www.GlobAlbedo.org

www.QA4ECV.eu

Lessons learnt and challenges from processing long time series within ESA-GlobAlbedo, ADAM and WACMOS-ET for the 35 years of ECVs (BRDF/albedo, fapar & LAI) on CEMS within the EU-FP7-QA4ECV project

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Neville Shane, Gerardo López

Mullard Space Science Laboratory, UCL

P.Lewis, M. Disney UCL Geography

Michael Vossbeck, Thomas Kaminski, FastOpt

Jürgen Fischer, Luis Guanter, Réné Preusker

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Peter North, Andreas Heckel, Swansea University

Olaf Danne, Marco Zülhke, Carsten Brockmann, Brockmann Consult

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Simon Pinnock, ESA ESRIN

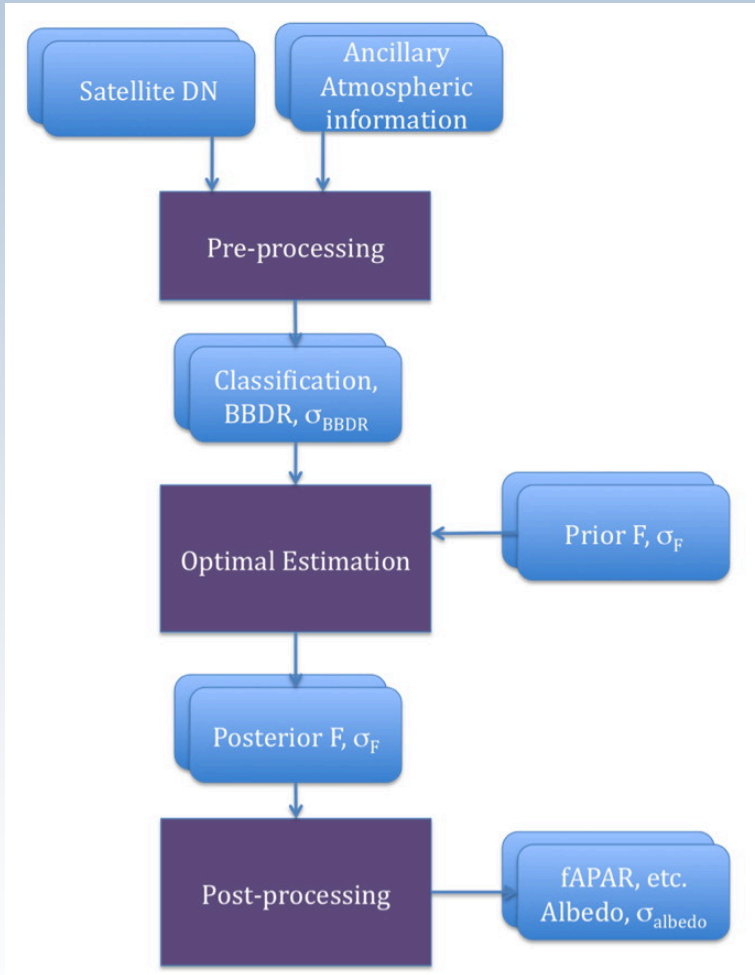
with contributions from Zhuosen Wang & Crystal Schaaf (U. of Mass., Boston), Gabriela Schaapman-Strub (U of Zurich)

QA4ECV Aims – Global Land surface products

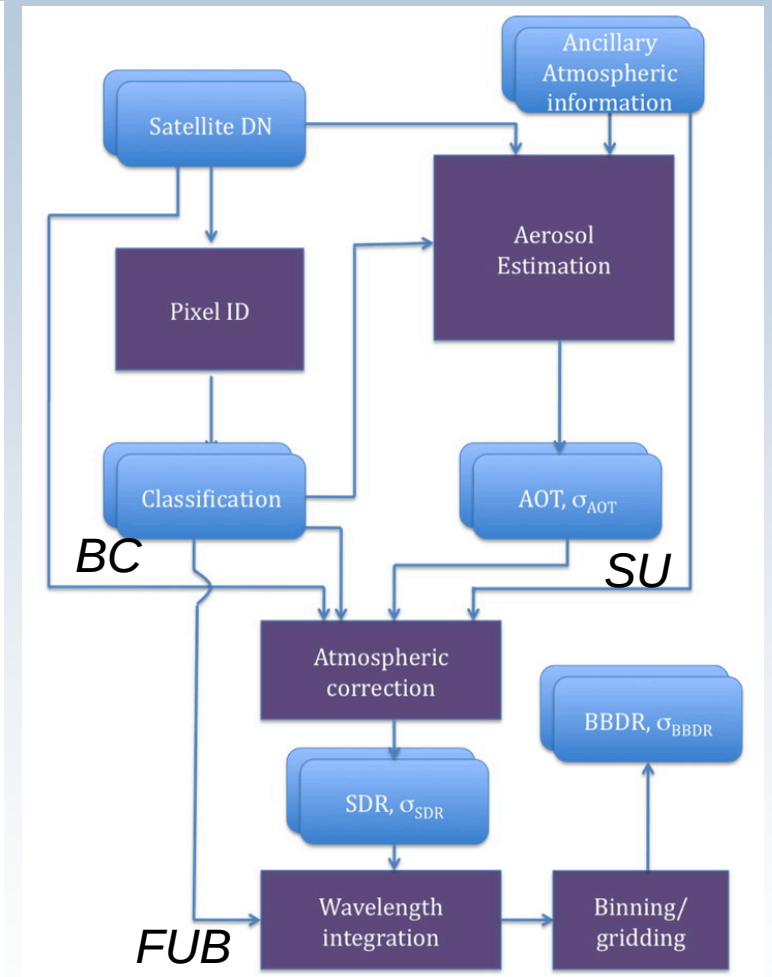
- Produce 35 years (1982-2016) of Land Surface Spectral & BroadBand BRDF/Albedo, fapar, LAI every day at 1, 5, 25km & monthly 0.05º & 0.5º from European & US space assets to generate Essential Climate Variables. Quality Assurance at each pixel using optimal estimation.
- Input data level 1b (radiometrically calibrated, satellite projection) with a priori climatology derived from MODIS C5 BRDF (3/2000-3/2014)
  - GEO (SCOPE-CM :1982-2016) & AVHRR (LTDR :1982-2016)
  - VEGETATION (3/1998-12/2013) & PROBA-V (9/2013-12/2016)
  - MERIS (6/2002-4/12) & ATSR2 6/95-3/00, AATSR 6/02-4/12
  - Level 2 only: MODIS C6 (3/2000-12/2016), MISR (3/2000-12/2016)
- Validation of final albedo products & intermediate products (e.g. sensor-to-sensor, cloud masks, aerosol AOD, narrow-to-broadband)
- 726Tb of CEMS space (NERC Big Data) - all products to be freely available via wget/curl, http, WPS and display browse & animations

Prior Art: GlobAlbedo Algorithm & Validation

- MERIS & VGT I/P
- Subset of GlobAlbedo products validated
- Focus on
  Pixel ID
  AOT
  SDR
  N-to-BB
  Albedo
- Internal validation performed by relevant producer
- Albedo validation performed over FLUXNET, BSRN, SURFRAD sites intercomparison with other EO



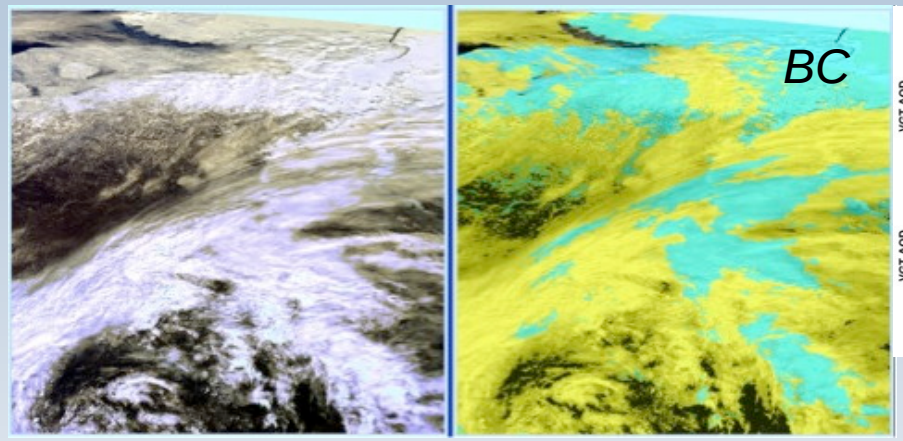
Overall GlobAlbedo processing chain
Muller et al., IGARSS12

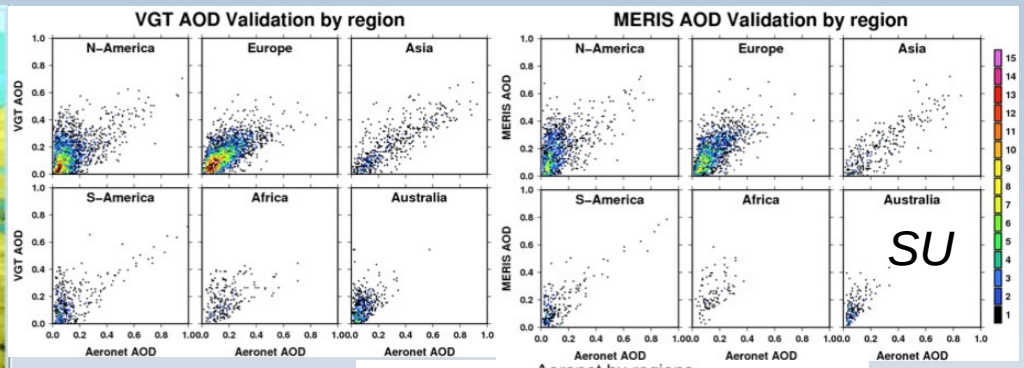


GlobAlbedo product flowchart
Lewis et al., IGARSS12

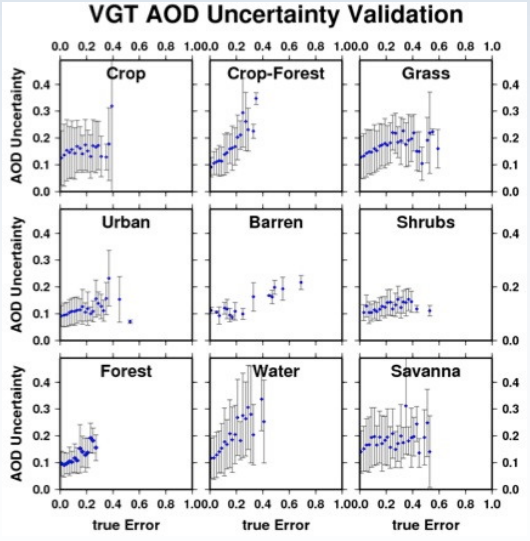
www.GlobAlbedo.org

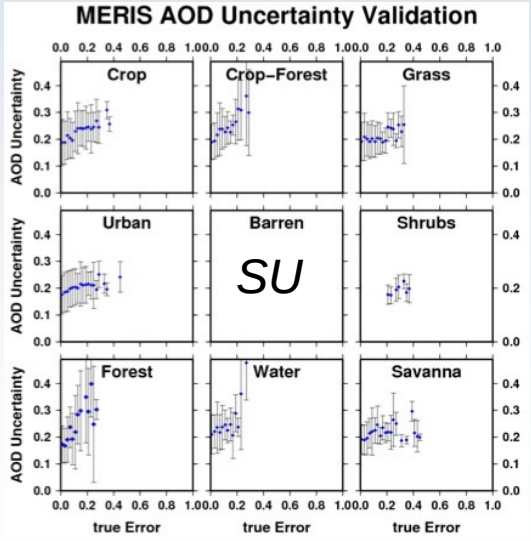
Validation of pre-processing stages from producers

