Climate Change and Hurricane-like Extratropical Cyclones: Projections for North-Atlantic Polar Lows and Medicanes based on CMIP5 Models

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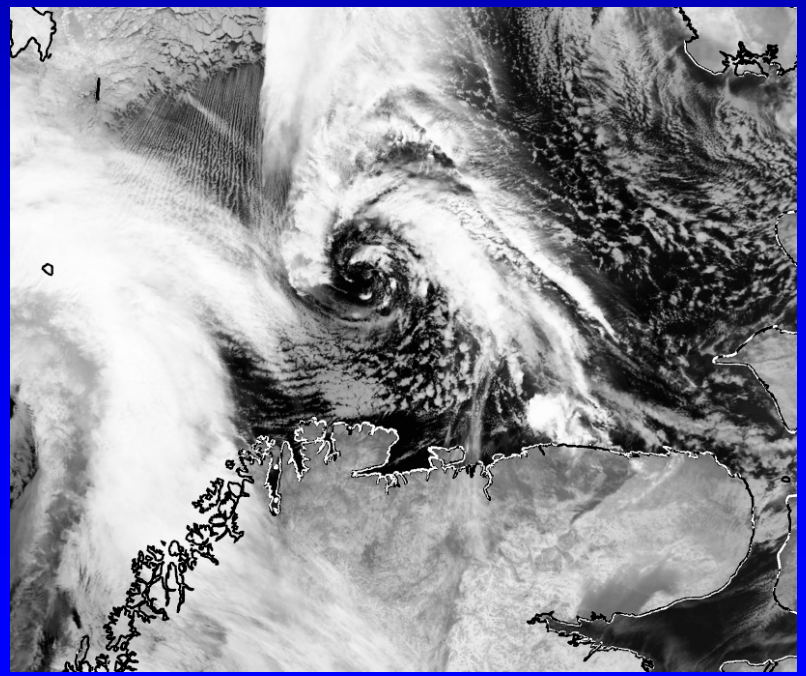
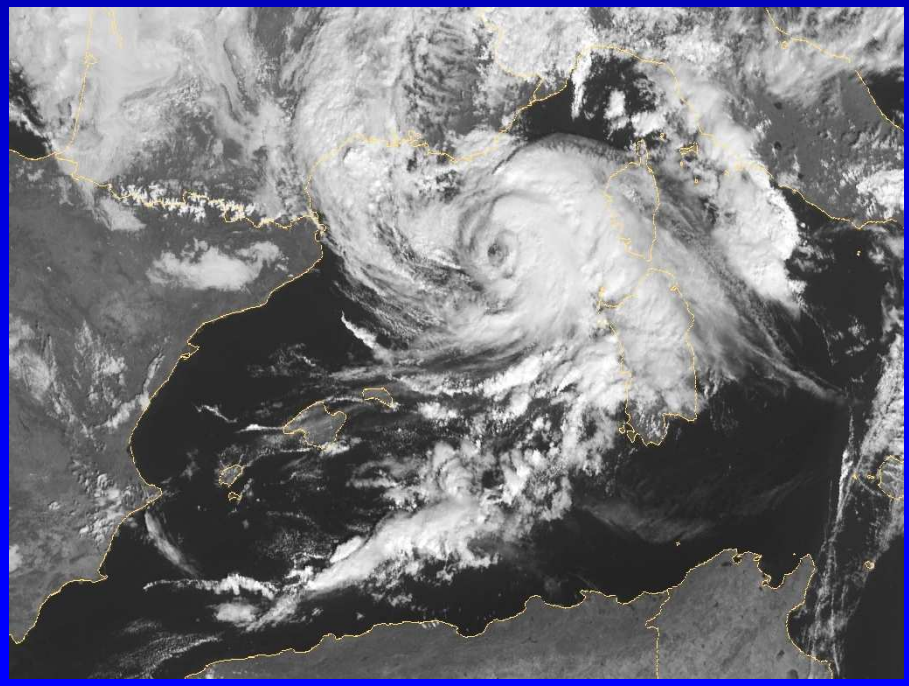
MOTIVATION

***Polar lows / Medicanes** are physically analogous to tropical cyclones (warm-core, surface flux-driven). These **extreme windstorms** pose serious **threat to** the affected islands and coastal regions and can adversely affect open sea activities such as shipping, fishing, cruises, recreational boating and gas and oil platforms operations:*

- ***Future changes** in frequency, intensity or regional variability **?***
- *No systematic effort to answer this question **in the context of CMIP5***





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/high-latitude weather systems. In addition, existing data of storm genesis is 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*

- **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)

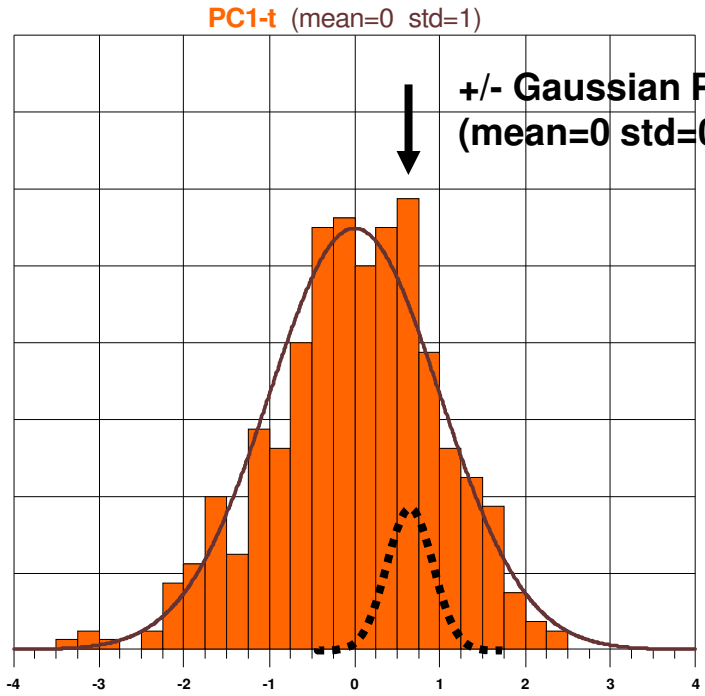
$$\eta \equiv 850\,hPa\ absolute\ vorticity\ (s^{-1}),$$

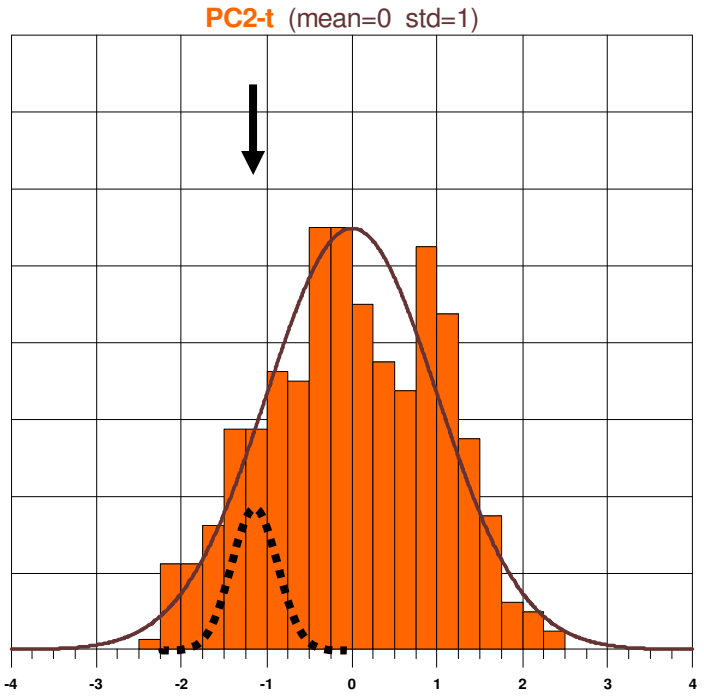
$$V_{pot} \equiv Potential\ wind\ speed\ (ms^{-1}),$$

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

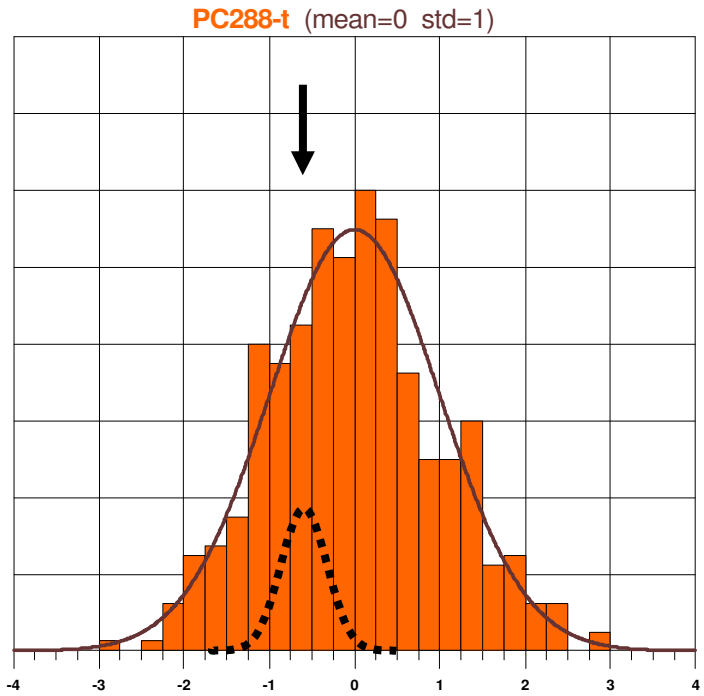
$$V_{shear} \equiv \left|\mathbf{V}_{850} - \mathbf{V}_{250}\right| \quad (ms^{-1}).$$

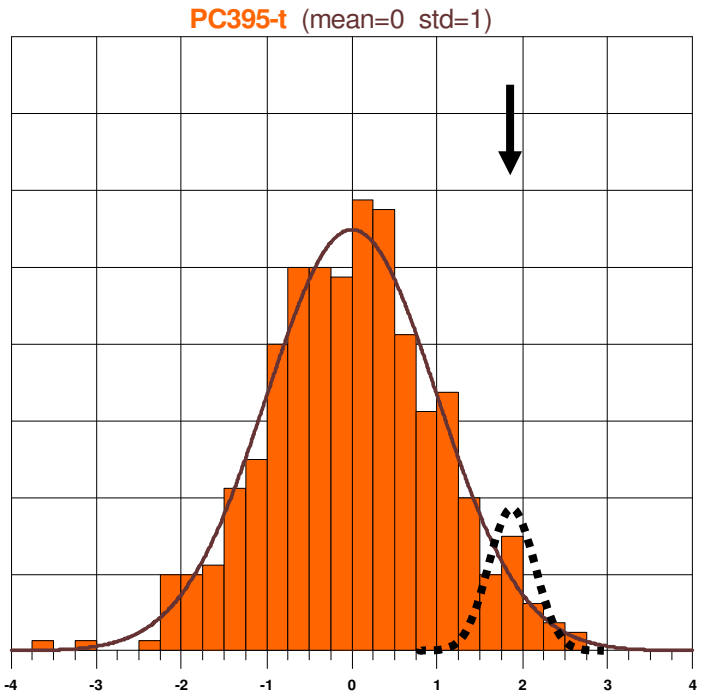
- **Necessary but no sufficient ingredient …**

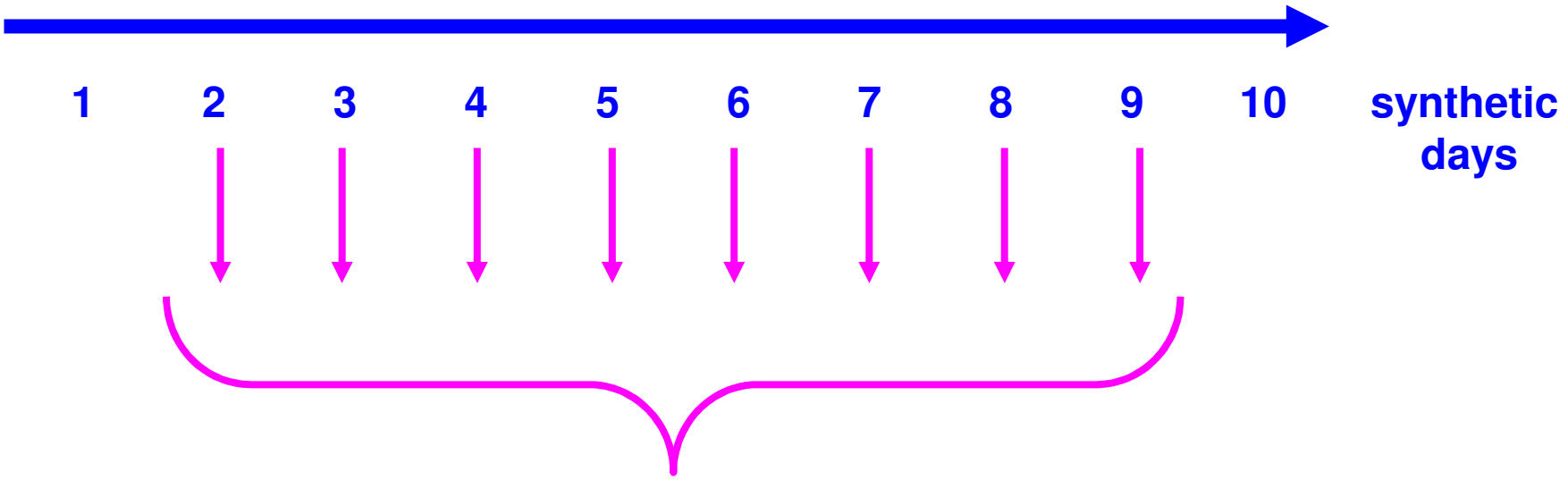




Production of synoptic evolutions that behave as analogs of locations actually visited in the climate phase space !!!







OPEN-SEA POINT + MAX OF GENIX > 10 + ABS VOR > 10 units ???

