Current and Future MEDICANE RISK based on the generation of synthetic storms

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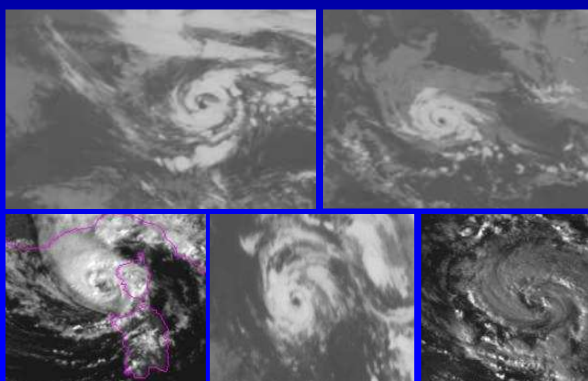
MOTIVATION

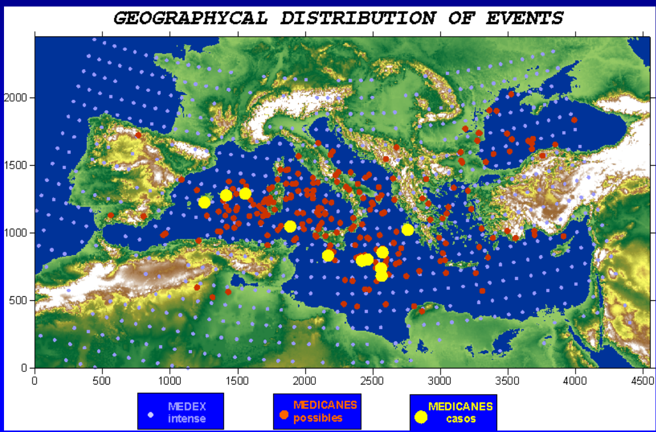
Medicanes are warm-core, surface flux-driven extreme windstorms potentially threatening the islands and coastal areas:

- *Are there favoured locations for medicane development ?*
- *How intense can they become ?*
- *How could they react in frequency and intensity to global warming ?*



MEDICANE RISK ???

With an average frequency of only 1-2 events per year and given the lack of systematic, multidecadal databases, an objective evaluation of the long-term risk of medicane-induced winds is impractical with standard methods

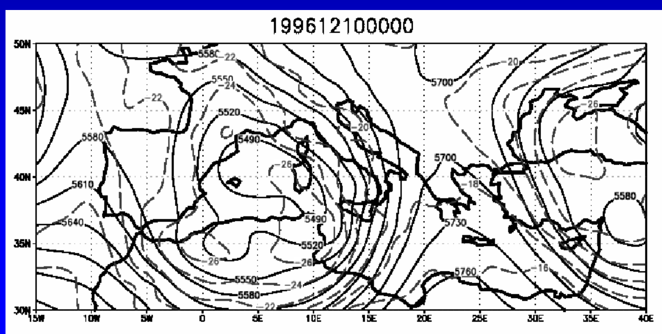


Database from satellite
(Tous and Romero, 2012)

FIRST APPROACH: Large-scale environmental proxies

Synoptic analyses of a few studied cases show that an inevitable precursor is the presence of a deep, cut-off, cold-core low in the upper and middle troposphere:

• But the infrequent occurrence of medicanes suggests that additional and very special meteorological conditions are necessary for these storms to occur …



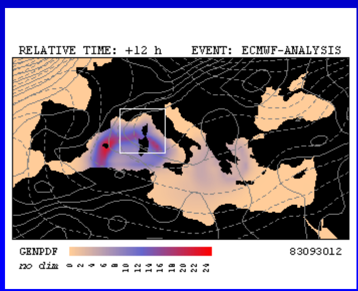
FIRST APPROACH: *Large-scale environmental proxies*

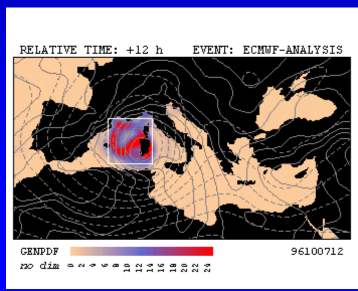
Application of an empirical index of genesis:

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

GENIX parameter
(Emanuel and Nolan, 2004)

- ***But these environmental proxies behave as necessary but no sufficient ingredients for the successful genesis of a medicane …***

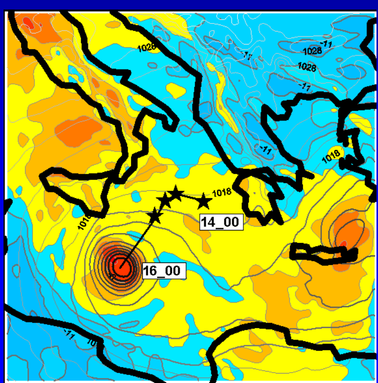


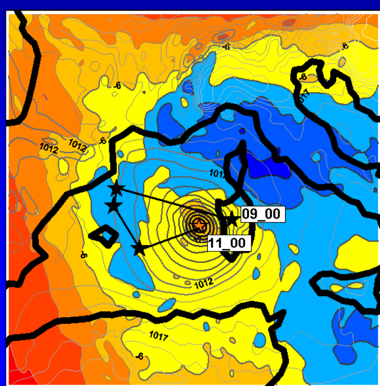


SECOND APPROACH: *Nested climatic simulations*

Detection and tracking of symmetric warm-core cyclonic disturbances generated in mesoscale simulations forced by Reanalysis and GCM data (see Next Talk by Tous et al.):

