ETH

Eidgenössische Technische Hochschule Zürich
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Soil moisture: Component of the climate system, model variable or observation dataset?

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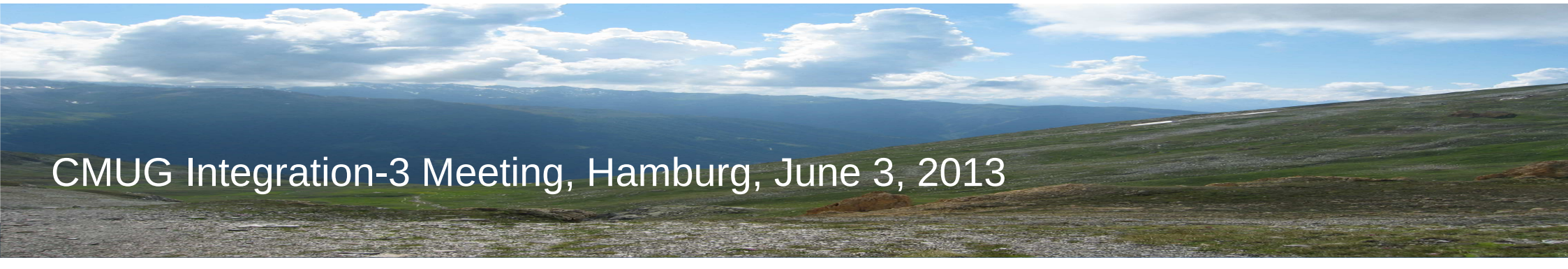


CMUG Integration-3 Meeting, Hamburg, June 3, 2013

Outline

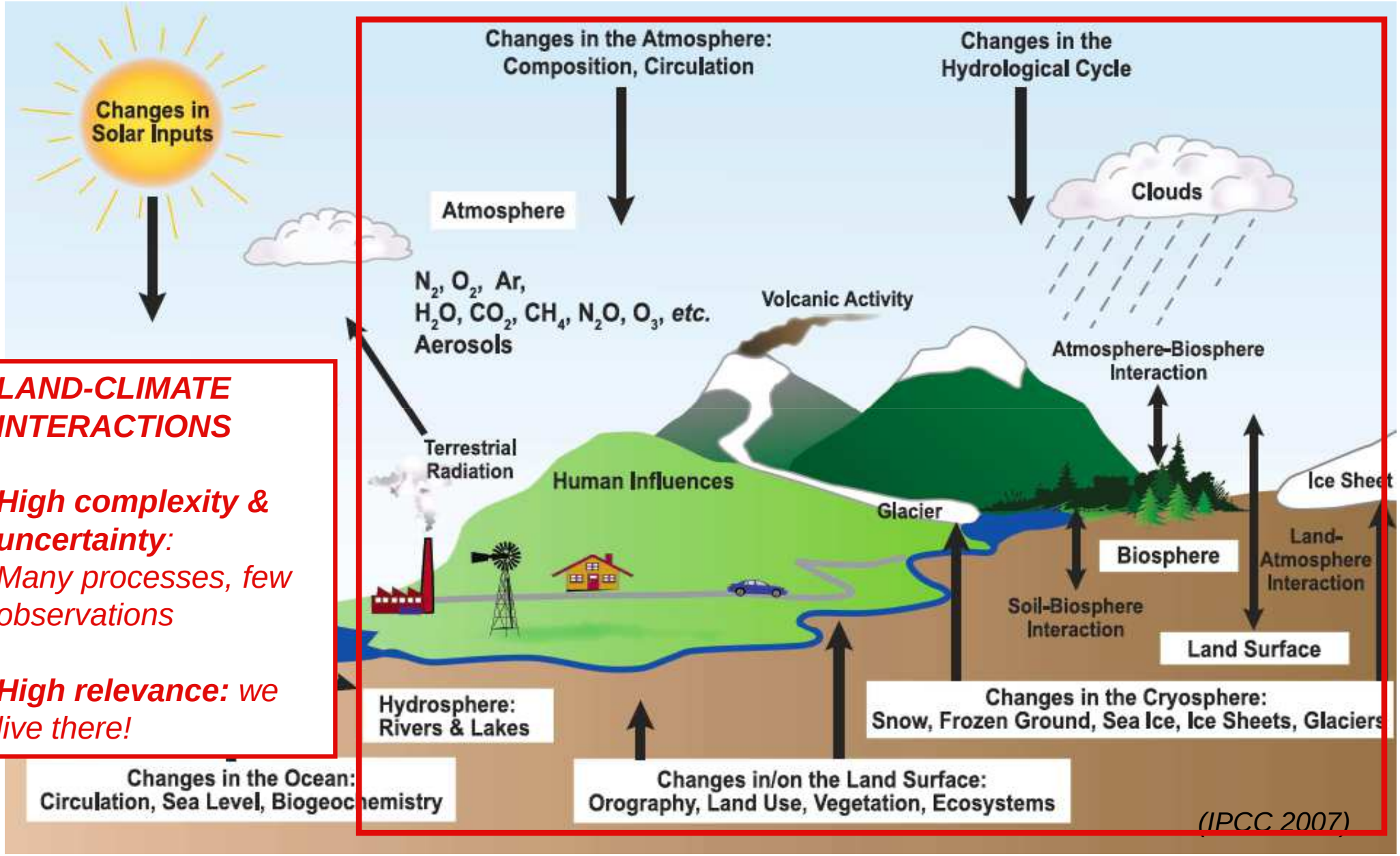
Introduction

Soil moisture in the climate system

Relevance of remote sensing-based soil moisture estimates

Conclusions

Introduction: Land surface processes in the climate system



LAND-CLIMATE INTERACTIONS

High complexity & uncertainty: *Many processes, few observations*

High relevance: *we live there!*

Soil moisture: Climate impacts

What is soil moisture?

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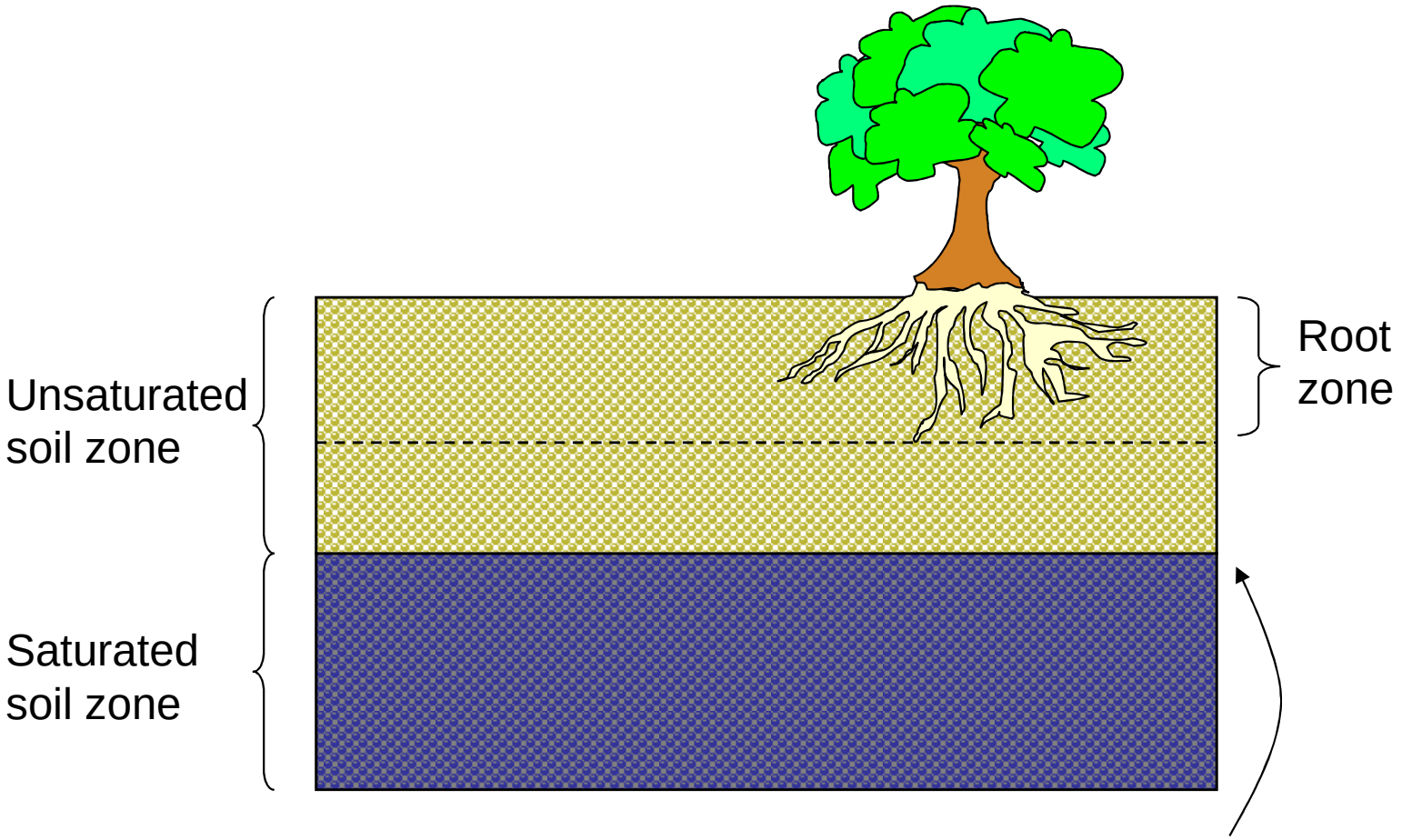

(Seneviratne et al. 2010, Earth-Science Reviews)

What is soil moisture?

