# SHORT-RANGE PREDICTION OF A MEDITERRANEAN SEVERE WEATHER EVENT USING EnKF: CONFIGURATION TESTS

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# OUTLINE

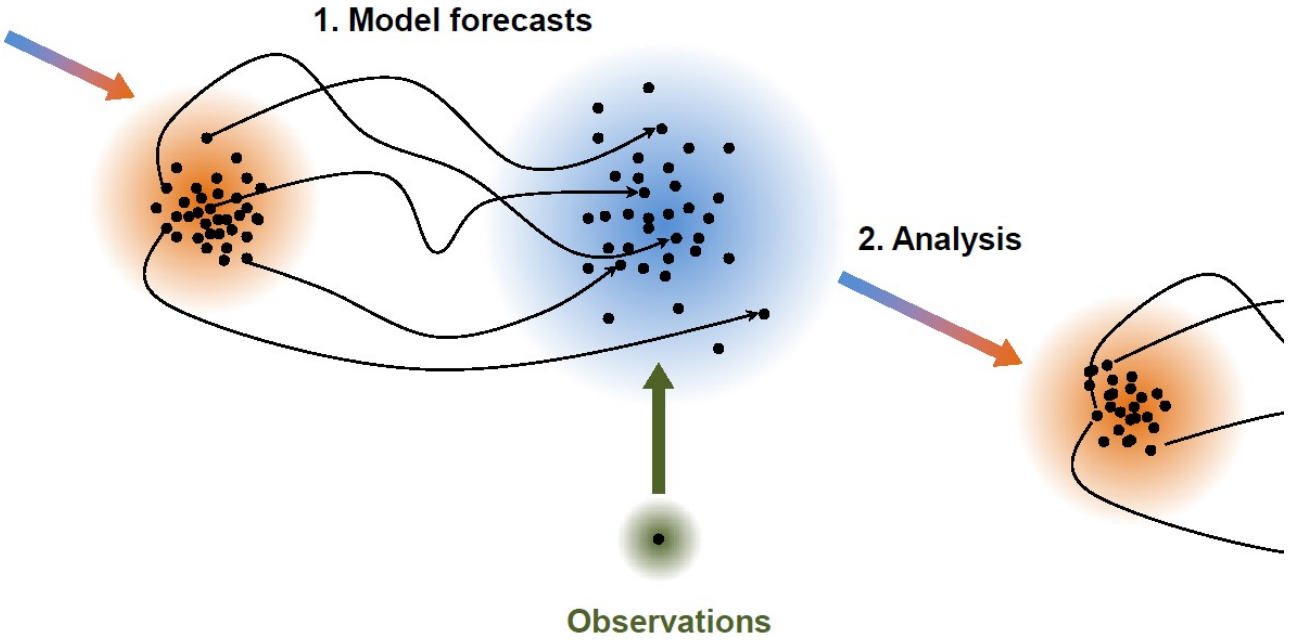
## PART I

- ***Motivation***
- ***Case presentation***
- ***Methodology***

*- Tools and Data*

*- Experiments*

- ***Results***
- ***Conclusions***




## PART II

- ***Future Work***

# PART I

# MOTIVATION

- Current operational forecasts still ***fail*** to predict severe mesoscale events
- Improve mesoscale forecasts to be able to enhance warning systems ***(mitigation)***
- Investigate the skill of a mesoscale ensemble data assimilation ***(EnKF)***
- Predict various aspects of the ***squall line*** occurred on 4th October 2007
- Compare EnKF performance against straightforward downscaling strategies

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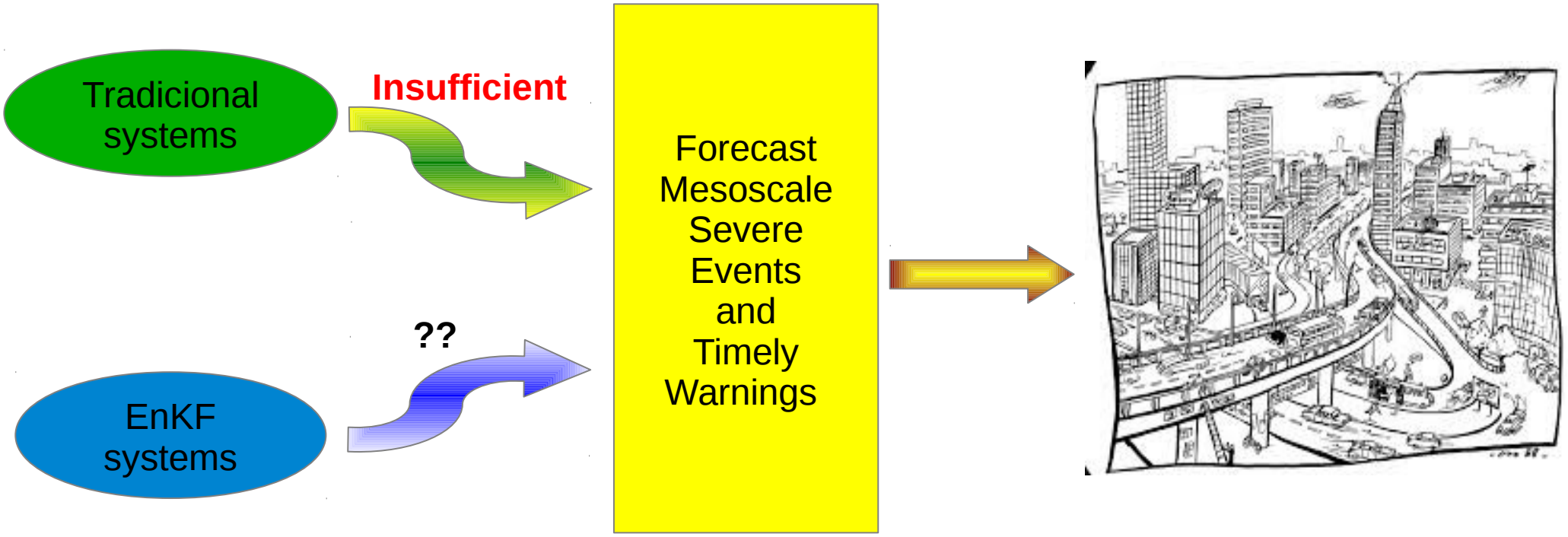
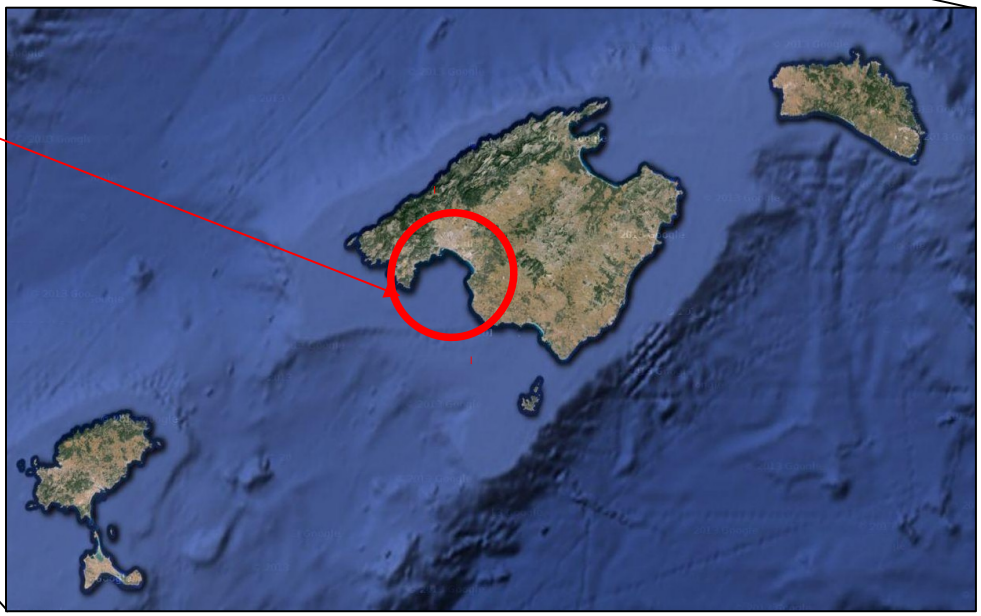


# CASE PRESENTATION

- Location of Mallorca:

Area most Affected by Squall Line



# CASE PRESENTATION

- Severe weather event during the afternoon on **October 4th of 2007** in Palma de Mallorca:

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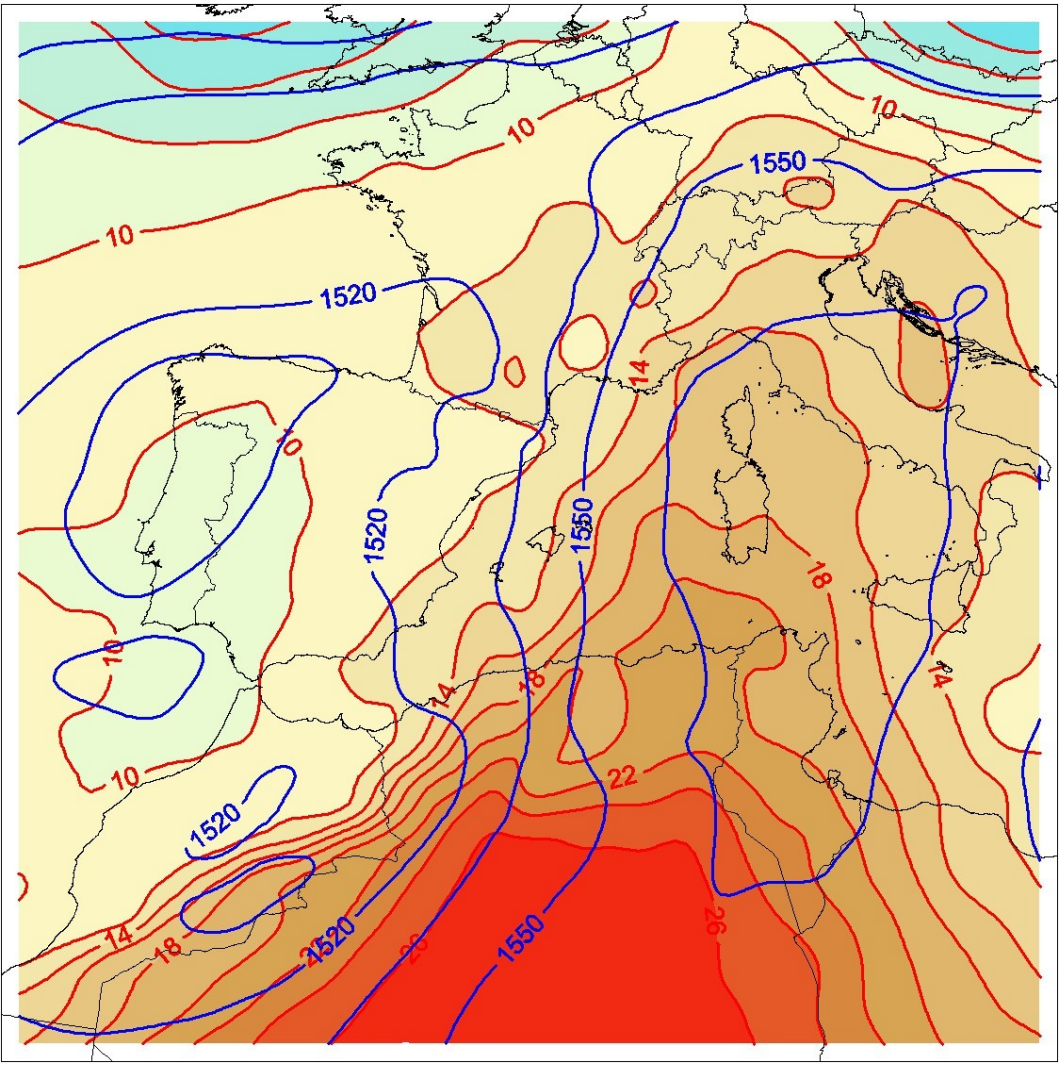
- Severe weather event during the afternoon on **October 4th of 2007** in Palma de Mallorca:

- **One person killed** and huge damage to property in the industrial area estimated at **10 M €**

