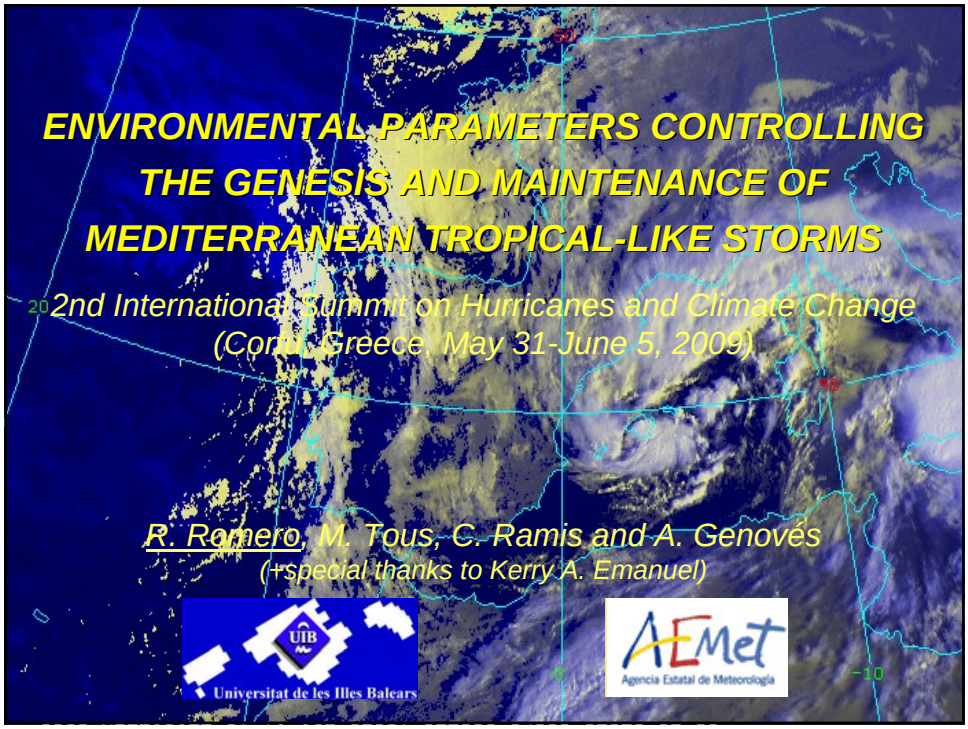


ENVIRONMENTAL PARAMETERS CONTROLLING THE GENESIS AND MAINTENANCE OF MEDITERRANEAN TROPICAL-LIKE STORMS

2nd International Summit on Hurricanes and Climate Change
(Corfu, Greece, May 31-June 5, 2009)

R. Romero, M. Tous, C. Ramis and A. Genovés
(+special thanks to Kerry A. Emanuel)

Universitat de les Illes Balears

AEMet Agencia Estatal de Meteorología

FRAMEWORK OF THE STUDY

MEDICANES – Spanish MEC project

Medicanes: Meteorological environments, Numerical Predictability and Risk Assessment in the Present and Future Climate

1) **Construction of a data base of medicanes from satellite information**

2) **Isolation of thermodynamical factors that are distinctive of medicane producing environments**

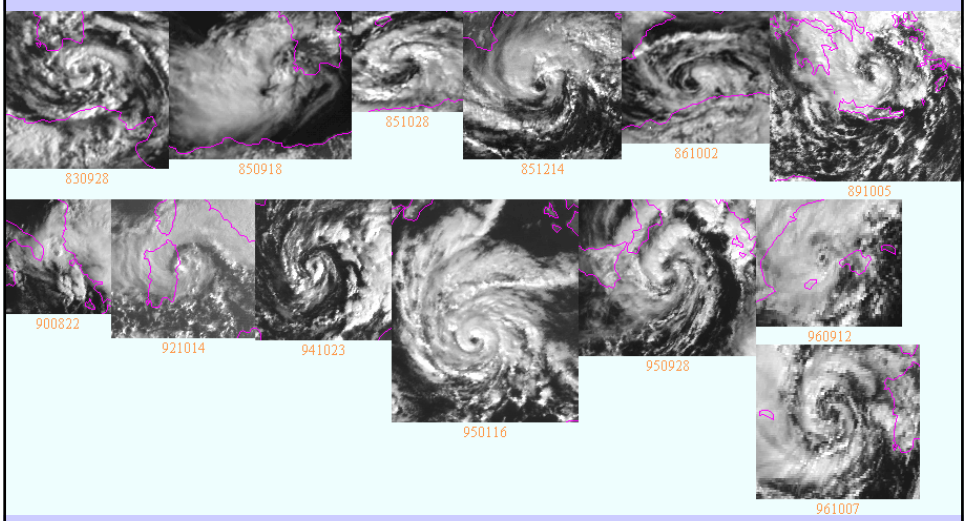
3) **To test for mesoscale high impact weather, in particular medicanes, the value of different kinds of EPSs**

4) **To assess the medicane risk and its uncertainty under the present and future climate conditions, by applying the probabilistic techniques of (3) to the medicane environments (2) extracted from a large collection of GCM simulations**

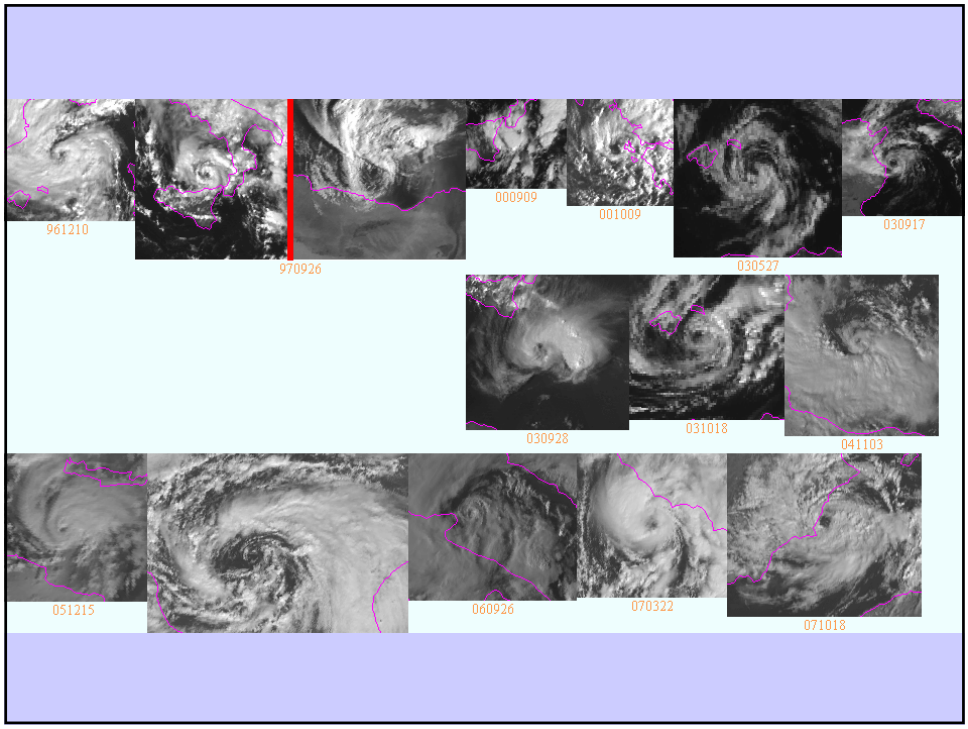
MEDICANES

- A few per year in the Mediterranean region, sometimes affecting islands (e.g. Mallorca)
- Most in autumn, of small dimensions and rarely reaching hurricane intensity
- Typically develop under deep, cold cut-off cyclones aloft
- Locally large air-sea thermodynamic disequilibrium favored by the primary disturbance

PARTICULAR CASES …



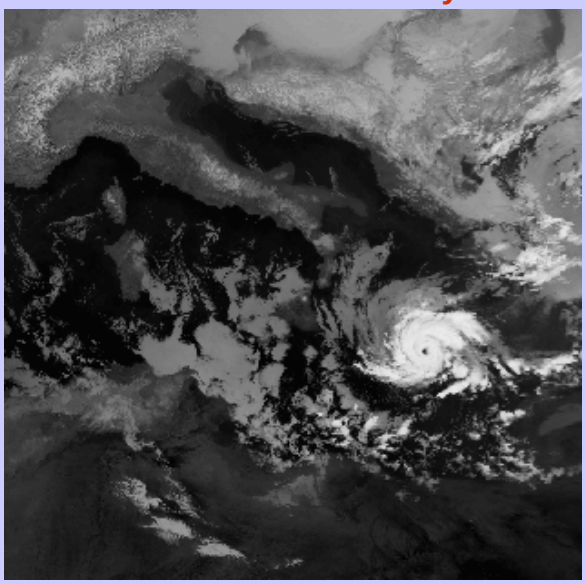
http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/MEDICANES



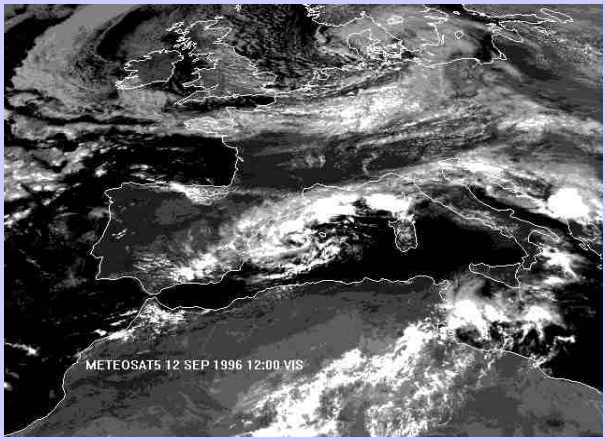
PENDING QUESTION

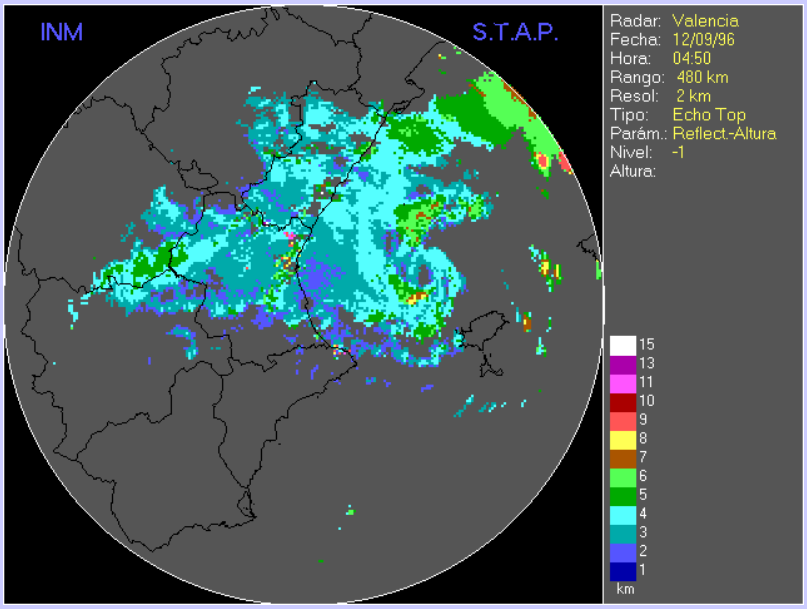
What is -and what is not- a medicane ???

