living planet symposium

Characterizing the surface dynamics for Land Cover mapping

Current achievements of the ESA CCI-LC project

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9–13 September 2013 | Edinburgh, UK

European Space Agency

CCI-LC users' consultation

- 4 levels of users surveys
- Particular findings:

– Priority for both stable and consistent LC products over time

– Need for more dynamic information reflecting LC change and vegetation phenology

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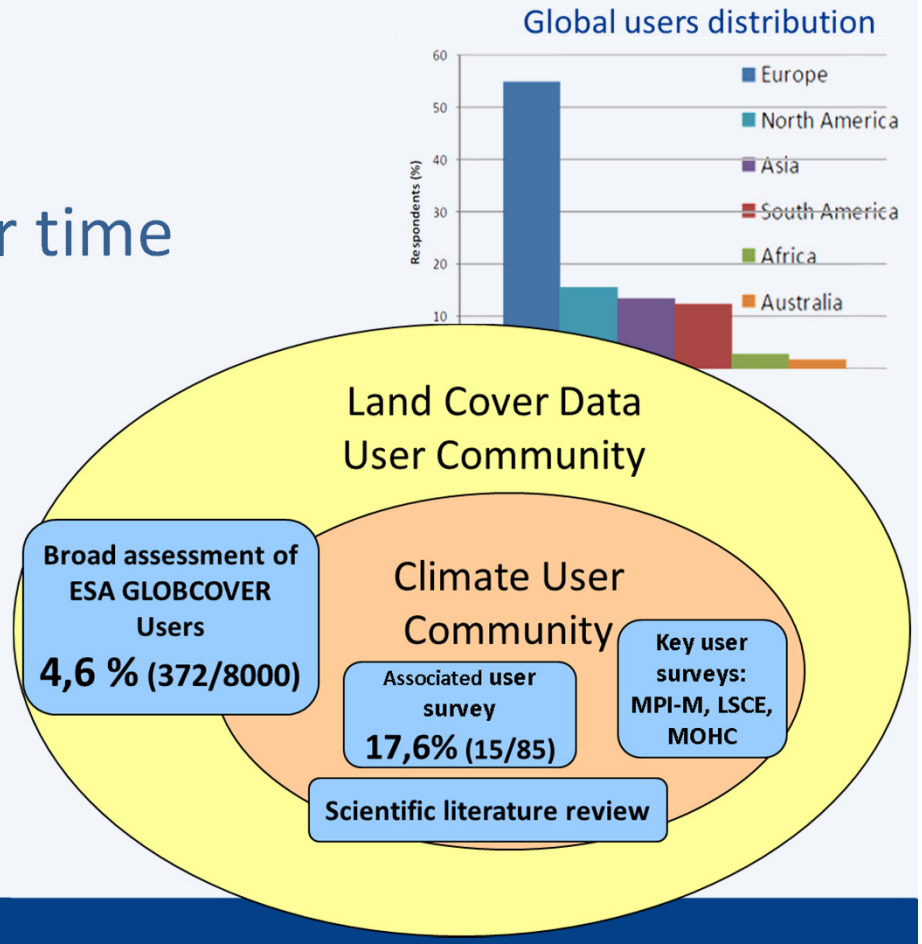


CCI-LC to revisit the LC concept

- **Land cover can not be the (observed) physical and biological cover on the terrestrial surface** (LCCS, 2005; GTOS ECV, 2009)**,**

  …and remain stable and consistent over time

  (as requested by users and by climate modelers)

→ New LC concept :

“land cover state ” and “land cover conditions”

CCI-LC Land Cover Concept

- **Mapping land cover state and land cover conditions through the use of land surface feature**

a stable ensemble of land surface features described by:
- **feature type** (tree, shrub, water, built-up areas, permanent snow, etc.)
- **feature structure** (veg. height, veg. density, building density, etc.)
- **feature homogeneity** (mosaic/patterns of different features)
- **feature nature** (level of artificiality, C3/C4 plant, etc).

- **The land cover change corresponds to a 'permanent' modification of the land cover state (not systematically mapped by CCI)**

(Defourny, P. and Bontemps, S., 2012)

CCI-LC Land Cover Concept

- **Mapping land cover state and land cover conditions**

set of annual time series describing the land surface status along the year:

- **green vegetation phenology** (NDVI, other VI ?)
- **snow occurrence** (duration, starting date)
- **inland water presence** (flooding, irrigation timing)
- **fire occurrence** (and burnt areas)

+ associated inter-annual variance for each land cover condition item

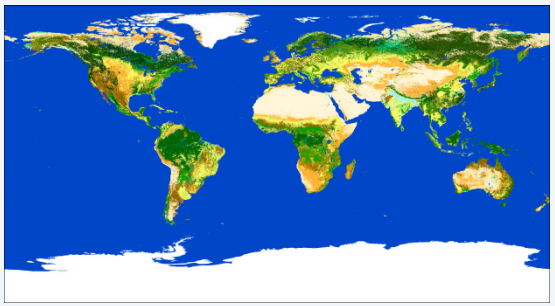
- **Consistency between land cover state and condition to be verified by cross-checking**

(Defourny, P. and Bontemps, S., 2012)

LC Conditions generation

- **In addition to the LC state,**
  - Generation of 3 condition products
  - Global scale
  - Period of interest : 1999 – 2012
  - Quality indicator

Consistency with LC-sate

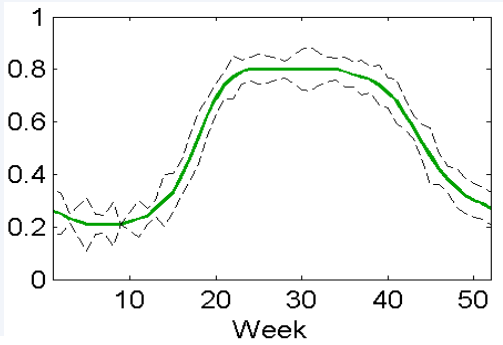


Land Cover State

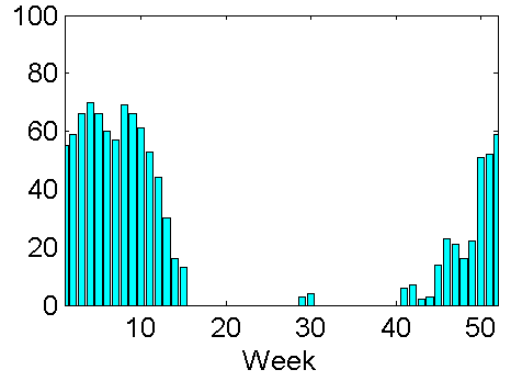
+

Land Cover Conditions

• **NDVI**
Average
Inter-annual
variability



• **Snow**
• **Burnt Areas**
Occurrence
Probability



Data sources

- Built from existing global and long-term datasets and auxiliary products with high temporal frequency and moderate spatial resolution

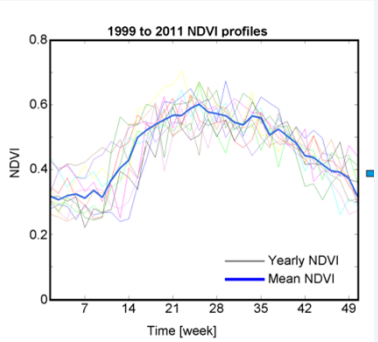
Condition	Input data set	Spatial resolution	Temporal coverage
NDVI	SPOT-VGT	1km	1999 – 2011
BA	MCD64A1	500m	2000 – 2012
Snow	MOD10A2	500m	2000 – 2012

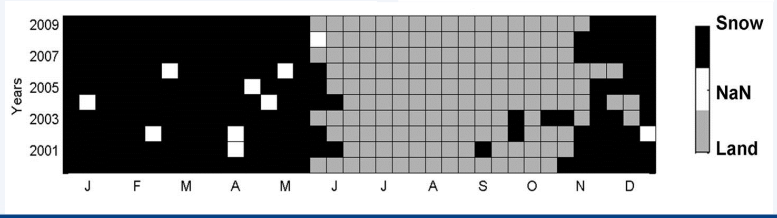
Will soon be tested with the CCI-Fire Product

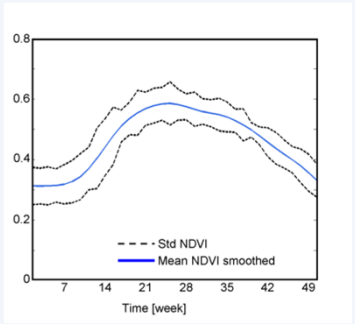
Methodology

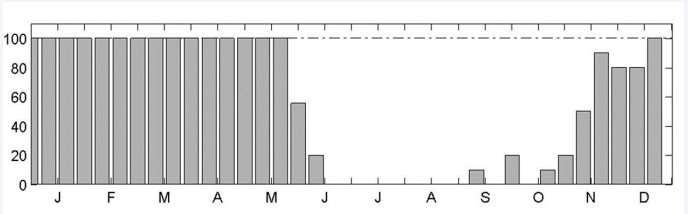
- For each of the 3 observable variables, the condition is a compilation:
  - from 13 years of 7d instantaneous observations
  - to 1 temporarily aggregated profile depicting, along the year, an average behaviour for vegetation greenness, snow, BA, water

