



Refinement of dynamically downscaled climate scenarios and hydrological modelling

Stein Beldring

Norwegian Water Resources and Energy Directorate

Torill Engen-Skaugen

Norwegian Meteorological Institute



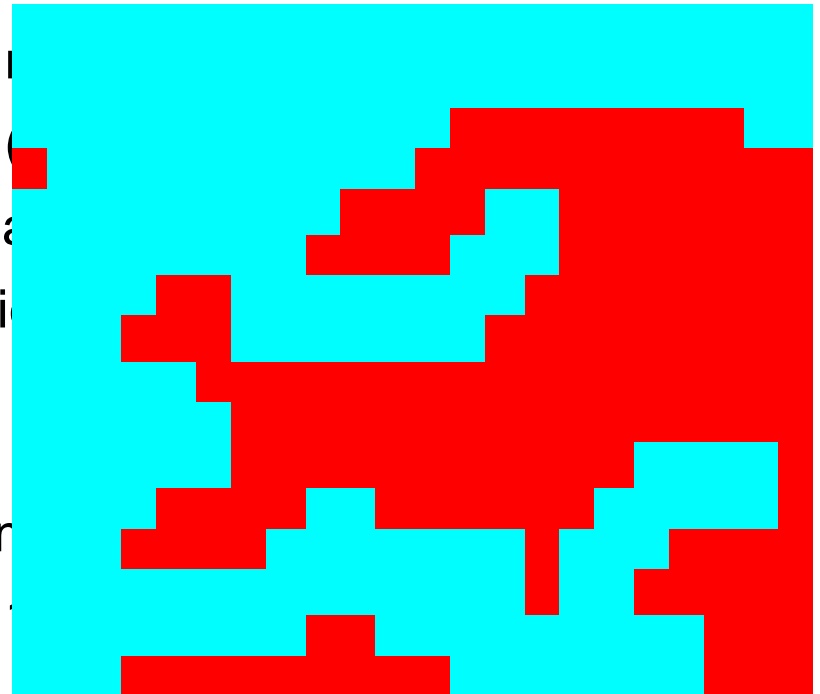
Refinement of dynamically downscaled climate scenarios and hydrological modelling

- **Downscaling from regional climate models to meteorological station sites using two methods: an empirical adjustment procedure and the delta change or perturbation approach**
- **Results for modelling climate change impacts on water resources**
- **Uncertainty in hydrological impact simulations caused by different methods for transferring regional climate model results to meteorological station sites**



Modeling climate change impacts on water resources

- Two emission scenarios for greenhouse gases:
 - A2 (larger emissions) and B2 (smaller emissions)
- To global climate models :
 - Max Planck Institut für Meteorologie ECHAM4/OPYC3
 - Hadley Centre for Climate Prediction and Research HadAM3H
- Dynamical downscaling with two models:
 - Rossby Centre RCAO model (Gleckler et al)
 - RegClim HIRHAM (Bjørge et al)
- Two methods for transferring regional climate model output to meteorological station sites:
 - Delta change approach
 - Empirical adjustment of dynamical downscaling output
- HBV hydrological model with 1 x 1 km resolution



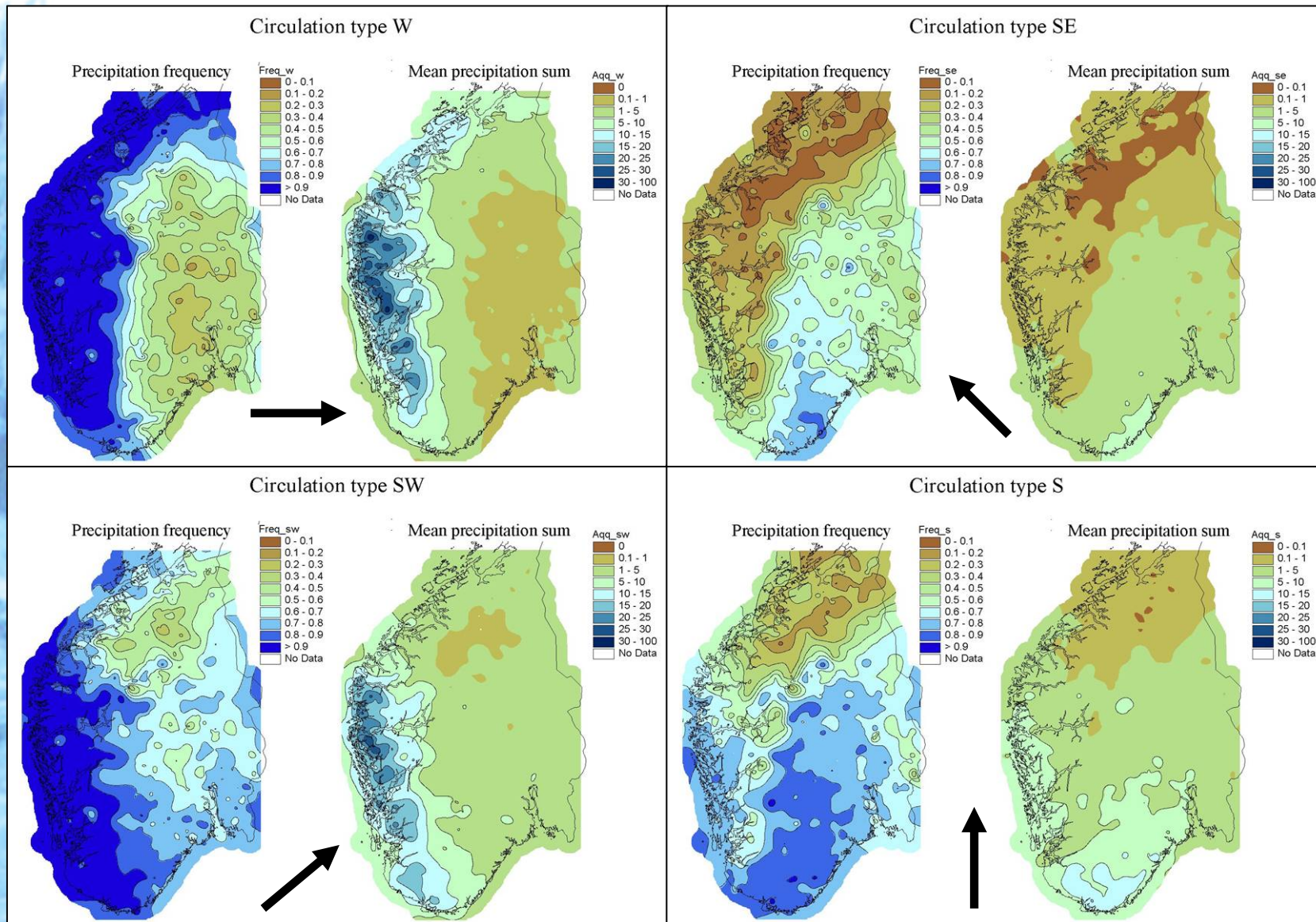


Atmospheric circulation and precipitation are related

Source: Tveito and Roald (2005)

”Echam type”

”Hadley type”

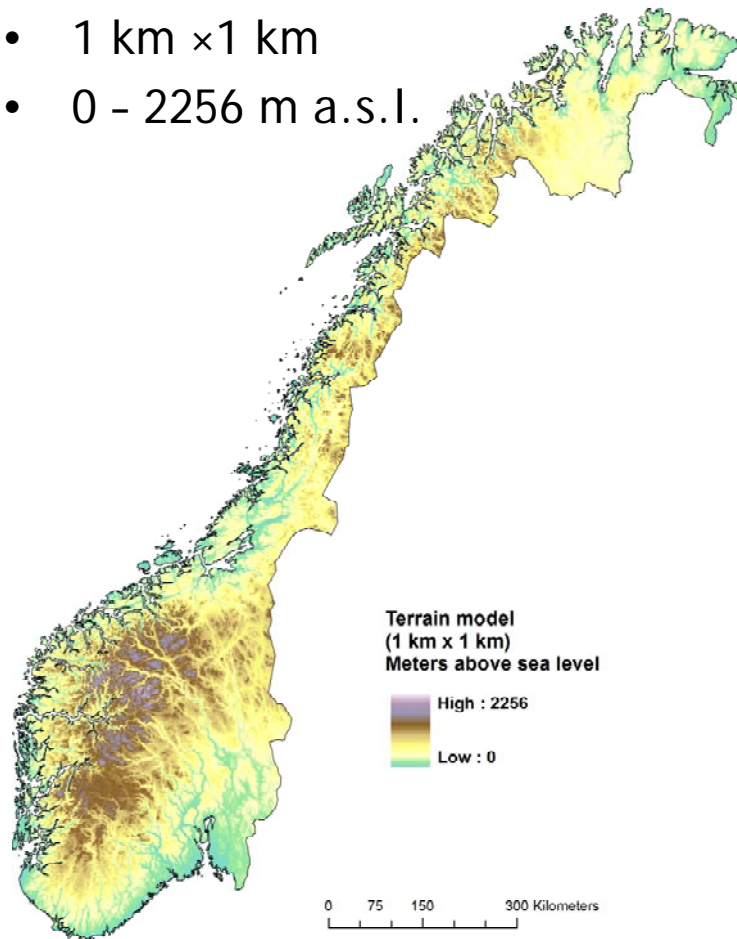




Different topography

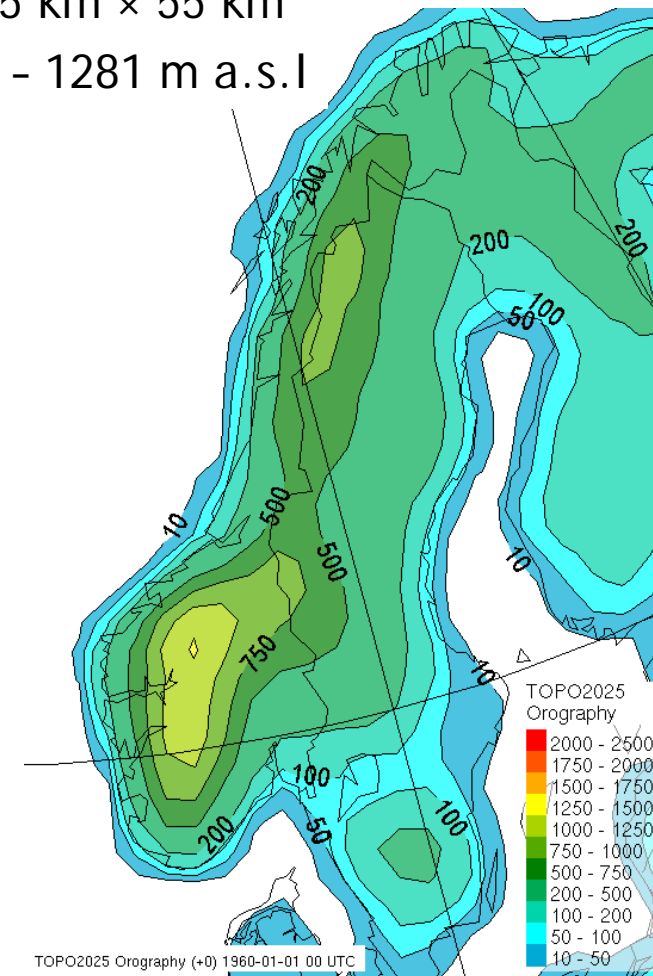
HBV

- 1 km × 1 km
- 0 - 2256 m a.s.l.



