Impact of Satellite Sounder Absence Across Diverse Geographic Regions

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1. Motivation & Research Questions

Why Revisit the Impact?

- Contribute to the World Meteorological Organization (WMO) Observation Impact Workshop.
- Provides recommendations to data producers to maintain a comprehensive global observing network.
- Provides scientific evidence to design and evolution of future observing system.
- Provides strategies for the selection of observations coverage area and frequency.

Research Questions:

- What is the performance of the different sounder observations we used in our global NWP system?
- Weather forecasting in some regions is challenging compared to others due to the scarcity of observations to be assimilated into the NWP system, so what is the role of sounder observations over those challenging areas?

2. System Configuration, Data and Methods

NWP System

Domain	Global
Trial Period	15/12/2022 – 15/03/2023
DA Method	Hybrid 4D-VAR
Model	Vertical Level: 70 Model top: 80 km Horizontal resolution: 40km (at mid-latitudes)
DA Cycle	6 Hourly

Method

- Data denial experiment (**DDE**)
- Forecast Sensitivity to Observation Impact (**FSOI**)

Observation

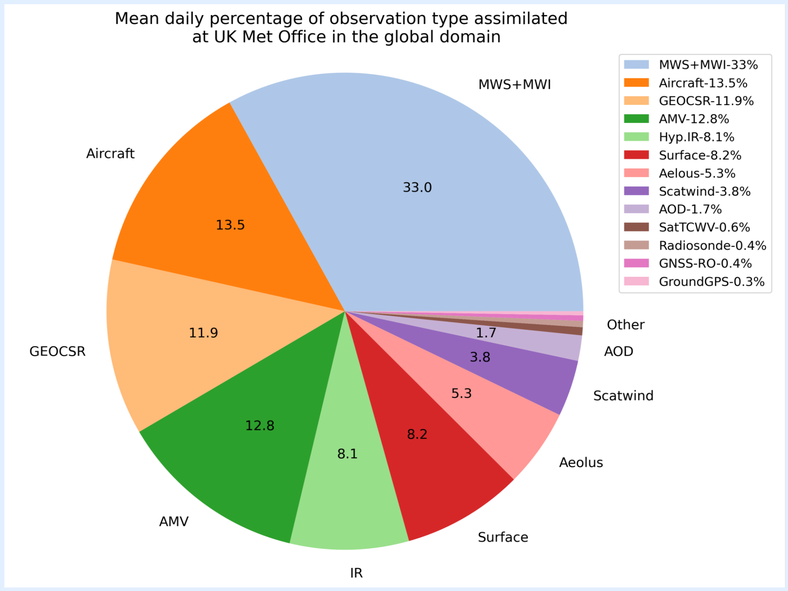


Figure: Mean daily percentage of observation from each observation type assimilated during the period 15th December 2022 to 15th March 2023 in global domain.

3. Experiments & Results

Workflow:

Firstly, we have run a control with full observing system. Then the following DDEs runs :

- **NO MW** : sounders and imagers
- **NO IR**: sounders
- **NO GEOCSR**: geostationary clear sky radiances
- **NO MWIM**: imagers

A few additional experiments also run for other observing system:

- **NO AMV**
- **NO GNSS-RO**

Scorecards: change in forecast error for selected key variables.

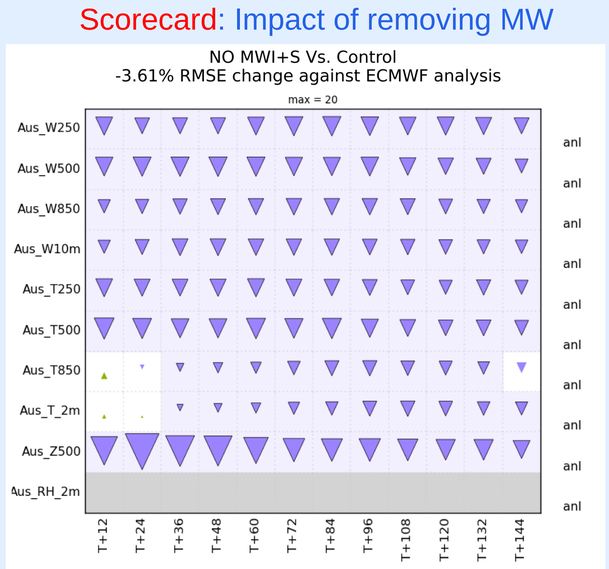
Positive ΔRMSE (positive impact).

