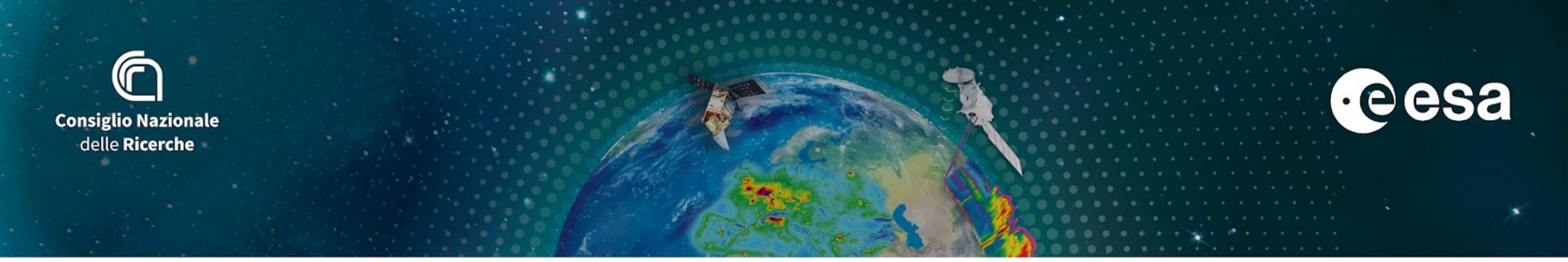

# INFLUENCE OF USING ABSOLUTE SLANT COLUMNS FOR TRACE GAS COLUMN RETRIEVALS

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Pandora spectrometer systems within the Pandonia Global Network (PGN), are used to retrieve direct sun total column amounts as well as tropospheric column, surface concentrations and profiles from sky radiance of trace gases such as NO2, O3, HCHO and SO2 at a global scale.

The Blick Software Suite (Blick) operates the instruments and does the data production. The current operational version is Blick v1.8 and Blick v1.9 is in a development stage.

- The retrieval of products from sky radiance measurements in the operational version Blick v1.8 is based on **relative slant columns**, where the a at the different viewing angles are referenced to the zenith observation.
- The development version Blick v1.9 also allows the use of **absolute slant columns**, where an absorption free spectrum is used as the reference.

## Tropospheric Column Retrieval

The tropospheric gas column amount ($VCT_{GAS}$) in V1.8 is calculated using:

$$SC_{AIR}(75°) = dSC_{AIR}(75°) - dSC_{AIR}(60°) + \mathbf{2.} * VC_{AIR}$$

$$m_{AIR}(75°) = SC_{AIR}(75°) / VC_{AIR}$$

$$VCT_{GAS} = dSC_{GAS}(75°) / m_{AIR}(75°)$$

dSC are the measured differential (relative to zenith) slant columns (SCs) for the trace gas ($dSC_{GAS}$) and for "air"($dSC_{AIR}$) (either from O2 or O202). $VC_{AIR}$ is the estimated total vertical air column, obtained from surface pressure and temperature climatology. 2. is approximately the (absolute) air mass factor (AMF) for VZA=60°. $m_{AIR}$ is the estimated absolute air AMF at VZA=75°.

V1.8 uses differential slant columns and estimates the air slant column using a simplified AMF of ~2 for VZA=60° or ~1 for VZA=0°. For V1.9 there are four more options added in this respect.

i. **Option 0** uses the differential SC (Zenith reference) as in V1.8.

ii. **Option 1** uses a simple AMF of **1.** to obtain absolute SC. This is similar, but not identical to V1.8, since instead of the equation shown above, which uses both VZA 75 and 60°, here only a single VZA is used ( example equation for VZA=75°), this scenario that use this value is "**S-scenarios**" ("S" for "simple").

$$SC_{AIR}(75°) = dSC_{AIR}(75°) + \mathbf{1.} * VC_{AIR}$$

i. **Option 2** uses the AMF from the Rayleigh tables for the specific conditions to obtain absolute SC, this scenario that use this value is "**R-scenarios**" ("R" for "Rayleigh tables").

ii. **Option 3** if given, uses the measured absolute SC (Synthetic reference), if not given it falls back to option 2, this scenario that use this value is "**A-scenarios**" ("A" for "absolute").

