Rapid Developing Thunderstorm (RDT)

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The EUMETSAT Network of Satellite Application Facilities
NWC SAF
Support to Nowcasting and Very Short Range Forecasting

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Presentation

Météopole, Toulouse

Jean-Marc Moisselin
Nowcasting department

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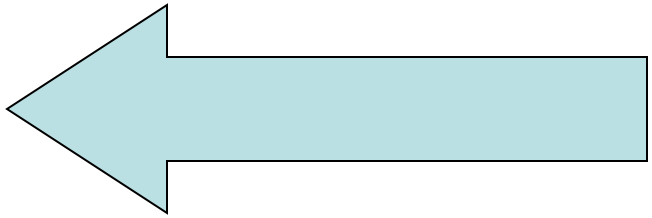
Overview

1. **Description**



2. Validation
3. Evolution

RDT product

- Rapid Development Thunderstorm
  CW: convection warning

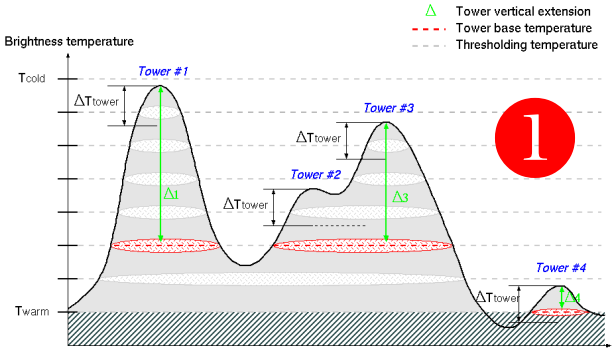
- PGE11 included in NWCSAF software package

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

3-steps algorithm of RDT

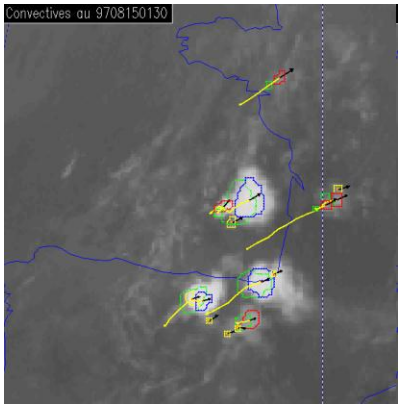
STEP1: Detection (in order to detect cells)

- *Using vertical profile of 10.8µm BT*
- *Cells (towers) are <u>detected</u> at each slot*
- *Vertical extension: at least 6°C*



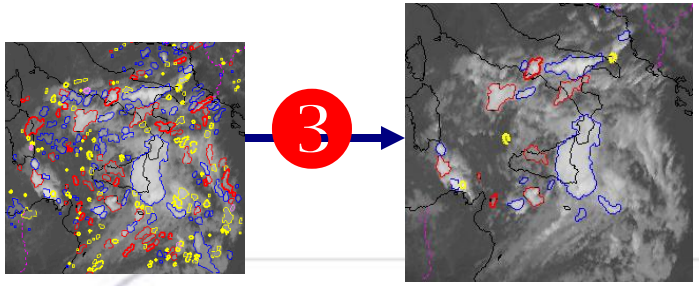
STEP2: <u>Tracking</u> (in order to recognize each cell in the previous slot)

- *Analysis of cloud cells overlap: each cell of the previous slot is advected*
- *Merges and splits are taken into account*
- *<u>Trends</u> of various parameters are calculated*



STEP3: <u>Discrimination</u> (in order to identify <u>convective</u> cells). *Statistical process*

- *Made complex by the <u>unbalanced</u> populations (1 convective for 100 non-convective), the wide variety of scales, and evolution-phases of systems*
- *Highly improved by the use of a <u>set of 5 IR-channels</u> as predictors, by the use of <u>NWP data</u>*
- *Very highly improved by the use of <u>lightning data</u>*



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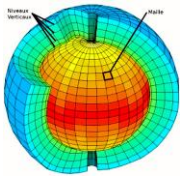
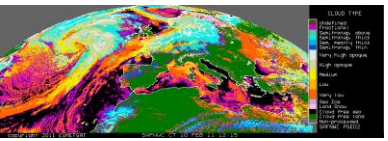
Data fusion helps to get a complete description of convection (1/2)

