ADAM: A surface reflectance Database for ESA's Earth Observation Missions

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Outline

The ADAM database has been created to address current and future mission requirements for a global surface spectral Bi-directional reflectance Distribution Function (BRDF) database of the land, sea and permanent ice sheets covering the entire wavelength region from 300-4000nm at 1nm spectral sampling with a monthly time-step, and at 0.1°x 0.1° spatial resolution.

The determination of land surface reflectances relies on a climatology of MODIS normalized surface reflectance data (after BRDF correction) processed by the FondsDeSol chain. The spectral interpolation is performed using spectral databases for common earth land surface materials. The computation of the surface BRDF is based on the Ross-Li-Maignan kernel driven model. A specific processing is applied to snow cover pixels, relying on the snow model of Kokhanovsky. Over ocean, the calculation of the ocean reflectance uses wind speed and ocean colour data derived respectively by the Quikscat scatterometer and SeaWiFS.

A dedicated website allows the visualisation of the data in different spectral regions, as well as online calculation features, the results of which can be displayed and downloaded. The calculations relies on a Python-based API that can be downloaded from the ADAM website and therefore used locally on the computer hardware of any user.

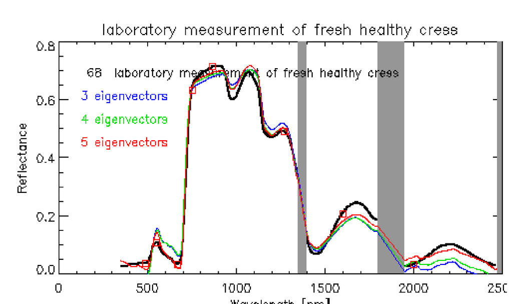
Evaluations of the ADAM database have been performed by inter-comparison with other datasets (independent MODIS products, MISR) and by assessing its impact on NO_2 and cloud parameter retrievals.

2. Calculation of Land reflectances

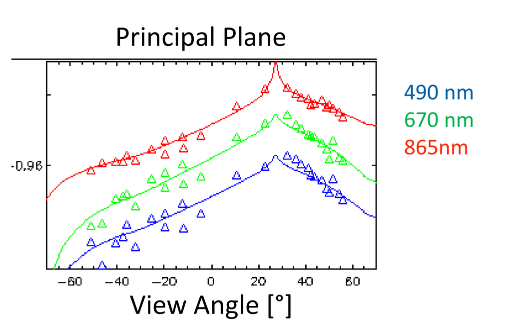
Spectral interpolation

- Statistical (EOF) analysis of available spectra over soil and vegetation used to constrain the eigenvectors weights based on the narrowband measurements.
- Final reconstruction of the reflectance spectrum from the 7 MODIS wavebands using 4 eigenvectors.
- Computation of the spectral interpolation uncertainty based on error variance-covariance matrix of the reflectance between the 7 MODIS bands.

Example of a reflectance spectrum reconstruction using 7 MODIS-like bands over 300-2500 nm



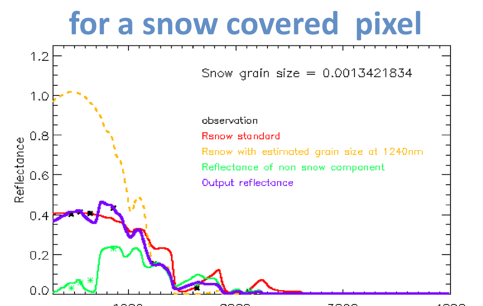
Fit of MODIS reflectance data using the Ross-Li-Maignan BRDF model



Directional modeling

- Land surface BRDF represented by the Ross-Li-Maignan BRDF model, with the directional coefficient parameterized as a function of the NDVI for each pixel (therefore accounting implicitly for the evolution of the vegetation cover with time).
- Computation of the directional variation of the uncertainty is function of the prior uncertainty on the directional parameters of the BRDF model.

Fit of the MODIS observations in the standard observation geometry for a snow covered pixel



Special processing of snow covered pixels

- Used of a stepwise algorithm, based on the Kokhanovsky snow reflectance model that reproduces the spectral and directional signatures of the snow.

