Analysis of convection in three tropical-like Mediterranean storms using satellite and lightning networks

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10th Plinius Conference on Mediterranean Storms

Medicanes

- One or two Tropical-like Mediterranean storms or Medicanes (Emanuel, K. A., 2005) are observed as much every year in satellite images.
- They are formed typically under the effects of a cold and isolated depression at the medium and high levels of the atmosphere.
- Under these conditions a strong sea-air temperature difference seems to be an important ingredient.
- The factors that impulse the formation of a Medicane instead of an ordinary depression are still not well known (Fita et al, 2007).
- Documented Medicanes have not usually achieved hurricane intensity (120 km/h=33.3 m/seg=64.8 knots).

- Some important study cases:

case	Beginning	Ending	Eye initial	eye end
950116	14/01 12^{00}	18/01 20^{00}	15/01 07^{00}	18/01 06^{30}
960912	11/09 21^{00}	13/09 02^{30}	12/09 05^{00}	12/09 12^{00}
961007	06/10 03^{30}	11/10 03^{00}	07/10 06^{30} 08/10 12^{00}	07/10 05^{30} 10/10 06^{00}
030527	25/03 12^{00}	28/05 04^{30}	27/05 08^{30}	27/05 15^{30}
031018	17/10 00^{00}	19/10 04^{00}	18/10 05^{30}	18/10 13^{30}
051027	26/10 20^{30}	29/10 14^{30}	28/10 10^{00}	28/10 12^{00}
051215	13/12 05^{00}	16/12 12^{15}	14/12 08^{00} 15/12 06^{00}	14/12 15^{15} 15/12 14^{15}

IR VIS WV

IR VIS WV

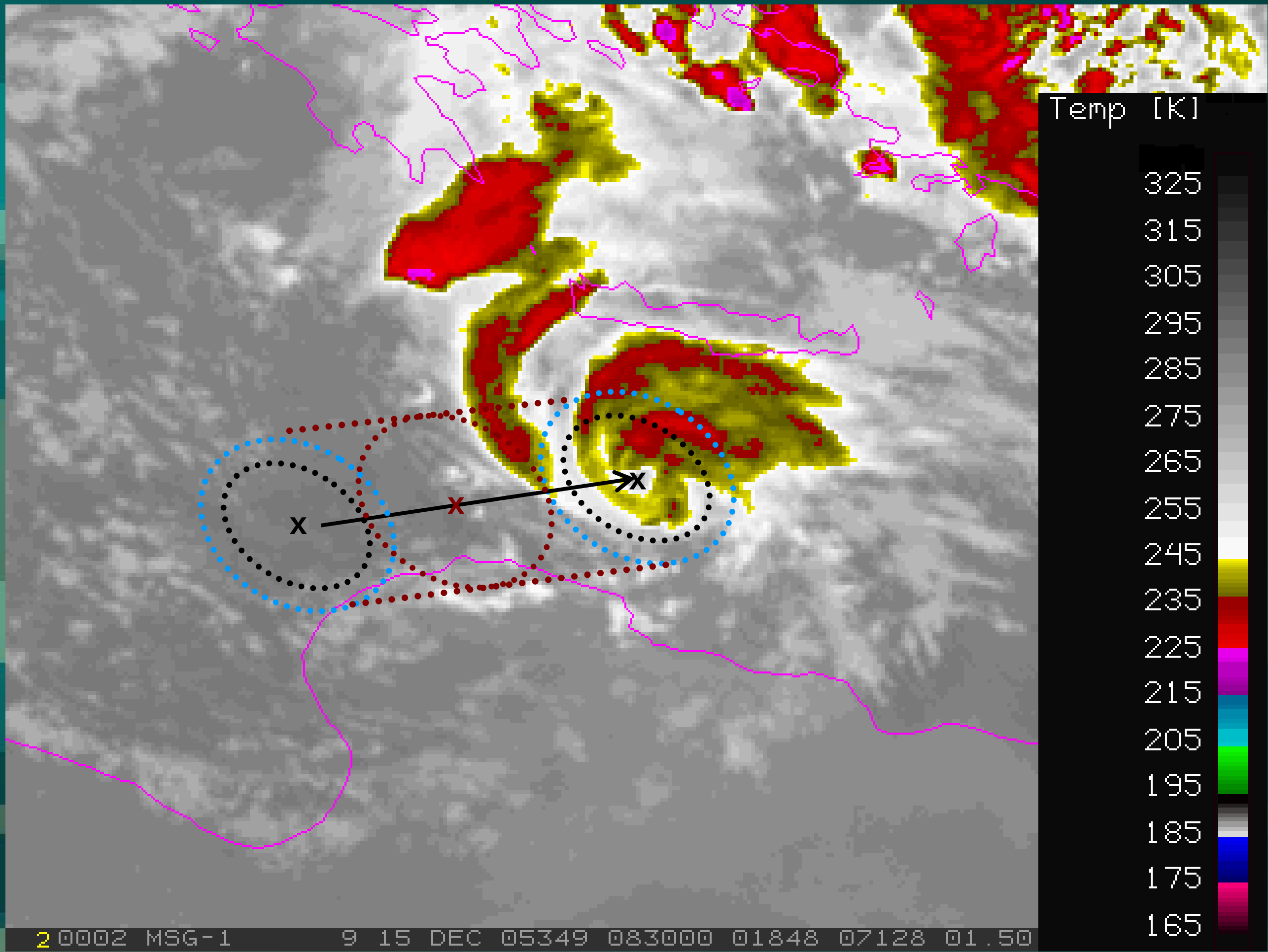
IR VIS WV

IR VIS WV

- All the satellite animations within a numerical analysis (Fita et al, 2006) can be found in:

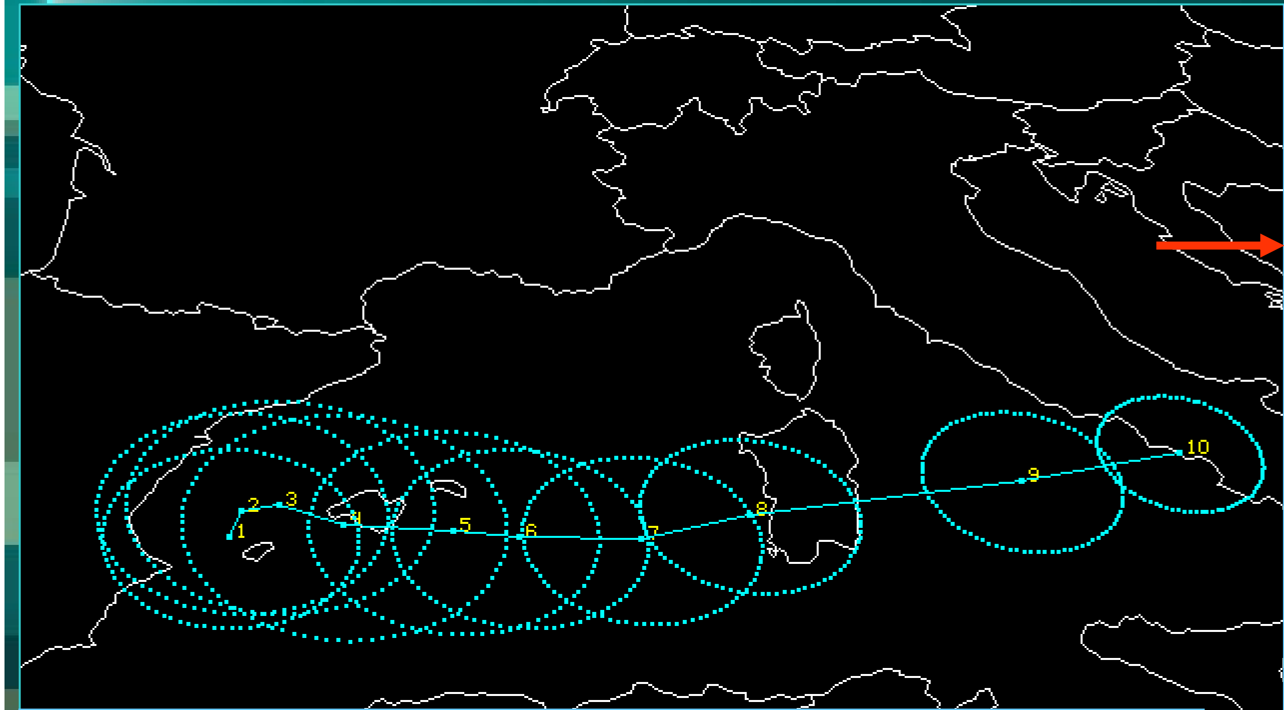
http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/MEDICANES/

- Measuring the area of influence of each Medicane



Dynamic Analysis of the case 960912

Centre trajectory, size and mean storm speed are measured using Meteosat5 and SSM/I images



	DAY	Time (UTC)	Radius (km)
1	96/09/12	01:30	130
2	“ / “ /12	05:00	150
3	“ / “ /12	09:30	160
4	“ / “ /12	12:30	180
5	“ / “ /12	16:00	160
6	“ / “ /12	17:00	140
7	“ / “ /12	19:00	130
8	“ / “ /12	20:30	120
9	“ / “ /13	02:00	110
10	“ / “ /13	04:30	100

