Retrieval Of Radiatively Consistent Sea Surface Temperature Under Clear And Aerosol-loaded Conditions Using An Optimal Estimation Scheme Across The Visible And Infrared

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1. Introduction

Sea Surface Temperature (SST) is an **essential climate variable**. Global SSTs, when derived from satellite infrared measurements, exclude data contaminated by aerosol. Although undetected aerosol may still bias SST measurements. Microwave measurements can retrieve SSTs under cloud and aerosol, but at a reduced spatial resolution.

Here, a method is presented where the properties of aerosol and SST are retrieved, using both infrared and visible data, giving a radiatively and physically consistent SST.

2. Method

The **ORAC** (Oxford-RAL Retrieval of Aerosol and Cloud) optimal estimation scheme has been used. **Optimal estimation** uses the best information on the atmosphere and surface, and combines this with a forward model that simulates the measured radiances from the satellite. Intelligent adjustment of the ‘state’ parameters we wish to retrieve (**aerosol optical depth, height and effective radius, SST**) using knowledge of all measurement uncertainties, produces physically and spectrally consistent retrievals.

Measurements
Advanced Along Track Scanning Radiometer (AATSR)

- made measurements at two viewing angles (0°, 55°) in 7 bands.
- Six of these bands are used (12 μm, 11 μm, 1.6 μm, 870 nm, 660 nm and 550 nm).
- best estimates of the uncertainties are incorporated into the model
- a correction factor is applied to the 12 μm band to account for instrument anomaly

‘a priori’ information
Contains the best information of each state, but should be independent of the validation dataset.

- Optical depth 0.6 (1e3)
- R_{eff} 0.7μm (0.5μm)
- Height of 2km (0.5km)
- SST from ECMWF with uncertainty of 5K

Forward model
•Aerosol model: DISORT into look-up tables, maritime and desert dust, OPAC database
•Surface model: BRDF, wind speed and view dependent emissivity
•Atmospheric model: Results from RFM put into look-up tables
•ECMWF model outputs [TCWV, temperature, pressure] and HNO3 climatology

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3. Global Validation

A global dataset of drifting buoys was used to validate the ORAC SST. The dataset was used in the ESA CCI Round Robin exercise, and contained auxiliary information such as cloud masking . The data went through quality checks and the cloud mask used may have screened out some aerosol too. Skin to depth temperature adjustments were made to the ORAC SST to account for the different types of measurements made by the buoys and satellite. Figure 1 shows ORAC aerosol and SST retrievals and figure 2 shoes the SST bias between ORAC and the in-situ buoys.

