Universität Bremen

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Fachbereich 01

Effects of surface reflectivity inhomogeneities on stratospheric ozone retrieval from limb scattering observations

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esa European Space Agency

NASA Goddard SPACE FLIGHT CENTER

Outline

1. Detection of an artefact in tropical Pacific ozone in limb retrievals
2. Investigating possible causes of the artefact
3. Role of a surface reflectivity inhomogeneity along the line of sight
4. Effects on radiance
5. Outlook: the ENFORCE project

1 Detection of the artefact

- Instrument: Ozone Mapper and Profile Suite - Limb Profiler (OMPS-LP);
- Data: ozone profiles retrieved at the University of Bremen;
- Radiative transfer model: SCIATRAN, assuming homogeneous atmospheric condition along the satellite line of sight (LOS)

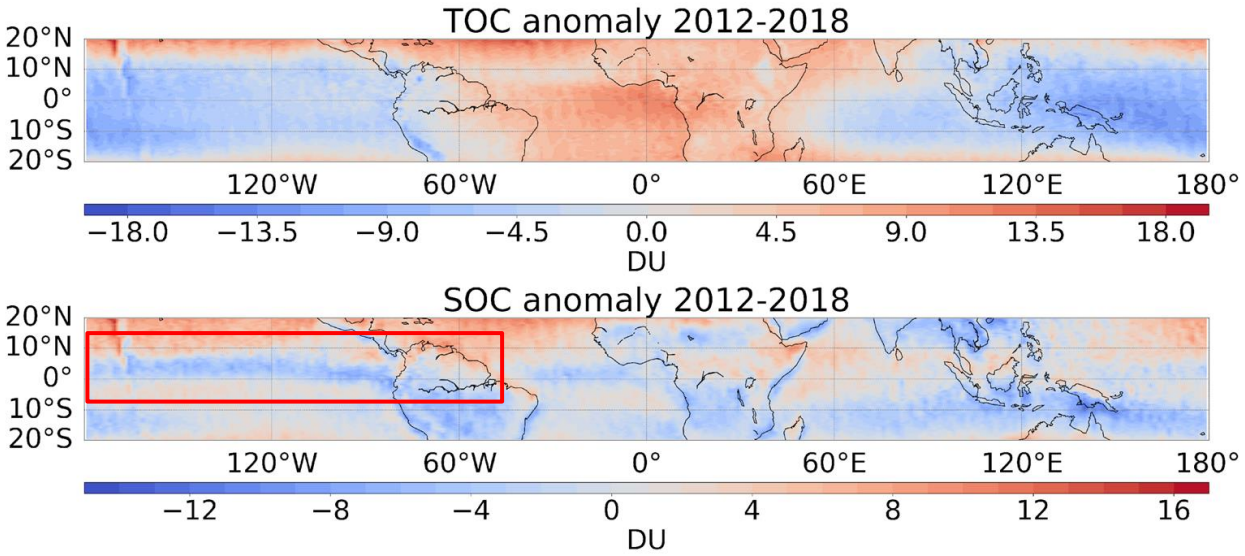
Total ozone column (TOC):

- fairly homogeneous field

Stratospheric ozone column (SOC):

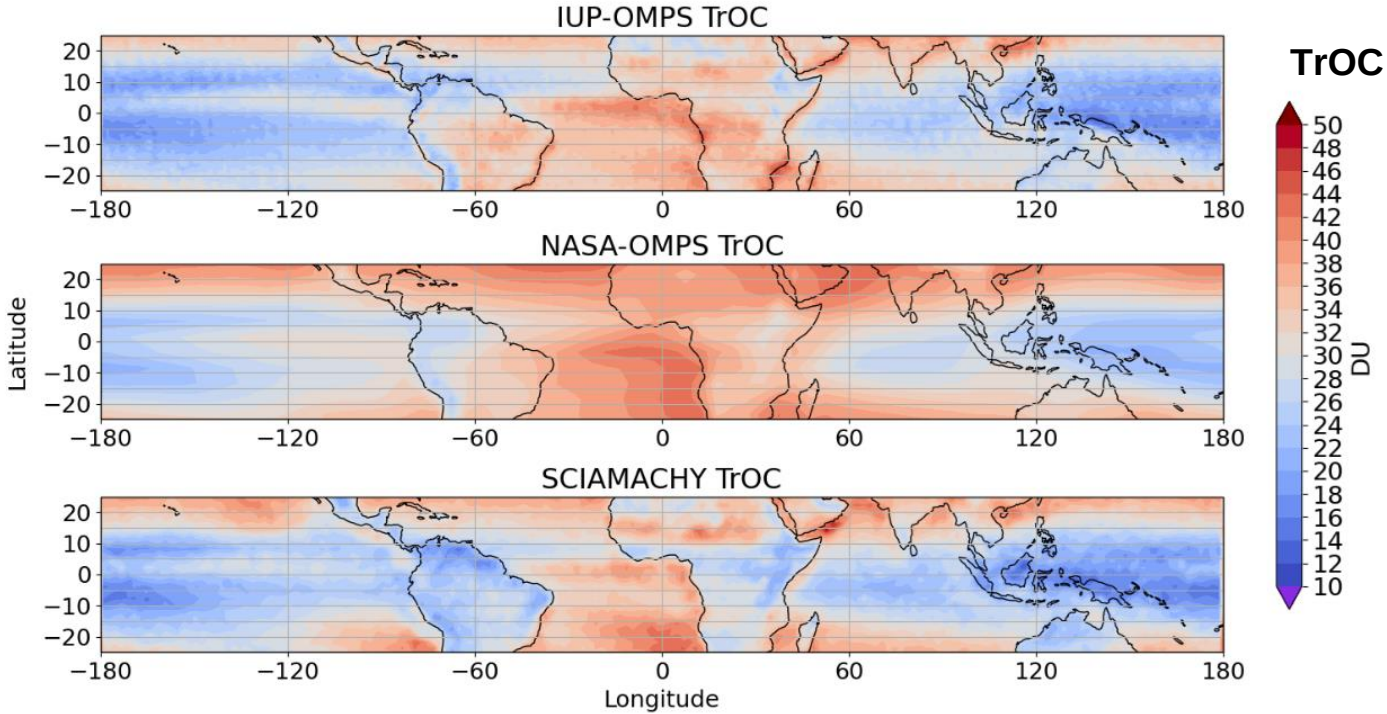
- anomalous ozone values detected in the tropical region.

The band-shaped artefact lies around 5° N and stretches across the Pacific.



Detection of the artefact

It is evident in the tropospheric ozone column (TrOC) field and it affects several UV-Vis products:



- TrOC obtained as residual between total column (TOC) and SOC;
- Negative artefact in SOC ⇒ Positive anomaly in TrOC in the tropical Pacific and Atlantic;
- Artefact present also in SCIAMACHY data.

Detection of the artefact

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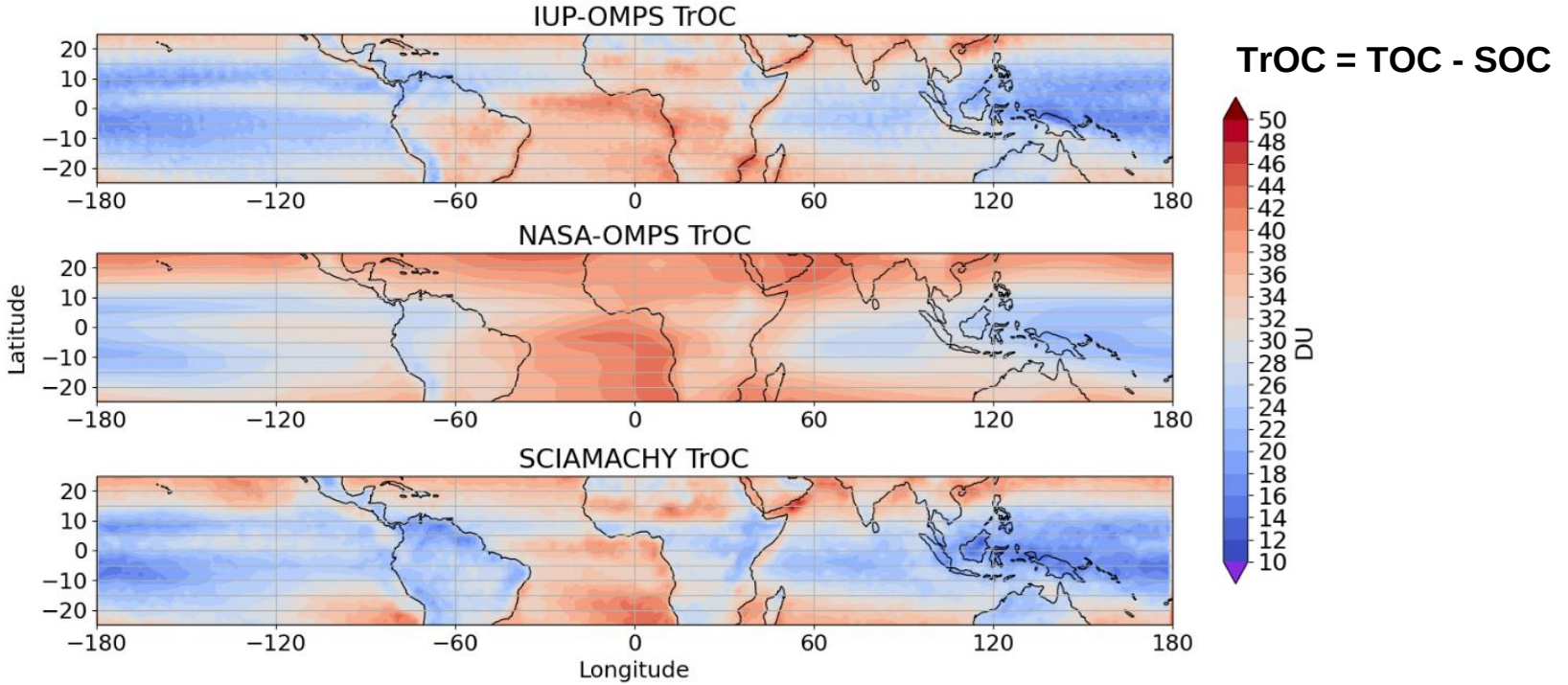
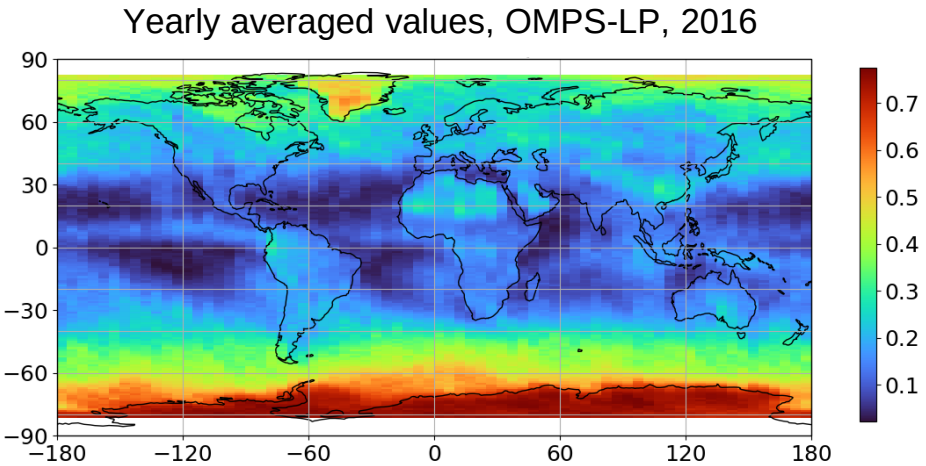


