# How can land surface modelers learn from ecosystem observations
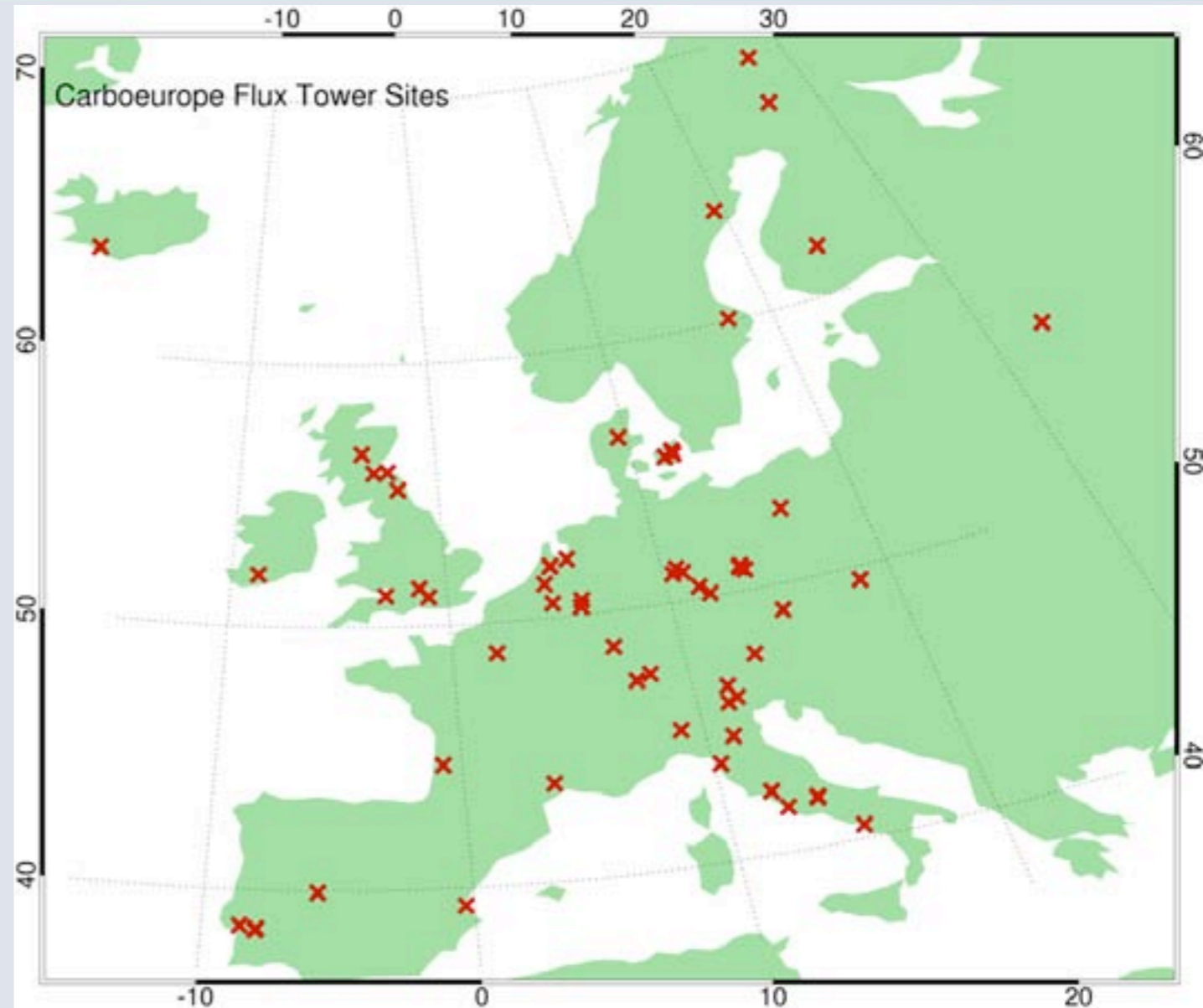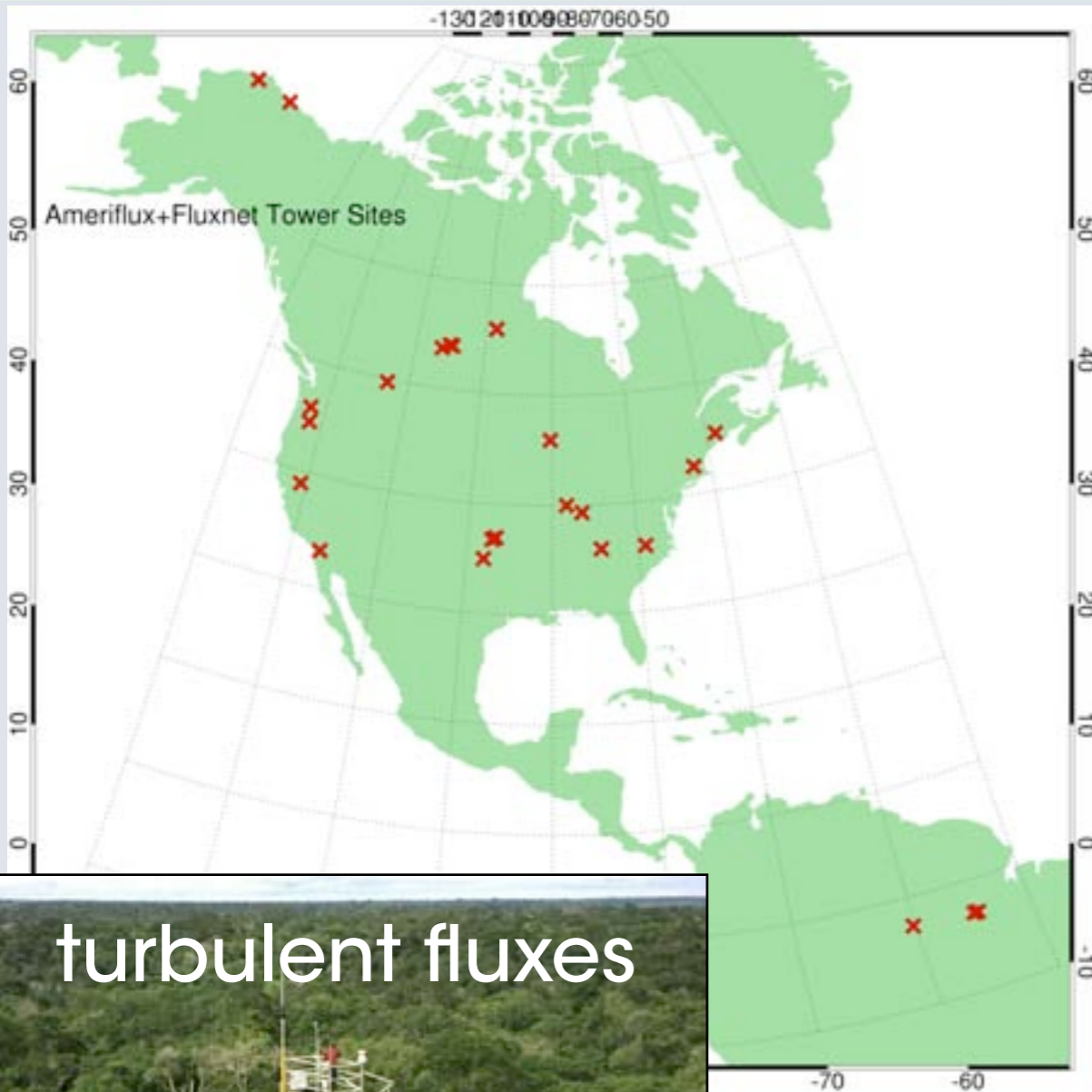
## A process-based analysis for JULES using flux towers and NASA's earth observing system

**Reto Stöckli**
**Colorado State University**
**stockli@atmos.colostate.edu**

# Fluxnet Ecosystem Observations



Ameriflux+Fluxnet Tower Sites

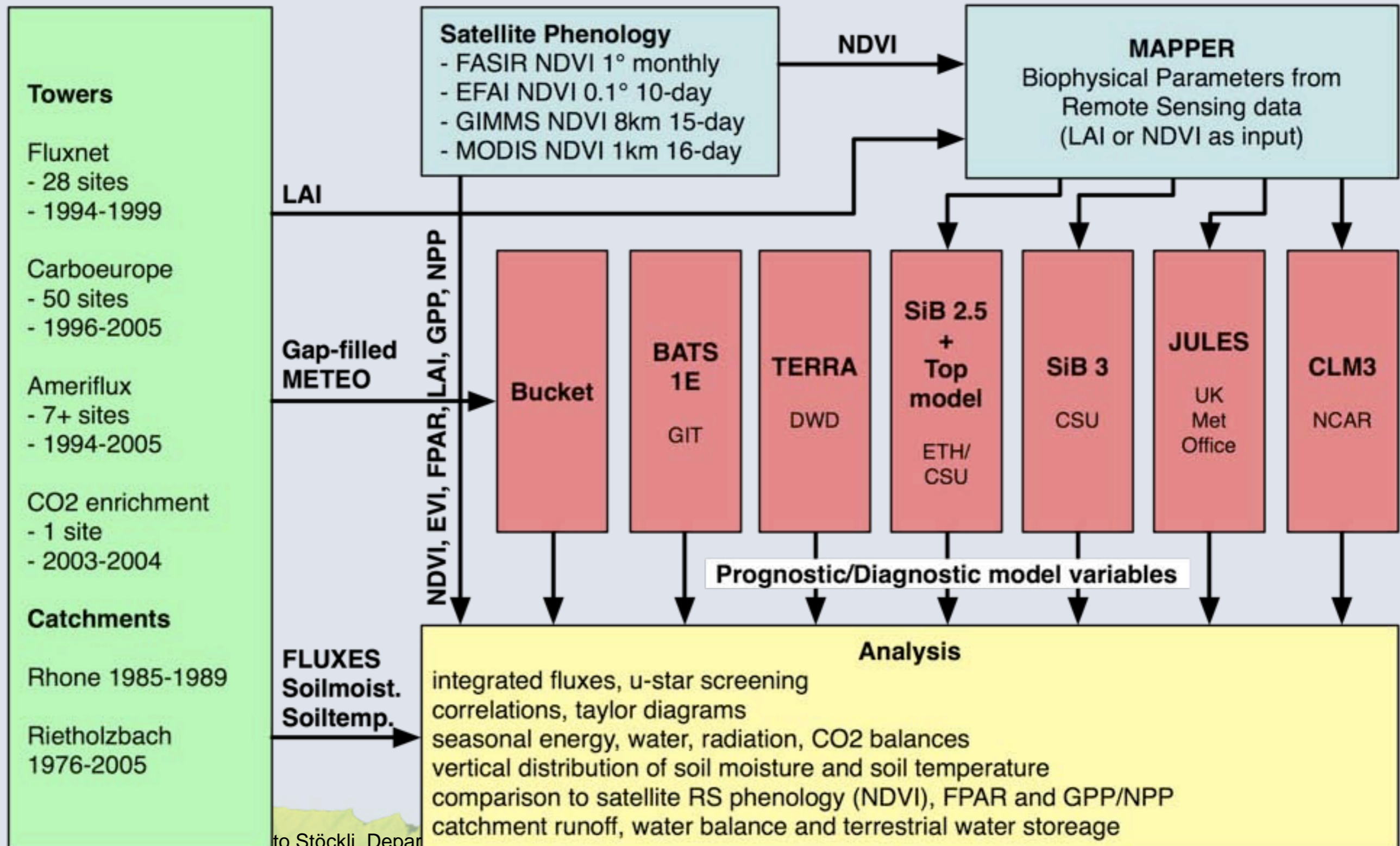Carboeurope Flux Tower Sites

turbulent fluxes

soil processes

**multi-year time series**
- wide range of bioclimatic zones
- both, driver and validation data

# The Modelfarm

**Integrating land surface models with observations from towers, catchments and satellites in a framework for process-based radiation, heat, water and carbon balance analyses of the biosphere-atmosphere interface**

