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Sen2Cor Atmospheric Correction with Meteorological Aerosol Optical Thickness

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Sen2Cor is a Level-2A processor with the main purpose to correct single-date Sentinel-2 Level 1C products from the effects of the atmosphere in order to deliver a **Level-2A surface reflectance (SR) product**. Side products are Cloud Screening and Scene Classification, Aerosol Optical Thickness (AOT) and Water Vapour (WV) maps. The accuracy of the retrieved surface reflectance product is strongly related to the accuracy of the atmospheric parameters used during the **atmospheric correction** process, mainly the **Aerosol Optical Thickness** and the Water Vapour content. The validation results of Sen2Cor have shown that the retrieval of water vapour is very accurate, whereas the method used to estimate the Aerosol Optical Thickness (AOT) at 550 nm, the Dark Dense Vegetation (DDV) pixel method, faces some limitations. The **AOT estimation** is not possible when there are no DDV pixels in the image. The current fallback solution for that case is to perform the atmospheric correction starting with a default AOT value.
A **novel fallback solution** for Sen2Cor is presented. The idea is to use **AOT estimates at 550 nm** from the **Copernicus Atmosphere Monitoring Service** (CAMS) retrieved from ECMWF. A first quality assessment of these meteorological AOT data over selected AERONET test sites is presented. Then the method of pre-processing and ingestion of this meteorological data in the Sen2Cor atmospheric correction module is described. Preliminary results are illustrated with an example of L2A surface reflectance product over a specific test site.

Copernicus Atmosphere Monitoring Service (CAMS)

The full description of this Copernicus service is available here: http://atmosphere.copernicus.eu

One of the dataset delivered by this CAMS service is of interest for Sen2Cor. It is the daily production of near-real-time analyses and forecasts of global atmospheric composition, especially very short term forecast of Total Aerosol Optical Depth at 550 nm or meteorological AOT.

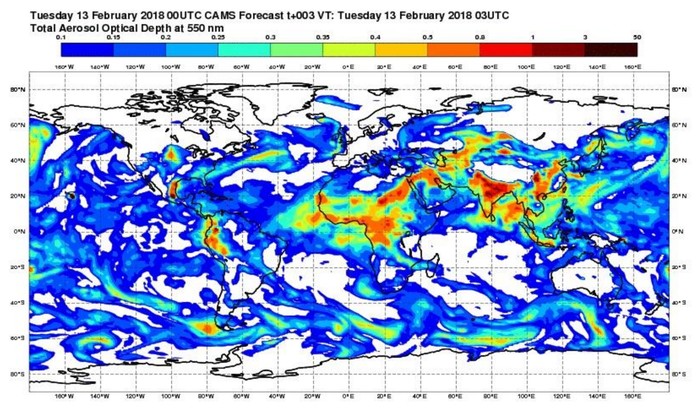


Figure 1: Example of CAMS Forecast of Aerosols Optical Depth

ASSESSMENT OF CAMS AOT

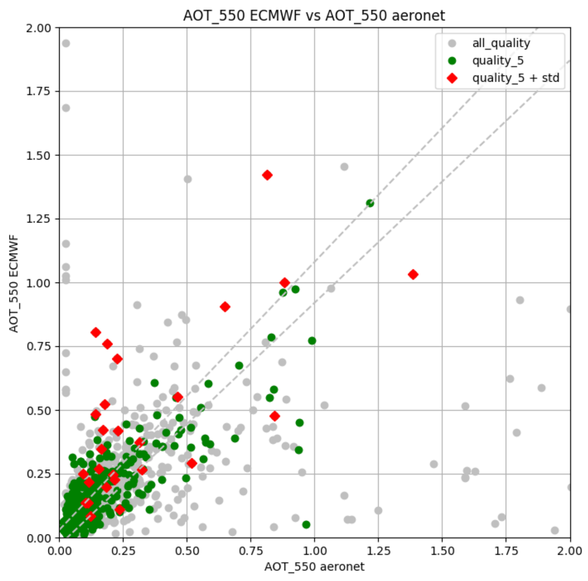


Figure 2: Scatter plot of CAMS AOT at 550 nm vs aeronet AOT at 550 nm (21 aeronet sites)

AOT dataset description:

CAMS AOT at 550 nm has been routinely collected since October 2016 at the location of 21 aeronet test sites around the world and at the time of Sentinel-2 satellites overpasses.

