ECOCLIMAP-II/Africa: A twofold database at 1km resolution of ecosystems and land surface parameters for meteorological applications

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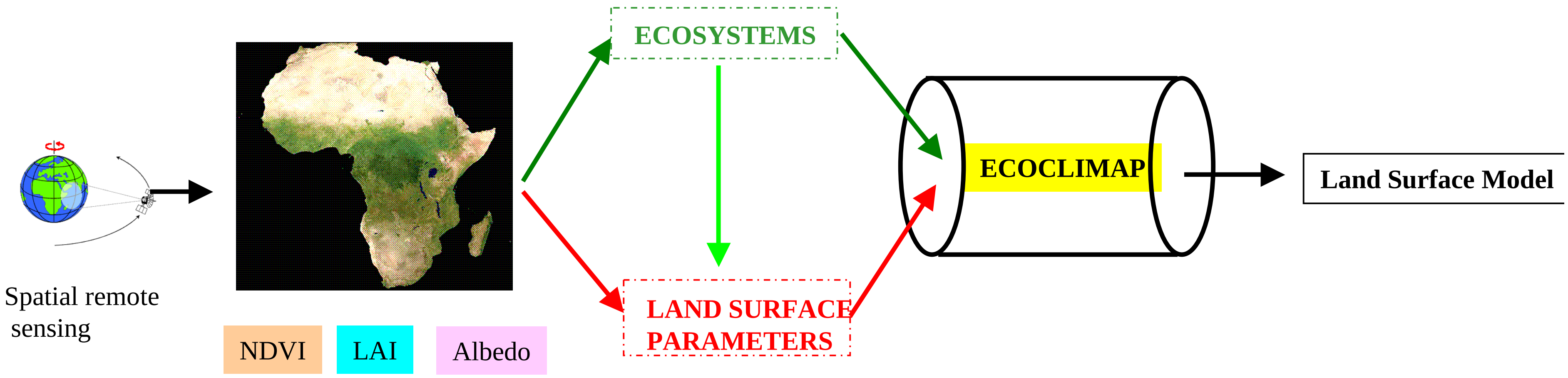
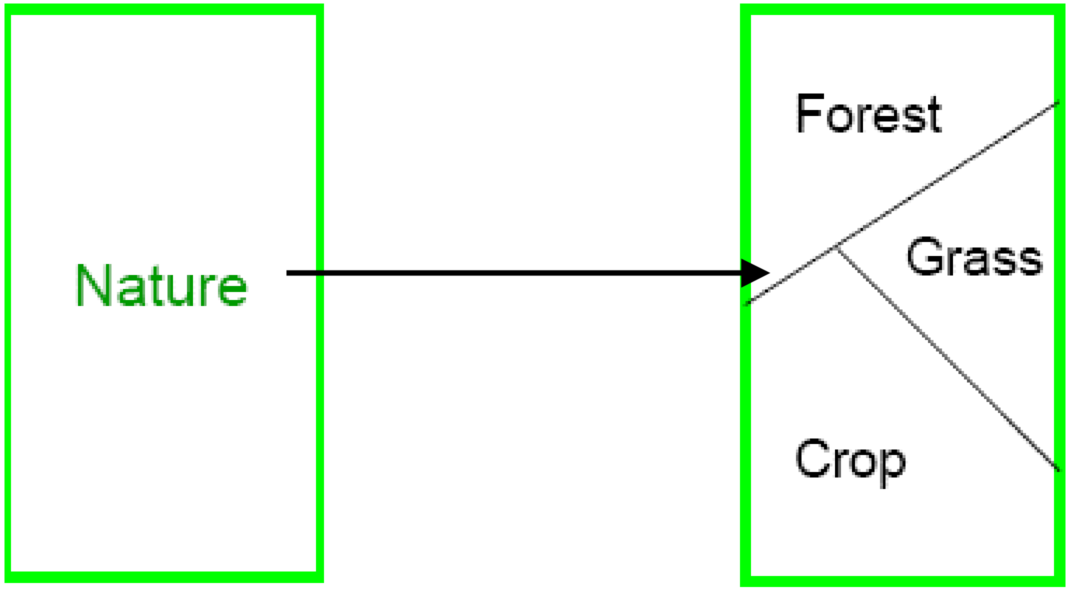
ECOCLIMAP-II/Africa – Definition



ECOCLIMAP = twofold database constituted by an ecosystem map and land surface parameters maps derived from this classification

ECOCLIMAP-II/Africa – The landscape



$$LAI = \%_{Forest} \times LAI_{Forest} + \%_{Grass} \times LAI_{Grass} + \alpha_{Crop} \times LAI_{Crop}$$

$$\%_{Forêt} + \%_{Herbe} + \%_{Culture} = 1$$

Performance of Tile « approach » *[Avissar et Pielke, Mon. Weather Rev., 1989]*

ECOCLIMAP-II/Africa – Set of surface parameters

These parameters are defined for each of the 12 functional types of the ISBA land surface model

- *Bare soil (NO)*
- *Rock (ROCK)*
- *Permanent Snow and Ice(PS)*
- *Deciduous broadleaf trees (TREE)*
- *Needle leaf trees (CONI)*
- *Evergreen broadleaf trees(EVER)*
- *C3 crops (C3)*
- *C4 crops (C4)*
- *Irrigated crops (IRR)*
- *Tropical grassland (TROG)*
- *Temperate grassland (GRAS)*
- *Swamp herbaceous and gardens (PARK)*

Depending on

-***soil***
  - *-Percentage of sand and clay*
  - *- Soil depth*

-***vegetation***
  - *- Fraction of vegetation (veg)*
  - *- Leaf Area Index(LAI)*
  - *-fraction of Photosyntetically Active radiation (fPAR)*
  - *- Minimal stomatal resistance*
  - *- Roughness length (z_0)*

-***On soil and vegetation***
  - *- Albedo*
  - *-Emissivity*

Plant functional type = group of species having similar responses to environmental conditions

ECOCLIMAP-II/Africa – Approach

- Why ECOCLIMAP-II?

