MERIS/AATSR synergy algorithms for cloud screening, aerosol retrieval and atmospheric correction over oceans

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The Medium Resolution Imaging Spectrometer MERIS and the Advanced Along-Track Scanning Radiometer AATSR instruments, both onboard ESA's Environmental Satellite ENVISAT, provide similar spatial resolution and swath but complementary information, encompassing different spectral domains and viewing geometries. Recent geophysical algorithms do not take advantage of a synergetic use of the measurements of both instruments, although the benefits in cloud and aerosol retrieval are obvious. This paper presents research on the synergistic use of MERIS and AATSR imagery, with the objectives to define and evaluate algorithms for (i) improved cloud screening, (ii) global aerosol retrieval and (iii) atmospheric correction.

MERIS is an imaging spectrometer with 15 programmable spectral bands in the range 400nm – 1050nm. The operational band setting positions of the 15 bands are between 412.5nm and 900nm, including one narrow channel at 761.375nm in the O_2 A-band absorption band, two bands to estimate the integrated water vapour content, and three bands to the retrieve aerosol properties. The MERIS swath covers 1150km across track. The original pixel size is 260m x 300m in nadir with a slight increase towards the edge of the swath. The full resolution data (FR) are spatially integrated (4x4 pixel) to the reduced resolution (RR) pixel with a 1040m x 1200m pixel size.
AATSR is a scanning radiometer with 7 spectral channels at visible, reflected infra-red and thermal infrared wavelengths with two ~500 km wide curved swaths, with 555 pixels across the nadir swath and 371 pixels across the forward swath. The nominal pixel size is 1km^2 at the centre of the nadir swath and 1,5 km^2 at the centre of the forward swath. This unique feature provides two views of the surface and improves the capacity for atmospheric correction and enables observations of the ocean surface under a tilt angle of ~46.9° in forward direction. The first 3 AATSR bands cover MERIS channels, however, the bandwidth of the AATSR channels is significantly larger.

For the development of the new algorithms, the radiative transfer code MOMO, based on the Matrix Operator Theory, is used to simulate synthetic measurements, considering the spectral channels and geometrical viewing of MERIS and AATSR [Fell and Fischer, 2001]. MOMO simulates scattering and absorption processes in clear and cloudy atmospheres above land or ocean surfaces and covers the solar reflective spectral region from 0.3µm up to 4µm, as well as the emitted radiation by land or water surfaces, and of the atmospheric layers depending on temperature and absorption of atmospheric gases. Figure 1 shows an example of TOA radiance simulated by MOMO over thermal and optical domains for a range of targets and cloud types. Look-Up-Tables derived from the model provide the basis for the development of the aerosol retrieval and cloud detection algorithms.

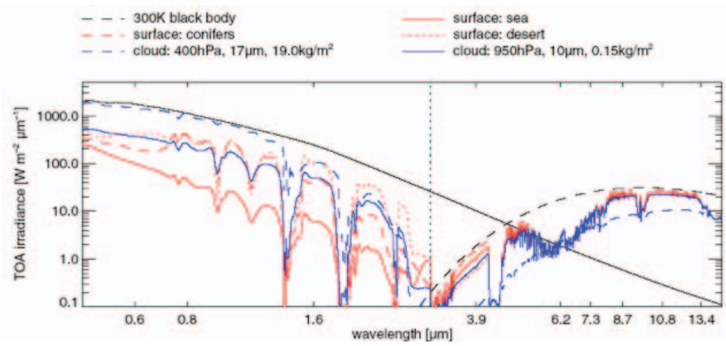

Figure 1: Modelled top of atmosphere (TOA) irradiance across optical and thermal domains using MOMO.

