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## The Copernicus CO2M mission

### Mission objectives

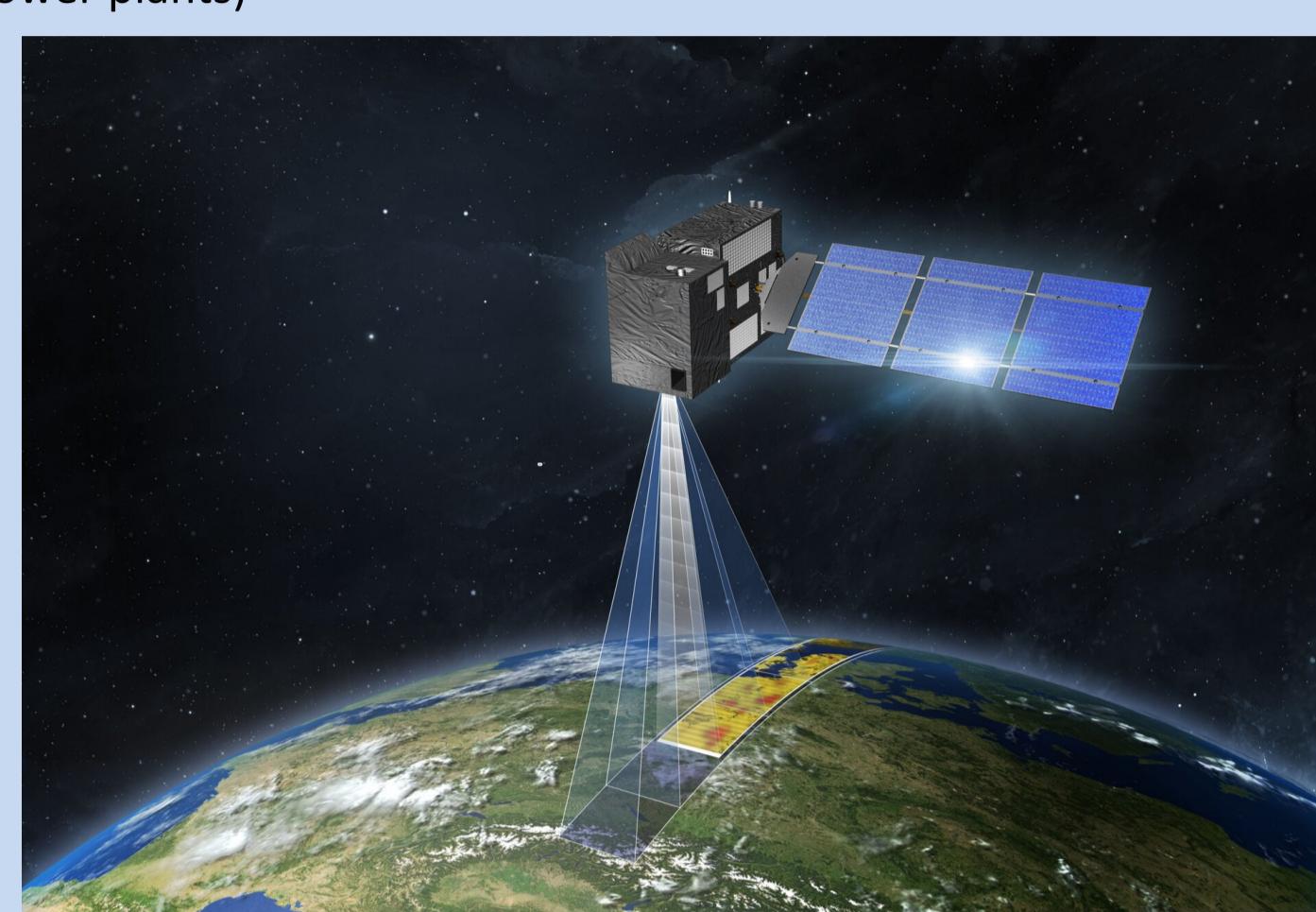
- Accurate, medium-resolution mapping of CO<sub>2</sub> and methane concentrations
- Detection and monitoring of emission hot spots (e.g., megacities, power plants)

