Three-dimensional distribution of aerosols from Australian wildfires revealed by TROPOMI satellite observations

F.Lemmouchi[(1)], J.Cuesta[(1)], M.Eremenko[(1)], G.Siour[(1)], C.Derognat[(2)], G.Dufour[(1)], D.Tran[(3)] , H.Tran[(3)], X.Liu[(4)], P.Zoogman[(4)]

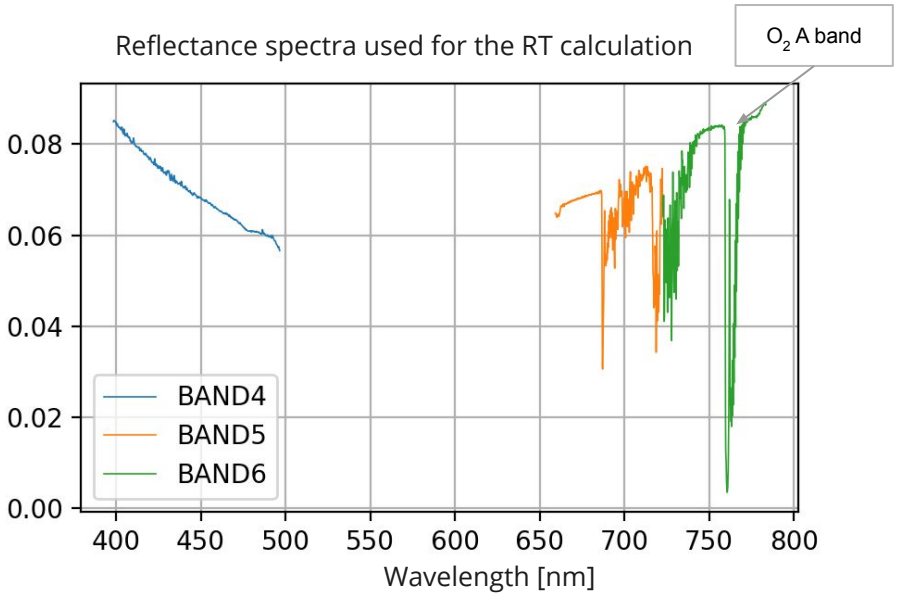
vEGU21

Measurements of TROPOMI instrument

AERO-3D S5P : retrieval approach adapted from AERO-3D METOP (Cuesta et al. in prep)

TROPOMI (S5P)
Resolution : 3.6 km x 5.6 km
Daily overpass : 13h30

12 Microwindows selected from TROPOMI bands 4, 5, and 6 used including O_2 A band.

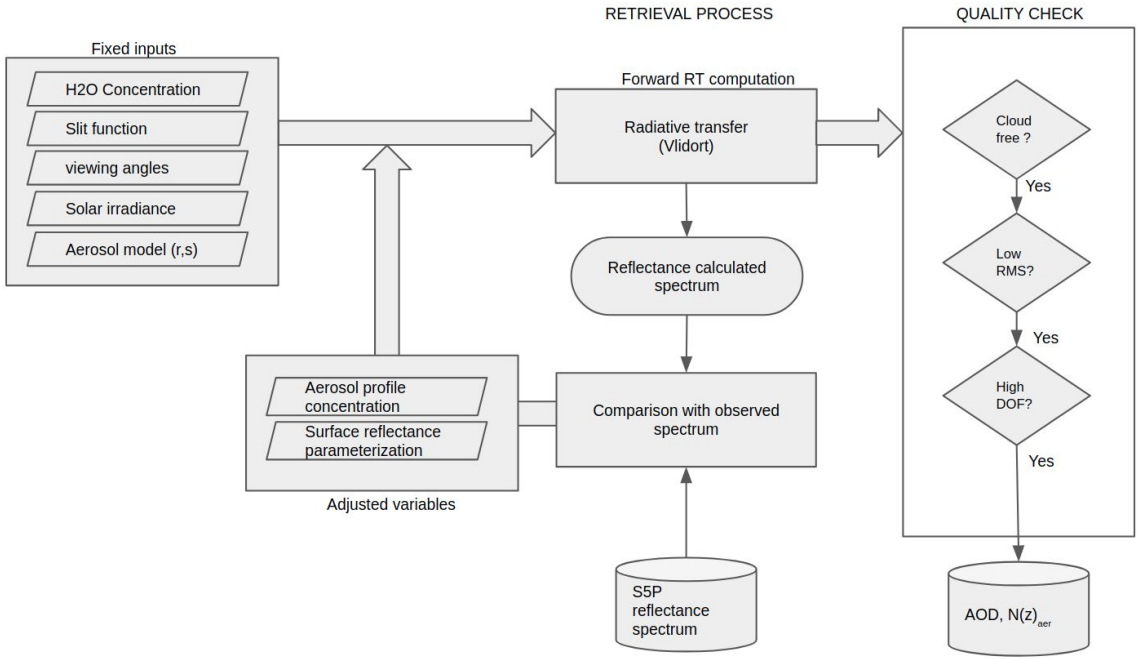


Vertical profile retrieval method

AERO-3D S5P : retrieval approach adapted from AERO-3D METOP (Cuesta et al. in prep)

A.Forward calculation :

We use VLIDORT radiative transfer code (Spurr. 2006) to simulate the reflectance using unique apriori concentration profile.
The aerosol model used is a fine mode distribution, and the refractive index is derived from an AERONET station.



