Land_Cover_CCI

The Temporal Mapping of Water Bodies from the Perspective of Climate Modelling

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Overview

- Importance of surface water bodies in climate modelling and NWP forecasts
- Modelling surface water bodies and evaluation of results
- Thermokarst lakes
- Conclusions

Importance of modeling water bodies in climate models

Water bodies = lakes, reservoirs, rivers..

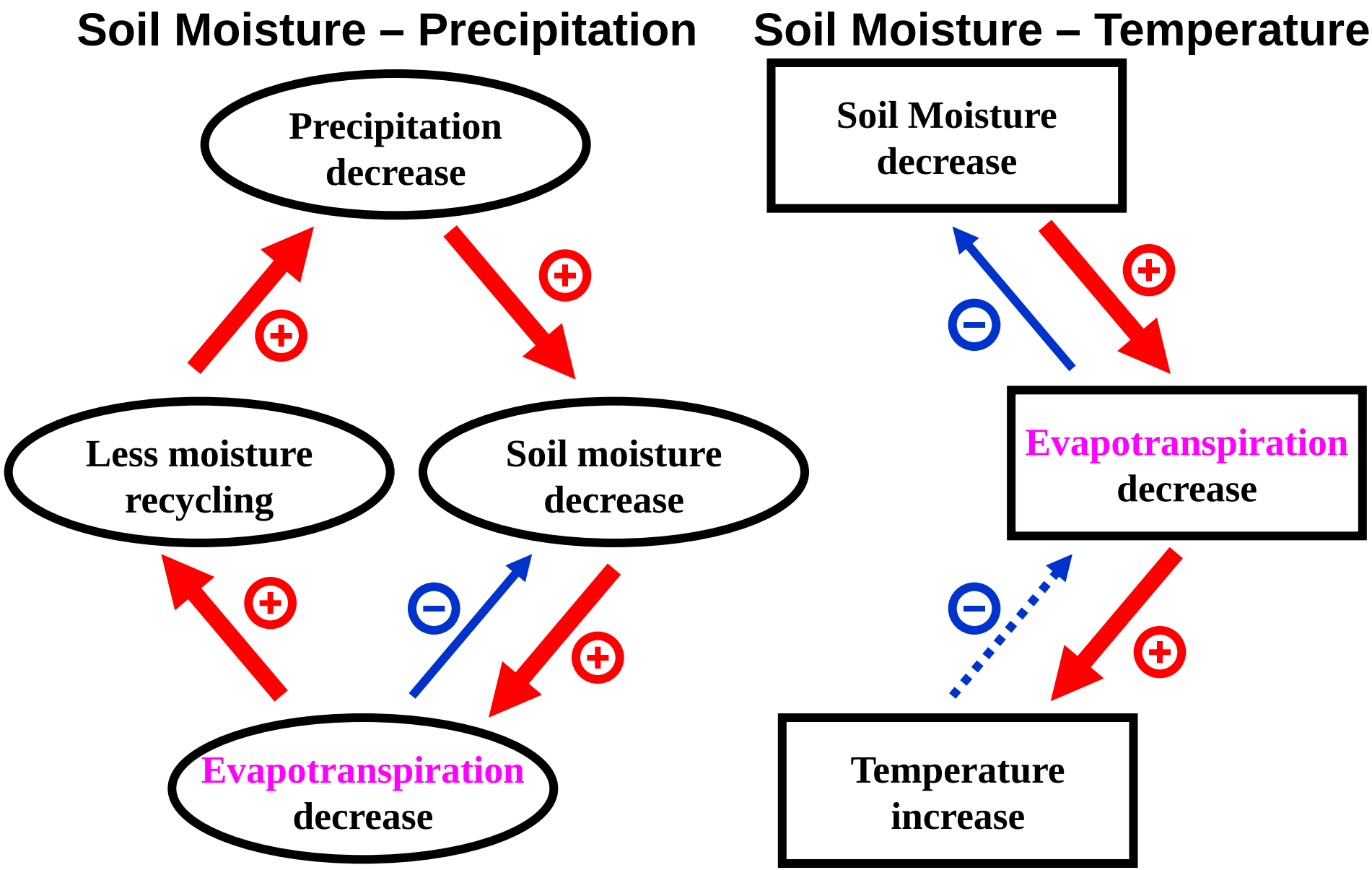
➔ Play a key role on regional and global water and energy cycles because of their different spectral/thermal/energy properties: albedo, heat capacity, roughness, …

➔ Impact heat and water fluxes into the atmosphere but also carbon and methane fluxes… (e.g. boreal wetlands…)

➔ Impact water discharges and water resources (role of reservoirs on flood control, irrigation supply and water diversion ; role of lake temperature on water quality, fish and aquatic life, etc…)

➔ Feedbacks on regional and global climates through atmospheric coupling

Soil Moisture/Surface Water Feedbacks



Seasonal Water Bodies for NWP Forecasts of dust

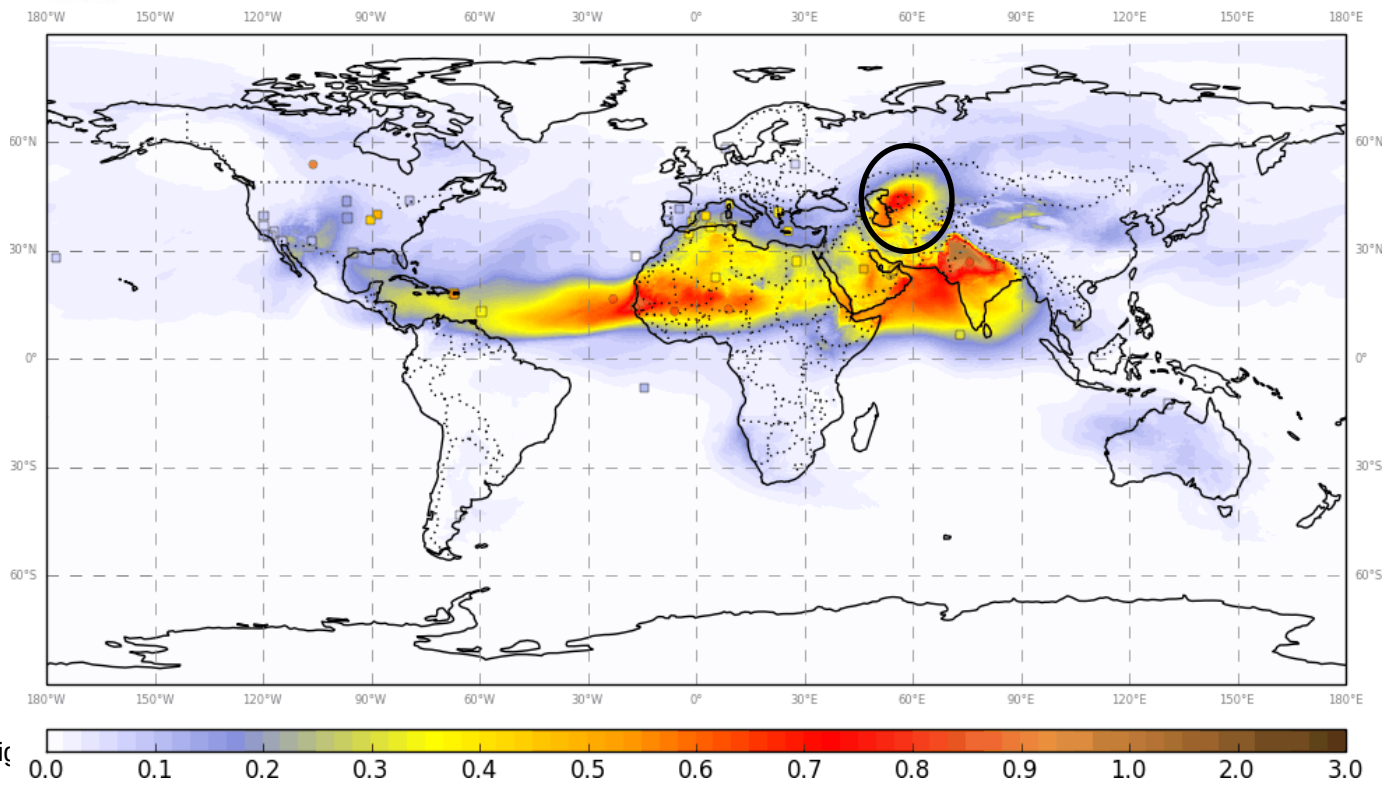
- More accurate and seasonal water body extent is needed for NWP simulation of dust storms
  - Static land cover is inadequate to describe these highly dynamic environments

