# The ARPA EMILIA-ROMAGNA instruments for forecasting and monitoring severe thunderstorms: summer 2011 analysis

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## AIM

The aim of this work is the evaluation of the instruments set up in Emilia-Romagna Region for the forecasting, nowcasting and monitoring of severe convective events, which was the object of a special project carried out during the summer season 2011.
The focus of the project was to develop and test an operational procedure for the warning emissions in case of heavy thunderstorms occurring in Emilia-Romagna, associated to effects on local territory (e.g. roads, small catchments flood and urban areas hydrological problems).
A preliminary analysis of the tools developed is presented hereafter.

## FORECAST

Since models usually have not the capability to catch the correct localization of convective cells, the probability of thunderstorm has been calculated using instability indices from forecasted soundings. For this purpose, COSMO I7 (7 km mesh grid and parametrized convection and COSMO I2 (2.8 km and explicit convection) limited area models are used. Different instability indices are combined to obtain a probability of development of heavy thunderstorm . Three classes are defined: low, medium and high. In the procedure, if the probability is high, after the forecaster evaluation, a warning is issued.
In Fig.1 the flow chart used to determine the probability level of severe thunderstorms and wind gusts is shown.

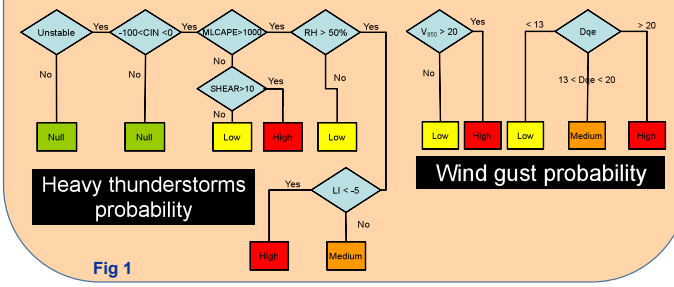



Fig 1

## SENSITIVITY ANALYSIS

The analysis is focused on observed or forecasted events during the period from 9th June to 10th September 2011. The events with high probability of severe thunderstorms and/or with radar hourly rain accumulation higher than 50 mm (threshold for the monitoring phase start up) are selected.
Tab.1 shows the forecasted probability of heavy thunderstorms and the forecasted probability of wind gusts (COSMO I2 and I7) compared to meteorological observations. Well predicted thunderstorms are shown in green, missing alarms in red and false alarms in blue. The table highlights that the number of successes respect of misses or false alarms is higher for COSMO I2 model.
The contingency tables are displayed in Tab. 2 and Tab. 3.

Tab. 1

| data | Heavy thunderstorm probability. Cosmo I2 | Wind gust probability Cosmo I2 | Heavy thunderstorm probability. Cosmo I7 | Wind gust probability COSMO I7 | Observations |
|---|---|---|---|---|---|
| 2011060900 | high | low | medium | low | **thunderstorms** |
| 2011061000 | high | low | high | low | thunderstorms |
| 2011061100 | high | medium | high | medium | **Squall line*** |
| 2011061200 | medium | low | high | low | |
| 2011061300 | high | medium | high | medium | **thunderstorms** |
| 2011061400 | high | low | high | medium | |
| 2011061700 | high | low | high | high | |
| 2011062900 | low | medium | medium | high | **Squall line** |
| 2011063000 | high | high | medium | high | **Squall line** |
| 2011070100 | medium | high | medium | medium | **Squall line**** * |
| 2011070200 | low | low | high | low | |
| 2011070400 | high | low | medium | medium | Squall line |
| 2011070500 | high | medium | high | medium | Squall line |
| 2011071700 | medium | high | high | high | |
| 2011071900 | high | low | high | medium | |
| 2011072000 | high | medium | high | medium | |
| 2011072300 | high | medium | high | medium | **thunderstorms** |
| 2011072400 | high | low | high | medium | **thunderstorms** |
| 2011072500 | high | low | high | low | |
| 2011072600 | medium | low | high | low | |
| 2011072700 | high | low | high | low | thunderstorms |
| 2011072800 | high | low | high | low | **thunderstorms** |
| 2011072900 | high | low | medium | medium | **thunderstorms** |
| 2011073100 | medium | medium | low | low | **isolated thunderstorm**** |
| 2011080100 | medium | medium | high | medium | **Air mass thunderstorms** |
| 2011080600 | medium | high | high | high | |
| 2011080700 | high | medium | high | medium | |
| 2011080800 | low | high | high | medium | |
| 2011081500 | high | medium | medium | medium | thunderstorms |
| 2011090300 | low | high | high | high | |
| 2011090400 | medium | high | high | high | **thunderstorms**** |
| 2011090500 | high | medium | high | medium | Squall line |

