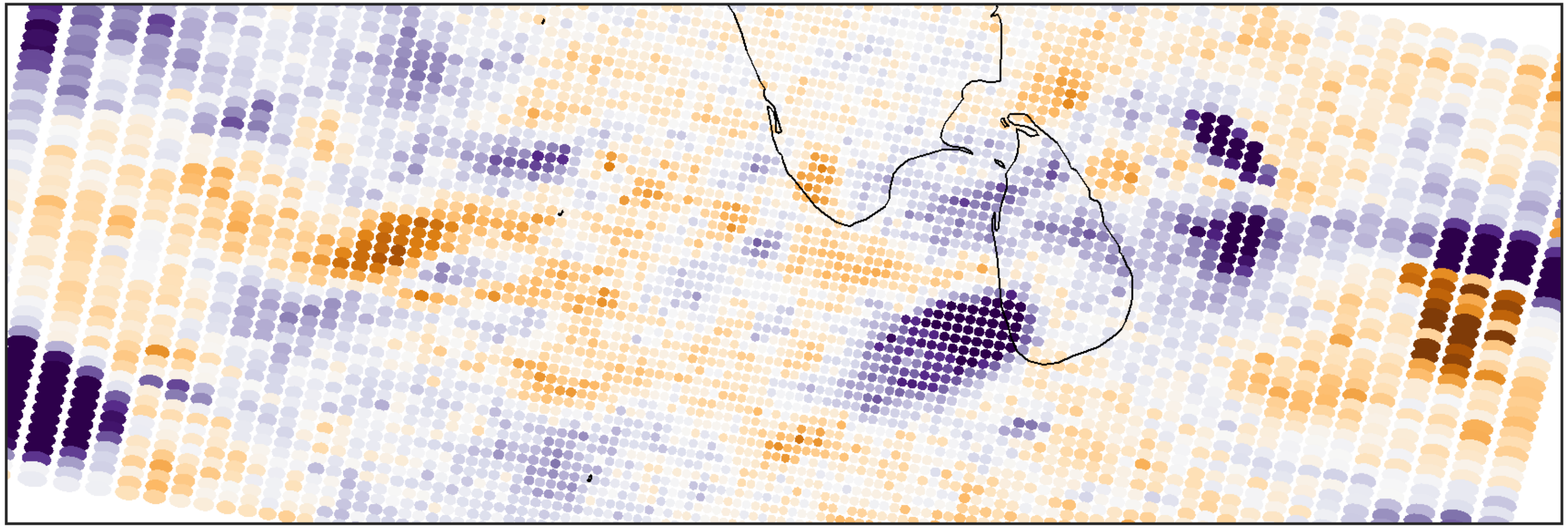

Optimising All-sky Assimilation of Microwave Humidity Sounders

ITSC-24

David I. Duncan, Niels Bormann, Alan Geer, Peter Weston

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Background

All-sky humidity sounders contribute significantly to forecast skill in the IFS – about 7% of FSOI in 2022

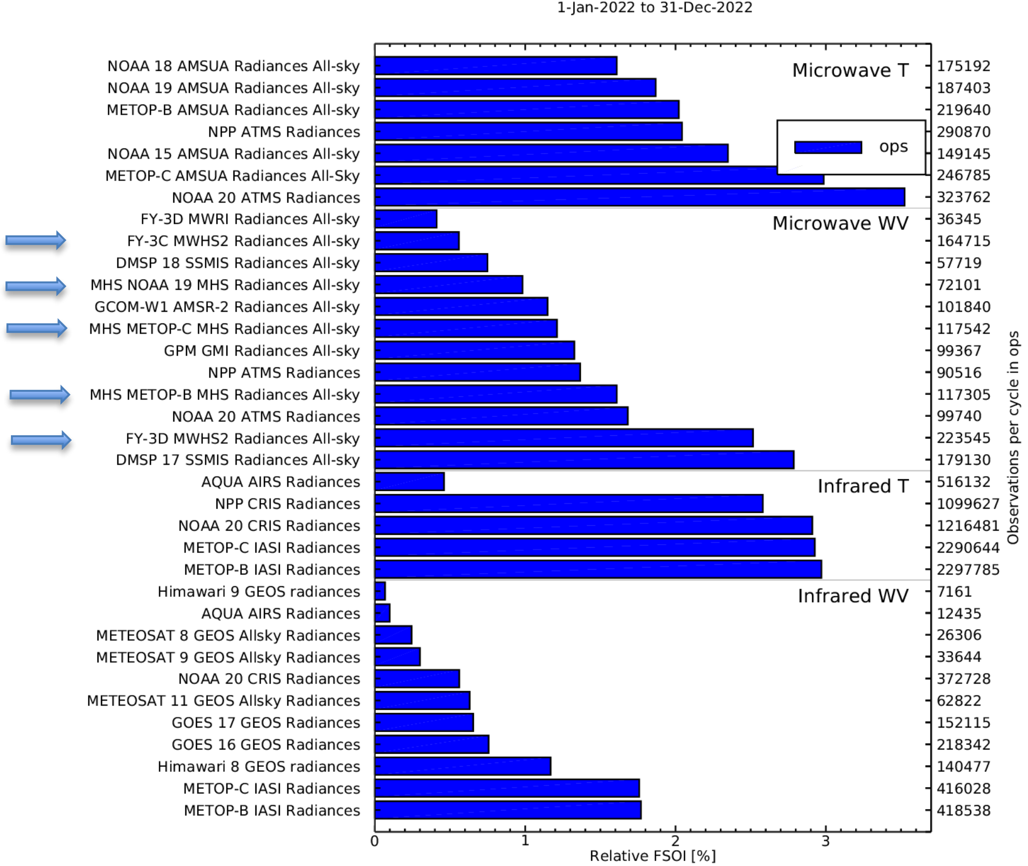
ECMWF uses humidity sounders in all-sky on **5 satellites:**

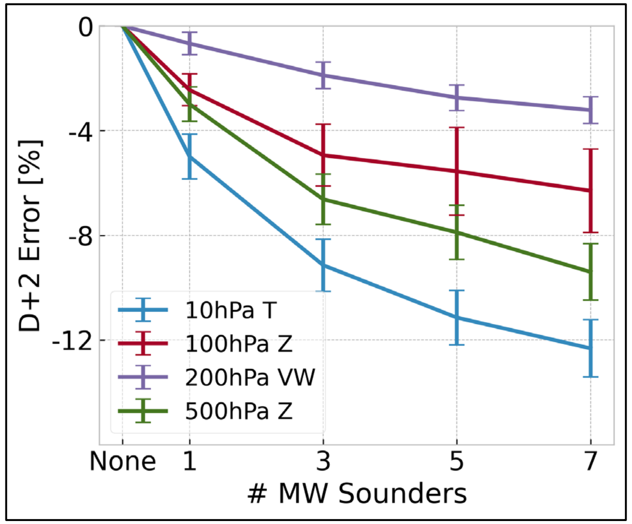
→ **MHS** (Metop-B/C, NOAA-19)

→ **MWHS2** (FY-3C/D) [*FY-3E added Feb 2023*]

Recent studies have shown no 'saturation' of microwave sounders (temperature & humidity) in the IFS

