

# Evaluation of ROMEX Data: Biases and Uncertainties

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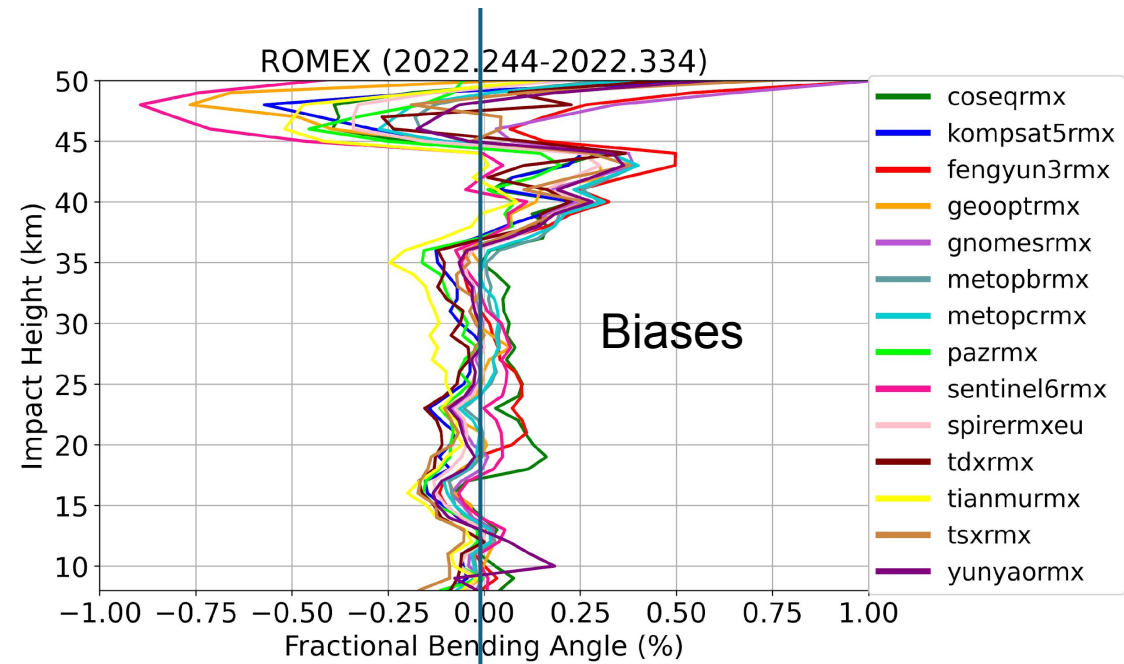
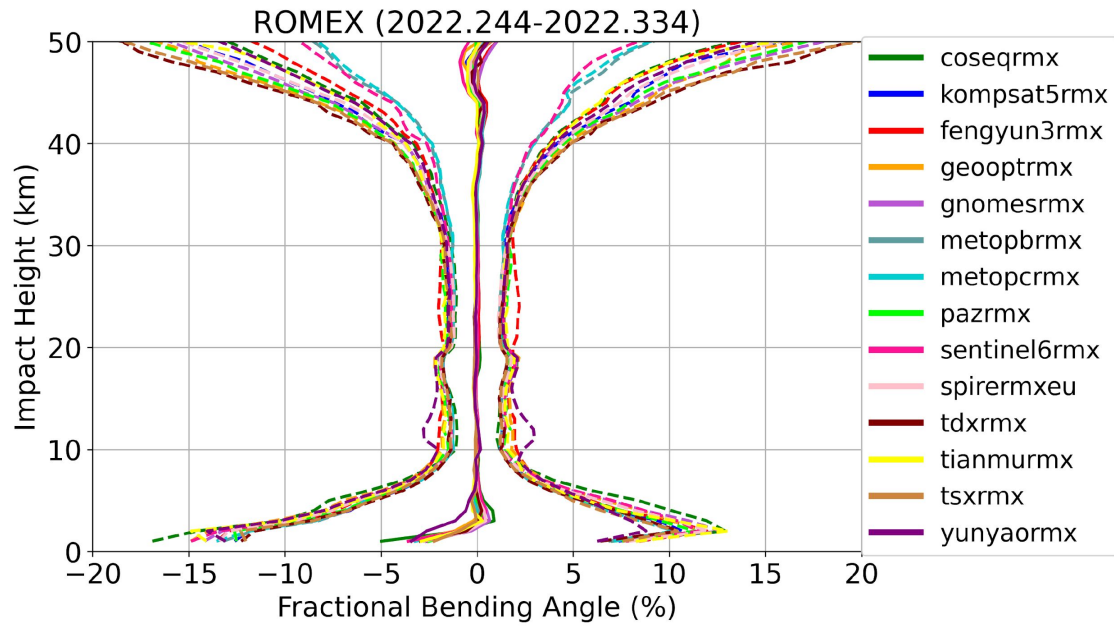


# ROMEX Data Evaluation-Summary

- 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

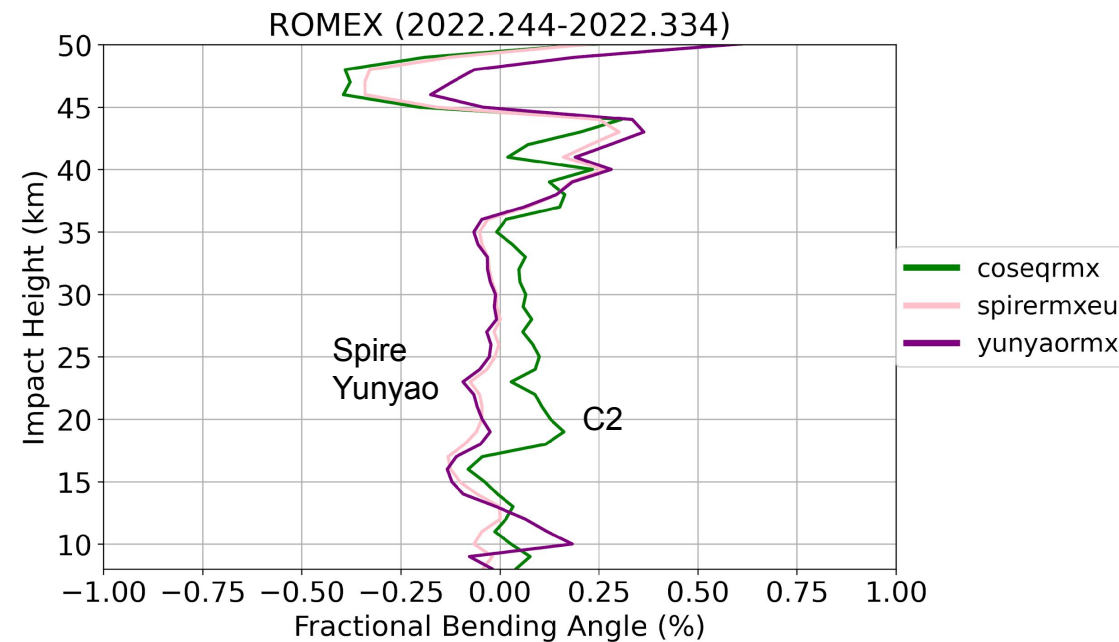
- All ROMEX data are of high quality and useful for NWP and other science studies with QC
- Small differences are scientifically interesting and understanding them will be useful for data providers and users
- NWP impact so far mixed because of
  - small biases in RO observations that have not been obvious 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

