Modified soil hydro-thermodynamics cause large spread in projections of Arctic and subarctic climate

Norman Julius Steinert[1,2], Jésus Fidel González-Rouco, Philipp de Vrese, Elena García-Bustamante, Stefan Hagemann, Johann Jungclaus, Stephan Lorenz, Victor Brovkin, Camilo Andres Melo-Aguilar, Félix García-Pereira, and Jorge Navarro

[1]Complutense University of Madrid, Department of Earth Physics and Astrophysics, Geosciences Institute IGEO (UCM-CSIC), Madrid, Spain
[2]NORCE Norwegian Research Centre, Climate and Environment, Bergen, Norway

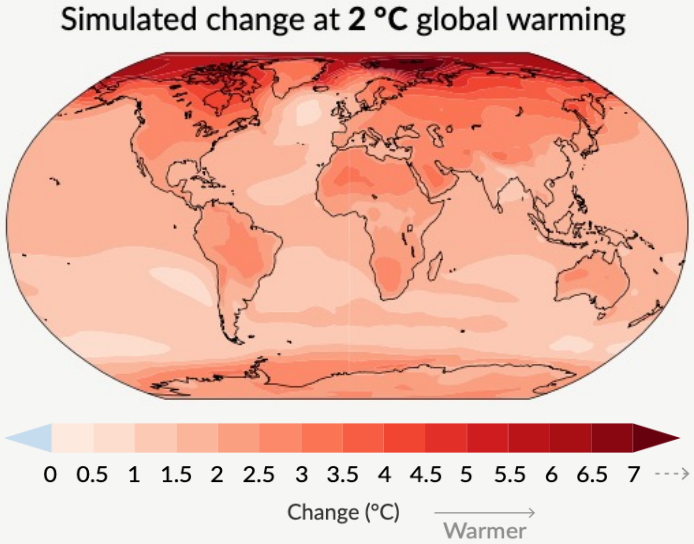
25. May 2022
EGU General Assemble 2022
CL4.8 Climate Variability and Prediction in High Latitudes

OSPP
Thank you!

High latitude under global warming

2x

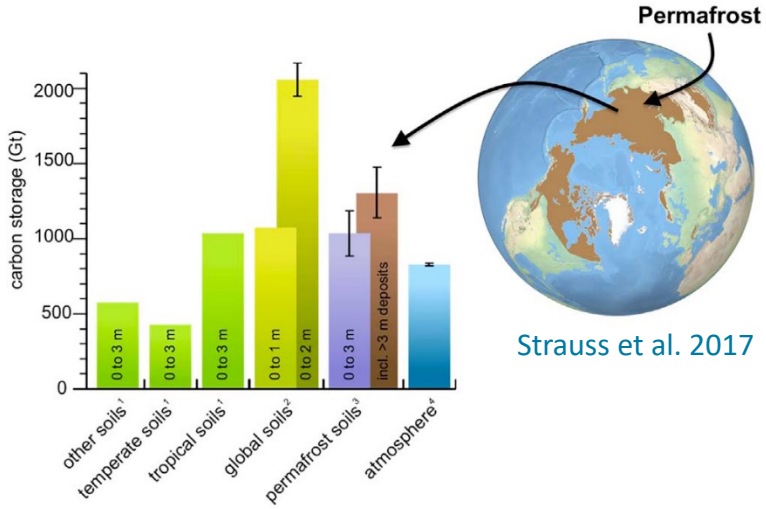
larger warming due to
arctic amplification



