Evaluation of ROMEX Data: Biases and Uncertainties

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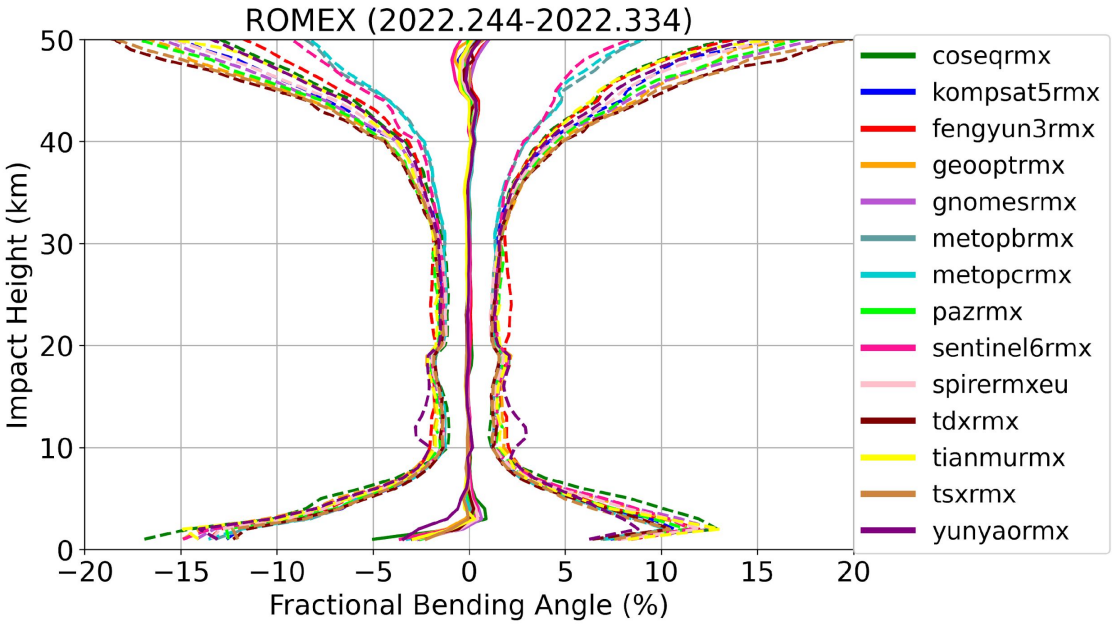
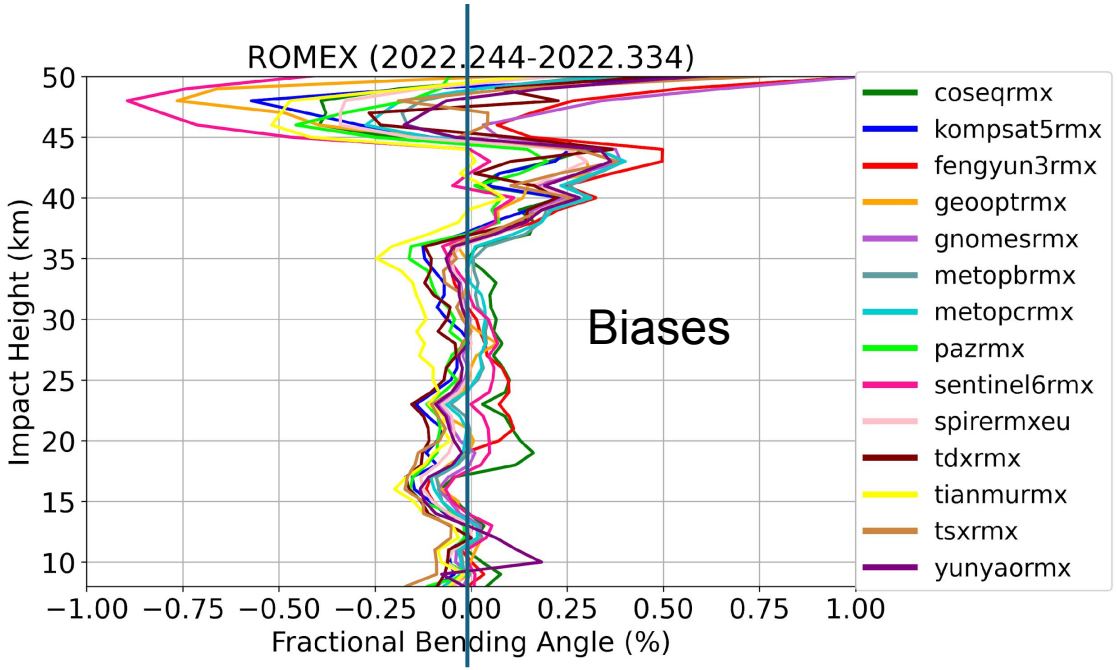
ROMEX Data Evaluation-Summary

- Unprecedented number of RO observations for 3 months
- Daily geographic coverage excellent
- Local time coverage only fair
- Penetration depths similar-50% reach 1 km or lower
- Statistics stable over 91 days
- UCAR and EUMETSAT processing similar
- Quality (biases and uncertainties) of 14 missions similar
- Biases small (+/- 0.2% or smaller) between 10-30 km

OVERALL MESSAGE

- All ROMEX data are of high quality and useful for NWP and other science studies with QC
- Small differences are scientifically interesting and understanding them will be useful for data providers and users
- NWP impact so far mixed because of
  - small biases in RO observations that have not been obvious with smaller numbers of RO data?
  - issues with the models/DA that are amplified and made visible by the massive numbers of high-quality RO data?