- Why is dust important?
  - Depending on level of atmosphere, dust can have a cooling or warming effect
  - Can affect regional precipitation
  - Dust storms impact on human health and transport infrastructure, especially aviation

Operational forecast model

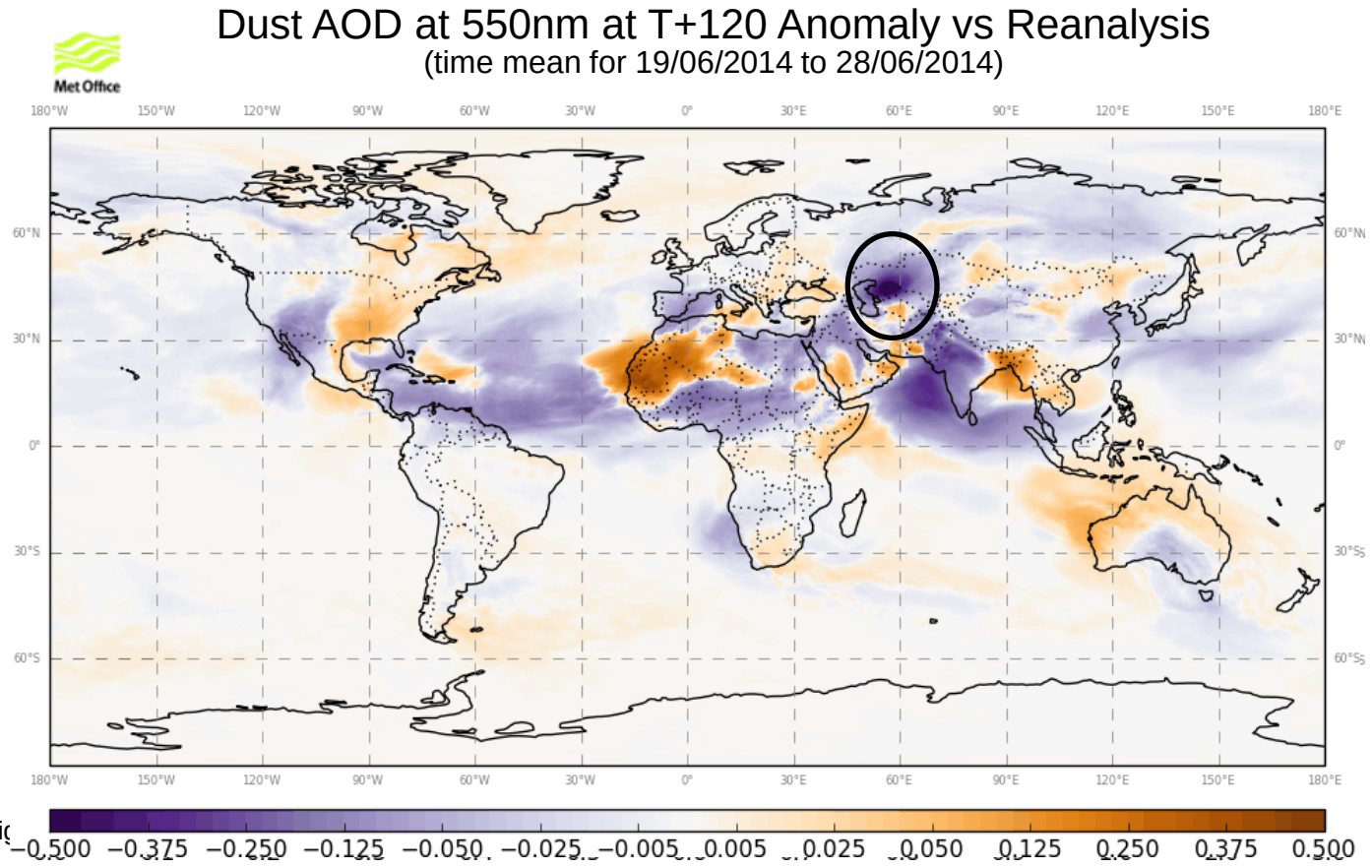
- Data Assimilation of MODIS Aerosol Optical Depth
- Produces best possible description of atmospheric dust at current time (T+0)

Dust AOD at 550nm at T+0
(time mean for 19/06/2014 to 28/06/2014)



Operational forecast model

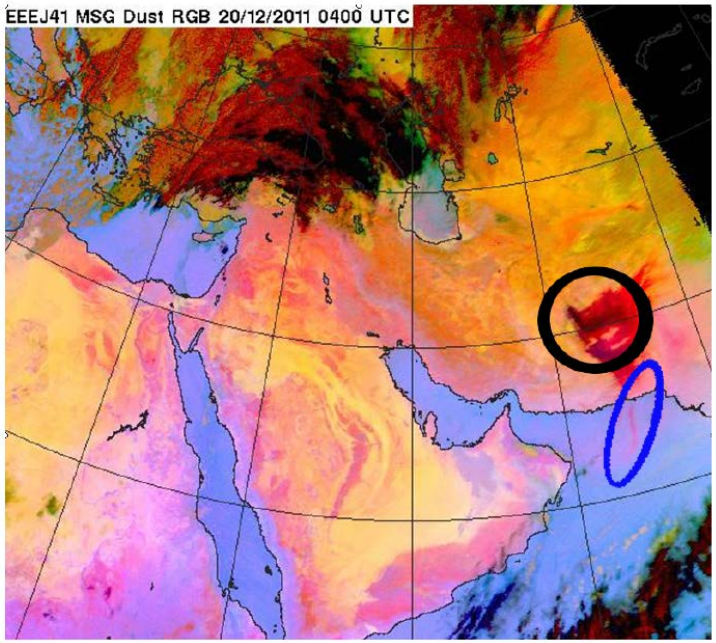
... But 5 days later (T+120), there are large negative anomalies of dust over the Aral Sea.



