Analysis of the Geometric Accuracy of MSG-SEVIRI Imagery with Focus on Estimation of Climate Variables

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Abstract: GCOS (Global Climate Observing System) is a long-term international program for monitoring the climate, detect changes, and assess their impact. Remote sensing techniques and satellite imagery are being increasingly used for climate-related measurements and derivation of Essential Climate Variables (ECVs). Under a research agreement between the Swiss GCOS Office at MeteoSwiss and ETH Zurich, the geometric accuracy of image products acquired from three different satellite sensors (SEVIRI, AVHRR and MODIS), which are often used to estimate climate variables, are being investigated. Such investigations are essential, since geometric errors, of even modest size, modify the location and possibly extent of derived climate variables and wrongly influence conclusions about their change. In particular, we investigate whether the geometric accuracy specifications of the related sensor products are really fulfilled.

In the first phase of the project, the geometric accuracy of images acquired by the Spinning Enhanced Visible and IR Imagery (SEVIRI) on board of the European geostationary satellites MSG-1 and MSG-2 has been assessed. The provided bands are High-Resolution-Visible (HRV) with 1-km GSD and several multispectral bands with 3-km GSD at sub-satellite point. Level 1.5 image data, obtained by post-processing of the satellite raw data, constitutes one of the main SEVIRI products. This data is corrected for undesired radiometric and geometric effects, geolocated using a standardized projection, and calibrated and radiance-linearized. Cloud masks are provided with the image data. Level 1.5 data during daytime covering Switzerland and its surrounding countries have been evaluated in this study. The aims include: a) assessment of the relative accuracy of consecutive HRV images; b) assessment of the absolute accuracy for HRV images; and c) evaluation of band-to-band registration accuracy between the HRV and multispectral channels.

A set of fully automated processing methods has been adopted, developed and implemented, using tools from photogrammetry, image processing and computer vision. For aims a) and c), a large number of feature points (e.g. 300-1000) are extracted and tracked through all images of the same day, using the KLT (Kanade-Lucas-Tomasi) tracker extended with statistical analysis and blunder detection procedures to ensure a robust evaluation with exclusion of matching errors. For aim c), the above procedure was slightly modified to account for the partially significant spectral differences between the SEVIRI bands. To assess absolute accuracy, lakes (with a sufficient size) in the area are used as reference, as they are the only clearly identifiable object. Lake polygons digitized from freely available Landsat orthoimages have been transformed into the HRV image coordinate system. The lake boundaries are matched in the images at sub-pixel level via a two-stage iterative procedure and 2D translations by robustly minimizing the intensity inside the polygons, based on the observation that water pixels are always darker than the surrounding lake-shores and taking

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into account the provided cloud mask, and matching even partially cloud-covered lakes. The matching accuracy in all tasks a) - c) is 0.1-0.2 pixels, sufficient to check whether the SEVIRI product accuracy specifications are fulfilled. A large number of SEVIRI images acquired in the year 2008 have been analyzed regarding the above three aims. In these tests, relative and absolute shifts of up to about 10 pixels have been observed, whereby some significantly worse results with some MSG-1 images have been detected. The results are presented and discussed in this paper.

Keywords: MSG-SEVIRI; geometric accuracy; climate variables; remote sensing; computer vision