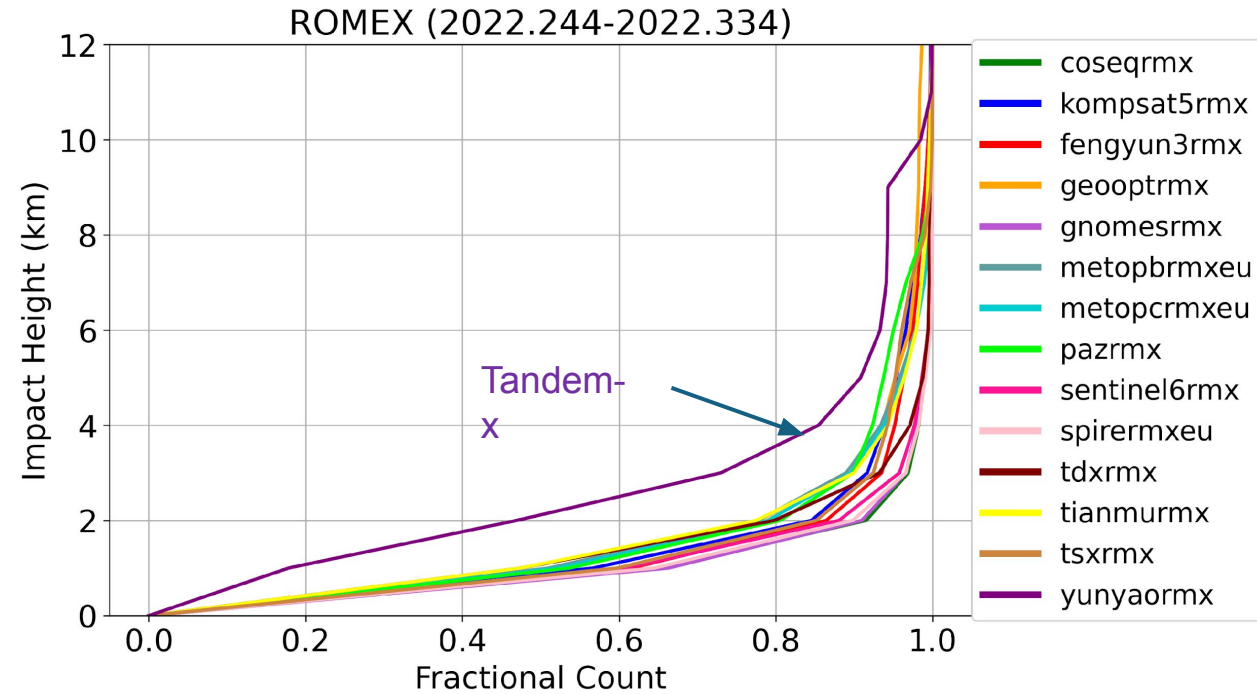
RO provides useful information on lower troposphere

