Hydropredict Wien 2012

Quantifying uncertainty in large-scale hydrological model inputs

– At what scale can we make predictions?

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What is Large-Scale Hydrological Modelling (to us)?

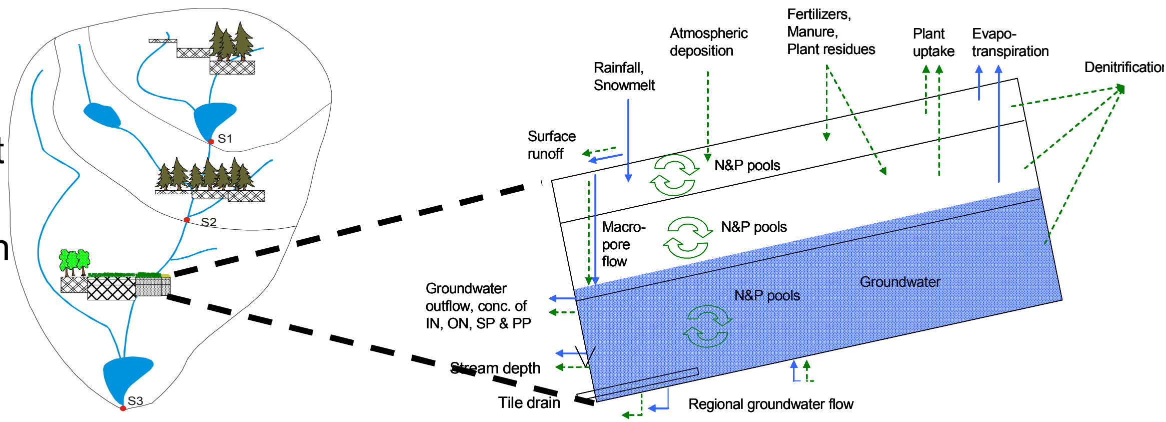
- Large domain, generally multi-basin (e.g. global, continental, national models)
- Too many catchments for individual checks of input data
- Too many catchments for calibration to individual rivers
- Accept lesser model performance locally to optimise the model's performance simultaneously across the whole domain

Why?

- Deliver continent wide assessments, all discharges to a sea, clim change, flood frequency, drought frequency etc..
- Transboundary rivers are treated homogenously
- All rivers within a region (e.g. a country) are treated homogenously
- Useful for PUB – gives an estimate of uncertainty

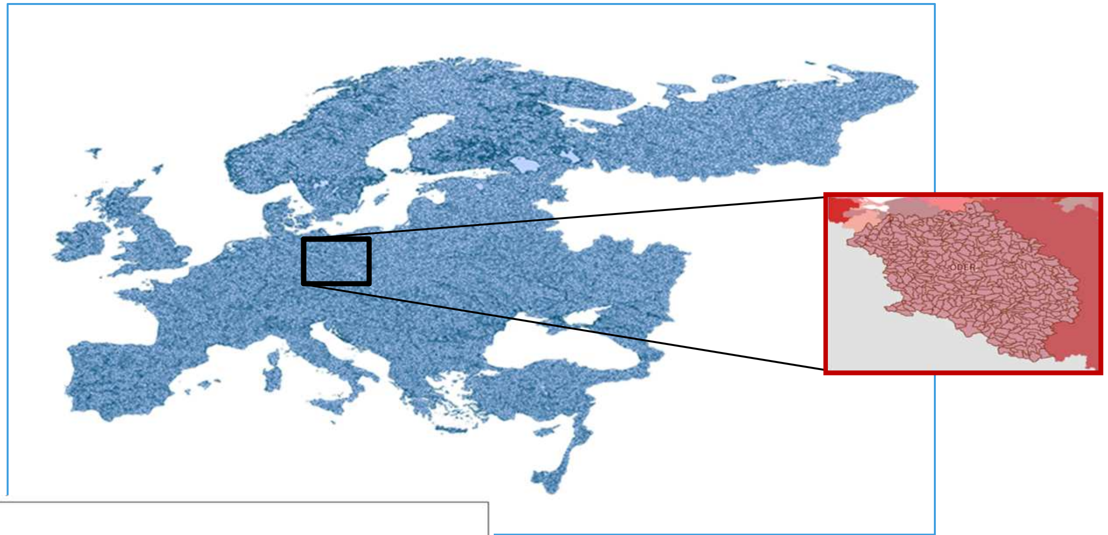
HYPE model: ***Hy****drological* ***P****redictions for the* ***E****nvironment:*

