Extreme El Nino events: What's the price?

CORECLIMAX Capacity Building Workshop

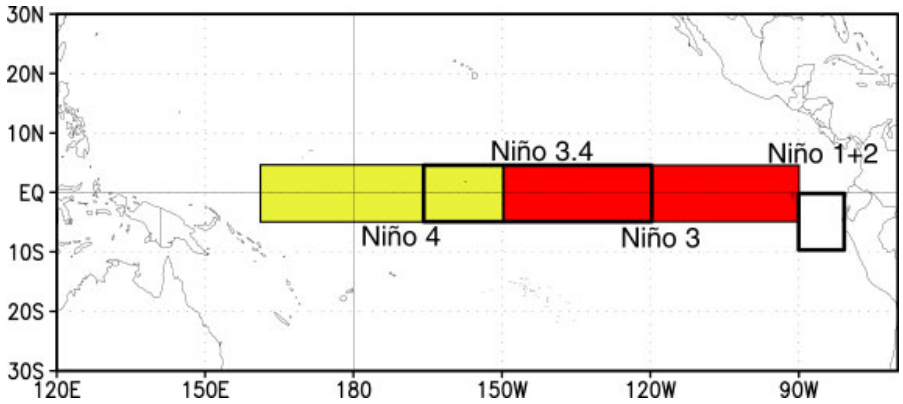
Prague,10 Oct 2014

Background

- The El Nino event in 1997 was the most extreme event in modern records.
- One of the most heavily affected areas was Peru.
  - Agricultural production decreased because of extreme rainfall.
  - Fish production decreased because of elevated sea surface temperature.
  - Floods and landslides destroyed private property and public infrastructure such as roads and bridges.
  - This caused further economic problems as transportation and electricity production were compromised.
  - Many businesses and private borrowers were forced to suspend loan payments: banks were also affected.
  - Insurance companies paid out large indemnifications.

Background

- An insurance company asked us to quote a product that would protect them from such events.
- The product is based on the November-December average of the Nino 1+2 index.