  - The land cover maps mainly used in meteorology (IGBP, UMD, ECOCLIMAP-I) are obsolete since they have been produced using observations acquired in 1990's and a map of natural ecosystems is typically valid on a decade basis.

  - The recent land cover maps (GLC2000, MODIS LC-I) are not sufficiently dependable for climate research since the surface need to be described in terms of leaf area index, albedo, …

- Main satellites data used for the elaboration of ECOCLIMAP-II
  (Taking into account of characteristics of African continent and constraints of the final product)

Product	Sensor	Spatial resolution	Temporal resolution	Availability	Reference
NDVI	VEGETATION	1 km	10 days	1999→	*Hagolle et al. [Remote Sens. Env., 2004]*
LAI	MODIS	1 km	8 days	2000→	*Yang et al. [Remote Sens. Env., 2006]*
Albedo	MODIS	1 km	8 days	2000→	*Salomon et al. [IEEE T. Geosci. Remote, 2006]*

ECOCLIMAP-II/Africa – Some key notions

- Land cover = observed (bio)physical cover on the earth's surface (e.g. Forest, grass, bare land, water) valid on a decade basis

  *[Di Gregorio et Jansen, **Land Cover Classification System**, 2000]*

- Ecosystem→Functional unit of land cover class (Number of ecosystems in a land cover class assesses its diversity; similar grassland of the same region)

- Classification via remote sensing science = Grouping pixel together by
  - recognizing phenological patterns from an analysis of long-term image time series
  - and translating it into an appropriate thematic map

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ECOCLIMAP-II/Africa – The User's dilemma

- Accurate and efficient ecosystem mapping via remote sensing depend to a large extent on the selection of an appropriate classification approach

- Dilemmas:
  - Choice of classifier: different classifiers → different results even with the use of the same input data

    -NDVI AVHRR (April 92-March 93)

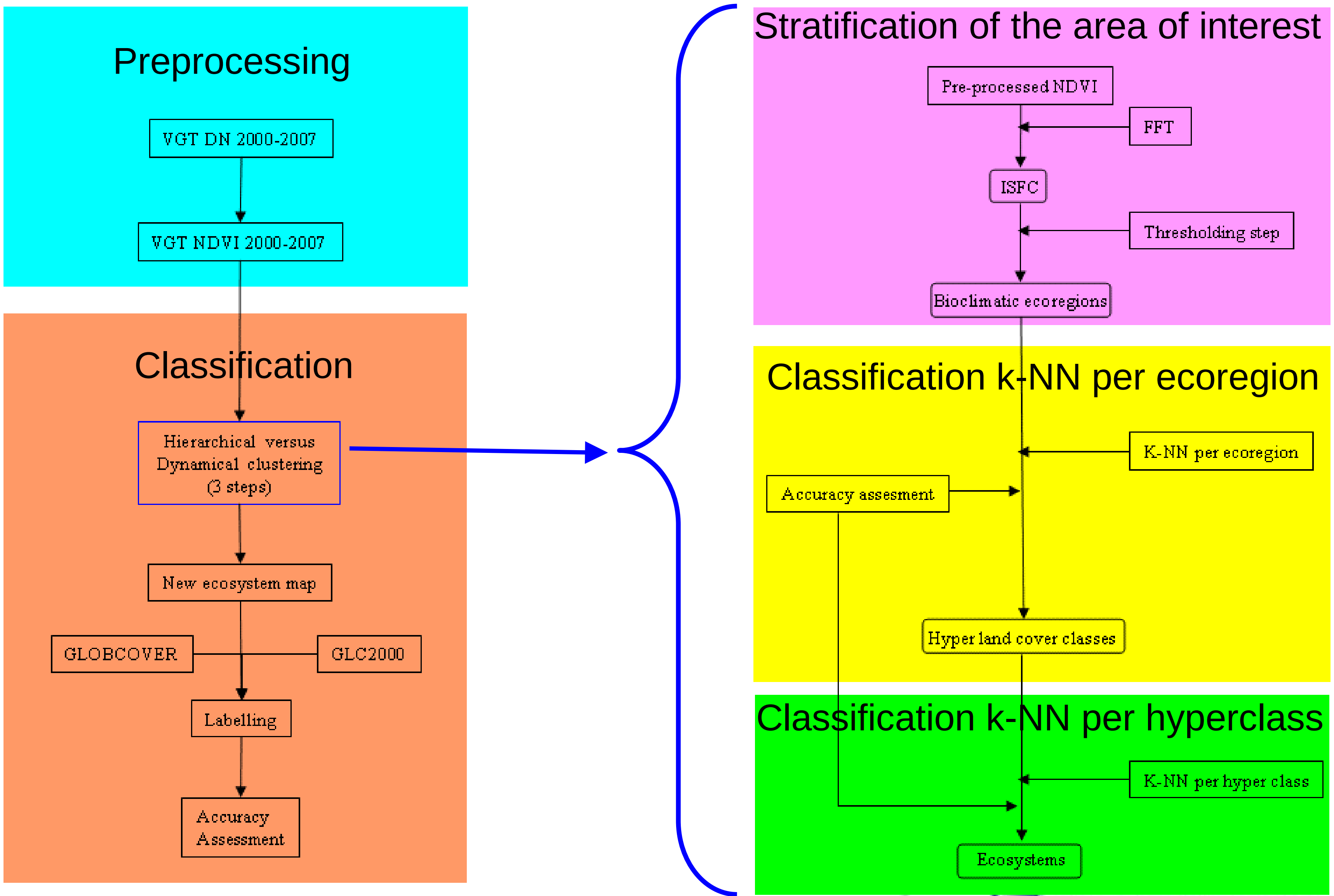
    -17 global land cover classes using the k-nearest neighbour (k-NN) classifier (unsupervised classifier) [Loveland et al., IJRS 2000]

