Radiative transfer along a slanted path

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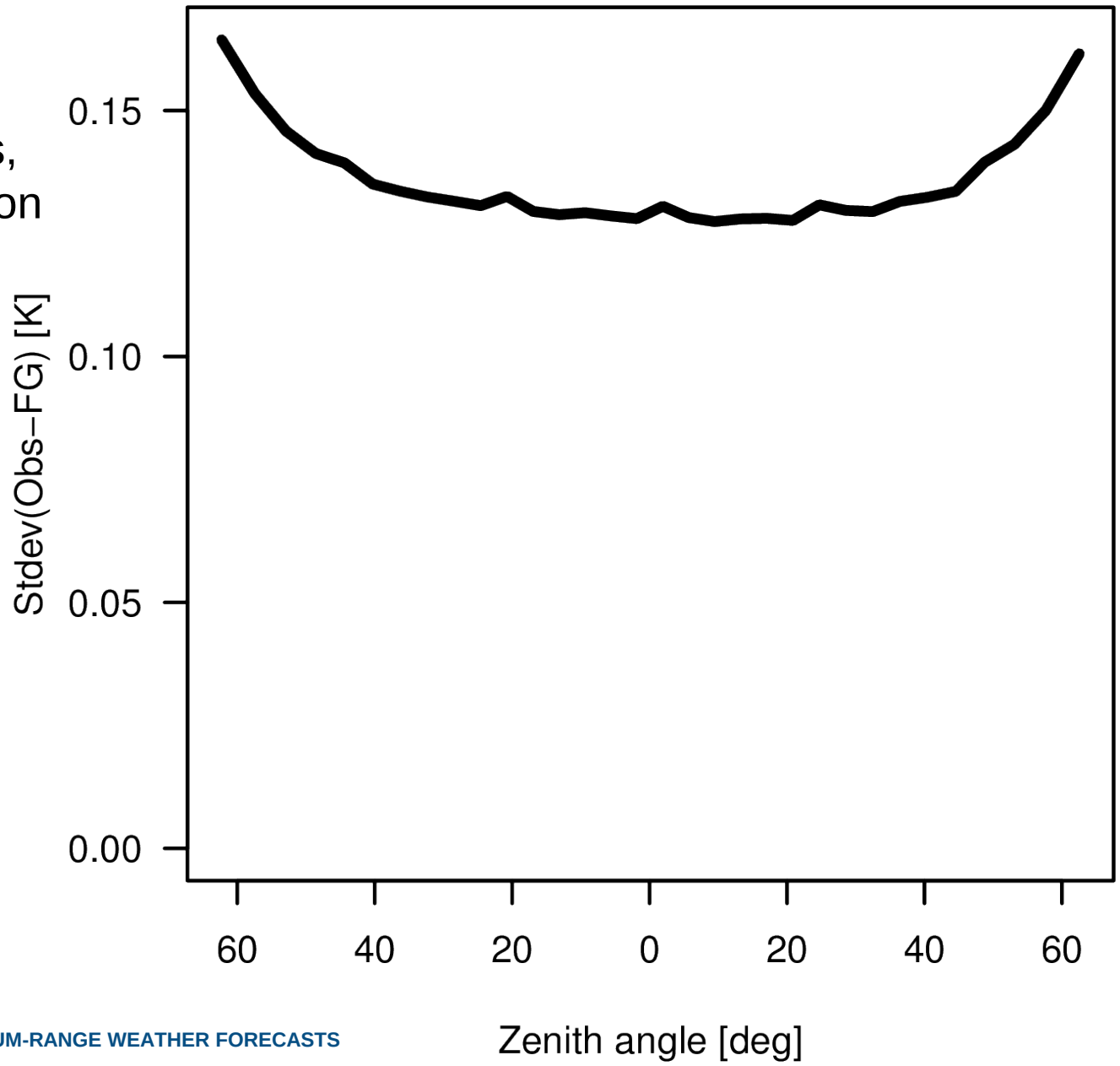
Why look at this?

