EGU General Assembly 2020
Vienna | Austria | 3-8 May 2020

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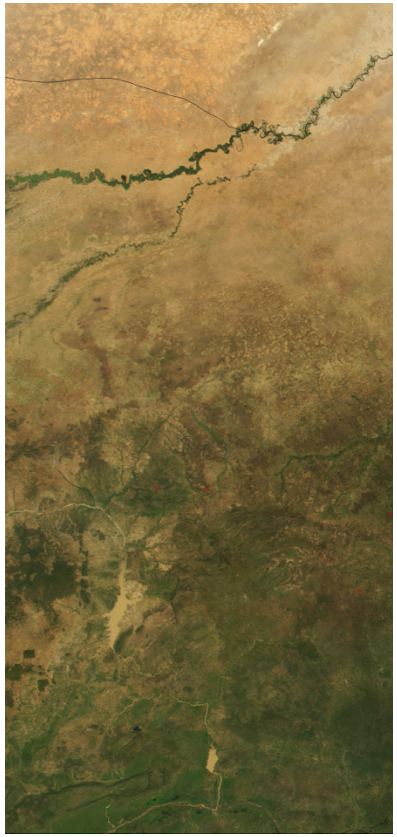
Hyperlinks to relevant papers are provided!

Understanding Turning Points in Dryland Ecosystem Functioning



Stéphanie Horion

Research programme for earth observation "STEREO III" Grant SR/00/339

belspo

Quick facts on U-TURN project

Project: *Understanding Turning Points in Dryland Ecosystem Functioning*

Main goal: Quantification of turning points in ecosystems functioning and drivers attribution by combining advanced Earth Observation (EO) techniques with Dynamic Vegetation Models (DVMs).

- Funded by the Belgian Science Policy Office (Grant SR/00/339)
- Budget: 887'925 Euros
- Timeframe: Dec. 2016 - April 2021
- Consortium of 6 partners: 3 Belgium, 3 international

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Defining interests and concepts

- A **turning point (TP)** is defined following Horion et al. (GCB, 2016) as:

  "a key moment in the ecosystem development where its functioning is significantly changed or altered without implying the irreversibility of the process, by opposition to the term 'tipping point' that implies irreversibility".

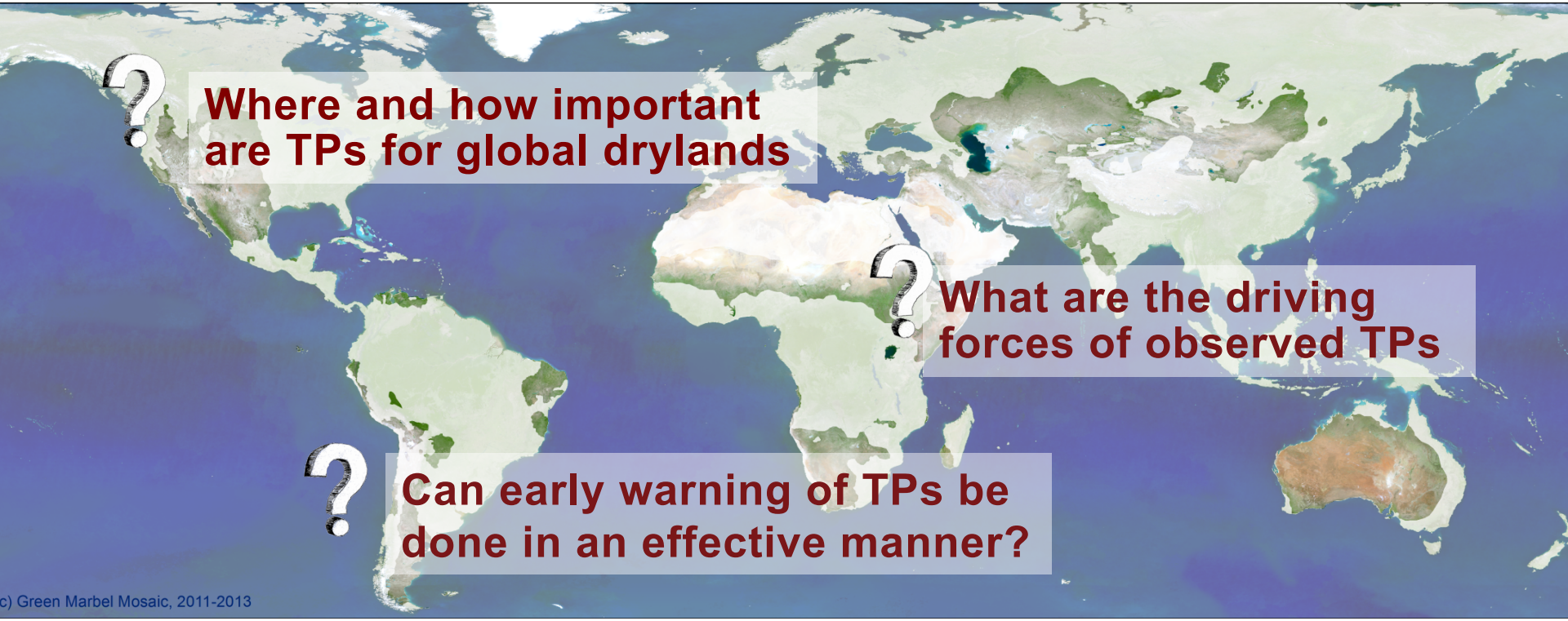
  Turning points in EF can be caused by e.g.
  - Climate extremes (e.g. severe droughts)
  - Land use land cover change
  - Climate / human -induced land degradation

