Royal Netherlands
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Aerosol Layer Height from Spectrometers

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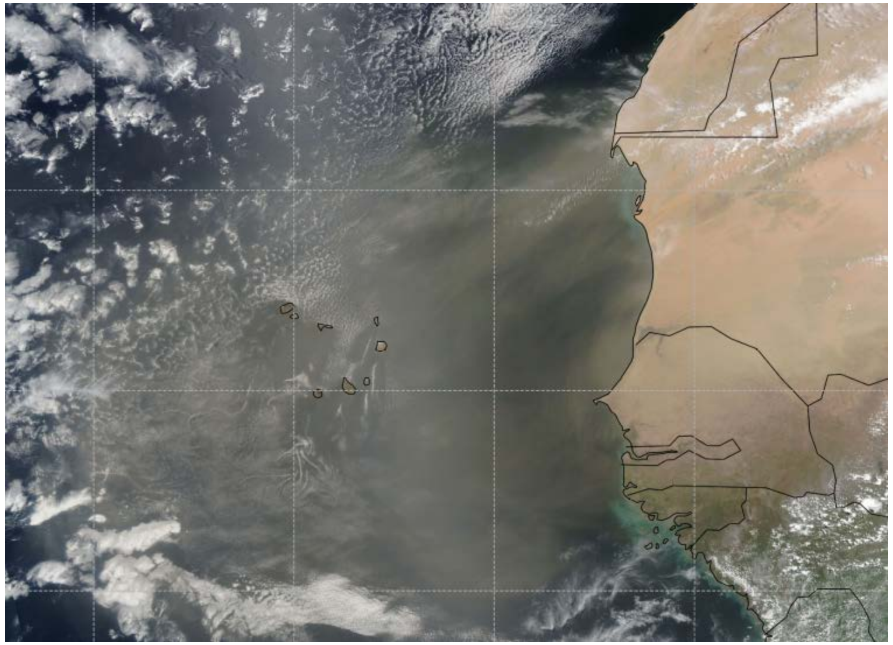
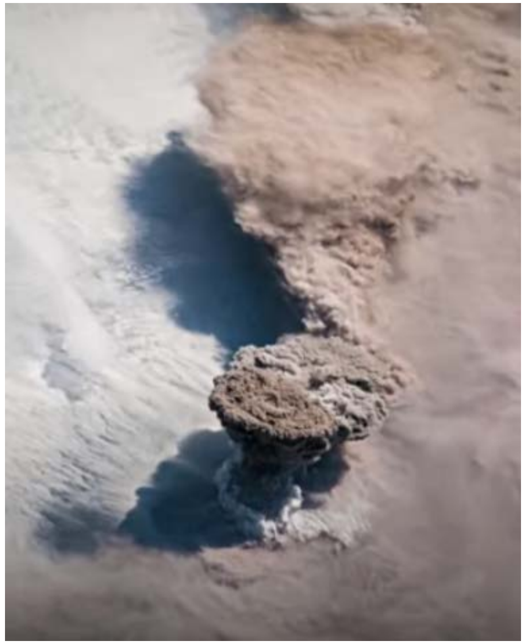
CEOS Atmospheric Composition Virtual Constellation AC-VC-16

Aerosol Vertical Information Applications

- Longe range transport of aerosol plumes
  - desert dust, biomass burning, volcanic ash, pollution
- Climate change by absorbing aerosols
- Aerosol correction for trace gas satellite observations





Aerosol Observations of Aerosol Vertical Distribution

ACTIVE

- LIDAR (Caliop, Aeolus, *Earthcare*)
- Pro: Vertical profiles
- Pro: Day and night observations
- Con: limited swath

