Météo-France update : evolution of the MOCAGE model and research results

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[2] MeteoSwiss

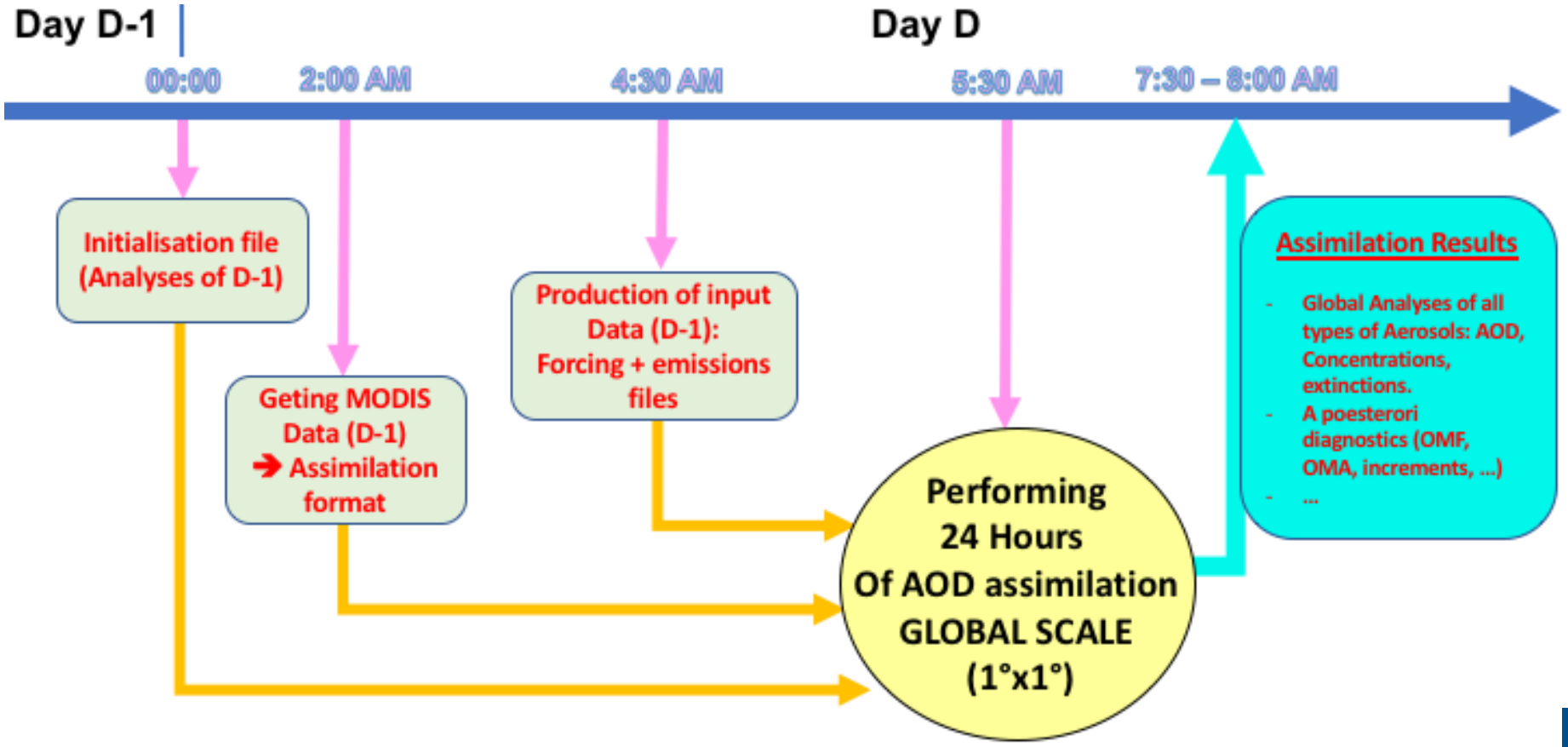
11th ICAP meeting, Tsukuba, Japan , 22-24 July 2019

Summary

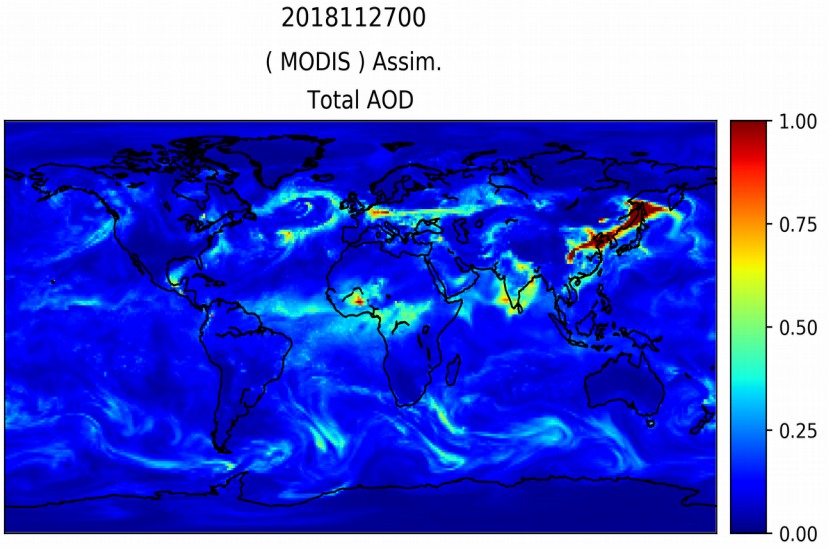
Towards an operational data assimilation system

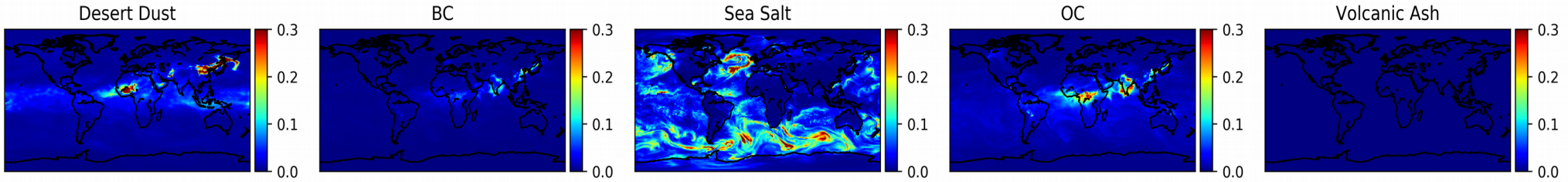
Pre-operational data assimilation chain

- There is a pre-operational MODIS AOD DA chain running every day at Météo-France able to take account for a volcanic eruption
- Aim is to have a DA system using MODIS AOD and the E-profile data at the same time



Example: AOD analyses for the 27th November 2018

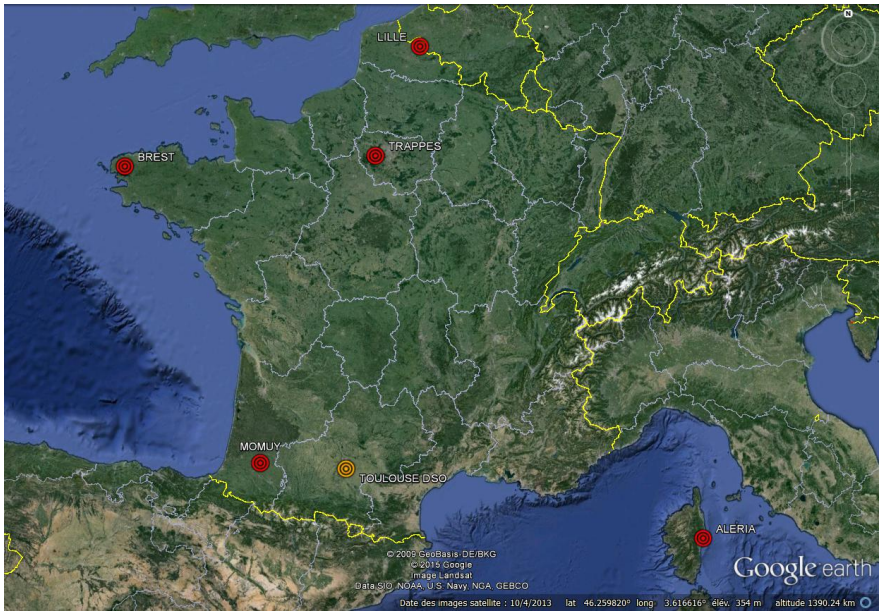




Planned to become operational in 2020

MPL lidar data assimilation

- Météo-France recently acquired 6 MPL lidar deployed on the French territory
- The aim is to use them in a MODIS AOD – MPL data assimilation
- First tests were made by assimilating MPL alone



