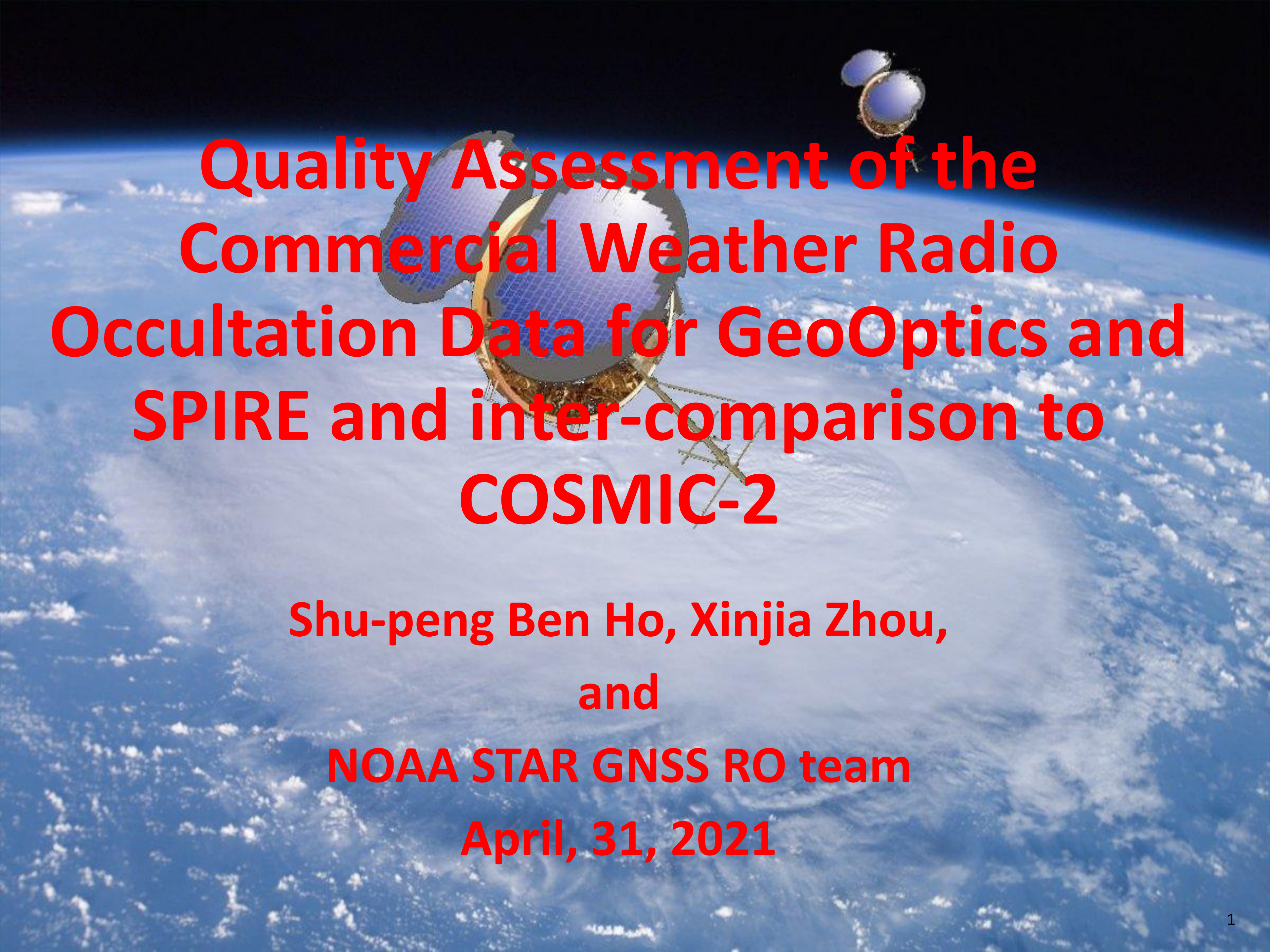


Quality Assessment of the Commercial Weather Radio Occultation Data for GeoOptics and SPIRE and inter-comparison to COSMIC-2

Shu-peng Ben Ho, Xinjia Zhou,

and

NOAA STAR GNSS RO team

April, 31, 2021

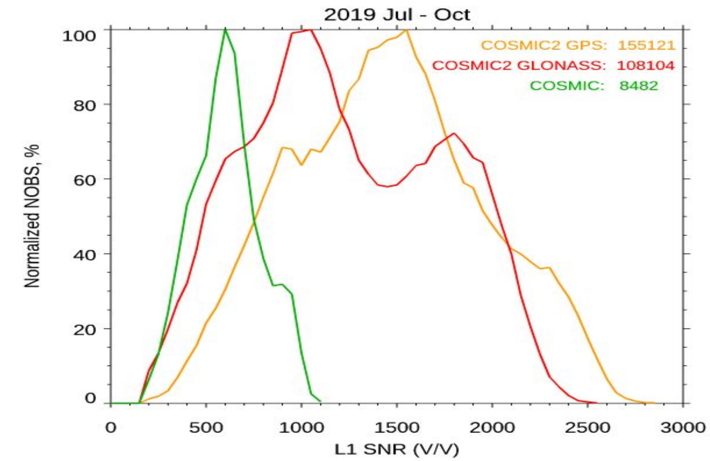
Motivations

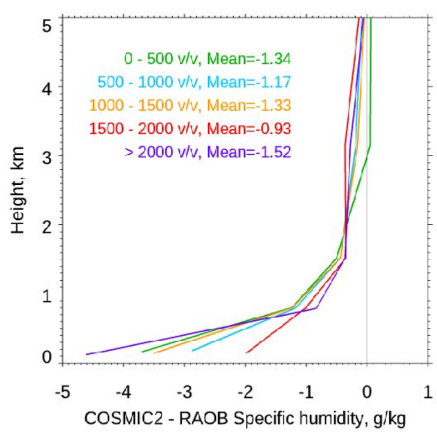
Q. Does higher Signal-Noise-ratio RO data provide improved retrieval Results ?

Q. Does higher Signal-Noise-ratio RO data provide smaller observation errors

Q. How to optimize RO data in the numerical weather forecast (NWP) system through data assimilation ?

Q. How to best use commercial weather RO data in the NCEP NWP system?





L1 SNR Range	Mean Difference (stds) for Water Vapor from the Surface to 5 km Altitude (g/kg)
0–500 v/v	−1.34 (2.51)
500–1000 v/v	−1.17 (2.63)
1000–1500 v/v	−1.33 (2.65)
1500–2000 v/v	−0.93 (2.55)
>2000 v/v	−1.52 (2.62)

COSMIC-2 – RS41 water vapor profiles for different SNR groups.

