Radiosonde data denial studies and implications for height attainment

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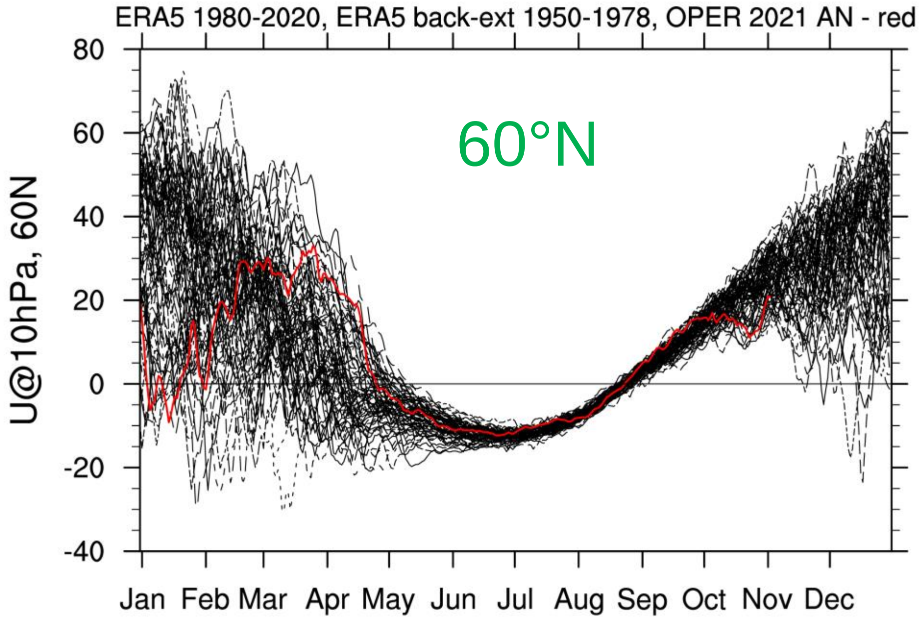
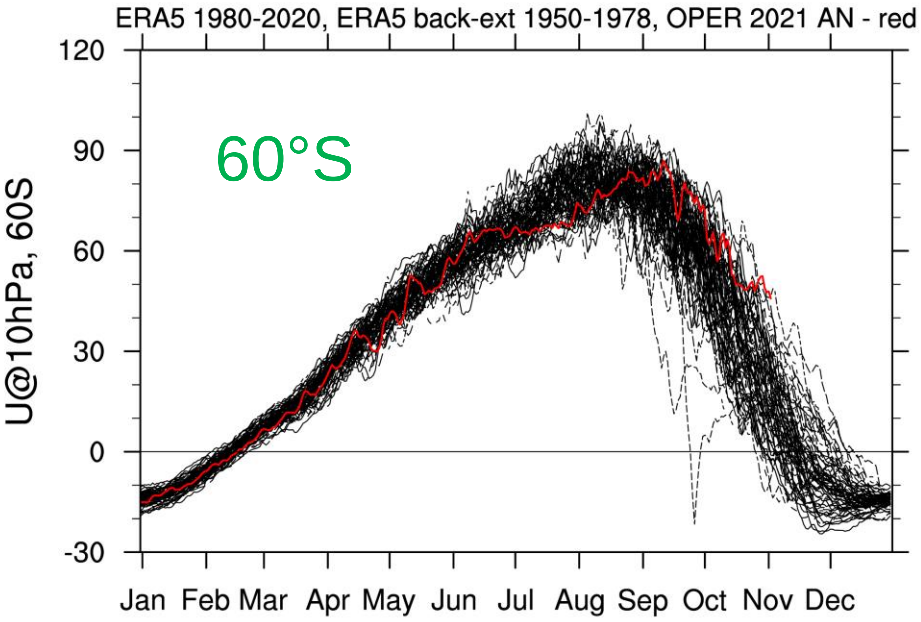
Overview

- Seasonality of stratospheric variability and FSOI (recap from Nov 2021)
- Results from data denial studies (OSEs)
  - Control (all data)
  - noRS – no radiosonde data
  - noRSlt100 – no radiosonde data for P<100 hPa
  - noRStq – no radiosonde temperature or humidity
- Geostrophic balance in the stratosphere
- Other: Modem O-B statistics, assimilation of stratospheric humidity?
- Summary