This artefact has a relevant impact on the TrOC product quality (on the order of 10% of typical TrOC)

Ozone anomaly - possible causes

VIS reflectivity

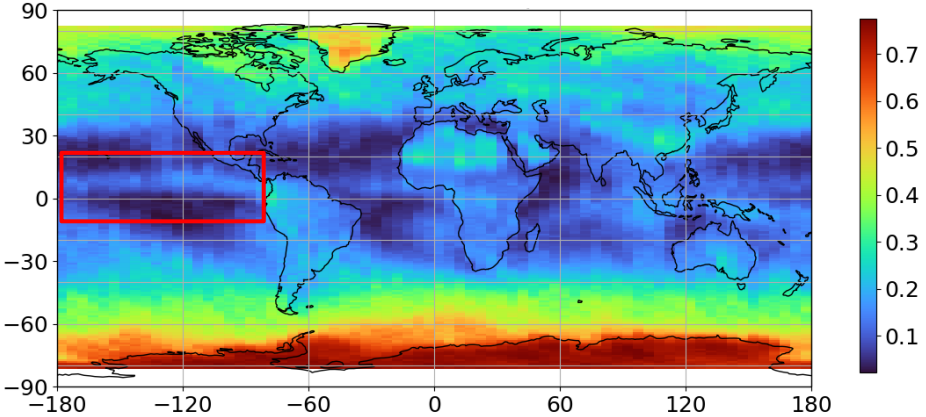


Stream of higher surface reflectivity values in the Pacific N of the equator

Ozone anomaly - possible causes

Yearly averaged values, OMPS-LP, 2016

VIS reflectivity



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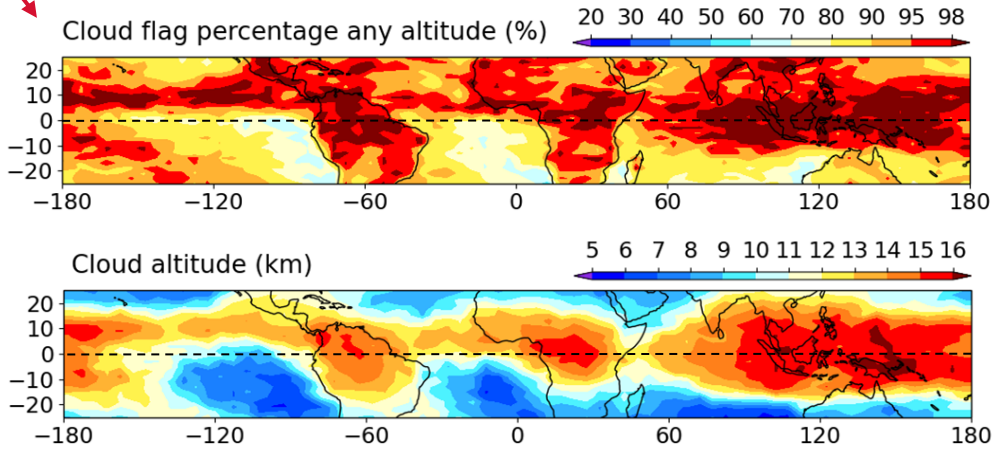
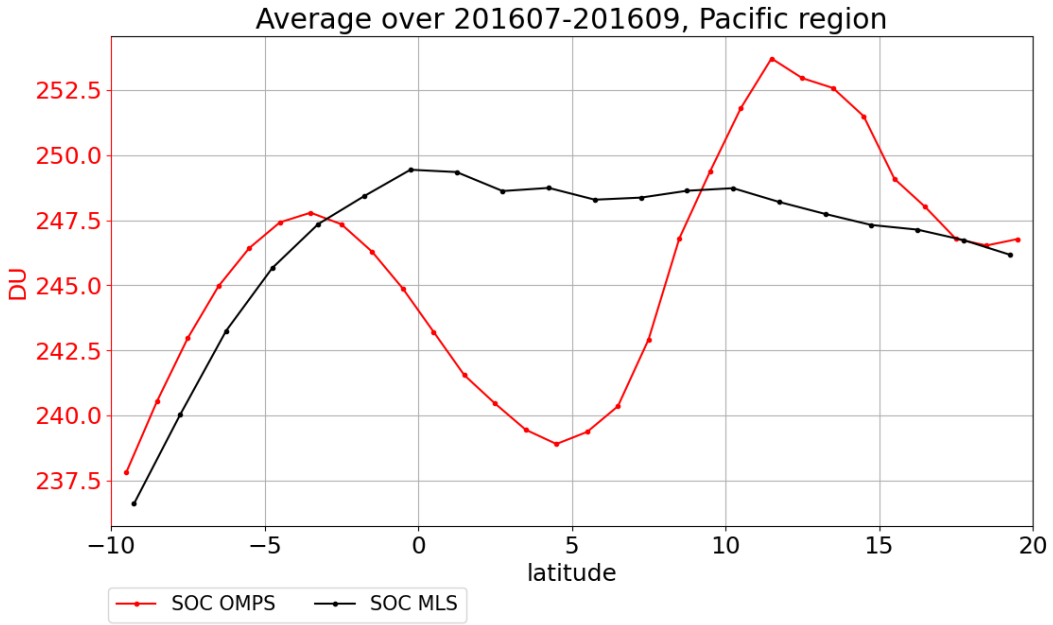


Cloud information from limb flagging:

In the tropical Pacific region frequent presence of clouds, with a sharp gradient across the equator

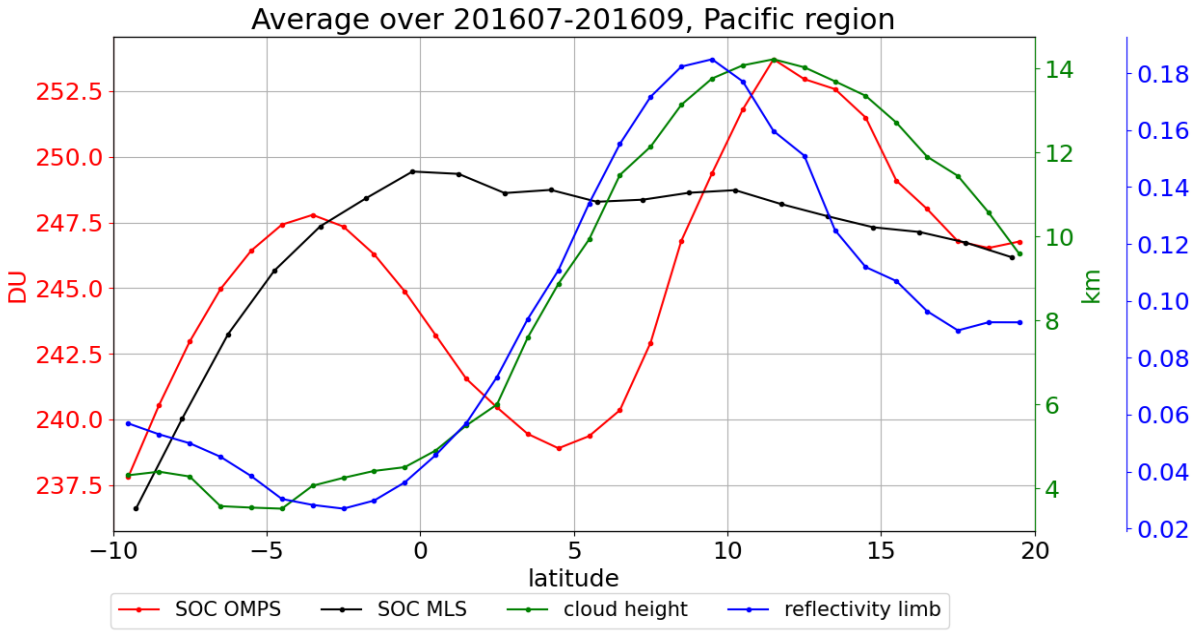
⇒ InterTropical Convergence Zone (**ITCZ**)

2 Ozone anomaly - possible causes



Comparison of OMPS-LP and MLS stratospheric column, averaged over the Pacific region as a function of latitude.

2 Ozone anomaly - possible causes



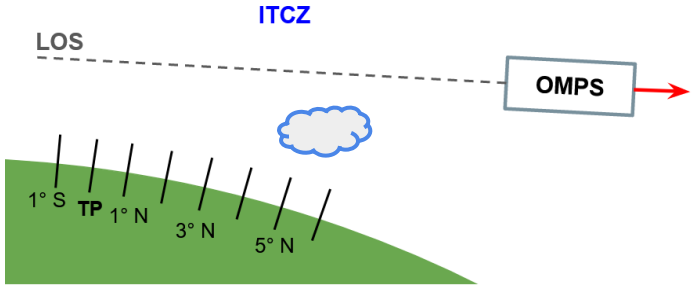
Comparison of OMPS-LP and MLS stratospheric column, averaged over the Pacific region as a function of latitude.

Superimposed:
cloud height and surface reflectivity

Dip in OMPS-LP SOC located to the South of the peak in reflectivity and cloud height:
⇒ Artefact directly related to the presence of a cloud to the North of the tangent point (TP).

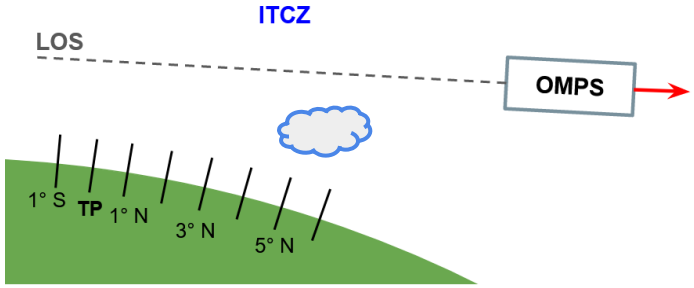
Explore how this artefact depends on the distance from a high reflectivity scene

3 Dependency on cloud distance



Typical observation geometry, with OMPS LOS crossing a high reflectivity cloud band.