The definition of soil moisture is complex:

What is relevant?

- Surface (2cm) soil moisture (retrievable from microwave remote sensible)
- Root-zone storage (about 30-100cm, variable in time)
- Total water storage (also includes snow, groundwater, surface water)

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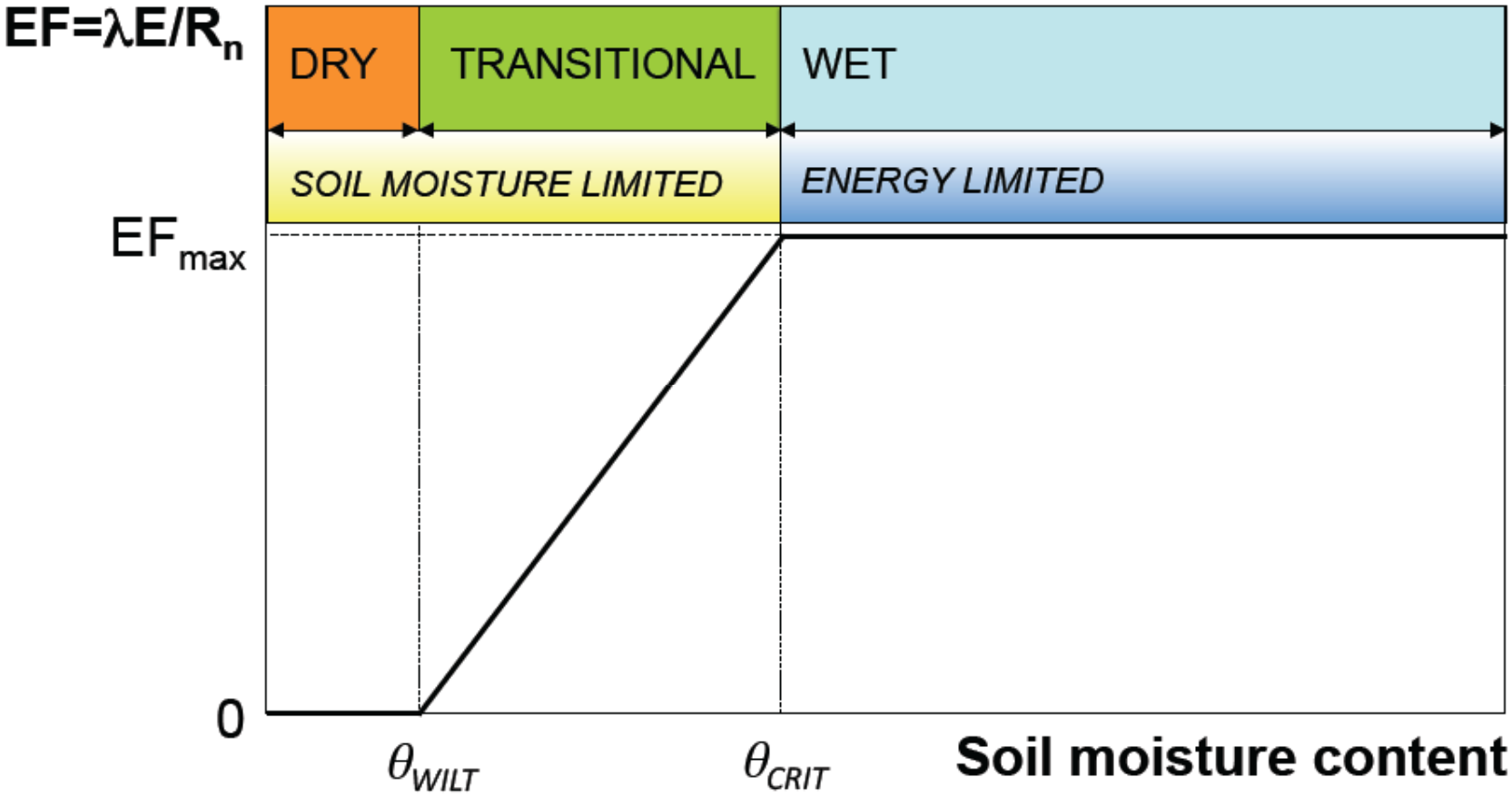
Impact of soil moisture on plant activity

(see also Budyko 1956)

Evaporative fraction



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Impact of soil moisture on plant activity

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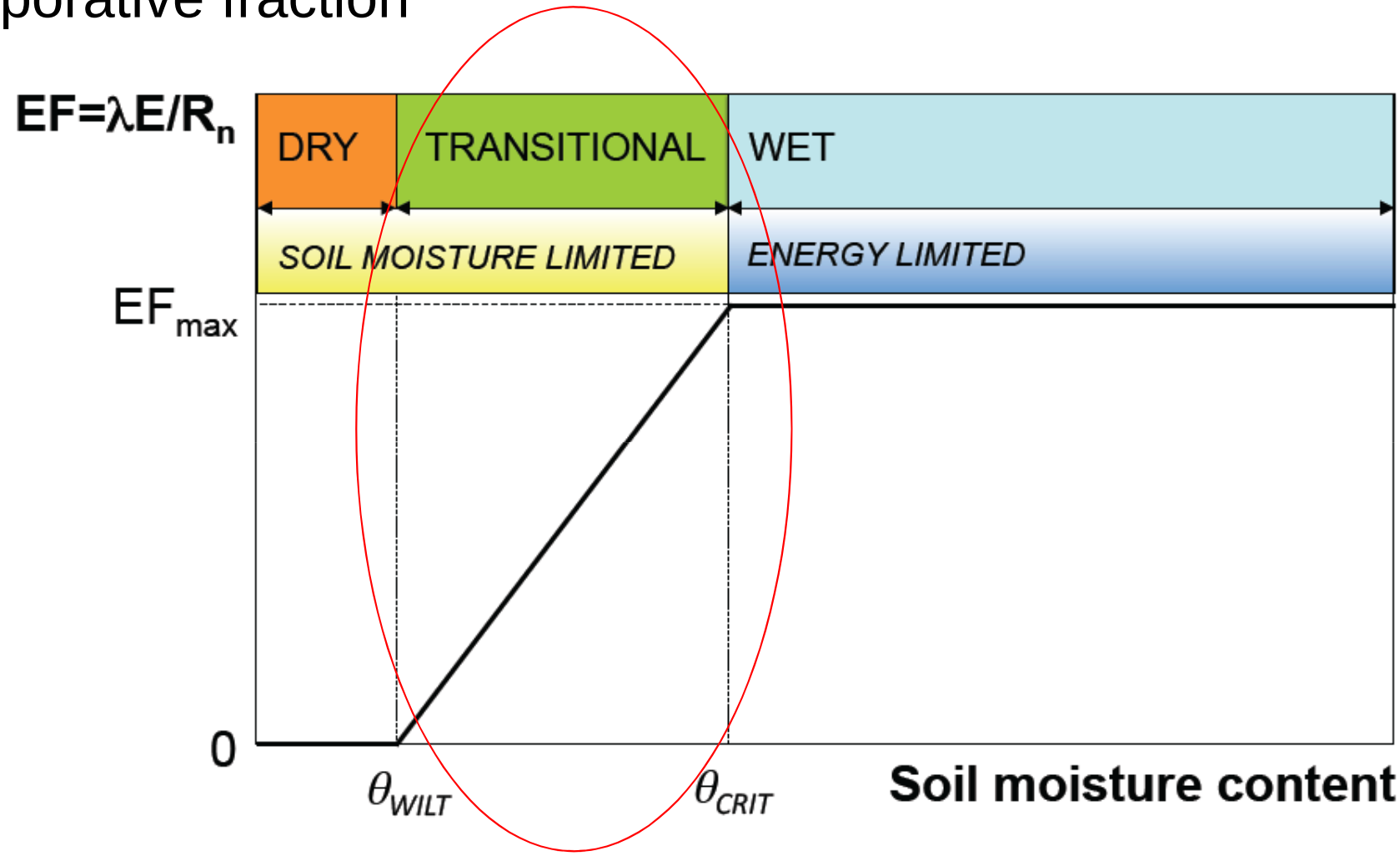
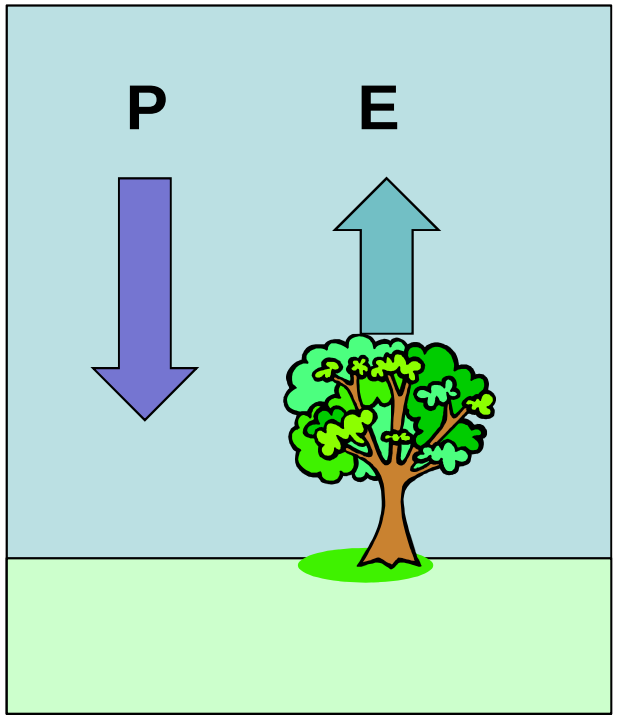


