Showcases for WGCV-WGISS QA4EO: DEMqis∞ & QAlbedo

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Lead, GEOSS Task IN-02-C2

Chairperson, CEOS-WGCV Sub-group on Terrain mapping from satellites

Chairperson, ISPRS Commission IV WG on "Global DEM Interoperability"

Chair, UK JISC Geospatial Working Group (2010-)

Chair, UK Space Agency Planetary Exploration Advisory Cmte (AurAC, 2010-)

Head, Imaging Group

Professor of Image Understanding and Remote Sensing

MSL Curiosity NASA Collaborator (MSL 2012)

HRSC Science Team Member (ESA Mars Express 2003)

Stereo Panoramic Camera Science Team Member (ESA EXOMARS 2018)

MODIS & MISR Science Team Member (NASA EOS Project)

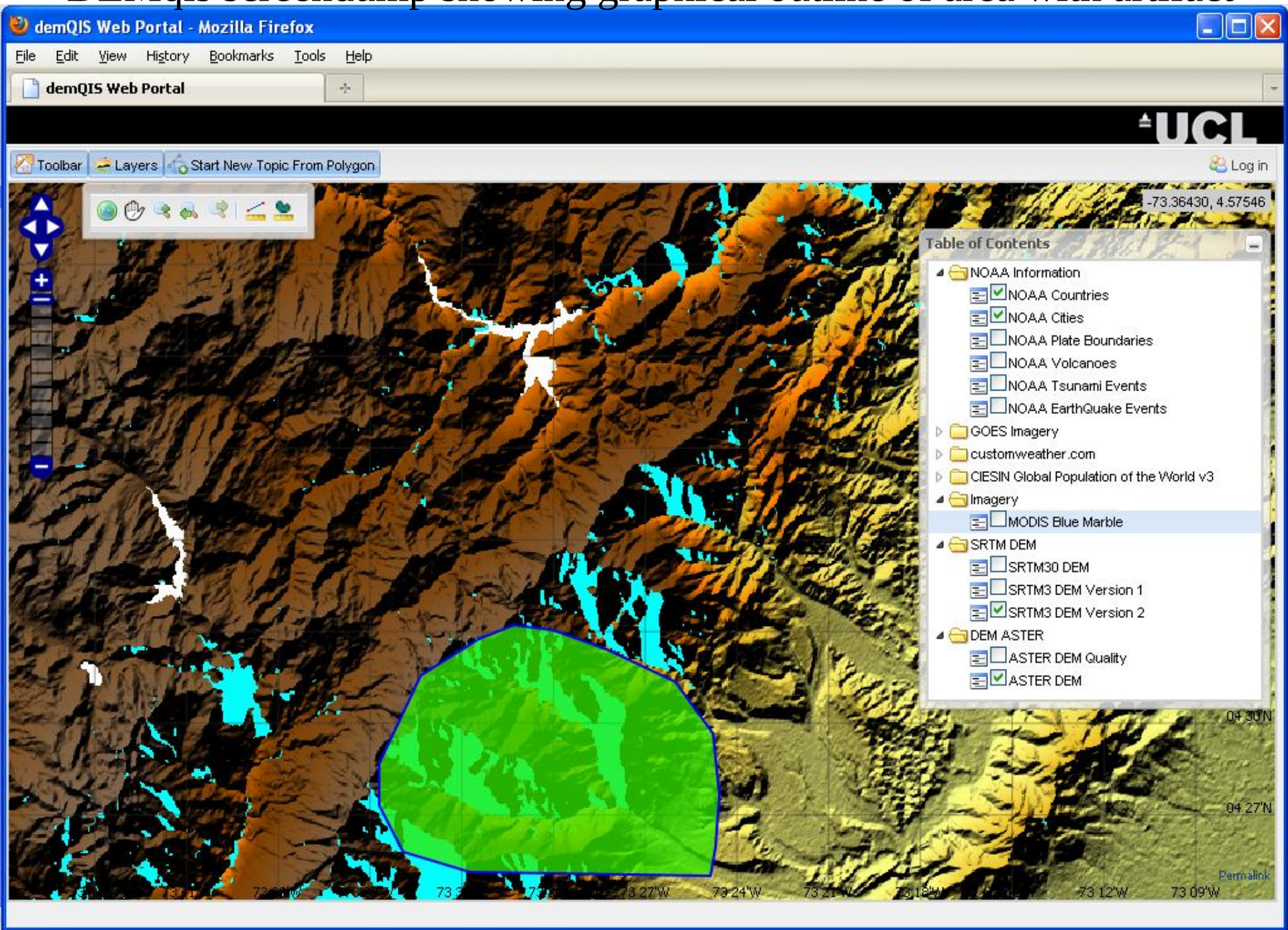
TerraSAR-X and TANDEM-X science team member (DLR-Astrium)