PASSIVE

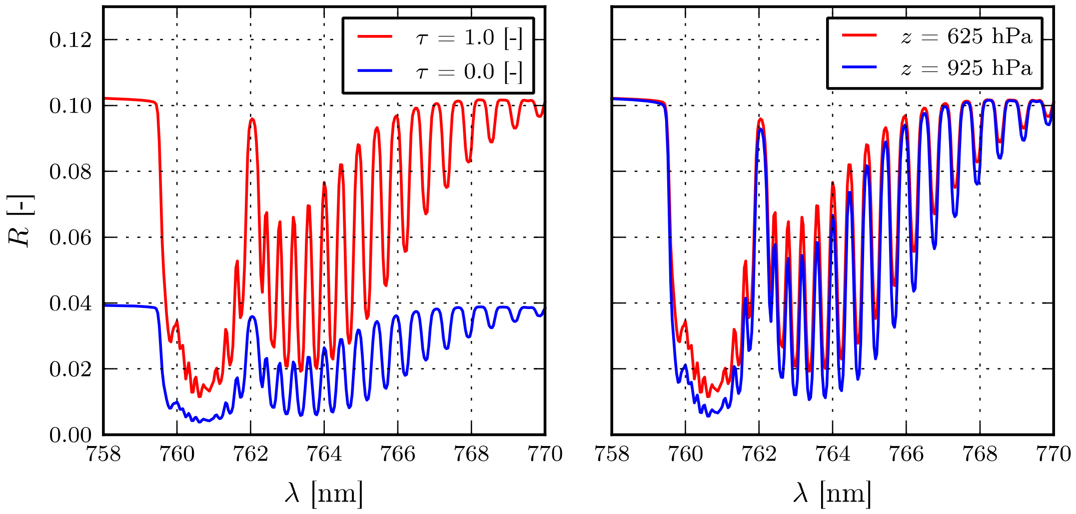
- VIS-NIR spectrometry using oxygen absorption.
- Multi-angle radiometry/polarimetry (MISR, POLDER/3MI, *Spex*)
- IR spectrometry (IASI, ..)

- Pro: wide swath
- Pro: large number of sensors
- Con: limited vertical information
- Con: Only daytime, except for IR observations of dust

Aerosol Layer Height from Oxygen Bands

- Physical principle is that the atmospheric oxygen profile is well-known.
- Usable oxygen absorptions are in the VIS (O_2-O_2 dimer weak absorptions) and in the NIR (O_2 A and B band strong absorption)
- Method is limited to moderate to strong aerosol loading under cloud-free conditions.

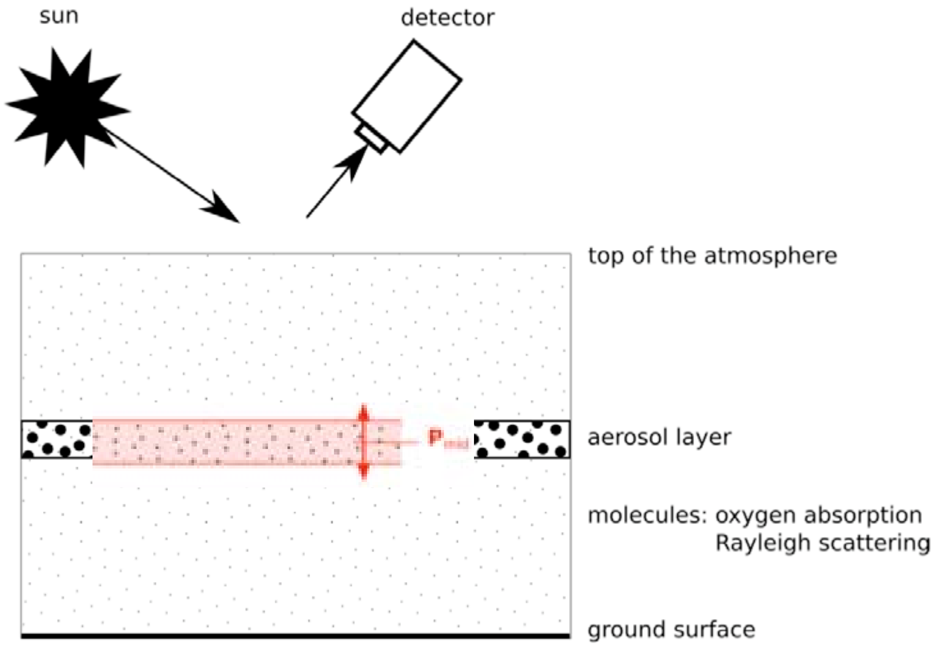
OMI	O_2-O_2
S5P/TROPOMI	O_2-O_2, O_2 A, O_2 B
GEMS	O_2-O_2
S4/UVN	O_2-O_2, O_2 A
S5/UVNS	O_2-O_2, O_2 A
TEMPO	O_2-O_2, O_2 B
CO2M	O_2-O_2, O_2 A