(Seneviratne et al. 2010, Earth-Science Reviews)

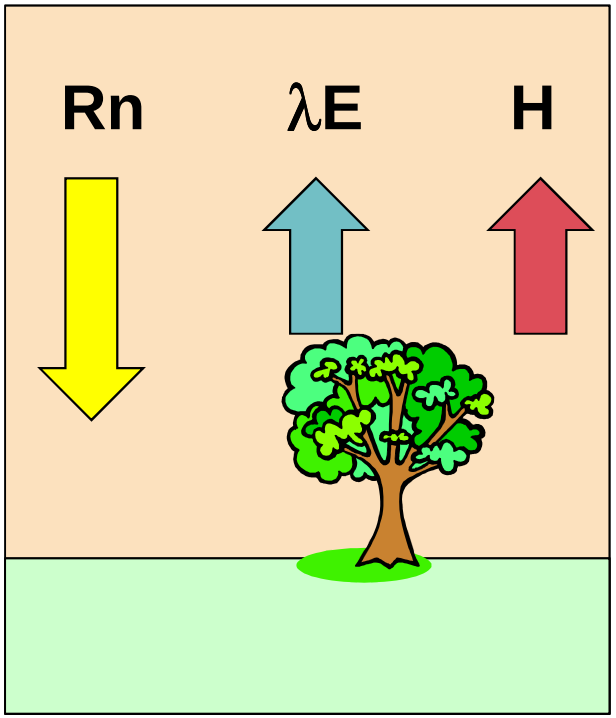
Soil moisture: Impact on water, energy and carbon balances

Water



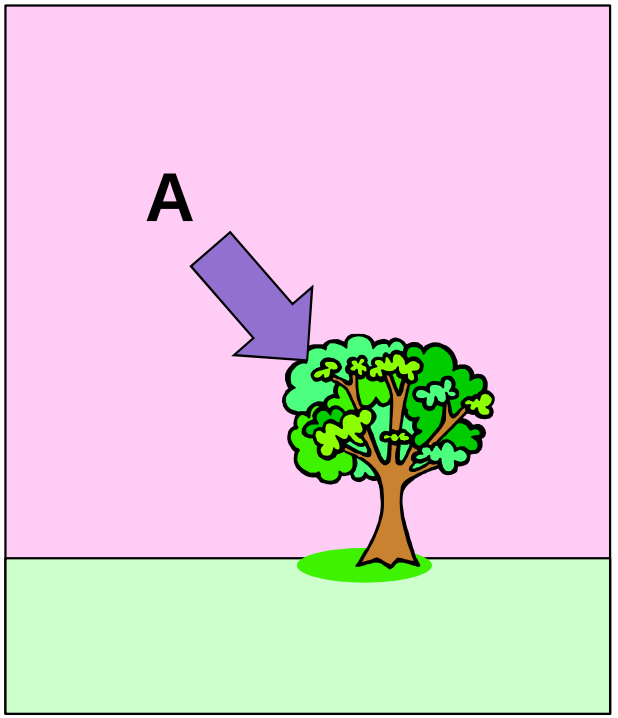
E=60%P

Energy



λE=50-60%Rn

Carbon



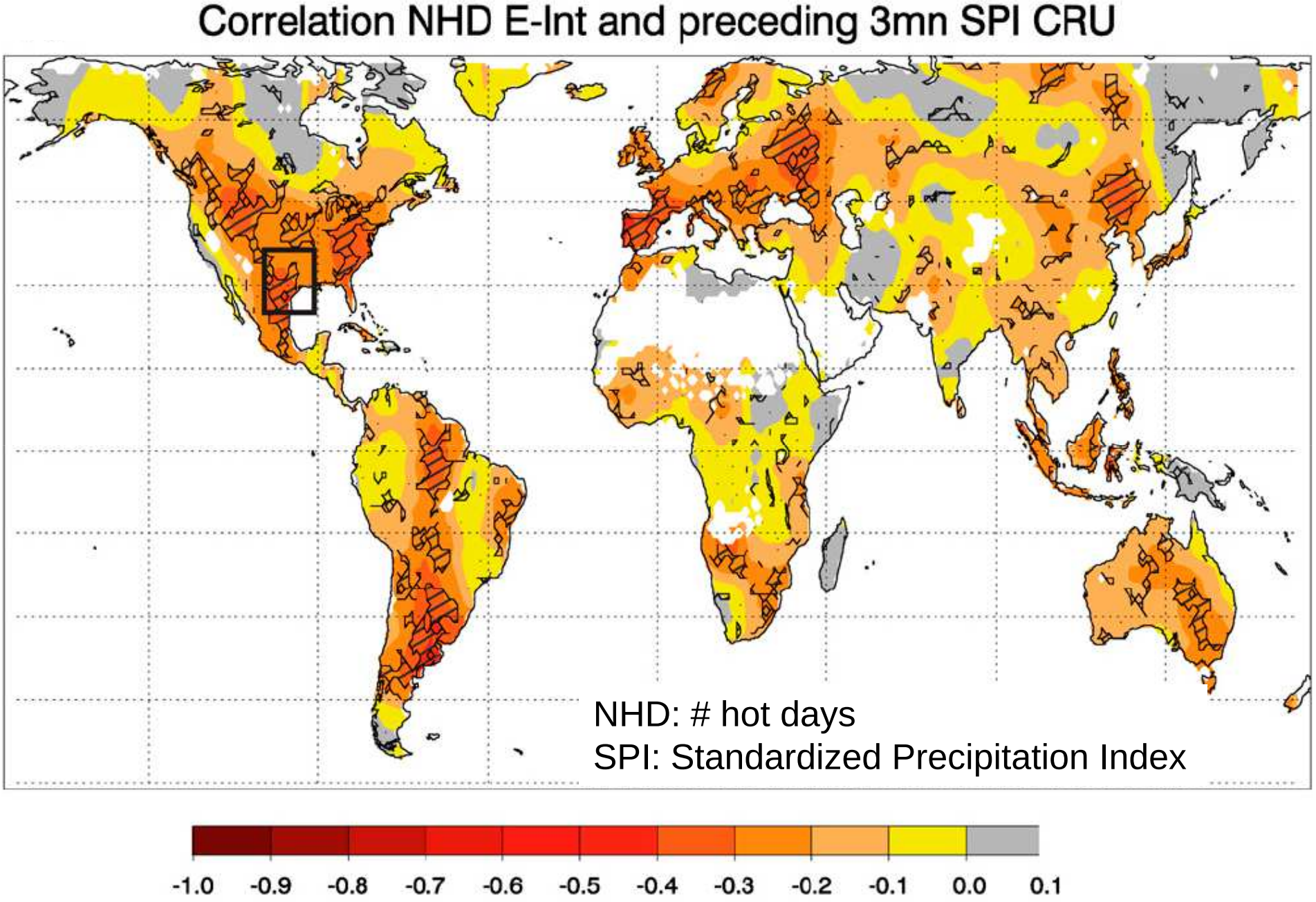
A is a sink for 30% of C emissions

Soil moisture-temperature coupling from observational data (global-scale analysis)

- **Temperature extremes**: Number of hot days per month (summer)
  - Number of days with maximum daily temperature above 90th percentile
  - **From reanalysis data (ERA-Interim, CFSR, MERRA)**
  - **Focusing on *hottest month at each location***

- **Drought index**
  - SPI: Standardized precipitation index
  - Accumulated precipitation over time frame preceding considered summer period **(3, 6 and 9 months)**
  - Calculated from observational precipitation **(CRU, GPCP, CPC)**

Soil moisture-temperature feedbacks from observations



(Mueller and Seneviratne 2012, PNAS)

