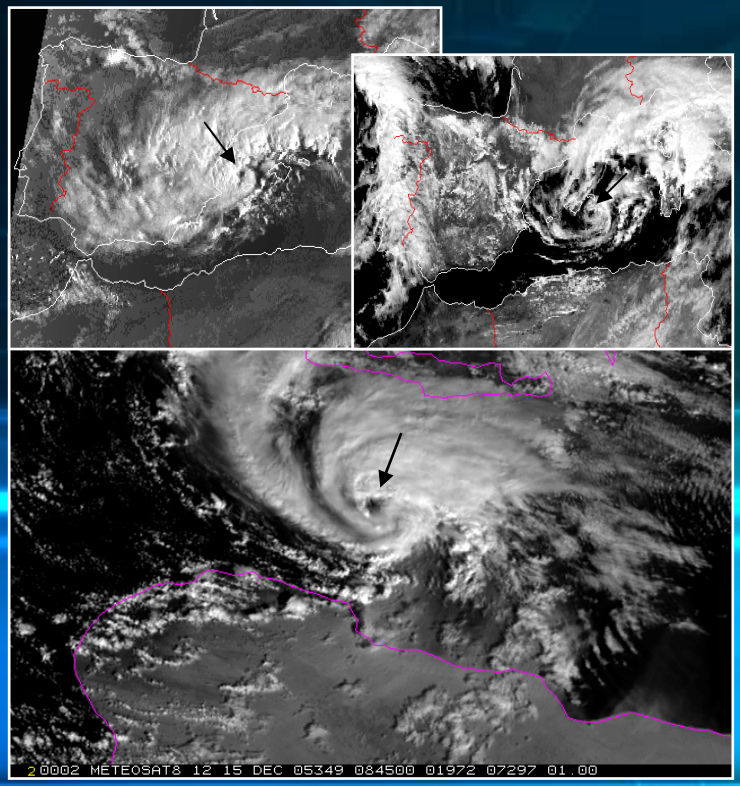
Tropical-like Mediterranean Storms: an analysis from satellite

Angel Luque, Lluis Fita, Romualdo Romero, Sergio Alonso



Group of Meteorology

Balearic Islands University, Spain

Universitat de les Illes Balears

Introduction

- Tropical-like storms or Medicanes (Emanuel, K. A., 2005) in the Mediterranean Sea are quite unusual. One or two cases as much are observed 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.
- However, situations like this happens very often in the Mediterranean basin. The factors that impulse the formation of a Medicane instead of an ordinary depression are still not well known (Fita et al, 2007).
- These storms, once generated over the sea, can affect islands and continental coastal lands. Although, documented tropical-like cyclones have not usually achieved hurricane intensity (120 km/h=33.3 m/seg=64.8 knots).

- The cases that we have monitored are:

