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Applying climate scenarios for prediction of future premiums

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Insuring Future Climate Change

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Outline

- Motivation
- Problem
- Data
- Claims models
- Predictions

Motivation

- The insurance industry is vulnerable to climate change
  - Non-life insurance: Buildings, cars, boats, …
  - Life insurance: Altered risks of death and diseases, …

Bergen, January 2005: Storm surge

Motivation

- In 1999, Gjensidige and NR started their investigation of water losses and climate
- Three major projects so far with focus on externally inflicted water damage to buildings in Norway

Admitting that there will be certain climatic changes, what are the level and geographical pattern of losses to be expected in the future?

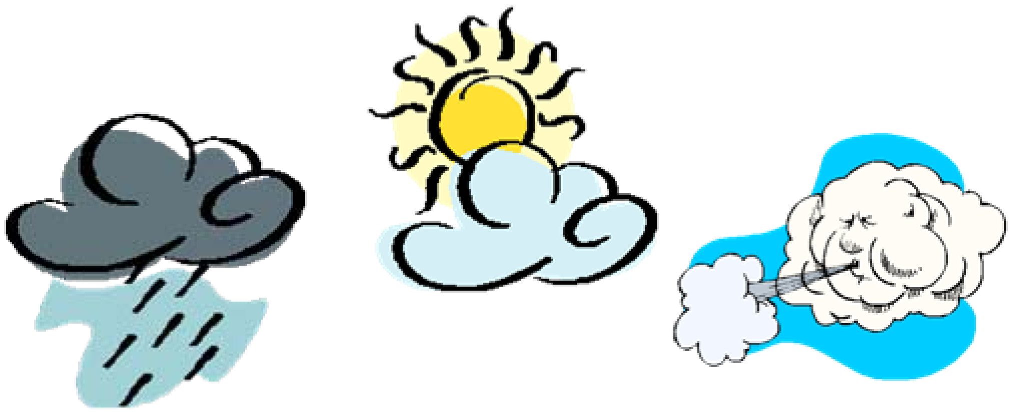
Motivation

- Utilization of results by Gjensidige:
  - Learn and understand future risks imposed by climate change
  - Limit the effects of climate change through in-advance discussions with customers and local regulators
  - (Update calculations of premiums and reserves)
  - …

Problem

What determines the losses in an area over time?

- The local climate

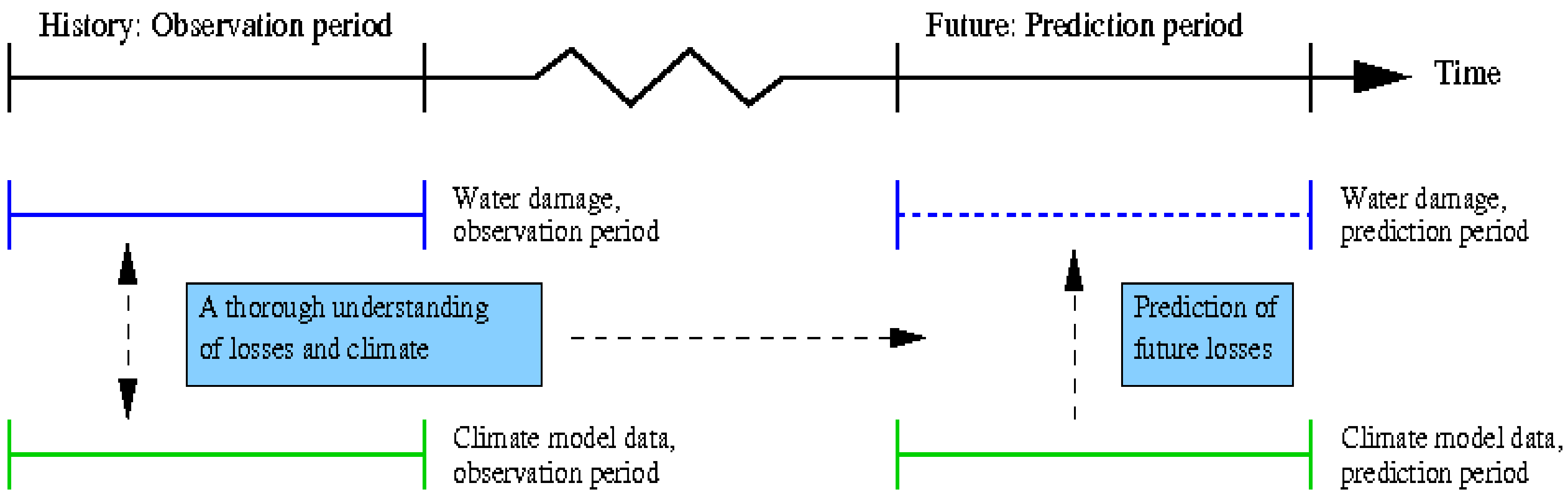


- The sensitivity of the buildings

Problem

- Prediction of future losses calls for:
  - Understanding the weather mechanisms that influence loss events
  - Information about future climate
  - Methods to merge the two types of knowledge
- Some relevant questions:
  - Can coherences between losses and weather be quantified?
  - Which weather elements are more important?
  - Do coherences differ among different areas?