Stdev(O-B) after bias corrections,
ATMS, channel 9, by scan-position

→ Larger departures for larger zenith angles

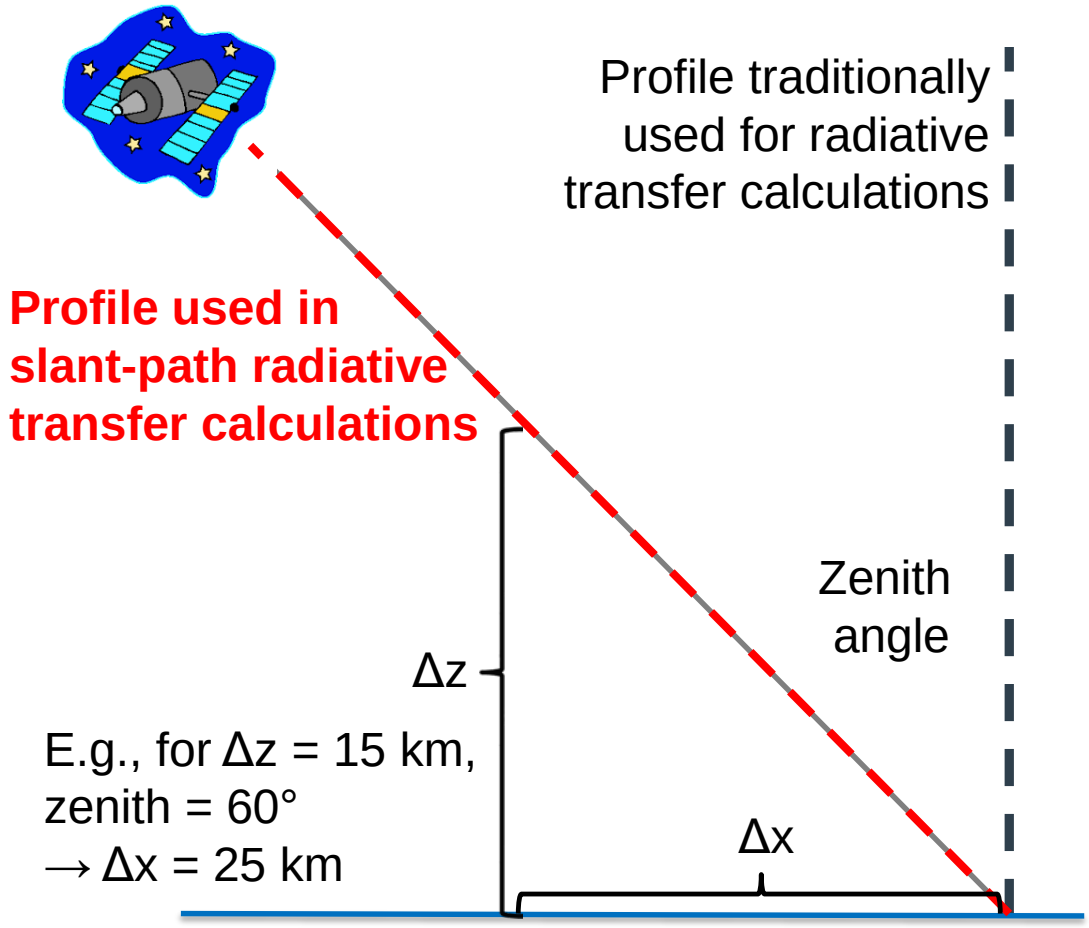


Slant path effect

Two geometric effects when zenith angle > 0°:

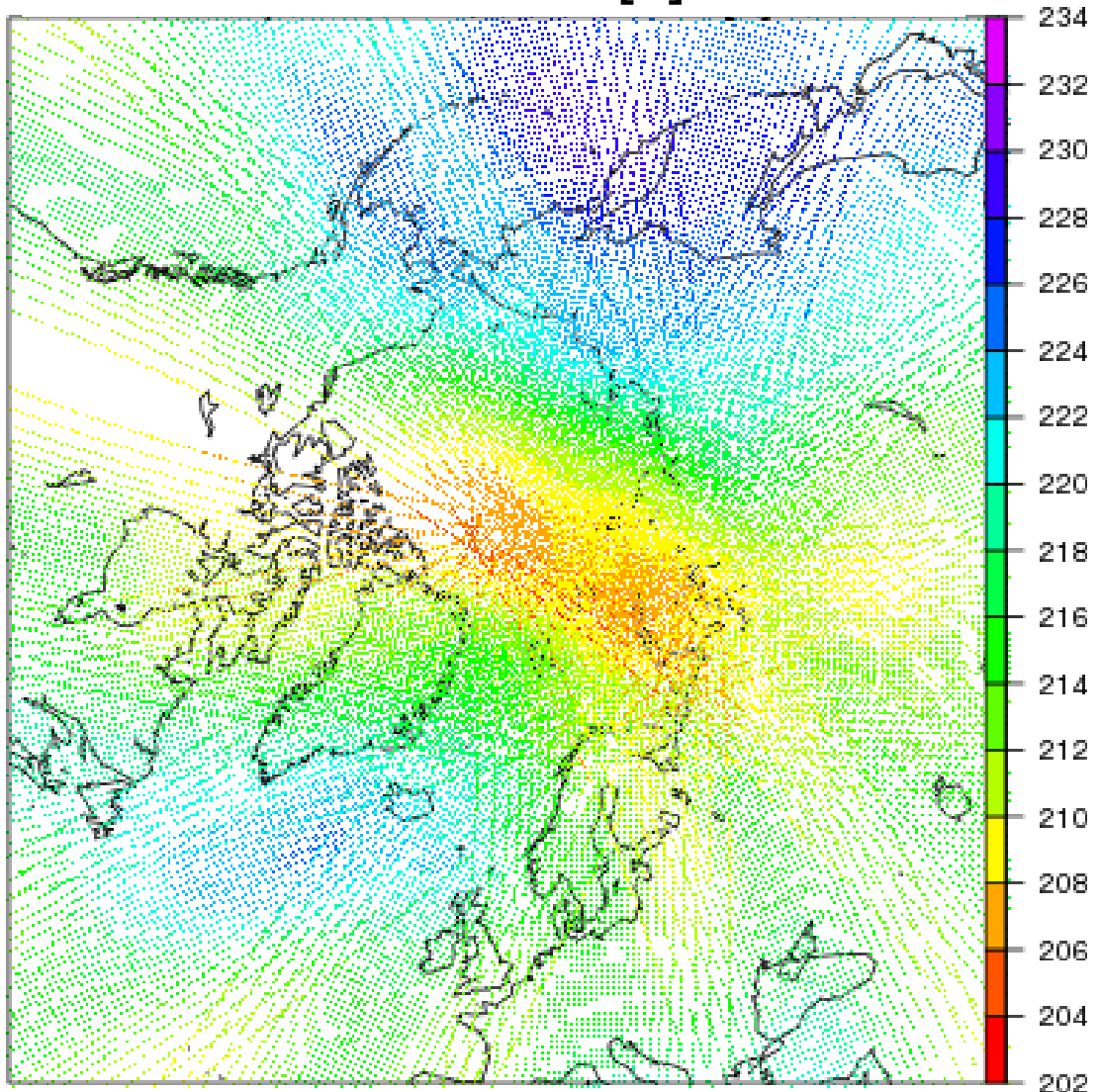
1) Viewing path longer = effect on optical depth:
   ✓ Taken care of by RTTOV

