THE LAND COVER COMPONENT OF THE ESA CLIMATE CHANGE INITIATIVE

CURRENT ACHIEVEMENTS : A CONSISTENT GLOBAL LAND COVER TIME SERIES AT 300 USED BY CLIMATE MODELING GROUPS

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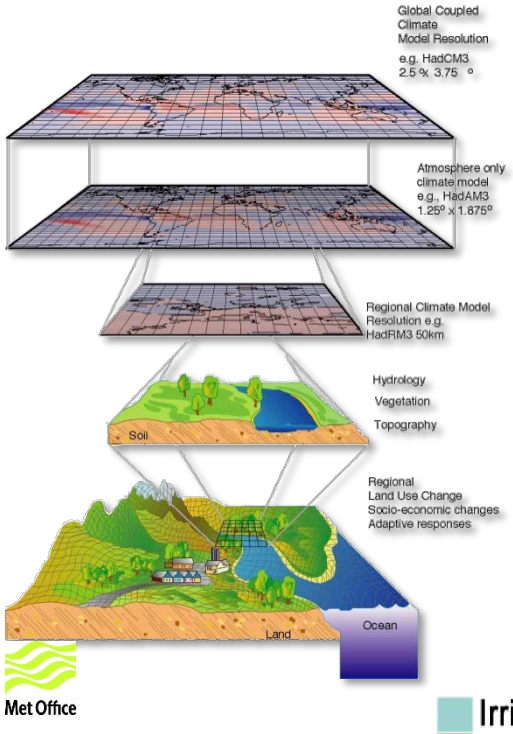
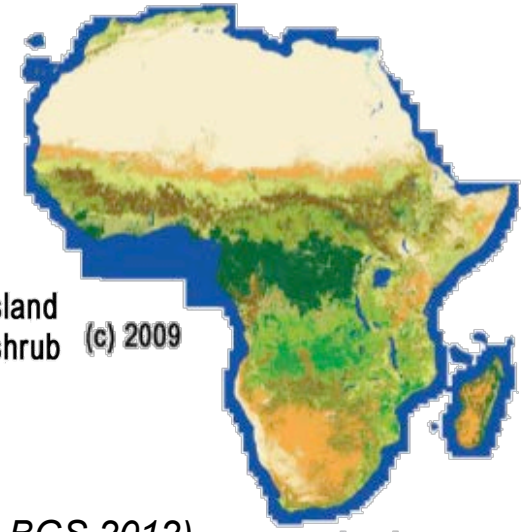
(1) UCLouvain-Geomatics, Belgium; (2) JRC, Italy; (3) Brockmann Consult GmbH, Germany;
(4) University of Pavia, Italy; (5) Max Plank Institute for Meteorology, Germany;
(6) MET Office, United Kingdom; (7) LSCE, France; (8) University of Jena, Germany;
(9) GAMMA Remote Sensing, Switzerland; (10) ESA, Italy, (11) LIST, Lux.

Land cover consistency over time: the priority for climate modelling





Irrigated crops
Rainfed crops
Mosaic crops / nat. vgt
Mosaic nat. vgt / crops
Closed broad. dec. forest
Mosaic forest-shrub / grassland
Mosaic grassland / forest-shrub
Shrubland
Grassland
Sparse vegetation
Bare areas

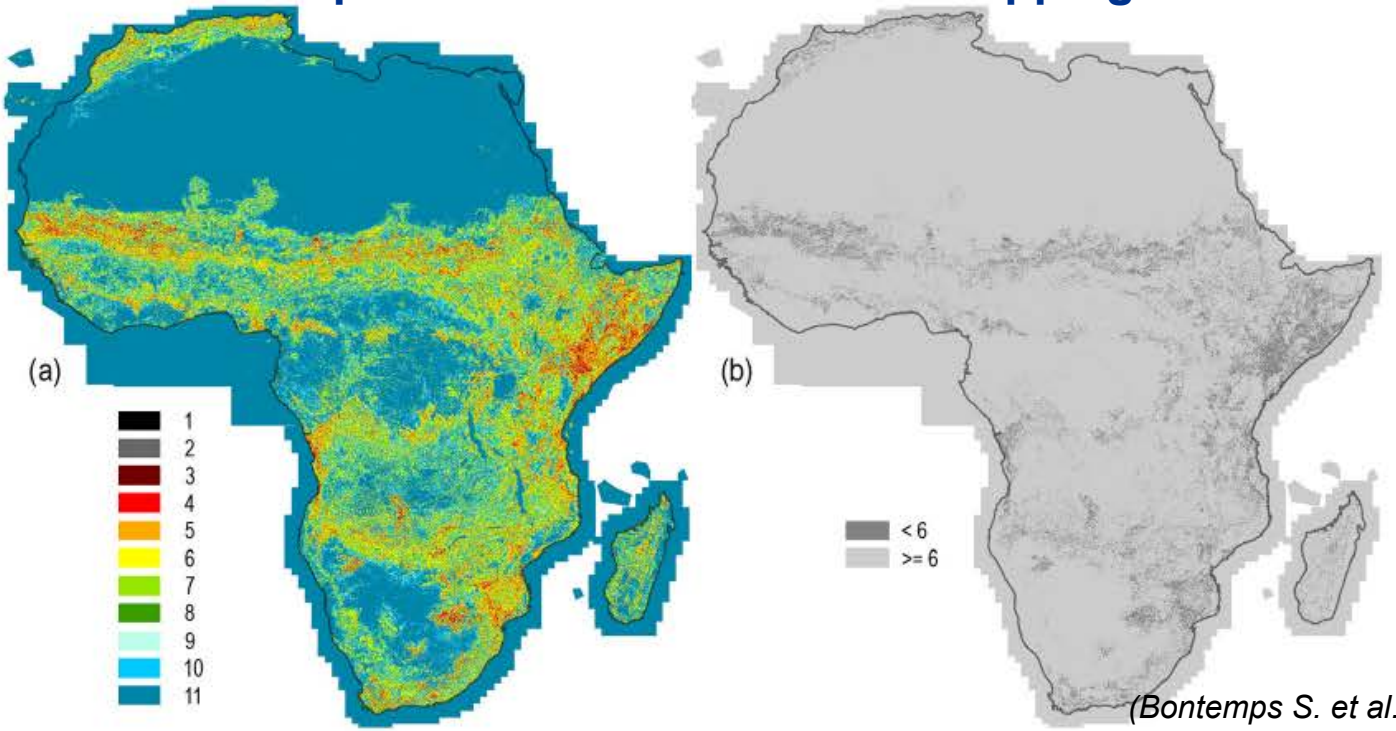
(Bontemps S. et al., BGS 2012)

GlobCover legend over Africa (color codes)

Annual EO time series : transition zone prone to LC unconsistency

Nbr of occurence of the same LC class from annual land cover maps

Stable versus less stable region for land cover mapping



(Bontemps S. et al., BGS 2012)

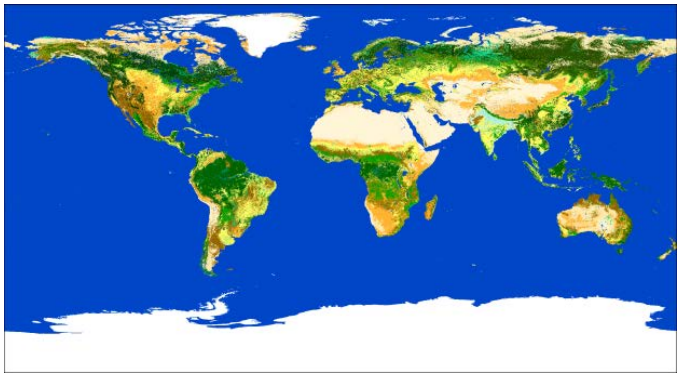
⇒ 3 strategies to address this major issue :

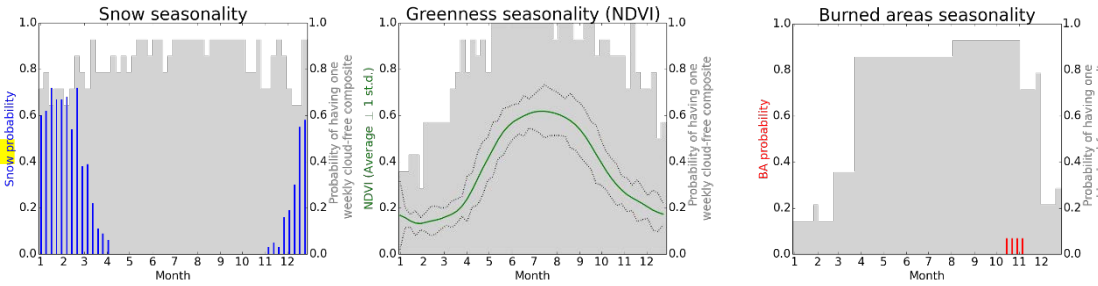
- to revisit land cover to include seasonal components
- to rely on full archive of EO rather than single/best year
- to design the appropriate workflows and algorithms

Revisited land cover concept: land cover + land surface seasonality

Land cover can not be the (observed) physical and biological cover on the terrestrial surface (LCCS 2005; GTOS ECV 2009) ...
and remains stable and consistent over time (as requested by climate modelers)

=> Mapping land cover and land surface seasonality





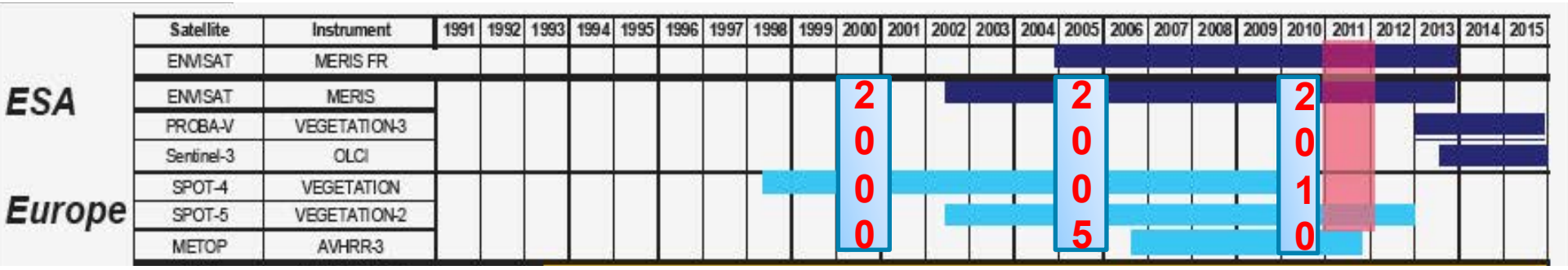
- **Snow**
  Occurrence
  Probability
- **NDVI**
  Average
  Inter-annual variability
- **Burnt Areas**
  Occurrence
  Probability

Climatology of 3 variables over 12 y.