Total-time(HH:MM)= 27:00 = 27 hours

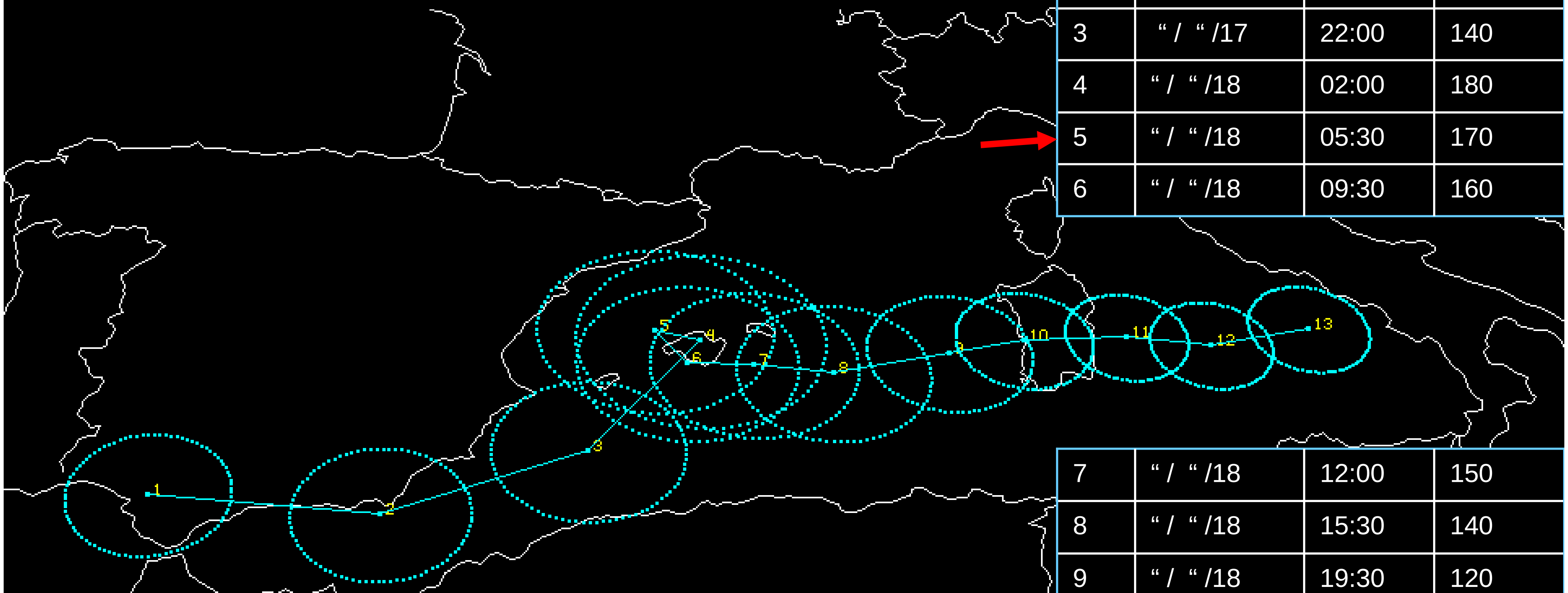
Mean A of I (radius)= 137 km

Total-dist= 1212 km Max winds = 60 knots

Speed of displacement= 44.89 Km/h = 24.24 knots

Dynamic Analysis of the case 031018

Centre trajectory, size and mean storm speed are measured using Meteosat7 and QuikScat wind images



	DAY	Time (UTC)	Radius (km)
1	03/10/17	02:00	120
2	" / " /17	11:30	130
3	" / " /17	22:00	140
4	" / " /18	02:00	180
5	" / " /18	05:30	170
6	" / " /18	09:30	160
7	" / " /18	12:00	150
8	" / " /18	15:30	140
9	" / " /18	19:30	120
10	" / " /18	21:30	100
11	" / " /19	02:30	90
12	" / " /19	09:30	90
13	" / " /19	14:30	90

Total-time(HH:MM)= 62:30 = 62.5 hours

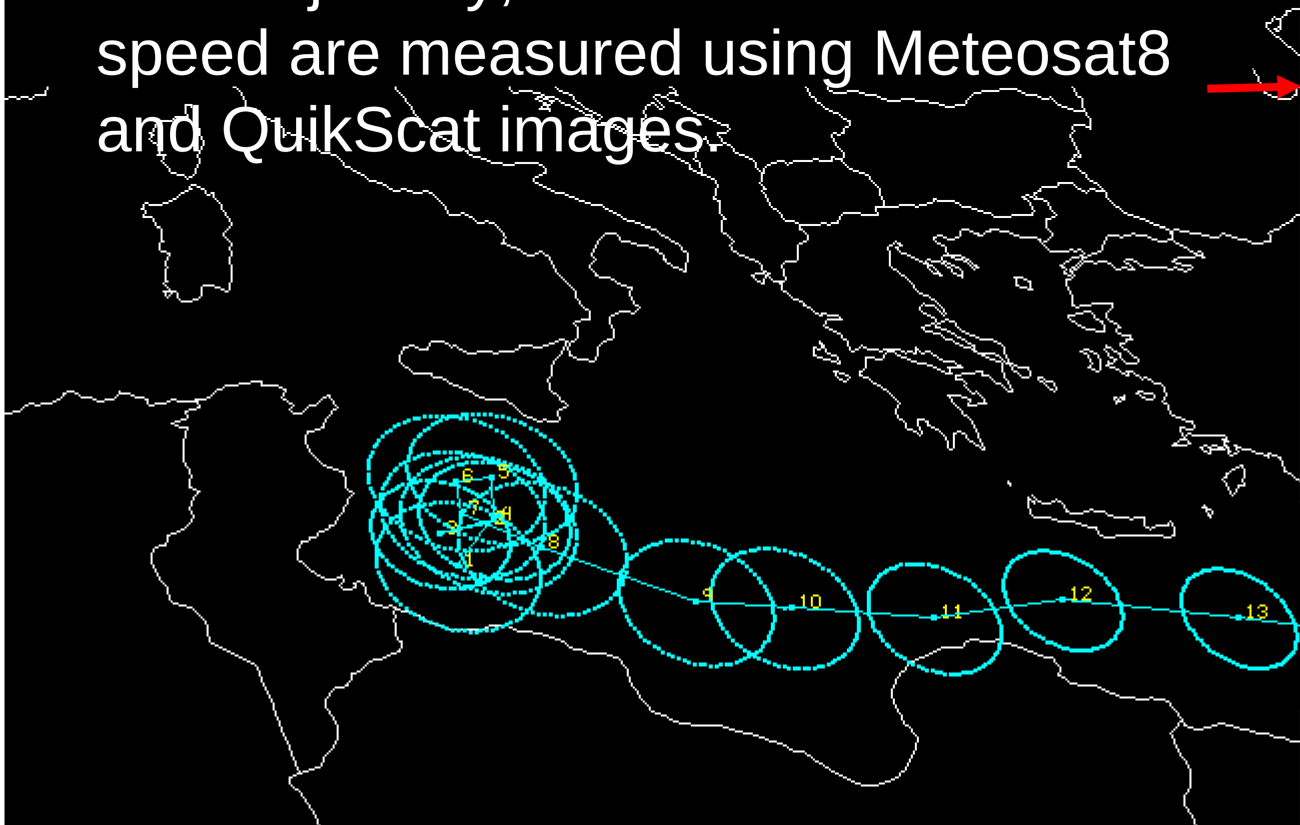
Mean A of I (radius)= 130 km

Total-dist= 2044 km   max winds = 45 knots

Speed of displacement= 32.7 Km/h = 17.65 knots

Dynamic Analysis of the case 051215

Centre trajectory, size and mean storm speed are measured using Meteosat8 and QuikScat images.



	DAY	Time (UTC)	Radius (km)
1	05/12/13	12:00	130
2	" / " /13	17:30	140
3	" / " /14	00:30	110
4	" / " /14	03:30	120
5	" / " /14	06:30	135
6	" / " /14	10:00	140
7	" / " /14	13:00	130
8	" / " /14	16:30	135
9	" / " /14	20:30	125
10	" / " /14	23:30	120
11	" / " /15	03:30	110
12	" / " /15	08:30	100
13	" / " /15	15:30	100
14	" / " /15	22:00	110
15	" / " /16	02:30	110
16	" / " /16	09:30	100

