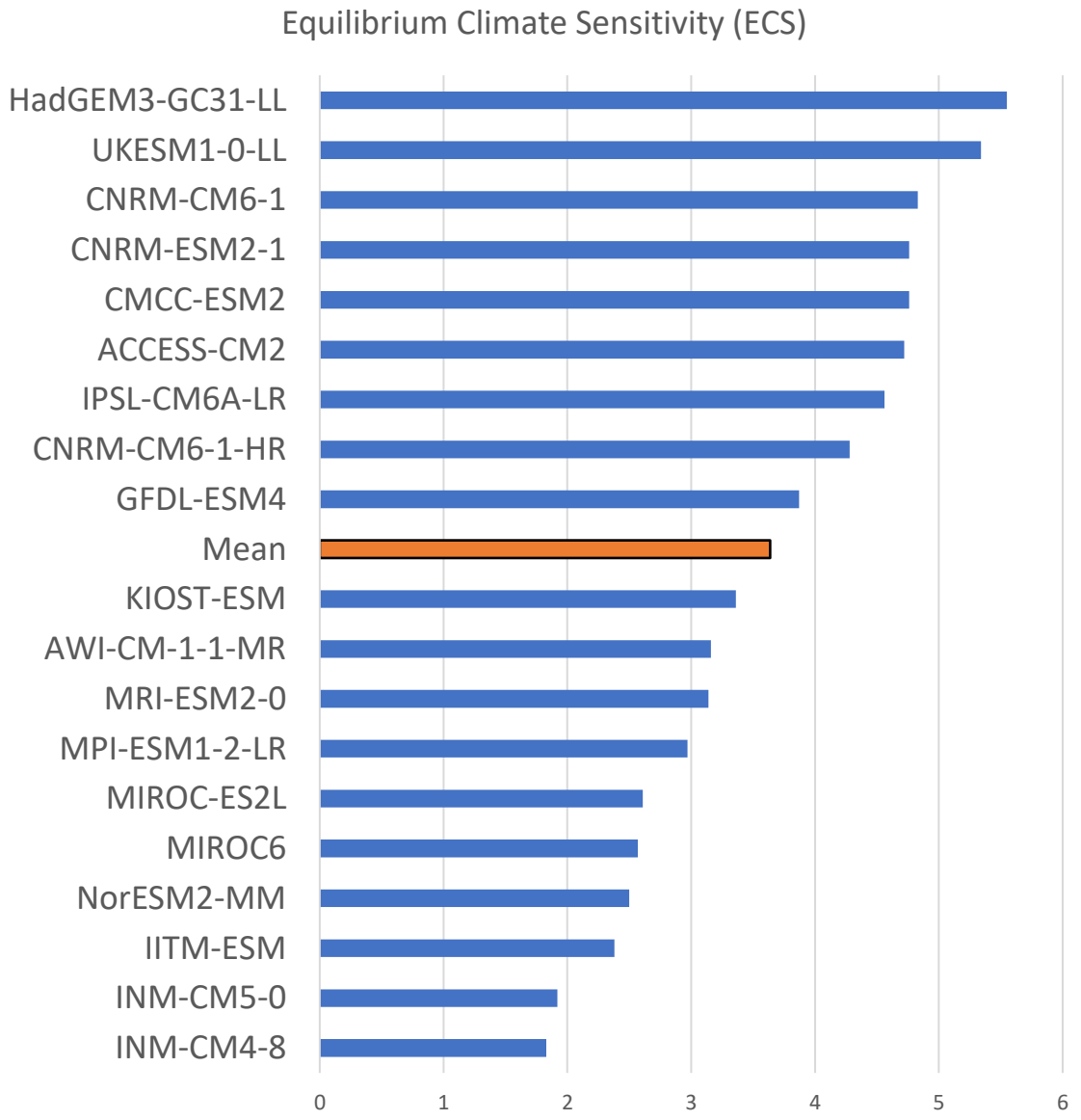
Climate change modelling results

Project “Ice-jam flood risk management in Latvian and Lithuanian regions with respect to climate change” (ICEREG)

