

Terrestrial water variability in Southern Siberia under different permafrost states

Li Han & Lucas Menzel

Chair in Hydrology and Climatology, Institute of Geography, Heidelberg University

Contact: li.han@uni-heidelberg.de

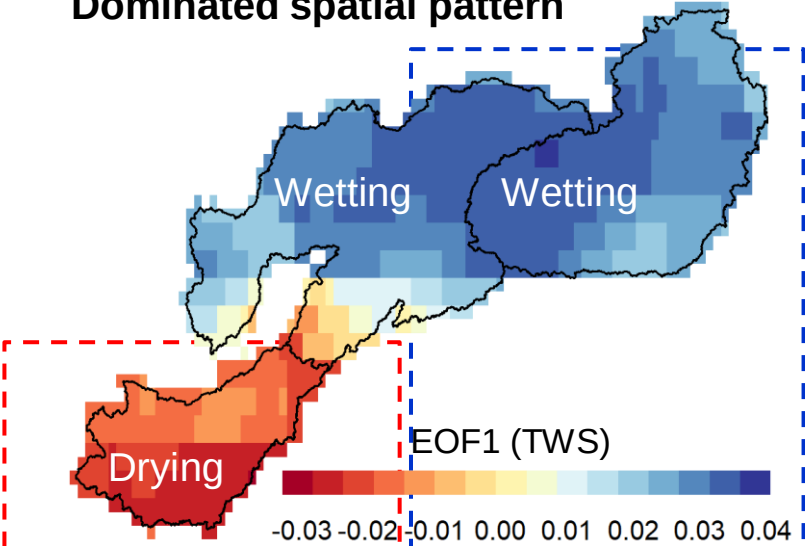
EGU General Assembly 2021

26th April 2021

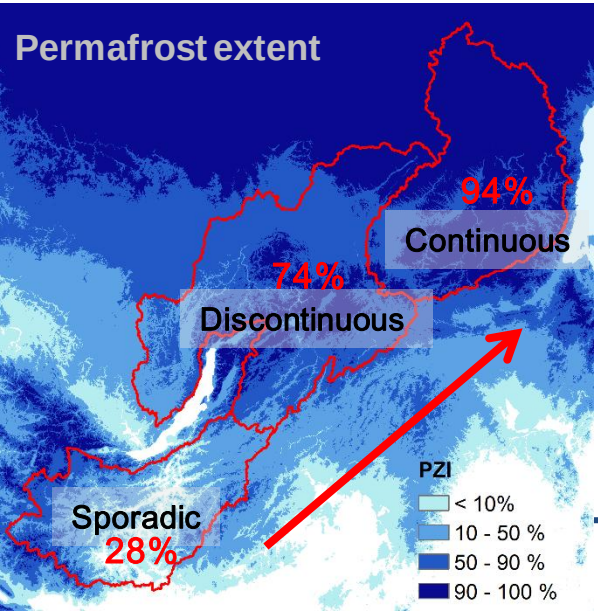
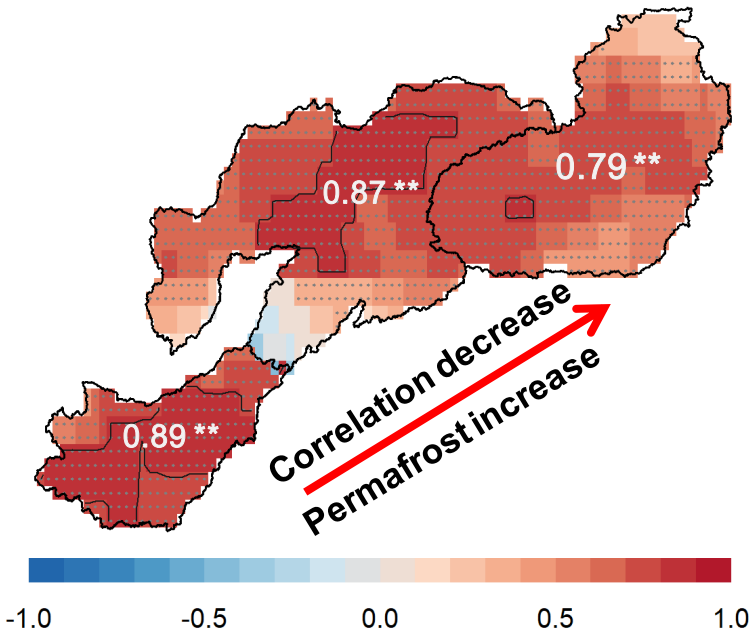
Study area



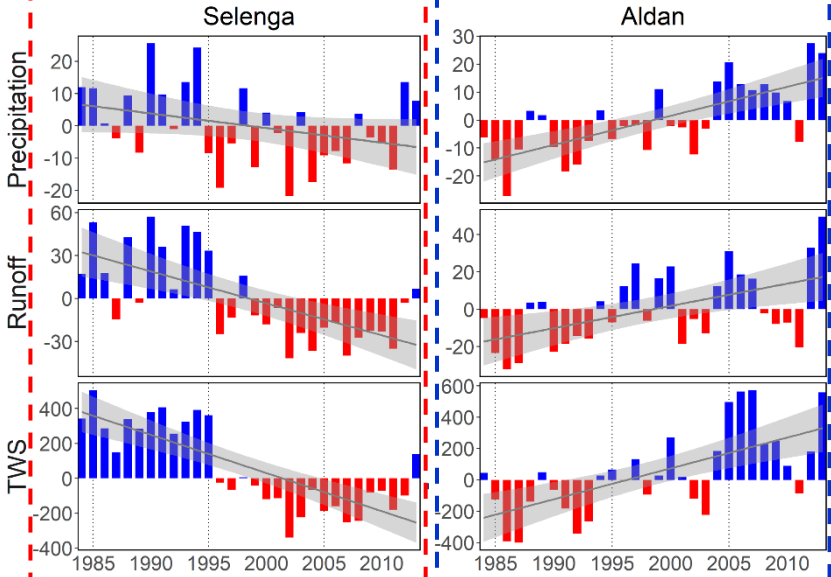
Dominated spatial pattern



Correlation: TWS & Runoff



Historical water



Take home messages:

- **Wetting: Continuous & Discontinuous**
- **Drying: Sporadic**
- **Stronger TWS & runoff connections in sporadic & discontinuous permafrost**

Study questions:

- What are the dominant patterns of terrestrial water variability in southern Siberia?
- Does warming climate affect permafrost condition?
- If so, how does permafrost degradation influence hydrological processes?