Synthetic oxygen A-band spectra for a cloudless atmosphere containing aerosols over a surface with and albedo of 0.03.
Left: Aerosol layer is fixed at a height of 900 hPa - 950 hPa, for two scenes are different aerosol optical thicknesses.
Right: Aerosol vertical distribution is varied for an aerosol optical thickness of 1.0 at 760 nm.

Operational ALH Retrieval Algorithm for O_2 A Band

- Optimal estimation algorithm with AOT and ALH as fitting parameters.
- Aerosol model is fixed and uses Henyey-Greenstein phase function.
- Online Radiative transfer uses a neural network approach.
- Currently the surface albedo is based on a monthly climatology.
- Requirement for ALH 1 km threshold, 0.5 km goal



Nanda, S., de Graaf, M., Veefkind, J. P., Sneep, M., ter Linden, M., Sun, J., and Levelt, P. F.: https://doi.org/10.5194/amt-2019-348
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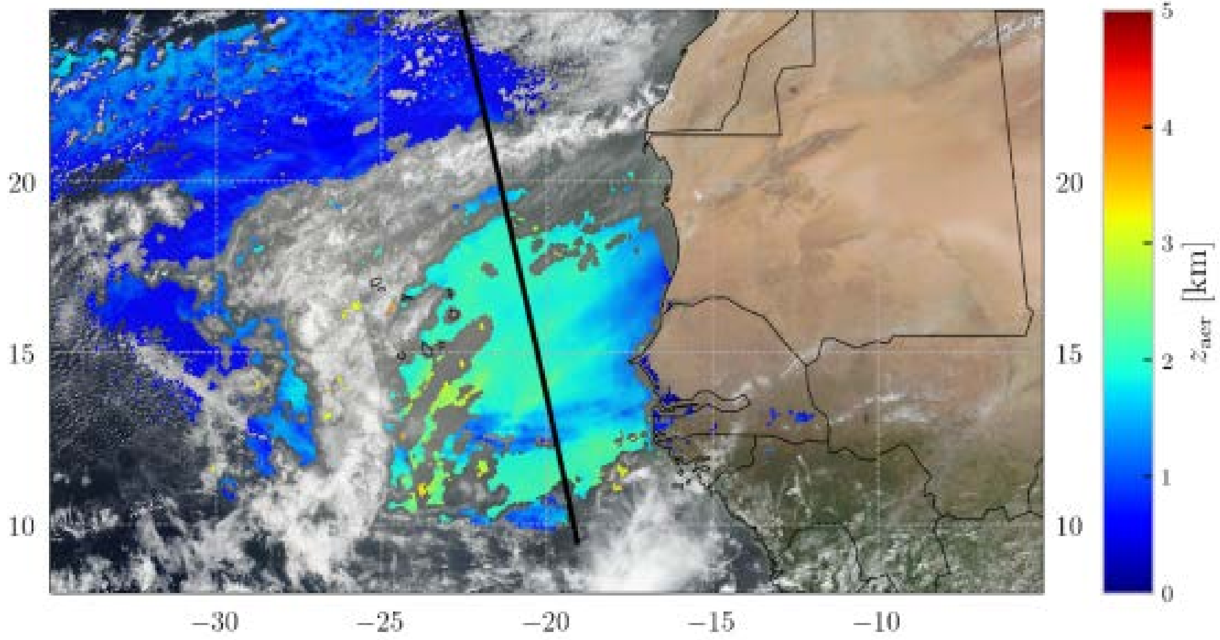
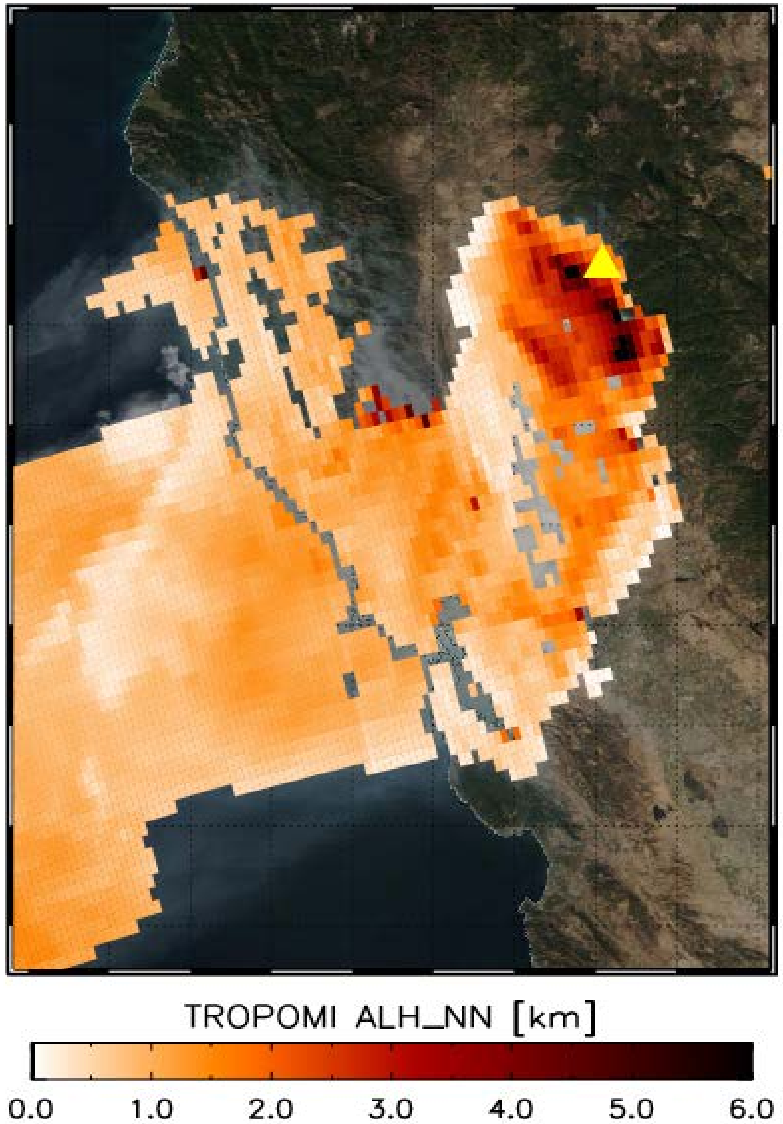
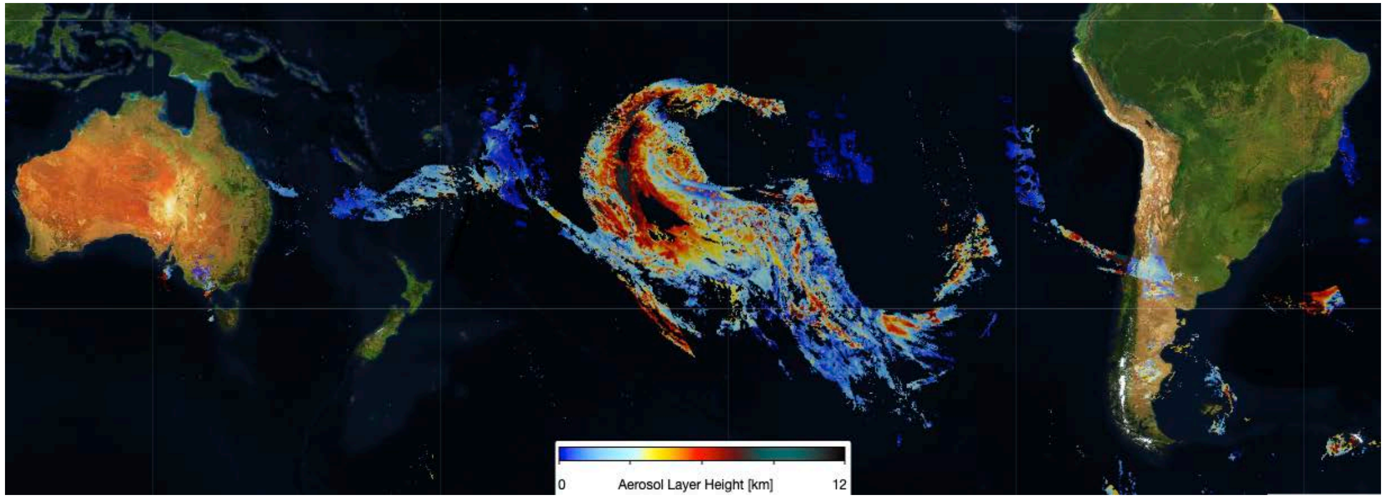
ALH Saharan Dust, 2018-06-08