Water vapor

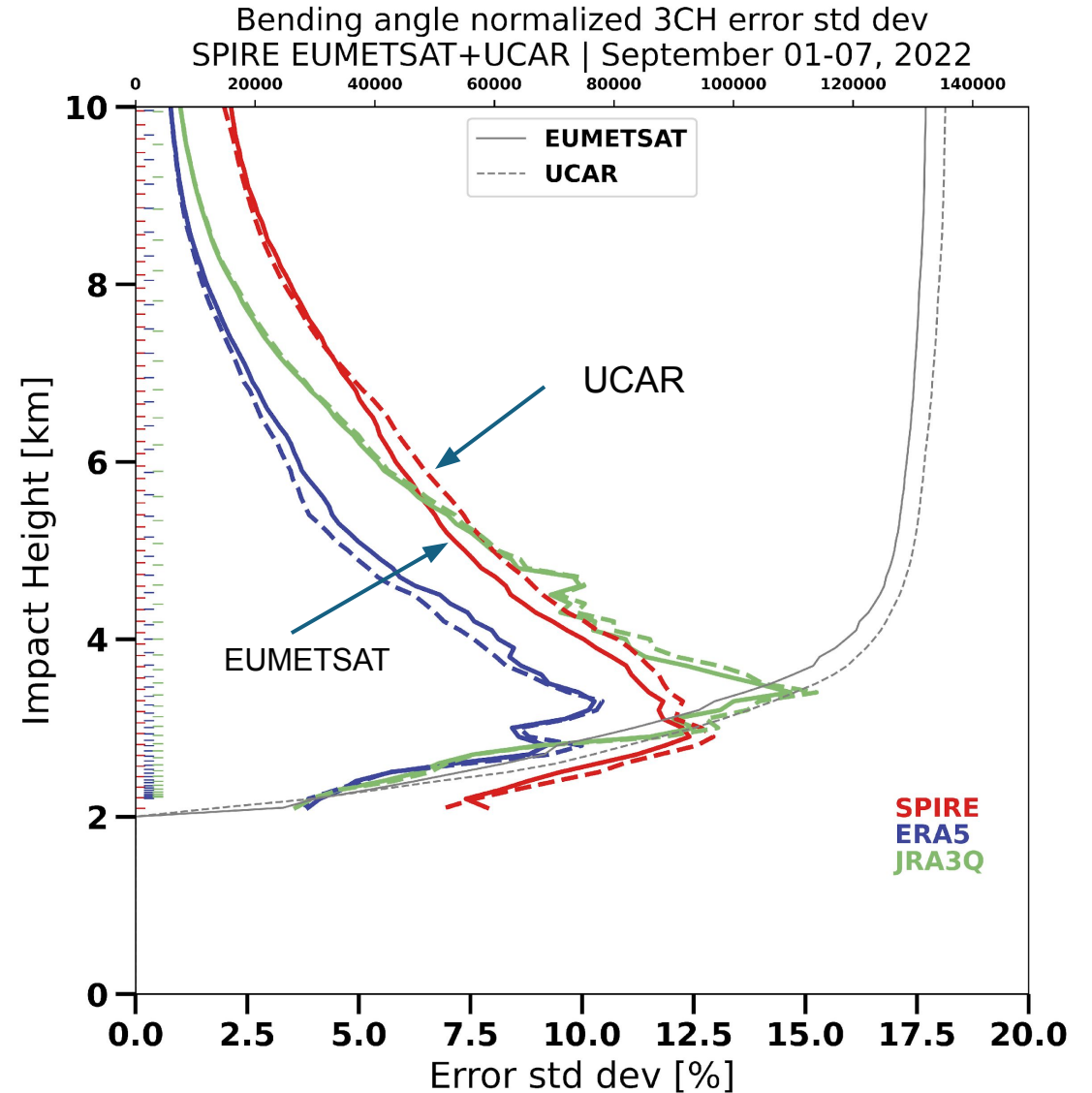
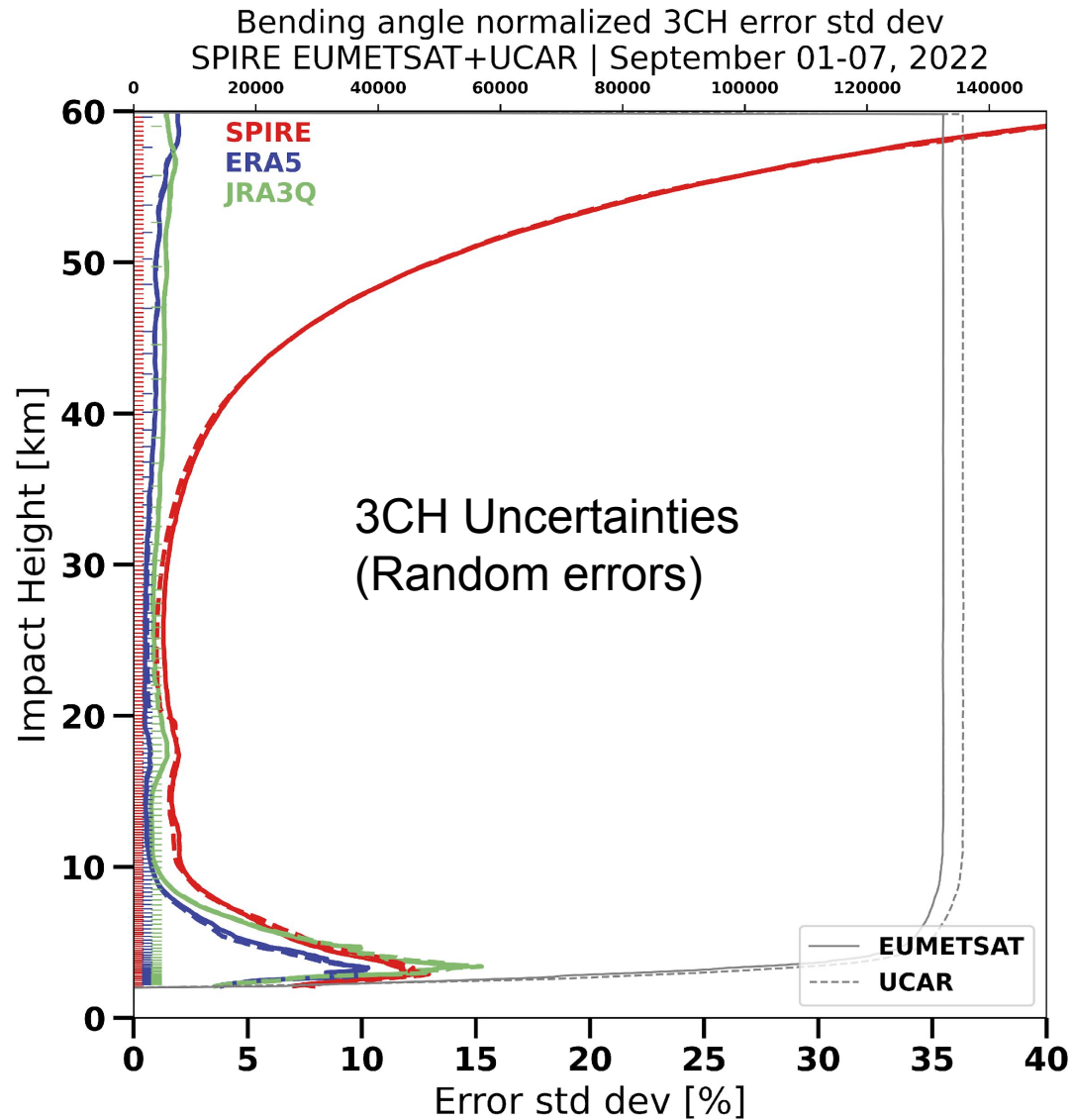
Height of PBL