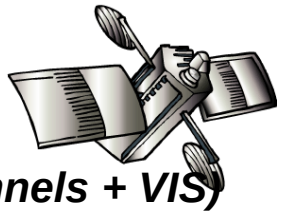
INPUT DATA: MULTISOURCE



NWP data



Other NWCSAF products



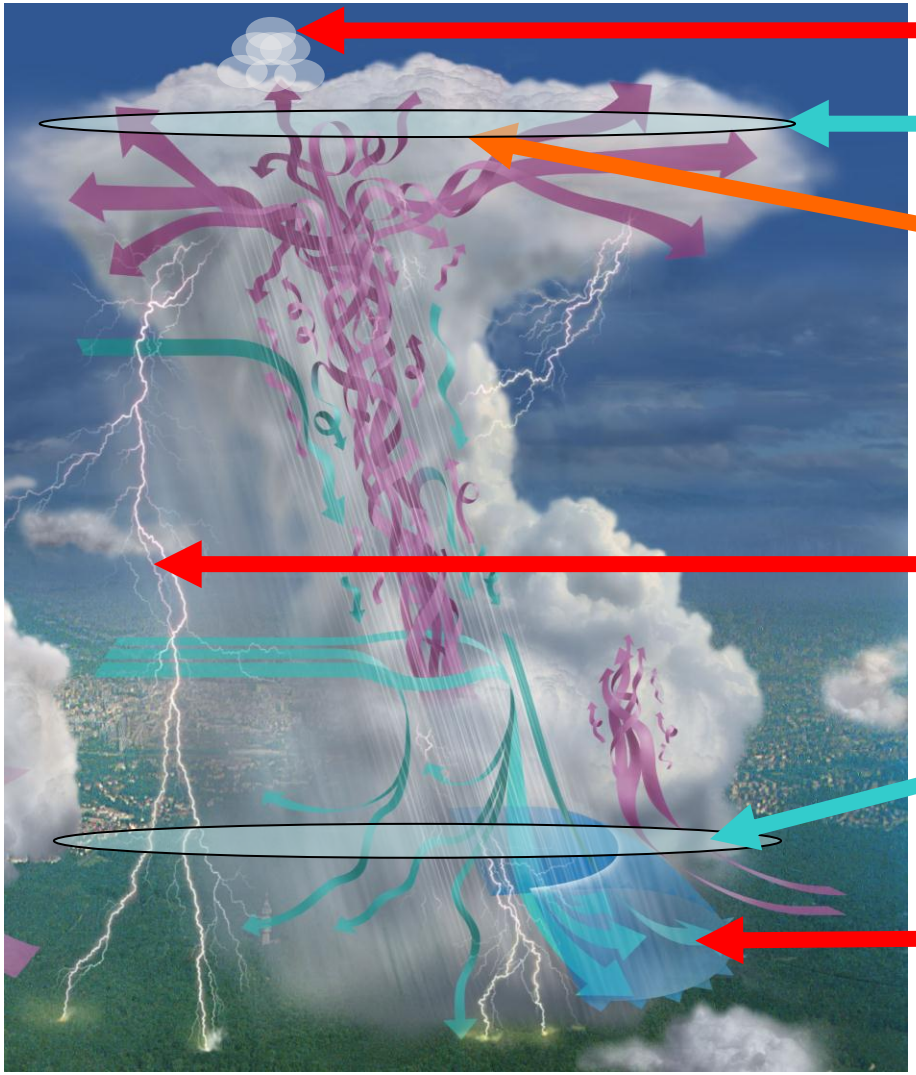
MSG data (5 IR channels + VIS)

PGE11

RDT

Lightning Data

Data fusion helps to get a complete description of convection (2/2)



OT detection: number, position, size, strengh, etc.

2nd Level of Cell definition

Top of Tower attributes: temperature, cooling rate, etc.

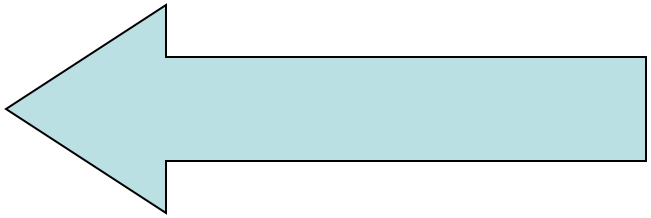
Lightning activity attribute

1st level of Cell definition: tracking, surface, etc.

Rainfall attribute

Overview

1. Description

2. Validation 

3.Evolution

Validation method

- ❑ Ground truth = lightning data (Euclid network)
- ❑ Full-trajectory or sections of trajectory or each time steps
- ❑ The possibility to use lightning data in Convection Yes/No RDT discrimination process is not activated

