Comparing European Streamflow Trends: Observations and Multi-model Simulations

Kerstin Stahl [1,2], Lena M. Tallaksen [2], Jamie Hannaford [3], Henny A.J. van Lanen [4]

UiO : University of Oslo

Motivation

In Europe, an overall appraisal of hydrological changes in recent decades has been hindered by the paucity of readily-available runoff data. European assessments of hydrological change at the continental scale hence often rely on models.

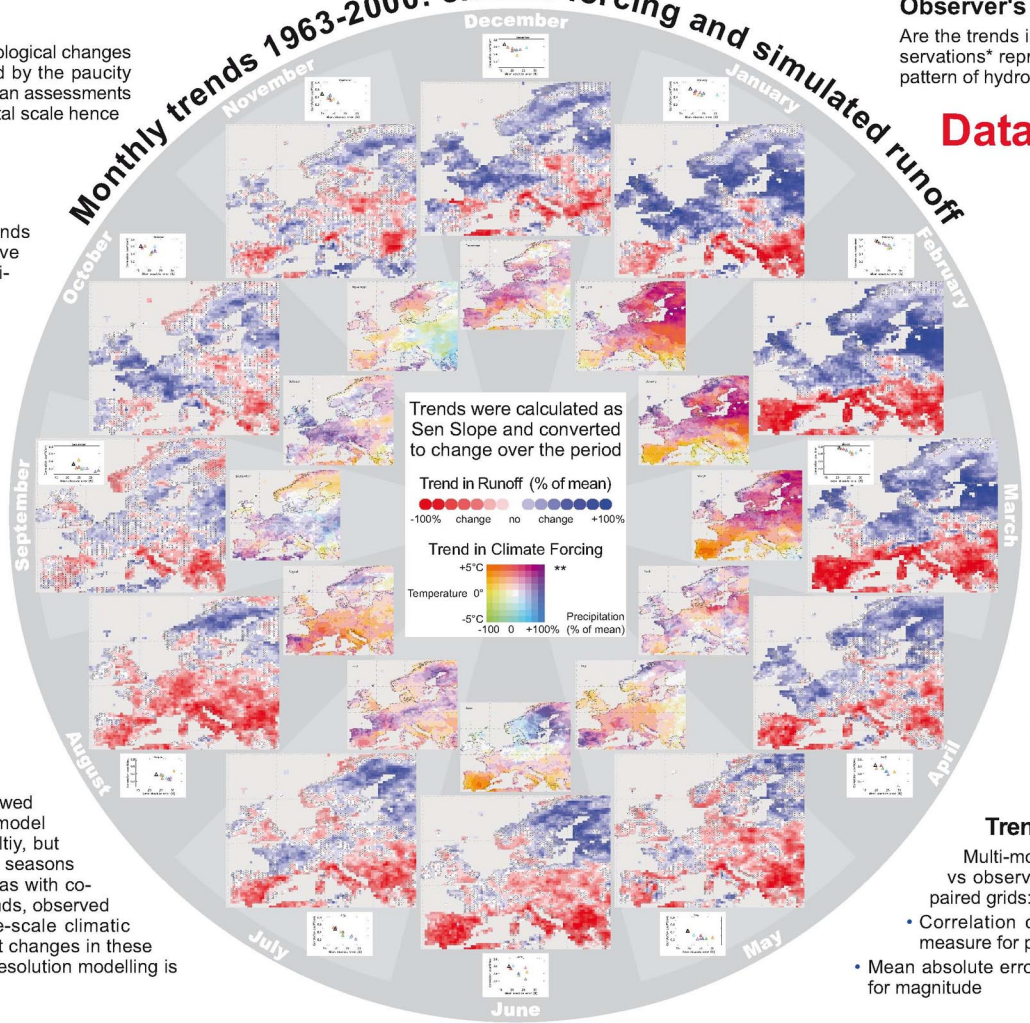
Results

A dipole pattern of positive runoff trends in the North & Northwest and negative runoff trends in the South & East dominates annual runoff and annual high flows. A similar pattern (though less coherent in the Northeast) dominates monthly runoff from Dec-April. Decreasing trends in the summer months peak in August and dominate summer low flow changes. Observed decreasing trends are underestimated by models.
The multi-model mean corresponds better than individual models' trends to trends in observations. Agreement of the sign of the trend in the eight different models is highest during winter in areas of strong postive precipitation trends and lowest in transition seasons and areas where trend direction changes over short distances. Modelled and observed trends agree least in the Alps and Scandinavia.