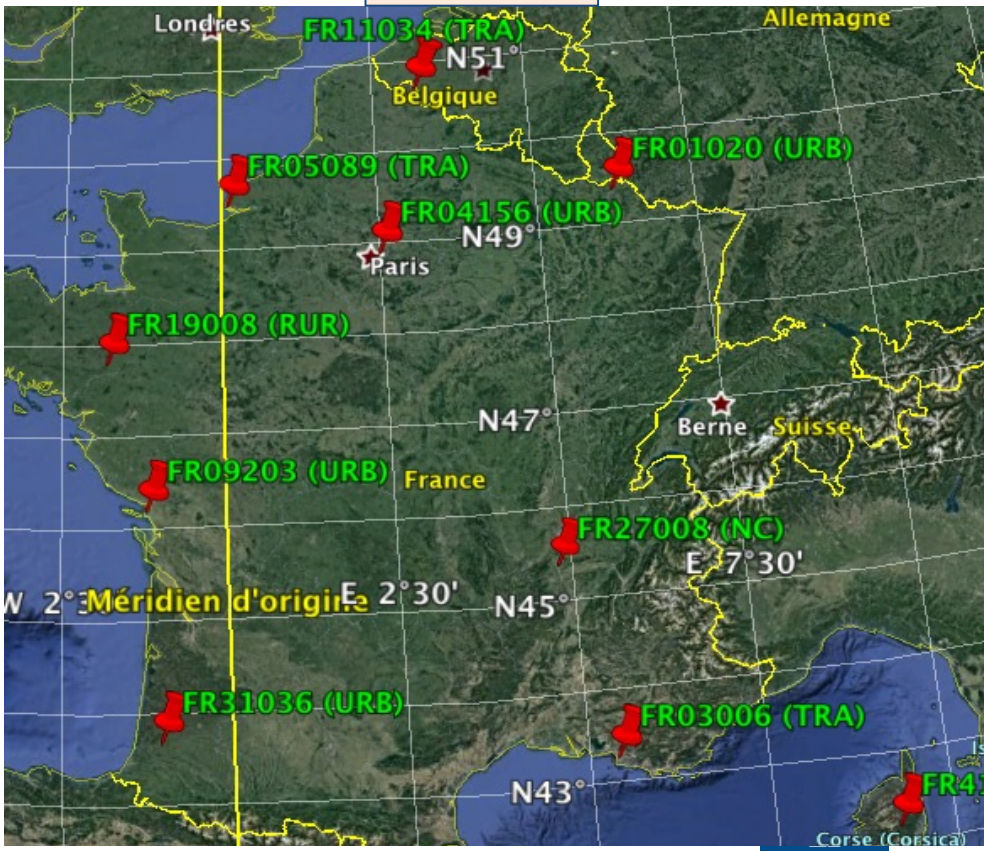
MPL lidar data assimilation

- Evaluation against:
  - PM data from EEA
  - AERONET data

AERONET sites

- Toulouse
- Palaiseau
- Toulon
- Ersa
- Lille
- Paris
- Aubière_LAMP
- Brest

PM sites

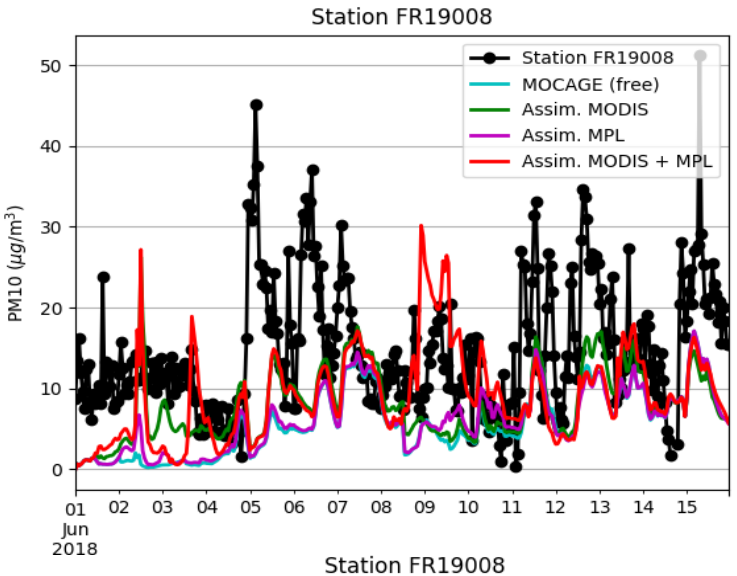


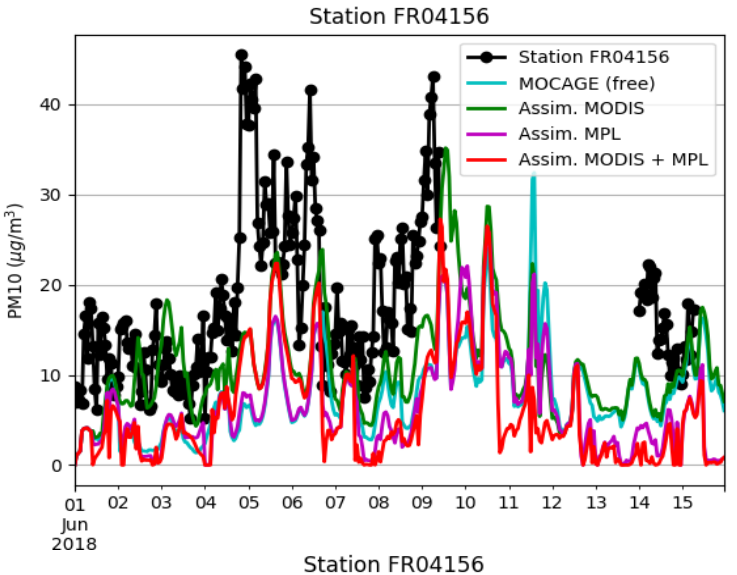
PM evaluation

North-West

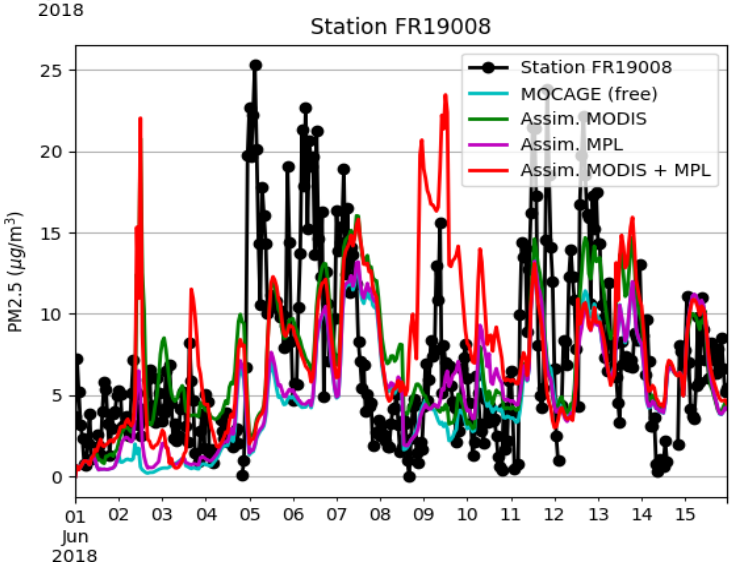
Paris

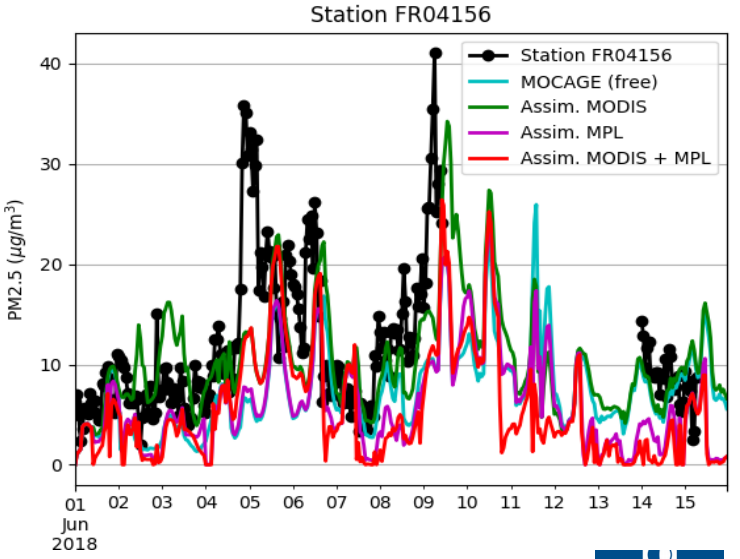
PM10



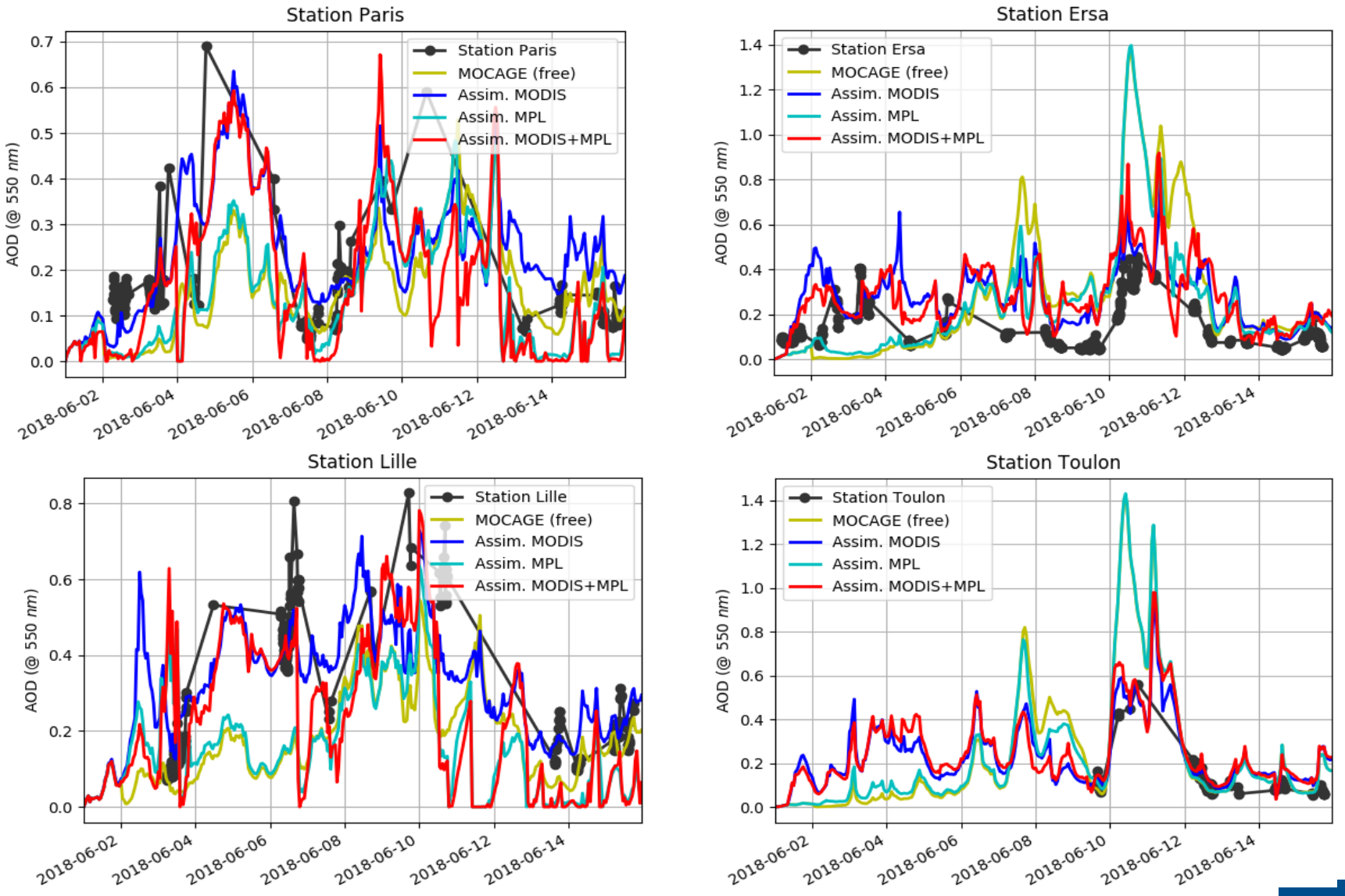


PM2.5

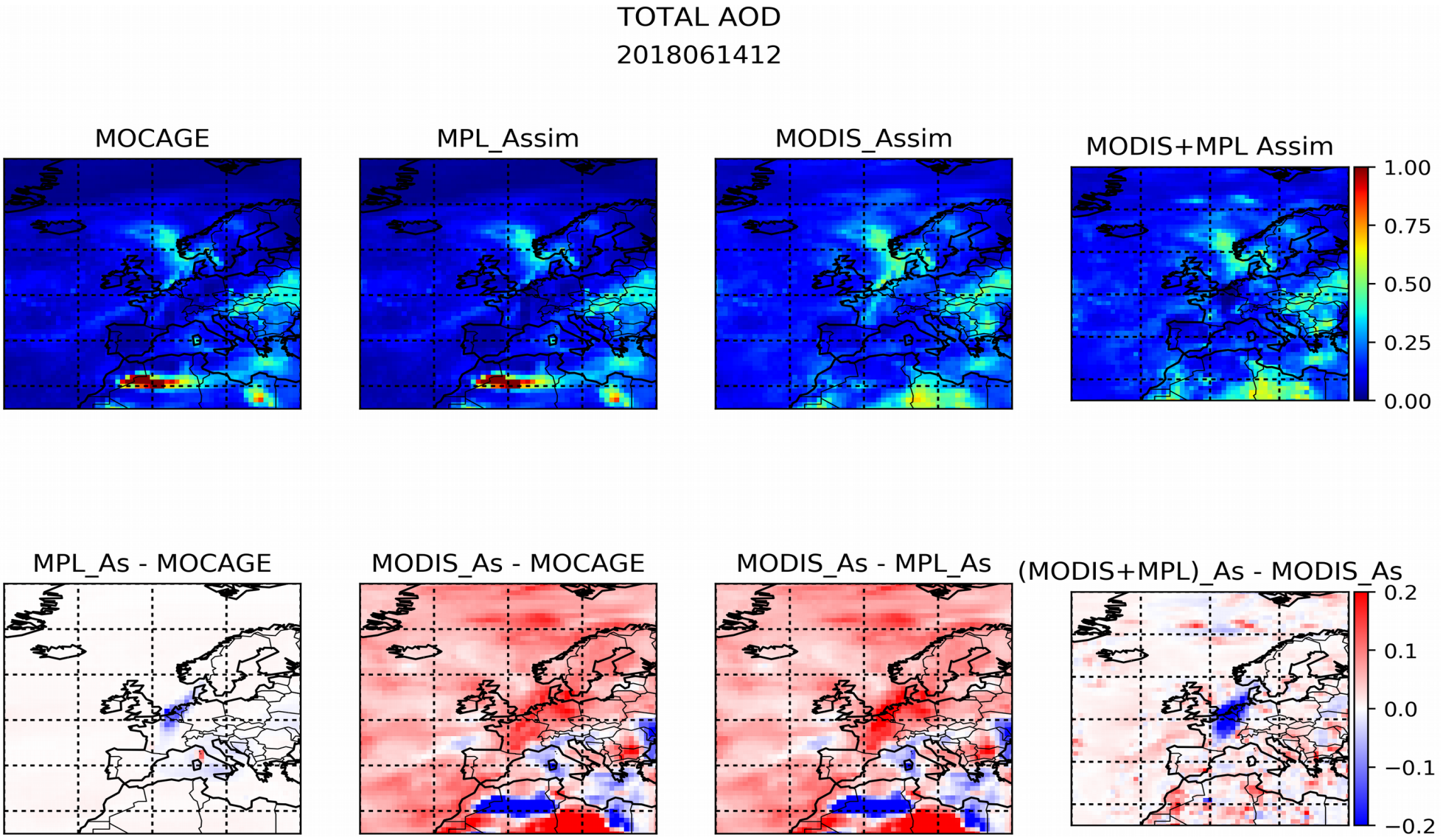




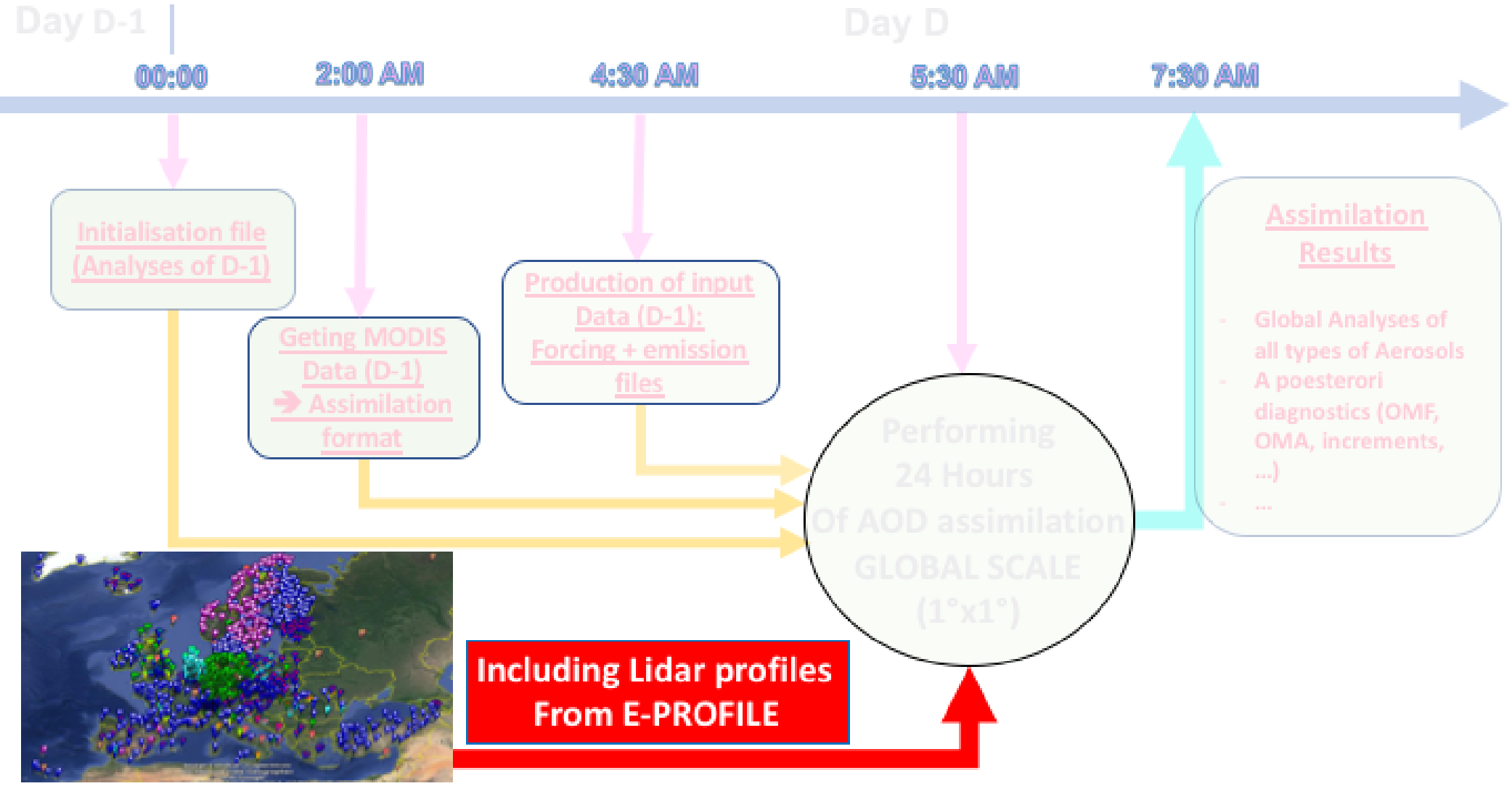
AOD Evaluation



Result comparison for June 2018



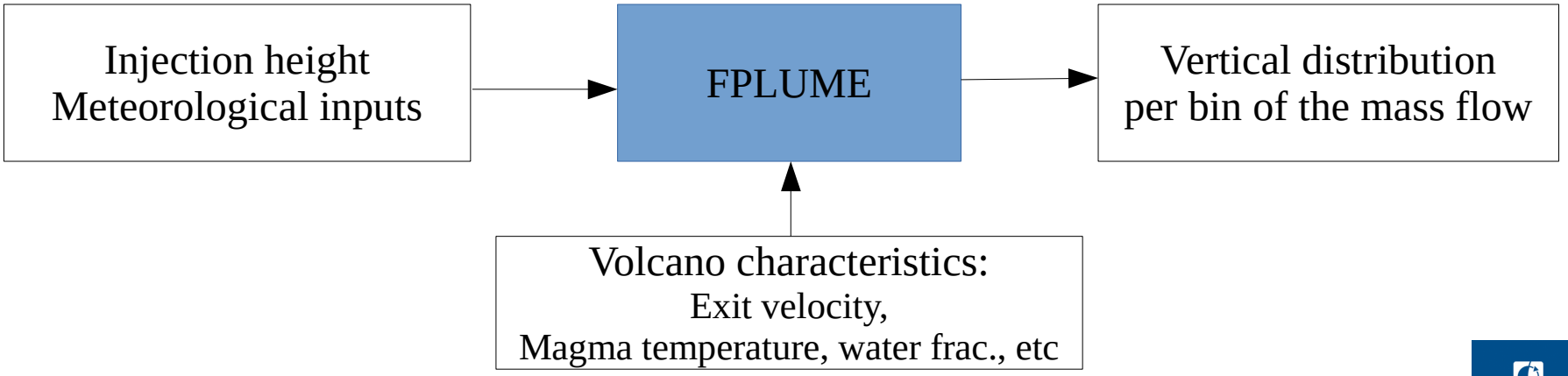
Future work


Day D-1
Day D
00:00
2:00 AM
4:30 AM
5:30 AM
7:30 AM
Initialisation file (Analyses of D-1)
