Lightning data valorisation for forecasters, media and NWP

Sylvain Le Moal
Direction des opérations pour la prévision
Centre de météorologie spatiale

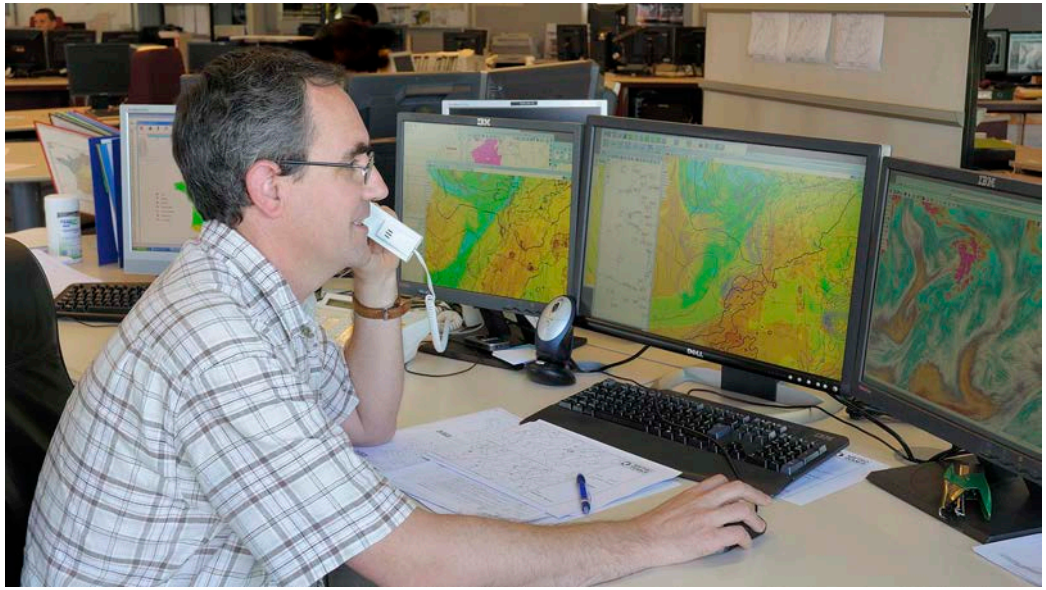
sylvain.lemoal@meteo.fr
@SylvainLeMoal
Sylvain Le Moal

Lightning data for the forecasters and for the media

A representation of the satellite lightning imager data adapted to the audience

Forecasters

Meteo-France Synopsis workstations



Media

TV channels

Lightning data for the forecasters

INPUT FILES

GLM L2 lightning products (flashes, groups, events) for GOES-16 (GOES-17 & -18) with 20 seconds refresh rate in netCDF format, collected in files (tared and gziped) of 5 minutes.

Example of netCDF file for Goes-16:

OR_GLM-L2-LCFA_G16_sYYYYDDDHHMMSSs_eYYYYDDDHHMMSSs_cYYYYDDDHHMMSSs.nc

s: start date & time – e: end date&time – c: creation date&time

OUTPUT FILES

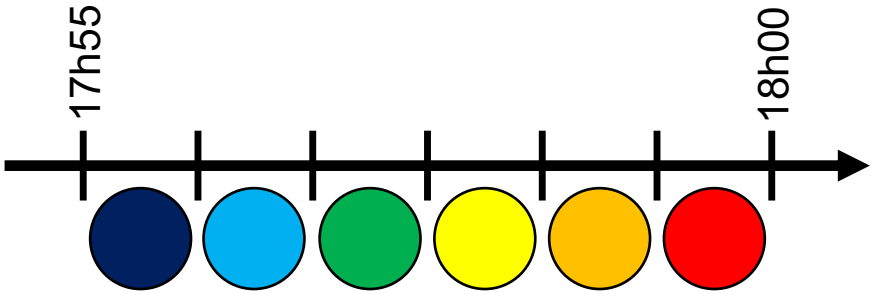
Extraction of flashes information from these netCDF files and creation of GeoJSON files every 5 minutes to display image of 5-min accumulated flashes on Meteo-France Synopsis workstations.

Example for one flash in the GeoJSON file:

"geometry": { "type": "Point", "coordinates": [-77.91044616699219, -2.9137792587280273] },
"type": "Feature", "properties": {
"quality_satellite": 0,
"area": 322,
"process": "geostationary_goes16",
"energy": 2.643e-13,
"duration": 267,
"strike_date": "2021-01-13T17:58:25Z",
"aggregate": "strike"

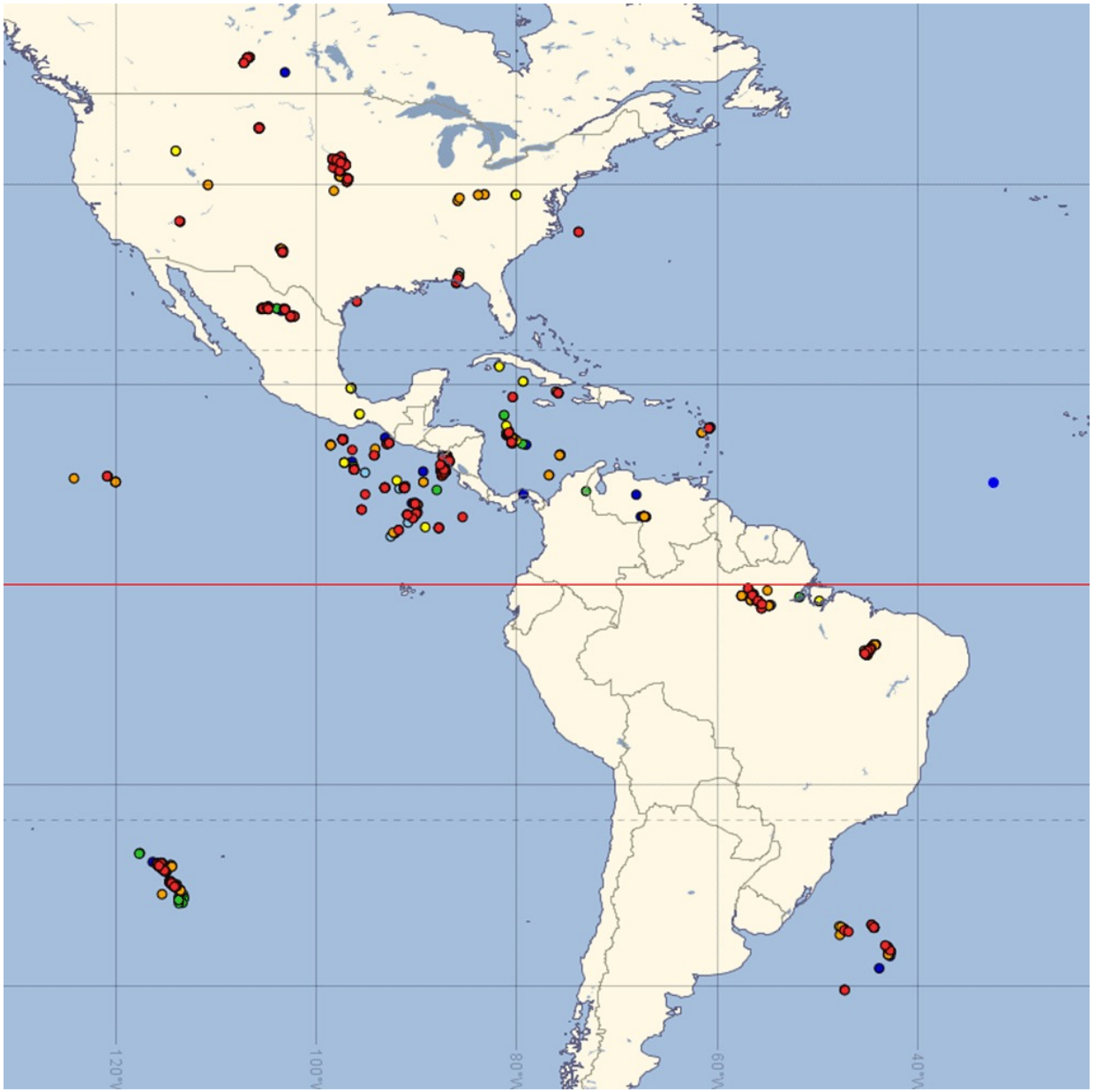
Lightning data for the forecasters
Goes-16 – 13th January 2021