Stratospheric seasonality
- work with Inna Polichtchouk
U10 hPa @ 60°N, 60°S

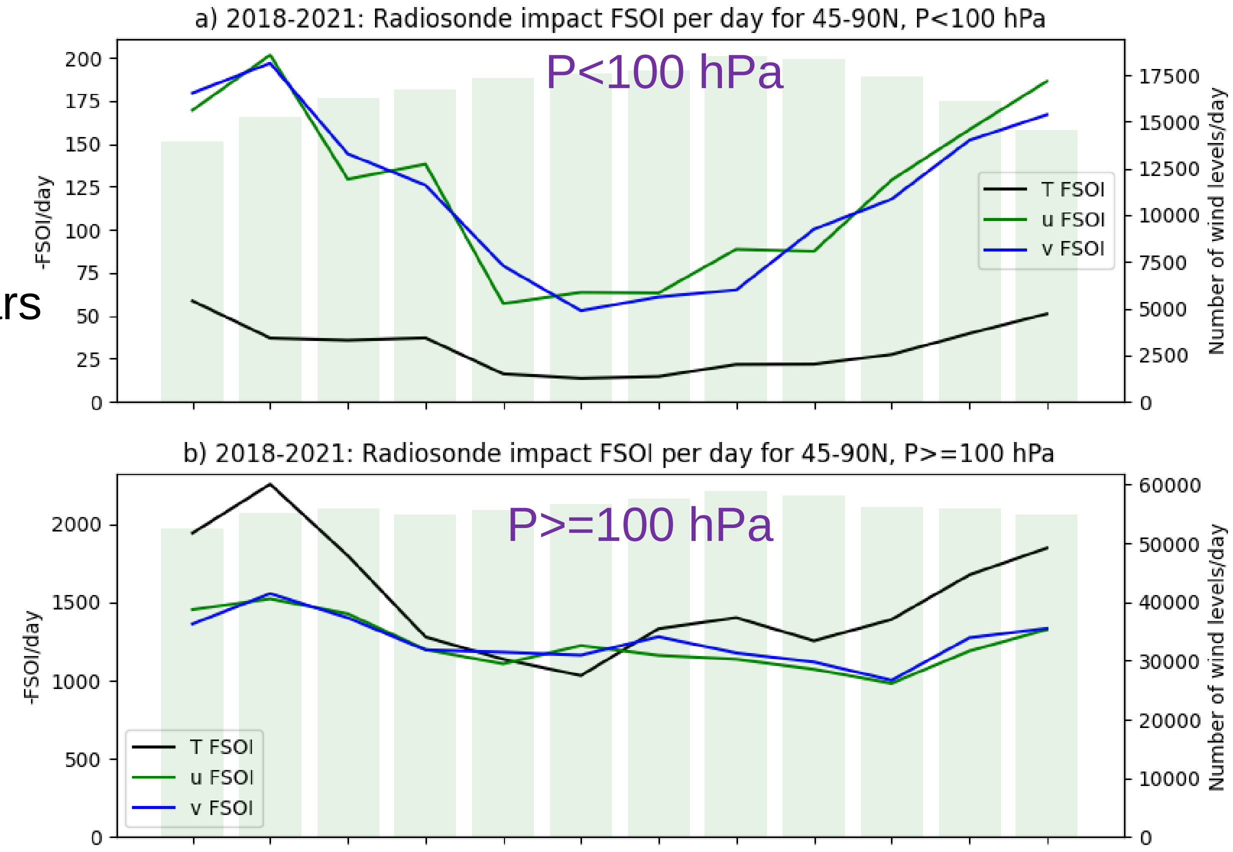
- Different years plotted 1950 to 2021
- Data from ERA5 (Hersbach et al, QJ, 2020)
- Winter: strong polar vortex
- SH vortex stable except when breaking down in Austral spring
- In NH winter planetary waves disturb the polar vortex
- Largest disturbances form stratospheric sudden warmings (SSWs)
- In summer there are about 4 months when nothing much happens – except a few gravity waves





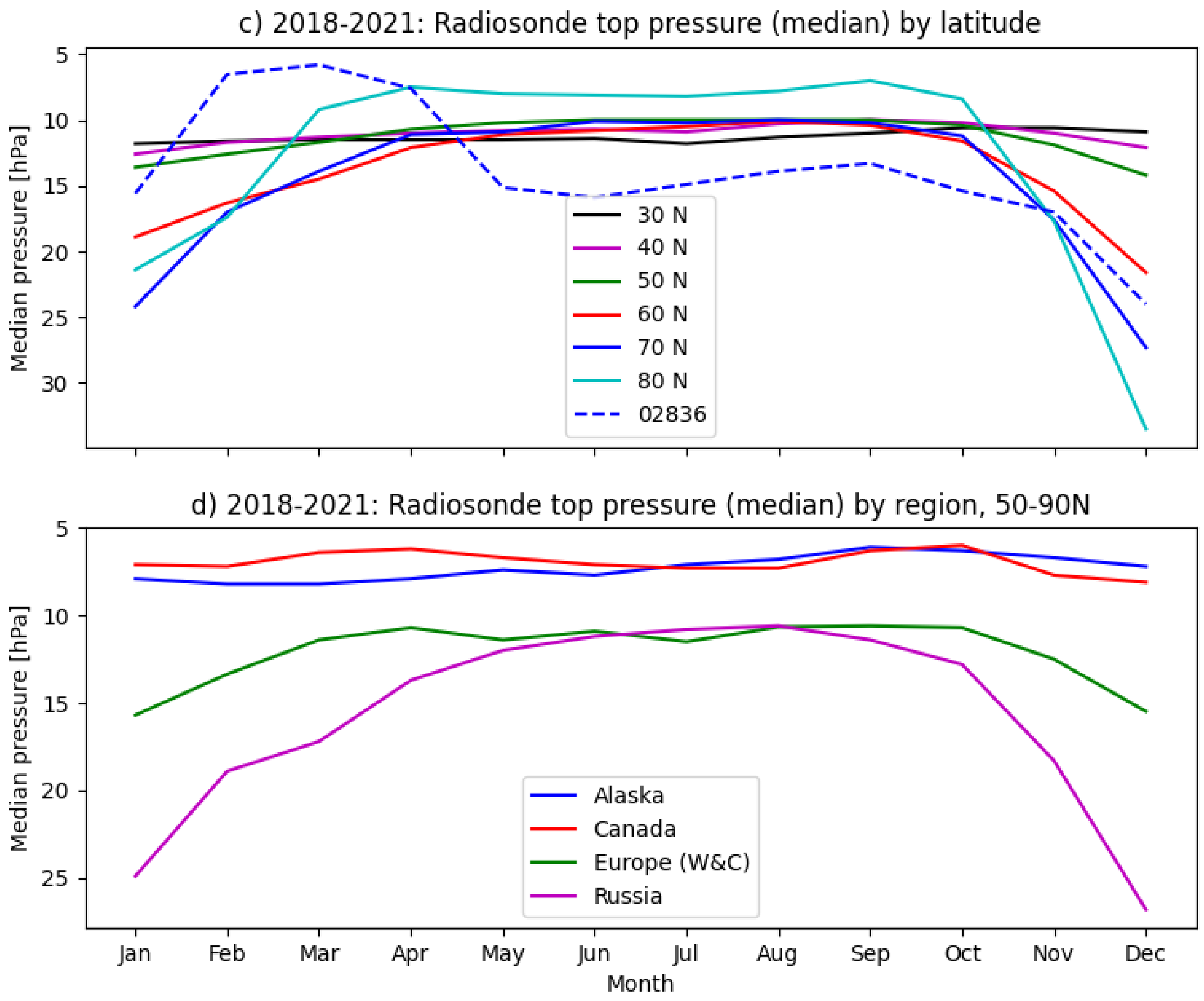
Annual cycle of radiosonde impact in stratosphere 45-90N