**Towers**

**Fluxnet**
- 28 sites
- 1994-1999

**Carboeurope**
- 50 sites
- 1996-2005

**Ameriflux**
- 7+ sites
- 1994-2005

**CO2 enrichment**
- 1 site
- 2003-2004

**Catchments**

Rhone 1985-1989

Rietholzbach 1976-2005

**Satellite Phenology**
- FASIR NDVI 1° monthly
- EFAI NDVI 0.1° 10-day
- GIMMS NDVI 8km 15-day
- MODIS NDVI 1km 16-day

**NDVI**

**MAPPER**
Biophysical Parameters from Remote Sensing data
(LAI or NDVI as input)

**LAI**

**Gap-filled METEO**

NDVI, EVI, FPAR, LAI, GPP, NPP

**FLUXES Soilmoist. Soiltemp.**

**Bucket**

**BATS 1E**
GIT

**TERRA**
DWD

**SiB 2.5 + Top model**
ETH/ CSU

**SiB 3**
CSU

**JULES**
UK Met Office

**CLM3**
NCAR

**Prognostic/Diagnostic model variables**

**Analysis**
integrated fluxes, u-star screening
correlations, taylor diagrams
seasonal energy, water, radiation, CO2 balances
vertical distribution of soil moisture and soil temperature
comparison to satellite RS phenology (NDVI), FPAR and GPP/NPP
catchment runoff, water balance and terrestrial water storeage

to Stöckli, Depar

# Ameriflux

- Morgan Monroe State Forest (1999-2005)
- Boreas Old Black Spruce (1994-2004)
- Lethbridge (1999-2004) GRASS
- Oklahoma Shidler (1998-1999) GRASS
- Atqasuk Alaska (2000-2001) TUNDRA

# LBA

- Santarem KM83 (2001-2003)
- Tapajos KM67 (2002-2005)

# Carboeurope

- Castelporziano (2000-2005)
- El Saler (1998-2005)
- Kaamanen (2000-2005) TUNDRA
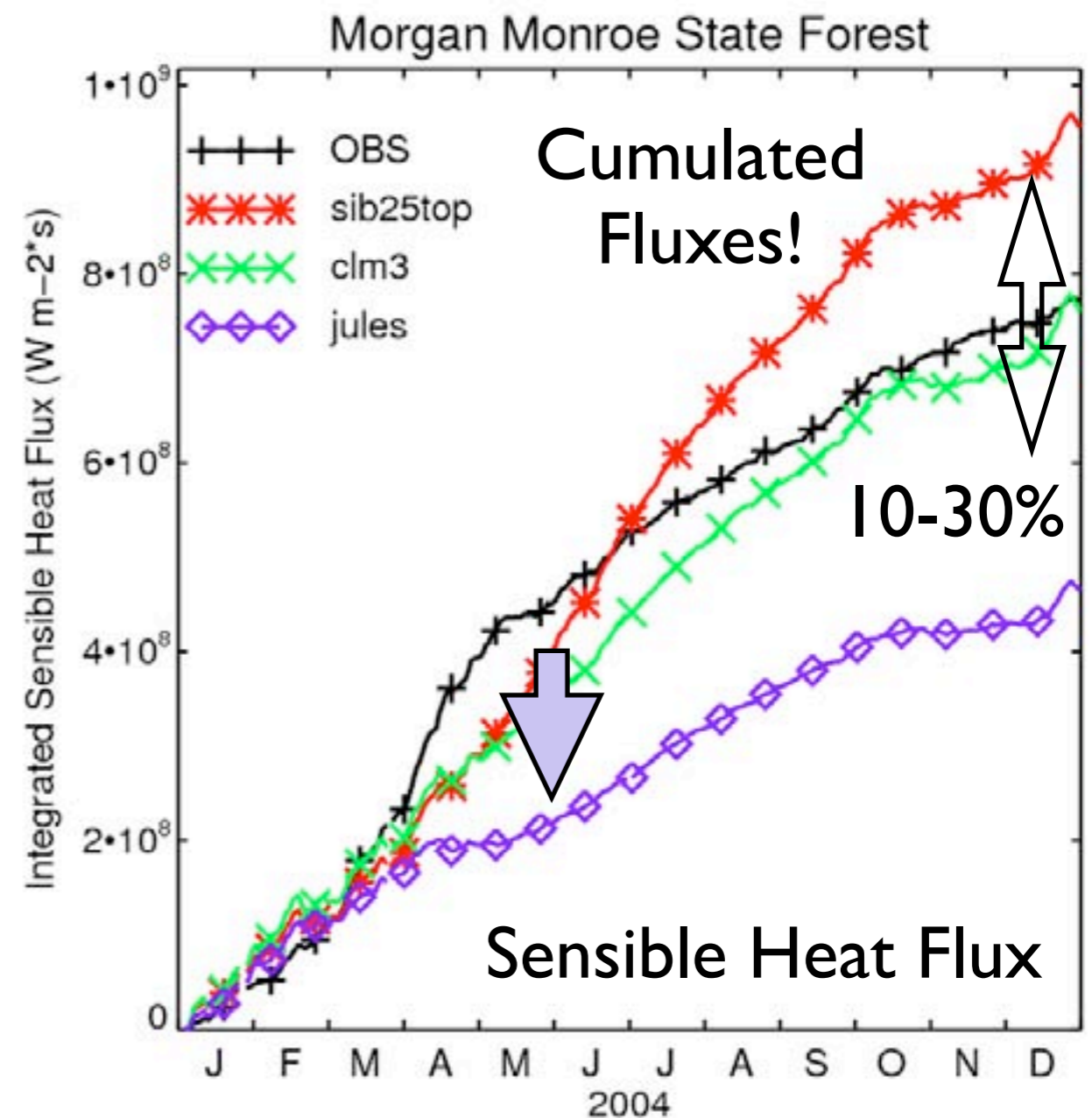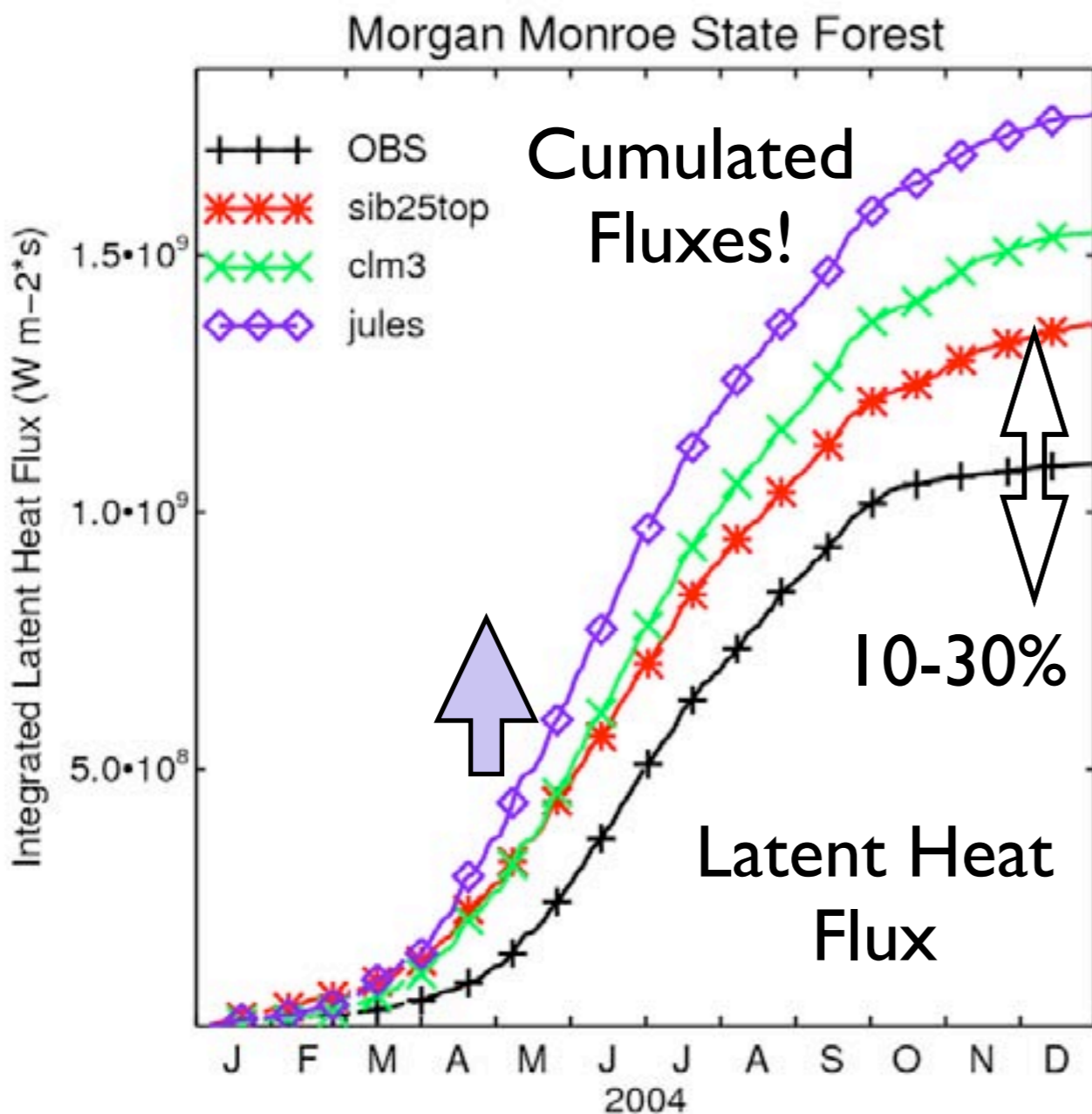- Hyytiala (1996-2005)
- Tharandt (1996-2005)
- Vielsalm (1996-2005)

**Color Legend:**

Temperate
Tropical
Boreal
Arctic
Semi-Arid

# Temperate Deciduous Forest

**JULES**
- good timing in seasonal LE flux
- excessive LE at SOS ->  low bowen ratio
- very precise summer/fall H fluxes



Morgan Monroe State Forest — Latent Heat Flux (Cumulated Fluxes!), Integrated Latent Heat Flux (W m−2*s), OBS, sib25top, clm3, jules, 10-30%

Morgan Monroe State Forest — Sensible Heat Flux (Cumulated Fluxes!), Integrated Sensible Heat Flux (W m−2*s), OBS, sib25top, clm3, jules, 10-30%

# Temperate Deciduous Forest

**JULES**

- precise magnitude and light response in GPP
- early start (remember LE in previous page)



