

**Validation of POLDER surface BRDF and albedo products
based on a review of other satellites,
ground and climate databases**

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A global analysis

Comparison between different land surface albedos products satisfying the next rules:

global, routine dissemination, free access

2 classes of products are analyzed:

a) Albedos from GCMs

(ECMWF, ARPEGE)

b) Albedos from a Production Center of satellite images

(MISR, MODIS, Meteosat)

A local analysis

Comparison with ground-based networks: SURFRAD, CarboEurope, AsiaFlux

Comparison obey to objective criteria of evaluation:

seasonal trend, spatial coherence, gap filling, % of erroneous data, quality assessment, attempt of error explanation by other means.

European observing systems of moderate resolution : characteristics



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	spatial resolution	temporal resolution	spectral channels	observation angles	illumination angle	data availability
→ POLDER :	6km	~1 day	5	variable	~constant	1997, 2003
→ VGT :	1km	~1 day	4	variable	~constant	1998-
AVHRR :	4km	~1 day	4	variable	~constant	1982-
→ SEVIRI :	3km	15 min	3	constant	variable	2003-2018+
MERIS :	1km	~2 days	15	variable	~constant	2002-

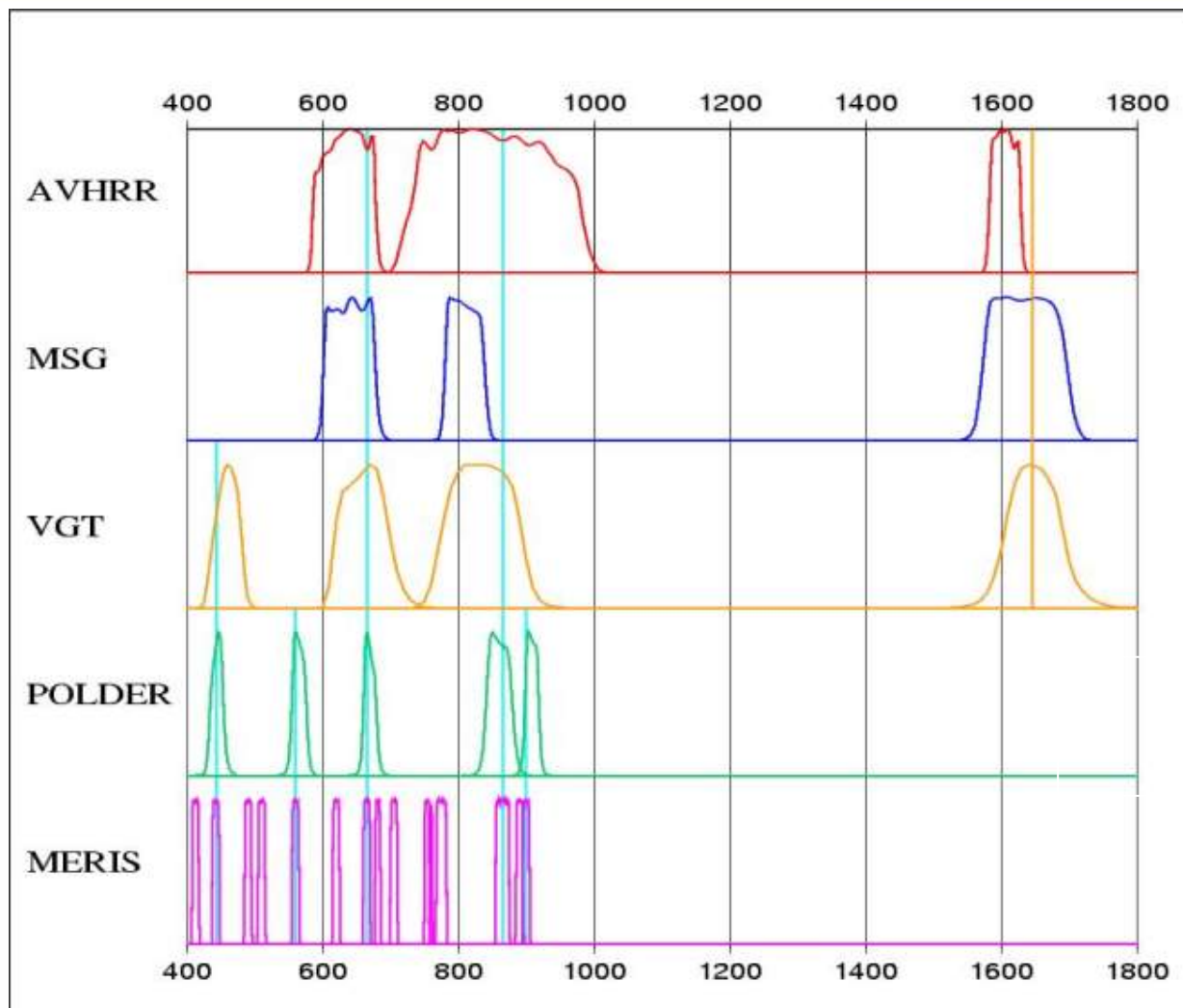


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European observing systems of moderate resolution : spectral responses



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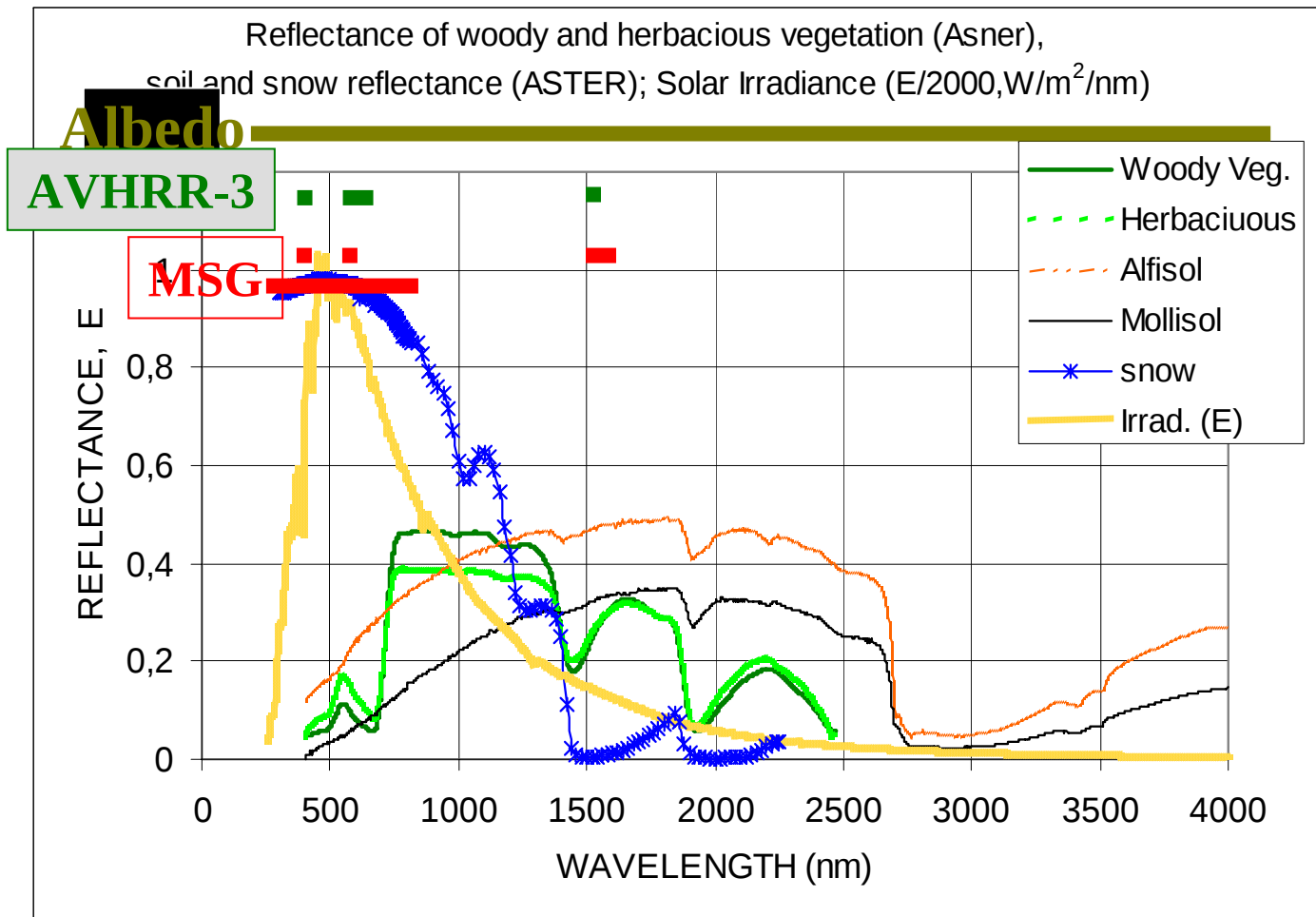