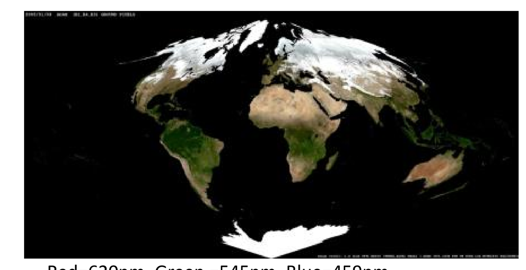
1. ADAM input datasets

Land Surfaces :

- **Monthly climatology of normalised land surface reflectances** in the 7 MODIS bands (VIS-NIR).
- Climatology derived from the FondsDeSol (FDS) processing chain of MOD09A1 TOC reflectances (8 days, 500 m) for year 2005 mainly.
- Correction of the measured reflectances from the surface anisotropy and calculation of the surface reflectance in a standard observation geometry (sun zenith angle at 45°, viewing at nadir) thanks to the biome directional signature determined from POLDER/PARASOL observations.
- Removal of the contaminated pixels in MOD09A1 reflectances from clouds and shadows using a contrast filtering method. Flagged or missing data are temporally interpolated from pixels with similar signatures and classifications in the 2003-2006 database.
- Determination of the variance-covariance matrix of the reflectance between the 7 bands based on the spatial variability of the surface reflectance within the 0.1°x0.1° pixels.

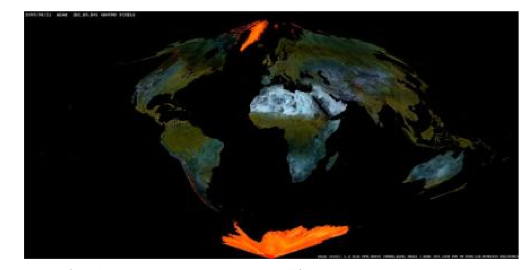
ADAM-FondsDeSol land surface climatology

January



Red=620nm, Green =545nm, Blue=459nm

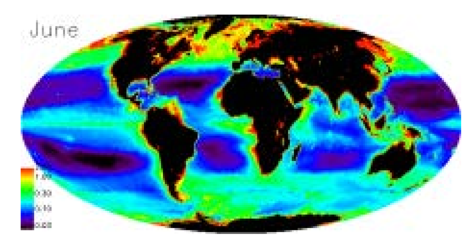
August



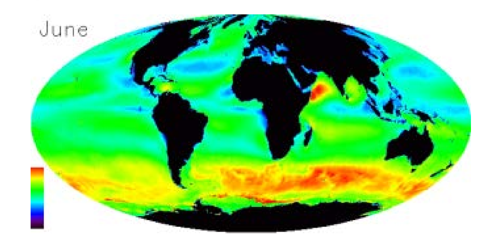
Red=841nm, Green=1230nm, Blue=1628nm
Absorption in the Green and Blue highlight ice and snow

Ocean Surfaces :

- **Chlorophyll content** monthly climatology at 0.5° derived from SeaWiFs monthly mean fields. Gap-filling over cloudy or absence of daylight areas.



- **Wind speed** monthly climatology datasets at 0.5° based on QuikScat dataset available from IFREMER. Average of the available monthly data.



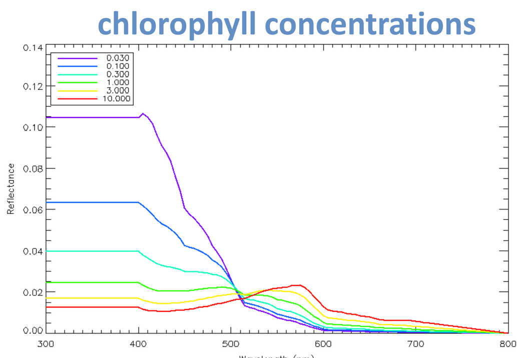
3. Calculation of Ocean reflectances

The ocean Reflectance is the sum of three terms

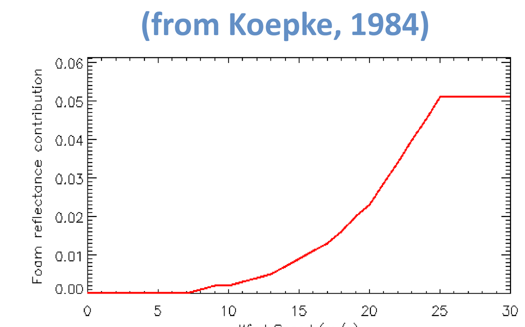
- **water column**: mostly a function of chlorophyll concentration.
- **specular reflection**: mostly a function of observation geometry and wind speed (ws). A modified version of the Cox & Munk model is used.
- **foam reflectance**: mostly a function of wind speed with a spectral dependency.

$$\rho_{ocean} = \rho_{chloro}(\lambda) + \rho_{sp}(\theta_s, \theta_v, \varphi, ws) + \rho_{foam}(ws, \lambda)$$