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}

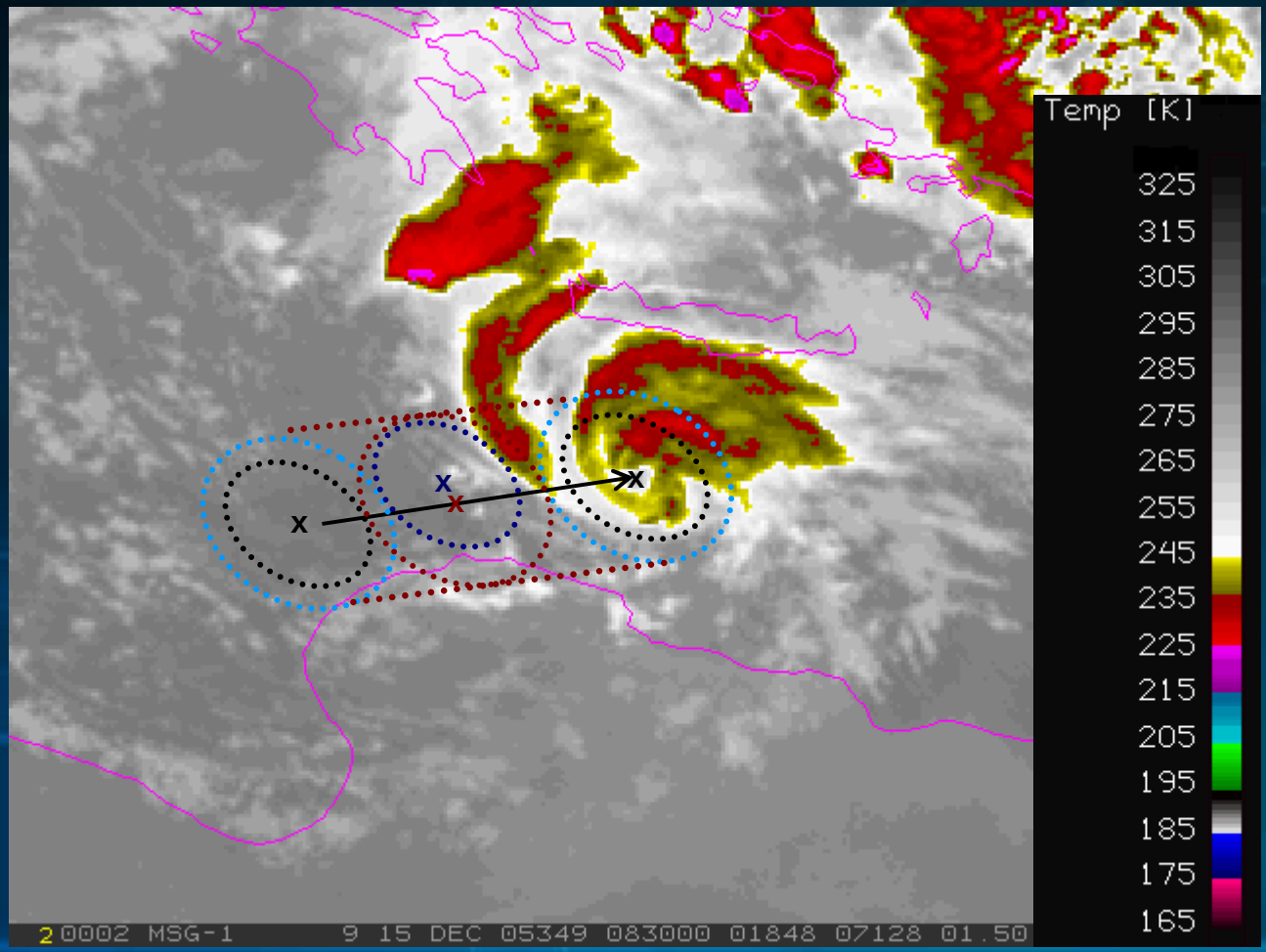
IR, VIS, WV

IR, VIS, WV

IR, VIS, WV

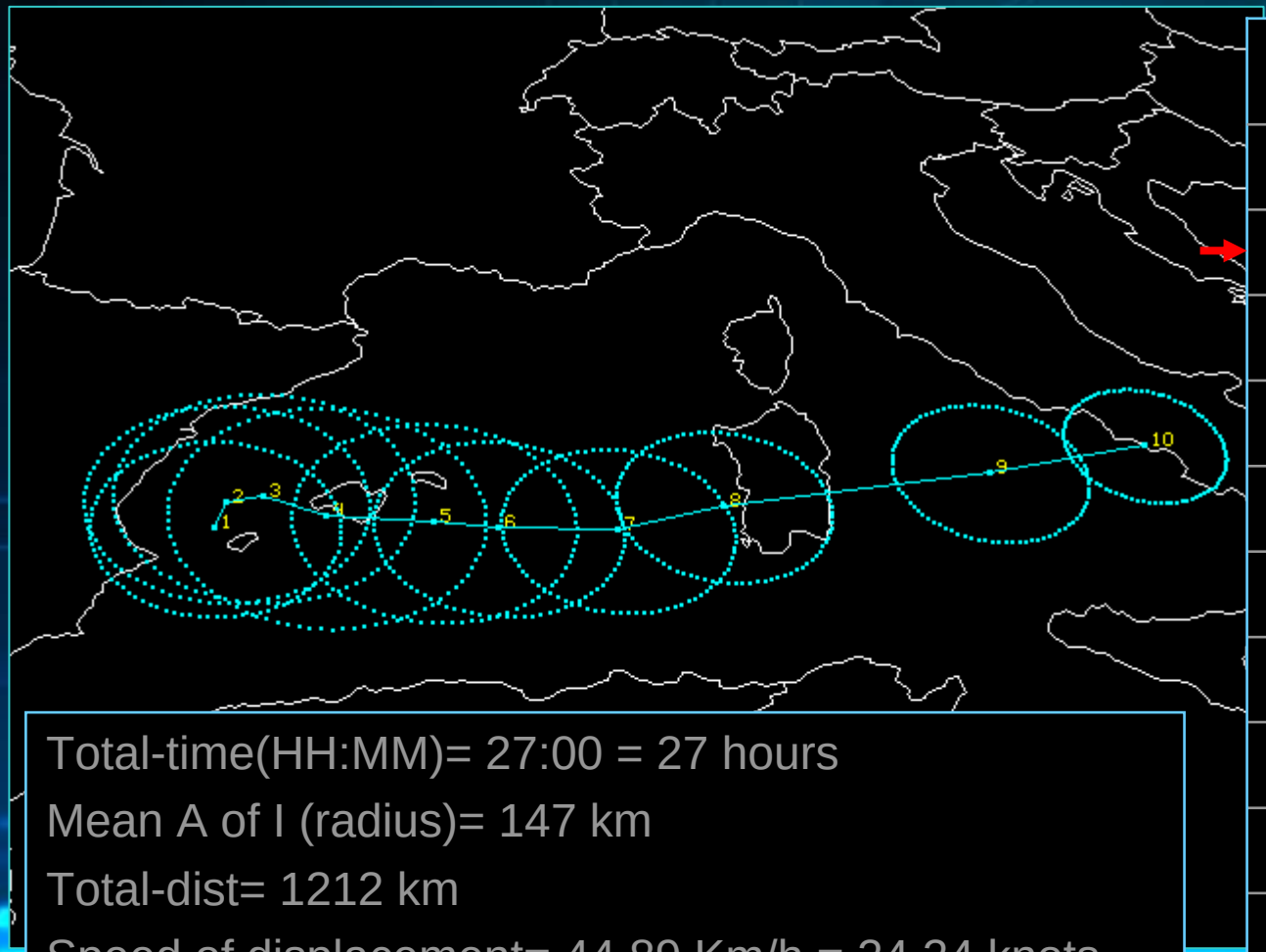
- All the satellite animations within a numerical analysis (Fita et al, 2006) can be found in:
  http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/LLUIS/medicanes/
- A more wide list of cases with images can be found in:
- http://www.fenomenitemporaleschi.it/ciclone.htm

- How are measured 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	140
2	" / " /12	05:00	160
3	" / " /12	09:30	170
4	" / " /12	12:30	190
5	" / " /12	16:00	170
6	" / " /12	17:00	150
7	" / " /12	19:00	140
8	" / " /12	20:30	130
9	" / " /13	02:00	120
10	" / " /13	04:30	100