Defourny et al., 2013

Surface reflectance production with improved QC and cloud screening

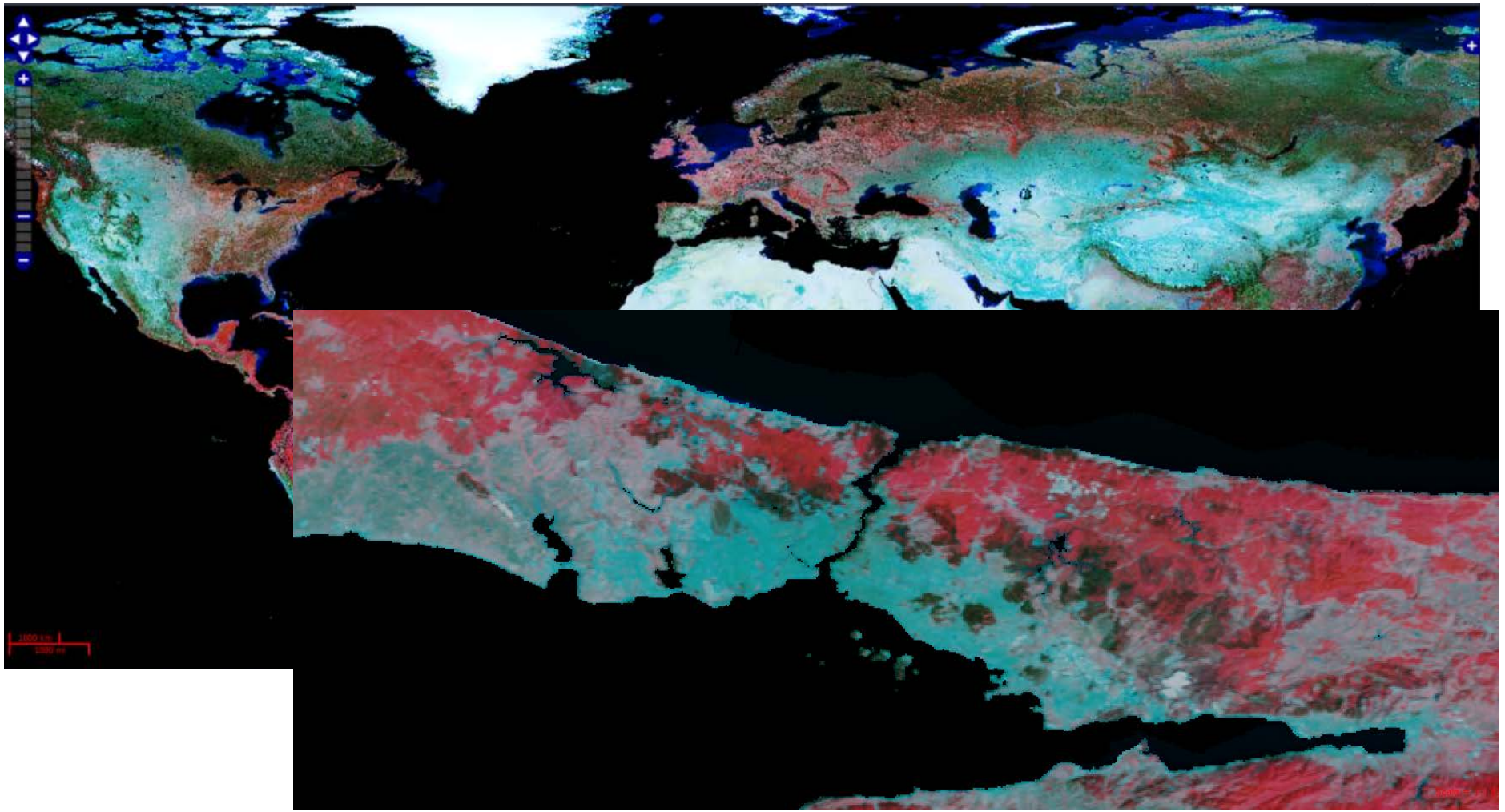
- 4 sets of full EO archive to process :
  - Envisat MERIS Full Resolution (nearly global every 3-9 days 300-m reflectance in 15 bands (blue to NIR), 2003-2012)
  - Envisat MERIS Reduced Resolution (global every 3 days 1.2 km reflectance in 15 bands (blue to NIR), 2003-2012)
  - SPOT Vegetation 1 & 2 (global daily 1-km surface reflectance in 4 bands (blue to SWIR), 1998-2012)
  - Envisat SAR WS & GM from 2005 to 2011



=> 3rd global full archive reprocessing of MERIS (160 TB) + VGT 10TB

MERIS 7-d surface reflectance time series (36 TB)

Full MERIS archive processed in surface reflectance (2003-2012)

