NWCSAF Convection products: v2018 improvements, validation and adaptability to end-users

Eumetrain Convection Week 2019
May, 22nd, 2019
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NWCSAF Products: storms monitoring at different development stages. A portfolio for convection

Courtesy NWCSAF LE

Pre-convective environment

iSHAI (imaging Satellite Humidity and Instability)

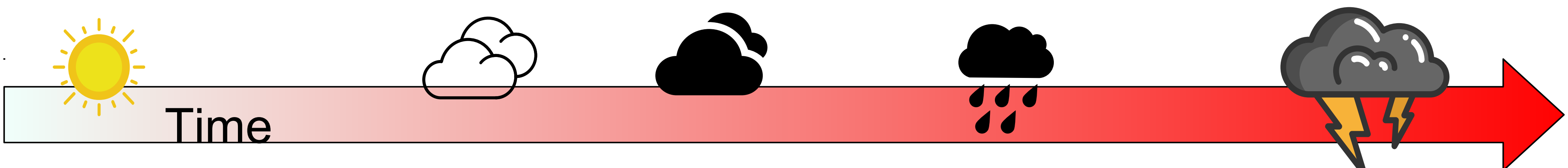
Convection Initiation

CI (convection initiation)

Developing convective storm

RDT-CW (Rapidly Developing Thunderstorm)

Precipitation products



Any time

Cloud products (**CMA**, **CT**, **CTTH**, **CMIC**), High Resolution Winds (**HRW**), ASII

Overview

1. RDT: Rapidly Developing Thunderstorm

2. CI: convection Initiation

3. Conclusion

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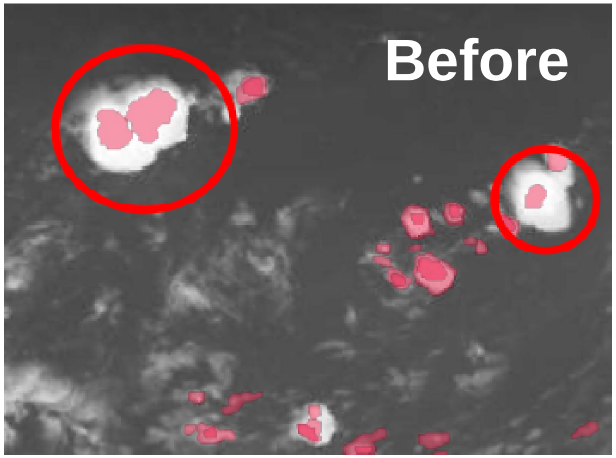
v2018 RDT - A well-known product

Operational (Eumetsat sense)

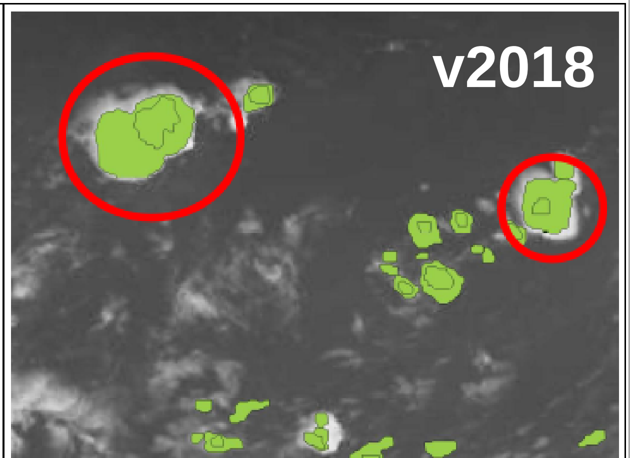
Many improvement in v2018:

- Improved and configurable detection (will be illustrated)
- Lightning jump (will be illustrated)
- Discrimination scheme adapted to handle wide variety of satellite configurations (CAL)
- New high altitude Ice Crystal calculation
- Technically and scientifically adapted to Himawari-8 (additionally to MSG)
- New lightning pairing rules

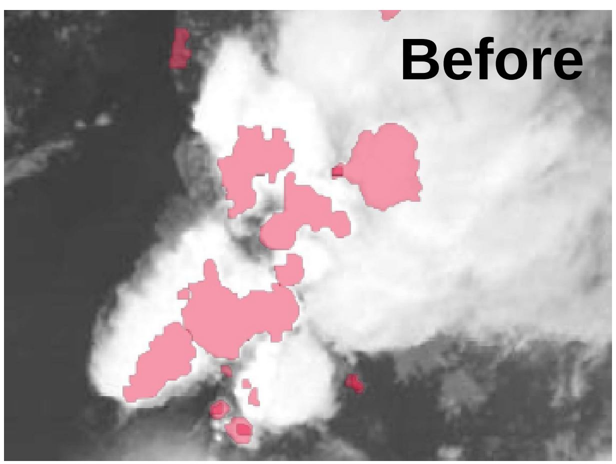
RDT v2018 -
Detection with less broke up systems



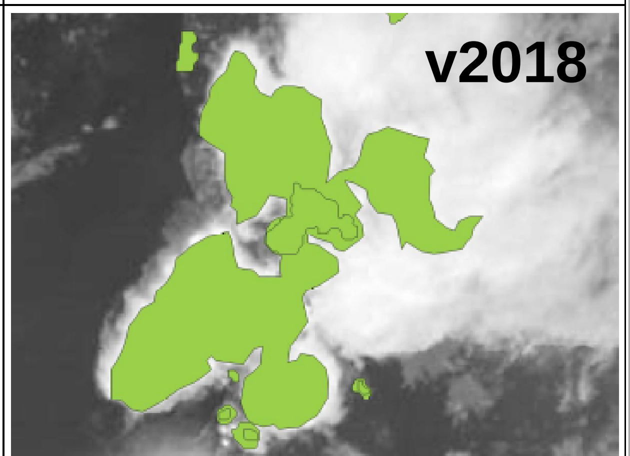
v2016: "base of tower" contours sometimes not including full cloud system



v2018: contour threshold limitation (T° and tropopause) : contours fit cloud systems



v2016: several towers (contours) for this Convective system



v2018: contour threshold limitation (T° and tropopause) : full including contour, plus top contour of main(coldest) tower

RDT contours:

With BTLIMIT and tropopause LIMIT, we avoid too cold/small outlines of base of towers

The 2^{nd} level of RDT helps to describe the coldest part

A better match of cloud systems

An improvements thanks to feedback of aeronautical end-users

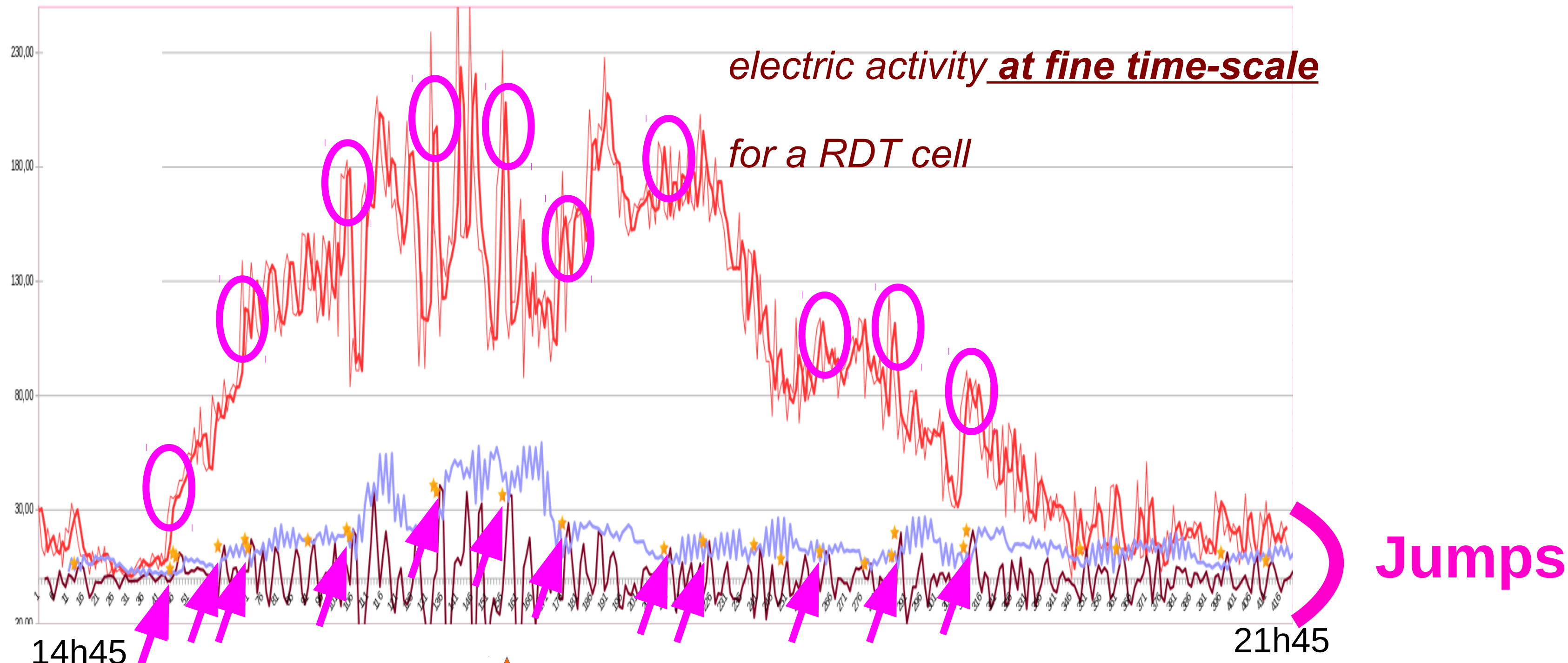
RDT v2018 - A lightning Jump diagnosis: how ?