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

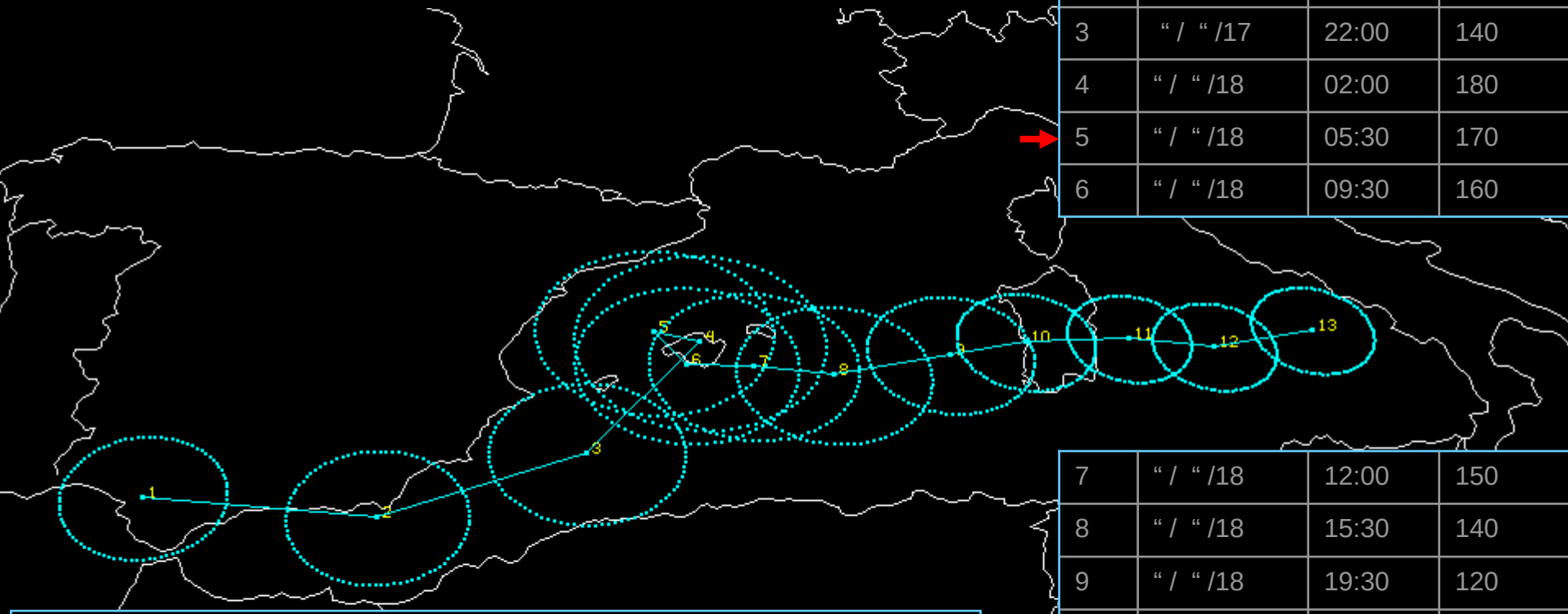
Mean A of I (radius)= 147 km

Total-dist= 1212 km

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

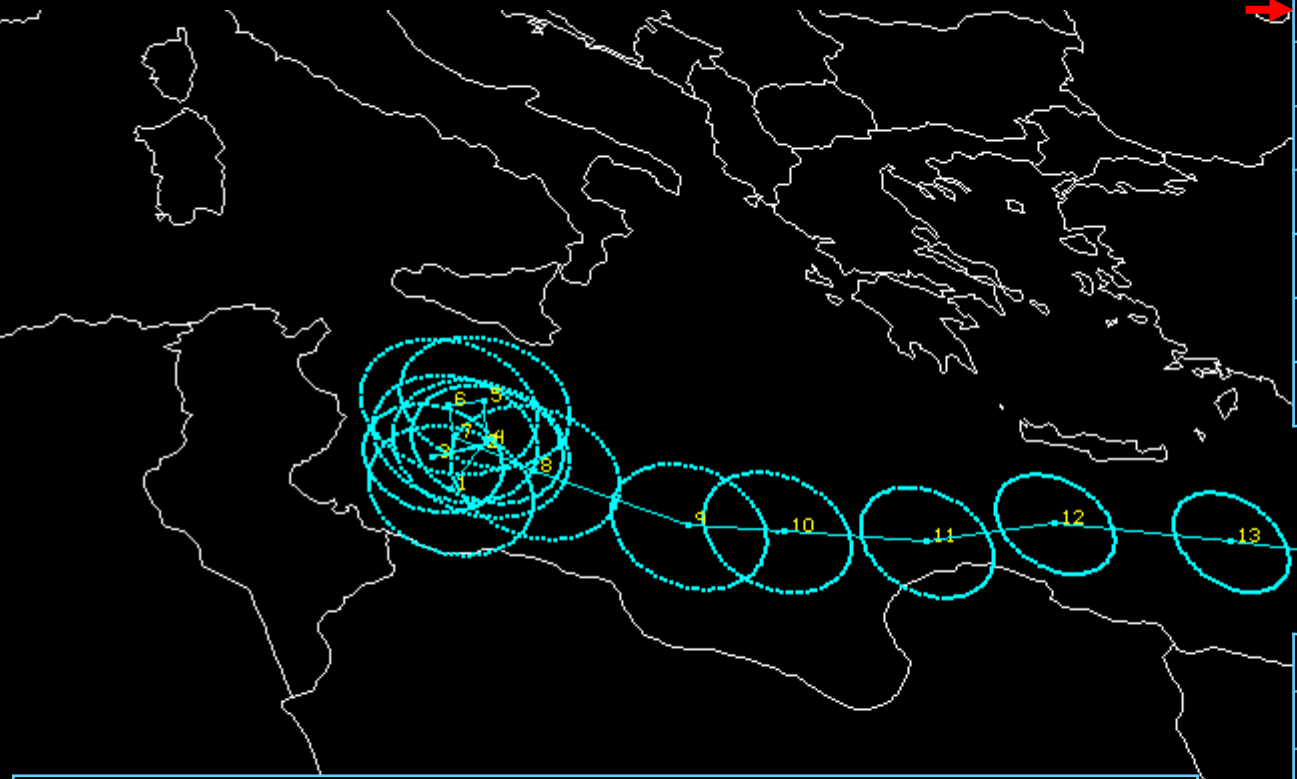
Mean A of I (radius)= 130 km

Total-dist= 2044 km

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

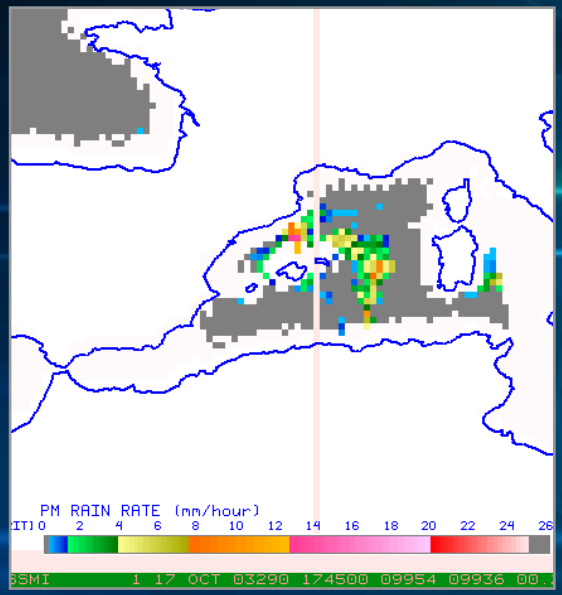
Mean A of I (radius)= 120 km

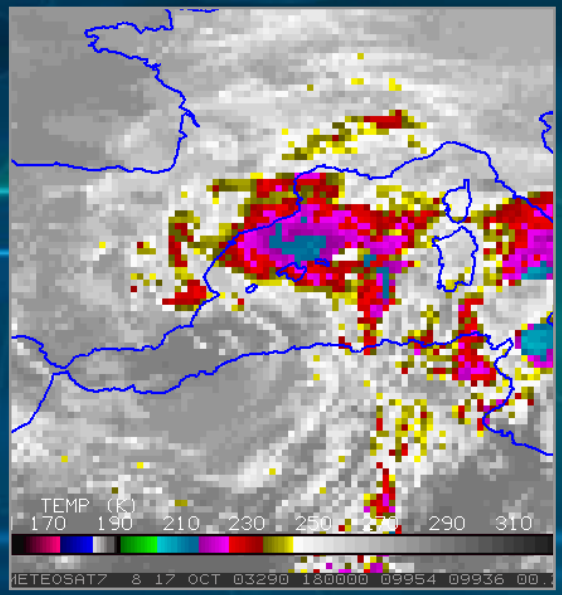
Total-dist= 2596 km

Speed of displacement= 37.4 Km/h = 20.17 knots

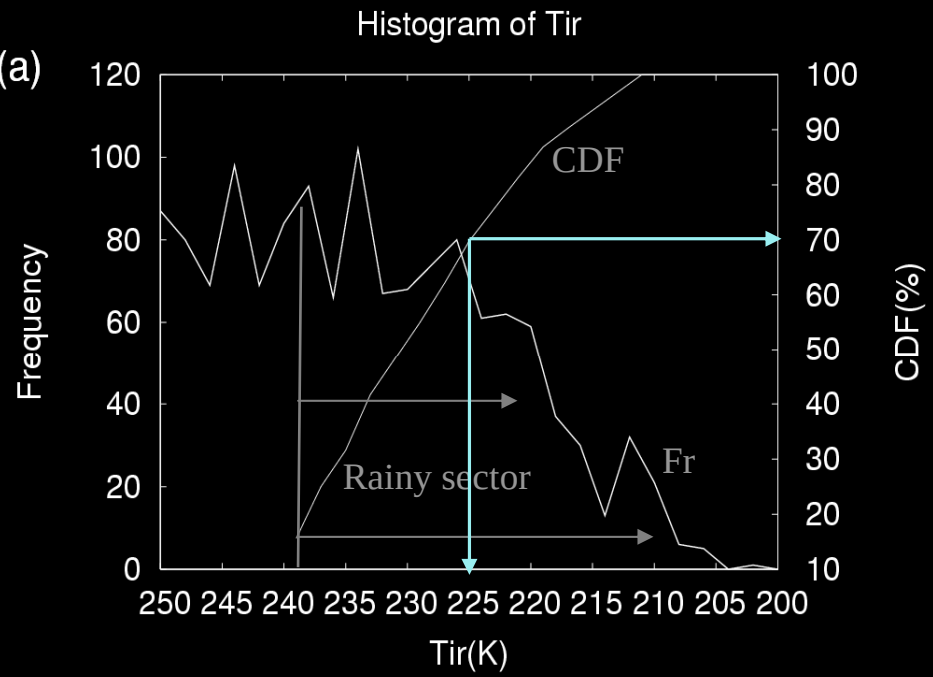
Estimation of the precipitation from Meteosat

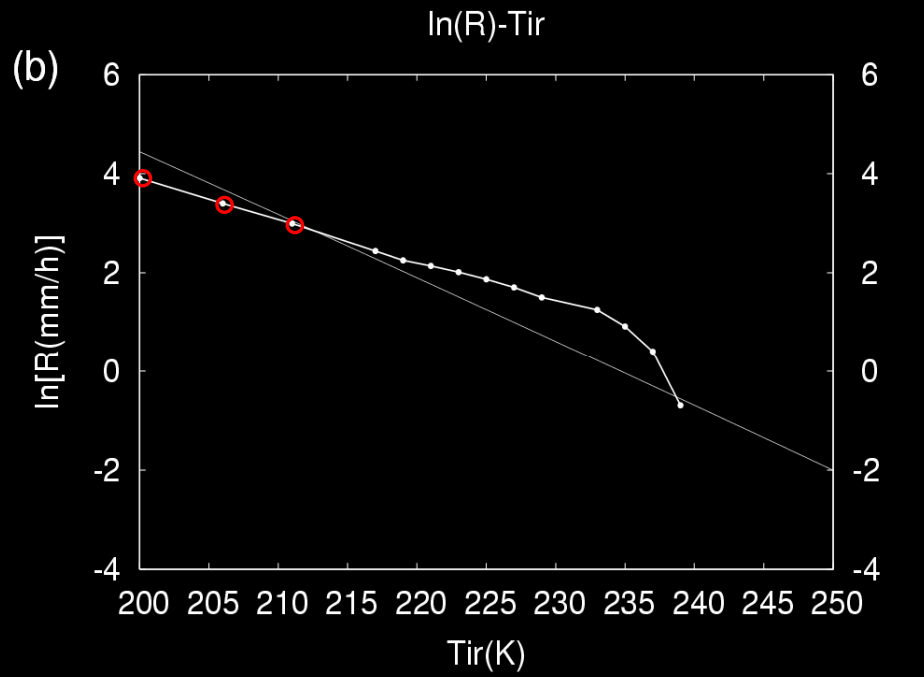
- Passive microwave precipitation images from SSM/I and AMRS sensors are combined with simultaneous infrared images to develop a rainfall curve.
- The technique applied was the Probability Matching Method (PMM) as documented by Turk et al (2000) and Kidd et al (2003).

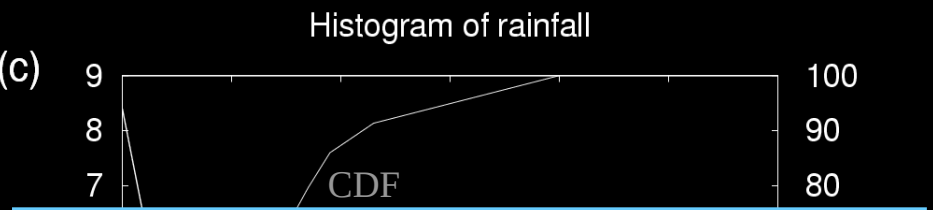




PM Day and UTM Time	MET Day and UTM Time	Nº of effective sea points
031017/ 17:45	031017/ 18:00	910
031017/ 20:42	031017/ 21:00	953
031018/ 09:00	031018/ 09:00	1014
031018/ 12:48	031018/ 13:00	1561
031018/ 17:30	031018/ 17:30	1064
		Total : 5502