** Partially supported by UK Space Agency under the ICP3 programme*

Proposed DEMqis functions - 1

- **Display a SIMPLE variable: elevation/bathymetry and associated QA information PER PIXEL, where available**
- **Display in-house hosted SRTM and ASTER GDEMv1,2 as WMS**
- **Cascade to WMS such as**
  - **George Mason University DEMexplorer WMS for ASTER-GDEM**
  - **DLR WMS for X-SRTM DEMs and in future**
  - **USGS-EROS GMTED2010 WMS (??)**
  - **ISRO Cartosat-1 WMS (??)**
  - **Astrim Geoservices SPOT-5 DEM WMS & TanDEM-X (??)**
  - **ALOS-PRISM WMS (??)**
  - **New spaceborne DEMs as they become available**
- **Includes transparency to mix and match different datasets and flicker to allow two datasets to be compared (e.g. ASTER, SRTM)**
- **Includes change of overlay priority from one dataset to another**
- **Includes graphical outlining of areas where artifacts have been identified**
- **Allows descriptive information to be added to each artifact located and inserted into the PostGreSQL database**
- **http://demqis.net still available**
- **New media services: YouTube channel for CEOS?**

DEMqis screendump showing graphical outline of area with artifact



Proposed DEMqis WPS functions

- **New web (value-adding) services could be developed by different space agencies irrespective of whether they produce or store/distribute DEMs:**
  - **New visual layers to add (e.g. land cover)**
  - **Extraction of point or transect or polygonal areas of DEMs**
  - **Inter-comparison of point or transect or polygonal area with display of statistics**
  - **New value-added products (e.g. bare earth retrieval of DTM)**
  - **River catchment extraction or hydrological network extraction with**
  - **Data fusion engines for combining different datasets**
- **Citizen science e.g.GalaxyZoo at http://www.galaxyzoo.org/**
  - **Identification of artefacts and subsequent feedback to data supplier for consideration to repair**

www.GlobAlbedo.org

The ESA GlobAlbedo Project for mapping the Earth's land surface albedo for 15 years from European Sensors

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•*With contributions from Crystal Schaaf (U. of Mass., Boston), Gabriela Schaapman-Strub (U of Zurich) and Alessandro Cescatti (FLUXNET at JRC Ispra)*

Overall Aims - GlobAlbedo

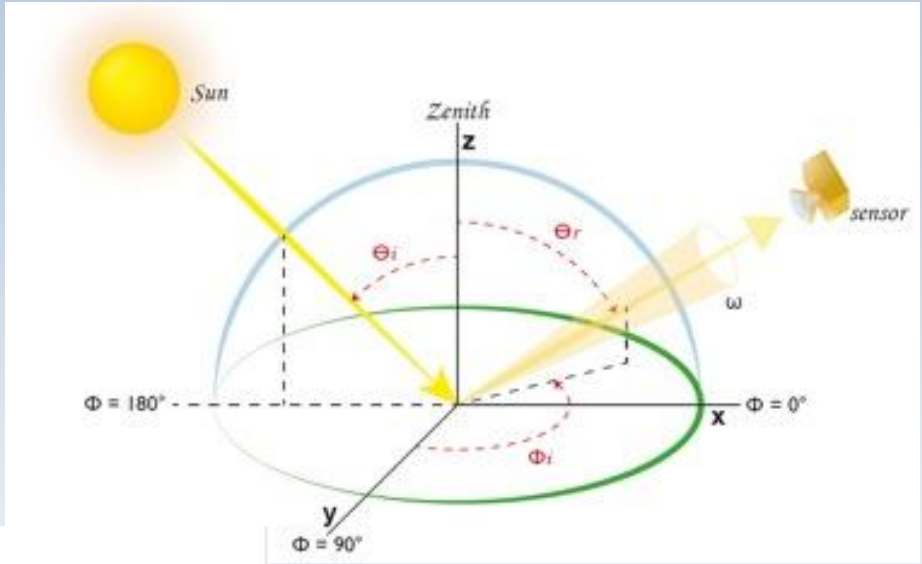
- Production of a 13 year record (1998-2011) of 1km Land Surface BroadBand Albedo (BBA) every 8 days and monthly from European space assets to provide an independent capability to generate this Essential Climate Variable
- Input data consists of level 1b (radiometrically calibrated, satellite projection) as well as MODIS MCD43A1,2 BRDF (3/2000-3/2012)
  - MERIS (6/2002-6/2011)
  - VGT (24.3.98-31.1.03) and VGT2 (1.2.03-30.6.11)
  - [ATSR2 6/95-3/00, AATSR 6/02-12/11 unusable due to geocoding]
- An estimated uncertainty (variance-covariance matrix) is produced for each output pixel using an optimal estimation framework
- Validation of final albedo products as well as intermediate products (e.g. cloud masks, aerosol retrievals, narrow-to-broadband)
- GlobAlbedo products are freely available via wget/curl, http and an OGC-compliant webGIS