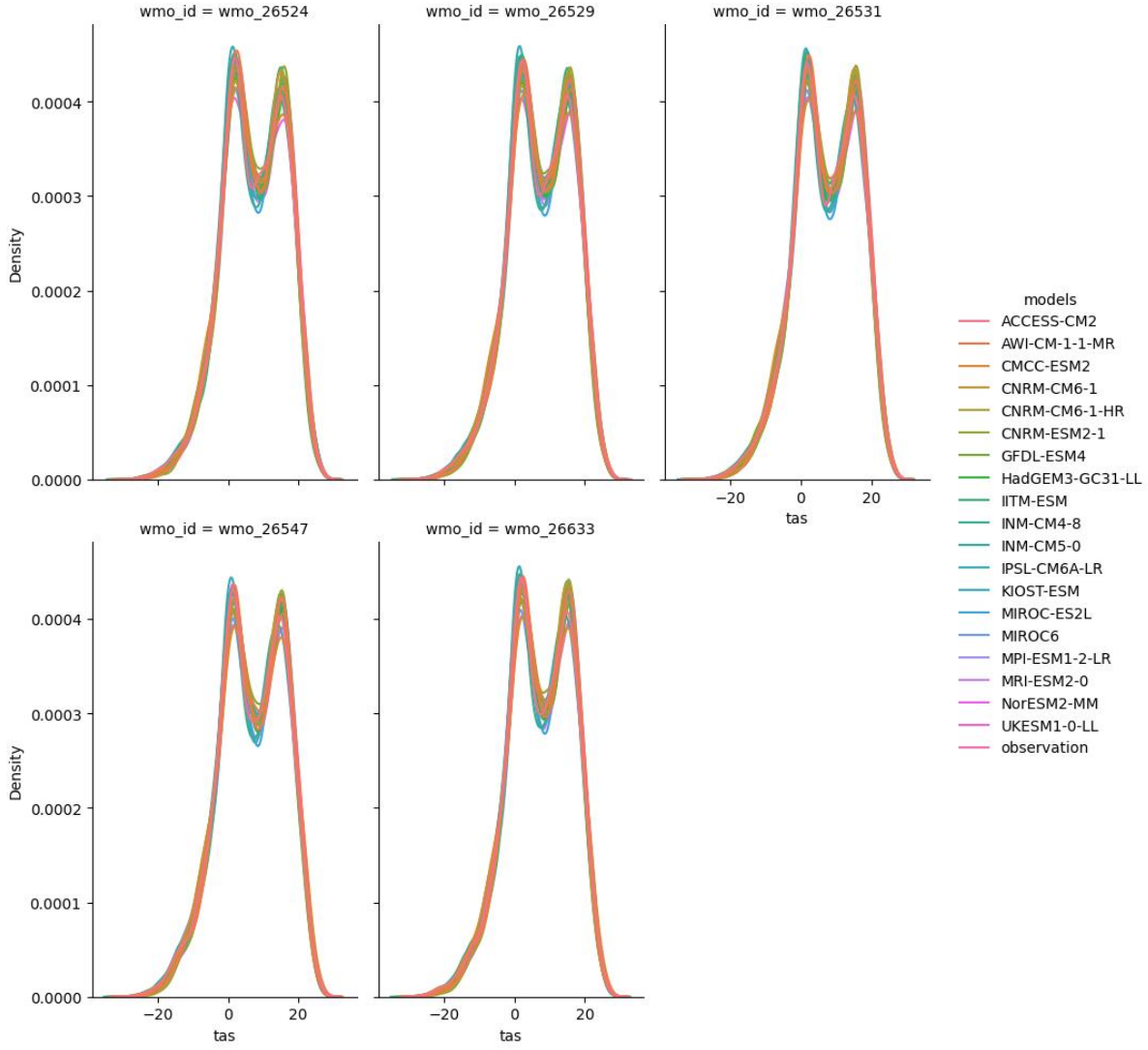
Initial data for projections

- Data from Copernicus Climate Data Store (CDS)
- CMIP6 GCM models with complete or almost - complete set of historical, **SSP2-4.5, SSP3-7.0**, scenarios.
- Variables: mean daily temperature and daily precipitation.
- Model ensemble mean is close to 4 °C, which shows well balanced sensitivity.