→ *Can we refine/optimise their usage?*



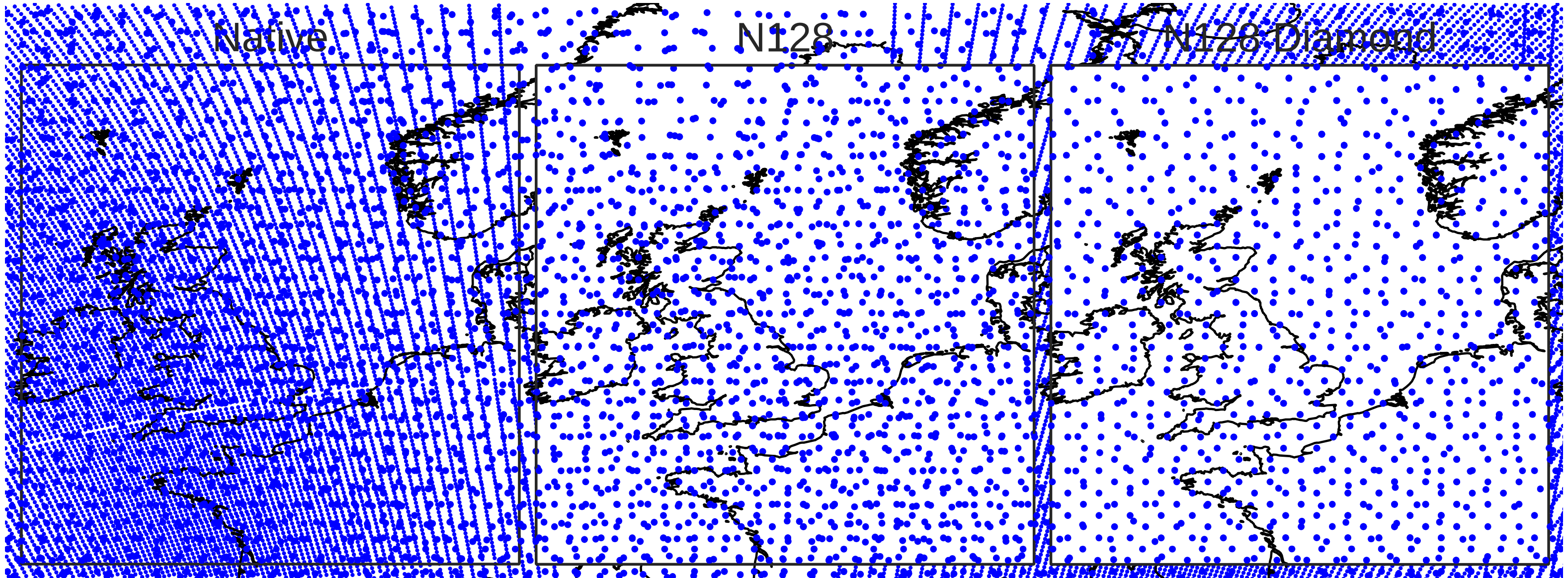


From *Duncan et al. 2021* [https://doi.org/10.1002/qj.4149]

Data

Currently in the IFS, MHS & MWHS-2 are thinned and not averaged

- Primary thinning on N128 gaussian grid (~78 km spacing)
- Secondary thinning removes data in diamond pattern (~110 km spacing)
- No averaging is applied, unlike imagers (e.g. GMI) which are *superobbed*

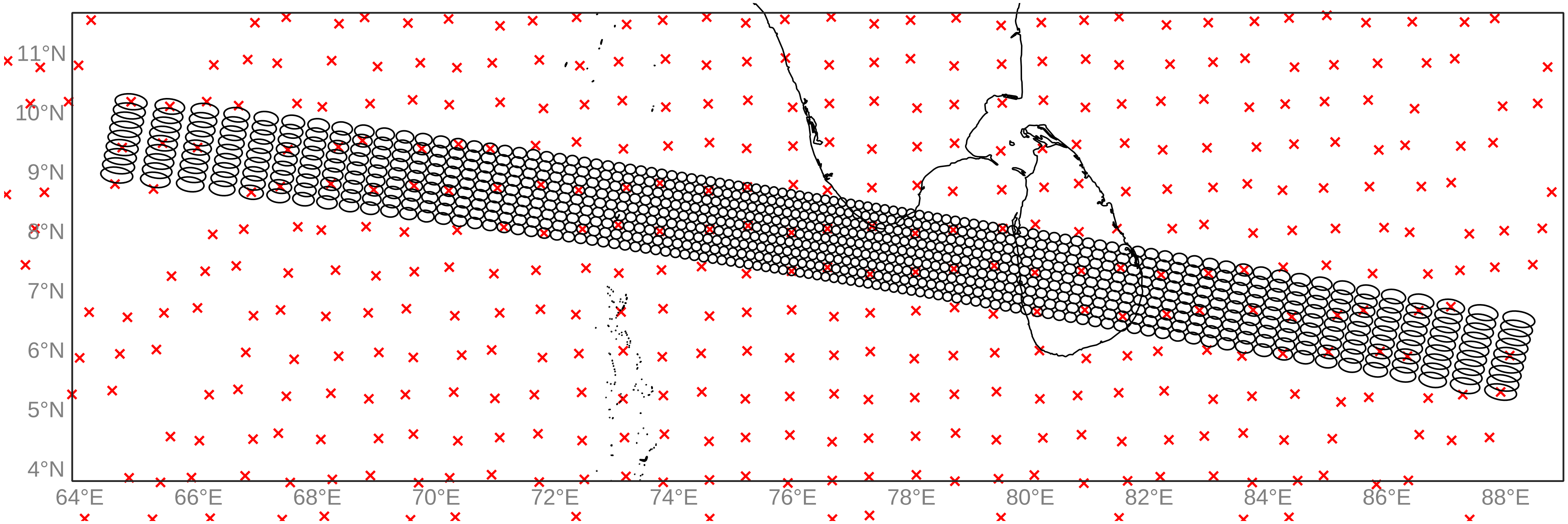


Data

MHS & MWHS-2 have **16 km spacing** (at nadir) with 16 km field of view (FOV) size