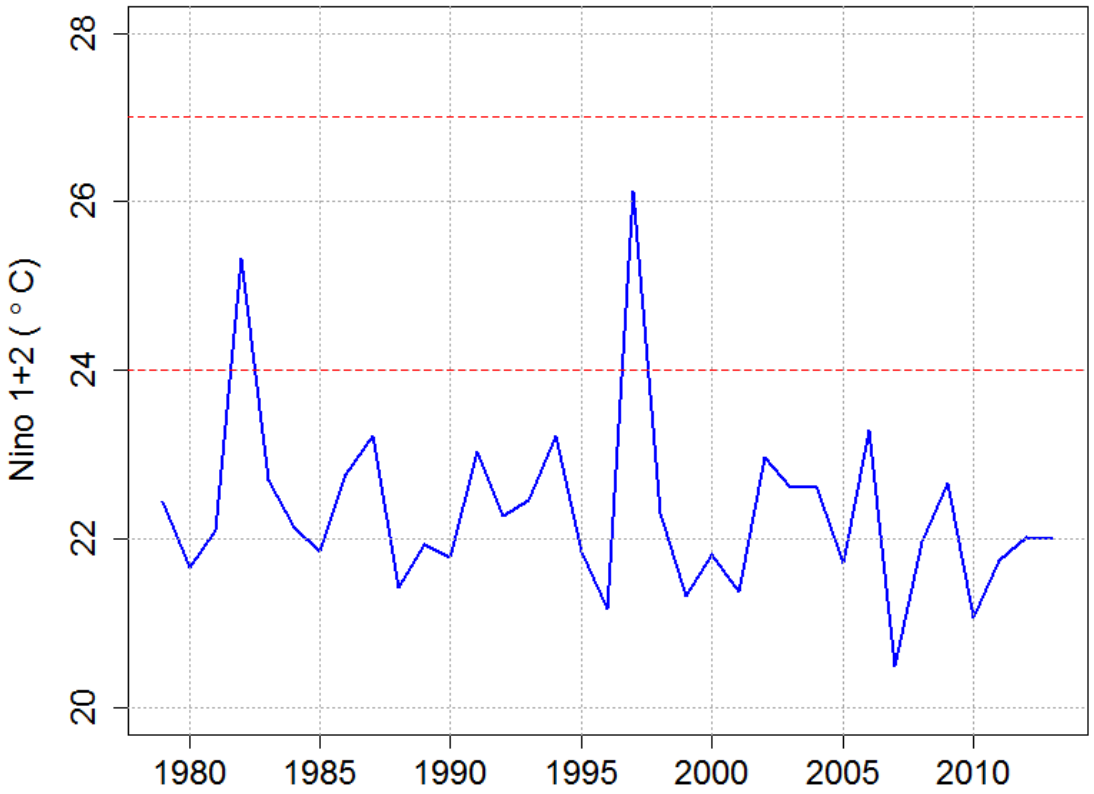


Various El Nino indices. Source: NCEP

- The idea is that when Nino 1+2 exceeds a certain threshold (entry point) the client receives some payout.
- This payout increases linearly up to a maximum amount for a certain Nino 1+2 value (exit point).
- Losses from catastrophic events start occurring around January. The November-December average has been chosen because it is available beginning of January each year. Thus, the client can receive indemnification when he mostly needs it.

Aim

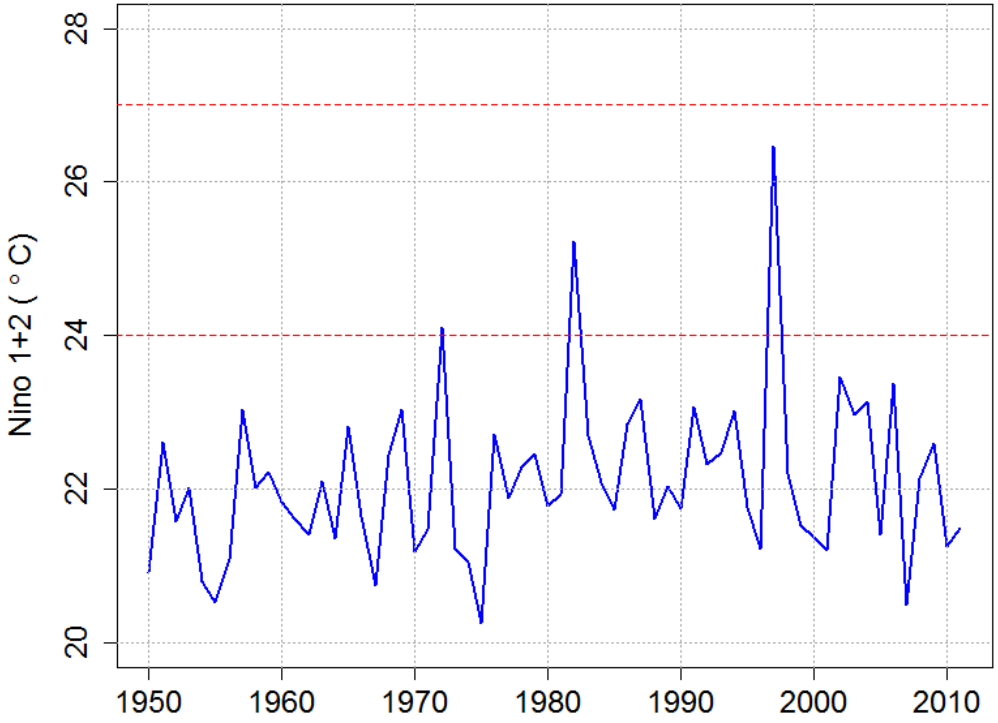
- The Nino 1+2 was about 26°C for the 1997 event.
- The following conditions have been set:
  - Entry point: 24°C
  - Exit point: 27°C
  - Max payout: 50 million USD.
- The aim is to calculate the annual premium for the suggested reinsurance program.