- ✔ Lightning (total) rate analysis (*min*$^{-1}$)
  - Input data at **fine time-scale** paired with RDT cell
  - For each RDT cell, **minute-analysis** of previous **12 minutes**
    - ✗ *Condition 1: **Lightning rate > 10 min^{-1}***
    - ✗ *Condition 2 : **Lightning rate trend > 2 x rms***
- ✔ Identification of «jumps», **precursor** for hazardous phenomena
  - Diagnosis during cloud cell pairing period
  - Input for **severity** index
- ✔ Implementation in **RDT v2018**

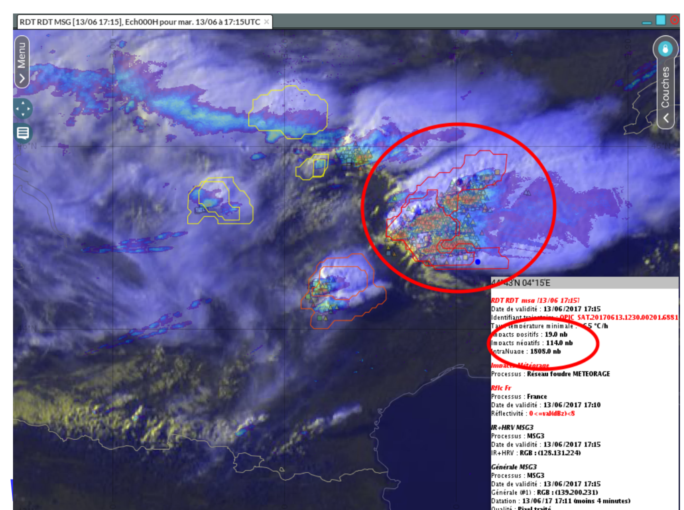
References
- Pedeboy, S., P.Barnéoud, C.Berthet, *First results on severe storms prediction based on the French Lightning Locating System*, 24th International Lightning Detection Conference, 18-20 April 2016, San Diego, USA
- Schultz,C.J., W.A. Petersen, and L.D. Carey, 2009, *Pre-liminary developmeent and evaluation of lightning jump algorithms for te realtime detection of severe weather*. J.Appl. Meteor. Climatol., 48, 2543-2563
- Schultz and al, *Enhanced verification of the lightning jump algorithm* . XV International Conference on Atmospheric electricity, 15-20 June 2014, Oklahoma, USA

RDT v2018 - A lightning Jump diagnosis: why ?

13/6/2017 case study - Extreme Thunderstorm in « Haute Loire » area Intense electric activity / hail event ~ 17h30Z



Hail event

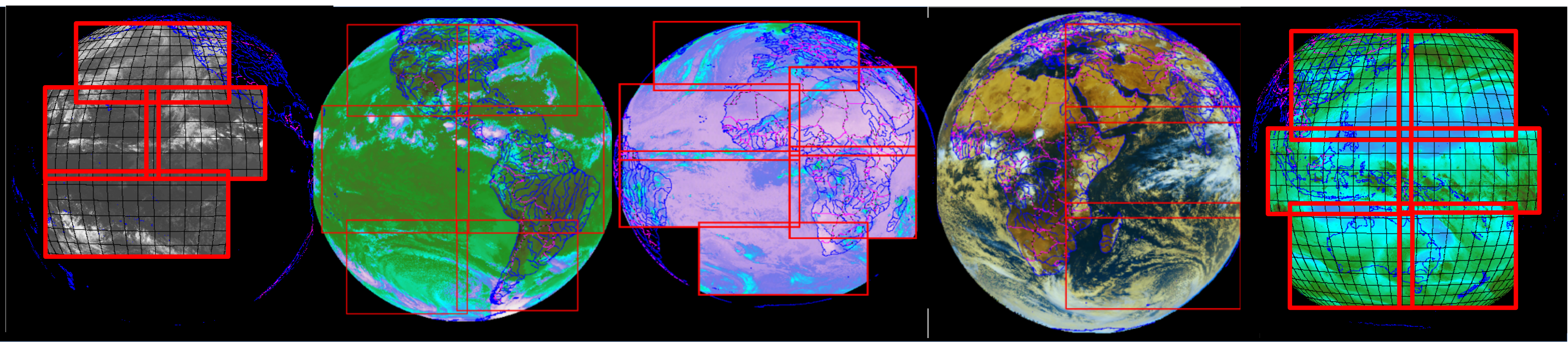


Lightning Jumps criteria on **amount and acceleration** of electric activity

LJ=Precursor + Proxy FOR HAIL

RDT – Météo-France productions

GOES-W 135°W | GOES-E 75°W | MSG 0° | MSG 41.5E | Himawari 140°E



15 min | 10 min | 15min | 15min | 20min

- Mutliple and parallel productions before blending in a single product
- A widely used product
- Global RDT operated by MF used by thousands of pilots (EFB eWas solution developed by GTD company)

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Validation of Overshooting Tops (OT) Detection within RDT (1/4)

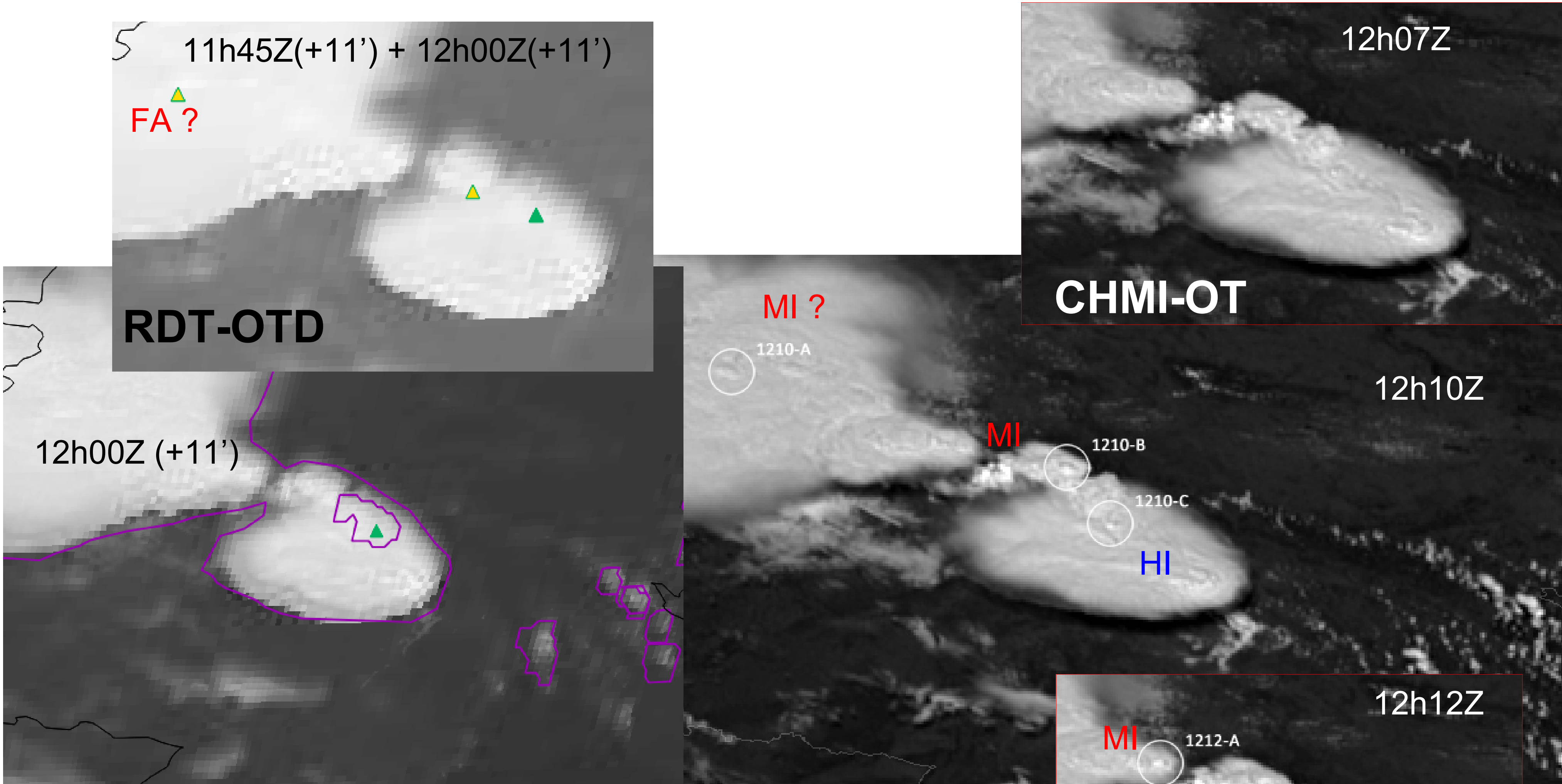
Data

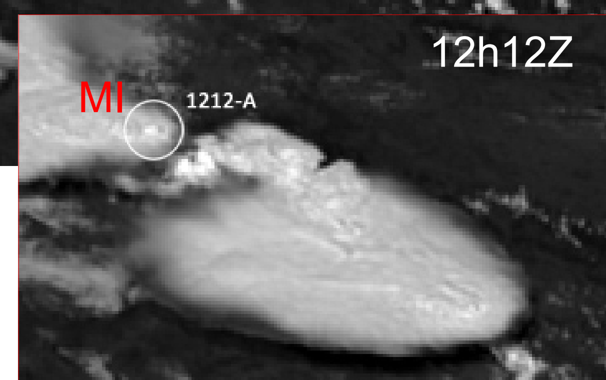
- Expertised CHMI OT database published by CWG, using 2.5’ experimental MSG1 scan
  - ✔ *2 dates deeply analysed & documented : 20130620 [09h-19h30] and 20130729 [13h-18h30]*
  - ✔ *Limited area over central Europe, but about 1800 OT identified*
- Reprocessed RDT : 4 configurations
  - ✔ *FDSS-15’ and RSS-5’*
  - ✔ *v2018 and dev^{t} version with use of HRV*

