Continuing development of ORAC

The Optimal Retrieval of Aerosol and Cloud

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Introduction

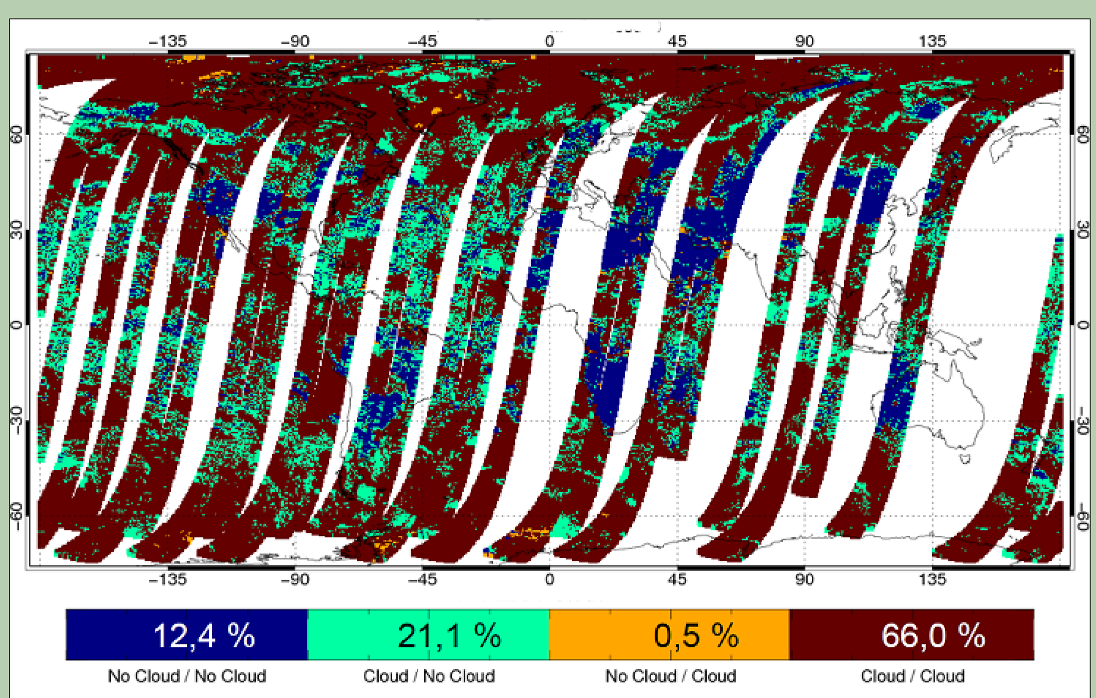
ORAC [1, 2] is a generalised optimal estimation scheme to retrieve cloud, aerosol, and surface properties from satellite-based visible and/or infrared measurements. Various implementations exist to process observations from (A)ATSR, AVHRR, MODIS, and SEVIRI retrieving either

- aerosol optical thickness and effective radius with surface reflectance (at 550 nm);
- aerosol optical thickness, effective radius, and layer height with sea surface temperature; or
- cloud optical thickness, effective radius, top pressure, and water/ice path with surface temperature.

Work is under way to integrate the various distinct modules into one computer code, homogenising the pre-processing of satellite data, the modelling of surface reflectance, and numerous efficiencies made over the past decade of development.

Aerosol and cloud masking

At the top of the atmosphere, a thin cloud closely resembles a thick aerosol plume. The ambiguity between their impact on the observed satellite radiances 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. This leads current aerosol and cloud products to stringently filter their observations to remove contamination and, though this confines analysis to only observations that should be well-modelled, it limits the spatial coverage of the data.



