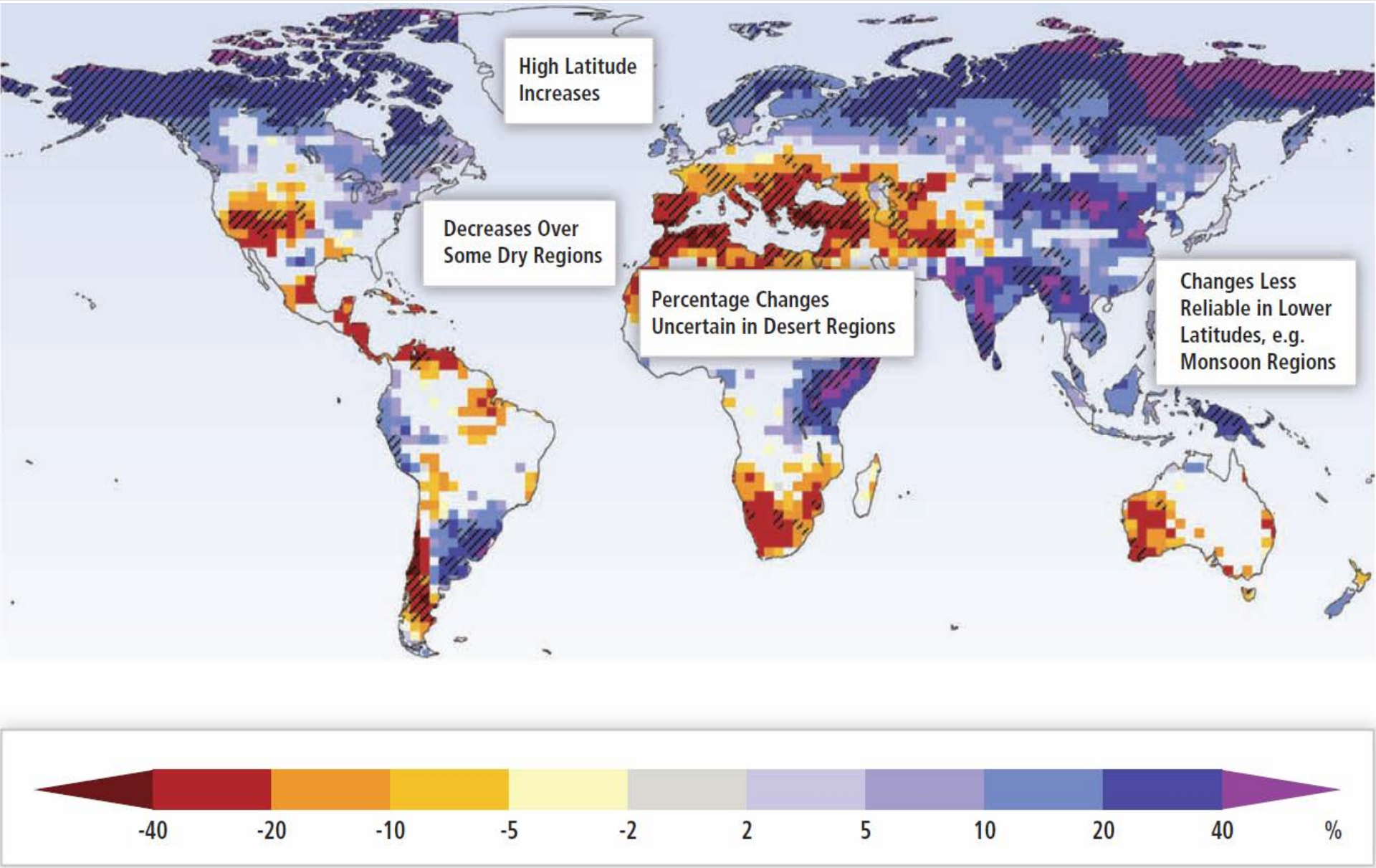
Mer vann og mer uvær?

Utfordringer for vannkraft innen hydrologi og klima

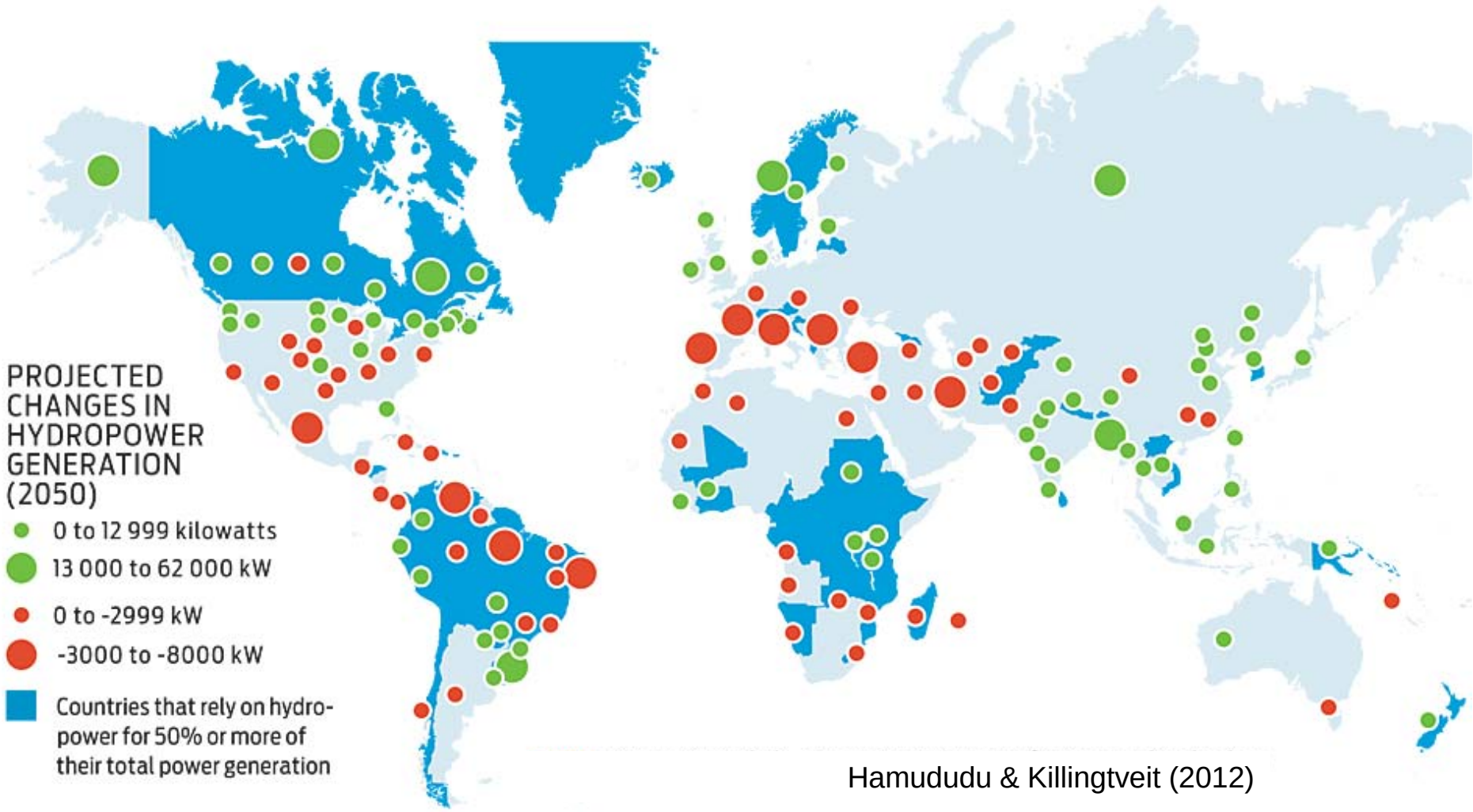
Sjur Kolberg, SINTEF Energi

I all hovedsak stjålet fra: Yisak Sultan Abdella, Knut Alfredsen, Idar Barstad, Thibault Boissy, Julie Charmasson, Haregewoin Haile Chernet, Kolbjørn Engeland, Anders Finstad, Hans-Petter Fjeldstad, Torbjørn Forseth, Solomon Gebre, Teklu Tesfaye Hailegeorgis, Byman Hamududu, Atle Harby, Richard Hedger, Ånund Killingtveit, Sara Martino, Julian Sauterlaute, Line Sundt-Hansen, Netra Prasad Timalsina, Lena S. Tøfte, Ola Ugedal, Peggy Zinke,...