FOV increases with scan angle → 16x16 to 51x27 km at scan edge

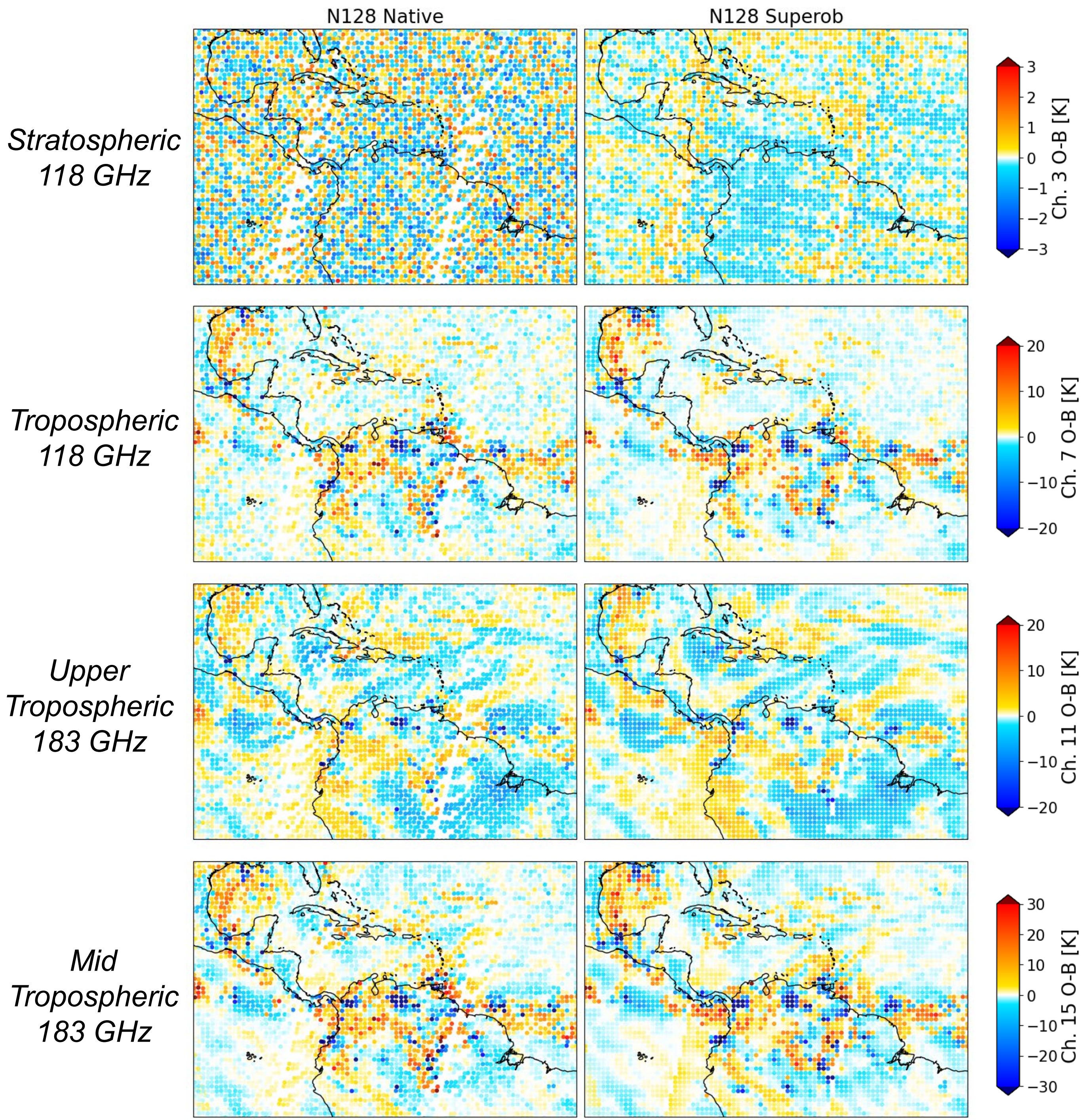
- *At nadir, ~95% of data points are discarded in primary thinning*
- *Different FOV sizes are not accounted for*



Superobbing

- Take all points within gaussian grid box and average them together into one ‘super observation’
- Superobbing acts to:
  - Decrease random noise
  - Make observations more representative
  - Implicitly deal with different FOV sizes
- Originally developed for the large, overlapping FOVs of microwave imagers

Impact of superobbing shown for MWHS-2 O-Bs →



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Method

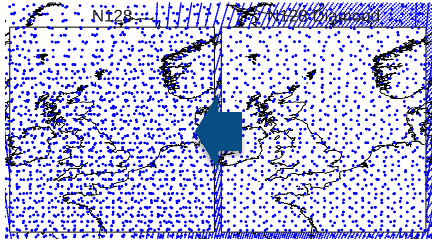
A set of experiments to answer a few questions:

- *Can we thin less, i.e. assimilate more radiances from existing sensors?*
- *Is there benefit from averaging (superobbing)?*
  - *If so, what is an optimal superob resolution?*
- *What if we combine averaging with less thinning?*

Experiments use IFS Cycle 48r1

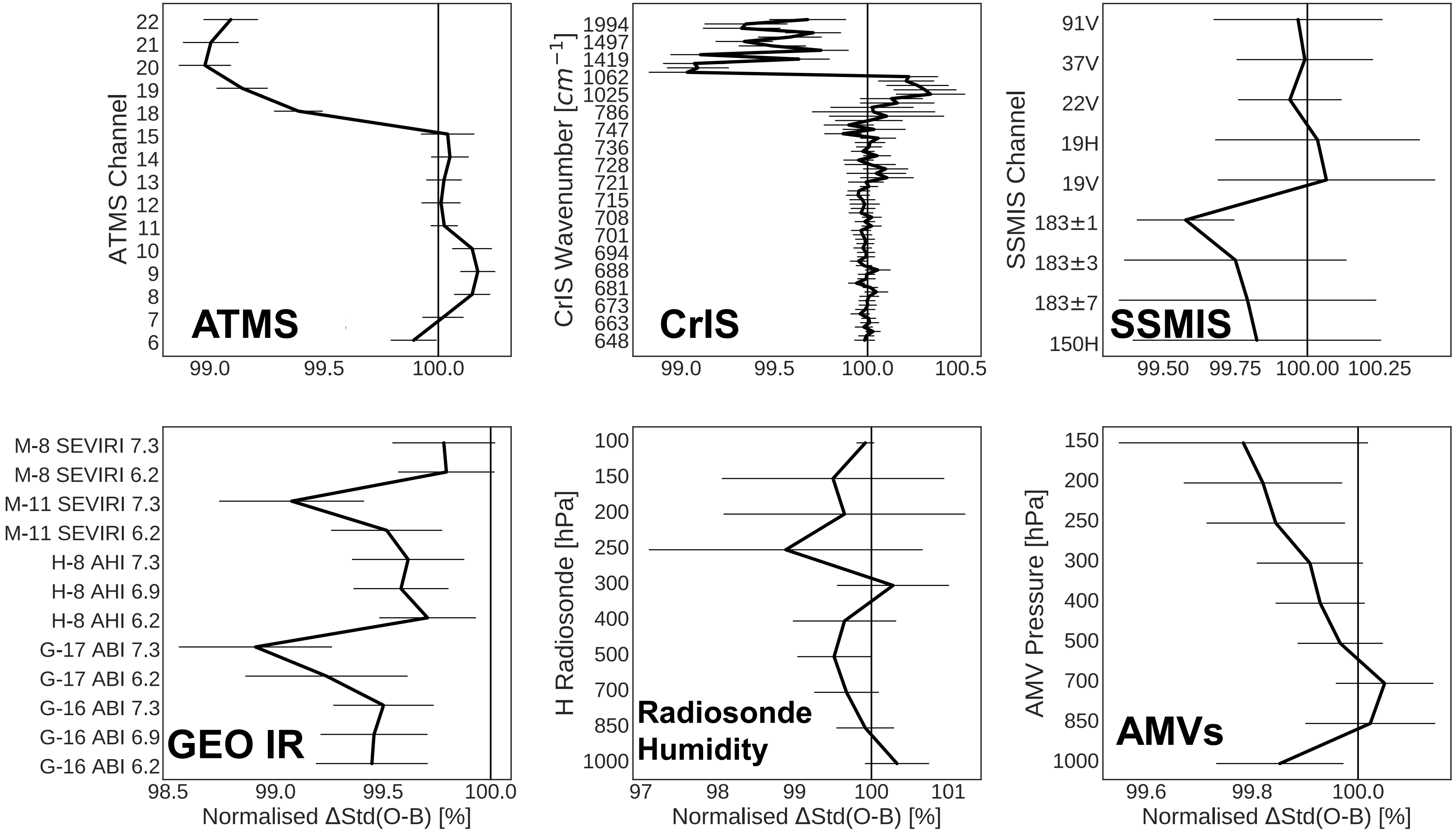
- 2 seasons: JJA 2021, DJF 21-22
- Full observing system assimilated – as in operations
- TCo399 (29km) final model resolution