IPCC, 2021

2x

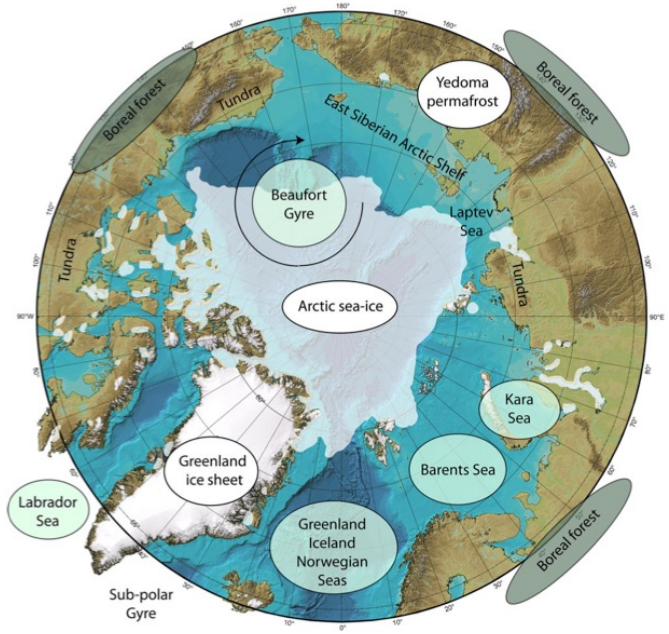
larger carbon storage
than the atmosphere



Strauss et al. 2017

Several

Tipping elements and inter-
connected climate feedbacks



Lenton, 2012

Global carbon budget

150-330 Gt (1.5-2.0°C)

anthropogenic — natural

Permafrost — **800-1400 Gt**

11-143 Gt (+1.4°C)