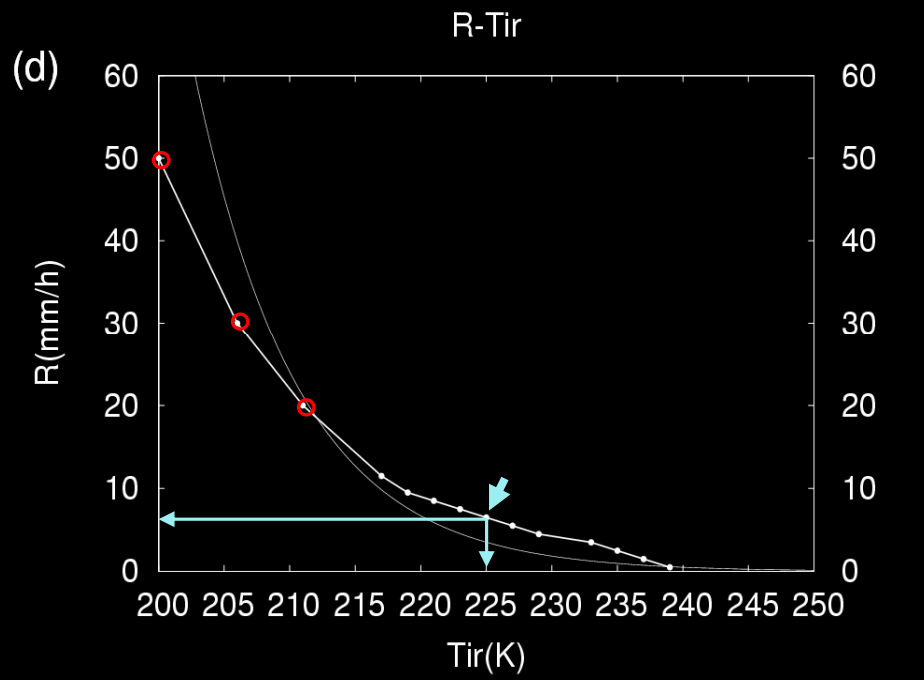


Nº of points= 5502

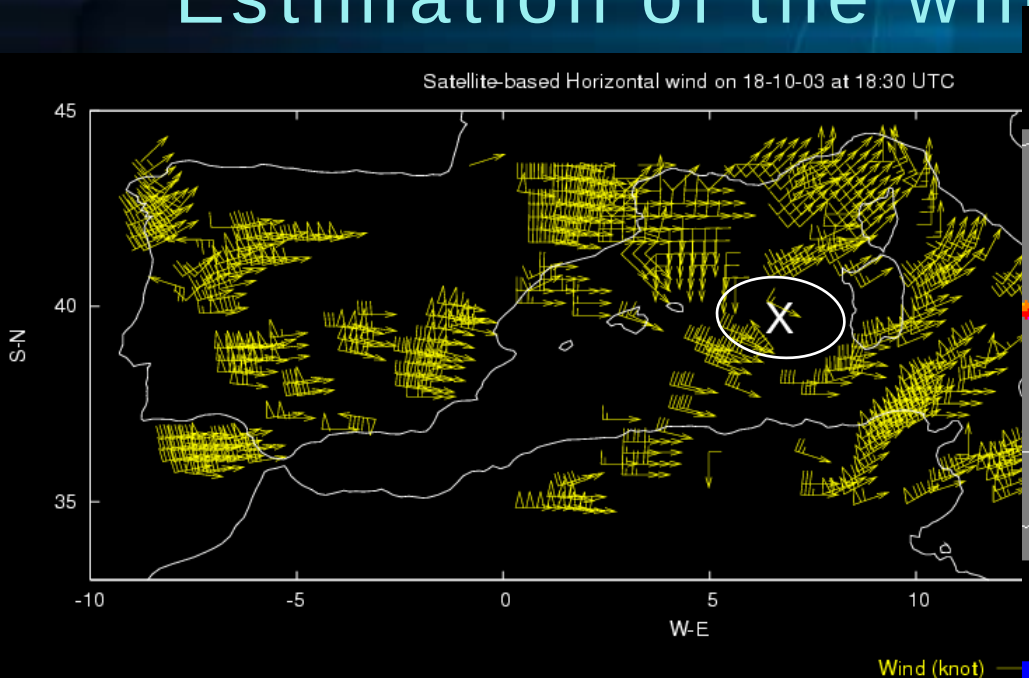
CORR = 0.59

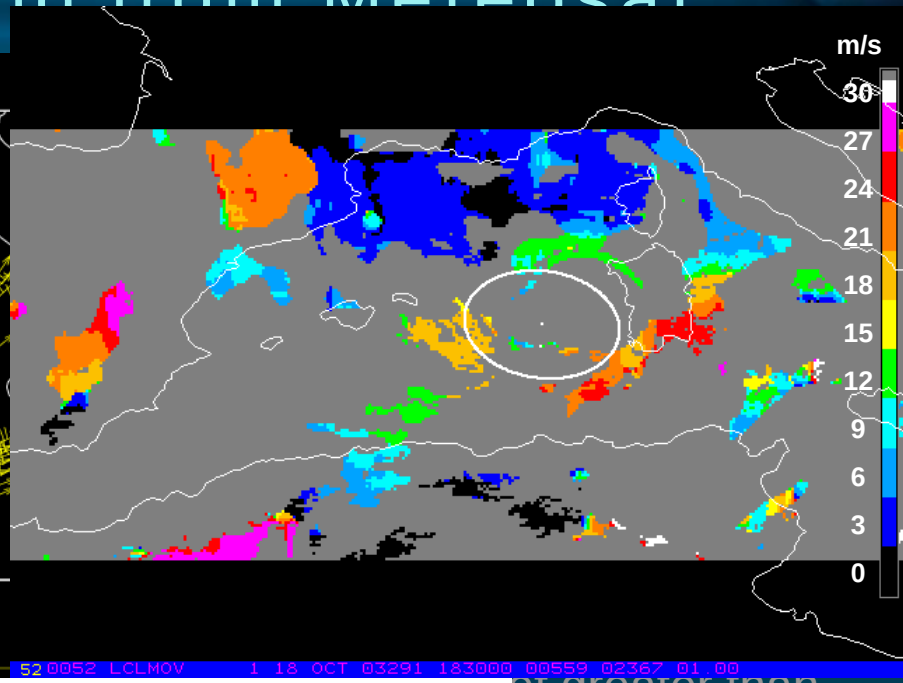
RMSE =1.1 mm/h

BIAS = 0.1 mm/h



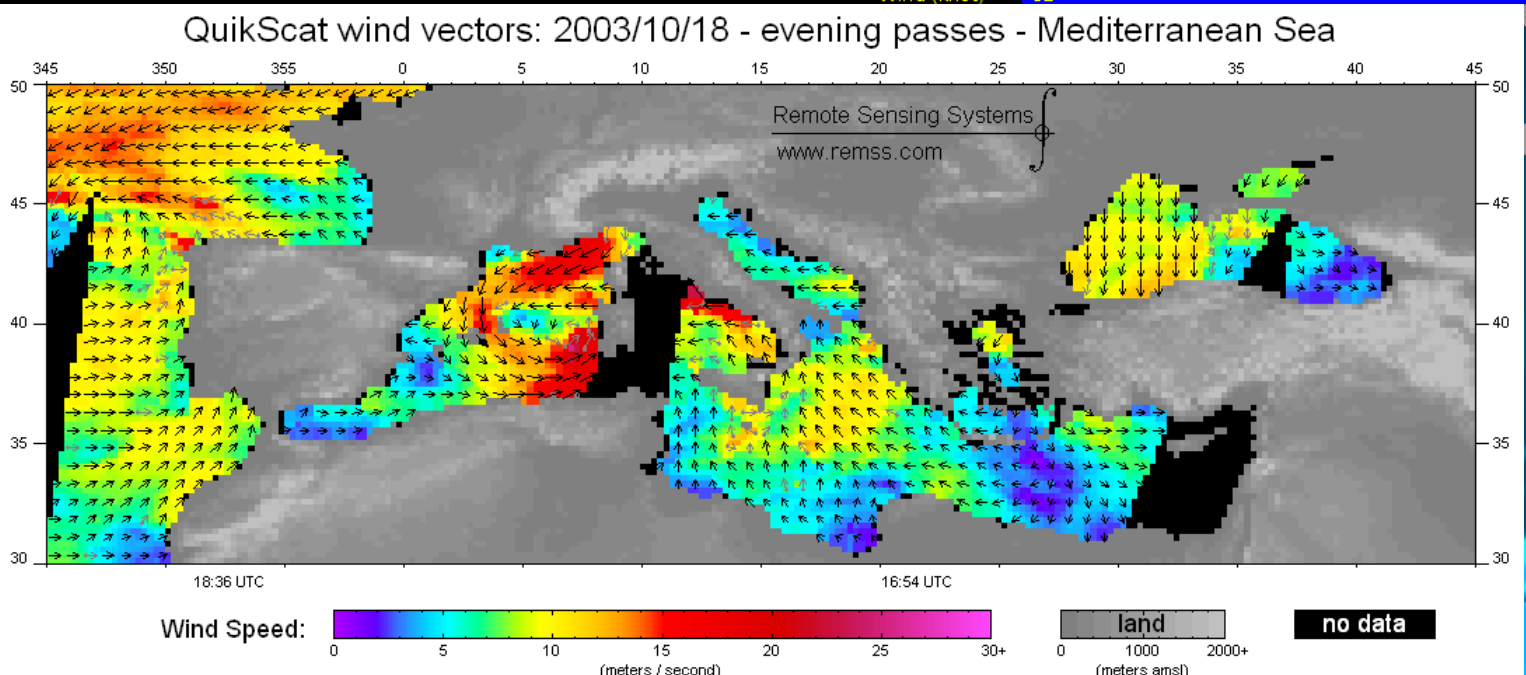
Estimation of the wind from Meteosat





Wind (knot)

