



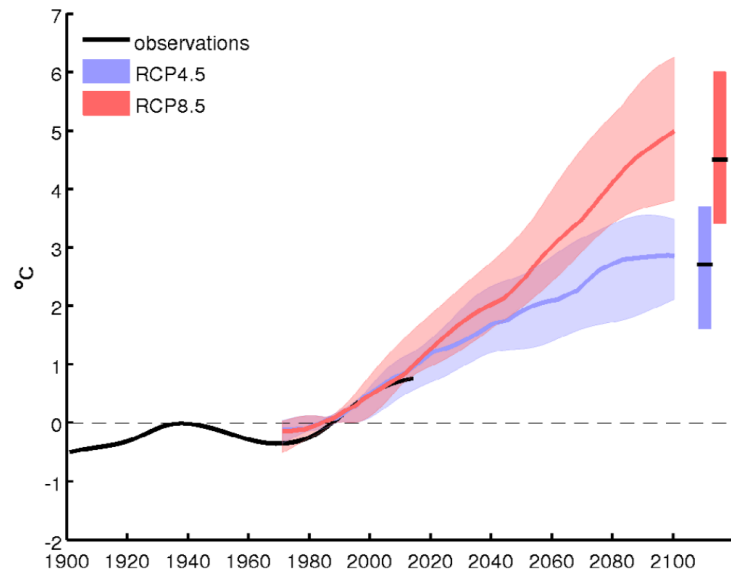
NVE

# WHAT WILL HAPPEN TO HYDRO POWER PRODUCTION IN NORWAY WITH A WARMER AND WETTER CLIMATE?

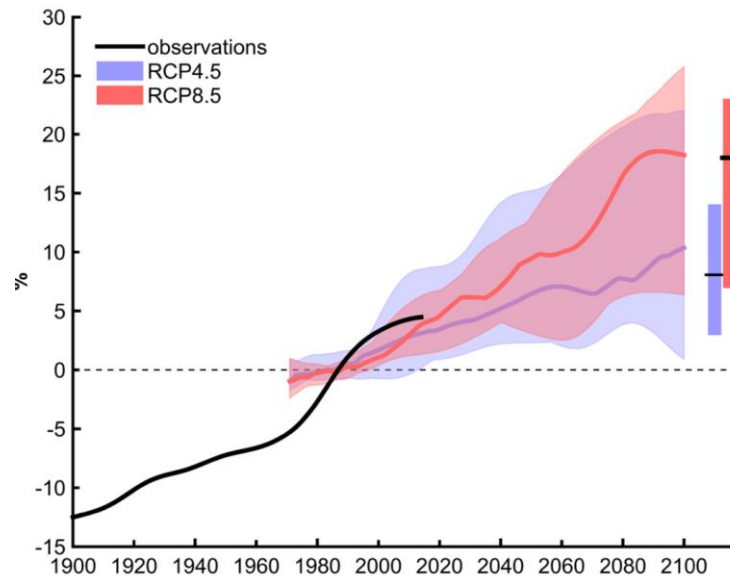
Fredrik Arnesen, NVE  
March 2019

# Climate in Norway: warmer and wetter

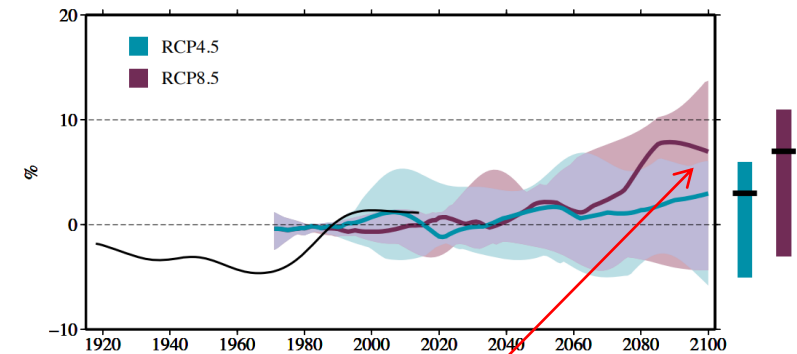
## Temperature change



## Percipitation change



## Runoff change

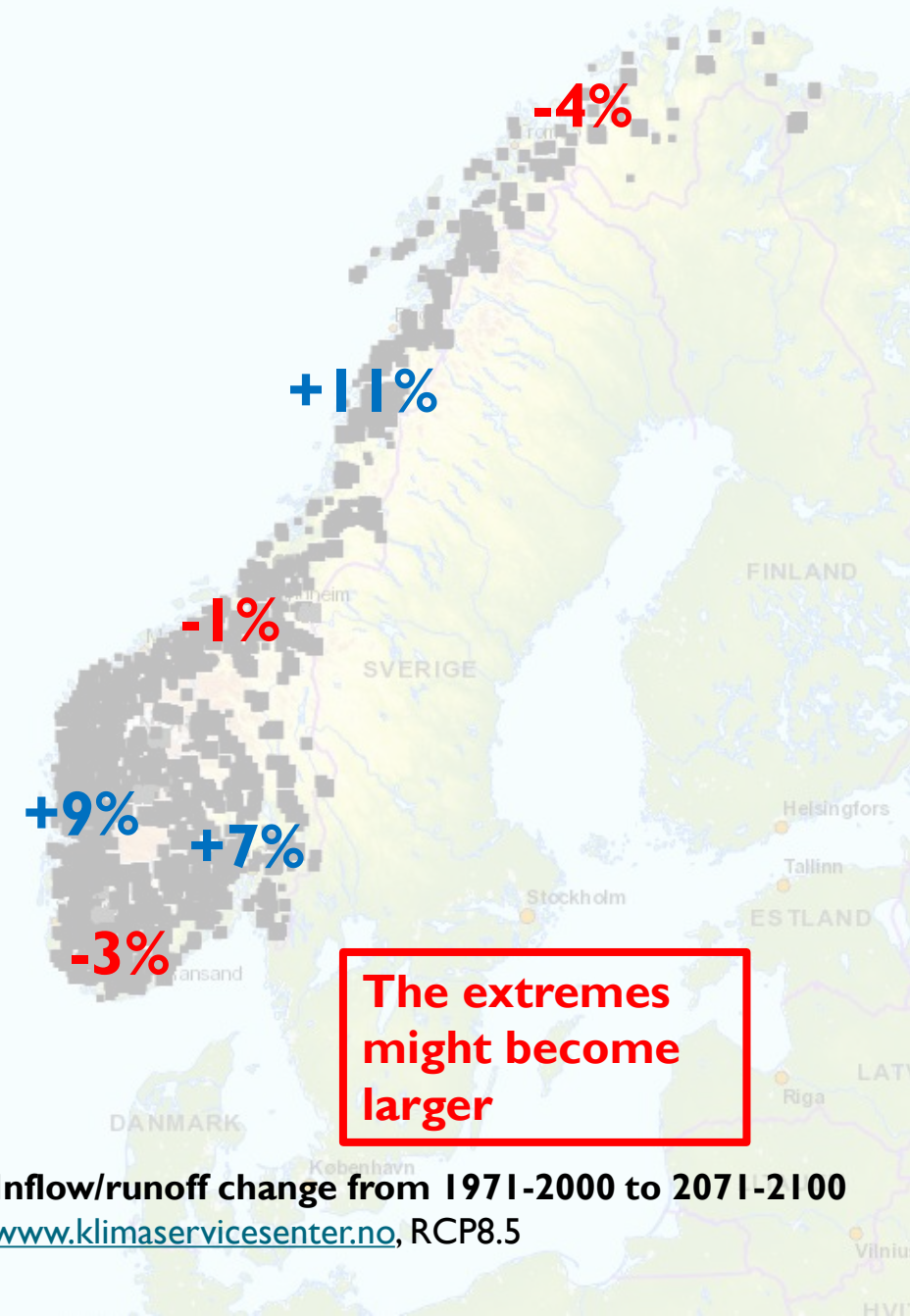


Runoff increases less than the percipitation  
because of evaporation



## 2100: Hydro power production increases, but not everywhere

- Climate changes can increase the Norwegian hydro power production by several **TWh**
- 2100 is still far away
  - Model results are uncertain
  - The hydro power system will change
  - New technologies
  - Consumption will change
  - More interconnections to Northern Europe