Morgan Monroe State Forest

OBS
sib25top
clm3
jules

Primary Production GPP

Morgan Monroe State Forest: 200407

Light Response of GPP

OBS: Global Radiation 46m (W/m2)
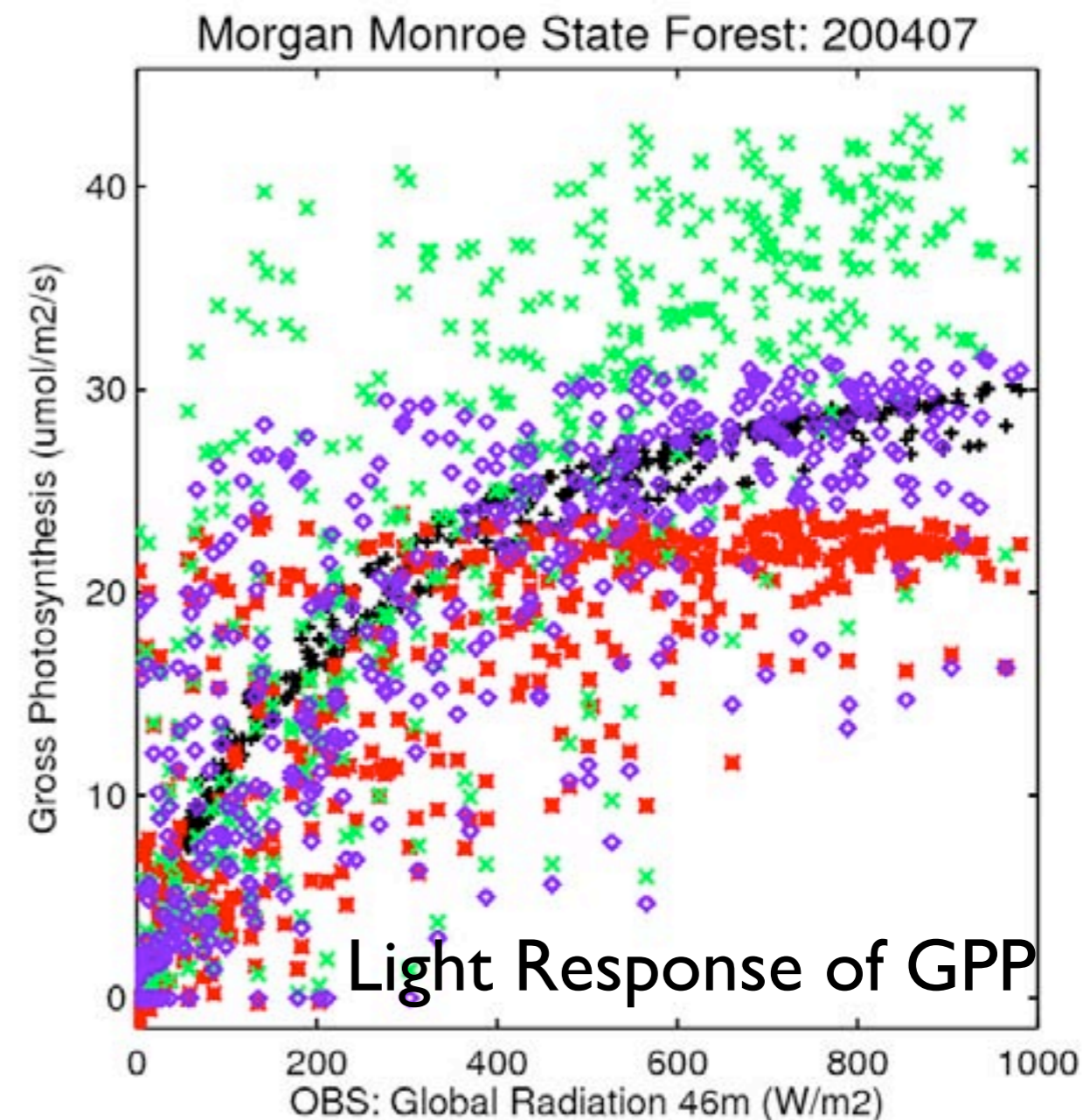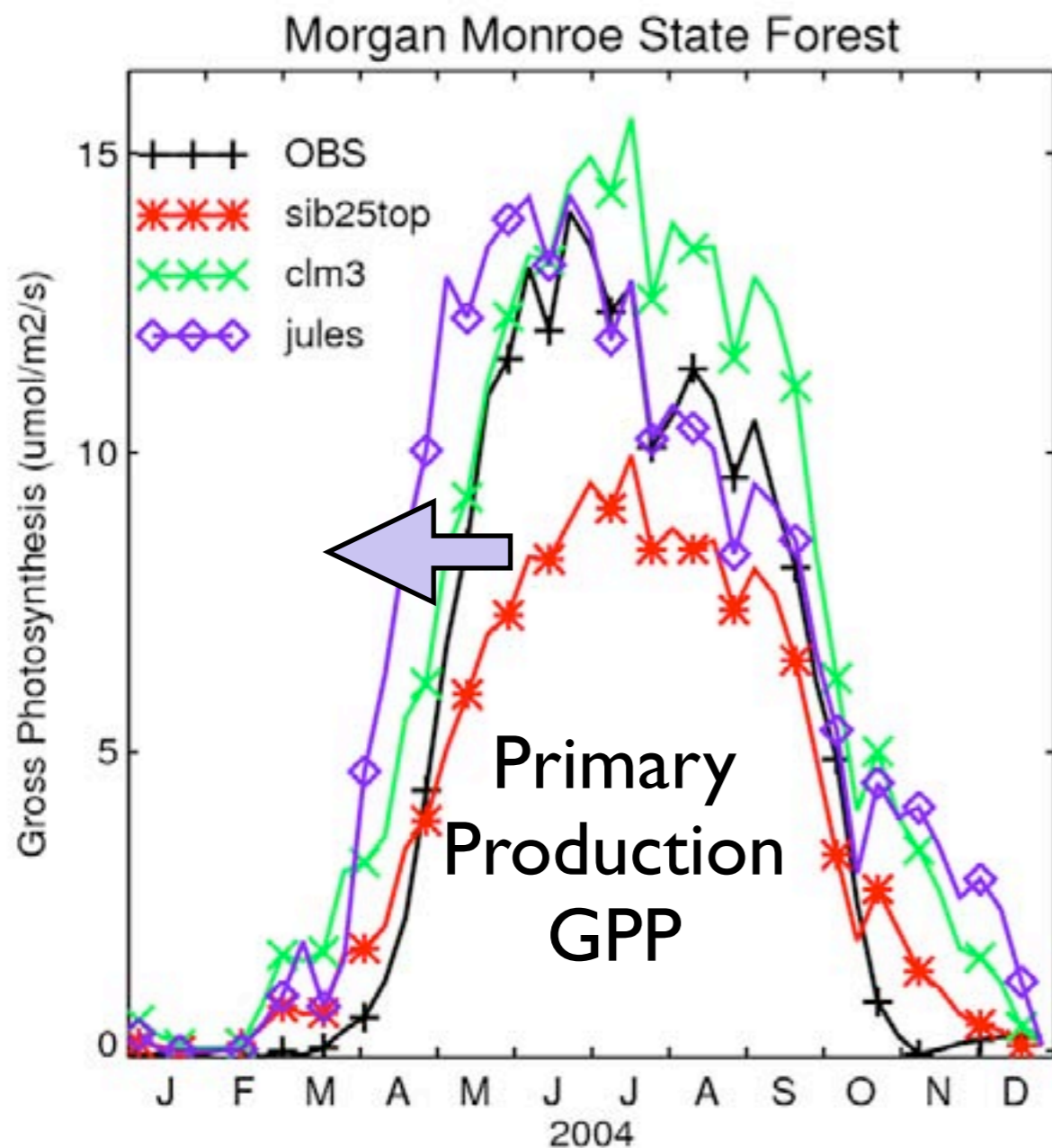
# Temperate Deciduous Forest