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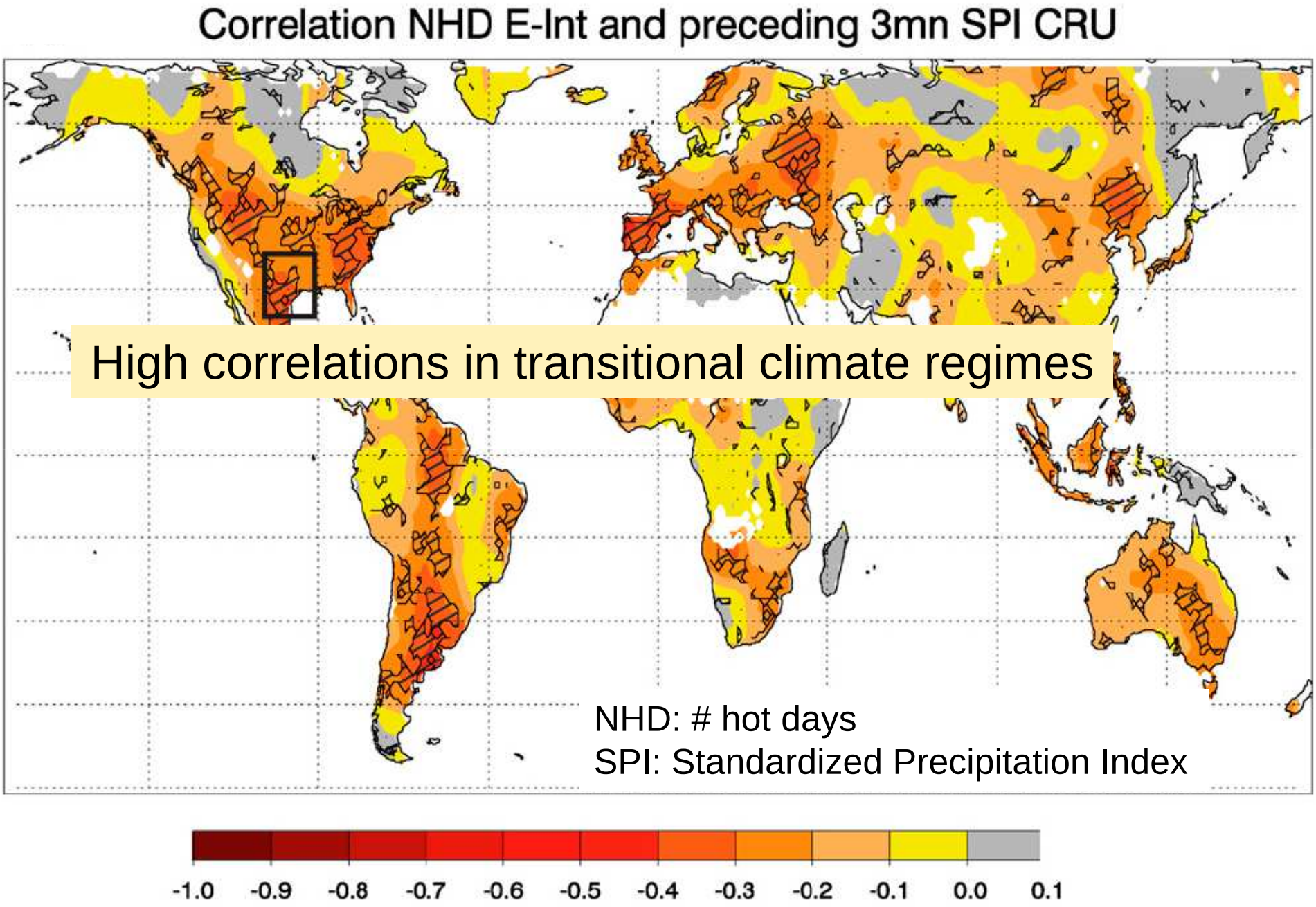

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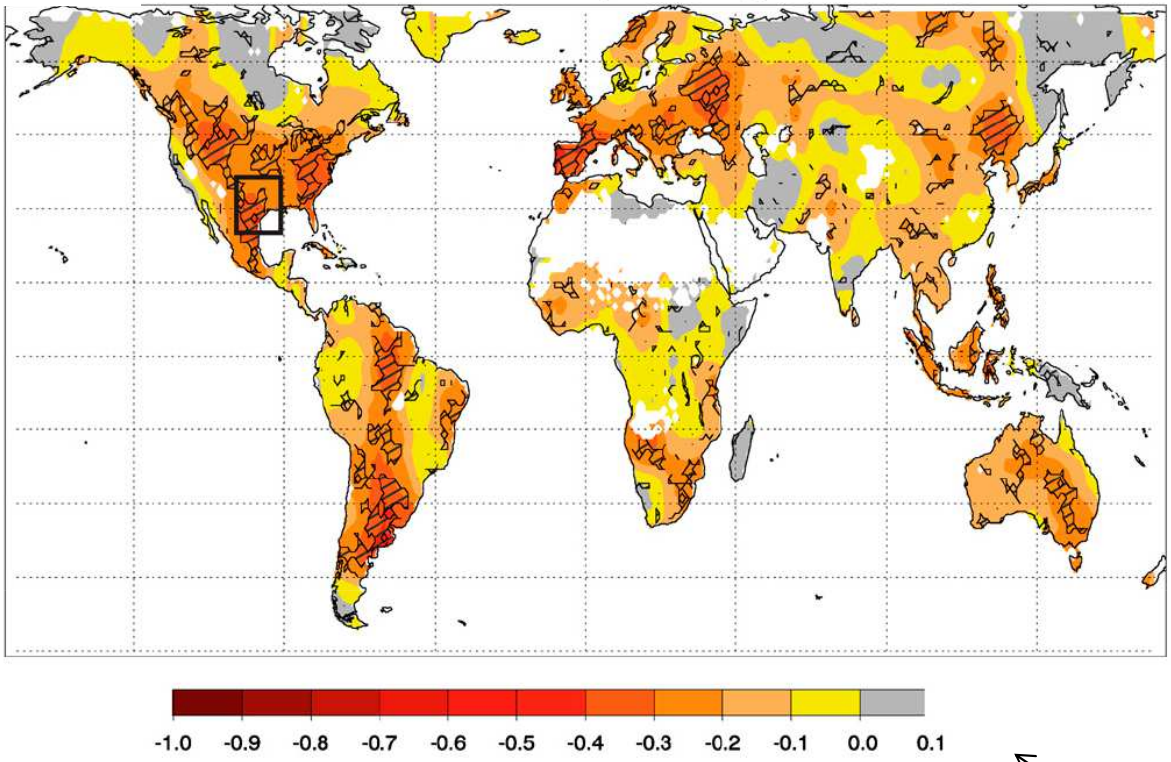
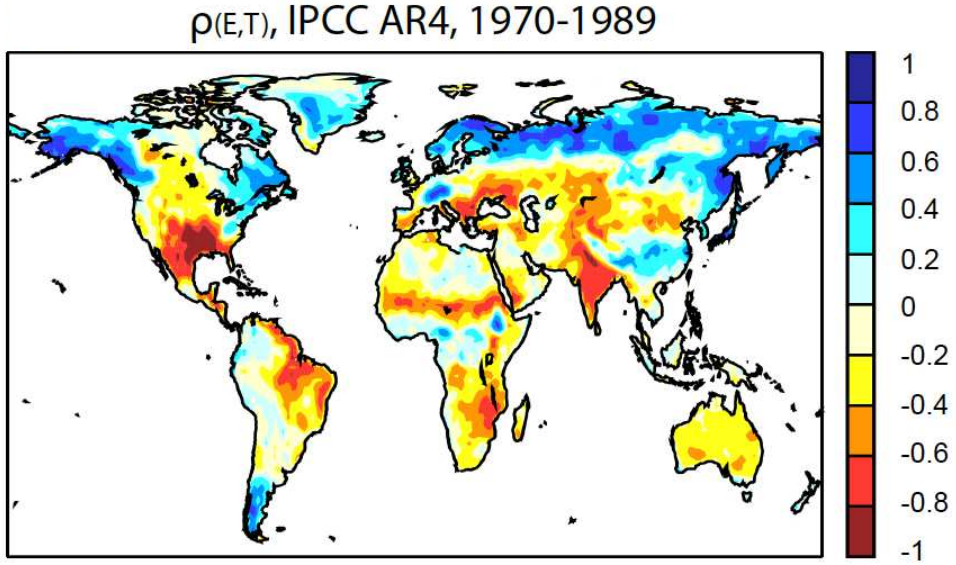


hottest month



JJA

Patterns of correlation are similar to model-based estimates of evaporative regimes

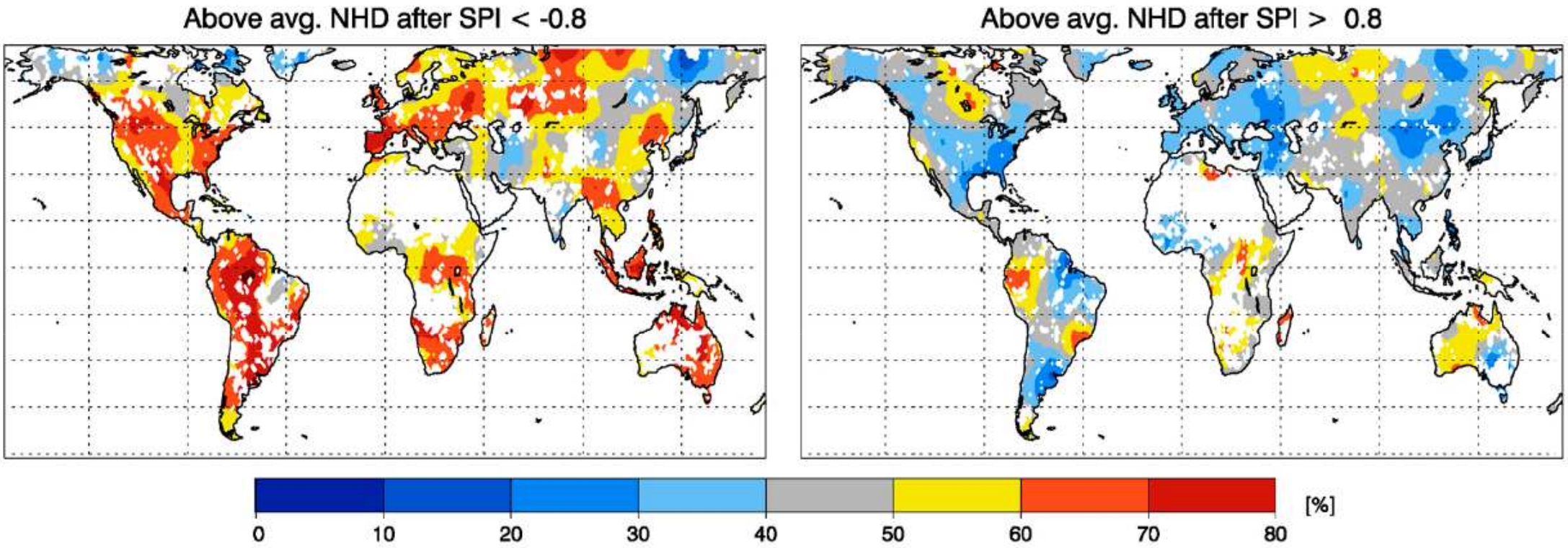
NHD: # hot days
SPI: Standardized Precipitation Index