Ground Truth in the vicinity of a RDT trajectory

Deduced Ground Truth trajectory

Validation method

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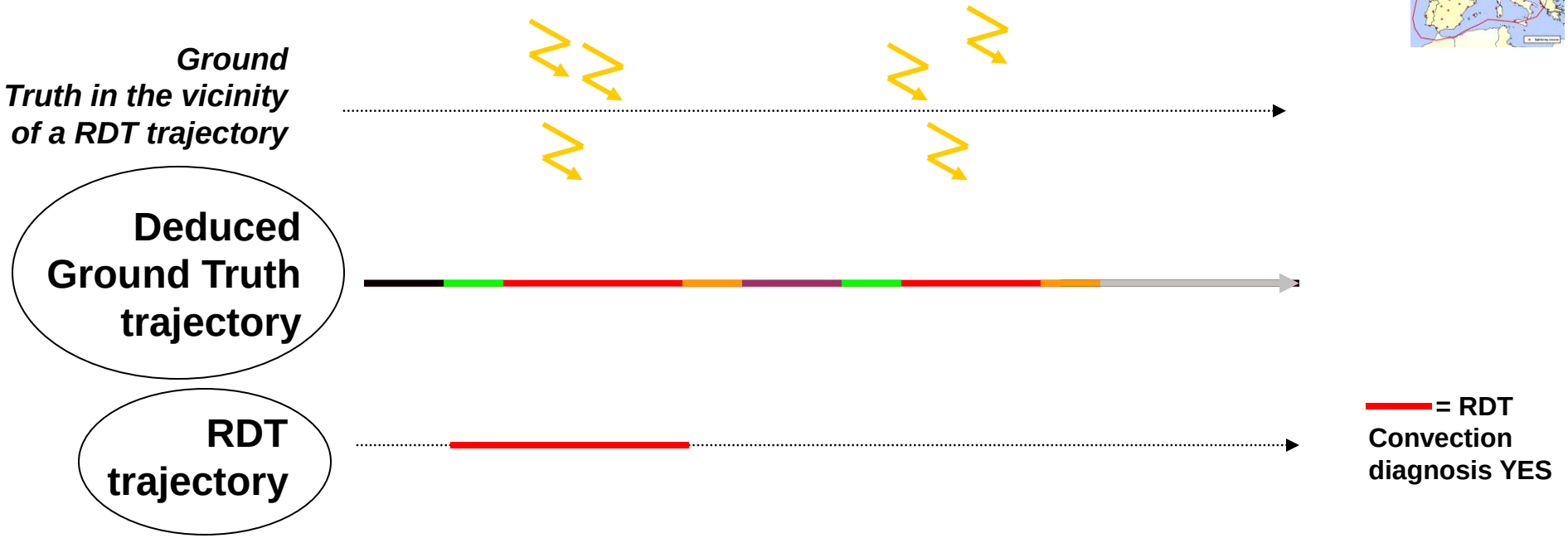
- ❑ Full-trajectory or sections of trajectory or each time steps
- ❑ The possibility to use lightning data in Convection Yes/No RDT discrimination process is not activated

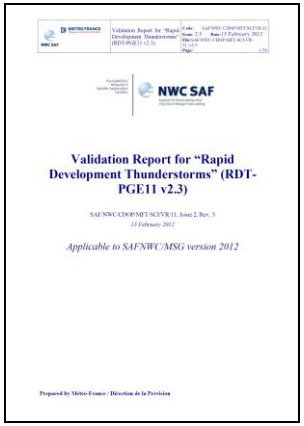


- ❑ In the example given above, it's a HIT if we consider a trajectory approach
- ❑ In term of section approach, there are a HIT, a non-detection, some correct rejections. The RDT convection diagnosis during "green" section (few minutes before lightning activity) can be seen as precocity (early diagnosis)

Validation method

- Control parameters
  - Lightning activity (low/moderate/high)
  - Distance trajectory-strokes
  - Whole trajectory approach/section approach/time-steps (15') approach
  - The way to consider early diagnosis (precocity) or decaying phases
  - Seasons
- Main categorical statistics are calculated: POD, FAR, POFD, TS

	⚡	⚡ with X
RDT Convection Diagnosis YES	HIT	FALSE ALARM
RDT Convection Diagnosis NO	MISS	CORRECT REJECTION



Validation main results

Scores for different validation methods and periods

(separation of non-electric and electric trajectories based on a moderate activity)

	POD	POFD	FAR	TS
Trajectory Approach, France, Summer 2005, Meteorage data, RDT v2009	66	2	44	43
Trajectory Approach Europe, Summer 2008 + summer 2009, EUCLID data, RDT v2011	75	3.5	31	56
Trajectory Approach Europe, Full period, EUCLID data, RDT v2011	74	3.5	34	53
Idem with flashes proximity tolerance of 35km	74	2	22	61
Section approach Europe, Full period, EUCLID data, RDT v2011	77	4	28	59
Idem with flashes proximity tolerance of 35km	77	3	21	64
Time steps approach Europe, Full period, EUCLID data, RDT v2011	65	1.5	20	56
Idem with flashes proximity tolerance of 35km	65	1	14	59