**JULES:**
- good magnitude and variability of GPP
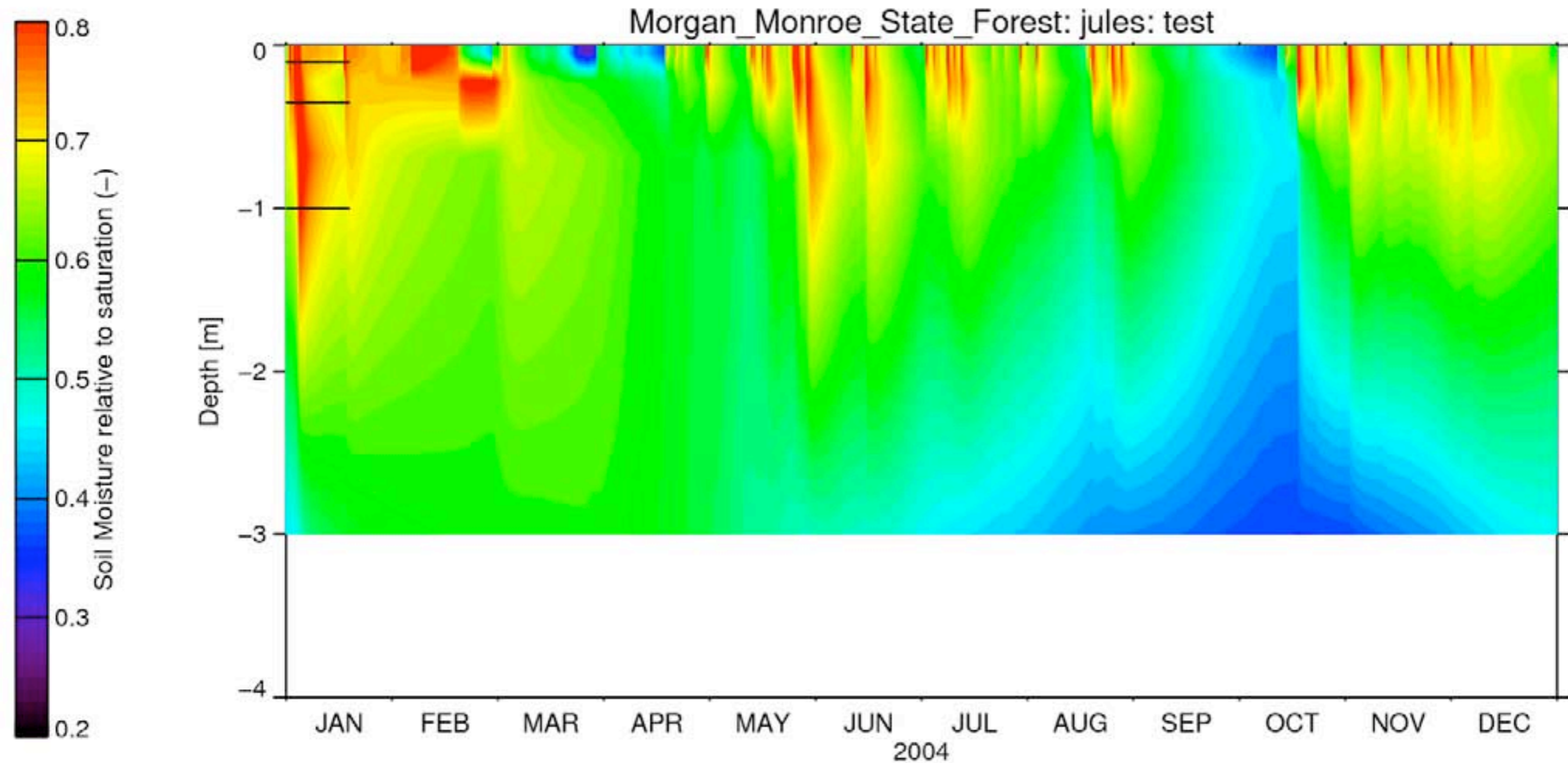- LE correlates better than H (most models!)
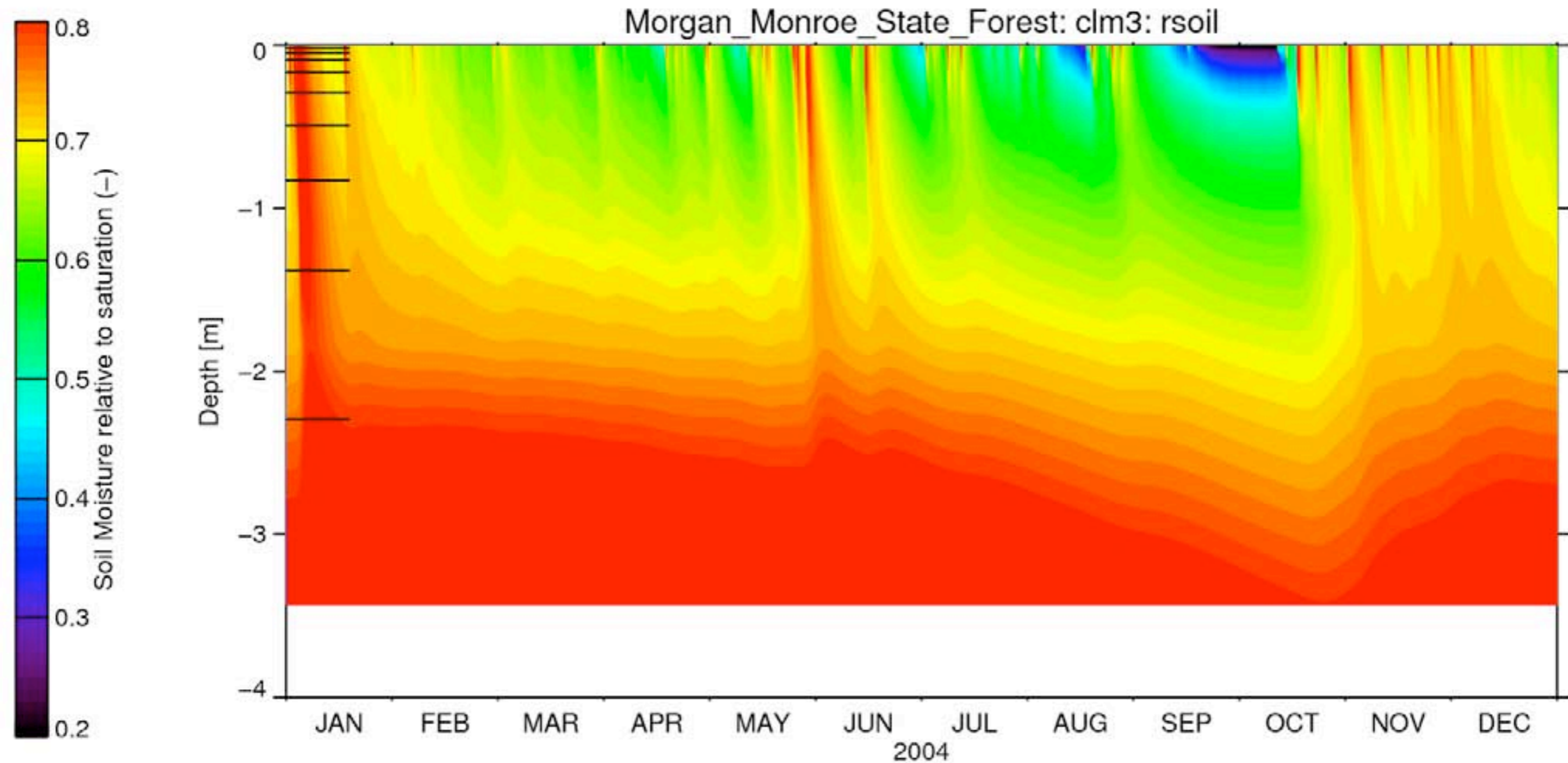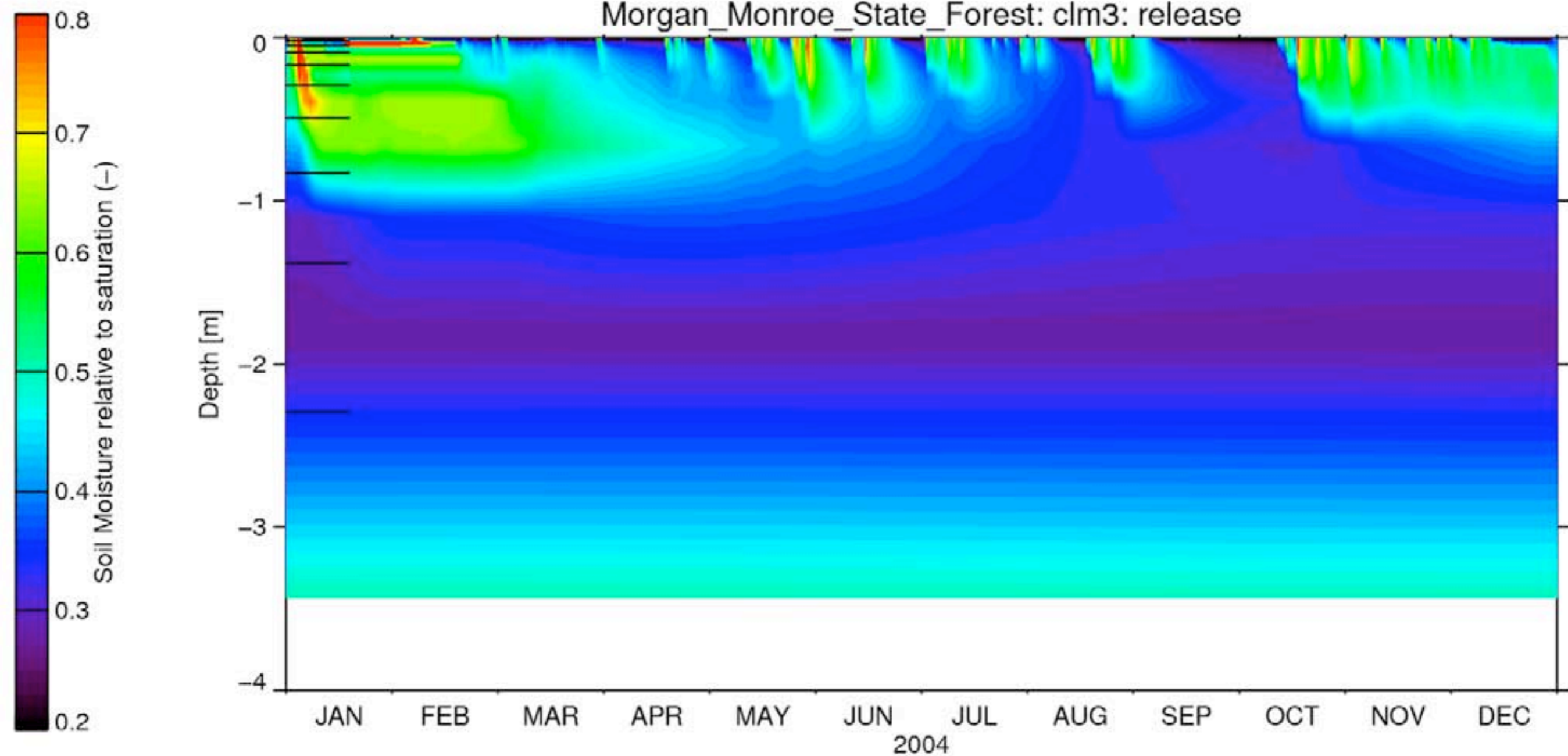
**Soil Moisture: mostly no deep soil observations**
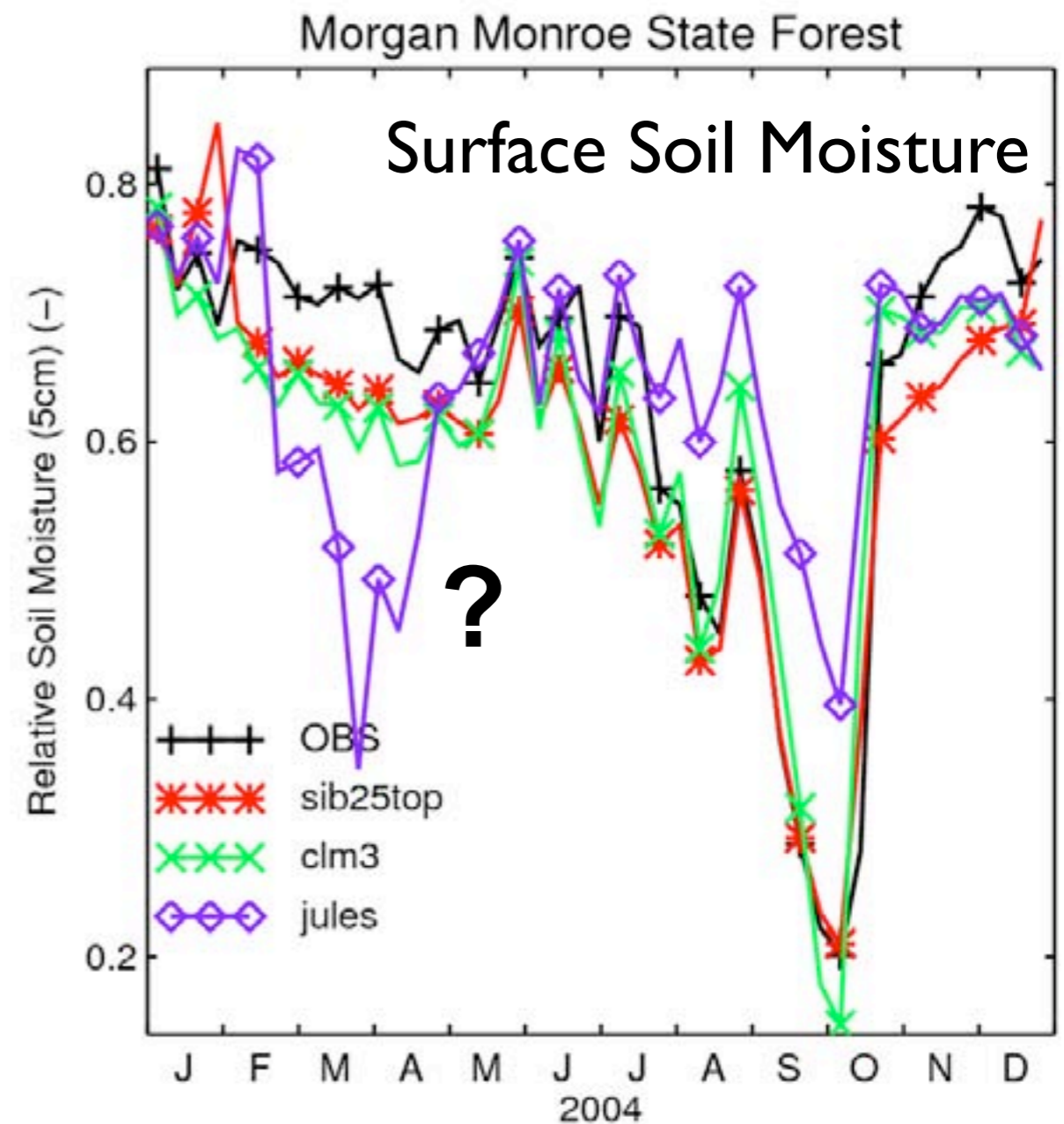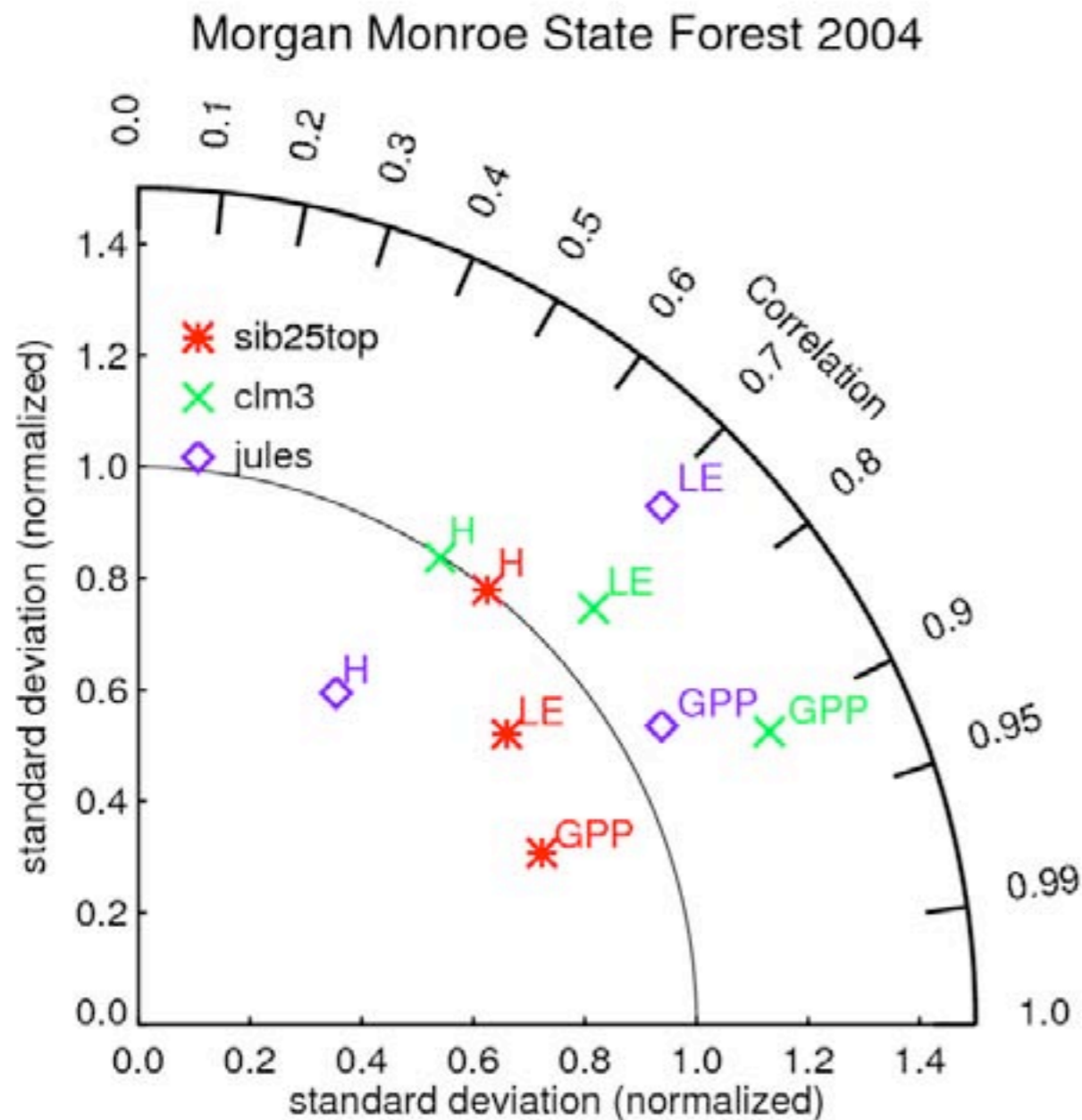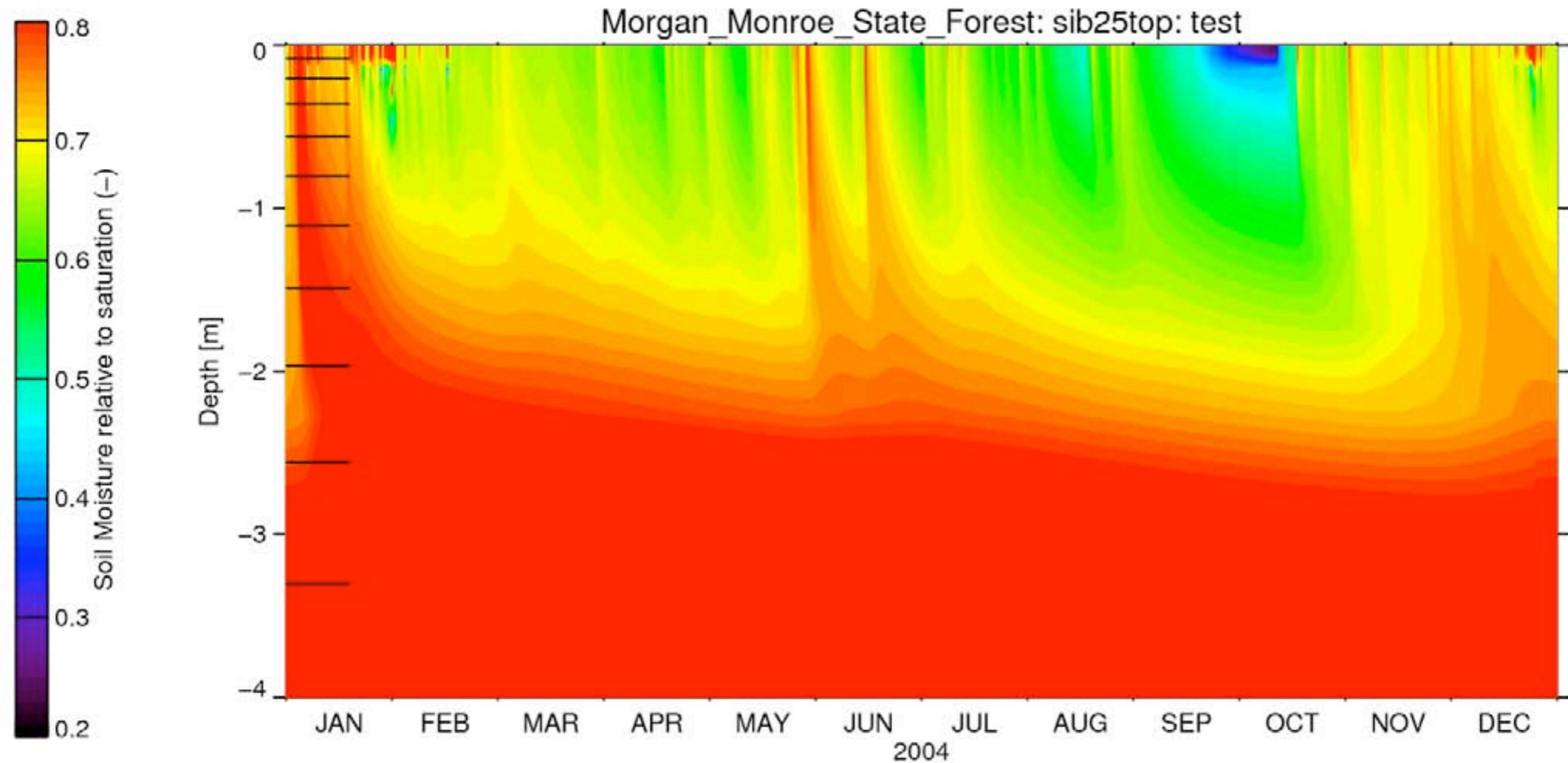