- ***But high computational cost: Limited horizontal resolution; Too few climatic realizations to permit a full sampling of the PDF of storms …***





THIS WORK: Statistical-deterministic approach

Developed by Emanuel and his team in the context of the long-term wind risk associated with tropical cyclones:

- *Low-cost generation of thousands of synthetic storms*
- *Statistically robust assessment of risk (e.g. return periods for winds)*

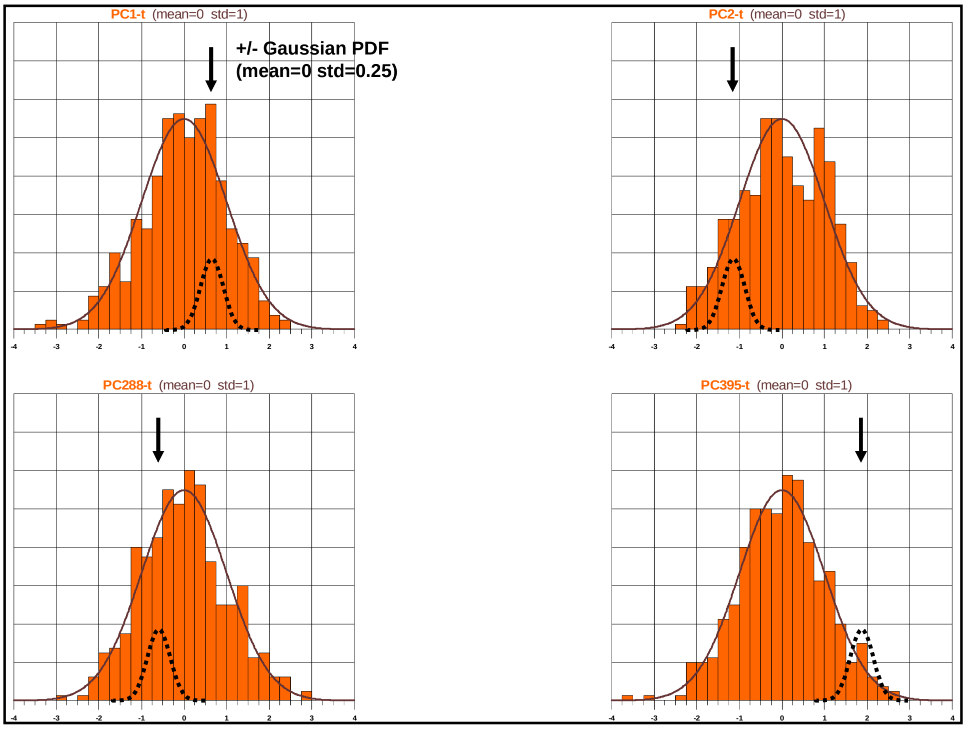
- *Genesis: Random draws from observed PDF or Random seeding*
- *Track: Randomly varying synthetic winds (respecting climatology)*
- *Environment: Previous winds + monthly-mean thermodynamic fields*
- *Intensity and radial distribution of winds: CHIPS model*

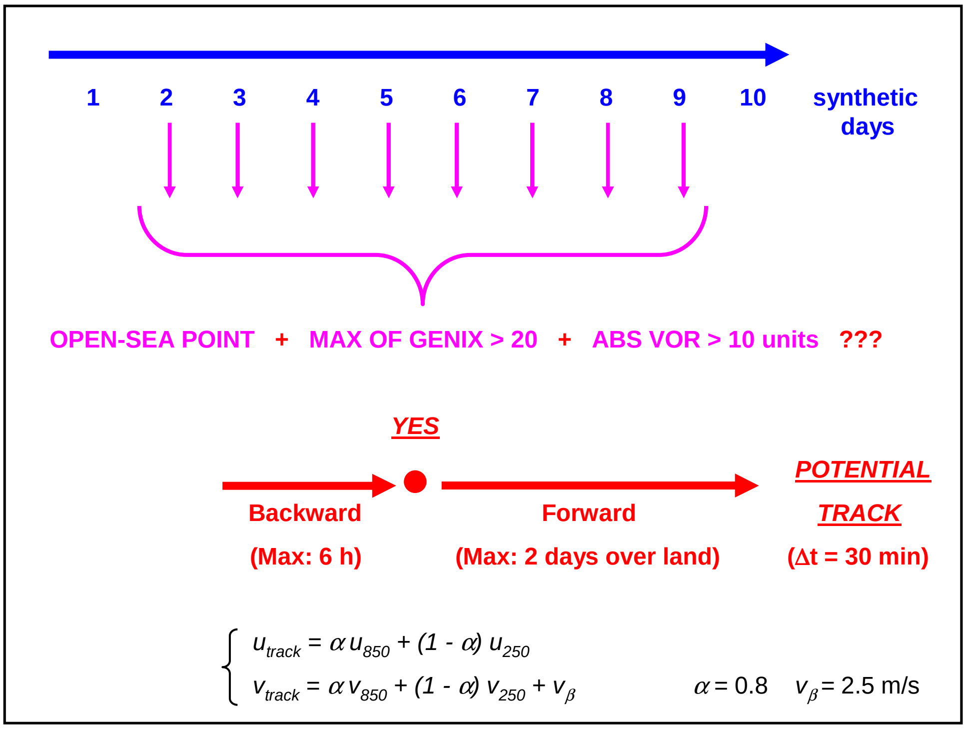
ADAPTATION OF THE METHOD

The separation of timescales made in the tropics between the synthetic wind field (fast scale) and the thermodynamic environment (slow scale) is not appropriate to represent the movement, growth and decay of mid-latitude weather systems. In addition, the history of medicane genesis is far too sparse to form a reasonable PDF of genesis, and random seeding would be very inefficient:

- *For each month, decomposition through PCA of 10-day synoptic evolutions of z250, z850, T600, R600 and PINT into the new space of independent PCs*
- *Random selection + random perturbation of the set of PCs*
- *This perturbed set of PCs is converted back into physical space*
- *This is tantamount to generating 10-day sequences of spatiotemporal coherent z250, z850, T600, R600 and PINT synthetic fields which also respect their mutual covariances*

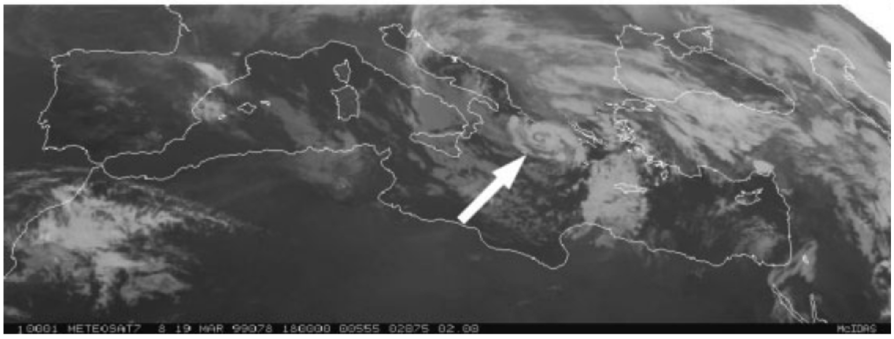
- *Potential Genesis: Based on the GENIX parameter*


PC1-t (mean=0 std=1)
+/- Gaussian PDF
(mean=0 std=0.25)
PC2-t (mean=0 std=1)
PC288-t (mean=0 std=1)
PC395-t (mean=0 std=1)

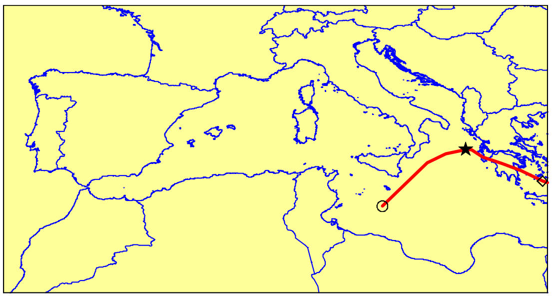

1 2 3 4 5 6 7 8 9 10 synthetic days
OPEN-SEA POINT + MAX OF GENIX > 20 + ABS VOR > 10 units ???
YES
Backward
(Max: 6 h)
Forward
(Max: 2 days over land)
POTENTIAL TRACK
(Δt = 30 min)
u_track = α u_850 + (1 - α) u_250
v_track = α v_850 + (1 - α) v_250 + v_β
α = 0.8 v_β = 2.5 m/s