Geting MODIS Data (D-1) → Assimilation format
Production of input Data (D-1): Forcing + emission files
Performing 24 Hours Of AOD assimilation GLOBAL SCALE (1°x1°)
Assimilation Results
- Global Analyses of all types of Aerosols
- A poesterori diagnostics (OMF, OMA, increments, ...)
- ...
Including Lidar profiles From E-PROFILE

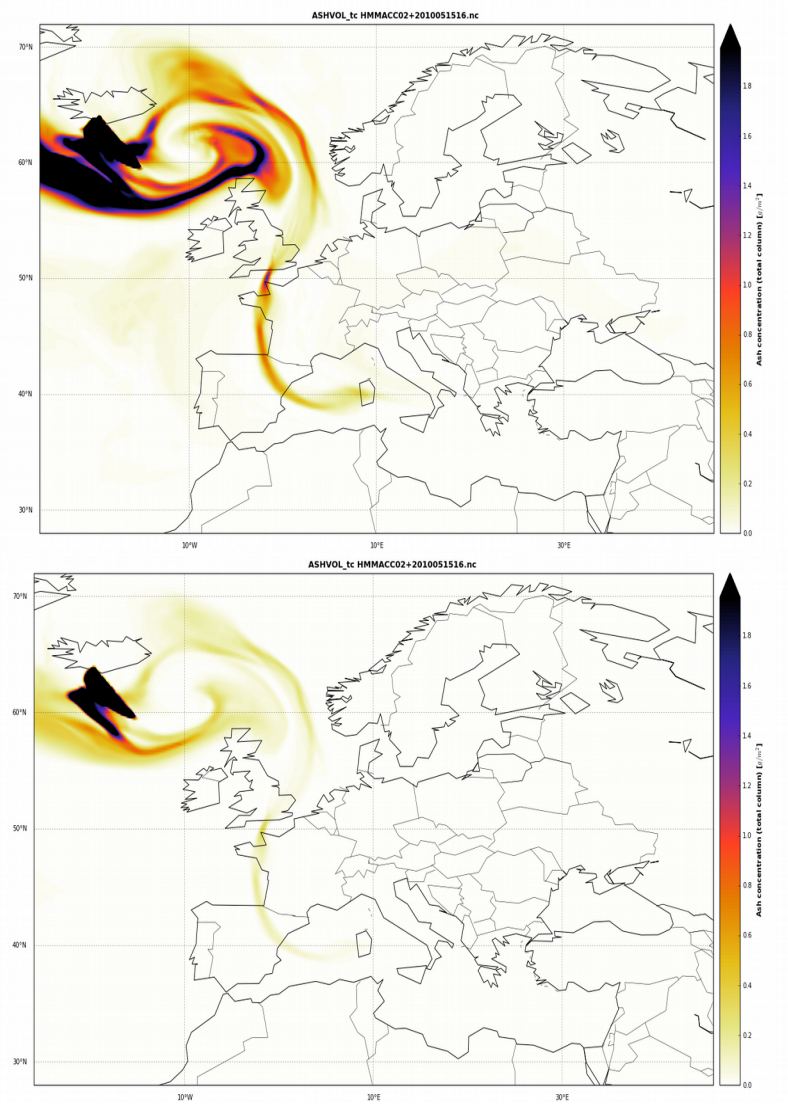
MODIS data assimilation on a volcanic eruption

2010 Eyjafjoll eruption

- Study the impact of assimilation for volcanic eruption tracking : Eyjafjoll 2010 case study
- Big incertitude on the emission (mass, injection height, vertical distribution, etc)
- MODIS AOD data assimilation
- Vertical distribution of the source:
  - Historically we use Mastins et al. (2009)
  - Recently: implementation of FPLUME (Folch et al., 2016)



