

# The impact of background error specification on microwave sounder OSEs

David I. Duncan\*, Niels Bormann, Elías Hólm

European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, UK \*David.Duncan@ecmwf.int



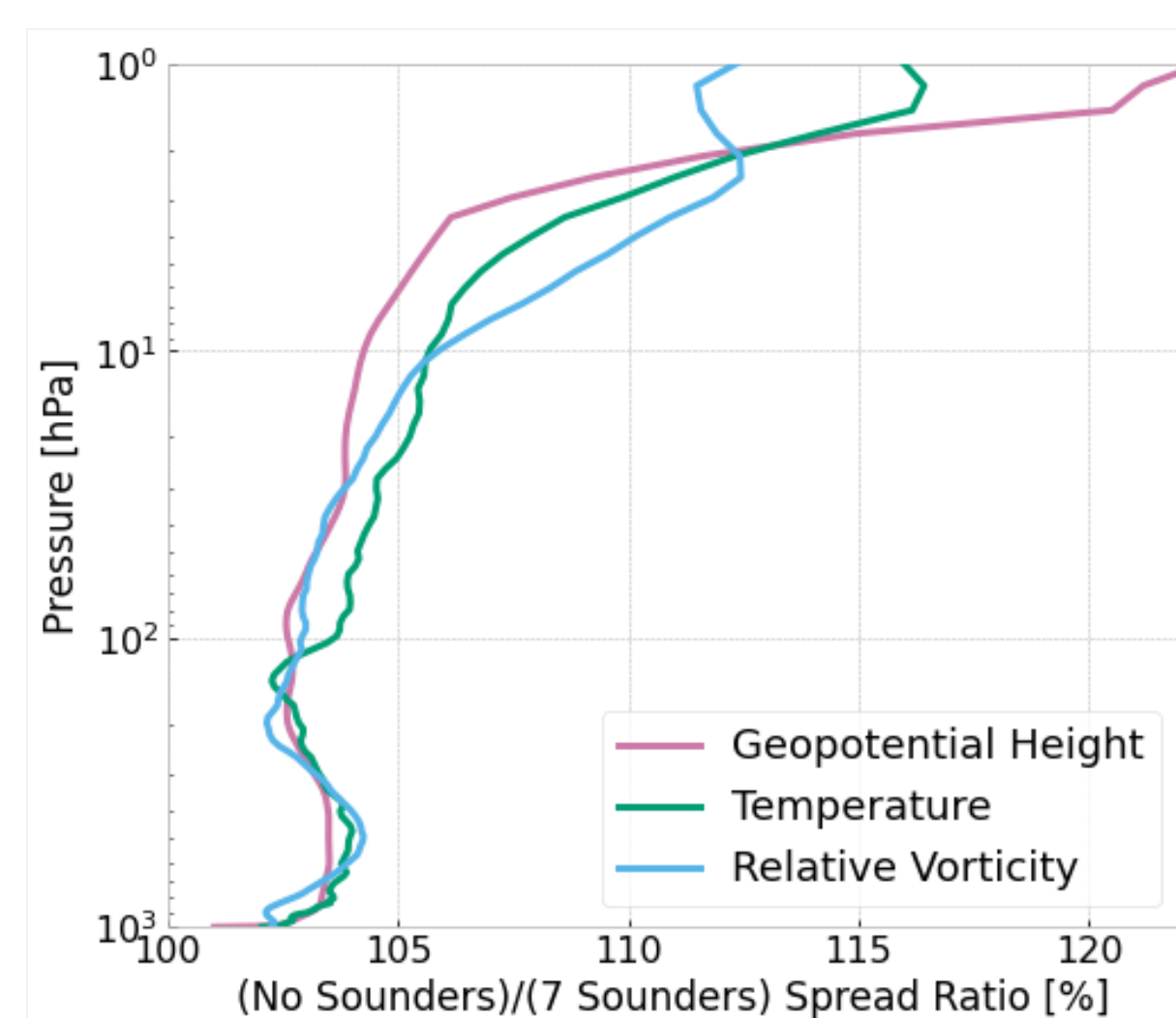
## 1. Abstract

We examine the addition of microwave (MW) temperature and humidity sounders from a baseline with no MW sounders at all, showing the incremental benefit from adding sounders to the assimilation system. Framed as a series of observing system experiments (OSEs), large improvements in forecast skill and background fits to independent observations are gained from the first sounders added. Significant further benefit is observed from additional sounders, with the impacts largest at high latitudes and no saturation evident in the maximal setup.