    -14 global land cover classes using a decision tree classifier (supervised classifier) [Hansen et al., IJRS 2000]

  - Combining classifiers → improve classification accuracy: Difficult to implement at large scales

- Implementation of an automatic hybrid clustering approach '**stacked segment classification**' based on multiannual NDVI datasets for the identification of ecosystems at any scale

ECOCLIMAP-II/Africa – Stacked segment classification



[Kaptué et al., Remote Sens. Env., 2010 a]

ECOCLIMAP-II/Africa – ISFC

- **Fourier theory → decomposition of any p–periodic function**

(1) $$f(t) = \sum_{r=0}^{\infty} \tilde{f}_r e^{(-2\pi r t j/p)}$$

(2) $$NDVI^*(d + yD) = \frac{1}{Y} \sum_{y=1}^{Y} NDVI_d^y$$ (annual periodicity, 360 days)

$$Y = 8$$
$$D = 36$$
$$\Delta = 10$$

(3) $$NDVI^*(d) = \sum_{r=0}^{D} f_{*,r} \cos\left(2\pi dr/(\Delta D) + \varphi_r\right)$$

(4) $$\boxed{\text{Index of Segmentation of Fourier Component} = \sum_{r=0}^{D-1} w_r f_{*,r}}$$ *(ISFC)*

(5) $$w_r = \frac{f_{*,r}^2}{\sum_{r=0}^{D-1} f_{*,r}^2}$$

$$\left(Total \quad power = \sum_{r=0}^{D-1} f_{*,r}^2 \quad \left[\text{Priestley, Spectral analysis and time series, 1981} \right] \right)$$

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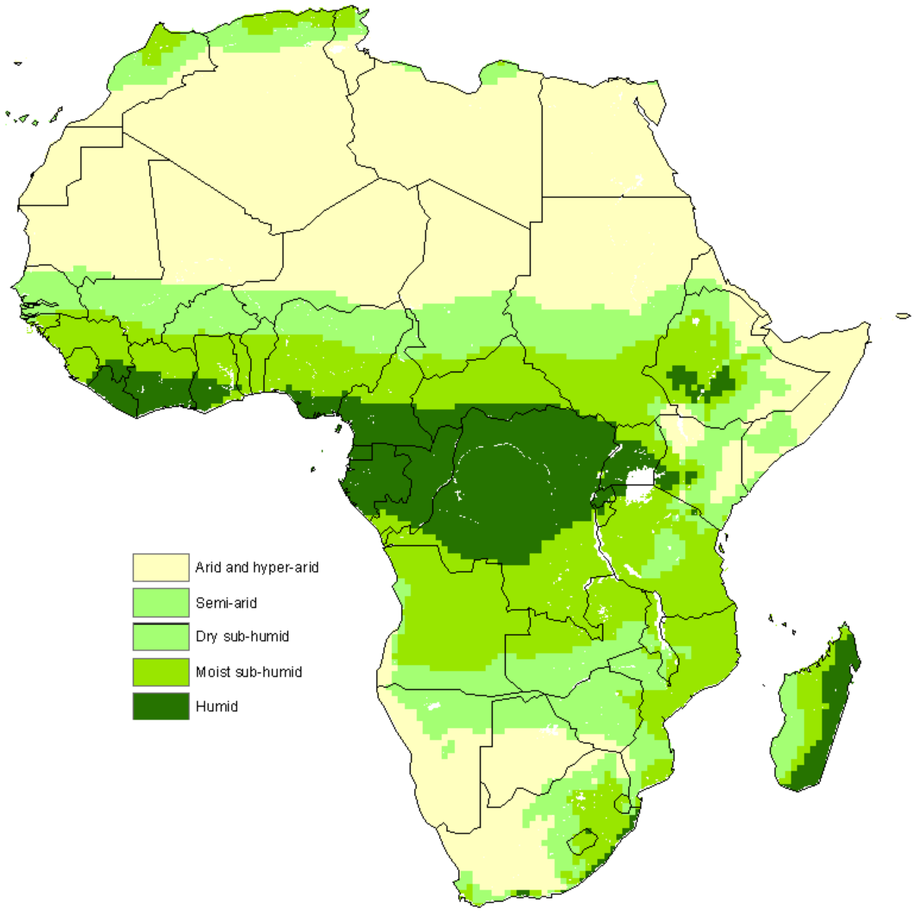
ECOCLIMAP-II/Africa – ISFC