### Mission requirements for CO<sub>2</sub> products

- Precision: 0.7 ppm
- Systematic error: < 0.5 ppm
- Spatial resolution: 2 x 2 km<sup>2</sup>
- Spatial scale: 250 x 250 km<sup>2</sup>

### Payload

- CO2IS: Spectrometer for CO<sub>2</sub> and methane measurements
- MAP: multi-angle polarimeter for aerosol characterization
- CLIM: cloud imager
- NO2IS: Spectrometer for NO<sub>2</sub> measurement

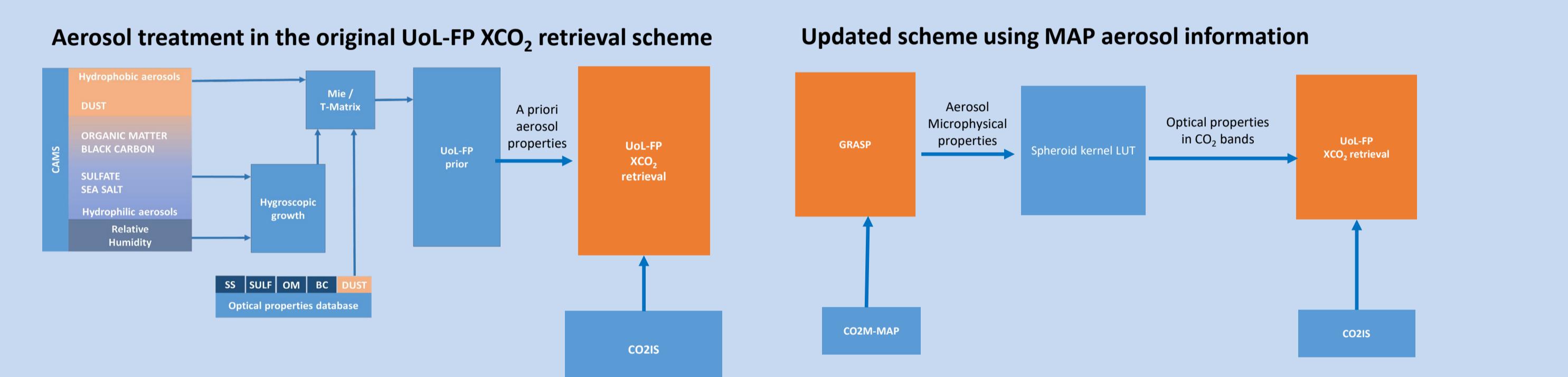


## Objectives of this study

- Develop a sequential retrieval using MAP aerosol information as a priori for the University of Leicester (UoL) CO<sub>2</sub> retrieval
- Optimize the MAP aerosol retrieval – based on GRASP – to provide a useful aerosol characterization for the UoL CO<sub>2</sub> retrieval
- Adapt the UoL CO<sub>2</sub> retrieval to better use the aerosol information provided by MAP

## GRASP-UoL sequential retrieval concept

- The standard University of Leicester XCO<sub>2</sub> retrieval uses CAMS climatology to generate scene-dependent a priori and optical properties for aerosols
- The approach we are developing replaces CAMS-based a priori with aerosols retrieved from MAP
- Aerosol retrievals from MAP are carried out through the GRASP algorithm
- Look-up table from Dubovik et al. (2006) used to compute optical properties at CO<sub>2</sub> channels from MAP-derived aerosol microphysical properties  
(doi: [10.1029/2005JD006619](https://doi.org/10.1029/2005JD006619))