- **Why are TPs interesting?** Hotspots where major changes occurred, hence **strategic areas for studying ecosystem resilience and stability**

Note: we are interested in change in ecosystem functioning EF defined as change in vegetation response to hydro-climatic conditions (Horion et al. 2016, 2019)

Project relevance and research questions

Drylands cover 40% Earth's land surface, account for 40% Global Net Primary productivity, are home to 30% population on Earth



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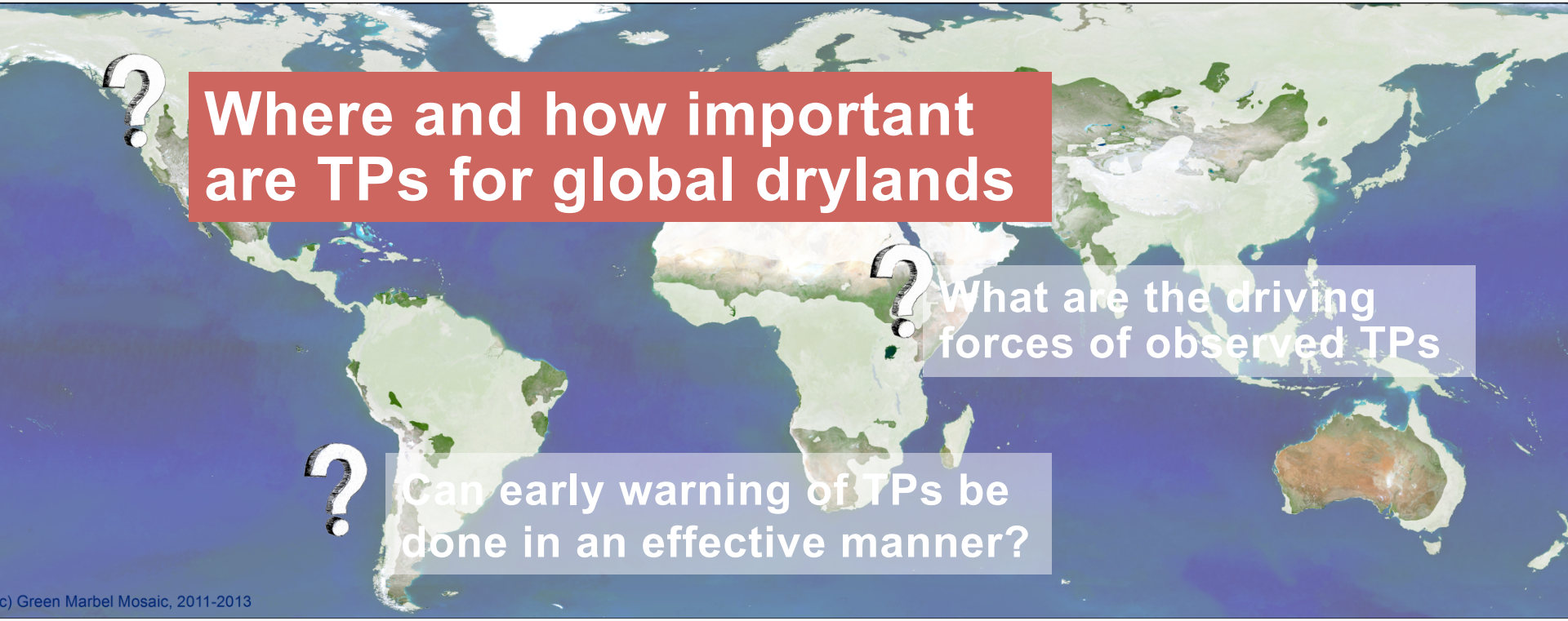
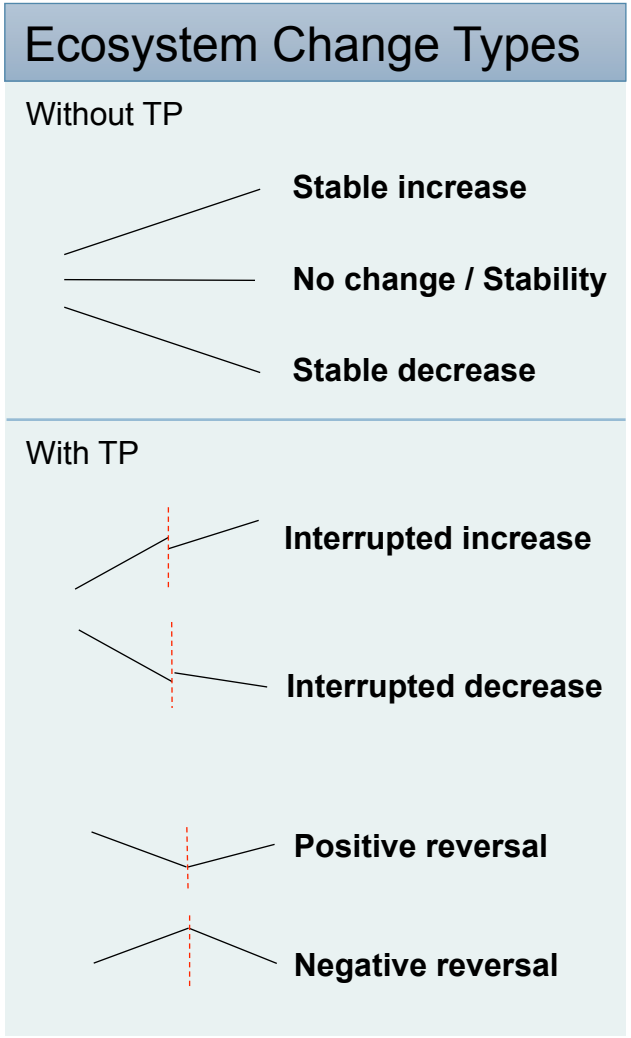