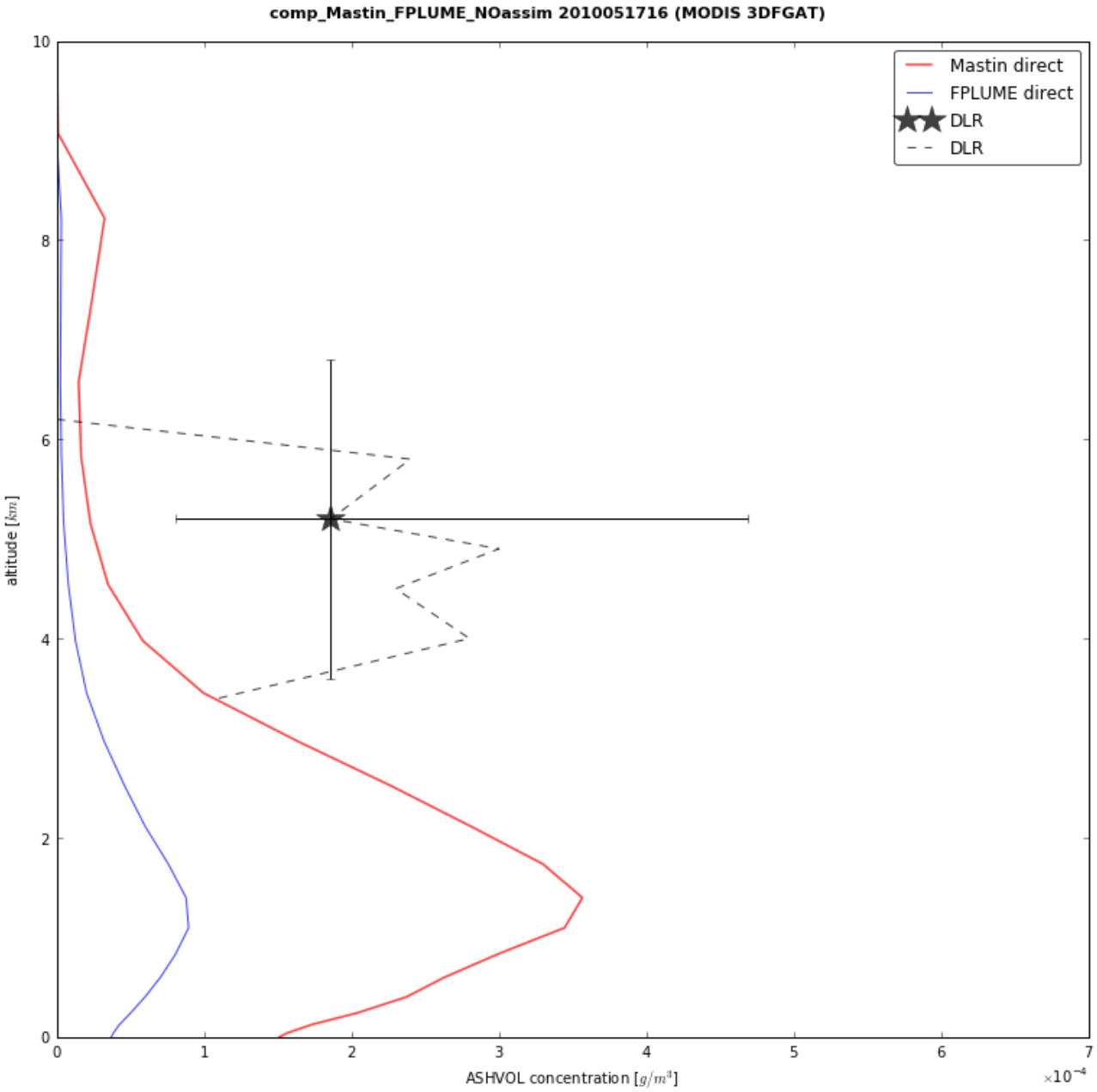
Mastins Vs FPLUME: Ash column



- Mastins: Gives more volcanic ash

- FPLUME: Seems more realistic

Mastins Vs FPLUME: Ash concentration



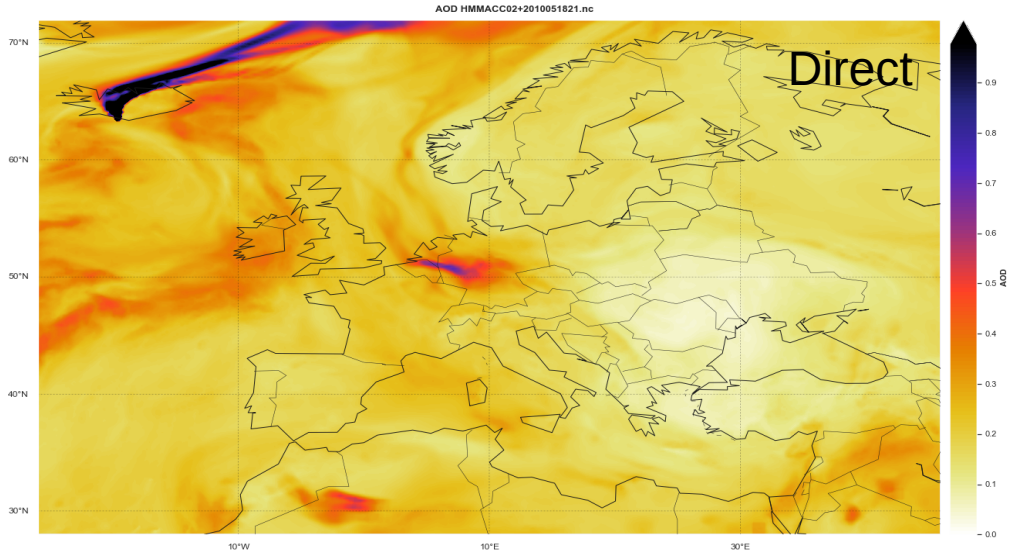
- Comparison with in-situ aircraft data over Germany
- Both approach gives a maximum too law in altitude → dynamic of the model
- Diverging results

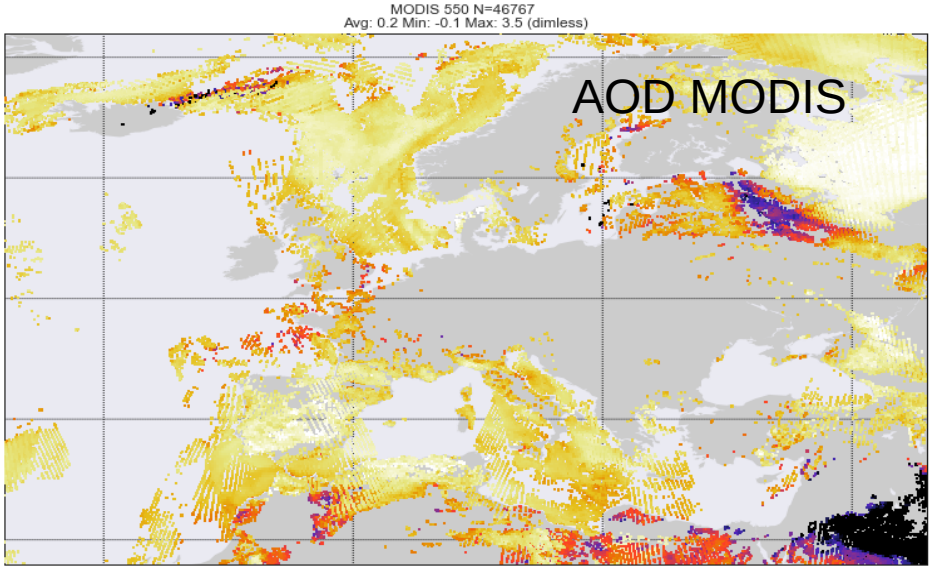
➔ Interest for data assimilation

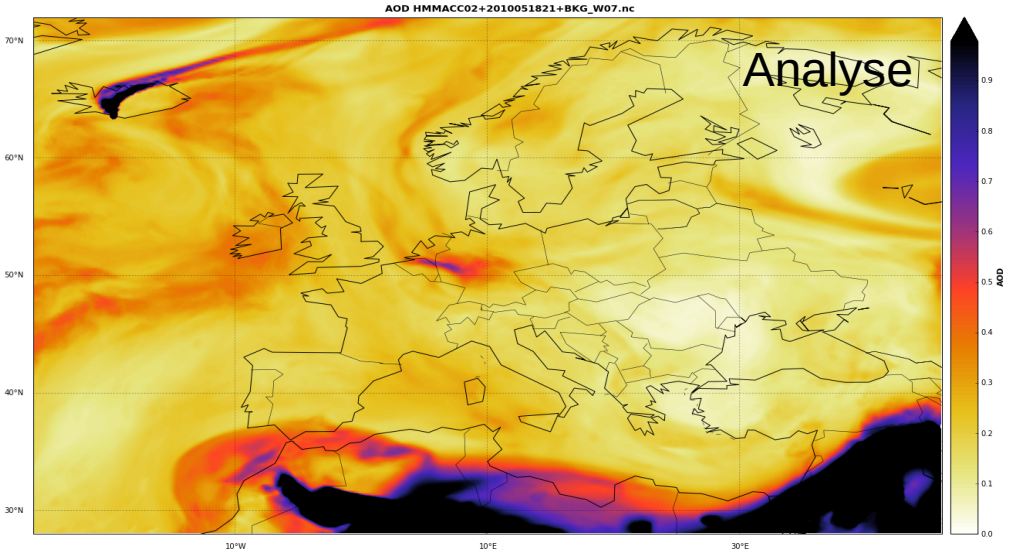
ly 2019

METEO FRANCE

MODIS AOD data assimilation (here with FPLUME)