Conclusion

European runoff in recent decades showed strong and opposing trends. A multi-model ensemble can increase model reliabiltiy, but uncertainty in the transition zones and seasons is high. At the boundary between areas with coherent climatic wetting and drying trends, observed runoff trends can deviate from large-scale climatic trends. Hence, monitoring of transient changes in these critical regions and improved higher-resolution modelling is important for prediction and planning.

Monthly trends 1963-2000: climate forcing and simulated runoff



Observer's question

Are the trends in scattered streamflow observations* representative of a continental pattern of hydrological change?

Modeler's question

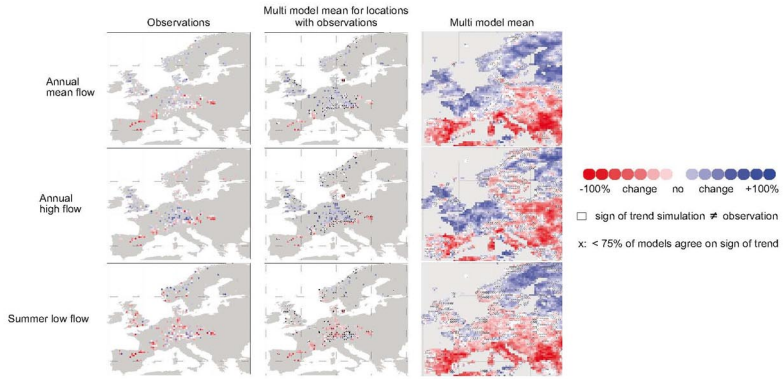
Are large-scale model simulations reliable enough to fill the white spaces on the map of observed trends and reveal the regional coherence or variability of hydrological change?

Data

EWA/WATCH observed streamflow from near-natural catchments:
- Catchments 10 - 2 000 km^2
- Model grid cells with observations: 293
- The largest catchment was used, where more than one occurred in a single grid cell.

WATCH Multi-model analysis of extremes data:
- Eight global hydrological models, naturalized runoff: GWAVA, HTESSEL, JULES, LPJmL, MATSIRO, MPI-HM, Orchidee, WaterGAP (Gudmundsson et al., 2011)
- Driven by WATCH forcing data (Weedon et al. 2010)
- Grid: 0.5 degrees (~ 2 500 km^2)
- Analysis for Europe

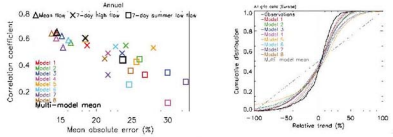
Annual, High, and Low Flow trends 1963-2000: observed and simulated runoff



Methods

Trend Validation

Multi-model mean trend vs observed trend in 293 paired grids:
- Correlation coefficient as a measure for pattern
- Mean absolute error as a measure for magnitude



Model Ensemble

Uncertainty:
- Trend maps indicating different trend direction in ≥ 6 out of 8 models
- Distribution of trends in observations and simulations from different models

(1) Institute of Hydrology, Albert-Ludwigs-University of Freiburg, DE
kerstin.stahl@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de
(2) Department of Geoscience, University of Oslo, NO
(3) Centre for Ecology and Hydrology, Wallingford, UK
(4) Centre for Water and Climate, Wageningen University, NL

* Referring to: Stahl et al. 2010. Streamflow trends in Europe: evidence from a dataset of near-natural catchments. Hydrology and Earth System Sciences 14: 2367-2382.
** Method from: Teuling R. et al., 2011. Bivariate colour maps for visualizing climate data. International Journal of Climatology 31: 1408–1412.
Weedon G. et al. 2011. Creation of the WATCH forcing data and its use to assess global and regional reference crop evaporation over land during the twentieth century. J. Hydrometeorol., 12: 823–848.
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