

Quantitative assessment of future climate conditions favorable to mediacane development

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UNIÓN EUROPEA
FONDO EUROPEO DE
DESARROLLO REGIONAL
"Una manera de hacer Europa"



MINISTERIO
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Universitat de les
Illes Balears

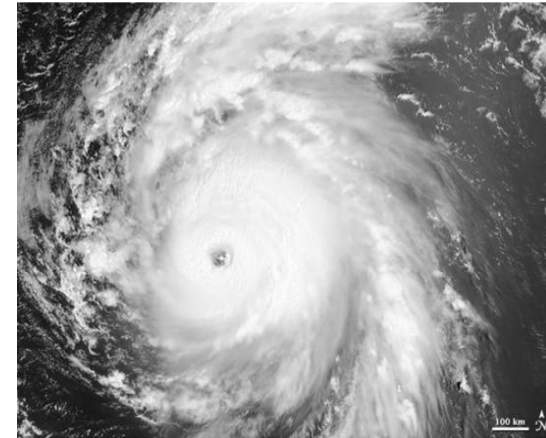
What are MEDICANES?



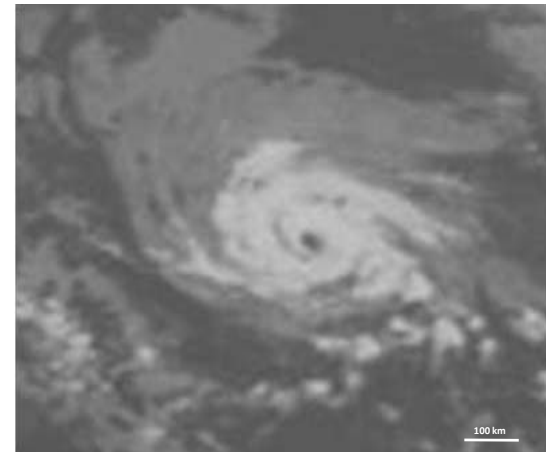
MEDiterranean
+ HurriCANES
MEDICANES

MEDICANES are tropical-like cyclones which develop over the Mediterranean Sea, sometimes attaining hurricane intensity.

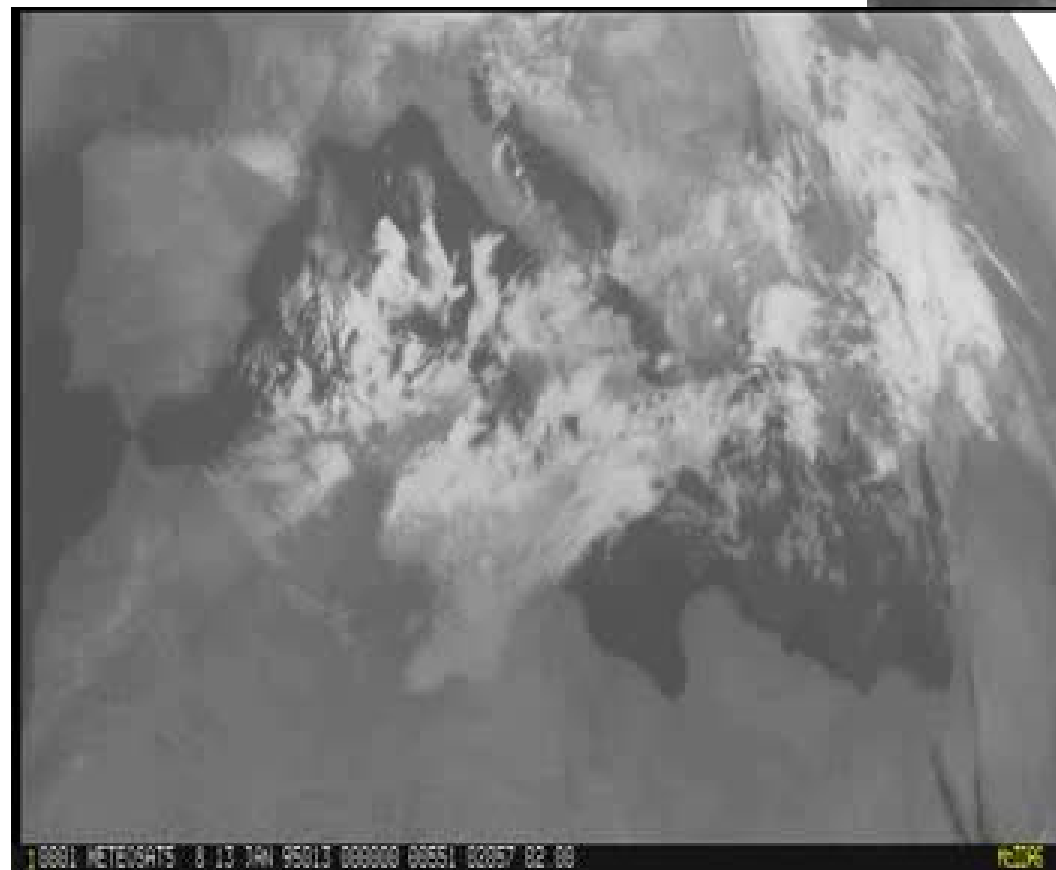
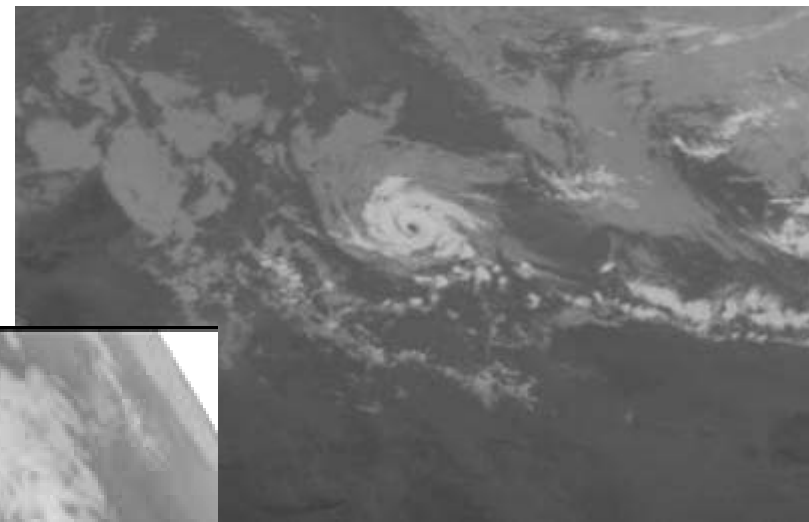
MEDICANES operate on the thermodynamical disequilibrium between the sea and the atmosphere and in this respect, as well in their visual appearance in satellite images, are much tropical cyclones.

