SENSITIVITY TO INITIAL CONDITION AND MODEL RESOLUTION OF PRECIPITATION FORECASTS MODELLED BY THE HYDROSTATIC BOLAM MODEL OVER THE MEDITERRANEAN BASIN

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

ISAC

ECSS
European Conference on Severe Storms

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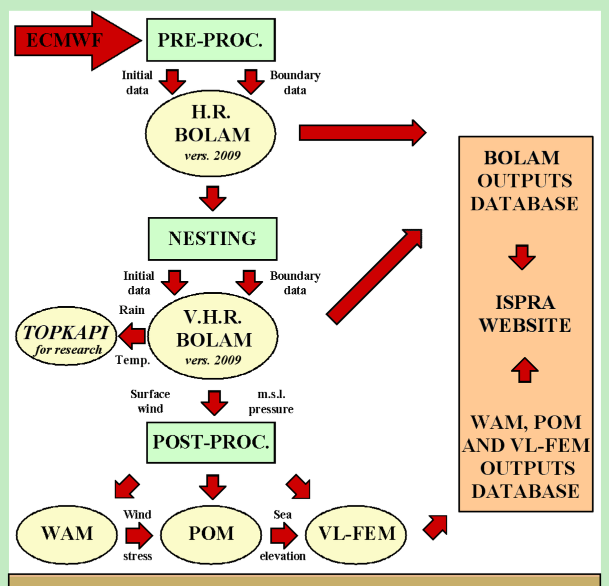
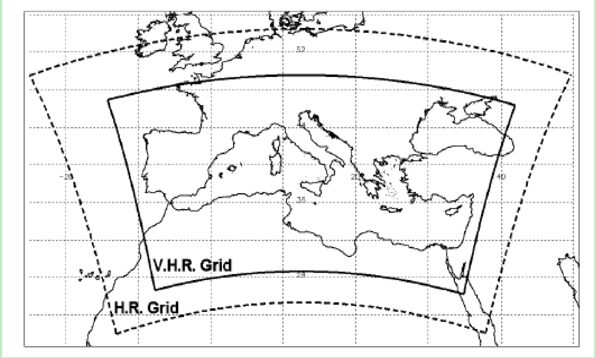
INTRODUCTION

This work addresses the capability to improve the quality of QPFs by an increase in LAM resolution. In the Mediterranean area, where orography and other local factors deeply affect weather systems' evolution, domain size can be a key issue. Obviously, the quality of initial and boundary fields plays also a major role.

The task has been afforded in the context of the ISPRA development activity on the Hydro-Meteo-Marine Forecasting System – SIMM.



⇑SIMM chain ⇓BOLAM domains



The SIMM model chain and its development

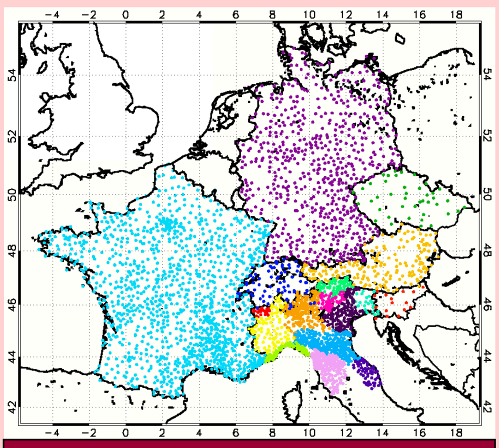
The SIMM is a cascade of numerical atmospheric and marine models, running on a SGI-Altix parallel platform. The hydrostatic BOLAM (BOlogna LAM, Buzzi *et al.*, 1994), fed by ECMWF initial and boundary conditions, provides 10-grid step input to a wave model on the Mediterranean Sea and to two sea elevation models over the Adriatic Sea and the Venice Lagoon. A new parallel version of the BOLAM code, developed at ISAC-CNR, was implemented and updated from 2009, replacing the former one (QBOLAM) originally tailored for the massively parallel SIMD platform QUADRICS and operational since 2000. The native SIMM configuration – a 30-km "father" LAM nested to a 10-km "son" LAM, starting 12h later as a spin-up – is presently unchanged and planned to be improved (in terms of vertical, horizontal and time resolution of input data, as well as of resolution and domain extension) after hardware upgrade. Thus, we need to evaluate the added value of possible model configuration improvements.