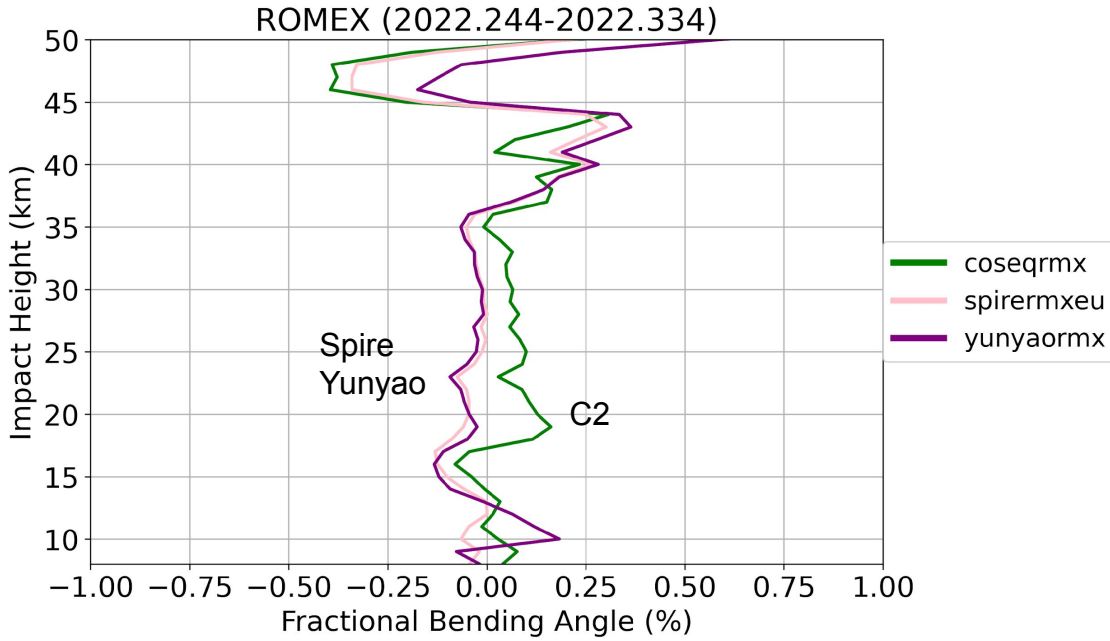




Biases and STD of differences compared to ECMWF analysis

Most of ROMEX data: negative bias 0.1-0.2% between 10-35 km in these estimates

C2 positive bias ~0.2% compared to Spire and Yunyao

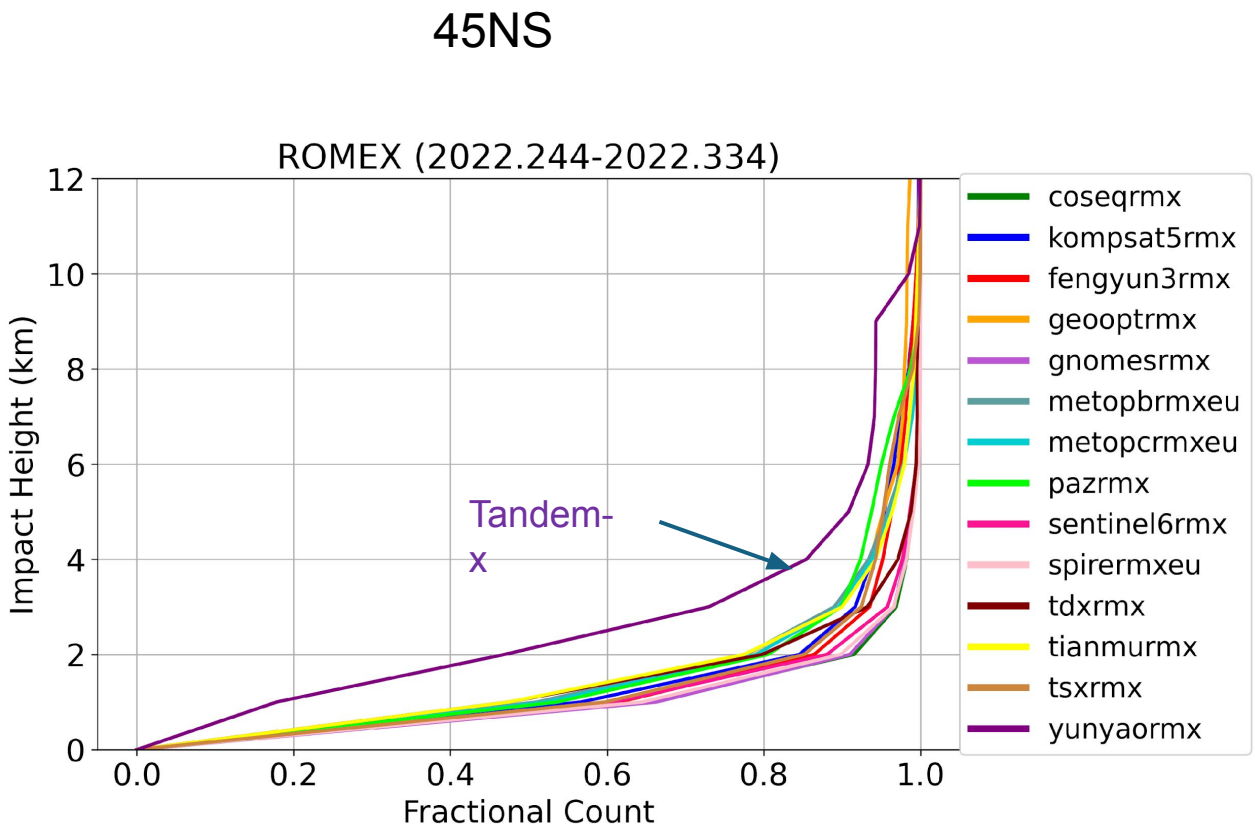


Penetration depths

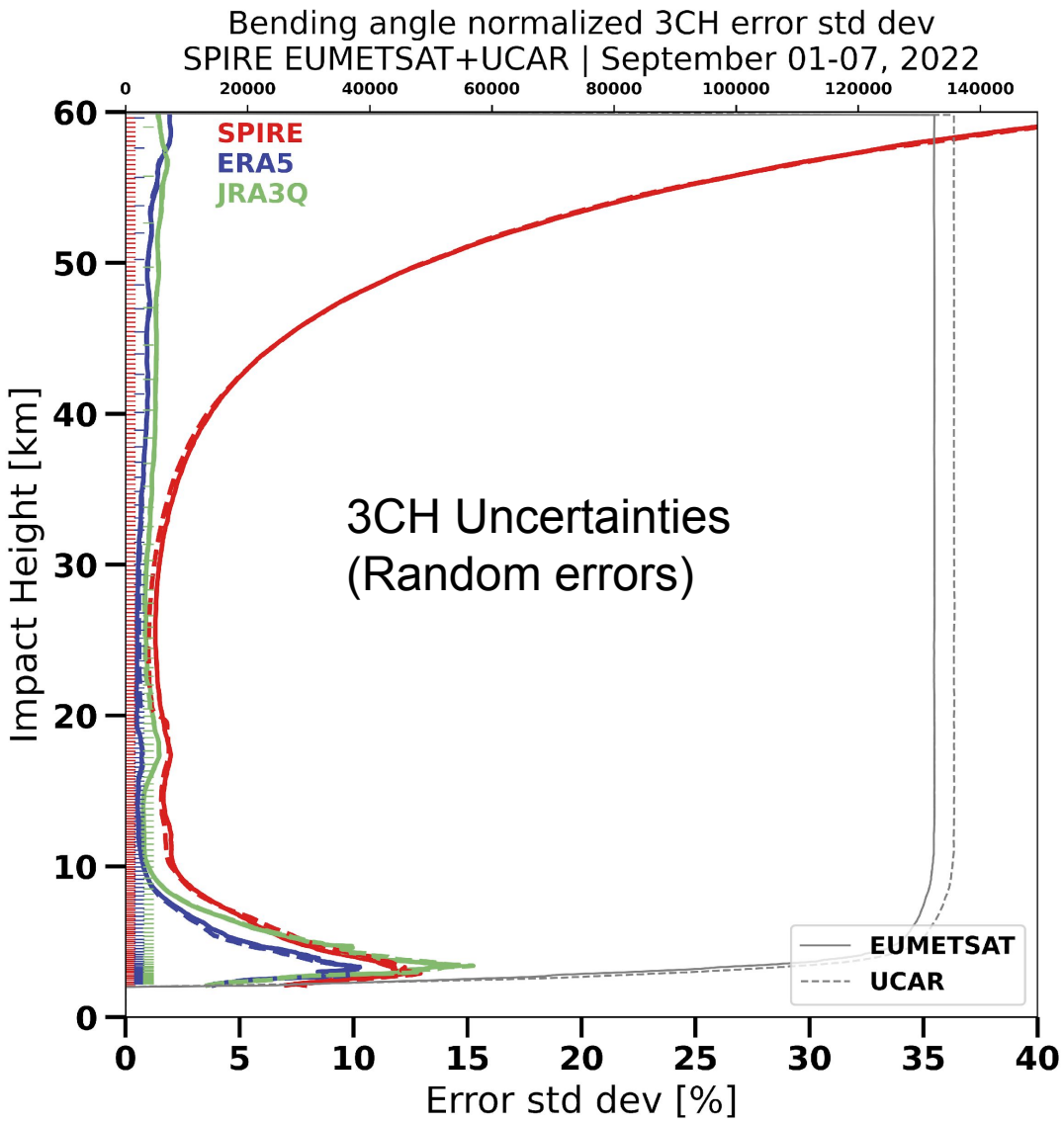
50% of all ROMEX profiles reach 1 km
80% of all ROMEX profiles reach 2 km

