

# **NRT DORIS Data** for Global Ionospheric Irregularity Monitoring

Ningbo Wang<sup>1</sup>, Donghu Lei<sup>1</sup>, Ang Liu<sup>1</sup>

Aerospace Information Research Institute (AIR), Chinese Academy of Sciences (CAS), 100094 Beijing, China

IDS AWG Meeting  
8 Nov, 2025



# Status of NRT DORIS Data

NRT DORIS data available from 9 satellite missions (~3 hrs latency)

| Satellite Missions | Abbreviations |
|--------------------|---------------|
| <i>Saral</i>       | <i>srl</i>    |
| <i>JASON-3</i>     | <i>ja3</i>    |
| <i>Sentinel-3A</i> | <i>s3a</i>    |
| <i>Sentinel-3B</i> | <i>s3b</i>    |
| <i>Sentinel-6A</i> | <i>s6a</i>    |
| <i>SWOT</i>        | <i>sw0</i>    |
| <i>Cryosat-2</i>   | <i>cs2</i>    |
| <i>HY-2C</i>       | <i>h2c</i>    |
| <i>HY-2D</i>       | <i>h2d</i>    |

FTP address: <ftp://doris.ign.fr>

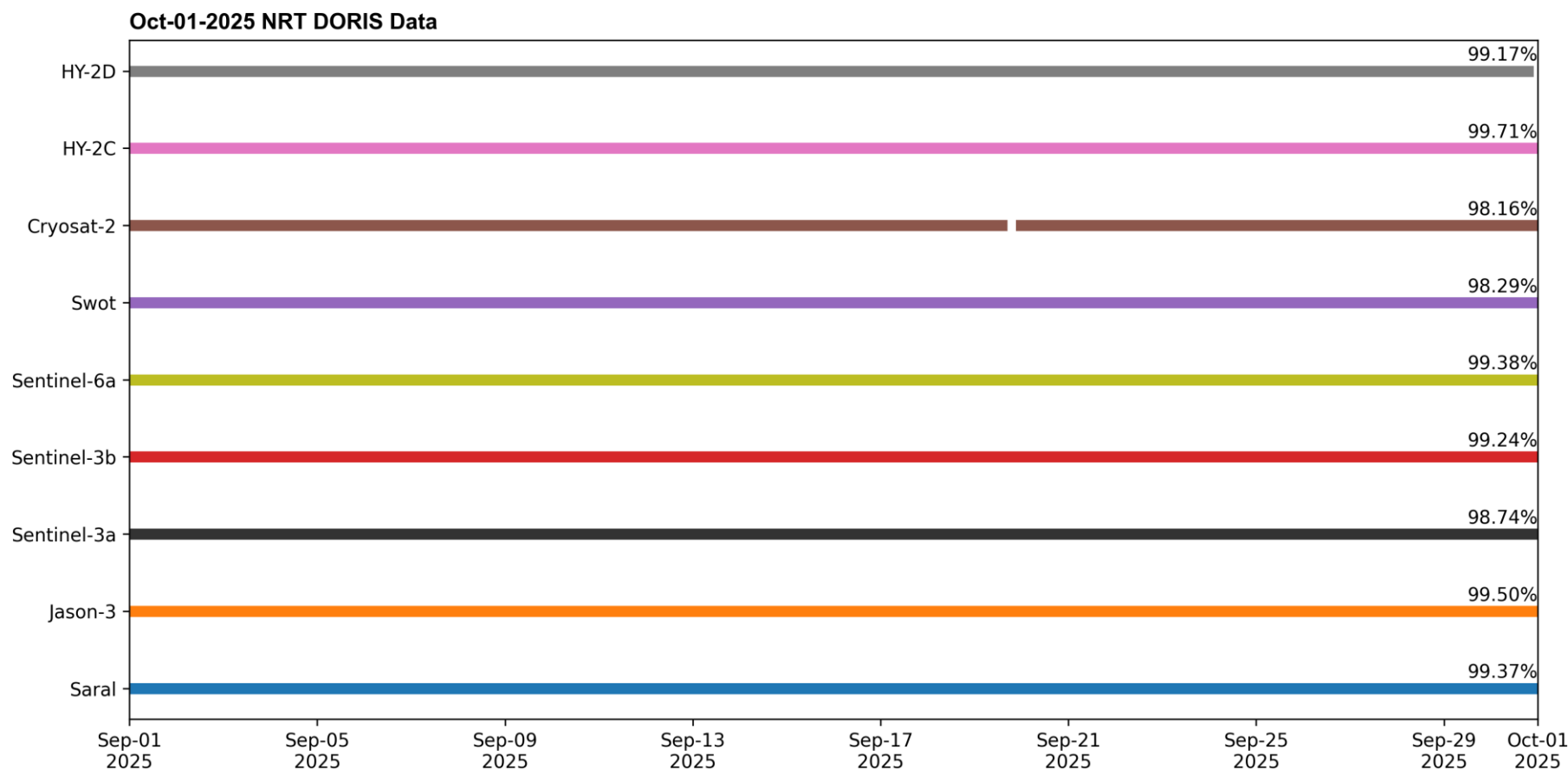
## Example:

`ftp://doris.ign.fr/pub/doris/data/$sss/NRT/DSA_MEP_1PaS$YYYY$MM$DD*`

- **sss** *satellite three-character abbreviation*
- **YYYY** *four-digit year*
- **MM** *two-digit month*
- **DD** *two-digit day of the month*