Statistical verification: Experiments and data sets

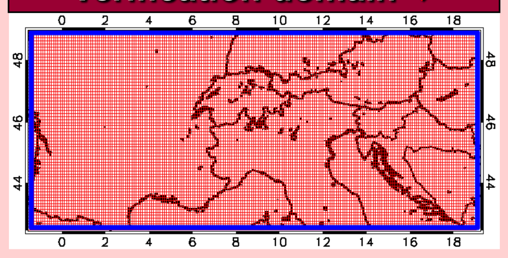
A robust evaluation of the effects of model configuration changes on forecast skill can be performed through a statistical precipitation verification. The 6-month observational dataset collected during the MAP D-PHASE Operations Period (DOP, Jun–Nov 2007) gives the base for this study.

Thus, a 6-month DOP reforecast has been built with the present SIMM configuration (*BOLAM11; EXP0*) *and* with two experimental configurations (EXP1, EXP2) tailored in order to resume all possible improvements of the system design.

A similar verification study was recently performed to evaluate the added value of BOLAM11 with respect to the previous QBOLAM model (see box below).



⇑ Rain gauge distribution
Verification domain ⇓



Although a true sensitivity study should require to test separately each factor, we group all them in two categories: "initialization" *and* "model grid".

EXP1 *uses improved ECMWF data (91 hybrid levels, any 3hrs, 0.3°grid) to drive the present son model (no father); while in* EXP2 *the original input drives without nesting a higher-res. (0.07°) BOLAM on a domain larger than the father one (see tables on the left).*

Parameter	BOLAM11	EXP1, EXP2
input grid step	0.5°	0.3°
input levels	15, pressure	91, hybrid
BC time interval	6h	3h
nesting	yes	no

Parameter	BOLAM11, EXP1	EXP2
model grid step	0.1°	0.07°
model grid points	386x210	810x498
approx. domain extension (km)	4300x2300	6200x3800

METHODOLOGY

- Categorical scores and skill scores calculated over a sum of daily contingency tables w.r.t. a set of given thresholds (Wilks, 2006); ROC curves (Mason, 1982).

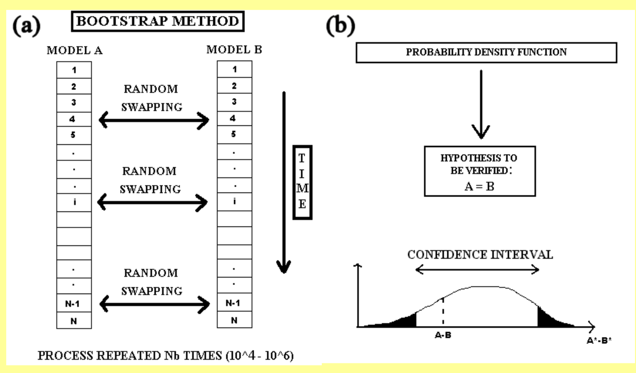
$$\mathrm{BIAS} = \frac{a+b}{a+c}$$

$$\mathrm{ETS} = \frac{a-a_r}{a+b+c-a_r} \quad \text{with} \quad a_r = \frac{(a+b)(a+c)}{a+b+c+d}$$

$$\mathrm{HK} = \frac{(ad-bc)}{(a+c)(b+d)} = \mathrm{POD} - \mathrm{F} = \frac{a}{a+c} - \frac{b}{b+d}$$

$$\mathrm{ORSS} = \frac{\mathrm{ODDS}-1}{\mathrm{ODDS}+1} = \frac{ad-bc}{ad+bc} \quad \text{where} \quad \mathrm{ODDS} = \frac{ad}{bc}$$

- 0.1° common verification grid; rain gauge analysis through a 2-pass Barnes (1973) scheme; model grid-to-grid trans-formation using a remapping scheme (Accadia et al., 2003).
- Bootstrap-based hypotesis test (Hamill, 1999) to provide the score differences between two "competing" models with confidence intervals.