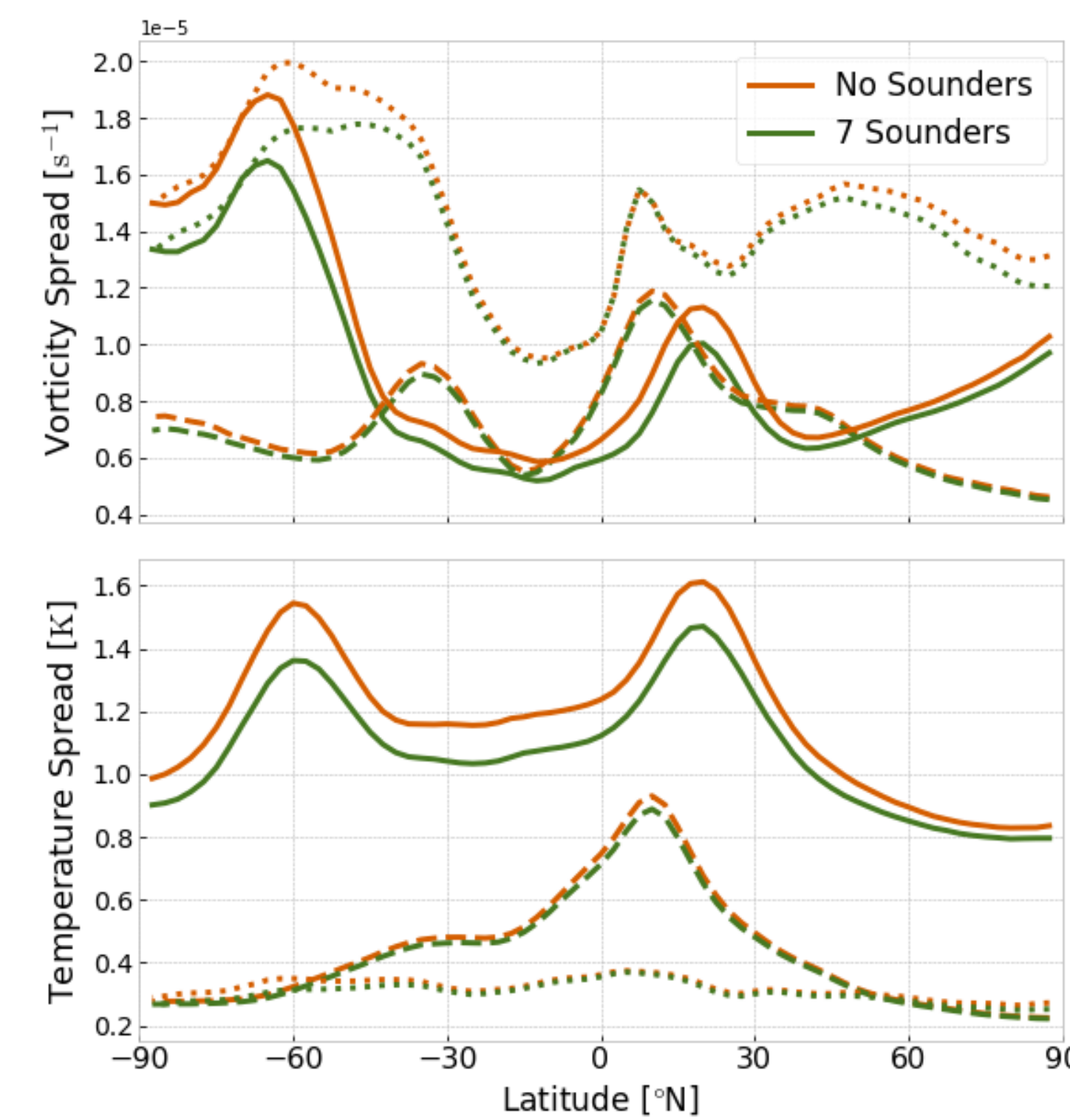
The importance of updating background errors for OSEs is then investigated to give context to the results. The ensemble of data assimilations (EDA) underlying the background error specification is re-run to be consistent with the observing system in the OSE. We find the effect of updating background errors is secondary to that caused by the observing system change itself. Rerunning the EDA can mitigate some of the forecast skill lost in a data denial experiment or gained when assessing data addition, but it is roughly 10% of the overall change. The results suggest that conclusions from OSEs without background error update are still valid, at least for OSEs that consider a comparable or smaller change to the observing system used.