2) Viewing path slants through the atmosphere:
   ✗ So far neglected

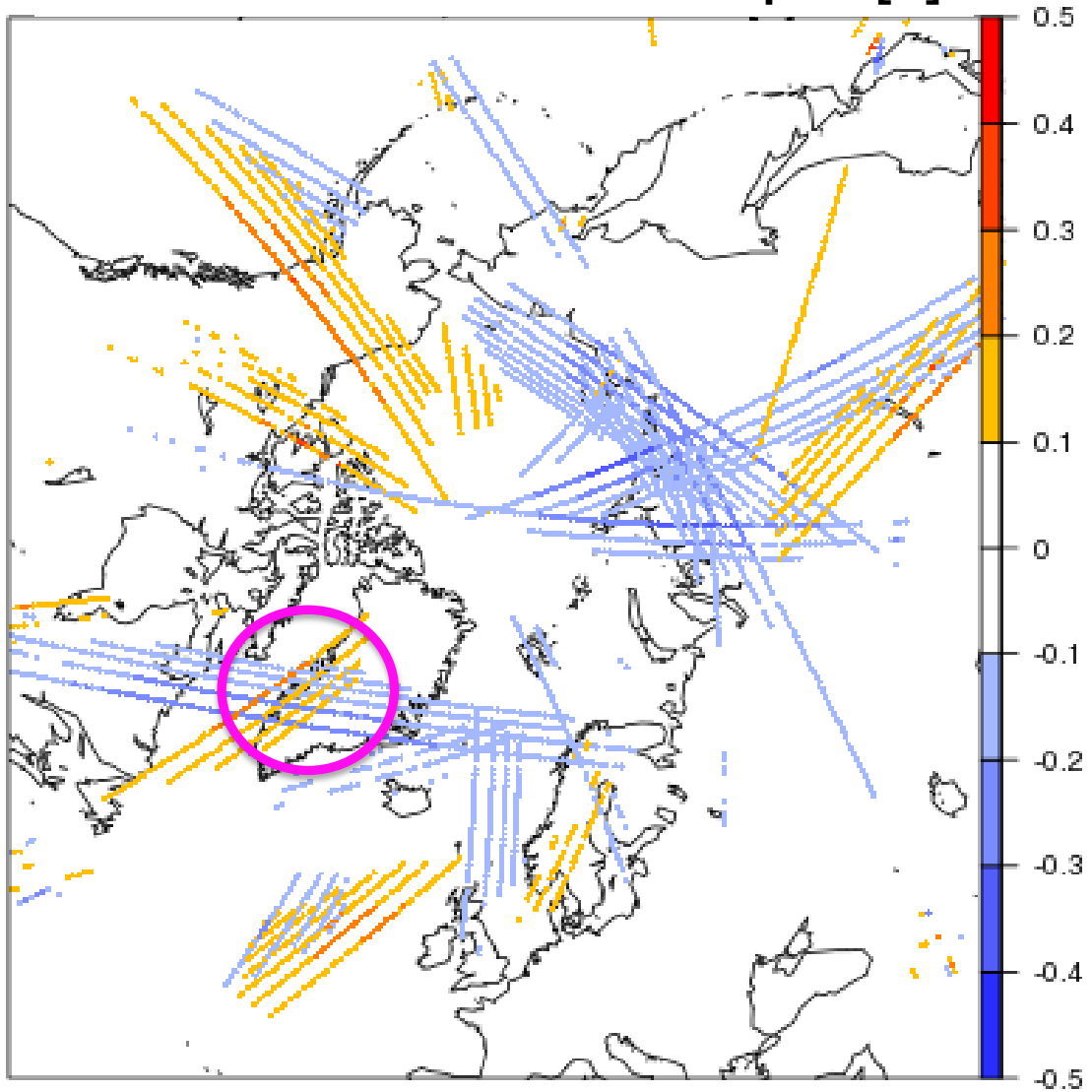


Effect on radiative transfer calculations, ATMS channel 9

Observations [K]