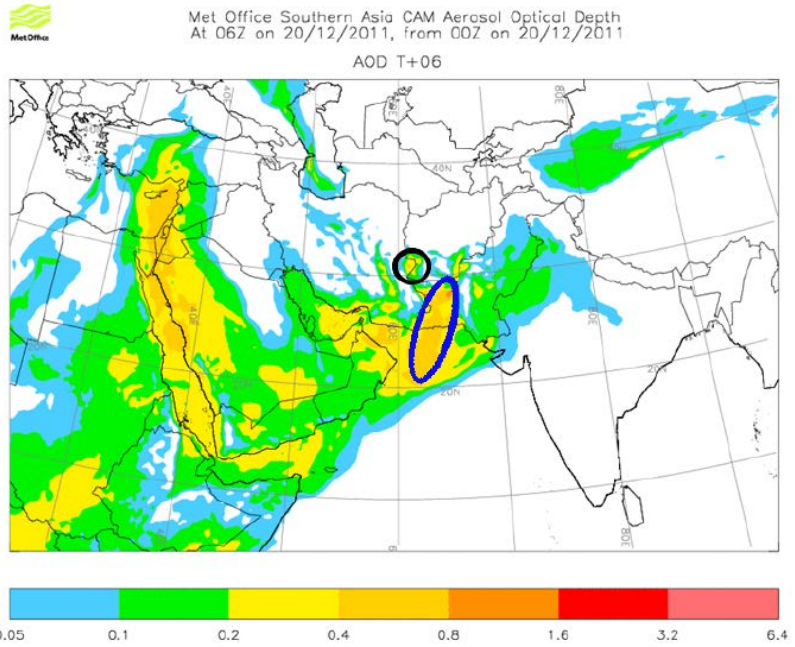
Case Study: aviation impact

On 20th December 2011, Prime Minister David Cameron made a surprise visit to British Forces in Afghanistan. The visit was disrupted by a large dust storm (a). Forecasts produced only a weak, small scale event (b). Cause of error was poor representation of dry lake beds.

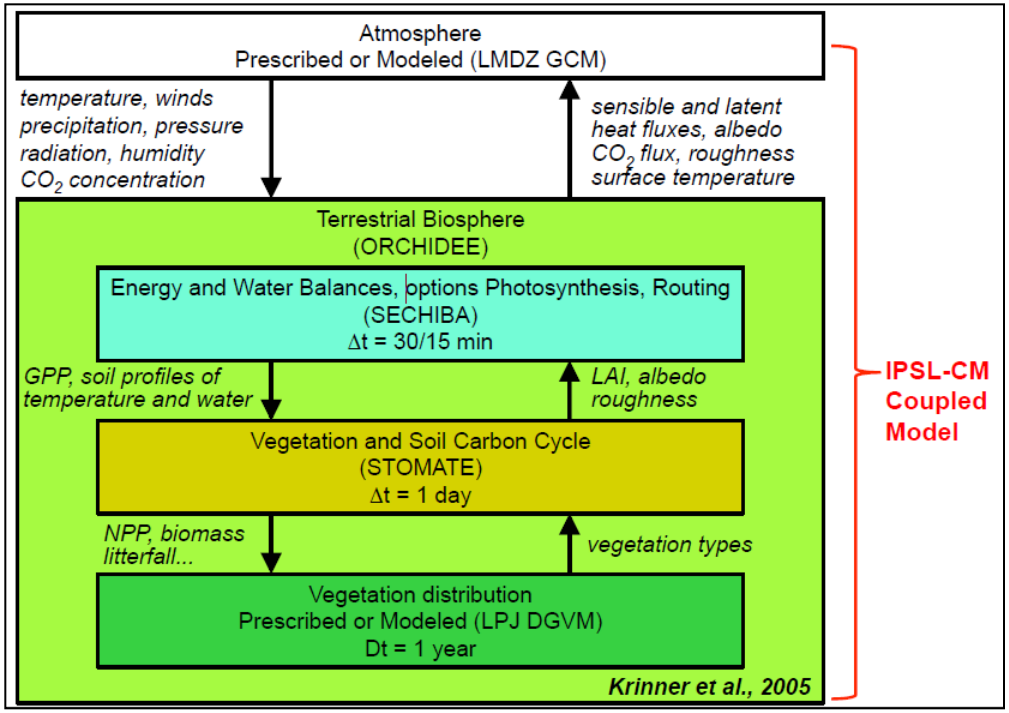
a)



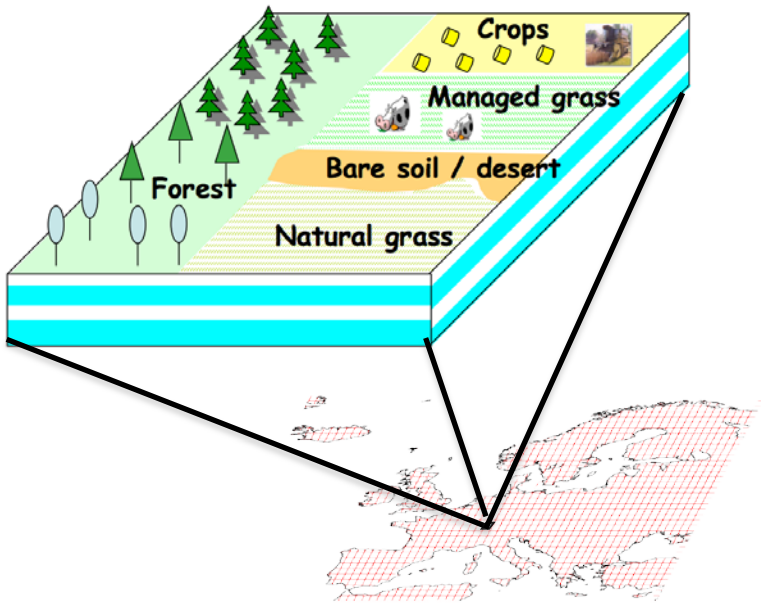
b)



ORCHIDEE (Land part of the IPSL-LMD-Z climate model)



