FORECASTING SKILL STUDY OF DIFFERENT NON-HYDROSTATIC METEOROLOGICAL MODEL CONFIGURATIONS IN SEVERE CONVECTIVE EVENTS SIMULATION

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I. INTRODUCTION

This study is part of a direct evaluation of the best possible configuration for a mid to high resolution model to be adapted as an RUC for the central Mediterranean and another high resolution model for explicit convection intended for use in making forecasts over Italy. The part of the work presented in this poster is intended to test two types of model simulations on a case study of very severe convective events that occurred over the south and south-eastern Po River Valley, often with ruinous results. These events were all either underestimated or completely ignored by mid to mid-high resolution global models or LAM. Actually, these are all phenomena (50-60% of the overall cases of severe convective events over the south and south-eastern Po River Valley) that cannot be attributed to direct synoptic frontal action, but only by dry-lines or mesofrontogenesis locally generated or prefrontal instability.

II. PARAMETRIZED AND EXPLICIT CONVECTION MODELS RESPONSE : 20 OUTBREAKS REFORECASTING (1999-2008, 45 TOTAL CONVECTIVE EVENTS)

The particular mesoscale conditions that occur under the circumstances being studied in the south and south-eastern part of the Po River Valley are particularly difficult for almost all convection parametrization schemes whether low level or deep layer control.
That environmental condition are frequently characterised by deep dry intrusion, low relative hygrometry in the cloud layer and the presence of very energetic PBL, difficul parametrization of entrainment-detrainment due to complex orographic profile and heterogeneous environmental conditions produced by rapidly changing heat flux dynamics from nearby sea (responsible to complex PBL energy budget) and convective triggering made by mountain-plain solenoidal circulation.
Contemporaneously, in nearly all the conditions analysed, there are upper level southern or south-western currents that give rise to more uniform and rich hygrometric profiles north of the Po, where parameterization schemes often tend to overestimate phenomena and concentrate widespread rainfall maximums.
Such events are very frequently underestimated, wrongly identified, or completely ignored by mid resolution global models and LAM with parameterized convection.
The model used derives from the WRF framework, using ARW (EM) and NMM core dynamics with variational initialization and with or without the nested domain. In general, the non-explicit models were calculated by means of a fixed extension grid measuring 1200x1200 km and 50 vertical levels hyperbolic tangent vertically distributed.
The explicit models are nested into non-explicit parent domain (1200x1200 km big) with 2 or 3 nesting levels.
The explicit domains were sized at 600x400 km in order to attain an integral representation of the Po River Valley and Northern Adriatic PBLs.
The number of vertical levels is 65, always with a hyperbolic tangent distribution.
The simulations were extended for 48 hours with the convective event centred between +18 and +36 hours in order to remove all potential spin-ups.
The set of severe convective events taken into consideration in the area being studied numbered about 20 outbreaks between 1999 and 2008, all of which manifested similar characteristics, like various intensities of hail storms, downbursts up to 100 km/h wind gusts, precipitation with rain-rates generally in excess of 100 mm/h, and a few vortical phenomena (land spouts, waterspouts, and a pair of suspected mesocyclonic tornadoes). However, in nearly all cases, none were correctly simulated by operational models (GCM above all).
Series of test simulations were conducted to evaluate the responsiveness of a set of mid resolution models run setted up with a series of parameterization schemes combinations, (PBL, Surface physics, low level control convective schemes, and deep layer convective schemes, surface layer) , for the purpose of profiling the model performances themselves for use as RUC for the central basin of the Mediterranean, The second part of the research, still ongoing, is directed in Data assimilation systems
In addition to the study on the configuration between 20 and 8 km, an in-depth analyses with re-forecasting of the events on finer grid domains (from 6 to 1 km) were conducted to evaluate the impact of different types of microphysics, PBL, and modified parameters of Landuse for the purpose of improving the skill of the model in managing convection, which generally appears to be overestimated.
-Modifications in Landuse- NON-EXPLICIT MODELS (20-8 km)
3 different configurations of LANDUSE were adopted: the first (cited as LU0) is the standard one; the second (cited as LU1) was provided with a 3% to 9% increase of the parameters of surface roughness (see table 1).
In the third (cited as LU2), there were further significant corrections concerning the same parameters (see table 1).
-Modifications in land use - EXPLICIT MODELS (6-1 km)
3 different configurations of LANDUSE were adopted:
The first (cited as LU0) is the standard one;
the second (cited as LU1) was provided with a -4% and -8,25% in the parameters of surface roughness (see table 2)

In the third (cited as LU2) there were further significant corrections concerning the same parameters (see tables)
The modifications were made by evaluating:
1-) overestimates as high as 20-30% and higher of the surface wind during the advection phase for models with domains between 15 and 8 km
2) increasing undrestimation below 5 km resolution relative to tests conducted for the sensitivity of the grid/bias resolution on the wind. These tests were conducted for wind power use

