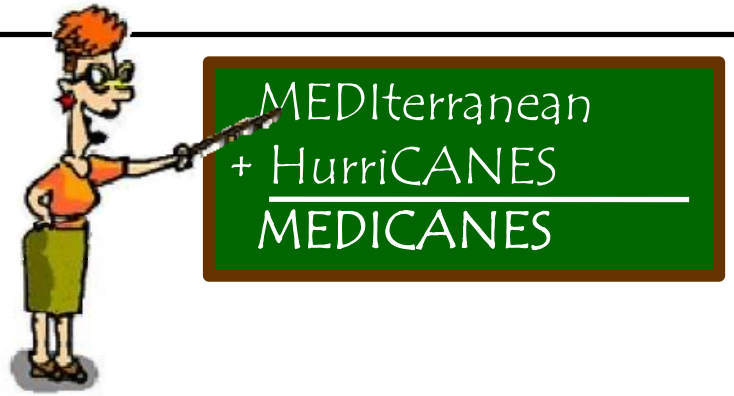
First steps towards a quantitative assessment of medicane risk under future climate conditions

M.Tous[(1)], R.Romero[(1)] and J. Martín[(2)]

[(1)]Universitat de les Illes Balears _UIB

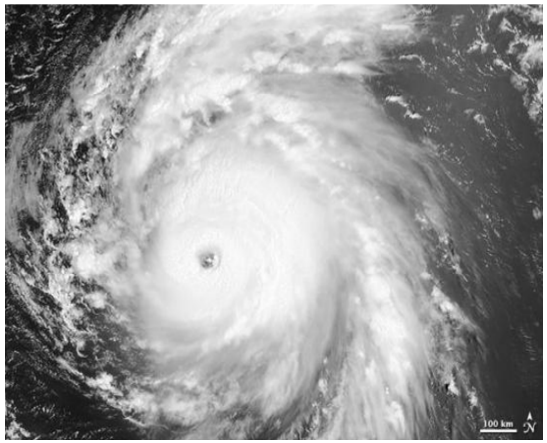
[(2)]Agencia Estatal de Meteorología _ AEMET

What are MEDICANES?

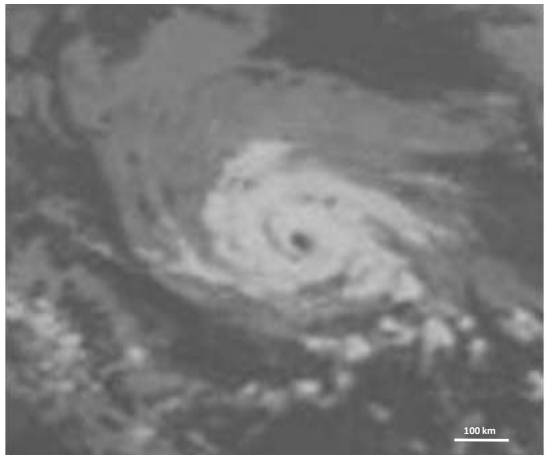


MEDICANES are tropical-like cyclones which develop over the Mediterranean Sea, sometimes attaining hurricane intensity.

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

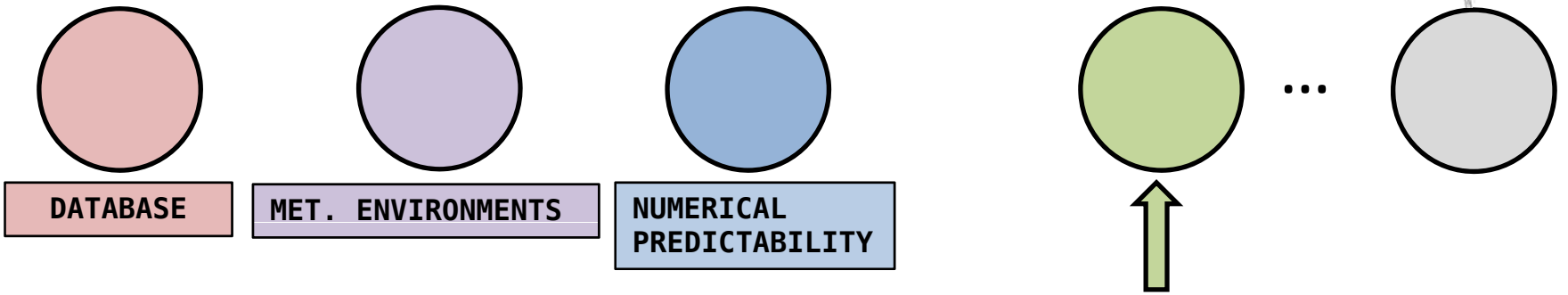


Medicane. Jan 1995

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.

