



HYDROPEAK

WP8

Knut Alfredsen, Netra P. Timalsina, Solomon B. Gebre, Thibault Boissy, Siv Heggen, Siri A. Stenhaug, Felix Beckers NTNU

Julie Charmasson, Hans-Petter Fjeldstad, SINTEF






Målet med arbeidet

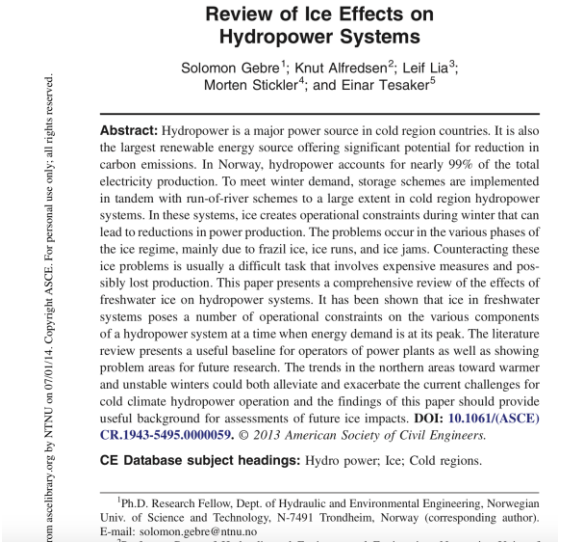
- Kva er status for kunnskapen om is?
- Testing og utprøving av ein modell for simulering av is i Norske vassdrag
- Utprøving på praktiske isproblem
- Metoder for observasjon av islegging og transport av is.
- Klimaverknader på istilhøve.

Samarbeid

- Arbeidet på Hydropeak WP8 er kopla mot to andre prosjekt:
  - Berekraftig Infrastruktur – SIP ved NTNU. Delprosjekt på is og infrastruktur.
  - Cryosphere-atmosphere interactions in a changing Arctic climate. Nordisk prosjekt under toppforskningsitiativet.

Kunnskapsopsummering

- Litteraturstudie på is og kraftproduksjon
  - Samla publiserte data frå tidsskrift, rapportar og konferanser i ei oppsummering
  - Journal of Cold Regions Eng.
- Status for is i nord-områda
  - Oppsummering av kunnskap sidan AMAP
  - SWIPA / Ambio
- Gjennomgang av norske observasjonsdata.
  - CRIPE konferanseartikkel



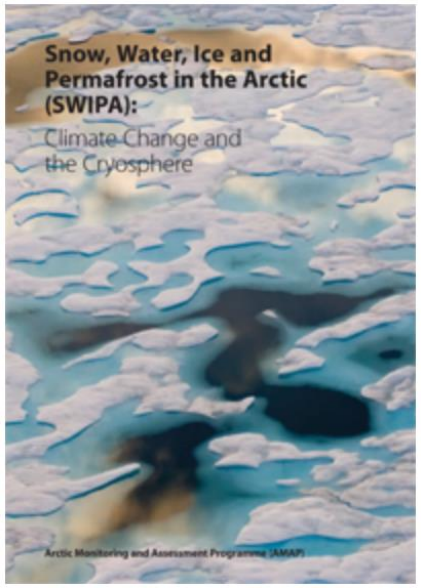
Review of Ice Effects on Hydropower Systems

Solomon Gebre[1]; Knut Alfredsen[2]; Leif Lia[3]; Morten Stickler[4]; and Einar Tesaker[5]

Abstract: Hydropower is a major power source in cold region countries. It is also the largest renewable energy source offering significant potential for reduction in carbon emissions. In Norway, hydropower accounts for nearly 99% of the total electricity production. To meet winter demand, storage schemes are implemented in tandem with run-of-river schemes to a large extent in cold region hydropower systems. In these systems, ice creates operational constraints during winter that can lead to reductions in power production. The problems occur in the various phases of the ice regime, mainly due to frazil ice, ice runs, and ice jams. Counteracting these ice problems is usually a difficult task that involves expensive measures and possibly lost production. This paper presents a comprehensive review of the effects of freshwater ice on hydropower systems. It has been shown that ice in freshwater systems poses a number of operational constraints on the various components of a hydropower system at a time when energy demand is at its peak. The literature review presents a useful baseline for operators of power plants as well as showing problem areas for future research. The trends in the northern areas toward warmer and unstable winters could both alleviate and exacerbate the current challenges for cold climate hydropower operation and the findings of this paper should provide useful background for assessments of future ice impacts. **DOI: 10.1061/(ASCE)CR.1943-5495.0000059.** © *2013 American Society of Civil Engineers.*

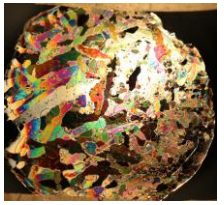
CE Database subject headings: Hydro power; Ice; Cold regions.

[1]Ph.D. Research Fellow, Dept. of Hydraulic and Environmental Engineering, Norwegian Univ. of Science and Technology, N-7491 Trondheim, Norway (corresponding author). E-mail: solomon.gebre@ntnu.no



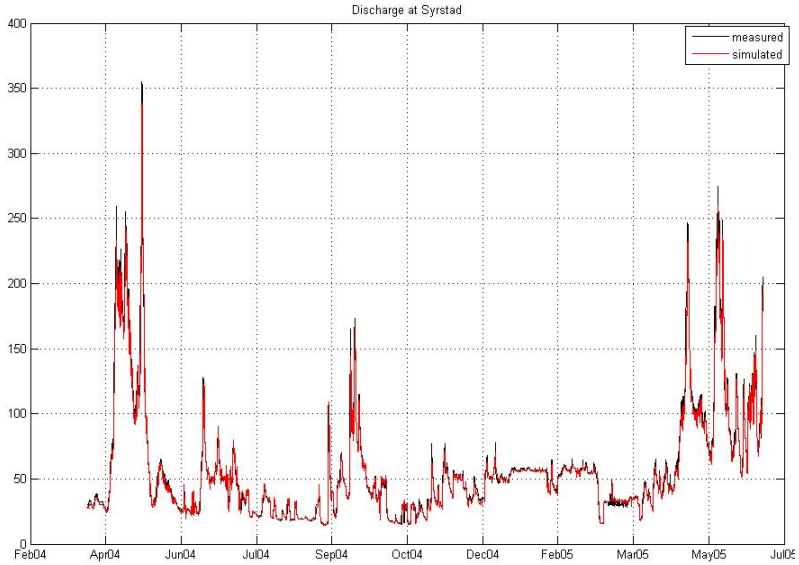
Måling av is

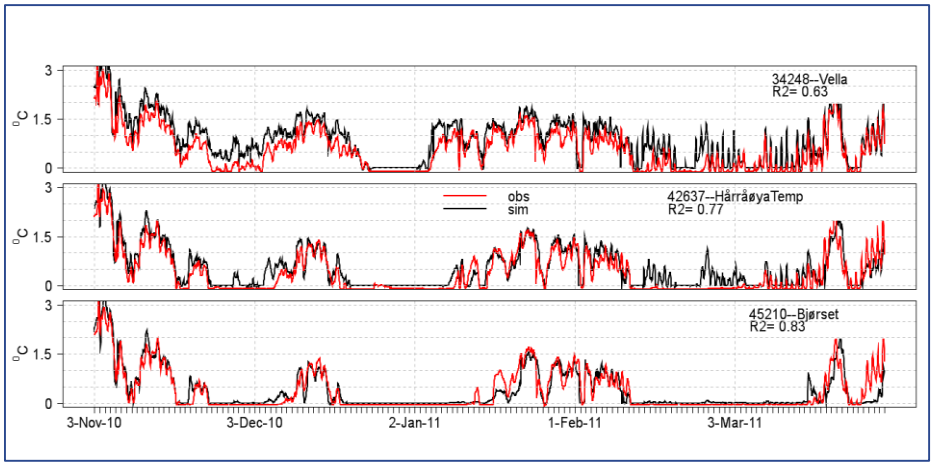
- Observasjon av is vha kamera frå land og lufta
  - Tolkning av bilete
  - Bruk i kalibrering og for vekstanalyse
- Måling av sarr vha Shallow Water Profiler
- Kjerneboring og analyse av vekst og struktur
- *Laserscanning*