What is a BRDF?

Relation of incoming and reflected radiance terminology used to describe reflectance quantities

Incoming/Reflected	Directional	Conical	Hemispherical
Directional	Bidirectional CASE 1	Directional–conical CASE 2	Directional–hemispherical CASE 3
Conical	Conical–directional CASE 4	Biconical CASE 5	Conical–hemispherical CASE 6
Hemispherical	Hemispherical–directional CASE 7	Hemispherical–conical CASE 8	Bihemispherical CASE 9

The labeling with 'Case' corresponds to the nomenclature of Nicodemus et al. (1977). Grey fields correspond to measurable quantities (Cases 5, 8), the others (Cases 1–4, 6, 7, 9) denote conceptual quantities.



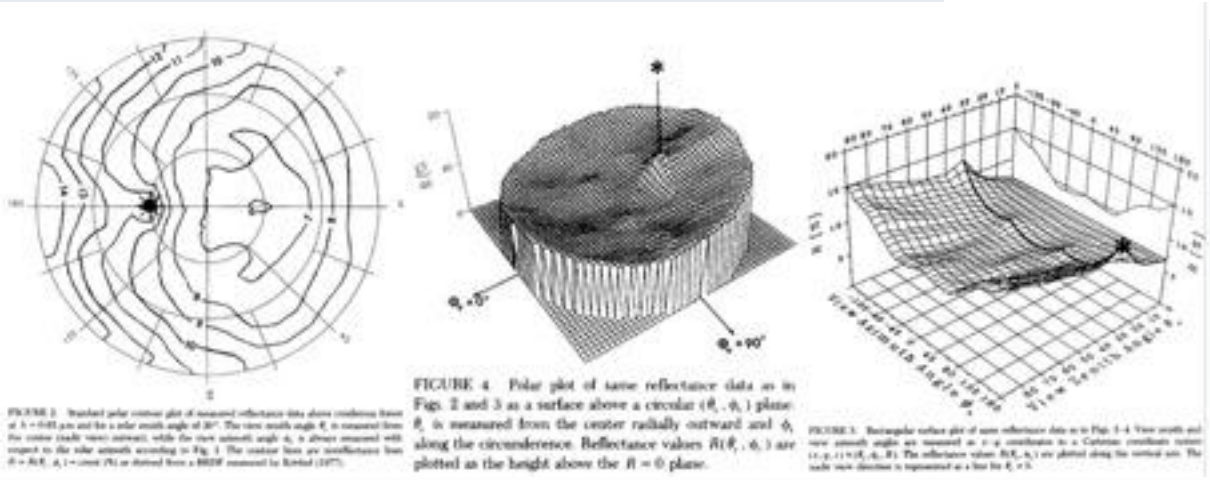


FIGURE 4 Polar plot of same reflectance data as in Figs. 2 and 3 as a surface above a circular (θ_r, ϕ_r) plane. θ_r is measured from the center radially outward and ϕ_r along the circumference. Reflectance values $R(\theta_r, \phi_r)$ are plotted as the height above the $R = 0$ plane.