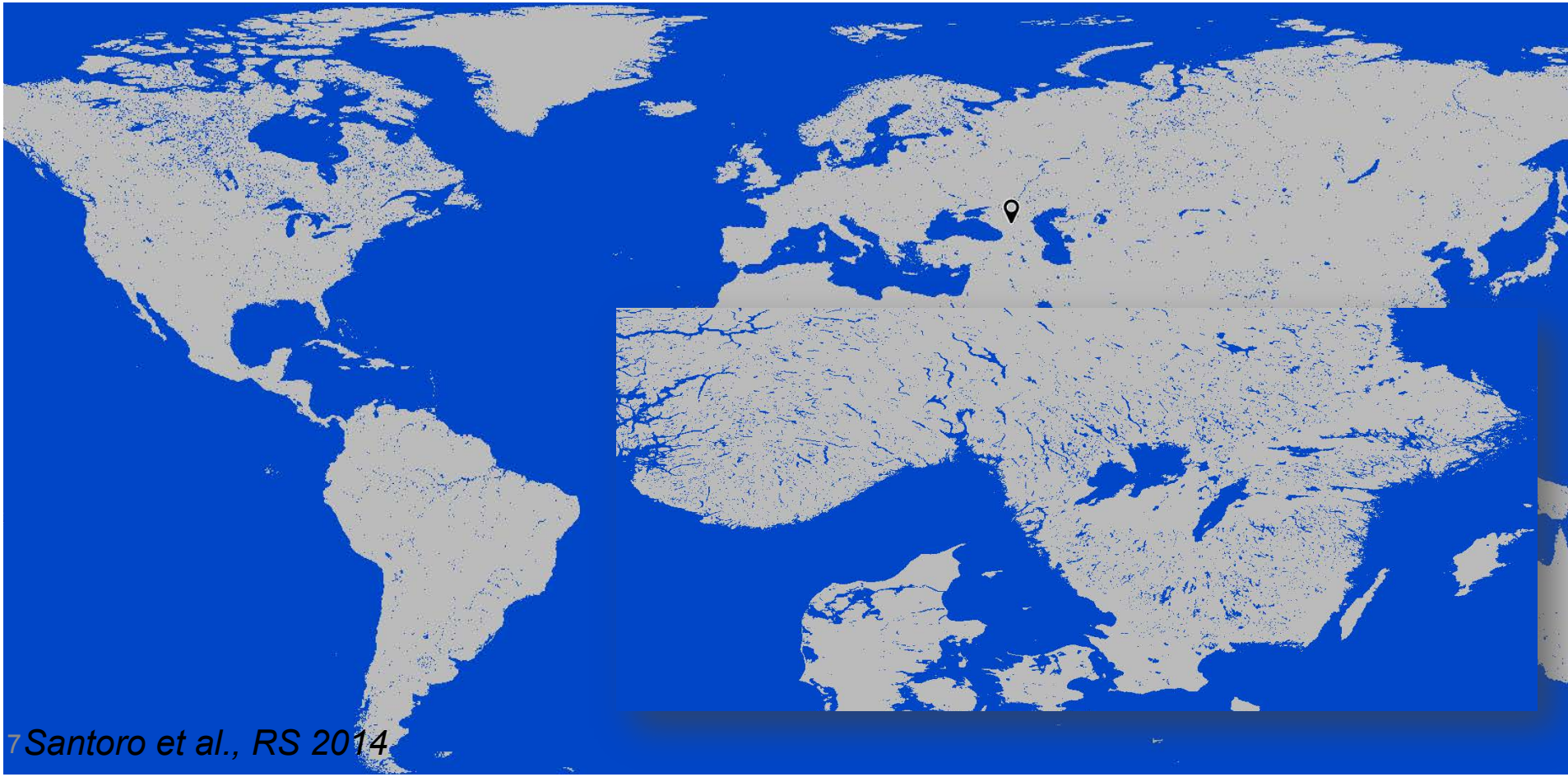


300 m global land/water mask as shared CCI dataset

6 years of ENVISAT SAR data on G-POD + consolidation wigh

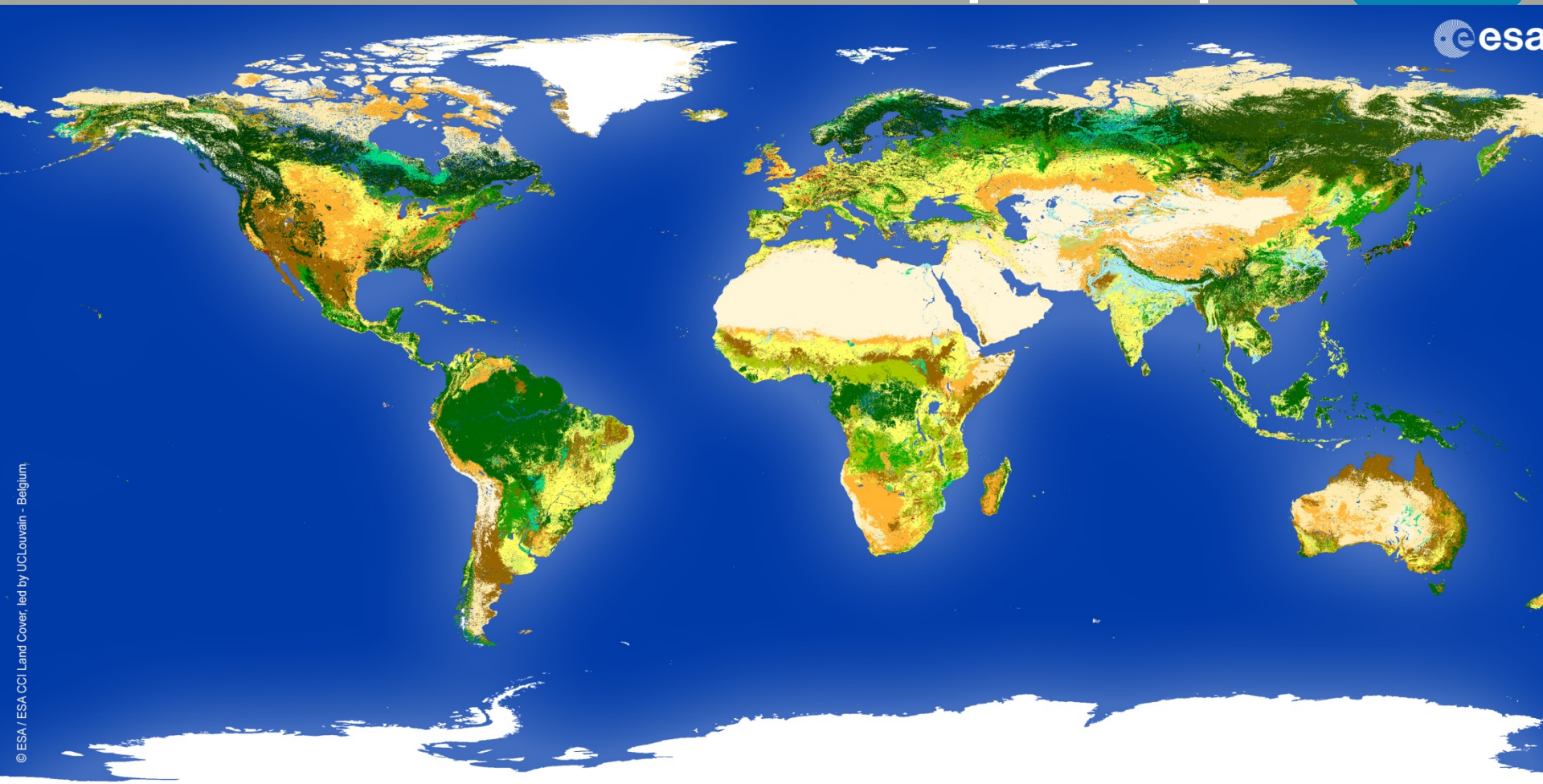
⇒ 1st release in Dec. . 2014 as output of phase 1

⇒ 2nd release in Sept. 2015 at 150 m resolution



Santoro et al., RS 2014

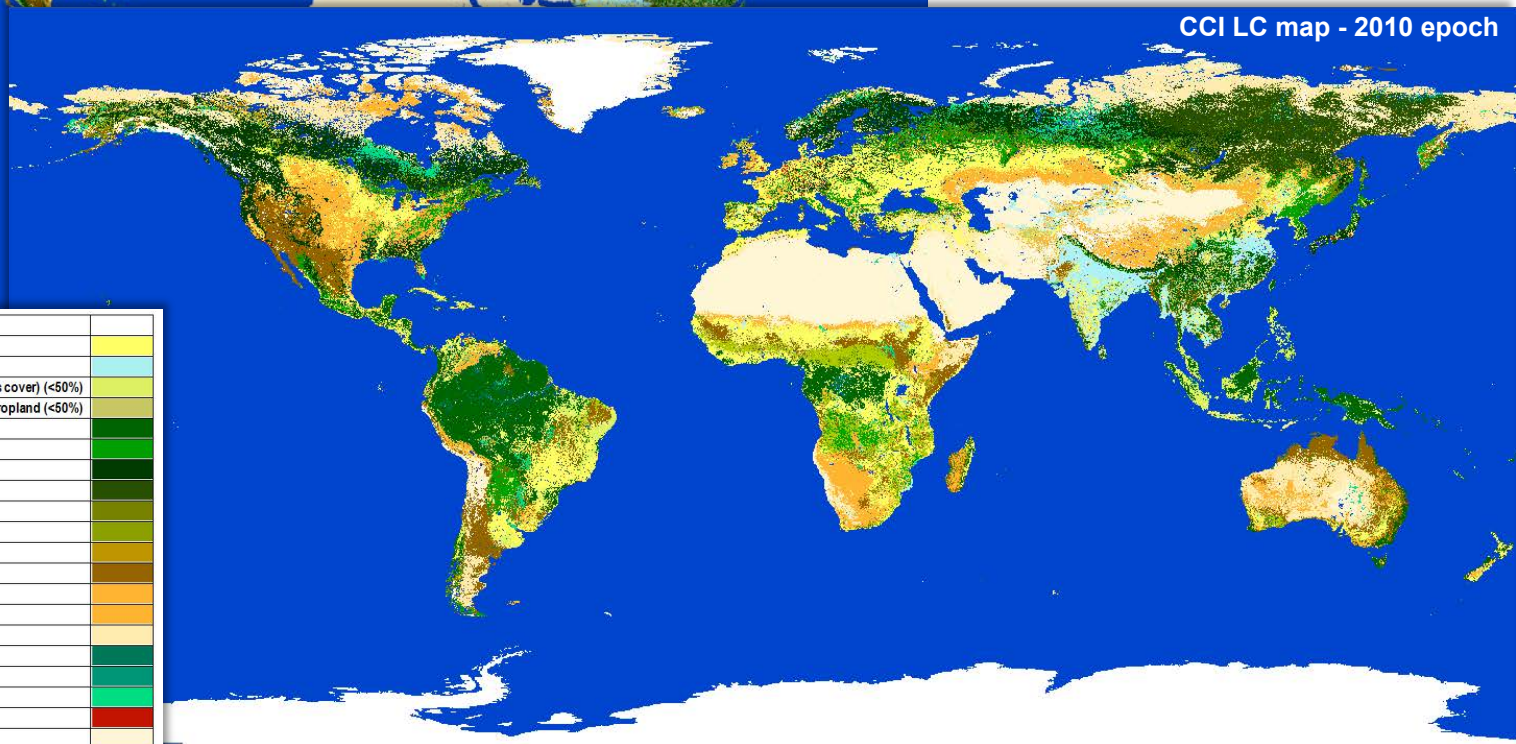
1st release of all CCI LC products in 2014
2nd release of the CCI LC maps in Sept 15



Climate Change Initiative | Land Cover 2008-2012 | 300m

UCL Université catholique de Louvain – UCL- Geomatics, Belgium
Brockmann Consult GmbH
GAMMA REMOTE SENSING
Wageningen University Wageningen UR
Max-Planck-Institut für Meteorologie
Centre de Recherche Public Gabriel Lippmann
European Commission
LSCE
Met Office
Friedrich-Schiller-Universität Jena

2000, 2005 and 2010 CCI Land cover products

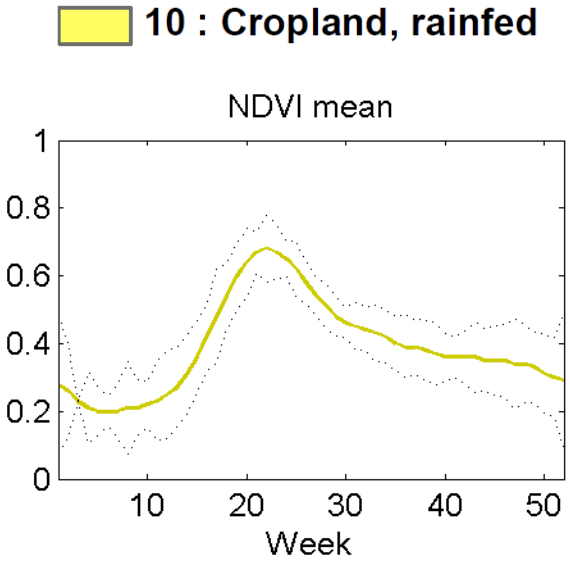


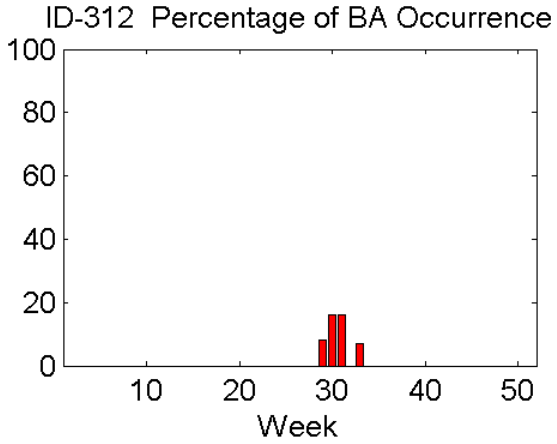
LC_CCI LAND COVER CLASSES	
Cropland, rainfed	
Cropland, irrigated or post-flooding	
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	
Tree cover, broadleaved, evergreen, closed to open (>15%)	
Tree cover, broadleaved, deciduous, closed to open (>15%)	
Tree cover, needleleaved, evergreen, closed to open (>15%)	
Tree cover, needleleaved, deciduous, closed to open (>15%)	
Tree cover, mixed leaf type (broadleaved and needleleaved)	
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	
Shrubland	
Grassland	
Lichens and mosses	
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	
Tree cover, flooded, fresh or brakish water	
Tree cover, flooded, saline water	
Shrub or herbaceous cover, flooded, fresh/saline/brakish water	
Urban areas	
Bare areas	
Water bodies	
Permanent snow and ice	

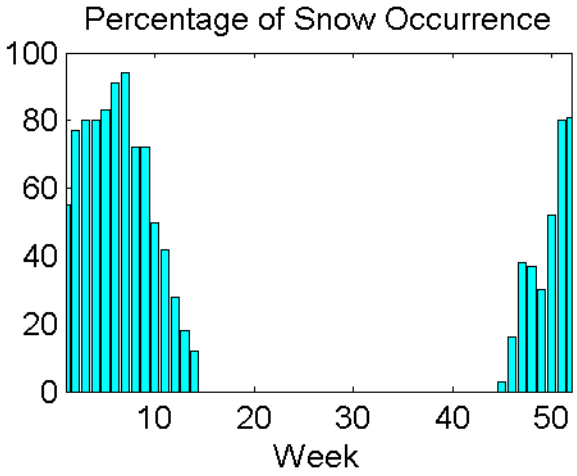
+ 4 quality&uncertainty flags and metadata

Great consistency between the land surface seasonality variables

7-day resolution for ‘climatological’ data set (computed from 12 years of data)

