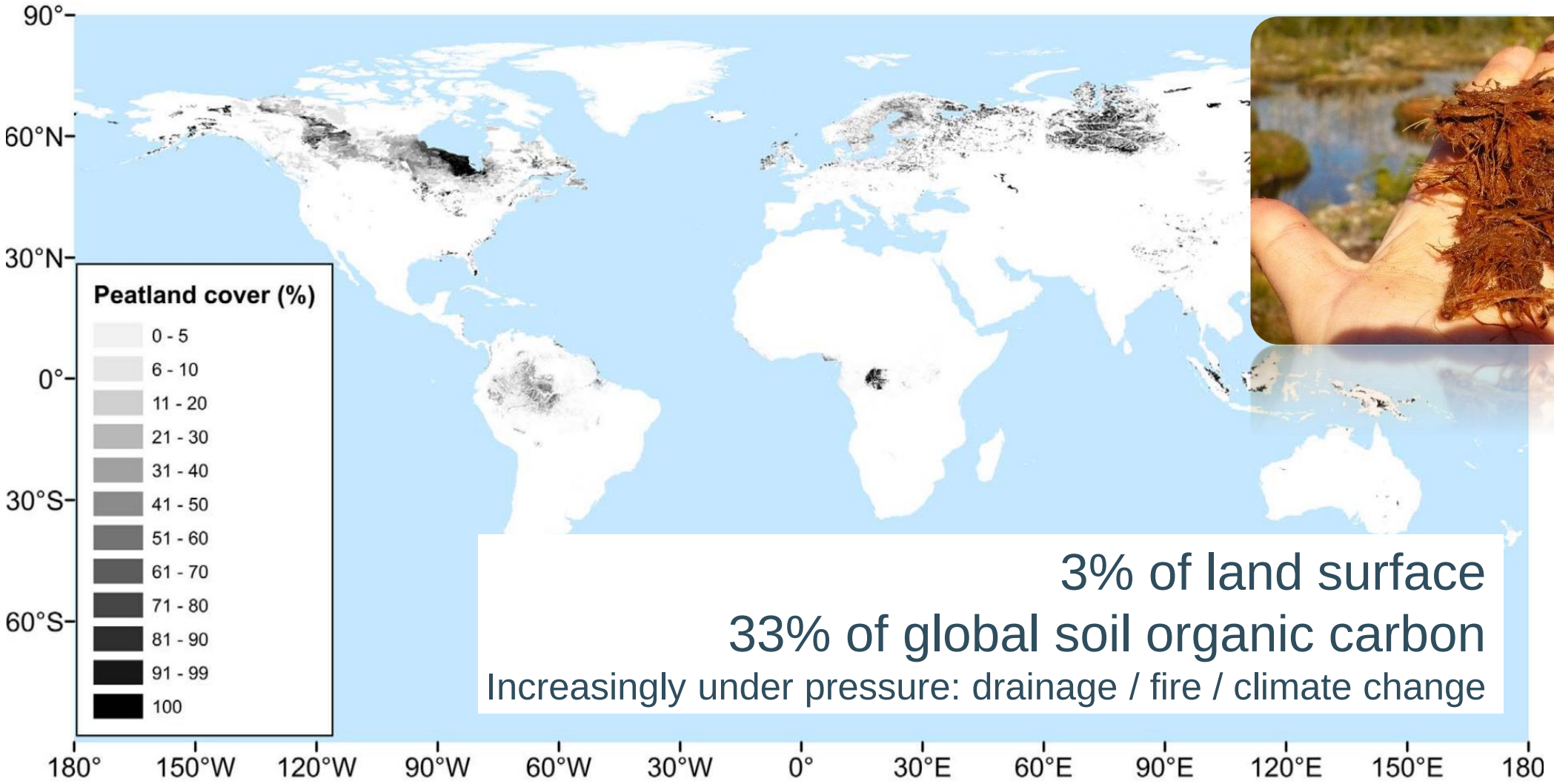
KU LEUVEN

Accounting for STATIC and DYNAMIC OPEN WATER in the modeling of SMAP brightness temperatures over peatlands

M. Bechtold[1], S. De Canniere[1], R. Reichle[2], G. De Lannoy[1]

[1] KU Leuven, Belgium, [2] NASA-GMAO, USA

Peatlands: Hotspots of soil organic carbon stocks



3% of land surface

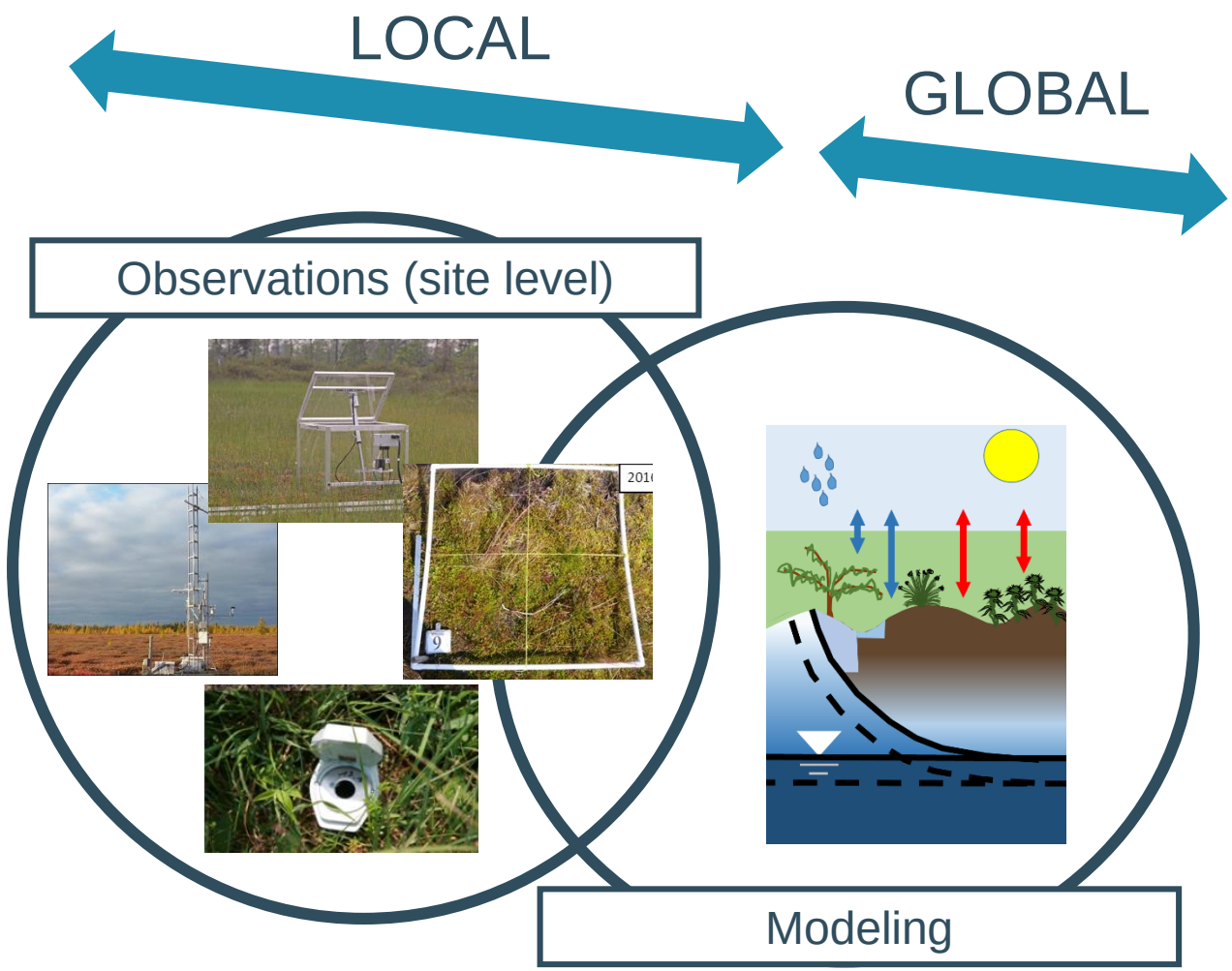
33% of global soil organic carbon

Increasingly under pressure: drainage / fire / climate change

Global Peatland (Histosol) Distribution; Xu et al., 2018

KU LEUVEN

Peatlands' global feedback to recent climate change?



