Preliminary results from the ESA-funded Aerosol Radiance Assimilation Study

ESA LPS19: Atmospheric Satellite Data Assimilation

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European Space Agency

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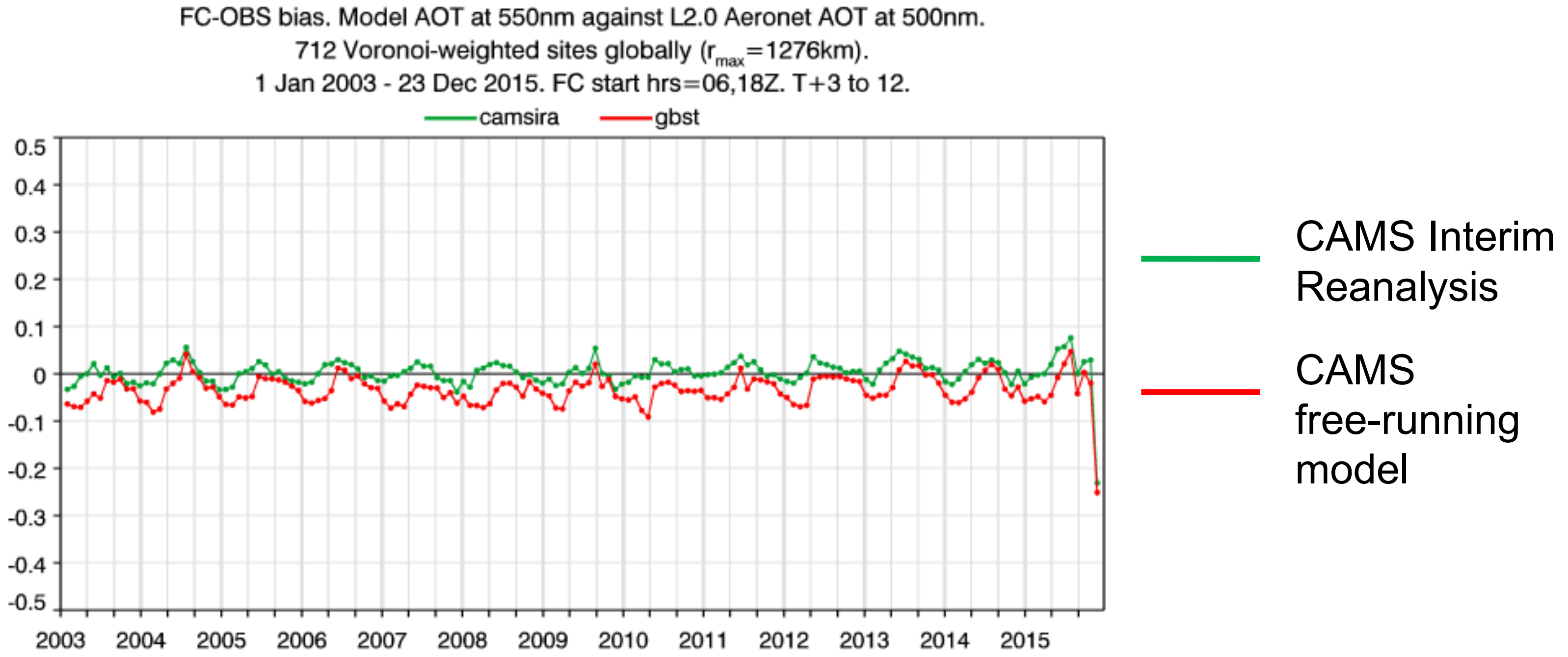
Presented by Ben Veihelmann, Technical Officer of the study, ESA, ESTEC

Outline

- Background
- Scientific motivation
- Technical challenges
- Selection of data and tools
- Experiment setup
- Preliminary results
- ARAS expectations

Background

- Large interest from the user community in the Copernicus Atmosphere Monitoring Service (CAMS) products related to aerosols
- Development of aerosol systems including assimilation of aerosol data for forecasting applications in the ECMWF's Integrated Forecast System (IFS)
- Assimilation of single-wavelength Aerosol Optical Depth has been ongoing for 10 years, reaching now (possibly) a saturation point.



Scientific motivation of ARAS

AOD assimilation **VS** Radiance assimilation

- New satellite instruments are coming up – difficult to characterize the relative uncertainties of AOD products. Using radiances could be more straightforward (once implemented)
- Use of aerosol affected radiances allows for further developments and easier uptake of new satellite instruments such as those on the Sentinel satellites
- The error characterization of radiances is easier than that of products and assimilation assumptions are all consistent (i.e. the same aerosol model is used from emissions to TOA radiances)
- 10+ years from Weaver et al 2007 (first study to assimilate MODIS reflectance) -> promising study, but no follow-on until now

Technical challenges

Direct assimilation of aerosol-sensitive radiances in an **online 4D-Var system** has never been successfully implemented

First time for IFS that …

… visible wavelength radiances are assimilated

… dual control variable is used for AOD

Radiative Transfer Model in the visible: Observation operator (Forward / TL / AD)

RTTOV is still not ready

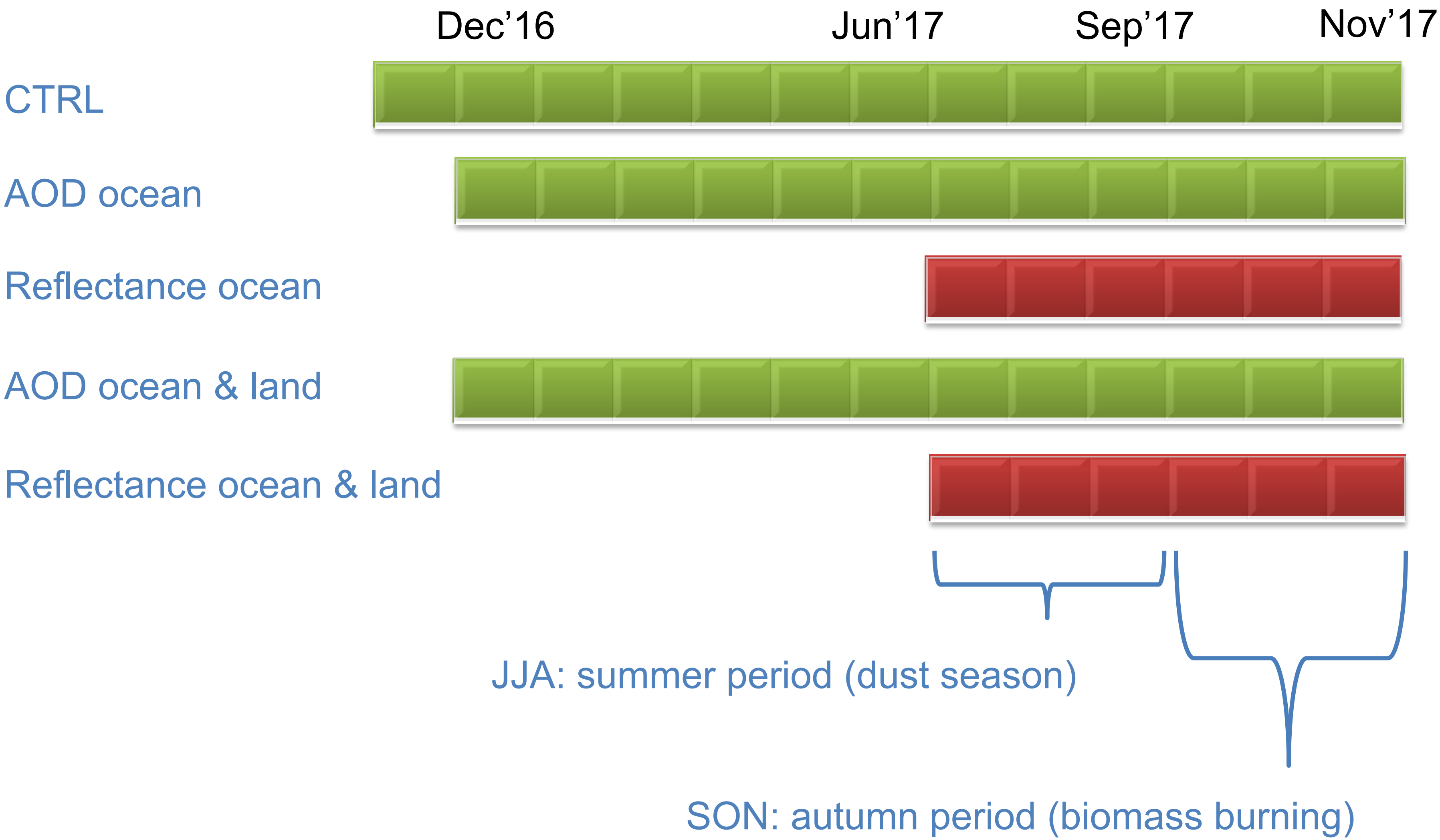
Selection of data and tools

- Radiative transfer model: Optimal Retrieval of Aerosol and Cloud (ORAC) developed at RAL and the University of Oxford (Thomas et al. 2009)
  - look-up-tables (LUTs) of aerosol transmission and reflectance