Their colour depends on the timing of the flash within a 5-min period:



Flash lat / lon:	02°50'S 77°55'W
	Impacts GOES16
	Processus : GOES16
Image date:	Date de validité : 13/01/2021 18:00
	Période de cumul : [5 Min]
	Qualité satellite : 0
Flash duration:	Durée de l'éclair : 267 ms
Flash energy:	Energie : 2.6e-13 J
Flash area:	Superficie : 322.0 km²
Flash date:	Date de l'impact : 13/01/2021 17:58:25

Lightning data for the forecasters

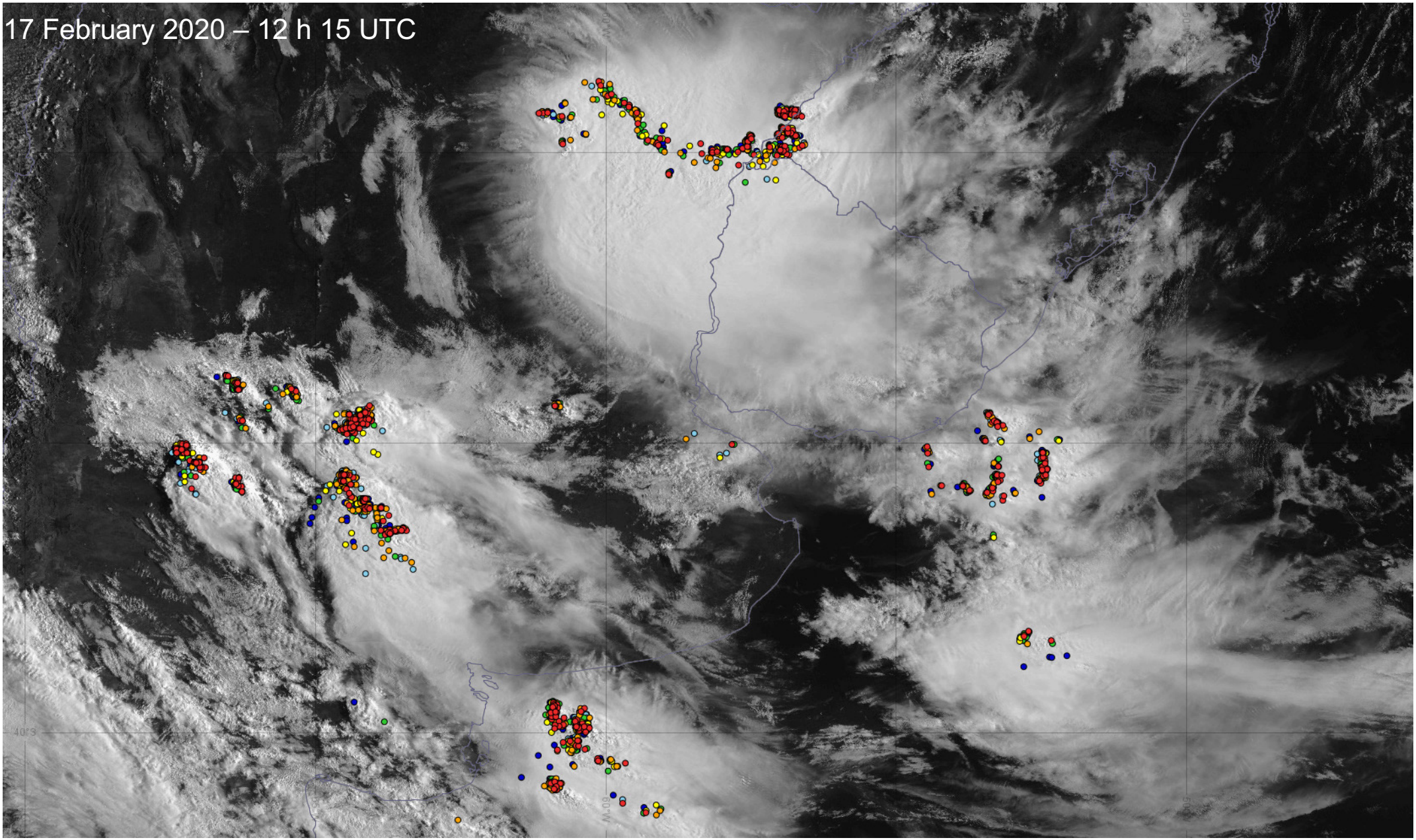


23rd May 2018

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

METEO FRANCE

Lightning data for the forecasters



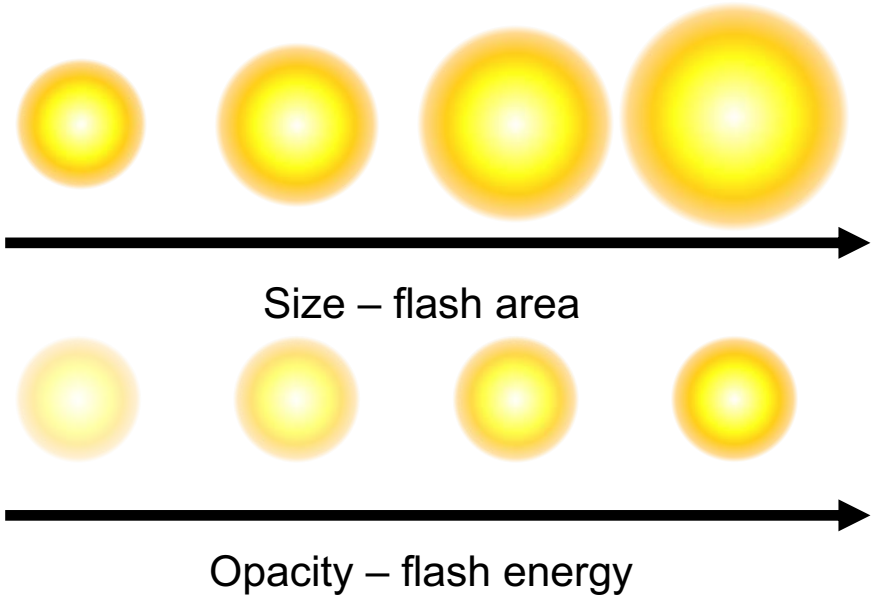
Lightning data for the media