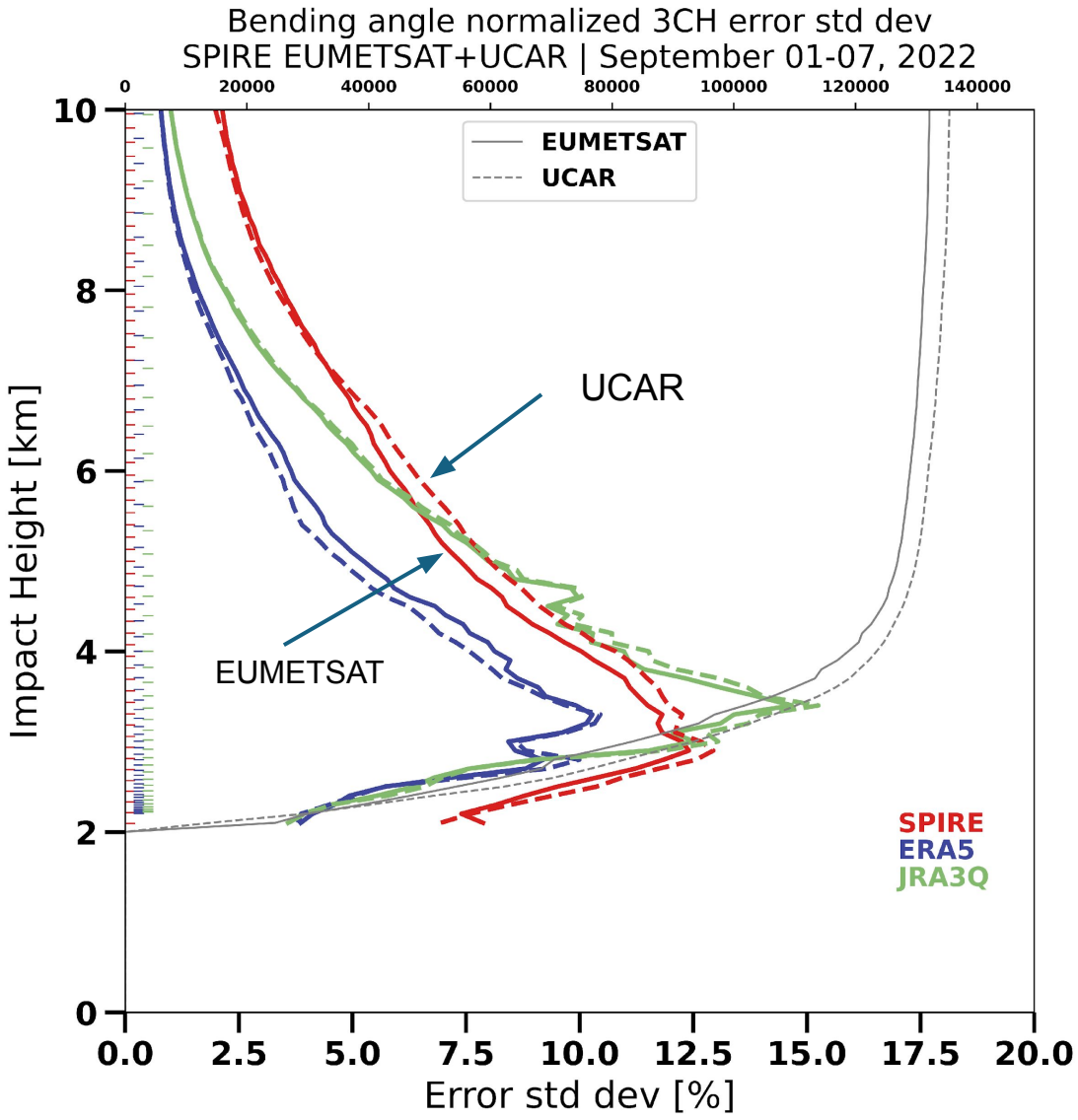
RO provides useful information on lower troposphere