HIRHAM

- 55 km × 55 km
- 0 - 1281 m a.s.l





Empirical adjustment of dynamically downscaled precipitation and temperature values

- RegClim HIRHAM results were downscaled to meteorological station sites using a method which preserves the frequency of precipitation and temperature events as predicted by the climate models, aiming at reproducing observed monthly means and standard deviations for the control period (Engen-Skaugen, 2005)
- HIRHAM model was run with ERA-15 data at the boundaries of the model domain
- Cubic spline interpolation to meteorological station sites
- Correction of data in order to preserve monthly mean values
- Residuals for corrected monthly RCM results
- Modify standard deviation for RCM simulations for control period
- Determine new precipitation and temperature values based on RCM residuals for the control period
- Modify standard deviation for RCM simulations for scenario period under the assumption that the monthly RCM error of variability is the same as for the control period
- Determine new precipitation and temperature values for the scenario period based on RCM residuals for the scenario period



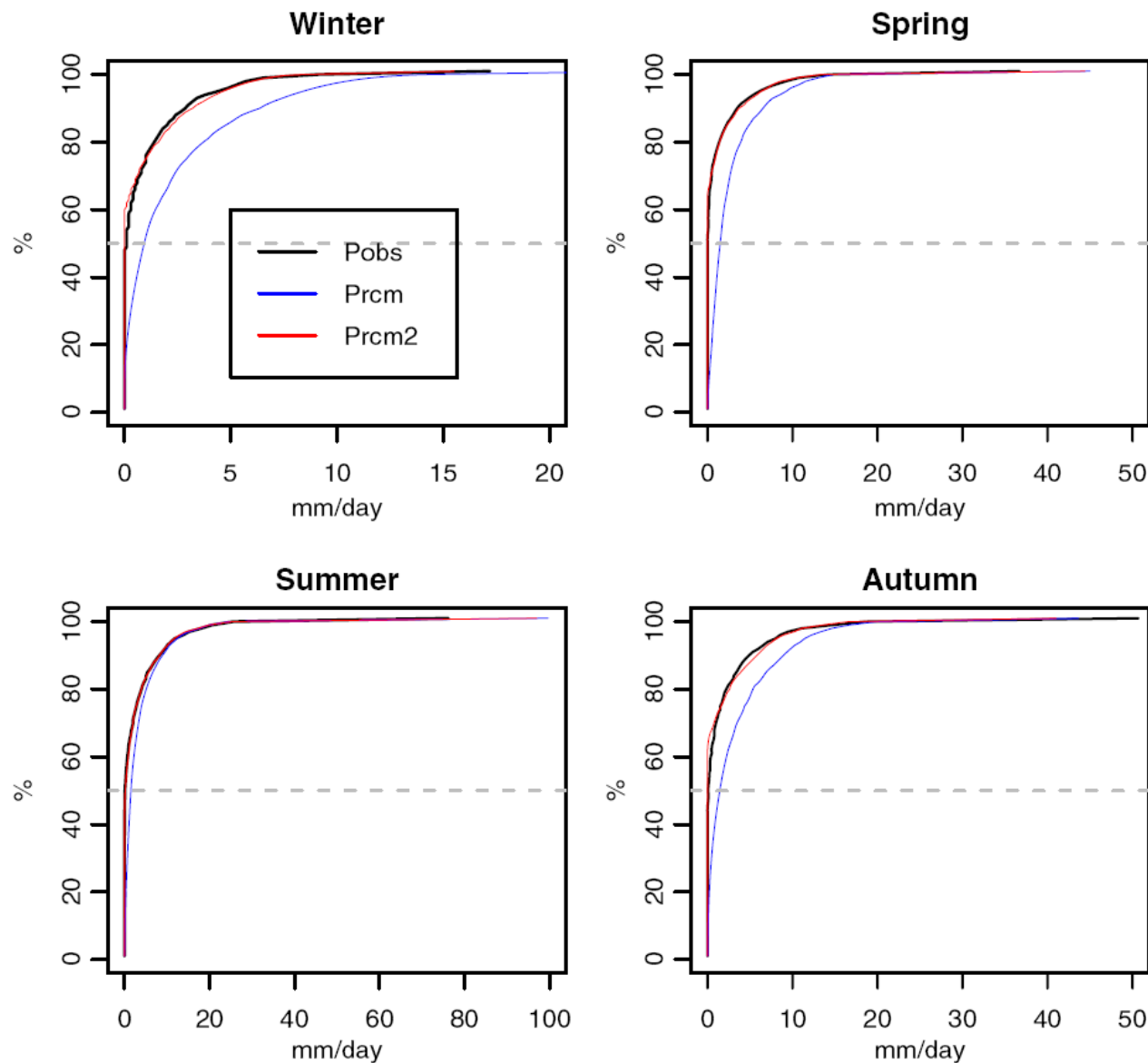
Delta change approach

- Changes in meteorological variables between the control and the scenario simulations from the regional climate model are being transferred to the observed meteorological data:
- Monthly precipitation and temperature changes
 - $P_{\text{scen,year,month,day}} = P_{\text{obs,year,month,day}} \cdot P_{\text{RCM,month,scen}} / P_{\text{RCM,month,ctrl}}$
 - $T_{\text{scen,year,month,day}} = T_{\text{obs,year,month,day}} + T_{\text{RCM,month,scen}} - T_{\text{RCM,month,ctrl}}$
 - Delta change factors are based on monthly mean values for the entire control and scenario periods
- This can be referred to as the delta change approach, and is a common method of transferring the signal of climate change from regional climate models to hydrological models.



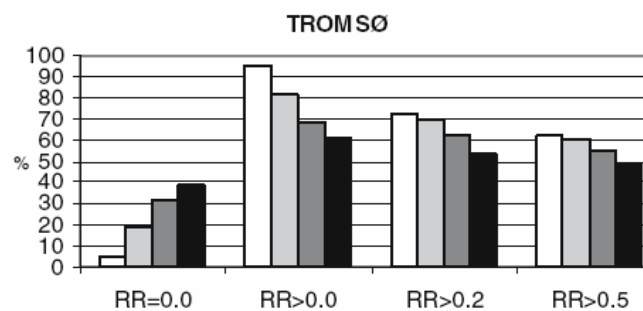
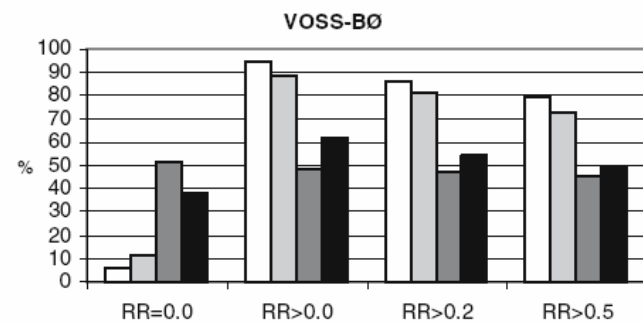
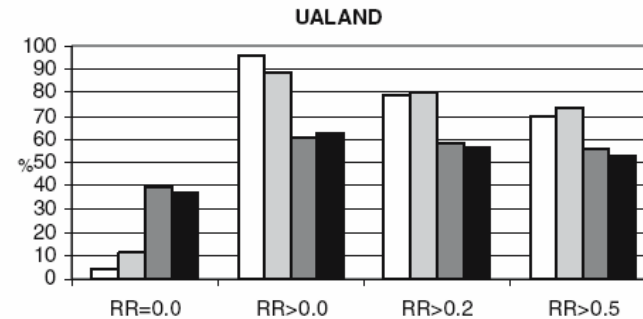
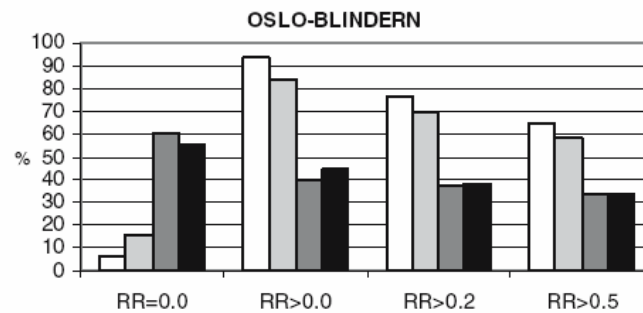
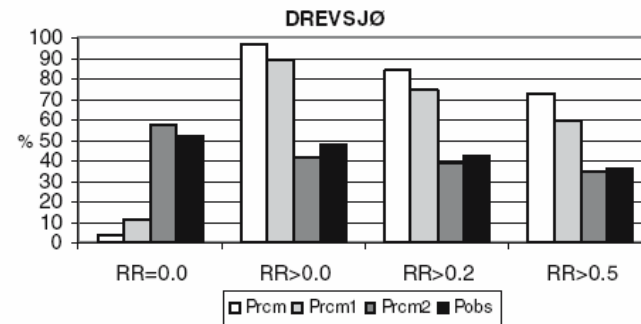


Cumulative distribution functions of observed (Pobs), simulated with the RCM (Prcm) and adjusted simulated with the RCM (Prcm2) daily precipitation at met. station 700 Drevsjø for control period



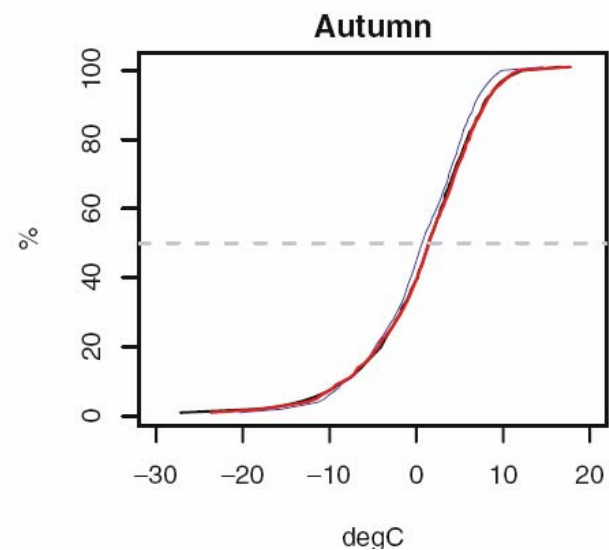
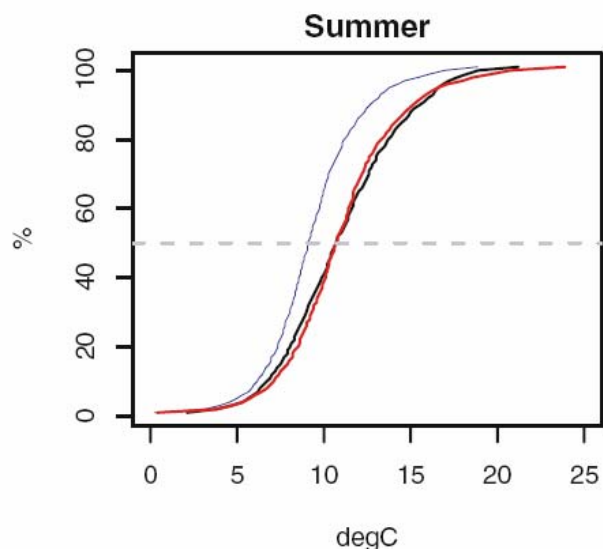
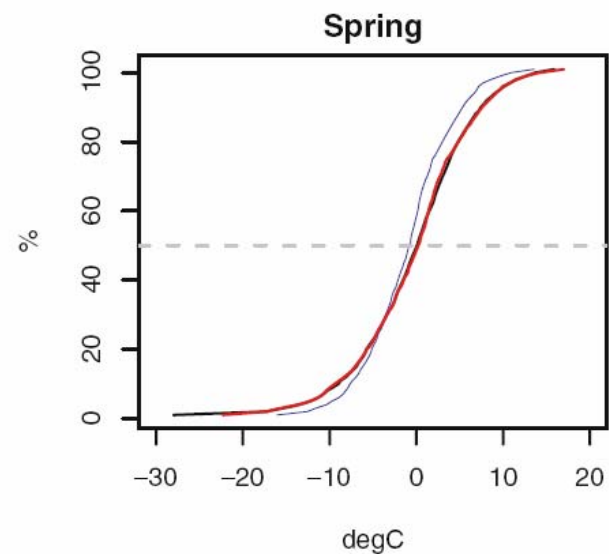
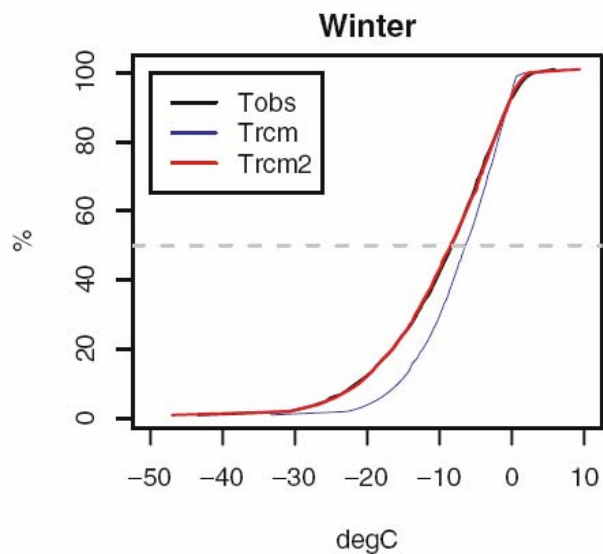


Number of days with precipitation >0.0 mm, >0.2 mm, >0.5 mm and number of days without precipitation ($= 0.0$ mm) interpolated from the RCM (Prcm), adjustment of monthly mean values (Prcm1), adjustment of monthly standard deviations (Prcm2), and observed (Pobs) for the control period