Goal: satellite images with an overlay of flashes as close as possible to lightning flashes seen from space, intended for TV channels.

Input files: GLM L2 lightning products (flashes, groups, events) for GOES-16 (and GOES-17) with 20 seconds refresh rate in netCDF format.

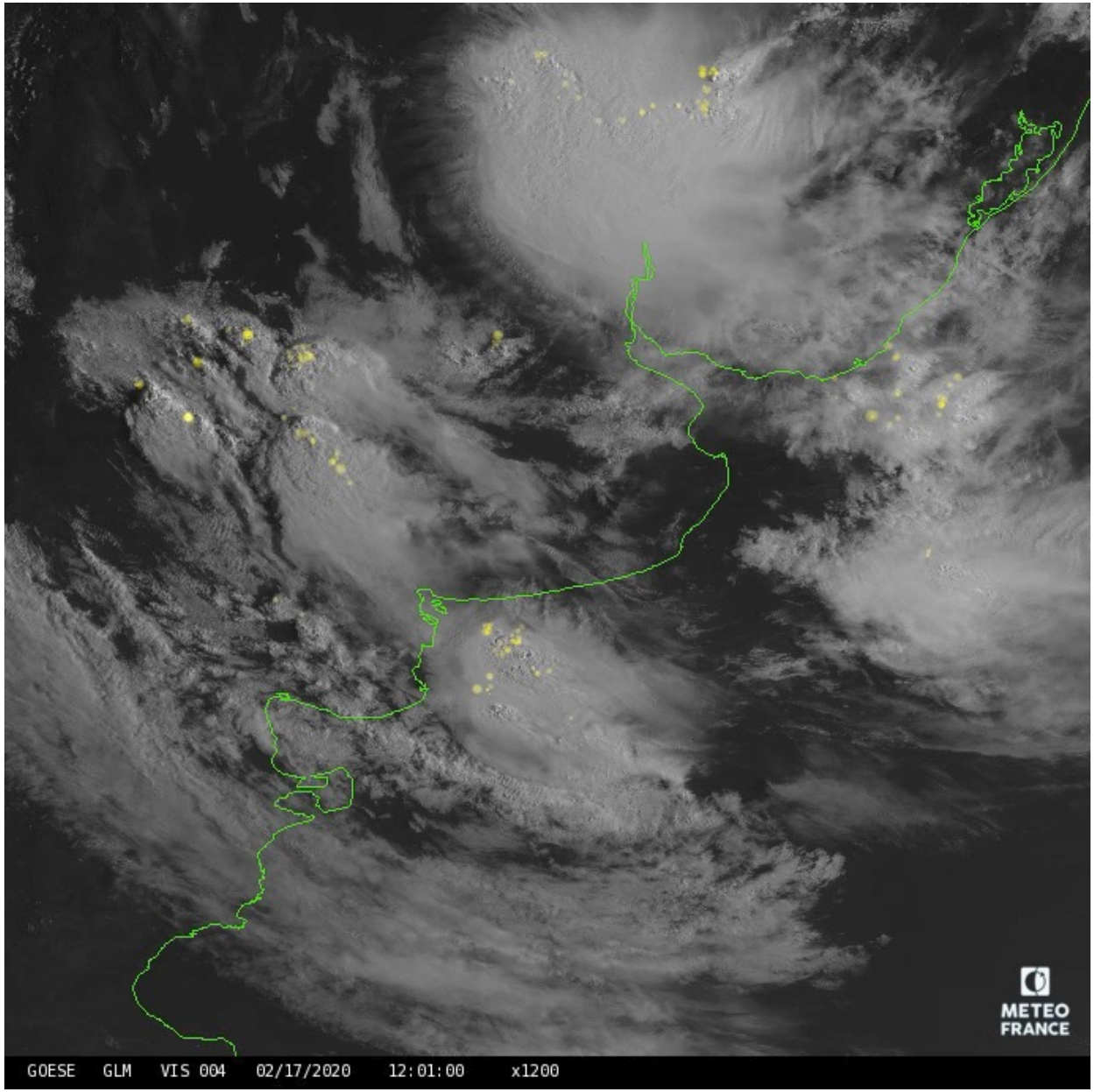
The process would take too much time if the lightning flashes were created one by one from the events or groups.

So, we use a single pattern (with the possibility to choose the colour) where the size and opacity depend respectively on flash area and flash energy.



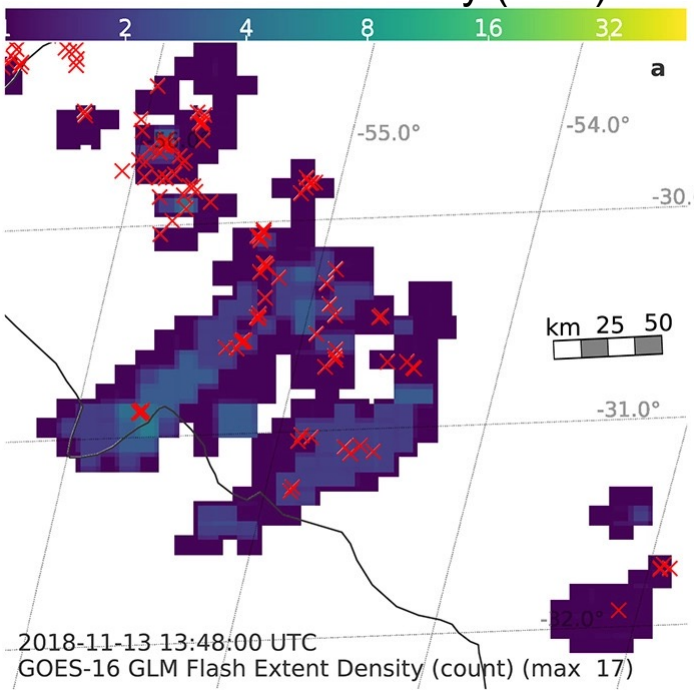
Lightning data for the media

Possibility of choosing the colour of the flashes depending on the background (black and white, colour composite or true colour image).