* flash floods  ** wind damages recorded

**Forecasted - Cosmo I7**

| | | YES | NO | tot |
|---|---|---|---|---|
| | YES | 11 | 8 | 19 |
| **Obs** | NO | 13 | 67 | 80 |
| | tot | 24 | 75 | 99 |

Tab. 2

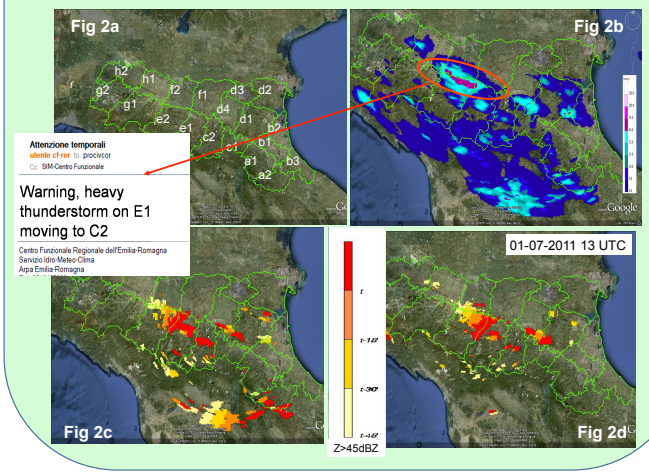
**Forecasted - Cosmo I2**

| | | YES | NO | tot |
|---|---|---|---|---|
| | YES | 14 | 5 | 19 |
| **Obs** | NO | 6 | 74 | 80 |
| | tot | 20 | 79 | 99 |

Tab. 3

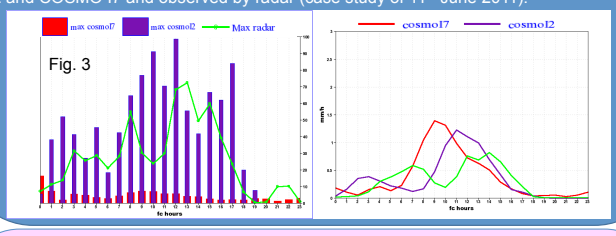
## MONITORING

When the radar hourly accumulated precipitation is higher than 50 mm the monitoring and nowcasting activities start and an e-mail message is sent to the Regional Civil Protection Agency with the indication of the warning areas (Fig. 2a) affect by heavy thunderstorm and if it is stationary or where it is moving into. For these activities instruments as radar, satellite, high frequency ground stations and lightning detector are used. To support this experimental activity some ad-hoc operational radar products have been developed, as accumulated precipitation in a floating interval (every 15 minutes, see Fig. 2b) and reflectivity above a critical threshold (45 dBZ) displayed with the past three radar acquisitions (Fig. 2c and 2d, respectively collected by San Pietro Capofiume and Gattatico radars). Operational product are displayed to forecaster on a high resolution visualization platform (Google Earth).




## MODEL PRECIPITATION

To complete the analysis, the maxima and the averaged precipitation forecasted by the two models are compared to the radar precipitation. Preliminary investigation shows that COSMO I2 precipitation maxima are closer to the radar. The averaged values indicate that the timing of COSMO I2 is more coherent as well.
Fig. 3 shows an example of the hourly accumulated precipitation maxima (on the left) and averages (on the right) in the Emilia-Romagna region, forecasted by the COSMO I2 and COSMO I7 and observed by radar (case study of 11th June 2011).




## CONCLUSIONS

- Regarding the forecast activity COSMO I2 provides the best probability of occurrence of heavy thunderstorms.
- Preliminary investigation shows that COSMO I2 provides a feasible information about the timing of the precipitation, even if COSMO I7 gives useful information about the spatial localization.
- The monitoring and nowcasting of convective cells are supported by radar products based on present and past data; an algorithm to track future trajectory of the thunderstorm has to be set.
- Partial information about observed wind does not permit to evaluate the performances of wind gust probability.
- Incomplete information about damages does not allow to extract certain conclusions about the relation between thunderstorm type and the effects on territory, but a preliminary look on the available data provides optimistic expectations, about the usability of the analyzed instruments in an operational warning system.