Probabilistic forecasts of temperature and precipitation change based on global climate model simulations

(CES deliverable 2.2)

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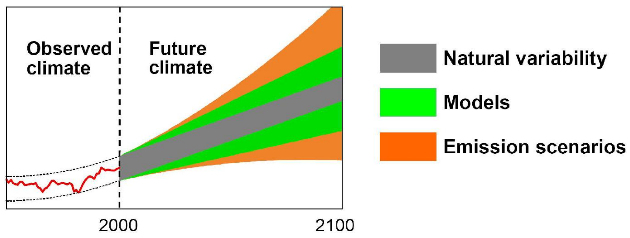
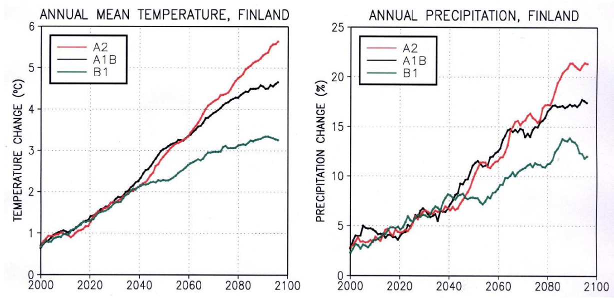
SOURCES OF UNCERTAINTY IN CLIMATE CHANGE FORECASTS



A schematic view of sources of uncertainty in climate change as a function of time. In the long run, most of the uncertainty relates to the magnitude of greenhouse gas emissions (unknown future behaviour of mankind) and differences between climate models (how climate responds to changes in atmospheric composition). In the short run, most of the uncertainty comes from natural variability.



As shown by this example (best-estimate temperature and precipitation changes in Finland), **the emission scenario uncertainty remains small until about the year 2040.** Thus, during the timeframe of the CES project, the uncertainty mainly comes from natural variability and differences between climate models.

DATA AND METHODS

The results shown here are based on simulations by **19 global climate models**. This so-called CMIP3 data set is described by Meehl et al. (2007).

The probabilistic forecasts are constructed using simulations for **SRES A1B** scenario (Nakićenović and Swart 2000). A resampling technique described by Räisänen and Ruokolainen (2006) is used to increase the sample size. All climate changes are expressed as differences from the **baseline 1971-2000**.

The results take into account the uncertainty resulting from both climate model differences and natural variability. The uncertainty in emission scenarios is not included, but this is quite small for the near future.

MAIN FINDINGS

- High probability of warming, already in the next decade.
- Somewhat lower probability of precipitation increase, due to the relatively larger impact of natural variability.
- **There is substantial quantitative uncertainty in climate change forecasts – do not neglect it**.

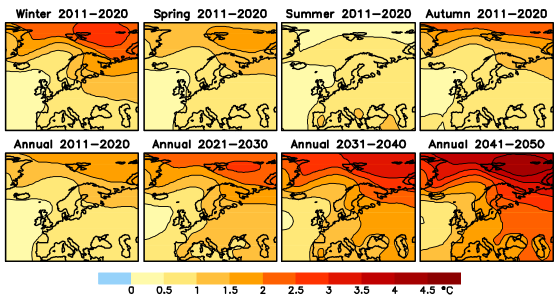
REFERENCES

Meehl, G.A., C. Covey, T. Delworth, M. Latif, B. McAvaney, J.F.B. Mitchell, R.J. Stouffer and K.E. Taylor 2007: The WCRP CMIP3 Multimodel Dataset: A New Era in Climate Change Research. *Bulletin of the Americal Meteorological Society*, **88**, 1383-1394.

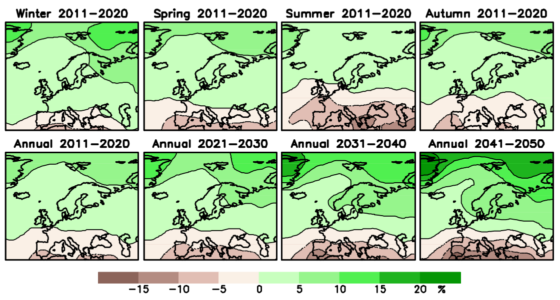
Nakićenović, N. and R. Swart (Eds.) 2000: *Emission Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 599 pp.

Räisänen, J. and L. Ruokolainen 2006: Probabilistic forecasts of near-term climate change based on a resampling ensemble technique. *Tellus*, **58A**, 461-472.