Wetting VS. drying

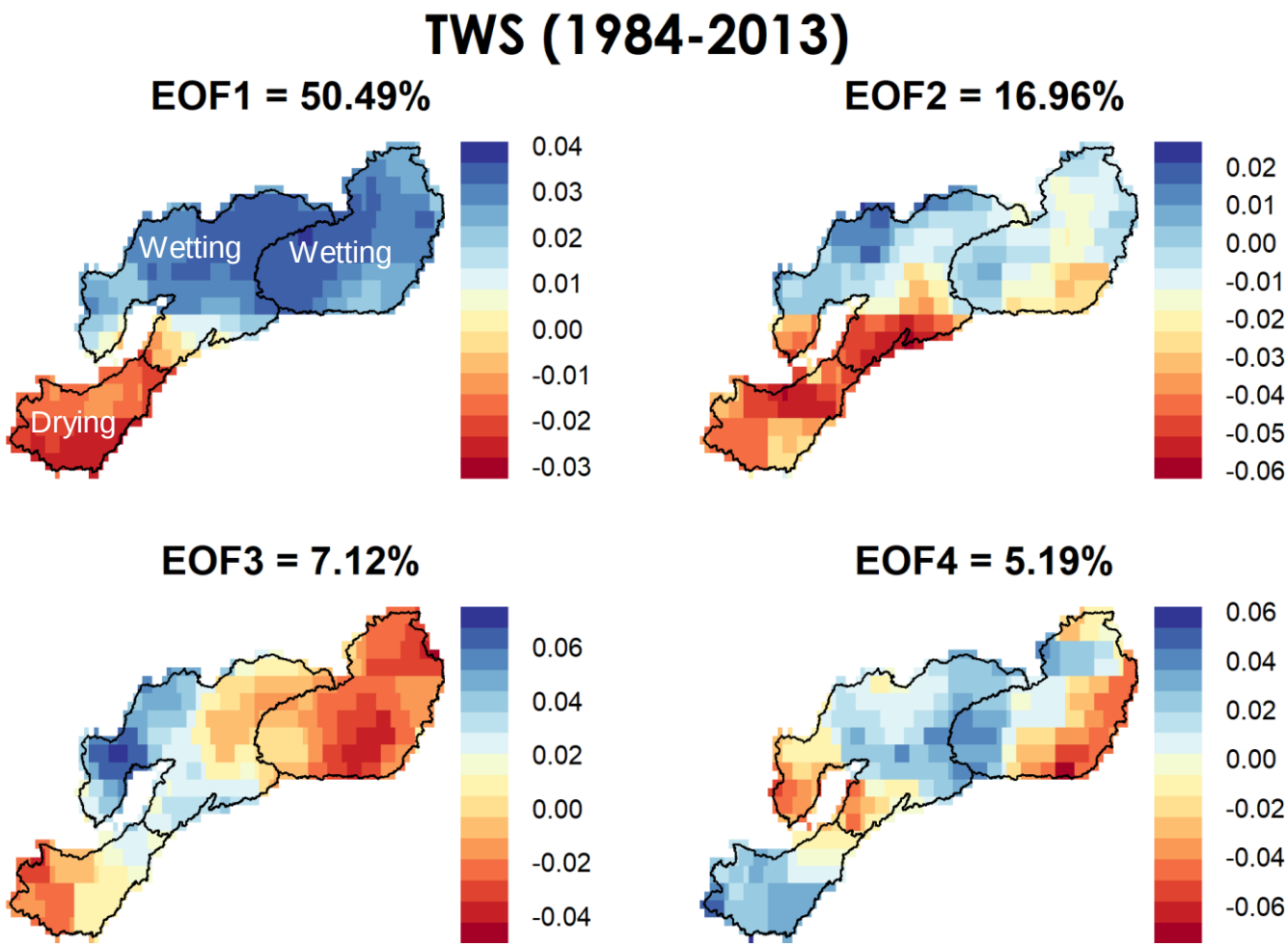
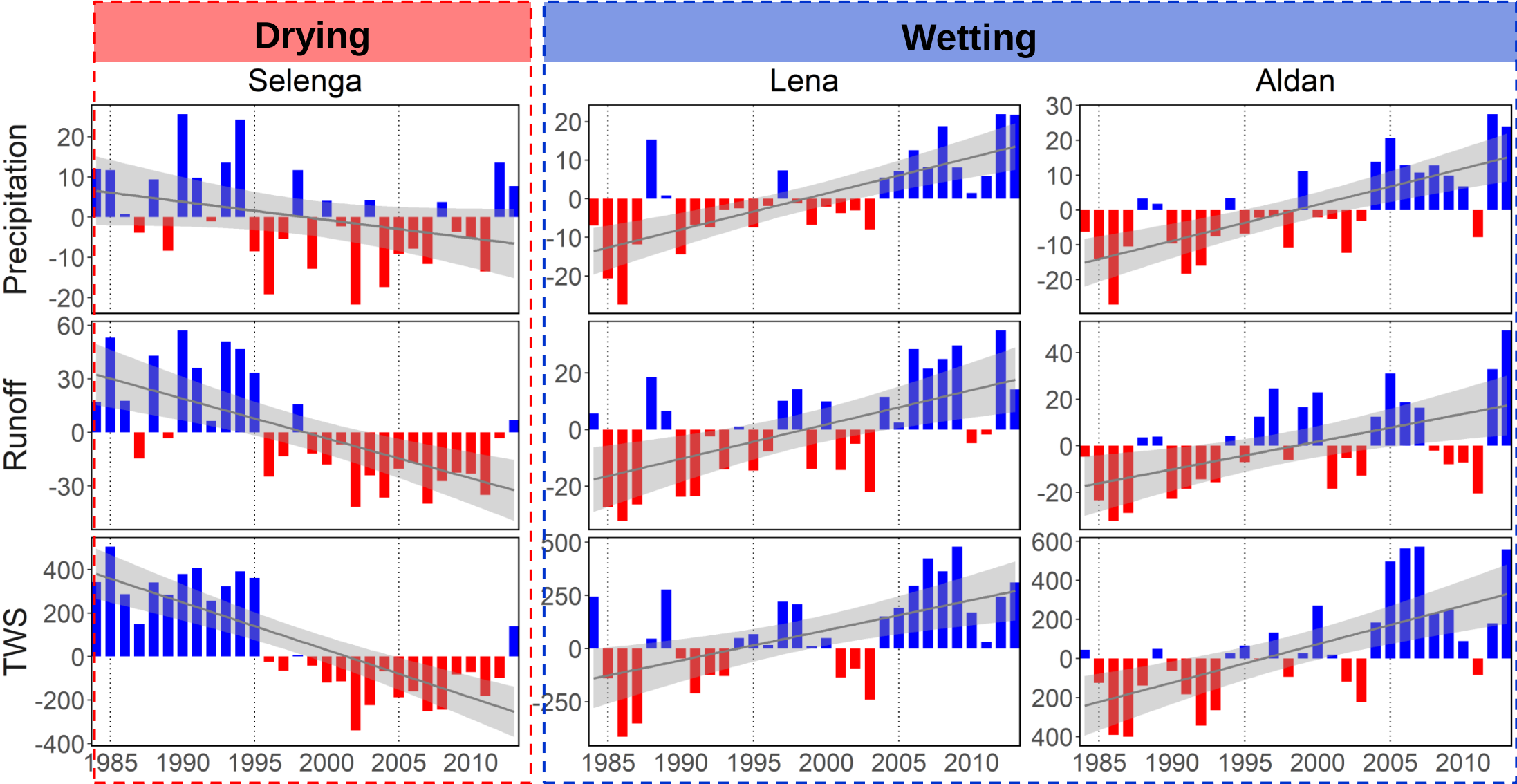


