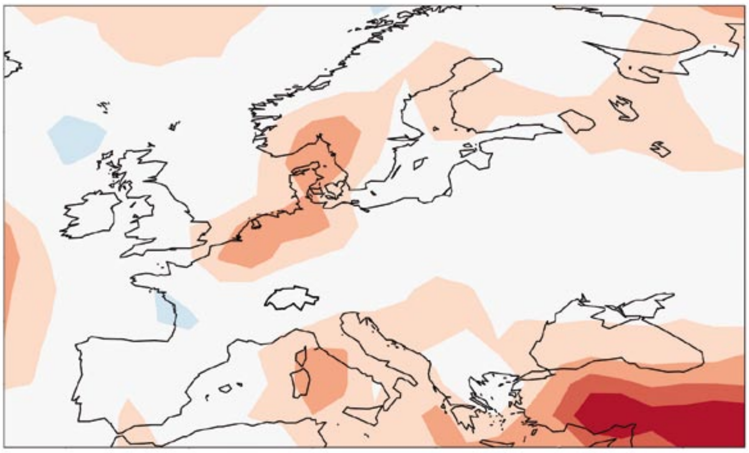
Climate Variability Today and Tomorrow: The Contribution of MeteoSwiss to NCCR Climate II

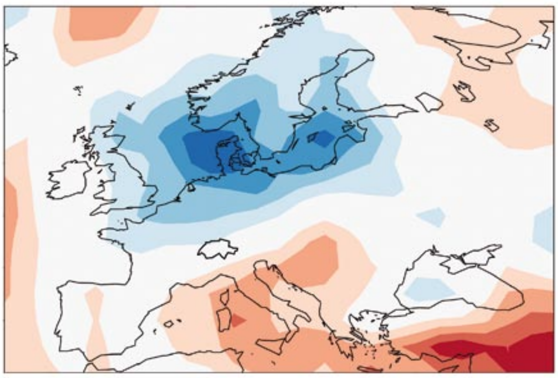
Society and many sectors of the economy have a growing need for the reliable assessment of weather and climate risks. In response to this, MeteoSwiss has chosen climate variability and its predictability as the focus of its activities for the National Centre of Competence in Climate Research (NCCR Climate). Research has been conducted in the following areas: improvement of monthly forecasts and seasonal forecasts, new methods for predicting heavy precipitation, damage potential of winter storms in Europe, connections between large scale circulation patterns and regional weather parameters such as temperature, snow and phenological phases. With these activities, MeteoSwiss supports on the one hand its customers in their effort to manage weather and climate risks more effectively, on the other hand it makes a contribution to current climate research.

Fig. 1: quality of seasonal forecasts of summer temperature in Europe from 1987 to 2007. Blue and white areas: no prediction skill; red areas: good prediction skill.

right: recalibrated seasonal forecasts.

below: seasonal forecasts





Long-term forecasts

Statements about seasonal climate development provide an important basis for industry to manage its weather and climate risks efficiently. Climatologists of MeteoSwiss have therefore examined the seasonal forecasts of the European Centre for Medium-Range Weather Forecasts (ECMWF). Until now, these forecasts reveal significant limitations. Their quality depends to a great extent on the region, the season, the prediction range and the meteorological parameters of interest. For instance, the European summer temperature can only be reliably forecasted in the Mediterranean region (Fig. 1, left) (Weigel et al. 2007 a, b). Moreover, seasonal forecasts fail to take climate warming into adequate account (Liniger et al. 2007). Often, the forecast uncertainties are not quantified correctly, either.

However, since recently the use of multi-models allows for improved seasonal forecasts. In order to do this, scientists combine the predictions of as many different models as possible to form a super-ensemble. This reduces, due to a kind of error compensation, the forecast uncertainties, thus improving the predictions (Weigel et al. 2008a).

Recalibration is a second possibility to improve seasonal forecasts. With this technique, correction factors can be determined from past forecasts, allowing for a better estimation of the forecast uncertainties (Weigel et al. 2009). In addition, recalibration can correct systematic model errors. Especially in Europe where prediction skill is very limited, recalibration can yield better results (Fig. 1, right).