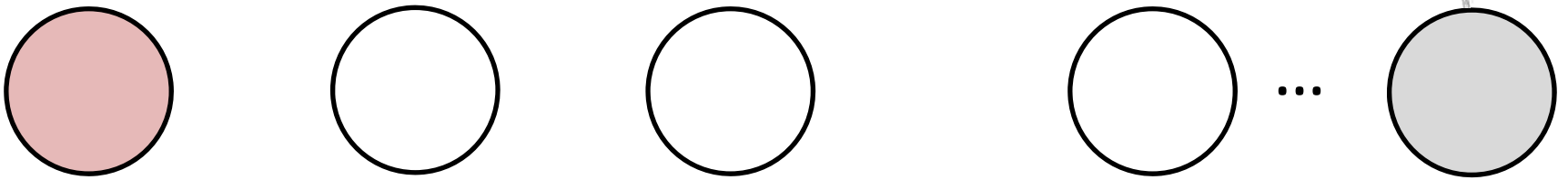


QUANTITATIVE ASSESSMENT OF MEDICANE RISK UNDER FUTURE CLIMATE CONDITIONS USING THE MM5 MODEL

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.



DATABASE

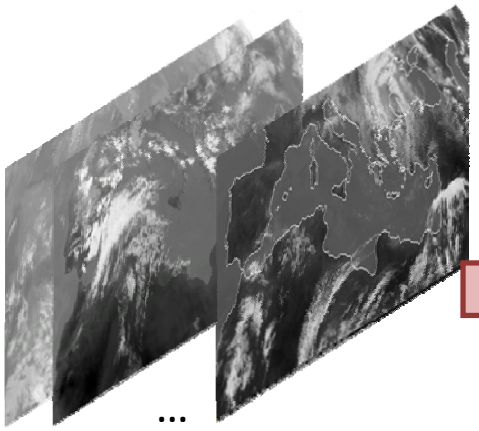
MET. ENVIRONMENTS

NUMERICAL PREDICTABILITY

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

TO CREATE A DATABASE OF EVENTS

Our database



…

IR satellite images (1982-2005)

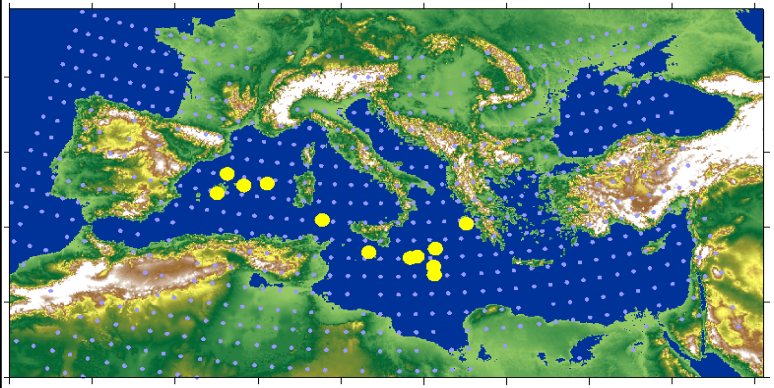
Medicane criteria

1) Continuous cloud cover
2) Cyclone eye clarity
3) Symmetric shape
4) Ø < 300 km
5) Lifetime > 6 h

12 events

Month (#medicanes)	
March (1)	September (2)
April (0)	October (1)
May (1)	November (1)
June (0)	December (4)
July (0)	January (2)
August (0)	February (0)

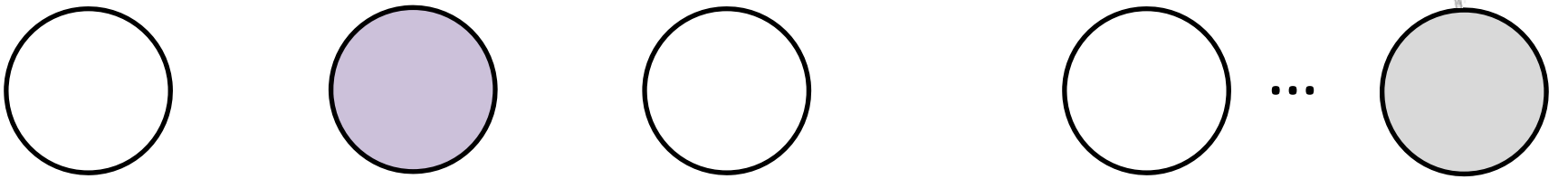
GEOGRAPHYCAL DISTRIBUTION OF EVENTS



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.