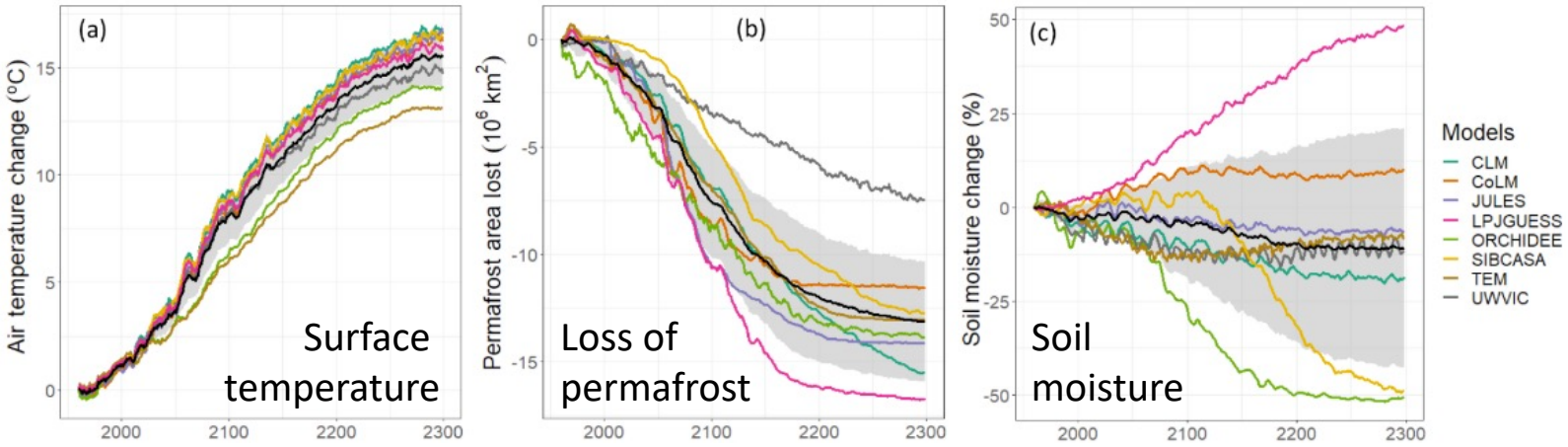
Koven et al. 2015, Gasser et al. 2018

High-latitude model uncertainty

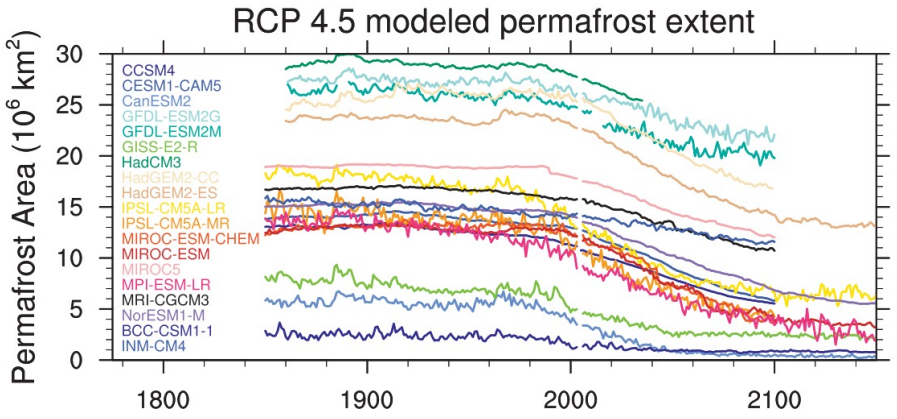
No consensus on whether Arctic soils become

wetter or drier

Arctic terrestrial **hydrological variables** relative to 1960 (RCP8.5)



Andresen et al. 2020



Koven et al. 2013

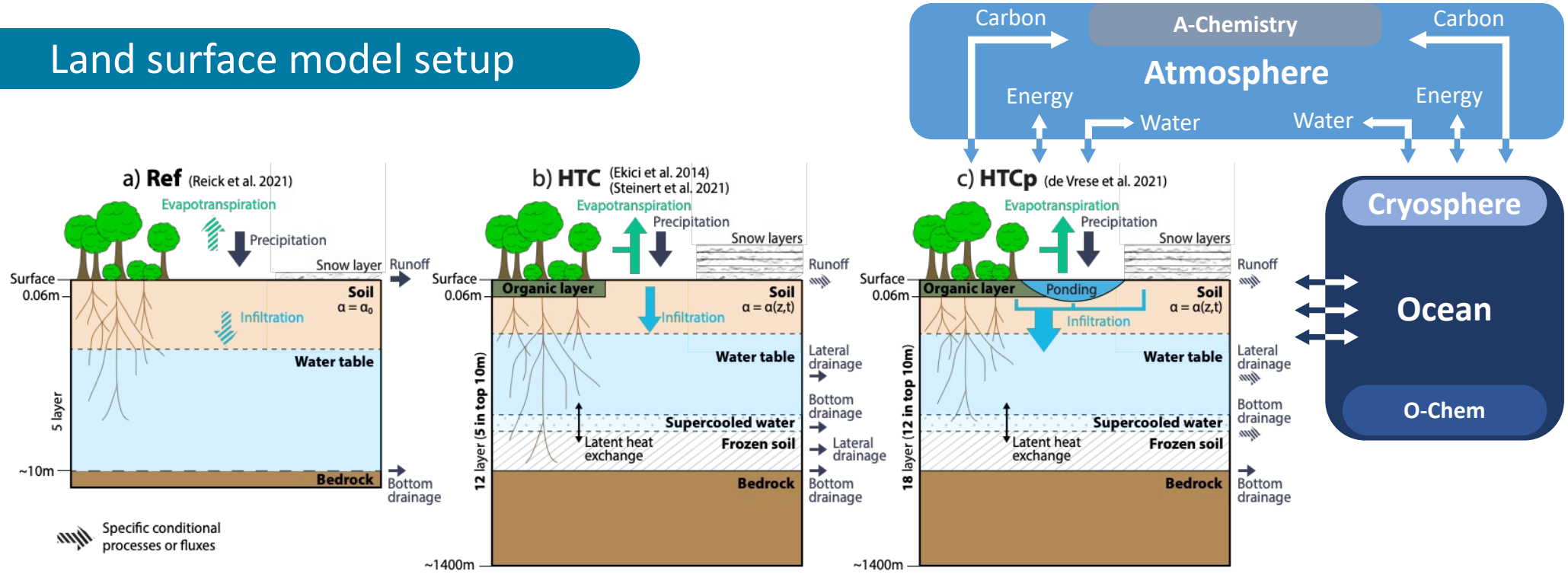
Hydrology ↔ Thermo-dynamics

Hydro-thermodynamic

interaction determines near-surface climate

To what extent does the CMIP6 **Uncertainty** depend on model structure and parameterizations?