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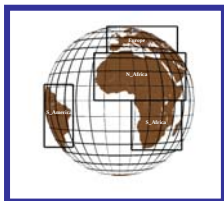
Broadband surface albedos : a question



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Product Requirement Table (EUMETSAT source) – MSG programme



Targeted applications => *NWP models, Carbon models, Climate monitoring*

Product Name	Characteristics and Methods	Input Satellite data	Dissemination type (NRT/off-l)	Dissemination Means	Format	Timeliness	spatial coverage	generation frequency	spatial resolution	threshold accuracy	target accuracy	optimal accuracy	Verification method	expected start of operation resp. availability
MSG Daily Surface Albedo (MDAL)	5-day composites of spectral & broad-band AL	MSG	NRT/off line	EUMETCast /web	HDF5	3 h	MSG disk	1 day	MSG pixel resolution	20%	AL>0.15: 20% AL<0.15: 0.03	7,5%	BSRN data / MODIS AL	Sep 05
MSG 10-day Surface Albedo (MTAL)	30-day composites of spectral & broad-band AL	MSG	NRT/off line	EUMETCast /web	HDF5	3 h	MSG disk	1 day	MSG pixel resolution	20%	AL>0.15: 10% AL<0.15: 0.015	5%	BSRN data / MODIS AL	Dec 07
EPS Surface Albedo (EAL)	30-day composites of spectral & broad-band AL	EPS	NRT/off line	EUMETCast /web	HDF5	3 h	Europe & High Latitudes	1 day	0.01° x 0.01°	20%	AL>0.15: 10% AL<0.15: 0.015	5%	BSRN data / MODIS AL	Oct 08

ADEOS/POLDER-1	1996-11-05 <-> 1997-06-25
ADEOS/POLDER-2	2003-04-05 <-> 2003-10-25
PARASOL/POLDER-3	2005-07-01 <-> present

<http://postel.mediasfrance.org>

CPP distributes 2 products:

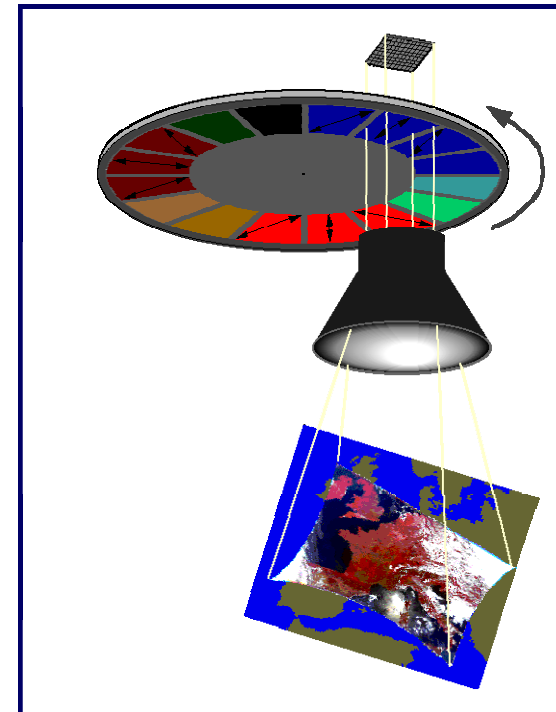
- Directional Parameters products :
spectral BRDF model coefficients.
- Albedo :
spectral DHR for median solar zenith angle
(changed for solar noon with POLDER-3)

Synthesis period : 30 days

Composite period : 10 days

[larger weight given to the data near central date]

DQX (Data Quality indeX) :
the 'level of noise' + the quality of BRDF retrieval



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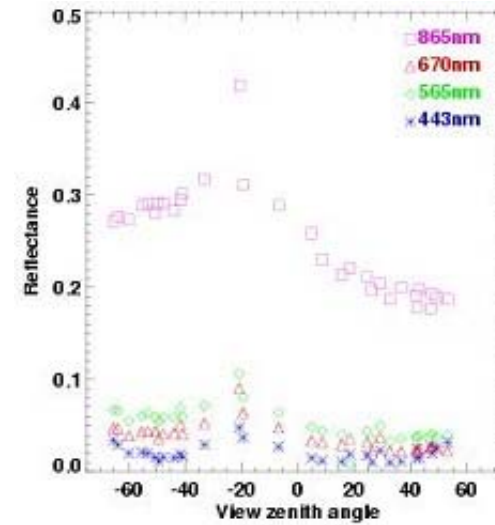
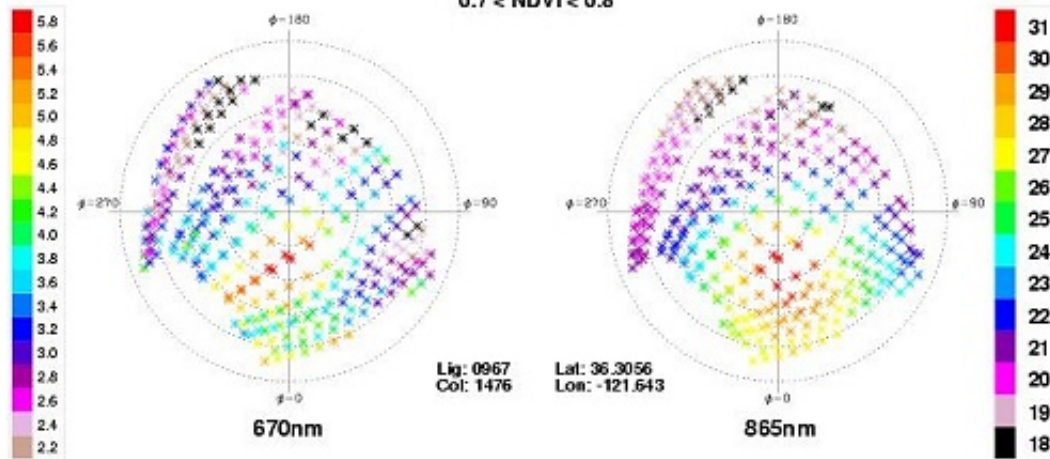
Examples of spectral BRDF signatures from POLDER-1



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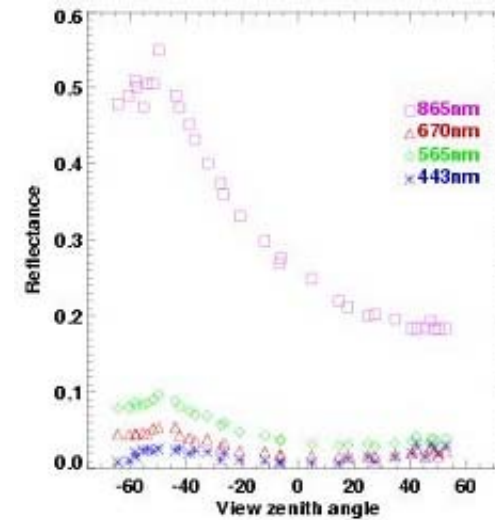
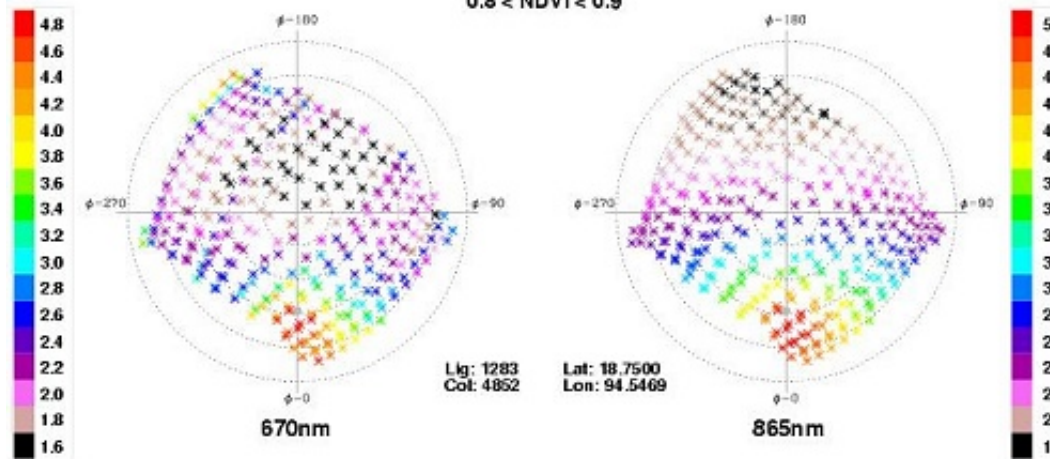
Evergreen needleleaf forest_199705