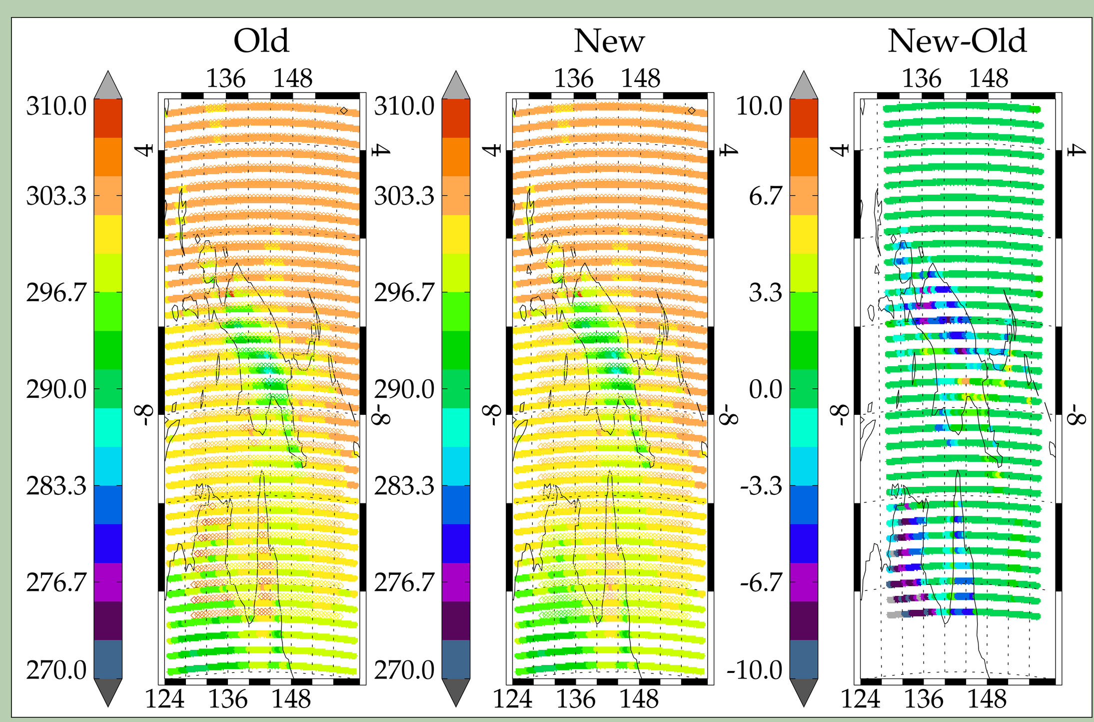
Aerosol CCI Cloud Flag/Cloud CCI Cloud Flag

Above is a comparison of the masks from the cloud and aerosol projects within the ESA Climate Change Initiative (CCI) for five days during September 2008 [3]. Dark blue and brown indicates the masks agree over the classification. However, 20 % of the globe is rejected by both masks (light blue). This represents a significant limitation to the spatial coverage of a supposedly global climate product.

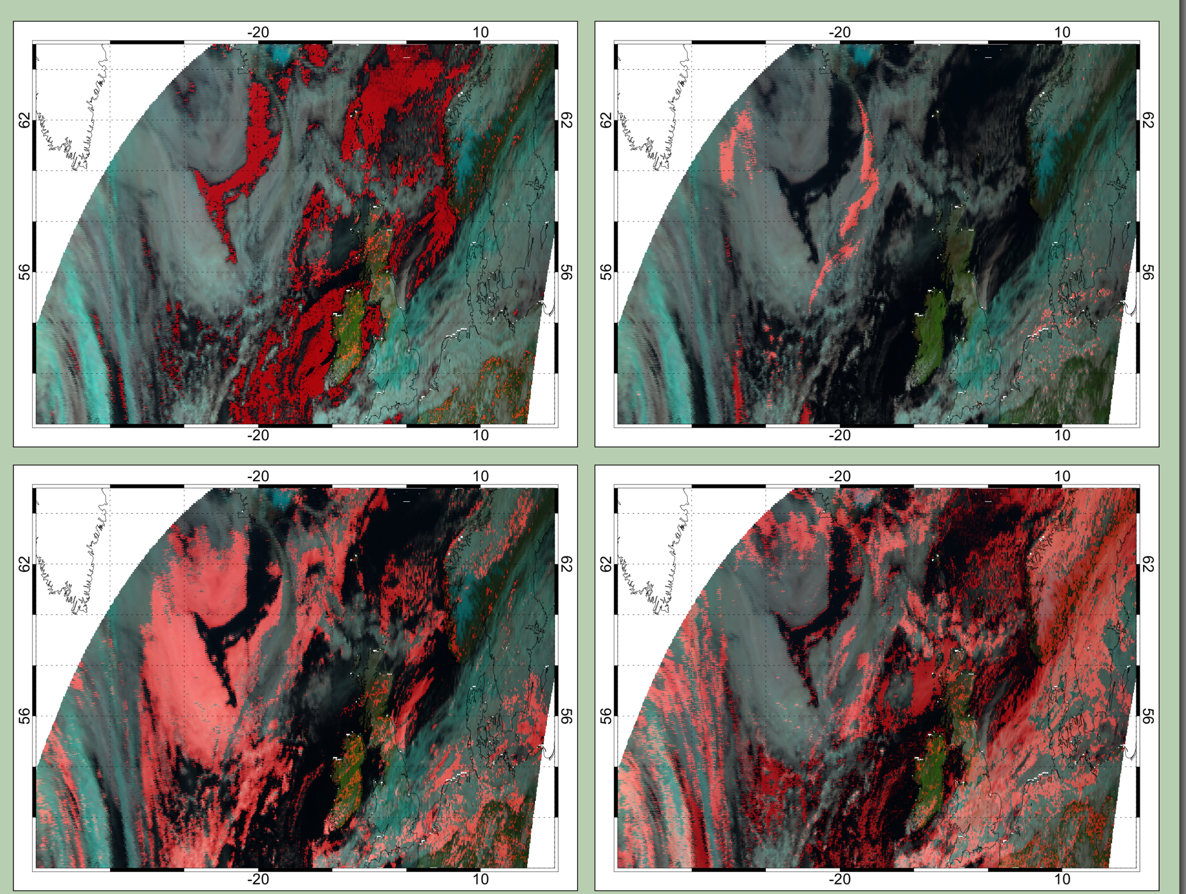
ORAC does not require masking as it contains models for both aerosol and cloud over land and sea. Instead, observations are processed using each model. The probability that the particles observed are then of some type can then be determined from the fit of the model to the observations (from the χ^2 value). This has been applied to a SEVIRI scene of the Eyjafallajökull ash plume in May 2010 (right).