Superrefraction and ducting

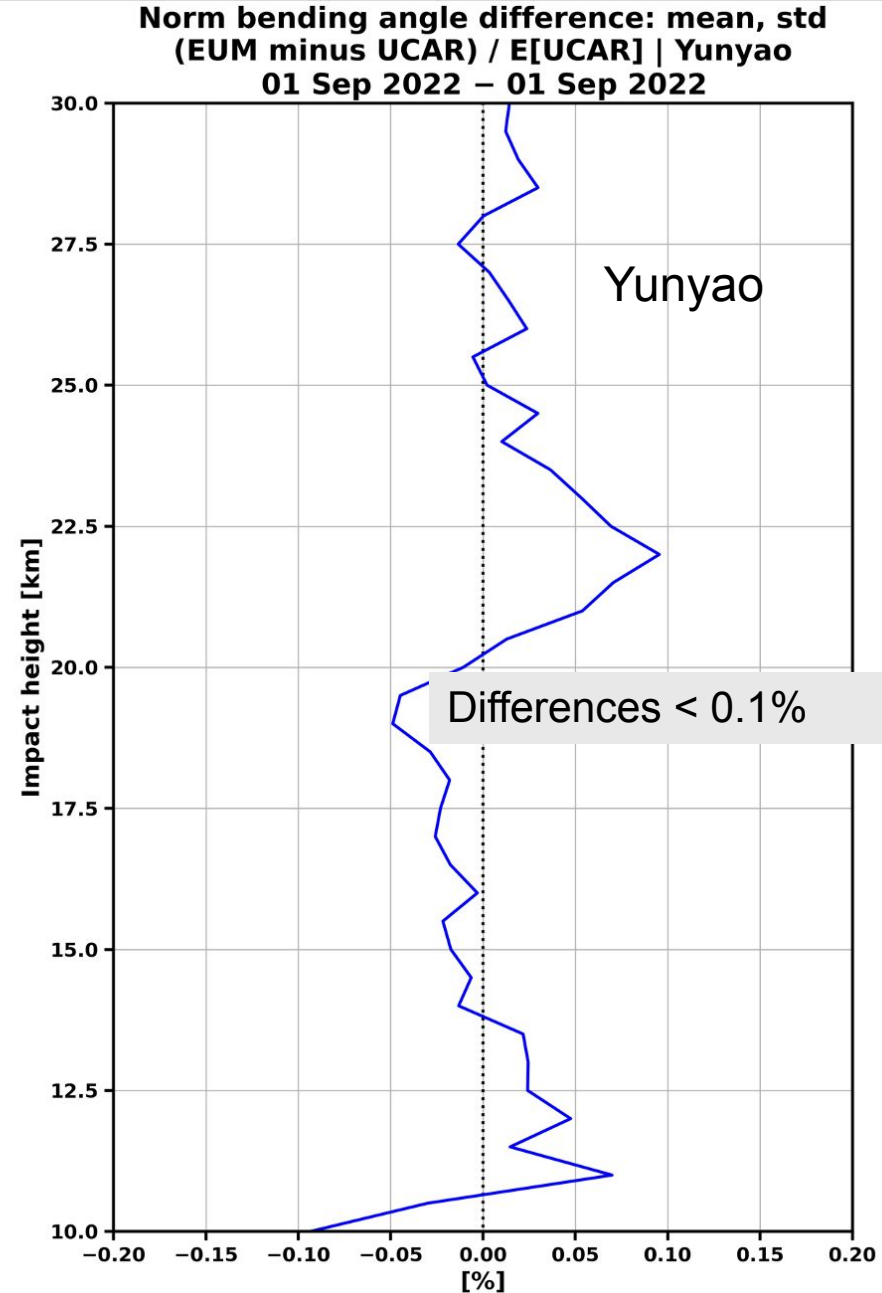
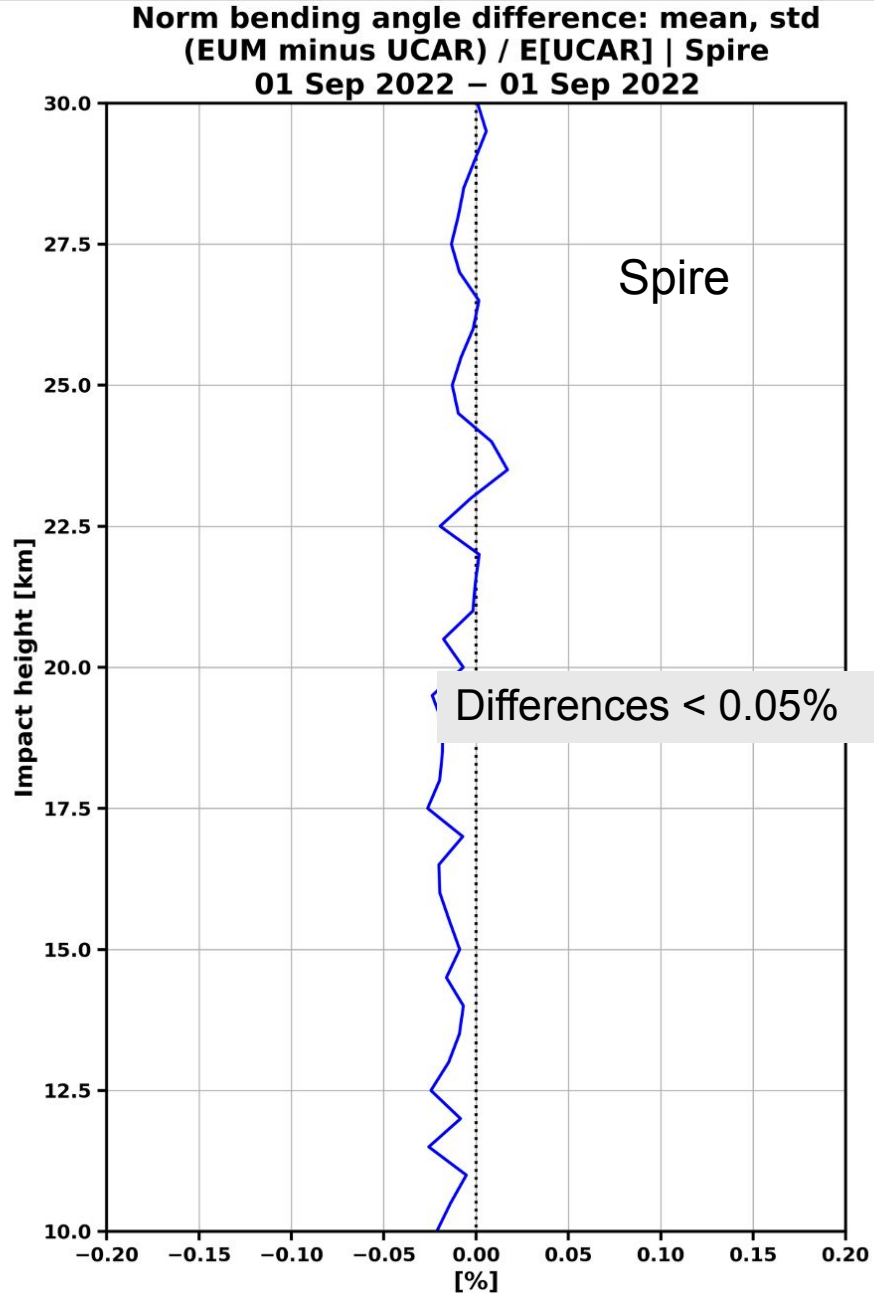
45NS