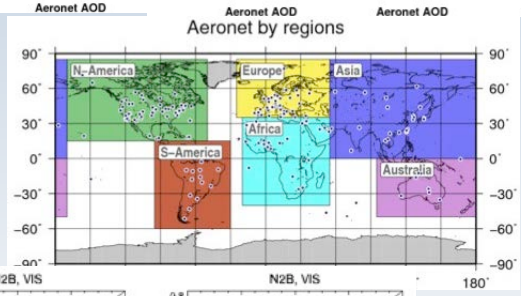


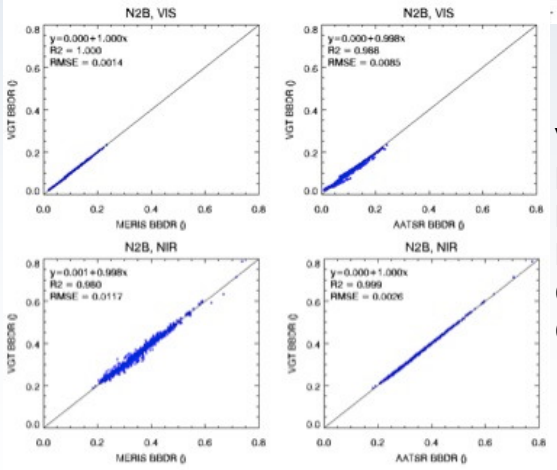


Pixel ID: Cloud, Snow/Ice, Water, Land





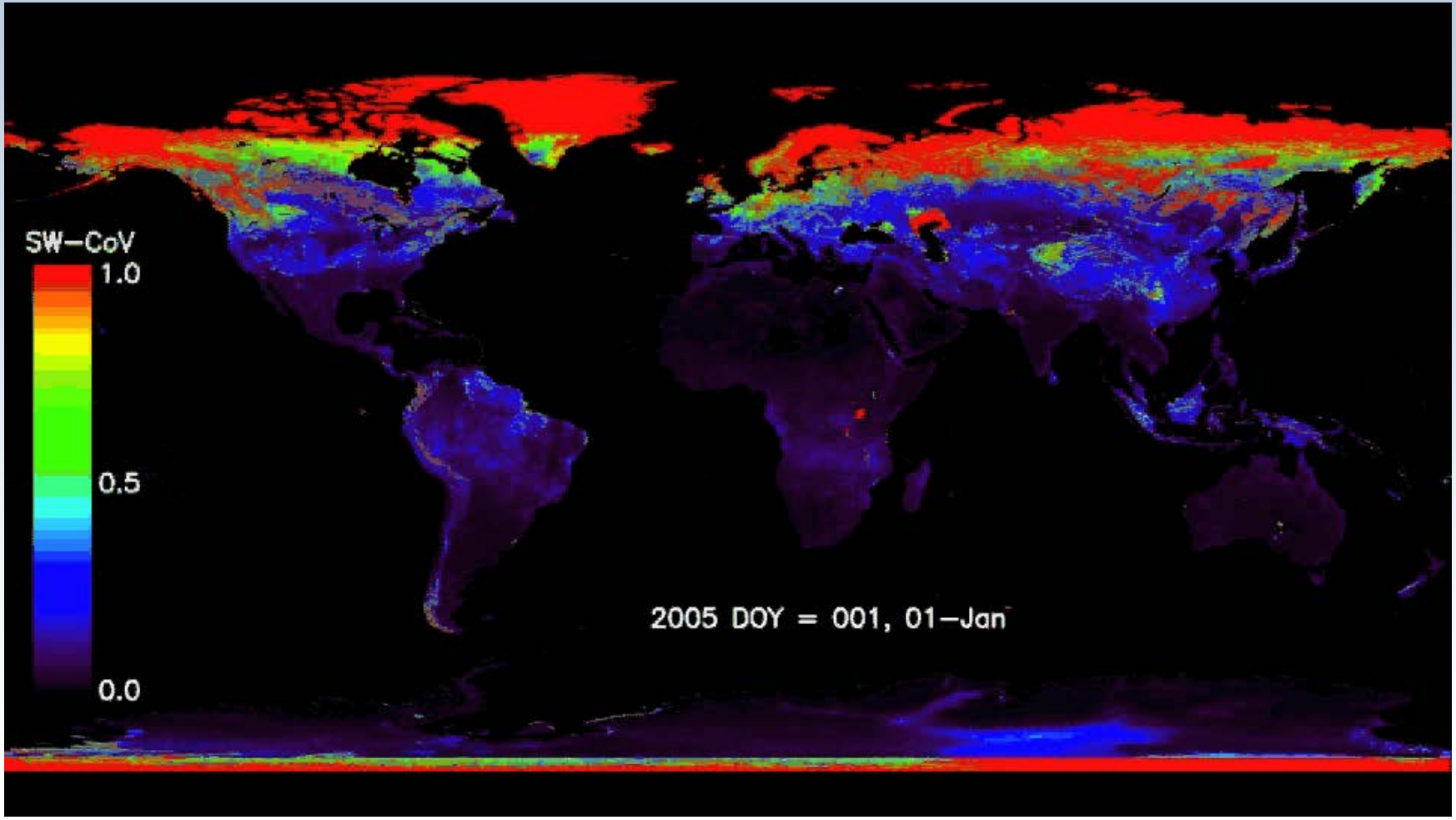




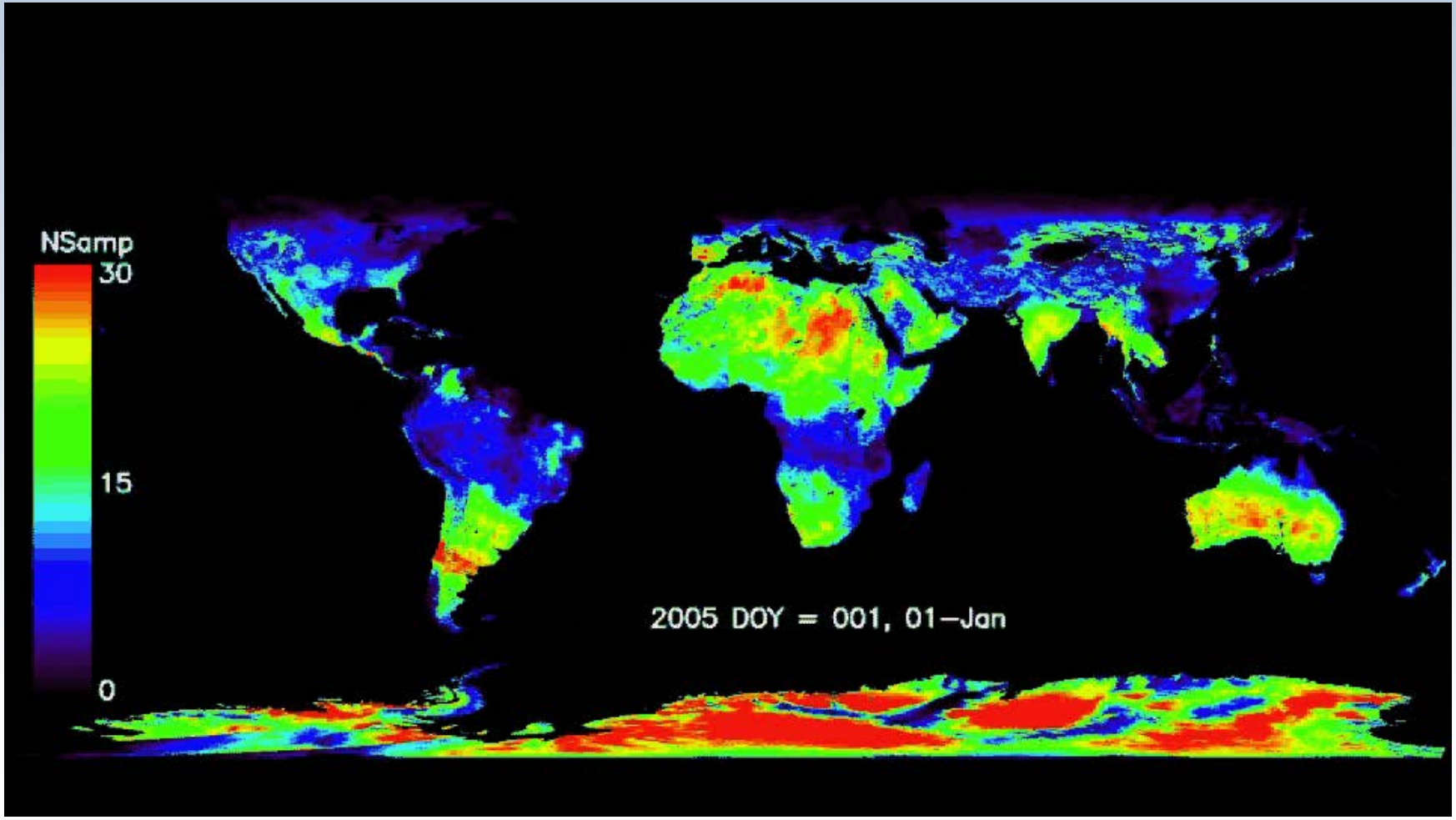
FUB

VGT vs MERIS
Not shown:
MODIS vs VGT
MODIS vs MERIS
CHRIS vs VGT
CHRIS vs MERIS

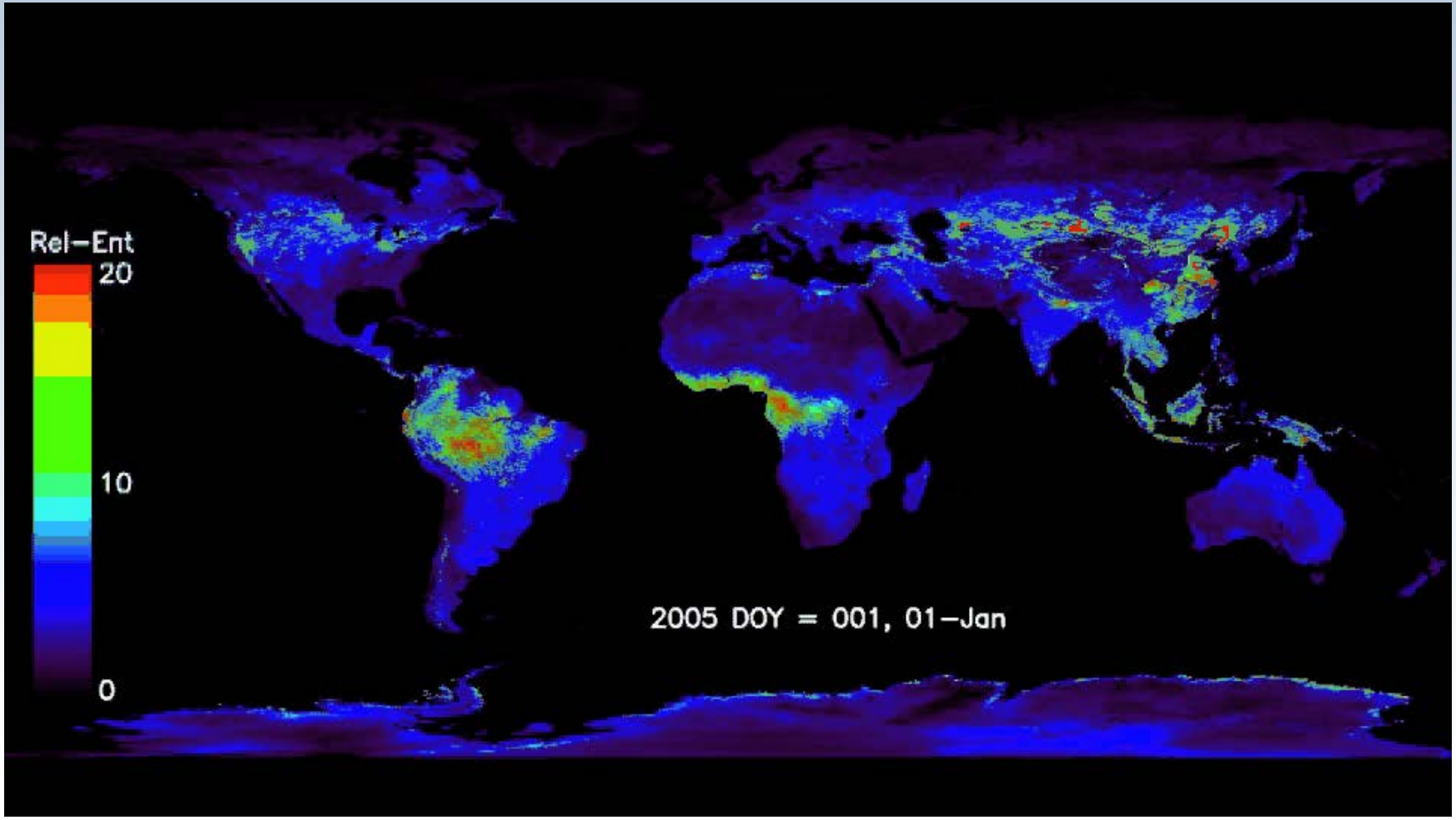
GlobAlbedo 8-daily Coefficient of Variation



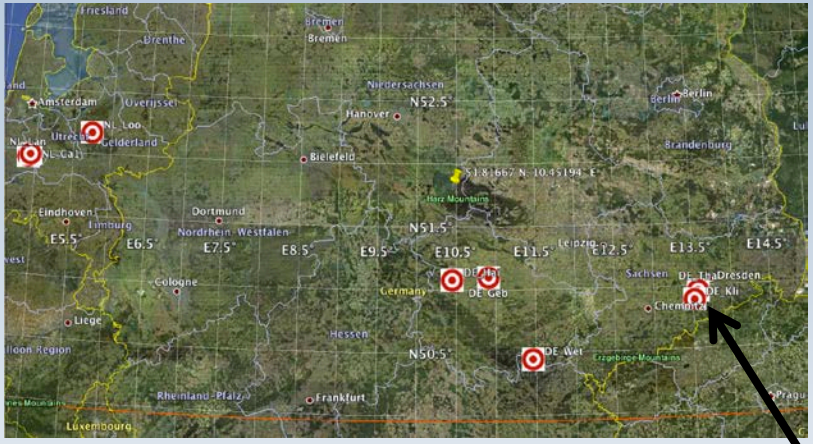
