Combining high-resolution numerical weather predictions with human expertise for real-time, localized www and mobile app weather forecasts.

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Introduction

The increasing demand of real-time, local scale weather forecast through electronic dissemination channels along with significant improvements in numerical weather prediction models, requires new solutions to integrate human expertise into weather forecasts. Since Autumn 2014, a new system is operationally producing forecast data for the MeteoSwiss Website and mobile app. This system, called "Data4WEB" (detailed description in [1]), has constantly evolved an provides weather forecasts to over 200,000 daily users for entire Switzerland. Data4WEB combines high resolution meteorological model fields (COSMO-1, COSMO-E, INCA and the ECMWF's IFS model), observations , and the expertise of the human forecasters in order to provide very localized and supervised forecasts.

Data4Web system

Data4Web system takes as input model grids, observations and forecaster's prediction. State of the art algorithm are used (see [2] for temperature). It combines all sources to produce grids which are uploaded in a central database. Final products are finally issued using these data.

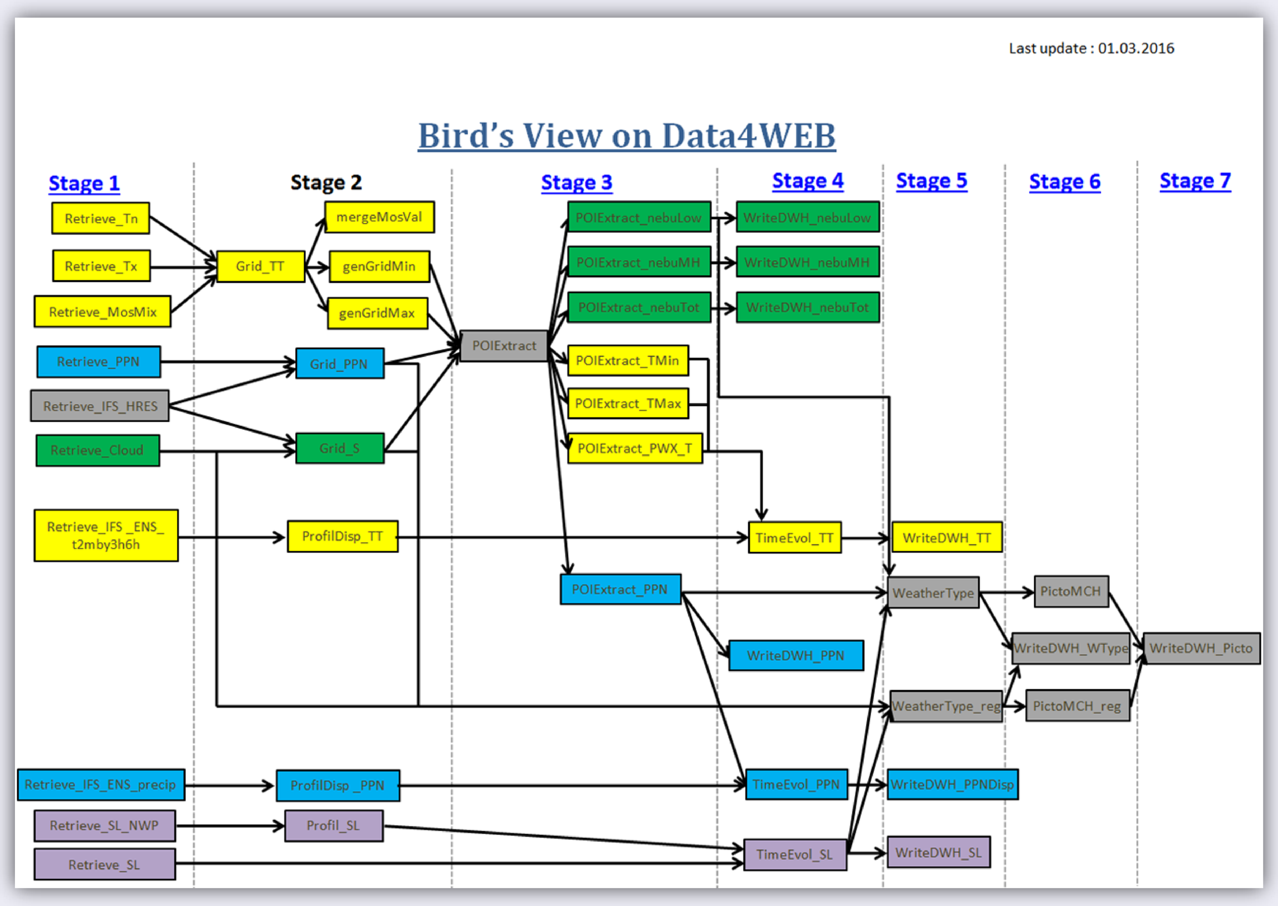

Figure 1: Data4Web chain production