BEST ESTIMATES OF TEMPERATURE AND PRECIPITATION CHANGE

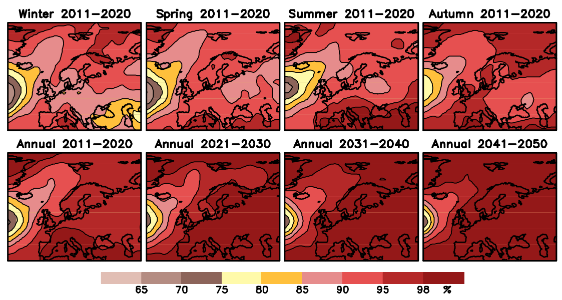


Best estimates of temperature change. Top: temperature changes for the decade 2011-2020 in four three-month seasons. Bottom: annual mean temperature change as a function of time, from 2011-2020 to 2041-2050. All changes are expressed relative to the mean temperature in 1971-2000.

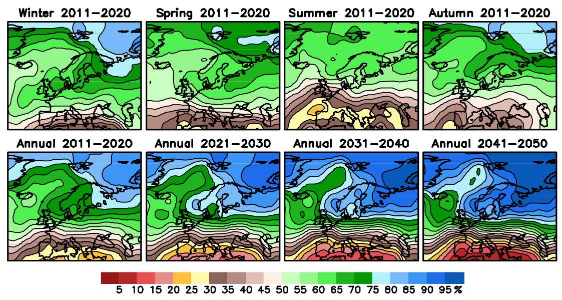


Best estimates of precipitation change. Top: precipitation changes for the decade 2011-2020 in four three-month seasons. Bottom: annual mean precipitation change as a function of time, from 2011-2020 to 2041-2050. All changes are expressed in per cent of the mean precipitation in 1971-2000.

HOW CERTAINLY WILL TEMPERATURE AND PRECIPITATION INCREASE?

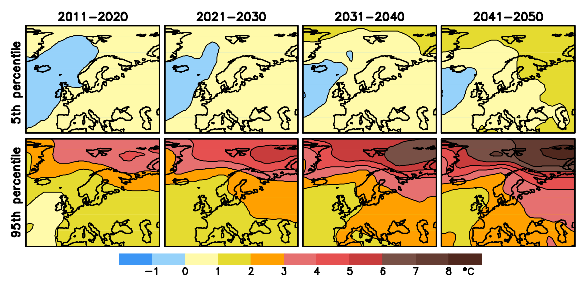


Probability of warming is very high. Top: probability that the average winter, spring, summer and autumn temperatures in the decade 2011-2020 will exceed their mean value in 1971-2000. Bottom: probability of annual mean warming as a function of time, from 2011-2020 to 2041-2050.

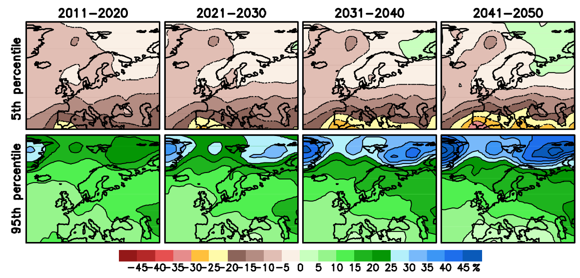


Probability of precipitation increase is not quite as high. Top: probability that the average winter, spring, summer and autumn precipitation in the decade 2011-2020 will exceed their mean value in 1971-2000. Bottom: probability of annual mean precipitation increase as a function of time, from 2011-2020 to 2041-2050.

5-95% UNCERTAINTY RANGES OF ANNUAL MEAN TEMPERATURE AND PRECIPITATION CHANGE

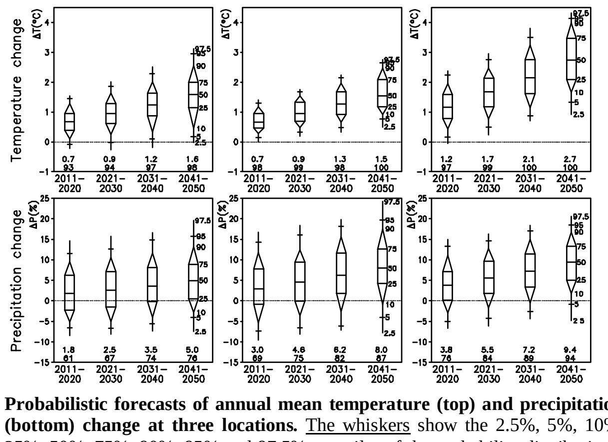


5th and 95th percentiles of annual mean temperature change as a function of time. There is, on the basis of the present model simulations, a 90% probability that the temperature changes in the real world will be between the 5th and the 95th percentiles.