Various influencing factors

- peatland type
- peat thickness
- vegetation composition
- climatic setting
- characteristics of climate change
- …

BUT:

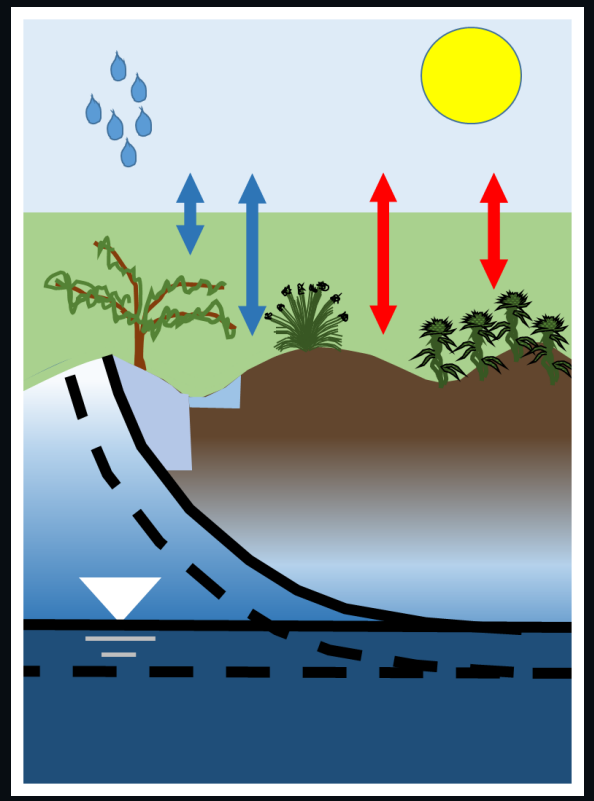
- Lack of spatial information on peatland properties
- Uncalibrated models
- High uncertainty