Nino 1+2 timeseries since 1979.
Data: ECMWF

Data and method

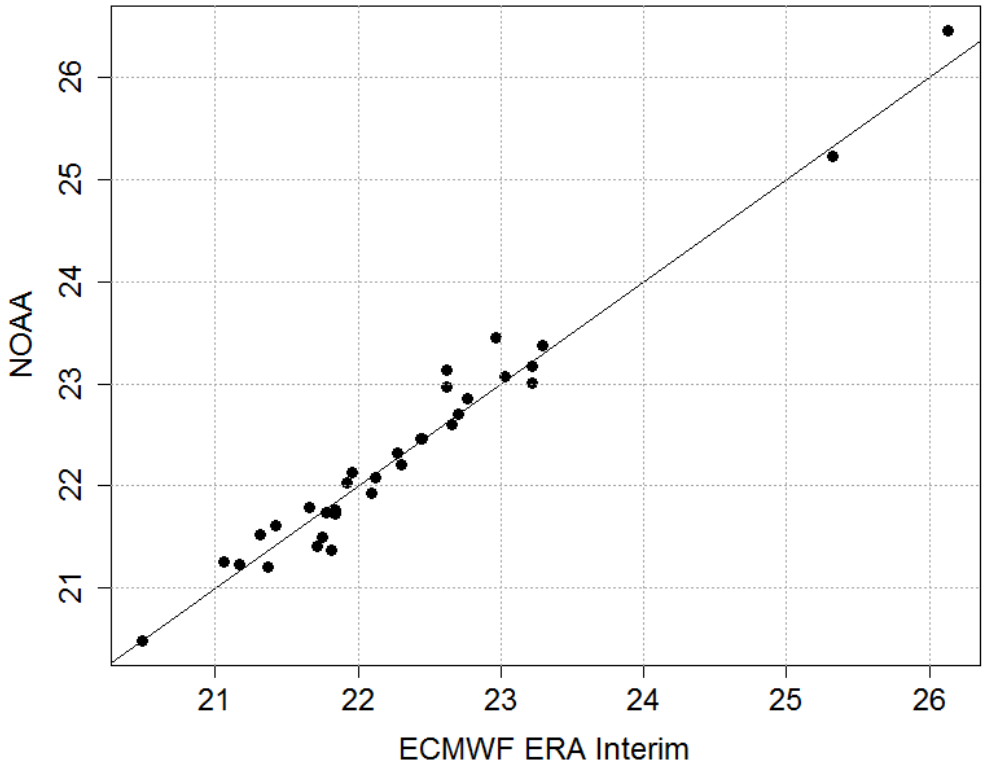
- Two datasets will be used: the ERA-Interim sea surface temperature data from ECMWF and the NOAA Climate Prediction Center Nino 1+2 index.
- For the ERA-Interim data, the Nino 1+2 index is calculated by averaging the sea surface temperature data in the area of interest.



Nino 1+2 timeseries since 1950.
Data: NOAA CPC

Data and method

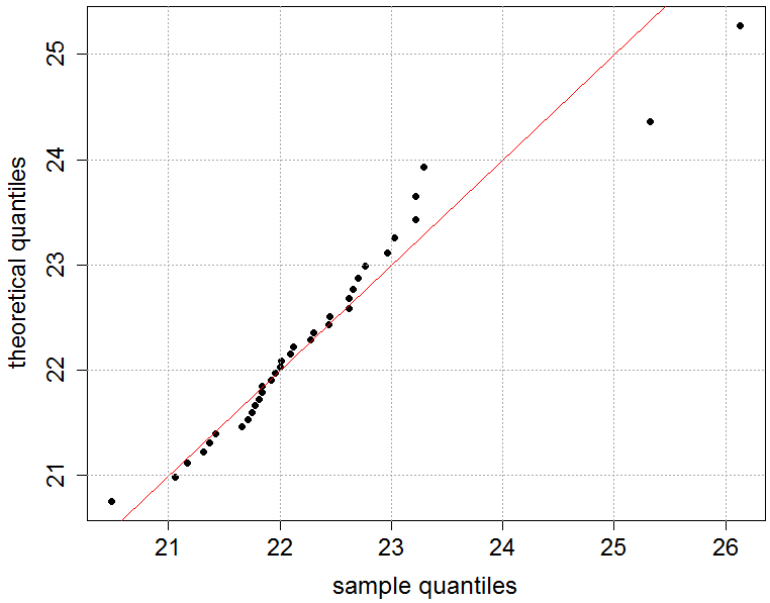
- The two datasets are quite similar:



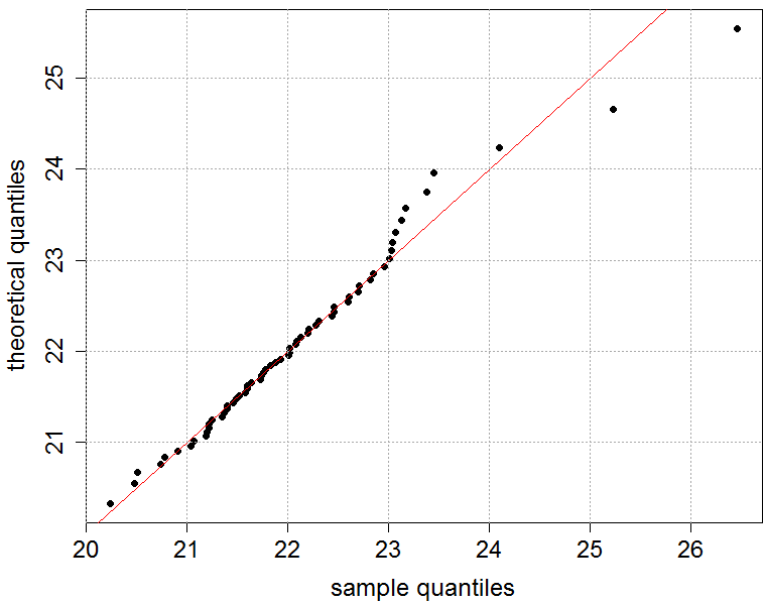
Data and method

- To estimate the probability that catastrophic events occur, a probability distribution is fitted to the data.
- When focusing on extremes, a «heavy tail» distribution is a good choice. Here the Generalized Extreme Value distribution has been used.
- Quantile-quantile plots have been used to assess goodness of fit.

