



# Total Ozone retrievals from multiple satellite sensors: a consolidated analysis updating their geophysical validation



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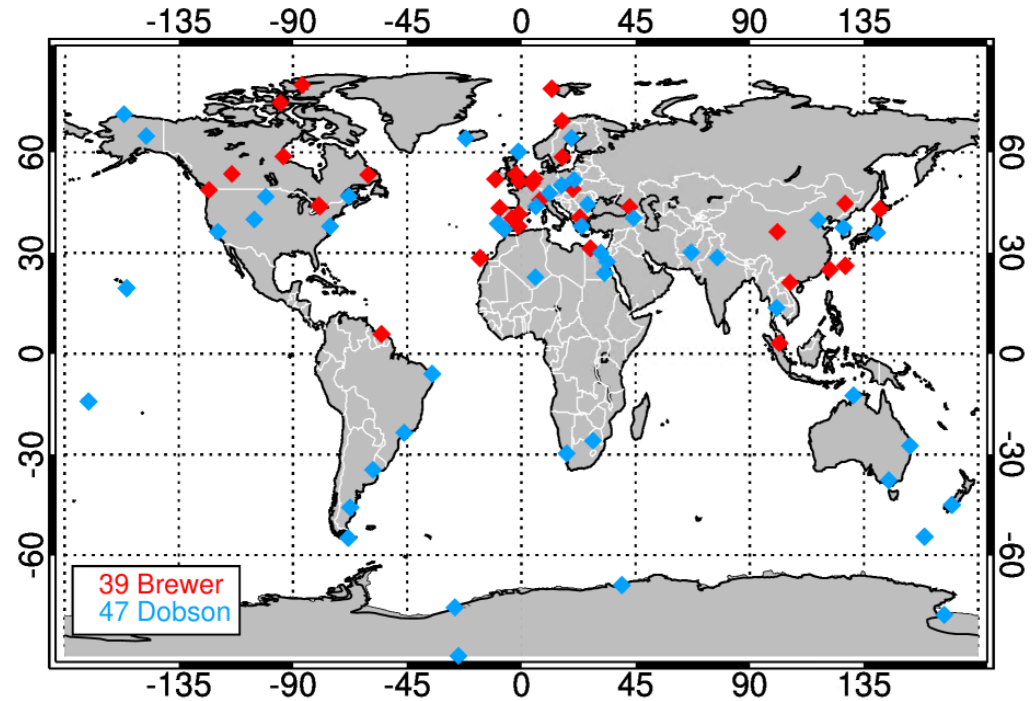
## Satellite data

- TROPOMI/S5P OFFL & NRTI
- GOME2-MetOpA GDP4.8
- GOME2-MetOpB GDP4.8 & GODFIT v4
- GOME2-MetOpC GDP4.9 & GODFIT v4
- OMI/Aura GODFITv4
- OMPS/Suomi-NPP GODFITv4



## Ground Based TOC measurements:

- Daily TOC DS measurements from WOUDC



## Co-location criteria

- Spatial search radius:
  - TROPOMI/S5P → up to 10 km (0-5 km for the majority of co-locations)
  - Other missions → up to 150 km (0-50 km for the majority of co-locations)
- WOUDC (daily TOCs): same day



Total ozone validation results for:

- TROPOMI/S5P OFFL & NRTI
- GOME2-A, -B, -C GDP4.8(4.9)
- GOME2-A, -B, -C, OMI, OMPS GODFIT v4

# TROPOMI/S5P NRTI & OFFL total ozone



- **Validation paper:** Garane et al., [AMT](#), 2019
  - 1 year of data, main results: OFFL mean bias up to +0.7 %, NRTI mean bias ~ +1.5 %
- **Algorithm changes:**
  - NRTI: surface albedo climatology → GE\_LER (7/2020, v2.1.3)
  - OFFL: **reprocessing 5/2018 – 7/2022**
  - L1b updates (currently v2.1, since 7/2022)

Continuously updated  
Quarterly Validation Reports  
(<https://s5p-mpc-vdaf.aeronomie.be/>)