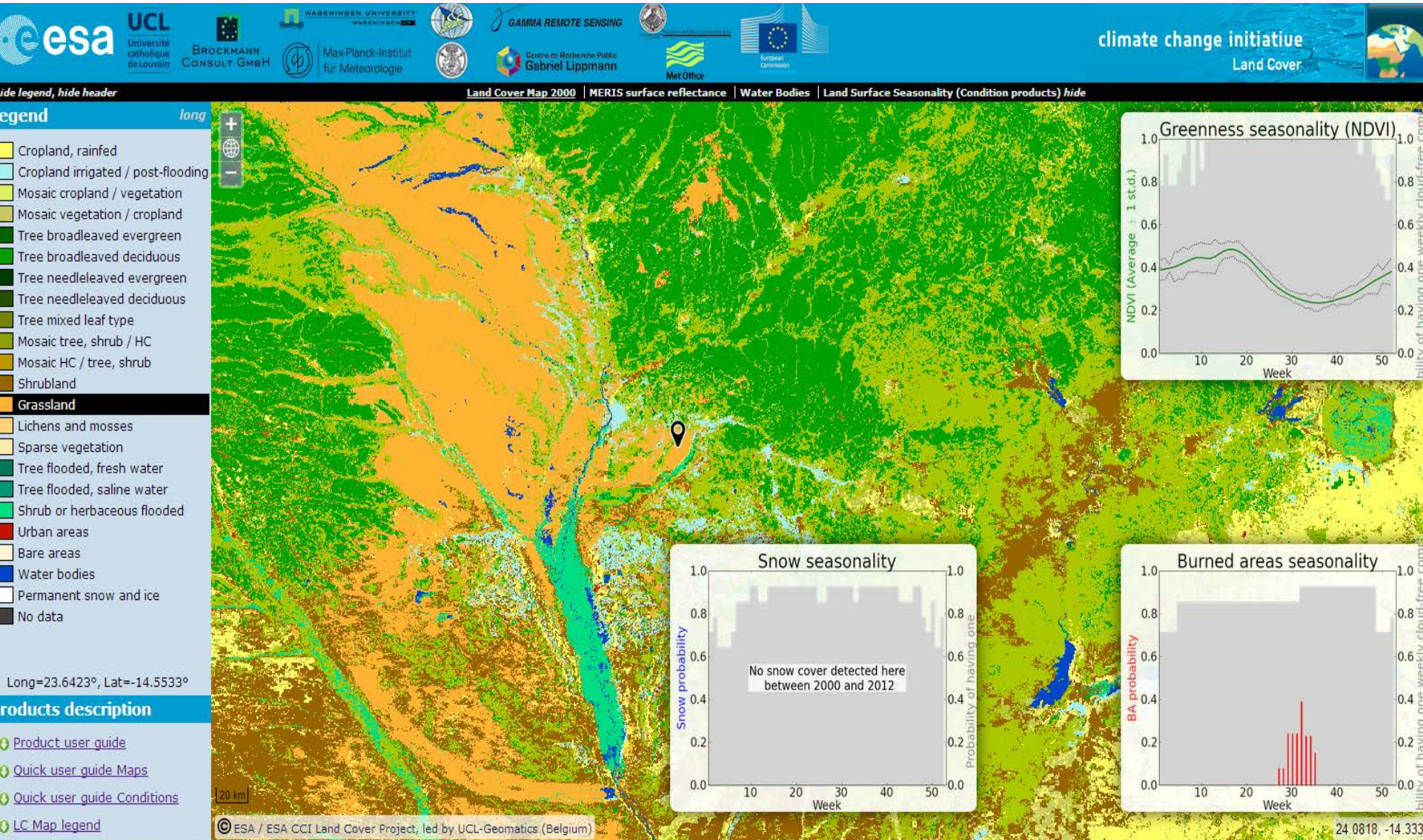






CCI LC maps viewer on-line with 3 consistent land surface season.

http://maps.elie.ucl.ac.be/CCI/viewer/index.html



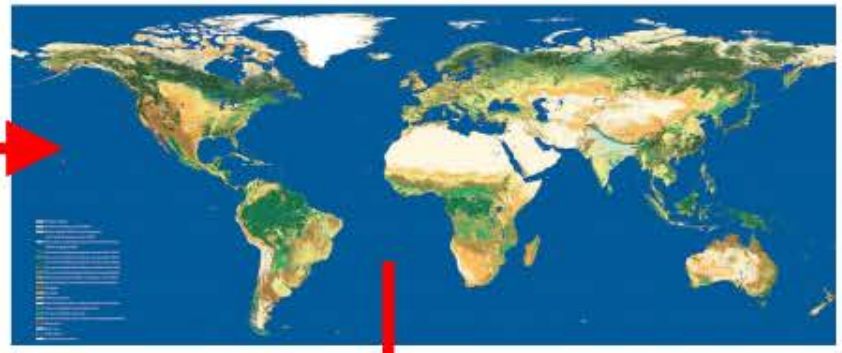
Usertool for climate modellers to convert in Plant Funtional Types

Met Office

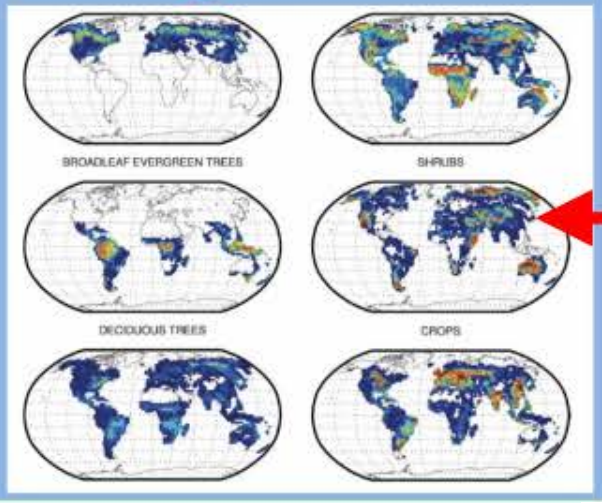
LSCE

Max-Planck-Institut für Meteorologie

cci



ESA LC_CCI PFT datasets



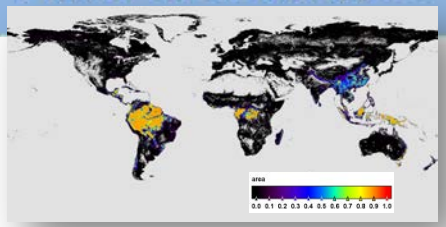
Land Cover -> PFT Conversion Tool (BEAM)

Köppen-Geiger climate zones

Land cover

Phenology & Physiognomy

Plant Functional Types

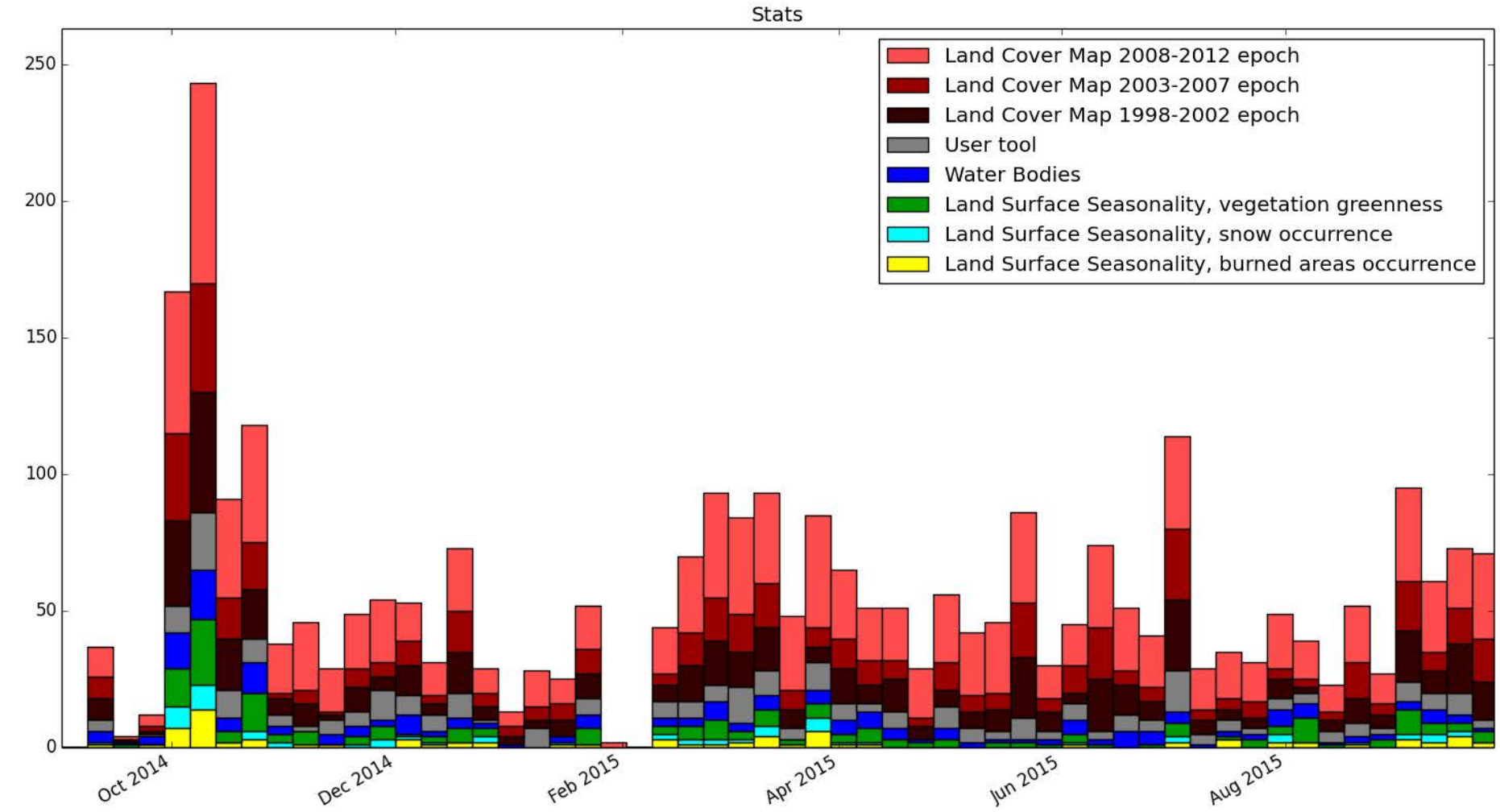


Tree broadleaf evergreen
at 9,8 km for 2003-2007

Poulter et al., 2011, 2015

Products download

Downloads over time



Good CCI LC products downloads

but very little download of uncertainty layers

Downloads by product

	Total
Land Cover Map 2008-2012 epoch	1236 downloads, 2,584.95 GB
Land Cover Map 2003-2007 epoch	521 downloads, 949.12 GB
Land Cover Map 1998-2002 epoch	550 downloads, 593.22 GB
User tool	315 downloads, 8.72 GB
Water Bodies	200 downloads, 91.08 GB
Land Surface Seasonality, vegetation greenness	205 downloads, 2,349.99 GB
Land Surface Seasonality, snow occurrence	70 downloads, 418.08 GB
Land Surface Seasonality, burned areas occurrence	87 downloads, 327.08 GB