Instantaneous observations







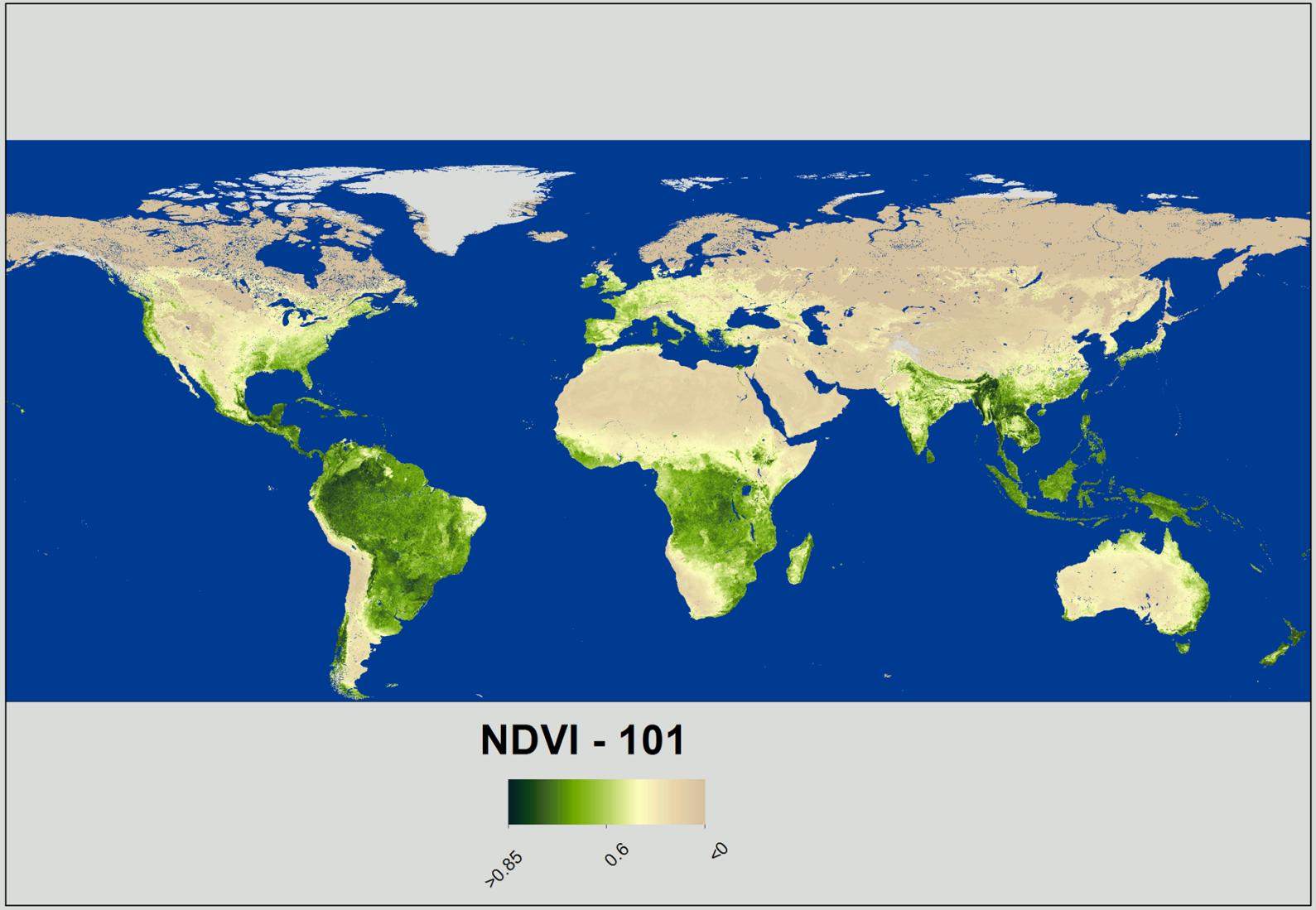


Condition products

NDVI condition dataset

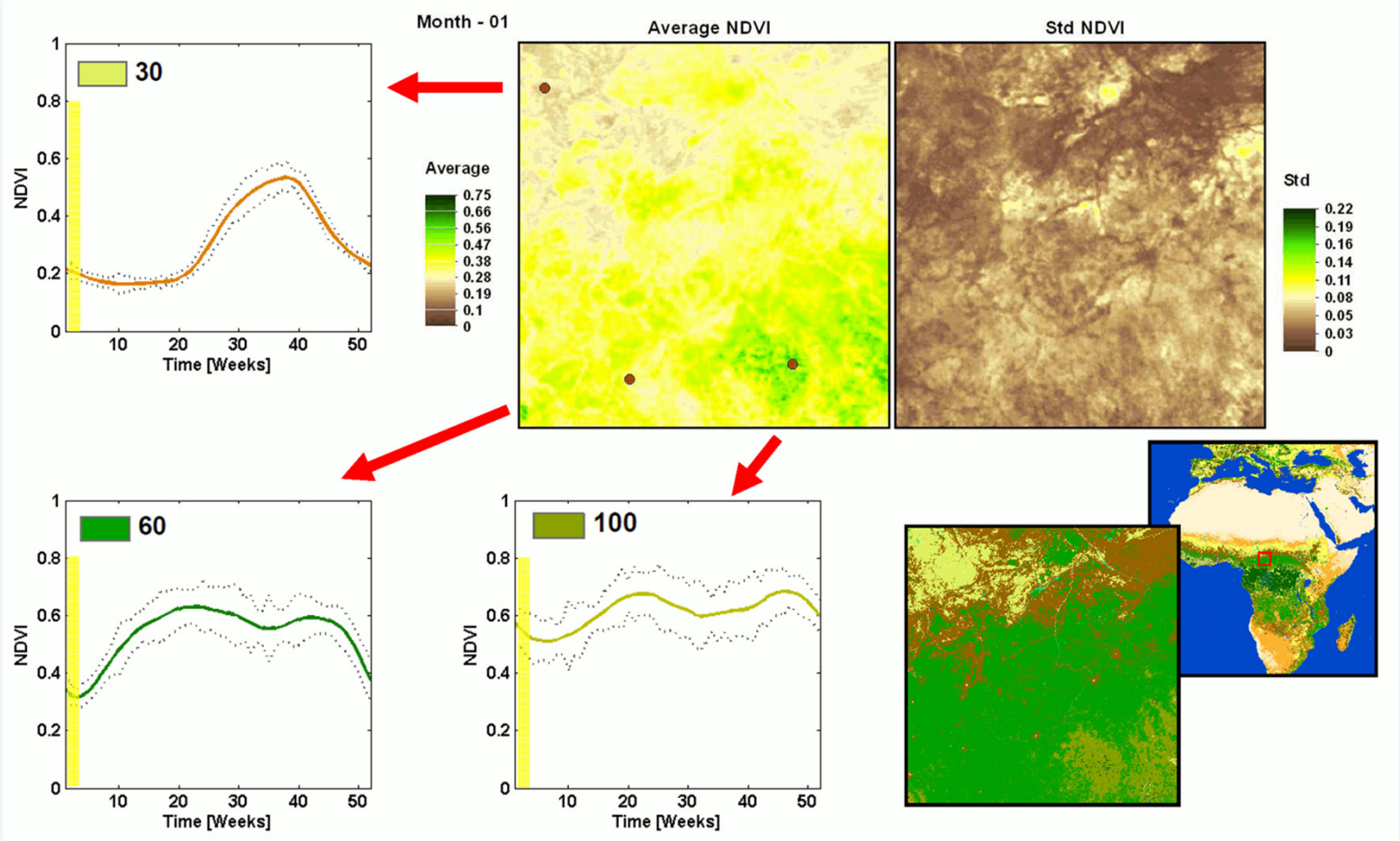
- 4 series of 52 layers :
  - **Smoothed NDVI** values corresponding to the averaged NDVI over the 1999-2011 period.
    - ➢ Yearly reference dynamic of the vegetation greenness at a 7-day frequency
  - **Standard deviation** of the average NDVI over the 1999-2011 period
    - ➢ Inter-annual variability
  - Number of **valid and cloud-free years** contributing to each 7-day period of the AggMean and Std series
  - **Status** of the pixel; 1 : land , 2 : water , 3 : snow, 4 : cloud
    - ➢ Quality Indicators

NDVI Condition



NDVI Condition

30 : Mosaic cropland (>50%)



60 : Tree cover, broadleaved deciduous, closed to open (>15%)

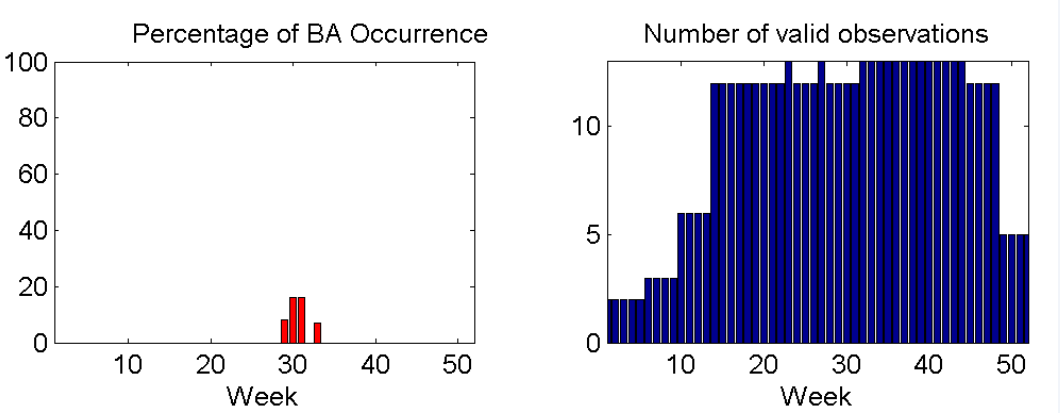
100 : Mosaic tree and shrub (>50%)

BA condition dataset

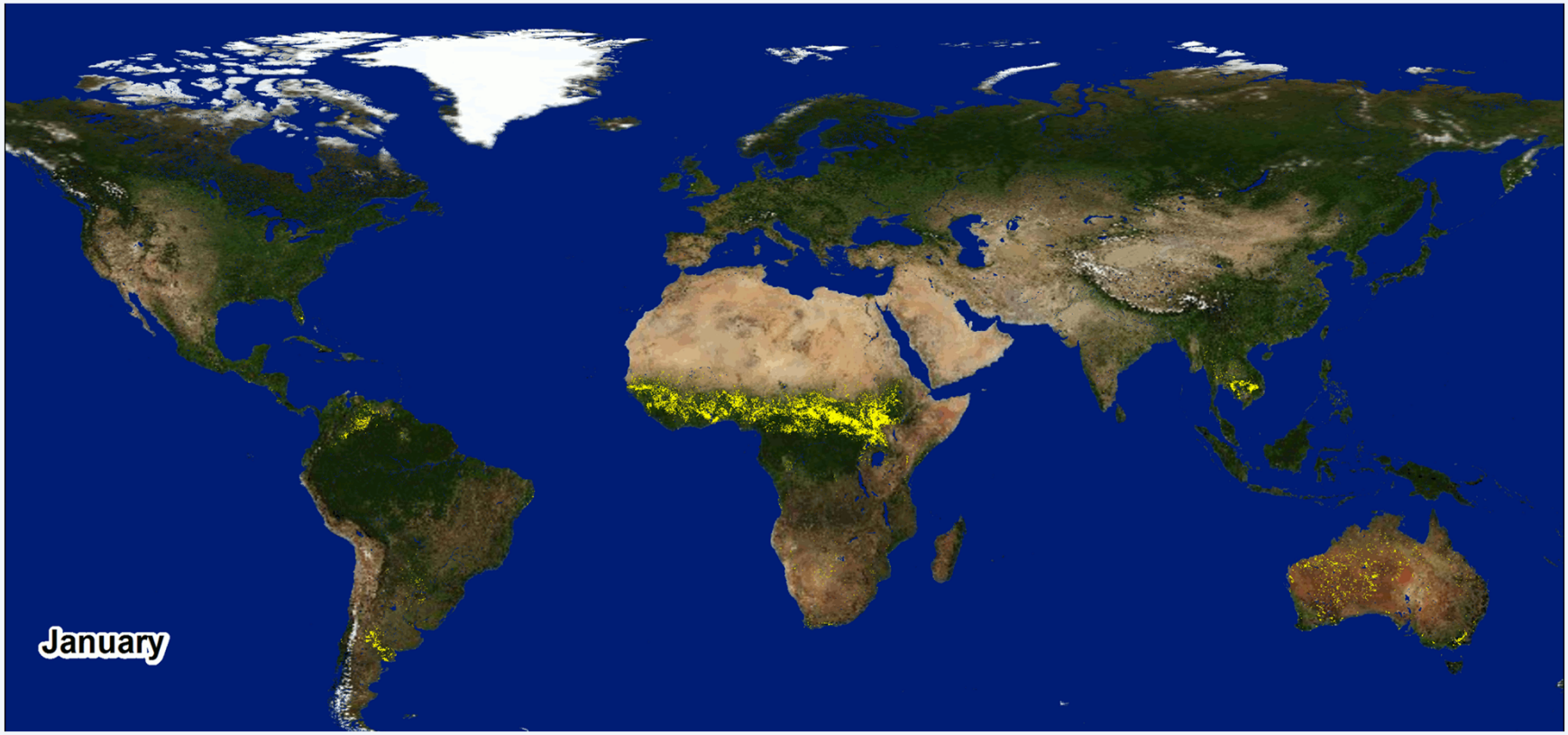
- 2 series of 52 layers :
  - **Percentage of Burnt Areas occurrence** as detected over the 2000-2012 period on a 7-day basis:

$$\text{Burnt Areas occurrence} = \left(\frac{\sum_{\text{week}} \text{BA detections}}{\sum \text{years}} \right) * 100$$

  - Number of **valid years** contributing to each 7-day period of the occurrence series

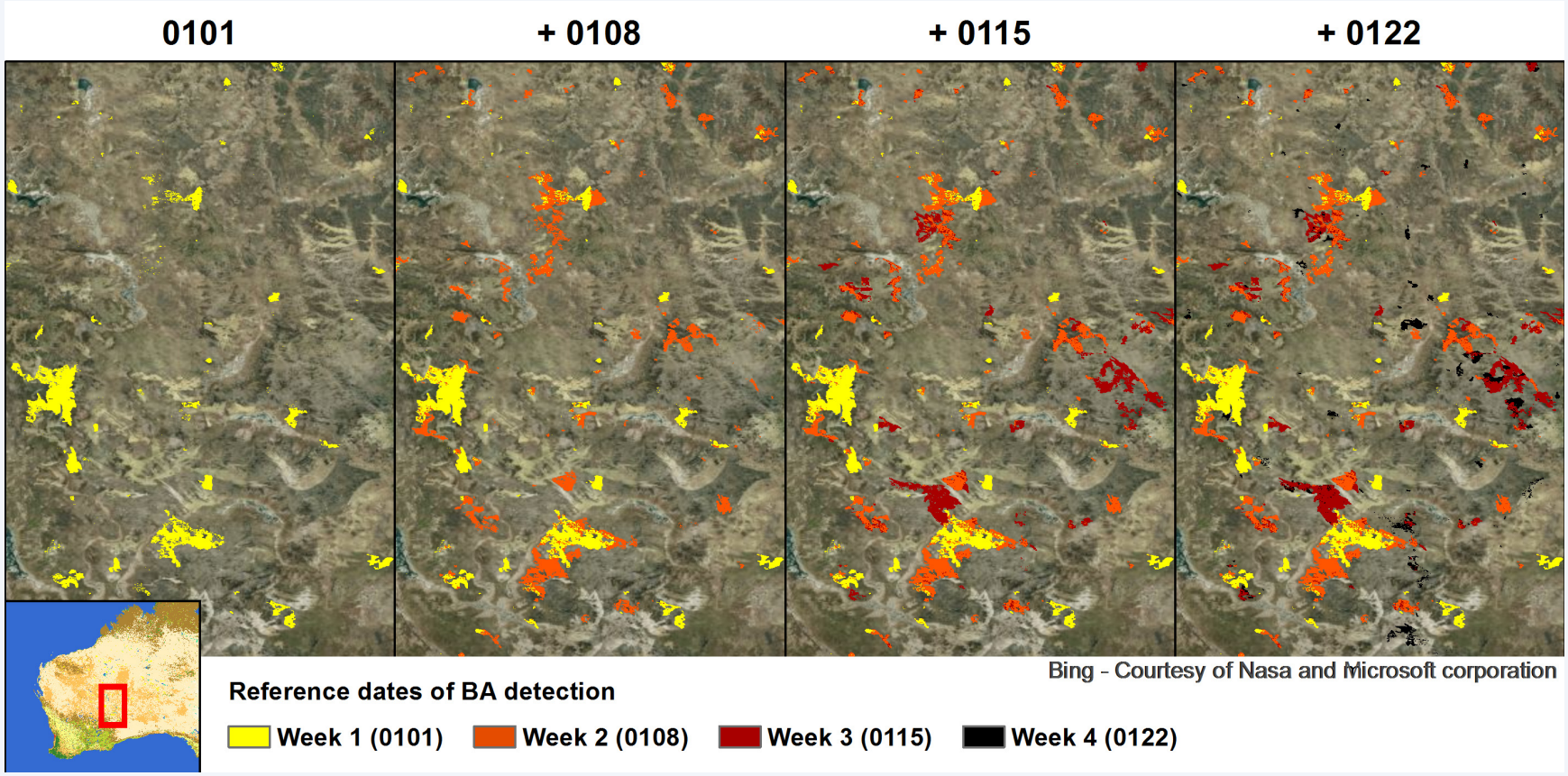


Burnt Areas condition



Low spatio-temporal consistency

BA detections on adjacent pixels may be separated by several weeks

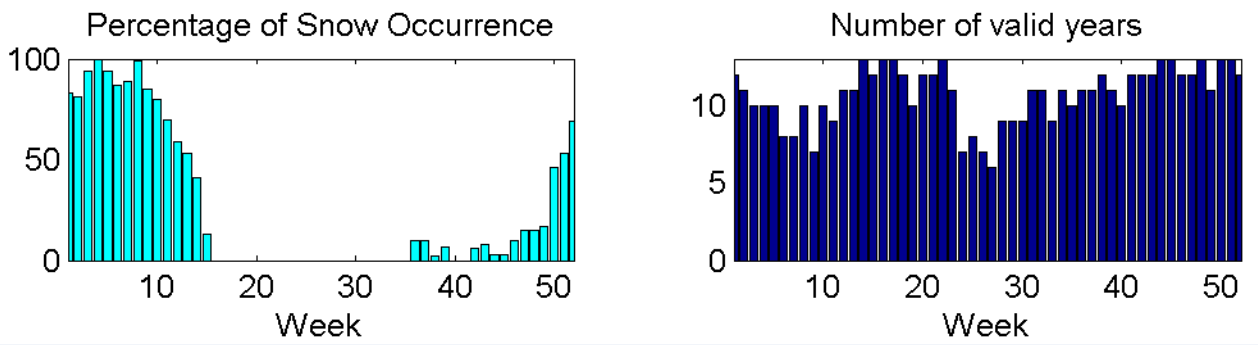


Snow condition dataset

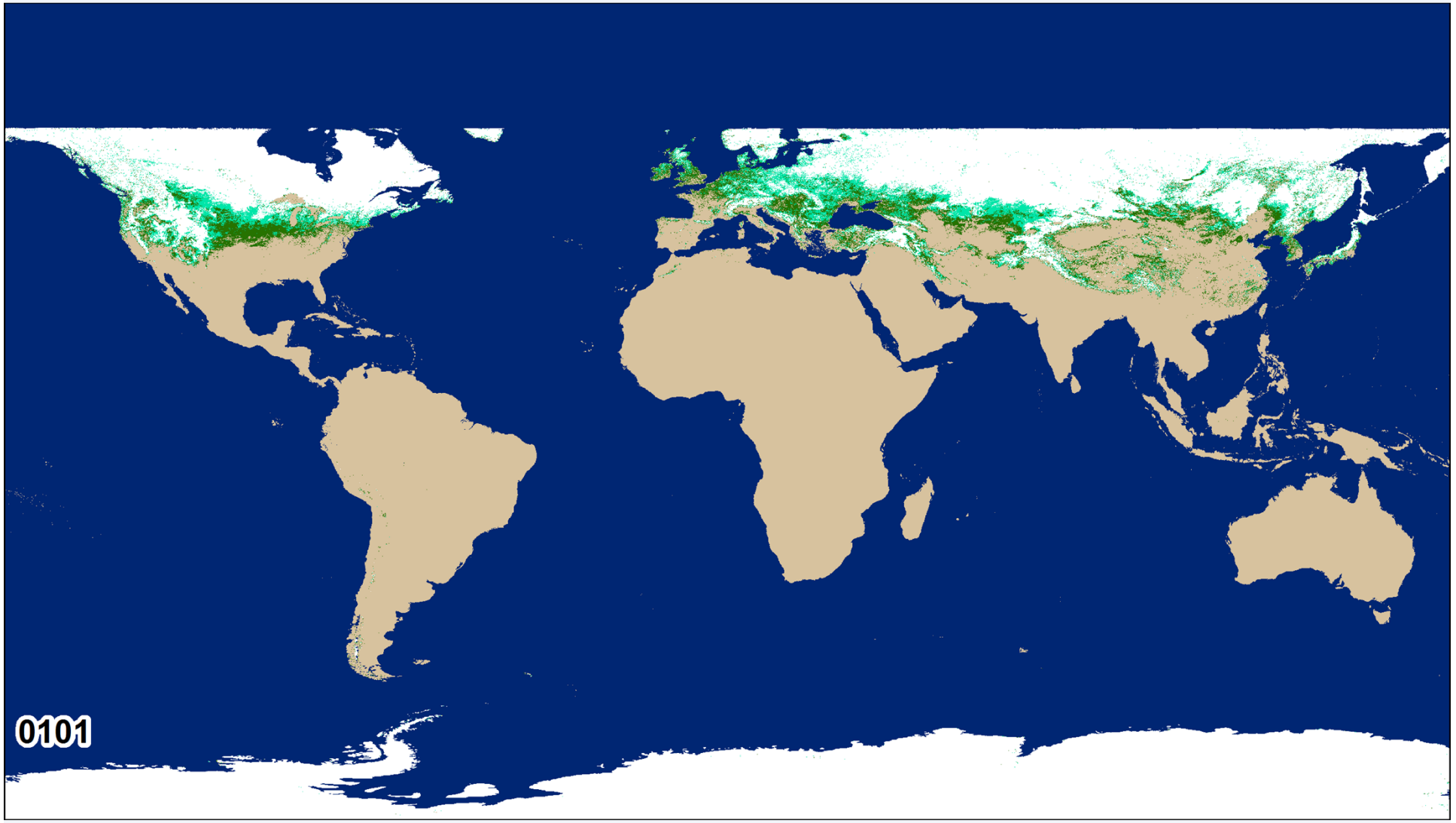
- 2 series of 52 layers :
  - **Percentage of snow occurrence** as detected over the 2000-2012 period on a 7-day basis

$$\text{snow occurrence} = \frac{\sum_{week} \text{snow observations}}{\text{valid years}} * 100$$