Pre-processing improvements

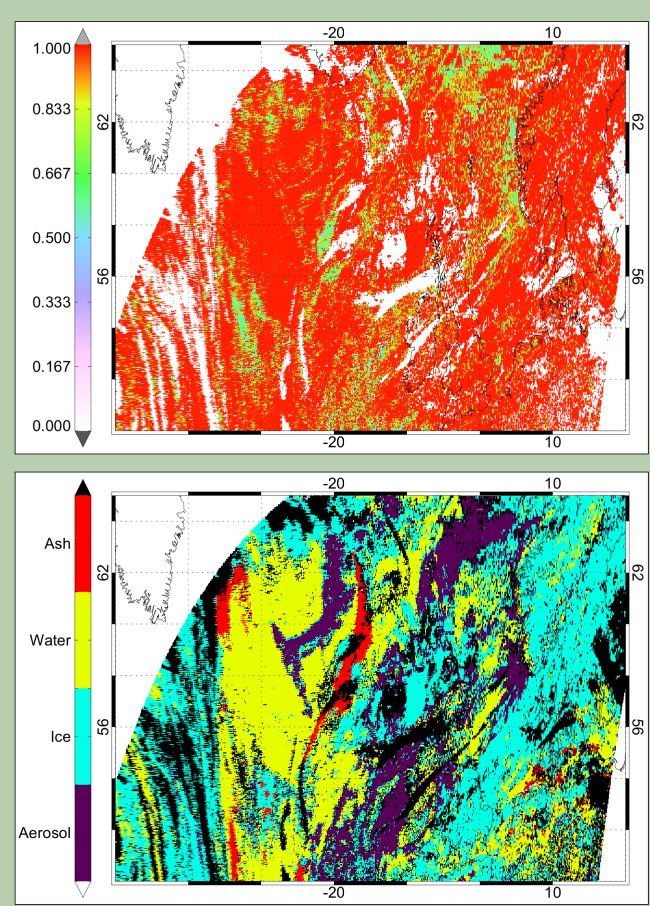
Various improvements have been made to the ingestion of auxiliary data required by ORAC. For example, meteorological information is taken from ECMWF ERA-Interim analyses. The EMOS interpolation package has been implemented to improve efficiency and accuracy. The ERA-Interim skin temperature is shown below on its native grid (circles) and ORAC's interpolated grid (diamonds). Note the improvement over land from a previous version (left) to now (centre; difference shown right).