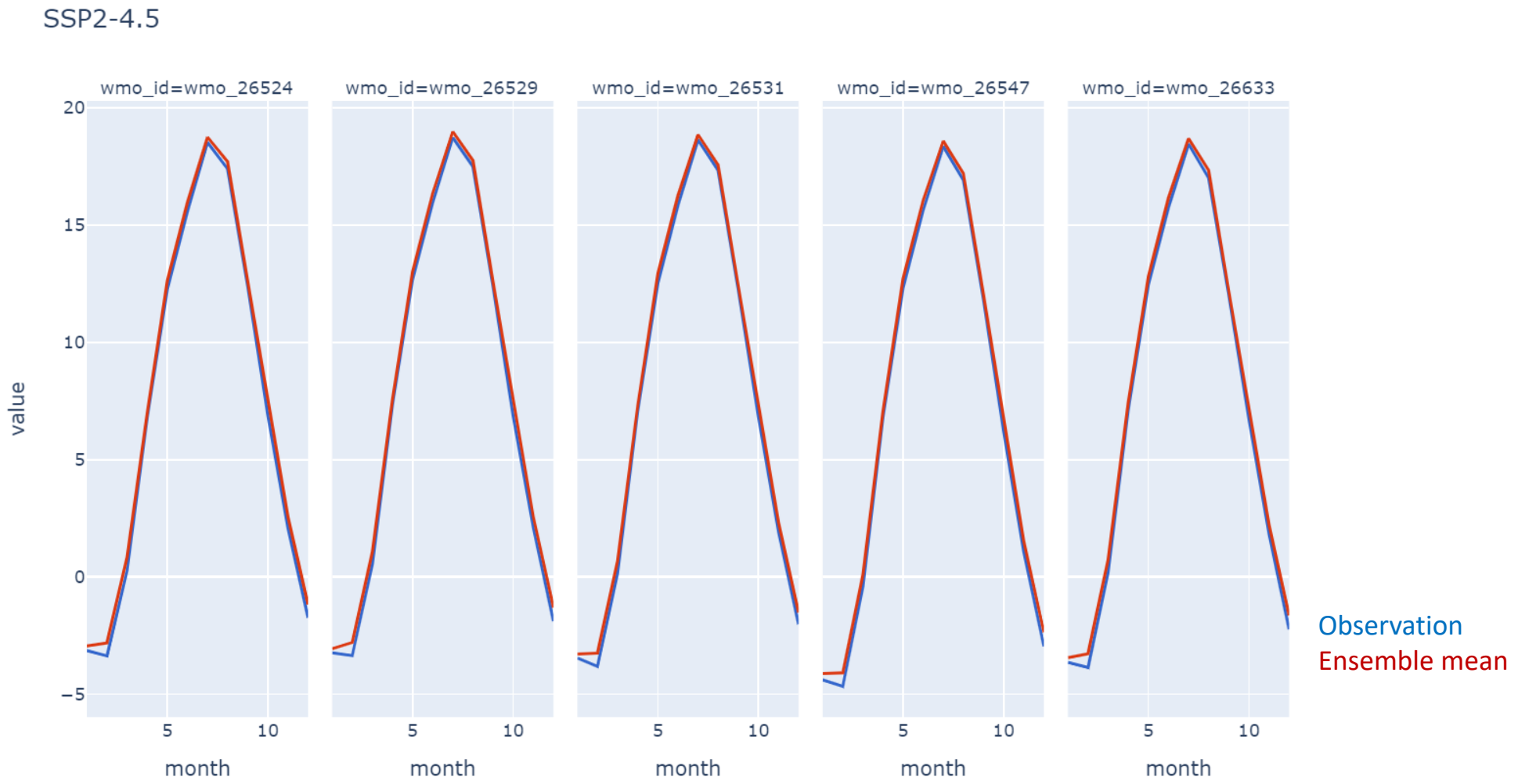
Bias correction of model outputs

- Detrended Quantile Mapping (DQM) (Cannon et al, 2015).
- DQM is designed to preserve the model climate change signal, while also bias-correcting the distribution of the target variable.
- The projection KDE for temperature and precipitation reasonably agrees with observation KDE.

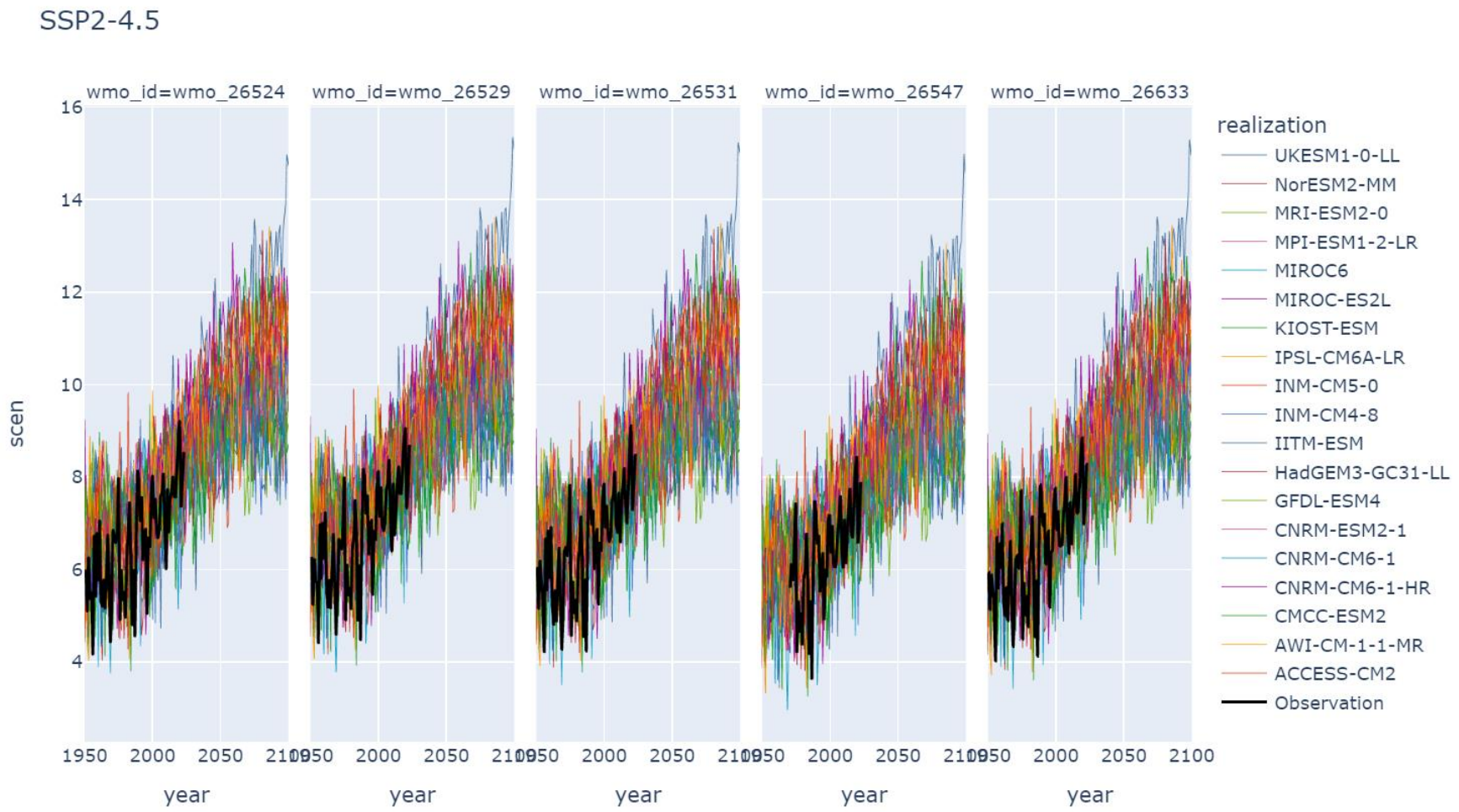


Kernel density estimation (KDE) of temperature in 1991-2020. Comparison of observation and bias corrected model KDEs.

