Recent developments in satellite remote sensing of aerosol with the Oxford-RAL Aerosol and Cloud retrieval

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Introduction

The Oxford-RAL Aerosol and Cloud (ORAC) scheme is an optimal estimation frame work for the retrieval of aerosol and/or cloud parameters from visible-IR satellite imagers. It has been globally applied to the (Advanced) Along Track Scanning Radiometer (ATSR-2 and AATSR) data record in the NERC Global Retrieval of ATSR cloud Parameters and Evaluation (GRAPE) and ESA GlobAEROSOL projects.

Development of the algorithm continues with involvement in ESA's Climate Change Initiative programme, the NERC "Characterisation of the Near-Field Eyjafjallajökull Volcanic Plume and its Long range Influence" project and through DPhil research.

ESA CCI

ESA's Climate Change Initiative programme consists of a range of international projects which have the aim of producing Essential Climate Variable (ECV) datasets from European satellite sensors. ORAC is playing a key role in two of these projects:

cloud_cci aerosol_cci

As part of the cloud_cci project, ORAC is to be released as a openly available community algorithm. Preparations for this are already underway: http://proj.badc.rl.ac.uk/orac

ORAC

The ORAC algorithm

ORAC is an optimal estimation retrieval scheme that is applicable to a range of satellite imaging instruments. Thus far it has been applied to ATSR-2, AATSR, the Spinning Enhanced Visible-IR Imager (SEVIRI), the Advanced Very High Resolution Radiometer (AVHRR) and the MODerate resolution Imaging Spectroradiometer (MODIS).

The scheme fits modelled top of atmosphere radiances, produced using a combination of the RTTOV and DISORT radiative transfer codes, to measured radiances as a function of aerosol or cloud properties.

When run as an aerosol retrieval, the scheme provides:

- Aerosol optical depth at 550 nm
- Aerosol effective radius
- Surface reflectance

The optimal estimation framework provides

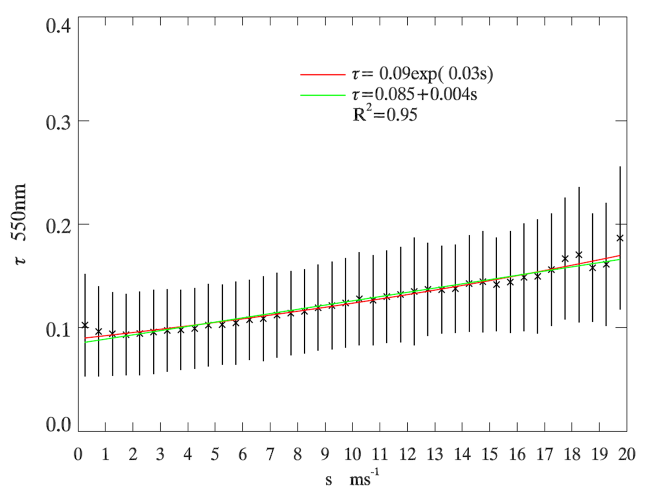
- The ability to include a priori information in a consistent and rigorous way
- Propagation of uncertainties (measurement, a priori and forward model) into the retrieved parameters, giving pixel-by-pixel error estimates
- Comprehensive retrieval diagnostic parameters, allowing for characterisation and quality control of the retrieval.

When applied to dual-view AATSR measurements, the retrieval is able to retrieve the surface reflectance at each measurement wavelength, with the viewing-directional anisotropy defined by prior knowledge (for single view instruments, both the spectral and angular dependence are determined from prior information, with a single reflectance at a nominal wavelength being retrieved).

In addition, the inclusion of thermal-IR measurements into the forward model adds surface temperature and (for optically thick aerosol layers) aerosol layer height to the retrieved parameters.

Thus ORAC also provides a surface reflectance and surface temperature retrieval with a physically based and radiatively consistent atmospheric correction.

Applications: Oceanic aerosol and wind-speed



Aerosol optical depth against wind speed AATSR-GlobAEROSOL in the Southern Ocean

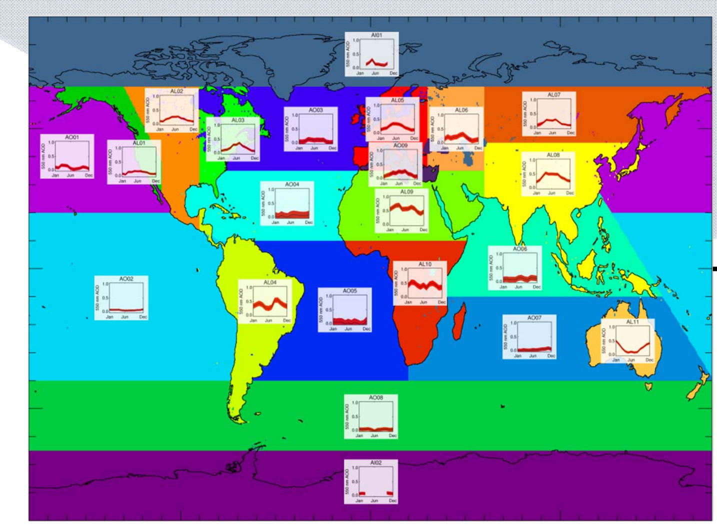
ORAC makes use of a comprehensive sea surface reflectance model to sea the a priori surface reflectance and constrain its anisotropy. The model takes into account:

- Surface roughness as a function of wind speed
- Foam coverage
- "Under-light", as a function of chlorophyll and Gelbstoff concentrations

This makes the algorithm ideal for investigating dependence of oceanic AOD to wind speed, as the wind's effect on surface reflectance is accounted for.