A new cloud-screening module has been developed relying on the synergistic use of MERIS and AATSR measurements to increase cloud detection accuracy. The algorithm exploits the combined information of the two instruments, such as the high spectral and radiometric resolutions of MERIS, the oxygen absorption feature on MERIS, the water vapour absorptions, and shortwave-infrared and thermal information from AATSR [Gomez-

Chova et al., 2008]. Thus, the proposed cloud-screening scheme relies on the extraction of meaningful physical features (e.g. brightness, whiteness, temperature) that are combined with atmospheric absorption features at specific spectral band locations (oxygen and water vapour absorptions). First results of the cloud classification based on the modelling study show improved cloud screening, especially compared to MERIS alone.

A new algorithm for aerosol retrieval over ocean, taking advantage of the synergy of MERIS and AATSR measurements, is under development [Fischer and Preusker, 2008]. It consists of three parts. The first step is the estimation of the ocean specular reflection at 3.7 micron, whereby an estimation of the thermally emitted part at 3.7 from the brightness temperatures at 11 and 12 micron is needed. The thermal emitted radiance is subtracted from the top of atmosphere radiance and corrected for water vapour, resulting in the specular reflectance at 3.7 micron. The second part is the propagation of this reflectance a) to the MERIS channels at 865nm and 779nm and b) to the corresponding MERIS observation geometry, which is necessary to account for the different scanning method of MERIS (line scanner) and AATSR (conical scanner). The wavelength dependence of the water refractive index is taken into account (see figure 3). The third part is the estimation of the aerosol optical thickness at both wavelengths utilising the surface reflection as the lower boundary condition. This procedure enables us to retrieve aerosol properties and will improve the atmospheric correction in glint and non-glint areas. An improved algorithm for the aerosol retrieval above land surfaces is under development as well [North et al., 1999, Gray et al., 2006].

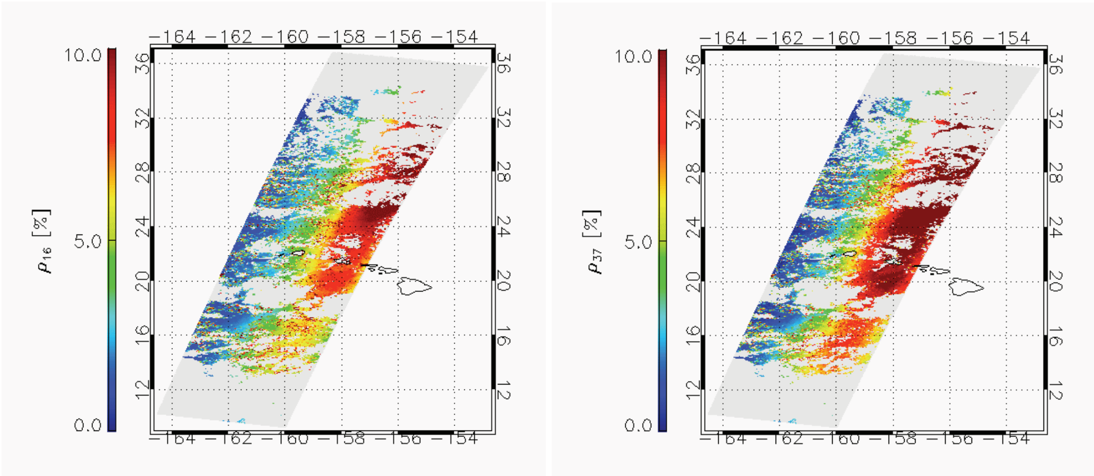

Figure 3: AATSR scene from1. June 2003 above the Hawaiian islands; measured specular reflectance at 1.6µm (left) and the calculated specular reflectance at 3.7 micron (right).

This study confirms the usefulness of the sensor concept for Sentinel 3, which is part of Global Monitoring for Environment and Security (GMES). Although the Sentinel 3 mission is primarily dedicated to ocean applications, monitoring of coastal zones and sea-ice, but also of land and clouds, will be provided. The entire mission consists of 4 (to 6) Sentinel 3 spacecrafts for maintaining the services during 20 years, performing continuous and systematic acquisitions [GMES, 2007]. This ensures long-time monitoring of sensitive environmental and climate properties.

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