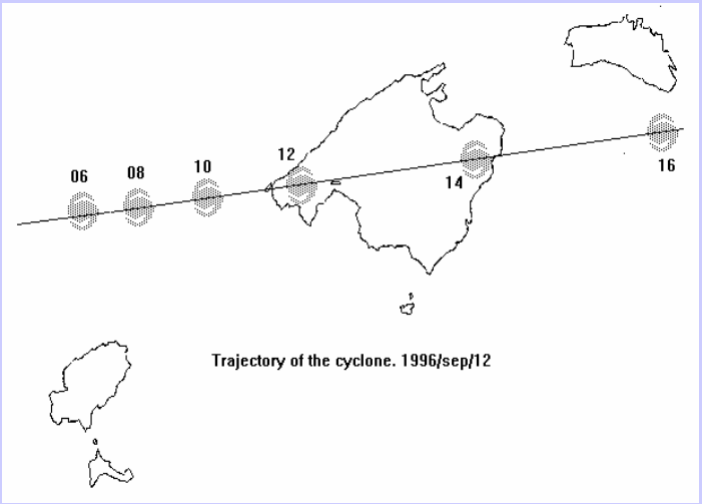
Medicane of 15-17 January 1995

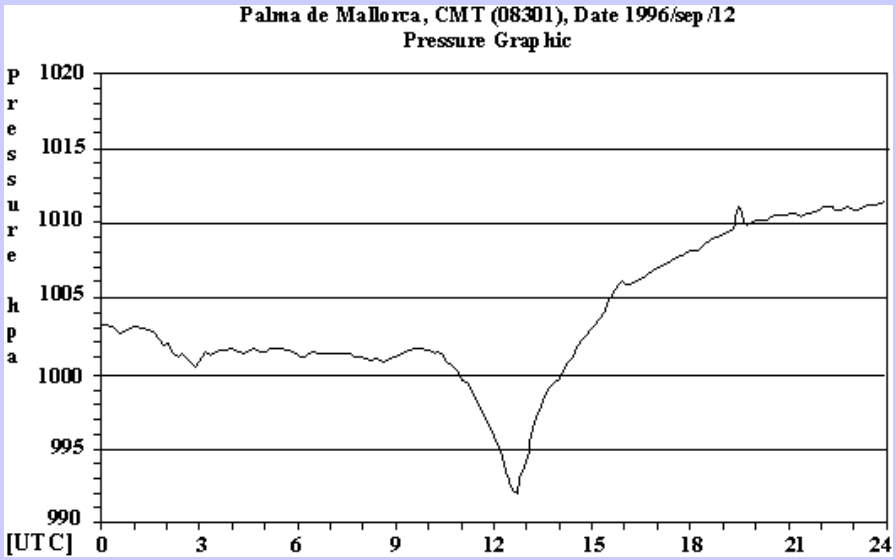


Medicane of 12 September, 1996



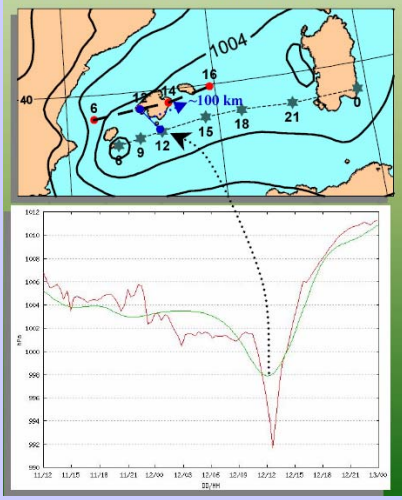

INM
S.T.A.P.
Radar: Valencia
Fecha: 12/09/96
Hora: 04:50
Rango: 480 km
Resol: 2 km
Tipo: Echo Top
Parám.: Reflect-Altura
Nivel: -1
Altura:
15
13
11
10
9
8
7
6
5
4
3
2
1
km


06
08
10
12
14
16
Trajectory of the cyclone. 1996/sep/12

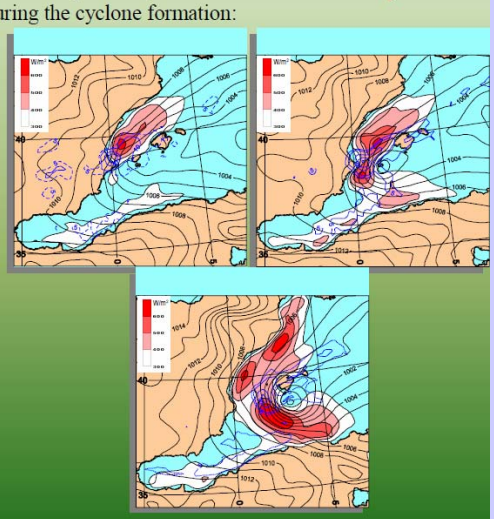


Control run

- Model run validation. Accurate simulation of the cyclone formation and eastern evolution is obtained. A southern shift of its trajectory of about 100 km is obtained.:

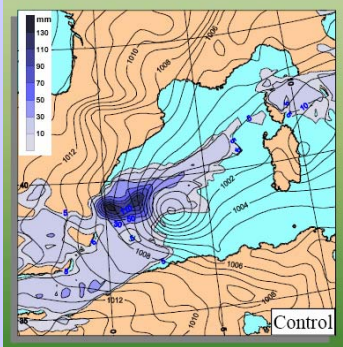


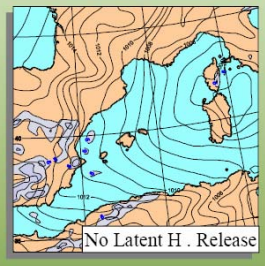
- Surface pressure, rainfall and sea surface evaporation during the cyclone formation:

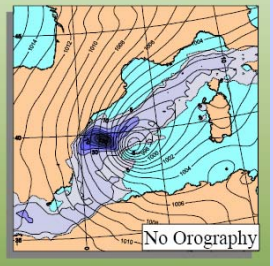


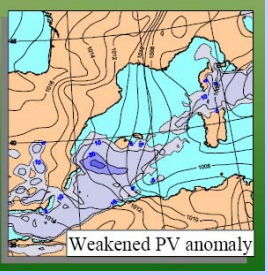
Sensitivity

Results of the sensitivity experiments in terms of surface pressure and accumulated precipitation at 1200 UTC:

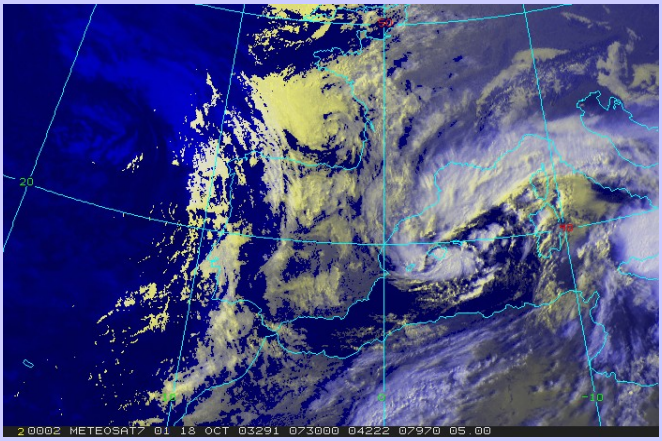


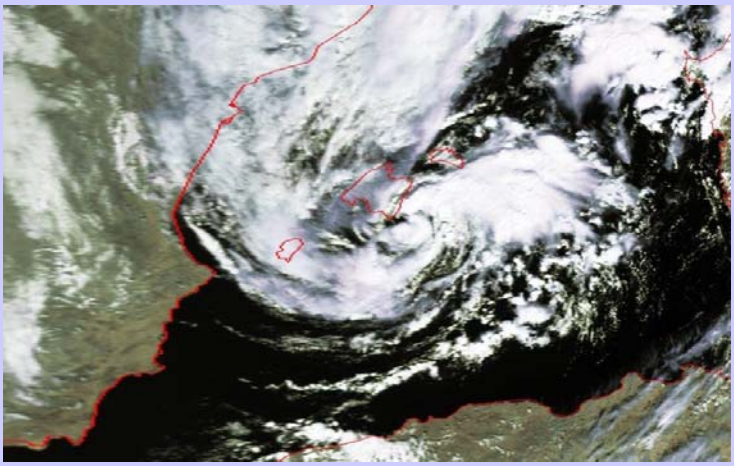


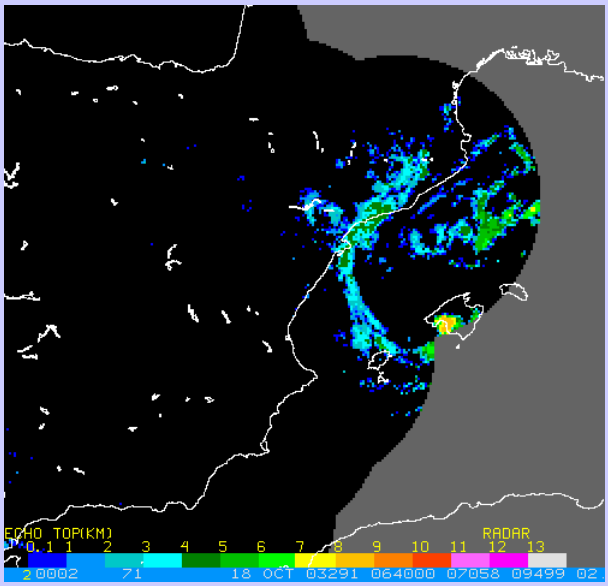


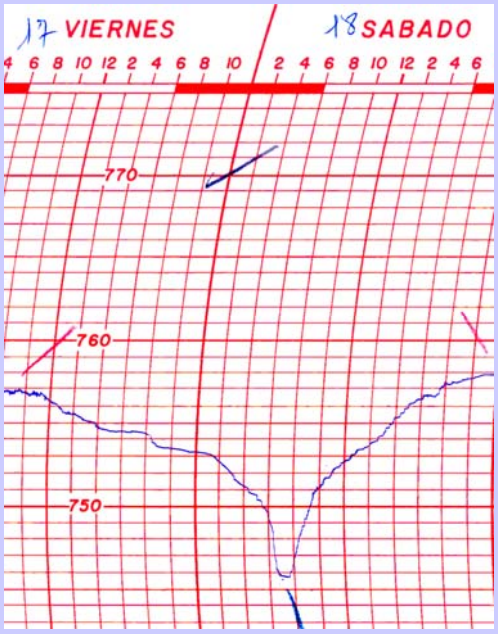


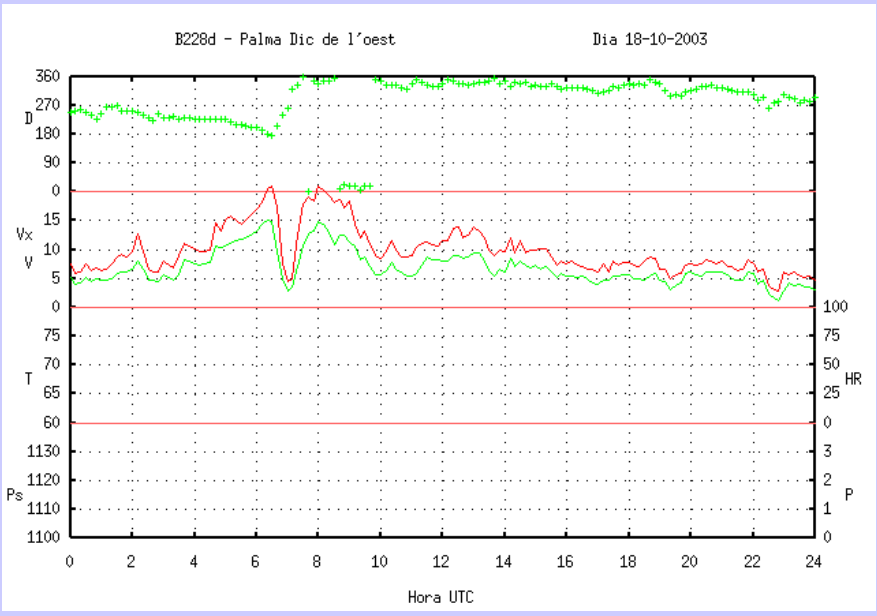
Medicane of 18 October, 2003






ECHO TOP(KM)
0.1 1 2 3 4 5 6 7 8 9 10 11 12 13
RADAR
2 0002 71 18 OCT 03291 064000 07058 09499 02


17 VIERNES
18 SABADO
4 6 8 10 12 2 4 6 8 10 2 4 6 8 10 12 2 4 6
770
760
750


B228d - Palma Dic de l'oest
Dia 18-10-2003
D
Vx
V
T
Ps
HR
P
Hora UTC

ENVIRONMENTAL FACTORS OF MEDICANES ???