- **Ho, S.-P., co-authors: The COSMIC/FORMOSAT-3 Radio Occultation Mission after 12 years: Accomplishments, Remaining Challenges, and Potential Impacts of COSMIC-2, *Bul. Amer. Meteor. Sci.*, DOI: 10.1175/BAMS-D-18-0290.1.**
- **Ho, S.-P., co-authors: Initial Assessment of the COSMIC-2/FORMOSAT-7 Neutral Atmosphere Data Quality in NESDIS/STAR using In Situ and Satellite Data, *Remote Sens.* 2020, *12*, 4099; doi:10.3390/rs12244099**

Outlines

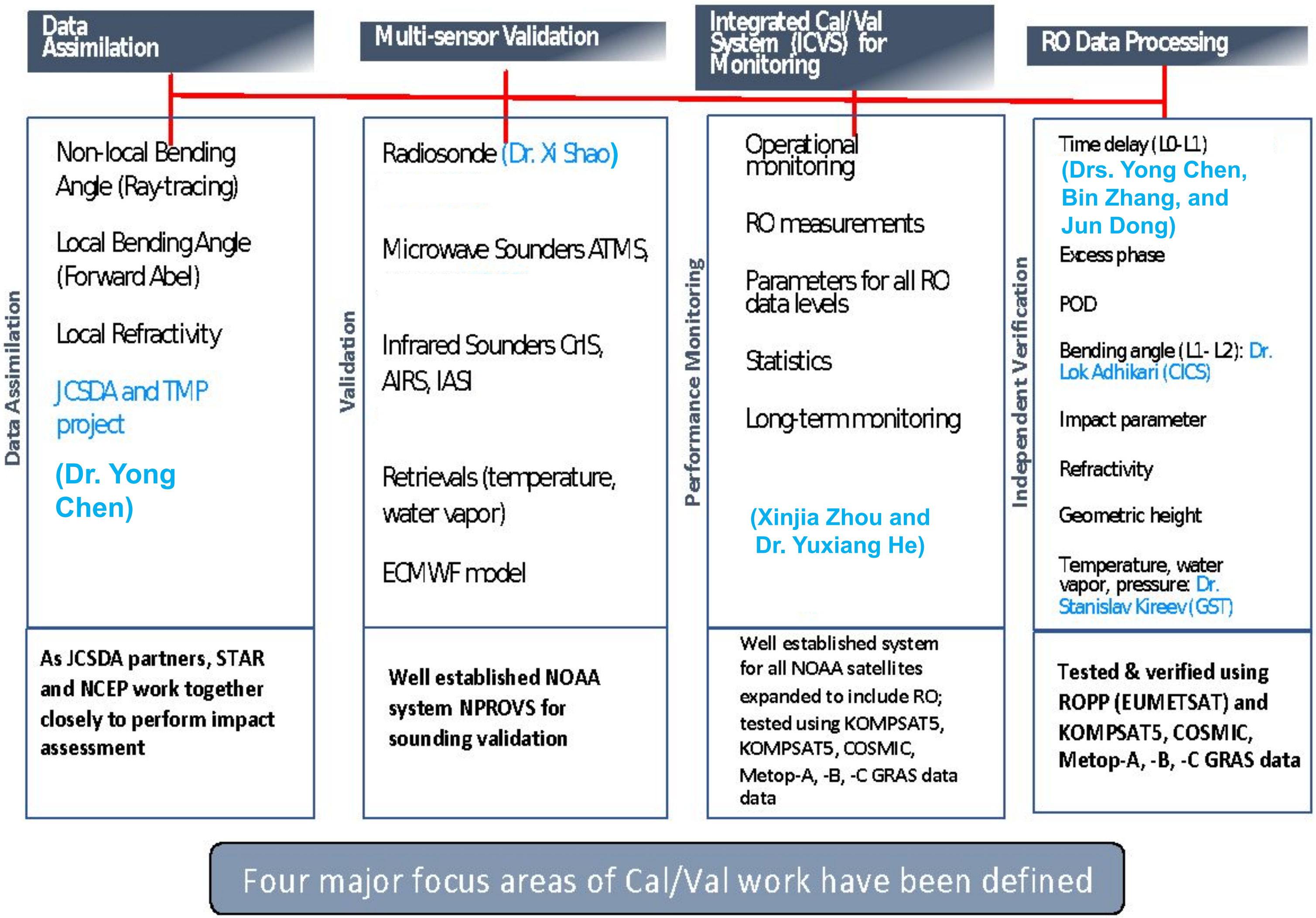
1. Using STAR GNSS RO Processing and Validation System to
   - Quantify GeoOptocs and SPIRE data
   - Penetration
   - Consistency
   - Stability
   - Accuracy