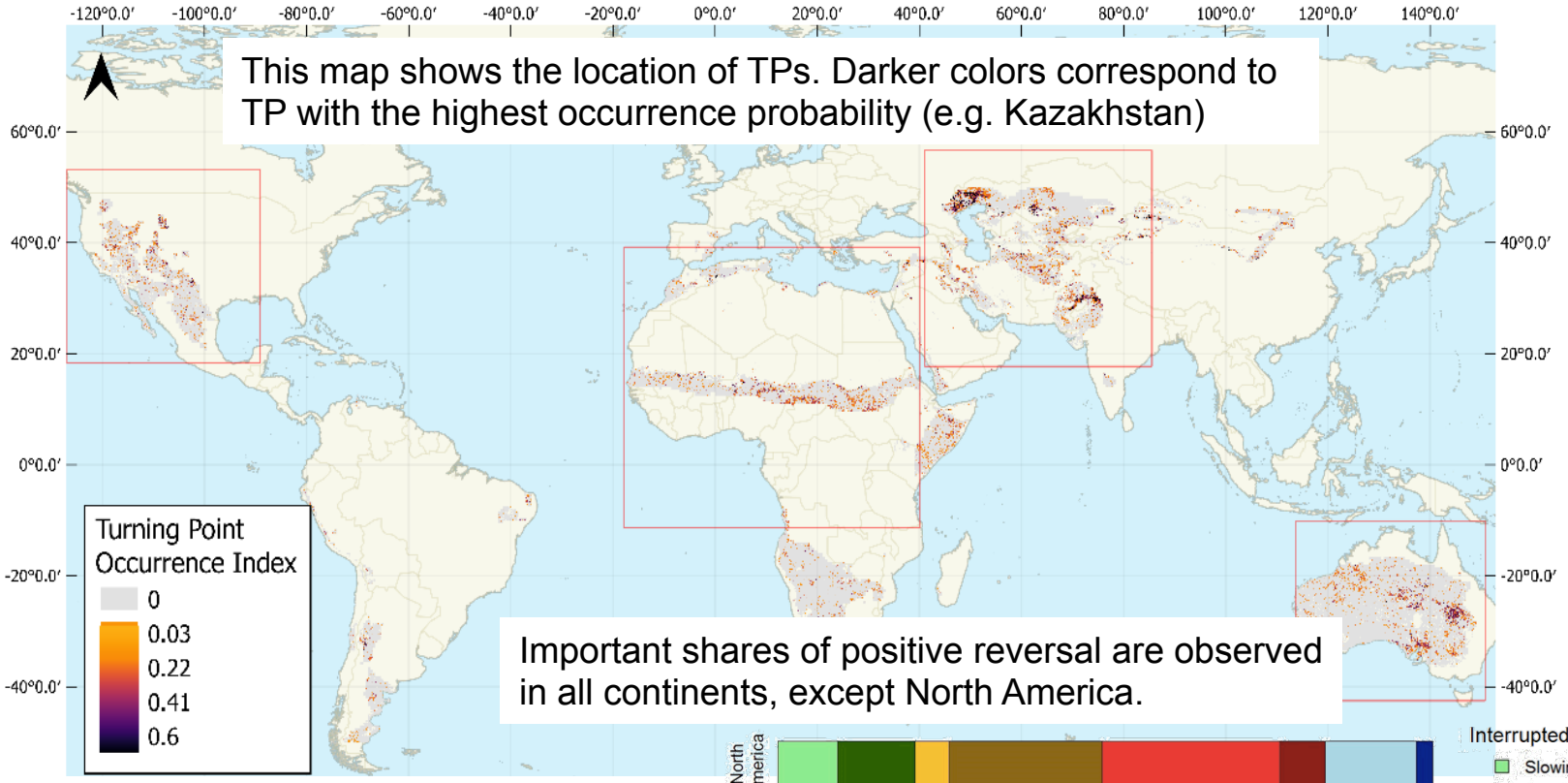
Mapping and characterizing TP for global drylands