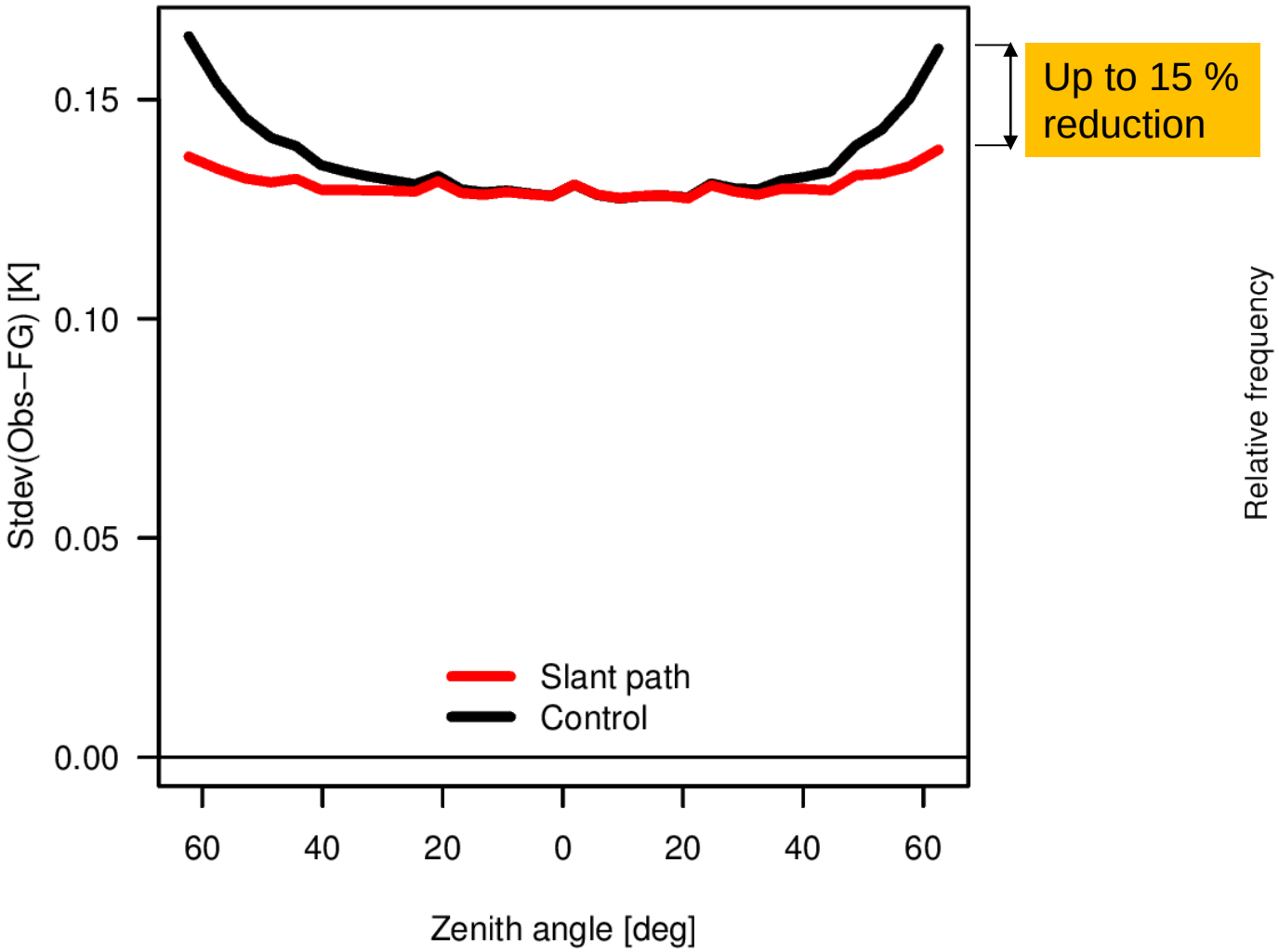


Difference with – without slant path [K]

