Rapidly Developing Thunderstorm (RDT)

Jean-Marc Moisselin, Frédéric Autones

Météo-France – Nowcasting Department
42, av. Gaspard Coriolis 31057 Toulouse France

jean-marc.moisselin@meteo.fr

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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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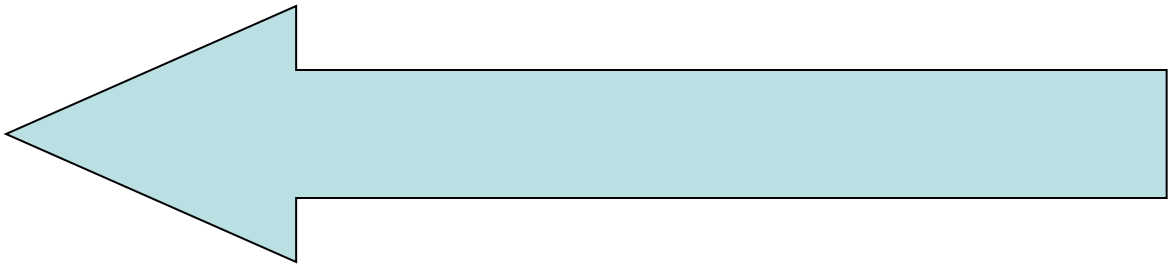
Overview

1. **RDT**



2. RDT for aeronautical applications
3. CI, future NWCSAF product

RDT product

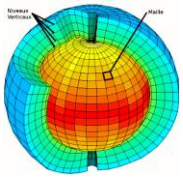
- Rapid Development Thunderstorm
  CW: convection warning

- PGE included in NWCSAF software package

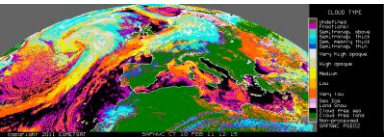
- Object-oriented satellite analysis
  - **Identification** and **tracking** of cloud systems as **objects**: attributes (trend, morphology, motion vector, etc.). Forecast of these objects
  - From meso-alpha scale (200-2000 km) down to smaller scales (few pixels)

RDT: data fusion for description of convection

INPUT DATA: MULTISOURCE

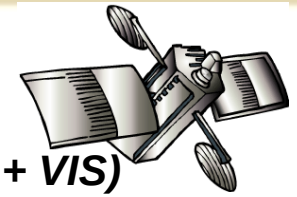


NWP data



Other NWCSAF products

MSG data (5 IR channels + VIS)

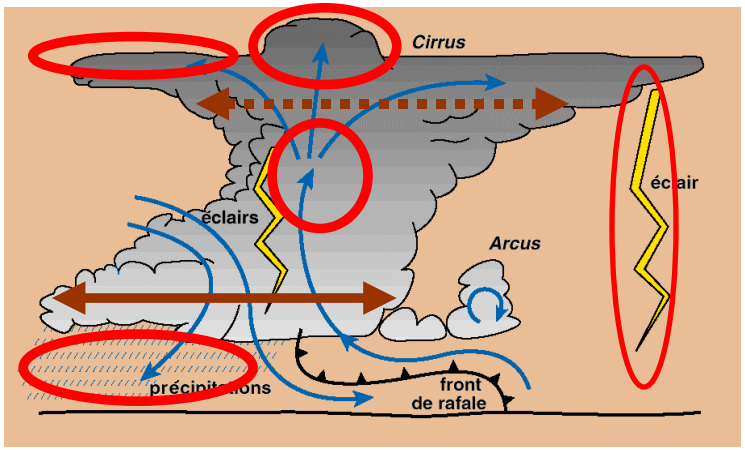


PGE11

RDT

Lightning Data

OUTPUT DATA: MULTILEVEL DESCRIPTION OF CONVECTION



- *Main description of cell: <u>Yes/No convection diagnosis</u>, cell-development phase, position, surface, T, gap to tropopause, cloud type and phase, cloud top pressure. Displacement Relevant trends are calculated*
- *Overshooting Tops, Lightning Activity, Convective Index, Rainfall Activity*

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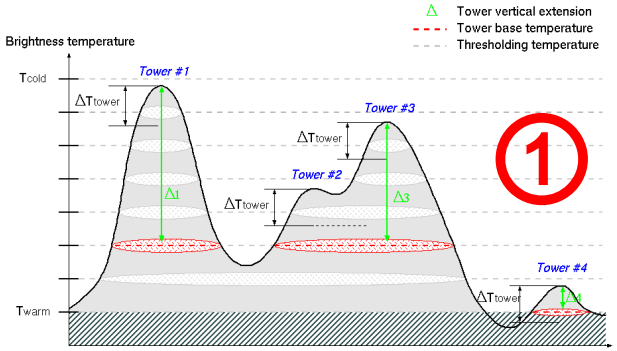
4-steps algorithm of RDT

