The use of radar data for the nowcasting of convection

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1. Introduction

Thunderstorms may cause various damages in many places of the world. Associated meteorological parameters are numerous (wind, lightning, hail, rainfall). Thunderstorms can also be seen as the most dangerous aviation weather hazard. Thunderstorms nowcasting is a major field development for many meteorological services.

Thunderstorms are well adapted to object approach as they have for example almost unambiguous spatial envelope. The object approach makes the tracking of systems easier. The use of some trend parameters allows to identify the strengthening systems.

Météo-France has developed a production chain to detect, track and characterize thunderstorms and to warn end-users. The steps are described in this paper.

2. Convection Nowcasting Object

An object-oriented diagnosis for convective clouds is run operationally and provided to the forecasters. The diagnosis is called CONO (COnvection Nowcasting Objects) and is applied to a smoothed reflectivity image of French radar mosaic. The French radar composite image is processed with 26 conventional radars. The radar network has following characteristics

- Radar mostly in C band (some of them in S-band or soon X-band),
- Few elevations,
- Spatial resolution of 1km,
- Reflectivity resolution of 1dBZ
- Time resolution of 5 minutes

Before computing the CONO algorithm, we pre-process the composite image with smoothing and morphological closing operations to merge cells by bridging gaps.

The reflectivity thresholds of CONO are 35 and 41 dBz. The tracking method aims at linking objects in two consecutive radar composite images (Fig. 1). The tracking algorithm determines for each cell the best choice of speed estimate between the following methods:

- Correlation (the privileged method),
- Neighbour (motion vector of neighbour cell),
- Persistence (previous motion vector),
- Level (motion vector of a larger cell that contains the cell of interest),
- Orphan (correlation method but with uncertainty about the cell father)

Merge and splits are managed. Ground truth is provided by lightning (Météorage network for France).

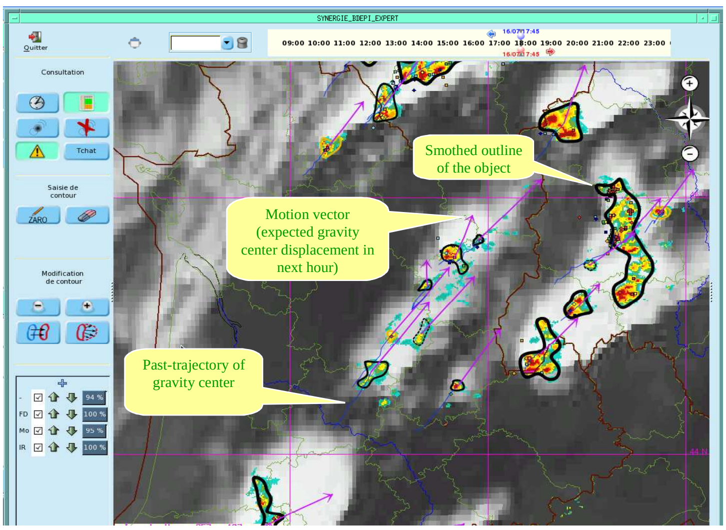

Fig. 1: visualization of CONO objects with Synergie (Météo-France forecasters' tool). Background image=IR10.8µm MSG channel + thresholded French radar reflectivity mosaic.

The CONO definition has changed in 2011. Previously a minimum vertical height of 6 DBz was necessary to define an object. This restriction has been given up and now:

- More cells are detected, with longer life-cycle
- The number of orphan lightning impacts (away from a convective cell) has decreased

3. Significant Weather Object Oriented Nowcasting system

In the SIGOONS system (Significant Weather Object Oriented Nowcasting system) CONO generated convective cells are further qualified regarding sensible weather and using various sources.

Since CONO uses the ARAMIS French radar network, the forecasters have access to the following parameters observed below the convective cell: maximum and mean precipitations rates, maximum and mean reflectivity, hail risk assessment, etc. New types of information provided by Doppler and dual polarization radar -for example the horizontal wind shear- will soon improve risk estimation for hazards associated to thunderstorms (like hail or strong gust).

The description of convective cells contains other attributes coming from different sources: Meteorage network (lightning), SAF/NWC products elaborated with MSG satellite data (cloud top temperature and height), NWP data (relative helicity). Knowing the past-trajectory of the object allows to calculate trends of various parameters (Fig. 2).