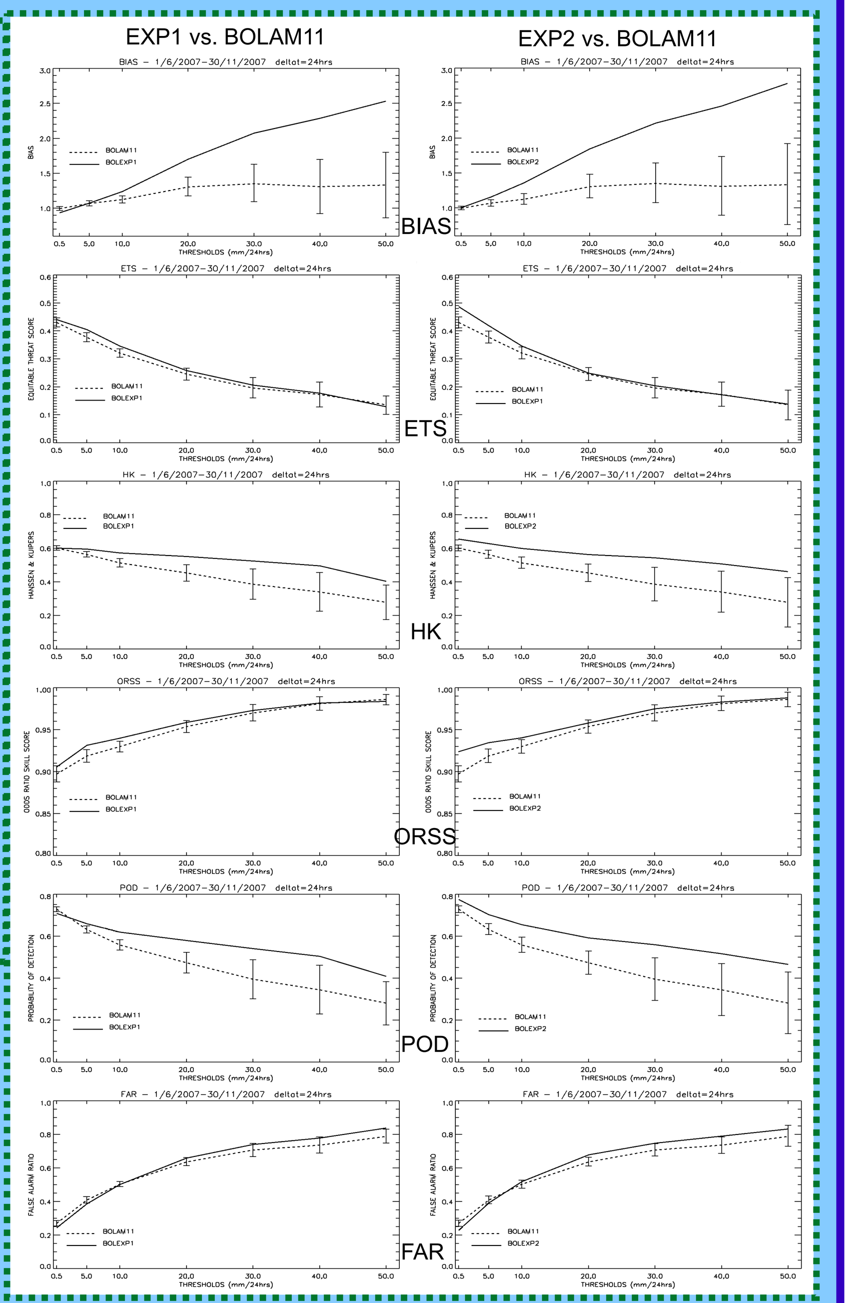


- Geographical mapping (on a 0.5° grid) of contingency table elements to provide physical interpretation of the scores.
- Case-study approach: eyeball subjective verification.