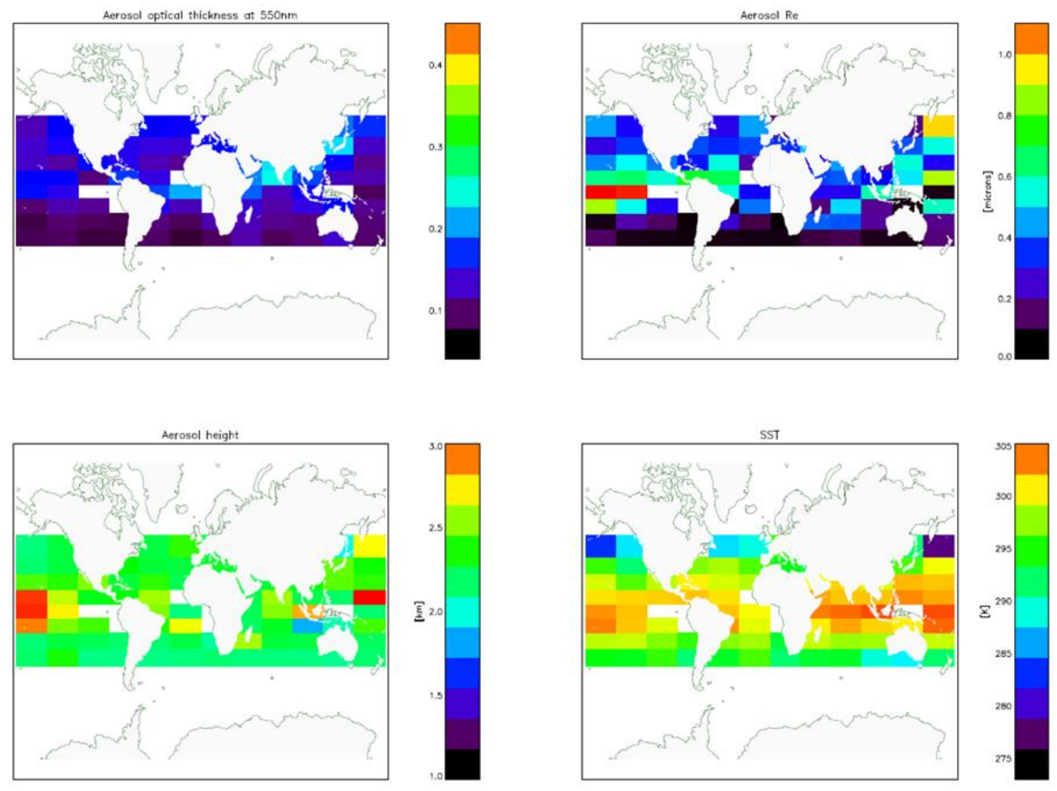

Figure 1. The ORAC retrieved aerosol optical depth, effective radius, height and SST.

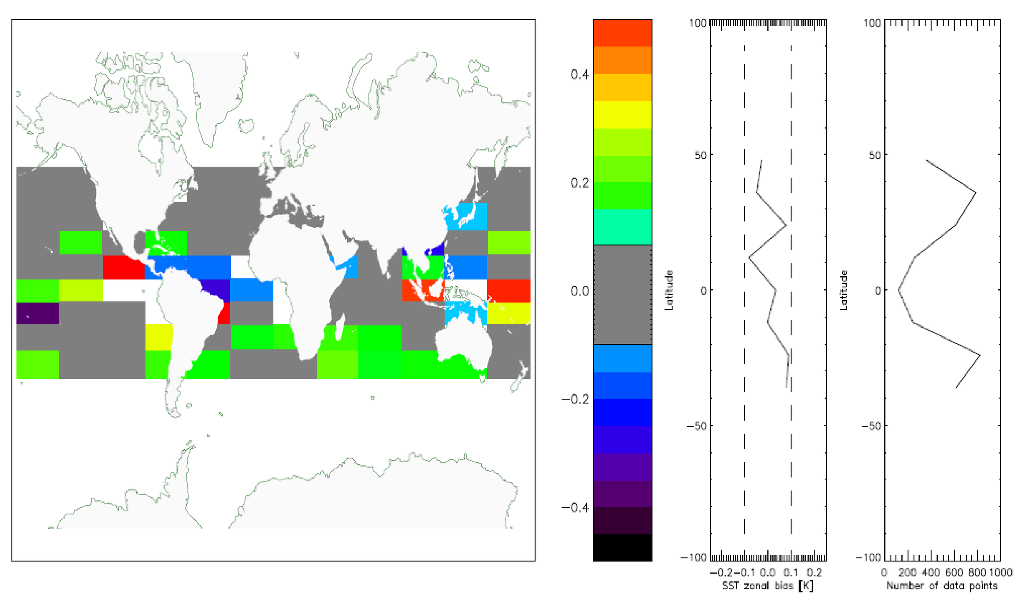

Figure 2. The SST bias between ORAC and in-situ measurements. Many measurements are within 0.1K, but there is some bias present that is linked to water vapour.