- Water vapor
- Height of PBL
- Superrefraction and ducting

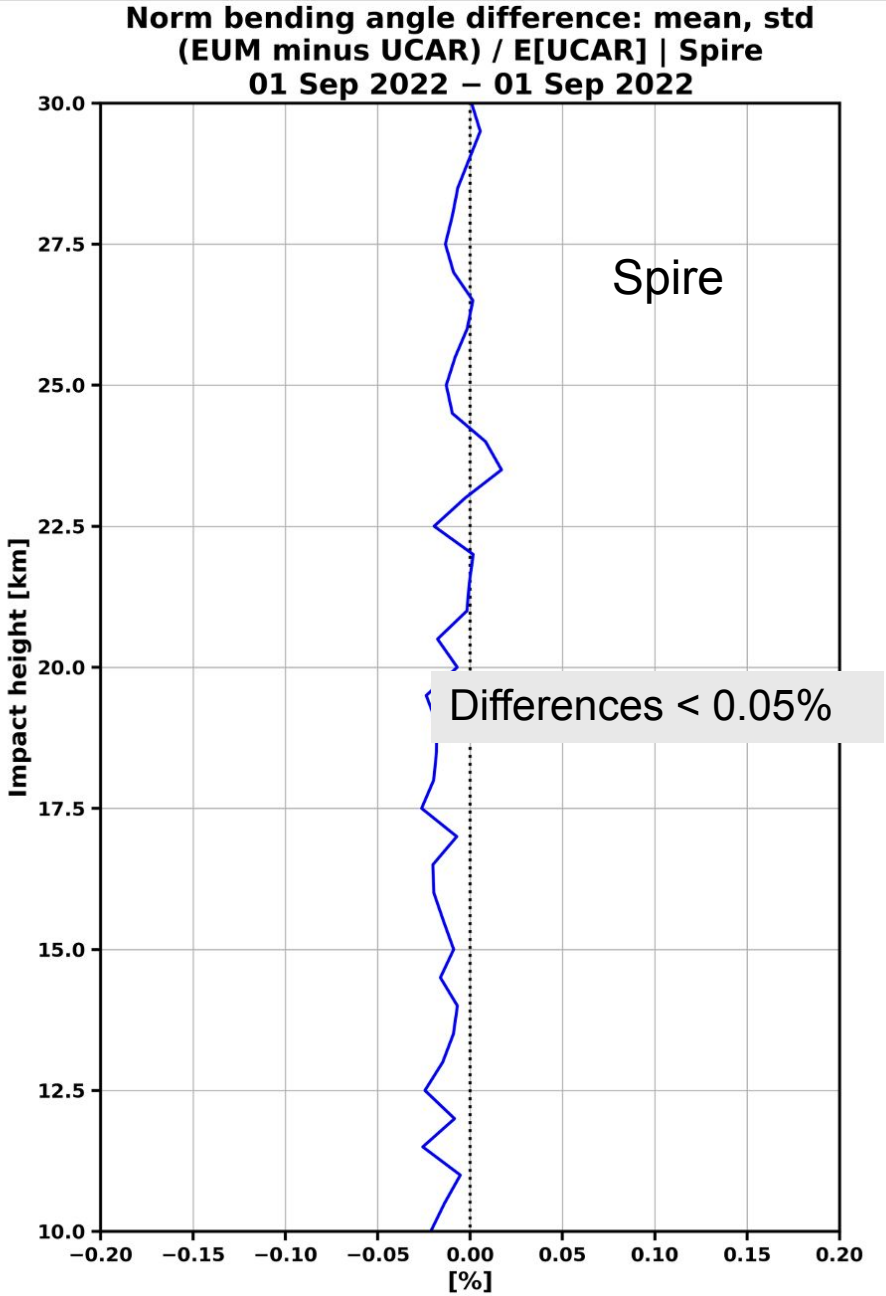


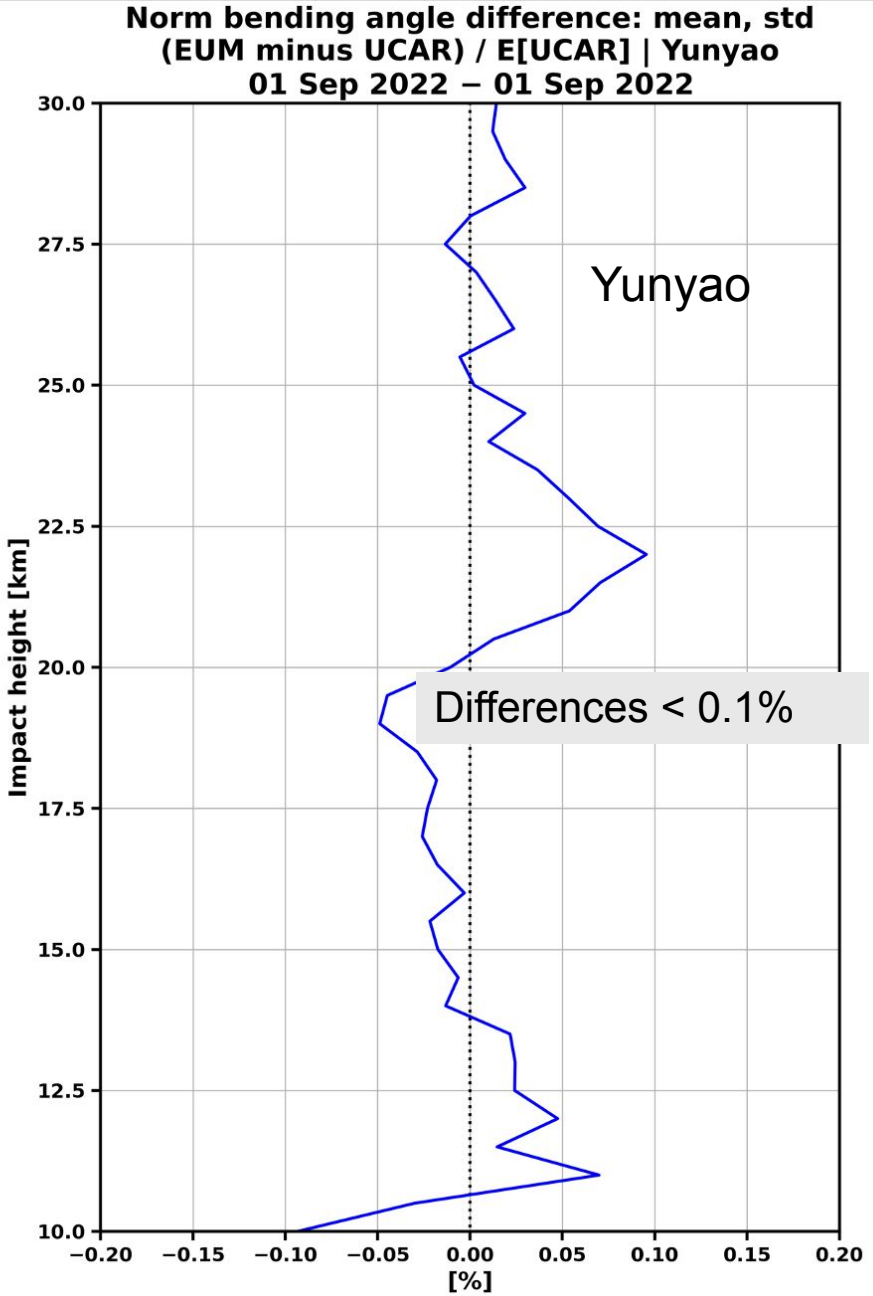
UCAR (solid red) and EUMETSAT (dashed red) processing similar