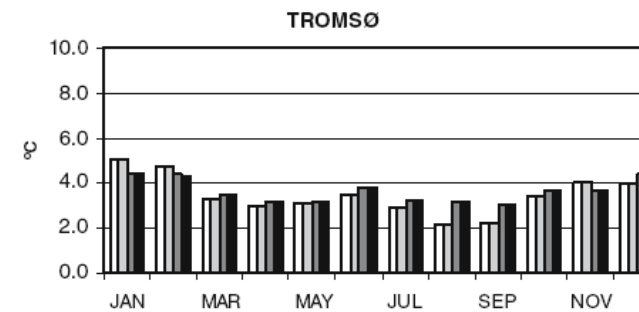
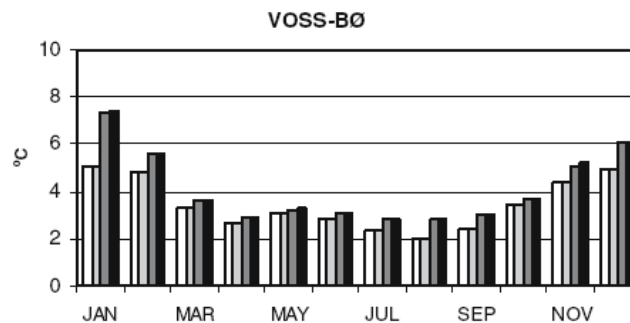
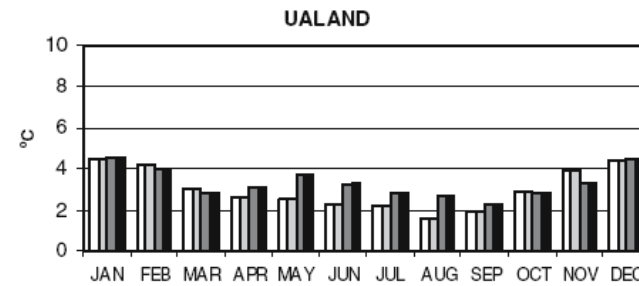
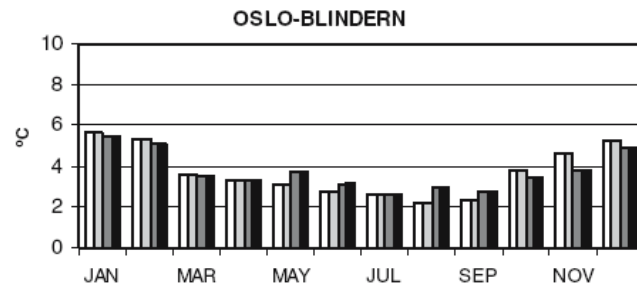
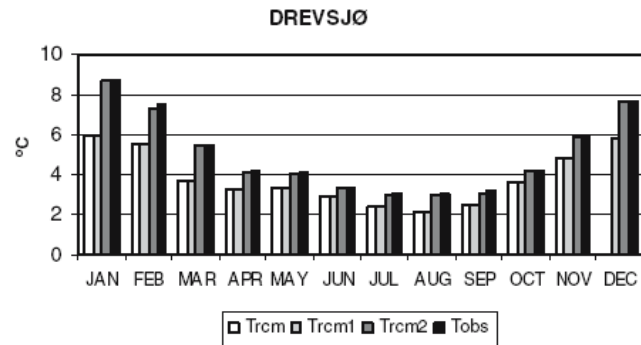


Cumulative distribution functions of observed (Tobs), simulated with the RCM (Trcm) and adjusted simulated with the RCM (Trcm2) daily temperature at met. station 700 Drevsjø for control period





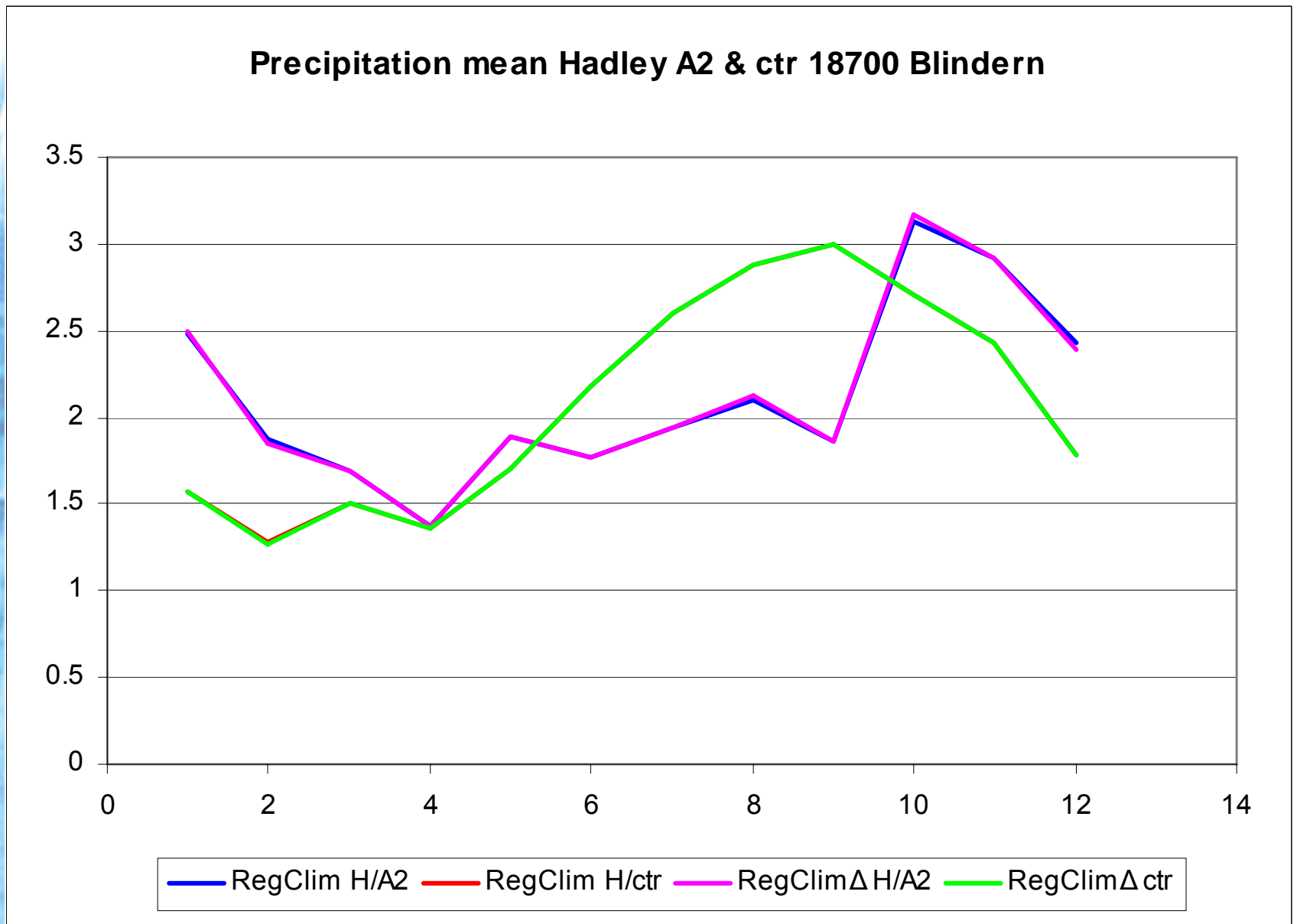
Standard deviations based on daily temperature values interpolated from RCM (Trcm), adjustment of monthly mean values (Trcm1), adjustment of monthly standard deviations (Trcm2), and observed (Tobs) for the control period





Mean values of daily precipitation for each calendar month

Meteorological station Blindern

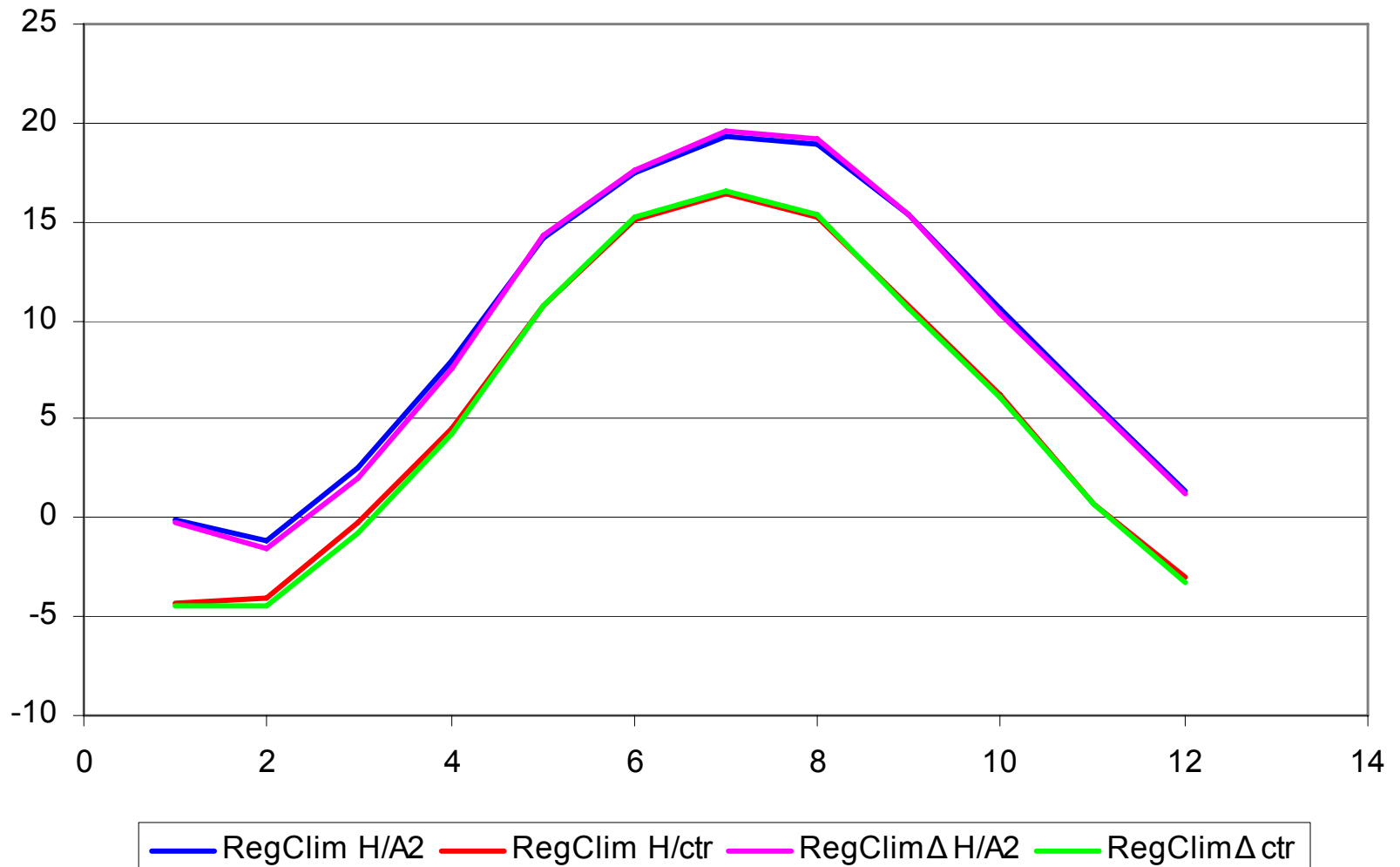




Mean values of daily temperature for each calendar month

Meteorological station Blindern

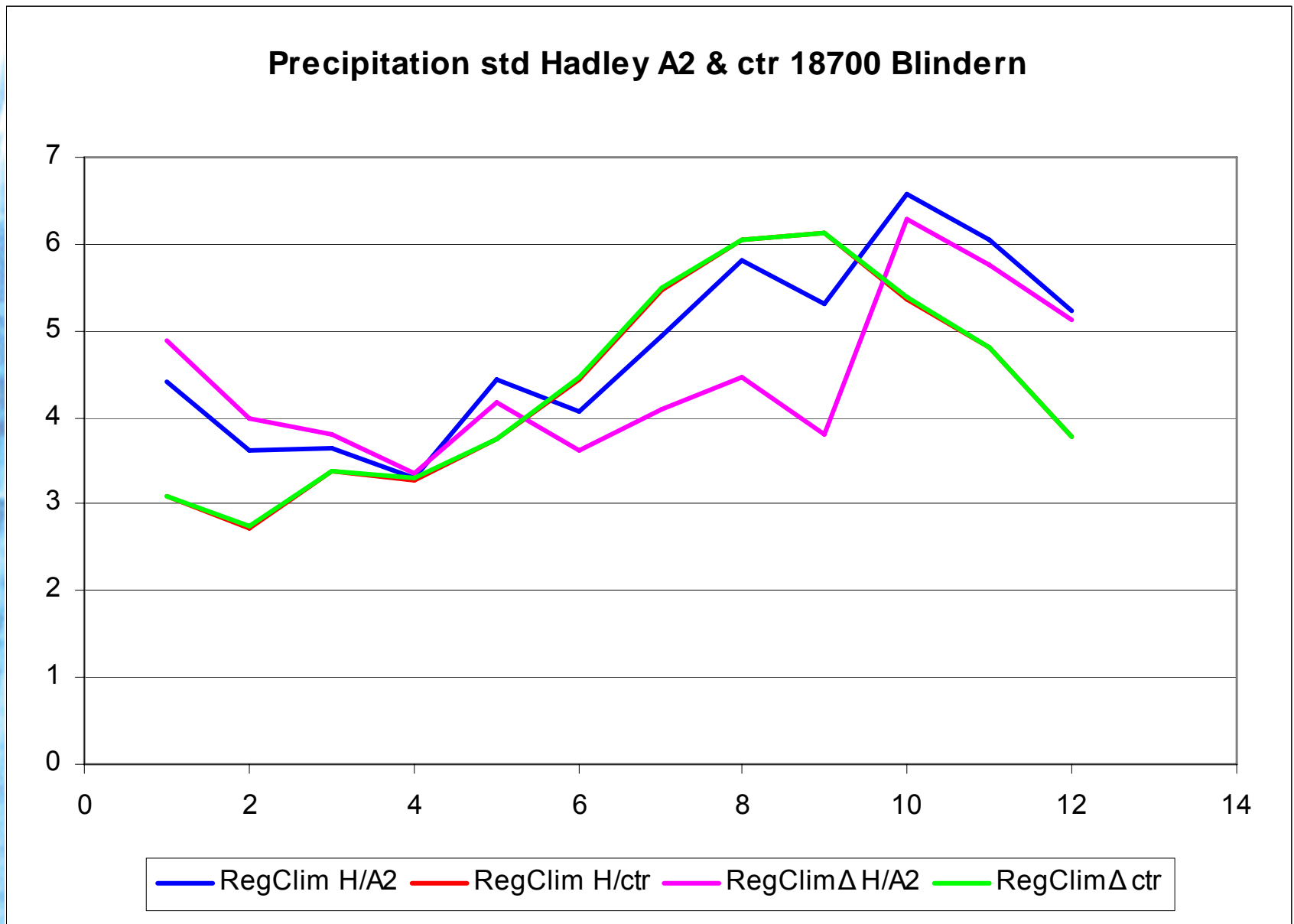
Temperature mean Hadley A2 & ctr 18700 Blindern





