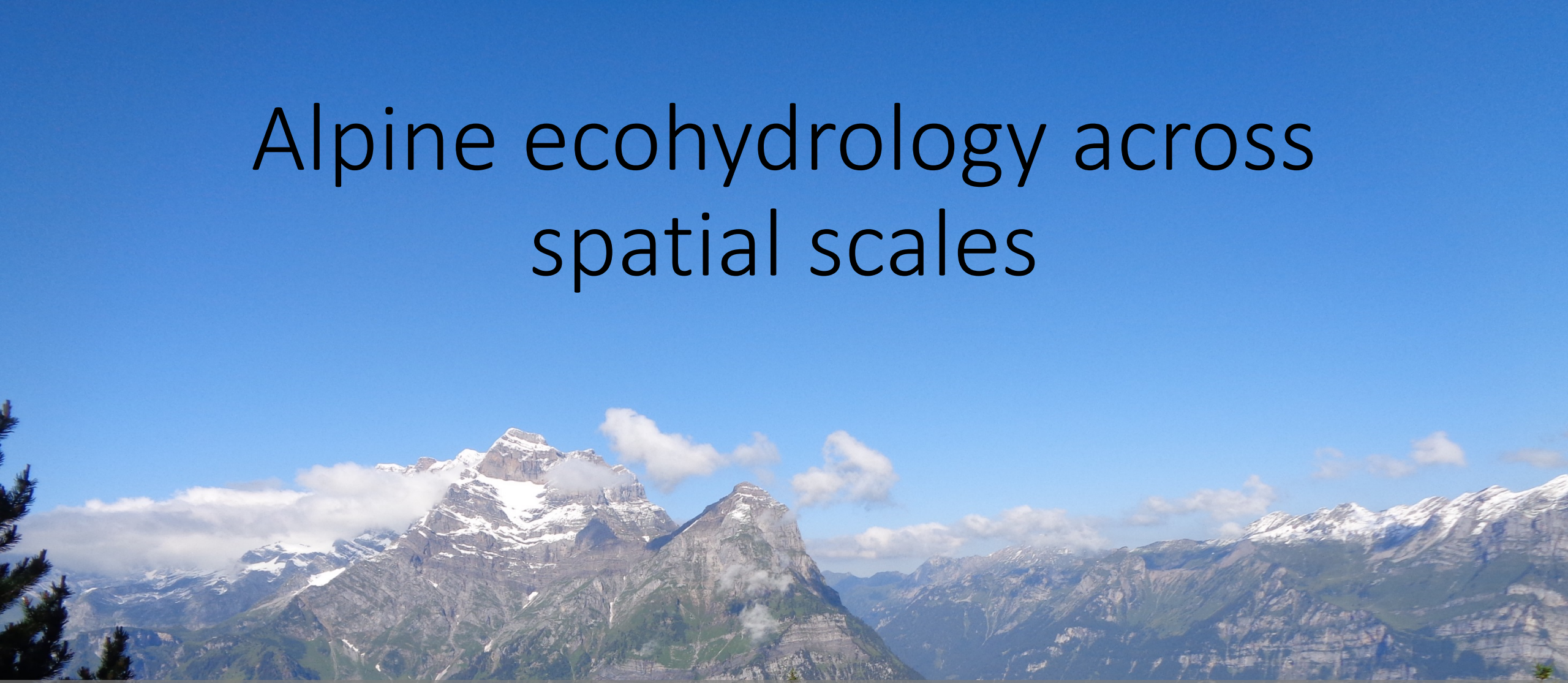
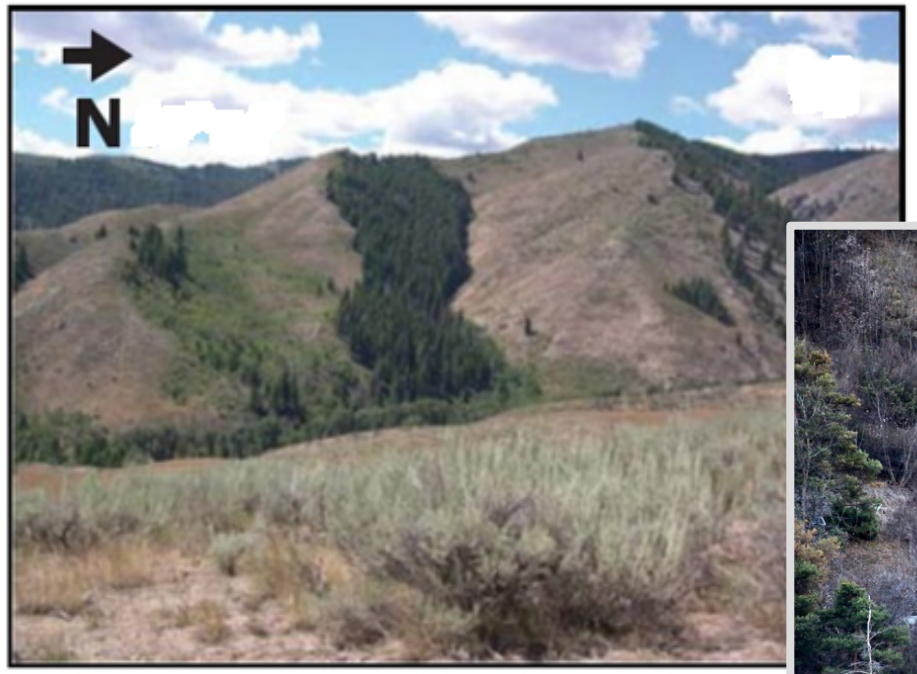
Alpine ecohydrology across spatial scales



Theodoros Mastrotheodoros, Christoforos Pappas, Peter Molnar, Paolo Burlando, Panagiotis Hadjidoukas and Simone Fatichi