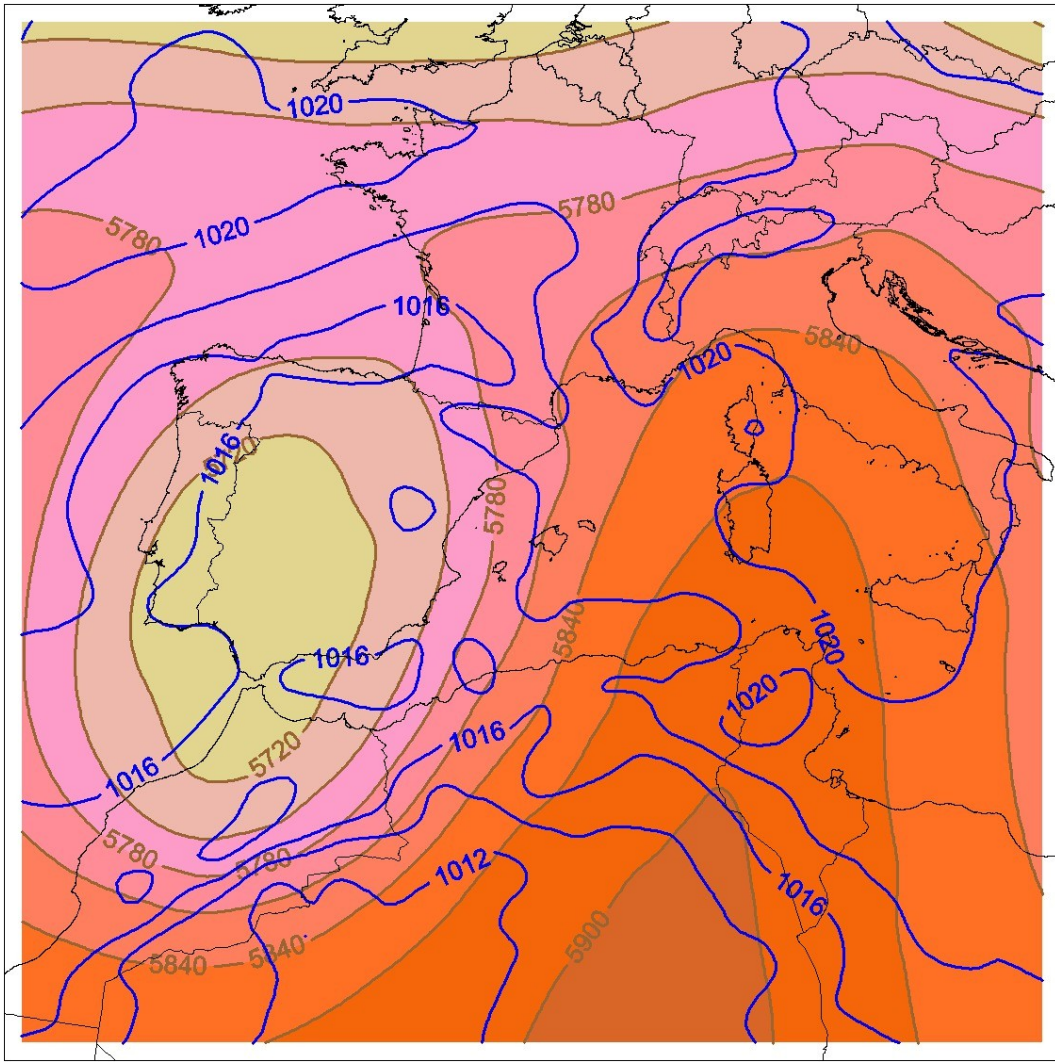
# CASE PRESENTATION

- Meteorological synoptic situation from ECMWF (*) on 4 October 2007 at 00:00 UTC

***850 hPa geopotential height (blue contours) and temperature (colour filled contours)***



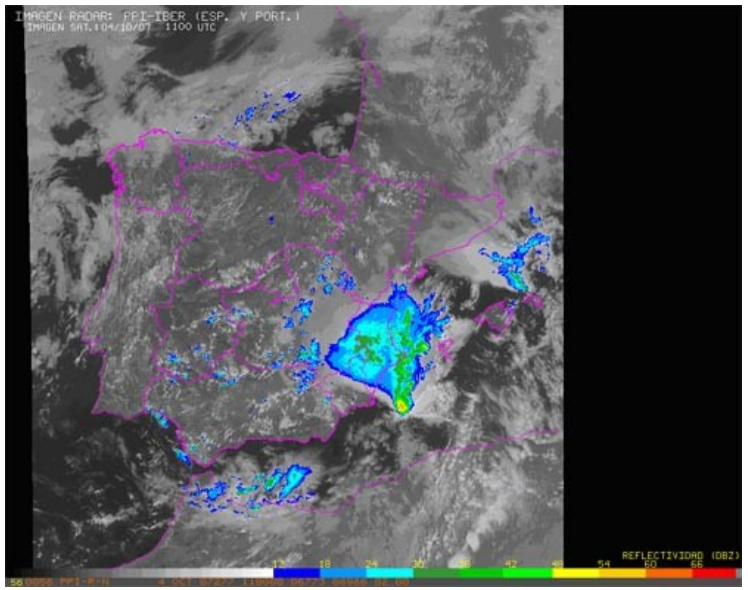

***500 hPa geopotential height (colour filled contours) and sea level pressure (blue contours)***




*(*) ECMWF: European Center for Medium-Range Weather Forecasts*

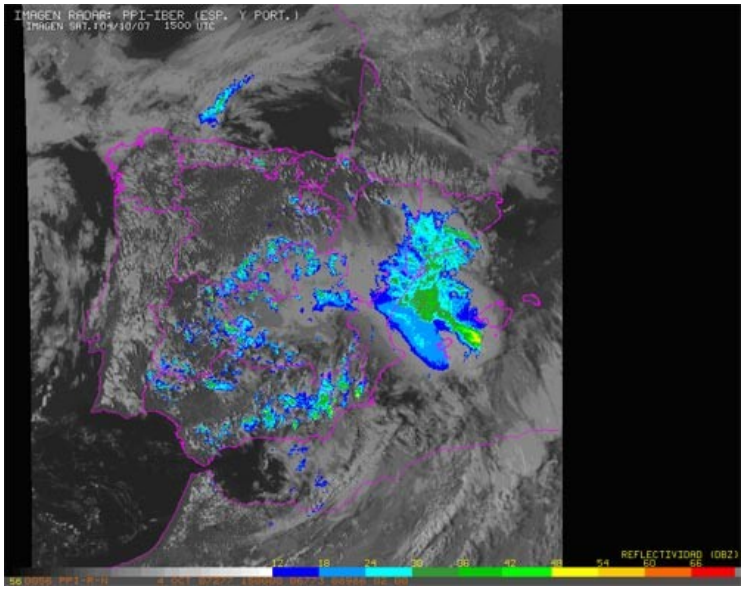
# CASE PRESENTATION

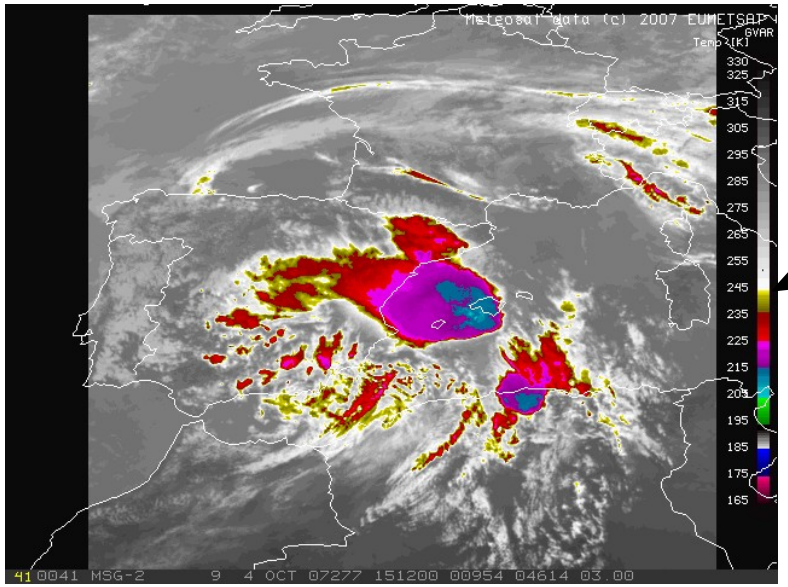
- Squall line organization, initiated in the morning offshore Murcia



Composite image:
Reflectivity
Radar 11:00 UTC
And Meteosat Visible
(squall line organization)

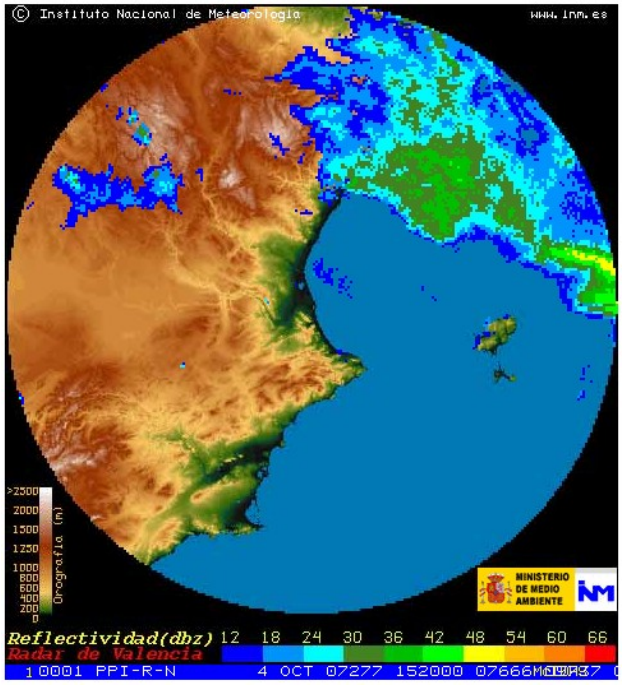
Composite image:
Reflectivity
Radar 15:00 UTC
And Meteosat Visible
(initation)





IR MSG-2,
4 Oct at 15:12 UTC
(cloud top
temperatures)

Reflectivity Radar
(Valencia) at 15:20 UTC



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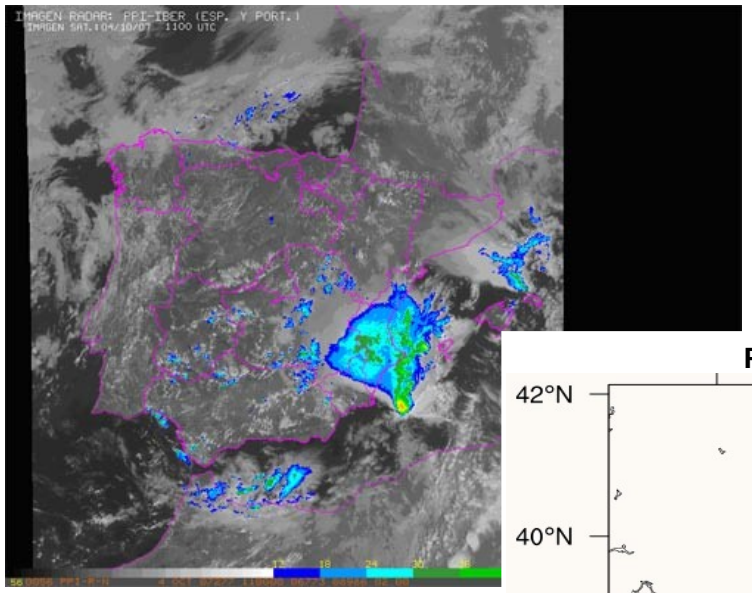