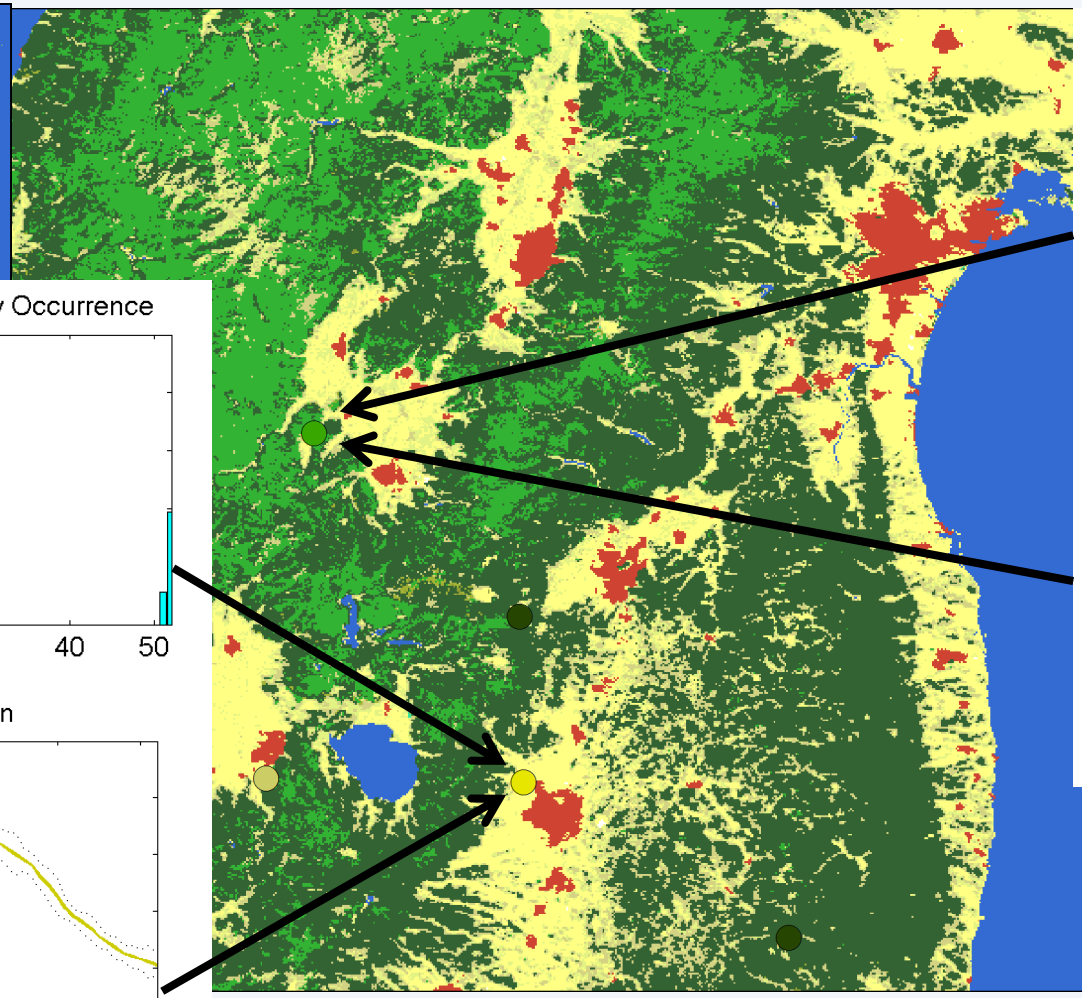
  - Number of **valid years** contributing to each 7-day period of the occurrence series

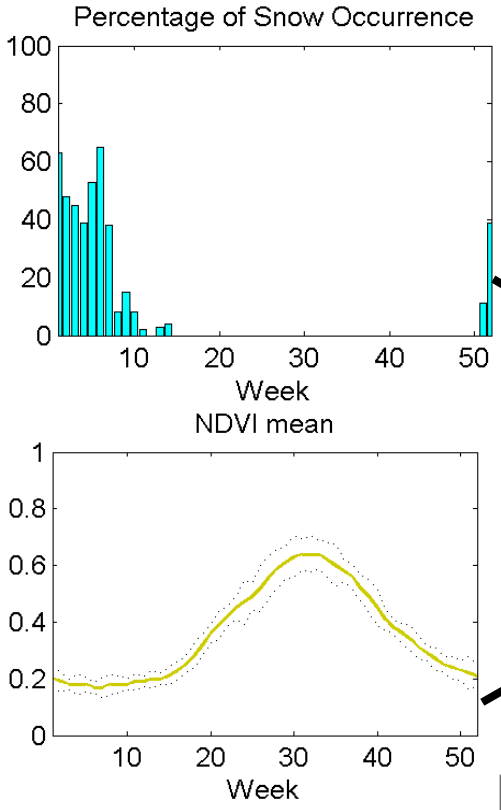


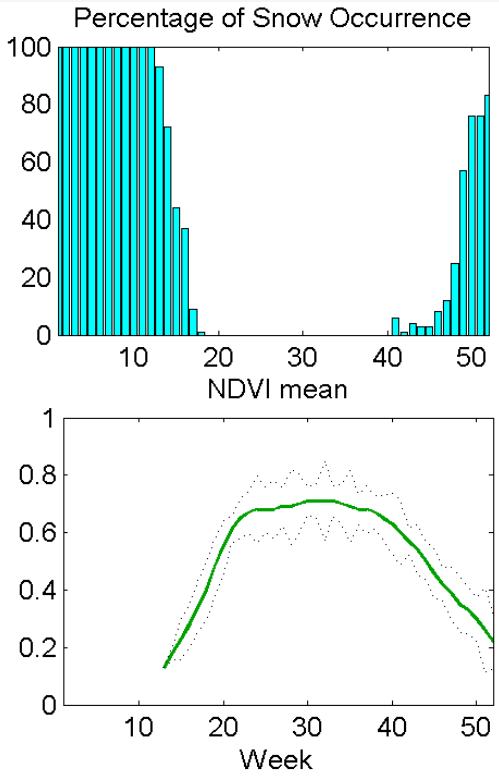
Dynamic snow behaviour



Variety of Snow conditions







60 : Tree cover, broadleaved, deciduous

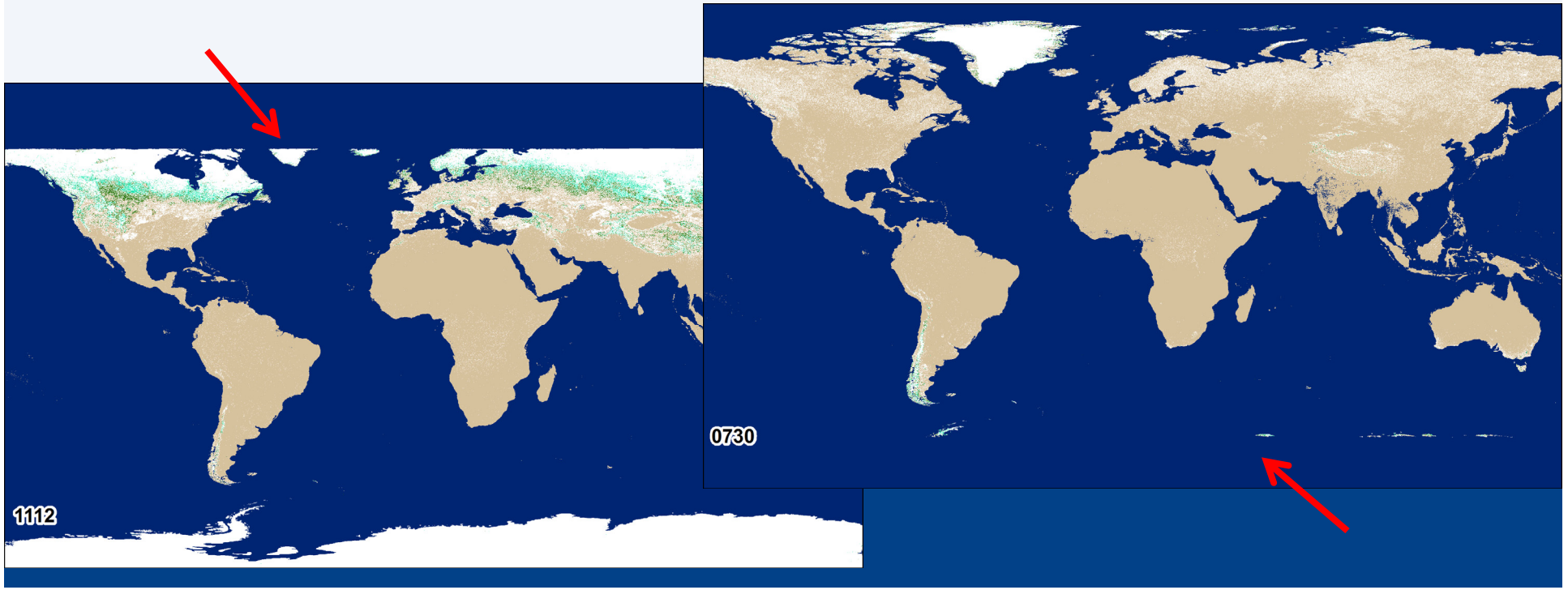
LC map 2010

10 : Cropland, rainfed

consistent with the NDVI condition

Missing observations at extreme latitudes

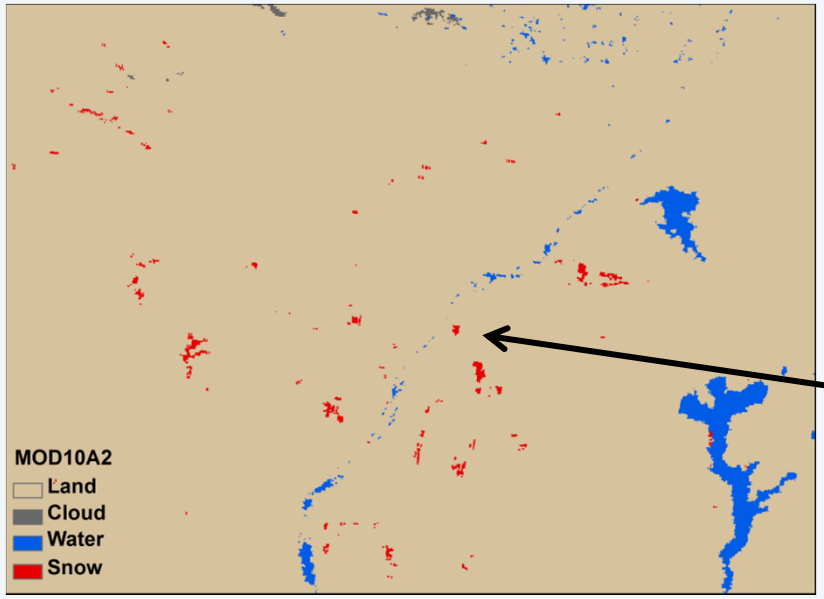
- Upper average latitude with valid obs. decreases from 80° N (September and October) to 60°N in the November to January period.
- « Dark circle » : the North Pole is not illuminated in winter; South Pole is not illuminated in summer

