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Sesar Engage KTN

Thematic challenge 3 – Efficient provision and use of meteorological information in ATM

13/11/2018, Brussels, Belgium

Climate change impacts and new developments in the atmospheric sciences

Riccardo Biondi

Summary

- Quick overview of the problem
- Global view of the climate change impact on severe convection
- Focus on Europe
- GNSS tools for improving our understanding of severe convection

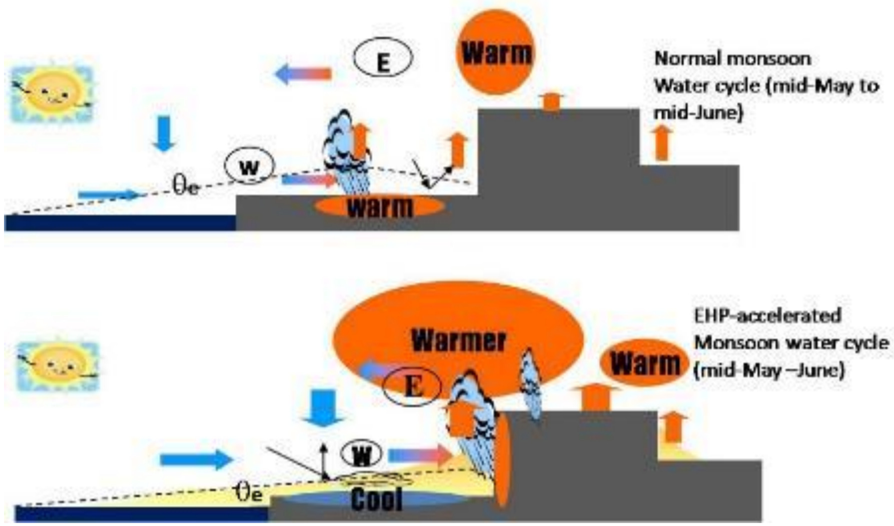
GHG concentration increase

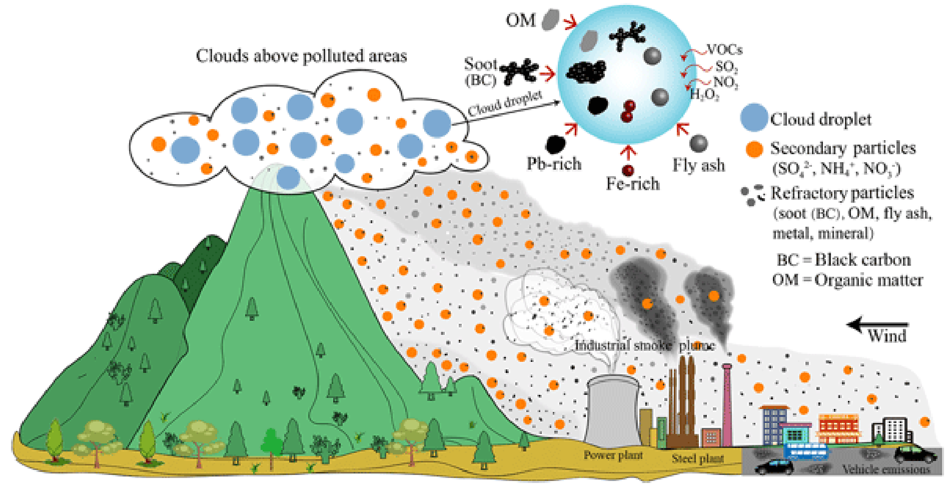
Climate Change

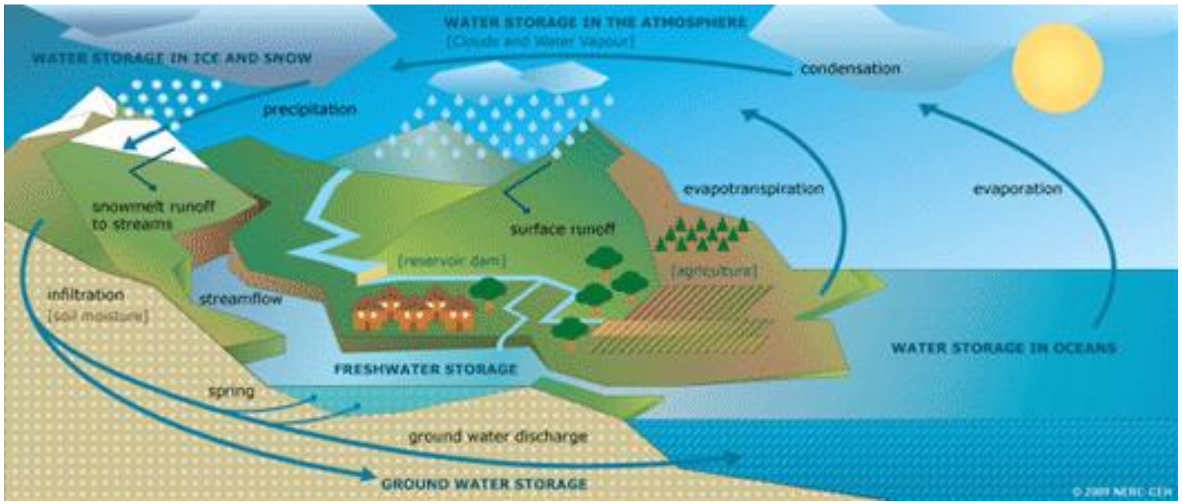
Temperature increase

Different surface and atmorpheric conditions

Change in weather phenomena development (intensity, duration, patterns)


Warm
E
Normal monsoon
Water cycle (mid-May to
mid-June)
W
θe
warm
Warmer
Warm
EHP-accelerated
Monsoon water cycle
(mid-May –June)
E
W
θe
Cool


Clouds above polluted areas
OM
Soot
(BC)
Cloud droplet
VOCs
SO_2
NO_2
H_2O_2
Pb-rich
Fe-rich
Fly ash
Cloud droplet
Secondary particles
(SO_4^{2-}, NH_4^+, NO_3^-)
Refractory particles
(soot (BC), OM, fly ash,
metal, mineral)
BC = Black carbon
OM = Organic matter
Wind
Industrial smoke plume
Power plant
Steel plant
Vehicle emissions


WATER STORAGE IN THE ATMOSPHERE
(Clouds and Water Vapour)
WATER STORAGE IN ICE AND SNOW
condensation
precipitation
snowmelt runoff
to streams
surface runoff
evapotranspiration
evaporation
(reservoir dam)
(agriculture)
infiltration
(soil moisture)
streamflow
FRESHWATER STORAGE
WATER STORAGE IN OCEANS
spring
ground water discharge
GROUND WATER STORAGE

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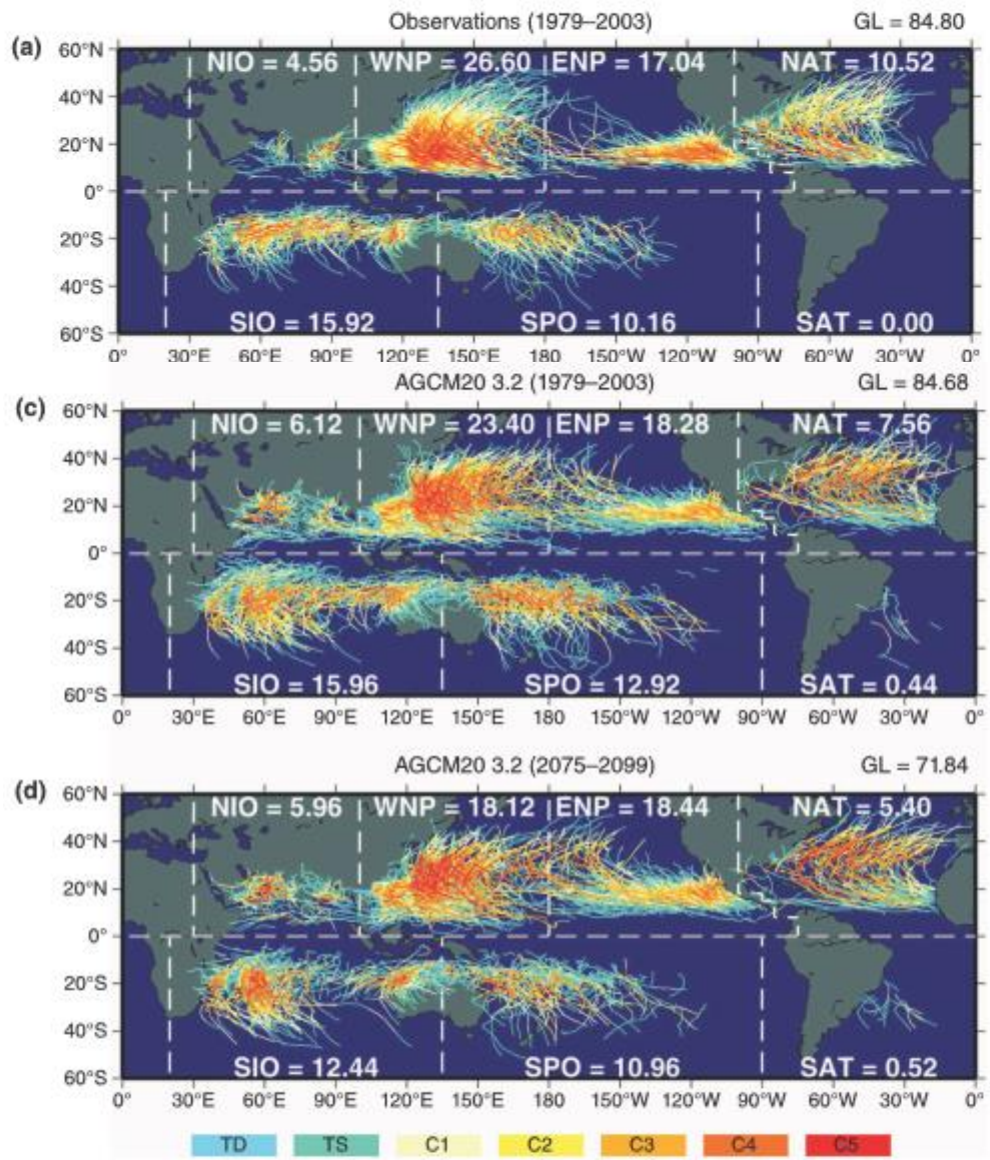


WIREs CLIMATE CHANGE

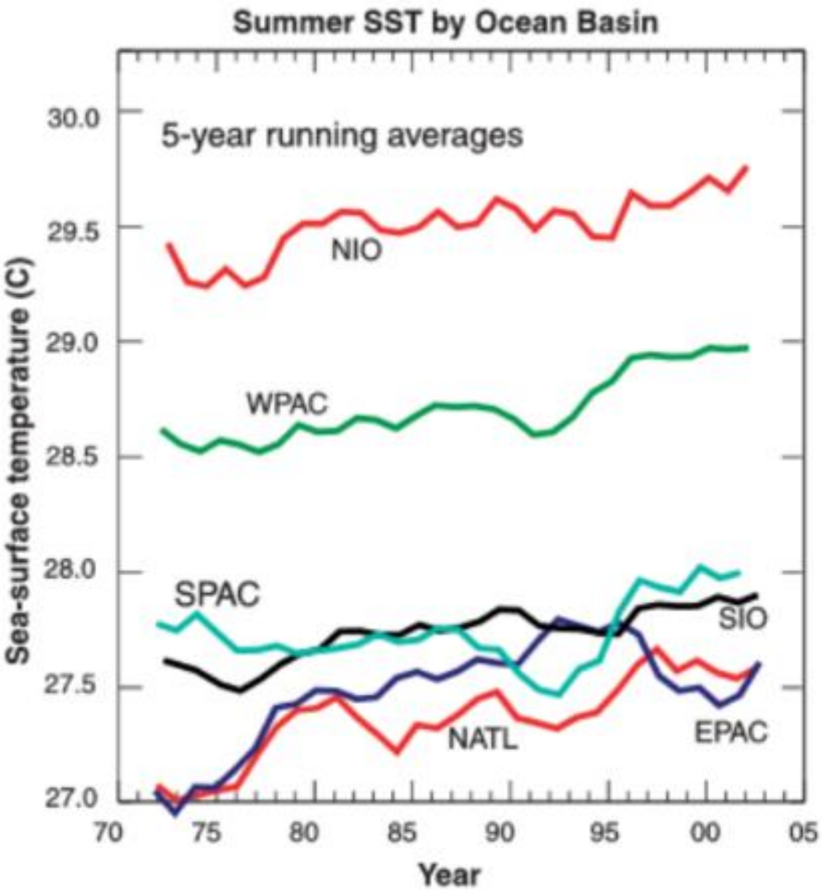
RMetS

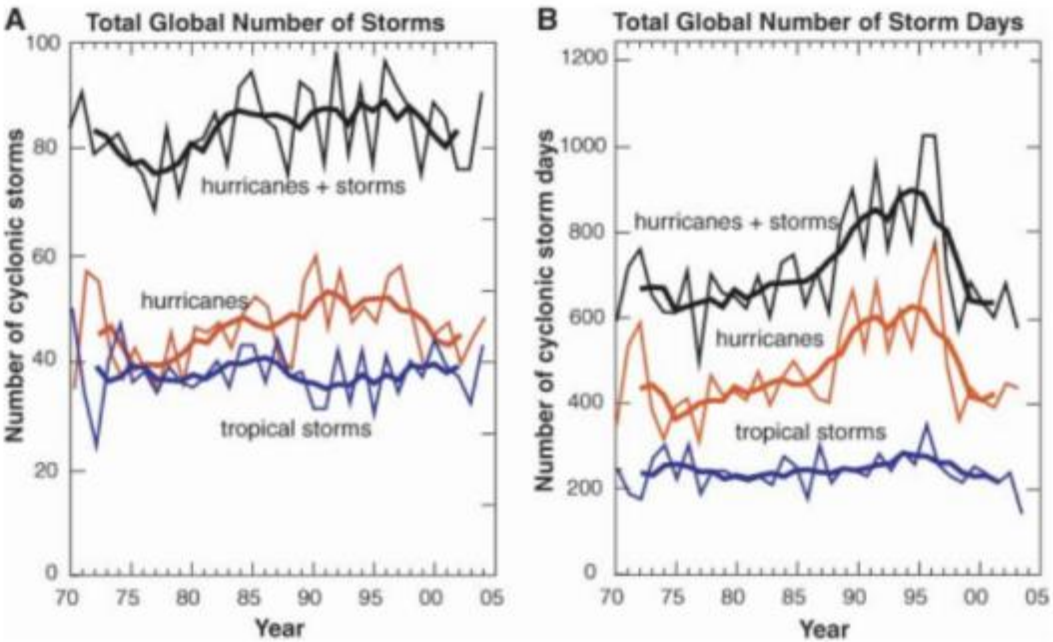
Advanced Review | Free Access

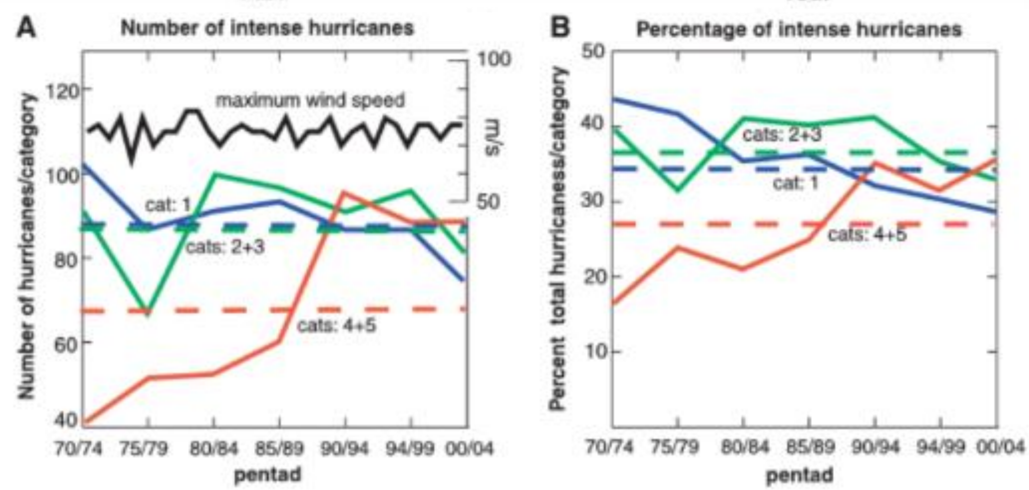
Tropical cyclones and climate change

Kevin J.E. Walsh, John L. McBride, Philip J. Klotzbach, Sethurathinam Balachandran, Suzana J. Camargo, Greg Holland, Thomas R. Knutson, James P. Kossin, Tsz-cheung Lee, Adam Sobel, Masato Sugi,

tion remains elusive. Climate models mostly continue to predict future decreases in global TC numbers, projected increases in the intensities of the strongest storms and increased rainfall rates. Sea level rise will likely contribute toward increased storm surge risk. Against the background of global climate change