3 Dependency on cloud distance



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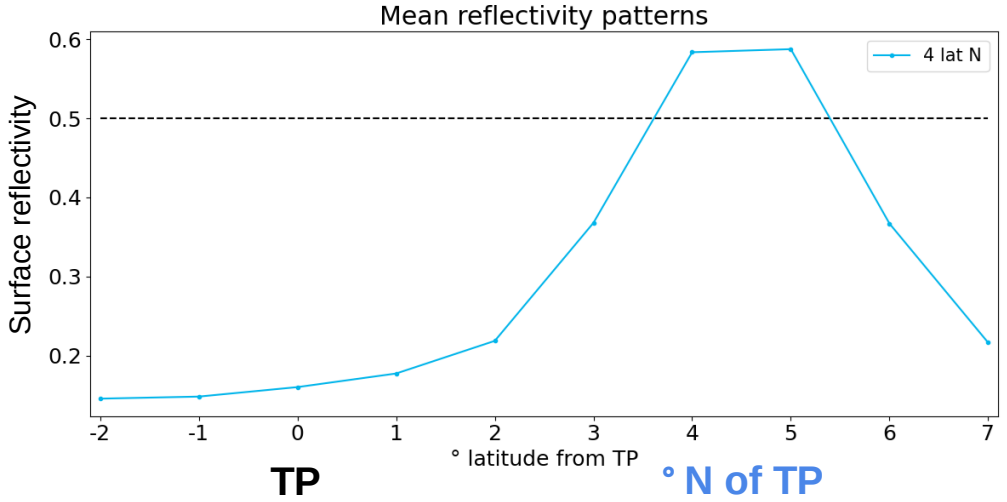
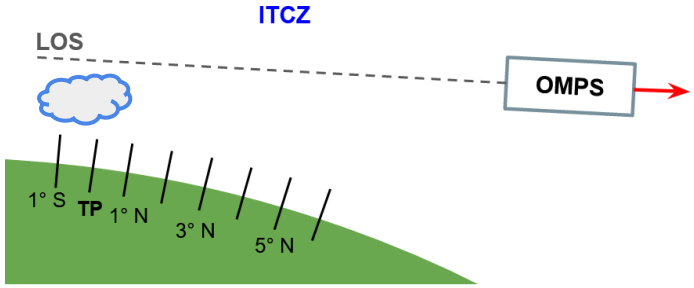


Compare the (380 nm) OMPS nadir reflectivity
@ OMPS-LP TP vs **@ x° lat from TP**

Classify profiles according to the surface reflectivity pattern.

3 Dependency on cloud distance



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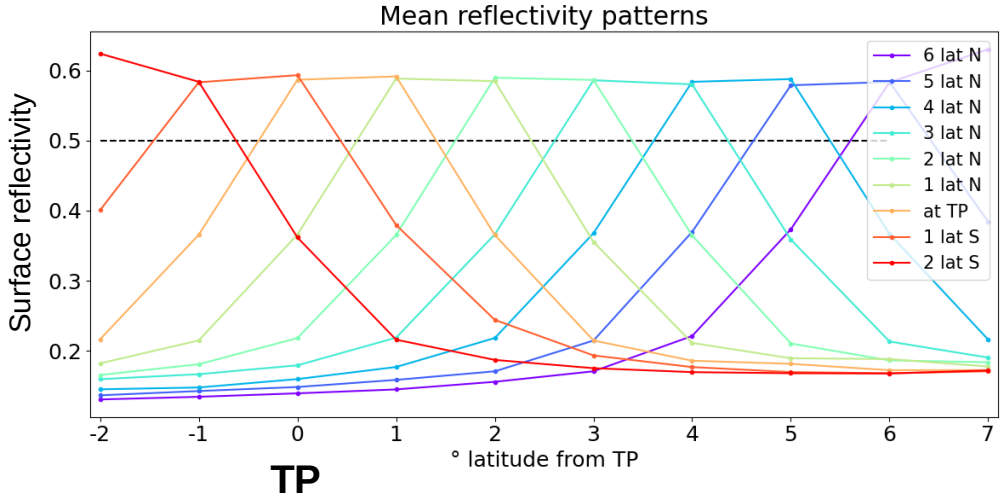
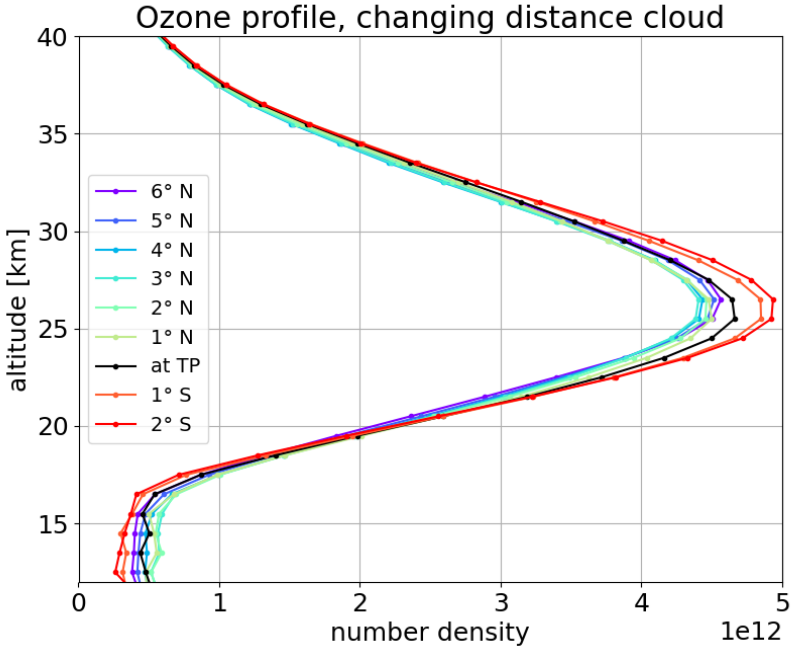
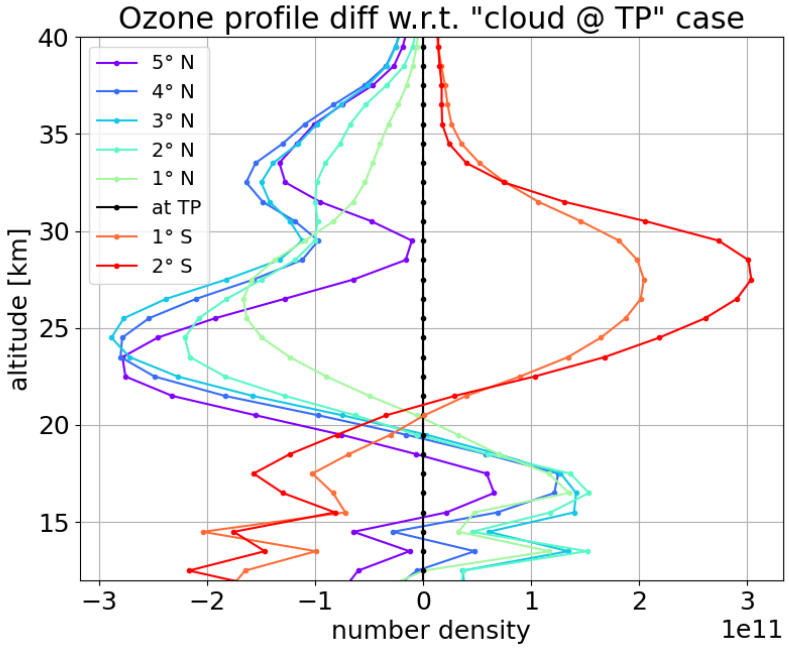


Eight year of OMPS data used, in July-Sept period, Pacific sector, [5° S, 20° N] window.

Check if reflectivity is higher than 0.5 in 2 consecutive bins starting from 6° N of TP down to to 2° S.
The classification is repeated by shifting the reflectivity requirement towards and across the TP location.

3 Dependency on cloud distance

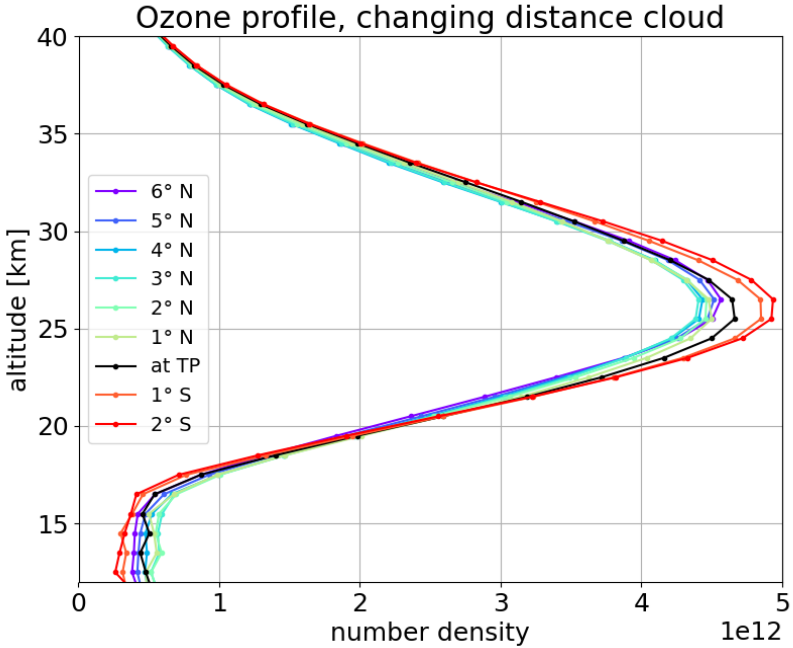


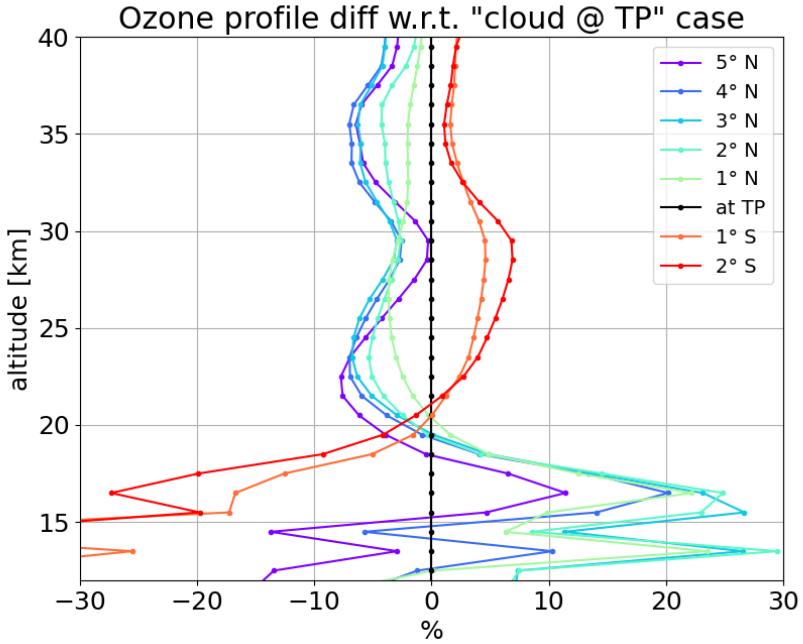


Sharp transition between the averaged profiles according to the position of the cloud (to the South or to the North of the TP).