$0.7 < \text{NDVI} < 0.8$

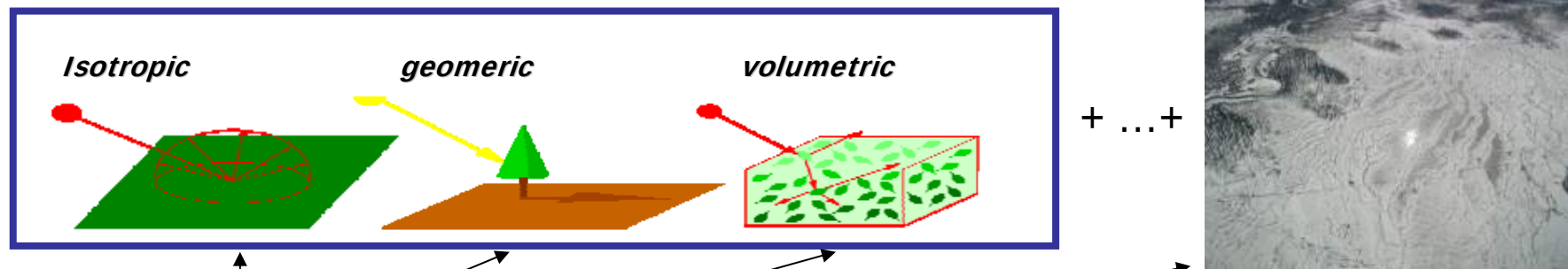


Evergreen broadleaf forest_199701

$0.8 < \text{NDVI} < 0.9$



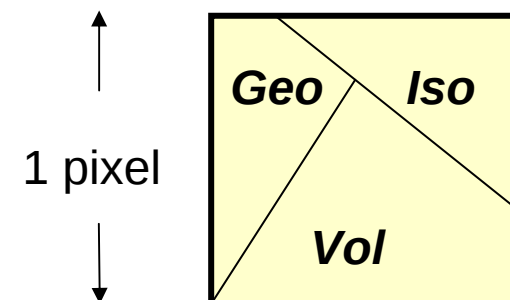
Kernel-driven BRDF models



$$\rho(\theta_s, \theta_s, \phi) = k_0 + k_1 \cdot f_1(\theta_s, \theta_s, \phi) + k_2 \cdot f_2(\theta_s, \theta_s, \phi) + \dots + k_n \cdot f_n(\theta_s, \theta_s, \phi)$$

BRDF

- k_0 : Lambertian coefficient
- k_1 : roughness coefficient
- k_2 : volume scattering coefficient
- ...
- k_n : specular coefficient



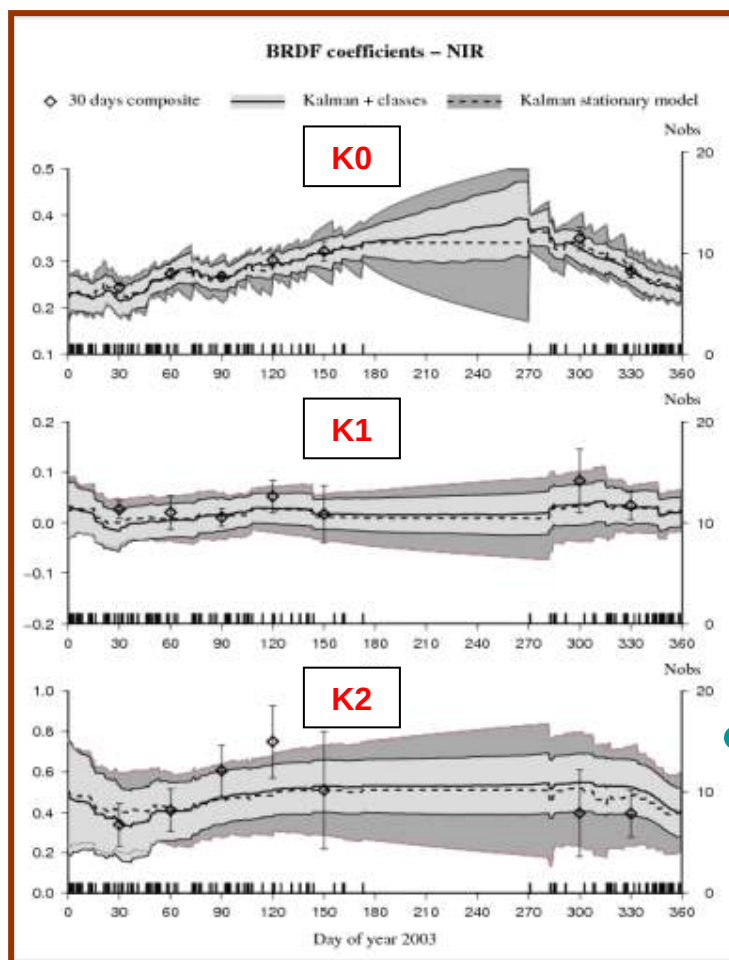


Assimilation – Kalman filter



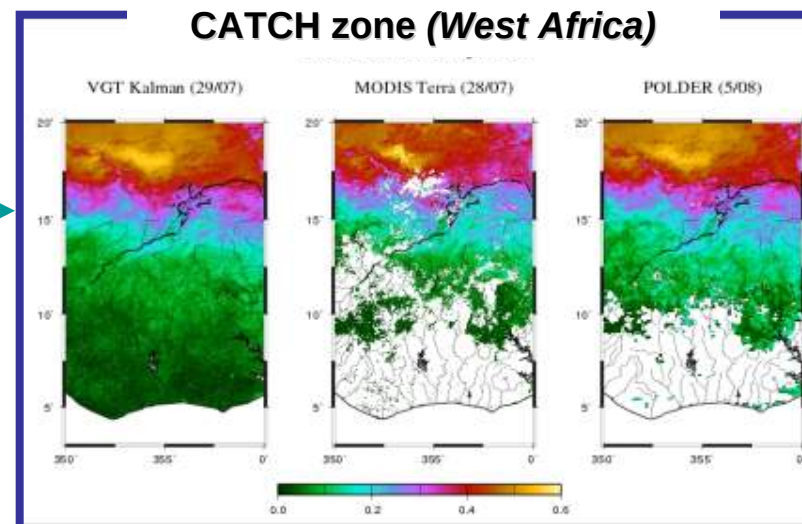
11/14

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**ECOClimap-II
land cover map
(305 classes)**

CATCH zone (West Africa)



$$\alpha_{\text{BRDF}} = \int \sum_i k_i f_i(\theta_s, \theta_o, \phi)$$

(Samain, Roujean and Geiger, RSE, 2007)



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DHR & BHR for various vegetation types