Climate Change will have impact on Water Resources

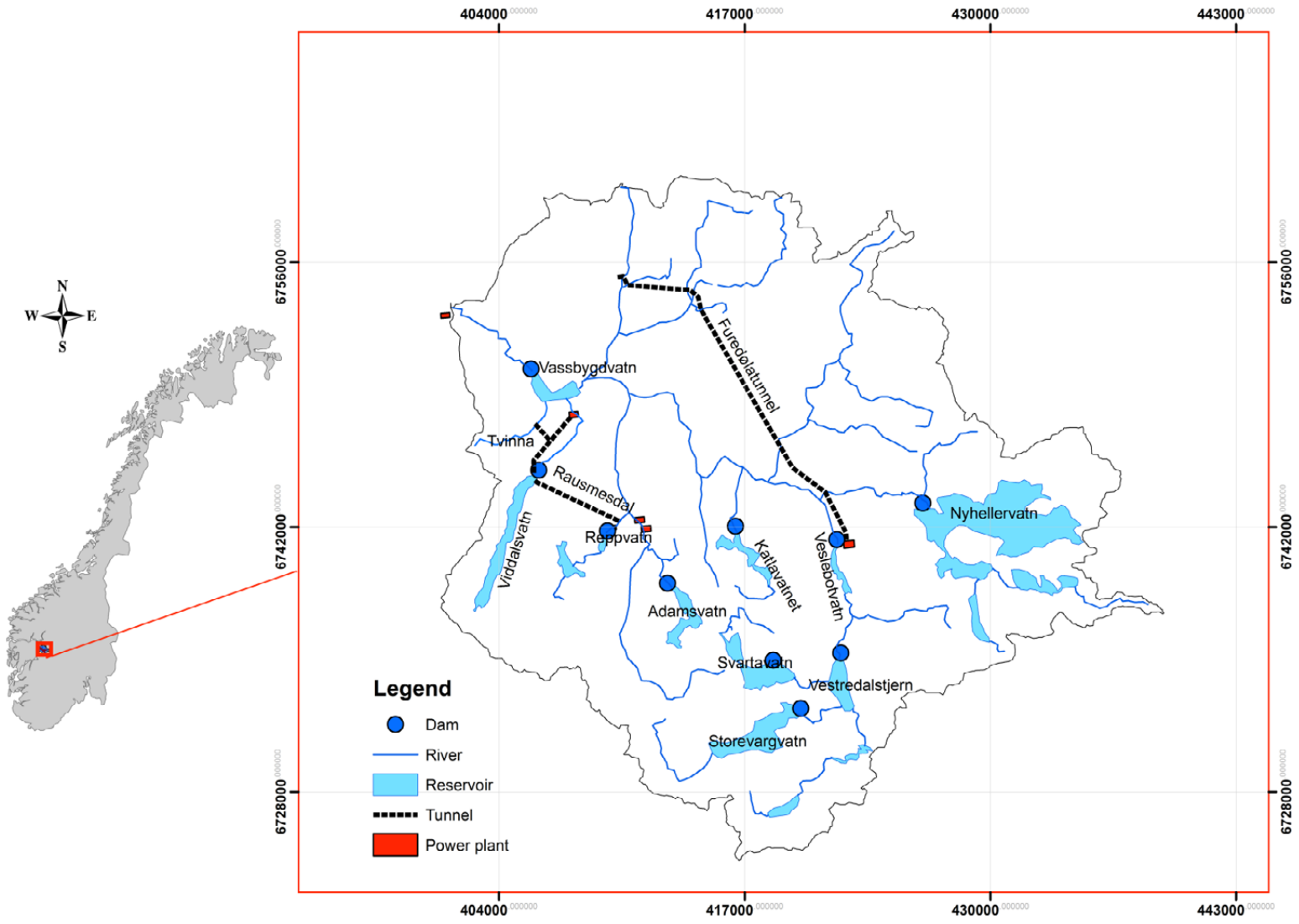


Hydropower and Climate Change



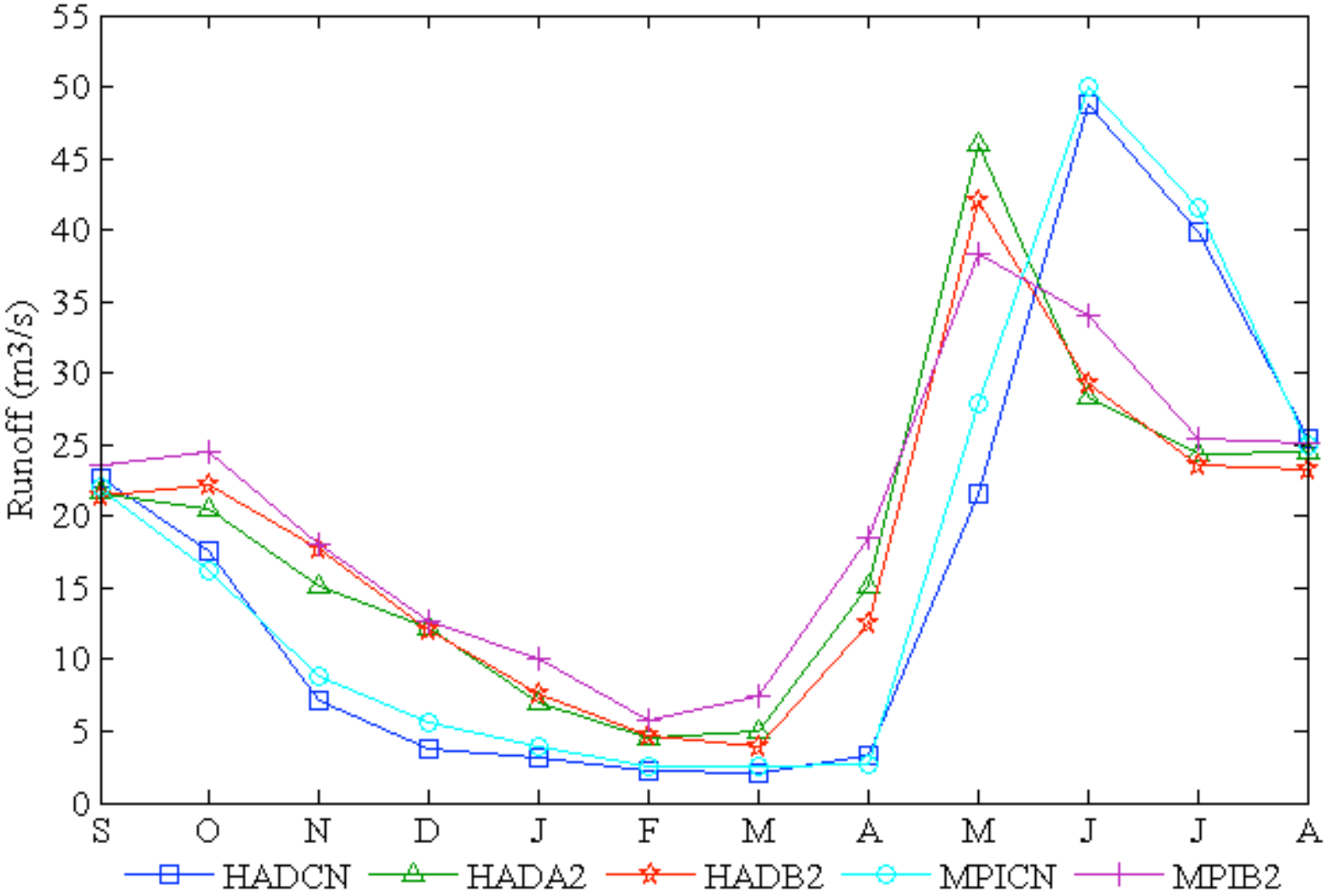
Hamududu & Killingtveit (2012)

Lokale verknader på kraftressursar



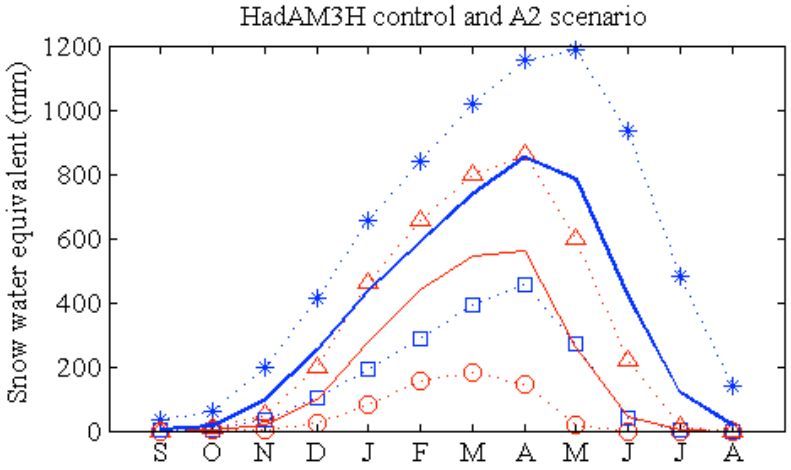
Chernet et al. 2013, Journal of water and climate change

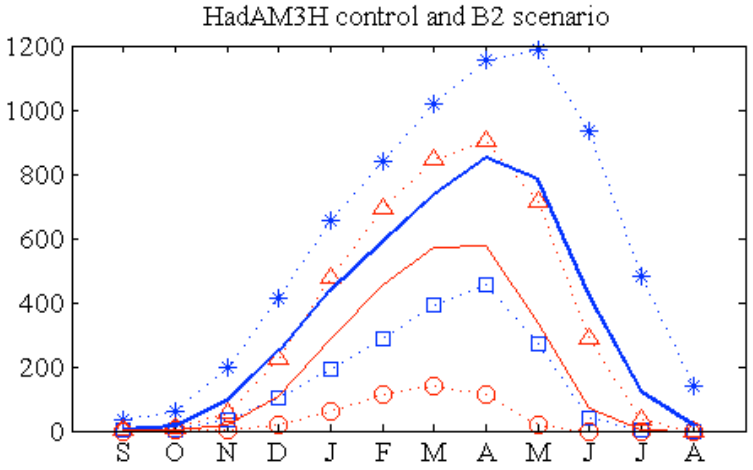
Tilsig simulert frå nedskalerte klimadata