Institute of Environmental Engineering, ETH Zurich

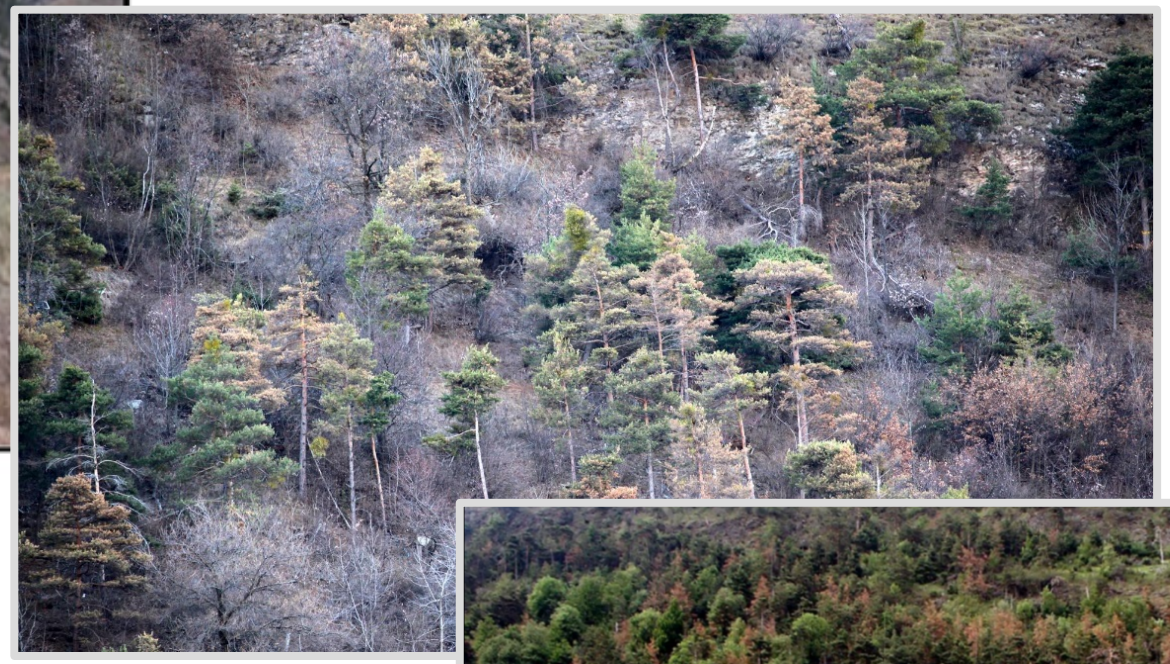
Mountain ecohydrology



Idaho, USA

Gutiérrez-Jurado et al. 2013, WRR

Species composition is changing in the inner Alps due to increasing droughts



Rigling et al. 2013, GCB

Valais, Switzerland

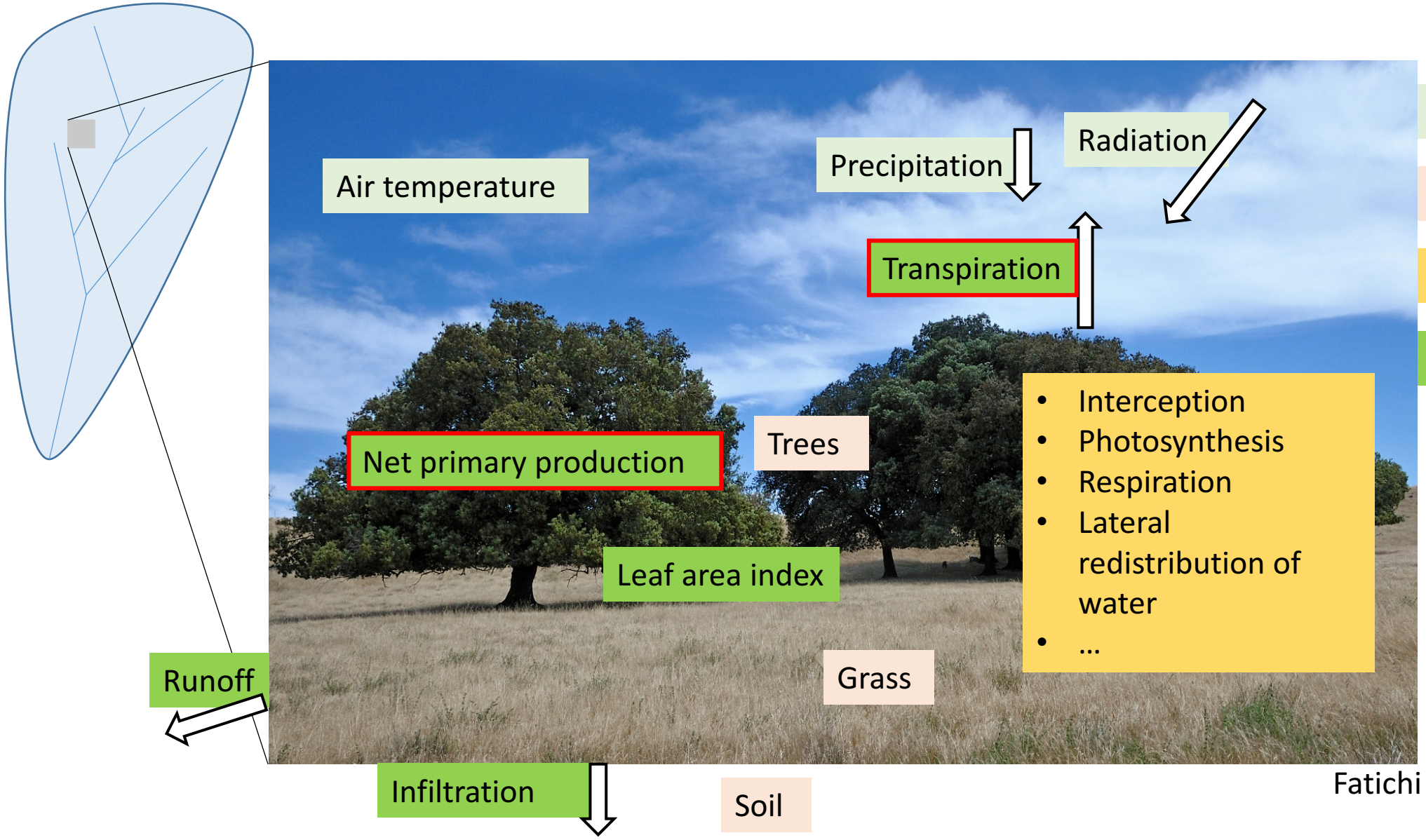
Research questions

What is the sensitivity of ecohydrological variables to temperature, radiation and soil moisture?