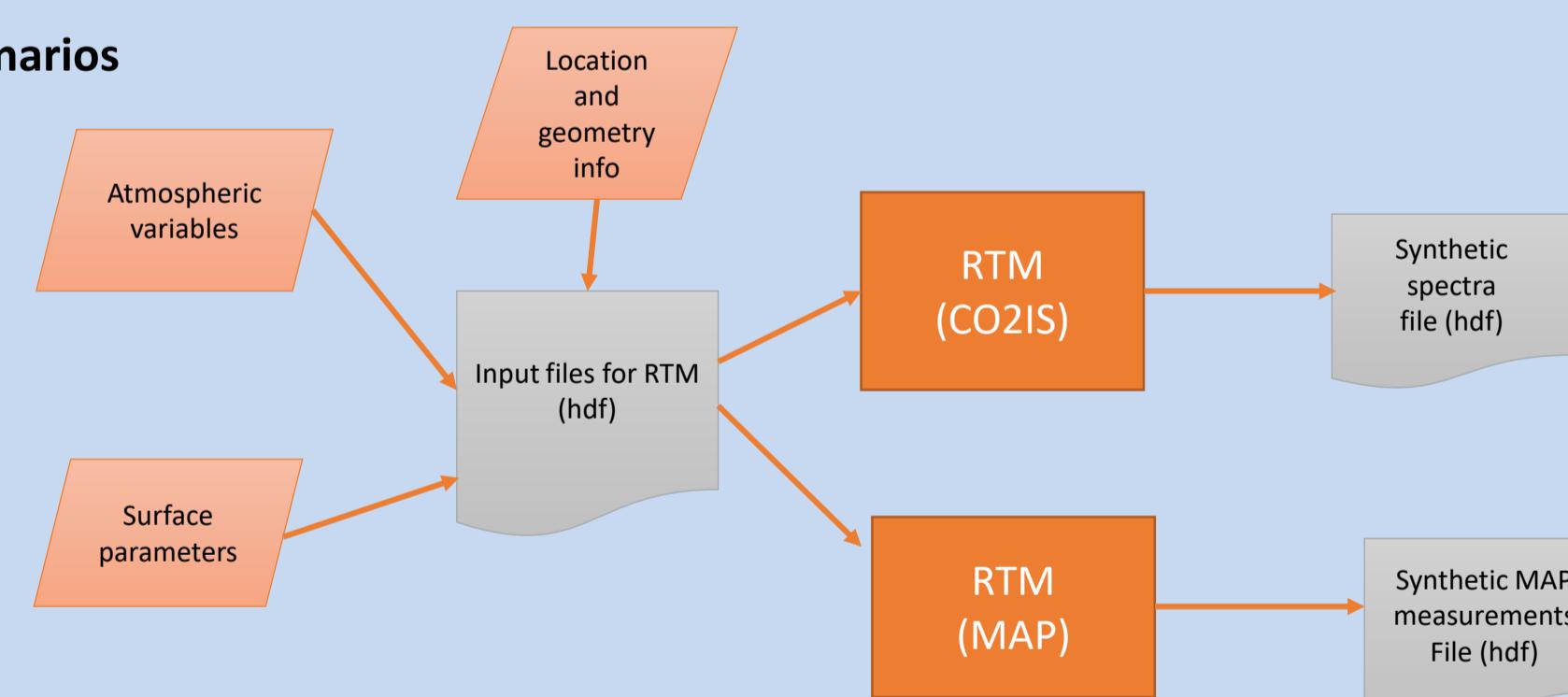