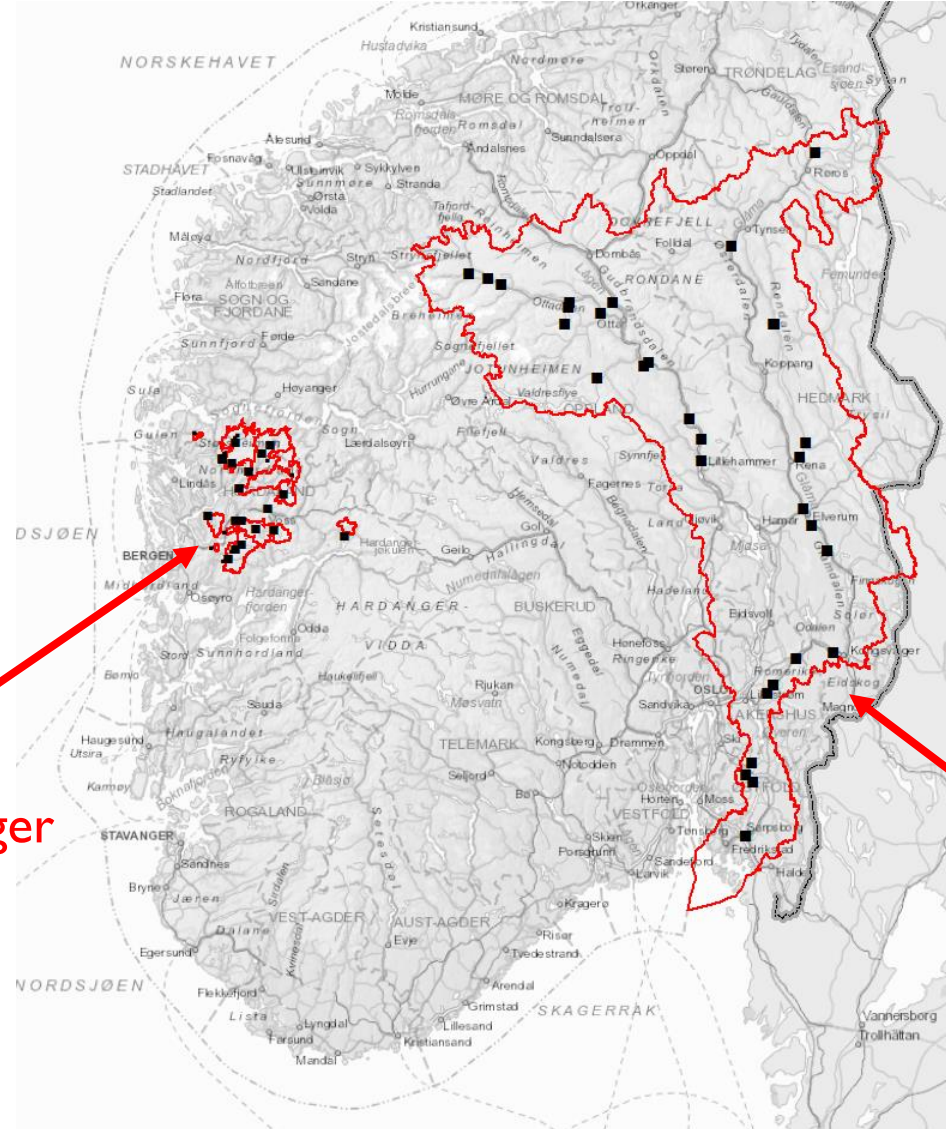


## 2 cases - Different climate

### WEST

- Much rain
- Coastal climate
- No runoff from glaciers

BKK:  
Samnanger  
Modal  
Matre  
Bergsdal  
++



