



The CEOS Leaf Area Index Inter-comparison as a prototype activity

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Outline

- 1) Background: CEOS
- 2) Global validation and inter-comparison approach
- 3) Inter-comparison of: GLOBCARBON, CYCLOPES, MODIS,
ECOCLIMAP and CCRS global datasets
- 4) Conclusions



Background (1/3): Leaf Area Index Product

- Leaf Area Index:
 - Key surface characteristic for land surface modeling
 - Essential Climate Variable as defined by GCOS
- LAI definition: half the total developed area of leaves per unit ground horizontal surface area (Chen and Black, 1992)
- Multiplicity of Global Leaf Area Index products from moderate resolution sensors:
 - MODIS (collection 4 and soon collection 5)
 - CYCLOPES (SPOT/VEGETATION),
 - GLOBCARBON (VEGETATION, ATSR),
 - MSG/SEVIRI (under development)
 - MISR
 - CCRS (SPOT/VEGETATION)



Background (2/3)

Rationale for validation and inter-comparison of LAI

- Understanding the uncertainty of a given LAI product and differences between products is critical for their proper use
- Help define how multiple products can be used in combination and how consistent time series can be constructed from different sensors
- **Direct validation:** establish the absolute accuracy of a given product by independent means
- **Product inter-comparison:** understand the differences between products both spatially and temporally



Background (3/3)

Land Product Validation group

<http://lpvs.gsfc.nasa.gov/>

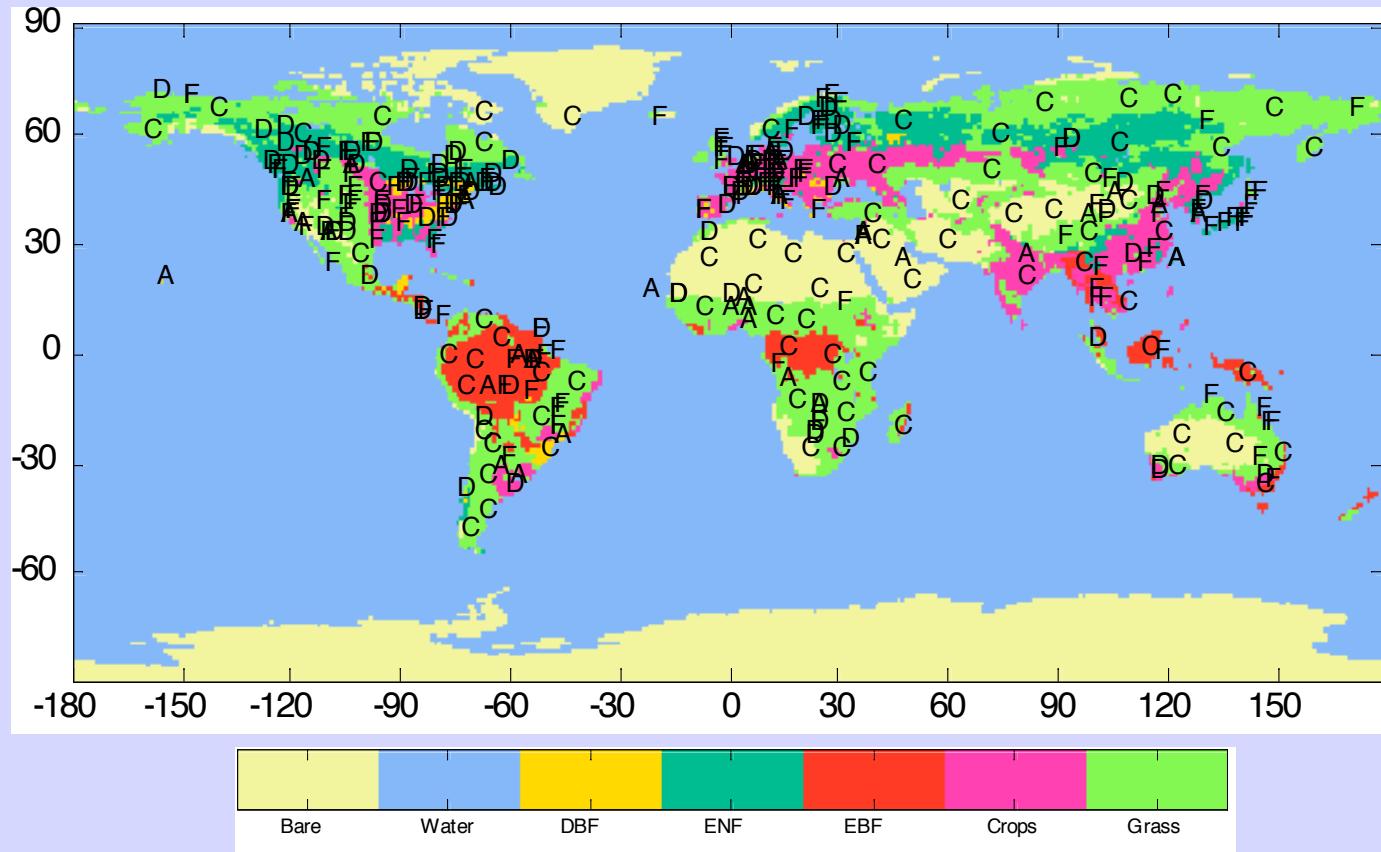
- CEOS/WGCV subgroup created in 1999 to foster quantitative validation of high-level global land products derived from remote sensing data
- International infrastructure to share data, validation approaches, and results relevant to global product validation
- Global LAI inter-comparison (Morisette et al., 2006)
 - coordination by NASA's GSFC
 - coordinated international effort:
 - USA: Boston University, Oregon State University, the USDA Forest Service, and the EPA, USA;
 - Canada: CCRS and University of Alberta, Canada;
 - Europe: France: ESA; INRA, CNES and Medias-France, France; the University of Milan-Bicocca, Italy; University of Helsinki, Finland; BIOTA/GLOWA groups, DLR, Germany



Method (1/5)

The BELMANIP Global Network of Sites

Baret, et al., 2006, TGARS special issue



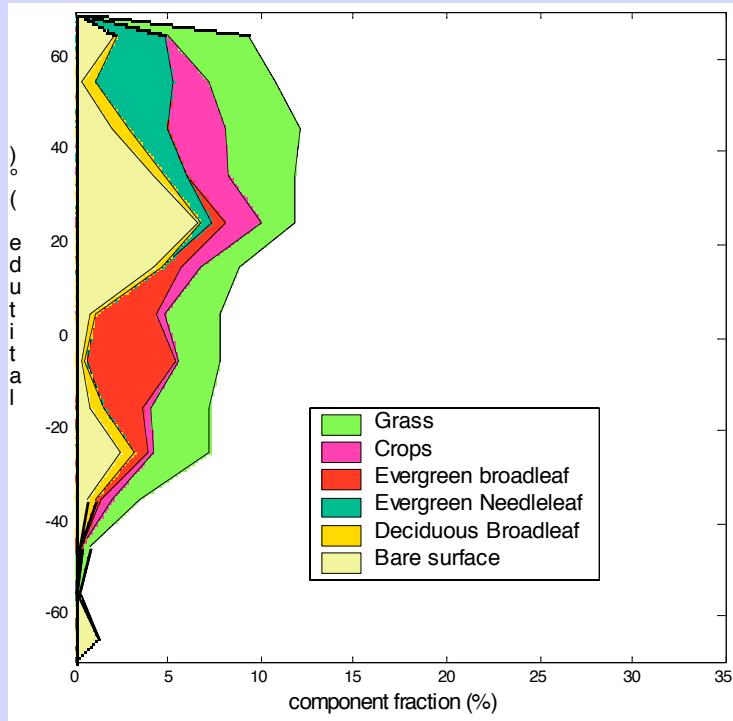
- representative sampling of global land surface types
- about 400 sites from several networks: direct validation sites (D: BIGFOOT, VALERI...)
AERONET (A), FLUXNET (F)...



Method (2/5)

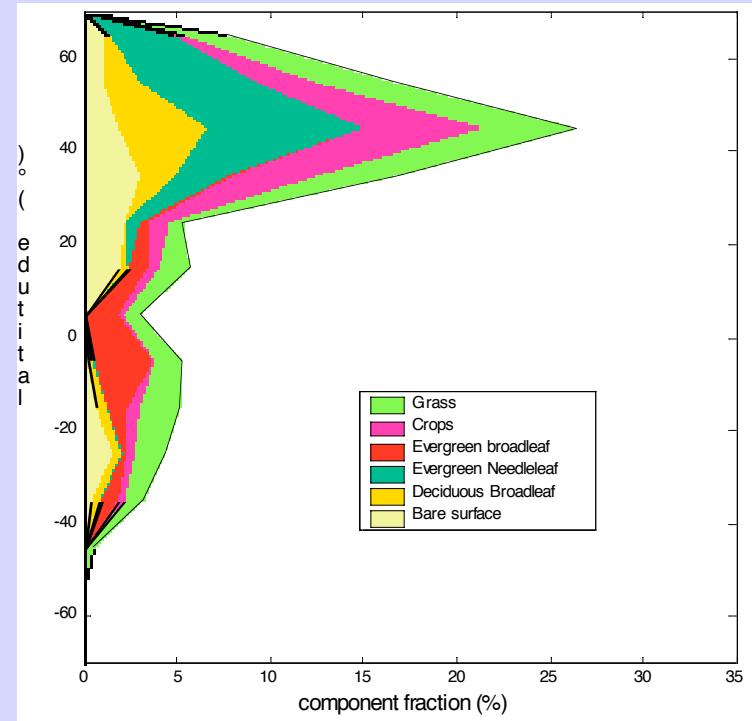
The BELMANIP Global Network of sites

ECOCLIMAP global classification (Masson et al, 2003)



Global surface type distribution

(Baret et al., 2006)



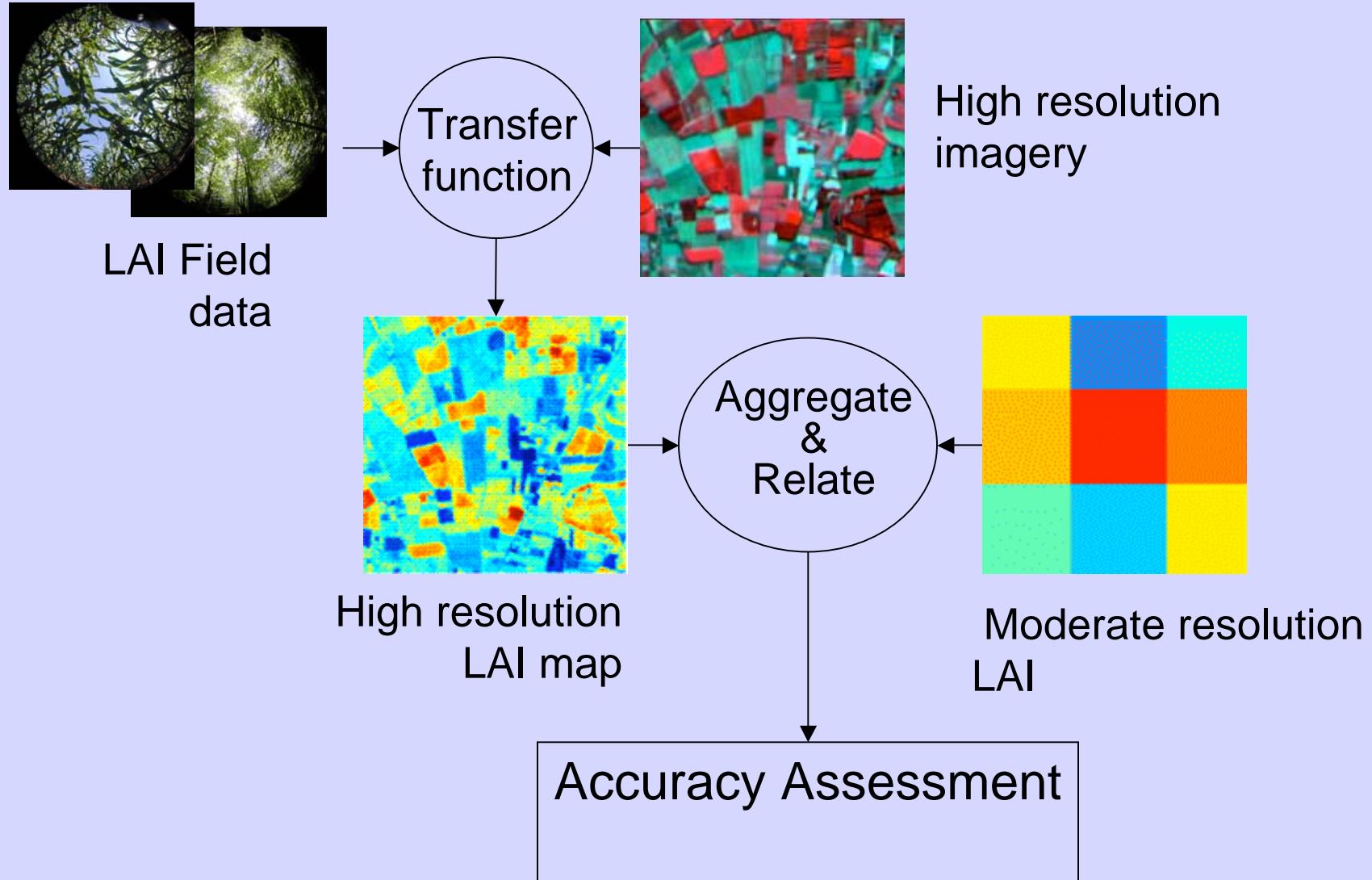
BELMANIP surface type distribution



76 sites were added to FLUXNET, AERONET and Direct Validation sites to better sample latitude, longitude and surface types (grass, bare surface, evergreen broadleaf forest)