GlobAlbedo 8-daily Weighted Number of Samples



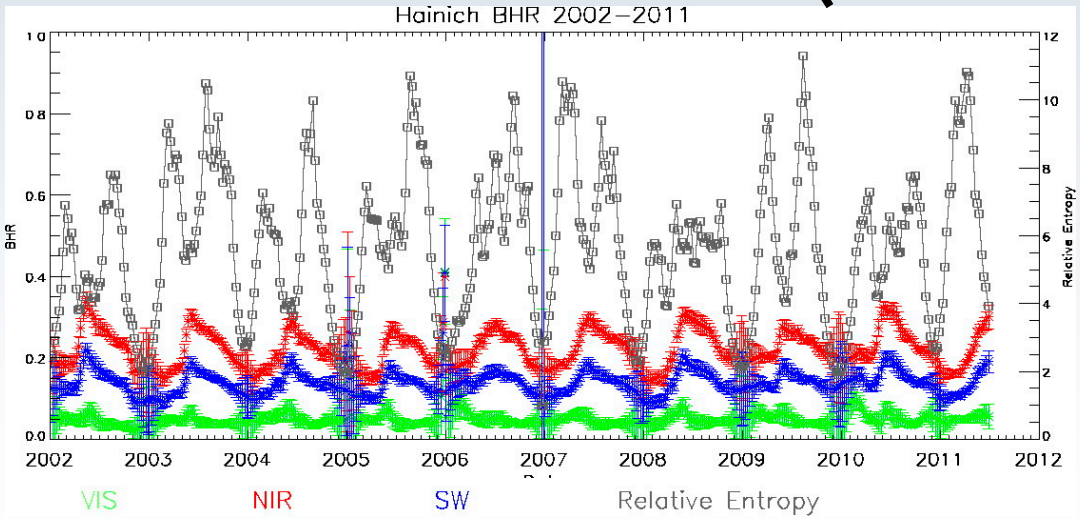
GlobAlbedo 8-daily Relative Entropy (≥20 MODIS prior high)

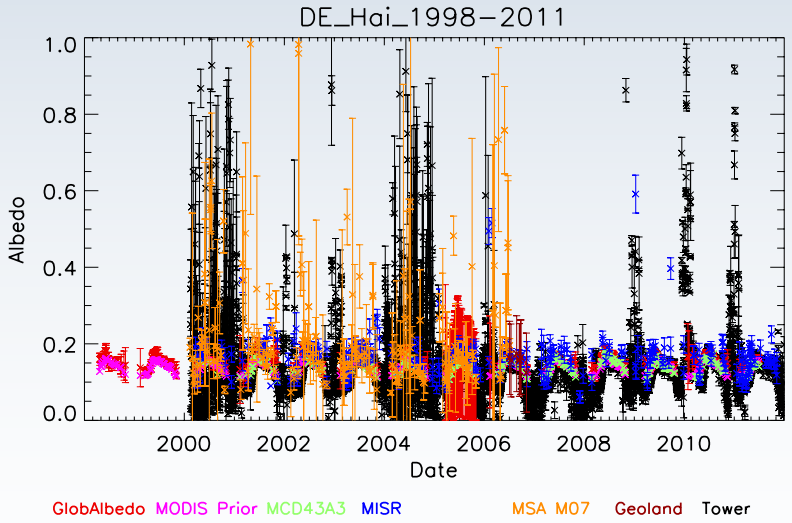


Prior Art - GlobAlbedo 8-daily BHR for FLUXNET site

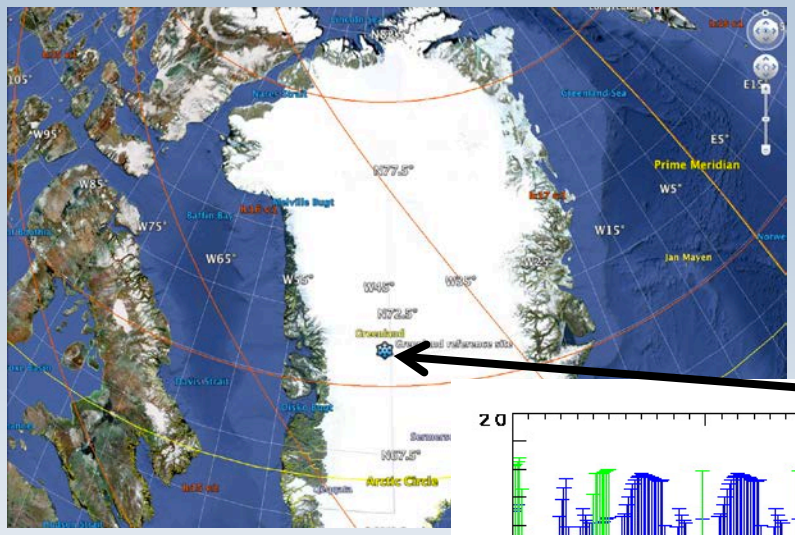


Internal subsetting allows any point or 3 x 3 area to be extracted and compared with other existing products including FLUXNET tower