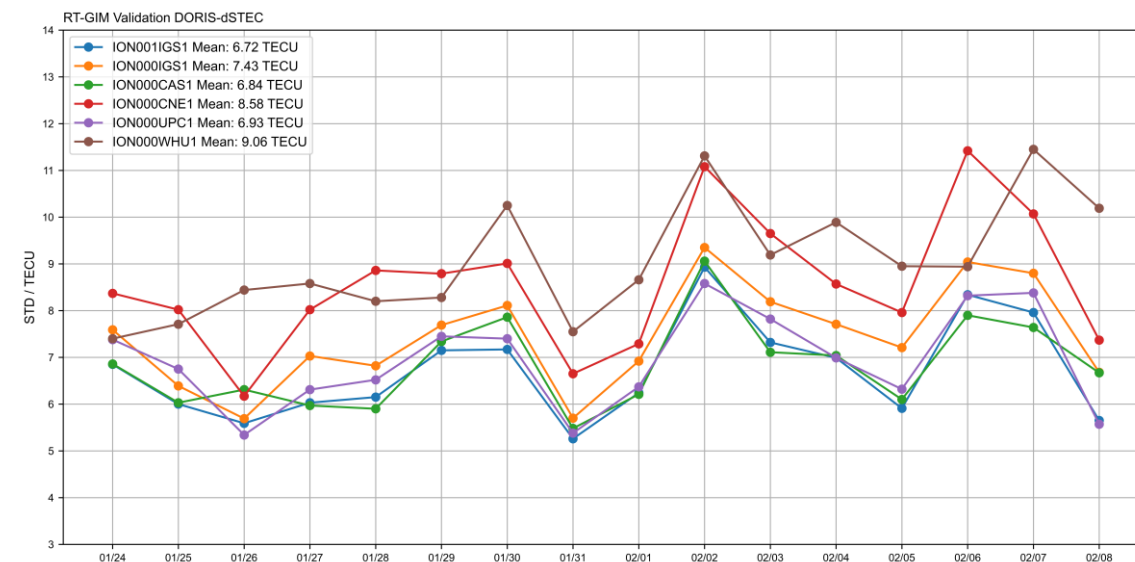
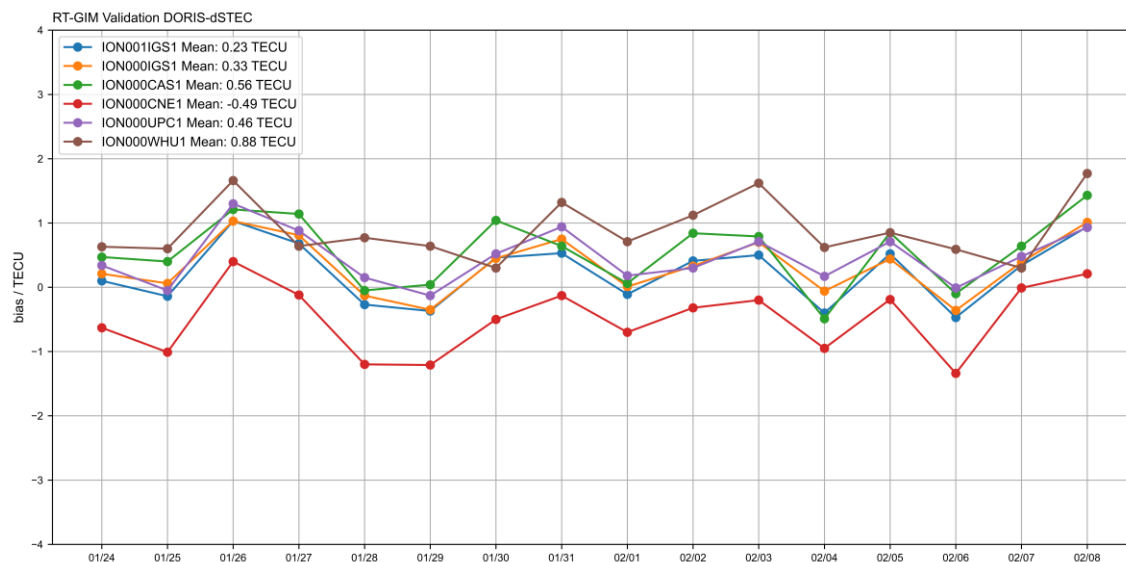
# Status of NRT DORIS Data

NRT DORIS data available from 9 satellite missions (~3 hrs latency)



# NRT DORIS Data for RT-GIM Validation

NRT Jason-3 data for IGS **real-time** global VTEC validation



**ION001IGS1**: CAS combined RT-GIM, **ION000IGS1**: UPC combined RT-GIM

**ION000CAS1**: CAS RT-GIM, **ION000CNE1**: CNES RT-GIM, **ION000UPC1**: UPC RT-GIM, **ION000WHU1**: WHU RT-GIM

# NRT DORIS Data for RT-GIM Validation

**NRT** DORIS differential Slant TEC (dSTEC)

**filename:** *CAS00PS***NRT**\_*\$YYYY\$DOY0000\_DRS\_\$SSS\_ION.DSTEC.gz*

- *\$YYYY: Year (e.g., 2023)*
- *\$DOY: Day of Year*
- *\$SSS: Satellite Identifier (e.g., JA3 for Jason-3)*

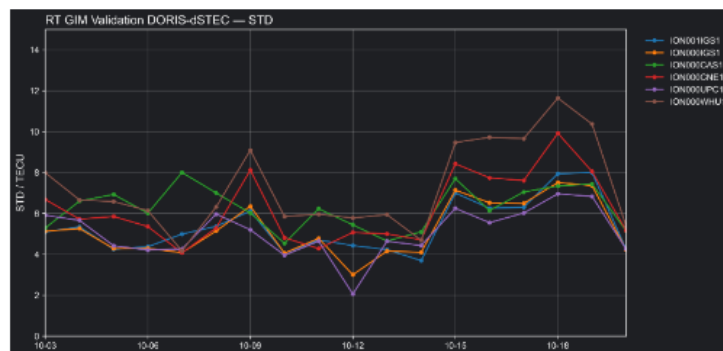
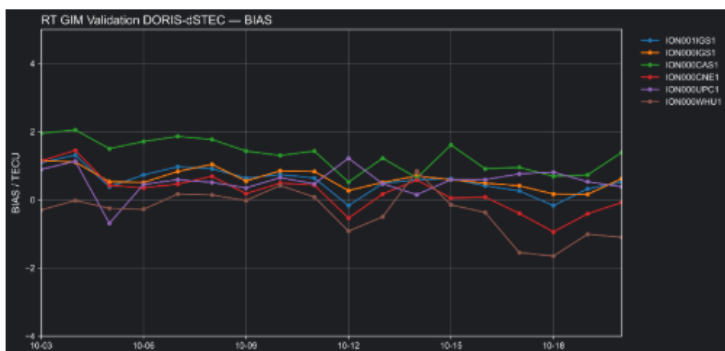
**example:** *CAS00PSNRT\_20231820000\_DRS\_JA3\_ION.DSTEC.gz*