❶: Better results for this validation compared to the previous one (mainly due to version change)

❷: Scores remain good when non-summer months are added

❸: Flash proximity tolerance lowers the FAR

❹: Best results concern the Section Approach (due to time-tolerance given to sections before and after lightning activity in the hypothesis chosen here)

❺: Time-step approach is very disadvantageous but scores are correct

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Conclusion on validation

The **objective** validation results fulfil the SAFNWC **target accuracy requirements** over a large domain. And there are others argument PRO RDT

Use of RDT

- By forecasters of Météo-France, in France and overseas territories (La Réunion, Antilles, Polynésie, Wallis et Futuna)
- In the analysis of Rio-Paris AF447 crash (2009).

Collaboration with: NOAA for a RDT GOES (Operation + Research), ACMAD, etc.

Projects: AMMA experiments; FlySafe, Hymex, HAIC, TOPMET

Survey distributed to NWCSAF end-users

*On the basis of the arguments summarized in previous slides, Steering Group agreed to upgrade PGE11 (RDT) to "**operational** »*

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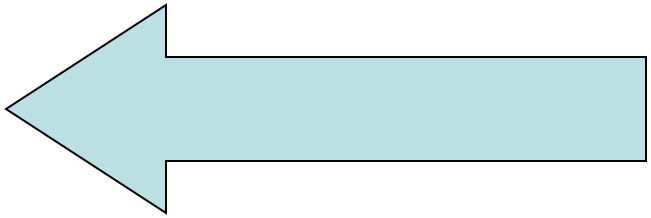
3. Evolution 

V2011 and v2012 evolutions

v2011 : NWP data

CONVECTIVE INDEX calculated for each pixel

- A mask is built at the beginning of RDT process. Allows to focus on areas of interest.

- Provides an additional predictor

Allows:

- To focus on areas of interest

- To strongly reduce the false alarms during intermediate and winter seasons

- To improve precocity for the convective cell

***MFT strong recommendation :* USE NWP DATA!!!**

v2012 : 2nd Level Description

When cell-extension is too large, it is interesting to have the depiction of another level additionally to « Base of Tower » level.

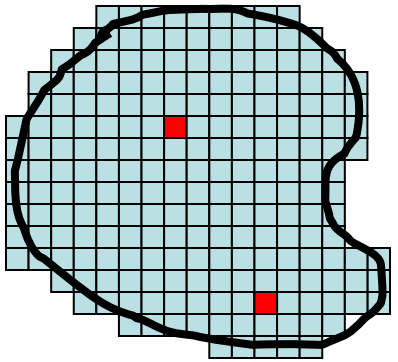
An outline related to the « Top of Tower » has been added

v2013: Overshooting Tops Detection (OTD)

Step 1: Cell Conditions

• Temperature of the coldest pixel of the cell below -50°C (threshold for mid-latitude regions)

• And at least one pixel with BTD WV6.2-IR10.8 (>0°C)



Step 2: Selection of Pixel of Interest.

• Coldest pixel

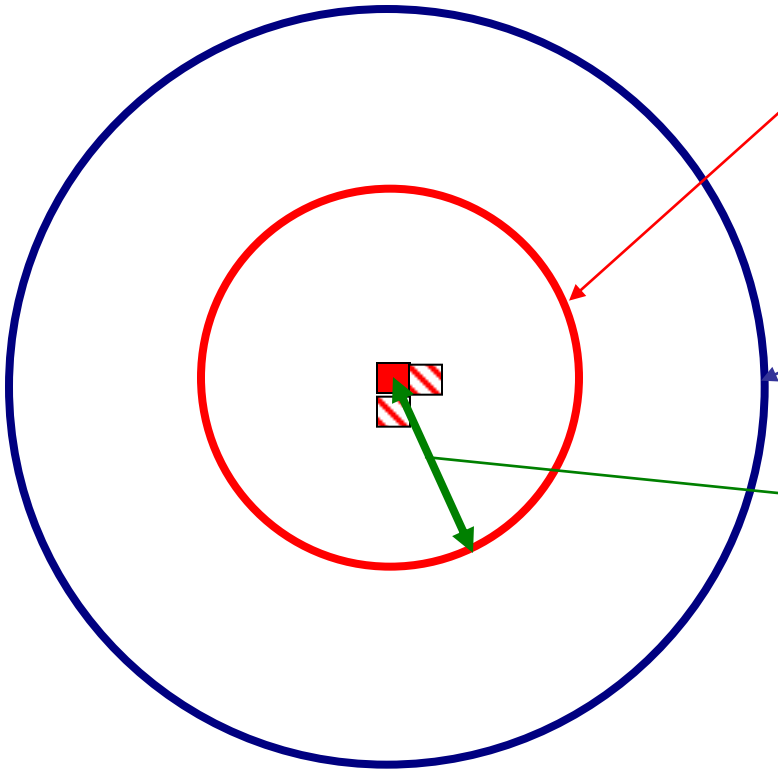
• *Other pixels of interest can be selected considering*
  • *BTD WV6.2-IR10.8*
  • *WBTD WV6.2-WV7.3*
  • *VIS06*

v2013: Overshooting Tops Detection (2/4)