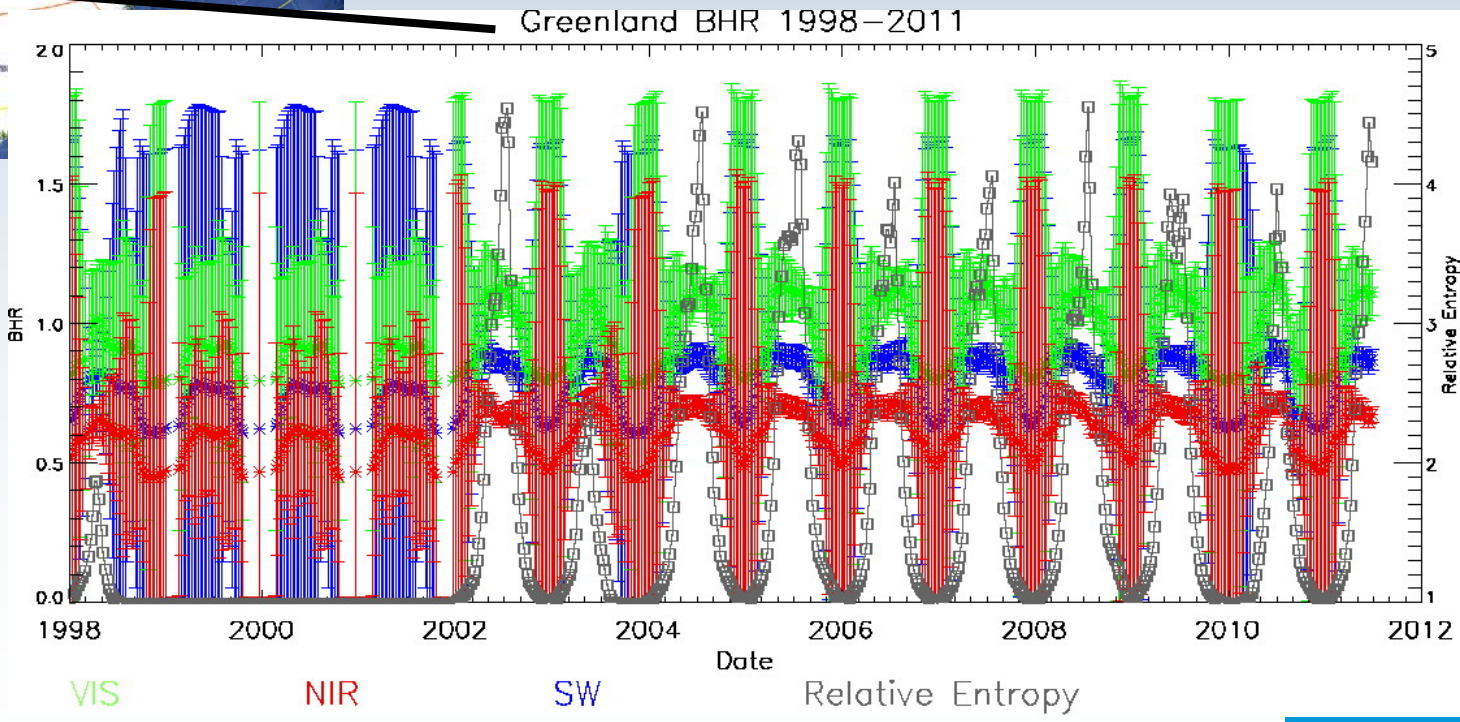


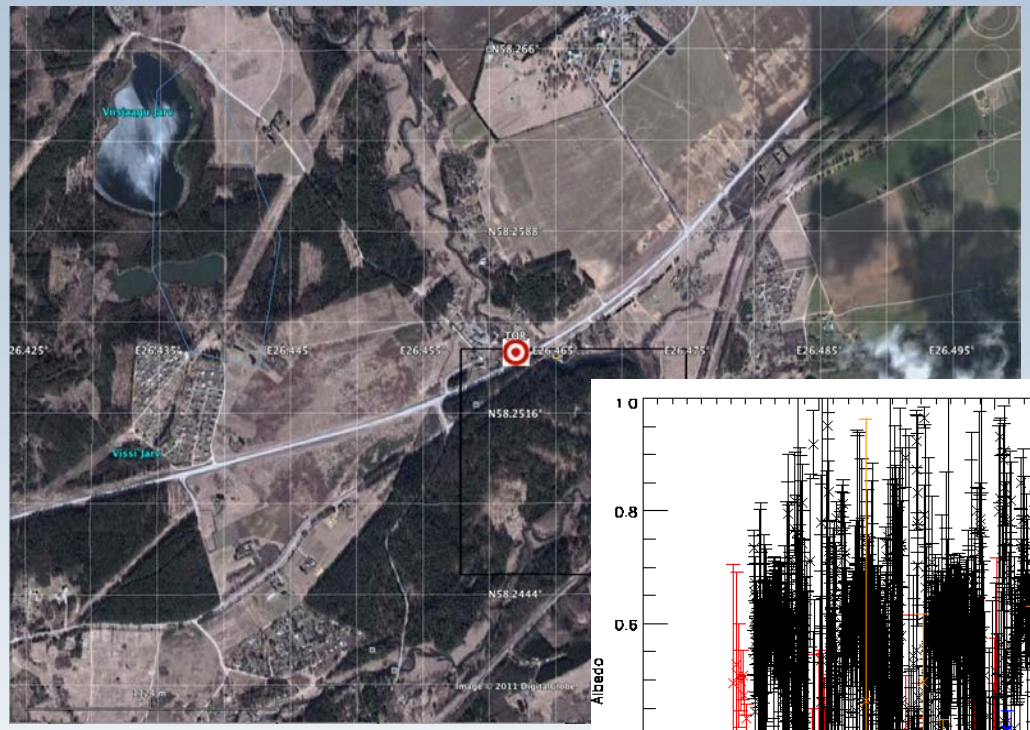


Prior Art: GlobAlbedo 8-daily BHR: impact of no MERIS prior to 2002



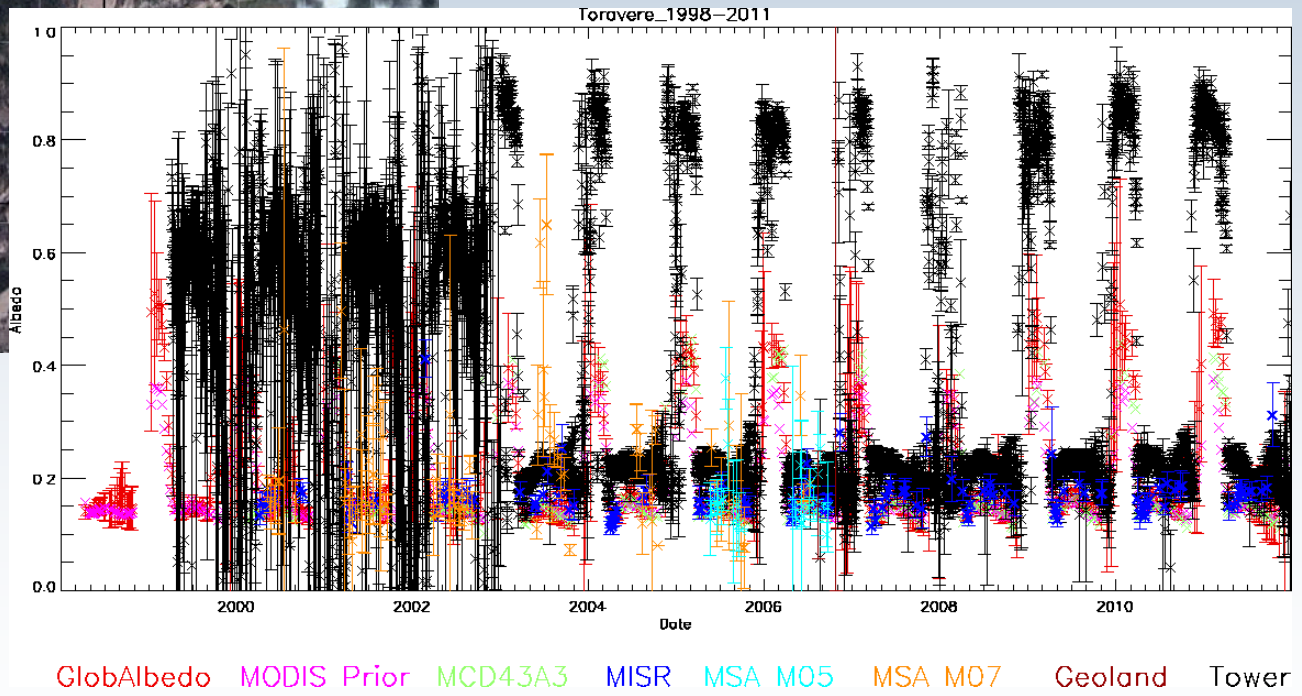
Internal subsetting allows any point or 3 x 3 area to be extracted as CSV and plotted





BSRN Toravere

Only “homogeneous” BSRN site at 1km

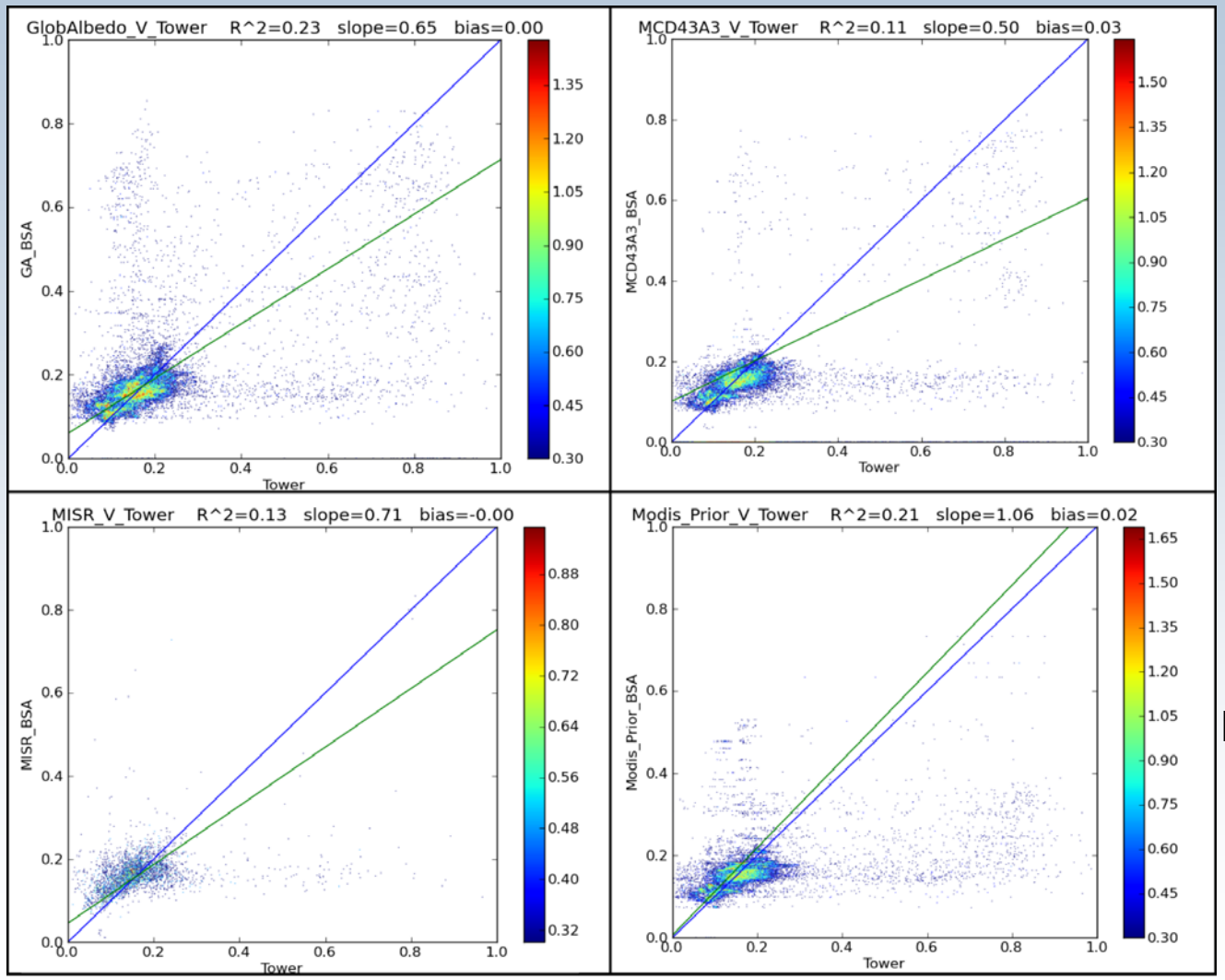


N.B. Very noisy tower albedometer data, much higher values from tower cf all other EO values

GlobAlbedo, MODIS & MISR vs Tower

GlobAlbedo

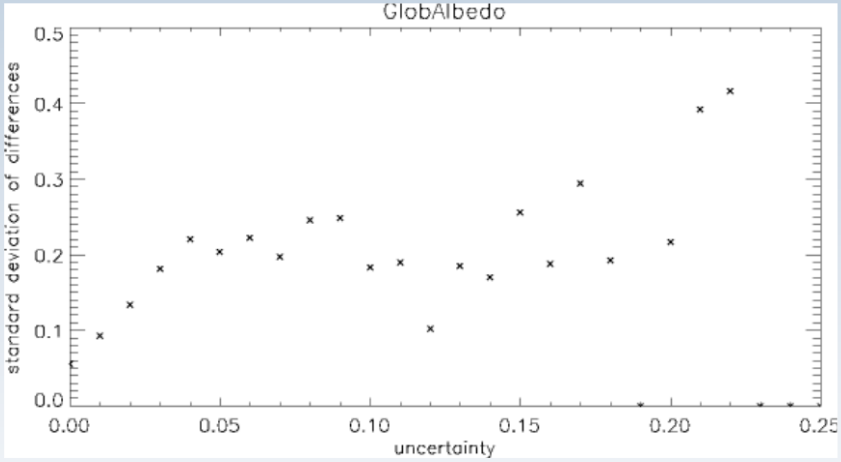
MISR



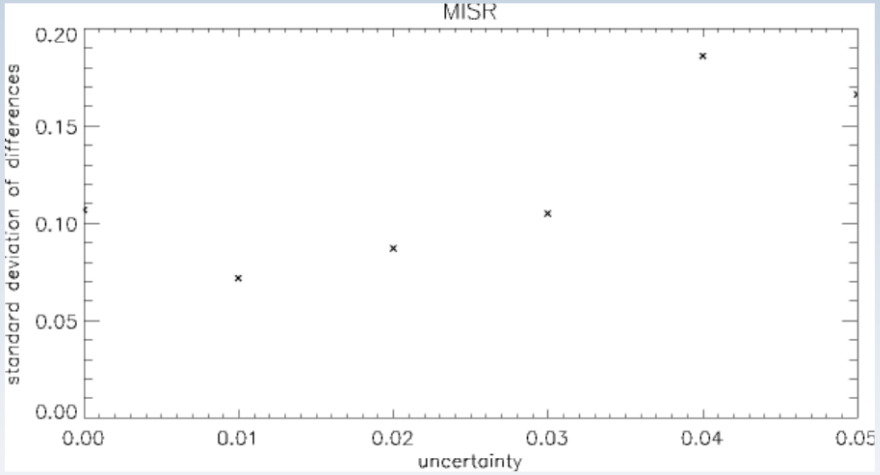
MCD43A3

MODIS priors

GlobAlbedo & MISR uncertainties vs Standard Deviations of differences cf. Tower Blue-Sky albedo measurements