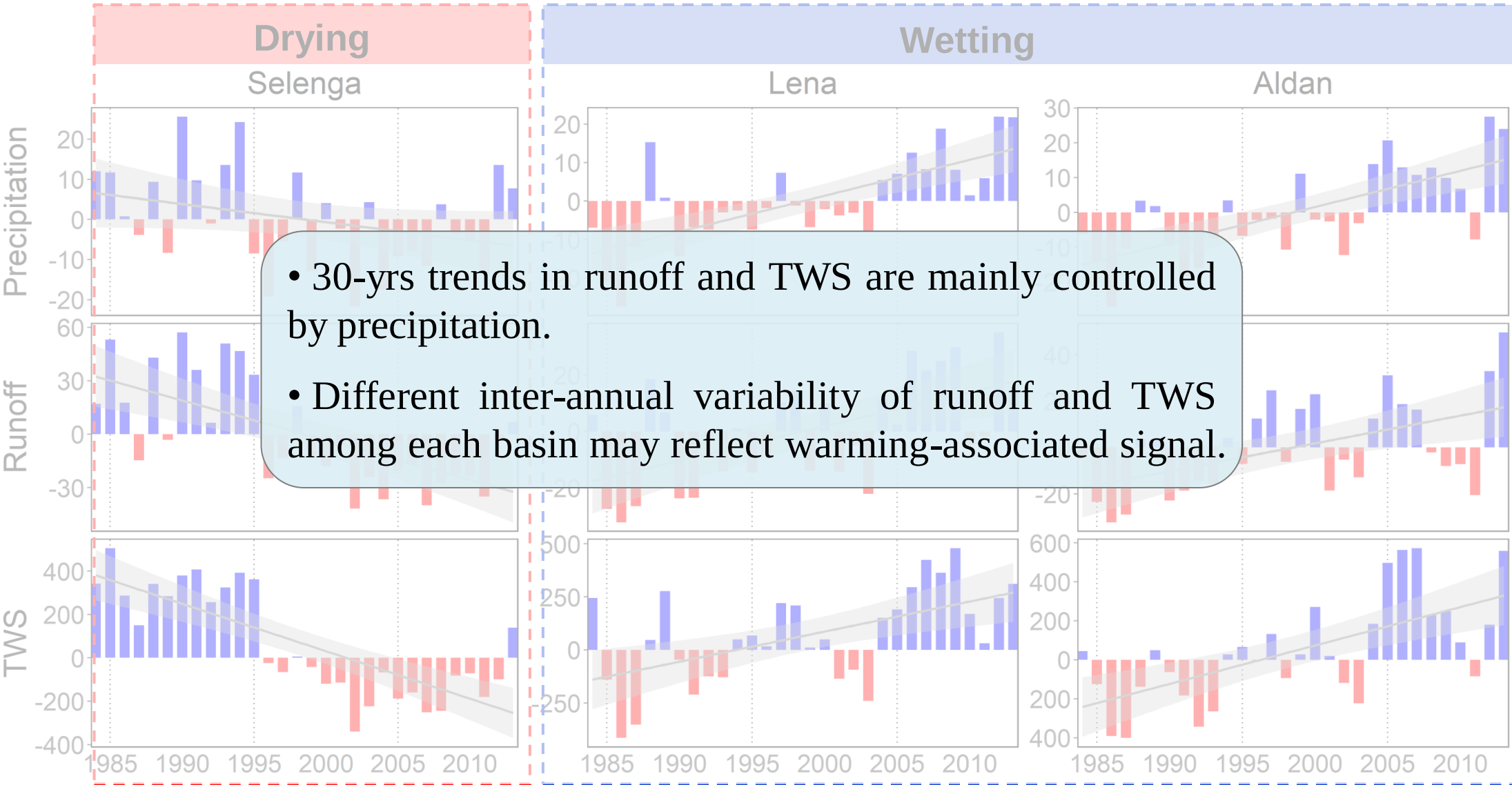
Figure. First four modes of the **empirical orthogonal functions (EOFs)** of the reconstructed GRACE TWS (**GRACE-REC***), explaining almost 80% of the total variance.

The first mode (EOF1, 50%) provides the most dominated feature of the spatial distribution of TWS, indicating the strong **wetting and drying contrast** between the northern and southern basins.