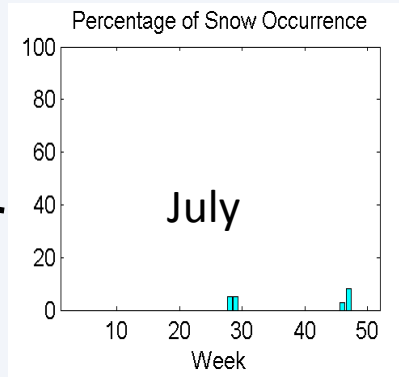


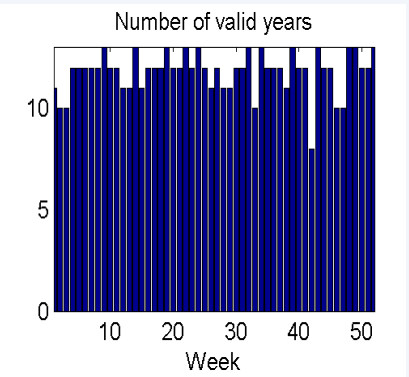
Contamination effect

- High frequency of clouds
- False detections over bright or cloudy areas

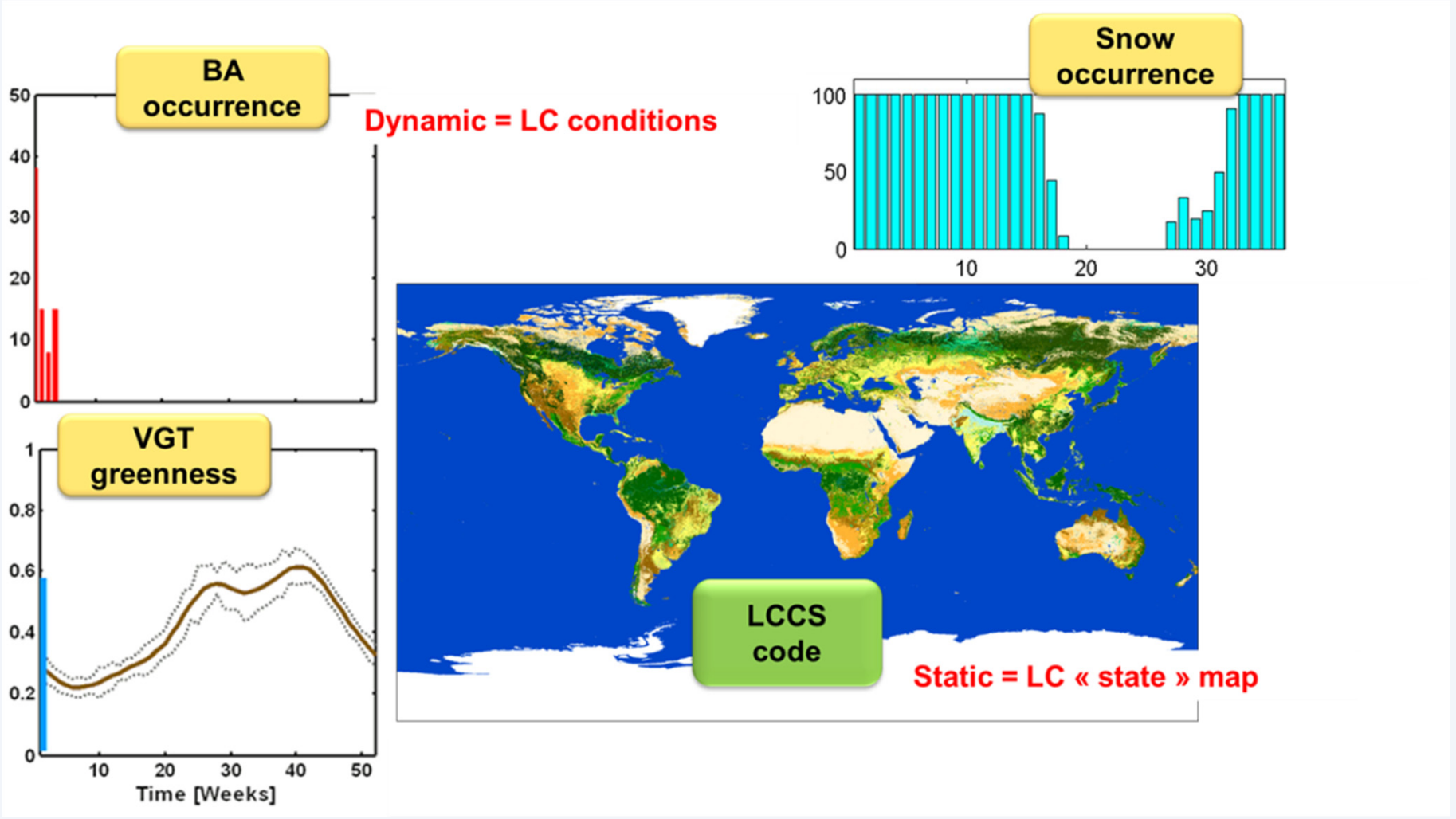
e.g. Central Africa







Overview


BA occurrence
Dynamic = LC conditions
Snow occurrence
VGT greenness
LCCS code
Static = LC « state » map
Time [Weeks]

Next steps - Consistency

Rationale

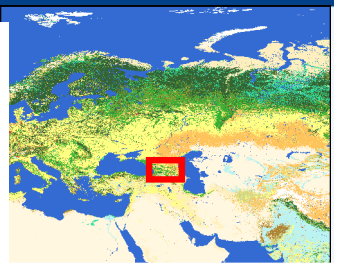
- The consistency between different model parameters (state and conditions) is found more important than the accuracy of individual parameters themselves
- Discrepancies between products remain a source of inaccuracy and lead to interoperability problems in the climate models

→ Identify and characterize the types of existing discrepancies (typology);

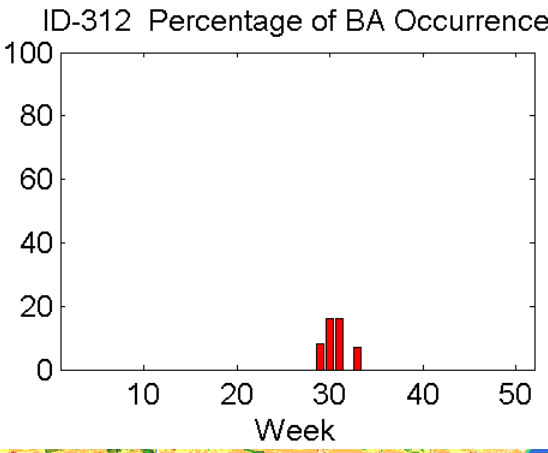
→ Build a pixel-based discrepancy indicator

Consistency characterization

Between LC maps and LC conditions = main focus

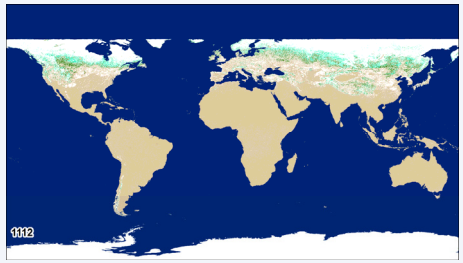


LC map 2010

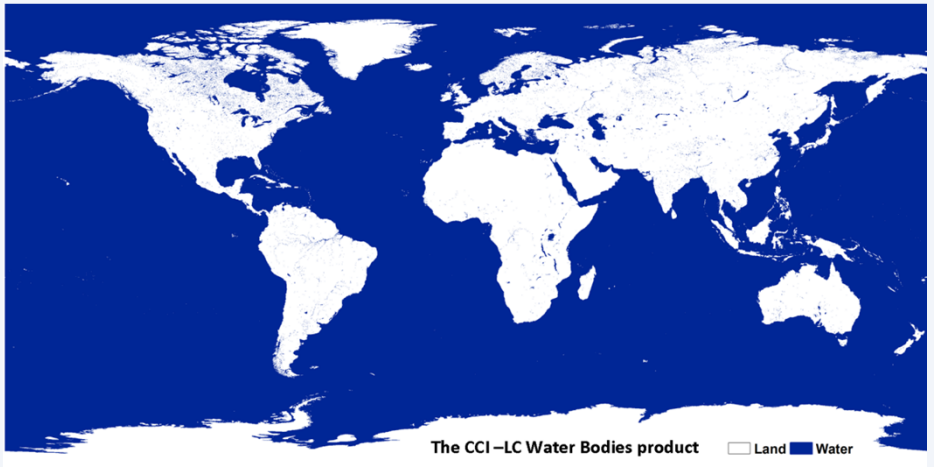


Conformity

- Conformity aspects between LC map and conditions in terms of:
  - Spatial coverage → true global
  - Land mask definition