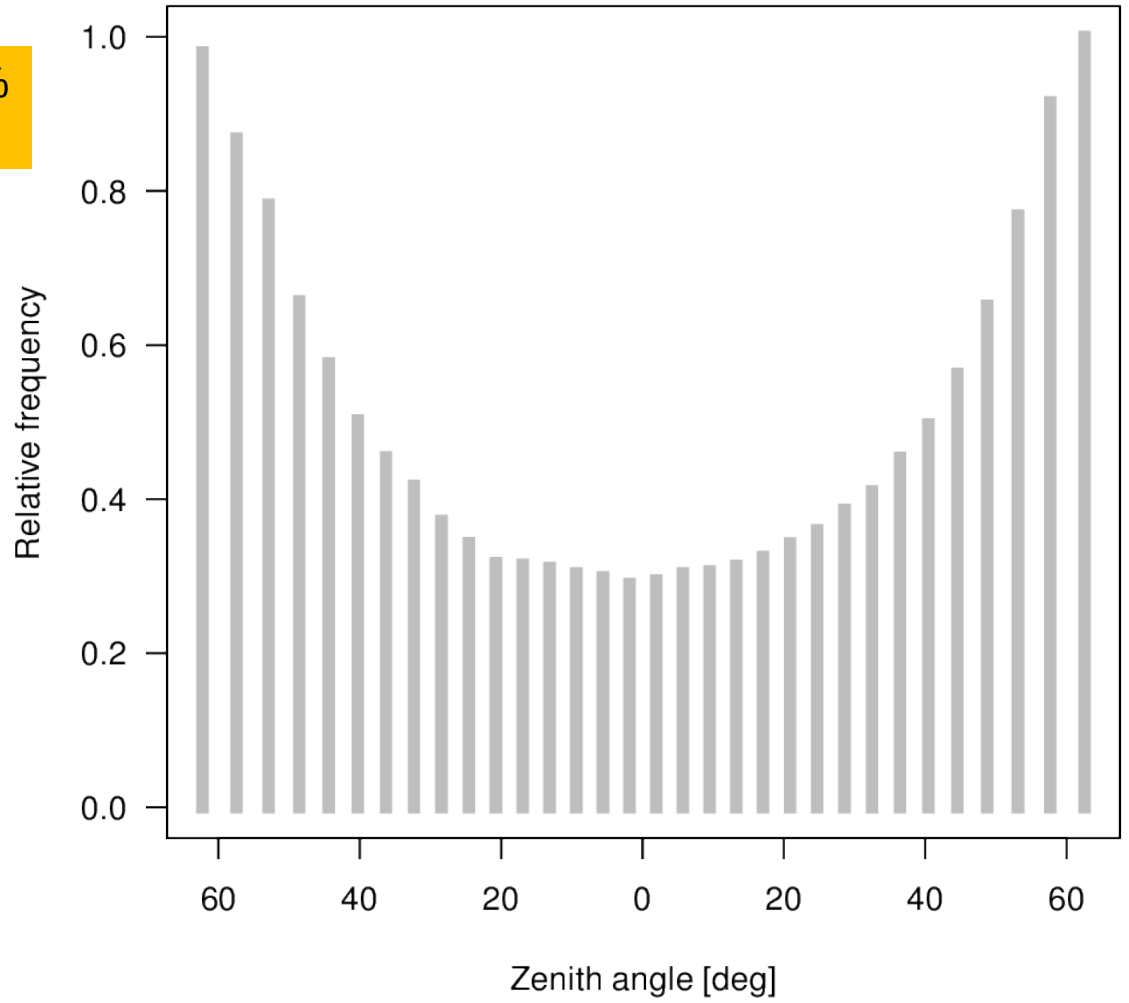


Better agreement with observations

Stdev(O-B), ATMS,
channel 9, by scan-position

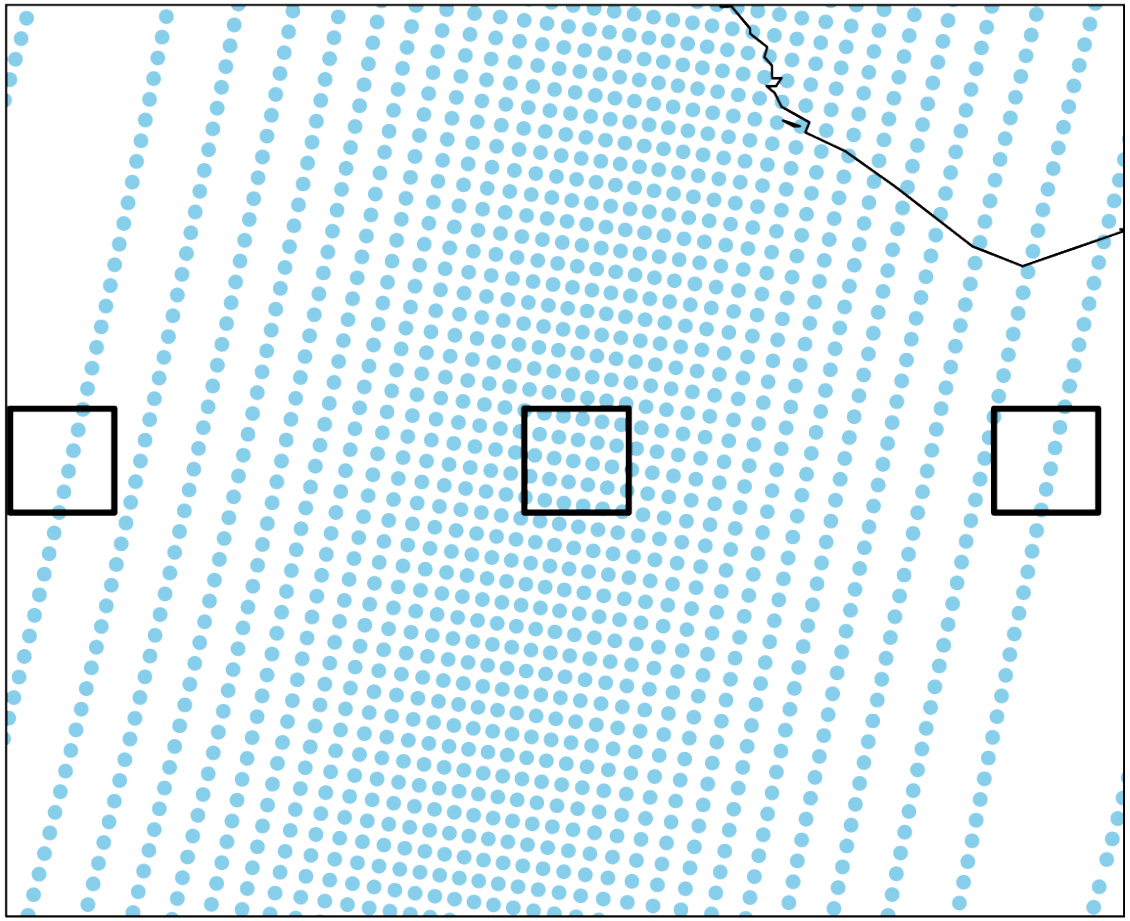


