# OBJECTIVE FORECAST OF CONDITIONS LEADING TO SEVERE THUNDERSTORMS BY USE OF THE MDA (MATERIAL DIFFERENTIAL ADVECTION). CASE STUDY FOR THE LOMBARDY PLAIN (YEARS 2004 – 2006)

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## I. INTRODUCTION

The plain of the Po river is characterized by the frequent occurrence of severe thunderstorms, mostly concentrated in the summer period. Some of these episodes are particularly violent and may evolve into low-energy tornadoes.

This evolution is often triggered by atmospheric instabilization from above, as cold air masses entering from the Alpine passes (Sempione, Spluga, Brennero) surmount warmer air stagnating closer to the ground, thus inducing strong vertical convective exchanges (Borghi and Minafra, 1969). The strength of vertical convection is enhanced by the water vapor content in the lower atmosphere, with its associated reduced cloud base and strong development of condensation latent heat. The local convergence occurring in a narrow layer below cumulonimbus clouds may originate extreme winds with speed in the order of 100 $ms^{-1}$ or more, with large damages (Borghi and Minafra, 1972).

Many thunderstorm prediction criteria have been developed and are in current use, among which the Whiting and Similä indices, or the SWEAT index (Borghi and Minafra, 1970).

## II. PRESENTATION OF RESEARCH

Among the conditions conductive to the development of strong instability over an area the following are of special interest in the area considered:

- A vertical temperature gradient stronger than the average ($-\Delta T/\Delta z > 6.5$ °C/km);
- A massive contents of water vapor close to surface, with elevated dew-point temperatures ($T_d > 20$ °C).

When these conditions are met, a further worsening is triggered by a selective cooling of upper atmospheric layer, not accompanied by a temperature adaptation in the lower atmosphere. This condition may be expressed quantitatively by the material differential advection (MDA, see Fujita, Bradbury, Van Thullenar, 1965):

$$\text{MDA} = -(\vec{V}_{700} - \vec{V}_{850}) \cdot \nabla T_{700}$$

where $V_{700}$ is wind speed recorded at 700 hPa, $V_{850}$ is wind speed at 850 hPa, and $T_{700}$ is temperature at 700 hPa.

In practice, the MDA represents temperature advection at approximately 3000m caused by wind shear occurring between 1500 and 3000m. In the site considered, wind at 3000m represents well the transfer of dynamical properties of the air masses from the area at north and northwest of the Alps to the Po plain.

Fixing attention to the approximate heights 1500m and 3000m, the conditions over temperature and dew-point temperature simplify to

(1) $T_{850} - T_{700} > 10$ °C (equivalent to a gradient in excess of 6,5 °C/km)
(2) $T_d > 20$ °C

To these two conditions, a third related to MDA is applied:

(3) MDA < 0, connected to cooling from above.

## III. RESULTS AND CONCLUSIONS

The objective prediction based on conditions (1), (2) and (3) (later designated as "MDA method") has been applied to Lombardy on the warm period of year from April to October in years 2004, 2005 and 2005 using data from the LAMI model.

The LAMI model is a version of the German "Lokalmodell" tuned to Italy, operating on a local curvilinear frame with a spatial resolution of approximately 7km and a time step of 3h in analysis mode, with predictions extending to more than 72h. These values are compatible with the space and time frame of severe thunderstorm events.

Predictions based on the MDA method have been compared to recorded thunderstorm events over Lombardy spanning the time periods considered.

The results obtained proved to be quite satisfactory, with negative values of the MDA (condition no.3) being strongly associated with the occurrence of severe thunderstorm events. Upon expressing advective cooling in units of °C/3h, and mapping the areas where conditions (1), (2) and (3) intersect, it has been also possible to discriminate the intensity of the phenomena observed.

## IV. REFERENCES

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