Method (3/5): Direct Validation approach





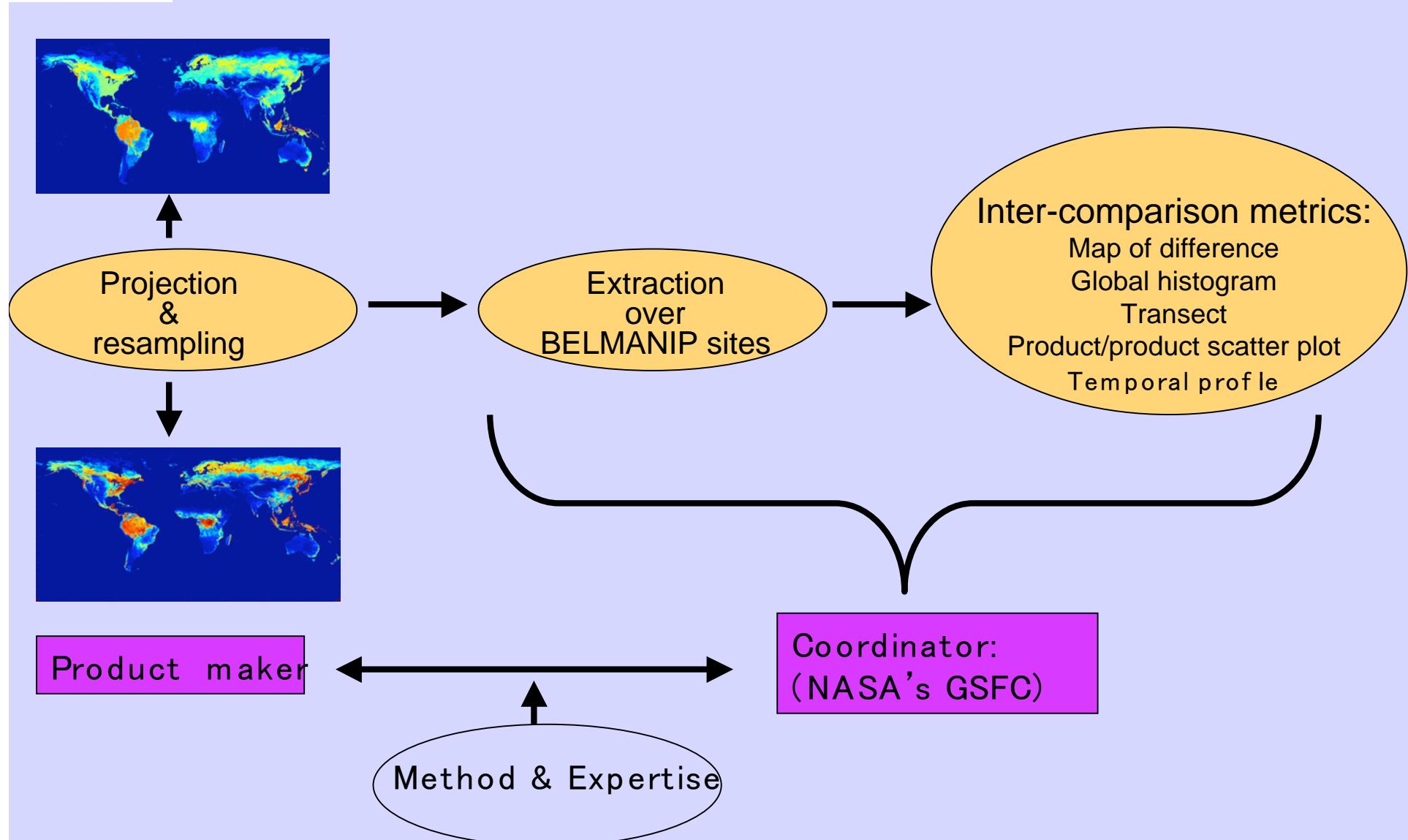
Method (4/5)

High Spatial Resolution LAI Map Database

- Direct validation conducted at BELMANIP sites at which high spatial resolution (HR) LAI maps have been generated
 - Using the LPV infrastructure to bring together HR LAI maps from several projects and groups:
 - North America: BIGFOOT, Boston University, EPA, CCRS, University of Alberta, USDA (SMEX02), NACP , CEOS/LPV ...
 - Europe: VALERI (INRA, France), CARBOEUROPE (Milan University, Italy), BIOTA/GLOWA-AFRICAN projects (DLR), MSG validation sites (Valencia University, Spain),
 - Others : ?
-  60 sites and 90 LAI HR maps available so far.
- Registration of the LAI map dataset in the Mercury system (ORNL)



Method (5/5): LAI inter-comparison approach





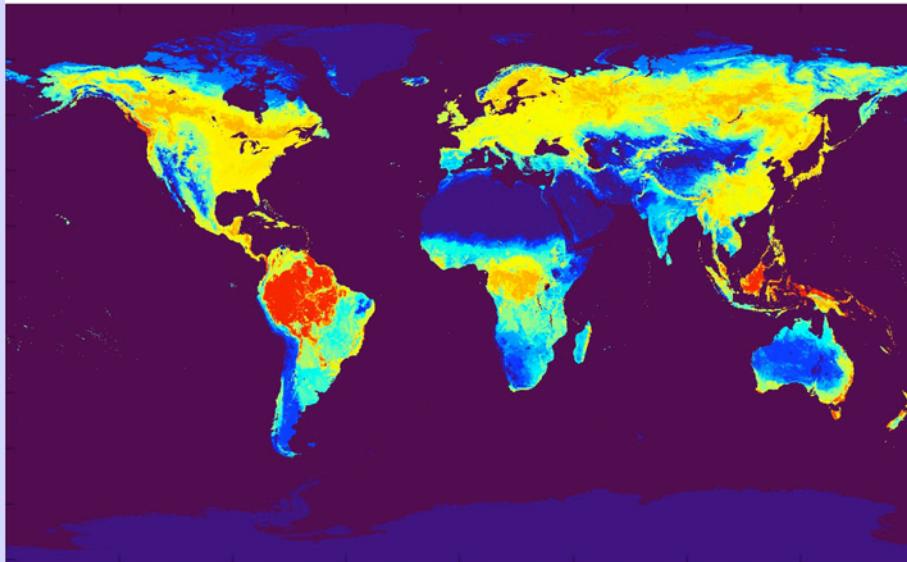
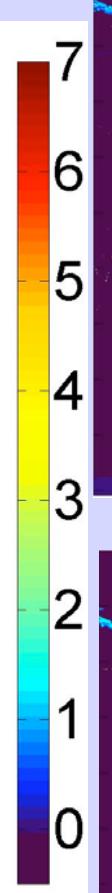
Results: Products investigated

Product	Algorithm	Clumping correction	Woody correction	Total LAI
GLOBCARBON (Plummer et al)	Semi-empirical relationship (SR, RSR VI, BRDF Correction and temporal filter)	yes	yes	yes
CYCLOPES	Radiative Transfer Inversion by neural network	no	no	yes
MODIS (Myneni et al., 2002)	Radiative Transfer Inversion by LUT	yes	yes	yes
ECOCLIMAP (Masson, et al., 2003)	Climatology from global climate distribution and NOAA AVHRR time series	yes	yes	yes
CCRS (Fernandes, et al., 2003)	Semi-empirical (SR, ISR, BRDF correction, land use specific retrieval, temporal filter)	yes	yes	no

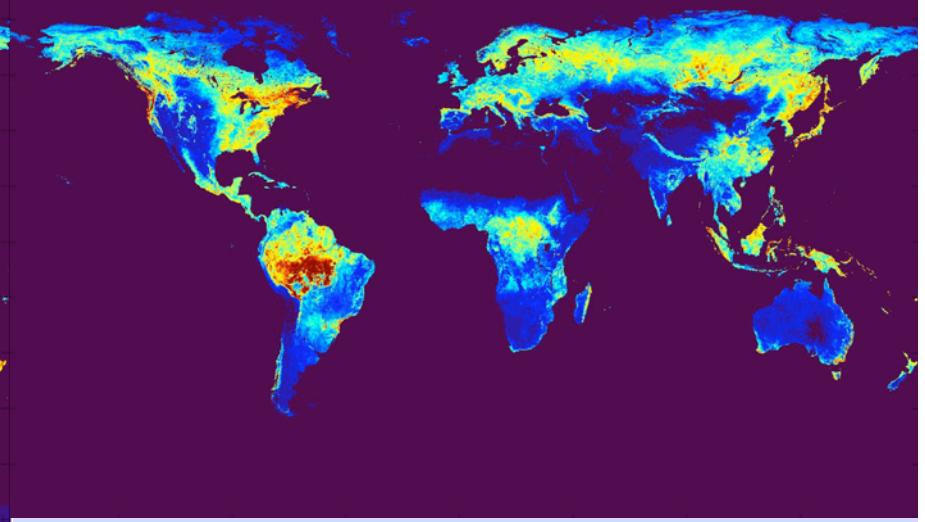


Results: Global maps (Aug 2002)