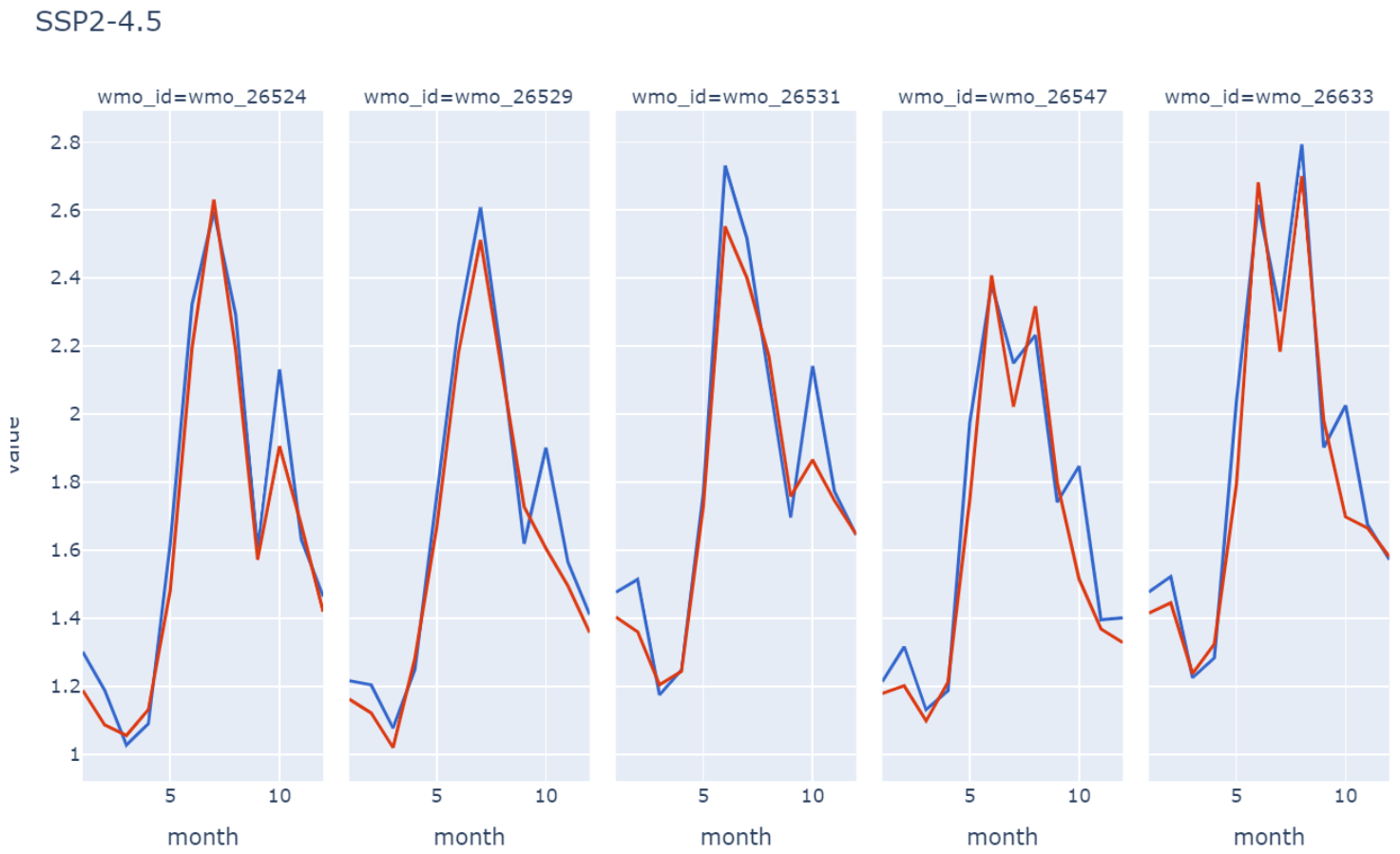
Multi-model ensemble mean temperature seasonality in ICEREG meteorological stations in 1991-2020



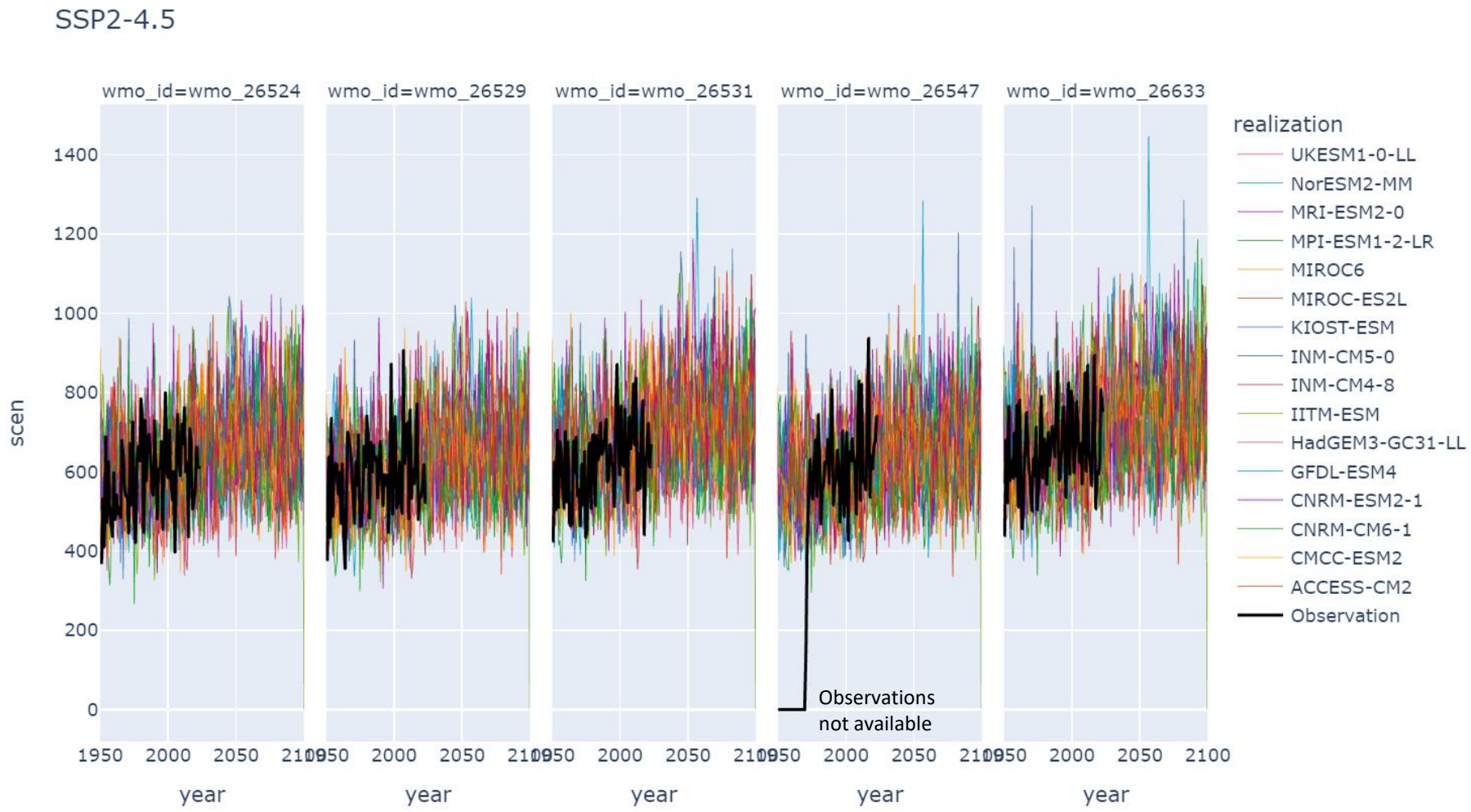
Temperature trend projected and observed in ICEREG meteorological stations