2. SNR distribution and Observation Error Estimate

3. Current EMC V16 rejection 90% of RO data in the lower troposphere

4. Conclusions

1. NOAA STAR GNSS RO processing and validation System

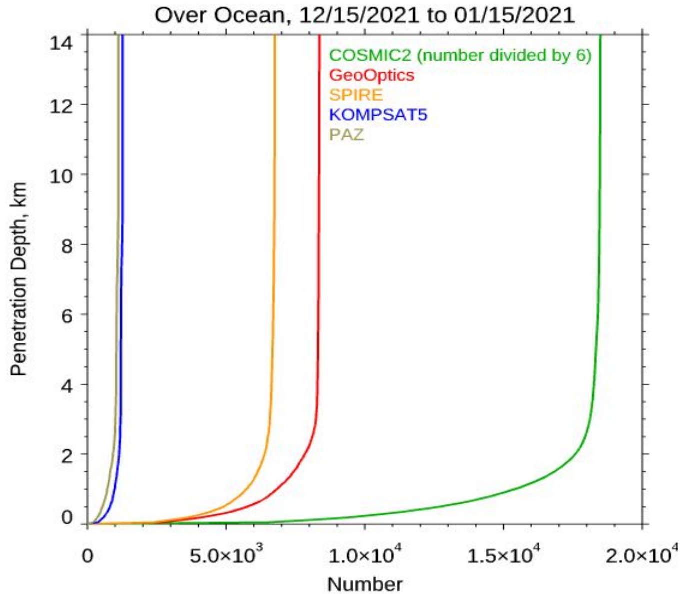


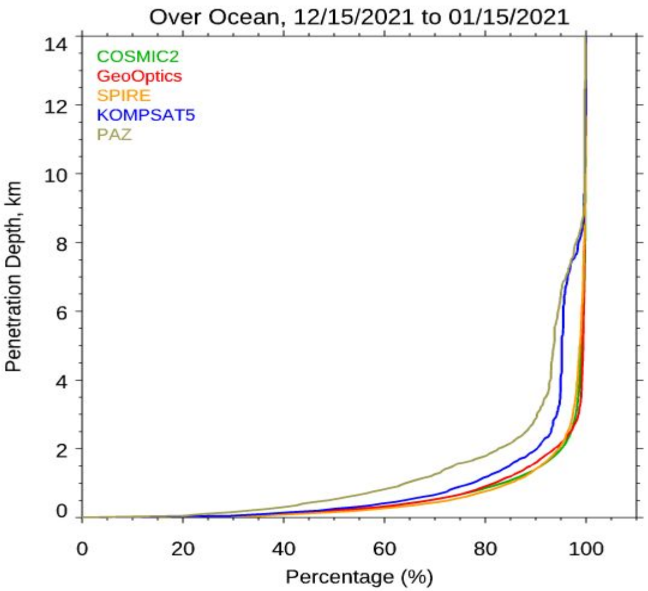
https://www.star.nesdis.noaa.gov/smcd/GNSSRO/RO/index.php

CWD RO Data Penetration

The numbers of observation and percentage observation at each penetration depth for multiple RO missions.

45S – 45N

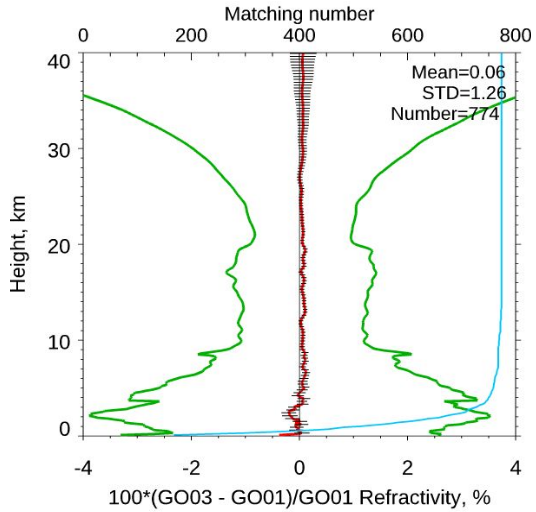


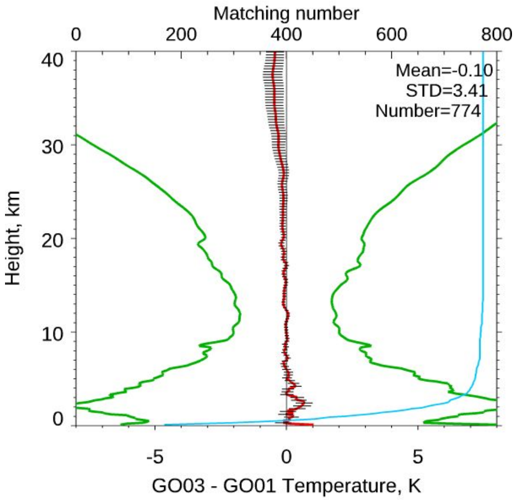


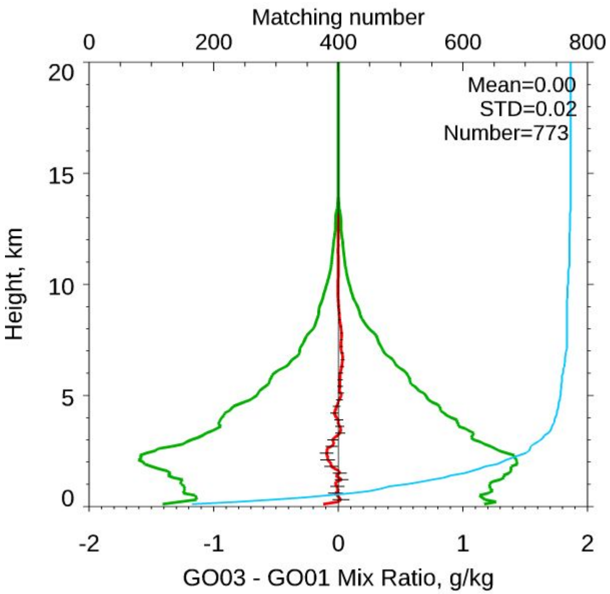
	10N-10 S	10N-30 N	30S-10 S	30N-45 N	45S-30 S	45N-60 N	60S-45 S	60N-90 N	90S-60 S
COSMIC-2	0.85	0.90	0.75	1.35	1.10				
GeoOptics	0.95	1.05	1.10	0.70	0.80	0.35	0.40	0.55	0.20
SPIRE	0.90	0.90	0.75	0.80	0.55	0.45	0.25	0.45	0.20
KOMPSAT-5	1.85	1.50	1.15	0.40	0.95	0.35	0.40	0.25	0.20
PAZ	2.65	1.85	2.05	0.90	1.30	0.45	0.45	0.35	0.25

The lowest penetration height of 80% of the total data for different RO missions at different latitudinal zones.

