Parallel Retrieval of Aerosol and Cloud

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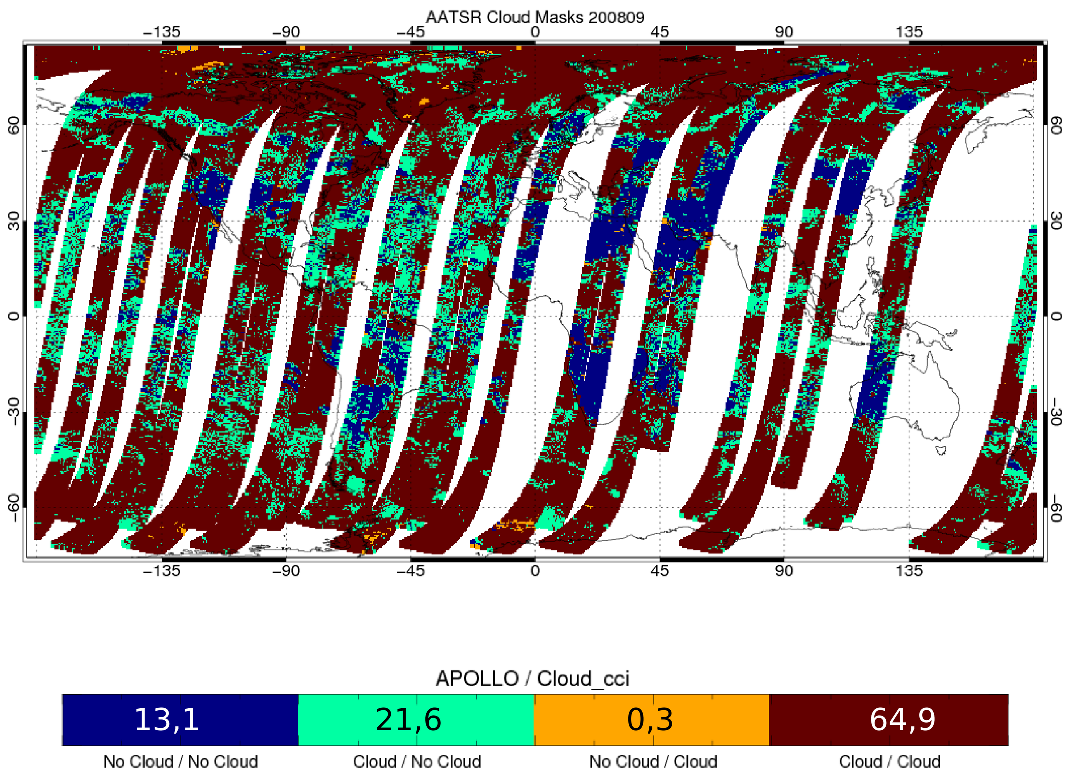
Wetter und Klima aus einer Hand

Aerosol and cloud masking

From the top of the atmosphere, a thin cloud resembles a thick aerosol plume. This ambiguity means that it is not currently possible to retrieve aerosol and cloud properties simultaneously from the same observation. In fact, each is a significant source of error in the retrieval of the other such that stringent filtering is applied to current products and, though this confines analysis to only observations that should be well-modelled, it limits the spatial coverage of the data.



Above is a comparison of the masks from the ESA CCI Cloud and Aerosol projects over five days in September 2008 [1]. Dark blue and brown indicates the masks agree in the classification. Note that 20 % of the globe is rejected by both masks (light blue), representing a significant limitation of the spatial coverage for a supposedly global climate product.

Optimal retrieval of aerosol and cloud

ORAC is a generalised optimal estimation scheme [2] to retrieve cloud, aerosol, and surface properties from satellite-based visible and/or infrared measurements. Various implementations exist to process observations from (A)ATSR, AVHRR, MODIS, and SEVIRI to retrieve:

- aerosol optical thickness (AOT) and effective radius with surface reflectance (at 550 nm);
- aerosol optical thickness, effective radius, and layer height with sea surface temperature;
- cloud optical thickness (COT), effective radius, and top pressure with surface temperature; or
- volcanic ash optical thickness, effective radius, and plume top pressure.

By integrating these modules, ORAC products can bypass the need for cloud or aerosol masking. Instead, observations are processed using each model and the probability that it conforms to a given type is determined from the fit of the model to the observations.