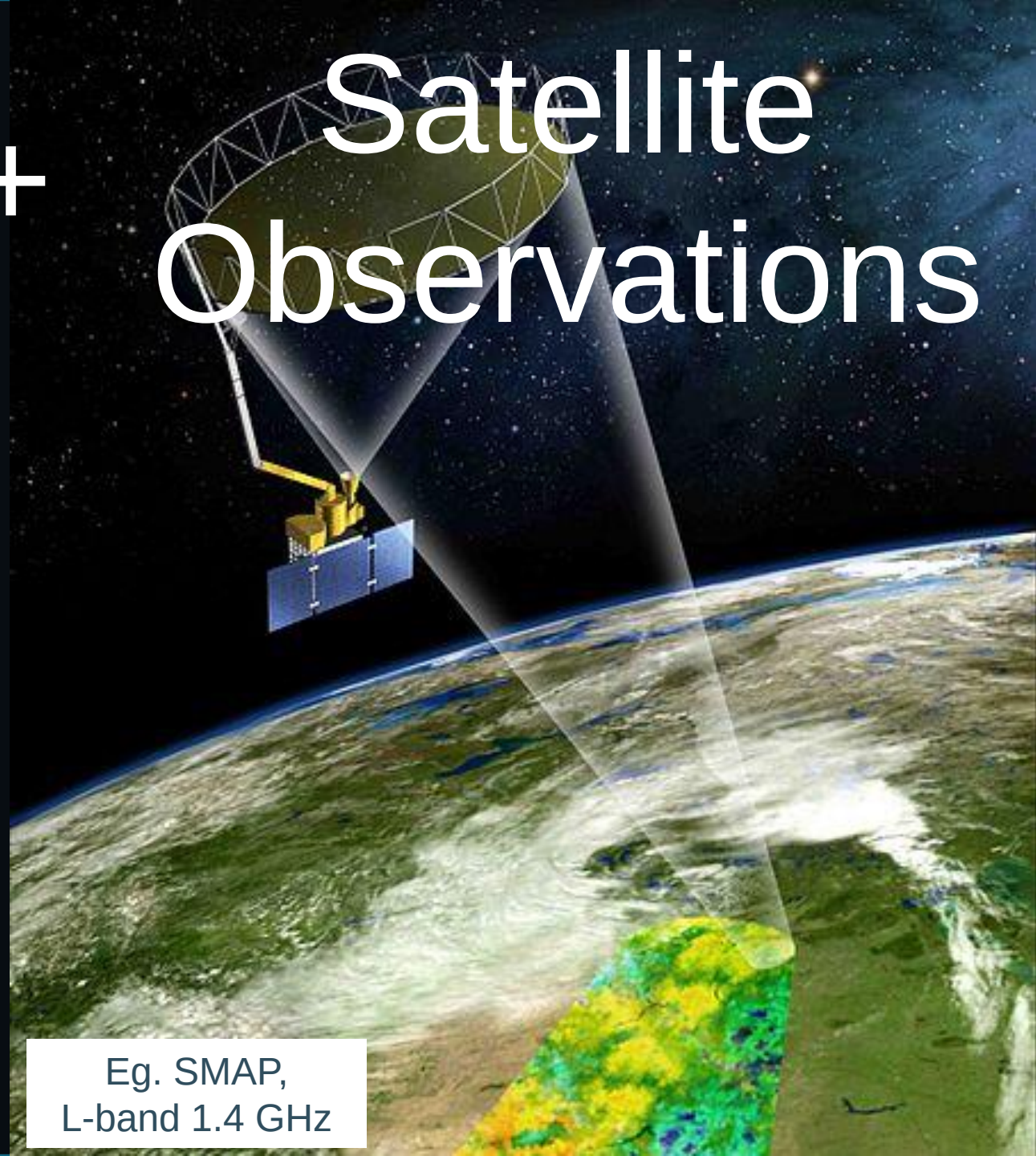
KU LEUVEN

Global modeling

+

Satellite Observations





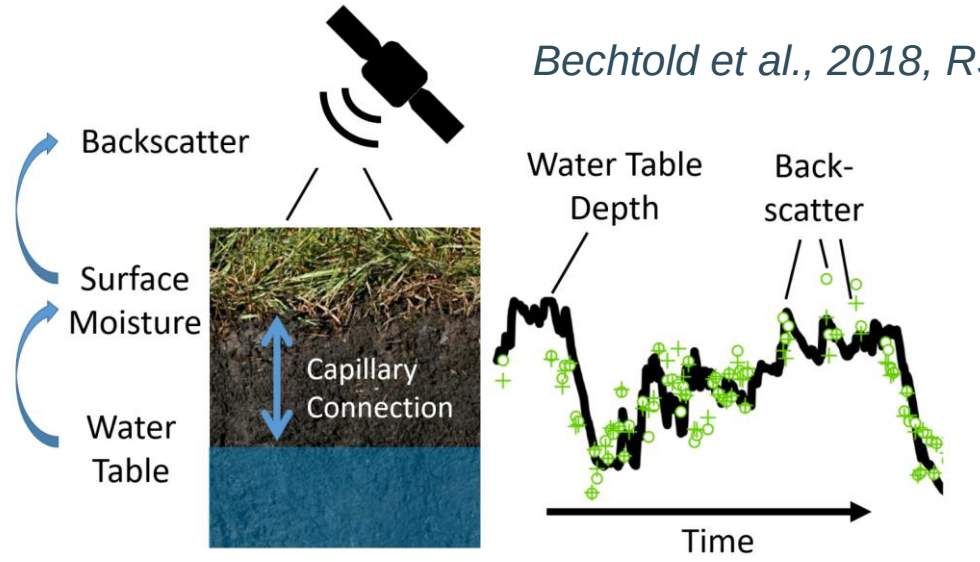
Eg. SMAP,
L-band 1.4 GHz

Microwave remote sensing of peatland hydrology

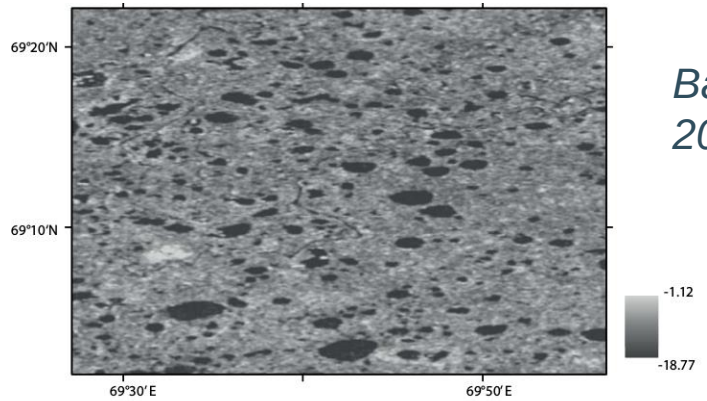
- Sensitivity to Surface Soil Moisture and Water Table Depth via capillary connection
  (Kasischke et al. 2009, Kim et al. 2017, Bechtold et al. 2018)

Thu, 10am, Poster Area R
Sentinel-1 over peatlands
#THP1.PR.8 (Asmuß et al.)

- Sensitivity to Open Water Dynamics
  (Bartsch et al. 2012, Kim et al. 2017, Du et al. 2018)



Bechtold et al., 2018, RS



Bartsch et al. 2012, BG

KU LEUVEN

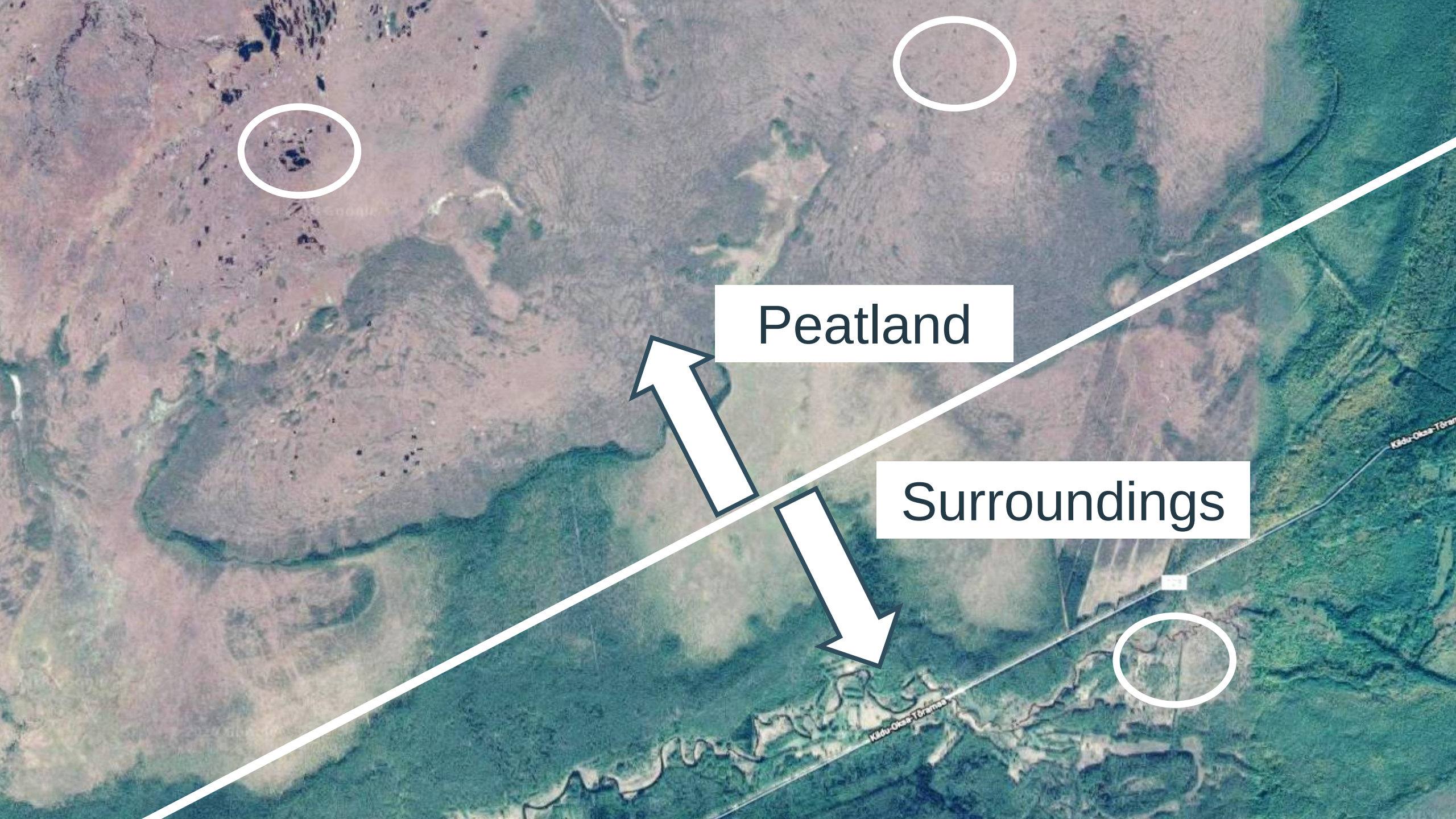
Objective

Improve radiative transfer modeling (RTM) of Tb over peatland areas by

- partitioning surface into land and open water fractions, and
- applying surface mixing models

Further outline

- Surface partitioning over peatlands
- RTM inputs
- Surface Mixing Model comparison
- Conclusions