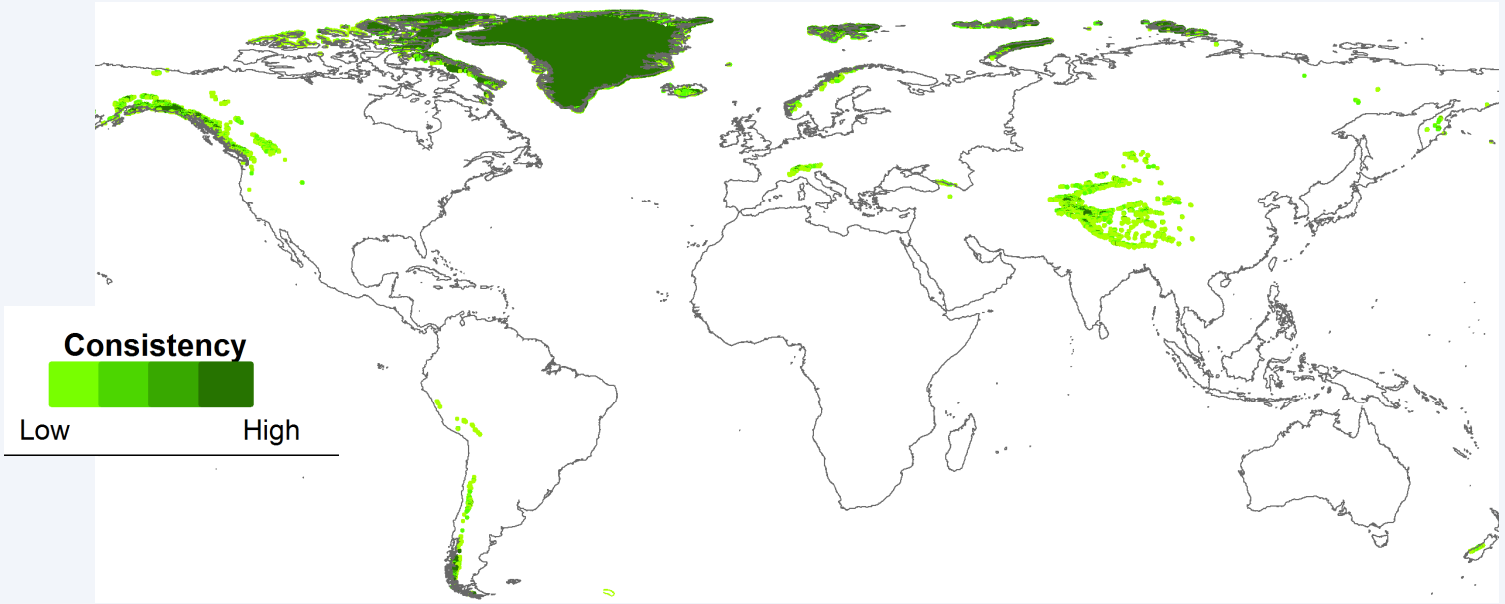


CCI-LC Water Bodies as the reference ?



Permanency

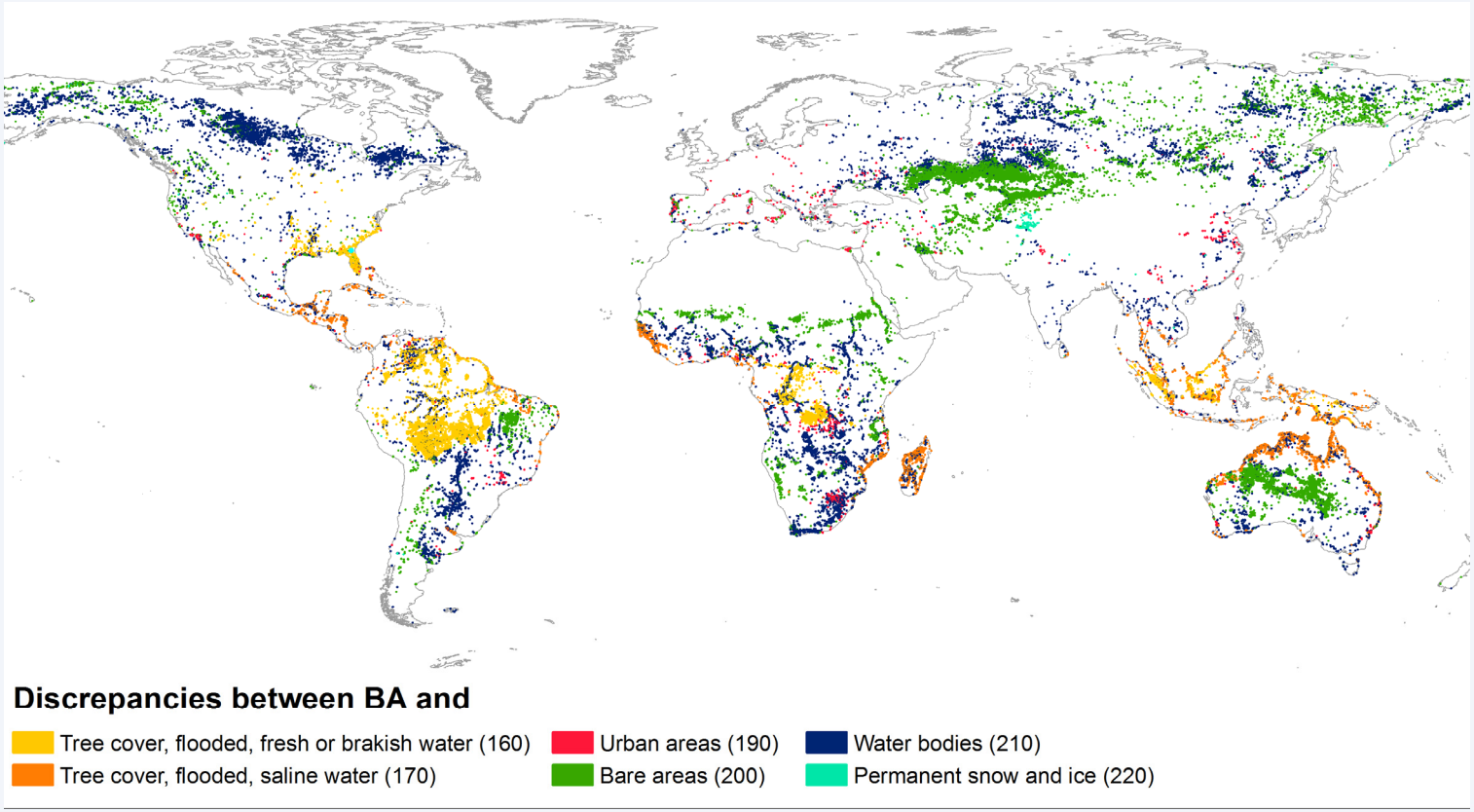
- discrepancies for pixels that are described simultaneously by a condition and a LC map class: water bodies (class 210) and permanent snow and ice (class 220)
- the permanency inferred by the LC state map definition should be confirmed by the condition and vice versa



Snow condition discrepancies against LC map class « permanent snow and ice »

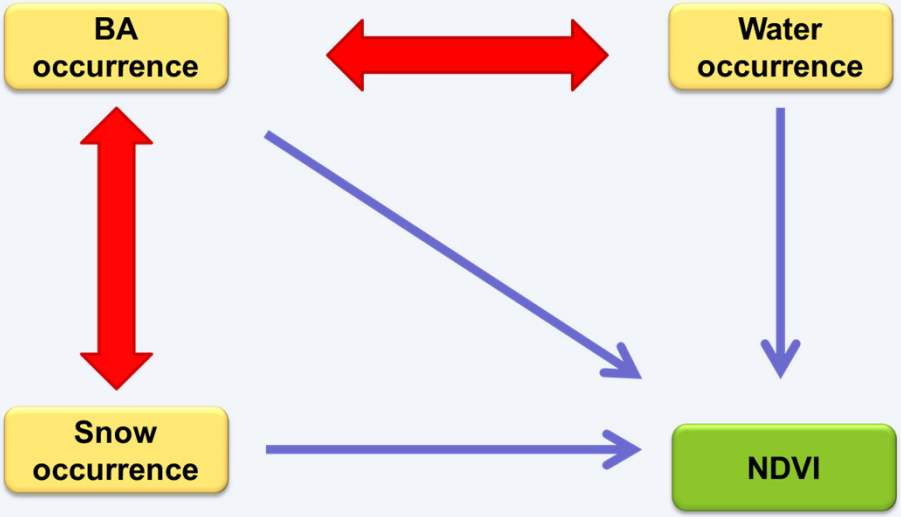
Plausibility

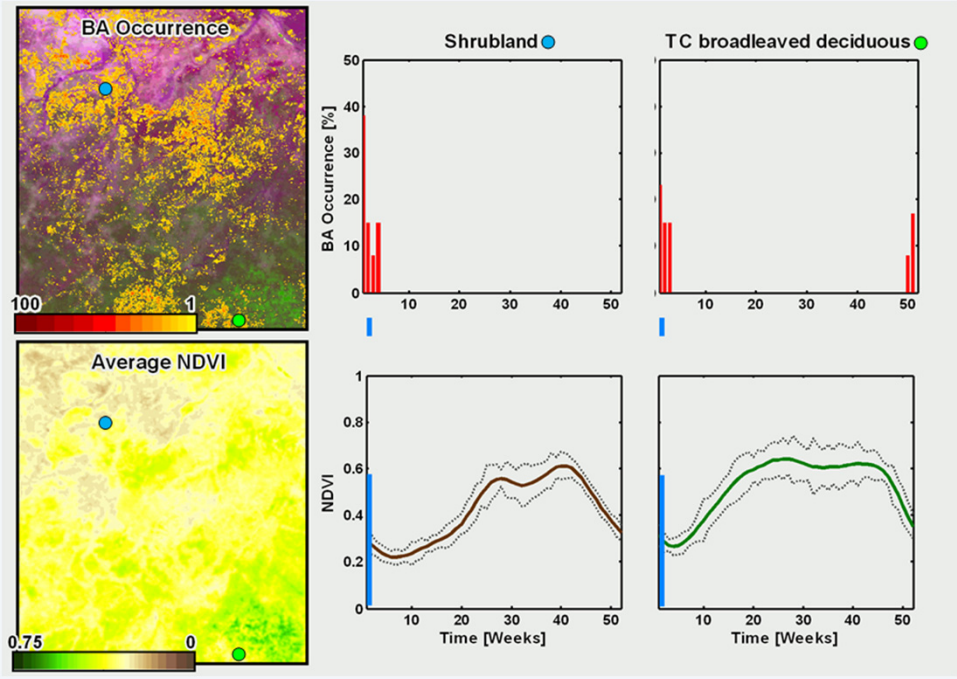
- for pixels that are not described simultaneously by a condition and a LC map class
- e.g. BA occurrence in LC map classes with little chance of burning