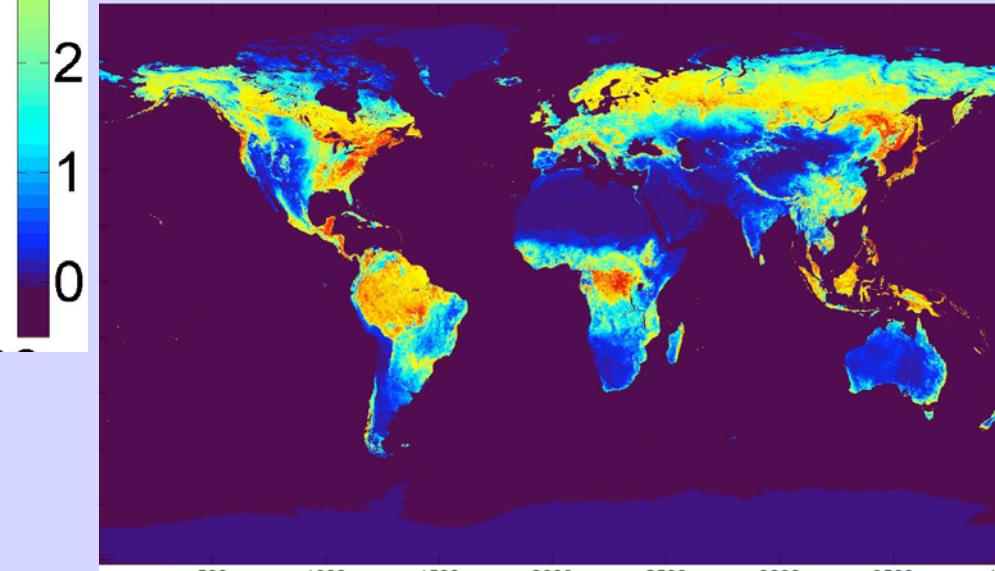
ECOCLIMAP



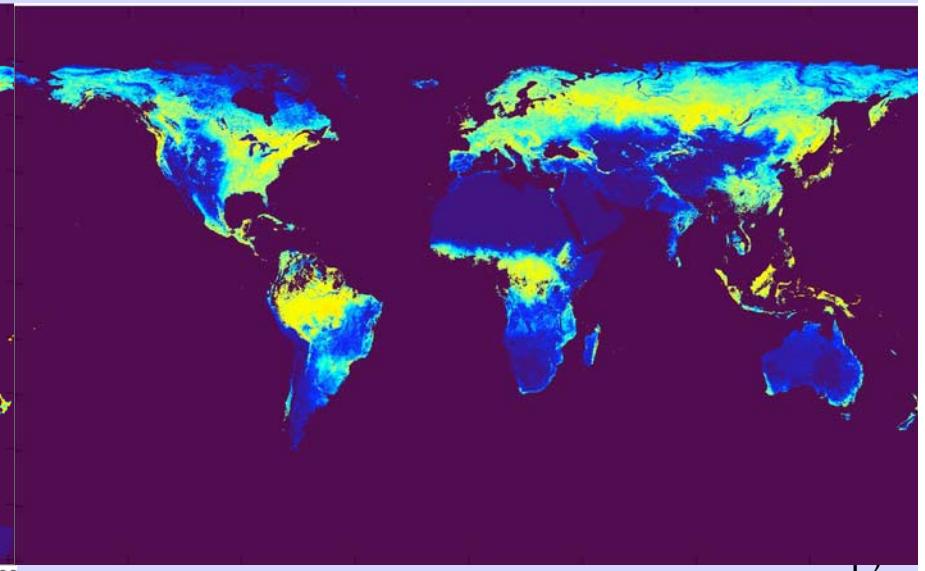
GLOBCARBON



MODIS

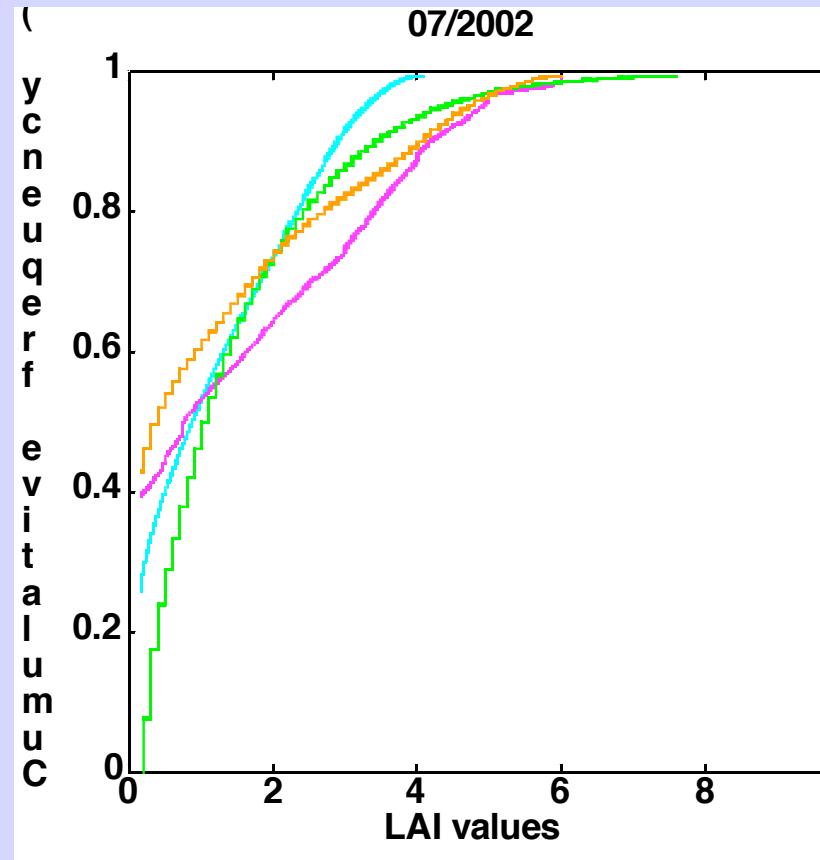
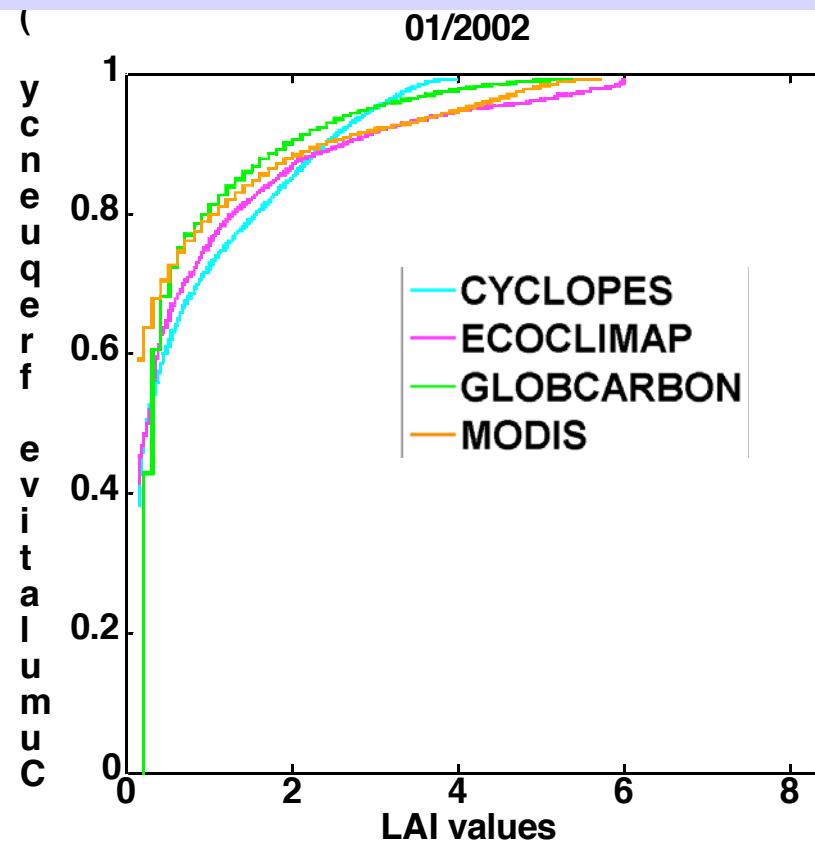


CYCLOPES





Results: Global histogram



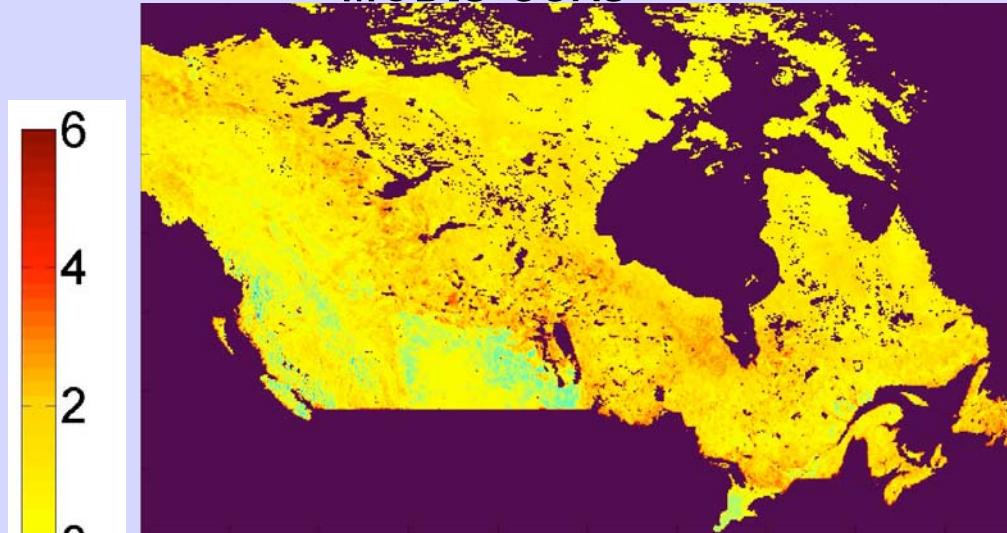
- differences of LAI range between products
- distribution of values more continuous for CYCLOPES than MODIS and GLOBCARBON