Total dwl: 3184 (7,322.24 GB)

2307 maps (4126 GB)

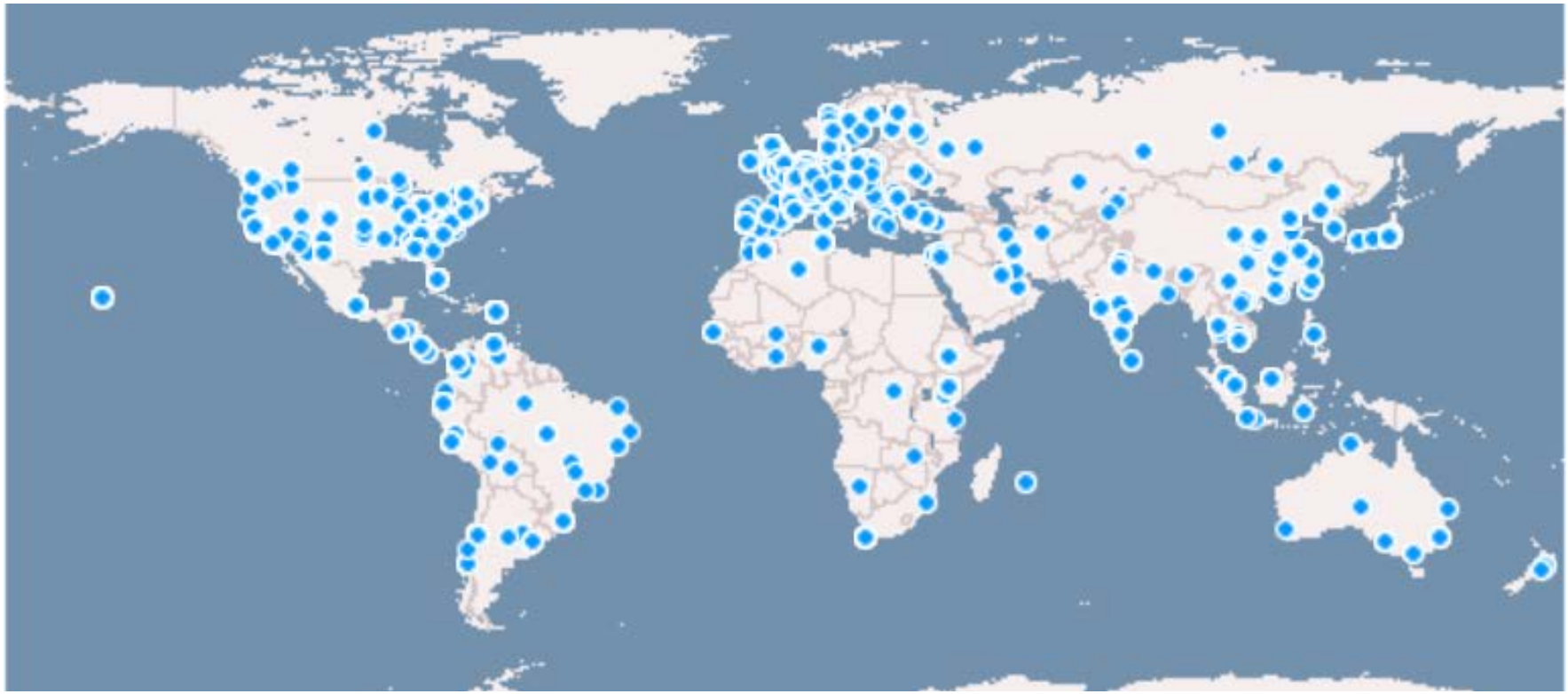
315 tools

362 LSS (3095 GB)

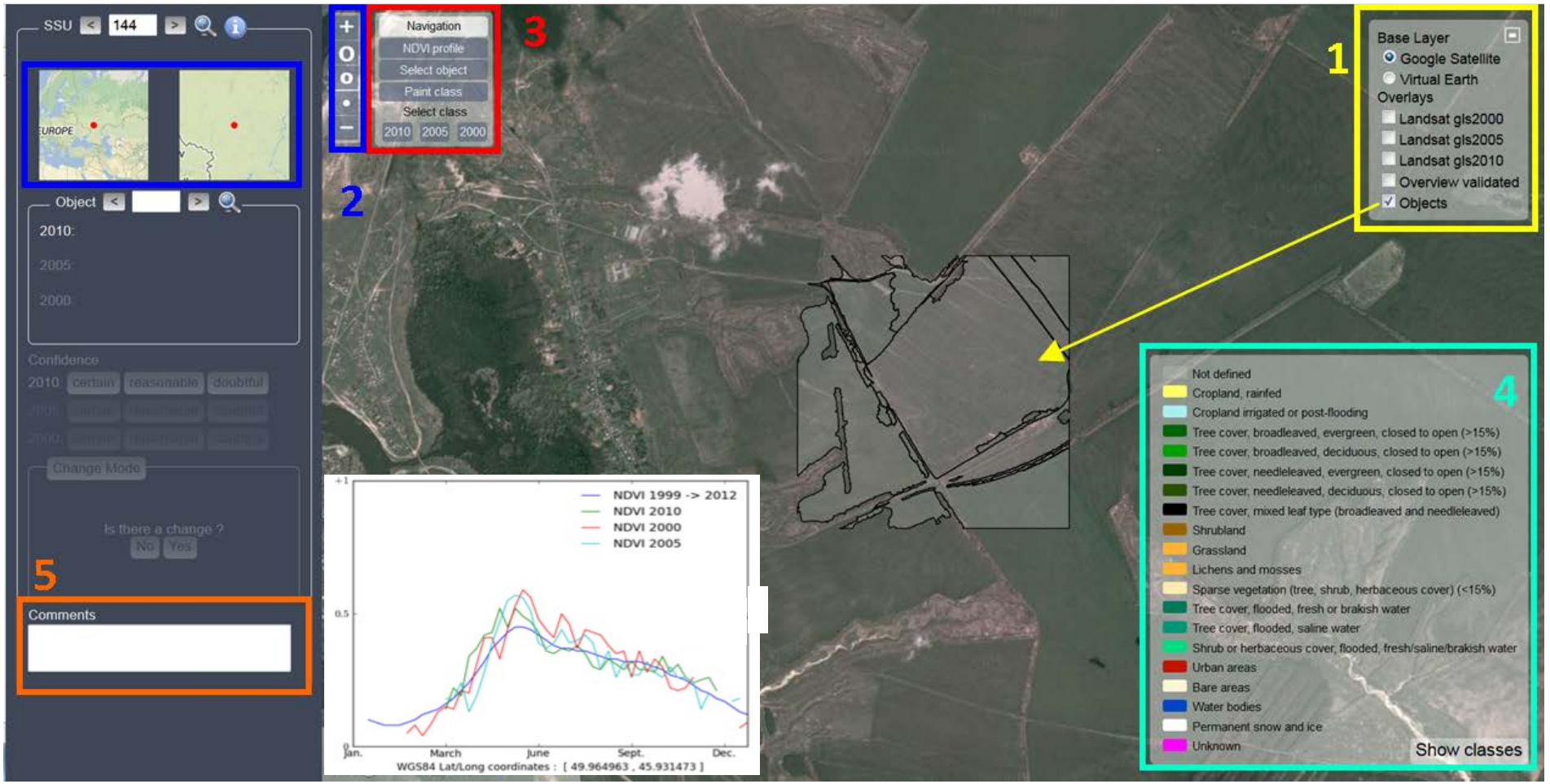
+ MERIS Surface reflectance time series

CCI LC Products downloads : Wide distribution of IP localisation

IP localization



Major CCI LC Validation effort by experts using specific interface

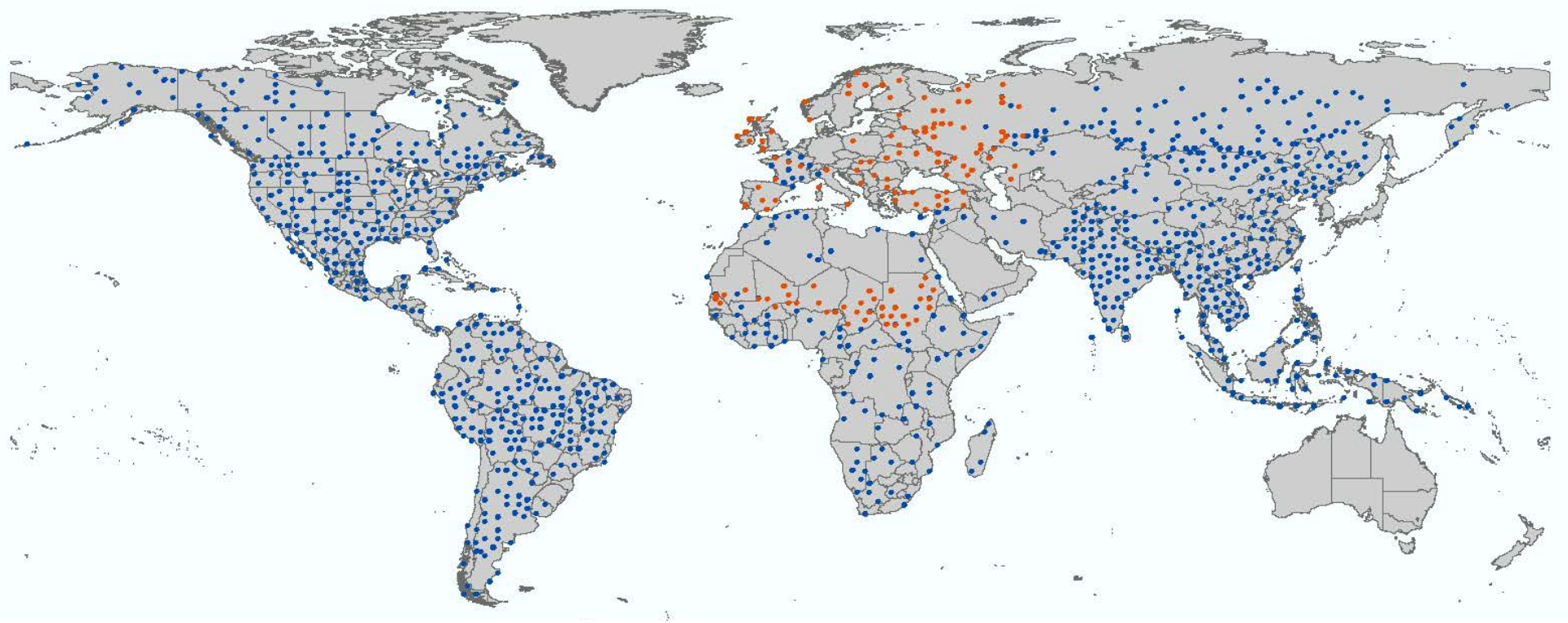


1. Layer box
2. Zooms
3. Tools (navigation, NDVI, select object, paint class)
4. Legend
5. Comment

Completion of the multi-epoch CCI LC Validation database

=> 2591 interpreted points for each epoch (2000/2005/2010) by 19 experts

(expert confidence : 64% certain, 30% reasonable, 6 % doubtful)