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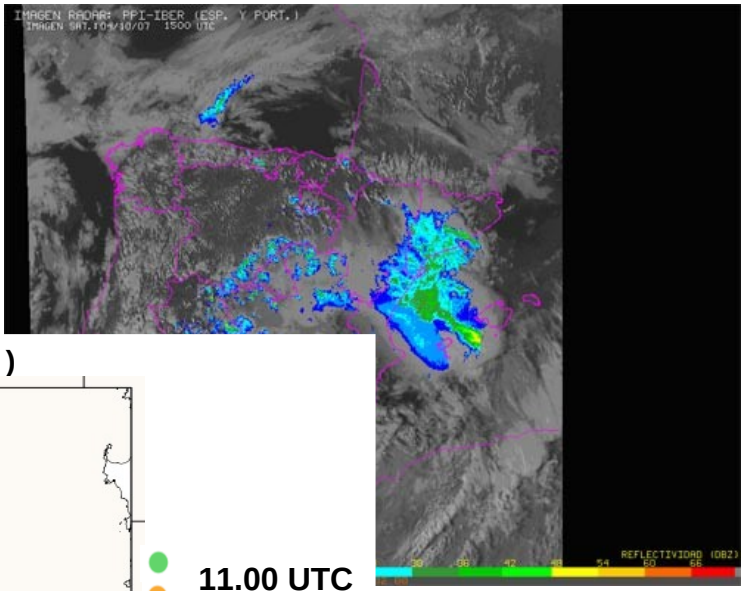
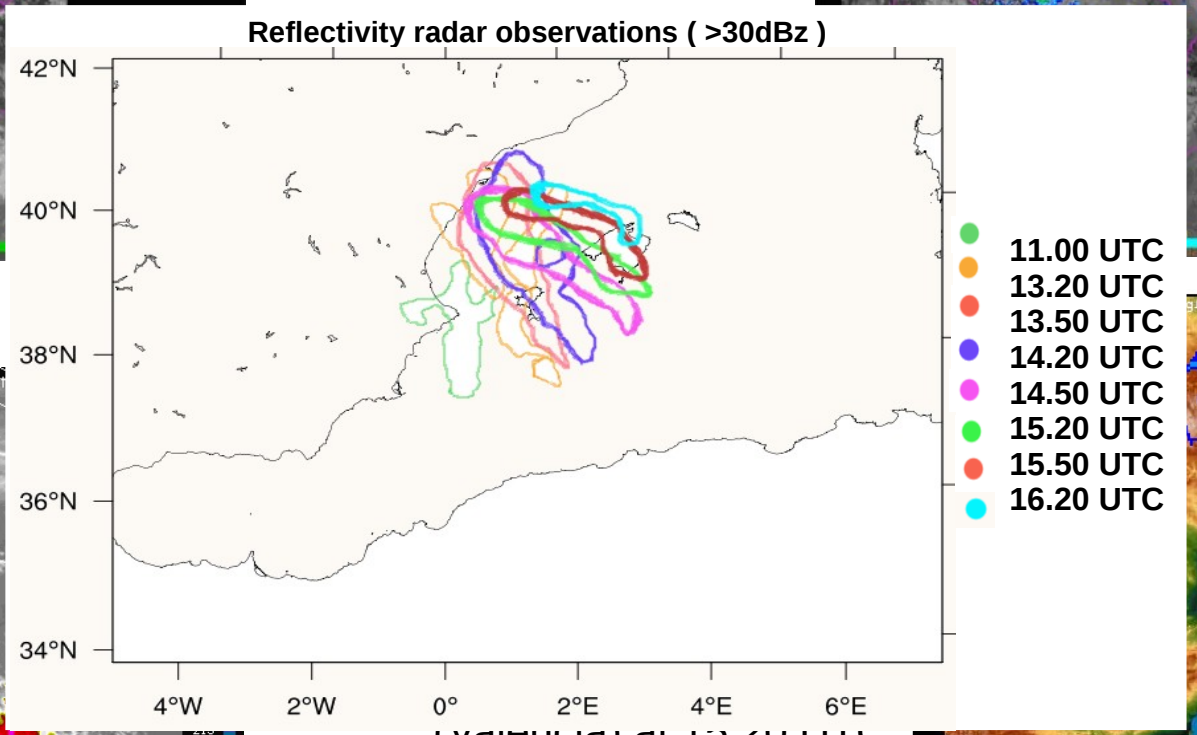
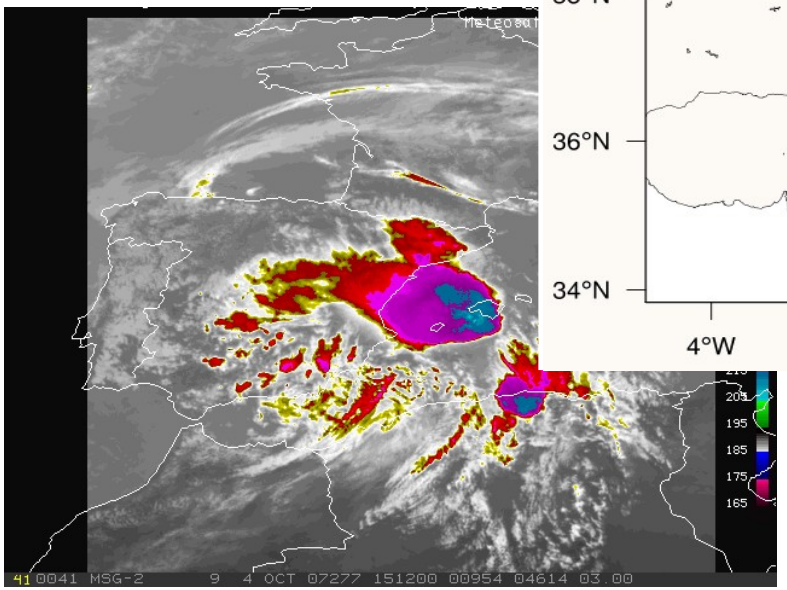
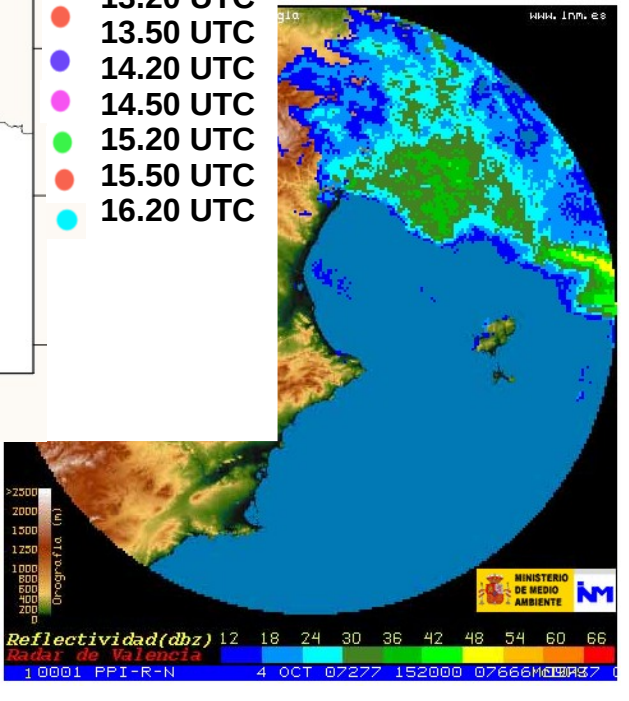




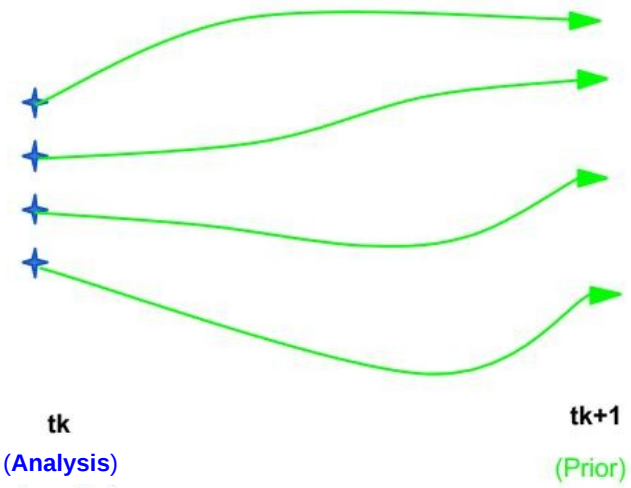
(Valencia) at 15:20 UTC



# METHODOLOGY

## A) TOOLS AND DATA

- Ensemble Kalman Filter (EnKF), used by DART (Data Assimilation Research Testbed) software.



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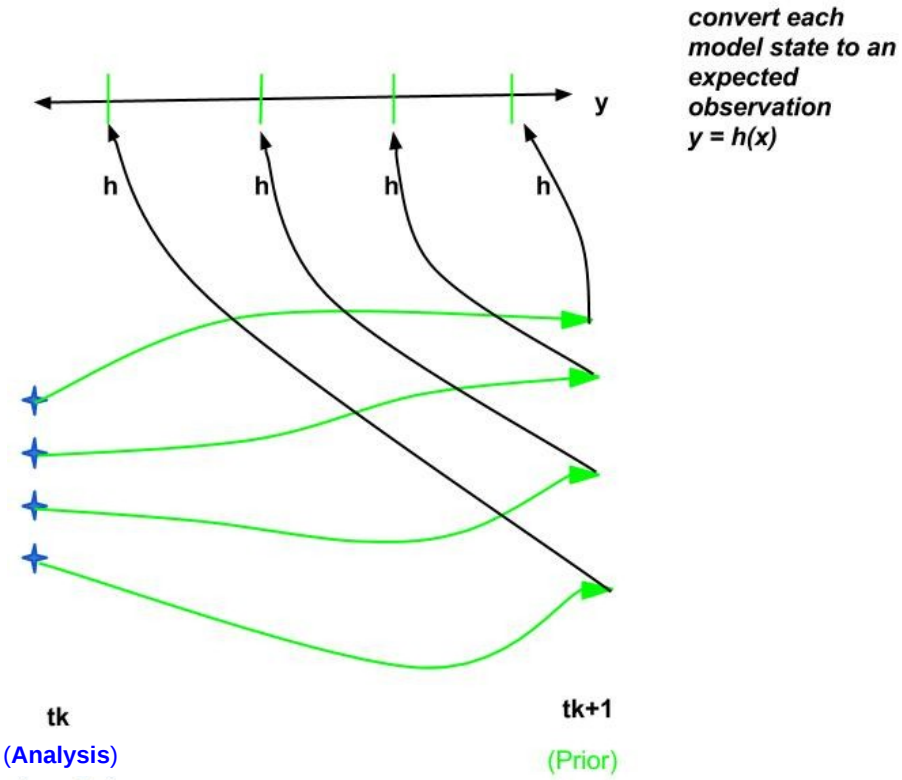

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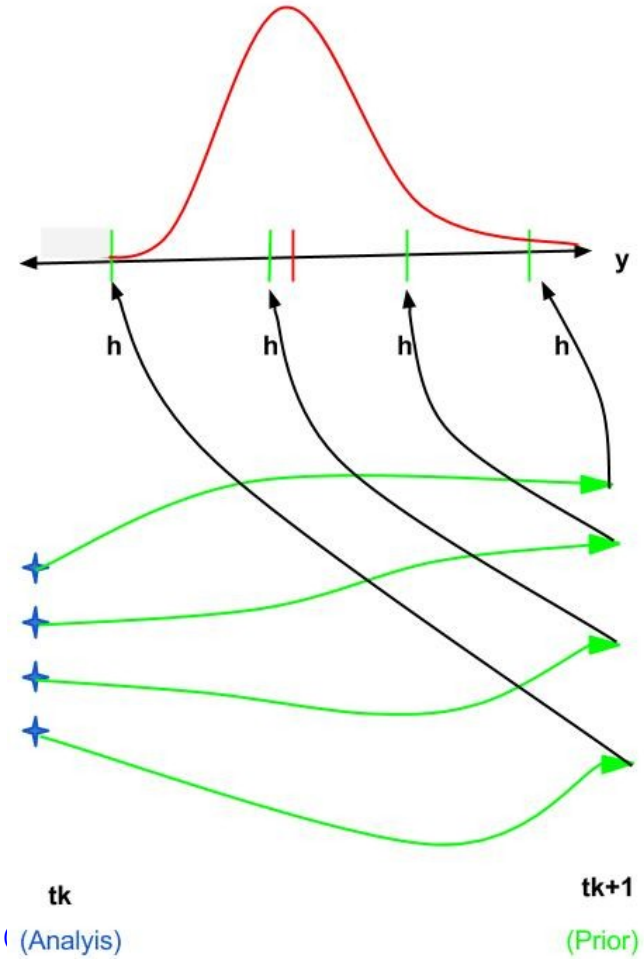


***take observation and observational error distribution***

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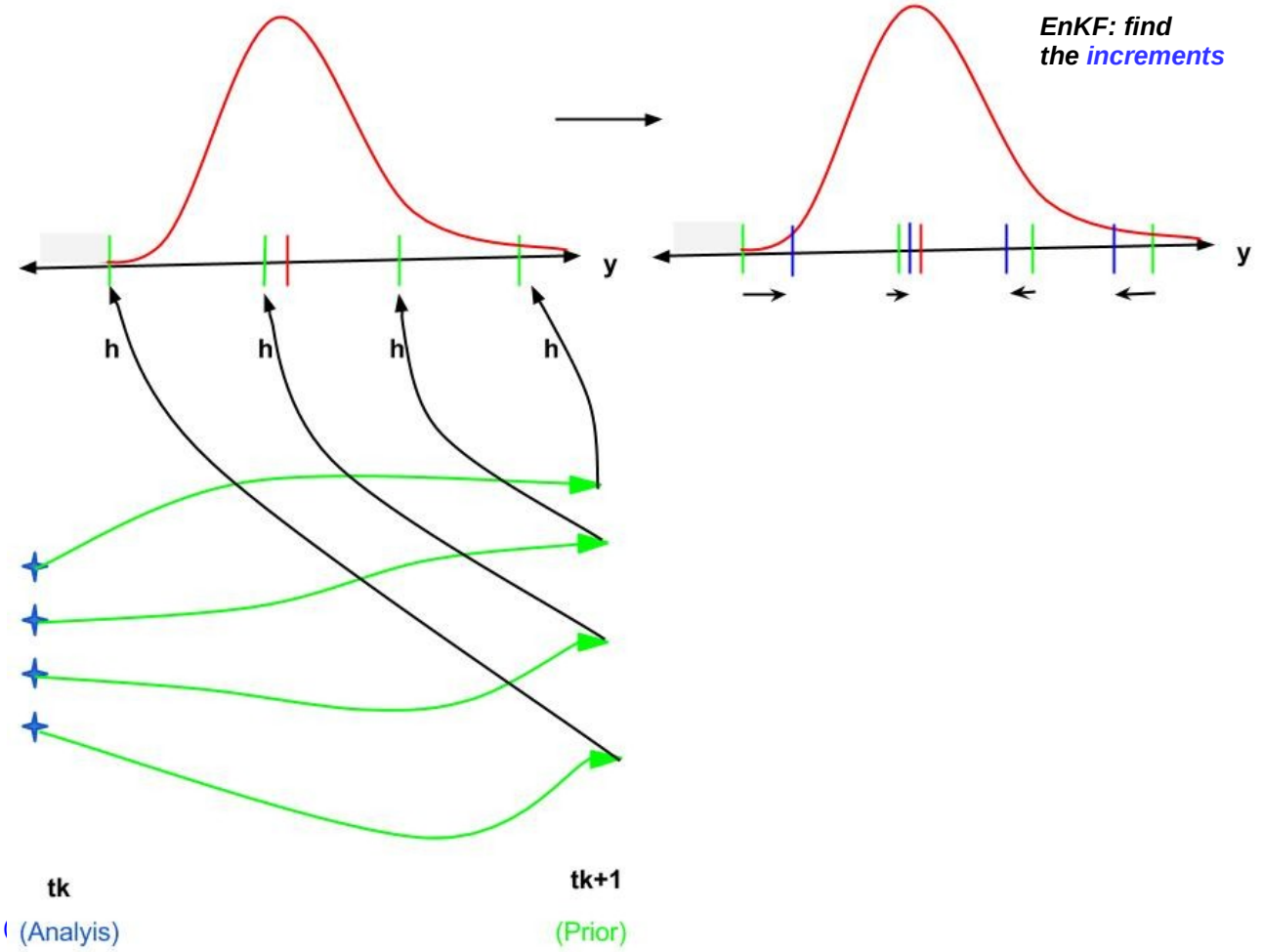