MODIS

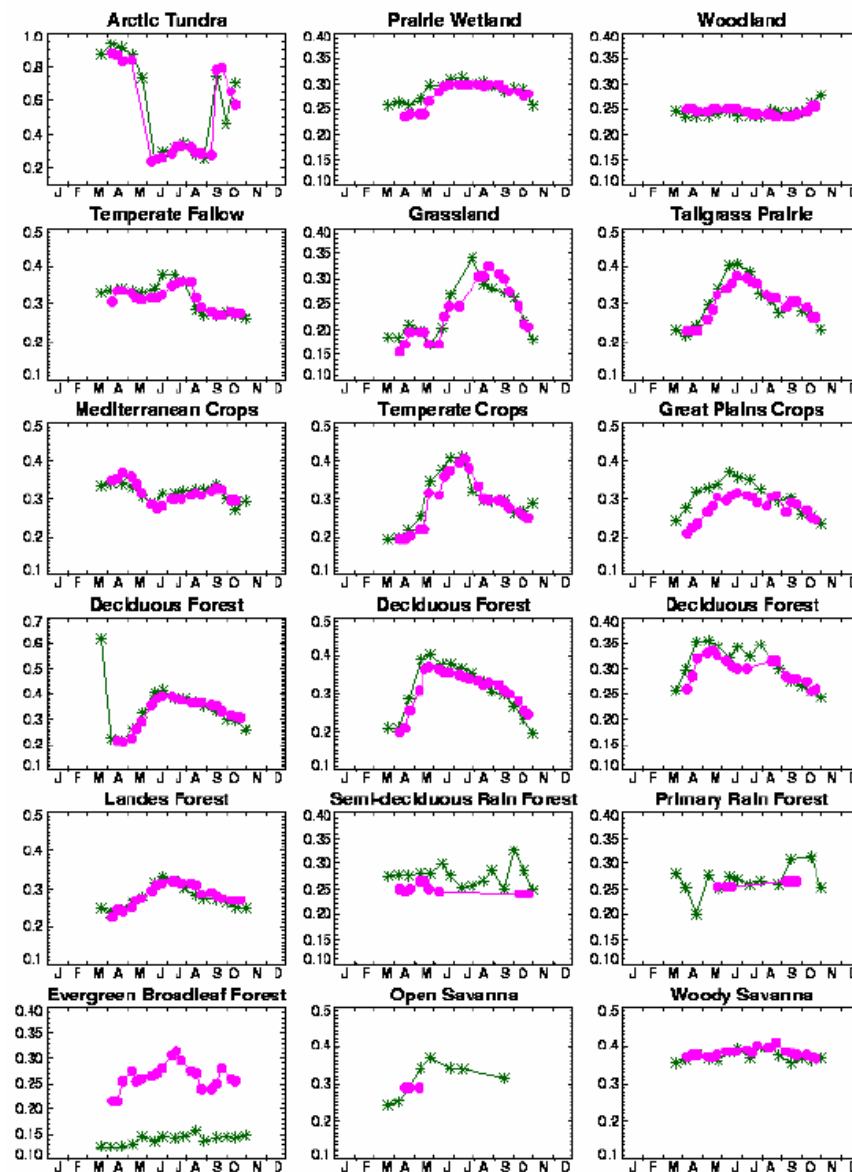
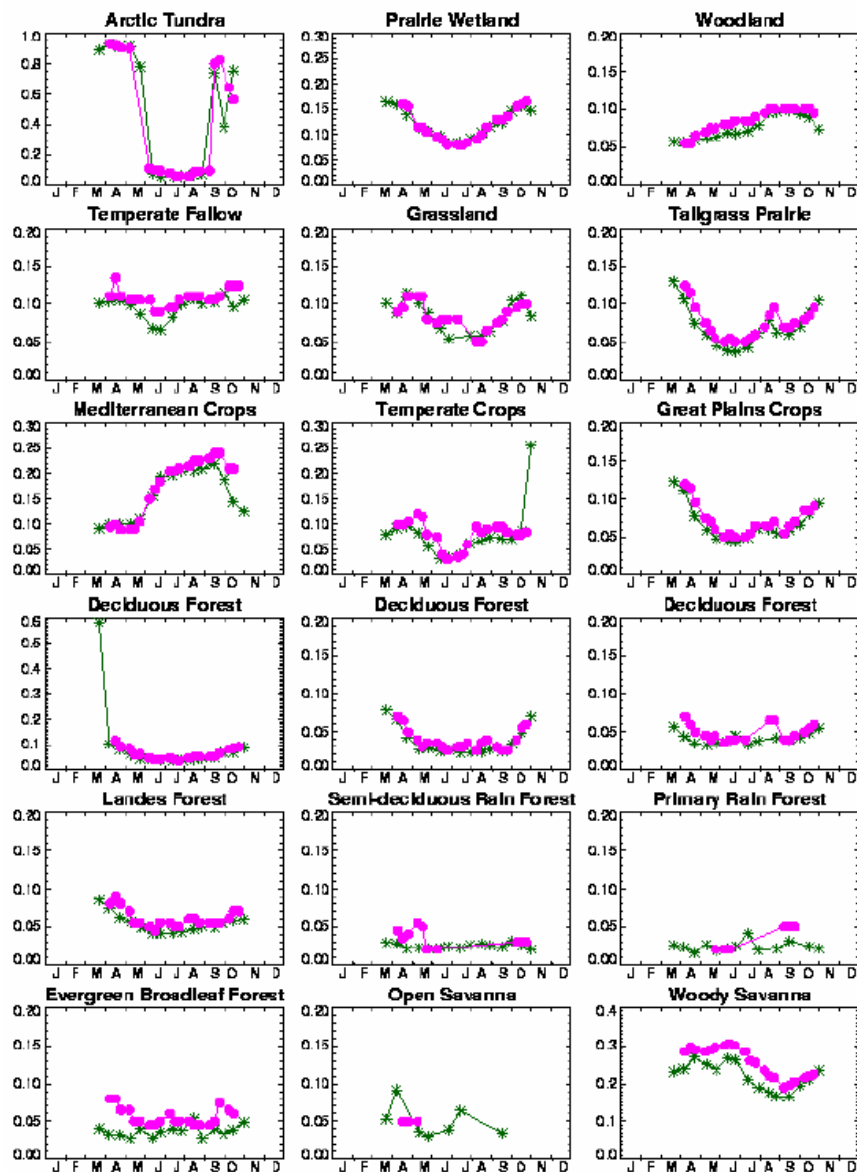
POLDER-2

670nm

865nm



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BLUE-> *in situ*

GREEN-> *POLDER*

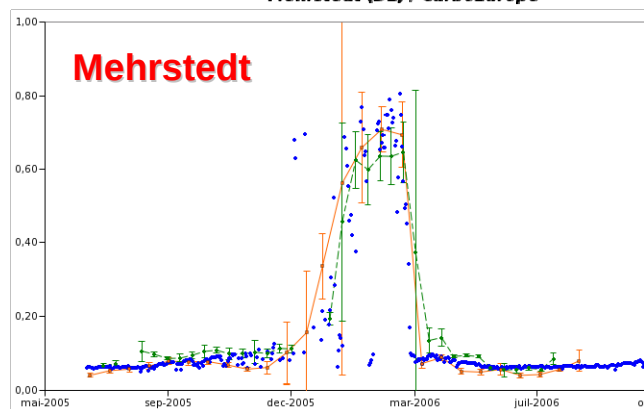
ORANGE-> *MODIS*



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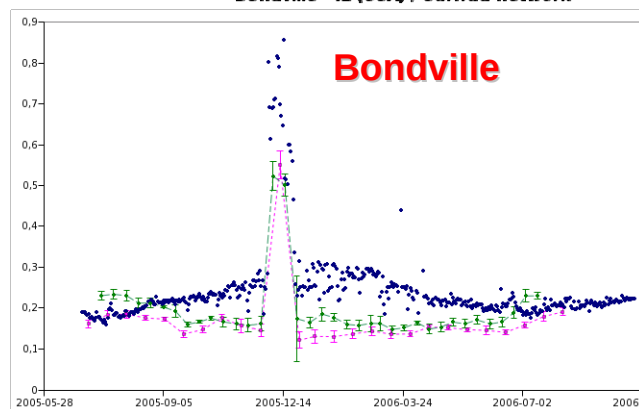
PAR - Fluxnet