Double data



Decrease thinning from 110km to 80km → double data

- Strong impact on other humidity-sensitive observations
- Small positive winds impact
- Comparable effect on O-B fits as adding a new sounder
- Slight degradation of UTLS channels on ATMS (chs 8-10)



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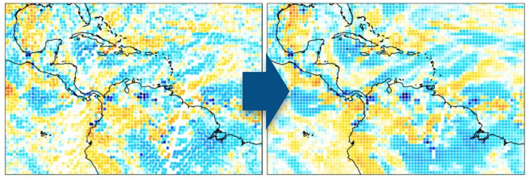
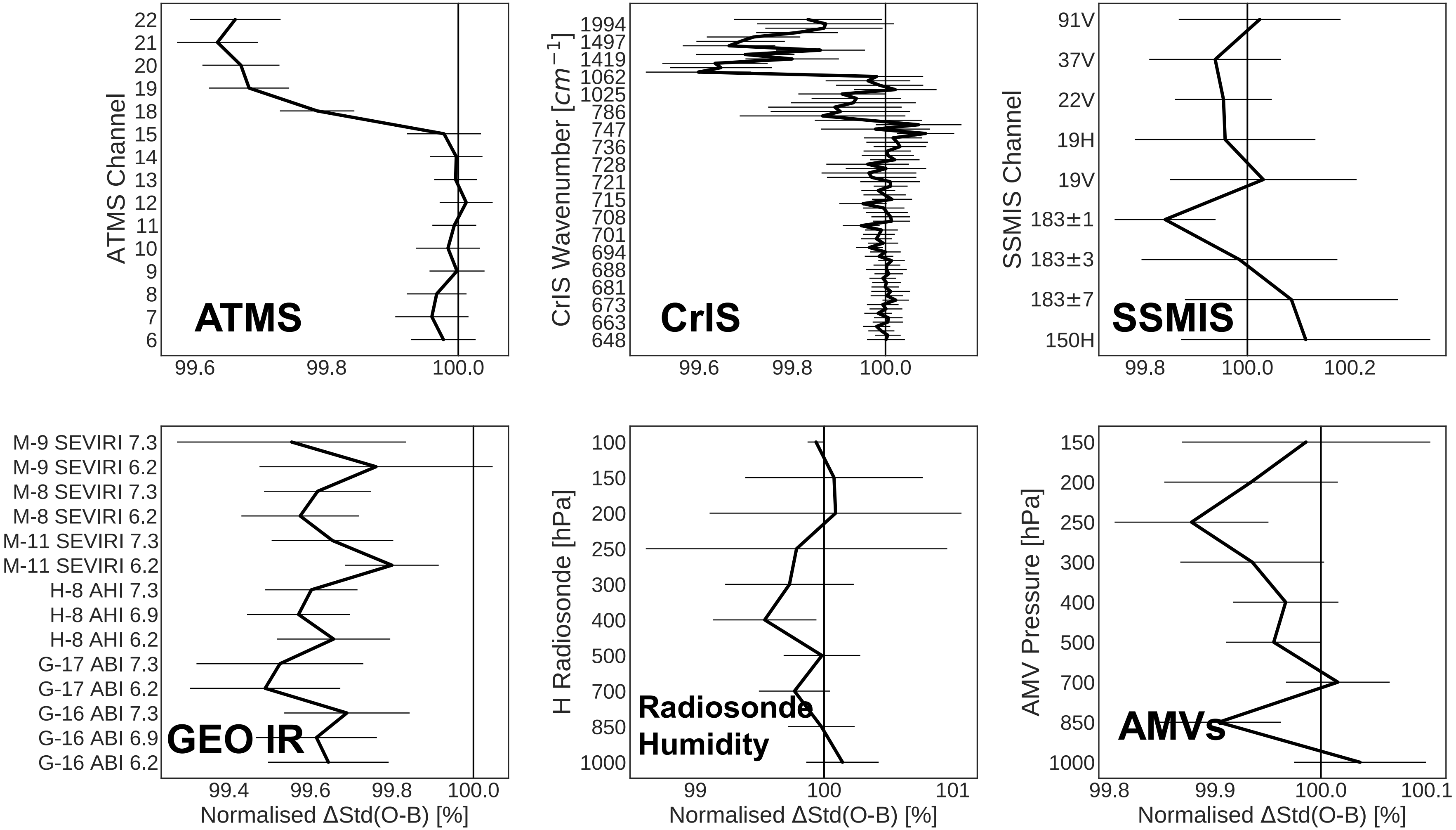
Superob data



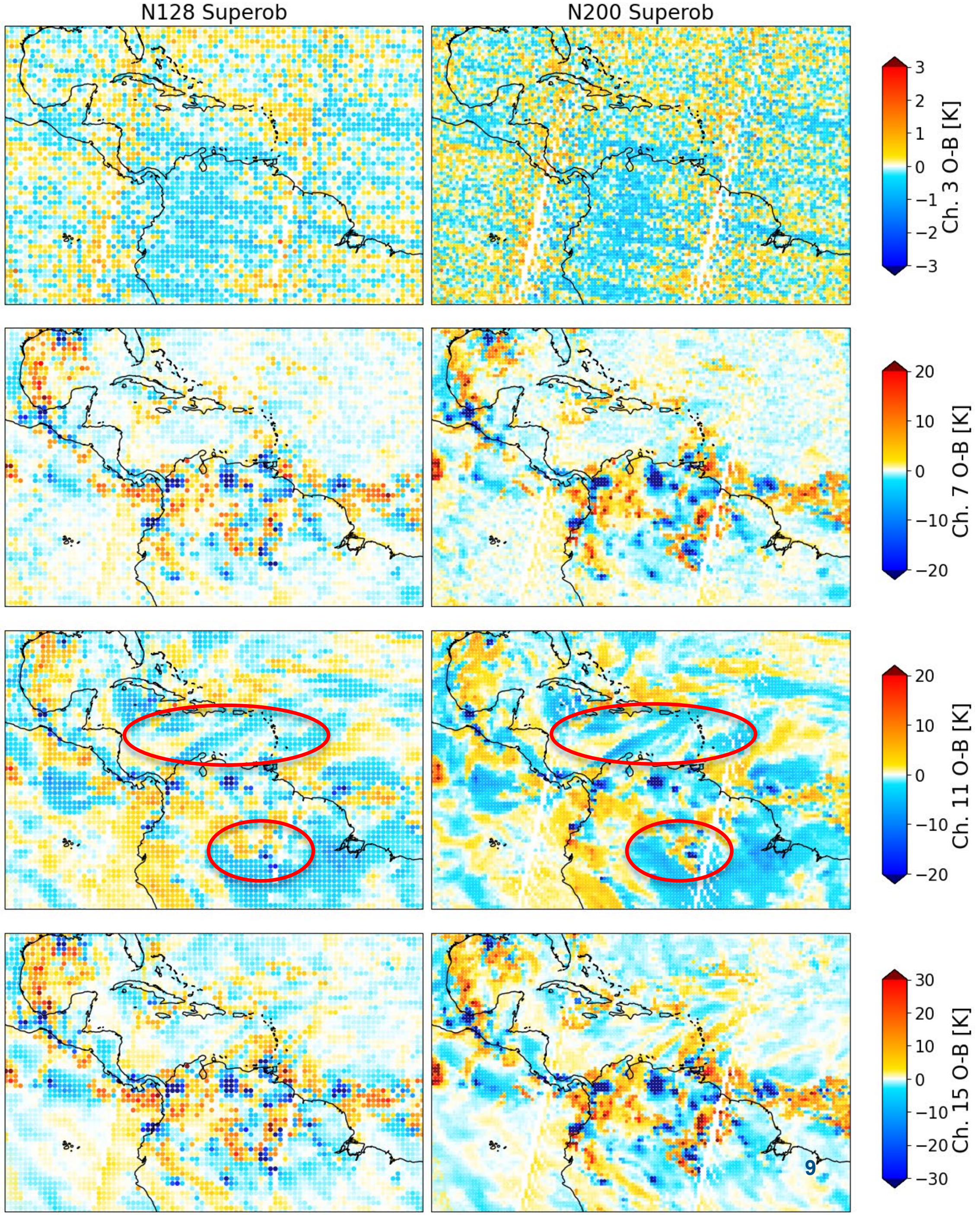
 # obs assimilated almost constant, thinning retained