- Forecast Sensitivity to Observation Impact (FSOI) – estimate of the importance of data in reducing errors in T+24 h forecasts (doesn't account for anchoring in bias correction)
- Radiosonde FSOI for different variables: 4 years
- Wind (U,V) FSOI > temperature FSOI
- Larger values Nov-April <u>despite</u> lower observation numbers (green bars)
  - Balloons burst at lower altitudes in winter ☹
  - Especially DJF
  - Could use larger balloons then (cost)
- Somewhat noisy plots …
- Upper level data in NDJF 'worth' about 3* the data in MJJA by this measure! See also OSEs



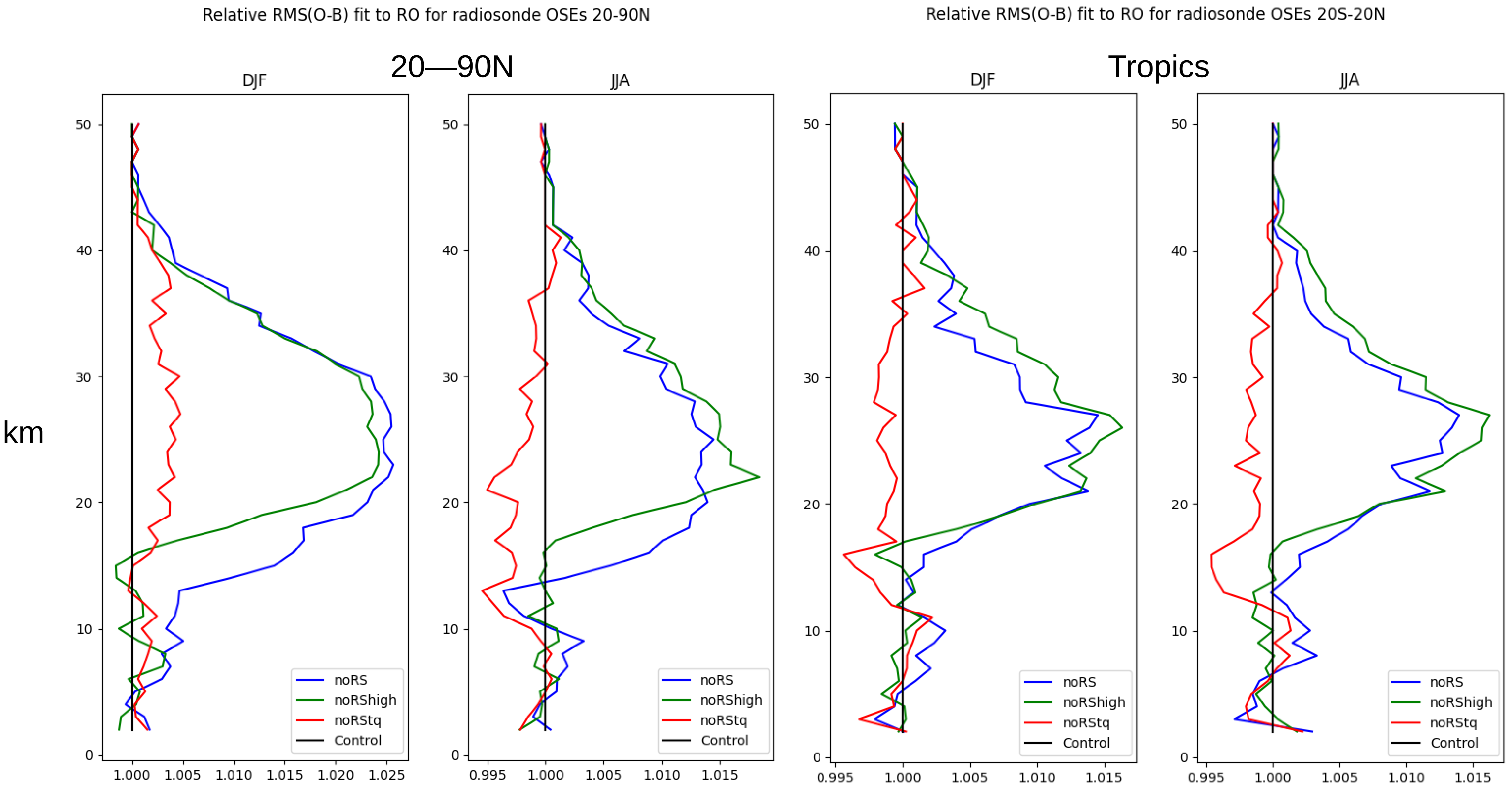
Annual cycle in (median) burst height

- Seasonality in burst height is largest at high latitudes
- Can see effect of larger balloon at Sodankyla (blue dashed line) – selected months
- Lower plot:
- Alaska: 600 g balloons
- Canada: 800 or 600 g
- Russia: 500 g
- Europe: varies, mainly 350 and 600 g
- Gas used will also affect height