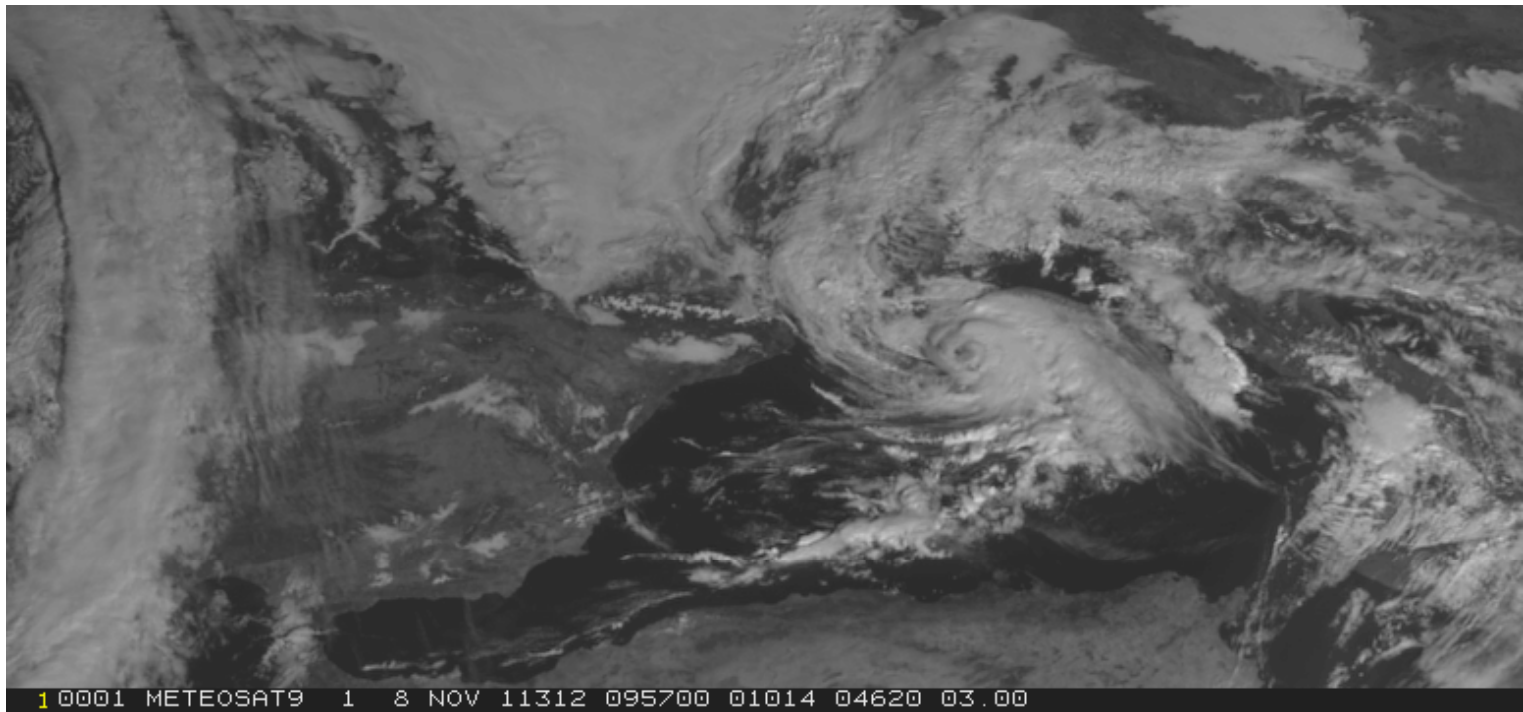
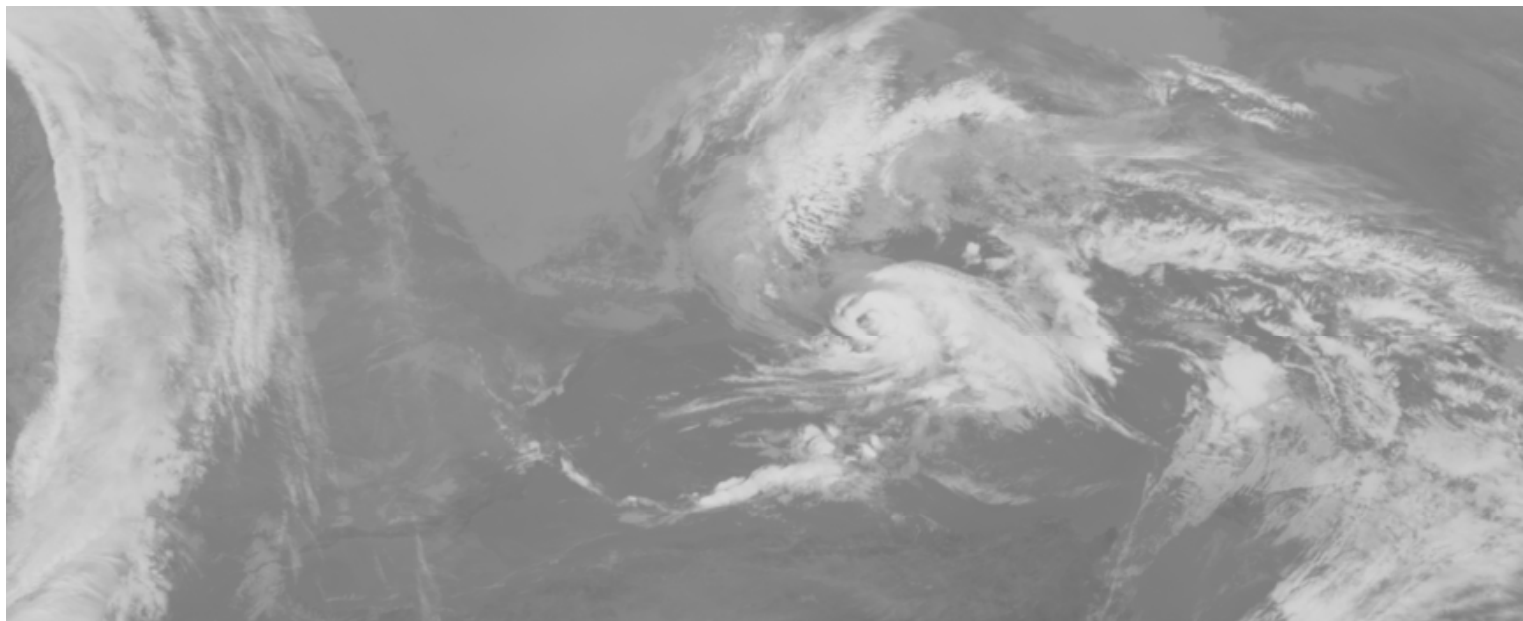