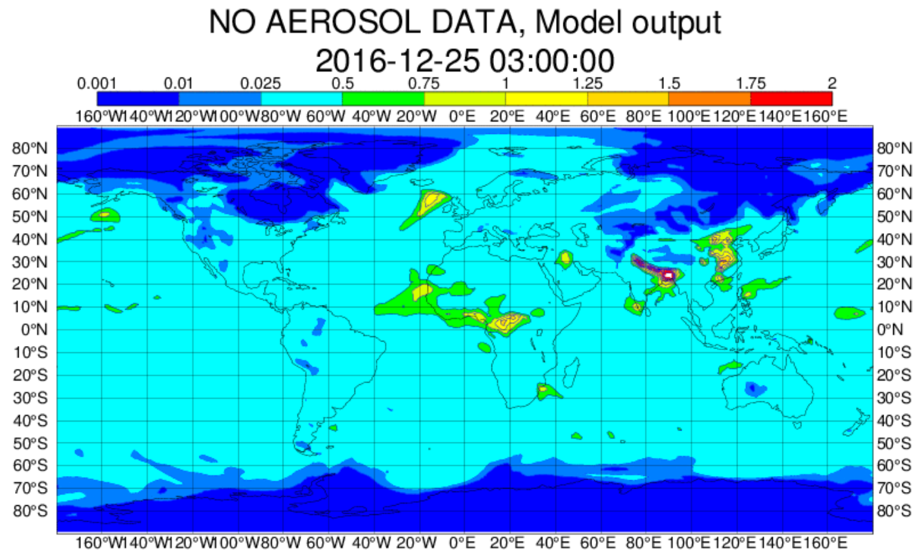
- Data: MODIS Aqua & Terra from collection 6 (Levy et al 2013)
  - multiwavelength AODs @ 670nm and 866nm
  - level-2 radiances (reflectances) @ 670nm and 866nm

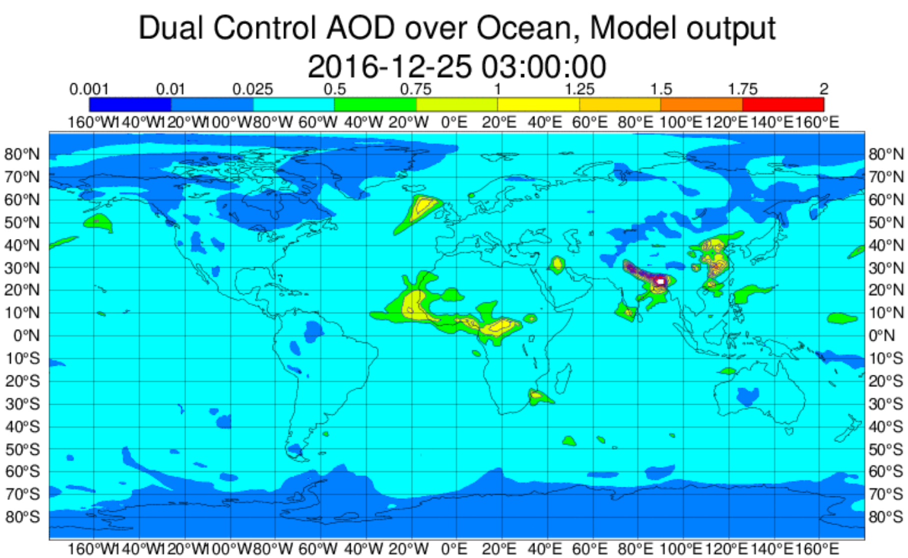
- Aerosol assimilation system: IFS (Integrated Forecast System) 4D-Var in composition configuration
  - Dual control variable AOD => up and running
  - Reflectances => currently being tested

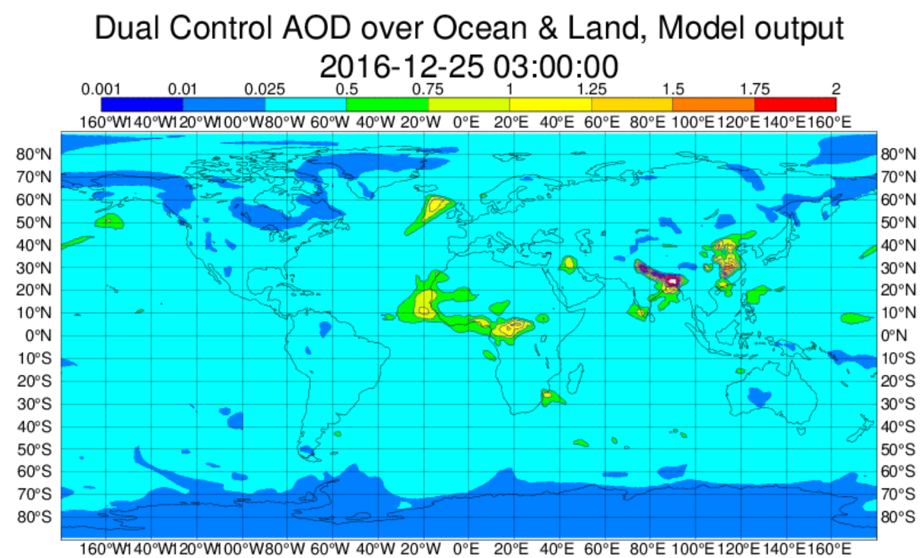
Experiment setup



Preliminary results: C-IFS model AOD @ 550nm







Preliminary results: comparison with Aeronet (FC-OBS)