YES

Backward

(Max: 12 h)

Forward

(Max: 12 h over land)

POTENTIAL TRACK

(Δt = 30 min)

$$\begin{cases} u_{track} = \alpha\, \underline{u}_{850} + (1 - \alpha)\, \underline{u}_{250} \\ v_{track} = \alpha\, \underline{v}_{850} + (1 - \alpha)\, \underline{v}_{250} \end{cases}$$

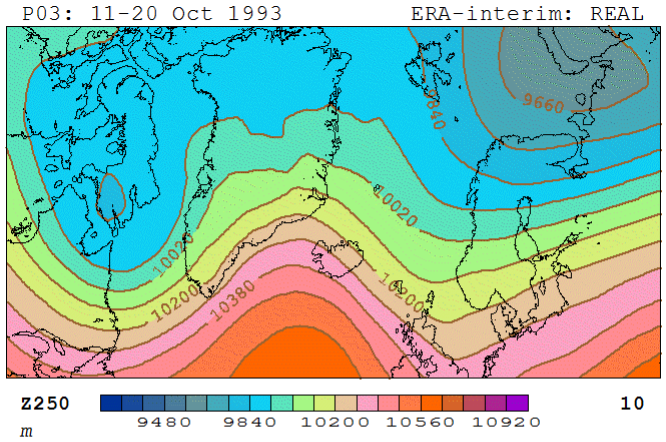
$\underline{AVG}_{time\text{-}space}$

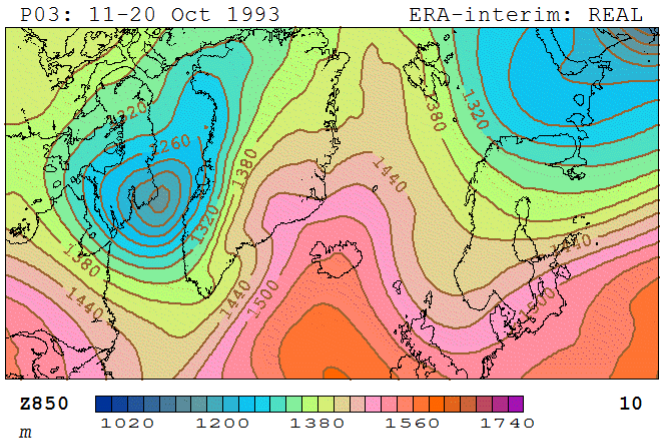
$\alpha = 0.8$

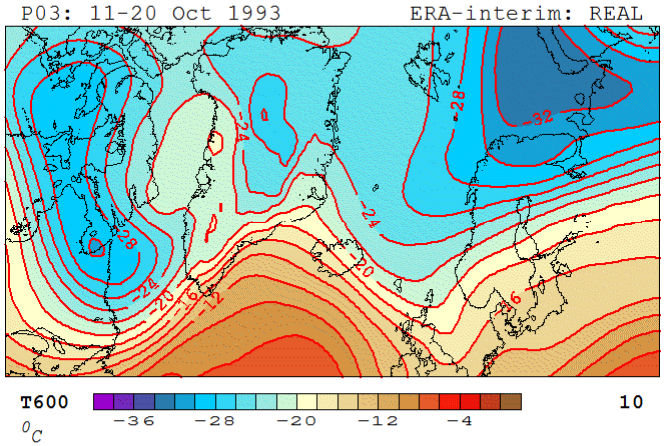
ILLUSTRATIVE EXAMPLE

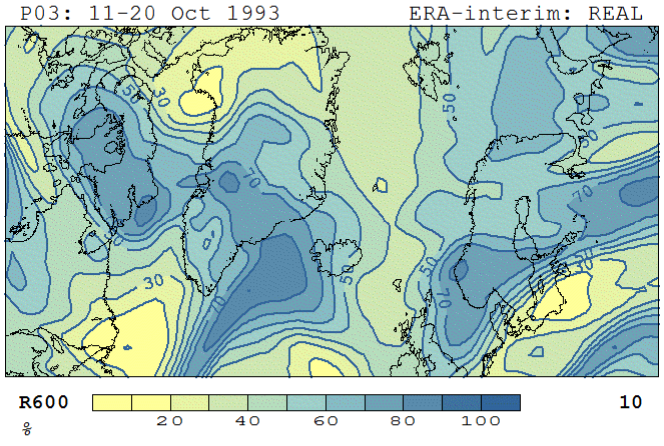
POLAR LOW “LE CYGNE”
Norwegian Sea, 13-15 October 1993

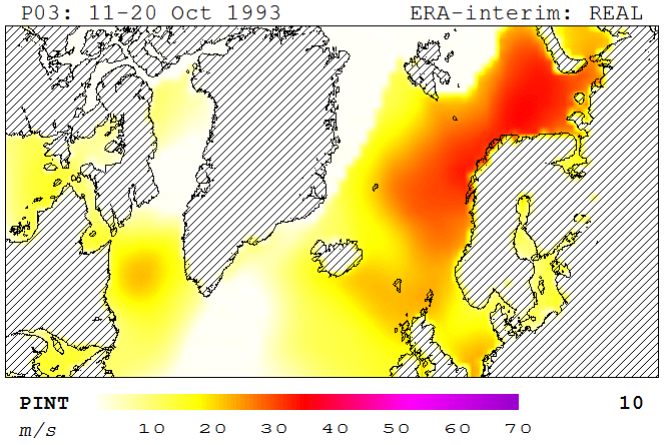
TRACKING method

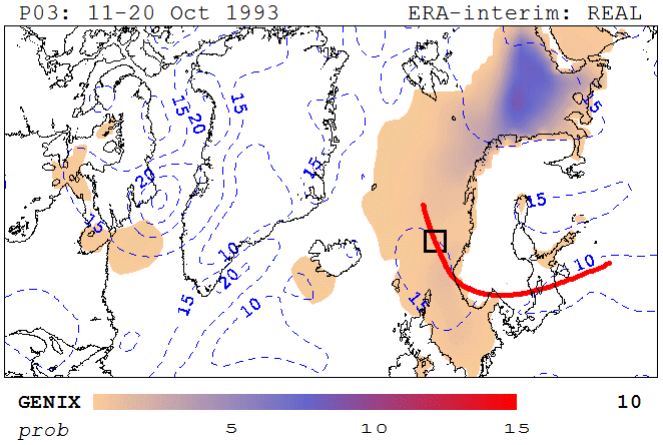




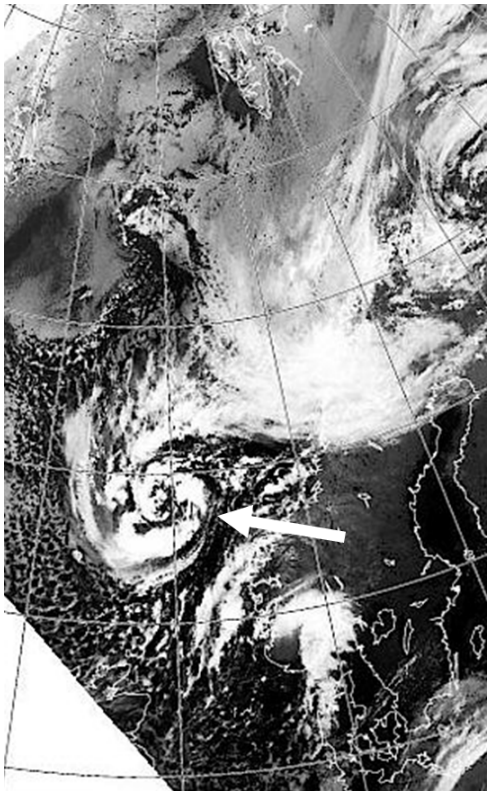


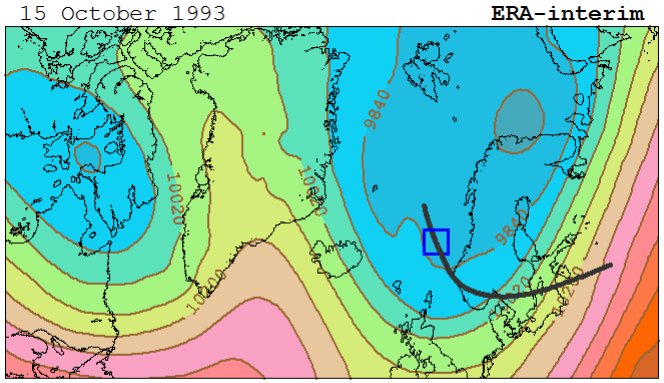




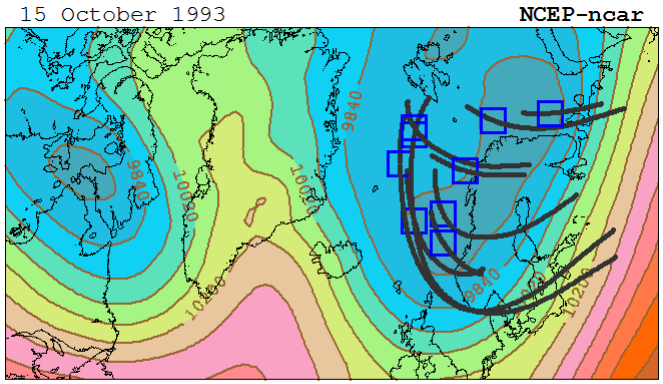


SYNTHETIC
analogues





REAL



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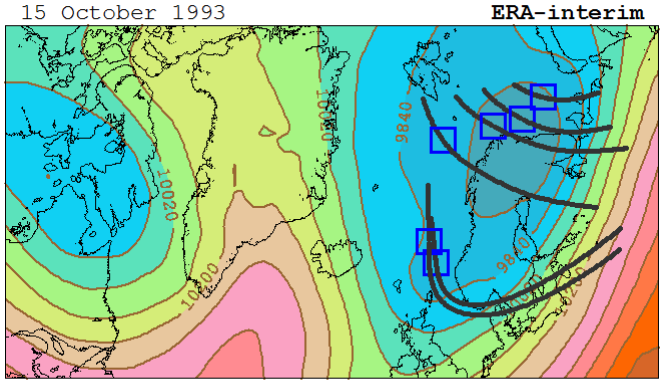

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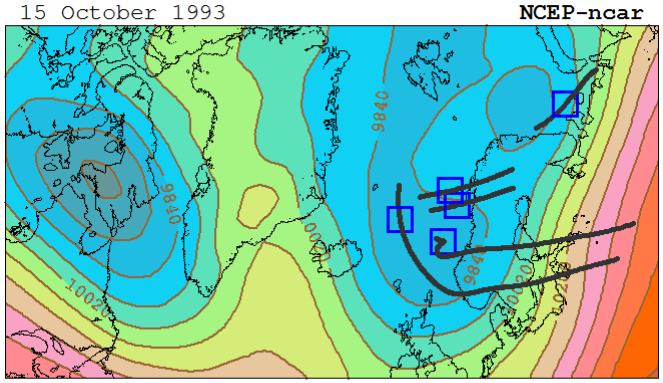

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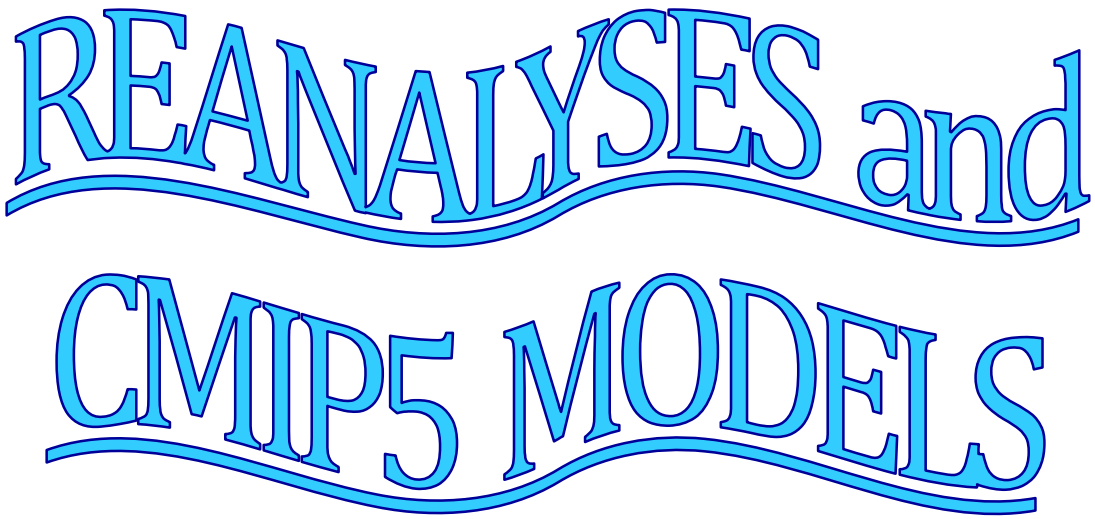

REANALYSES and
CMIP5 MODELS

REANALYSIS 1

ERA-interim

ECMWF
(Europe)