52 0052 LCLMOV 1 18 OCT 03291 183000 00559 02367 01 00



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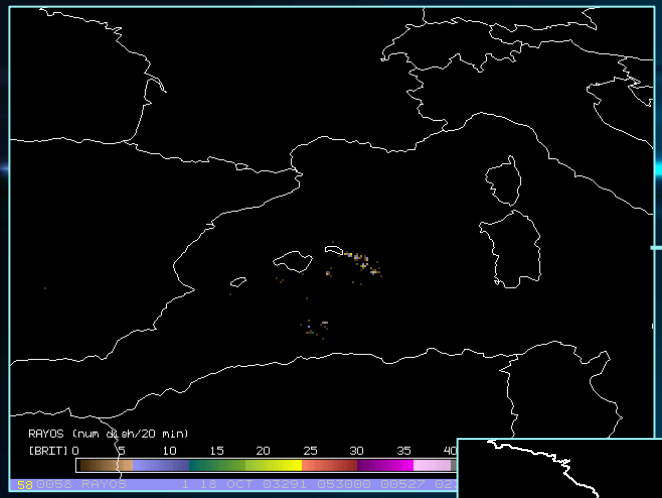
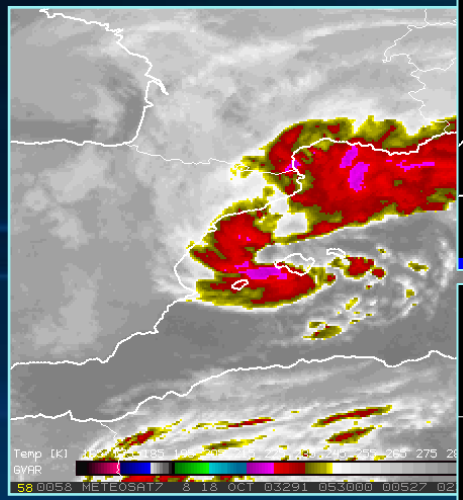
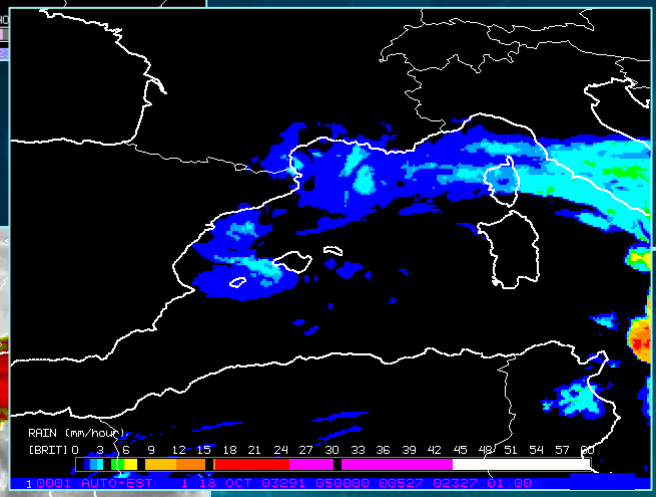
ts.

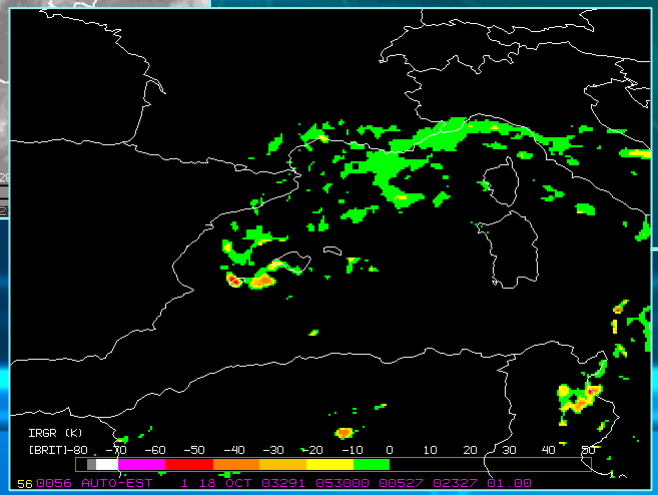
Estimation of Stratiform-Convective rain points from Meteosat and lightning

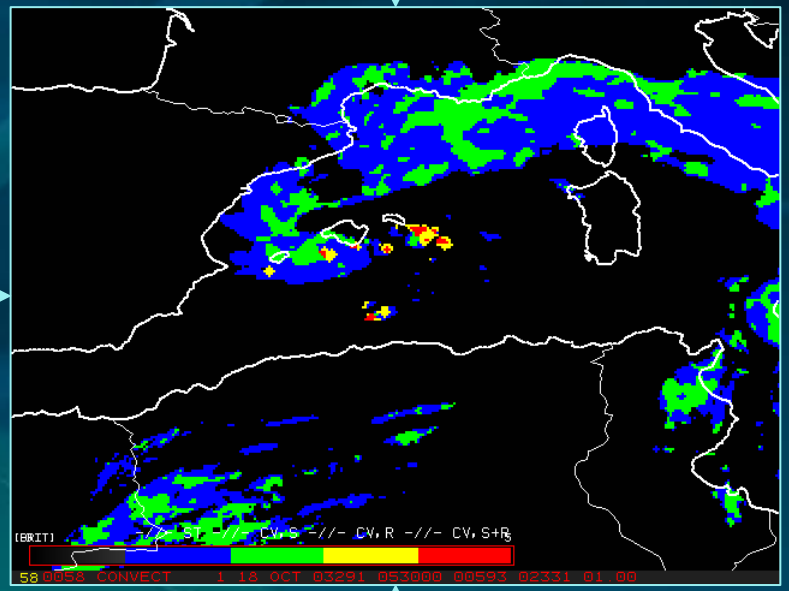
- Convective rain pixels are defined as those in which:
  - Electrical activity are detected (lightning data provided by the Spanish Weather Service, INM).
  - Meteosat infrared temperature pixel is cooling with respect to the time. A cloud pixel tracking algorithm was developed for this.
- Stratiform rain pixels are the rest.