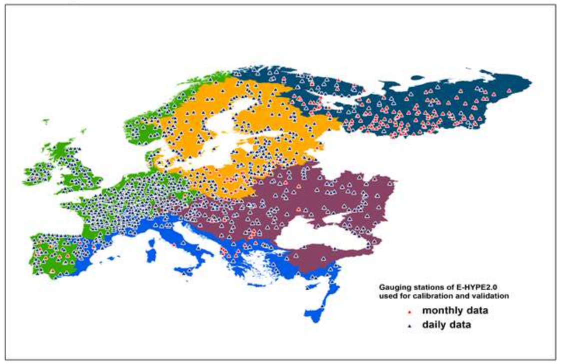
- Developed 2003 to 2008 at SMHI, following on from the very successful HBV concept
- Processes can be landuse or soil-type dependent
- Simulates routing, lake processes and simplified regulation, simplified crop water user and irrigation routine
- Water and Nutrients
- Can be set up for large domains at relatively high resolution using readily available databases for input data



- E-Hype (Europe, Q)
- Balt-HYPE (Baltic Sea basin, Q, N & P)
- S-HYPE (Sweden, Q, N & P)
- Arctic-HYPE (Arctic, Q)
- LPB-HYPE (La Plata Basin, Q)
- MENA-HYPE (Middle East, Northern Africa, Q)
- Niger-HYPE (Niger River, Q)

E-HYPE – pan European HYPE application





- 35000 subbasins
- Median size 215 km^2
- V2.0 delivers Q variables
- V2.1 to deliver WQ (N&P also)
- Used in many FP7 projects
- Used for hindcasting, operational forecasting and future climate predictions
- Under constant development

>1000 stations for calibration/validation
- Selected from GRDC, EWA and Baltex
- Allows for validation of catchment sizes from 200 km^2 to 800 000 km^2 - natural & affected flows

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What is important for large-scale models?

Increasing Effect on Model Performance

- **Deliniation and linking of watersheds from continental DEMs/l**

- **Getting correct precipitation from continental scale grid**

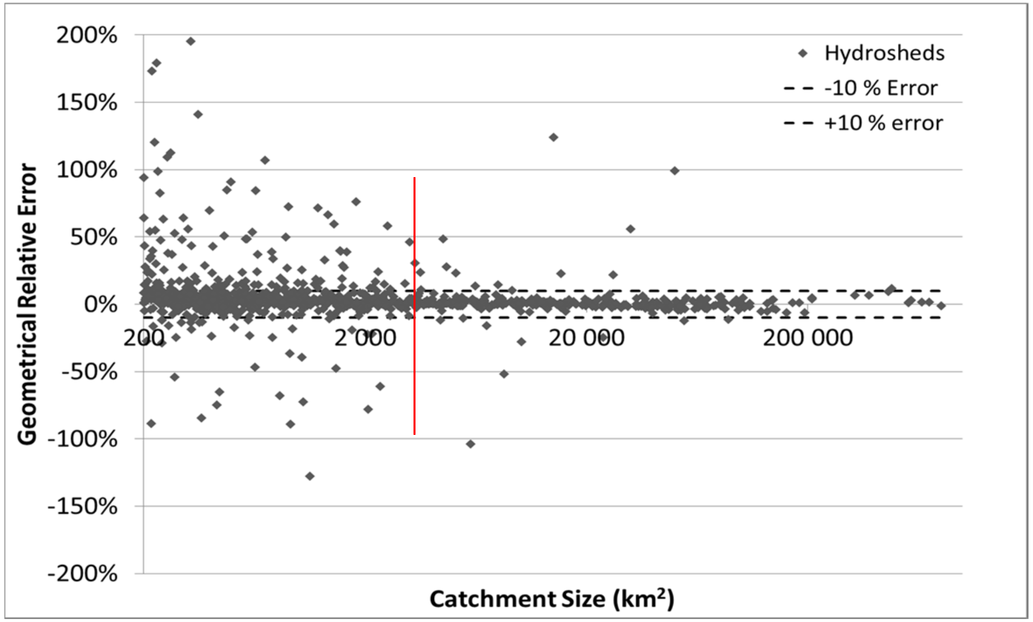
- **Extractions: Irrigation, TWS and Industrial** Local!
- **Groundwater losses** Local!

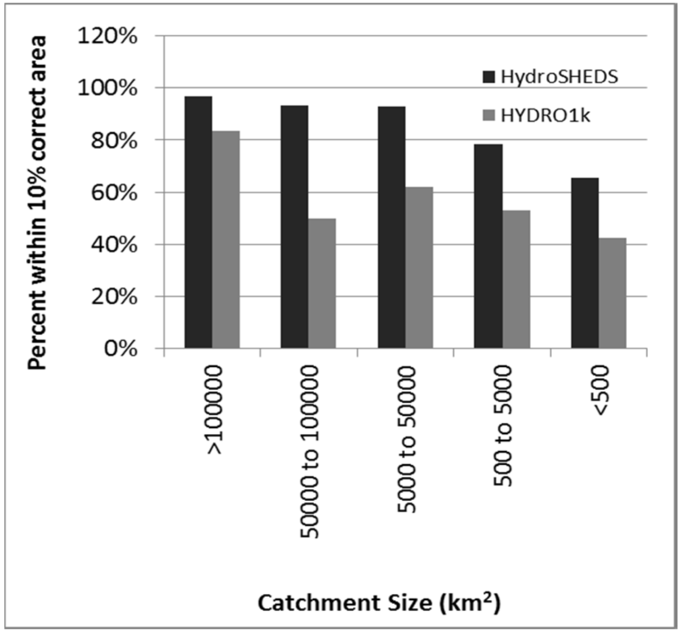
- **Lake/reservoir information (incl regulation)**