## Uncertainty Mission Requirements:

- due to Systematic Effects: 5 %
- due to Random Effects: 2.5 %

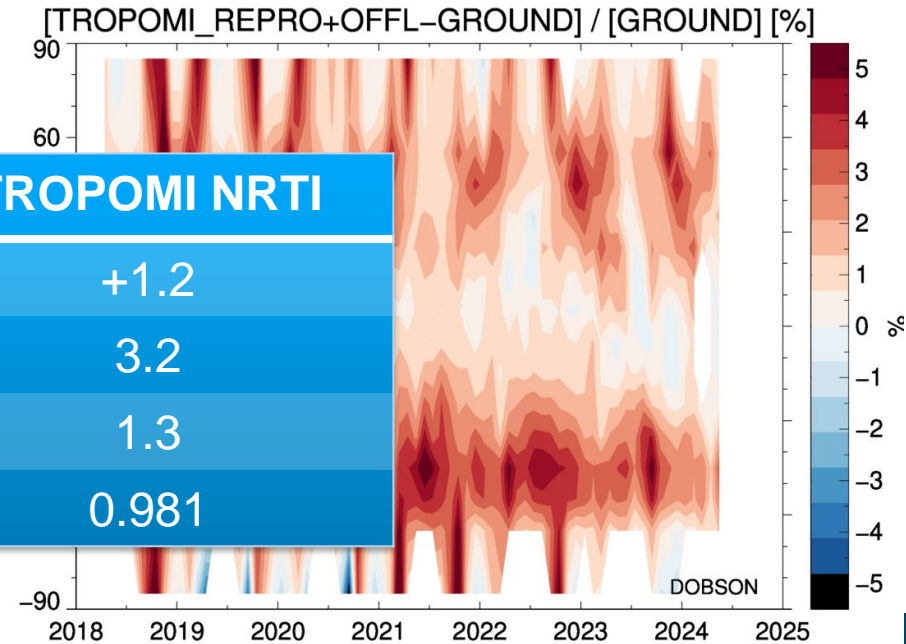
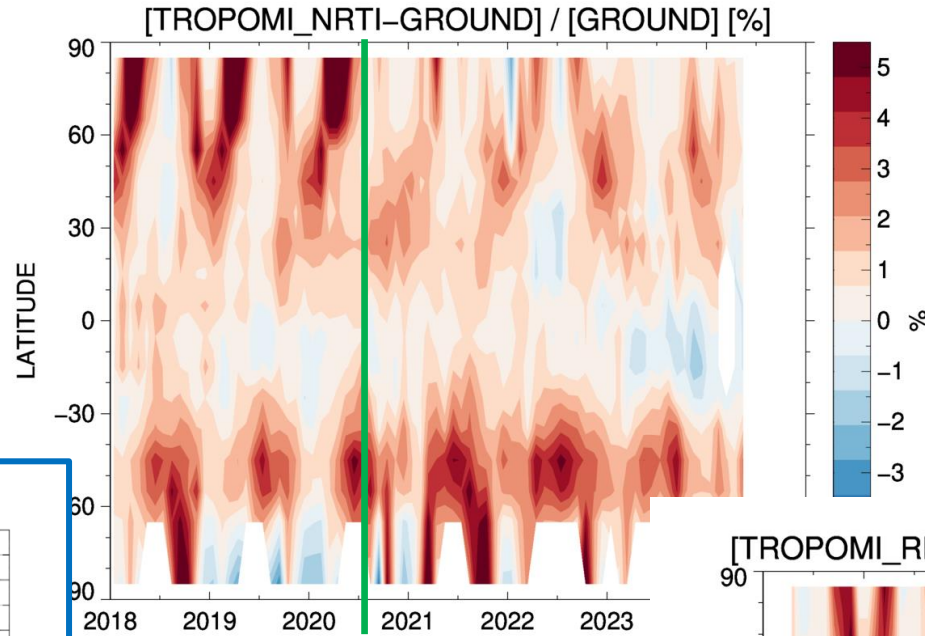
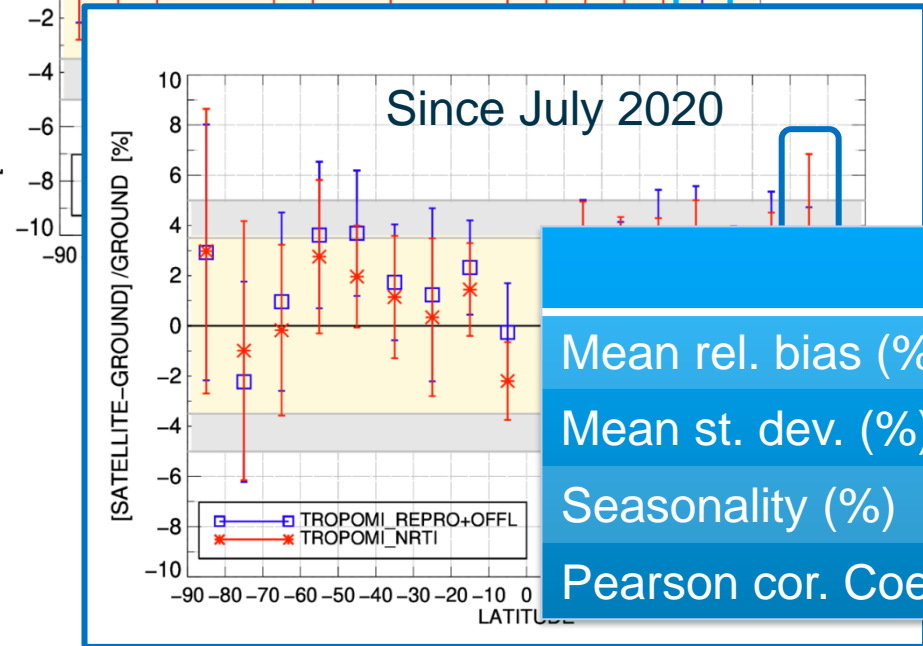
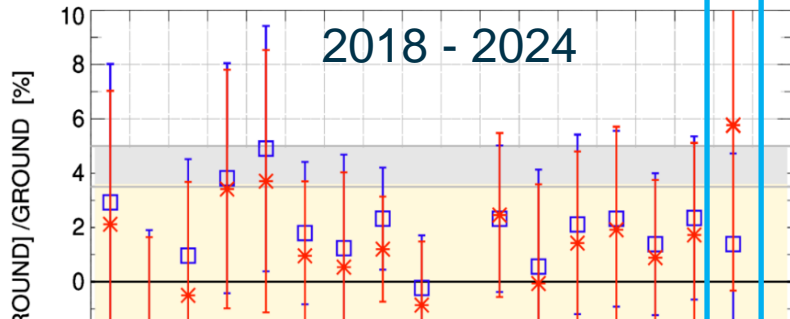


# TROPOMI/S5P NRTI & OFFL total ozone



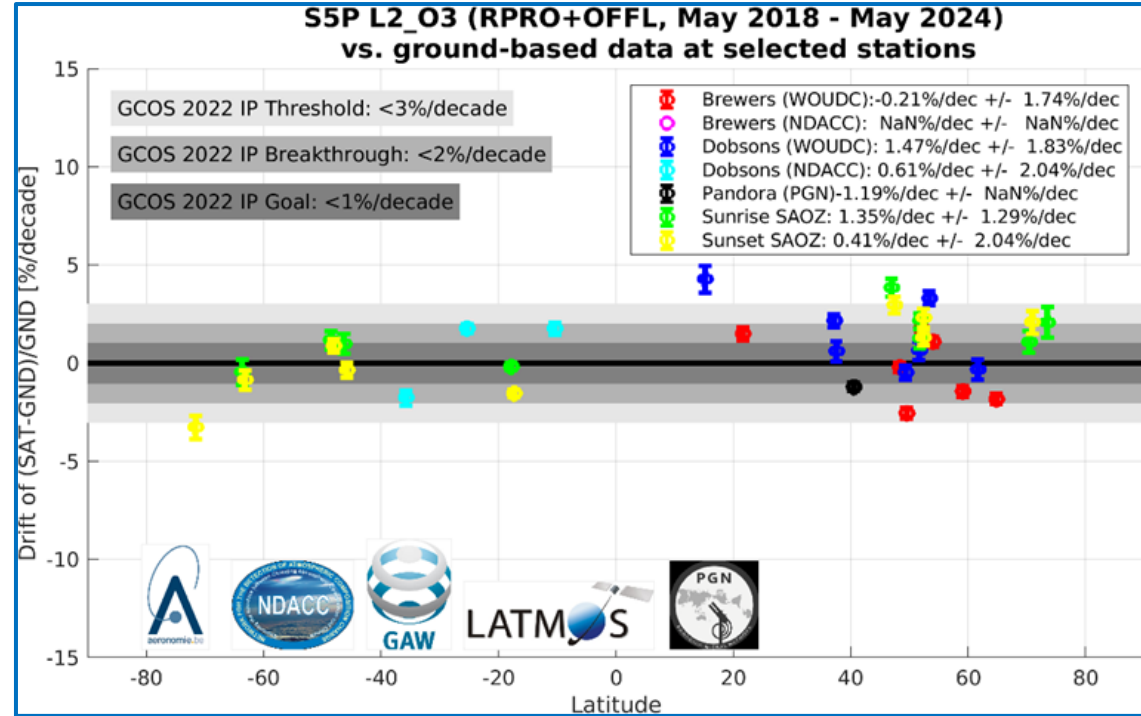
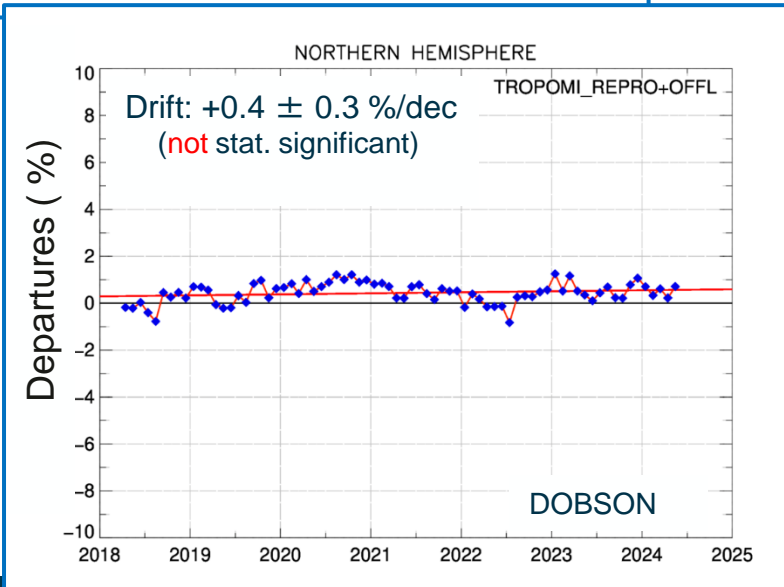
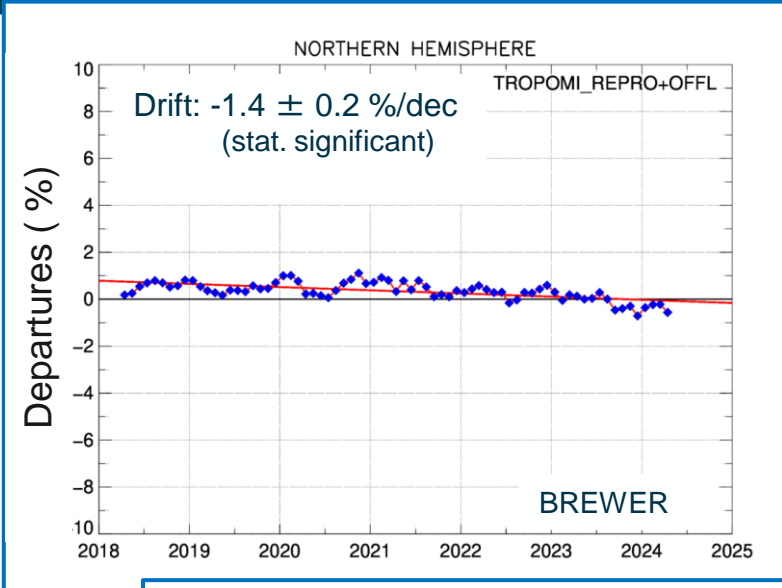
## RePRO+OFFL