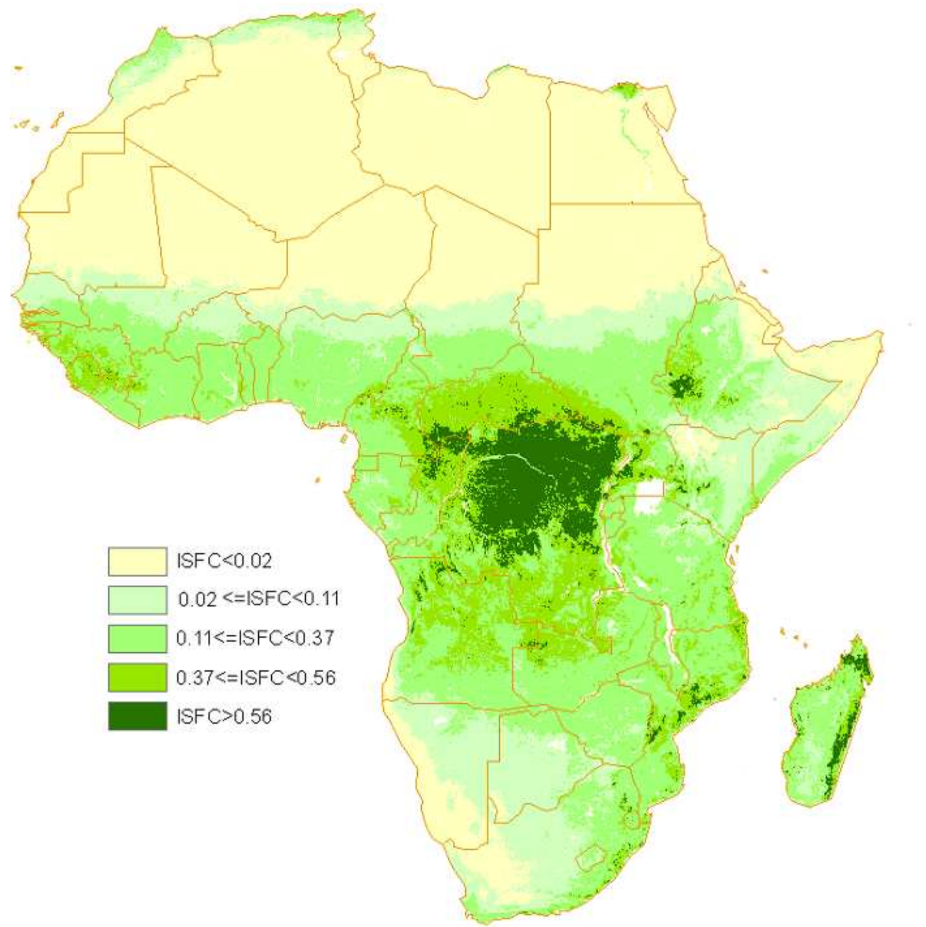
Ecoregion map of the FAO

[Fischer et al., The Global Agroecological Zones, 2002]

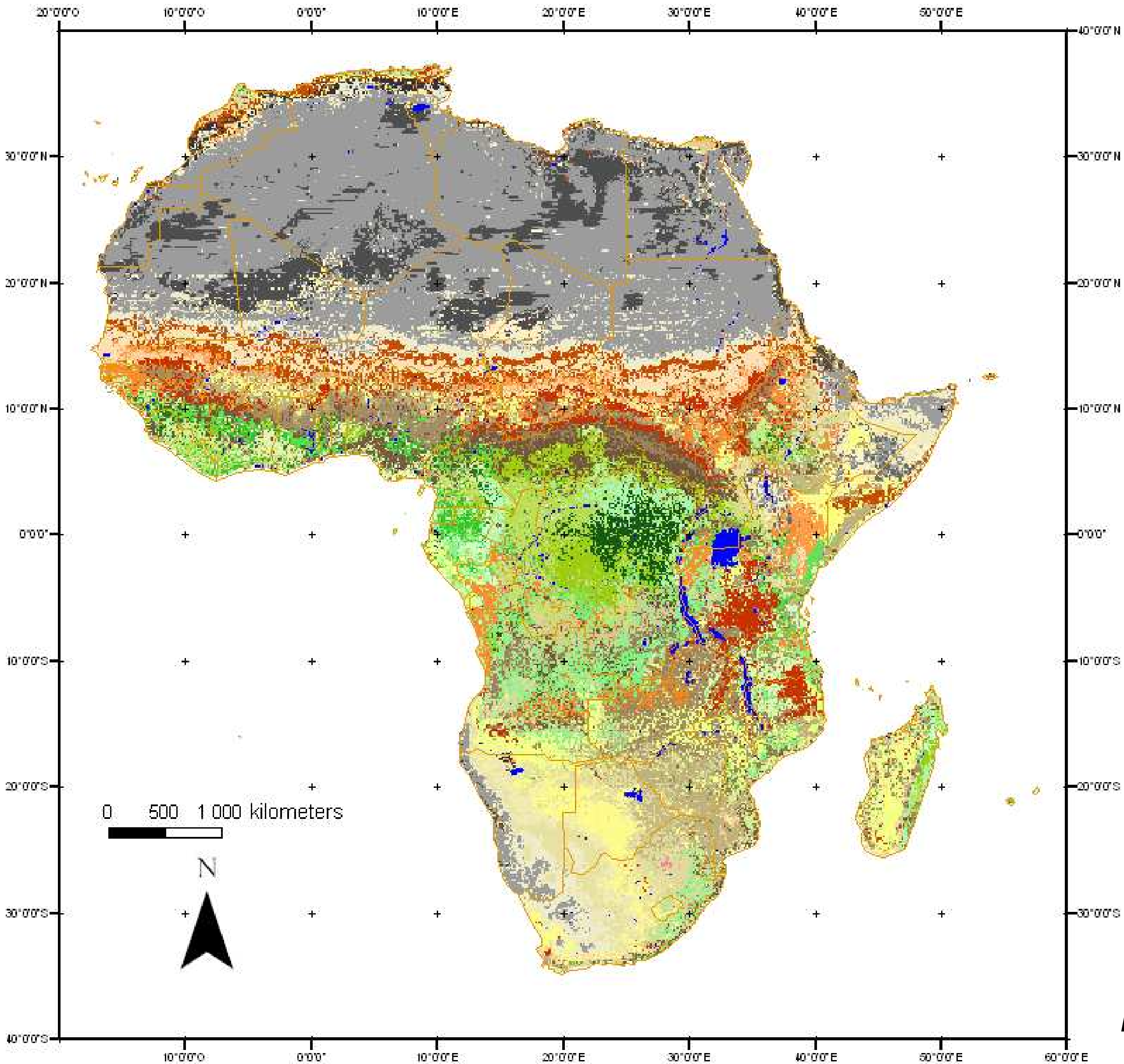


Ecoregion map derived from the ISFC (1 km)