- **Hypothesis:** **Physically speaking, medicanes can be considered small-scale analogues of tropical cyclones**
- **Air-sea interaction theory:** **Steady-state maintenance of tropical cyclones can be idealized as a Carnot engine. This idealized model correctly predicts the maximum wind speed –or minimum central pressure– achievable in real events (Potential Intensity)**
- **Genesis:** **Empirical genesis index successfully tested against the true space-time probability of tropical cyclone genesis**
- **Objective:** **To apply the above ideas to the Mediterranean region**
  - Test the appropriateness of these ingredients on particular events
  - Climatological analysis using reanalyses and GCM data sets

Empirical Tropical Genesis Index

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

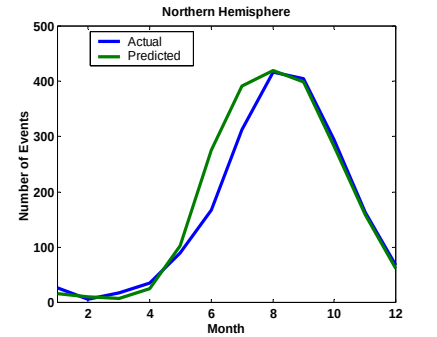
$\eta \equiv 850\,hPa\ absolute\ vorticity\ (s^{-1})$,

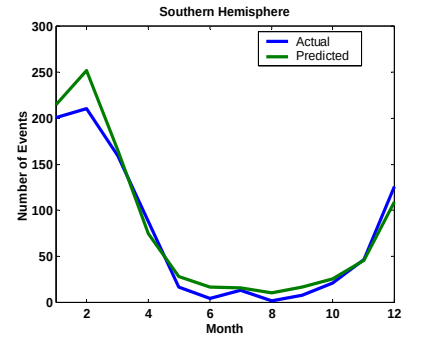
$V_{pot} \equiv Potential\ wind\ speed\ (ms^{-1})$,

$H \equiv 600\,mb\ relative\ humidity\ (\%)$,

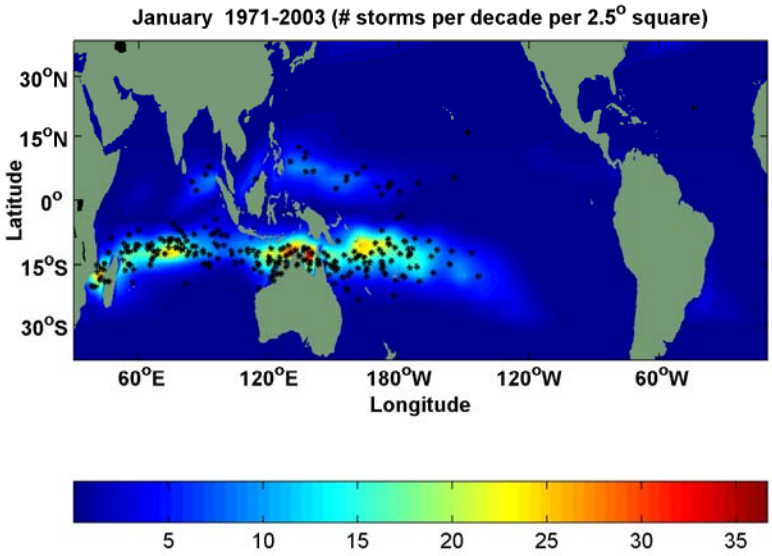
$V_{shear} \equiv \left| \mathbf{V}_{850} - \mathbf{V}_{250} \right| \ (ms^{-1})$.

Seasonal Variability

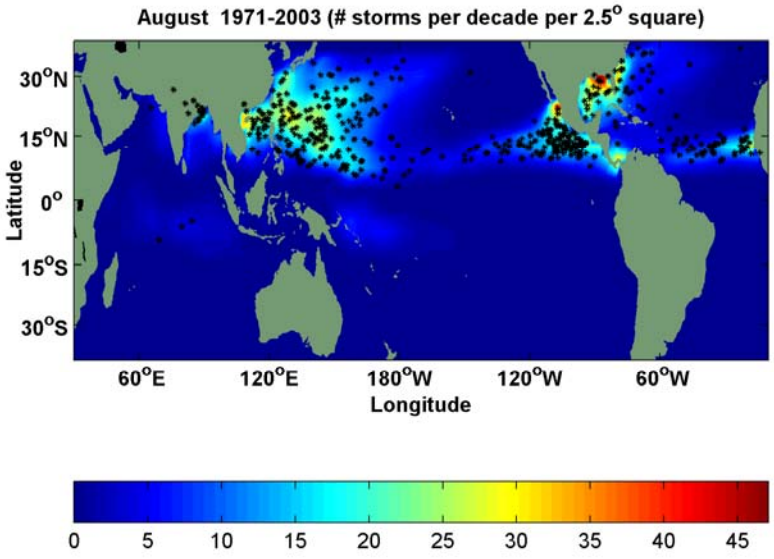


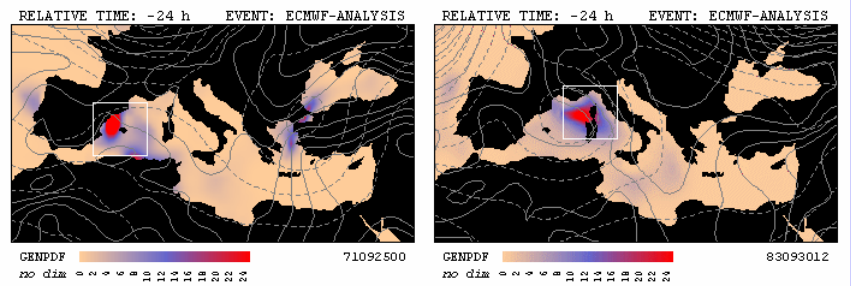


Spatial Variability (S.H.)

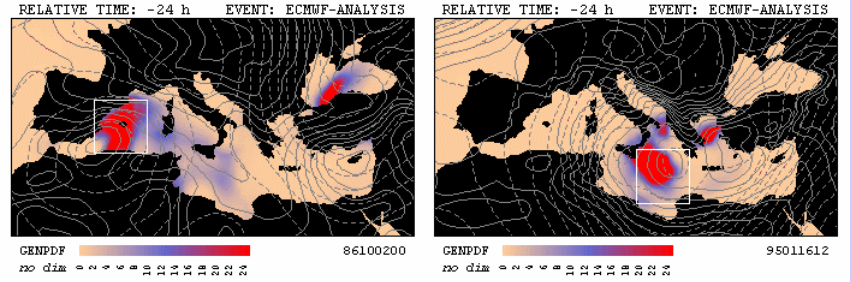


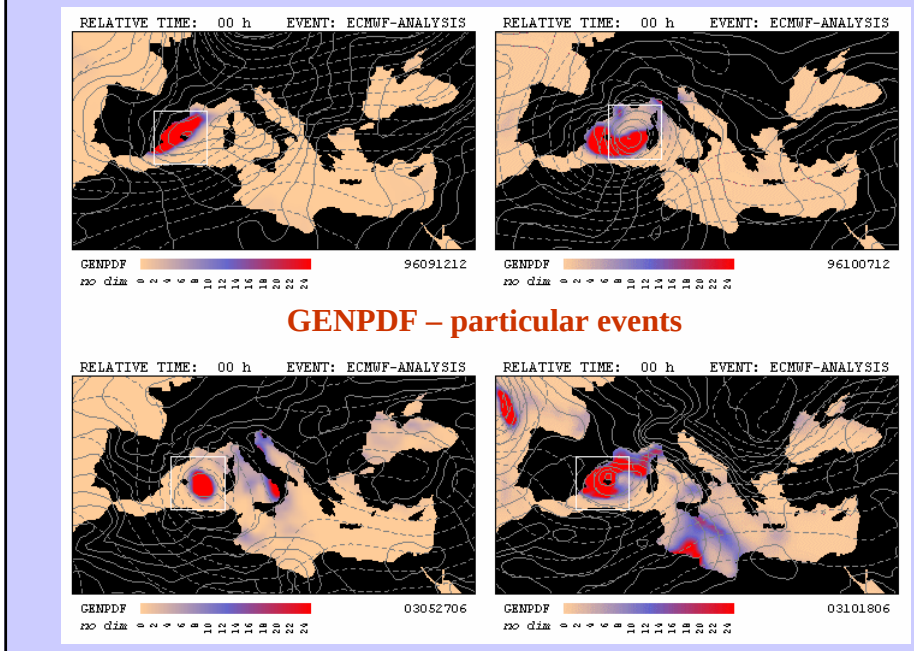
Spatial Variability (N.H.)