Multi-model ensemble precipitation seasonality in ICEREG meteorological stations in 1991-2020

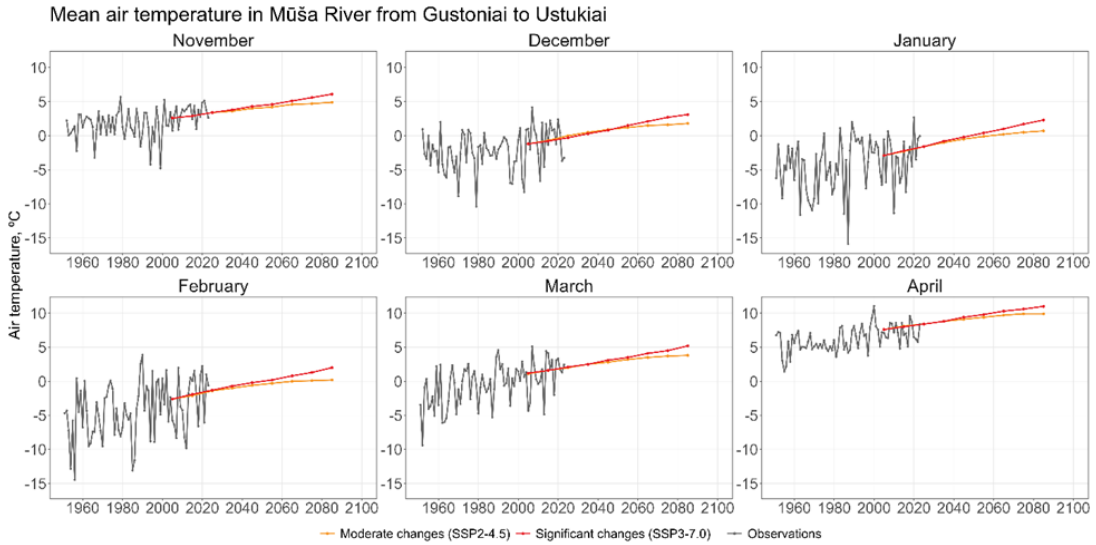


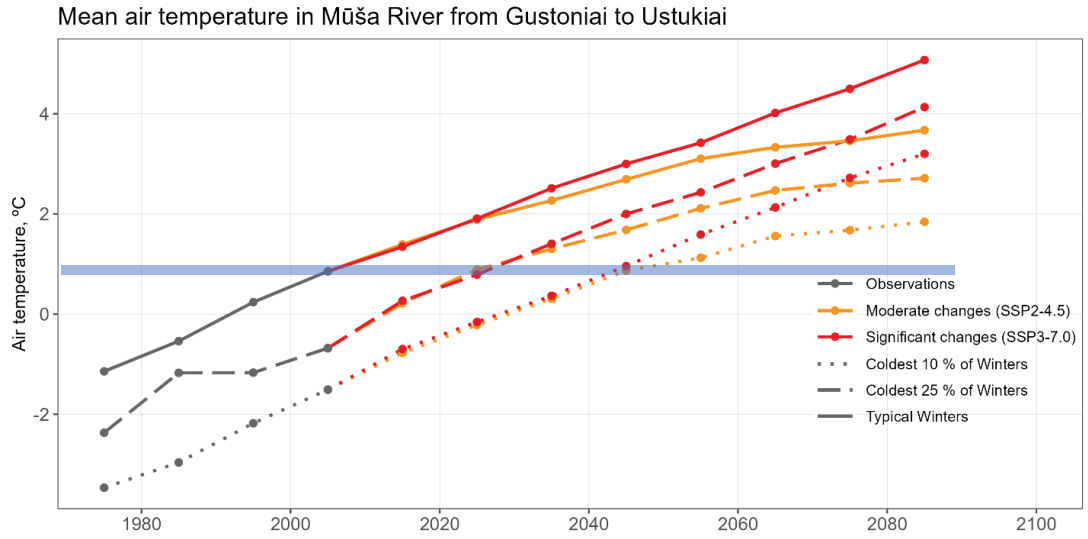
Precipitation trend projected and observed in ICEREG meteorological stations