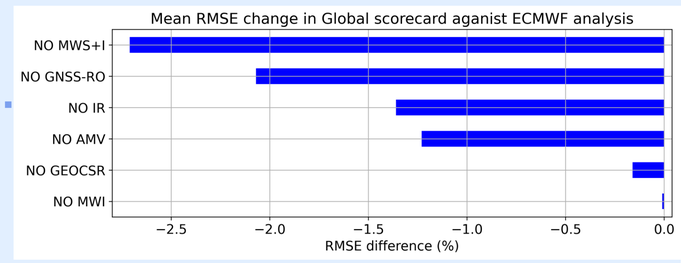
Negative ΔRMSE (negative impact).

The size of each triangle represents the magnitude of each value and shading of the background means statistically significant.

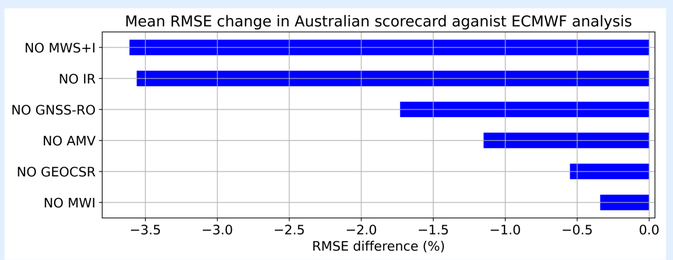
Results:

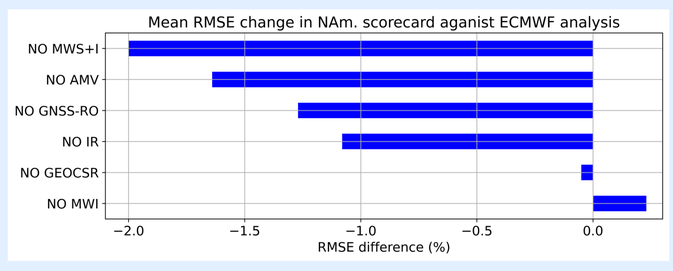
Scorecard: Impact of removing MW

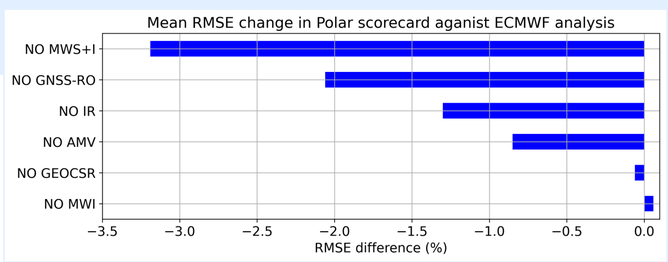


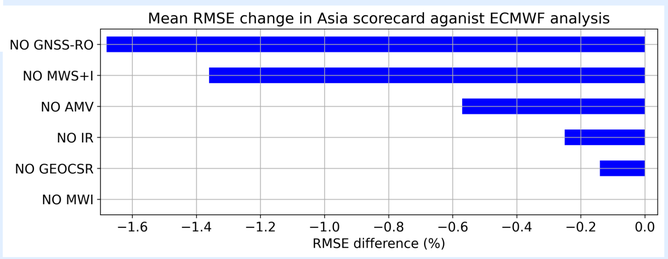


- MW radiances and GNSS-RO observations show the most impact globally as well as over the most regions.
- MW and IR have a strong impact over Australia, GNSS-RO have strong impact over Asia and Polar regions, and AMV over North America.









Figures: The mean change in data denial scorecard for each observation category over different regions(verified using ECMWF analyses)

Polar Regions DDE's

Main focus:

only concentrate on the observations at latitude of 60°N-90°N for northern polar region and 60°S-90°S for southern polar region

Experiment:

- **NO MW**
- **NO IR**
- **NO Conv. Obs.**
- **NO MW + IR + Conv. Obs.**

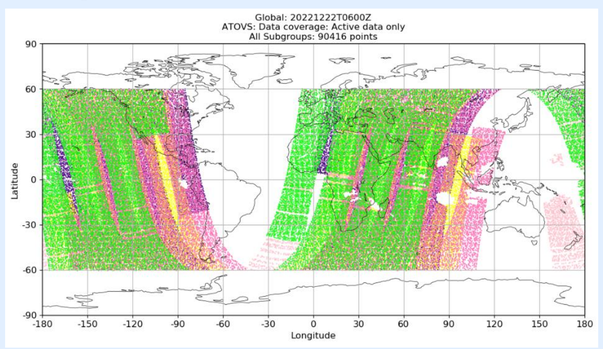


Figure: ATOVS coverage after remove over polar regions

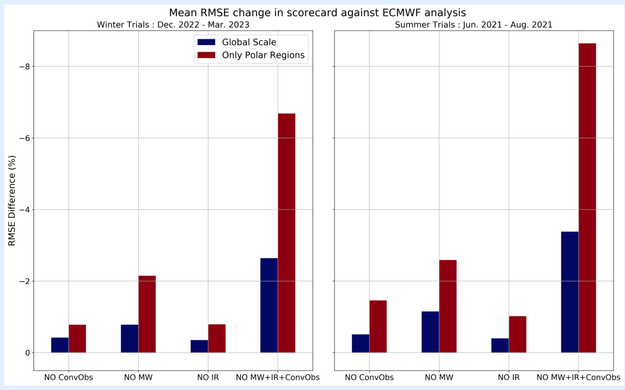
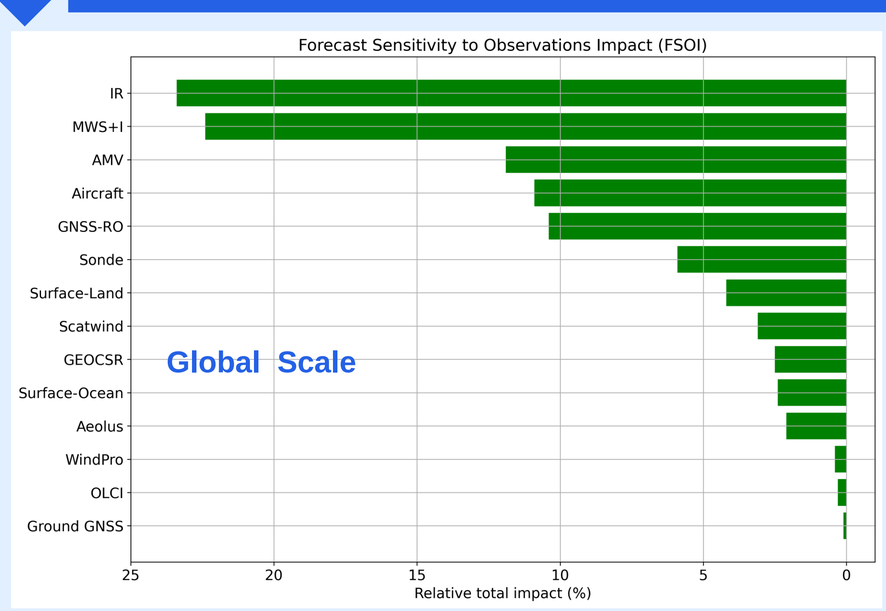
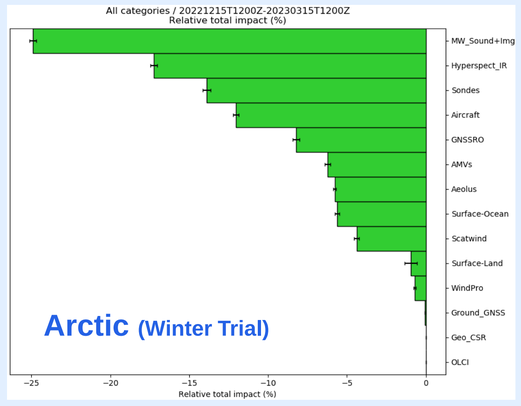


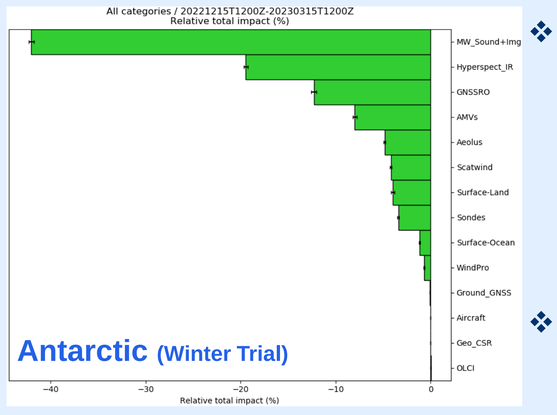
Figure: Mean change in scorecard for each observation type

- MW observations are very important data sources in both polar regions.

4. FSOI







- Previous studies (Candy et al., 2021, Samrat et al., 2025) show the MW category yields the highest impact, whereas for this recent study it is the hyperspectral IR category
- However, in previous study, GNSS-RO rank 8 and in this study, it becomes 5th in FSOI based ranking. This consistent with DDEs ranking (Section 3 and Samrat et al., 2025)
- FSOI estimation over Polar regions only shows that MW has the most significant impact in the Antarctic for both seasons (another season FSOI not shown here).
- However, IR takes over MW over the Arctic during the summer trial.

5. Conclusions

- MW and GNSSRO show a bigger impact than others globally. This is different from a previous study in 2021, which found the two most important categories to be infrared and microwave sounders.
- One notable difference between DDE's and FSOI diagnostics ranking is the relative position of IR Hyperspectral sounders.
- Overall, it is found that each observation category shows a mean beneficial impact on the forecasts across various regions.

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