How to predict future losses?



Data: Insurance data

- Water losses from Gjensidige's portfolio of Private building policies
- 10 years of data (1997-2006)
- Spatial resolution at the level of municipalities
- Variables:
  - Daily number of claims and total payment
  - Number of policies

Data: Insurance data

- Data are frequency claims (as opposed to major catastrophes)
- Main categories:
  - Water running into basements from above the ground
  - Blocked pipes
  - The principal cause of the losses is heavy rainfall
- Claims are covered by the insurance companies

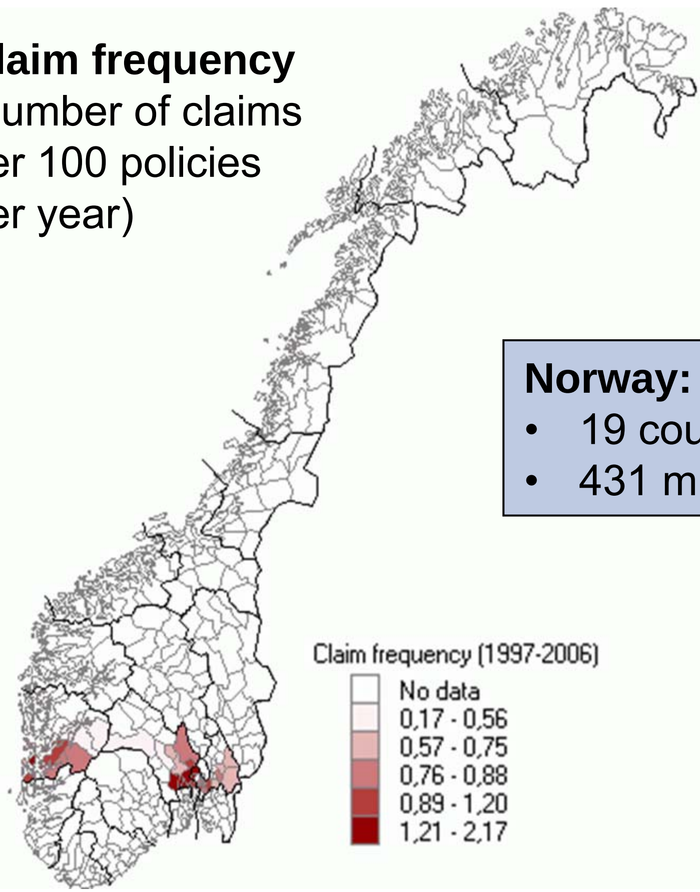
Bergen, September 2005: Extreme precipitation event

Data: Insurance data

- Not included: Losses due to floods, storm, slides, storm surge, … (natural disasters)
- Such losses are taken care of by either
  - The Norwegian Natural Perils Pool
  - The Norwegian National Fund for Natural Damage Assistance

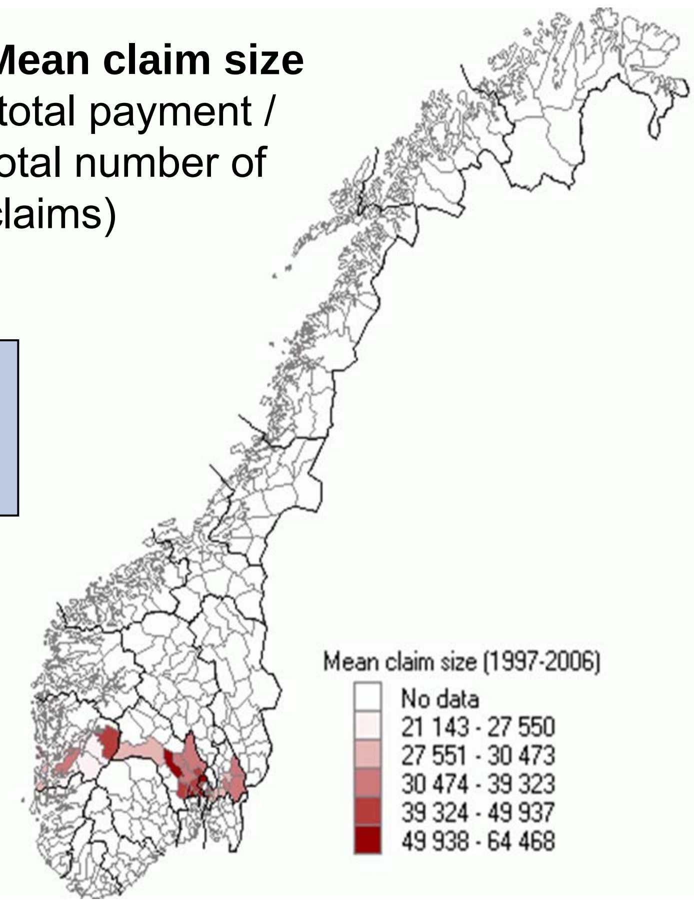
Data: Claims from 1997-2006

Claim frequency
(number of claims per 100 policies per year)