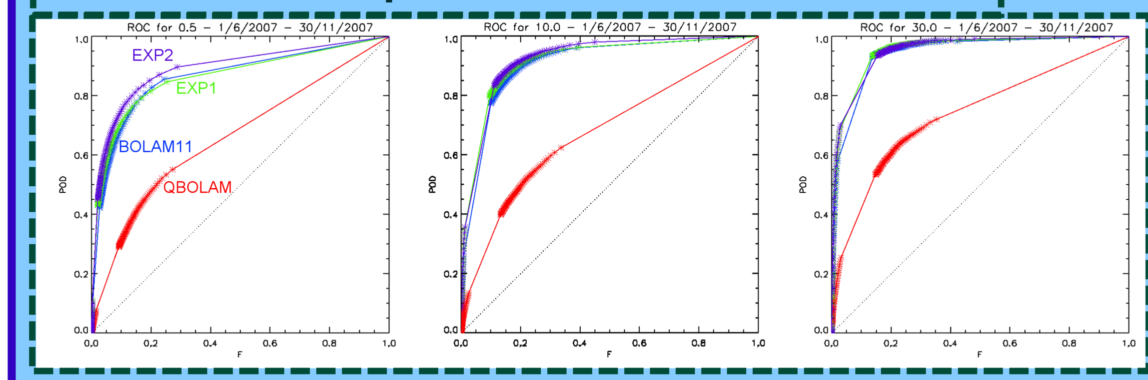
EXP1, EXP2 vs. BOLAM2011: Statistical verification results

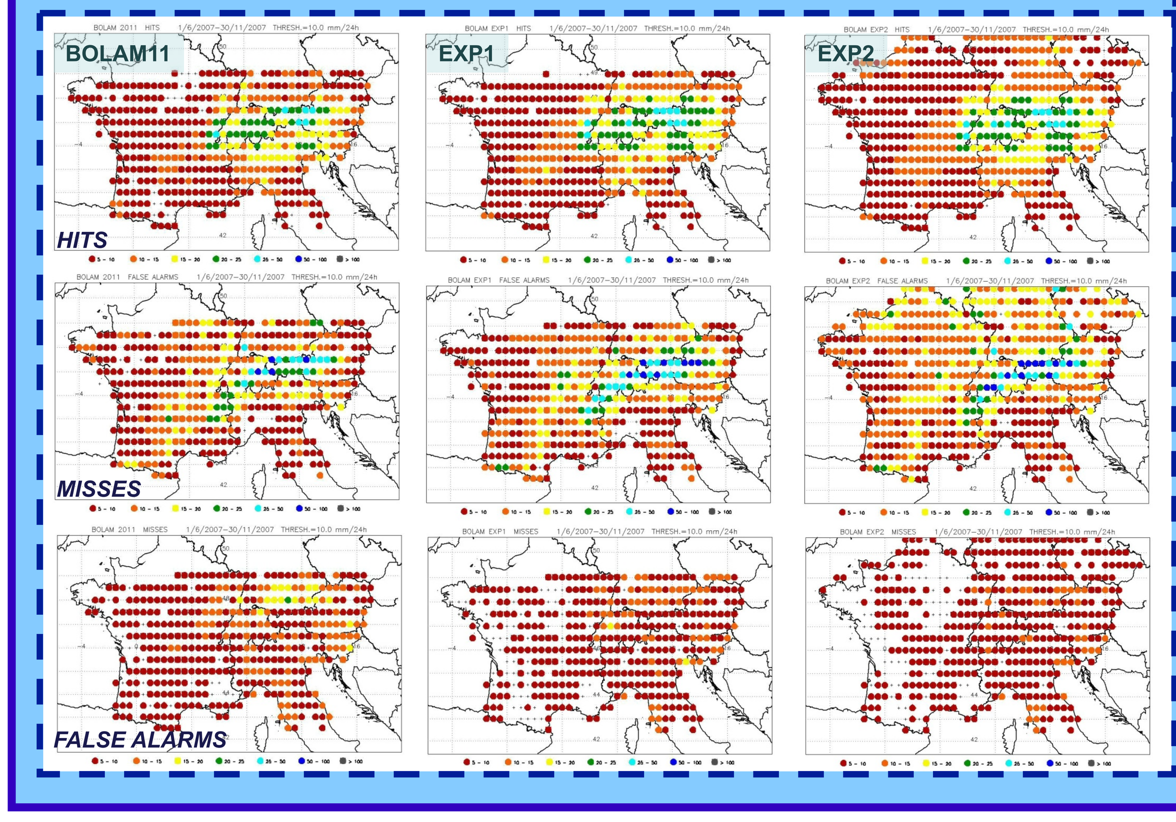
At a first glance, the benefit in employing better IC/BC (EXP1) and, all the more, for increasing resolution & domain size (EXP2) is not straightforward. A skill improvement is visible on HK (while it is marginal on ETS & ORSS), but it is paid with a large, increasing with threshold, positive BIAS. This seems to reintroduce the main QBOLAM criticality, but without degrading forecast accuracy. In fact, false alarms do not increase (see FAR), while a relevant increase in POD indicates a strong reduction of misses.