- Similar effects of data doubling but smaller magnitude
- Effectively *extracting more information content* by discarding less data
- Impressive result from averaging alone



Combine more data & superob

- Test N200 (50 km) superobs with diamond thinning
  - Yields ~70 km spacing
  - ~140% more data assimilated at 183 GHz
- Finer spatial structures revealed in gravity waves and convection
- Finer superob (i.e. 50 vs. 80 km) useful for diagnostics



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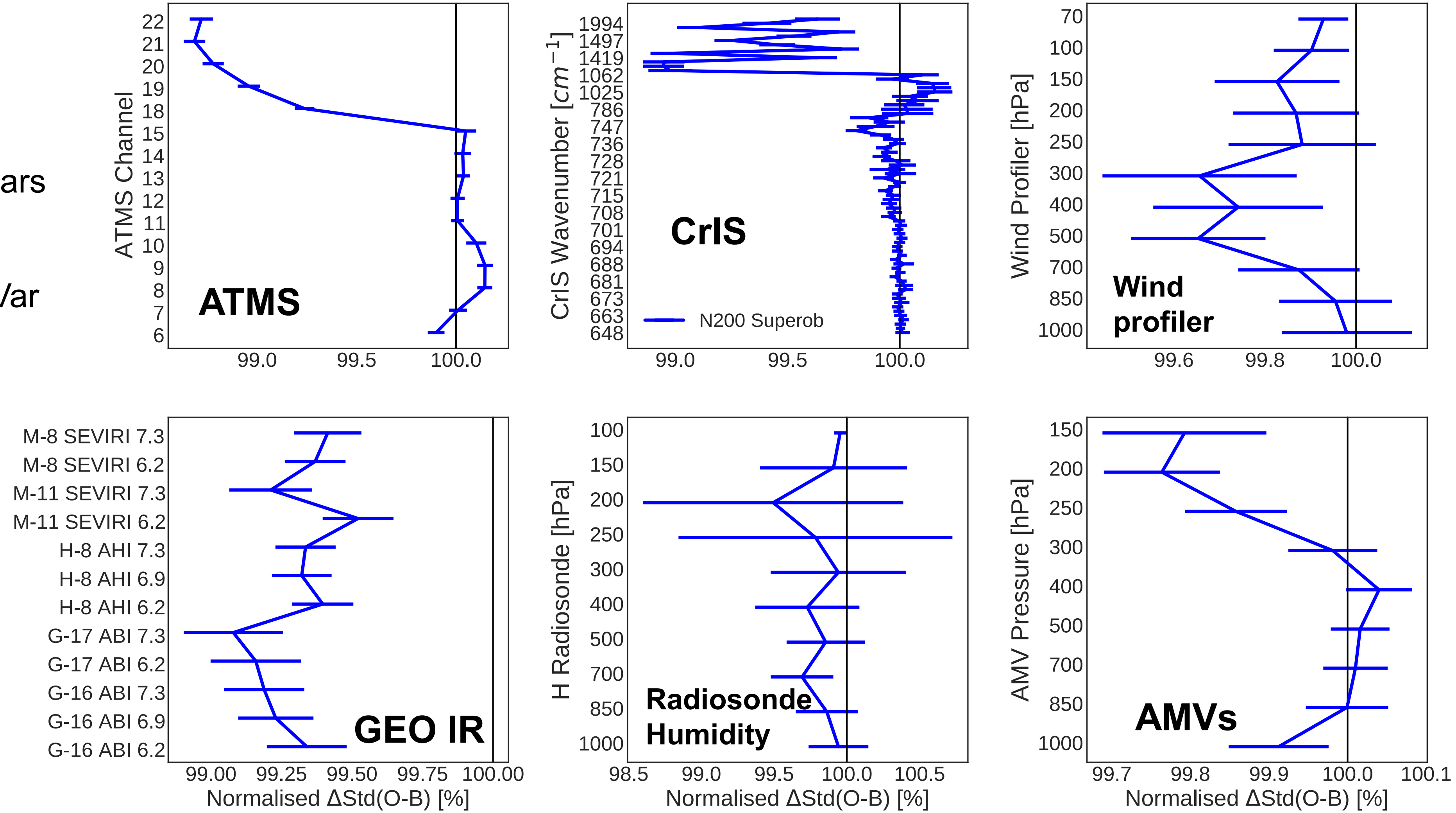
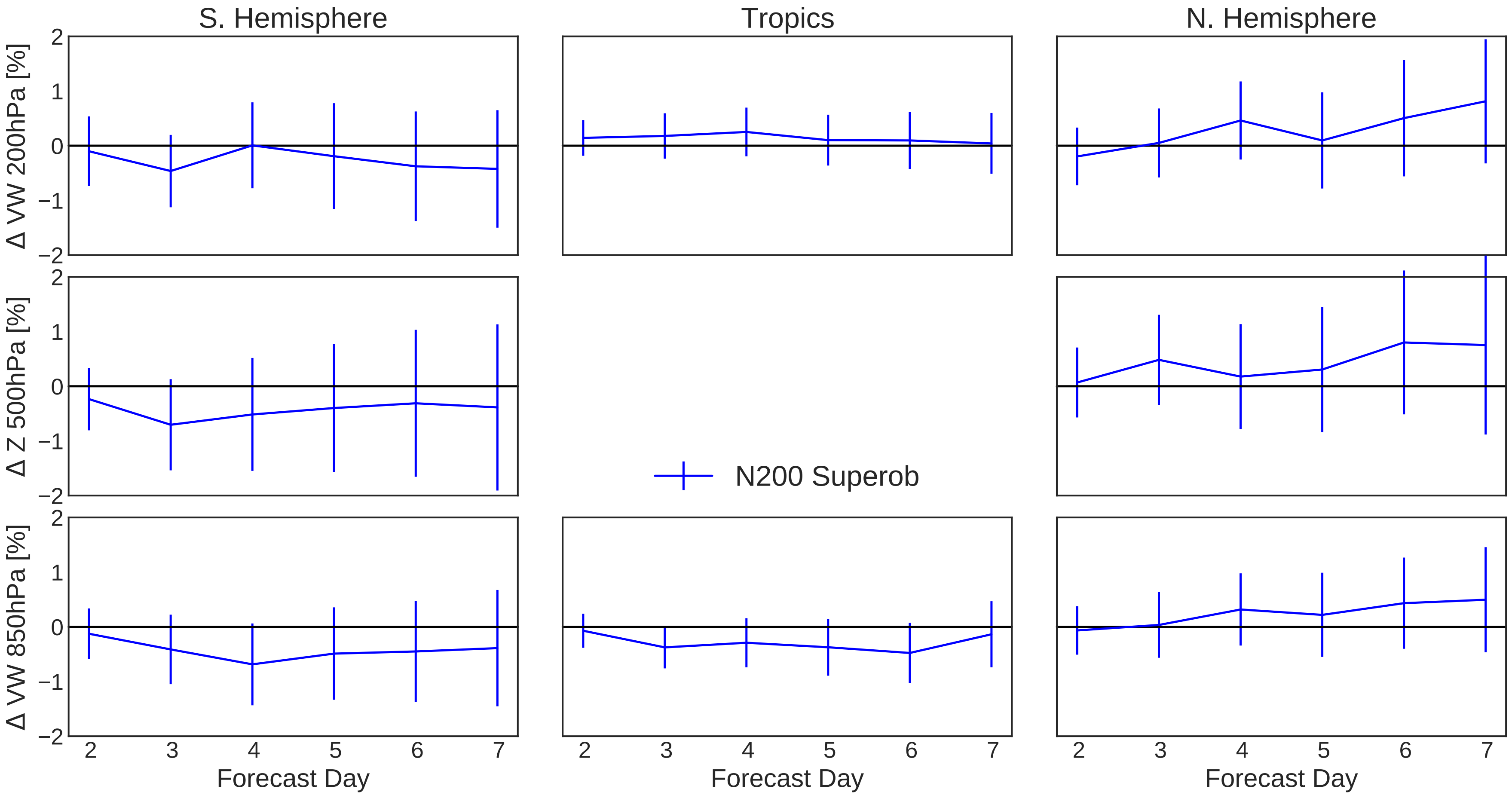
Combine more data & superob

