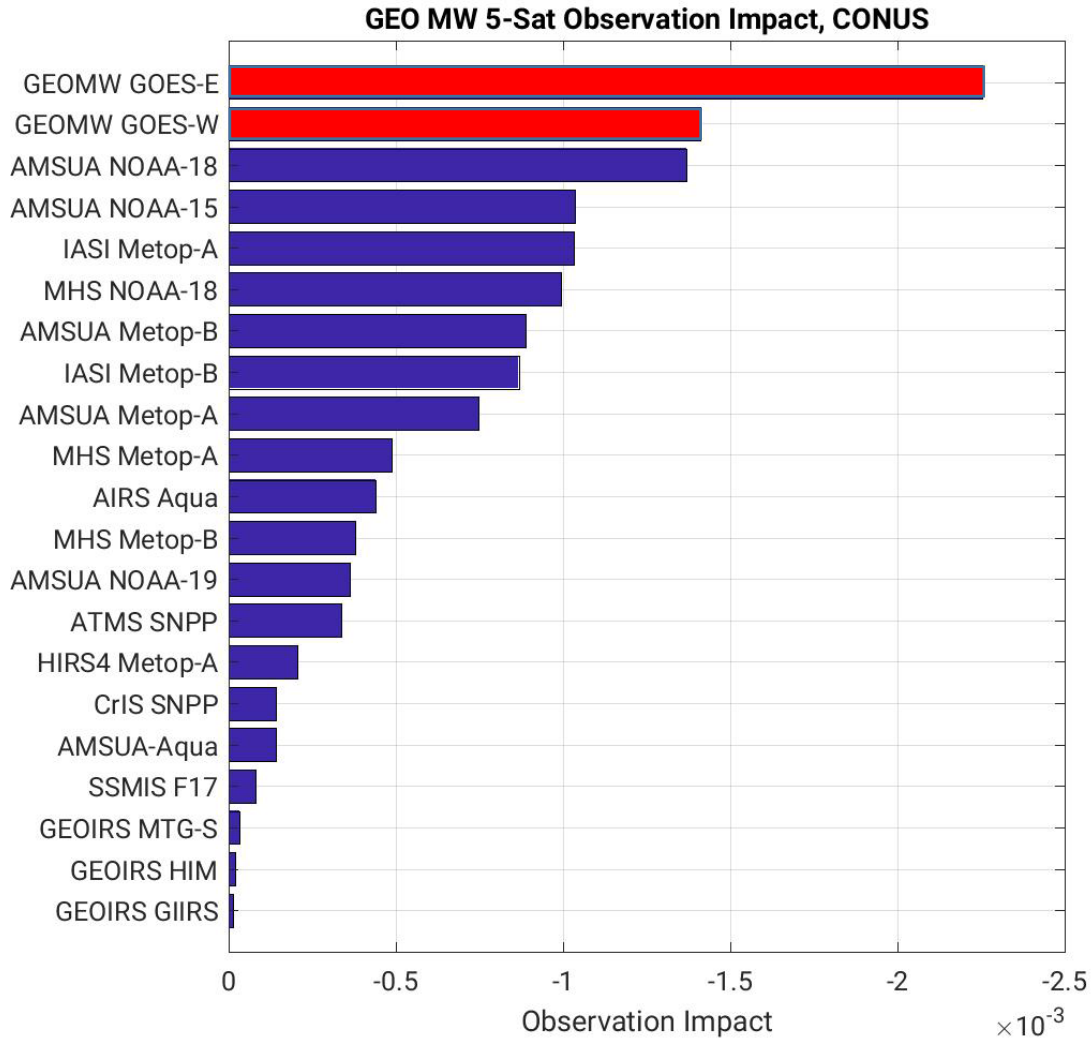
Forecast impacts for GEO-MW similar to IR for temperature and humidity

Slightly better forecast impacts for zonal wind with MW

Conclusions - Microwave

Results are similar in both experiments relative to the GOES positions

- IR and MW in GOES-E, GOES-W slots showed similar impact
- GIIRS actually dropped notably from IR to LW experiment, but the data are the same in each
  - This method can be sensitive to numeric instabilities



Conclusions

Microwave impact assessment

- MW in GOES-E, GOES-W slots showed similar impact as simulated IR instruments
- Engineering assessment posed challenges
  - Required a dedicated spacecraft.
  - Challenging to get right curvature/flatness of the dish.
  - Probably needed to go to higher frequencies (118 GHz), which would require research (reflectivity).
    - 118GHz would also have information content impact on OSSE assessment as well

GeoXO GXS impact assessment experiment

- GXS shows many potential gains for numerical weather prediction
  - Impact of forecast skill is generally beneficial for the first 24-48 hours
  - After this point, the OSSE is fighting the Nature Run because of systematic differences in model physics
- GXS-like observations perform the most work of the satellite radiances to reduce forecast error growth (via FSOI) over CONUS over the diurnal cycle

Simulation work continues:

- Submitted for peer review a manuscript that documents GeoXO GXS (infrared) impact assessment in *Journal of Atmospheric and Oceanic Technology*
- OSSE framework being updated to a new system
  - Updated system is expected to produce larger difference between the nature run and the experiments, meaning more work for the observations to perform and allowing a larger impact
  - Updated observing system more similar to what is expected to be in orbit when GeoXO launches
  - Extending simulations to include Atlantic TCs that occurred in Sept.
- Working to develop better interfaces with economists