

IDEAS-QA4EO WP 2250- 2251: "DOAS-BO: TOWARDS A NEW FRM4DOAS- COMPLIANT SITE"



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MASSIMO VALERI²

1 CNR-ISAC

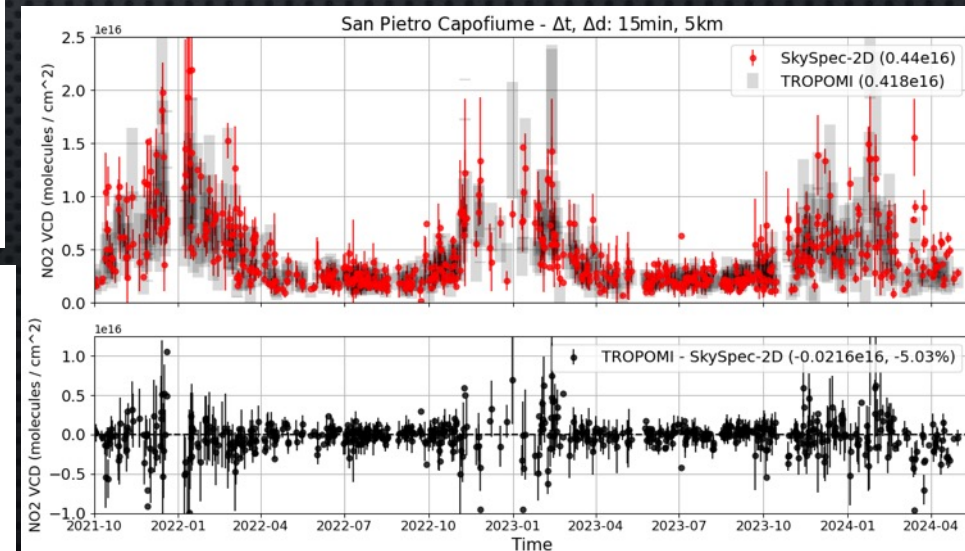
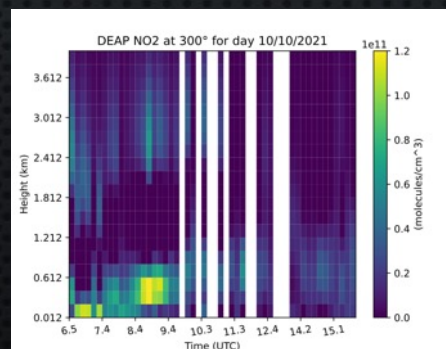
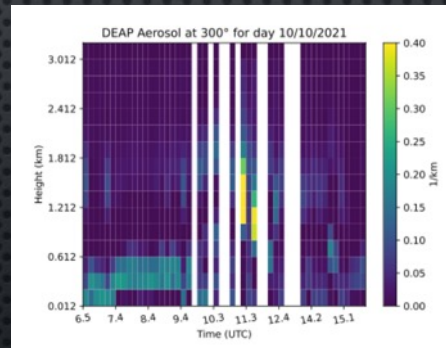
2 SERCO S.P.A.

3 UNIBO

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- **RATIONALE:**

- WE SET-UP A MAX DOAS INSTRUMENT IN SAN PIETRO CAPOFIUME (SPC, BO) IN THE PO VALLEY, WE PERFORMED 2 MEASUREMENT CAMPAIGNS ONE IN BOLOGNA AGAINST A CUSTOM BUILT SYSTEM AND ON IN BAQUININ AGAINST PANDORA. THE TARGET WAS TOTAL COLUMN NO_2 .
- WE DEVELOPED A RETRIEVAL CODE FOR THE RETRIEVAL OF AEROSOL EXTINCTION AND GASEOUS PROFILES FROM MAX-DOAS MEASUREMENTS. WE TESTED THE CODE ON SPC MEASUREMENTS AND COMPARE THEM WITH AERESOLS AND NO_2 SATELLITE DATA.



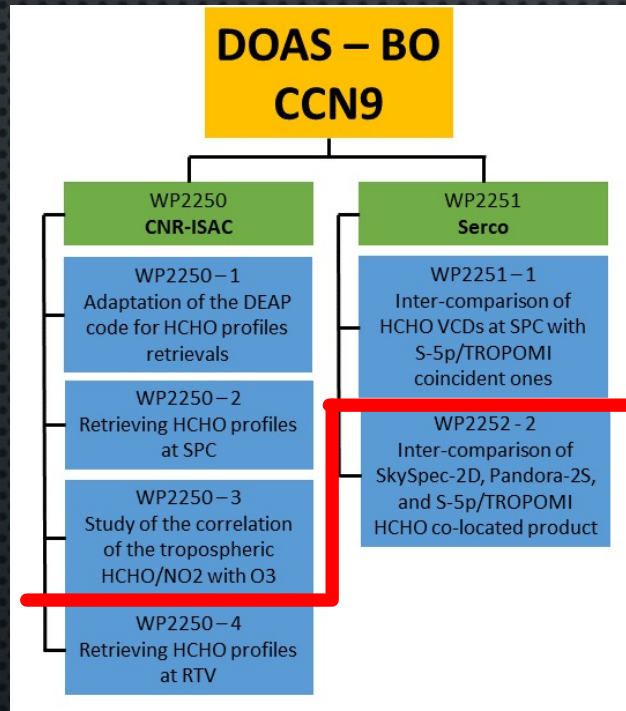
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CCN 9:

- SINCE THE RETRIEVAL CODE HAS BEEN TESTED ON NO_2 AND PROVED ITS VALIDITY, WE DECIDED TO EXTEND THE ANALYSIS TO FORMALDEHYDE (HCHO).
- HCHO PLAYS A FUNDAMENTAL ROLE IN AIR QUALITY STUDIES
- AT SPC, WE WILL USE THE SUBSEQUENT DATASET TO EVALUATE THE RATIO OF TROPOSPHERIC VCD OF HCHO AND NO_2 , WHICH HAS BECOME INCREASINGLY IMPORTANT IN UNDERSTANDING O_3 FORMATION IN POLLUTED CONDITIONS
- USING THE ISAC MAX-DOAS SYSTEM LOCATED AT ROMA TOR VERGATA (RTV) NEAR THE PANDORA #117, WE WILL COMPARE THE MAX-DOAS HCHO TROPOSPHERIC VCDs TO THE PANDORA ONES.