- Combined impact follows previous results (additive)
- The data addition signal appears to dominate
- Impact on winds through 4D-Var tracer effect



Combine more data & superob

- Medium-range scores fairly neutral
- Winds at 850 hPa just at edge of 95% confidence levels
- Verification against own-analysis leads to apparent degradation at short-range



Conclusion

Superobbing humidity sounders has benefit on its own

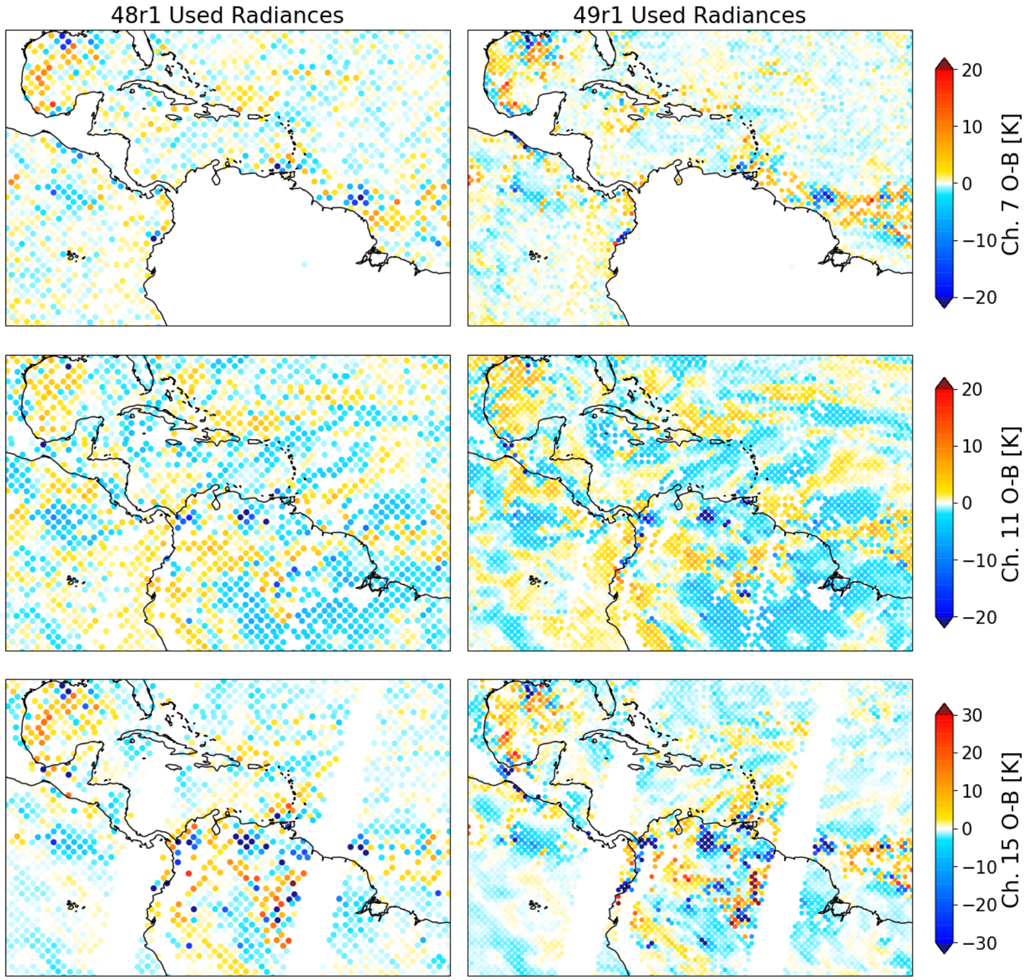
- Improve representation error particularly near nadir
- Effectively discard fewer observations; fuller use of total information content

Decreased thinning has even larger benefit

- Comparable impact to adding a new sounder

In upcoming IFS Cycle 49r1, all-sky humidity sounder pre-processing will change

- 110 km → *70 km thinning*; native resolution → *50 km superob*
- This increases 183 GHz radiances assimilated from MHS & MWHS-2 by 140%
- Significant improvements to short-range humidity and wind forecasts