Morgan Monroe State Forest 2004



Morgan Monroe State Forest

Surface Soil Moisture

# Temperate Deciduous Forest



Morgan_Monroe_State_Forest: sib25top: test

Reto Stöckli, Department of Atmospheric Science, CSU, e-mail: stockli@atmos.colostate.edu

# Temperate Deciduous Forest



Morgan_Monroe_State_Forest: jules: test

# Temperate Deciduous Forest



Morgan_Monroe_State_Forest: clm3: rsoil

# Temperate Deciduous Forest



Morgan_Monroe_State_Forest: clm3: release

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# Tropical Forest

**Eastern Brazil: Pronounced rainy/dry season**
- light-limited during rain season?
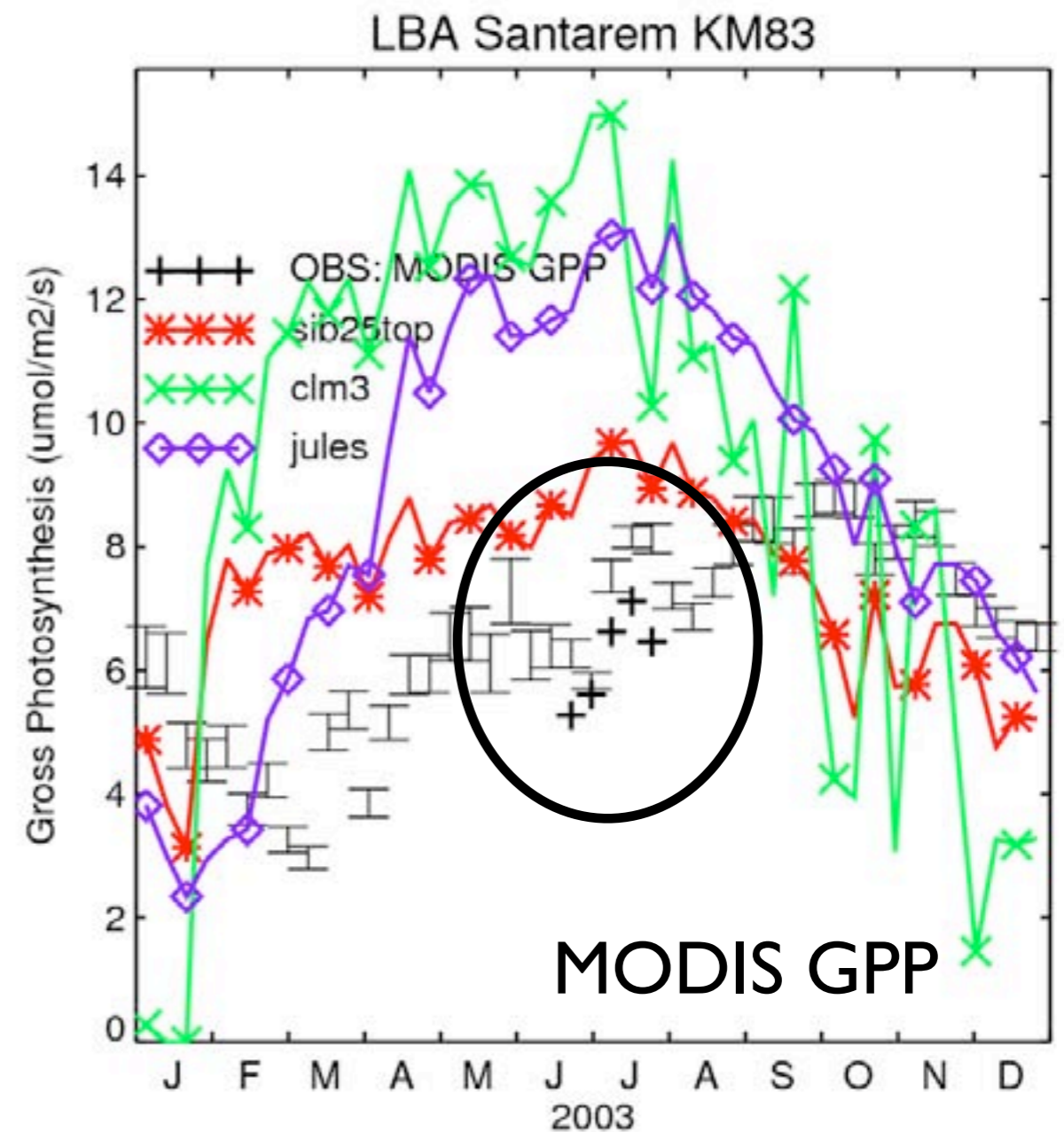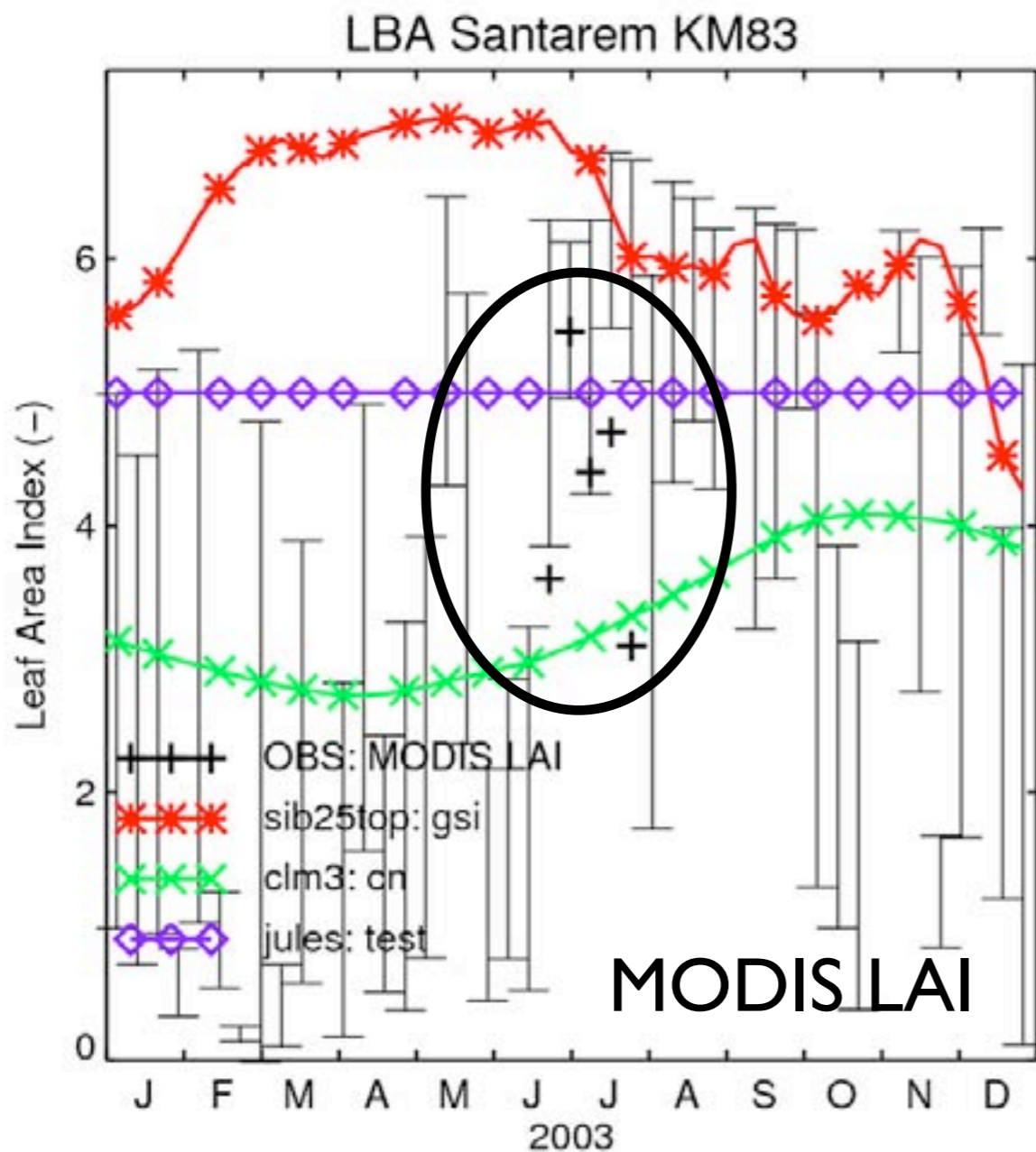- water-limited during dry season?