Modellering av isproduksjon

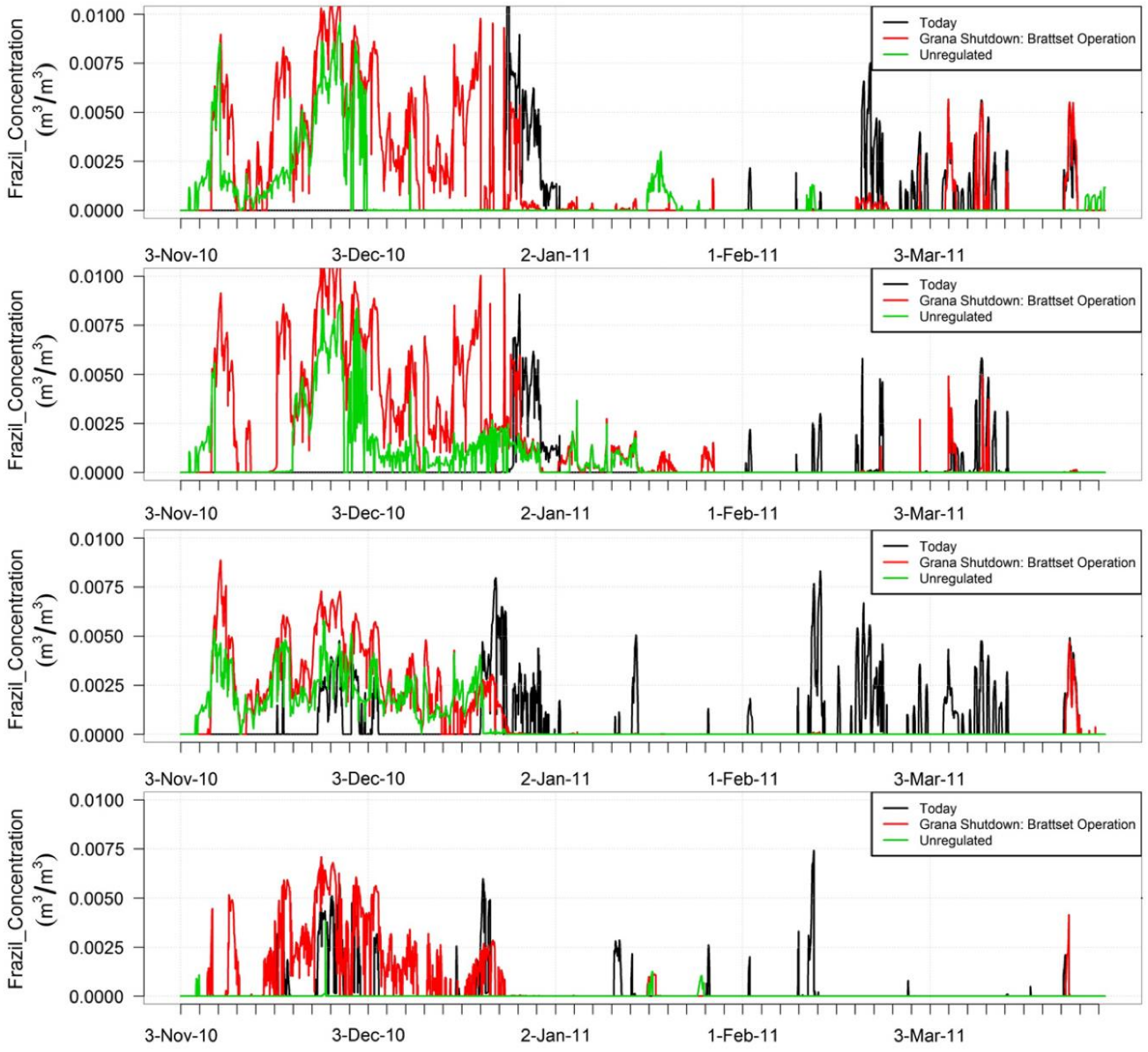
- Tilpassing og oppsett av MIKE-ICE i Orkla
  - Måling av inngangs og kalibreringsdata
  - Rutinetilpassing (norske elver er bratte)
  - Testing og utprøving
  - Identifisering av manglar og moglege forbetringar

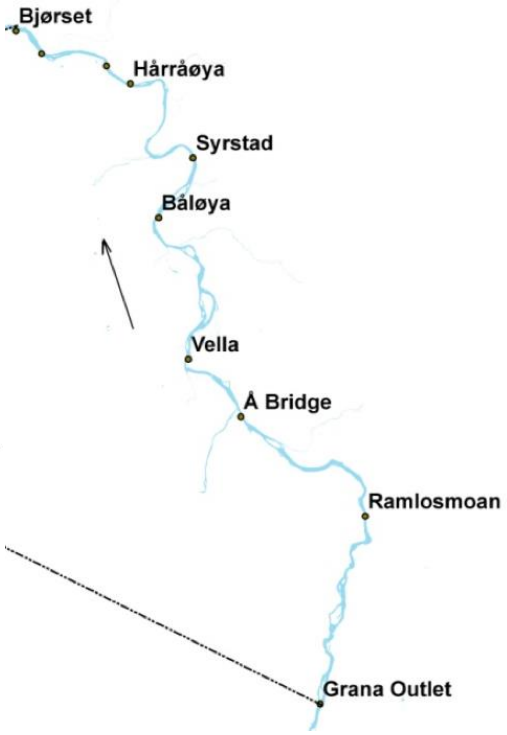




Timalsina et al 2013, CRST)