Pairing method between RDT-OT and CHMI-OT

- Time synchronisation: area is scanned approximatively 11’ after the beginning for MSG/FDSS, 3’ for MSG/RSS, ~ 1’ for MSG-2.5’
- Compromise between spatial and time tolerance
  - ✔ *Time tolerance: maximum 5’ or 15’ between RDT-OT and CHMI-OT depending on RSS or FDSS mode*
  - ✔ *Spatial tolerance: maximum distance for pairing => 20 km (~ mean OT size)*
- Score calculation:
  - ✔ *HIT: at least one RDT-OT associated to a CHMI-OT*
  - ✔ *MISS : CHMI-OT without associated RDT-OT*
  - ✔ *FA : RDT-OT without associated CHMI-OT*

RDT-OT vs CHMI-OT (2/4) – 20130620 case study



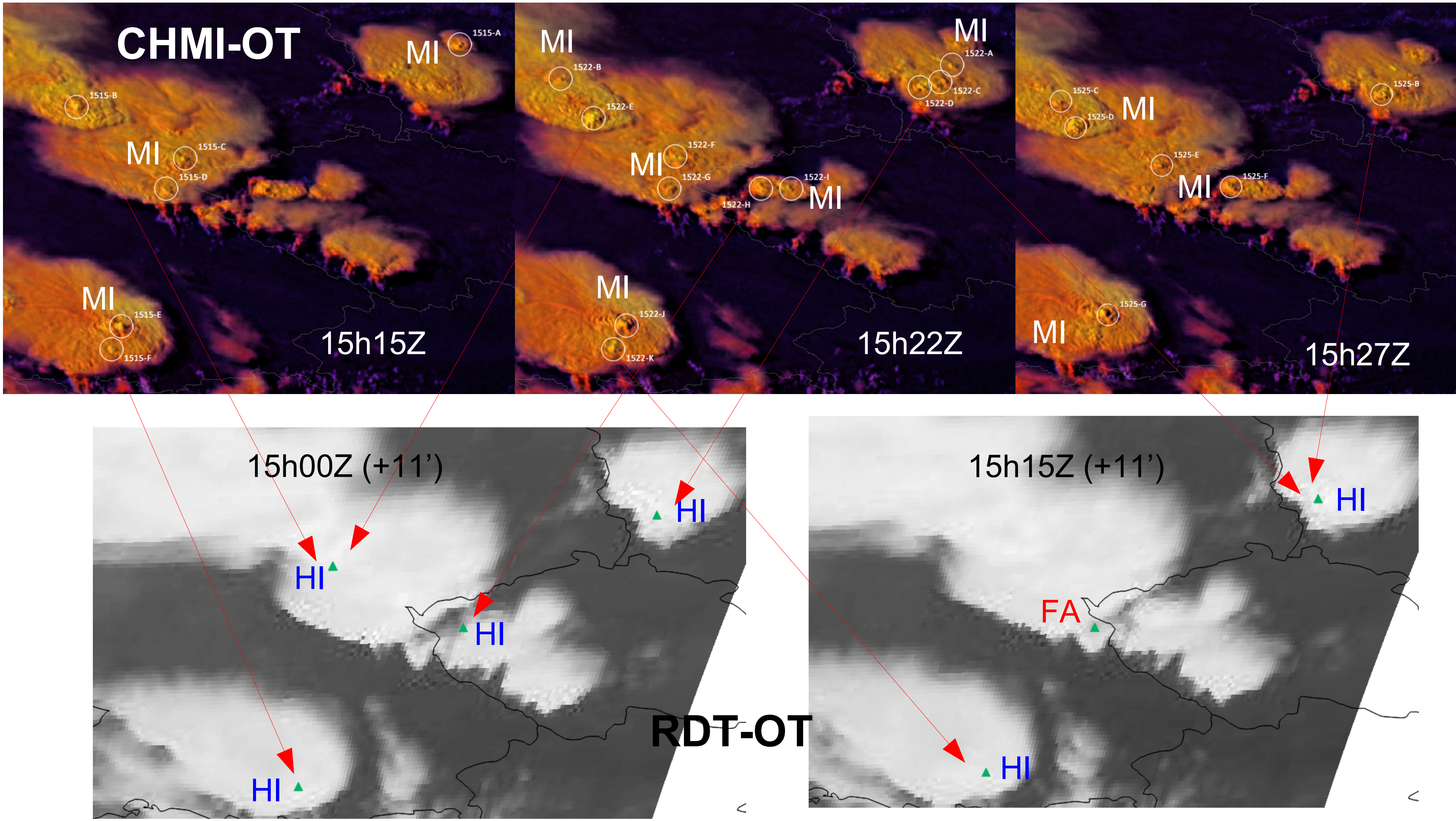


Expert OTs:

- much more numerous
- high space & time variability of OTs from one slot to the other

RDT-OT: seems subjectively more or less OK, even if lot of misses

RDT-OT vs CHMI-OT (3/4) – 20130620 case study



Time tolerance required: several 2.5' slots needed to identify HI, FA and MI

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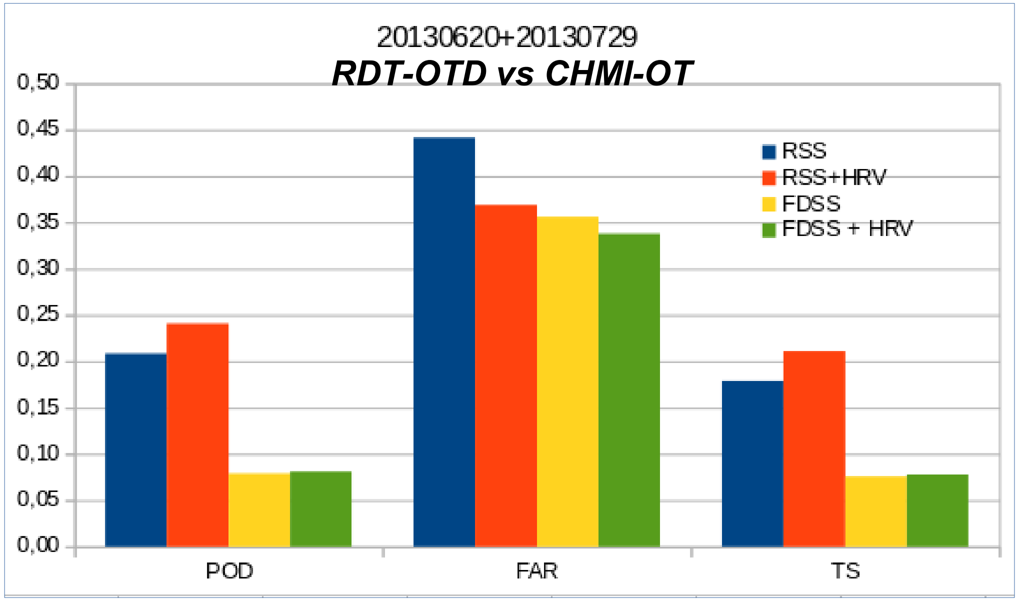
RDT-OT vs CHMI-OT (4/4) – Quantitative Results

- Large number of misses, due to largely different update rates (~1800 expert OTs vs ~700 RDT-OT RSS and ~200 RDT-OT FDSS)

  *Expected low POD = HI/(HI+**MI**) or TS=HI/(HI+FA+**MI**)*

  Focus on FAR=FA/(HI+FA)

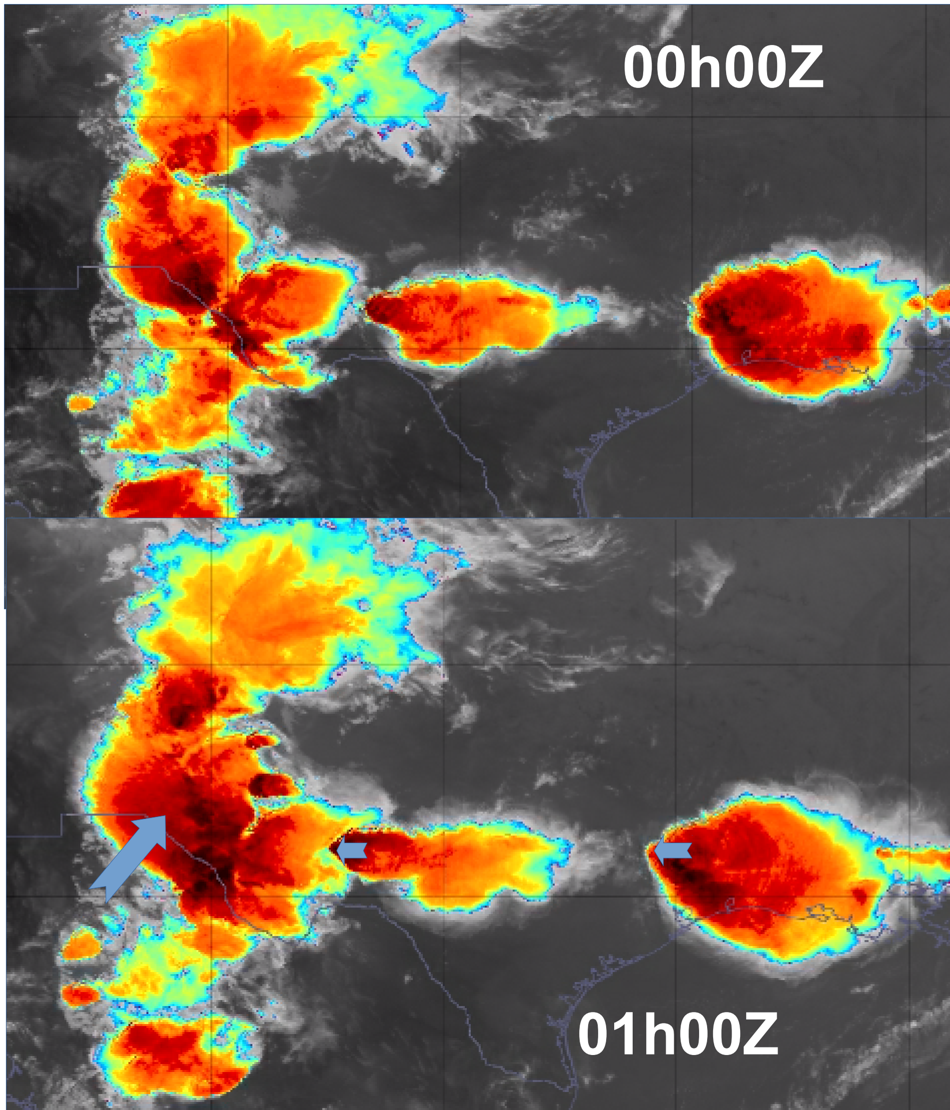


- Globally better results with RSS mode for RDT-OT
  - *- Higher scan rate allow easier detection of short-lived OT*
- Use of HRV *(rather than VIS06)* slightly improves scores
  - *Seems to lower FA on some cases, to increase HI on others, but limited impact*
- Results dependent on mode and day
  - *RDT-OTD apparently more efficient (scores) on 20130729, especially with RSS mode*
  - *Signatures of OTs' parameters (BTD, BT, reflectance) within RDT different from one day to the other*