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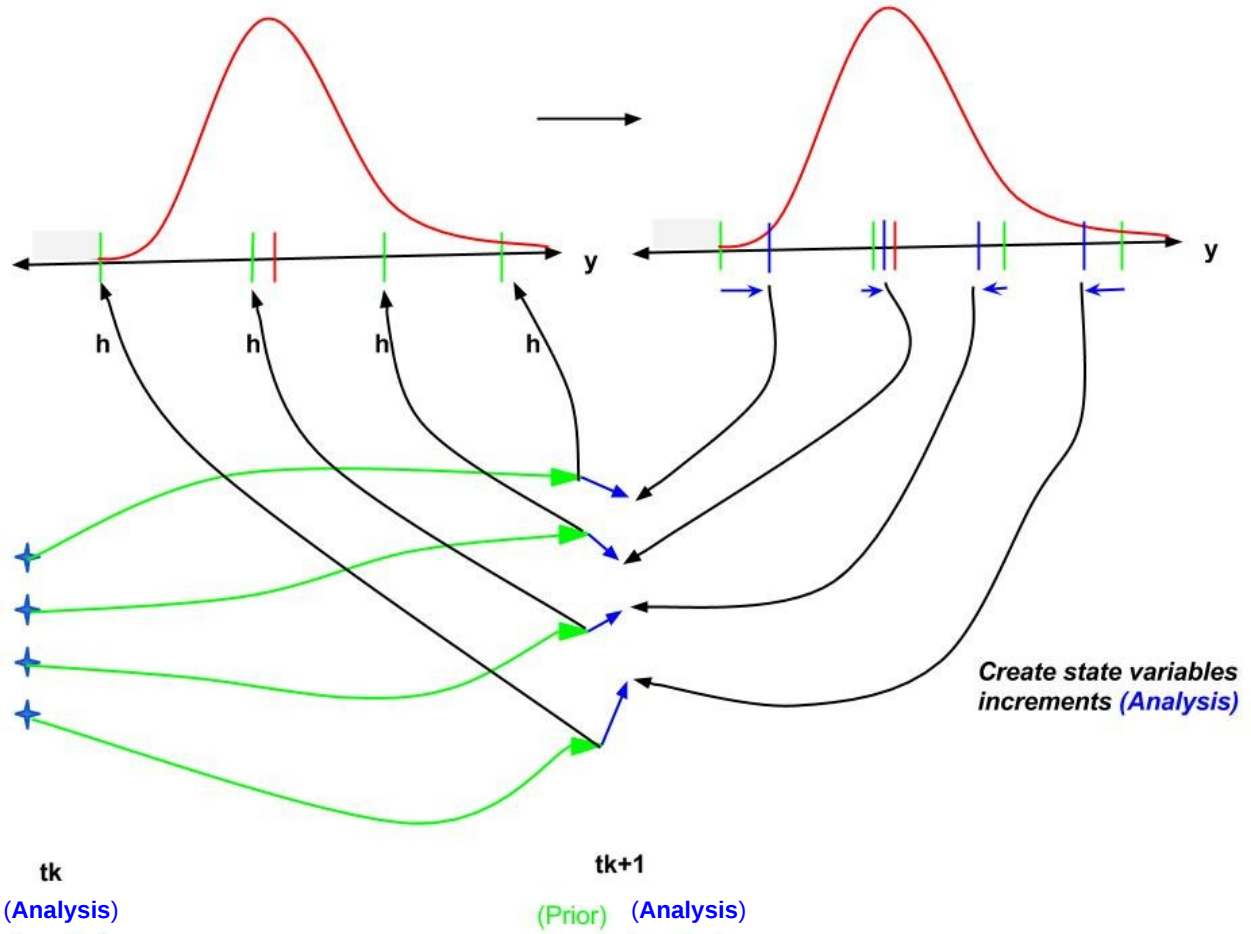

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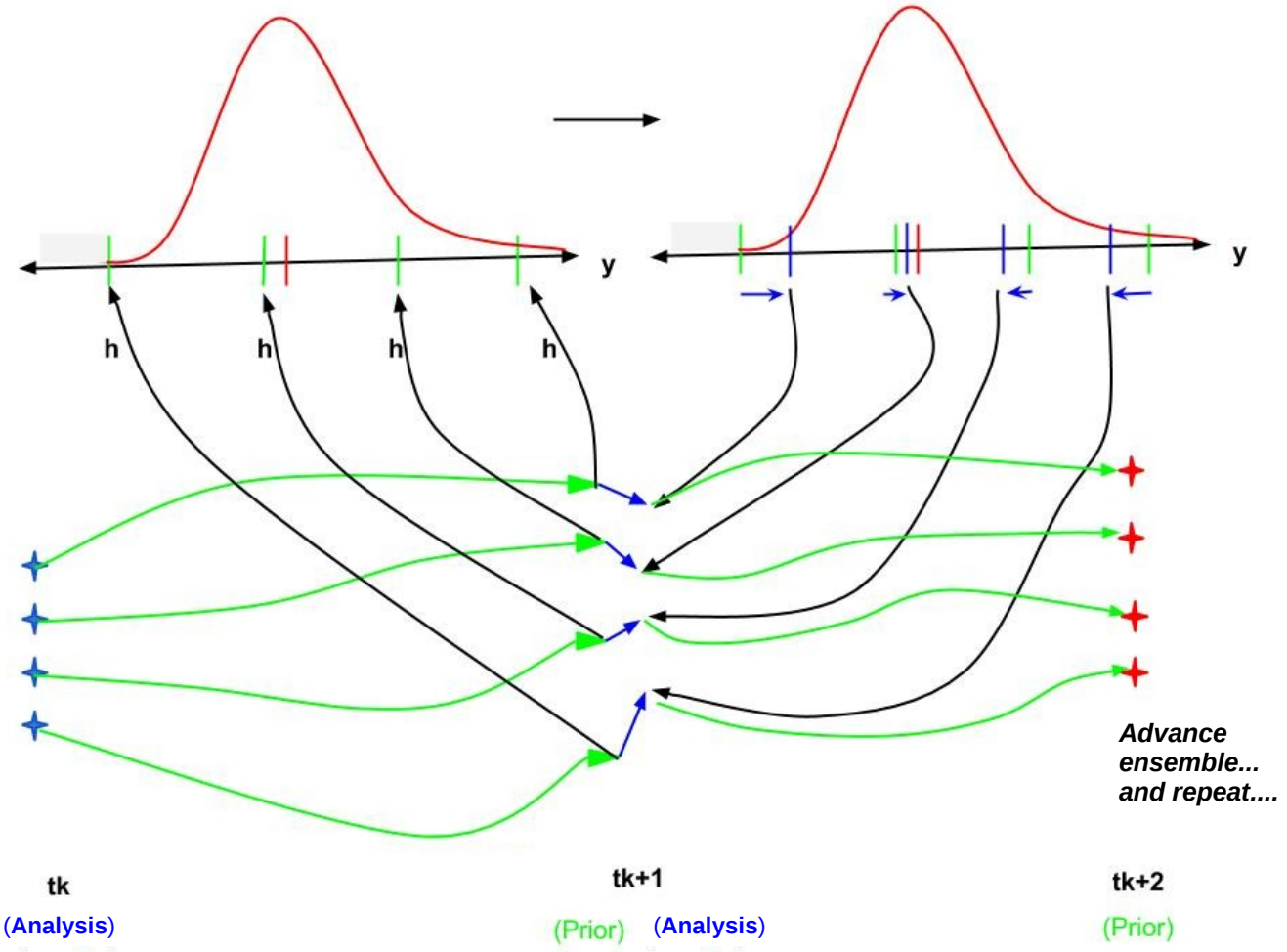


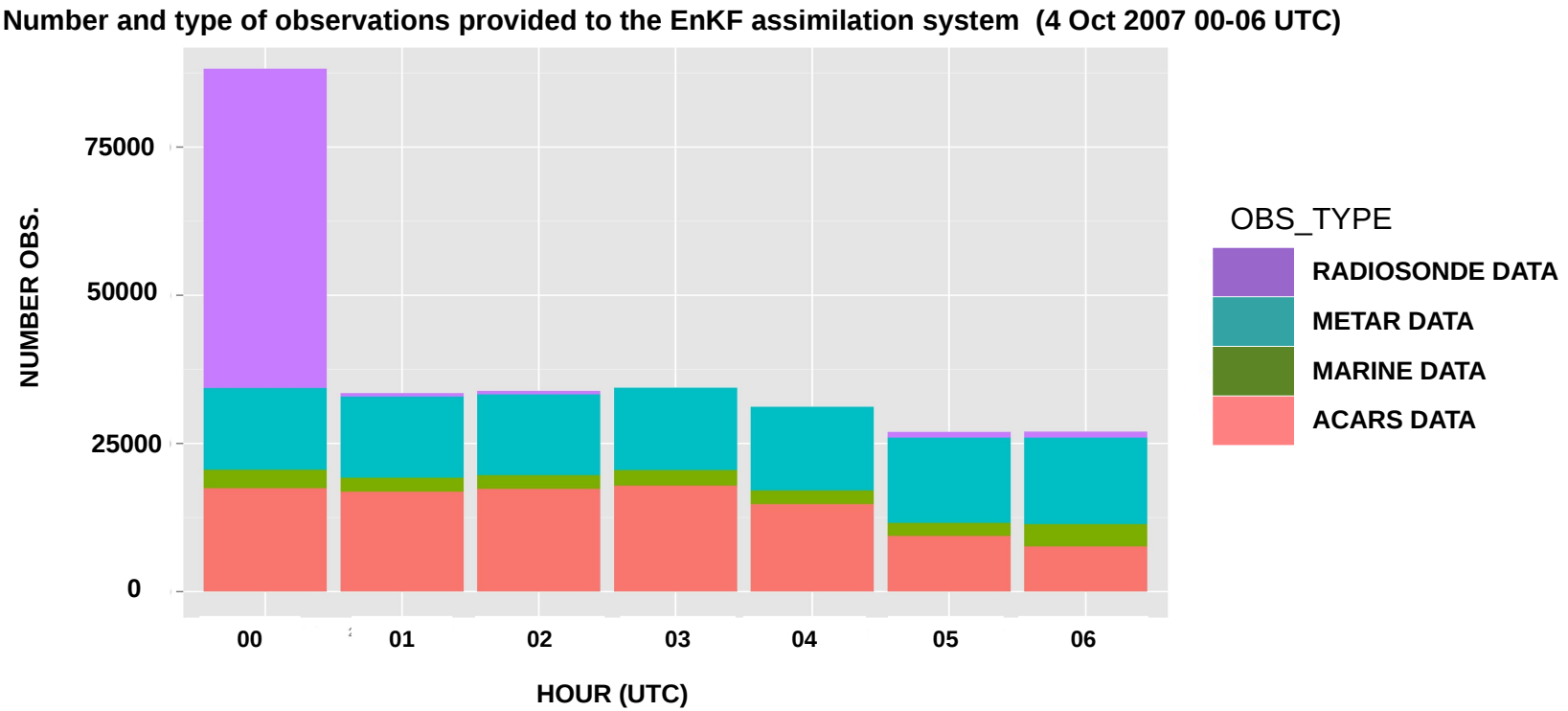
# METHODOLOGY

## A) TOOLS AND DATA

- Characteristics of the EnKF

| |
|---|
| Members of Ensemble: 24 |
| Boundary and Initial Conditions from EPS ECMWF (3h) |
| 1h assimilation cycle with in-situ observations from MADIS |

- Data assimilated from MADIS (Meteorological Assimilation Data Ingest System) source