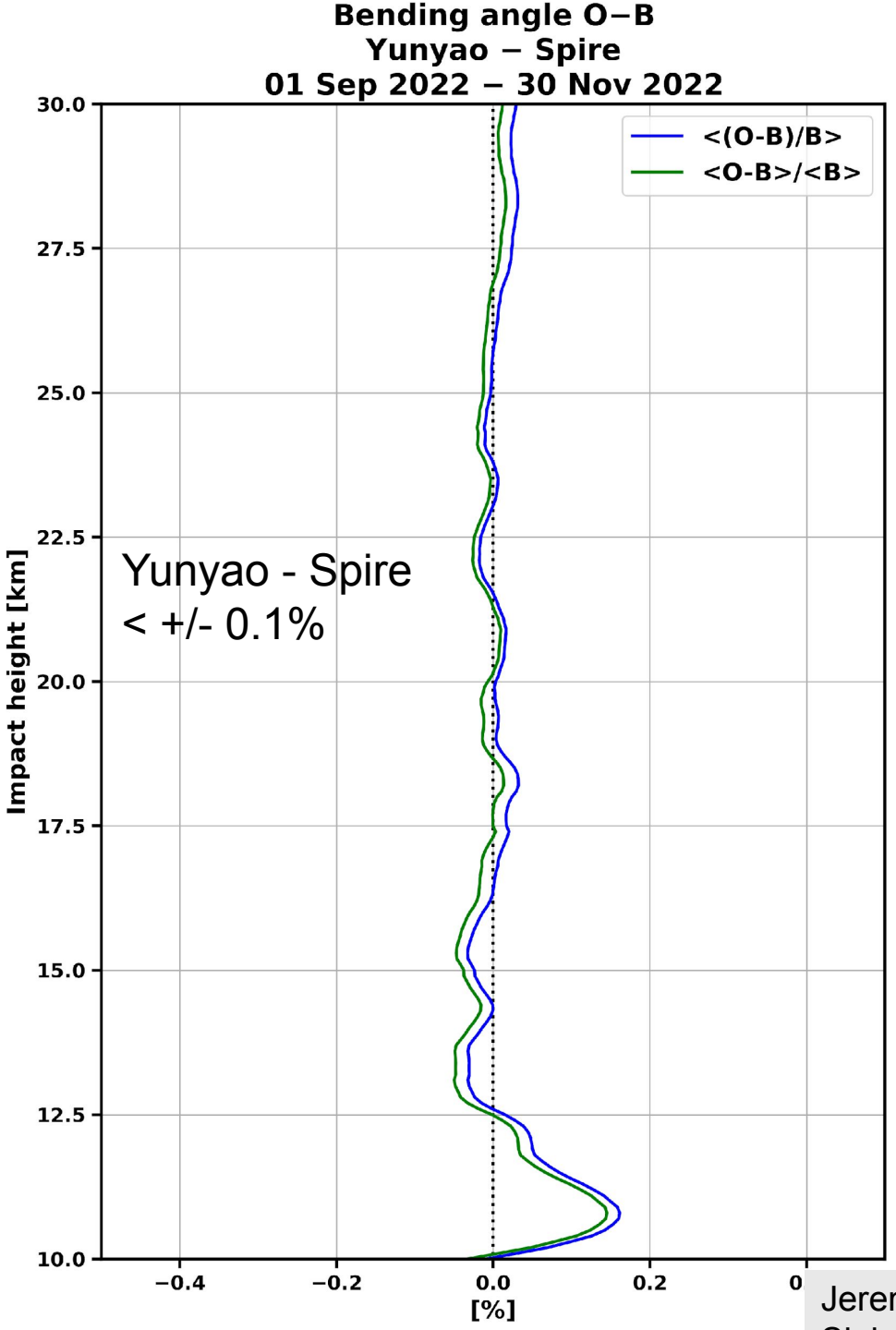
EUMETSAT and UCAR Biases wrt ERA5 similar