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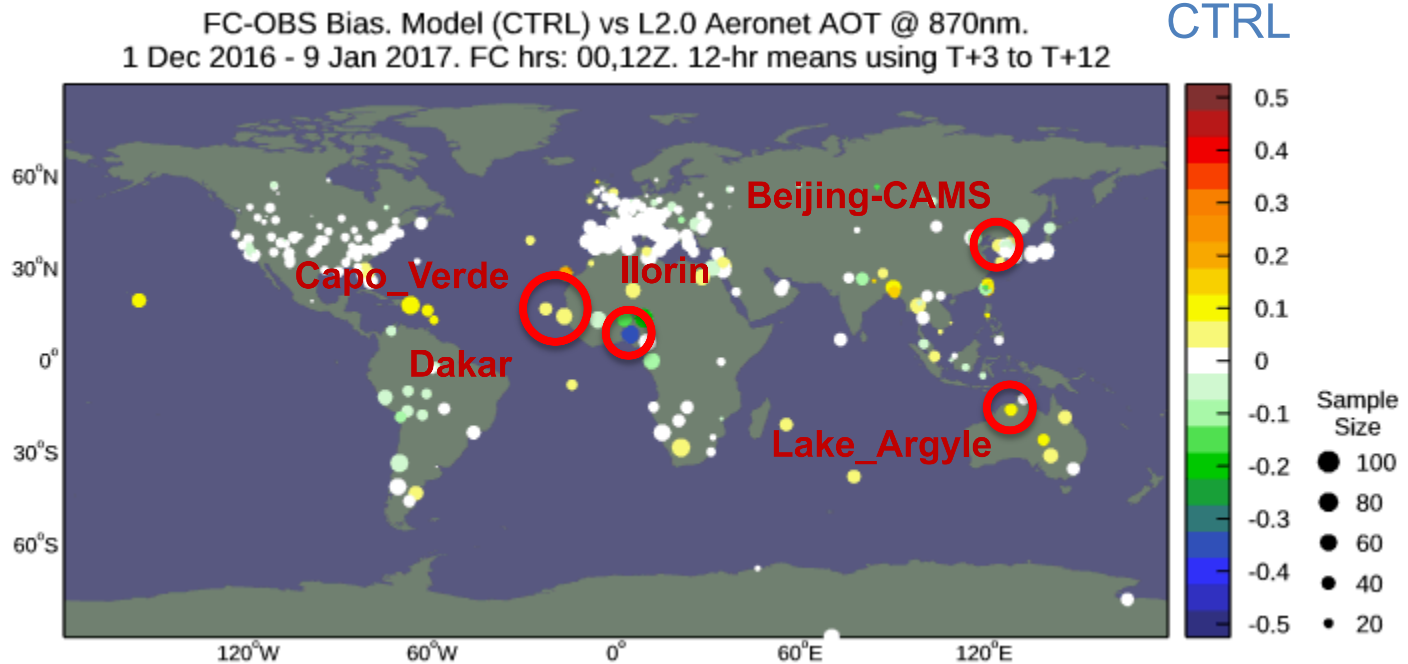
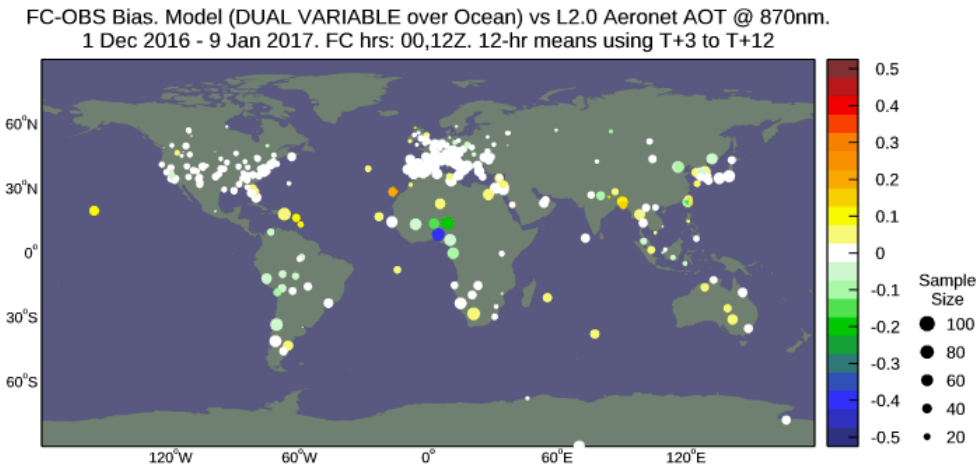
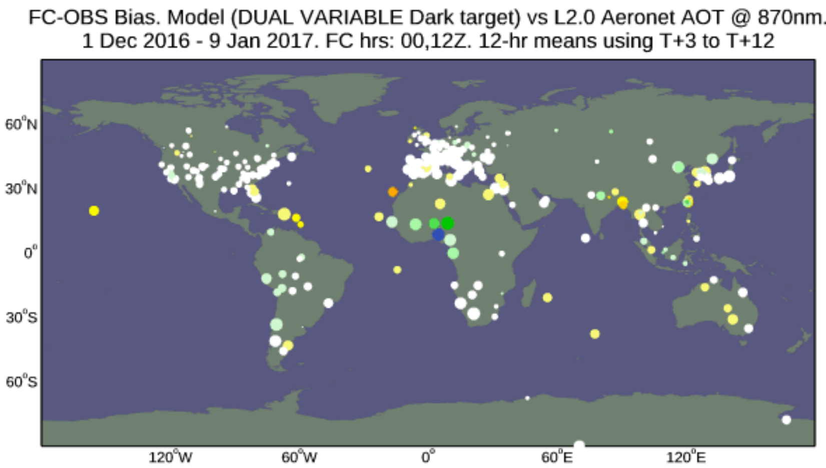


Dual variable over Ocean



Dual variable over Ocean & Land



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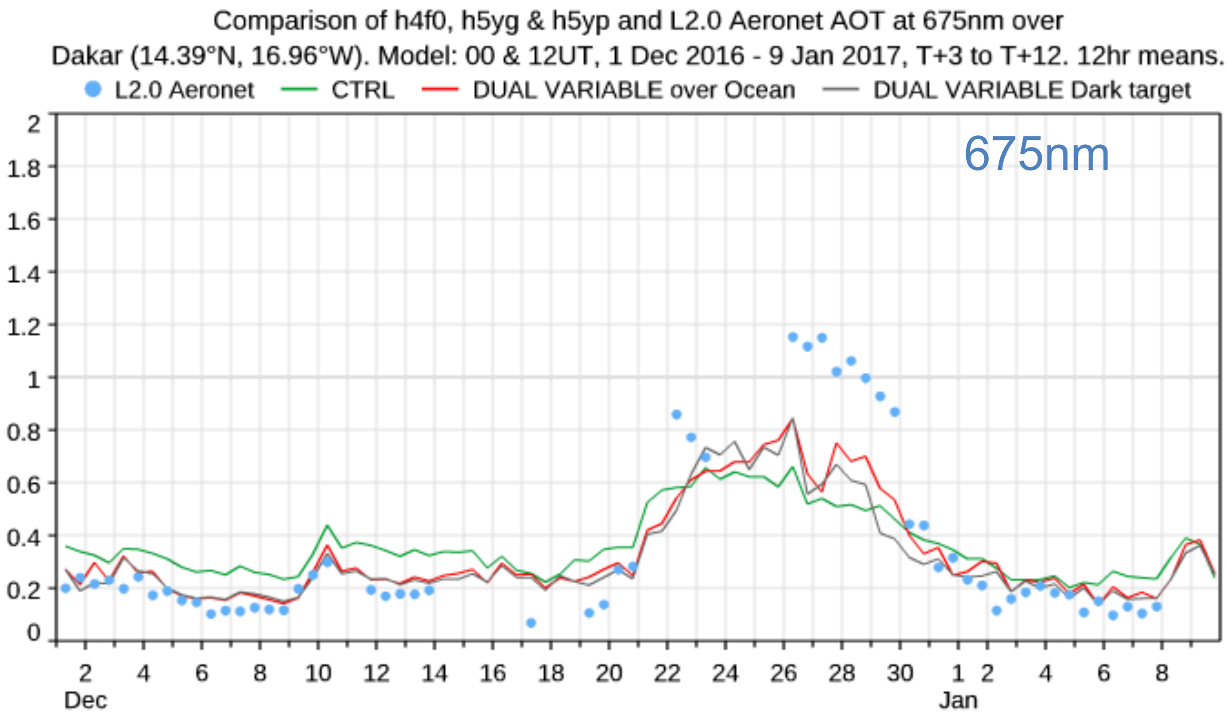
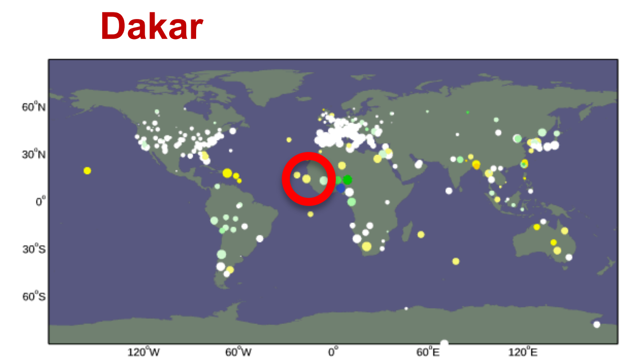
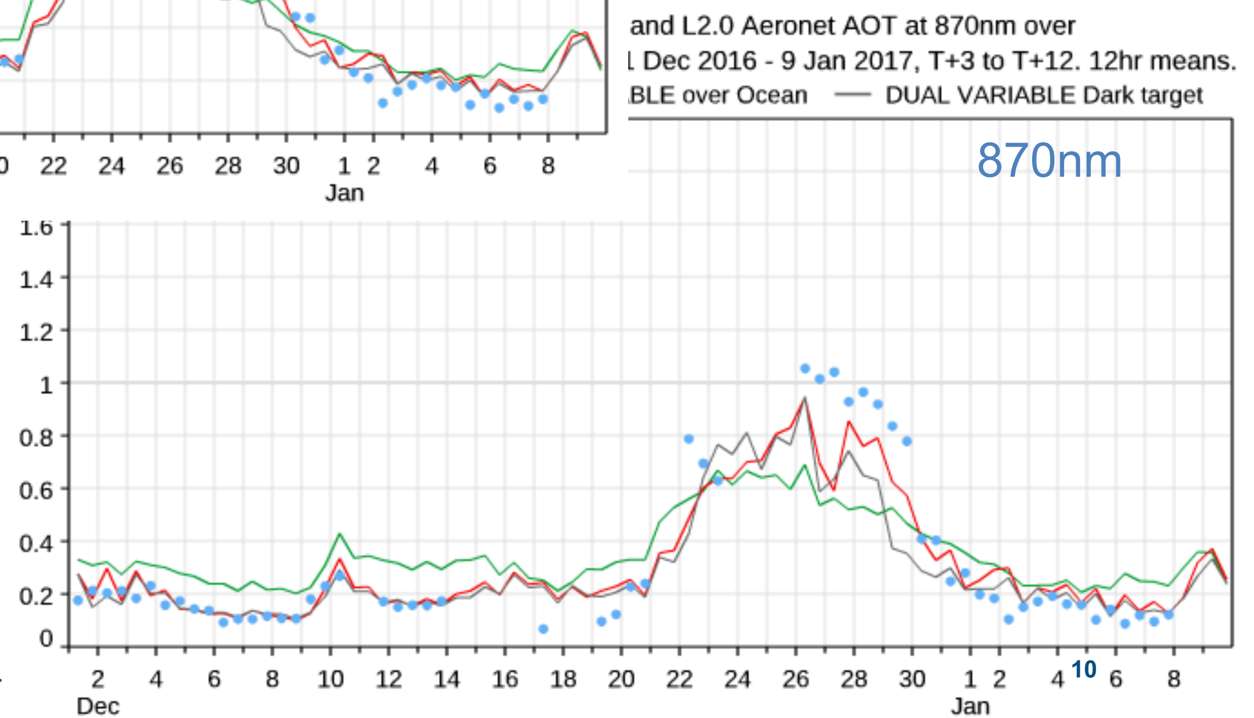
Preliminary results