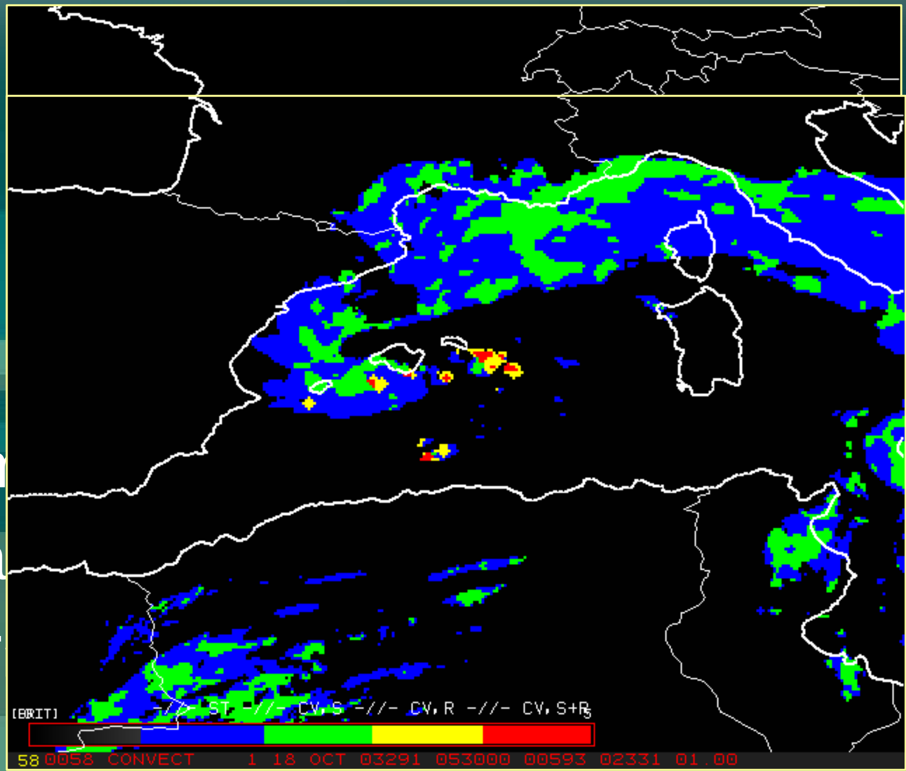
Total-time(HH:MM)= 69:30 = 69.5 hours

Mean A of I (radius)= 120 km

Total-dist= 2596 km   max winds = 60 knots

Speed of displacement= 37.4 Km/h = 20.17 knots

Motivati



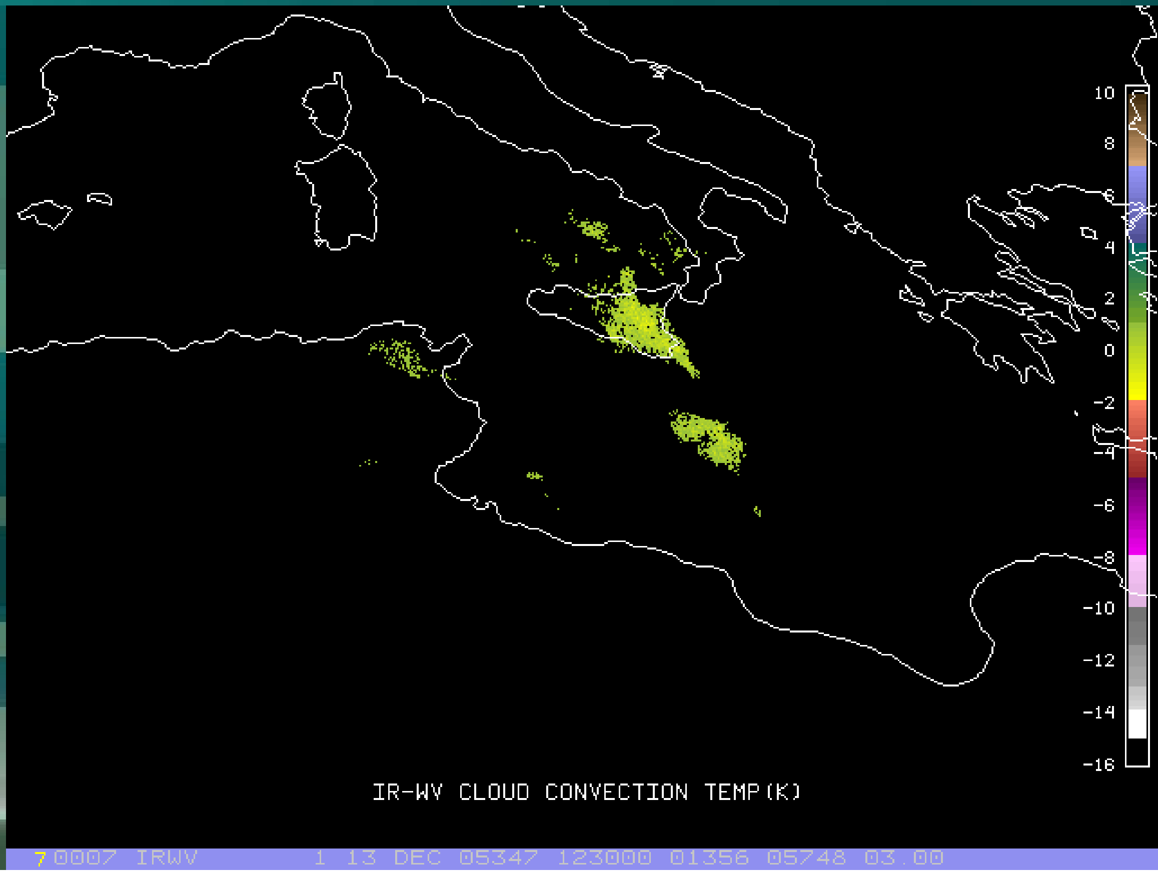
- Medicanes by the numerical m
- An assimila ous supply of convective- osat is projected.
- Once the rain area in infrared images is defined the detection of convective points is easier than for the stratiform ones.
- Different methods to find these convective points are used by us

Satellite algorithms to detect convective pixels

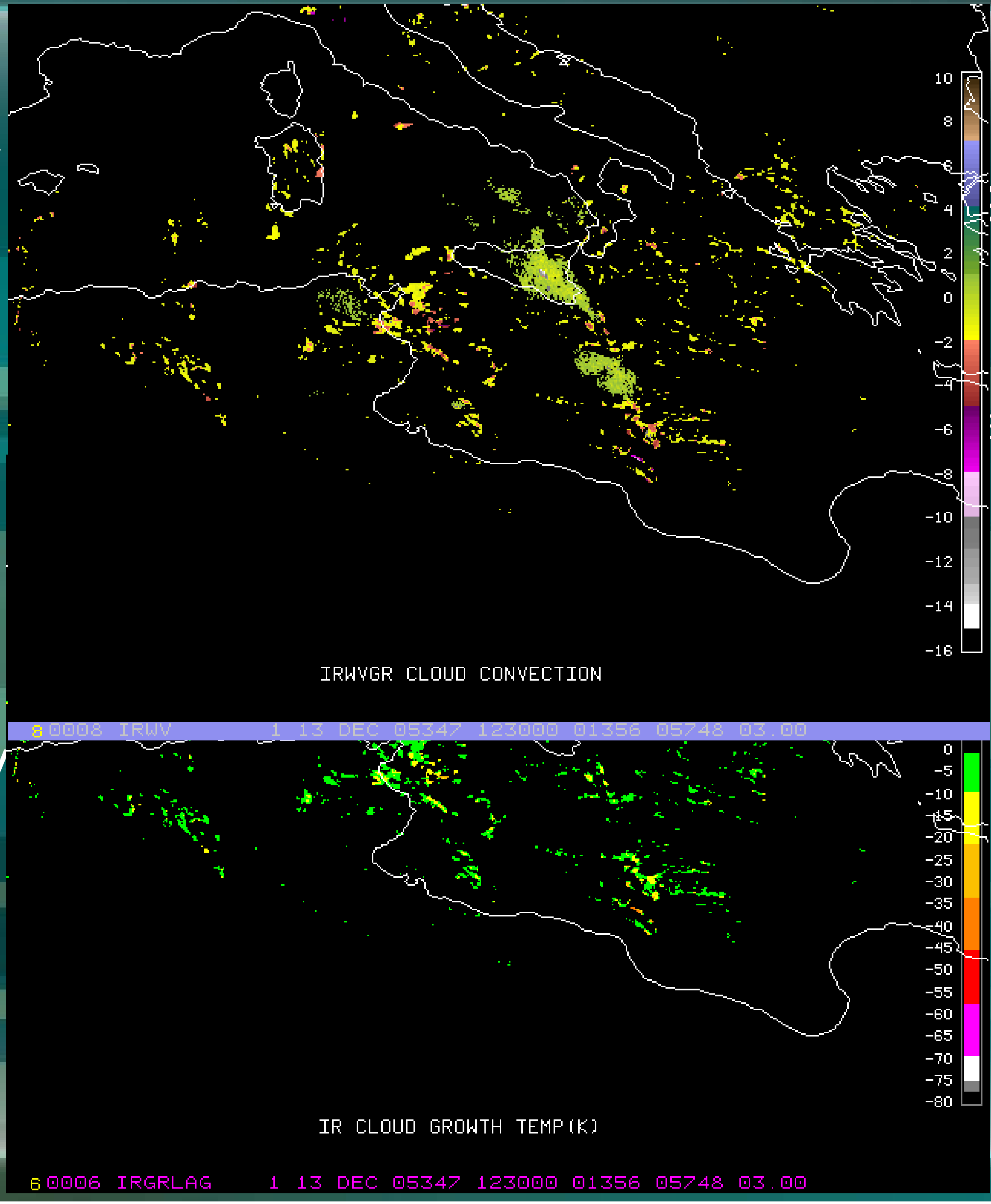
- IRWV → Convective points are those that

$$T_{WV}(t) - T_{IR}(t) > 1^o$$

l., 2005)