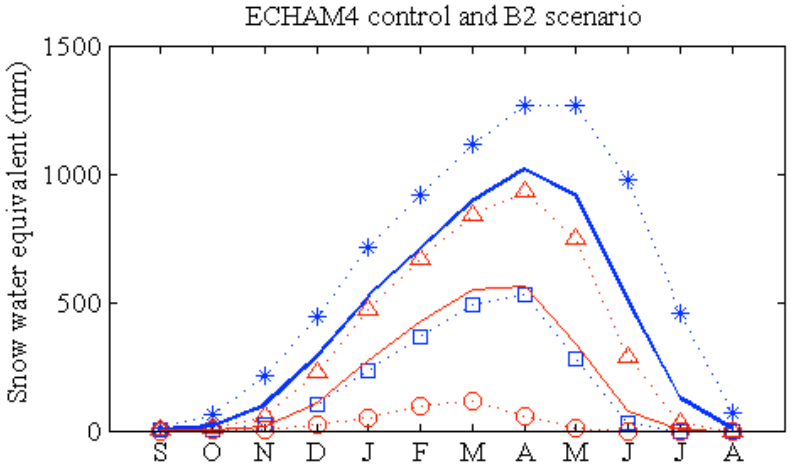


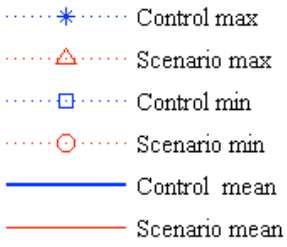
Chernet et al. 2013, Journal of water and climate change

Simulert snømagasin





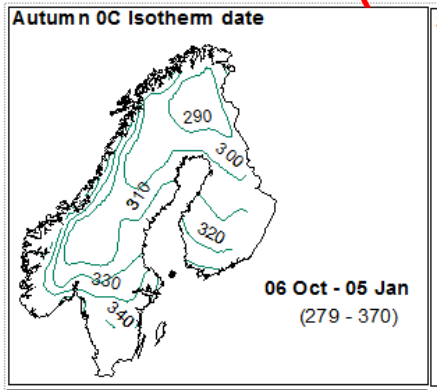


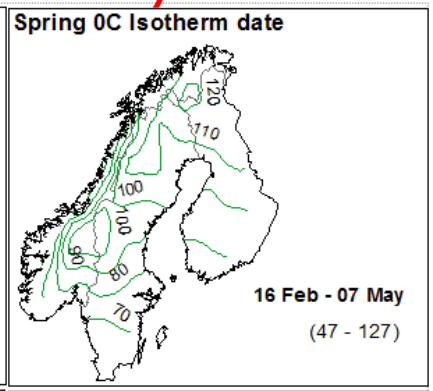


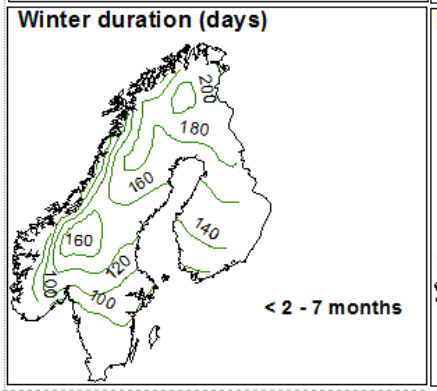
Chernet et al. 2013, Journal of water and climate change

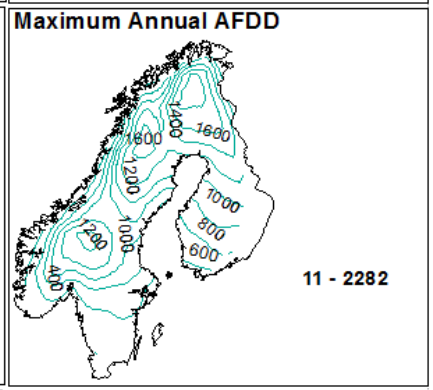
Climate change, ice, water temperature

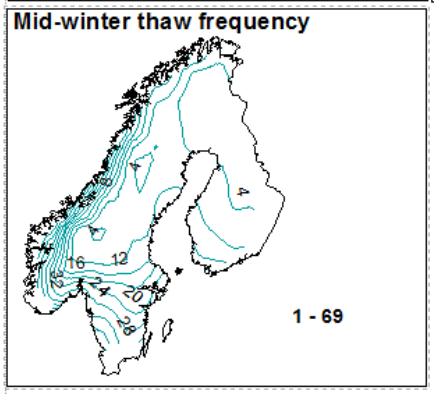
Current (1961-1990)



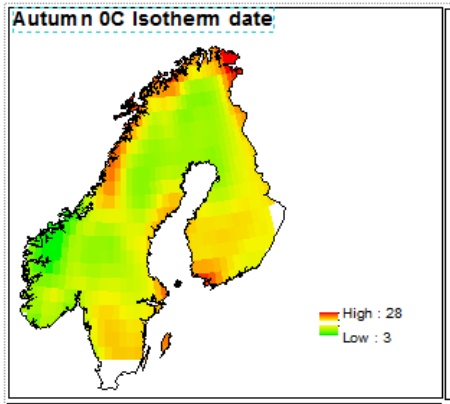


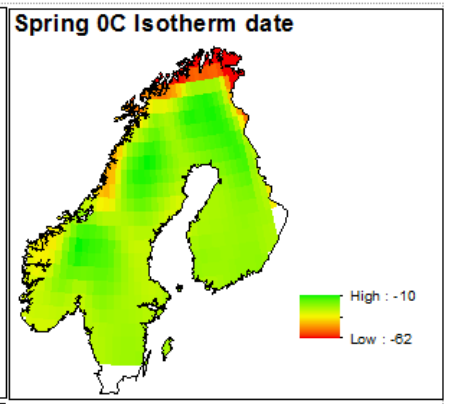


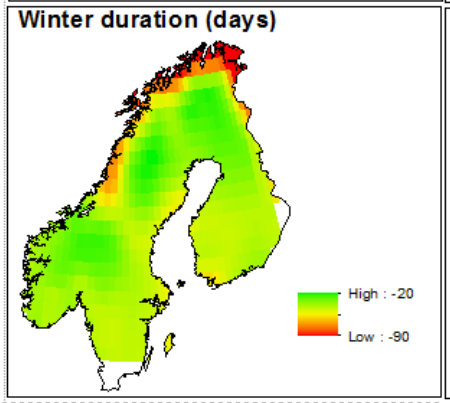


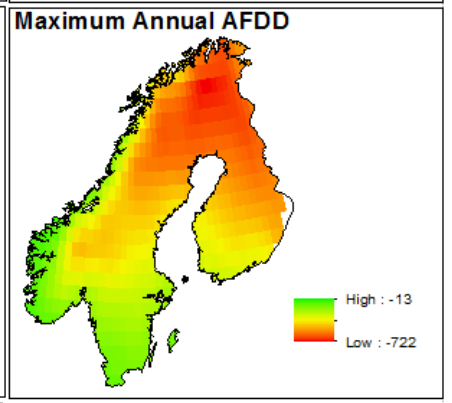


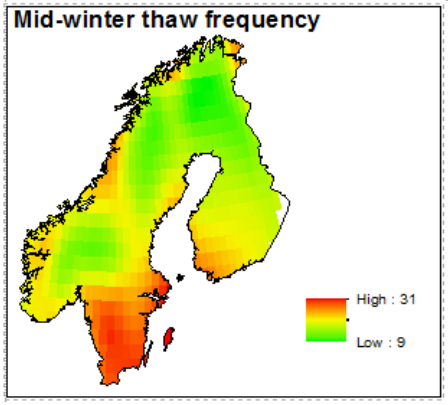
Future (2041-2070)