Graph analysis:

This scatter plot represents all the "match-ups" between AOT aeronet measurement and short term forecast CAMS AOT.

Green points represent the AOT aeronet measurements of good quality, i.e. a relative stability of AOT measurements at the time of Sentinel-2 acquisitions, with enough measurements before and after the sensing time (N_meas >=5).

Red points represent the AOT forecast with a high spatial variability, e.g. weather front.

R (aot_quality>=5) = 0.793, Nsamples: 408

AOT RETRIEVAL WORKFLOW FOR SEN2COR

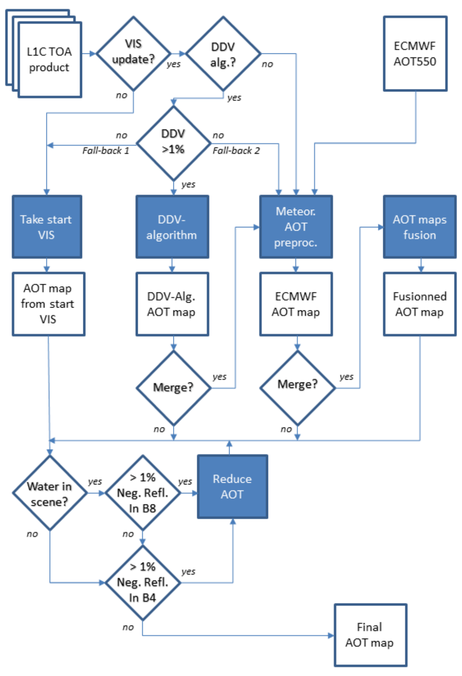


Figure 3: Sen2Cor prototype with Meteorological AOT.

This meteorological AOT will be used by Sen2Cor as an alternative or in addition to AOT retrieval based of the DDV-algorithm. Meteorological AOT will be downloaded from ECMWF ftp-server and pre-processed, which includes spatial extraction and resampling and temporal resampling.

Use of meteorological AOT data can be configured 1) to provide a fallback solution for the DDV algorithm or 2) generally to replace the DDV algorithm. A third option is 3) to merge Sen2Cor AOT map from DDV algorithm with CAMS pre-processed AOT.

Sen2Cor DDV AOT map has the advantage of higher spatial resolution than CAMS pre-processed AOT map. It has the disadvantage of possible tile-edge border effects due to the independent processing on granule level. Merging both AOT maps has the objective to remove any tile-edge border effect and still benefit from image-based, higher spatial resolution AOT retrieved by Sen2Cor with the DDV-algorithm.

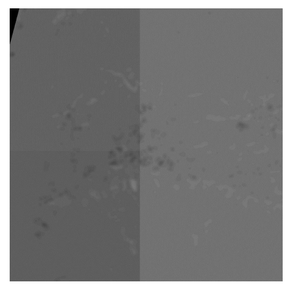
PRELIMINARY MERGING ALGORITHM

Merging CAMS and Sen2Cor AOT:

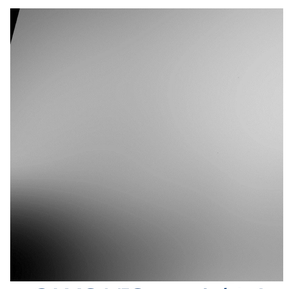
➔ Assign weight A to CAMS_AOT and weight B to Sen2Cor_AOT:

- Equal weight for A and B
- weight A < weight B
- weight A > weight B

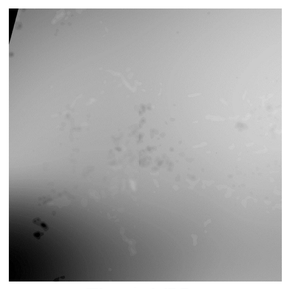
(inter-tiles homogeneity)