Change patterns of water availability

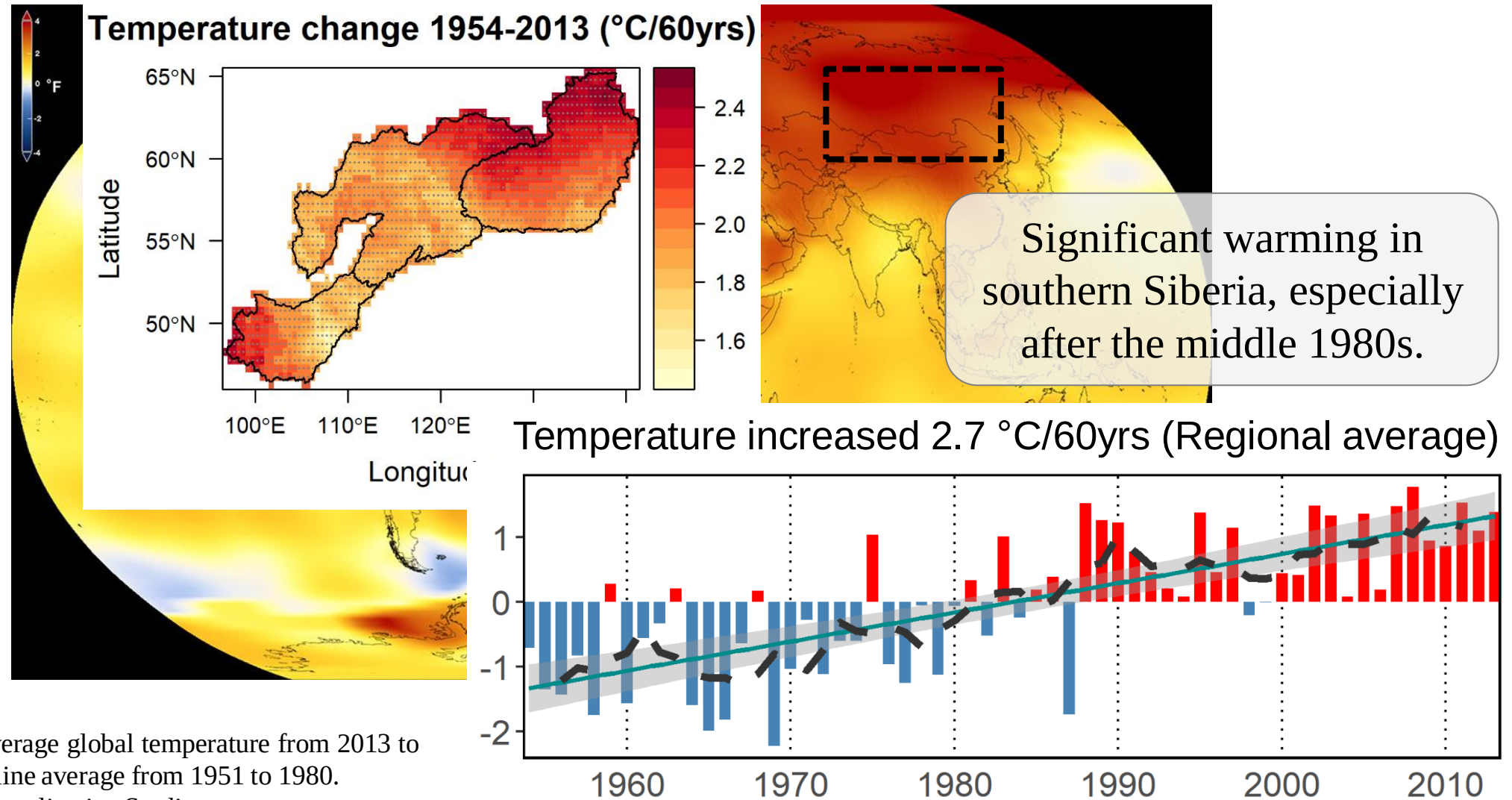


Change patterns of water availability



Degrading permafrost under climate warming

Warming in southern Siberia



Background map: Earth's average global temperature from 2013 to 2017, as compared to a baseline average from 1951 to 1980.
Credit: NASA's Scientific Visualization Studio.

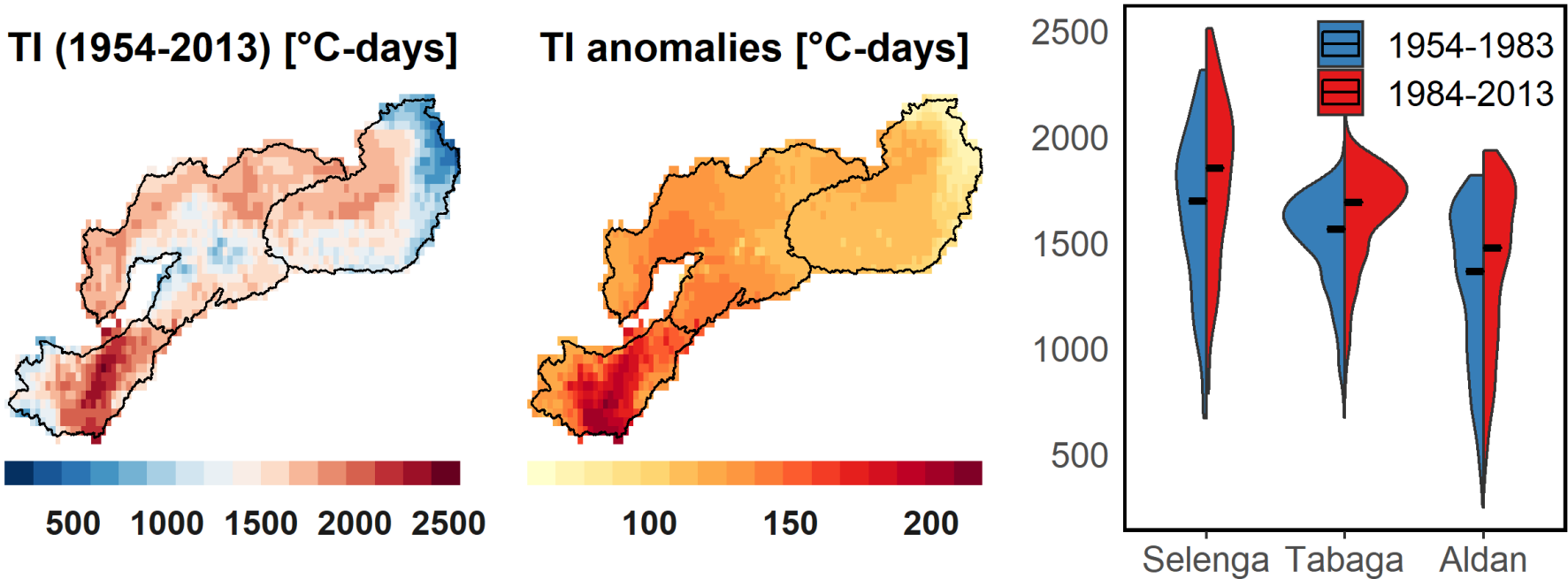


Figure. The spatial distribution of the long-term average of thawing index (TI). The first column is the mean value from 1954-2013 period, the second column is the average differences between two periods before and after 1984 (i.e., the 1954-1983 and the 1984-2013), and the last column is the distribution of the long-term average during these two periods for each catchments. The left and right violins represents the distribution of the long-term average during 1954-1983 and 1984-2013 periods, respectively.