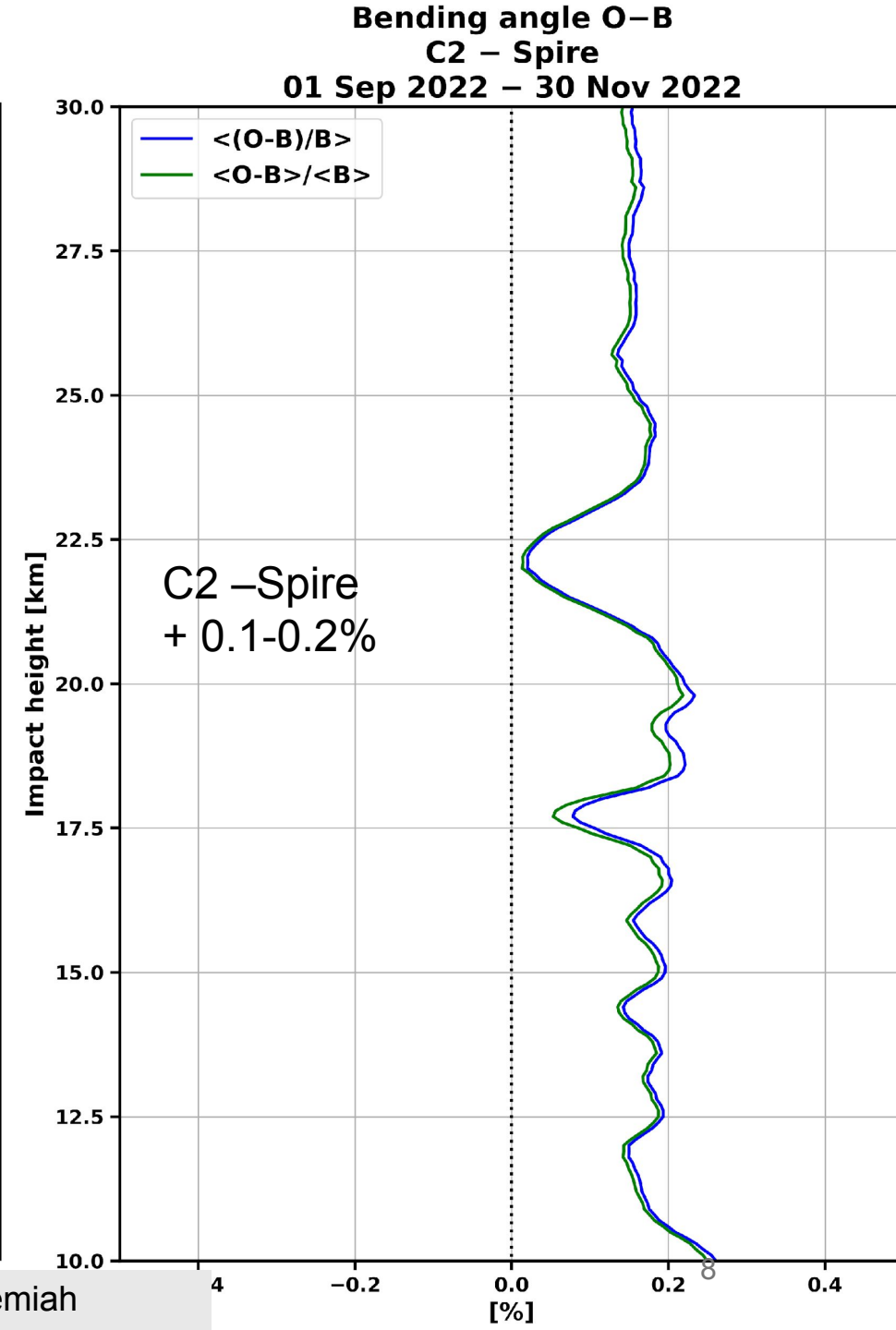




Yunyao minus Spire
and
COSMIC-2 minus
Spire

Collocation:
100 km 3 hours





Jeremiah

ROMEX observation biases

- Assimilation of ROMEX data change model biases; some positive, some negative
- ROMEX observations are common to all models so they are one of many suspects

Determining ROMEX biases

Determining ROMEX biases

Difficult to estimate biases because Truth is unknown and not well defined

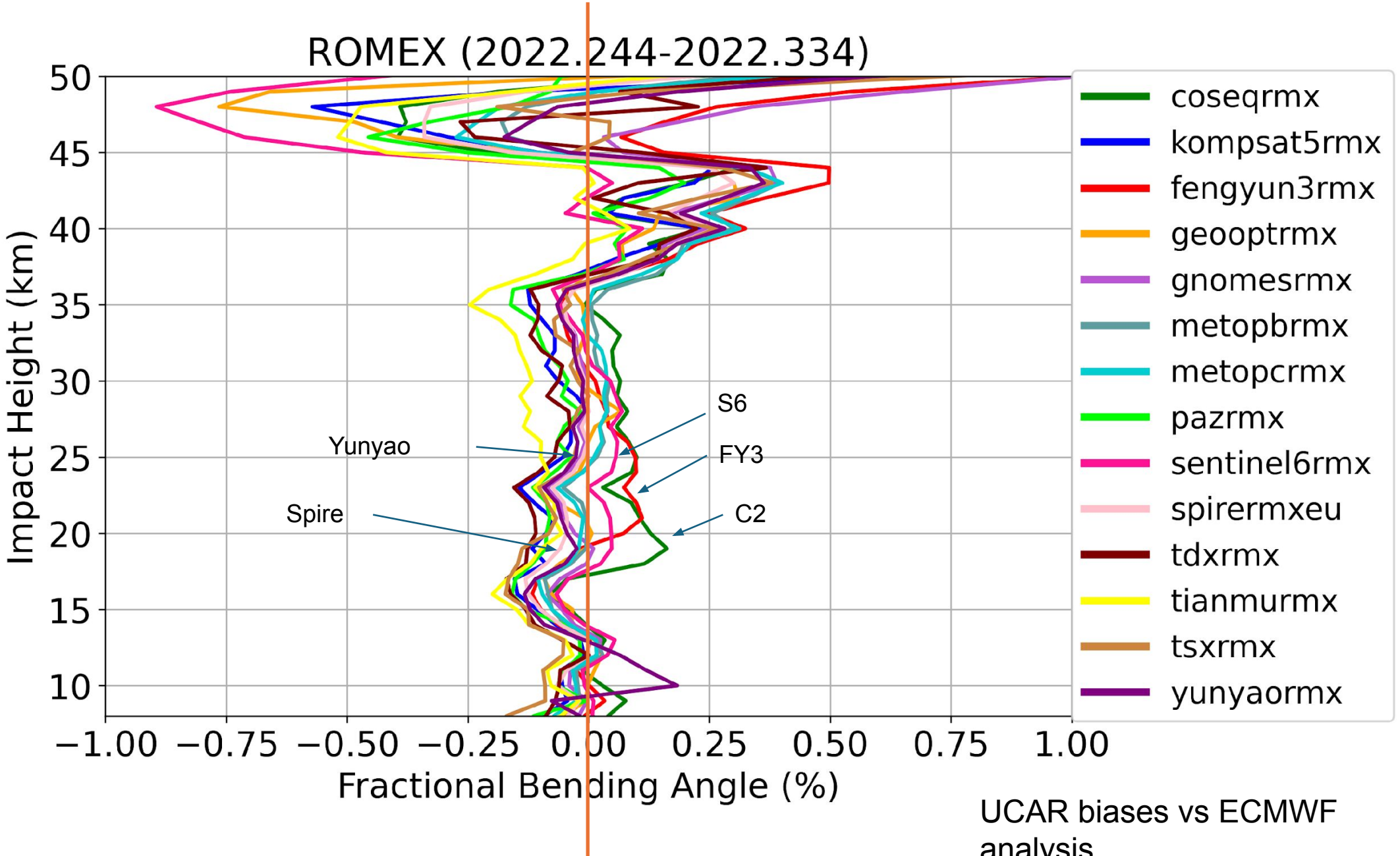
Sensitive to how they are estimated (reference data and its forward model, refractivity equation, QC, sampling, collocation……)

We compare RO datasets

- Processed by different centers (structural uncertainty)
- High-quality radiosondes (in progress)
- Each other (e.g. COSMIC vs Spire)
- High-quality model data (GFS, ECMWF, ERA5, JRA-3Q)

Results suggest that RO bending angle biases less than +/- 0.2% in the region of most NWP impact (8-30 km)-maybe smaller