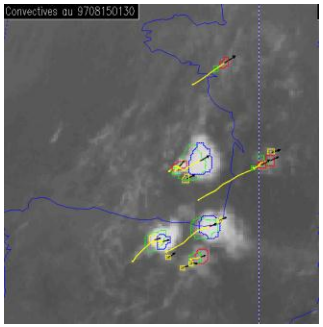
STEP1: 10.8 µm detection

- *in order to detect cells*
- *Vertical extension: at least 6°C*



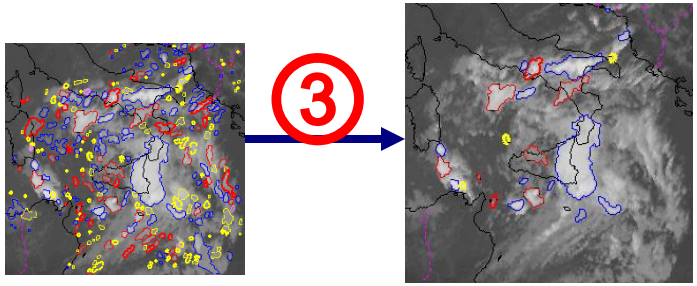
STEP2: Tracking

- *in order to recognize each cell in the previous slot)*
- *Trends calculation is then allowed*

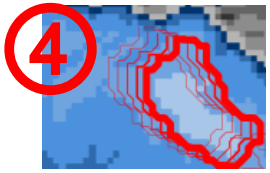


STEP3: Discrimination

- *in order to identify convective cells*
- *Statistical process*



STEP4: Forecast *(v2016)*



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Evolution of RDT product

- Since IOP (2002-2007)
- Pursued in CDOP, CDOP2, *proposal for CDOP3*

- Evolutions
  - v2011: use of NWP data
  - v2012: main cloud phase of the cell, highest convective rain rate inside the cell, second vertical level description
  - v2013: overshooting tops
  - *v2016: advection scheme + change in NWCSAF Library + new output format + CTRAJ*

  - *v2018: overlapping CDOP2 and CDOP3*
  - *v2020: MTG (CDOP3)*
  - *v2022: overlapping CDOP3 and CDOP4*

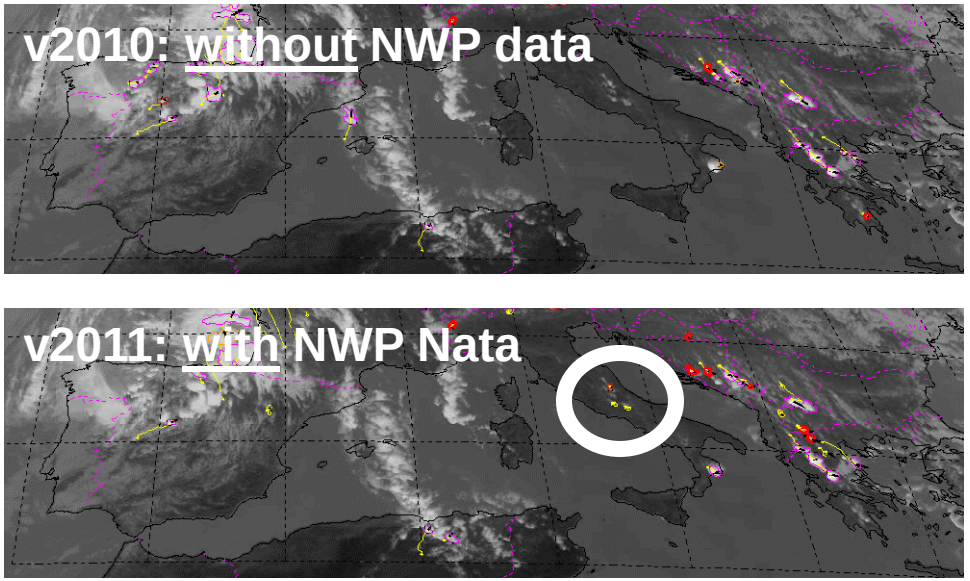
v2011: impact of NWP data

How:
CONVECTIVE INDEX calculated for each pixel: mask + predictor

Consequences:
- *New attribute*
- *Reduction of the FAR*
- *Improvement of early detection*

EXAMPLE
25 May 2009, 12h15 UTC.