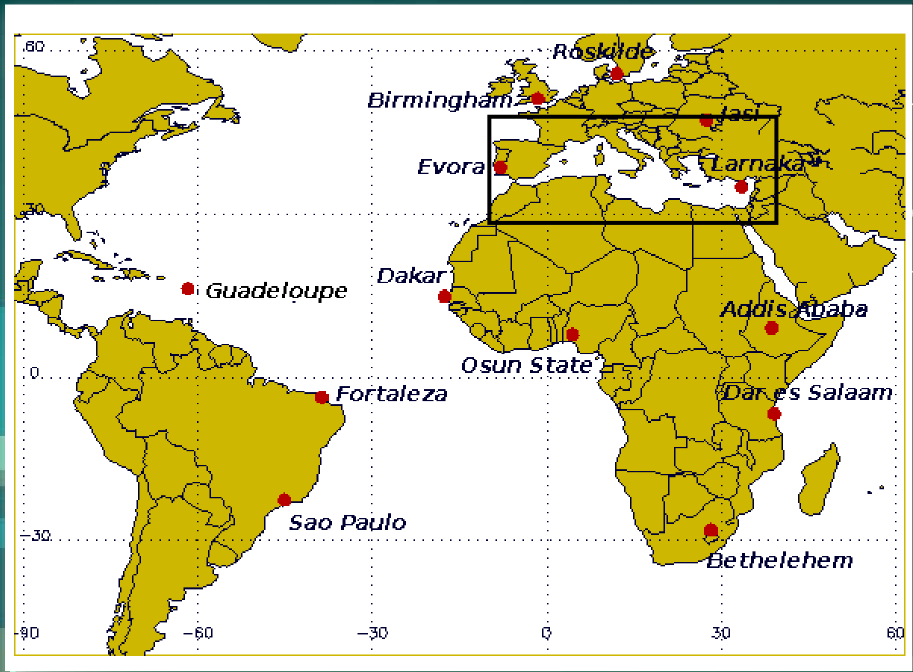
- IRGR

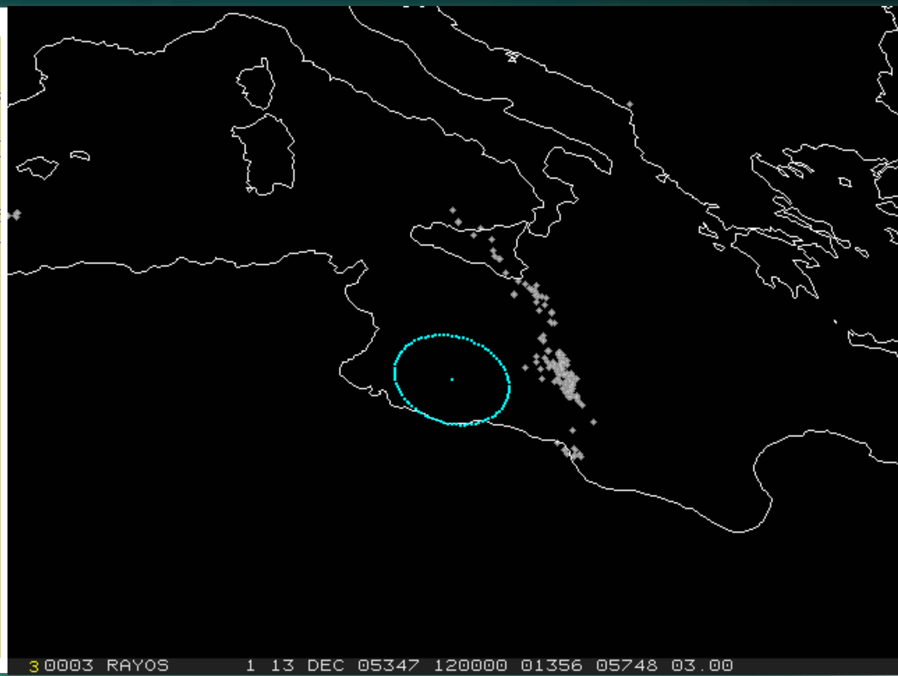


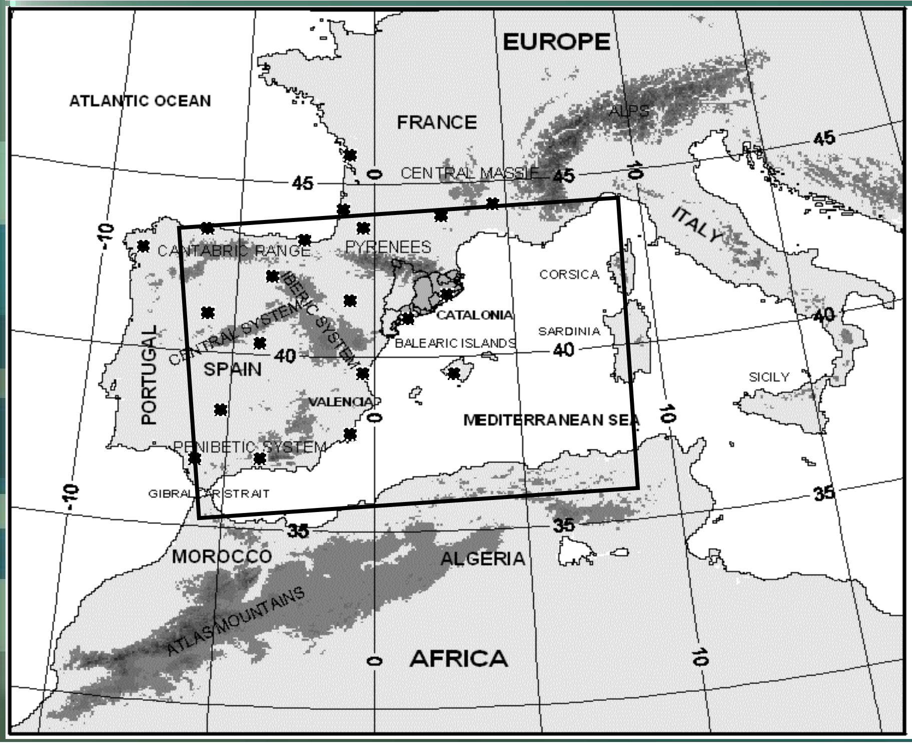
ent

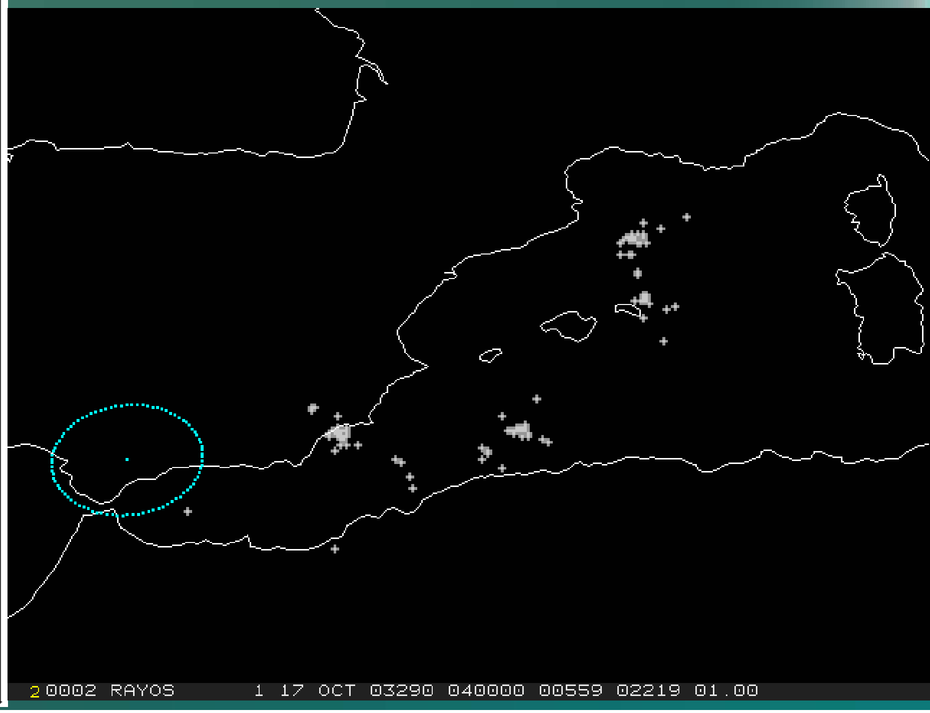
- IRWV

ion

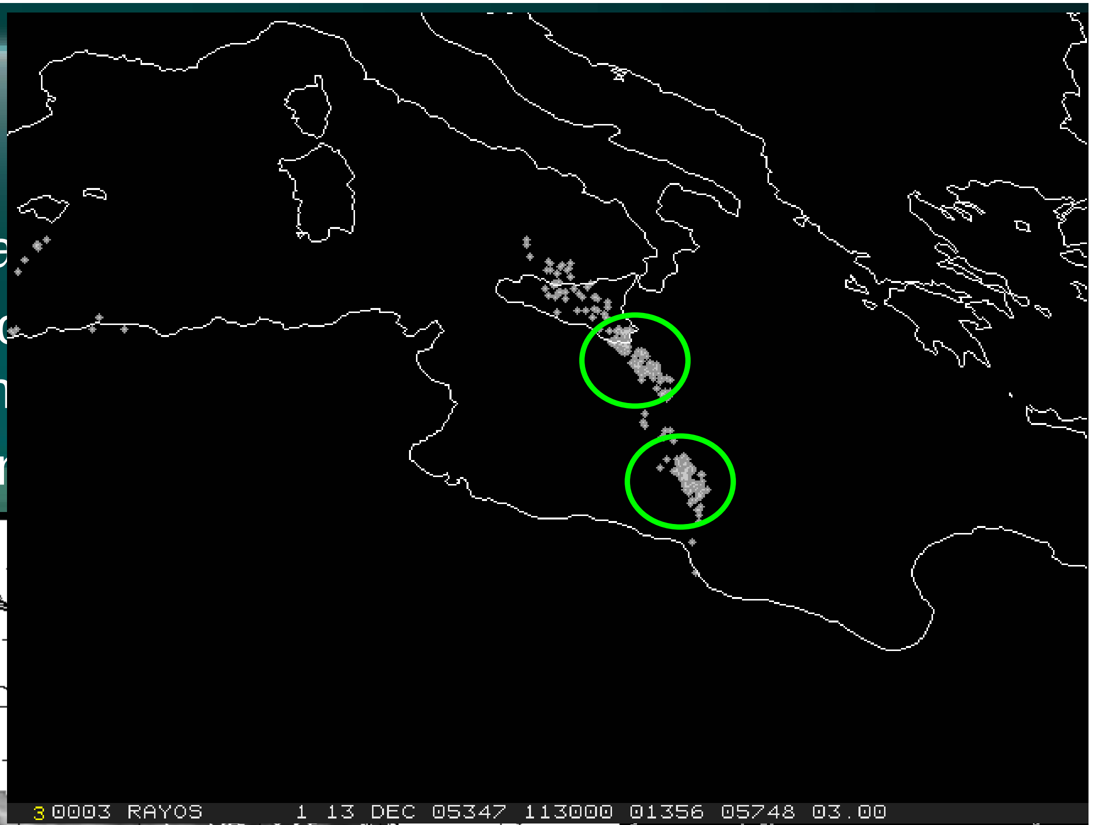

Roskilde
Birmingham
Iasi
Evora
Larnaka
Guadeloupe
Dakar
Addis Ababa
Osun State
Fortaleza
Dar es Salaam
Sao Paulo
Bethelehem
60
30
0
-30
-90
-60
-30
0
30
60