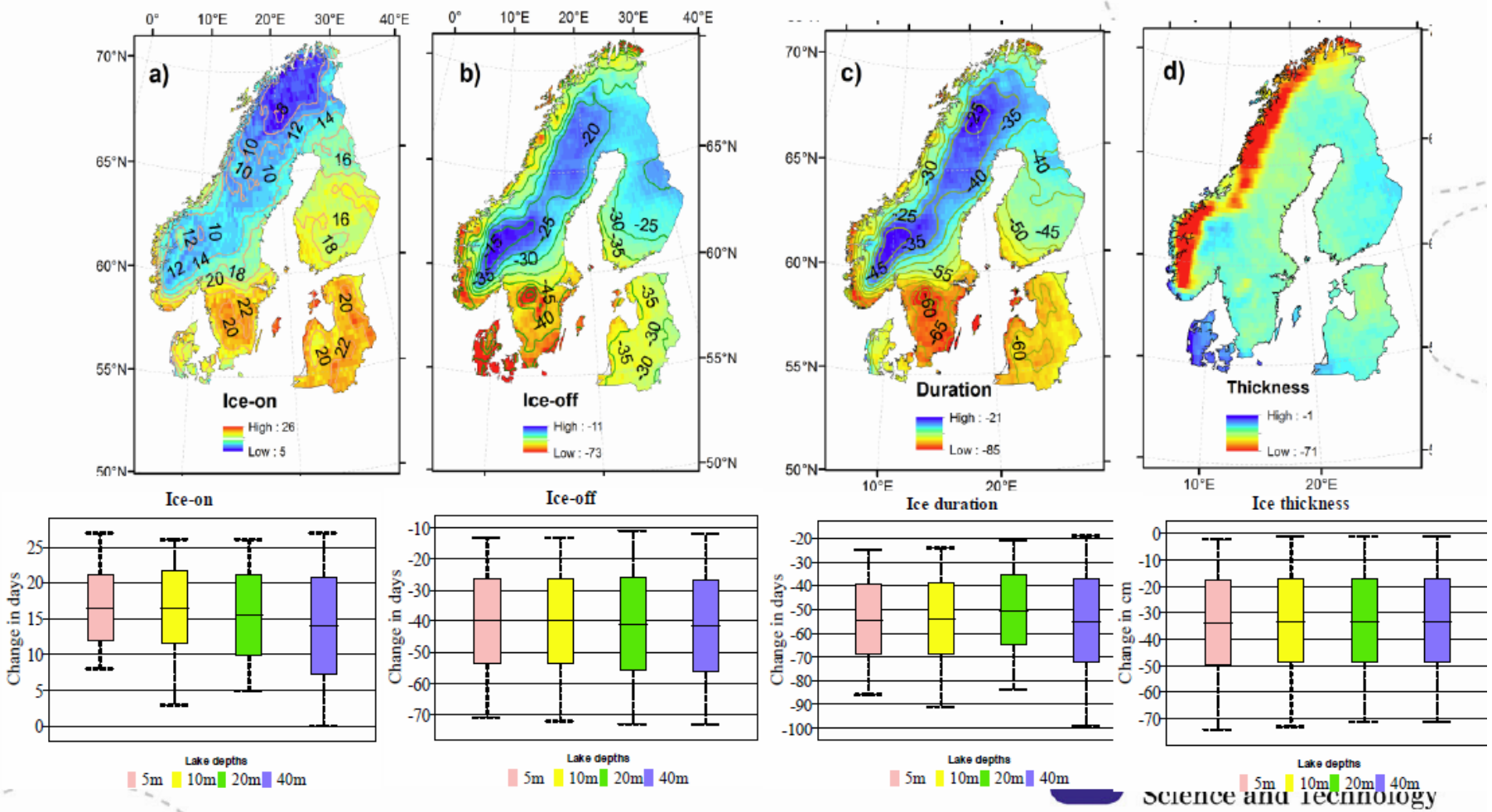






Gebre et al. Hydrology Research

Endringar i innsjøis i framtida

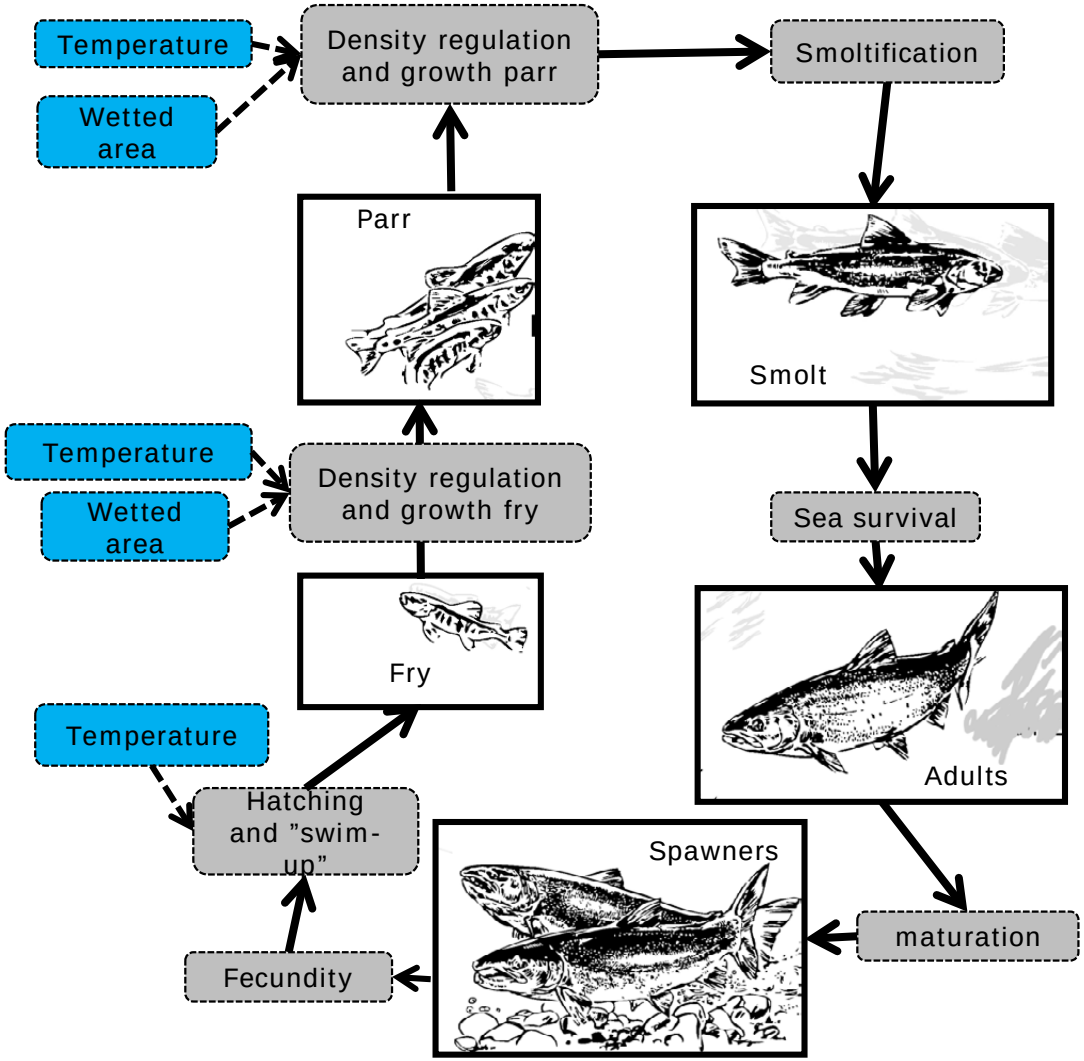


Gebre, Boissy & Alfredsen, The Cryospjere Discussions (in review)

IB-salmon

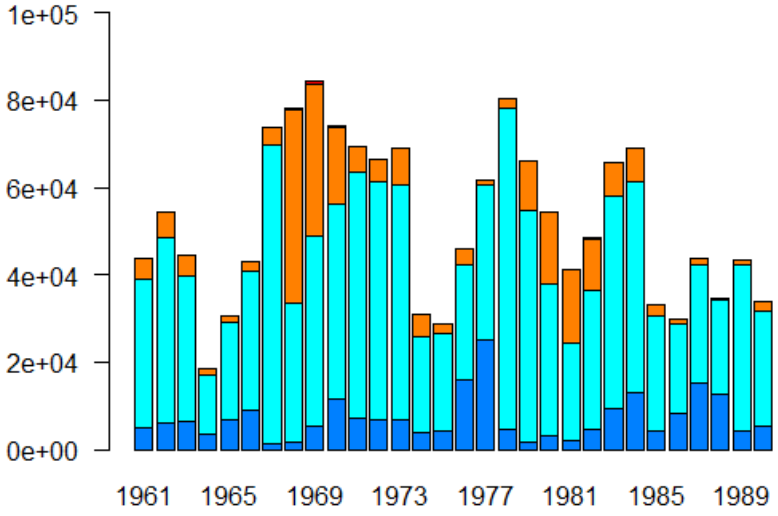
Abiotic input:
Water temperature
Wetted area per section (discharge)

Biological input:
Egg deposition (per section)
Habitat quality (each year)