### NRTI



	TROPOMI OFFL	TROPOMI NRTI
Mean rel. bias (%)	+1.5	+1.2
Mean st. dev. (%)	2.5	3.2
Seasonality (%)	0.8	1.3
Pearson cor. Coef.	0.986	0.981

# TROPOMI/S5P NRTI & OFFL total ozone



Courtesy of Tijl Verhoelst, BIRA

Overall drift: up to  $\pm 1.4$  %/ decade

Good stability, within the limit of the measurements' uncertainties



Total ozone validation results for:

➤ TROPOMI/S5P OFFL & NRTI

➤ GOME2-A, -B, -C GDP4.8(4.9)

➤ GOME2-A, -B, -C, OMI, OMPS GODFIT v4

# GOME2-A, -B, -C GDP4.8(4.9) total ozone



➤ Validation reports available from EUMETSAT ACSAF: <https://acsaf.org/valreps.php>

➤ *Datasets are continuously provided by DLR* 

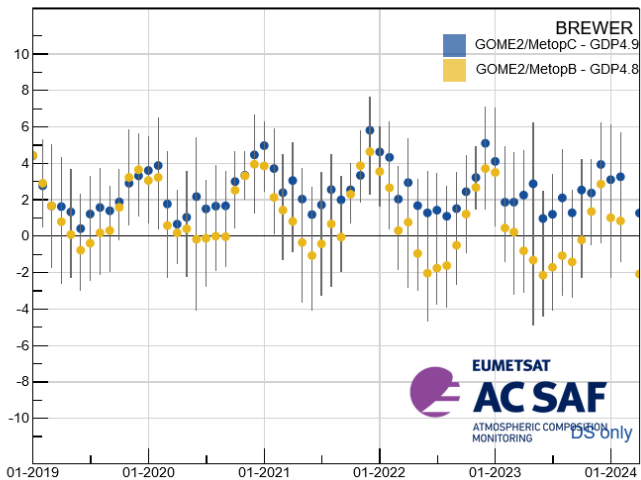
➤ Operational online validation performed by LAP/AUTH: <http://acsaf.physics.auth.gr/eumetsat/>

- Per station
- Zonal
- Hemispherical, Global

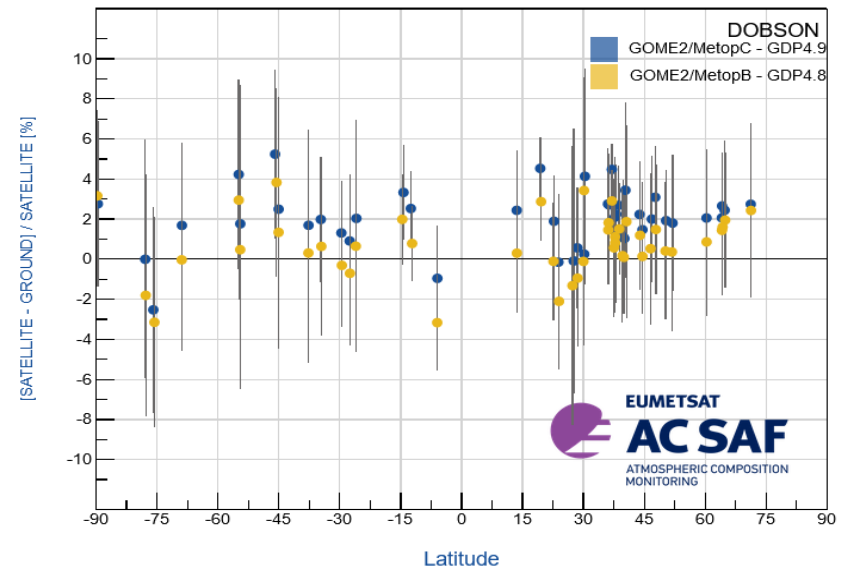
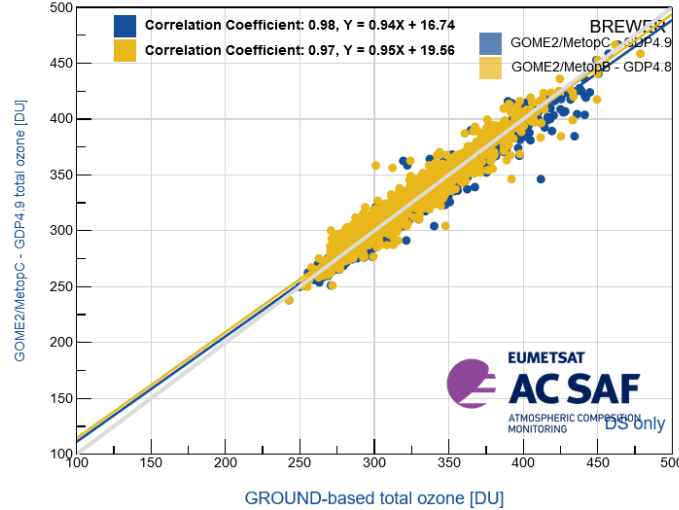