Bayesian type identification



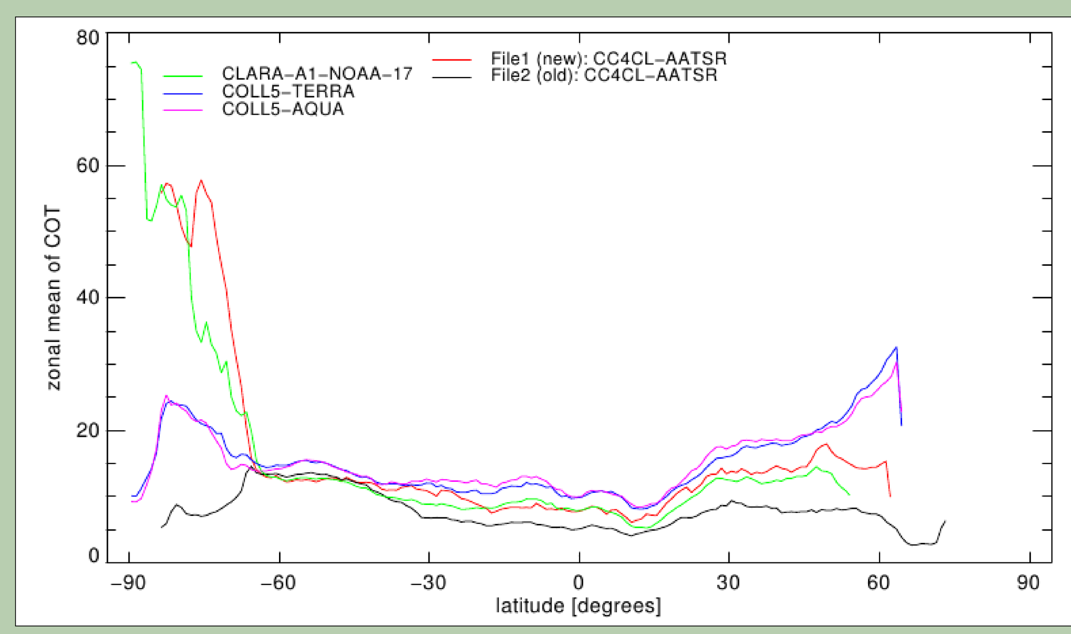
These figures plot the probability that a pixel contains aerosol, ash, water cloud, or ice cloud (top left, top right, bottom left, bottom right, respectively). Most pixels have a significant probability of being only one type.



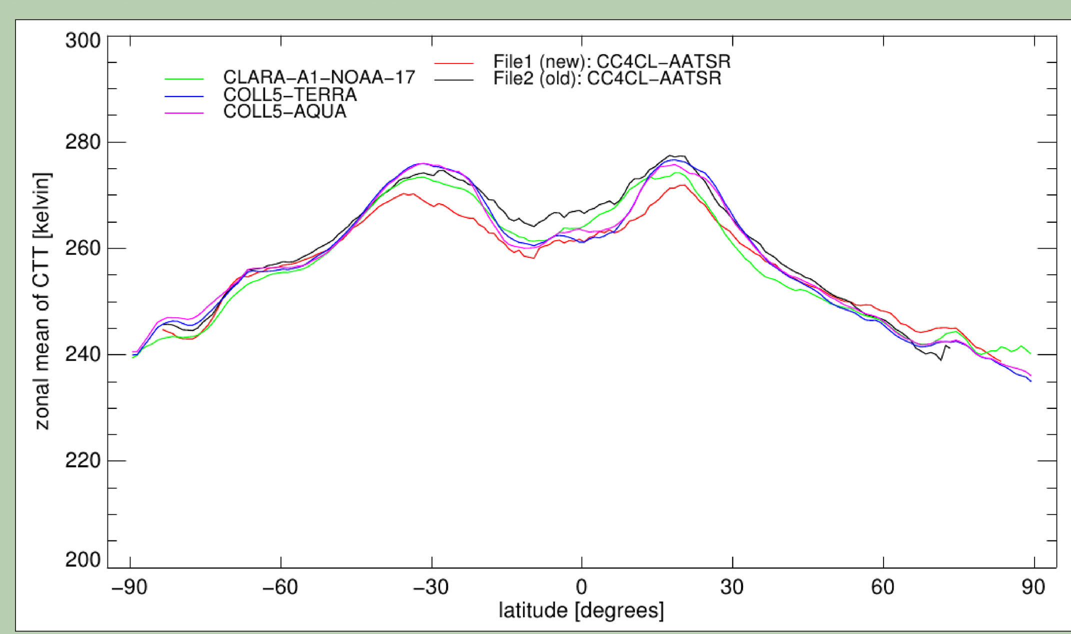
To identify where the retrieval has insufficient information to make an identification, these probabilities can be combined to determine the probability that the most likely type is a correct identification (top). Probabilities below 75 % are neglected to give the type identification shown (bottom).