Step 3: The OT candidates

We look around the Pixel of Interest, using typical values of OT-size values. For each pixel of interest, the aims of this step are

- **To define** the pixels that may belong to the OT
- **To confirm** that there are much warmer surrounding pixels



Inside this area, all the pixels with a light temperature difference (<3°C) with Pixel of Interest belong to the OT

Inside this area, there must be at least two pixels much warmer (6°C) than Pixel of Interest

40km
2x typical OT-size

v2013: Overshooting Tops Detection (3/4)

At the end of step 3, some cold pixels surrounded by warm pixels are identified. But do they really correspond to an overshooting top? Is this a domelike protrusion above the cumulonimbus anvil ?

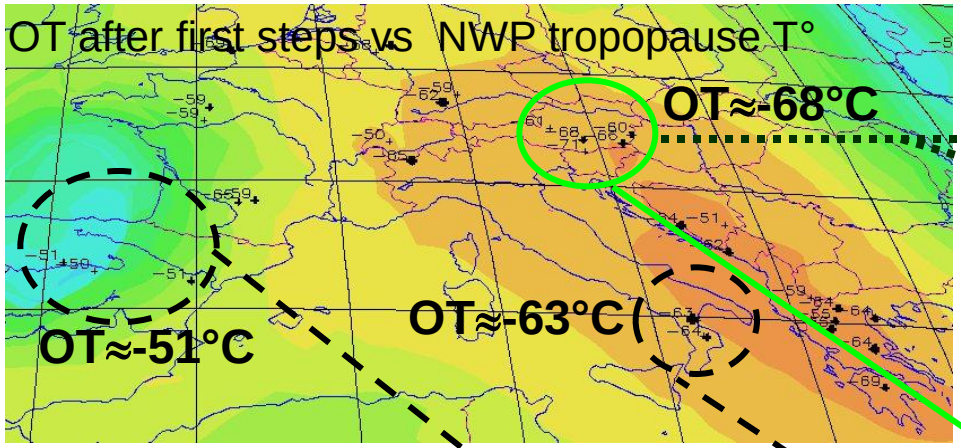
Step 4: final conditions to be satisfied

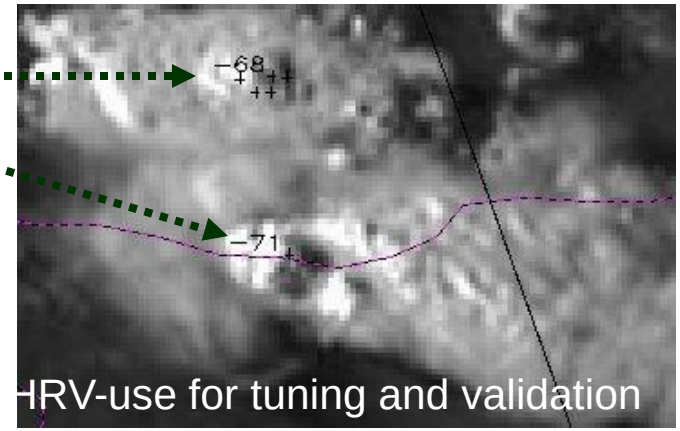
- OT candidate at least 5°C colder than **NWP** tropopause (*wet adiabatic relaxation of the air particle*)
- Or a condition using following parameters of interest
  - Temperature difference between OT and NWP tropopause,
  - BTD=WV6.3-IR10.8,
  - VIS0.6 reflectance,
  - Temperature difference between OT and cloud-cell

Parameters of Interest adapted from « Best Practice Document For EUMETSAT Convection Working Group » Editors J. Mecikalski, K. Bedka, M. Marianne König

V2013: Overshooting Tops Detection (4/4)

Topical Case study (25th May 2009)