REPORT

Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment

P. J. Webster[1], G. J. Holland[2], J. A. Curry[1], H.-R. Chang[1]
+ See all authors and affiliations

Science 16 Sep 2005:
Vol. 309, Issue 5742, pp. 1844-1846
DOI: 10.1126/science.1116448

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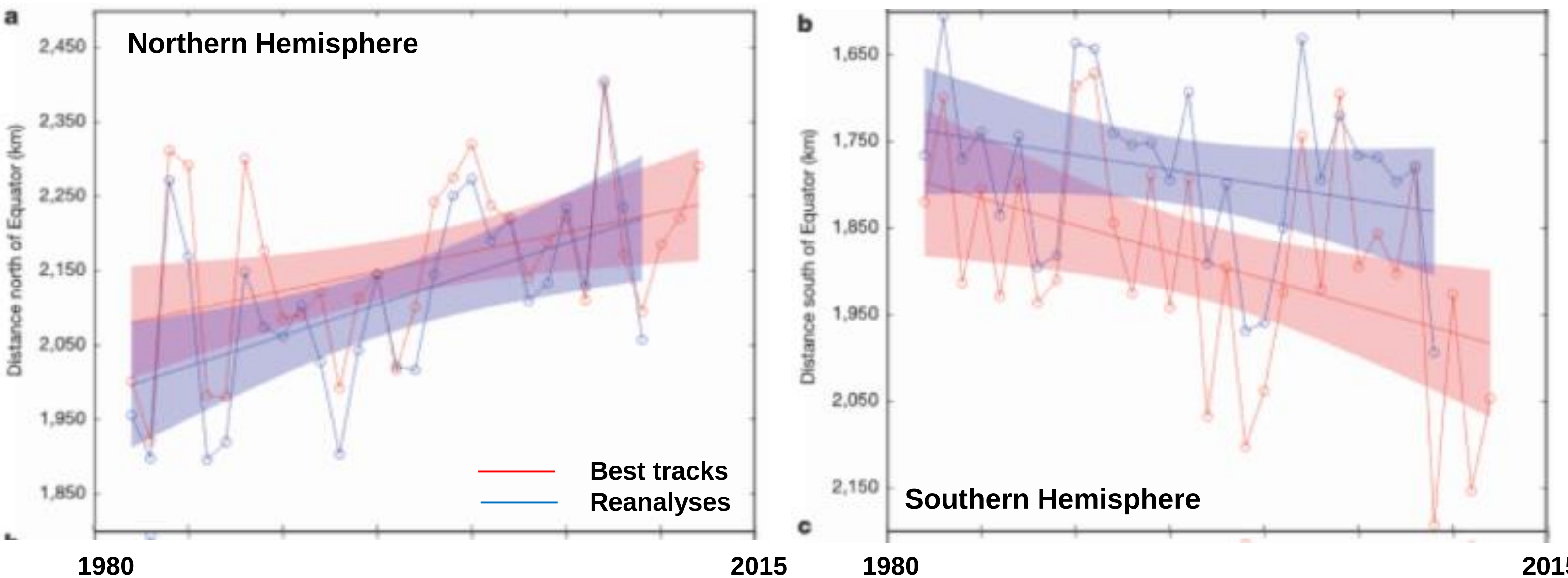
Table 1 | Linear trends, by region, of annual-mean latitude of LMI (Lifetime maximum intensity)

	NHEM	SHEM	NATL	WPAC	EPAC	NIO	SIO	SPAC	Global
Best track	+53 ± 43	+62 ± 48	+7 ± 98	+37 ± 55	+10 ± 32	−25 ± 78	+67 ± 55	+51 ± 68	+115 ± 70
ADT-HURSAT	+83 ± 50	+35 ± 44	−12 ± 126	+105 ± 71	+34 ± 30	+10 ± 106	+30 ± 52	+54 ± 79	+118 ± 70

Trends are deduced from the best-track and ADT-HURSAT data sets. The slope (kilometres per decade) and the 95% two-sided confidence bounds are shown. Positive slopes represent poleward migration. NHEM, Northern Hemisphere; SHEM, Southern Hemisphere; NATL, North Atlantic; WPAC, western Pacific; EPAC, eastern Pacific; NIO, North Indian Ocean; SIO, South Indian Ocean; SPAC, South Pacific.



nature
International journal of science

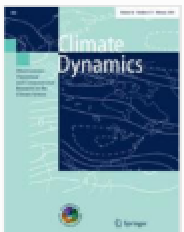
Letter | Published: 14 May 2014

The poleward migration of the location of tropical cyclone maximum intensity

James P. Kossin, Kerry A. Emanuel & Gabriel A. Vecchi

Nature 509, 349–352 (15 May 2014) | Download Citation

Observed changes in vertical wind shear and potential intensity over the past 30 yr seem to have resulted in a poleward shift, in both hemispheres, of the regions most favourable for tropical cyclone development (Fig. 2), and an associated migration of tropical cyclone activity away from the tropics (Fig. 1). If these environmental changes continue, a con-



Climate Dynamics
February 2014, Volume 42, Issue 3–4, pp 617–627 | Cite as

Recent intense hurricane response to global climate change

Authors | Authors and affiliations

Greg Holland , Cindy L. Bruyère

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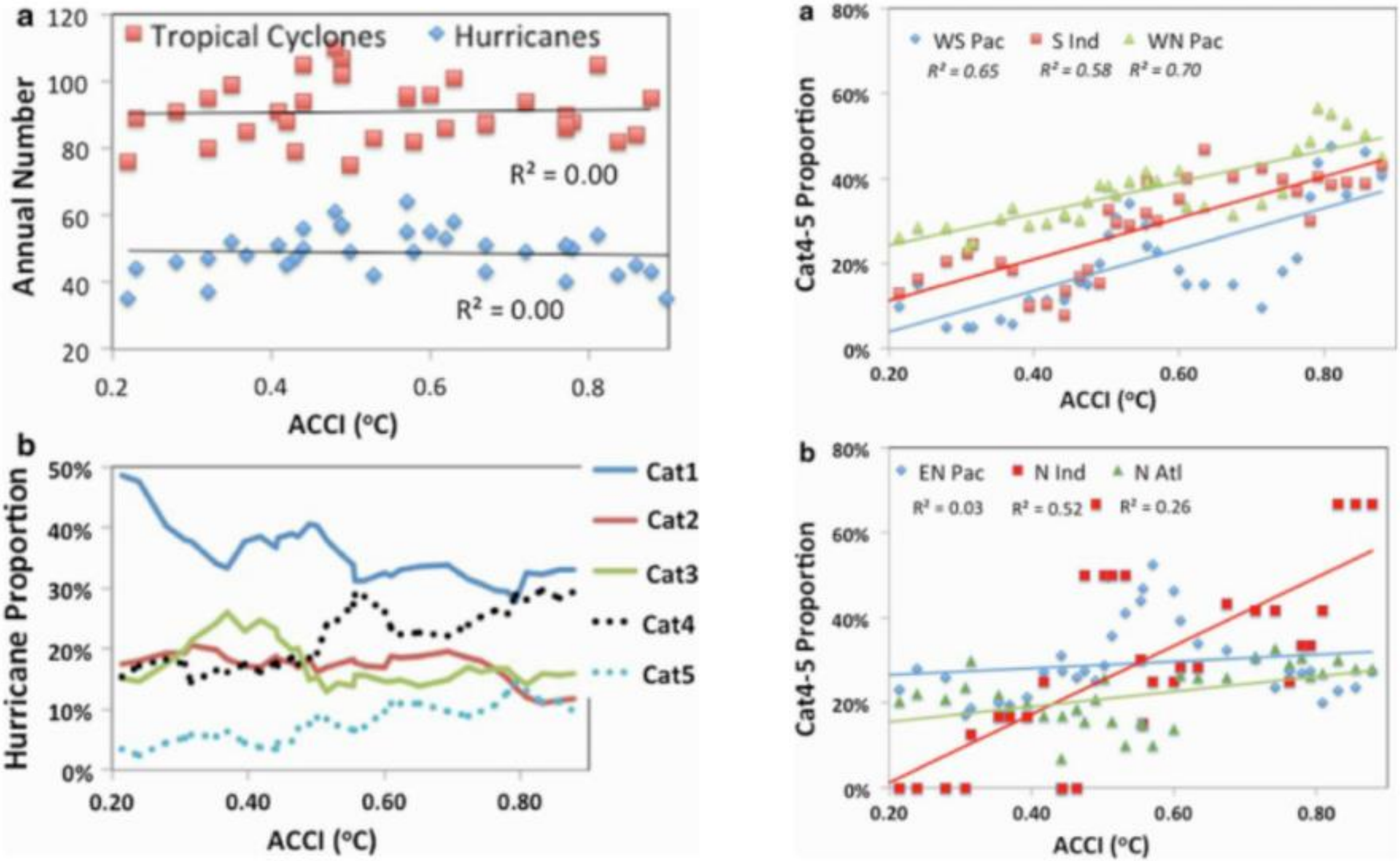
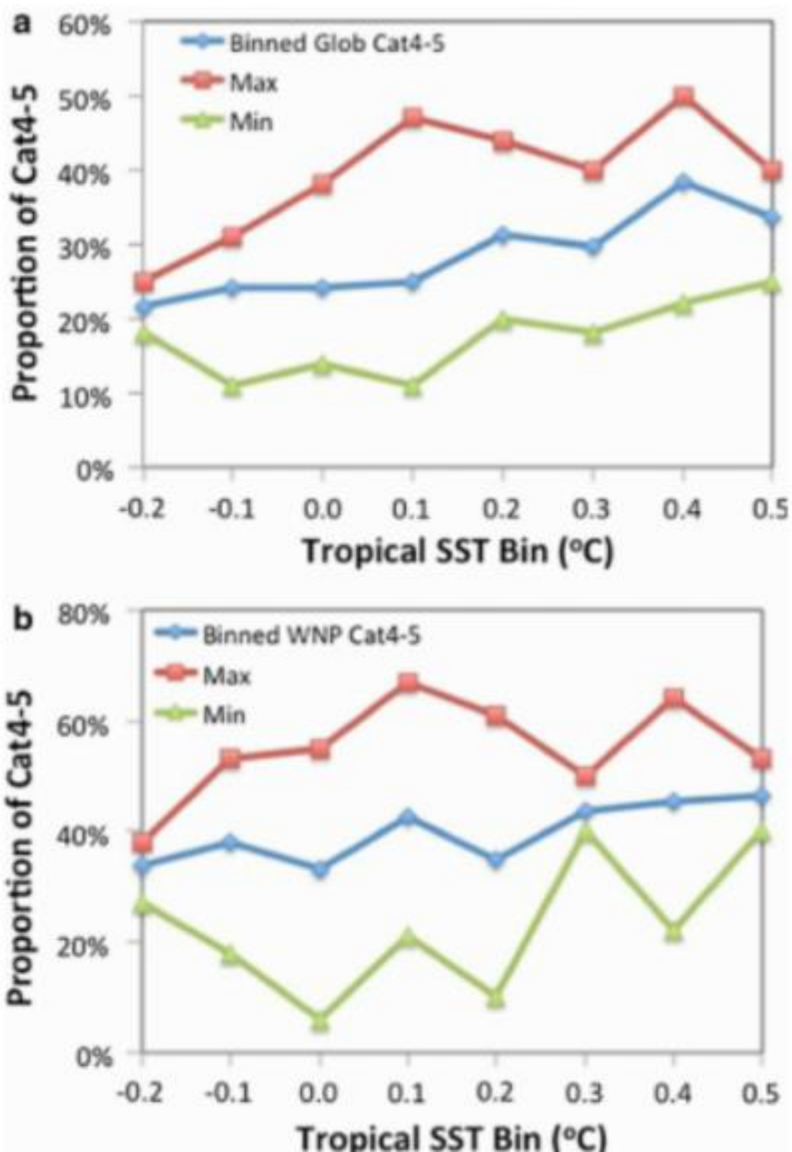
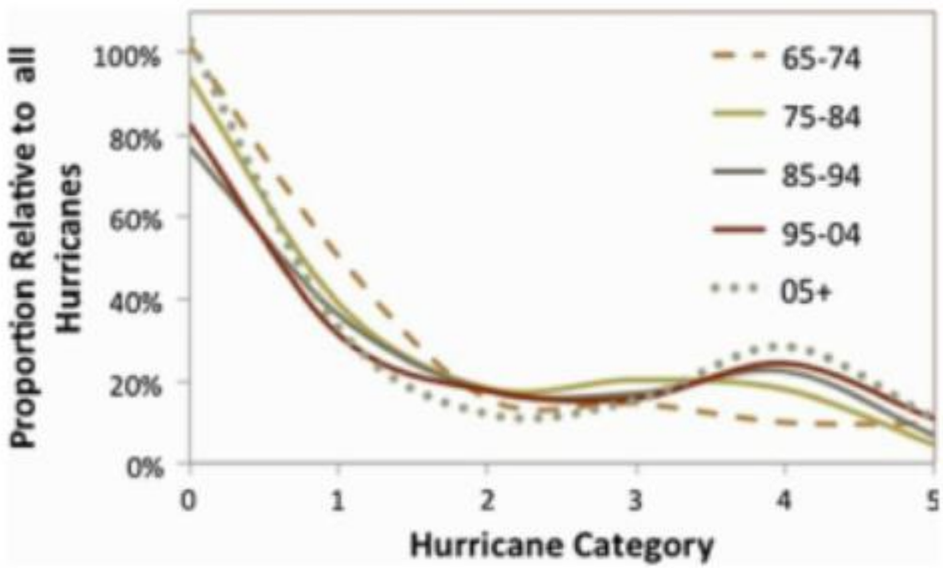


Anthropogenic Climate Change Index (ACCI): difference between model simulation with and without anthropogenic gases





(Table 1). We conclude that since 1975 there has been a substantial and observable regional and global increase in the proportion of Cat 4–5 hurricanes of 25–30 % per °C of anthropogenic global warming.