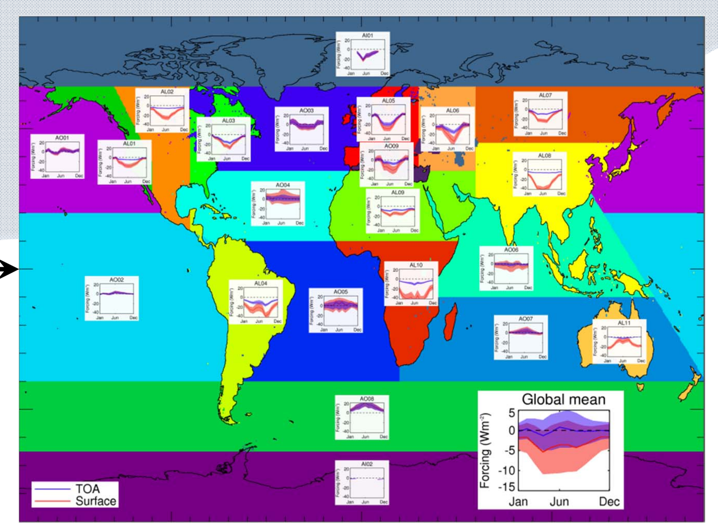
Huang et al., ACP, 10, 5943-5950, 2010

Applications: Radiative forcing calculations



Regional AOD from GlobAEROSOL-AATSR with error characterisation + bias correction from AERONET

Radiative transfer code

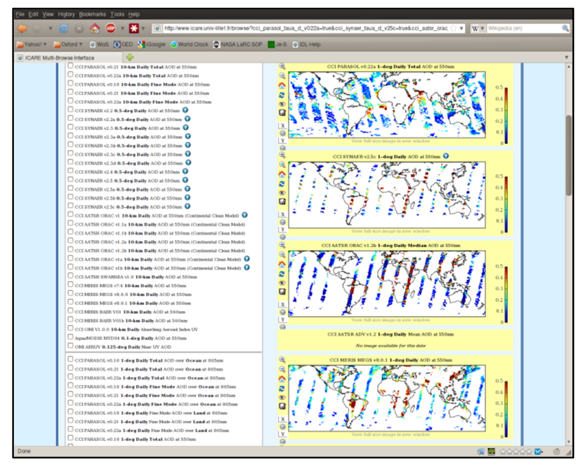


Regional and Global clear-sky direct aerosol radiative forcing, including modelling, averaging AOD uncertainty ranges

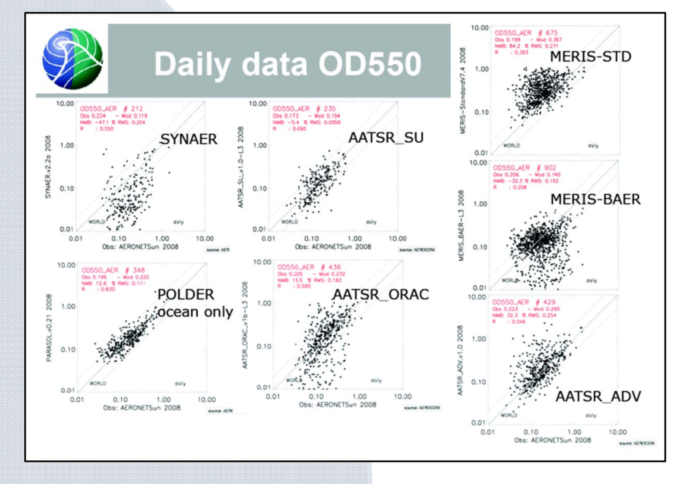
Under the ADIENT project with the University of Reading*, the GlobAEROSOL AATSR product has been used to produce estimates of clear-sky aerosol direct radiative forcing.

*Ellie Highwood, Nicky Chalmers and Bethan Harris

Evaluation: Aerosol_cci



The iCare multi-browse interface showing a selection of aerosol_cci datasets



Preliminary AERONET intercomparison for all 7 Aerosol_cci baseline datasets (Michael Schulz, Met.no)

The main current activity of the aerosol_cci project is a comprehensive evaluation of the various precursor algorithms by a range groups not directly involved with the various retrieval algorithms. The evaluation teams include:

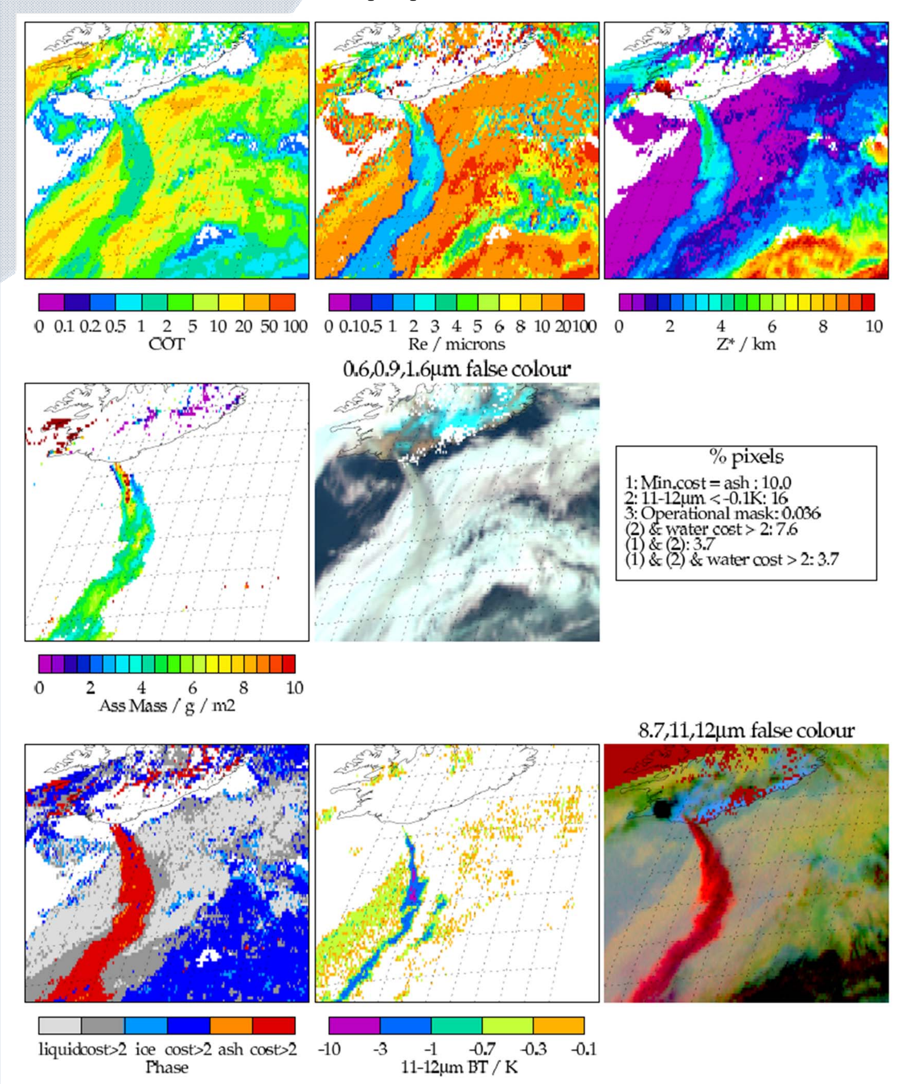
- The Norwegian Meteorological Institute
- The Max-Plank Institute in Hamburg
- iCare (including data archiving)
- The Norwegian Institute for Air Research (NILU)

All algorithms involved in the evaluation are taking part in a series of intercomparison rounds, in which various algorithm differences are eliminated, including:

- Using a common cloud masking
- A common set of aerosol microphysical models
- Harmonising ancillary data (surface wind speed, a priori surface reflectance etc)

The exercise represents one of the most comprehensive assessments of satellite aerosol retrieval algorithms ever undertaken.

Applications: Volcanic ash retrieval

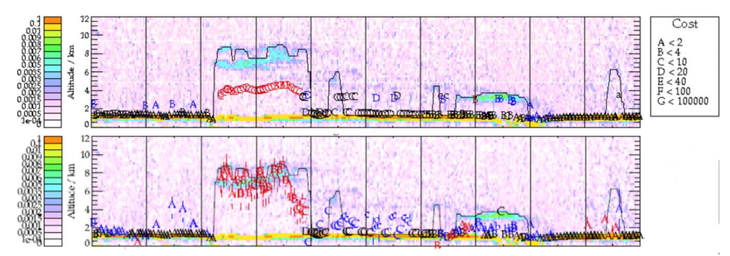


Retrieval results from the Eyjafjallajökull eruption 8th May 2010, showing optical depth, effective radius, cloud/plume height and particle type. Also shown are a derived ash mass, the 11-12 µm brightness temperature difference and two false colour images of the scene.

These plots show results of a combined aerosol and cloud retrieval from SEVIRI, using both shortwave and thermal –IR channels, specifically targeting the volcanic ash plume from the Eyjafjallajökull eruption in Iceland in May 2010.

The retrieval can be seen to be a very robust way to identify the ash plume, although the presence of underlying causes unreliable results for optical depth and plume height, as the forward model assumes a single cloud/ash layer.

Experiments with a two layer model, where the lower cloud layer's properties are determined by surrounding cloud, have shown promising results.



The effect using a two layer forward model on the plume height retrieval (lower panel) compared to the standard single layer (upper panel). Collocated Calipso lidar profiles are included for reference.

Credit: Richard Siddans