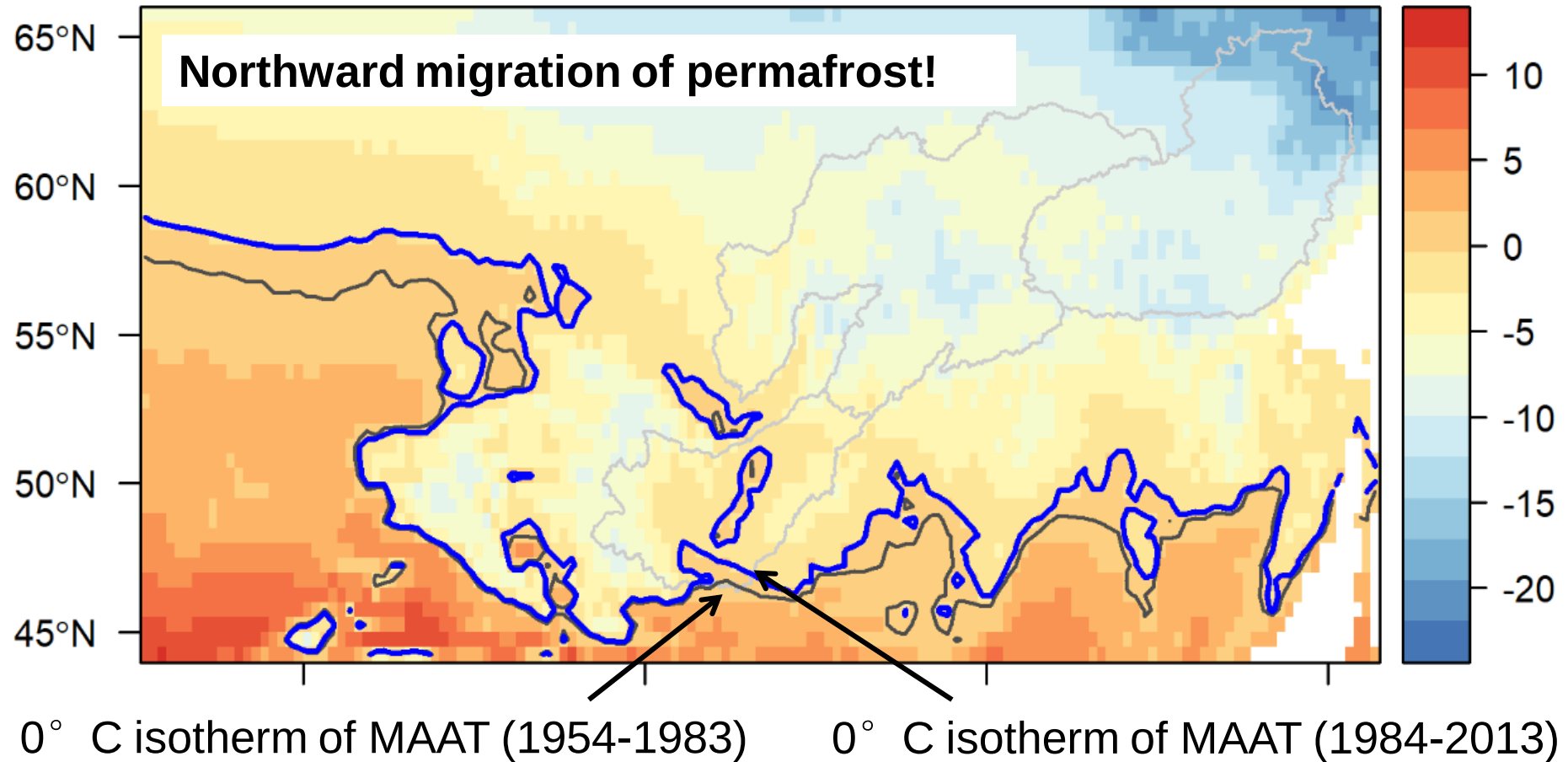
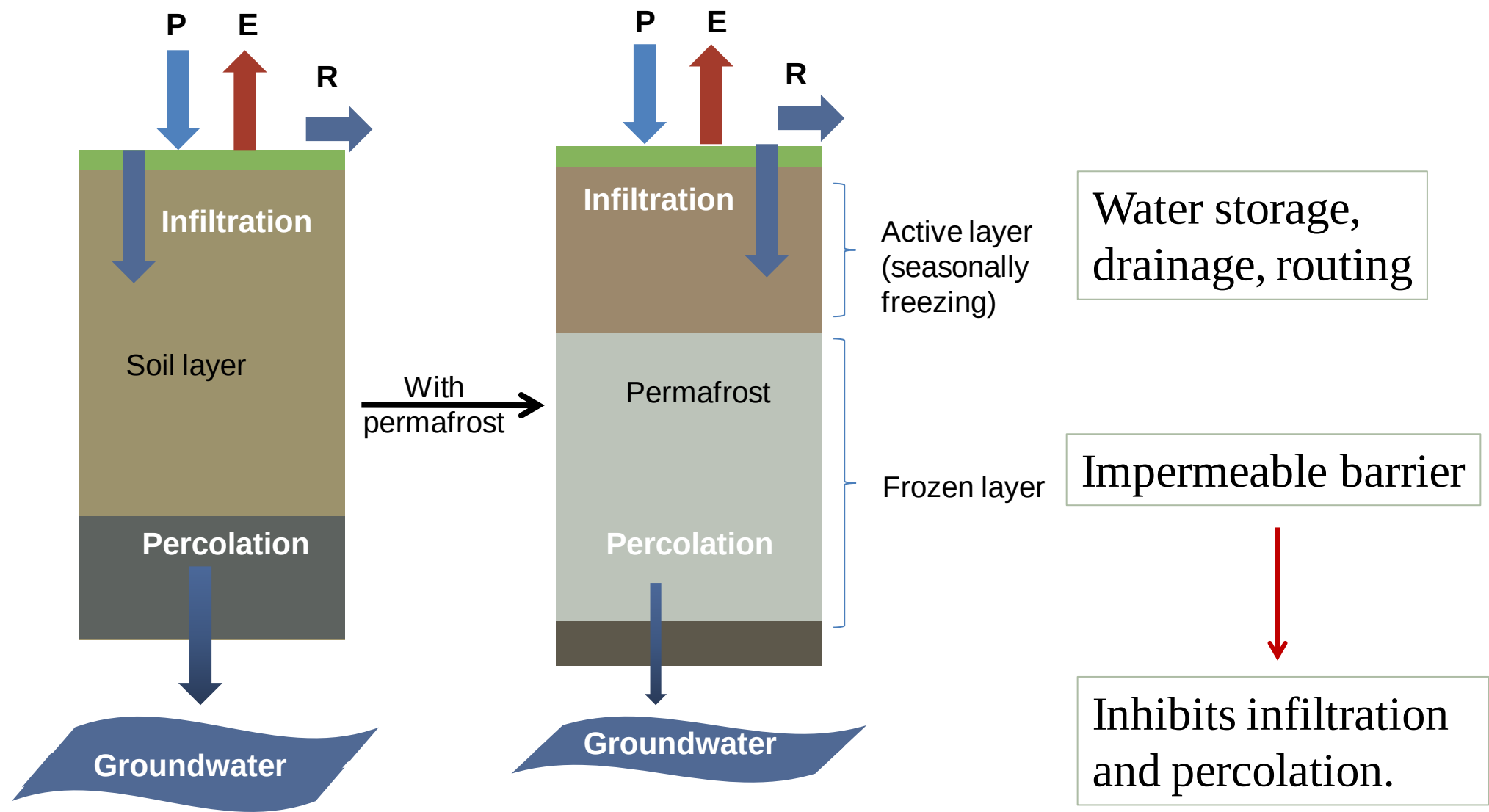
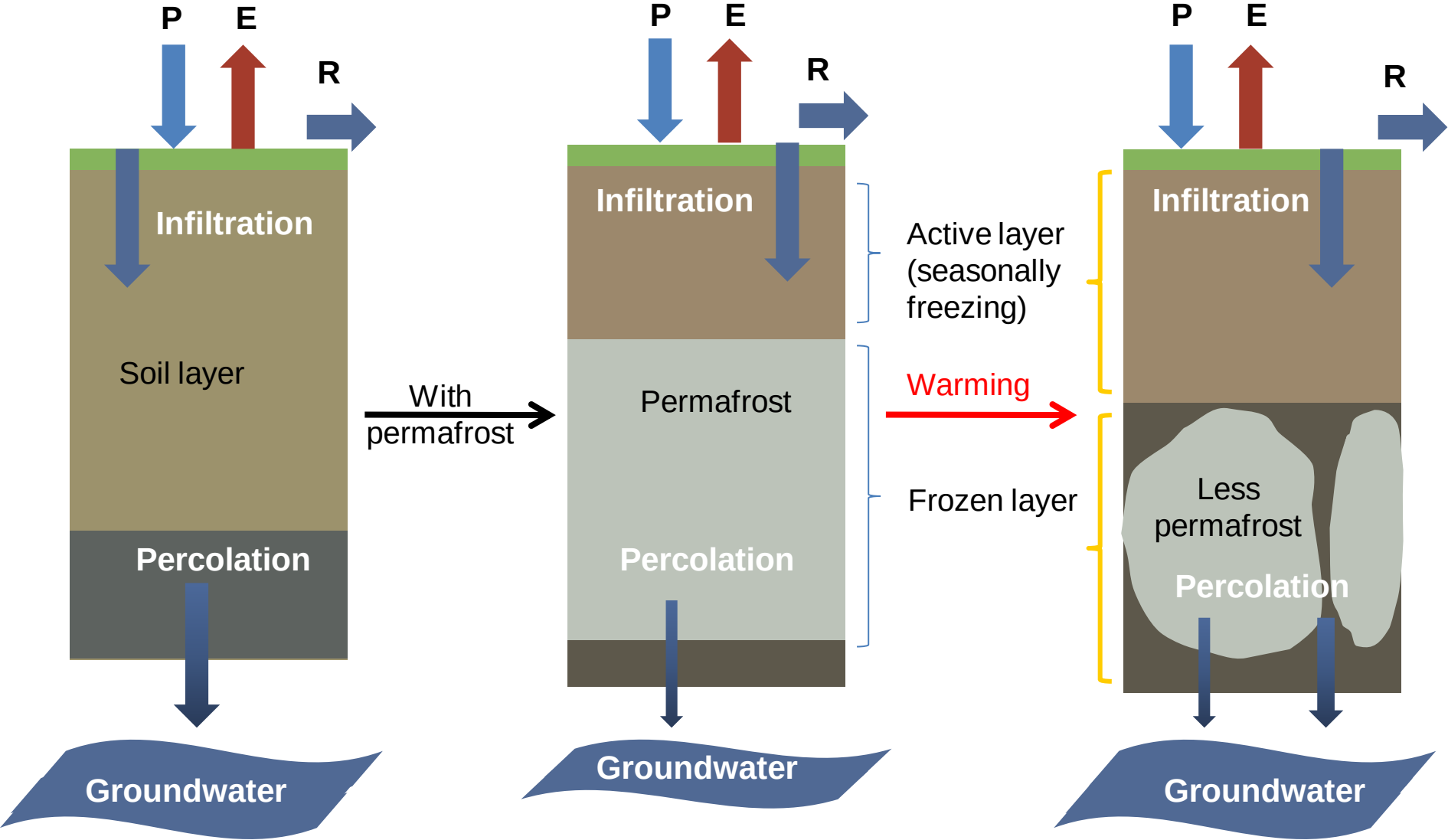


