Climate change and flood frequency: The critical roles of process and seasonality

Deborah Lawrence
Norwegian Water Resources and Energy Directorate

HydroPredict 2012, Vienna, 24 – 27 September

AWA The Interreg IVB North Sea Region Programme
EUROPEAN UNION European Regional Development Fund
FLOODFREQ COST Action ES0901 European Procedures for Flood Frequency Estimation
Norwegian Meteorological Institute met.no
CES Nordic Project on Climate and Energy Systems
norden Nordic Energy Research

Climate Change and the EU Flood Directive:

Impacts of climate change on the occurrence of floods should be taken into account in flood risk assessment and management

National CC adaptation strategy (NVE, 2010):

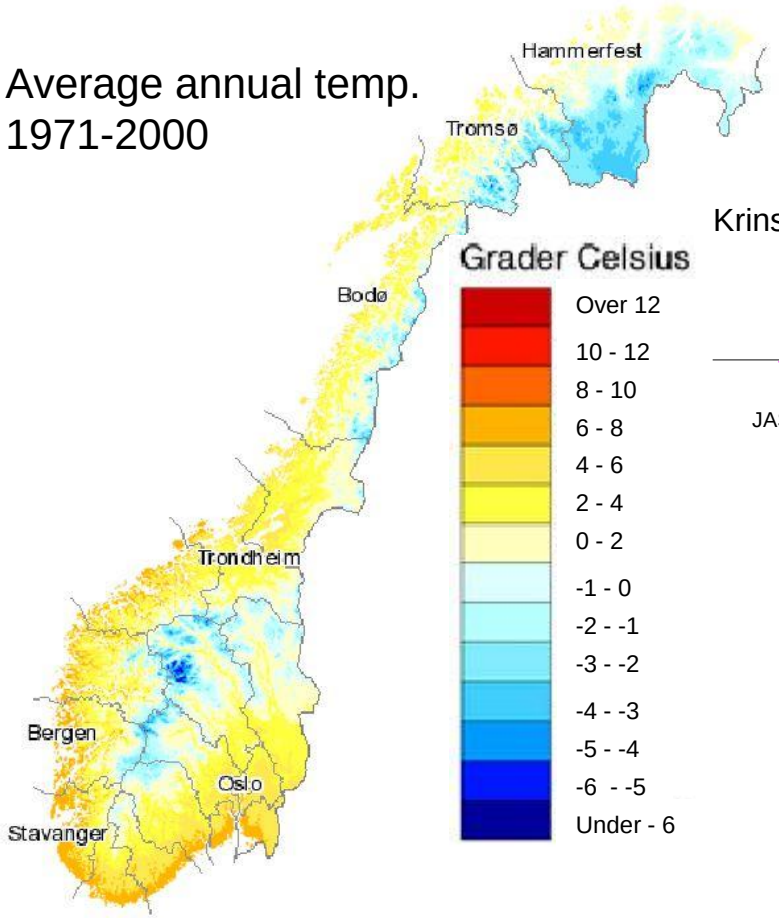
Flood hazard mapping should include an assessment of the potential effects of climate change on flood inundation

Overview

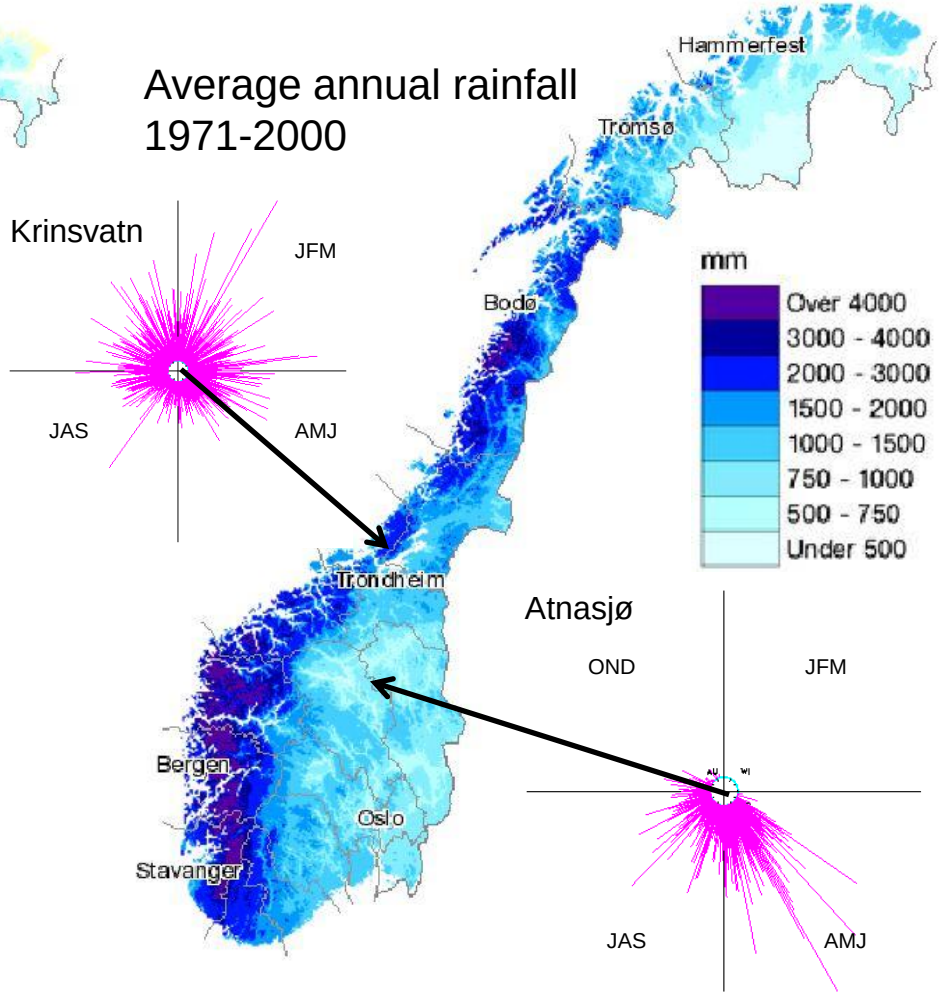
- **Climate, flood regimes and CC in Norway**
- **Methods for developing hydrological projections**
- **Projections for likely changes in flooding**
  - Regional changes in 200-year flood
  - Use of these results in CC adaptation in Norway
- **Changes in seasonality of flooding**
- **Summary and further comments**

