Investigating possible contributions of IASI/IASI-NG for bridging the upcoming gap of limb sounding observation capabilities

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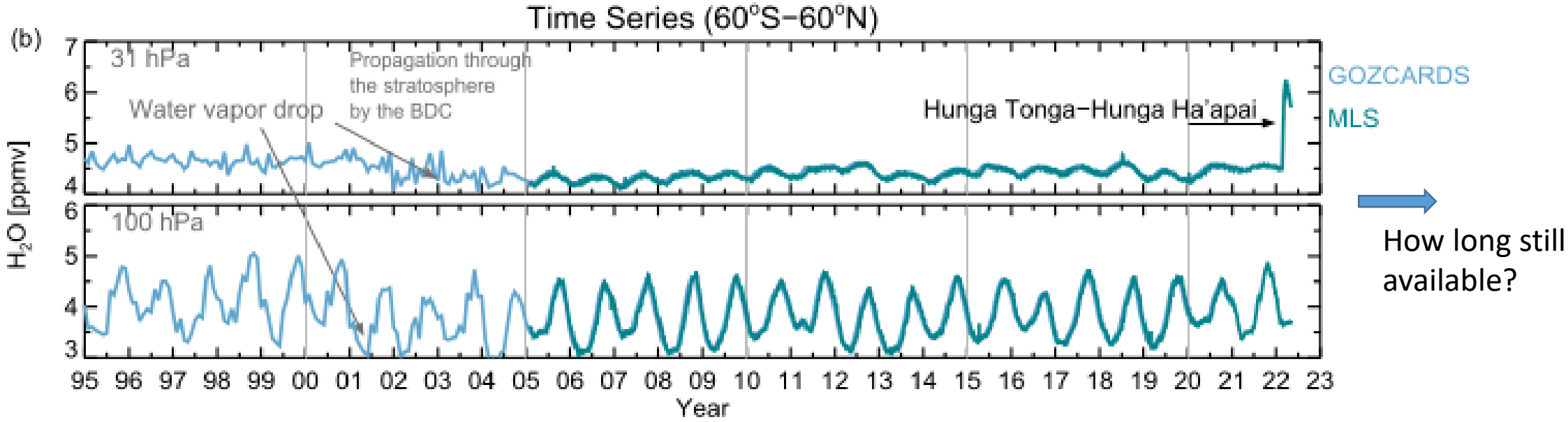
- Motivation
- Stratospheric WV from thermal nadir observations: problem, idea, possibility, …
- Performance test
- Some first results (ongoing work…)
- Summary

Motivation

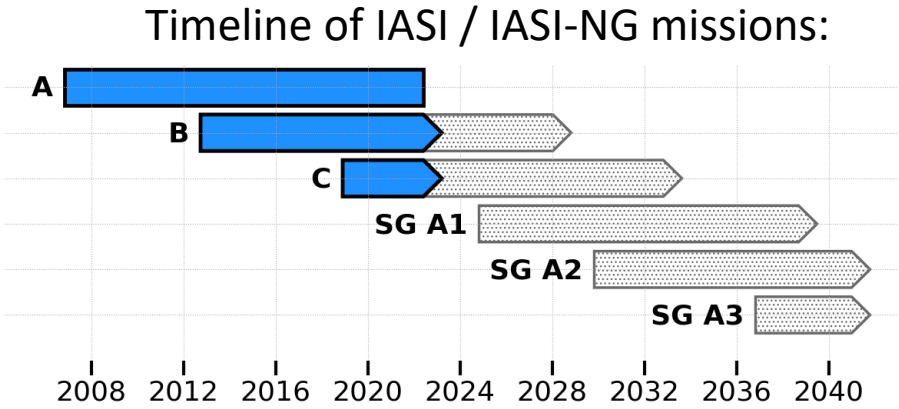
Satellite instruments that measure the atmosphere in limb-viewing geometry are very successful in observing vertical profiles in and above the UTLS (upper troposphere/lower stratosphere), thus providing a unique data pool for investigating the impact of the UTLS on weather and climate. Unfortunately, missions like MIPAS, ACE-FTS, or Aura/MLS have already ended or are expected to end in several years before respective next-generation missions will be operative (e.g. the current ESA Earth Explorer 11 candidate CAIRT). Here we discuss to what extent IASI/IASI-NG can bridge this upcoming observational gap



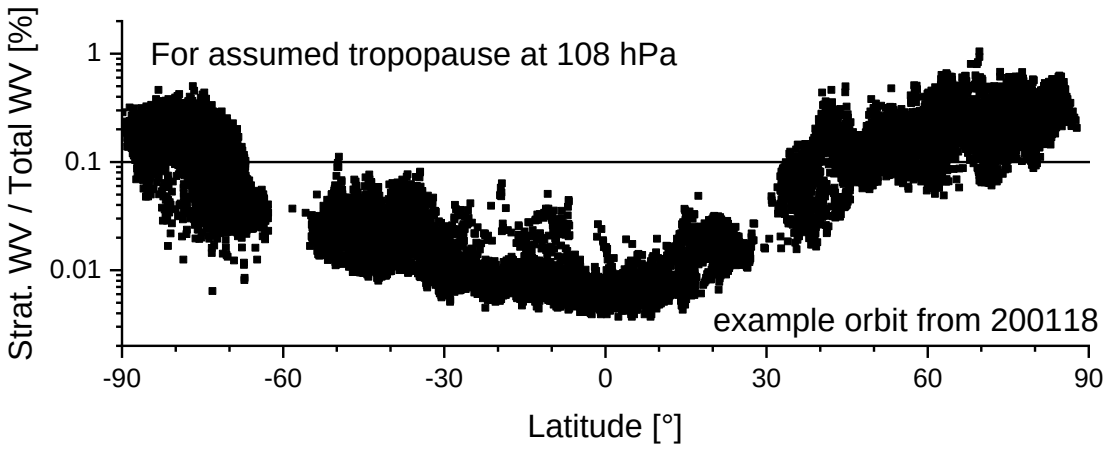
Millán et al. (2022)