Land use	Parametrized convection			
	roughnesss		Soil moisture	
	LU1	LU2	LU1	LU2
Urban and Built-Up Land	5,20%	11,40%	-	-
Dryland Cropland and Pasture	7,10%	14,20%	-	-
Deciduous Broadleaf Forest	3,50%	7,00%	4,00%	8,00%
Evergreen Needleleaf Forest	4,50%	9,00%	4,00%	8,00%
Industrial or Commercial	2,50%	5,00%	4,00%	8,00%
High Intensity Residential	6,20%	10,00%	4,00%	8,00%
Low Intensity Residential	7,00%	12,00%	4,00%	8,00%
Barren or Sparsely Vegetated	5,00%	10,00%	2,00%	4,00%
Mixed Forest	5,00%	10,00%	4,00%	8,00%
Cropland/Woodland Mosaic	6,50%	12,00%	2,00%	4,00%
Cropland/Grassland Mosaic	7,00%	13,00%	2,00%	4,00%
Irrigated Cropland and Pasture	7,50%	13,00%	2,00%	4,00%

TABLE I: landuse modifications in 20km -8 km grid models (non explicit)

Land use	Explicit convection			
	roughnesss		Soil moisture	
	LU1	LU2	LU1	LU2
Urban and Built-Up Land	-3,00%	-5,00%	-	-
Dryland Cropl. Pasture	-2,00%	-4,00%	-	-
Deciduous Broadleaf Forest	-7,50%	-13,00%	-2,00%	-4,00%
Evergreen Needleleaf Forest	-7,50%	-13,00%	-2,00%	-4,00%
Industrial or Commercial	-2,50%	-5,00%	-2,00%	-4,00%
High Intensity Residential	-6,20%	-12,00%	-2,00%	-4,00%
Low Intensity Residential	-7,00%	-12,00%	-2,00%	-4,00%
Barren or Sparsely Vegetated	-5,00%	-10,00%	-2,00%	-4,00%
Mixed Forest	-5,00%	-10,00%	-2,00%	-4,00%
Cropland/Woodland Mosaic	-6,50%	-12,00%	-2,00%	-4,00%
Cropland/Grassland Mosaic	-7,00%	-13,00%	-2,00%	-4,00%
Irrigated Cropl. Pasture	-7,50%	-13,00%	-2,00%	-4,00%

TABLE 2 landuse modifications in 20km -8 km grid models (non explicit)

III. RESULTS AND CONCLUSIONS

Parametrized convection models

- PBL scheme play a foundamental rule in convective parametrization skill due to latent heat and sensible heat flux from Adriatic and heat and energy budget inside Po Valley
- KF scheme sistematically fails to correctly locate rainfall maximum sometimes of several hundreds kilometers. The scheme skill deteriorates reducing grid space
- KF put from 80 to 95% of rainfalls on Alps where RH profile in cloud layer tends to be more rich due to predominant sotherly or south westerly mid tropospheric winds.
- GR scheme behaviour is more heterogeneous; it produces less rainfall on Alps and a little bit more on Apennines when coupled to MYJ PBL, a lot of rainfalls (strongly overstimated) on large rainfalls maximums in central Po Valley or northerly Po Delta when copuled to BouLac PBL and partially with Pleim PBL or frequently similar to KF with Pleim PBL but with less rainfalls on Alps
- BMJ has adeguate skill to locate correctly rainfall maximums, expecially with BouLac PBL, but always produces strong understimation of 48h cumulated rain

Explicit convection models

- a 3 km grid domain seems to be the best solution here for depiction of severe storm in southern part on Po Valley , coarse model is less able to resolve correctly mesoscale convective features
- the convection localization skill increase costantly until 2 km grid, after that the improvement is small or negligible
- the convective rainfall overstimation dramatically explode below 3 km grid in southern Po Valley, below 5 km in the rest of domain, the Ferrier microphysics extremize this behaviour
- Microphysics Lin and WSM 6-class have a better skill in contanining rainfalls overstimation below 3 km and have better skill in localizing convective overtures
- Variational initialization give a better skill in cell localization and trigger timing but it can't contain rainfall overstimation
- Landuse parameter fine tuning reduces convective rainfall overstimation from 20 to 35%; the reduction of landuse roughess below -15% con drive too large negative bias, otherwise, +15% of rougness lenght drive to large negative temperature bias to (and positive wind bias) , due to domain convection and cold pool effects “explosions” and increased downdrafts number. A change in summer landuse roughess and soil moisture contents parameter respectively from -8 and -12% and -4% seems to be the best for overstimation bias
- spatial correlation get worse below 2 km only due to very large rainfall overstimation despite better localization skill

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