Consistency for GeoOptics: only 20 minutes and 300 km apart

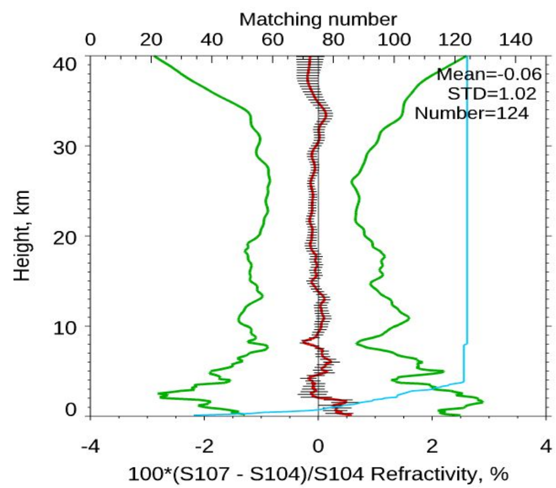


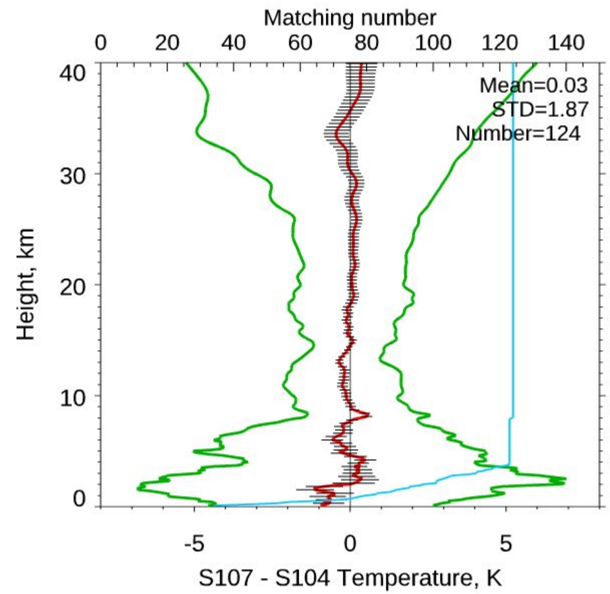


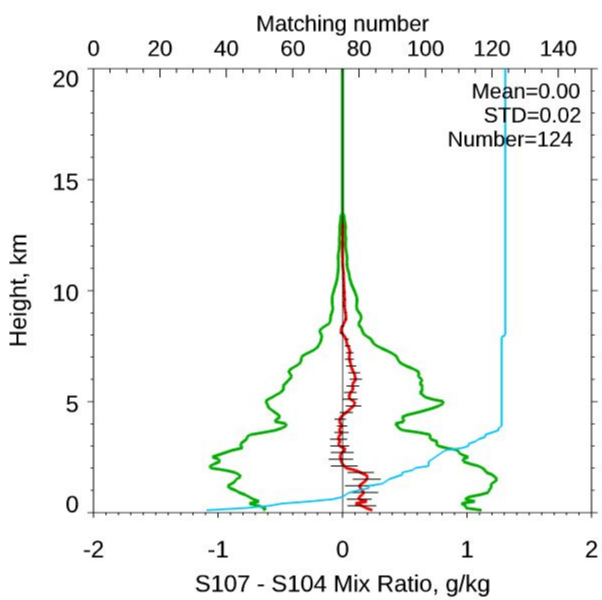


The mean difference (red line) and Median Absolute Deviation (MAD) (green line) of (a) refractivity, (b) dry temperature, and (c) water vapor mixing ratio from collocated GeoOptics GO01 and GO03 receivers.

Consistency : Spire only 20 minutes and 300 km apart





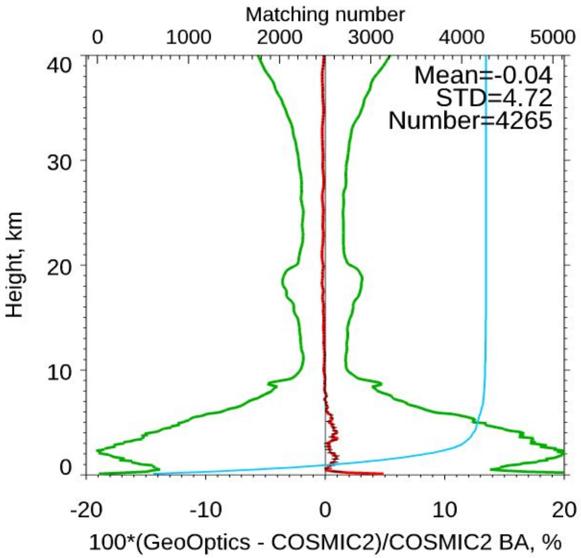


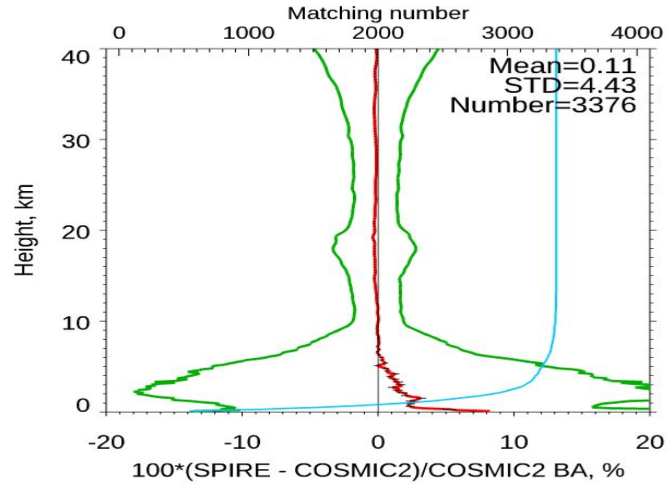
The mean difference (red line) and Median Absolute Deviation (MAD) (green line) of

(a) refractivity, (b) dry temperature, and
(b) (c) water vapor mixing ratio from
(c) collocated Spire S104 and S107 receivers.