## 4. Ensemble of Data Assimilations (EDA)

- 10-member EDA experiments calculate **B** matrix for minimal (No Sounders) and maximal (7 Sounders) observing systems
- Run at TCo639 L137 (~18km) final resolution, for same time period
- Addition of MW sounders has largest impact on EDA spread at high latitudes and upper stratosphere, matching regions of largest forecast impacts seen in OSEs.



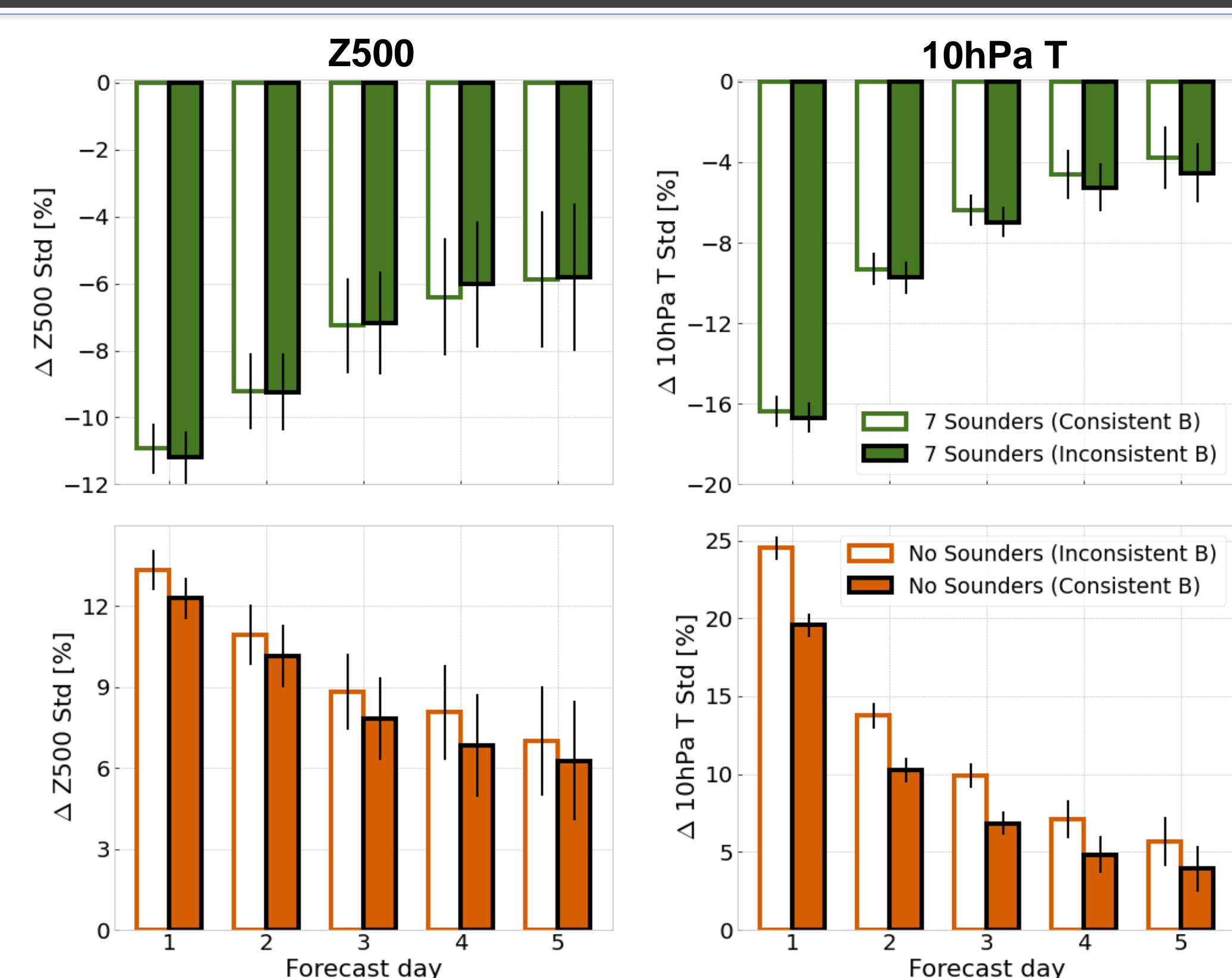
- Global mean EDA spread (i.e. **B**) is larger for No Sounders at all model levels
- Spread difference maximises in upper stratosphere (10-20%)
- Subtler changes in spread in troposphere (2-5%) that maximise in mid troposphere high latitudes