Number of used observations
by scan-position

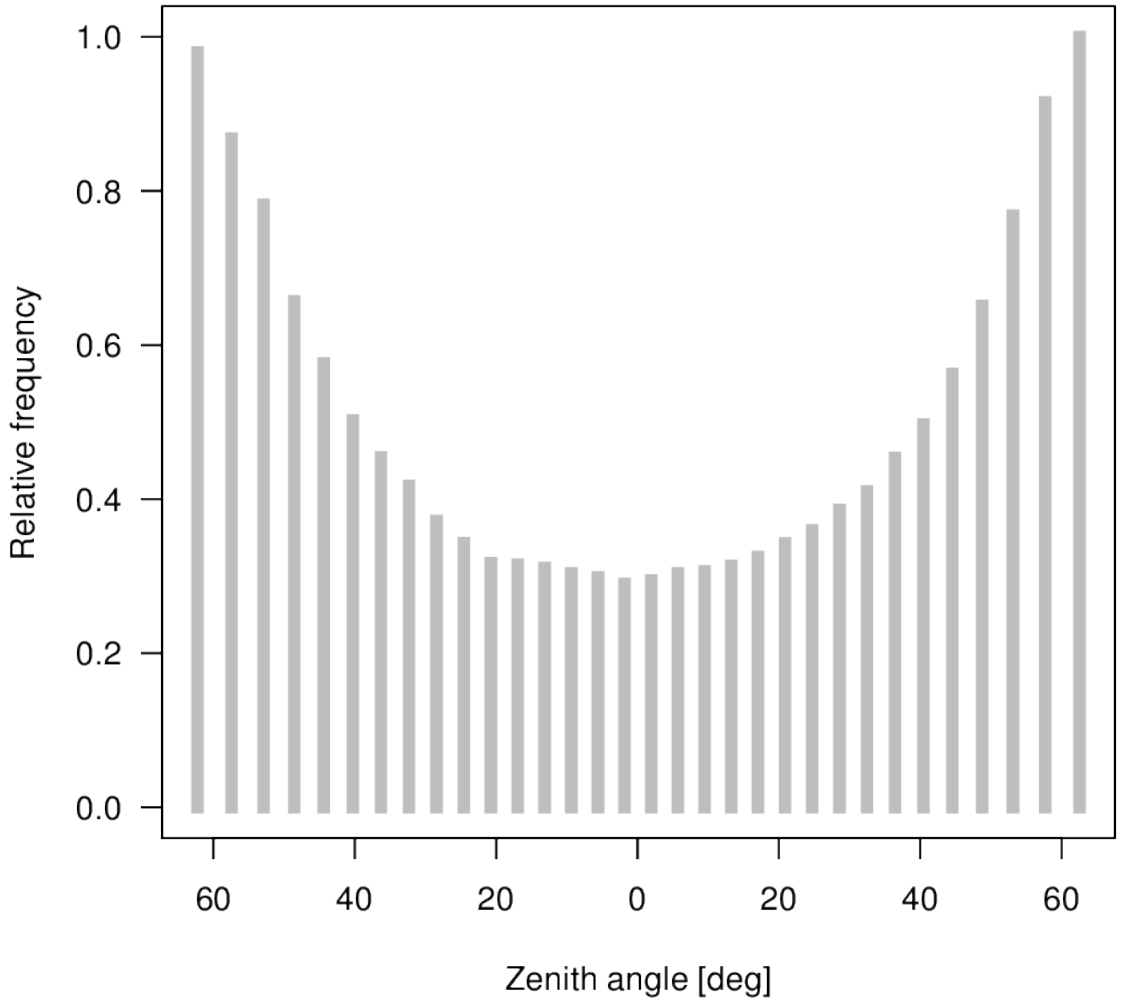


Importance of outer fields of view

Spatial thinning means outer fields of view are used more often.