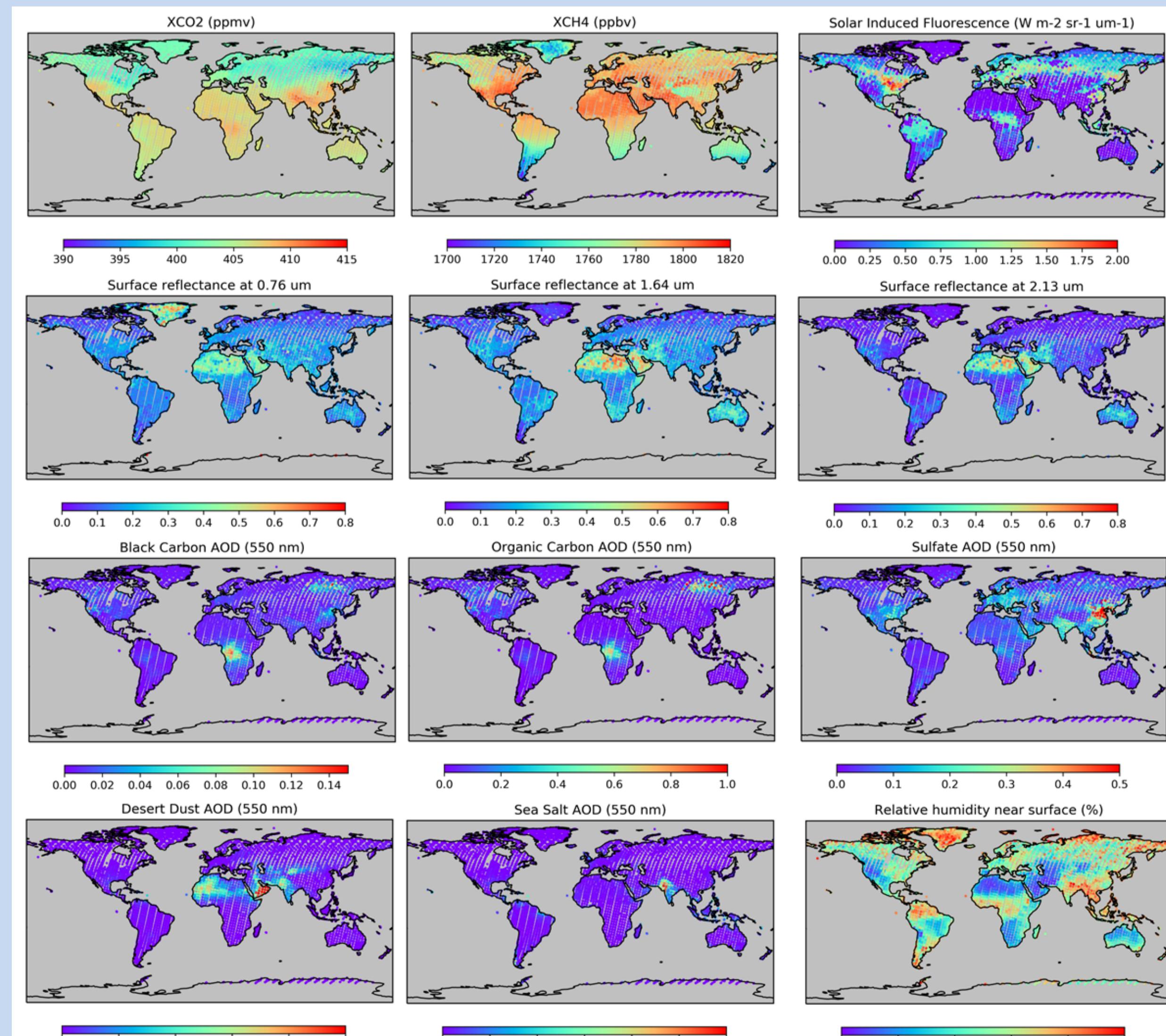