Hurricane Bill. Aug 2009



Medicane. Jan 1995





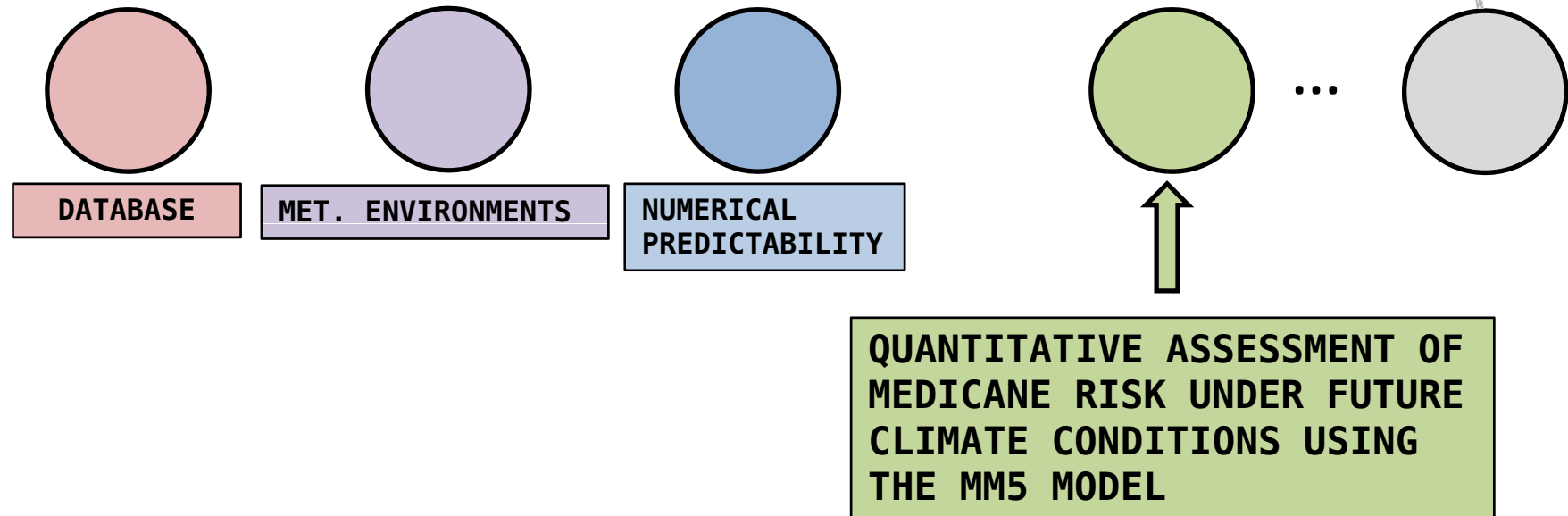


MEDiterranean
+ HurriCANES
MEDICANES

MEDICANES: Meteorological Environments, Numerical
Predictability and Risk Assessment in the Present and Future
Climate (MEC, CGL2008-01271/CLI)

OBJECTIVE

**TO ASSESS THE MEDICANE RISK UNDER THE
PRESENT AND FUTURE CLIMATE CONDITIONS.**



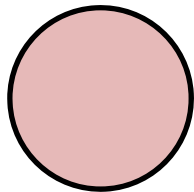


MEDiterranean
+ HurriCANES
MEDICANES

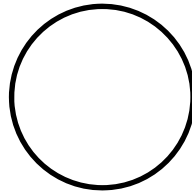
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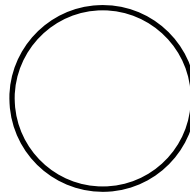
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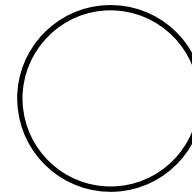
DATABASE



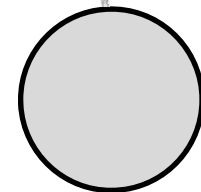
MET. ENVIRONMENTS



**NUMERICAL
PREDICTABILITY**



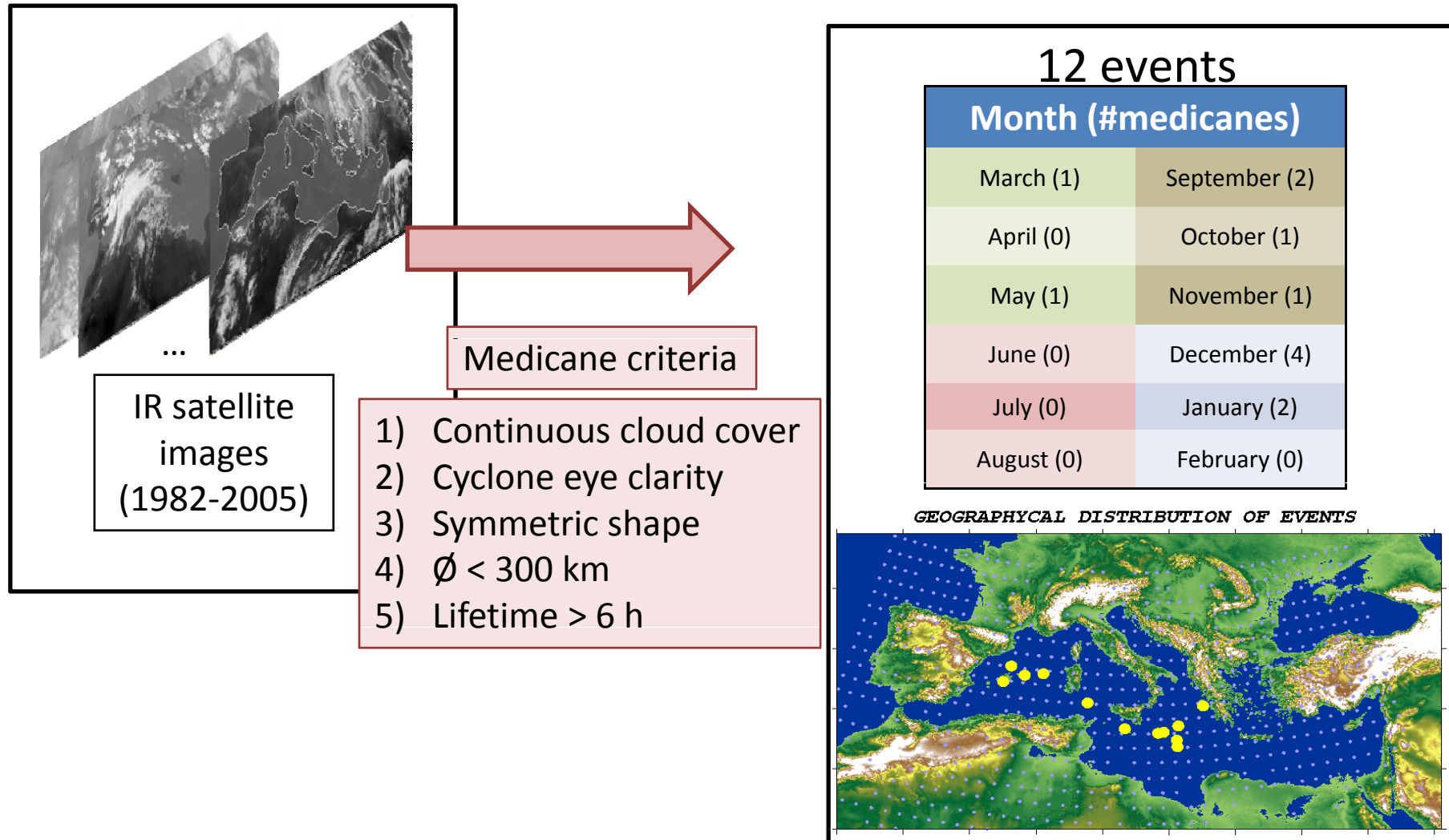
...



**QUANTITATIVE ASSESSMENT OF MEDICANE
RISK UNDER FUTURE CLIMATE CONDITIONS
USING THE MM5 MODEL**

TO CREATE A DATABASE OF EVENTS

Our database



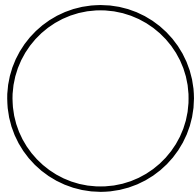


MEDiterranean
+ HurriCANES
MEDICANES

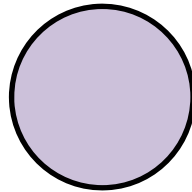
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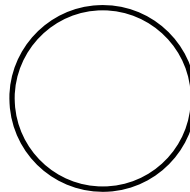
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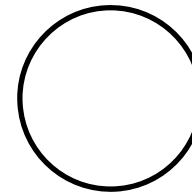
DATABASE



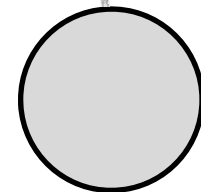
MET. ENVIRONMENTS



**NUMERICAL
PREDICTABILITY**



...