The production system is launched every 30 minutes. The first stage determines which module should be run, based on whether new data arrived. The second stage generates the modified grids, followed by stage 3 and 4 which make extrapolation on a list of about 5000 point of interest. The last two stages upload data to the central MeteoSwiss database.

Verification

Establishing the system's input quality is necessary to scientifically choose which source should be used. One can use that information to educate forecasters on the model's use. Similarly, evaluating the system's output quality, allow us to compare its performance against other forecasts and to reveal possible weaknesses.

Models

Raw model data are constantly monitored and verified. But verification is often hard to understand for end-users. To leverage that problem, we use mind-maps allowing forecasters and developers to easily find the relevant information.

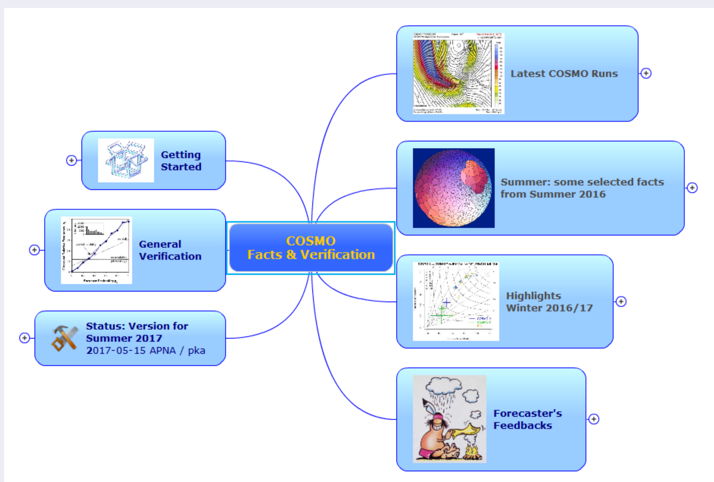

Figure 2: Model's verification guide

Forecasters

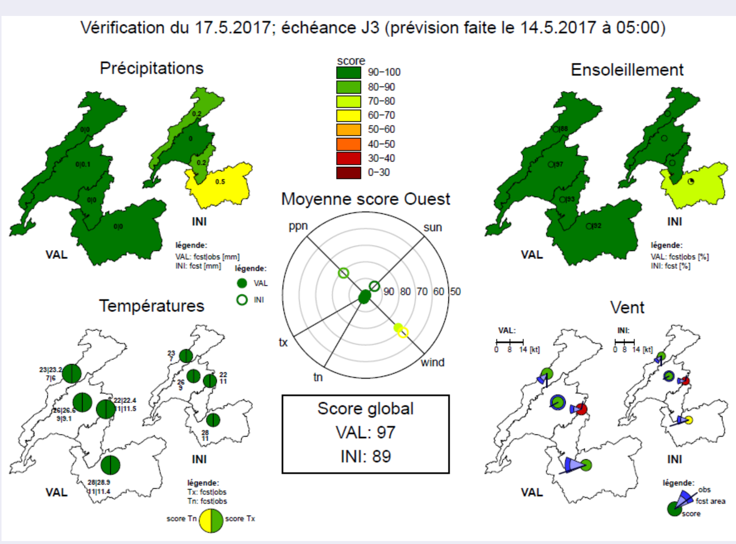

Figure 3: Verification bulletin sent to forecasters

Every forecasts is verified using an internal score based on the COMFORT [3] score. A feedback is automatically sent to the forecasters as soon as possible. His performance (VAL) is measured for critical parameters over each region. Additionally the forecast he used as initial value (INI) is evaluated. The forecaster can hence assess its contribution.

