Section Sciences et Ingénierie de l'environnement
Design Project 2023 (semestre de printemps)

Proposition n°20

Improving precipitation estimates in an Alpine catchment

Partenaire externe ou laboratoire IIE
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Descriptif du projet

Alpine regions are particularly vulnerable to floods due to their complex topography. In Switzerland, a number of recent flooding events has highlighted the need for more reliable forecasting systems to mitigate flood impacts. Since 2013, the CREALP (research center on alpine environment) is operating a real-time flood forecasting system for the upper Rhone River basin and is continuously improving it since then (Foehn, 2019). Among the different sources of uncertainty, precipitation estimates at high elevation remain a challenge major. The high spatial variability, the harsh conditions and the lack of measuring stations at high altitude partly explain the difficulty of interpolating spatially these observations.

Switzerland is fortunate to have a dense meteorological and snow measurement network especially in the Alps. Unfortunately, these data are not fully used, especially in operational systems. We therefore propose to take advantage of them to improve the precipitation estimates that are used as input in the real-time flood forecasting system of the Rhone River. Based on classic meteorological observations (precipitation, temperature, wind) provided by MeteoSwiss, the students will analyze and correct known bias such as precipitation

undercatch. They will also investigate a more advanced method that combines in-situ observations from IMIS stations and numerical modelling. This method could provide valuable precipitation estimates at high altitude during the winter period.

The results of this project will be compared and validated against state-of-the-art products (e.g. Combiprecip product from MeteoSwiss or SWE measurements from SLF). They will also be used as input of a hydrological model in order to quantify the benefit of such data. These new and innovative methods could significantly reduce the uncertainty of precipitation estimates and spatial interpolation in the Alps.

Objectif et buts

The main objective of the current project is to improve the precipitation estimates in Wallis. To do so, we propose to investigate two innovative methods that could be used operationally at CREALP if the results are convincing.

The first part of the project will focus on the correction of solid precipitation from the SwissMetNet stations operated by MeteoSwiss. Based on the latest research outcomes, the students will choose, implement and compare the most promising methods to correct precipitation undercatch due to wind. They will also investigate how the bias correction is changing over the Rhone River basin (as a function of elevation for example).

The second part of the project will investigate the integration on snow height measurements from IMIS stations to indirectly estimate precipitation amount during the winter season. This will require the use of the physically-based SNOWPACK model. The plausibility of the results will have to be analyzed in comparison with surrounding stations.

The validation will be performed in 2 steps. First of all, the results will be compared with independent dataset available in Wallis. This is mostly the CombiPrecip product from MeteoSwiss, which combines radar data and rain gauges and SWE measurements provided by the SLF observers. The final step of the validation will consist in comparing a hydrological simulation with classic input and with the advanced precipitation estimates derived from the current project.

Descriptif tâches

During the first month of the project, the students will perform a literature review, collect and prepare the data for the next step. They will then work simultaneously for a month on the undercatch correction (method choice and implementation) and the SNOWPACK modelling. The results will be analysed and validated against state-of-the-art data. During these two phases, they should also annotate carefully their code/work to facilitate any future use. Finally, the students will write a report with their main findings and potential failures.

ACTIVITY	February		March				April				May				
	20 - 24	27 - 03	06 - 10	13 - 17	20 - 24	27 - 31	03 - 07	10 - 14	17 - 21	24 - 28	01 - 05	08 - 12	15 - 19	22 - 26	29 - 02
	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	week 13	week 14	week 15
1. LITTERATURE REVIEW AND DATA PREPARATION															
1.1 Precipitation measurements and bias correction															
1.2 Physically-based snow models															
1.3 Data collection for undercatch correction															
1.4 Data collection for SNOWPACK simulation															
1.5 Data collection for results validation															
2. UNDERCATCH CORRECTION AND SNOW MODELLING															
2.1 Choice of the method															
2.2 Method implementation															
2.3 SNOWPACK simulation															
3.RESULTS ANALYSIS AND VALIDATION															
3.1 Spatial analysis of undercatch correction															
3.2 Analysis of SNOWPACK results plausability															
3.3 Validation against independent datasets and hydrological modelling															
4. DELIVERABLES															
4.1 Reports (intermediate / final)															
4.2 Code documentation															

Divers

The students should have completed the course *Physics and hydrology of snow*. They must also be comfortable with programming (R, Python) and be interested in numerical modeling tools.

Foehn Alain, Radar-rain gauge merging and discharge data assimilation for flood forecasting in Alpine catchments, PhD dissertation, 2019, EPFL.