Climatic regimes and peak flows

Average annual temp.
1971-2000

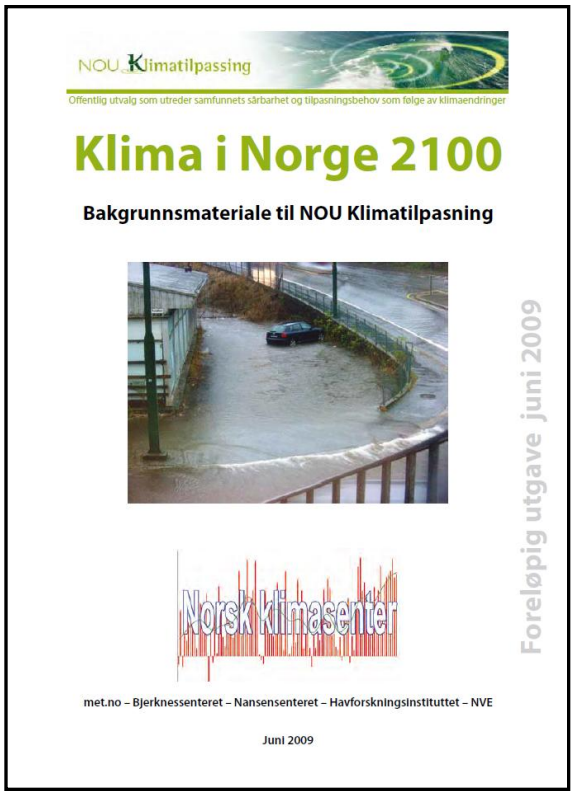


Average annual rainfall
1971-2000



Future climate in Norway

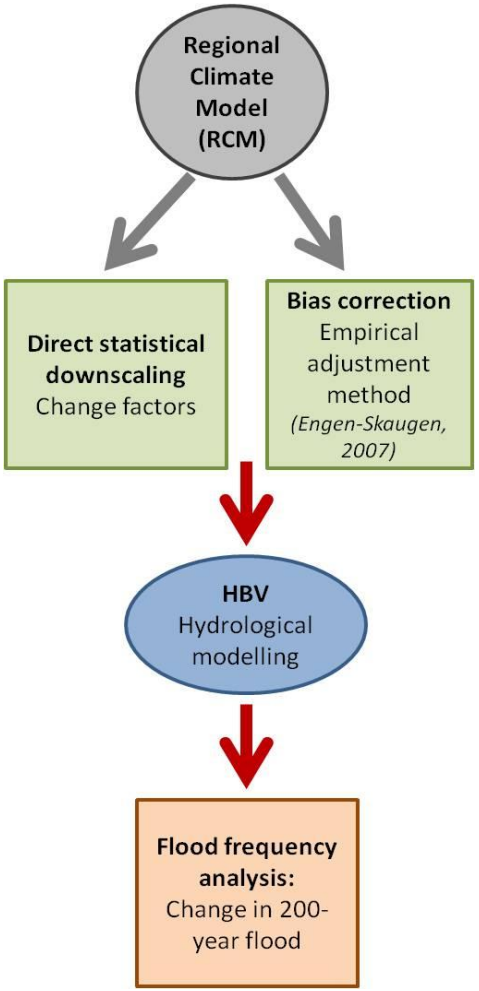
- Projected changes for Norway: Increased T (all seasons)
  Increased P (esp. autumn/winter)
  Increased extreme P
  Changes in snow storage and runoff



Hanssen-Bauer, I. *m.fl*. *Klima i Norge 2100. Bakgrunnsmateriale til NOU Klimatilpassing. (Climate in Norway 2100. Background material for Norwegian Committee on Climate Change Adaptation.)* Norsk klimasenter, September 2009, Oslo.