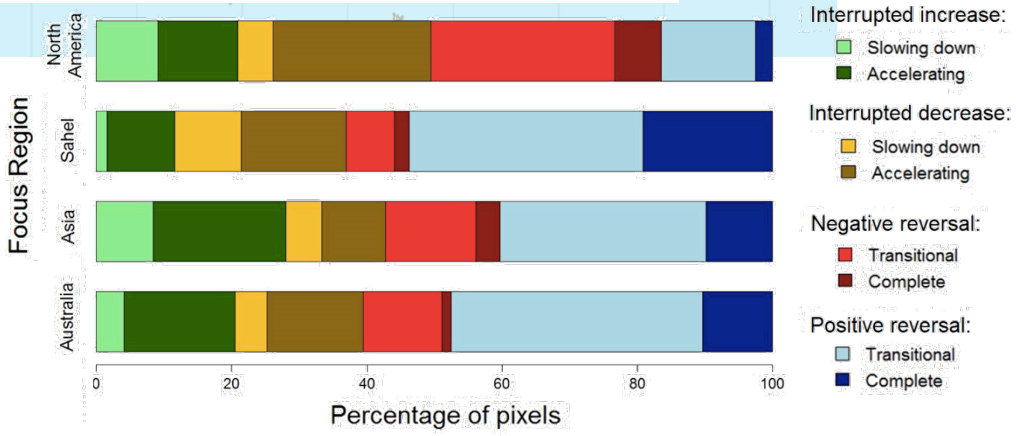


Key facts on data and method:

- EO based time series of rain- / water- use efficiency
- Segmented trend analysis (e.g. BFAST Verbesselt et al. 2010)
- Improved categorization of **Ecosystem Change Types** (Horion et al. LDD 2019, Bernardino et al., GEB 2020)
- Sub-types associated with rate of change (e.g accelerating, transitional)
- Probability of occurrence of TP

Mapping and characterizing TP for global drylands





[Bernardino et al., GEB 2020]

[EGU 2020] (live chat later this afternoon)

