Documentation of MeteoSwiss Grid-Data Products

Hourly Precipitation Estimation through Raingauge-Radar: CombiPrecip

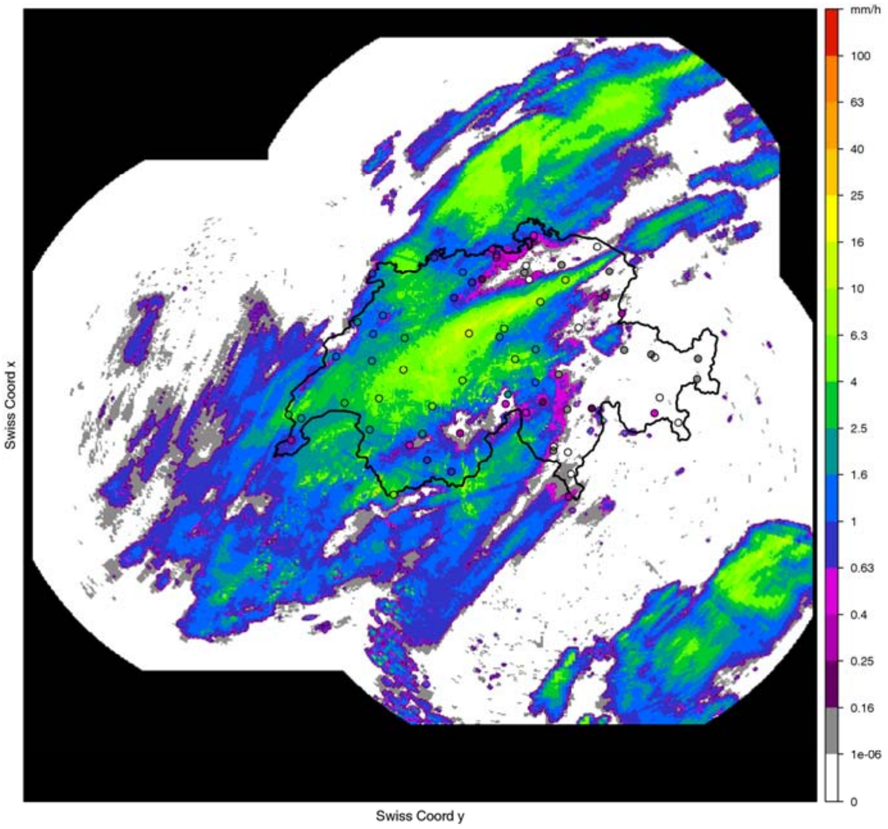

Figure 1: Hourly precipitation total (mm) on 21 August 2005 between 19:00 and 20:00 UTC. The circles represent raingauge measurements of precipitation.

Variable Precipitation for hour *H (UTC)*, corresponding to rainfall accumulated in the interval from *H-1* UTC to *H* UTC. Estimates are in millimeters (equivalent to liters per square meter).

Application Civil protection, rainfall runoff modeling, flash flood and debris flow warnings, intervention during flooding, flood prevention, hydropower management, verification of precipitation forecasts of numerical weather prediction models, environmental modeling, agriculture, tourism, and water resources modeling.

Hourly Precipitation: CombiPrecip

Overview

CombiPrecip is a dataset of hourly precipitation fields, which are computed using a geostatistical combination of rain-gauge measurements and radar estimates. The CombiPrecip fields cover the entire area monitored by the Swiss radars. This extends typically to about 100-150 km away from the Swiss border. The CombiPrecip fields are produced in real-time, every 10 minutes, and represent hourly sums (sum over a 60 minutes moving window). They are available from 1.1.2013. A real-time delivery is possible, about 10-15 minutes after the nominal hour, based on all the data available. Every week a "revised version" is available, based on rain-gauge values after full quality check controls. For summer 2013 we are planning the recalculation of older CombiPrecip fields since year 2005 (at least).

Data base

CombiPrecip combines information from two sources: (a) hourly aggregations of rain-gauge precipitation measurements at the SwissMetNet (SMN) stations and (b) radar estimates from the original composite raster product (Germann and Joss, 2004, Germann et al., 2006) representing the hourly precipitation field. The temporal resolution of the SMN rain-gauges is 10 minutes, and there are currently 100 stations in operation (state: 1.1.2013). Measurements are made by tipping-bucket gauges. The radar estimates result from a series of processing steps and a composition of backscatter measurements made by three meteorological C-band radars located within Switzerland. The spatial resolution of the radar product is 1 km^2, while its temporal resolution is 5 min.

Method

The hourly precipitation fields are computed using geostatistical techniques, that consider precipitation as a stochastic process (Creutin et al. 1988; Erdin 2009; Erdin and Frei 2012; Goovaerts 1997; Haberlandt 2007; Krajewski 1987; Schuurmans et al. 2007; Seo et al. 1990).

The raingauge data are introduced into the mechanism as a primary variable, the value of which has to be respected within the extent of a variance used to describe errors and microvariability effects (nugget effect). The radar raster is used as a trend and, in practice, is locally increased or decreased in value depending on the precipitation measurements of the raingauges in the vicinity.

Correlations that characterize a precipitation field are computed through fitting a pre-defined theoretical model (exponential dependence) to the available data provided by both the raingauge measurements and the radar estimates at raingauge locations. This is the most sensitive step of the combination process; the accuracy and stability of the precipitation estimation depends heavily on how successful this modeling is.

