Analysis of climate change in Hesse (Germany) based on the period 1901-2003

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Regarding the global climate change and its dominant anthropogenic forcing within industrial time, the structures of this phenomenon have been analysed for the region 49° - 52° N / 7° - 11° E (Hesse and some parts of adjacent areas within Germany) considering surface air temperature and precipitation. This analysis is focused on the period 1951-2000 (2003) where temperature information is available from 53 and precipitation information from 674 stations. For the period since 1901, also considered, the data base is poor.

Averaged for this area, the annual temperature trend 1951-2000 amounts to 0.9 °C with its maximum in winter (1.6 °C) and minimum in autumn (0.2 °C). On a monthly data basis the maximum trend arises in August whereas in November a very small cooling is reported. As usual in climate time series these trends are superimposed by relatively long-term fluctuations and relatively short-term anomalies. The seasonal regional patterns are quite uniform with the exception of autumn where cooling dominates in the north and warming in the south (up to trends of roughly 0.5 °C in each case).

The precipitation trends appear to be much more complicated. First, averaged for the area specified an increase in the annual precipitation totals by 8.5 % is observed. In spring, autumn and winter this increase has an order of magnitude of approximately 20-25 % whereas in summer a decrease of ca 18 % is found, all for the period 1951-2000. On a monthly data basis an enormous increase in October and especially in March (62 %) is the most outstanding effect. The summer decrease is concentrated on June and especially August. As far as the regional trend patterns are concerned, they reach from roughly 0-40 % increase in winter to roughly 5-30 % decrease in summer. Again on a monthly data basis, particularly the July patterns are worth noting: pronounced decrease (up to 30 %) in northern parts, even more pronounced increase in middle parts (up to 50 % and more) and moderate increase (5-20 %) in southern parts.

Performing a corresponding analysis of extremes, a new method has been applied which allows the computation of the probability density function (PDF) of the underlying data from time step to time step. Consequently, the probability of exceeding or lying below certain thresholds can also be computed in terms of time functions. The results show a lot of details. In the case of temperature, however, the effects are relatively uniform in the sense that low temperatures become more seldom and warm/hot temperatures more frequent. For example, in the case of the annual mean temperature at Kassel (northern part of Hesse) the probability of occurring values exceeding 10 °C increased from 2 % in 1901 to 14.5 % in 2003.

Precipitation PDF shifts, especially in winter, are often linked with an increase in variance so that both extremely low and extremely high precipitation becomes more frequent. For example, at the station Eppenrod (western part), within 1901-2003, the probability of winter precipitation falling below 100 mm increased approximately from 1 % to 4 % and exceeding 300 mm increased from 1 % to 25 %. However, especially the summer results show a different picture and in general the precipitation behaviour varies considerably from season to season and station to station. A supplementary analysis of extreme days is consistent with the monthly data analysis results but shows, in addition, that the length of dry spells in summer increases.

It is a well-known fact that climatological cause-effect analyses and simulations succeed much more on a global than on a regional scale. Nevertheless, a statistical multiple regression technique has been applied which aims at the separation of natural and anthropogenic forcing in observed temperature time series. Again as an example, referring to the Frankfurt annual mean temperature time series 1885-2003, the increasing anthropogenic greenhouse gas signal has exceeded the 90 % confidence level since approximately 1980.

A comparison of observed climate variations and climate model future projections reveals at least qualitatively consistent results in the case of temperature such as winter and summer precipitation, but some uncertainties with respect to spring and autumn precipitation.