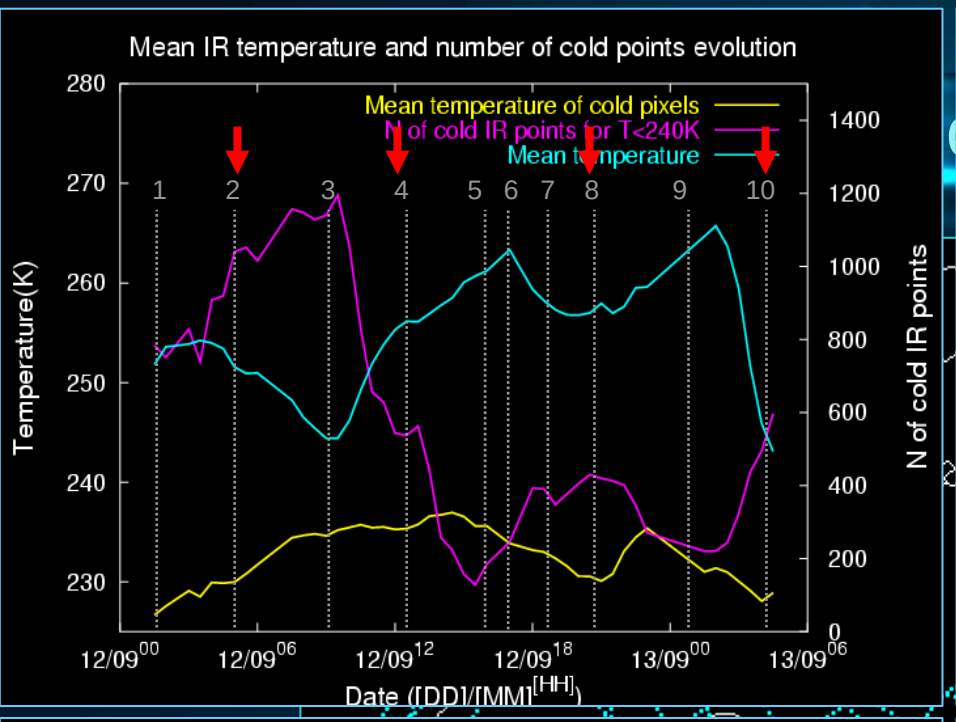

RAYOS (num d
[BRIT] 0 5 10 15 20 25 30 35 40

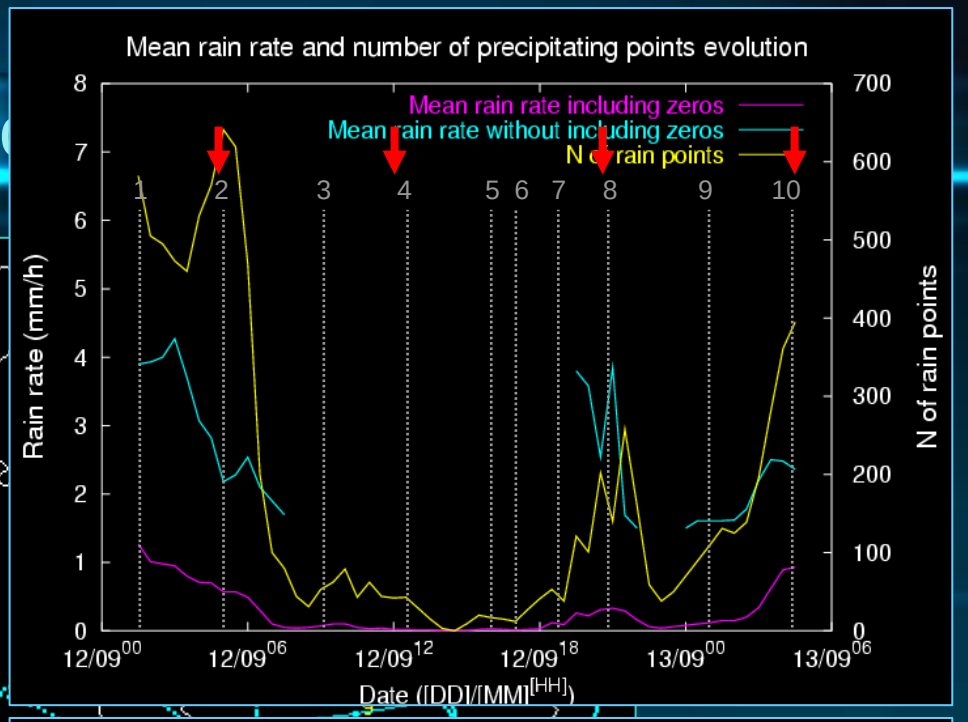

Temp [K]
GVAR
58 0058 METEOSAT7 8 18 OCT 03291 053000 00527 02

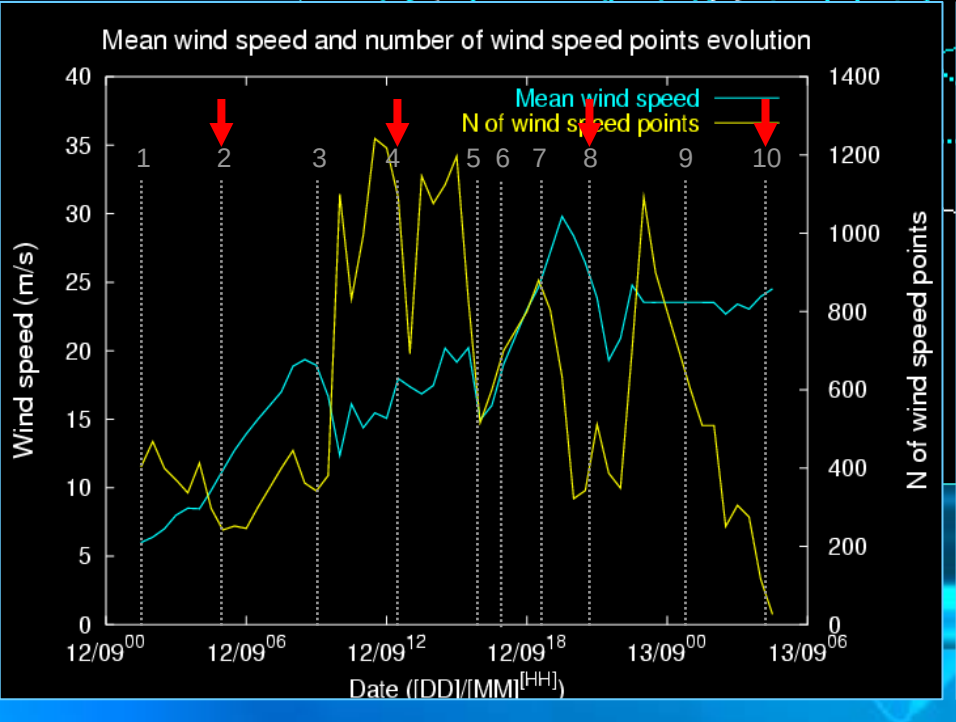

RAIN (mm/hour)
[BRIT] 0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60
1 0001 AUTO-EST 1 18 OCT 03291 050000 00527 02327 01.00

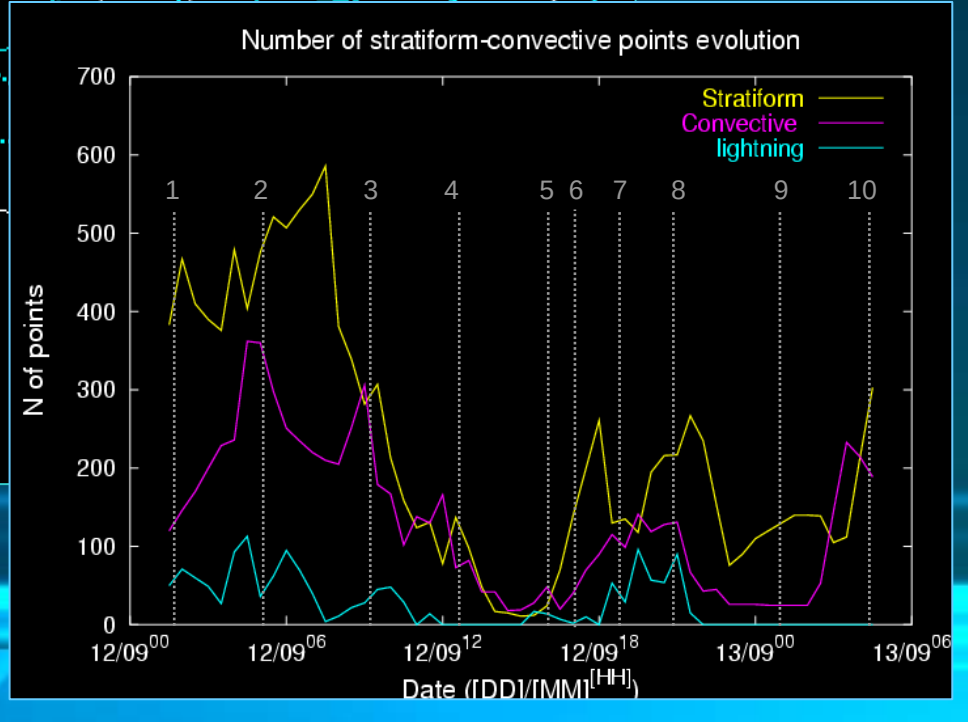

IRGR (K)
[BRIT] -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50
56 0056 AUTO-EST 1 18 OCT 03291 053000 00527 02327 01.00

