The impact of different NWP forecasting systems on acqua alta forecasts: Two IOP case studies over the NEI target site

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RESEARCH PURPOSE *This work is part of the strong coordinated activity carried on by the Italian HyMeX partners during the first Special Observation Period (SOP1: 5 Sep-6 Nov 2012).This activity, described in Ferretti et al. (2013), included the deployment of several observational instruments and weather forecasting modelling chains and the support to the HyMeX Operational Centre in Montpellier (France) during Intensive Operation Periods (IOPs).*
Model forecasts and observational data provided by some of these partners are deployed here in a cross-verification study on two IOPs associated to intense precipitations in the North-Eastern Italy (NEI) hydro-meteorological monitoring site and storm surge events ("acqua alta") in the Venice Lagoon.

NWP & TIDE MODELING CHAINS

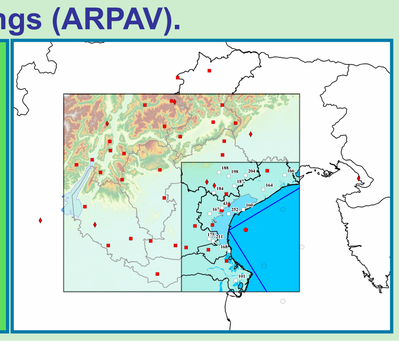
NWP model chains:
- the GFS-driven 0.1° BOLAM-ISAC + 0.0207° MOLOCH chain developed and run by CNR-ISAC;
- the ECMWF-driven 0.3° BOLAM + 0.1° BOLAM chain and the new 0.07° BOLAM + 0.0225° MOLOCH chain run by ISPRA.

Tide forecasting systems:
- the ISPRA statistical model;
- the ISPRA SHYFEM developed by CNR-ISMAR and driven by ECMWF model and ISPRA's 0.1° BOLAM.
- the CNR-ISMAR KASSANDRA syst. based on SHYFEM and the BOLAM-MOLOCH chain of ISAC (*not shown*).

OBSERVATIONAL DATASETS

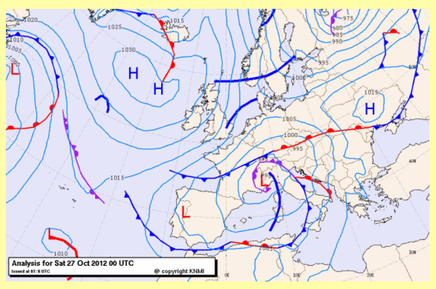
In addition to common data (e.g. MSG) and HyMeX datasets (e.g. rain gauges), ARPAV and ARPA FVG radars, ground data, profilers and lidars (ARPAV) were deployed together with the CALMET analyses on part of Veneto region, employing surface stations and radiosoundings (ARPAV).

ARPAV CALMET
Ground stations:
♦ SYNOP
● CNR platform
■ other
Radiosoundings:
- Milano
- Udine

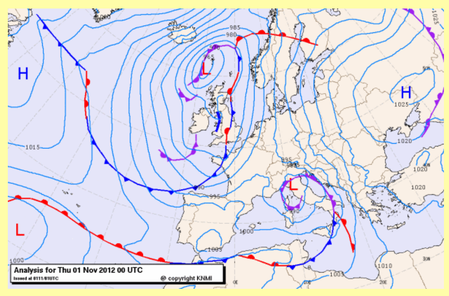


IOPs' synoptic analysis

- IOP 16 (25–29 Oct): the transit of a synoptic trough over the Alps (27) generates a Genoa secondary cyclone on day 28. In both days, persistent SE flow on the Adriatic Sea produces heavy precipitation on NEI and *acqua alta* on Venice.



- IOP 18: (31 Oct–1 Nov): on day 31, cyclogenesis occurs on Gulf of Lion. The cyclone rapidly moves eastwards, crossing Italy from Northern Tyrrhenian Sea to Northern Adriatic Sea, providing heavy rainfall, a low-level jet (*scirocco*) on the Adriatic Sea, and exceptional *acqua alta* (142 cm, the 13th sea level found in Venice since 1872).



ISPRA SHYFEM "acqua alta" forecasts

For the whole period (25 Oct-2 Nov 2012), tide forecasts were provided by SHYFEM, varying configuration and NWP model input. Results obtained with ECMWF and ISPRA's 0.1° BOLAM and 0.07° BOLAM are discussed here.

