# PREDICTIVE CAPABILITY OF A HIGH-RESOLUTION HYDRO-METEOROLOGICAL FORECASTING FRAMEWORK COUPLING WRF CYCLING 3DVAR AND CONTINUUM.

M. Lagasio 1#, F. Silvestro 1, L. Campo 1, A. Parodi 1

1 CIMA Research Foundation (Italy)

#martina.lagasio@cimafoundation.org

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RESEARCH FOUNDATION cima OBSERVE TO PREDICT, PREDICT TO PREVENT.

## MESOSCALE CONVECTIVE SYSTEMS: CINQUETERRE 2011, GENOA 2011, GENOA 2014

### WHY FOCUSING ON MCSs

The complex orography typical of the Mediterranean area supports the formation, mainly during the fall season, of the so-called back-building Mesoscale Convective Systems (MCSs) producing torrential rainfall often resulting into flash floods.
These events are hardly predictable from a hydro-meteorological standpoint and may cause significant amount of fatalities and socio-economic damages

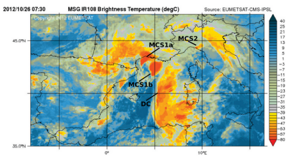
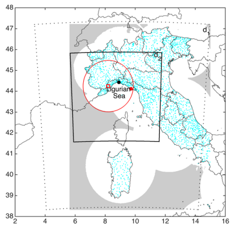
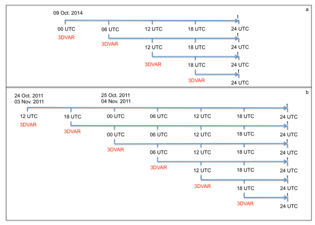


Fig. 10. The 10.8-μm infrared brightness temperature from MSG at 0730 UTC 26 Oct 2012.

[Ducrocq et al., 2014]

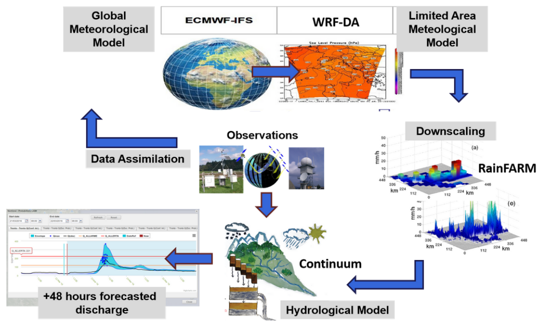




⇦ Numerical model domains and observations assimilated (left).

⇦ Initialization and assimilation timing (right).

### THE HYDRO-METEOROLOGICAL CHAIN ⇩



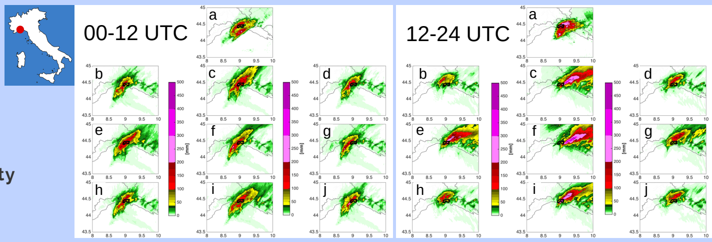

### WORK AIM, USE CASES AND SETUP:

- AIM: To gain further insights into the hydro-meteorological prediction of back-building MCSs combining WRF 6-hour cycling simulations with Continuum through RainFARM stochastic downscaling.
- USE CASES: Cinqueterre 25 Oct. 2011, Genoa 4 Nov. 2011, Genoa 9 Oct. 2014
- SETUP: two nested domains (5 km, 1km); 50 vertical levels; explicit treatment of convection; WSM6 microphysics parameterization.

## METEOROLOGICAL EVALUATION OF THE 3DVAR SENSITIVITY: THE GENOA 2014 CASE

Ensemble of 9 simulations using 4 different reflectivity operators in combination with SYNOP stations data

| Run abbreviation | Run description |
|---|---|
| Open Loop | Run without data assimilation |
| ALL-direct | Assimilation of reflectivity and SYNOP with direct method |
| ALL-indirect | Assimilation of reflectivity and SYNOP with indirect method |
| ALL-indirect-rqv | Assimilation of reflectivity and SYNOP with indirect method adding the in-cloud humidity estimation |
| Radar-direct | Assimilation of reflectivity only with direct method |
| Radar-direct-modif | Assimilation of reflectivity only with direct method using the modified reflectivity operator |
| Radar-indirect | Assimilation of reflectivity only with indirect method |
| Radar-indirect-rqv | Assimilation of reflectivity only with indirect method adding the in-cloud humidity estimation |
| Stations-only | Assimilation of SYNOP stations only |



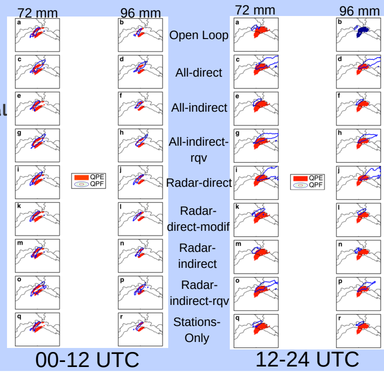

⇦ QPE from Settepani radar (Panel a), the Open Loop QPF (Panel b) and the QPF of each member of the sensitivity: ALL-direct (Panel c), ALL-indirect (Panel d), ALL-indirect-rqv (Panel e), Radar-direct (Panel f), Radar-direct-modif (Panel g), Radar-indirect (Panel h), Radar-indirect-rqv (Panel i) and Stations-only (Panel j). Black bold contour highlight the Bisagno catchment hit subjected to the flood.