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CCN 9:



| | Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----------|--------------|---|---|---|---|---|-----|------|-----|---|----|-----|-------------|
| | Deliverables | | | | | | D-1 | D-2A | D-3 | | | D-4 | D-2B D-5 |
| CNR-ISAC | WP2250-1 | | | | | | | | | | | | |
| | WP2250-2 | | | | | | | | | | | | |
| | WP2250-3 | | | | | | | | | | | | |
| | WP2250-4 | | | | | | | | | | | | |
| Serco | WP2251-1 | | | | | | | | | | | | |
| | WP2251-2 | | | | | | | | | | | | |

- [D-1]: HCHO profiles and Tropospheric VCDs database at SPC
- [D-2A]: TN describing HCHO dataset including inter-comparisons against similar S-5p/TROPOMI products

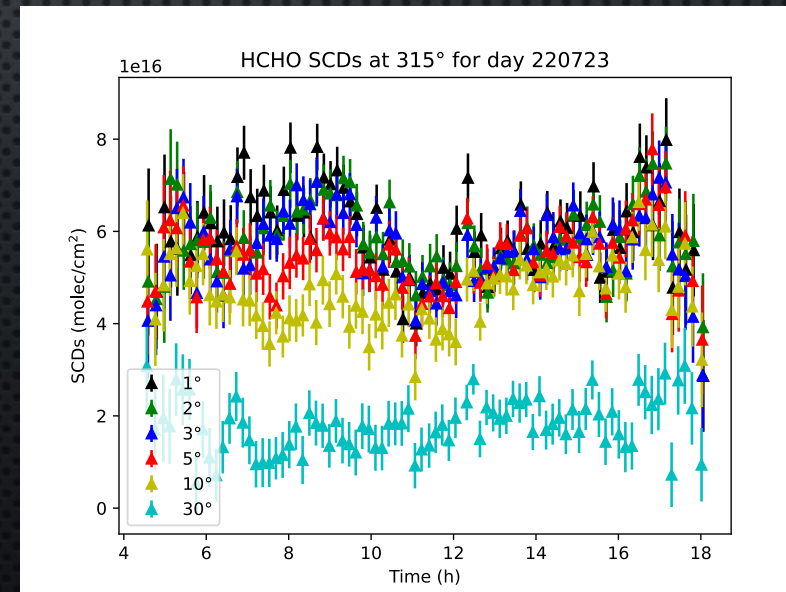
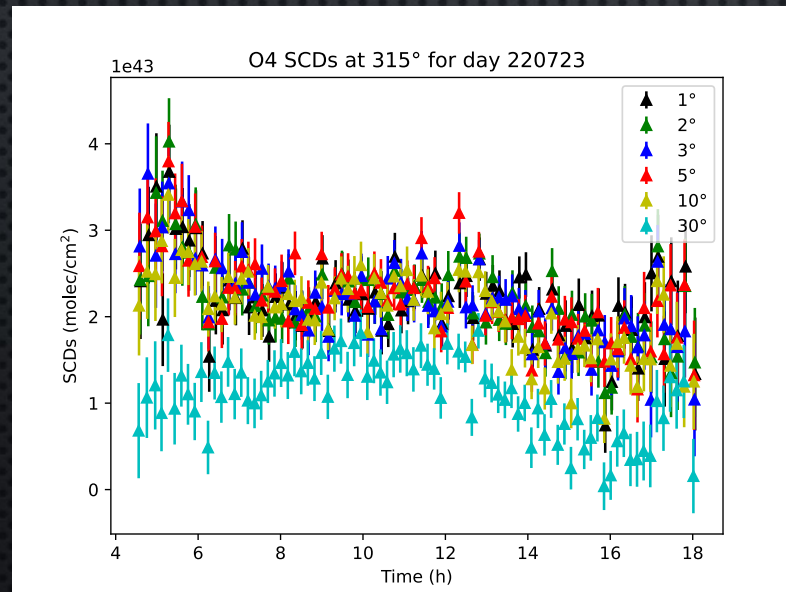
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2250-1: ADAPTATION OF THE DEAP CODE FOR HCHO PROFILES RETRIEVALS

THE DEAP CODE HAS BEEN ADAPTED TO RETRIEVE HCHO INSTEAD OF NO_2 , THE MAIN DIFFERENCES ARE DUE TO THE DIFFERENT SPECTRAL RANGE USED FOR THE ANALYSIS:

VISIBLE IN CASE OF N_2O , ULTRAVIOLET IN CASE OF HCHO

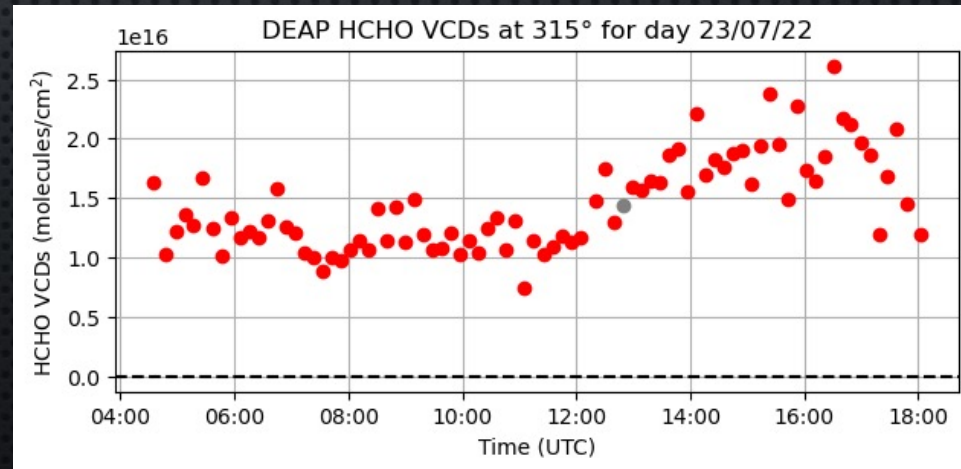
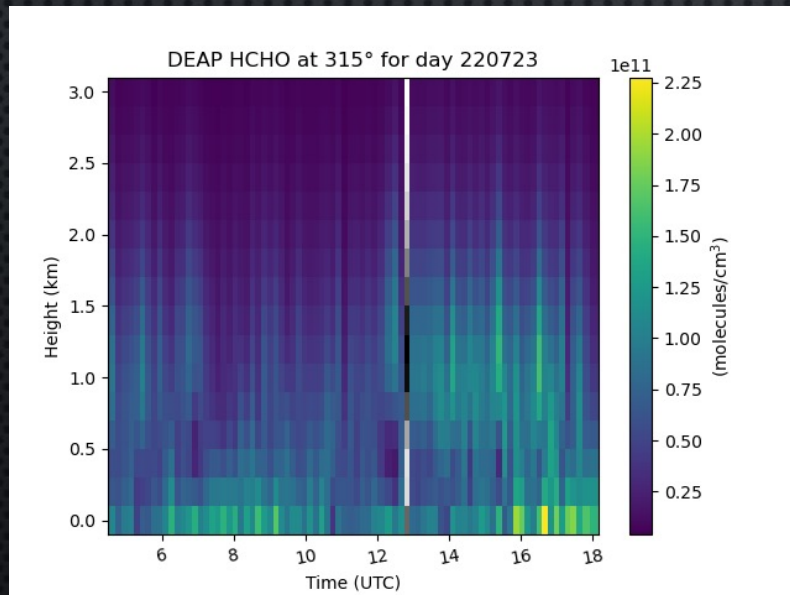
SPC



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2250-2: RETRIEVING HCHO PROFILES AT SPC

THE DEAP CODE HAS BEEN APPLIED TO 1 YEAR OF DATA AT SPC FROM 1 OCTOBER 2021 TO 1 OCTOBER 2022
WITH RESPECT TO NO_2 , HCHO SHOWS HIGH VALUES ALSO ABOVE THE FIRST LEVEL UP TO 1-1.5KM IN AGREEMENT WITH LITERATURE

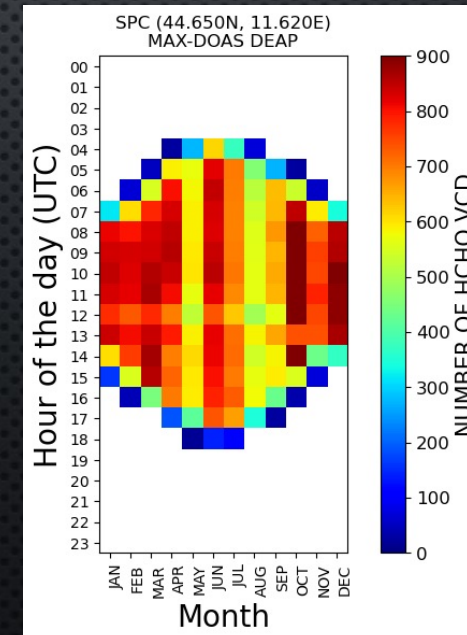
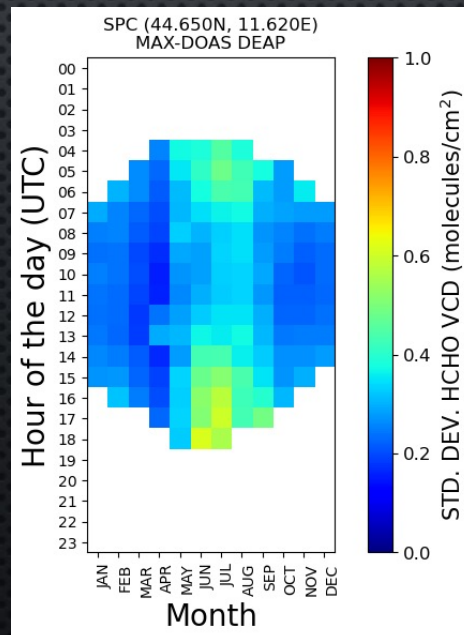
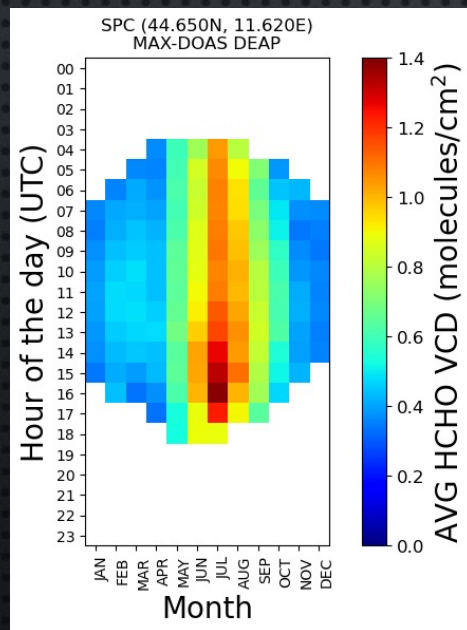


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2250-2: RETRIEVING HCHO PROFILES AT SPC

INTEGRATING THE VERTICAL PROFILES WE CAN OBTAIN THE TROPOSPHERIC HCHO VCDs.

LOOKING AT 1 YEAR OF DATA WE CAN INFER THE SEASONAL BEHAVIOUR WITH HIGHEST VALUES IN SUMMER IN THE AFTERNOON.