[Kaptué et al., Remote Sens. Env., 2010 a]



ECOCLIMAP-II/Africa – The new ecosystem map (73 classes)



[Kaptué et al., Remote Sens. Env., 2010 a]

ECOCLIMAP-II/Africa – Dry bare soil albedo

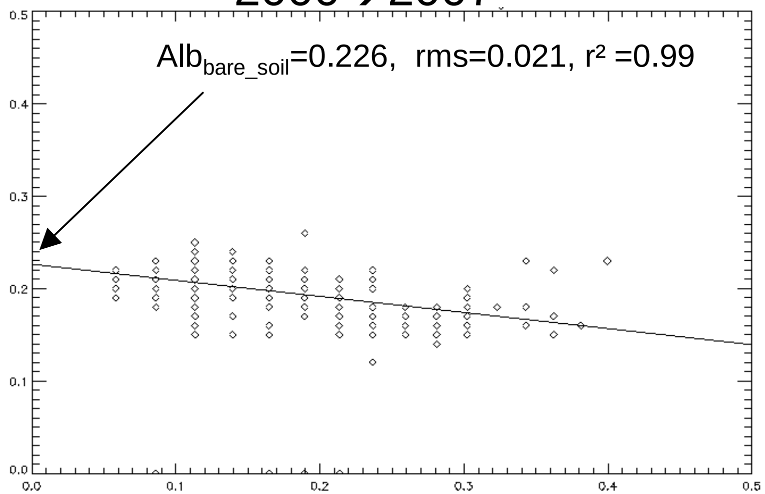
$$(1) \quad Alb = (1-veg)Alb_{bare\_soil} + veg * Alb_{veg}$$
$$= veg * \left(Alb_{veg} - Alb_{bare\_soil}\right) + Alb_{bare\_soil}$$

[Kaptué et al., Remote Sens. Env., 2010 b]

$$(2) \quad veg = 1 - \exp(-0.6 * LAI)$$

The slope $Alb_{veg} - Alb_{bare\_soil}$ is spectrally signed (< 0 in the ViS, > 0 in the NIR