- **Calibration**

Delineation of Catchments

Error in catchment area derived from HydroSHEDS as compared to published area at 1007 stations in Europe

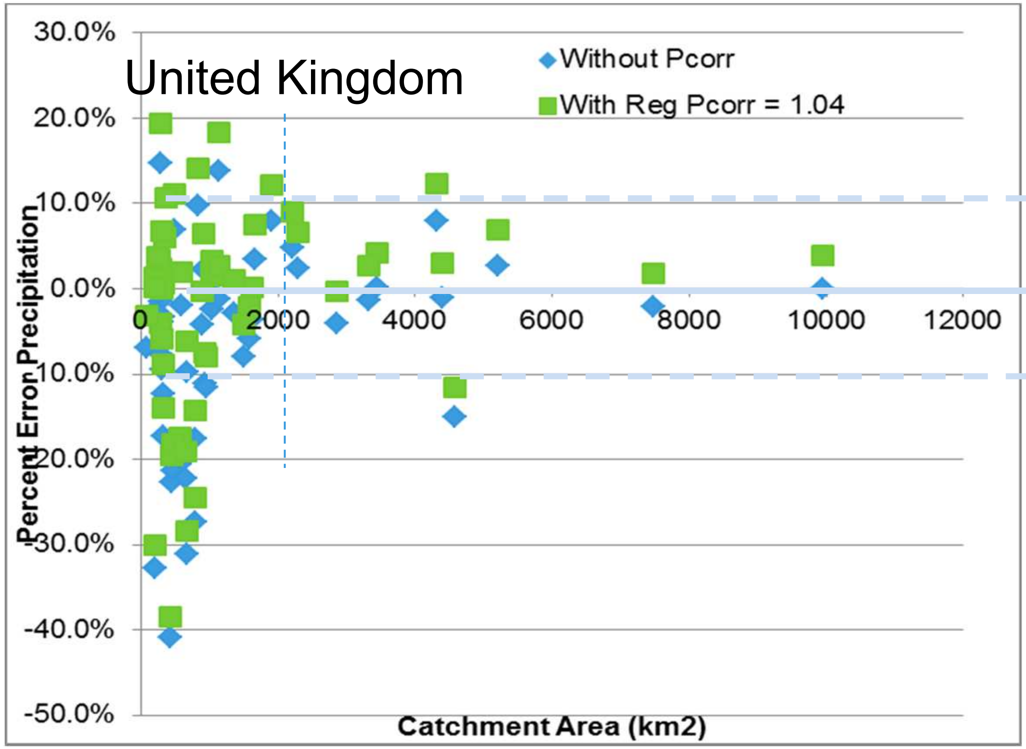


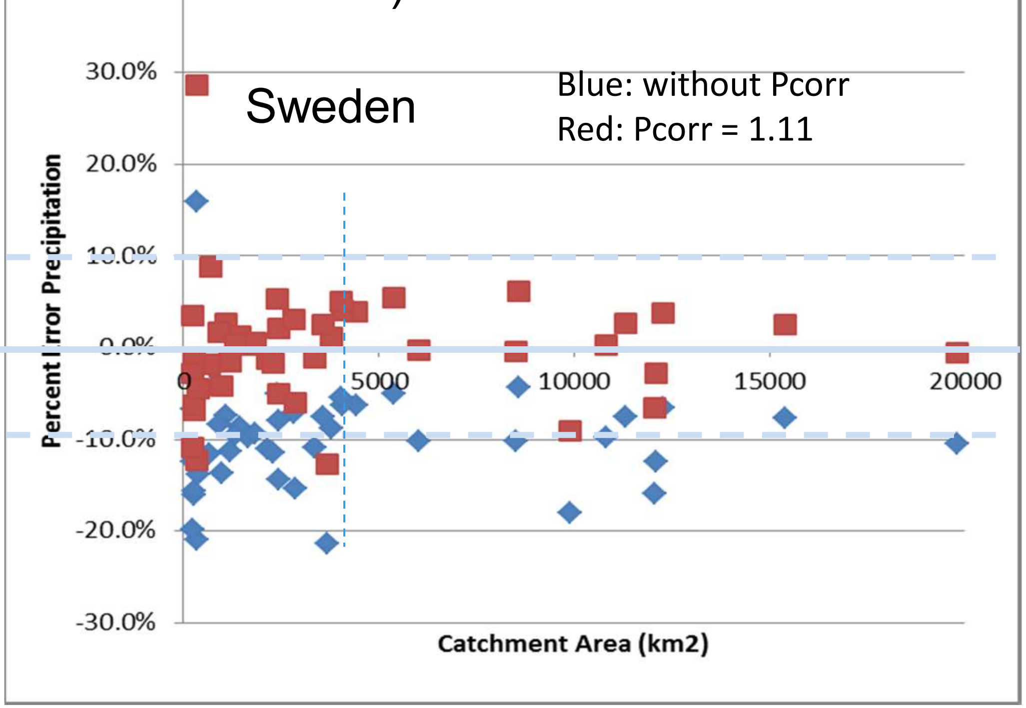


Donnelly, C., Rosberg, J., Isberg, K. ***A Validation of River Routing Networks for Catchment Modelling from Small to Large Scales.*** *Hydrology Research (in press)**.***

Pan-European Gridded Precipitation