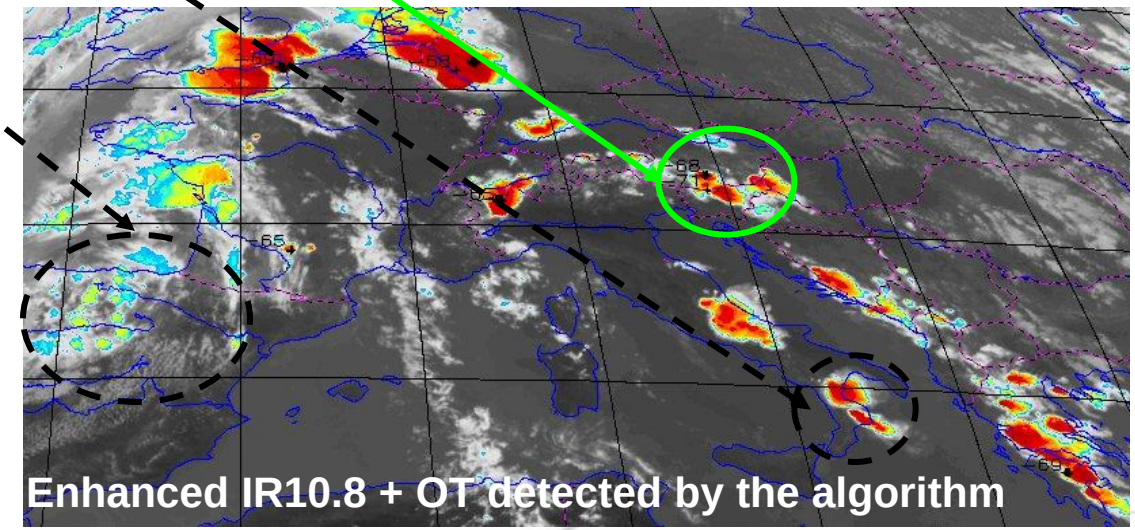




COLDER

Much COLDER

Very much COLDER



Tropopause T° diagnosis helps to eliminate wrong OT detected after 1st step

MFT strong recommendation:
USE NWP DATA!!!

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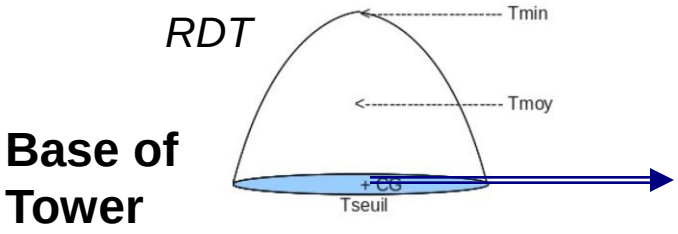
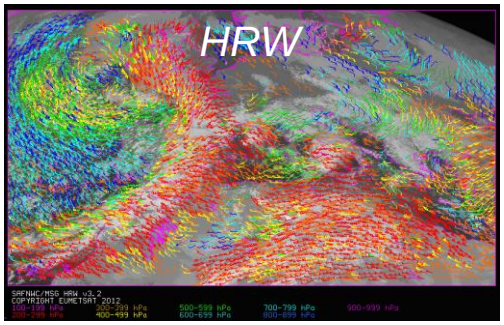
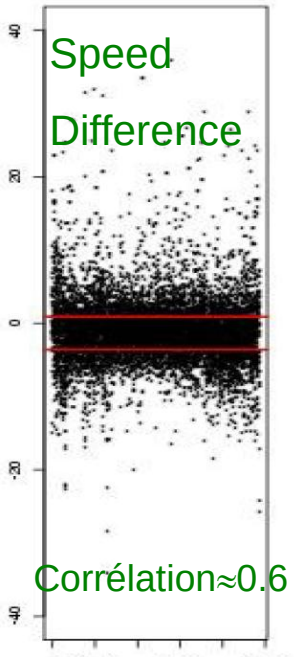
Next version v2015
Toward a better Motion Vector Estimate (1/2)

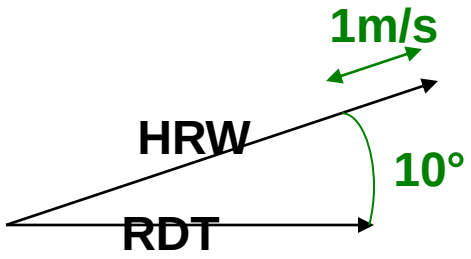
- Link between 2 NWCSAF products: RDT and HRW-AMV
- Preliminary study. Period 1-7/6/2013
- HRW taken at the level closest to the base of each convective tower