The differences between EXP1 and EXP2 are small and concentrated at the lower thresholds, suggesting that high resolution helps to forecast rain/non rain areas more than intense precipitation events.



ROC curves confirm this picture: Accuracy differences among the three configurations are much smaller than the difference between each of them and QBOLAM. However, at the rain/non rain threshold, EXP2 shows to provide some added value.





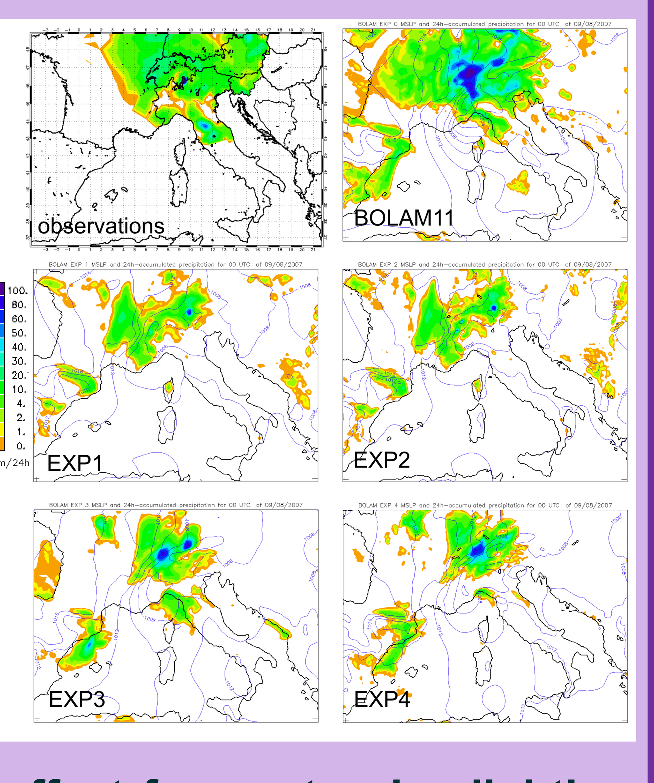
50-km maps of CT elements show that improving IC/BC is effective in reducing misses and (slightly) increasing hits. At a lesser extent, hi-res has the same effect. False alarms grow from BOLAM11 to EXP1 and from EXP1 to EXP2, both in rainy, mountain areas and in the French-German plains.

Globally, the improved model configurations seem to be too "wet", even if some increase in the forecast skill is found. Since the "father" provides to the "son" a more stable atmosphere, probably it is not proper to avoid nesting, even if the analysis resolution is close to the model one.