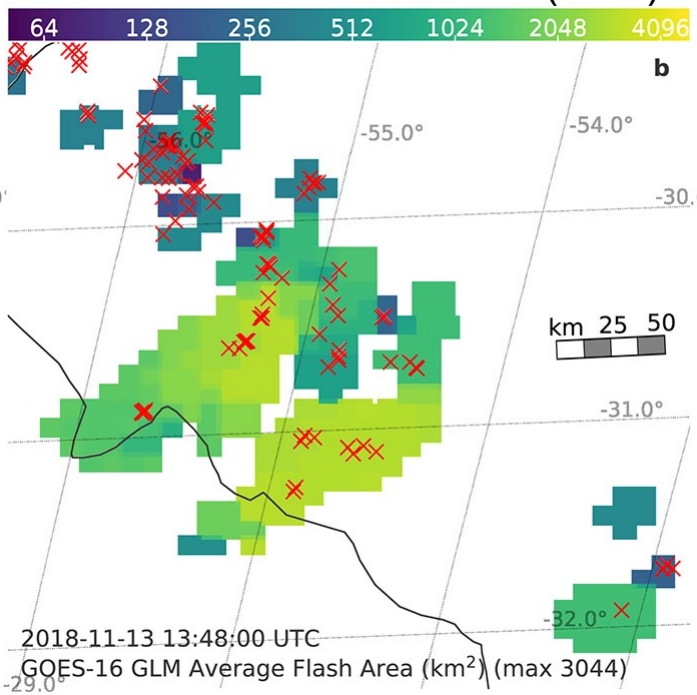


Accumulated products – GLM

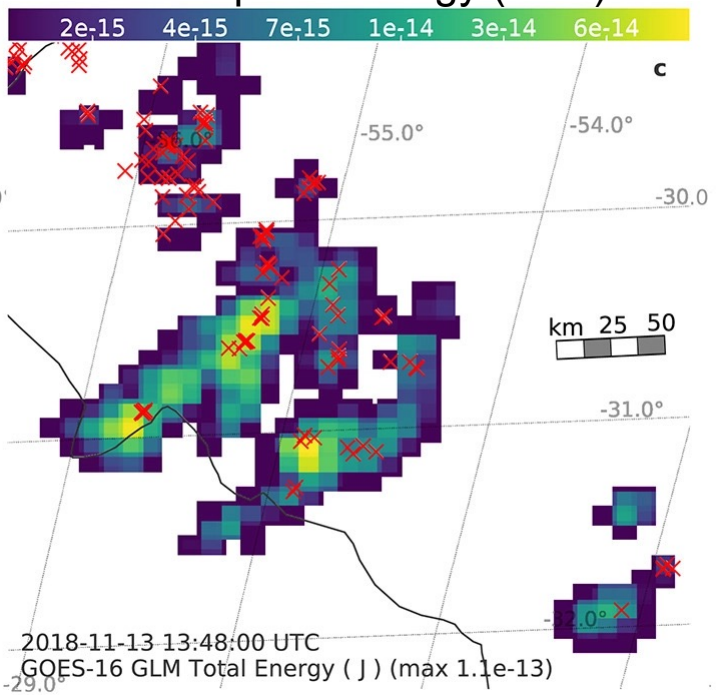
Flash Extent Density (FED)



Average Flash Area (AFA) and
now Minimum Flash Area (MFA)



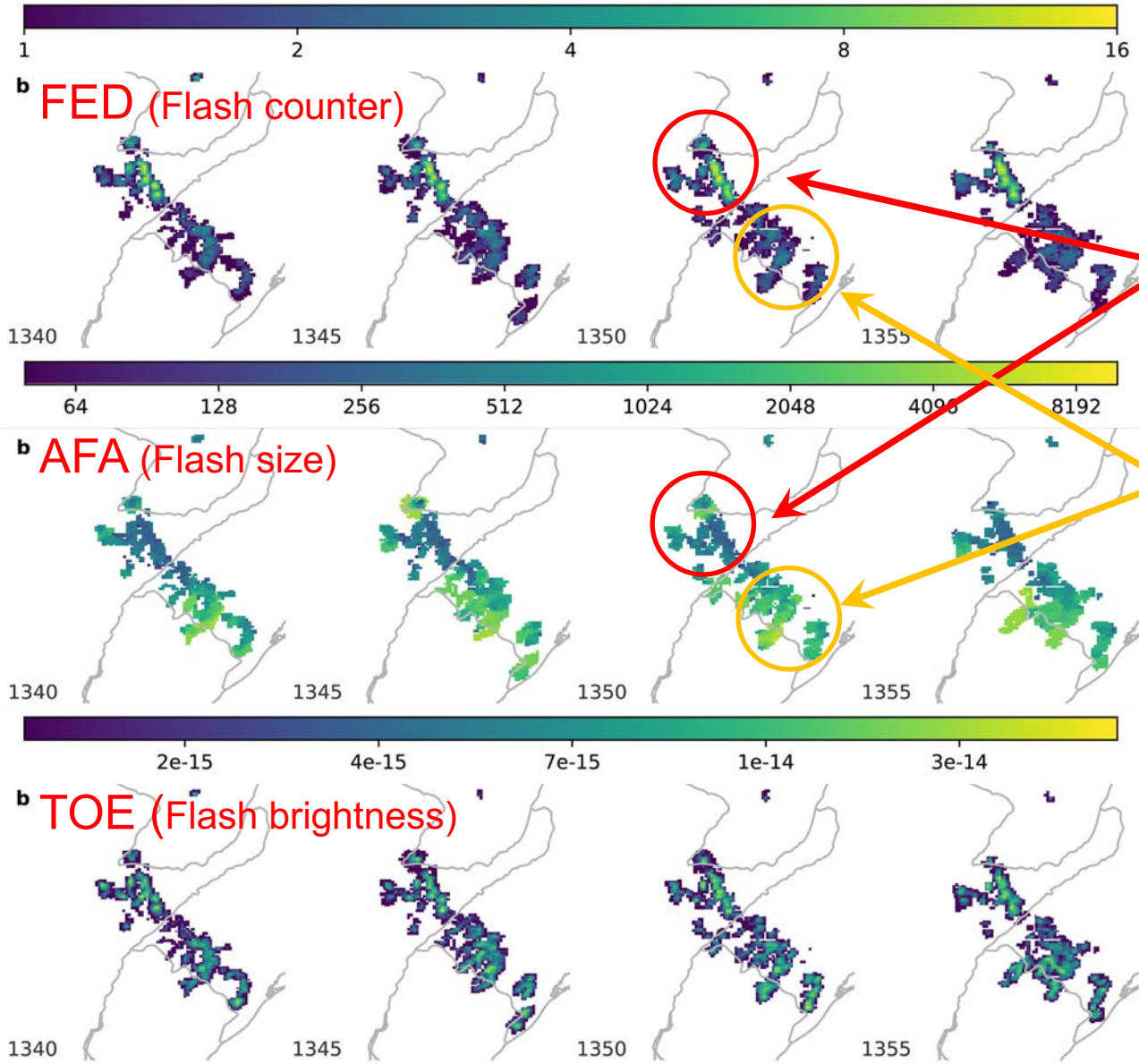
Total Optical Energy (TOE)



and Illuminated Flash Fraction (IFF)