Zonal means of EDA ensemble spread for three model levels: 3hPa (solid), 100hPa (dashed), 600hPa (dotted).

## 5. Background error results

- EDA's control member provides 'consistent **B**'
- EDAs provide input for separate assimilation experiments. Can test with 'inconsistent' background errors, e.g. pairing the No Sounders observing system with 7 Sounders **B**.
- These experiment pairs help us simulate typical OSEs where **B** does not reflect observing system change: *data denial* or *data addition*
- Only upper stratosphere sees significant differences in forecast scores
- Z500 score changes are not statistically different at any lead time, for data addition or denial OSEs.
- Conclude that impact of **B** on OSE results can be significant, but not for most OSEs. This may be estimated from EDA spread magnitude (above).

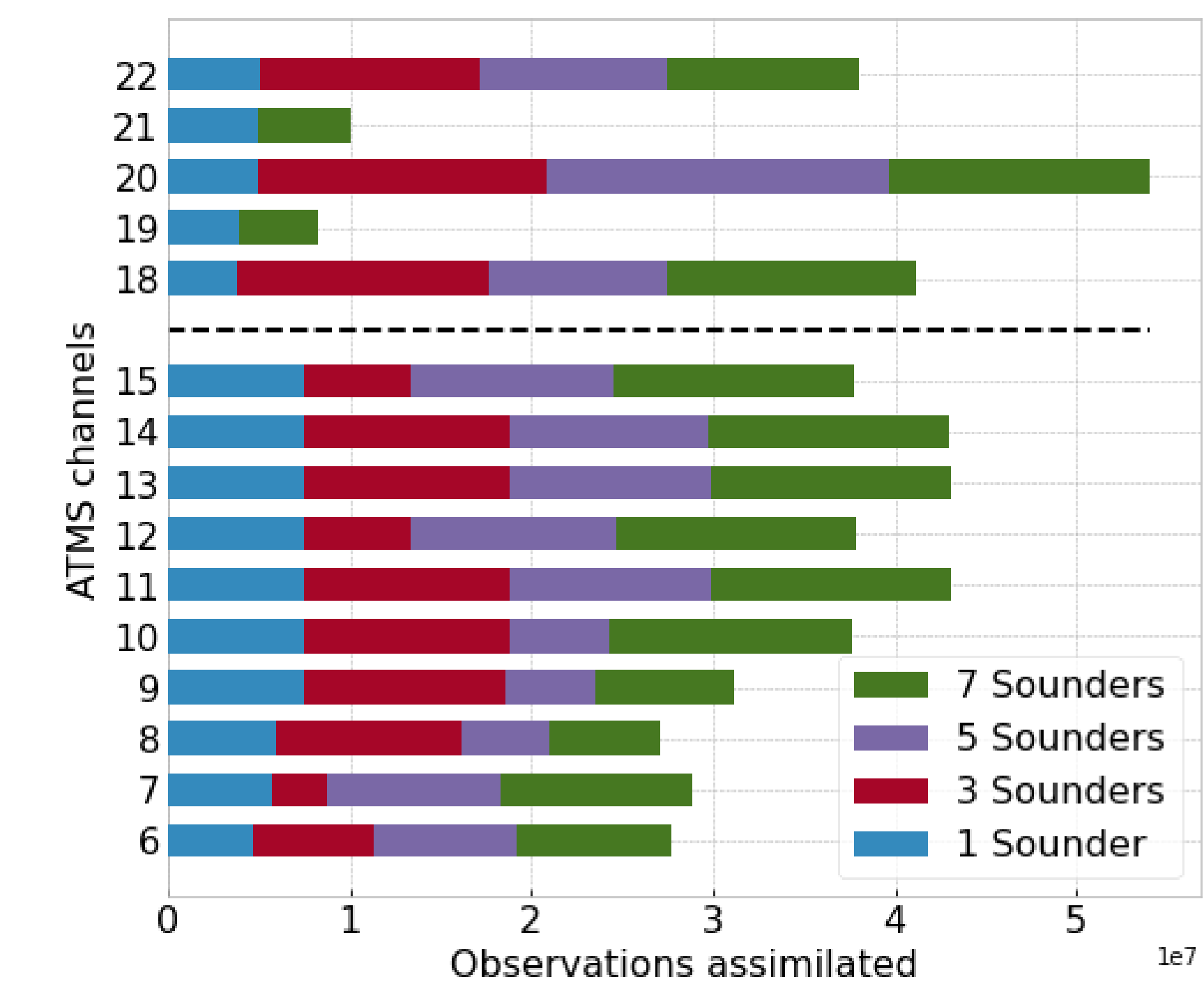


Change from No Sounders baseline (top) simulates data addition OSE with and without **B** update; change from 7 Sounders baseline (bottom) simulates data denial with and without **B** update.