GENPDF – particular events




RELATIVE TIME: 00 h EVENT: ECMWF-ANALYSIS
GENPDF 96091212
no dim
RELATIVE TIME: 00 h EVENT: ECMWF-ANALYSIS
GENPDF 96100712
no dim
GENPDF – particular events
RELATIVE TIME: 00 h EVENT: ECMWF-ANALYSIS
GENPDF 03052706
no dim
RELATIVE TIME: 00 h EVENT: ECMWF-ANALYSIS
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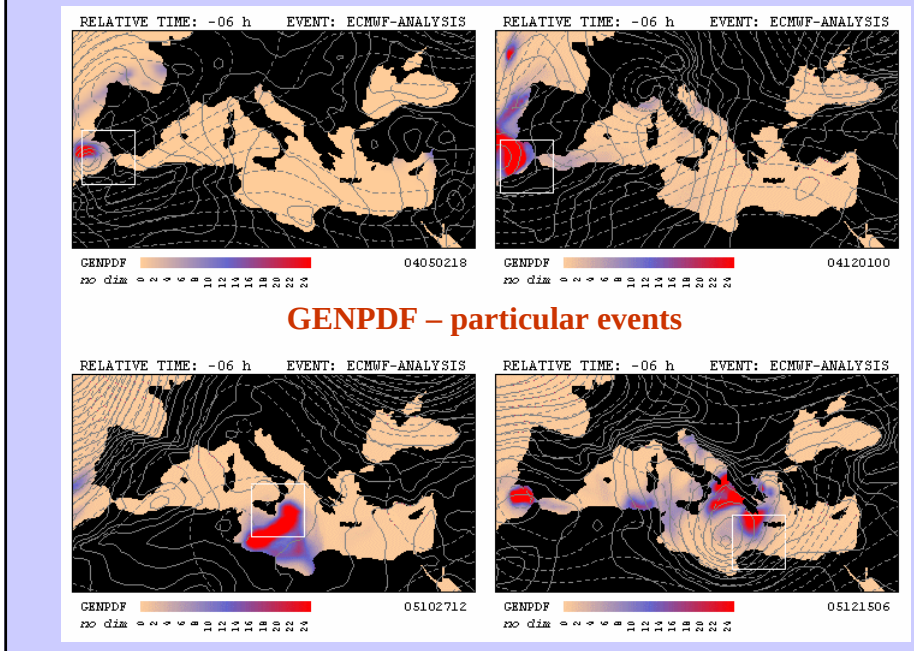
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GENPDF 04120100
no dim
GENPDF – particular events
RELATIVE TIME: -06 h EVENT: ECMWF-ANALYSIS
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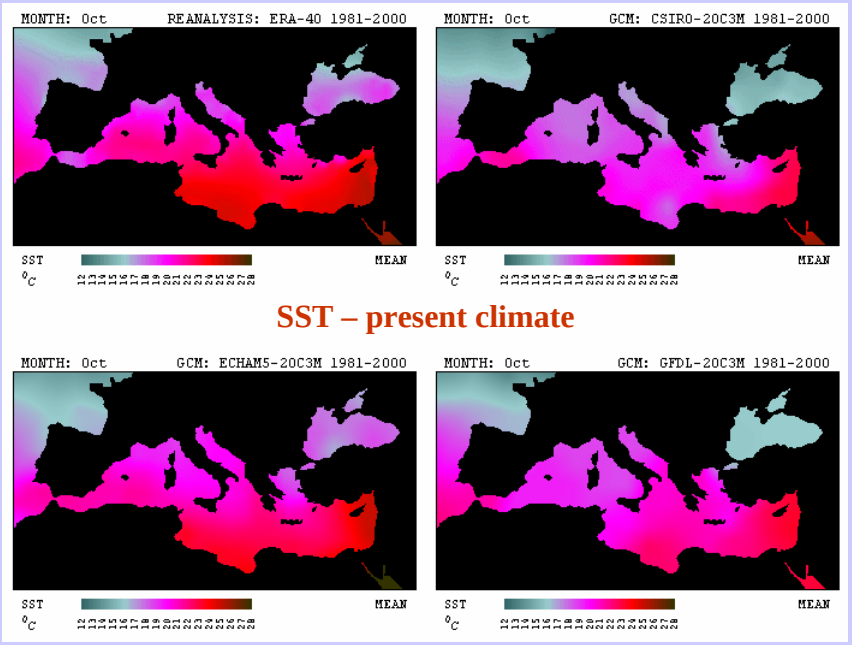
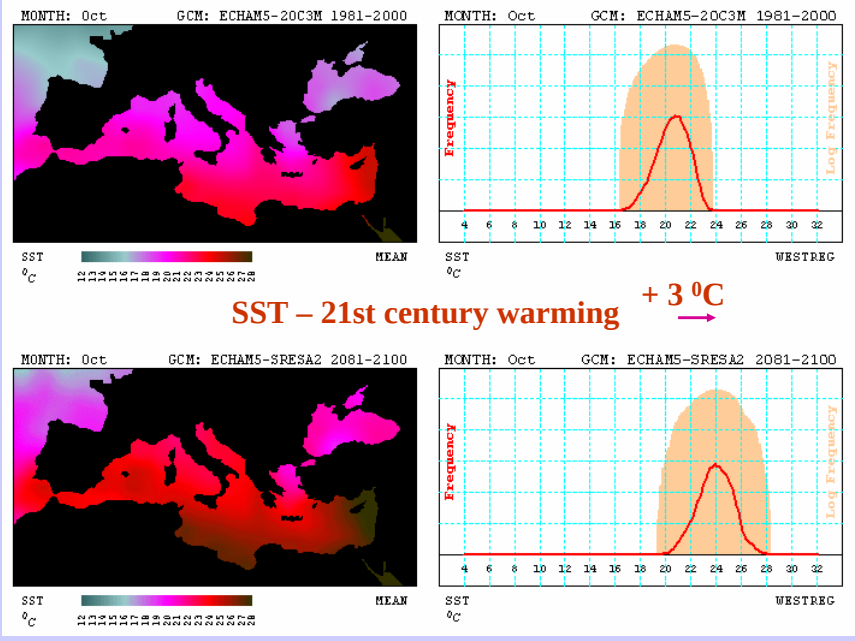
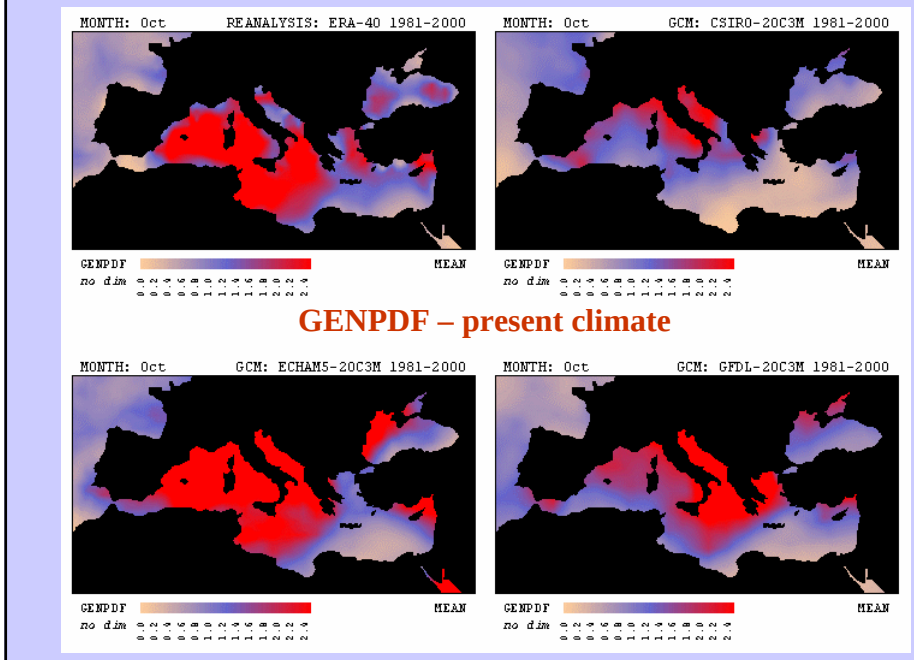
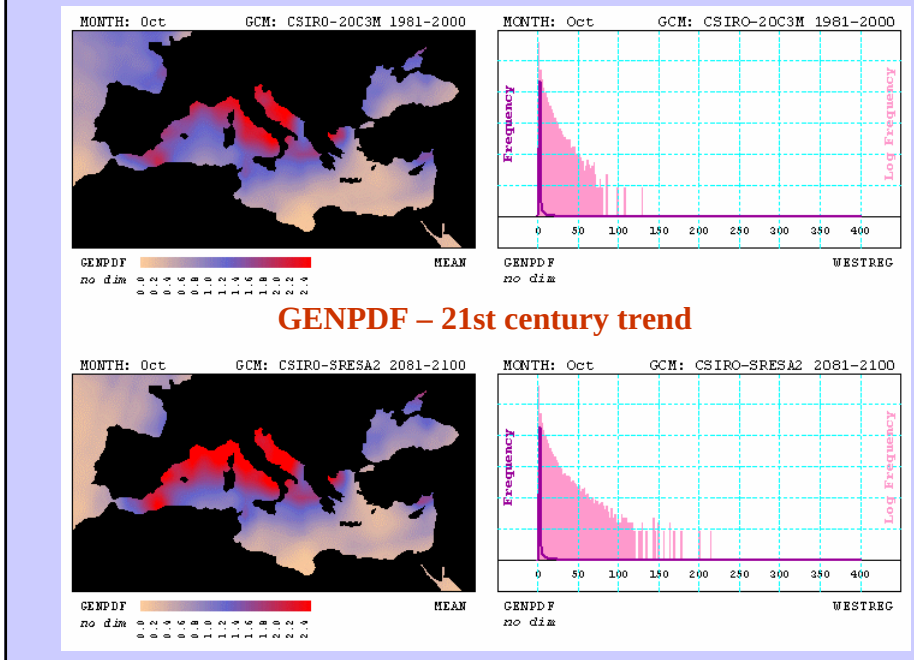
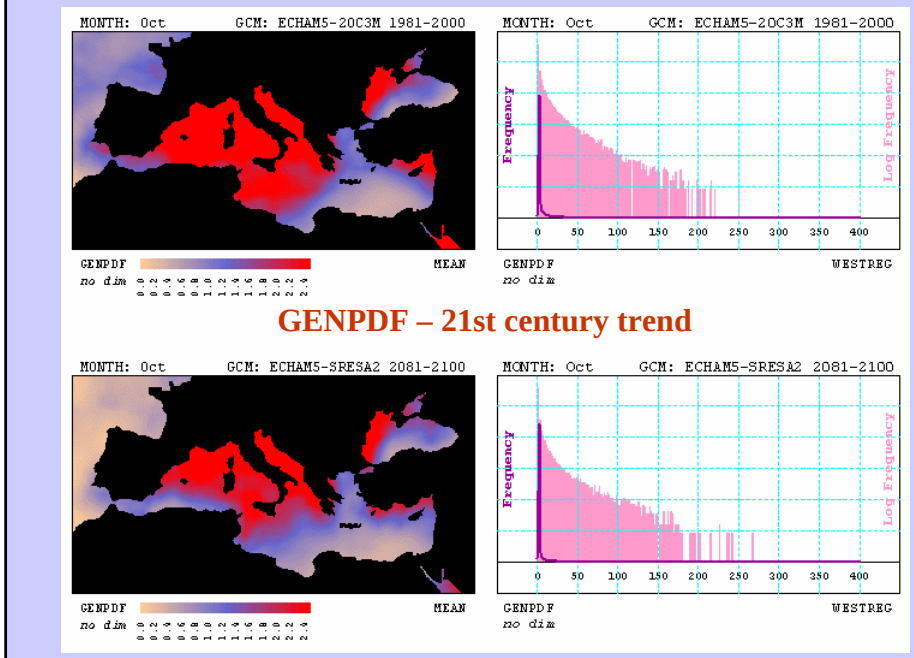
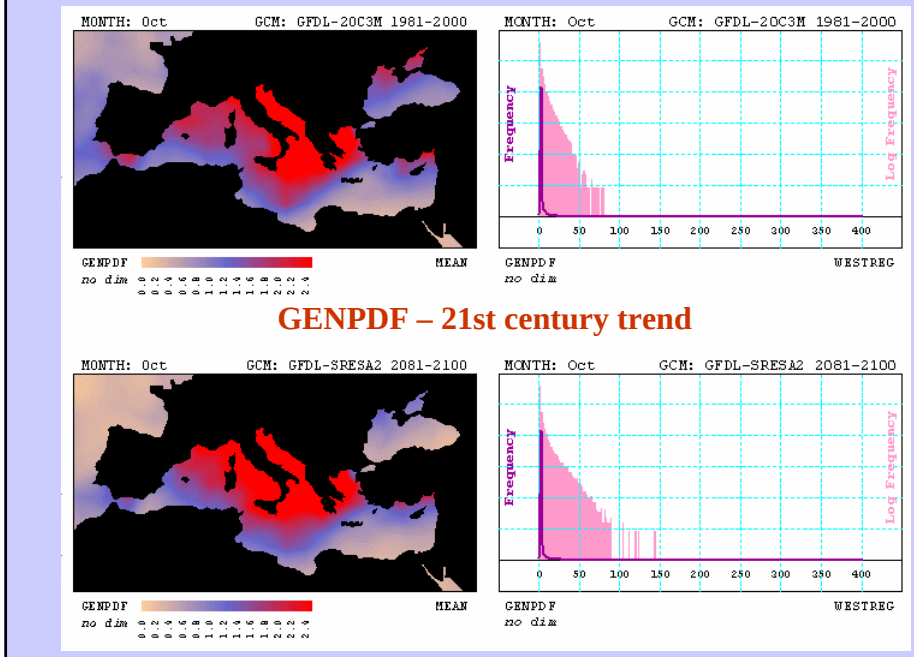

MONTH: Oct
REANALYSIS: ERA-40 1981-2000
MONTH: Oct
GCM: CSIRO-20C3M 1981-2000
SST
MEAN
SST – present climate
MONTH: Oct
GCM: ECHAM5-20C3M 1981-2000
MONTH: Oct
GCM: GFDL-20C3M 1981-2000


MONTH: Oct
GCM: ECHAM5-20C3M 1981-2000
Frequency
Log Frequency
SST
MEAN
WESTREG
SST – 21st century warming
+ 3 °C
MONTH: Oct
GCM: ECHAM5-SRESA2 2081-2100


MONTH: Oct
REANALYSIS: ERA-40 1981-2000
MONTH: Oct
GCM: CSIRO-20C3M 1981-2000
GENPDF
no dim
MEAN
GENPDF – present climate
MONTH: Oct
GCM: ECHAM5-20C3M 1981-2000
MONTH: Oct
GCM: GFDL-20C3M 1981-2000


MONTH: Oct
GCM: CSIRO-20C3M 1981-2000
MONTH: Oct
GCM: CSIRO-20C3M 1981-2000
Frequency
Log Frequency
0
50
100
150
200
250
300
350
400
GENPDF
no dim
WESTREG
GENPDF – 21st century trend
MONTH: Oct
GCM: CSIRO-SRESA2 2081-2100
MONTH: Oct
GCM: CSIRO-SRESA2 2081-2100


MONTH: Oct
GCM: ECHAM5-20C3M 1981-2000
GENPDF
no dim
MEAN
MONTH: Oct
GCM: ECHAM5-20C3M 1981-2000
Frequency
Log Frequency
0 50 100 150 200 250 300 350 400
GENPDF
no dim
WESTREG
GENPDF – 21st century trend
MONTH: Oct
GCM: ECHAM5-SRESA2 2081-2100
GENPDF
no dim
MEAN
MONTH: Oct
GCM: ECHAM5-SRESA2 2081-2100
Frequency
Log Frequency
0 50 100 150 200 250 300 350 400
GENPDF
no dim
WESTREG


MONTH: Oct
GCM: GFDL-20C3M 1981-2000
GENPDF
no dim
MEAN
MONTH: Oct
GCM: GFDL-20C3M 1981-2000
Frequency
Log Frequency
0 50 100 150 200 250 300 350 400
GENPDF
no dim
WESTREG
GENPDF – 21st century trend
MONTH: Oct
GCM: GFDL-SRESA2 2081-2100
GENPDF
no dim
MEAN
MONTH: Oct
GCM: GFDL-SRESA2 2081-2100
Frequency
Log Frequency
0 50 100 150 200 250 300 350 400
GENPDF
no dim
WESTREG

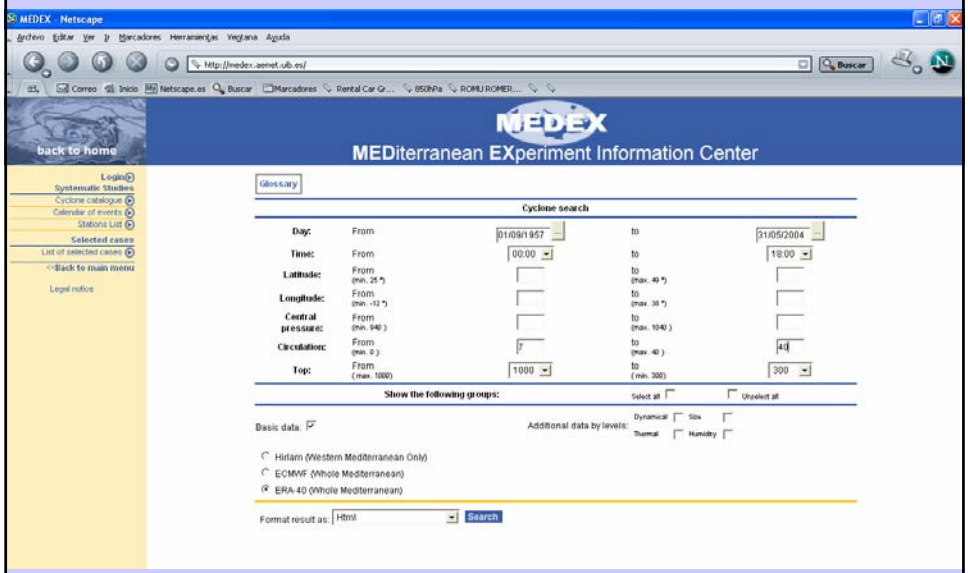
BUT …

Is GENPF –or other ingredients involved in its formulation– a clear discriminative factor of