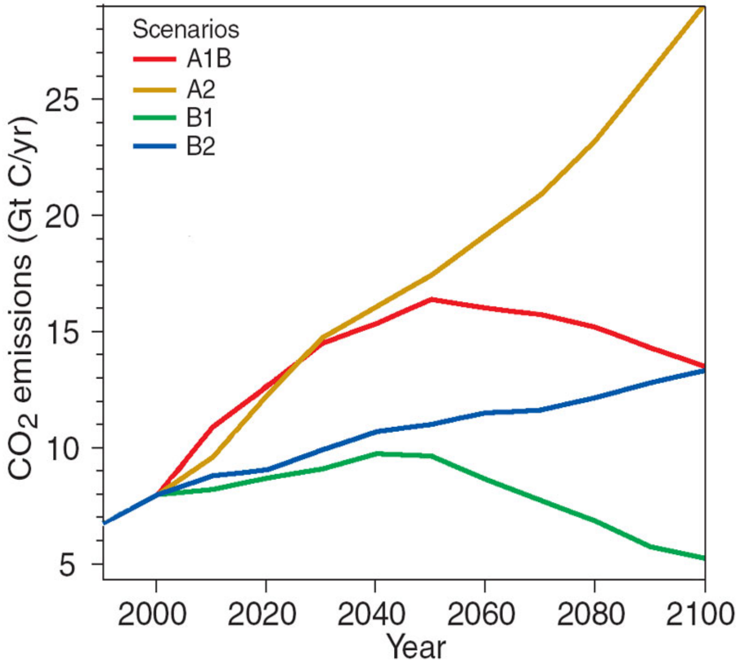
Norway:
- 19 counties
- 431 municipalities

Mean claim size
(total payment / total number of claims)



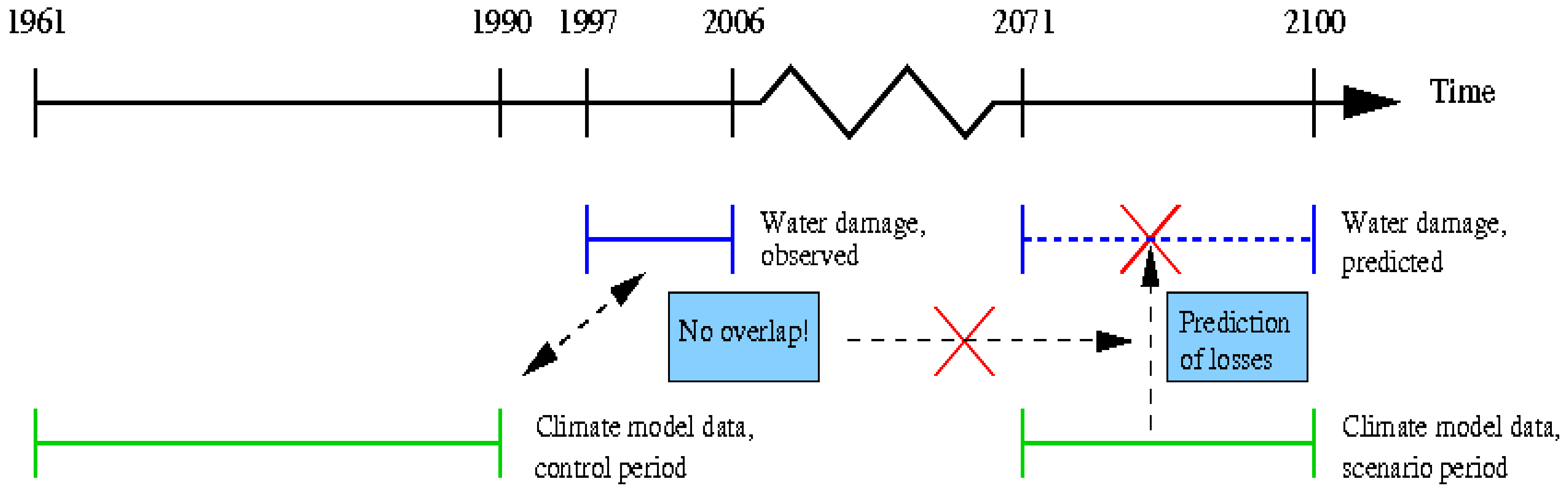
Data: Climate model data

- Regionally downscaled and locally adjusted global Hadley Institute HadAM3H model runs under the CO2 emissions scenarios A2 and B2
- Daily municipality values of:
  - Precipitation and temperature
  - Runoff and snow water contents
- Climate model runs cover two separate periods:
  - 1961 – 1990 (control)
  - 2071 – 2100 (scenario)