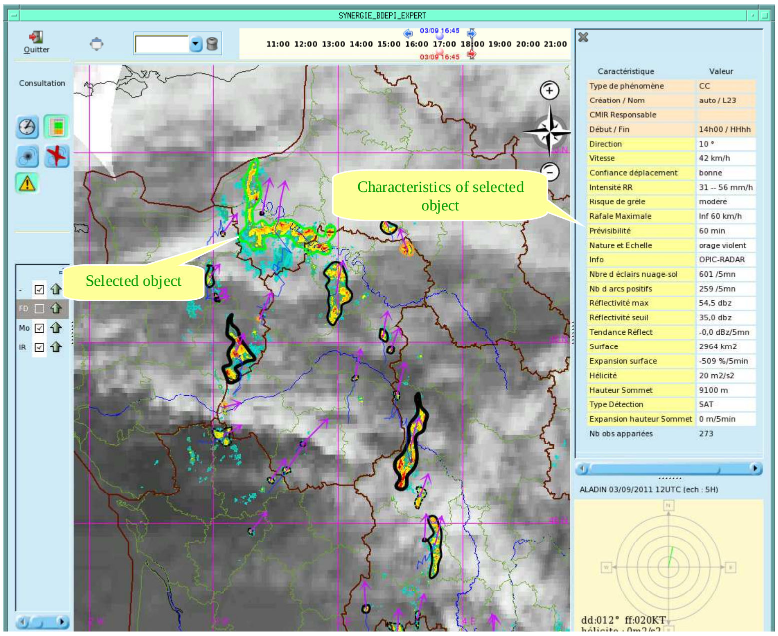

Fig. 2: data associated to CONO object

The analysis of Hautmont Tornado (North of France, August 2008) conducted by Météo-France has shown that two proxies could be useful to anticipate the phenomena: helicity and wind shear. Relative helicity has been implemented since 2011 while wind shear will be soon used in an integrated algorithm for estimation of gust risk (Fig. 3).

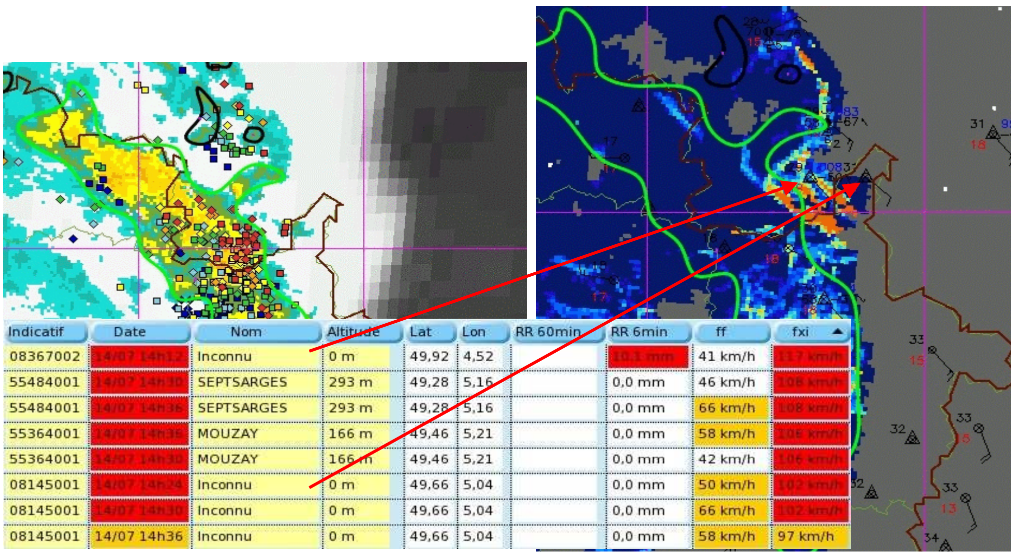

Fig. 3: heavy gusts in the vicinity of high wind shear area

Cells are also extrapolated up to one hour ahead (Fig. 1), with a dilatation rate increasing with time to describe the displacement uncertainty.

SIGOONS are a useful help for forecasters since the automatic process synthesizes and merges different information associated to convection. Forecasters' expertise is highly requested and necessary for the validation and verification phases of products.

4. Warning of end-users

Forecast production is heavily based on automated process, it uses the Significant Weather Object (SWO) database and merges it with a customer requirement database for generating customer-specific warnings and forecast updates. End-user defines the location, the severity of the thunderstorms and the level of warning required.

SIGOONS allows to provide to customers an operational thunderstorm risk warning service through SMS (Short Message Service), email and extranet graphics. Messages occur when the risk of thunderstorm in the chosen location appears, strengthens or is at an end.

The service has been operational since 2008 and has been extended to full year since winter 2011.

5. Outlooks

Another approach has been developed for convection detection. RDT (Rapid Development Thunderstorm) product is based on satellite data. The RDT has been developed in the context of Eumetsat's Satellite Application Facility for Nowcasting (SAF-NWC). RDT software tracks clouds, identifies those that are convective, and provides some descriptive attributes for their dynamics. Compared to CONO algorithm, RDT algorithm is more complex. Indeed, measurements provided by satellite are less directly linked to convection as radar ones'. MSG data are used both in FDSS (Full Disk Scan Service) and RSS (Rapid Scan Service). RDT data input can also come from GOES-E, GOES-W and METEOSAT7. Almost all French oversea territories are covered. RDT offers an alternative to CONO where radar network is not available (mountainous areas, oceans, areas with sparse radar network)/

Another field of development concerns the use of NWP data. A data fusion system Nowcasting–NWP is under development. It will be built from a configuration of AROME named AROME-PI. AROME-Nowcasting main characteristics are:

- 3DVAR assimilation
- Dense forecast of several parameters (wind, temperature, humidity, but also reflectivities, precipitation, kind of hydrometeors)
- High frequency of forecast (hourly refreshed)
- High geographical and temporal resolution: mesh of 2.5km and for a given run, forecast fields are produced for each 15 minutes interval
- Maximum forecast range between 3 and 6 hours
- These forecasts will be available within 30 minutes after the latest observation

The use of NWP in nowcasting will offer the possibility to extend the forecast range and help to determine the strengthening or decaying cells.

At the moment SIGOONS manages SWO for thunderstorms and convection-prone areas. It can be adapted to other parameters of phenomena. Snow SWO are in progress (feasibility phase).