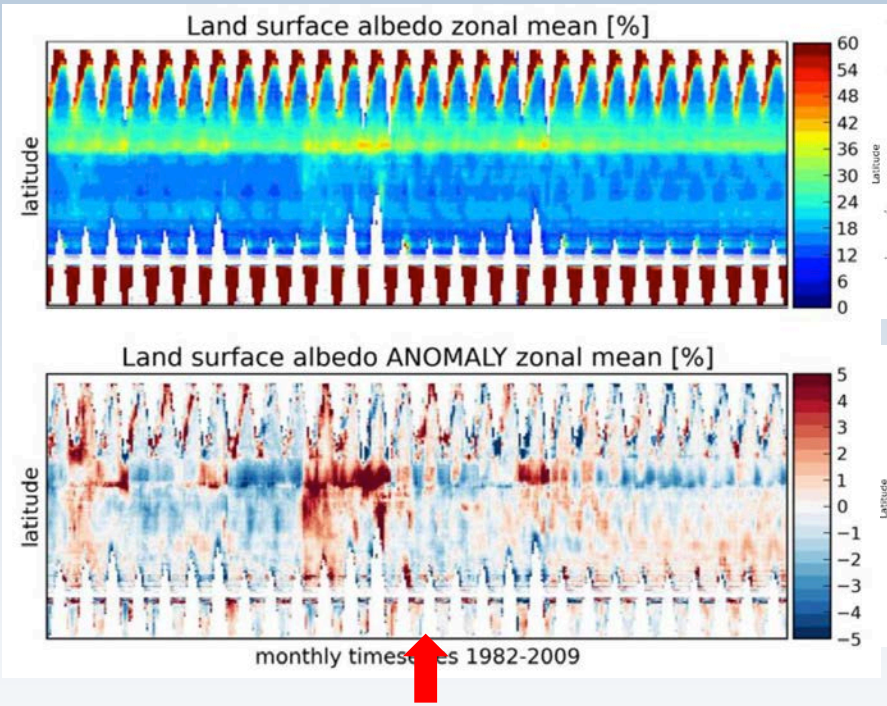


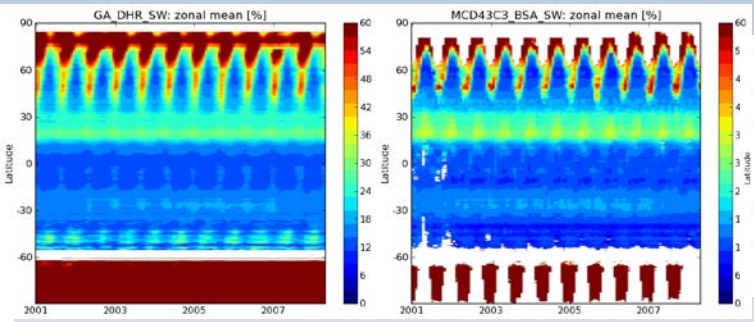
GlobAlbedo

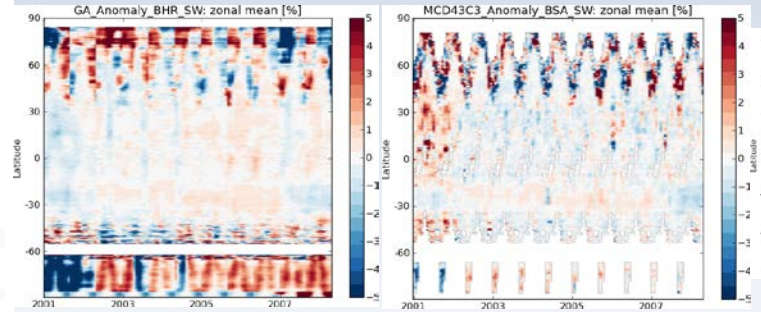


MISR

Hovmöller Plots of CLARA-SAL vs EO-derived DHR Albedos







CLARA/SAL (AVHRR)
Courtesy of Alexander Loew, MPI

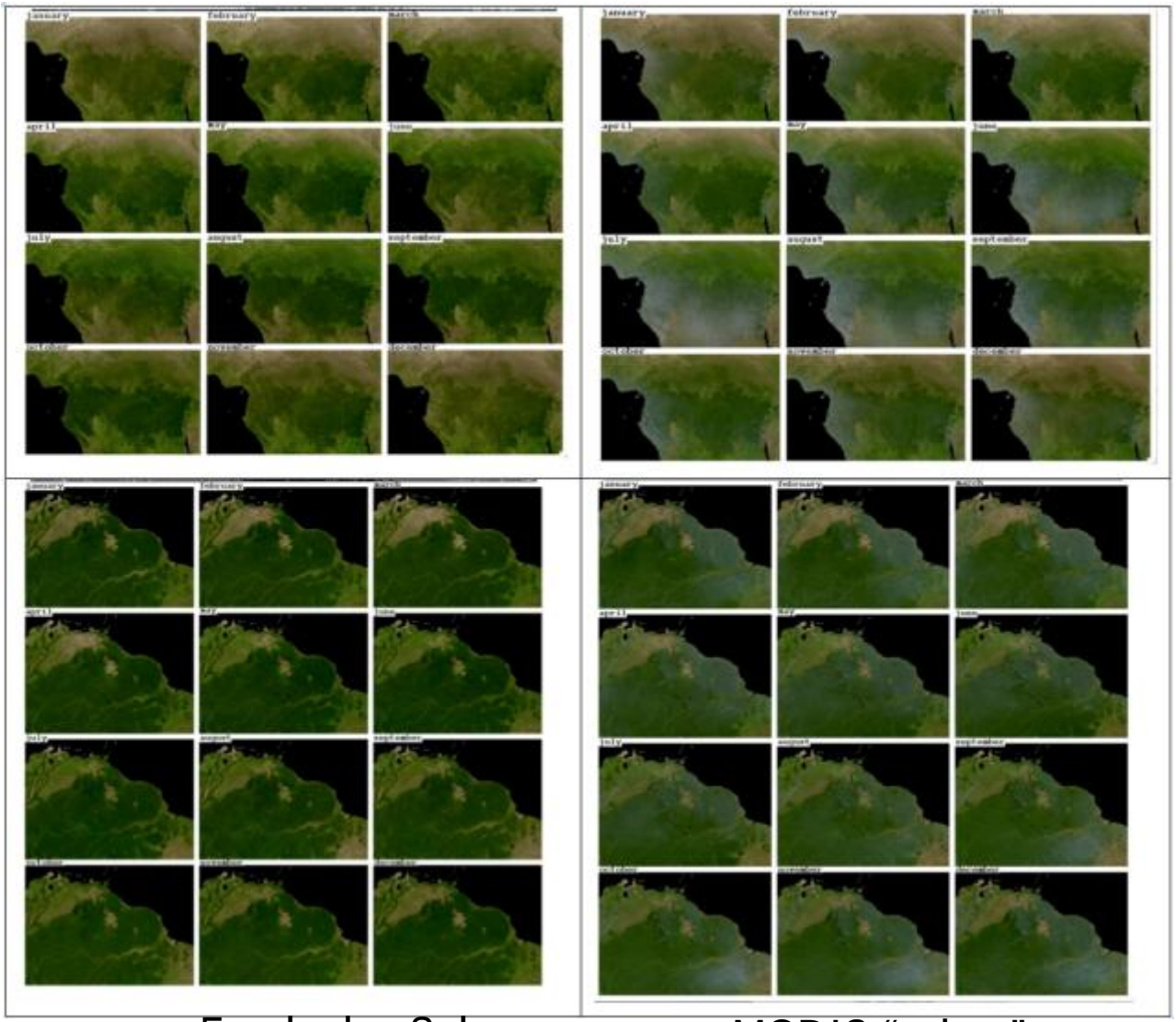
GlobAlbedo

MODIS

MISR

Atmospheric contamination of MCD43 MODIS Prior products

- Africa (upper panel) and S. America (lower panel)
- ADAM (left) vs GA (right)
- Note the whitish hue due to uncorrected aerosol/cloud contamination issues which are highlighted in the GA product
- ADAM uses pixel interpolation/extrapolation to explicitly remove aerosol/cloud in monthly composites"