Data: Claims and climate model data

- Aim: Establish *claims models* that describe connections between claims and weather



Data: Climate model data

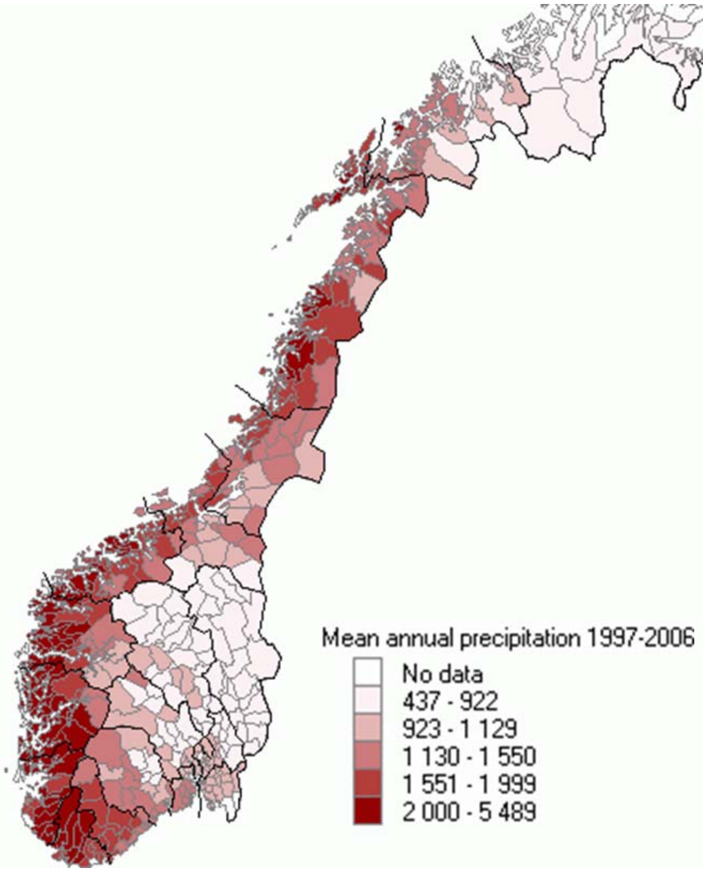
- Shortcomings of the climate model data for claims modeling purposes:
  - Do not overlap in time with the claims data
  - Not representative of the observed weather on a certain day
- Circumvention:
  - We use interpolated weather observations to establish the claims models

Data: Weather data

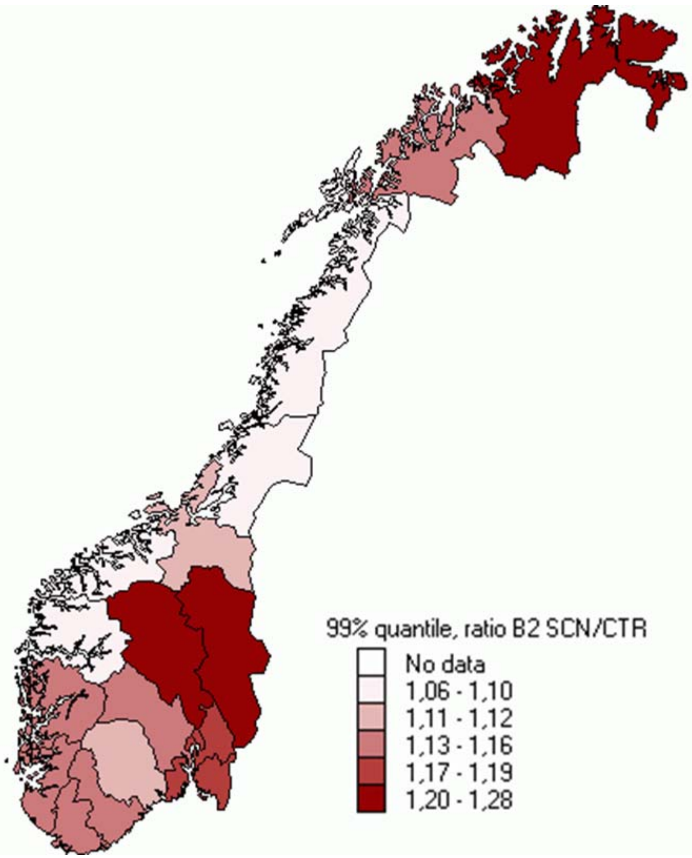
- The Norwegian Meteorological Institute (MI) and Norwegian Water Resources and Energy Directorate (NVE):
  - Daily values for each municipality (1961-2006) based on averages of interpolated (1x1 km^2) observations of
    - Precipitation and temperature
    - Runoff and snow water contents
- Spatial representativity is improved by averaging over the most densely populated areas, *i.e.* the areas where losses will primarily occur
  - Essential since harmful weather often is very local