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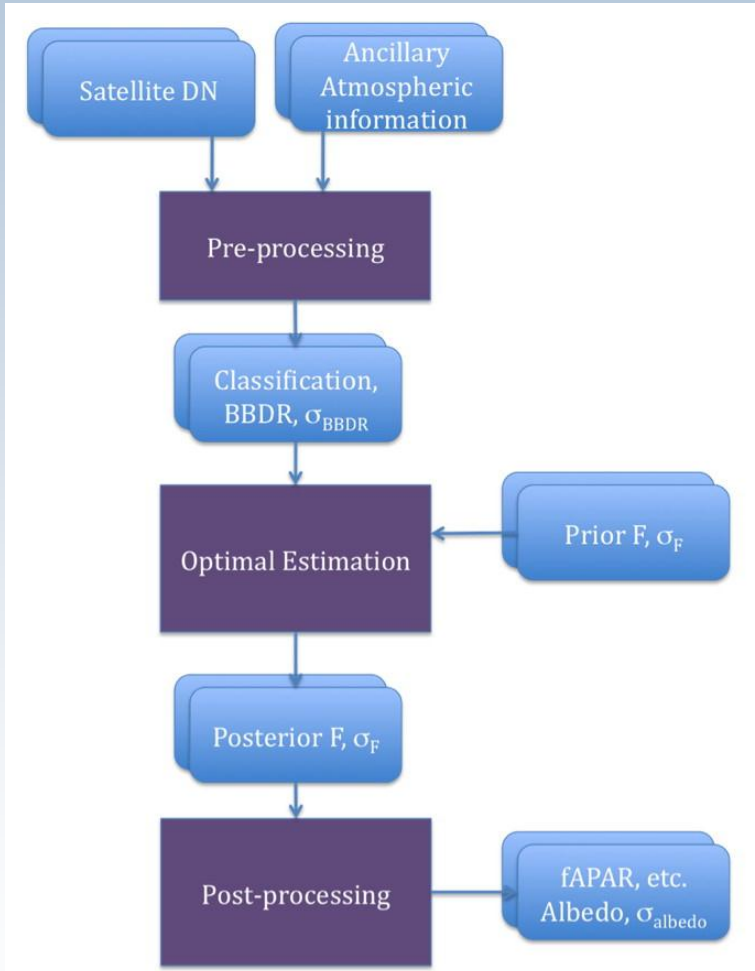
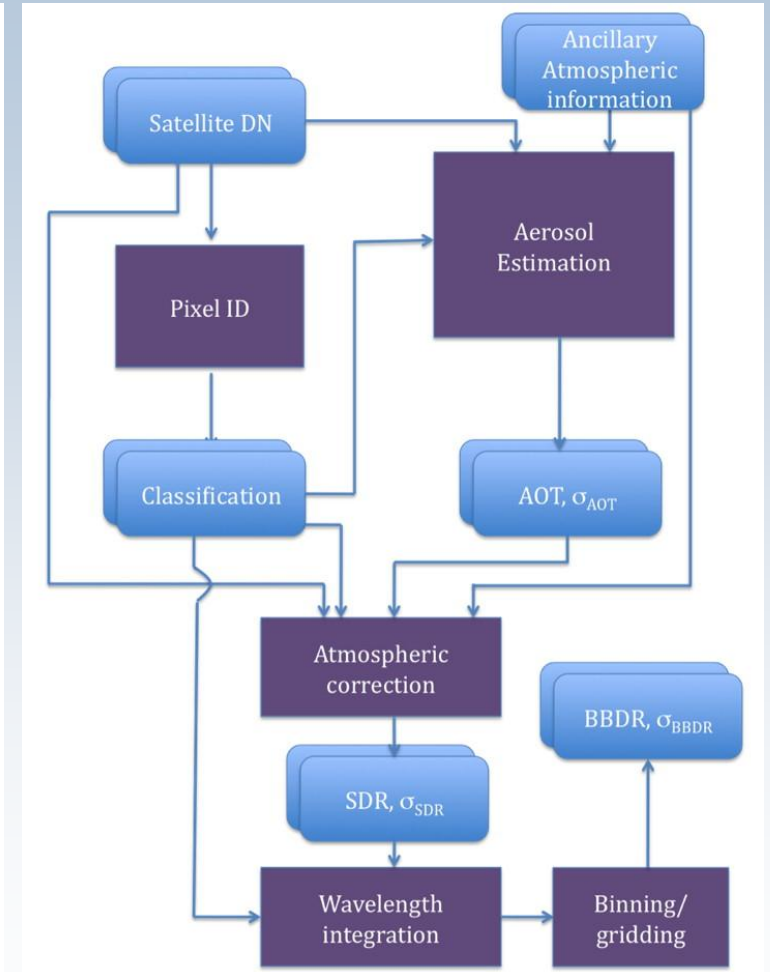
Product Processing and Validation