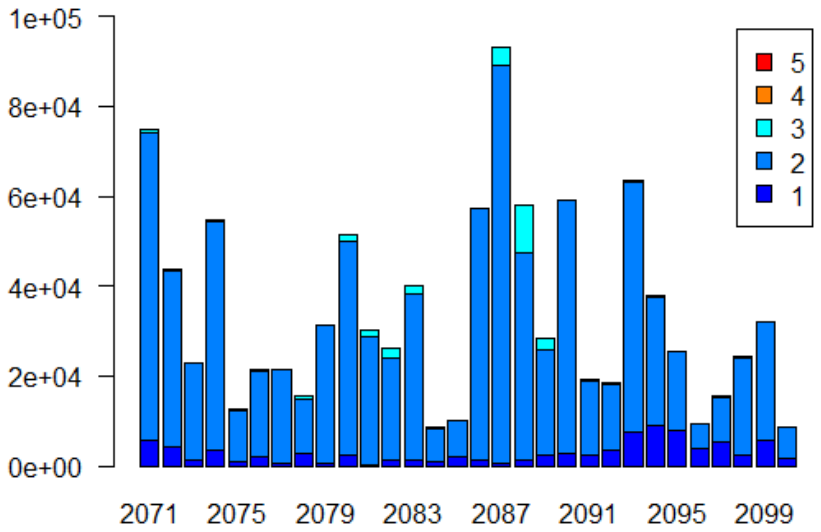


L. Sundt-Hansen, R. Hedger, O. Ugedal, O. Diserud, A. G. Finstad, T. Forseth, L. Tøfte & J. Sauterleute

Smolt age control

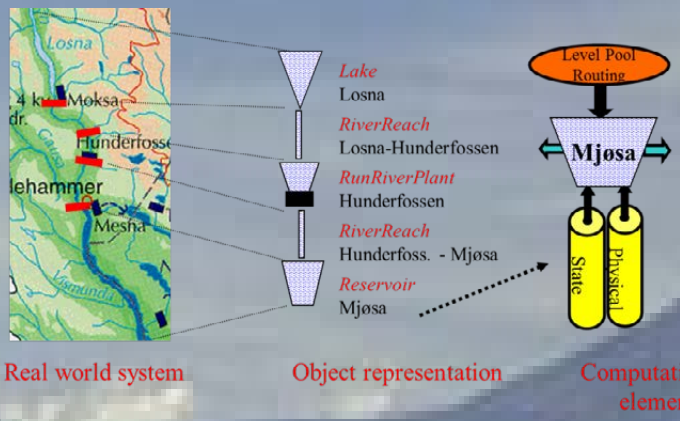


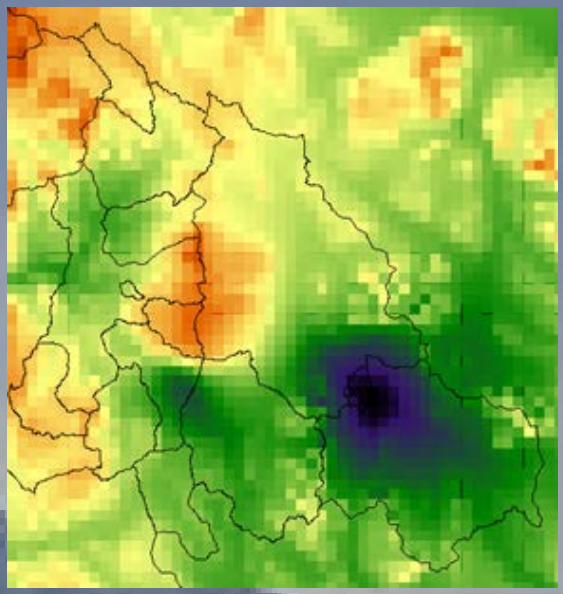
Smolt age scenario

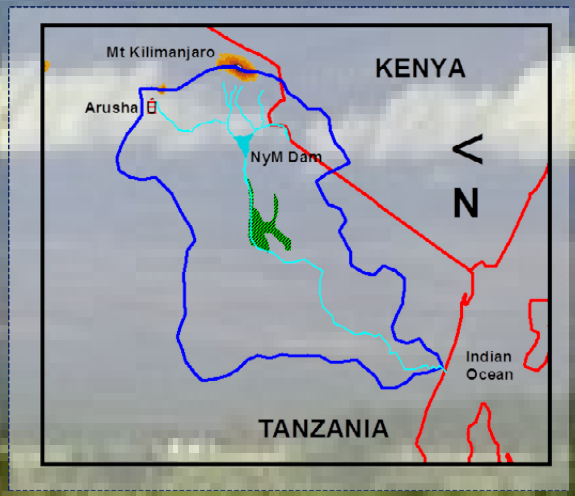


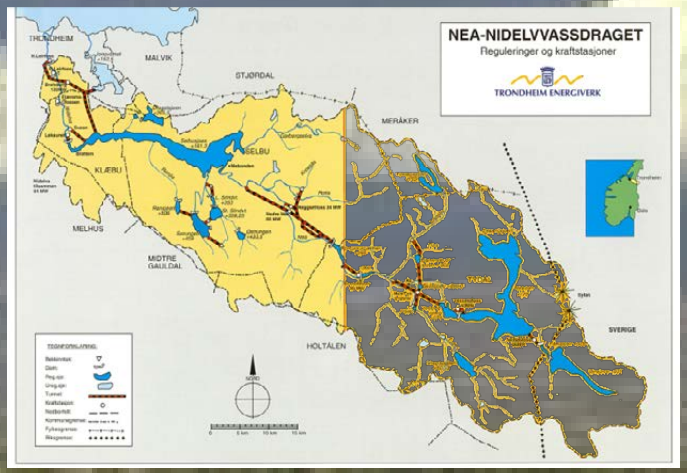
- Salmon juveniles grow faster, smoltify younger
- Increased mortality in summers due to reduction in wetted area
- **Reduced recruitment and reduced production of salmon in future scenario**

Hydrologisk modellering

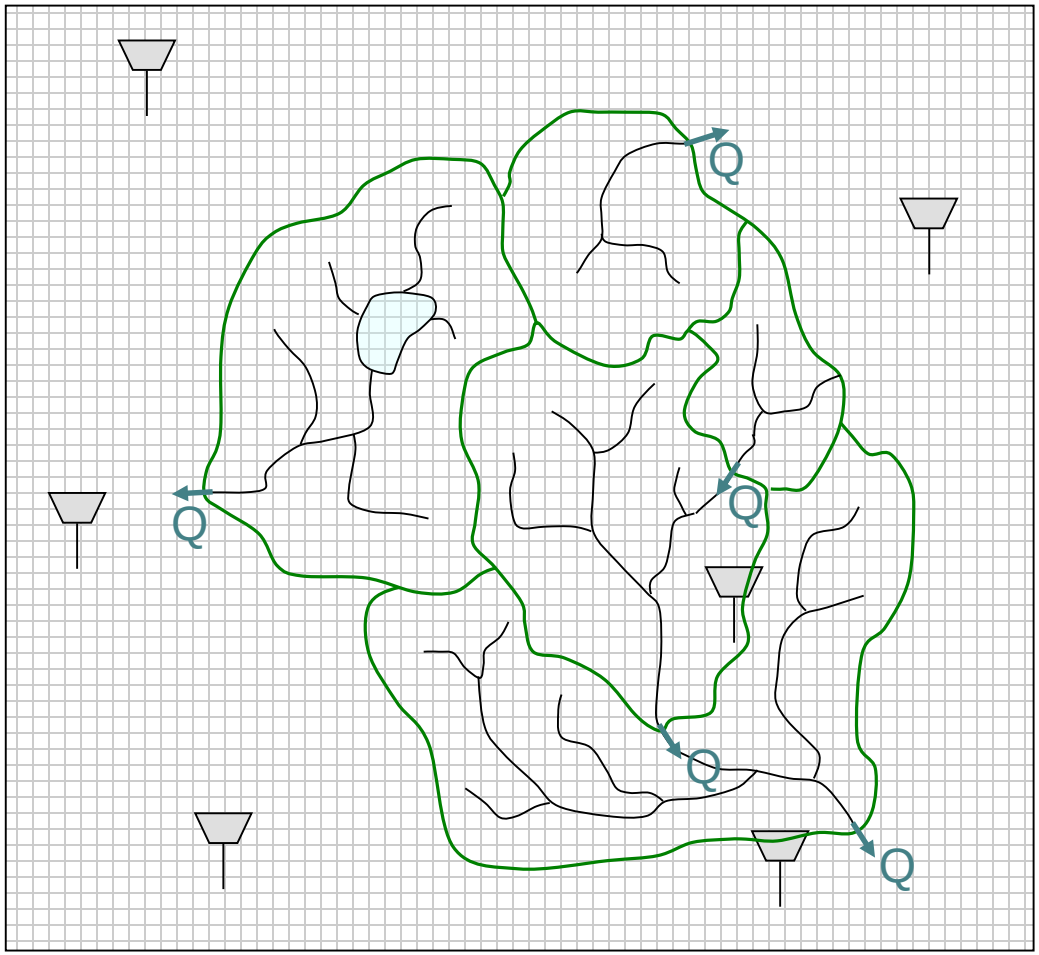








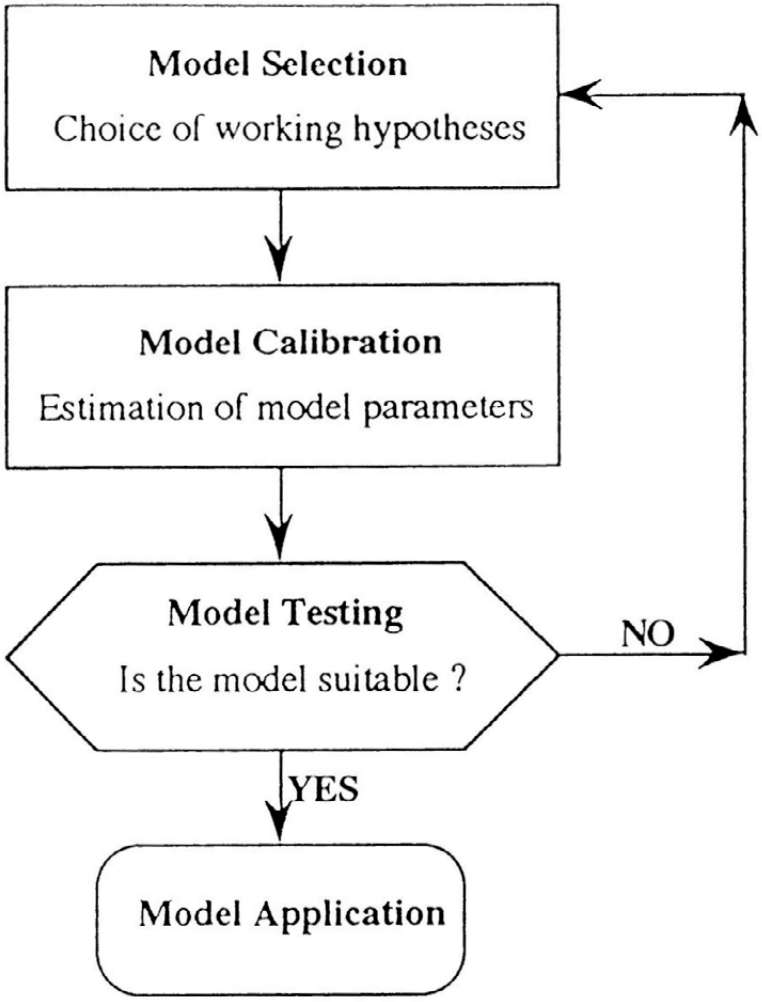
Enki:



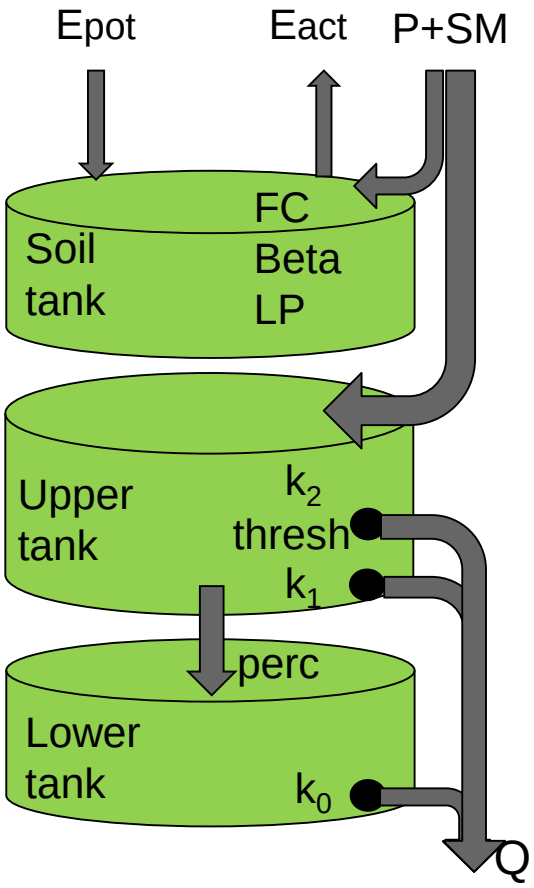
- Rammeverk for modellutvikling
- Fordelte vs integrerte modeller
- FoU-versjon utviklet 2002-2014 ved SINTEF
- Operativ versjon utviklet 2014-2015 ved Statkraft
- Begge versjoner Open Source
- På vei inn i operasjonell programvare (Powel)

Model Development

- Model selection:
  - Operational needs
  - Dominant processes
  - Available data
- Validation
  - Required performance
  - Achievable performance
  - Physical correctness
  - Stability and robustness
- Two often quoted statements:
  - ”All models are wrong. Some, however, are useful.” (Box, 1979)
  - “A model must work well for the right reasons” (Klemes, 1986)

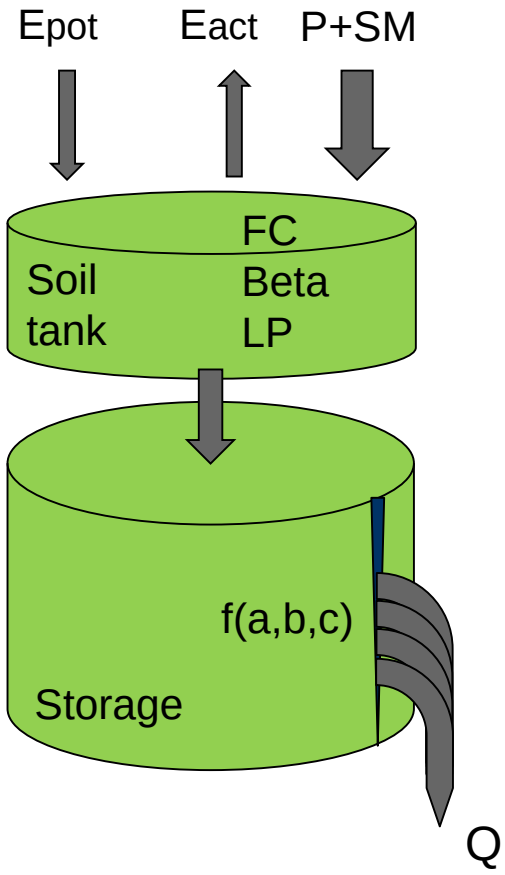


Simplification of response routines



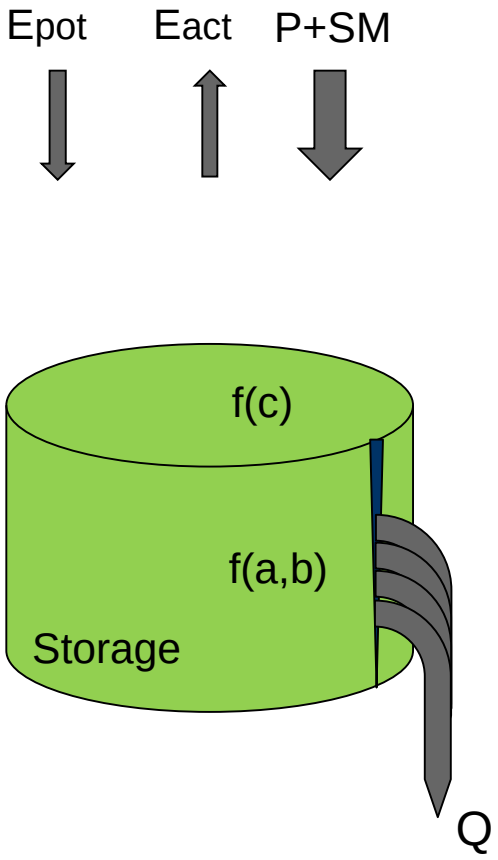
HBV response + soil

- 8 parameters
- 3 states



3-par Kirchner + soil

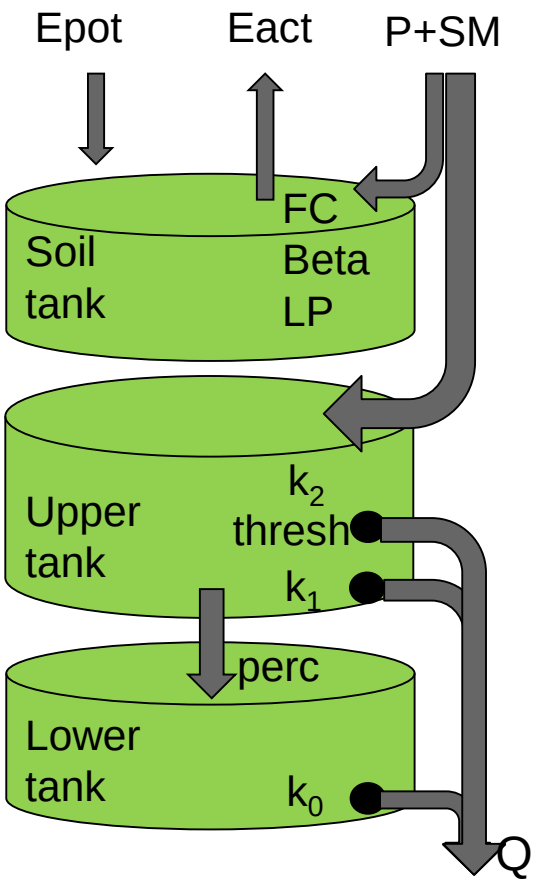
- 6 parameters
- 2 states



2-par Kirchner

- 3 parameters
- 1 state (Q)

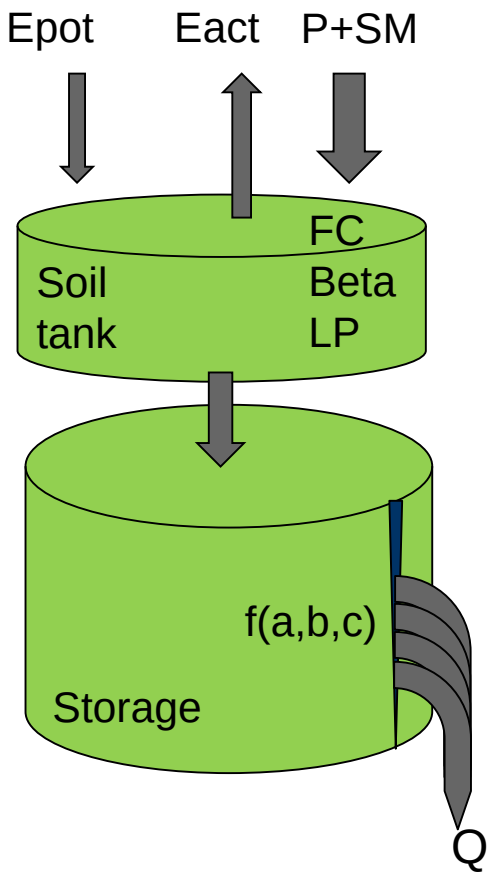
Performance (average R^2 of 22 catchments)