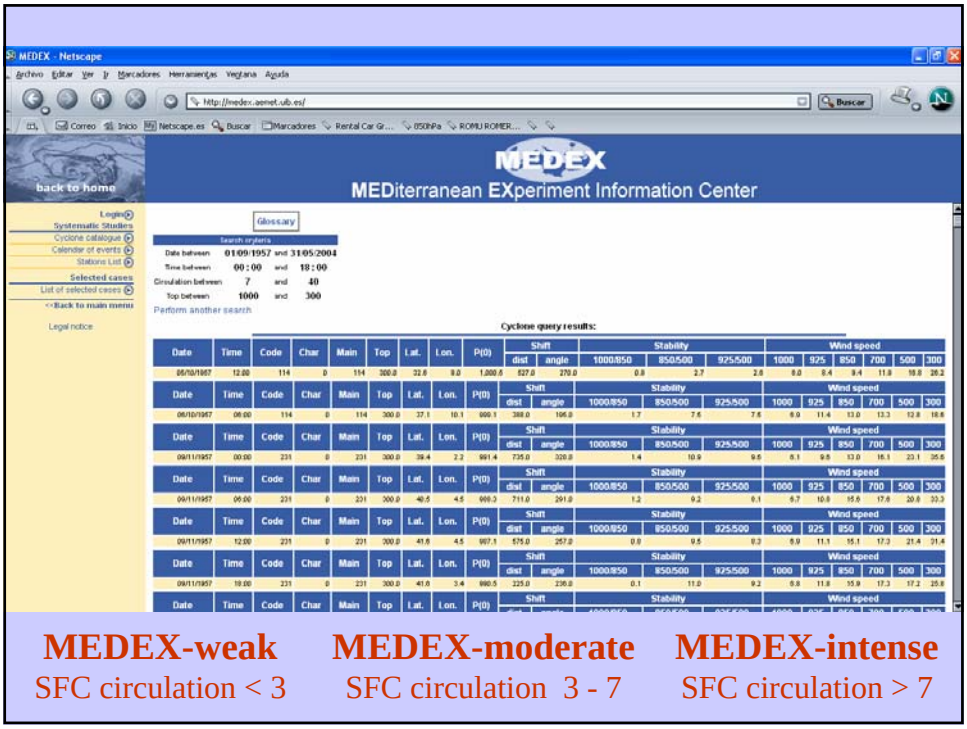
medicanes environments

vs

ordinary cyclonic environments ???



ERA-40: Sept 1957 – Aug 2002

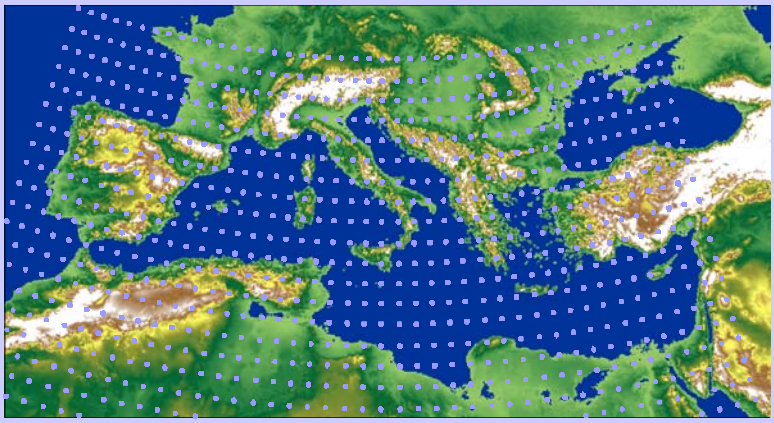


MEDEX-weak SFC circulation < 3

MEDEX-moderate SFC circulation 3 - 7

MEDEX-intense SFC circulation > 7

GEOGRAPHYCAL DISTRIBUTION OF EVENTS



MEDEX-intense(4823)
MEDEX-moderate(40813)
MEDEX-weak(23681)

MEDICANES_llista1 - WordPad

Archivo Edición Ver Insertar Formato Ayuda

Courier New 10 Occidental

```
1982030412  31.50 -21.90
1982030612  38.32 -12.03
1982031418  40.47 -18.17
1982041418  40.65 -18.10
1982042506  42.18 -9.22
1982050100  39.63 -9.60
1982070912  44.90 -35.22
1982071300  44.37 -20.00
1982090206  39.92 -5.22
1982091006  41.25 -19.22
1982092306  40.77 -20.68
1982102106  39.90 -1.10
```

MEDICANES-1

1982 – 1991

MEDICANES_llista2 - WordPad

Archivo Edición Ver Insertar Formato Ayuda

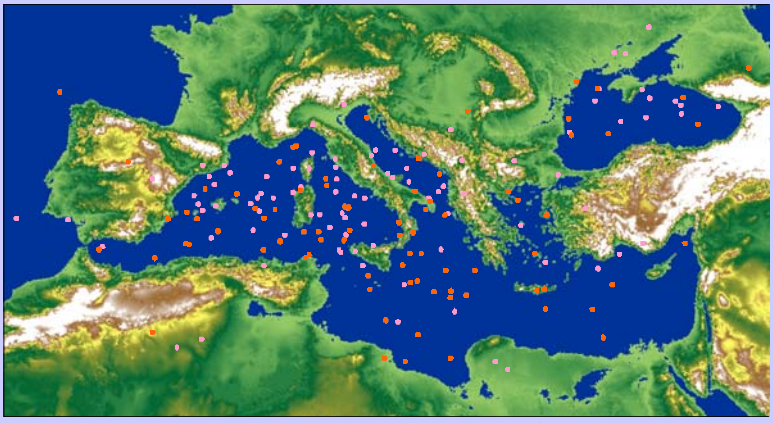
Courier New 10 Occidental

```
1982030612  38.32 -12.03
1982031418  40.47 -18.17
1982111812  40.68 -23.93
1982120118  40.13 -12.28
1983040800  40.18 -12.00
1983082800  38.92 -0.80
1983092012  40.15 -24.52
1983092800  38.27 -10.43
1983111118  34.75 -30.07
1984021718  40.02 -17.85
1984040700  36.10 -17.10
1984112806  36.98 -16.10
1984120500  38.70 -10.23
1984122912  36.38 -13.77
1985020900  37.25 -9.45
```