- Subset of GlobAlbedo products validated
- Focus on
  Pixel ID
  AOT
  SDR
  N-to-BB
  Albedo
- Validation performed by relevant producer with support from PI
- Russian Albedo validation performed by G. Schaapman-Strub for 2005



Overall GlobAlbedo processing chain



GlobAlbedo product flowchart

BRDF TILE product (**not currently distributed**)

- 9 kernels [isotropic, geometric, volumetric] x [VIS, NIR, SW]
- 45 layers from 9 x 9 error variance/covariance matrix per pixel
- Pixel classification (land or water), Relative entropy (impact of priors), SZA
- Nsamples and Mdays used in BRDF retrieval from accumulator arrays
- 59 band product with each layer of 32-bit floating point arrays (324.09 MB)
- netCDF of ≈4.5 Tb (uncompressed) for a single processed year

Albedo TILE product (distributed)

- 6 albedos [DHR, BHR] x [VIS, NIR, SW]
- 6 standard errors for [DHR, BHR] for [VIS, NIR, BBA] derived from error variance/covariance matrix per pixel
- Pixel classification (water or land [snow or no-snow depending on Mdays]), Relative entropy (impact of priors), posteriori entropy
- Nsamples and Mdays used in BRDF retrieval from accumulator arrays
- 17-band product with each layer of 32-bit floating point arrays (93.37MB)
- netCDF of ≈1.5 Tb (uncompressed) for a single processed year

Generation of priors

- Input: MODIS Collection V005 BRDF-Albedo model parameters product
  - MCD43A1, MCD43A2 at 500m* (2000-2012)
- Same kernel models used as used in GlobAlbedo
- Estimate climatology and uncertainty in parameters
  - Uncertainty to include actual variation: conservative
- Product has no uncertainty information, but 4 QA states
  - Apply weighting to QA states: *relative* uncertainty

$$W_{c0} = \frac{1}{\sigma_{QAc0,k}}$$

Code	Meaning
0	best quality, full inversion (WoDs, RMSE majority good)
1	good quality, full inversion
2	Magnitude inversion (numobs >=7)
3	Magnitude inversion (numobs >=3&<7)
4	Fill value

* *Thanks to Dave Obler and Robert Wolfe for supply of data on USB2 disks*

Generation of priors

- Mean:

$$\overline{f}_k(i,j) = \frac{1}{N_{(i,j)}} \sum_{c=0}^{c=3} \sum_{yQAc} W_{c0} f_{QAc,k}(i,j)$$