DATABASE

MET. ENVIRONMENTS

NUMERICAL PREDICTABILITY

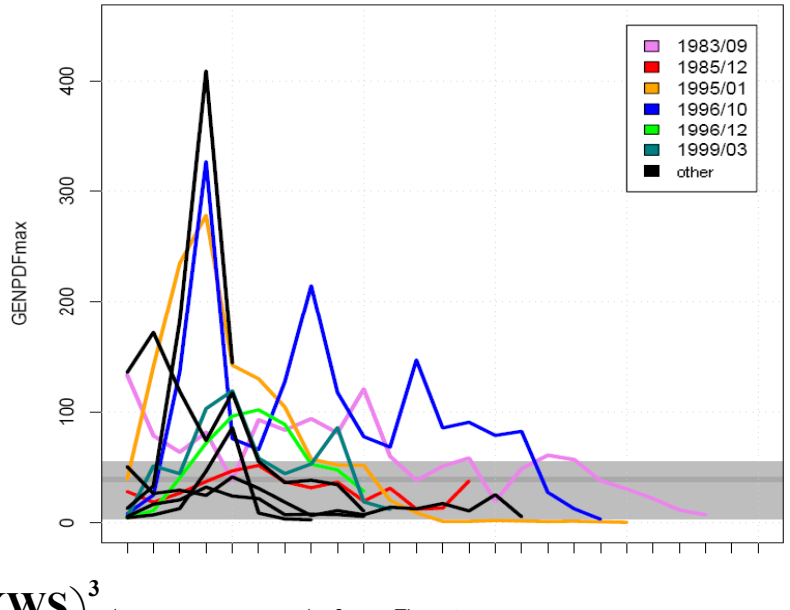
QUANTITATIVE ASSESSMENT OF MEDICANE RISK UNDER FUTURE CLIMATE CONDITIONS USING THE MM5 MODEL

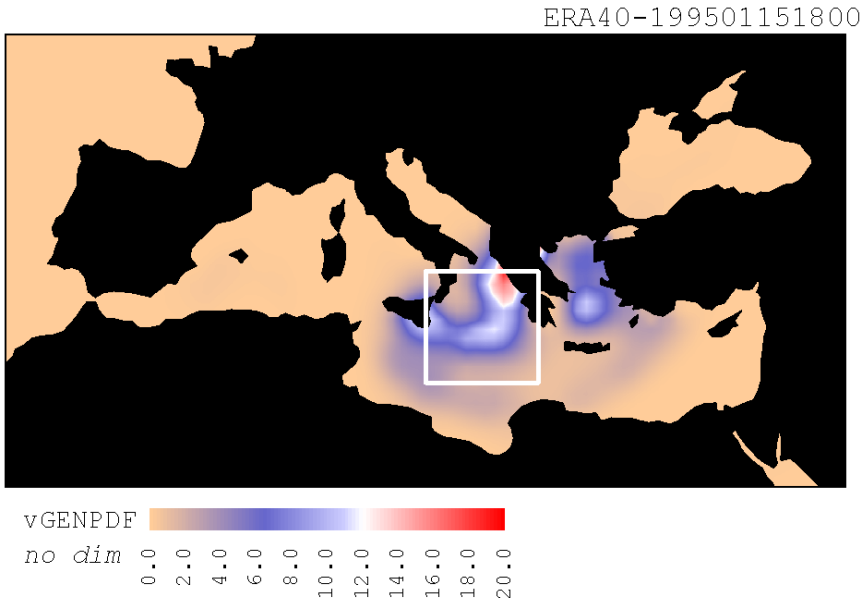
AVOR850 (η)	Low-tropospheric vorticity
DIAB1000	Diabatic contribution to surface level equivalent potential temperature
RH600 (H)	Mid-tropospheric relative humidity
SST (T_S)	Sea Surface Temperature
VSHEAR8525 (V_{shear})	Tropospheric wind shear
MAXWS (V_{max})	Idealized maximum surface wind speed
GENPDF	Empirical genesis index

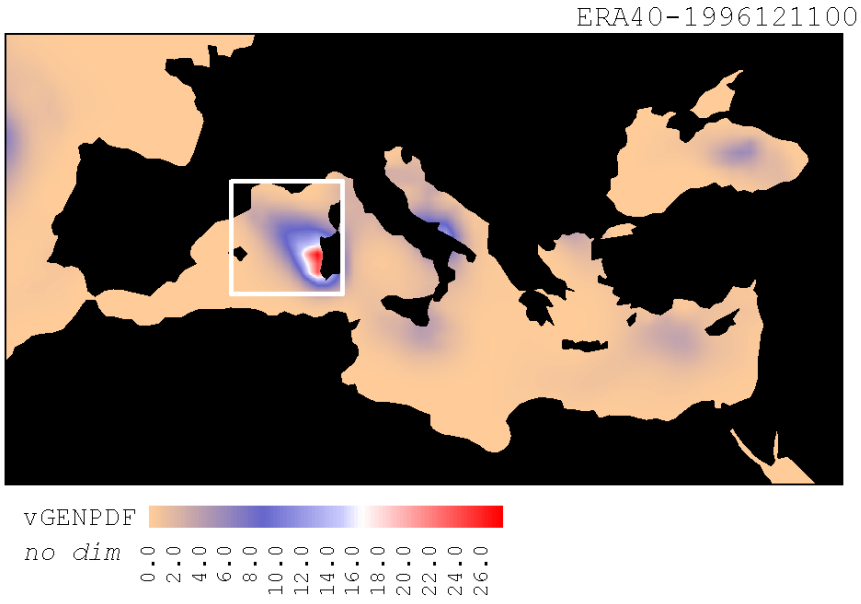
AVOR850 (η)
DIAB1000
RH600 (H)
SST (T_S)
VSHEAR8525 (V_{shear})
MAXWS (V_{max})
GENPDF