An important finding is that the proportion of intense hurricanes appears to initially increase in response to warming oceans, but then approach a saturation level after which no further increases occur. There is tentative evidence that the saturation level will differ across the tropical cyclone basins and that the global proportion of Cat 4–5 hurricanes may already be near it's saturation level of ~40–50 %. This has considerable societal implications

Conclusions from observations

- The number of tropical cyclones will be constant or decreasing
- The tropical cyclones tracks are shifted poleward in both hemispheres
- The intense tropical cyclones increases until they get a saturation

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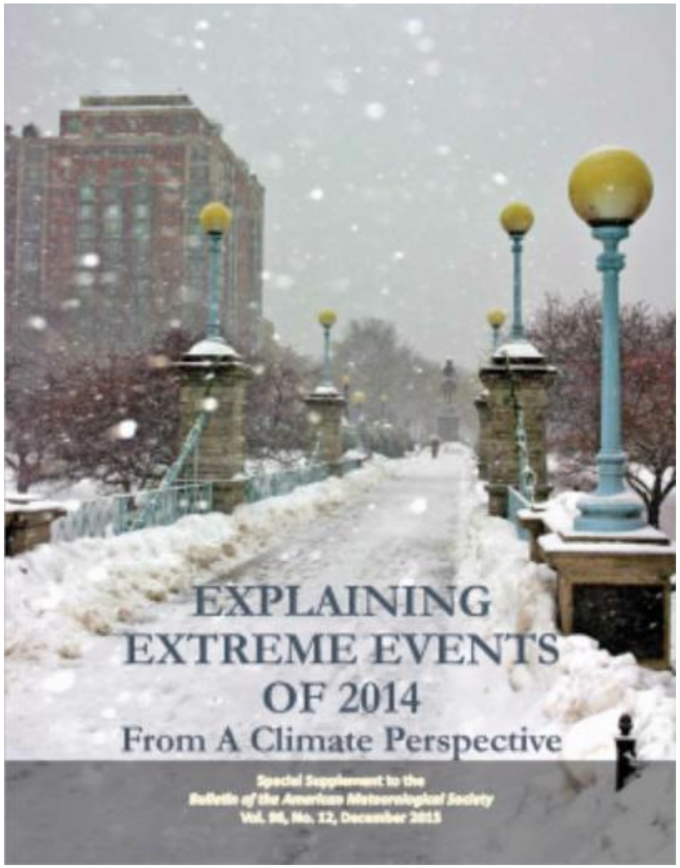

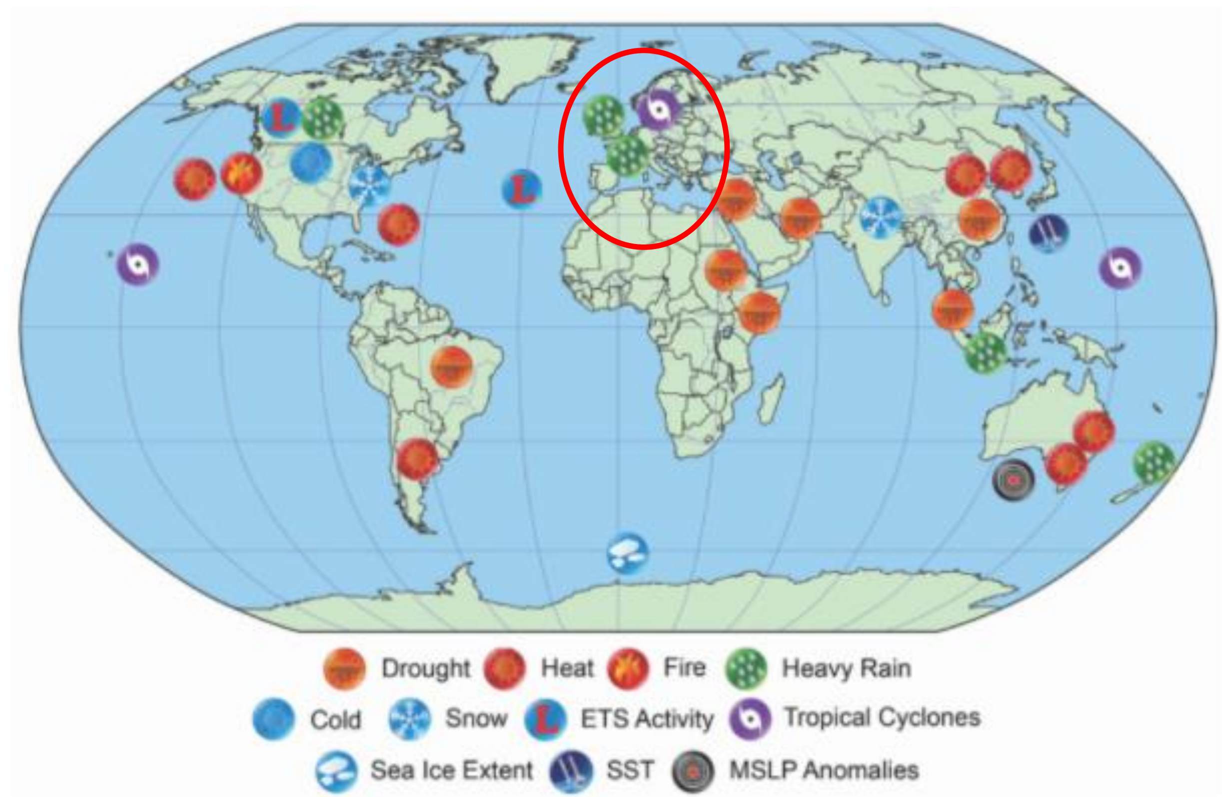

Fig. 1.1. Location and types of events analyzed in this publication.

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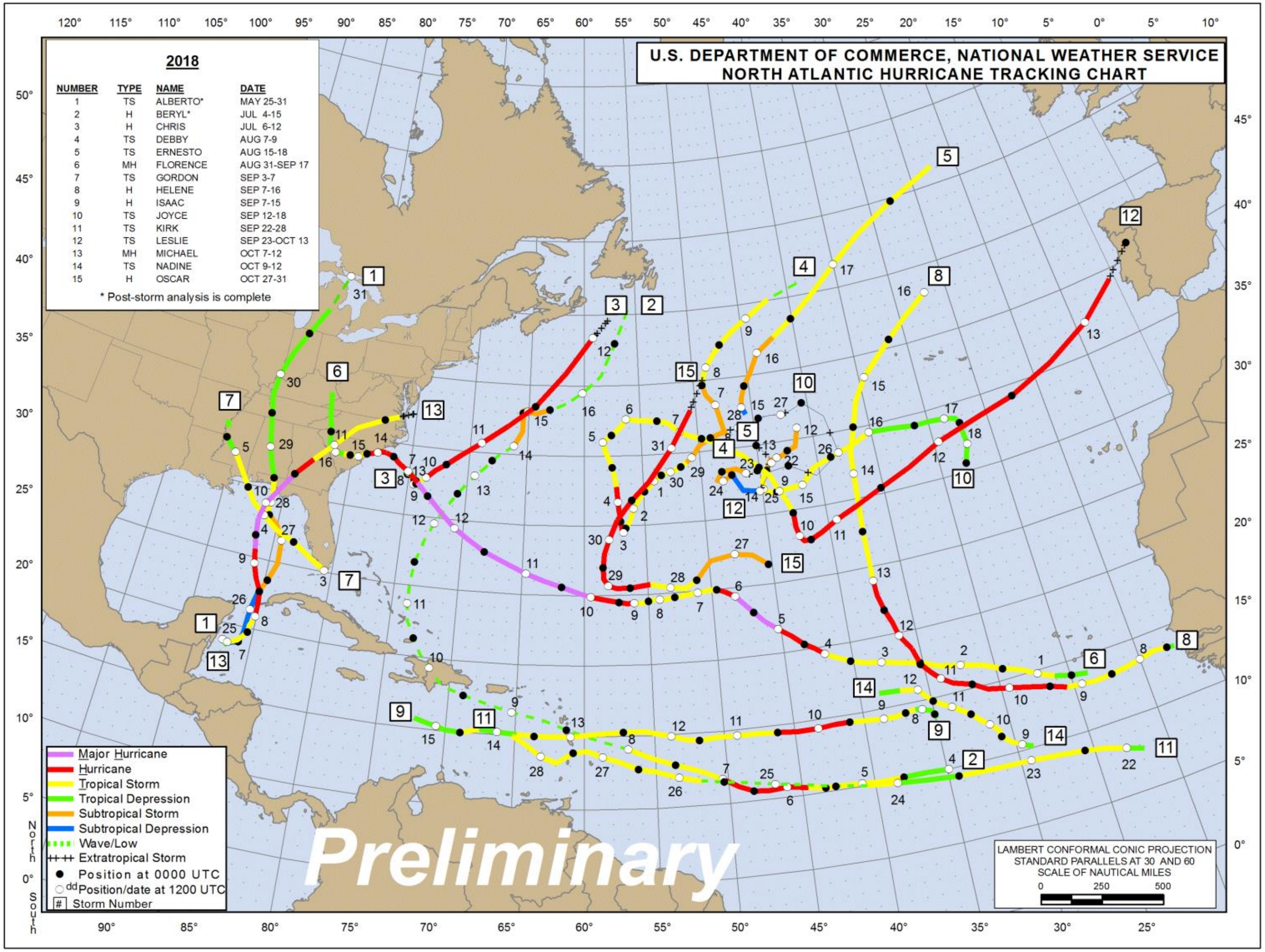

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Climate Change and Hurricane-Like Extratropical Cyclones: Projections for North Atlantic Polar Lows and Medicanes Based on CMIP5 Models

R. Romero

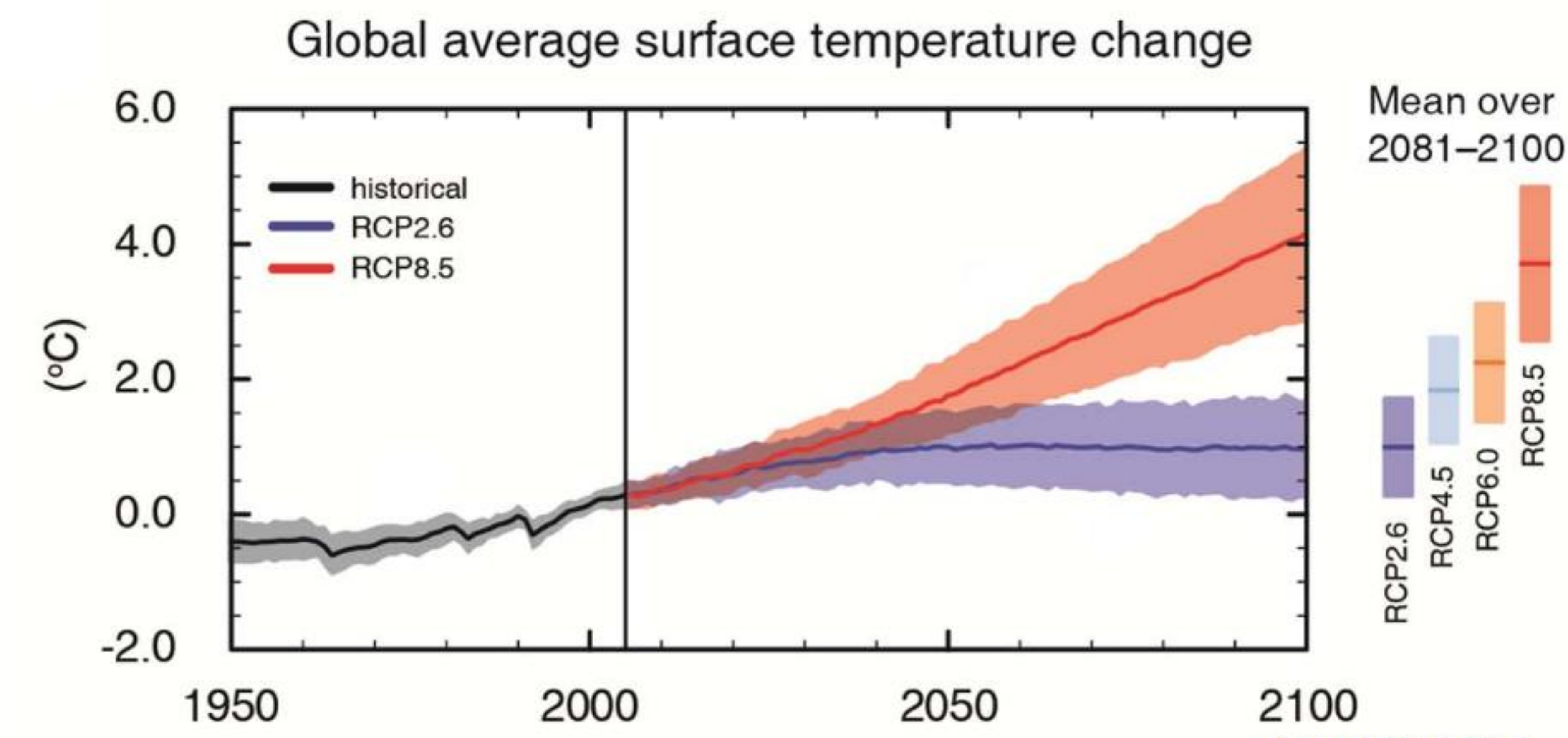
Departament de Física, Universitat de les Illes Balears, Palma de Mallorca, Spain

K. Emanuel

Department of Atmospheric Science, Massachusetts Institute of Technology, Cambridge, Massachusetts

January 2017

Comparison between the **worst scenario** with a radiative forcing of 8.5 W/m² at the end of the century and the **historical scenario** privileging in each case the subset of 20 models exhibiting the highest agreement with the results yielded by two reanalyses for the historical period (ERA-Interim and NCEP–NCAR)



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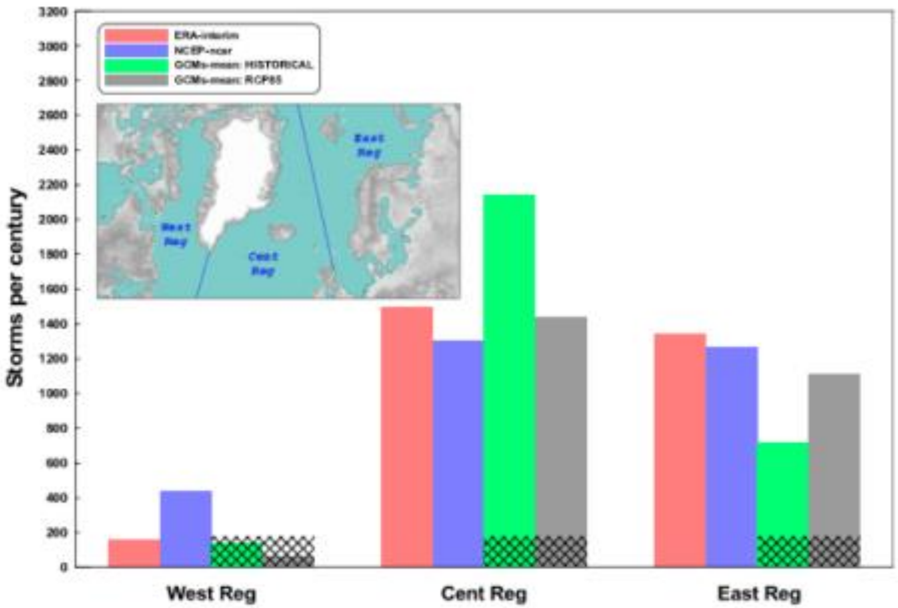