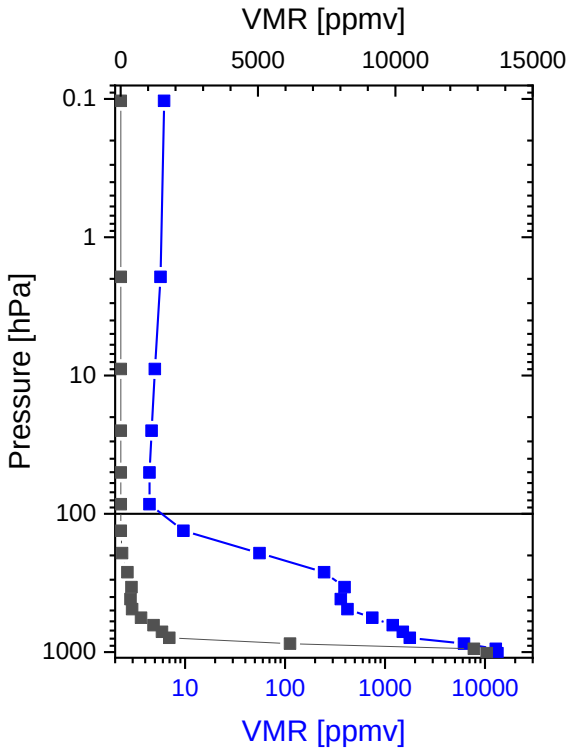
Motivation + Problem

Can thermal nadir observations help to bridge the upcoming gap?
IASI and IASI-NG is/will be available for many decades.



<u>Problem:</u>
Nadir viewing geometry, only very small amount of water is in the stratosphere.
Generally more than 99.9% is in the troposphere.





Approach

… to minimize interferences of variations of tropospheric WV on the stratospheric WV retrieval:

- Avoid an independent temperature and WV retrieval in the troposphere (there is a physical relation between both). Instead make an optimal estimation of RH.
- In the stratosphere humidity is clearly below saturation and RH is not important: independent retrieval of temperature and WV

(1) Retrieval WV on log-scale

(2) According to WMO (Guide to Meteorological Instruments and Methods of Observation, Appendix 4B, WMO-No. 8 (CIMO Guide), Geneva 2008): $x_{H2O}^{sat} = \frac{6.112\, e^{\left(\frac{17.62\, T}{243.12+T}\right)}}{p}$

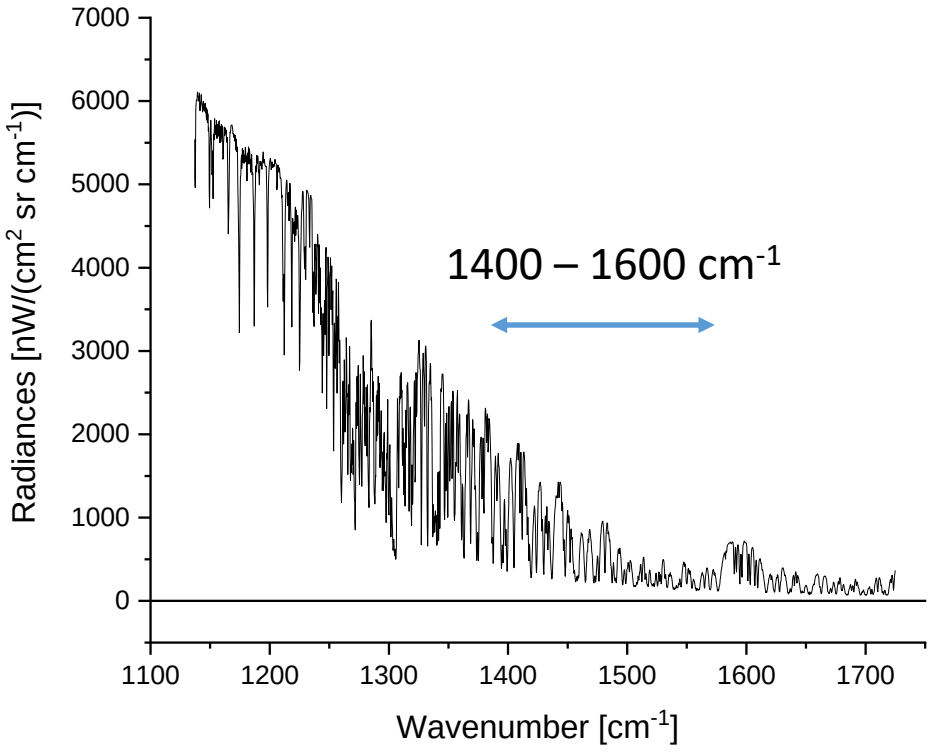
$$\rightarrow \quad \frac{\Delta \ln(x_{H2O}^{sat})}{\Delta T} = \frac{17.62 * 243.12}{(243.12+T)^2}$$