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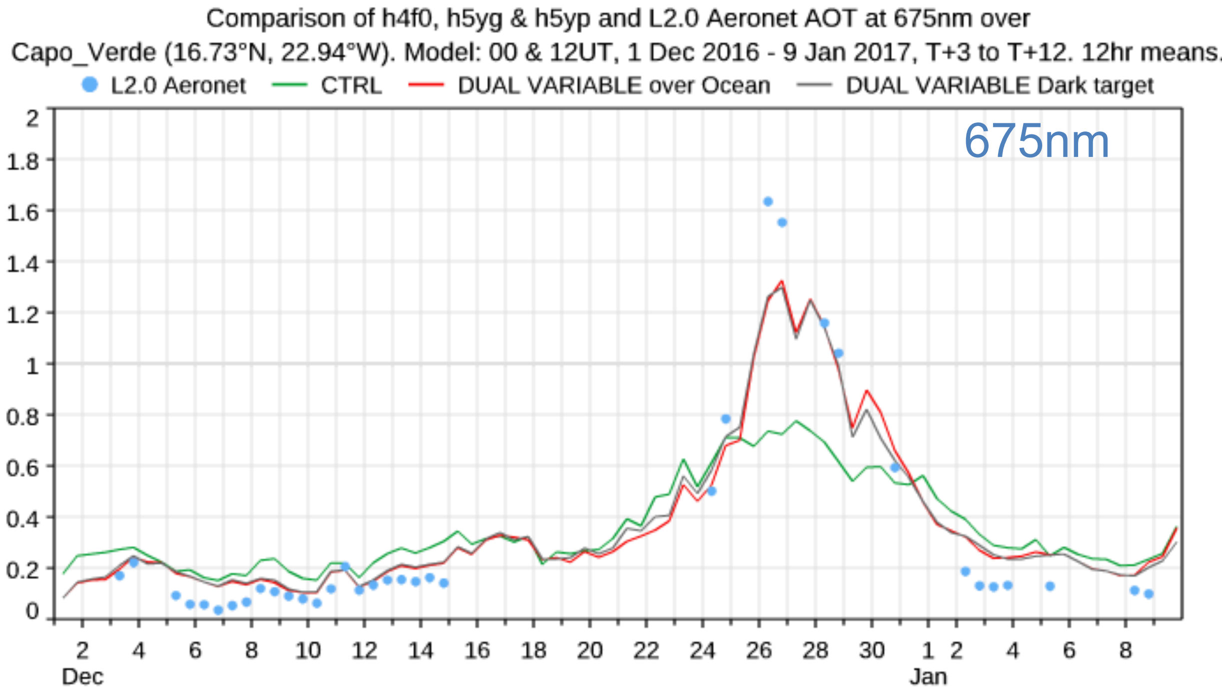
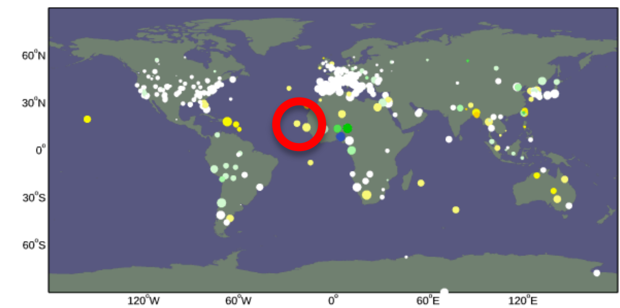
DUAL VARIABLE over Ocean

