# Severe weather: some case studies for medium-range forecasting

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In this presentation a list of events concerning severe weather is introduced, that could leads to issue a medium range alert message over Italy. The synoptic configurations causing them are also described, highlighting the processes reducing the predictability.

## Introduction

The role of C.N.M.C.A. is to produce weather analyses and forecast products to several types of users and also in support of public weather forecasts. One is the meteorological alert message; this is provided to National Public Safety Agency for guidance and is issued only in occurrence of severe weather.

The issuing time scale and related alert messages used at C.N.M.C.A. are the following:

From +12h to +24 h (D Day) is called "intense"

From +24h to +60h (Day +1) is called "warning"

From +60h to +84h (Day+2) is called "early warning"

Specifically, the issue of meteorological alert message in medium range forecast consists of an early warning; at the moment, this type of warning plays a minor role in the warning activity of the C.N.M.C.A.

## The decision process

Currently, two models are used by medium-range forecasters - the ECMWF and EUROHRM (Rome); nevertheless the local area model called LAMI, is also taken in consideration for short-range forecasting up to 48 hours. The current products suite of medium range includes classical elements such as cumulative precipitation, temperature, wind, snow precipitation, deep convection, dew point temperature and more.

A list of severe weather thresholds for each element has been defined, mainly referring to prevailing conditions (Fig.1).

- Rainfall more than 50 mm / 24 h on wide area (regional areas); more then 40 mm / 6 h on local areas (heavy showers);
- Snowfall more than 10 cm / 12 h on the plain on regional areas; more than 50 cm / 24 h on mountain areas;
- Thunderstorm, hail heavy thunderstorms or thunderstorms with hail high wind mean speed more than 33 knots;
- Gusts speed more than 33 knots sea state very rough or more (Sea state 6, wave height more than 4-6 meters)
- Temperature decrease 10°C or more in 24 h; Temperature rise, above 32°C, for 48 h at least
- Fog on wide area, for at least 48 h

Fig. 1 Phenomena and threholds leading to meteorological alert at Italian Weather Service.

## The use of conceptual models

Unfortunately, numerical weather prediction models are not always capable of predicting these types of events; on the other hand, high-resolution local area models at given lead-time, give frequent false alarm. As a consequence, the prediction of severe events up to several days, based only on the numerical models, is not usually convenient. As a consequence, a semi-subjective prognostic technique is considered as necessary in the decision process, mainly in medium range. That is to say that severe weather forecast involve the operational use of conceptual models.

The 'conceptual models' technique is usually utilized to help the forecaster to select the model offering the most likely solution. Such technique includes objective and subjective methods of model verification and consistency as well as incorporation of ensemble techniques; on the other hand, the severe weather type, and related synoptic or meso-synoptic characteristics, routinely diagnosed by forecasters on the basis of conceptual models validate numerical models output in the decision process required for issuing Met Alerts

Here is a temptative list of conceptual models causing severe weather in Italy (Fig.2):

| Phenomena | Synoptic or meso-synoptic characteristics | Forecast | | |
|---|---|---|---|---|
| | | Medium-range | Short-range | Nowcasting |
| **Heavy and persistent precipitations** | V-shaped trough with a stationary warm conveyor belt | yes | | |
| | Frontal and post-frontal convergence lines | | | yes |
| | Interaction between continental pseudo-cold front and occlusion | | occasional | yes |
| | **Frontal system deformation due to topographical interactions (Topographical S-shape)** | | yes | |
| **Strong winds** | **Deep and rapid cyclone devlopment** | | yes | |
| **Snowfalls over the plains** | Interaction between continental pseudo-cold front and occlusion | | occasional | yes |
| | Eddy Vortex from Eastern Europe | | occasional | yes |
| | Warm conveyor belt over cold lake in the Po Valley | very occasional | occasional | yes |
| **Heavy thunderstorms** | Post-frontal or isolated commas from upper eddy vortexes (Possible topographical effects) | | yes | |
| | Frontal and post-frontal convergence lines | | | yes |
| | Heat thunderstorm | | occasional | yes |
| **Squall line** | Induced over Po Valleyby cold front North of the Alps | | occasional | yes |
| **Wide area fog** | Intense anticyclone developing over Italy | | yes | |
| **Heat waves** | Anticylonic belt | yes | | |
| **Cold spells** | Continental pseudo-cold front | occasional | yes | |
| **Forest fire** | Anticyclonic subtropical continental air masses currents from Africa (very hot and dry air in sunny and windy weather conditions) | yes | | |

Fig. 2 Severe weather types, and related synoptic or meso-synoptic characteristics, routinely diagnosed on the basis of conceptual models to justify numerical outputs in the decision process performed fro issuing meteorological alerts.