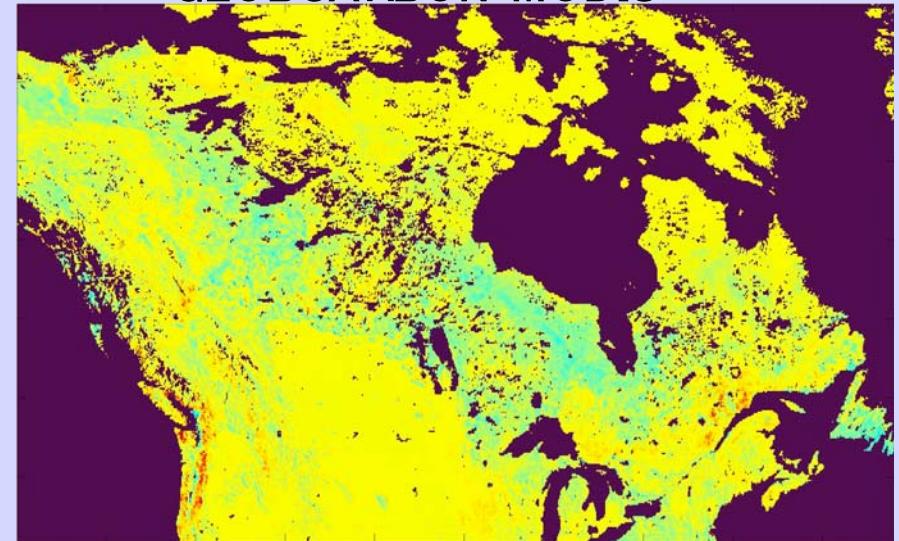
Results: Map of differences over Canada

July 2002

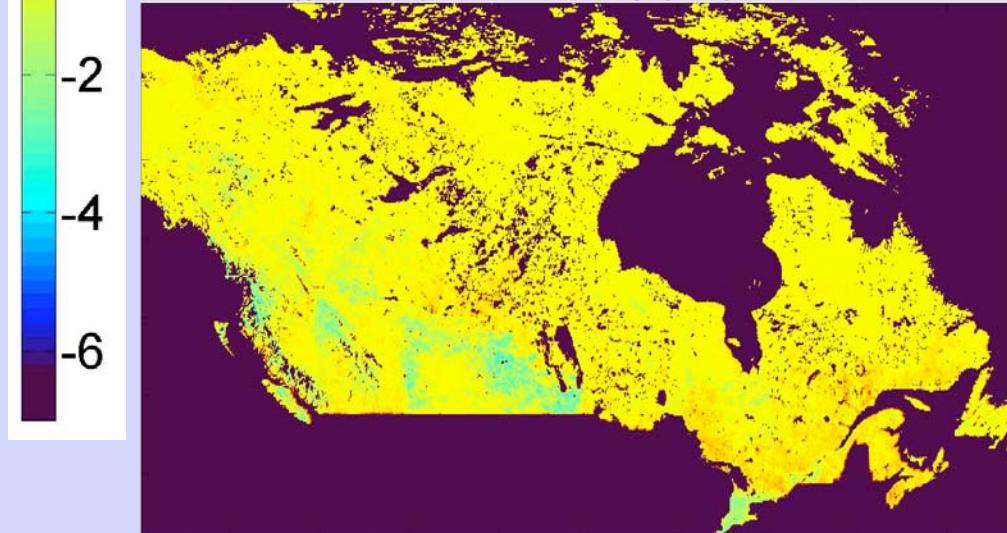
MODIS-CCRS



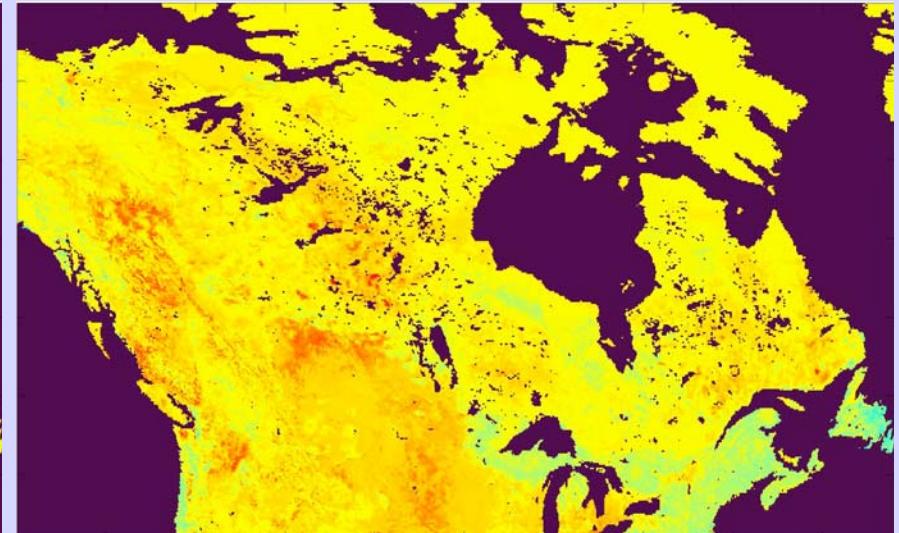
GLOBCARBON-MODIS

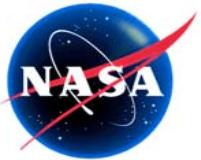


GLOBCARBON-CCRS



ECOCLIMAP-MODIS

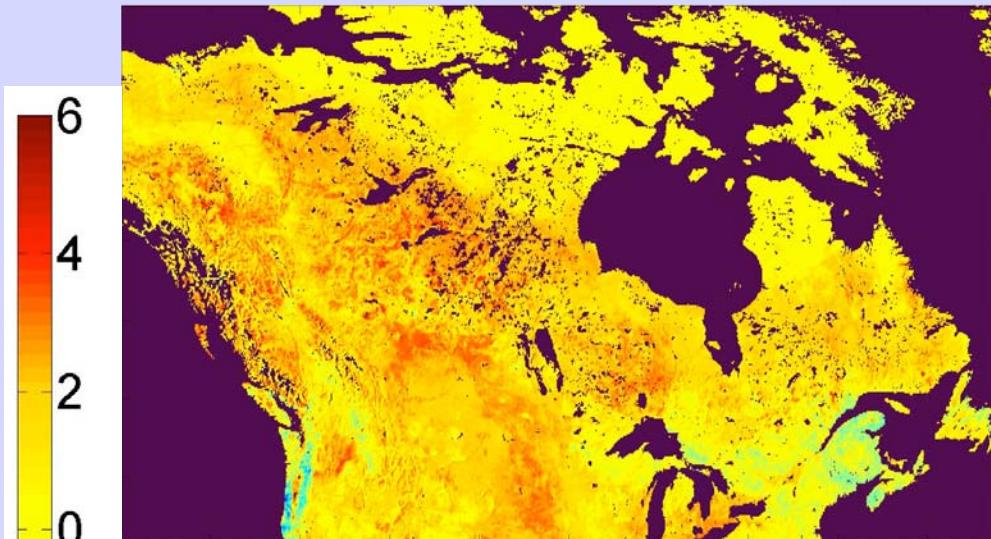




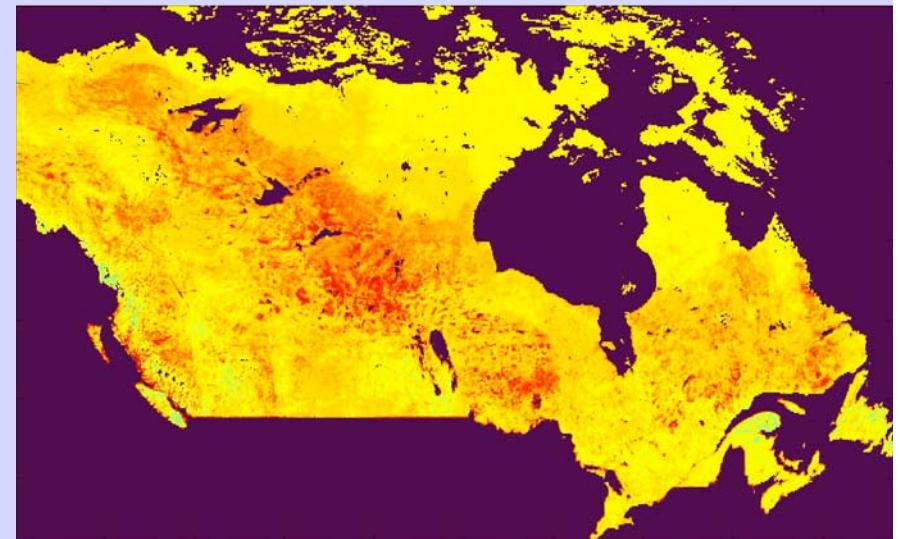
Results: Map of differences over Canada

July 2002

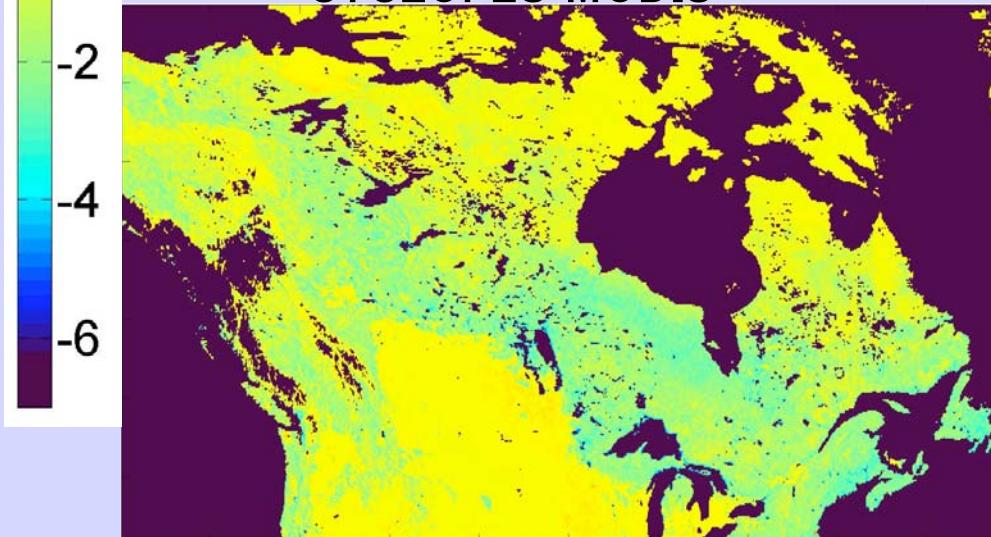
ECOCLIMAP-GLOBCARBON



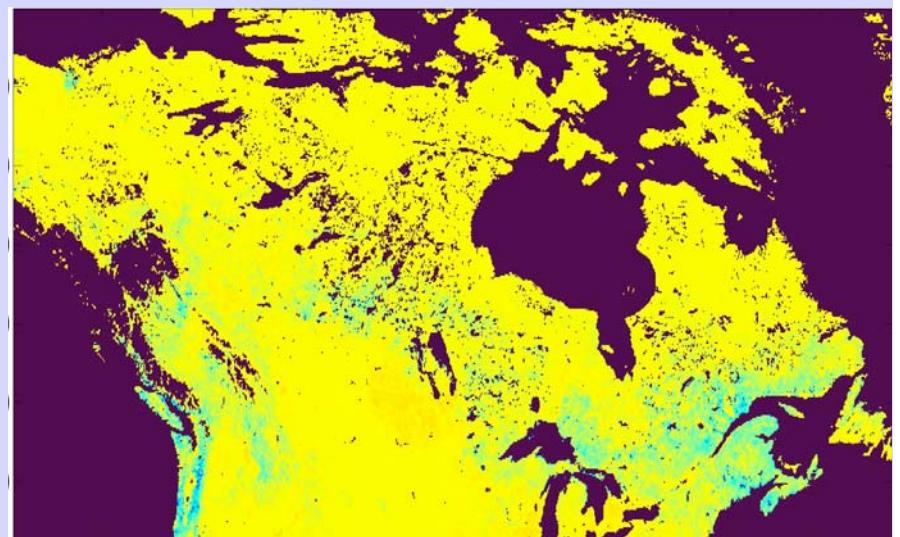