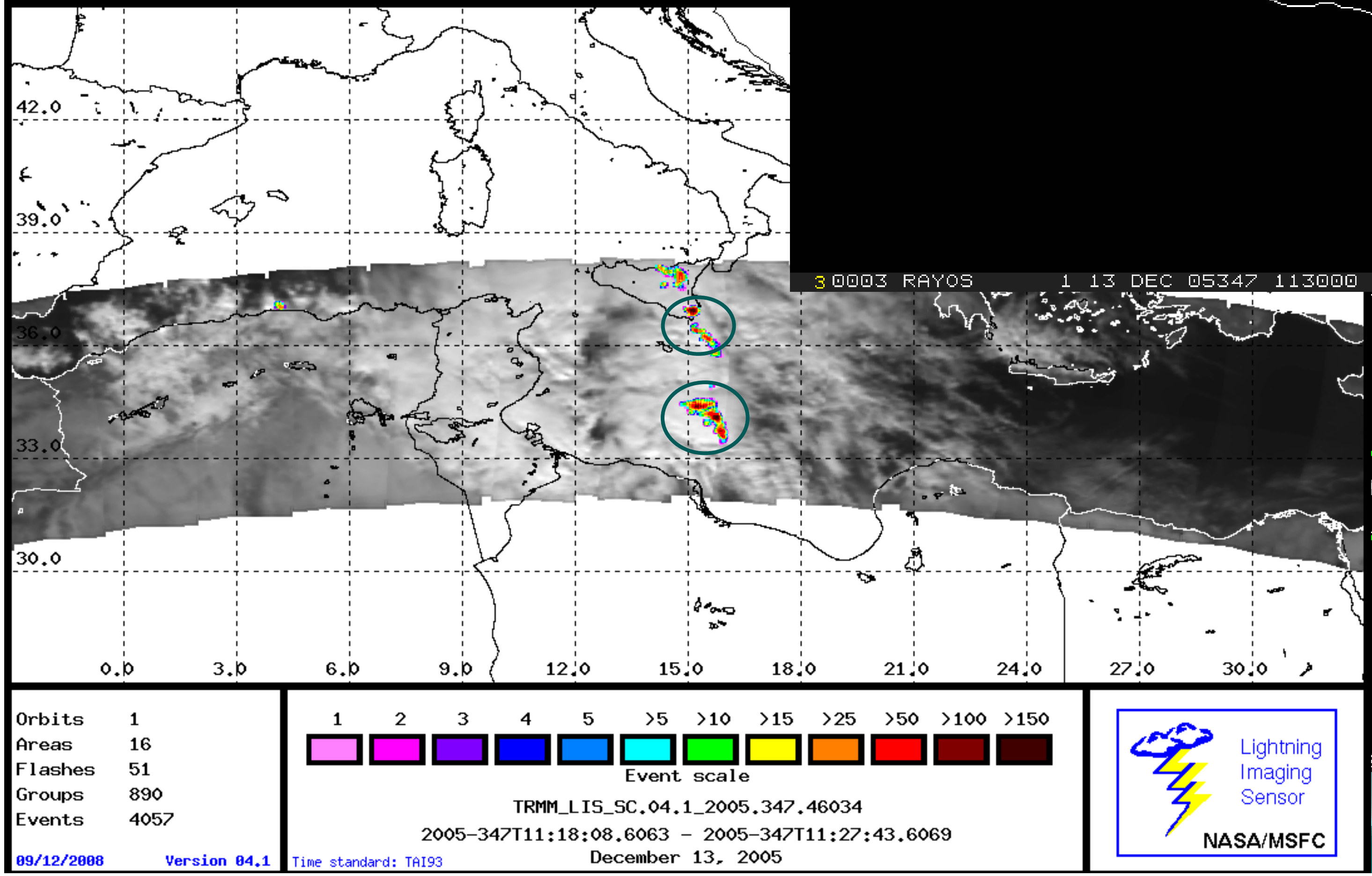

3 0003 RAYOS 1 13 DEC 05347 120000 01356 05748 03.00

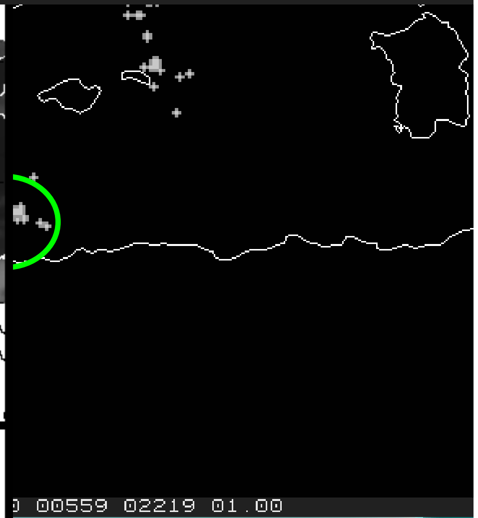

EUROPE
ATLANTIC OCEAN
FRANCE
ALPS
CENTRAL MASSIF
ITALY
CANTABRIC RANGE
PYRENEES
CORSICA
CATALONIA
SARDINIA
BALEARIC ISLANDS
IBERIC SYSTEM
CENTRAL SYSTEM
PORTUGAL
SPAIN
VALENCIA
SICILY
MEDITERRANEAN SEA
PENIBETIC SYSTEM
GIBRALTAR STRAIT
MOROCCO
ALGERIA
ATLAS MOUNTAINS
AFRICA


2 0002 RAYOS 1 17 OCT 03290 040000 00559 02219 01.00

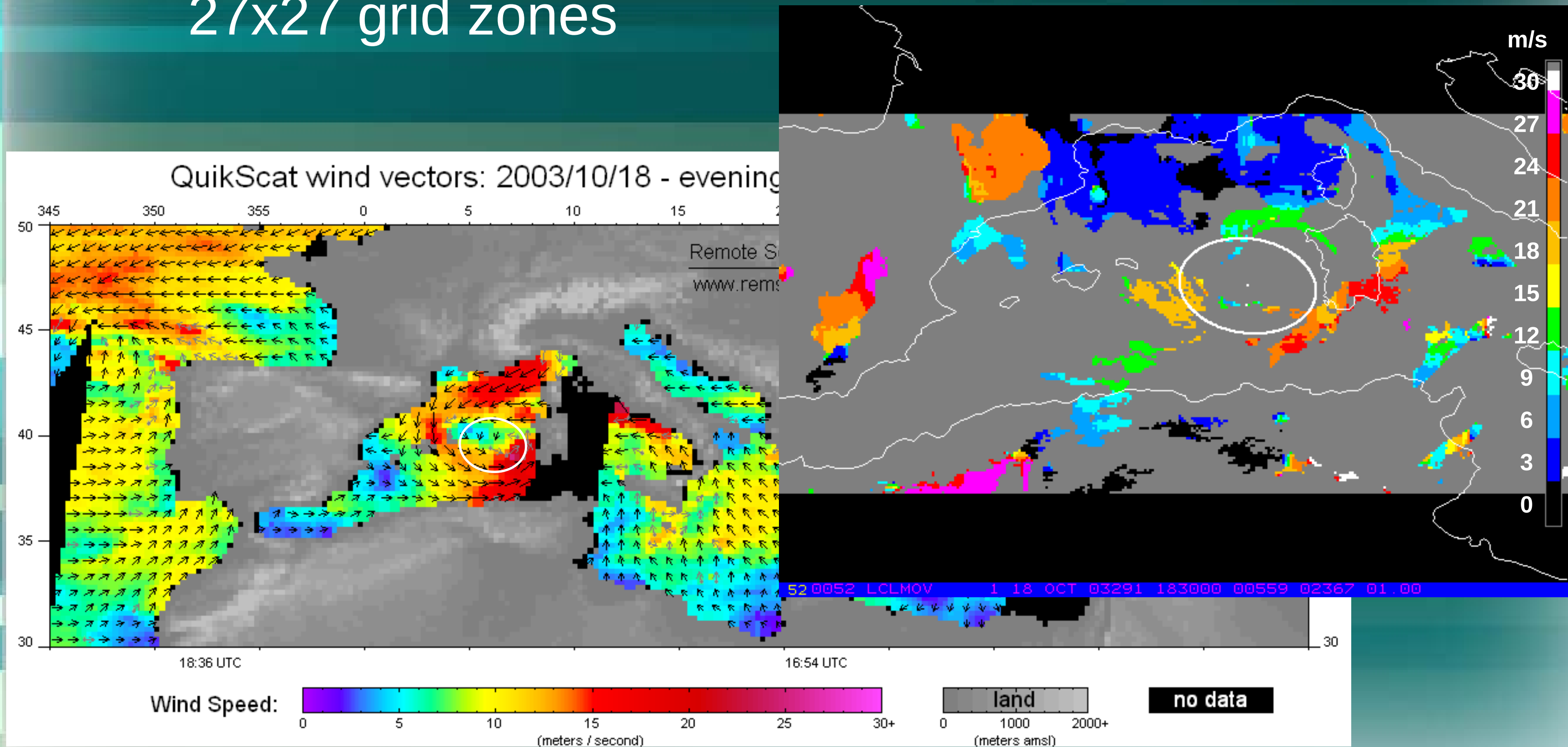
- LIS
  - Detects C-G, G-C, C-C a
  - Space based sensor in l
    and 2 images per day an
  - Used to verify AEMET ar