Peatland
Surroundings

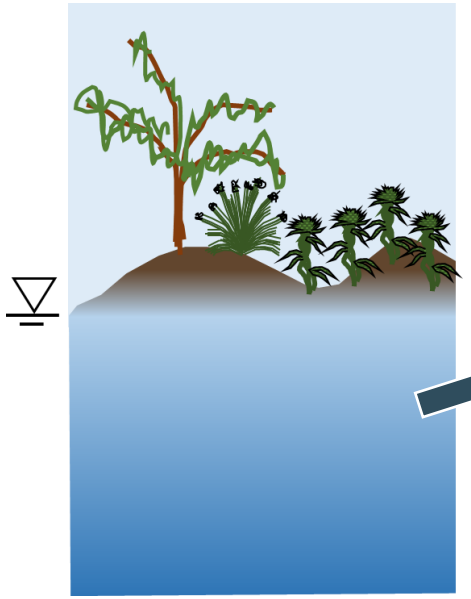
Surface partitioning over peatland areas

Surface fraction

Vegetation cover

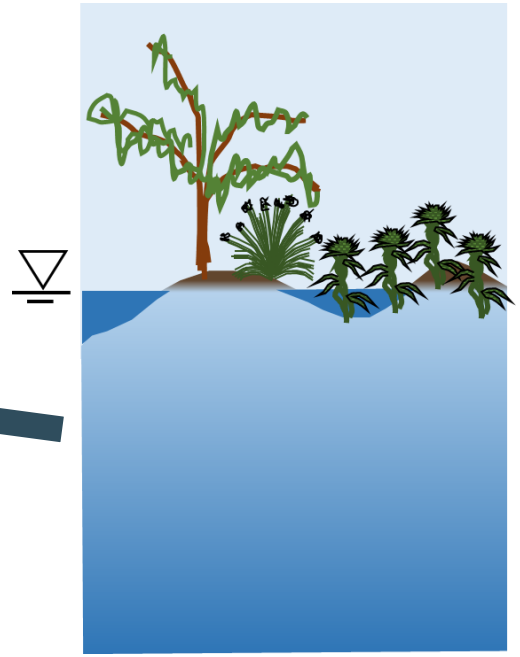
No vegetation cover (‘exposed open water’)

Surface fractions with vegetation cover



f_{sm}

$f_{dow,veg}$



‘Exposed’ open water fractions (=noveg)

$f_{SOW,noveg}$

$f_{DOW,noveg}$

Surface partitioning over peatland areas

Surface fraction

Vegetation cover

f_{SM} Water level < Soil surface

$f_{DOW,veg}$ Water level > Soil surface

No vegetation cover (‘exposed open water’)

$f_{SOW,noveg}$ Static open water

$f_{DOW,noveg}$ Dynamic open water

Tb modeling approach

$\tau - \omega$ model
SMAP algorithm
(RTM parameters: De Lannoy and Reichle, 2016, HESS)

ε_G
(emissivity of ground)

- Soil moisture from LSM
- Smooth water surface

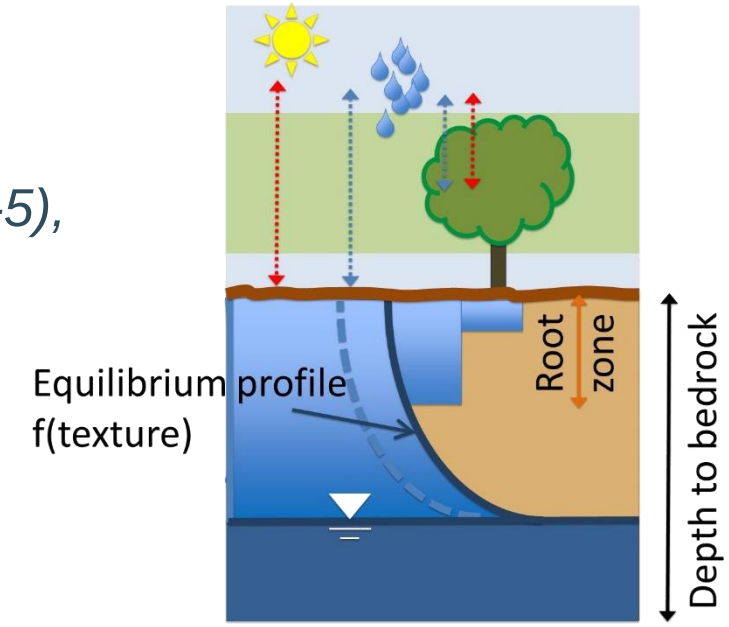
Tb of smooth water surface

- Dielectric perm. of fresh water (Klein and Swift,1977)
- Fresnel equations
- $T_{water} = T_{soil,5cm}$

CLSM: Catchment Land Surface Model

Koster et al. 2000

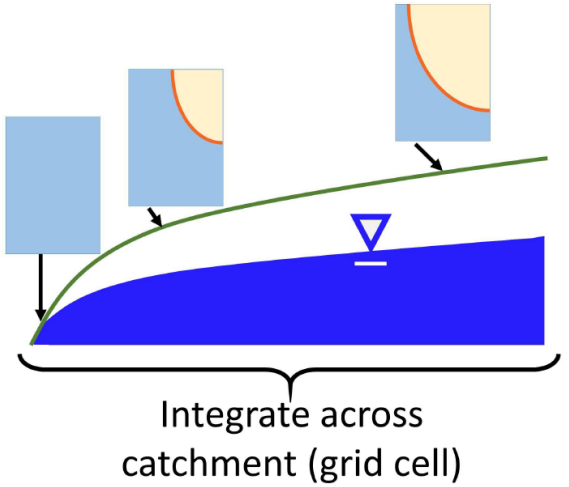
→ LSM of NASA's Goddard Earth Observing System Model (GEOS-5), e.g. used for MERRA-2 reanalysis and SMAP soil moisture products



Main Characteristics:

- Partitioning of land surface into hydrologic catchments
- Water level !
- Topographic Wetness Index based model
  → subgrid soil moisture + water level variability and runoff
- Dynamic partitioning of catchment into hydrologic regimes (saturated, transpiring and wilting areas)

- Peat as soil class (De Lannoy et al. 2014, JAMES)