Land surface model setup



JSBACH - MPI Earth system model

structural and parameterization modifications

0	**BBCP**	10m -> 160m
1	**SNOW**	5-layer snow scheme
2	**DCC**	moisture-dependent soil thermal properties
3	**LHE**	freeze-thaw processes with latent heat exchange
4	**SCW**	supercooled water (portion of water stays liquid)

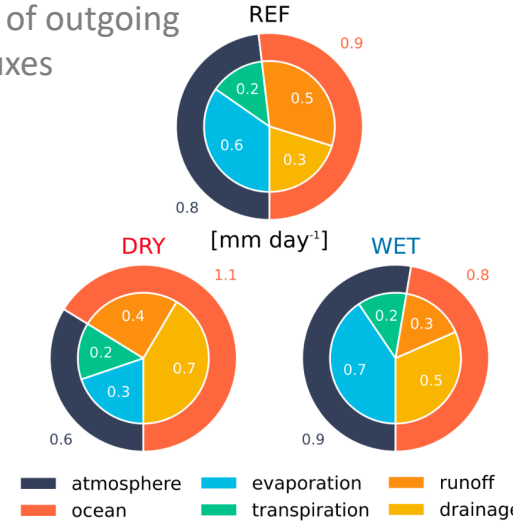
Evapotranspiration
Infiltration
Drainage
Organic layer
Ponding