How will these changes affect flooding?

Developing hydrological projections

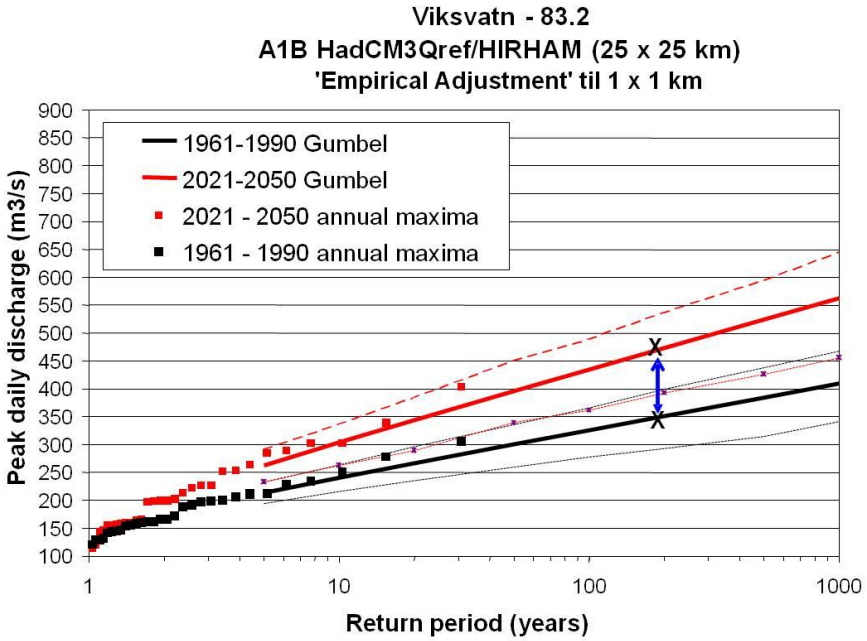


13 climate projections (daily P, T) from different GCM/RCM combinations for periods: 1961-1990, 2021-2050 (A1B), and 2071-2100 (A1B, A2, B2)

2 methods for local adjustment of P, T to catchment scale

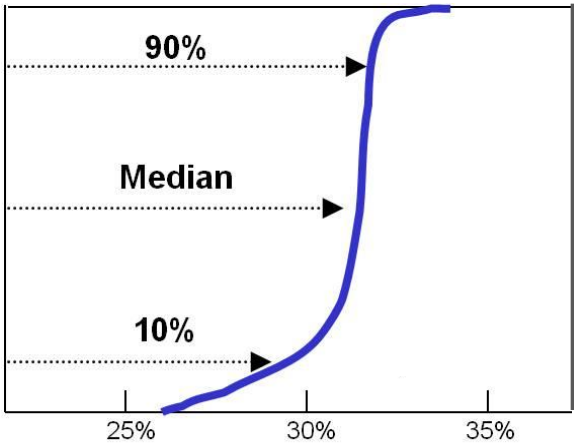
25 calibrated HBV parameter sets with similar fits for each of 115 catchments

FFA based on simulated AMS (GEV)
Projections for 2071-2100 have also considered uncertainty in FF curve



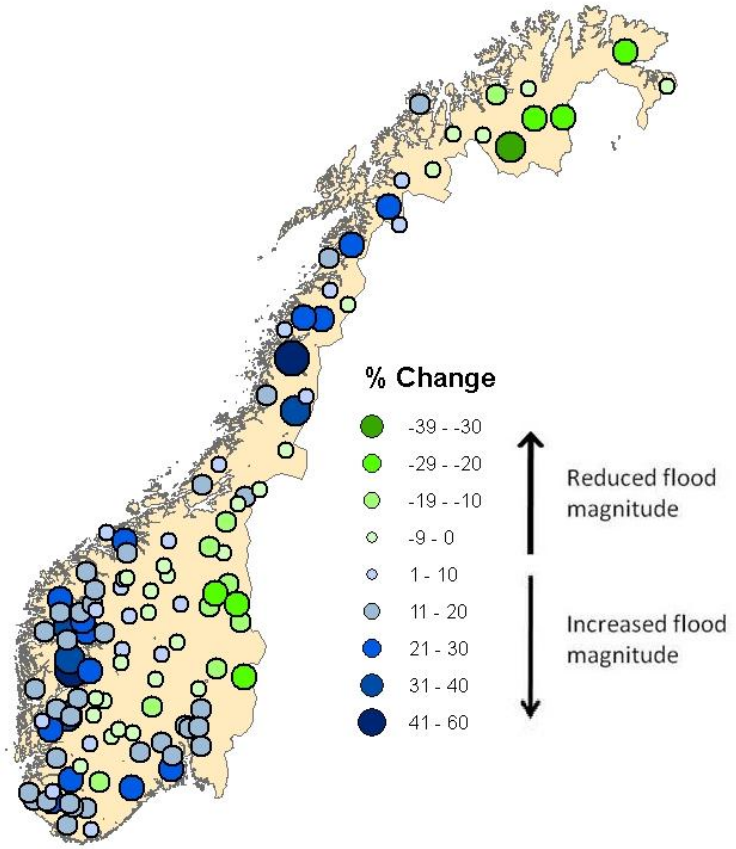
Flood frequency analysis is applied to simulated AMS to estimate % change in 200-yr. flood