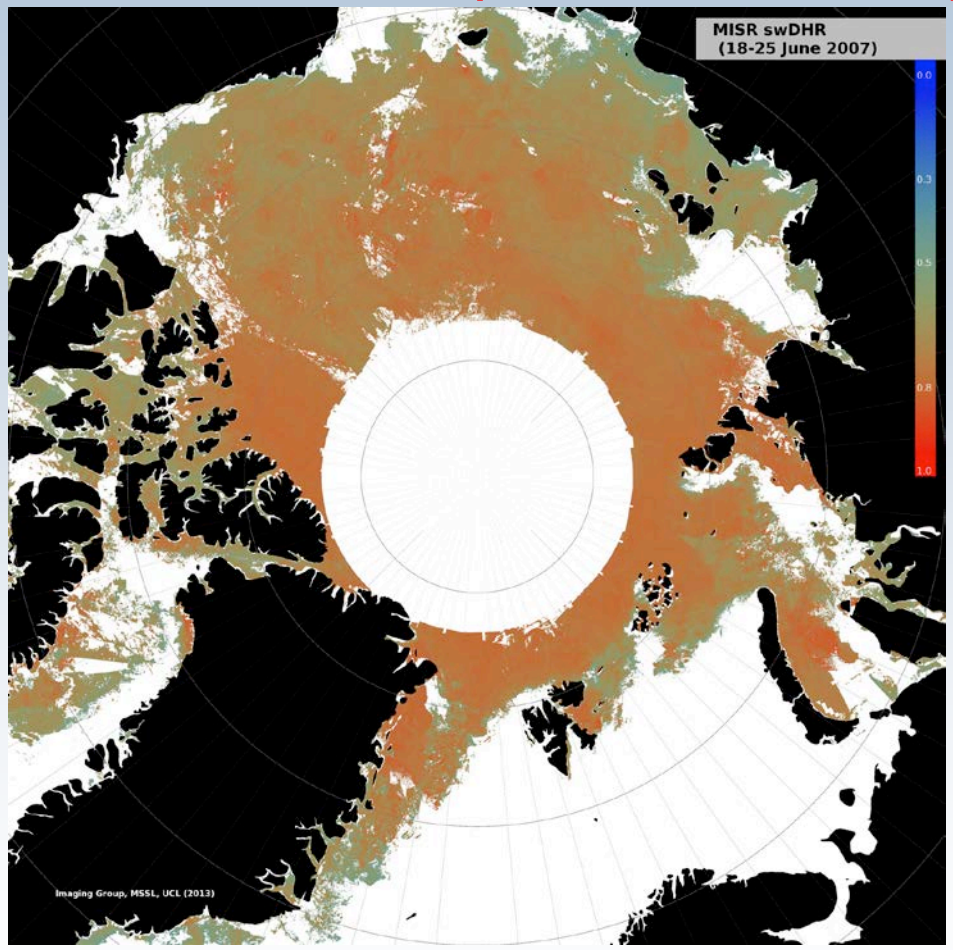


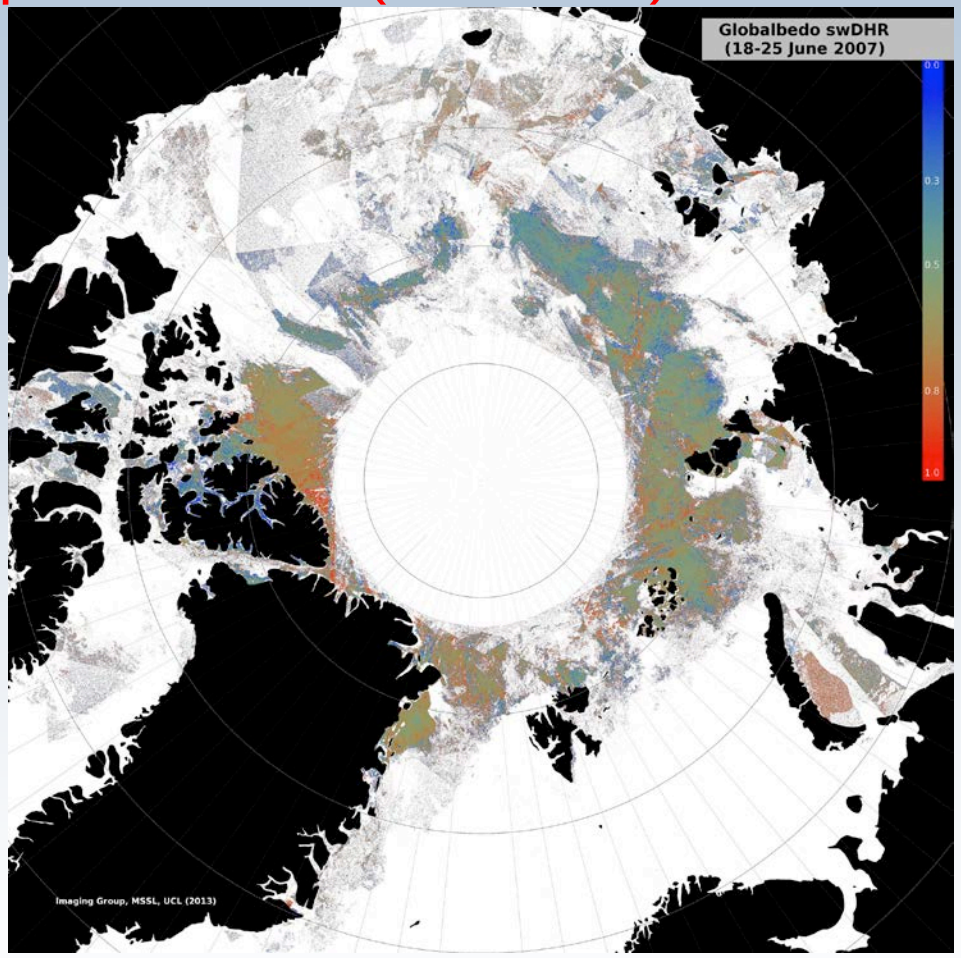
Fonds des Sols

MODIS "priors"

http://adam.noveltis.com/

Arctic polar sea-ice maps of albedo (SW-DHR)

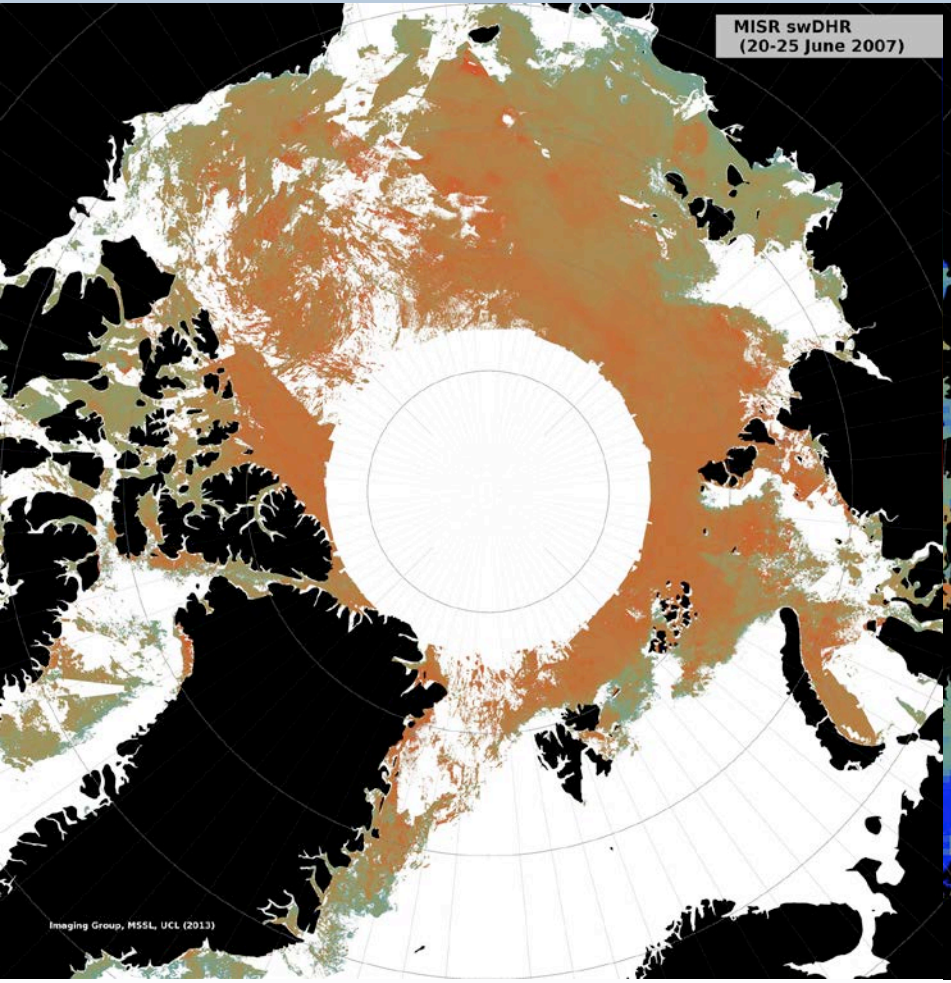




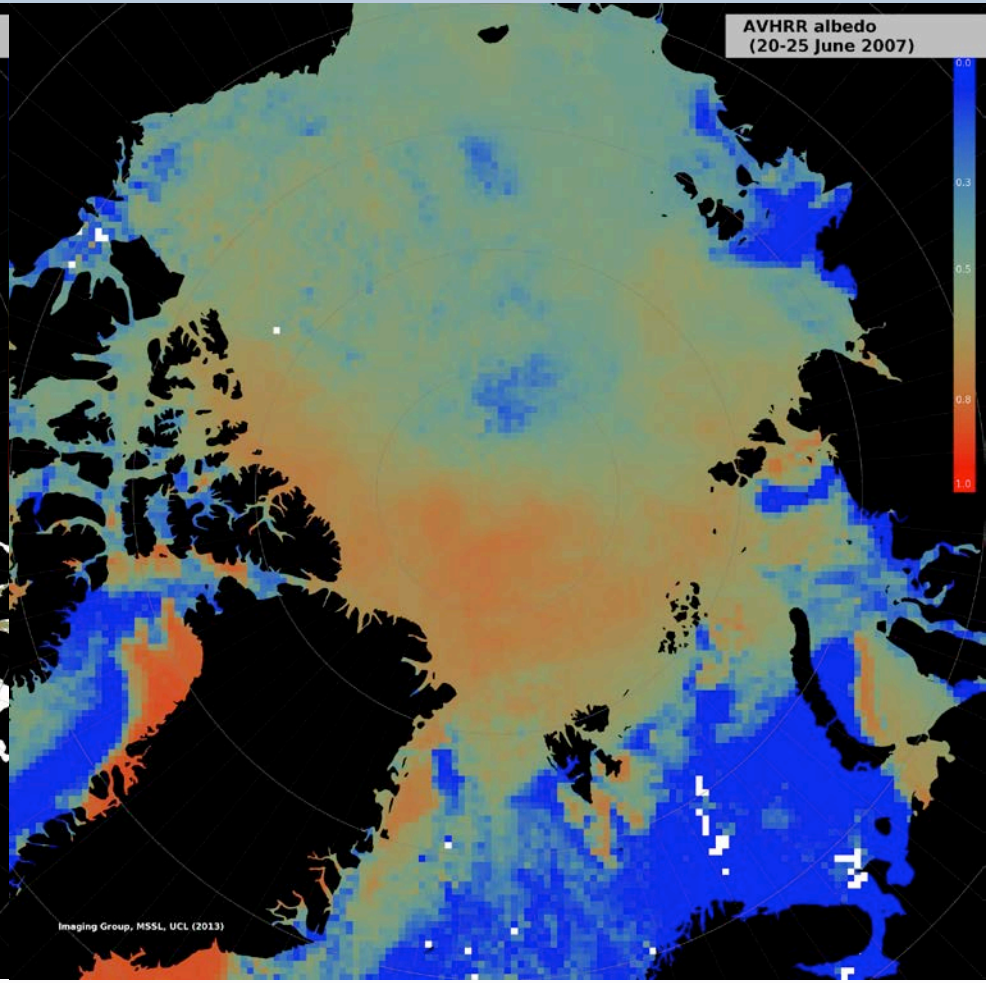
NASA MISR+MODIS

ESA AATSR+MERIS

Arctic polar sea-ice maps of albedo (SW-DHR)



