Probabilistic Weather Forecasts for Insurance Risk Assessment and Pricing of Weather Derivatives

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Aims:

- **motivate the need for probabilistic weather forecasts (PWF)**
- **outline strategies for producing PWF**
  - statistical forecast models
  - dynamical forecast models
- **explain where we're at now and what the future holds.**

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Weather Risk Management

Customers want protection from the adverse impacts of weather on their business.

"adverse weather" could be:

a) rare extreme events

b) more common weather conditions

a - the traditional realm of insurers

b - a vast potential market, currently providing the stimulus for the development of weather derivatives.

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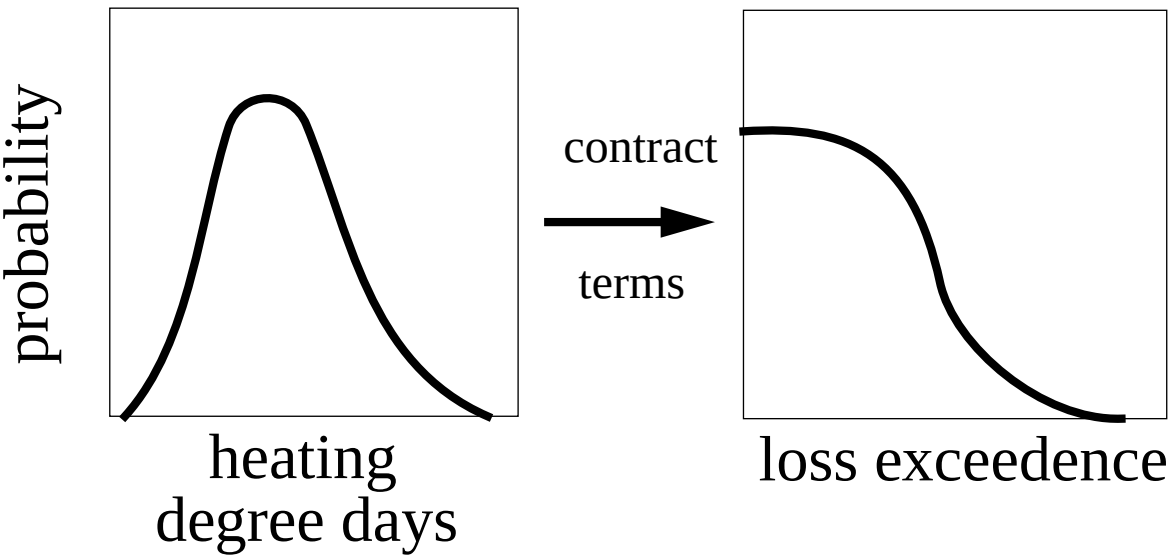
To assess weather risk, for rare or for common events, one needs:

a forecast probability distribution for the relevant weather conditions, i.e. a probabilistic weather forecast (PWF)



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How can a PWF be obtained?

a) Exploit past experience
(i.e. historical data)

b) Exploit scientific understanding of the causes of weather fluctuations

Forecasting strategies differ in the extent to which, and the ways in which, they employ *a* and/or *b*.

Two basic classes:

Statistical forecast models
- focus on *a*, but must also employ *b*

Dynamical forecast models
- focus on *b*

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Statistical forecast models

Much of the variability in weather is random, but an important part is related to slow changes in the ocean state.

Historical data are analysed to:

- characterise the random variability
- identify relationships to ocean conditions
- identify any external influences

➥ A mathematical model is developed that:

- is consistent with the historical data
- exploits our understanding of the causes of weather fluctuations

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Dynamical forecast models

Starting point: physical laws that describe the behaviour of the atmosphere and ocean

- Laws are expressed as mathematical equations describing the state of the atmosphere and ocean on a global grid of points
- Dynamical models are MUCH more complex than statistical models
- Historical data are not used directly, but data describing the present state of the atmosphere and ocean are needed.

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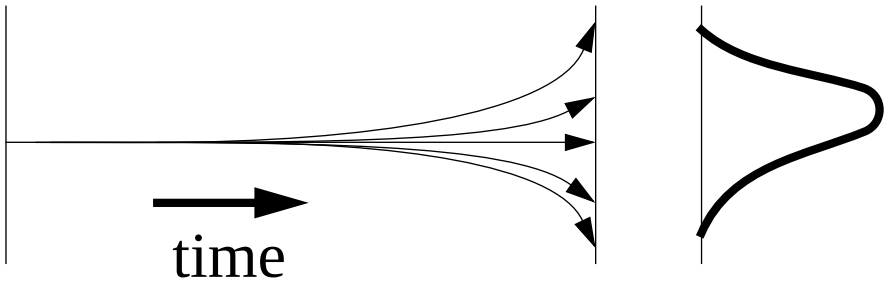
Ensemble Forecasting

To generate a PWF multiple forecasts are made from slightly different initial conditions

Because the atmosphere is *chaotic*, different forecasts diverge



With a large ensemble of forecasts one can compute probability distributions for future weather conditions, i.e. PWF.

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Advantages of Dynamical Forecasts

- Makes maximal use of scientific understanding
- Does not rely on historical data
- Better able to predict unprecedented events

Disadvantages of Dynamical Forecasts

- Cost
- Systematic model errors
- Low spatial resolution
- Current ensemble sizes are small

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Statistical vs Dynamical Forecasts

- Dynamical forecasts are superior for lead-times of a few days

- For longer timescale “seasonal” forecasts, the best approach depends on the specific application (location, timescale, variable etc)

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Where are we now?

- Dynamical seasonal forecasts are made at a number of centres around the world. These offer useful skill for some applications but:

  - the availability of output is very restricted

  - systematic errors are a serious problem

- We are able now to provide statistical forecasts for applications such as as Heating/Cooling Degree Days.

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Where is the future?

- In the long run, as systematic errors are reduced and ensemble sizes increase, dynamical models should provide the best forecasts.

- In the meantime the optimum strategy will be to combine statistical and dynamical forecasts to exploit the benefits of both.

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