Air temperature

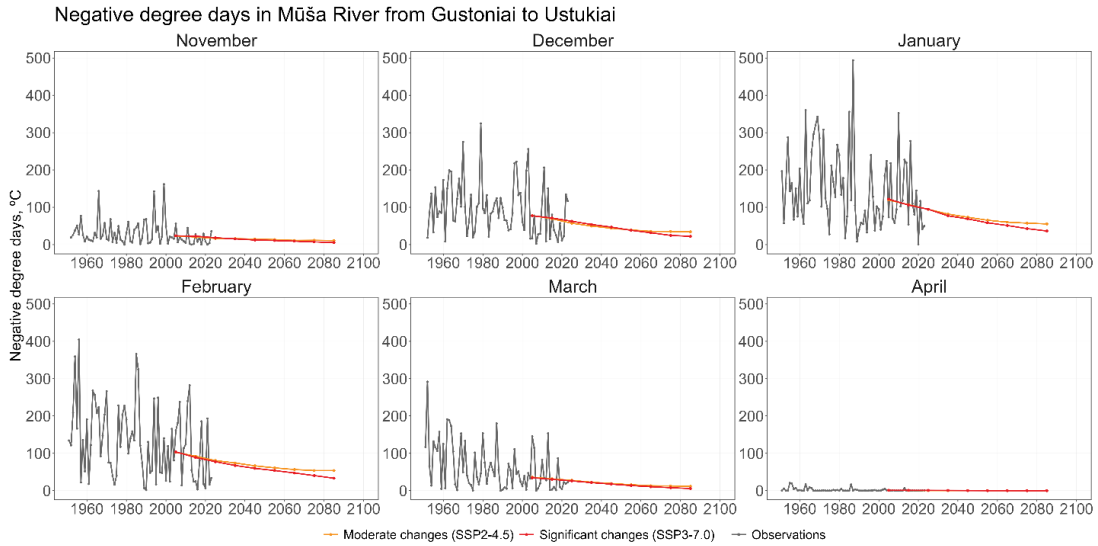
- The historical warming trend is evident when comparing the reference period (1961–1990) to the climate norm (1991–2020).
- Future projections under SSP2-4.5 show moderate yet substantial warming, with temperatures rising by 2.8 °C to 3.5 °C relative to 1991–2020 by the end of the century.
- Under SSP3-7.0, the warming is more pronounced, increasing 4.2 °C to 4.8 °C by 2100, particularly during the coldest winters.
- Even the coldest 10% and 25% of winters are expected to be warmer than the typical winters of the 1991–2020.

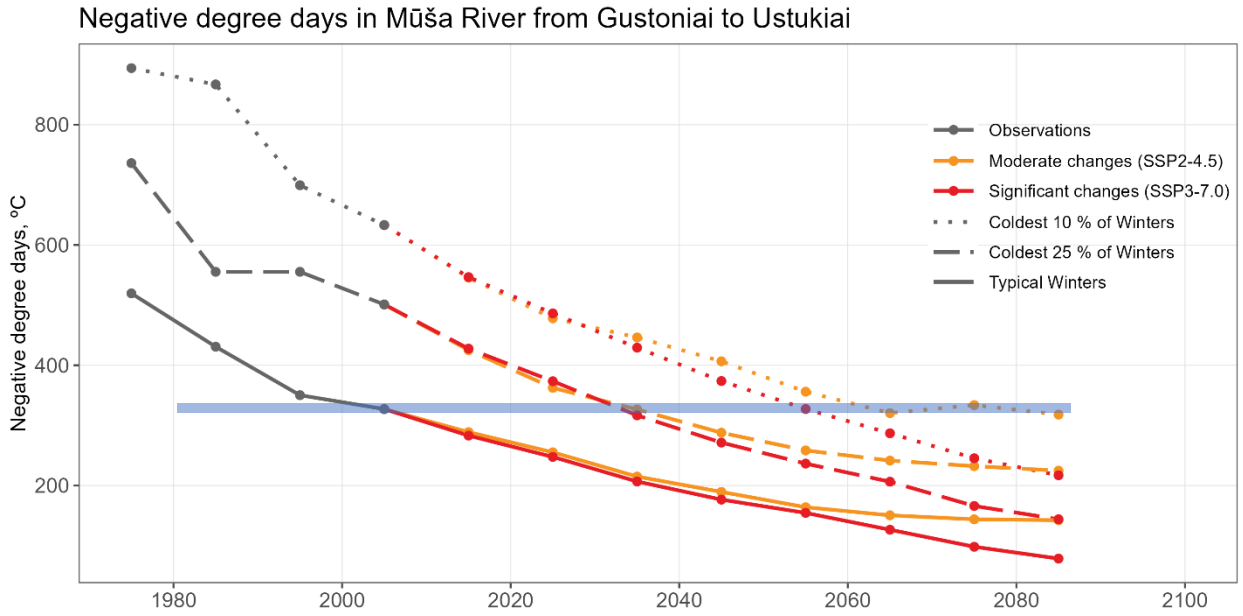




Negative degree days (NDDs)