➔ **A mosaic of vegetation**



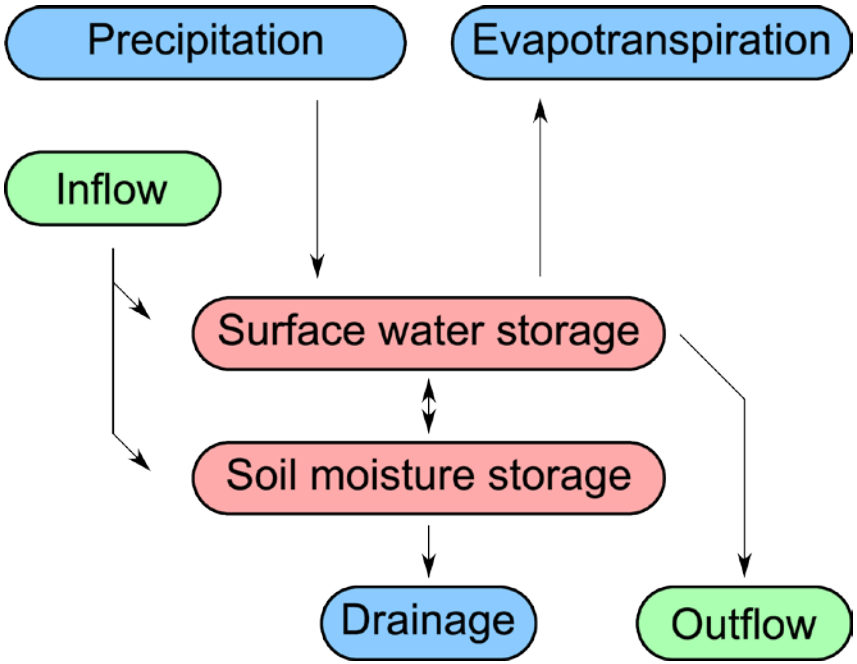
➔ **13 Plant Functional Types**

➔ Complex description of the vegetation processes but no explicit treatment of water bodies!

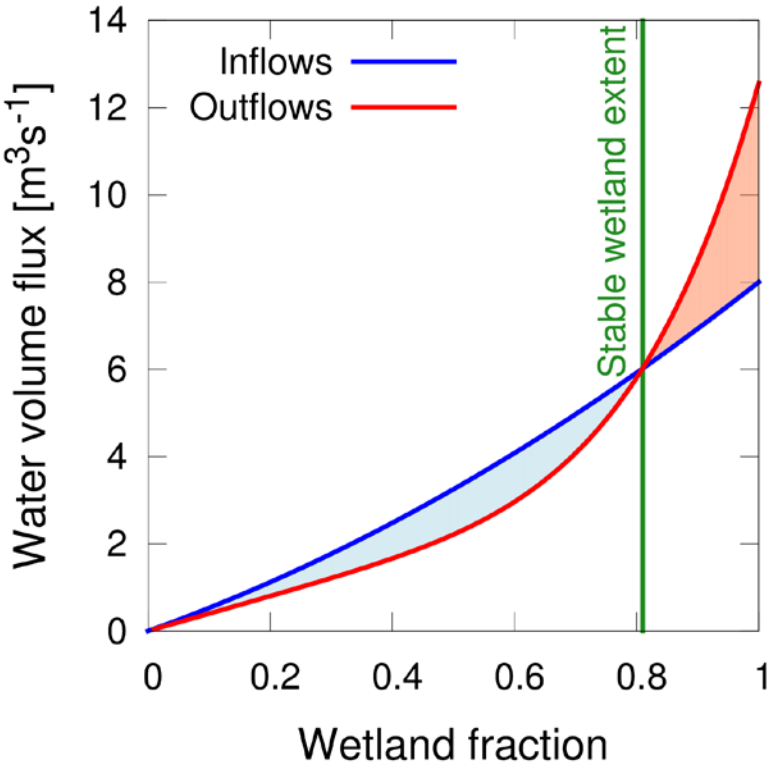
➔ Preliminary developments in permafrost regions:
the representation of thermokarst lakes and related emissions of CH4 and CO2
(Peng et al., in preparation)

