Rapid Developing Thunderstorm (RDT)

Convection Week 2011
SESSION 3
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METEO-France, Nowcasting Department, J.-M. Moisselin
jean-marc.moisselin@meteo.fr
Who Am I?

Jean-Marc Moisselin
Météo-France, Toulouse
Forecast Department, Nowcasting Division
Outlines

- RDT Science and new development
  - Overview, input data, mechanism
  - Improvements of 2011 version
  - Output, adaptation on different territories, display

- Case studies

- CDOP2: The evolution planned on the 2012-2017 period
Part of SAF Nowcasting, EUMETSAT project for MSG

- **Software** Included in SAFNWC software package (PGE11)

- **Object-oriented satellite analysis**
  - Identification and tracking of cloud systems as objects: attributes (trend, morphology, etc.), motion vector, etc.
  - from meso-alpha scale (200-2000 km) down to smaller scales (few pixels)

- Possible data fusion
RDT main principles

 brightness temperature

 Cloud Products SAF/NWC

 Foudre

 NWP indices

 RDT–PGE 11
 Detection
 +
 Discrimination

 BUFR
What are the input data of RDT?

- **Satellite-based data**
  - **main and non-optional channel**: IR10.8 μm (useful for detection and tracking)
  - other satellite channels WV6.2, WV7.3, IR8.7, and IR12.0 μm (useful for convective discrimination)
  - other SAF Nowcasting products: pressure at the cloud top, cloud type

- **Other data**
  - Lightning data
  - Numerical Weather Product data (v2011)
RDT = Detection + Discrimination

- **Phase 1: detection**
  - towers identification, based upon 10.8 mm channel
  - Adapative threshold (reflectivity!)

- **Phase 2: discrimination** (statistical model and empirical rules for storm classification/declassification). Tuning in **hindcast mode** for different categories
RDT– detection

3D

2D map of cells « to be tracked »

Threshold choice => identification of cells « to be tracked »

No statistical tuning at this step

RDT–PGE 11
1 Detection
2 Discrimination
RDT– convective discrimination (classification)

**Difficulties:**
- Unbalanced populations (1 conv for 100 non conv),
- Various sizes (isolated, embedded, MCS),
- Various stages (warm to mature)

**Method Definition**
- Prerequisite statistical tuning (learning DataBase) vs “ground truth” (lightnings)
- Use of space and time satellite parameters
- Since v2011: NWP (Numerical Weather Prediction) data as input guidance
- Real-time processing: use of lightning data (useful for attribute or guidance)

**Implementation**
- Numerous Parameters (predictors) from
  - Channels IR10.8, WV6.2, WV7.3, IR8.7, IR12.0 (incl. Trends)
  - Static and morphological parameters
  - NWP data
- Diagnosis relies on statistical models vs:
  - Vertical development => categories
  - Recent past history (15’ to 1h)
  - Focus on ascending cloud systems
- Empirical rules for continuous « managing » of convective property

Numerous equation regression : we have to deal with different data input configuration, we have a statistical model for each category and each history configuration
Discrimination of convective systems

The picture above displays all RDT detected cells. This picture points out the detection and tracking efficiency of RDT.

We can notice the diversity of phenomena (in term of type or size)

The next image displays convective objects only. The ratio between no convective and convective objects is about 100.
RDT v2011: Overview

- The major improvements of RDT v2011 concerns the use of NWP data:
  - Mask established from 3 stability indexes (which are calculated with NWP data), in order to
    - Ignore cloud cells in stable areas
    - Reduce the unbalance between convective and non-convective population
  - New attributes for RDT cells

- Other improvements concern the speed estimate:
  - more realistic values
  - tracking improvement
RDT v2011: NWP convective mask

- NWP data for convective mask

Union of 3 indexes to exclude stable areas from convective diagnosis

Allows
- To focus RDT on areas of interest,
- To strongly reduce the false alarms during intermediate and winter seasons
RDT v2011: NWP Impact on Precocity

20 September 2010, 11:15 UTC

Trajectories, cells and motion vectors from RDT v2010 (left) VS v2011 (right).

v2011 shows an increase of 30 min in precocity for the convective cell near Portugal-Spain frontier.