LON 0.75º x LAT 0.75º

REANALYSIS 2

NCEP-ncar

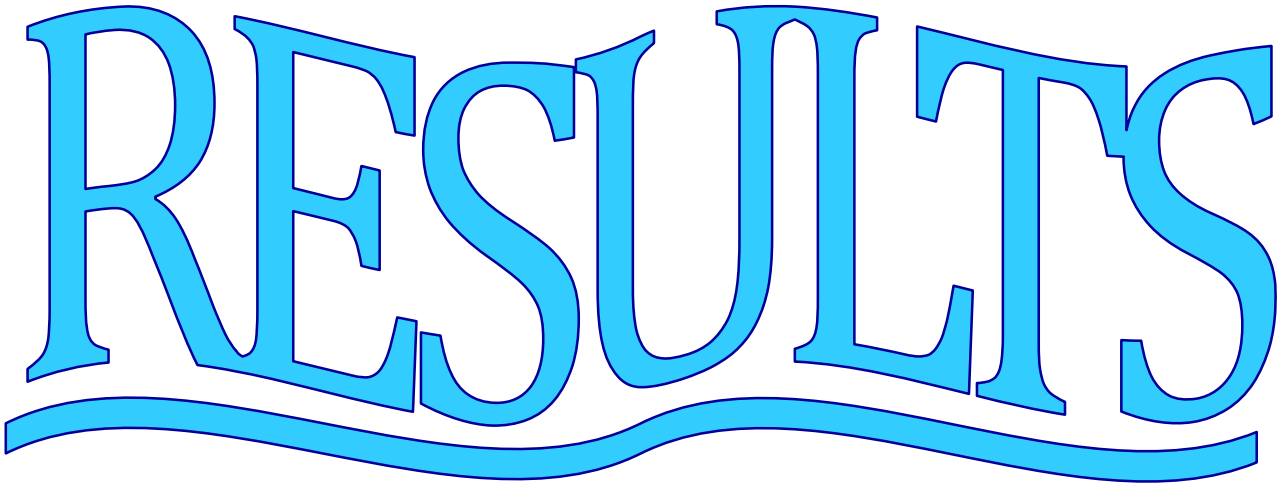
NOAA
(USA)

LON 2.5º x LAT 2.5º

HISTORICAL scenario

1986-2005

GCM-01 ***ACCESS1.0*** CSIRO and BOM (Australia) LON 1.88º x LAT 1.25º	**GCM-02** ***ACCESS1.3*** CSIRO and BOM (Australia) LON 1.88º x LAT 1.25º	**GCM-06** ***CanESM2*** Cent. Clim. Mod. Anal. (Canada) LON 2.81º x LAT 2.79º	**GCM-07** ***CCSM4*** NCAR (USA) LON 1.25º x LAT 0.94º	**GCM-11** ***CNRM-CM5*** CNRM and CERFACS (France) LON 1.41º x LAT 1.40º	**GCM-12** ***CSIRO-Mk3.6.0*** QCCCE and CSIRO (Australia) LON 1.88º x LAT 1.86º
GCM-03 ***BCC-CSM1.1*** Beijing Climate Center (China) LON 2.81º x LAT 2.79º	**GCM-04** ***BCC-CSM1.1(m)*** Beijing Climate Center (China) LON 1.13º x LAT 1.12º	**GCM-08** ***CMCC-CESM*** Cent. EuroMed C.Clim. (Italy) LON 3.75º x LAT 3.71º	**GCM-09** ***CMCC-CM*** Cent. EuroMed C.Clim. (Italy) LON 0.75º x LAT 0.75º	**GCM-13** ***EC-EARTH*** EC-Earth Consortium (Europe) LON 1.13º x LAT 1.12º	**GCM-14** ***FGOALS-g2*** LASG-CESS (China) LON 2.81º x LAT 2.81º
GCM-05 ***BNU-ESM*** Beijing Normal University (China) LON 2.81º x LAT 2.79º	***HISTORICAL scenario*** **1986-2005**	**GCM-10** ***CMCC-CMS*** Cent. EuroMed C.Clim. (Italy) LON 1.88º x LAT 1.86º	***RCP85 scenario*** **2081-2100**	**GCM-15** ***GFDL-CM3*** NOAA GFDL (USA) LON 2.50º x LAT 2.00º	
GCM-16 ***GFDL-ESM2G*** NOAA GFDL (USA) LON 2.50º x LAT 2.00º	**GCM-17** ***GFDL-ESM2M*** NOAA GFDL (USA) LON 2.50º x LAT 2.00º	**GCM-21** ***IPSL-CM5A-MR*** IPSL (France) LON 2.50º x LAT 1.27º	**GCM-22** ***IPSL-CM5B-LR*** IPSL (France) LON 3.75º x LAT 1.89º	**GCM-26** ***MPI-ESM-LR*** Max Planck Int. Meteor. (Germany) LON 1.88º x LAT 1.86º	**GCM-27** ***MPI-ESM-MR*** Max Planck Int. Meteor. (Germany) LON 1.88º x LAT 1.86º
GCM-18 ***HadGEM2-CC*** Met Office Hadley Cent (UK) LON 1.88º x LAT 1.25º	**GCM-19** ***INM-CM4*** Rus. Inst. Num. Math. (Russia) LON 2.00º x LAT 1.50º	**GCM-23** ***MIROC5*** U.Tok-NIES-JAMSTEC (Japan) LON 1.41º x LAT 1.40º	**GCM-24** ***MIROC-ESM*** U.Tok-NIES-JAMSTEC (Japan) LON 2.81º x LAT 2.79º	**GCM-28** ***MRI-CGCM3*** Meteor. Res. Inst. (Japan) LON 1.13º x LAT 1.12º	**GCM-29** ***MRI-ESM1*** Meteor. Res. Inst. (Japan) LON 1.13º x LAT 1.12º
GCM-20 ***IPSL-CM5A-LR*** IPSL (France) LON 3.75º x LAT 1.89º		**GCM-25** ***MIROC-ESM-CHEM*** U.Tok-NIES-JAMSTEC (Japan) LON 2.81º x LAT 2.79º		**GCM-30** ***NorESM1-M*** Nor. Clim. Cent. (Norway) LON 2.50º x LAT 1.90º	



Polar Lows

REANALYSIS 1

ERA-interim

20178 tracks
3898 survivors

3000 storms/century

REANALYSIS 2

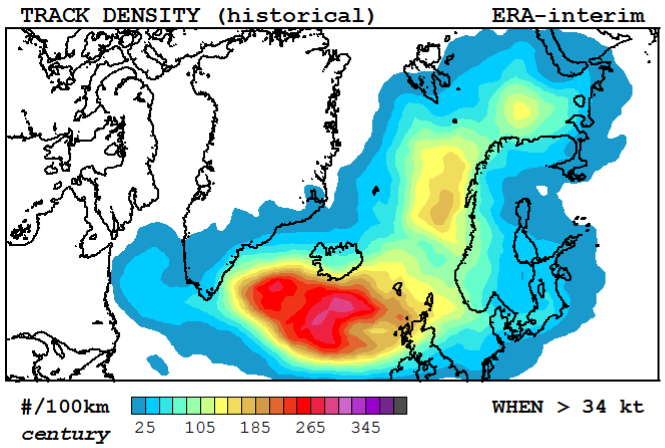
NCEP-ncar

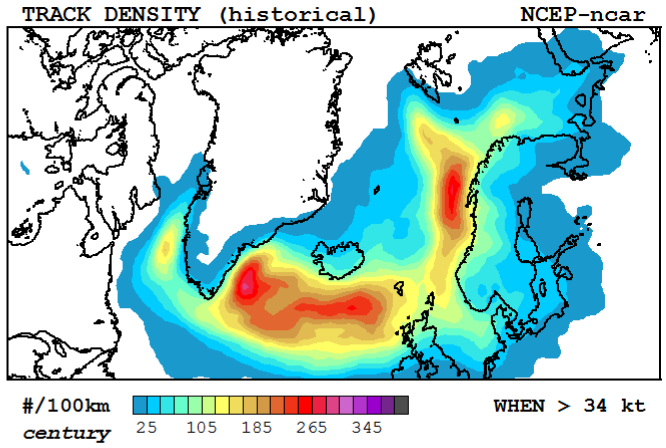
20638 tracks
3223 survivors

3000 storms/century

HISTORICAL scenario

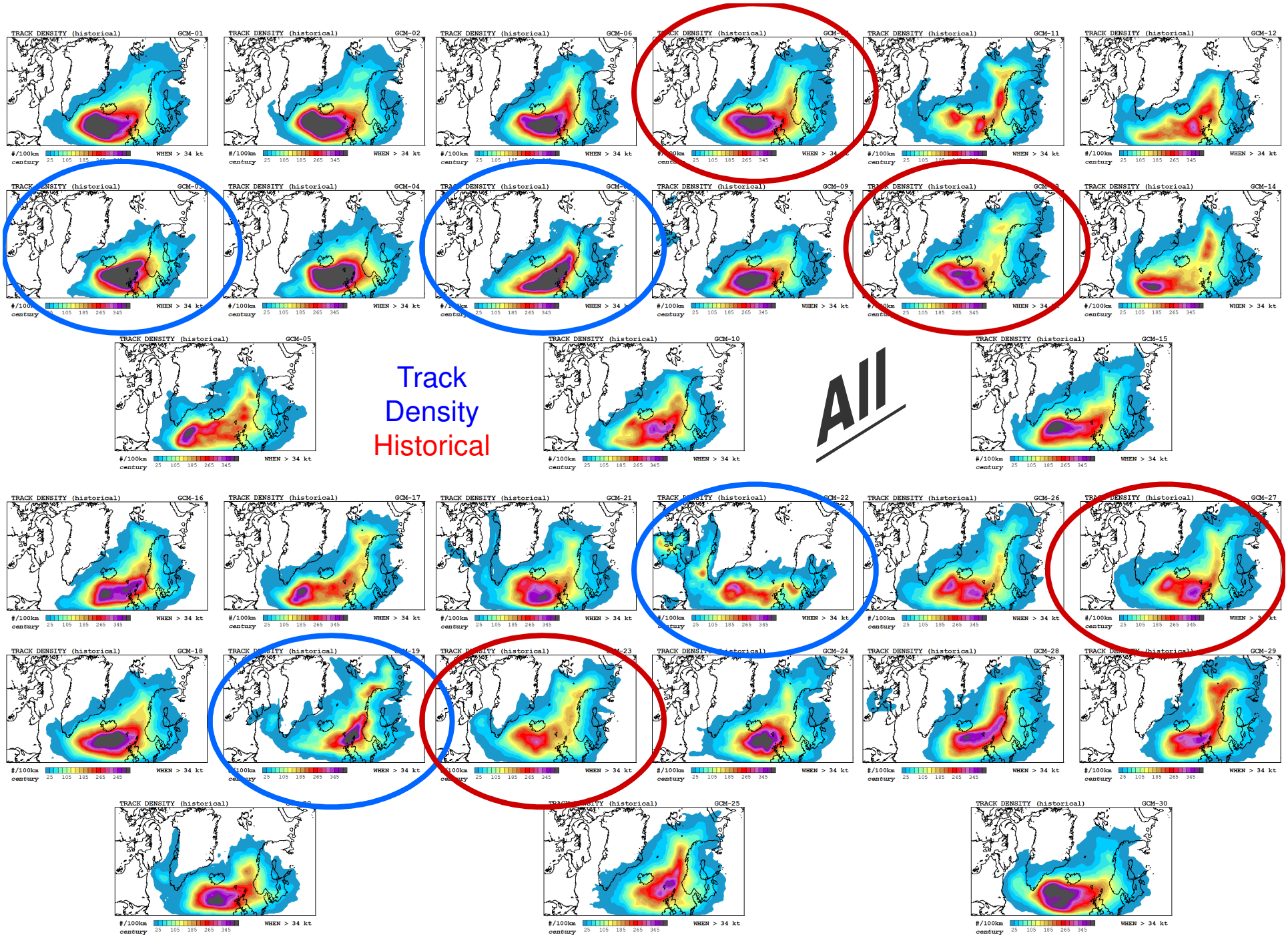
3000 storms
(per century)





GCM-01 ***ACCESS1.0*** 20054 tracks 7882 survivors 3000 storms/century	**GCM-02** ***ACCESS1.3*** 20022 tracks 8093 survivors 3000 storms/century	**GCM-06** ***CanESM2*** 20875 tracks 5130 survivors 3000 storms/century	**GCM-07** ***CCSM4*** 20491 tracks 6256 survivors 3000 storms/century	**GCM-11** ***CNRM-CM5*** 20274 tracks 2436 survivors 3000 storms/century	**GCM-12** ***CSIRO-Mk3.6.0*** 20222 tracks 3911 survivors 3000 storms/century
GCM-03 ***BCC-CSM1.1*** 20076 tracks 3713 survivors 3000 storms/century	**GCM-04** ***BCC-CSM1.1(m)*** 20045 tracks 4552 survivors 3000 storms/century	**GCM-08** ***CMCC-CESM*** 20345 tracks 2654 survivors 3000 storms/century	**GCM-09** ***CMCC-CM*** 20304 tracks 4905 survivors 3000 storms/century	**GCM-13** ***EC-EARTH*** 20193 tracks 4475 survivors 3000 storms/century	**GCM-14** ***FGOALS-g2*** 20677 tracks 5279 survivors 3000 storms/century
GCM-05 ***BNU-ESM*** 20477 tracks 3212 survivors 3000 storms/century	***HISTORICAL scenario*** **3000 storms (per century)**	**GCM-10** ***CMCC-CMS*** 20464 tracks 3936 survivors 3000 storms/century	ALL	**GCM-15** ***GFDL-CM3*** 20923 tracks 5211 survivors 3000 storms/century	
GCM-16 ***GFDL-ESM2G*** 20277 tracks 4269 survivors 3000 storms/century	**GCM-17** ***GFDL-ESM2M*** 20432 tracks 3998 survivors 3000 storms/century	**GCM-21** ***IPSL-CM5A-MR*** 20125 tracks 4733 survivors 3000 storms/century	**GCM-22** ***IPSL-CM5B-LR*** 20054 tracks 2890 survivors 3000 storms/century	**GCM-26** ***MPI-ESM-LR*** 20430 tracks 3631 survivors 3000 storms/century	**GCM-27** ***MPI-ESM-MR*** 20280 tracks 3707 survivors 3000 storms/century
GCM-18 ***HadGEM2-CC*** 20378 tracks 7298 survivors 3000 storms/century	**GCM-19** ***INM-CM4*** 20052 tracks 2604 survivors 3000 storms/century	**GCM-23** ***MIROC5*** 20124 tracks 4567 survivors 3000 storms/century	**GCM-24** ***MIROC-ESM*** 20271 tracks 3105 survivors 3000 storms/century	**GCM-28** ***MRI-CGCM3*** 20675 tracks 4140 survivors 3000 storms/century	**GCM-29** ***MRI-ESM1*** 21114 tracks 4191 survivors 3000 storms/century
GCM-20 ***IPSL-CM5A-LR*** 20137 tracks 4307 survivors 3000 storms/century		**GCM-25** ***MIROC-ESM-CHEM*** 20453 tracks 3487 survivors 3000 storms/century		**GCM-30** ***NorESM1-M*** 20548 tracks 5520 survivors 3000 storms/century	