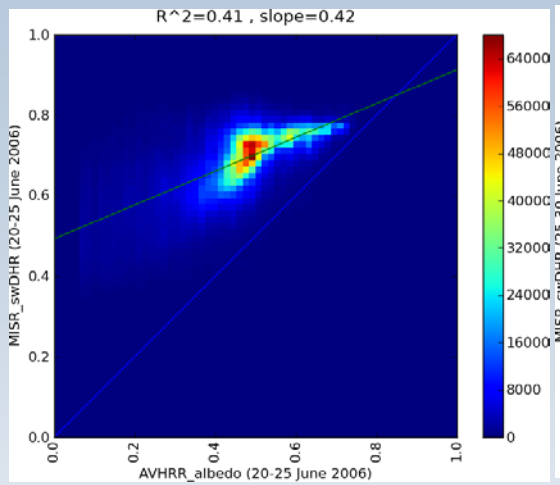
NASA MISR+MODIS



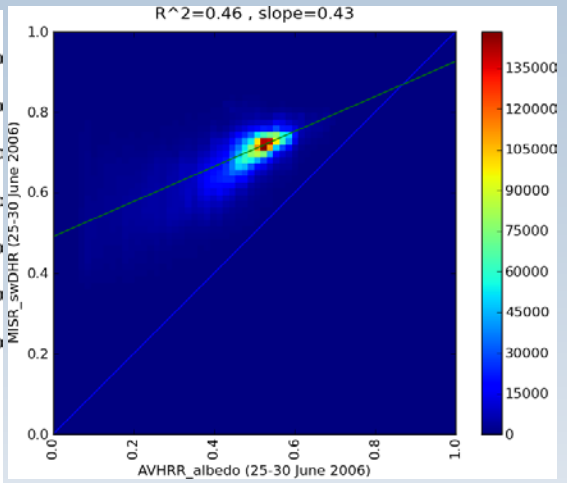
FMI-VTT-DWD AVHRR CLARA-SAL

DHR albedo intercomparisons

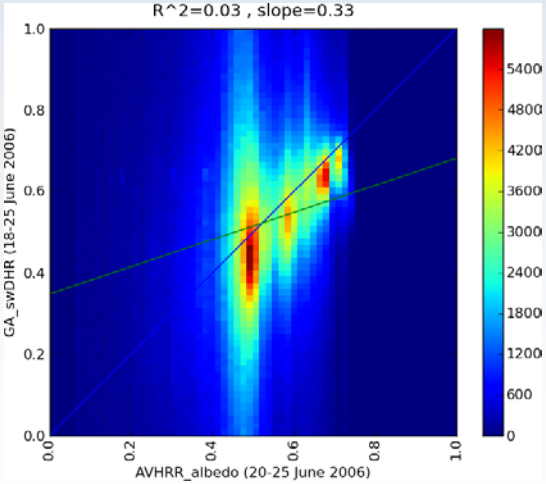
- Appears to be a bias of MISR cf AVHRR & GlobAlbedo (AATSR+MERIS)
- This is not present for GlobAlbedo cf AVHRR
- So there is something wrong with the MISR spectral-to-shortwave conversion
- Shunlin Liang looking into his conversion formulae for sea-ice as NIR produce only negative results



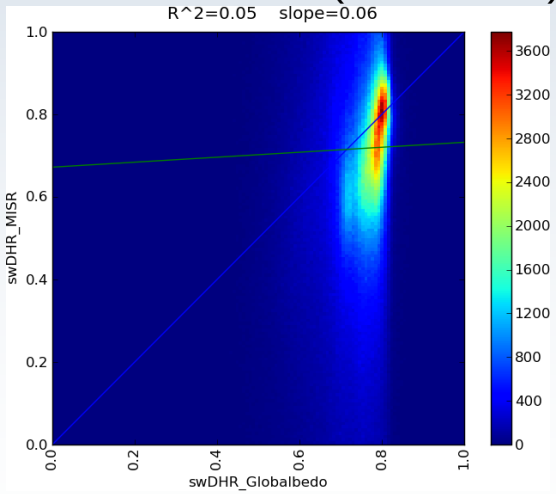
MISR vs AVHRR (6/20-25/07)



MISR vs AVHRR (6/25-30/07)



GA vs AVHRR (6/20-25/07)



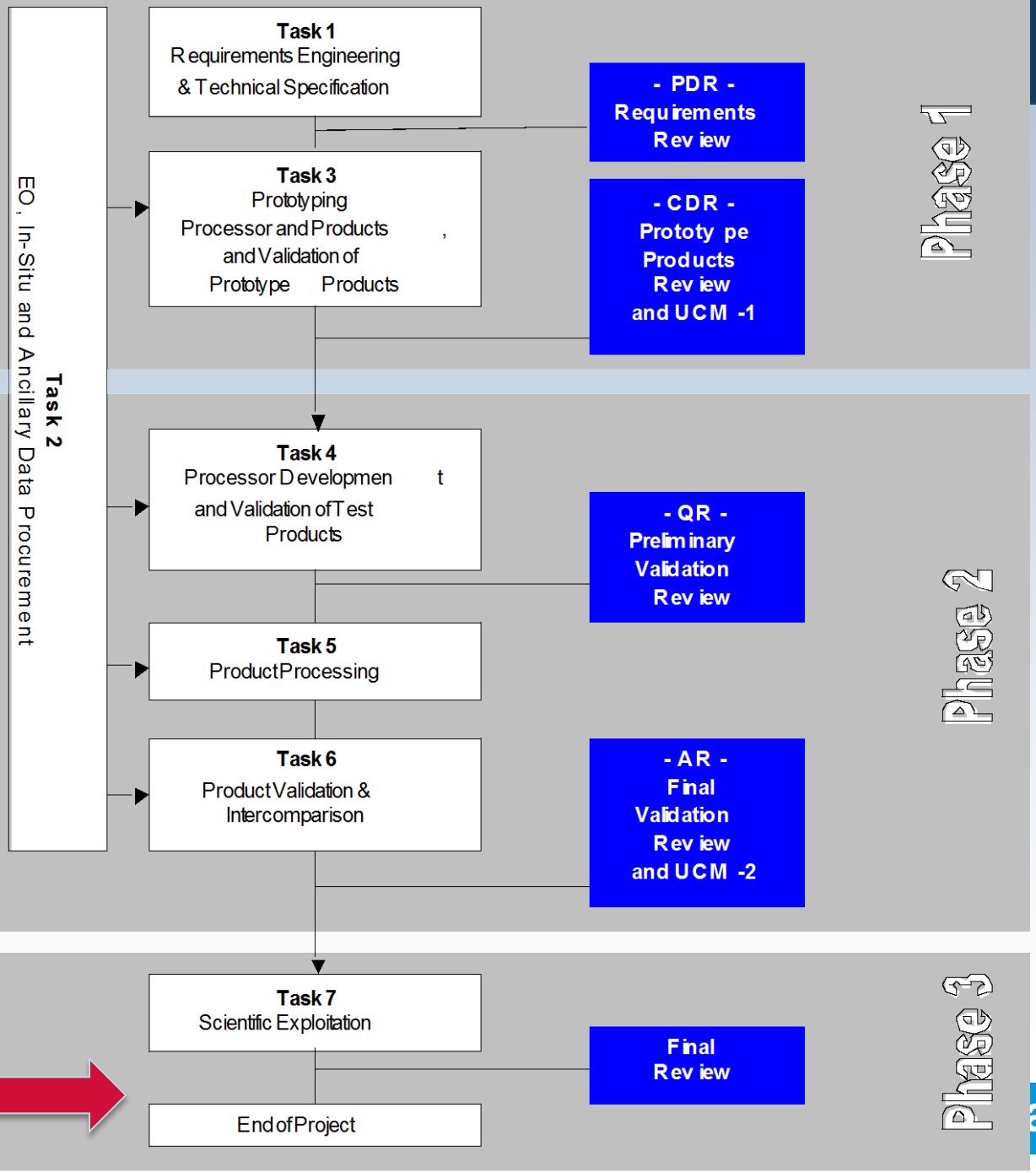
MISR vs GA (6/18-25/07)

Lessons learnt from GlobAlbedo

- Data fusion of MERIS & VEGETATION BBDRs with MODIS priors successful
- GlobAlbedo uncertainties positively correlated with Blue Sky Albedo magnitudes and with standard deviation of differences
- Production of any global product requires at least 3 sets of processing to iron out all the bugs. This needs to be included in any project plan/funding schedule
- There is no ideal set of "*in situ*" blue-sky (BHR) albedo data. It is inherently very noisy and only covers a small fraction of an EO pixel
- EO-derived results are generally very consistent with each other (with the exception of METEOSAT) but they are often offset from *in situ*
- EO albedo results all lower than tower for snow conditions (N.B. issue appears to be resolved when dealing with daily retrievals MODIS C6)
- MISR is the only EO sensor flying in space which has the potential to map instantaneous sea-ice albedo, a key Essential Climate Variable

What next?

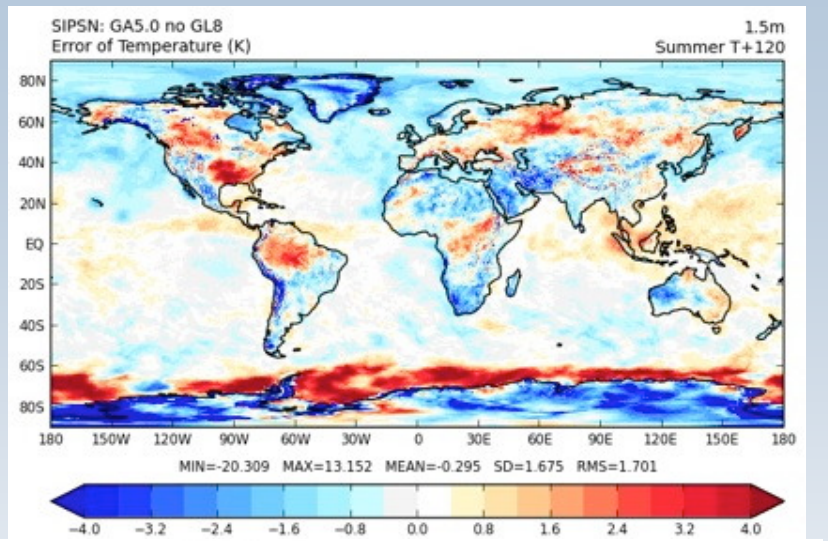
- 1998-2011 complete and available online (V3)
- Validation datasets are established from FLUXNET and BSRN for global sites for entire time period
- Inter-comparisons done with MISR, MCD43, METEOSAT, MSG Land-SAF,GEOLAND2
- MPI Hamburg, UK Met Office, ETHZ, CICERO, NCEO, ITI, ECMWF, Météo-France all testing impact of uncertainties on NWP forecasts
- Working with scientific partners on evaluation

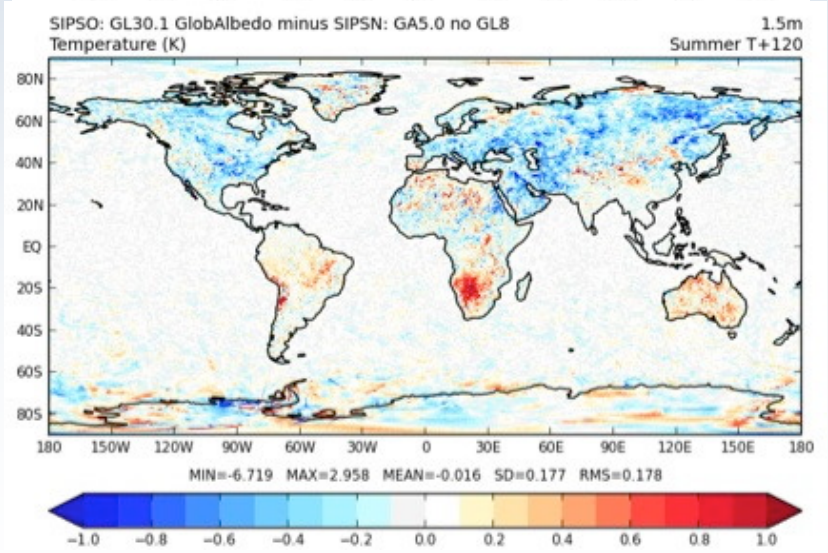


Who uses our data now and what has it been used for?