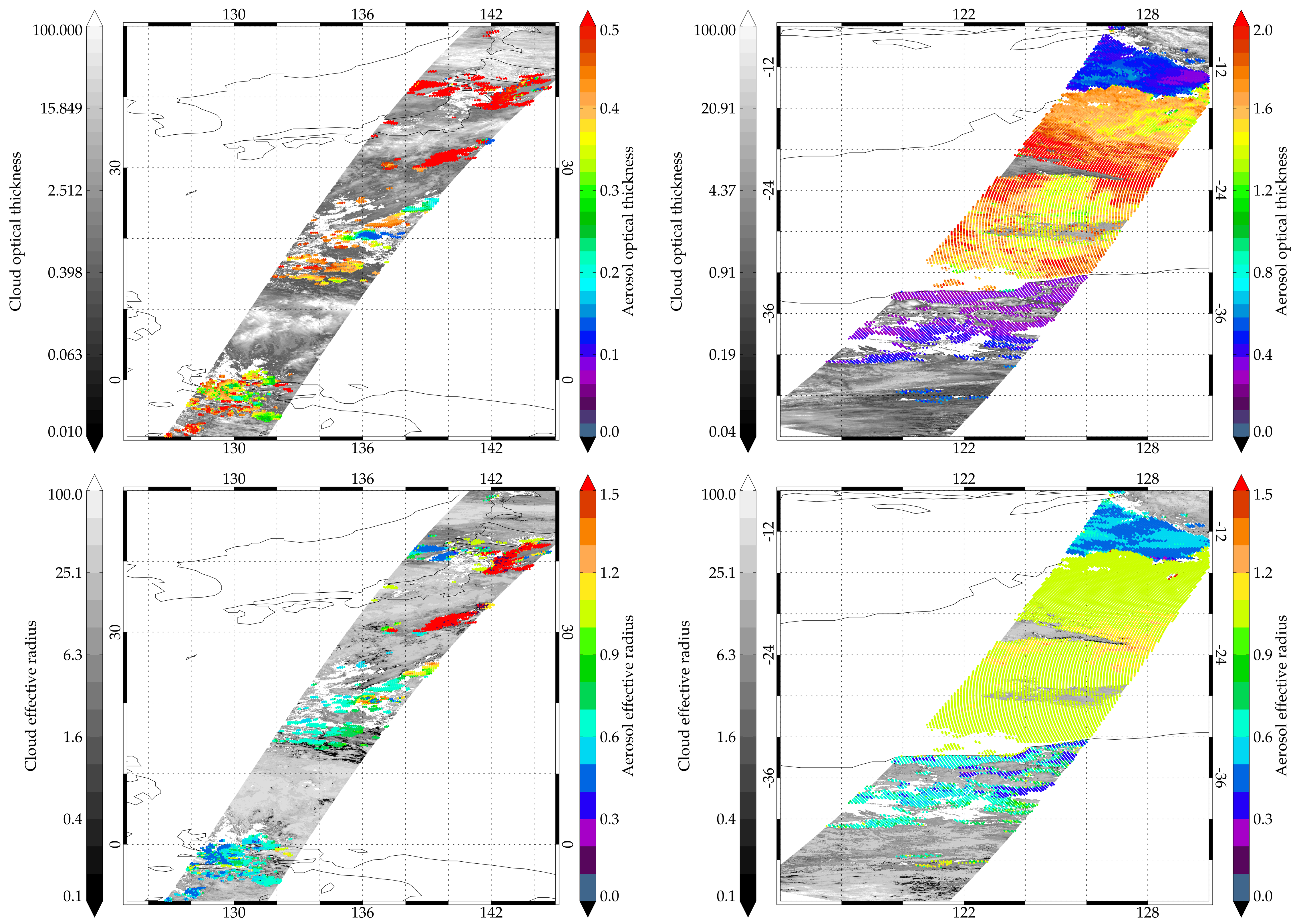
This poster outlines work under way to integrate the various distinct modules into one computer code and homogenise the pre-processing of satellite data, the modelling of surface reflectance, and numerous efficiencies made over the past decade of development. The last module is demonstrated in poster 183 of this session, 'Volcanic ash retrievals using ORAC and satellite imager measurements in the visible and IR.'

Community code

ORAC is open-source software developed by a world-wide community of researchers within a version control system managed by the British Atmospheric Data Group (BADC). The Fortran 90 source code can be obtained from `http://proj.badc.rl.ac.uk/orac`. Currently only the cloud retrieval for ATSR, AVHRR, and MODIS is available, though the aerosol retrieval should appear this year. Introducing additional radiometers, if desired, is generally straightforward.