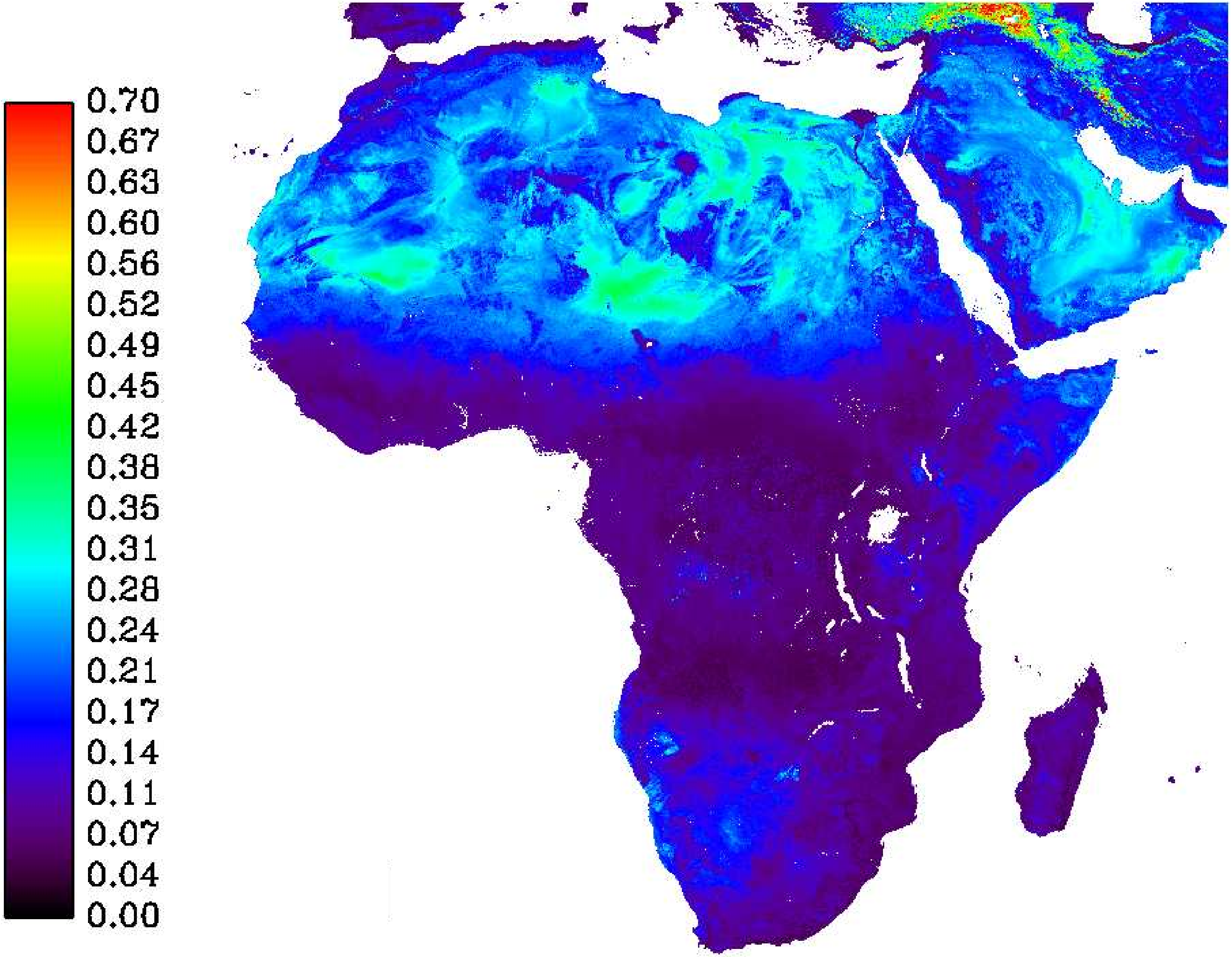
2000→2007



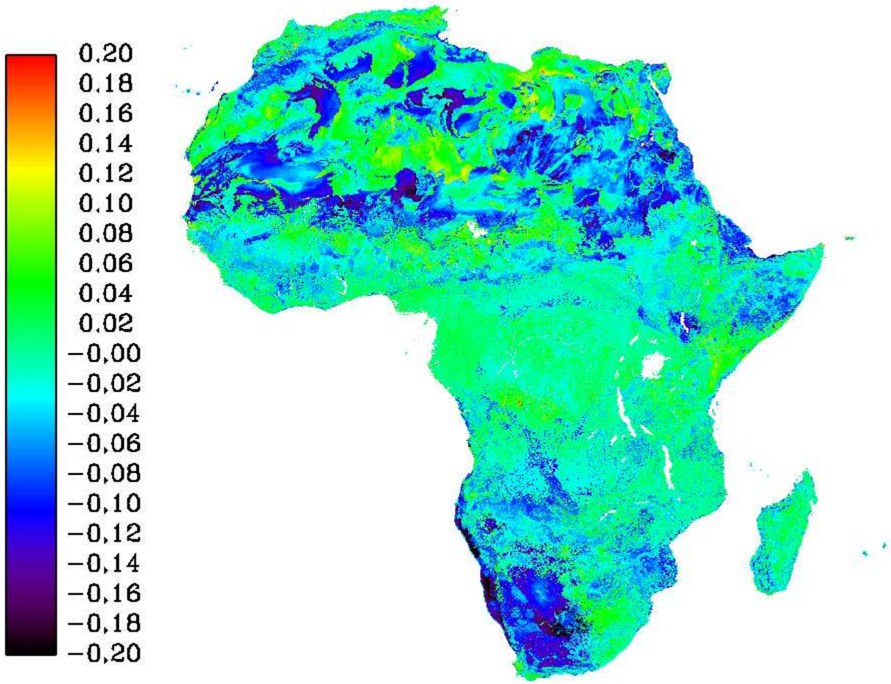
Banizoumbou (Niger), lat=13,54, lon=2.665

Optimal analysis from SEVIRI albedo → Update bare soil albedo

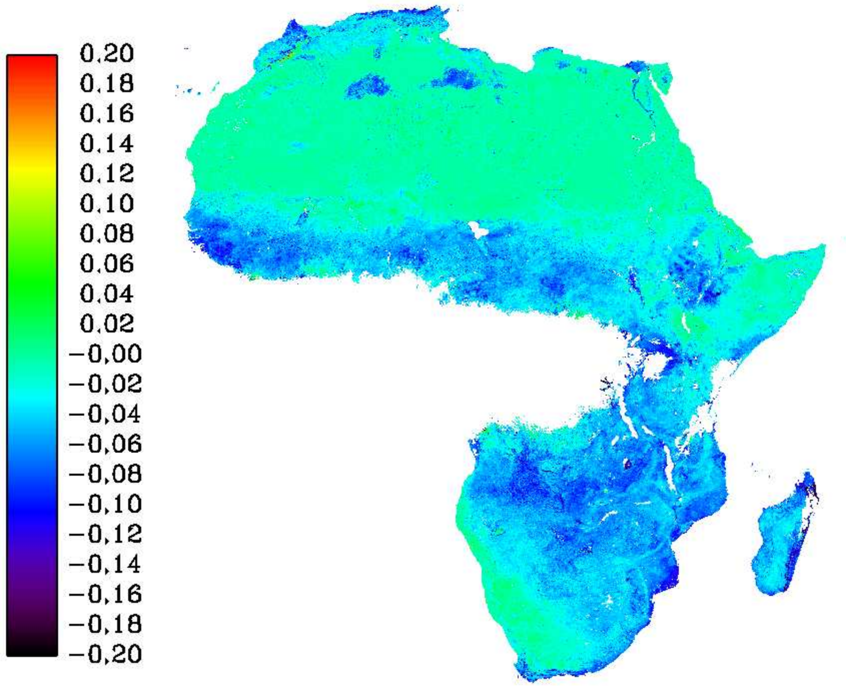
ECOCLIMAP-II/Africa – Bare soil albedo map in the visible (1 km)