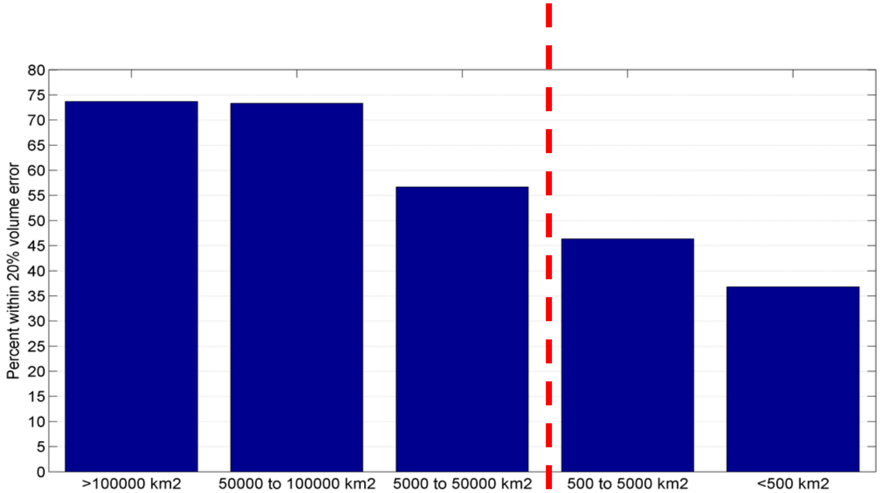
Compared published catchment precipitaiton in UK and SE with catchment precipitation from driving data (ERA-INTERIM corrected to GPCC)



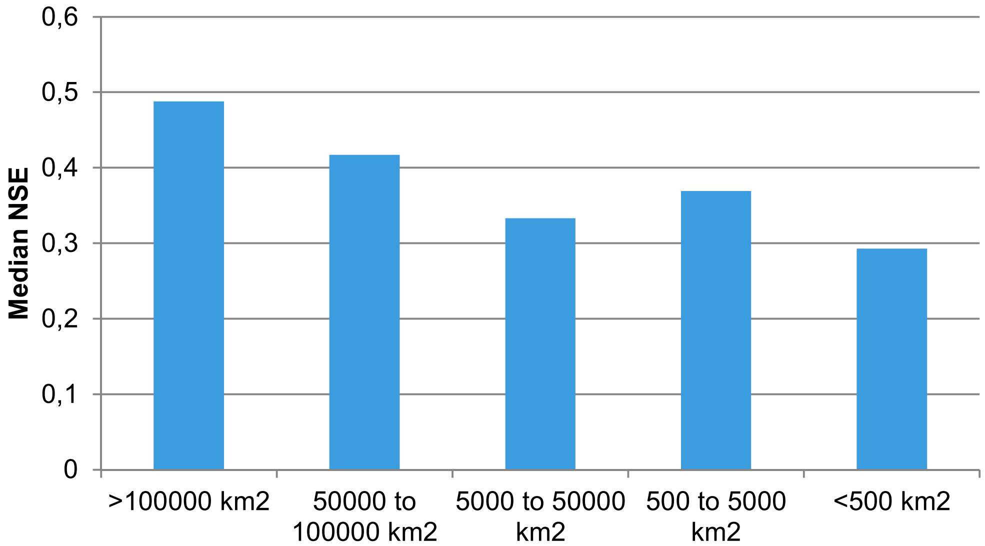


Spread of precipitation errors reduces (to within 10 %) around 2000 to 4000 km^2
Remember: ERAINTERIM ca 7000 km^2 grid, GPCC ca 3000 km^{2}grid. – but doesn't say anything about variability!