*v2011 benefits from a better tuning in warmer categories, with higher early detection (cells over Italy diagnosed **30 min** when v2011 and v2010 releases are compared)*



RECOMMENDATION: USE NWP DATA!

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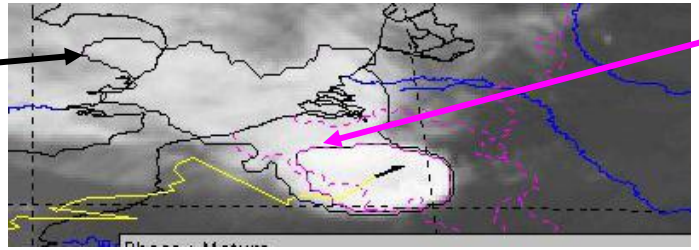
v2012: 2nd level description

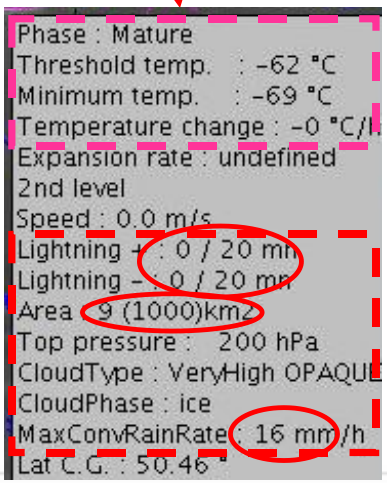
When cell-extension is too large, it is interesting to have the depiction of another level additionally to « Base of Tower » level.

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

main contour: general attributes, including tracking attributes

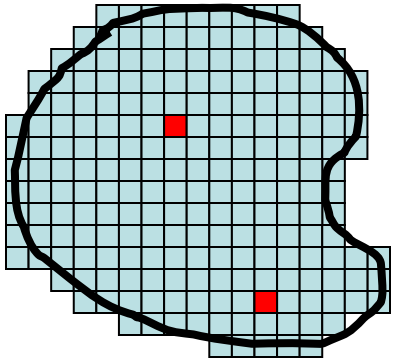


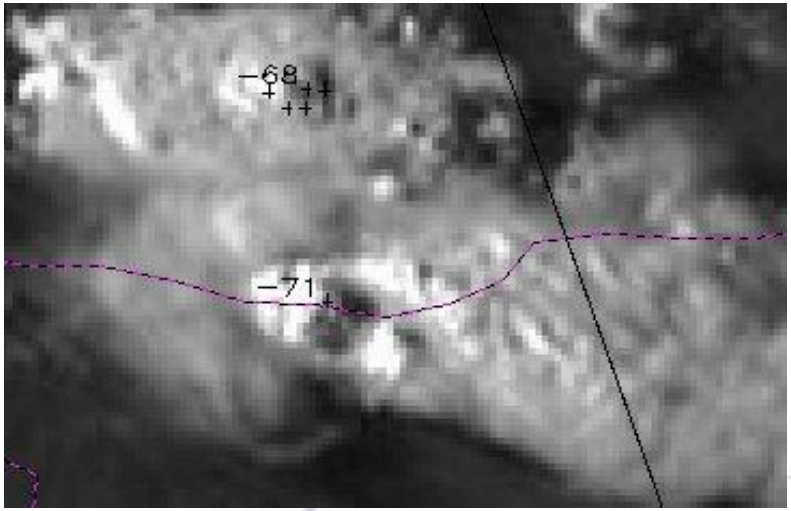
2nd contour: specific attributes



v2013: OTD (Overshooting Tops Detection)

- OTD Inside each RDT cell
  - Criteria: temperature of coldest pixel, BTD WV6.2-IR10.8, WBTD WV6.2-WV7.3, reflectance VIS0.6, gap to NWP tropopause.
  - Morphologic criteria to confirm a spot of cold temperatures and to determine the pixels that belong to an OT
  - HRV for tuning/validation

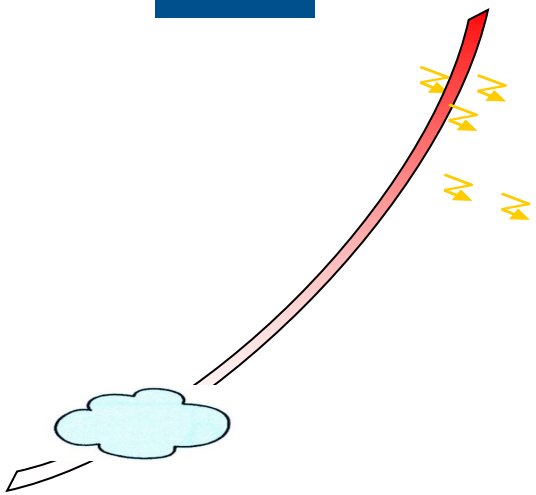




RDT: validation

- **Subjective** validation by Météo-France experts

various case studies, use of topical case for each release.