Relevancy of cells' contour limitation (1/2)

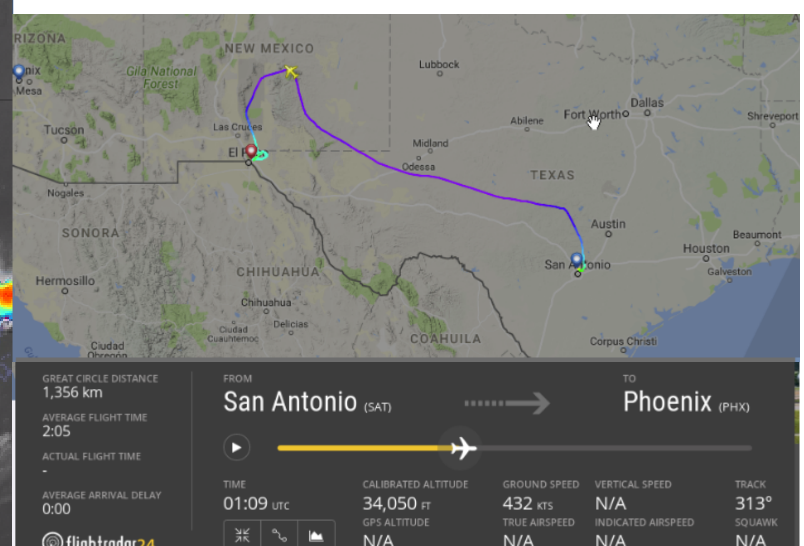
A users' need, expressed through various pilot feedback concerning CBs avoidance

- Visual validation through various mid-latitude and tropical MCSs
- Relevancy of the modification on specific cases study :



Intense MCSs rapidly growing over Mexico and southern US states between 03/06/2018 21h00Z and 04/06/2018 00h00Z

Aeronautical incident 20180604 – 01h10Z , with emergency landing following hail event



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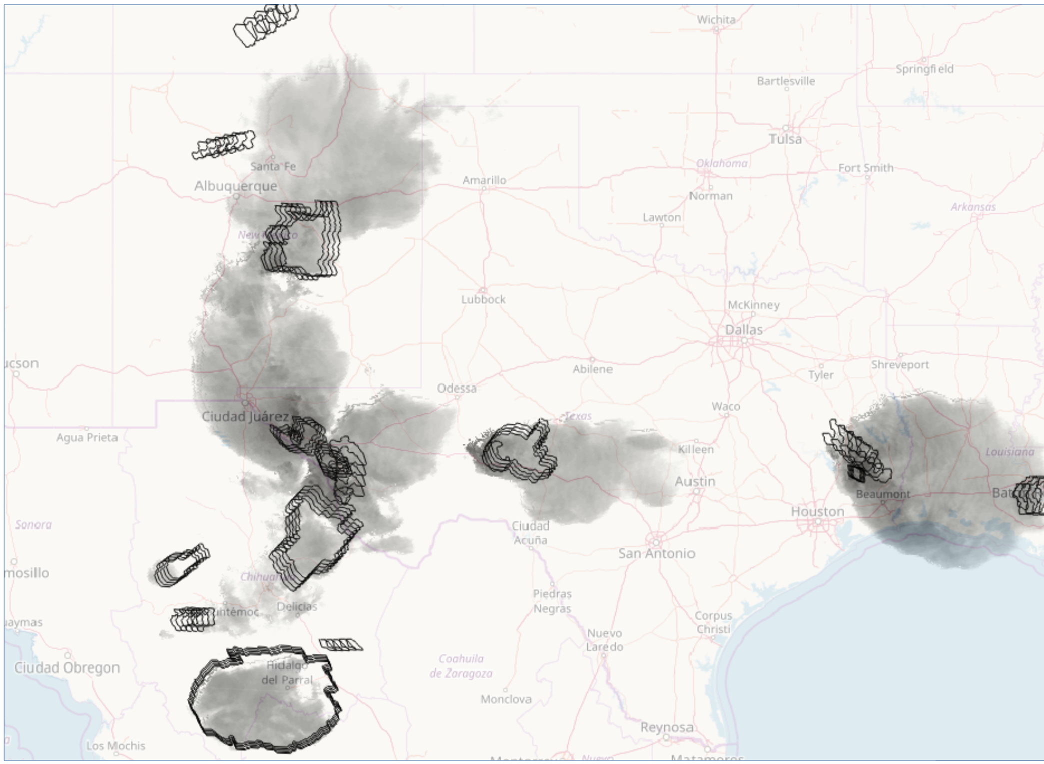
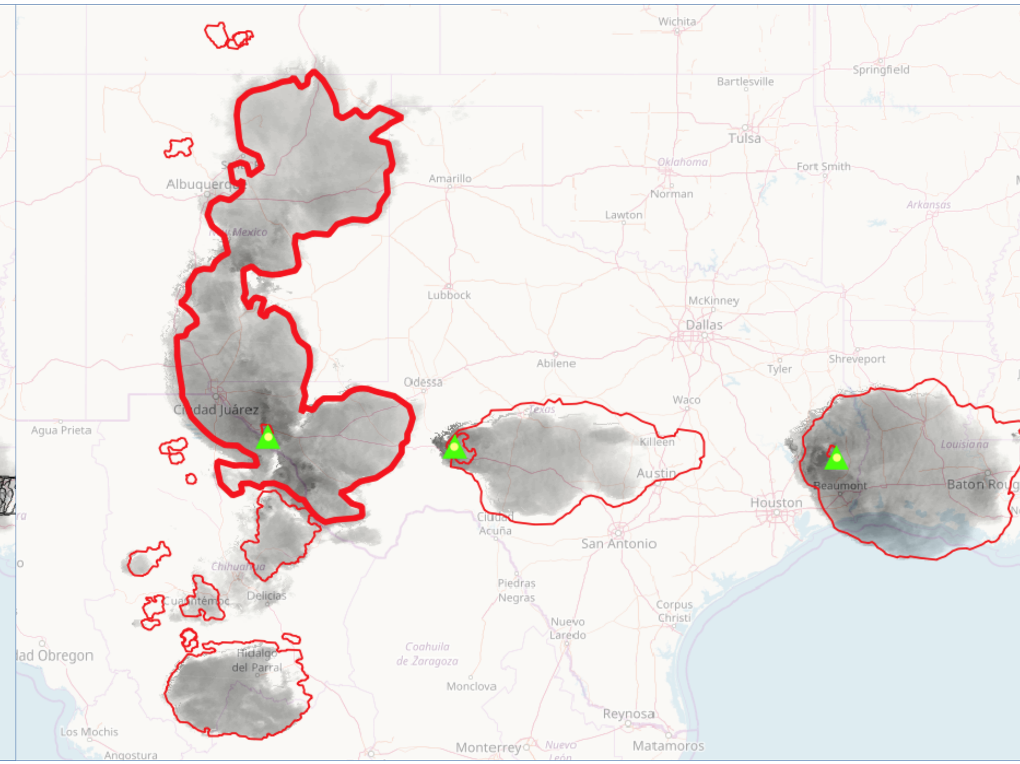
Relevancy of cells’ contour limitation (2/2)

What kind of information could have bring RDT-CW end-product ?





v2016 RDT-CW 00h00Z analysed contours (and 1h-extrapolated)

- *Base of Tower contours focused on most active towers*
- *Lack of information in the neighbourhood of RDT cells*

v2018 RDT-CW 00h00Z analysed contours, with **T° tropopause + T° -60°C limitations**,

- *Most active towers still highlighted by OTDs*
- *Contours more representative of whole MCS*
- *More suitable for planification*

Lighning Jump Validation (1/3) - Data and method

How to validate Lightning Jump algorithm within RDT ?

Bibliography and previous studies :

- *Correlations between severe weather and rapid increase of total lightning trend*
- *Lightning Jumps supposed to be precursor of severe weather*

Two references (Ground Truths)

- *France : use of MF HYDRE product for Hydrometeor diagnosis (Data-Fusion radar+sat+NWP+obs)*
  - ✗ *5min updated*
  - ✗ *Reliable medium/large Hail diagnosis (forecasters feedback)*
- *Larger domain : ESSL European Severe Weather Database (ESWD)*
  - ✗ *Reports of Severe convective weather events (hail, wind gusts, tornadoes, lightning damages) over a period*

Case study

- *RDT-MSG-FDSS v2018 processed for 20180529 with CG+IC lightning data (Meteorage & Partners networks)*
- *Visualisation of cells with lightning jump diagnosis* <u>*prior to*</u> *hail events from HYDRE and ESWD severe weather events (71 reports with 19 hail events)*