Results of all simulations are combined as a distribution function to evaluate level of agreement amongst projections



Percentage change in 200-year flood

Change (%) in 200-yr. flood between 1961-1990 and 2021-2050 (median of all projections)



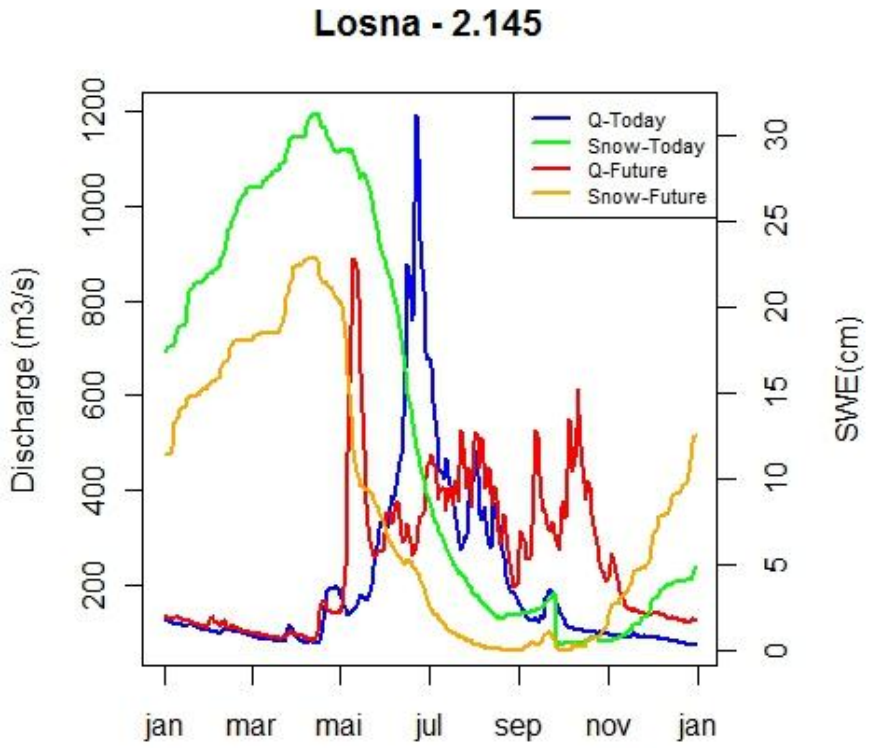
Inland and northernmost areas – Flood regimes dominated by spring/early summer **snowmelt**

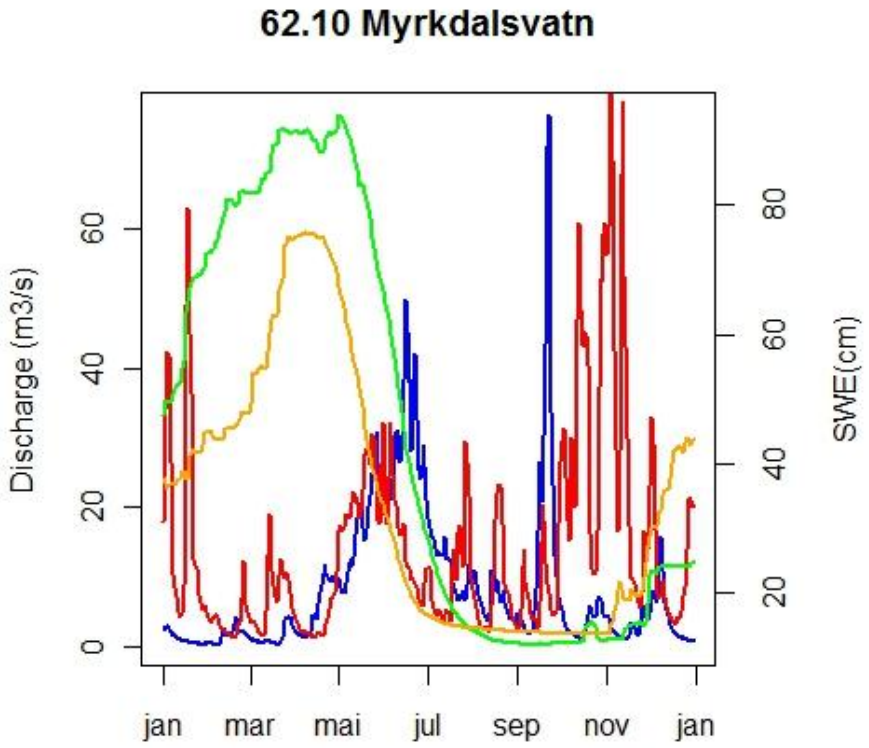
→ **Reduced flood magnitude**

Coastal areas and western Norway – Flood regimes dominated by autumn/winter **rainfall**