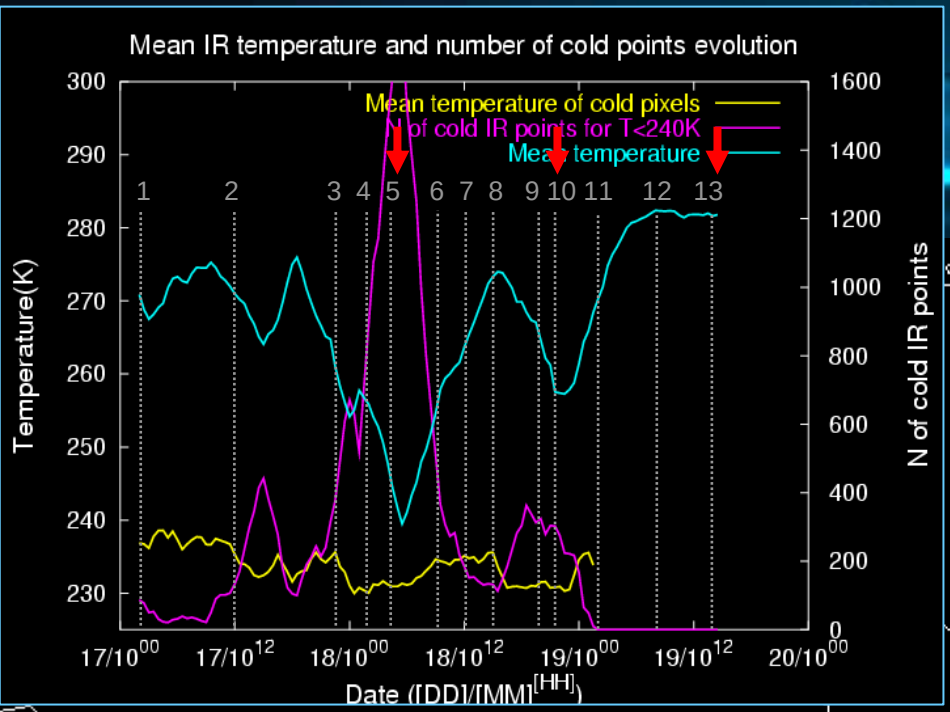

[BRIT] -//- CV,S -//- CV,R -//- CV,S+R
58 0058 CONVECT 1 18 OCT 03291 053000 00593 02331 01.00

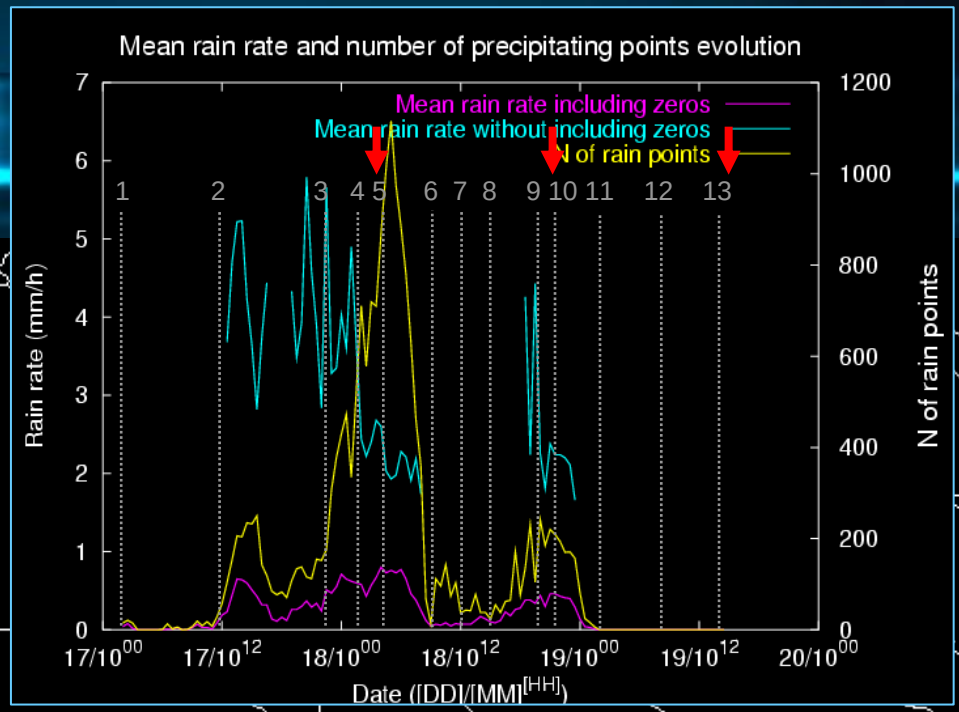

Mean IR temperature and number of cold points evolution
Mean temperature of cold pixels
N of cold IR points for T<240K
Mean temperature
Temperature(K)
N of cold IR points
Date ([DD]/[MM][HH])

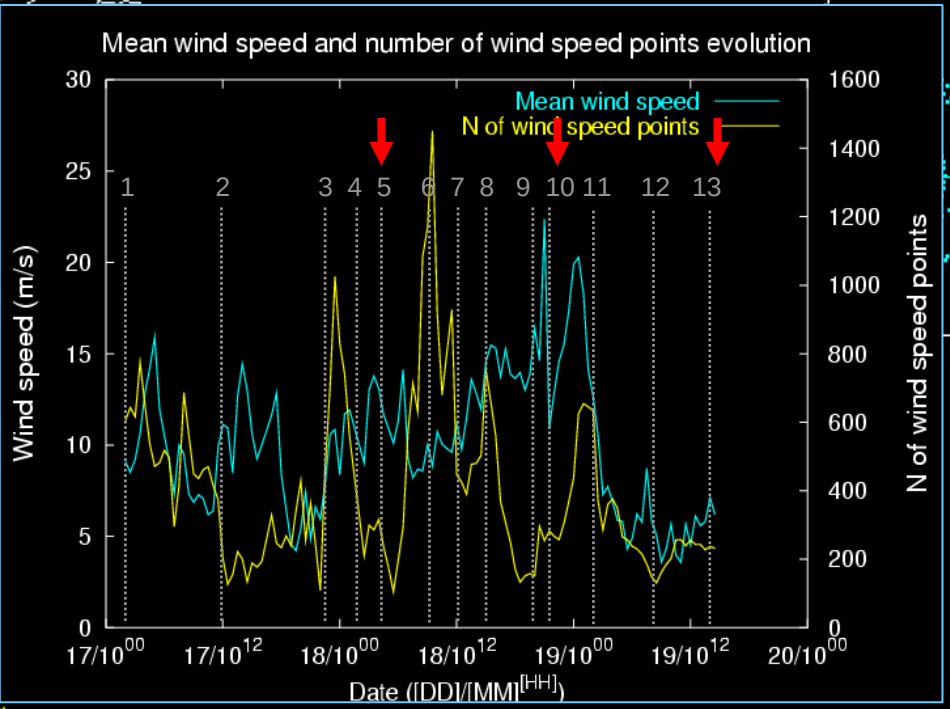

Mean rain rate and number of precipitating points evolution
Mean rain rate including zeros
Mean rain rate without including zeros
N of rain points
Rain rate (mm/h)
N of rain points
Date ([DD]/[MM][HH])

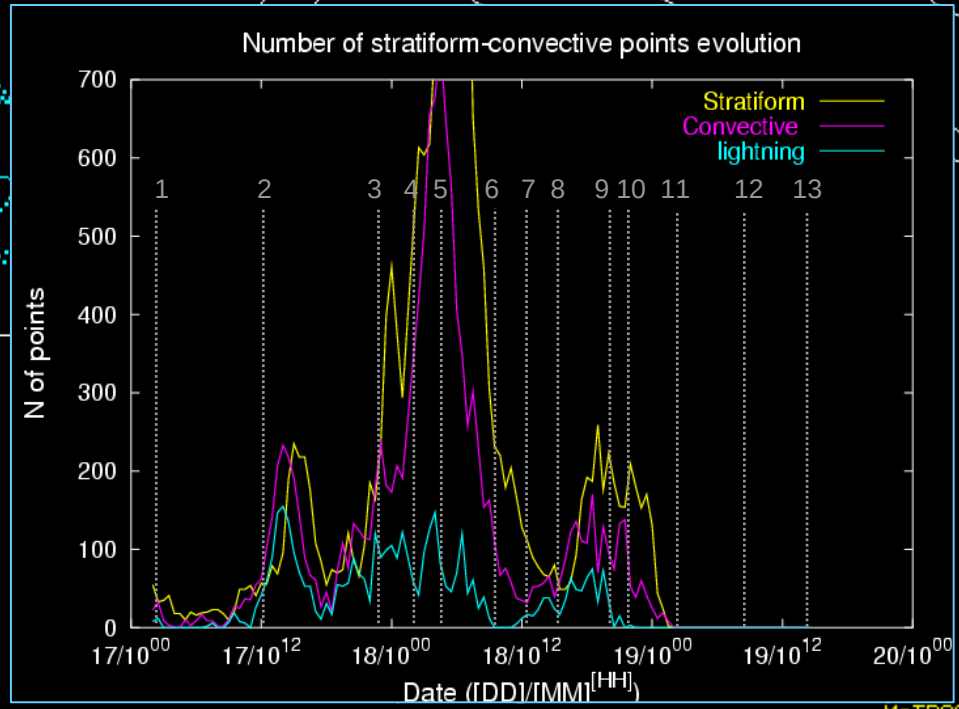

Mean wind speed and number of wind speed points evolution
Mean wind speed
N of wind speed points
Wind speed (m/s)
N of wind speed points
Date ([DD]/[MM][HH])