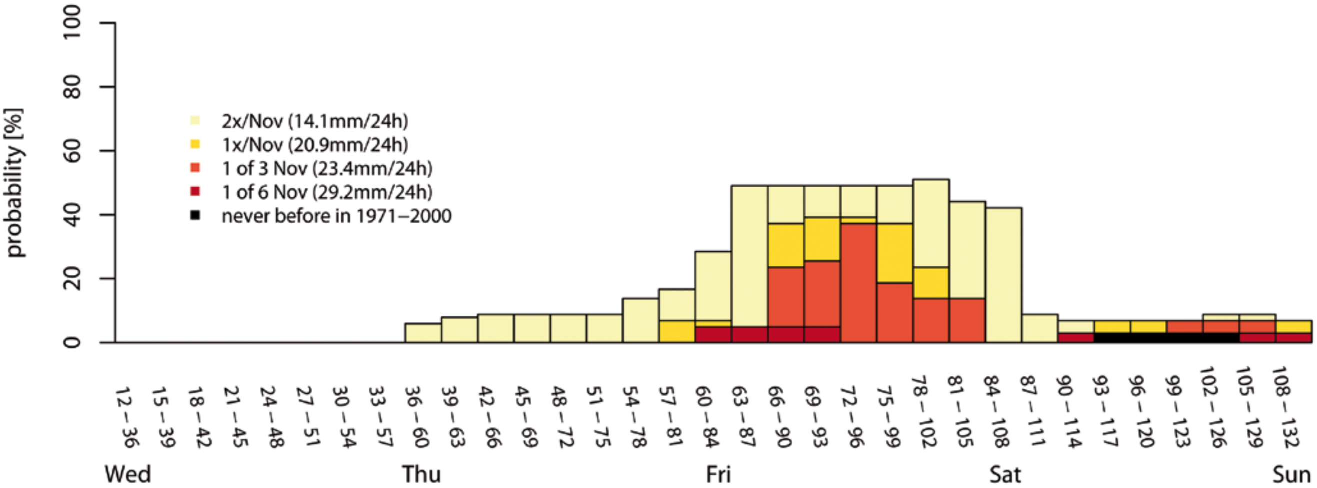


Fig. 2: warning diagram for a 5½ day COSMO-LEPS forecast of 24h precipitation totals. Colours indicate the frequency of the events, column heights the probability of their occurrence.

Besides seasonal forecasts, scientists of MeteoSwiss have examined so-called monthly forecasts which cover the prediction range of the following two to four weeks. They reveal a substantially better prediction skill in Central Europe than the seasonal forecasts and therefore have a higher potential for application in this region (Baggenstos 2007, Weigel et al. 2008b).

Warnings of infrequent weather events

Infrequent and high-impact weather events have been in the centre of public interest even more since the big storms of the past years. By means of climatologic approaches, forecasting of such events can be improved (Fundel et al. 2009). MeteoSwiss has re-calculated forecasts of the ensemble prediction system COSMO-LEPS for the past 30 years (Montani et al. 2003) and used these for calibration. Automatic warnings can thereby be issued up to 24 hours earlier. Warning systems such as the internet platform of the project MAP D-PHASE (Rotach et al. 2009) have already made use of these forecasts (Fig. 2).

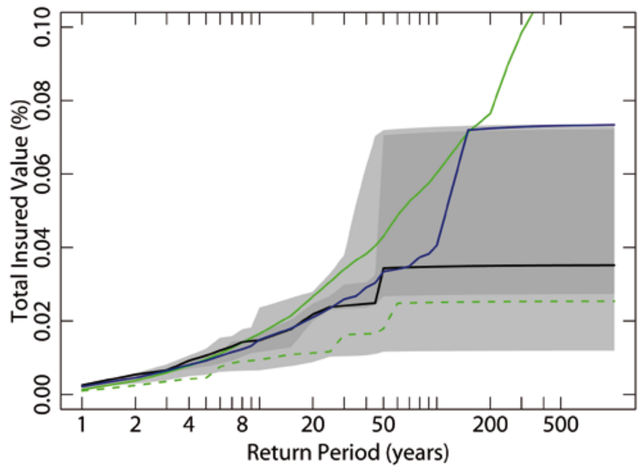


Fig. 3: potential storm damages, calculated in the conventional way (green), using observation data (black), and applying the new method (blue, with grey uncertainty field).

Frequency and damage potential of European winter storms

Winter storms over Europe are high risk events for the society and also for reinsurance companies such as Swiss Re. In order to evaluate their risk potential, Swiss Re used to combine their portfolio of historical storms with damage models. However, high-quality wind data were often missing. A joint project of Swiss Re and MeteoSwiss made use of seasonal forecasts in order to generate an artificial data set of more than 300 years representative for the current winter climate. (Della-Marta 2008, 2009).