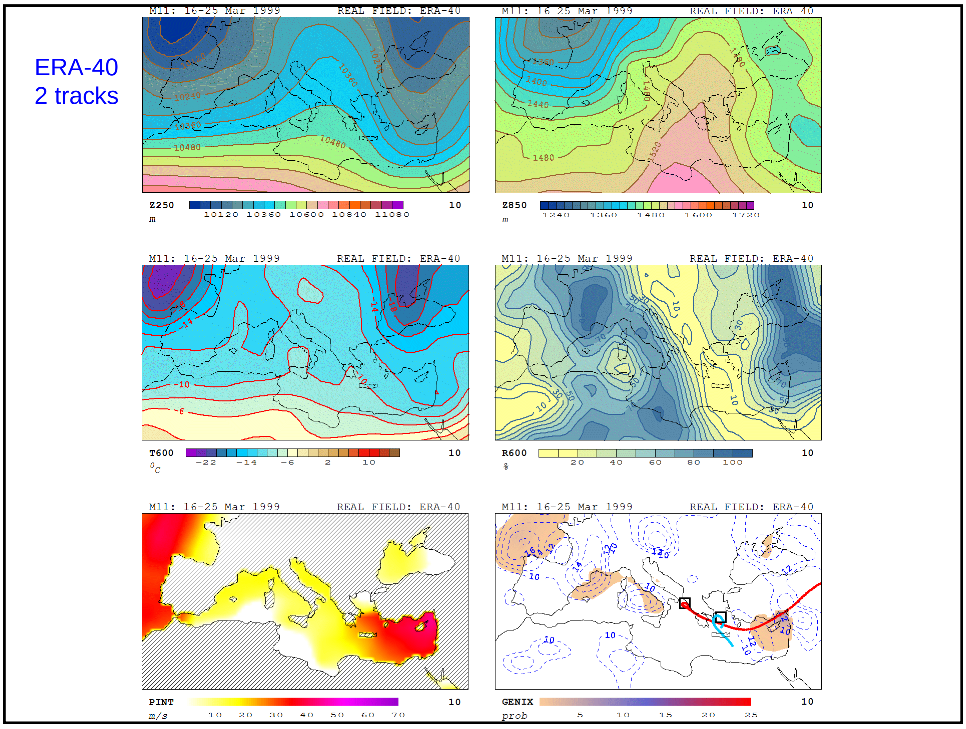
EXEMPLE FOR A REAL EVENT

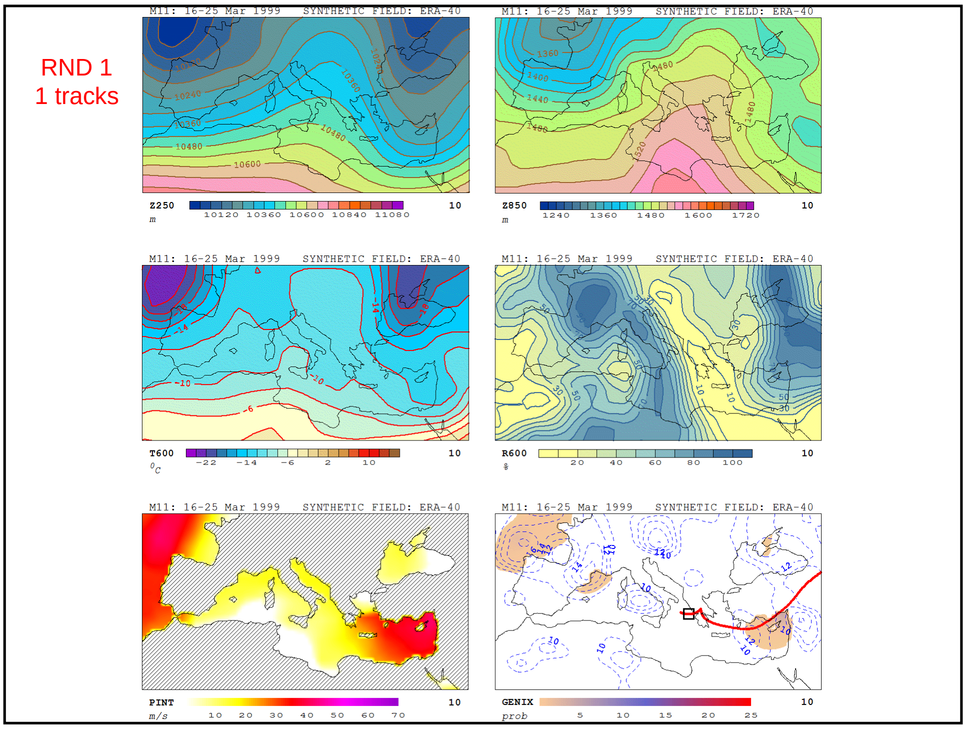
(d) 19-March-1999, 18 UTC



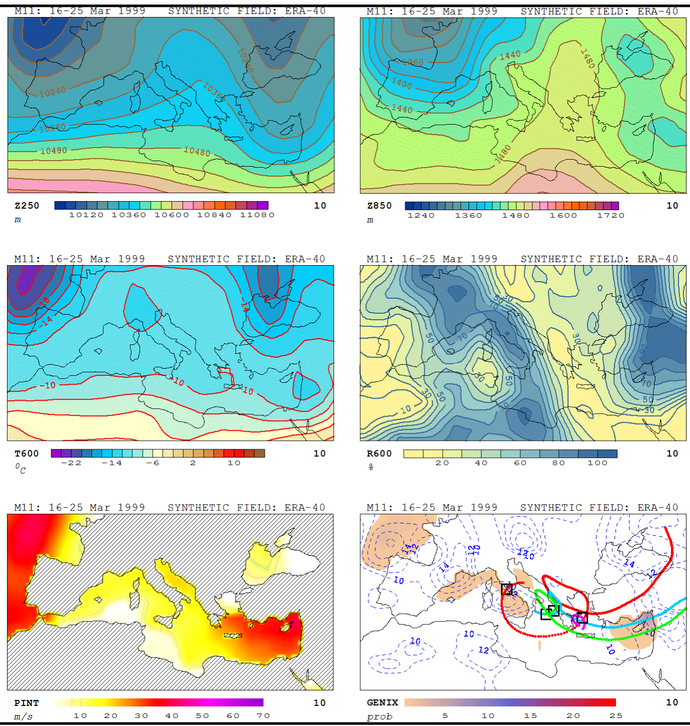
M11



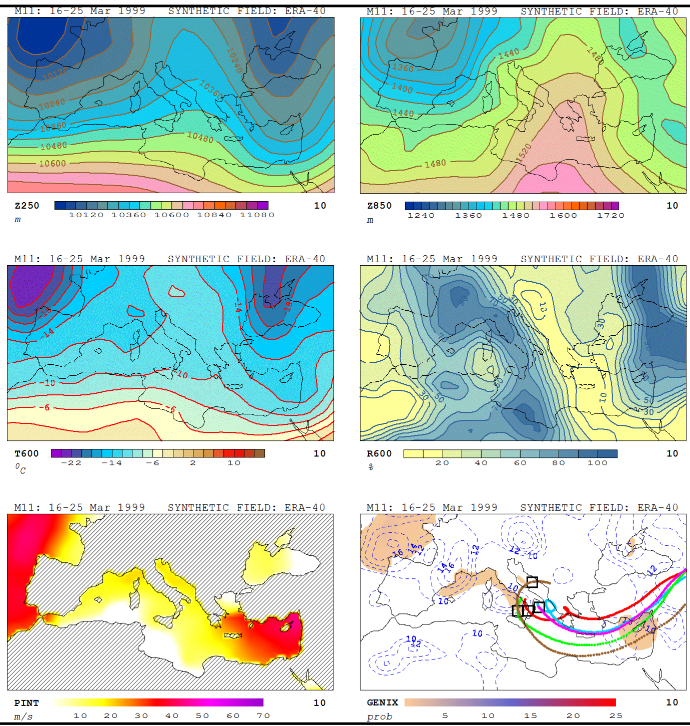

ERA-40
2 tracks
M11: 16-25 Mar 1999 REAL FIELD: ERA-40
Z250
m
10120 10360 10600 10840 11080
Z850
1240 1360 1480 1600 1720
T600
°C
-22 -14 -6 2 10
R600
%
20 40 60 80 100
PINT
m/s
10 20 30 40 50 60 70
GENIX
prob
5 10 15 20 25