(Mueller and Seneviratne 2012, PNAS)

(Seneviratne et al. 2006, Nature)

Soil moisture-temperature feedbacks: Predictability

Link to forecasting: conditional probability



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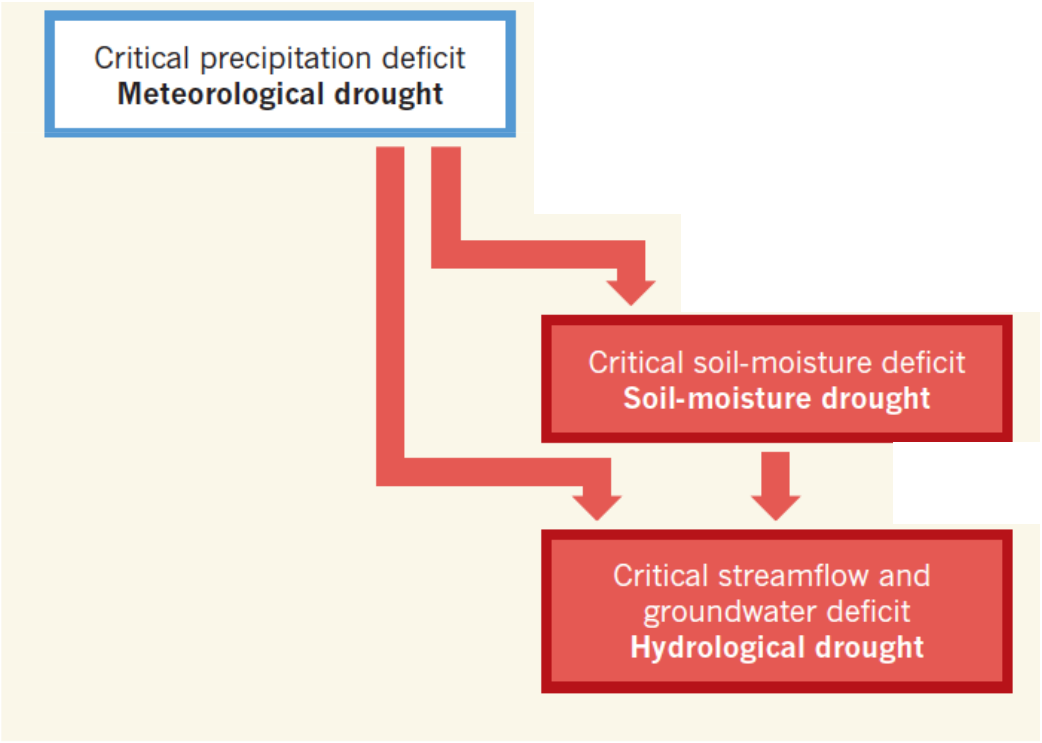
(Mueller and Seneviratne 2012, PNAS)

Soil moisture (agricultural) drought



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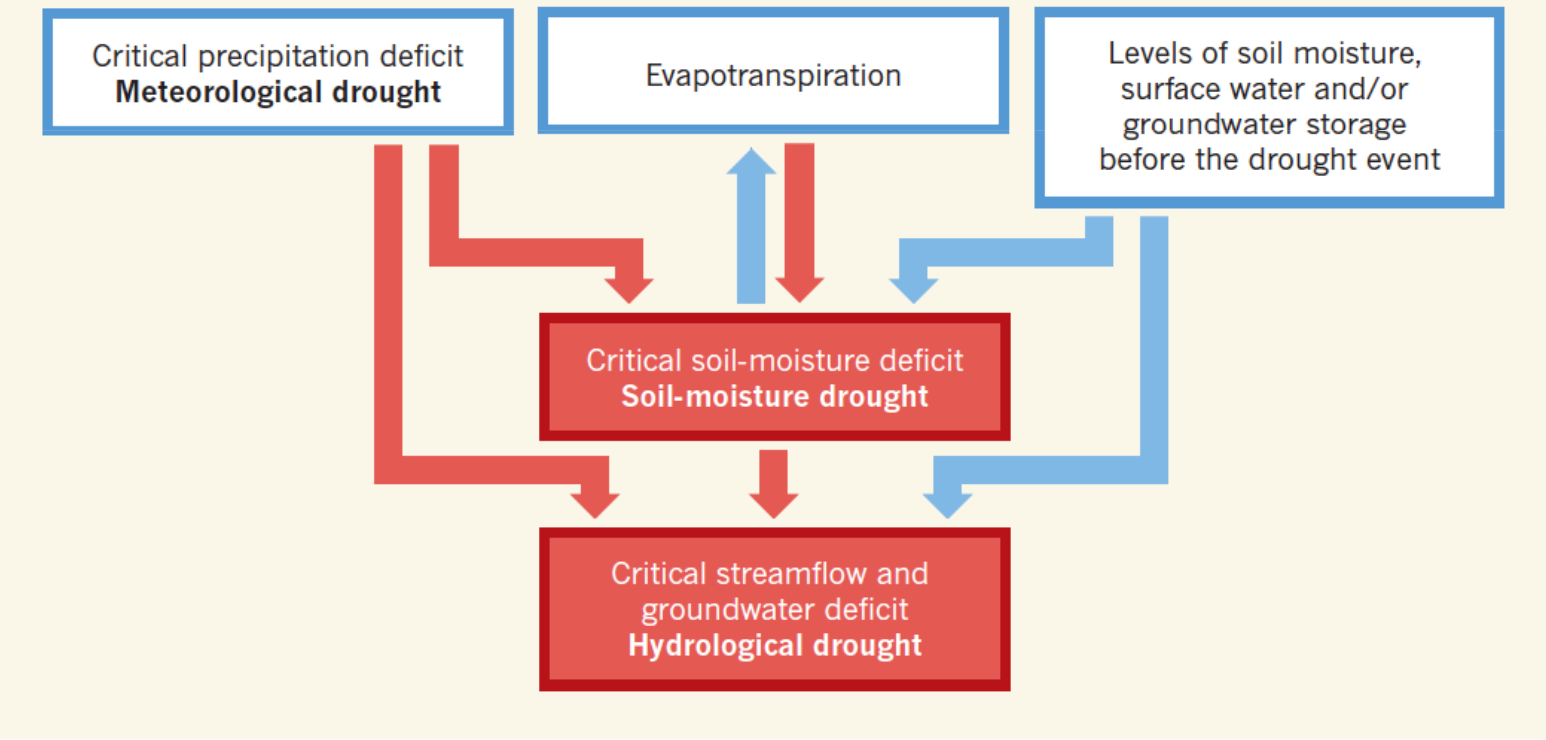