**GOME2-A**  
**GOME2-B**

Monthly mean differences  
HOHENPEISSENBERG - BREWER: lat=47.80 lon=11.02

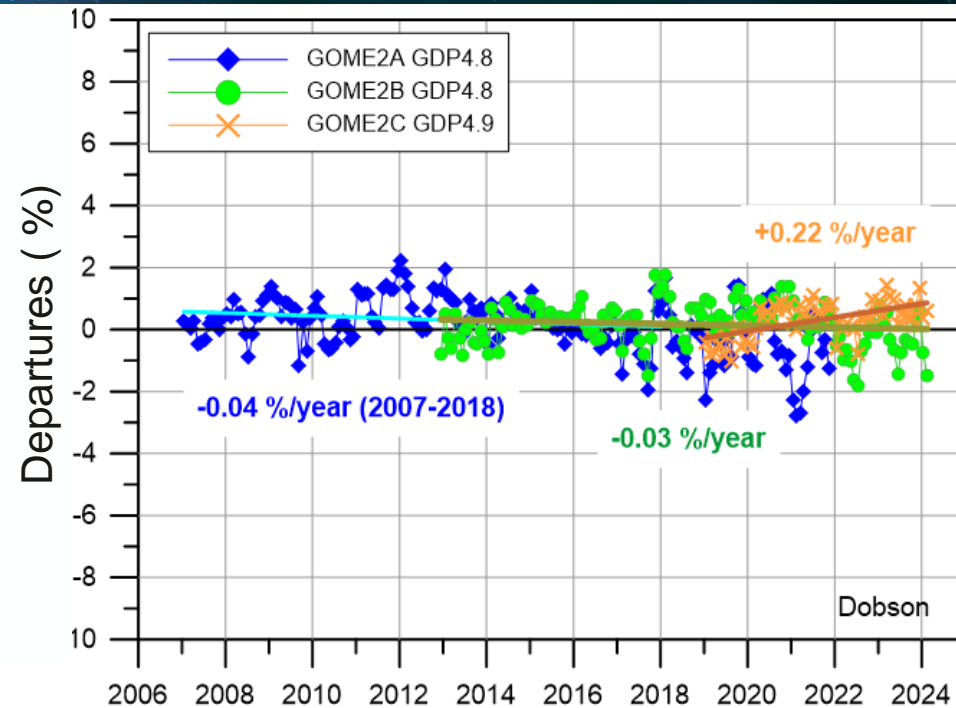
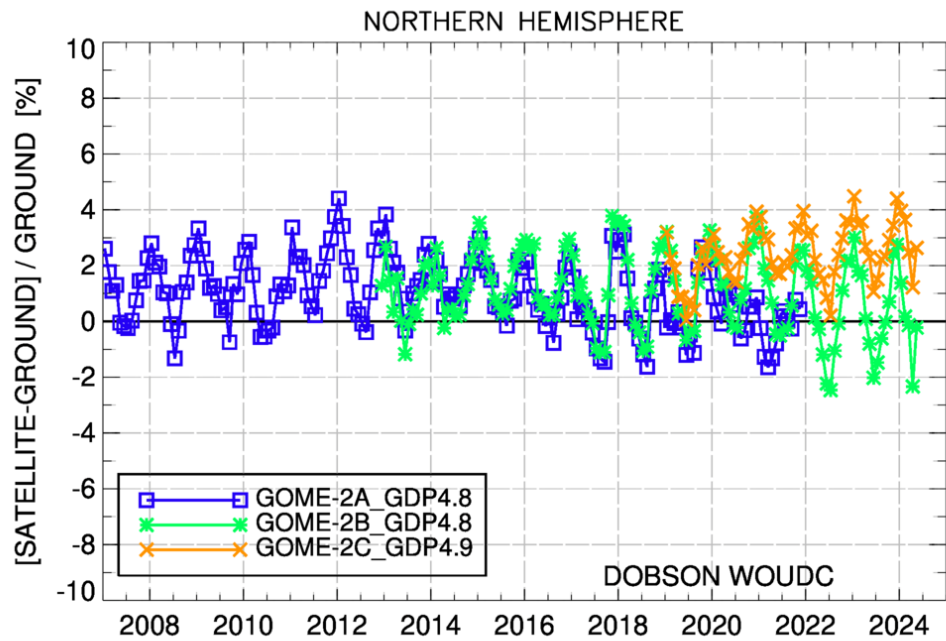


Scatter diagram between TOCs  
THESSALONIKI - BREWER: lat=40.52 lon=22.97





# GOME2-A, -B, -C GDP4.8(4.9) total ozone



GOME-2A  
GOME-2B  
GOME-2C

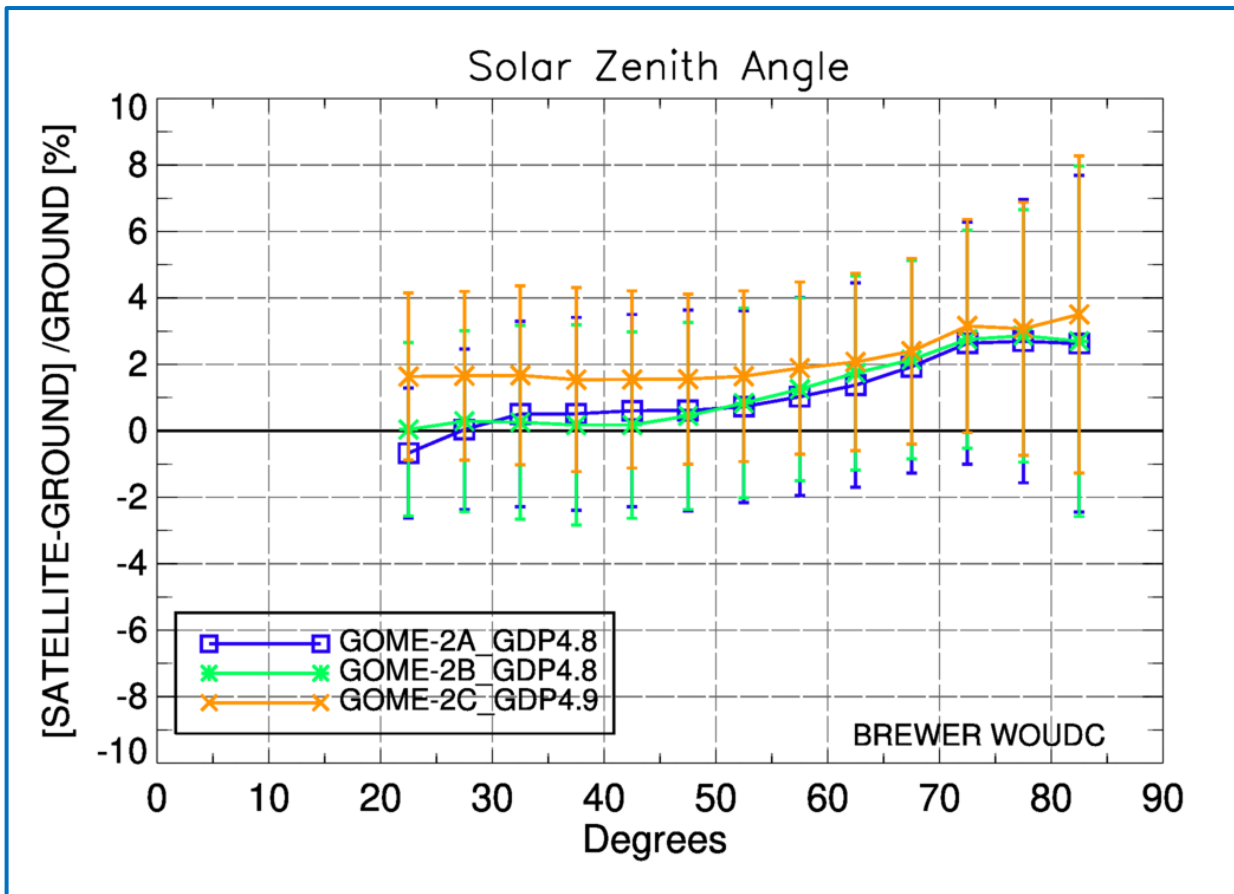
	GOME-2A	GOME-2B	GOME-2C
Mean rel. bias (%)	+1.1	+1.1	+2.1
Mean st. dev. (%)	3.5	3.5	3.0
Seasonality (%)	1.9	2.1	1.4
Pearson cor. Coef.	0.963	0.957	0.960



