ALPINE SNOW COVER CLIMATOLOGY – A SWISS GCOS PILOT PROJECT

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ABSTRACT

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations necessary to address climate-related issues are defined, obtained and made available to all potential users. The Swiss GCOS Office at the Federal Office of Meteorology and Climatology MeteoSwiss is responsible to coordinate all climate relevant measurements on the national level in Switzerland. Given the long tradition of ground-based in-situ measurement networks in Switzerland since the middle of the 19th century, these data provide a unique opportunity to analyze the development of the climate over the last 150 years, in particular the regional climate change in the Alpine region.

Snow properties are important parameters for the Alpine climatology. Traditionally, they have been measured by nearly 250 in-situ stations in Switzerland. The complementary use of satellite data for snow cover mapping (e.g. NOAA AVHRR since 1985) has shown the added value of satellite data for the snow analysis. However, the low time frequency of the NOAA satellites compared to Meteosat-8 implies a lower probability of cloud-free pixels to be classified as 'snow' vs. 'no snow'. Therefore, an operational processing chain has been implemented at MeteoSwiss to derive snow cover maps from Meteosat-8 every 15 minutes.

In this paper, the role of satellite data in the emerging integrated observing system GCOS is shown. For this purpose, the extent and variability of seasonal snow cover extent is demonstrated using the operationally derived MeteoSwiss daily snow cover product for the winter 2005/2006 and 2006/2007.

INTRODUCTION

For the understanding of the climate system, continuous long-term systematic observations are needed on the national, regional and global scale. The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations necessary to address climate-related issues on all three spatial scales are defined, obtained and made available to potential users. Primarily, the GCOS observations should assist Parties in meeting their responsibilities under the UN Framework Convention on Climate Change (UNFCCC), and also provide the systematic and sustained observations needed by the World Climate Research Programme (WCRP) and the Intergovernmental Panel on Climate Change (IPCC). In 2004, a 10-years GCOS Implementation Plan in support of the UNFCCC was compiled (WMO, 2004). The Implementation Plan describes a feasible and cost-effective path toward an integrated observing system which depends on both in-situ and satellite-based measurements.

In Switzerland, the climate relevant measurements are coordinated by the Swiss GCOS Office at the Federal Office of Meteorology and Climatology MeteoSwiss. Given the long tradition of ground-based in-situ measurement networks in Switzerland since the middle of the 19th century, these data provide a unique opportunity to analyze the development of the climate over the last 150 years, in particular the regional climate change in the Alpine region (Seiz and Foppa, 2007).

The Swiss GCOS Office is also exploring new measurement techniques and methods for improving the long-term monitoring of the Essential Climate Variables (ECVs; see e.g. WMO, 2004) in Switzerland, in particular from satellites. The estimation of snow parameters such as snow extent, snow depth and snow water equivalent are vital for winter tourism as well as for the management of water resources. Accurate monitoring of regional snow cover is a key component in the study of global change.

ALPINE SNOW COVER CLIMATOLOGY BASED ON METEOSAT-8

Since October 2005, a new processing chain is operational at the Federal Office of Meteorology and Climatology MeteoSwiss to derive snow cover data from the SEVIRI instrument of the operational MSG satellite. The resulting snow cover map is subsequently used in the snow analysis of the regional NWP model at MeteoSwiss (COSMO). The methodology for the snow cover retrieval from MSG is described in detail in De Ruyter de Wildt et al. (2007), including comparison with the MODIS snow product and in-situ data.

Figure 1 shows the extracted mean snow cover amount over Europe for the two winters 2005/06 and 2006/07. Also included is a quality index which is a function of the updating period (i.e. age of the pixel information). It is obvious that the two winters have been completely different in terms of snow cover. The winter 2005/06 started with an early increase of mean snow cover at the beginning of December which then stayed more or less constant over the whole winter. In 2006/07, there was not much snow until January, and also later in the winter, the mean snow cover stayed much smaller than in the previous year. The corresponding quality index shows a few peaks of up to 7 days in the winter 2005/06. These periods are caused by some missing data. In winter 2006/07, the maximum age of pixels was significantly lower. However, there are still some periods with a mean pixel age of 3-4 days, caused by several days with overcast sky. One reason for the rather long cloudy periods is the setup of the snow algorithm. It is tuned to avoid any misclassification of snow, i.e. to assign a pixel as ‘snow’ when it is actually ‘cloudy’, so the threshold in the cloud classification is set very conservatively. This setup is optimal for the NWP application, where any misclassified ‘snow’ pixel can have a large negative influence on the snow analysis within the model and subsequently the near-surface temperature fields and forecasting skills.