ERA-Interim



NOAA CPC



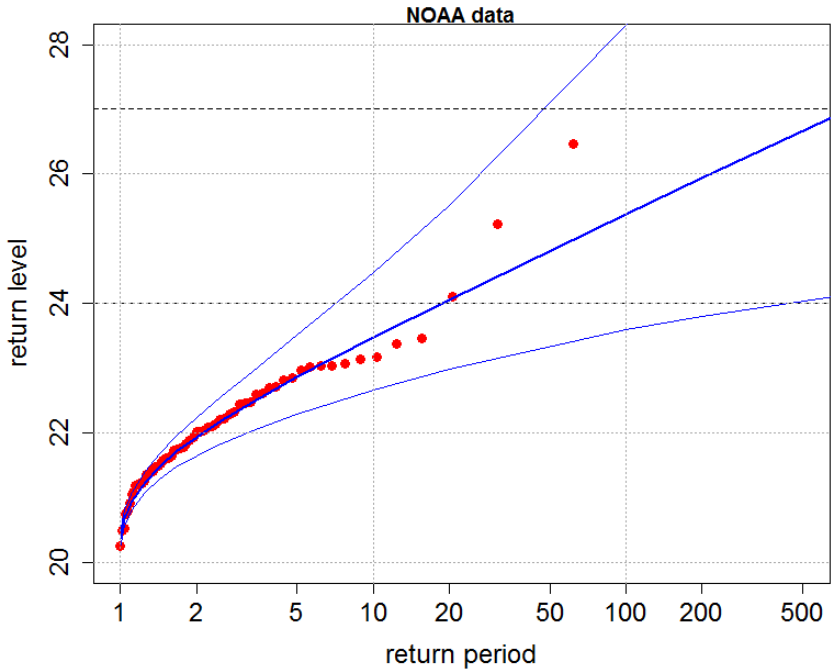
Data and method

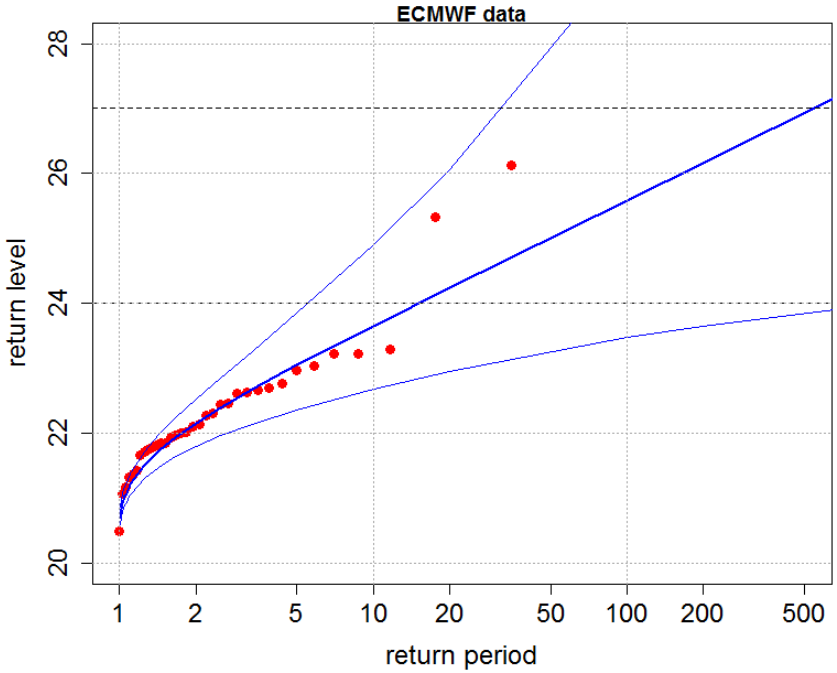
- Useful concepts for the price calculation:
  - Cumulative probability CP: the probability that a random variable is less than or equal to a specified value
  - Exceedance probability EP: the probability that a random variable is greater than or equal to a specified value
  - Return period RP: time interval between two instances where the random value exceeds a specified value.

$$RP = \frac{1}{EP} = \frac{1}{1 - CP}$$

Results

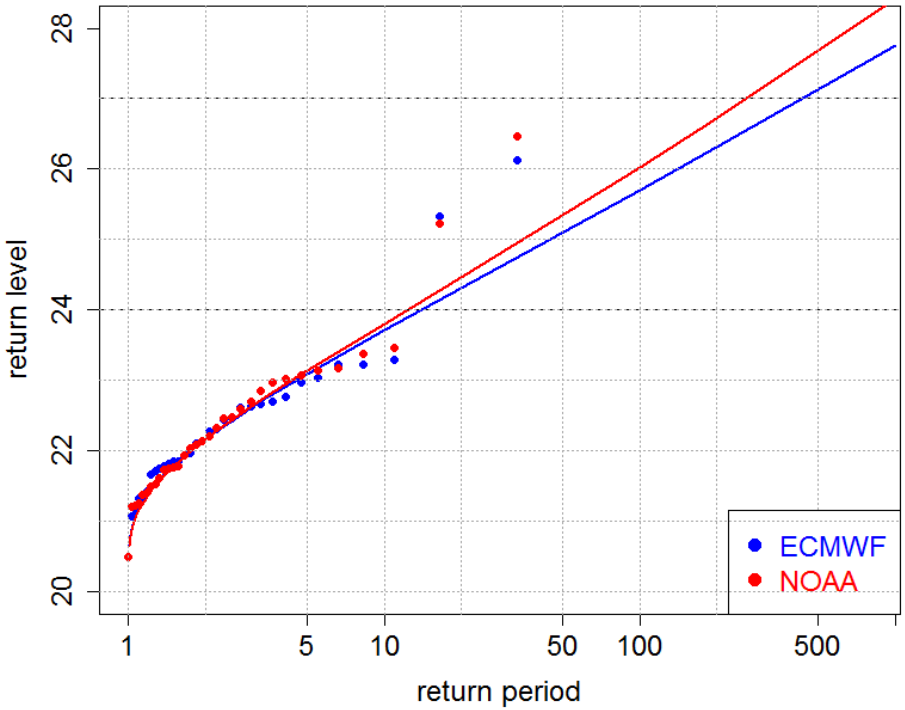
- One can get an overview of the risk by looking at the return period plots.
- E.g. from the NOAA data one can estimate that a payout will occur every 20 years and from ECMWF every 15 years.