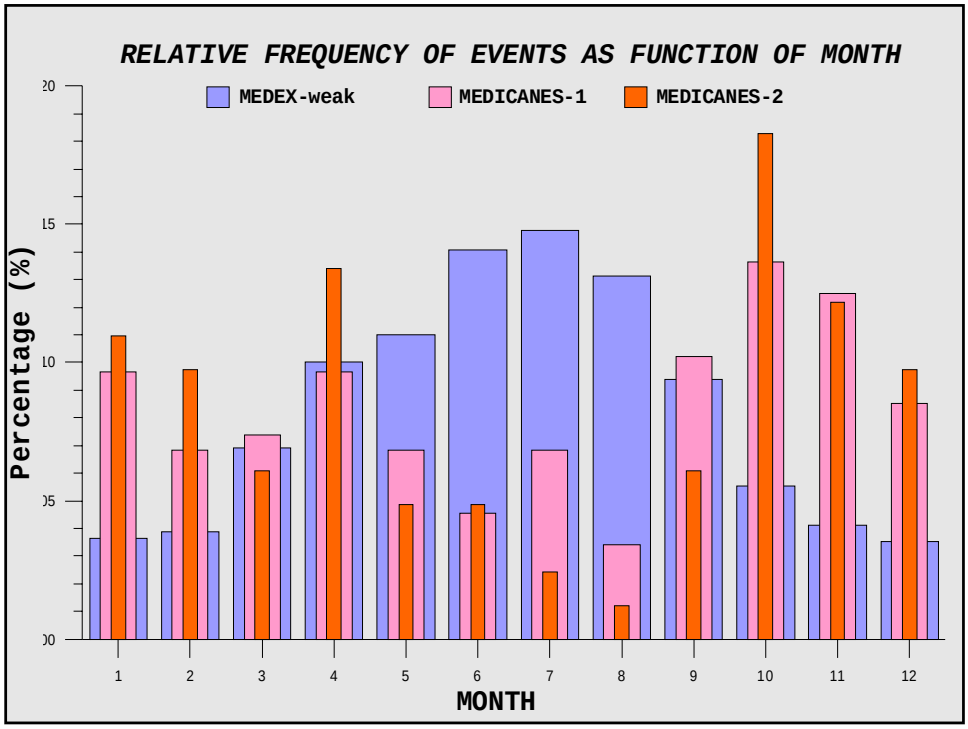
MEDICANES-2

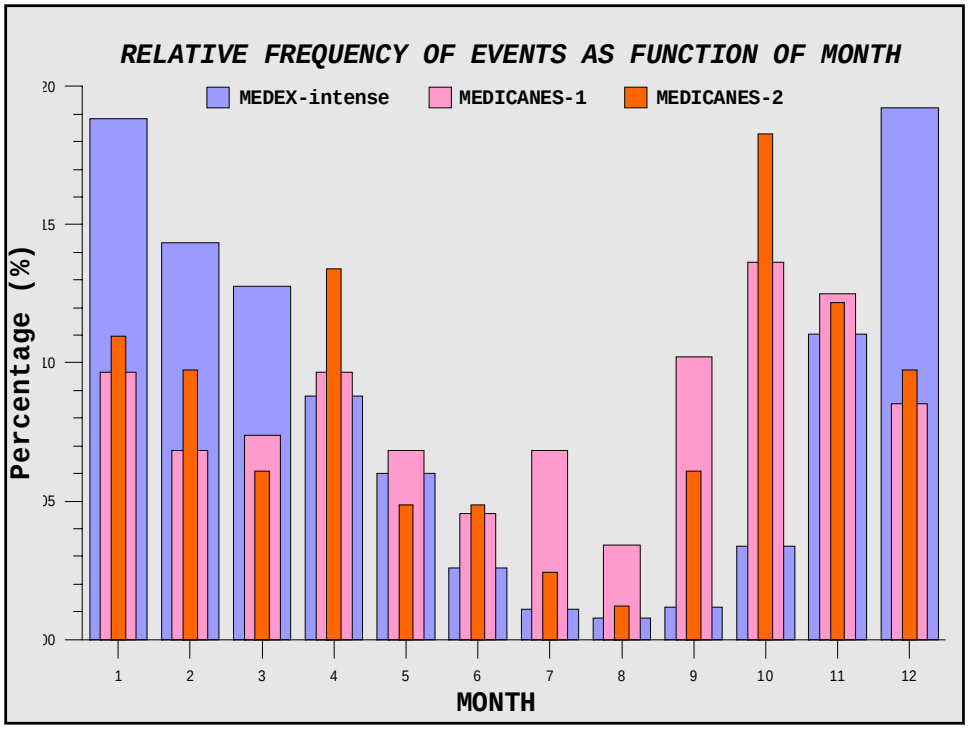
1982 – 1991

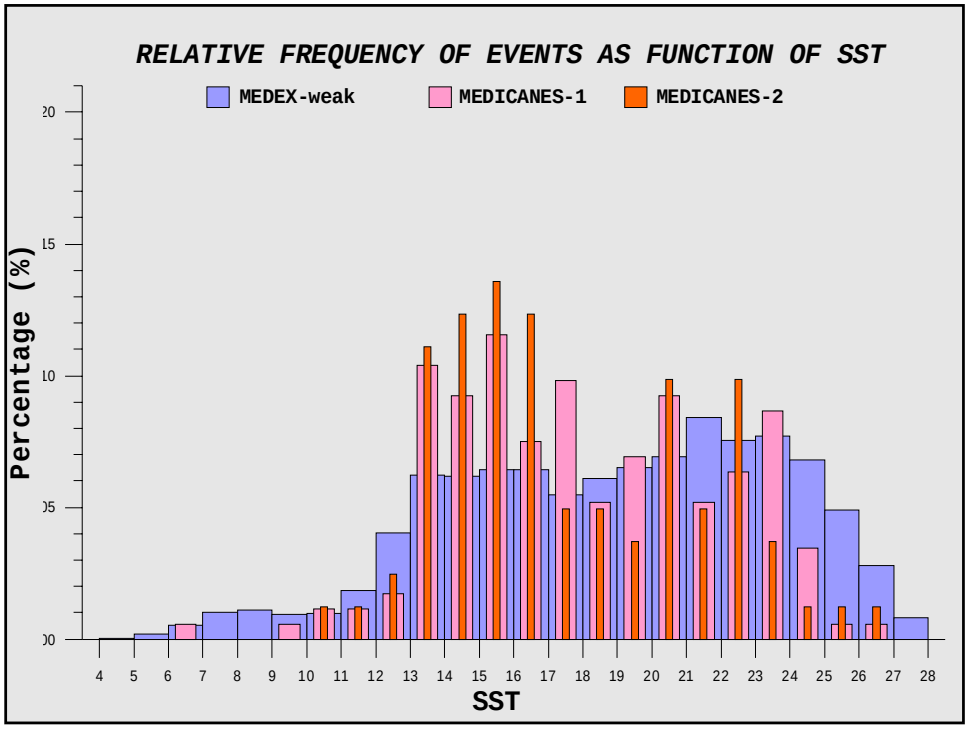
GEOGRAPHYCAL DISTRIBUTION OF EVENTS

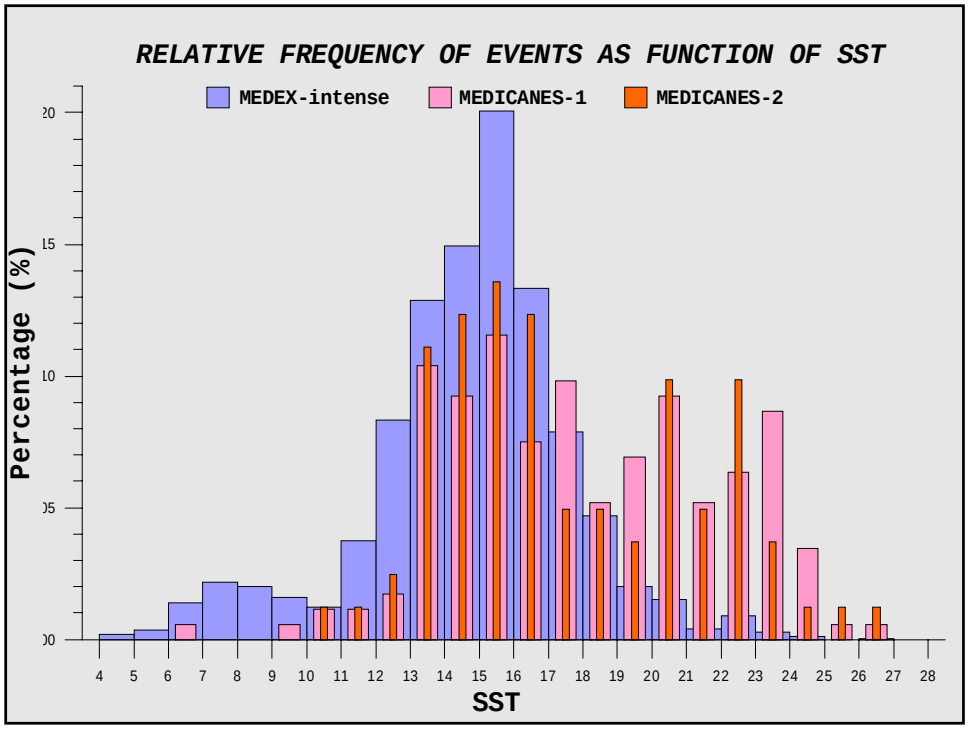


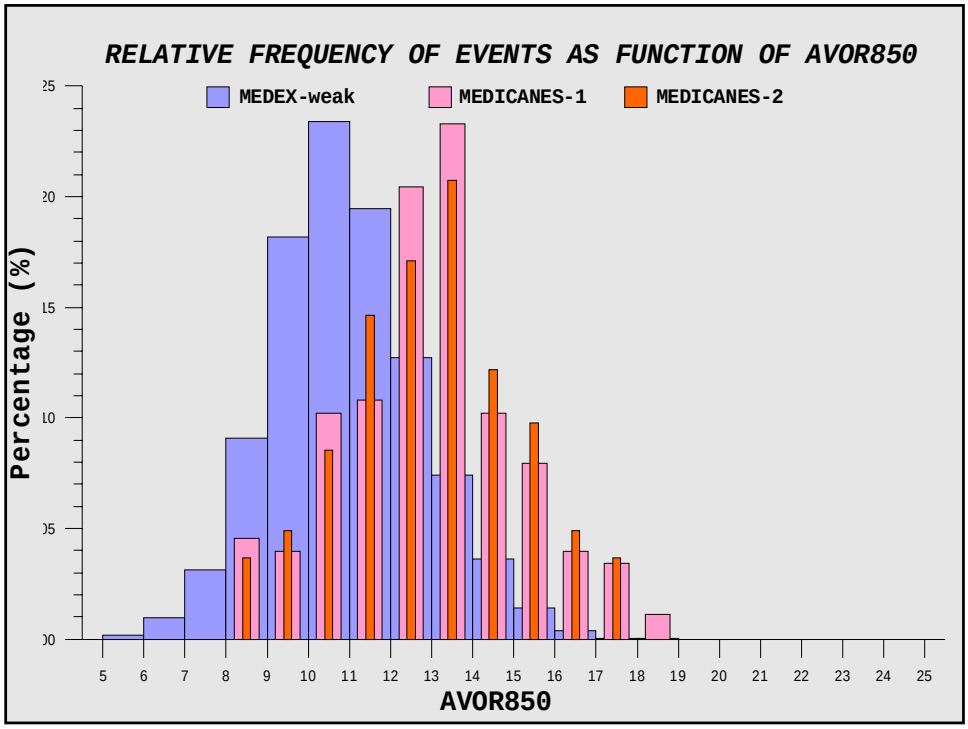
MEDICANES-1(176) MEDICANES-2(82)

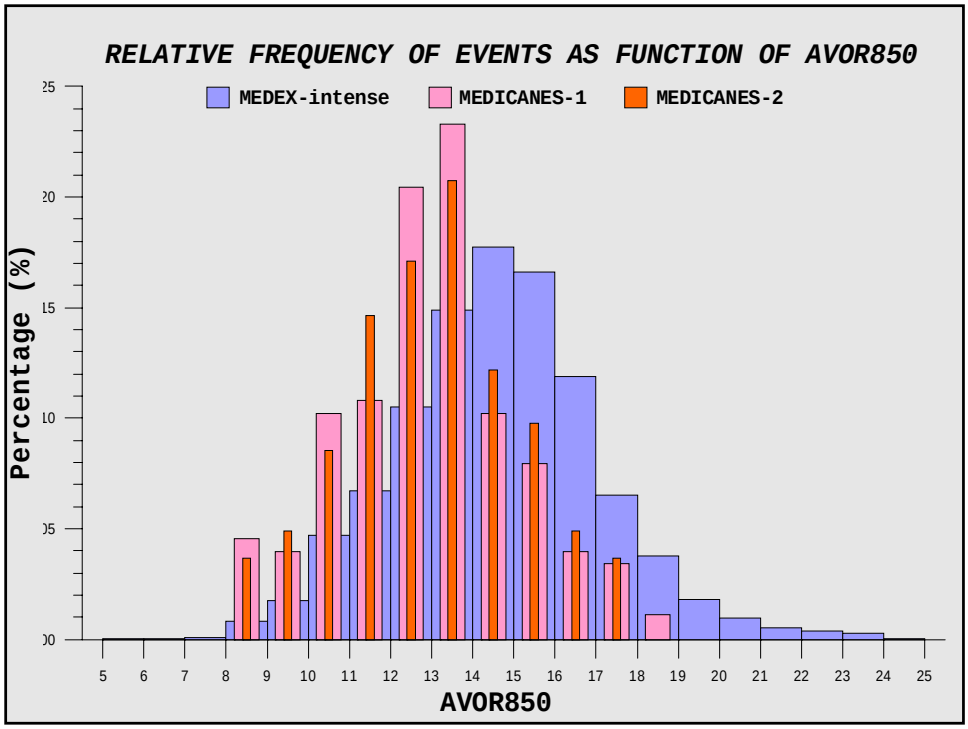

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MONTH
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
MONTH
1
2
3
4
5
6
7
8
9
10
11
12

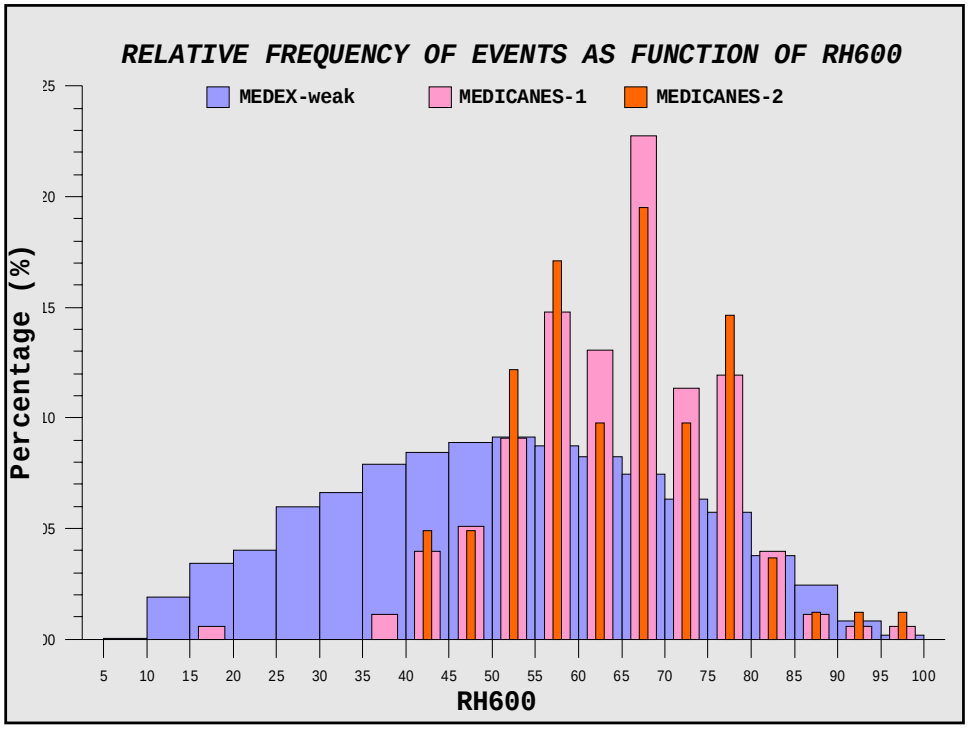

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MONTH
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
MONTH
1
2
3
4
5
6
7
8
9
10
11
12

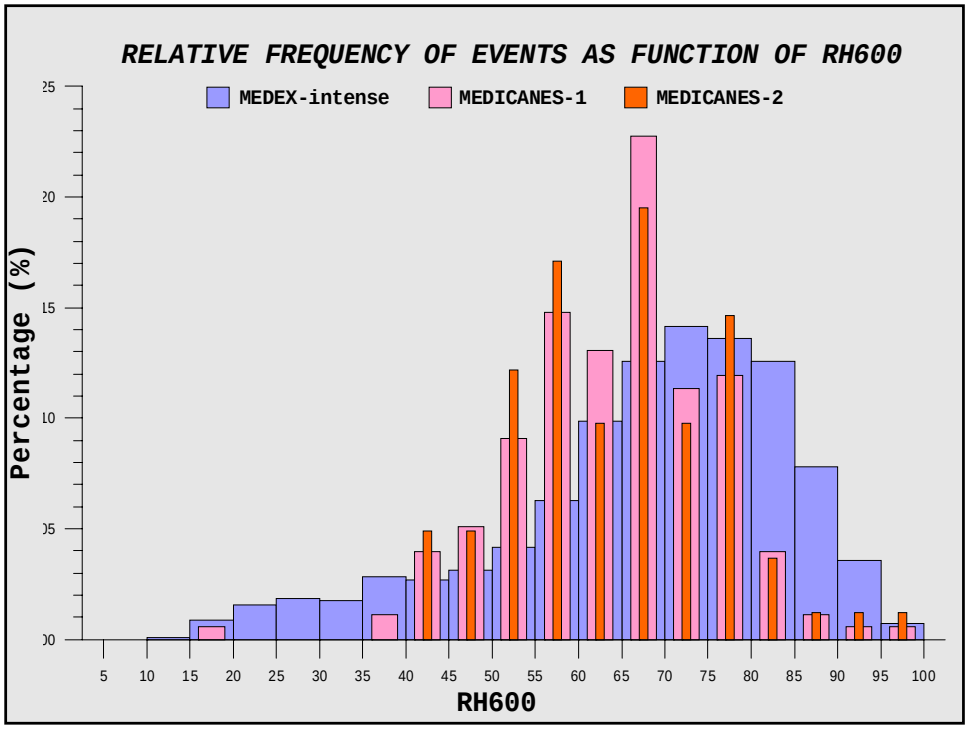

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF SST
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
SST
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