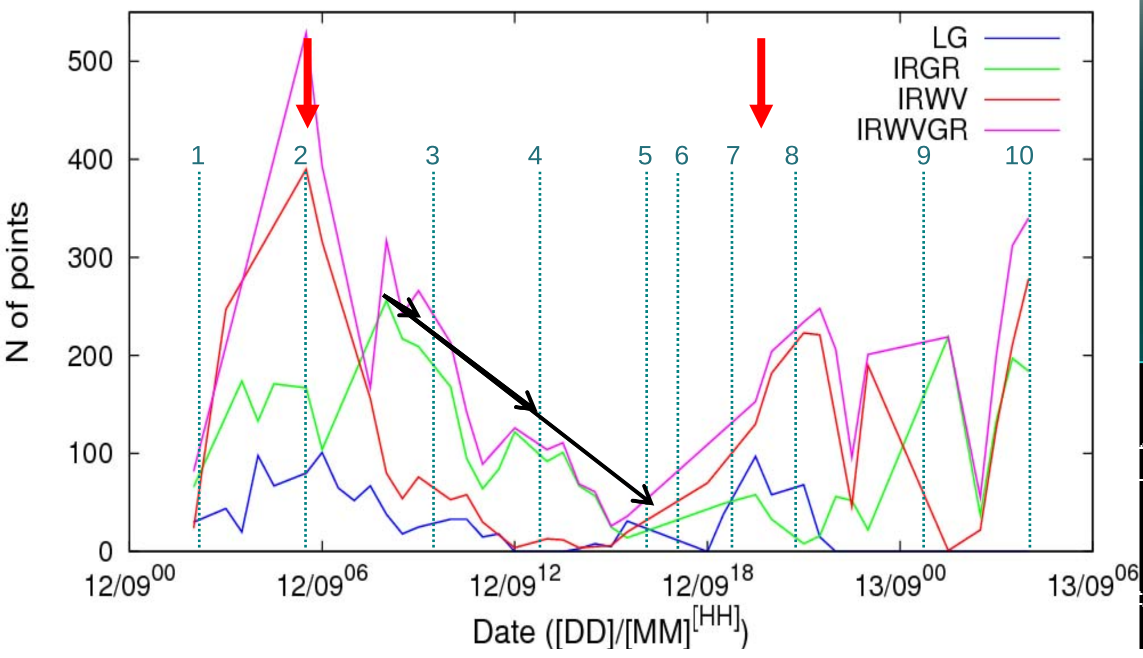




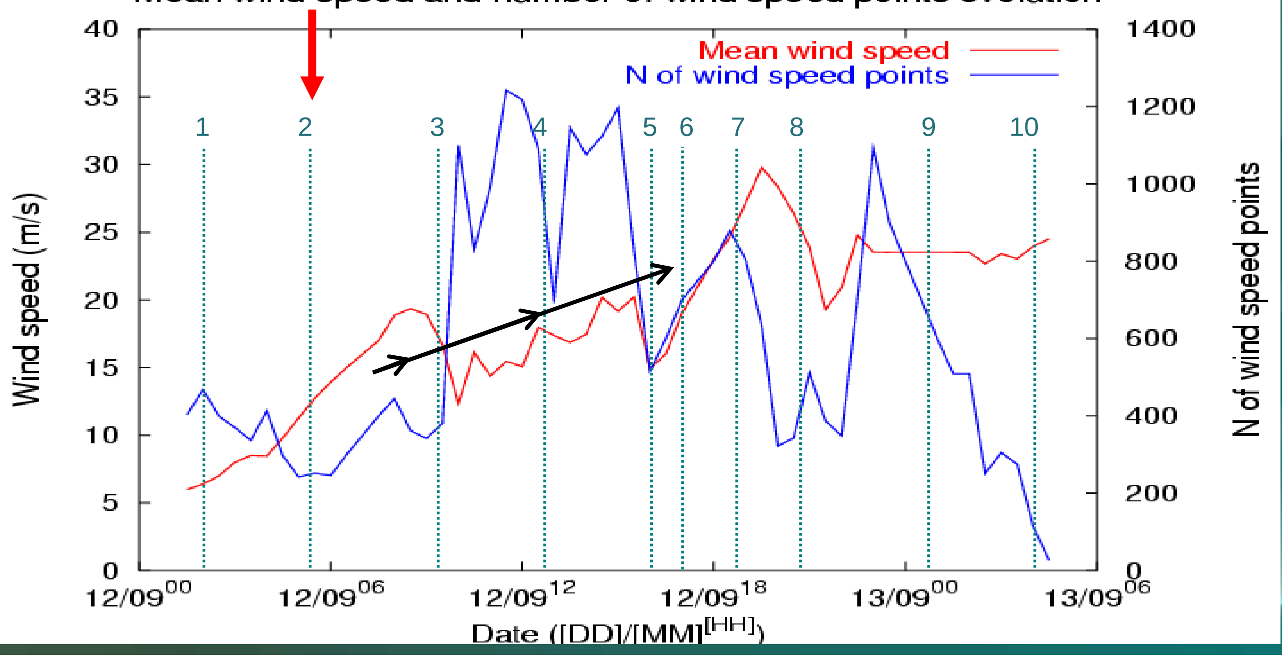
- Meteosat infrared based low cloud velocity estimation
  - Low warm clouds are tracked and speeds are measured in the medicane areas of influence
  - This is based on a cross-correlation method applied in 27x27 grid zones