T+12 fit to radio occultation (RO) data when removing sondes

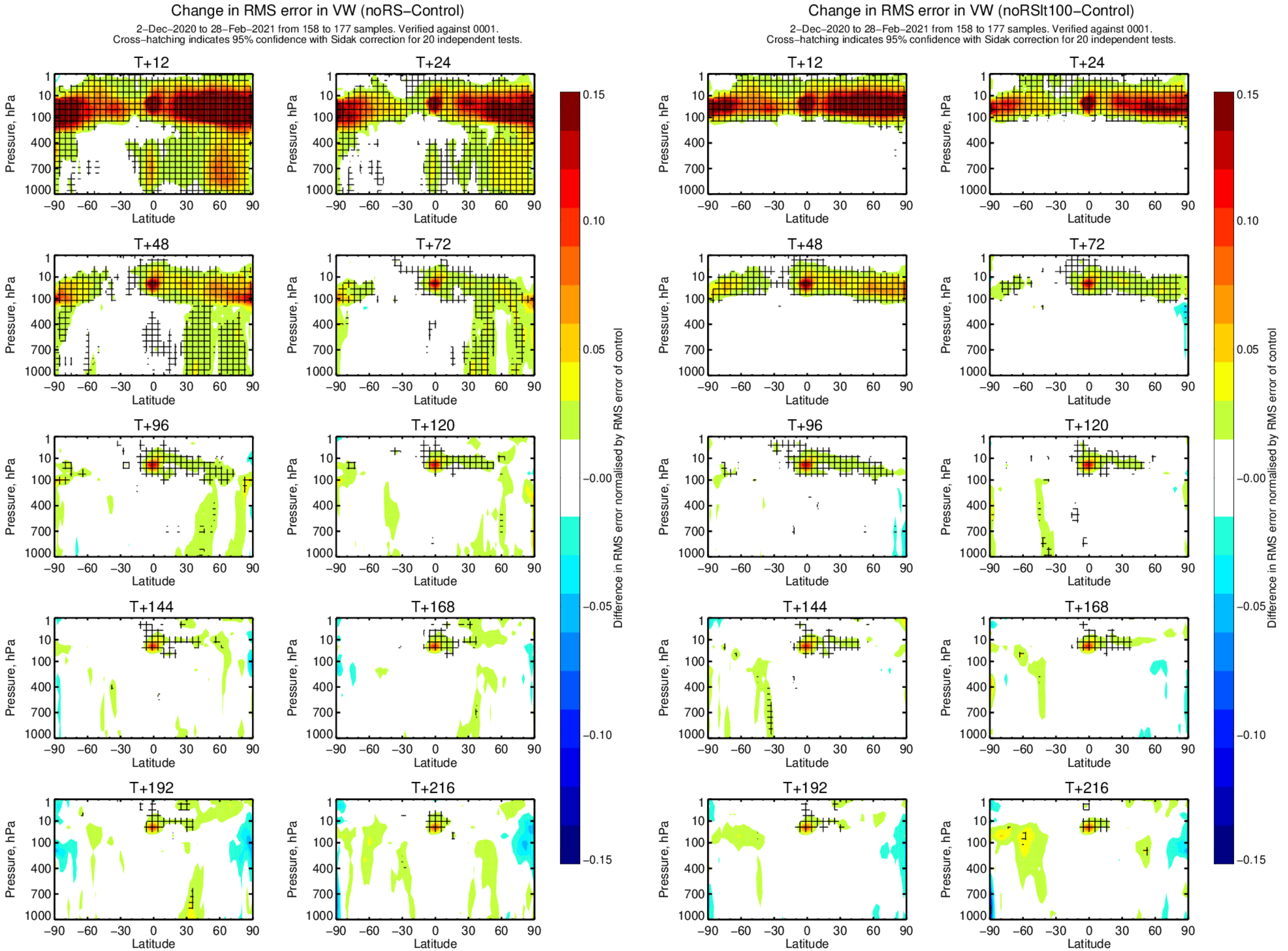
- In NH ~60% larger impact in DJF; minor impact of temperature (red line)



Wind impact from T+12 to day 9: noRS and noRSlt100

- Vs operational analyses
- Largest impact at short-range in NH (expected)
- Largest impact 150-50 hPa
- noRSlt100: impact mainly local, stays at P<100 hPa

- Larger impact of RS winds than temperatures partly because there are plenty of satellite data giving mass information
- Few satellite winds, esp. at upper levels