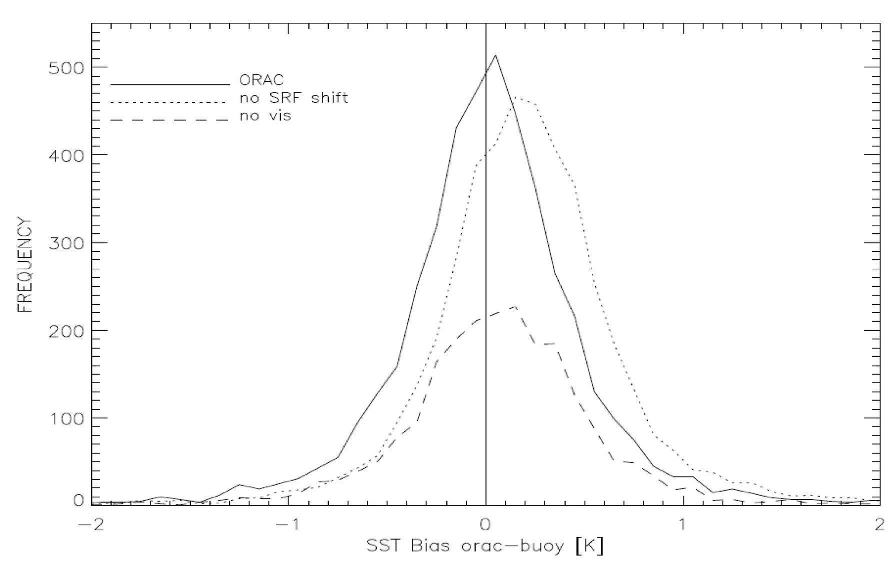

Figure 3. Here the importance of spectral and physical consistency. is shown. When no correction is made to the 12μm channel, the SST bias is increased. Also, by using the visible channels, although not impacting the SST, they improve the SST bias by allowing the retrieval of aerosols alongside the SST.

4. Regional Validation Under Dust Dust

As higher concentrations of aerosol may have been removed by the cloud masking, a region that commonly experiences dust aerosol is studied. All matchups within the region to the West of the Sahara have been processed without using the cloud mask contained in the database. It is a common issue that cloud masks cannot reliably discriminate between aerosol and cloud, and therefore this small sun-set of data has been visually cloud-cleared so as not to remove aerosol. Figure 4 shows the retrievals and SST biases. We see that increased aerosol does not affect the ORAC SST retrieval, yet for standard dual-view, 2 channel daytime coefficient based SST retrievals, the SST bias has increased.

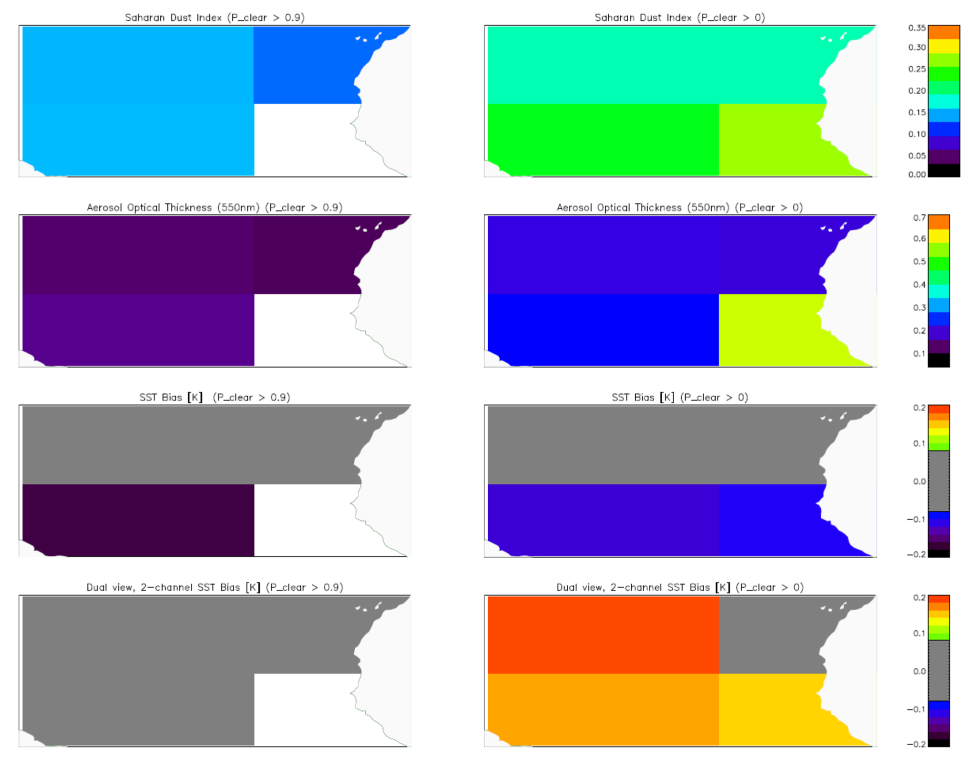

Figure 4. The left hand side shows the regional results with the strict cloud mask. The right hand sides shows results which include more aerosols.