On IOP16 peaks, BOLAMs improve SHYFEM skill…

… 0.07° BOLAM seems to improve general curve fit.

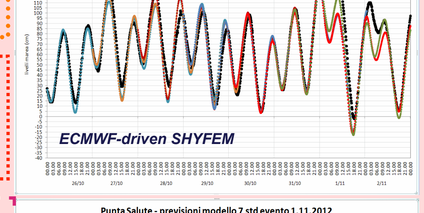
***… BUT* this is not straightforward for the major peak!**

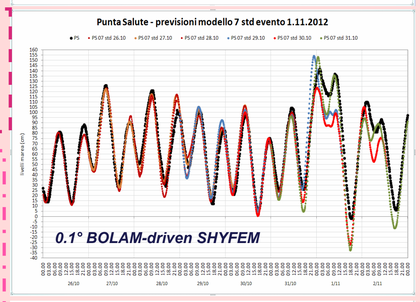
Forecast skill seems quite sensitive to BOLAM grid step...

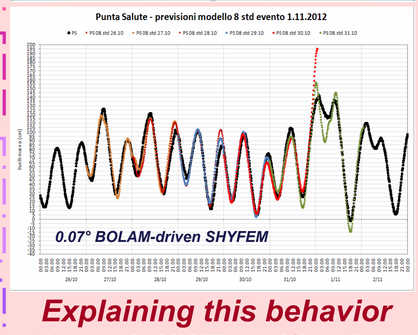
… and to the date of initial analysis!!

Forecasts starting at 12UTC of 29 Oct have a poor skill…

… and display an opposite behavior when increasing BOLAM resolution.



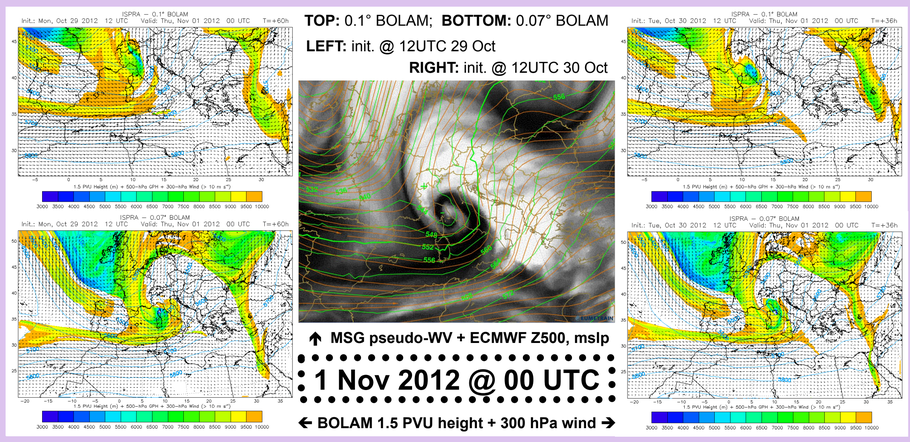




Explaining this behavior through NWP verification. The key issue is: different PREDICTABILITY of the weather systems.