**product archive:** <https://data.bdsmart.cn/pub/product/iono/nrtdoris/dstec/>

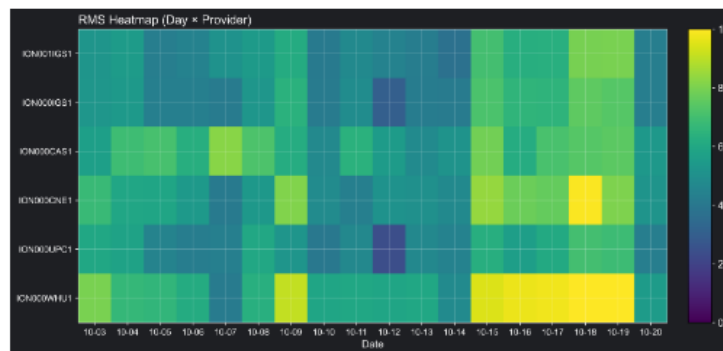
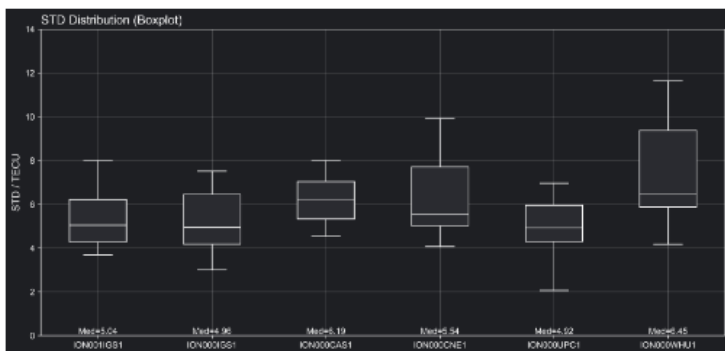
# NRT DORIS data for RT-GIM validation on IGS RTS Website



Bias and STD time series



STD distribution (boxplot) and RMS heatmap



<https://igs.org/rt/monitoring/>

Many thanks to Andrea Stuerze from BKG Germany for coordination



# NRT DORIS based ROTI computation

- ▶ The dual-frequency NRT DORIS carrier-phase measurements can be used for **Rate of TEC Index** (ROTI) computation.
- ▶ The sampling interval of the DORIS satellite is 10 seconds:
  - ▶ The first channel data points at:  $T_0+0s$ ,  $T_0+10s$ ,  $T_0+20s$ ,  $T_0+30s$  ...
  - ▶ The second channel data points at:  $T_0+3s$ ,  $T_0+13s$ ,  $T_0+23s$ ,  $T_0+33s$  ...
- ▶ When combining the two channels, we get the data points at:  $T_0+3s$ ,  $T_0+10s$ ,  $T_0+13s$ ,  $T_0+20s$  ... resulting the data intervals 3 or 7 seconds (i.e., 3s, 7s, 3s, 7s, ...).
- ▶ We conduct two DORIS-ROTI computation algorithms, i.e., **single-channel** versus **dual-channel**, for comparison purpose.

# NRT DORIS based ROTI computation

## ➤ ROTI computation

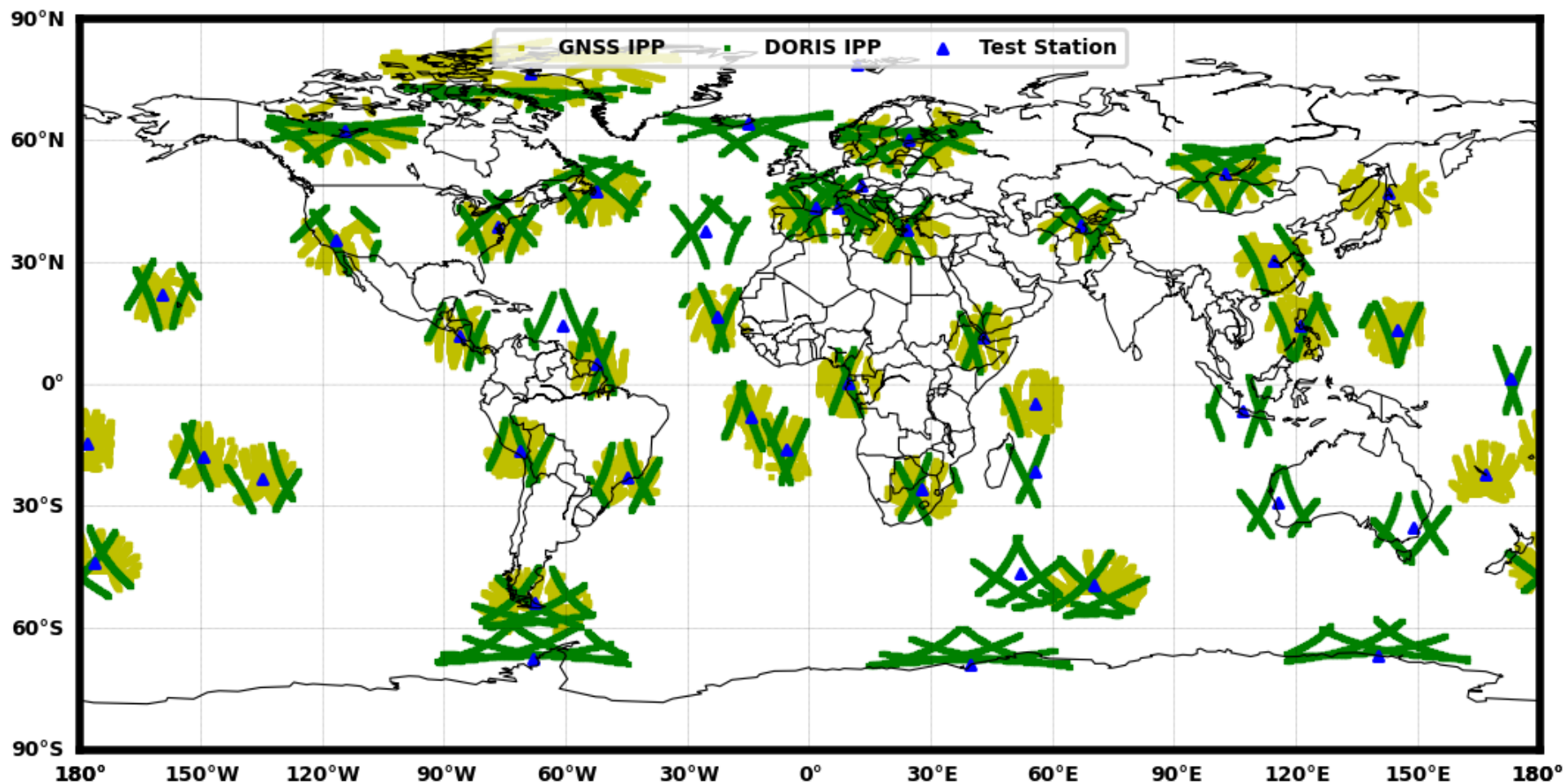
$$ROT_k = \frac{STEC_k - STEC_{k-1}}{t_k - t_{k-1}}$$