Data4Web

The Data4WEB system predicts a large range of parameters, from precipitation quantity to pictogram. Our final goal is to get a verification for each of them. We present here the result for 2 m temperature. The neighbouring figures shows that prediction for elevated stations is worse than on low terrain. Moreover, region prone to cold air pool, are more subject to error. Such conclusions are than used to direct future enhancement.

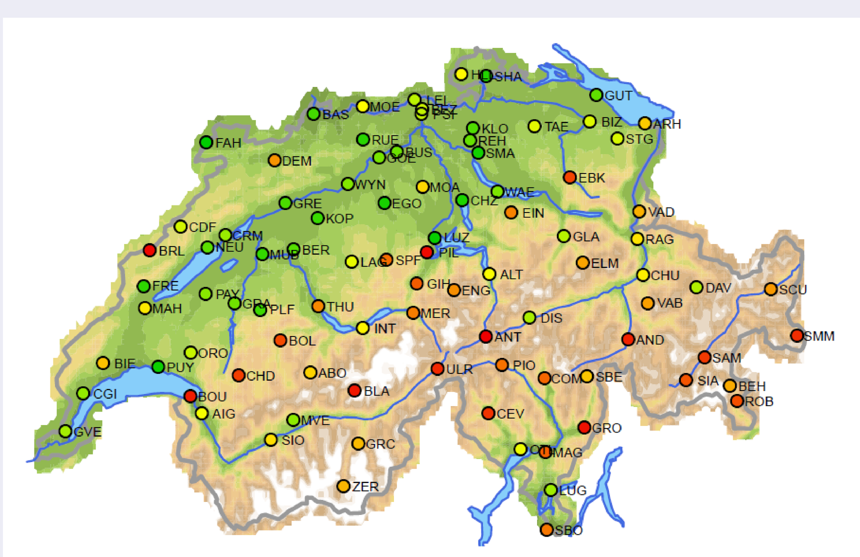

Figure 4: 2m temperature verification for 2015. Stations are ranked according to mean absolute error. Green for top rank, red for low.

Enhancement

The information gathered from verification is used to improve the system.

Forecaster

The verifications, sent to the forecasters as soon as the forecasted period has passed, allow him to evaluate its own performance while he still remembers his reasoning. He can then improve his decision making. On the other hand, the whole verifications' bulletins is analysed to extract general guidelines.

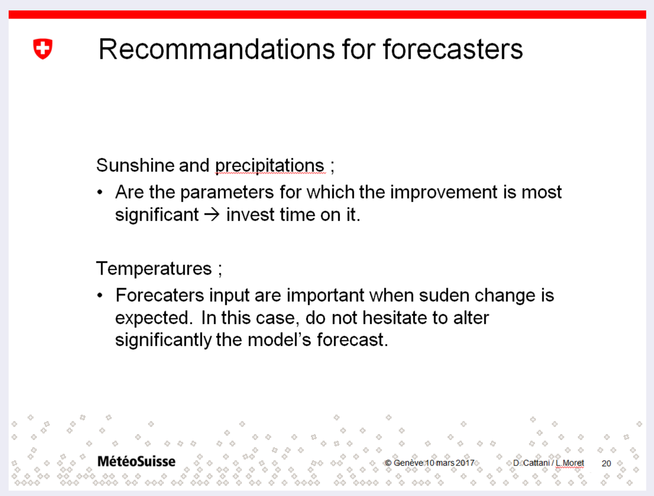

Figure 5: Forecaster's guidelines for model modification.