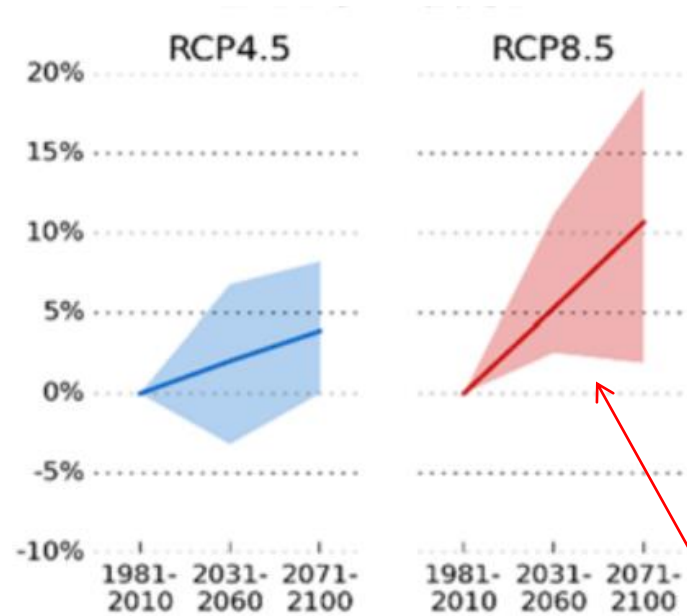
### EAST

- Some rain
- Inland climate
- Some runoff from glaciers

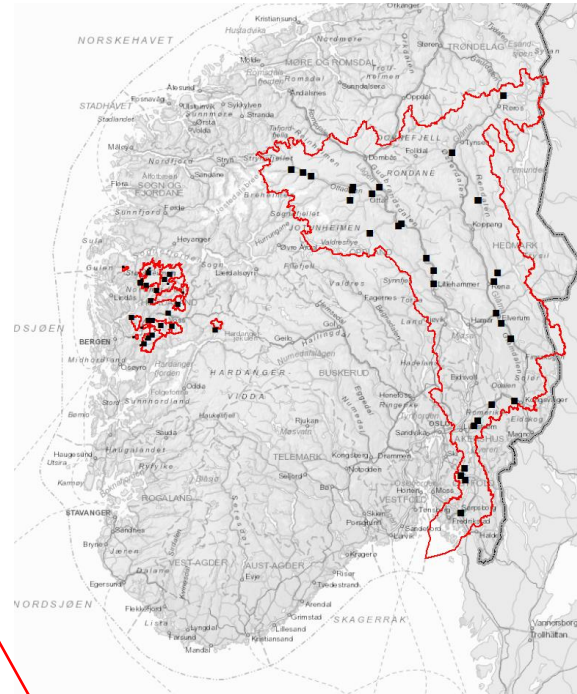
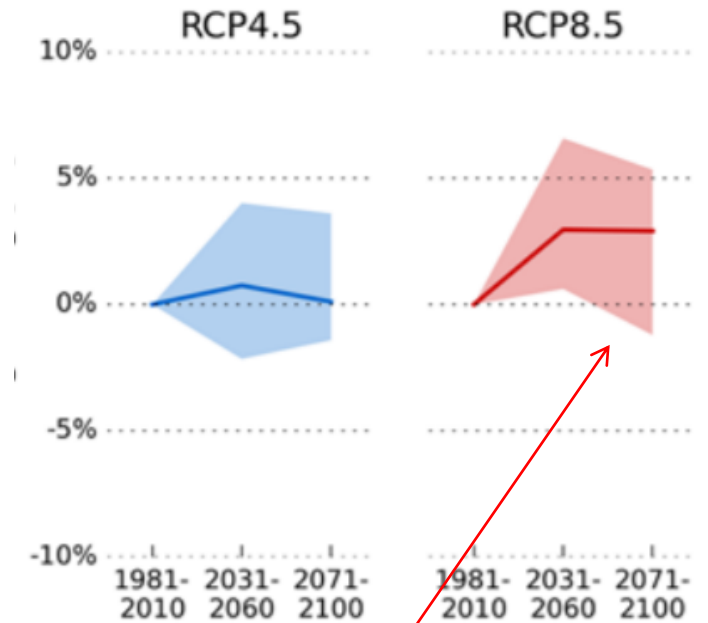
Glomma og Lågen:  
Norway's biggest river