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

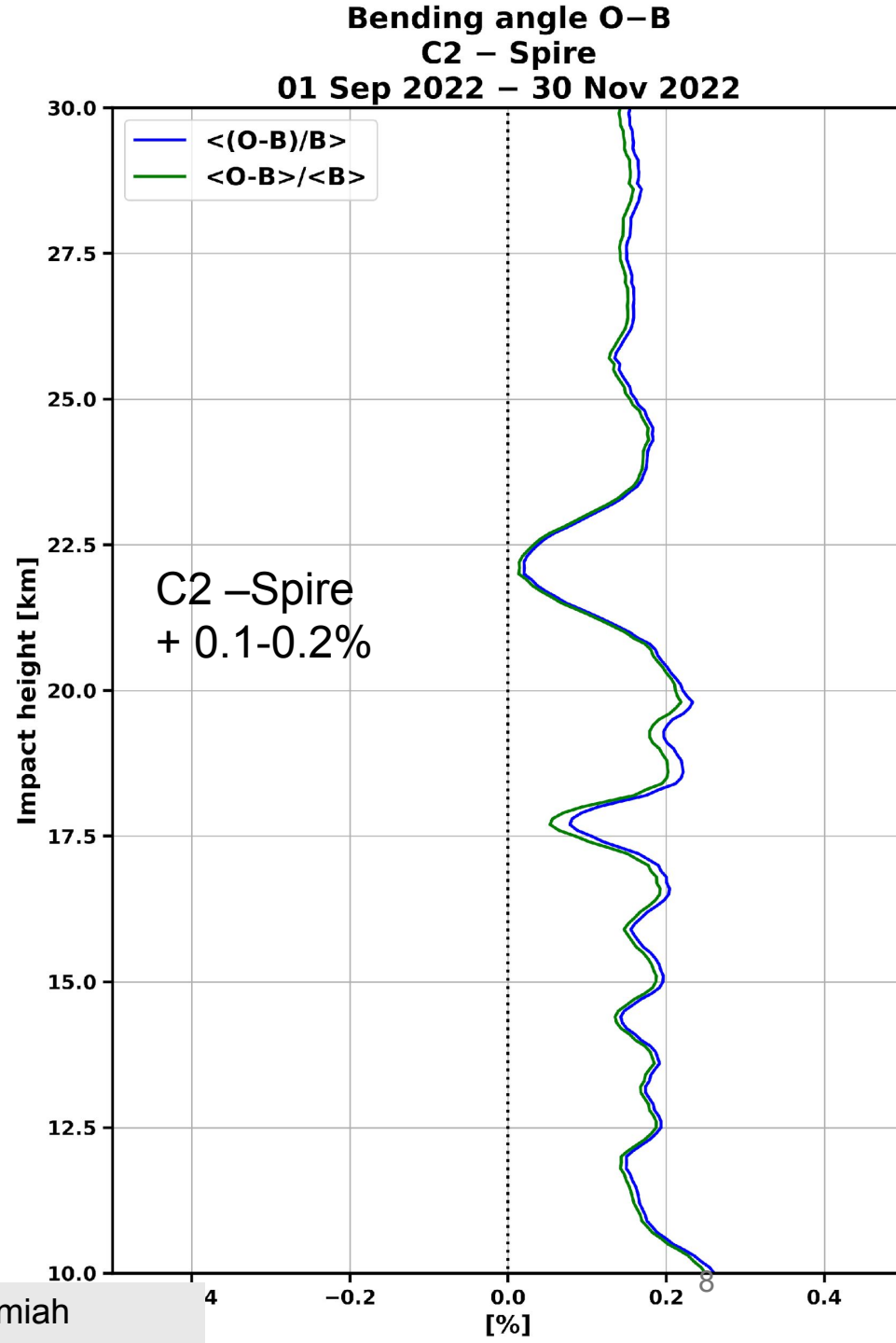
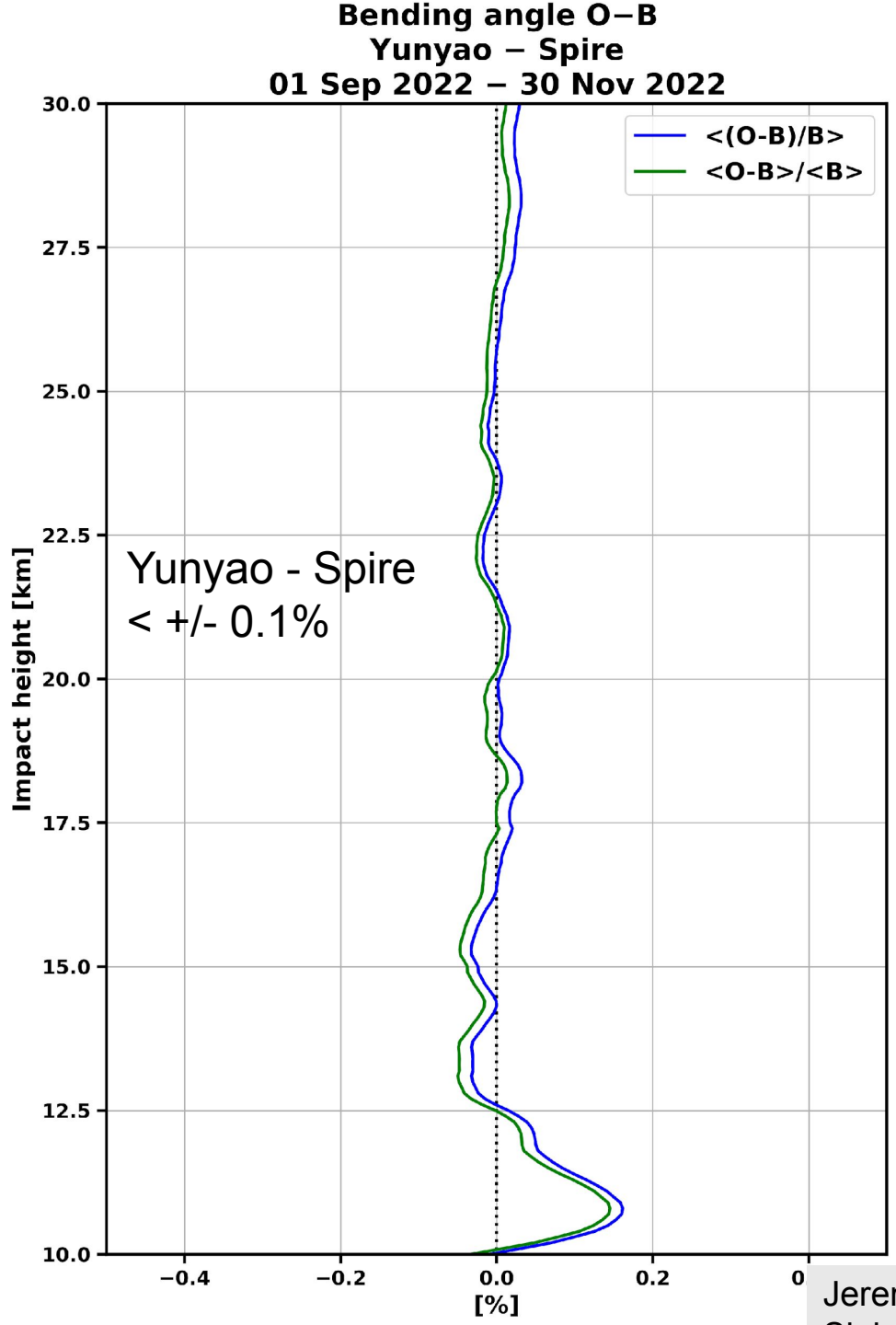