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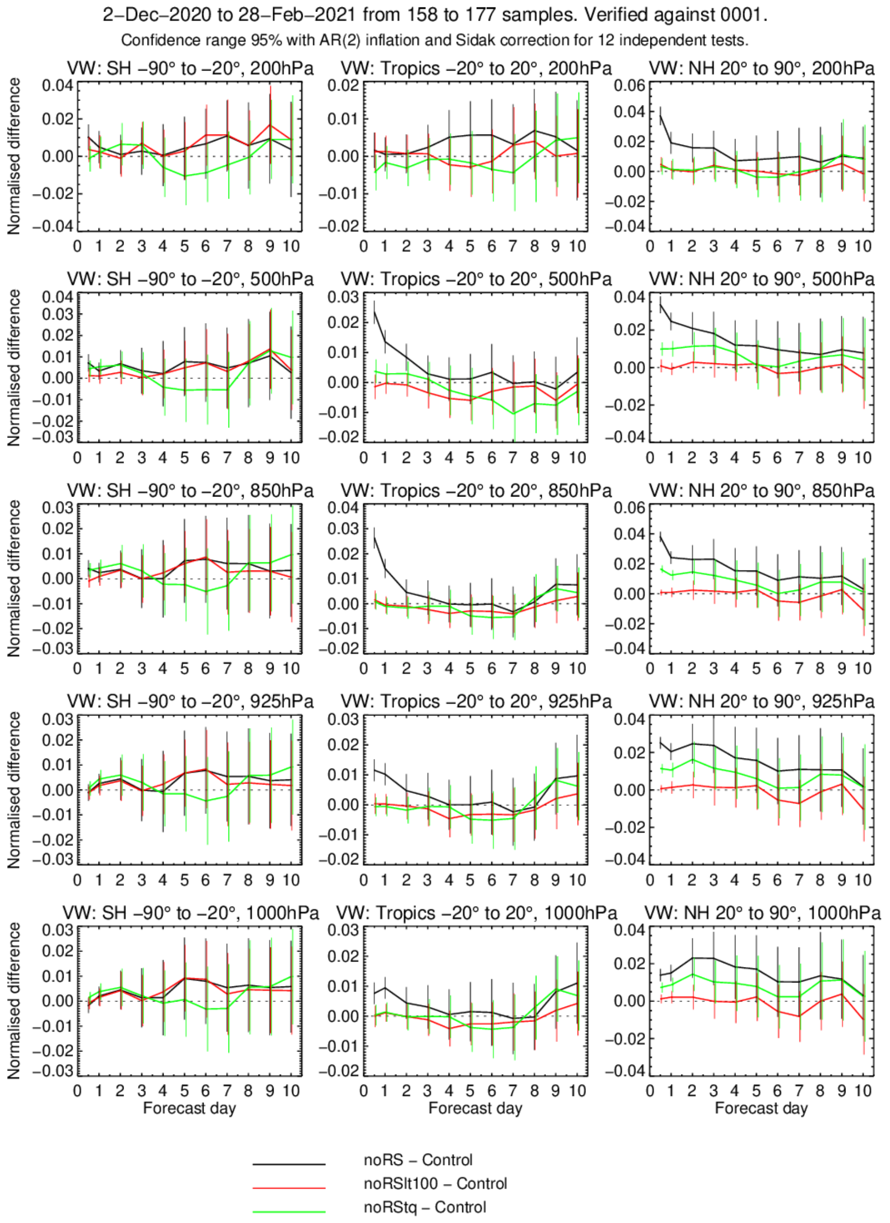
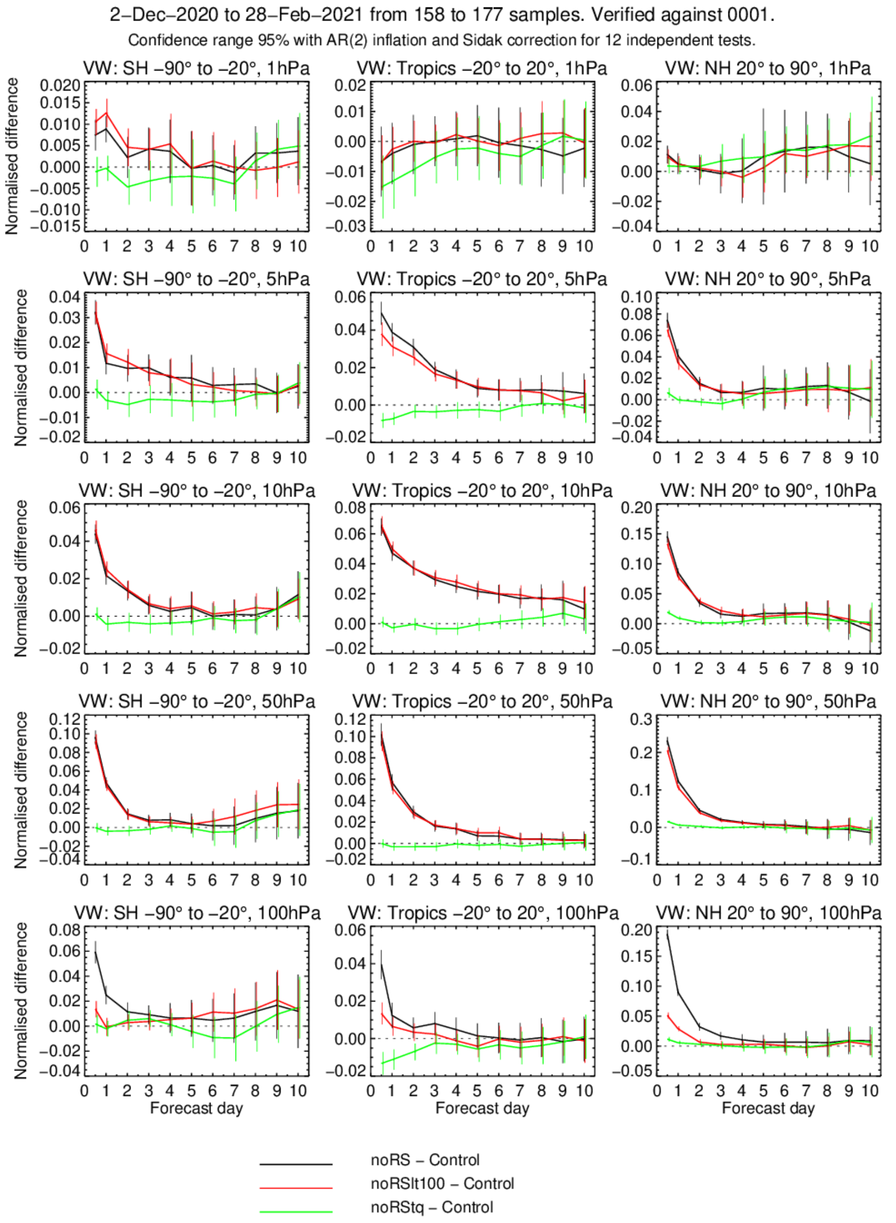
Timeseries vs forecast range