ECOCLIMAP-CCRS



CYCLOPES-MODIS



CYCLOPES-GLOBCARBON

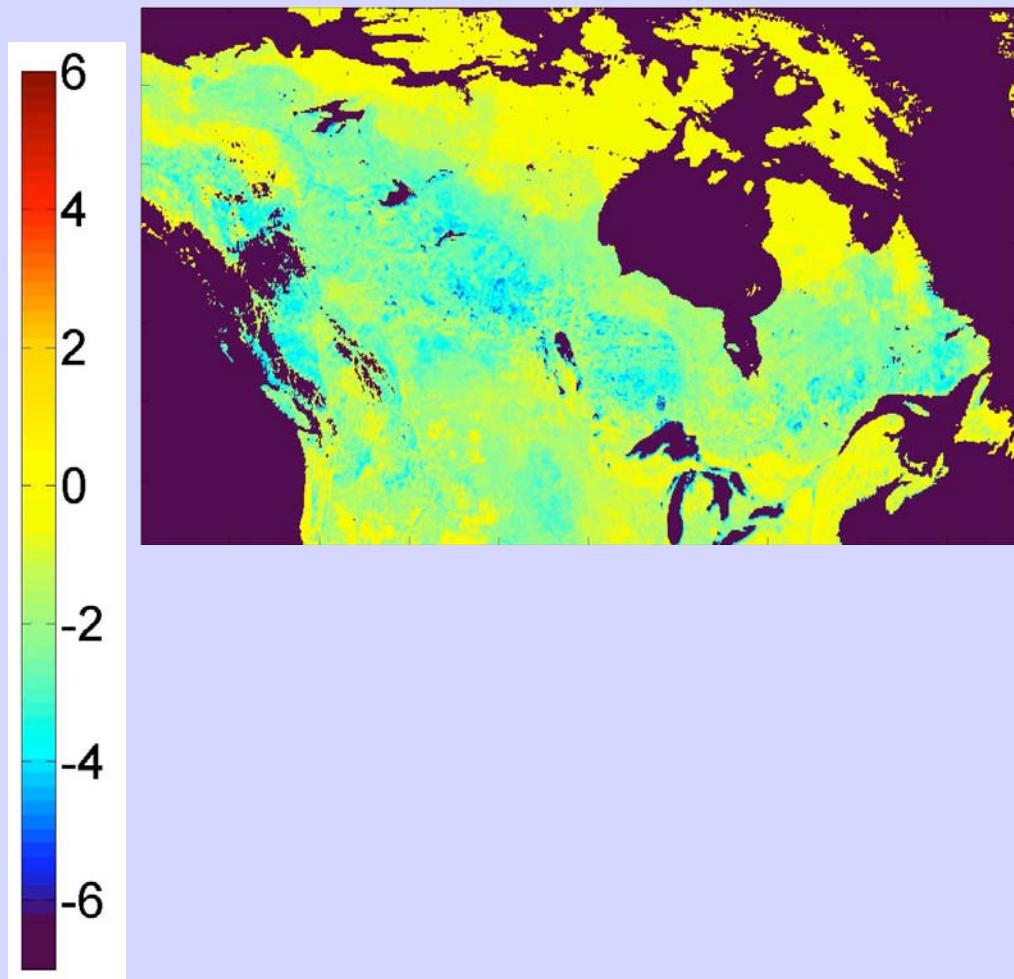




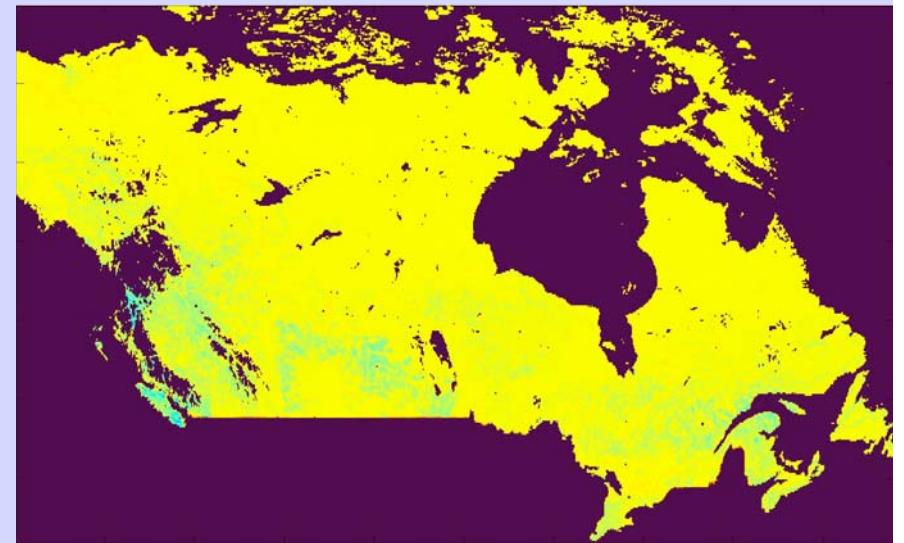
Results: Map of differences over Canada

July 2002

CYCLOPES-ECOCLIMAP



CYCLOPES-CCRS



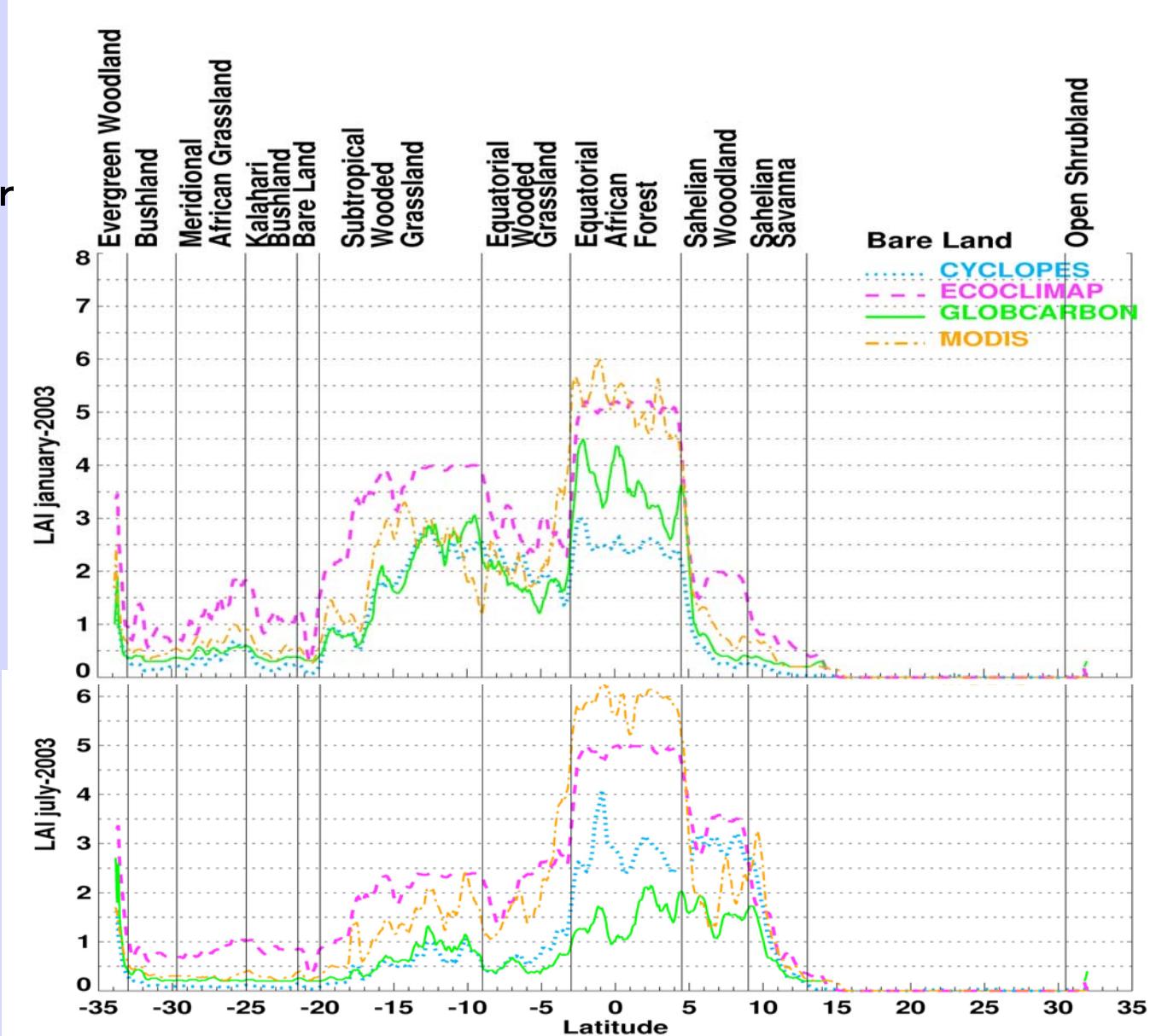


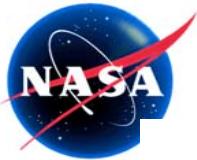
Results: Transect over Africa (25° est)

Land Cover

Jan 2003

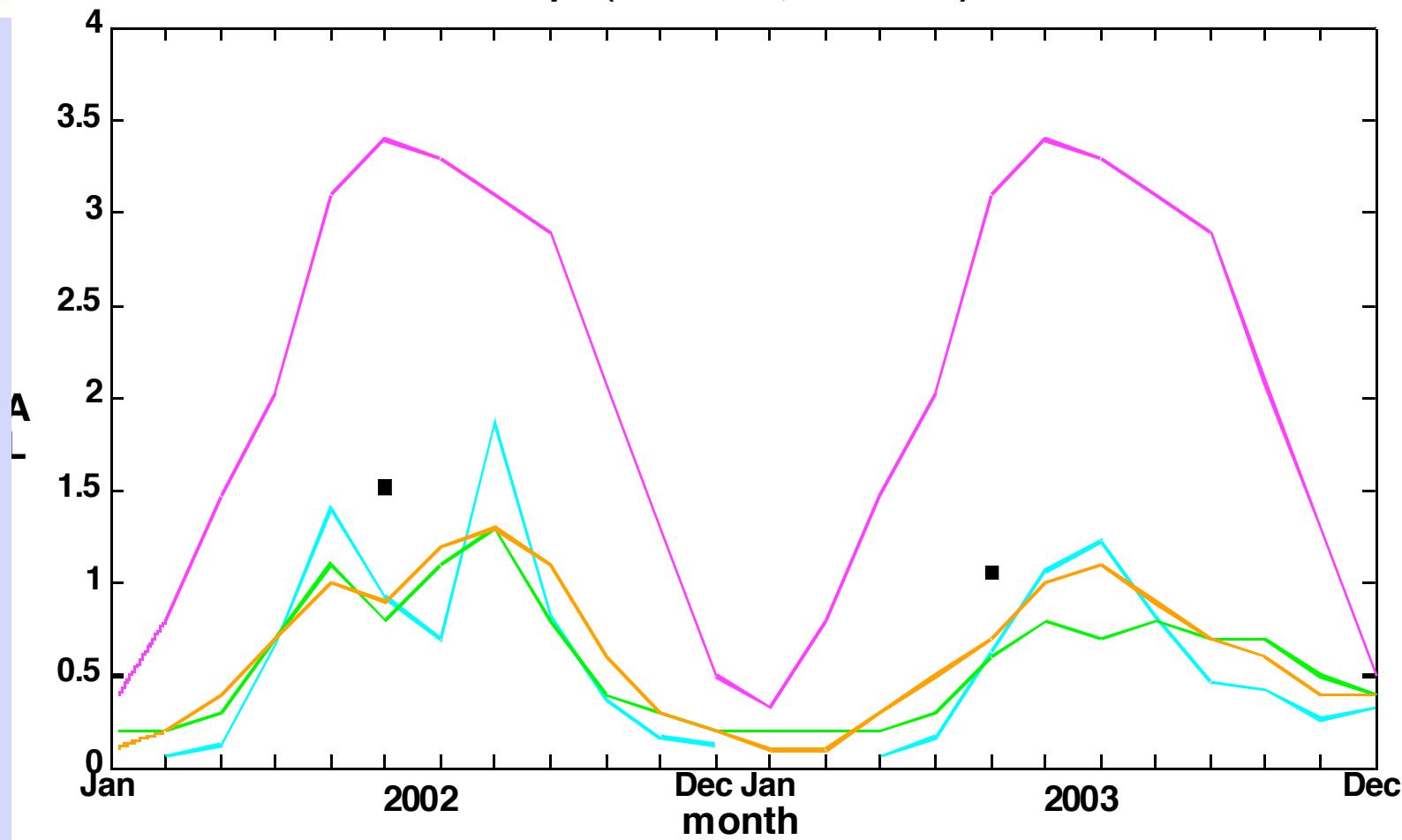
Jul 2003





Results: Time series over crop sites

Crops (Fundulea, Romania)