Figure. The spatial distribution of mean annual air temperature (MAAT) during 1954-2013, the black contour represents the 0 ° C isotherm of MAAT during 1954-1983, and the blue contour denotes the 0 ° C isotherm of MAAT during 1984-2013.

How does permafrost degradation affect hydrological processes?



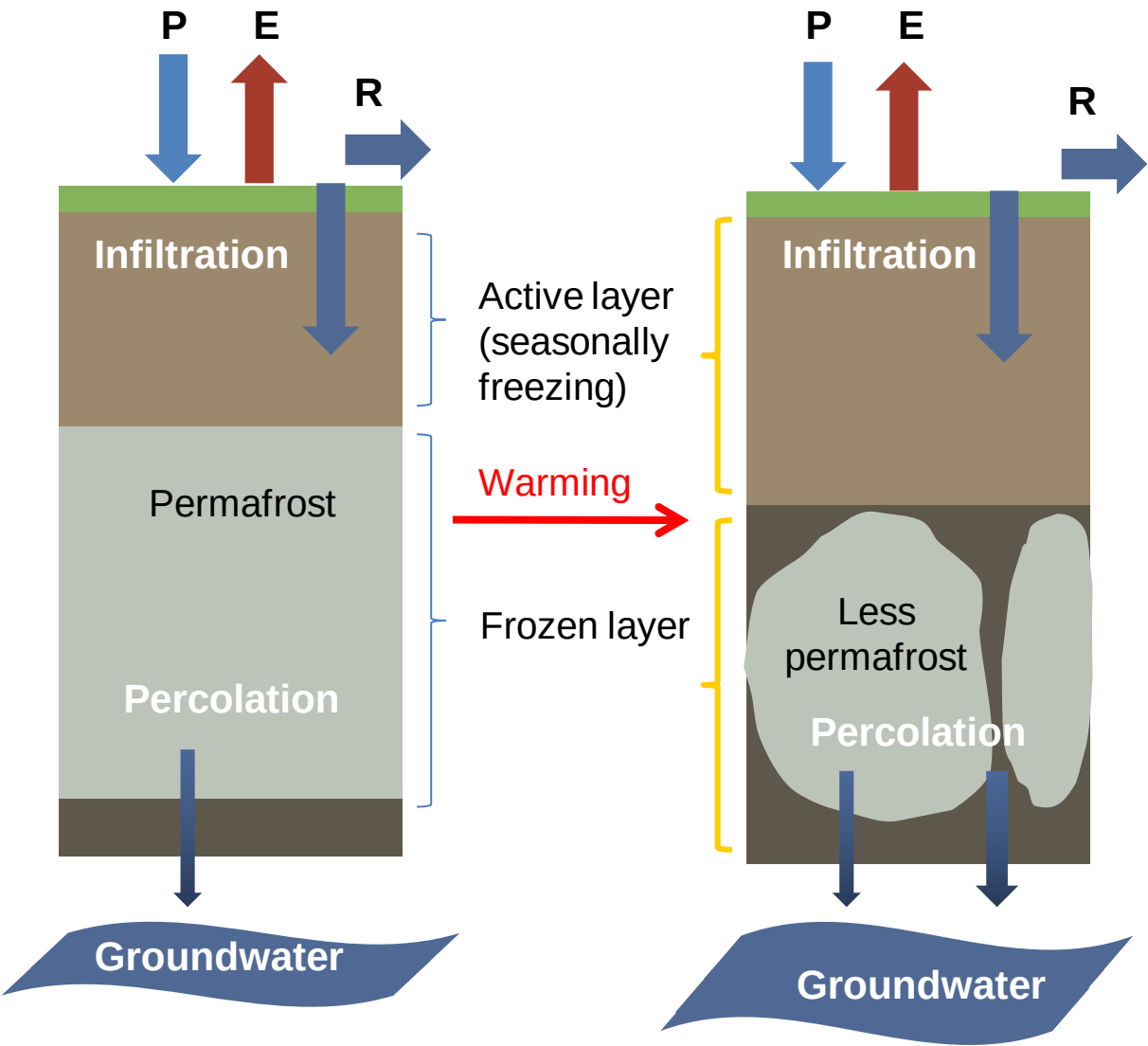


Permafrost warming:

- Deepening active layer
- Decreased permafrost extent

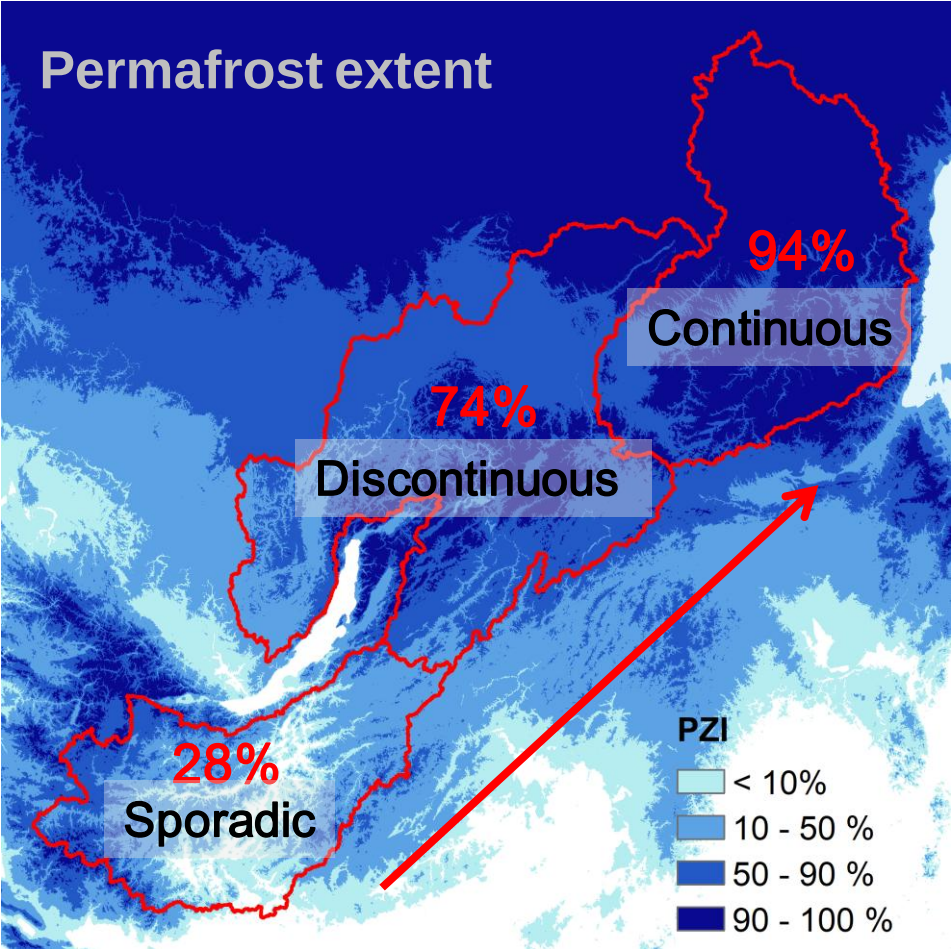


Increased connectivity
between surface
and subsurface

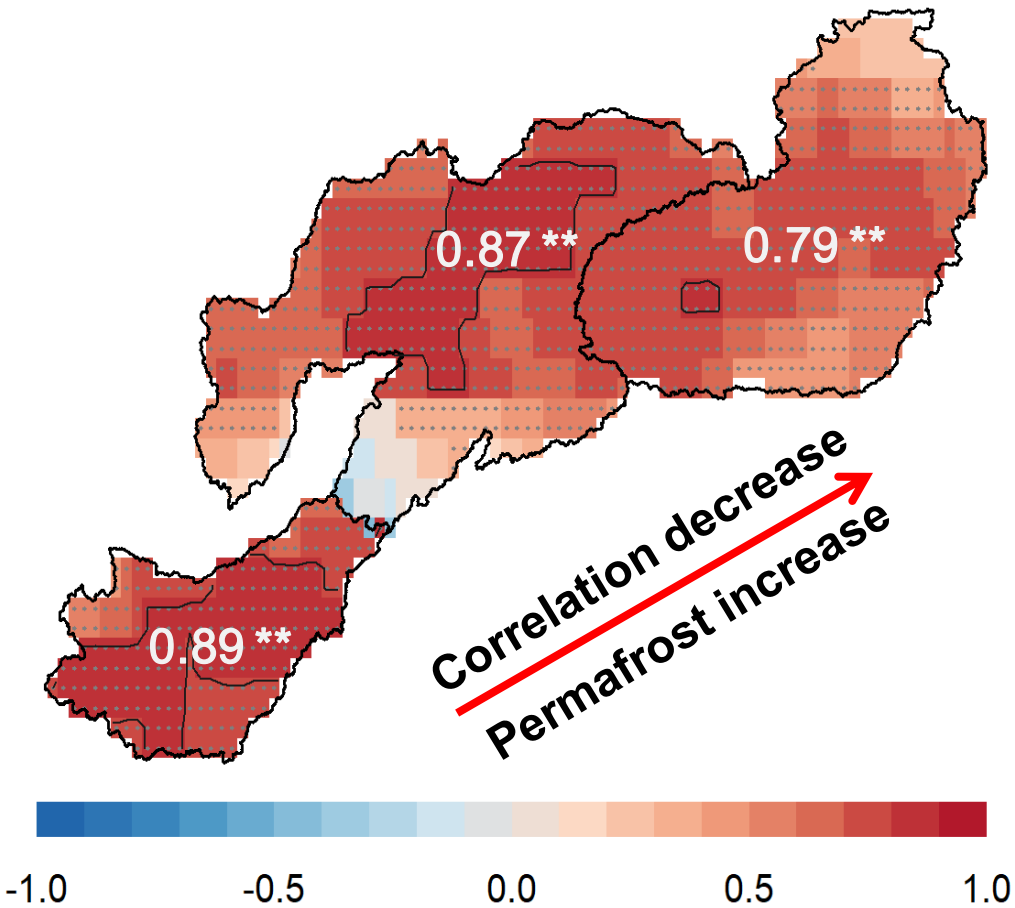


Initial condition

Condition after warming



Correlation: TWS & Runoff



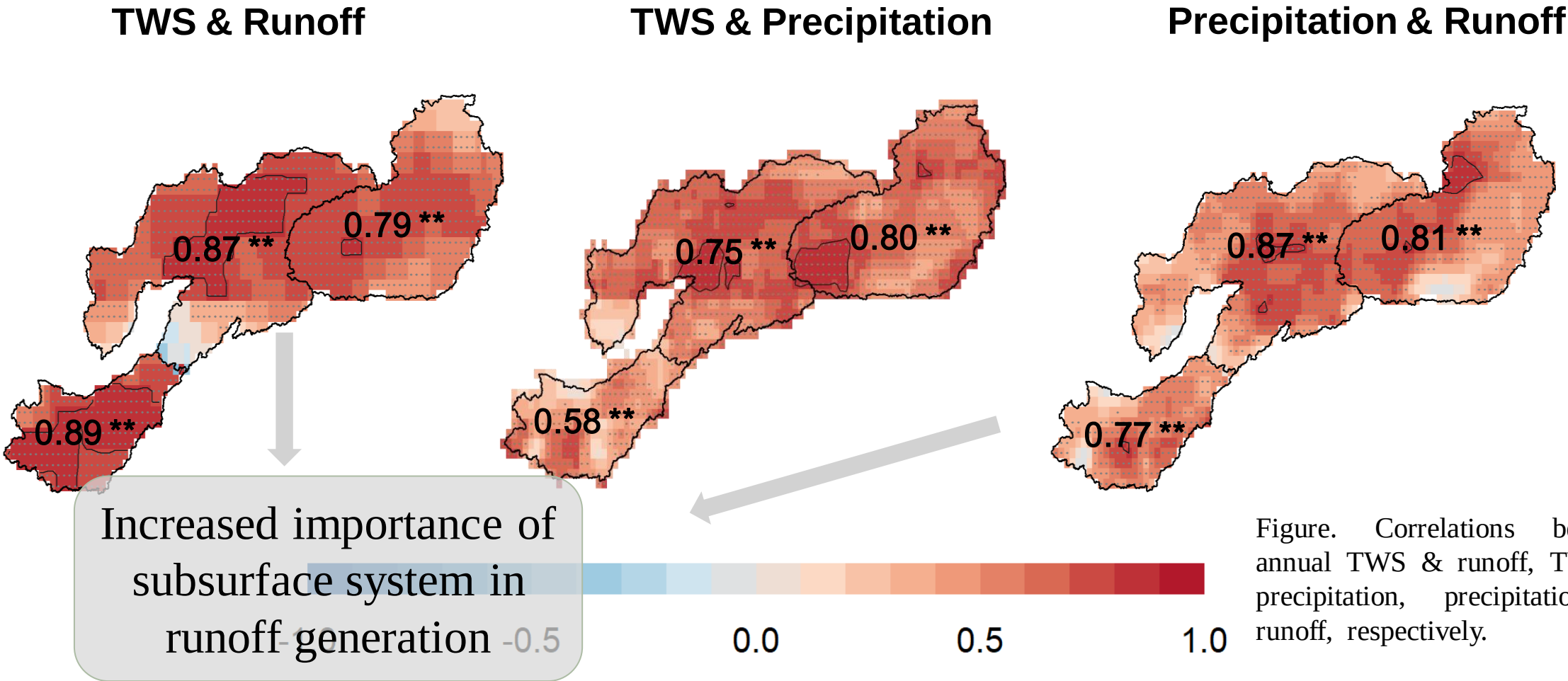


Figure. Correlations between annual TWS & runoff, TWS & precipitation, precipitation & runoff, respectively.

TWS & runoff connections: seasonal correlations

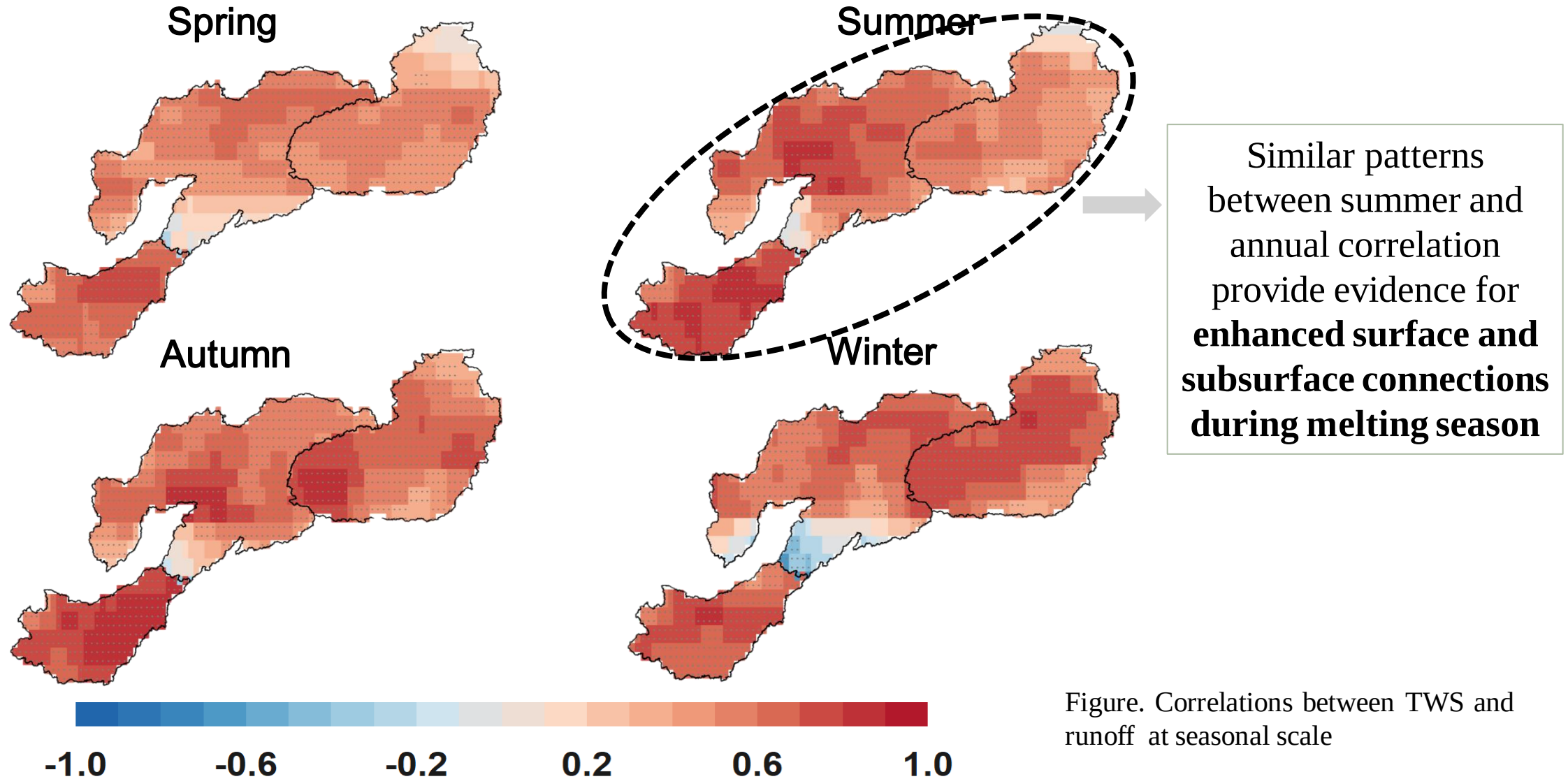


Figure. Correlations between TWS and runoff at seasonal scale

- In southern Siberia, continuous and discontinuous permafrost region are becoming wetter, while sporadic permafrost region gets drier;
- Warming climate during melting season triggers permafrost degradation;
- Degrading permafrost induces enhanced connectivity between surface and subsurface water systems;
- Other satellite data for evaluating soil moisture and snow water equivalent should be included to separate the partition of groundwater in the TWS.

Thanks for your attention!

If anyone has questions or comments, please do not
hesitate to contact me!

Contact: li.han@uni-heidelberg.de