Effect of BA biases on NWP models



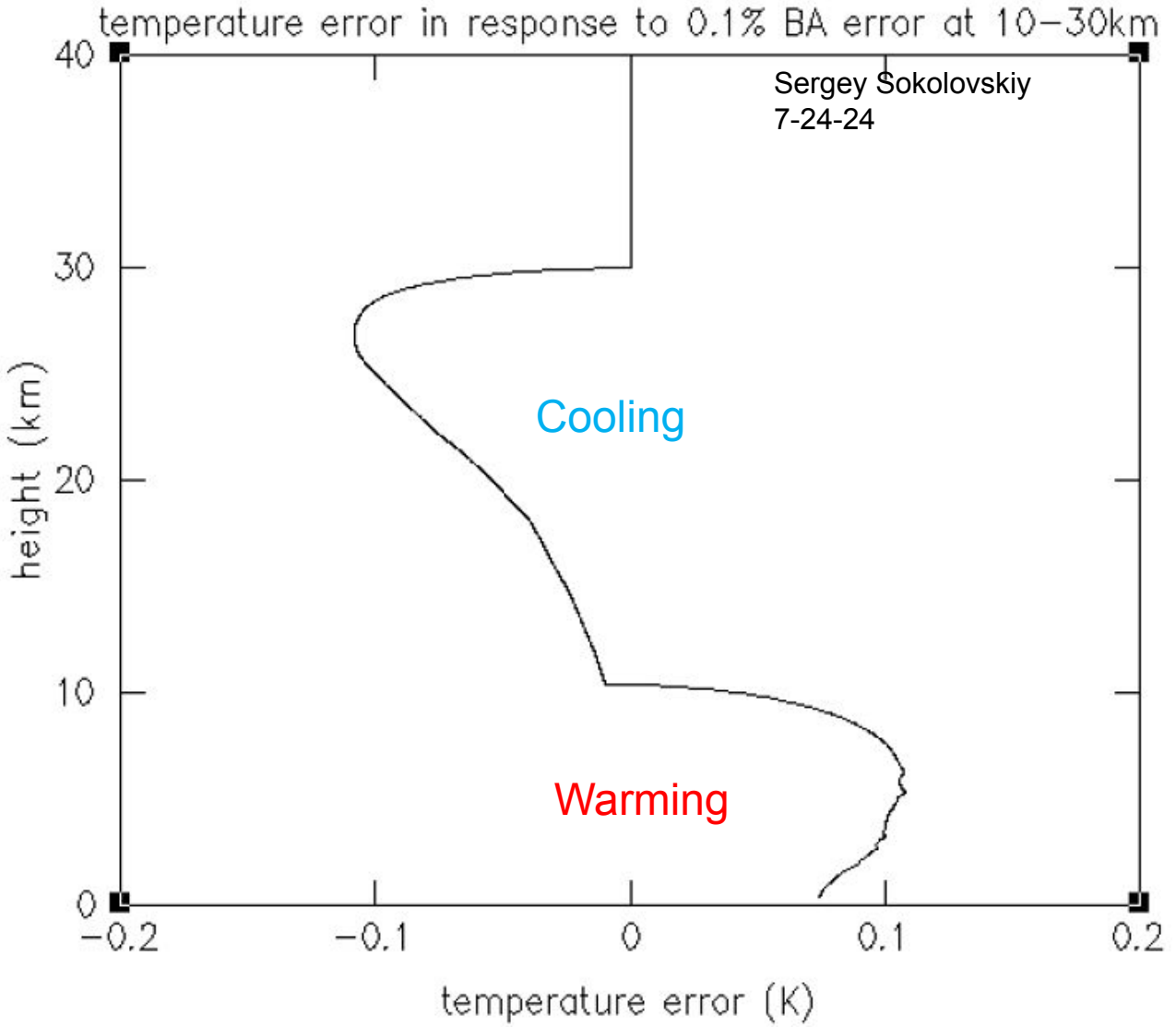
UCAR biases vs ECMWF analysis

Effect of a 0.1% positive bias in bending angle between 10-30 km on dry temperature retrieval

Opposite effect for negative bias in BA 10-30 km (most of ROMEX compared to ECMWF)

Long “hydrostatic tail” below bottom of biased layer.

$$n(r) = \mathrm{Exp}\left[\frac{1}{\pi}\int_{a_1}^{\infty}\frac{\alpha}{\sqrt{a^2 - a_1^2}}\,da\right]$$



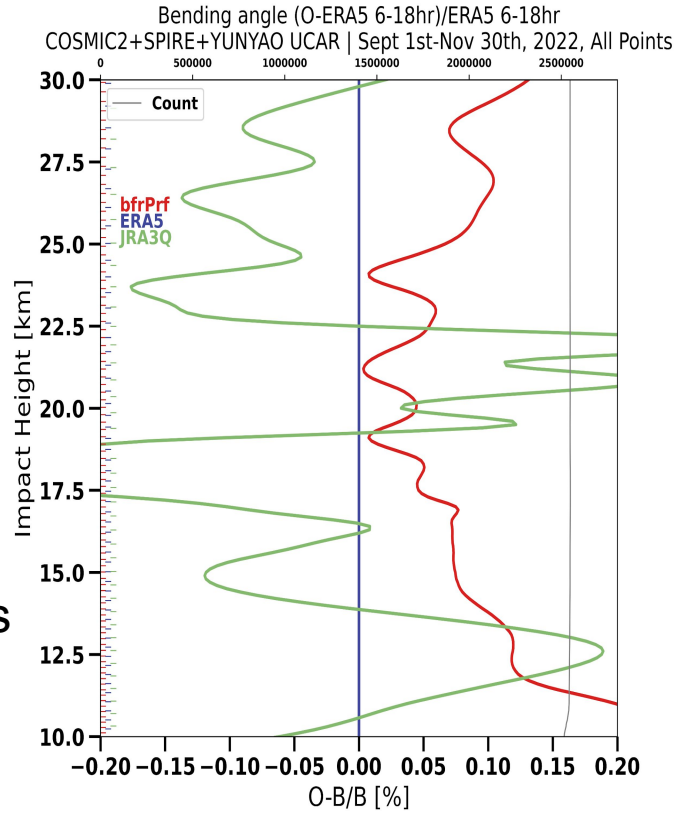
Spire + C2 + Yunyao (78% ROMEX data) biased + to ERA5

Different bias results!

Left: This talk: + 0.1%
Right: Ben's : -0.2%

Possible differences:

1. QC
2. Forward model for ERA5
3. ERA5 fcst vs analysis
4. Different collocation codes
   Especially vertical colloc



H (km)