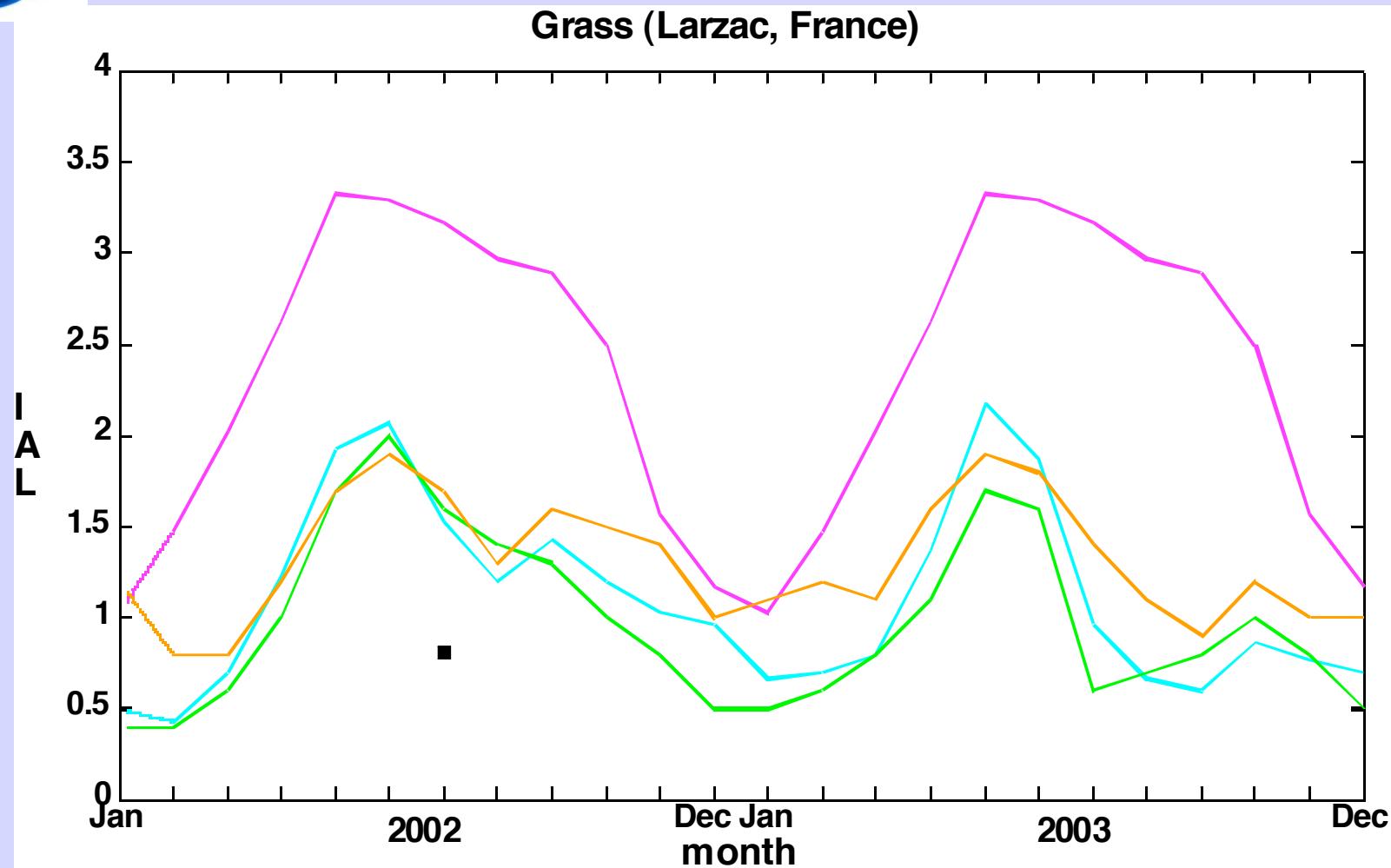


- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

— over-estimation of ECOCLIMAP
— Good agreement between other products in 2003

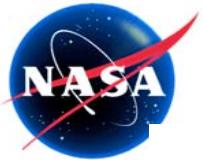


Results: Time series over grassland



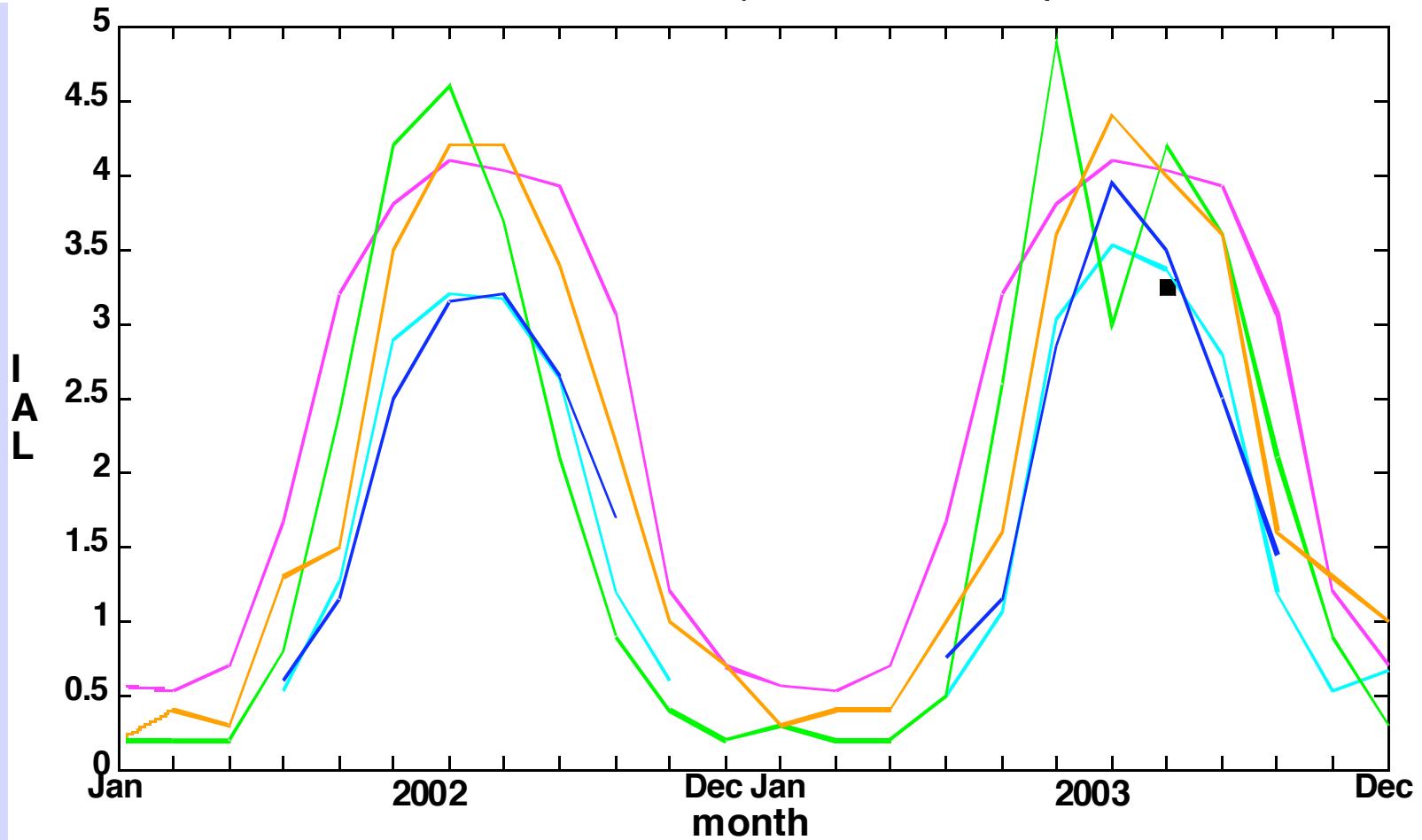
- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

- over-estimation of ECOCLIMAP
- Good consistency between MODIS, CYCLOPES & GLOBCARBON



Results: Time series over DBF

Decid. Broad. For. (Larose2, Canada)



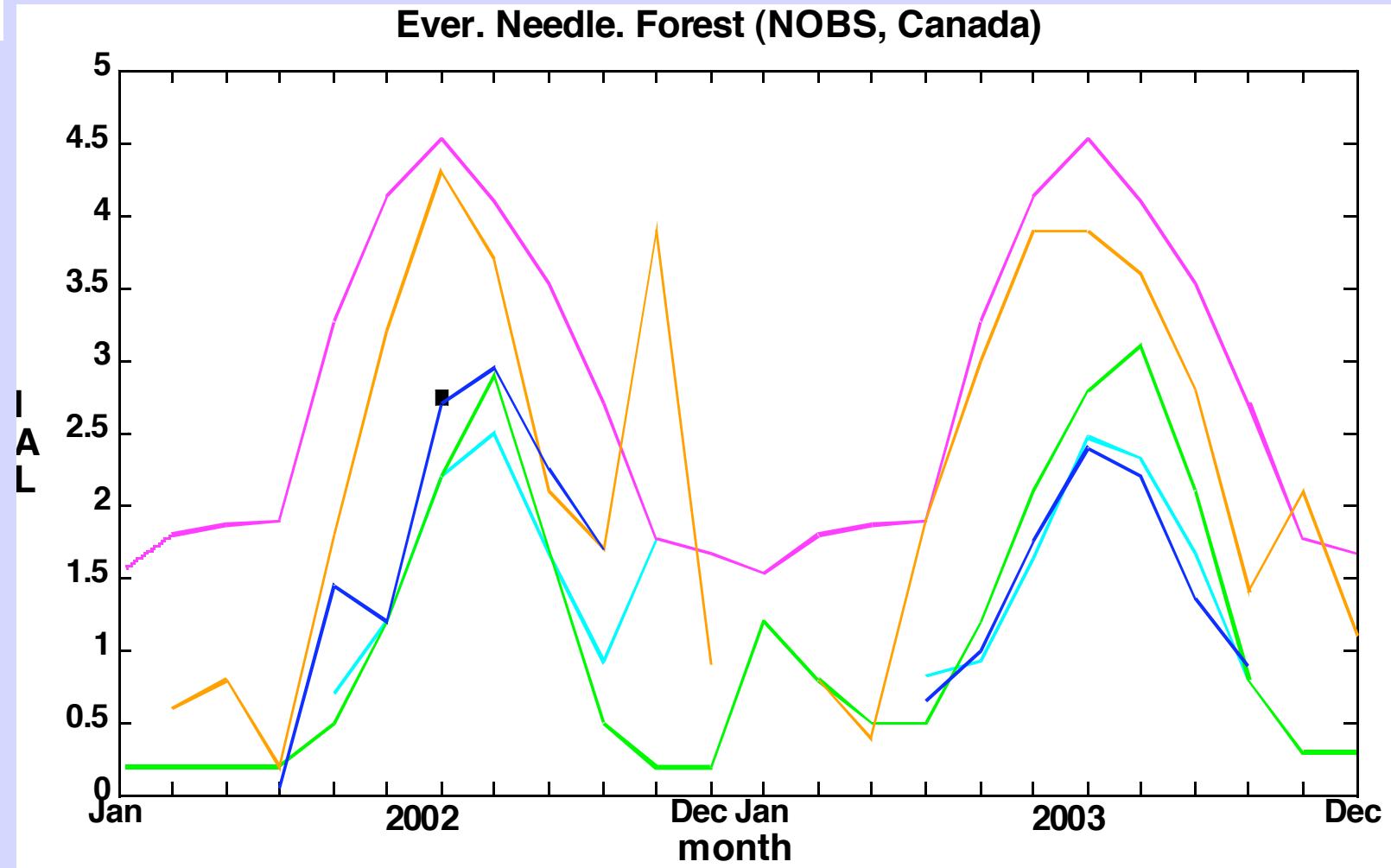
- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

- Good consistency of seasonal variation between most products
- Important difference of magnitude in 2002



Results: Time series over ENF

Ever. Needle. Forest (NOBS, Canada)



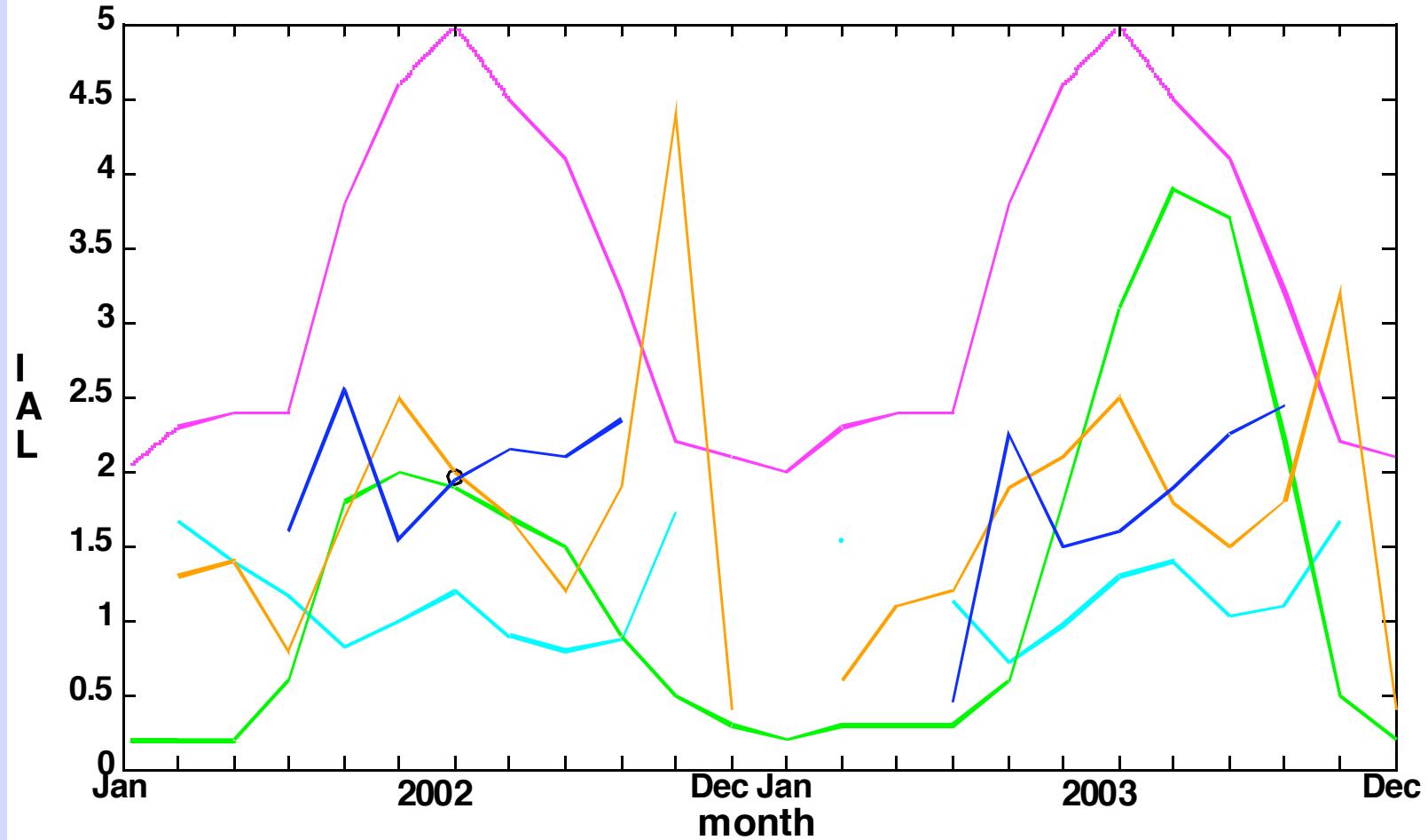
- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

– Relative good agreement between CYCLOPES, CCRS
– High magnitude of MODIS values



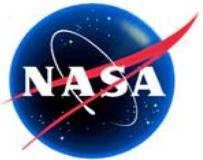
Results: Time series over ENF

Ever. Needle. Forest (WatsonLake, Yukon, Canada)