GCM-01 ***ACCESS1.0*** 13794 tracks 3876 survivors 1475.3 storms/century	**GCM-02** ***ACCESS1.3*** 15212 tracks 4725 survivors 1751.5 storms/century	**GCM-06** ***CanESM2*** 27035 tracks 5578 survivors 3262.0 storms/century	**GCM-07** ***CCSM4*** 19217 tracks 5353 survivors 2567.0 storms/century	**GCM-11** ***CNRM-CM5*** 15277 tracks 1351 survivors 1663.8 storms/century	**GCM-12** ***CSIRO-Mk3.6.0*** 13710 tracks 1458 survivors 1118.4 storms/century
GCM-03 ***BCC-CSM1.1*** 23528 tracks 2845 survivors 2298.7 storms/century	**GCM-04** ***BCC-CSM1.1(m)*** 19276 tracks 3268 survivors 2153.8 storms/century	**GCM-08** ***CMCC-CESM*** 40425 tracks 4364 survivors 4932.9 storms/century	**GCM-09** ***CMCC-CM*** 51229 tracks 7962 survivors 4869.7 storms/century	**GCM-13** ***EC-EARTH*** 16691 tracks 3513 survivors 2355.1 storms/century	**GCM-14** ***FGOALS-g2*** 34225 tracks 8766 survivors 4981.6 storms/century
GCM-05 ***BNU-ESM*** 19724 tracks 1886 survivors 1761.5 storms/century	***RCP85 scenario*** **2806.5 storms (per century)**	**GCM-10** ***CMCC-CMS*** 32433 tracks 4320 survivors 3292.7 storms/century	ALL	**GCM-15** ***GFDL-CM3*** 26208 tracks 4126 survivors 2375.4 storms/century	
GCM-16 ***GFDL-ESM2G*** 32751 tracks 6024 survivors 4233.3 storms/century	**GCM-17** ***GFDL-ESM2M*** 14802 tracks 1994 survivors 1496.3 storms/century	**GCM-21** ***IPSL-CM5A-MR*** 16072 tracks 2692 survivors 1706.3 storms/century	**GCM-22** ***IPSL-CM5B-LR*** 48981 tracks 5686 survivors 5902.4 storms/century	**GCM-26** ***MPI-ESM-LR*** 21306 tracks 3290 survivors 2718.3 storms/century	**GCM-27** ***MPI-ESM-MR*** 15744 tracks 2070 survivors 1675.2 storms/century
GCM-18 ***HadGEM2-CC*** 18125 tracks 4075 survivors 1675.1 storms/century	**GCM-19** ***INM-CM4*** 16465 tracks 1305 survivors 1503.5 storms/century	**GCM-23** ***MIROC5*** 16300 tracks 2291 survivors 1504.9 storms/century	**GCM-24** ***MIROC-ESM*** 18160 tracks 2603 survivors 2515.0 storms/century	**GCM-28** ***MRI-CGCM3*** 40967 tracks 7367 survivors 5338.4 storms/century	**GCM-29** ***MRI-ESM1*** 38784 tracks 7043 survivors 5041.5 storms/century
GCM-20 ***IPSL-CM5A-LR*** 30113 tracks 4033 survivors 2809.2 storms/century	**20 models** ▼▼▼	**GCM-25** ***MIROC-ESM-CHEM*** 24243 tracks 3660 survivors 3148.8 storms/century	**10 models** ▲▲▲	**GCM-30** ***NorESM1-M*** 18125 tracks 3803 survivors 2066.9 storms/century	


TRACK DENSITY (historical) GCM-01
TRACK DENSITY (historical) GCM-02
TRACK DENSITY (historical) GCM-06
TRACK DENSITY (historical) GCM-11
TRACK DENSITY (historical) GCM-12
TRACK DENSITY (historical) GCM-03
TRACK DENSITY (historical) GCM-04
TRACK DENSITY (historical) GCM-09
TRACK DENSITY (historical) GCM-14
TRACK DENSITY (historical) GCM-05
TRACK DENSITY (historical) GCM-10
TRACK DENSITY (historical) GCM-15
Track
Density
Historical
All
TRACK DENSITY (historical) GCM-16
TRACK DENSITY (historical) GCM-17
TRACK DENSITY (historical) GCM-21
TRACK DENSITY (historical) GCM-22
TRACK DENSITY (historical) GCM-26
TRACK DENSITY (historical) GCM-27
TRACK DENSITY (historical) GCM-18
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TRACK DENSITY (historical) GCM-29
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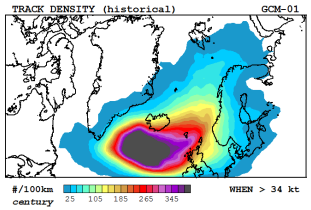
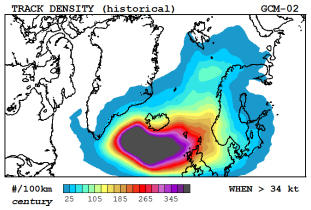
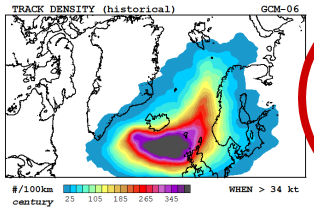
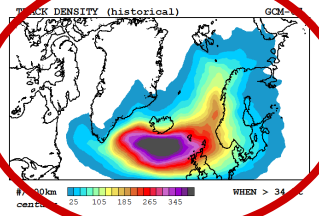
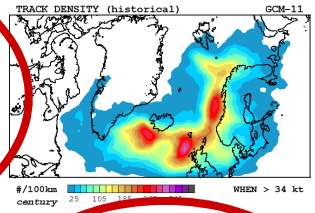
TRACK DENSITY (historical) GCM-30
#/100km
century
25 105 185 265 345
WHEN > 34 kt

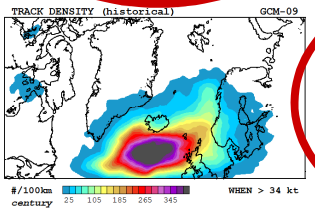


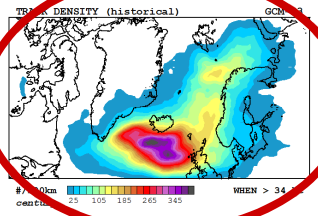


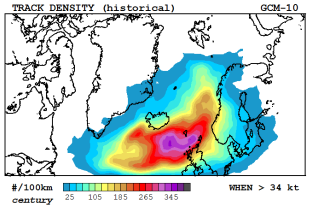






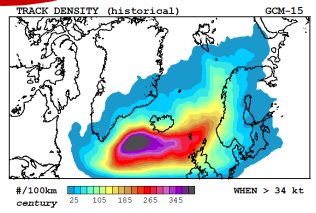


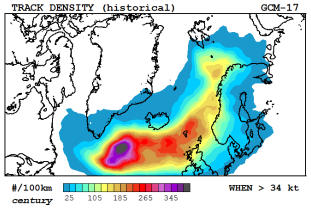


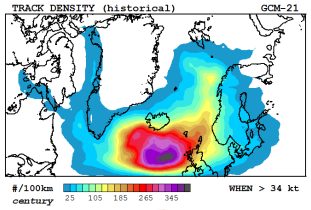


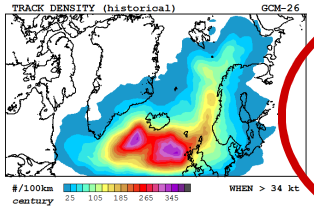
Track
Density
Historical

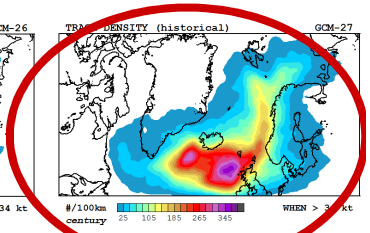
Best

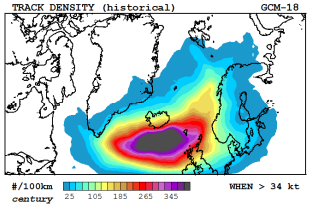


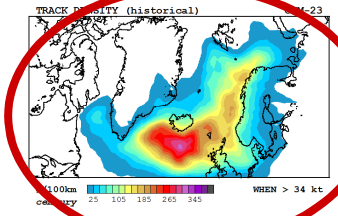


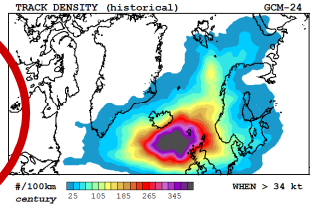


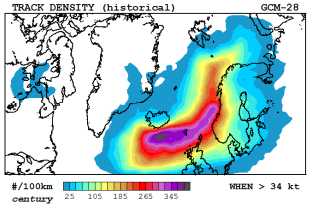


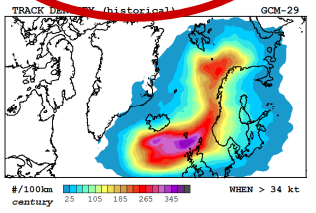


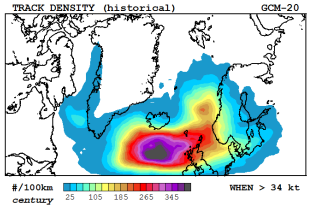


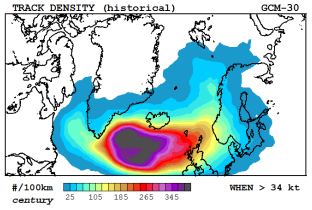




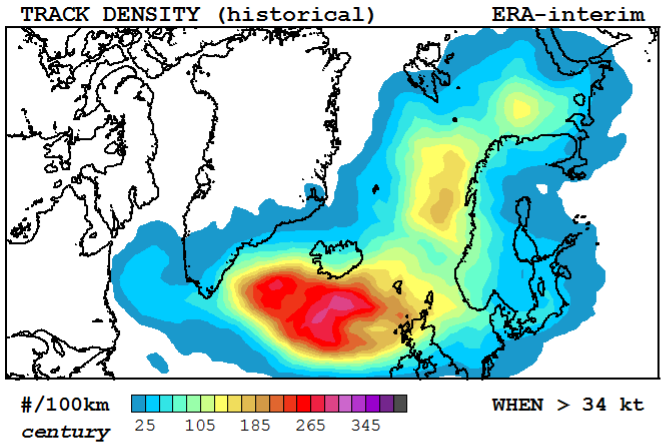


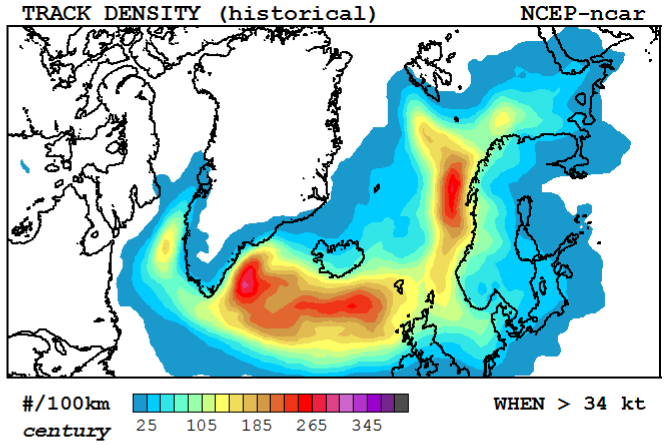







GCM-01
ACCESS1.0
13794 tracks
3876 survivors
1475.3 storms/century
GCM-02
ACCESS1.3
15212 tracks
4725 survivors
1751.5 storms/century
GCM-06
CanESM2
27035 tracks
5578 survivors
3262.0 storms/century
GCM-07
CCSM4
19217 tracks
5353 survivors
2567.0 storms/century
GCM-11
CNRM-CM5
15277 tracks
1351 survivors
1663.8 storms/century
GCM-09
CMCC-CM
51229 tracks
7962 survivors
4869.7 storms/century
GCM-13
EC-EARTH
16691 tracks
3513 survivors
2355.1 storms/century
HISTORICAL scenario
3000 storms (per century)
- 13 %
RCP85 scenario
2608.0 storms (per century)
GCM-10
CMCC-CMS
32433 tracks
4320 survivors
3292.7 storms/century
BEST
GCM-15
GFDL-CM3
26208 tracks
4126 survivors
2375.4 storms/century
GCM-17
GFDL-ESM2M
14802 tracks
1994 survivors
1496.3 storms/century
GCM-21
IPSL-CM5A-MR
16072 tracks
2692 survivors
1706.3 storms/century
GCM-26
MPI-ESM-LR
21306 tracks
3290 survivors
2718.3 storms/century
GCM-27
MPI-ESM-MR
15744 tracks
2070 survivors
1675.2 storms/century
GCM-18
HadGEM2-CC
18125 tracks
4075 survivors
1675.1 storms/century
GCM-23
MIROC5
16300 tracks
2291 survivors
1504.9 storms/century
GCM-24
MIROC-ESM
18160 tracks
2603 survivors
2515.0 storms/century
GCM-28
MRI-CGCM3
40967 tracks
7367 survivors
5338.4 storms/century
GCM-29
MRI-ESM1
38784 tracks
7043 survivors
5041.5 storms/century
GCM-20
IPSL-CM5A-LR
30113 tracks
4033 survivors
2809.2 storms/century
15 models
5 models
GCM-30
NorESM1-M
18125 tracks
3803 survivors
2066.9 storms/century