- NCEO Reading for data assimilation in coupled atmosphere-land models
- University of Leicester for atmospheric chemistry retrievals
- UK Met Office, MPI Hamburg, University of Zürich, CICERO, ITC, ECMWF, Météo-France, Princeton, ESTELLUS testing impact of uncertainties on Climate and Hydrology forecasts
- ESA press release (7/9/13)

"Tests show that GlobAlbedo data help to give more accurate temperature forecasts over the United States and Asia, especially in summer," said Dr Malcolm Brooks from the Met Office. "We expect to be producing operational forecasts using GlobAlbedo data in the spring of 2014."





Quality Assurance for Essential Climate Variables

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(boersma@knmi.nl)
Co-ordinator
(Precursor GHG)

Jan-Peter Muller
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Deputy
Co-ordinator (Land)

Daily albedo (and derived fapar, LAI) for 1982-2016

FP7-SPACE-2013-1
Project No. 607405
1.1.14-31.12.17

SPA.2013.1.1-03: Traceable quality assurance system for multi-decadal ECVs

Motivation

User perspective:

I need good new data … and quickly. A new data product could be very good, but if it is not being conveniently served and described, it is not good for me…
So I am going to use whatever I have and know already.

User

10/21/2011 Leptoukh QA4EO'11

This is where QA4ECV comes in

Mission statement QA4ECV

- QA4ECV will show how trustable assessments of satellite data quality can facilitate users in judging fitness-for-purpose of the ECV Climate Data Record.

- QA4ECV will provide quality assured long-term Climate Data Records of several ECVs relevant for policy and climate change assessments.

ESA CCI Aerosol Cloud CMUG Fire GHG Glaciers Ice Sheets Land Cover Ocean Colour Ozone Sea Ice Sea Level S

CCI

ESA Climate Change Initiative

Wed, 2010-09-01 11:03
Climate change is arguably the greatest challenge facing mankind in the twenty-first century. Its importance has been recognised in re
reports from the IPCC and from UNFCCC, and the overwhelming economic consequences are set out in the Stern Report.

GCOS Essential Climate Variables

The 50 GCOS Essential Climate Variables (ECVs) (2010) are required to support the work of the UNFCCC and the IPCC. All ECVs are technically and economically feasible for systematic observation. It is these variables for which international exchange is required for both current and historical observations. Additional variables required for research purposes are not included in this table. It is emphasized that the ordering within the table is simply for convenience and is not an indicator of relative priority.

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget.
	Upper-air:[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance)

http://www.qa4eo.org/survey/

Target Requirements

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
Black-sky albedo	1km	N/A	Daily to weekly	max(5%; 0.0025)	max(1%; 0.0001)
White-sky albedo	1km	N/A	Daily to weekly	max(5%; 0.0025)	max(1%; 0.0001)

ECV and precursors

- **Motivated by**
- gaps in EUMETSAT and ESA CCI activities
- For the “love” of our work, we have chosen:

Land ECVs

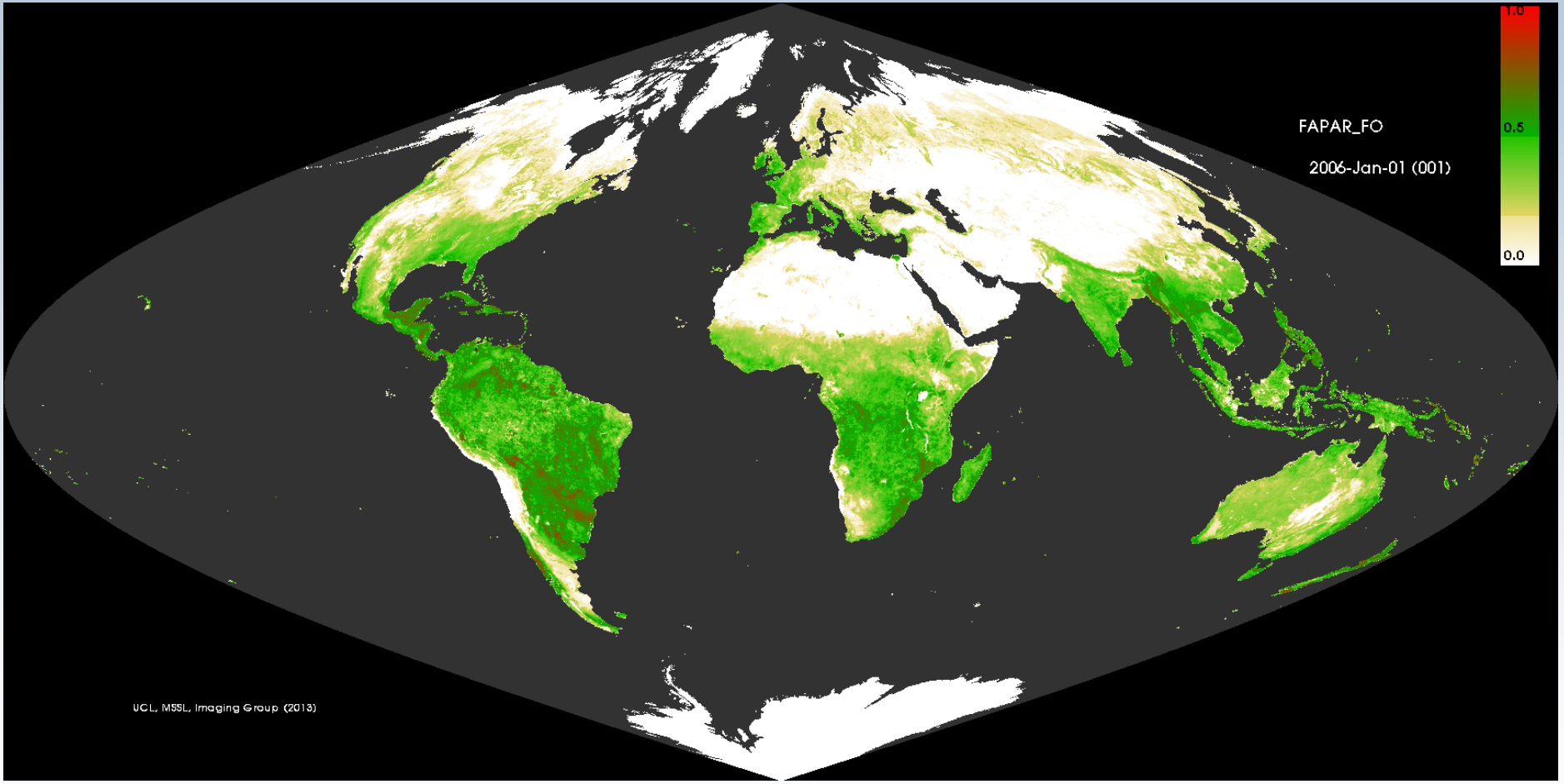
- Spectral/broadband BRDF/albedo
- Leaf area index (LAI)
- Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

Atmospheric Precursors

- Tropospheric nitrogen dioxide column (NO2)
- Tropospheric formaldehyde column (HCHO)
- Tropospheric carbon monoxide column (CO)

j.muller@ucl.ac.uk

Prior Art - Example fapar derived from GlobAlbedo using TIP*



Completed fapar & LAI for 2002-2011

* Pinty et al. (2007) J. Geophys. Res.-Atmos. 112 (D10), D10116

Example uses of CEMS-JASMIN for global land surface products

- **Objective 1:** Re-project BRDF files from SIN-coordinates to lat/lon using an Energy Conservation method
  - **Challenge:** the projected SIN-Tiles into lat/lon results for non-rectangular shapes, with different SIN tiles
  - **Solution:** SIN and Lat,Lon Cells are represented by geometry polygons rather than simple points and then the process is based on ratios of common area rather than on simple distance
    - **Challenge**: huge number of polygons to be spatiality indexed and processed. **This process requires massive RAM and usually takes a very long time!**
    - **Solution**: Use Cloud-computing system on CEMS-JASMIN (~100 times faster than 224-core in house linux cluster!)
- **Objective 2:** Create specific albedo products for computation of 8-daily LAI/fAPAR between 2002 and 2011 at 3 different resolutions: 1km, 5km and 25km
  - **Challenge:** Upscale big data BRDF (50TB) from 1km to 5km and 25km using energy conservation method, and then create separate Albedo-Snow_only and Albedo-Snow_Free products: **This process is extremely time consuming!**
  - **Solution**: Cloud-computing system in CEMS-JASMIN (~100 times faster than 224-core in house linux cluster)

Example use of CEMS-JASMIN(2) for near-line subsetting

Query

- Region of interest
- Time period
- Product/Bands
- Landcover classes
- Email address

MSSL-UCL

www.globalabedo.org

Rewrite and stock Queries
(first come, first serve)

CEMS-JASMIN

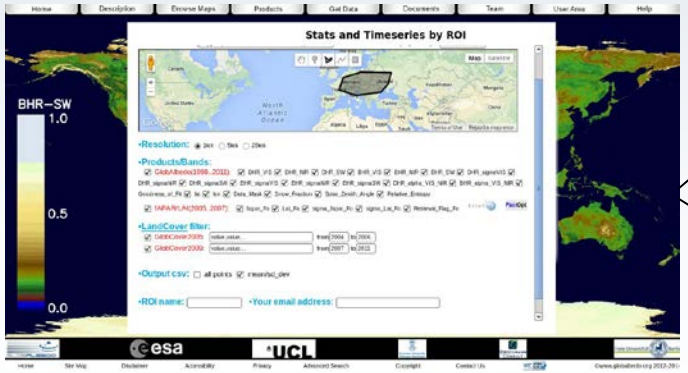
Reproject Region of interest
from lat,lon to SIN

Albedo
fAPAR
LAI

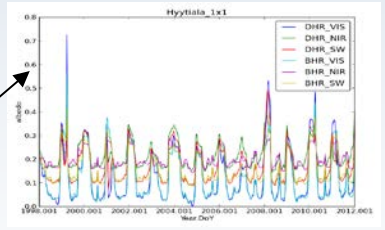
Extract, Filter, Calculate Statistics

URLs by email

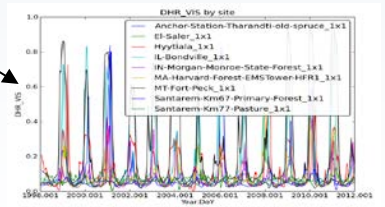
csv files
& Plots
(timeseries)



Stat by band



Stat by site



On-line statistics (Albedo, LAI/fAPAR, filtered by landcover) by Region of Interest: point, line or polygon.

Being integrated into Microsoft-Azure

Where are we now and where do we go next?

- All GlobAlbedo BBDRs and BRDFs copied onto CEMS after 2 re-processing
- All MODIS Collection 5 (MOD09 & MYD09) BRFs downloaded (25 Mbytes/day) to CEMS. Will download Collection 6 when available (from July 2014)
- All MISR (MISR2AS) BRFs downloaded. All AVHRR LTDRs available
- MERIS & ATSR2 & AATSR level-1b already available. VEGETATION level-1b about to be copied onto CEMS
- GEO data from METEOESAT has been processed for a test year into BRFs. Testing software for ingestion into data fusion
- GEO data from GOES & GMS is being processed into BRFs
- FastOpt processed 10 years of GlobAlbedo data into fapar & LAI
- All previous products available through GlobAlbedo.org website
- Systematic processing of 35 years starts in July 2015