# The energy inflow to the reservoirs is expected to increase

Change in energy inflow – West



Change in energy inflow – East



Much more water

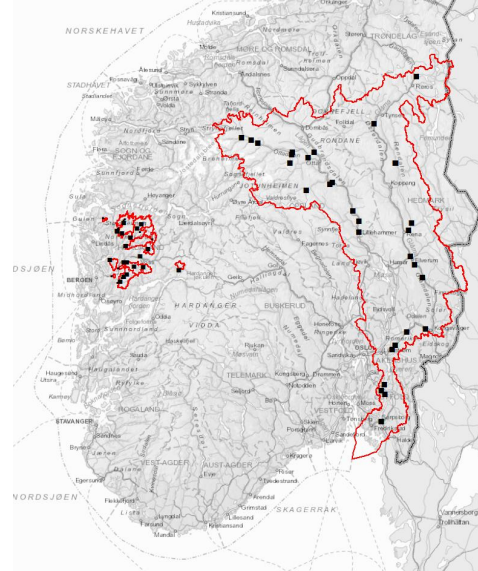
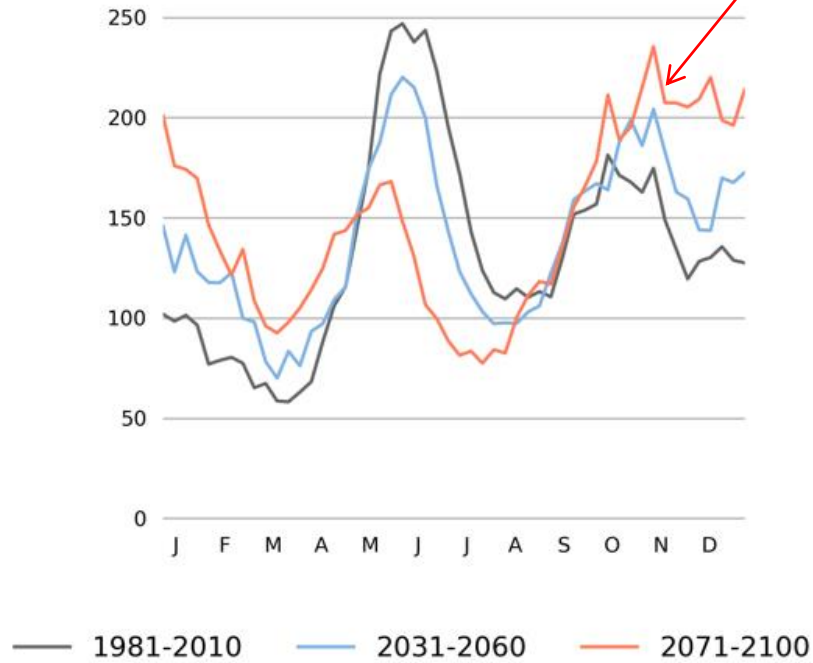
Some more water