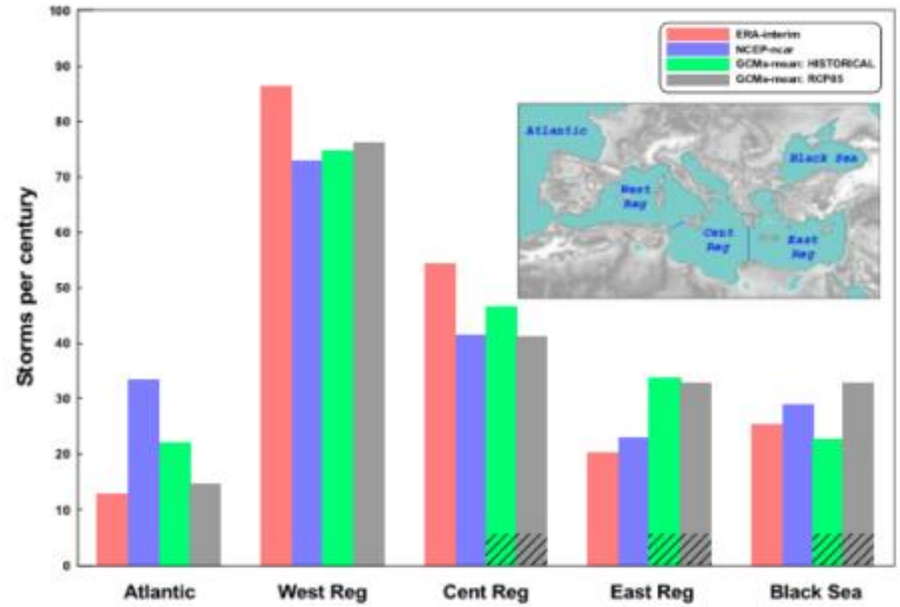

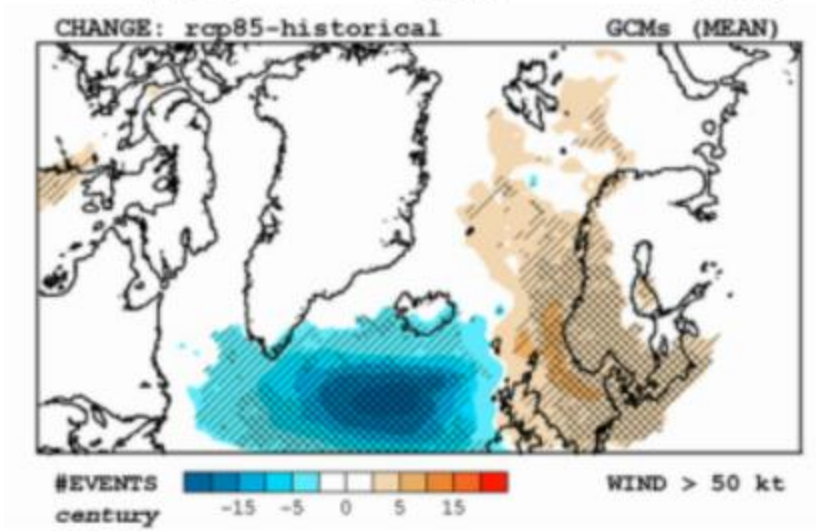

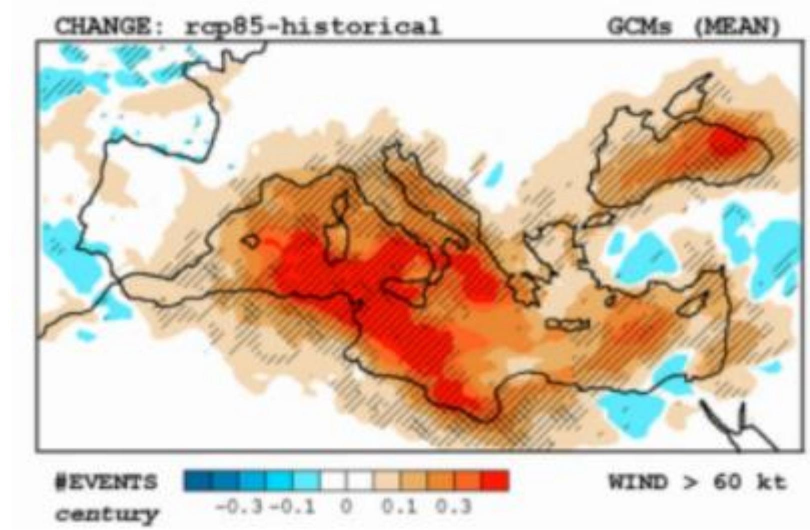

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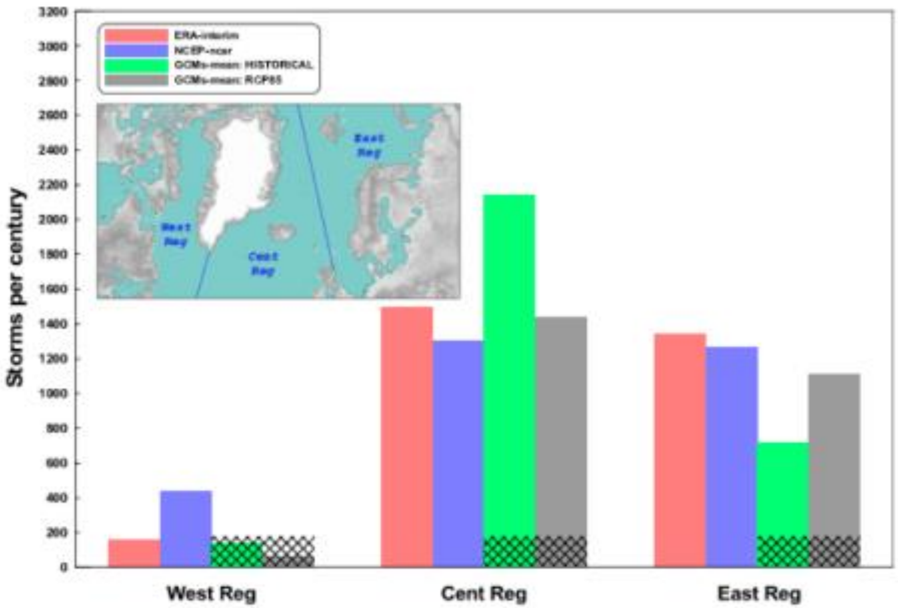

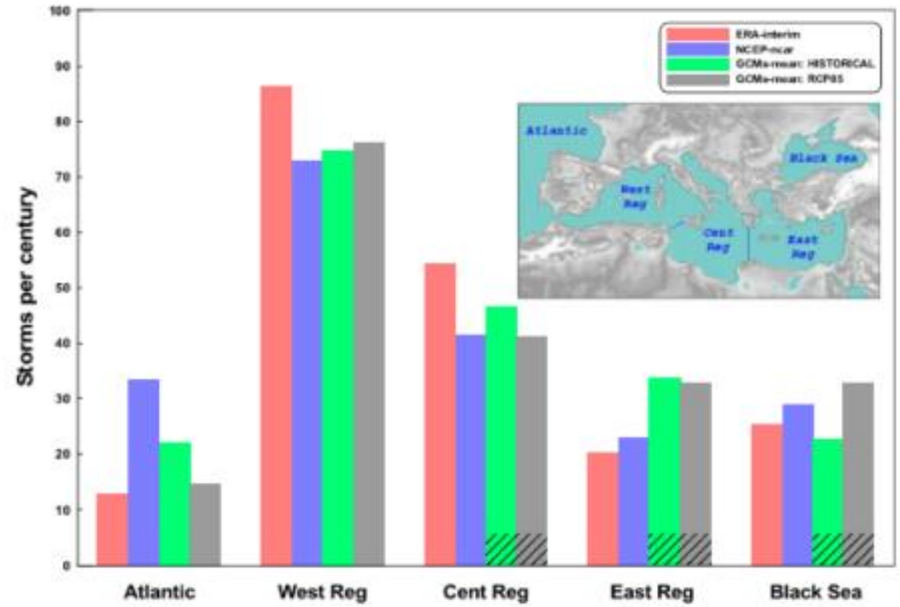

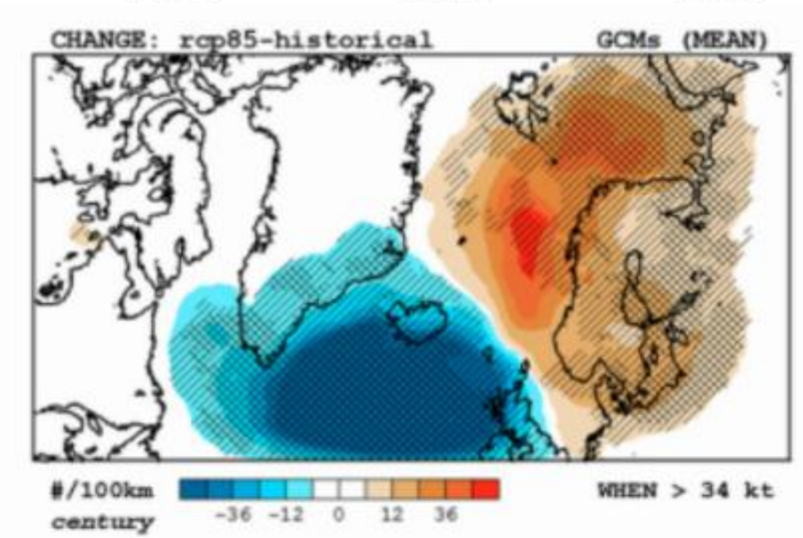

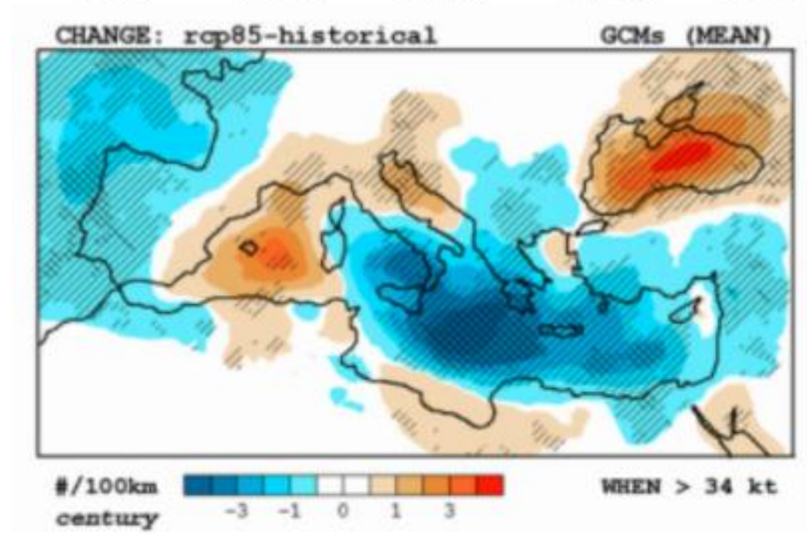

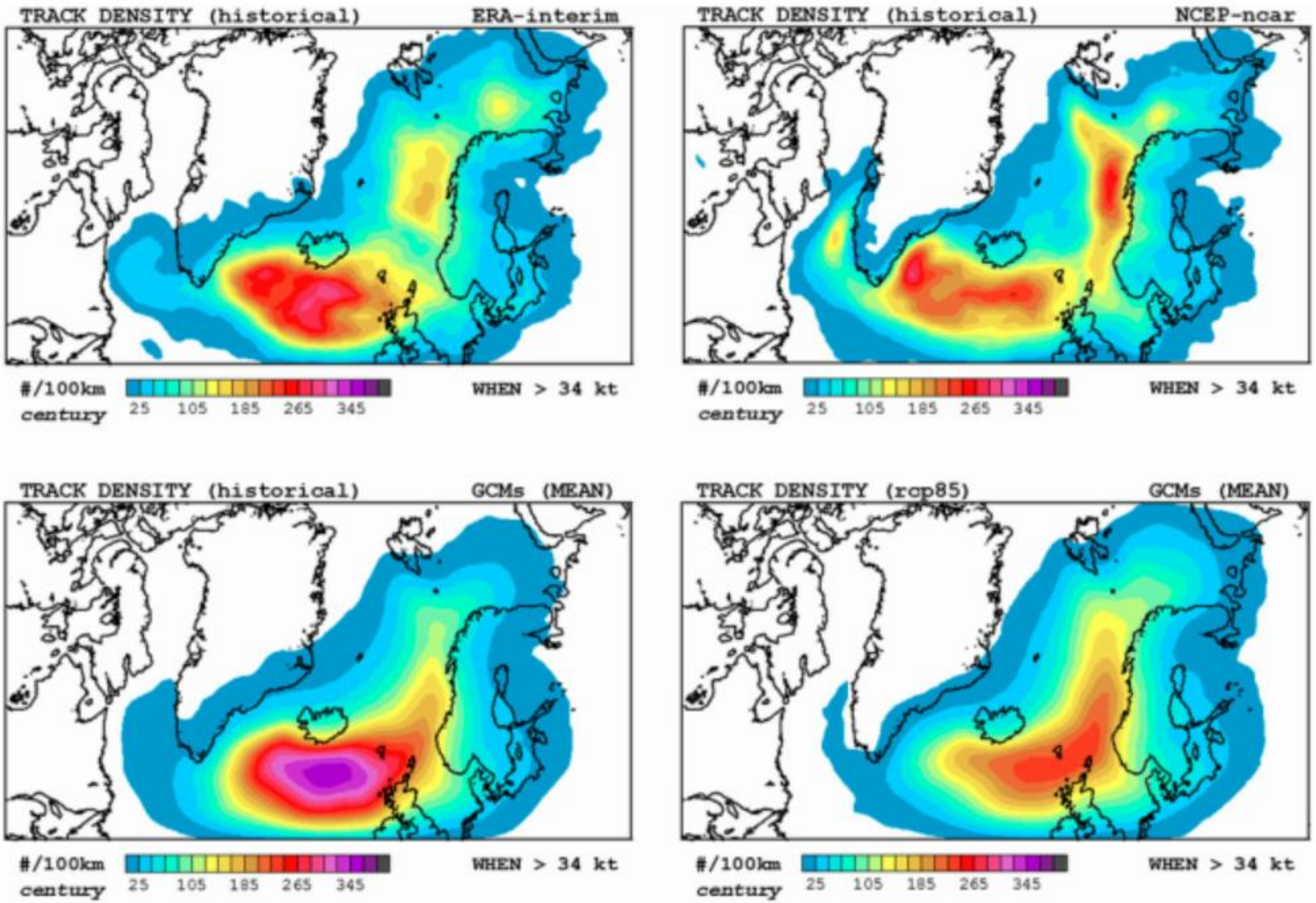
TRACK DENSITY (historical)
ERA-interim
#/100km century
25 105 185 265 345
WHEN > 34 kt
TRACK DENSITY (historical)
NCEP-ncar
#/100km century
25 105 185 265 345
WHEN > 34 kt
TRACK DENSITY (historical)
GCMs (MEAN)
#/100km century
25 105 185 265 345
WHEN > 34 kt
TRACK DENSITY (rcp85)
GCMs (MEAN)
#/100km century
25 105 185 265 345
WHEN > 34 kt