- Encouraging results





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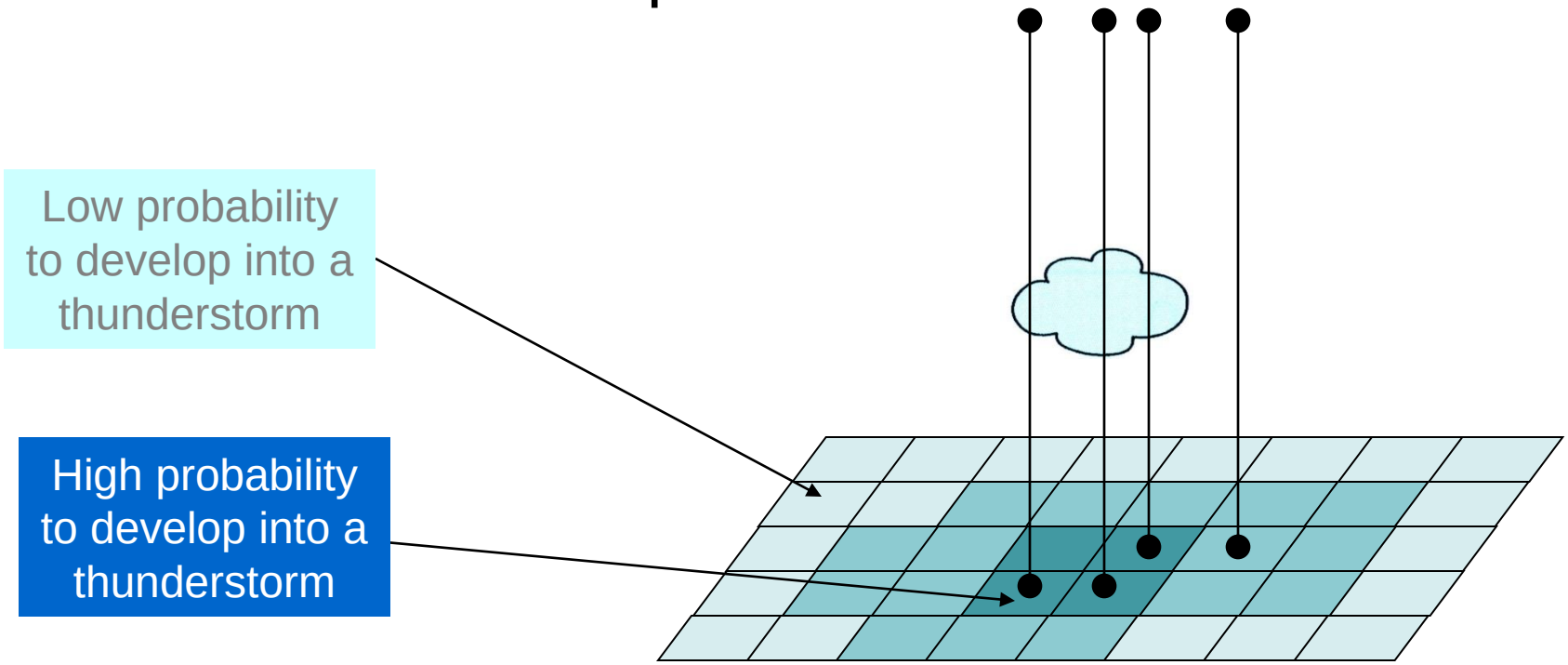
Toward a better Motion Vector Estimate (2/2)

- Increase of computation-time
- Some RDT cells are orphan of surrounding HRW-AMV data

- Alternative of estimation of motion vector for RDT, especially in case of
  - New cell (without father)
  - Uncertainty on father-cell
  - Fusion or Fission of cells
  - Change of base of tower characteristics between two consecutive slots (surface, temperature)
  - Incoherence between neighbouring cells in term of motion vector

- Increase of interaction and coherence between NWCSAF products
- Quantify the uncertainty on motion vector estimate
- Positive impact expected on **advection scheme (foreseen for v2015)**

Convection Initiation (CI)
New NWC SAF product foreseen for v2015



The convection probability for each pixel is based on:

- BT or BTD values or trends, e.g. BDT 6.2-10.8µm.

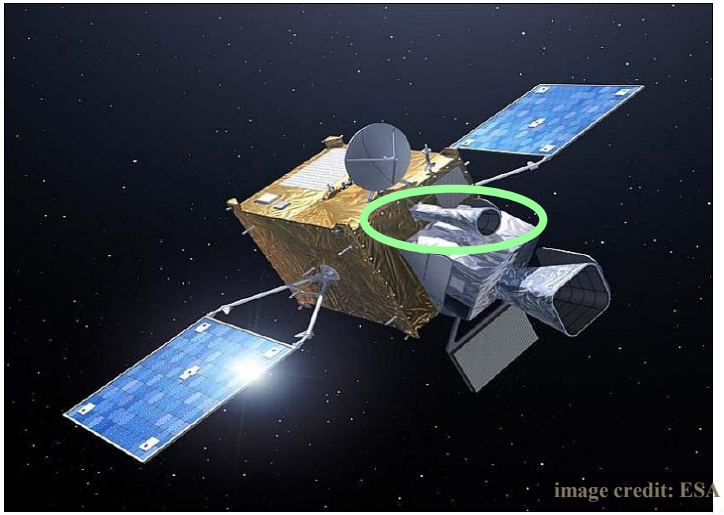
  Some relevant Parameters of Interest in « Best Practice Document For EUMETSAT Convection Working Group » Editors J. Mecikalski, K. Bedka, M. Marianne König
- NWCSAF products: Clear Air Products, Cloud Products, Wind Products
- NWP data
- Past positions and characteristics of pixel