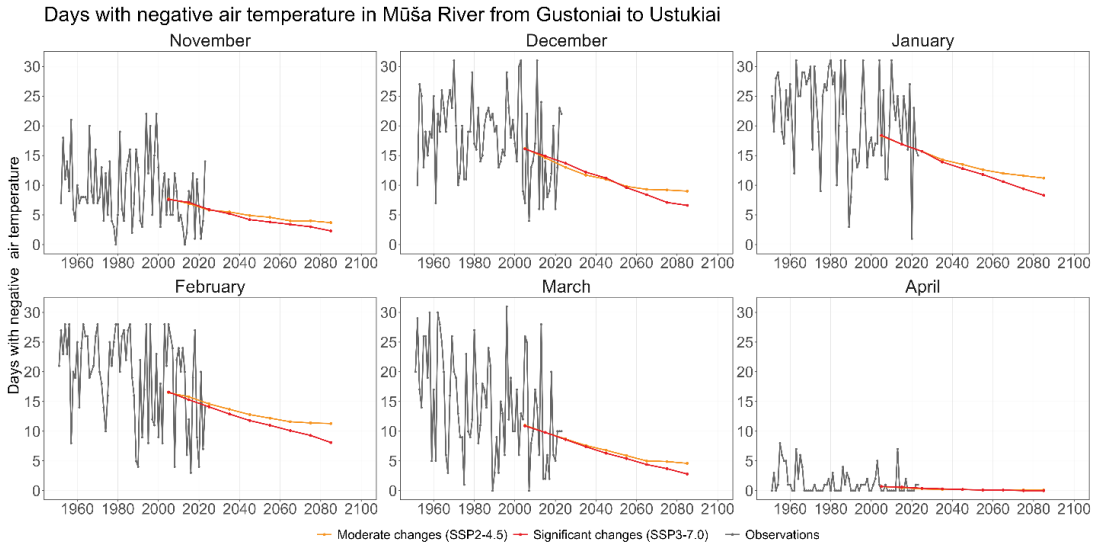
- Negative degree days (NDDs), which are indicative of ice formation and thickening, are projected to decline substantially.
- Larger NDD values historically contributed to the accumulation of thicker ice covers, increasing the likelihood of ice-jams when the ice cover broke. Thicker ice transported by rivers typically leads to the formation of more resistant ice jams and more severe flooding.

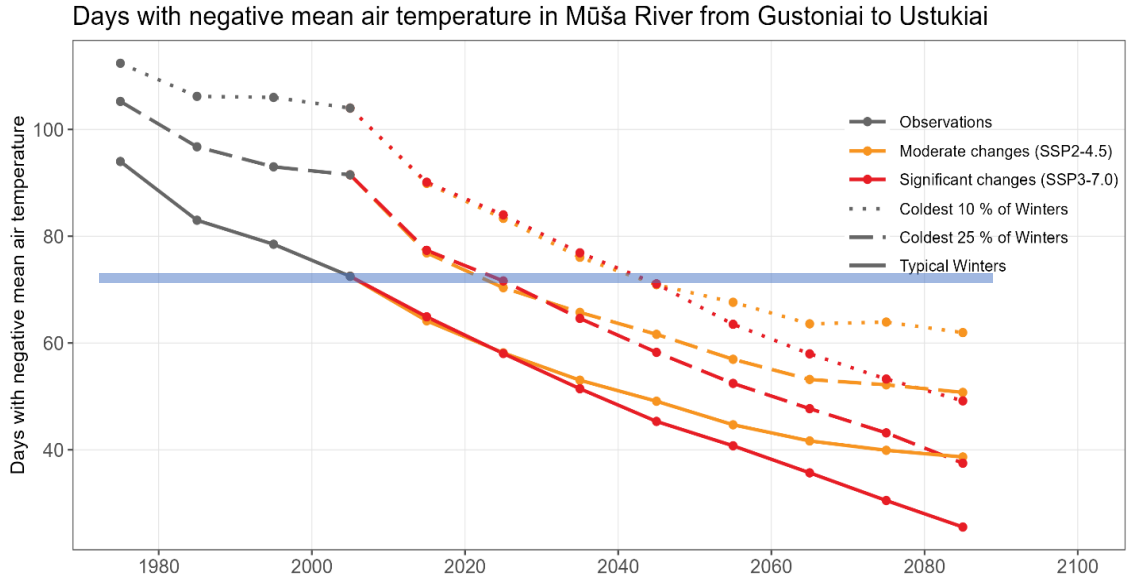




The number of days with mean air temperatures below 0 °C

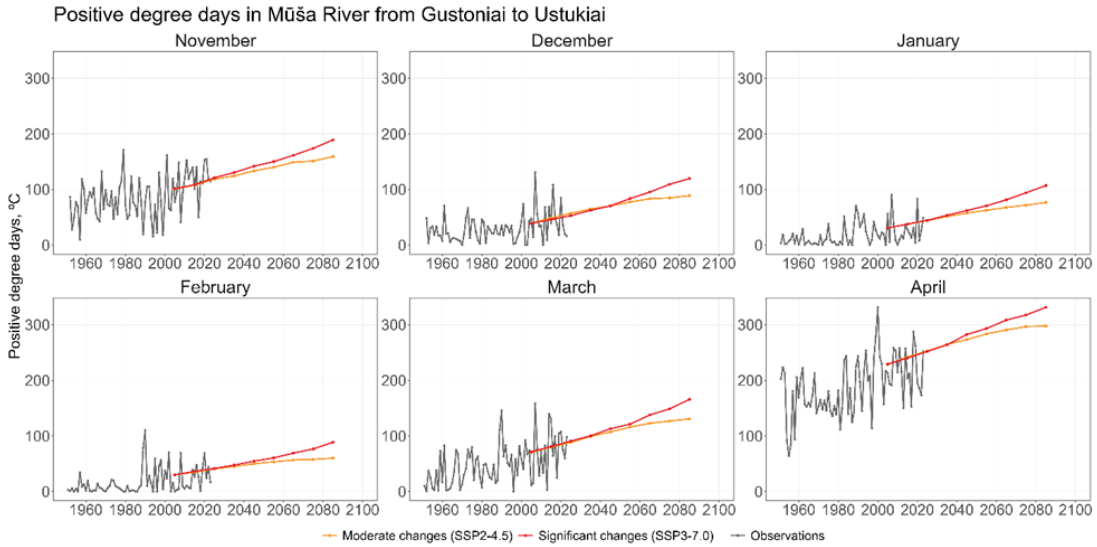
- The number of days with mean air temperatures below 0 °C, crucial for frazil ice formation and freeze-up jams, will also decline significantly.
- Projections show a consistent reduction in the number of days with mean temperatures below 0 °C across all scenarios.