$$\mathbf{MAXWS} \approx \frac{C_k}{C_D}\frac{T_S - T_0}{T_0}(k_0^* - k)$$

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



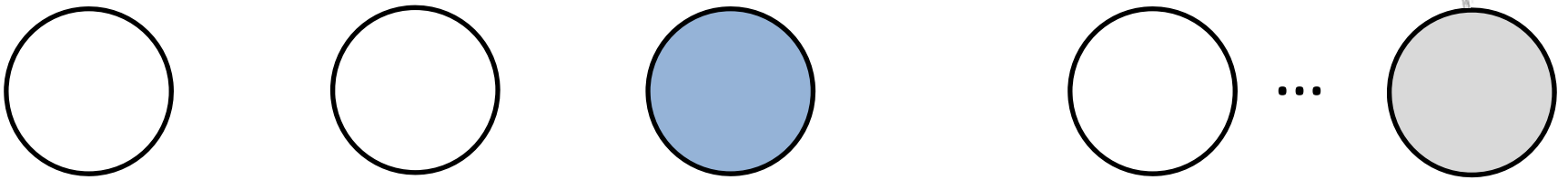




MEDICANES: Meteorological Environments, Numerical Predictability and Risk Assessment in the Present and Future Climate (MEC, CGL2008-01271/CLI)

OBJECTIVE

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



DATABASE

MET. ENVIRONMENTS

NUMERICAL PREDICTABILITY

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

CONTROL

ECMWF
T213 (~ 85 km)
+ obs.

fine GCM res.

ECMWF
(~ 125km)

typical GCM res.

ECMWF
(~ 250 km)

MESOSCALE MODEL SIMULATION

48h

196x196

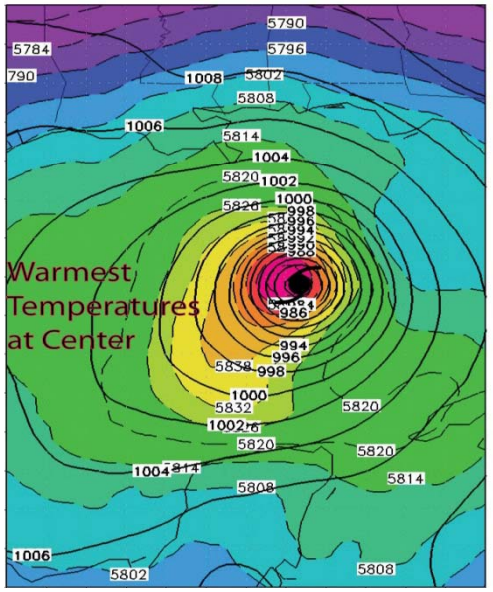
MM5
7.5 km

LOW RESOLUTION of the input large scale fields

TO EXAMINE NUMERICAL PREDICTABILITY OF MEDICANES.

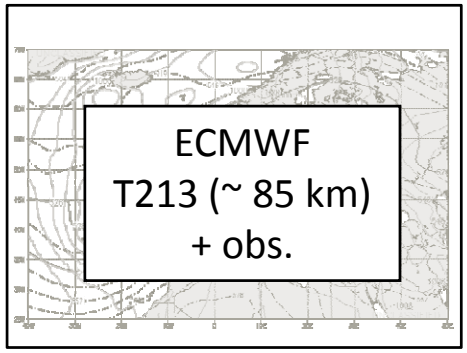
Quasi-symmetric intense low-pressure centres at surface with an isolated warm-core structure aloft.