From Eric C. Bruning – Lighting meteorology group

Accumulated products – GLM



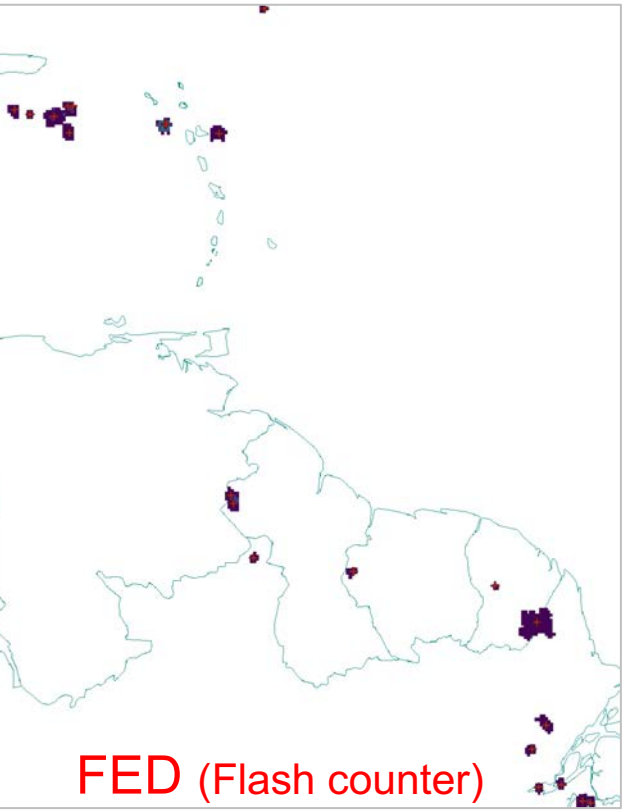
Complementary signals in each product combined to give confidence in the meteorological interpretation of the imagery.

In such a system, deep convective drafts with the largest vertical velocities would be expected in the leading line, where relatively large flash rates and small flash sizes are found.

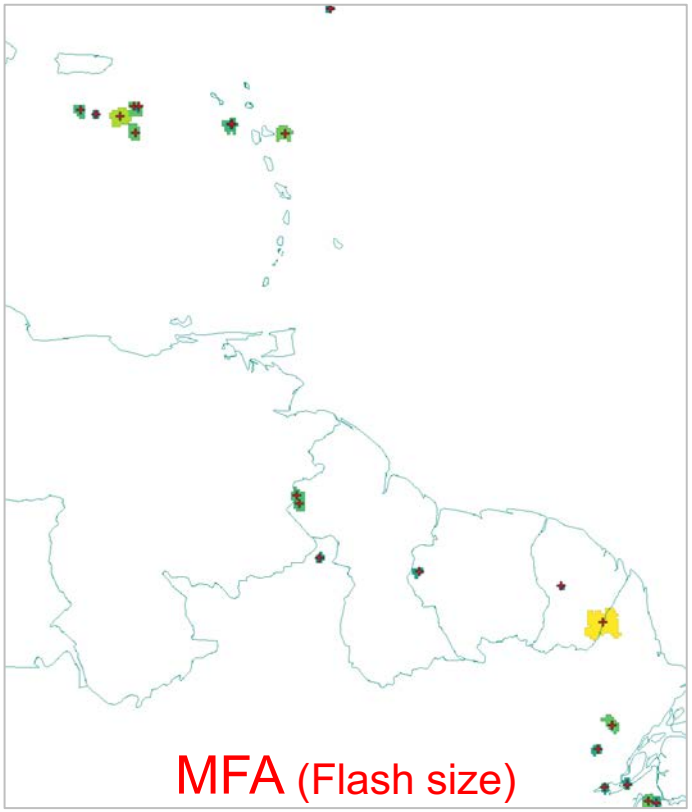
To the rear, less frequent but larger flashes would be expected in trailing stratiform precipitation.

From Eric C. Bruning – Lighting meteorology group

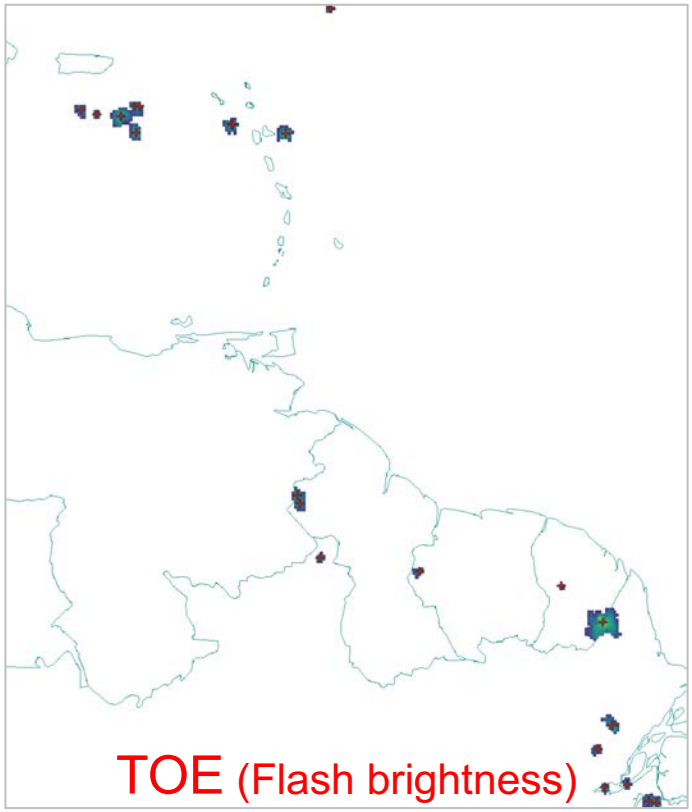
Accumulated products – GLM



FED (Flash counter)



MFA (Flash size)



TOE (Flash brightness)

Accumulated products – LI

Containing the accumulated information over 30 second re-gridded on the FCI 2 km IR grid for Accumulated flash (AF), Accumulated Flash Area (AFA), and Accumulated Flash Radiance (AFR); in detail:

- The AF product contains the accumulated events normalised by the total number of events in the flash itself computed for all the flashes,
- The AFA product contains the accumulated footprint of all the flashes,
- Finally, the AFR product contains the accumulated irradiance for all the flashes.