Model performance at various catchment scales



Percent of catchments within +/- 20 % volume error by catchment size



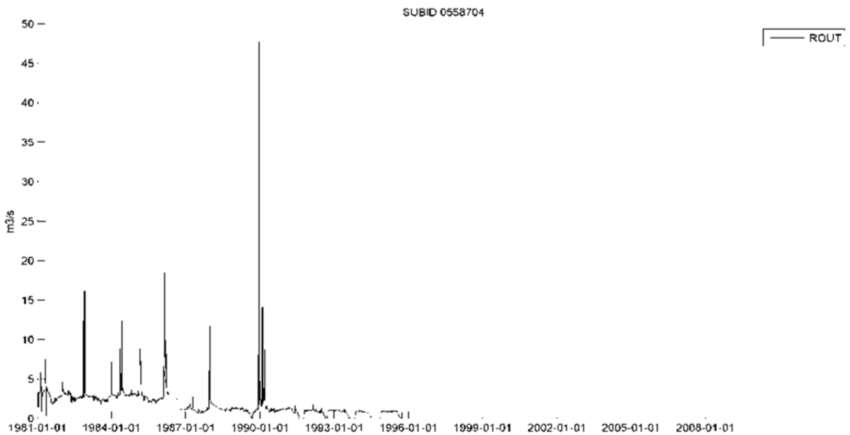
Median NSE by catchment size

Other significant sources of volume error

- Anthropogenic
- Extractions for TWS, irrigation, industry

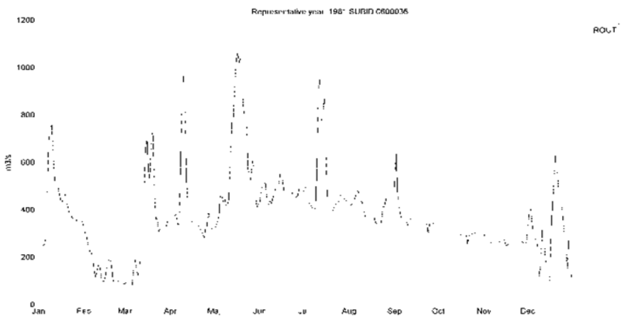
- Groundwater Losses (and gains)

- Measurement/Reporting Error – caution when using data from large scale databases. Visual check of all hydrographs required.

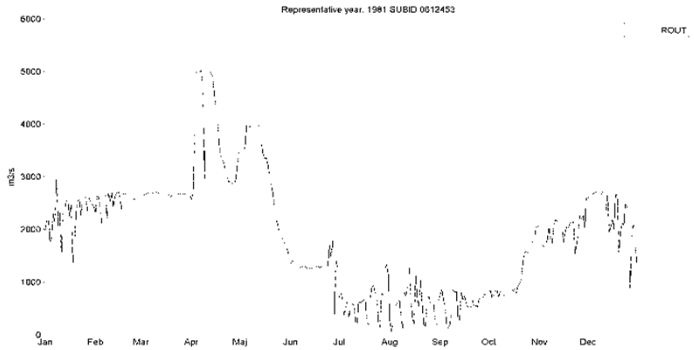


Spain –Change in regulation regime and extractions

Gypsey Race – Boynton – flows as GW intermittently? But small catchment – these effects 'relatively' much smaller in larger catchments



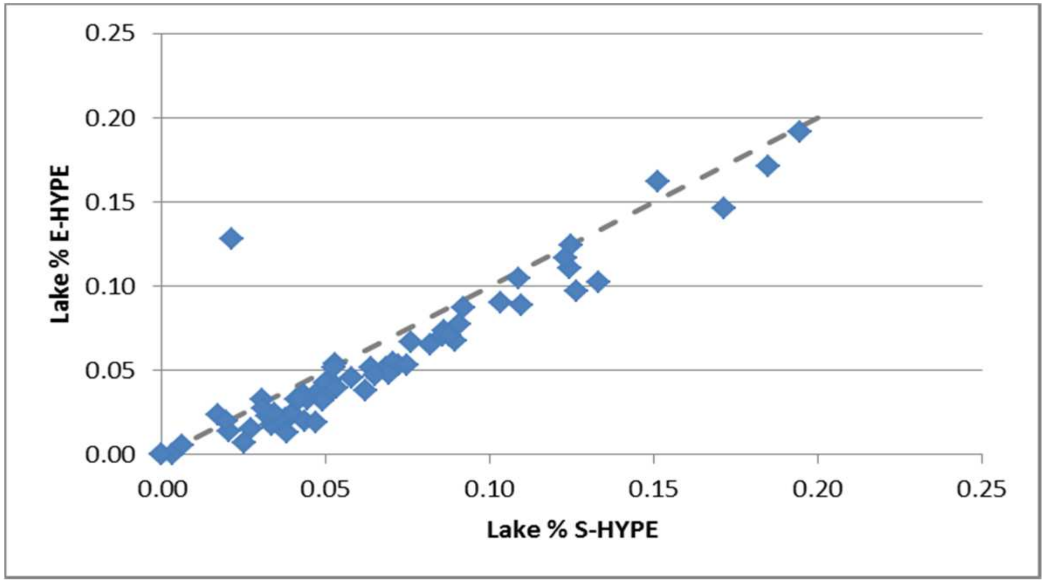
Kuban River Russia - Very unnatural flows, regulation, extractions from reservoir?