ECOCLIMAP-II/Africa – Comparison with existing bare soil albedo datasets



ECOCLIMAP-II – ECOCLIMAP-I

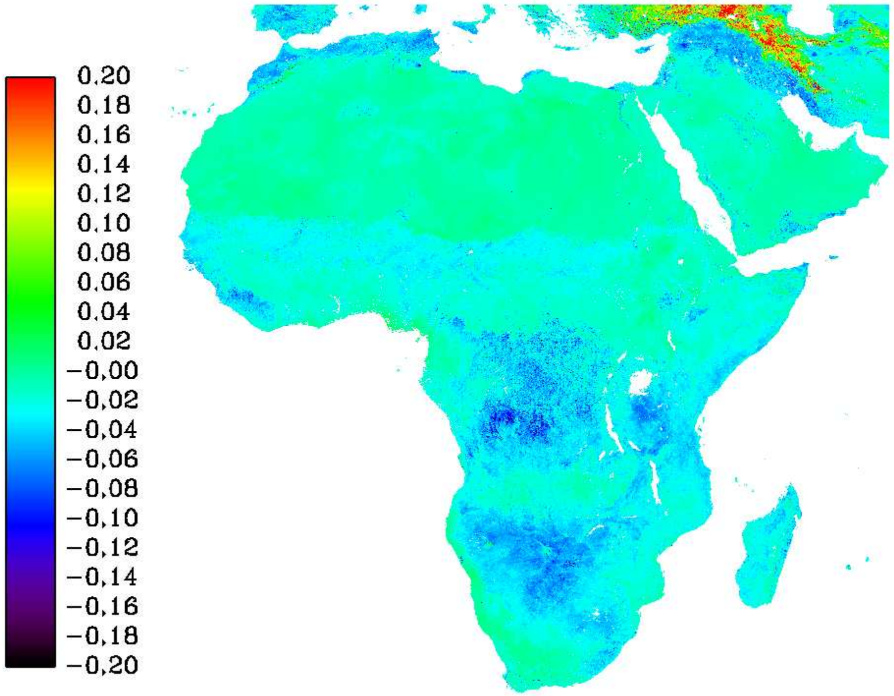


ECOCLIMAP-II – MET OFFICE

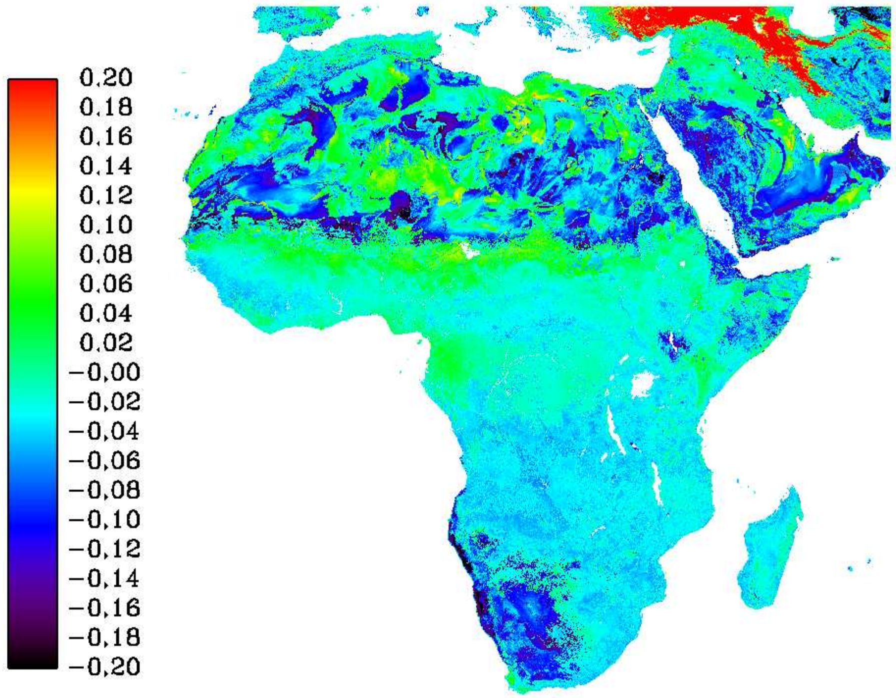
- MET OFFICE ← MODIS at 0.5-degree resolution
- ECOCLIMAP-I ←% of sand and clay of the FAO at 1-degree resolution

ECOCLIMAP-II/Africa – Better estimation of albedo

- Comparison with MODIS data: January 2000-2007 (Visible)



MODIS-ECOCLIMAP-II



MODIS-ECOCLIMAP-I

	ECOCLIMAP-I		ECOCLIMAP-II	
	Vegetated	Bare land	Vegetated	Bare land
RMSE	0.042	0.072	0.029	0.010