$$N_{(i,j)} = \sum_{c=0}^{c=3} \sum_{yQAc} W_{c0}$$

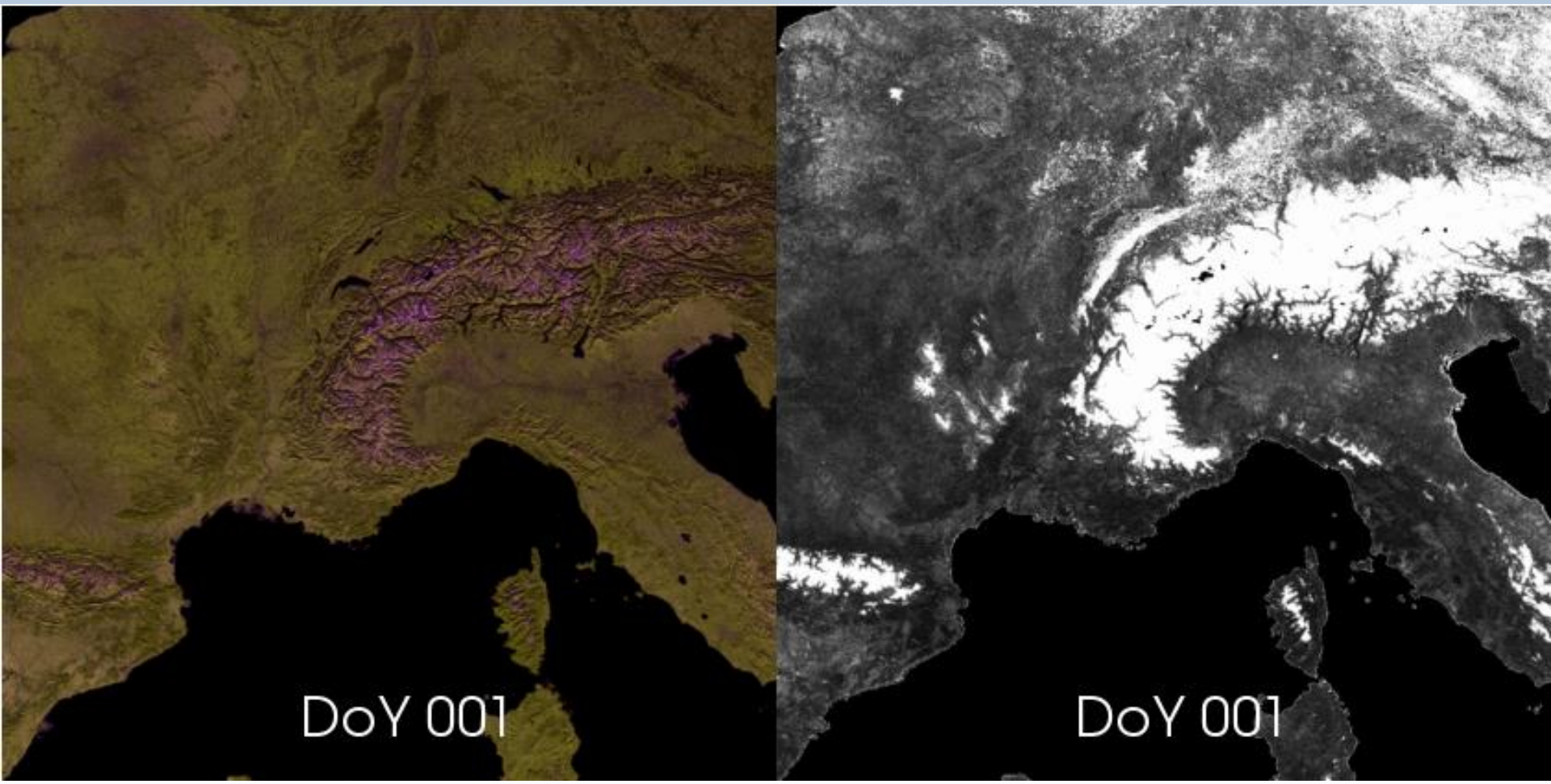
- Standard error (incl. small number bias correction):

$$\sigma'^2_{1,2} = \frac{\sum_{i=1}^{i=n} w_{QAi} \sum_{i=1}^{i=n} \left[w_{QAi} \left(x_{1,i} - \bar{x}_1 \right) \left(x_{2,i} - \bar{x}_2 \right) \right]}{\left(\sum_{i=1}^{i=n} w_{QAi} \right)^2 - \sum_{i=1}^{i=n} w_{QAi}^2}$$