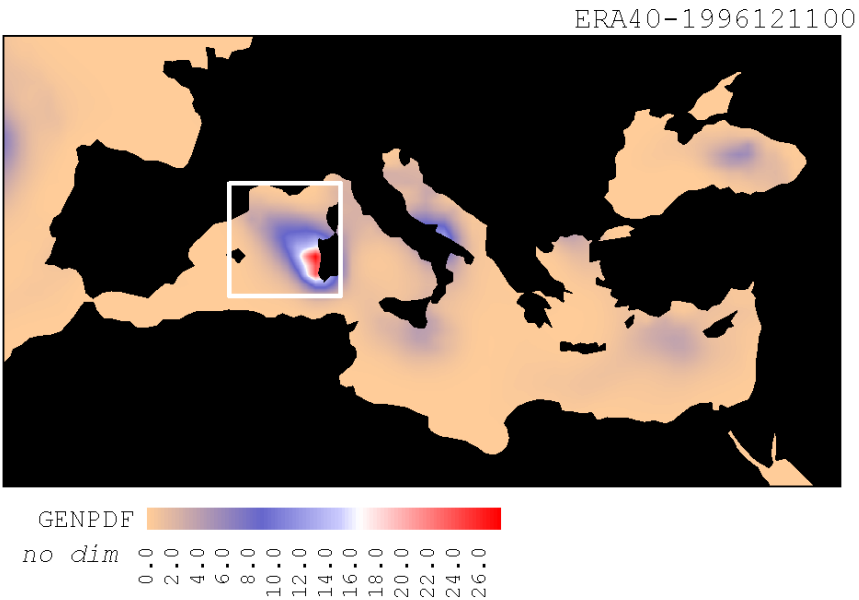
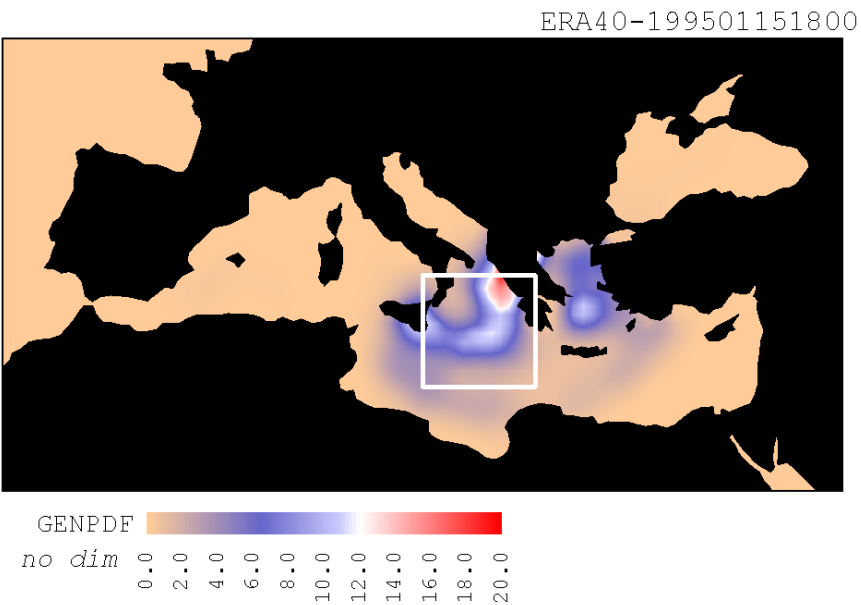
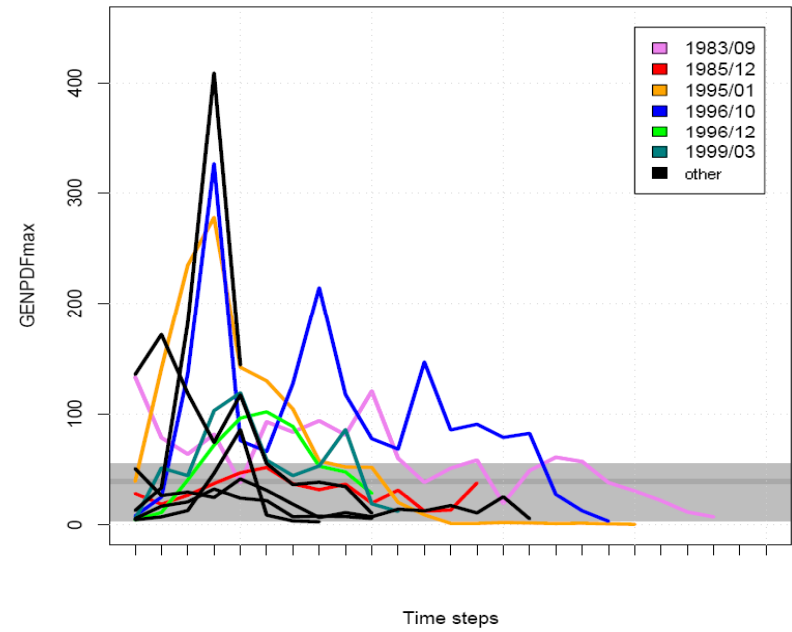
**QUANTITATIVE ASSESSMENT OF MEDICANE
RISK UNDER FUTURE CLIMATE CONDITIONS
USING THE MM5 MODEL**

AVOR850 (η)	Low-tropospheric vorticity
DIAB1000	Diabatic contribution to surface level equivalent potential temperature
RH600 (H)	Mid-tropospheric relative humidity
SST (T_s)	Sea Surface Temperature
VSHEAR8525 (V_{shear})	Tropospheric wind shear
P.I.	Potential Index
GENPDF	Empirical genesis index

$$\text{P.I.} \approx \frac{C_k}{C_D} \frac{T_s - T_0}{T_0} (k_0^* - k)$$

$$\text{GENPDF} = \left| 10^5 \eta \right|^{3/2} \left(\frac{H}{50} \right)^3 \left(\frac{\text{P.I.}}{70} \right)^3 (1 + 0.1 V_{\text{shear}})^{-2}$$

AVOR850 (η)
DIAB1000
RH600 (H)
SST (T_s)
VSHEAR8525 (v_{shear})
P.I.
GENPDF



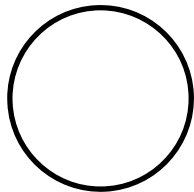


MEDiterranean
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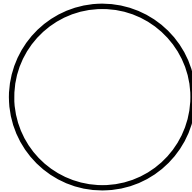
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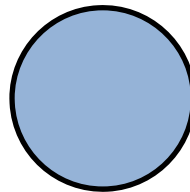
**TO ASSESS THE MEDICANE RISK UNDER THE
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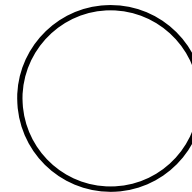
DATABASE



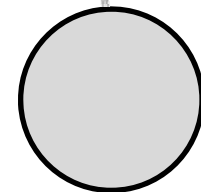
MET. ENVIRONMENTS



**NUMERICAL
PREDICTABILITY**

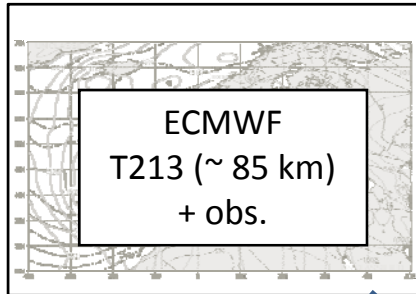


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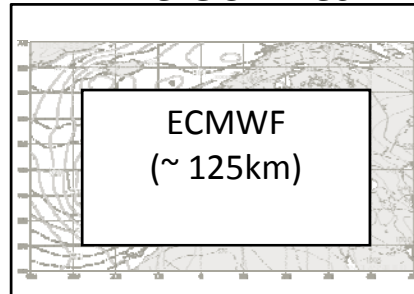


**QUANTITATIVE ASSESSMENT OF MEDICANE
RISK UNDER FUTURE CLIMATE CONDITIONS
USING MM5 MODEL**

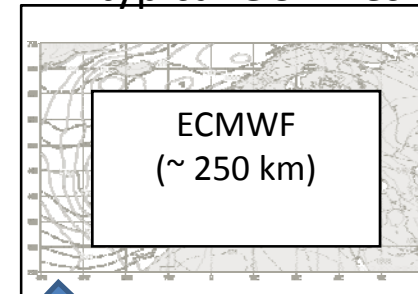
CONTROL



fine GCM res.