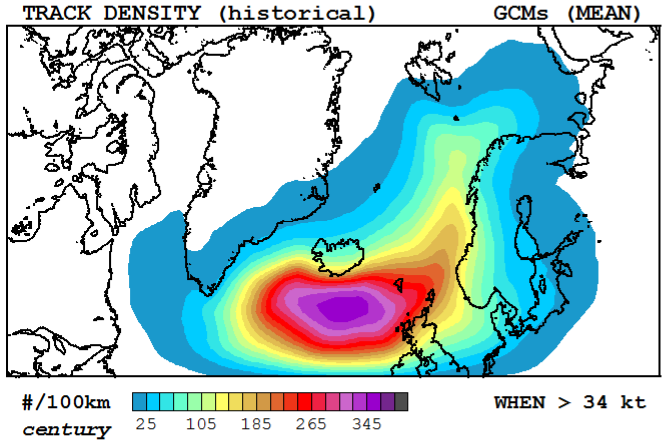


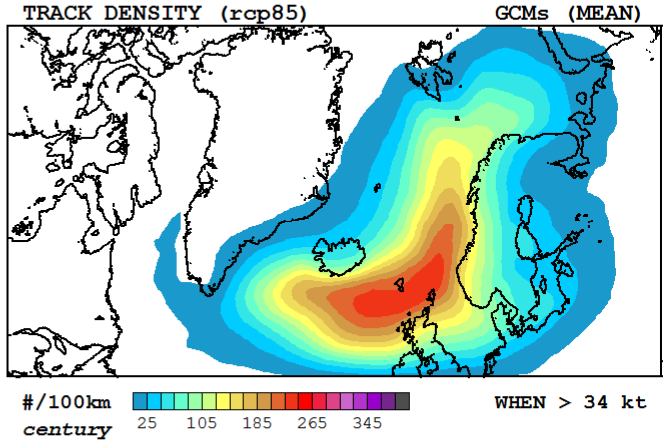
CORR

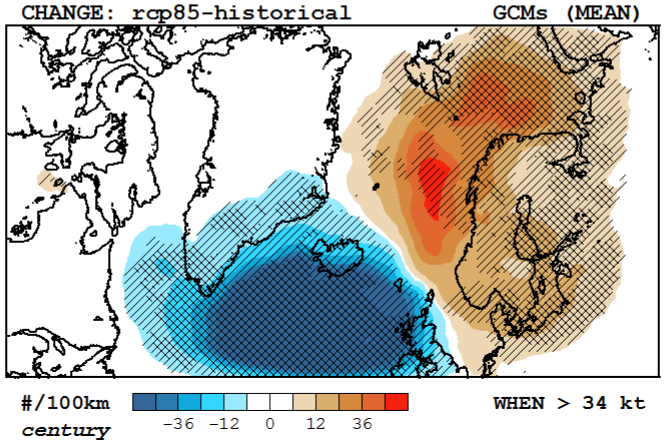
REAn01 = 0.933
REAn02 = 0.863
MEAN = **0.898**

RMSE

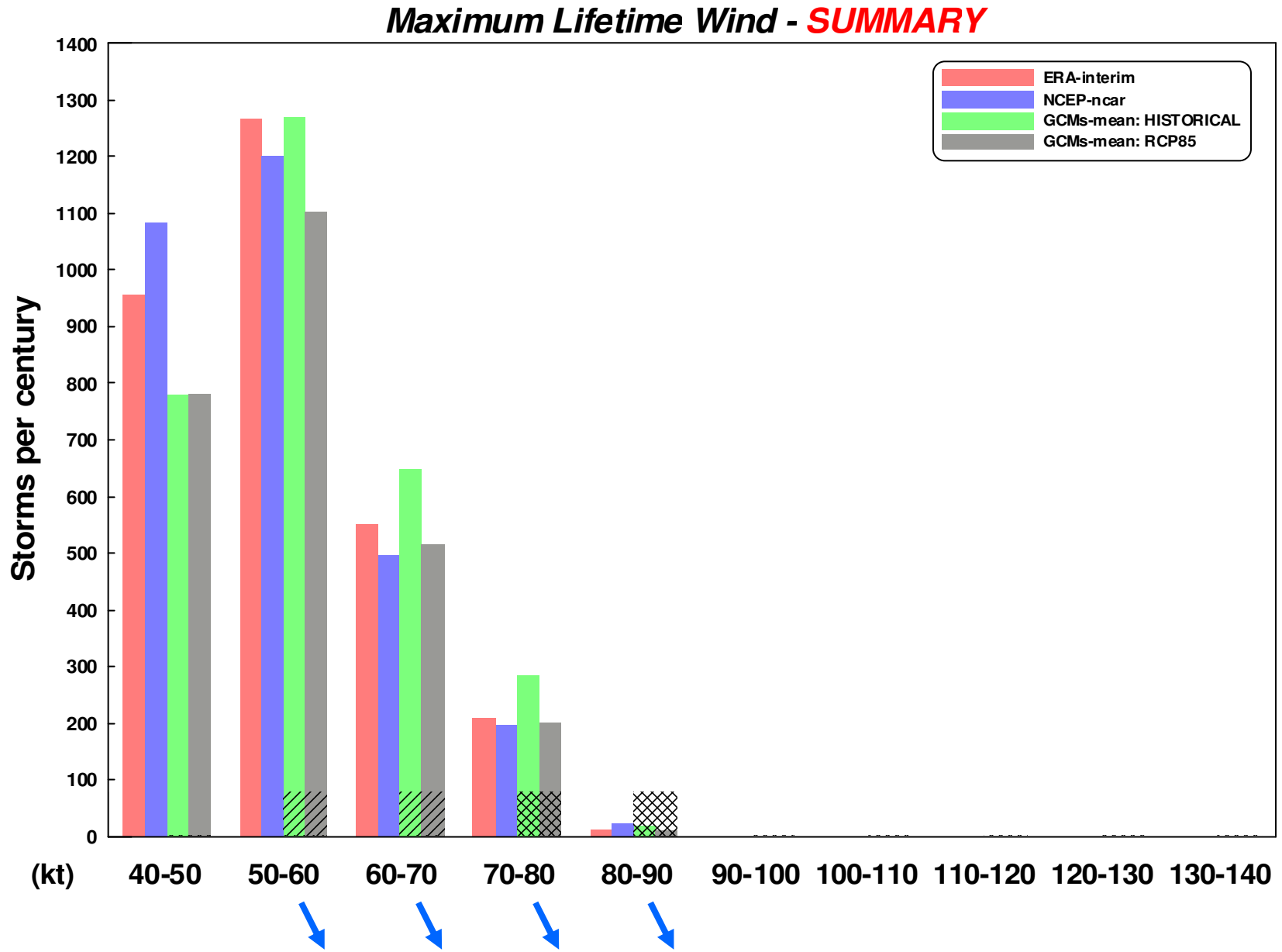
REAn01 = 27.100
REAn02 = 36.663
MEAN = **31.882**

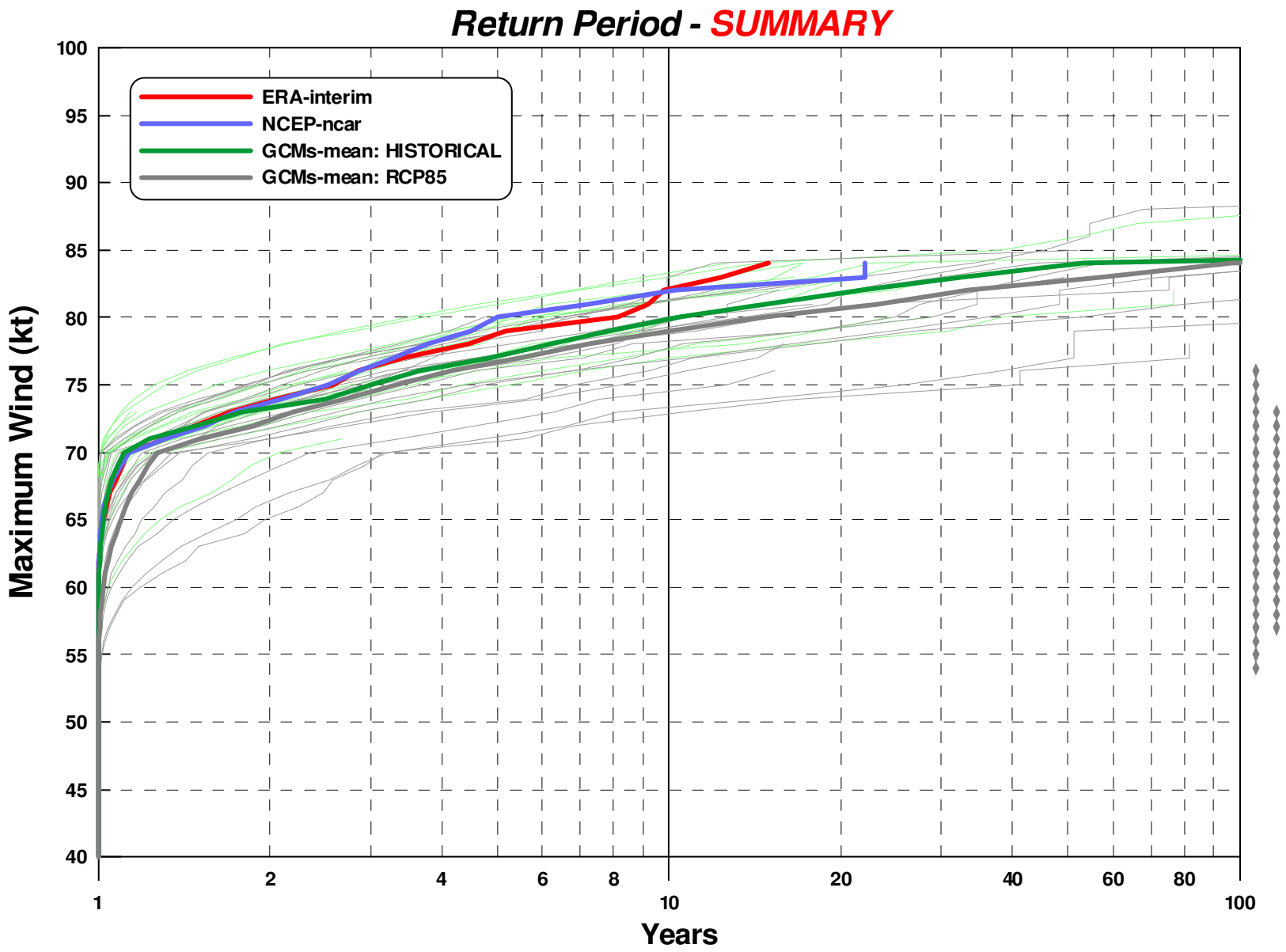


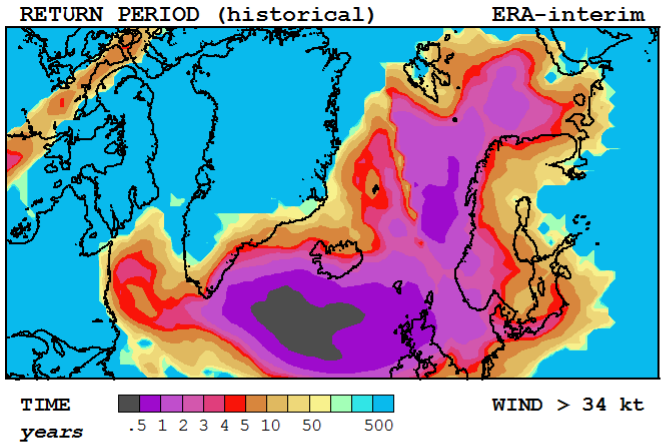


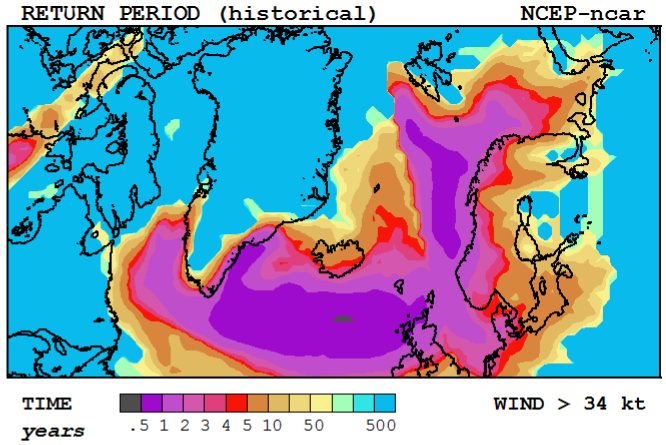


Track Density Summary


Maximum Lifetime Wind - SUMMARY
ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Storms per century
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
(kt)
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140


Return Period - SUMMARY
ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Maximum Wind (kt)
100
95
90
85
80
75
70
65
60
55
50
45
40
1
2
4
6
8
10
20
40
60
80
100
Years