MPI-M: WEED scheme

Wetland water balance

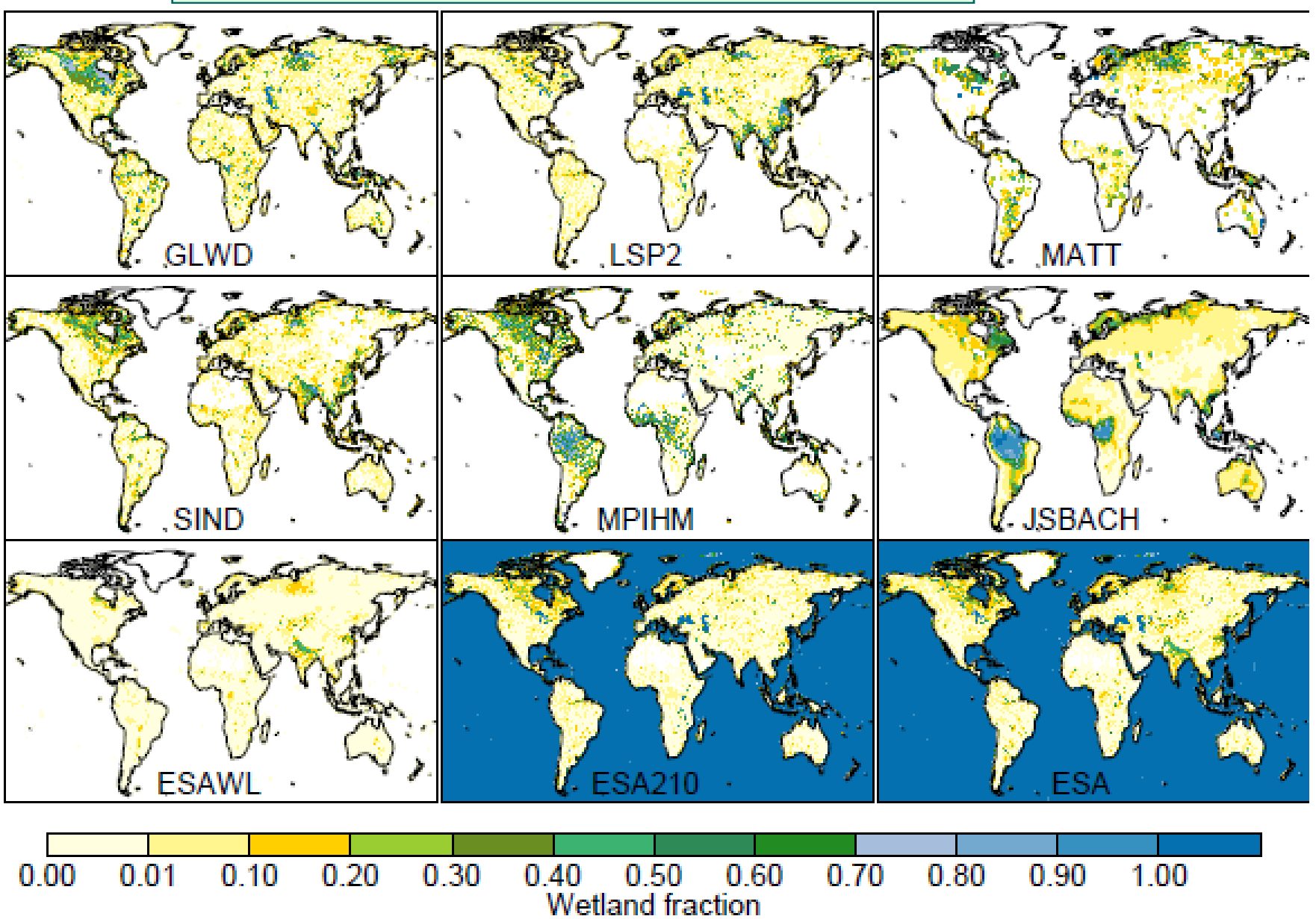


Equilibrium approach

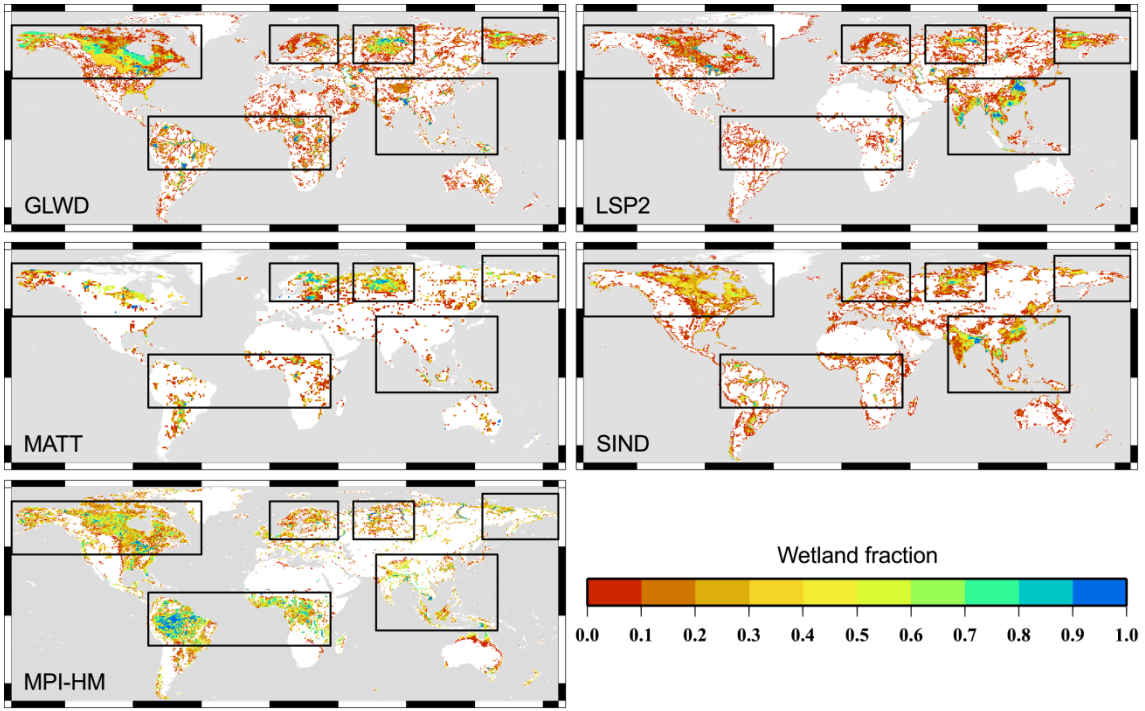


- MPI-HM implementation: Stacke & Hagemann (2012) HESS.
- JSBACH → Goran Georgievski' s presentation.