Mehrstedt (DE) / CarboEurope

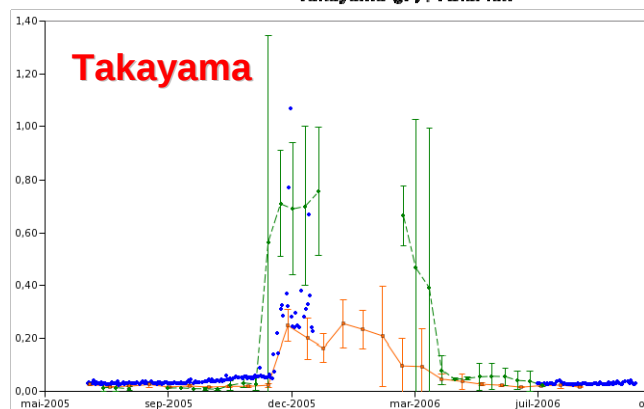


SW - SURFRAD

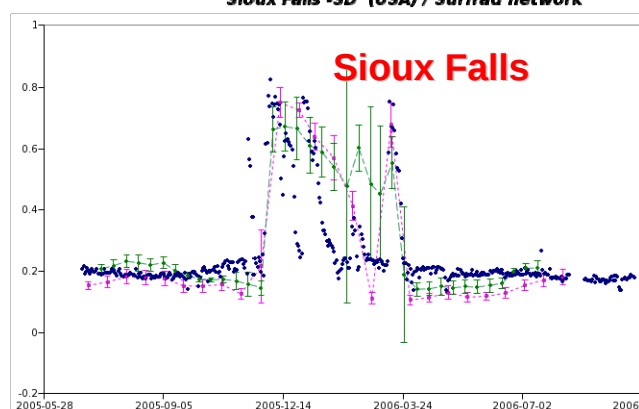
Bondville - IL (USA) / Surfrad network



Takayama (JP) / AsiaFlux



Sioux Falls -SD (USA) / Surfrad network



march 2005 -> nov. 2006



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SURFRAD

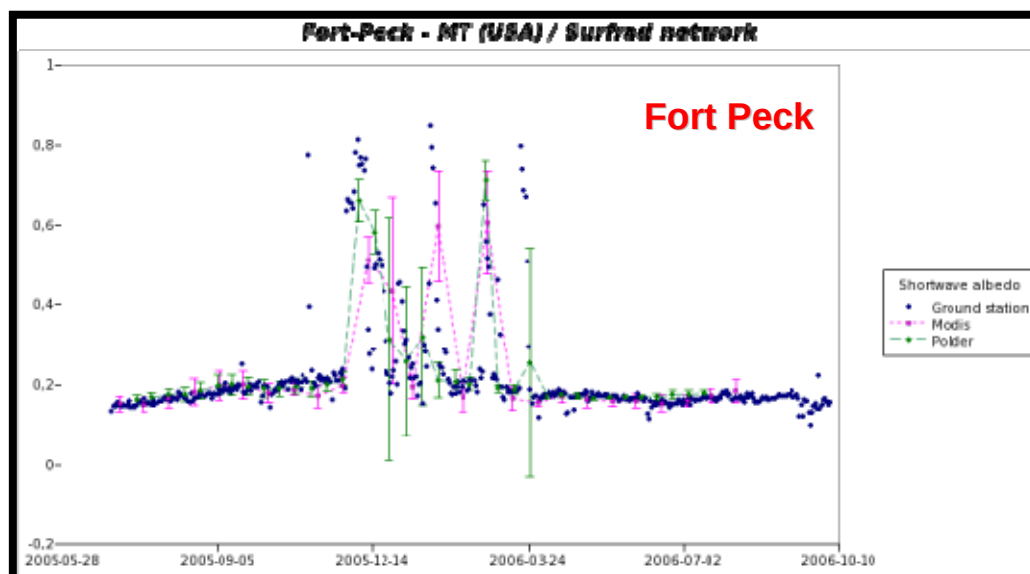
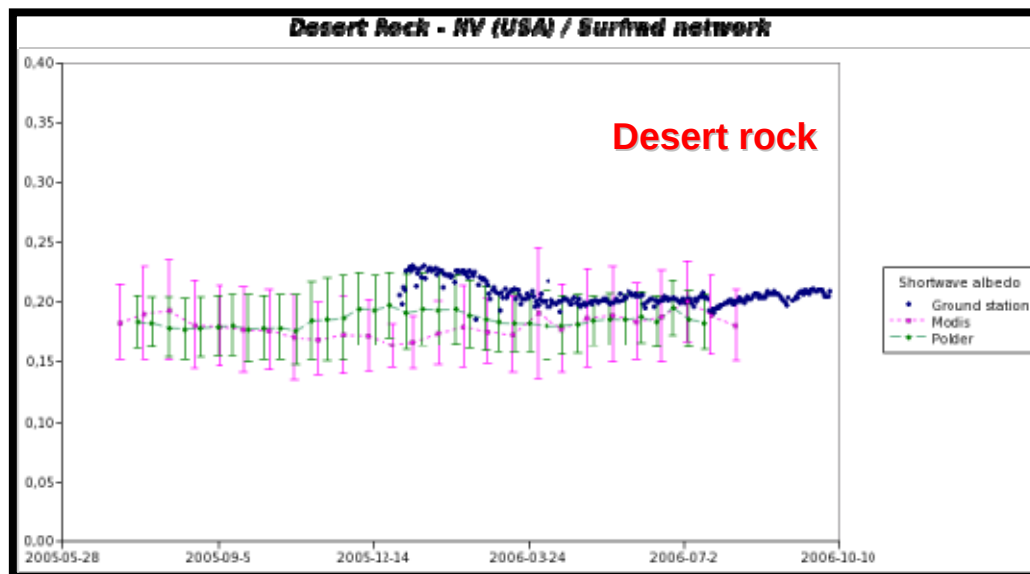


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BLUE-> *in situ*

GREEN-> POLDER

PINK-> MODIS



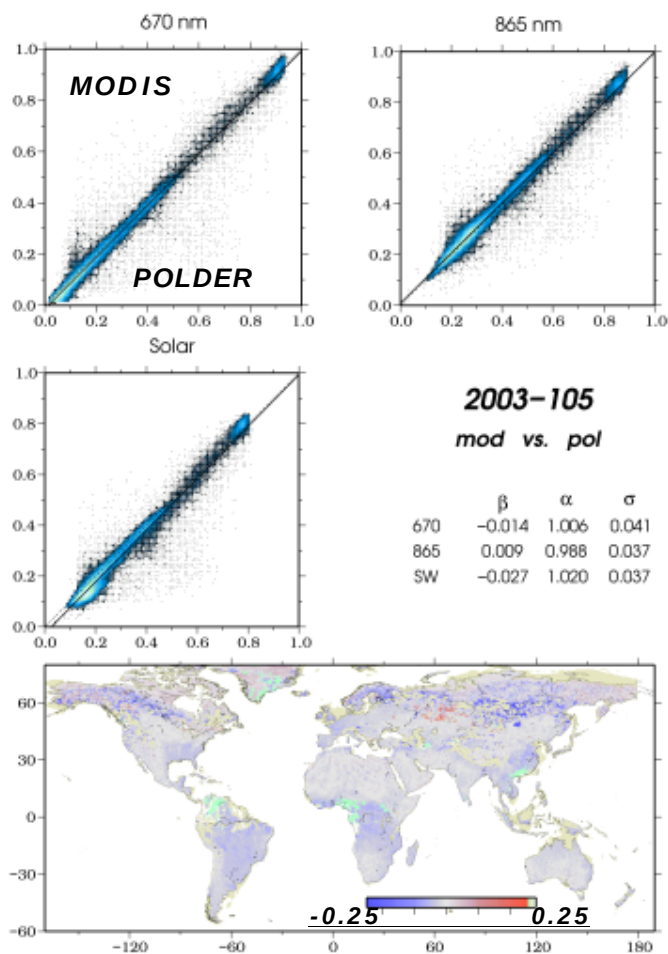
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[MODIS – POLDER] - range of variations [-0.25 ; 0.25]

