

# Spatiotemporal dynamics in remotely sensed soil moisture and their impact on the carbon cycle

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## The Global Carbon Budget 2014



 $E_{FF} + E_{LUC} = G_{ATM} + S_{OCEAN} + S_{LAND}$ 

Land sink is estimated as remainder of other sources



DGVM ensemble (yellow)

Potential climatic constraints to plant growth derived from long-term climate statistics



Modified from Nemani et al. (2003), Science. Image credit: Jonathan Barichivich



# Will this pattern change with predicted climate change?



[IPCC, AR5, 2014]

# Changes not only in averages but also in extremes

#### Predicted changes in extremes (1980-1999 to 2081-2100)

#### % days with Tmin > 20°C



#### P intensity wet days



#### # Consecutive dry days





Dryness

0.75





#### [Seneviratne, IPCC-SREX, 2013]

# Effects of drought on the carbon cycle





[Van der Molen et al. (2012), AFM]

# **Vegetation observables from space**



# Microwave earth observations of soil moisture

Climatology of ESA Climate Change Initiative multi-satellite soil moisture





[Based on Liu et al., 2011, HESS, Liu et al., 2012, RSE]

## Soil moisture as driver of vegetation "greenness"

Correlation between summer (JJA) GIMMS NDVI3G and:

- a) Temperature CRU TS3.20
- b) Precipitation GPCC
- c) Drought index- scPDSI
- d) Soil moisture soil wetness





Correlation between CCI soil moisture and leading Empirical Orthogonal Function (EOF) of *Araucaria* tree ring archives (1979-2000)





[Muñoz, A. A. et al. (2014). Austral Ecology; image courtesy http://www.wikipedia.org]

## Direct assimilation of soil moisture into DGVMs

Assimilation of ASCAT **soil moisture**, TIP **fAPAR** and **CO<sub>2</sub>** from flasks into **BETHY** Dynamic Global Vegetation Model



[Scholze et al., in prep]

## Trends in soil moisture and vegetation

Trends (1988-2010) in CCI soil moisture and multi-satellite vegetation greenness



#### [Dorigo, W.A et al., 2012, GRL]

Trends (1988-2010) in microwave and land surface model soil moisture estimates, and satellite-based precipitation







ERA Interim soil moisture







[Dorigo W.A. et al., 2012, *GRL*]

# What is the role of climate oscillations?

### Complex Emprical Orthogonal Functions of CCI soil moisture



# Increasing frequency of extreme El Niño events due to greenhouse warming

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# **Relationship between ENSO and the land surface**

 Effect of El Niño Southern Oscillation on evaporation (GLEAM), soil moisture (ESA CCI) and NDVI (GIMMS 3G)





[Miralles, D. et al. 2014 Nature Climate Change]

# **Conclusions and outlook**

- Satellite products have a large potential for better understanding the interaction between soil moisture and vegetation.
- Effects of soil moisture take effect at **different temporal scales**:
  - Intra- and interannual variability
  - Extremes (droughts)
  - Trends
- EO data can help to improve Earth System Models and, hence, predictions of atmospheric CO<sub>2</sub> and ultimately global warming and climate change
- Understanding uncertainties, characteristics, and stability of EO data is crucial





# **Interested?**

# 1 project assistant (Postdoc) 1 project assistant (Phd-student)

Use EO data to quantify role of soil moisture in driving vegetation dynamics
Benchmark DGVMs and Earth System Models for soil moisture – vegetation coupling

- Quantify impact of climate change on soil moisture dynamics
- Assess impact of global water cycle acceleration on vegetation

Start: Summer/Autumn 2015 at TU Wien

Several longer visits at partner research institutes are foreseen

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**Fast**Opt