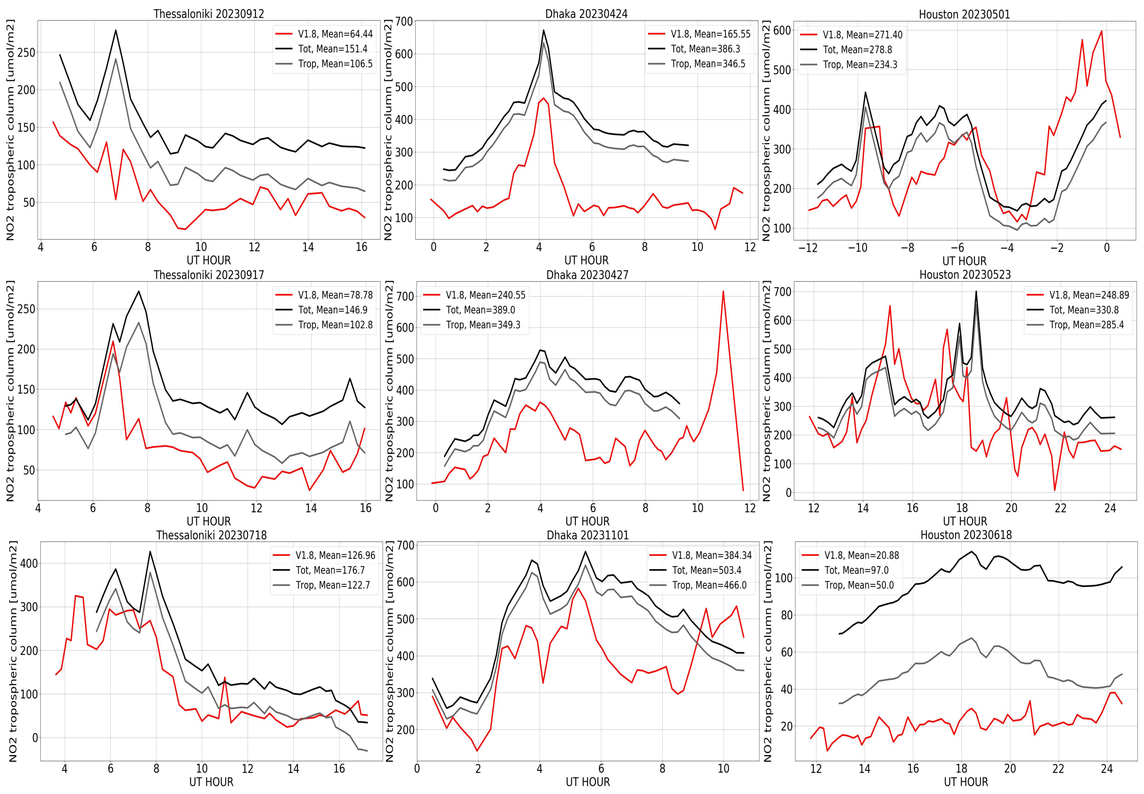
**Thessaloniki**
i. 12 Sep 2023 (very clean)
ii. 17 Sep 2023 (somewhat polluted)
iii. 18 Jul 2023 (increasingly polluted)

**Dhaka**
i. 24 Apr 2023 (polluted)
ii. 27 Apr 2023 (very polluted, probably with clouds in the afternoon)
iii. 1 Nov 2023 (increasingly polluted)