First detection occurs in “transition warm” category (yellow line) for v2011, in “mature” category (purple line) for v2010.
RDT v2011: NWP Impact on discrimination Tuning

20 September 2010, slots 12:15 UTC

More numerous and earlier convective diagnosis.
The situation not only displays the improvement on warm categories discrimination, but also higher detection of mature ones.

**Small systems on the eastern French frontier** are all convective cooling systems, most of them associated with lightning flashes, and **diagnosed by v2011 only**. Other small systems (yellow contours) are relevant (good precocity east of Corsica at 13:15). Some others are not confirmed (French Alps).

v2011 allows to **decrease false alarms** and **increase precocity of detection**, thanks to a better tuning in all categories. Probability of detection is higher than in previous versions, especially in the warmest categories. Convective systems are thus more numerous.

Please keep in mind that the fact to classify cloud systems in the warmest categories, you will increase the false alarm rate. Thus we have decided to keep warm discrimination as an option (“-precocite “ argument of PGE11 model configuration file).
The RDT product
A storm classifier as well as a cloud tracker

Cloud tracking

- Methods
  - Overlapping, Correlation, Neighborhood
- Trajectories builder (temporal link)
  - Split and merge management
  - Temporal characteristics processing

- Update of cell’s speed
- Access to the history of cloud system (temporal links)
- Reconstitution of cloud system Trajectory
Satellite-diagnosis: RDT thunderstorm tracking

Phase: Mature
Threshold temp.: -33 °C
Minimum temp.: -56 °C
Temperature change: -47 °C/h
Expansion rate: +327% / 15 mn (-33 => +2339 km2/h)
Duration: 101 mn
Speed: 5.6 m/s
Lightning +: 0 / 20 mn
Lightning -: 1 / 20 mn
Lightning: 0 / 20 mn
Area: 0.76 (1000)km2
Top pressure: 274 hPa
Lat C.G.: 42.49°
Lon C.G.: 13.55°
RDT v2011: Impact on Tracking

Speed estimation and tracking improvement

- Suppression of erroneous motion vectors, following splits and merges
  In case of too high speeds estimated, the speed of the previous slot is associated to the object.

- Improvement of the tracking when the threshold temperature changes
  Estimation of the speed based on “Top of Towers”

- More coherent and realistic speed values

Trajectories are less chaotic (gravity center of each cell is defined at a higher level)

20 September 2010, slots 09:45 (top) to 10:00 UTC (bottom).
Trajectories, cells and motion vectors from PGE11 v2010 (left) VS v2011 (right).
v2011 shows more coherent values of motion and more stable cell contours and trajectory path
Objective Validation.

Method
- RDT (v2009) validated against lightning strokes, during summer period (3 months)
- Diagnosis evaluated on whole trajectories
- Criteria: lightning proximity, lightning activity

Conclusions
- Good representation of convective activity
- POD > 70% on convective periods
- Lack of precocity:
  - 25% diagnosed 15min before the 1st stroke
  - 80% within the 30mn period following the 1st stroke

Globally satisfactory, few misses, but still some false alarms and lack of precocity

Further releases: Extended validation over Europe and not limited to summer period. EUCLID data are now available! Work in progress!!

Subjective Validation

Very interesting improvement with v2011 thanks to NWP guidance.
Output data of RDT

Output

- Current cloud systems (convective or not): Binary BUFR file
- Full history of cloud systems (achieved trajectories): ASCII file
- no image output but …

…. some visualization chains exist following PGE11

- website « SAF/NWC HelpDesk »
- For MF forecasters : through Synergie (Forecasters Workstation)
- For MF users : through different web site, e.g. http://www.meteorologie.eu.org/RDT/
Visualization/Display of RDT

- RDT Automatic update
- RDT superimposed with IR image
- RDT associated with lightning data
- Meaningful graphical attributes
- Quantitative attributes using a pointer
- Possible time series display on click, helpful for the characterization of development stage

contour colors and stages (categories)
- **mature** (coldest)
- **growing** (intermediate)
- **triggering** (warmest)
- **splits**
RDT is processed on different territories