$$ROTI = \sqrt{\langle ROT^2 \rangle - \langle ROT \rangle^2}$$

## ➤ GNSS and DORIS based ROTI computation

| ROTI                               | Data sampling | Time window | Expect ROT number | Maximum data loss |
|------------------------------------|---------------|-------------|-------------------|-------------------|
| <i>GNSS-based</i>                  | 30s           | 5min        | 10                | 2                 |
| <b><i>DORIS dual-channel</i></b>   | 3s / 7s       | 1/2/3/5min  | 12/24/36/60       | 2/7/13/25         |
| <b><i>DORIS single-channel</i></b> | 10s           | 2/3/5min    | 12/18/30          | 2/5/10            |

# NRT DORIS based ROTI computation

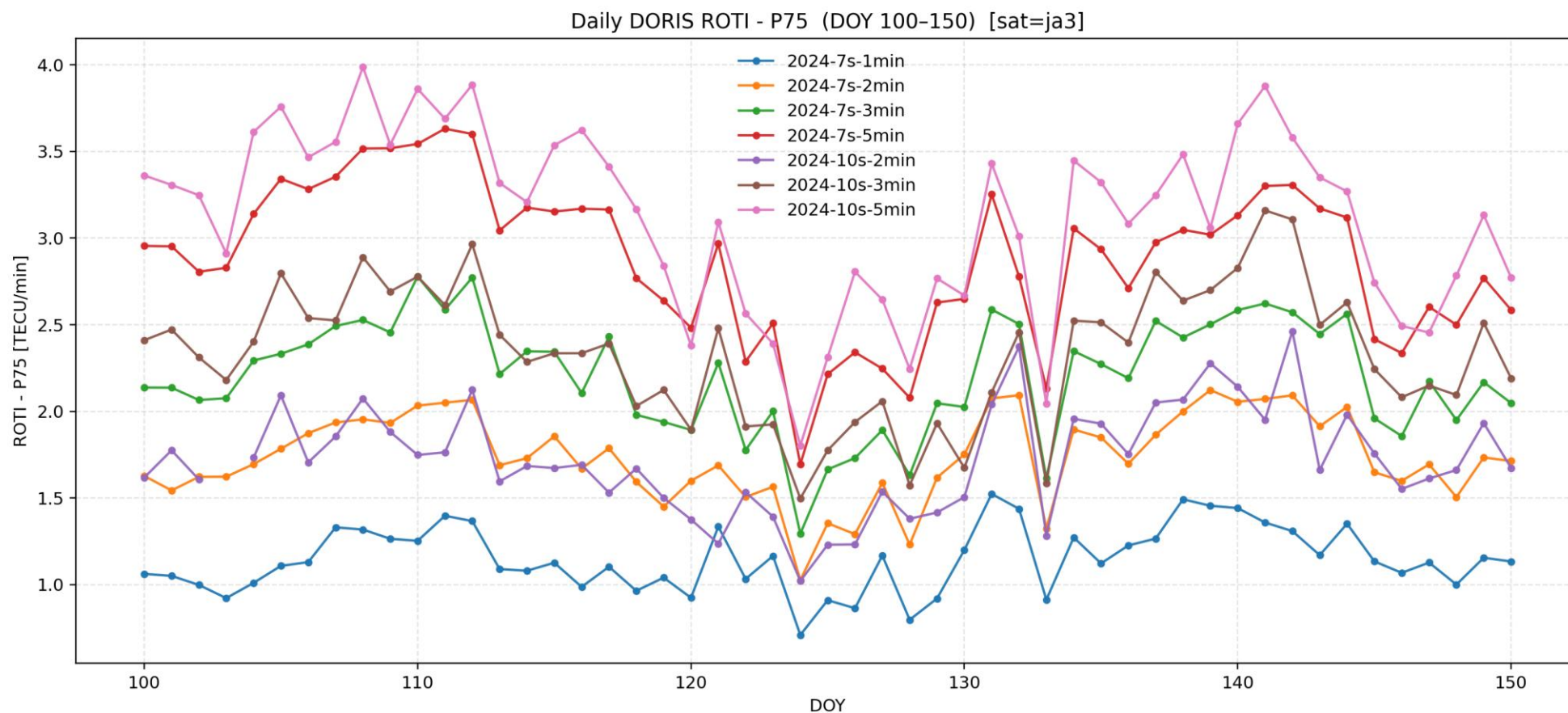


DORIS ground beacons and co-located GNSS stations (~45)