- **Objective** validation by Météo-France (v2012)
  - *Accuracy requirements fulfilled*
  - *Detection is superior to 70%*
  - *Early diagnosis for 25% of convective systems*

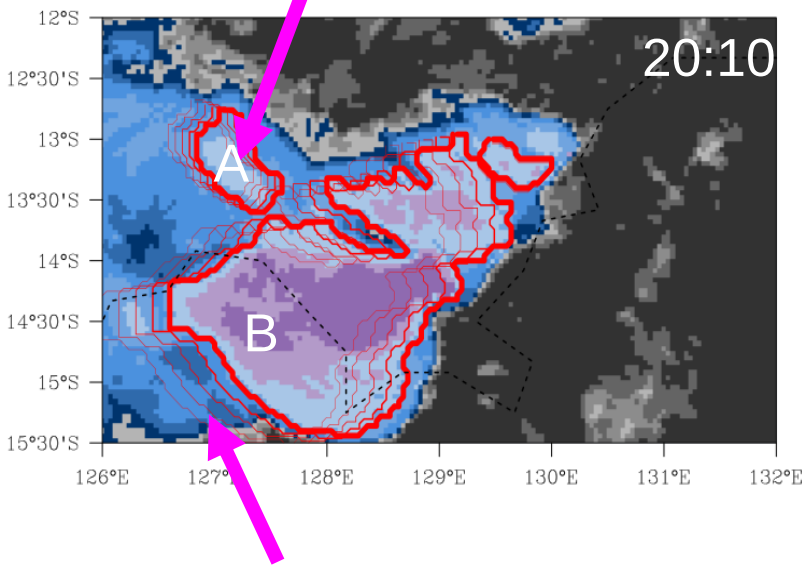
- Validation by **users**
  - *Research Projects, NMS, other NWCSAF users*
  - *User Survey 2014:*
    - *RDT is rated 6.7 (/10) in term of usefulness by users*
    - *Convection Initiation most expected product*

- ***Any feedback is welcome !*** ☎ ✉

RDT: v2016

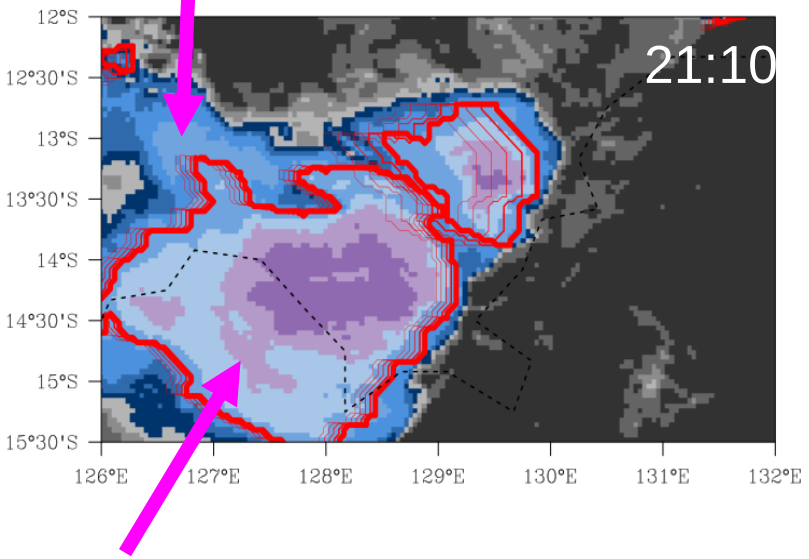
- *Advection scheme + change in NWCSAF Library + new output format + CTRAJ + use of CMIC*
- *Advection scheme: RDT motion vector + HRW*

WNW displacement of "A"



WSW displacement of cell "B"

"A" cell has disappeared. Bad forecast (False Detection)



"B" at the expected location. Even if change in morphology is not forecast

MTG Context

Lightning Imager (LI) 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.