Vertical profile retrieval method

AEROS5P : retrieval approach adapted from AERO-3D METOP (Cuesta et al, in prep)

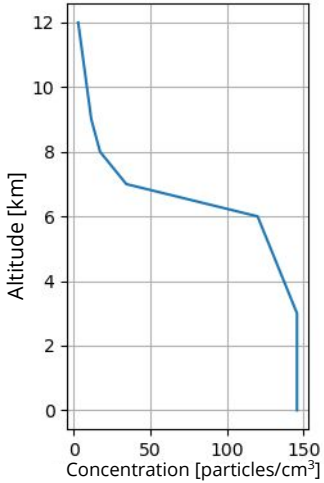
B.Inversion :

It is a least square minimisation of the residuals between the measured reflectance by S5P and the simulated one, regularized with Tikhonov-Philips method. (Cuesta et al. 2013, Cuesta et al. 2015)

$$[\mathbf{y} - \mathbf{F}(\mathbf{x})]^T \mathbf{S}_\epsilon^{-1} [\mathbf{y} - \mathbf{F}(\mathbf{x})] + (\mathbf{x} - \mathbf{x}_a)^T \mathbf{R} (\mathbf{x} - \mathbf{x}_a)$$ (Steck. 2002)

$\mathbf{y}$: measurement vector
$\mathbf{x}$: state vector
$\mathbf{x_a}$: apriori state vector
$\mathbf{F}$: Forward model
$\mathbf{S}$: Error covariance matrix
$\mathbf{R}$: Regularization matrix

Jointly adjust aerosol concentration profile, and surface reflectance



Case study : Australian wildfire

22-12-2019

1- Horizontal distribution 22-12-2019

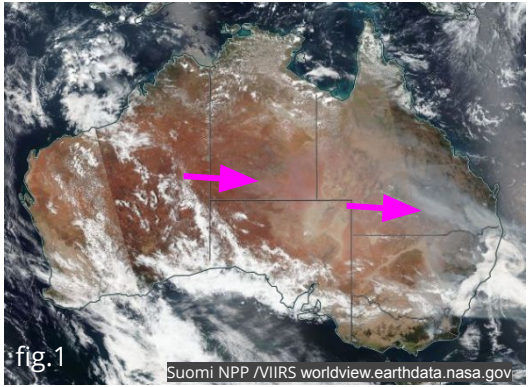
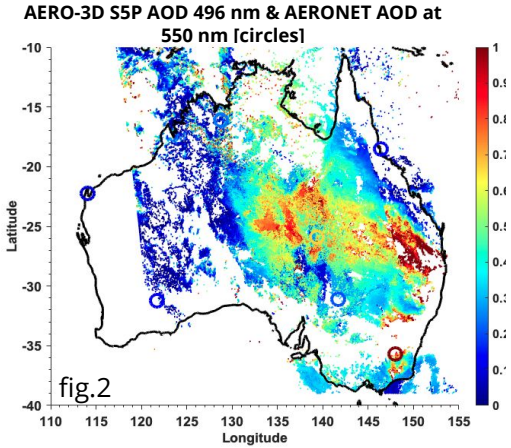


fig.1: Plumes concentrated in the east and the center of the continent, the intense smokes are visible with the naked eye from space whereas the subtle plumes are hard to observe.



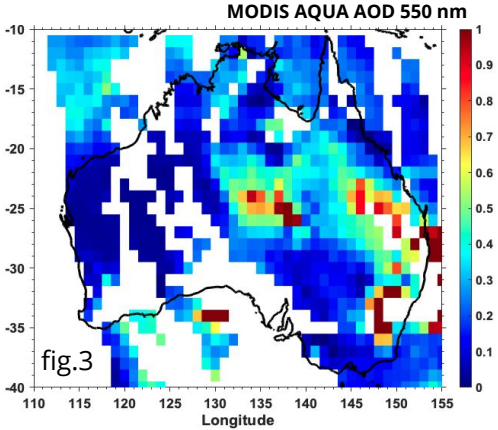
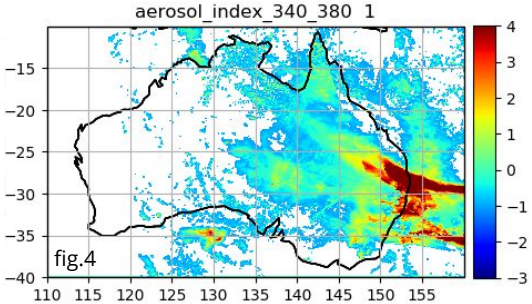


fig.2 vs fig.3: AOD 2D distribution of AERO-3D S5P and MODIS is comparable, and are consistent with AERONET observations.

fig.2 vs fig.4: AERO-3D S5P integrated AOD manage to pick up the aerosols in the center of the continent, and provided complementary information to S5P aerosol index.