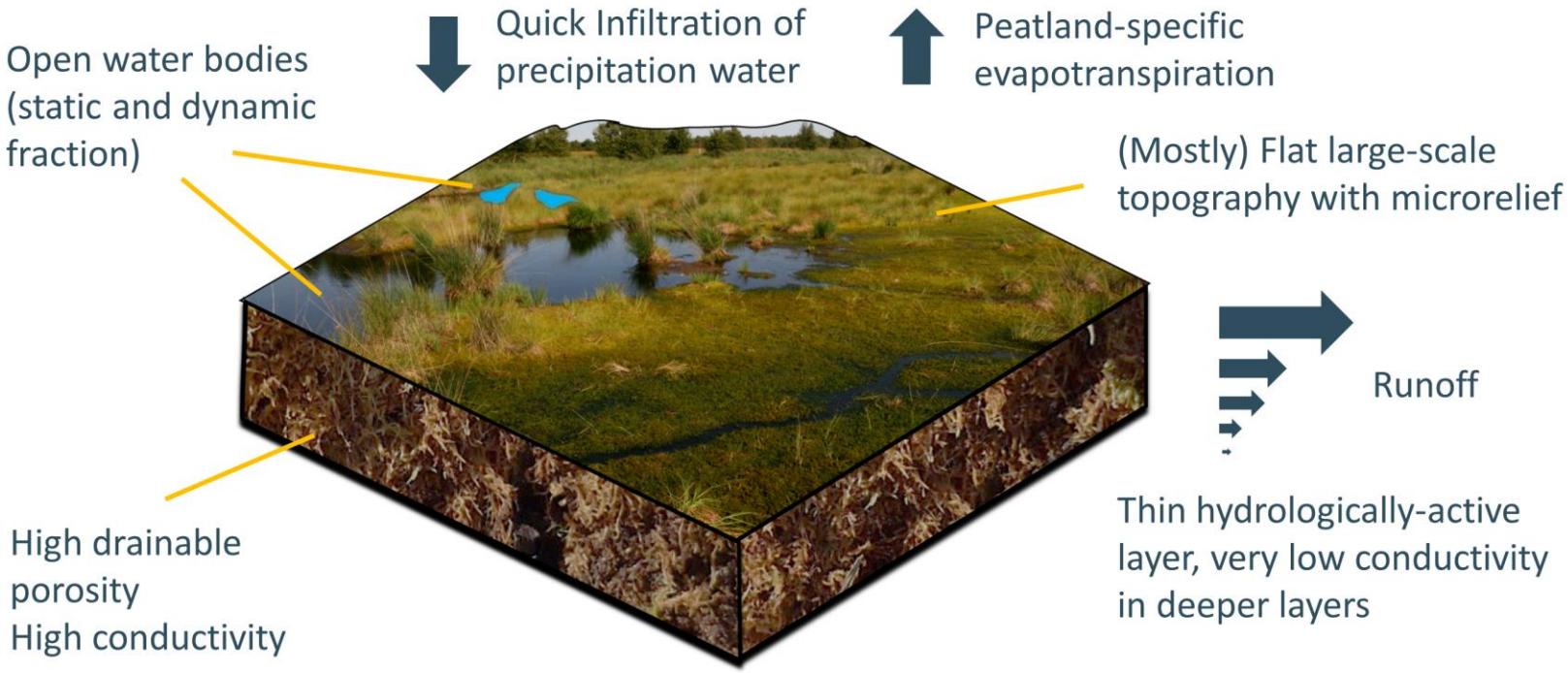


KU LEUVEN

PEAT-CLSM

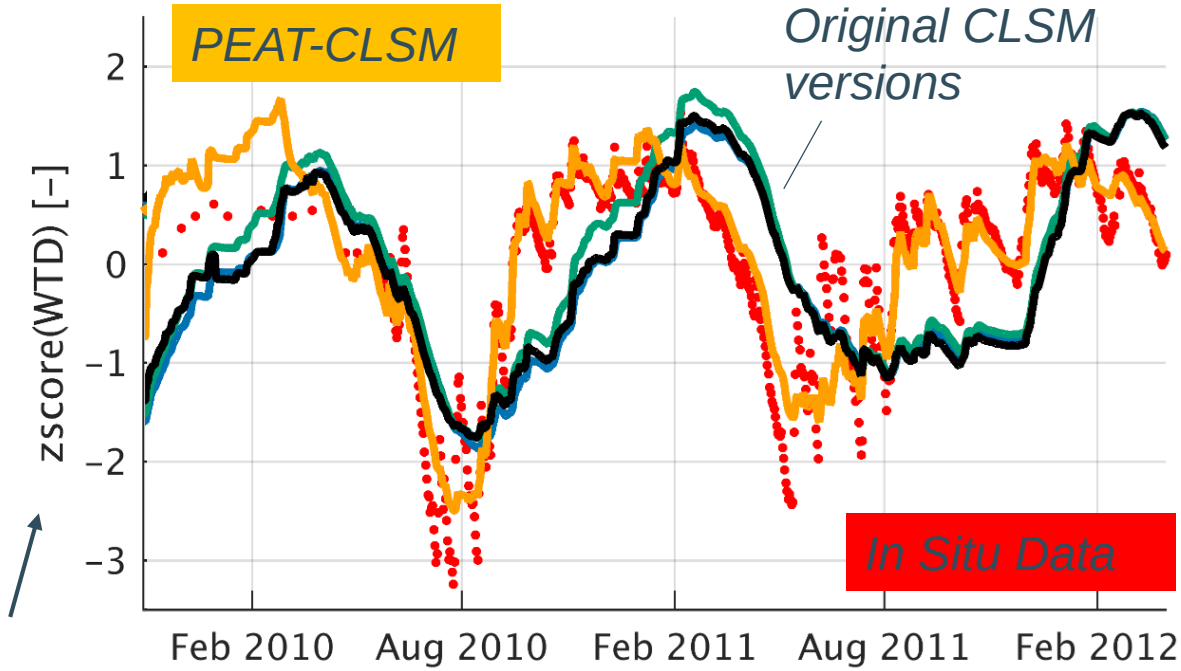
Bechtold et al., in prep.

- Revised model structure for peatland hydrological processes
- Modeled dynamic surface fraction with ponding water (to be interpreted mainly as shallow ponding, i.e. vegetation covered surface water → $f_{DOW,veg}$)



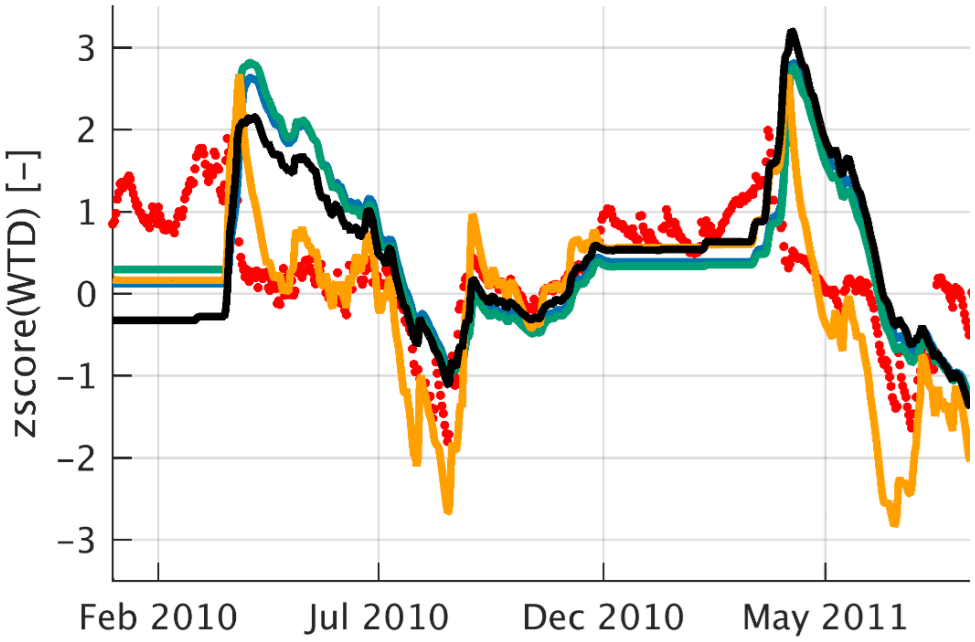
PEAT-CLSM: Validation (water table depth data)