Sen2Cor VIS - weight B



CAMS VIS - weight A



Final_VIS

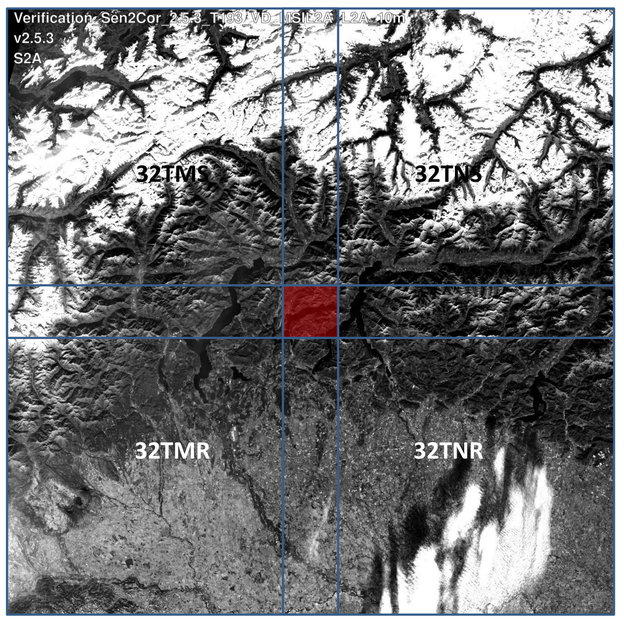
➔ Compute the AOT/VIS background

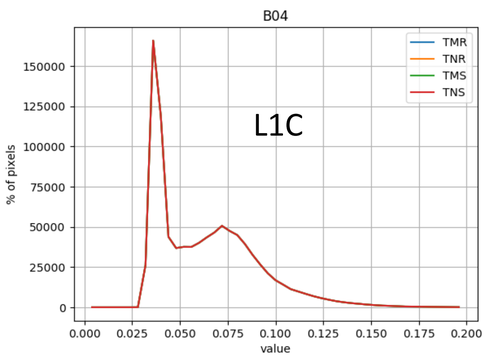
- Bckg_VIS = A * CAMS_VIS + B * mean(Sen2Cor_VIS)

➔ Compute the Final AOT/VIS:

- Final_VIS = Bckg_VIS + (Sen2Cor_VIS - mean(Sen2Cor_VIS)) * mean(CAMS _VIS) / mean(Sen2Cor_VIS)

FIRST RESULTS





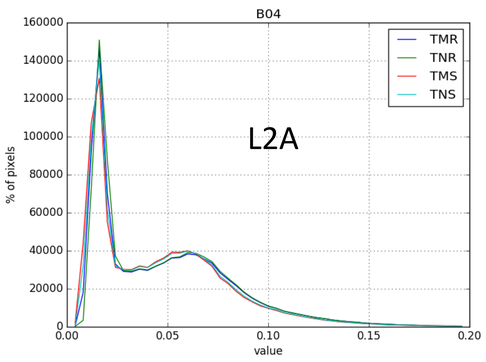


Figure 4: on top: 4 granules product over Ispra region. Intertiles region of interest in transparent red. On right: L1C and L2A statistics of band B04 surface reflectance

CONCLUSION

The assessment of CAMS AOT data have shown that these AOT values give relative good estimates compared to Aeronet measurements compiled on 21 different aeronet sites. Best correlation is obtained for test sites without relief located close to the sea, e.g. Capo Verde site.

Different workflows have been presented. The alternative fallback solution when no DDV pixels are present should clearly improve Sen2Cor AOT retrieval, whereas further validation is required to determine if the AOT estimates fusion (CAMS & Sen2Cor) is a workflow suitable for operational implementation.

Preliminary results looks promising, especially for applications where the inter-tiles surface reflectance homogeneity is essential, e.g. regional cloud free mosaics.

Some further developments are needed to implement a Sen2Cor version available for toolbox users, especially because of the CAMS data access. One efficient approach could be to embed the CAMS AOT as auxiliary data in Level-1C products.