HBV response + soil

Regional cal: 0.679

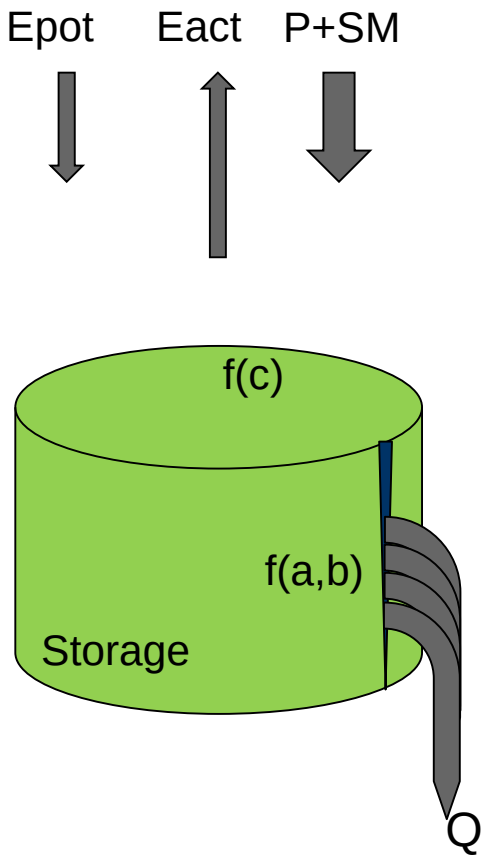
Local cal: 0.741



3-par Kirchner + soil

Regional cal: 0.683

Local cal: 0.762

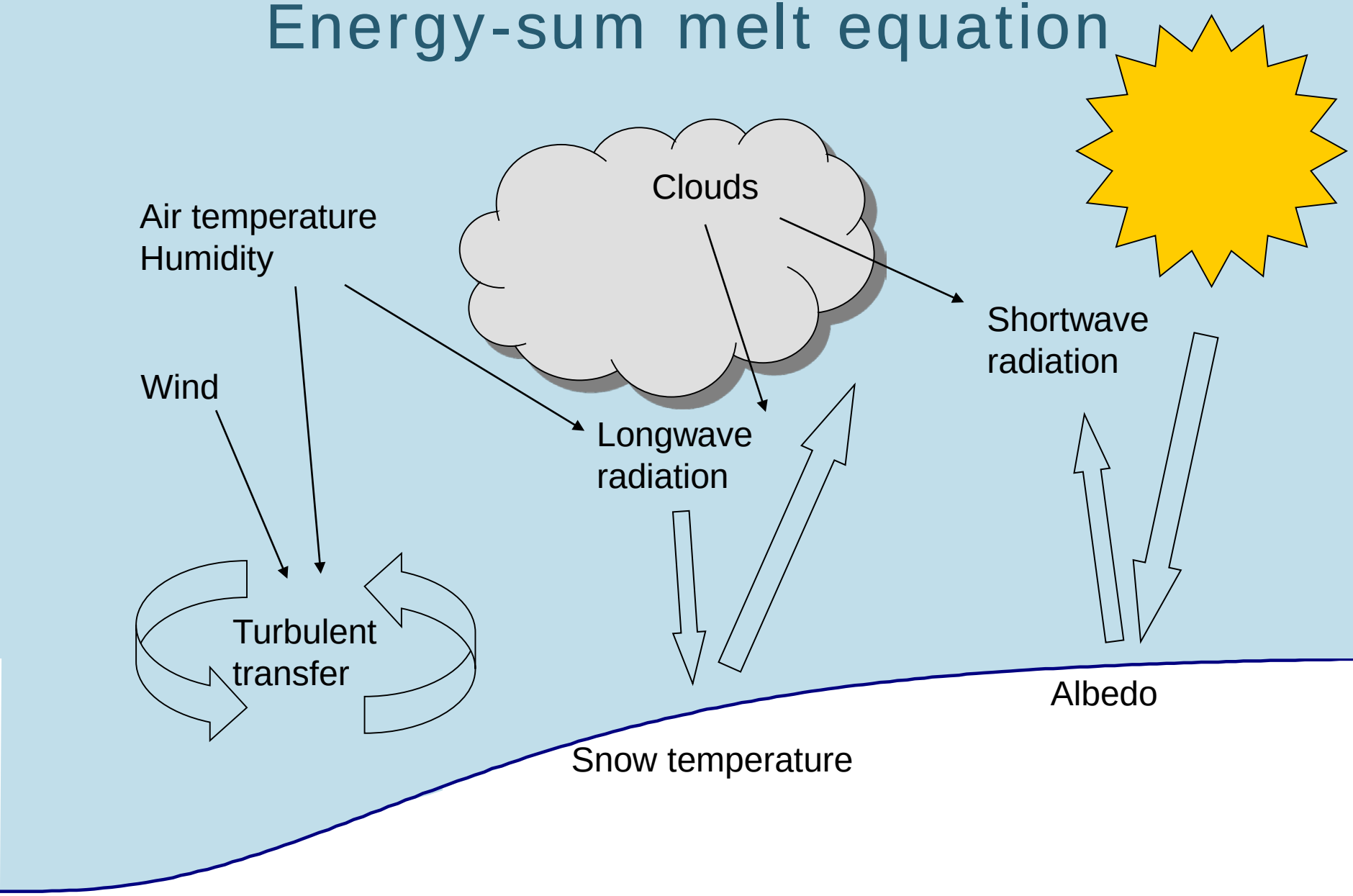


2-par Kirchner

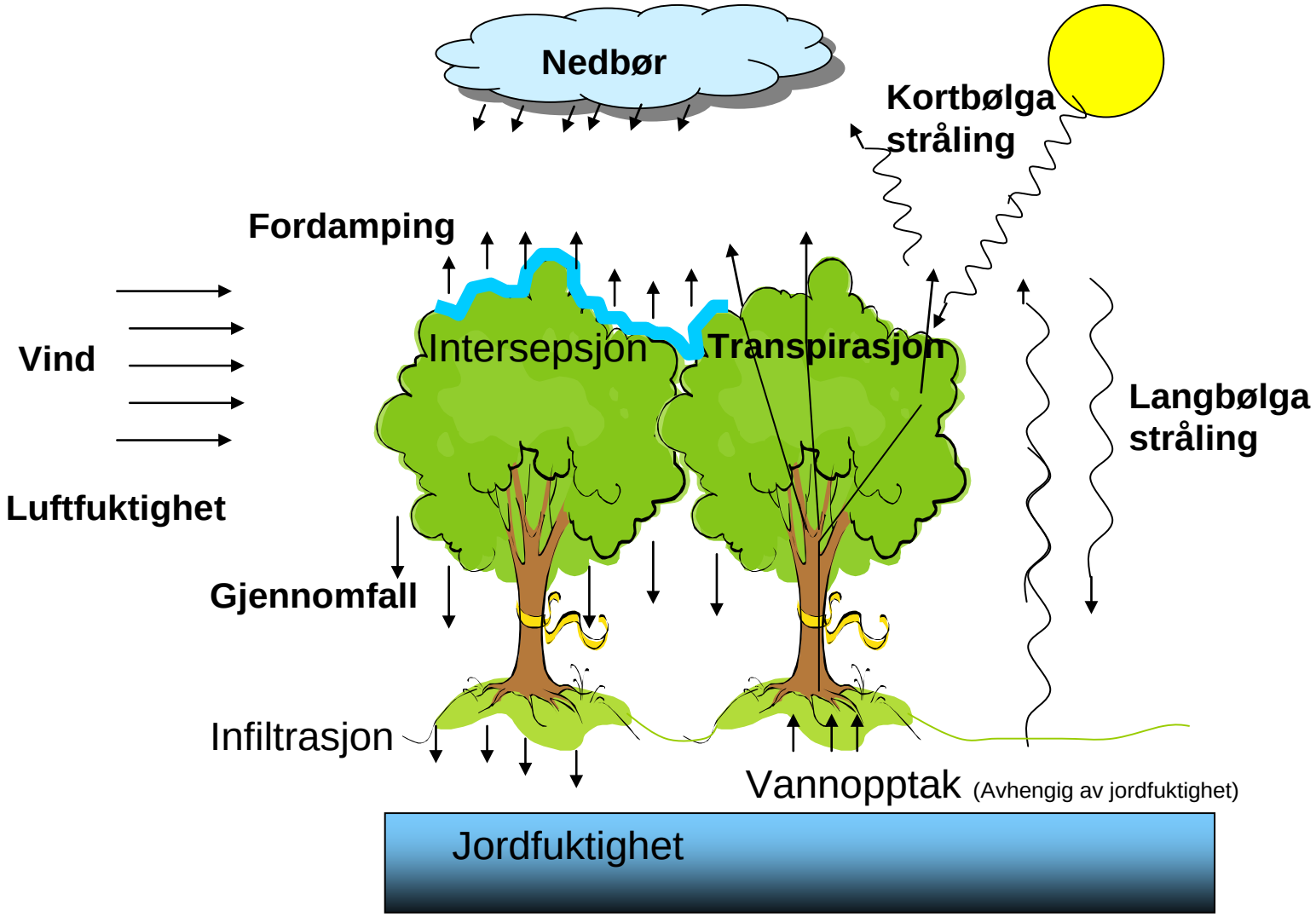
Regional cal: 0.684

Local cal: 0.752

Energy-sum melt equation

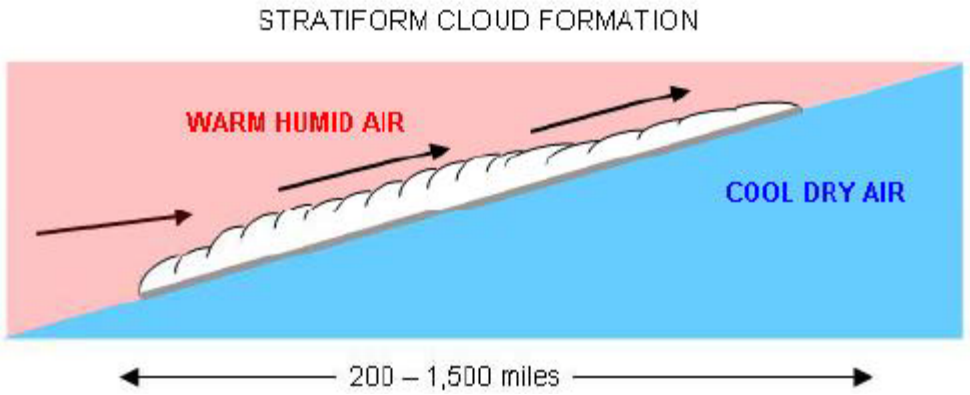


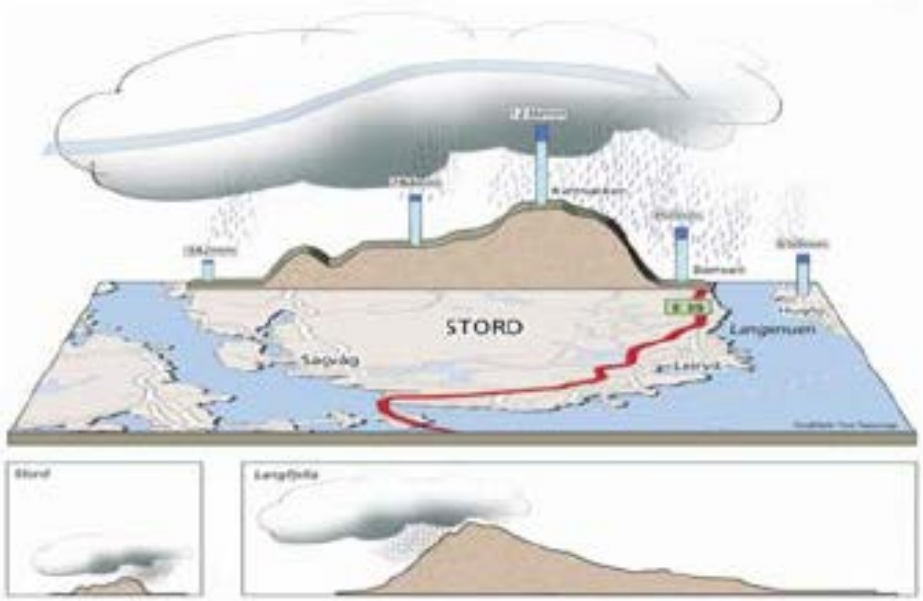
Prosesses in land surface evaporation

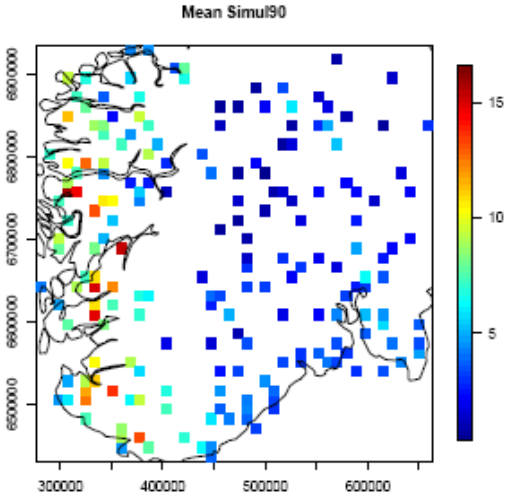


Forms of precipitation

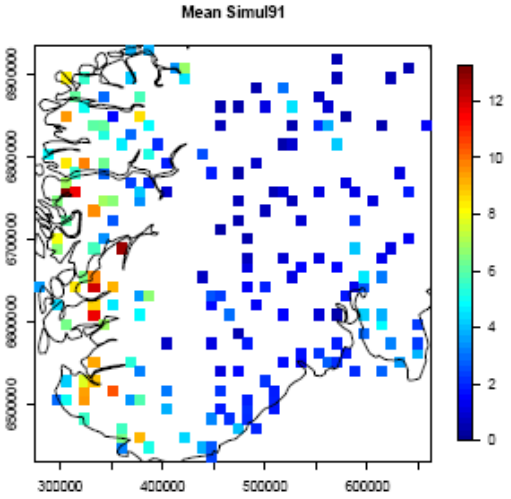
- Stratiform precipitation
  - Warm front
  - Cold front
- Convective precipitation
- Orografically enhanced precipitation