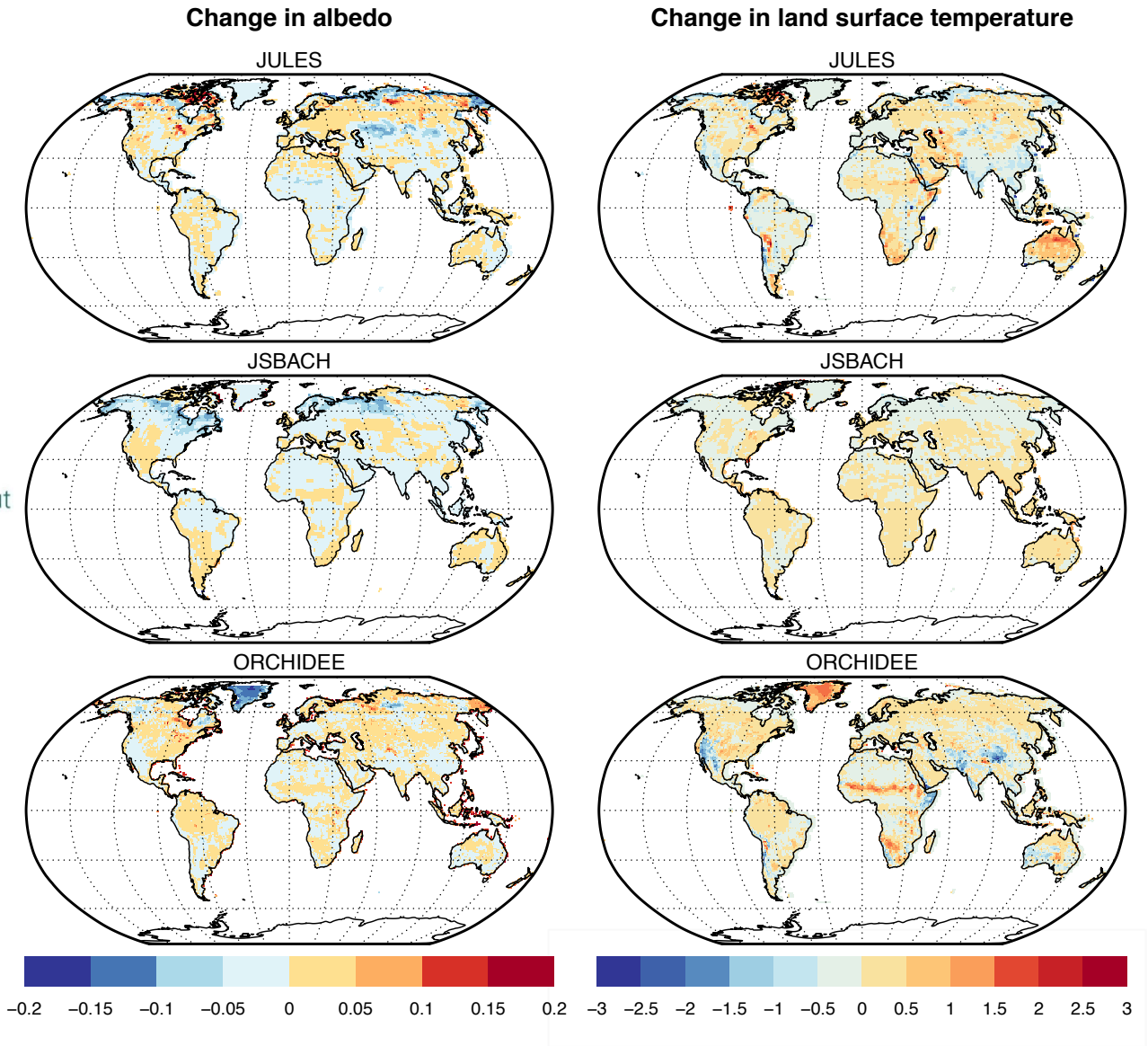
3 climate models experiment : on LC and PFT table on albedo and LST

CCI - Default

Met Office

Max-Planck-Institut für Meteorologie

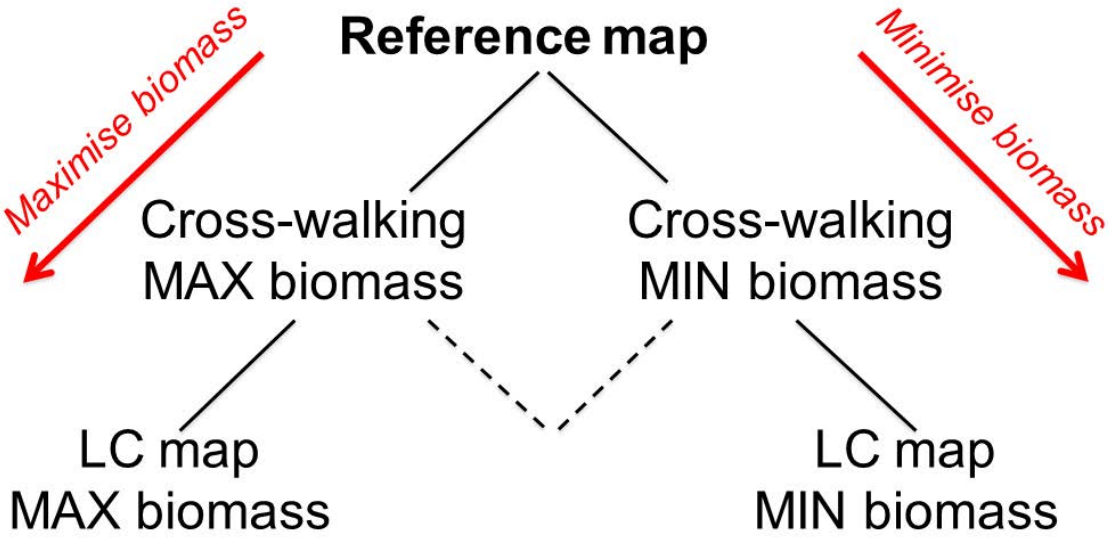
LSCE



On-going experiment using uncertainty : LC and PFT conversion uncertainty impacts on model input and output

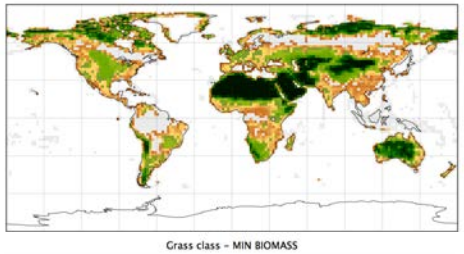
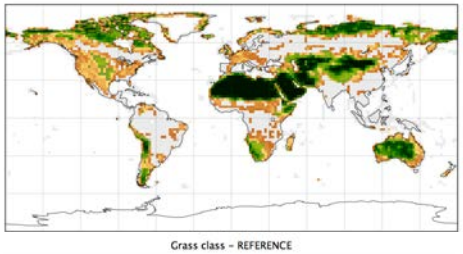
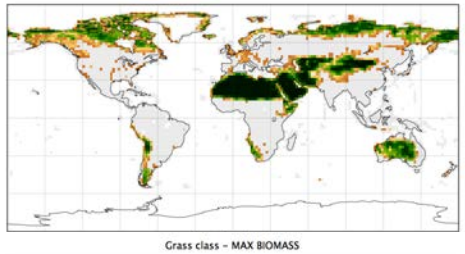
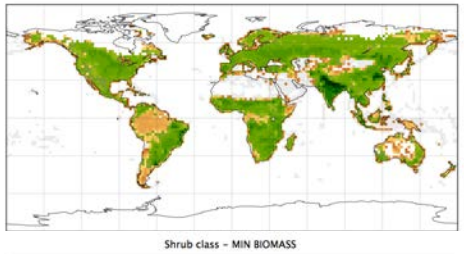
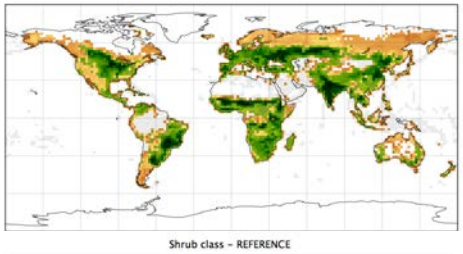
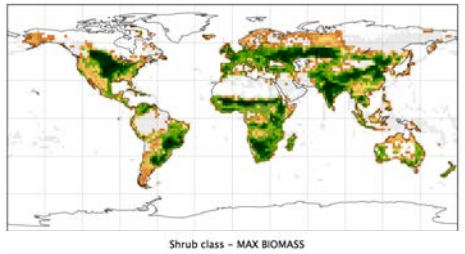
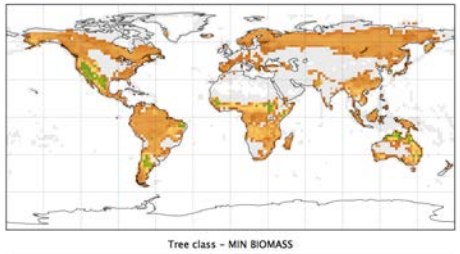
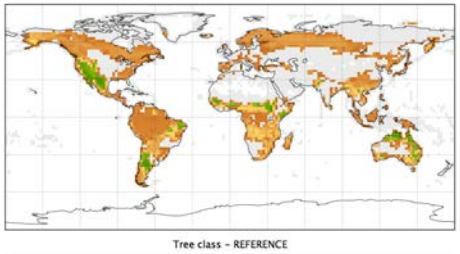
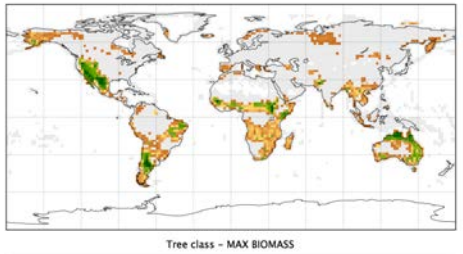
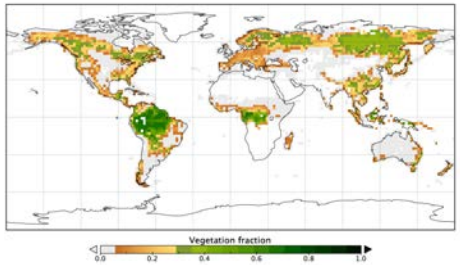
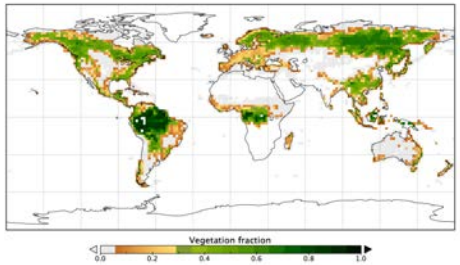
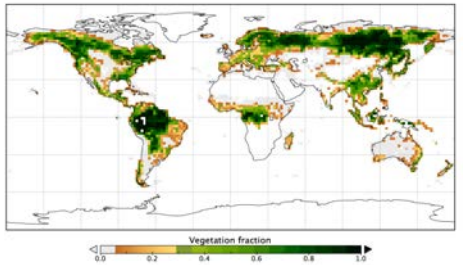
4 different perturbations of PFT fractions generated using 2 levels :