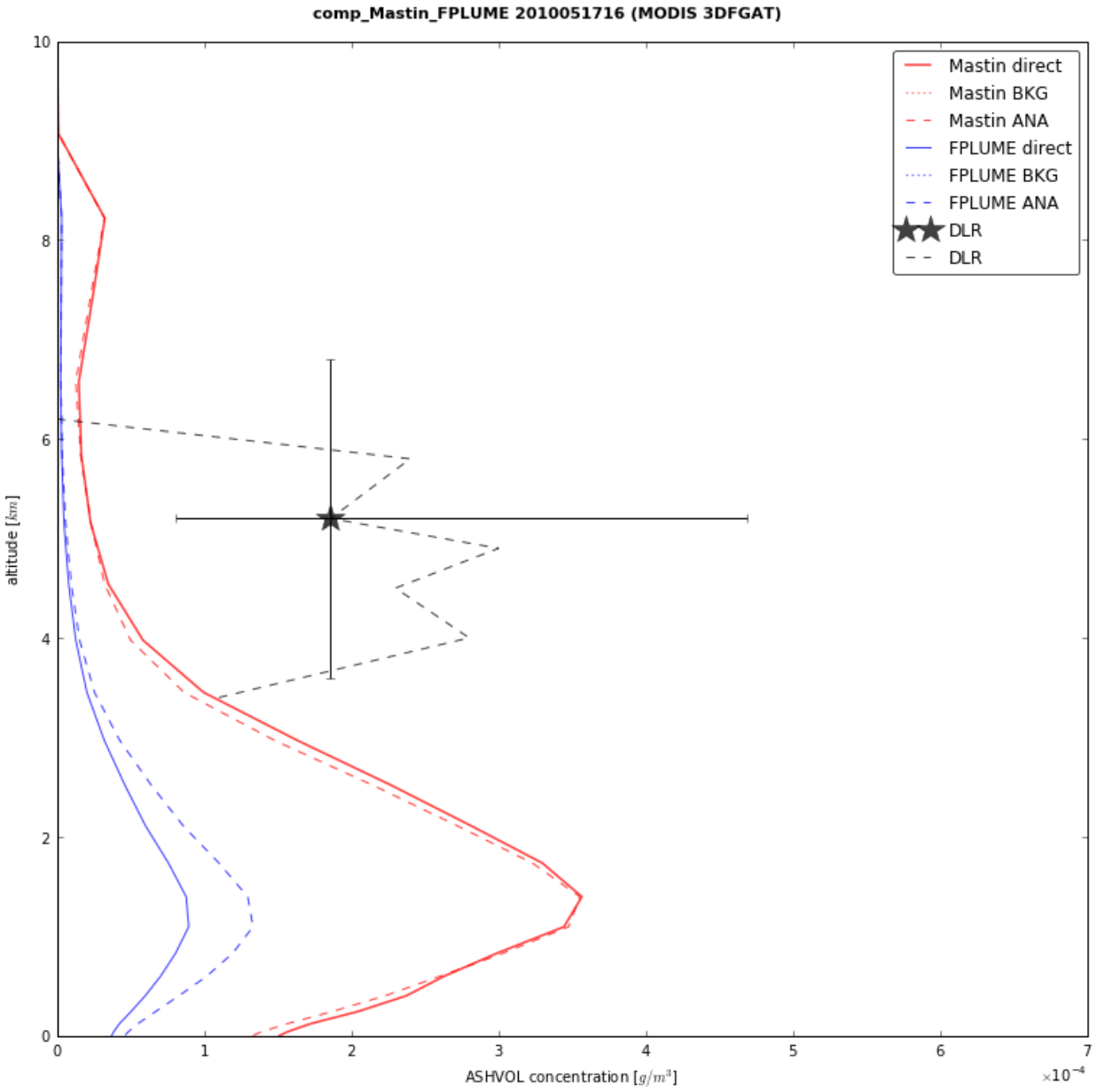






- 3D-FGAT Data assimilation
  - Reduction of the geographic extension of the ash cloud
  - Correction of a missed desert dust event in the South

Ash concentration versus observations



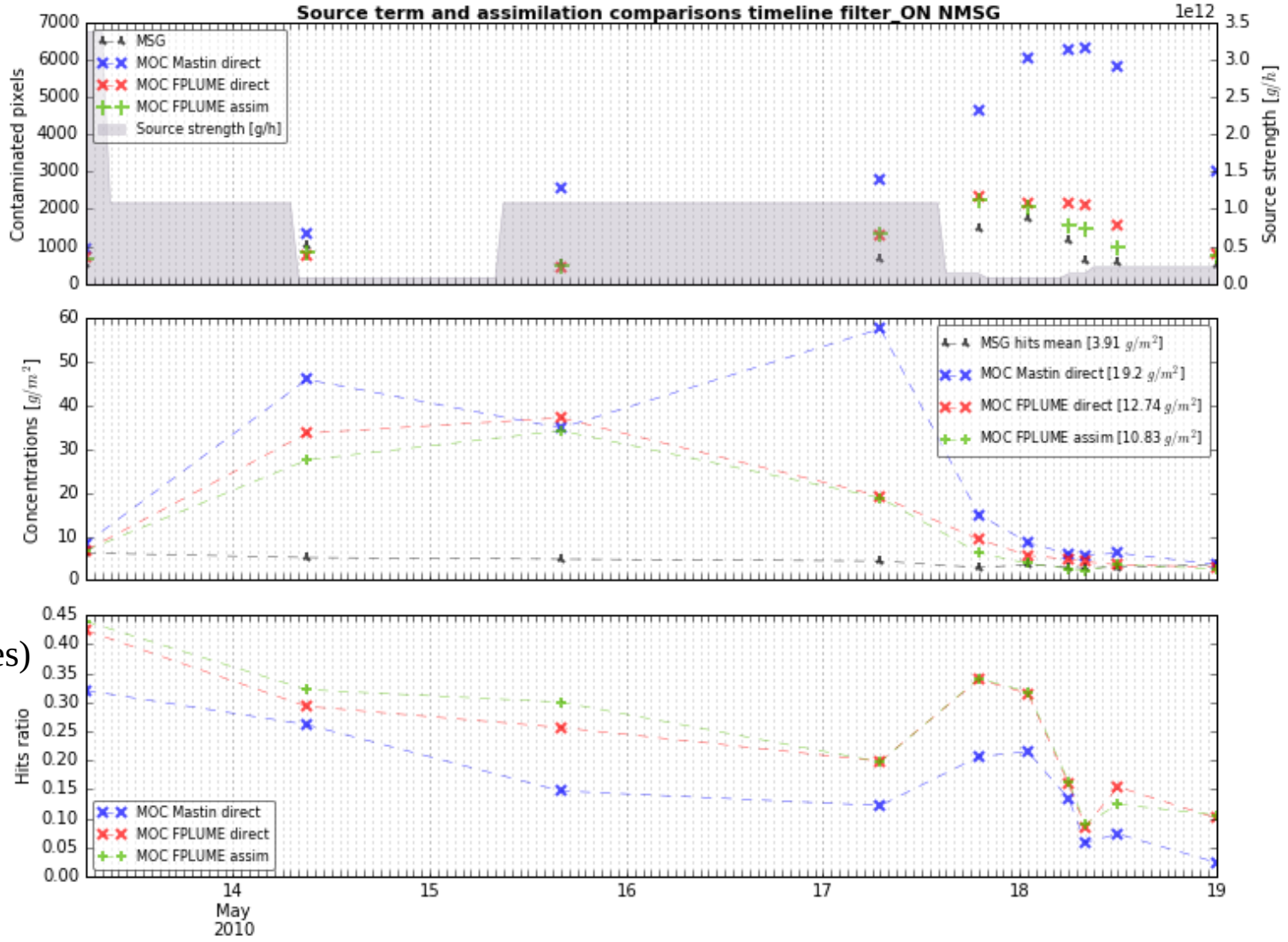
- Limited impact on the vertical distribution
  - Need for lidar data assimilation
  - Earlinet DA in progress

Comparison with MSG ash product

Number of detected ash cell (C > 1g/m^2)

Mass concentration (MSG ash concentrations are given with big incertitudes)

Hits ratio = Hits / (Hits + Misses)



First Caliop data assimilation attempt

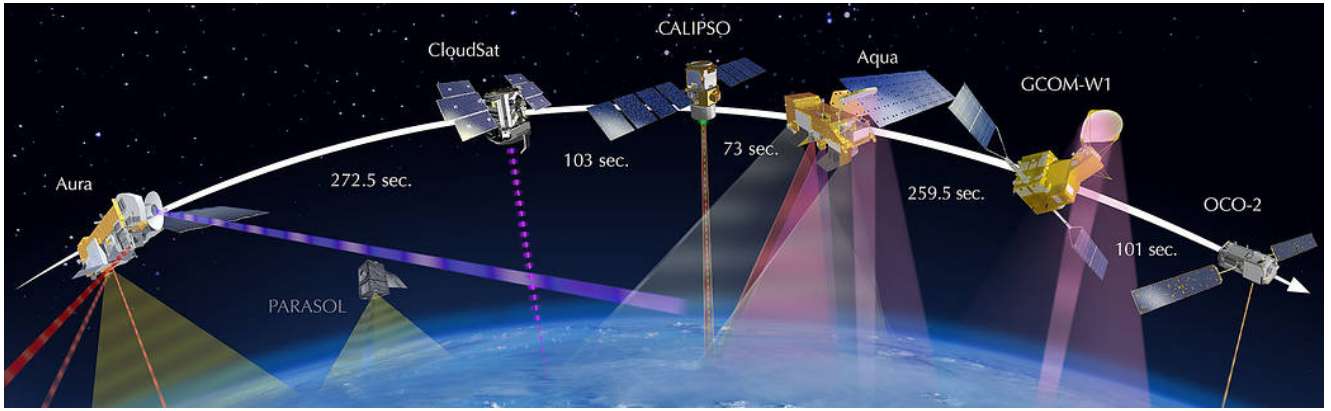
CALIPSO – Mission

- **CALIPSO** mission launched April 28, 2006
  → Heliosynchronous orbit – low altitude (705-km / 98.2°)

- Objectives :
  → Specify the estimation of radiative flux waves and atmospheric warming.
  → Obtain a more accurate assessment of climate cloud feedback.
  → Improve the estimation of the direct and indirect effect of aerosols.

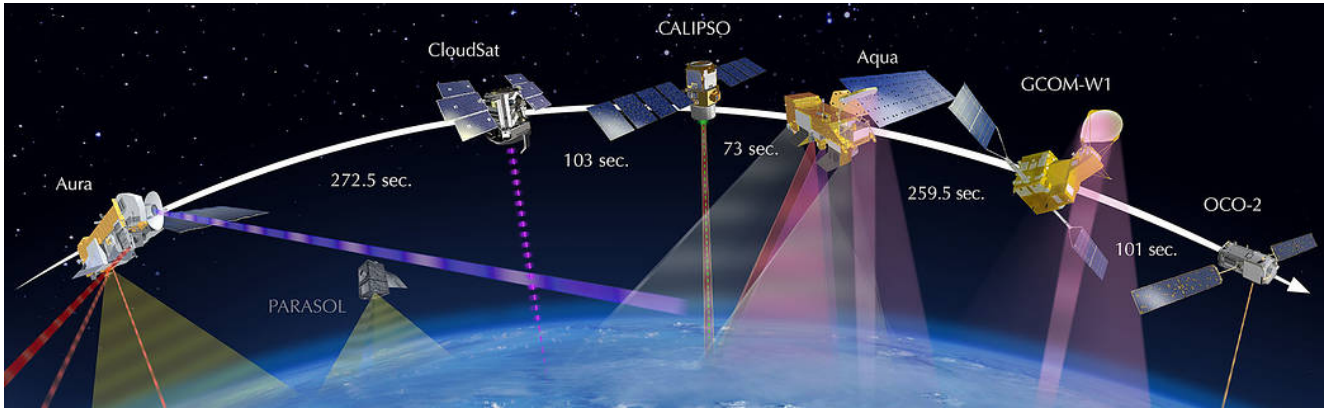
- Instruments :
  → IIR (Imaging Infrared Radiometer)
  → WFC (Wide Field Camera)
  → CALIOP

  – CNES
  – Ball Aerospace
  – NASA



CALIOP – Instrument

- **CALIOP** : Cloud-Aerosol Lidar with Orthogonal Polarization
- Elastic backscatter vertical profile acquisition (1064 & 532 nm)
- Measurement of vertical distribution of aerosols and clouds
  Recovery of extinction coefficient profiles
- New! Observations above reflective (desert), and under thin clouds



CALIOP – Assimilation

- **Objective:** Assimilation of lidar data from the CALIOP instrument in MOCAGE CTM of Météo-France

  Quantity assimilated :

  Extinction coefficient at 532 nm

  Quantities studied :