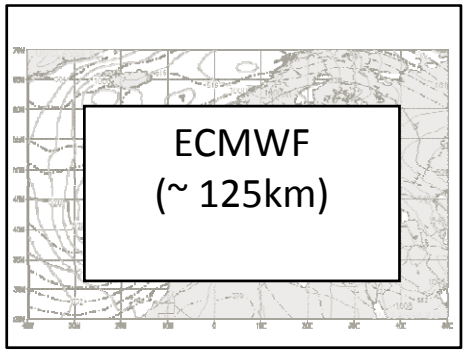
Katrina, Warm Core Low

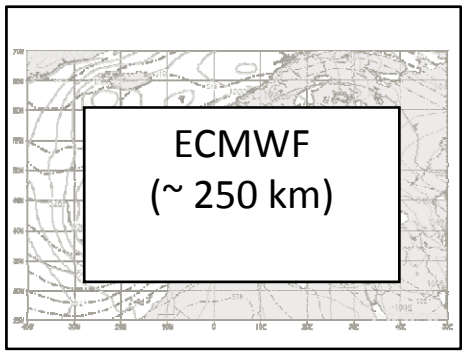


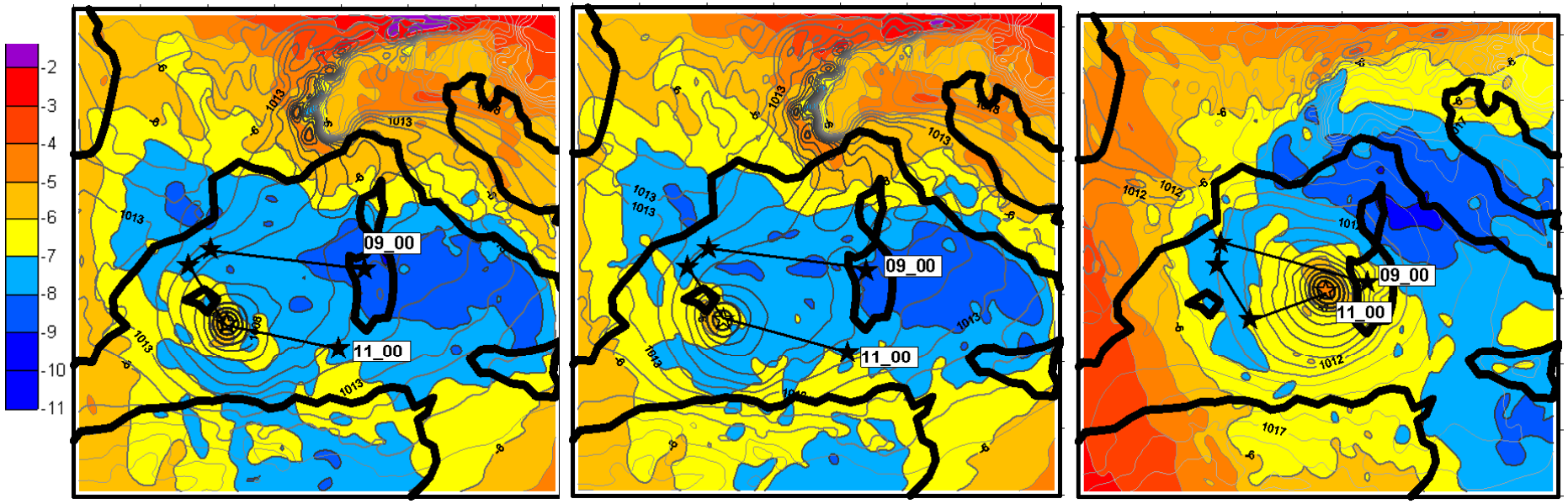
Sfc Isobars (solid, mb)
Sfc-500 mb Mean Temp (shaded)
12 UTC 28 Aug 2005

http://tornado.sfsu.edu/









CONTROL
85 km + obs.

Fine GCM res.
125 km

Typical GCM res.
250 km

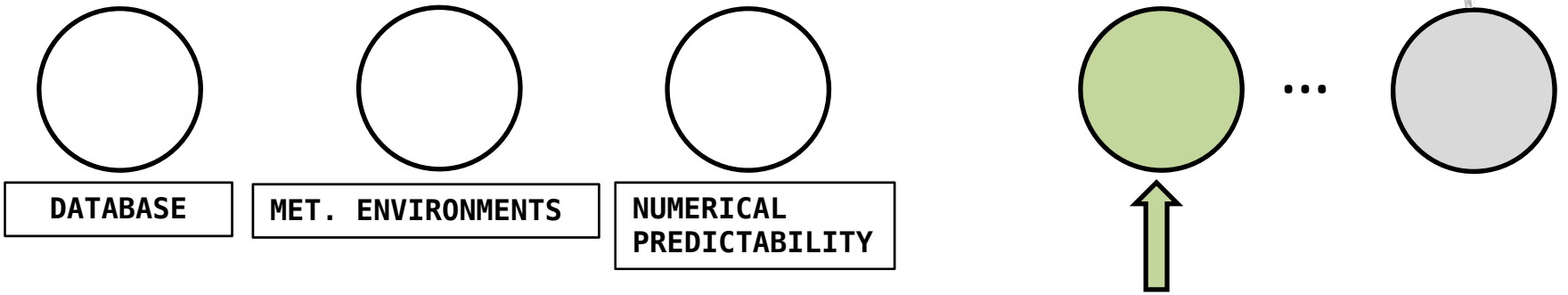
MM5
7.5 km

Contours: PSEALVL every 1 hPa. Colored:Temp.(ºC) 700 hPa

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.