Flexible Combined Imager is eagerly expected

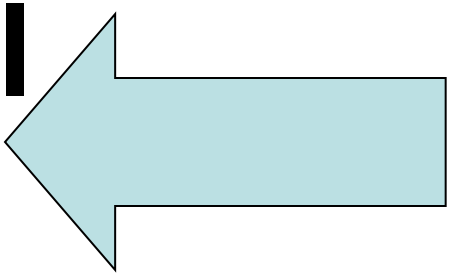
- New channels: e.g. for FCI: 0.91µm (total column precipitable water)
- **Resolution:** better estimate of morphological parameters and small scale phenomena
- **Spectral accuracy:** better estimate of BT input data of RDT

RSS Challenge. The lack of channels in RSS would mean for RDT a lack of predictors and a lower quality. Under Discussion

Overview

1. RDT

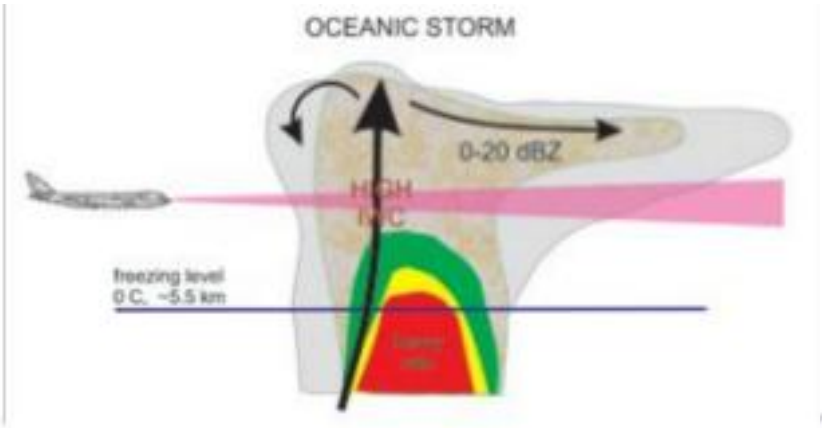
2. RDT for aeronautical applications



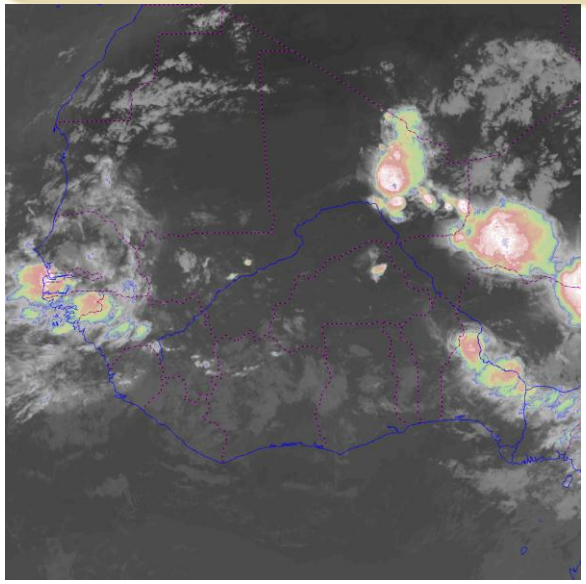
3. CI, future NWCSAF product

RDT warnings for Aviation

- RDT can provide information on location and intensity of convection for aviation, interested in mixed phase and glaciated icing conditions
- Light format output can be sent on board the aircraft
- Interesting as RDT product available over Tropical Ocean where few other observation are available and where the highest risks in terms of glaciated icing conditions are found

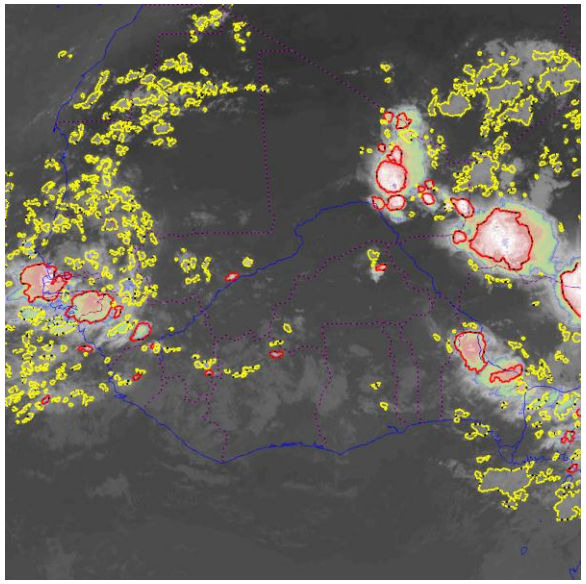


From Satellite Image to convective objects (1/2)



Enhanced satellite 10.8µm image

Convection is here. *Where precisely*?