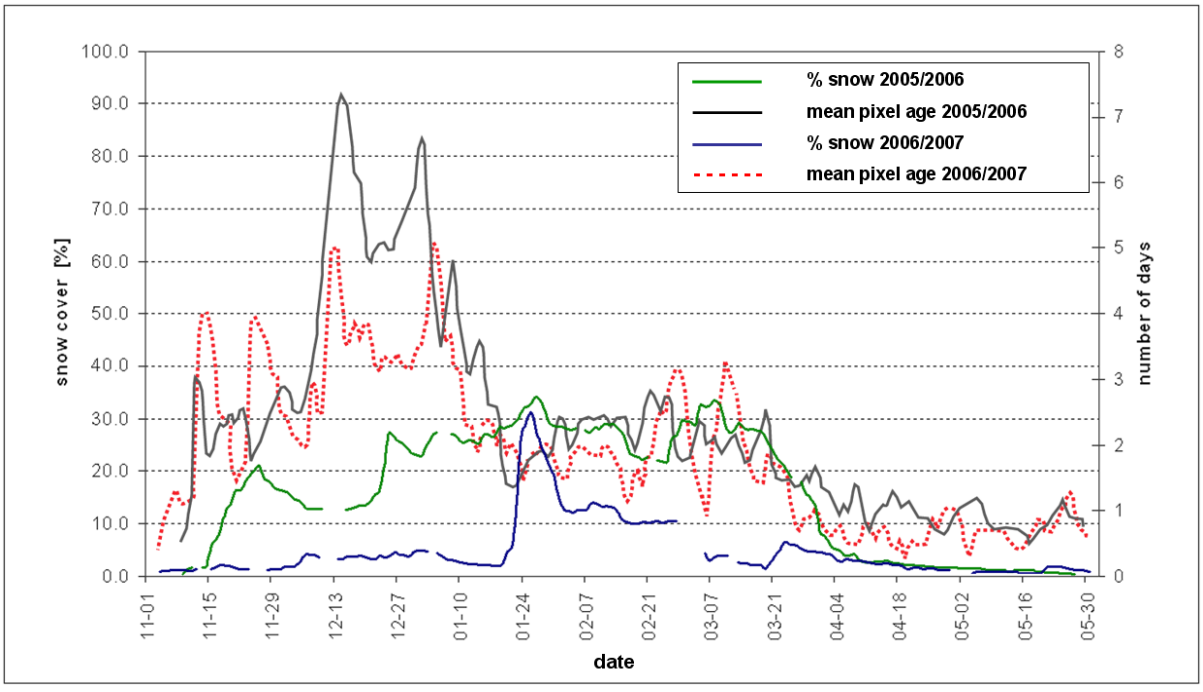

Figure 1: Results from the operational snow cover mapping from Meteosat-8 for the winters 2005/06 and 2006/07.

SUMMARY AND FUTURE PLANS

This paper has presented the role of the Swiss GCOS Office for exploring the potential of satellite data for the long-term monitoring of Essential Climate Variables in Switzerland. The example of snow cover has been chosen. The snow cover product from Meteosat-8 (and Meteosat-9, respectively), which is operational at MeteoSwiss since November 2005, has been demonstrated for the two winters 2005/06 and 2006/07. In general, the satellite-based results give a good overview of the snow cover situation in Switzerland. However, the restriction of the method to cloud-free situations leads to the problem of long time periods with no update of the snow information. Despite the use of every 15 minute time step of MSG, the updating period (i.e. age of the pixel information) can be up to 3-4 days. This pixel age information has consequently been included as quality indicator in the processing chain.

In the winter 2007/08, the snow cover product will be further analysed and compared with other snow products. Thereby, emphasis is given to improve the mean pixel age, e.g. by adapting the retrieval strategy in terms of cloud classification. Furthermore, it will be studied, how to optimally combine geostationary and polar-orbiting satellite information, as well as in-situ data, for snow cover monitoring. Finally, a strategy will be outlined how to extend the snow cover data record of Switzerland back to the start of NOAA AVHRR data in 1985.

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