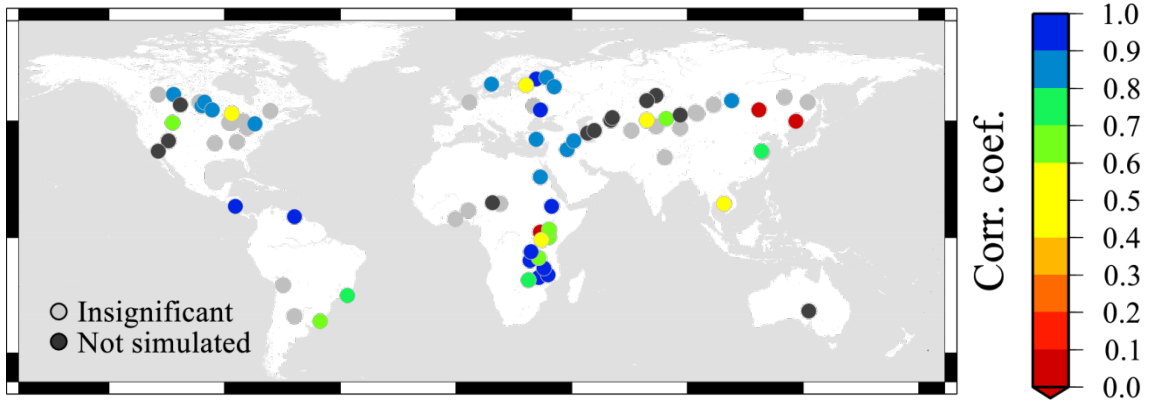
Various water body & wetland data



The validation problem



Large uncertainty between datasets complicates validation and model optimization

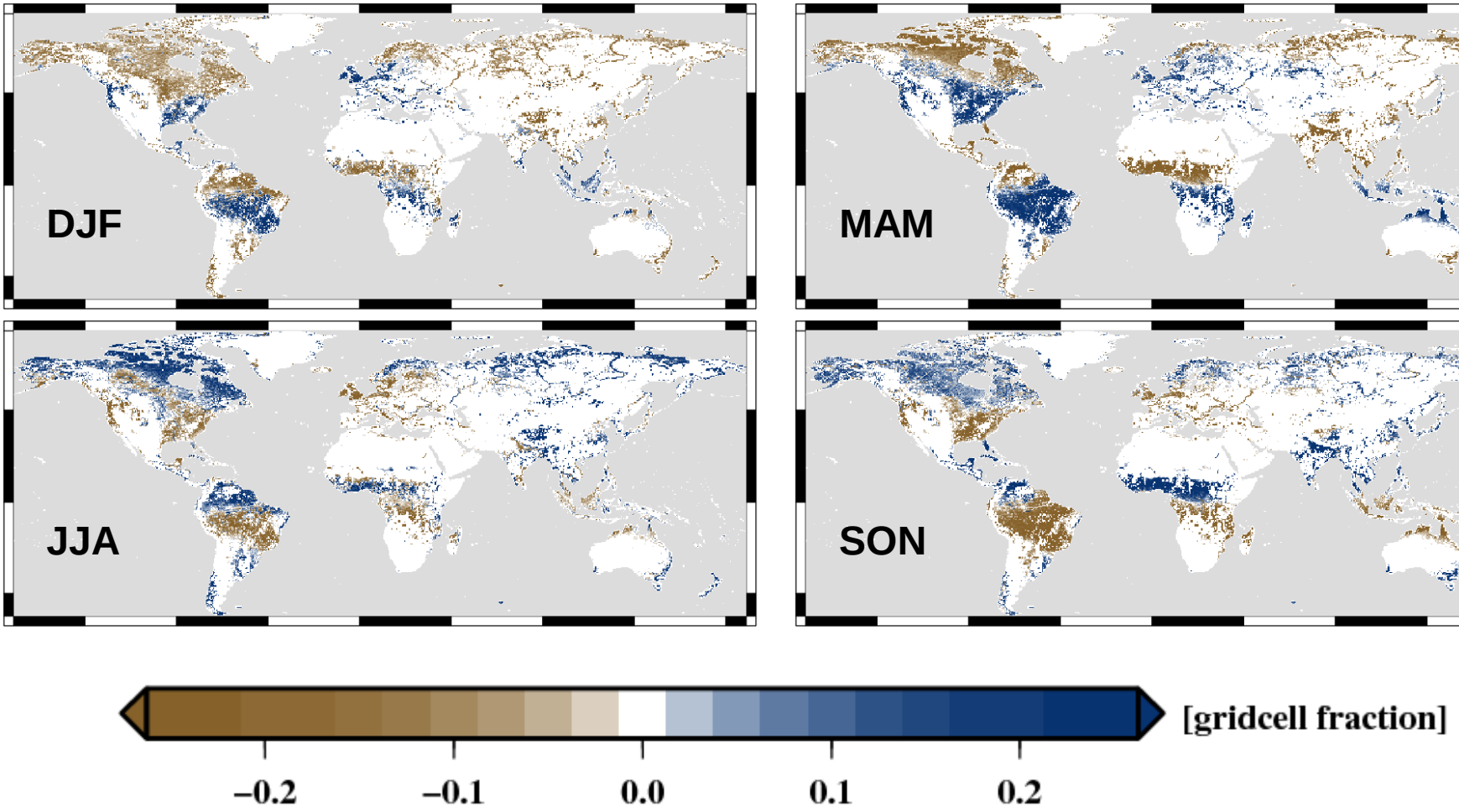


Only at few locations observation data on lake level variations are available for the validation of lake dynamics

Stacke & Hagemann (2012)

MPI-HM: Seasonal variations

Seasonal deviations from mean wetland extent

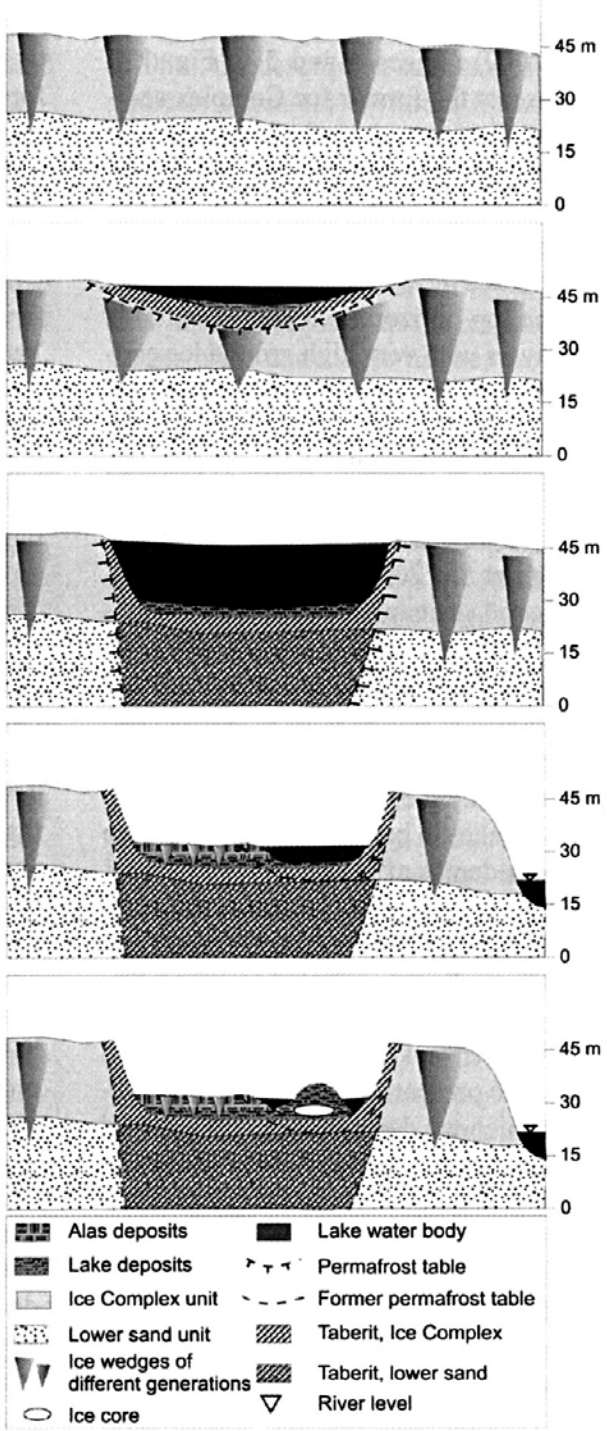


Thermokarst

- Melt of segregated ice and ice wedges

Thermokarst

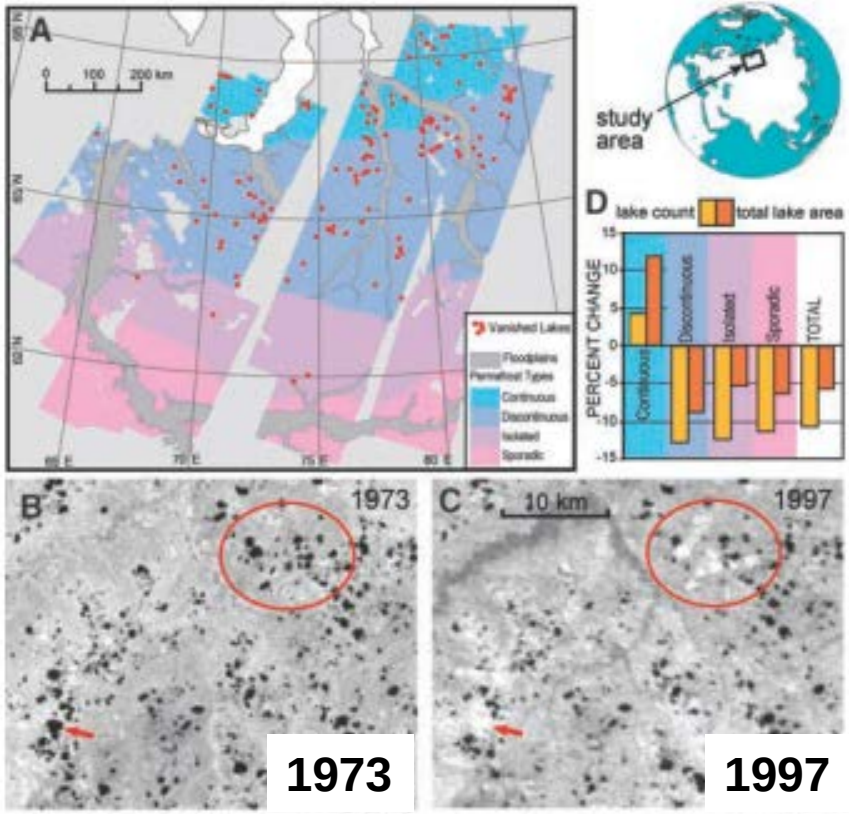
- Impact of disturbance on surface heat balance
- Increase of active layer thickness
- Permafrost degradation
- Melt of segregated ice
- Soil subsidence
- Water accumulation
- Change of surface heat balance