Ocean column reflectance models as a function of chlorophyll concentrations



Maximum foam reflectance as a function of wind speed (from Koepke, 1984)

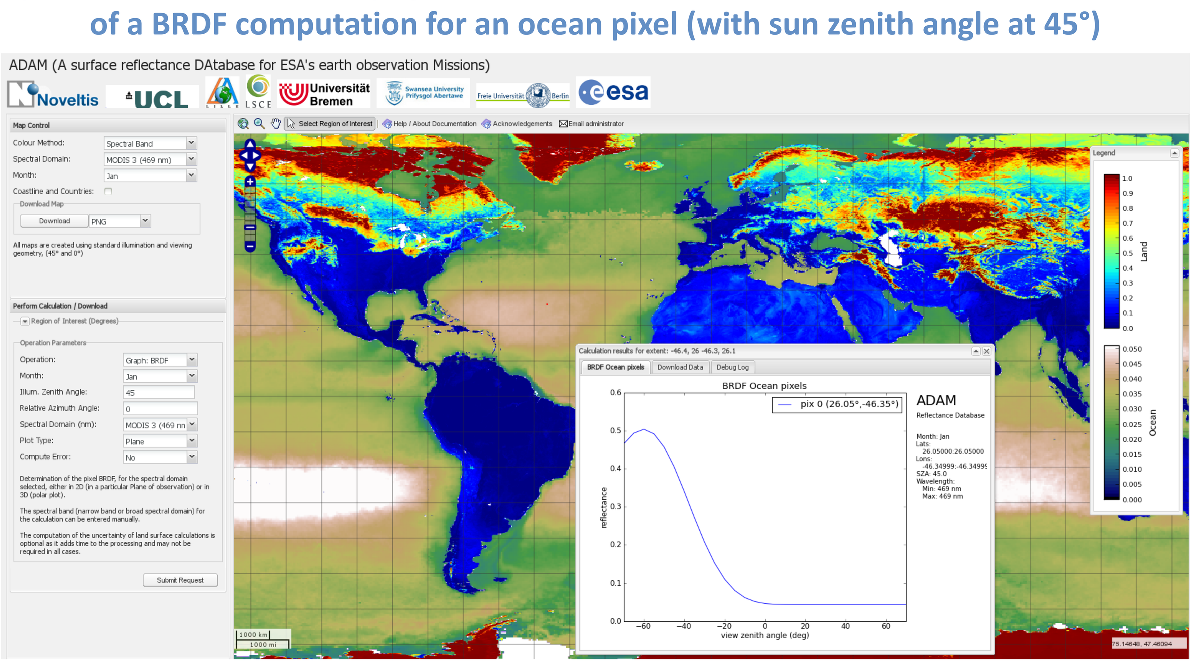


4. ADAM web interface www.adam.noveltis.fr

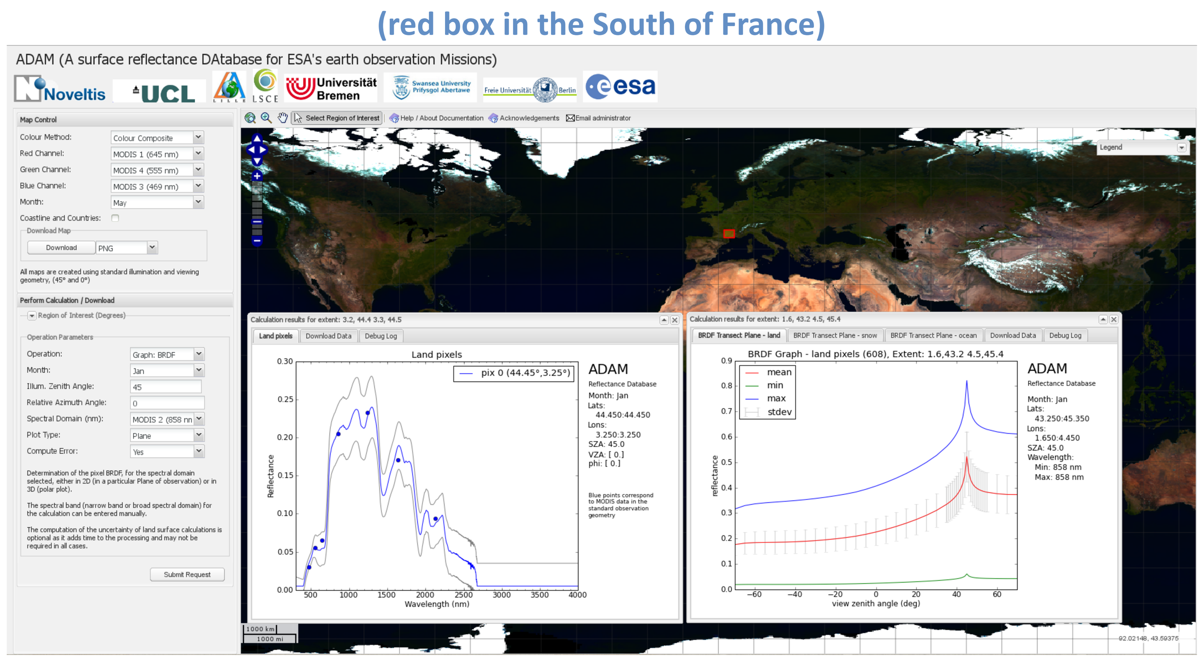
Interactive Web-based mapping application allowing:

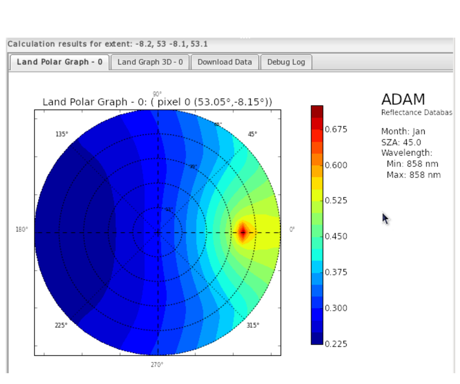
- access to the whole or part of the ADAM input climatologies (over land and ocean).
- dynamic and interactive computation, for an area of interest, of :
  - o the **reflectance spectra** of the corresponding pixels from 300 up to 4000nm (1nm spectral resolution
  - o the **directional variation of the surface reflectance** (particular transect plane or in 3D)
  - o the **time series** of the surface reflectances

Snapshot of the ADAM web page: Earth surface reflectances in MODIS 3 band and result of a BRDF computation for an ocean pixel (with sun zenith angle at 45°)



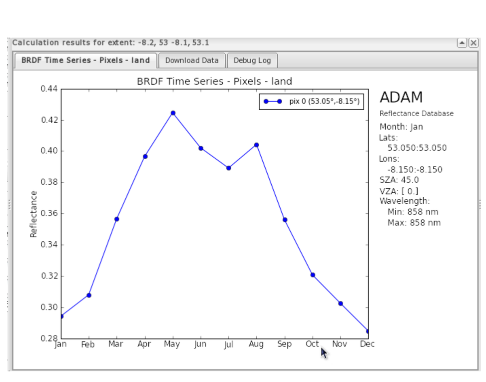
Snapshot of the ADAM web page: Colour composite of the Earth surface reflectances and results of a reflectance spectrum interpolation & BRDF calculation for an area of interest (red box in the South of France)





Example of a land surface BRDF display in polar plot representation

Example of a reflectance time series of a vegetation pixel at 858 nm



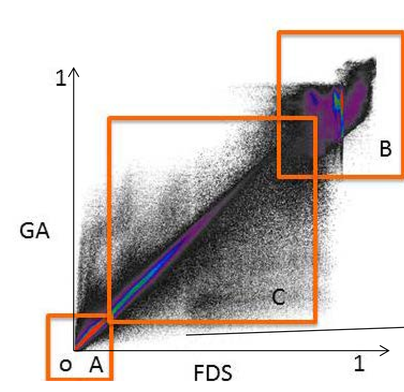
5. Evaluation of the ADAM product

Direct validation of the Land products

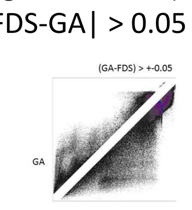
Comparison with consistent GlobAlbedo dataset

- Determination of a monthly climatology of normalized reflectances based on the GlobAlbedo (GA) processing chain, using 10 years of MODIS BRDF data (MCD43A1)

Comparison of ADAM-FDS and ADAM-GA Directional Hemispherical Reflectances (all wavebands)