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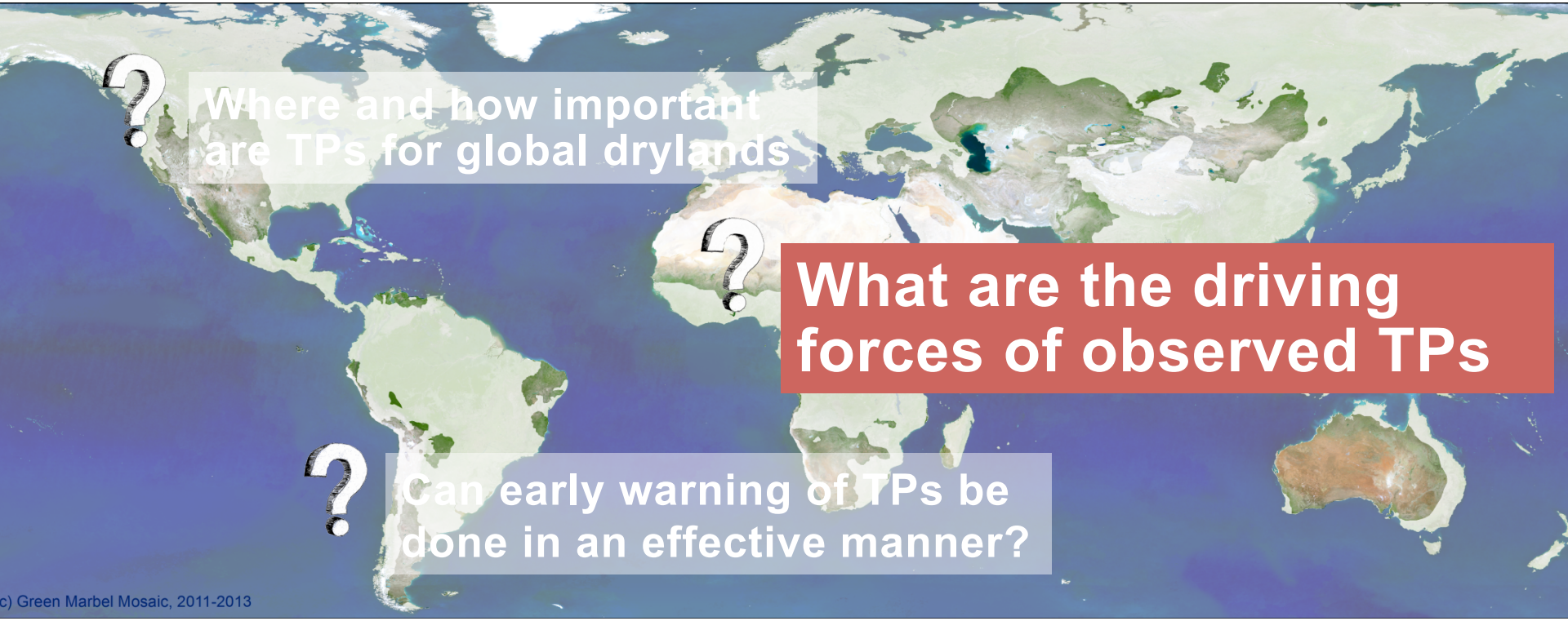
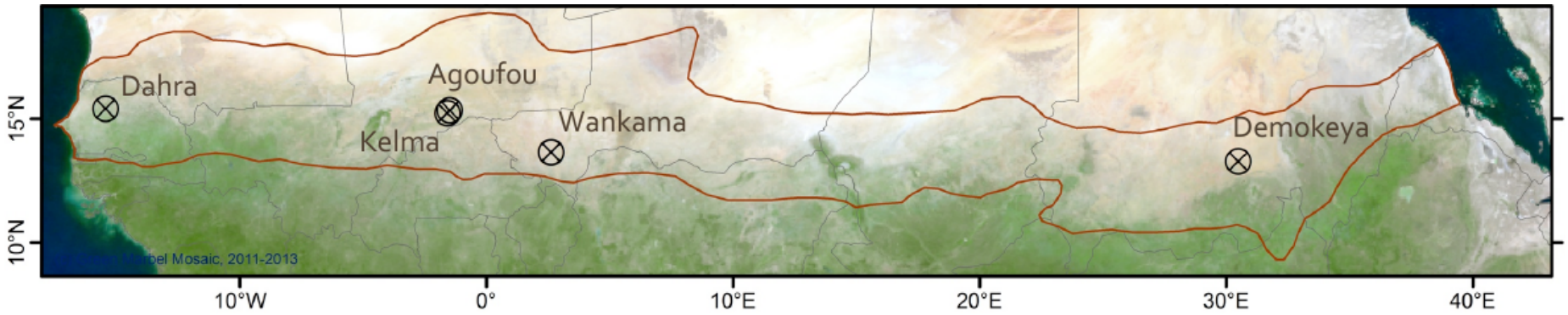