50

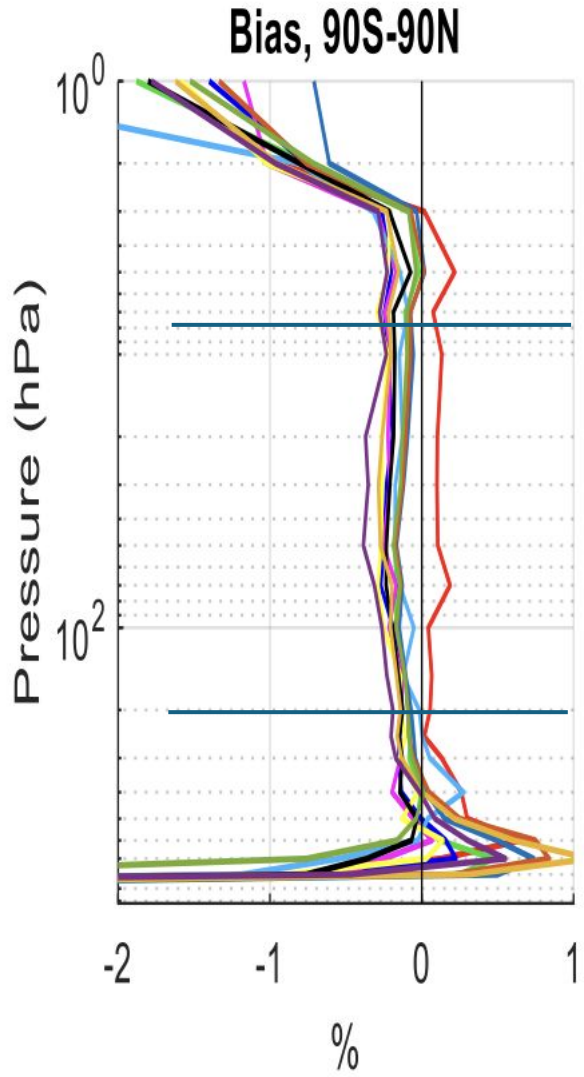
30

20

16

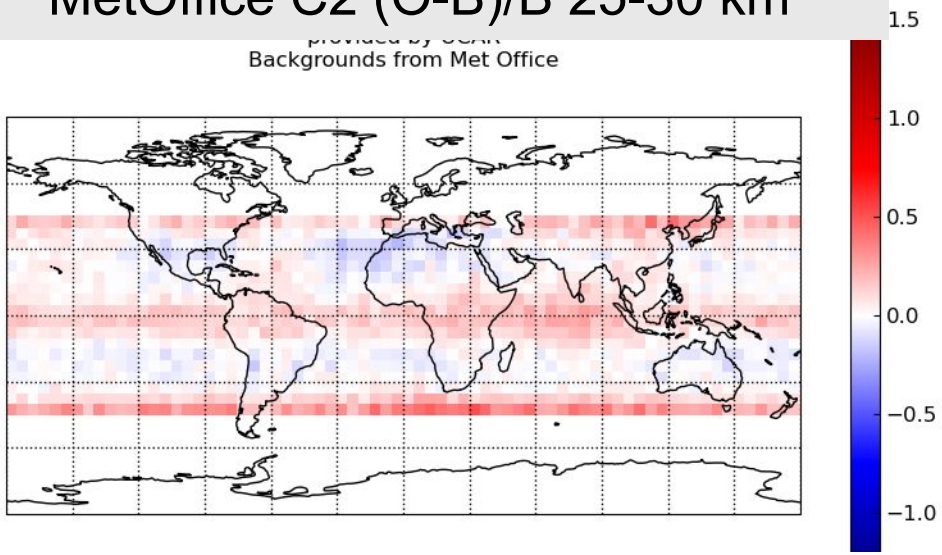
10

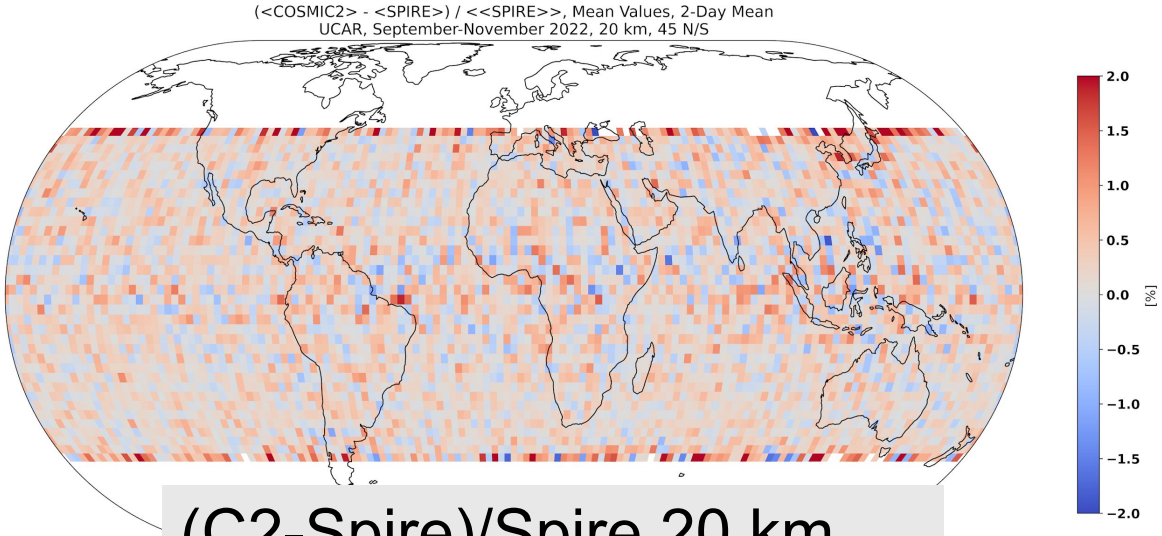
5



One possible source of COSMIC-2 biases?

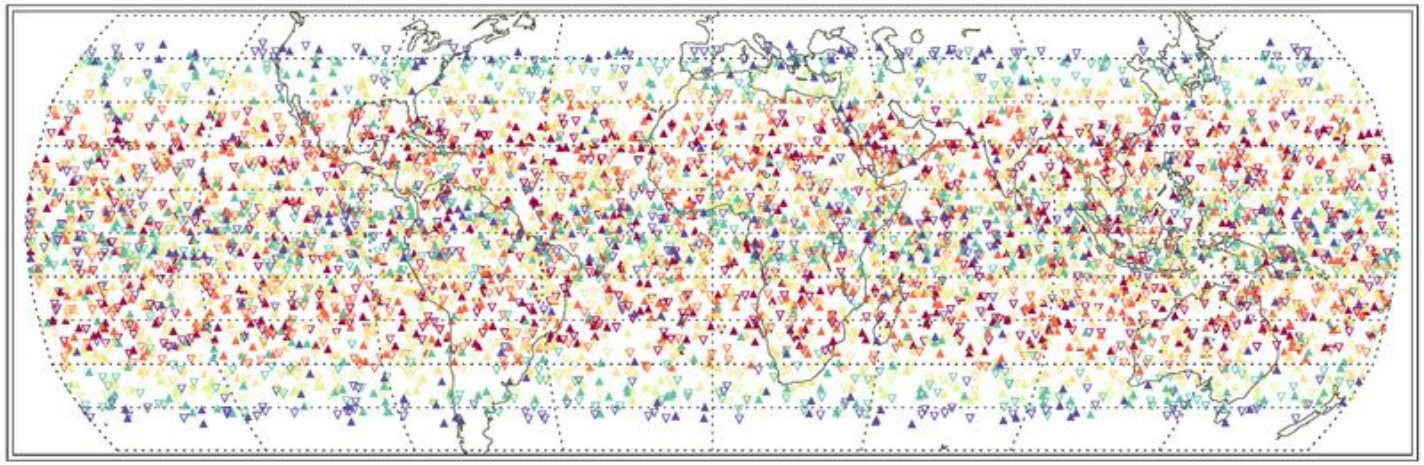
MetOffice C2 (O-B)/B 25-30 km





(C2-Spire)/Spire 20 km

C2 Azimuth angle



Final comment

Enormous value of international community looking at same large RO dataset

Thank you!