CO total column [mol/m^{-2}], fire pits in magenta color

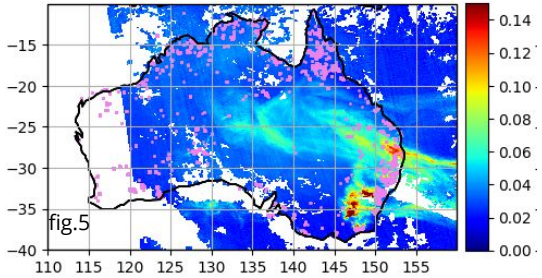
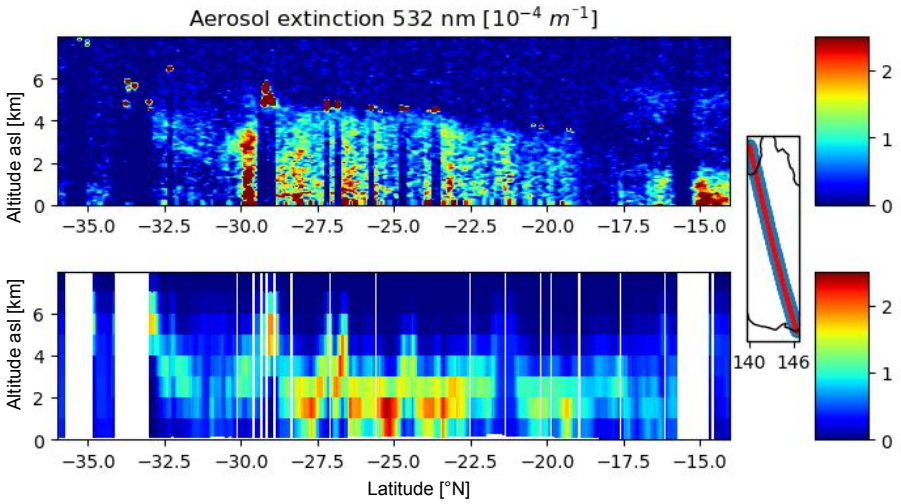


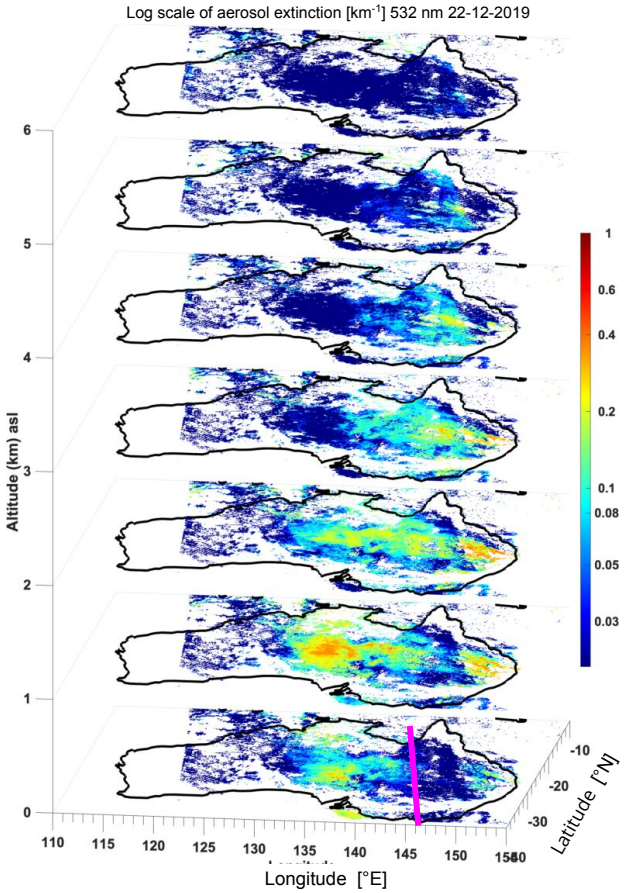
fig.2 vs fig.5: Aerosols locations are consistent with the smoke proxy (carbon monoxide)

1- Vertical distribution 22-12-2019

CALIOP
04:40 UTC

AERO-3D(*) S5P
03:00 UTC





We observe that the aerosol plume is vertically spread up to 4 km, between -30 and -19 degree north, with a fair agreement with the LIDAR.

(*) smoothed with a moving average

Conclusion

- The AERO-3D S5P integrated AOD shows a good agreement with the MODIS AOD for cloudfree pixels.
- The vertical distribution of aerosols from AERO-3D S5P and CALIOP are fairly similar.

Perspectives

- Observing aerosol profiles in the greater Paris region and on some african agglomerations, and comparing the results with in-situ measurements.

Data resources :

- TROPOMI data : https://s5phub.copernicus.eu/dhus/#/home
- MODIS data : https://worldview.earthdata.nasa.gov/ and https://www.icare.univ-lille.fr/
- CALIOP data : https://worldview.earthdata.nasa.gov/
- Meteorology : https://www.ecmwfig.int/
- Surface BRDF : https://www.grasp-sas.com/projects/aod-brdf_sentinel-5p-innovation/