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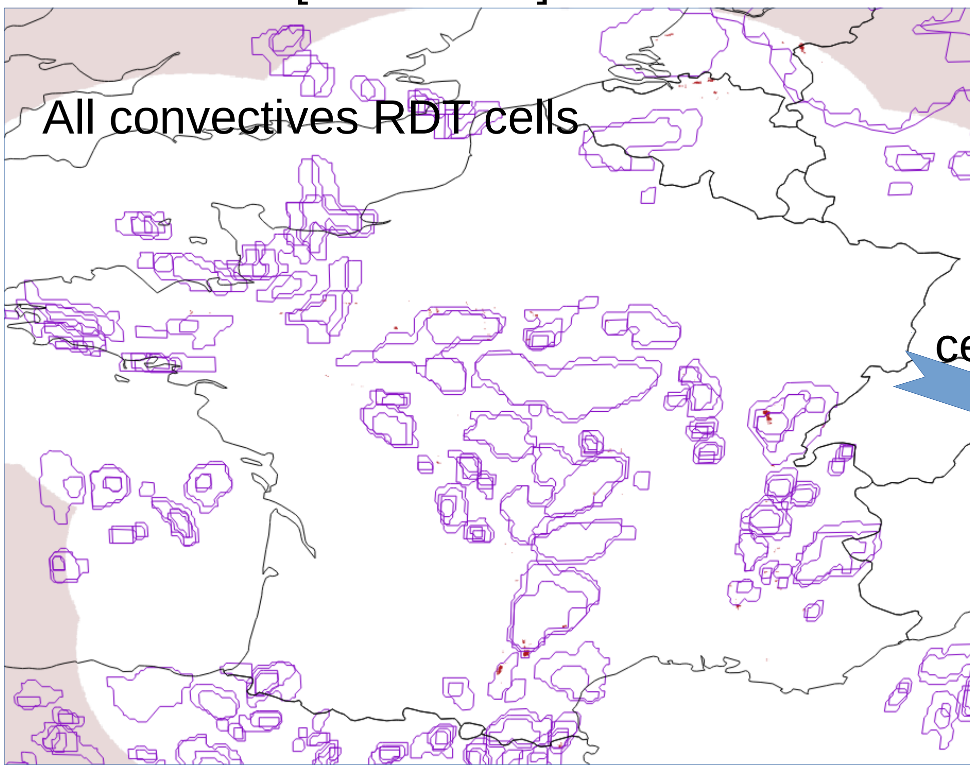
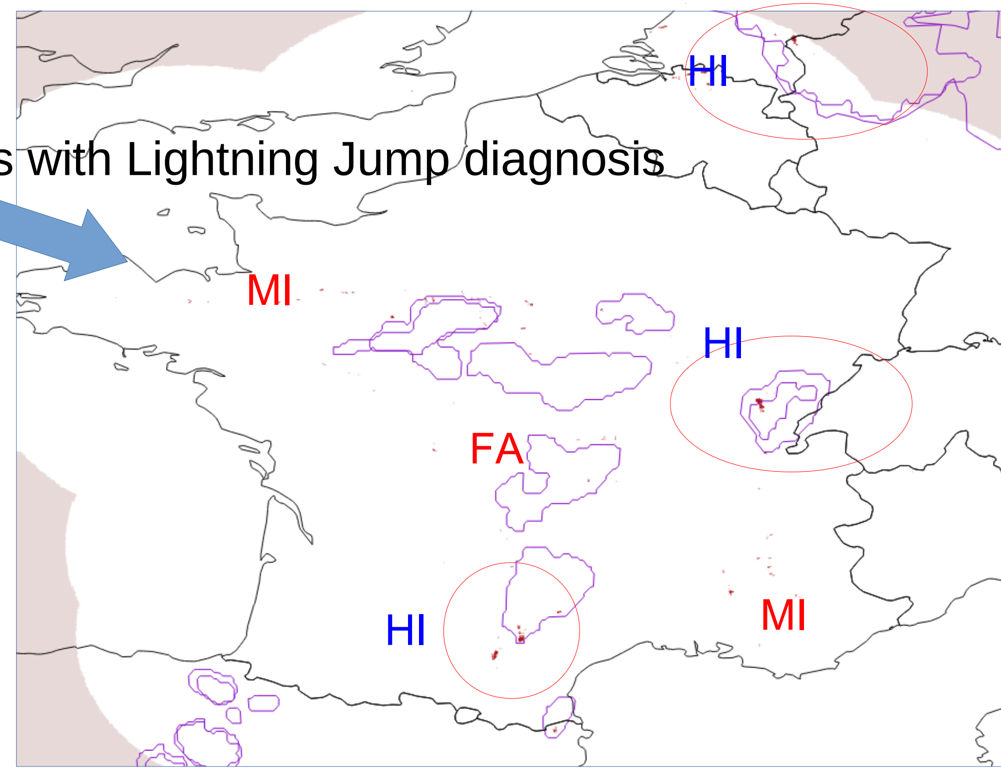
Lighning Jump Validation (2/3)
RDT-LJ vs HYDRE Hail detection

20180529 case study:

- 15h30+15h45 RDT (contours)
- [16h-16h15] HYDRE medium and large hail detection (accumulated pixels)

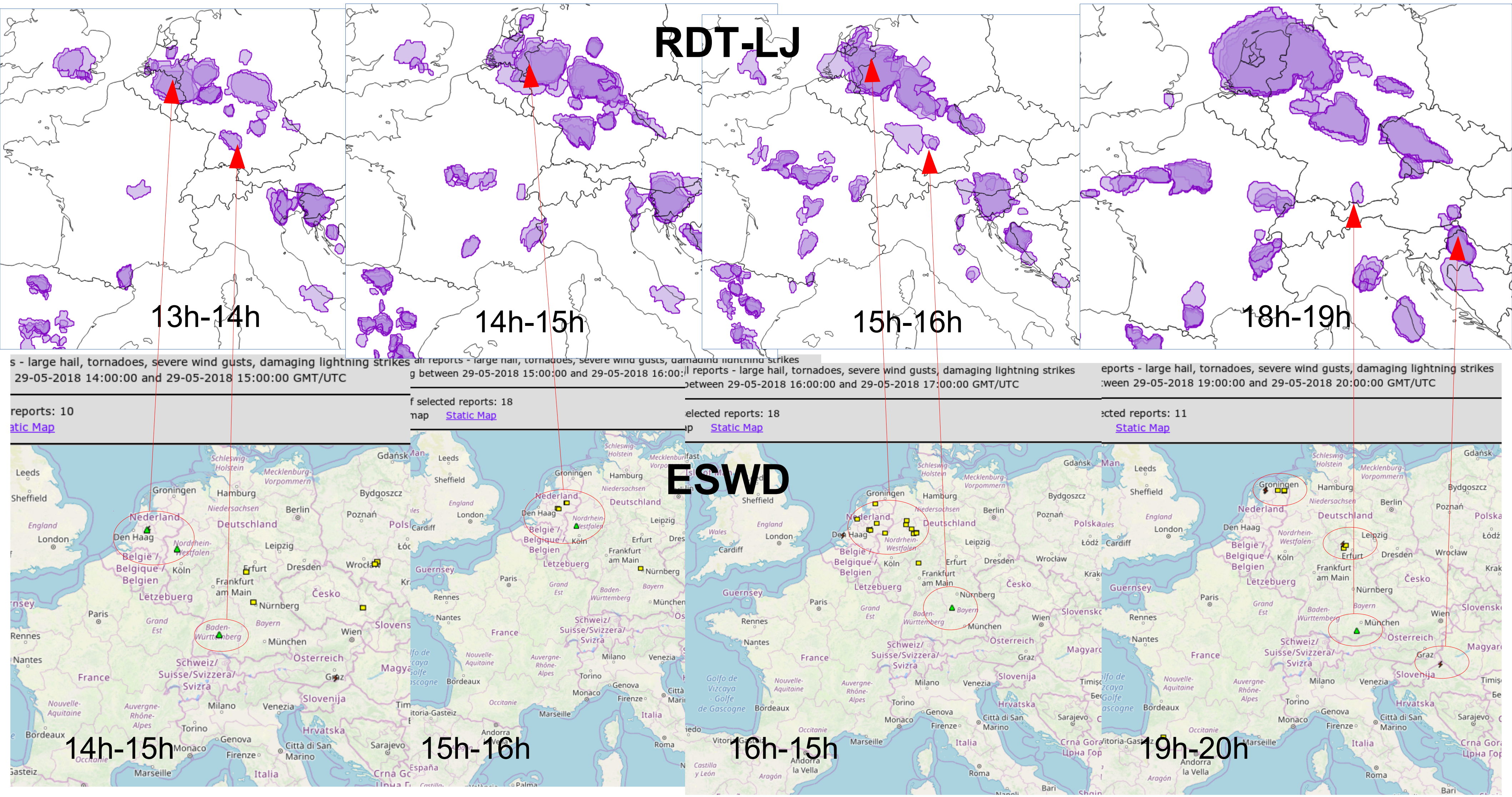




- Subjectively good co-location Hail/RDT-LJ
- RDT-LJ sometimes precursor of Hail event
  (still need to be quantified/confirmed)
- Need detailed analysis of hail events
- Isolated Hail pixels to be considered ?