CORR

REAn01 = 0.694

REAn02 = 0.684

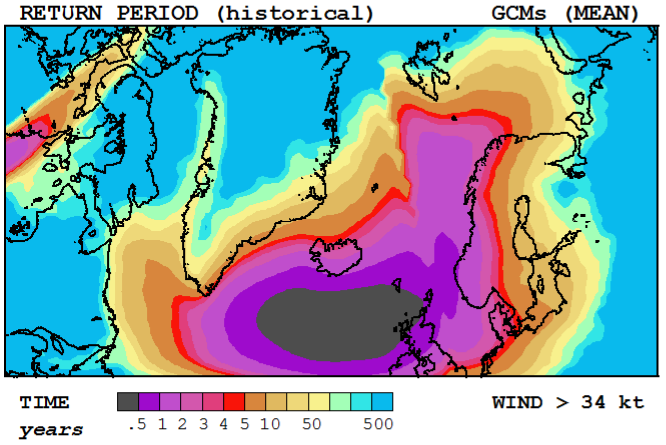
MEAN = **0.689**

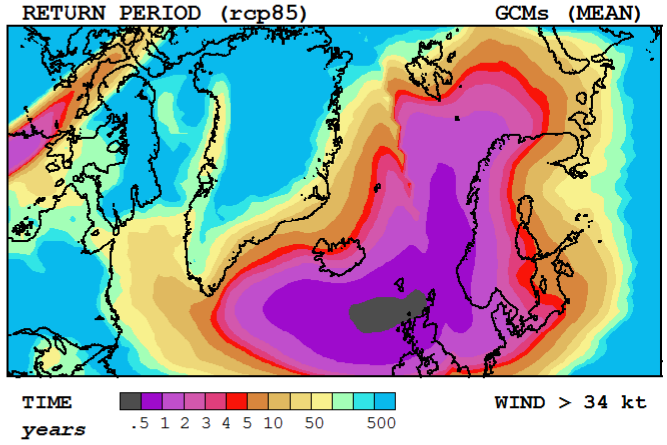
RMSE

REAn01 = 9.232

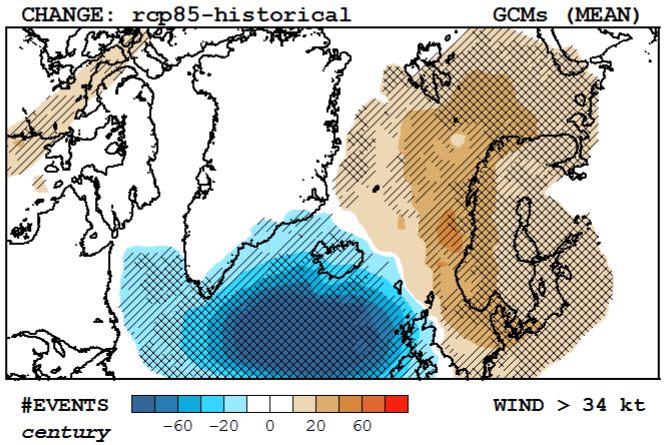
REAn02 = 9.445

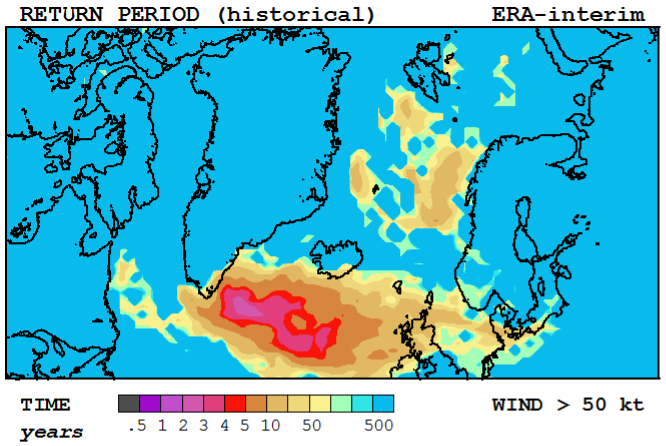
MEAN = **9.339**

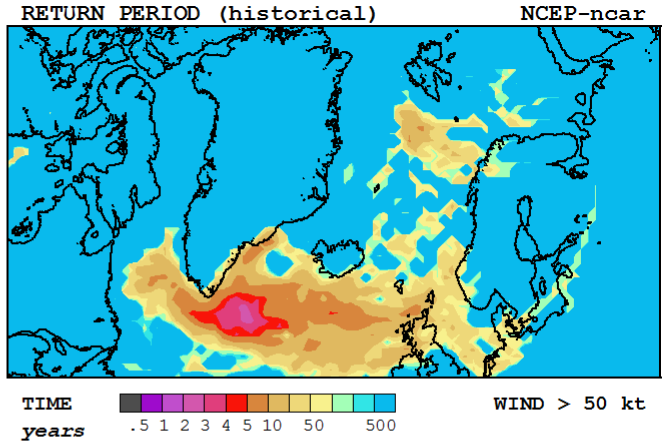




Return Period 34 kt Summary







CORR

REAn01 = 0.675

REAn02 = 0.686

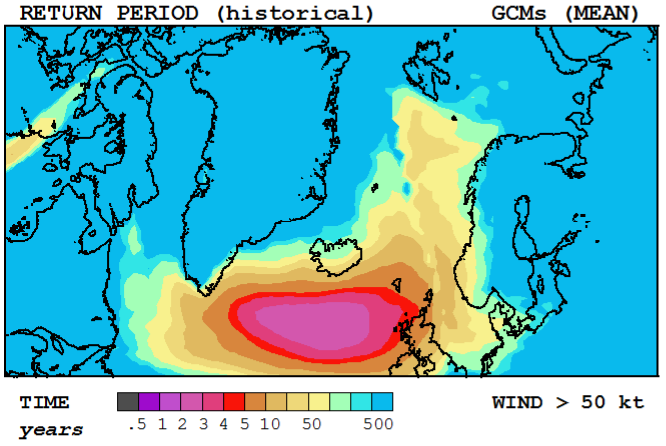
MEAN = **0.680**

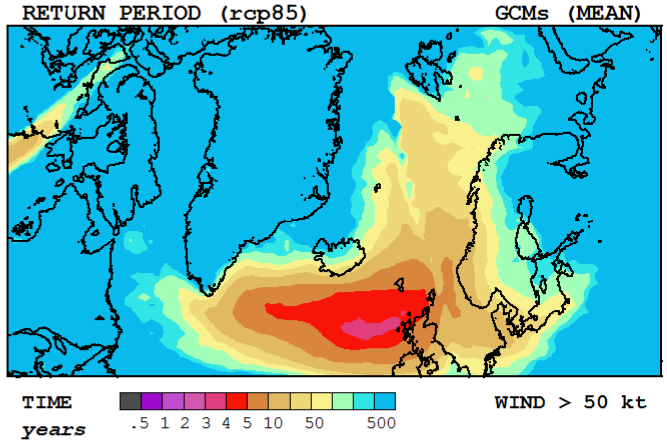
RMSE

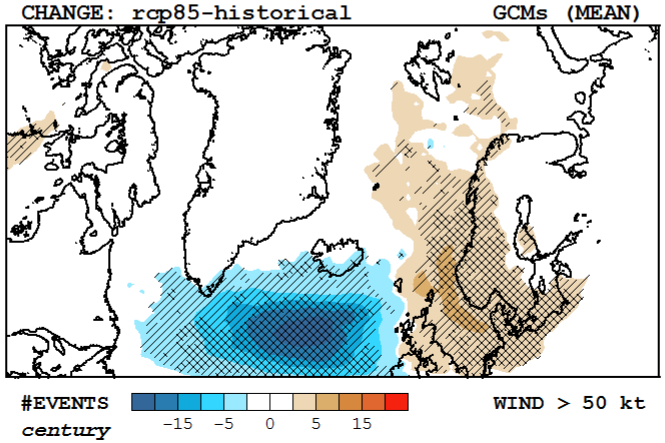
REAn01 = 9.780

REAn02 = 9.637

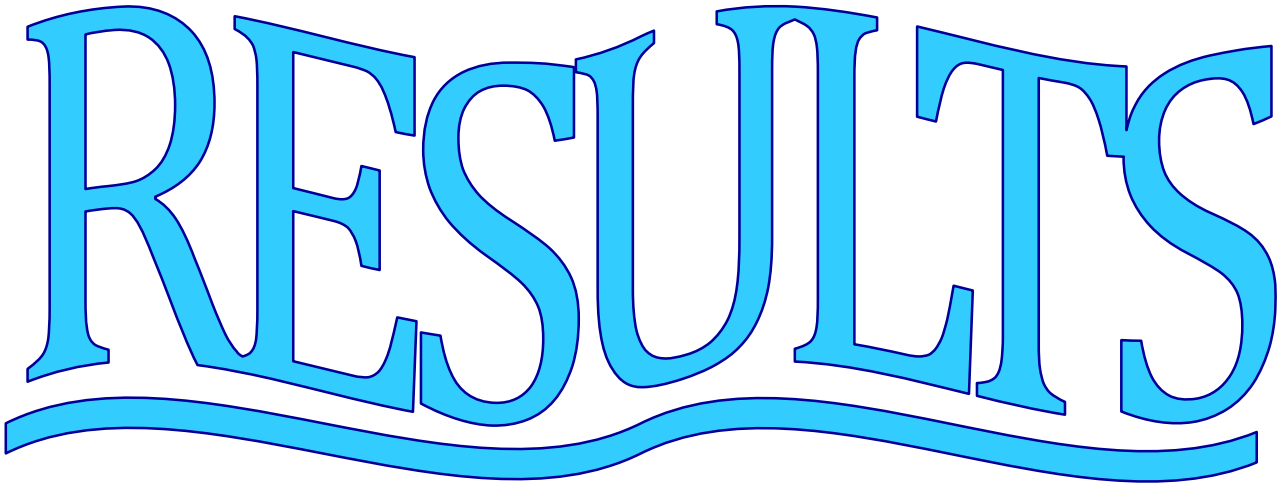
MEAN = **9.709**







Return Period 50 kt Summary



Medicanes

REANALYSIS 1

ERA-interim

20349 tracks
7918 survivors

200 storms/century

REANALYSIS 2

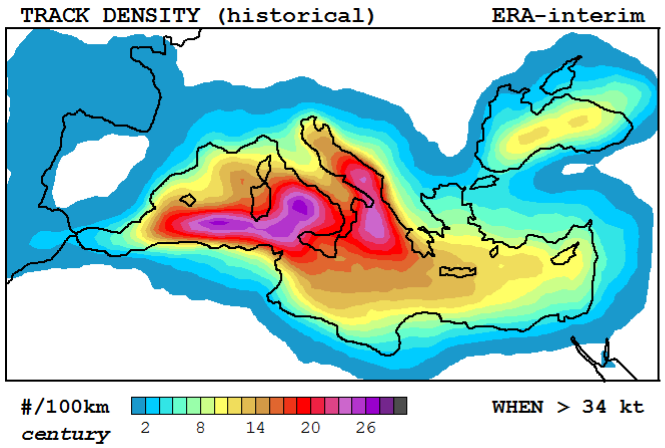
NCEP-ncar

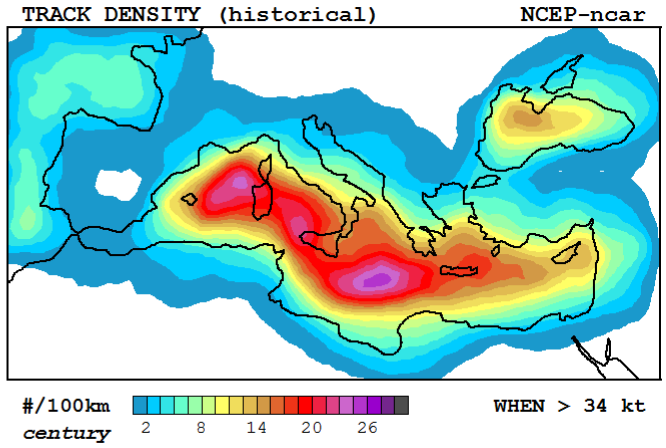
20276 tracks
6379 survivors

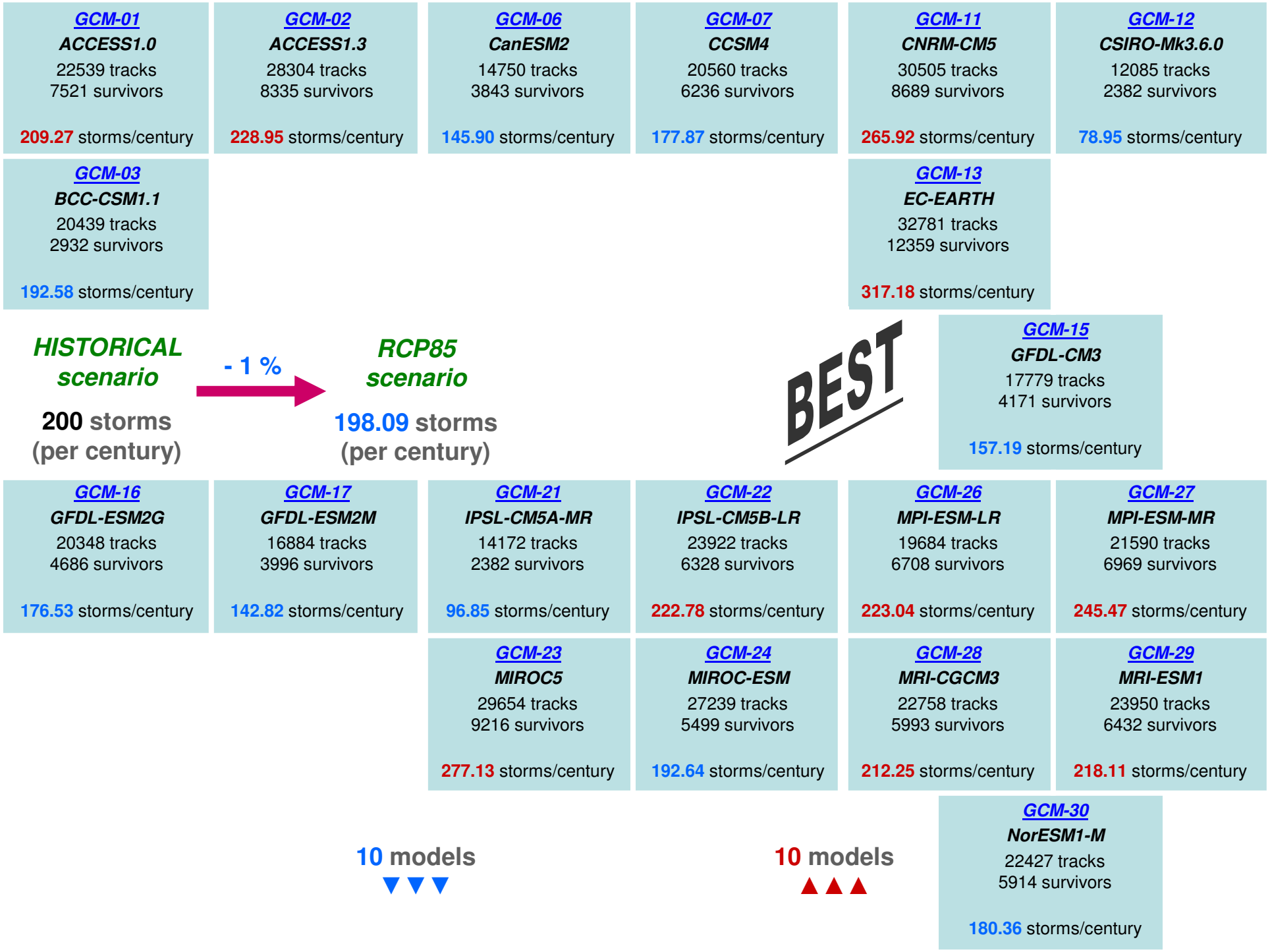
200 storms/century

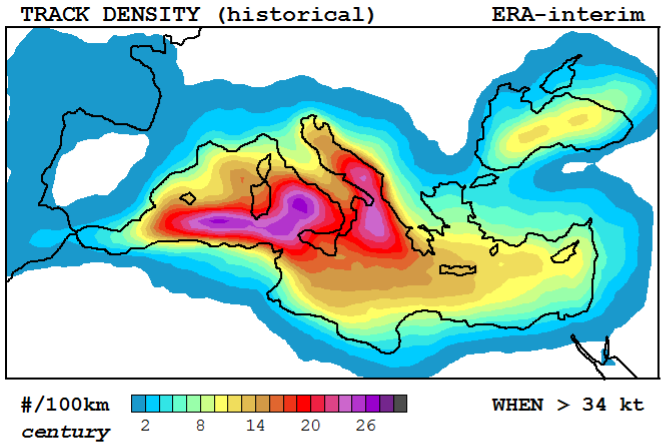
HISTORICAL scenario

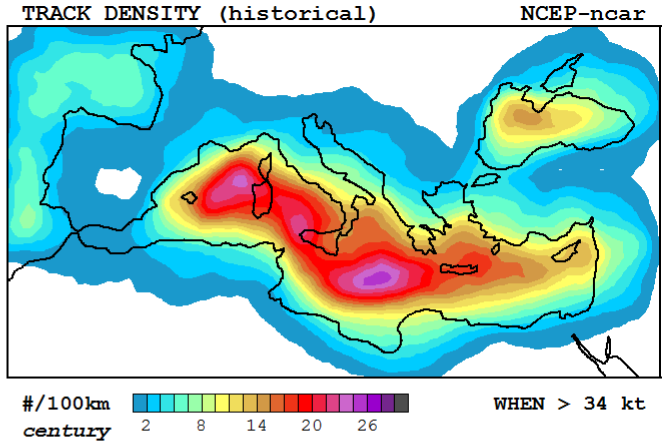
200 storms
(per century)






GCM-01
ACCESS1.0
22539 tracks
7521 survivors
209.27 storms/century
GCM-02
ACCESS1.3
28304 tracks
8335 survivors
228.95 storms/century
GCM-06
CanESM2
14750 tracks
3843 survivors
145.90 storms/century
GCM-07
CCSM4
20560 tracks
6236 survivors
177.87 storms/century
GCM-11
CNRM-CM5
30505 tracks
8689 survivors
265.92 storms/century