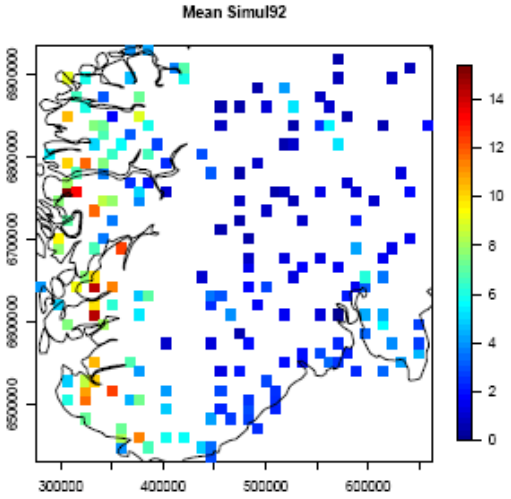




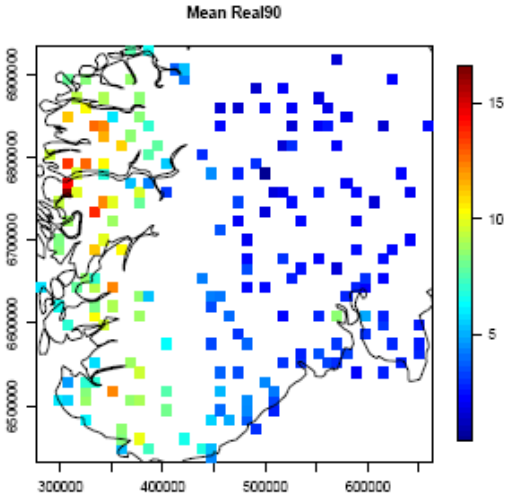
Mean real 1990



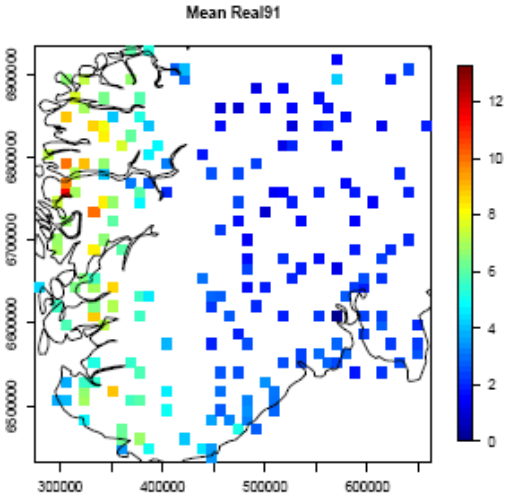
Mean real 1991



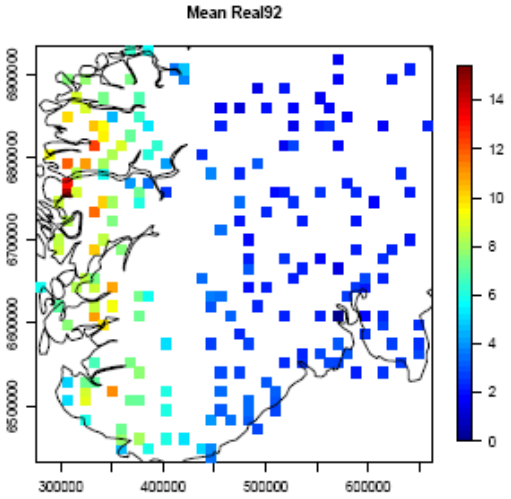
Mean real 1992



Mean simul 1990



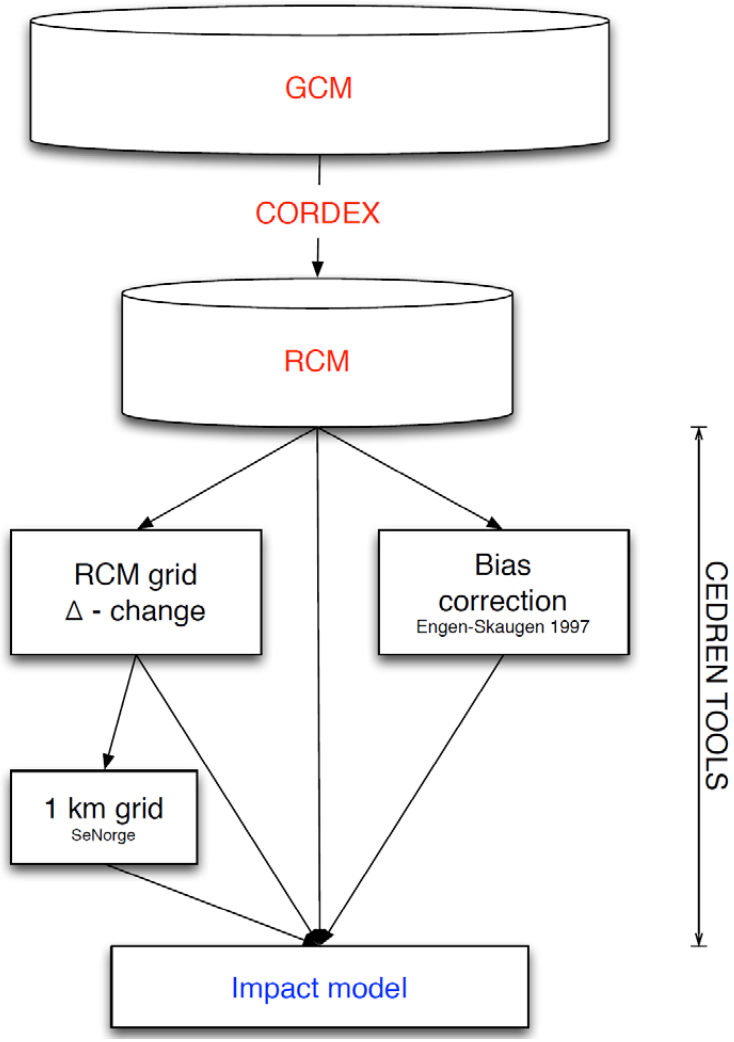
Mean simul 1991



Mean simul 1991

TOOLS: Routines for efficient analysis

- Et felles grensesnitt for
  - Hydrologiske modeller
  - Planleggingsmodeller
  - Miljømodeller
- Rutiner for datafangst
  - Klimascenarier
  - Reanalyse, varslingsgrid
  - Fjernmålingsdata
  - GIS-data
  - Punkt-måleserier
- Nedskaleringsrutiner



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HYDRO

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ECO

Lyse