Model

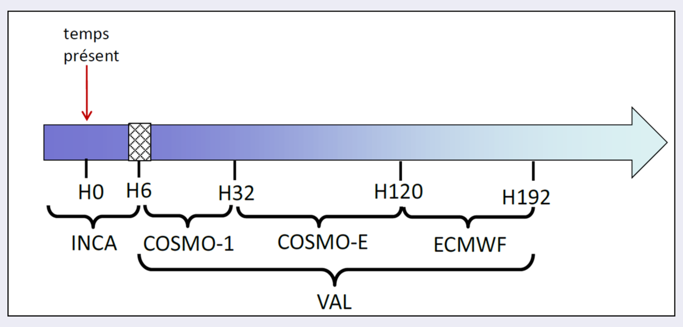

Figure 6: Model choice

Model's verification allow us to scientifically select the system's input. In most cases, the model with the highest spatial resolution performs best. Nevertheless, for specific parameters such as temperature extremal, Model Output Statistic are better. The choice indeed depend on the parameter.

Data4Web

The daily verification carried out by forecasters has shown that the early version of the nebulosity modification algorithm underperforms in fog situation. A new method has then been developed to better use the forecasters prediction and the model forecast in these specific situation.

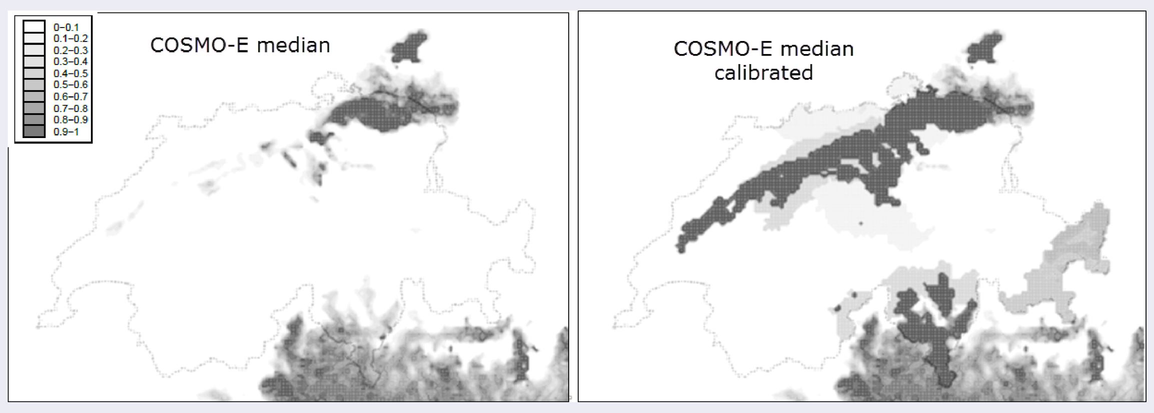

Figure 7: Model modification by forecasters in a fog case

Users feedbacks shows that probability forecasts needs to be easily understood. Coherence with deterministic forecasts is then of great importance. One needs than to modify probabilistic forecasts.