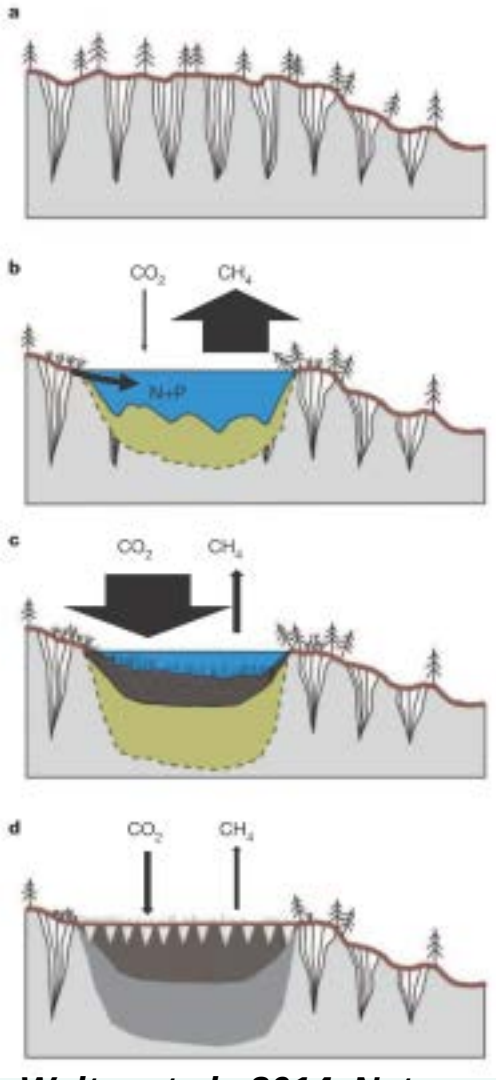
Thermokarst lakes are important for climate change

- Represent large fraction of lakes in high latitudes
- Rapid changes observed : decrease in discontinuous permafrost areas by increased drainage…