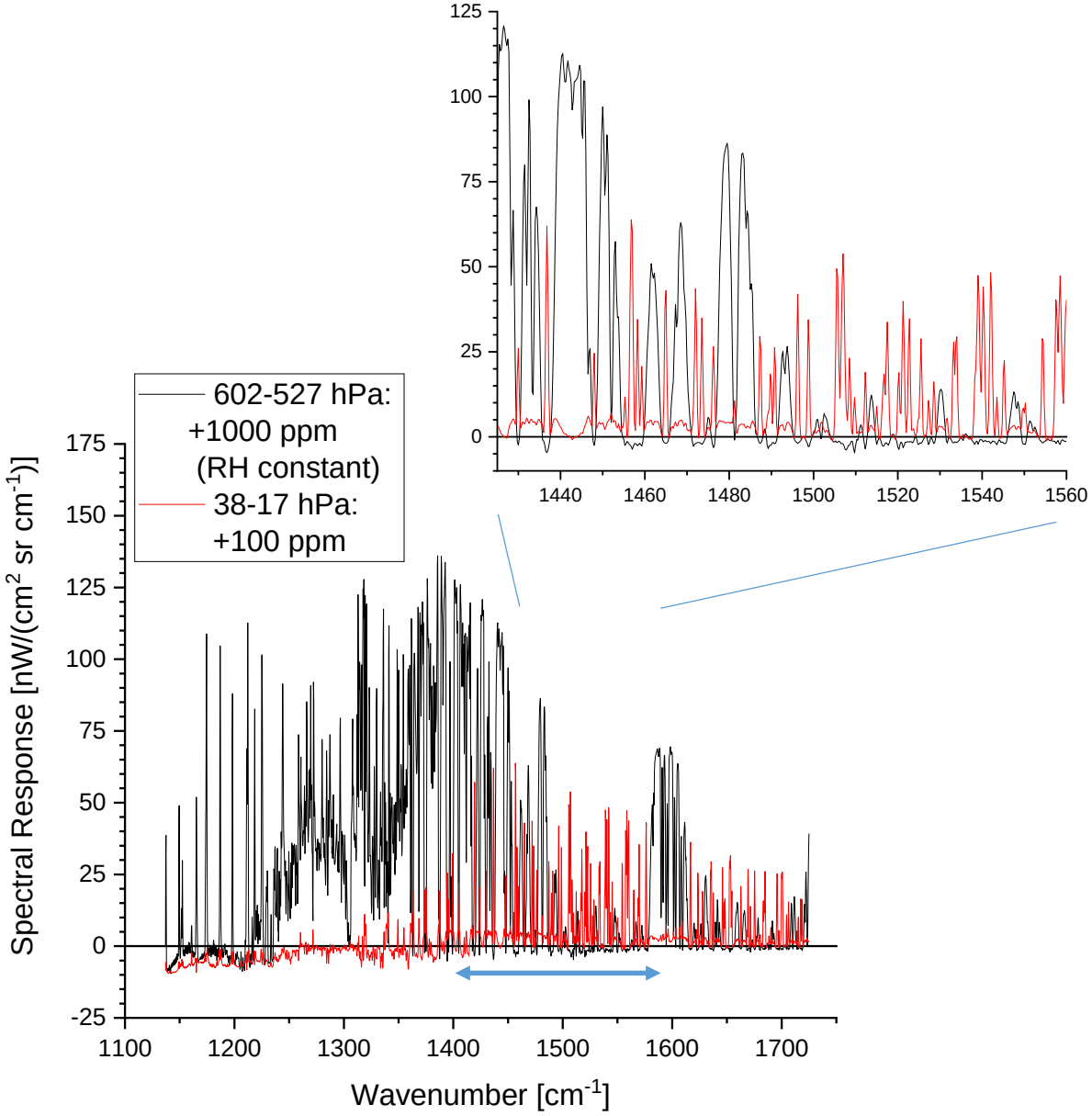
(3) Cross-constraint between $\ln(x_{H2O}^{sat})$ and T is a constraint on RH