Data: Weather and climate data

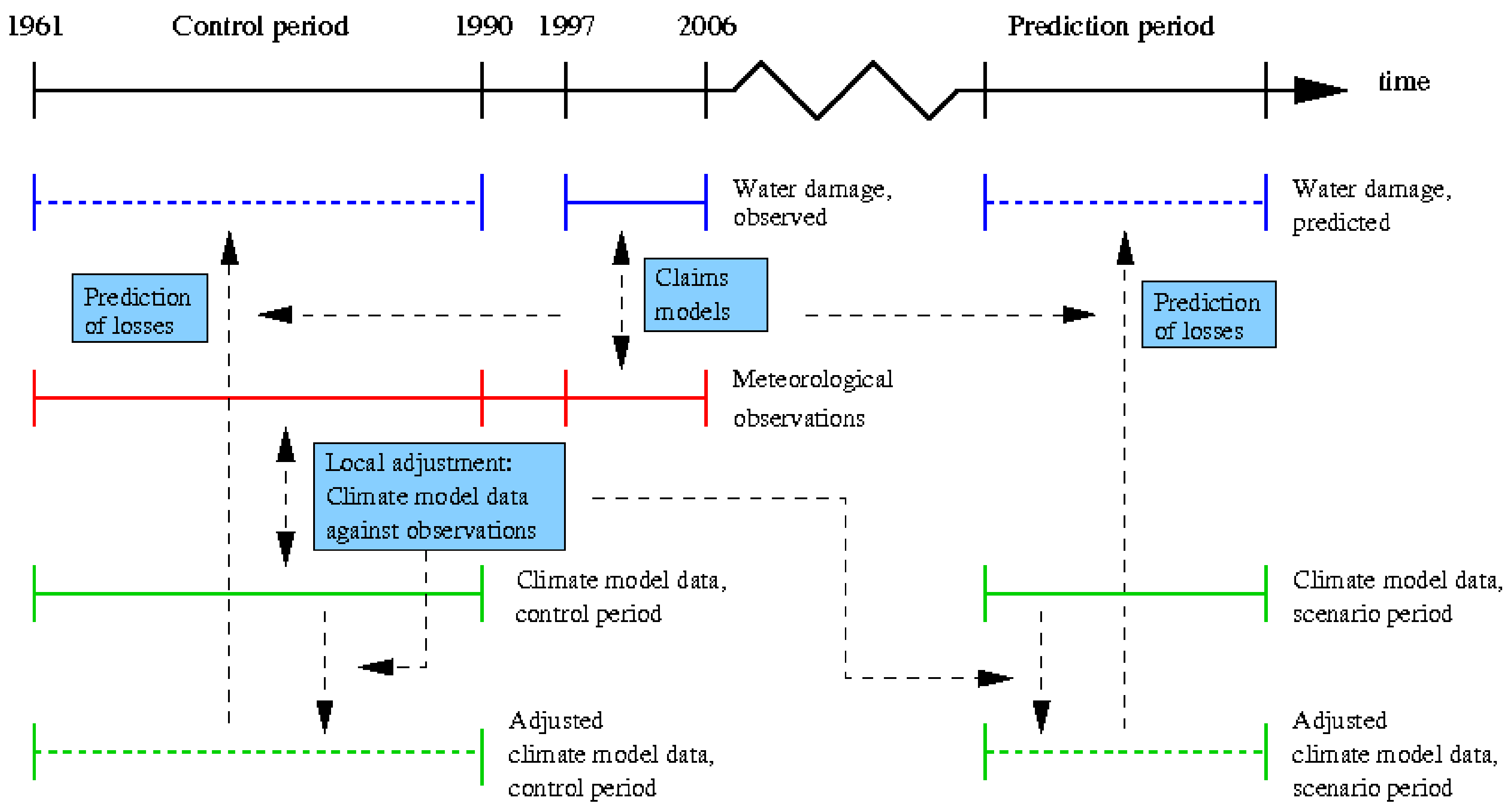
Mean annual precipitation 1997 - 2006



Change in precipitation: Ratio of 99% quantiles from B2 scenario and control period