RND 1
1 tracks
M11: 16-25 Mar 1999 SYNTHETIC FIELD: ERA-40
Z250
m
10120 10360 10600 10840 11080
Z850
1240 1360 1480 1600 1720
T600
°C
-22 -14 -6 2 10
R600
%
20 40 60 80 100
PINT
m/s
10 20 30 40 50 60 70
GENIX
prob
5 10 15 20 25

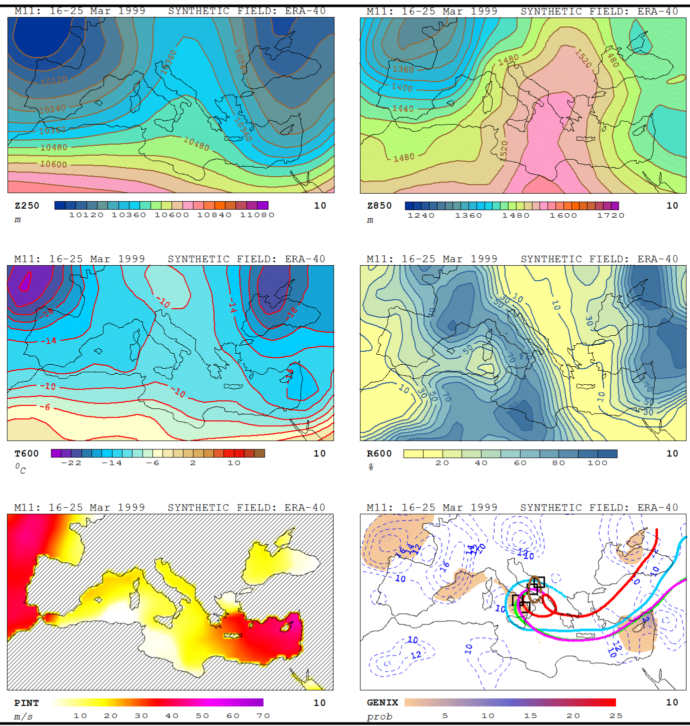
RND 2
4 tracks



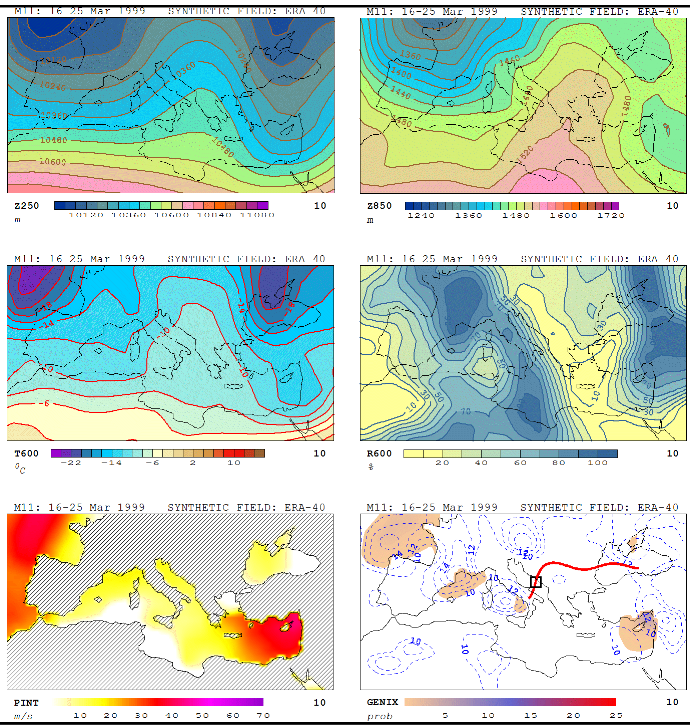
RND 3
5 tracks



RND 4
5 tracks



RND 5
1 tracks



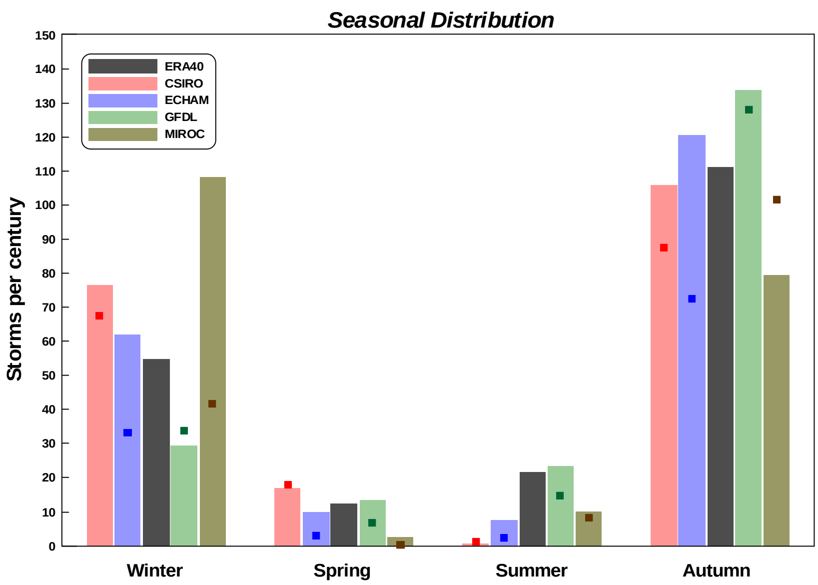
APPLICATION OF THE METHOD

We synthetically generate a total of ~15000 potential tracks for each climate/model. These are simulated with CHIPS and checked for intensification above TS category (34 kt):