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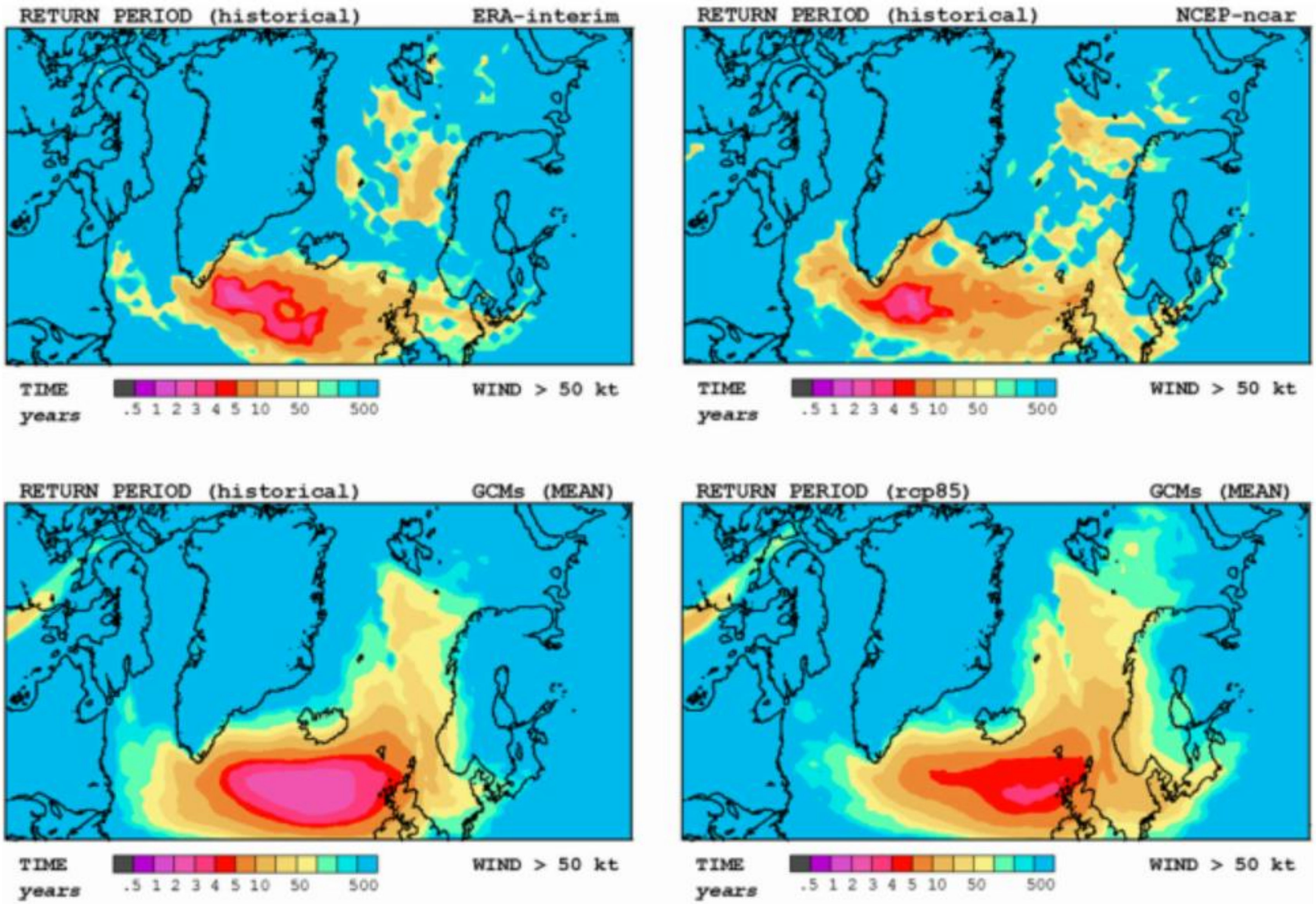
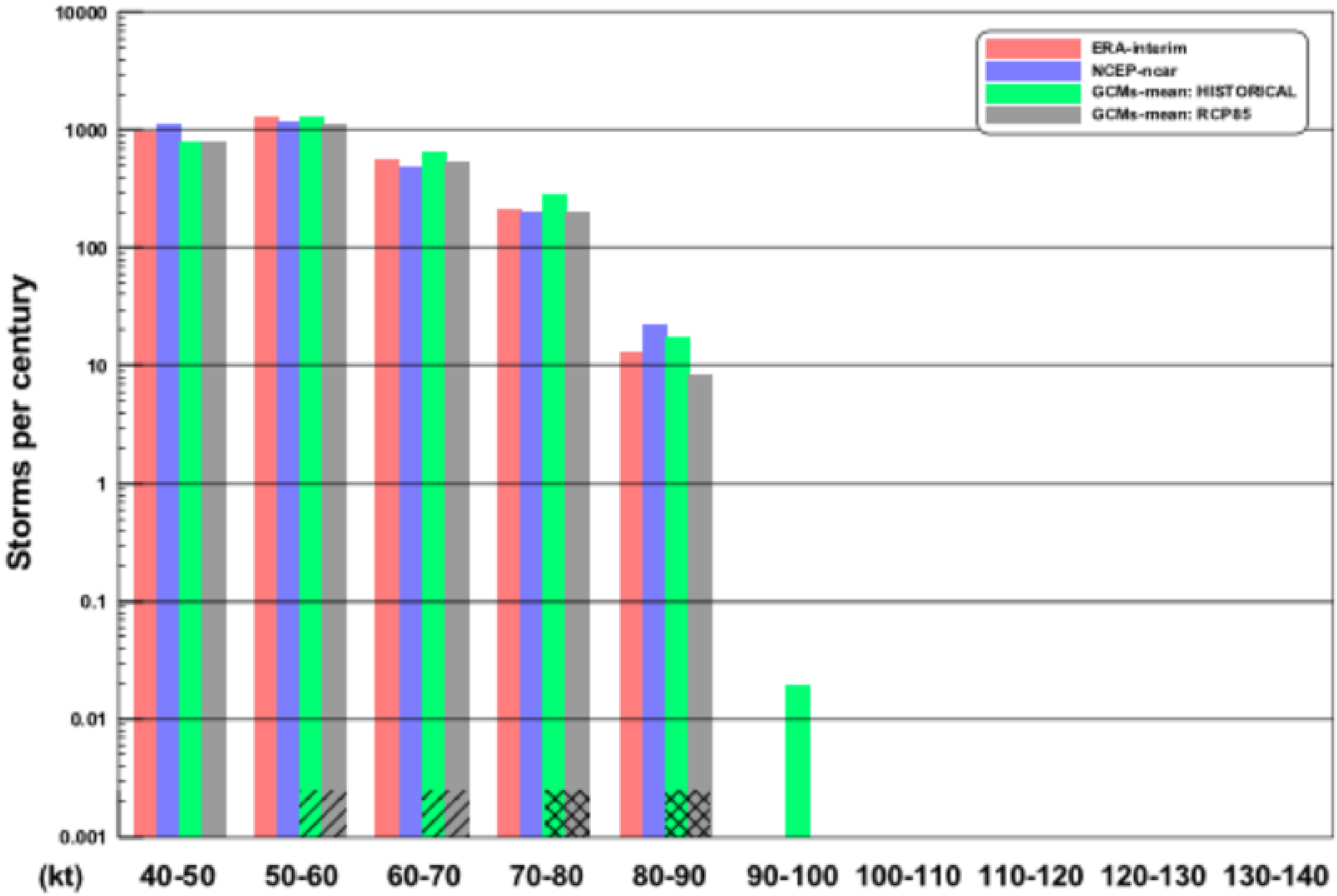
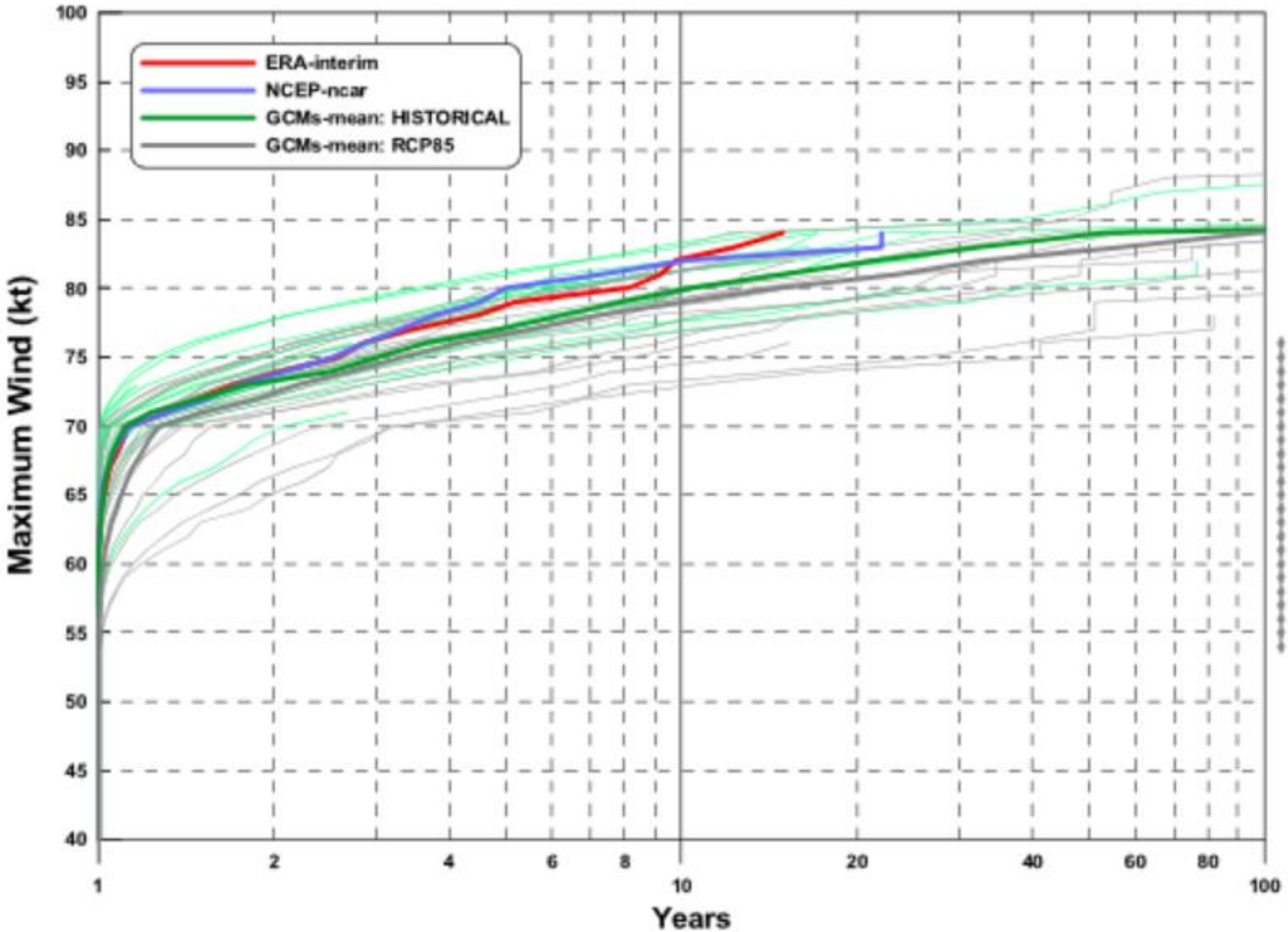
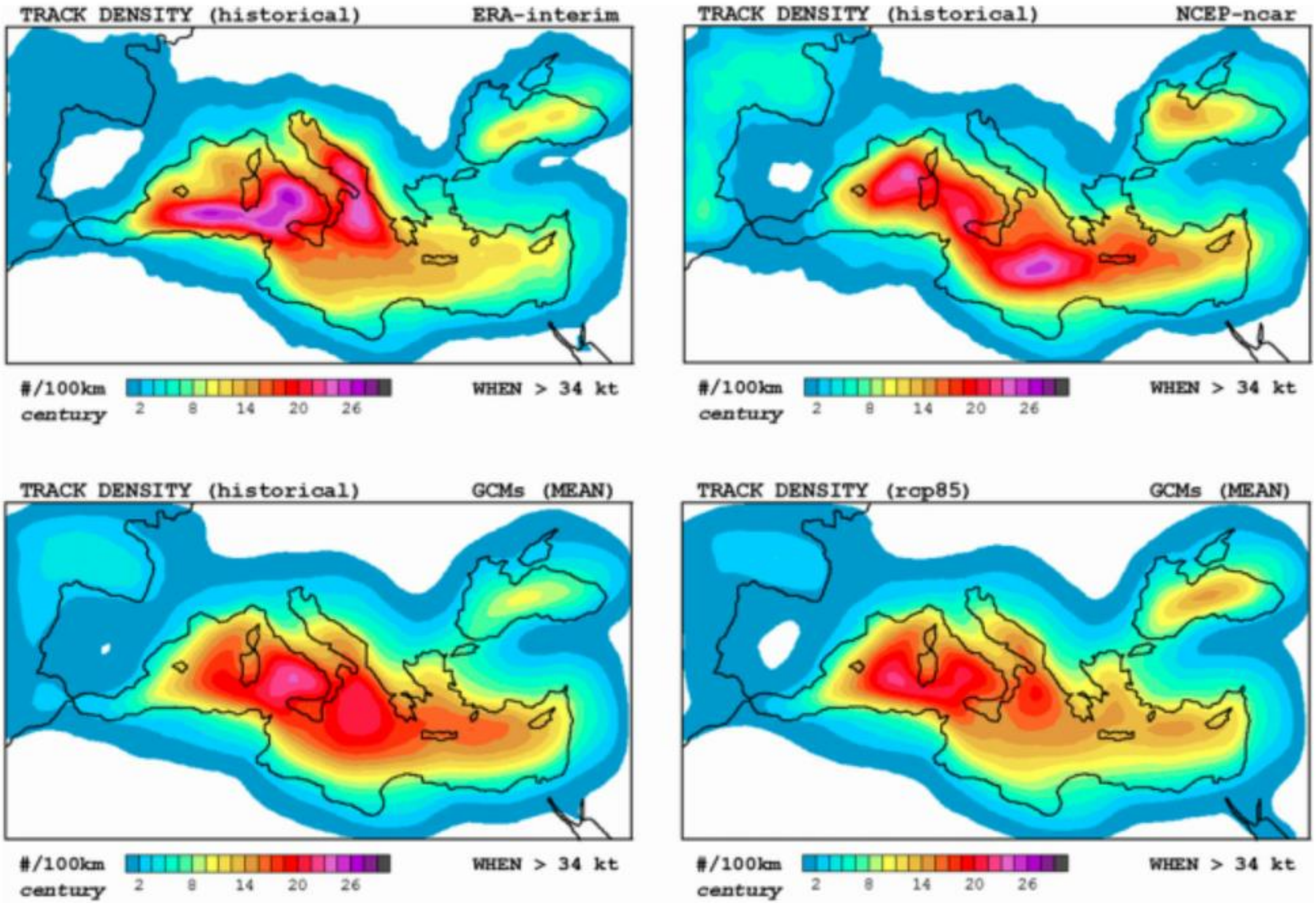
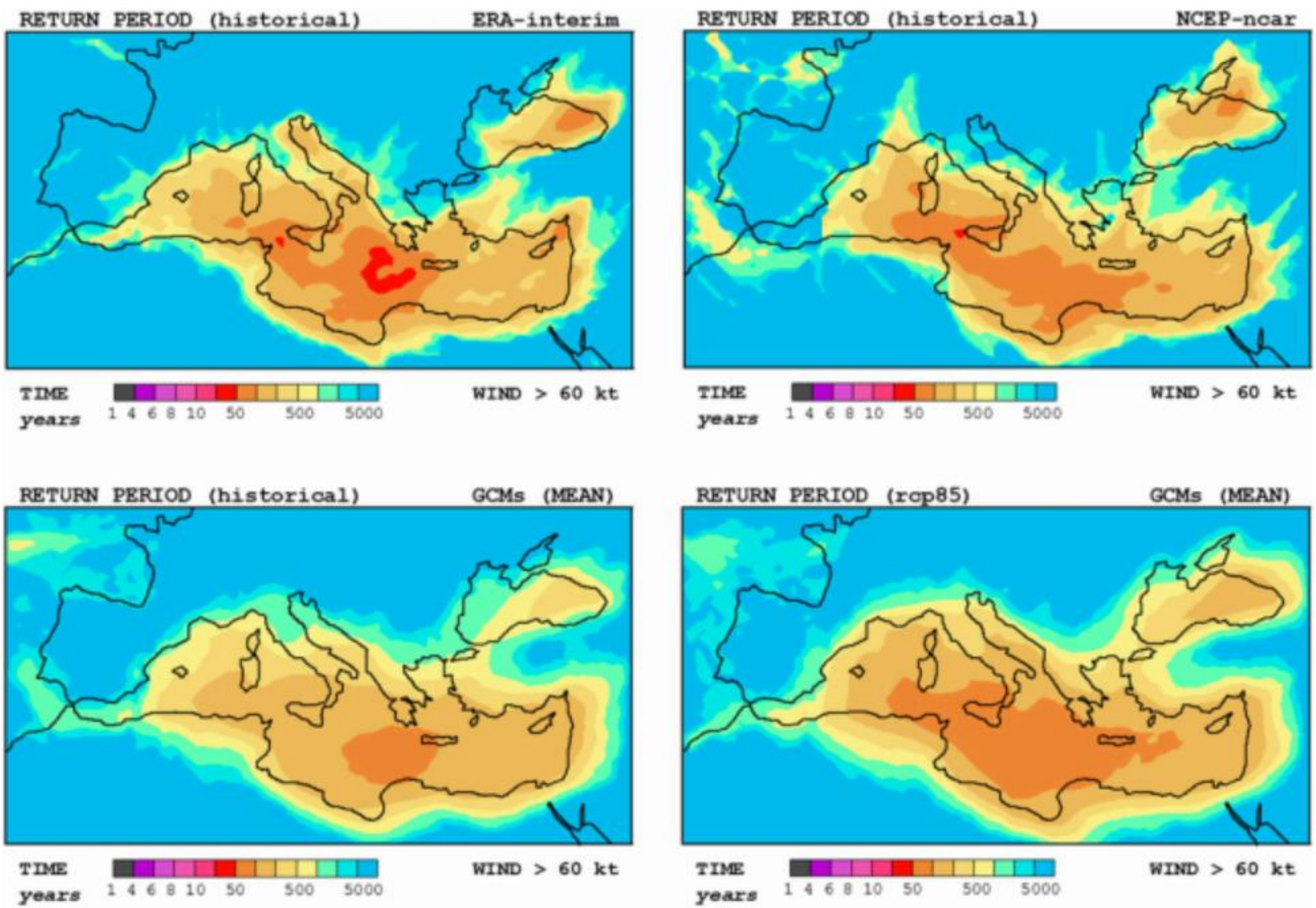
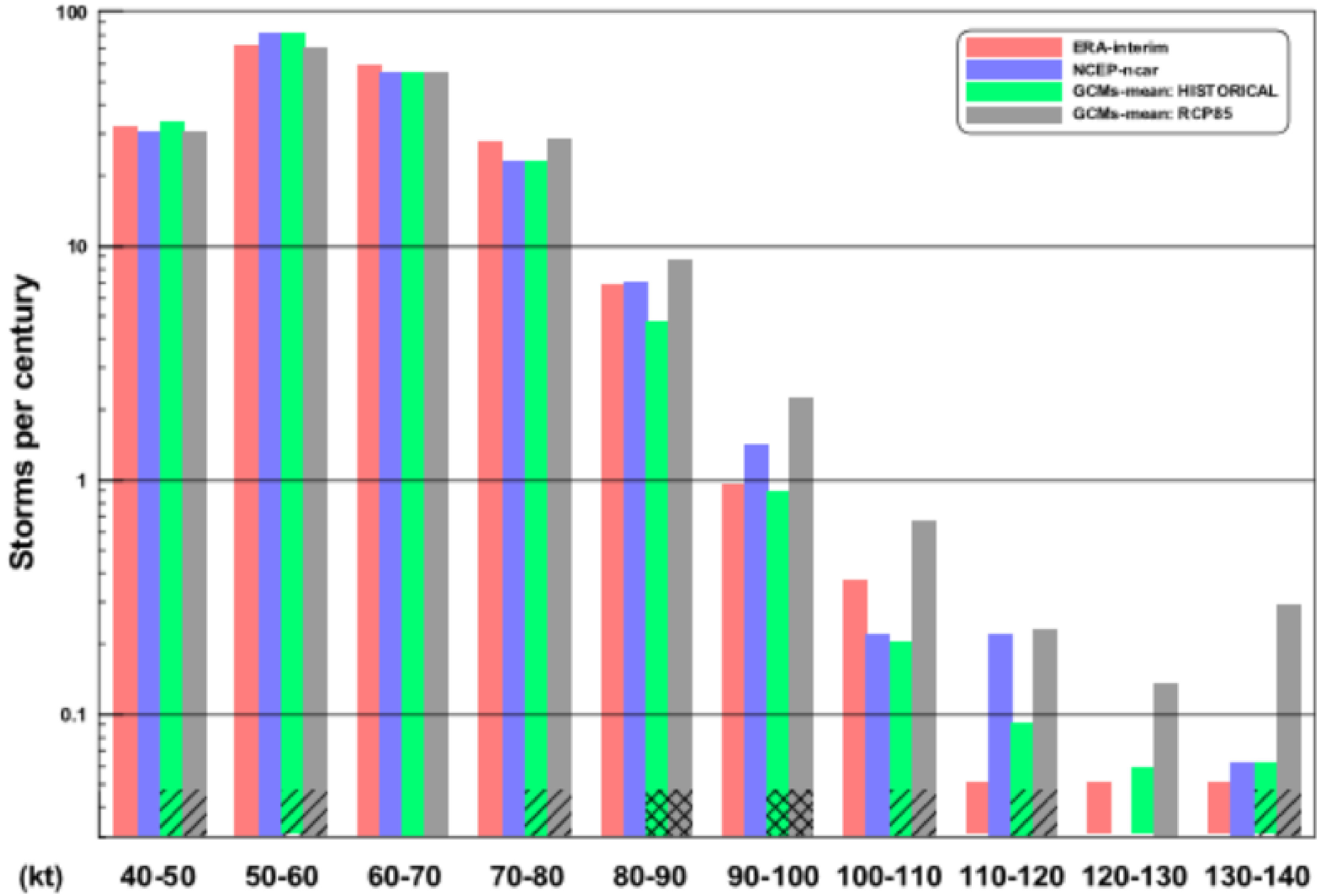



ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Storms per century
10000
1000
100
10
1
0.1
0.01
0.001
(kt)
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140


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


TRACK DENSITY (historical) ERA-interim
#/100km century
2 8 14 20 26
WHEN > 34 kt
TRACK DENSITY (historical) NCEP-ncar
#/100km century
2 8 14 20 26
WHEN > 34 kt
TRACK DENSITY (historical) GCMs (MEAN)
#/100km century
2 8 14 20 26
WHEN > 34 kt
TRACK DENSITY (rcp85) GCMs (MEAN)
#/100km century
2 8 14 20 26
WHEN > 34 kt


RETURN PERIOD (historical) ERA-interim
TIME years 1 4 6 8 10 50 500 5000
WIND > 60 kt
RETURN PERIOD (historical) NCEP-ncar
TIME years 1 4 6 8 10 50 500 5000
WIND > 60 kt
RETURN PERIOD (historical) GCMs (MEAN)
TIME years 1 4 6 8 10 50 500 5000
WIND > 60 kt
RETURN PERIOD (rcp85) GCMs (MEAN)
TIME years 1 4 6 8 10 50 500 5000
WIND > 60 kt


ERA-interim
NCEP-ncar
GCMs-mean: HISTORICAL
GCMs-mean: RCP85
Storms per century
100
10
1
0.1
(kt)
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140

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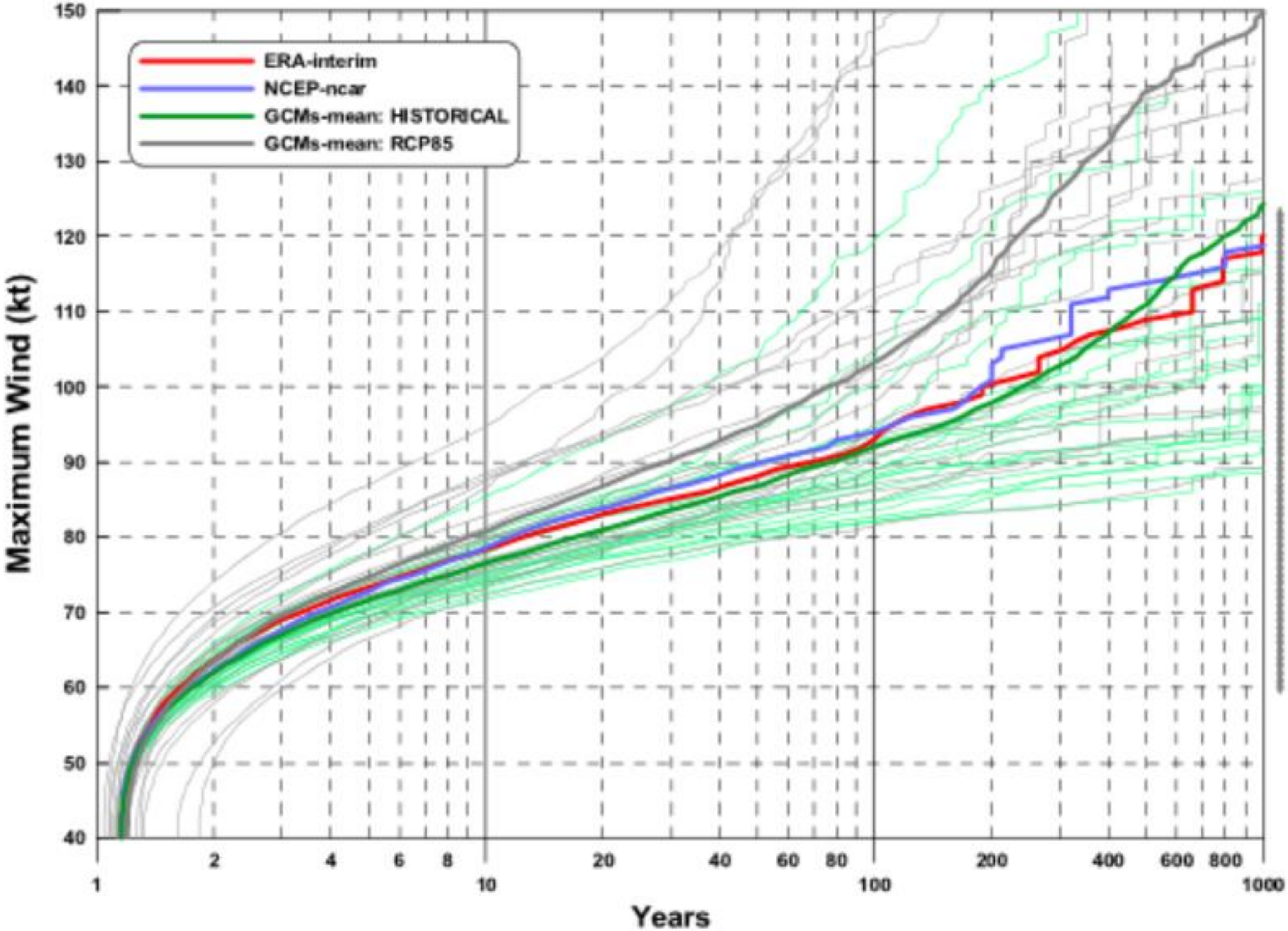
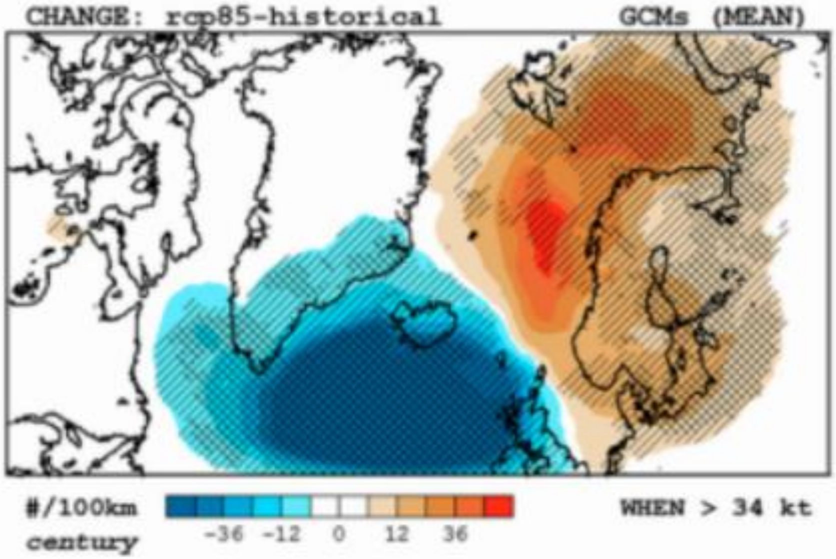


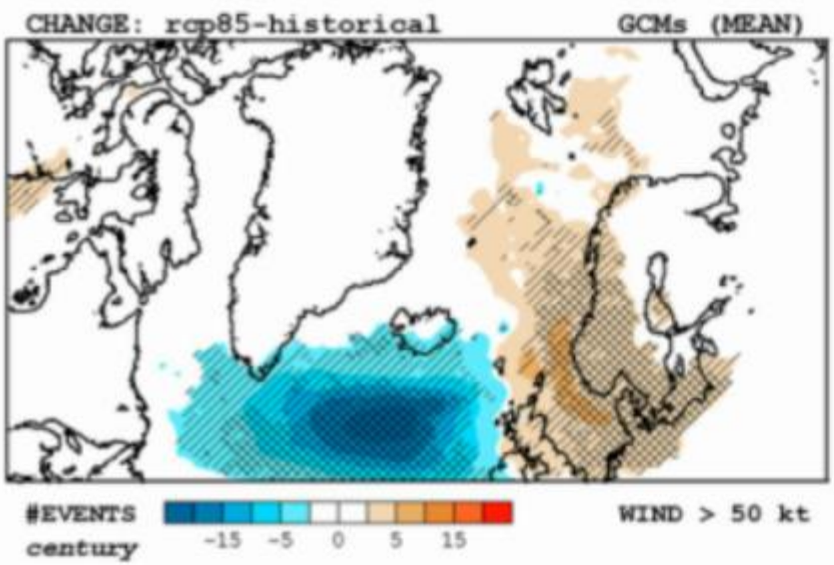
(i) We expect a reduction in the overall frequency of events that would uniformly affect the full spectrum of storm intensities over all cold season months. The annual number of NA polar lows would be lowered by 10%–15% on average with respect to the historical rate, but there is great uncertainty in the frequency change among models.