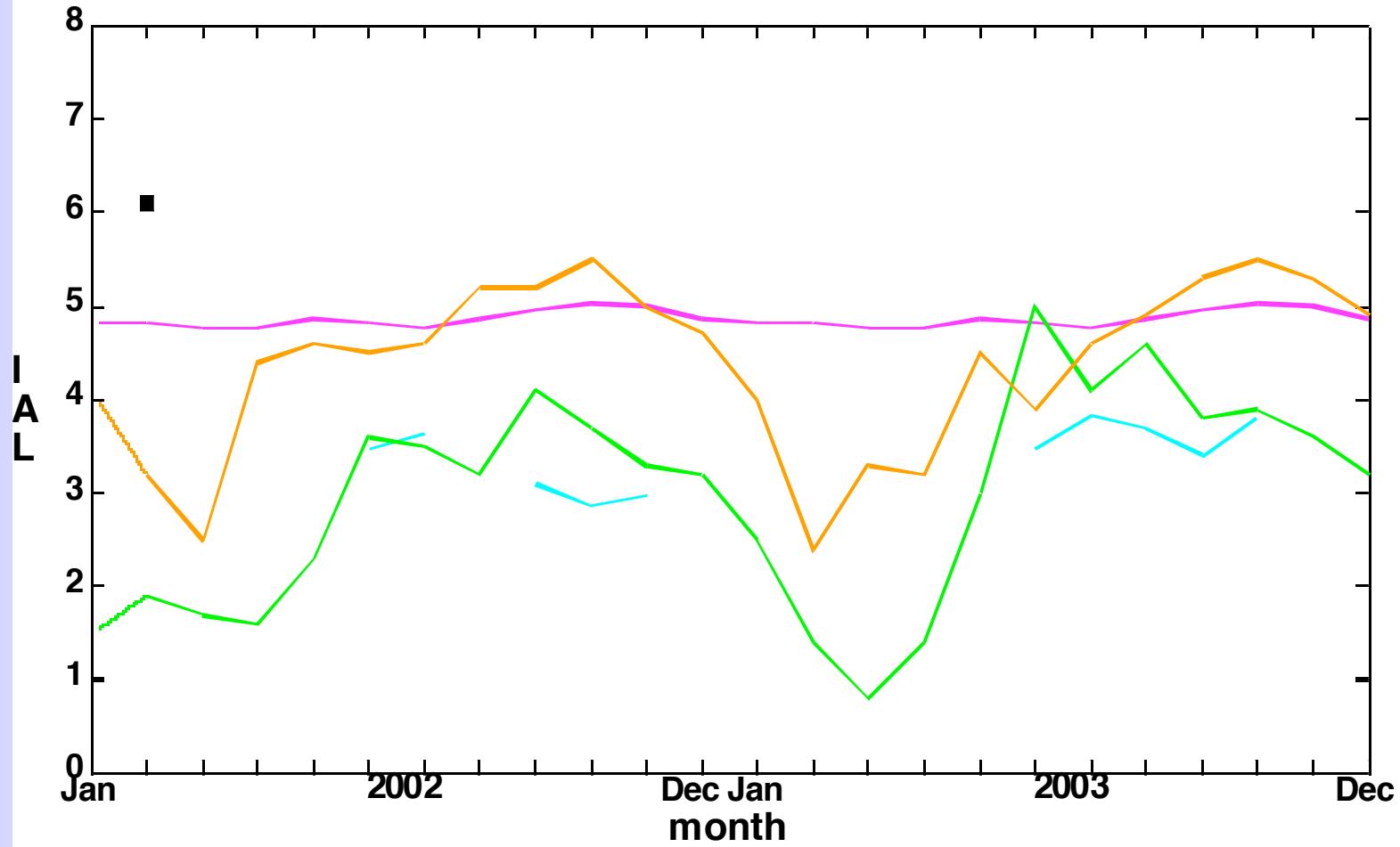
- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

Important dispersion between products: problem of atmospheric correction, cloud detection...



Results: Time series over EBF

Ever. Broad. Forest (TAPA, Brazil)

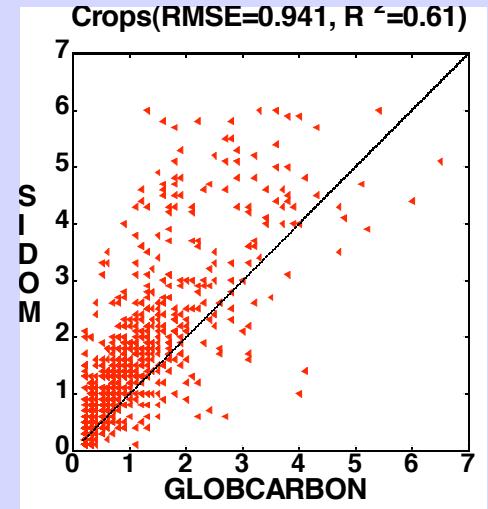
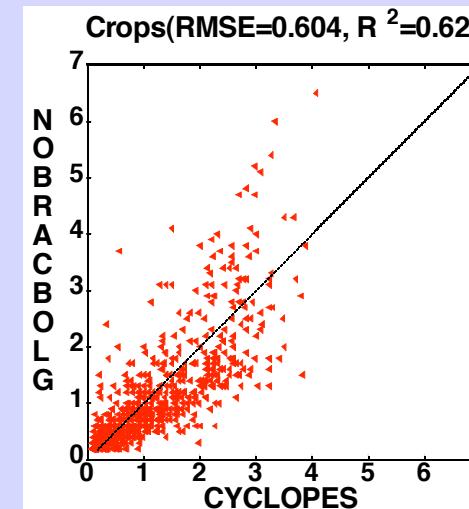
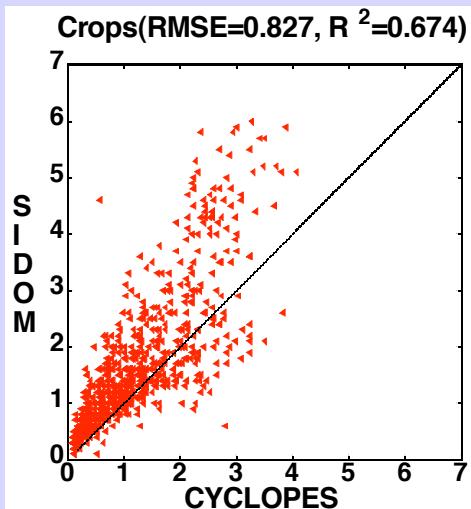
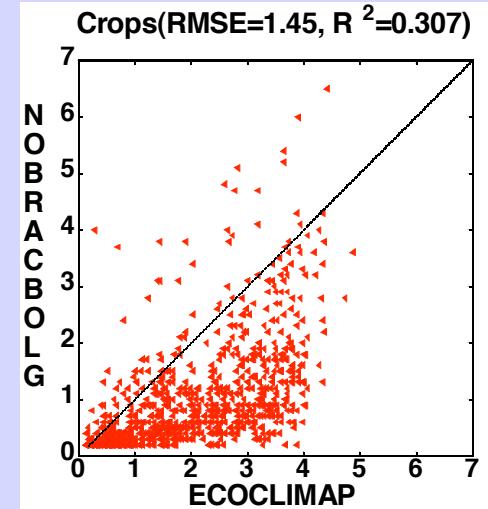
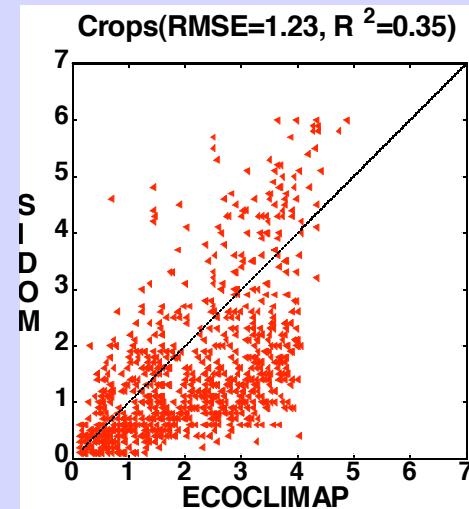
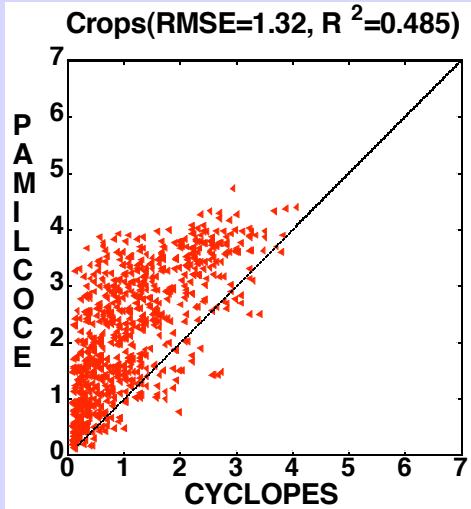


- CYCLOPES
- ECOCLIMAP
- GLOBCARBON
- MODIS
- CCRS

— problem of cloud detection
— high magnitude of MODIS LAI
— consistency between MODIS and GLOBCARBON cycles

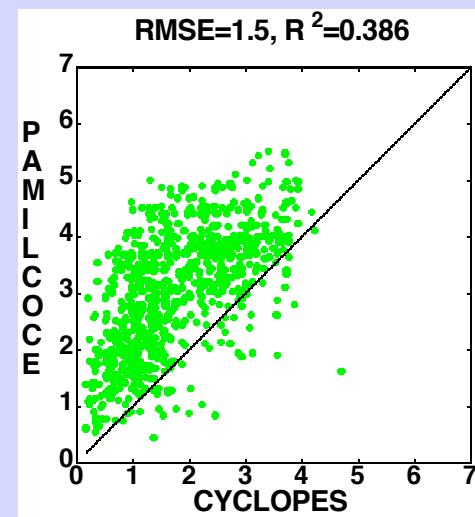
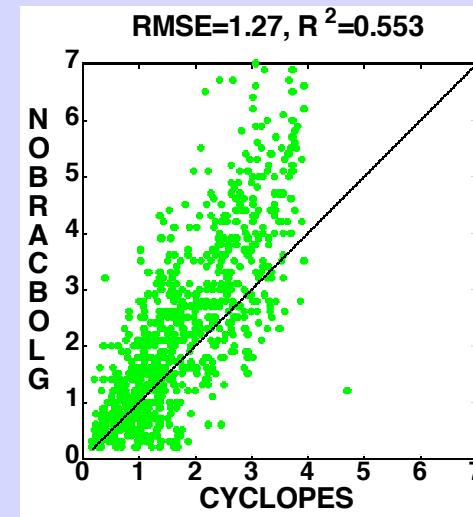
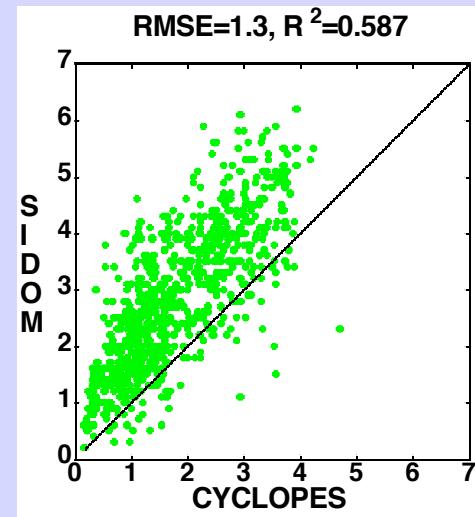
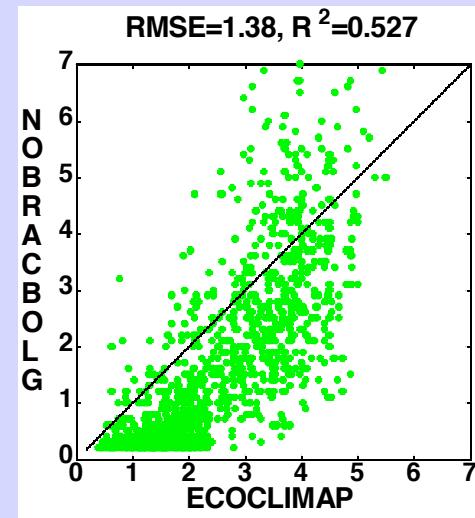
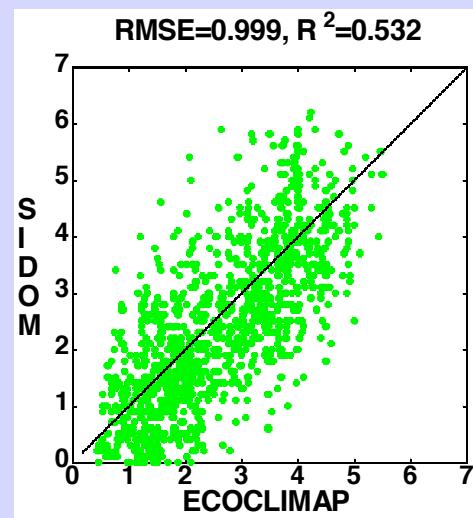
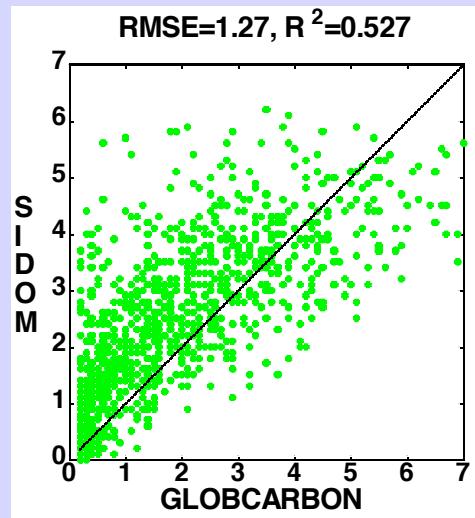