- **Land cover uncertainty** with alternative classes selected only when
  (i) biomass is minimised , (ii) biomass is maximised
- **Cross walking table uncertainty** with fractions adjusted to
  (i) minimise biomass, (ii) maximise biomass



1st Results – impact related to uncertainty from LC or/and PFT table according to regions

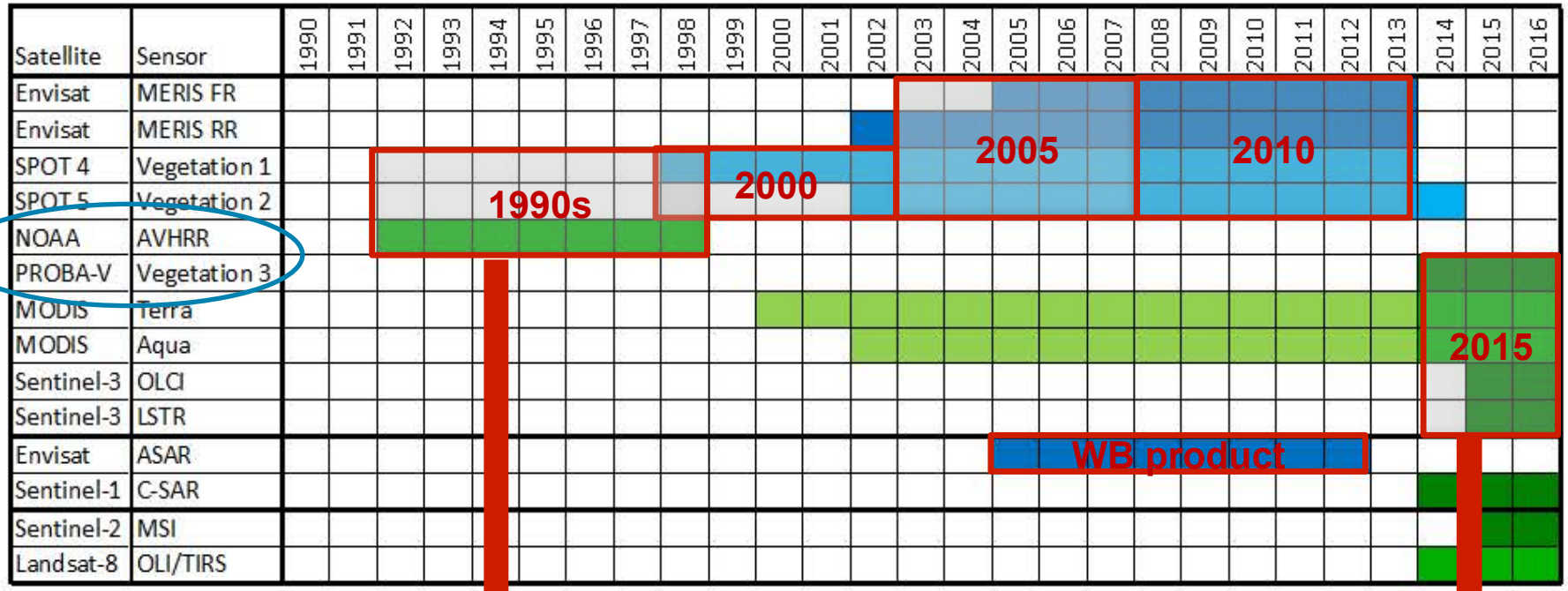
Scenario

PFT	**MIN biomass**	**Reference**	**MAX biomass**
Bare soil	 Grass class – MIN BIOMASS	 Grass class – REFERENCE	 Grass class – MAX BIOMASS
Grass	 Shrub class – MIN BIOMASS	 Shrub class – REFERENCE	 Shrub class – MAX BIOMASS
Shrub	 Tree class – MIN BIOMASS	 Tree class – REFERENCE	 Tree class – MAX BIOMASS
Tree	 Vegetation fraction 0.0 0.2 0.4 0.6 0.8 1.0	 Vegetation fraction 0.0 0.2 0.4 0.6 0.8 1.0	 Vegetation fraction 0.0 0.2 0.4 0.6 0.8 1.0

Phase II : temporal extension
LC time series from 1990 to 2015

7 different instruments plus Sentinel-1 and 2

SR time series + LC maps

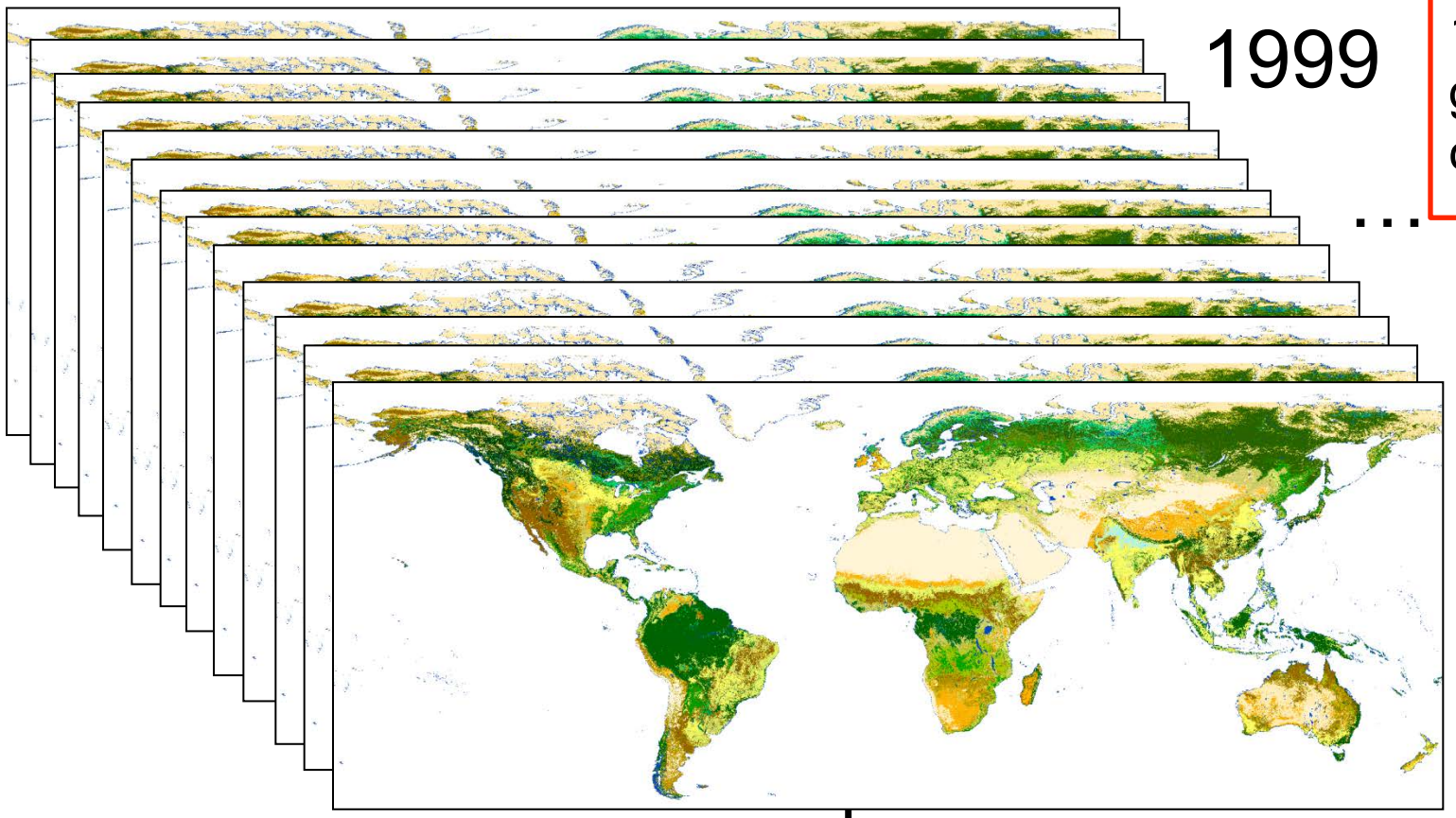


AVHRR archives – 1km HRPT - 1992-1998

PROBA-V – 300 m & 100 m 2014 -2015

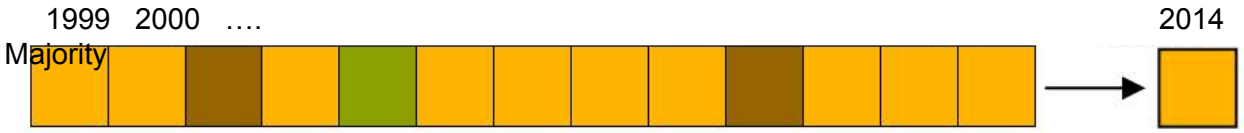
Sentinel-3 OLCI –SLSTR SYN product – 300 m