GCM-12
CSIRO-Mk3.6.0
12085 tracks
2382 survivors
78.95 storms/century
GCM-03
BCC-CSM1.1
20439 tracks
2932 survivors
192.58 storms/century
GCM-13
EC-EARTH
32781 tracks
12359 survivors
317.18 storms/century
HISTORICAL scenario
200 storms (per century)
- 1 %
RCP85 scenario
198.09 storms (per century)
BEST
GCM-15
GFDL-CM3
17779 tracks
4171 survivors
157.19 storms/century
GCM-16
GFDL-ESM2G
20348 tracks
4686 survivors
176.53 storms/century
GCM-17
GFDL-ESM2M
16884 tracks
3996 survivors
142.82 storms/century
GCM-21
IPSL-CM5A-MR
14172 tracks
2382 survivors
96.85 storms/century
GCM-22
IPSL-CM5B-LR
23922 tracks
6328 survivors
222.78 storms/century
GCM-26
MPI-ESM-LR
19684 tracks
6708 survivors
223.04 storms/century
GCM-27
MPI-ESM-MR
21590 tracks
6969 survivors
245.47 storms/century
GCM-23
MIROC5
29654 tracks
9216 survivors
277.13 storms/century
GCM-24
MIROC-ESM
27239 tracks
5499 survivors
192.64 storms/century
GCM-28
MRI-CGCM3
22758 tracks
5993 survivors
212.25 storms/century
GCM-29
MRI-ESM1
23950 tracks
6432 survivors
218.11 storms/century
10 models
10 models
GCM-30
NorESM1-M
22427 tracks
5914 survivors
180.36 storms/century



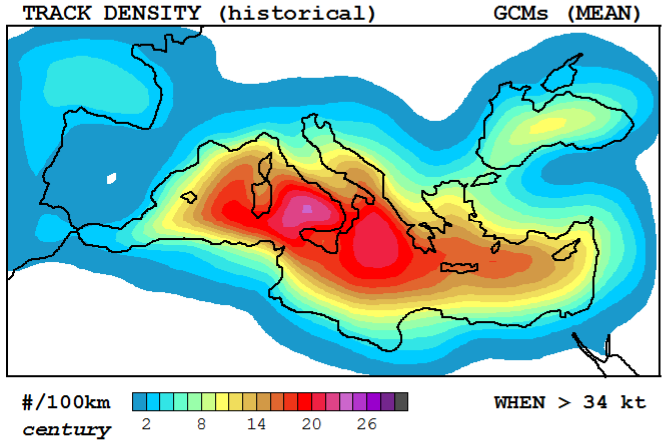


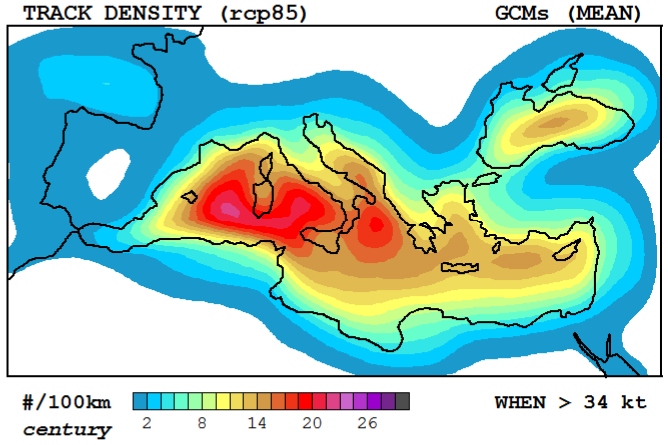
CORR

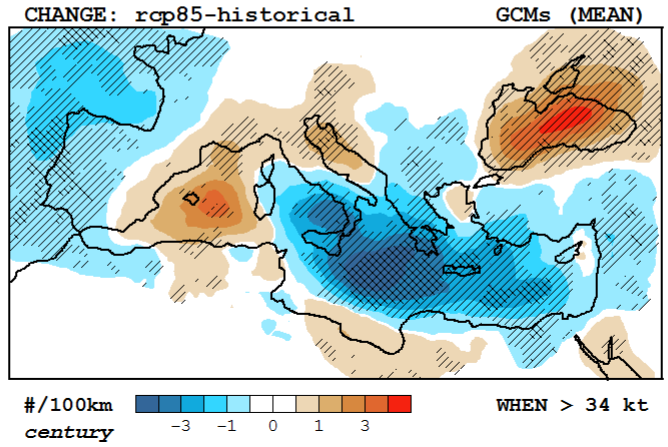
REAn01 = 0.948
REAn02 = 0.942
MEAN = **0.945**

RMSE

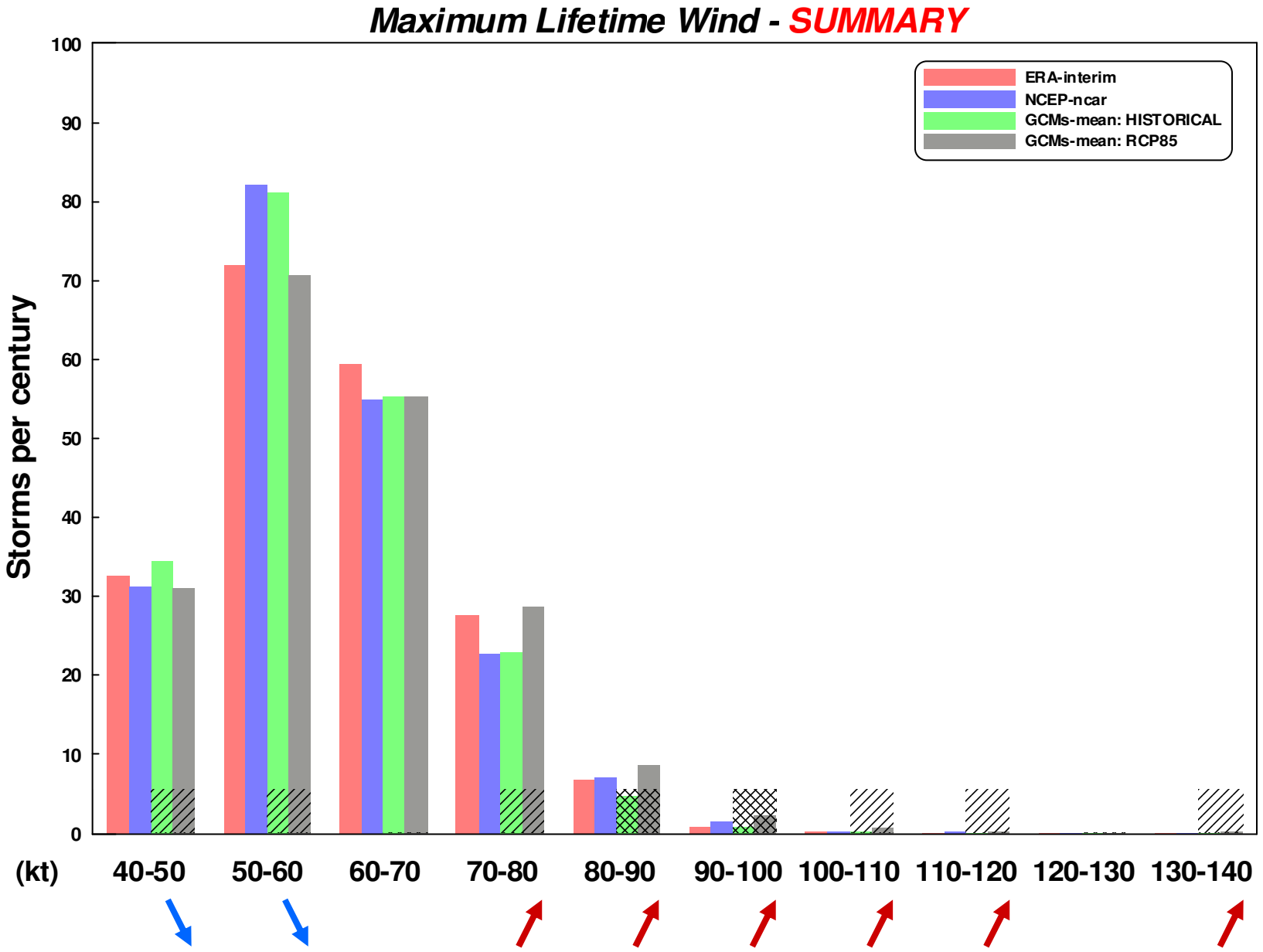
REAn01 = 1.907
REAn02 = 1.930
MEAN = **1.918**