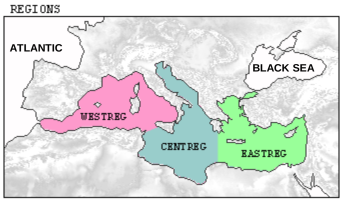
Climate Scenario	Reanalysis or GCM	Successful Storms	Storms per century
PRESENT 1981 – 2000	ERA40	3048	200
	CSIRO	3286	200
	ECHAM	1924	200
	GFDL	1343	200
	MIROC	1567	200
FUTURE 2081 – 2100 SRES A2	CSIRO	2857	174
	ECHAM	1072	111
	GFDL	1226	183
	MIROC	2389	152

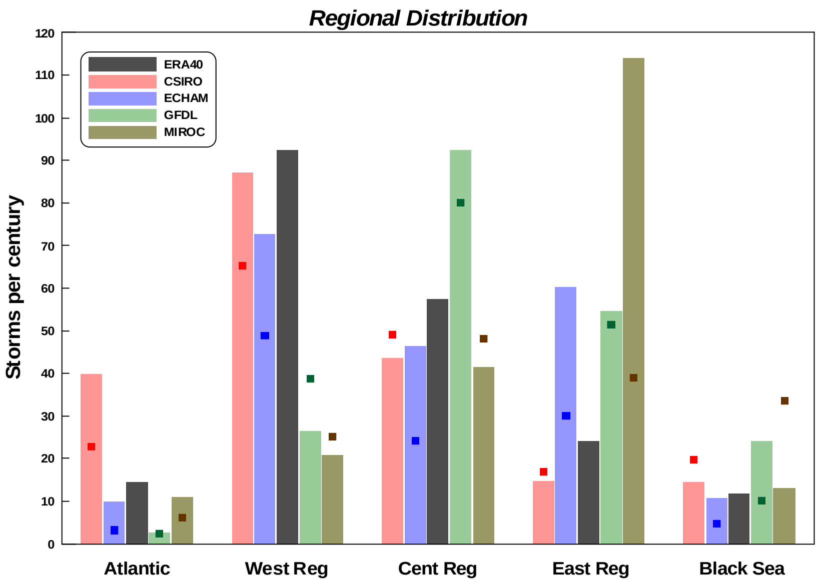
RESULTS

NUMBER OF STORMS PER SEASON

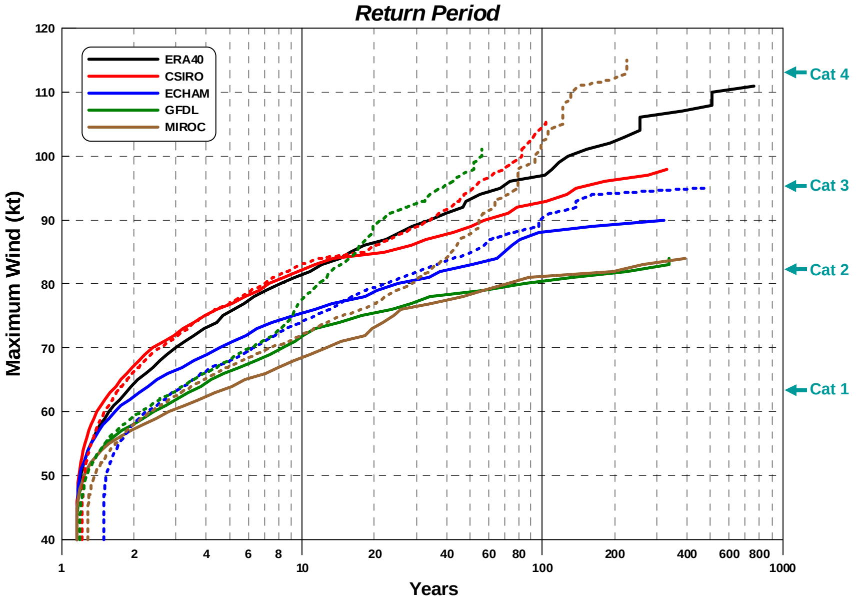


NUMBER OF STORMS PER REGION

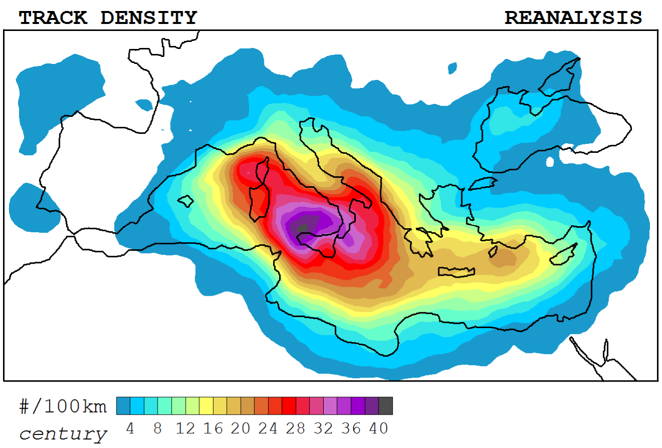




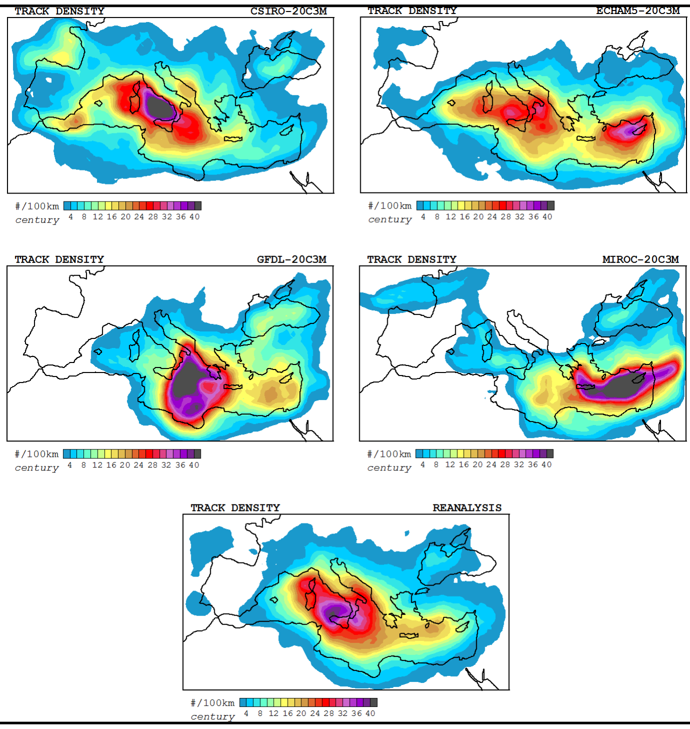
RETURN PERIOD OF STORMS



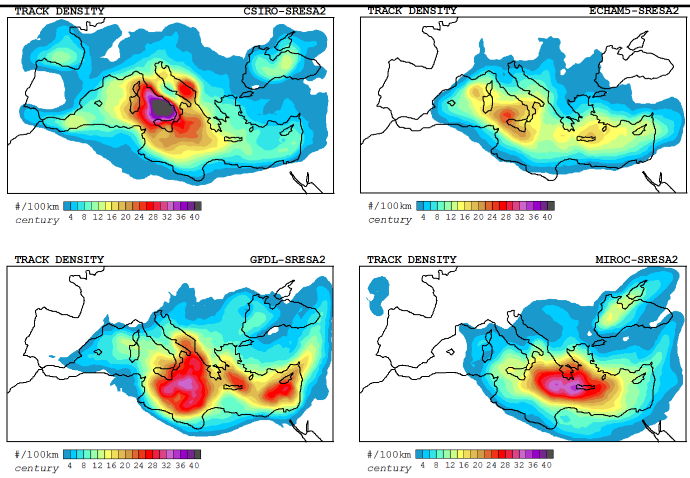