On-going annual 1-km change detection using a 13-y SPOT-VEGETATION + PROBA-V

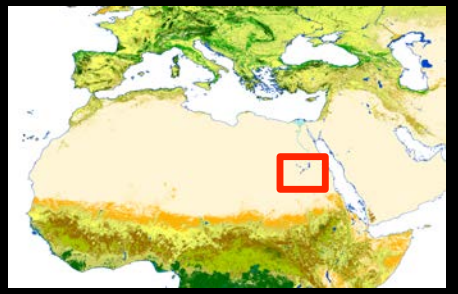


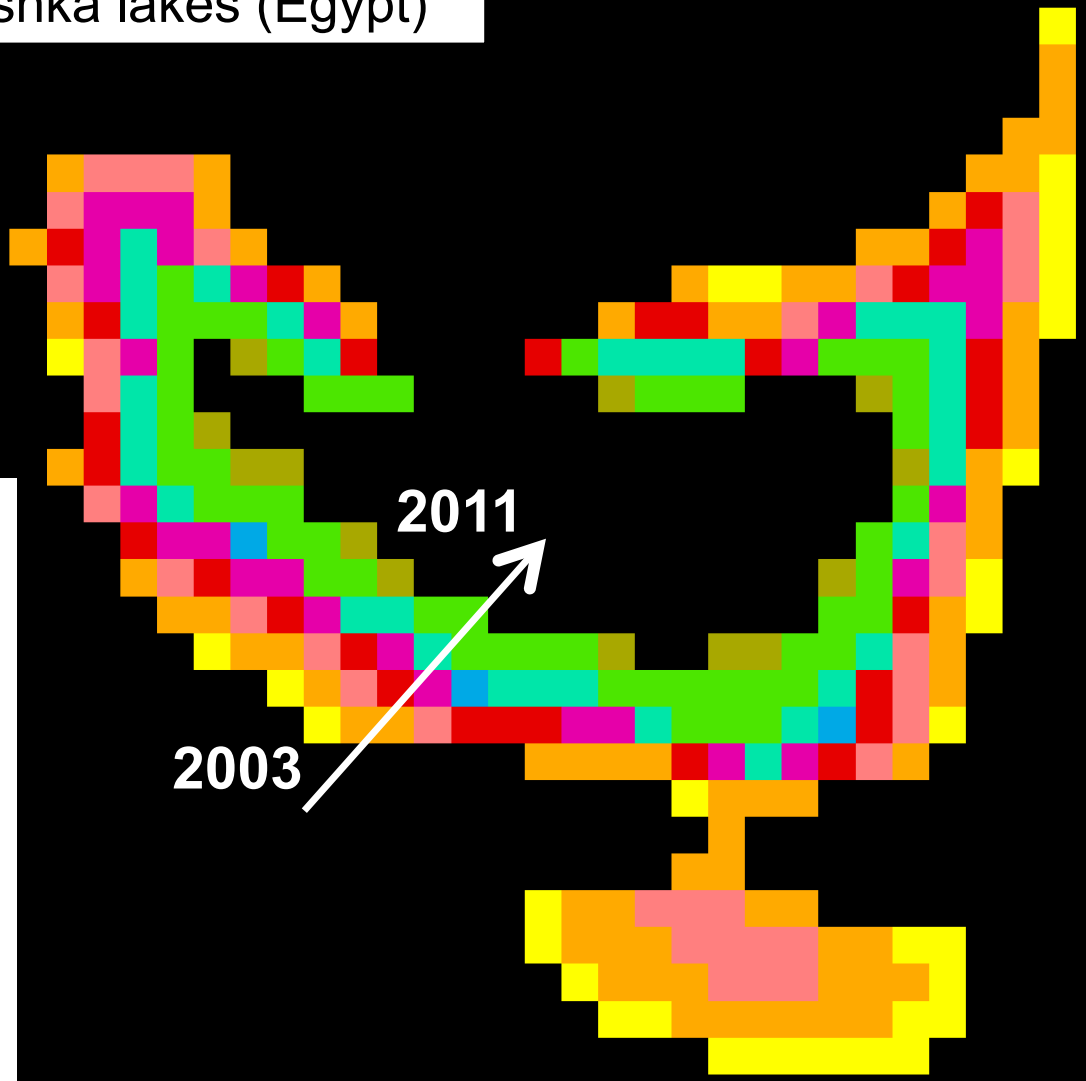
16 annual global land cover products

Majority and specific decision rules (pixel based)



tection of annual change:
ving up of Toshka lakes (Egypt)





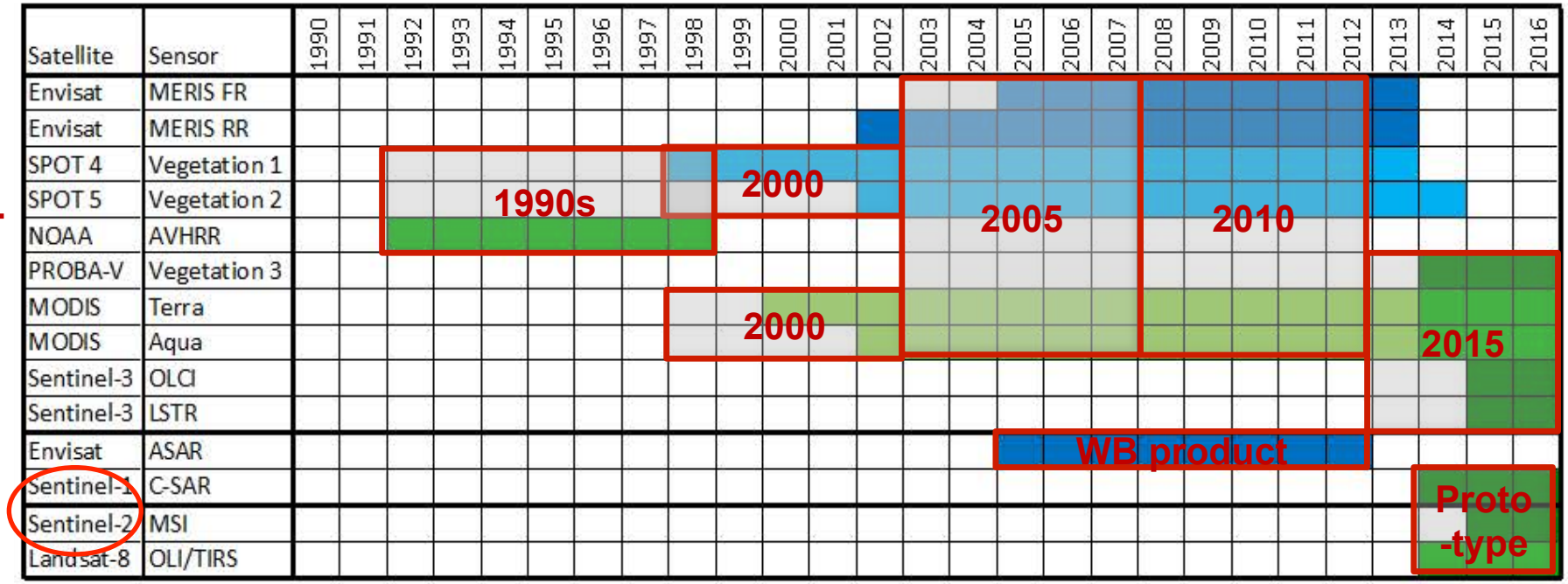
Year of change

- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

Starting Sentinel 1 & 2 data use as input for high resolution output

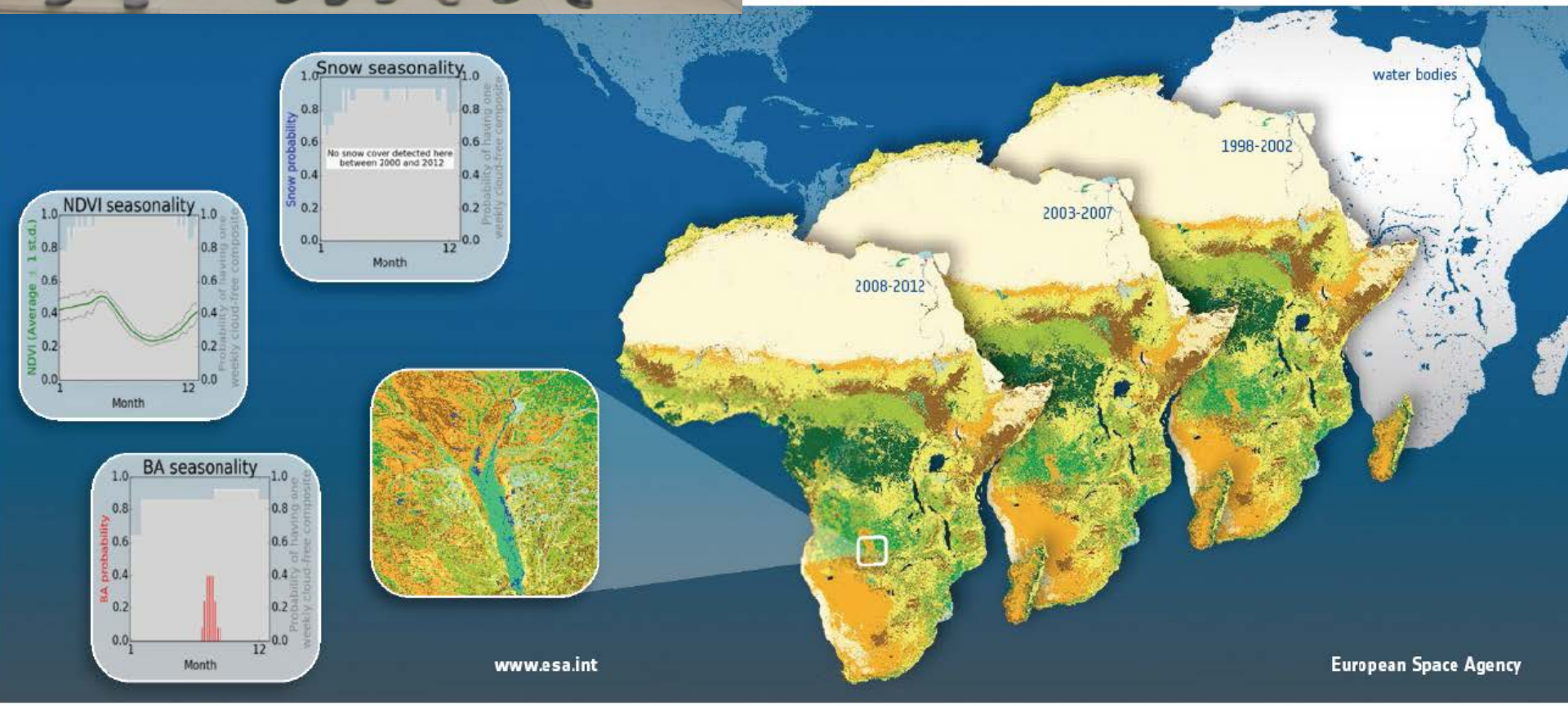
- On-going round robin to exploit Sentinel-1 time series for urban
- Sentinel-2 processing test over large scale

SR time series + LC maps



Sentinel-2 time series (Africa)

Sentinel-1 time series (Boreal zone) + RR on urban mapping

Last but not least achievement :
a very collaborative team with 3 climate groups closely interacting among them and with the EO groups

Thank you for attention