Comparison against CLARA

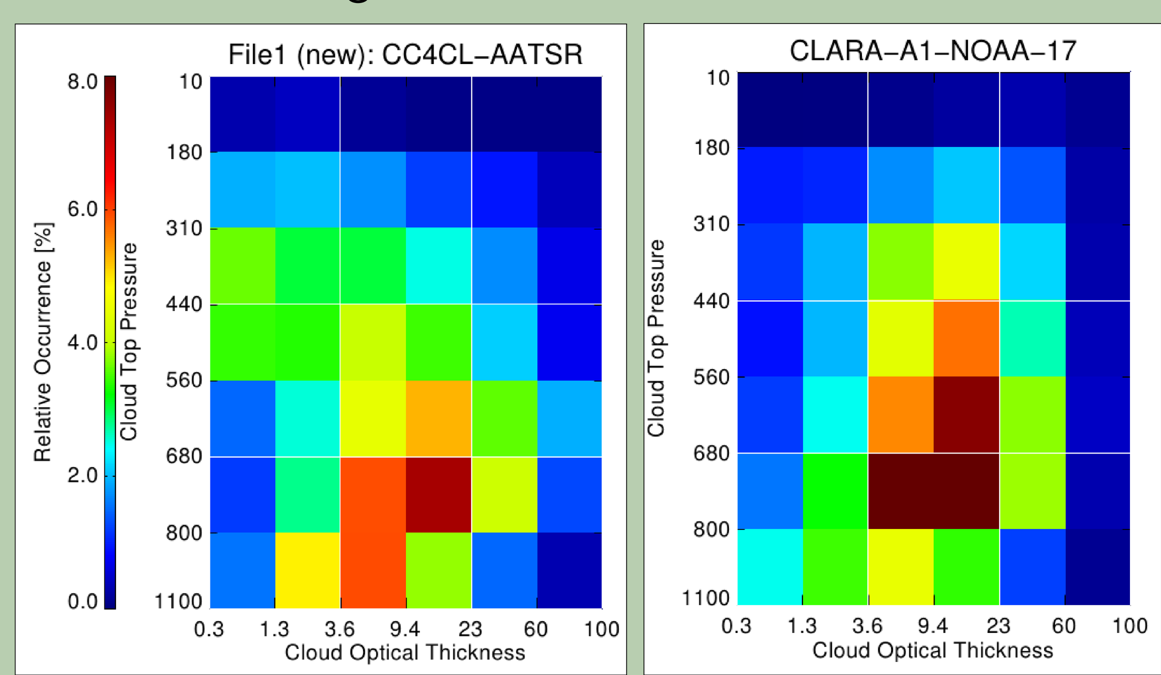
CLARA-A1 (CLoud, Albedo and RAdiation dataset, AVHRR-based, version 1) is a global dataset of cloud properties, surface albedo and surface radiation products, generated by EUMETSAT. The outputs of ORAC have been compared to CLARA for January 2008.



The above figure shows the zonal mean cloud optical thickness given by CLARA (green), ORAC (red), and the Collection 5 MODIS TERRA and AQUA products (blue and pink). ORAC closely resembles the CLARA distribution, but both differ from the MODIS result. This is likely due to the MODIS observations using channels beyond those on the AVHRR instrument.



A close agreement is found in cloud top temperature between the various products, though ORAC finds higher cloud around 30° latitude.



This increase can be illuminated by the above comparison, which considers the distribution of clouds as a function of cloud top pressure (y-axis) and optical thickness (x-axis) for ORAC (left) and CLARA (right). ORAC is identifying more thin, high clouds than CLARA.

References

[1] C.A. Poulsen, R. Siddans, G.E. Thomas, A.M. Sayer, R.G. Grainger, E. Campmany, S.M. Dean, C. Arnold, and P.D. Watts (2012) *AMT*, 5:1889–1910, doi:10.5194/amt-5-1889-2012.

[2] G.E. Thomas, C.A. Poulsen, A.M. Sayer, S.H. Marsh, S.M. Dean, E. Carboni, R. Siddans, R.G. Grainger, and B.N. Lawrence (2009) *AMT*, 2:679–701, doi:10.5194/amt-2-679-2009.

[3] L. Klüser and S. Stapelberg (2013) Cloud mask consistency analysis report (version 1.0), http://www.esa-aerosol-cci.org/?q=webfm_send/507.

CLARA comparison plots compliments of Stefan Stapelberg (DWD).

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