Can we rank the importance of these factors?

What is the role of aspect in streamflow response?

The ecohydrological model Tethys-Chloris



Model Input

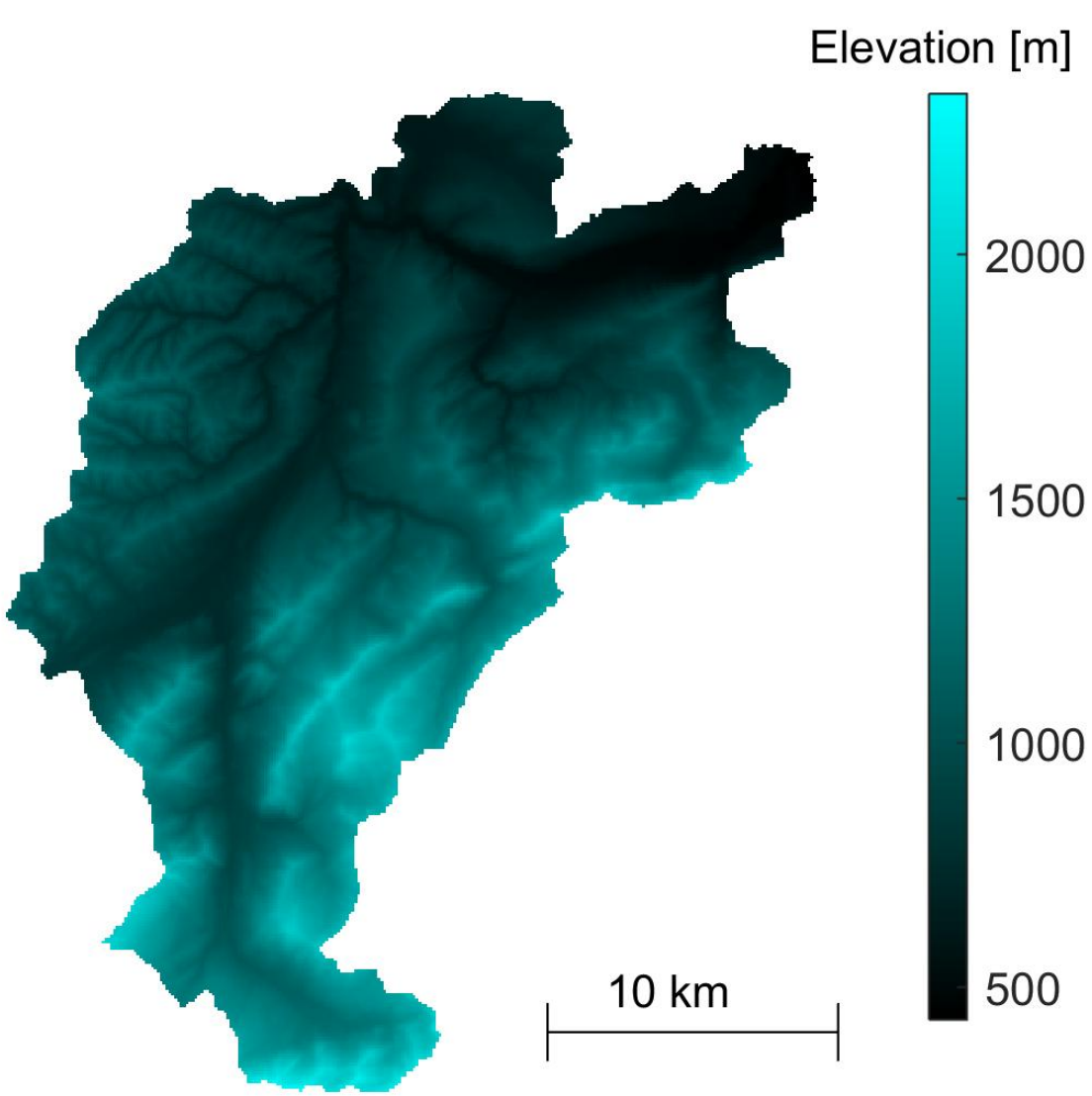
Parametrization

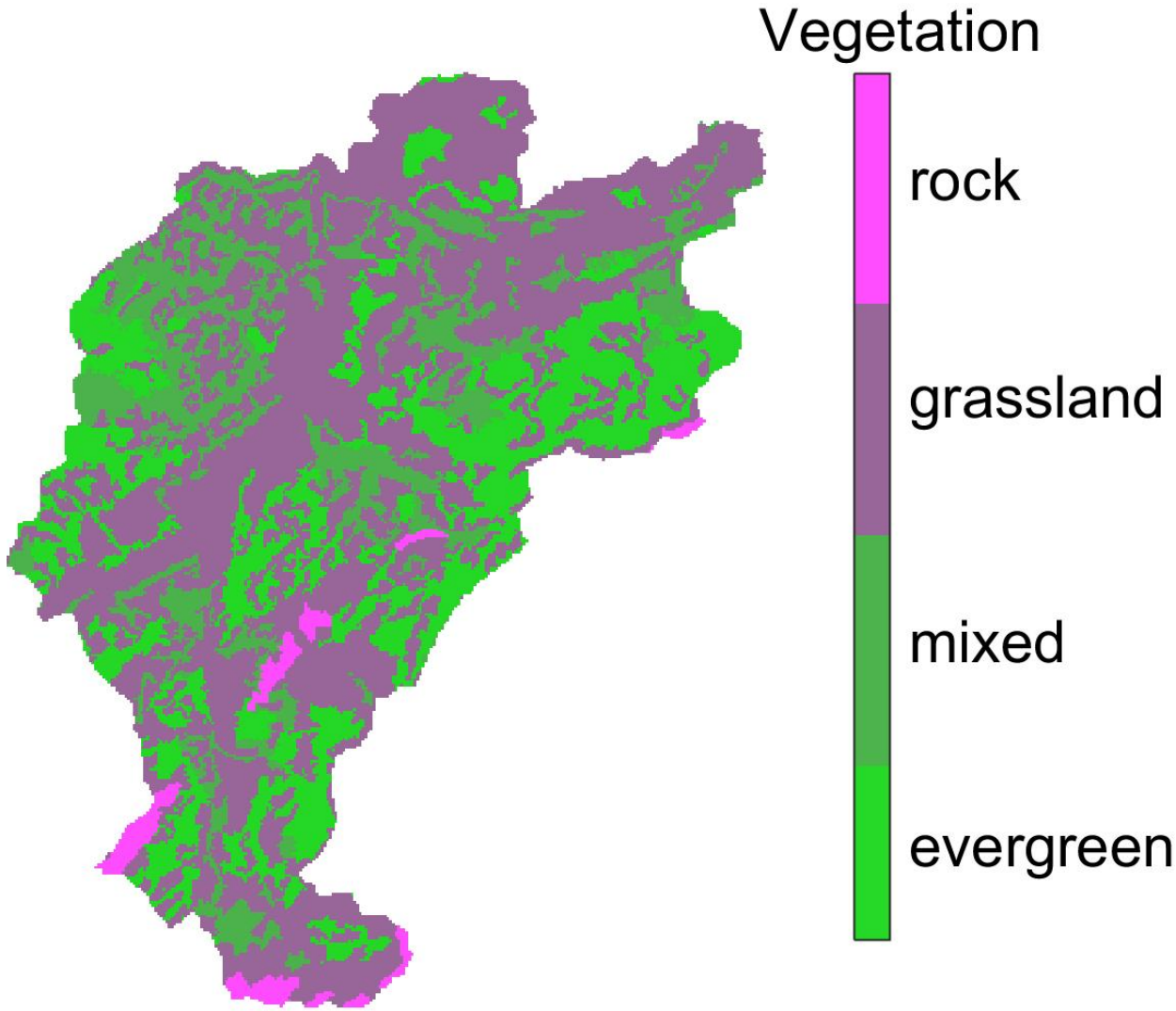
Simulated processes

Model output

Fatichi et al. 2014, WRR

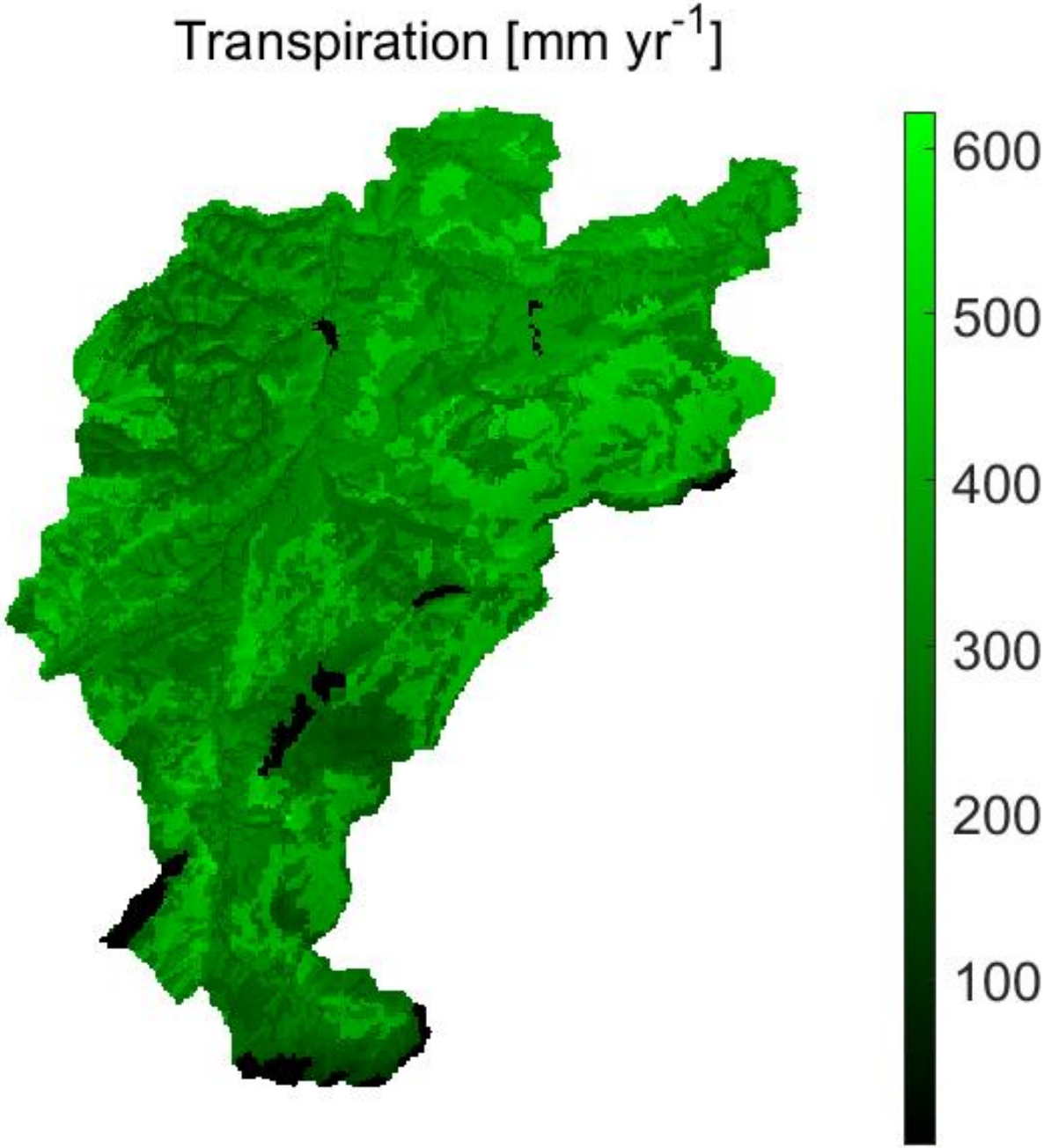
The Kleine Emme catchment