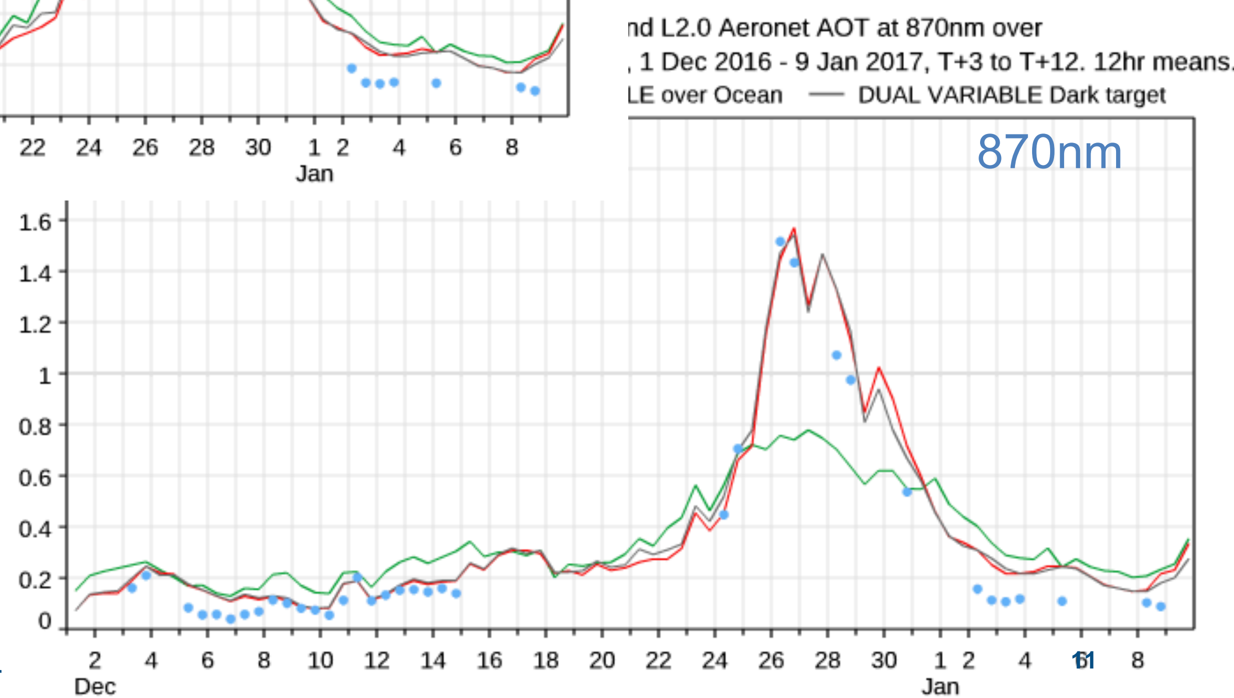
DUAL VARIABLE Ocean + Land

Preliminary results



Capo_Verde





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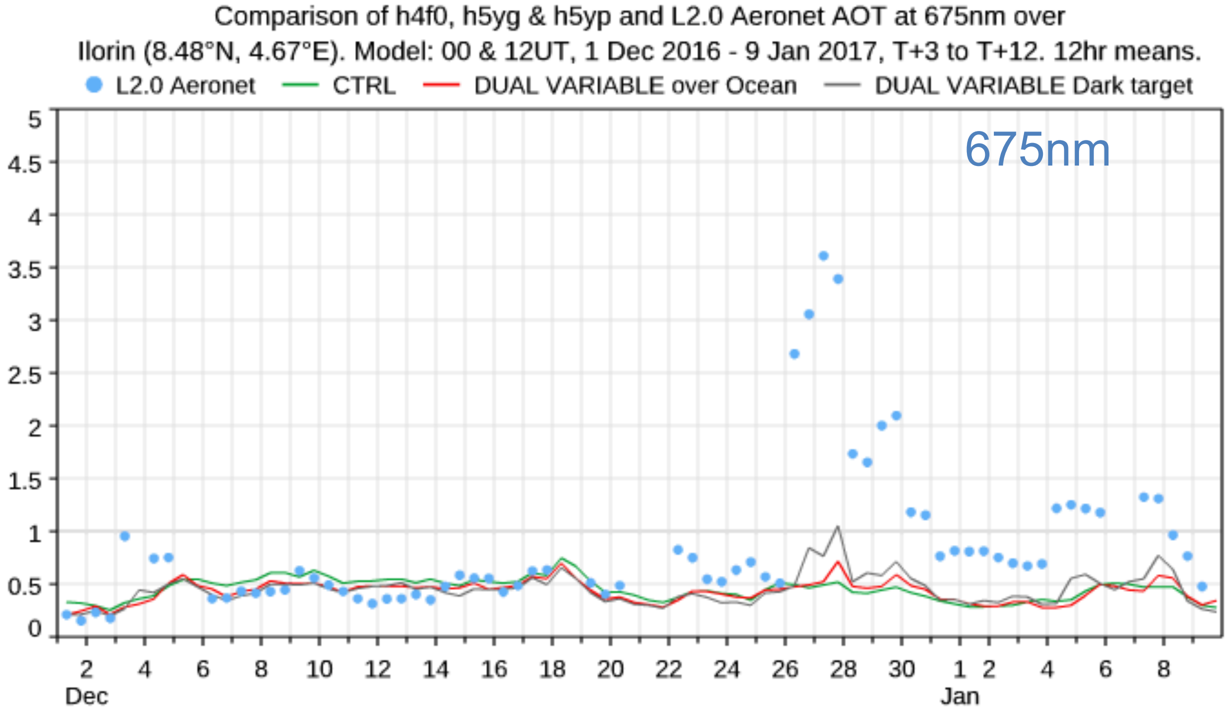
ECMWF

Preliminary results



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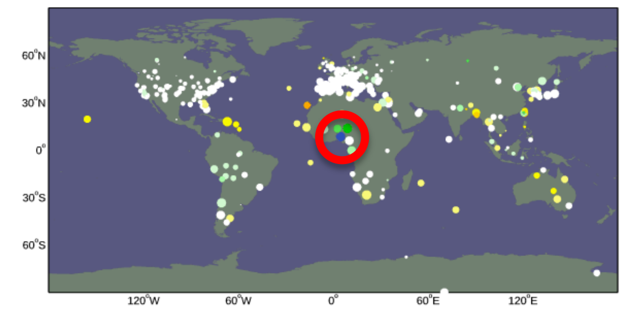