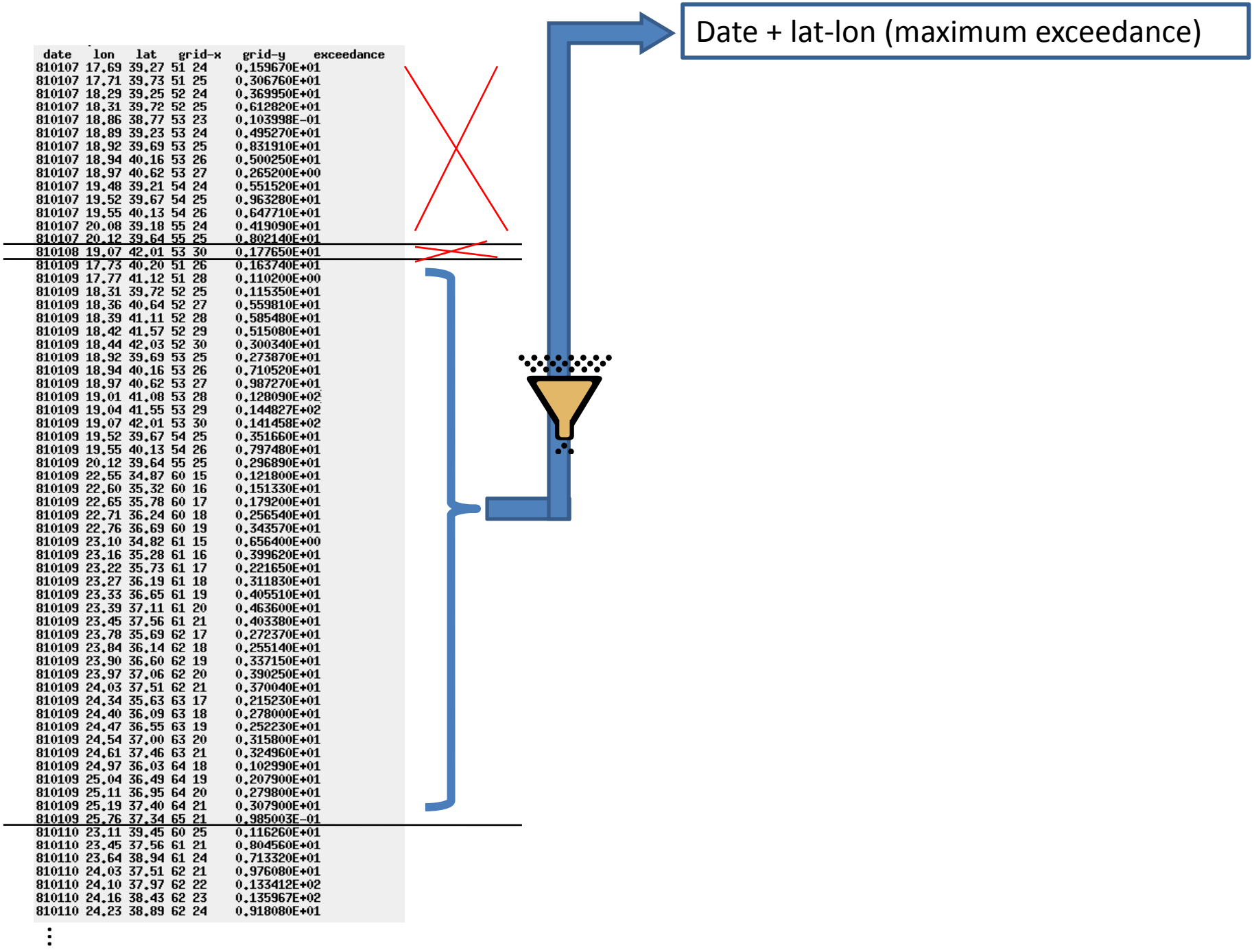


QUANTITATIVE ASSESSMENT OF MEDICANE RISK UNDER FUTURE CLIMATE CONDITIONS USING THE MM5 MODEL

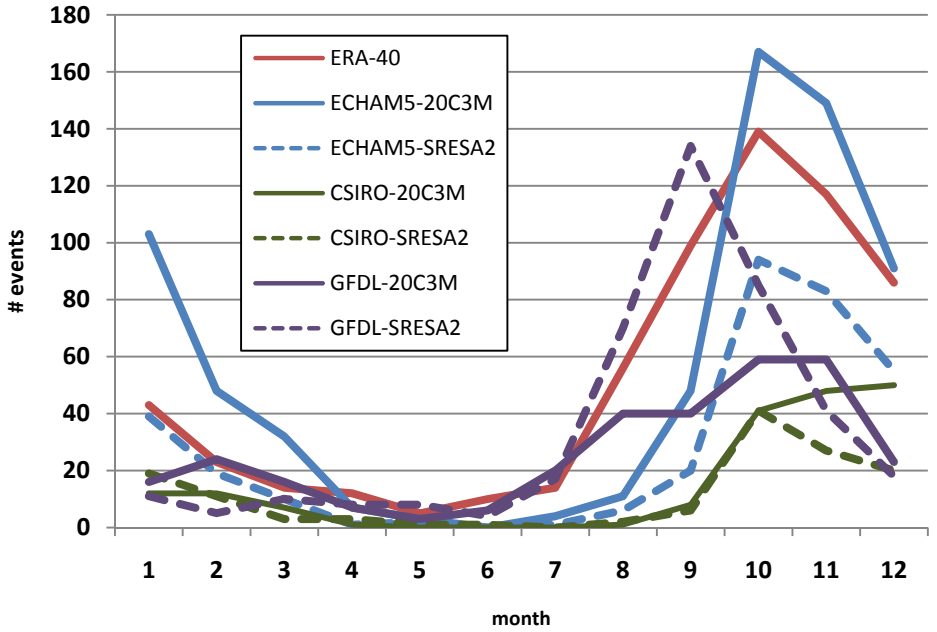
MODEL	PRESENT	FUTURE (2081-2100)	
ERA-40	1981-2000		
ECHAM5	20C3M	SRESA2	SRESA1B
MIRO	20C3M	SRESA2	SRESA1B
CSIRO	20C3M	SRESA2	SRESA1B
GFDL	20C3M	SRESA2	SRESA1B

date	lon	lat	grid-x	grid-y	exceedance
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

⋮



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

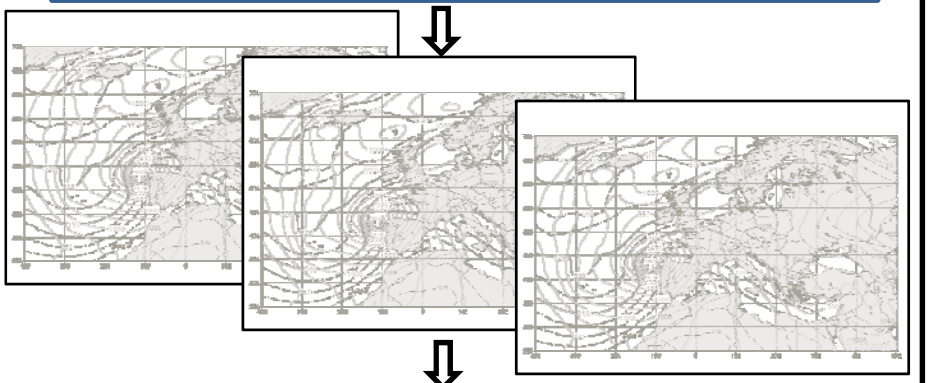


MODEL/MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ERA-40	43	23	14	12	5	10	14	56	99	139	117	86	**618**
ECHAM 20C	103	48	32	7	3	0	4	11	48	167	149	91	**663**
ECHAM A2	39	19	10	1	2	0	1	6	20	94	83	55	**330**
CSIRO 20C	12	12	7	1	0	0	0	1	8	41	48	50	**180**
CSIRO A2	19	11	3	3	1	1	0	2	6	41	27	20	**134**
GFDL 20C	16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

date	lon	lat	grid-x	grid-y	exceedance
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

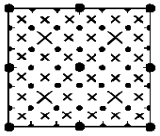
⋮

Date + lat-lon (maximum excedence)