➔ Link with dynamic of ice wedges



Smith et al., 2005, Science; Picture from

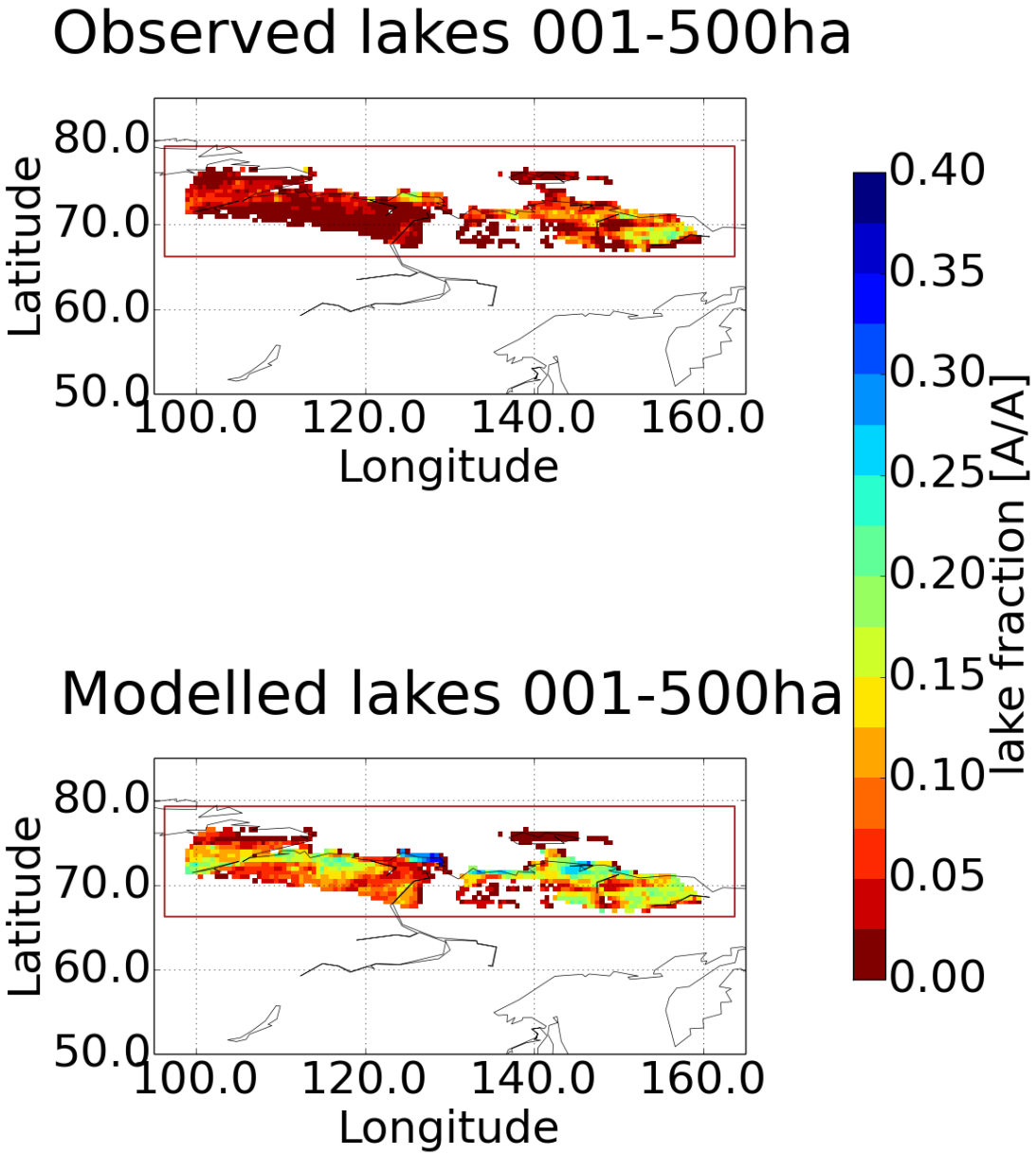


Walter et al., 2014, Nature

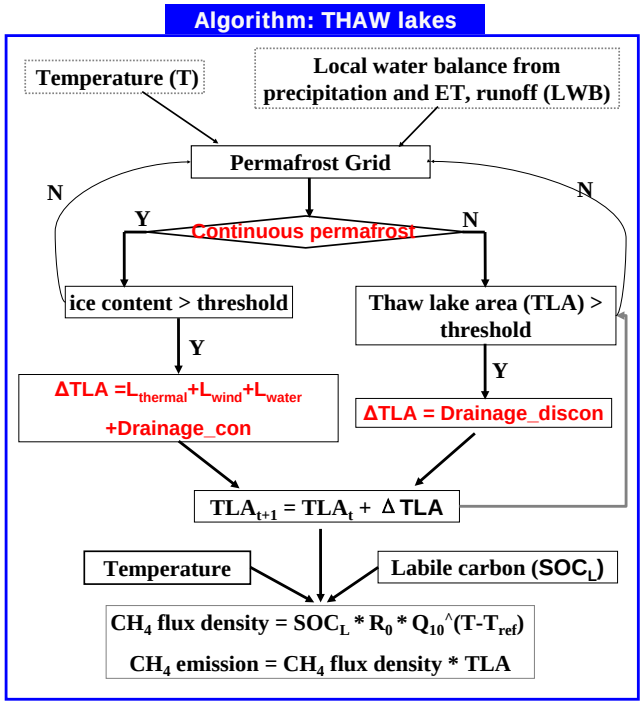
Thermokarst

JSBACH

- Simplified biophysical model with annual timestep
- Ph. D. thesis
  T. Schöngassner



Modeling of thermokarst lakes in ORCHIDEE *: Added processes*



Ground ice modeling (prescribed initial cover)

Temperature increase

"Seedling" of small water bodies

Flake model (Mironov 2008)
➔Lake temperature profile
➔Ice melting

Lake lateral expansion from
- **thermal erosion (from ice melt)**
- **wind erosion**
- **local water balance**
- **drainage**

ORC Soil Organic Carbon

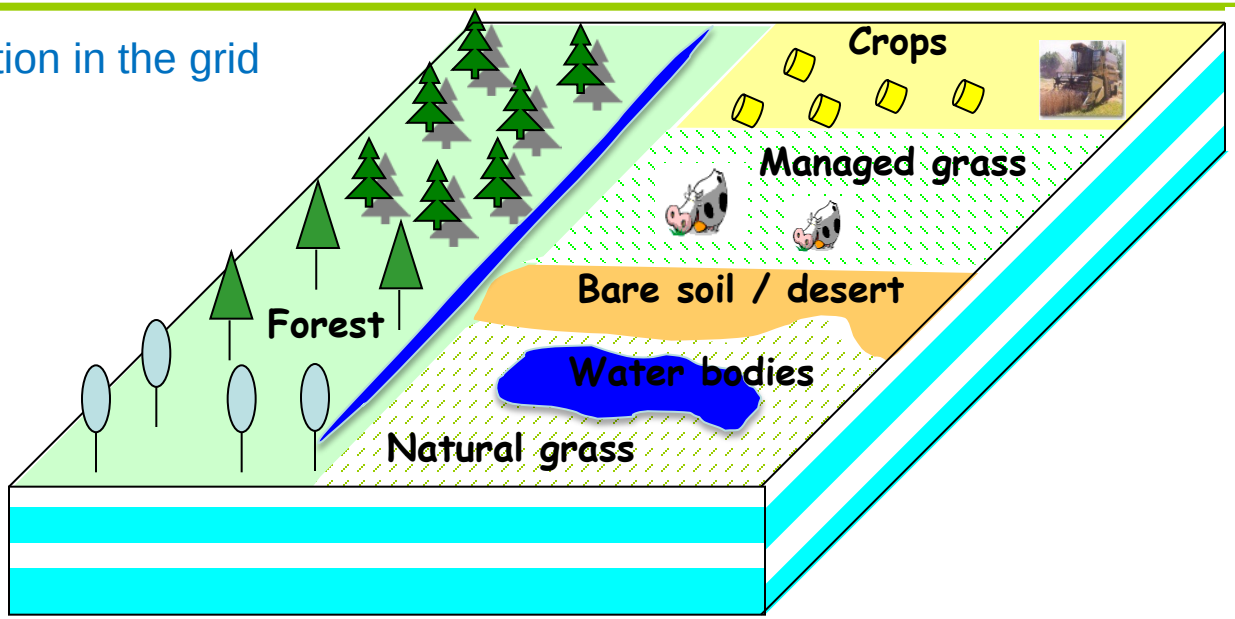
Methane Emissions

PAGE21

(Peng et al., in prep.)

Foreseen developments in ORCHIDEE

- ➔ Representation of a water fraction in the grid (separate lakes and rivers)
- ➔ Separate energy balance and surface temperature
- ➔ Surface area set with satellite products.
- ➔ lake/river depths defined with available databases



- ➔ Calibration with remote sensing products (surface temperature from IRT data, water level variations from altimetry, water surface extent, albedo, evaporation, etc…)

Data required

- ❖ Water bodies maps : discrimination between lakes and rivers
- ❖ Seasonal and interannual variations
- ❖ Spatial and temporal coherence of WB with Lcover, Surf. Temp, Albedo

Surface water body requirements

Spatial mapping

- Spatial distribution at high resolution with uncertainty information
- Temporal changes on monthly or higher resolution
- Mapping of extends e.g. floodplains/events even for vegetation covered areas (e.g. Amazon Basin)

Additional information

- Time series of water depth with uncertainty information
- Freezing events
- Surface water body temperature
- Distinction between lakes and wetlands

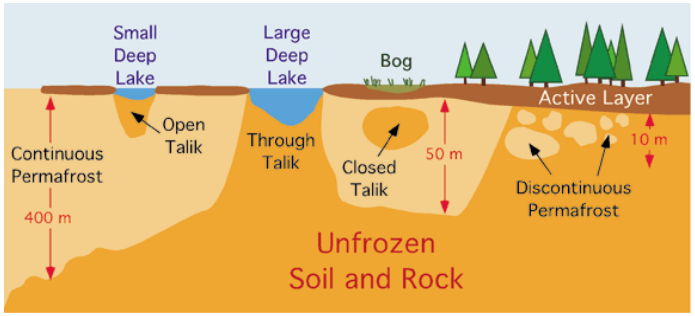
Thank you for your attention!

- Long-term monitoring of changing landscape characteristics, e.g. thermokarst lakes
  - ➢ Annual states with high spatial resolution

CT: From tundra climate to taiga

Steps of Transition:

- Dry ice-rich continuous permafrost
- Warming of soil surface
- Melt of segregated ice
- Water accumulation at the surface
- Further permafrost thawing
- Moist sporadic permafrost
- Development of swamps and boreal forests



Surface water bodies include wetlands

- Anoxic decomposition produces methane

- Increase in wetlands area → more methane production

Scientific questions

- How the distribution of surface water bodies is affected by climate change conditions?
- How does a change their extend impacts the local and regional climate?

- Dynamic modelling required: e.g. Stacke & Hagemann (2012) HESS.