Data: Flow diagram



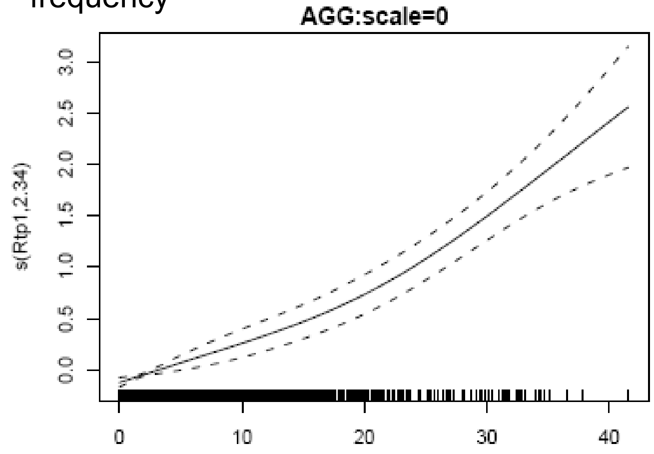
Claims models

- Statistical models for the coherence between water damage and daily weather variables (by means of Generalized Additive/Linear Models (GAM/GLM))
- *Number of claims* and *mean claim size* modelled separately
- Number of claims:
  - All days contribute information, also those with no claims
  - Lots of data, large variability
- Mean claim size:
  - Less data: Only days with claims contribute

Claims models: Explanatory variables

- Tentatively, all weather variables are included
  - Precipitation, temperature, runoff, snow water contents
- Additionally:
  - Trend: Accounts for systematic development over time that is not related to weather
  - Seasonality: Periodic variation in claims level throughout the year

Claims models



- GAM plots are used to identify the most likely parametric forms of the explanatory variables
- GLM model fitting:
  - Applied to data from 1997 – 2006
  - Matched at municipality
  - Identical models throughout (most of) the country
- NB! Claims models are not linked to any particular climate model!

Claims models: Number of claims

- Separate models fits for each county
- Individual constant terms for each municipality
- Other explanatory variables have coefficients that are common to all municipalities within a county

Example

Sogn og Fjordane county:
26 municipalities

Claims models: Number of claims

- Quasibinomial model:
  - The number of claims in municipality *k* on day *t* depends on

    Number of policies, A_{kt}
    Claims probability, p_{kt}

  - ”Quasi”: Accounts for large variability through overdispersion

- The claims and weather relate through the claims probability:

$$\begin{aligned} p_{kt} \sim f(&\text{county constant term} \\ &+ \text{municipality constant term}_k \\ &+ \beta_1 \cdot \text{precipitation}_{kt} + \beta_2 \cdot \text{temperature}_{kt} + \ldots) \end{aligned}$$

sums to 0

Claims models: Claim size

- Gamma model:
  - Assume the number of claims in municipality *k* on day *t* is known
  - Model the mean claim size given this information,

$$\bar{S}_{kt} \mid N_{kt} \quad \text{(with expectation } \xi_{kt}\text{)}$$

- Link the mean claim size to the weather through its expectation

$$\begin{aligned}\xi_{kt} \sim g(&\text{region constant term} \\ &+ \text{county constant term}_{F(k)} \\ &+ \alpha_1 \cdot \text{precipitation}_{kt} + \alpha_2 \cdot \text{temperature}_{kt} + \ldots)\end{aligned}$$

sums to 0

Claims models: Total payment

- Total payment:
  - Derived from the number of claims model and the mean claim size model
- Expected payment on day *t* in municipality *k* is simply the product

Number of policies_{kt}
• Claims probability_{kt}
• Expected mean claim size_{kt}

Predictions

- Claim level predictions for the control and scenario periods are calculated from:
  - Fitted claims models
  - Adjusted climate model data for both periods

Predictions: Claims change

- Compare loss predictions for the control and scenario periods using ratios, e.g:

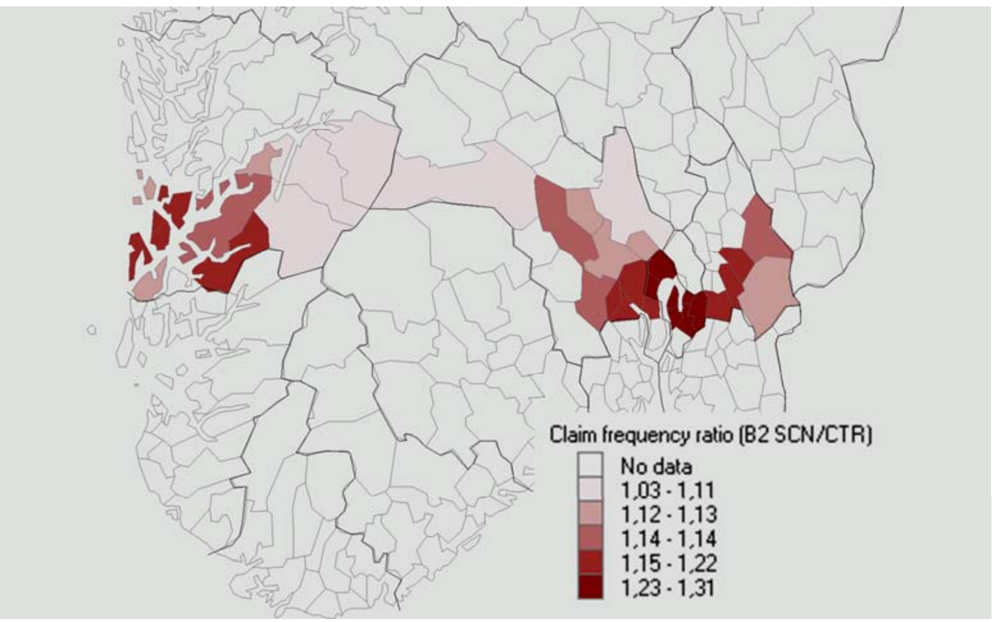
$$\frac{\text{sum}_{t \in scn}\ (\text{Number of claims in scenario period})}{\text{sum}_{t \in ctr}\ (\text{Number of claims in control period})}$$