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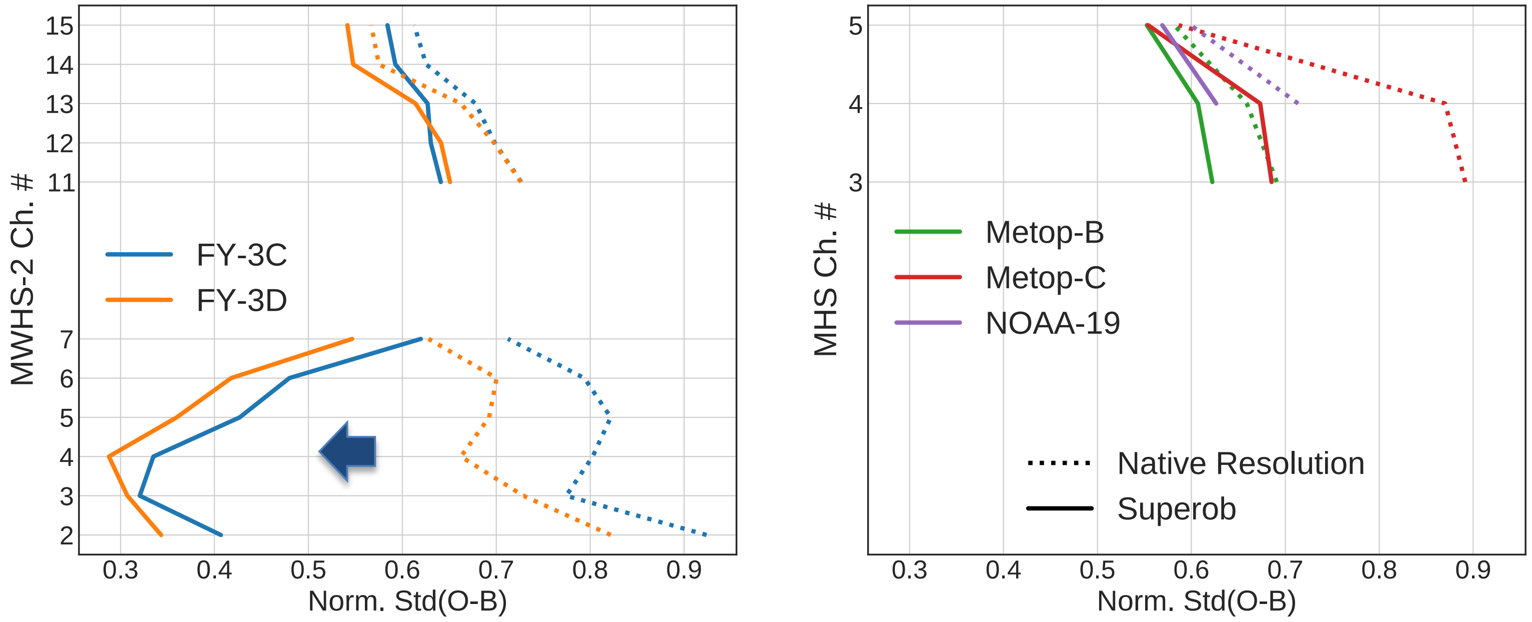
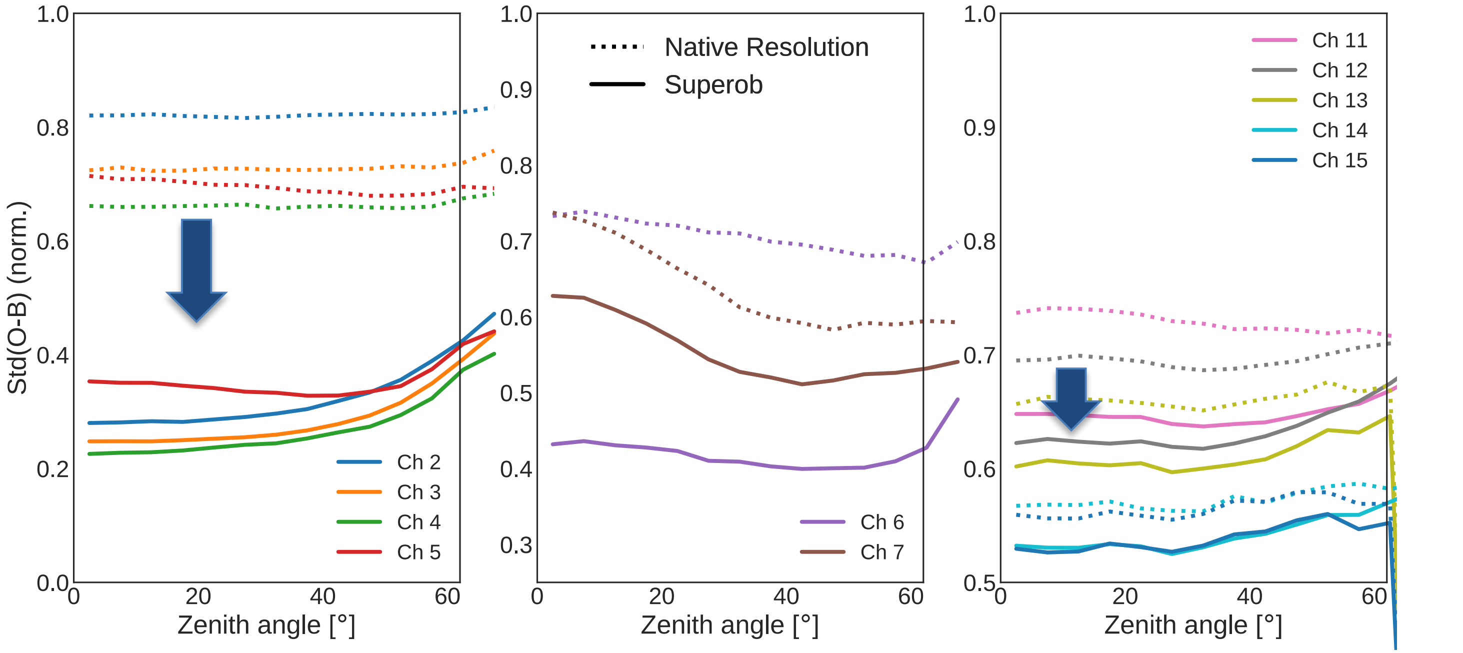
Tech Memo just published: Duncan et al. (2023) http://dx.doi.org/10.21957/5c3b9c8d9f

Backup Slides

Superobbing

- N128 (80 km) Superob shown here
- Superobbing decreases std(O-B):
  - 5-15% for 183 GHz
  - 15-60% for 118 GHz
- Normalised departures change significantly if obs. errors not retuned
- Effect has noticeable zenith angle dependence – more radiances averaged together near nadir