Regulert og uregulert

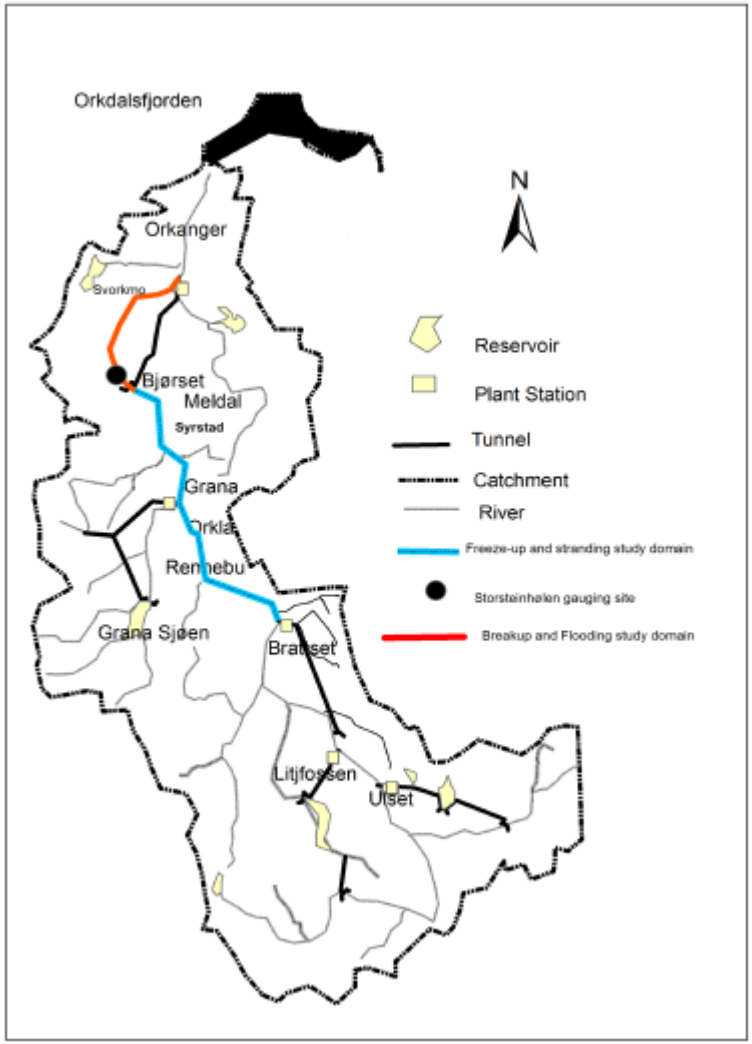


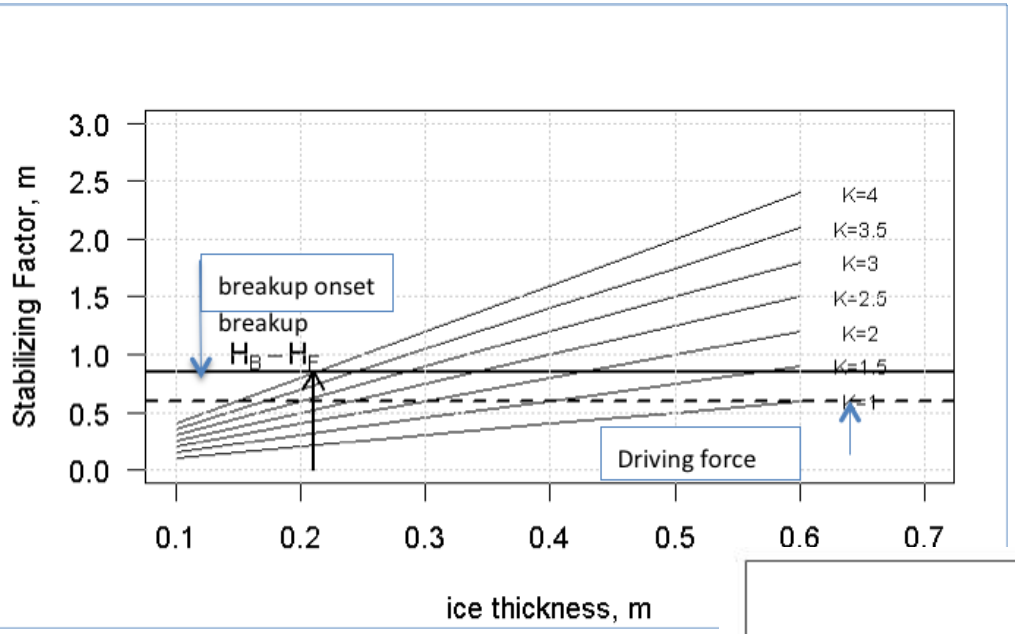


Timalsina et al 2013, CRST)

Is og drift av kraftverk

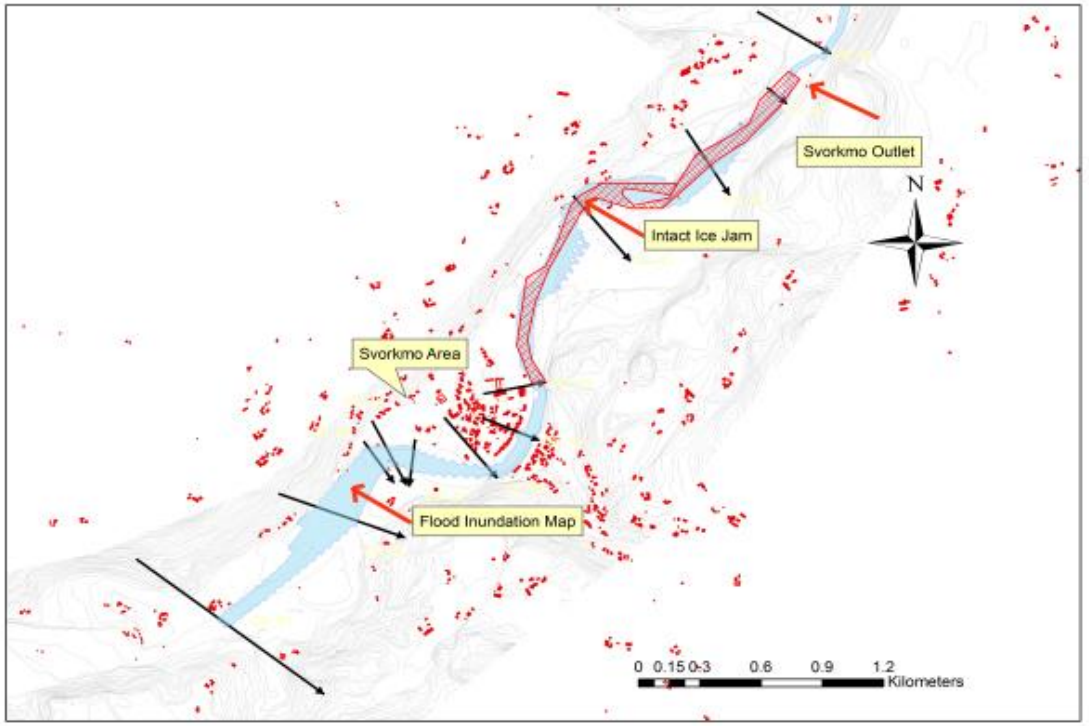
- Reguleringsbestemmelsen for Orkla seier at Brattset og Grana må stoppast ved utfall i Svorkmo pga isproblem.
- Kva effekt har dette for isen nedstraums?
- Kva skjer med elva oppstraums?