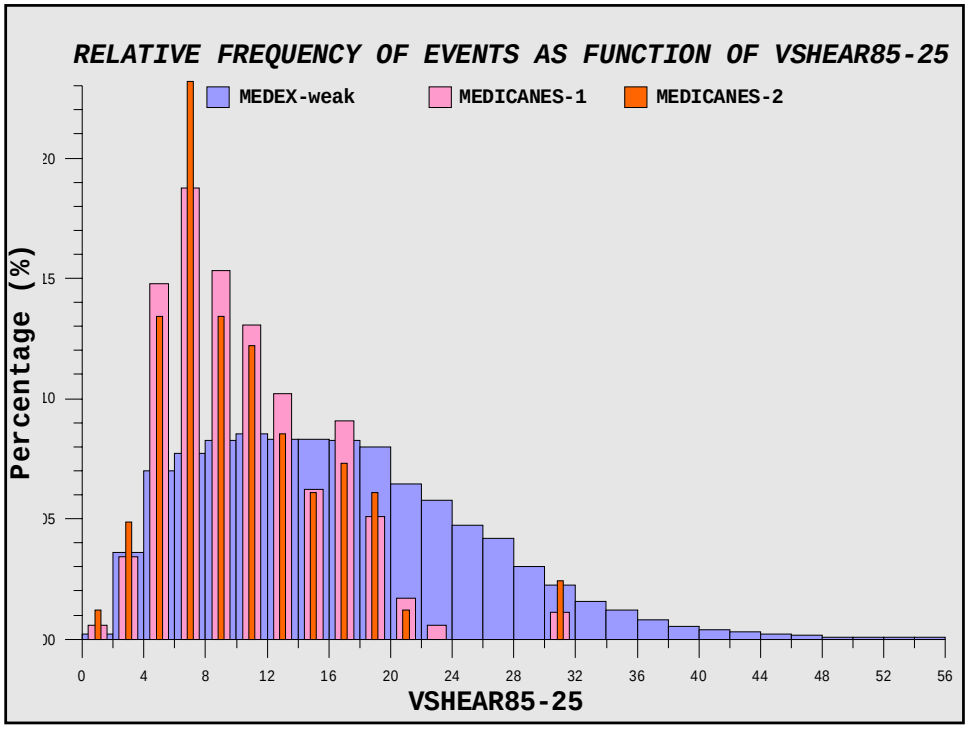

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF SST
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
SST
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

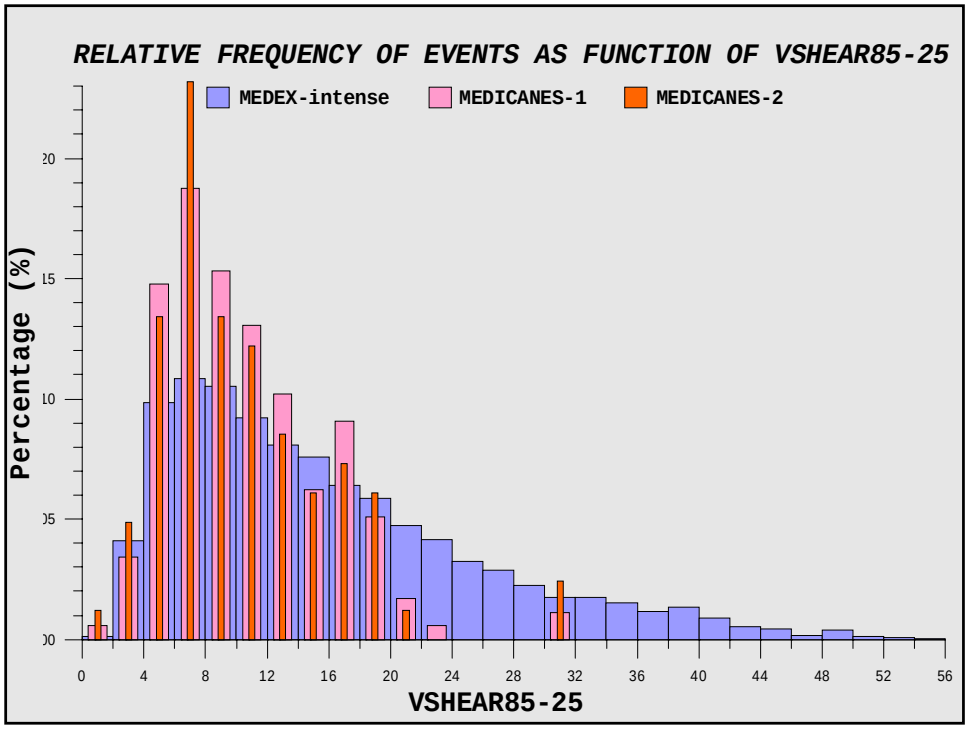

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF AVOR850
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
AVOR850

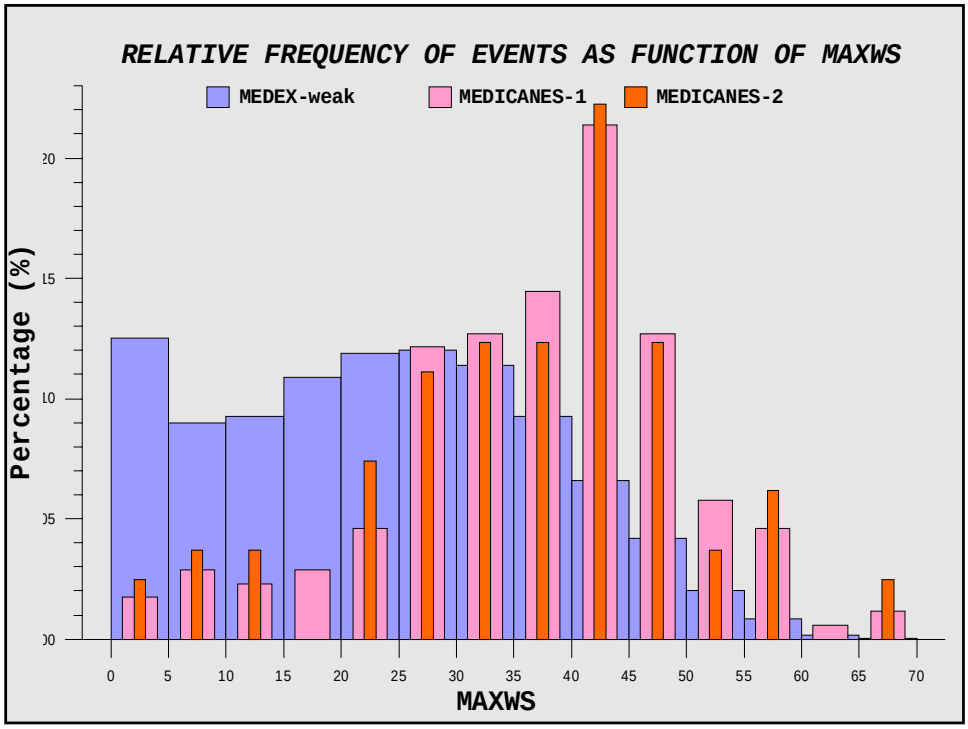

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF AVOR850
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
AVOR850

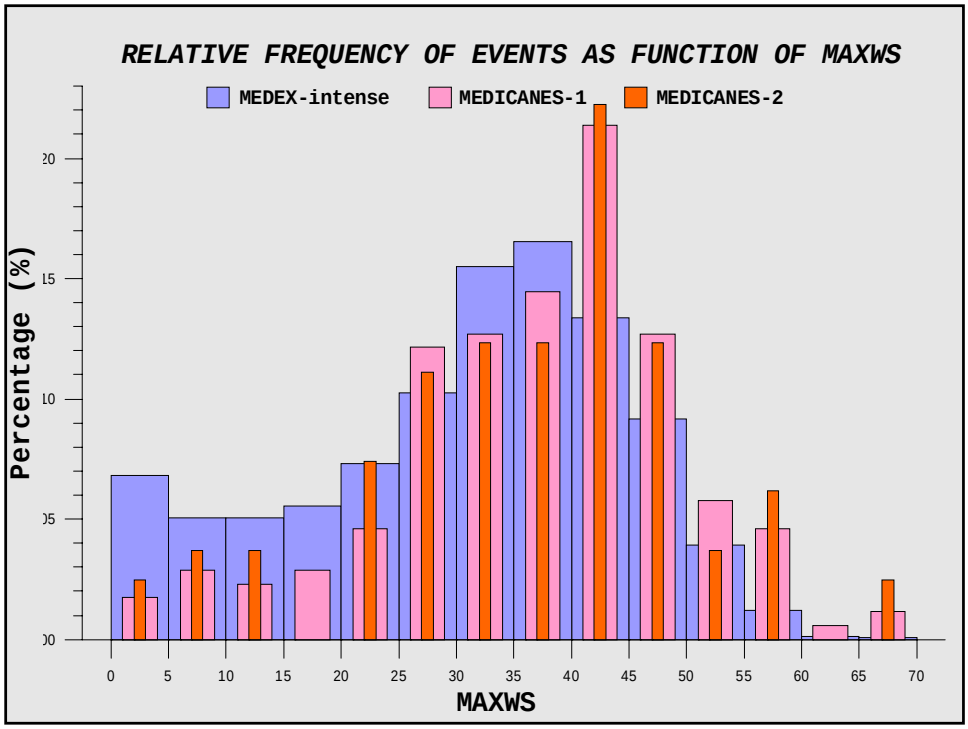

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF RH600
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
RH600
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

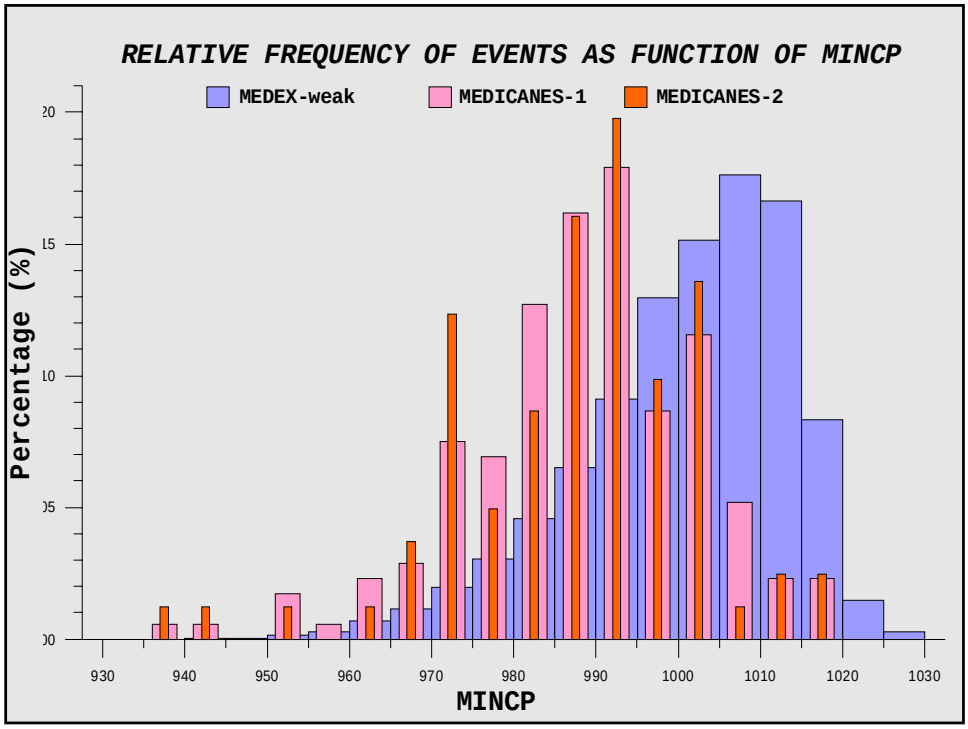

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF RH600
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
RH600
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