Standard deviation of daily precipitation for each calendar month

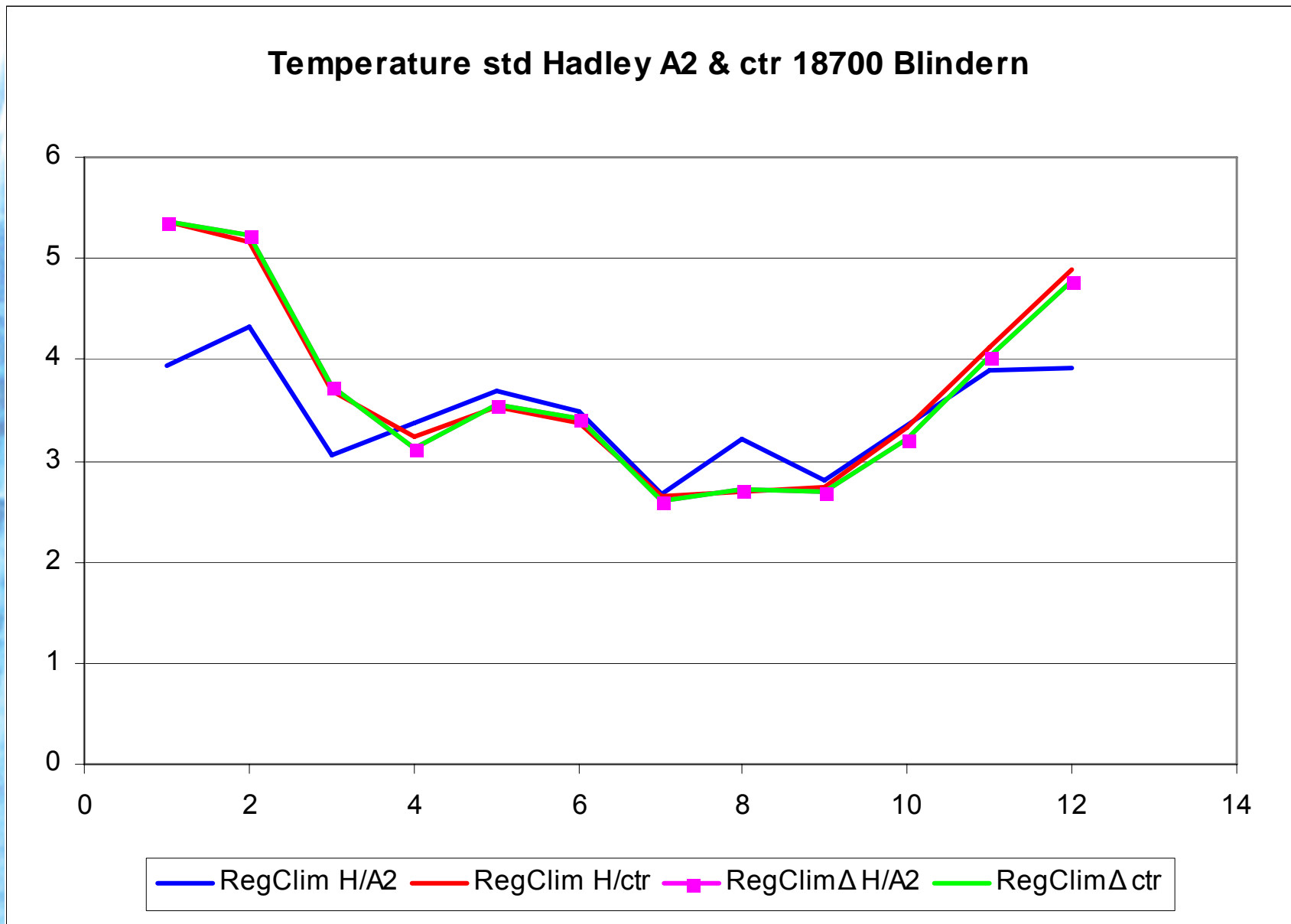
Meteorological station Blindern





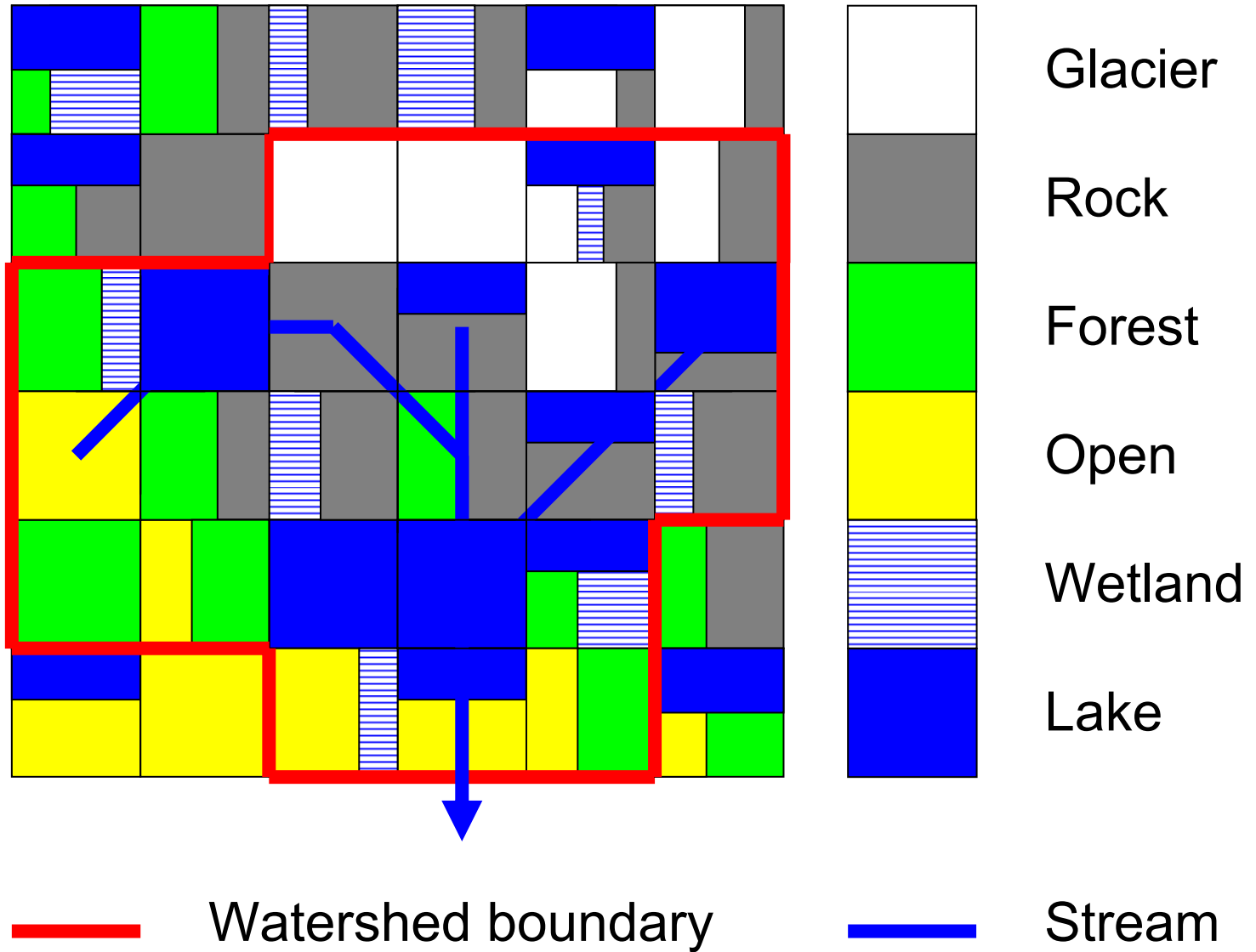
Standard deviation of daily temperature for each calendar month