Spectroscopic responses

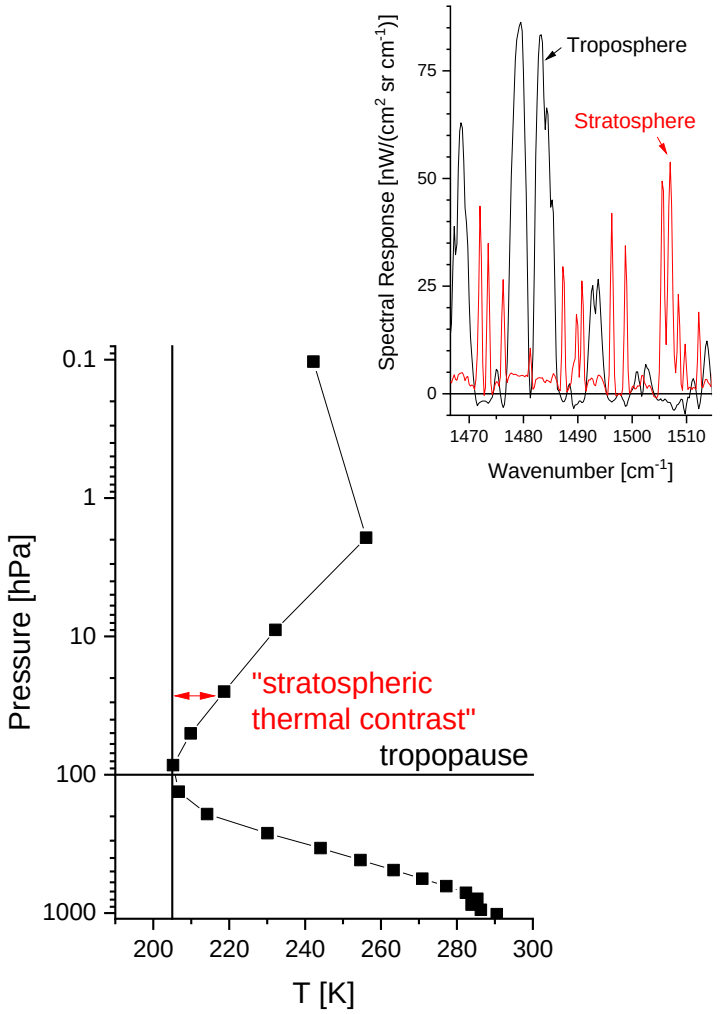
Stratospheric WV variations are visible in the spectral region from 1400 to 1600 cm^{-1}

Example for 220112, 32°S:

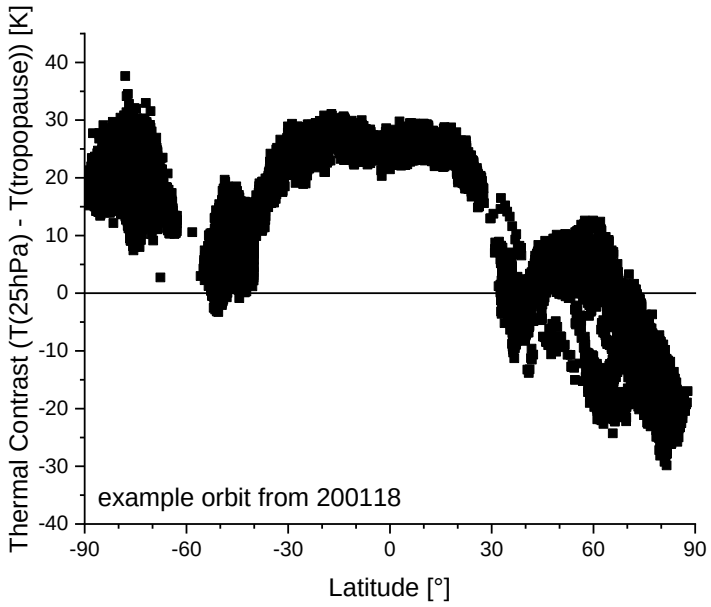


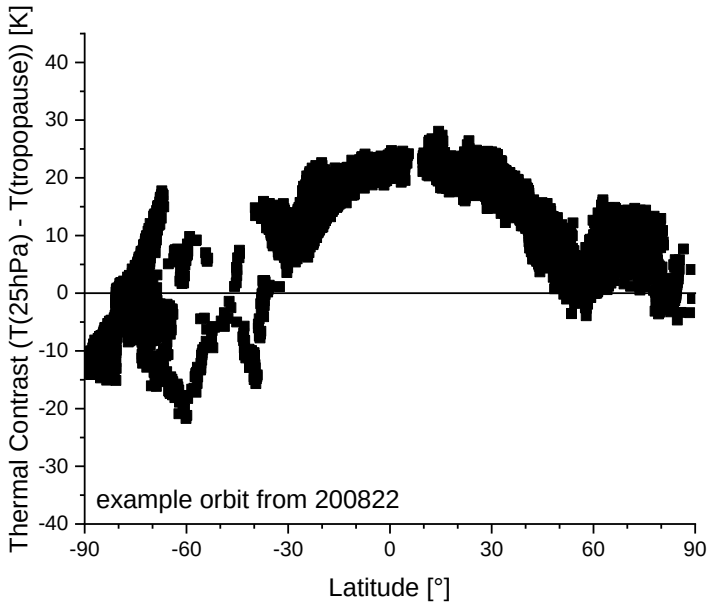


Spectroscopic responses



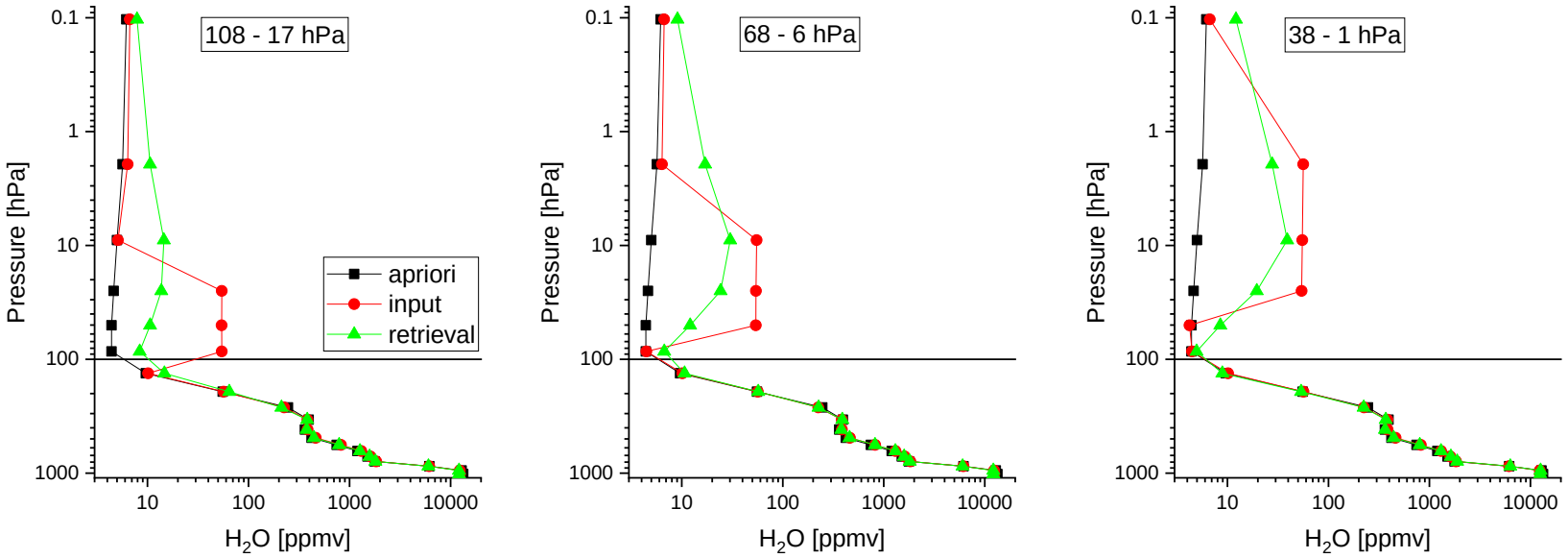
"Stratospheric thermal contrast" is important.
→ we expect the best stratospheric WV signals in thermal nadir radiances for lower latitudes.





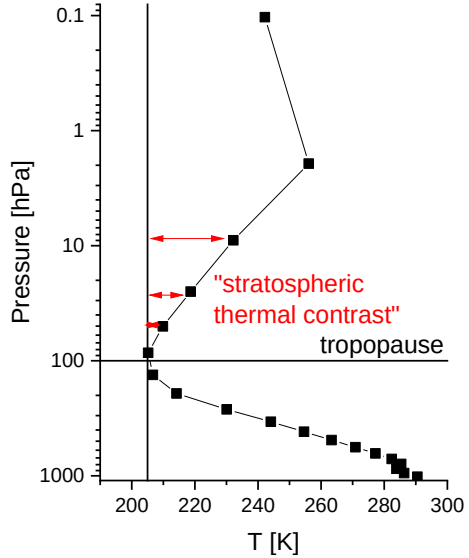
Performance test

We simulate spectra with typical noise and different stratospheric WV layers:

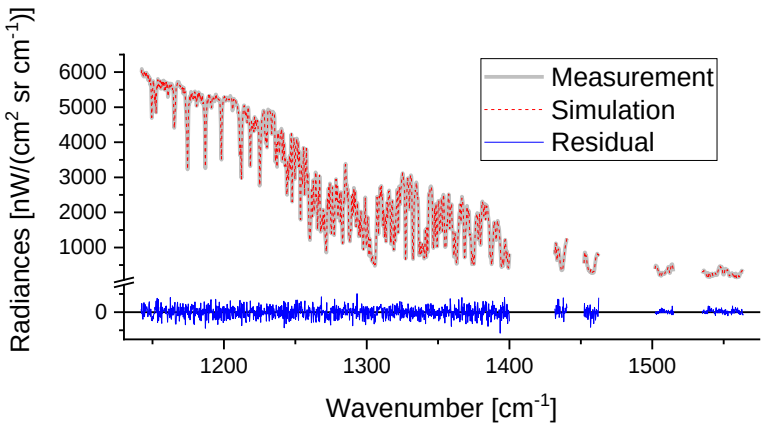


IASI has potential for detecting stratospheric WV:

Increasing sensitivity from 108 to 5 hPa, because of increasing thermal contrast.

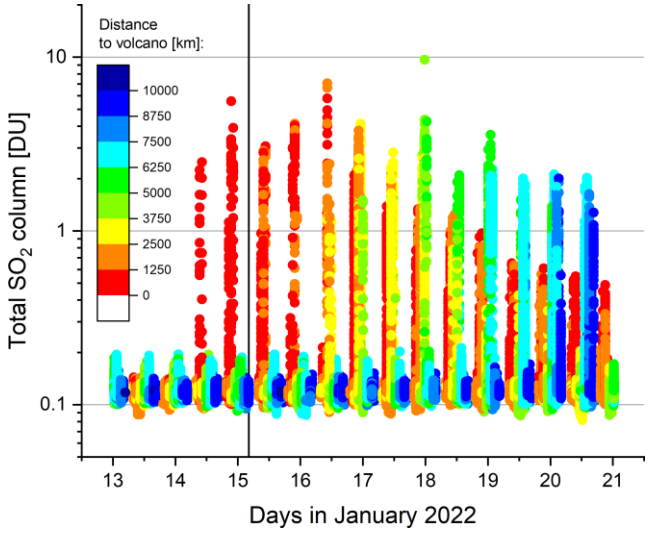


Retrieval setting (used spectral windows):