IOP 18: Synoptic-scale verification for ISPRA's BOLAMs

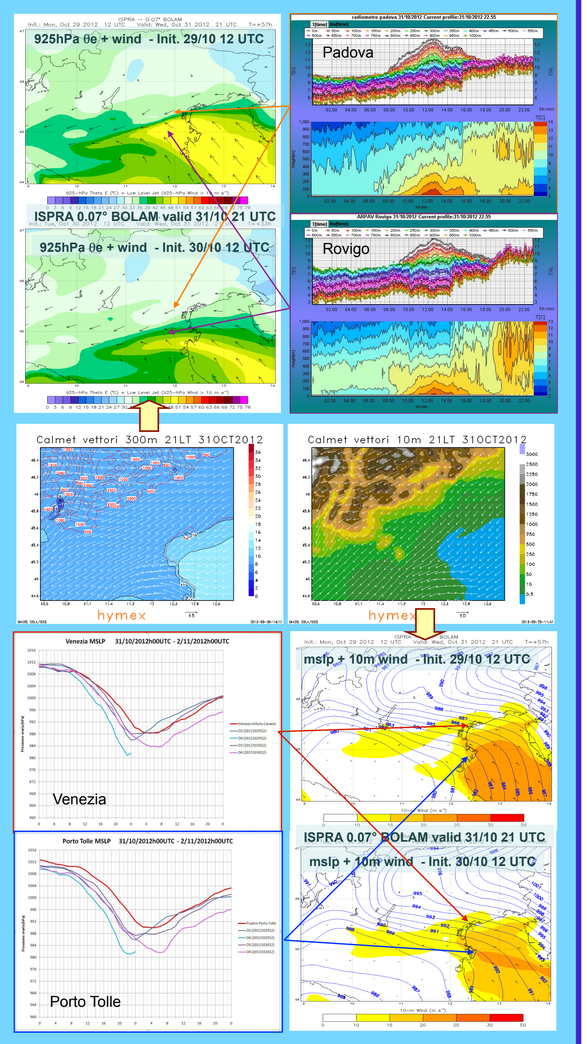
Large changes are found in path and evolution of the 31 Oct Mediterranean cyclone in the ISPRA's BOLAM forecasts when varying the grid step (0.1° *vs.* 0.07°) and initial time (from 28 to 31 Oct, @ 12UTC). Satellite images (MSG pseudo-WV) evidence wrong cyclone position and depth in both runs starting on 29 Oct, @ 12UTC.



- 29 Oct runs: weak, misplaced cyclone (0.1°: too northward; 0.07°: too southward).
- 30 Oct runs: very good placement (0.1: a bit too weak; 0.07°: a bit too strong).
- Differences in the Adriatic low-level jet direction (*not shown*).

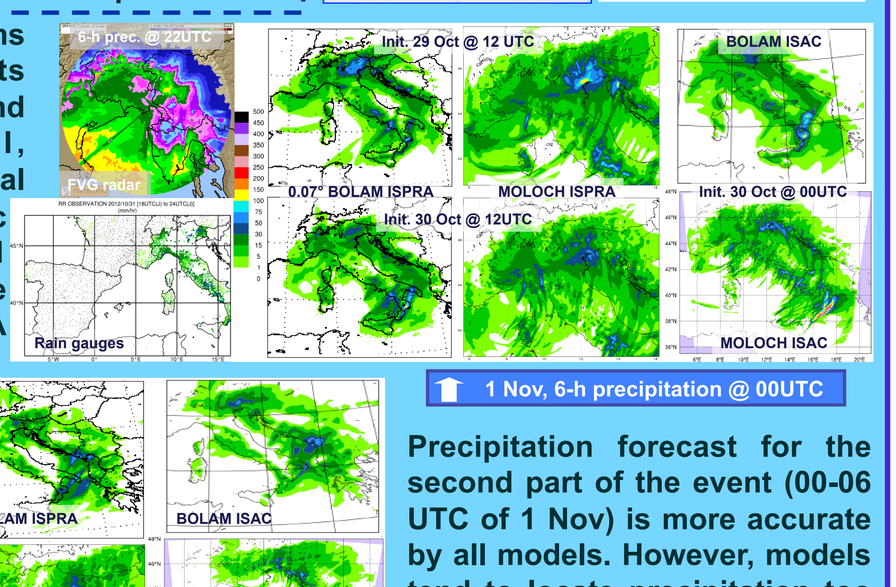
IOP 18: BOLAM/MOLOCH verification over NEI

Availability of many observation data sources on NEI allows a thorough verification of the NWP factors contributing to the Venice storm surge forecast quality.
Here, only ISPRA's BOLAMs results are presented. The 0.07° BOLAM init. on 29 Oct predicts a sharper front and a stronger low-level jet than the run init. on 30 Oct: *Scirocco* is forecast to hit Venice Lagoon in late 31 Oct night. But observations are in better agreement with the run init. on 30 Oct. Profilers on Venice and Rovigo provide the timing for the frontal passage. CALMET analyses show the curvature of the low-level wind field on southern Veneto, even more pronounced than in the 30 Oct forecast. In the 29 Oct forecast, the *scirocco* wind moves north too rapidly and is too strong.