Reintroducing father domain (EXP3, EXP4): Case-study verification

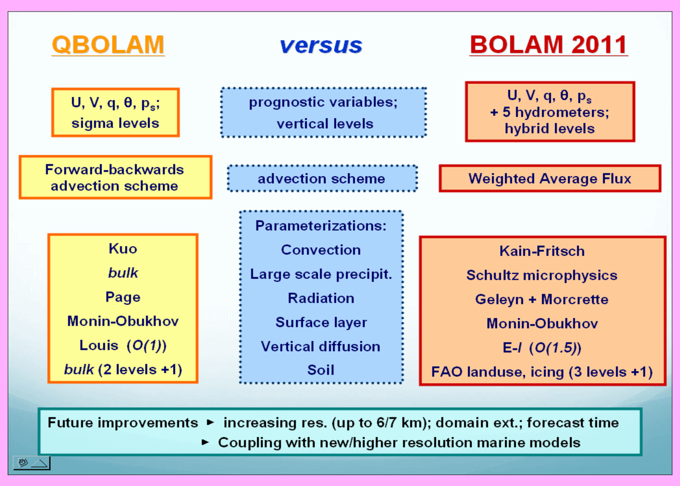
To test the need for nesting, two new experiments are considered. In EXP3, the EXP1 input is provided to the operational "father-son" configuration. In EXP4, a 0.2° "father" is run over the EXP2 domain with the improved input data and nested to a 0.07° "son" on a 690x418 domain, slightly smaller than the EXP2 one.

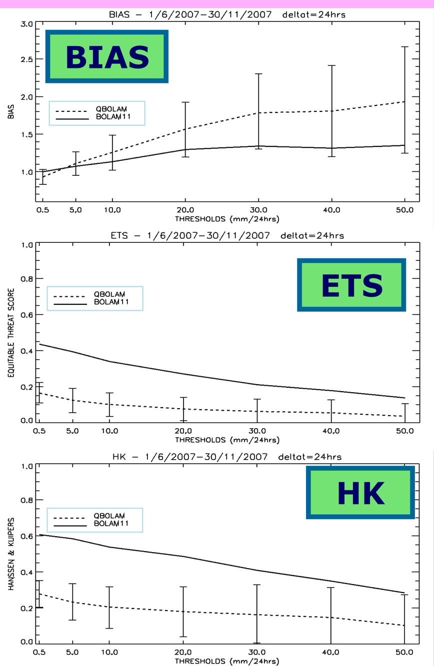
Waiting for DOP reforecasting, a case-study (8/8/2007) with intense rainfall over Alps and south Germany has been analyzed. In this case, the above-evidenced BIAS tendency is not visible. BOLAM11 seems to reproduce precipitation pattern better than EXP1-4, but overestimating rainfall peak. The reintroduction of the father (EXP1→EXP3, EXP2→EXP4) clearly improves the event representation. Increasing resolution and the domain size (EXP1→EXP2, EXP3→EXP4) seems to affect forecast only slightly, even if EXP4 reproduces better than others the main peak's position and intensity.



BOLAM 2011 / QBOLAM intercomparison on MAP D-PHASE DOP: summary of results

This 6-month verification of the new model skill (Mariani and Casaioli, E2011) gave quite encouraging results. The model improvements w.r.t. QBOLAM (see scheme) arise in a dramatic increase in skill scores and BIAS decrease. The geographic CT analysis confirm such a net increase in the model forecasting ability, displaying more hits and less misses and false alarms in intense rain and/or previously "critical" areas.





Conclusions and future work

Results suggest that a suitable configuration tuning should be required in order to exploit the potential added value of input data / resolution / domain enhancement. An added value has been found anyway, even it is unlikely to be so strong as the one from BOLAM code update was.

Further studies are needed to complete this work:

- Statistical verification on EXP3 and EXP4 configuration.
- Extensive case-study verification employing also object-oriented methods and intercomparison with satellite data, focusing on "critical areas" displayed by CT maps.
- Spectral analysis of model output is needed to define the appropriate grid scale for statistical intercomparison.

References

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