Differences in ozone profiles w.r.t. the case with cloud @ TP.
The dependency is clear, values corresponding to about 5-10 % difference between 20 and 35 km.

3 Dependency on cloud distance





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Differences in ozone profiles w.r.t. the case with cloud @ TP.
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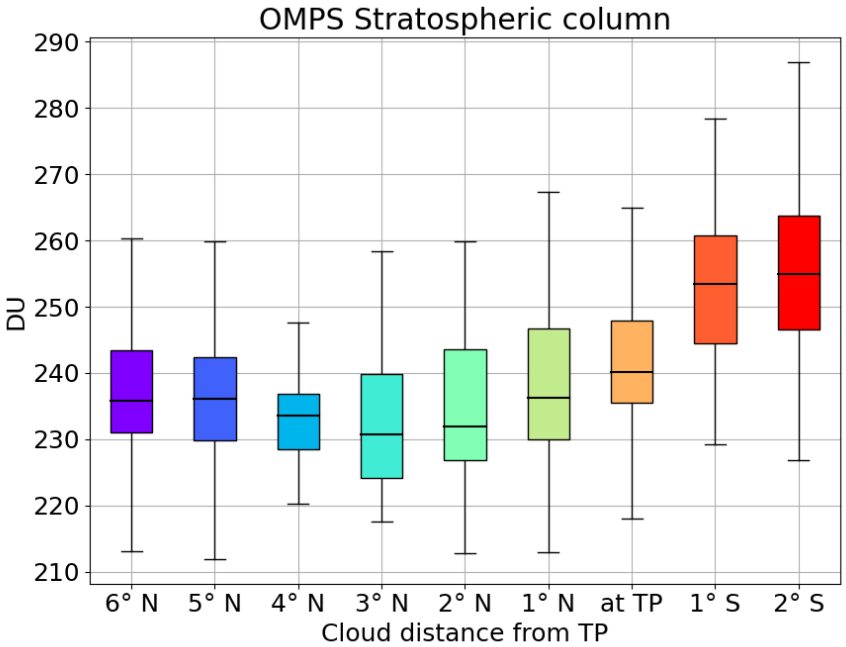
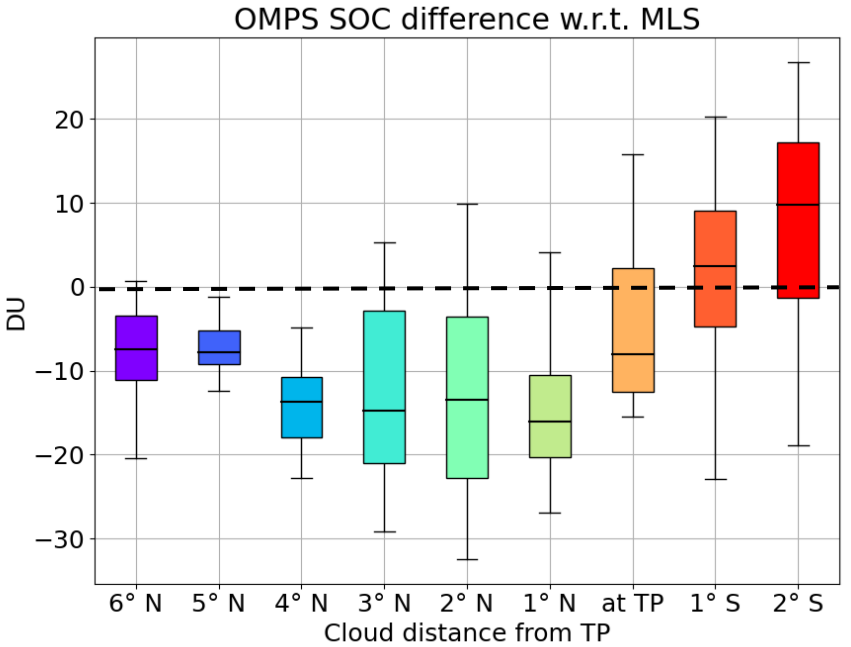
Dependency on cloud distance

Effects of the ozone artefact in terms of SOC:

- Largest negative dip for class of data with a high reflectivity values located 2° N of the TP;
- The impact on SOC is about 10 DU, which corresponds in magnitude to the artefact in TrOC and SOC.

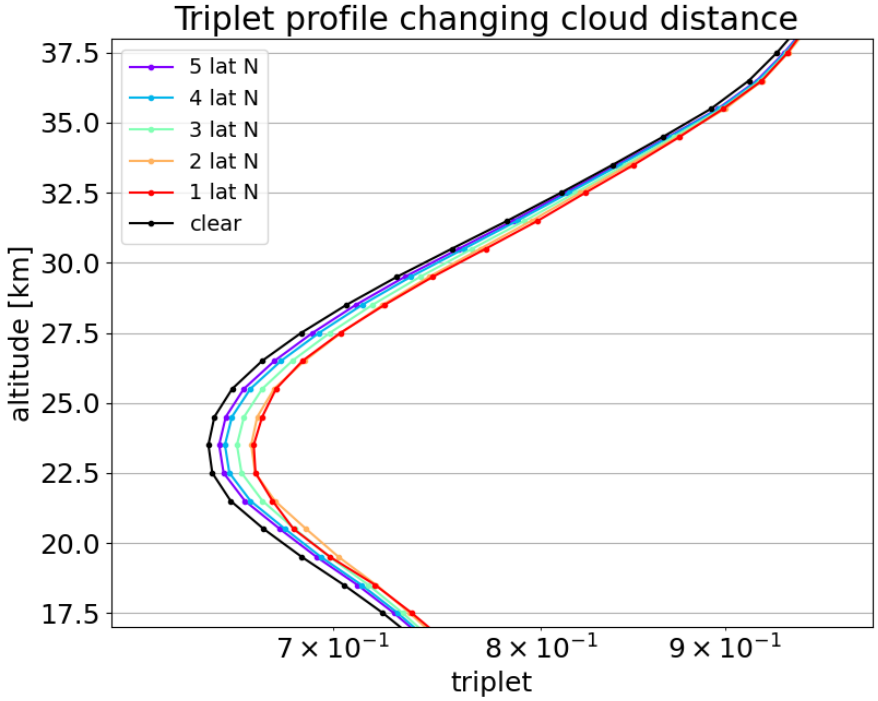


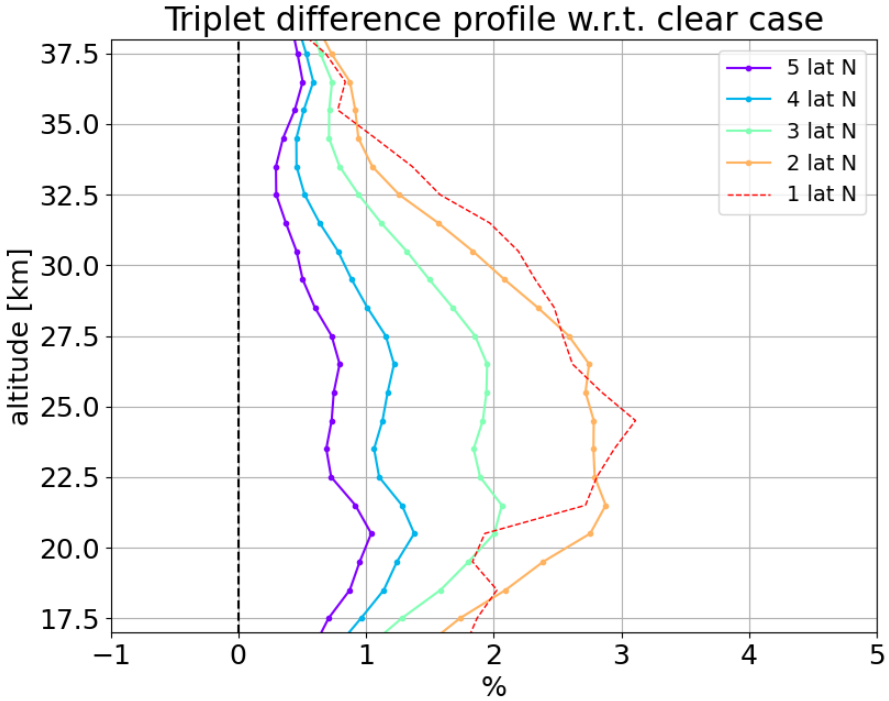


Effects on radiance

How does the triplet vector changes as a function of cloud distance?

Triplet = $\frac{I_{\lambda=600\,nm}}{I^{w1}_{\lambda=510\,nm} * I^{w2}_{\lambda=675\,nm}}$





For the triplet we see a clear change between 20 and 30 km when the cloud approaches the TP.

5 Outlook

Effect of I**n**homogeneities in the Sur**f**ace Reflectivity on Tropo**o**spheric Ozone Columns **R**etrieved by Using the Limb-Nadir Mat**c**hing T**e**chnique (ENFORCE)

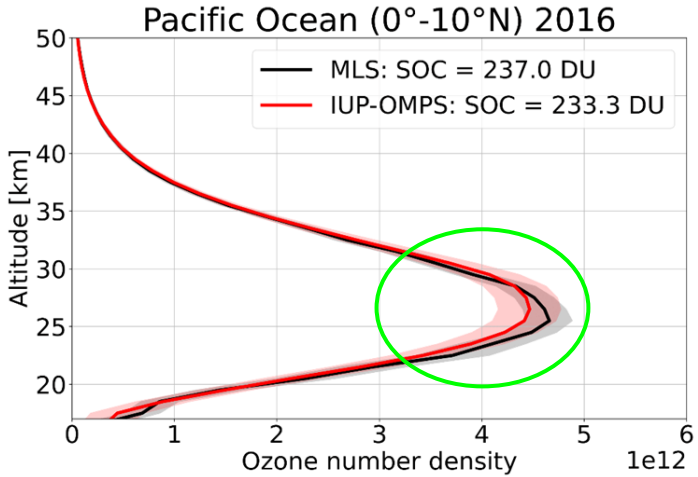
It is a 18-months project funded by ESA to tackle this artefact.