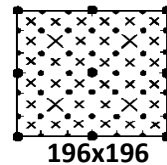


typical GCM res.



MESOSCALE MODEL SIMULATION

48h



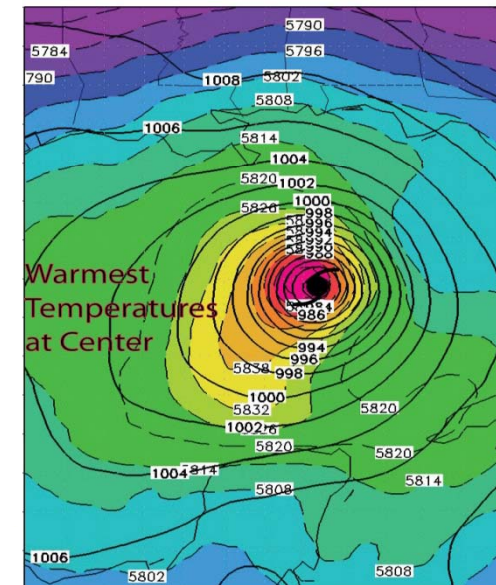
MM5
7.5 km

LOW RESOLUTION
of the input large
scale fields

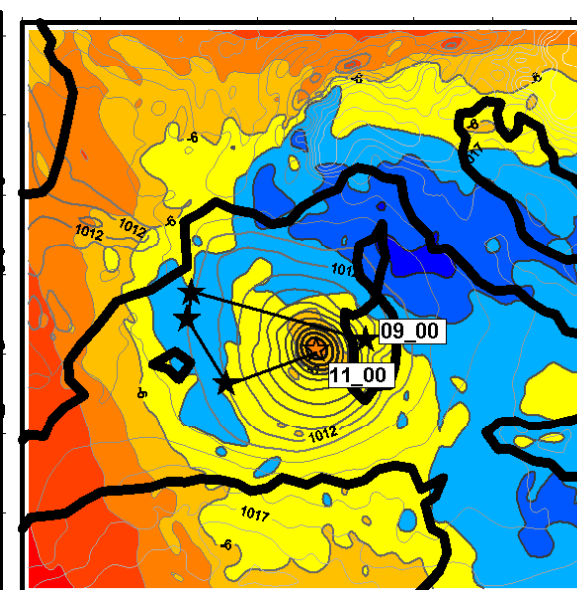
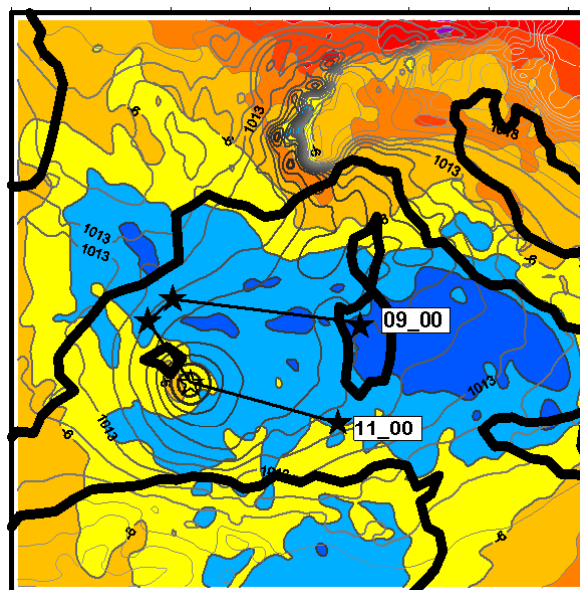
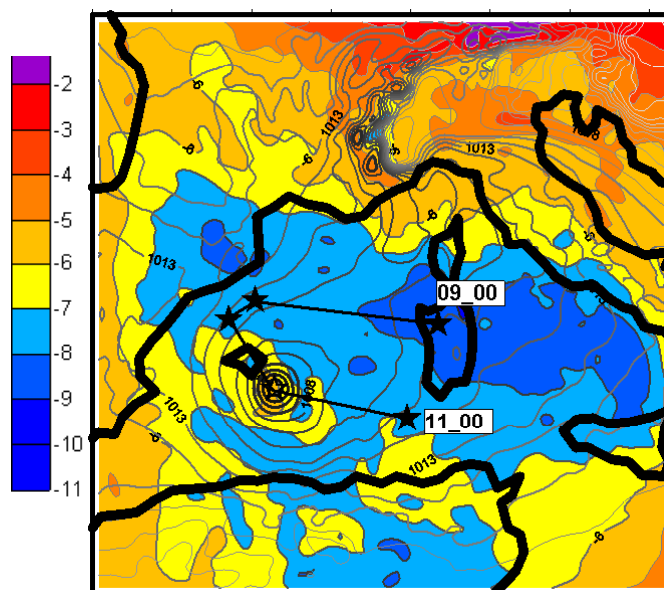
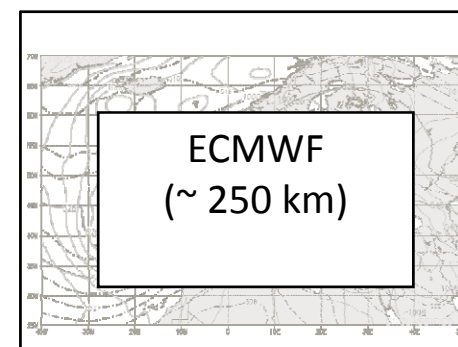
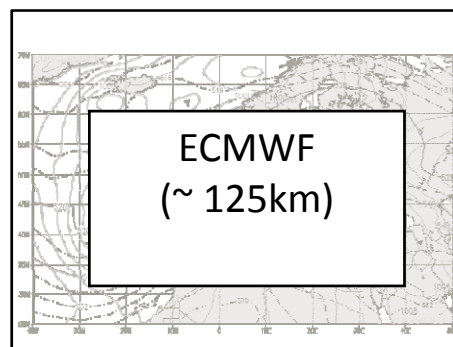
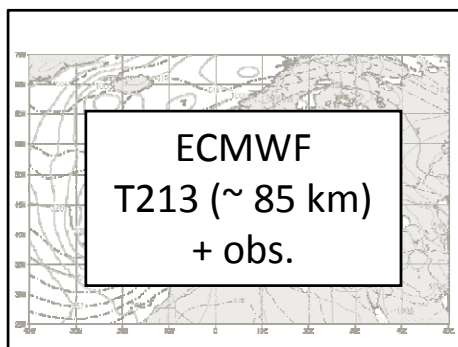
TO EXAMINE NUMERICAL
PREDICTABILITY OF
MEDICANES.

Quasi-symmetric intense low-
pressure centres at surface with
an isolated warm-core structure
aloft.