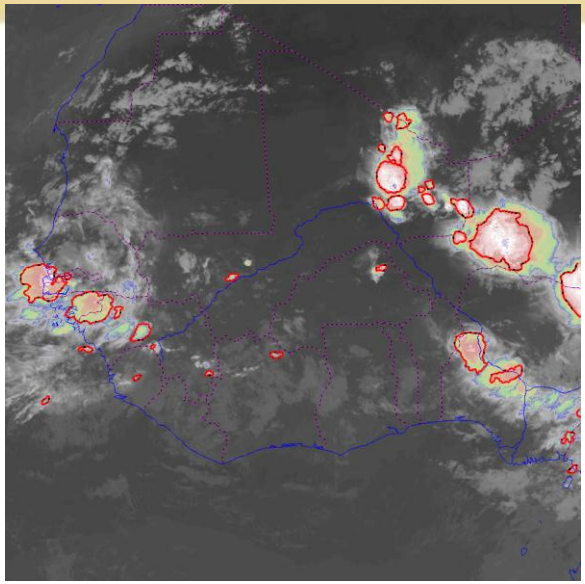
Enhanced satellite 10.8µm image + objects that have at least 6°C of vertical extension

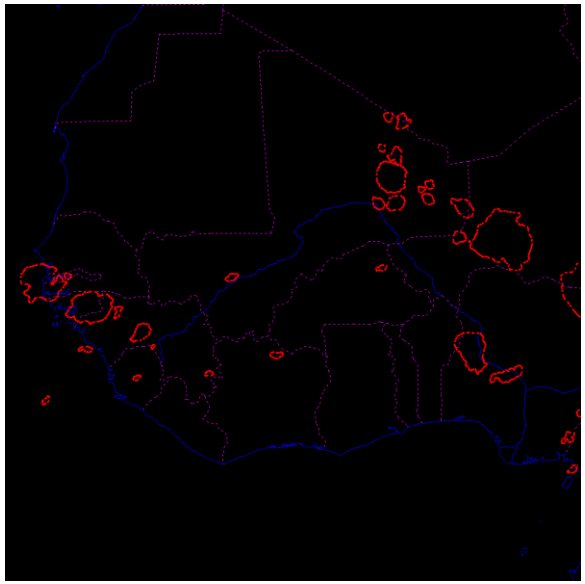
Note:

- Even non-convective objects may be tracked and described
- Non convective-objects are watched because they may become convection in next image.

If we only focus on convection … (next slide)

From Satellite Image to convective objects (2/2)





Enhanced satellite 10.8µm image + convective objects

After the “discrimination” phase of the RDT algorithm

Each object is described with a complete set of attributes

If we want to reduce the information to its kernel

Convective objects outlines alone

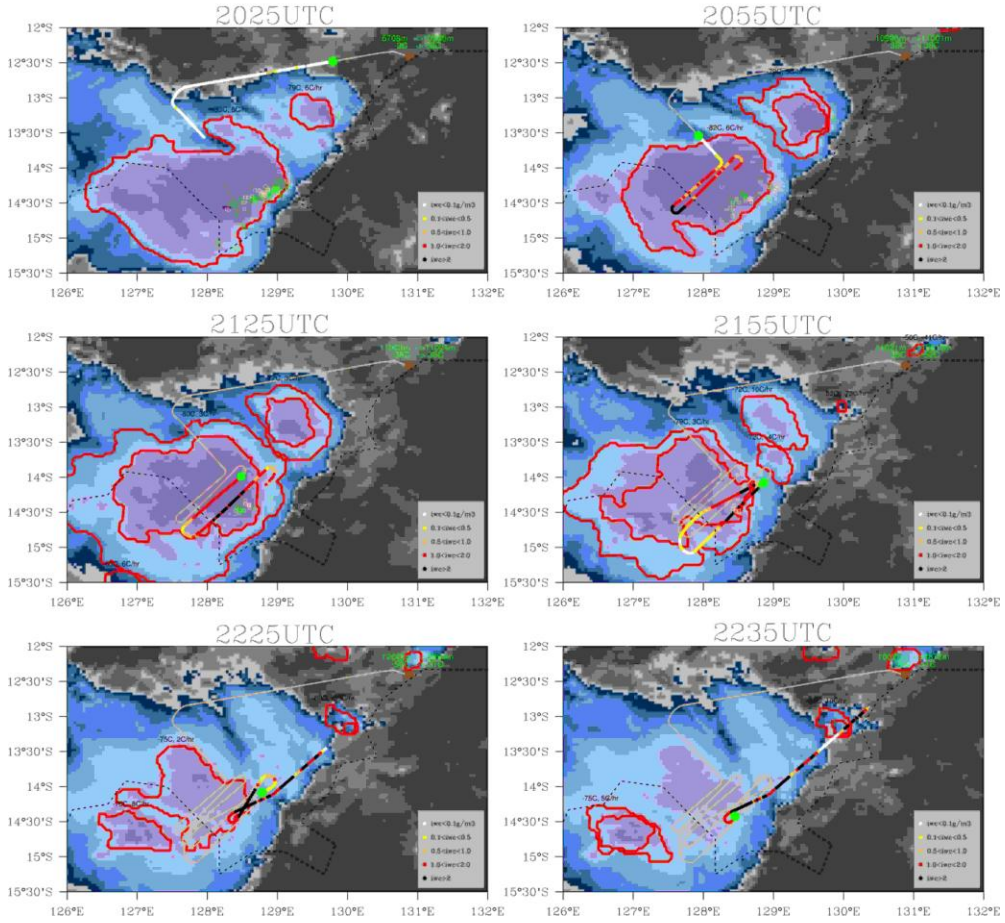
+ Possibility to reduce the set of attributes