Five years simulation, hourly time step, 100 m resolution

Results for Kleine Emme: five-year average



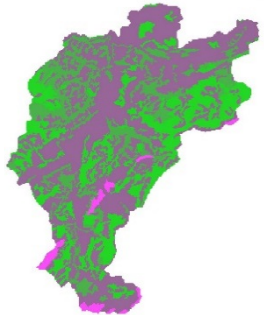
How do meteorological (topographic) variables control the ecohydrological response?

Temperature (altitude)?

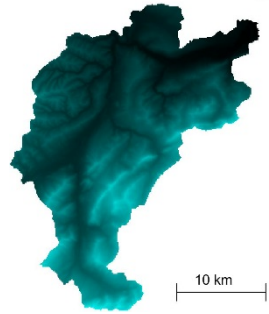
Radiation (aspect)?

Soil moisture (topographic index)?

Land cover

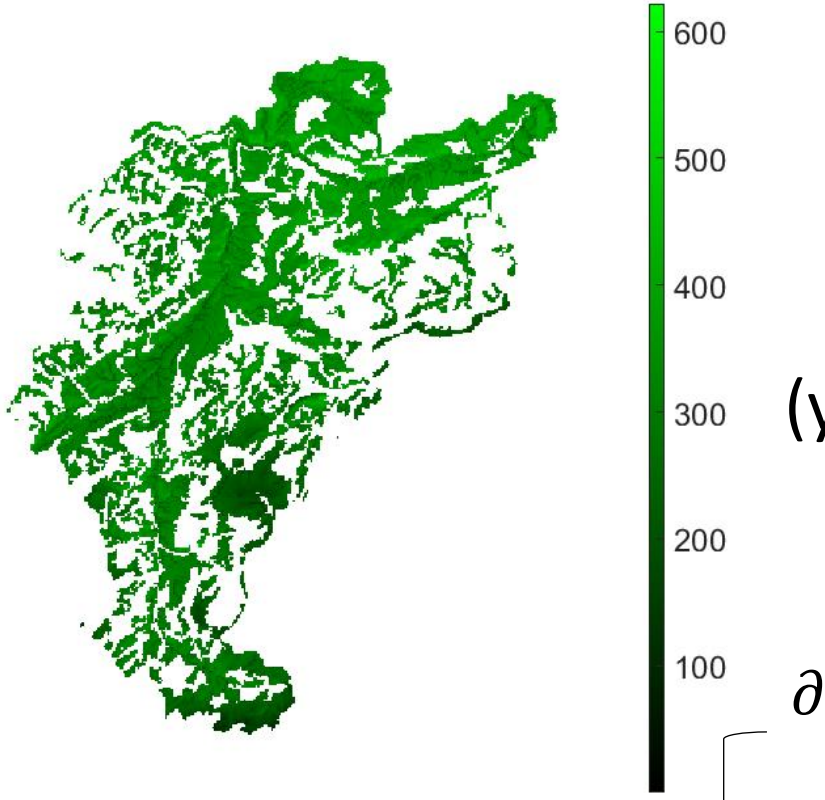


Altitude



Sensitivity analysis

Grassland annual transpiration [mm]



(y)

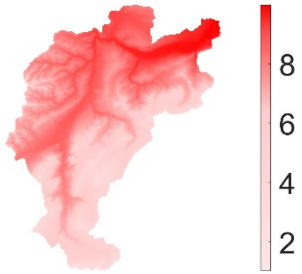
$$y = f(x_1, x_2, x_3)$$

$$\partial y/\partial x_1$$

$$\partial y/\partial x_2$$

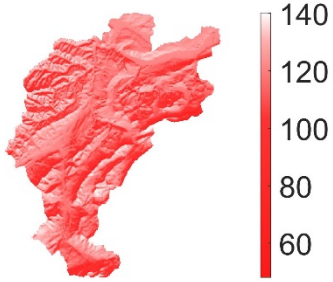
$$\partial y/\partial x_3$$

Temperature [°C]



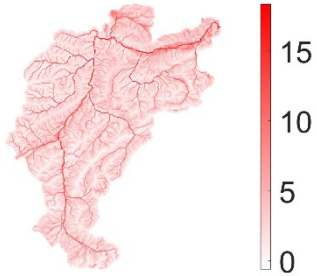
(x_1)

Shortwave radiation [W m^{-2}]