Equivalences – Be careful!

Accumulated product	GLM – Goes	LI – Meteosat
Flash count	FED (Flash Extent Density)	AFA (Accumulated Flash Area or Accumulated Flash Index)
Flash size	AFA (Average Flash Area) & MFA (Minimum Flash Area)	
Flash brightness	TOE (Total Optical Energy)	AFR (Accumulated Flash Radiance)
Accumulated events normalised by the total number of events in the flash itself	IFF (Illuminated Flash Fraction or Event Weighted Illuminated Flash Fraction)	AF (Accumulated Flash)

Lightning data assimilation

Objective: Preparation for the assimilation of MTG LI data in AROME-France.

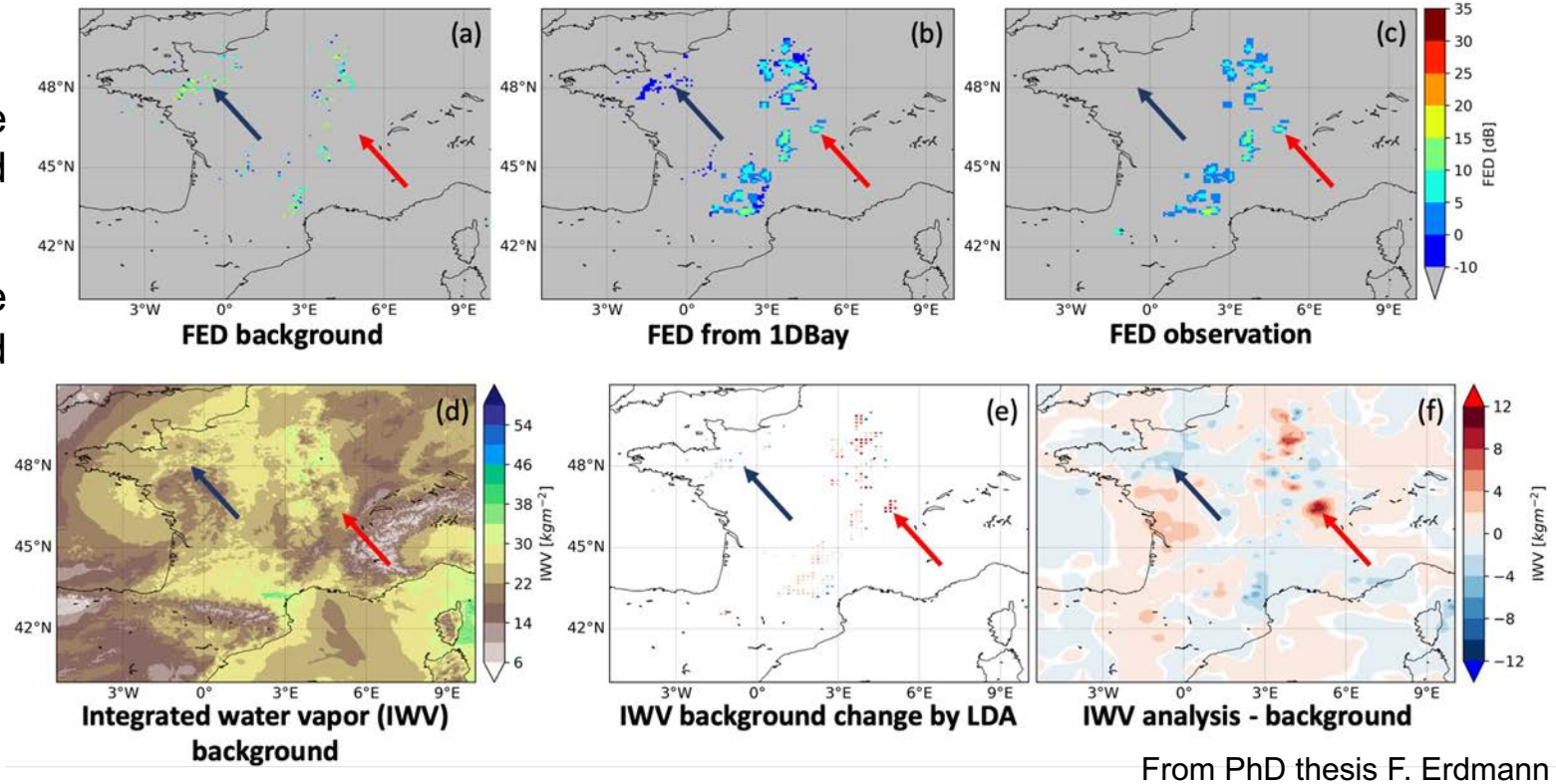
Data: LI pseudo-observations created from Meteorage data using machine-learning algorithms (Erdmann et al. in revision for *JTECH*).

Data assimilation system: AROME-France 1D Bay + 3DVar = Flash Extent Density (FED) converted via 1D Bayesian retrieval into relative humidity before assimilation in 3DVar (Caumont et al. 2010).

Observation operator for FED: based on vertically-integrated graupel mass (Deierling et al. 2008).

Data assimilation able to:

- Add humidity where lightning is observed and not simulated
- Decrease humidity where lightning is not observed but simulated



From PhD thesis F. Erdmann

Lightning data assimilation

Fractions Skill Score (FSS, Roberts and Lean 2008) with 0.5 ° neighbourhood for:

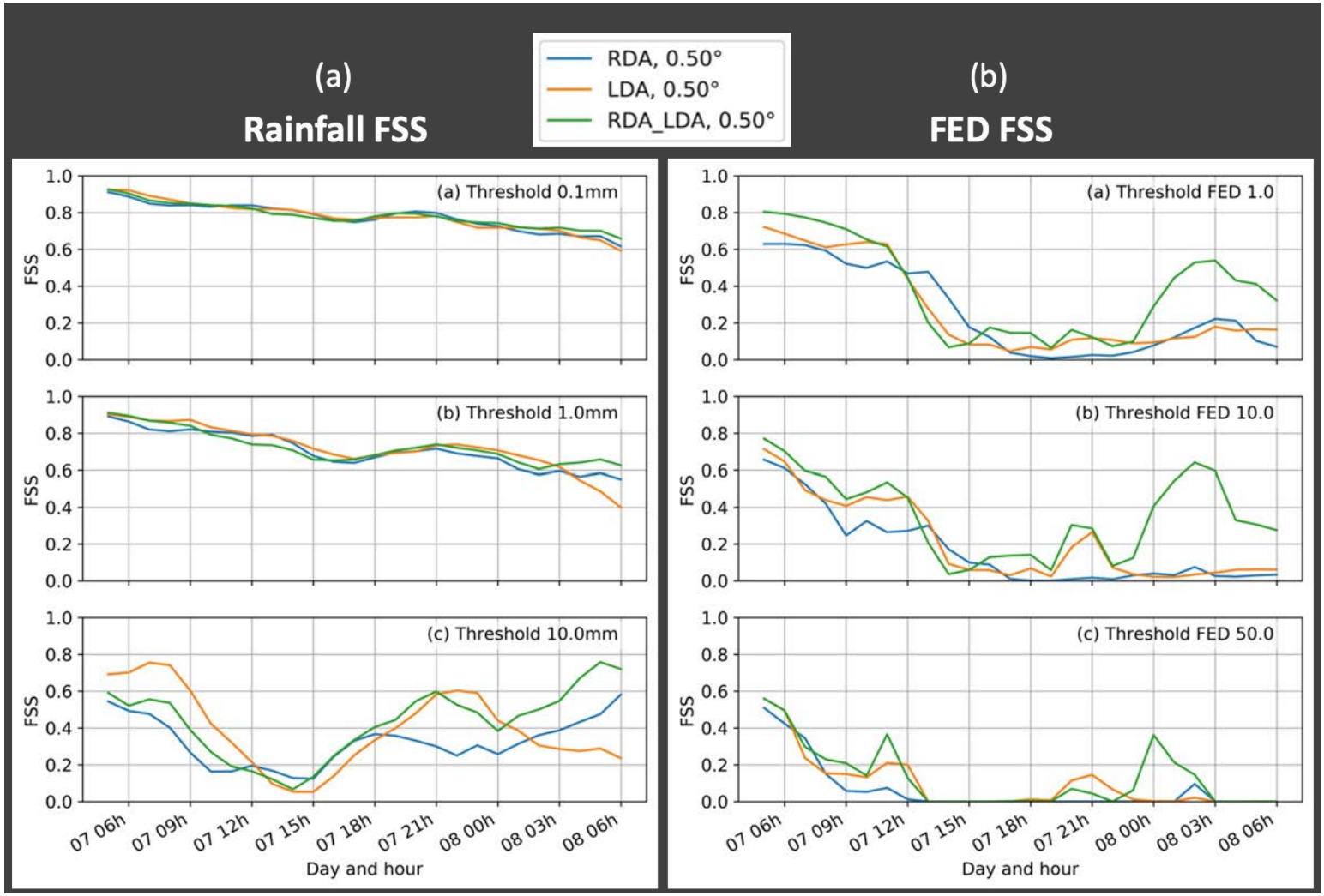
(a) 6 h accumulated rainfall (b) FED forecasts (starting 7 Oct. 2018, 00 UTC)

RDA = Radar Data Assimilation (~operational)

LDA = Lightning Data Assimilation

RDA_LDA = Radar + Lightning Data Assimilation

LDA with similar or even better performance than the RDA

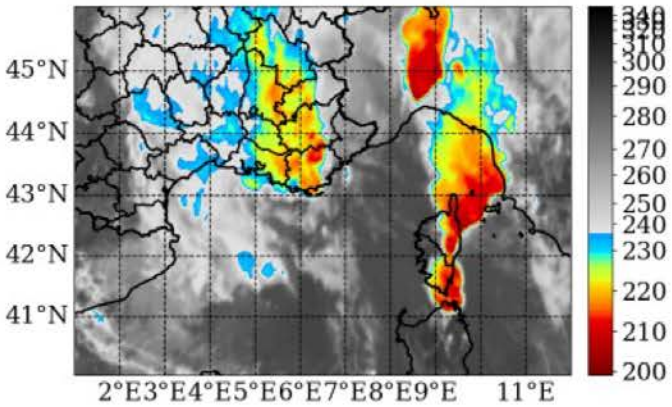


From PhD thesis F. Erdmann

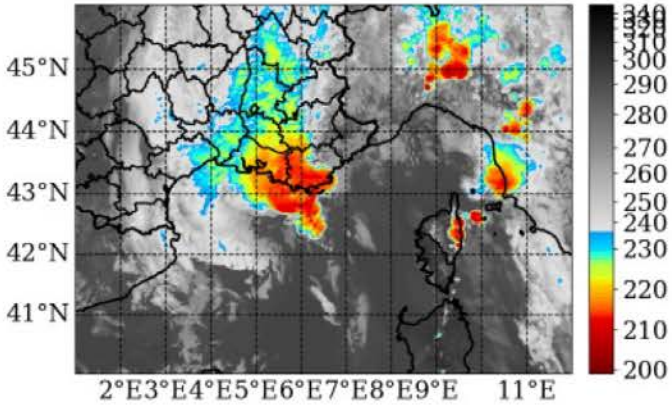
Lightning data assimilation in the Meteo France regional model Arome

In the context of data assimilation in the Meteo France regional model Arome, a sensitivity study was conducted on the best duration of the accumulated lightning product → 10 minutes.

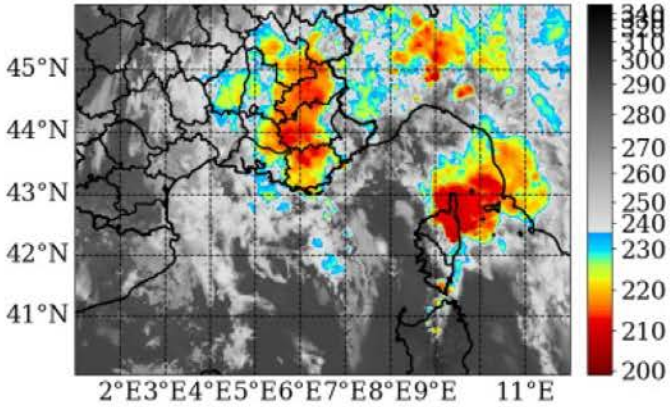
The first assimilation tests show an impact of the use of these observations simulated on stormy situations.