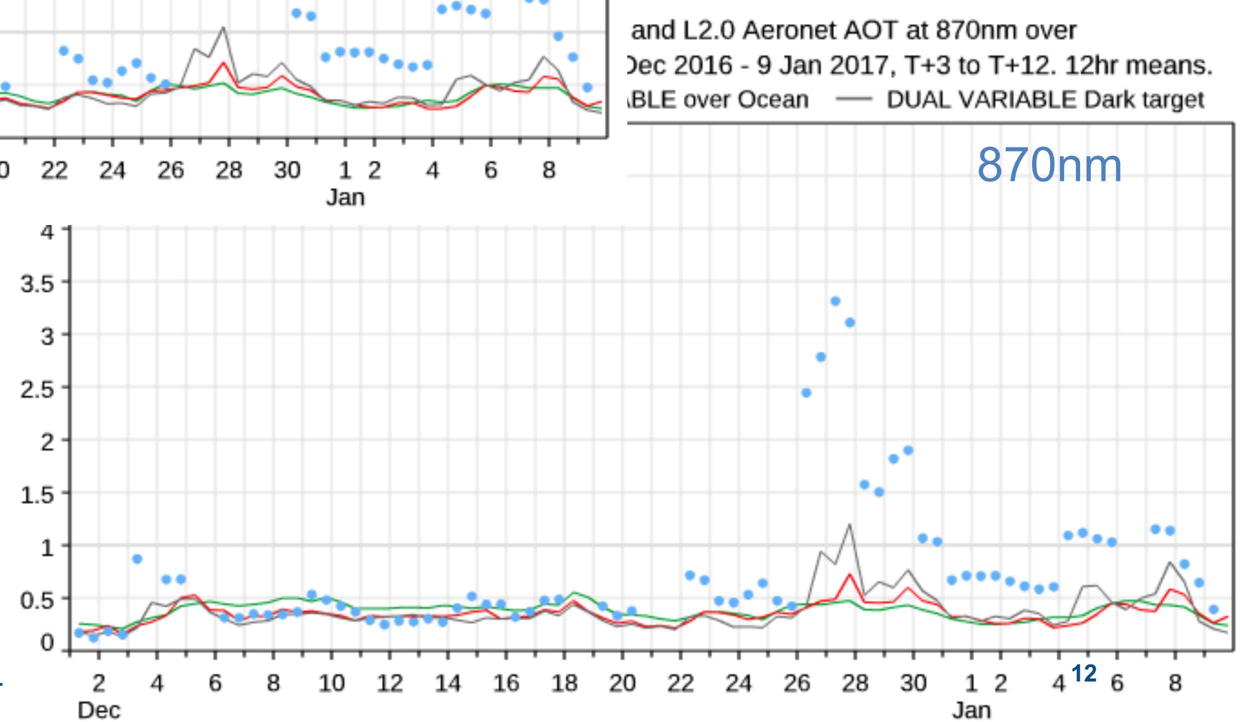

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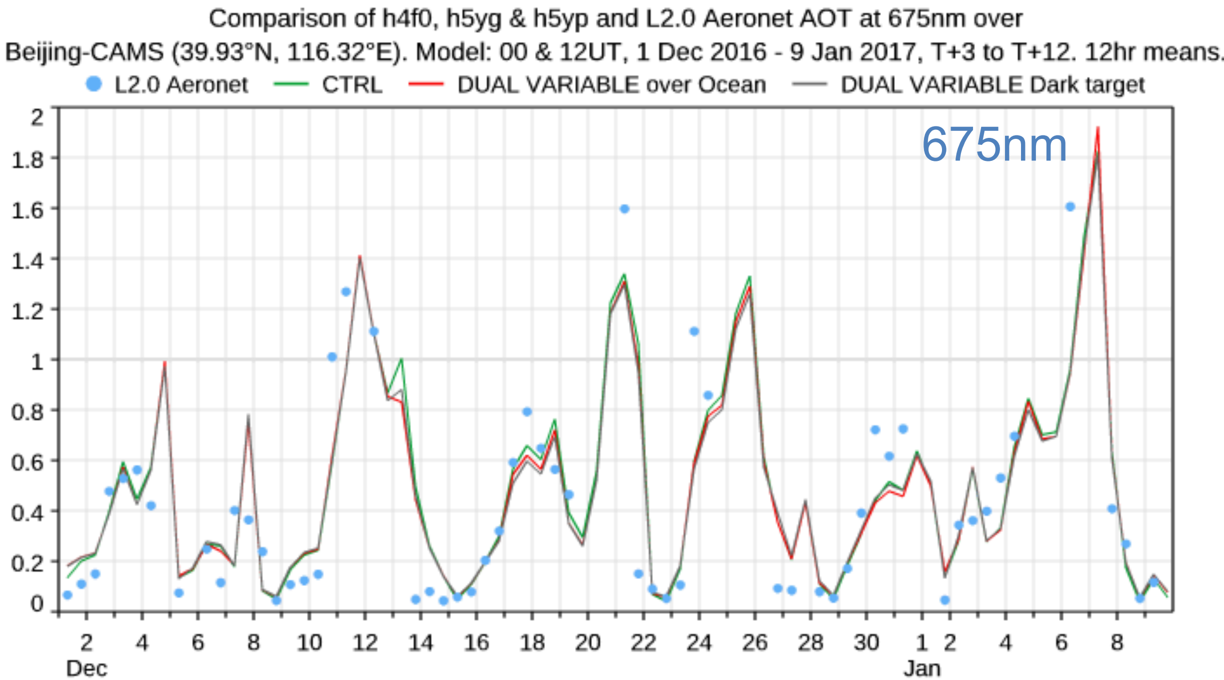