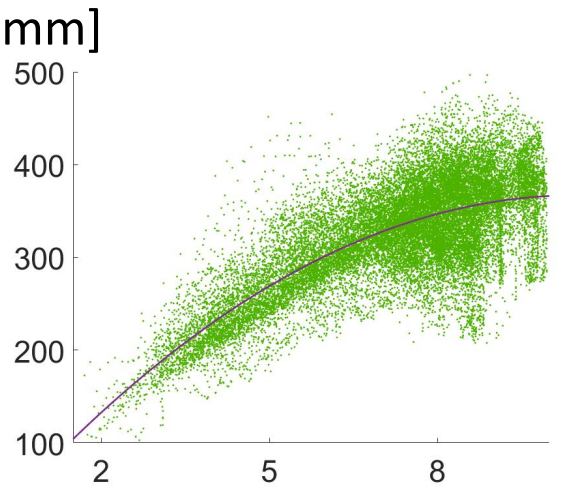


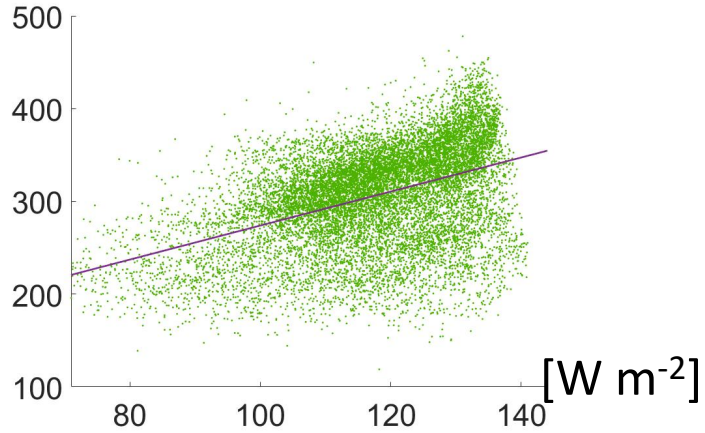
(x_2)

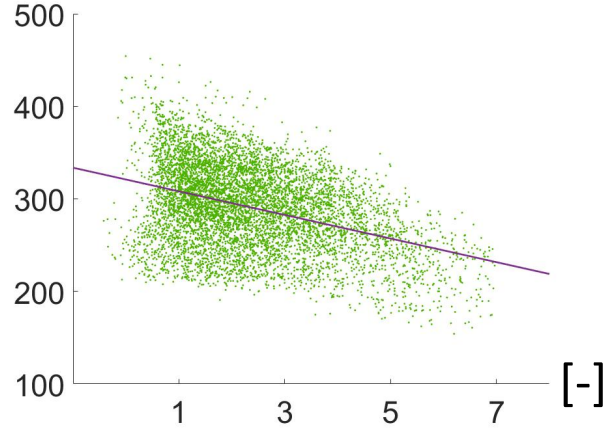
Topographic Index [-]



(x_3)

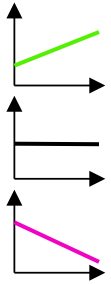






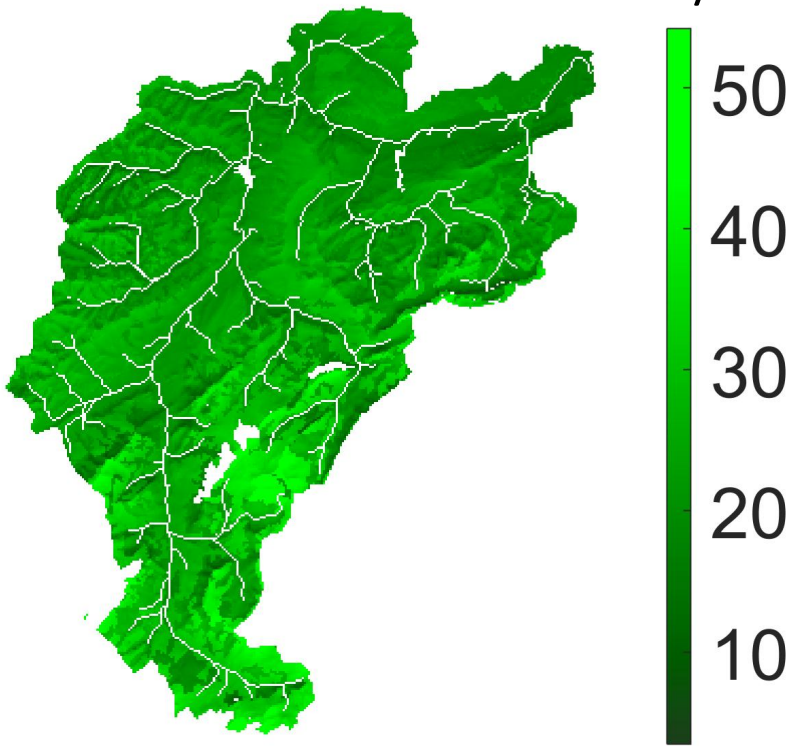
Sensitivity of annual transpiration

positive
insensitive
negative



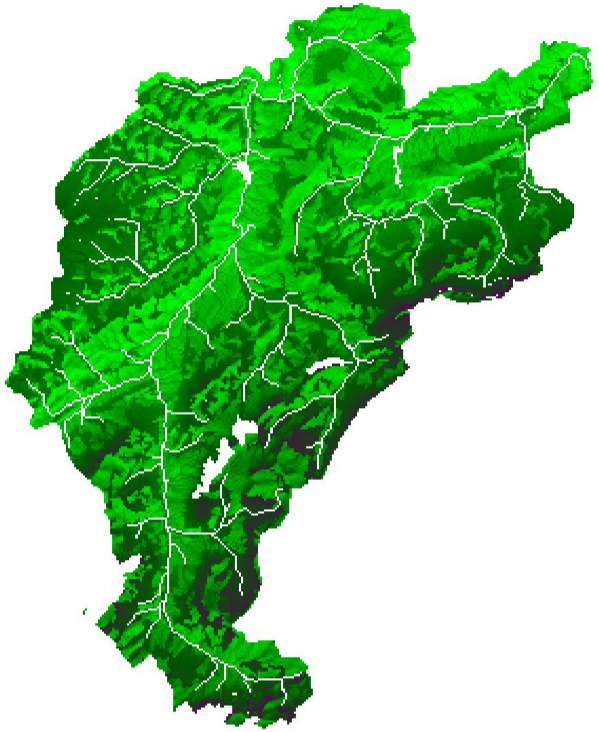
Which is the relative importance of each variable?

