Projecting climate change impacts on water resources in Switzerland

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Simulations from 4 different models / 3 different groups … all wrong?
Current water resources?

Swiss water balance 1901-2000

Evaporation 464 mm/y
Precipitation 1431 mm/y

Inflow 318 mm/y

Lakes
Soil- and groundwater

Total streamflow 1299 mm/y
Locally generated streamflow 981 mm/y
Storage change -14 mm/y

Hubacher and Schädler, 2010
Current water resources?

- Precip
- Runoff
- Net ice melt
- Transpiration
- Evaporation
- Ground water

Hubscher and Schäffer, 2010
Role of (un-)certainty ranges

- Present day model uncertainty
- Probability distribution
- Uncertainty for scenario
- Target variable (e.g. average streamflow)
- Change prediction impossible
Role of natural variability

Target variable (e.g., average streamflow)

Present day natural variability

Scenario variability

Probability distribution

Significance of changes?
Climate change model chain

**Global scale**
- Emission scenario
  - Global climate model
    - Global climate

**Regional scale**
- Regional climate model
  - Time series generator

**Local scale**
- Precip. Temp.
  - Landuse model
  - Hydro.-hydraul. model
    - Stream-flow
    - Sediments
    - Land use
    - Ecosystem model
    - Management model
Model development

Calibration period

Development/calibration

Validation

Observed state

Observed meteo, reanalysis data

Natural variability

Model quality/uncertainty

Global scale
- Global climate model
- Emission scenario

Regional scale
- Time series generator
- Regional climate model

Local scale
- Precip., Temp.
- Land use
- Hydro-hydraulic model
- Precip., Temp.

Global climate

Emission scenario

Global scale

Regional scale

Local scale

Time series generator

Ecosystem model

Electricity production

Water release

Stream-flow

Land use

Land use

Sediments

Hydro.

Hydraul.

Precip.

Temp.

Ecosystem quality

Stream-flow

Land use

Sediments

Hydro.-hydraul.

model

Regional climate

Regional climate

Global scale

Global climate

Global climate

Emission scenario

Global climate model

Global climate model

Time series generator

Time series generator

Ecosystem model

Electricity production

Water release

Stream-flow

Land use

Sediments

Hydro.

Hydraul.
Model development

- Calibration period
  - Observed meteo, reanalysis data
- Development/calibration
  - Validation
- Observed state

Control simulation

- Control period
- Simulated meteo

Control state

- Model quality/uncertainty
- Natural variability

Legend:
- Global scale: Global climate model, Emission scenario, Time series generator
- Regional scale: Regional climate model, Emission scenario, Regional climate
- Streamflow, Sediments, Water release, Electricity production, Ecosystem model, Ecosystem quality, Stream-flow
- Land use, Sediments, Precip.

Uncertain changes

Can we make useful climate change predictions?

Answer 1: No because ...

- Scenario production with calibrated models & simulated meteorology
Uncertain changes

Can we make useful climate change predictions?

Answer 2: No because ...

Probability

Present day

Prediction impossible

Future scenario

Target variable (e.g. hydropower offer)
Can we make useful climate change predictions?

Answer 3: No because ...

- Baseline prediction uncertainty
Certain changes!

Can we make useful climate change predictions?

Answer 4: Yes but only for certain aspects...
Climate change impact on water resources

(source: «report «CCHydro Veredelung»)

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2.5% glacier covered

Mean net ice loss:
-0.62 m/yr = 0.7 km³/yr (1980-2010)

Fischer et al., 2014, 2015
Moment of peak water?

- Ongoing estimation of all glacier volumes with ice penetrating radar
Future water temperatures?

Water temperature from 29 CH catchments

Norm. water temperature [-]

2010 2011 2012
Months

Groundwater-fed
Proglacial stream

Gallice et al., 2015
(c) Adrian Michael
Future sediment loads?

• Several ongoing projects
  • SCCER-SoE
  • NRP70
  • SedFate (SNF Sinergia)
Quantification of extremes

Stochastic tools for local-scale meteo scenarios

New tools to assess model chain reliability

Understand vulnerability & risk reduction tools
Focus on vulnerability?

- Quantify water resources vulnerability
  - Catalogue of climate-related critical events
  - Vulnerability assessment via scenarios from observed data
  - Assessment of spatial co-variations of water resources
- Real-time forecasting to decrease risks
Conclusion - challenges

- Water resources quantification
  - Better quantification of baseline scenarios (uncertainty)
  - Experimental catchments!

- Prediction of extremes
  - Focus on meteo & scenario generators
  - Limits of predictability for selected case studies
  - Shift to vulnerability assessment?