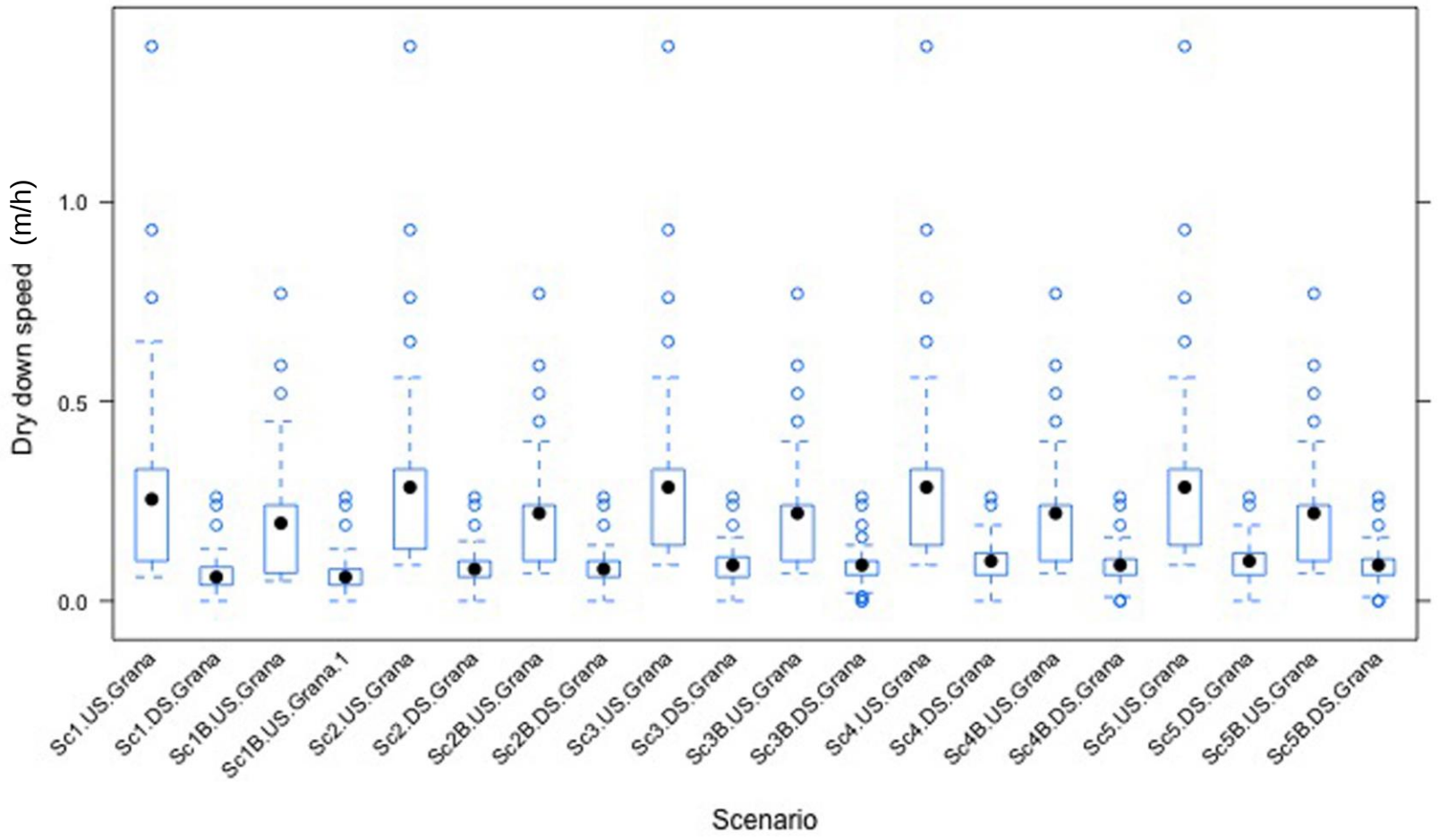
Potensial for isgang ved Bjørset etter Beltaos sin empiriske modell.

Oversvømmelse ved Svorkmo simulert med HEC-Ras, data frå isgang i 2007.



Timalsina, Beckers & Alfredsen (in review)

Effekt oppstraums



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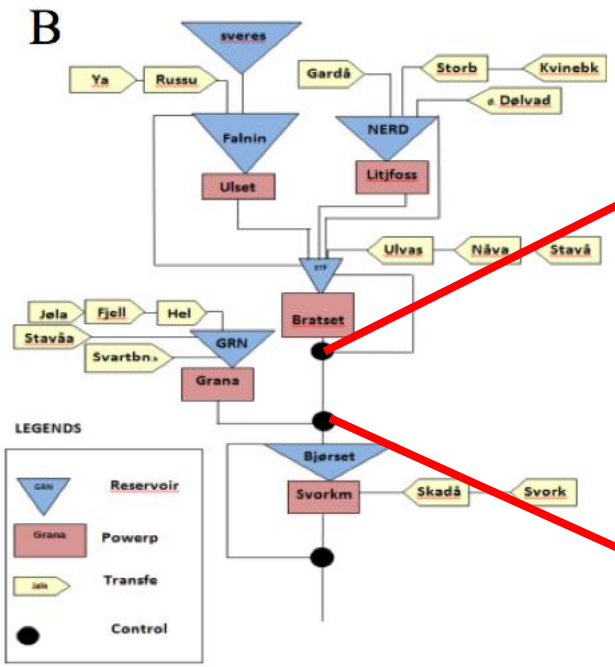
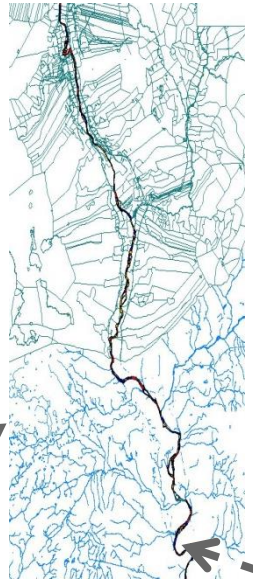
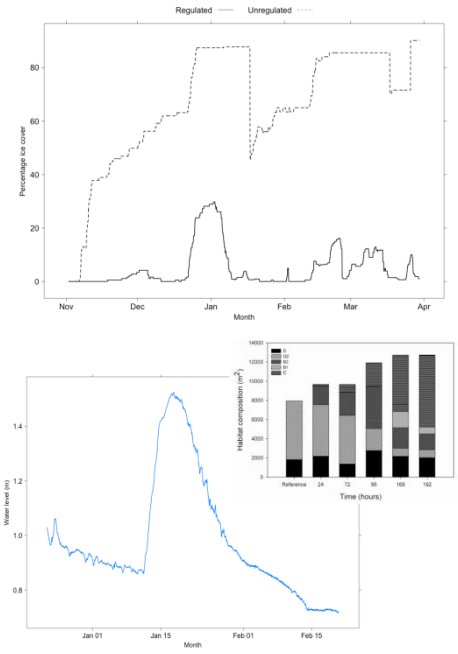
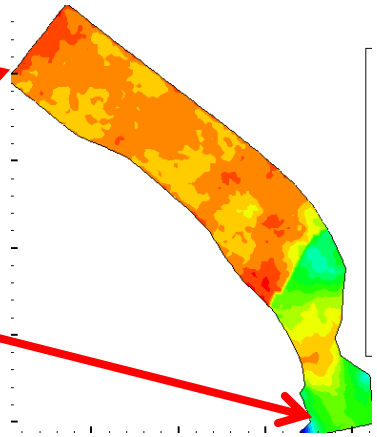
Is og vassdragsmiljø