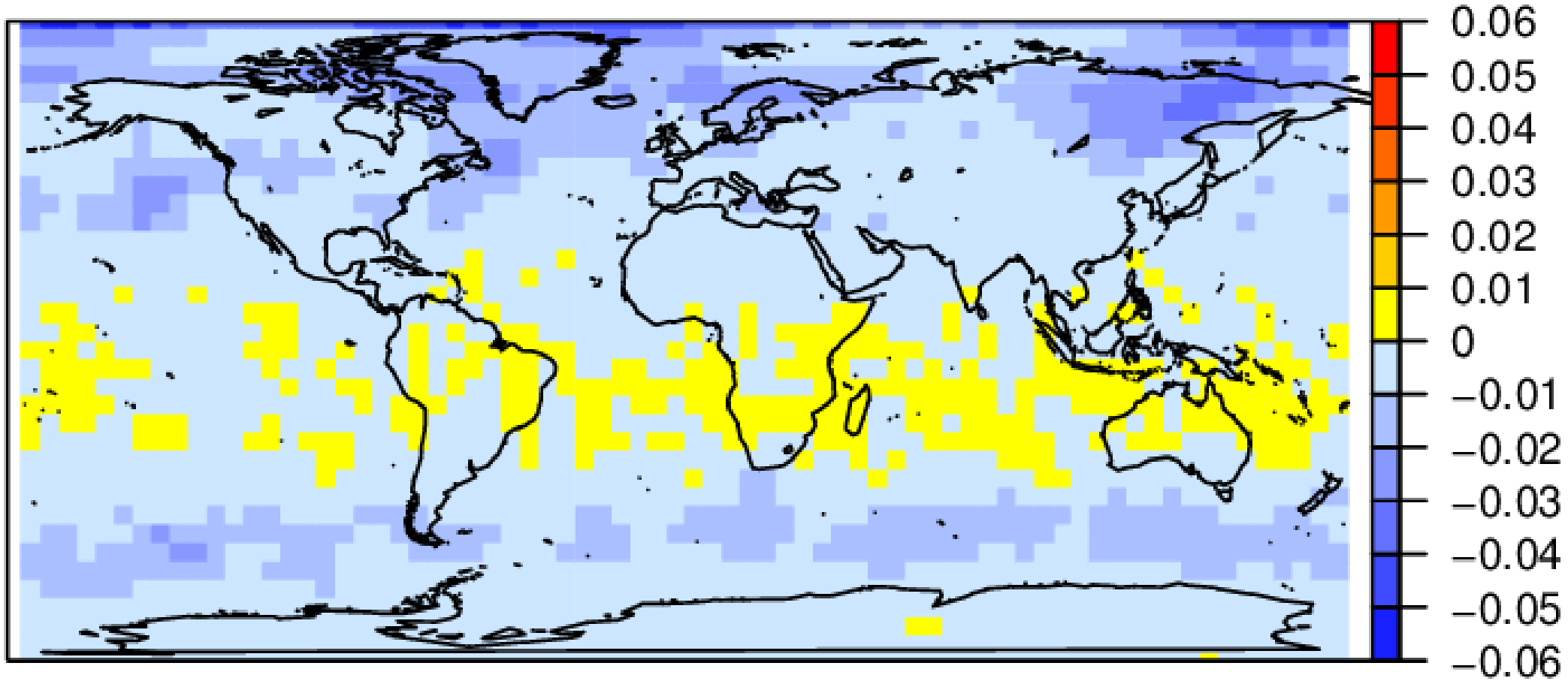


Number of used observations by scan-position



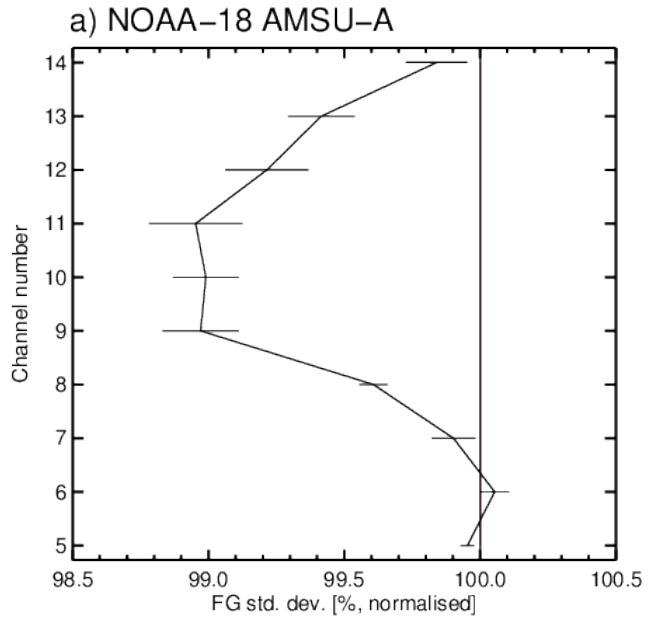
Largest effect at mid/higher latitudes

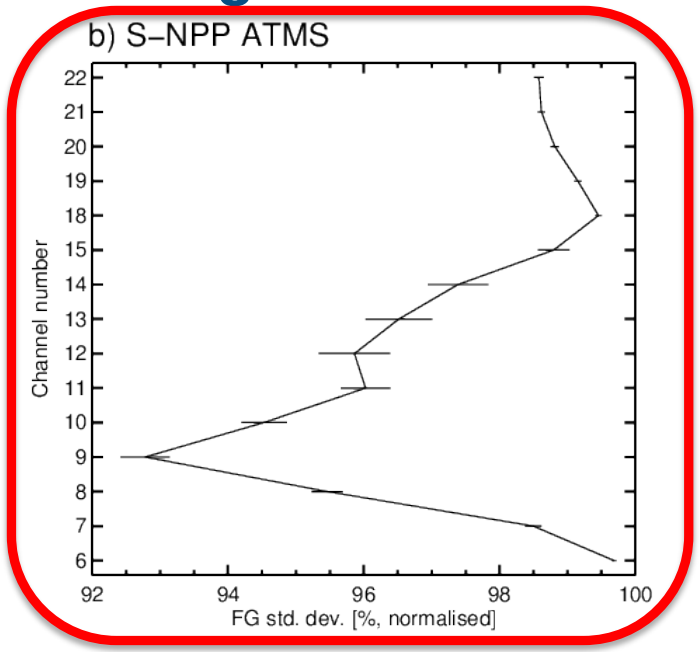
Stdev(o-b), SlantPath – Control, ATMS channel 9
(25 Jan – 24 Feb 2015, same b for both)

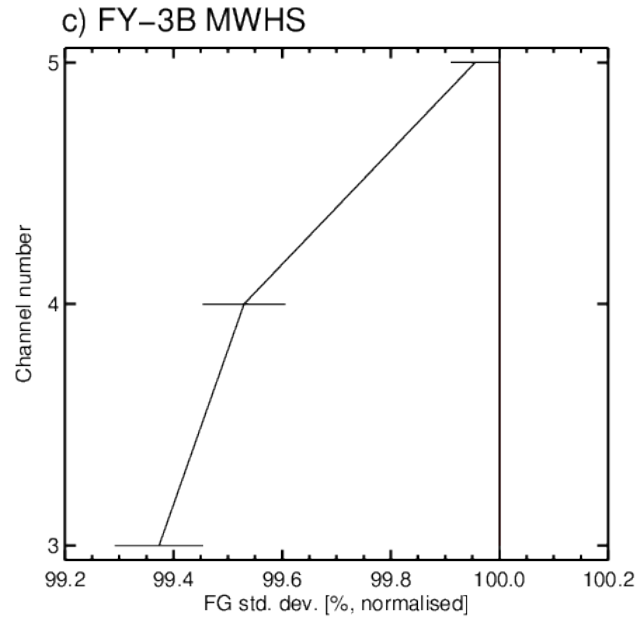


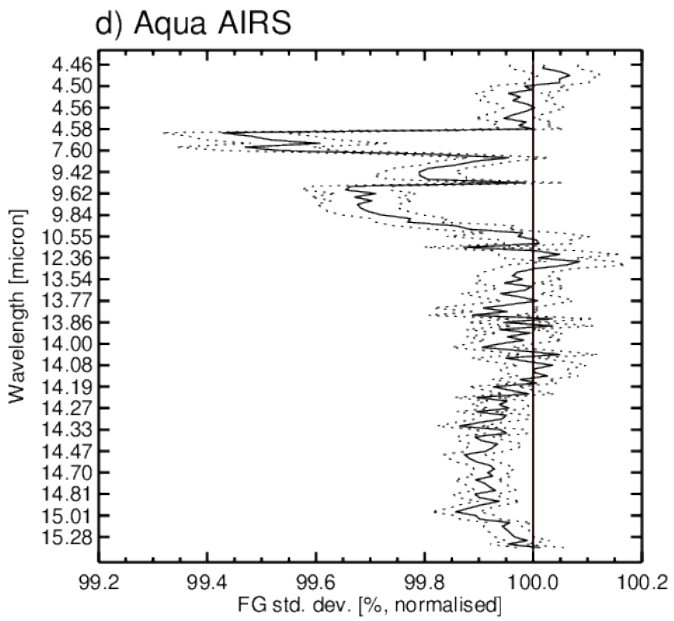
Better background-equivalents for sounding observations

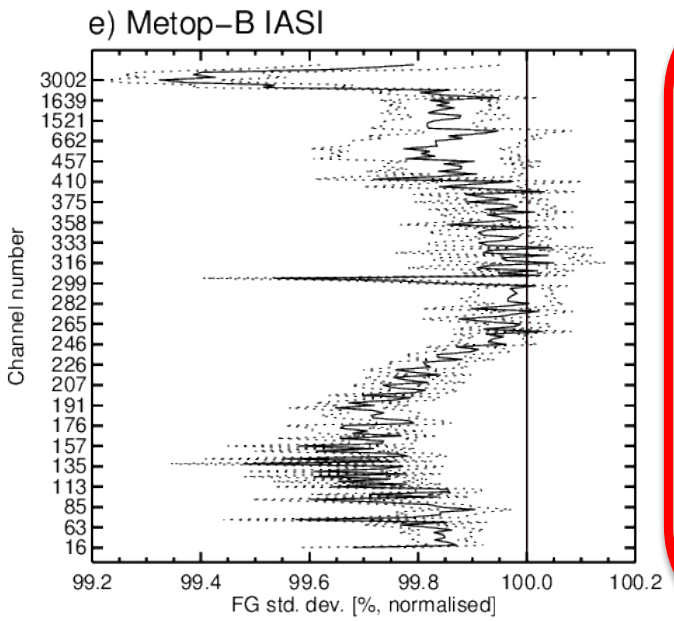
Stdev(o-b), normalised by Control, global, 25 Jan– 24 Feb 2015, same b