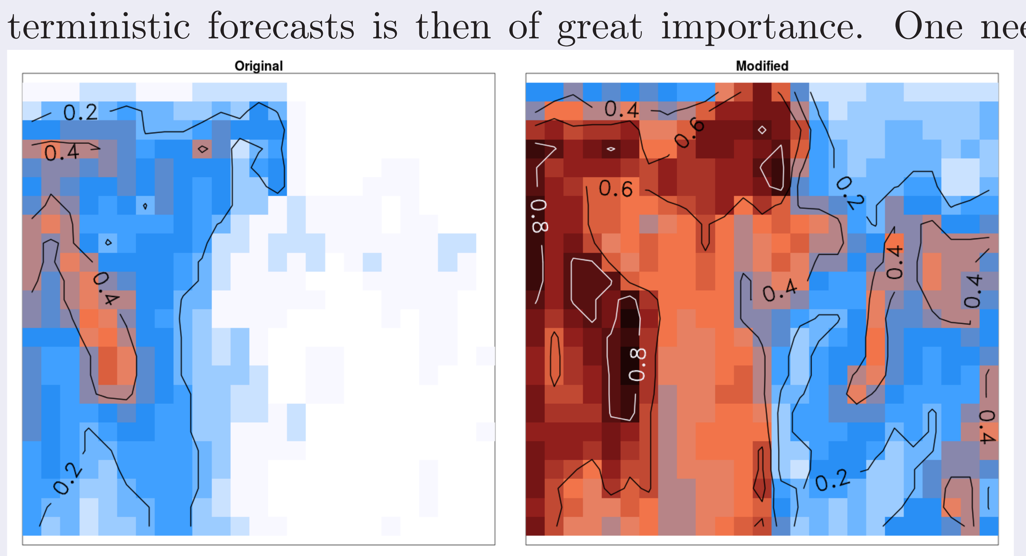

Figure 8: Probability to exceed 6 mm of precipitation during the forecast period $]h+49, h+55]$ over a $40 \times 40\ km^2$ region. Raw model on the left, modified on the right.

The model ensemble forecasts a median of 6 mm in the in the interval $]h+49, h+55]$ over a $40 \times 40\ km^2$ region. The forecasters predicting about twice more, the ensemble forecast must be modified so that its median (2.52 mm) matches the forecasters' one (7 mm). As we might expect, the probability to exceed 6 mm for that new ensemble increases all over the region.

Coherence among different parameters is also key. Road state forecasting was previously calculated outside of the Data4Web systems. Contradictions could than appear on forecasts. The next release will include a full energy balance model of the road solving this issue (implementation described in [4]).

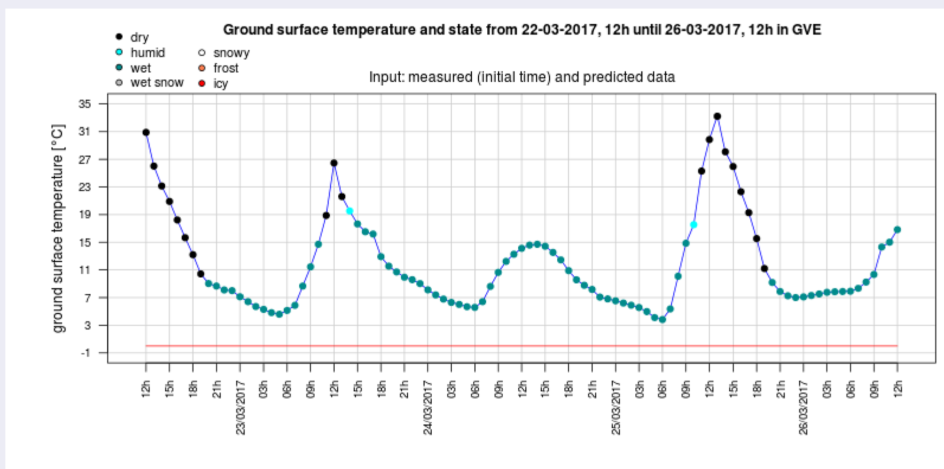

Figure 9: road state forecast

Future developments

The Data4WEB system will continue to evolve in the coming years. We plan to:

- Produce more parameters such as ground temperature, thunderstorm probability, accumulated snow depth, ...
- Extend forecasting range
- Provide a seamless prediction from measure up to end of time range, for each parameters.
- Generalise probabilistic forecasts.

References

[1] M. Matter. Data4web, guide de l'utilisateur. Internal report MeteoSwiss, 2016.

[2] Frei C. Interpolation of temperature in a mountainous region using non-linear profiles and non-euclidean distances. *International Journal of Climatology*, 2013.

[3] Cattani D., A. Faes, M. Giroud Gaillard, and M. Matter. COMFORT: continuous MeteoSwiss forecast quality score. *Scientific Report MeteoSwiss*, 99:45pp, 2015.

[4] M. Ferrara. Rapport EBM. Internal report MeteoSwiss, 2017.