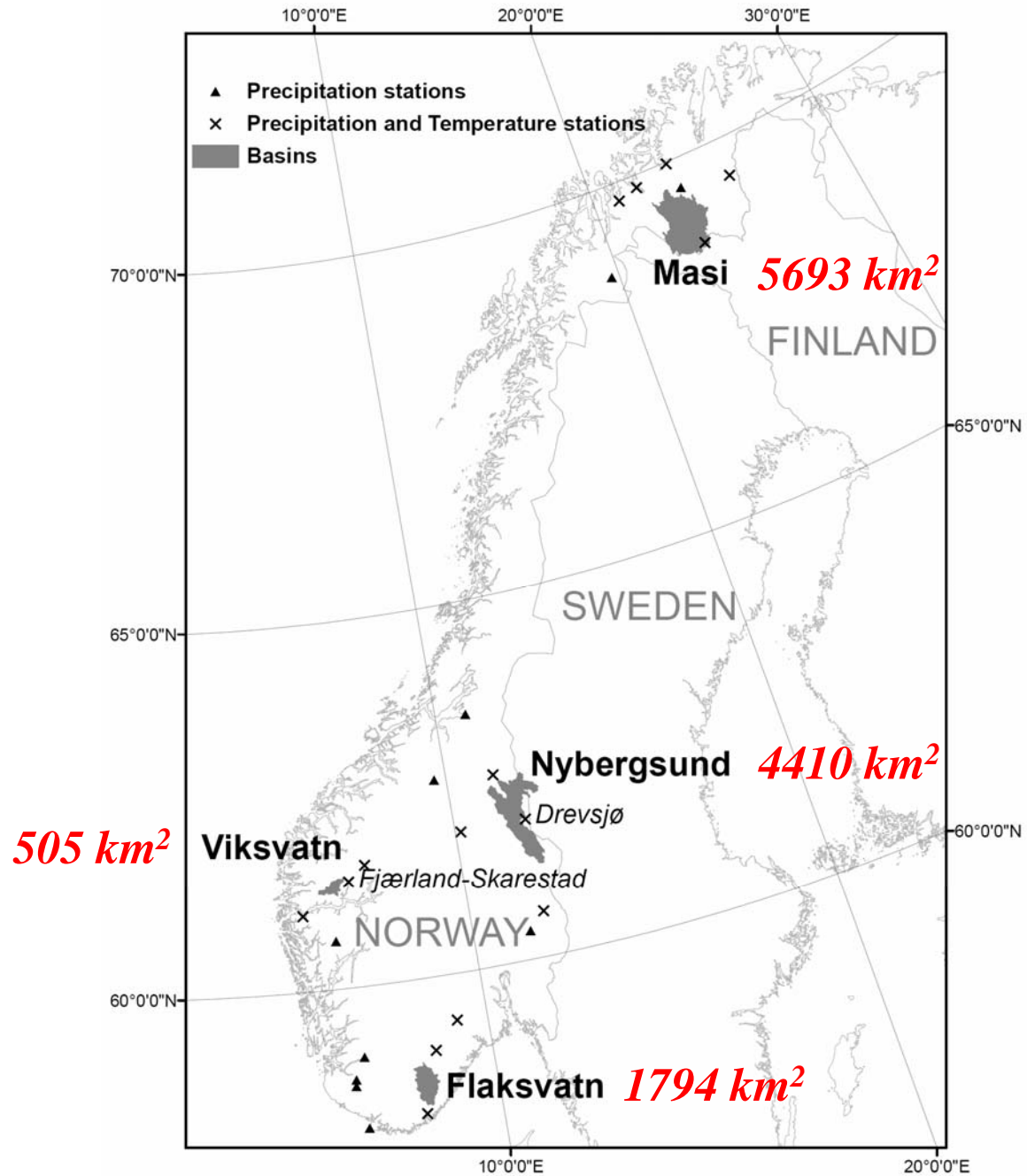
Meteorological station Blindern

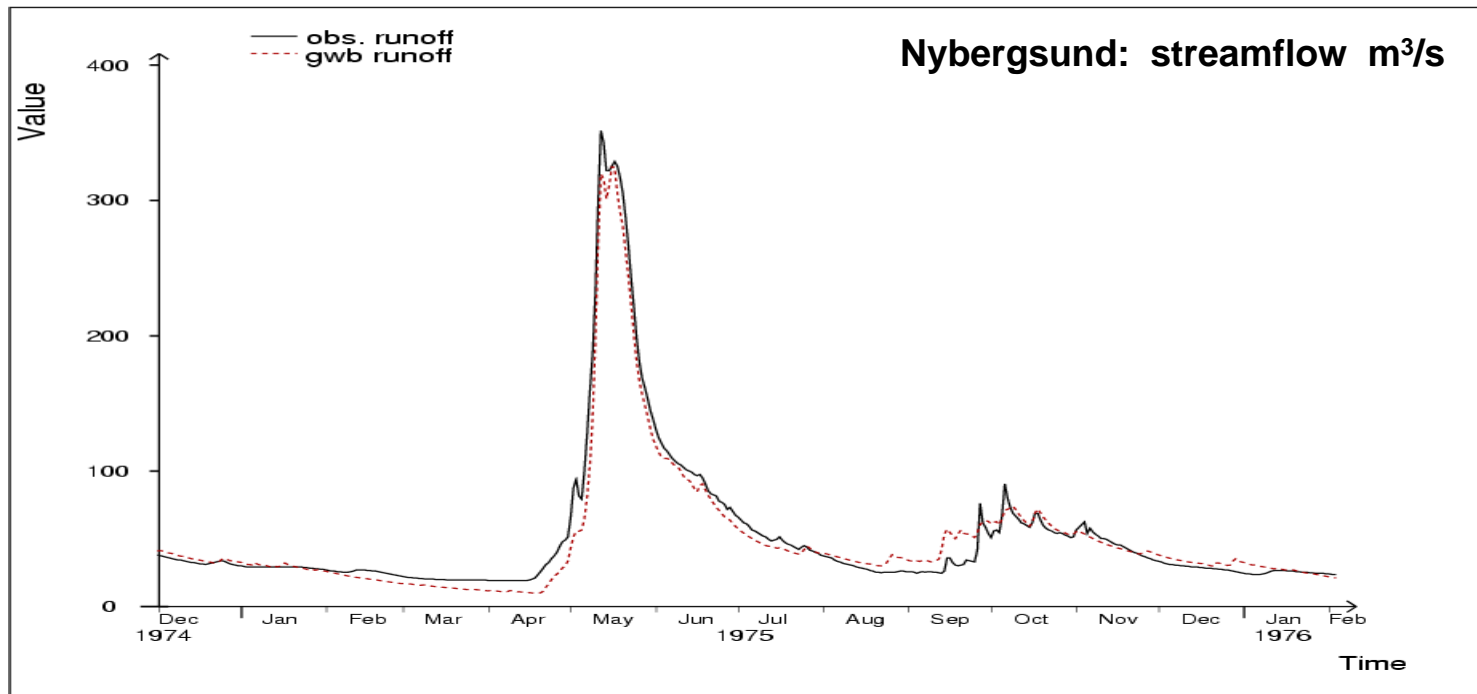
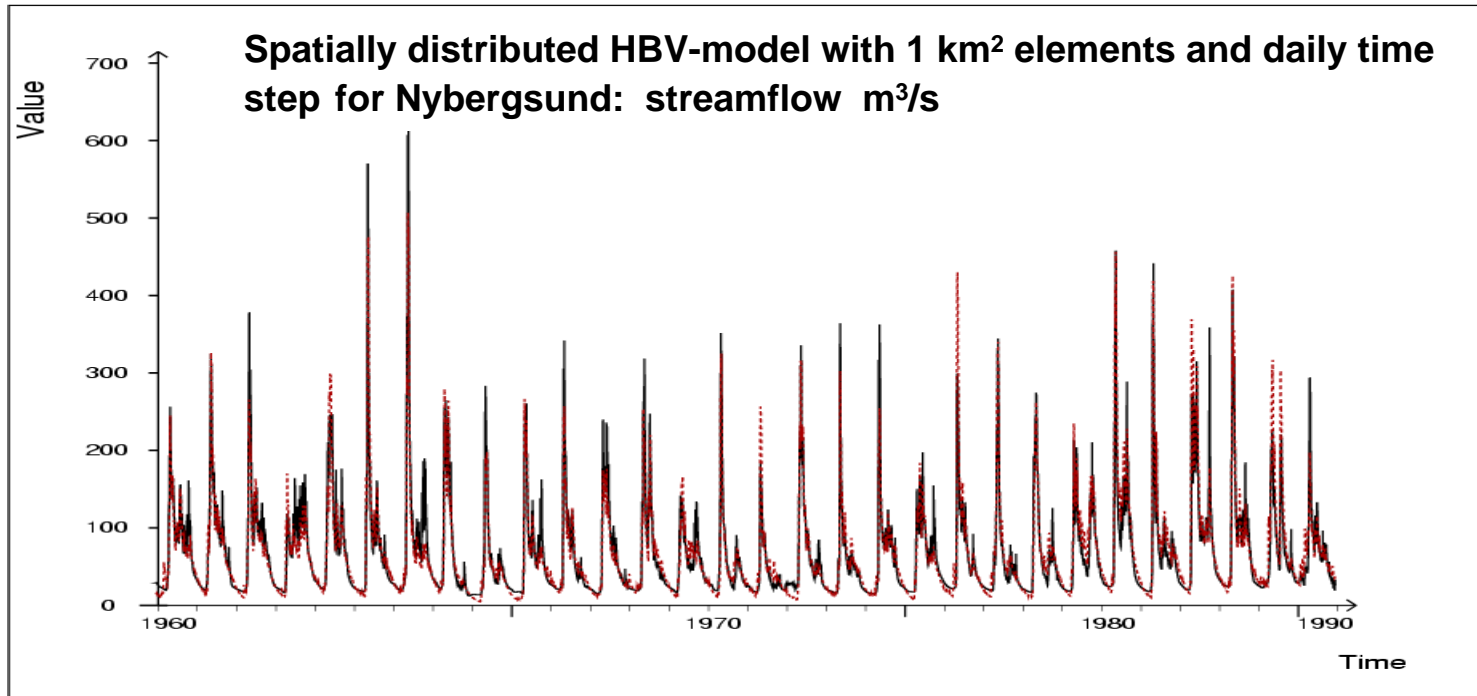


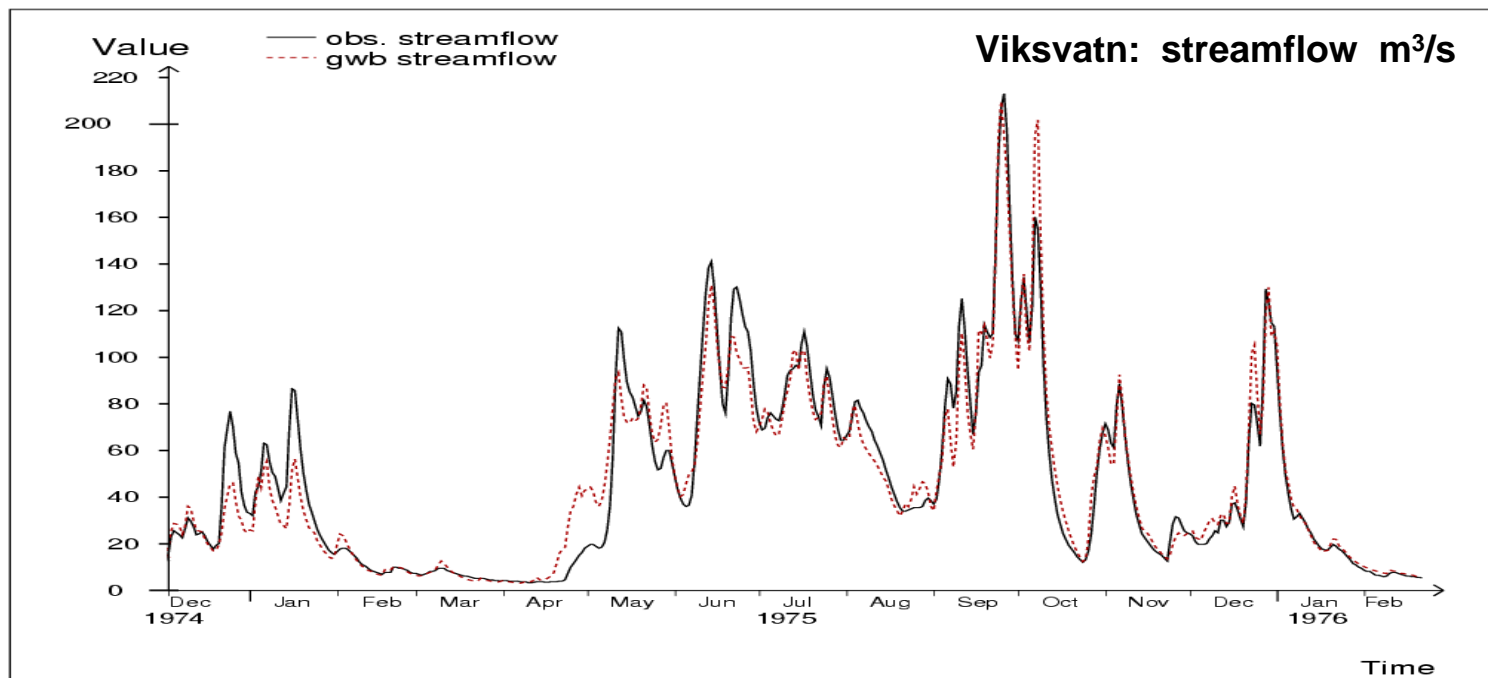
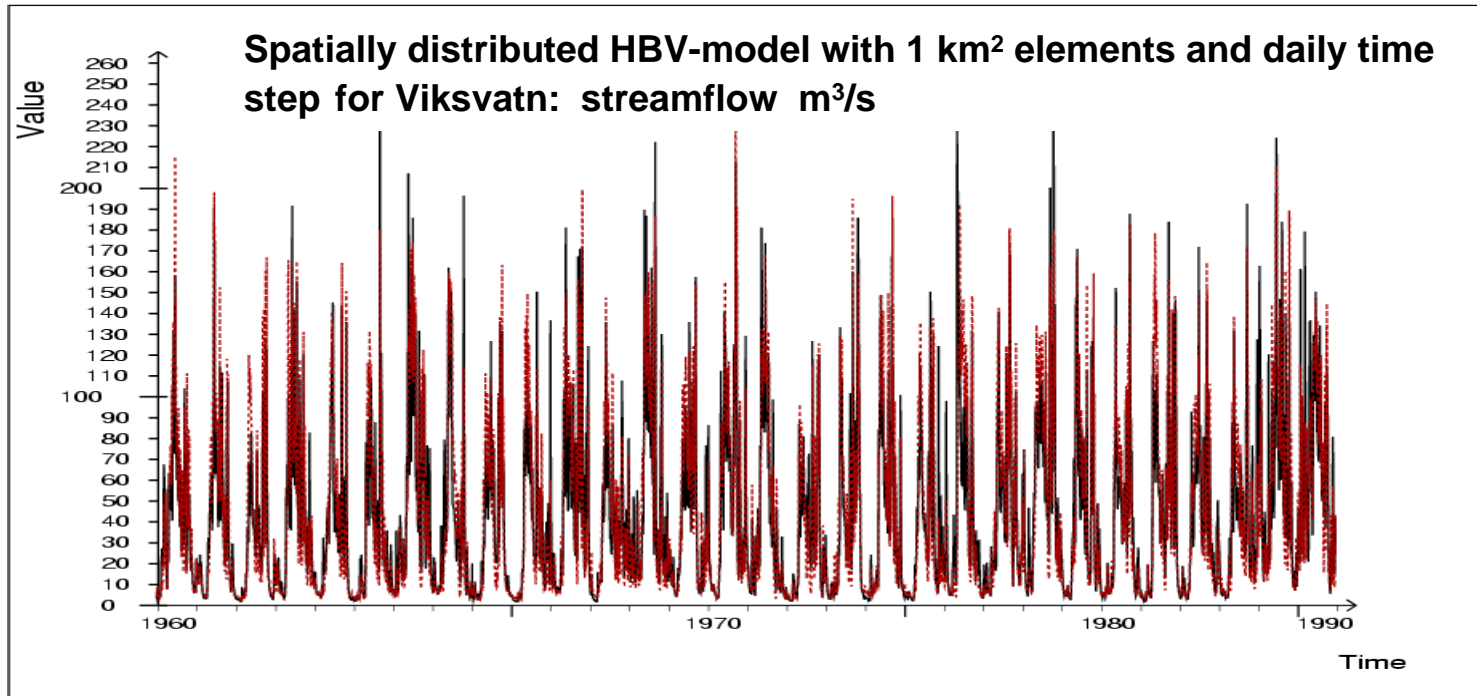