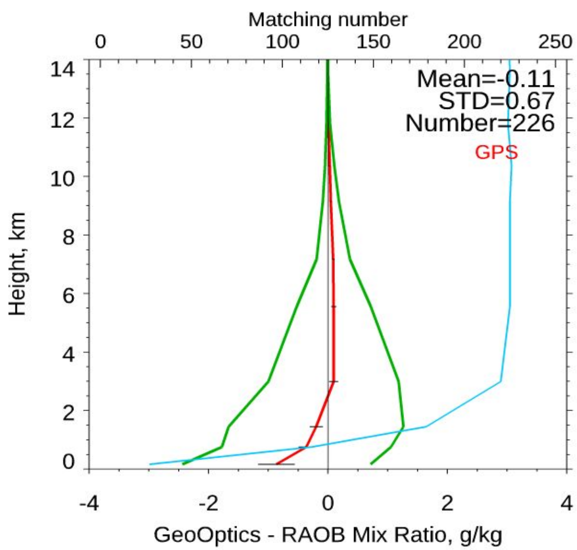
Stability and accuracy

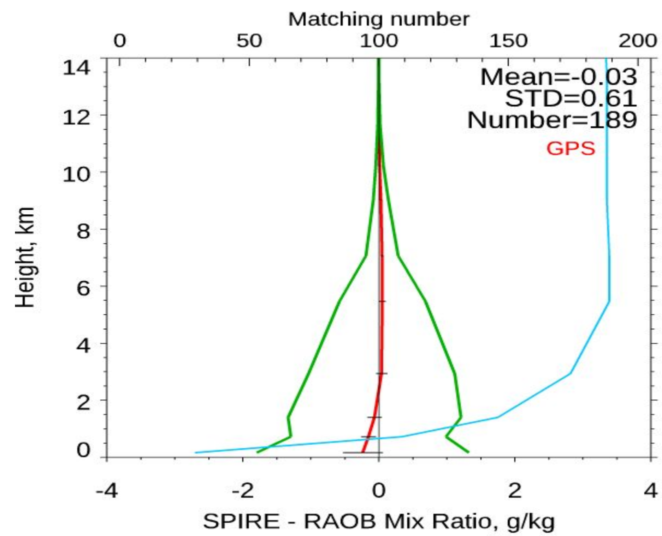
Stability





Accuracy



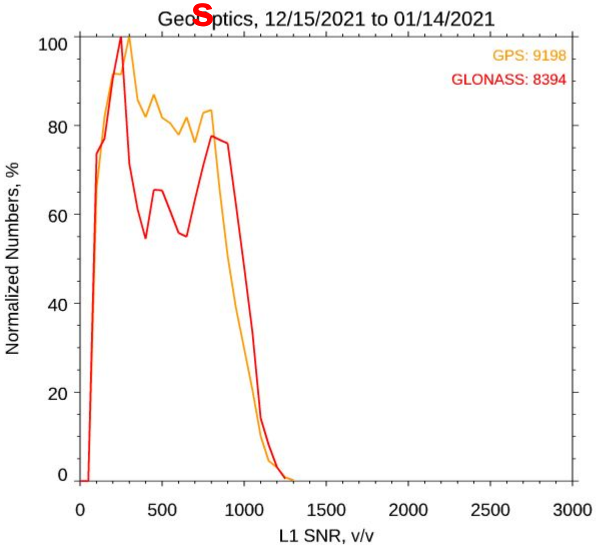


GeoOptics

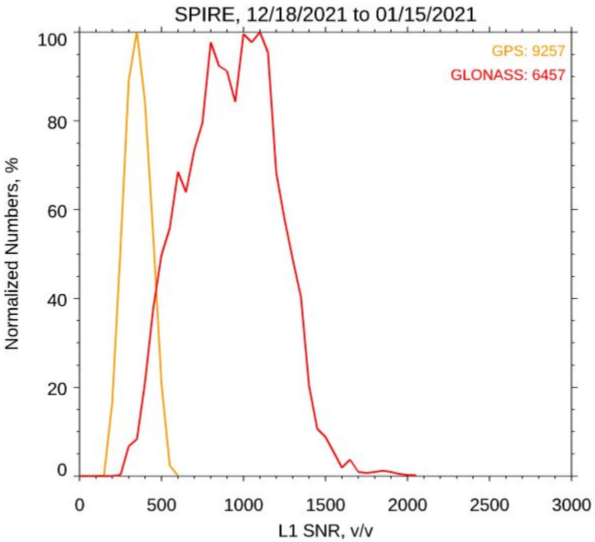
SPIRE

2. SNR distribution and Observation Error Estimate

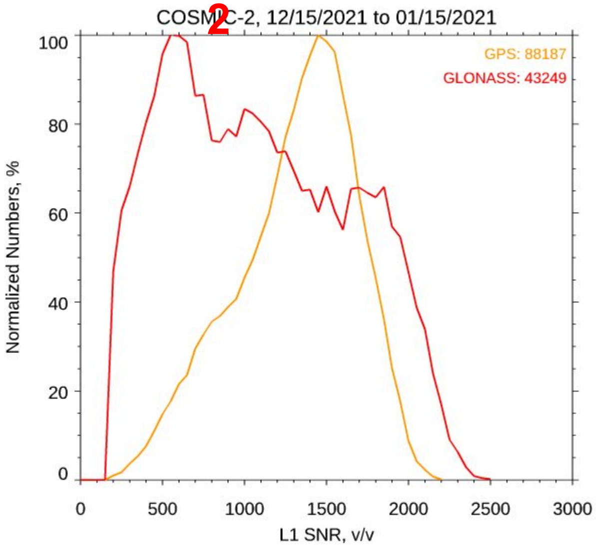
GeoOptics

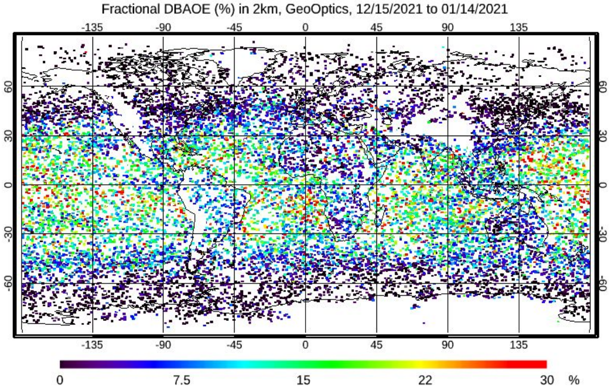


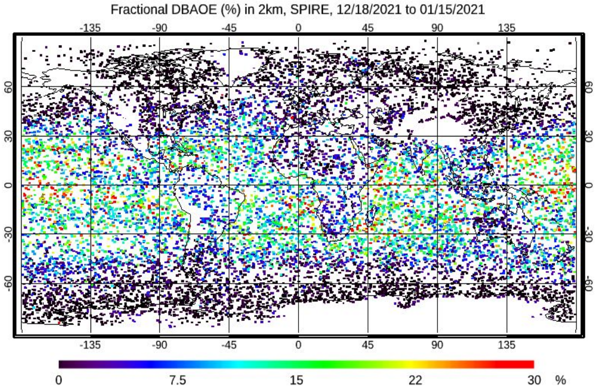
SPIR