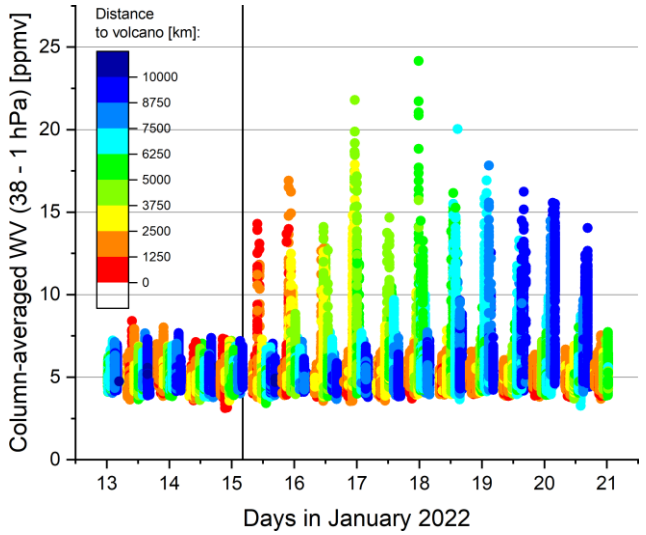


Results: comparison of the HTHH and Raikoke volcanic eruptions

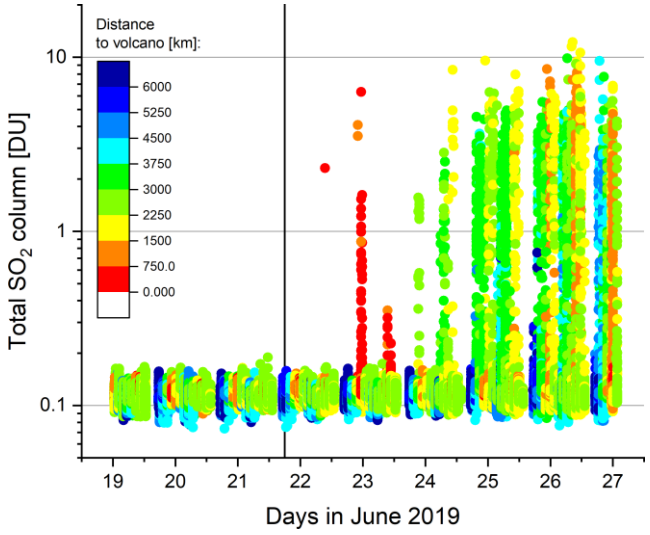
HTHH, January 2022

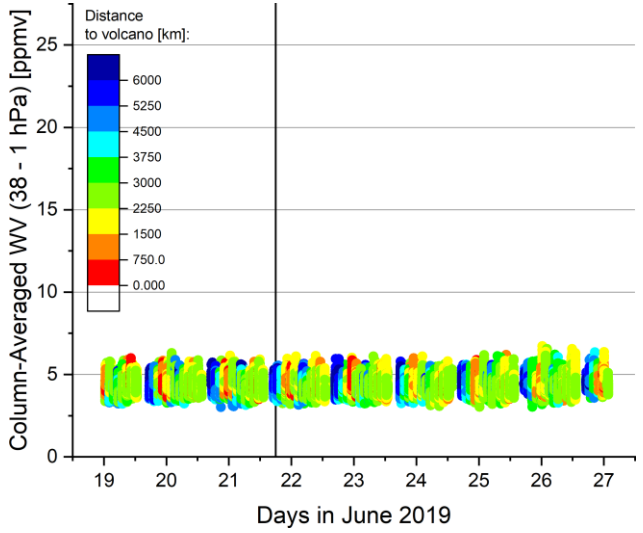


Stratospheric Water Vapour



Raikoke, June 2019





Data are filtered for stratospheric thermal contrast larger than 5K.