WP2250-2251: DOAS-BO

2251-1: INTER-COMPARISON OF HCHO VCDs WITH TROPOMI-5P

WE USED A 20 KM RADIUS AND 15 MINUTES FOR COINCIDENCES.

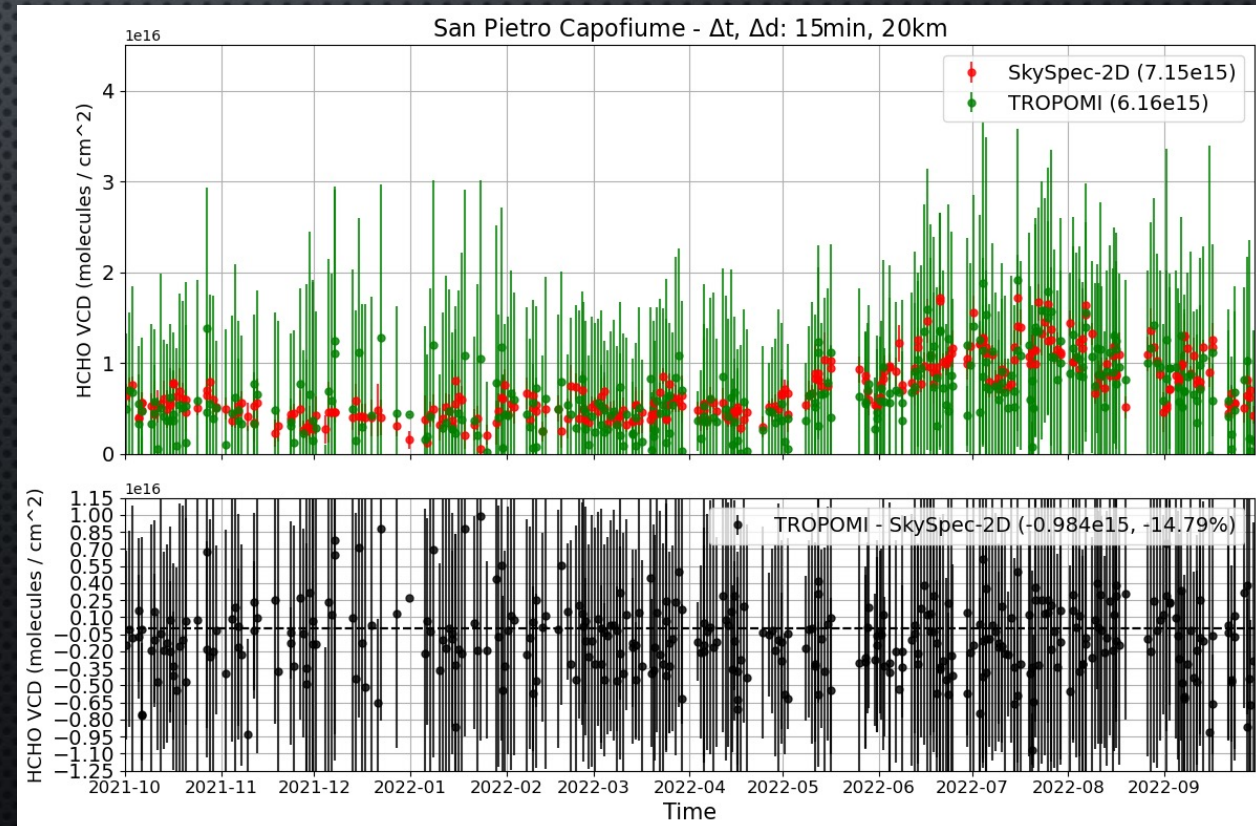
TROPOMI SHOWS A NEGATIVE BIAS WITH RESPECT