## 2. Sounder Addition OSEs

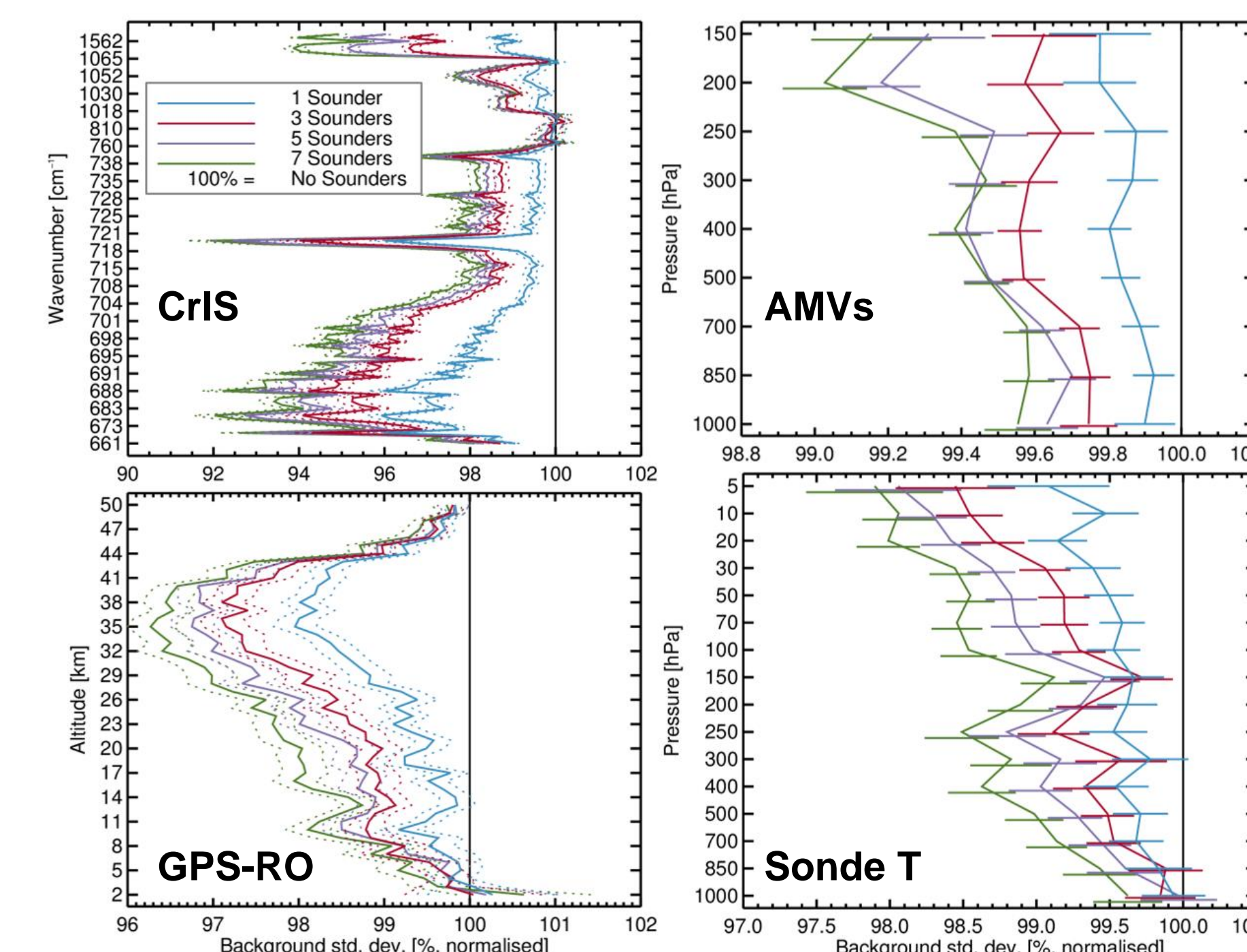
- Add MW sounder pairs (1 T sounder + 1 H sounder) in complementary orbits. ATMS or AMSU-A/MHS combination = 1 MW sounder pair.
- From No Sounders baseline add 1, 3, 5, 7 Sounders to see gradual impact
- For these OSEs background errors (**B**) remain unchanged, i.e. full system **B**
- Experiments at TCo399 L137 (~29km) resolution, IFS Cycle 46R1, Jun-Sep 2018

Experiment Name	Satellites with Sounders Active
No Sounders	-
1 Sounder	NOAA-20
3 Sounders	NOAA-20, Metop-B, F-17, NOAA-15
5 Sounders	NOAA-20, Metop-B, F-17, NOAA-15, NOAA-18, NOAA-19
7 Sounders	NOAA-20, Metop-B, F-17, NOAA-15, NOAA-18, NOAA-19, SNPP, Metop-A