Temperature



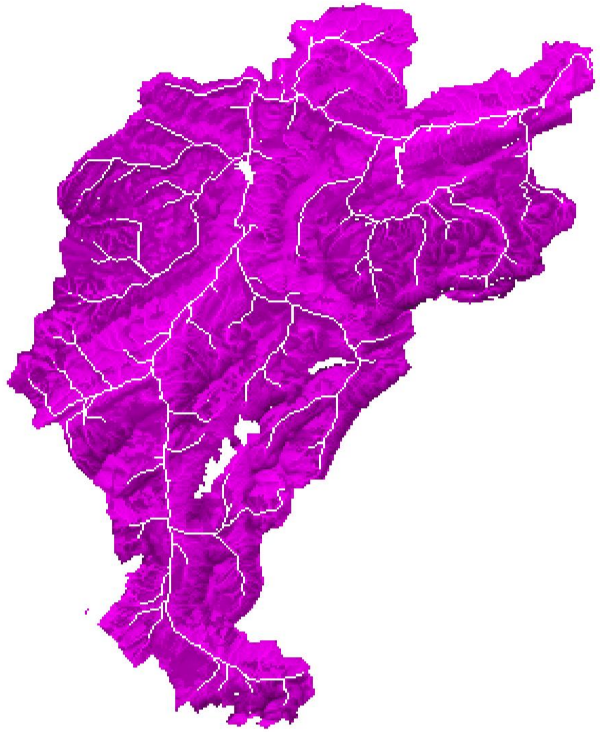
mm/°C
50
40
30
20
10

Radiation



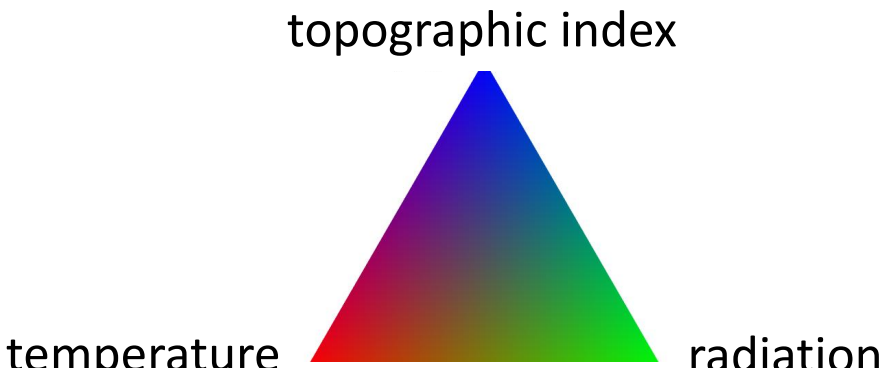
mm/(W m^{-2})
3
2
1
0
-1

Topographic index

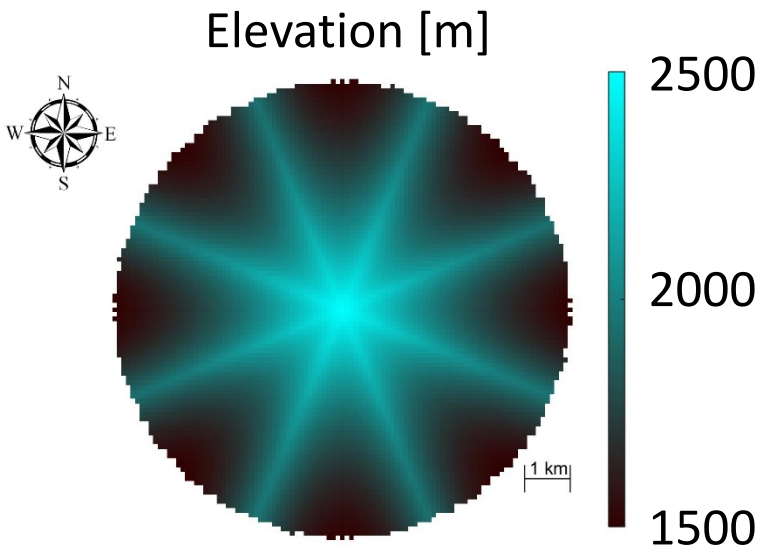


mm/[-]
-5
-10
-15
-20

Relative sensitivity of annual transpiration



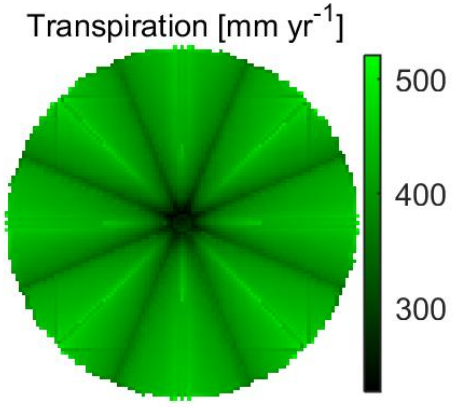
The virtual mountain

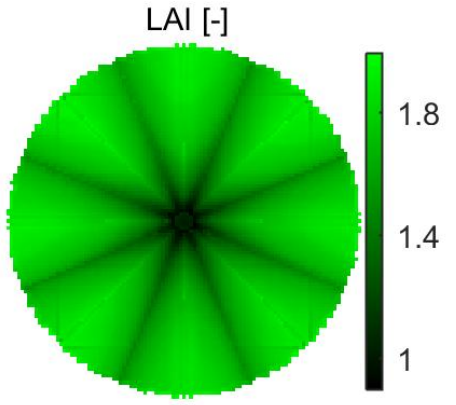


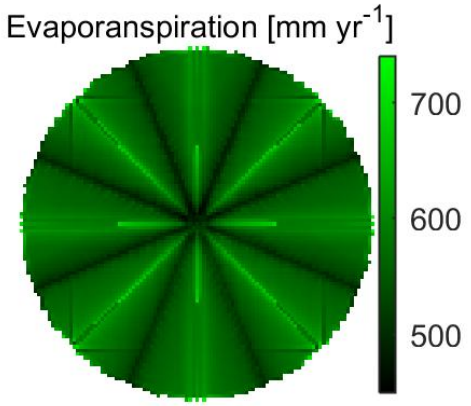
Four experiments
(dry/wet & evergreen/grassland)