$$s^2_{1,2} = \sigma'^2_{1,2} \Big/ \sum_{i=1}^{i=n} w_{QAi}$$

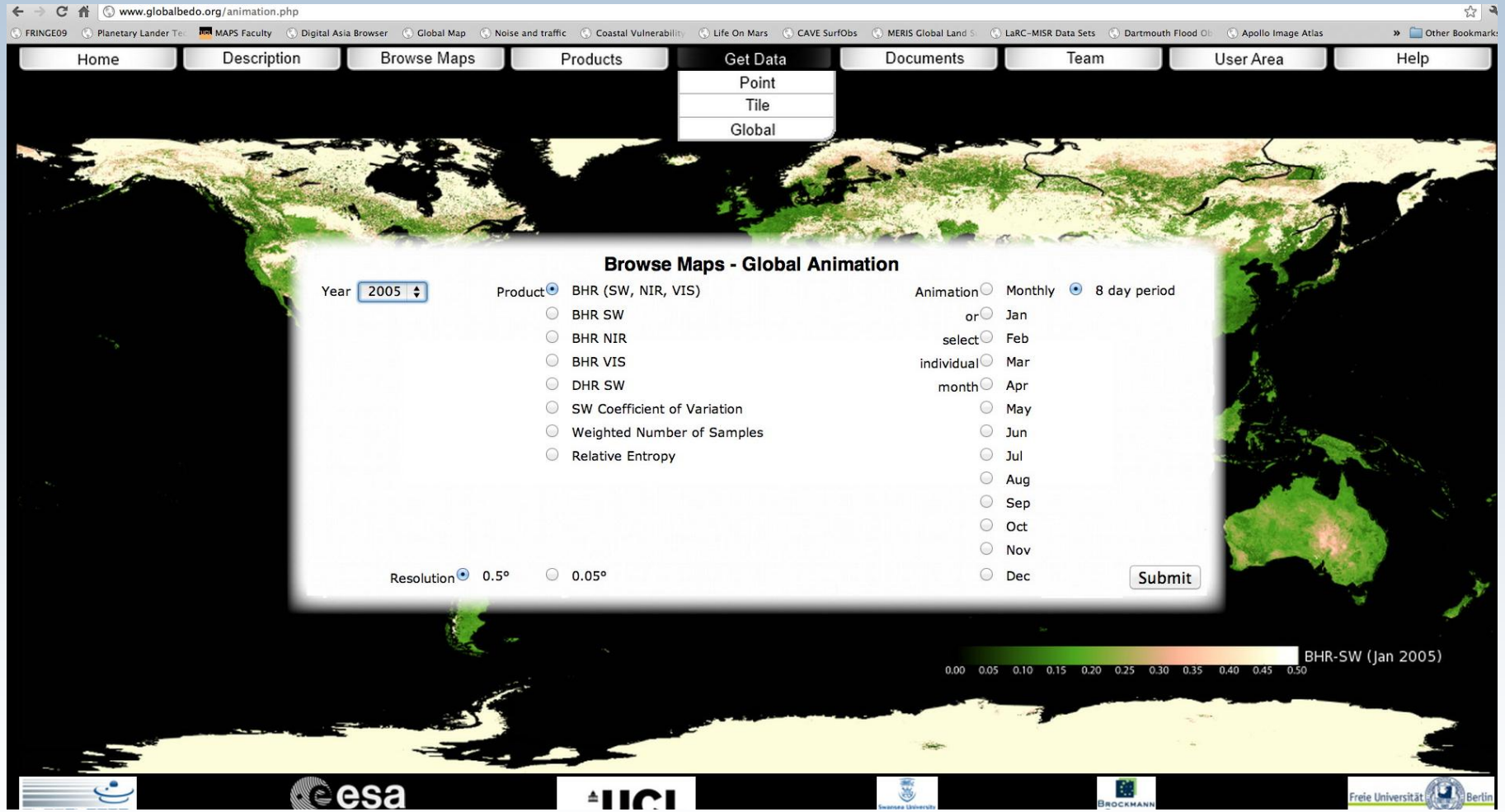
- Examined temporal-weighting of priors:
  - Very similar to a weighting of climatology priors

MODIS - Prior



MODIS-derived prior for tile h18v04 for 2005 – FCC SW f0, NIR f0, VIS f0 (RGB) and standard error model parameter f0 VIS, image scaled 0:0.25