5th and 95th percentiles of annual mean precipitation change as a function of time. There is, on the basis of the present model simulations, a 90% probability that the precipitation changes in the real world will be between the 5th and the 95th percentiles.

PROBABILISTIC FORECASTS OF CLIMATE CHANGE FOR THREE EXAMPLE LOCATIONS

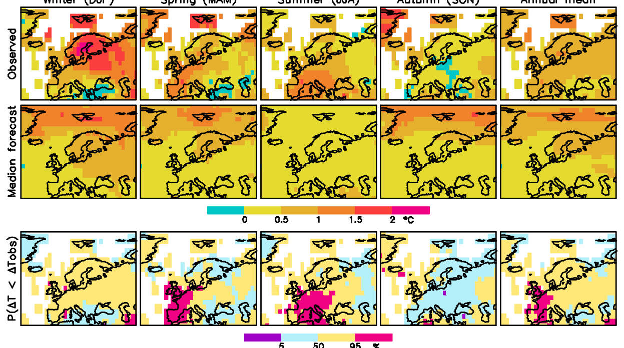


Probabilistic forecasts of annual mean temperature (top) and precipitation (bottom) change at three locations. The whiskers show the 2.5%, 5%, 10%, 25%, 50%, 75%, 90%, 95% and 97.5% quantiles of the probability distributions, which are given separately for the four decades 2011-2020, 2021-2030, 2031-2040 and 2041-2050. The two numbers on the bottom of each panel give the median estimate of the change relative to the baseline 1971-2000 (in ºC for temperature and in per cent for precipitation), and the probability (in per cent) that the forecast period will be warmer/wetter than 1971-2000.

The full report gives similar box-whisker plots for the seasonal mean temperature and precipitation changes in the same three locations.

Note that the three locations were chosen just as examples. Similar diagrams for other locations can be constructed upon request.

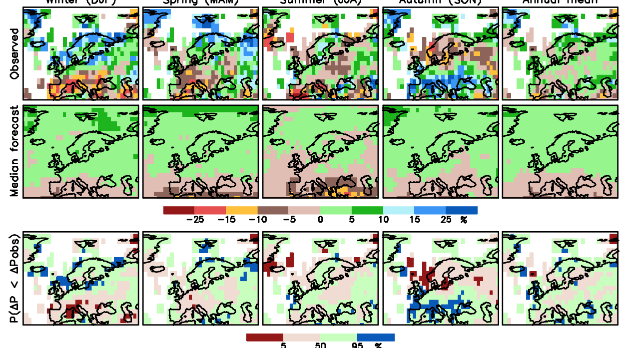
HINDCAST VERIFICATION OF TEMPERATURE CHANGES BETWEEN 1961-1990 AND 1991-2005



Hindcast verification of seasonal and annual mean temperature changes between 1961-1990 and 1991-2005. Top: observed changes. Middle: best-estimate (median) changes from the model-based hindcast. Bottom: the location of the observed change within the hindcast probability distribution. Dark red (violet) shading indicates areas where the observed change was above the 95th percentile (below the 5th percentile) of the hindcast distribution.

These maps show that there was only a broad agreement between the best-estimate temperature change hindcast and the observations. However, the hindcast and the observations are not inconsistent, because the area in which the observed changes fell to the tails of the hindcast distribution is relatively small.

HINDCAST VERIFICATION OF PRECIPITATION CHANGES BETWEEN 1961-1990 AND 1991-2005



Hindcast verification of seasonal and annual mean precipitation changes between 1961-1990 and 1991-2005. Top: observed changes. Middle: best-estimate (median) changes from the model-based hindcast. Bottom: the location of the observed change within the hindcast probability distribution. Blue (red) shading indicates areas where the observed change was above the 95th percentile (below the 5th percentile) of the hindcast distribution.

These maps show that there was no detailed agreement between the best-estimate precipitation change hindcast and the observations. Because natural variability acted to increase precipitation in some areas and to reduce it elsewhere, the observed distributions look much more noisy than the best estimate from the models. However, the hindcast and the observations are not inconsistent, because the area in which the observed changes fell to the tails of the hindcast distribution is relatively small.

These verification tests bear a very important message to the end-users of climate change forecasts. It is extremely unlikely that a deterministic forecast of future climate change, regardless of how this forecast was produced, would be precisely correct. It is therefore necessary to take into account the uncertainty, rather than just rely on the most likely outcome.