The modeling technique "CED.E" (Co-kriging with External Drift with Extensive capabilities) currently employed in CombiPrecip is novel in incorporating not only spatial but also temporal information (Sideris et al. 2012a). Evidence suggests that this approach provides enhanced stability in comparison to geostatistical techniques incorporating spatial data only. The term 'stability' refers to producing output which is not unrealistic due to modeling failures. This is considered beneficial due to the complexity of the product and the automatic, no-human-intervention character of the production process.

Moreover, a relaxation towards the original radar raster for regions outside Switzerland has been introduced. This was motivated by the need for a smooth transition between the geostatistical precipitation estimates within the Swiss area, and the radar estimates far away from Switzerland, where no rain-gauge measurement are currently at our disposal. The effect is achieved through a combination of virtual raingauges (radar precipitation estimates that pose as rain-gauge measurements) and follow-up filtering (Sideris et al. 2012b).

Hourly Precipitation: CombiPrecip

Target users

Thanks to its comparatively high temporal and spatial resolution, the CombiPrecip output should be valuable for applications that need high resolution input data. This product is expected to be useful especially for a number of practical applications where high temporal resolution real-time precipitation estimates are of importance, e.g. civil protection, flash flood warnings, intervention during flooding. The archived dataset can be interesting for flood prevention, hydro-power management, agriculture, tourism and the research community.

Accuracy and interpretation

The accuracy of the product depends heavily on the quality of the input data, i.e. the raingauge measurements and the radar estimates of precipitation.

The mechanism of the combination is based to its major part on modeling reasonably well the correlation structure of precipitation. This takes place through employing a statistical measure of correlations, the sample (semi)variogram, and attempting to fit a pre-defined theoretical model to it. The estimation of the parameter values of the theoretical model can be seriously affected by the particulars of the underlying sample variogram. Errors of the input data play a significant role (e.g. Zawadzki 1975; Zawadzki 1984); moreover, the sample variogram becomes progressively less intelligible the smaller the number of wet raingauges is. Since the raingauge data are used as reference, it follows that the smaller the number of wet raingauges (precipitation less than a small, predefined threshold) is the less accurate the combination output is. Consequently, a system of producing confidence flags was necessary and has been incorporated within the mechanism in order to inform clients on the quality of the product. This flag combines the information from the original quality flag of the radar composite product and the number of available wet raingauges, in order to produce a new composite flag which describes the level of our confidence regarding the combination result. Provided that the number of wet raingauges is sufficiently large and the original radar coverage is satisfactory the combination map is considered to be acceptably accurate.

Exhaustive tests over several individual cases different in nature but also extensive periods of time (the entire year 2008) (Erdin 2011; Keller 2012; Willi et al. 2011) suggest that the overall bias of the cross-validation results is typically very close to zero, a significant correction over the corresponding radar composite product.

The cumulative skill scores for the entire month September 2012 are representative for the performances of the CombiPrecip algorithm: the overall bias decreased from 1.8 to 0.1 dB, the root-mean-squared-error (RMSE) from 0.95 to 0.75 mm, the Hanssen-Kuipers discriminant (1-HK) from 0.35 to 0.22 and the scatter from 2.6 to 2.1 dB.

It's important to underline that the scores of CombiPrecip depend strong on factors like the weather situation (e.g. convective or not-convective situation), the season or the region in question. Indeed the quality of radar precipitation estimates depends in a complex way to a large extent on: (a) the distance from the radar, the so-called "range degradation" effect, and (b) the height above sea level of the lowest unshielded beams above the target region, the so-called "radar visibility" (including Earth's curvature, partial beam shielding by orography and the highly variable in space and time vertical reflectivity profile). The most reliable radar echoes are at short range from the radars (say between 3 and 60 km) and at an altitude where most or all hydrometeors are in liquid phase (hence, summer better than winter).

The uncertainty of the raingauge-radar combination process drops with increasing distance from the raingauge locations. This situation does not affect significantly the interior of Switzerland since this is monitored sufficiently well by raingauges, but it does affect the region outside the Swiss border. Understandably, in very large distances from the border confidence of the combination estimation is no better than the confidence in the original radar product. For this reason an algorithm complements the modeling-estimation geostatistical scheme, which aims at relaxing in a continuous fashion the combination output towards the original radar map as distance from raingauges increases. This solution provides conceptually the best possible precipitation map within and nearby Switzerland (combination), and far from Switzerland (radar).

Related products

Radar: Original radar precipitation estimates (e.g. the Swiss radar composite NASS). These products are continuously updated, are available in real-time and at even higher time resolution (up to 5 minutes). The NASS data result from a sequence of processing steps applied to the early-stage-processed radar data, aiming to produce the best quantitative precipitation estimation without using external measurements such as raingauge data in a short-time basis (e.g. hourly); the NASS product incorporates only a broader, yearly-based, raingauge adjustment. NASS has been re-sampled to a spatial resolution of 1 km (same as RdisaggH) and is available for the period 2005-2012.

Raingauges: raingauges data have been elaborated in daily, monthly or yearly high resolution precipitation fields in Switzerland (RhiresD; RhiresM; RhiresY).

Grid structures

Regular 1-km grid in the Swiss coordinate system.

Versions

Current version: CombiPrecip v1.0

Previous versions: None

Update cycle

The update cycle has not yet been decided.

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