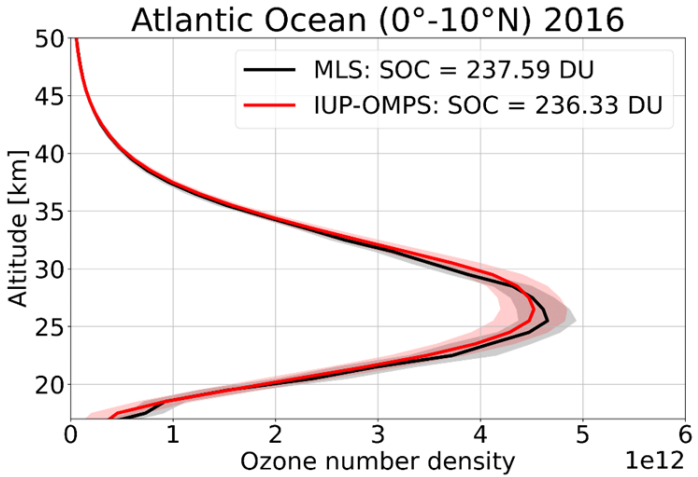
Main steps:

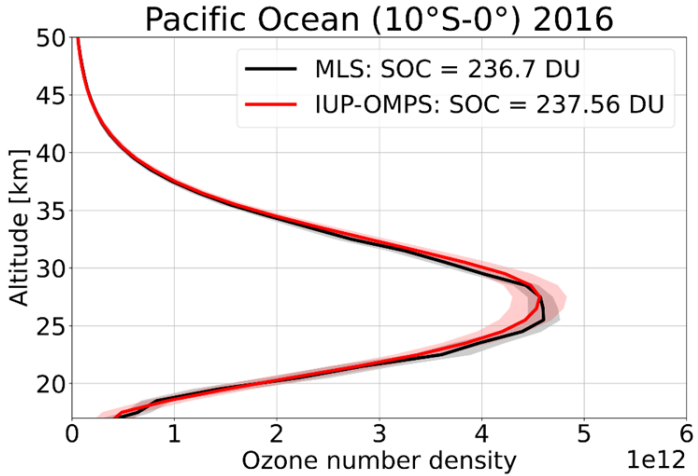
- Extension of the SCIATRAN radiative transfer model (RTM) to take into account variations of atmospheric and surface properties along the LOS;
- Adaptation of the retrieval algorithm, process a subset of data and assessment of the data quality;
  - In case implement a vicarious correction on L2 data.
- Production and validation of the stratospheric ozone and of the tropospheric ozone product.
- Check differences w.r.t. the standard retrieval also in other cases, such as land-ocean boundaries.

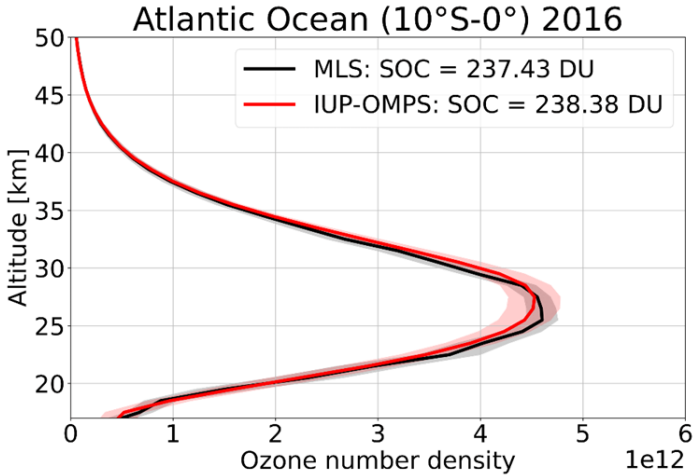
Backup slides

1 Detection of the artefact









Comparison with collocated MLS profiles in the Pacific and Atlantic region

Lower values at the ozone number density peak and larger spread in OMPS-LP profiles

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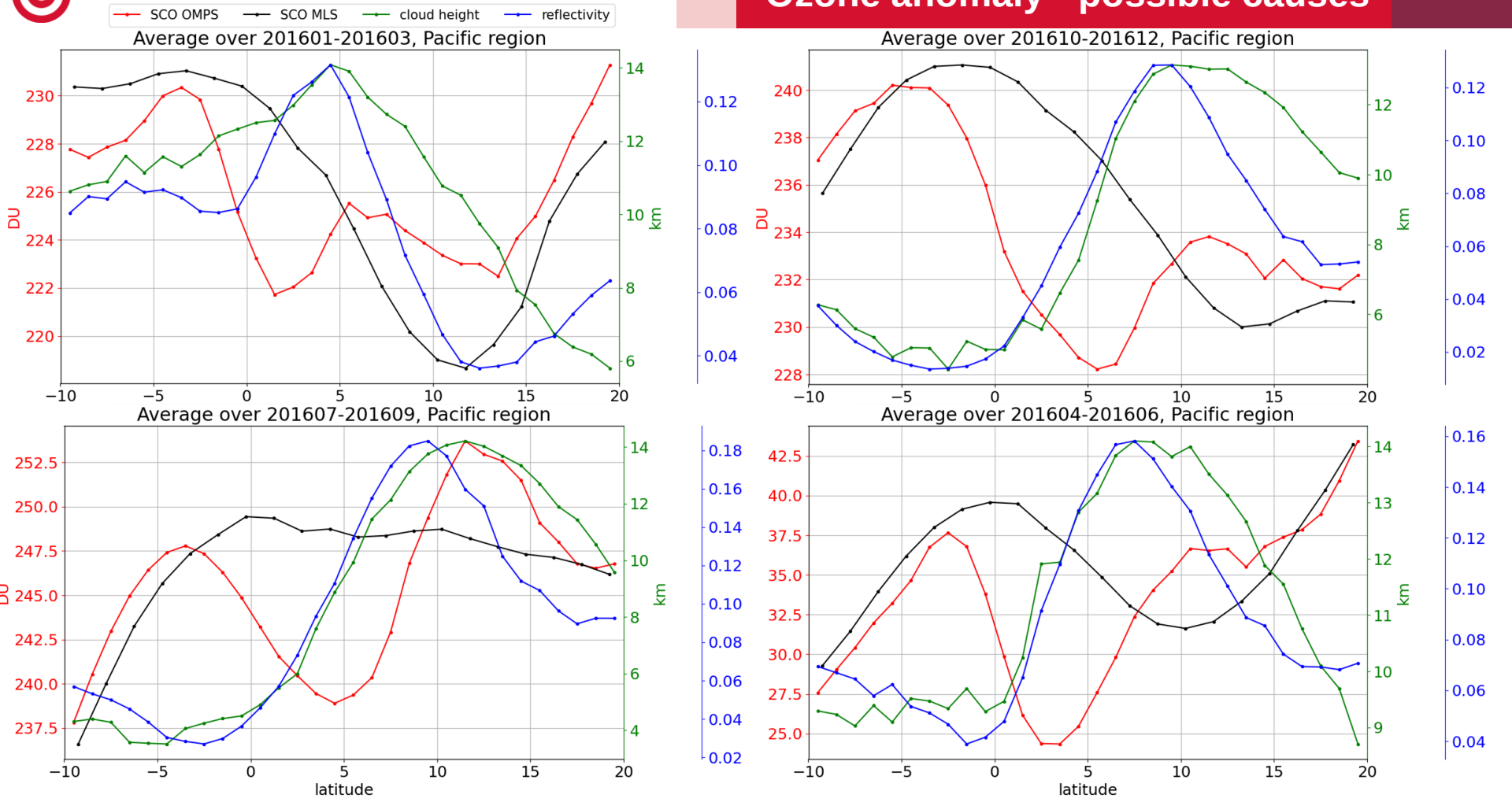
Ozone anomaly - possible causes



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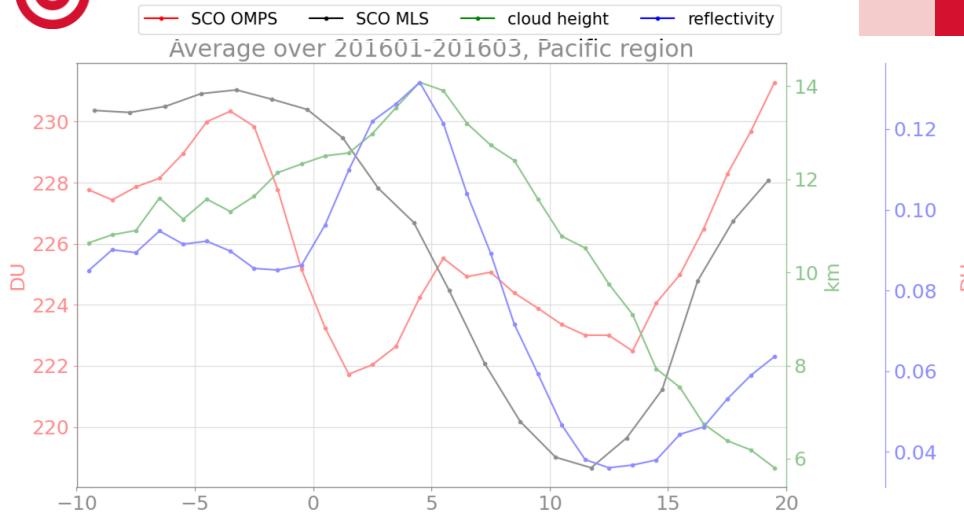