Spatially distributed hydrological response units – HBV model



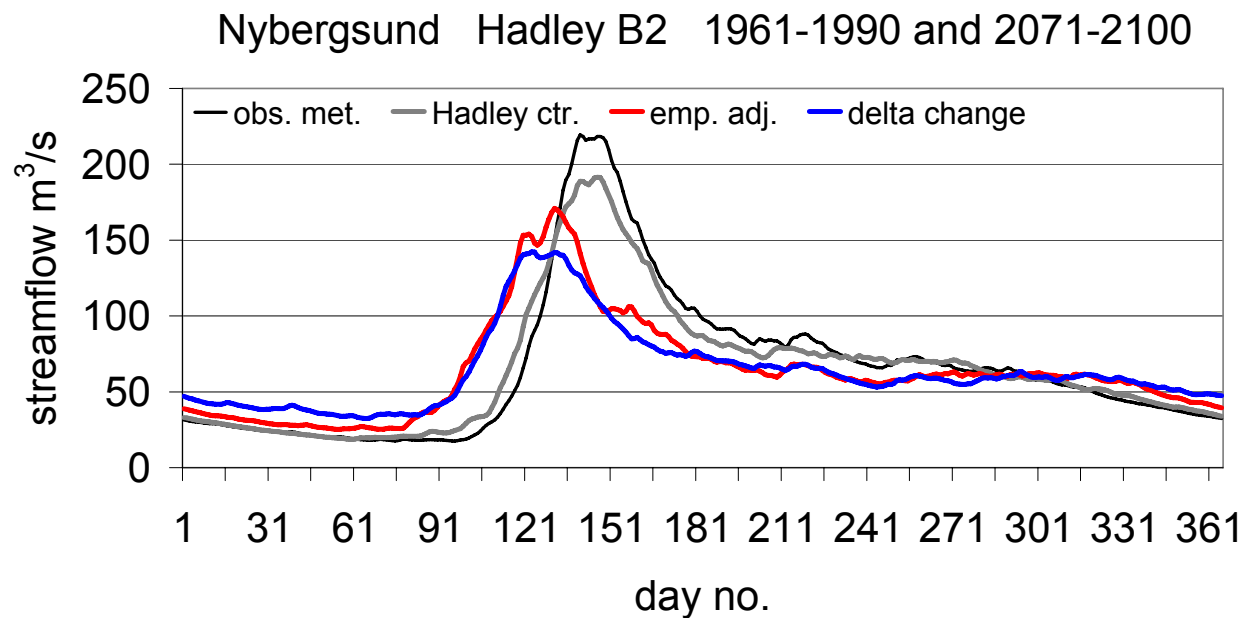
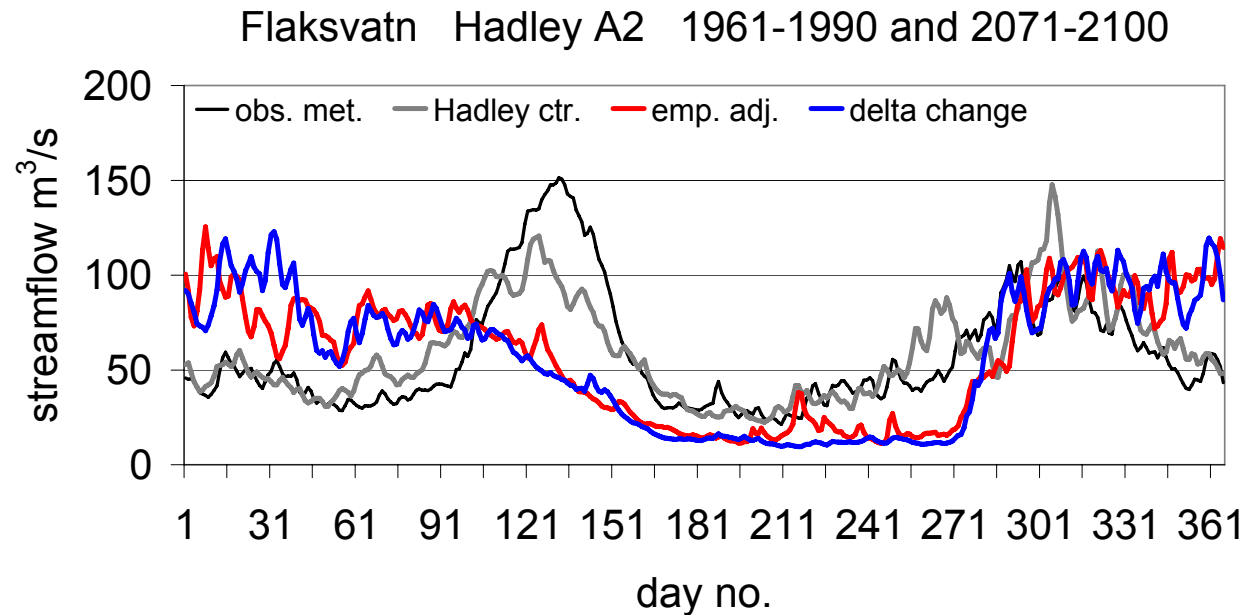






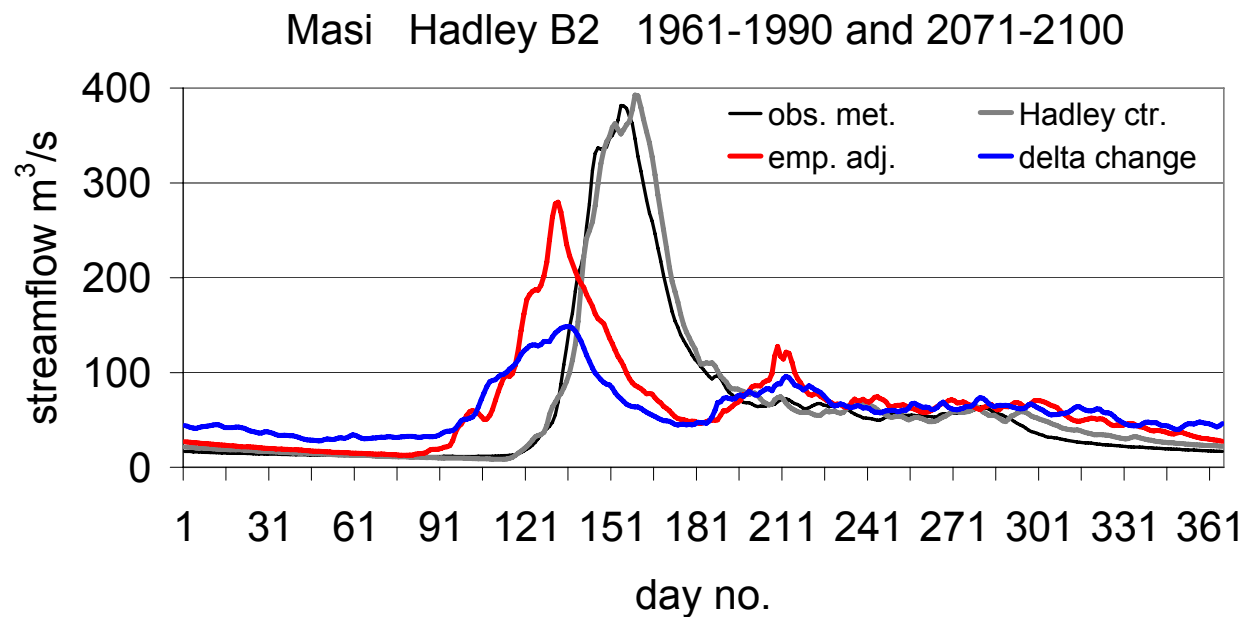
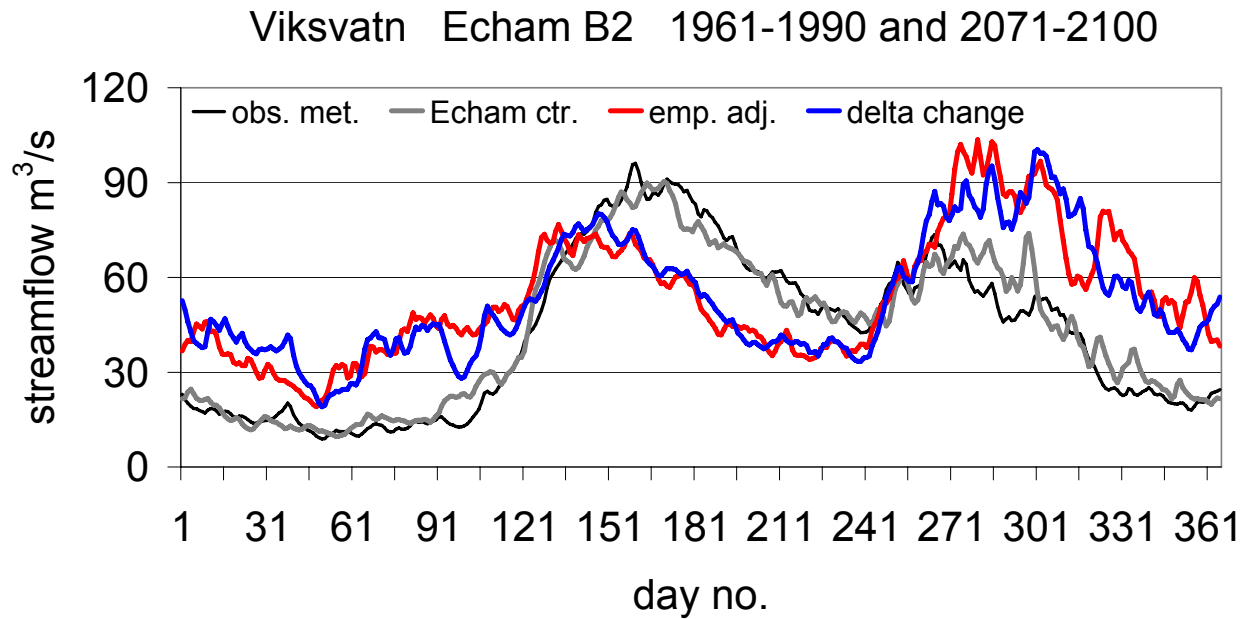


Mean daily streamflow for 1961-1990 and projected mean daily streamflow for 2071-2100



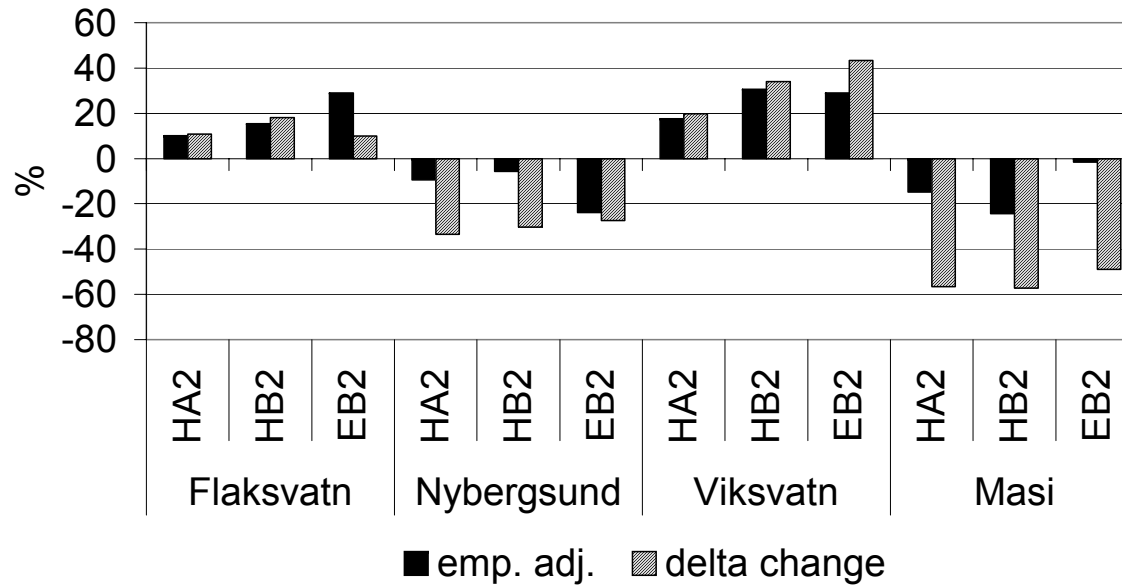


Mean daily streamflow for 1961-1990 and projected mean daily streamflow for 2071-2100