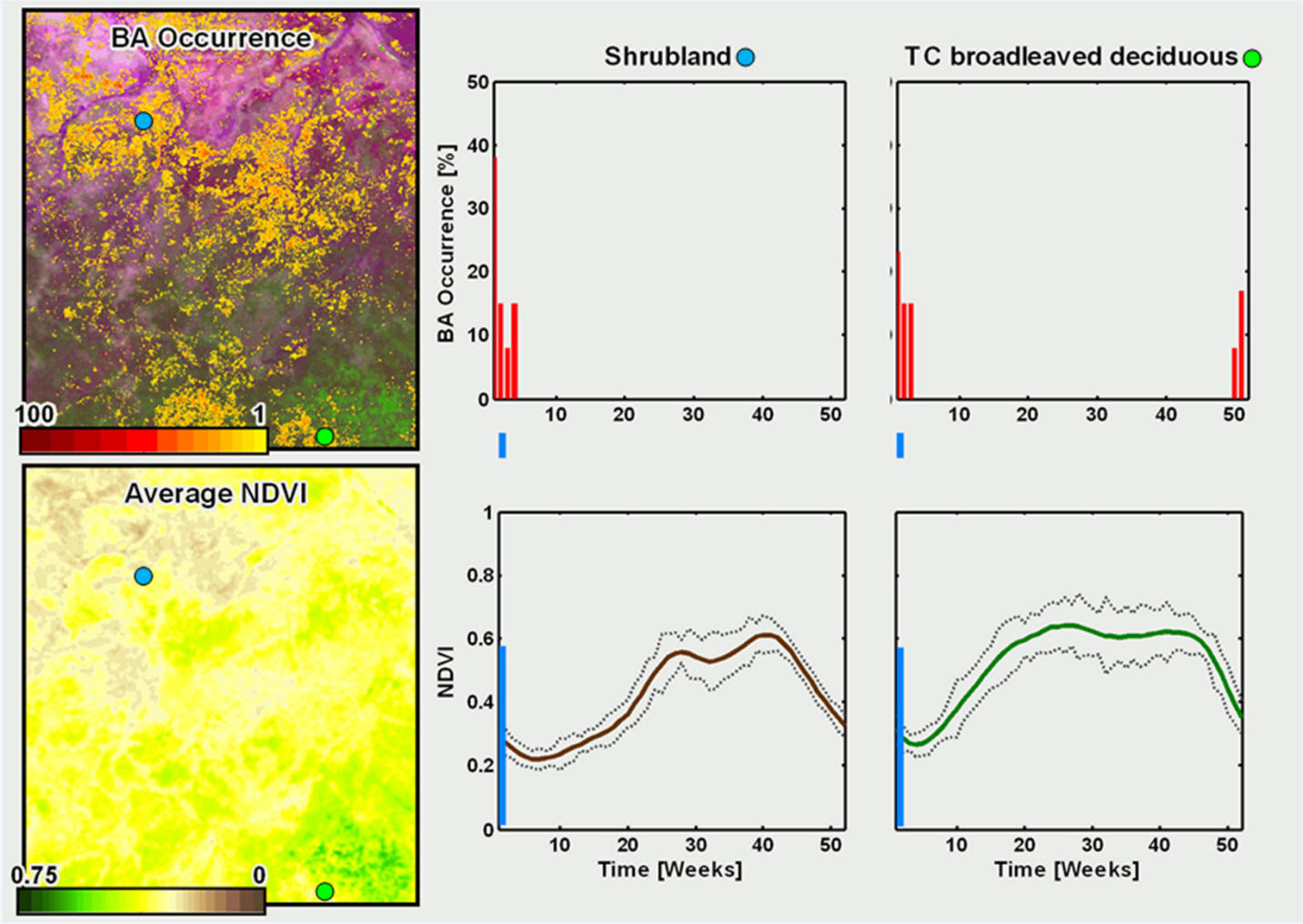
Discrepancy between conditions

- Mutually exclusive conditions





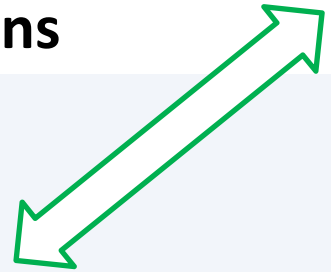
Temporality of events

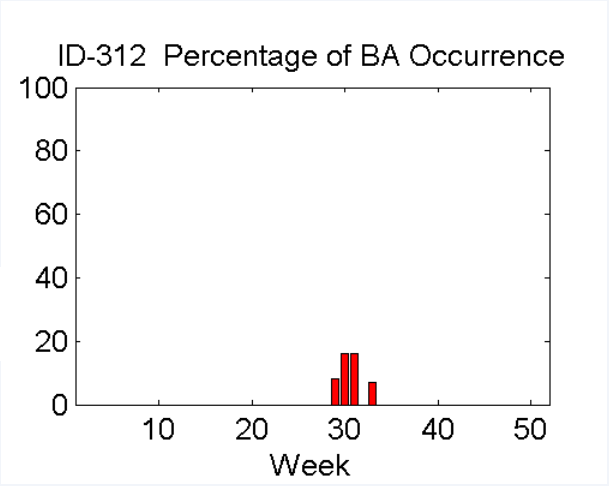


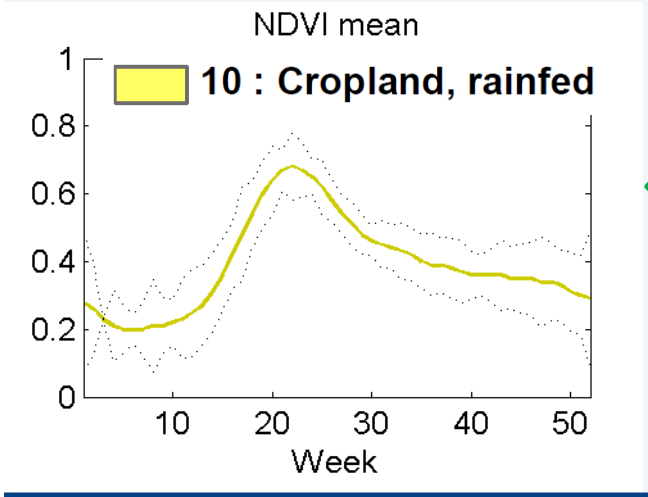
- Additionnal slides

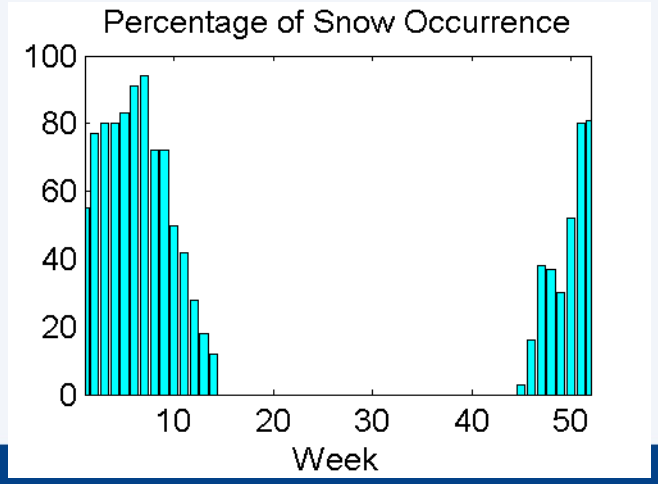
Consistency characterization

Between conditions

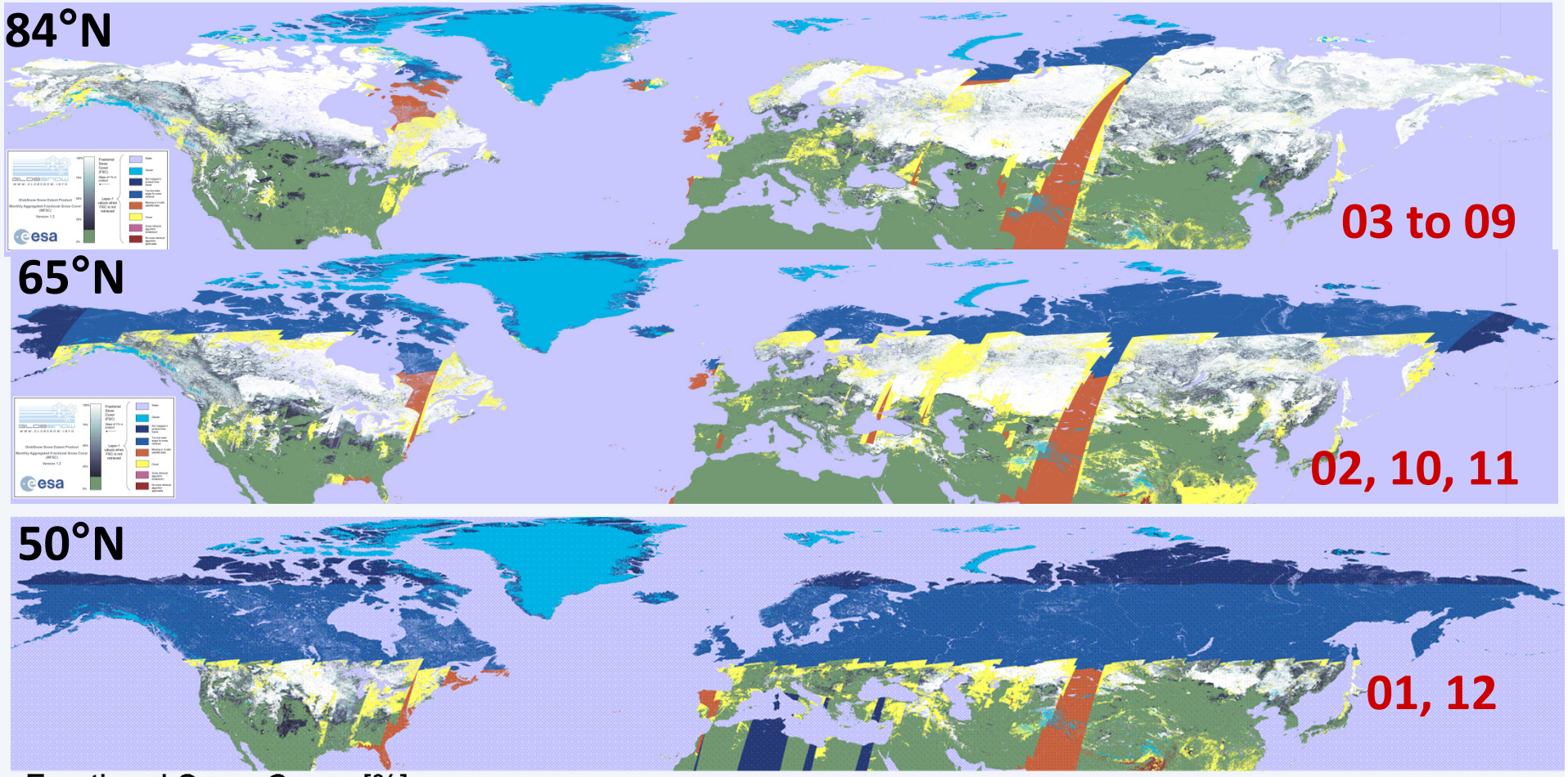




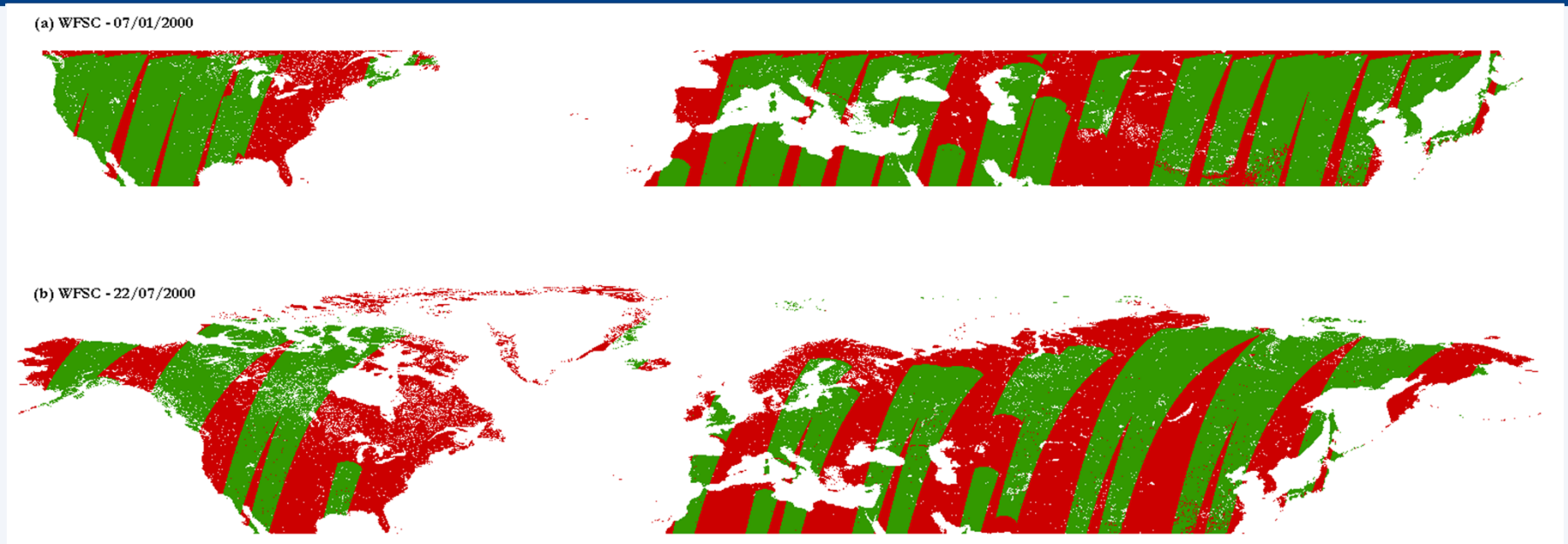




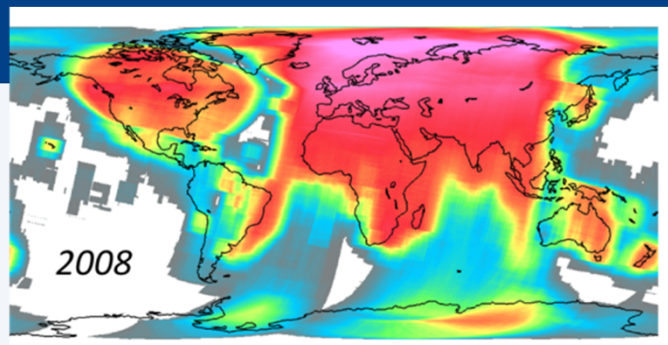
Globsnow extent



Low number of valid obs.



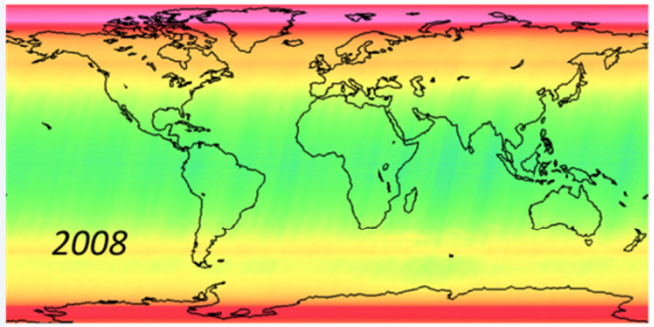
Representation of the spatial extent of valid (green) and invalid (red) observations for the Weekly Aggregated Fractional Snow Cover for 07/01/2000 (a) and 22/07/2000 (b). In (a), available data represents 63% of the area; in (b), 48%. Available observations include "FSC" and "Cloud" while invalid data gather zones "not mapped in the product time frame", with "too low solar angle for snow retrieval (<17°)", "Missing or invalid satellite data" and "No snow retrieval algorithm applicable". "Glaciers" and "Water bodies" were excluded from the analysis. When only "FSC" is considered, the percentage of usable data decreases to 35% (a) and 30% (b).



MERIS Full Resolution

13 June 2002 - 30 March 2012