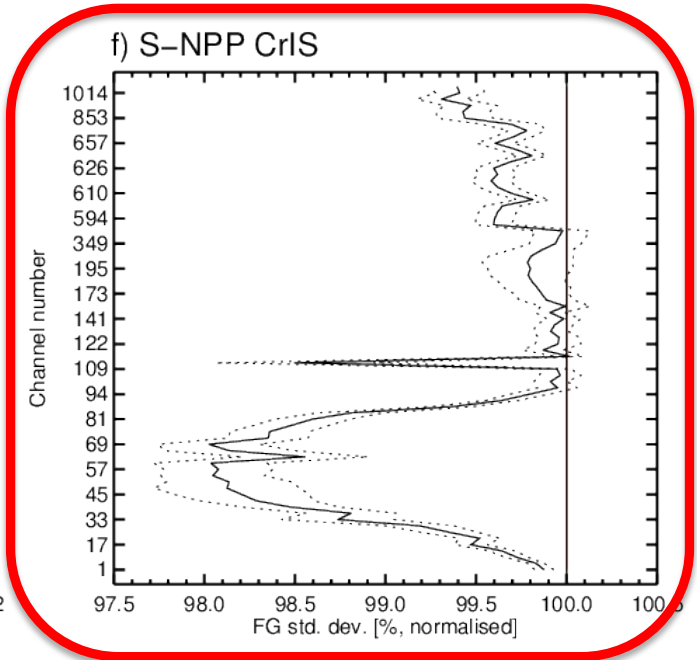








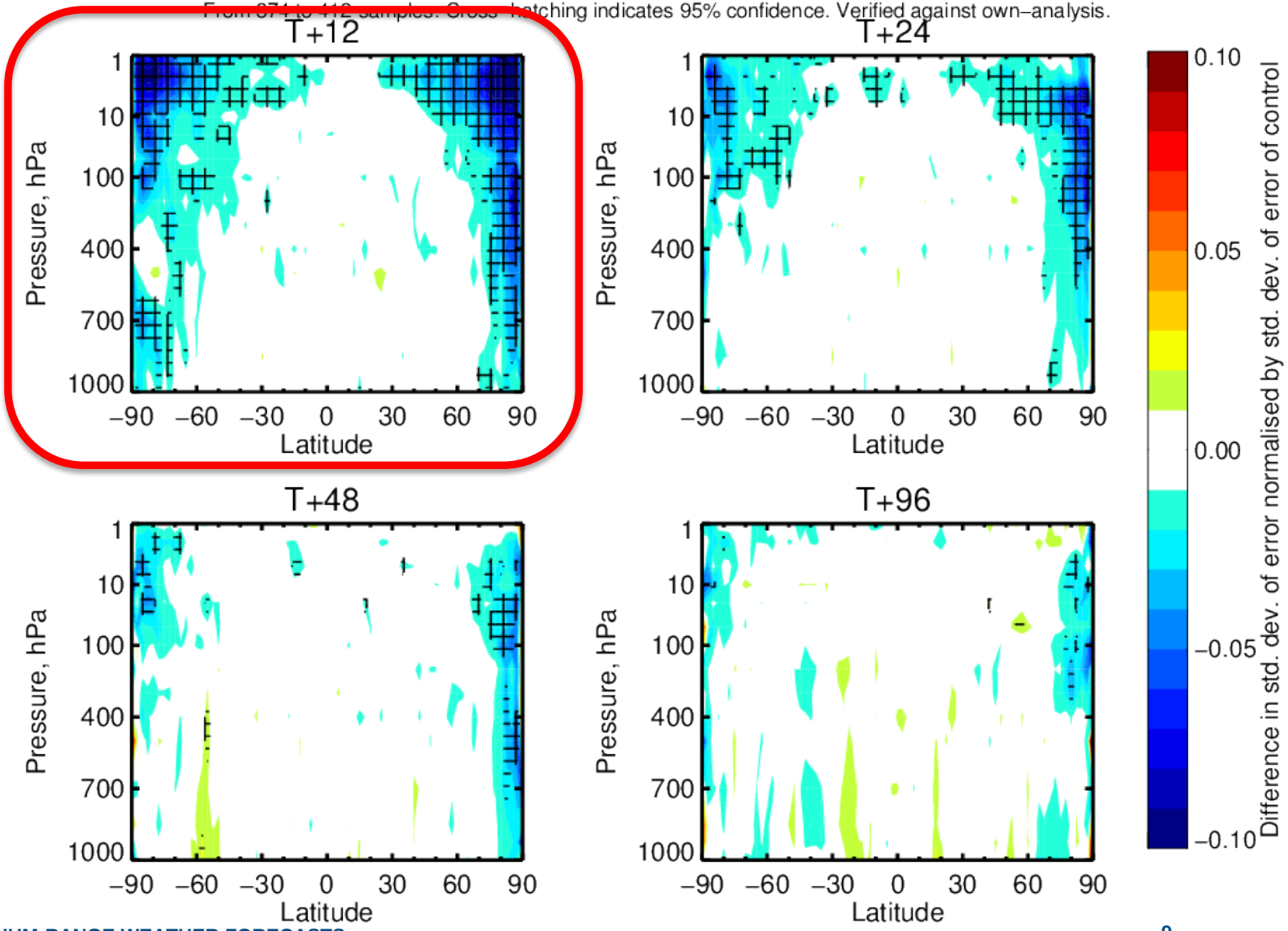




Impact in assimilation experiments

Applied in forward calculations as well as in TL/adjoint

Normalised difference in stdev of forecast error, VW, ~ 7 months



→ Much reduced increments, small positive forecast impact

Summary and conclusions

- Taking the slant-path effect into account significantly improves the agreement between observations and model equivalents.
  - Particularly relevant for temperature sounders with low noise and high viewing angles, but also for humidity sounders.
  - Largest effect for mid/higher latitudes.
- This leads to significantly reduced increments and some forecast benefits out to day 3.
  - Strongest at high latitudes and in the stratosphere.
- Used operationally for LEO sounders in clear-sky since 22 November 2016.

- Effect likely to be particularly relevant for geostationary sounders (see poster 9p.07 by Chris Burrows) or for SSMIS UAS channels (not considered here).
- See also poster 2p.11 by Louis Garand.

- Further details see Bormann (2017), Tellus.

Some technical aspects

- Interpolation to slant-path is done in three steps:
  1) Interpolate model fields to a series of profiles along the azimuthal plane (performed at processor owning the model grid points)
  2) Pass profiles to processor owning the observations
  3) Interpolate series of profiles to slanted path (at processor owning the observations)

  6 profiles with Δx = 32 km for trajectory calculations
  3 profiles with Δx = 80 km for minimisation