WET setup

DRY setup

Changes in soil **hydrological cycle**

Partitioning of outgoing moisture fluxes



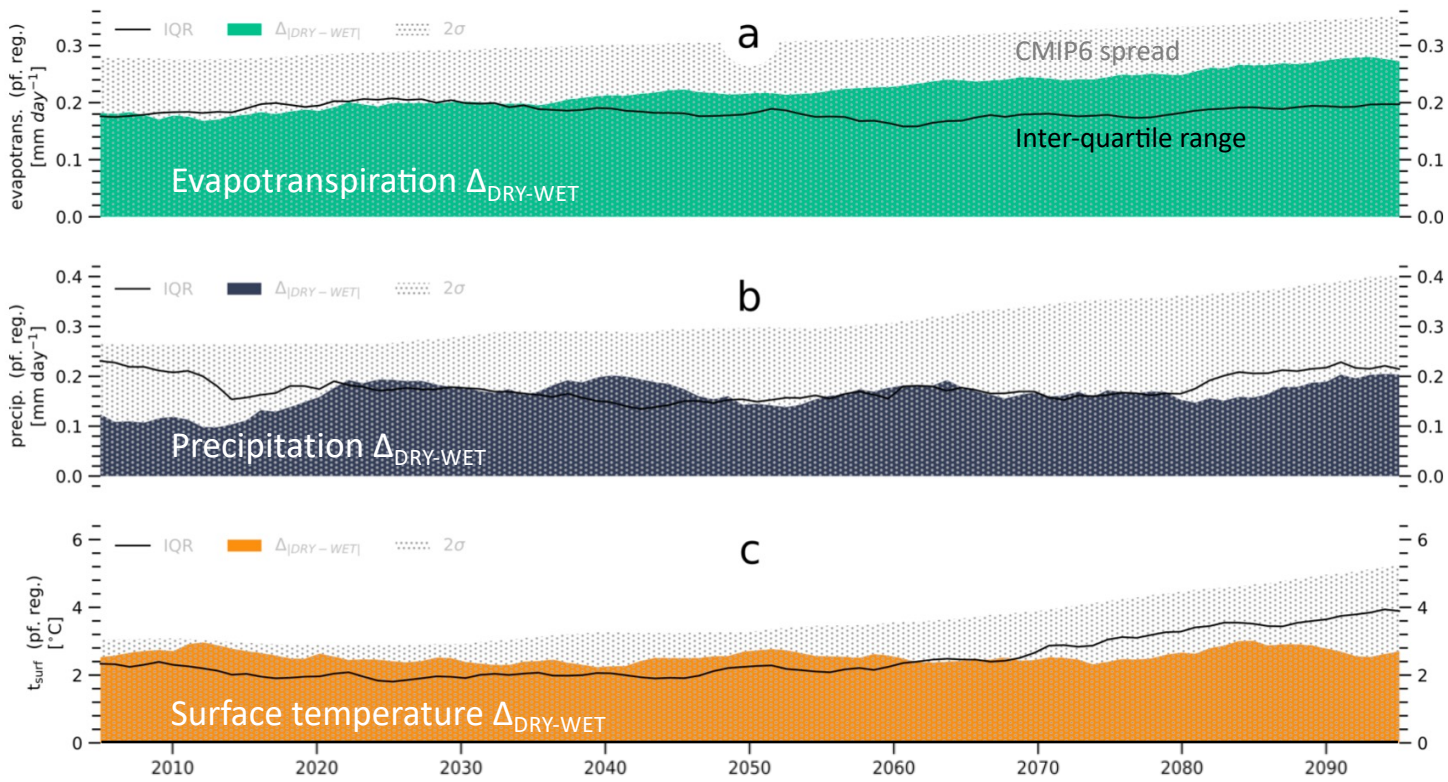
Soil hydrology in frame of CMIP6

Hydrological setups explain large fraction of

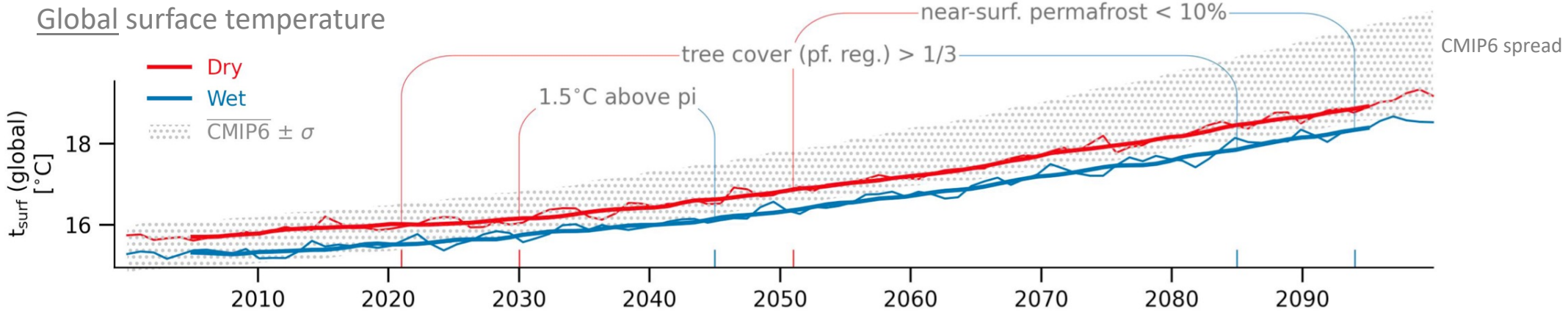
inter-model spread

Significantly different **onset timings**
of key climate-change indicators

Permafrost region hydrological control parameters ($\Delta_{DRY-WET}$)