As we can see, there are only few conceptual models leading to alert message in medium range; they specifically concern the evolution of synoptic configurations such as waves with large amplitude, but without transients producing reciprocal interactions between them. Moreover, for a few of them, interactions with external factors, like orography, are known and should be considered, such as in the case of 'V-Shaped Trough' configurations.

## Heavy rain

Heavy rain will be already detectable by medium-range tools such as EPS methods, in particular if produced by Warm conveyor belt. It is important to underline that these events can have severe influences on the local hydrology situation (c.f. Po Valley) (Fig.3).

Some aspects affect negatively the predictability of this precipitation pattern:

- Cumulative precipitations depend on the condensation level;
- Forcing due orographic effect is very sensitive to the wind;
- Eventual convectively in Conditional Symmetric Instability;

## Snow warning

Caution is required to issue snow warning over land more than 24-36 hours in advance of the onset of the event. This is mainly due to the uncertainties of the thermal conditions in low levels; however, the snow is not frequent phenomenon over Italian plains; nevertheless, this event, whenever occurring, severely disrupts all human activities.

## Heat waves

Heat Waves represent one of the few events having high social impact, that is remarkable well predictable. For this phenomenon, it is possible to identify some characteristic features in the medium range, such as extremely high geopotential values in the Mediterranean basin (Fig 4).

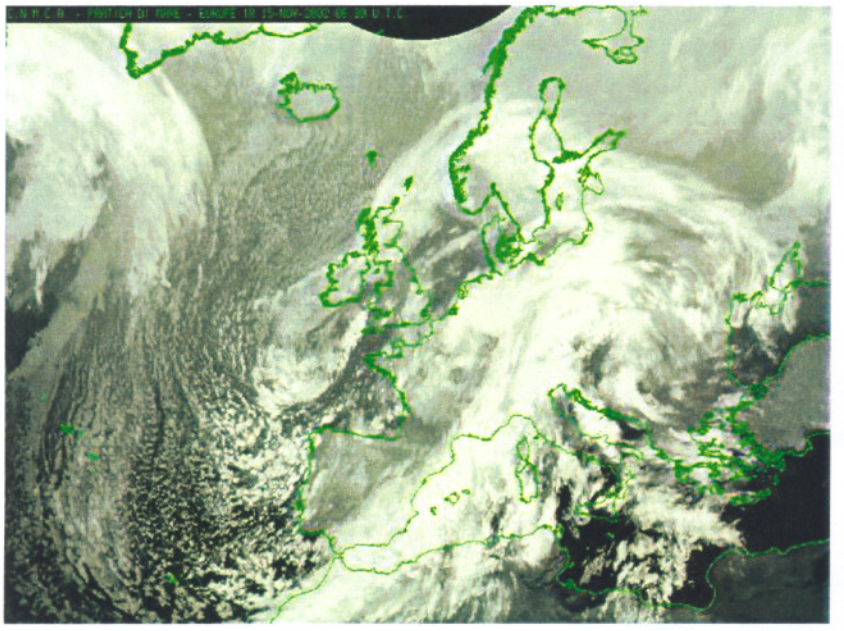

Fig. 3 The warm conveyor belt over the Po Valley

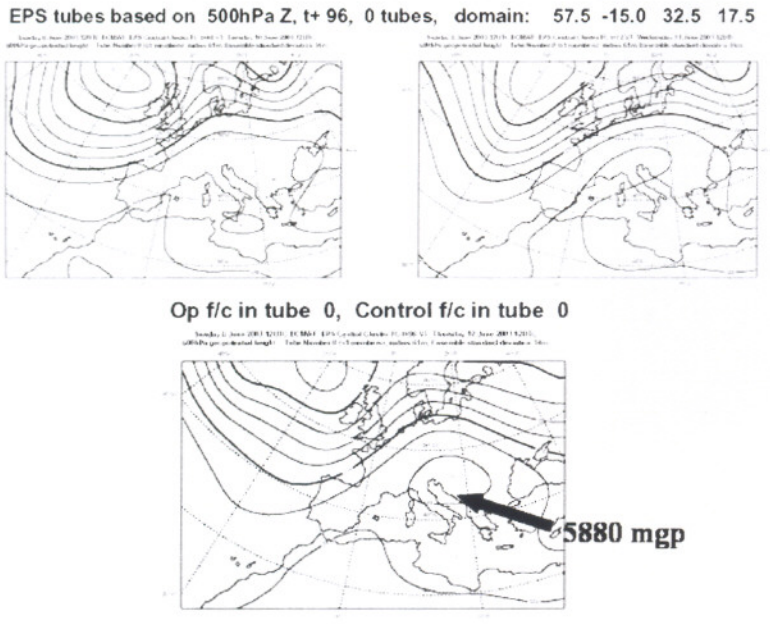


Fig. 4 The EPS tubes

The relative synoptic configuration consists of an intense anticyclone induced by the northward displacement of the subtropical belt. We can observe high predictability in summer and late spring; moreover the predictability is correlated to the length of the anticiclonic wave. Some problems related to the lifetime, depend on the interactions between anticyclone and Atlantic troughs (Fig.5).