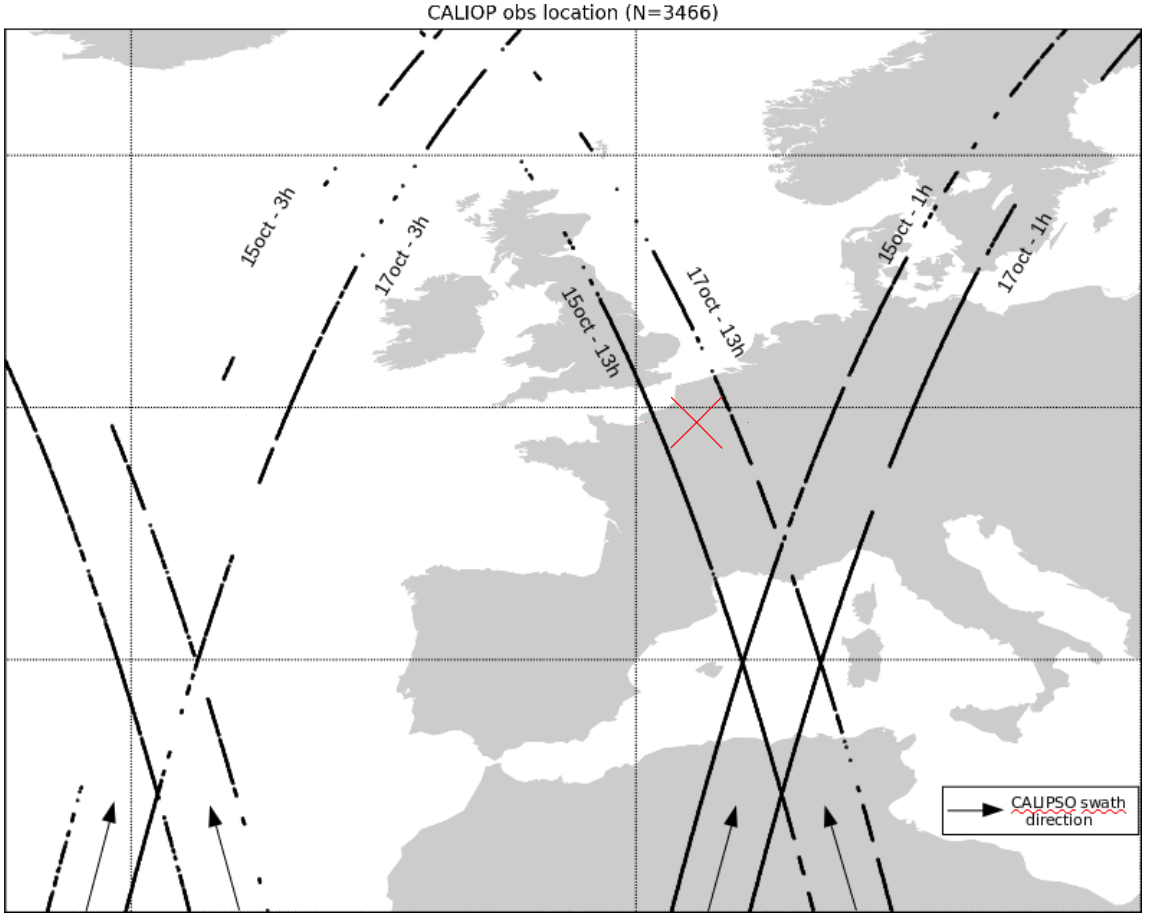
  Aerosols total column (Desert dust, Black carbon, ...)
  Aerosol optical thickness (AOD)
  Fine particles (PM10 – PM2.5)

- Configuration MOCAGE:

  Global Domain - Resolution 1 ° x 1 °

Desert Dust focus

- Case of the Ophelia Storm (October 9th – October 19th, 2017)



Geographical location of observation on CALIOP's swath between 15/10-18/10

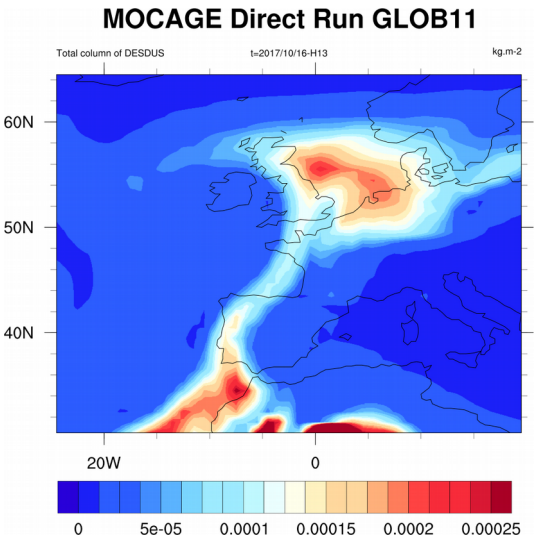
CALIOP – Assimilation

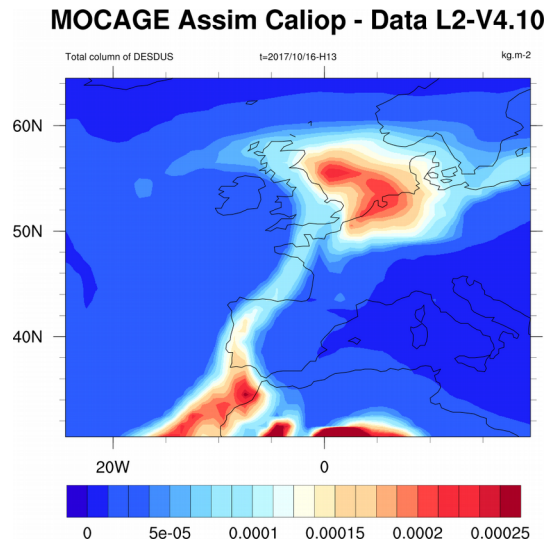
- Model evaluation of desert dust total column

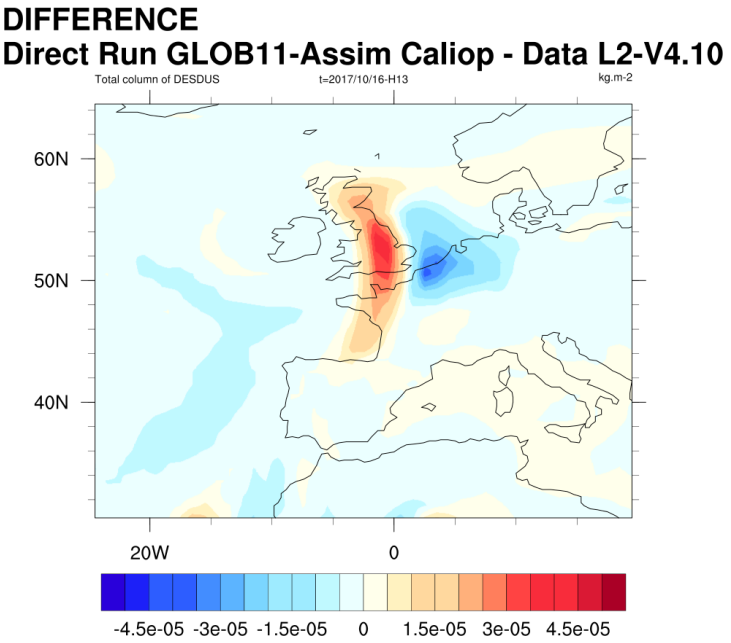
- Weak difference between simulations:
  - Shape similar
  - Difference in terms of intensity

- Causes ?
  → Restricted spatial coverage of Caliop

  → Lack of data during the event. Intensity too high for the instrument ?





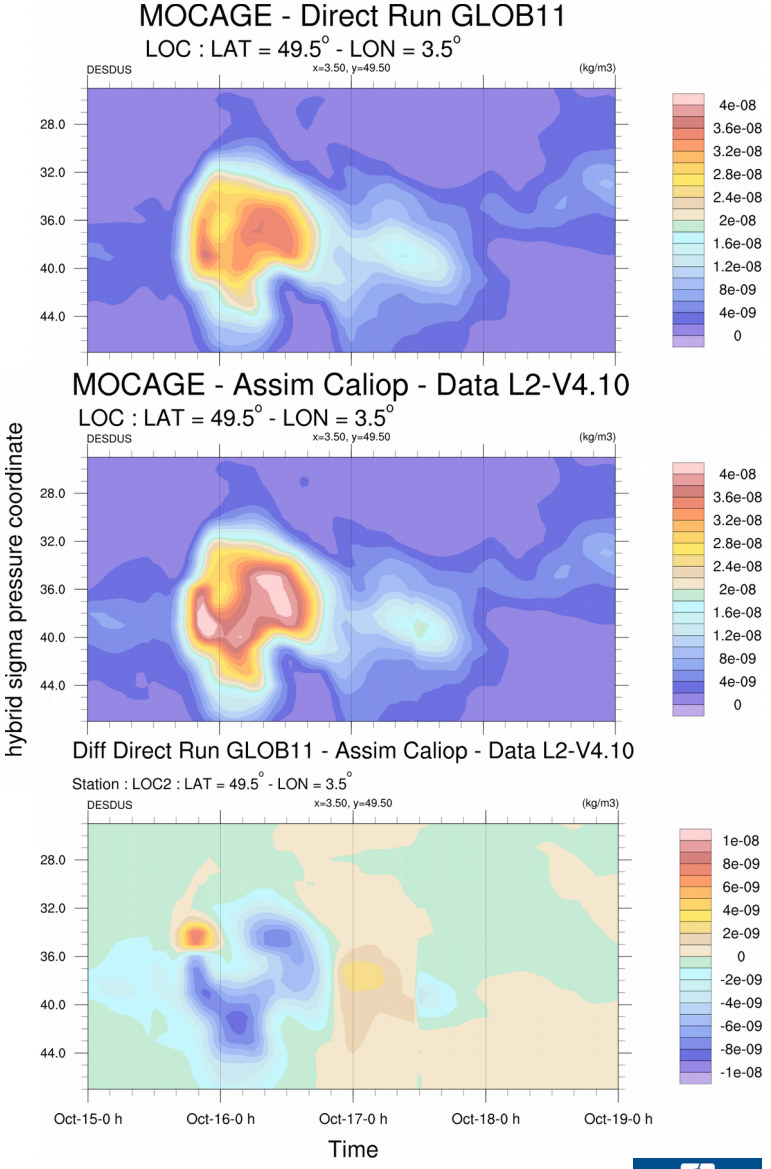


CALIOP – Assimilation

- Model evaluation of desert dust column.
  → Vertical profiles over time

- Difference between simulations inside the atmospheric column
  - Difference in terms of intensity
  - Difference in terms of distribution

- Locally Caliop assimilation induce deep change in the atmospheric column



CALIOP – Assimilation

- Difficult to evaluate CALIOP contribution for such a localised event over a short period.

  Different reasons :
  - the spatial coverage of CALIOP swaths
  - the availability of CALIOP data

- For such case, this instrument seems less efficient to assimilated in the MCT Mocage then an instrument like MODIS with a good spatial coverage.