5. An Example Scene

An AATSR image from 1st April 2008 from Western Sahara shows a dust event. We have run ORAC over the scene and the aerosol retrievals compare well visually.

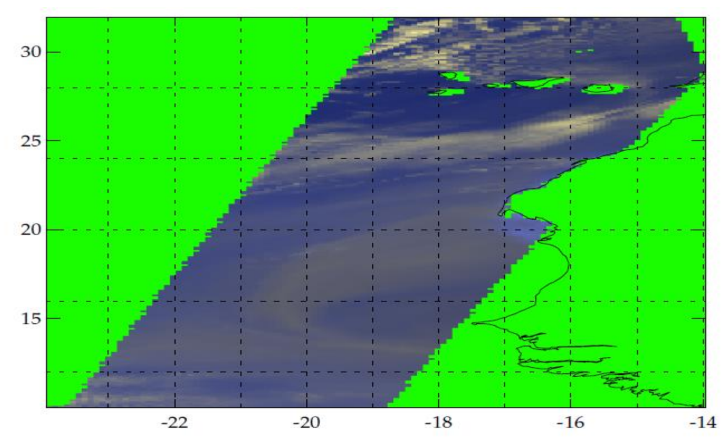

Figure 5. A visible RGB image of a dust event off the Sahara

The ORAC SST has been compared with the AATSR Level 2 product, and we retrieve cooler SSTs by -0.12K in the purely dusty region. This is in agreement with AATSR dual view SSTs exhibiting a warm bias in the presence of dust.

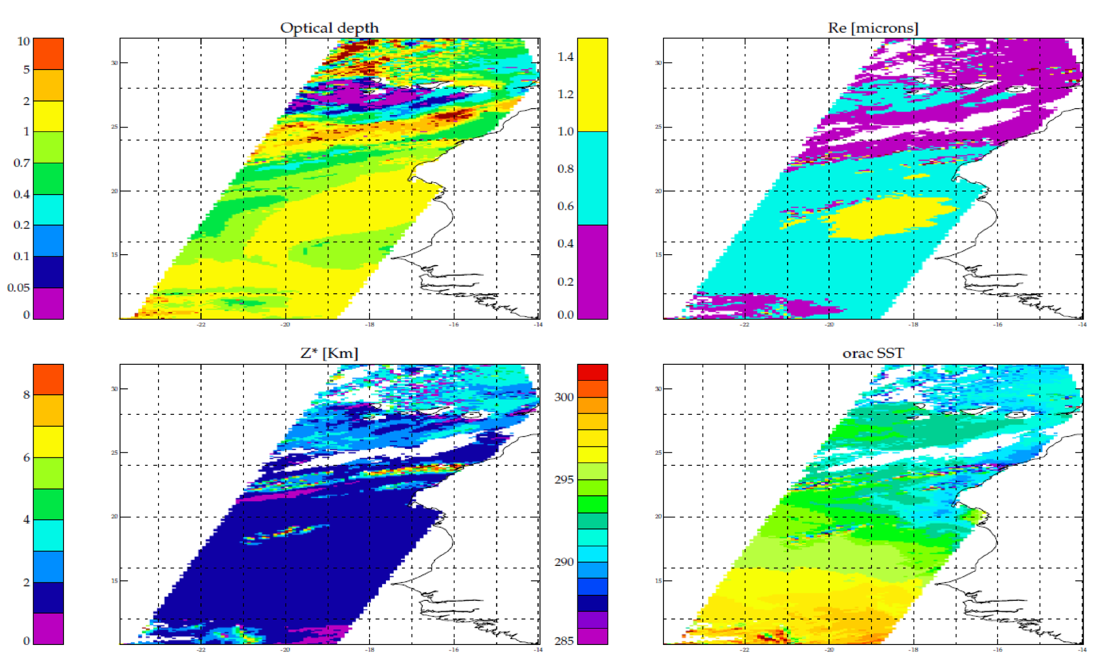

Figure 6. ORAC retrievals over the scene.

6. Summary

ORAC SST shows a global bias of less than 0.1K, but improvements need to be made to regional water vapour effects. The real advantage to this scheme however, is evident in the presence of higher concentrations of aerosol where improvements over the standard AATSR SST are observed. Further validation studies are required. This work could also be extended to other satellite instruments .

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