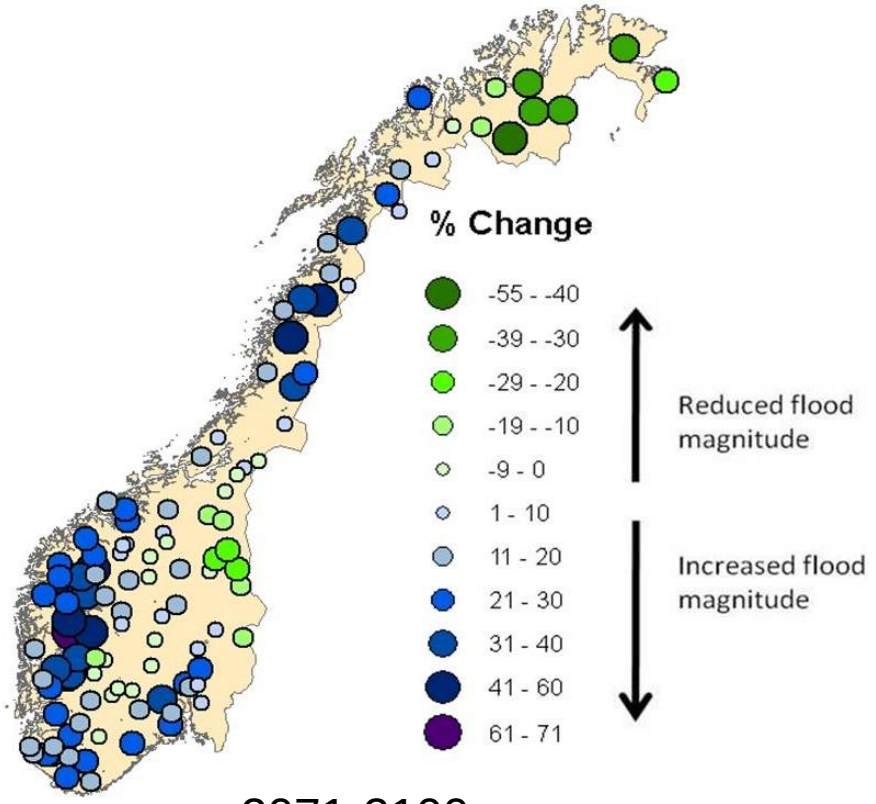
→ **Increased flood magnitude**

Typical patterns of runoff – Now and in the future

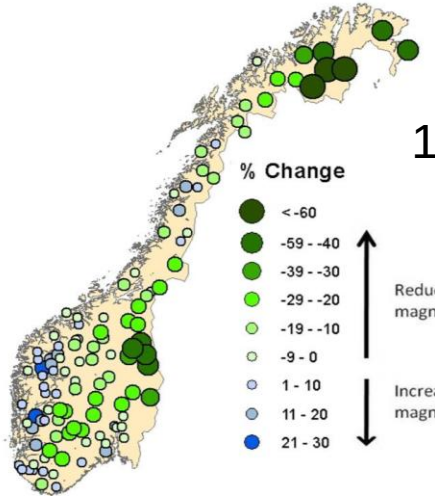




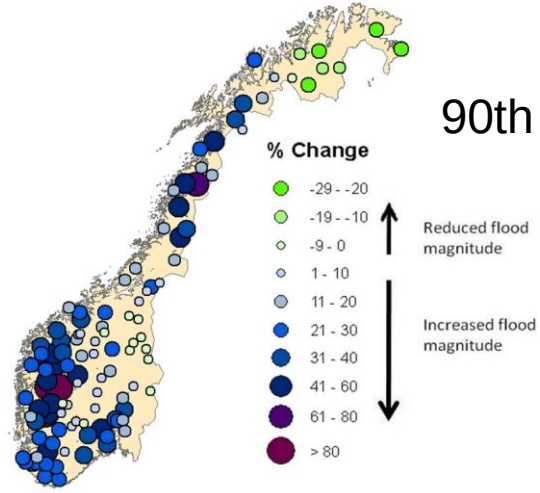
Median change and range in projections



2071-2100
Projected change in 200-year flow



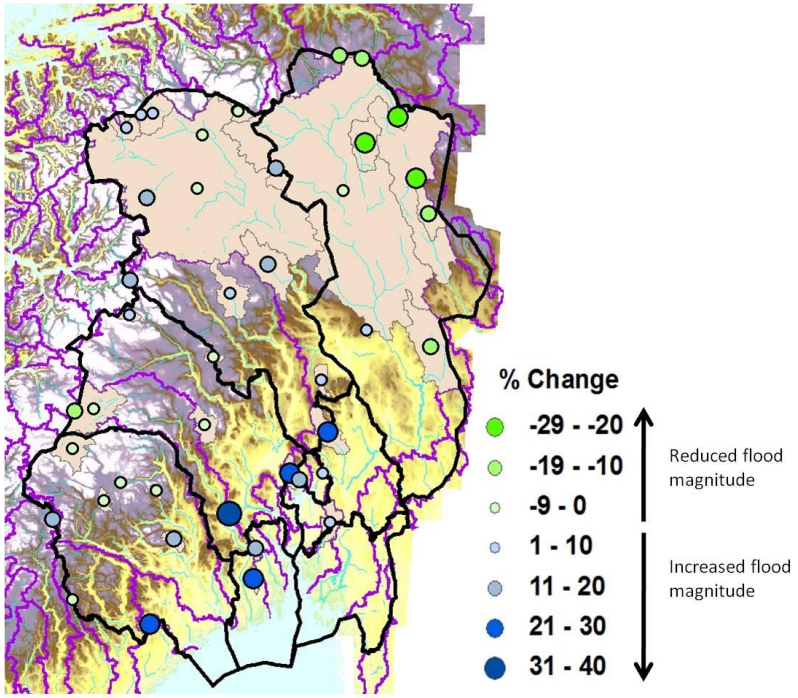
10th percentile



90th percentile

In practise (flood risk management, dam safety):

- Regional guidance has been developed using three categories: 0%, 20%, 40% – NVE Report, 5-2011
- Actual numbers from projections not used



Excerpt from Guidance for Østlandet region

0% increase – Inland catchments dominated by spring/early summer snowmelt floods in the current climate
20% increase – Catchments in more coastal locations with local source areas (*e.g*. see location of catchments indicating a > 20% increase in Figure 8.11. This includes, for example, catchments with local source areas in Vestfold, Akershus, Oslo and Østfold.
20% increase – All catchments with areas < 100 km^2