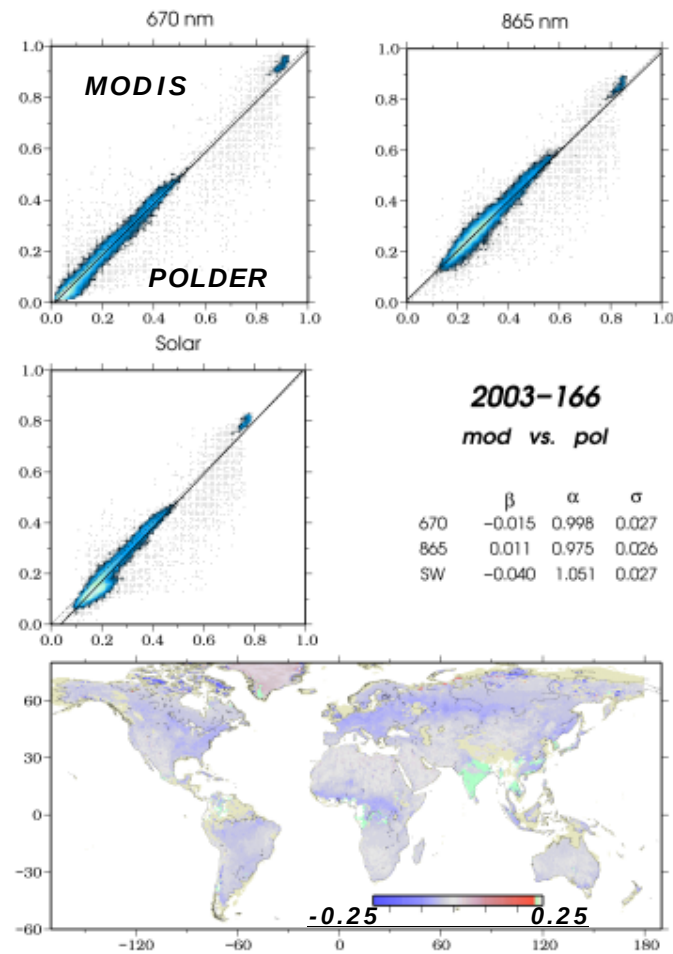


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15 April 2003



15 June 2003

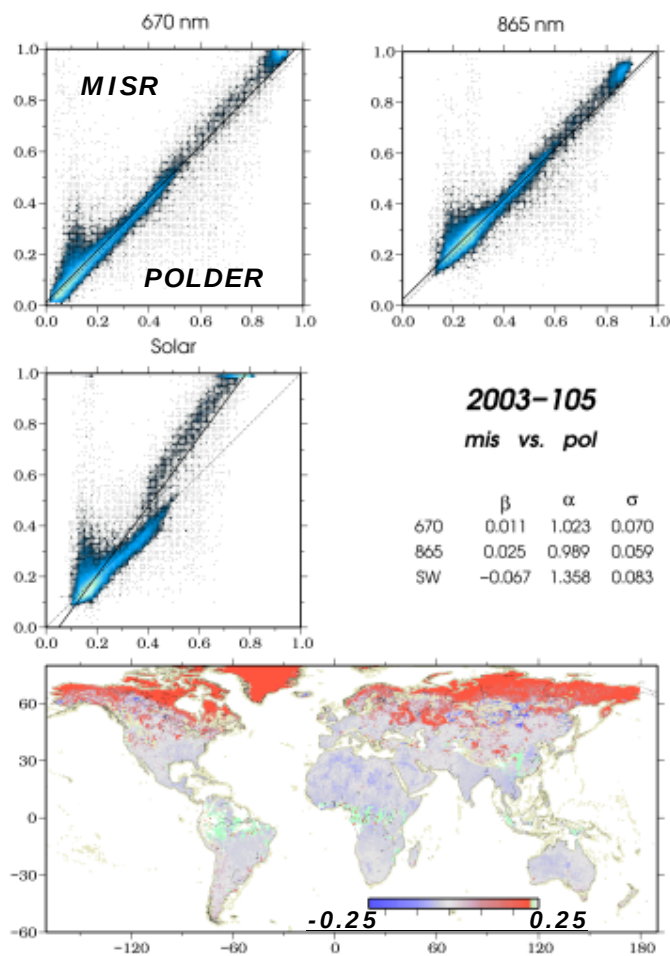


[MISR – POLDER] - range of variations [-0.25 ; 0.25]

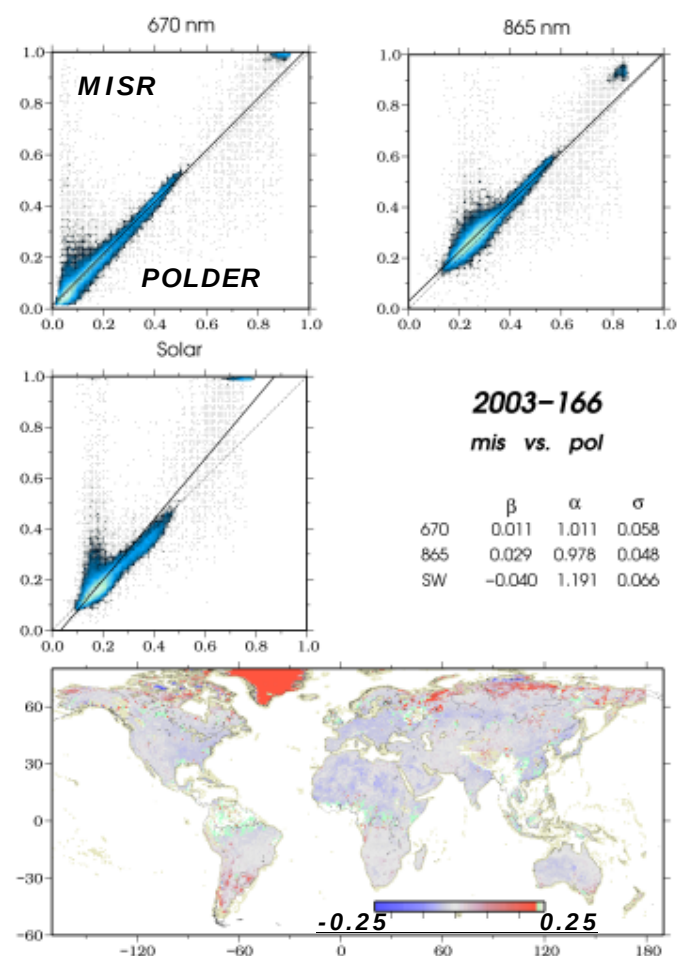


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15 April 2003



15 June 2003



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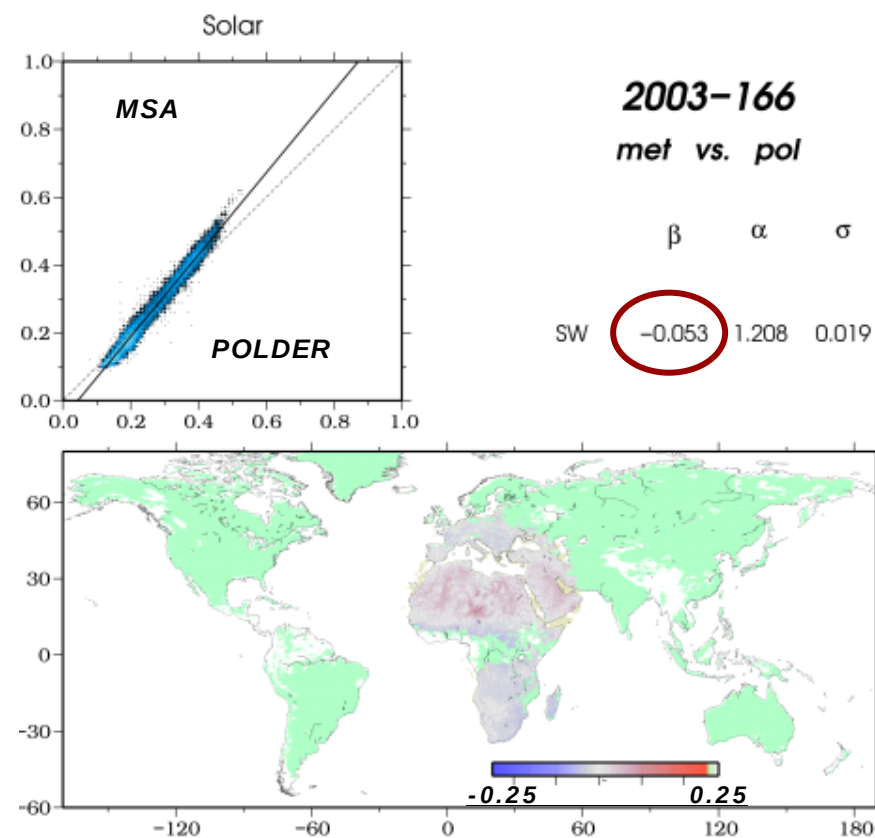
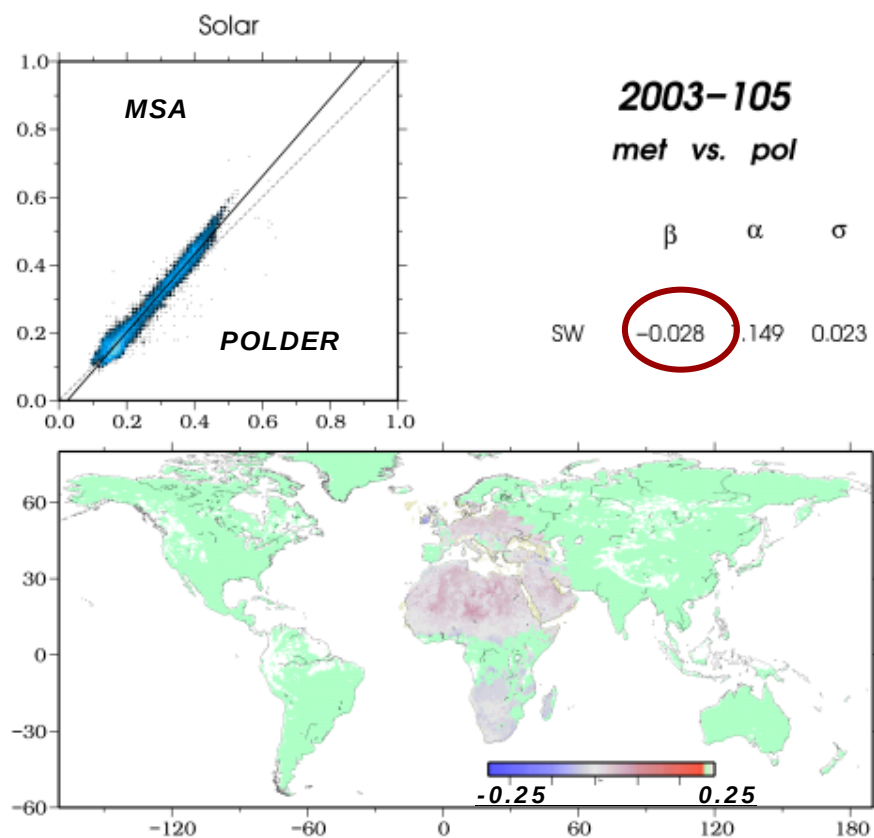
[MSA – POLDER] - range of variations [-0.25 ; 0.25]