Example 1: Bog in NW Germany
Mild winter, high precipitation, R=0.9



bias + std corrected

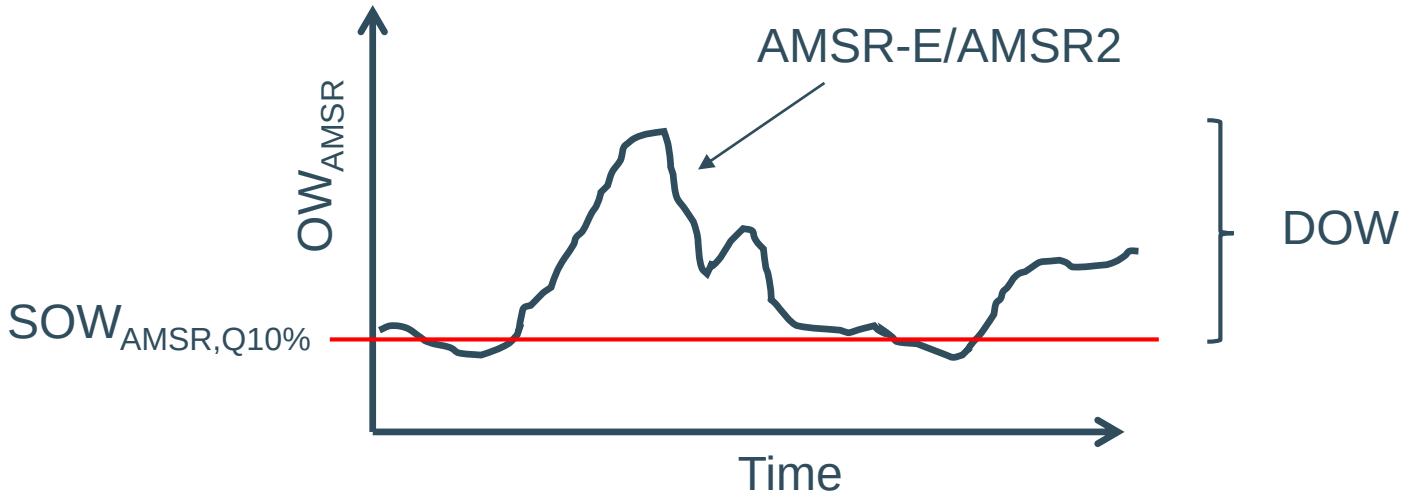
Example 2: Bog in Belarus
Long freezing period, R=0.6



Not calibrated !

Ancillary input (for ‘noveg’ OW fractions)

- SMAP static water / land mask
  → $f_{SOW,noveg}$
- Daily Global Land Parameters Derived from AMSR-E and AMSR2 (Du et al., 2017)
  → $f_{DOW,noveg}$



Evaluation of mixing models

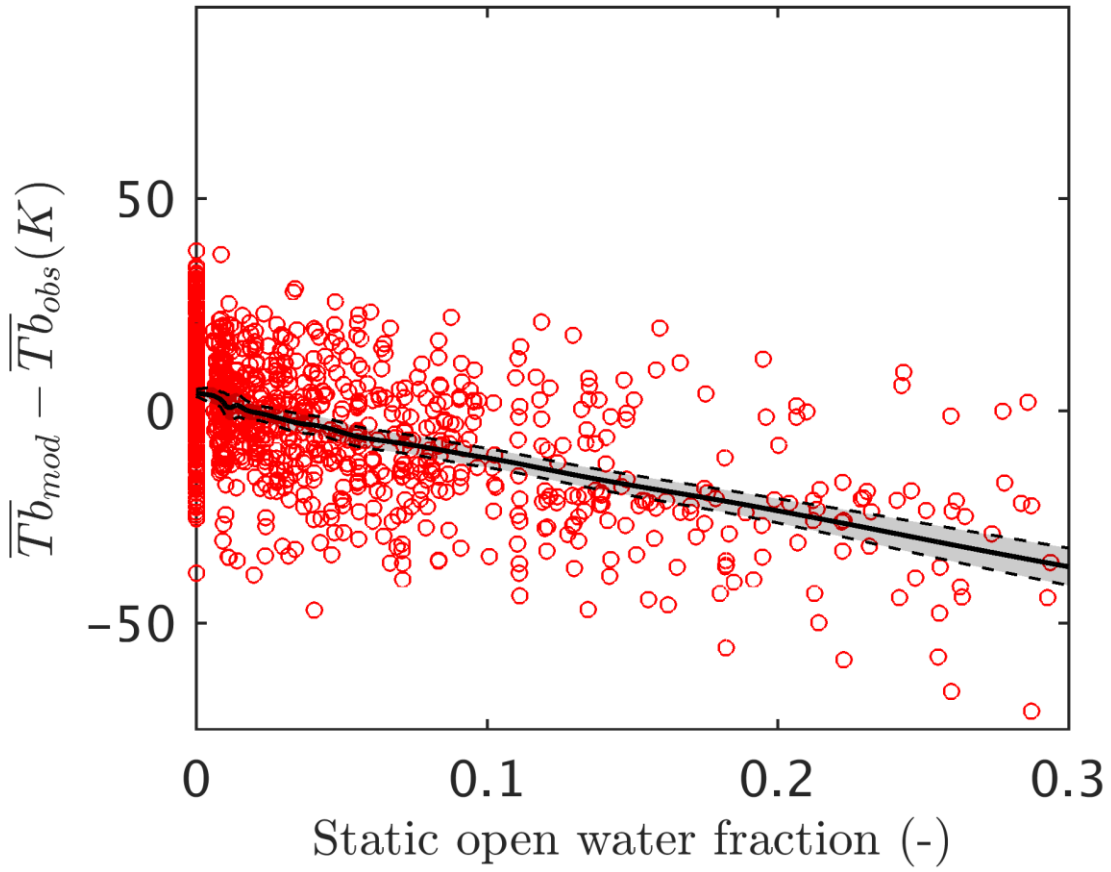
$Tb_{mod} \Leftrightarrow Tb_{obs}$

- SMAPL1C data, H-pol
- Time: snow-free periods 2015 and 2016
- Area: Northern Hemisphere, south of permafrost
  ~650 M36km pixels