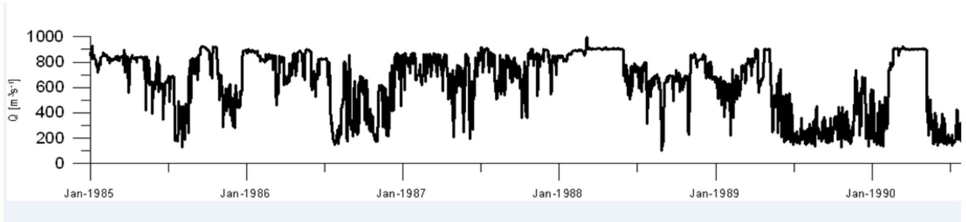
Dniepr –Very unnatural flows, regulation , extractions from reservoir (Ukraine)

Other inputs affecting variability

Lake area is fairly consistently underestimated – probably because GLWD consistently ignores lakes less than grid resolution



Regulation
- Can approximate for many hydropower dams, but harder for multipurpose reservoirs:



Göta River at Lake Vänern outlet

Useful to know degree of regulation upstream of each point in the model domain.

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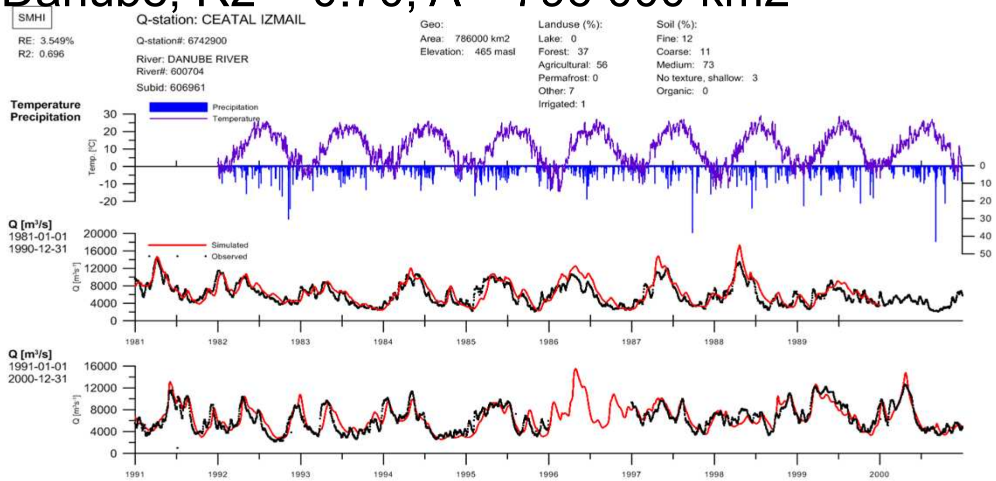
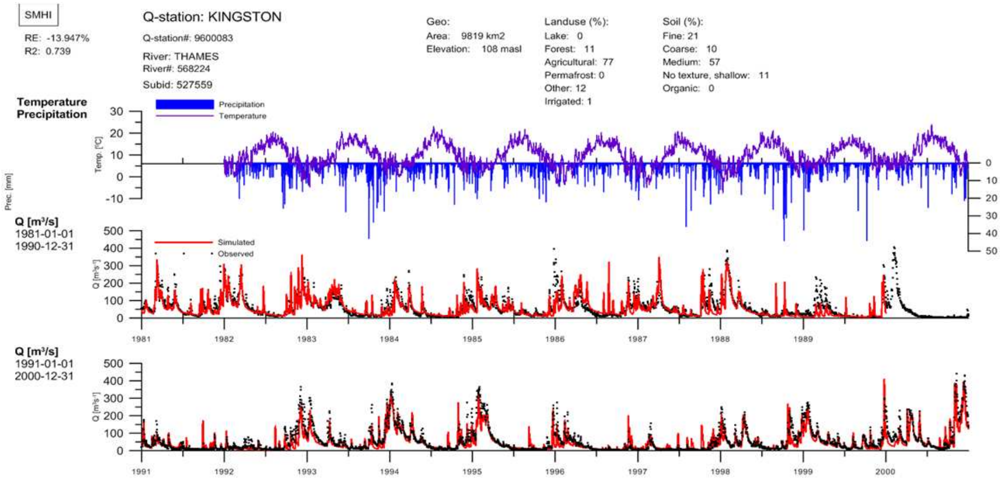
Some Results