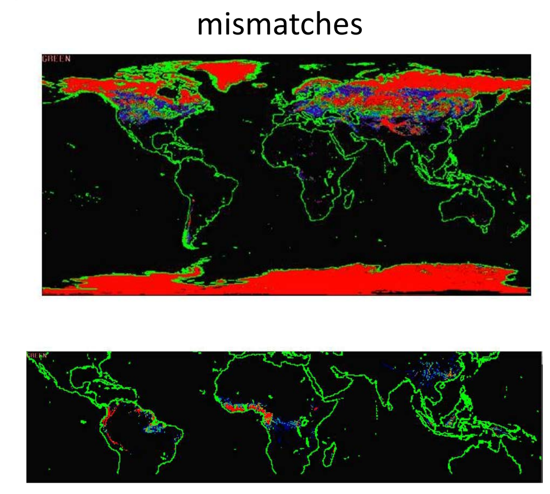


region B and C (where |FDS-GA| > 0.05



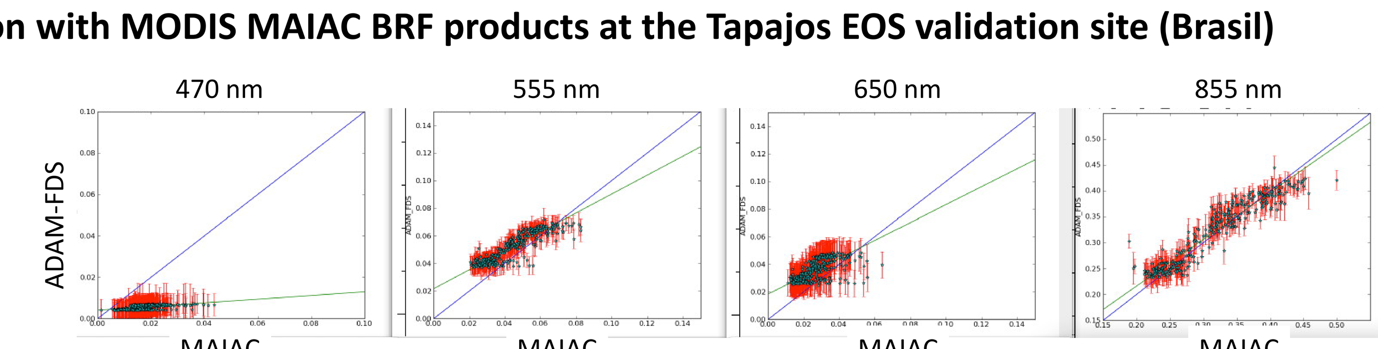
region A

Geographical distribution of ADAM-FDS vs ADAM-GA mismatches



- Overall excellent agreement between the two datasets
- The largest differences correspond to :
  - o (region B and C) differences in the accounting of the snow cover dynamics along with the data processing (how a pixel with changing snow coverage within the temporal window of averaging is treated) and by the use of different BRDF models over snow
  - o (region A) remaining aerosol/cloud contamination in GlobAlbedo

Comparison with MODIS MAIAC BRF products at the Tapajos EOS validation site (Brasil)

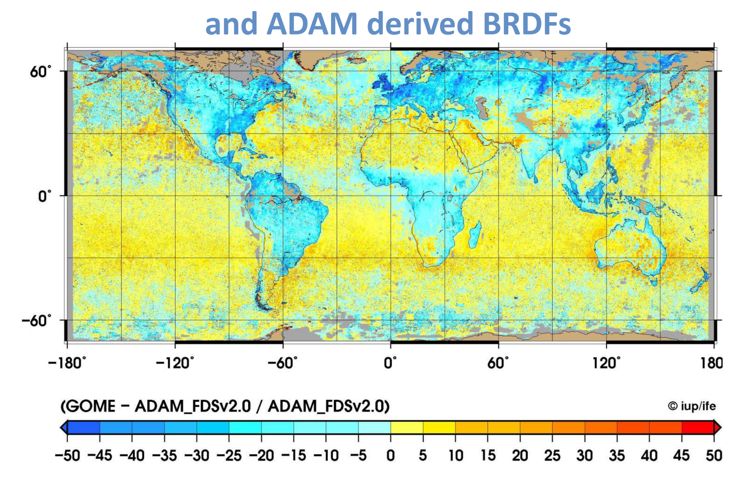


Indirect validation and assessment

Evaluation of the impact of using surface BRDFs derived from ADAM for the retrieval of tropospheric NO_2 from SCIAMACHY as compared with the classical use of GOME Lambertian reflectance data.

- The retrieved NO_2 vertical column density are similar over waters and deserts.
- The significant differences over vegetation suggests that the retrieval are strongly affected by LER assumption wrt more realistic BRDF models.

Relative differences in SCIAMACHY tropospheric NO_2 vertical column densities between retrievals using GOME LER dataset and ADAM derived BRDFs



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