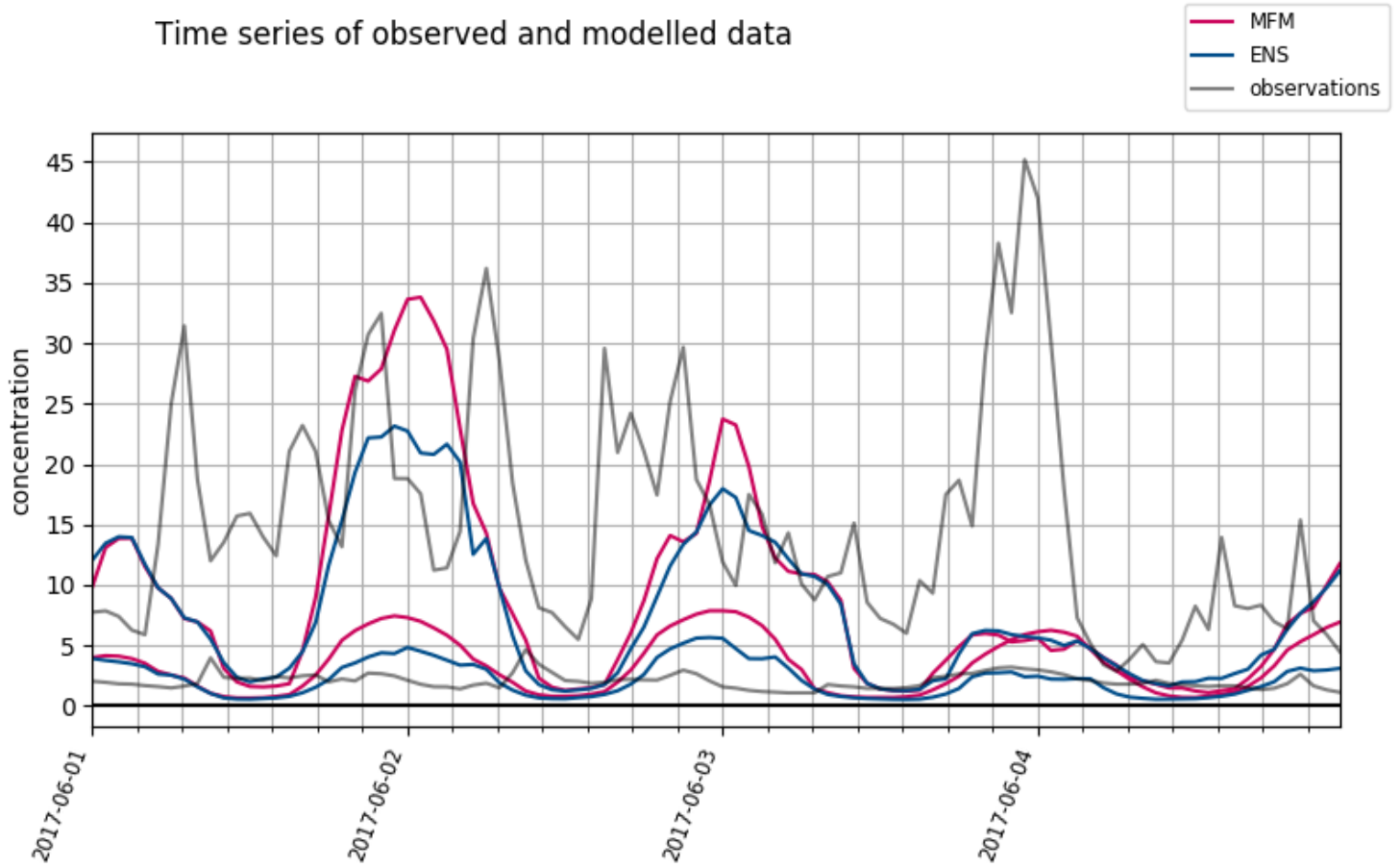
- However several studies showed that CALIOP seems more efficient to characterise tendencies over longer period. [1]

[1] Ma, X., Bartlett, K., Harmon, K., and Yu, F.: Comparison of AOD between CALIPSO and MODIS: significant differences over major dust and biomass burning regions, Atmos. Meas. Tech., 6, 2391-2401, https://doi.org/10.5194/amt-6-2391-2013, 2013.

Evaltools: a python package for evaluation

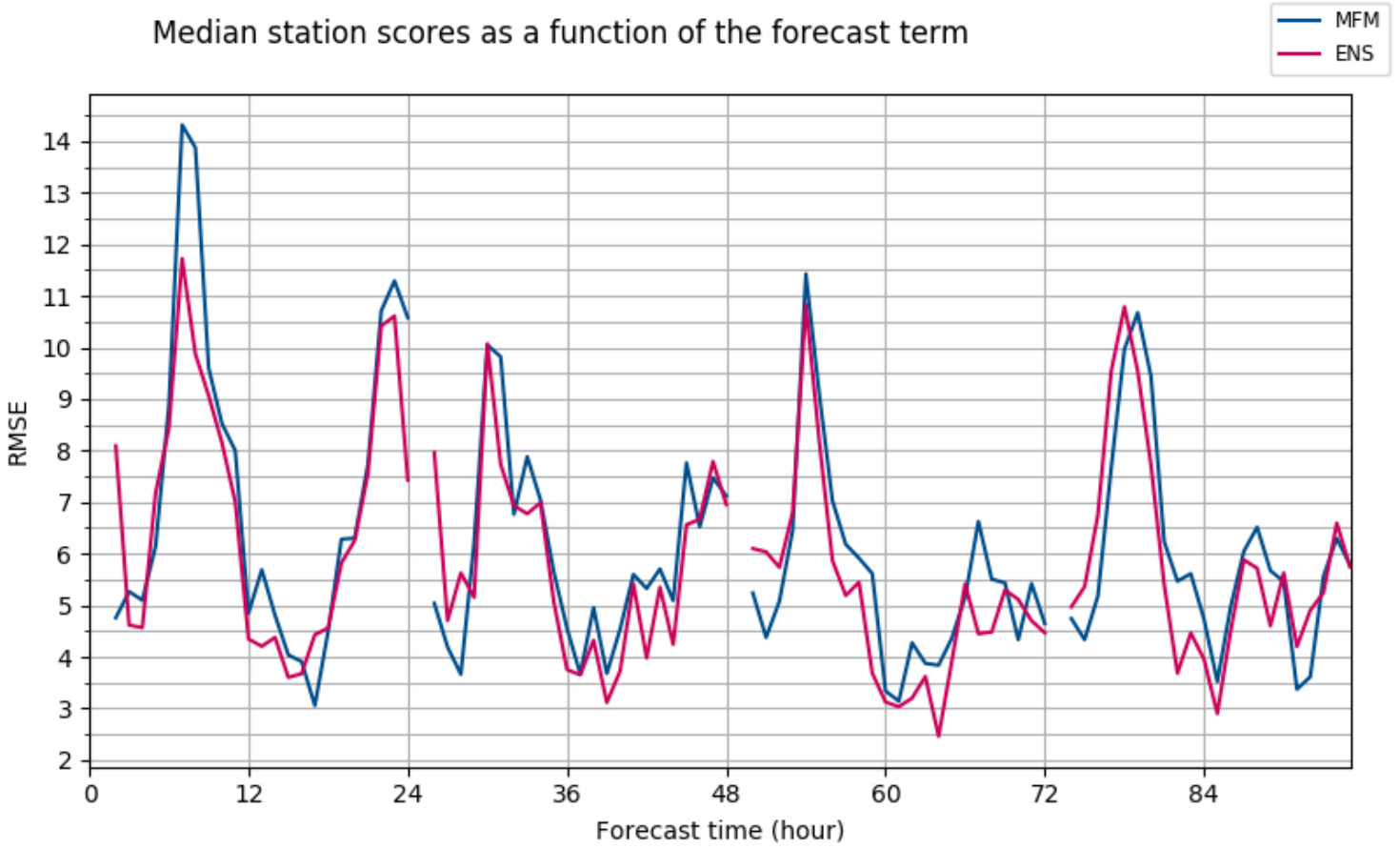
Evaltools: a python package for evaluation

The Python package evaltools is developed inside Copernicus Atmosphere Monitoring Service (CAMS) project. It is designed to assess surface atmosphere composition prediction models regarding to in-situ observations. This package provides different tools to compute model scores and plot them.