Katrina, Warm Core Low



Sfc Isobars (solid, mb)
Sfc-500 mb Mean Temp (shaded)
12 UTC 28 Aug 2005
<http://tornado.sfsu.edu/>



MM5
7.5 km

Contours: SLP every 1 hPa. Colored:Temp.(°C) 700 hPa

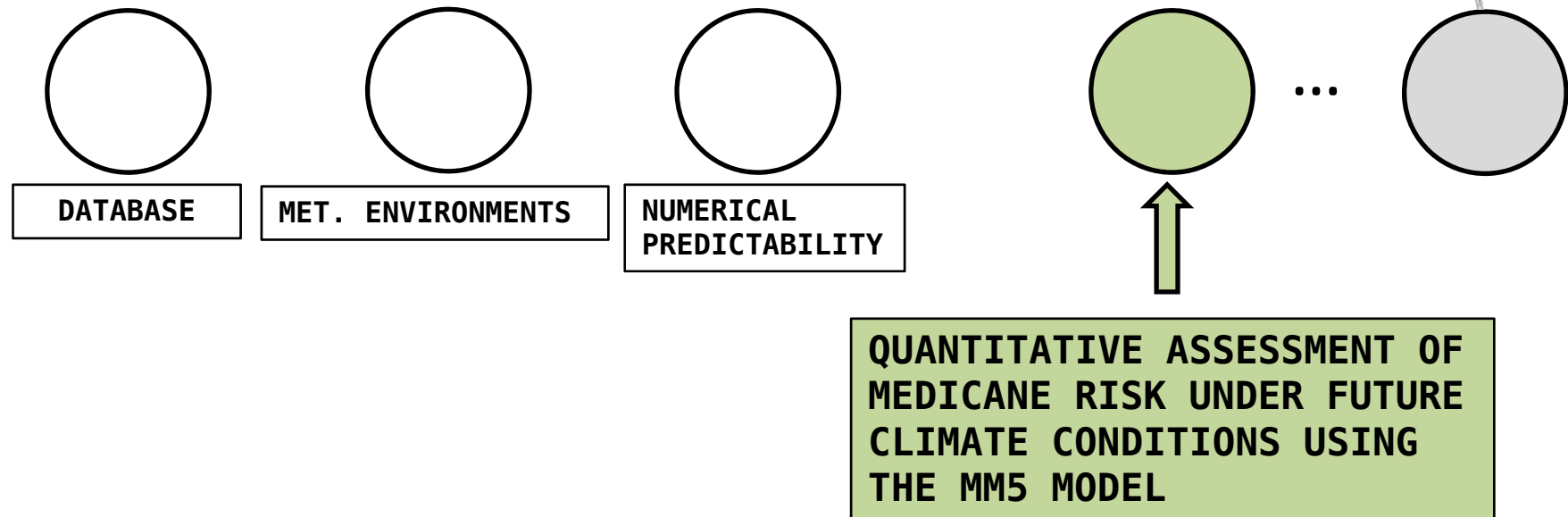


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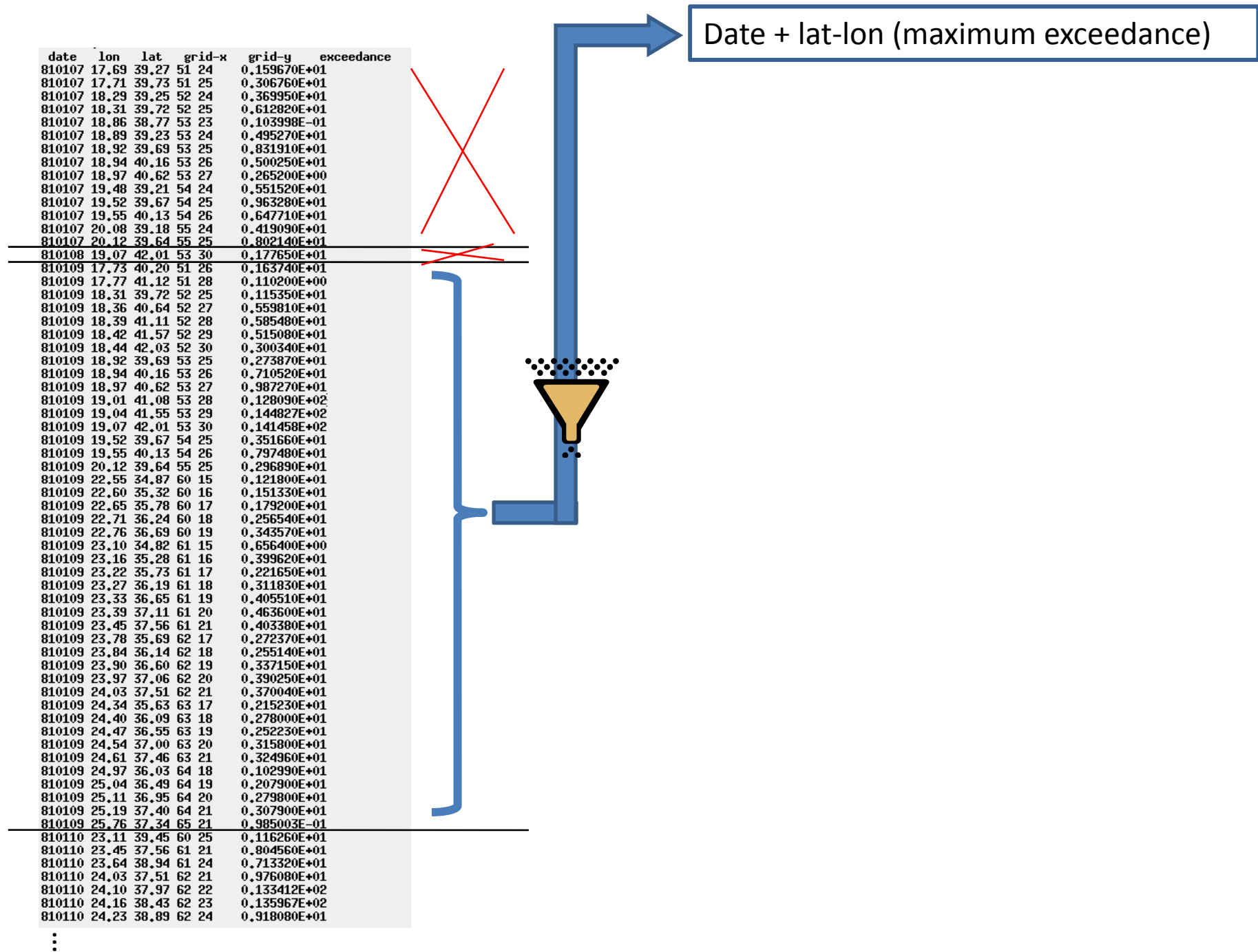
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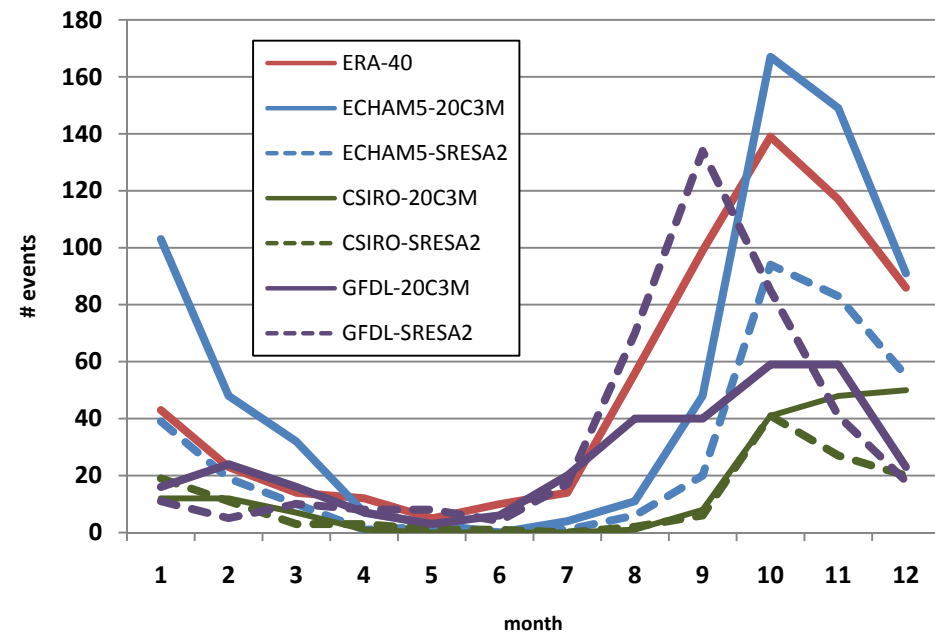