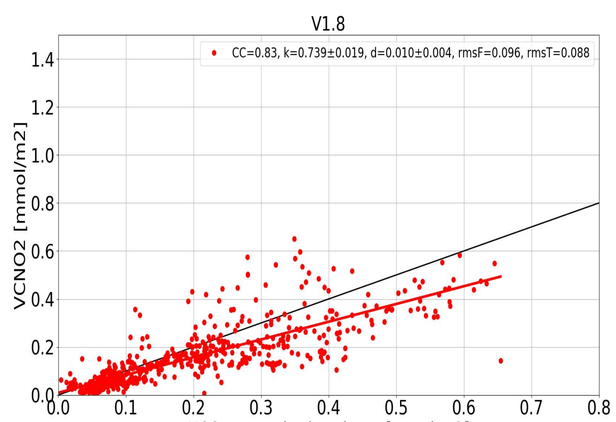
**Houston**
i. 1 May 2023 (clean)
ii. 23 May 2023 (polluted)
iii. 18 Jun 2023 (somewhat polluted)

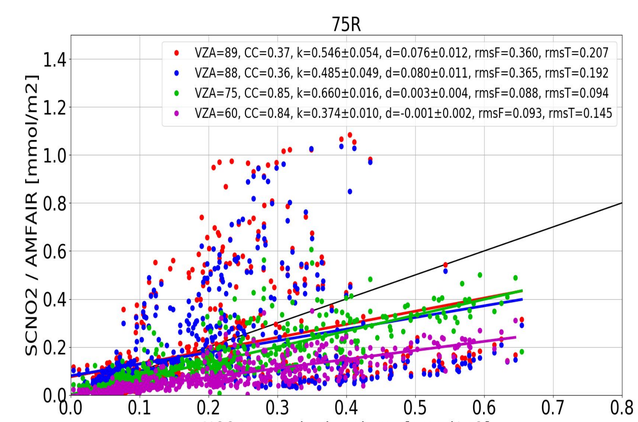
## NO2 tropospheric columns ($VCT_{NO2}$)

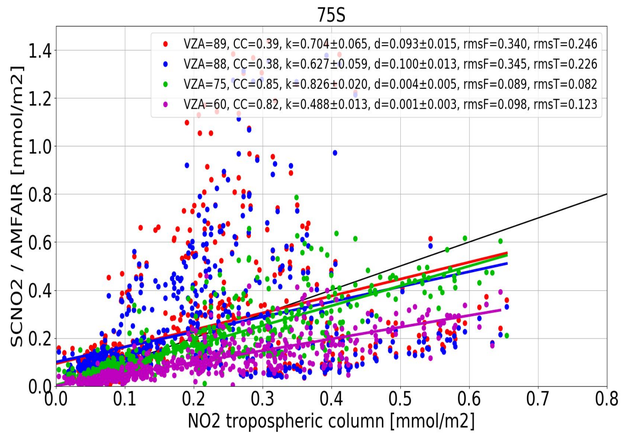
The retrieved $VCT_{NO2}$(Tot-black) should be compared with the tropospheric (Trop-gray) column (averaged direct sun total columns reduced by the climatological stratospheric amount), and the retrieved tropospheric column from V1.8 (red). There seems to be a systematic underestimation of $VCT_{NO2}$ by the sky retrievals, mostly in the very low amount regions (Thessaloniki) or the very high amount regions (Dhaka).

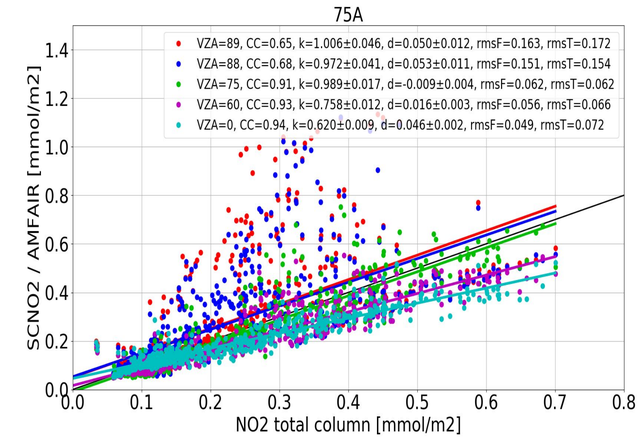



"S"-scenarios (75S) is as good or even better than "V1.8". The "R"-scenarios (75R) do not seem to have a clear advantage over the "S"-scenarios. The "A"-scenarios (75A) have clearly the best results.