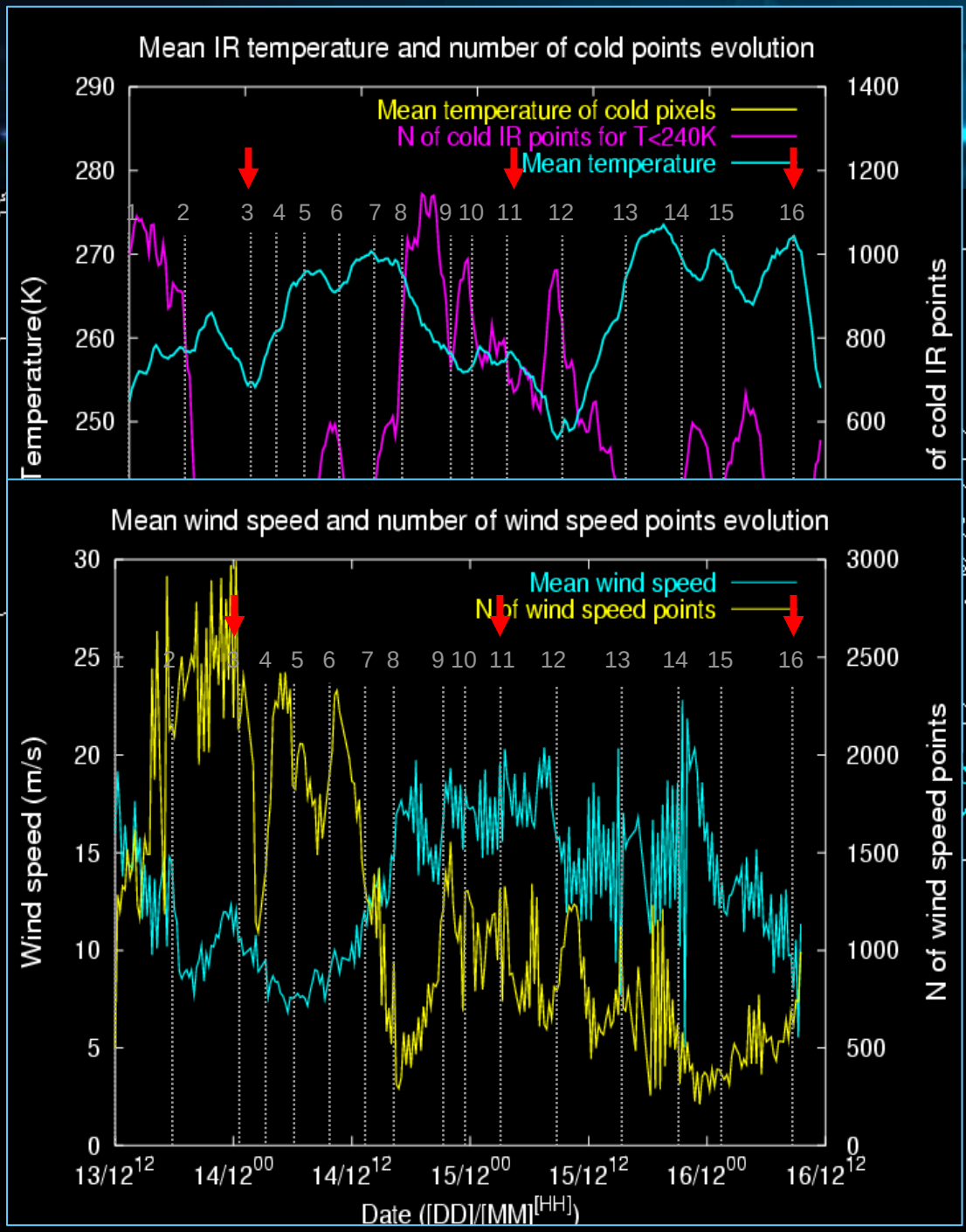

Number of stratiform-convective points evolution
Stratiform
Convective
lightning
N of points
Date ([DD]/[MM][HH])

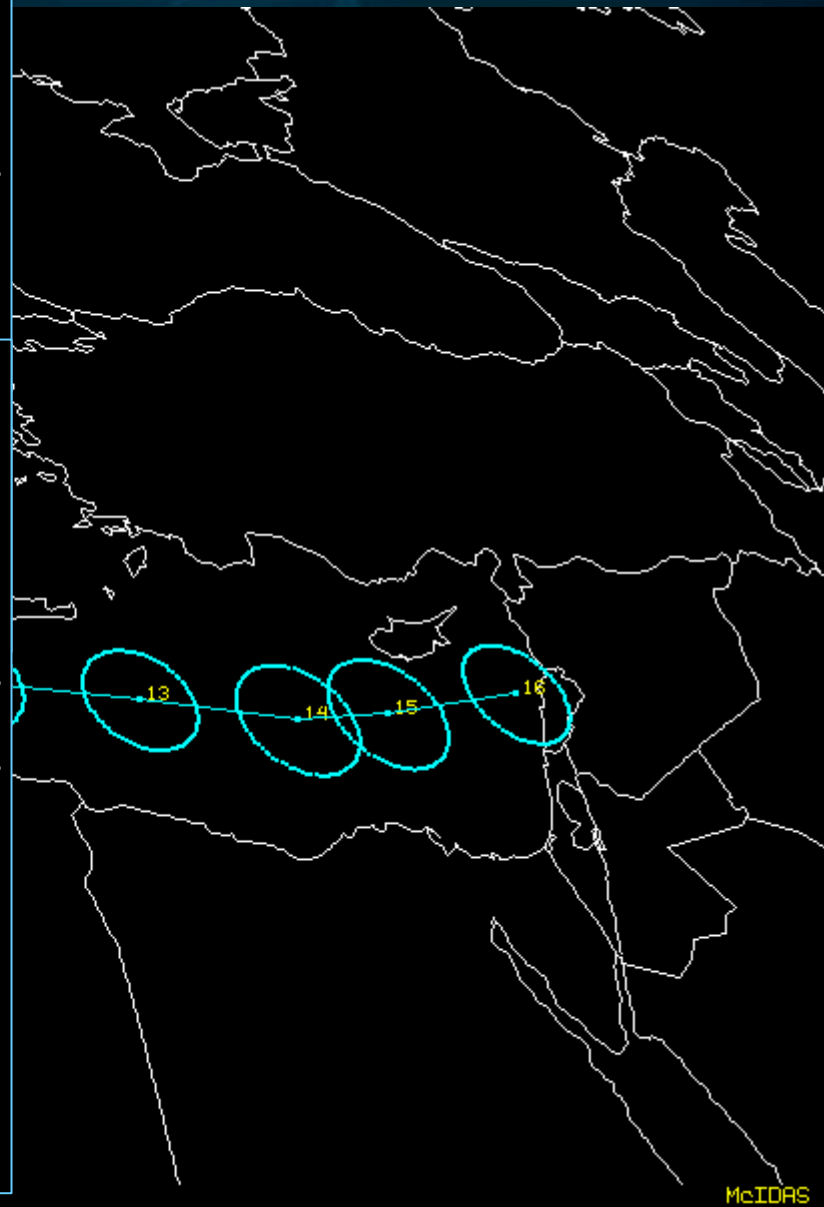

Mean IR temperature and number of cold points evolution
Mean temperature of cold pixels
N of cold IR points for T<240K
Mean temperature
Temperature(K)
N of cold IR points
Date ([DD]/[MM][HH])


Mean rain rate and number of precipitating points evolution
Mean rain rate including zeros
Mean rain rate without including zeros
N of rain points
Rain rate (mm/h)
N of rain points
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])


Number of stratiform-convective points evolution
Stratiform
Convective
lightning
N of points
Date ([DD]/[MM][HH])


Mean IR temperature and number of cold points evolution
Mean temperature of cold pixels
N of cold IR points for T<240K
Mean temperature
Temperature(K)
of cold IR points
290
280
270
260
250
1400
1200
1000
800
600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
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
30
25
20
15
10
5
0
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
13/12^12
14/12^00
14/12^12
15/12^00
15/12^12
16/12^00
16/12^12
Date ([DD]/[MM][HH])


13
14
15
16
McIDAS

Conclusions

- Three phases in the live of a medicane are observed:
  - **Pre-medicane**:
    - 960912, 051215, Strong convection and heavy rainfalls but no clear vortex.
    - 031018, Clear small vortex moving in one side of the convective system.
  - **Stationary phase**: An eye is observed for the first time, heavy rainfalls (max 17 mm/h), convection and winds (mean 12 m/s).
  - **Travelling phase**: The medicane is moving fast in a clear direction, not much rainfall but strong wind speeds are estimated (mean 18 m/s).

- The number of precipitating points is reduced significantly when the medicane pass to the travelling phase.

- Convection and rainfall are increased when the medicane pass over an island or when it arrives to mainland.

- Wind speed seems to increase gradually during the travelling phase.

Thank you

Special thanks to the institutions that have provided free and qualified data for this work:
EUMETSAT, Remote Sensing Systems (RSS) and Spanish Weather Service (INM)

Animations -> http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/LLUIS/medicanes/
Medicane list -> http://www.fenomenitemporaleschi.it/ciclone.htm

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