# GOME2-A, -B, -C GDP4.8(4.9) total ozone



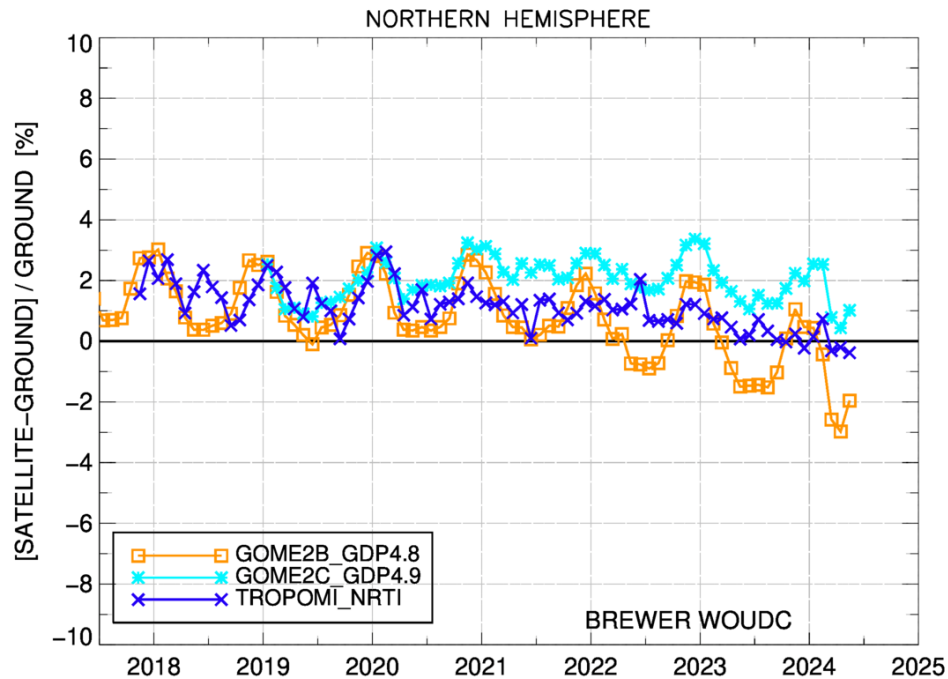
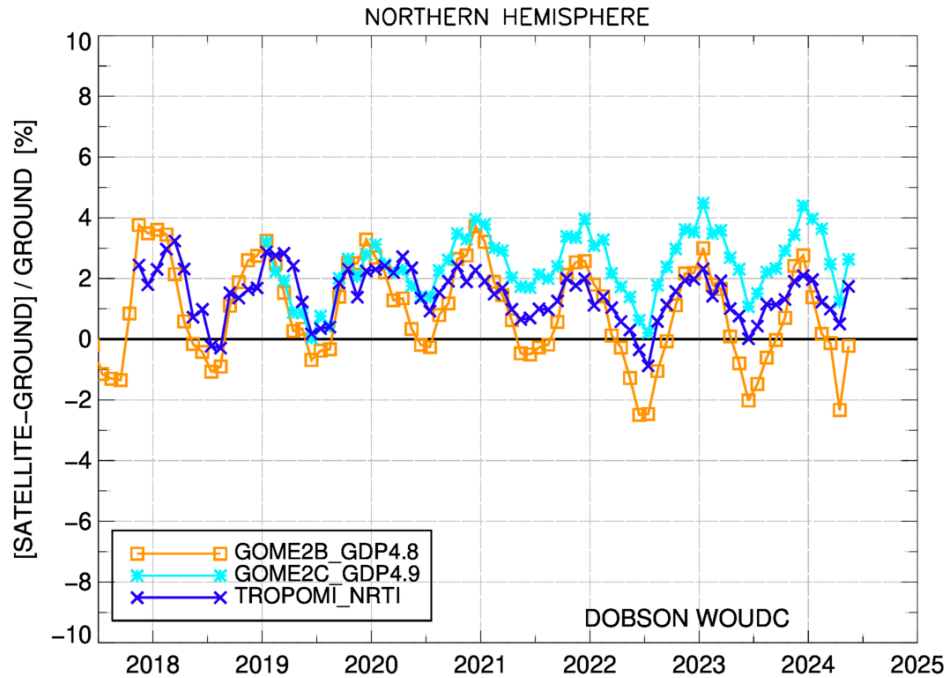
GOME-2A  
GOME-2B  
GOME-2C



- Requirements:
- Accuracy target 3% (sza < 80° )
  - Accuracy target 6% (sza > 80° )



# GOME-2 GDP and TROPOMI NRTI total ozone



- GOME-2C: biased higher since mid-2020 by ~1-2%
- TROPOMI & GOME-2C: similar seasonality
- GOME-2B: drifting...