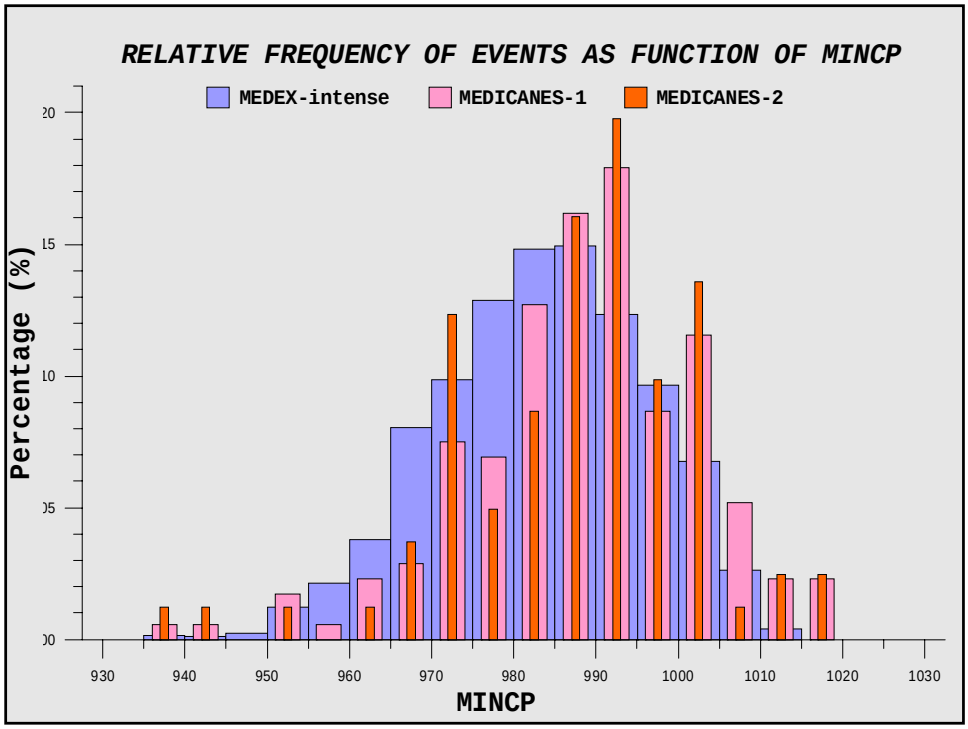

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF VSHEAR85-25
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
VSHEAR85-25

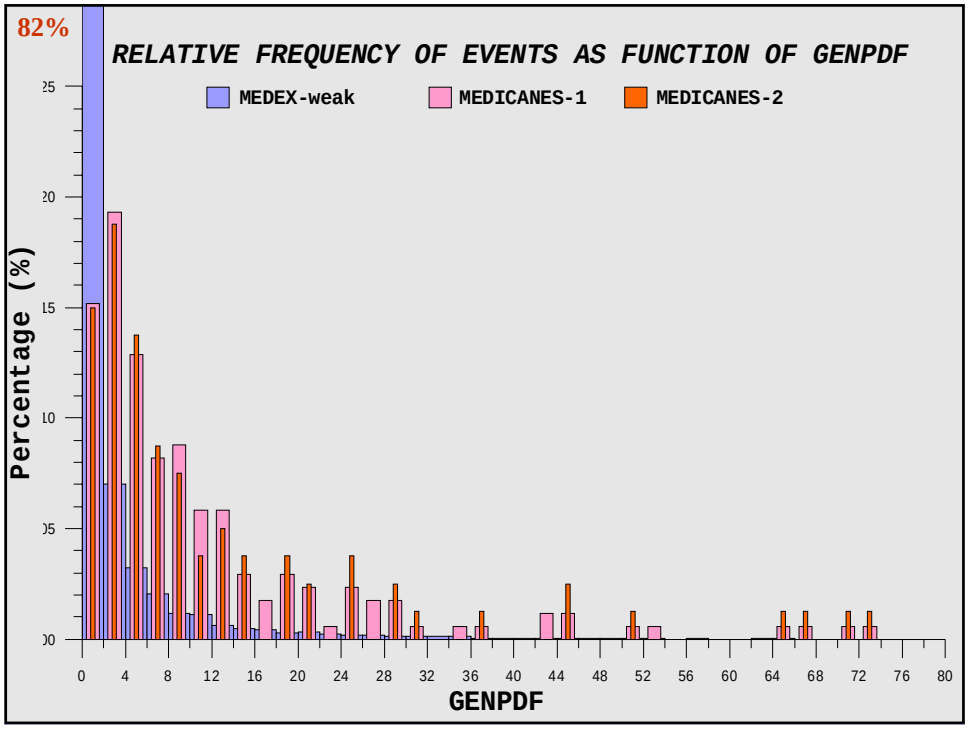

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF VSHEAR85-25
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
VSHEAR85-25

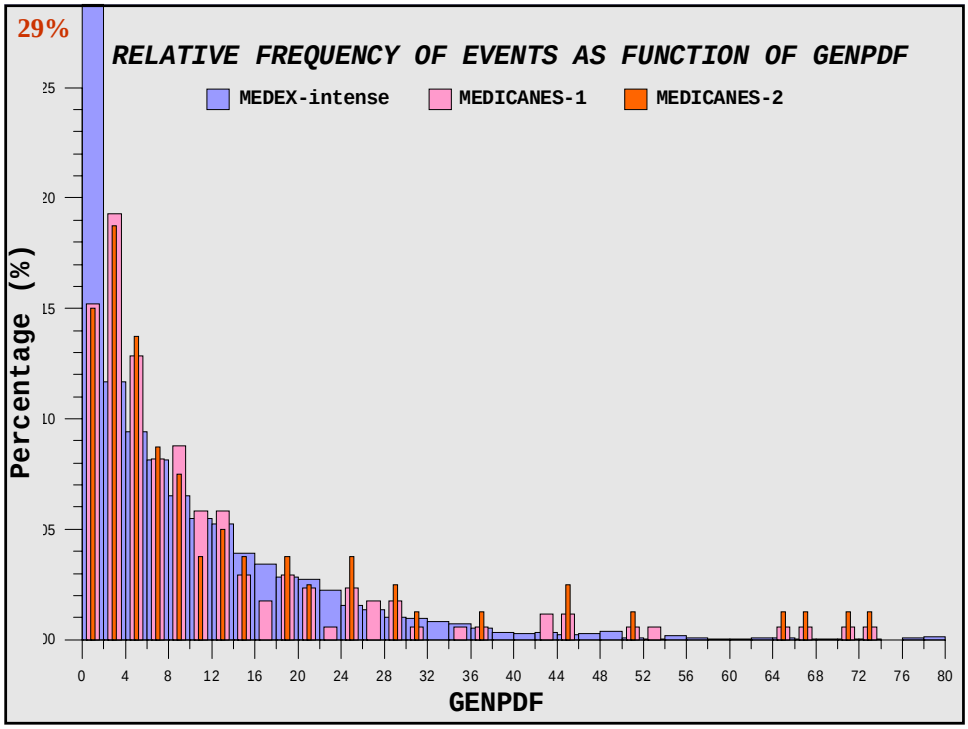

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MAXWS
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
MAXWS

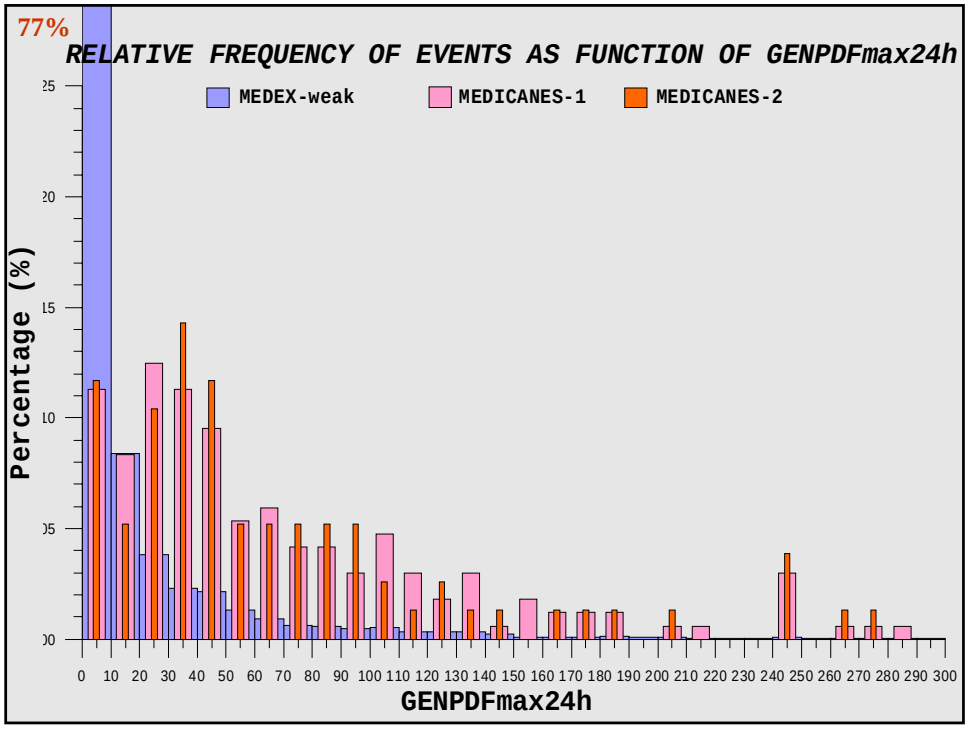

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MAXWS
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
MAXWS

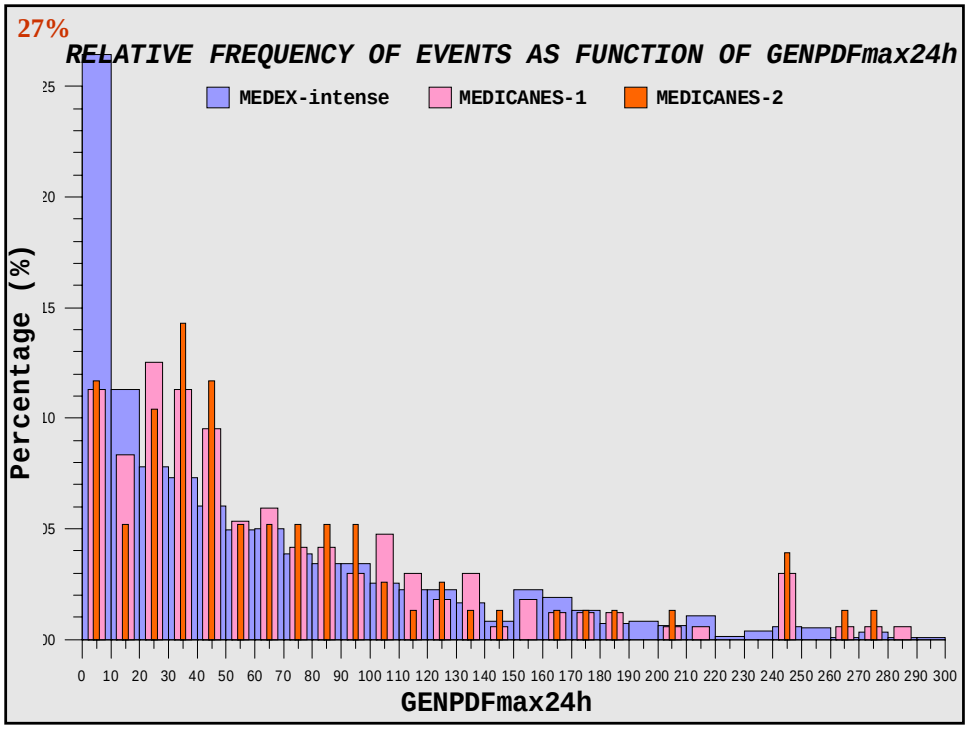

RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MINCP
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
MINCP
930
940
950
960
970
980
990
1000
1010
1020
1030


RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF MINCP
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
MINCP
930
940
950
960
970
980
990
1000
1010
1020
1030


82%
RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF GENPDF
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
GENPDF
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80


29%
RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF GENPDF
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
GENPDF
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80


77%
RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF GENPDFmax24h
MEDEX-weak
MEDICANES-1
MEDICANES-2
Percentage (%)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300
GENPDFmax24h


27%
RELATIVE FREQUENCY OF EVENTS AS FUNCTION OF GENPDFmax24h
MEDEX-intense
MEDICANES-1
MEDICANES-2
Percentage (%)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300
GENPDFmax24h

CONCLUSIONS

- **Medicane?** A clear definition of tropical-like Mediterranean storm is needed. Ideally, some criteria that could be easily applied on the satellite images, in order to build a systematic data base of events

- **Large-scale environments:** High values of the empirical tropical index GENPDF tend to be obtained for medicane events, indicating that such an index can be a good candidate to estimate –or forecast– the likelihood of Medicane genesis. However, a clear isolation of medicane environments *vs* intense baroclinic cyclonic environments does not appear to be possible

- **Climate change effects:** The GCMs exhibit some problems to simulate the regional climate (e.g. CSIRO). In spite of the large increase of SST imposed by global warming , the long term risk –according to GENPDF– of these violent Mediterranean windstorms is not clear: CSIRO and GFDL indicate an enhanced risk, while ECHAM5 a reduced risk. Nevertheless, additional ingredients and extreme values rather than mean fields should be examined !!!