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Arctic observing system and atmospheric climate research

We know that the Arctic is warming; the current warming rate is about twice the average global value. At the same time Arctic sea ice is melting rapidly and the Greenland ice sheet appears to be shrinking, albeit at a relatively slow rate. The current meteorological and climatological observing system in the Arctic is mainly concentrated at the surface and over land areas with observing stations recording temperature, pressure, humidity and wind. At a few stations regular weather balloon ascents (radiosondes) are made, twice daily vertical profiles of the main meteorological variables are measured. Another major source of weather information are weather satellites, measurements of infrared and visible electromagnetic radiation can be converted to temperature and humidity profiles as well as information about cloud and ice cover.

Despite the comparatively good coverage provided by operational meteorological stations we are still uncertain about the mechanisms that regulate climate change in the Arctic. The sudden ice retreat this year has come as a surprise to many climate scientists. There has been a steady decline in the summer Arctic ice cover over the past 50 years or so, but the sudden collapse this year was not predicted. Arctic warming is generally thought to be caused by the so called ice-albedo feedback, greenhouse gas induced warming reduces the ice cover and a reduced ice cover leads to an increased absorption of solar radiation during the summer season. Some of the enhanced warming over the Arctic can be explained by this phenomenon, but it is not a sufficient explanation. There must be other processes that cause enhanced feedbacks leading to an intensified warming and a number of such processes have been proposed in the literature. We are, however, still lacking the basic observation data needed to confirm or reject many of the hypotheses proposed.

In climate research a so called re-analysis technique is used to construct comprehensive and homogenous data sets covering long time periods. One example is the ERA-40, a 40 year atmospheric data set produced at the European Centre for Medium Range Weather Forecasts in Reading UK. This data set is extensively used in present day climate research. Data assimilation techniques are a vital part of reanalyses, an atmospheric forecast model is combined with observations to produce a homogeneous and physically consistent set of atmospheric data. Due to a lack of observations in the Arctic much of the atmospheric state information is provided by the assimilating forecast model. As different observation sources give somewhat different information about temperature, wind and pressure the assimilation system must weigh the observations together with information extrapolated from the forecast model. This procedure is optimal in the sense that it uses the observation information in the best possible way, but a lack of observation information will lead to a degradation of the quality of the resulting data set.

At present we primarily need wind information to improve the quality of atmospheric data sets. Above the surface we also need independent, in situ, temperature information. Today most of the temperature information is provided by satellites, although the satellites have a very good spatial coverage the accuracy of the observations are not as good as the accuracy of

in situ observations from radiosondes. Other, more unconventional, observation platforms have been proposed. An example is unmanned aircraft, if technically and practically feasible such platforms could provide in situ observations in remote areas such as the Arctic region.

To enhance our understanding of Arctic climate change we must improve the atmospheric observing system in the Arctic. Conventional, in situ, observations are lacking and due to the limited accuracy of satellite data we need to enhance the present observing system. For climate studies long time series are needed, the reanalysis technique is a vital tool to reconstruct atmospheric states from unevenly distributed and intermittent observations. The reanalysis efforts at the European Centre for Medium Range Weather Forecasts in Reading, UK, needs to be continued and enhanced with new observation information.