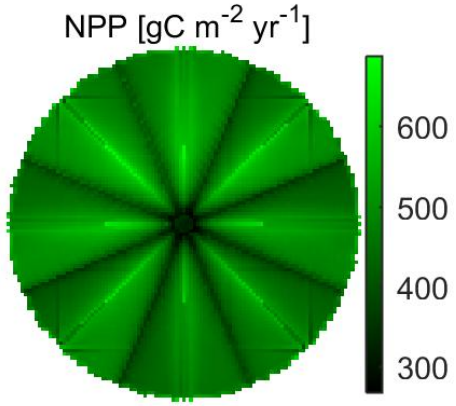
How important is aspect for streamflow?

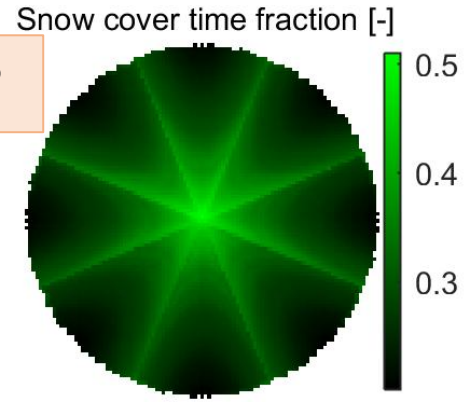
Results for the dry grassland: 5-year average

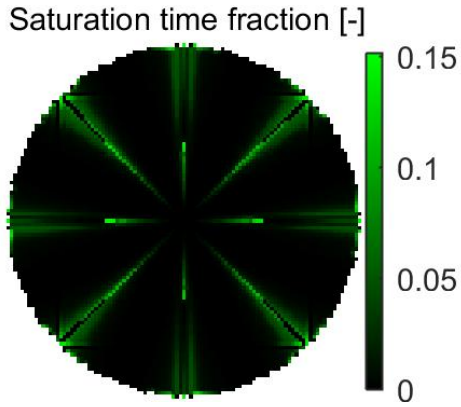




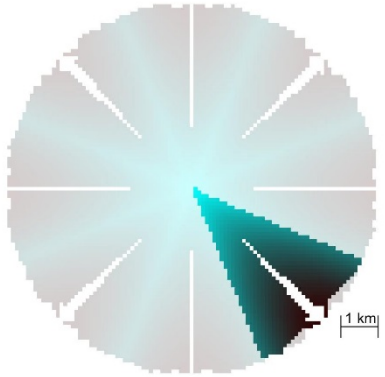




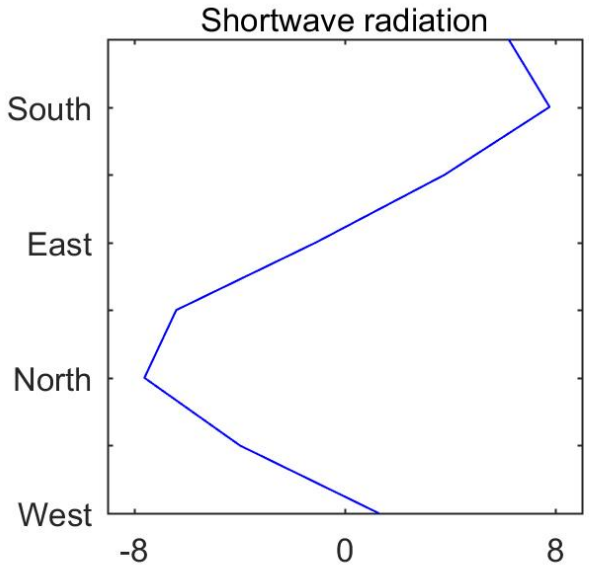




The effect of aspect on streamflow



Catchment orientation



wet grassland

wet evergreen forest

Departure from the mean [% of the mean]

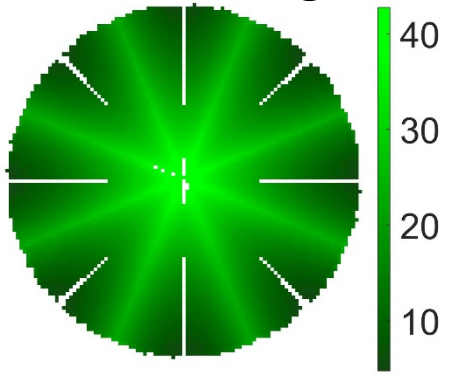
Different climates in the Alps: evergreen forest annual NPP sensitivity

positive
insensitive
negative

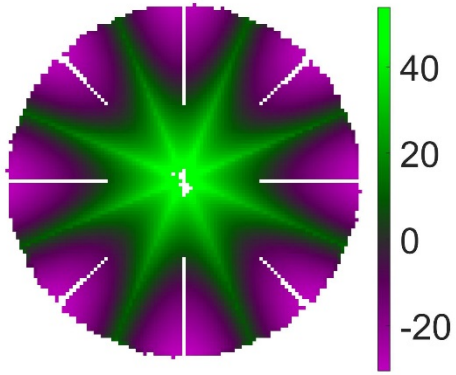
Temperature

[gC m^{-2}]/°C

wet



dry



Conclusions

In the higher parts of the wet catchments temperature limitation dominates.
Radiation becomes important in lower areas

Dry catchments are water-limited below 2000 m

Outlook: combine vegetation sensitivity with climate projections

Thank you! Questions?