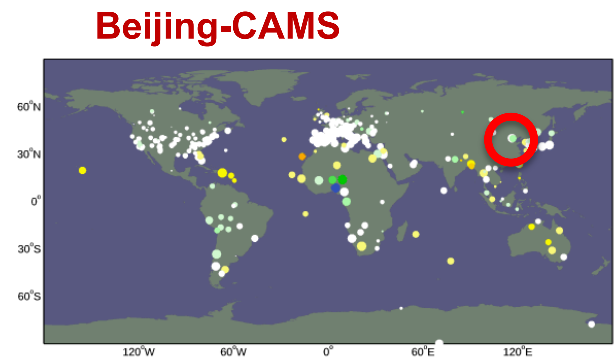

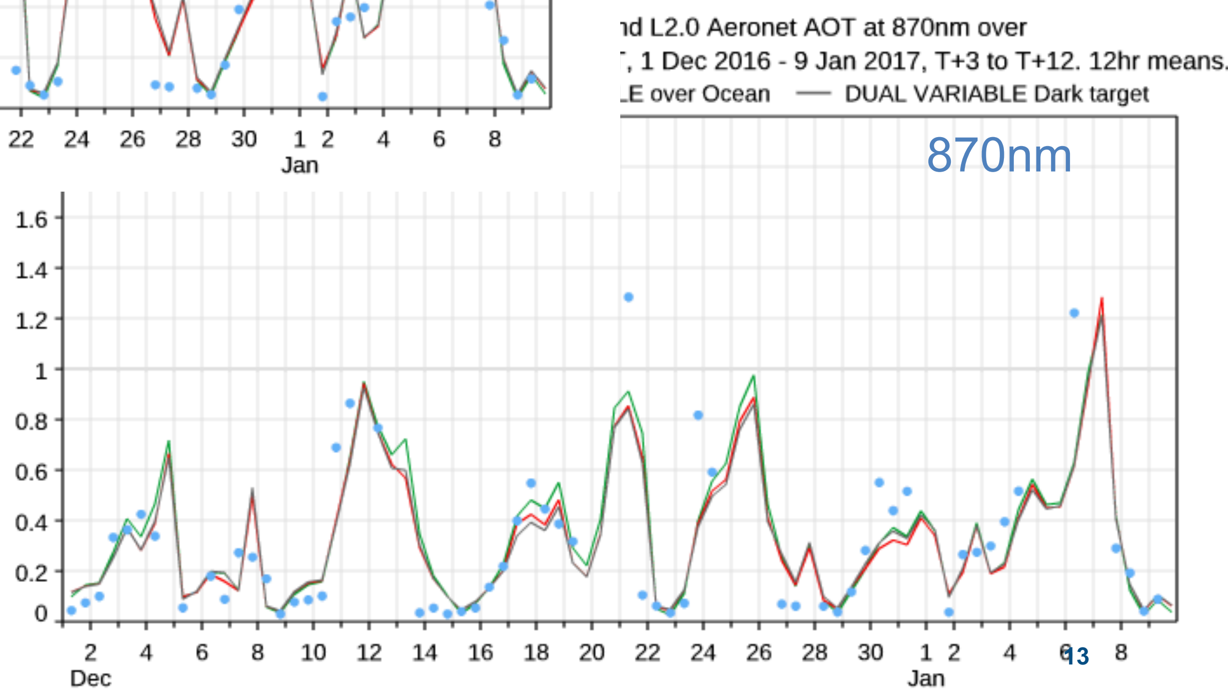

- CTRL
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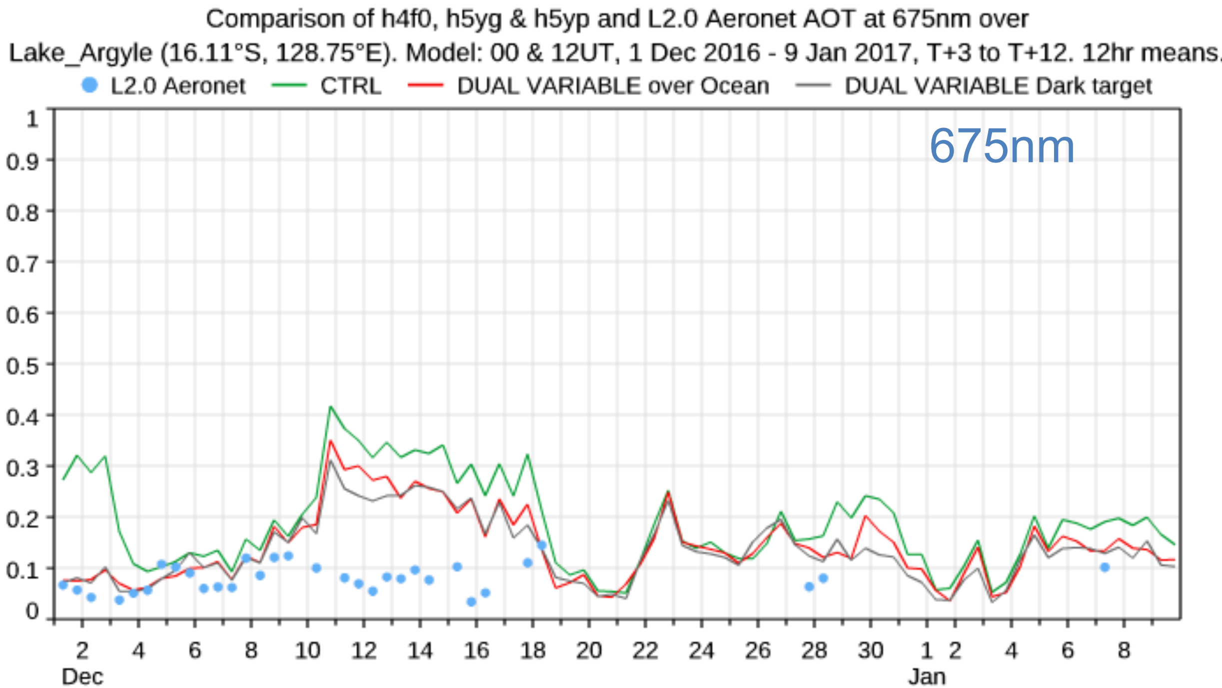
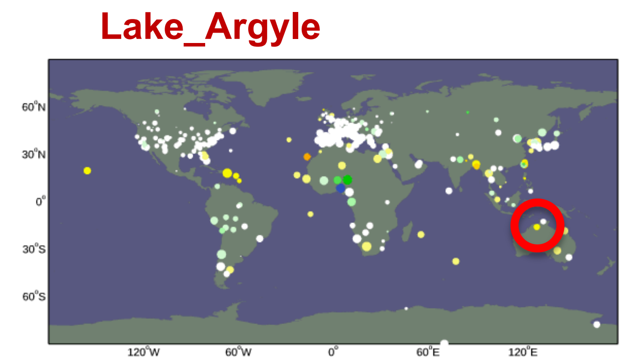
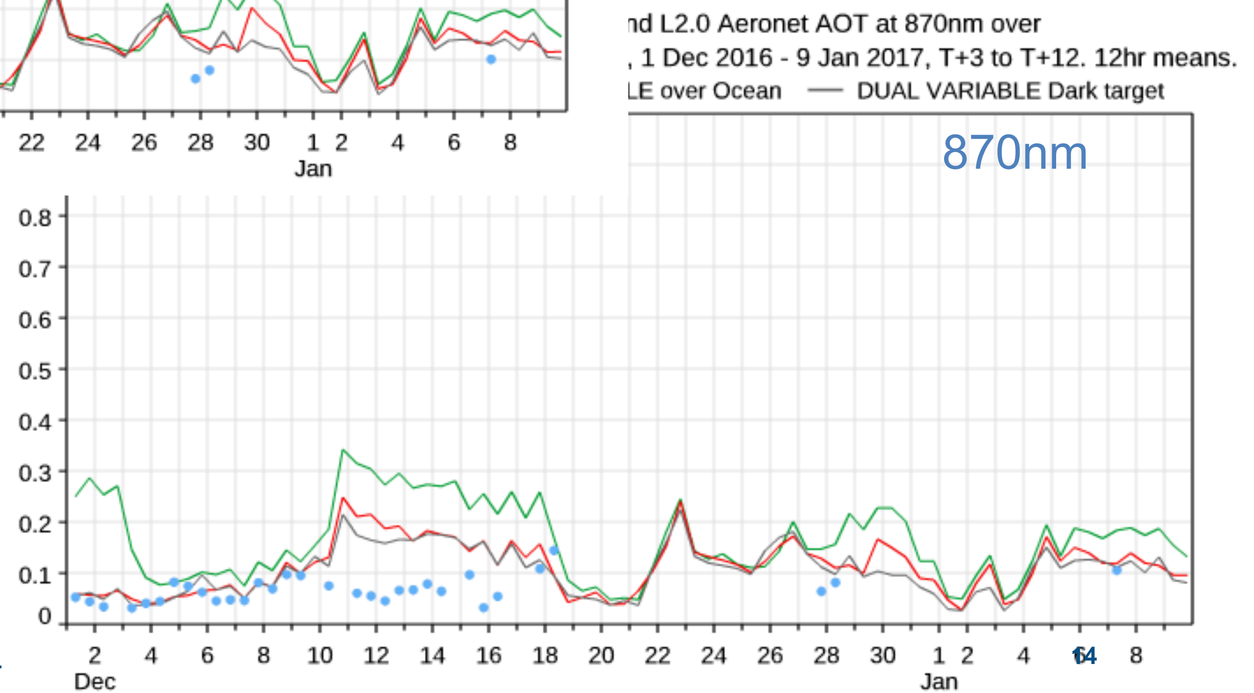
Preliminary results







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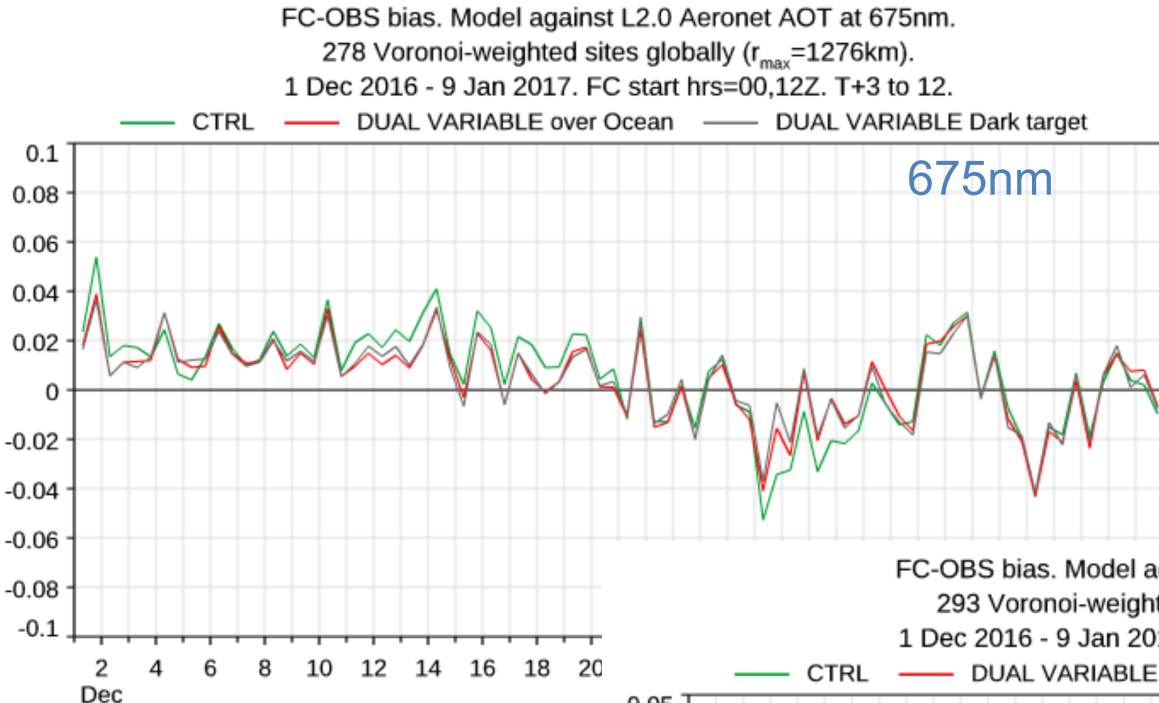
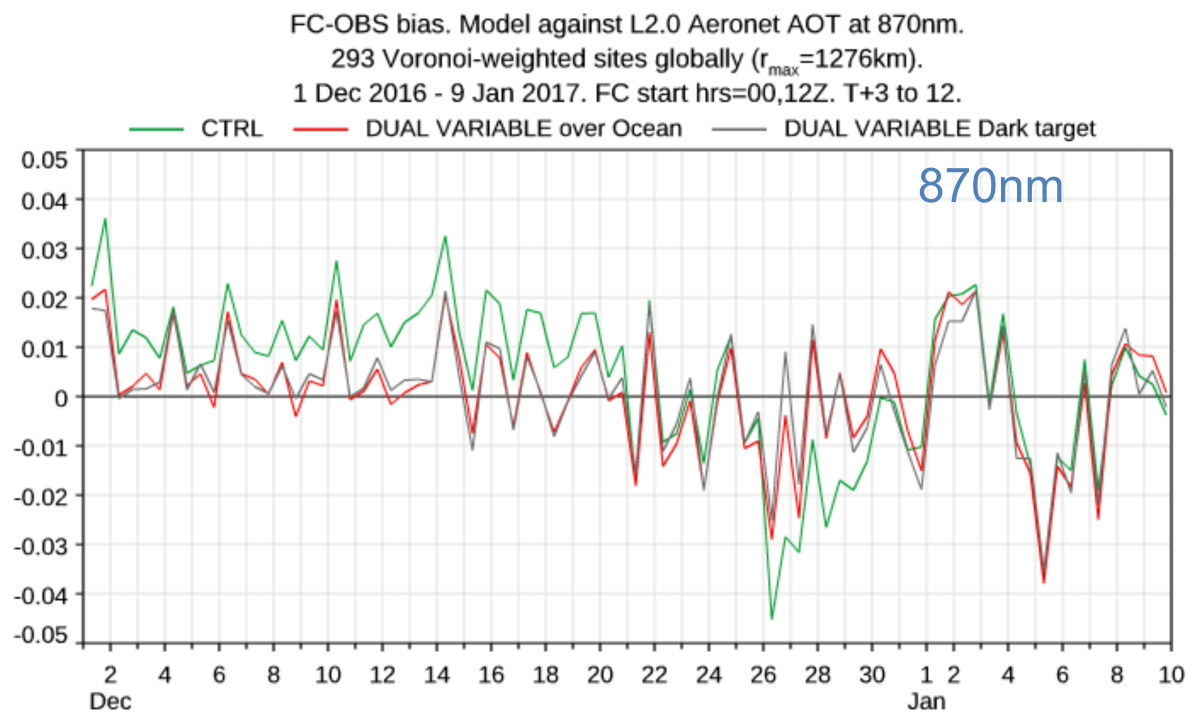
ECMWF