TO MAX-DOAS RETRIEVALS OF ABOUT 15%

$1 \text{E}+15 \text{ MOL/CM}^2$

THE OBSERVED NEGATIVE BIAS IS EXPECTED FROM

THE VALIDATION EXERCISE,



WP2250-2251: DOAS-BO

2251-1: INTER-COMPARISON OF HCHO VCDs WITH TROPOMI-5P

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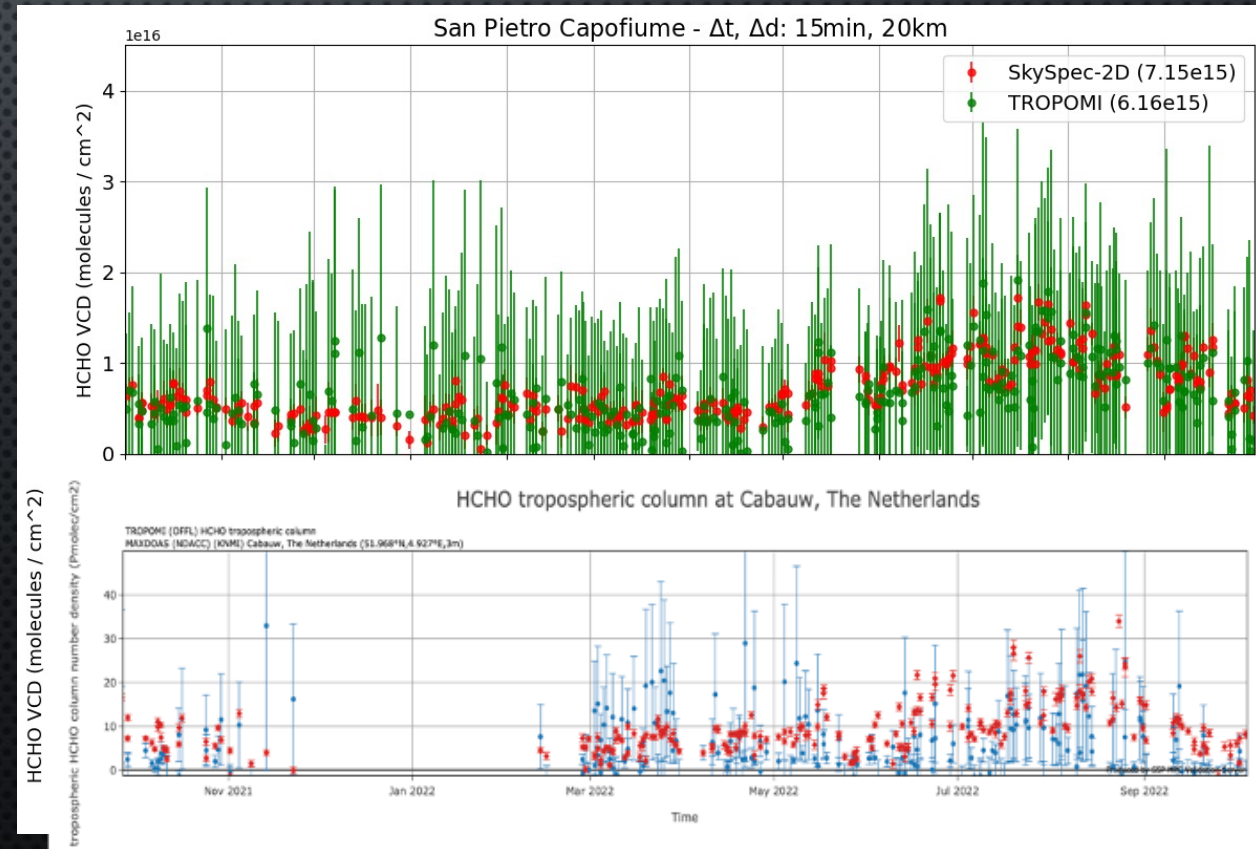
$1 \text{E}+15 \text{ MOL/CM}^2$

THE OBSERVED NEGATIVE BIAS IS EXPECTED FROM

THE VALIDATION EXERCISE, HOWEVER, WE FOUND

A LOWER BIAS WITH RESPECT TO OTHER MAX-DOAS

<https://mpc-vdaf-server.tropomi.eu/hcho/hcho-offl-maxdoas/cabauw>



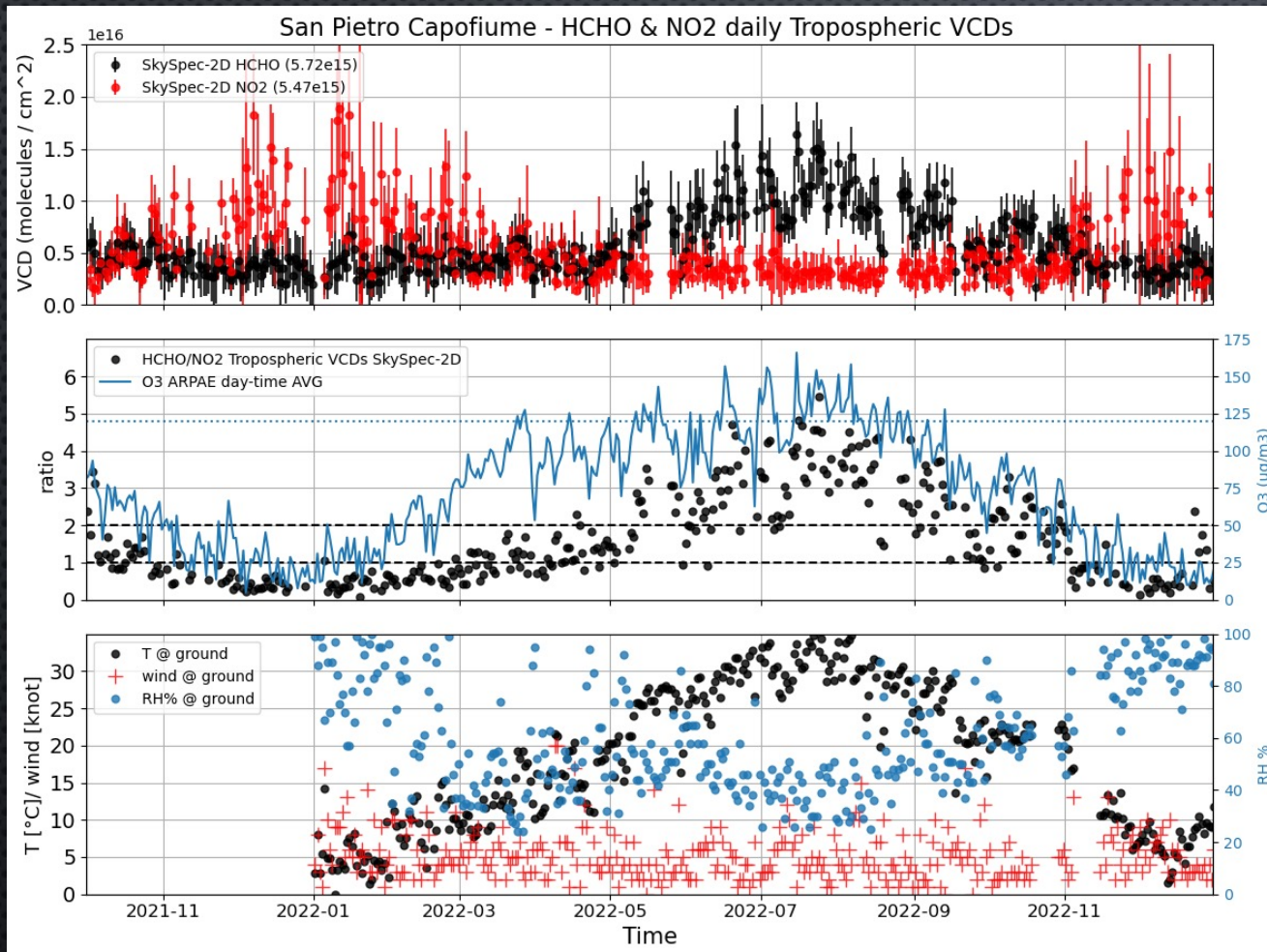
WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃

- SEVERAL PAPERS DEMONSTRATED THE CAPABILITY OF SATELLITE AND MAX-DOAS GROUND-BASED MEASUREMENTS TO DISCUSS THE VOC/NO_x REGIME IN RELATIONS TO O₃ FORMATION IN POLLUTION CONDITIONS. VOC SENSITIVE REGIMES ARE REPRESENTED BY HCHO/NO₂ RATIO LESS THAN 1 WHILE VALUES GREATER THAN 2 INDICATE A NO_x SENSITIVE REGIME.
- FOR THIS TASK WE EXPLOITED HOURLY AVERAGED ARPAE O₃ IN SITU DATA MEASURED AT SPC FROM ([HTTPS://DATI.ARPAE.IT/DATASET/QUALITA-DELL-ARIA-RETE-DI-MONITORAGGIO/RESOURCE/7EFD47BC-31E3-4F7D-BCA4-E1B01F80A304](https://dati.arpae.it/dataset/qualita-dell-aria-rete-di-monitoraggio/resource/7efd47bc-31e3-4f7d-bca4-e1b01f80a304))
- THE LIMIT FOR 8 HOURS O₃ AVG IS 120 UG/M₃
- WE PRODUCE A DAILY AVERAGE OF THESE DATA CONSIDERING THE TIME FRAME BETWEEN 10:00 AND 18:00
- THE SAME TIME FRAME HAS BEEN USED TO AVERAGE THE HCHO AND NO₂ DATA
- WE ALSO USED THE TEMPERATURE AND RH AT GROUND (12 M A.S.L) AS EXTRACTED FROM SPC RADIOSOUNDINGS AT 12:00 UTC ([HTTPS://WEATHER.UWYO.EDU/UPPERAIR/SOUNDING.HTML](https://weather.uwyo.edu/upperair/sounding.html)) FOR 2022 AS CORRELATIVE INFORMATIONS.

WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃



Correlation between HCHO/NO₂ ratio and O₃ apart from spring (possibly due to transport events)

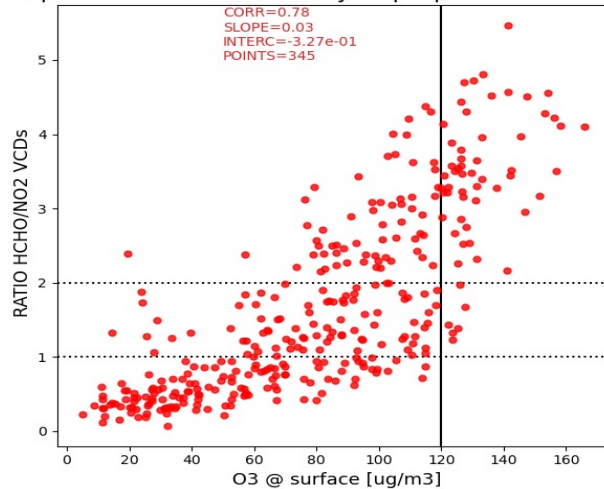
O₃ over the 120 ug/m³ limit in some days during summer

Correlation between O₃ and Temperature
anti correlation with water vapour

WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃

San Pietro Capofiume - HCHO/NO₂ daily Tropospheric VCDs vs O₃ at surface

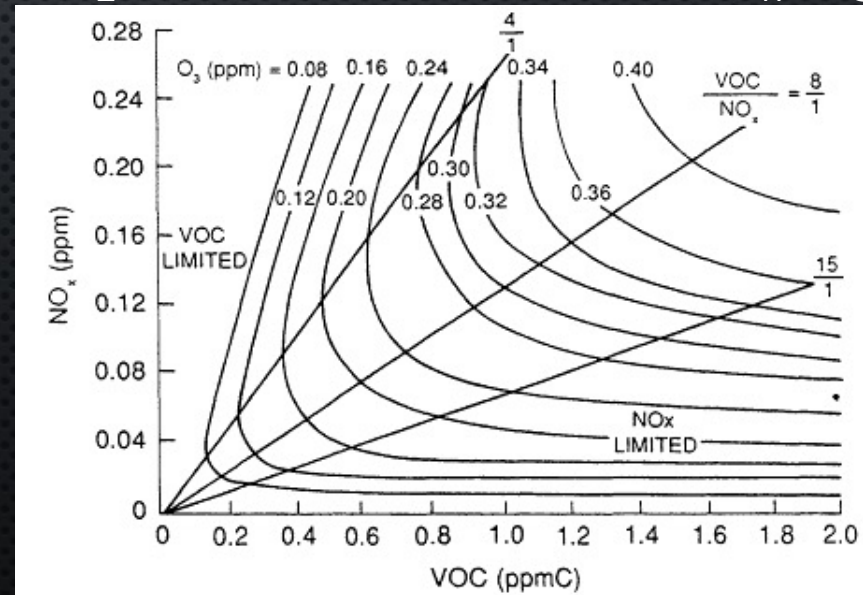
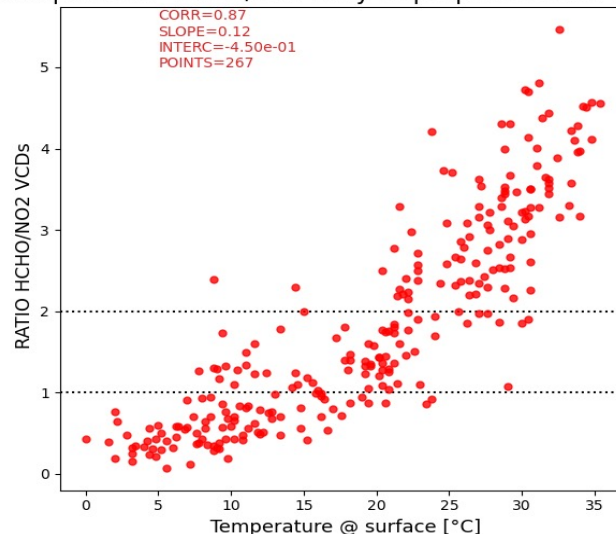