# Winter runoff increases

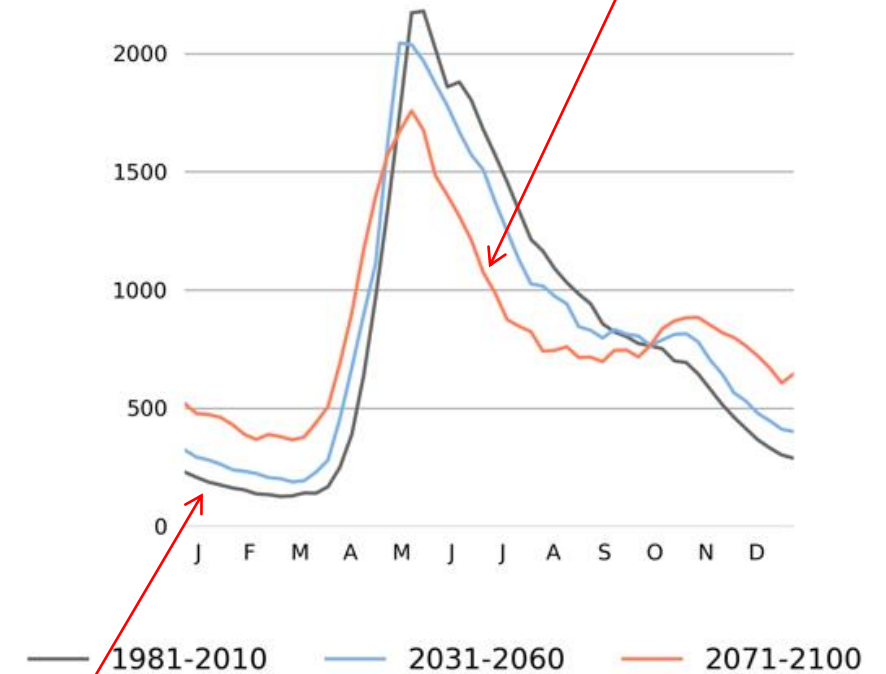
Winter storms increase

Less melting glaciers left  
and more evaporation

**WEST: Inflow profile [GWh/week], RCP 8.5**



**EAST: Inflow profile [GWh/week], RCP 8.5**

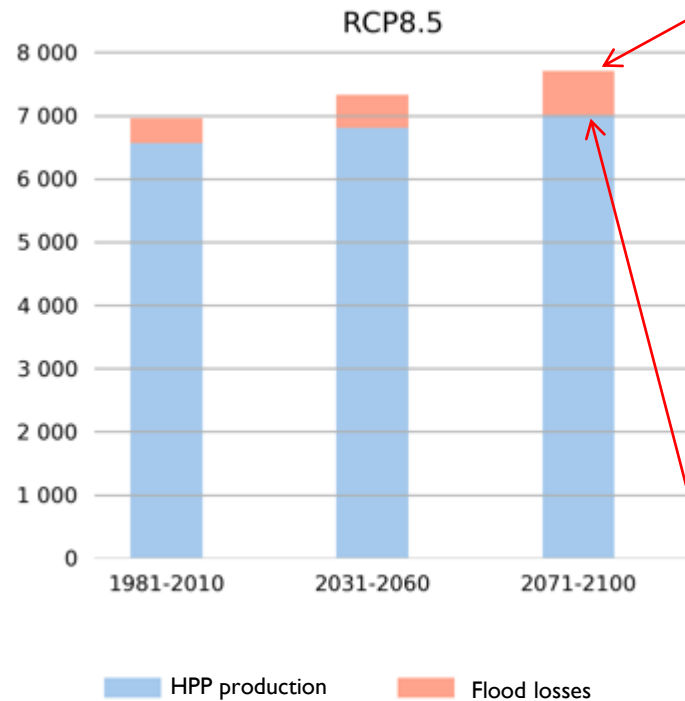


Energy Inflow  
increases by 150 % in  
winter



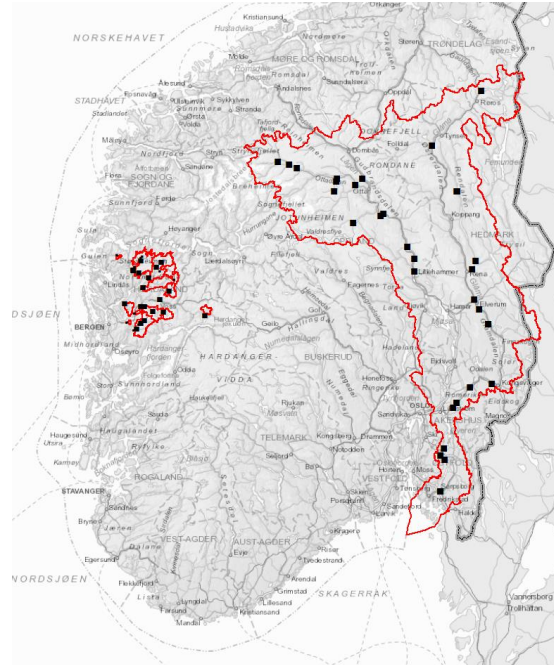
# Flood losses and hydro power production [GWh/year]

## WEST

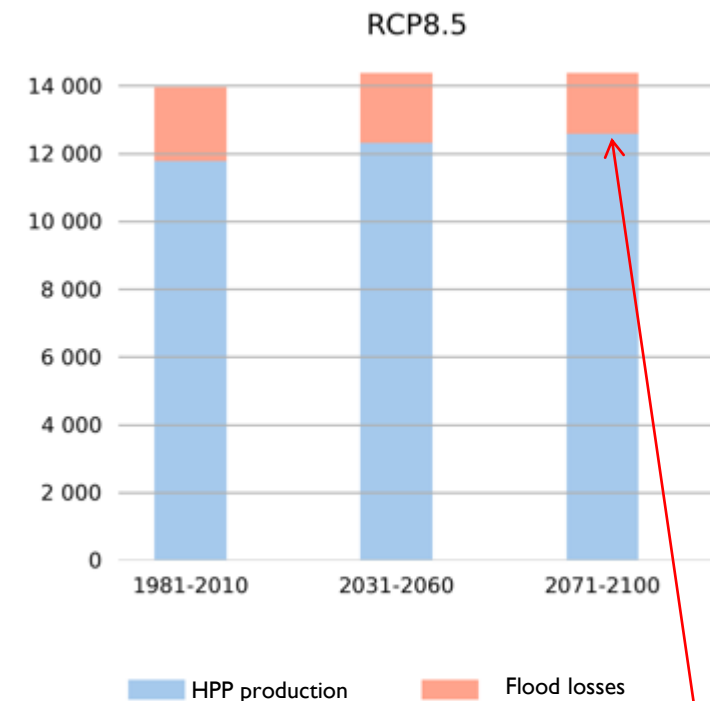


Big increase in flood losses...

... but the production will increase as well.