The newly-developed data set was combined with the damage model of Swiss Re and potential damages were calculated. While the calculated damages for short return periods were consistent for all methods applied, differences increased considerably with the rareness of the event (Fig. 3). Particularly for the determination of extreme damages and their uncertainty, it is therefore important that the newly-developed artificial data set and alternative methods are taken into account.

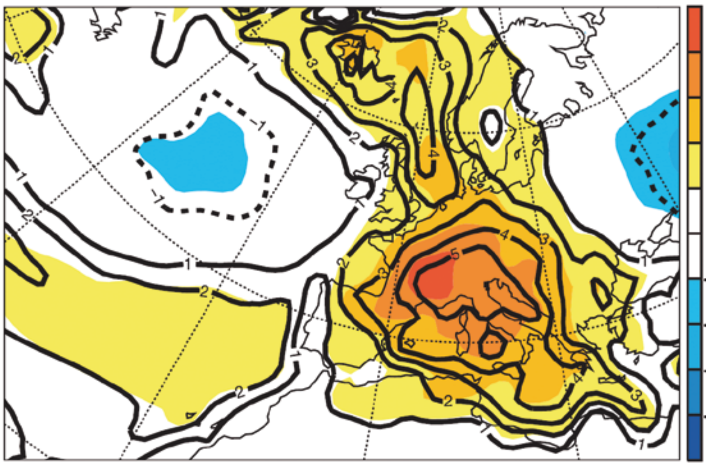


Fig. 4:
summer heatwave 2003: positive temperature anomaly over Europe. Temperatures exceed the normal mean (1961–1990) by up to four degrees Celsius.

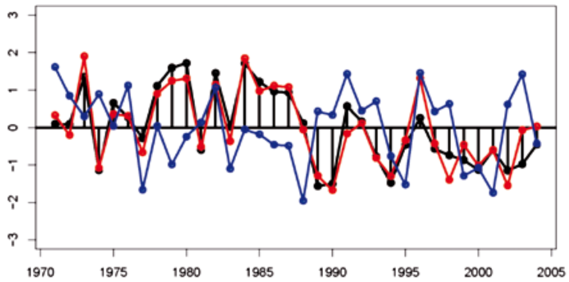


Fig. 5:
time series for the onset of spring in the entire Alpine region relating to phenology (black), temperatures (red) and precipitation totals (blue). High values indicate a late spring onset.

Temperature and snow in the Swiss alpine region

In the context of climate change, snow and temperature are important parameters in Switzerland. Our analysis has proved that the amount of winter snow below 1300 m above sea level has decreased significantly since the late 1980s, and that there is a strong correlation between snow conditions on the one hand and both the predominant directions of air currents and the location of pressure systems on the other hand (Scherrer et al. 2006). A cooperation with other scientists within NCCR Climate has demonstrated that in the past years both seasonal and monthly temperatures reached several long-term records over large areas (Fig. 4, Schär et al. 2004, Luterbacher et al. 2007). Particularly in summer, observations as well as model runs show a dominant increase in temperature as well as a slight increase in year-to-year variability (Scherrer et al. 2008). The high degree of consistency between observation and climate scenarios provides a good basis for the detailed research of climate change in Switzerland.

Phenological observations

In many biological systems the impact of climate change can be detected and retraced. The seasonal development phases of plants (phenology) are an ideal indicator of environmental change due to the many systematic observations in the Alpine region.

An index derived from phenological data of various plants in the wider alpine region (1971–2004) reveals the spatial patterns and their relation with climate change (Meier, 2009). Scientists of MeteoSwiss have compared observations with daily temperature and precipitation data. It turned out that temperature, not precipitation, was the limiting factor (Fig. 5).

A comparison of phenological observations with satellite data over several decades shows a clear correlation, even for the complex topography of Switzerland (Studer et al., 2007). Satellites therefore have the potential to provide large-scale, continuous observation data.