# EUMETSAT and UCAR Biases wrt ERA5 similar



# Yunyao minus Spire and COSMIC-2 minus Spire

Collocation:  
100 km 3 hours





# 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



WILD-GOOSE-CHASE

# 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)

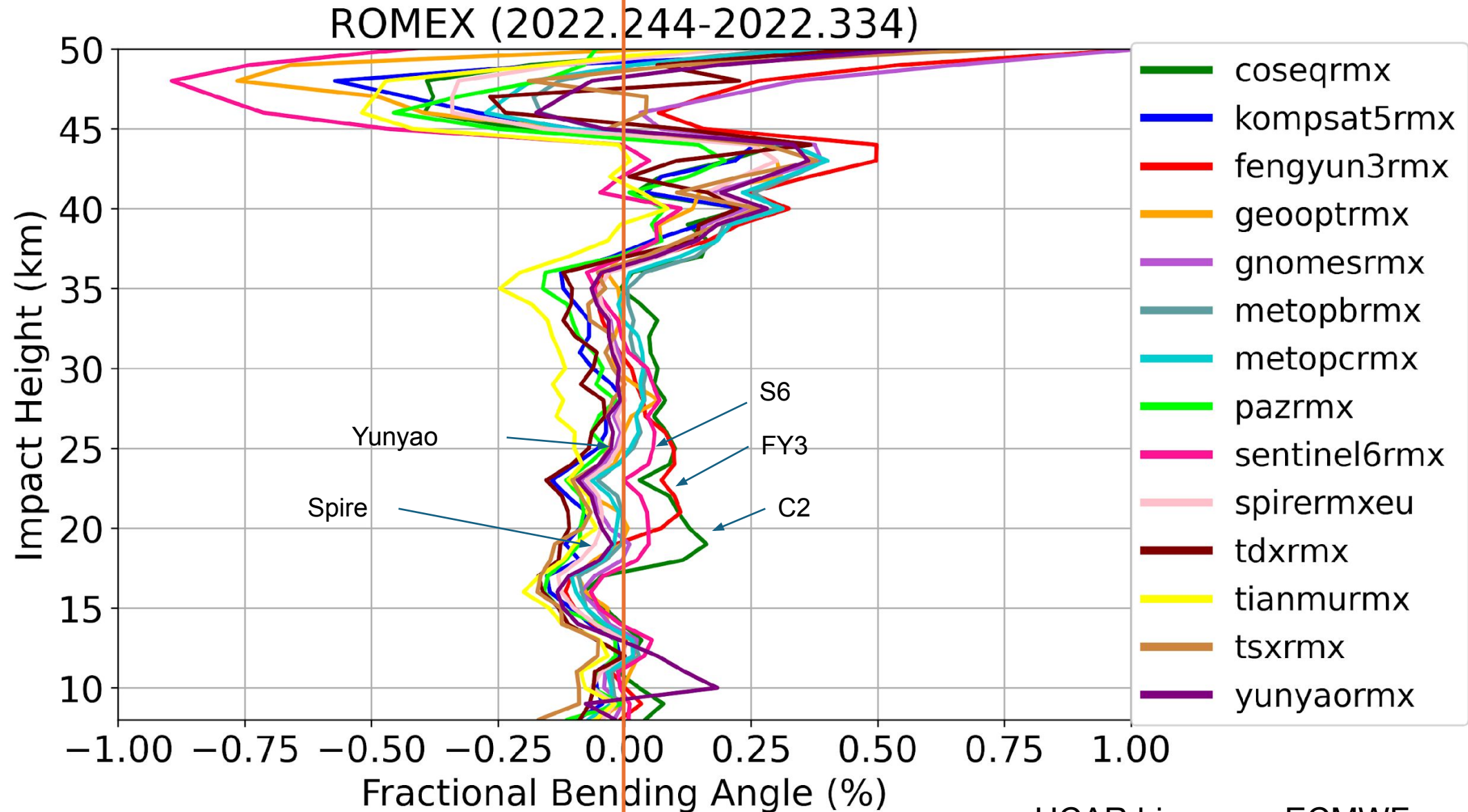
- High-quality radiosondes (in progress)