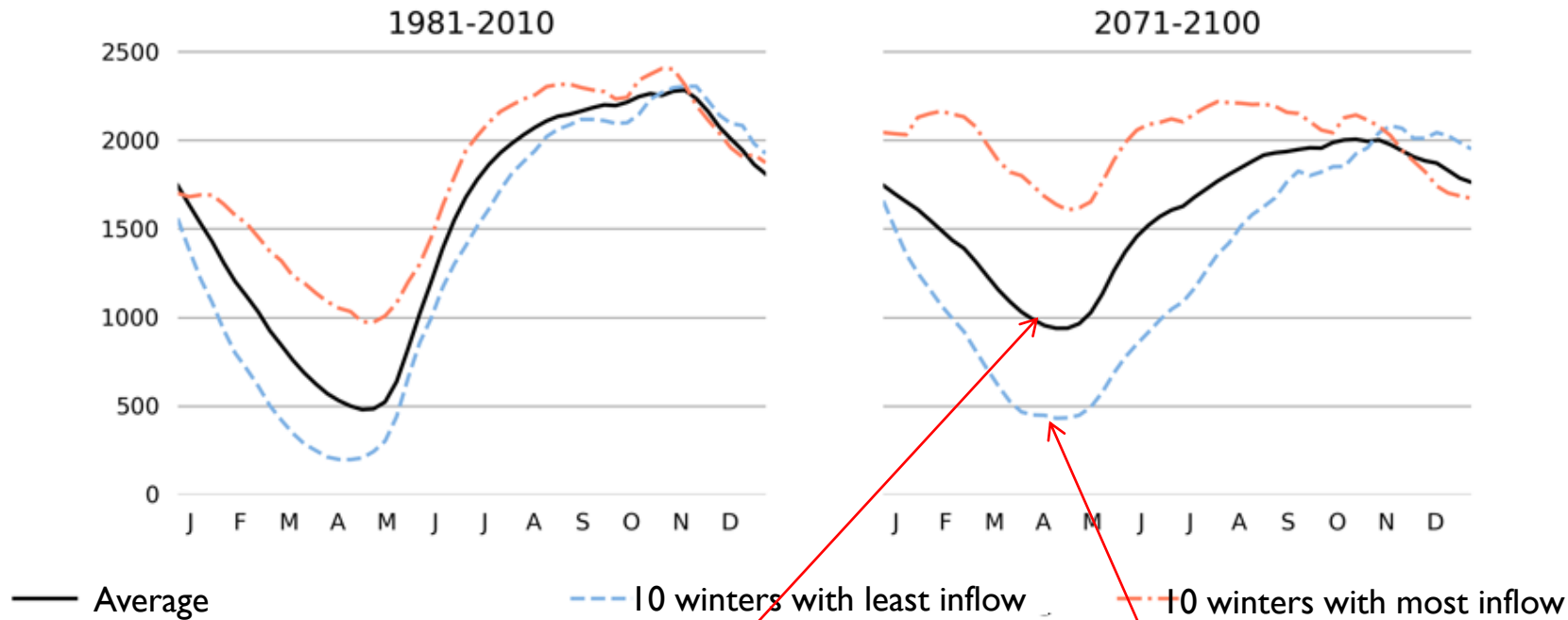
## EAST



Hydro power production increases more than the flood losses because of smaller floods from snow melting in the spring

# Reservoir management will become more challenging

Reservoir profiles [GWh]