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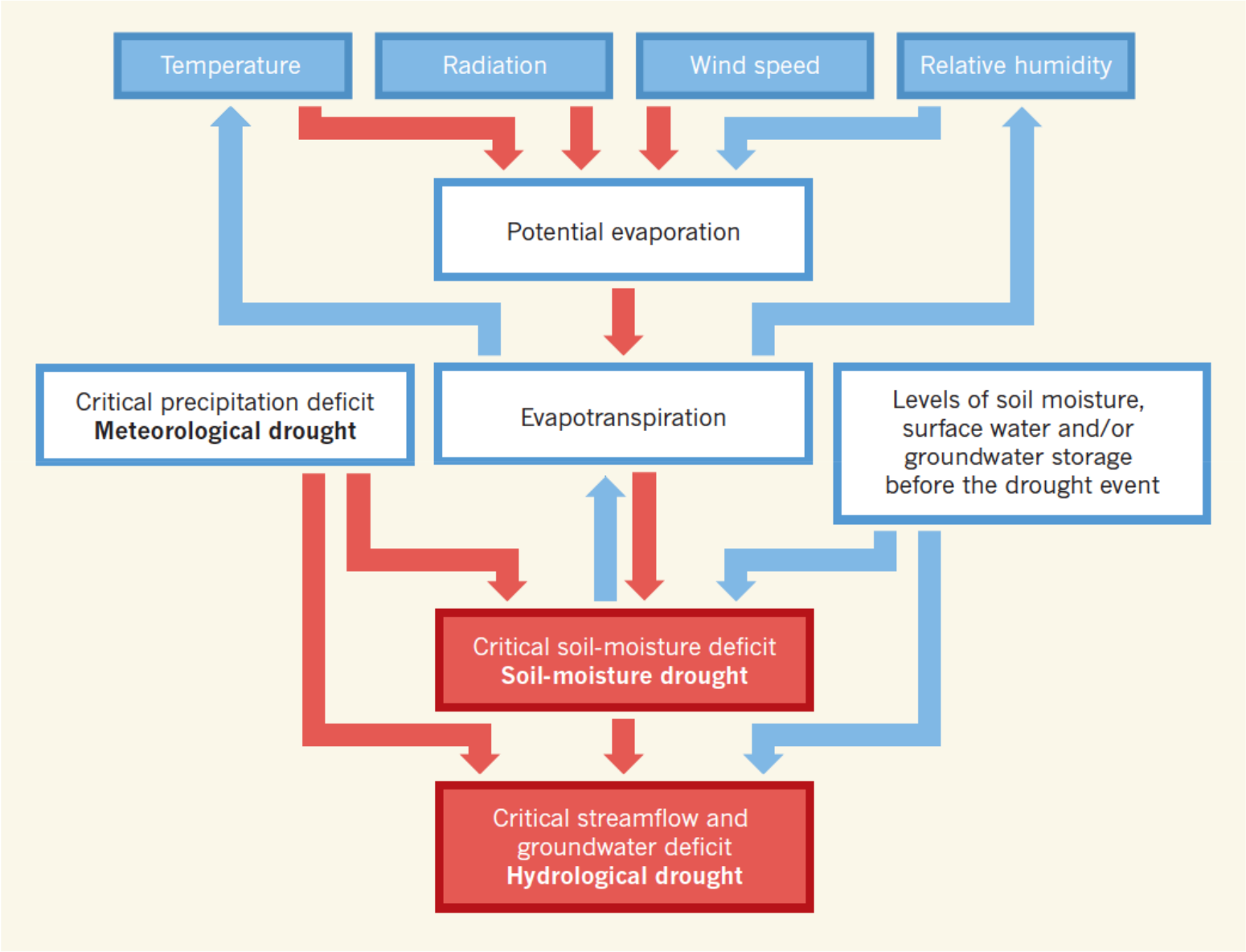
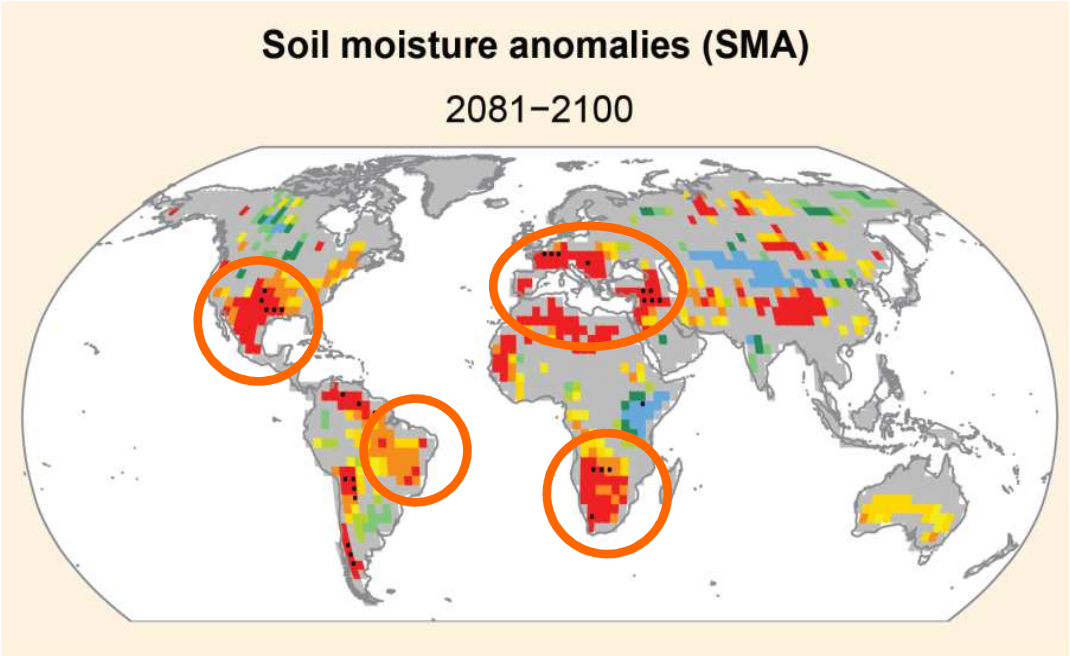
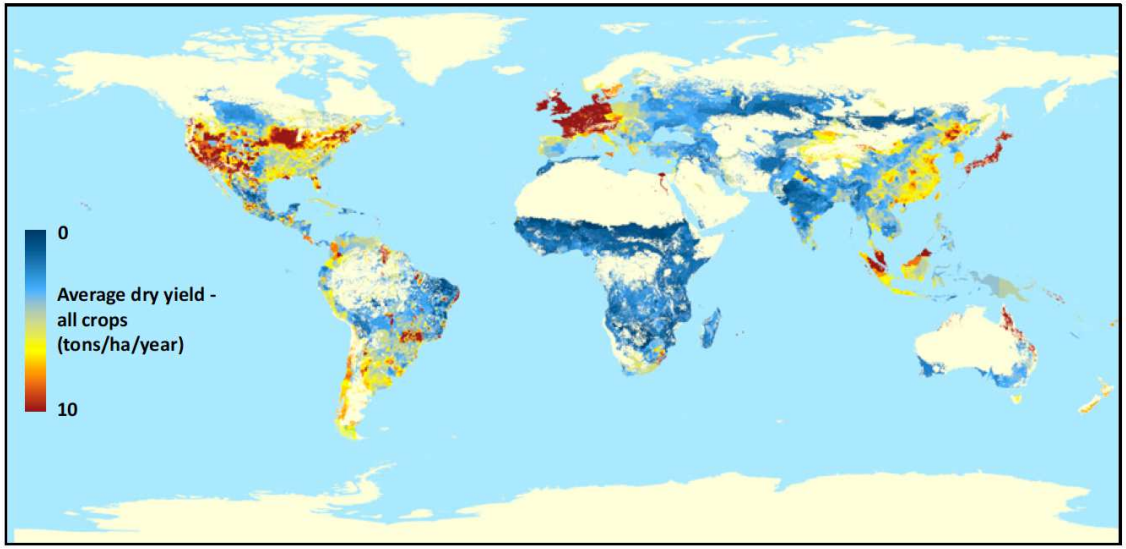


(Seneviratne 2012, Nature)

Projected changes in soil moisture drought





Several regions projected to be more strongly affected by dryness conditions

➔ **global implications for water, energy & carbon cycles**

➔ **also critical for impacts including crop production**

(IPCC SREX, 2012; West et al. 2010, PNAS)

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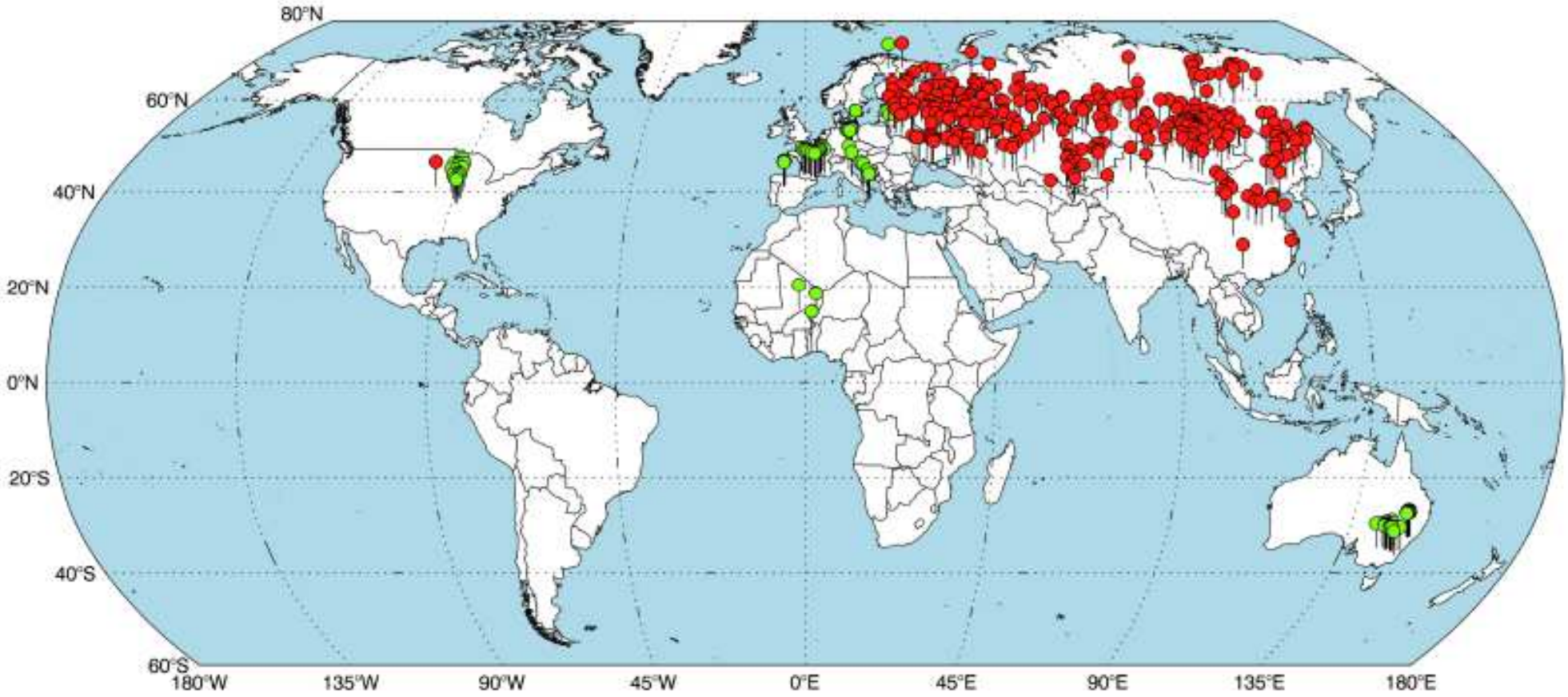
Soil moisture: Current monitoring networks

Since 2010, Soil moisture is a GCOS ECV, but:

- Lack of large-scale ground observations networks
- Measurements discontinued in some regions (e.g. former Soviet Union)