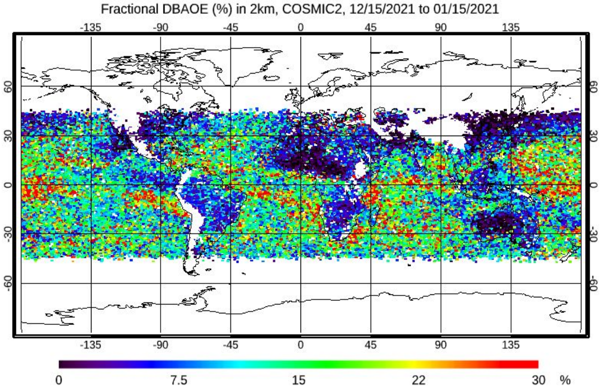


COSMIC 2



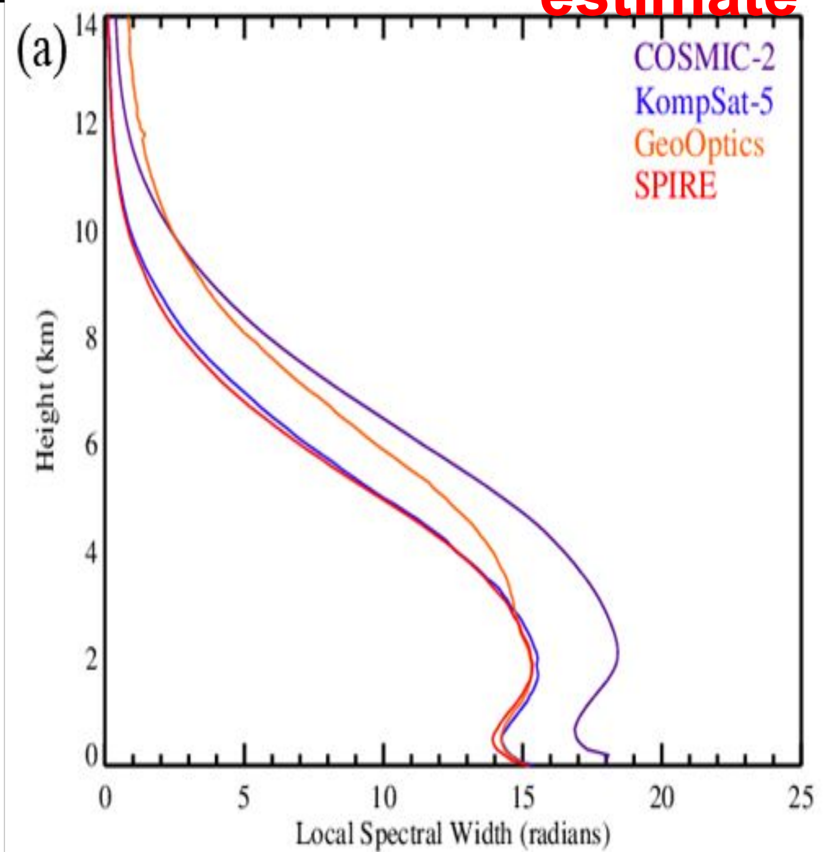


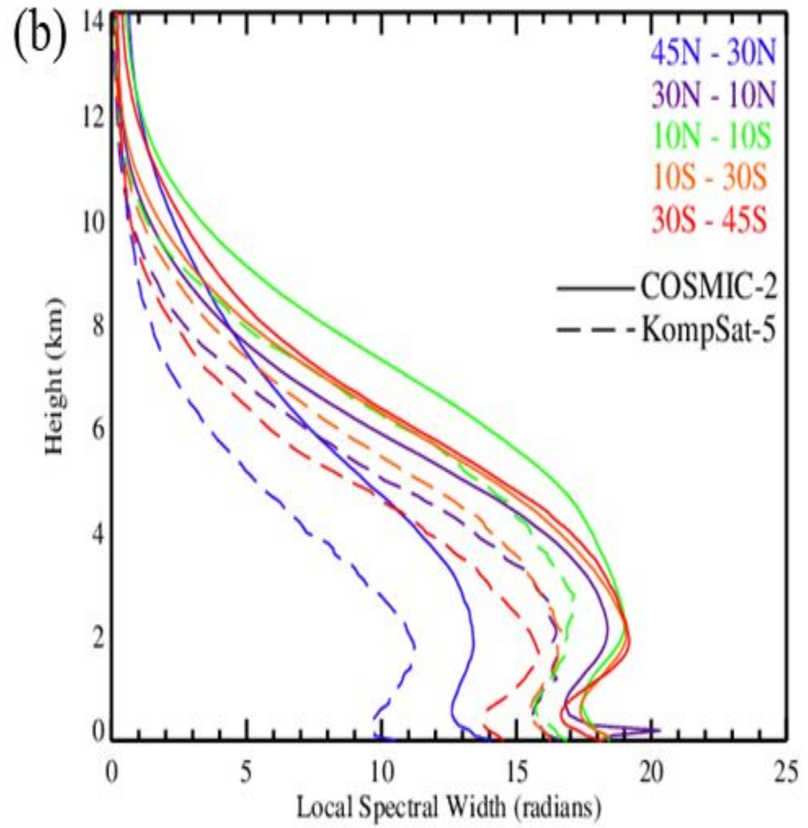




LSW estimate of observation errors

STAR LSW estimate

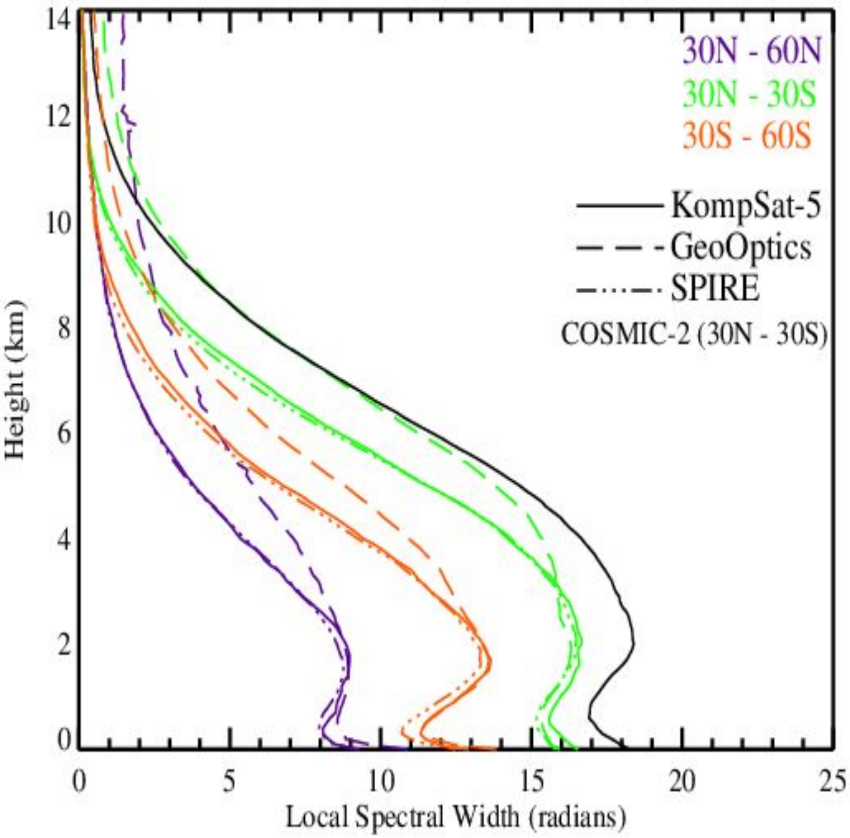




LSW as a function of height for GNSS RO missions COSMIC-2, KOmpSat-5, GeoOptics, and SPIRE in the latitude range 45˚N - 45˚S.

LSW for COSMIC-2 and KompSat-5 at different latitude bands.

