Hydrological drought characteristics in catchments: to what extent are they reproduced by regional climate models?

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HYDROLOGY

Background

Land surface schemes and large-scale hydrological models have been compared mostly with observed streamflow records from large basins that aggregate small-scale hydrological variability.

However, high-resolution regional climate model output is now becoming more readily available and hence more likely to be used and interpreted at smaller scales, relevant for example for hydrological process studies and catchment scale drought management. This poster explores the potential limits for such use.

Objective

To compare observed characteristics of hydrological drought in small basins (mostly <1000 km^2) across Europe with those from flow-constituting variables of the WATCH high-resolution reanalysis for Europe.

Specific questions

Do events occur simultaneously in space and time?

Are the relative severities of the dry extremes comparable?

exceedance percentiles

P100 (dry) P50 (median) P0 (wet)

Data

	Observed Streamflow	RCM Modelled Runoff
Origin	Gauged records from small undisturbed basins	'Poor Man's Reanalysis' over Europe: dynamical downscaling with the RCM nested into ERA40 re-analysis
Source	European Water Archive (UNESCO IHP – FRIEND programme)	Performed with HIRHAM5 (DMI) for the EU-WATCH project (*Berg and Christensen, 2008*)
Spatial extent	Western and Central Europe	Europe
Resolution	>700 records	0.12 degrees (13km) resolution
Time period	1962-2004 (with many longer records)	1960-2005
Resolution	Daily means	Hourly, Daily means

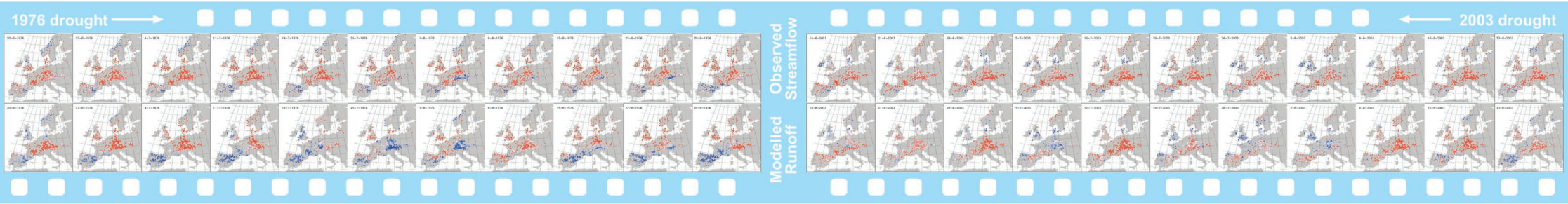
Data Transformation

- Extraction of corresponding daily time series of discharge and runoff: to each gauging station, the nearest model grid cell was assigned and time series of the RCM variables 'runoff' and 'drainage' were extracted and added for each time step.
- Seven-day backward smoothing of all series
- Transformation of time series into their daily exceedance percentiles with respect to the day-of-year: e.g. all n Jan1st values are ranked (M) and transformed into the exceedance probability P=(n+1-M)/(n+1)*100, the same was done for all Jan2nd values, etc..

Methods

Comparison of daily exceedance probability of observed streamflow P_{obs}(t) and modelled runoff P_{sim}(t):

- Mapping of daily P_{obs} and P_{sim} during droughts
- Spatial correlation - analysis in time
- Correlation of time series - analysis in space
  - time series of percentiles
  - monthly average percentiles
  - annual maxima (dry extremes over 30 days)
  - correspondence of drought (P_{obs} and P_{sim} >90)



Mapping

Daily snap-shots

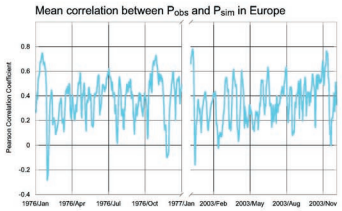
Known major European Droughts are reproduced.

Observed streamflow percentiles are more spatially variable than modelled percentiles.

1976 drought: delayed onset of modelled drought in some areas of western Europe and inter-ruption and early termination in July.

2003 drought: stronger and more persistent drought in observed streamflow percentile.

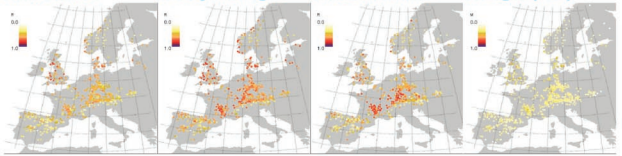
Space - Correlation



Correlations of P_{obs} and P_{sim} vary strongly. There is no obvious seasonal impact, but wetting periods are generally higher correlated than drying periods.

Time - Correlation

Time series | 30-day averages | Annual Maxima | Drought (P90)

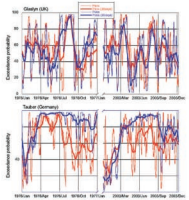


- Correlation generally increases with averaging interval
- High correlations of daily series for UK, S-coast Norway, Denmark, France
- Weak correlations for Mountain Regions, Spain*
- Annual Maxima correlate best in France and southern Germany
- Drought correspondence (P > 90) is generally low

*problem with reanalysis data, as wrong soil type was used for South

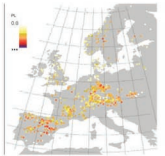
Discussion

Co-variability of percentiles for two basins:



First test to estimate persistence lack of grid cell percentile compared to small-basin streamflow percentile. Further tests should include soil information used for simulation, catchment area, elevation, etc.

While monthly fluctuations in UK river are well simulated by grid cell runoff and drainage,the more persistent drought signal of the Tauber is not captured.



Conclusions

- For some regions and some small river basins, percentiles of RCM grid cell runoff and drainage are reasonably correlated with basin outflow.
- Further work should attribute the generally noted lack of persistence of dry spells in the simulations. They may be a result of low model soil water storage or may be due to comparison for example with larger basins.
- Regional differences in the comparability of RCM simulated hydrological drought with observations from catchments may allow to classify the relative importance of competing influences of climatic drivers and local catchment storage on drought and low flows.

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