Number of images available per year

1 25 50 75 100 150 300

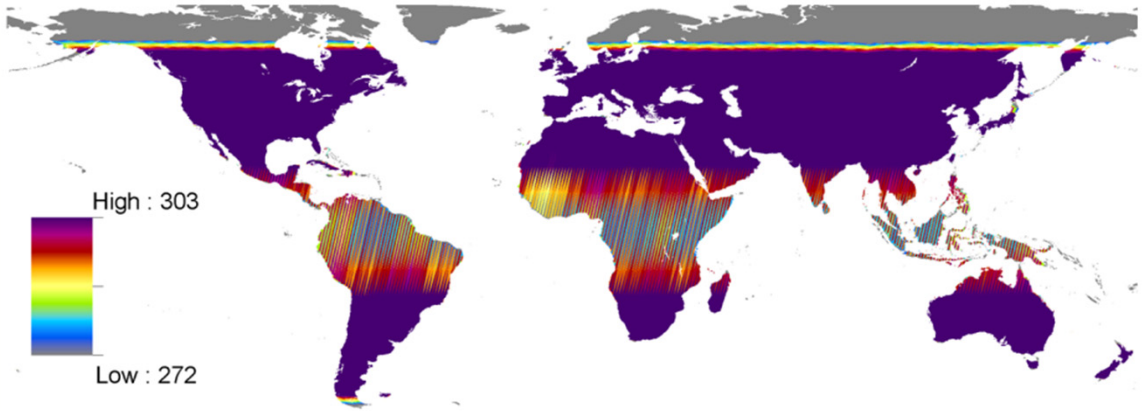


MERIS Reduced Resolution

13 June 2002 - 30 March 2012
Number of images available per year

1 100 150 200 300 500 900

SPOT-VGT S1 number of observations - Year 2008

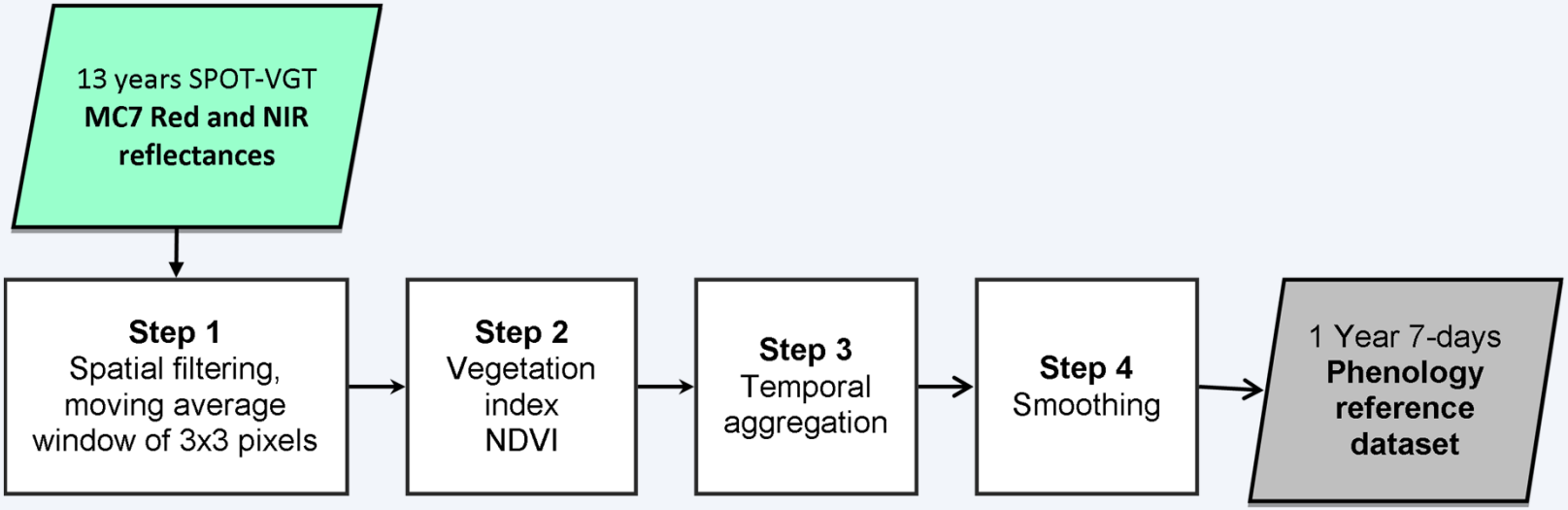


The larger number and distribution of valid observations from SPOT-VGT (bottom) is more suited for the NDVI condition production than the one of MERIS Full Resolution (top) and MERIS Reduced Resolution (center) datasets. Example of year 2008. The range is different for each colormap.

NDVI - methodology

- Based on daily surface reflectance SPOT-VGT S1
  - Global extent
  - 1km spatial resolution
  - Composited to 7days based on the Mean Compositing

(Vancutsem et al.., 2007)



Burnt Areas - methodology

- Based on the MODIS Direct Broadcast Monthly Burned Area:
  - Monthly layers of the « Julian day » of BA detections from 2000 to 2012
  - Global extent
  - 500m spatial resolution
  - HDF 1200km*1200km
  - Sinusoidal projection

Will be tested with the CCI-Fire Product

Snow - methodology

- Based on 8-day maximum snow extent (MOD10A2):
  - from 2000 to 2012
  - Global extent
  - 500m spatial resolution
  - HDF 1200km*1200km
  - Sinusoidal projection