Impacts of Geostationary Infrared Sounders within NASA's Observing System Simulation Experiment Framework

Erica L. McGrath-Spangler[1,2], Will McCarty[3], Nikki Privé[1,2], Isaac Moradi[1,4], Joel McCorkel[5], Bryan Karpowicz[1,6]

[1]NASA GMAO, [2]Morgan State University, [3]NASA HQ, [4]University of Maryland, [5]NASA Biospheric Sciences, [6]University of Maryland Baltimore County

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Motivation

Goal of numerical weather prediction (NWP) is to enable better decision-making. This requires a good forecast initialization, which benefits from good observations combined with a global model through data assimilation. Low Earth Orbit (LEO) hyperspectral infrared radiances provide high vertical resolution temperature and water vapor measurements essential to NWP but suffer from limited horizontal and temporal resolution.

Geostationary eXtended Observations (GeoXO) program is the US contribution to the World Meteorological Organization (WMO) Integrated Global Observing System (WIGOS) vision in 2040.

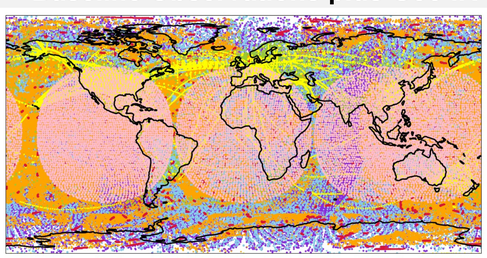
- Provides higher spatiotemporal resolution observations, allowing views between clouds, more homogeneity in cloudy scenes, and ability to observe rapidly evolving phenomena with lower data latency
- Provides new information content for NWP, including wind information from the higher temporal resolution

Observing System Simulation Experiments

A tool to test the utility of the GeoXO program is the GMAO OSSE system, used to assess sensitivities and capabilities of proposed observing systems. Includes:

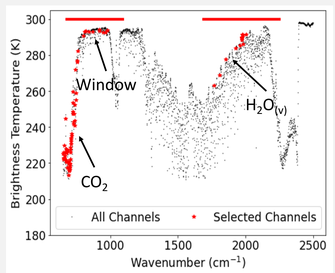
- GMAO Nature Run (7 km horizontal, 30 min temporal resolution)
- Goddard Earth Observing System (GEOS) atmospheric data assimilation system (ADAS) assimilating data in hourly bins
- Global observations simulated from the NR with realistic errors added to statistically resemble operational system for 2015
  - Meteosat Third Generation (MTG) at 0º
  - Himwawari at 140ºE
  - FY-4A at 105ºE
  - **GeoXO Sounder at 105ºW**

Baseline Observations plus Geo IR



Pink indicates location of hourly Geo IR in addition to baseline observations.

Geo IR



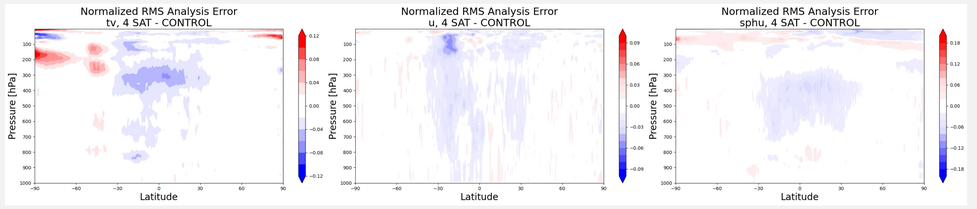
MTG-S used as baseline with instrument spectral range of 650 – 2500 cm^{-1} yielding 4 km spatial resolution and an hourly "full-disk" scan. 85 total channels assimilated with 70 temperature sounding channels from 650 cm^{-1} – 980 cm^{-1} and 15 water vapor channels from 1765 cm^{-1} – 2005 cm^{-1}.

Results

Addition of Geostationary hyperspectral infrared reduces root mean square error in the analysis, primarily in the tropics.

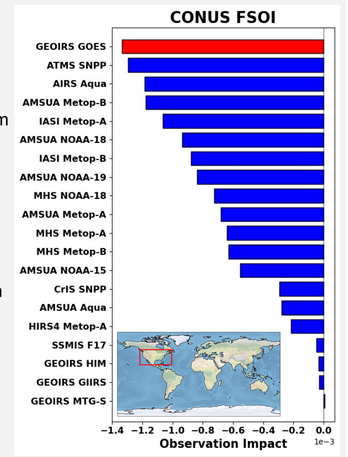
- Modest temperature improvement in the tropics with a largely neutral impact poleward of 30ºN and curious degradation poleward of 30ºS.
- An important wind improvement results from increased temporal resolution of the observations and results in an improved water vapor estimate in the free troposphere and tropics.
- The regional forecast sensitivity observation impact (FSOI) over the CONUS region, calculated over the 4 synoptic times, shows that the proposed **GeoXO instrument has the largest observation impact on the 24-hour forecast error**.

RMS Analysis Error for OSSE experiment minus control



Normalized zonally averaged, root mean square analysis error difference (OSSE experiment assimilating 4 Geo IR satellites minus a control assimilating only the baseline observations) for (left) temperature, (middle) zonal wind, and (right) specific humidity. Blue colors indicate the Geo IR observations reduce the error while red colors indicate the opposite. Values are given as a fractional error reduction.

Regional FSOI calculated over the CONUS region, outlined in red, from 00, 06, 12, and 18 UTC analysis cycles shows the temporally persistent Geo IR sounder at 105º W outperforms polar orbiters that vary in coverage by synoptic time.



Summary and Future Work

The GeoXO sounder shows potential gains for NWP with coherent gains in the analysis and reduction in the FSOI. Impact on forecast skill is generally beneficial in the first 24-48 hours after which point the OSSE DAS system has systemic differences in model physics from the NR. Further evaluation of land-sensitive and ozone-sensitive channels and addressing any potential issues with error correlation will be necessary. The GMAO OSSE system is transitioning to an updated data assimilation framework within which the GeoXO IR data may be tested.

E-mail: erica.l.mcgrath-spangler@nasa.gov | *Web:* gmao.gsfc.nasa.gov

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