Scatter plot over the BELMANIP sites-class=crop

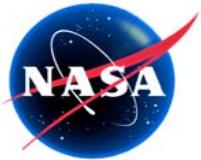


-Good agreement between CYCLOPES, MODIS and GLOBCARBON
- MODIS higher than CYCLOPES and GLOBCARBON

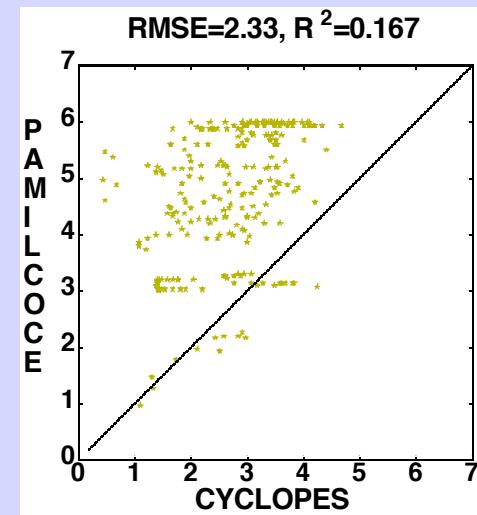
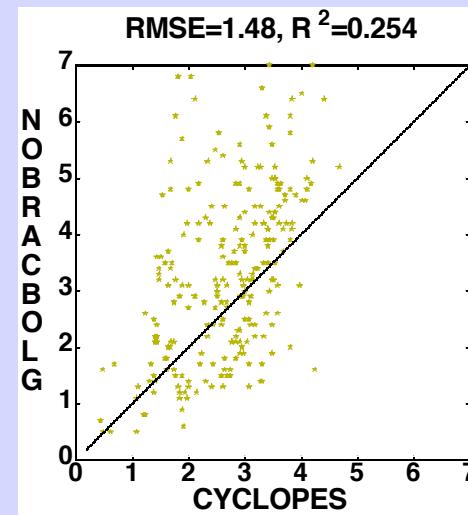
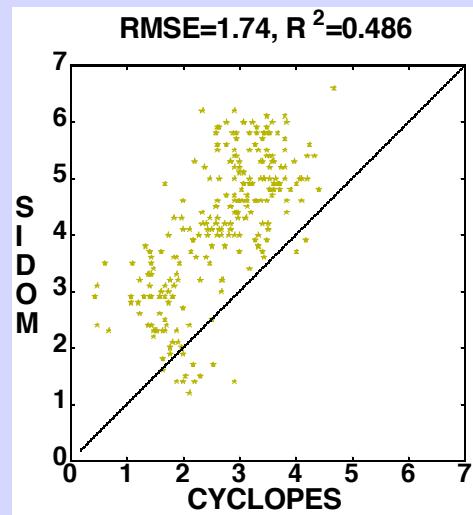
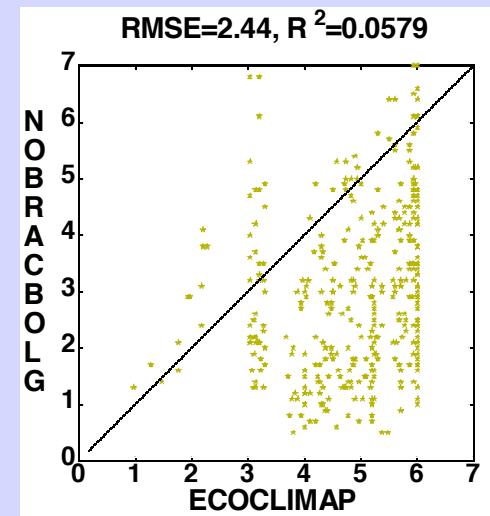
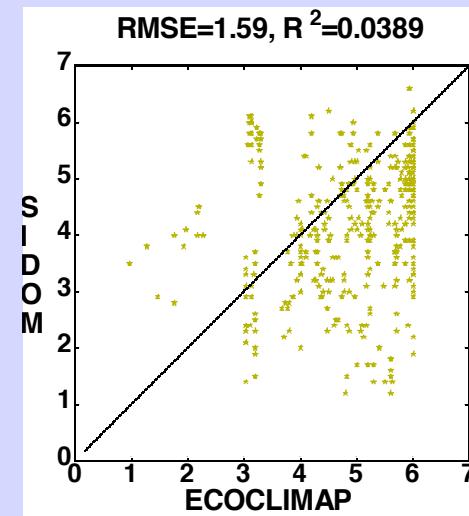
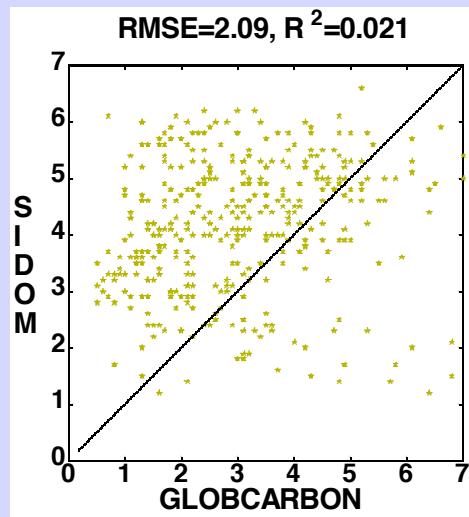
Scatter plot over the BELMANIP sites-class=ENF



- low value of CYCLOPES
- MODIS and ECOCLIMAP higher than other products



Scatter plot over the BELMANIP sites-class=EBF

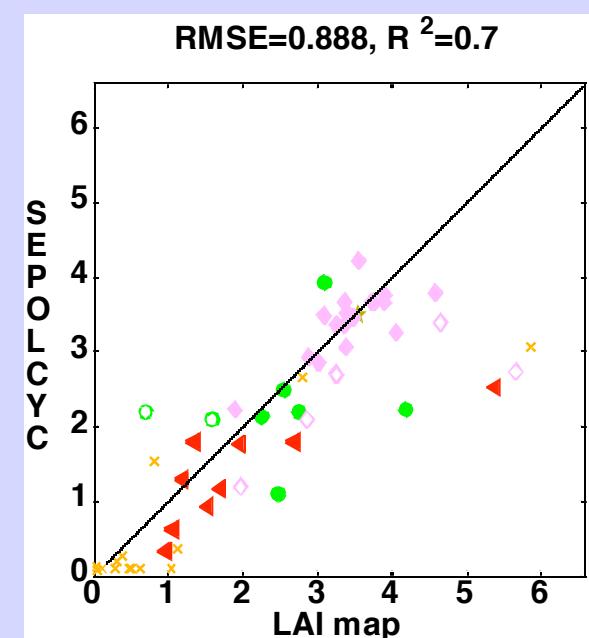
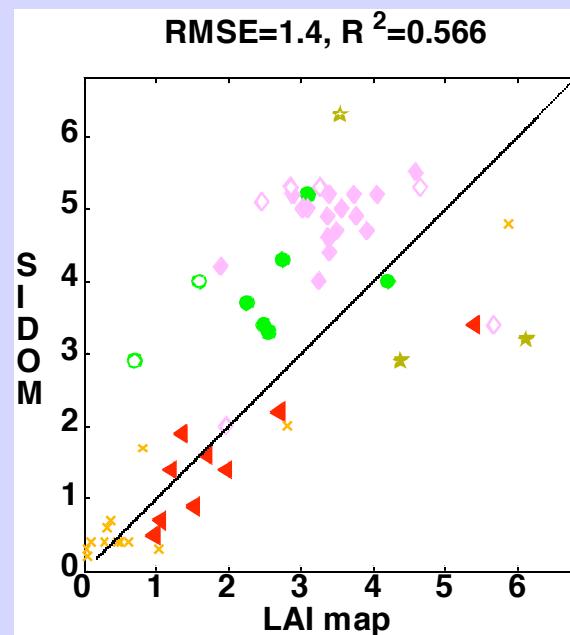
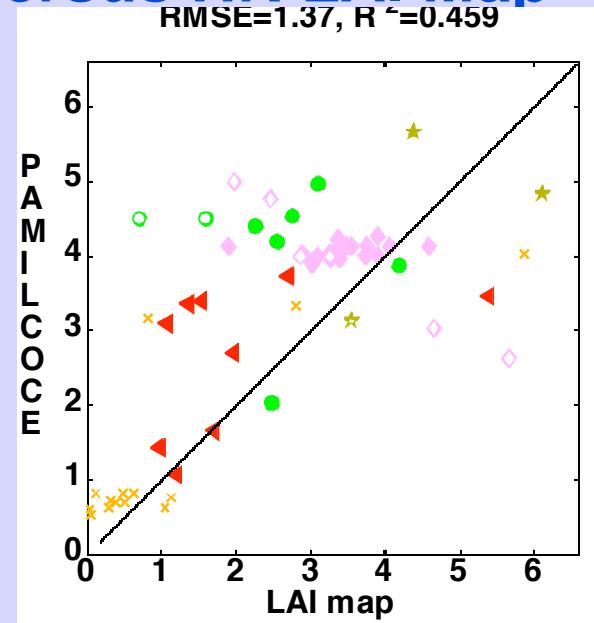
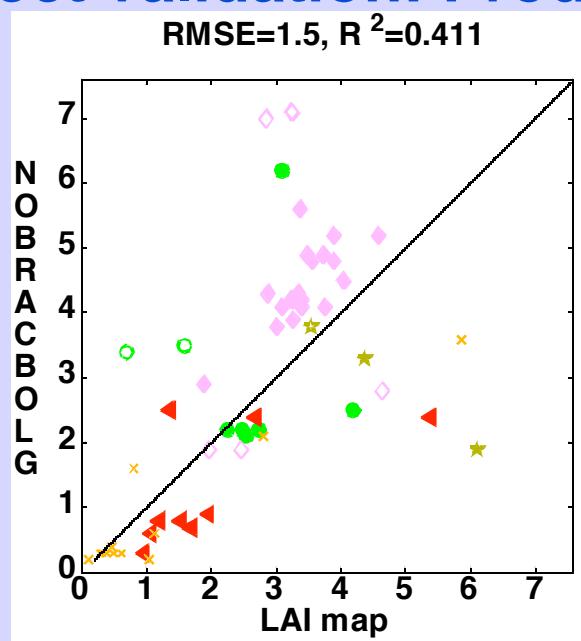


– important discrepancy between products



Direct validation: Product versus HR LAI Map

- Decid. Broad. For.
- Ever. Needle. Forest
- ★ Ever. Broad. Forest
- ◀ Crops
- ×
- Grass
- ◊ Mixed Forest
- ◆ same year
- ◊ different year





Results summary

	ECOCLI	MODIS	GLOBCAR	CYCL	CCRS
Missing data	++++	++	+++	+	+
global LAI distribution	++++	+++	+	++++	NA
Spatial gradient	++++	+++	++	+++	NA
Seasonal trends	++++	++	++	+++	+++
Magnitude	+	++	++	++	+++
In situ data	+	+++	++	++++	NA



Pending issues

- Limitation of the surface covered by most LAI maps for the validation at 10km spatial resolution
- Need to have an actual error bar associated with the HR LAI map
- Need to have a comprehensive error budget of the LAI product
- Next step : inter-comparison at 1km, 8/10 days of MODIS (collection 5), CYCLOPES, MERIS LAI (TBD) and CCRS over Canada



Concluding Remarks

- This work is critical for users, “a product without accuracy statement assessed by independent means in a systematic and robust way is not a finished product”
- Users want consistent products both spatially and temporally with no missing data
- **Dynamic exercise** that has to be repeated with each new product or version of product
- General approach that can and needs to be extended to others products
- International collaboration component is critical
- This activity should be lead independently from the product producers to ensure objectivity but needs to be properly supported by the space agencies