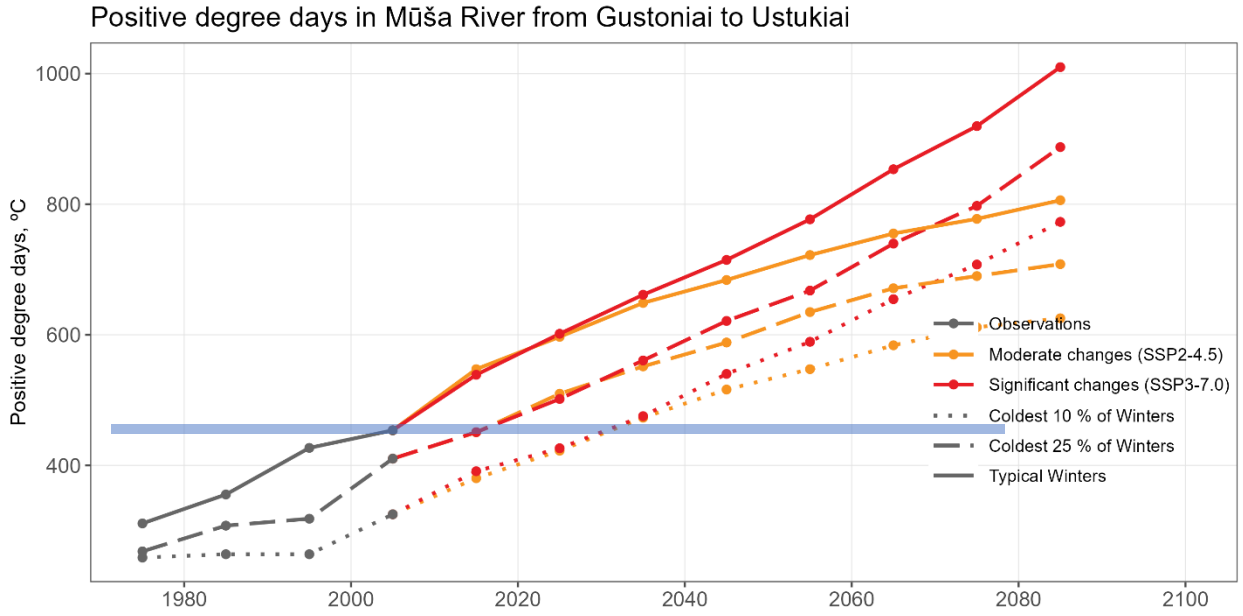




Positive degree days (PDDs)

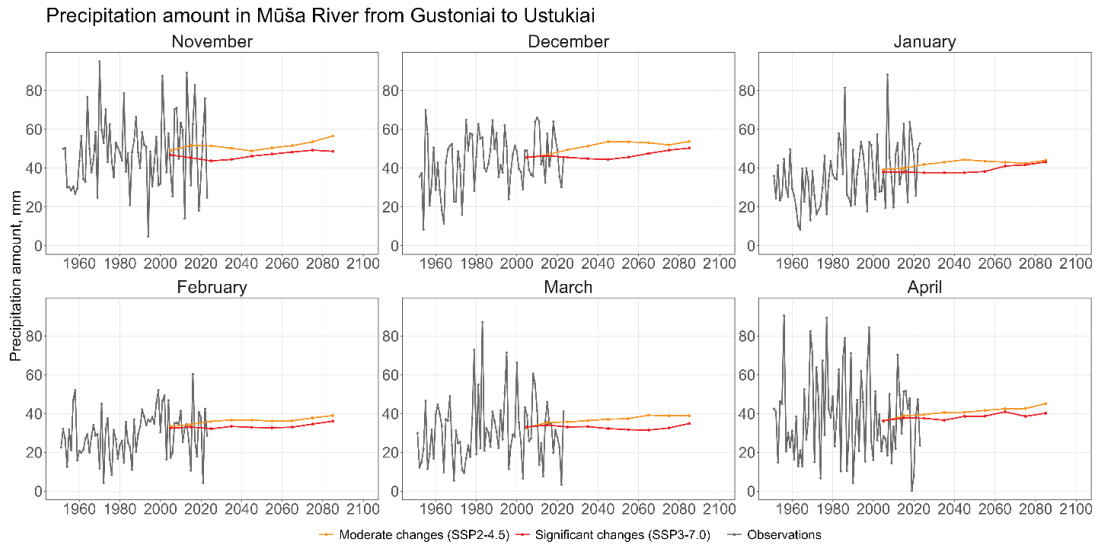
- Positive degree days (PDDs), which are linked to thawing events that could trigger thermal or physical ice cover breaks, are projected to increase.
- Very high PDD values may indicate conditions too warm for ice cover to form or significant limitations on ice accumulation.
- PDDs could be associated with ice-jam formation only after substantial NDD accumulation and a preceding period of below-freezing days.





Precipitation

- Precipitation indirectly affects ice-jams through runoff formation and can directly weaken ice cover during extended rain spells.
- While increased precipitation in cold months could create more favourable conditions for ice-jam formation, substantial warming during the cold season will likely offset this effect.



Conclusions

- Climate change will significantly reduce the frequency and severity of ice-jams due to warmer temperatures, fewer freezing days, shorter accumulation periods for NDDs, and declining frazil ice formation.
- The SSP2-4.5 scenario projects more stable conditions, while SSP3-7.0 suggests greater variability throughout the century and a more extreme reduction of ice-jam risk.
- Despite projected warming and reduced ice-jam hazard, the possibility of ice-jam formation during colder winters will be possible. Consequently, it is essential to implement low-maintenance but effective ice-jam risk management measures.