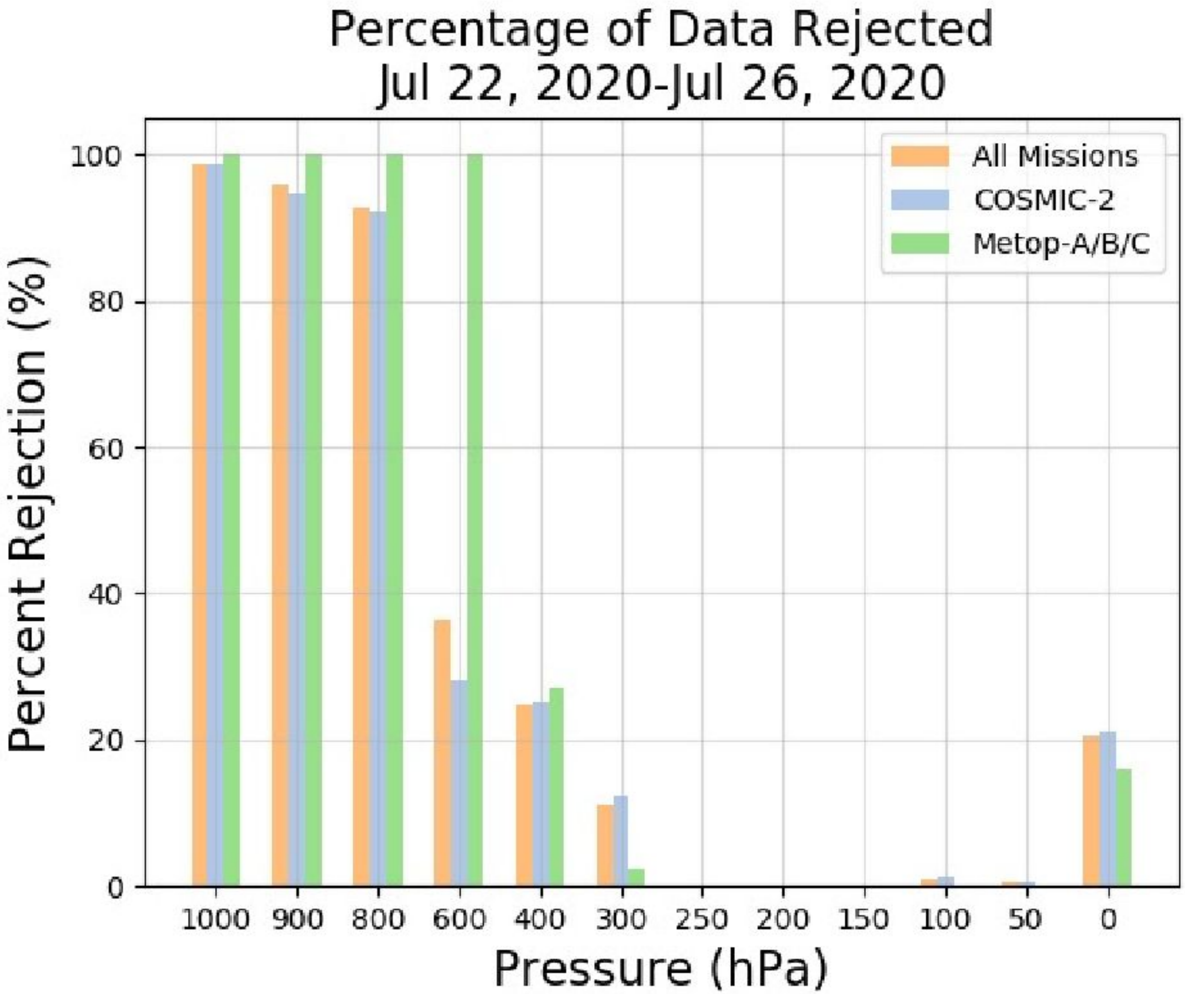
2019/1



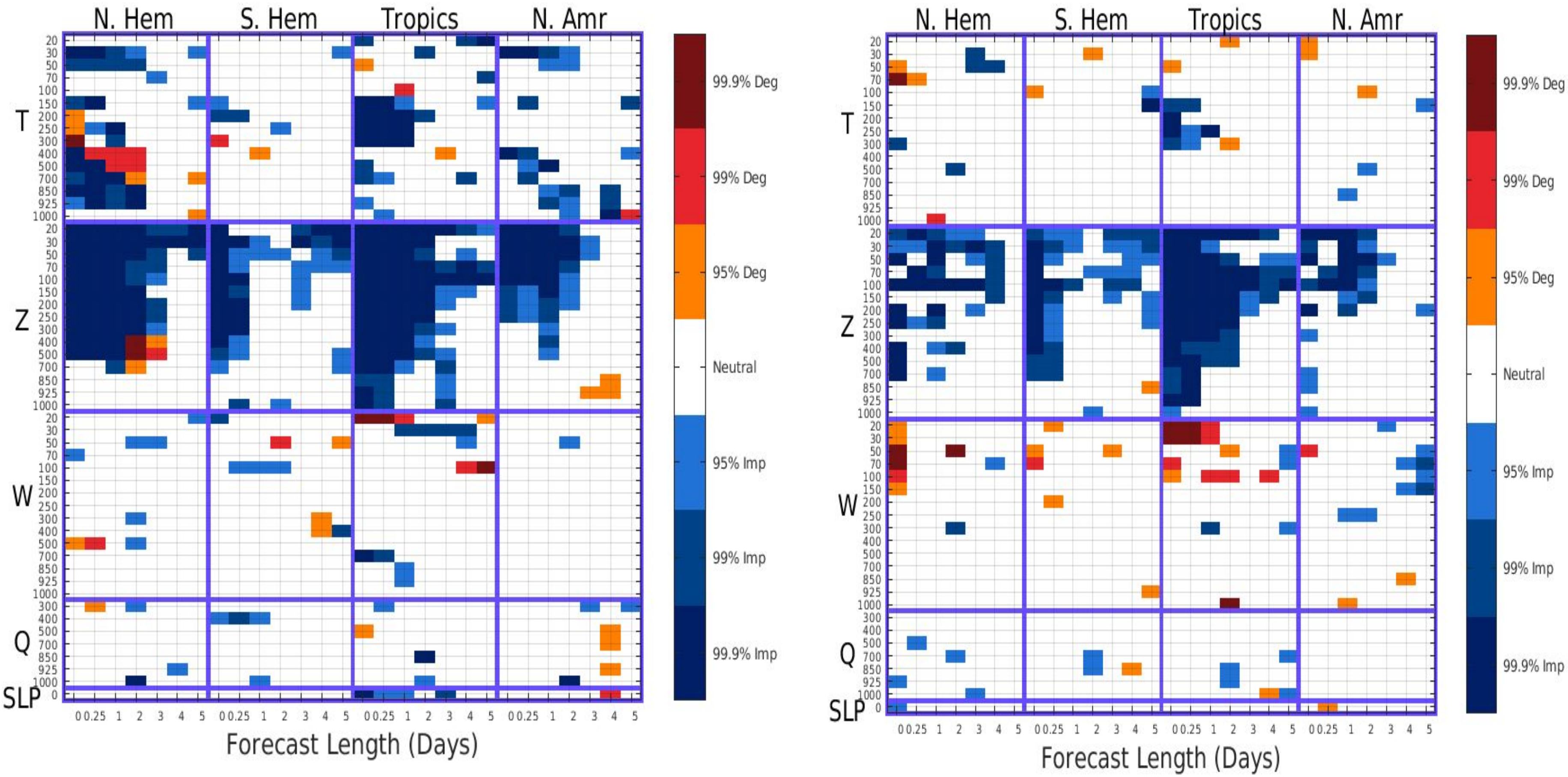
LSW for commercial RO missions, GeoOptics and SPIRE and KompSat-5 in the tropics (30˚ N – 30˚S), northern hemisphere mid-latitudes (30˚ N – 60˚N), and southern hemisphere mid-latitudes (30˚ S – 60˚S). COSMIC-2 LSW for the tropics is shown in black.