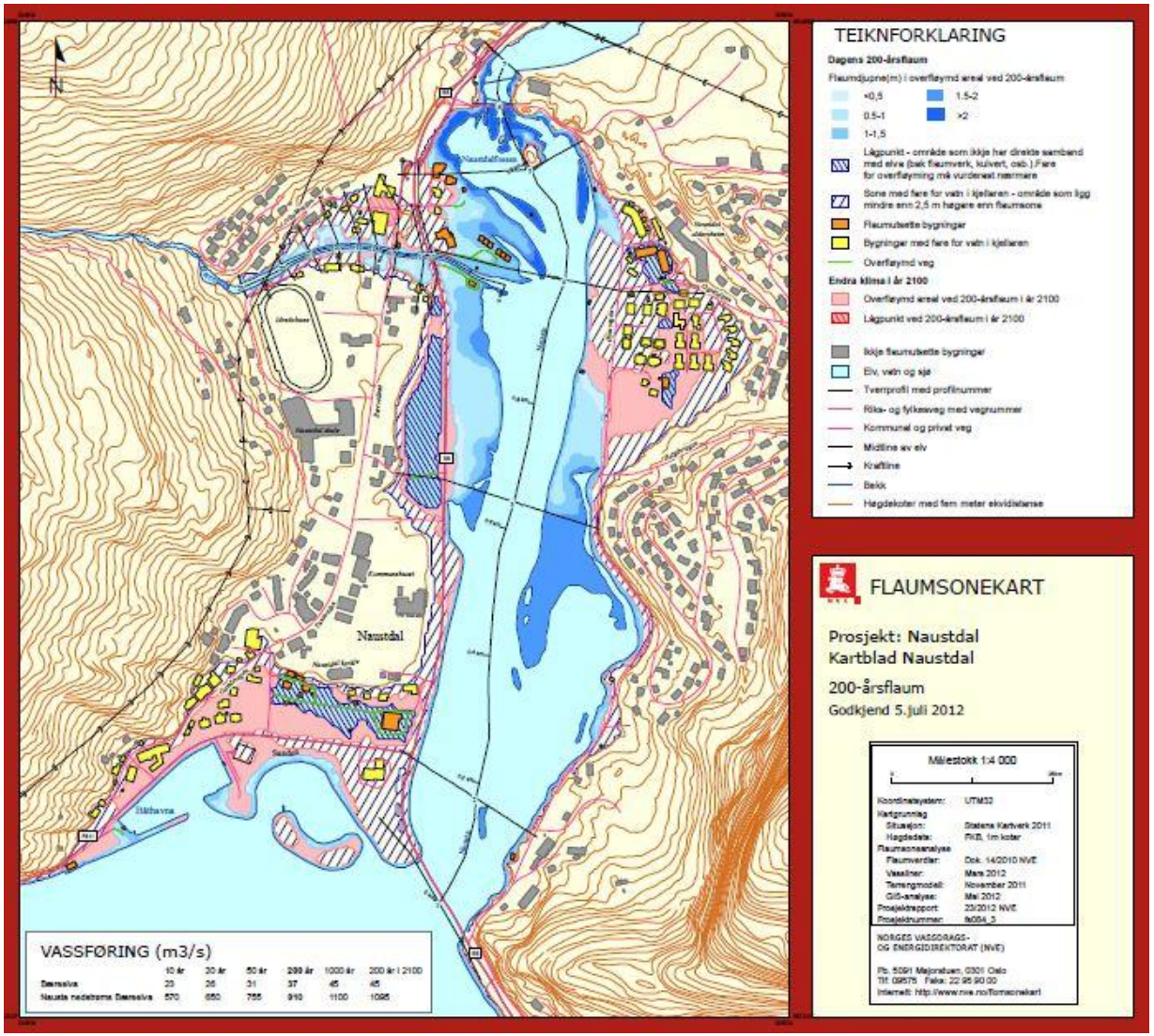
Flood hazard map for Naustdal

(coastal western Norway)