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Meteosat Surface Albedo (MSA) < JRC + EUMETSAT



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Characteristics of GCMs albedo products [for 2003]



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- a solar product (0.4 μm - 3.0 μm)
- global
- monthly (snow-free)
- tri-hourly (snow)

ARPEGE *(Météo-France)*

- 1° degree (spatial resolution)
- diffuse / direct albedos
- ECOCLIMAP land cover

ECMWF *(European Center for Medium-range Weather Forecast)*

- 0.5° degree (spatial resolution)
- climatology ISLSCP Initiative II updated with soil reflectance, biophysical parameters [Los et al., 2000]
- vegetation albedo = 0.07
- snow albedo exposed = [0.5 , 0.85]
- snow albedo shaded = 0.2
- diffuse / direct albedos

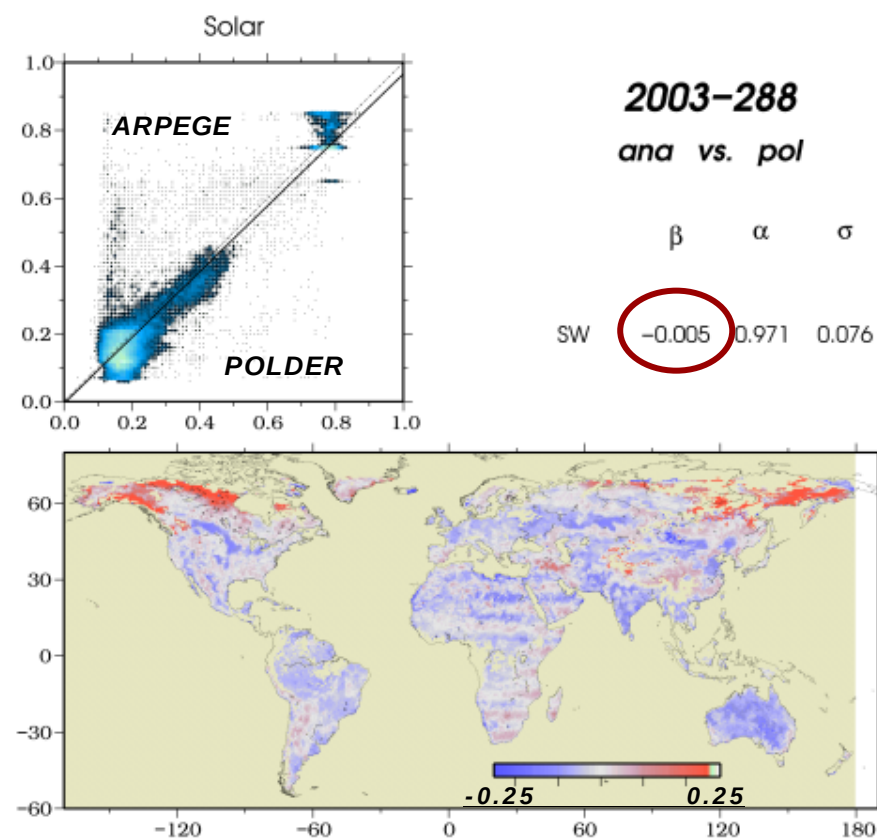
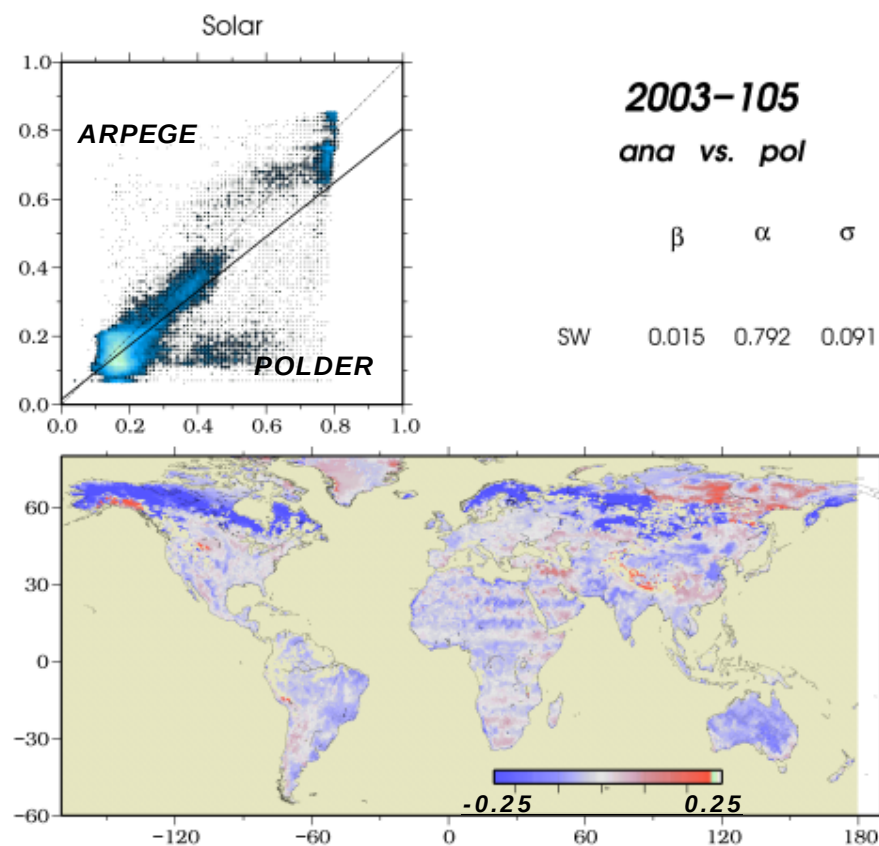
[analysis ARPEGE – POLDER] - range of variations [-0.25 ; 0.25]