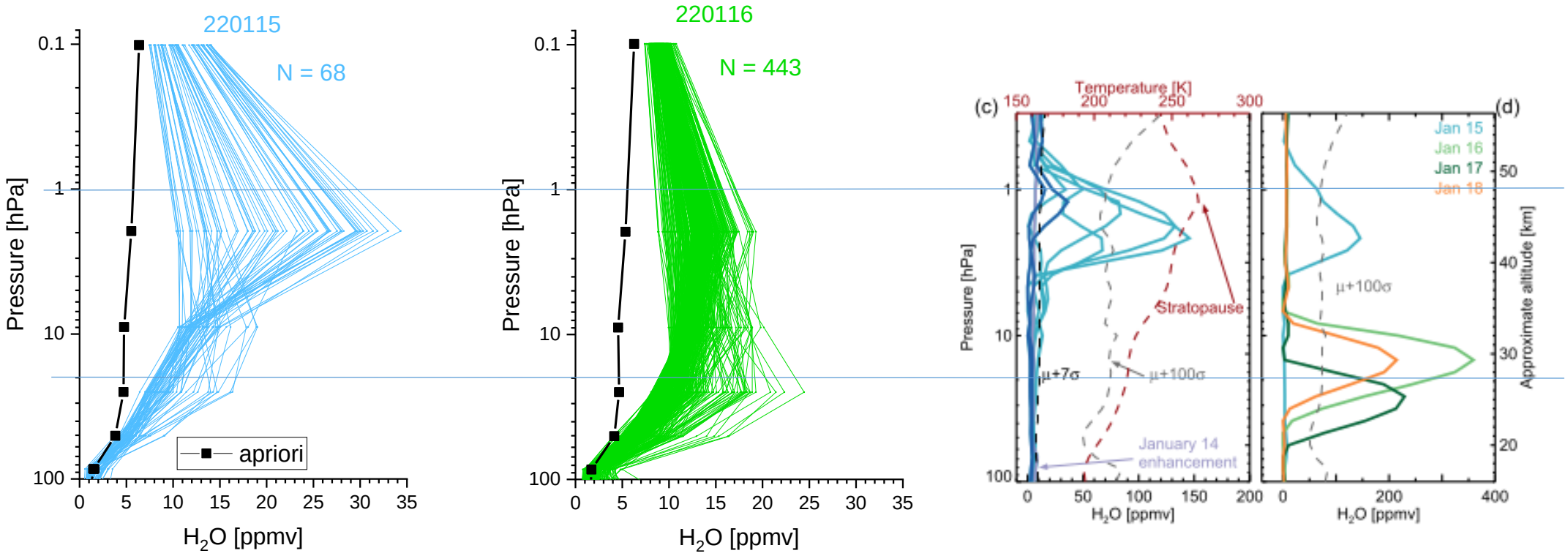
HTHH: significant SO_2 emission already on 220114, but explosive eruption on 220115. H_2O cloud from explosive eruption, no further H_2O injection at the HTHH location.

Raikoke: Similar amount of SO_2, but no significant H_2O injection.

Results: comparison to MLS

Vertical anomalies detected by IASI

… and by MLS (Millán et al., 2022)

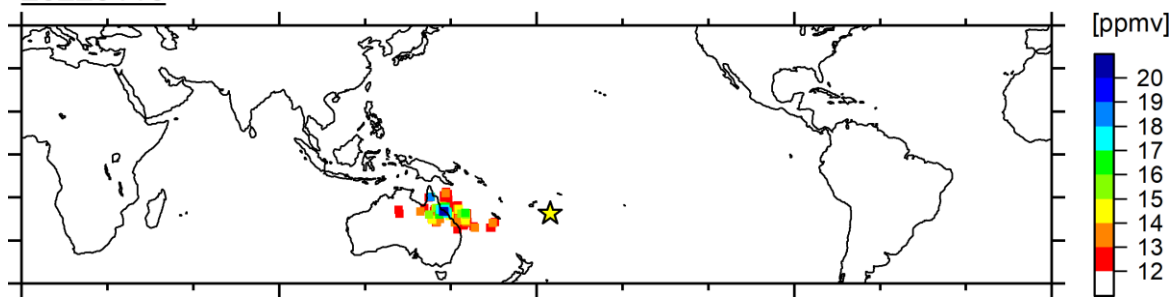


There seems to be some information on the altitude of the stratospheric WV layer.

Results: comparison to MLS

Horizontal distribution of anomalies detected by IASI

20220116



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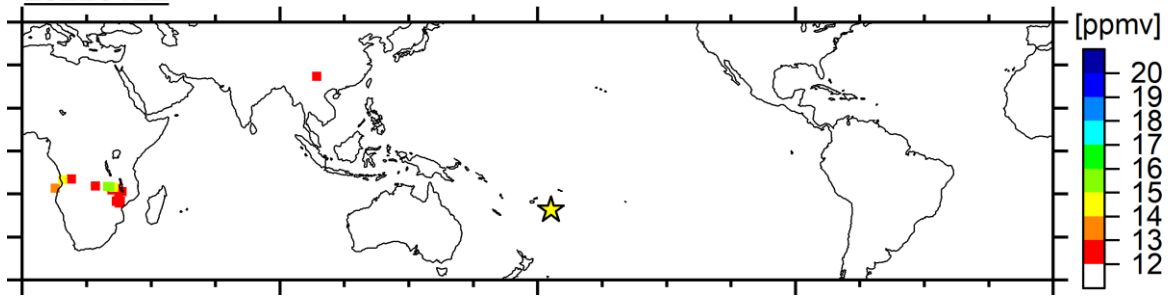