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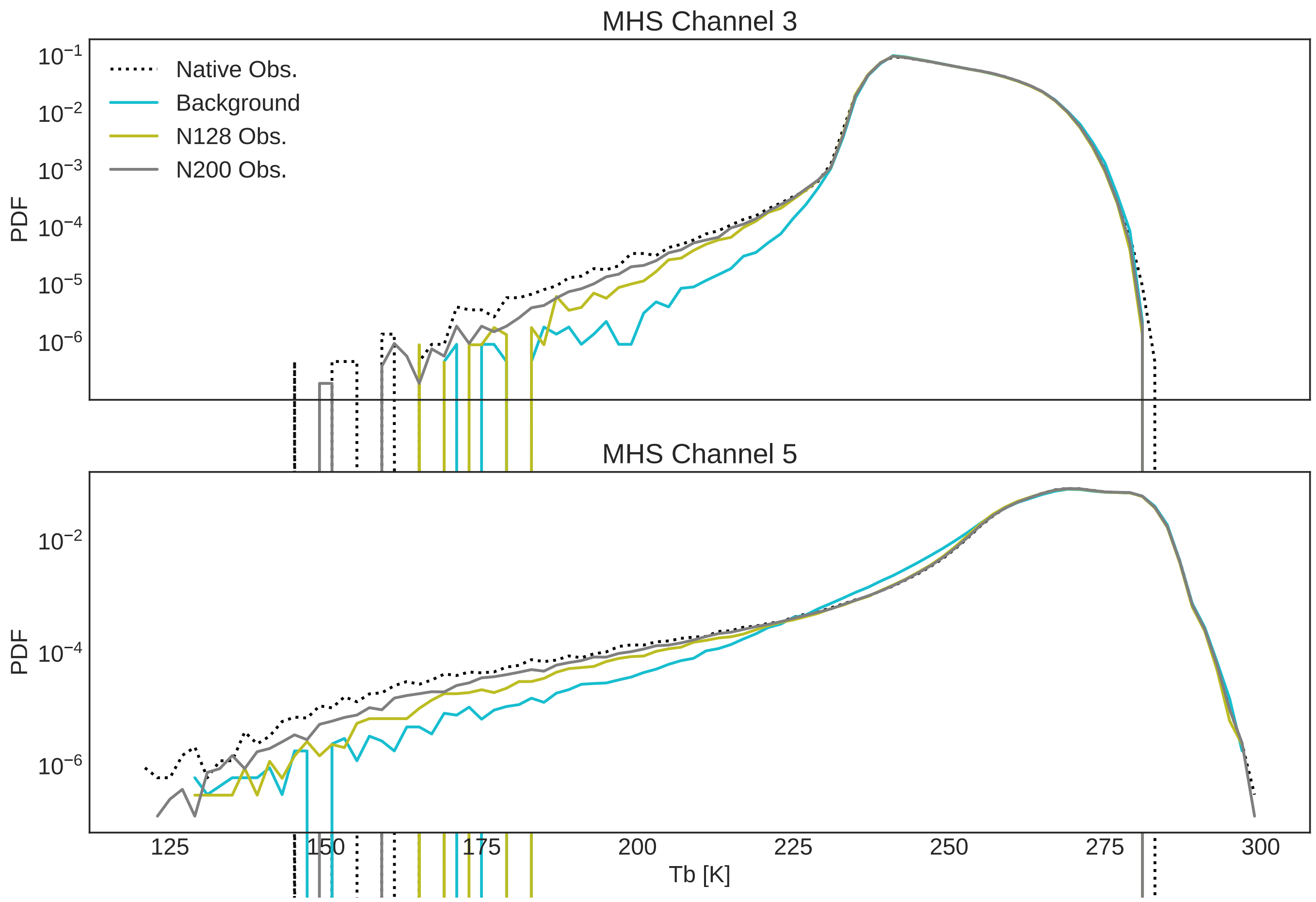
Superobbing

- Some advantage in averaging radiances to better fit model background PDF
- Frequency of coldest TBs (heavily scattering scenes) better match model background
- This should help with representation error



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Optimal superob size?

**N128 = 78 km*

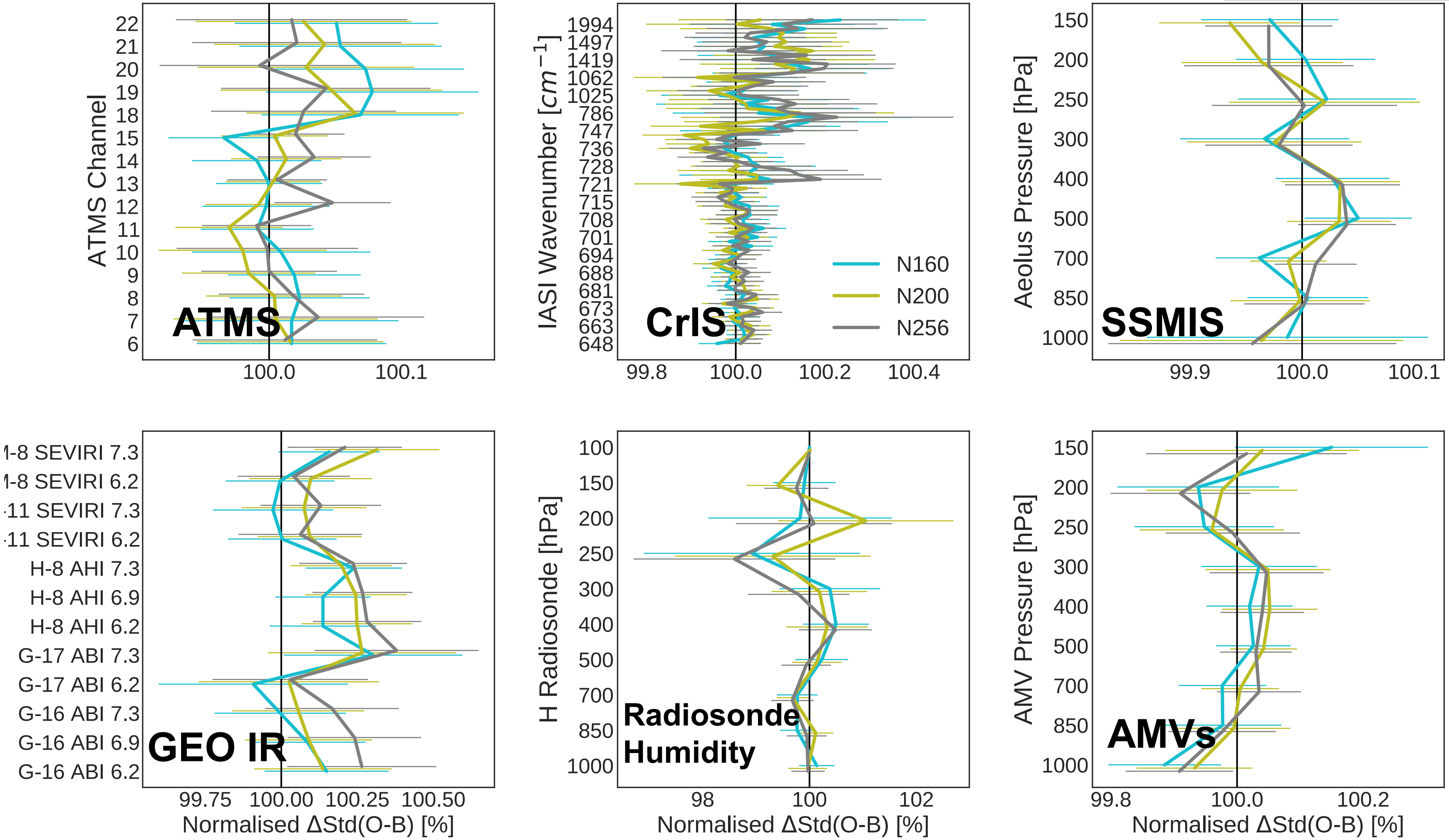
N160 = 62 km

N200 = 50 km

N256 = 39 km

Test **finer superob resolutions** whilst conserving # obs

- Here 80 km superob is the control (100%)
- Little impact
- If observations should ideally approach model "effective resolution" (roughly 3-4x model res), N128 might be near ideal for TCo399?
  - 29 km * 3-4 ≈ 80-120 km
- These results would likely change if run at higher model resolution



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