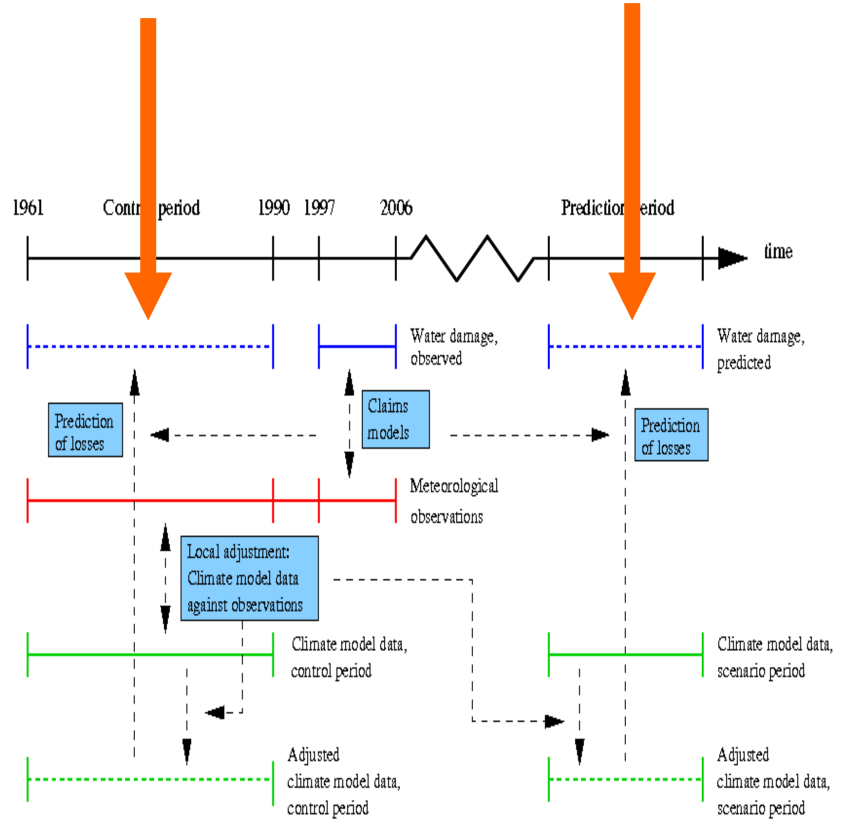
- This ratio is a function of
  - Local vulnerability of the buildings (claims model)
  - Climatic change as told by climate models
- Ratios > 1 indicate an increased future loss level

Predictions: Change in number of claims

Ratio of number of claims (scenario period divided by control period)