MODEL	PRESENT	FUTURE (2081-2100)	
ERA-40	1981-2000		
ECHAM5	20C3M	SRESA2	SRESA1B
MIRO	20C3M	SRESA2	SRESA1B
CSIRO	20C3M	SRESA2	SRESA1B
GFDL	20C3M	SRESA2	SRESA1B





MODEL	PRESENT	FUTURE (2081-2100)	
ERA-40	1981-2000		
ECHAM5	20C3M	SRESA2	SRESA1B
MIRO	20C3M	SRESA2	SRESA1B
CSIRO	20C3M	SRESA2	SRESA1B
GFDL	20C3M	SRESA2	SRESA1B

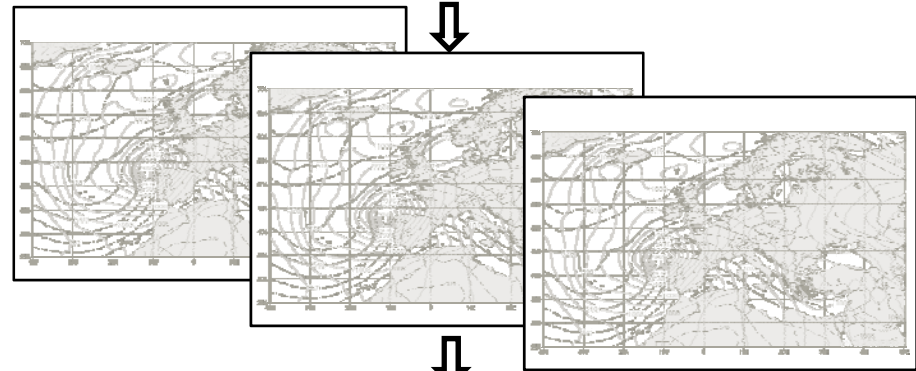


➡

MODEL/MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ERA-40	43	23	14	12	5	10	14	56	99	139	117	86	618
ECHAM 20C	103	48	32	7	3	0	4	11	48	167	149	91	663
ECHAM A2	39	19	10	1	2	0	1	6	20	94	83	55	330
CSIRO 20C	12	12	7	1	0	0	0	1	8	41	48	50	180
CSIRO A2	19	11	3	3	1	1	0	2	6	41	27	20	134
GFDL 20C	16	24	16	7	3	6	20	40	40	59	59	23	313
GFDL A2	11	5	10	8	8	4	17	70	134	85	41	18	411

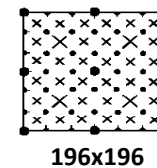
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810107	17.69	39.27	51 24	0.159670E+01	
810107	17.71	39.73	51 25	0.306760E+01	
810107	18.29	39.25	52 24	0.369950E+01	
810107	18.31	39.72	52 25	0.612820E+01	
810107	18.86	38.77	53 23	0.103998E-01	
810107	18.89	39.23	53 24	0.495270E+01	
810107	18.92	39.69	53 25	0.831910E+01	
810107	18.94	40.16	53 26	0.500250E+01	
810107	18.97	40.62	53 27	0.265200E+00	
810107	19.48	39.21	54 24	0.551520E+01	
810107	19.52	39.67	54 25	0.963280E+01	
810107	19.55	40.13	54 26	0.647710E+01	
810107	20.08	39.18	55 24	0.419090E+01	
810107	20.12	39.64	55 25	0.802140E+01	
810108	19.07	42.01	53 30	0.177650E+01	
810109	17.73	40.20	51 26	0.163740E+01	
810109	17.77	41.12	51 28	0.110200E+00	
810109	18.31	39.72	52 25	0.115350E+01	
810109	18.36	40.64	52 27	0.559810E+01	
810109	18.39	41.11	52 28	0.585480E+01	
810109	18.42	41.57	52 29	0.515080E+01	
810109	18.44	42.03	52 30	0.300340E+01	
810109	18.92	39.69	53 25	0.273870E+01	
810109	18.94	40.16	53 26	0.710520E+01	
810109	18.97	40.62	53 27	0.987270E+01	
810109	19.01	41.08	53 28	0.128090E+02	
810109	19.04	41.55	53 29	0.144827E+02	
810109	19.07	42.01	53 30	0.141458E+02	
810109	19.52	39.67	54 25	0.351660E+01	
810109	19.55	40.13	54 26	0.797480E+01	
810109	20.12	39.64	55 25	0.296890E+01	
810109	22.55	34.87	60 15	0.121800E+01	
810109	22.60	35.32	60 16	0.151330E+01	
810109	22.65	35.78	60 17	0.179200E+01	
810109	22.71	36.24	60 18	0.256540E+01	
810109	22.76	36.69	60 19	0.343570E+01	
810109	23.10	34.82	61 15	0.656400E+00	
810109	23.16	35.28	61 16	0.399620E+01	
810109	23.22	35.73	61 17	0.221650E+01	
810109	23.27	36.19	61 18	0.311830E+01	
810109	23.33	36.65	61 19	0.405510E+01	
810109	23.39	37.11	61 20	0.463600E+01	
810109	23.45	37.56	61 21	0.403380E+01	
810109	23.78	35.69	62 17	0.272370E+01	
810109	23.84	36.14	62 18	0.255140E+01	
810109	23.90	36.60	62 19	0.337150E+01	
810109	23.97	37.06	62 20	0.390250E+01	
810109	24.03	37.51	62 21	0.370040E+01	
810109	24.34	35.63	63 17	0.215230E+01	
810109	24.40	36.09	63 18	0.278000E+01	
810109	24.47	36.55	63 19	0.252230E+01	
810109	24.54	37.00	63 20	0.315800E+01	
810109	24.61	37.46	63 21	0.324960E+01	
810109	24.97	36.03	64 18	0.102990E+01	
810109	25.04	36.49	64 19	0.207900E+01	
810109	25.11	36.95	64 20	0.279800E+01	
810109	25.19	37.40	64 21	0.307900E+01	
810109	25.76	37.34	65 21	0.985003E-01	
810110	23.11	39.45	60 25	0.116260E+01	
810110	23.45	37.56	61 21	0.804560E+01	
810110	23.64	38.94	61 24	0.713320E+01	
810110	24.03	37.51	62 21	0.976080E+01	
810110	24.10	37.97	62 22	0.133412E+02	
810110	24.16	38.43	62 23	0.135967E+02	
810110	24.23	38.89	62 24	0.918080E+01	

Date + lat-lon (maximum exceedance)