| CENTROID DIST | ANGLE DIFF | AREA RATIO | SYMMETRIC DIFF | INTERSECTION AREA | UNION AREA | SYMMETRIC DIFF |
|---|---|---|---|---|---|---|

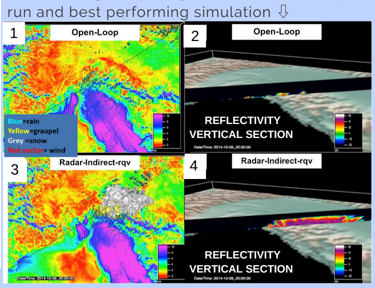
| FBIAS | PODY | FAR | CSI | HK | HSS |
|---|---|---|---|---|---|

Evaluated 13 different statistical indices calculated by MODE ⇨

Meteorological validation performed through the Method for object-based evaluation (MODE) tool.




3d rendering comparing between Open Loop run and best performing simulation ⇩



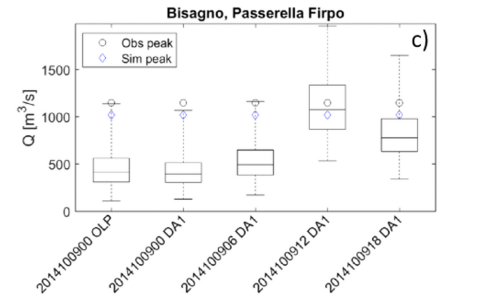

### Concluding Remarks:

The use of reflectivity assimilation allowed obtaining a more intense convective structure quite absent in the Open Loop.

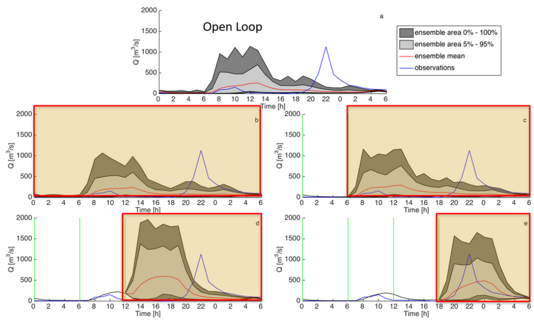
For Genoa 2014 flood best performing operator: Radar-Indirect-rqv.
For both 2011 floods best performing operator: Radar-direct-modif.

## HYDROLOGICAL IMPACT EVALUATION OF DATA ASSIMILATION

The streamflow forecast obtained with WRF in open-loop configuration is compared with the ones obtained with 3DVAR Radar-indirect-rqv experiment performed every 6 hours.



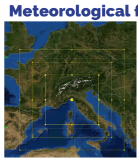

⇧ Results of hydrological verification in terms of peak flows. X axis reports the time of assimilation or the Open Loop NWPS run, y axes report peak flows. DA1 stands for data assimilation, OLP stands for Open Loop. Box plot represents the predicted peaks distribution, black circle the observed peak, blue diamond the simulated peak obtained using observations as input to hydrological model.



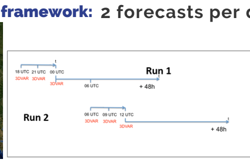

DA performed at 12 UTC, which would have been available from an operational point of view around 15 UTC, namely 5-6 hours earlier than the run forced with 12UTC analysis, improves significantly the rainfall prediction between 12UTC and 24UTC thus leading to an improvement of the discharge forecast accuracy. The 95 percentile is around 1200 m3/s and the average peak timing is around 18 UTC much closer to the observed one, significantly improving also the finding of Parodi et al (2017).

### WORK OUTPUT: PRE-OPERATIONAL CHAIN

**Meteorological framework:** 2 forecasts per day operational



Current domain

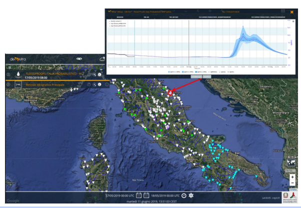



Run and DA timing

Future domain

3 Nested domains: 22.5, 7.5 and 2.5 km; 50 vertical levels.

**Hydrological framework:** A Pre-Operational full hydro-meteorological chain is implemented at National scale, in collaboration with Italian National Department; it runs in parallel with COSMO-M5 chain.



Currently running with an Open Loop WRF simulation at 1.5 km resolution covering all Italy

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**References:**
Ducrocq, V., I. Braud, S. Davolio, R. Ferretti, C. Flamant, A. Jansa, ... & S. Belamari, 2014: HyMeX-SOP1: The field campaign dedicated to heavy precipitation and flash flooding in the northwestern Mediterranean. Bull. Amer. Meteor. Soc., 95(7), 1083-100, https://doi.org/10.1175/BAMS-D-12-00244.1.
Parodi, A., D. Kranzlmüller, A. Clematis, E. Danovaro, A. Galizia, L. Garrote, ... & F. Siccardi, 2017: DRIHM (2US): An e-Science Environment for Hydrometeorological Research on High-Impact Weather Events. Bull. Amer. Meteor. Soc., 98(10), 2149-958 2166.