STORM TRACK DENSITY



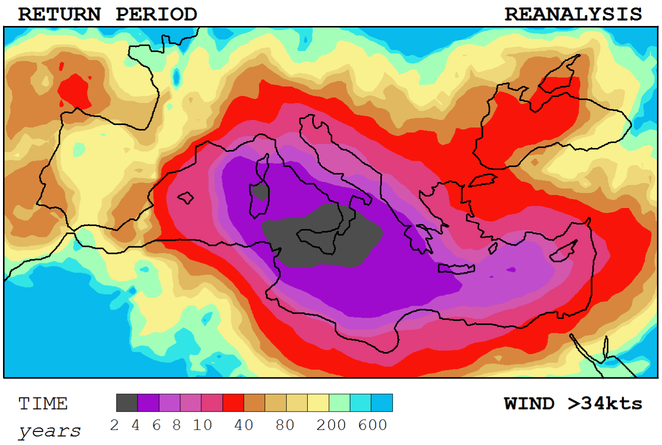
20C3M
scenario



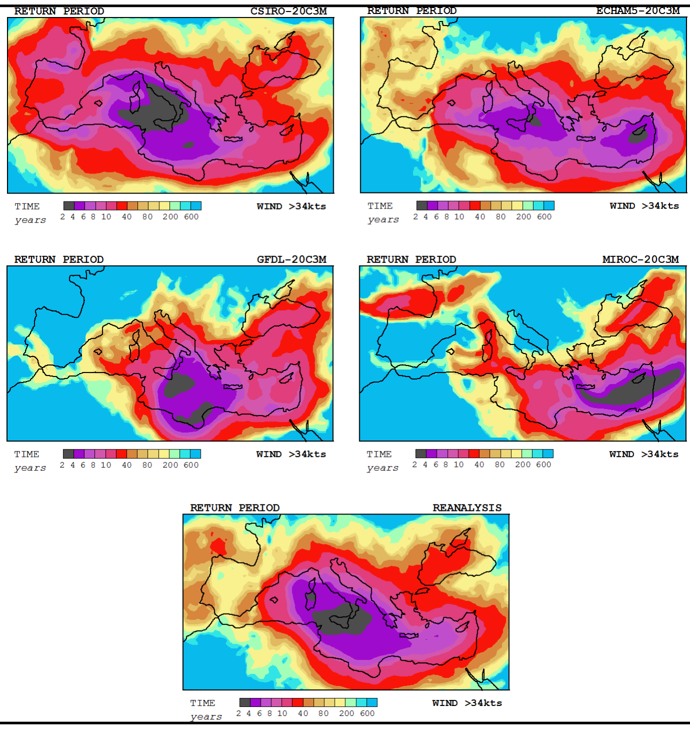
SRESA2
scenario



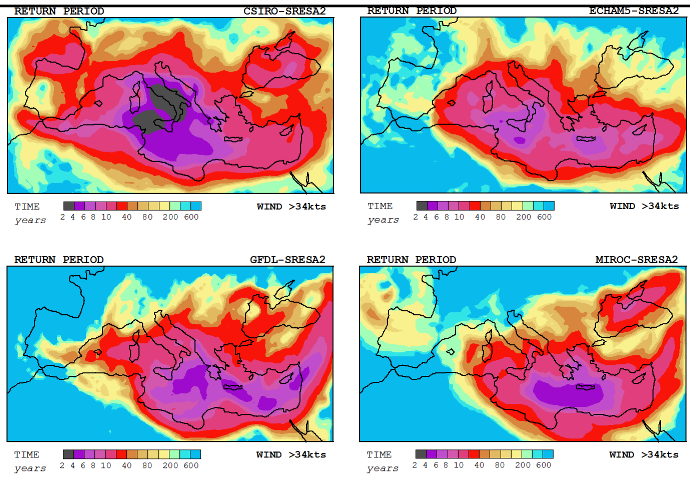
Return Period for Wind >34kts



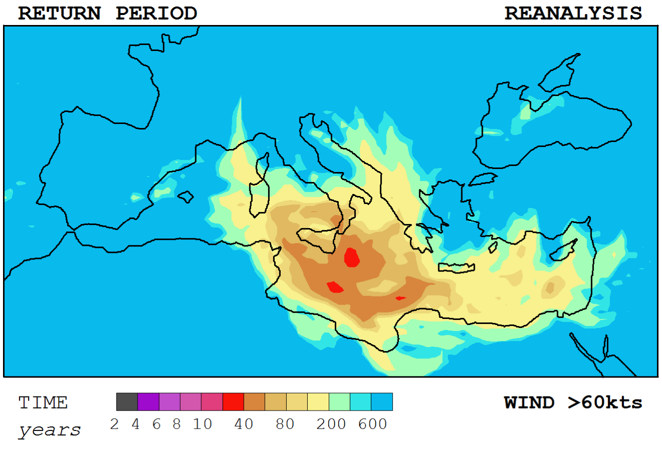
20C3M
scenario



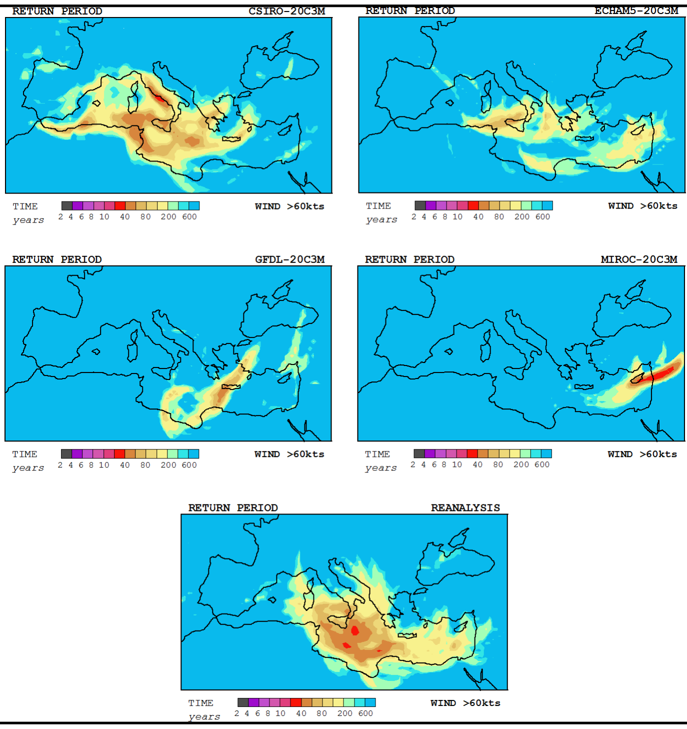
SRESA2
scenario



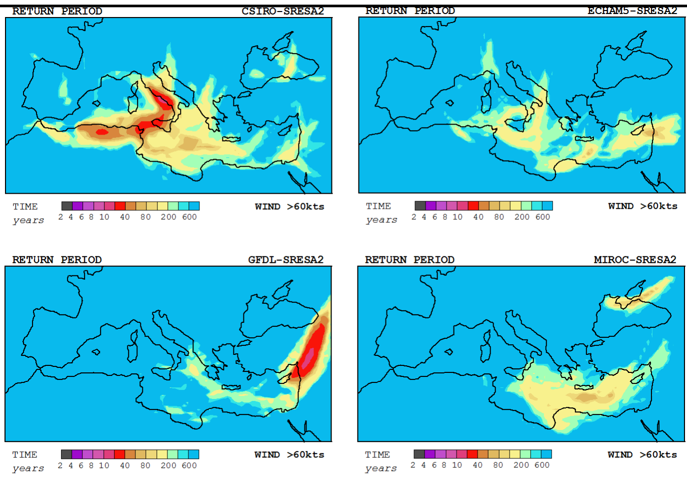
Return Period for Wind >60kts



20C3M scenario



SRESA2 scenario



CONCLUSIONS

- The statistical-deterministic approach is a good alternative to computationally expensive classical methods (e.g. dynamical downscaling of medicanes), with the extra benefit of producing statistically large populations of events

- We attained unprecedented medicane-wind risk maps for the Mediterranean region

- General agreement with the "known" phenomenology of medicanes in the current climate (e.g. maximum in the cold season and central Mediterranean)

- In spite of some geographical uncertainties, GCMs tend to project fewer medicanes at the end of the century compared to present but a higher number of violent storms, suggesting an increased probability of major economic and social impacts as the century progresses