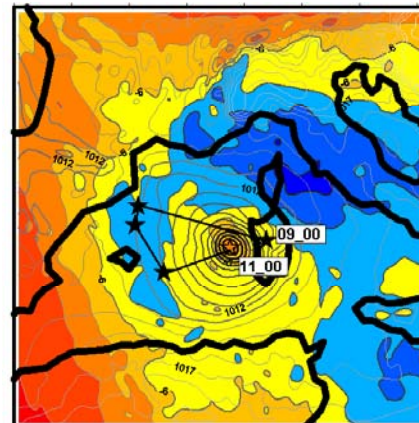
MESOSCALE MODEL SIMULATION

48h



MM5
7.5 km

AUTOMATIC DETECTION
PROCESS

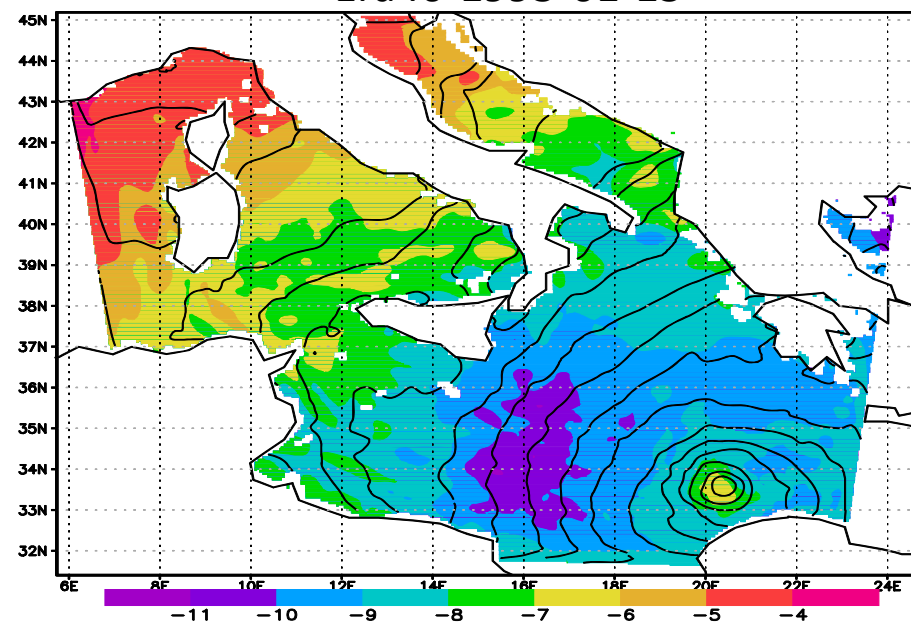


Quasi-symmetric intense
low-pressure centres at
surface with an isolated
warm-core structure aloft.

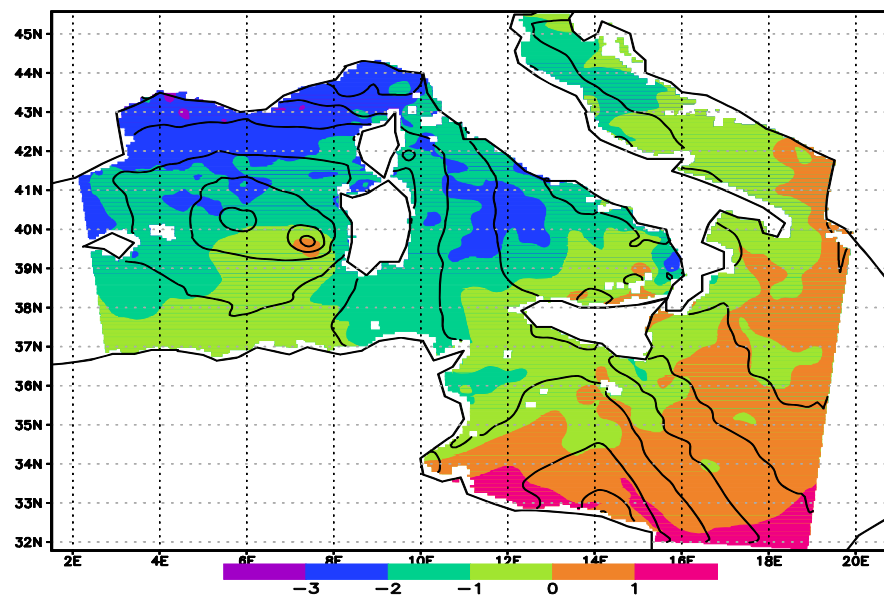
	ERA-40
1983-09-29	○
1984-04-07	○
1984-12-29	○
1985-12-14	○
1991-12-05	○
1995-01-15	○
1996-09-12	○
1996-10-07	○
1996-12-10	○
1998-01-26	○
1999-03-19	○

	ERA-40
1983-09-29	●
1984-04-07	●
1984-12-29	●
1985-12-14	●
1991-12-05	●
1995-01-15	●
1996-09-12	●
1996-10-07	●
1996-12-10	●
1998-01-26	●
1999-03-19	●

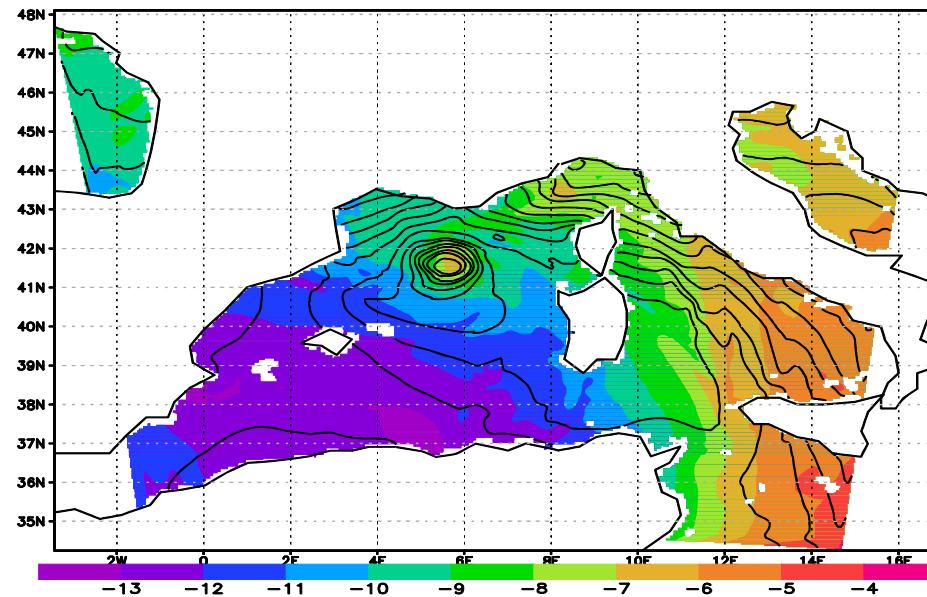
Era40-1995-01-15



Era40-1983-09-29



Era40-1996-12-10



CONCLUSIONS:

- All GCMs exhibit a similar pattern, with higher values of GenPDF in cold season than in warm season. Furthermore, the frequency of day/areas with extreme values of GenPDF, in present climate, is very similar in ECHAM-5 and ERA-40. CSIRO and GFDL underestimate this frequency.
- Satellite-observed medicanes are effectively captured as extreme GenPDF synoptic situations. They are also well simulated using the MM5 model.

FURTHER WORK:

- **To implement an automatic objective algorithm** aimed at detecting intense small-scale warm-core cyclones in the GCM-forced simulations.
- **To compare** this type of quantitative assessment of medicane risk under future climate conditions with results from other methods, as for example, the CHIPS-synthetic cyclone generation system developed by Prof. Kerry Emanuel (Emanuel et al, 2008).