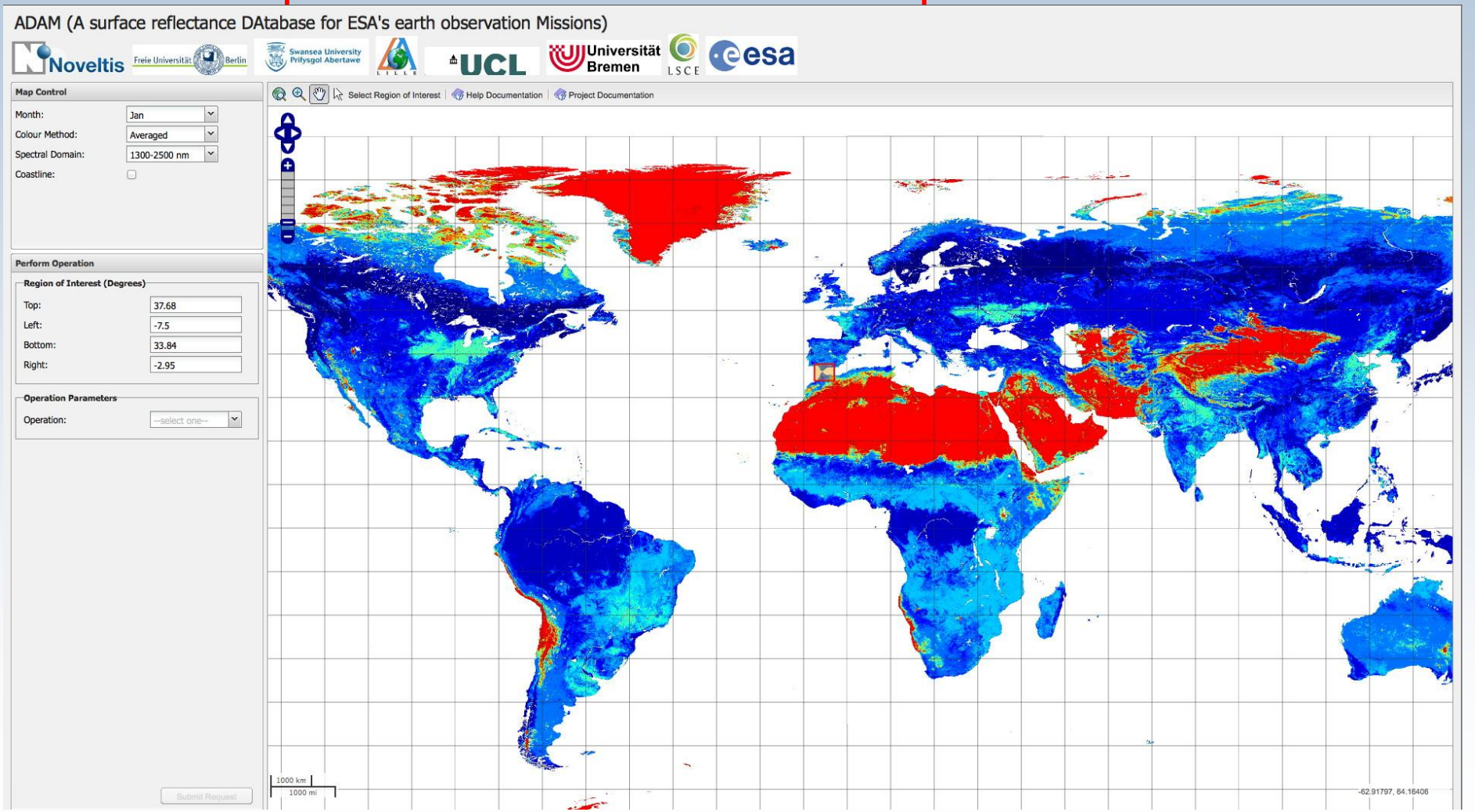
GlobAlbedo web-page: source for browsing & getting data



N.B. Tile at 1km and Global mosaic at 0.05º and 0.5º available in netCDF in scriptable "wget"

www.GlobAlbedo.org

ESA-ADAM: Global spectral BRDF at MODIS wavelengths at 10km interpolated to 1nm from MODIS priors & VGT/MERIS



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QAlbedo showcase

- **Users of GCM land surface albedo (including downstream services such as fapar & eLAI) need the ability to be able to calculate "on-the-fly" albedo (as this is time/sun-angle dependent)**
- **50Tb of global BRDF at 1km for broadband and 4Tb for 2005 only at 10 x 10km used as input both with per pixel variance-covariance matrices**
- **Value-added services to be provided by WGISS members to include**
  - **GUI front-end or wget "extract point" from GlobAlbedo, MODIS, MISR, METEOSAT, etc…**
  - **WPS services to process these BRDFs given a particular time requirement into the spatio-temporal requirements of an end user**
  - **WPS services to allow simulation of Top-of-Atmosphere radiance signals including interface to 3D radiative transfer model with atmospheric state (WV, aerosols, etc..)**
  - **New ECVs as and when developed**