- 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

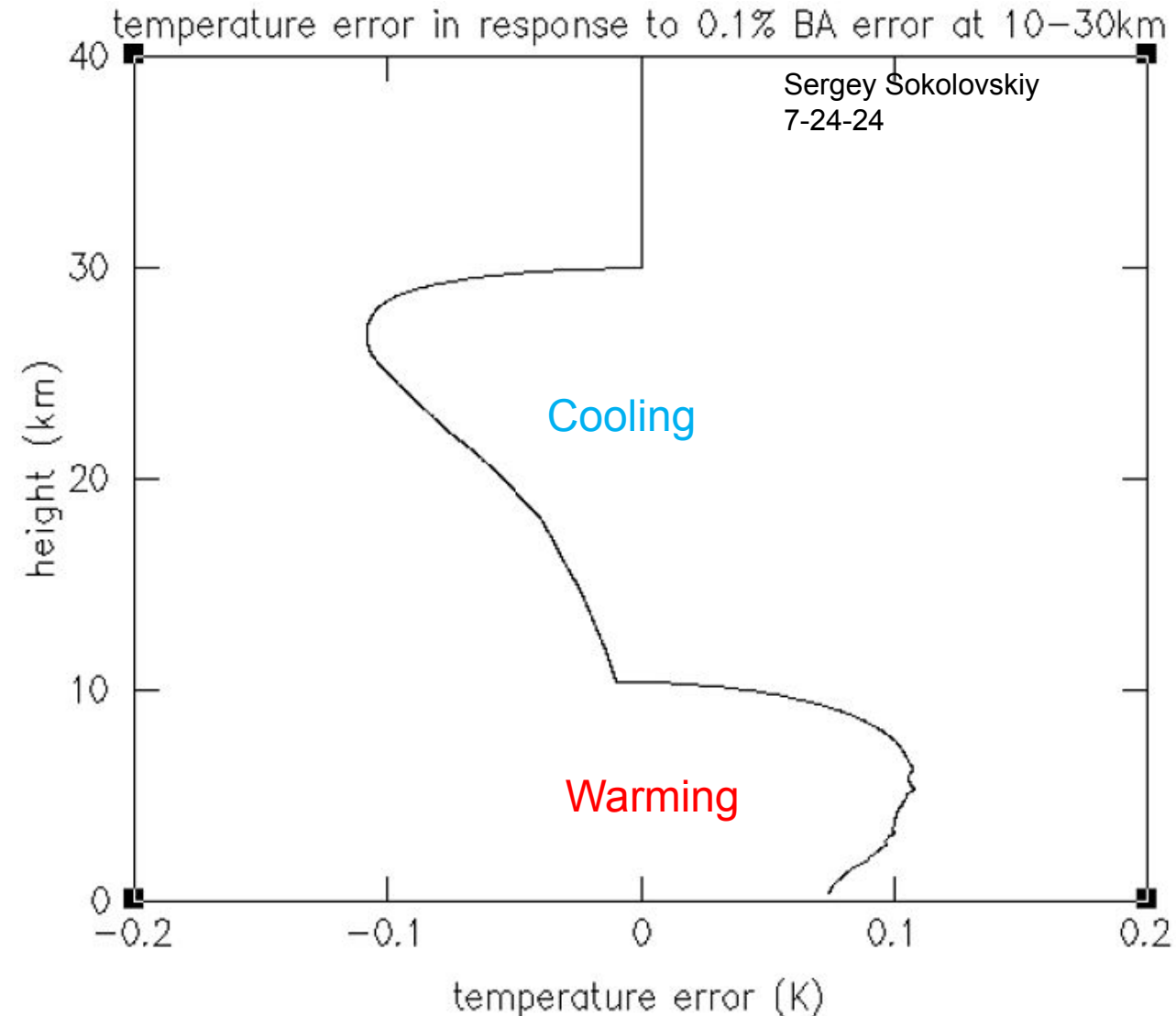


# Effect of a 0.1% **positive** bias in bending angle between 10-30 km on dry temperature retrieval

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

Long “hydrostatic tail” below bottom of biased layer.

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



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

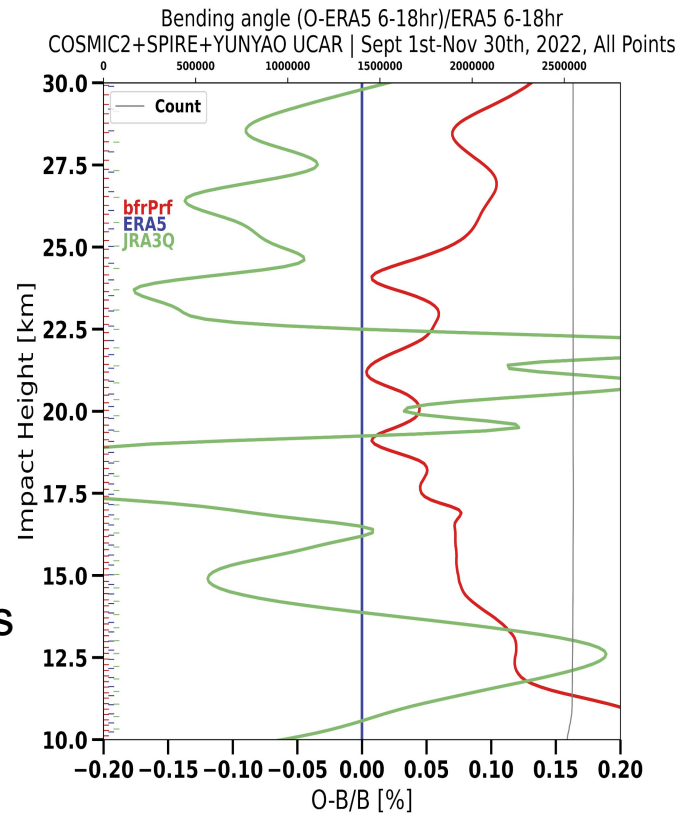
Different bias results!