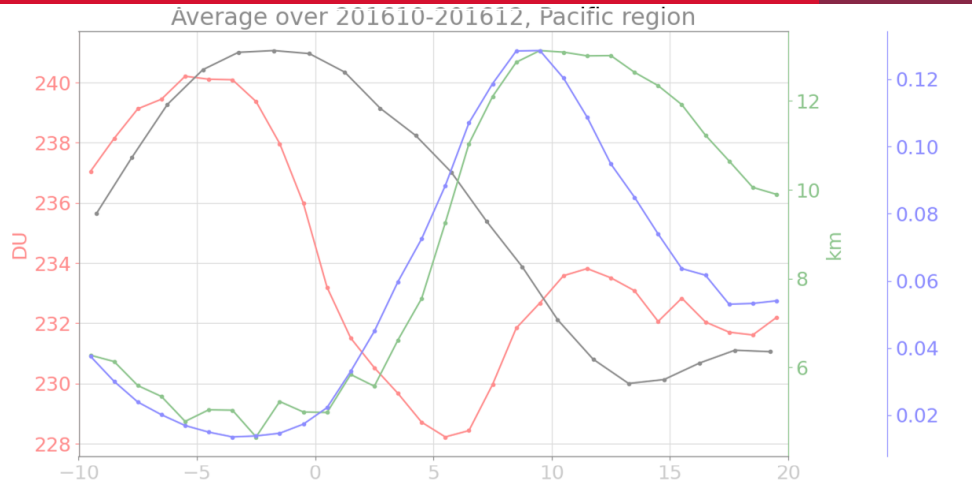

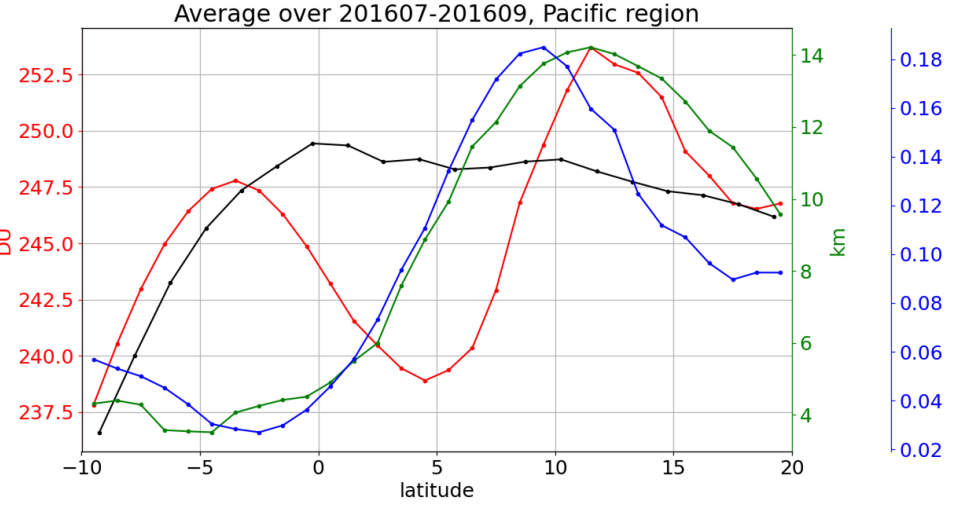

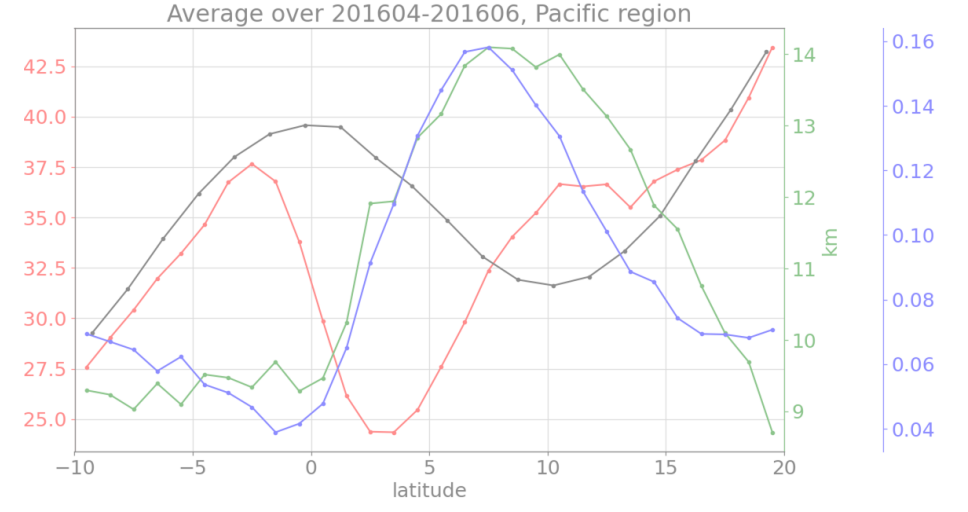

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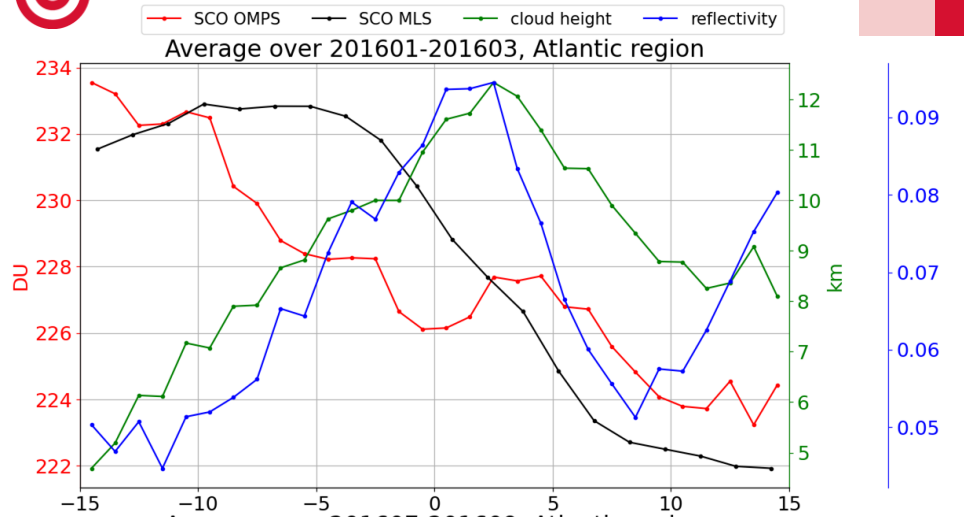
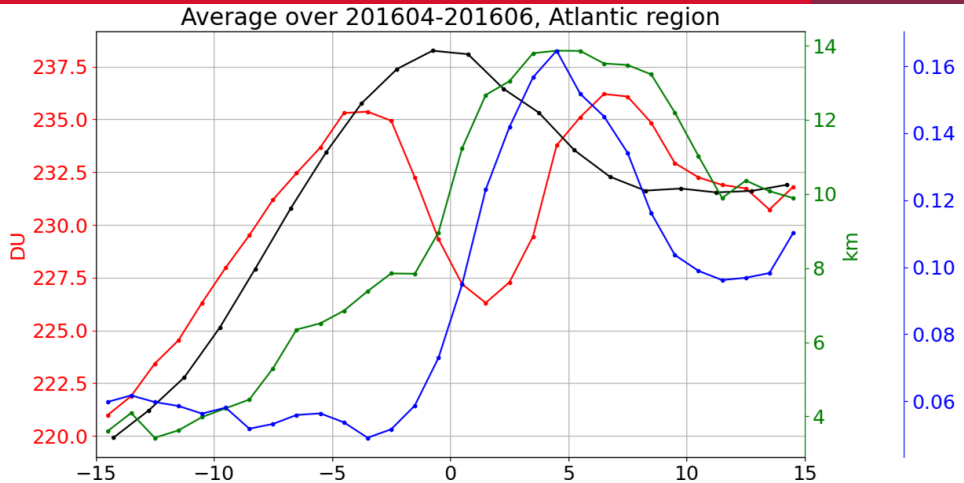
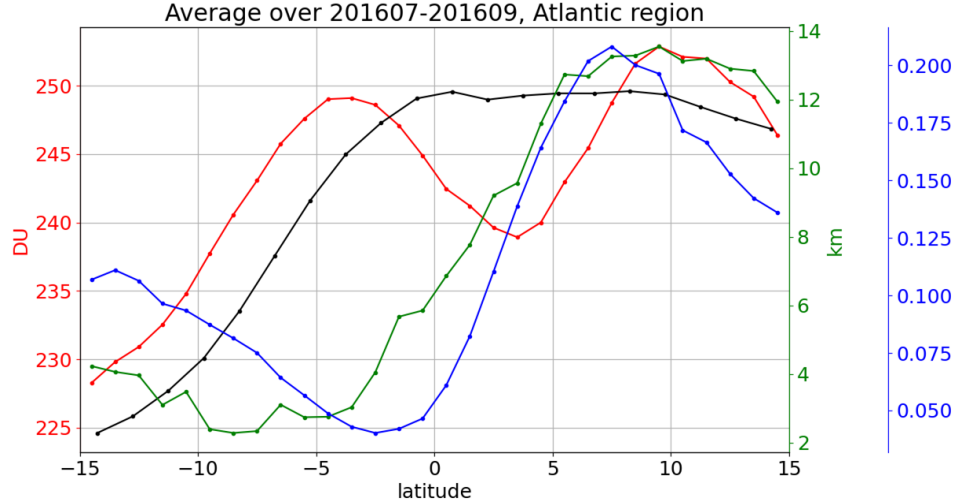
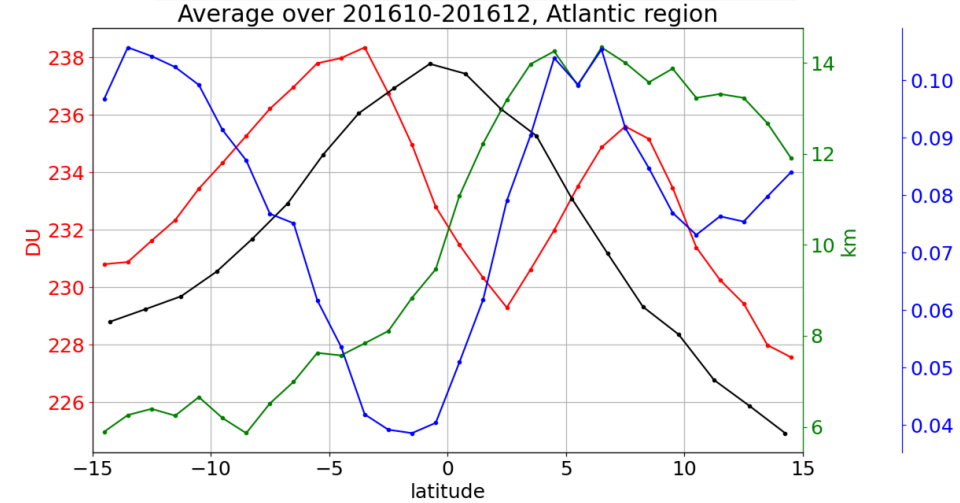