International Soil Moisture Network (http://www.ipf.tuwien.ac.at/insitu/)

esa climate change initiative
European Space Agency

ESA | CCI | Aerosol | Cloud | CMUG | Fire | GHG | Glaciers | Ice Sheets | Land Cover | Ocean Colour | Ozone | Sea Ice | Sea Level | SST

Soil Moisture CCI

Navigation

- About Soil Moisture CCI
- Products description
- VIEW products
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- Project plan
- Resources
- Support

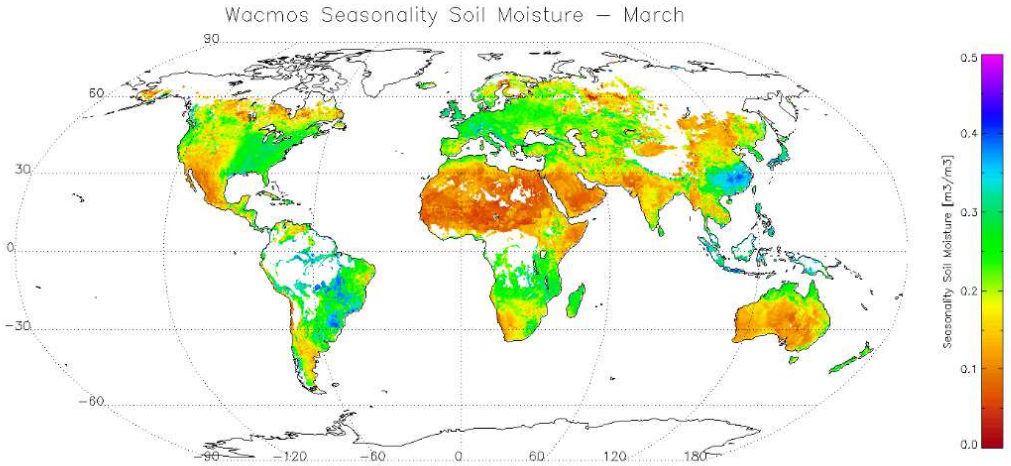
Recent updates

- CCI soil moisture project mentioned in the "WMO statement on the status of the global

Soil Moisture Essential Climate Variable

Submitted by admin on Wed, 2010-09-01 12:03

The important role of soil moisture for the environment and climate system is well known. Soil moisture influences hydrological and agricultural processes, runoff generation, drought development and many other processes. It also impacts on the climate system through atmospheric feedbacks. Soil moisture is a source of water for evapotranspiration over the continents, and is involved in both the water and the energy cycles. Soil moisture was recognised as an Essential Climate Variable (ECV) in 2010.



click image to enlarge

Soil moisture seasonality (climatology) derived from the combination of six active and passive sensors over the period 1979 to 2010 (Source: TUW)

DOWNLOAD the ECV Soil Moisture dataset

Consortium

TU WIEN | IPF | VU UNIVERSITY AMSTERDAM | ETH Zürich | GeoVille Group | AWST | NILU | IGI | FMI

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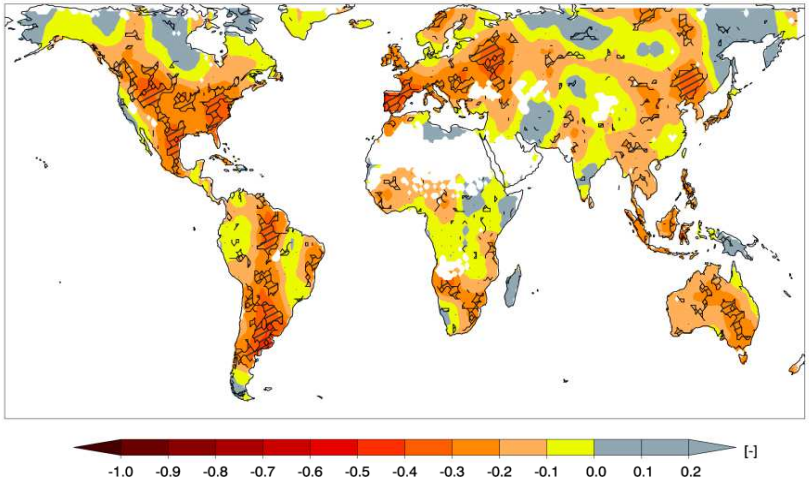
Events

« June 2013 »

Mon	Tue	Wed	Thu	Fri	Sat	Sun

SM-T coupling with CCI-based soil moisture dataset

SPI CRU



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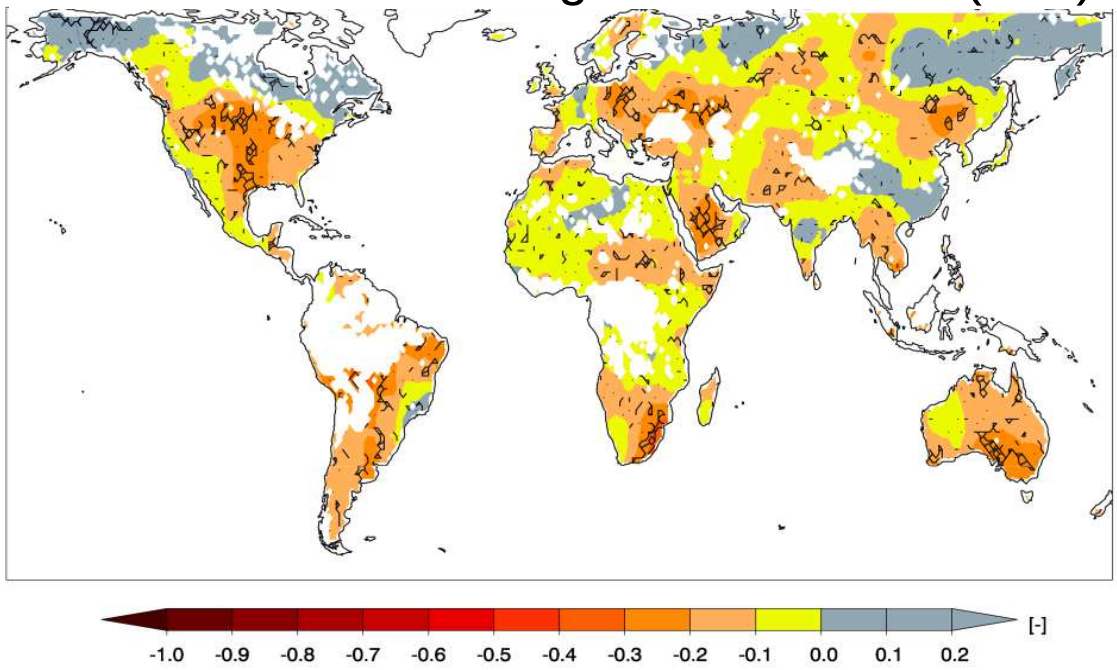
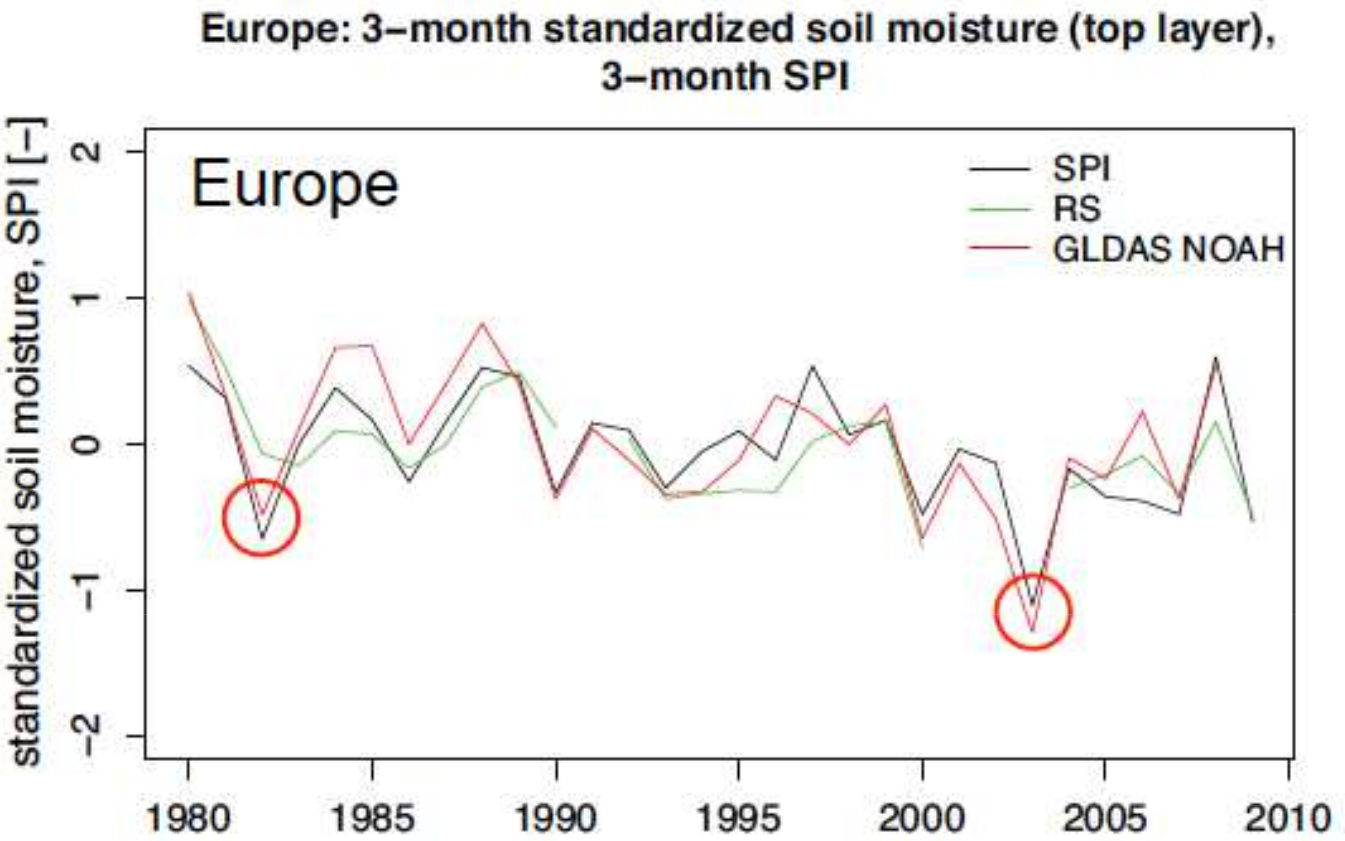
Merged satellite SM (CCI)



(Hirschi et al., in prep.)