Preliminary results: comparison with Aeronet (FC-OBS)





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- DUAL VARIABLE over Ocean
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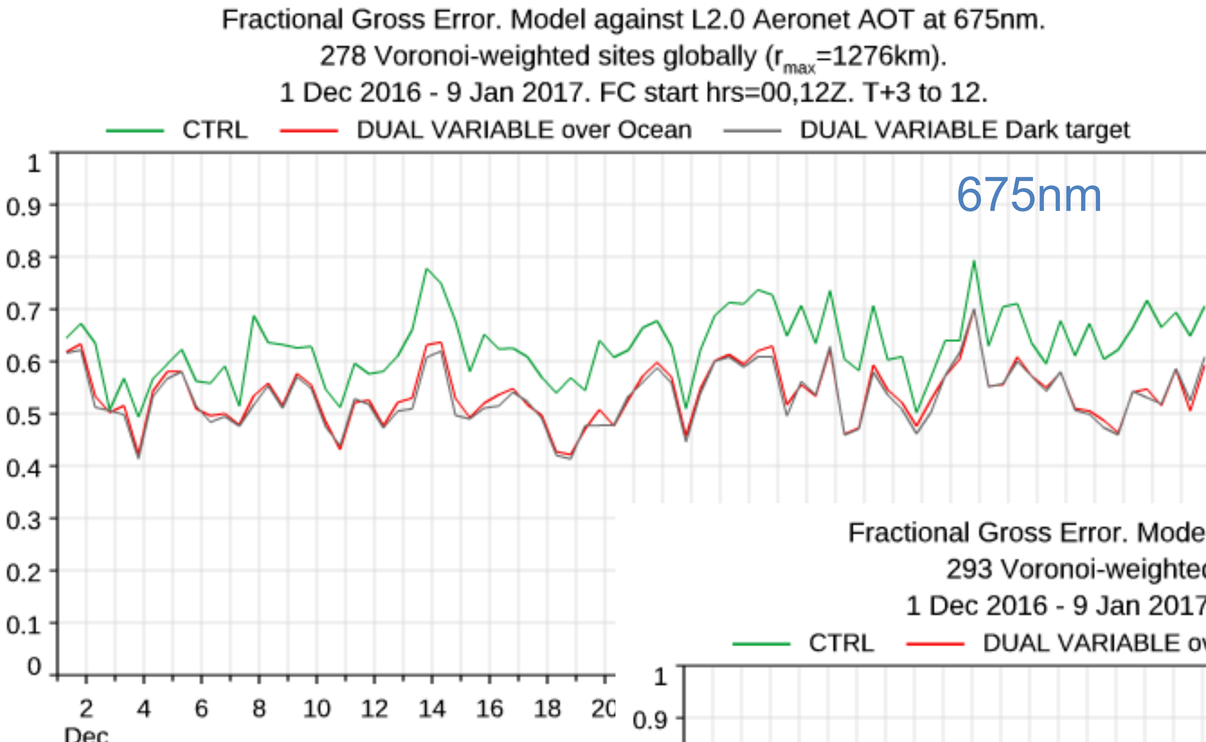
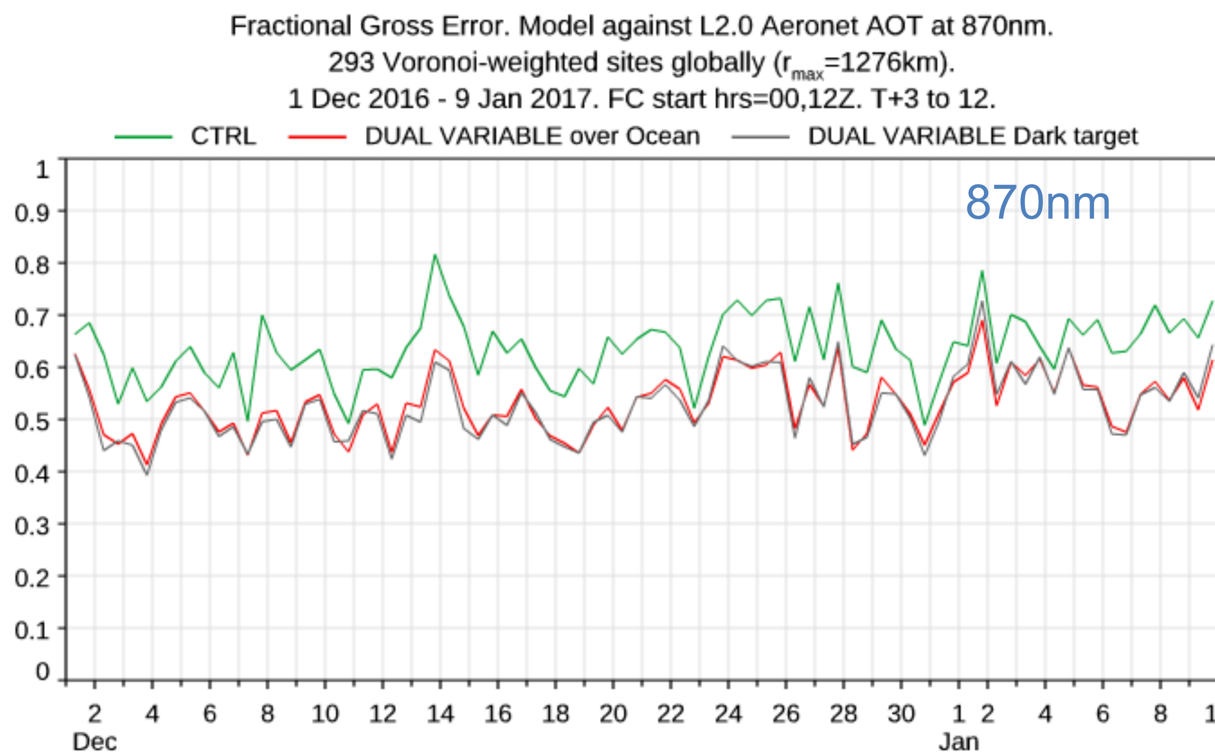
ECMWF EUR

Preliminary results: comparison with Aeronet (FGE)





- CTRL
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ECMWF

ARAS expectations

ARAS is an exploratory project to assess the benefits of the assimilation of aerosol-sensitive radiances

- ✓ Implementation of fast radiative transfer code for aerosol assimilation (ORAC LUTs in RTTOV framework)
- ✓ First comparisons of long-term global assimilation experiments of reflectance assimilation versus AOD assimilation in a full 4D-Var system
- ✓ Technical outputs (visible radiative transfer code in IFS) might be adapted to other aerosol sensors/satellites
- ✓ All developments can serve to inform CAMS in a possible future operational implementation of the aerosol radiance assimilation in the system

Thanks for your attention

Any questions?