Satellite image



1 hour Arome forecast without lightning assimilation

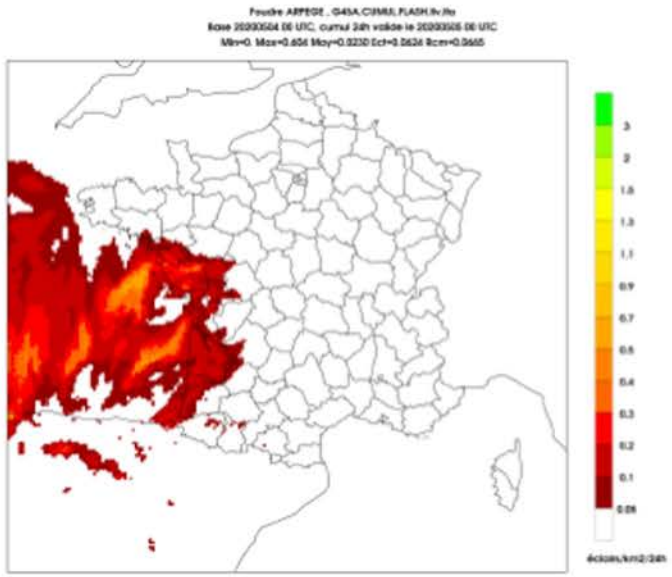


1 hour Arome forecast with lightning assimilation

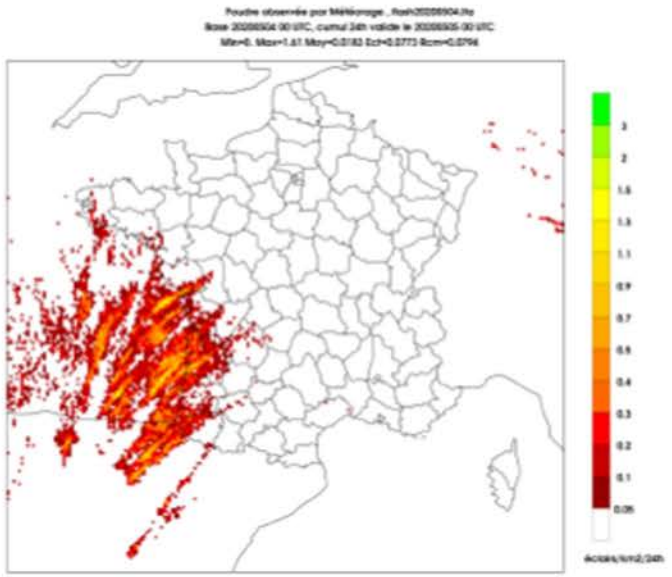
From PhD thesis P. Combarnous

NWP diagnosis illustration

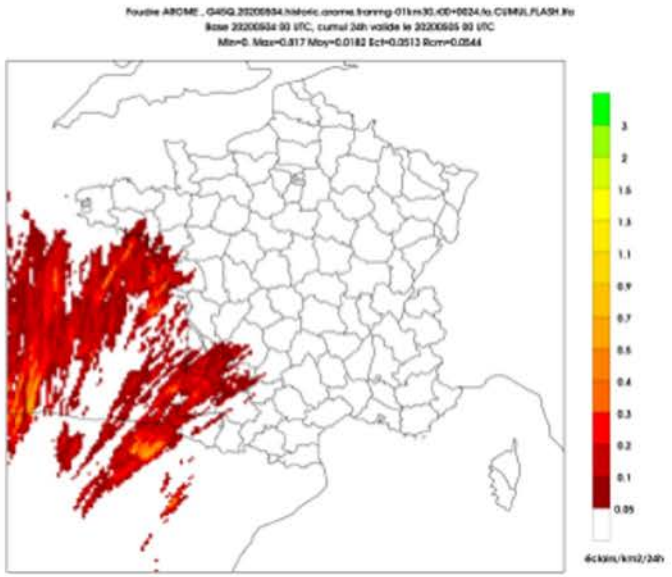
24-hour flash accumulation 4th May 2020, Total lightning / km²



ARPEGE

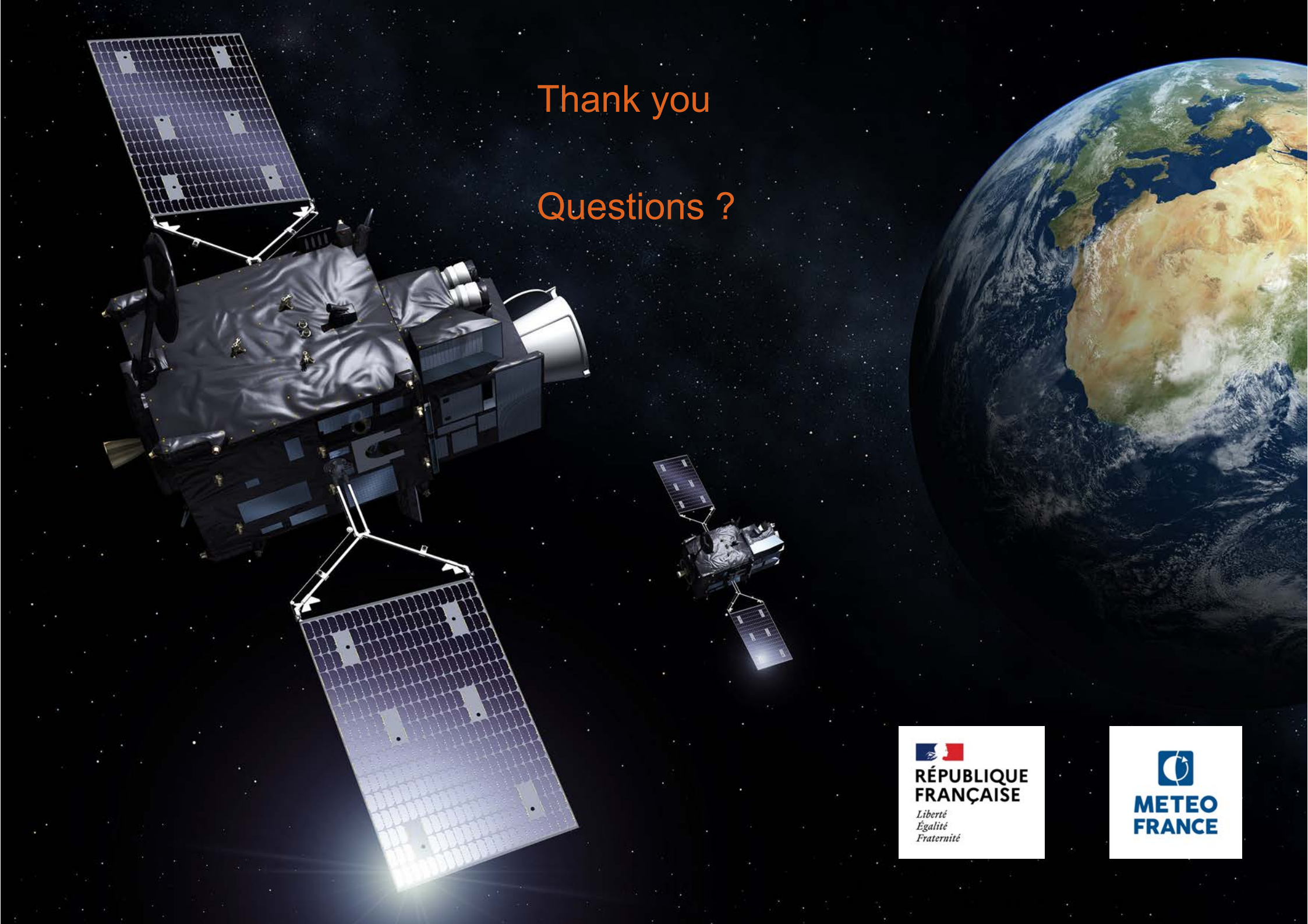


METEORAGE



AROME

NWP lightning diagnosis will need lightning data to be verified.


Thank you
Questions ?
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité
METEO FRANCE