Outlook

MeteoSwiss will intensify its own research activities as well as cooperation with institutes and universities in the course of the third phase of the national NCCR Climate and the Center for Climate Systems Modeling (C2SM). C2SM is the recently founded scientific network of the Federal Institute of Technology in Zurich, MeteoSwiss, Empa and ART, focusing on climate systems modeling. Two future research priorities of MeteoSwiss will be the development of national climate scenarios from multi-models as well as the development of climate data with a high spatial and temporal resolution. These data will enable comprehensive applications in hydrology or agriculture in the Alpine region.

References

Baggenstos, D. 2007:
Probabilistic verification of operational monthly temperature forecasts. Veröffentlichung der MeteoSchweiz, 76, 52 pp.

Della-Marta, P. M., Mathis, H., Frei, C., Liniger, M. A., Appenzeller, C. 2007:
Extreme Wind Storms over Europe: Statistical Analyses of ERA-40. Arbeitsbericht der MeteoSchweiz, 216, 79 pp.

Della-Marta, P. M., Mathis, H., Frei, C., Liniger, M. A., Kleinn, J. and Appenzeller, C. 2008:
The return period of wind storms over Europe. International Journal of Climatology, DOI: 10.1002/joc.1794.

Della-Marta, P. M., Liniger, M. A., Appenzeller, C., Bresch, D. N., Köllner-Heck, P., Muccione, V. 2009:
Improved estimates of the European winter wind storm climate and the risk of reinsurance loss, submitted.

Fundel, F., Liniger M. A., Appenzeller C., Walser A. and Frei C. 2009:
Calibrated Warnings of Precipitation Events over Switzerland Using COSMO-LEPS Reforecasts, in prep.

Liniger, M. A., Mathis H., Appenzeller, C. and Doblas-Reyes, F. J. 2007:
Realistic Greenhouse Gas Forcing and Seasonal Forecasts. Geophys. Res. Lett., 34 L04705.

Luterbacher, J., Liniger, M. A., Menzel, A., Estrella, N., Della-Marta, P. M., Pfister, C., Rutishauser, T. and Xoplaki, E. 2007:
Exceptional European warmth of autumn 2006 and winter 2007: Historical context, the underlying dynamics, and its phenological impacts. Geophys. Res. Lett., 34 L12704.

Meier, N. 2009:
Phänologische Muster und ihre Beziehung zum Klimawandel im grösseren Alpenraum, in prep.

Rotach, M. et al. 2009:
MAP D-PHASE: Real-time Demonstration of Weather Forecast Quality in the Alpine Region, submitted.

Schär, C., Vidale, P., Luethi, D., Frei, C., Haeberli, C., Liniger, M. A., Appenzeller, C., 2004:
The role of increasing temperature variability for European summer heatwaves. Nature, 427, 332-336.

Scherrer, S. C., et al., 2008:
Distribution changes of seasonal mean temperature in observations and climate change scenarios. In: Climate variability and extremes during the past 100 years, S. Brönnimann, et. al. Eds., Springer, Vol. 33 in the Advances in Global Change Research Book Series, 364p, ISBN: 978-1-4020-6765-5.

Scherrer, S. C., and C. Appenzeller, 2006:
Swiss Alpine snow pack variability: major patterns and links to local climate and large-scale flow. Climate Research, 32, 187-199.

Studer, S., Stöckli, R., Appenzeller, C. and Vidale, P. L. 2007:
A comparative study of satellite and ground-based phenology. Int. J. Biometeorol., 51(5) 405-414.

Weigel, A. P., Liniger M. A. and Appenzeller, C. 2007a:
The discrete Brier and ranked probability skill scores. Mon. Wea. Rev., 135(1) 118–124.

Weigel, A. P., Liniger M. A. and Appenzeller, C. 2007b:
Generalization of the Discrete Brier and Ranked Probability Skill Scores for Weighted Multimodel Ensemble Forecasts. Mon. Wea. Rev., 135(7) 2778–2785.

Weigel, A. P., Liniger, M. A. and Appenzeller, C. 2008a:
Can multi-model combination really enhance the prediction skill of probabilistic ensemble forecasts? Quart. J. Roy. Met. Soc., 134 241-260.

Weigel, A. P., Baggenstos, D., Liniger, M. A., Vitart, F. and Appenzeller, C. 2008b:
Probabilistic verification of monthly temperature forecasts. Mon. Wea. Rev., 136, 5162-5182.

Weigel, A. P., Liniger, M. A. and Appenzeller, C. 2009:
Seasonal ensemble forecasts: Are recalibrated single models better than multi-models? Mon. Wea. Rev. in press.

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