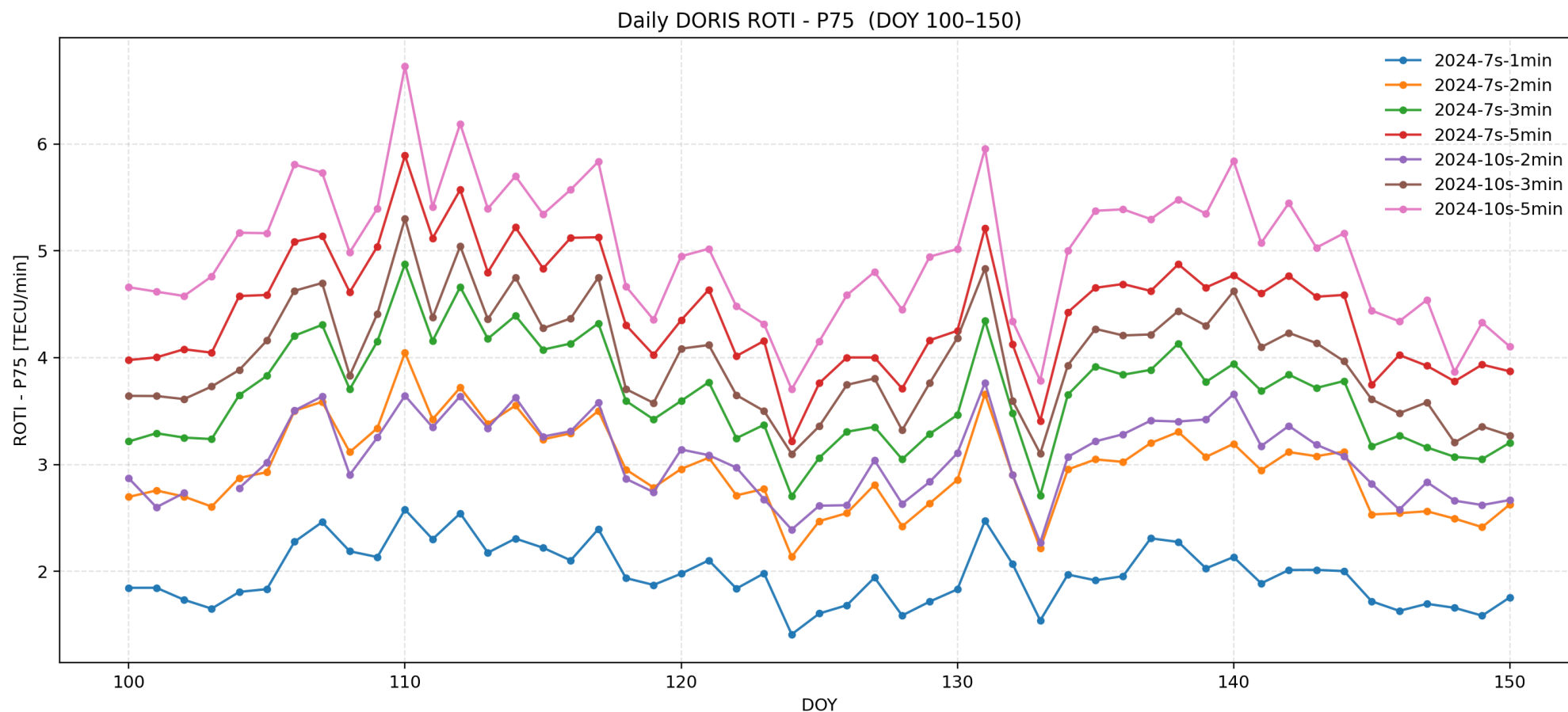
# NRT DORIS based ROTI computation

DORIS ROTI derived from **Jason-3 NRT DORIS** data (DoY 100-150, 2024)

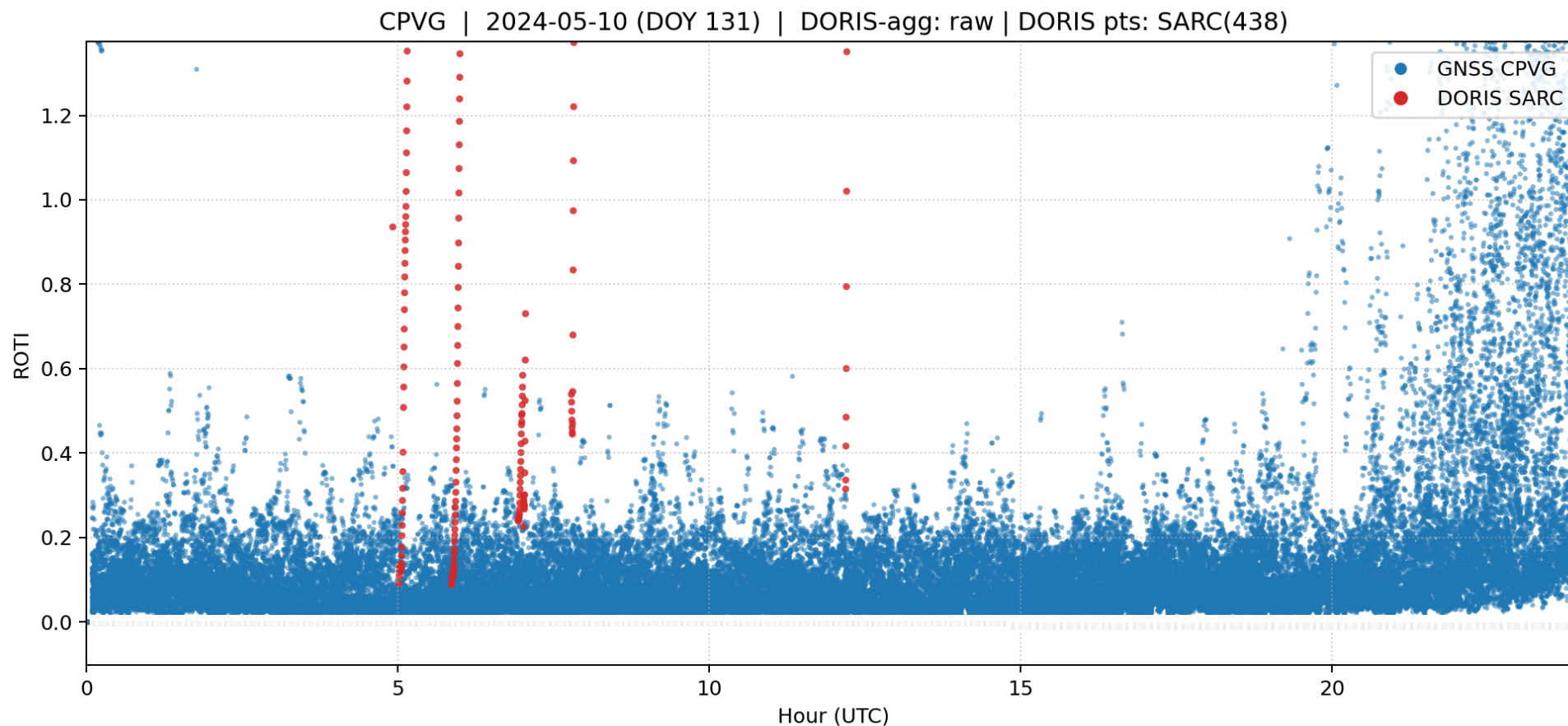


# NRT DORIS based ROTI computation

DORIS ROTI derived from **ALL NRT DORIS** data (DoY 100-150, 2024)