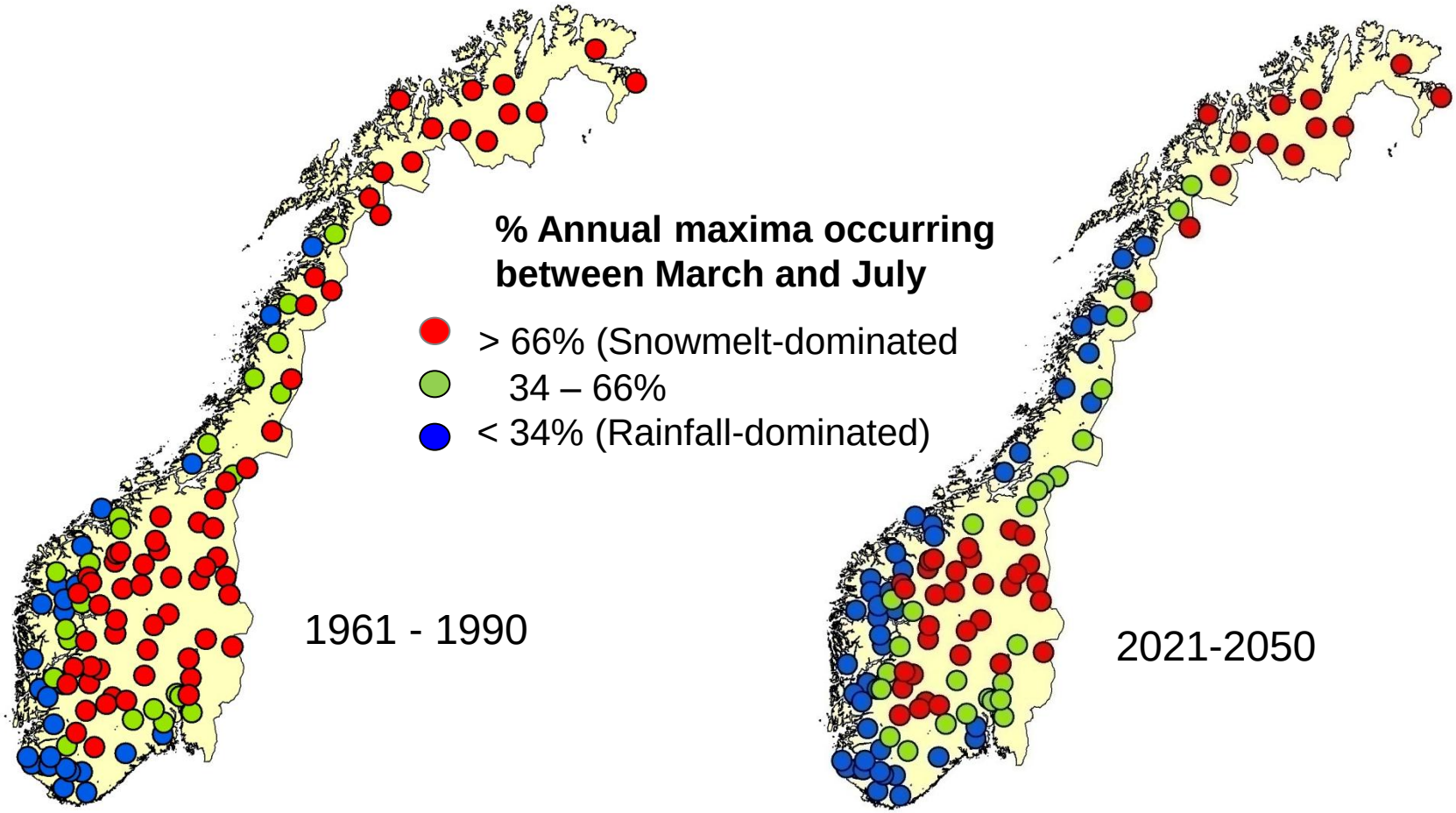
Published July, 2012

Blue – **200 yr. flood in today's climate**

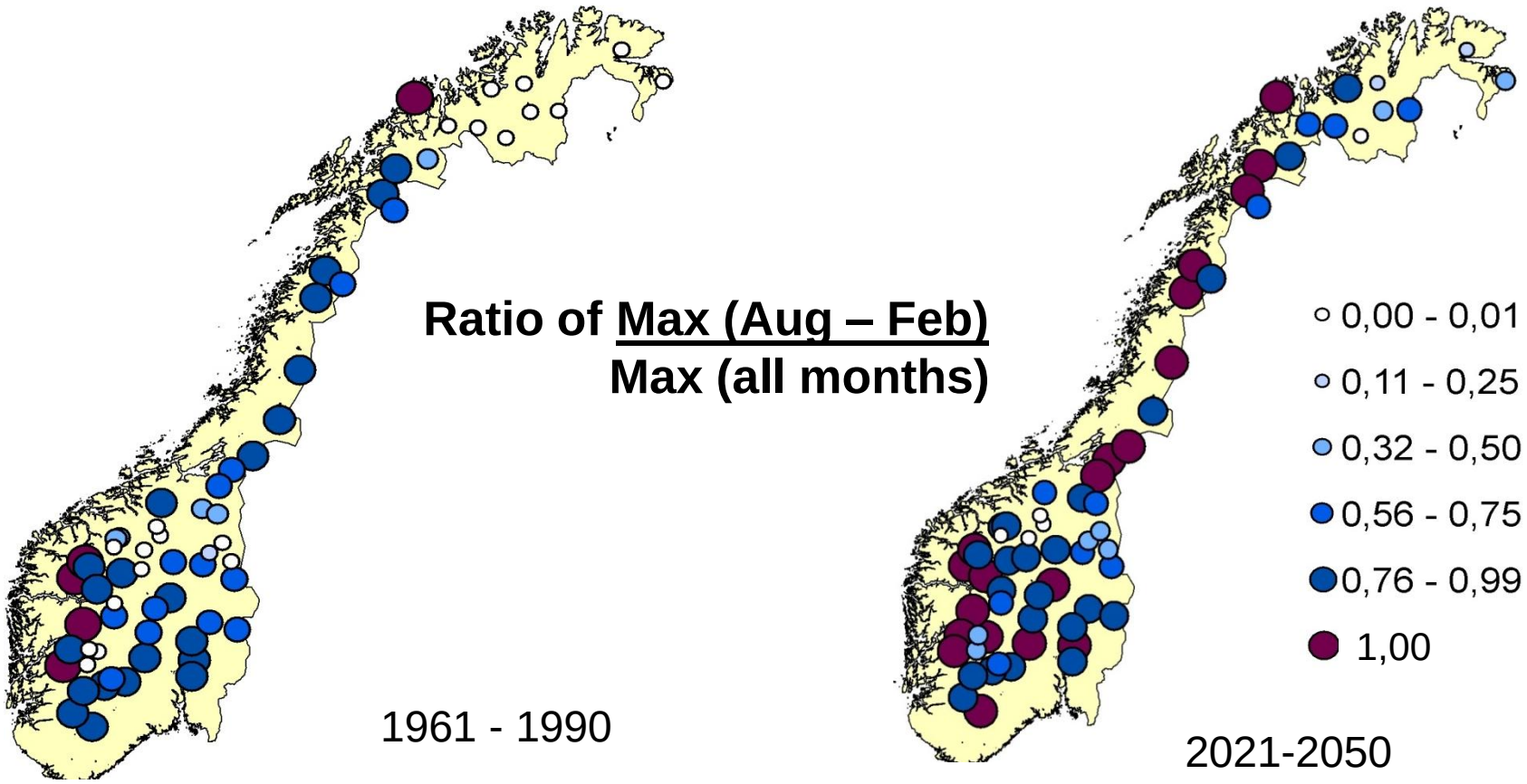
Pink – **200 yr. flood in 2100**



Seasonal changes in annual flood series



Magnitude of autumn/winter flood events in annual maximum series



Largest peak flow in some 'snowmelt-dominated' areas is actually an autumn/winter rainfall flood

Summary and further comments:

- Broad regional patterns of **likely increase *vs.* decrease in flood magnitudes** under a future climate have been identifed for Norway based on multiple GCM/RCM combinations, two local adjustment methods, catchment-based hydrological modelling and flood frequency analysis
- The results have been used to develop regional guidance for use in climate change adaptation using three simple categories: 0%, 20% and 40%
- Seasonal GPD analyses have indicated that the development of **autumn/winter rainfall flooding** could have implications for the current recommendations in some areas
- Robust estimates of changes in flood behaviour are ultimately dependent on reliable P extremes from RCMs, and there is much ongoing work on this topic