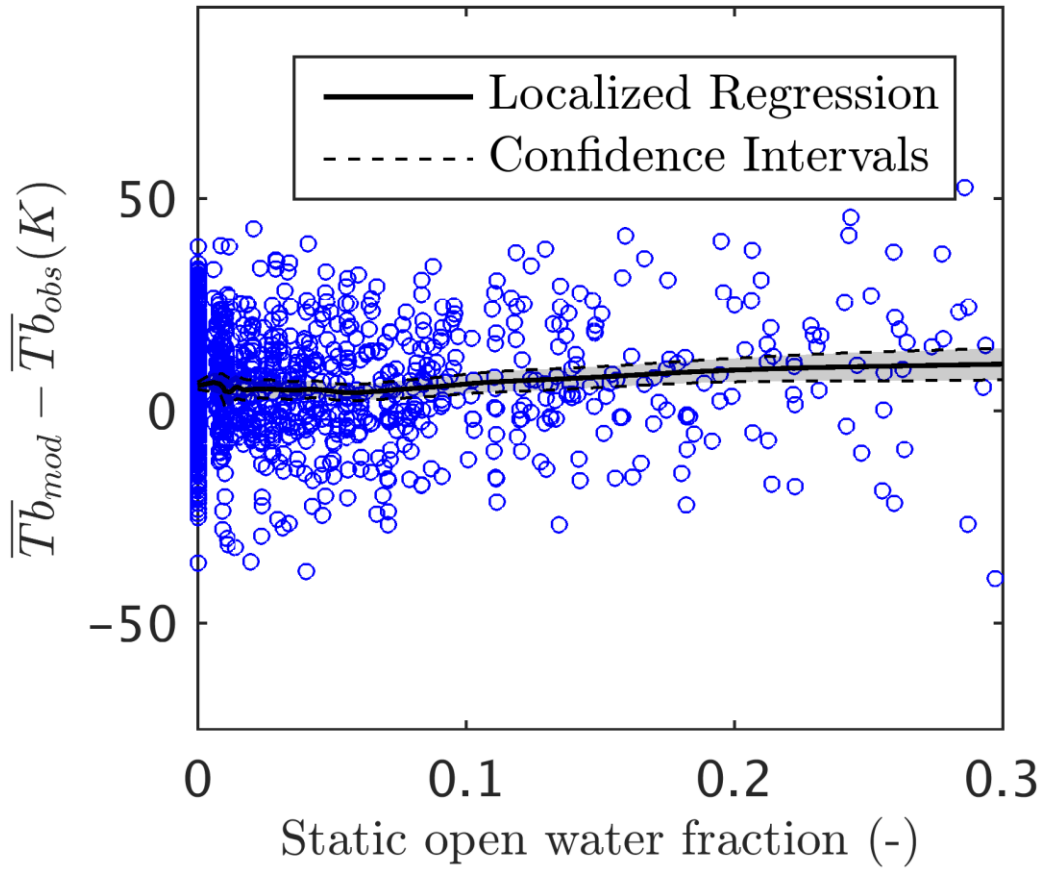
$$Tb_{mod} = f_{SM}*Tb_{SM} + (f_{SOW,noveg}+f_{DOW,noveg})*Tb_{OW,noveg} + f_{DOW,veg}*Tb_{OW,veg}$$