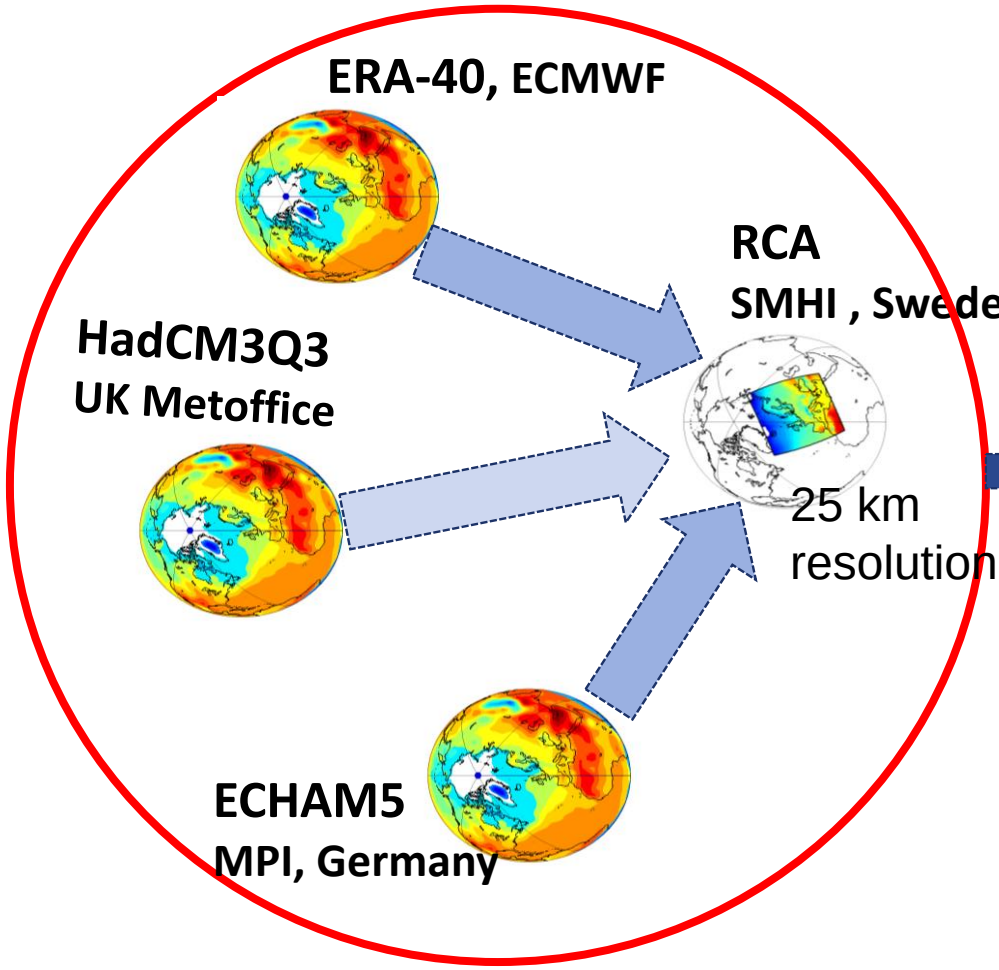






Macro ⟷ Micro

Scenario for framtidas klima



DATA EXTRACTION

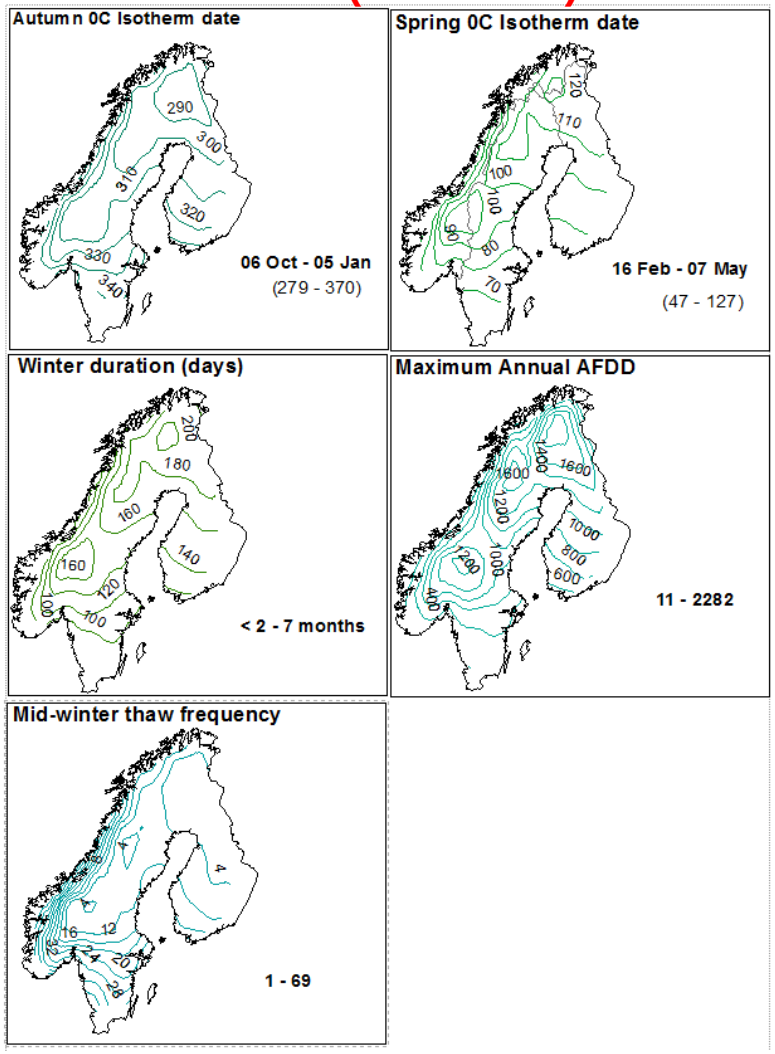
Reanalysis for current climate

Delta change perturbed for future climate

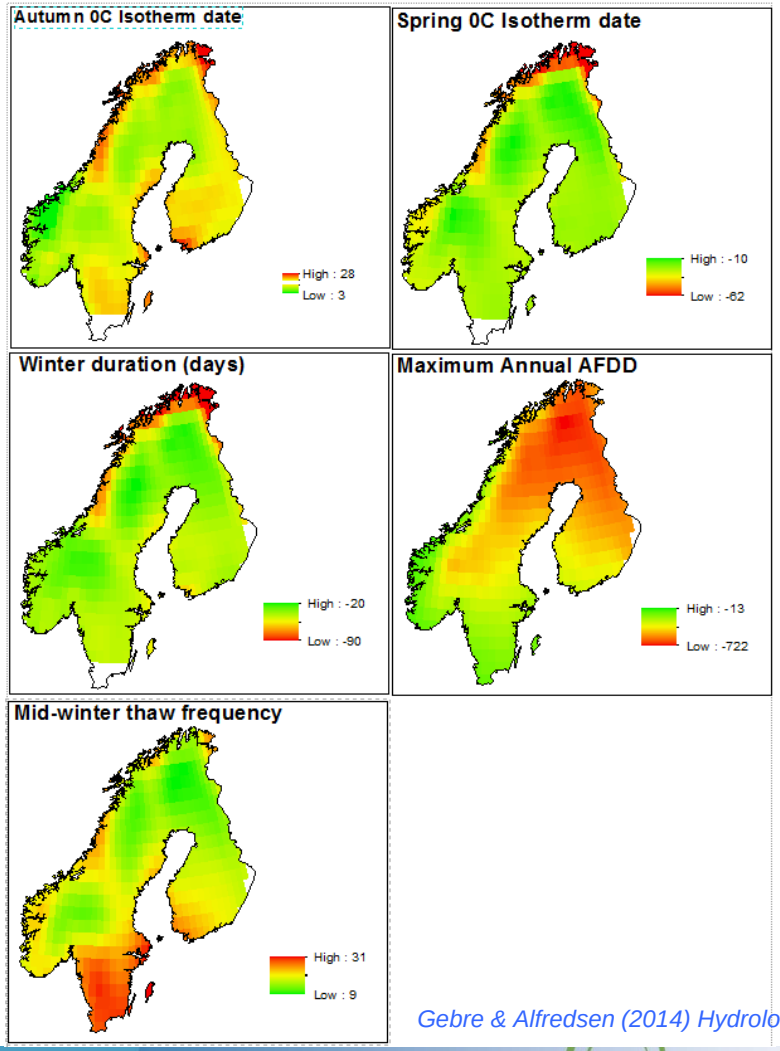