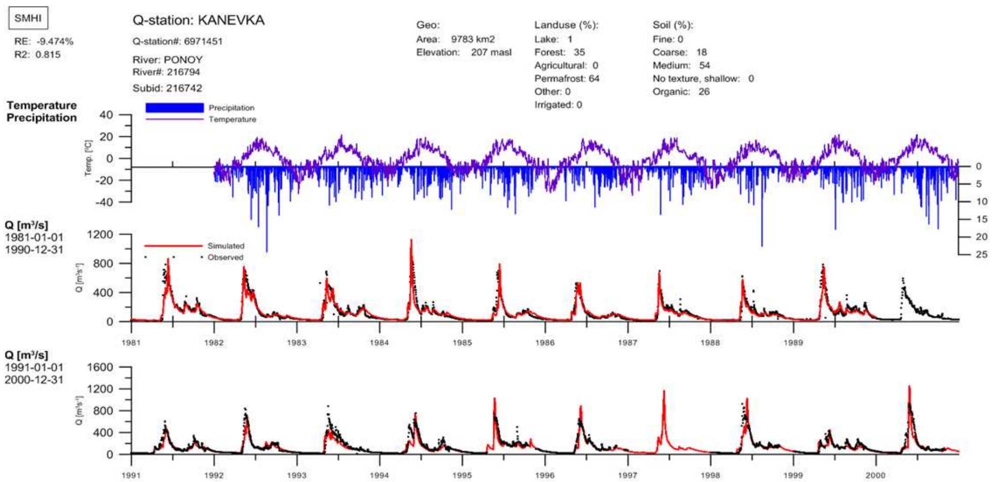
Danube, R2 = 0.70, A = 796 000 km2



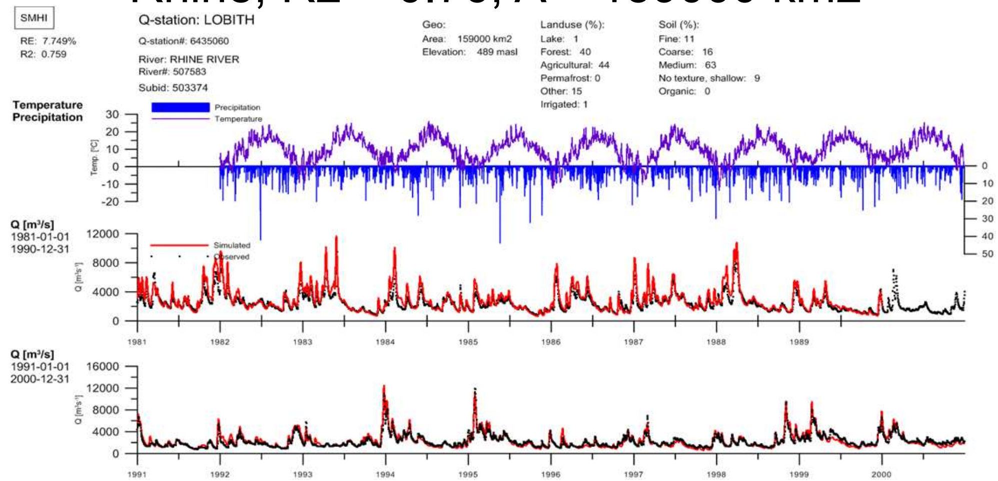
Thames, R2 = 0.74, A = 9600 km2



Ponoy, R2 = 0.82, A = 9800 km2



Rhine, R2 = 0.76, A = 159000 km2



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Conclusions

- We can do a good job in simulating natural flows in catchments 5000 to 800 000 km2 – even with minimal calibration
- Catchment delineations from regional/global databases are good for larger rivers, but as catchment size decreases, the chance of errors increases. We suggest minimum catchment size for Hydrosheds in Europe of 5000 km^2,
- Minimum catchment size should be limited to precipitation input resolution - Simple bias correction of a reanalysis data set to a finer grid does not capture sufficient variability of precipitation
- Anthropogenic impacts difficult to model on large scale using readily available data!
- Runoff databases need better metadata on human impacts! (Hannah et al. 2010)

Any Questions?




Input Data – Readily available global/regional databases

	BALT-HYPE	E-HYPE
Areal extent	1,8 million km^2	9,6 million km^2
Median Subbasin Resolution	325 km^2	215 km^2
No. Subbasins	5128	35000
Topography/routing	Hydro1K (USGS 2000)	HydroSHEDS (Lehner et al., 2008), (Hydro1K for latitude > 60 deg)
Forcing Data	ERAMESAN 1980-2004 (Jansson et al., 2007), Resolution = 11 km.	GPCC scaled ERA-INTERIM
Landcover	Globcover 2000	CORINE
Soil-types	European Soils Database (JRC, 2006)	European Soils Database (JRC, 2006)
Runoff Data	GRDC (GRDC, 2009b), BHDC (2009)	GRDC. EWA (GRDC, 2009a), BHDC
No. Calibration Stations	35	Total
No. Validation Stations	121	