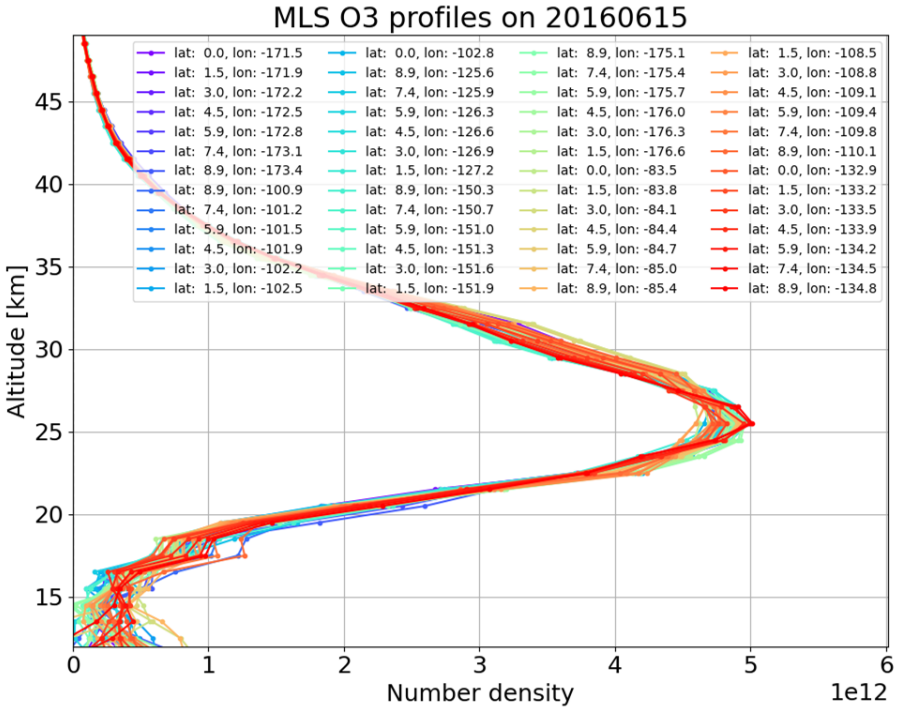


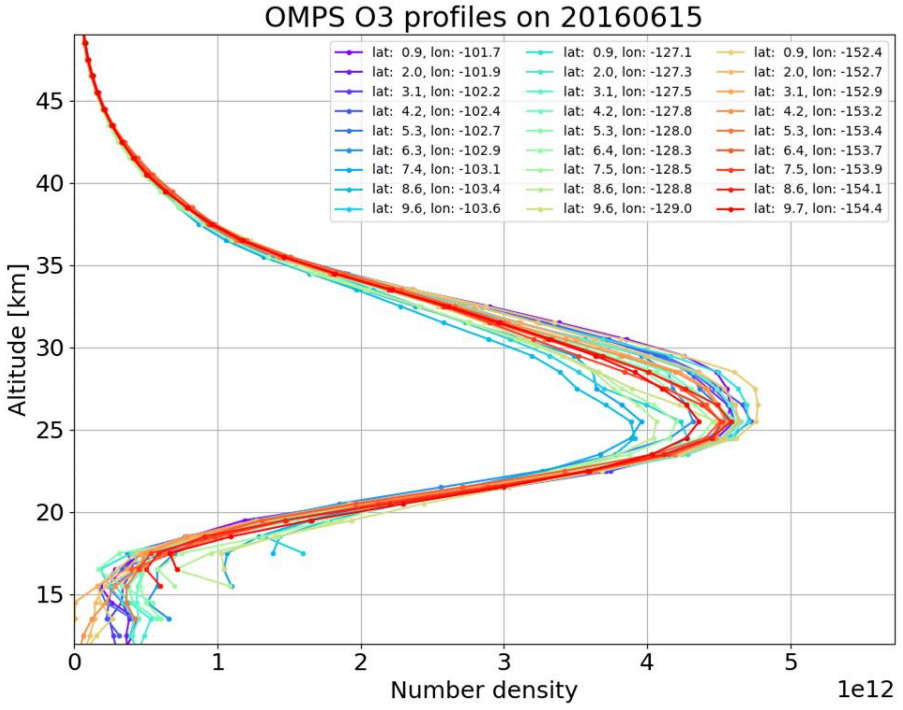


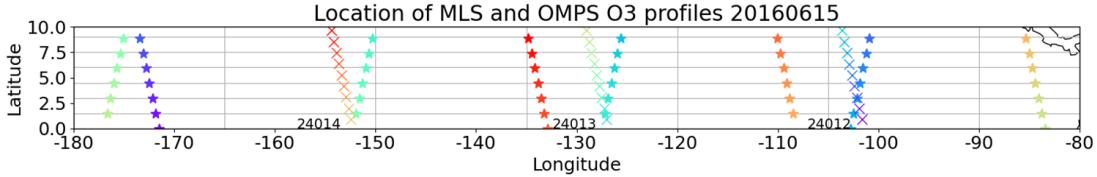


Ozone anomaly - possible causes

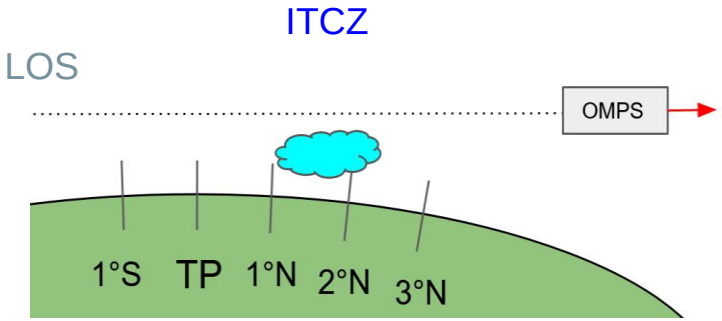
Looking at the ozone profiles for a single day in the Pacific area, from MLS and OMPS-LP







3 Dependency on cloud distance



Typical observation geometry, with OMPS LOS passing over a high reflectivity cloud band.

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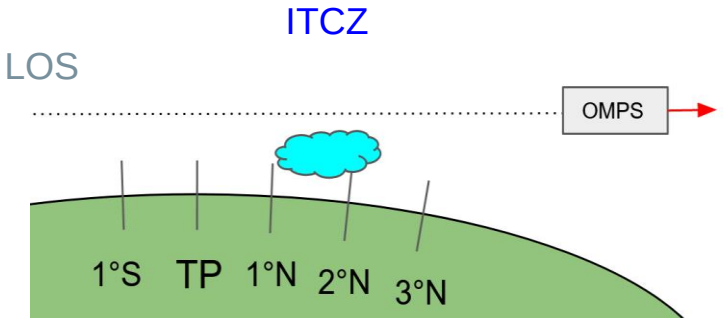
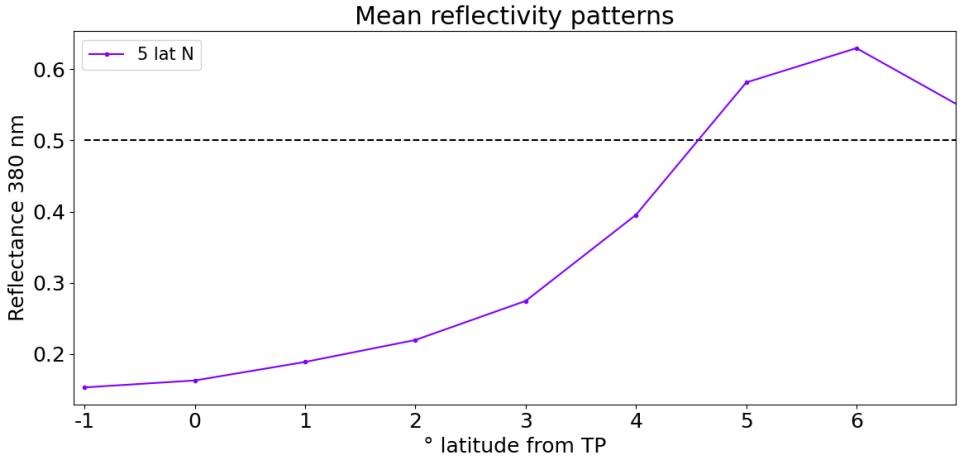


Typical observation geometry, with OMPS LOS passing over a high reflectivity cloud band.

Compare the 380 nm reflectivity from OMPS NM at the location of OMPS-LP TP w.r.t. its value at a distance x° N of the TP.

Classify the profiles:

- surface reflectivity @ TP < 0.2,
- surface reflectivity @ x° N of TP > 0.5.



Eight year of OMPS data used, in July-Sept period, Pacific sector, [5° S, 20° N] window.

Check if reflectivity is > than 0.5 in 2 consecutive bins starting from 5-6° N of TP

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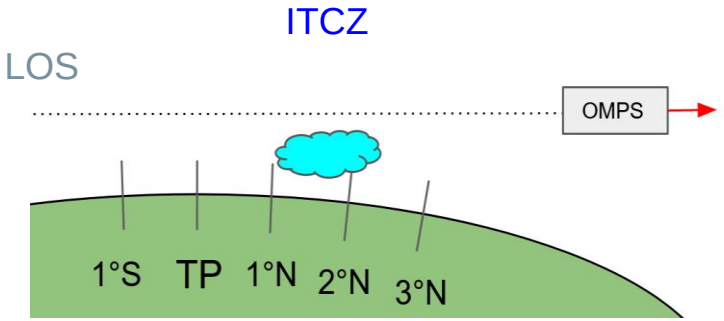