## Conclusions

At the state-of-the-art, only few types of severe weather have high predictability in medium-range forecasts in Italy; this depends on the usual development of eddies in the Mediterranean area, which might affect the reliability of the numerical models.

Correspondingly, the guidance of conceptual models is required; Forecaster selects the conceptual model likely to detect eventually severe weather type. Furthermore then the reliability of the operational model run has to be confirmed with EPS products and finally with EFI.

## References

KNMI, ZAMG, FMI, EUMETSAT Manual of Synoptic Satellite Meteorology Conceptual Models

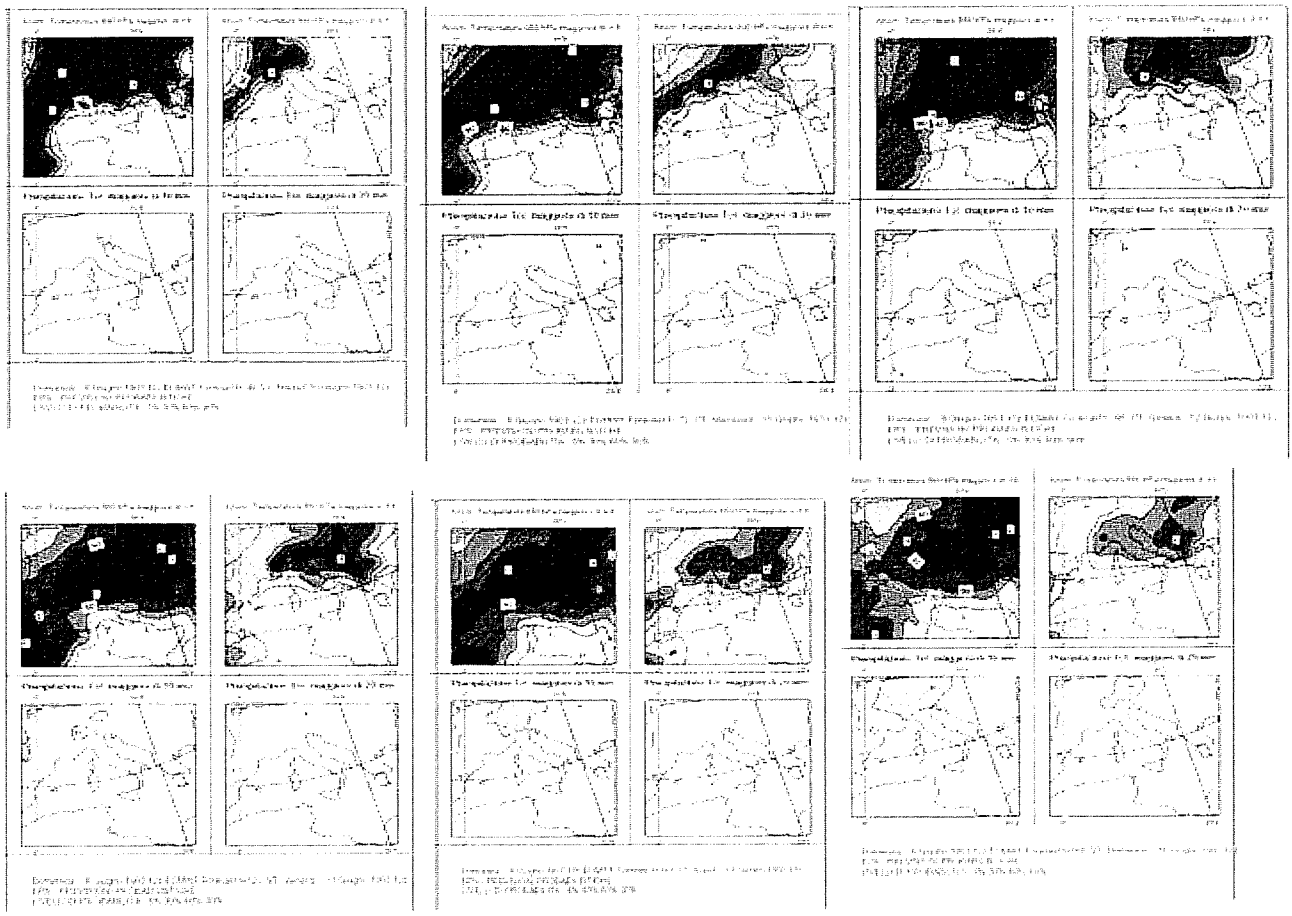

Fig. 5 EPS temperature anomaly in the medium-range.