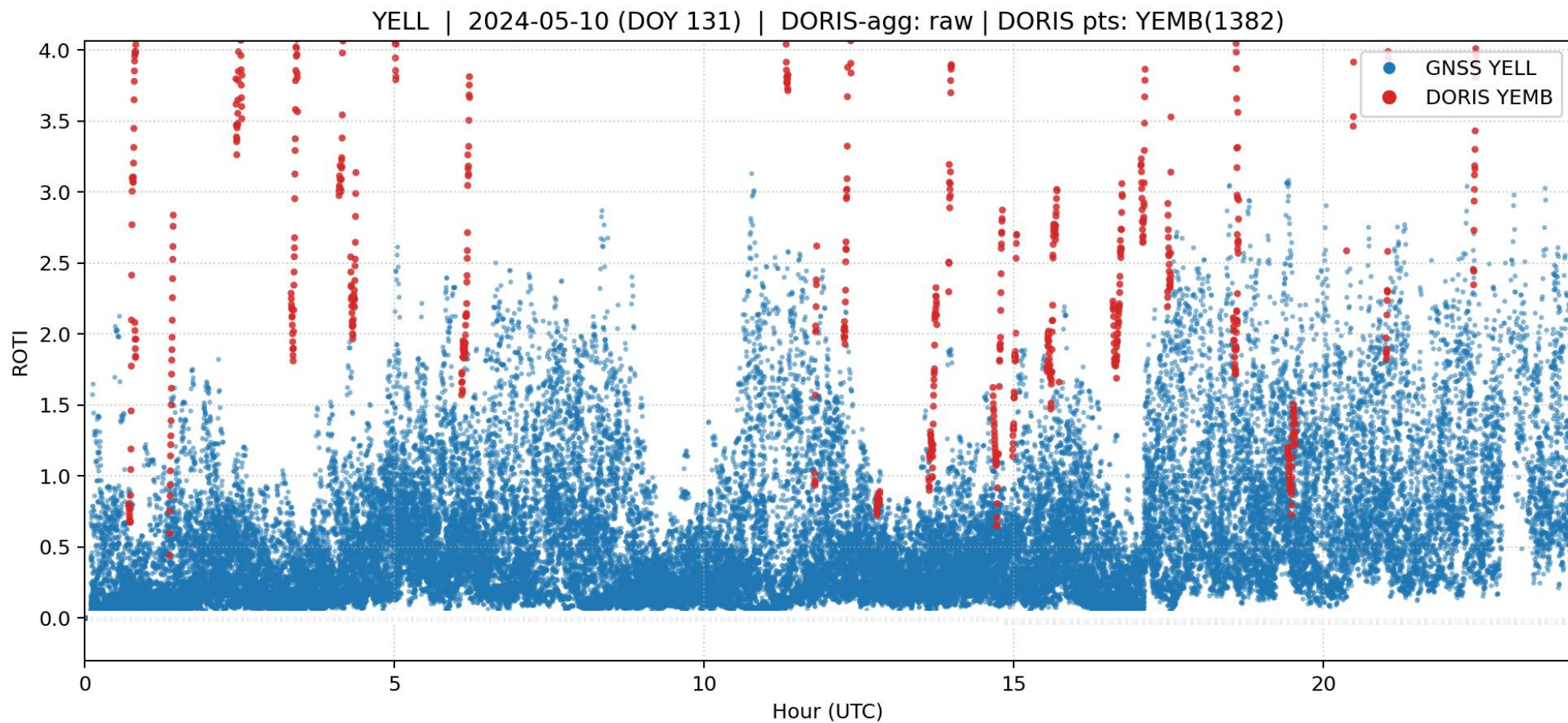
# GNSS ROTI versus NRT DORIS ROTI



CPVG (SARC), 10 May 2024



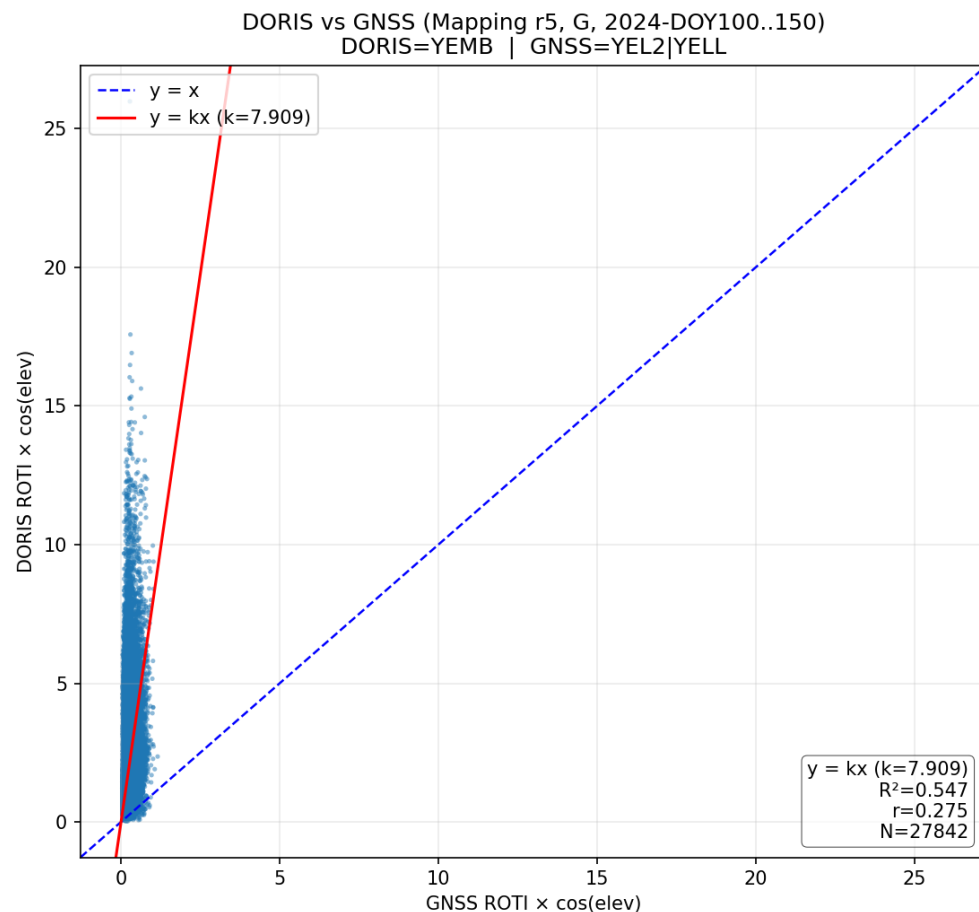
# GNSS ROTI versus NRT DORIS ROTI



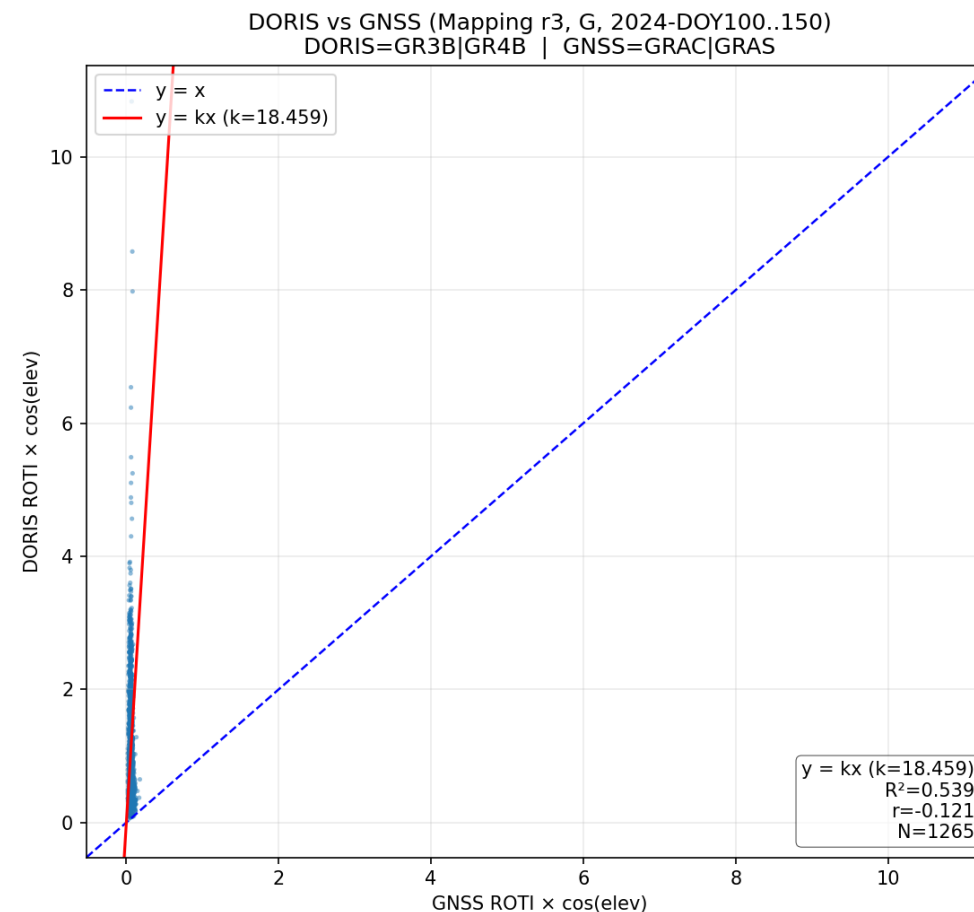
YELL (YEMB), 10 May 2024

# GNSS ROTI versus NRT DORIS ROTI

Comparison between GNSS- and DORIS- ROTI at co-located stations

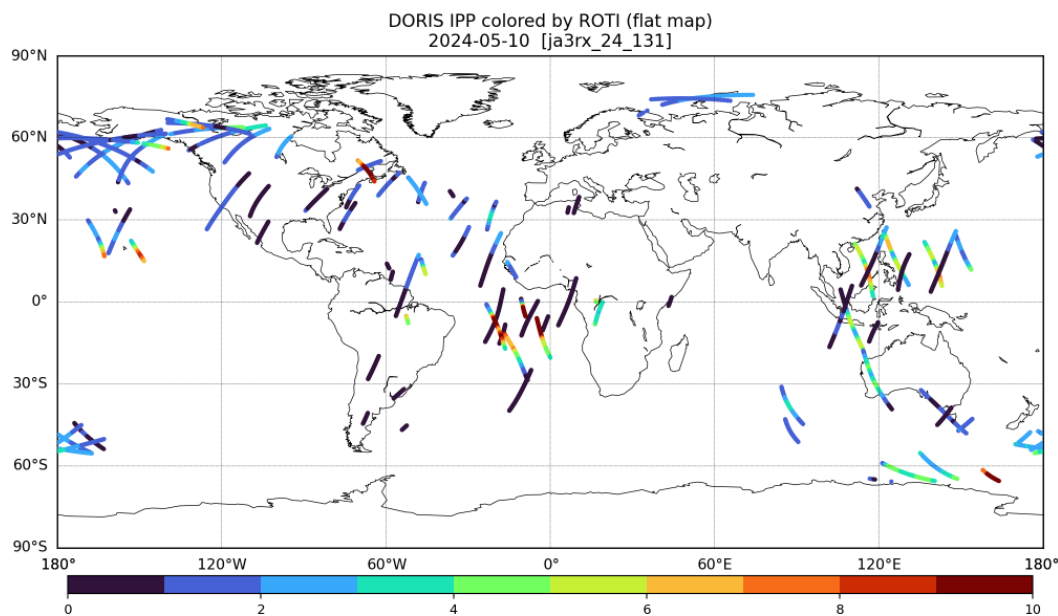


YELL (YEMB), 10 May 2024

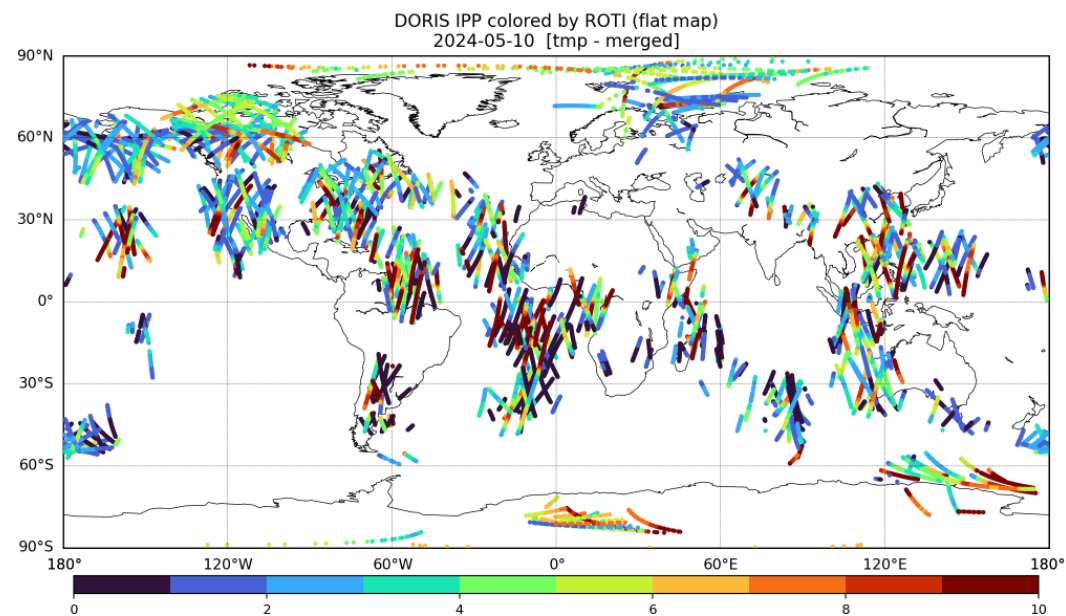


RGAC (GR3B), 10 May 2024

# Global NRT DORIS ROTI mapping

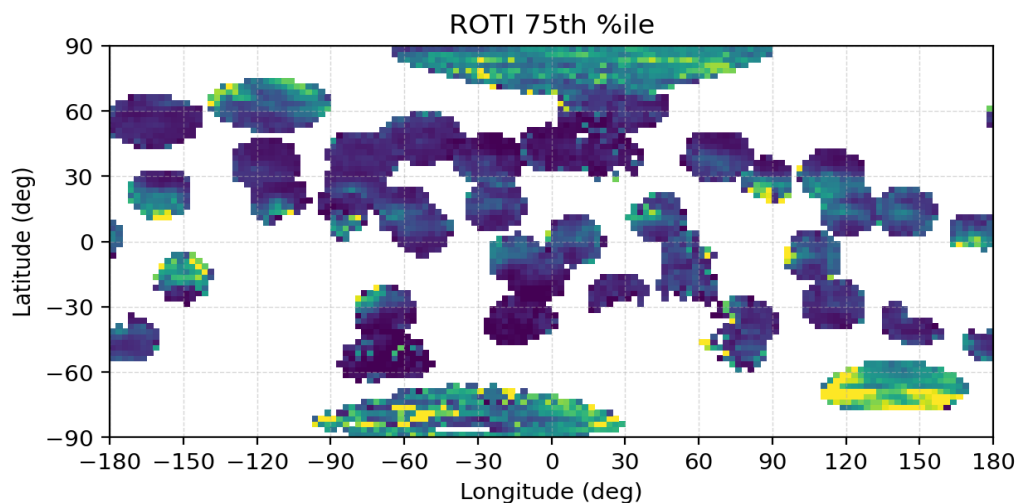