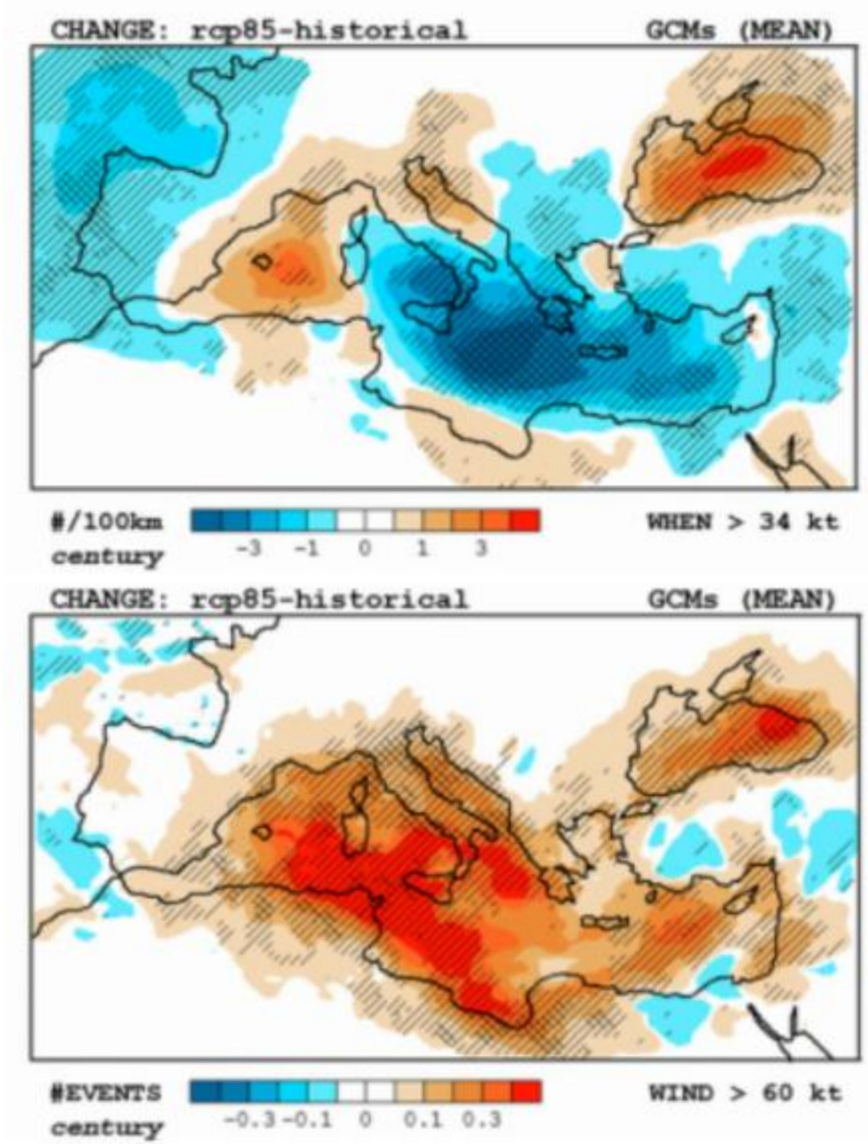
(ii) The future decrease of polar lows is far from uniform across the North Atlantic basin. Rather, a very robust regional redistribution of cases is projected—namely, a shift of polar low activity from the south Greenland–Icelandic sector toward the Nordic seas closer to Scandinavia.

(iii) Future conditions do not seem to lead to any significant variation in the relative weights of weak, moderate, and strong polar lows at basin scale. But since the number of storms is expected to decrease, we project a reduced probability of any surface wind threshold (i.e., longer return periods), considering the basin as a whole.

(iv) Again, large regional variability is expected, and while the future risk of strong polar low winds is projected to be lower in the western half of the North Atlantic, more extreme events are expected eastward, thus potentially affecting the coasts of Europe.







(i) Future change in the number of medicanes is unclear (on average the total frequency of storms does not vary), but a profound spatial redistribution is found. Our method projects an increased occurrence of medicanes in the western Mediterranean and Black Sea, balanced by a reduction of storm tracks in contiguous areas, particularly in the central Mediterranean.

(ii) The probability of medicanes may increase during the summer while it may decrease during the late fall and winter; the probability maximum will still occur around October.

(iii) We found a remarkable modification of the spectrum of lifetime maximum winds; the results project a higher number of moderate and violent medicanes at the expense of weak storms.

(iv) In particular, future extreme events (winds > 60 kt) become more likely in all Mediterranean regions, and the probability of violent medicanes (winds > 90 kt) for the basin as a whole more than doubles the current risk. As the destructive power of the storms is proportional to the wind speed cubed, these projected changes of storm intensity raise concern about the future vulnerability of Mediterranean coastal provinces.

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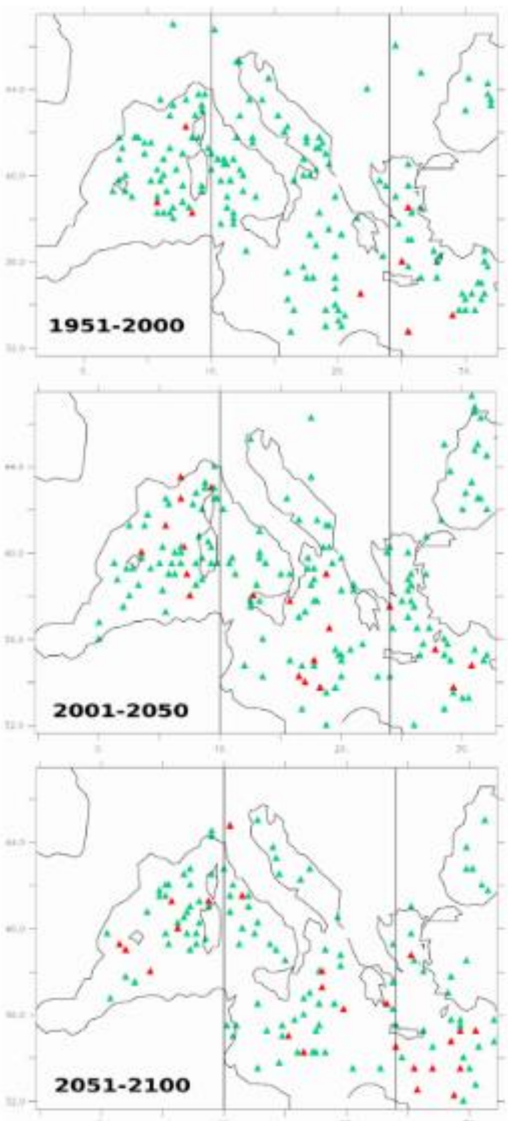

ELSEVIER

Global and Planetary Change

Volume 151, April 2017, Pages 134-143

Climate change projections of medicanes with a large multi-model ensemble of regional climate models

Raquel Romera [a], Miguel Ángel Gaertner [b], Enrique Sánchez [b], Marta Domínguez [c], Juan Jesús González-Alemán [a], Mario Marcello Miglietta [d]

No clear future changes are found in the monthly distribution of medicanes, but again a few noticeable exceptions are seen, as in two simulations a shift towards an earlier monthly maximum is obtained, together with an increase in August medicanes. On the other hand, the projected decrease in medicanes shows some dependence on the spatial distribution. The central zone of the Mediterranean Sea, which presently is the subregion with a larger number of events, will experience a larger decrease than the western and eastern zones. Remarkably, when the Mediterranean Sea is divided into northern and southern subregions, no future medicane decrease is identified in the southern part, in clear contrast to the northern part. At the same time, the extreme intensity of medicanes is projected to increase more clearly in the southern part.

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Geophysical Research Letters

AN AGU JOURNAL

Research Letter | Free Access

Heavy precipitation in a changing climate: Does short-term summer precipitation increase faster?

Nikolina Ban, Juerg Schmidli, Christoph Schär

Consistent with conventional climate models [*Collins and Knutti*, 2013], high-resolution climate change simulations project pronounced decreases in mean summer precipitation over middle and southern Europe. We demonstrate that this decrease is associated with frequency reductions of small and intermediate precipitation events. On daily and hourly time scales, heavy events are projected to become more frequent and more intense, but not as pronounced as in some previous studies. In particular, in distinction to previous studies, we find that even at hourly time scales these increases are consistent with the Clausius-Clapeyron scaling, i.e., with an intensity increase of up to 6–7% per degree warming. Our analyses did not reveal any indication of a faster (superadiabatic) intensity increase with changing climate, although our model replicates the respective scaling for the current and future climate [*Ban et al.*, 2014] (see also Figure S8 in the supporting information). The inability to extrapolate from present-day superadiabatic scaling into the future is due to changes in the fraction of wet hours (see Figure S4 in the supporting information).

Our results are of significant importance, since they suggest that a comparatively simple scaling relationship can be used as a tool for climate change adaptation in the area of heavy precipitation. In particular, it is highly remarkable that the projected percentage increases in high-percentile hourly events exhibit comparatively little geographical structure (Figure 3), despite the presence of complex topography and pronounced patterns in absolute precipitation amounts.

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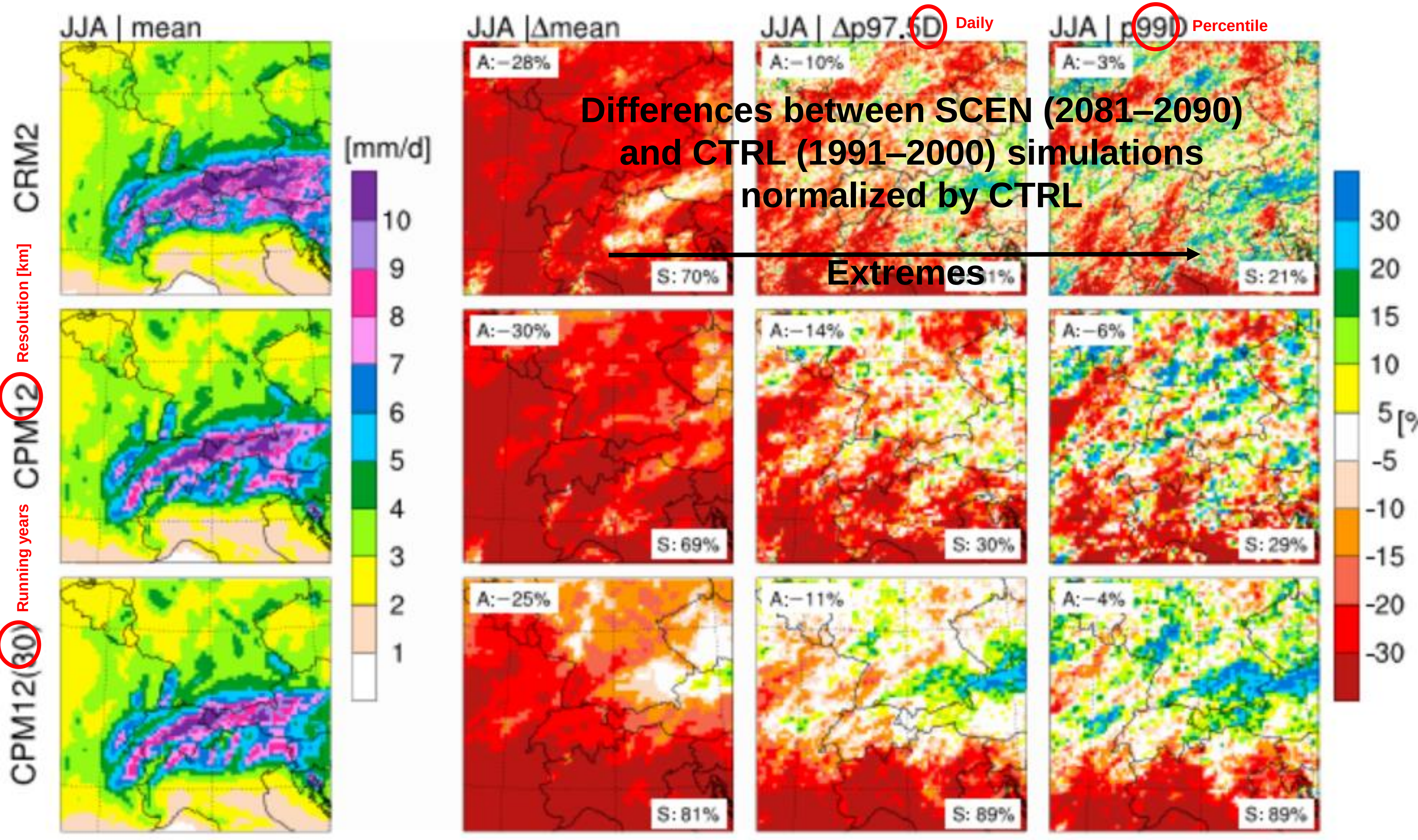

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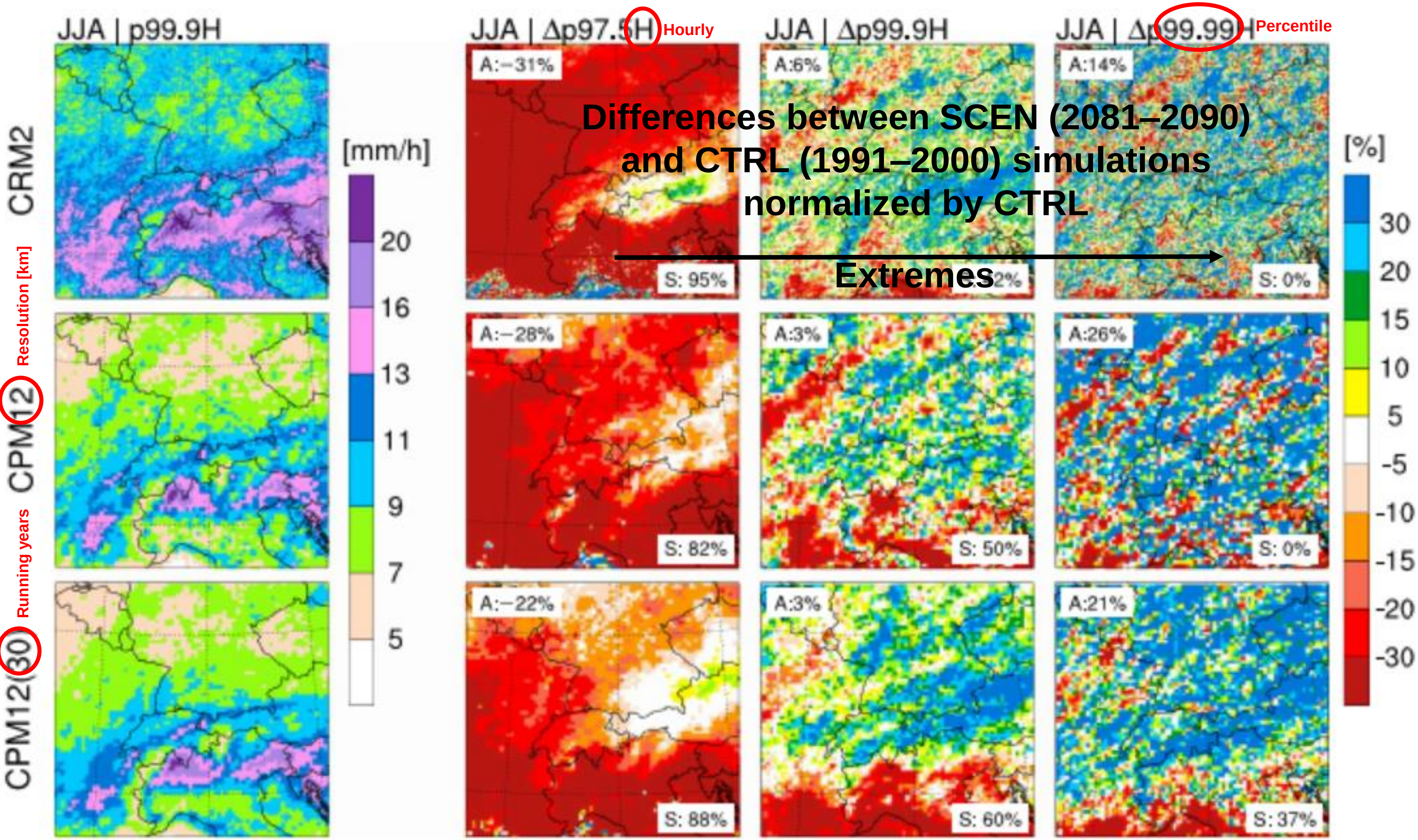