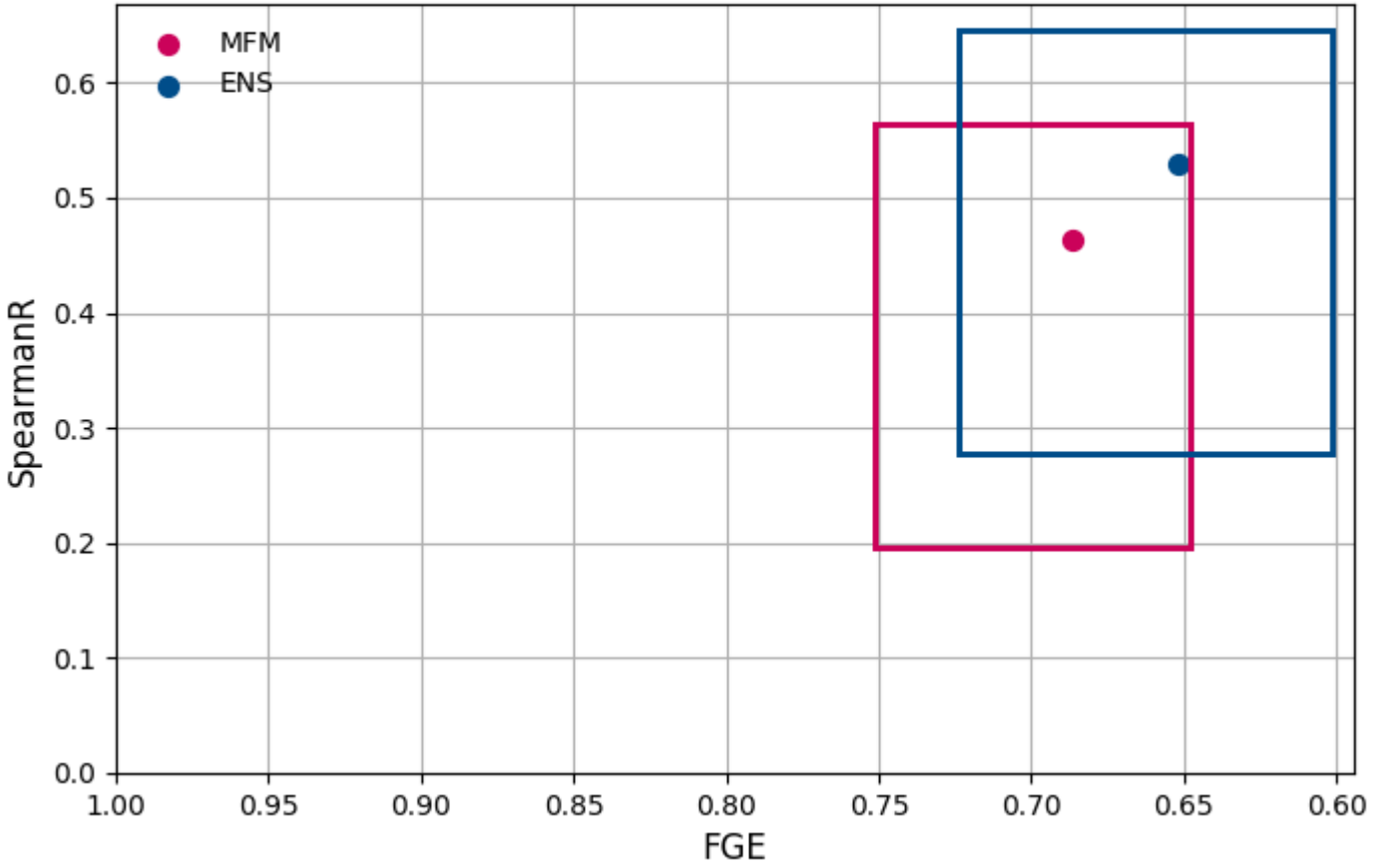


Evaltools: a python package for evaluation

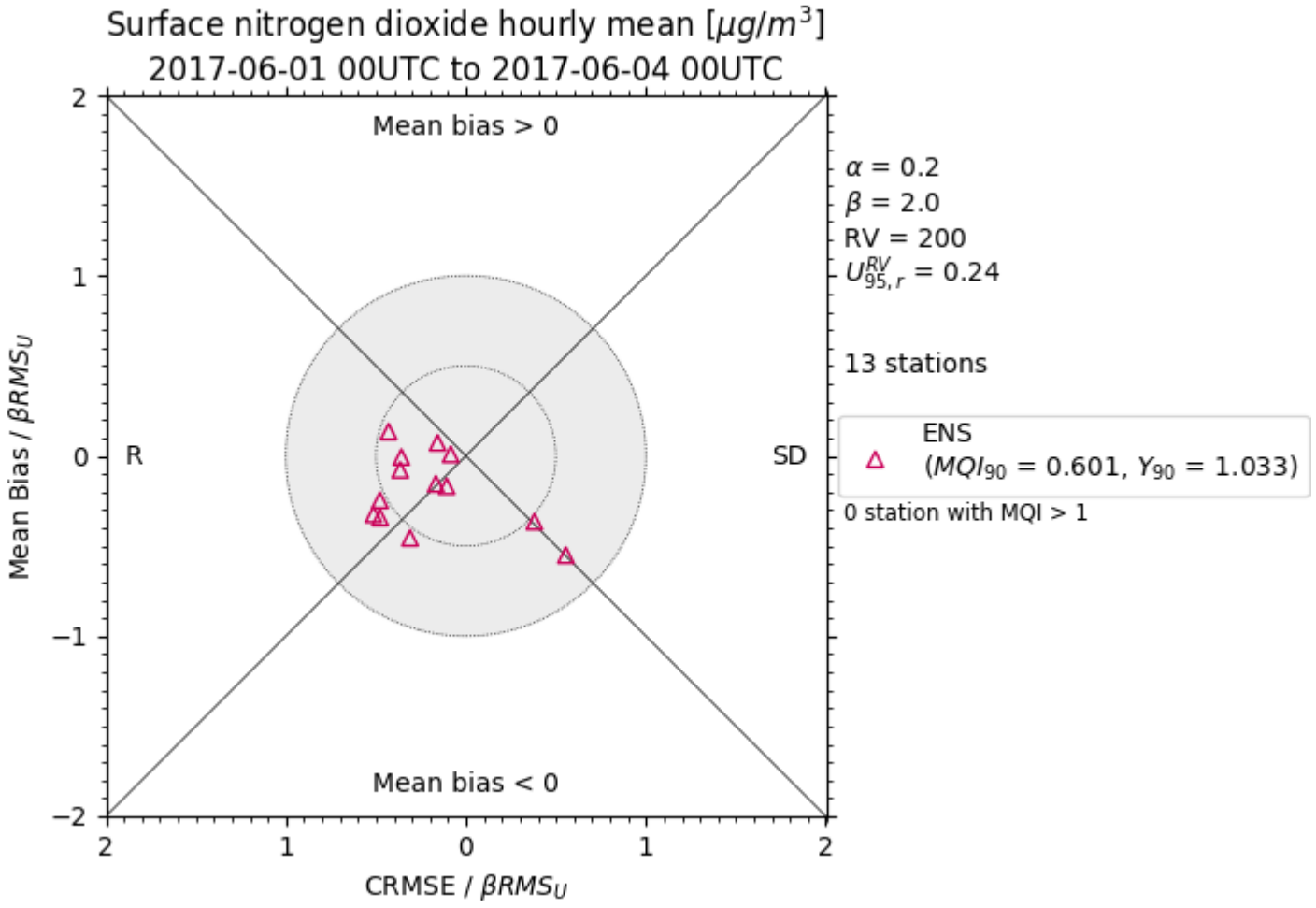
The concept of evaltools is to compare observations (measured over time in fixed lat/lon locations) to simulations (that can have a forecast horizon of several days) computed over a period of several days. Therefore, it can be suited for other data types like AERONET data, but will not manage data with a vertical component.



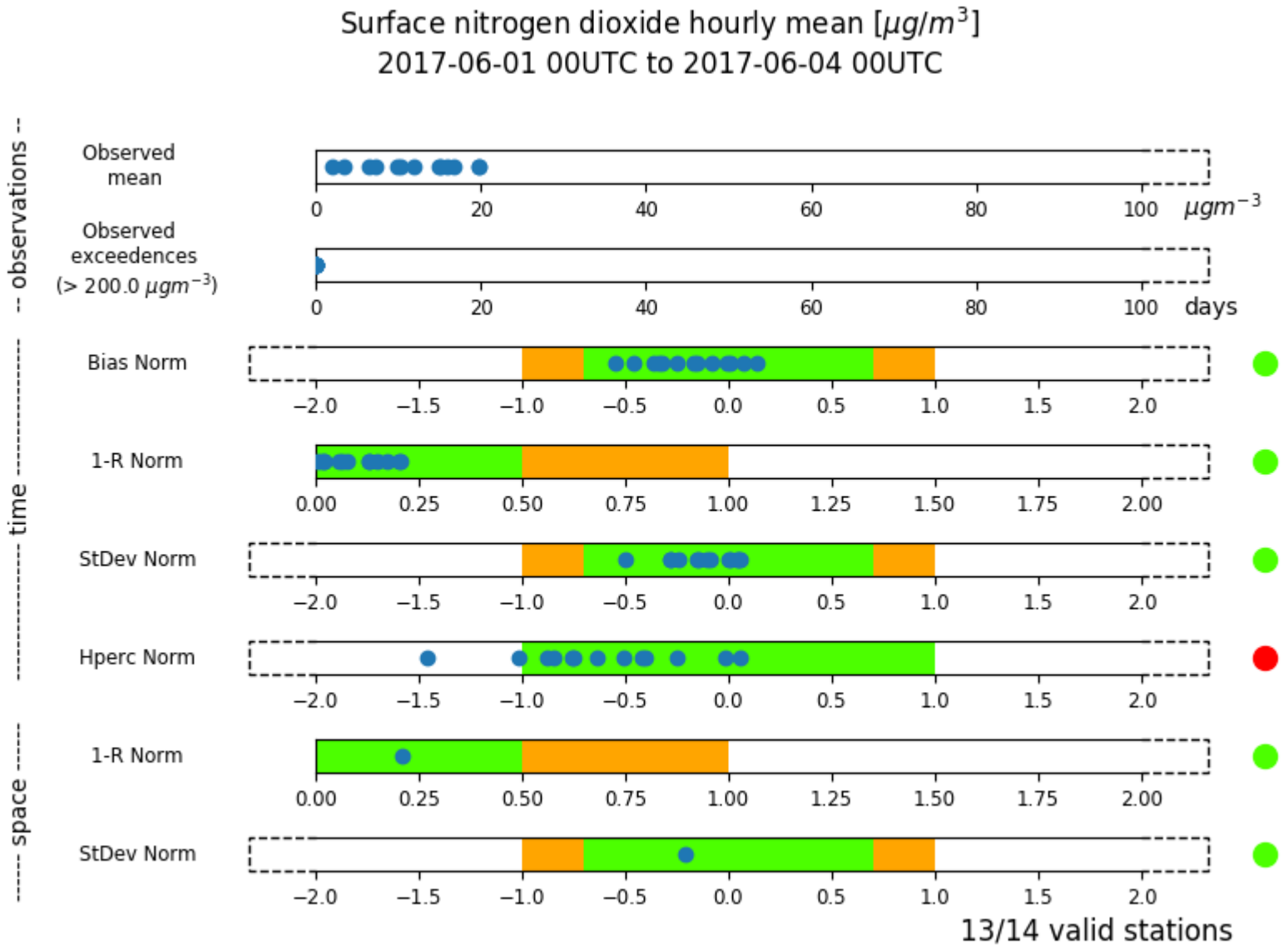
Scatter plot of score quartiles



Fairmode diagrams: Target diagram

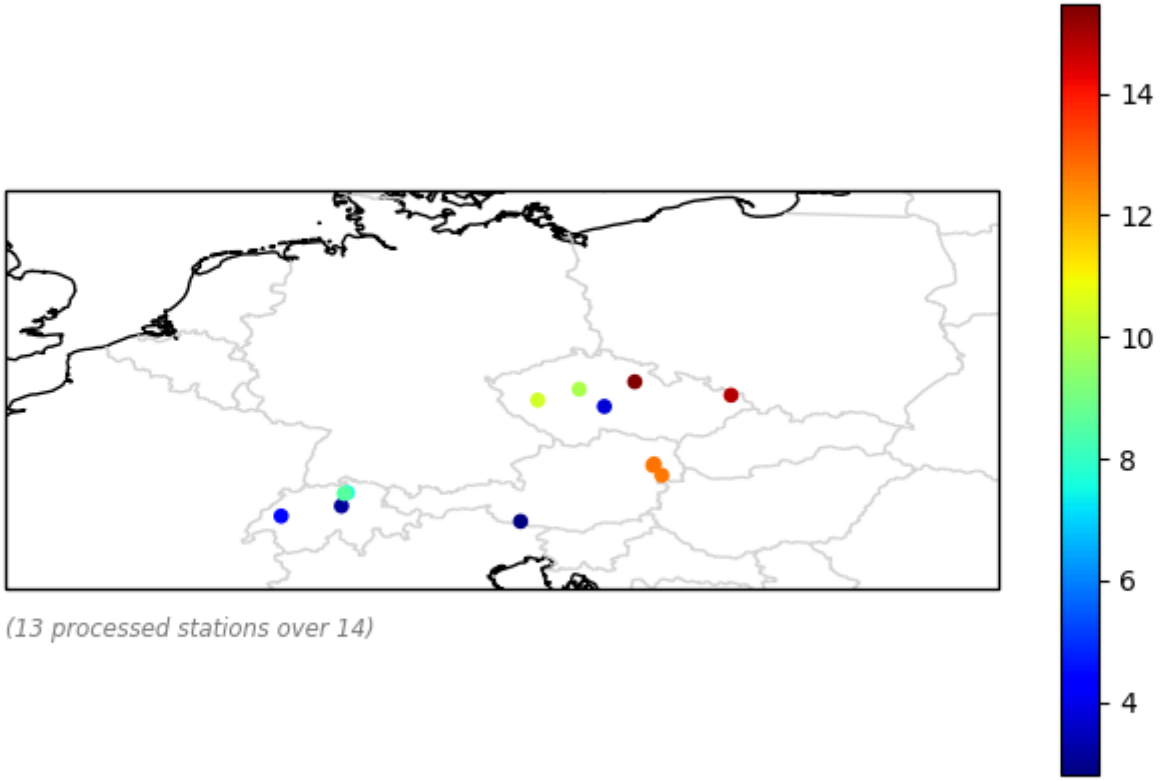


Fairmode diagrams: summary report



Evaltools website for documentation and download

https://opensource.umr-cnrm.fr/projects/evaltools



Conclusion - Perspectives

- Pre-operational MODIS AOD data assimilation chain is running everyday
- Work on data assimilation combining both MODIS and lidar data in progress

  → All dates are subject to changes because of the replacement of the HPC system at Météo-France next year

- Python package evaltool made for model evaluation comparison to in-situ data is able for you to test:

  https://opensource.umr-cnrm.fr/projects/evaltools

Thank you for your attention !

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