Jason-3 NRT DORIS ROTI  
10 May 2024

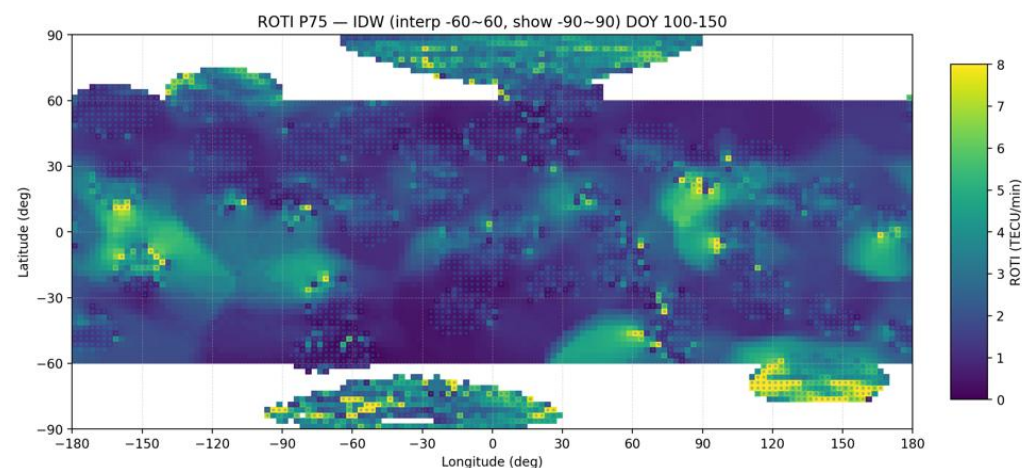


ALL NRT DORIS ROTI  
10 May 2024

# Global NRT DORIS ROTI mapping



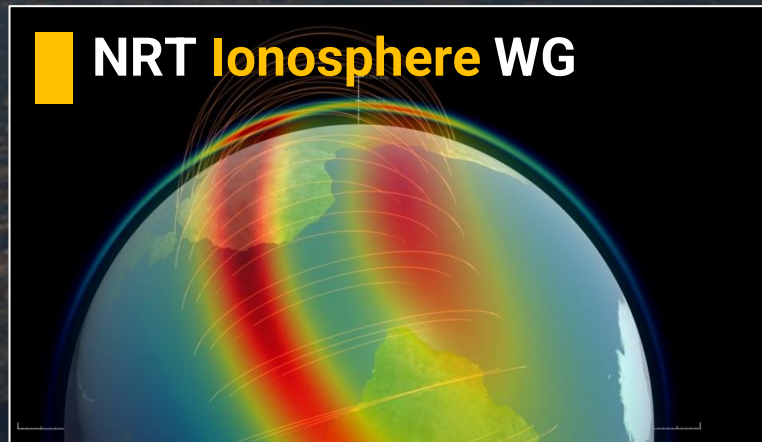
DORIS based ROTI (ALL satellites, 75 percentile )  
DoY 100-150, 2024



IDW Interpolation (ALL satellites, 75 percentile )  
DoY 100-150, 2024

# Summary

- ▶ First attempt to use dual-frequency DORIS data for ionospheric irregularity analysis through generating DORIS-based ROTI index.
- ▶ While offering a high sampling rate than ground GNSS data (10 vs. 30 seconds), the low-orbital altitude and short observation arcs result in large DORIS-ROTI values.
- ▶ Consistency analysis between DORIS- and GNSS-derived ROTI at individual stations is difficult, because of the limited arc length of DORIS measurements
- ▶ Pronounced ionospheric irregularity in equatorial regions can still be clearly identified from the DORIS derived ROTI maps
- ▶ For ionospheric analysis purpose: more dense ground DORIS beacons in low-latitude regions (if possible?)



# Thank You!

**Contact:**

Ningbo Wang

wangningbo@aoe.ac.cn