Denominator **Nominator**



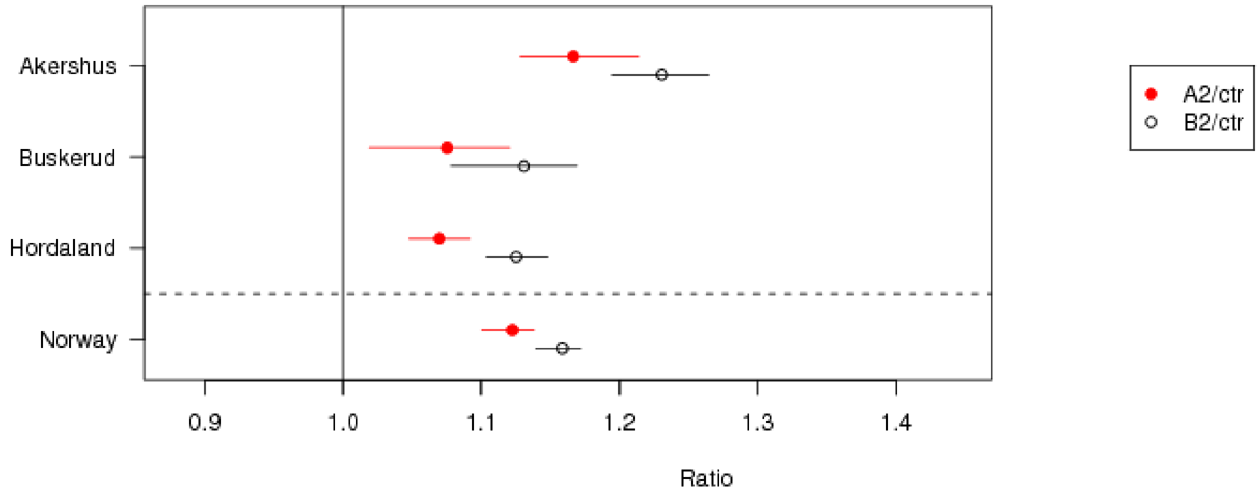


Predictions: Uncertainty

- Uncertainty due to model fit (quantifiable)
- Error due to true model discrepancy (not quantifiable)
- Uncertainty in the climate model data (not quantifiable)

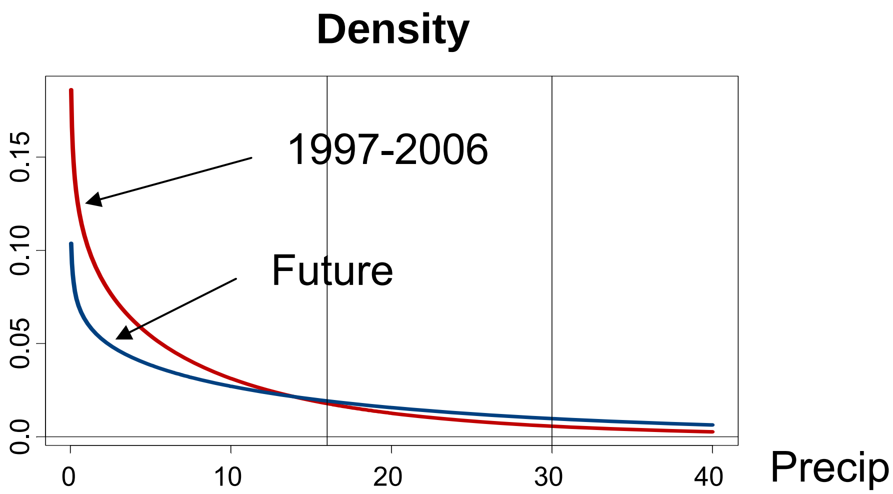
Predictions: Estimation uncertainty

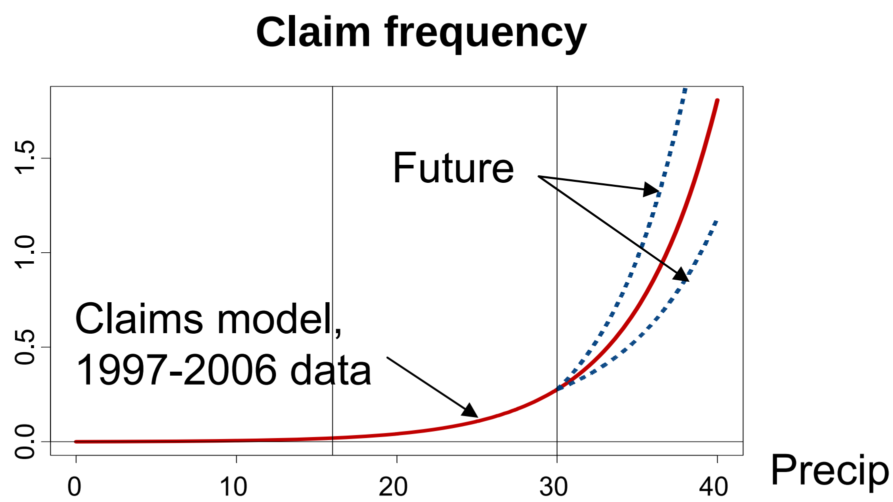
- Fitted claims models: Assume a multinormal distribution for the model coefficients
- Compute a set of ratios from a simulation study (n=100)
- Use empirical quantiles as confidence limits



Predictions and model breakdown

- Claims models based on 1997-2006 data
- Future weather situations might not yet have been experienced
- Loss and weather data might not follow the claims model for these values (above or below)
  - Above: E.g. pipeline systems at the limit of their capacity
  - Below: E.g. improved building constructions





Summary

- Rough estimates: Future loss levels will increase
- Predictions show considerable geographical variation
- Prediction uncertainty is possibly substantial, due to:
  - Claims models misspecification (+ estimation)
  - Climate model data uncertainty
- Wanted - to improve scientific insight:
  - Similar study on more data sets (e.g. from other countries)
- Further research will be carried out
  - EU (Marie-Curie) granted project (2008-2011): *Climate Change and Insurance Industry* (*CCII*), together with London School of Economics, Lloyds and Gjensidige Forsikring