## Synthetic dataset for algorithm evaluation

### Synthetic dataset encompassing ~60000 realistic scenarios

- CO<sub>2</sub> profiles from CarbonTracker
- CH<sub>4</sub> profiles from CAMS
- Aerosol mass mixing ratio profiles from MERRA-2
- Solar induced fluorescence from OCO-2/MODIS
- Surface reflectance from MODIS
- Meteorological variables from ECMWF ERA-5
- Clouds not considered at the moment

### Only land observations considered



## CO<sub>2</sub> retrievals without MAP aerosol input

### XCO<sub>2</sub> retrieval algorithm

- Retrieval based on optimal estimation
- Pre-retrieval of Solar Induced Fluorescence using Fraunhofer lines
- CO<sub>2</sub> volume mixing ratio profiled retrieved at 20 pressure levels
- Extinction profiles for two aerosol modes retrieved alongside CO<sub>2</sub>

### Experimental setup

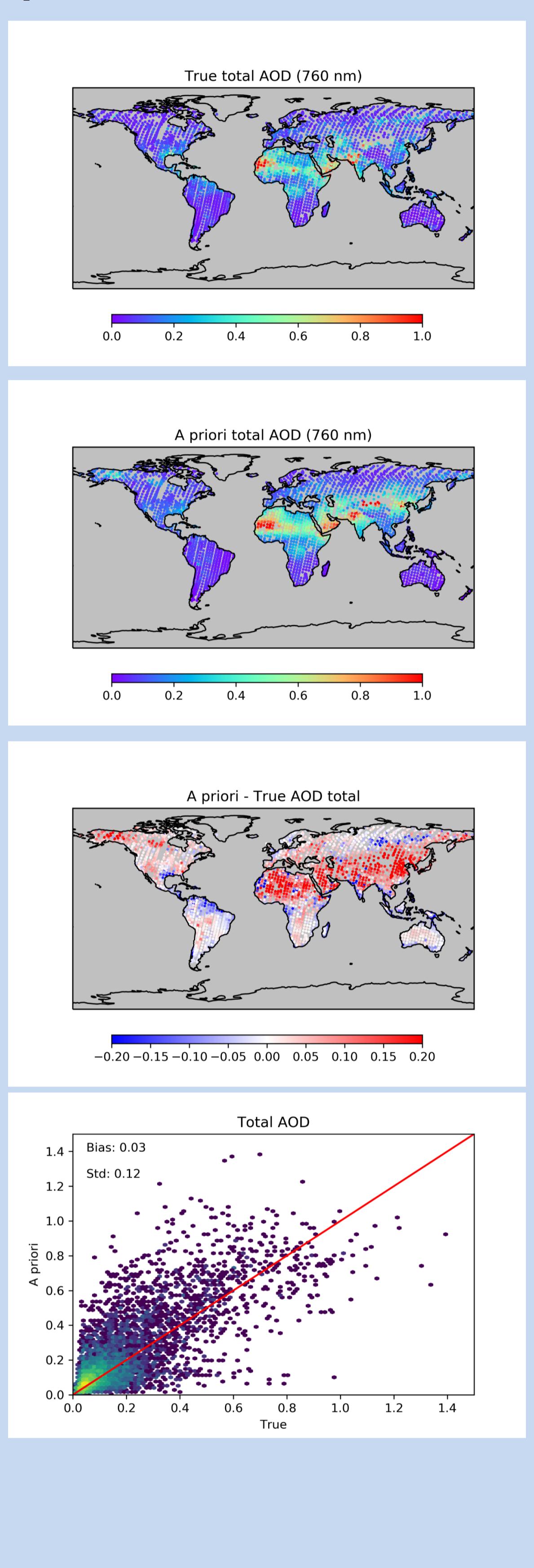
A priori meteorological quantities assumed perfectly known, to isolate the effect of aerosols on the XCO<sub>2</sub> retrieval

### Aerosol settings

- A priori aerosols from CAMS climatology
- Same aerosol types as in MERRA-2, but different setups
  - Different definition of size bins for sea salt and dust
  - Different optical properties
  - CAMS climatology used in retrieval a priori, MERRA-2 daily aerosols used for simulations