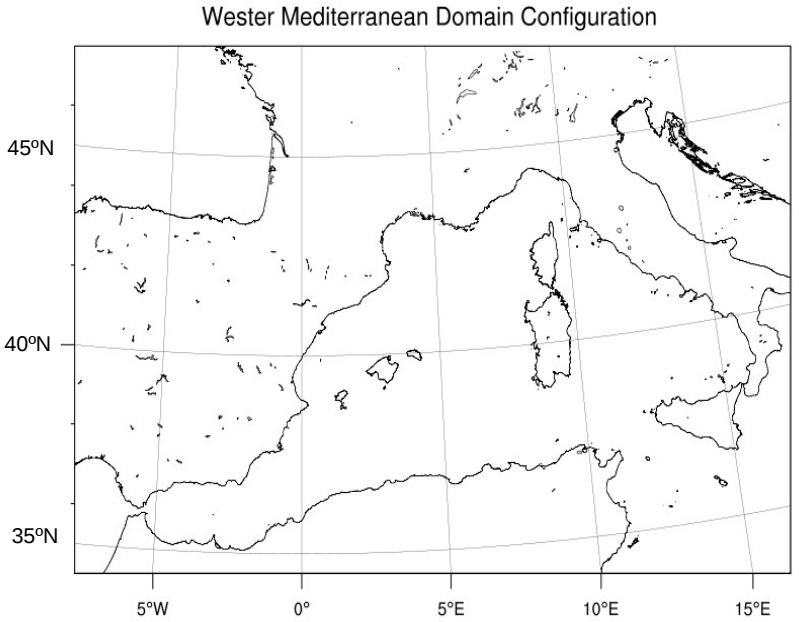


# METHODOLOGY

## A) TOOLS AND DATA

- WRF-ARW (Weather Research and Forecast) model V.3.4: Fully compressible, non-hydrostatic model

| |
|---|
| Domain: 138x93 grid points |
| Δt=60s |
| Δx=16km |
| Vertical levels=50 |
| Number members of ensemble=24 |
| Initial/Boundary Conditions provided by ECMWF EPS |

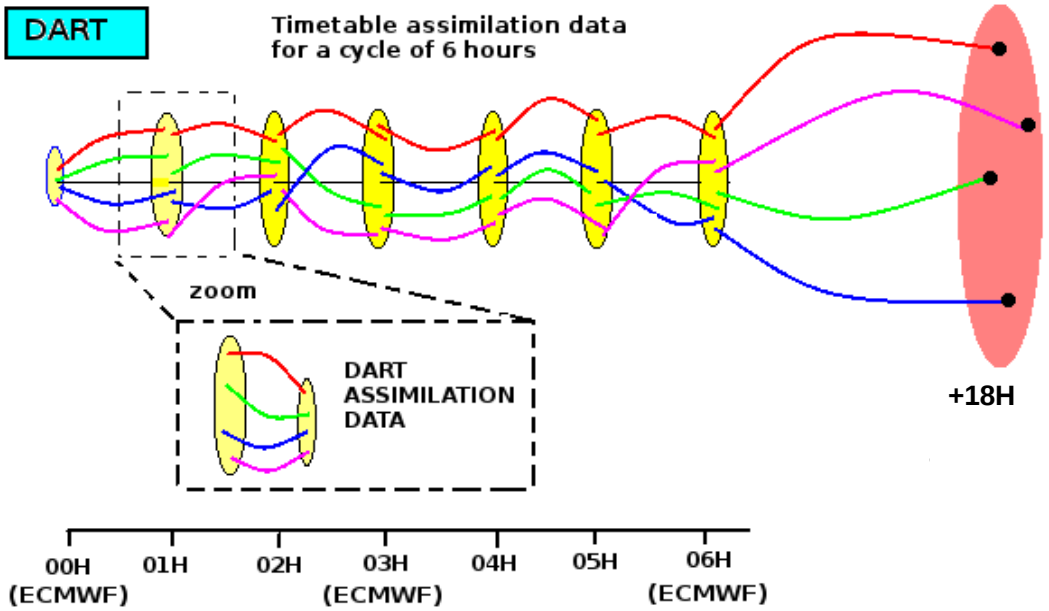



- Multiphysic configurations: 24 members with 4 PBL schemes, 3 prescribed concentrations of cloud condensation nuclei and 2 cumulus schemes:

| **PBL** | YSU | MYJ | ACM2 | MYNN2 |
|---|---|---|---|---|
| **CCN** | 1,5E9 | 1,0E9 | 0,5E9 | |
| **Cumuls** | Kain-Fritsch | New Simplied Arakawa-Schubert | | |

# METHODOLOGY

## B) EXPERIMENTS



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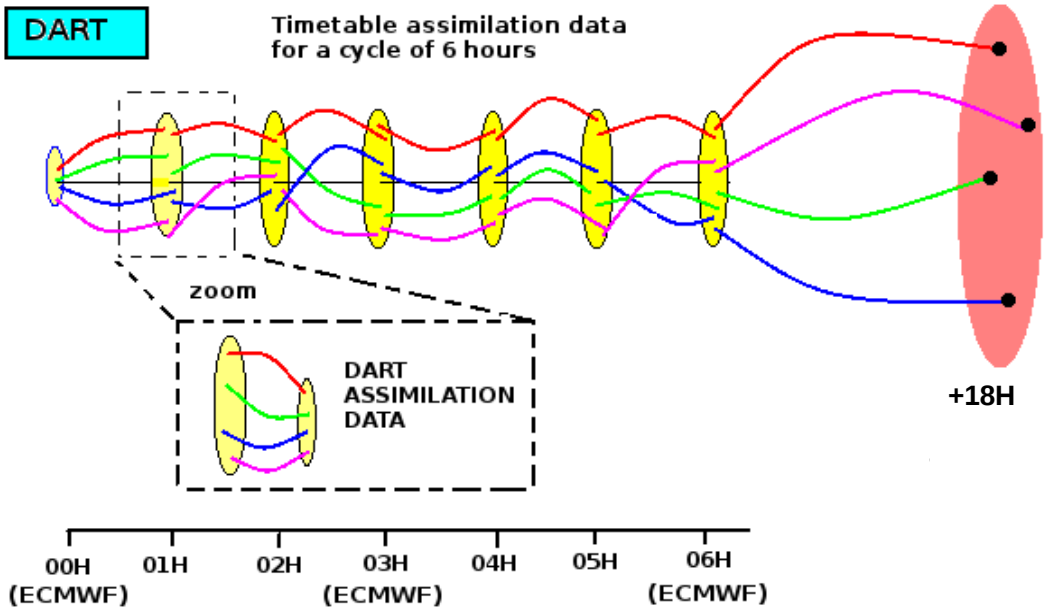


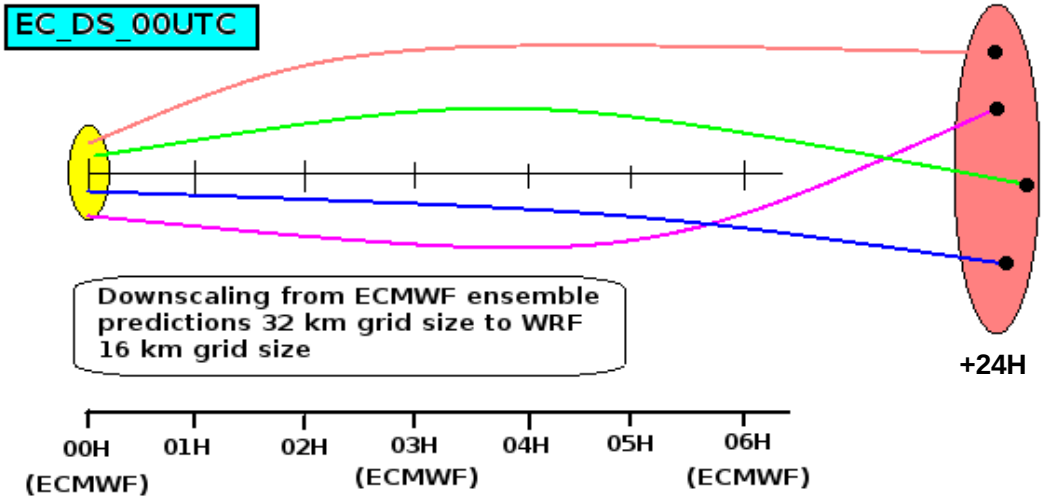

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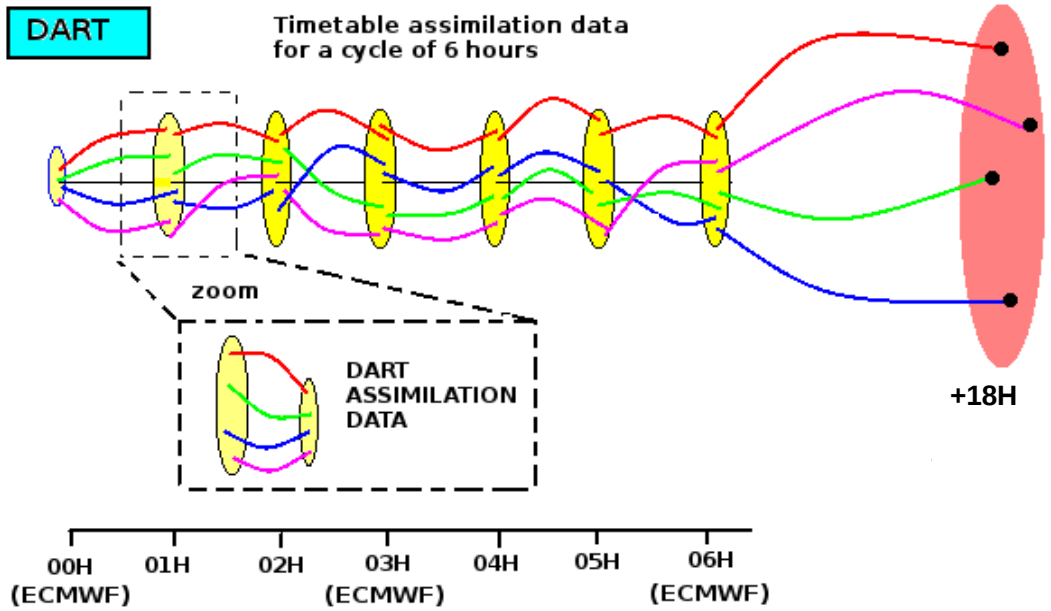
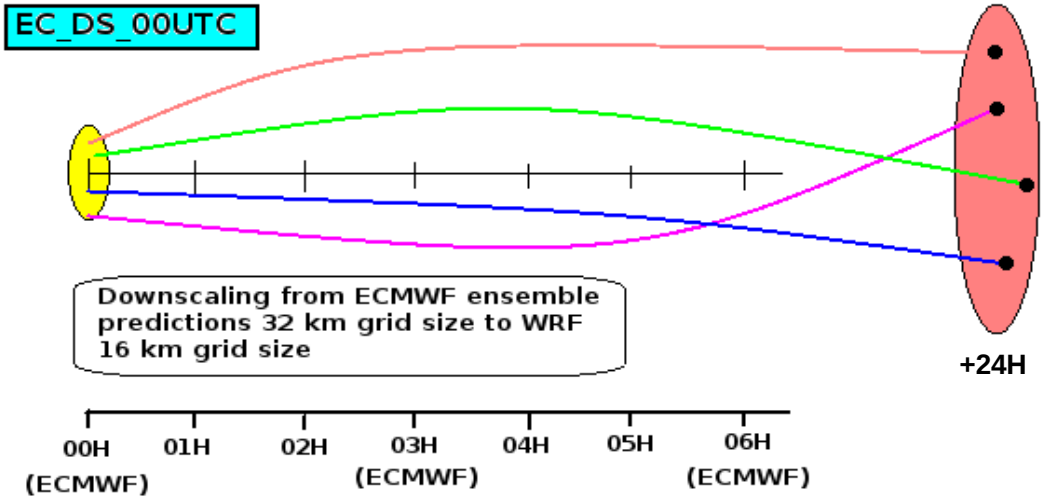
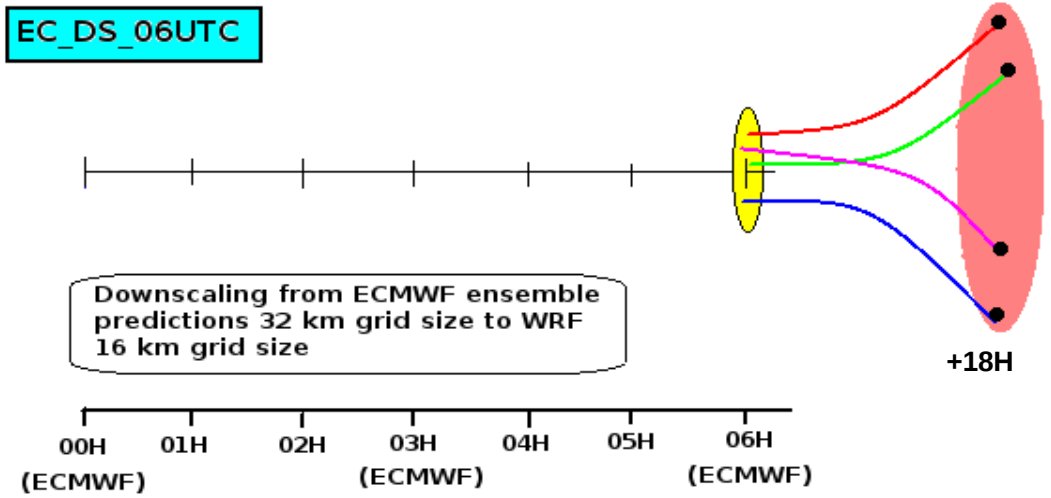