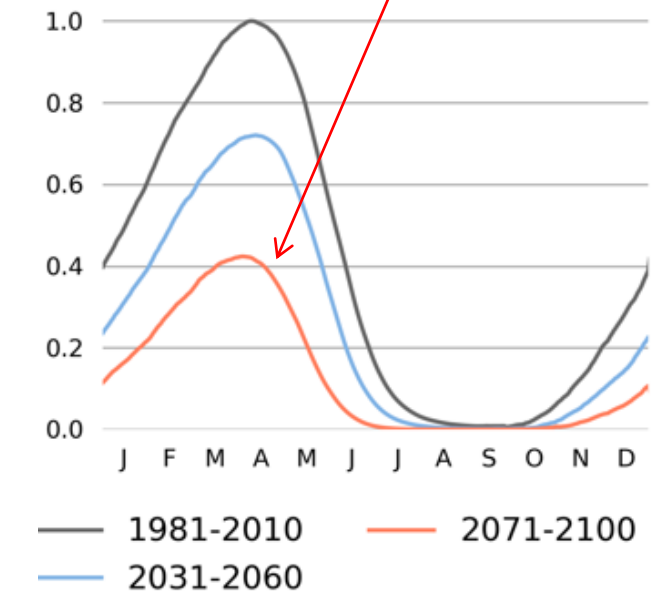


Most years, reservoir levels will be kept higher throughout the winter

... but the reservoir levels will still be needed in cold and dry years

Smaller snow reservoirs

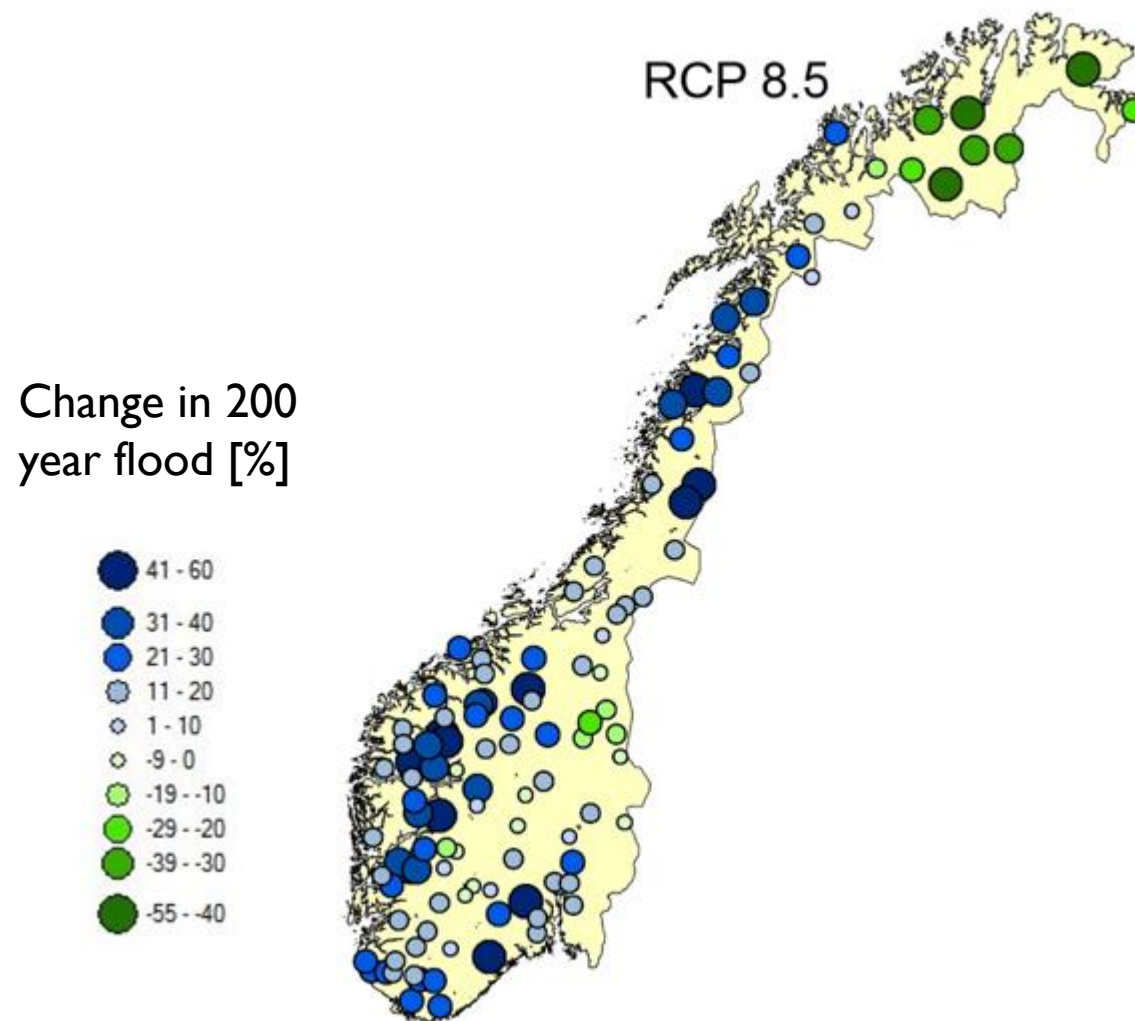
Snow reservoir profiles RCP 8.5



The variability in the amount of snow stored will increase. This makes it harder to plan.



# Mitigation measures – NVE's recommendations



Hydro power production will increase, but climate changes give challenges as well.

— **Today's climate:**

- Every 50-100 years

— **For mitigation measures  
NVE recommends:**

- Every 20 years



Songeelva i Osdalen, Froland, 23.10.2017. Foto: Petter Våge, NVE





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photo Gobotndammen in Matre by NVE, Knut Svendheim, 1974