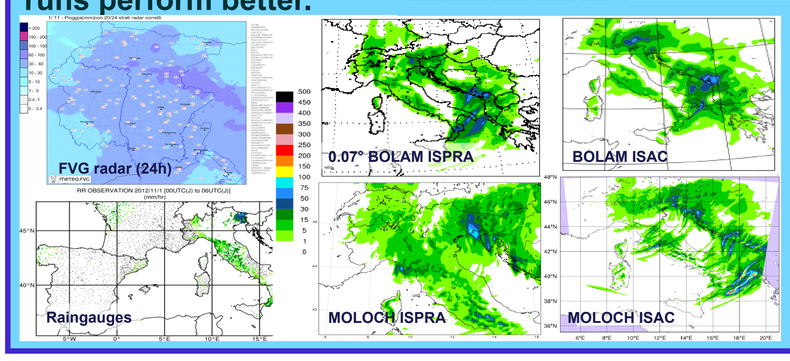


Surface pressure strongly impacts tide forecast. Pressure gradient on Venice Lagoon is much stronger in the 0.07° BOLAM run init. on 29 Oct than in the next day's run of the same model. Pressure verification on single station display time and intensity error in surface pressure forecast for 29 Oct runs. However, the 30 Oct 0.07° run overestimates the low depth, while the 30 Oct 0.1° run gives the best forecast of local surface pressure.

QPF verification confirms these results. Forecasts (espec. the 29 Oct's) tend to misplace rainfall, overestimating the frontal component (Adriatic coast; since rain in late 31 Oct is mostly orogr.). The 30 Oct. ISAC and ISPRA runs perform better.



1 Nov, 6-h precipitation @ 00UTC

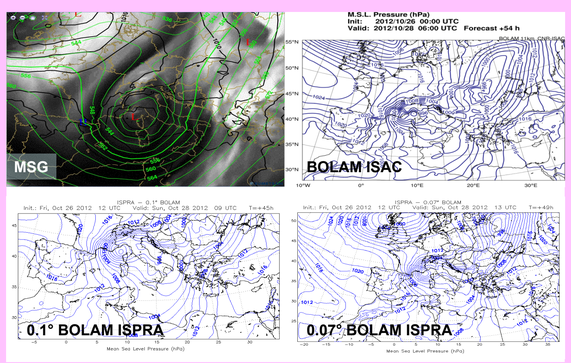


Precipitation forecast for the second part of the event (00-06 UTC of 1 Nov) is more accurate by all models. However, models tend to locate precipitation too southerly.

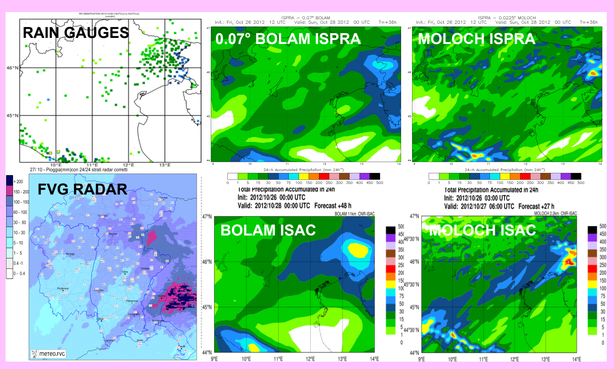
1 Nov, 6-h precipitation @ 06UTC

IOP 16: Meteorological forecast verification

The IOP16 event involves high-predictability weather systems (synoptic trough, Alpine cyclogenesis. As a result, forecasts provided by different models and/or with different initial dates does not differ much among them, all displaying good forecasting ability (see below cyclogenesis and rainfall event over NEI).



28 Oct, 06 UTC mslp forecast *vs.* MSG pseudo-WV



27 Oct, 24h-precipitation forecast *vs.* daily observations

Conclusions and future work

- Low predictability strongly affects the tide forecast for the IOP18 Venice *acqua alta* event (contrarily to IOP16).
- Peak forecast skill can be strongly degraded by "small" errors in predicting local features as low level jet shape and details in the surface low trajectory.
- All these features can be verified thanks to the wide observational database collected within HyMeX.
- Precipitation verification is suitable for assessing model skill even when rain is not the target of the forecast.
- *Future work*: SHYFEM sensitivity study to drag coeffs.; incl. the Kassandra syst.; completing QPF verif.; study of forecast error development in the different models/runs;

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