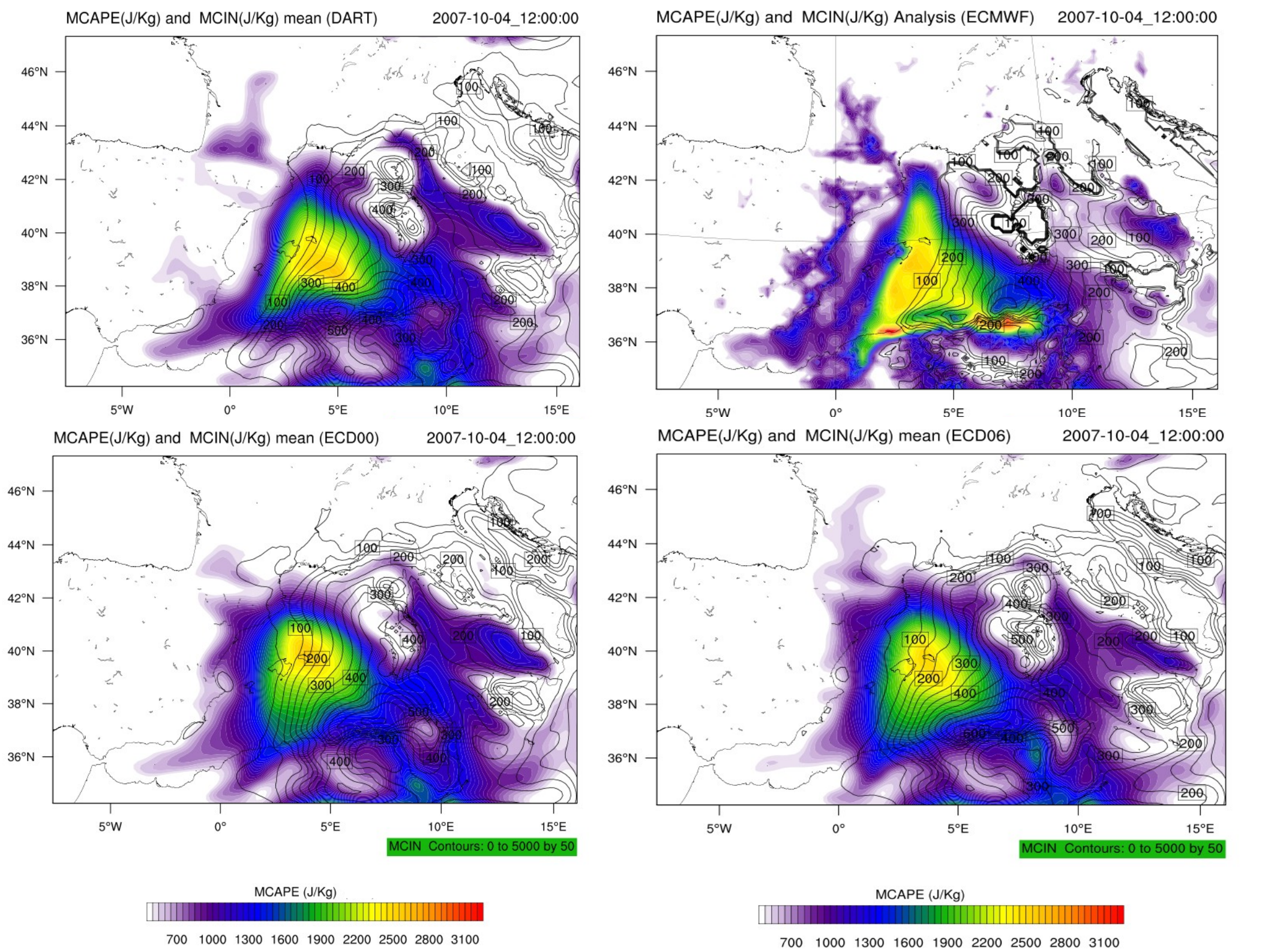



# RESULTS

**Products**:

**- CAPE + CIN mean**
- CAPE + CIN maximum
- Divergence and convective activity
- Probability of Severe Weather (PoS)


MCAPE(J/Kg) and MCIN(J/Kg) mean (DART) 2007-10-04_12:00:00
MCAPE(J/Kg) and MCIN(J/Kg) Analysis (ECMWF) 2007-10-04_12:00:00
MCAPE(J/Kg) and MCIN(J/Kg) mean (ECD00) 2007-10-04_12:00:00
MCAPE(J/Kg) and MCIN(J/Kg) mean (ECD06) 2007-10-04_12:00:00
46°N
44°N
42°N
40°N
38°N
36°N
5°W
0°
5°E
10°E
15°E
MCIN Contours: 0 to 5000 by 50
MCAPE (J/Kg)
700 1000 1300 1600 1900 2200 2500 2800 3100

# RESULTS

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**- CAPE + CIN maximum**
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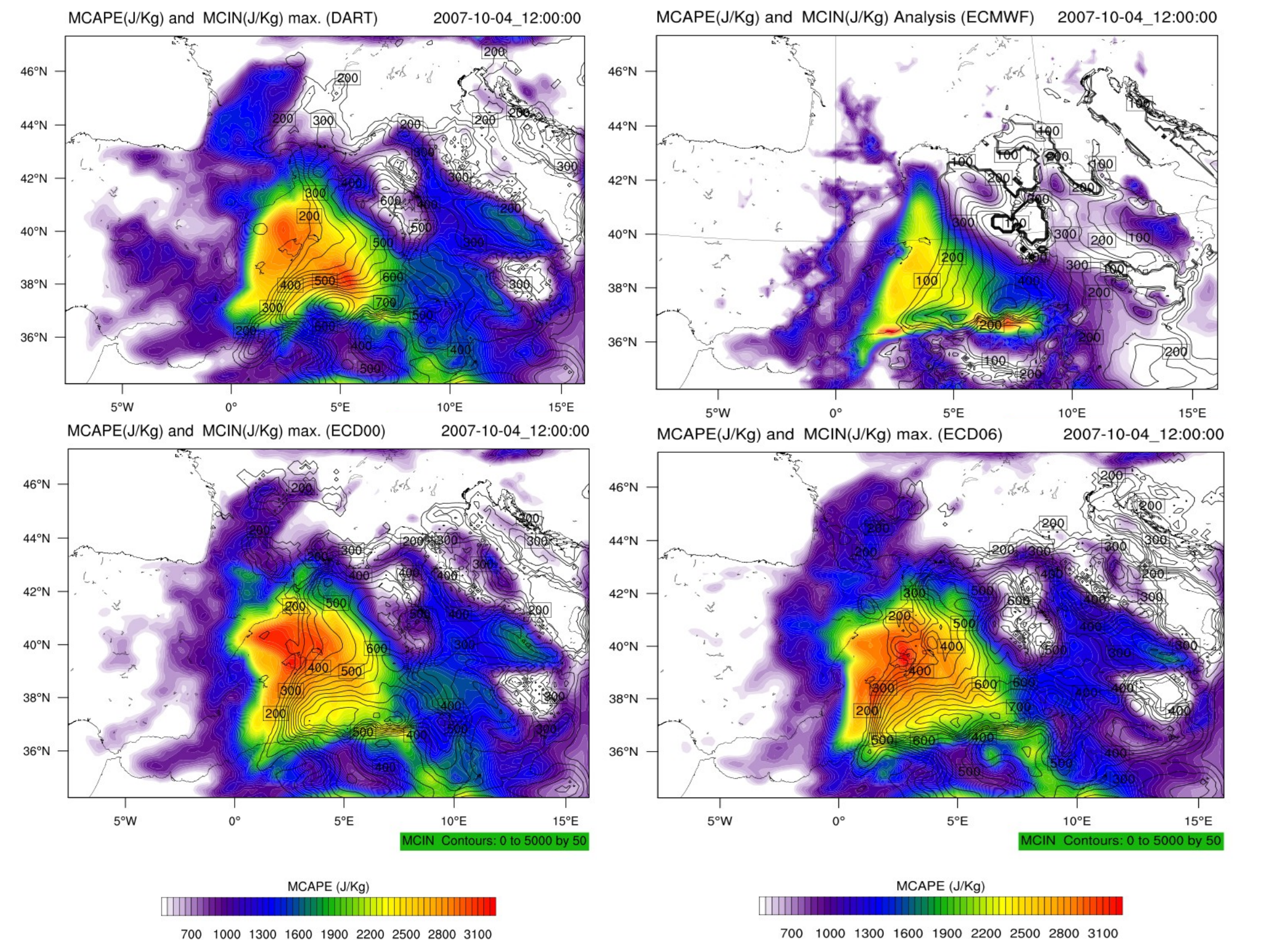
MCAPE(J/Kg) and MCIN(J/Kg) max. (DART) 2007-10-04_12:00:00
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46°N
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MCIN Contours: 0 to 5000 by 50
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700 1000 1300 1600 1900 2200 2500 2800 3100

# RESULTS

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- CAPE + CIN mean
- CAPE + CIN maximum
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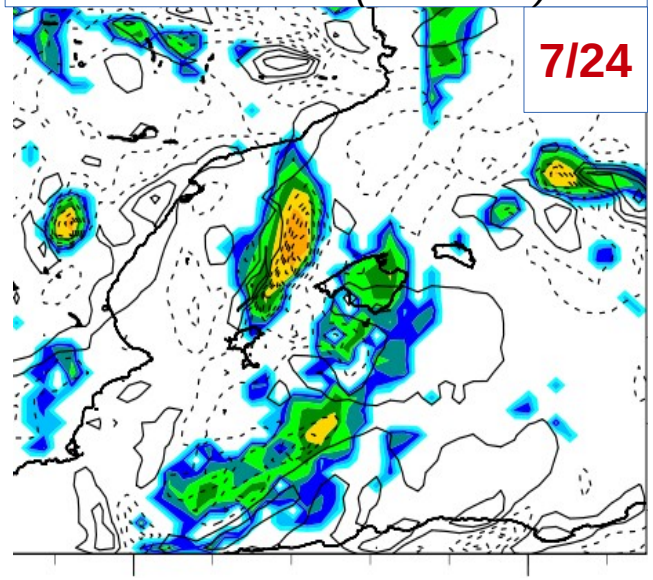
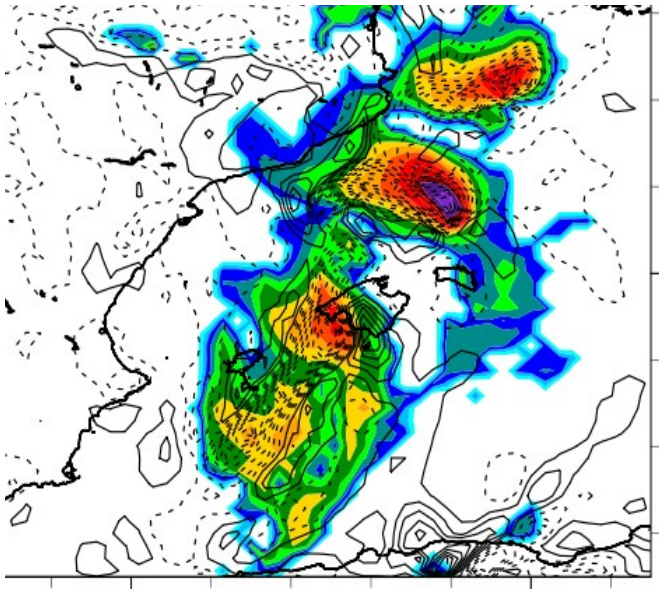
## DART:

*Divergence (s^-1) and max. reflectivity (dBz)*

*Best Initiation (memb:17)*



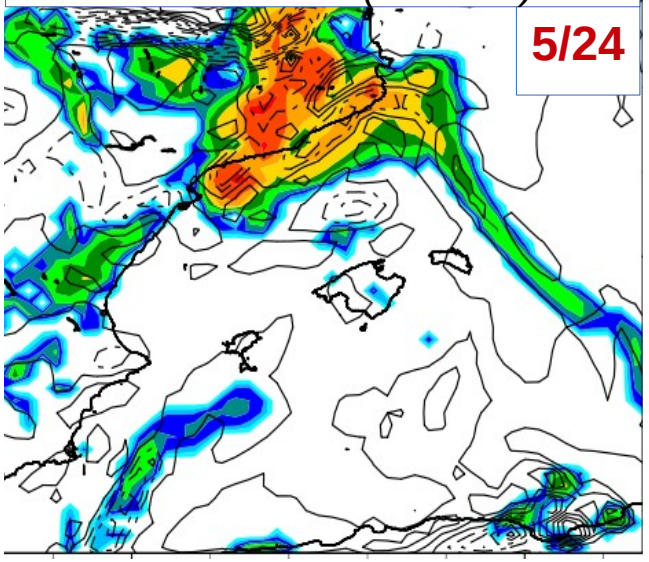

*Evolution event (memb:17)*



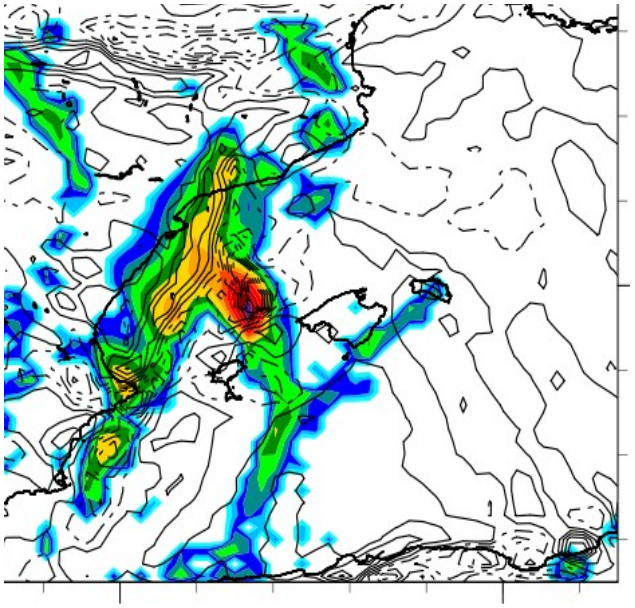
## EC_DS_00:

*Divergence (s^-1) and max. reflectivity (dBz)*

*Best Initiation (memb:1)*



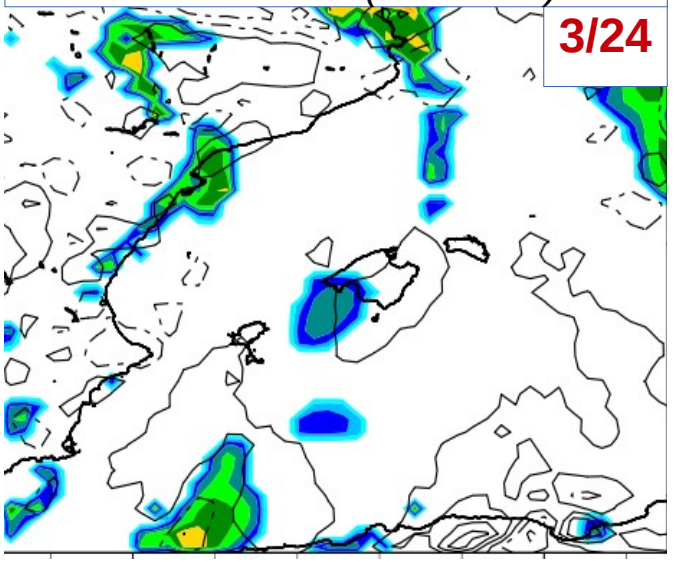

*Evolution event (memb:1)*



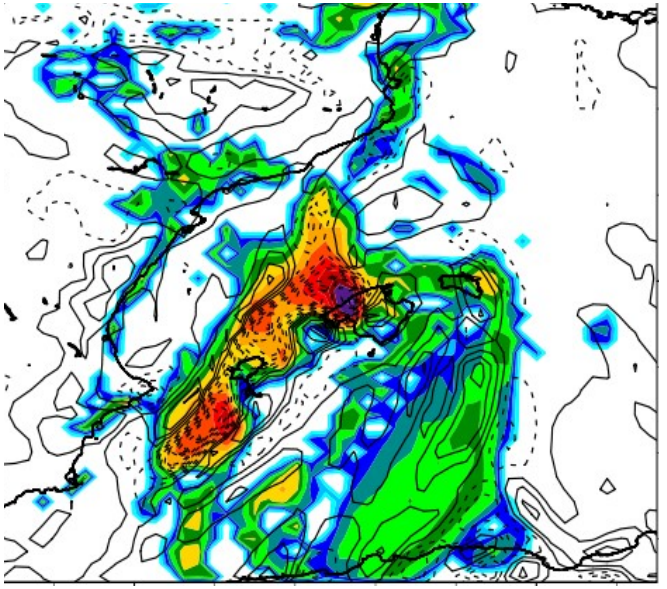
## EC_DS_06:

*Divergence (s^-1) and max. reflectivity (dBz)*

*Best Initiation (memb:24)*




*Evolution event (memb:24)*



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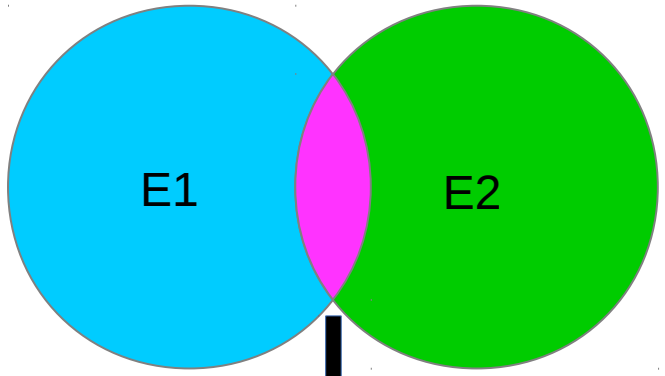
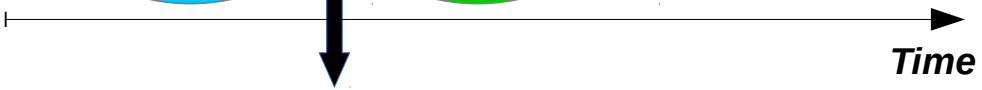
**Venn Diagram**




*E1 : Probability of severe weather at 7 UTC*

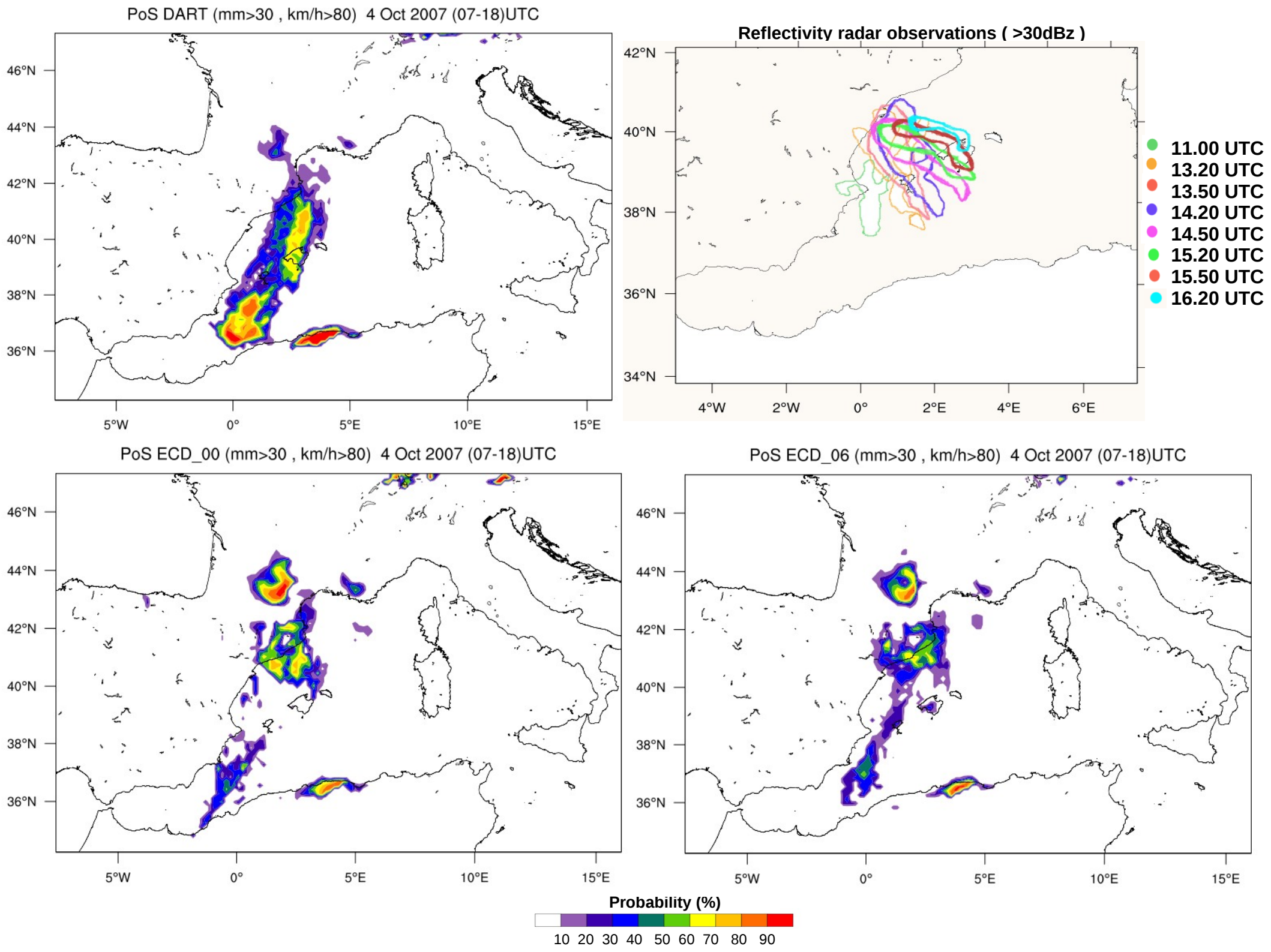
*E2 : Probability of severe weather at 8 UTC*




Intersection of E1 and E2

**Additive law of probabilities**

$$Pr\{E1 \cup E2\} = Pr\{E1\} + Pr\{E2\} - Pr\{E1 \cap E2\}$$


PoS DART (mm>30 , km/h>80) 4 Oct 2007 (07-18)UTC
Reflectivity radar observations ( >30dBz )
11.00 UTC
13.20 UTC
13.50 UTC
14.20 UTC
14.50 UTC
15.20 UTC
15.50 UTC
16.20 UTC
PoS ECD_00 (mm>30 , km/h>80) 4 Oct 2007 (07-18)UTC
PoS ECD_06 (mm>30 , km/h>80) 4 Oct 2007 (07-18)UTC
Probability (%)
10 20 30 40 50 60 70 80 90

# CONCLUSIONS

- DART EnKF has shown large potential of these forecasting systems in advecting observational information from land sites toward data-void areas over the sea

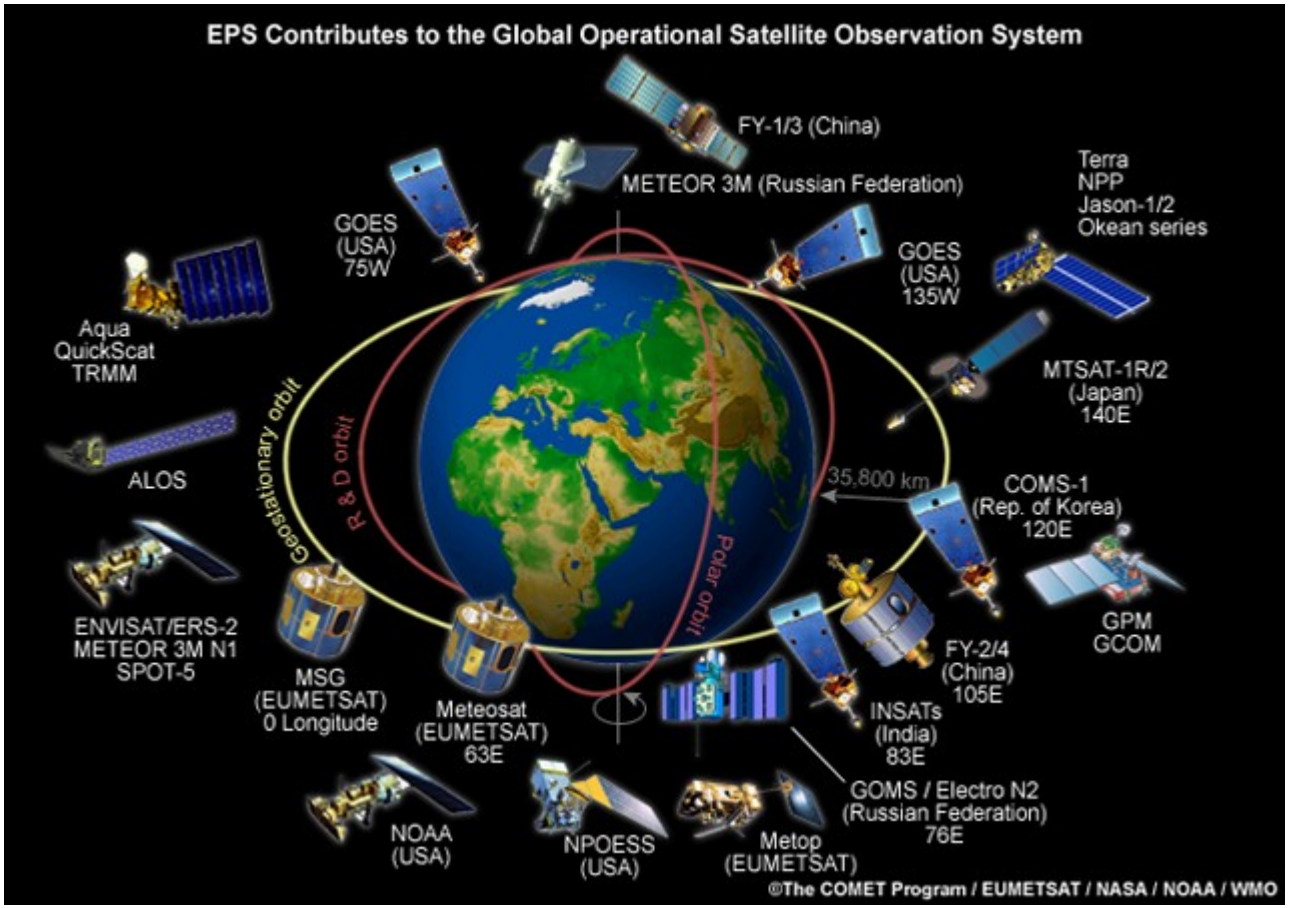
- Improved representation of the mesoscale environment in which the system initiated and evolved which a more realistic distribution of CAPE and CIN values

- Better representation of the mesoscale environment leads to a superior quantification of the potential for severe derived from the EnKF than those derived by direct downscaling of ECMWF EPS forecass.

