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The importance of coupling meteorological and hydrological forecasts to anticipate Flash Floods. The case of Sant Llorenç des Cardassar (Illes Balears – Spain)

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The following analysis tries to address if the combination of meteorological and hydrological models can give more information to the Civil Protection authorities to take measurements to palliate the impacts of flash flood damages of the town of Sant Llorenç des Cardassar on the island of Mallorca (Illes Balears-Spain) that suffered the afternoon of October 9, 2018 a flash flood due to a Convective Mesoscale System whereby the Torrent Ses Planes Basin (ephemeral creek) overflowed in the channeling of this town flooding part of its urban center with the tragic result of 13 killed and extensive material damages.

The basin is ungauged, and we proceeded to reconstruct the hydrometeorological event in a comprehensive manner with a feedback to calibrate/validate the response of the basin through a hydrological TOPKAPI-X model acronym of (TOPographic Kinematic APproximation and Integration-eXtended) physically-based distributed rainfall-runoff model deriving from the integration in space of the kinematic wave. The approach transforms the rainfall-runoff and runoff routing processes into four 'structurally-similar' non-linear reservoir differential equations describing different hydrological/hydraulic processes. Once having the hydrological model calibrated/validated and operative forcing it with the forecasts of the Meteorological model HARMONIE-AROME acronym of HARMONIE (HIRLAM ALADIN Research on Meso-scale Operational NWP In Europe), AROME (Application of Research to Operations at MEsoscale) which is a non-hydrostatic spectral model, the dynamical core is based on a two-time level semi-implicit Semi-Lagrangian discretization, in the reference cycle 40h1.1, lateral boundary conditions are routinely used from the ECMWF model. Sixty-five levels are used in the vertical with model top at 10 hPa and lowest level at 12 m. The horizontal resolution is 2.5 km, and time step is 75 s.

The feedback process begins with the reconstruction of the spatial-temporal precipitation pattern, combining satellite products PERSIANN-CSS, GPM-IMERG, the product of the AEMET meteorological radar and the 4 closest raingauges to force the hydrological model TOPKAPI-X and obtain the response of the basin that in turn serves to force a bidimensional hydraulic model IBER, which is a 2D model for the simulation of free surface flow in rivers and can solve hydrodynamics, turbulence and sediment transport, to reproduce water depths, flooded area and its hydrodynamics in the surroundings of the urban center of Sant Llorenç contrasted in turn with recorded data post-event (observed/measured water levels, videography and satellite maps processed by Rapid Mapping COPERNICUS-EMS).

Finally, once the hydrological model was calibrated/validated and operational, we proceeded to force it with Runs (00Z, 06Z, 12Z) of the HARMONIE-AROME to analyze if the warning or alarm thresholds had been exceeded, in hydrological terms, with enough anticipation to warn to the citizens of an imminent situation of flash flood. The results reveal that coupling meteorological/ hydrological models at an operational level can give a better input for the decision-making process to mitigate extreme natural hazards. This coupling seams extremely necessary and useful to the authorities due to the high non-linearity of the rainfall-runoff processes. This modelist cascade could offer the possibility to issue different types of warnings from meteorological and hydrological or hydraulic point of view.