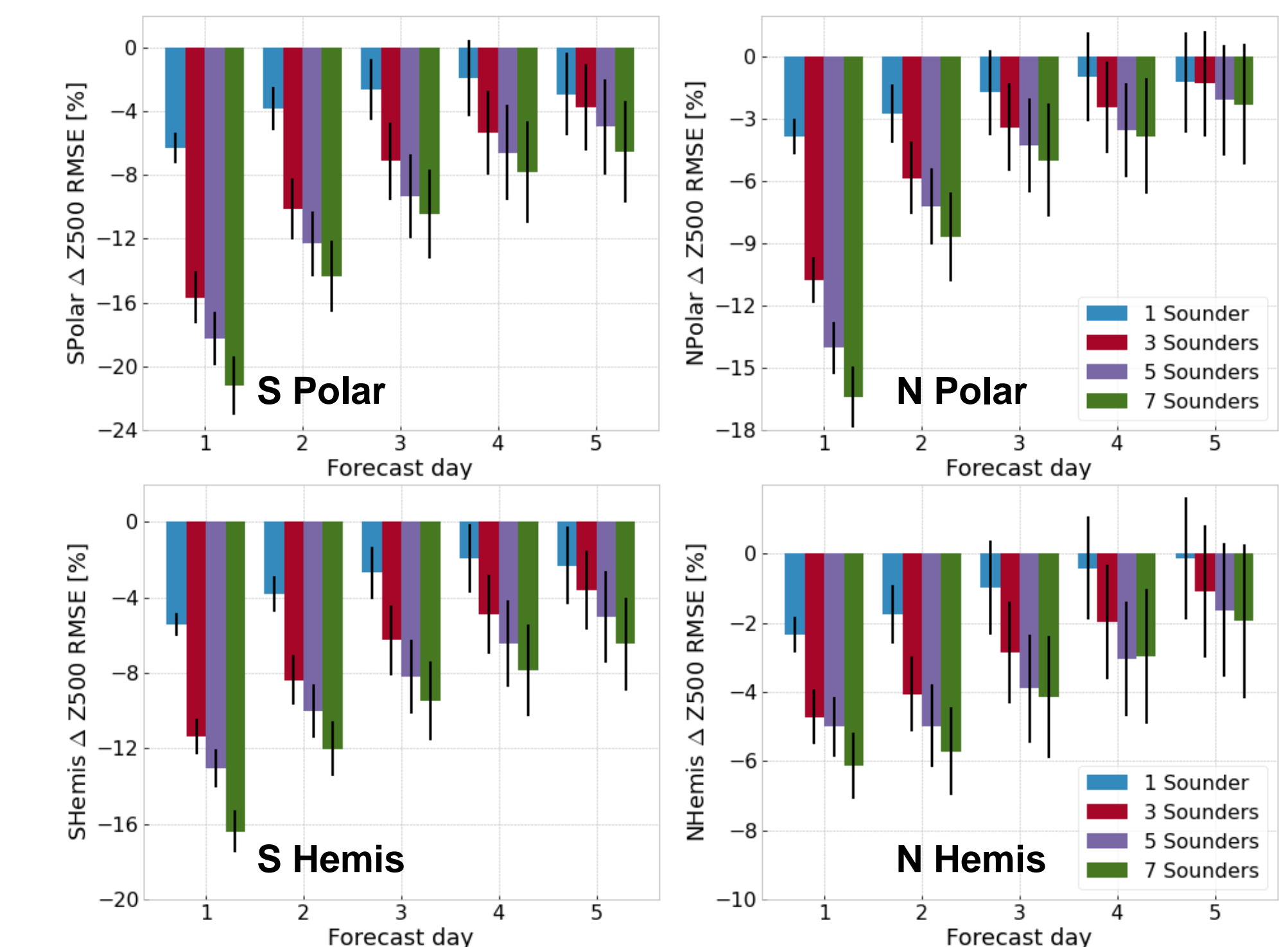


## 3. Sounder Addition Results

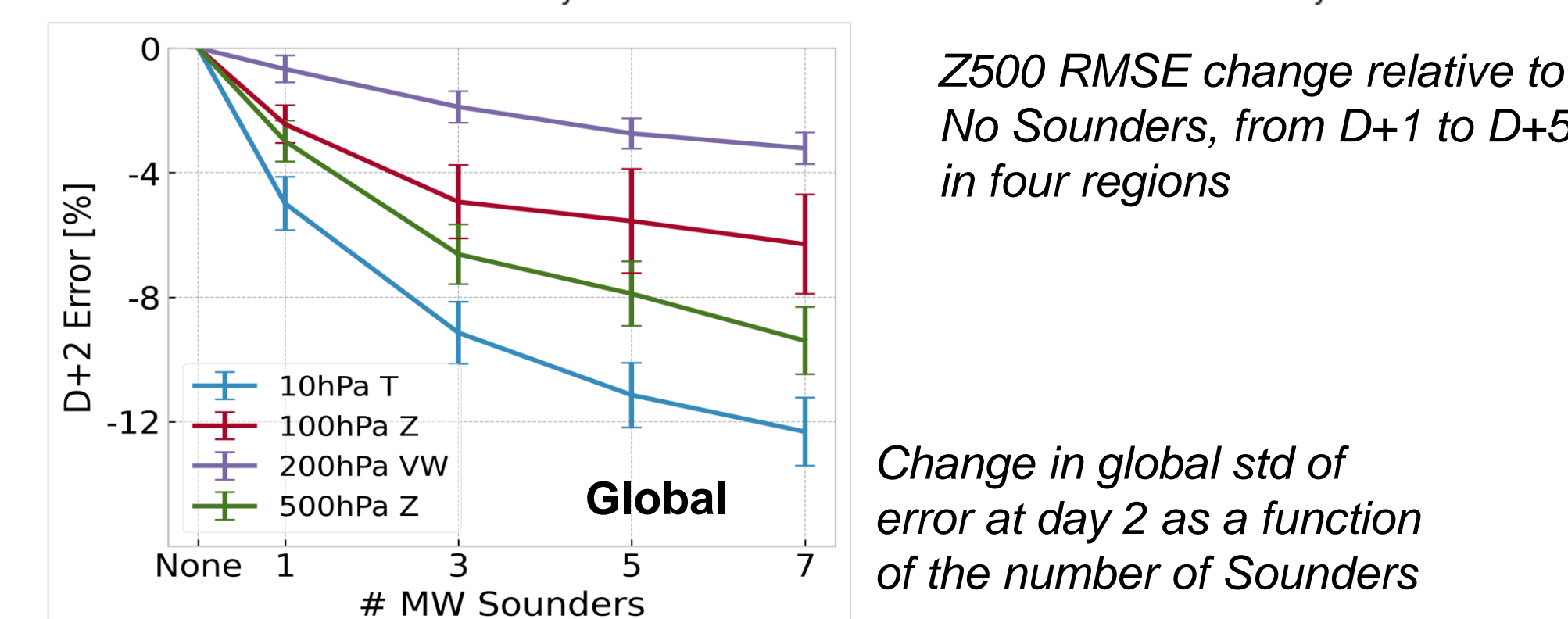
- From No Sounders baseline, first sounder added has large positive impact
- Dramatic improvement seen in background fits to independent observations
- Medium-range forecast scores improve most in regions like Southern Hemisphere and polar regions where satellite data are main constraint
- Effects largest in stratosphere and mid troposphere



Change in global std(O-B) for CrIS, AMVs, GPS-RO, and radiosonde T, compared to No Sounders



Z500 RMSE change relative to No Sounders, from D+1 to D+5 in four regions



Change in global std of error at day 2 as a function of the number of Sounders

## Summary

- Addition of MW sounders causes a significant increase in NWP skill, seen consistently in medium-range forecast scores and independent observations. The effect is largest in the stratosphere but is visible for all parameters and levels analysed.
- First sounder has biggest impact, but no sign of "saturation" with measurable improvement visible from 5 to 7 sounders.
- A custom-made background error does improve forecast skill in the OSEs, but signal is small (~10%) compared to the change in skill caused by the observing system changes themselves
- Most OSEs would not see a significant effect on results or interpretation from using mildly inconsistent (e.g. operational) **B**

Acknowledgements: David is funded through the EUMETSAT Research Fellowship.

Manuscript submitted: Duncan, D. I., Bormann, N. and Holm, E. (In review). On the addition of microwave sounders and NWP skill. QJRMS.