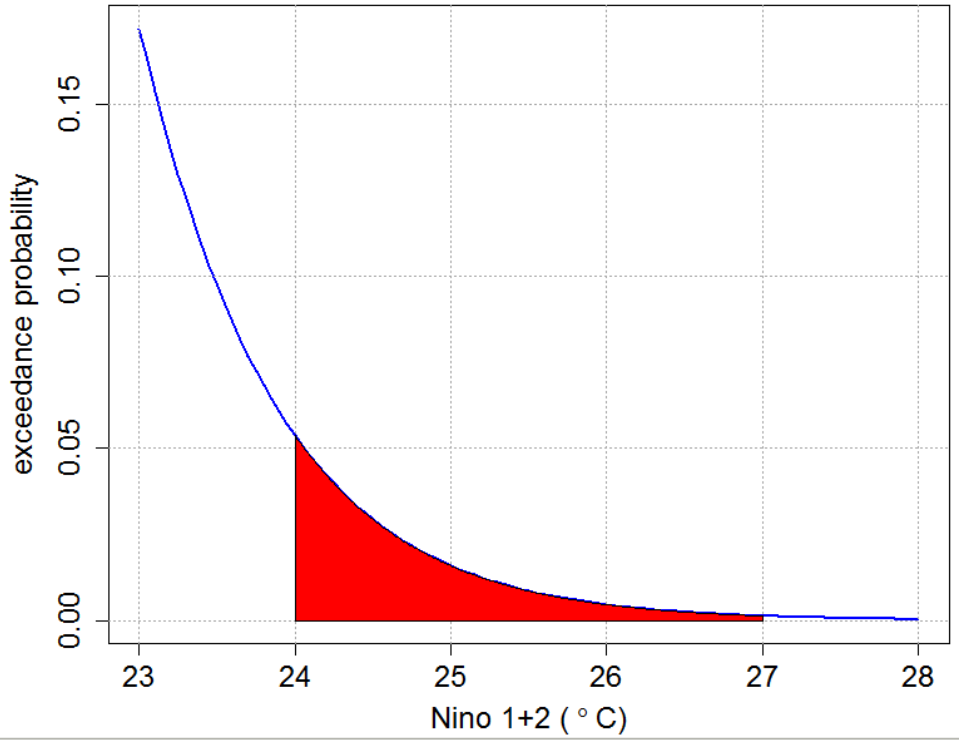
Results

- The two datasets yield different result in terms of return periods: At the entry point the difference is about 4 years and at the exit point it reaches about 200 years.



Results

- Return periods (or their inverse, exceedance probabilities) form the basis for the price calculation.
- For the linear payoff contract, the expected exceedance probability for the agreed temparature range (24 - 27°C) is required.
  - This is calculated as the integral of the exceedance probability function in the desired range.



Results

- The expected value of the exceedance probability is:
  - ERA-Interim 0.018
  - NOAA 0.014
- The corresponding annual premiums are 0.018 * 50 million USD = 893000 USD using ERA-Interim data and 0.014 * 50 million USD = 716000 USD using NOAA data.
- This is sometimes called the «pure» premium. The final price will include «loadings» for expenses, brokerage, cost of capital, profit etc.

- Although the original data were similar, the difference in the final price is quite substantial.
  - This is often the case for extreme values, where the exceedance probability changes “fast” with changes in the quantile.
  - Observations of extreme events are sparse, therefore statistics based on these observations often have considerable bias.