Klimaeffekt på is i framtida

Temperaturindeksar

Current (1961-1990)



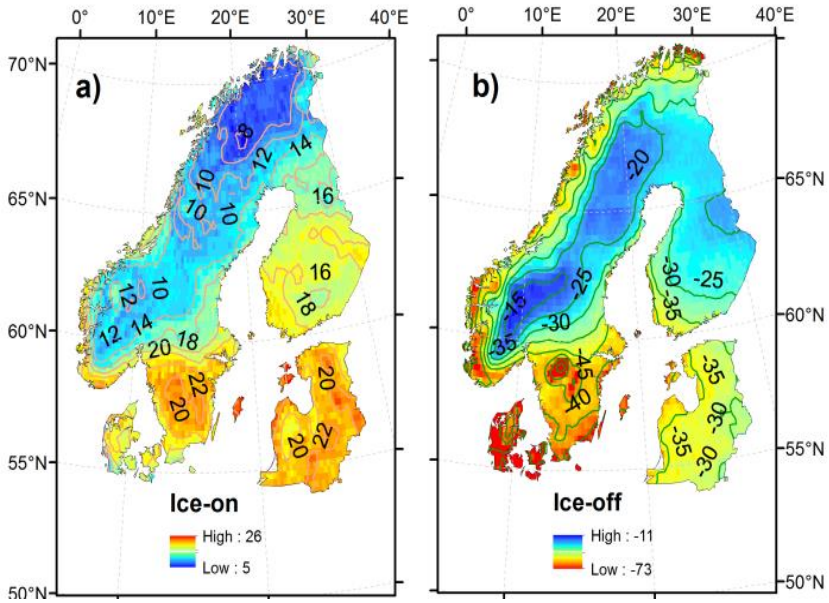
Future (2041-2070)

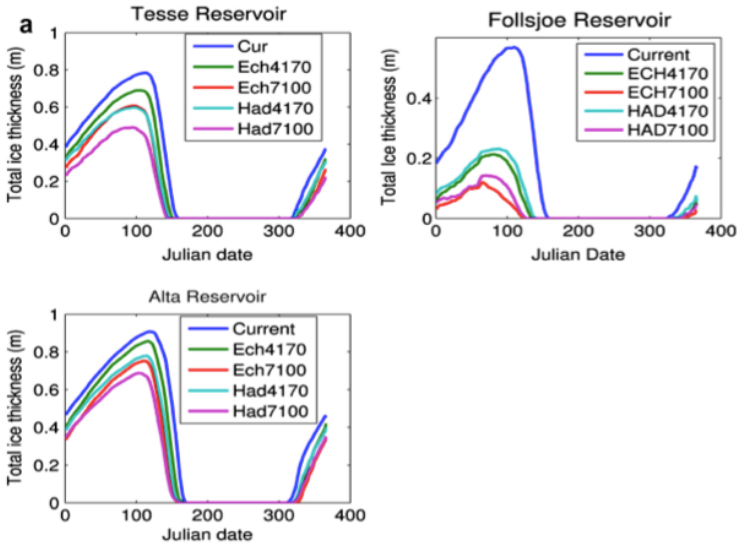


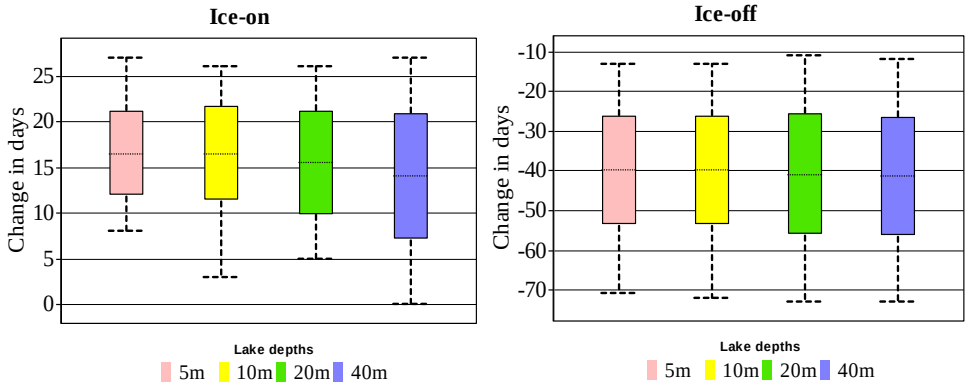
Gebre & Alfredsen (2014) Hydrology Research