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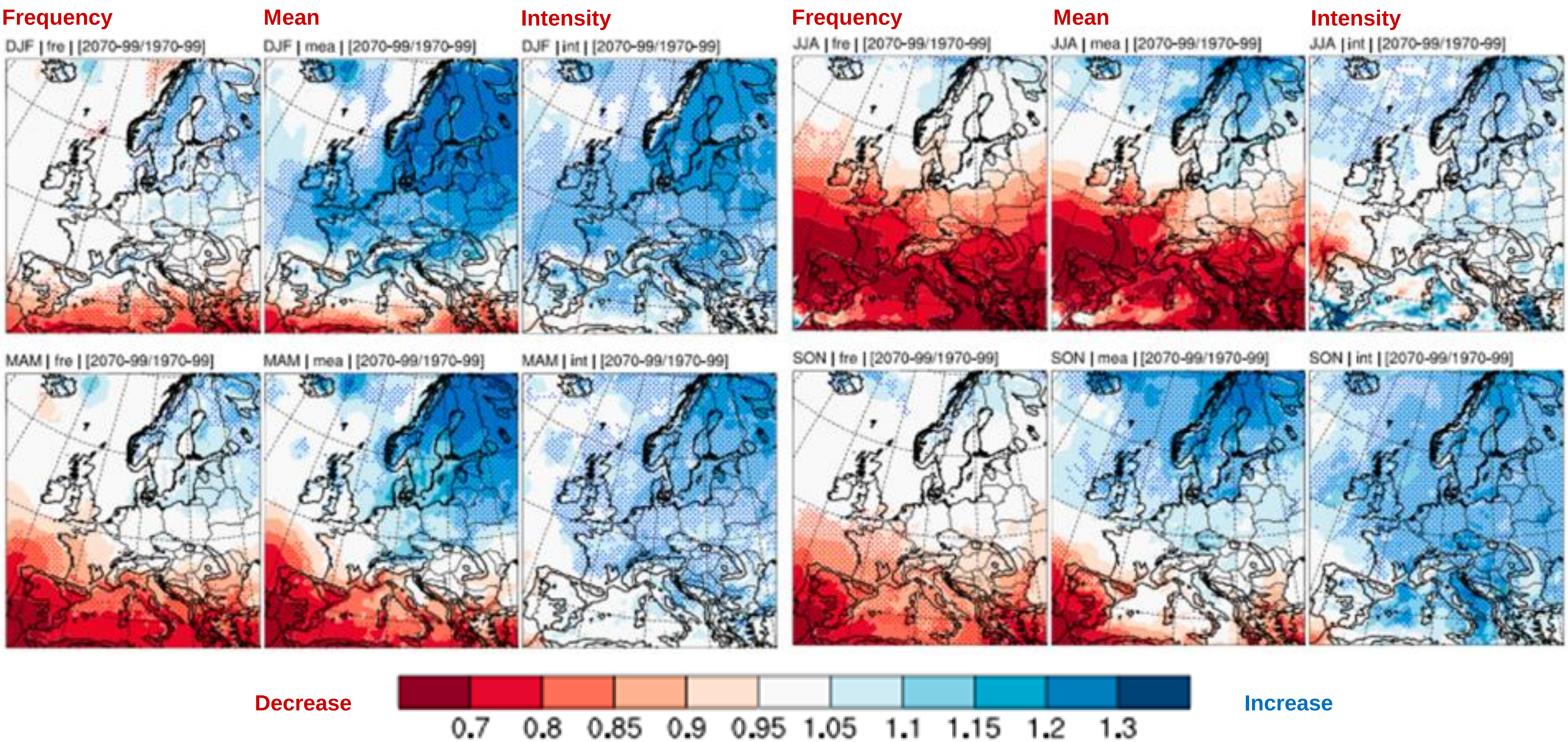
JOURNAL OF GEOPHYSICAL RESEARCH
Atmospheres
AN AGU JOURNAL

Regular Article | Free Access

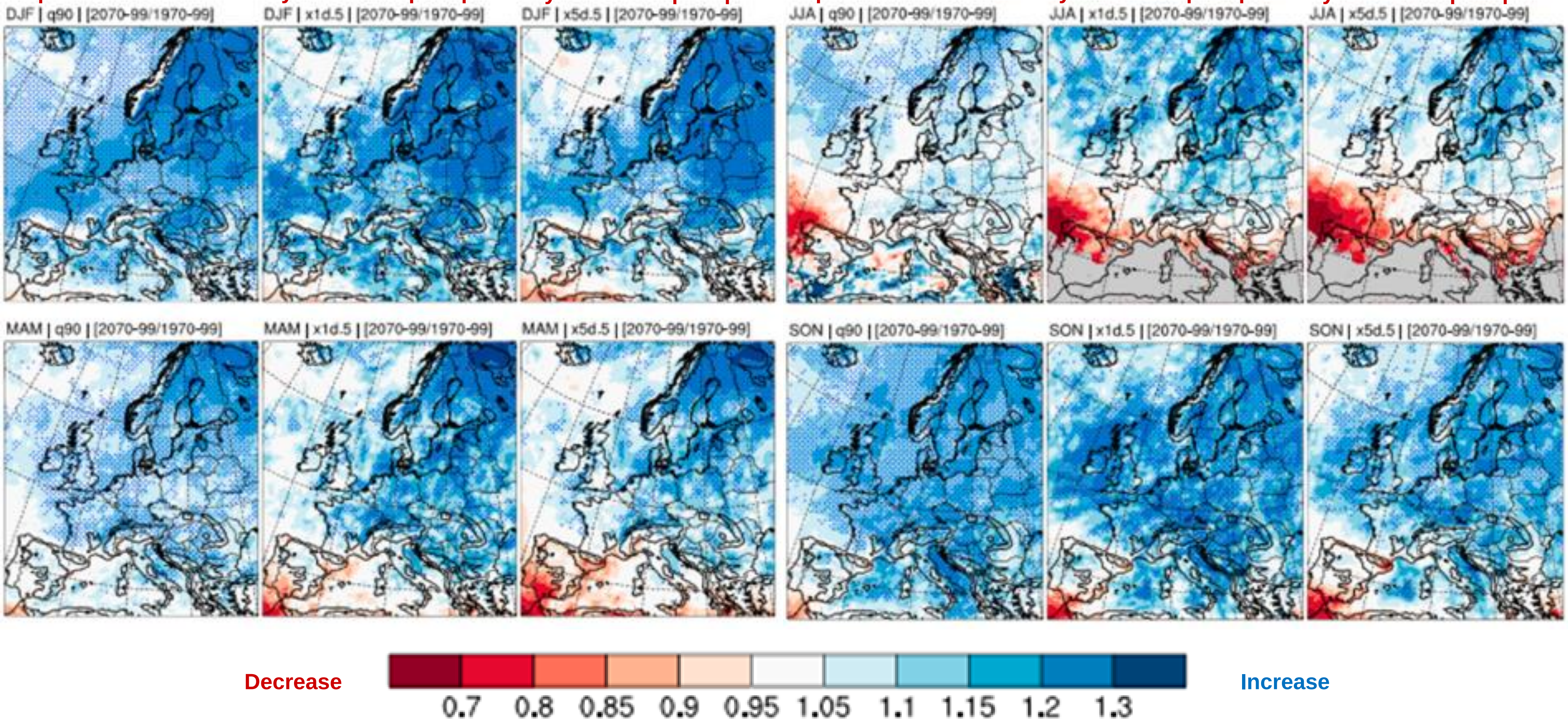
Projections of extreme precipitation events in regional climate simulations for Europe and the Alpine Region

J. Rajczak, P. Pall, C. Schär

[68] The presented projections suggest that remarkable changes in the character of European precipitation are to be expected by the end of the 21st century. The results imply a rising probability of more frequent extreme precipitation events and extended dry spells.


Frequency
Mean
Intensity
Frequency
Mean
Intensity
DJF | fre | [2070-99/1970-99]
DJF | mea | [2070-99/1970-99]
DJF | int | [2070-99/1970-99]
JJA | fre | [2070-99/1970-99]
JJA | mea | [2070-99/1970-99]
JJA | int | [2070-99/1970-99]
MAM | fre | [2070-99/1970-99]
MAM | mea | [2070-99/1970-99]
MAM | int | [2070-99/1970-99]
SON | fre | [2070-99/1970-99]
SON | mea | [2070-99/1970-99]
SON | int | [2070-99/1970-99]
Decrease
0.7 0.8 0.85 0.9 0.95 1.05 1.1 1.15 1.2 1.3
Increase

90 percentile | 5-y return 1-d precip | 5-y return 5-d precip | 90 percentile | 5-y return 1-d precip | 5-y return 5-d precip



Conclusions from future projections in Europe

- Decrease of storm frequency
- Increase of storm intensity
- Increase of frequency of intense summer precipitation

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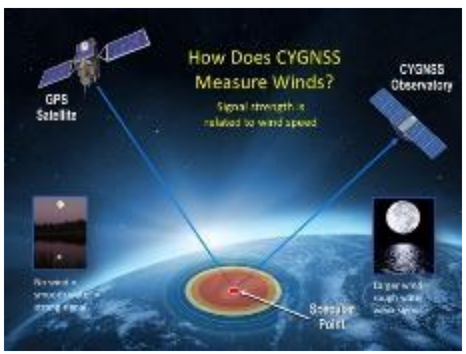
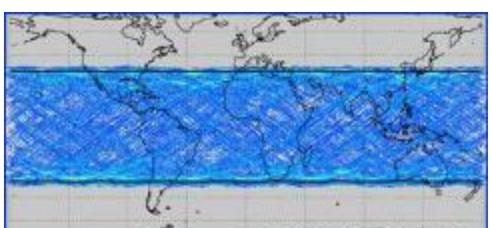
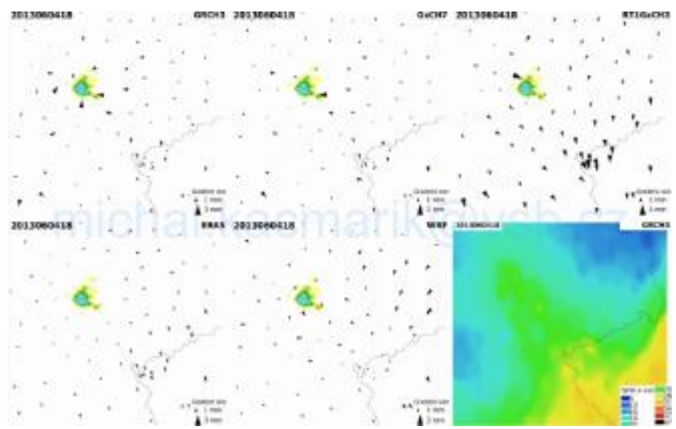
Engage

GNSS for extreme weather

Wind from GNSS

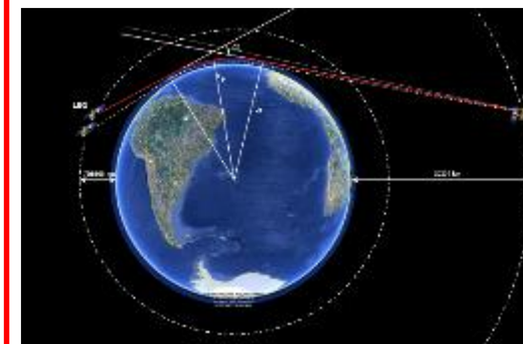


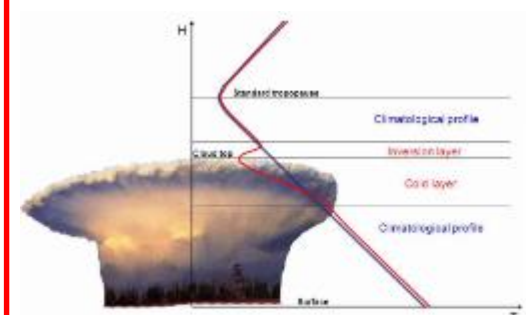


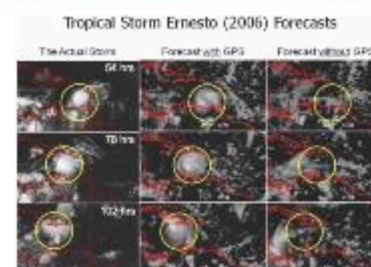


GReD

GNSS RO profiles







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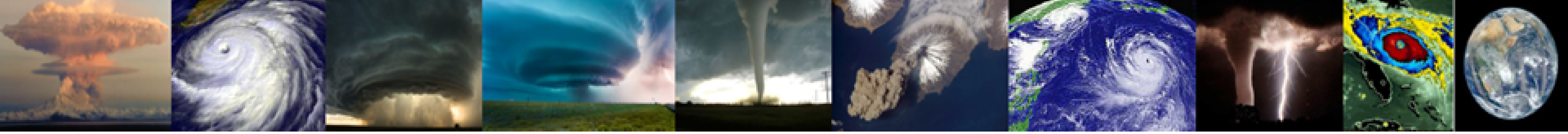
Thank you!



5th International Training School on

Convective and Volcanic Clouds (CVC) detection, monitoring and modeling

Italy, 2-10 October 2019

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Frank Silvio Marzano (La Sapienza Univ., Italy)
Marcello Miglietta (ISAC-CNR, Italy)
Fred Prata (AIRES Ltd, UK)
Dorinel Visoiu (ROMATSA, Romania)

Lecturers

Riccardo Biondi (Univ. of Padova, Italy)
Tatjana Bolic (Univ. of Trieste, Italy)
Hugues Brenot (BIRA, Belgium)
Elisa Carboni (Univ. of Oxford, UK)
Stefano Corradini (INGV, Italy)
Guergana Guerova (Univ. of Sofia, Bulgaria)
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