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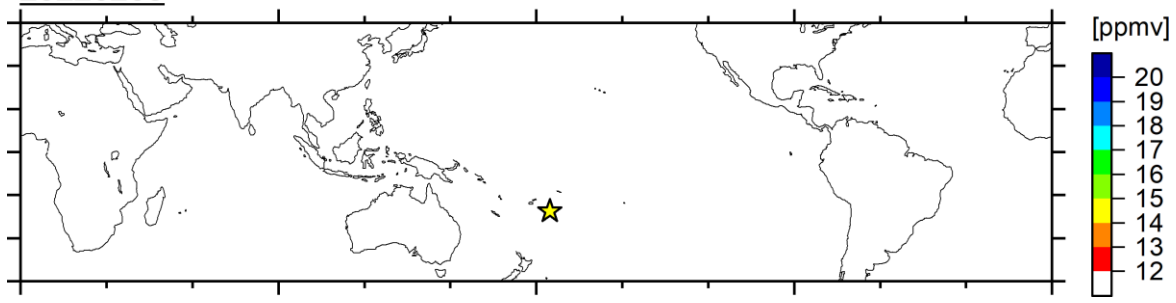
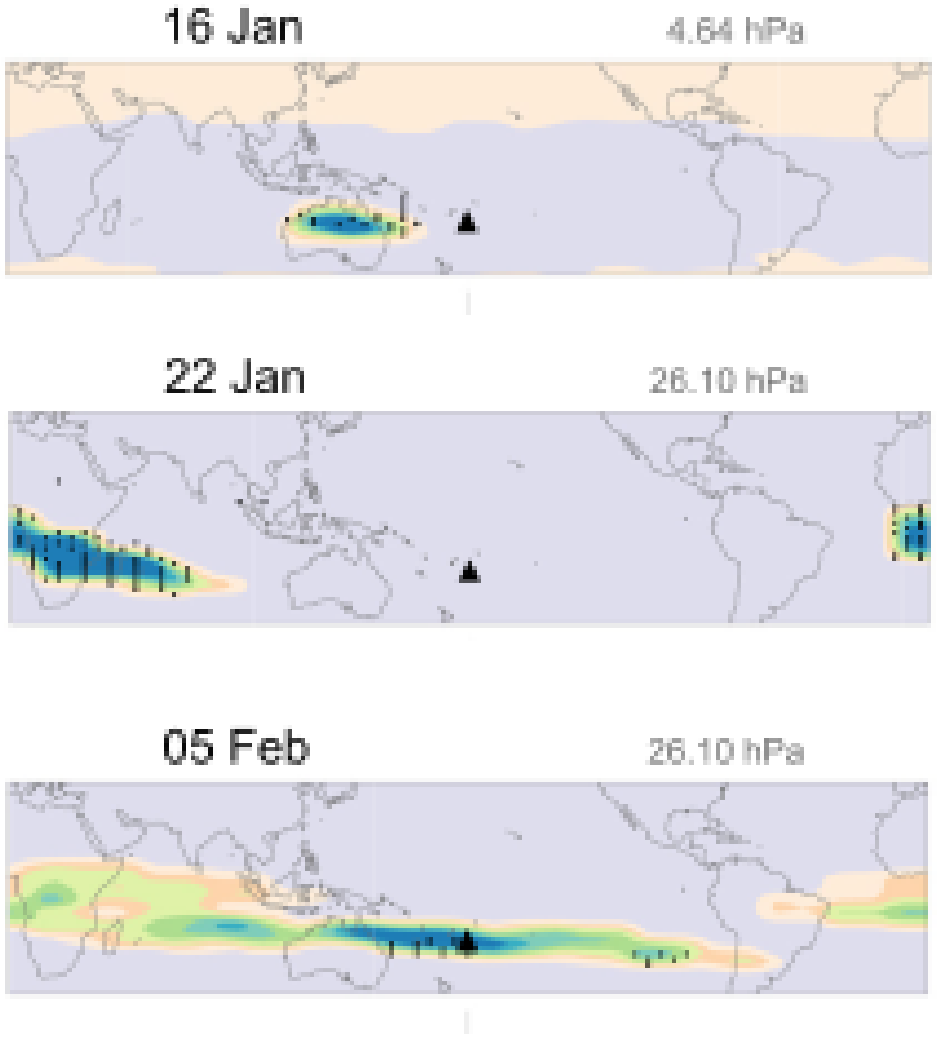


… and by MLS (Millán et al., 2022)



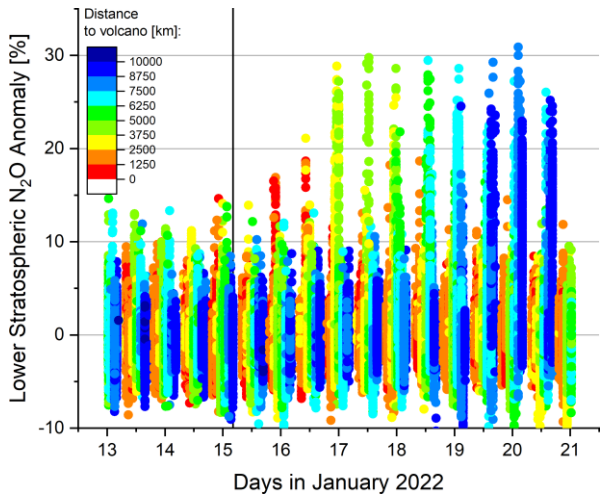
Only very strong stratospheric WV anomalies can be detected by IASI.

Summary

- Problem: tropospheric WV and T interferences on stratospheric WV signals:
  → Constraint of RH, instead of individual constraints of WV and T.
- Thermal contrast: stratosphere is (generally) significantly warmer than the tropopause:
  → Stratospheric WV emission signal in thermal nadir radiances
- Retrieval performance check demonstrates the possibilities.
- The HTHH event is well-suited for investigating/demonstrating possibilities and limitations!

IASI/IASI-NG can (of course) not compete with dedicated limb-sounding instruments, but it can make a some contribution …

… outlook:



Thanks for your attention!