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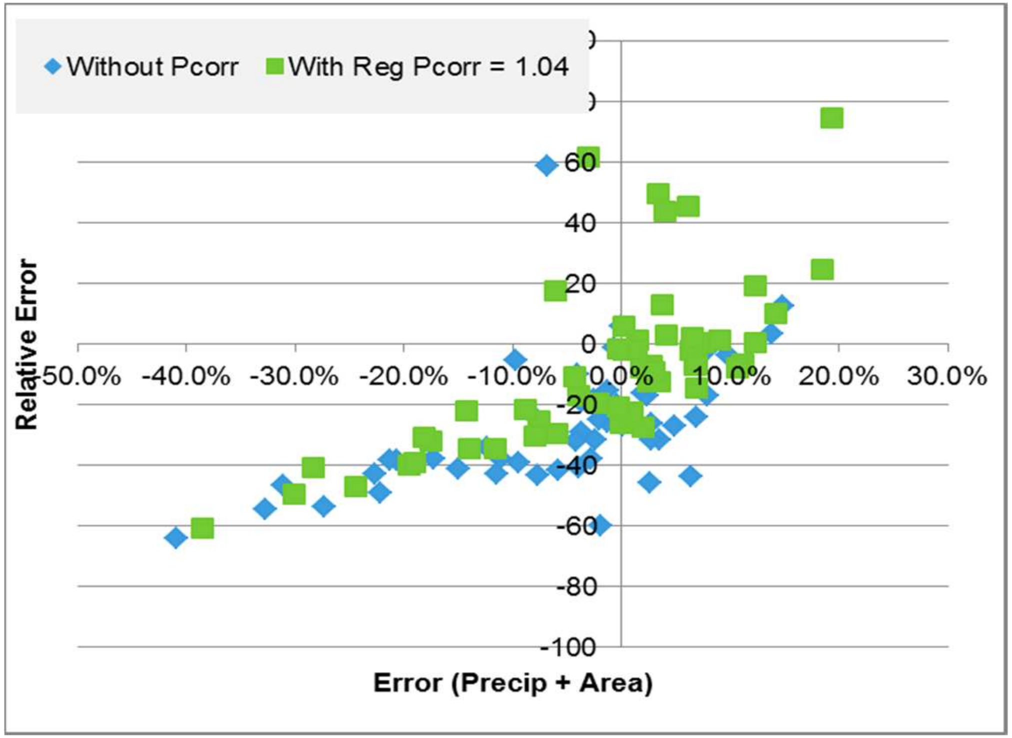
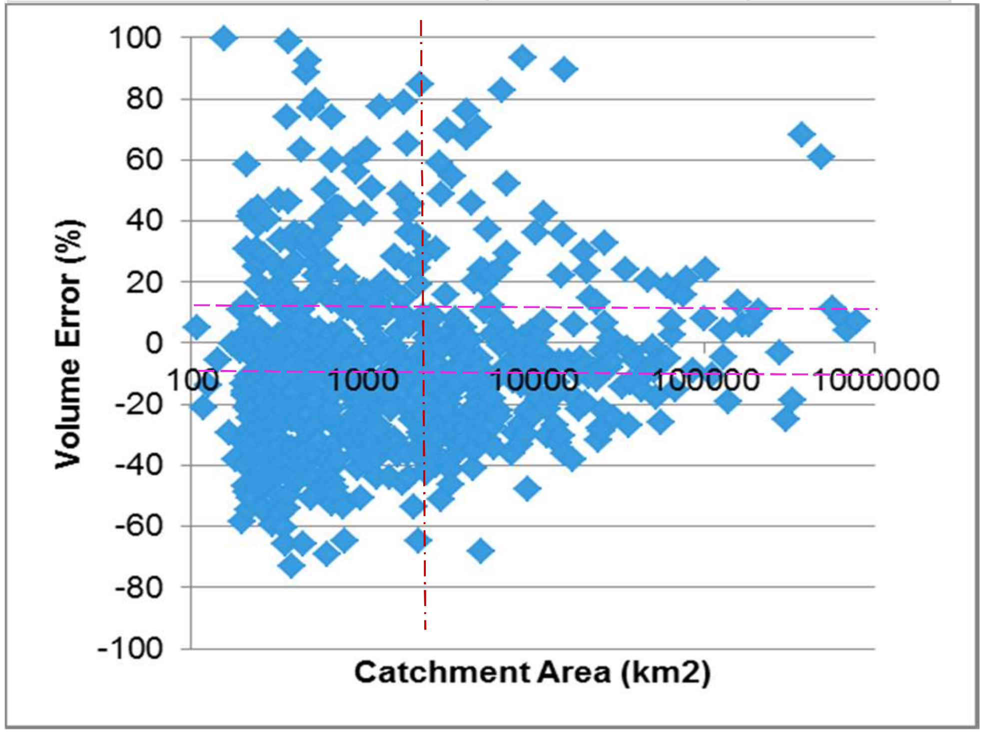
I vilken skala kan vi använda E-HYPE resultat?

	St Dev RE	Median R2
Alla stationer	90.2	0.29
Stationer > 5000 km2	62.1	0.36





Resultaten blir bättre je större avrinningsområdet blir med det finns fortfarande några väsentliga fel kvar för vissa avrinningsområden