Precipitation

Global Radiation
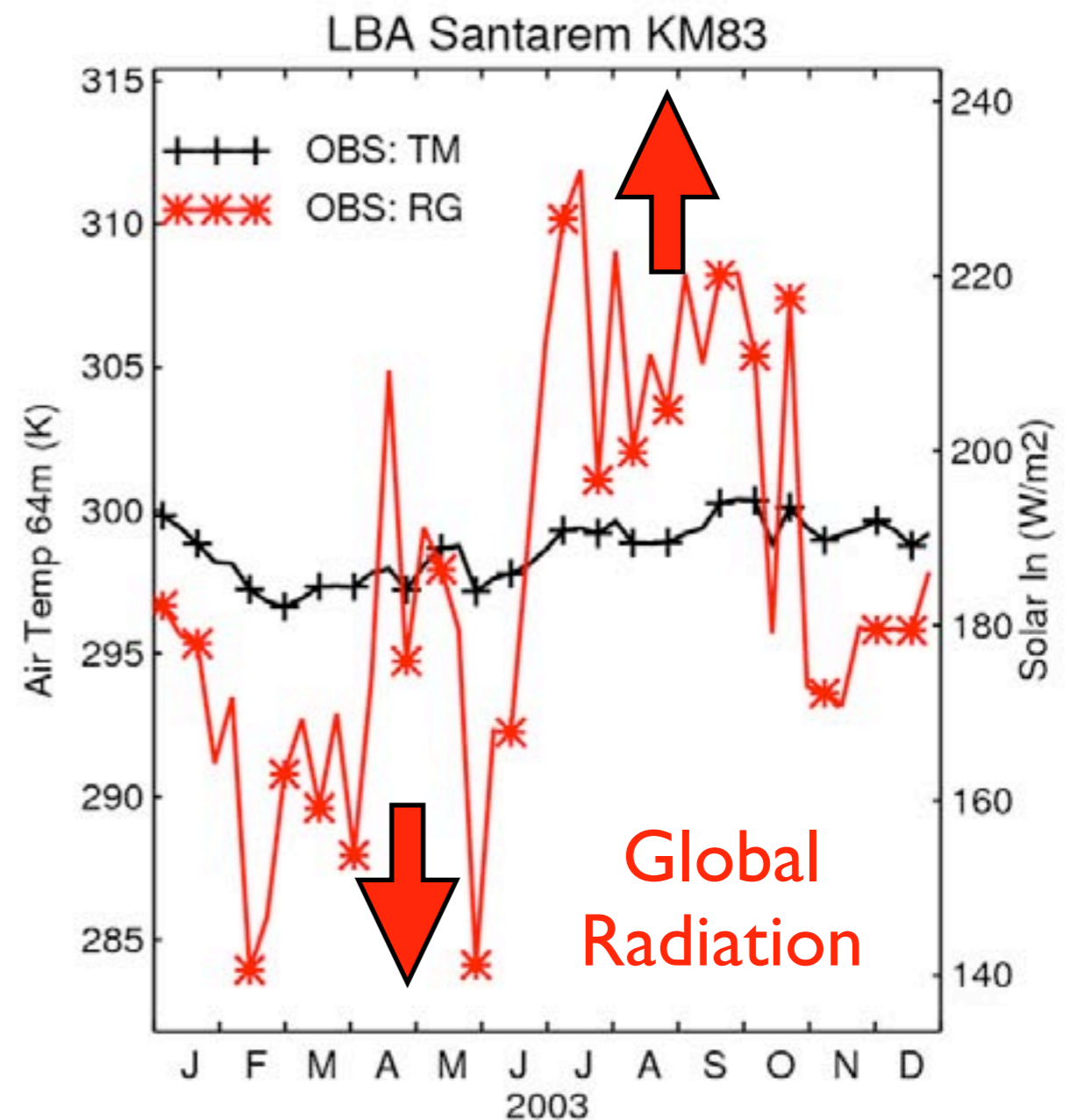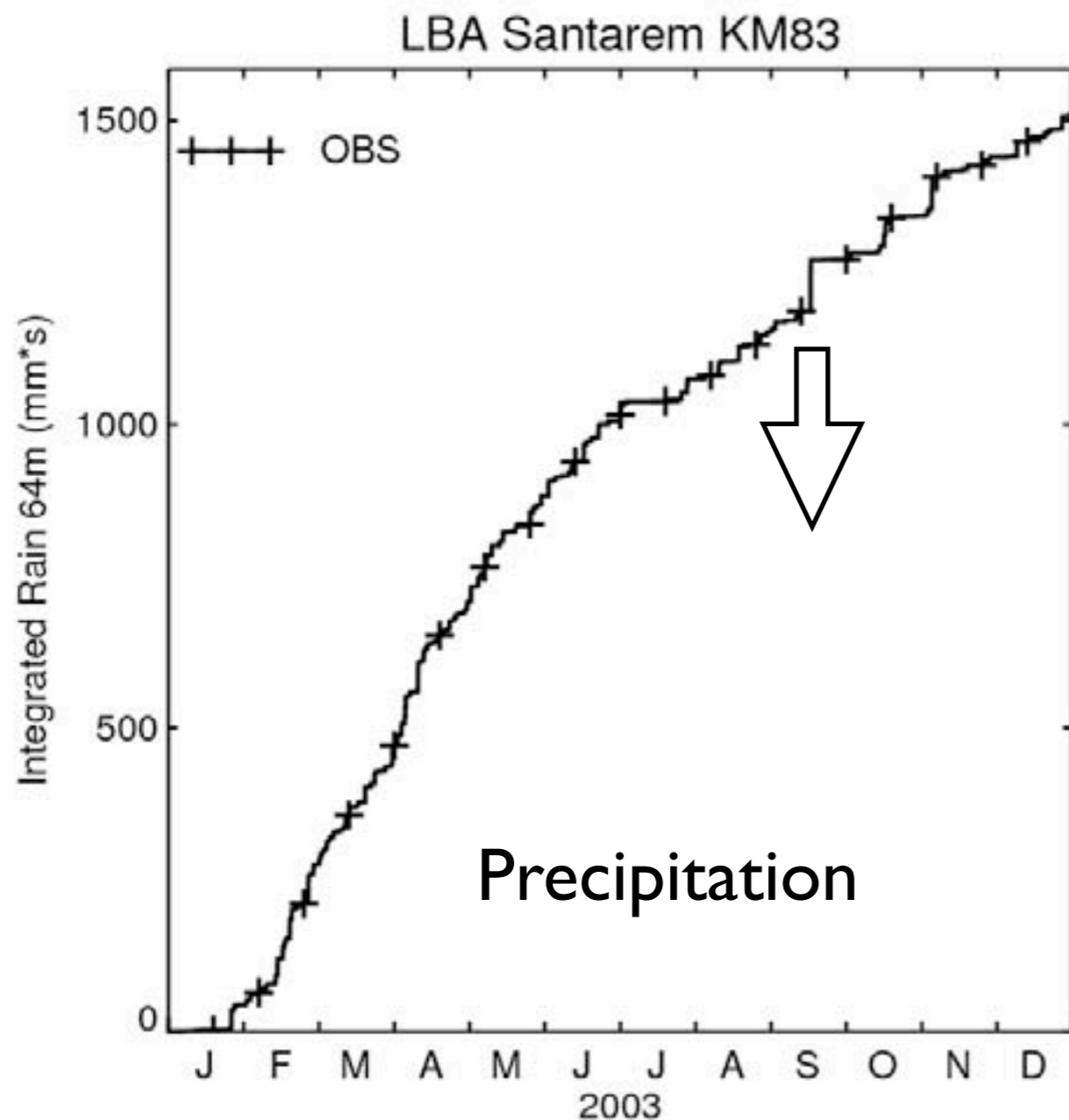
# Tropical Forest

**JULES:**

- 300-400mm terrestrial water storage capacity
- root soil moisture reasonable
- observations indicate hydraulic lift from GW
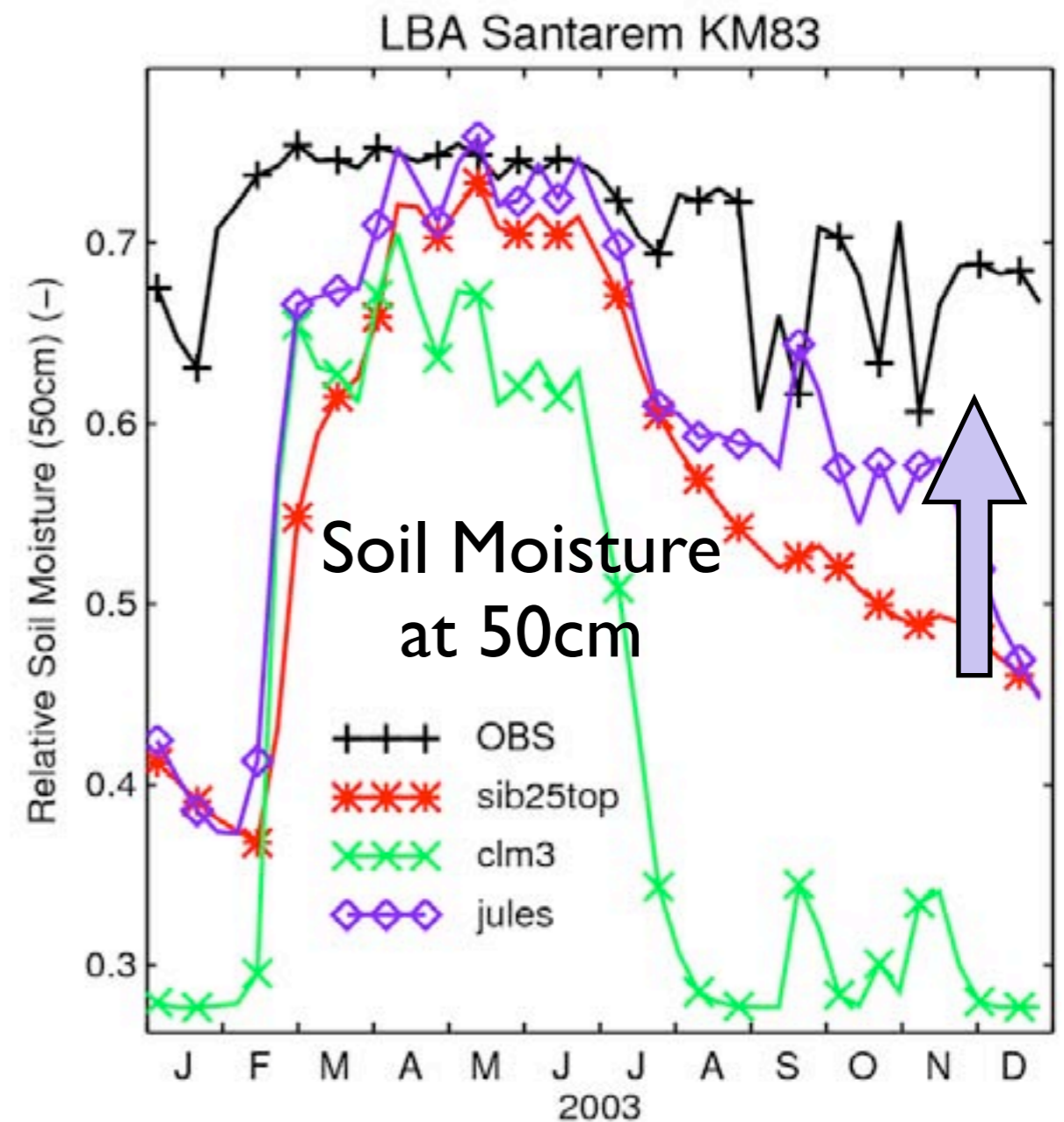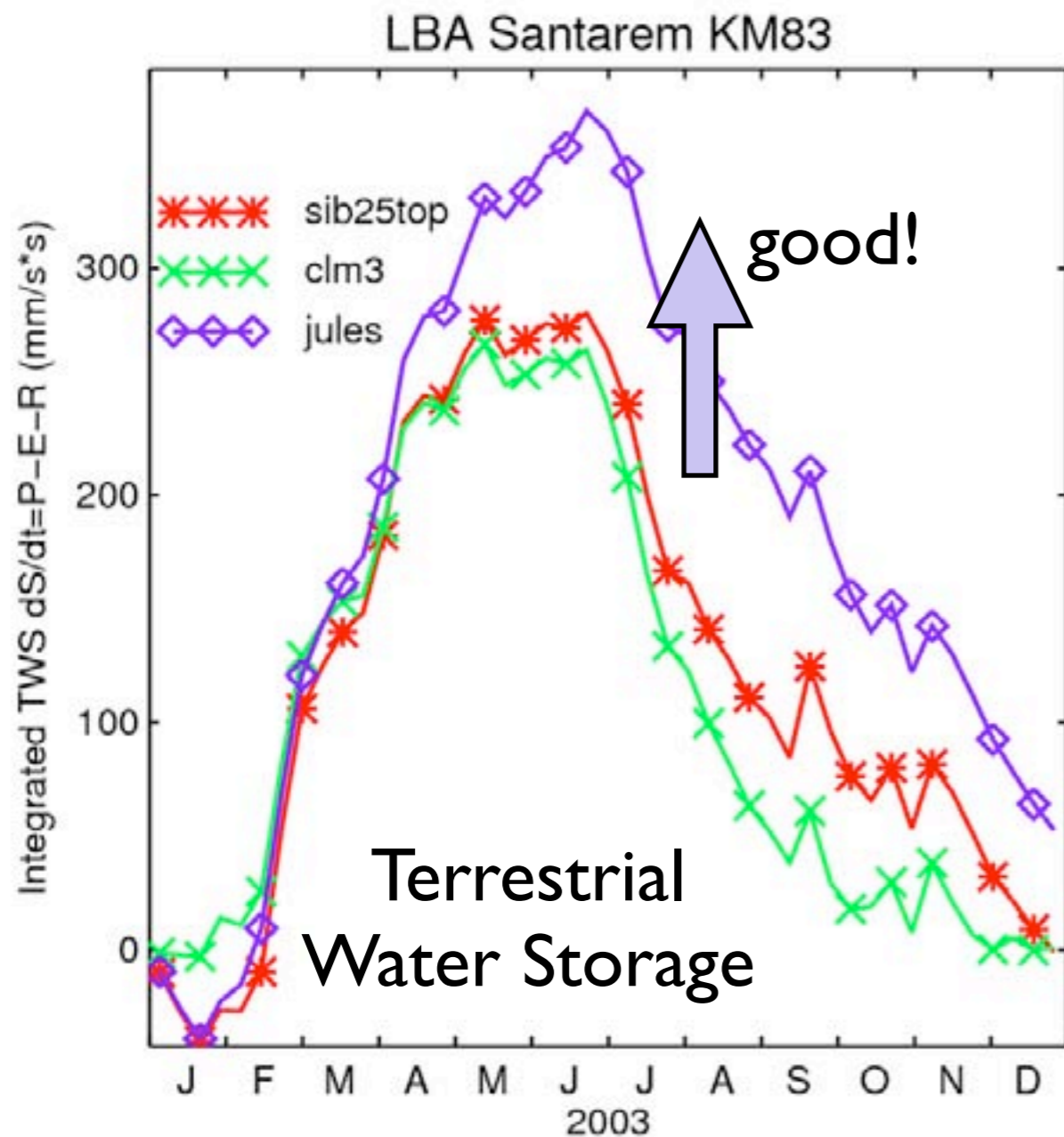
# Tropical Forest