### Differences in assumptions between true and a priori aerosol optical properties

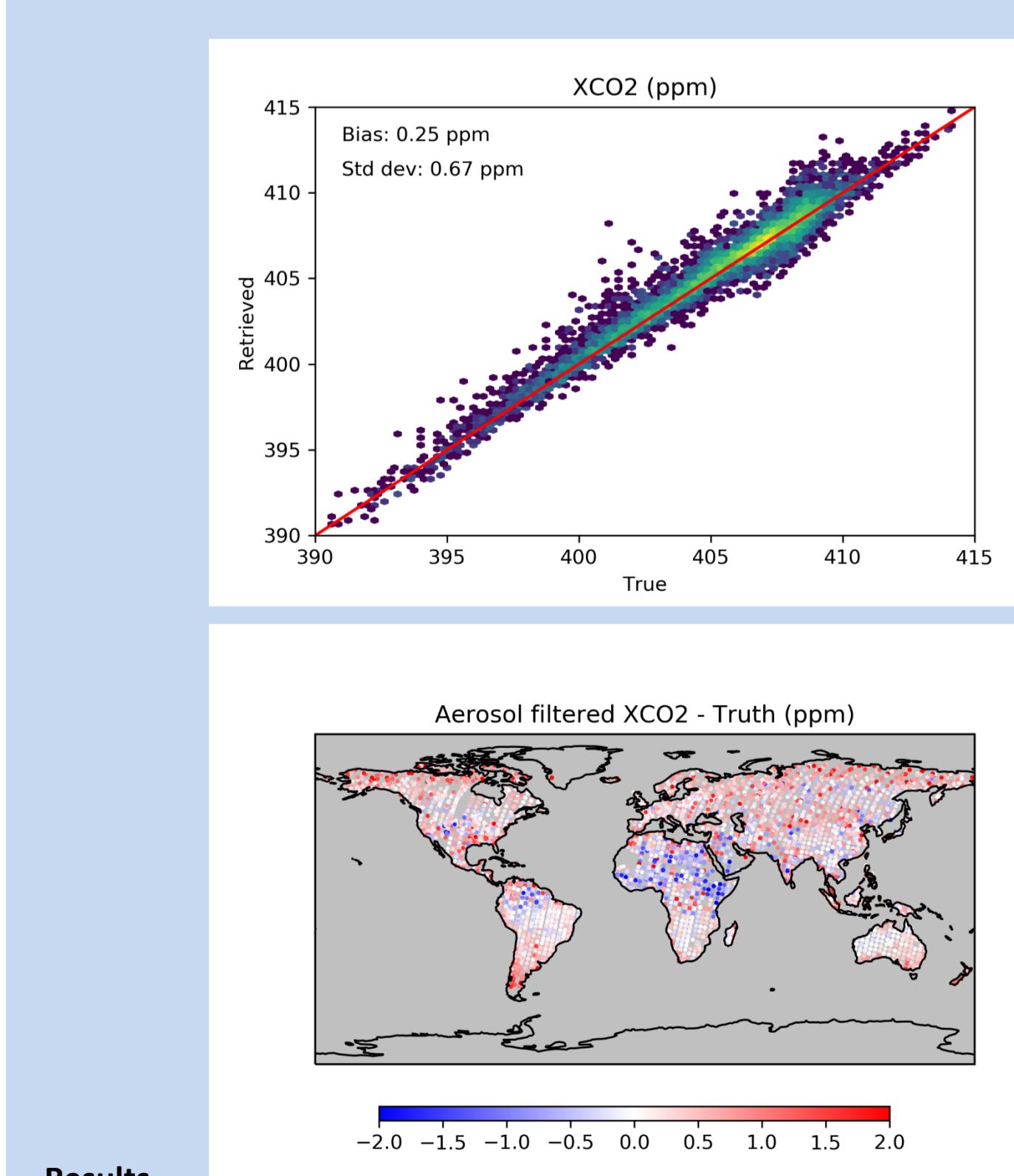
Aerosol type	CAMS (A priori)	MERRA-2 (truth)
Black carbon - hydrophilic	Hgropscosity not accounted for Size range: 0.005-0.5 μm	Hgropscosity considered Size range: 0.005-0.3 μm
Black carbon - hydrophobic	Size range: 0.005-0.5 μm	Size range: 0.005-0.3 μm
Organic carbon - hydrophilic	Mixture of 3 components (OPAC soot, INSO, WASO)	OPAC soot only
Organic carbon - hydrophobic	Mixture of 3 components (OPAC soot, INSO, WASO)	OPAC soot only
Desert dust	3 size bins	5 size bins
Sea salt	3 size bins	5 size bins
Sulfates	Dry mode radius = 0.04 μm	Dry mode radius = 0.07 μm



## CO<sub>2</sub> retrievals with MAP aerosol input: First results

### GRASP setup

- Two log-normal aerosol modes (fine, coarse)
- Retrieved aerosol properties for each mode
  - Volume concentration
  - Volume mean radius
  - Geometric standard deviation
  - Complex refractive index
  - Spherical particle fraction (coarse)
  - Aerosol layer height (common to both modes)
  - Refractive index linearly extrapolated to CO<sub>2</sub> bands



- GRASP retrieved AOD in line with GCOS requirements (max{0.03, 10%})
- MAP-based aerosol a priori globally brings XCO<sub>2</sub> difference standard deviation below 0.7 ppm requirement
- Bias requirement satisfied in 61% of cases for AOD < 0.5, further optimization needed for better performance
- Additional experiments will be needed to optimize the approach: work still in progress
  - Investigation of alternative GRASP retrieval settings (more than 2 modes, retrieval of chemical components)
  - Optimization of aerosol constraint strength in UoL-FP