Lighning Jump Validation (3/3)
RDT-LJ vs ESWD data

- Step by step analysis of **RDT-LJ sequences** vs **<u>following</u> SW** allow subjective good pairing
- Most severe weather events find a correspondence with previous RDT with LJ
- Numerous non paired RDT-LJ : false alarms or lack of observation ?
- Objective quantification needed for “paired” and “missed” SW events



Overview

1. RDT : Rapidly Developing Thunderstorm

2. CI: Convection Initiation

3. Conclusion

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Convection Initiation at a glance

Probability for a pixel to become a thunderstorm

First version : v2016. Now : v2018 (PRE-OPERATIONAL status)

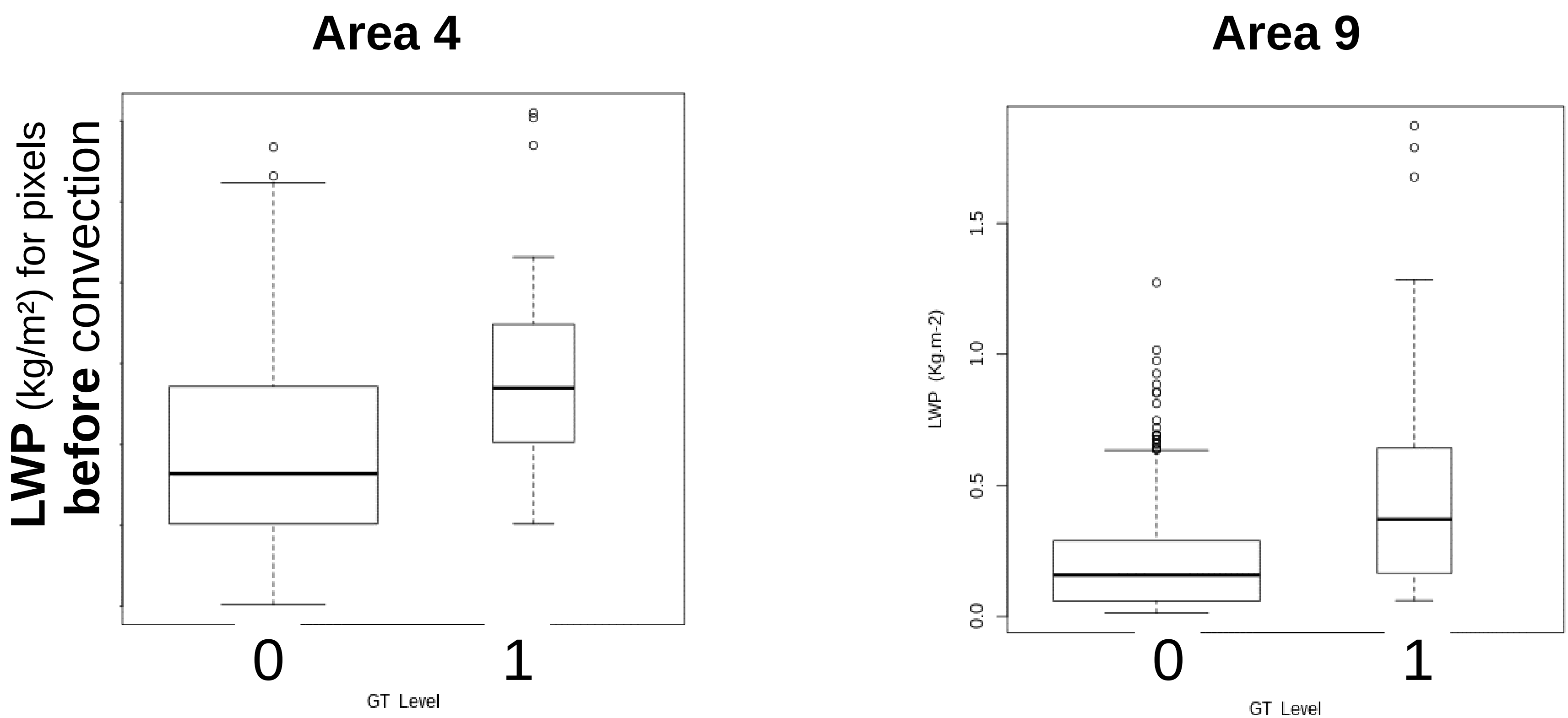
Based on :

- Satellite data (multiple channels)
- Numerical Weather Prediction data
- NWCSAF products: Cloud Products (CT, CTTH, CMIC), HRW

Output :

NetCDF Pixel-based product, with 4 classes of probability (very low, low, medium, high) and 3 forecast periods (30, 60 and 90 minutes)

CI discrimination process : tuning of thresholds for parameters of interest - Radar data as Ground Truth



CI verification - no (0) or yes (1)

Boxplots for various regions and test cases helped to define the relevant thresholds

Karagiannidis, A., **2016**, *Final Report on Visiting Scientist Activity for the validation and improvement of the Convection Initiation (CI) product of NWC SAF v2016 and v2018*, Visiting Scientist Activity followed in Nowcasting Department of Météo France, Toulouse, France Period June-December 2016

CI diagnosis
From parameters categories to decision tree

SATCAST Methodology

Height parameters	Growth parameters	Glaciation parameters
✗ (6.2 µm – 10.8 µm) BTD ✗ (6.2 µm – 7.3 µm) BTD ✗ (12 µm – 10.8 µm) BTD ✗ (13.4 µm – 10.8 µm) BTD	✗ BTRate(15’) for 10.8 µm channel ✗ BTRate(30’) for 10.8 µm channel ✗ BTDRate(15’) for (6.2µm – 10.8 µm) BTD ✗ BTDRate(15’) for (6.2µm – 10.8 µm) BTD	✗ 10.8 µm BT ✗ Time since freezing point (10.8 µm BT) ✗ (10.8 µm – 8.7 µm) BTD

⇨

Nb of Height relevant parameters (over 4)	*Number of Growth relevant parameters (over 4)*	*Nb of Glaciation relevant parameters (over 3)*	*CI diagnosis*
≥ 4	≥ 3	≥ 3	HIGHPROB (4)
≥ 3	≥ 3	≥ 3	MODPROB (3)
≥ 4	≥ 3	≥ 2	LOWPROB (2)
≥ 4	≥ 2	≥ 3	MODPROB (3)
≥ 3	≥ 2	≥ 3	LOWPROB (2)
≥ 4	≥ 2	≥ 2	VLOWPROB (1)
≥ 4	>=1	≥ 3	VLOWPROB (1)
Other cases			0

BT = Brightness Temperature
BTD = Brightness Temperature Difference
BTRate(15’) = (BT(t) – BT(t-15min))/15

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CI product validation process

2018 NWC SAF Validation Report for Convection products

ONGOING

FUTURE

MSG Qualitative Validation

Radar data as ground truth

Pixels with reflectivity over threshold (30 or 35 dBZ)

TROPOS Quantitative Validation

Radar data as ground truth

Newly developed objects with reflectivity over threshold (35 dBZ)

GOES-16 Qualitative Validation

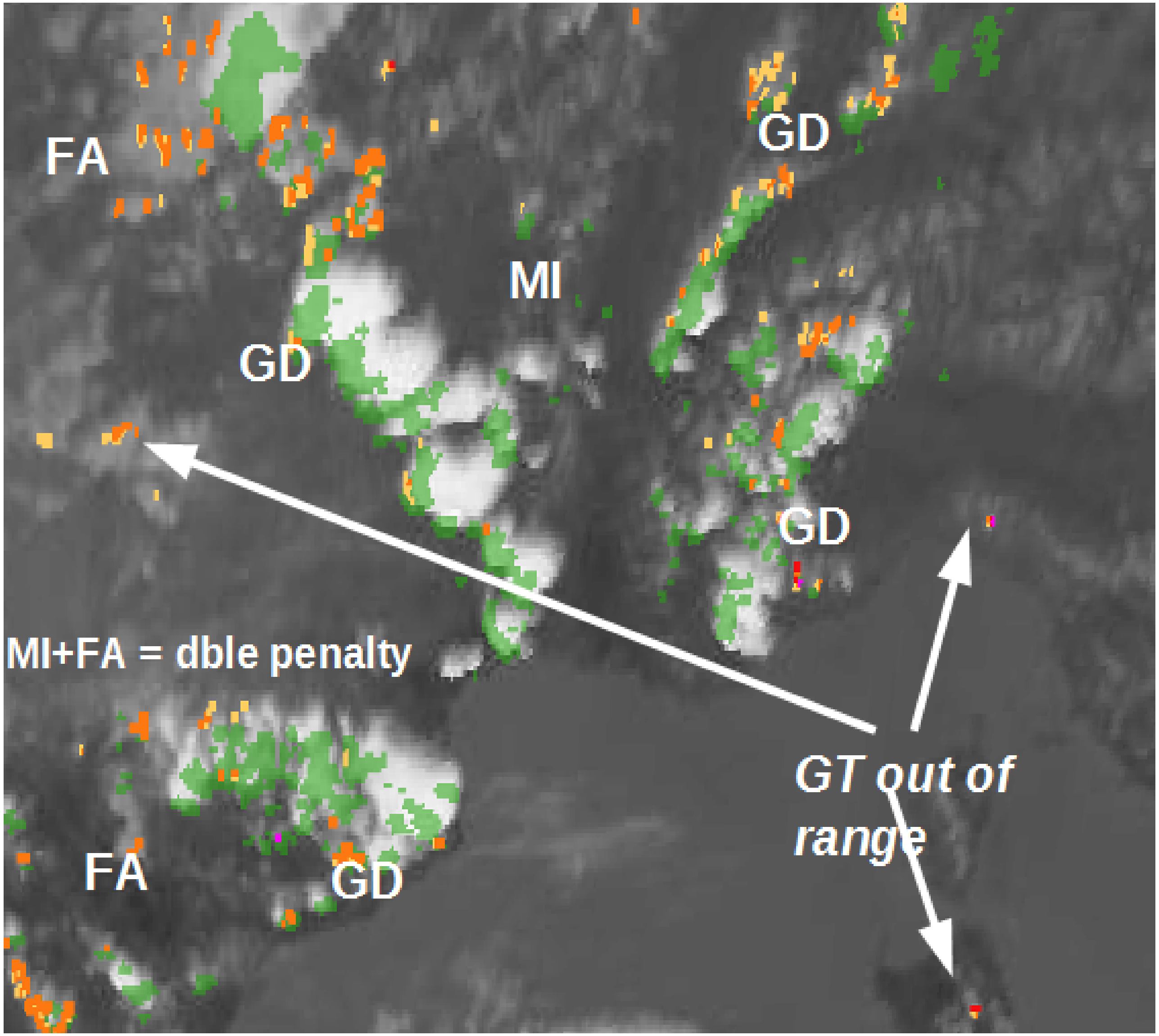
Radar-derived convective objects as ground truth

Tracked radar convective cells
Use of parameters (age, lightning pairing)