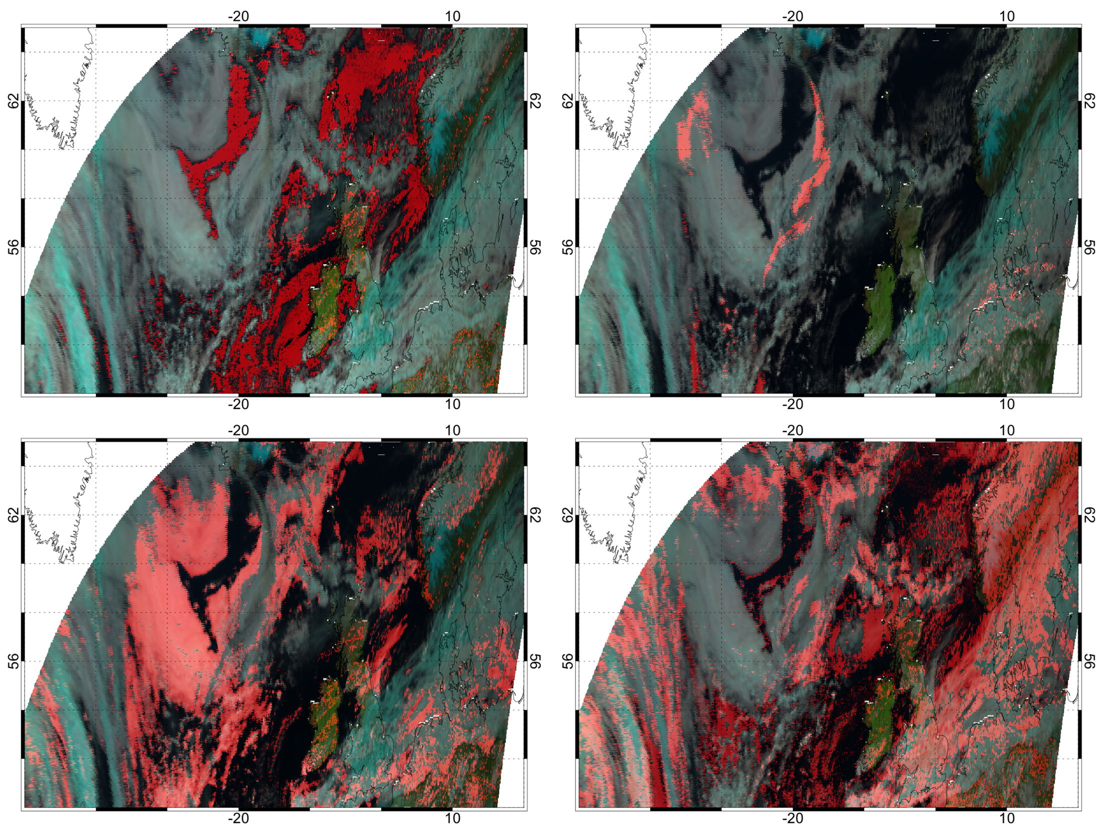
Parallel retrieval of optical properties

Examples of current ORAC retrievals from a bootstrapped integration of the modules are shown below for two sections of an AATSR orbit (left: Japan to Papa New Guinea; right: central Australia) on June 20th 2008. Cloud optical thickness (top) and effective radius (bottom) are plotted in grey, with the corresponding aerosol values in colour. Cloud retrievals are at native resolution while aerosol is retrieved over 10x10 km superpixels. (Native resolution aerosol retrieval is under development.) Only pixels which resulted in a high quality retrieval are plotted. These products are currently being validated within the CCI program.



Classification

The above plots simply show the values retrieved by the aerosol and cloud modules of ORAC. It is possible to use these separate solutions to classify each observation by particle type. These are demonstrated in the below plots for a SEVIRI scene on May 8th 2010 during the Eyjafjallajökull eruption. Each shows the false colour image overlaid in red with the probability that the pixel is sea-salt aerosol (top left), volcanic ash (top right), water cloud (bottom left), ice cloud (bottom right).



The algorithm does a reasonable job of distinguishing between different aerosol types, with each observation having only a single type show a significant probability for identification (or being a poor fit to all types considered). Aerosol is primarily identified in regions that appear to be clear sky, as one would expect. It also highlights a plume of ash emitted from the volcano. The identification isn't perfect as the ash and ice cloud selections are noisy.

Available datasets

Several aerosol and cloud datasets have been produced with ORAC and are freely available:

- ESA's Climate Change Initiative (CCI) aims to produce climate data records that extend from the 1980s to the present for both aerosol and cloud properties.
  - The first phase of the aerosol project (`www.esa-aerosol-cci.org`) has produced AOT at 550 and 870 nm with 10 km resolution for 2003 and 2008 from ATSR-2 and AATSR. [3]
  - The cloud project (`www.esa-cloud-cci.org`) provides all cloud properties from ATSR-2 and AATSR at the sensor's native 1 km resolution, though AVHRR and MODIS also will be included in the eventual record. [4]
- GlobAEROSOL (`www.globaerosol.info`) retrieved AOT at 550 and 870 nm (and the Ångström coefficient over that range) with 10 km resolution. The data cover 1995 to 2008 from ATSR-2, AATSR, and SEVIRI and include pixel-level uncertainty estimates. [5, 6]
- GRAPE, the Global Retrieval of ATSR Cloud Parameters and Evaluation (`badc.nerc.ac.uk/data/grape`), retrieved cloud optical depth, phase, particle size, top pressure, fraction, and water path from ATSR-2 and AATSR on the same grid as the GlobAEROSOL data. [7]

Level 3 daily and monthly averages of all of these are also available.

References

[1] L. Klüser and S. Stapelberg (2013), `www.esa-aerosol-cci.org/?q=webfm_send/507`.

[2] C. Rodgers (2000), Inverse Methods for Atmospheric Sounding: Theory and Practice, World Scientific.

[3] T. Holzer-Popp et. al. (2013), doi:10.5194/amt-6-1919-2013.

[4] M. Stengel et. al. (2013), doi:10.1016/j.rse.2013.10.035.

[5] G.E. Thomas et. al. (2009), doi:10.5194/amt-2-679-2009.

[6] G.E. Thomas et. al. (2010), doi:10.5194/acp-10-4849/2010.

[7] C.A. Poulsen et. al. (2012), doi:10.5194/amt-5-1889-2012.