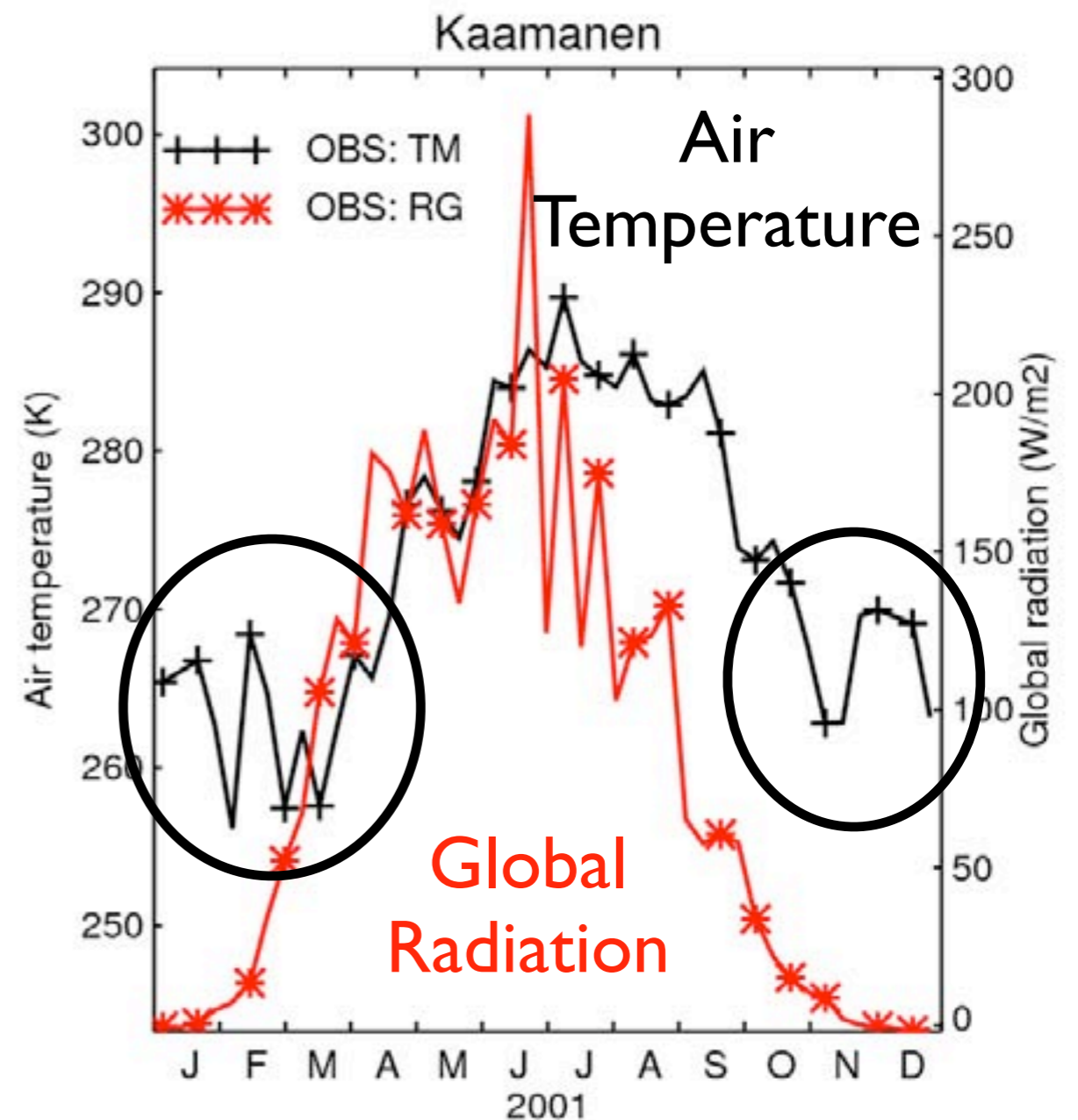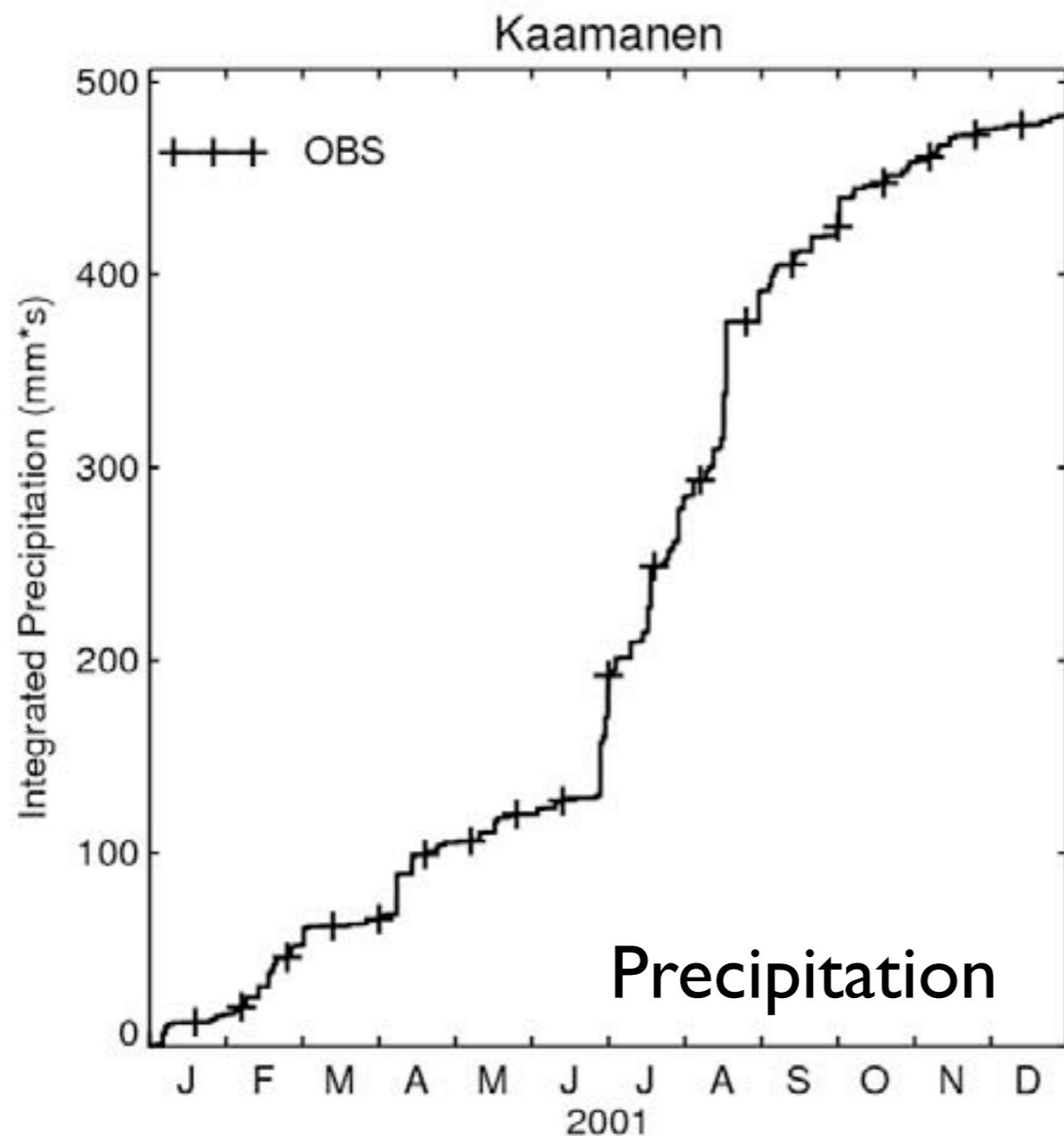## Check against Satellite Remote Sensing
- always consider uncertainty in RS data
- LAI & GPP: light-response or drought-response?
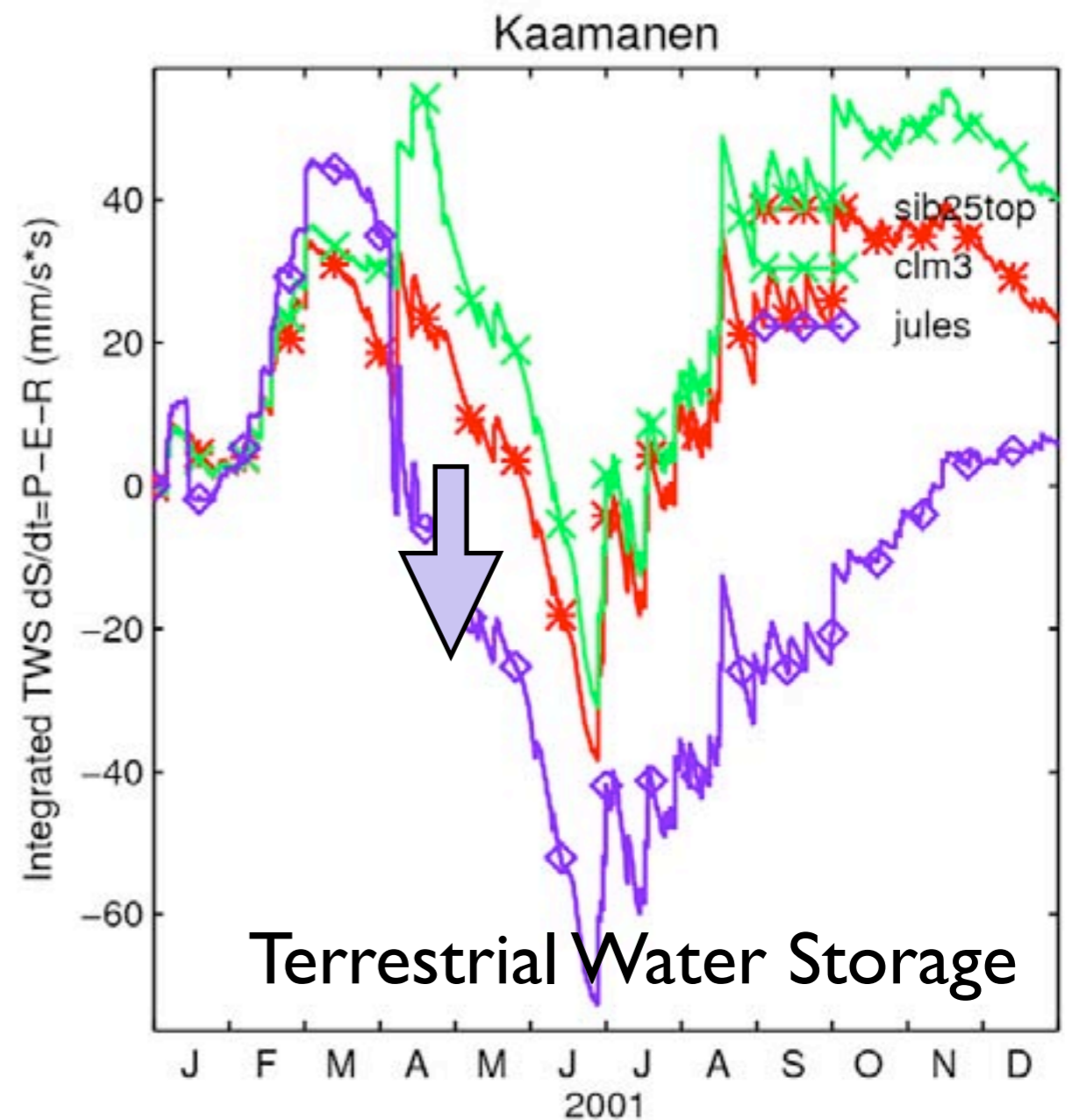
# Arctic Grassland
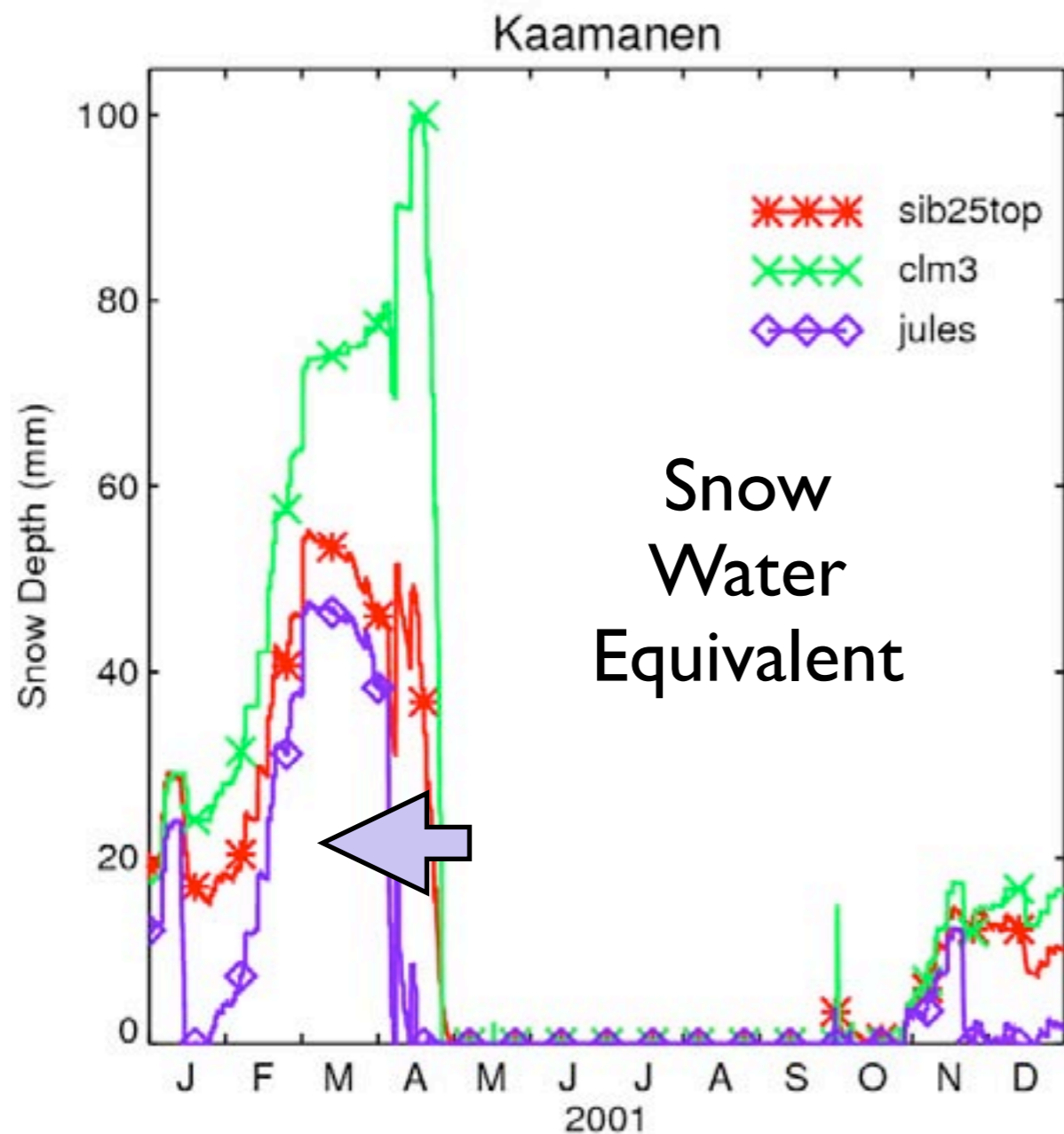
## Northern Finland, Tundra
- Short growing season
- 6-9 months below freezing
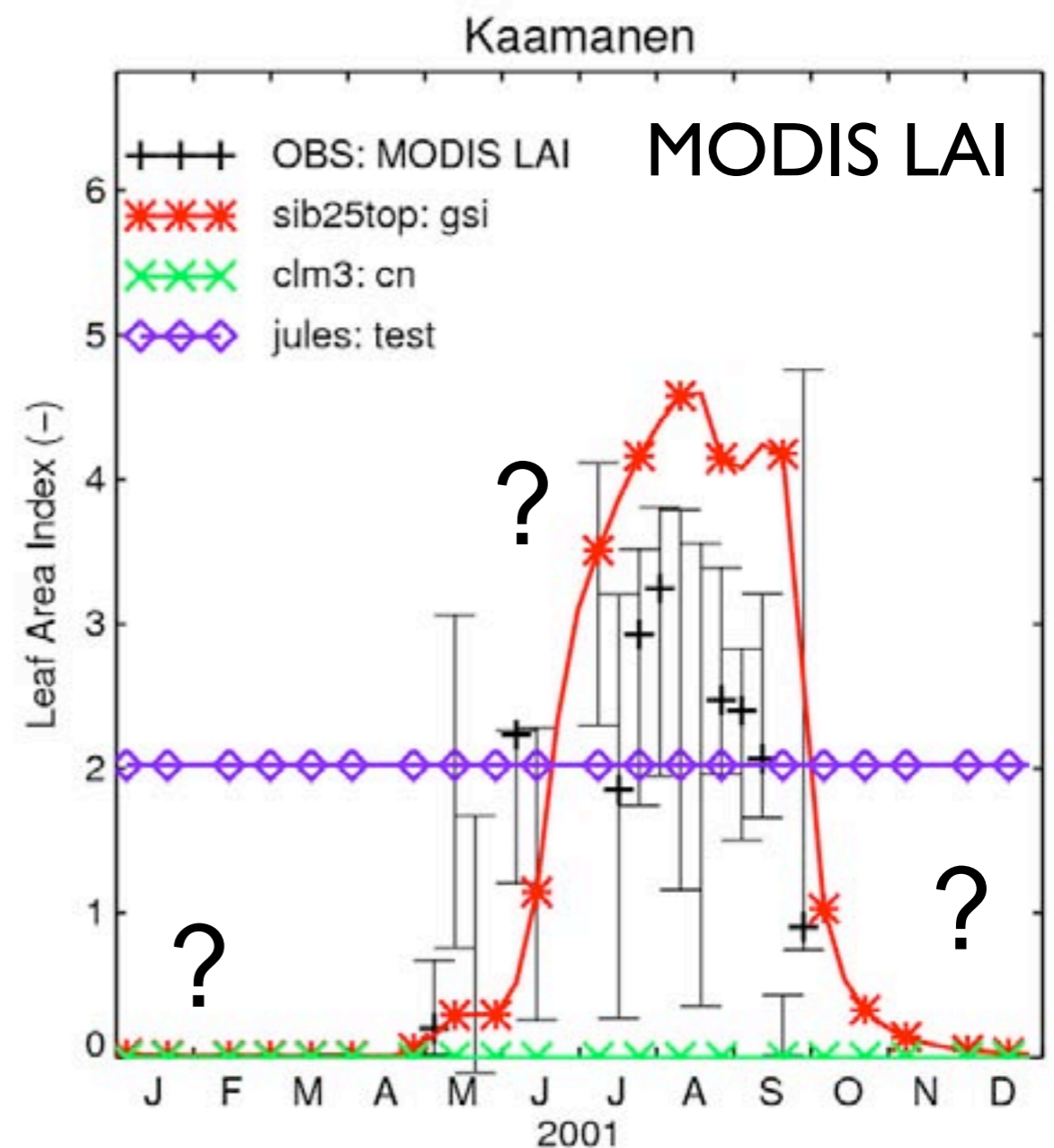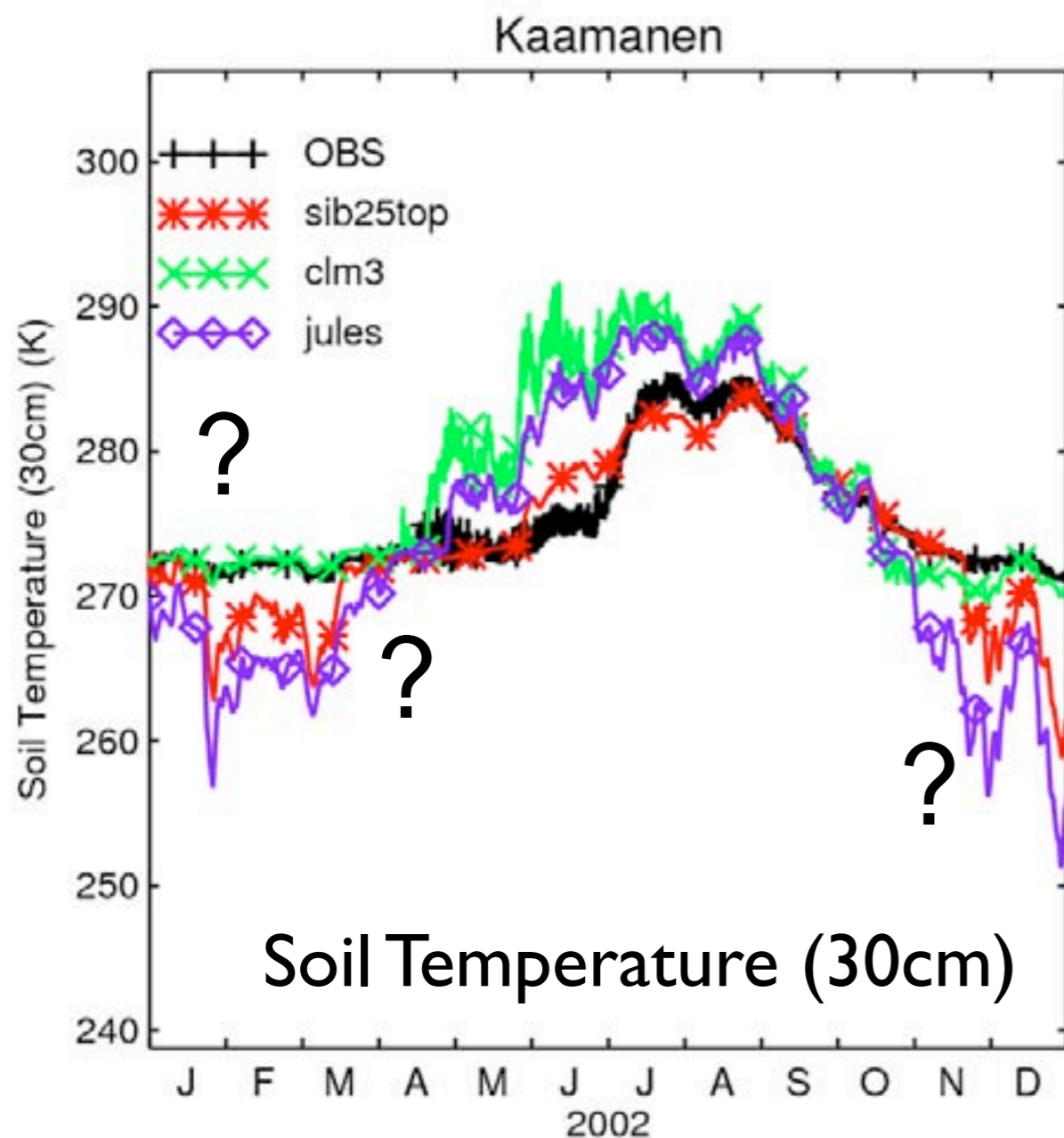
# Arctic grassland

**JULES:**

- snow buildup and snow height comparable
- snow melt 10-20 days too early
- melt water lost from system (frozen soil?)

# Arctic Grassland

**Open Questions (general, all LSM's) …out of many**
- below-snow soil heat storage?
- prognostic phenology of arctic grasslands?

# Conclusions

**Ecosystem observations from ground & space**
- directly comparable to model prognostics
- wide range of vegetation/climate zones

**Offline single point LSM simulations**
- cheap: interactive model development
- less complexity: observational constraints

**Combination: process-based HW&C analysis**

**JULES, preliminary summary:**
- seasonal H/W fluxes stable for all climates
- analyze timing & magnitude of LE & GPP
- analyze soil hydrology: snowmelt + GW storage