Incl. static open water reduces bias in Tb forward modeling

without $f_{SOW,noveg}$*$Tb_{OW,noveg}$

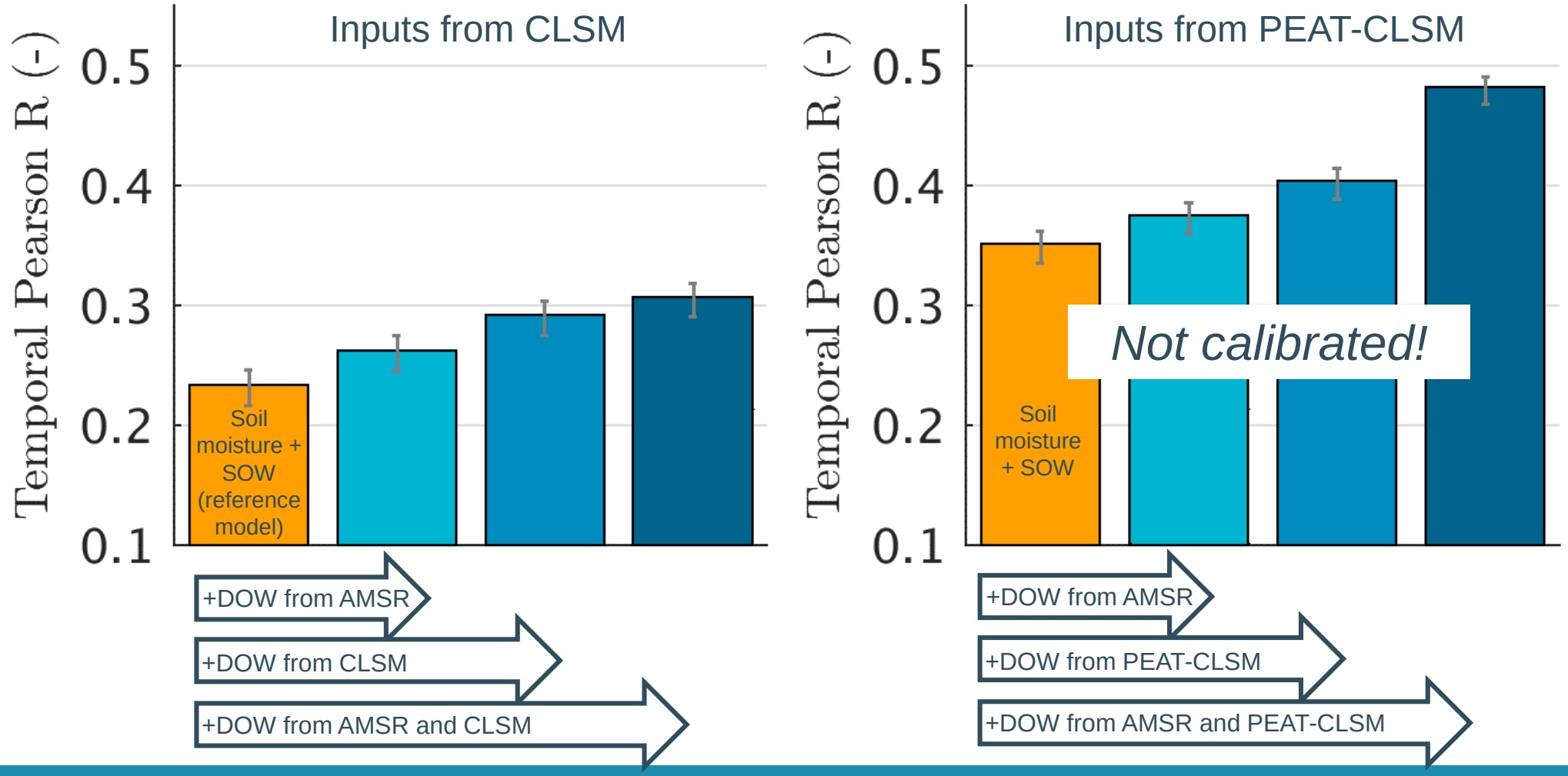


with $f_{SOW,noveg}$*$Tb_{OW,noveg}$



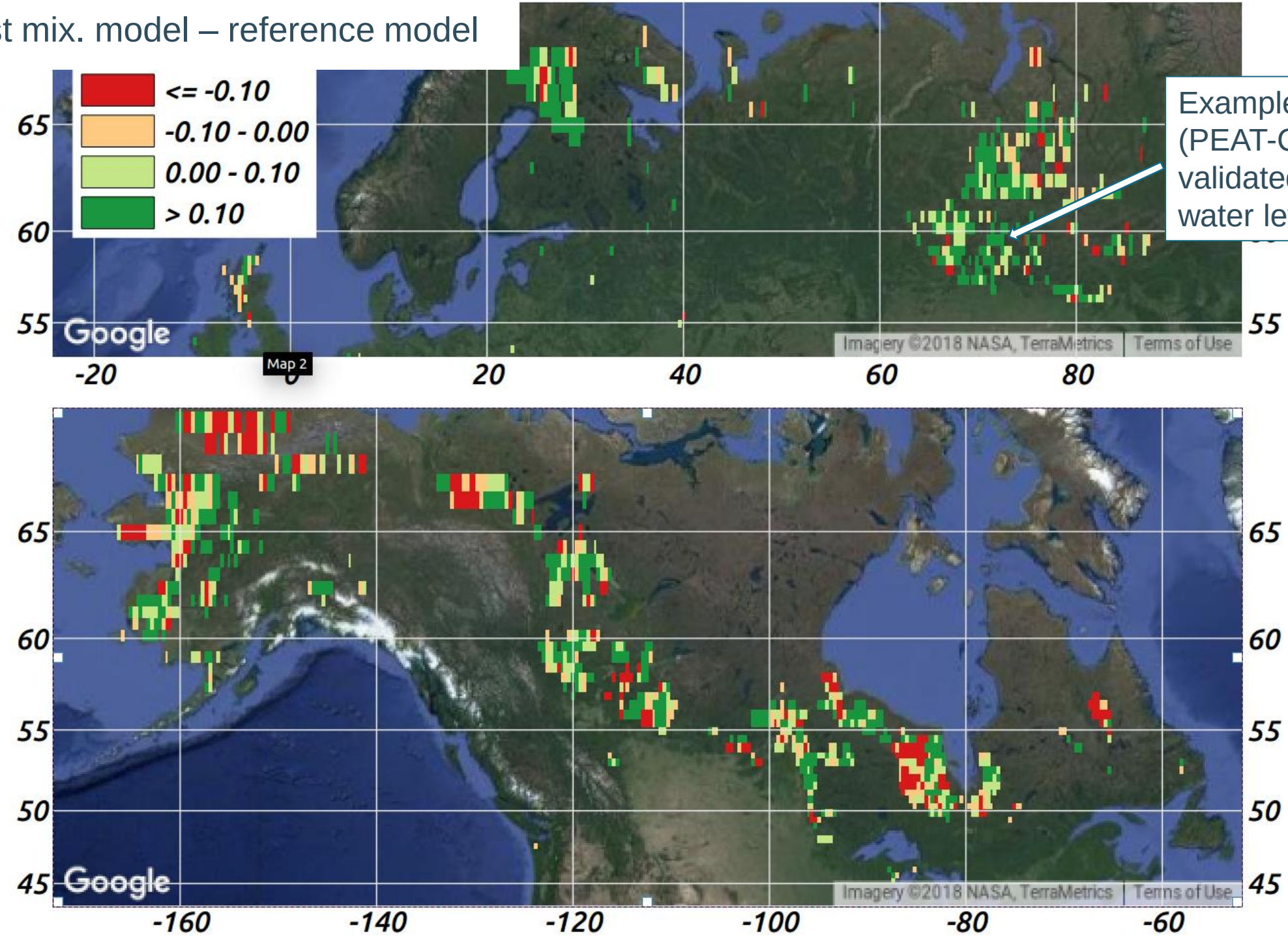
Mixing model comparison: Corr(Tb_{obs}/T_{soil}, Tb_{mod}/T_{soil})

- Evaluation for emissivity to increase sensitivity to dynamics of water storage components



KU LEUVEN

ΔR (best mix. model – reference model

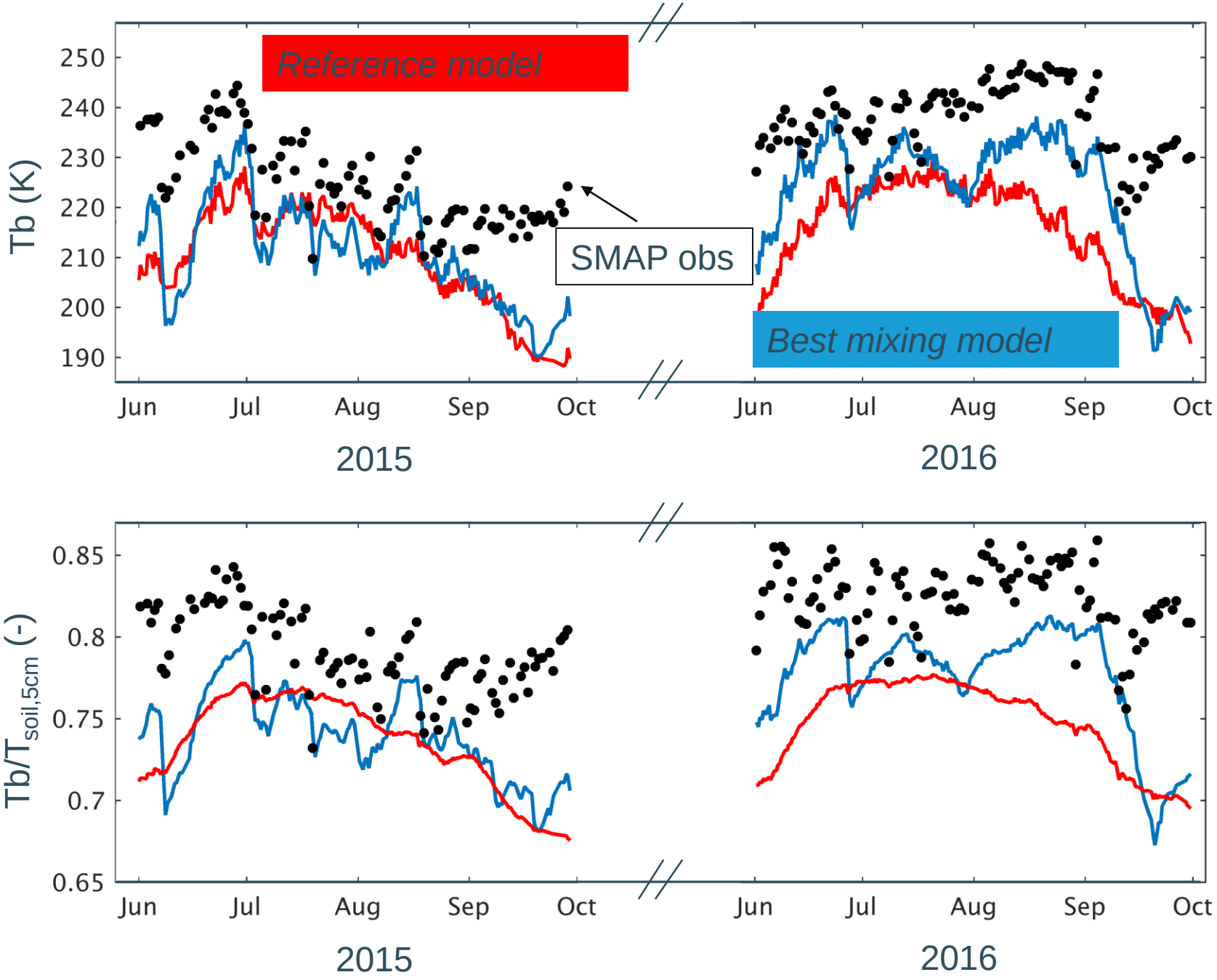


Example time series (PEAT-CLSM model validated by in situ water level data)

Example time series (Western Siberian Lowlands)

OW statistics	example site	mean of all M36 pixels
SOW	0.01	0.04
DOW_{AMSR2} (max-min)	0.05	0.03
$DOW_{PEAT-CLSM}$ (max-min)	0.40	0.46

- Dynamics → “Best mixing model” with intra- and interannual features also seen in observations



Conclusions

- Current reference model: no dynamic OW + soil moisture from original CLSM

  → low temporal correlation with observed emissivity (mean R = ~0.25)

- Surface mixing models accounting for various open water fractions

  → improved temporal correlation over most peatland areas

- LSM output (peatland version) on ponding water below vegetation cover

  → useful input for RTM mixing models

Acknowledgments

Feodor Lynen
Fellowship

Alexander von Humboldt
Stiftung/Foundation