MTG Context

LI is eagerly expected

LI instrument is eagerly expected to improve many components of RDT:

- Statistical scheme,
- Real time mode,
- Enhancement of characteristics for a more complete description of convection,
- Monitoring.



MTG Context

FCI is eagerly expected

Number of channels:

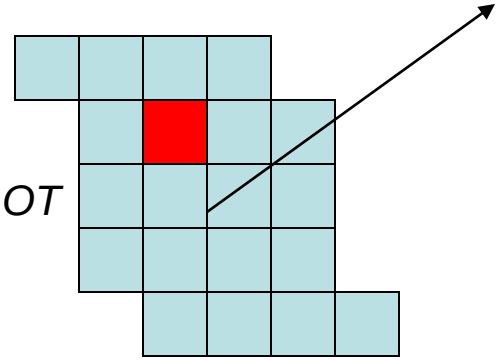
FCI
MSG SEVIRI
Meteosat7

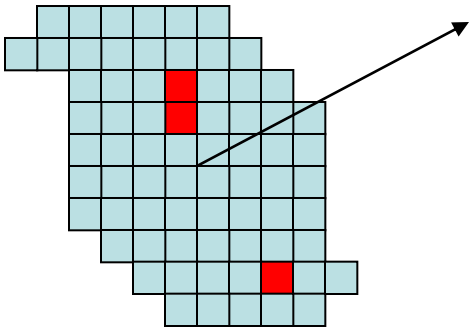
In previous years, RDT algorithm has always taken a lot of advantages from the increase of the number of channels
e.g. for FCI: 0.91µm (total column precipitable water)

Resolution:

Better estimate of morphological parameters and small scale phenomena

RDT Cell with OT





Spectral accuracy: better estimate of BT input data of RDT

RSS Challenge

The lack of channels in RSS would mean for RDT a lack of predictors. Possibility : RSS used to update a part of RDT characteristics

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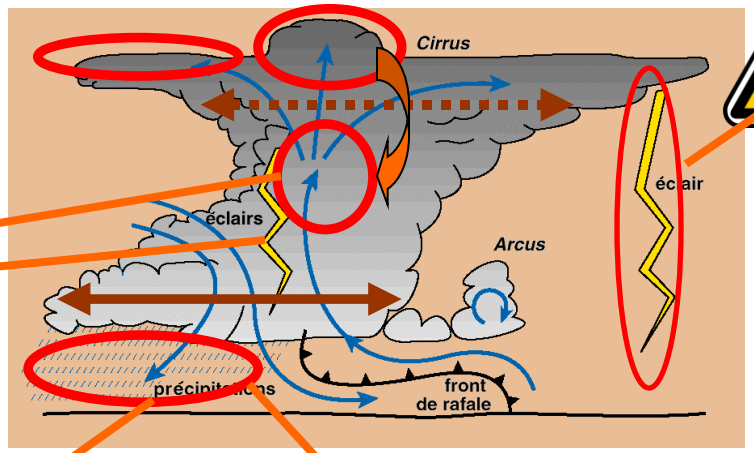
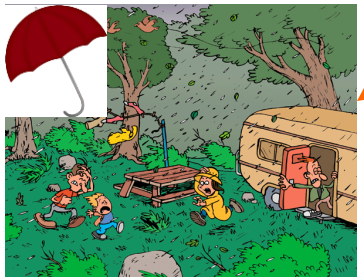
Conclusion (1/2)

- Warn and watch.
- Automatic or not.
- Alone or integrated to other systems





- Research tool

Conclusion (2/2)

The use of other PGEs is a key point for RDT PGE since it is placed at the end of the NWCSAF processing chain. In the future releases the description of convective cells will be more sophisticated, giving a high priority to the use of other NWCSAF products:

- Cloud products
- Identification of aeronautical hazardous areas using CRR over a threshold, the estimation of motion vector using both cell speed estimation
- NWCSAF AMV product.

MTG will improve RDT quality

- Step similar to previous ones: FCI-FDSS
- New steps and challenges: Lightning Imager, *FCI-RSS*
- *IRS impact*