O₃ values above 120 $\mu\text{g}/\text{m}^3$ mainly corresponds to HCHO/NO₂ ratio above 2 \rightarrow NO_x limited regime

Correlation between HCHO/NO₂ ratio and Temperature anti correlation with water vapour

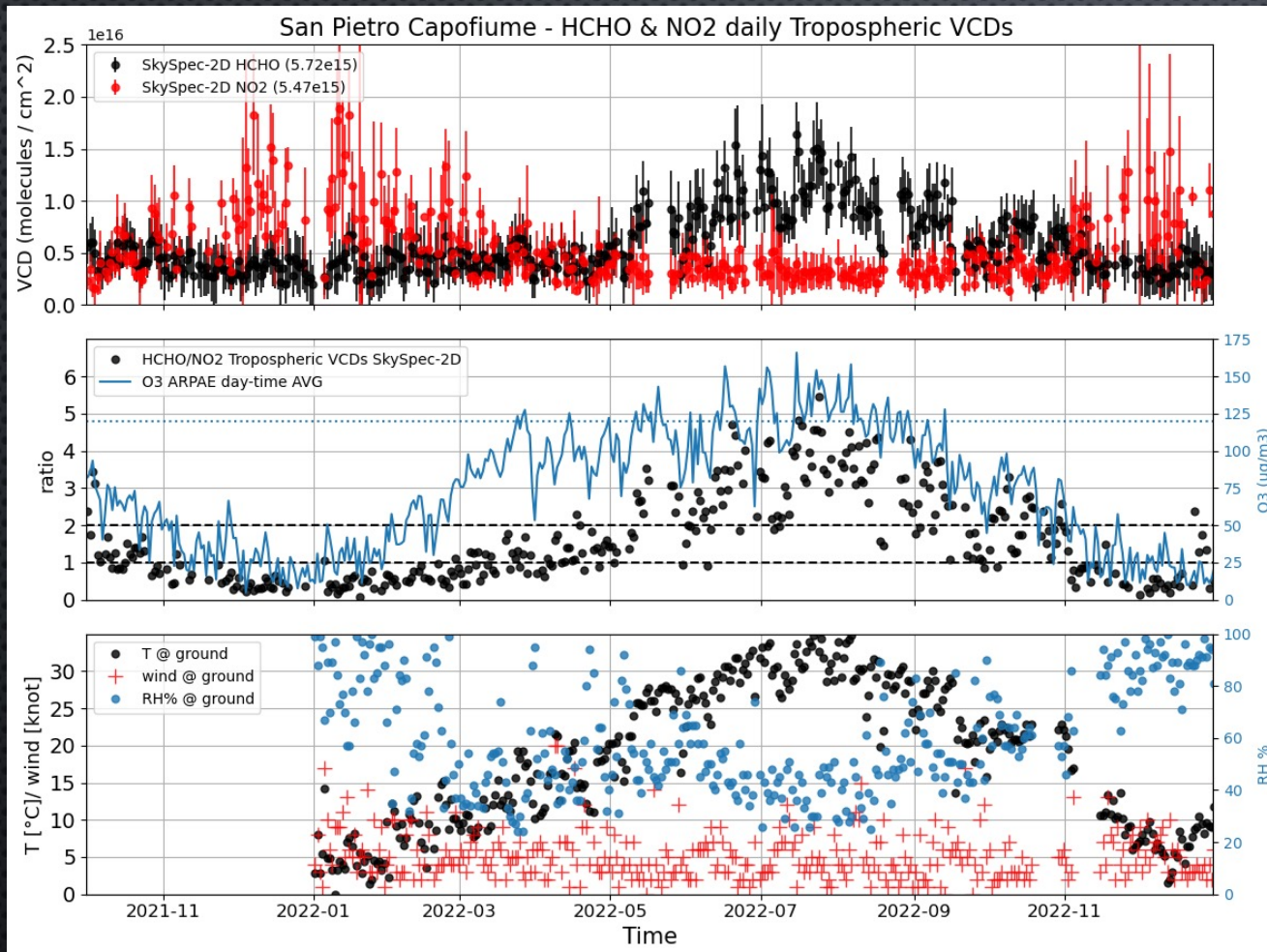
High temperature values are mainly correlated to HCHO/NO₂ ratio above 2 thus to NO_x regime