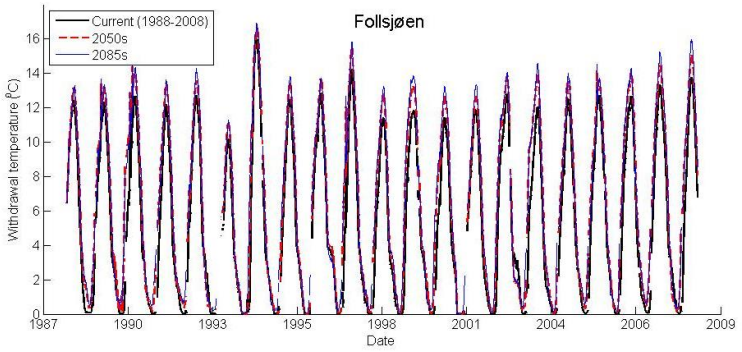
Klimaeffekt på is i framtida

Sjøar og magasin







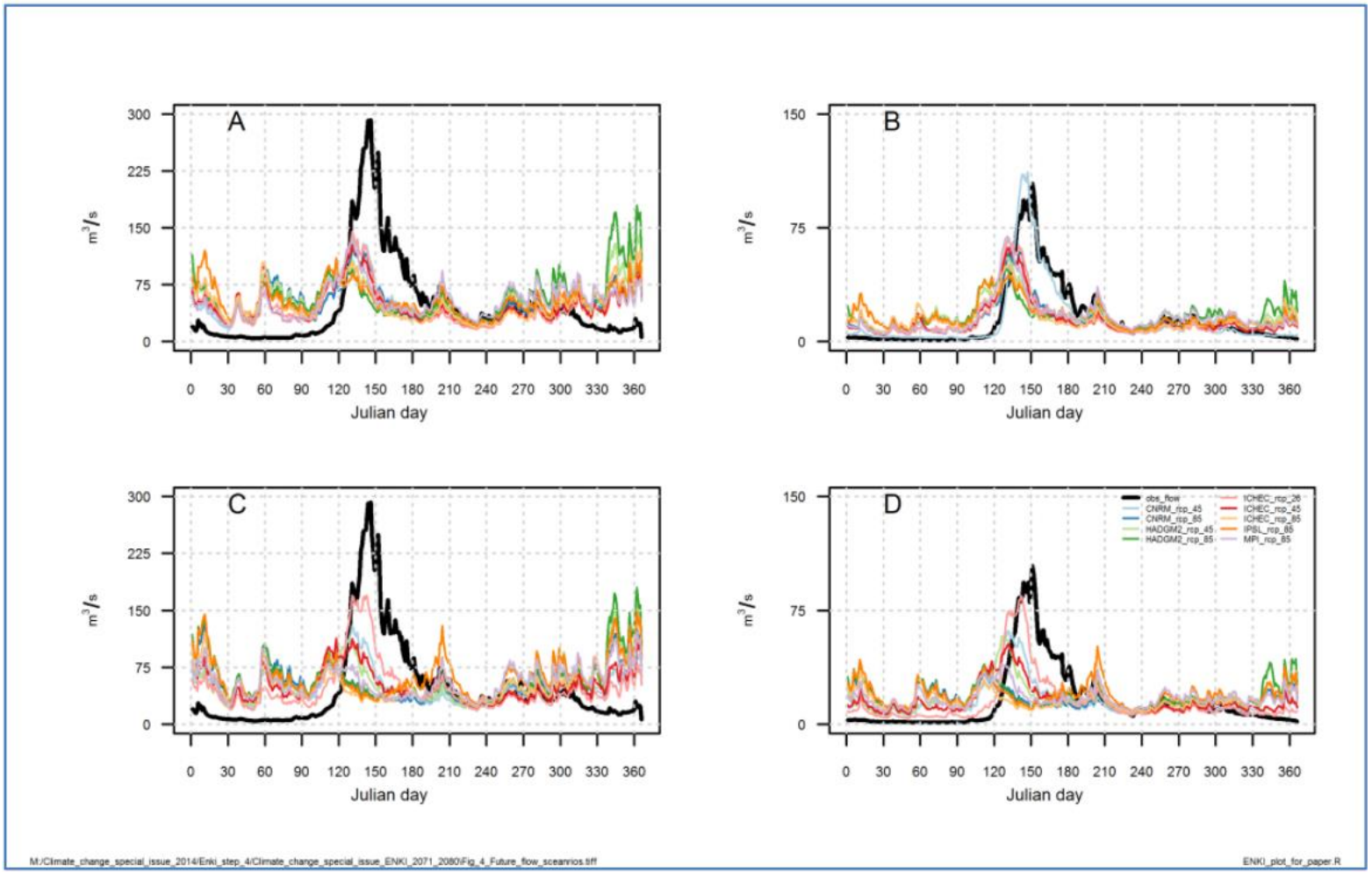


Gebre, Boissy & Alfredsen (2014) The Cryosphere

Gebre, Boissy & Alfredsen (2014) J. of Hydrology

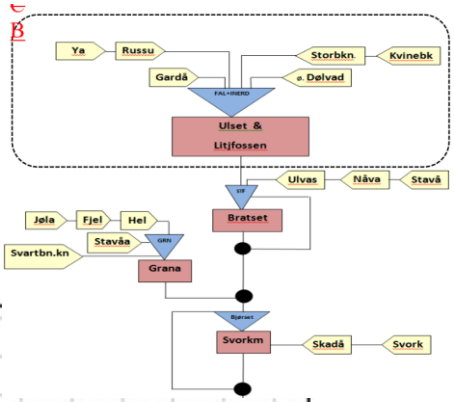
Klimaeffekt på is i regulerte elver

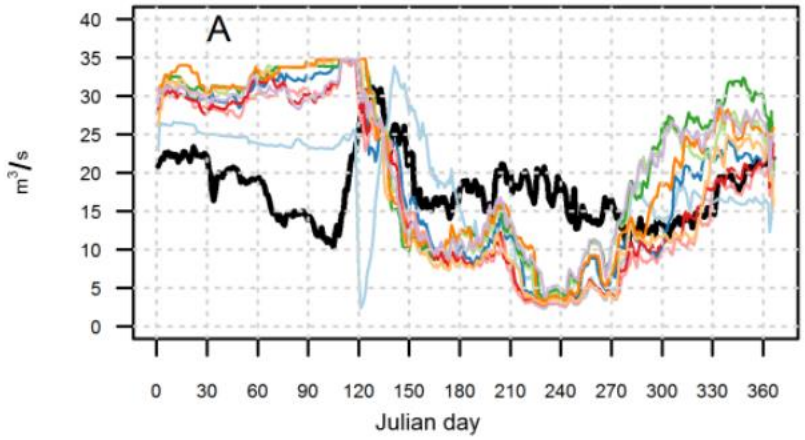
Tilsig

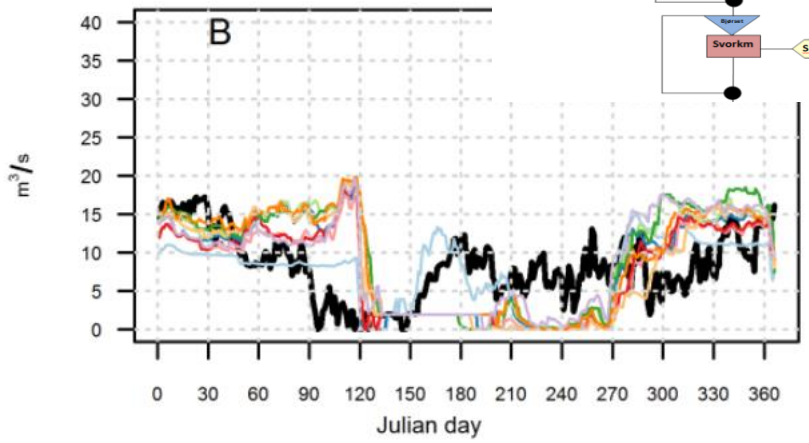


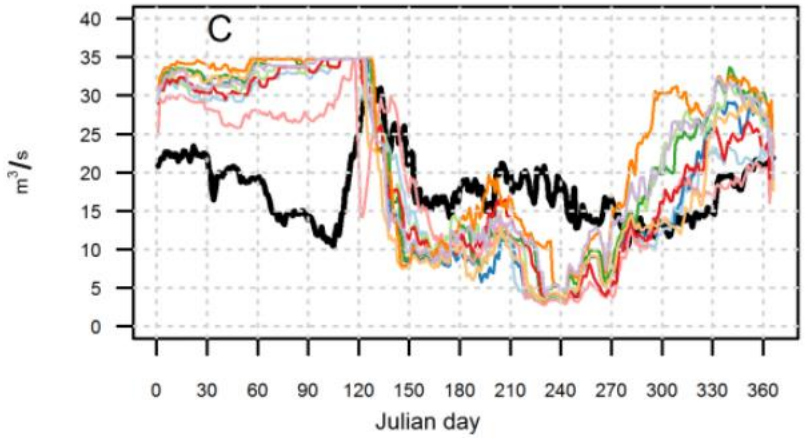
Timalsina, Alfredsen & Killingtveit, (in review CJCE)