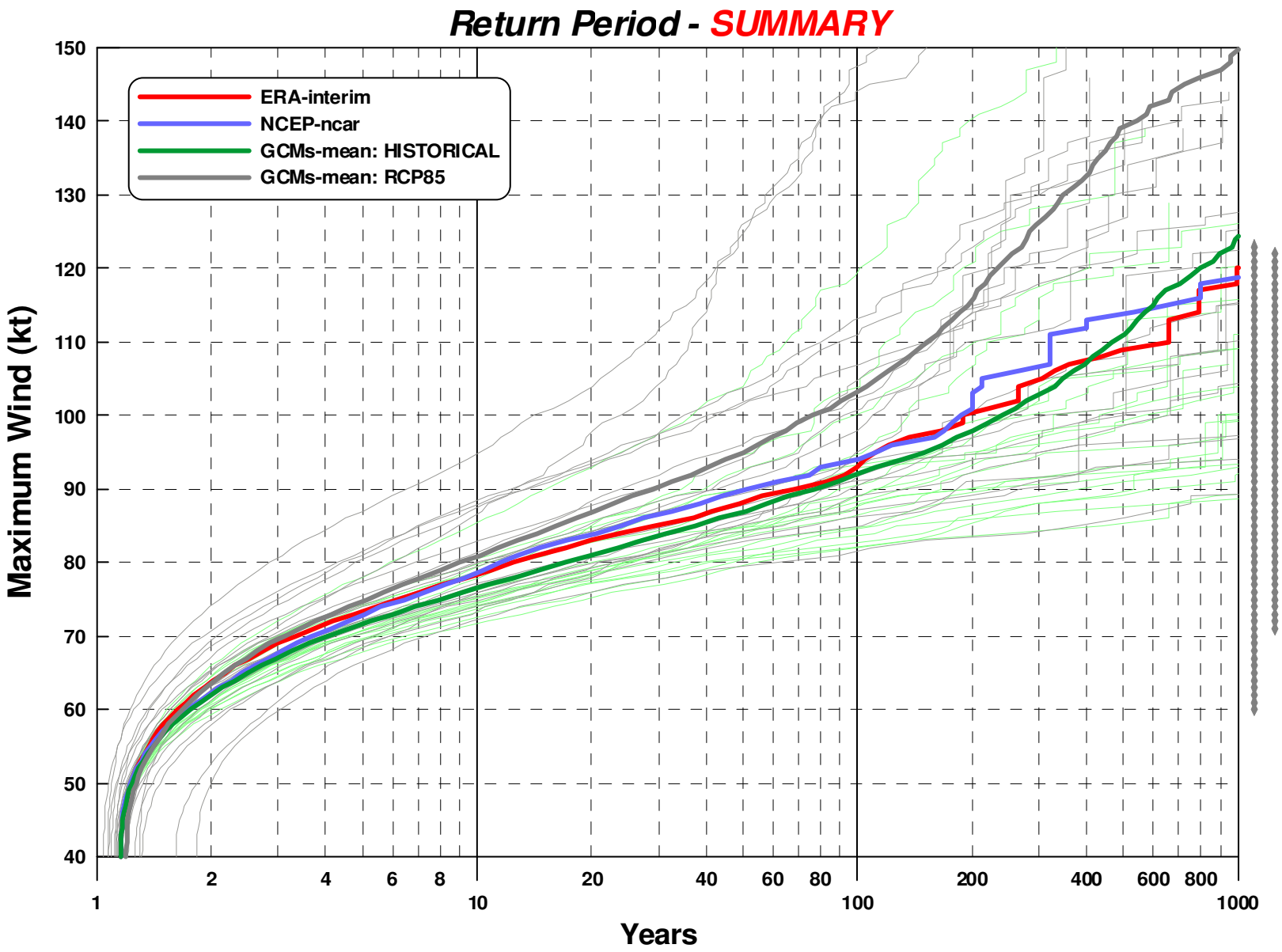


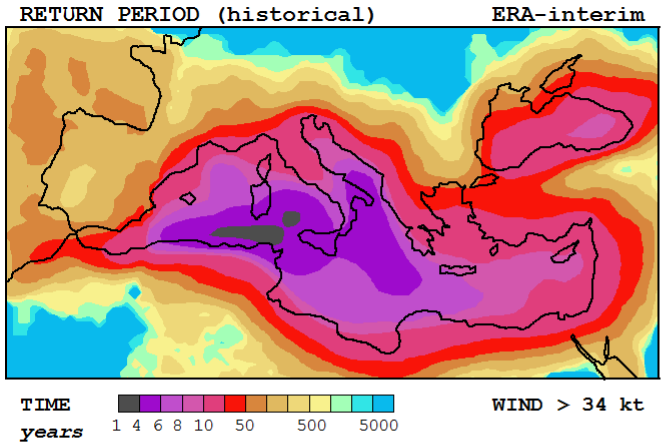


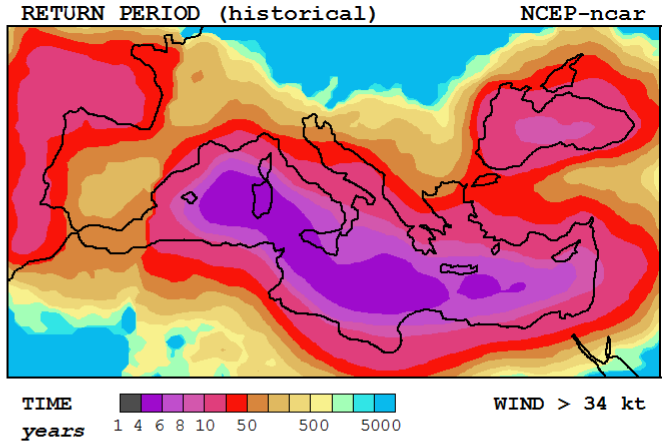


Track Density Summary


Maximum Lifetime Wind - SUMMARY
ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Storms per century
100
90
80
70
60
50
40
30
20
10
0
(kt)
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140


Return Period - SUMMARY
ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Maximum Wind (kt)
150
140
130
120
110
100
90
80
70
60
50
40
1
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
Years





CORR

REAn01 = 0.768

REAn02 = 0.742

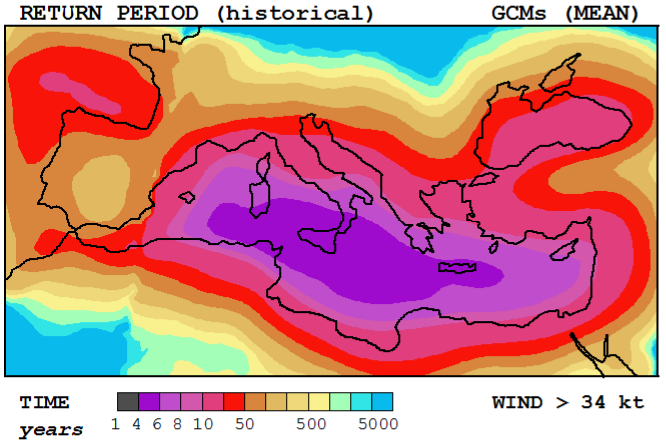
MEAN = **0.755**

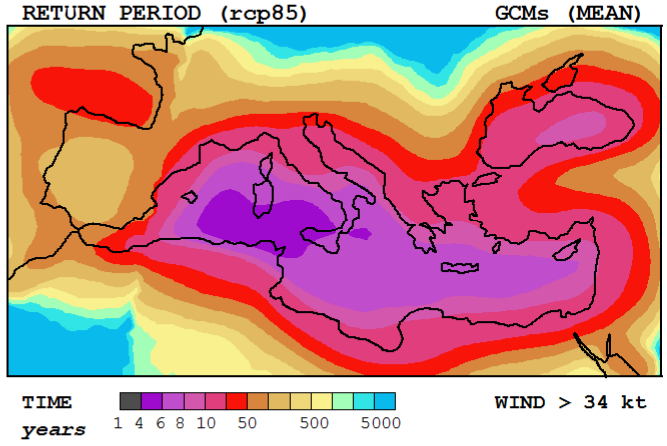
RMSE

REAn01 = 2.157

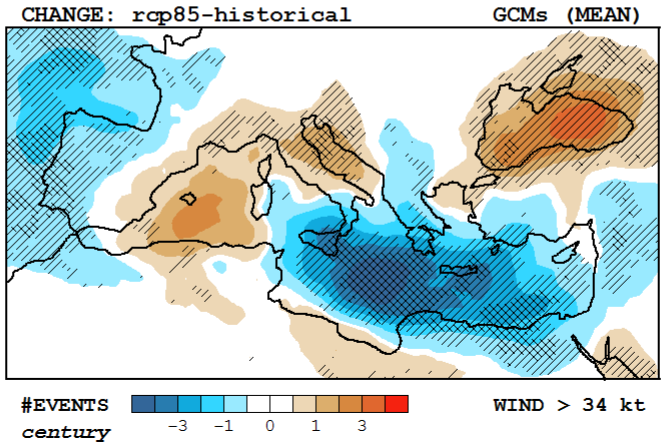
REAn02 = 4.131

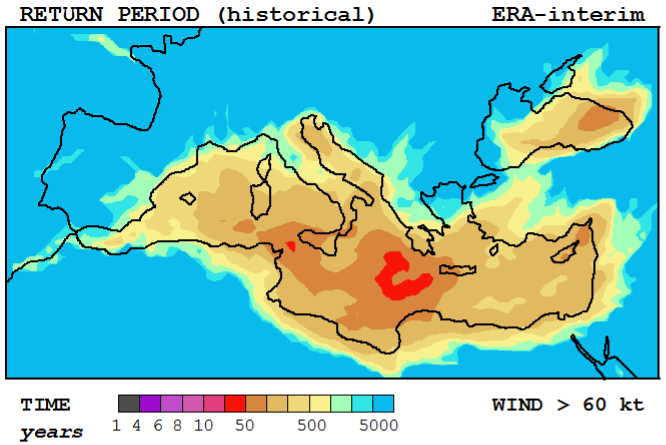
MEAN = **3.144**

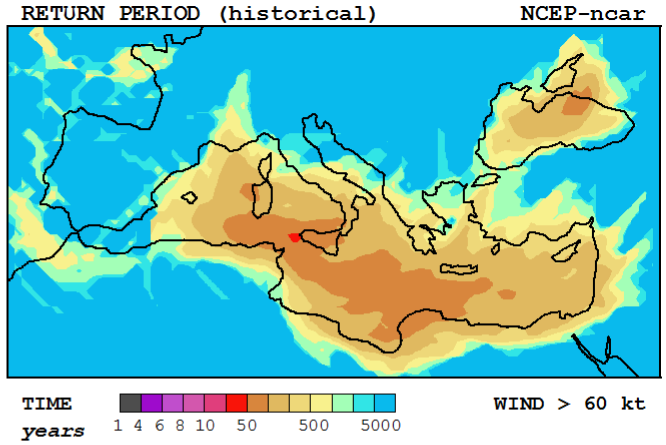




Return Period 34 kt Summary





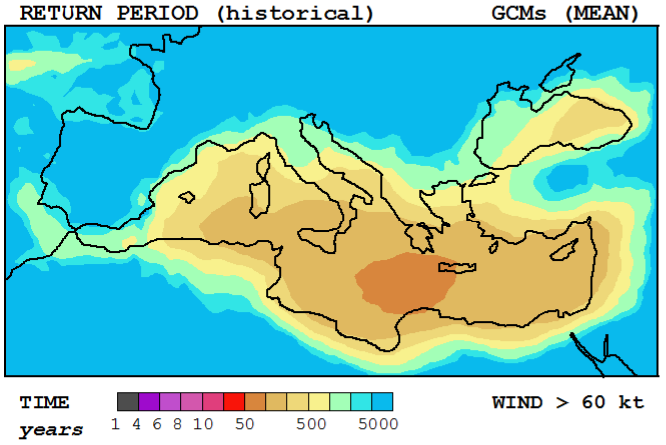


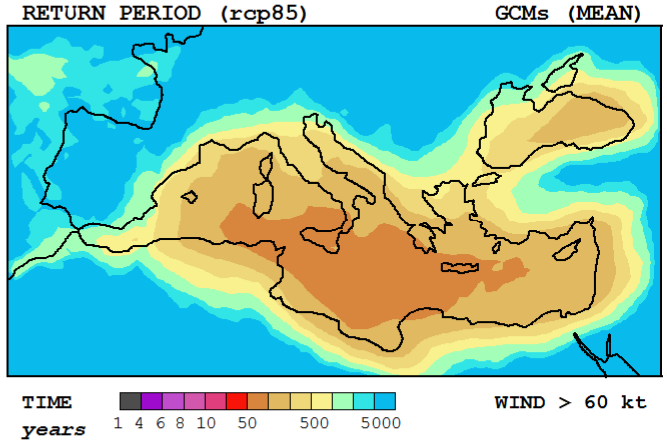
CORR

REAn01 = 0.604
REAn02 = 0.649
MEAN = **0.626**

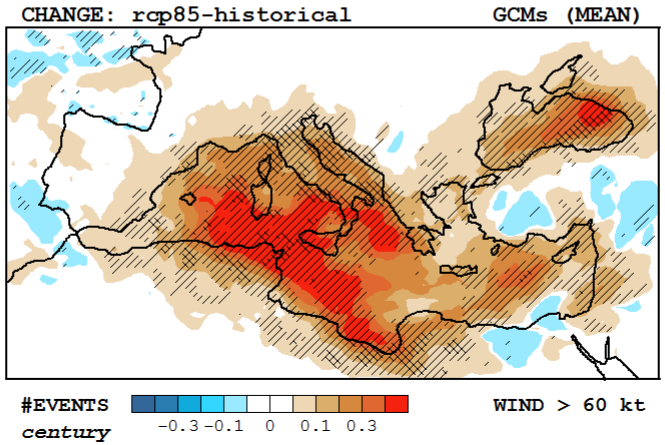
RMSE

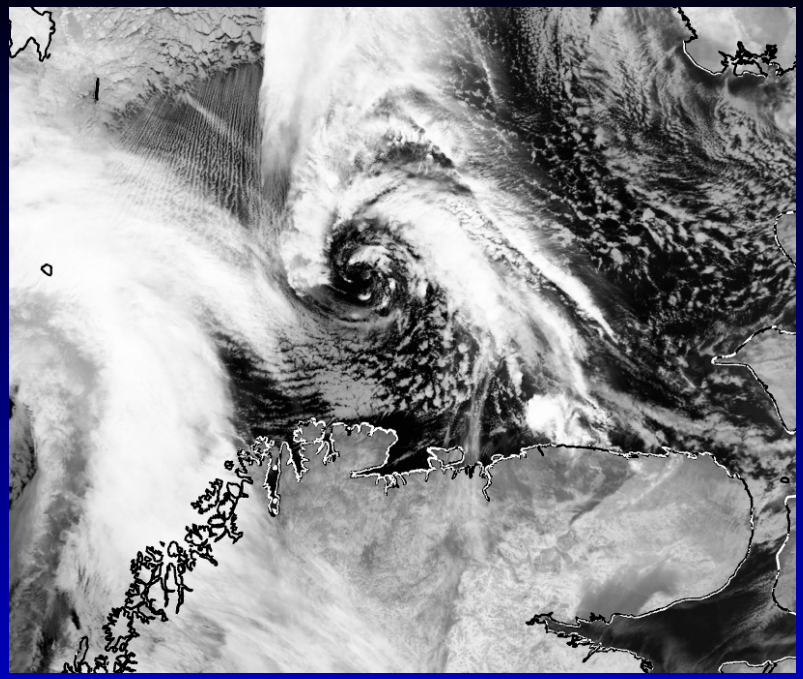
REAn01 = 4.972
REAn02 = 8.418
MEAN = **6.695**





Return Period 60 kt Summary





THANK YOU !!!