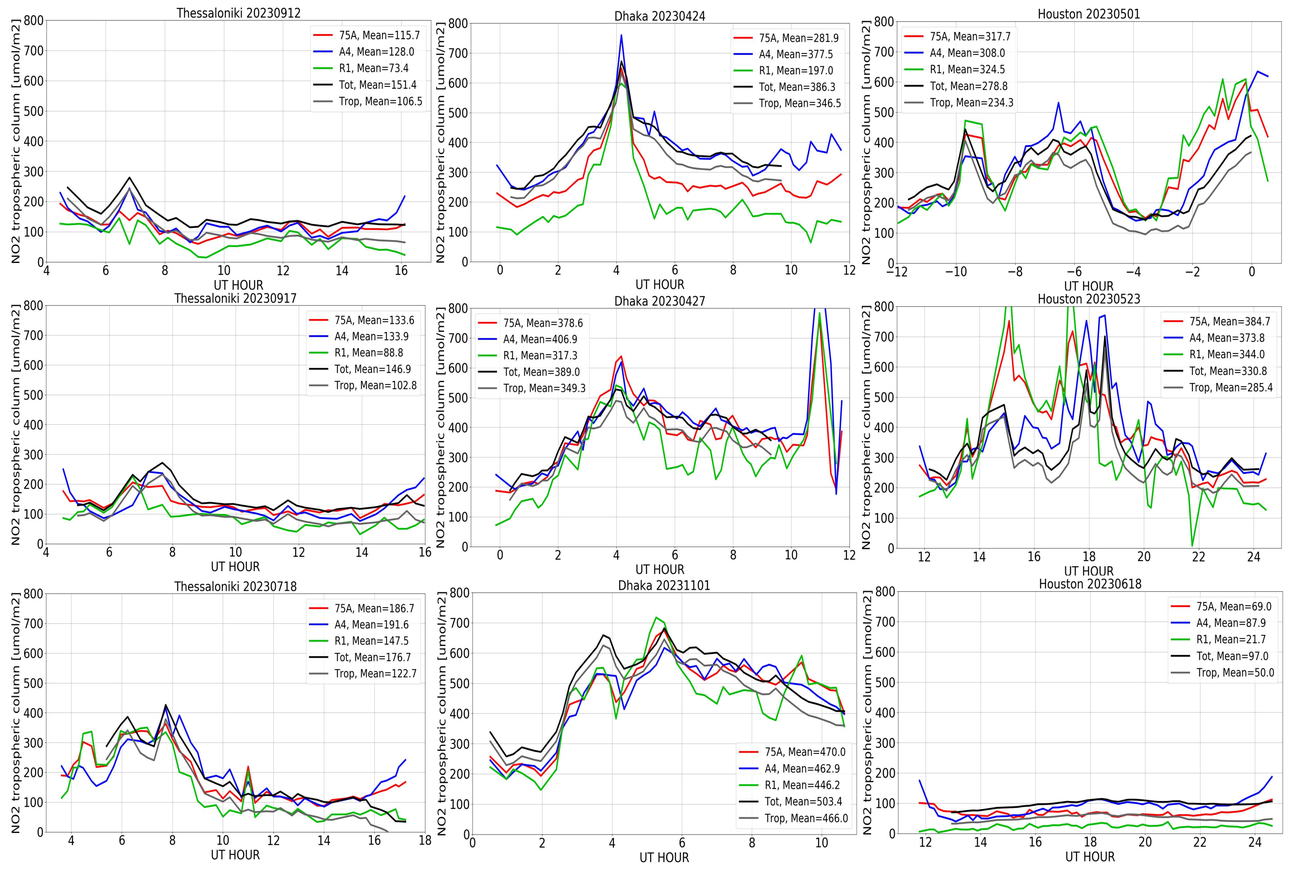




## Optimized $VC_{NO2}$ Comparison

The uncorrected VZA 75°("75A" -red) calculations and the corrected absolute zenith calculations ("A4" -blue) should be compared with the total column (Tot-black) and the corrected VZA 75° ("R1" -green) with the tropospheric column (Trop- gray).



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