COSMIC-2 LSW

3. Current EMC RO data Rejection Rate

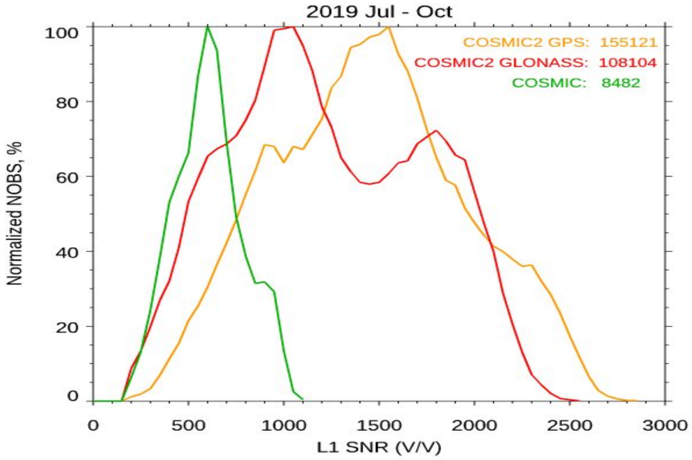


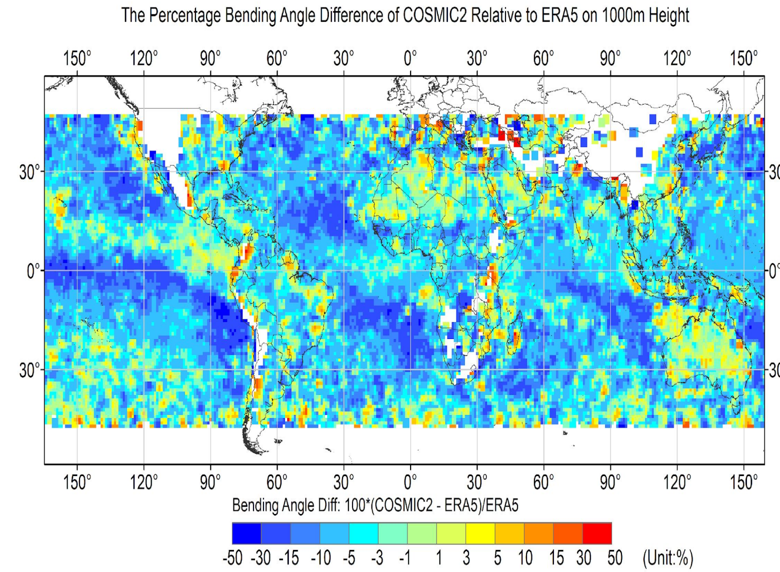
Percentage of the RO data rejected by the GFSv16-GSI quality control algorithm



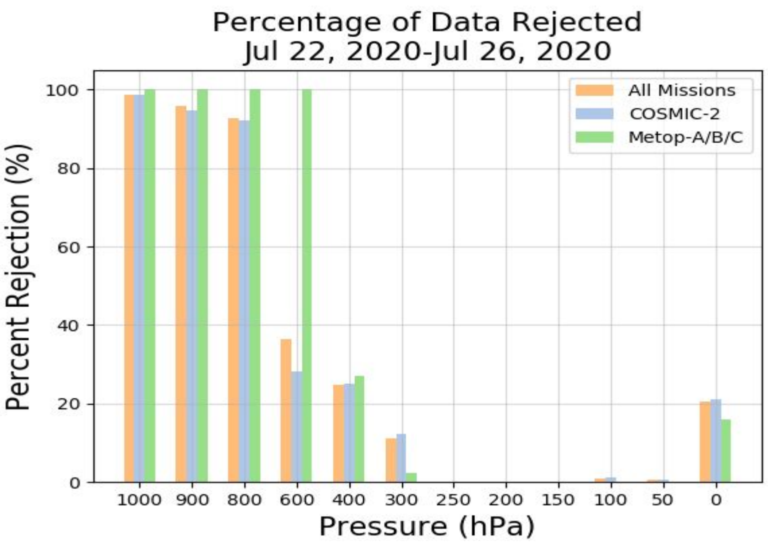
Overall CWD RO (GeoOptics and Spire) forecast impacts on temperature (T), geo-potential height (Z), wind (W), water vapor (Q), and surface-level pressure (SLP) from 00hr to 5 days forecast over four regions: Northern hemisphere, Southern hemisphere, tropics, and North American. Left panel: bias; right panel: root means square (RMS). Blue indicates CWDP data reduced forecast errors, and red indicates CWDP data degraded forecast errors. (https://www.emc.ncep.noaa.gov/gc_wmb/kbathmann/vsdb/comm_gnss/)

4. Conclusions





- COSMIC-2 high SNR measurements
  provide slightly better refractivity and water vapor retrievals
- GeoOpitcs and SPIRE data quality are very similar to those from COSMIC-2
- COSMIC-2 observation errors seem slightly larger than those from other RO missions
- Current QCs in EMC reject about most of RO data below 700-800 mb.



Disclaimer: The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author(s) and do not necessarily reflect those of NOAA or the Department of Commerce.