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

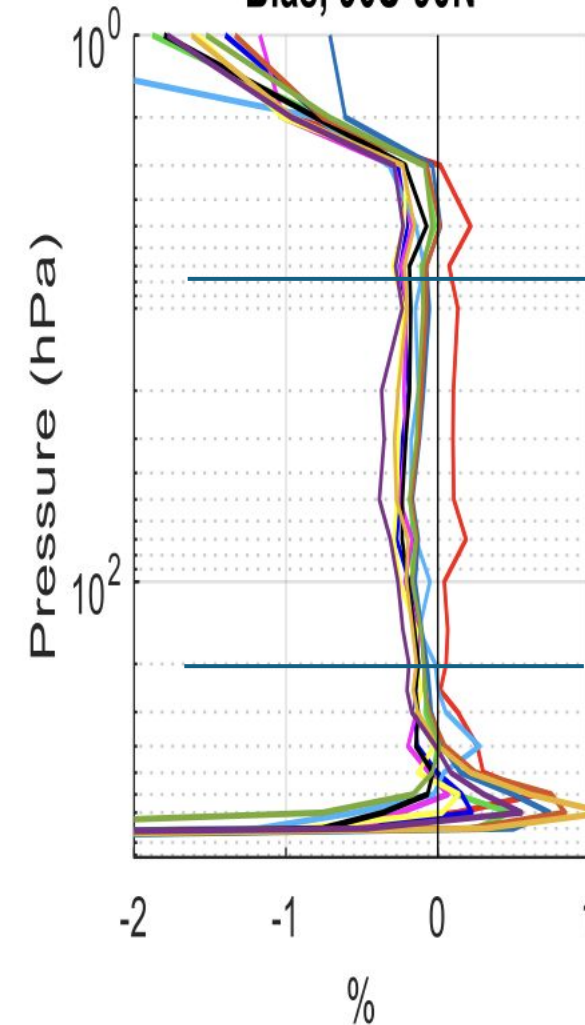
20

16

10

5

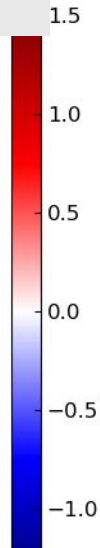
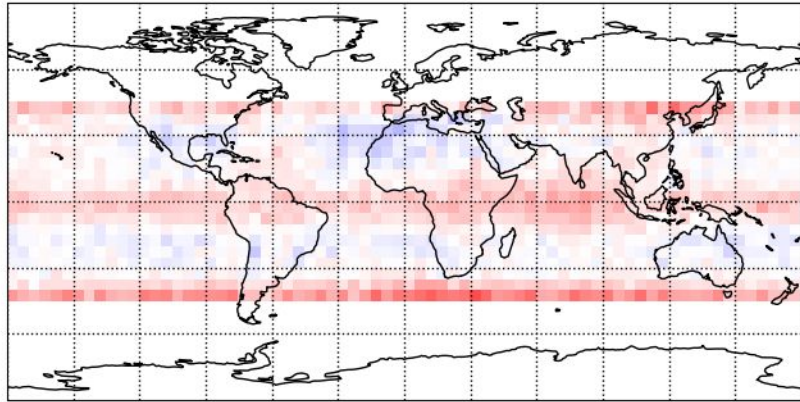
Bias, 90S-90N



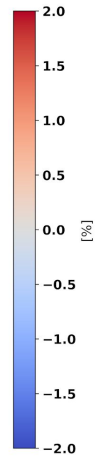
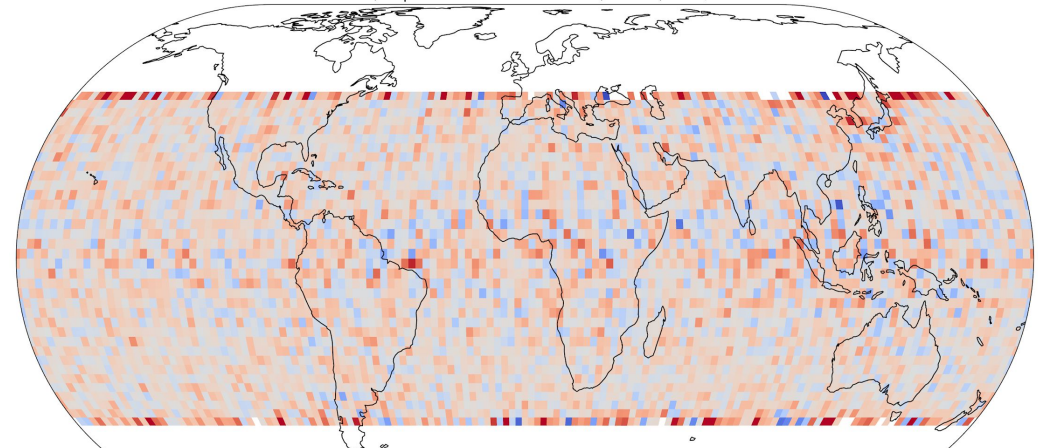
# One possible source of COSMIC-2 biases?

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

provided by COSMOS  
Backgrounds from Met Office

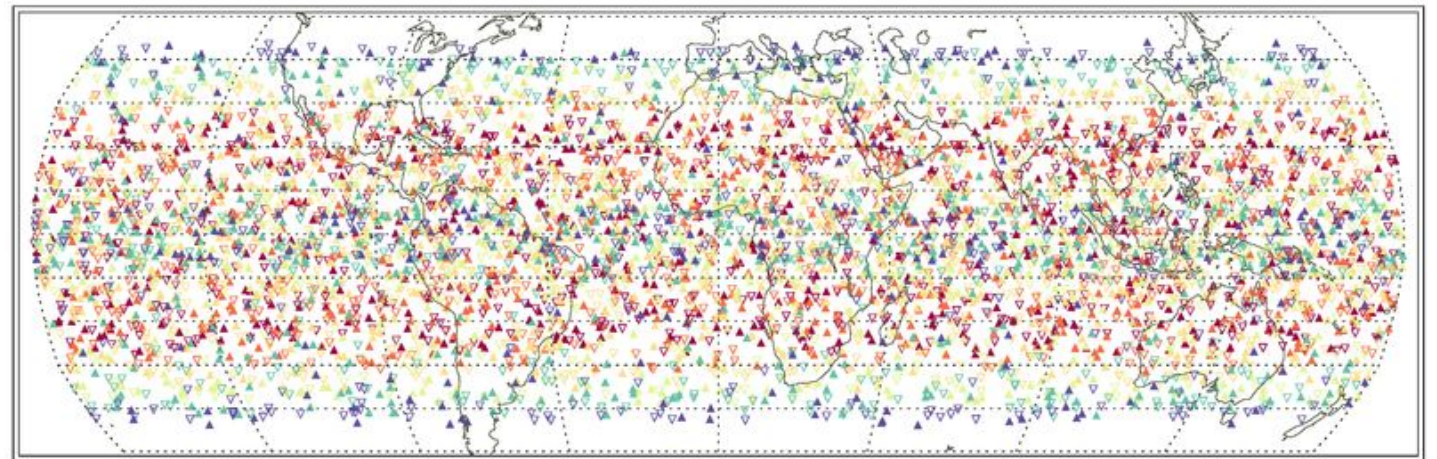


$(\langle \text{COSMIC2} \rangle - \langle \text{SPIRE} \rangle) / \langle \langle \text{SPIRE} \rangle \rangle$ , Mean Values, 2-Day Mean  
UCAR, September-November 2022, 20 km, 45 N/S

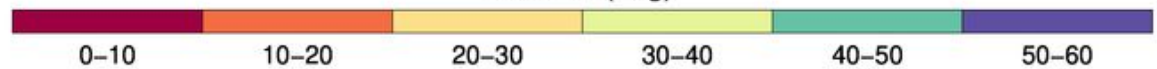


(C2-Spire)/Spire 20 km

C2  
Azimuth  
angle



antazim (deg)



Enormous value of international community  
looking at same large RO dataset

Thank you!