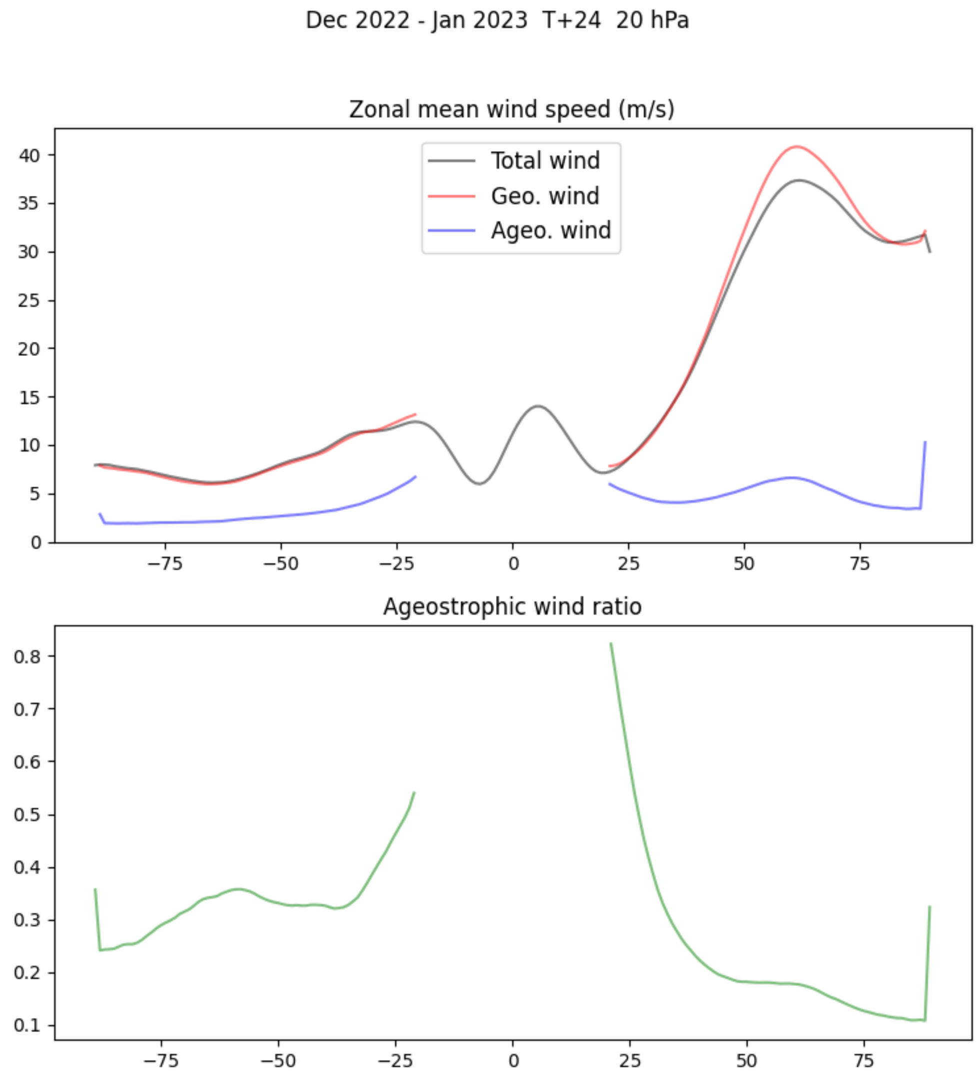
- ~20% impact at 100 and 50hPa in NH from noRS
- At 50 hPa and higher the lt100 results match the noRS (black) results (right-hand panel)