MESOSCALE MODEL SIMULATION

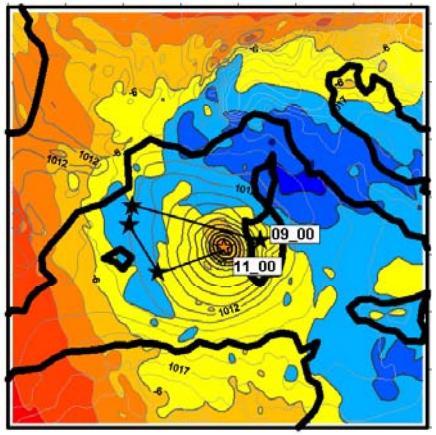
48h



196x196

MM5
7.5 km

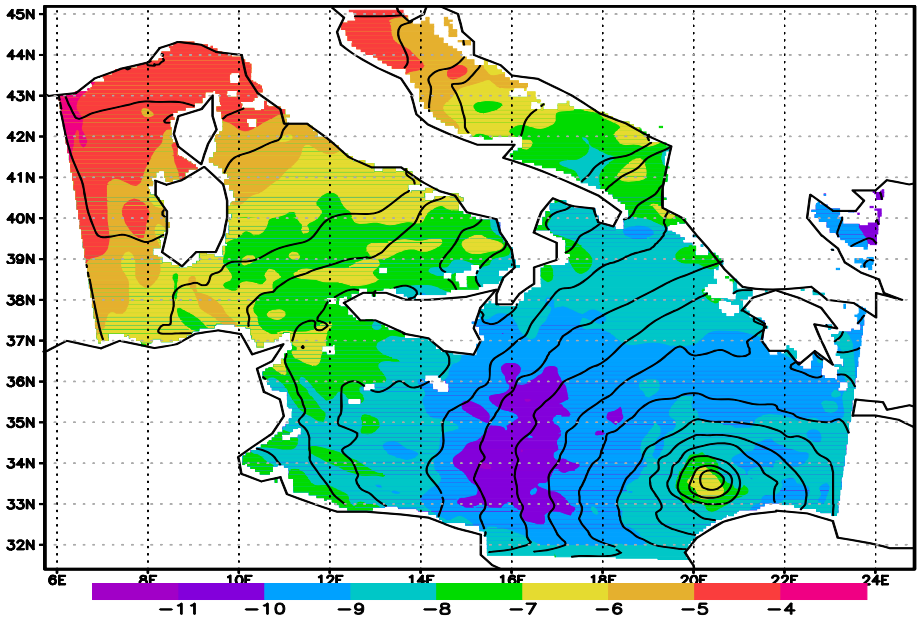
AUTOMATIC DETECTION PROCESS



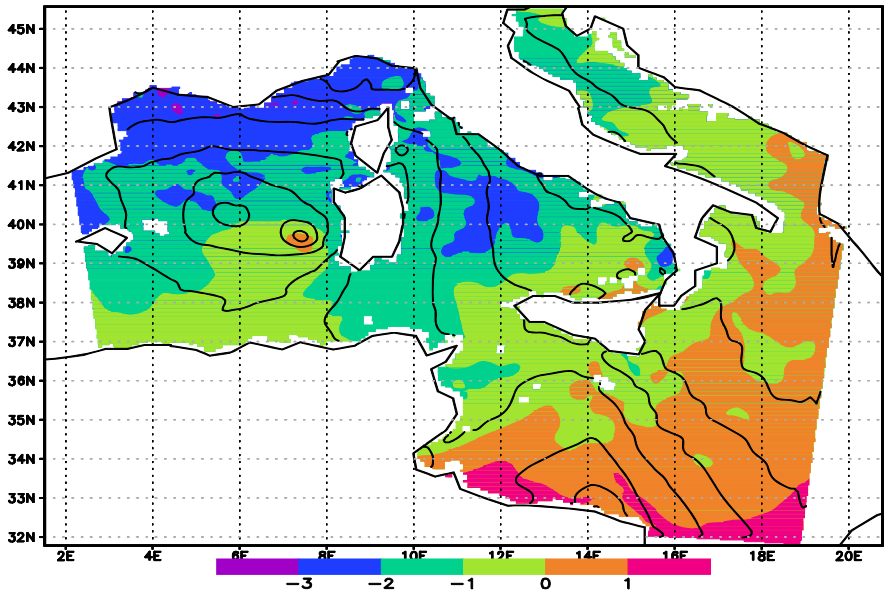
Quasi-symmetric intense low-pressure centres at surface with an isolated warm-core structure aloft.

	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	

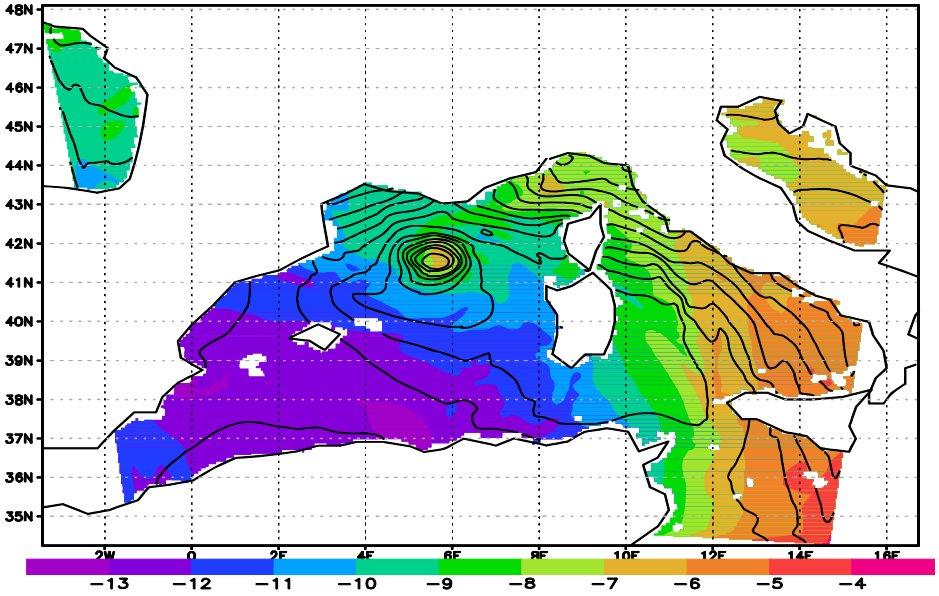
Era40-1995-01-15



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).