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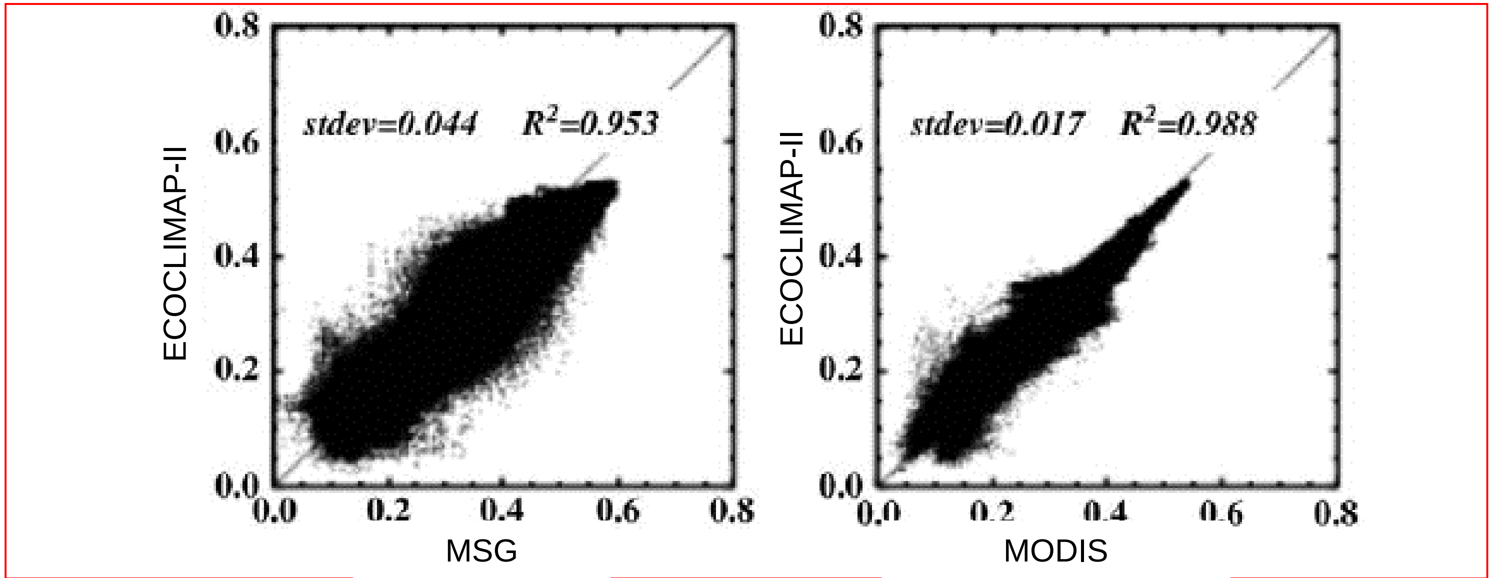
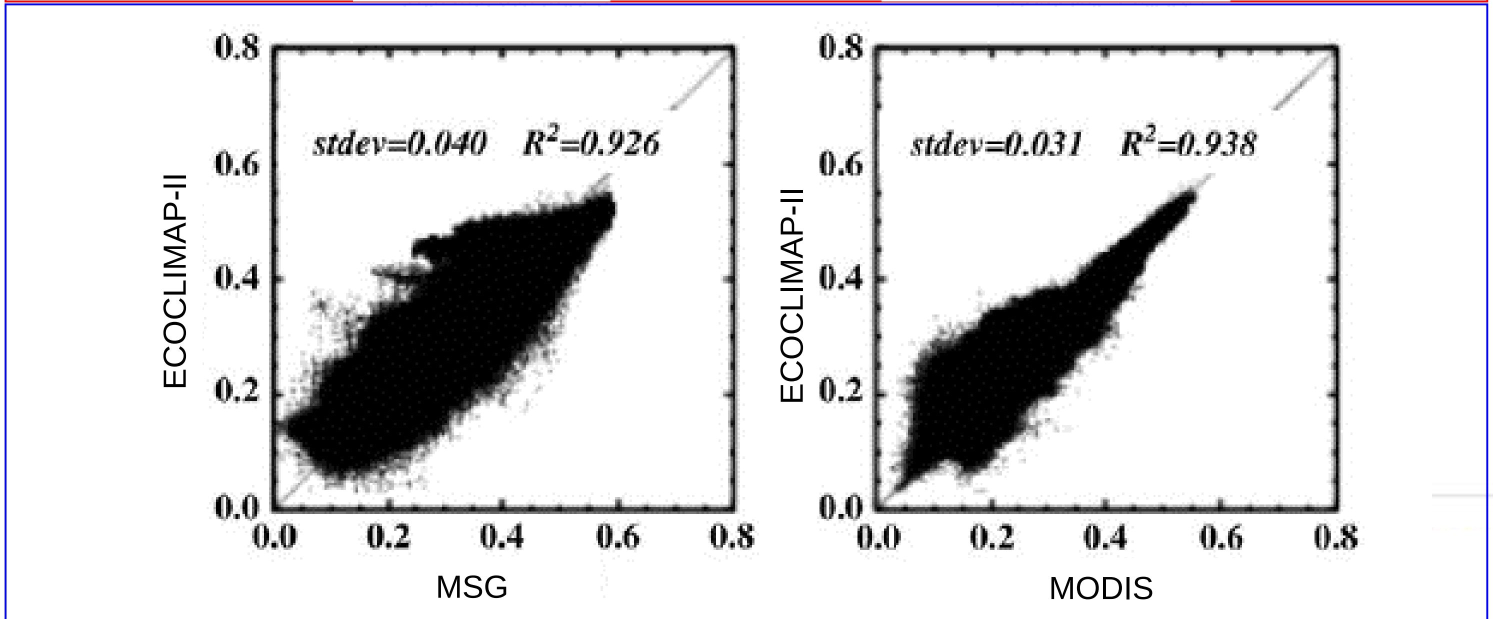
ECOCLIMAP-II/Africa – Comparison with shortwave broadband albedo

6th March 2006



6th September 2006



ECOCLIMAP-II/Africa – Summary

- ISFC = Formalism of segmentation that can be applied at any scale (local, national, regional, continental or global) independently of the spatial resolution (low, moderate or high) and of the remote sensing domain (optical or radar).

- Development of the “Stacked segment classification” leading to an upgraded 1-km classification of ecosystems (= key variable for biodiversity studies) without constraints of atypical annual events.

- Physical computation of the contribution of the vegetative canopy and bare soil to the land surface albedo by bringing consistency between albedo and leaf area index.

- Better agreement of the new database with recent products.

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ECOCLIMAP-II/Africa – Perspectives

- Fusion of optical data (SPOT/VEGETATION) and microwave data (ASAR/ENVISAT) at the pixel level (e.g. principal component analysis) to overcome the persistent cloud coverage observed over the western african coastline.

- Characterization of the four axes with relevance to biodiversity (topography, productivity, fragmentation, perturbation) using the Index of Segmentation of Fourier Component or ISFC.

- Imminent comparison of leaf area index of ECOCLIMAP-II and SAFLAND

- Update of the ECOCLIMAP database at the global scale from 2000→.

Field Campaign in Mali, Summer 2008