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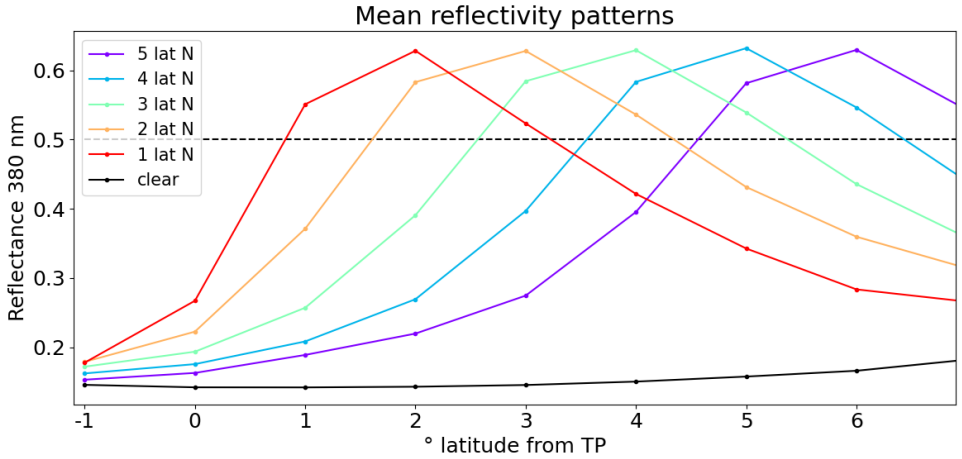
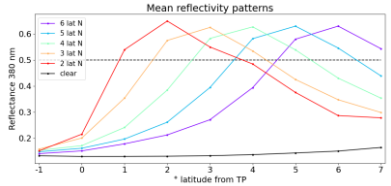
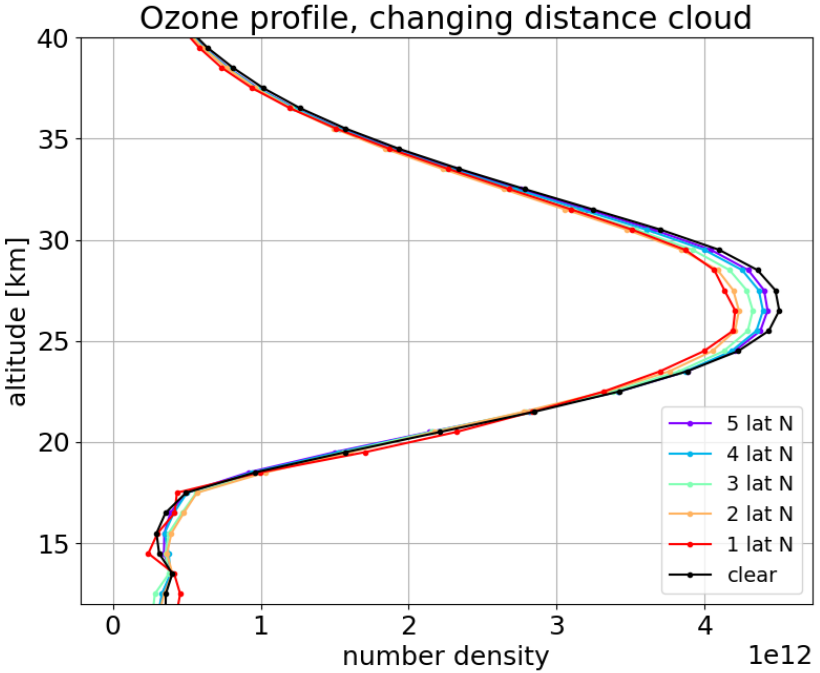


Eight year of OMPS data used, in July-Sept period, Pacific sector, [5° S, 20° N] window.

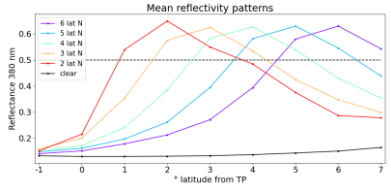
Check if reflectivity is > than 0.5 in 2 consecutive bins starting from 5-6° N of TP down to to 1° N.
Black line is “clear case”, i.e. low reflectivity for all points along the orbit.

3 Dependency on cloud distance





As the high reflectance pixel approaches the TP, the disturbance in the ozone profile becomes more evident.



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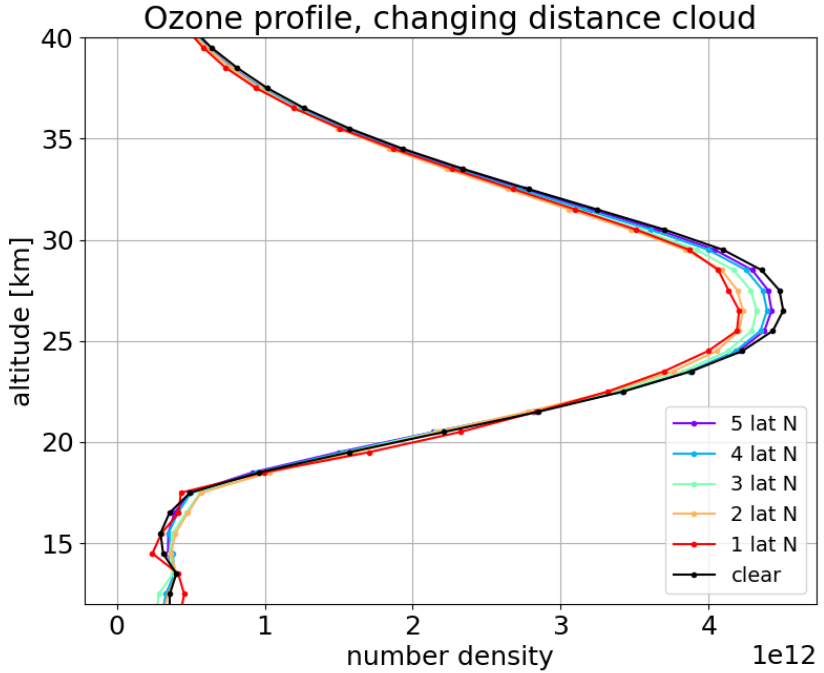
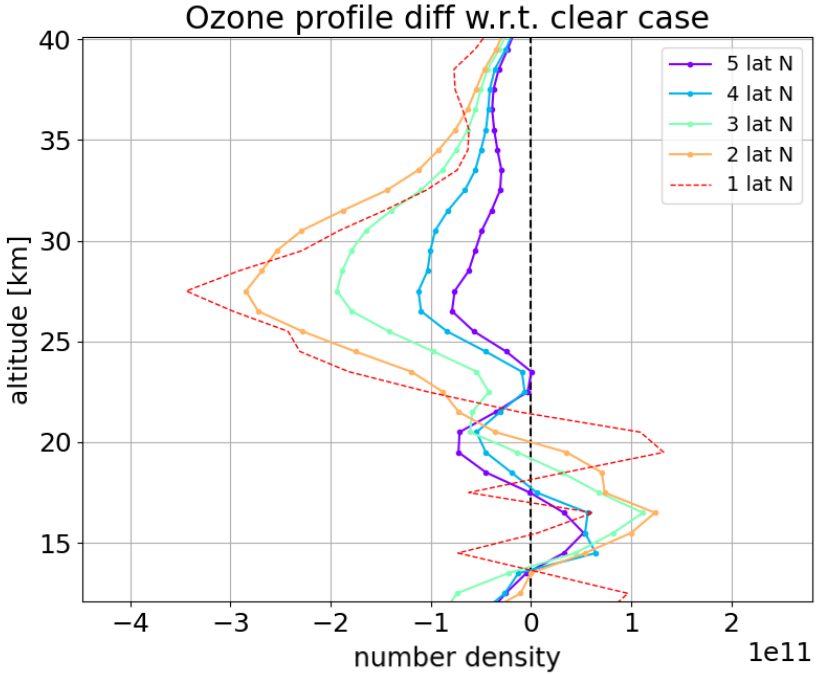




As the high reflectance pixel approaches the TP, the disturbance in the ozone profile becomes more evident.

Differences in ozone profiles w.r.t. to the clear case. Values up to 5-7% difference at 25-30 km w.r.t. the clear case.

Conclusion and outlook

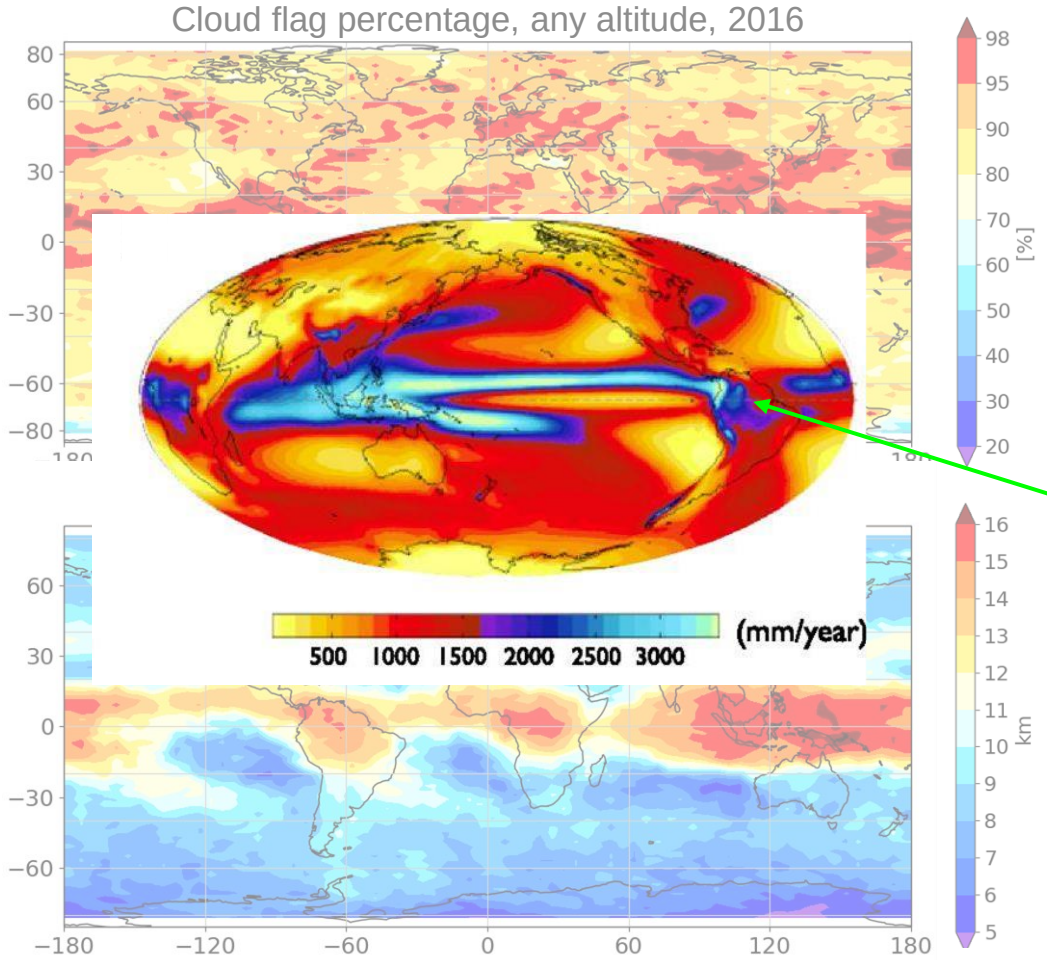
Conclusion

- Evident artefact in SOC identified in tropical Pacific region.
- Relevant link to the presence of the ITCZ across the satellite line of sight.
- Significative dependency of the anomaly from the distance of the profile from the high reflectivity scene.
- Effect on ozone triplet identified

Outlook

- Need for RTM simulations of this effect by using a retrieval which can take into account variations of reflectivity along the line of sight. The surface reflectivity shall be prescribed from Nadir observations: need for an a-priori knowledge to constrain the retrieval.
- Possible development of an a-posteriori correction depending on the distance from high reflectivity pixels.

Ozone anomaly - possible causes



Cloud information from limb flagging:

- In the tropical Pacific region: frequent presence of clouds, with a sharp gradient across the equator, ⇒ InterTropical Convergence Zone (**ITCZ**);
- High clouds mostly detected in the northern tropical Pacific.