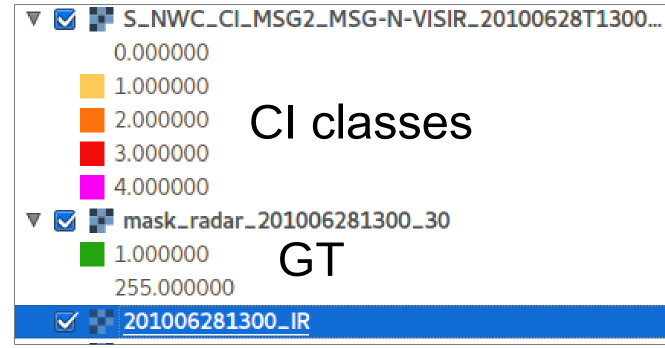
MSG Quantitative Validation

Radar-derived convective objects as ground truth

v2018 CI - Validation on MSG case studies
Radar Ground Truth



MSG-IR10.8 + CI probability [0'-30'] product 13h00Z
+ Ground Truth = radar > 30dBZ [13Z-13h30Z]



Generally relevant, even if all cases encountered :

- Good Detection (GD)
- False Alarms (FA)
- Misses (MI)
- Double penalties

The relevancy is clearly to analyse regarding the situation *(isolated, embedded, edge of cloud systems, etc.)*

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v2018 CI - Validation on case studies - Summary

FAR problem seems the main one
- Sometimes explained by spatial double penalty as CI not so far away from new convective clouds
- Sometimes explained by delayed convection (CI [0-30’] should have been CI [0-60’])

Less relevant in cold-air mass. Explanations :
- Threshold to be tuned
- Fractioned cloud type excluded of CI calculation
- Movement field more difficult to assess in that case

Useful signal for forecasters or other experienced users. As additional information (rather than replacing other ones)

CI v2018 - Quantitative validation methodology

Cloud Object	Radar Object
✗ **HRV field filtered using a Gaussian filter** ✗ Minimum life time = 30 minutes ✗ Minimum object size = 10 pixels ✗ Connectivity-type = 8 pixels ✗ Parallax-corrected tracks ✗ Motion of cloud fields using the TV-L1 optical flow algorithm	✗ **Newly developing convective cells** ✗ Reflectivity threshold at 35 dBZ ✗ Minimum life time = 30 minutes

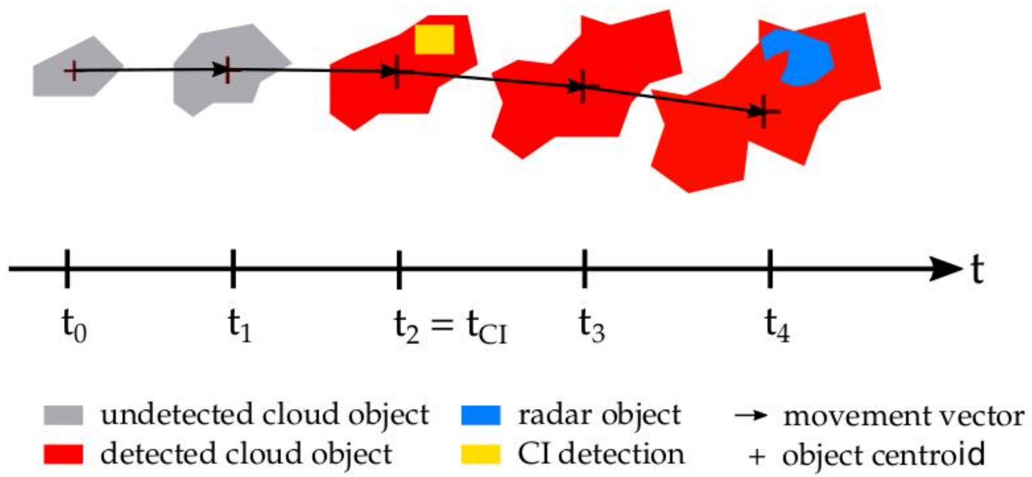
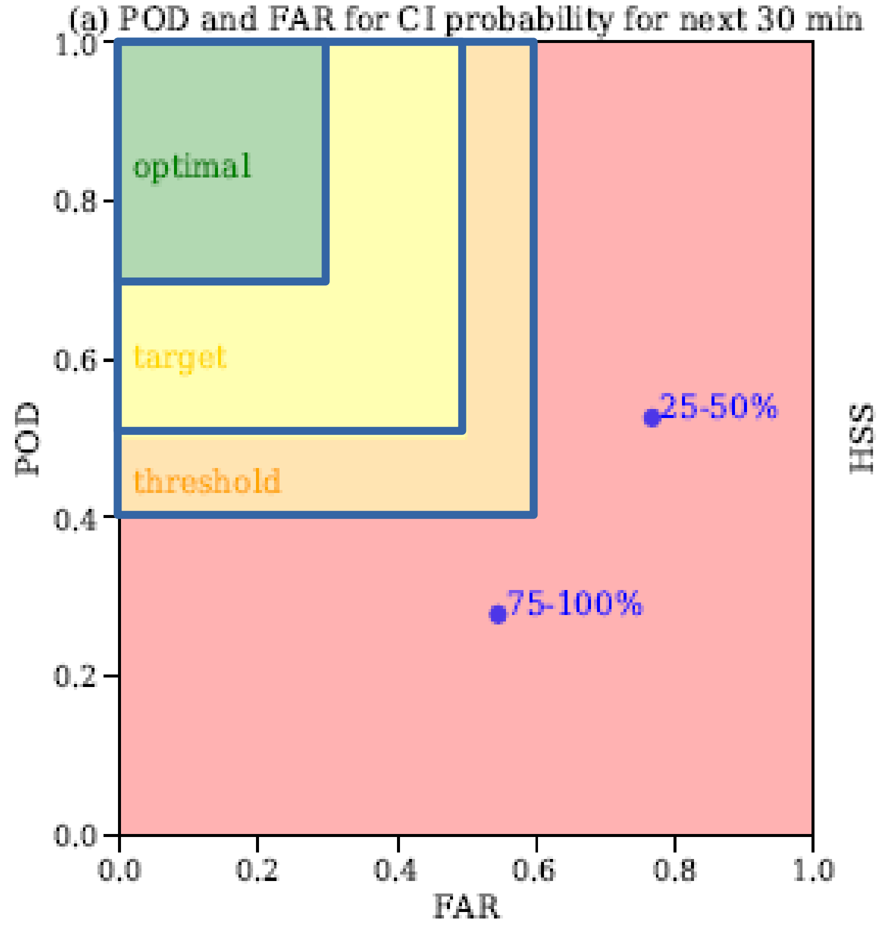


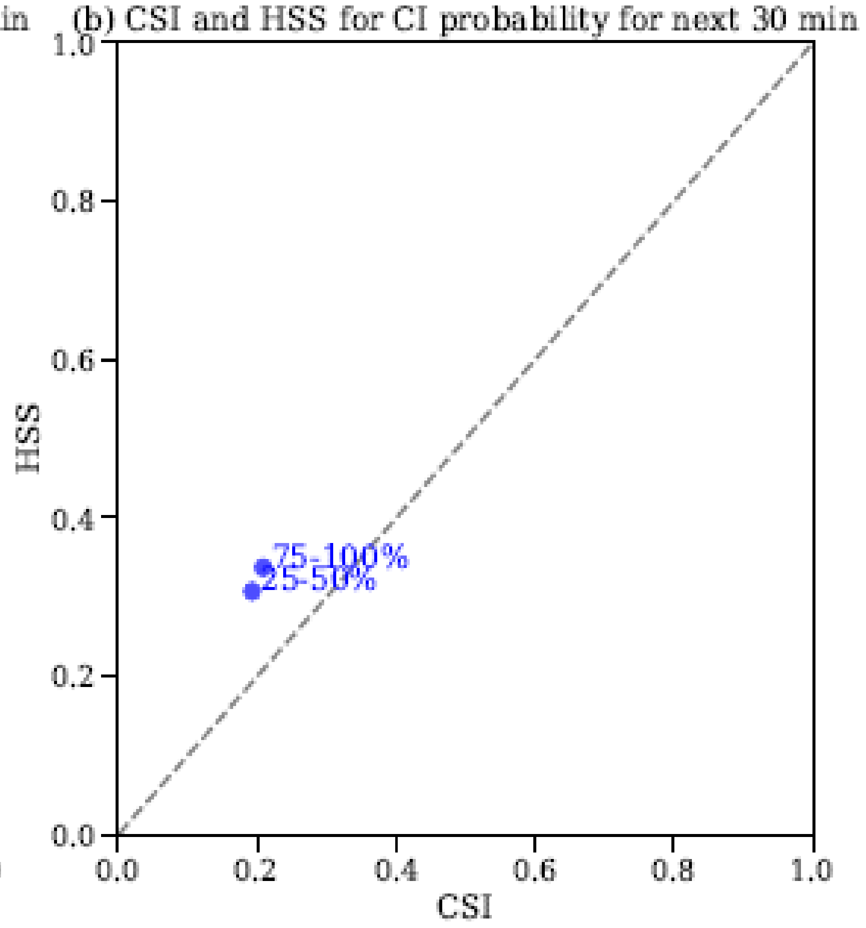
Figure 9: Schematic of the validation approach. Starting from a cloud object (grey and red) a cloud object track is created (denoted by the vector arrows) . If a CI object (yellow) is inside the validation area a new object track with validation region is created. If a radar object (blue) is detected inside the new 30 min validation area the cloud object is counted as a true positive

from TROPOS AS report

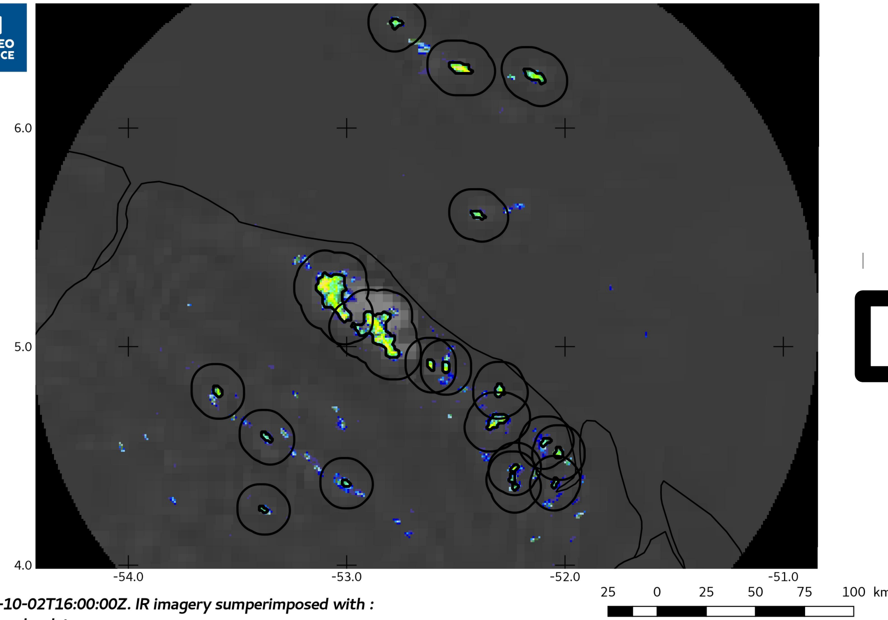
CI v2018 - Quantitative validation results