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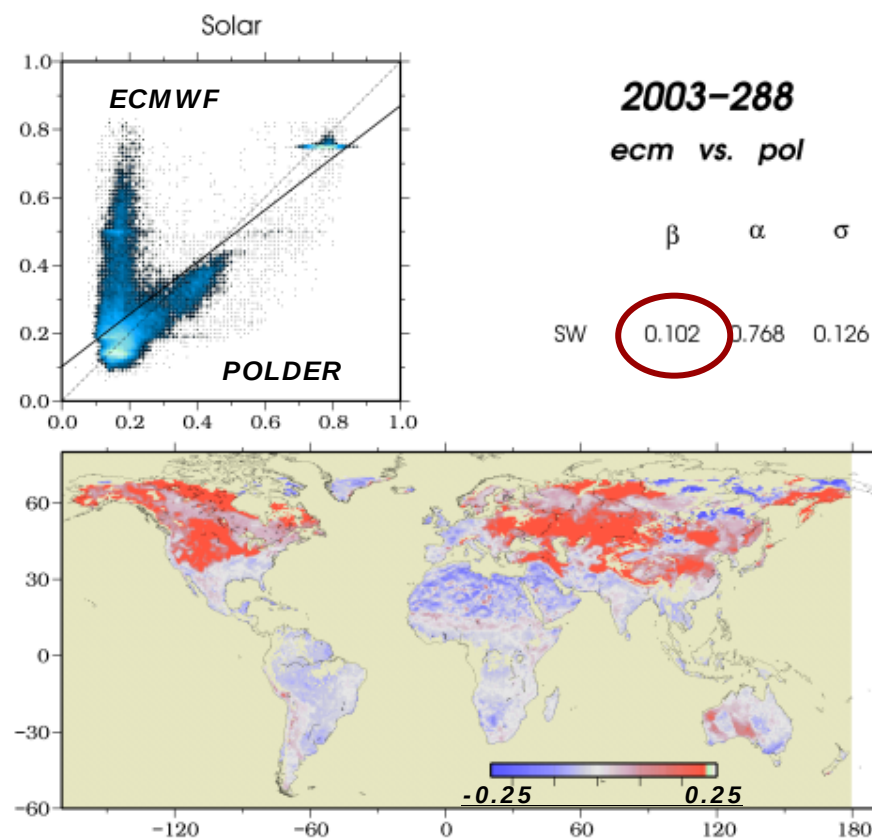
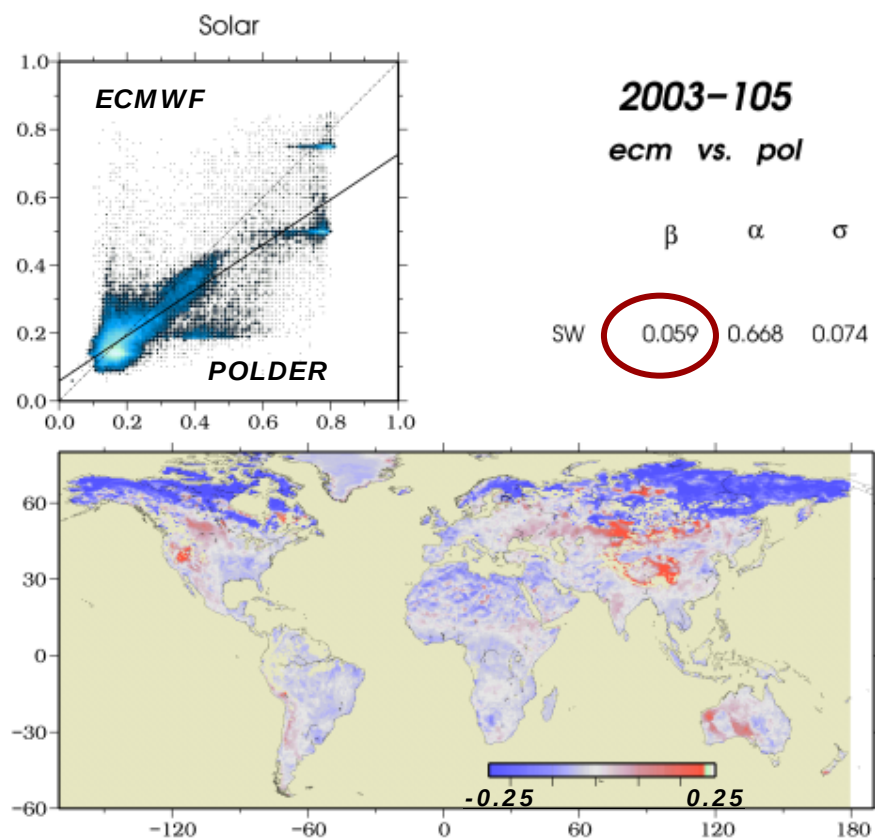
15 April 2003

15 October 2003



15 April 2003

15 October 2003



=> critical errors for ECMWF snow albedo : 0.06 (spring), 0.10 (fall)

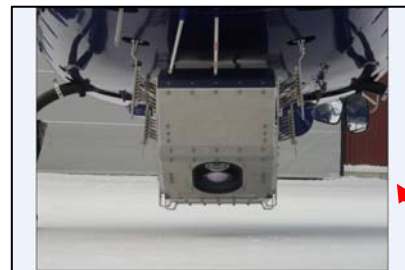


SNORTEX campaign



SNORTEX (SNOW Reflectance Transition EXperiment) (*Lapland, coll. Finland institutes*)

- **Radiative Transfer** - *Measuring and modeling anisotropy effects of boreal ecosystem radiation*
- **Spatial scale** - *Effects of the footprint size (with OSIRIS airborne data)*
- **Temporal scale** - *Snowmelting patterns, interannual variability [2008 -> 2010]*
- **Snow albedo** - *Validation, optimal analysis in GCM, assimilation of AVHRR/METOP data*



OSIRIS
(AirPOLDER)



(VIS, NIR, SWIR,
polarization)

OSIRIS scenes



SNORTEX – Some BRDF results of IOP 2008

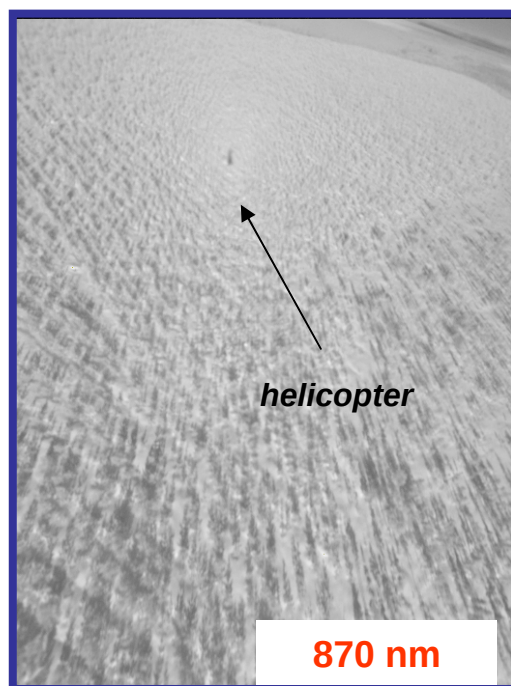


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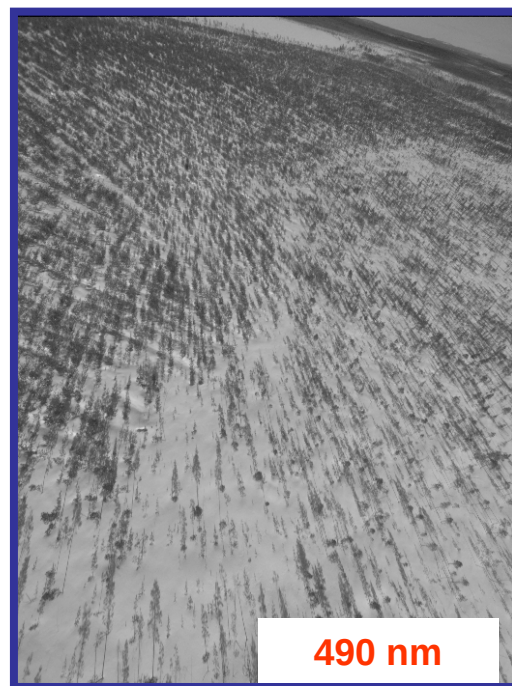
OSIRIS flights:

8 march: 1 technical flight (55 mn);
3 april: 1 flight [MF + FMI] (120 mn)
10 april: 1 flight [MF + FMI] (135 mn)

hot spot -10 april - solar zenith angle $\sim 70^\circ$



870 nm



490 nm

Snow measurements

[FMI]: 30 March -> 18 April;
heigh, density,
grain size,
water content equivalence,
spectrometry analysis,
...

Atmospheric measurements

FMI]:

Radiosoundings
(synop. scale x2 on flight day)
aerosol & ozone (in routine)



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Snow albedo combined with high vegetation is underestimated in Numerical Weather Prediction (NWP) compared to satellite products

- > a disregard to light travelling through canopy gaps and reaching soil
- > large amount of sun-flecks enhances snow contribution to surface albedo and somewhat as a paradox contributes to snow melting as a typical feedback process

Bidirectional Reflectance Distribution Function (BRDF) of snow-forest system brings new insight

- > a complex BRDF due to strong RADIOMETRIC and DIRECTIONAL contrasts between snow and vegetation attributes.
- > BRDF sampling from space in boreal regions is limited by high frequency of cloud coverage (a severe limit to study snow metamorphism from shortwave measurements)

General conclusions on operating satellite sensors



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- the best agreement is observed between POLDER and MODIS
- satellite albedo offers a good diagnostic to improve the energy budget (net absorbed radiation) in Numerical Weather Prediction (NWP) models and GCMs
- Specifications required by NWP models is assessed around 0.03 (absolute units) for a snow-free albedo product
- Snow situations: it seems to be a major drawback of GCMs (misrepresentation for high vegetation particularly).



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