- Territories: Europe, French overseas territories, Africa

- **Different satellites**: MSG, GOES W, GOES E, METEOSAT7
  - Difference in term of **frequencies** (5’/15’/30’/60’)
  - Difference in **channels**, in term of
    - Number (e.g. few channels with METEOSAT 7)
    - Central value (10.80 µm for MSG, 10.67 µm for GOES)
    - Spectral interval around central value [9.8, 11.8] for MSG 10.8 µm
  - Different **pixel sizes** (3km for MSG)
  - Different **data format**
  - **Reception** configuration, image **availability** problems

- Ground Truth: availability and precision

- Different meteorological areas: mid-latitudes, tropical/equatorial regions

  Example: low latitude issues to deal with:
  - Ground truth: scarce network
  - Detection: Thicker troposphere in low latitudes
  - Tracking: **Generally lower moving speeds**, except large systems (SQL). **Not adapted to hurricanes** (focus on cloud towers)
  - Convective Discrimination: Tuning not representative of deep convection, Colder tops of CB, stronger dynamic, larger durations, convective systems more numerous

- **SOLUTION=TUNING !!!**
The sun never sets on RDT!
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- CDOP2: The evolution planned on the 2012-2017 period
25/4/11: a Squall line over TOGO, following the dissipation of a huge Cb.
In some places the lack of satellite channels penalizes the RDT algorithm (case submitted by MF La Réunion forecasters)

13\textsuperscript{th} of May 2011

- Development of a thunderstorm on “La Réunion” island, moving toward North-East, intensifying in a SQL form until 15:30 UTC

- Why is there nothing on picture?

- Because
  - System is too warm,
  - System is too small
  - There is a BTD bias for METEOSAT7 compared to MSG: only few channels are used
RDT: Impact of differences in channels characteristics

METEOSAT7-IODC, MSG

- IR colder, WV warmer => BTD differences are biased (BTD=WV6.2-IR10.8),

BTD MSG

RDT is tuned with this BTD

BTD IODC

overdiscrimination is observed when RDT is used with this BTD
RDT example: 25\textsuperscript{th} of May 2009

Severe Thunderstorm event over France, with heavy gusts and heavy hail, associated with convergence line

Satisfying behaviour of RDT (bur forecasters prefer radar products!)

- very few misses
- not all cloud systems are compatible with good precocity
- some false alarms, especially in warmest categories
Dean Hurricane case (September 2007)

A single meteorological object (hurricane) defined by several objects (RDT)
Tracking: 15 June 2010 – Flash flood on Var region

V-shape stationnary convective system during afternoon over SE France

Unstable track due to
- Time variability of cloud contour
  - Splits/merges
  - Morphology variability

New system in the evening

good track and speed estimate despite of splits/merges

Hymex visu
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- **CDOP2: The evolution planned on the 2012-2017 period**
Increase reliability of speed estimate for nowcasting: Multi-level speed estimation, use of a guess field (AMV, NWP)
- Other channels (IR3.9µm, Vis, …)
- Other data sources: Phase of cloud (SAFNWC Cphase), Microphysical characteristics (SAFNWC CMIC), other convective data (CI, GII, …)
- Nowcast of the phenomena (about 1h)
- MSG/GOES/MTSAT(cont): Tuning and validation
Convection Initiation (CI)

The convection probability for each pixel is based on:

- SAFNWC Clear Air Product, ie Precipitable Water parameters, Instability Indices based on Physical Retrieval
- SAFNWC Cloud Product, ie type of cloud, vertical extension, liquid water/ice path
- (SAFNWC) Wind Product, ie convergence, vorticity
- Model product, ie instability index
- History of Pixel
Probability of the formation of a thunderstorm depends on the evolution of local conditions and on the advection of clouds. For the latter point, CI is unfortunately too scarce for an object approach: a correct tracking of CI is not really possible.

To take into account the historic of convection, historic of the pixel will be added as a predictor.
Convection Trajectory (CTRAJ)

Endded trajectories
Fully CW-dependent
Helpful for climatological studies
Interaction between products

- NWP
- Historic CI
- Other SAF Products
- Historic CW
- Other SAF Products
- NWP
- CW
- MTG LI
- CTRAJ
- Ground Truth (Euclide network, Météorage network, radar network)

: Input (predictor) or attribute

: Validation
## CDOP2 releases

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- Thanks a lot for you attention
- Thanks to EUMETRAIN for the organization
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