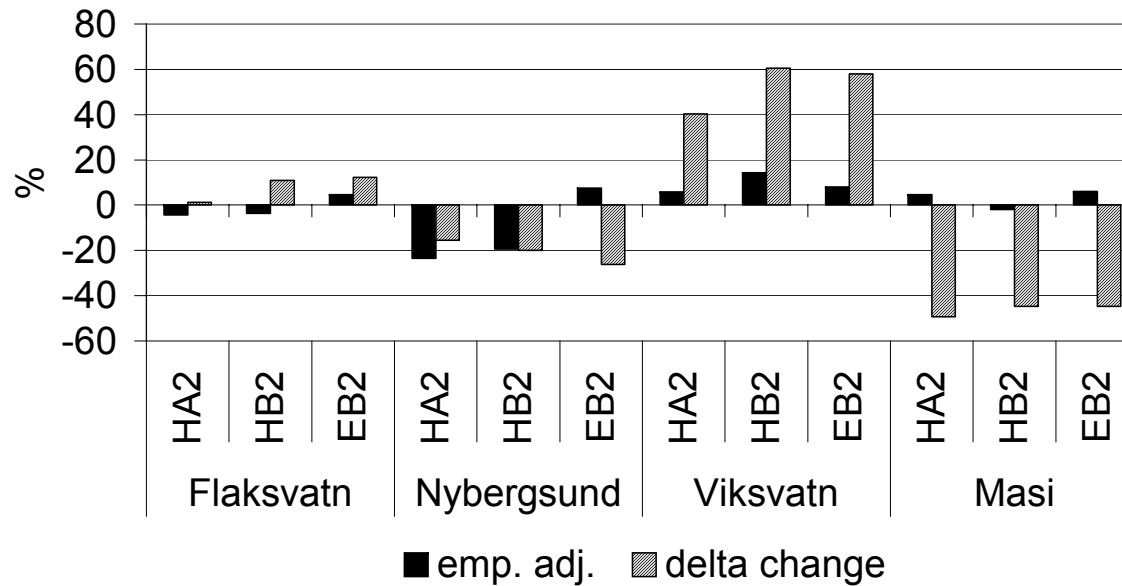




Percentage change in mean annual flood
from 1961-1990 to 2071-2100

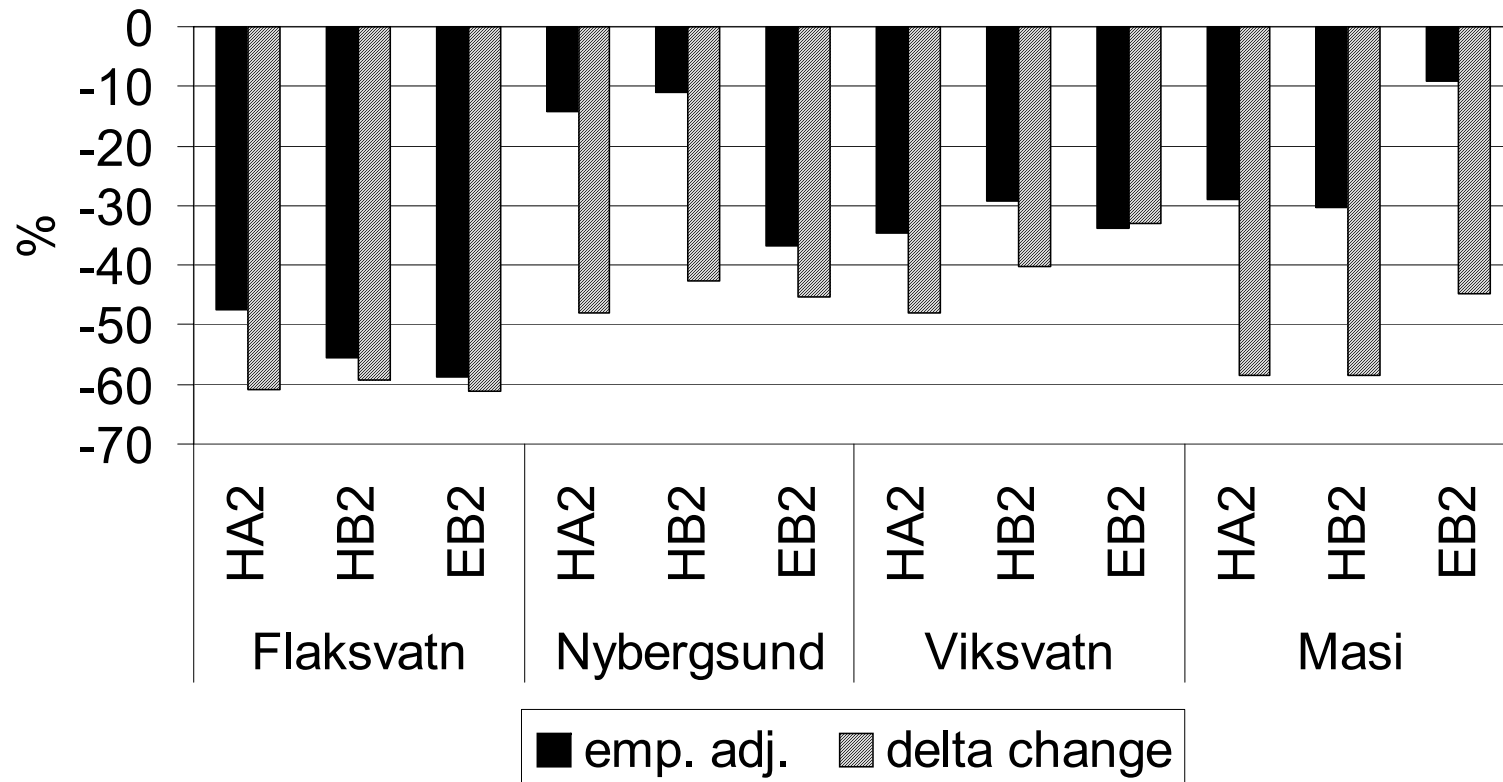


Percentage change in 50-year flood
from 1961-1990 to 2071-2100





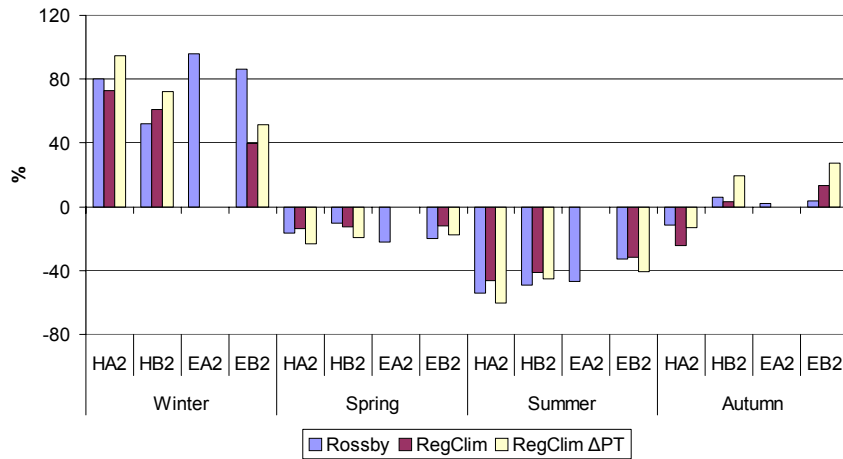
Percentage change in mean annual maximum snow storage from 1961-1990 to 2071-2100



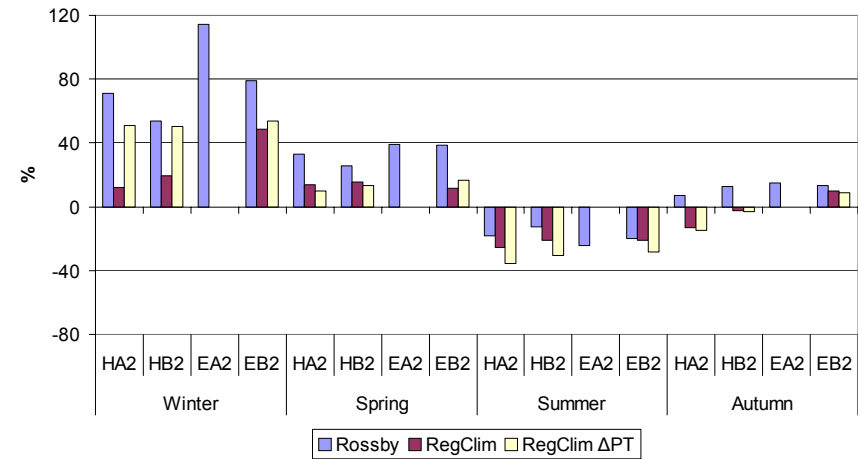


Projected percentage change in seasonal streamflow from 1961-1990 to 2071-2100 based on RCMs Rossby Centre RCAO and RegClim HIRHAM

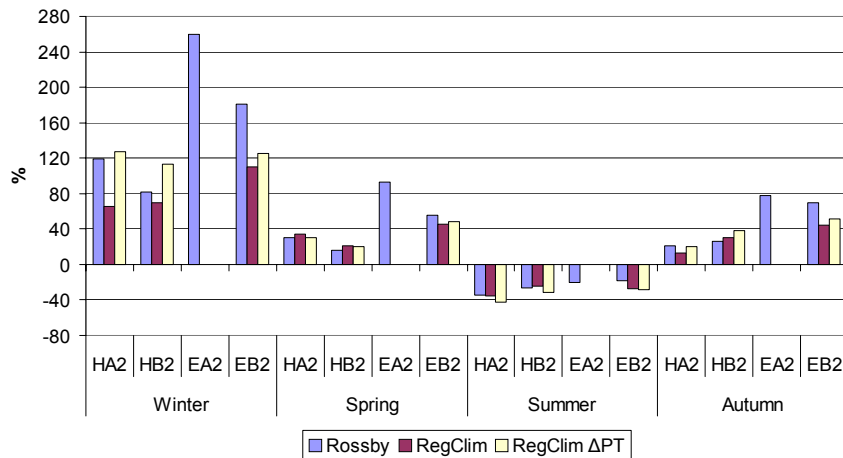
Percentage change in streamflow for Flaksvatn



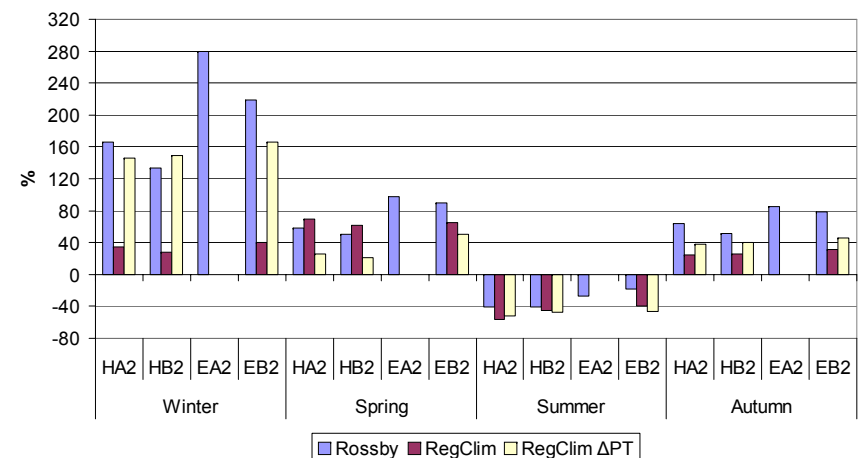
Percentage change in streamflow for Nybergsund



Percentage change in streamflow for Viksvatn



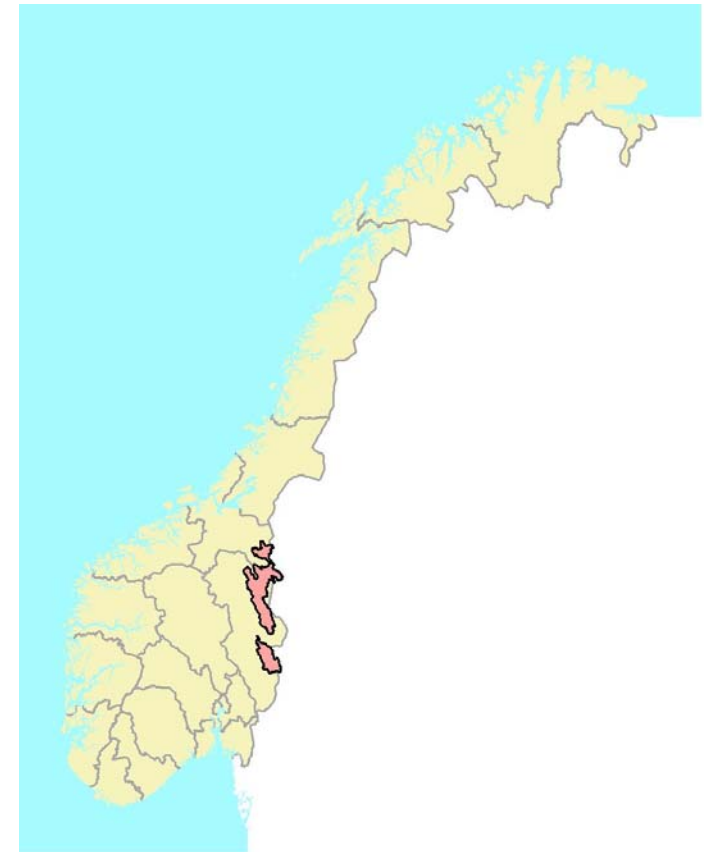
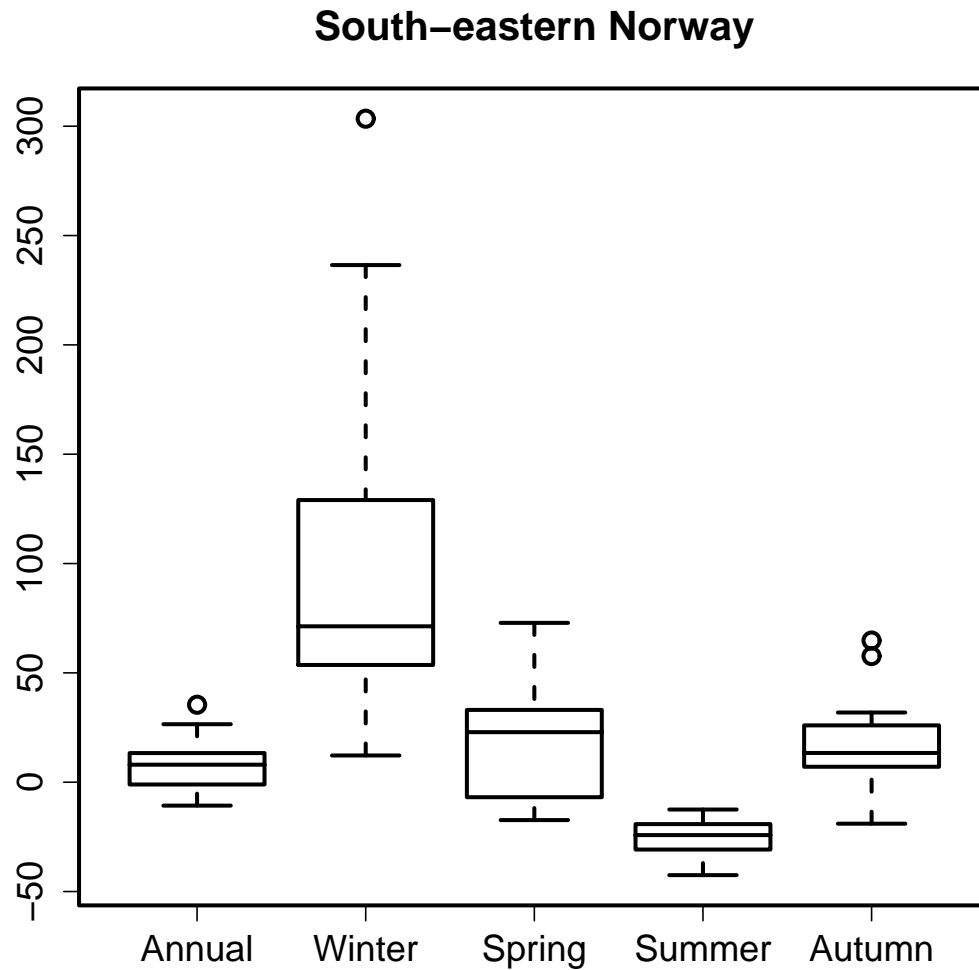
Percentage change in streamflow for Masi