ALH Biomass Burning, 2018-11-09

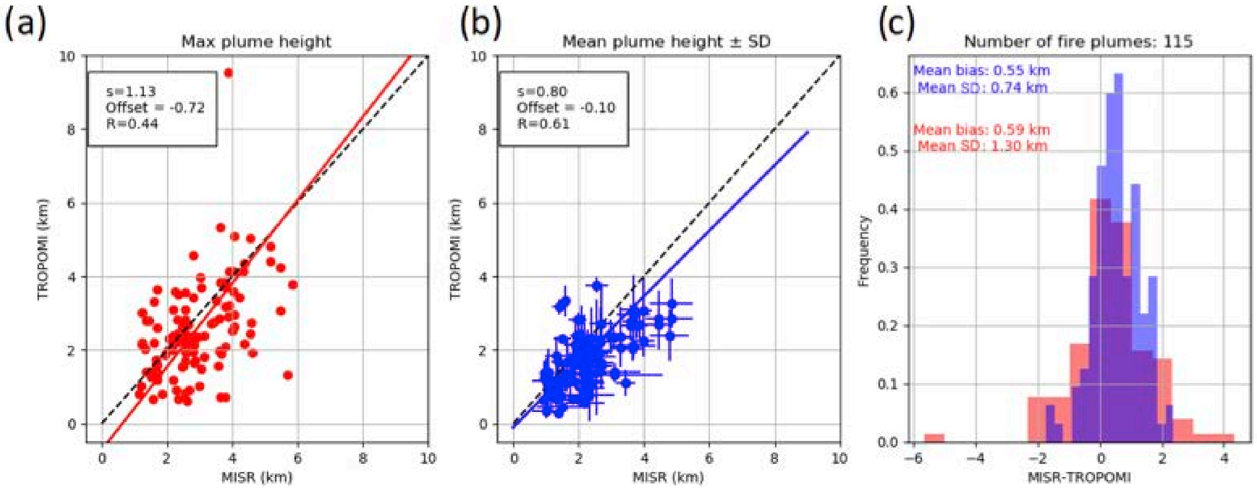


ALH Biomass Burning, 2020-01-09



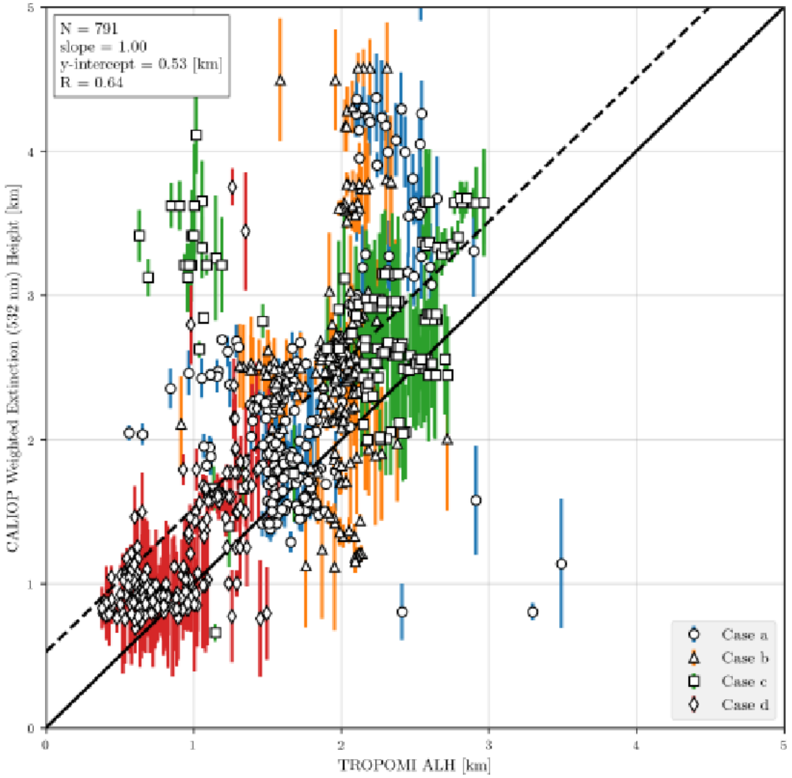
Validation Examples

Biomass Burning N-America



Comparison to MISR over continental N-America.
Griffin et al. www.atmos-meas-tech.net/13/1427/2020/

Saharan Dust, Atlantic Ocean

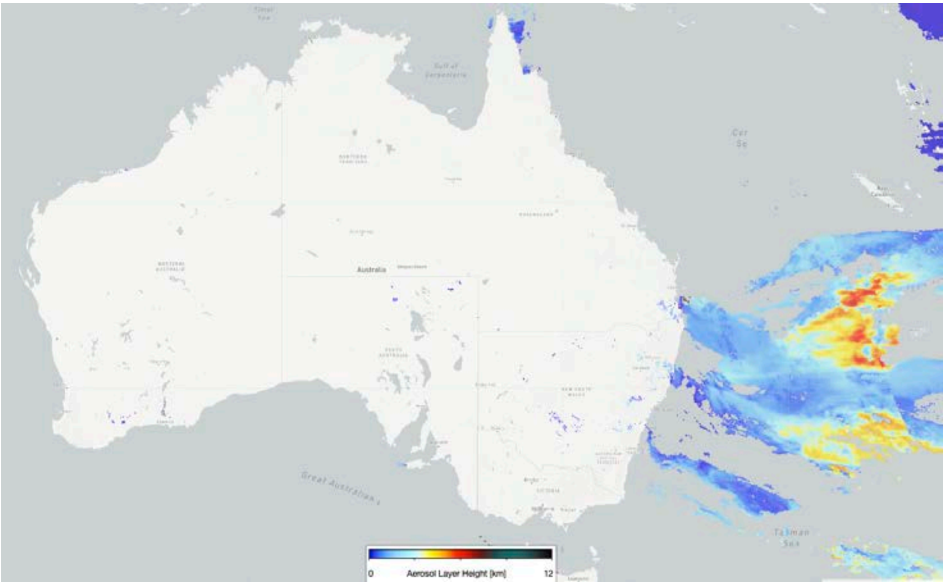


Nanda et al: https://doi.org/10.5194/amt-2019-348

Planned Algorithm Improvements

- Co-fit the surface reflectance.
- Increase the number of retrievals.
- Expand the vertical range.
- Explore the O_2 B band for Tropomi.
- Improving the cloud clearing.

Conclusion



- Current and planned spectrometers allow for retrieval of aerosol layer height.
- The S5P/TROPOMI ALH product is the first operational data product.
  - For S4 and S5 operational products are in development.
- Validation is performed with CALIOP.
  - Results are good over the ocean, but over high-reflective surfaces retrievals are more challenging.
- ALH is a new product, further developments are foreseen.

More Information:
http://www.tropomi.eu/data-products/aerosol-layer-height

https://s5phub.copernicus.eu/dhus/#/home