Swiss Confederation

Federal Office of Meteorology and Climatology MeteoSwiss

Severe Convection Nowcasting in the Alpine region: the approach COALITION

Luca Nisi, Igor Giunta, Paolo Ambrosetti
MeteoSwiss, Locarno Monti, Switzerland
luca.nisi@meteoswiss.ch

Motivation

Many of current nowcasting heuristic models are based on inertial rules and their algorithms analyze data from only a single observation source (e.g. satellite, radar). This kind of models is typically employed for forecasting position and intensity in the next 15/60 minutes of mature thunderstorms, through the identification, tracking and classification of single feature, like rain rate. Such persistence rules however can not sufficiently reproduce important dynamic features, which are driven by other factors, in particular during the initial phases. This results in low performances in the early phases (low POD) and in the evolution forecast (high FAR).

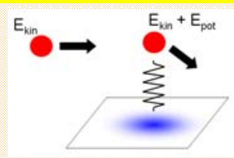
Objectives

COALITION aims to develop a flexible entity-oriented model which produces probabilistic information about the evolution of severe thunderstorms by merging severe convection predictors with evolving thunderstorm properties. The final goal is to produce early assessments of thunderstorms in terms of severity and location, through rapid modeling of the available convection signals.

COALITION blending technique

→ [Object,Environment] pairs are selected according to convection phase (context + scale); the influence of the environment onto objects (e.g. forcing) is modeled as particle-field interaction.

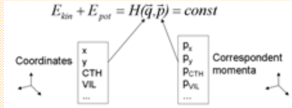
→ A solution to each particle–field dynamics is sought within an Hamilton framework: a set of object attributes are used as generalized coordinates, where energy and momenta behavior are opportunely formulated as minimization problem. The integral over last time steps returns forward operators, and deviations from the observations provide a measure of the solution accuracy. Residuals are cumulated over the characteristic time-scale and, together with the uncertainties intrinsic to the data, used for spreading the possible solutions as ensemble forecasts.



Algorithm

Objects are generated either by ad-hoc confinement rules or by external algorithms (e.g. SAFNWC/RDT). The external environment is searched among all available observation fields, for which well known physical or heuristic correlations with the object attributes are given (e.g. cloud top cooling and radar echoes). **Potential fields** are built up on these environment characteristics. The dynamics of the object attributes is then modelled as interaction particle-potential problem, where the energy conservation is forced by adding an external potential field (E_{pot}) to the kinetic component (E_{kin}):

$$E_{kin} + E_{pot} = H(\vec{q},\vec{p}) = const$$



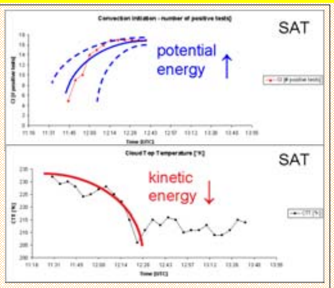
This Hamiltonian is integrated over past time steps to obtain forward propagators. For this aim a set of attempted solutions (ensemble) is built according to uncertainties (object location and attributes) and to residuals. An ensemble forecast is finally performed.

→ a simplified 1-DIM harmonic oscillator is assumed

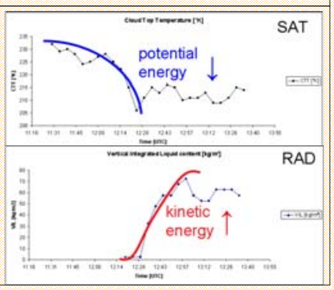
$$H(q,p,t) = \frac{1}{2}m\dot{q}^2 + f(t)q^2$$

where q is the object attribute and f(t) the correlation between object attribute evolution and the external field.

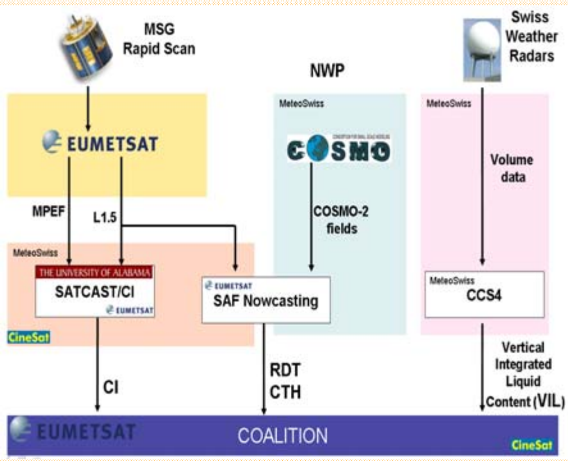
First module:



Second module:

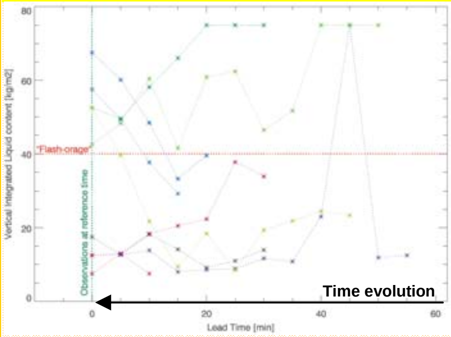


Datasets



→ **60 stormy days** → **~ 200 thunderstorm cells** → **2TB**

Preliminary results



→ Second module's results

→ Different thunderstorm cells analyzed

→ For the severe ones (over the red line) the reference time represent the moment when the thunderstorm cell was recognised as severe by the forecaster

→ For the weak ones (under the red line) the reference time represent the moment when the thunderstorm cell show the maximal VIL value

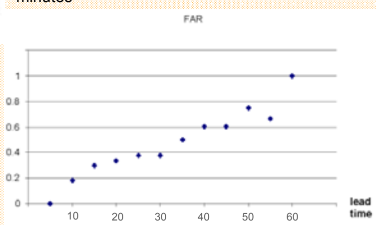
→ For the severe ones the diagram show good skills for lead times up to 15 minutes; for the weak ones good skills for lead times up 30 minutes

First assessment based on 13 different case studies ←

For lead-time till 30 min the FAR is acceptable ←

Good skill scores for 5 and 10 min lead time ←

Between 15 and 30 minutes the FAR values are between 30% and 40% ←



Conclusions and Outlook

→ COALITION is a newly developed approach to forecast severe convective storms by collecting and assimilating information from different data sources into a simplified model; first modules combining satellite and radar products are implemented

→ Cloud Top Temperature and Vertical Integrated Liquid are forecasted for the next 5 to 60 min for each considered thunderstorm cell

→ Validation has been done on 13 cases for different lead-times (5 to 60 min). For severe thunderstorms we obtained good skill scores for lead times up to 10 min and acceptable scores for lead time up to 30 min. For the weak ones we obtained good skill scores for lead time up 30 min

→ Currently we are including all selected cases of the database for a statistical evaluation of the algorithm skill

→ Inclusion of the correlation of other potential fields to object attributes (new modules); in particular we are including the topographic information by means of a lightning climatology

→ Summarize the results of different modules in a probability map

Acknowledgements

This project is founded by EUMETSAT. Warm thanks to R. Stuhlmann (EUMETSAT Fellowship program), the SAF/Nowcasting Consortium (software and support), J. Mecikalski (Convection Initiation algorithm), M. König (scientific and technical support), GEPARD J. Scheiber (Software Development Kid), L. Clementi (informatic solutions) and the whole MeteoSwiss staff.