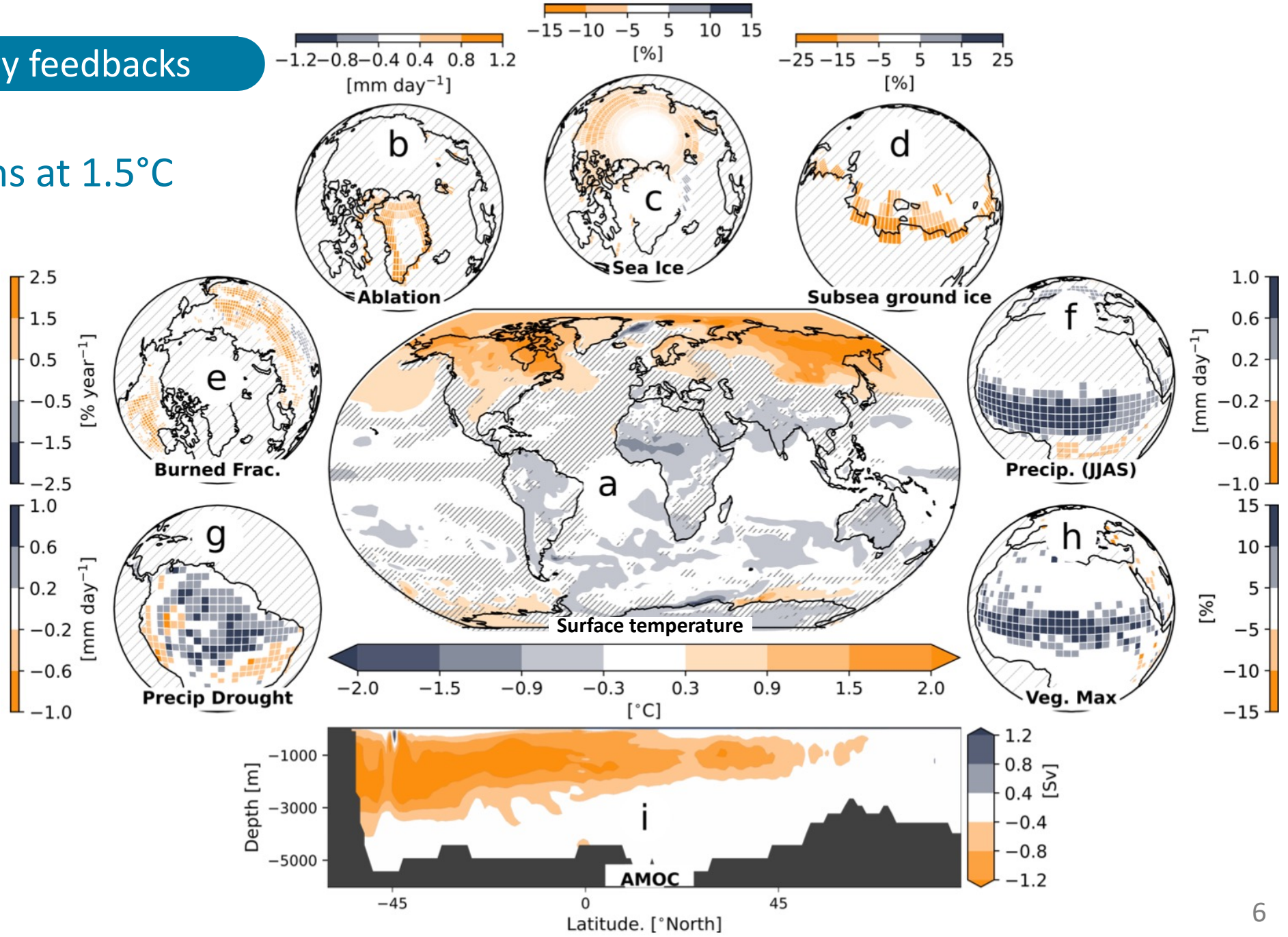
Global surface temperature



High lat. soil hydrology feedbacks

Core climate regions at 1.5°C

Hydro-thermodynamic sensitivity affects a range of components of the Earth system



Conclusions

Modified soil hydro-thermodynamics influence state of high-latitude land surface climate

Changes in **land-atmosphere exchange** of energy and moisture

Differences in hydrological setups **explain inter-model spread** CMIP6 to a large part

Far reaching impacts for major climate components as far south as to the tropics

With both setups **similarly plausible**, further need for observational constraints

OSPP
Thank you!