San Pietro Capofiume - HCHO/NO₂ daily Tropospheric VCDs vs T at surface



WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃

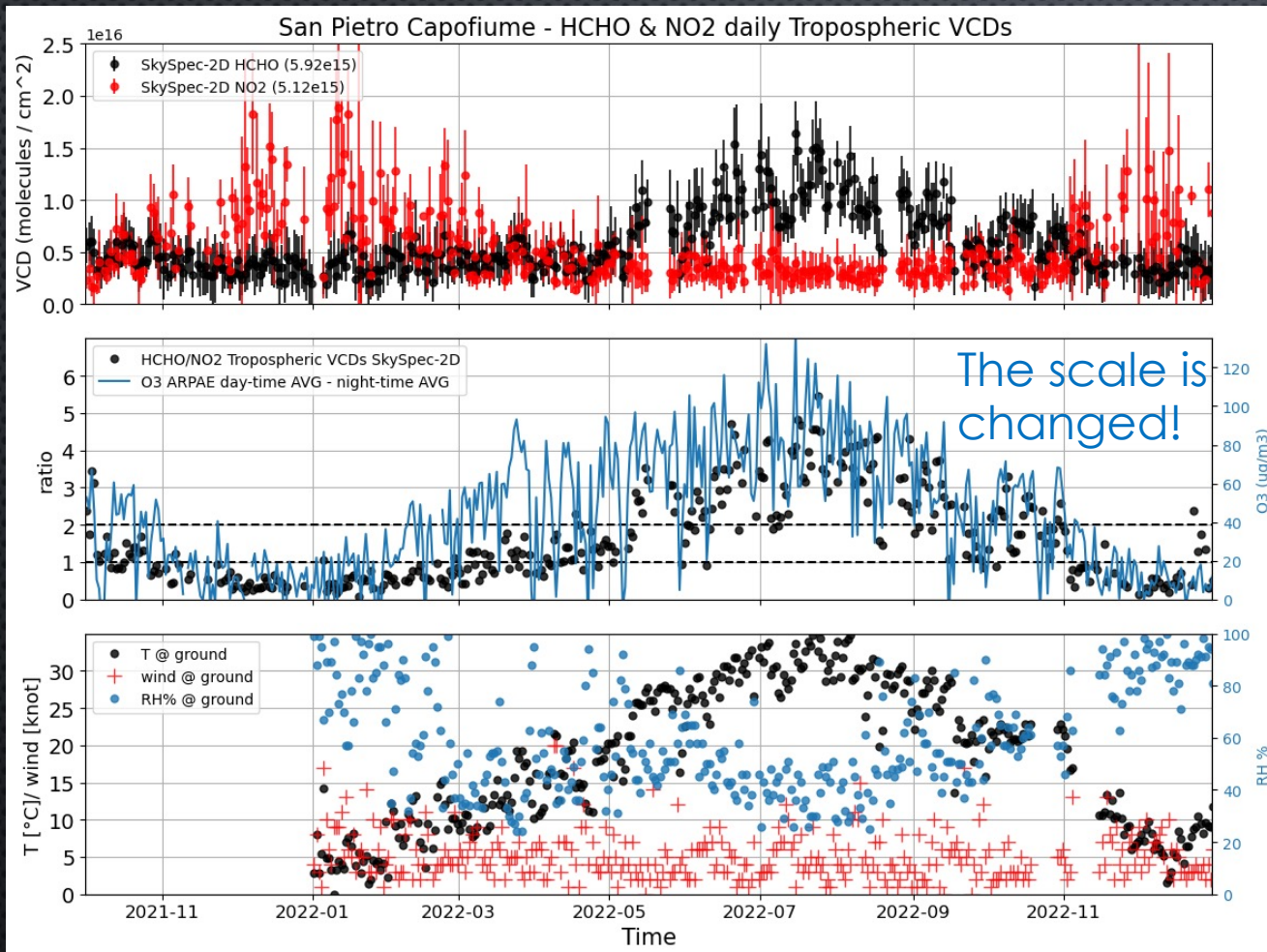


Correlation between HCHO/NO₂ ratio and O₃ apart from spring (possibly due to transport events)

To decouple transport from production of O₃ one option is to use the difference between day and night O₃

WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃



Correlation between HCHO/NO₂ ratio and O₃ apart from spring (possibly due to transport events)

To decouple transport from production of O₃ one option is to use the difference between day and night O₃

Some high values in spring disappear while some others are still present

WP2250-2251: DOAS-BO

2250-3: STUDY OF THE CORRELATIONS BETWEEN TROPOSPHERIC HCHO/NO₂ AND O₃

- HCHO/NO₂ RATIO FROM MAX-DOAS MEASUREMENT IN SPC CAN BE USED TO STUDY THE PROCESSES RELATED TO O₃ FORMATION AND POLLUTION AT GROUND.
- THE HCHO/NO₂ RATIO CORRELATES WELL WITH O₃ AT GROUND AND WITH Δ O₃ AT GROUND WITH AN INDICATION OF SOME TRANSPORT OF O₃ POLLUTED AIR MASSES IN SPRING. AT SPC WE ARE IN PRESENCE OF A NO_x LIMITED (OR SENSITIVE) REGIME.
- FURTHER INVESTIGATIONS ARE REQUIRED TO UNDERSTAND THE ENTITY OF TRANSPORT OF AIR MASSES ON O₃ VALUES. IN ADDITION, REMOVING THE SEASONALITY FROM THE DATA CAN BETTER EVIDENCE CORRELATIONS IN SOME SPECIFIC CASES.
- UNFORTUNATELY, NO CO MEASUREMENT AT GROUND IS AVAILABLE AT SPC THUS IT IS NOT POSSIBLE TO DISTINGUISH BETWEEN PRIMARY AND SECONDARY SOURCES OF THE O₃ PRODUCTION.

WP2250-2251: DOAS-BO: CONCLUSIONS

WORK DONE

ACTIVITIES AT SPC

WP 2250-1: SET UP OF THE DEAP CODE FOR HCHO RETRIEVAL

WP 2250-2: ANALYSIS OF MAX-DOAS SPC DATA FOR HCHO

WP 2251-1: VALIDATION AGAINST TROPOMI

WP 2250-3: INVESTIGATION OF HCHO/NO₂ RATIO VS O₃ POLLUTION

D1 AND D2A DELIVERED, D3 IN PREPARATION

NEXT STEPS

ACTIVITIES AT RTV

- WP 2250-4
- WP 2251-2

WP2250-2251: DOAS-BO: CONCLUSIONS

FUTURE WORK

PRODUCTS IMPROVEMENTS: Use of the NO₂ TROPOSPHERIC PROFILES CALCULATED WITH THE DEAP CODE TO IMPROVE THE AMF FOR THE NO₂ TOTAL COLUMN CALCULATIONS / VALIDATION WITH TROPOMI AND COMPARISONS WITH THE PREVIOUS VERSION

SCIENTIFIC EXPLOITATION: STUDY OF THE FEASIBILITY OF USING POINTING SCAN SEQUENCE TO INVESTIGATE AEROSOL EXTINCTION