Coupling DVMs and EO for improved drivers attribution

'At any given place on Earth, complex human-environment interactions are at play, which include differing rates and magnitudes of drivers (e.g. overgrazing, climate change) and consequences (e.g. changes in productivity). WAD, 2019

Here, we use the Sahel as 'prototype' for drylands

- Selection of 5 focus areas (5deg. X 5deg.) centered on available flux towers



Prior coupling DVMs and EO data, key technical challenges needed to be addressed:

1. Retracing the history of Land Use Land Cover Changes in the Sahel at an adequate spatial resolution (i.e. below 100m)
2. Optimizing DVMs to dryland conditions (e.g. adjusting current PFTs to dryland ecosystems)

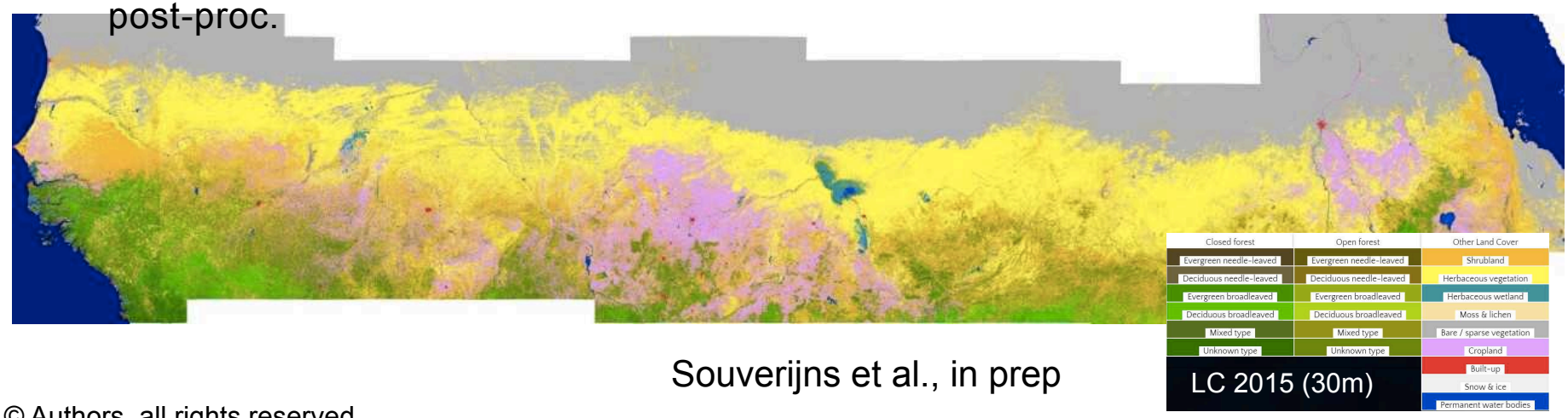
(1) Retracing the history of LULCC

Main challenges:

- high fragmentation of agricultural landscape, small scale field, fallow/crop rotation
- retracing LULCC back to the 80s due to low Landsat data availability
- produce time series of vegetation fraction cover for benchmarking the DVMs

Solution:

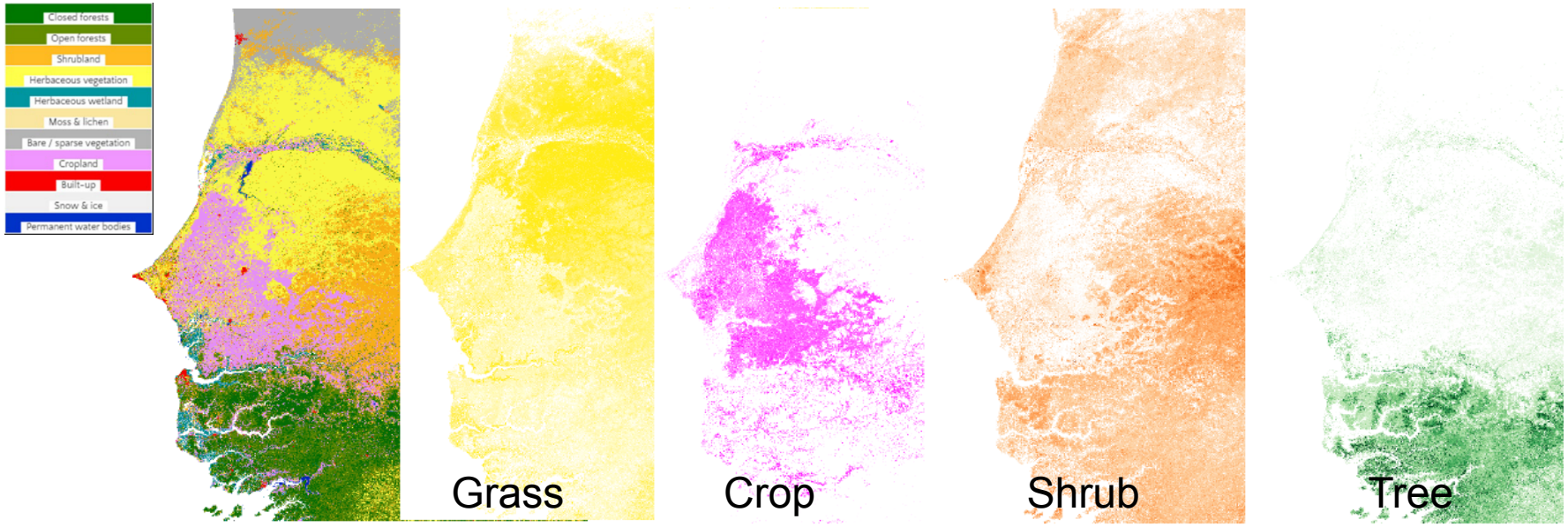
- Use of Landsat Archives and GEE to produce **yearly products between 2000-2015, and 5y epoch maps prior 2000 over 5 focus areas (5x5deg)**
- Full scale Sahel LULC map also available for 2015
- Classification scheme: Random forest supervised machine learning, Hidden Markov post-proc.



Souverijns et al., in prep

(1) Retracing the history of LULCC

In addition to LC map, Vegetation fraction covers also available for the focus areas as well as for the entire Sahel for year 2015



Souverijns et al., in prep

Training and validation

- Geowiki training data used for training and validation
- As FC are key information for DVMs simulation (either forcing data or validation), additional validation is on-going using VHR imagery

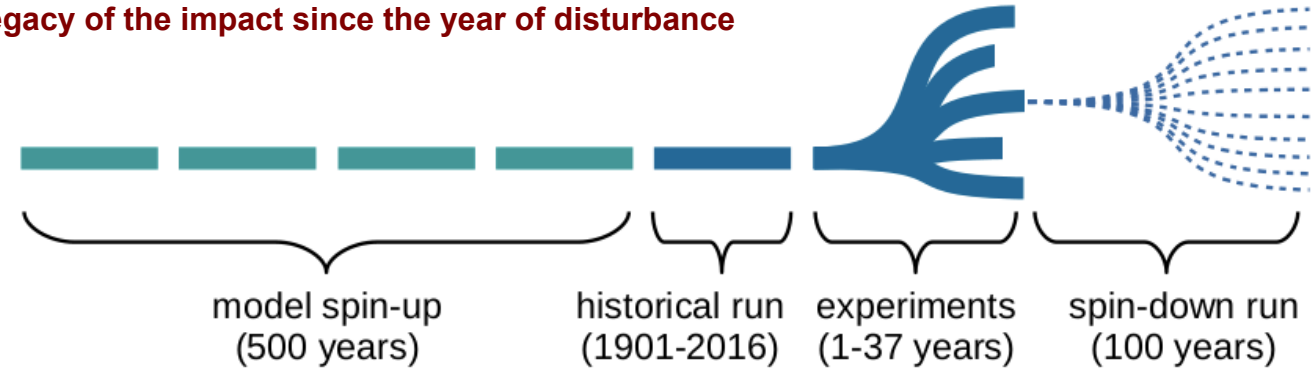
(2) Physically based insights from DVMs

- Use of 2 DVMs (LPJ-Guess and ED2) to gain insight on the drivers and mechanism of TPs
- Major technical step: DVMs optimization for dryland conditions (done for LPJ-Guess, on-going for ED2)
- Example use of LPJ-Guess to gain insight into vegetation response to extreme change in seasonal rainfall characteristics:

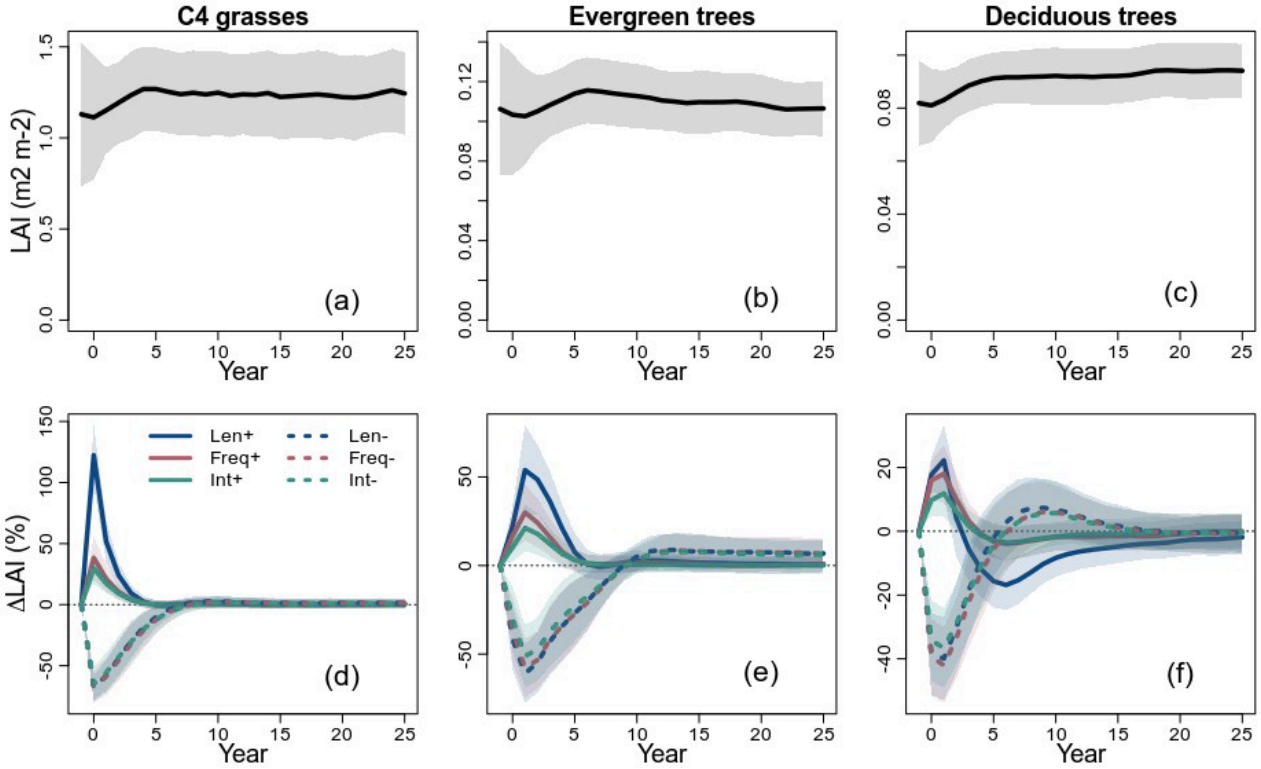
Disturbance of total rainfall by ±2σ by manipulating either event frequency, season length or event intensity

- We run our model experiments on the site-level at four fluxtower locations.
- Resample other meteorological drivers for internal consistency
- Study the **magnitude and legacy of the impact since the year of disturbance**

Verbruggen et al, submitted



(2) Physically based insights from DVMs



Contrasting responses of PFTs to changes in rainfall characteristics

Differences due to carbon allocation and root distribution: lower soil layer integrates precipitation over longer time frame.

	C4 grasses	Trees
Peak impact	During year of disturbance	Following year of disturbance
Sensitivity	Highest response to increased season length	Lower amplitude than for grasses, especially for longer season
Legacy	Decay after 4-6y	Longer legacy of disturbance (5-20y)

Verbruggen et al, submitted

Work in progress

- Modeling large scale vegetation die-offs using EO and DVMs
- Quantifying change in human appropriation of dryland ecosystems
- Testing EW proxies of TPs

Take-home messages

- **The new ecosystem state assessment method (*)** is a valuable for expert decision making as it highlights **hotspots of potentially altered ecosystems**
- **We retraced the history of LULCC in Sahel back to the 80's**
  LULC products at 30m resolution to be released on Zendono
- **LPJ-Guess is optimized to dryland conditions (*) and provided new insights into the drivers of TPs**

(*) codes and dataset available on demand, codes soon to be released on Github

The U-TURN consortium

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. Jan Verbesselt (WU)
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Thank you!

For more information: U-TURN website

I'll be happy to answer you questions during the live chat or via email (Stephanie.horion@ign.ku.dk)

Research programme for earth observation "STEREO III" Grant SR/00/339

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