# PART II

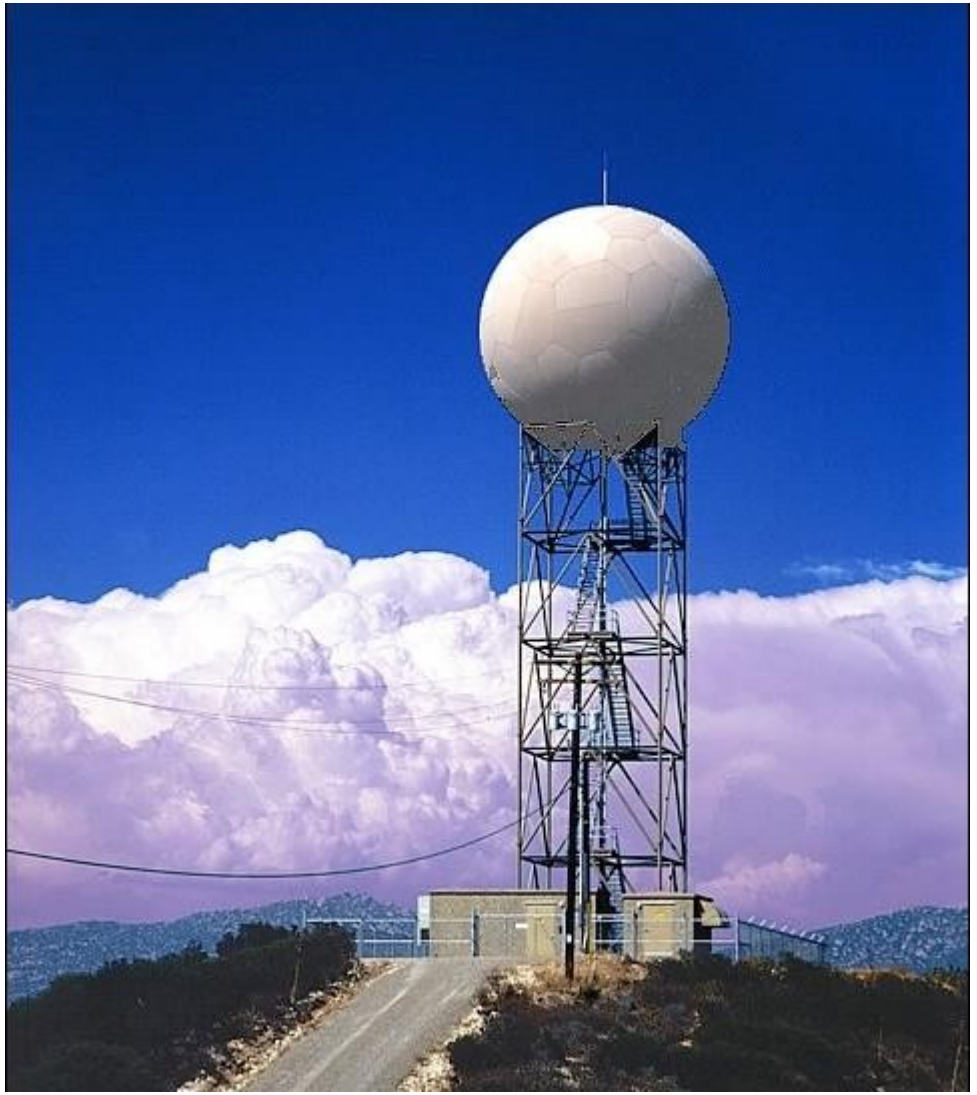
# FUTURE WORK

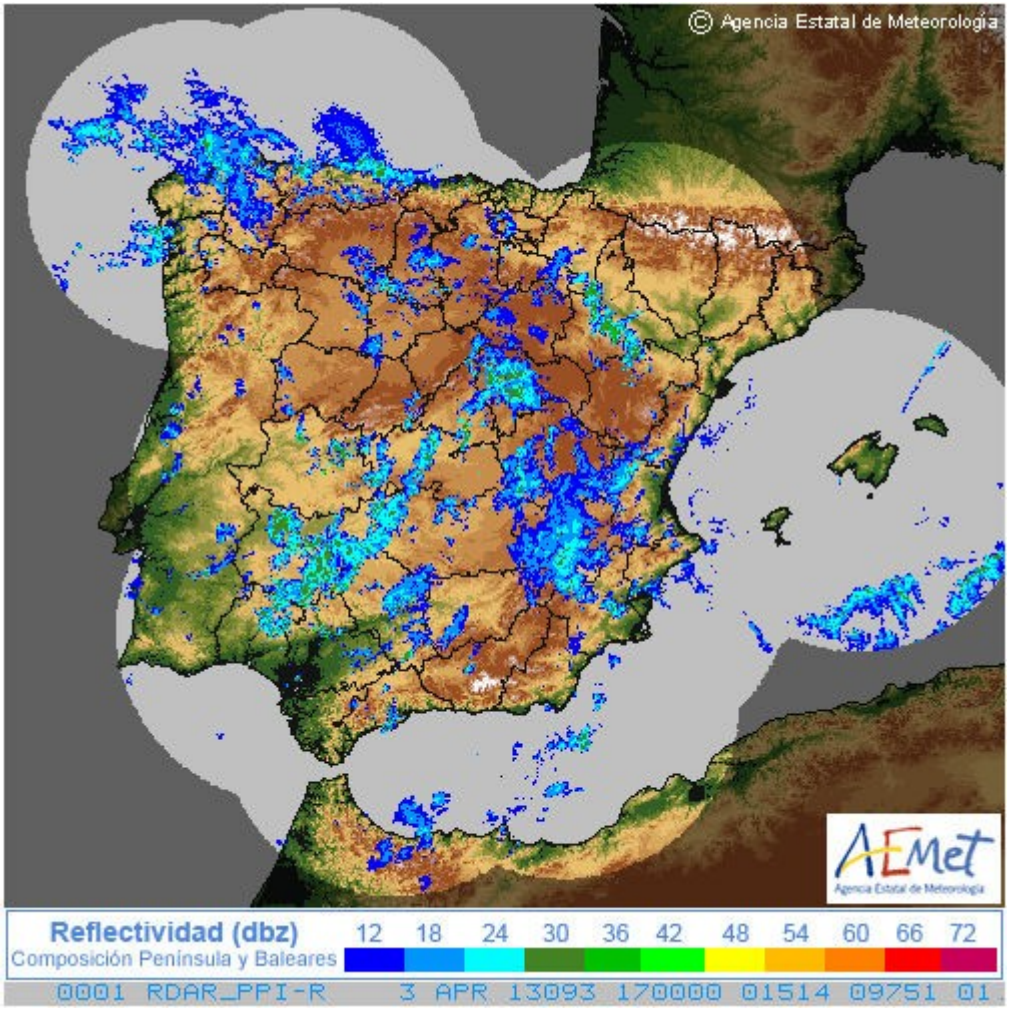
- Improve the assimilation over the Western Mediterranean which contains too few in-situ observations (most of the area is Sea), using data from remote sensing instruments:
  - Satellite Data Assimilation



# FUTURE WORK

- Radar Data Assimilation



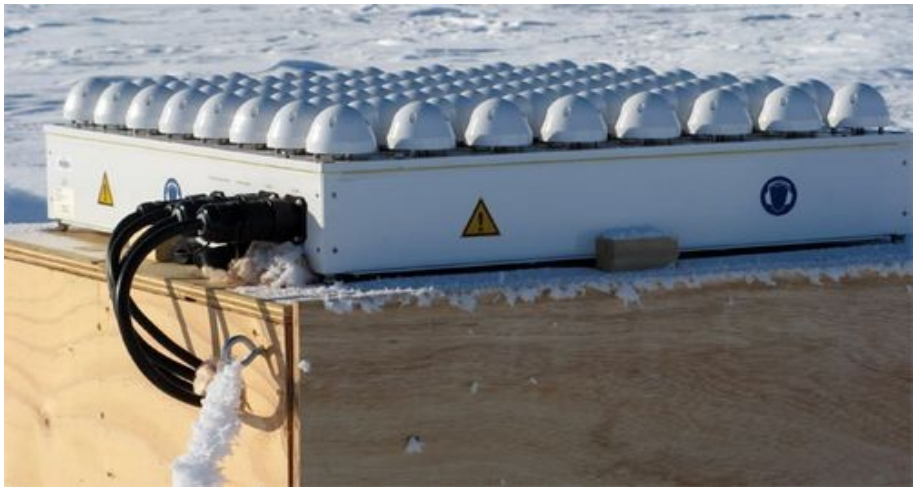


# FUTURE WORK

- Other Experimental Assimilation of Experimental Observations

Lidar (terrestrial)

Constant-height balloons



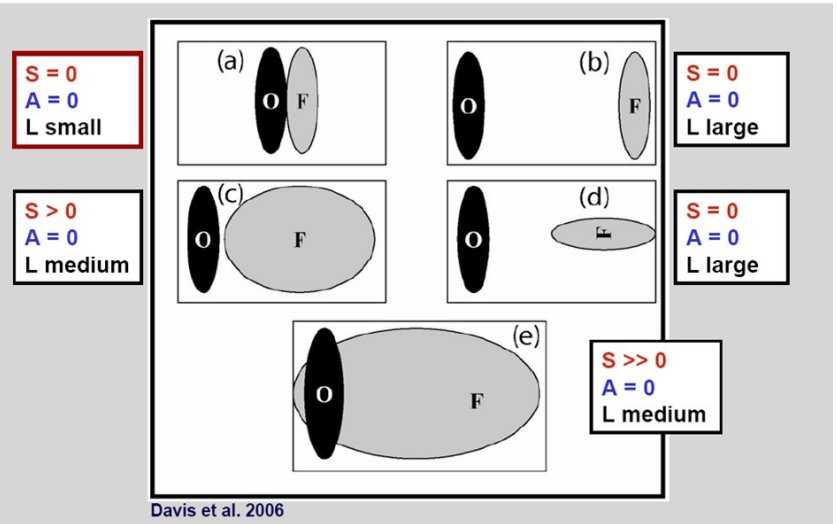
Sodar

# FUTURE WORK

- Kilometric and Sub-Kilometric space resolution, to explore the prediction of convective modes (linear, scattered, MCS)
- What is the predictability limit of hight impact phenomena?
- Post-Process: What kind of tools we can use to take maximum advantage of the model's output information? (maximum updraft helicity o severity index, ...)
- Verification:

  - Index Verification: Frequency Bias, Brier Skill, Equitable Threat Score, Attributes Diagram,...

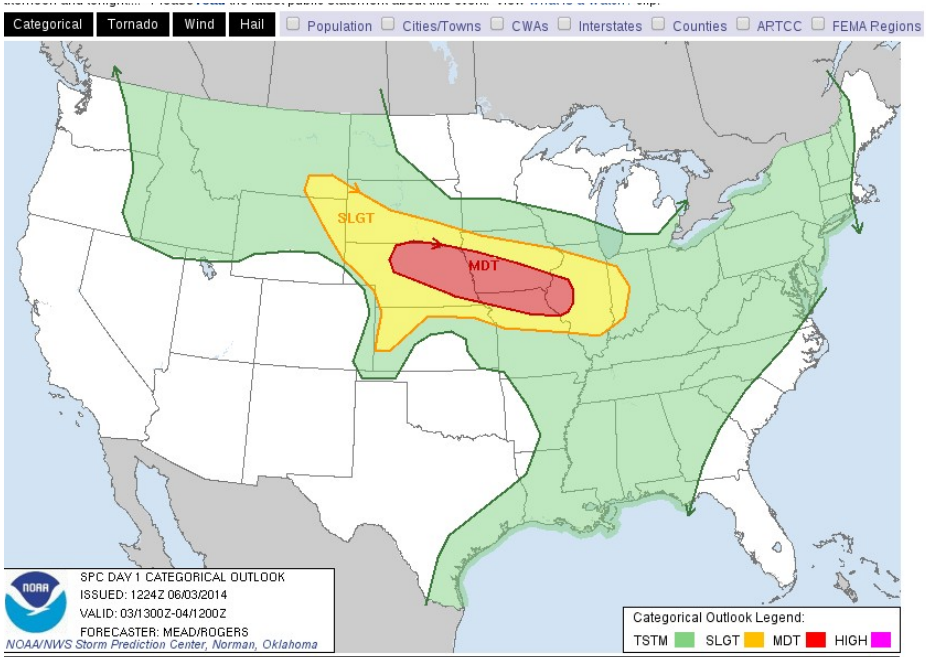
  - Get useful information of our fields predicted: SAL (Structure Amplitude and Location), MODE (Method for Object-Based Diagnostic Evaluation)




SAL method

# FUTURE WORK

- Convective Outlooks: Automatic generation of warnings




Convective Outlook

- Reproduce and design synthetic prediction fields, highly informative and easy to interpret directly for use in statal-regional weather services from Western Mediterranean region.

# THANK YOU FOR YOUR ATTENTION

***QUESTIONS, COMMENTS OR REMARKS?***