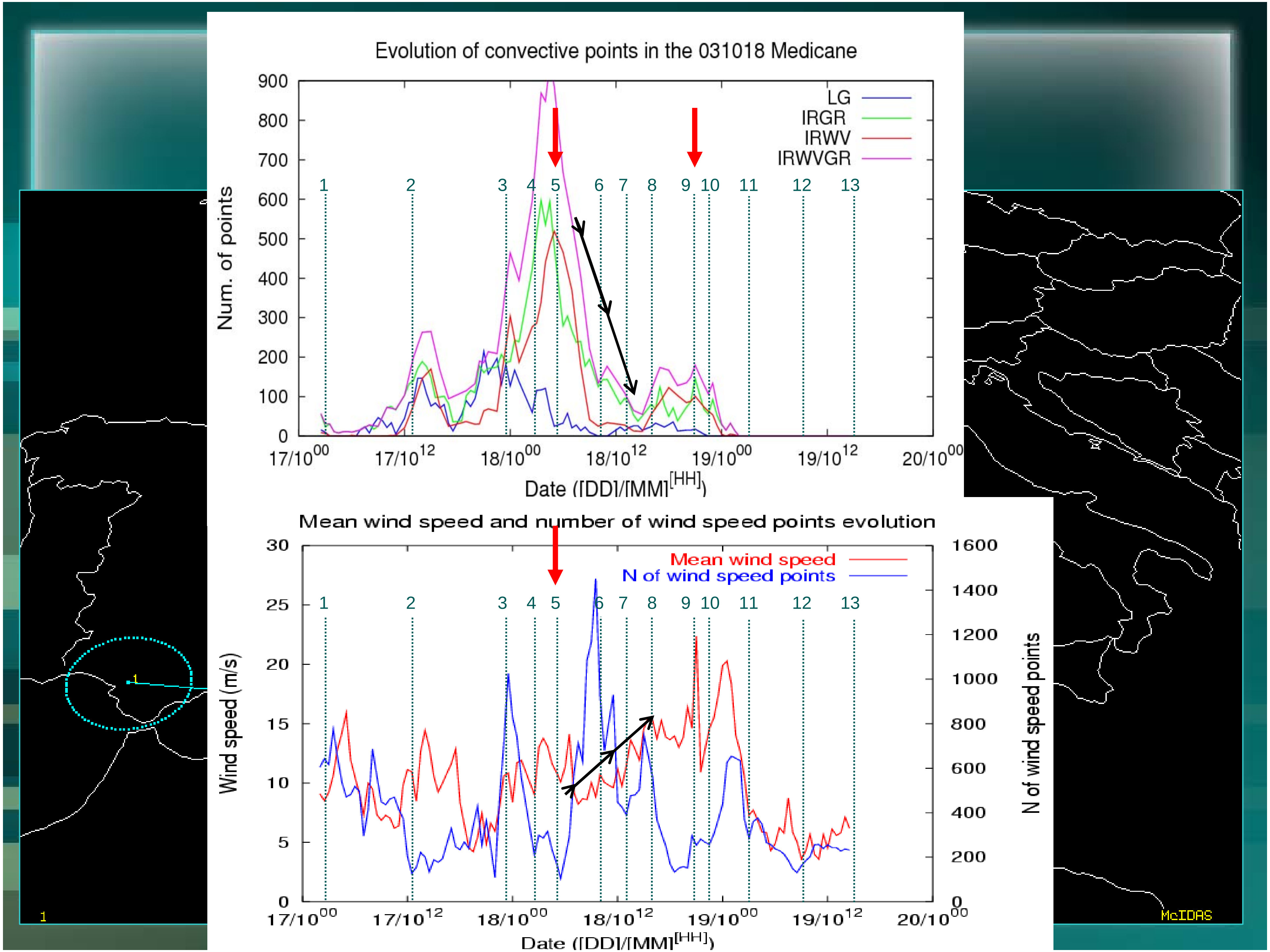


Evolution of convective points in a Medicane

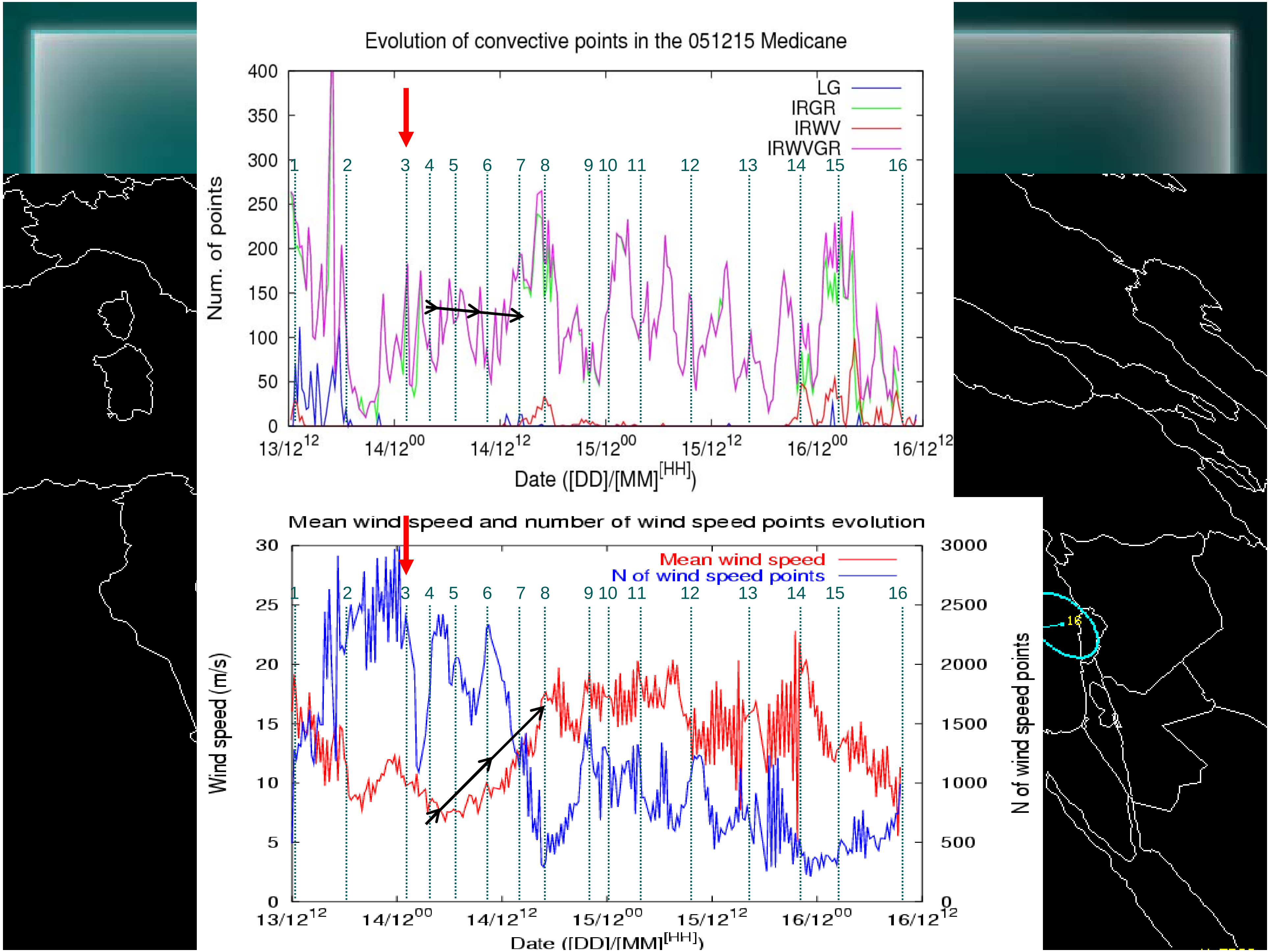


Mean wind speed and number of wind speed points evolution



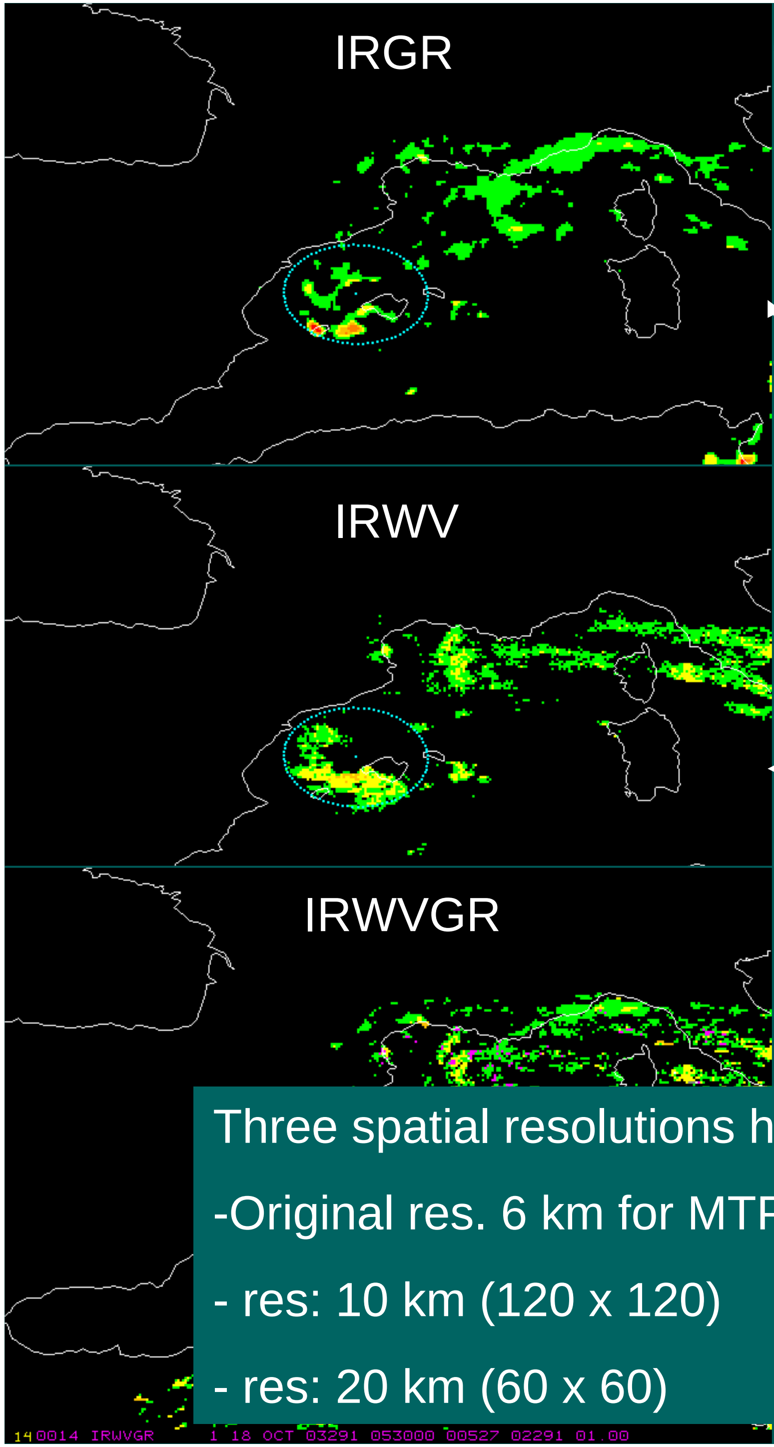


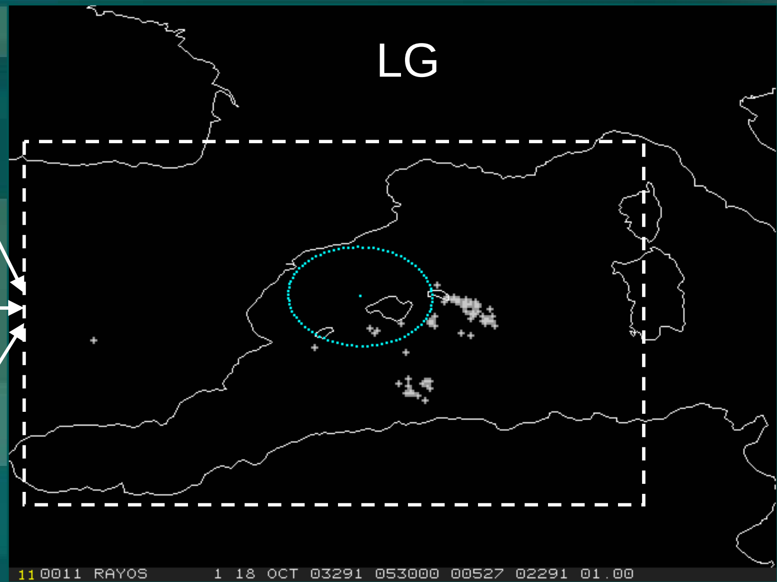
Evolution of convective points in the 031018 Medicane
Num. of points
LG
IRGR
IRWV
IRWVGR
1 2 3 4 5 6 7 8 9 10 11 12 13
17/10^00 17/10^12 18/10^00 18/10^12 19/10^00 19/10^12 20/10^00
Date ([DD]/[MM]^[HH])
Mean wind speed and number of wind speed points evolution
Mean wind speed
N of wind speed points
Wind speed (m/s)
N of wind speed points
Date ([DD]/[MM]^[HH])
McIDAS