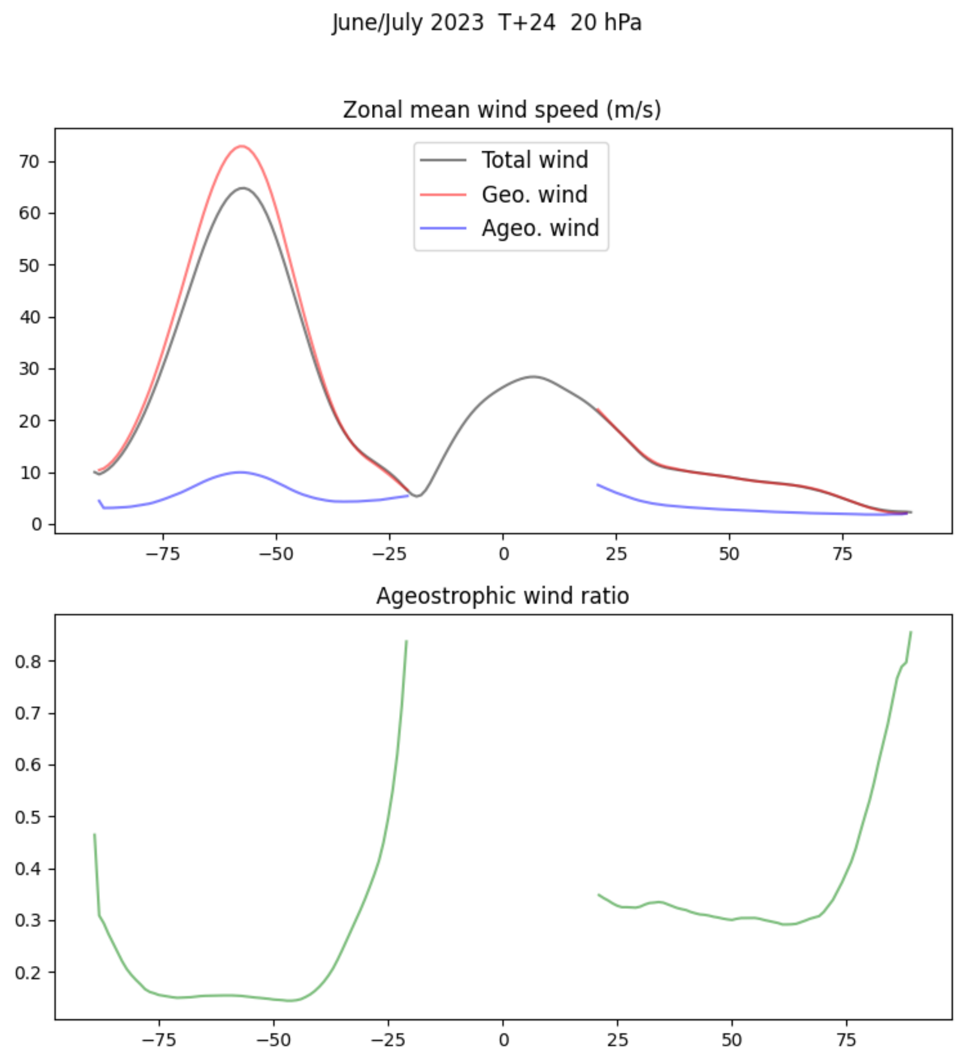




Geostrophic balance at 20 hPa, op T+24 fcs on 1x1 deg grid

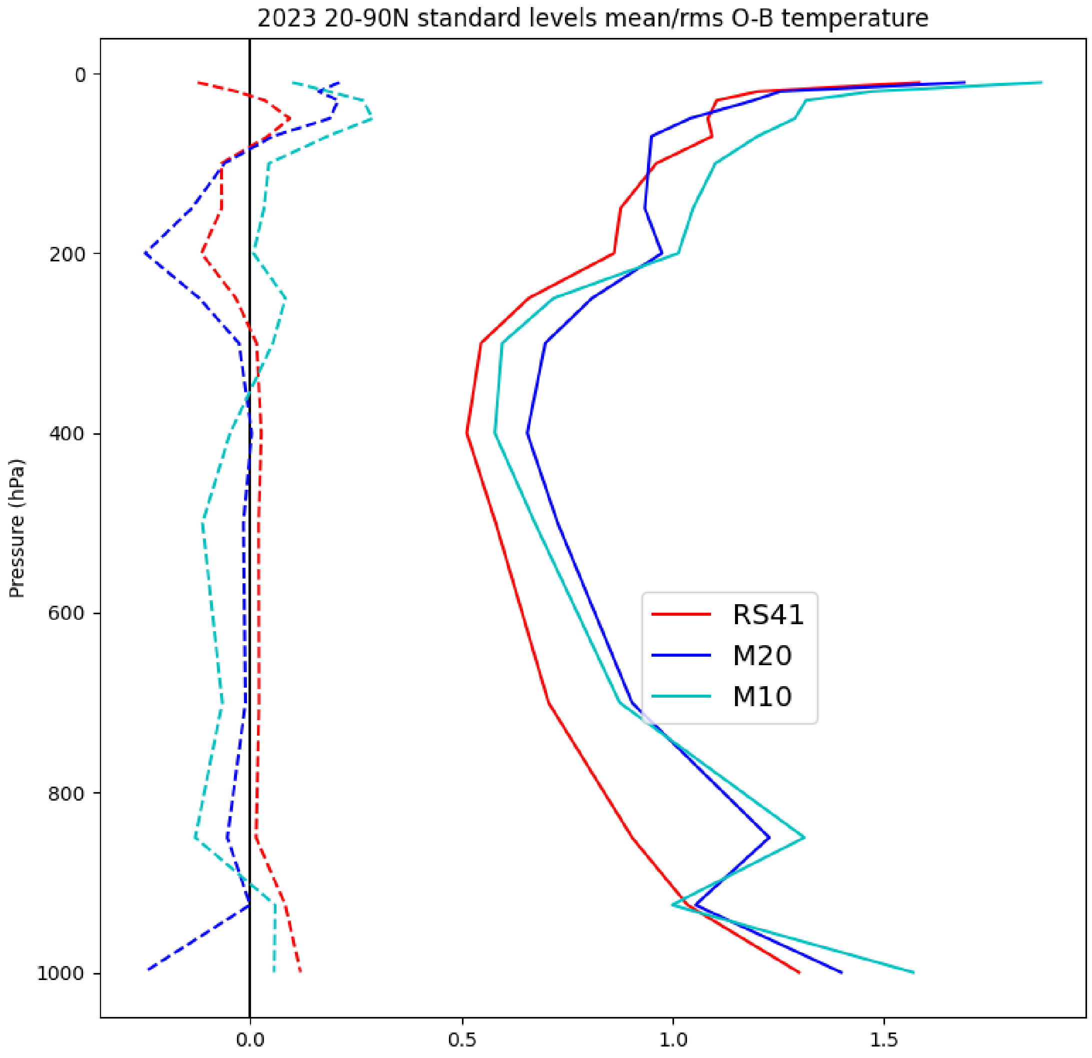
- Winter mid-latitudes close to geostrophic balance
- Also very strong winds
- The balance means that satellite data help with the winds more in winter