Total ozone validation results for:

- TROPOMI/S5P OFFL & NRTI
- GOME2-A, -B, -C GDP4.8(4.9)
- GOME2-A, -B, -C, OMI, OMPS GODFIT v4

# GODFIT v4 total ozone

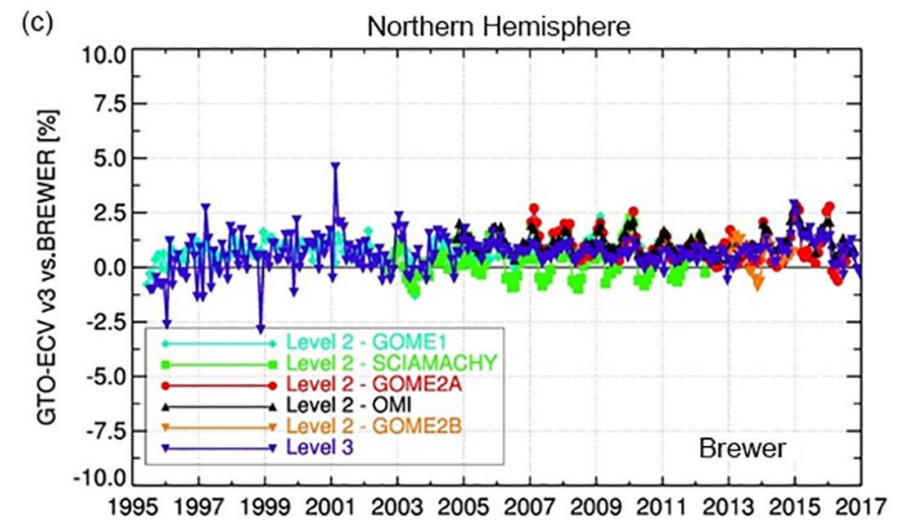
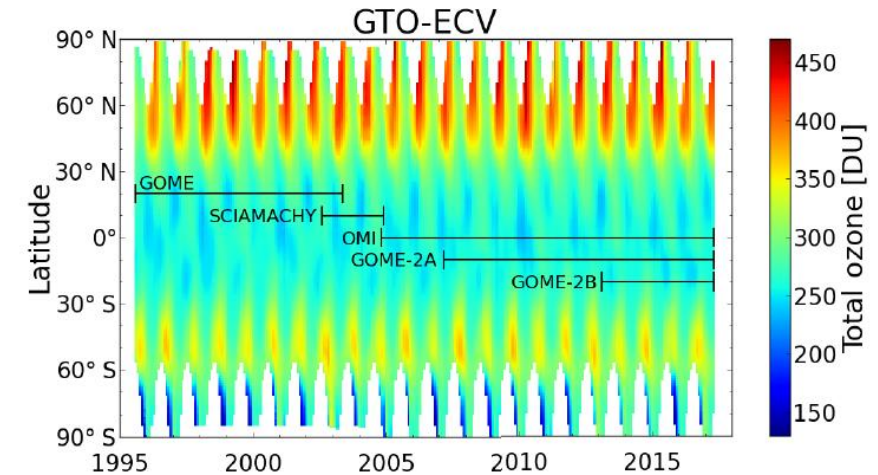


- **Validation paper:** Garane et al., [AMT](#), 2018 (Level 2 GODFIT v4 & Level 3 GTO-ECV up to 2017)
- **Level 2 datasets:**
  1. converted to L3 total ozone and
  2. combined
 to generate the Ozone CCI+ GOME-type Total Ozone Essential Climate Variable (GTO-ECV) [Coldewey-Egbers et al., *AMT*, 2015 & *ACP*, 2022]
- **Level 2 Datasets are continuously updated within the C3S project (BIRA-IASB)**



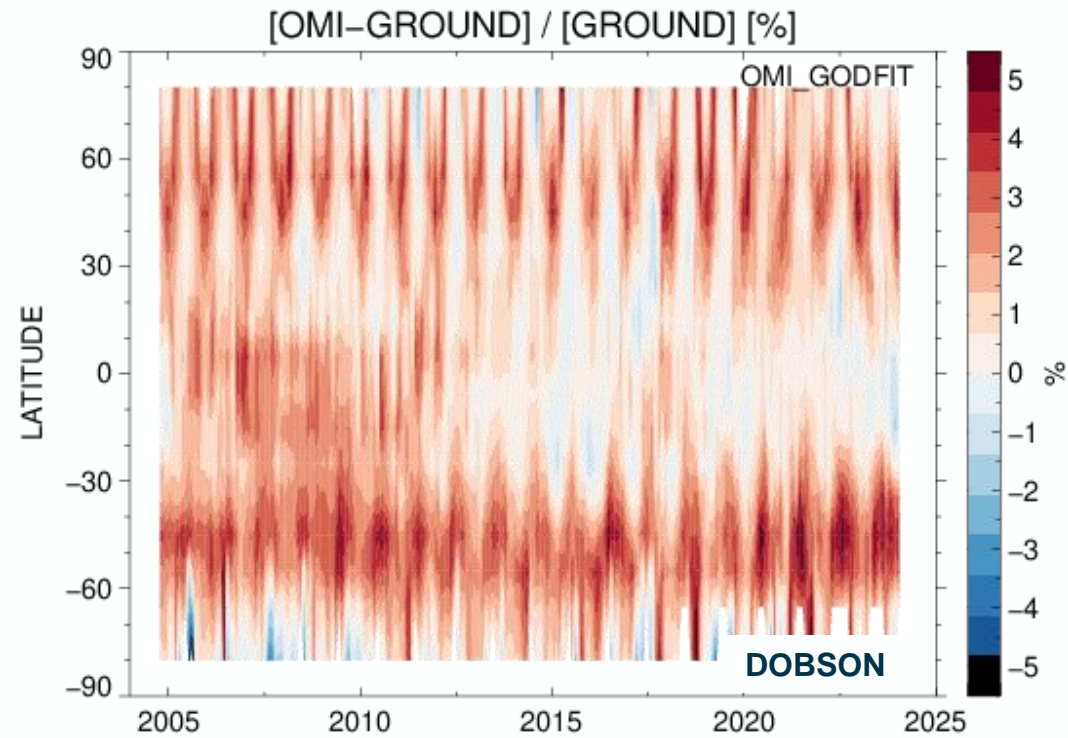
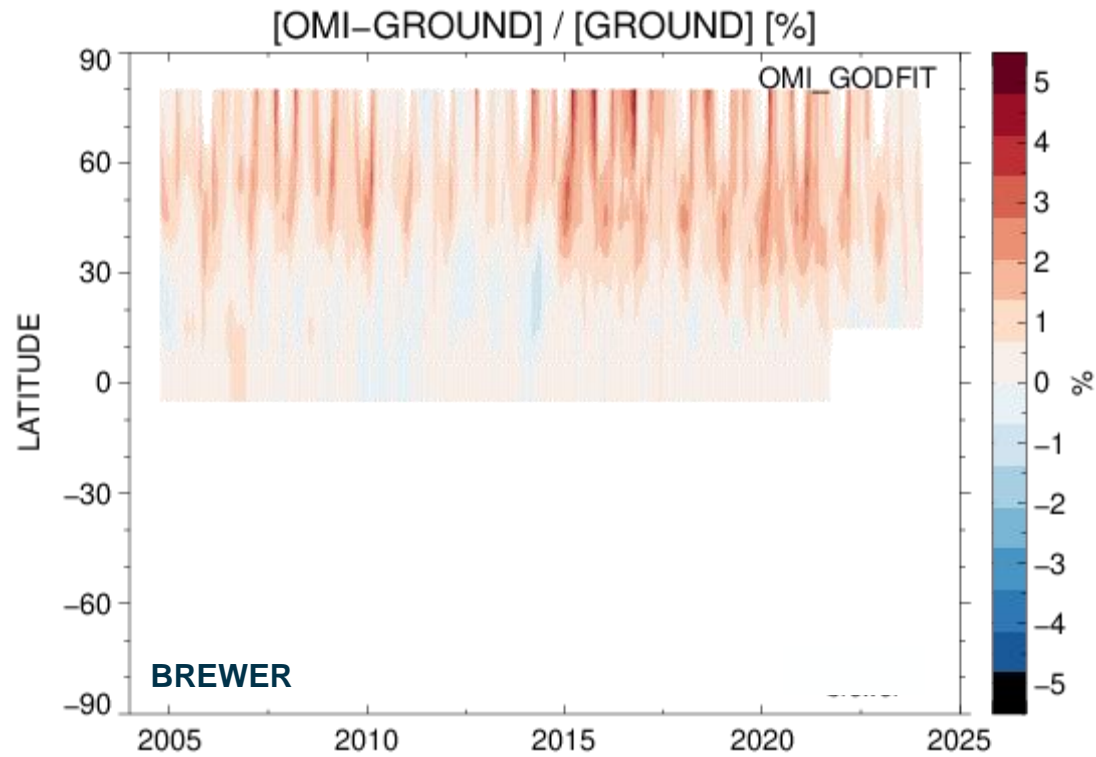
## Total ozone Requirements:

- Radiative forcing: 2%
- Seasonal cycle: 3%
- Stability: 1-3 %/decade



Garane et al., [AMT](#), 2018

# GODFIT v4 total ozone



To be updated (reprocessed) based on OMI L1b collection 4

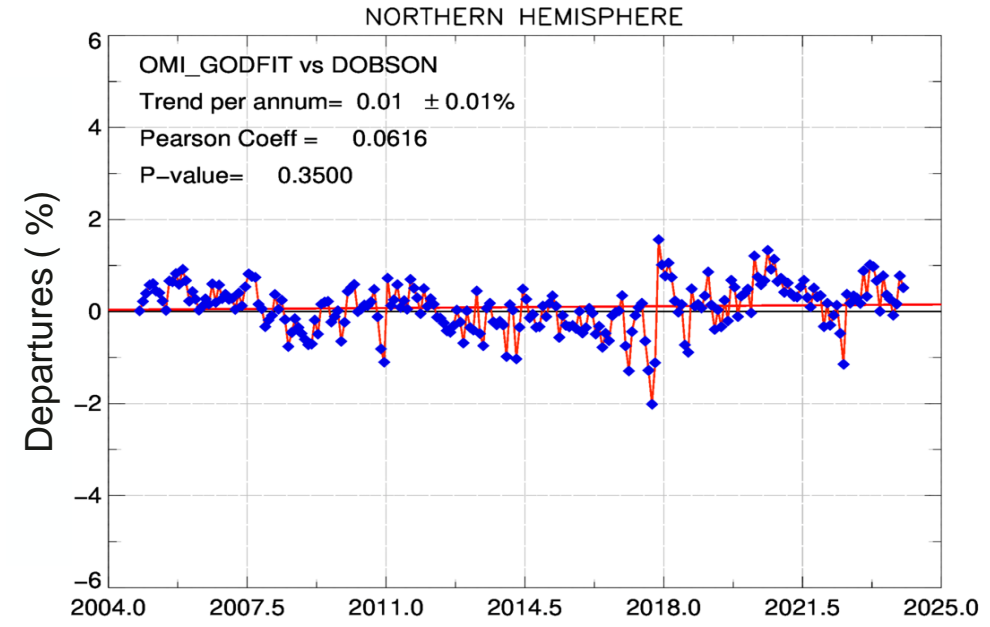
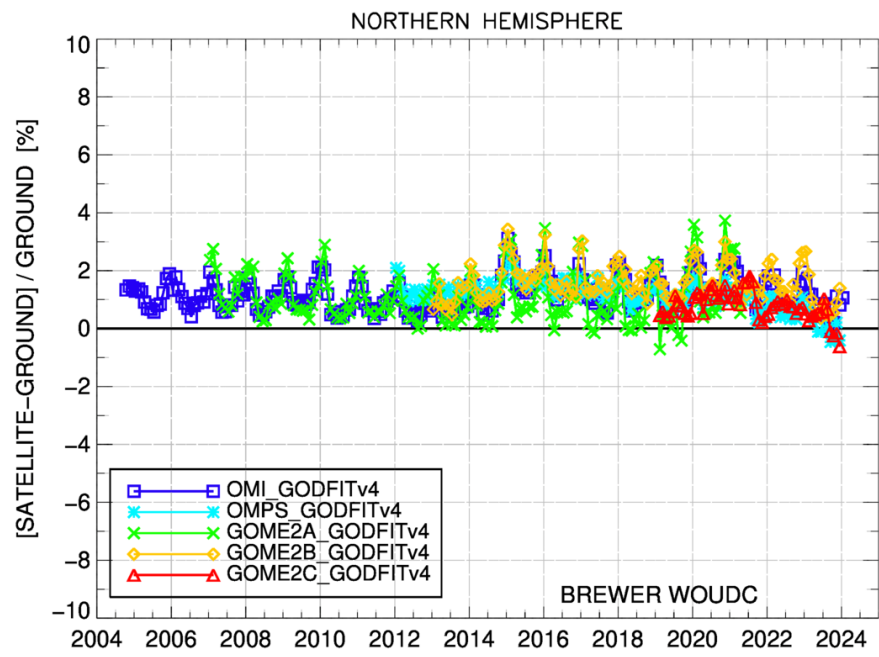




# GODFIT v4 total ozone



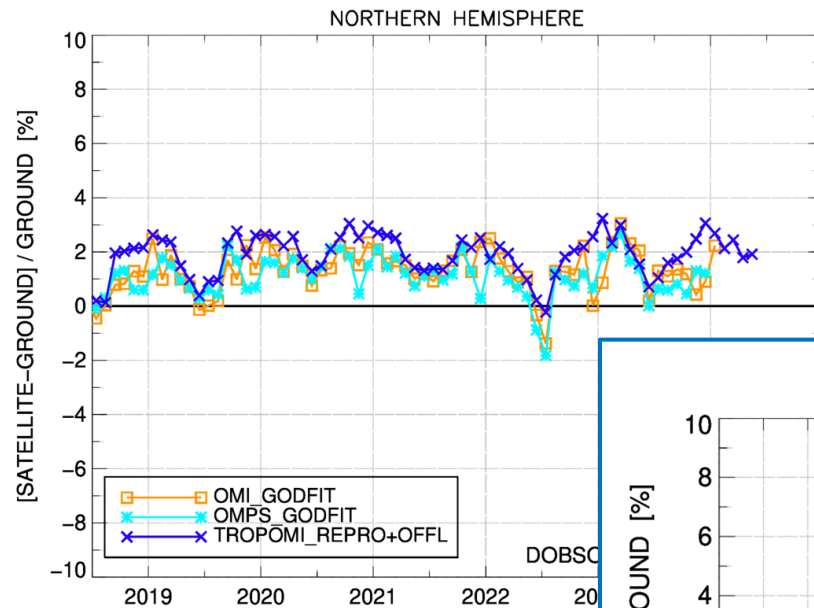
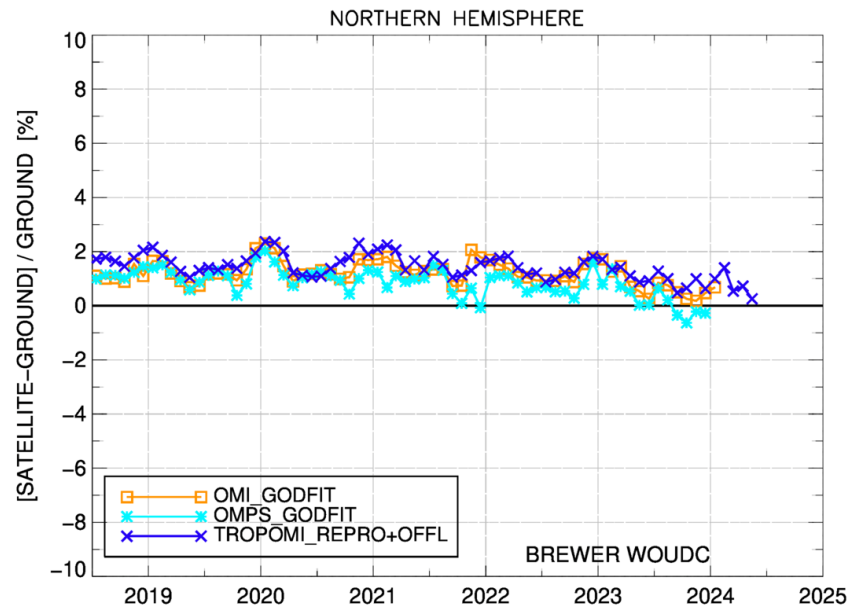
- OMI
- OMPS
- GOME-2A
- GOME-2B
- GOME-2C