*Plot of the **POD FAR** (figure on the left) **CSI** and **HSS** (figure on the right) of the validation of the v2018 CI 0-30' forecast product for the CI probability levels 25-50% and 75-100%. For the figure on the left the colour surfaces denotes the optimal/target/threshold values of **POD** and **FAR** given in **PRD***



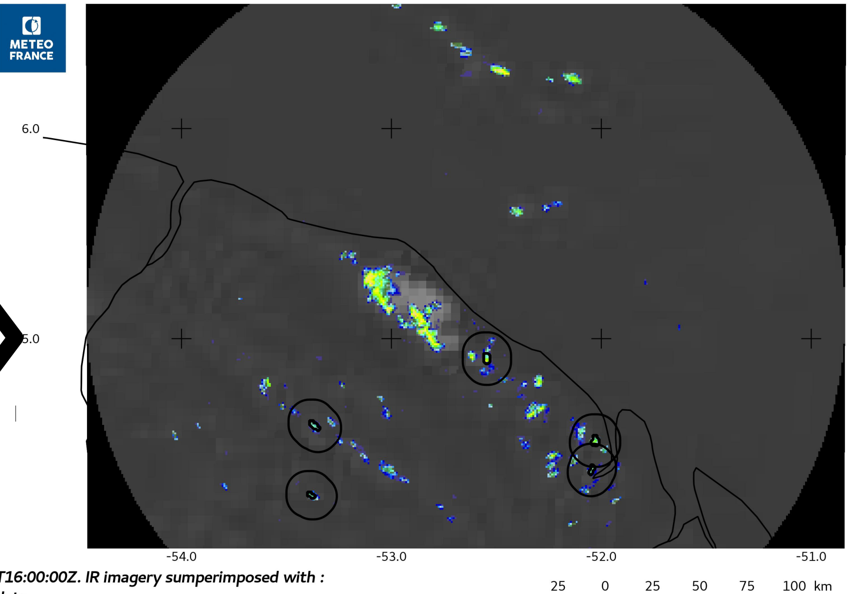


CI v2018 – GOES-16 qualitative validation
Use of radar-derived convection objects



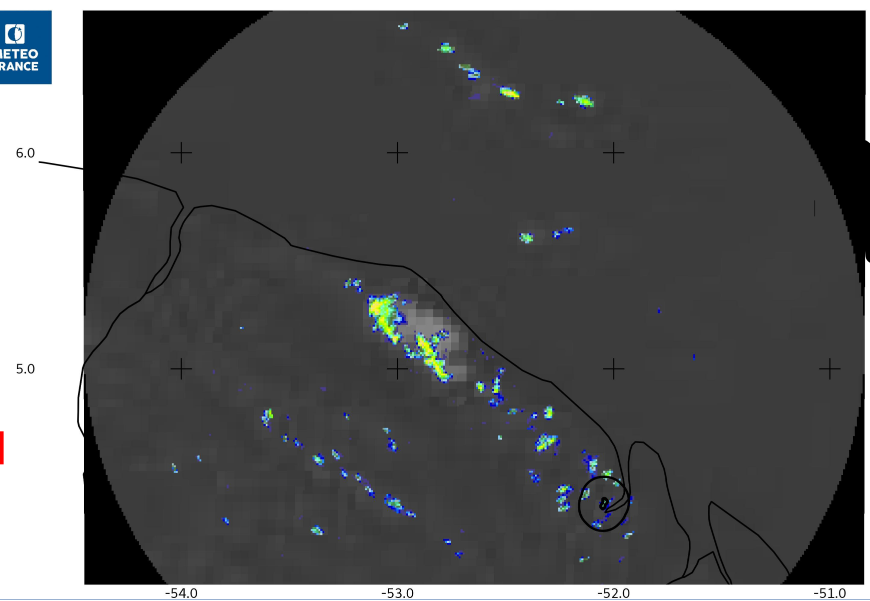
2018-10-02T16:00:00Z. IR imagery sumperimposed with :
- raw radar data
- polygons of convective objects (Threshold = 32 dBZ)
- polygons of convective objects (Threshold = 32 dBZ) with a spatial tolerance of 0.1°

ALL CELLS



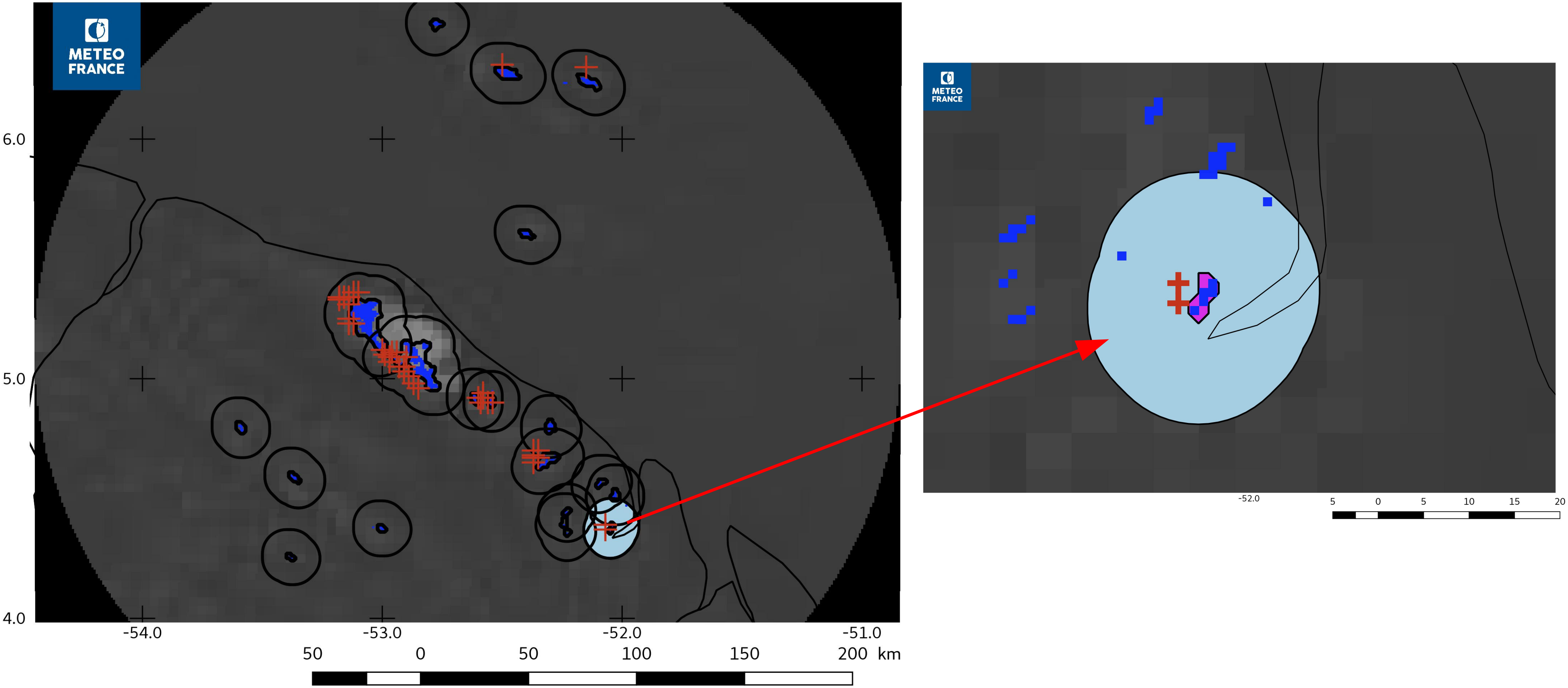
2018-10-02T16:00:00Z. IR imagery sumperimposed with :
- raw radar data
- polygons of NEW convective objects (Threshold = 32 dBZ)
- polygons of NEW convective objects (Threshold = 32 dBZ) with a spatial tolerance of 0.1°

NEW CELLS



NEW CELLS PAIRED WITH LIGHTNING

CI v2018 – GOES-16 qualitative validation
Use of radar-derived convection objects



2018-10-02T16:00:00Z Satellite imagery superimposed with :

- radar data (threshold at 32 dBZ, blue pixels)
- CI detection (red cross, CI transformed in Yes/No product)
- Polygons of all Convective objects
  - without filling : when they are not paired with lightning or when they are not new
  - with filling : when they are new and paired with lightning

Overview

1. CI: Convection initiation

2. RDT: Rapidly Developing Thunderstorm

3.Conclusion

Conclusion – Way forward

CI

- Validation

  Ongoing work to define Ground Truth with radar-derived convective objects to validate the product (qualitative and quantitative validation) - Tuning improvement
- Other

  Use of rapid scan and visible channels - Probabilities calibration improvement

RDT

- OTD

  Achieve tuning of OTD and use of HRV and other channels *(BTDs with O3 & CO2)*
- Lightning Jump

  RDT reprocessing to evaluate vs ESWD 2017 database - Routine evaluation over France Hail-HYDRE vs LJ-RDT - Calculate LJ with other lightning sources (GLM) – Detailed analysis of periods prior to hail events

BOTH

Last version v2018

Next: patch for GOES16

Thanks for your attention