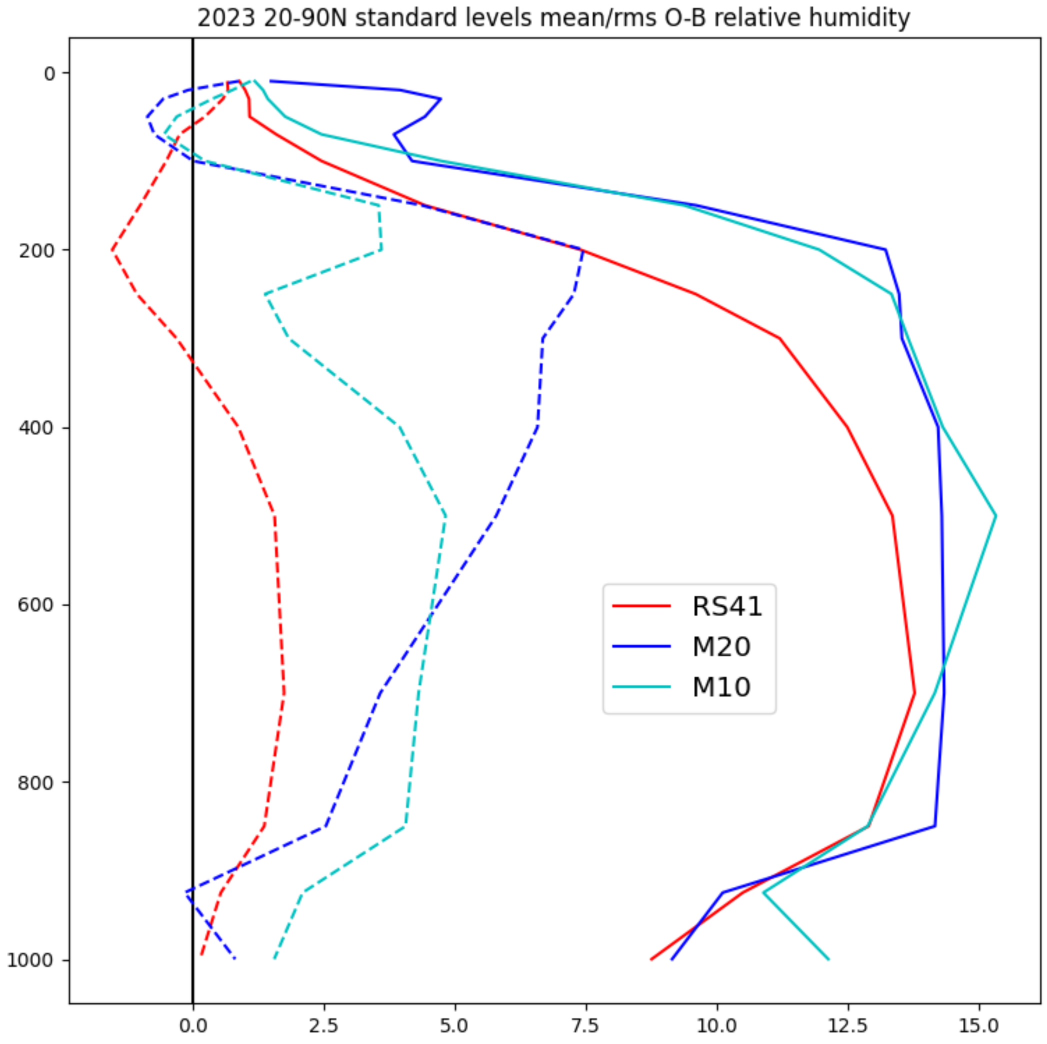




Misc 1. Modem O-B statistics vs RS41, standard levels, 2023

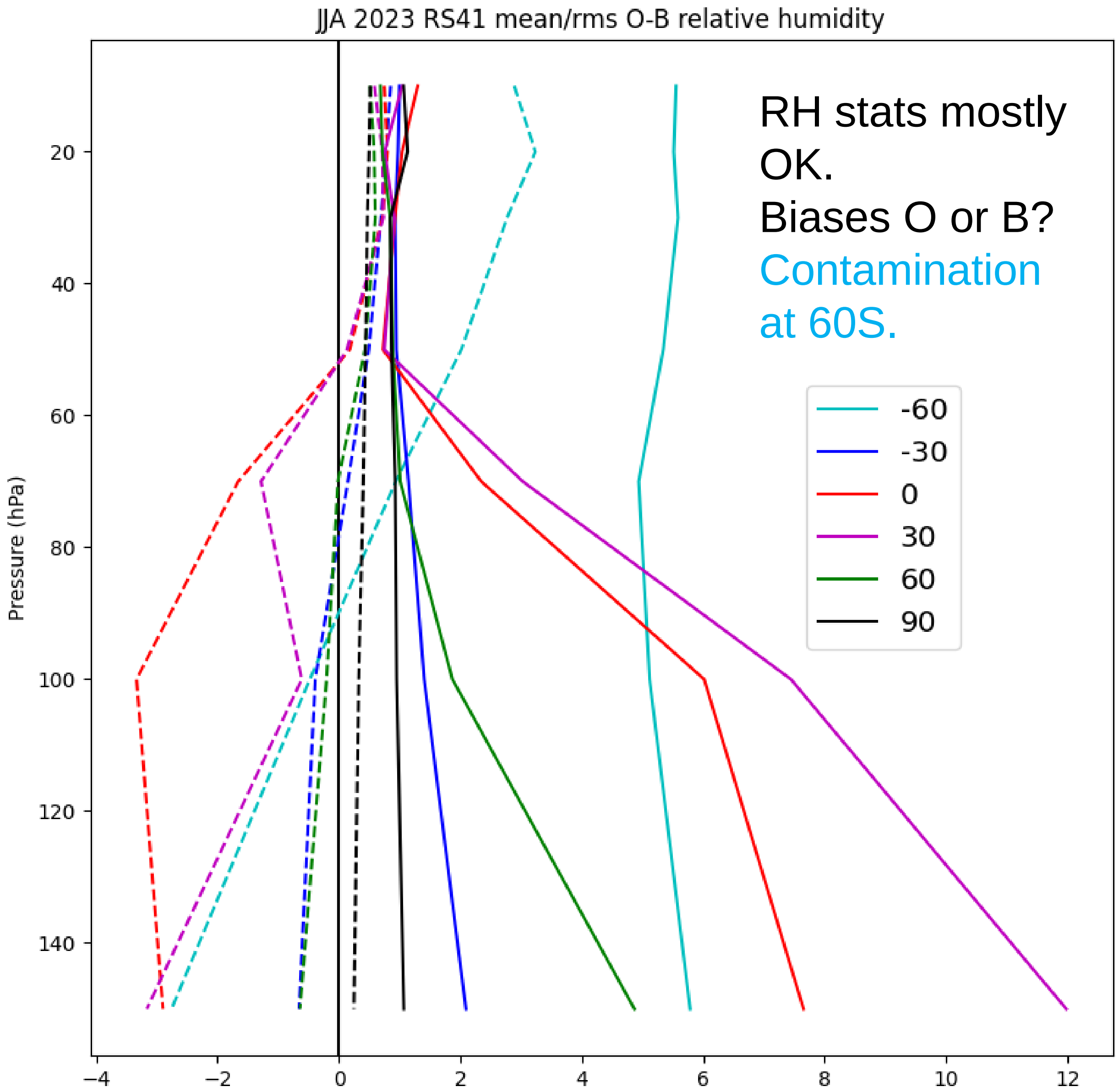
- 20-90N, T and wind (not shown) OK; RH, M20 has bias up to 7.5% at 200 hPa
- RS41 presumed ~unbiased, known that model is too wet just above tropopause





Misc 2: RS41 RH Summer 2023 by latitude band: 150-10 hPa

- To date ECMWF has assimilated humidity in the troposphere but not the stratosphere
- Starting to plan for assimilation of lower stratospheric humidity
    - Help with model biases
    - Hunga-Tonga eruption!
- Hence look at RS41 humidity:
- Mostly usable (if sparse)? ☺
- Check model T-q error correlation
- Main data problem appears to be in profiles from Antarctica – would omit those



RH stats mostly OK.
Biases O or B?
Contamination at 60S.

Stratospheric seasonality summary

- Much more variability in NH winter (SH spring) stratosphere than in summer
- Radiosondes have much larger FSOI <100 hPa in Winter, mainly from winds
- OSEs show smaller seasonality, but more impact in Winter, mainly from winds
- Satellite temperature data very important – helps more with the winds in Winter: approximate geostrophic balance then
- Removing sonde data at P<100 hPa impact is largely local
- Larger RS impact in Winter is despite lower burst height then – case for larger balloons + more gas in Winter