	OMI	OMPS	GOME-2A	GOME-2B	GOME-2C
Mean rel. bias (%)	+1.1	+1.2	+0.9	+1.5	+0.8
Mean st. dev. (%)	2.6	2.8	2.9	2.7	2.5
Seasonality (%)	1.0	0.6	1.8	1.3	0.9
Pearson cor. Coef.	0.984	0.983	0.981	0.984	0.984
Drift (%/decade)	+0.1 (NS)	-0.3 (NS)	-0.2 (S)	-0.1 (NS)	+0.3 (NS)



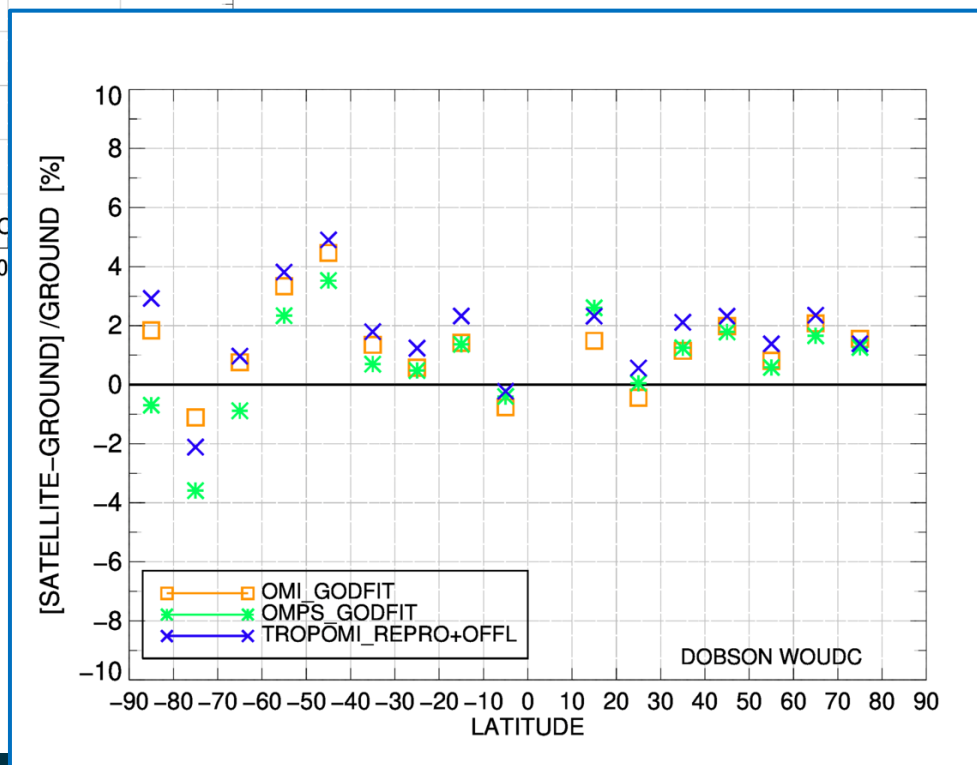
# GODFIT v4 and TROPOMI OFFL total ozone



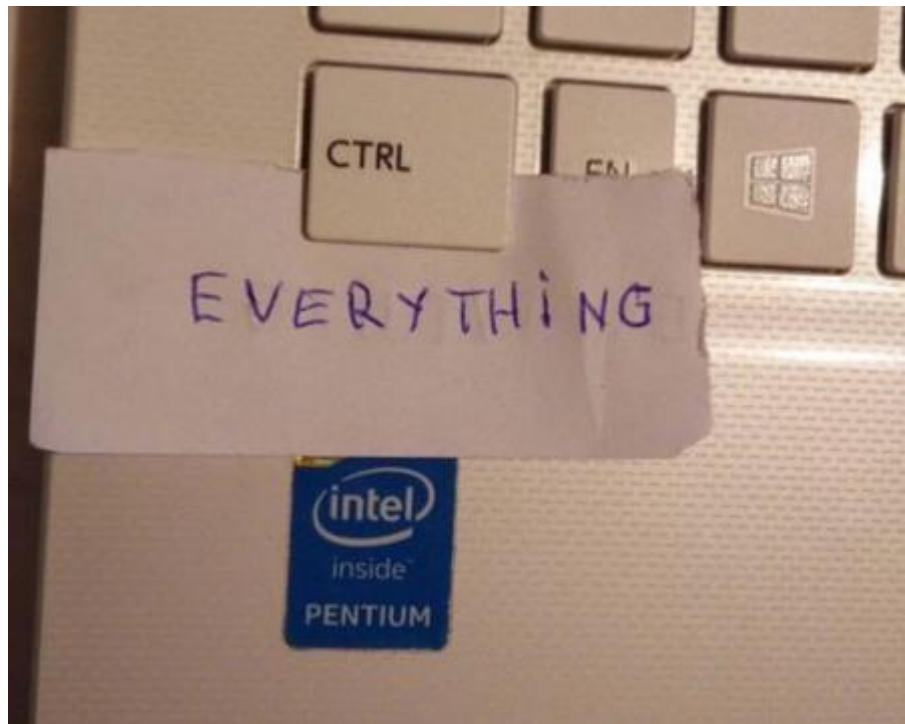
TROPOMI  
OMI  
OMPS



- TROPOMI OFFL: excellent agreement, within 0 – 0.5 % w.r.t. OMI & OMPS
- Higher divergencies (~1%) for the higher SH stations



Take away message:



*Thank you  
for your attention!*



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