Similar regions of soil moisture-temperature coupling found with satellite retrieved surface soil moisture, but coupling less strong

CCI-based soil moisture dataset: Timeseries



Time series of SPI vs CCI and model (GLDAS) soil moisture in selected hot spot regions, before hottest month of the year:

➔CCI surface soil moisture: Less variability, pronounced anomalies not well captured, problem of data gaps

(Hirschi et al, in prep.)

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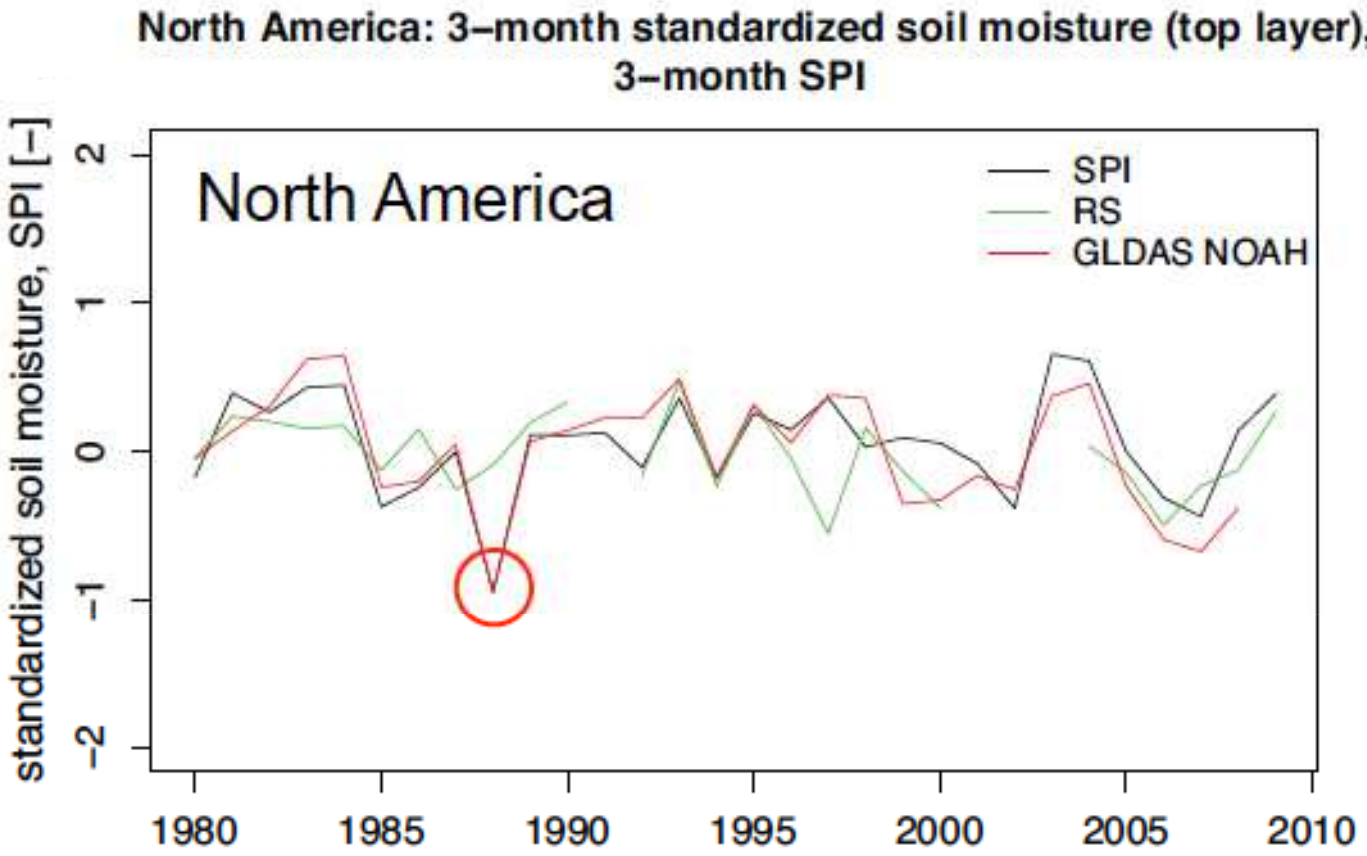

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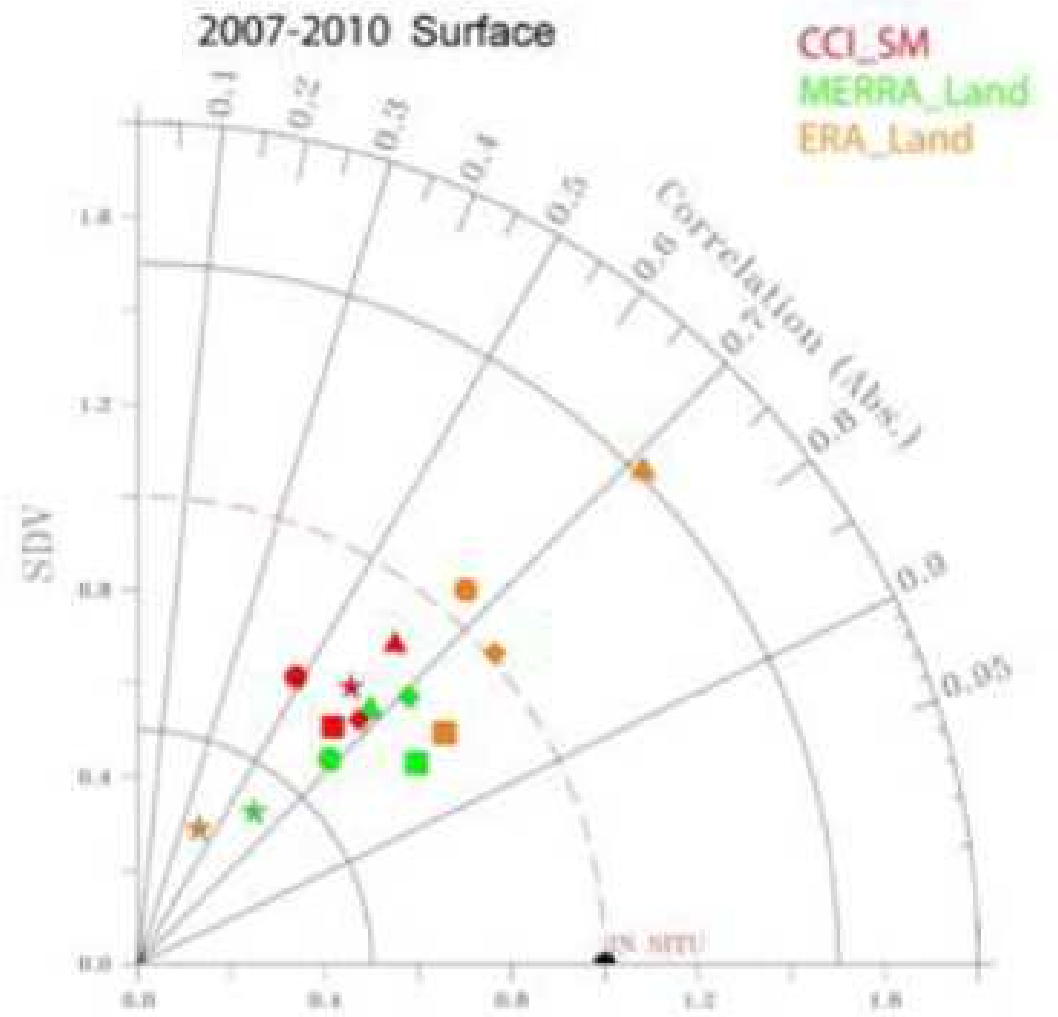
CCI-based soil moisture dataset: Evaluation with ground obs



(Albergel et al., JHM, in press)

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- **Soil moisture is a key ECV:**
  - Soil moisture drought: Impacts ecosystems and crop production
  - Numerous climate feedbacks (e.g. extreme temperatures, global carbon cycle, precipitation)
  - Strongly affected by climate change

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- **Soil moisture is a key ECV:**
  - Soil moisture drought: Impacts ecosystems and crop production
  - Numerous climate feedbacks (e.g. extreme temperatures, global carbon cycle, precipitation)
  - Strongly affected by climate change

- **Lack of ground observations:**
  - Remote sensing based datasets are *one* avenue to derive estimates
  - But only for surface soil moisture, and may not capture full variability
  - Need to be considered in combination with other data sources (e.g. observation-driven land surface models, precipitation-based indices)
  - Of particular strong relevance in data scarce regions
  - Improved ground observation networks are also necessary