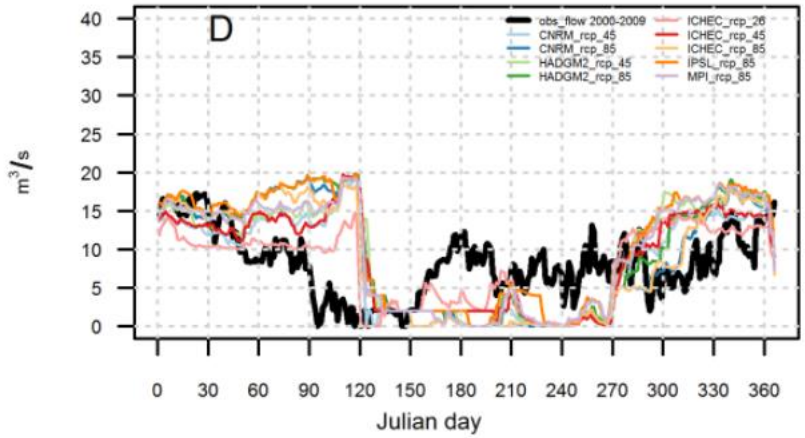
Regulert vassføring







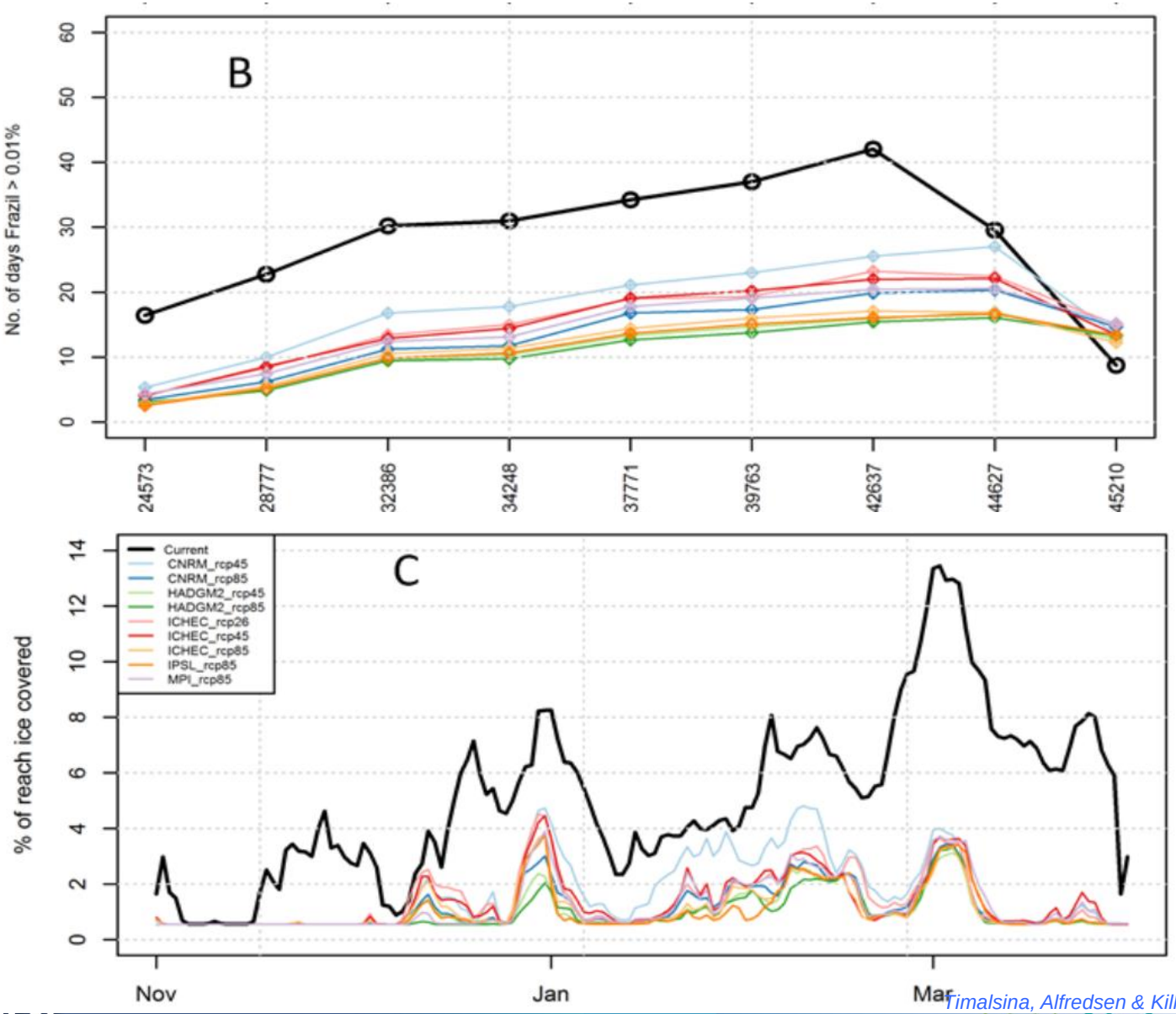




Timalsina, Alfredsen & Killingtveit, (in review CJCE)

Is

Gjennomsnitt 9 år – 2050s



Timalsina, Alfredsen & Killingtveit, (in review CJCE)

Vasskraft i framtidas klima

Hydropower component	Current effects	Climate impact (+)	Climate impact (−)
Dams	Ice loads on dams and dam faces.	Reduced ice loads on dams. Reduced floe size.	More frequent river breakups—more dynamic load on river constructions.
Spillways	Frozen gates, ice formation in spillway tunnels.	Shorter winter season.	-
Reservoirs	Ice forces on banks. Transport.	Reduced ice thickness.	Reduced transport potential.
Trash racks	Clogging by frazil and drifting ice.	Reduced winter season and reduced frazil production—less need for operational constraints and ice removal.	Potential for more ice runs, clogging of intakes. More frazil in rivers with run of the river plants—potential intake problems.
Intake gates	Frost and ice loads on gate.	Shorter season and less ice reduce load.	More mechanical breakups—increased dynamic load.
Water outlets	Stability in reservoirs. Accumulation in river outlets.	Less ice in river outlets.	Further decrease of stability due to lessened ice thickness.
Rivers	Unstable winter ice conditions downstream of outlets.	Reduced length of winter season. Reduced ice formation.	More unstable regime.
Operational	Limits flow variability during ice season.	Reduced ice season—more unrestricted production.	More unstable conditions, blocking by breakups and restraints on operation.

Gebre, Timalsina & Alfredsen (2014) Energies

Oppsummering WP8

- Vi har metoder for å samle data for både å forstå isproduksjon, transport og vekst. Potensiale for vidare bruk av desse metodene.
- God oversikt over modellering av is med MIKE-ICE, modellen verkar å vere den beste så langt for norske elver.
- Modelloppsett for køyring av scenario, både klima og anna. Krev mykje prosessering. Rutiner utvikla.
- Resultat er presentert og publisert.
- 1 stipendiat på WP8 disputerer 9/12, stipendiaten på ISP var ferdig i April.