Evolution of convective points in the 051215 Medicane
Num. of points
LG
IRGR
IRWV
IRWVGR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Date ([DD]/[MM][HH])
13/12 12
14/12 00
14/12 12
15/12 00
15/12 12
16/12 00
16/12 12
Mean wind speed and number of wind speed points evolution
Mean wind speed
N of wind speed points
Wind speed (m/s)
N of wind speed points

verification method

n the environment of the medicanes





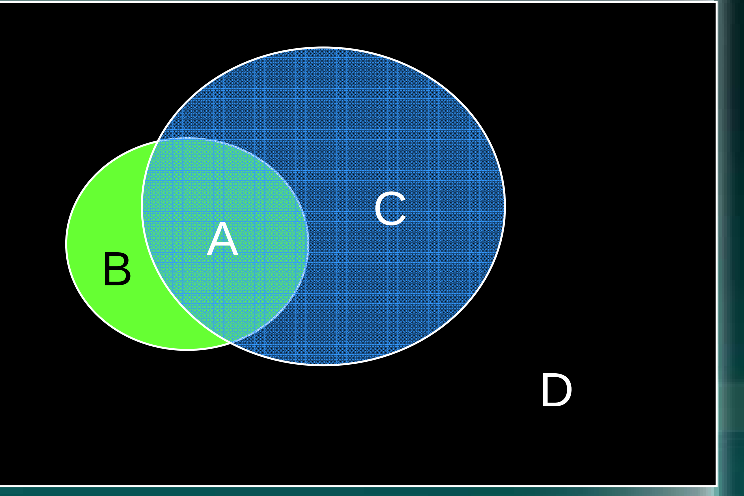
Three spatial resolutions have been used:

-Original res. 6 km for MTP (160 x 220) and 4 km for MSG-1 (200 x 300)

- res: 10 km (120 x 120)

- res: 20 km (60 x 60)

Contingency Table				
	LG			
SAT		yes	no	Total
	yes	Hits (A)	false alarms (C)	forecast yes
	no	Misses (B)	correct negatives (D)	forecast no
	Total	observed yes	observed no	total



$$\text{Acuracy} = \frac{A + D}{A + B + C + D}$$

$$\text{BIAS} = \frac{A + C}{A + B}$$

over-estimation ->BIAS > 1,
under-estimation ->BIAS < 1

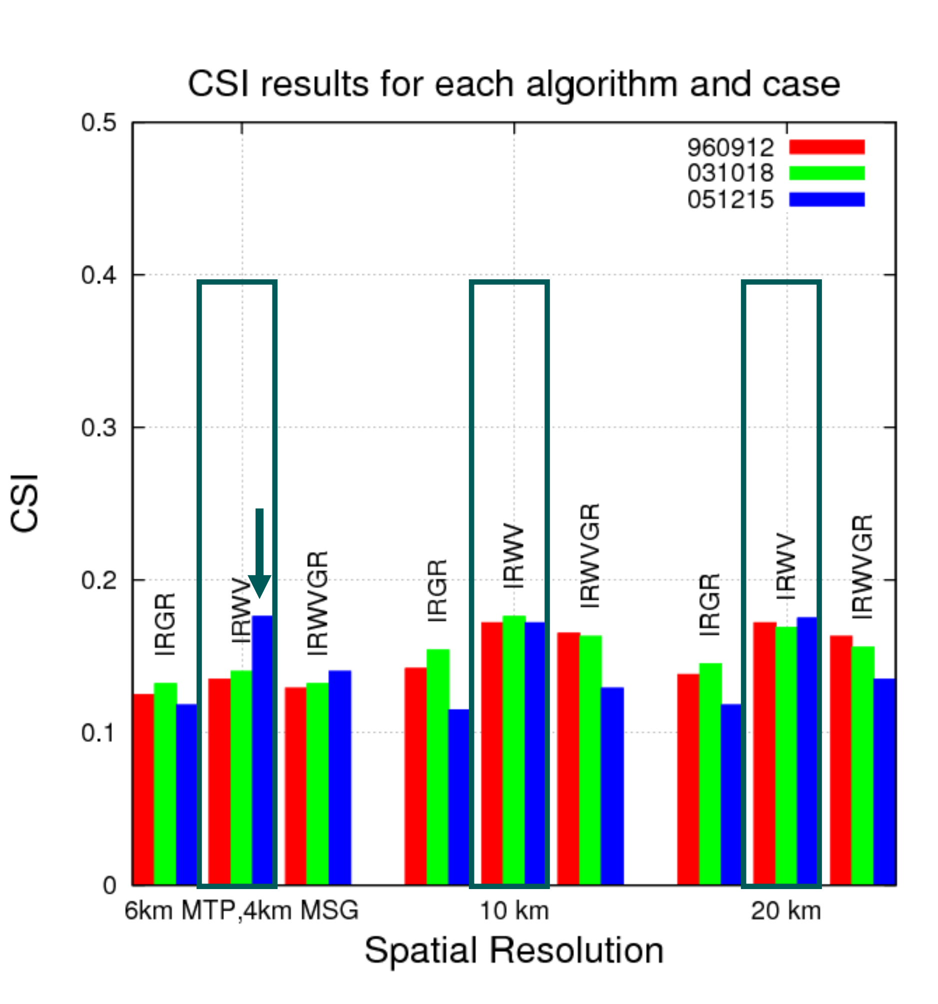
$$\text{POD} = \frac{A}{A + B}$$

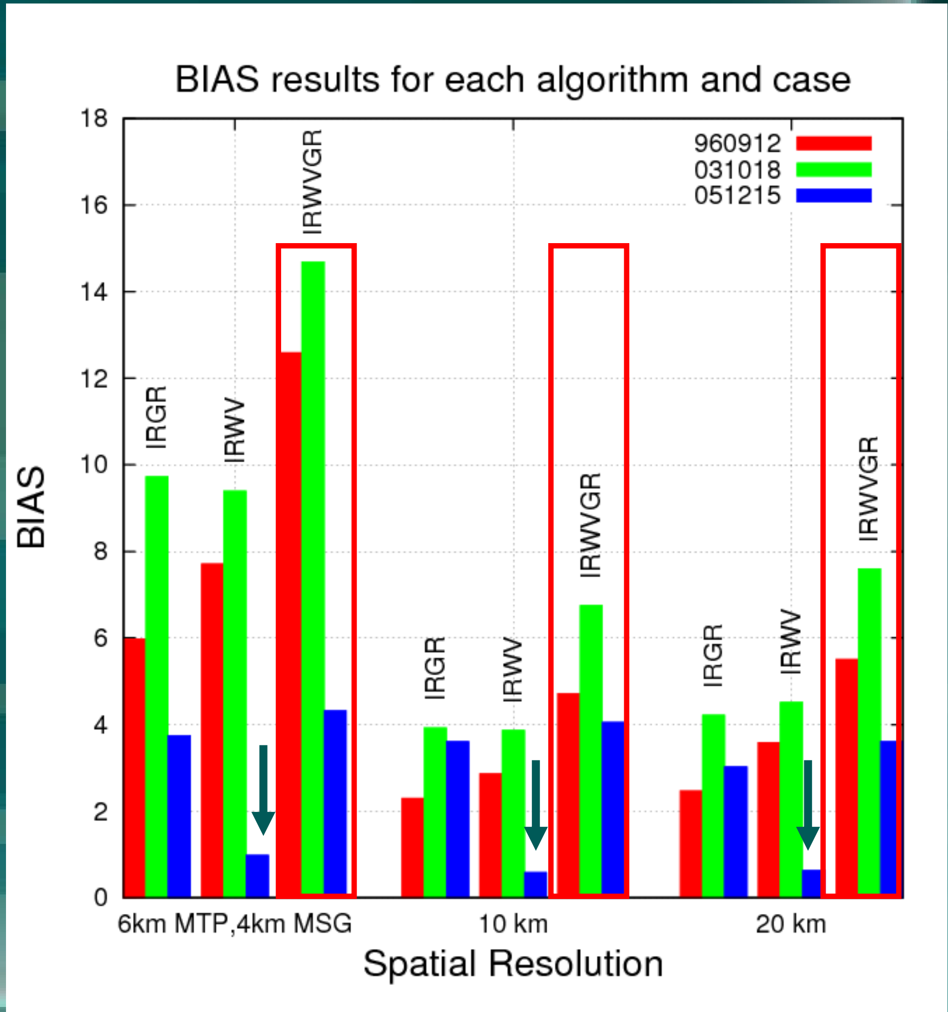
$$\text{FAR} = \frac{C}{A + C}$$

$$\text{CSI} = \frac{A}{A + B + C}$$

from 0 to 1. How close is the satellite estimation to the lightning hits

CSI and BIAS results





General Conclusions

- Three phases in the live of a medicane are observed:
  - **Pre-medicane**: Strong convection before the eye appears.
  - **Stationary phase**: The medicane moves slowly. An eye is observed for the first time, convection decays and horizontal speed of low clouds began to increase (mean 12 m/s).
  - **traveller phase**: The medicane moves fast in a clear direction (at 20 knots), clouds speeds continue increasing (mean 18 m/s).

- During the medicane evolution, estimations show that convective energy is transforming to kinetic horizontal energy.

- The IRWV estimation method shows in general a better performance with respect the lightning data based on:
  - The IRWV shows a slightly better CSI score than the other two (significance?).
  - The IRWV shows the lowest BIAS score for the 051215 case (MSG1?) while the IRWVGR method shows the higher BIAS score in general.

Thank you

Special thanks to the institutions that have provided free and qualified data for this work:
EUMETSAT, Remote Sensing Systems (RSS), Spanish Weather Service (AEMET) and NASA.
Dr. Kostas Lagouvardos for providing ZEUS lightning data.

Animations and more information about Medicanes in:
http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/MEDICANES/

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