UPLINK

Use of RDT during the HAIC-HIWC campaign

Field Campaign based in Darwin, Australia (January-Marc 2014). 23 research flights within deep convective systems

Aircraft equipped with in-situ and remote sensing instruments to estimate ice water content – potentially hazardous for commercial aircrafts



Near real time RDT chain run using MTSAT satellite data to locate high ice water content

Promising results for RDT in using it to locate area with glaciated icing conditions

May 2015: new campaign in Cayenne

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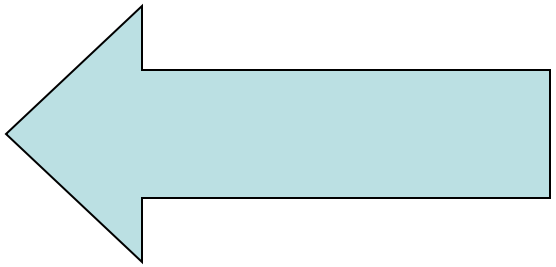
Overview

1. RDT
2. RDT for aeronautical applications

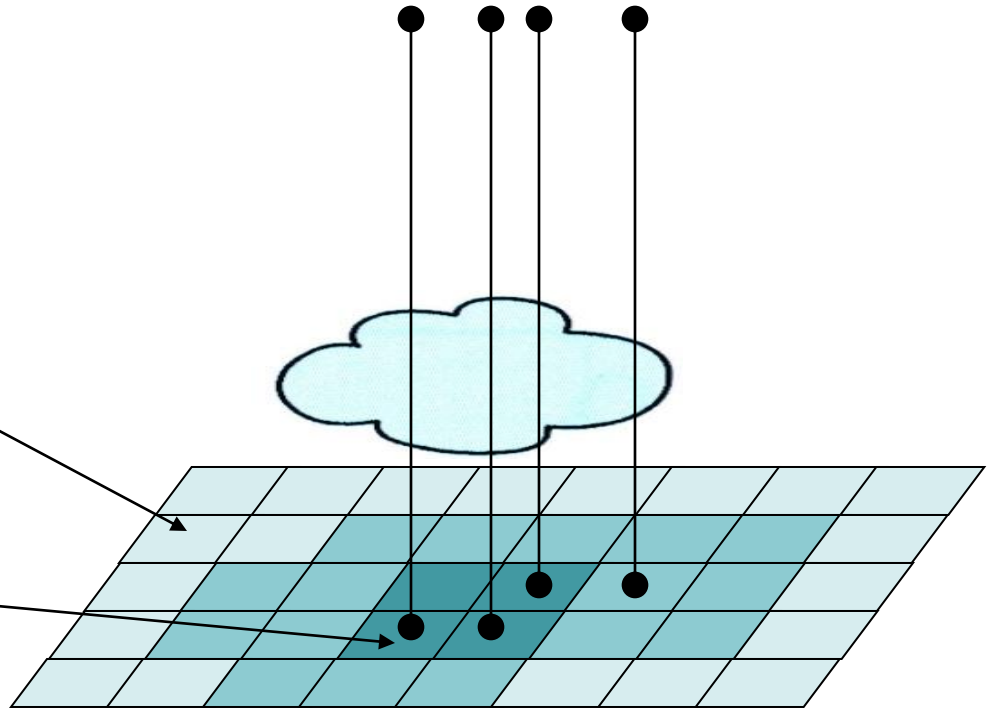
3. CI future NWCSAF product



Convection Initiation (CI)
New NWC SAF product released in v2016

Low probability to develop into a thunderstorm

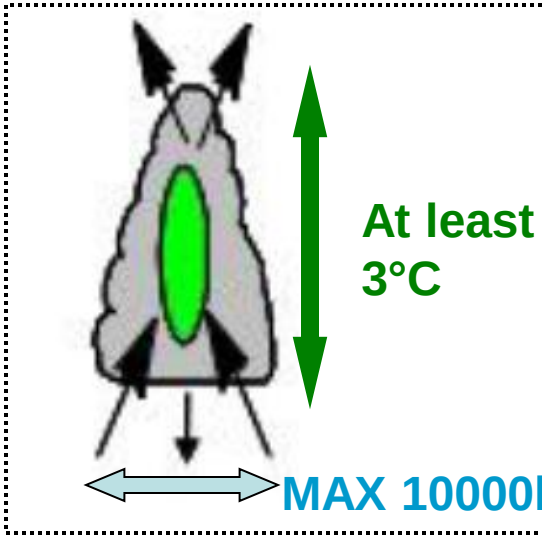
High probability to develop into a thunderstorm



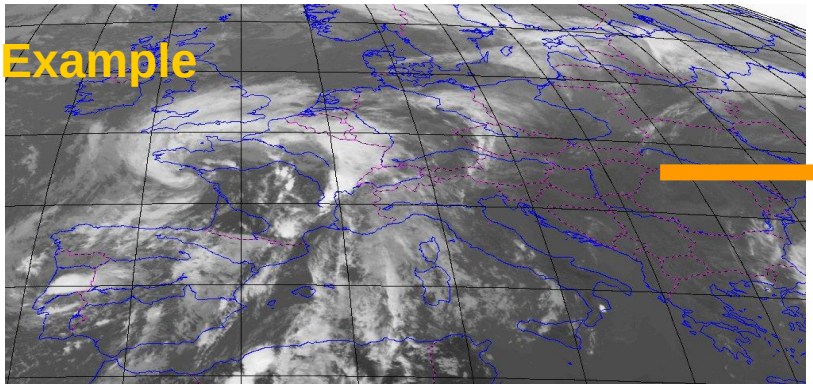
CI – Main principle (1/2)

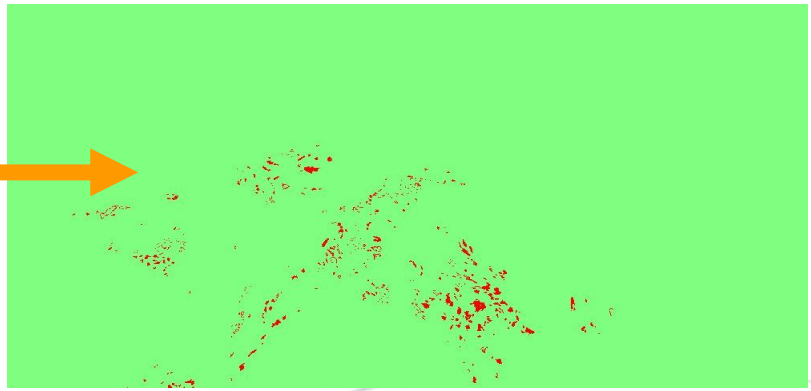
- **First step:** the selection of pixels of interest

Cloud-free pixels



Too cold pixel





CI – Main principle (2/2)

- **First step:** the selection of pixels of interest
- **Second step:** the probability calculation. Accordingly to literature on the subject three categories of predictors will be considered:
  - **Vertical extension** of the cloud,
  - **Ice presence**,
  - **Cloud growing rate**
- In order to compute the trends we take into account cloud-displacement and calculate **the past position of the cloud**.

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

- Verification/tuning: RDT / radar / lightning data

Links between products

- A new product will increase the number of links between products and thus the strength of NWC chain

  - Input data:
    - Mask: e.g. PGE cloud mask before operating RDT
    - Decision tree: e.g. strong CRR for RDT
    - Advection: HRW for RDT
    - Description: e.g *microphysics* (CMIC) for RDT (v2016)

  - Validation: e.g. RDT for CI

Conclusion

- RDT product
  - Data fusion for large description of convective systems
  - Mature product (since IOP). Still many ways of improvement (e.g. MTG)

- CI product
  - Coming soon !

Thanks for your attention

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