Projected percentage change in seasonal streamflow from 1961-1990 to 2071-2100 for south-eastern Norway

The box shows the interquartile range (IQR:25-75 percentiles), the horizontal line gives the median value and the whiskers extend to the most extreme data points which are not more than $|1.5|$ times the interquartile range from the box

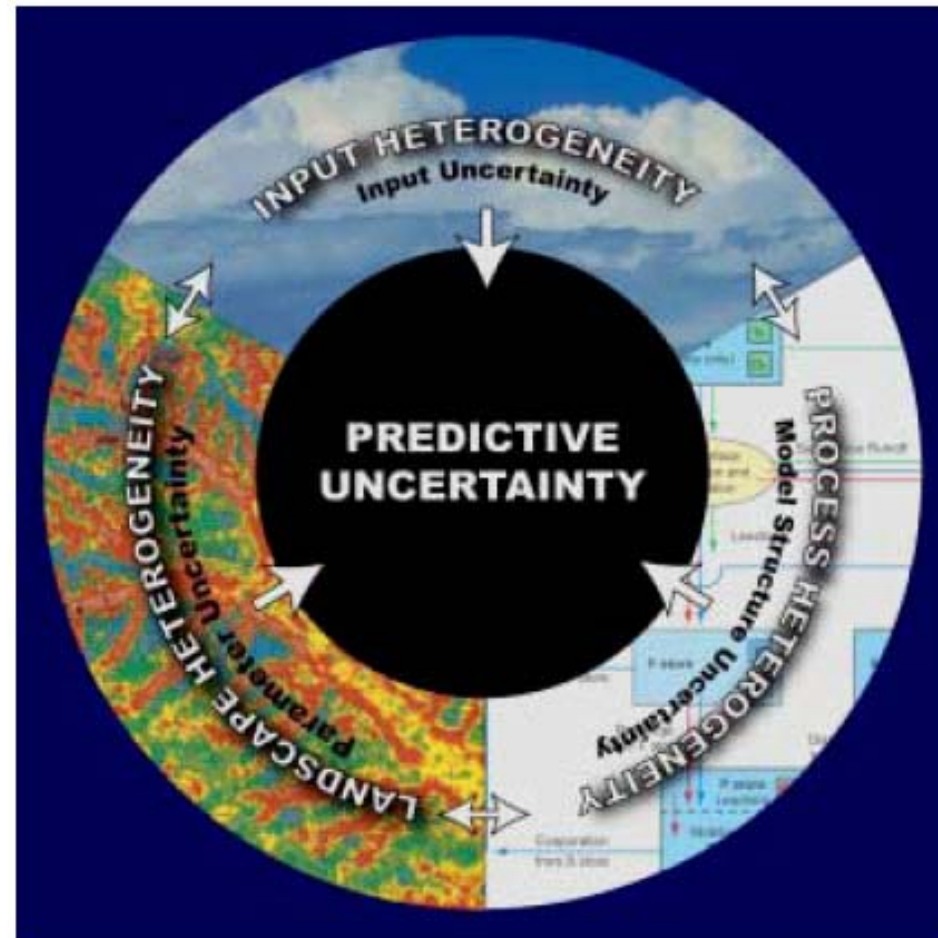




Hydrological models - Sources of uncertainty

Atmosphere

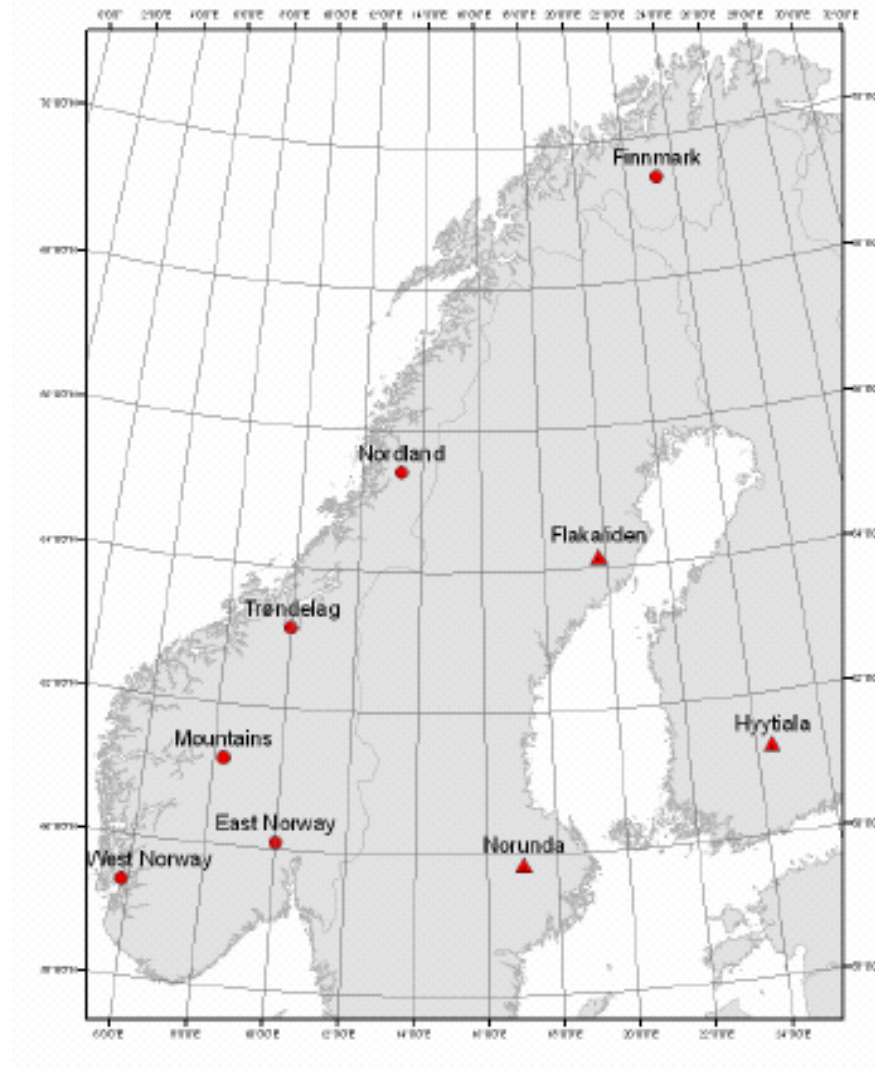
Land surface

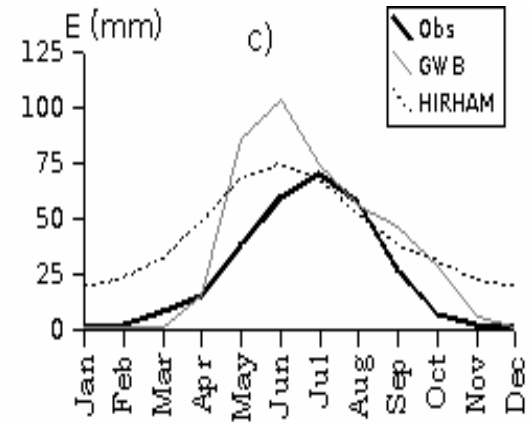
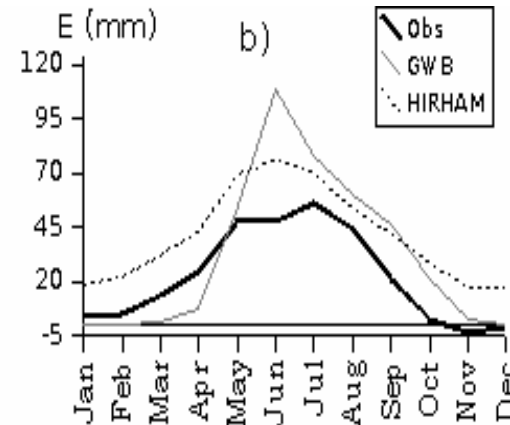
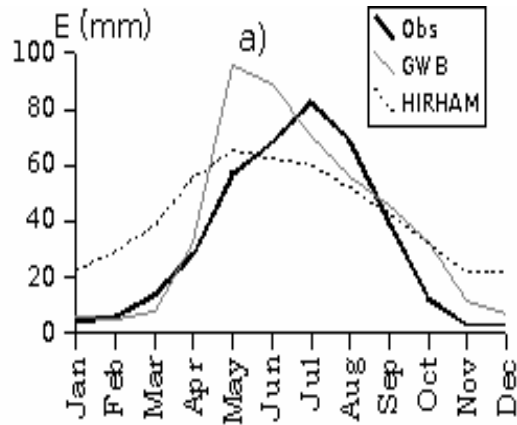


Hydrological model

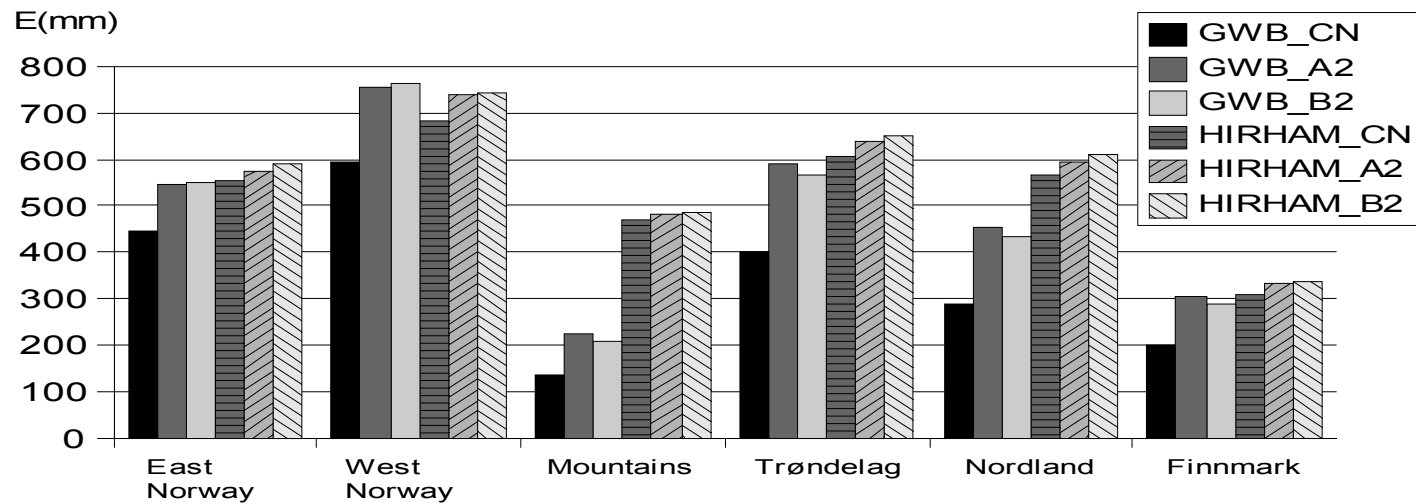


Sites used for comparing latent heat flux from the HIRHAM and HBV models





**Observed and simulated mean monthly latent heat flux for
a) Norunda (Sweden) b) Flakaliden (Sweden) c) Hyytiala (Finland)**



Mean annual latent heat flux for different regions in Norway

Source: Engeland et al. (2004)



Conclusions

- The empirical adjustment procedure improves the statistical moments mean and standard deviation for monthly values compared to the delta change approach
- The delta change method has the advantage that the control period climate is described by observed meteorological data, but it does not alter the frequency of precipitation and temperature events
- The delta change method provides better results for streamflow simulations for the control climate than the empirical adjustment procedure
- The empirical adjustment procedure does not capture the day to day variations of precipitation and temperature
- The empirical adjustment procedure does not preserve the consistency between atmospheric variables

