Mediterranean Cyclones in a changing climate. Results from JMA-GSM model

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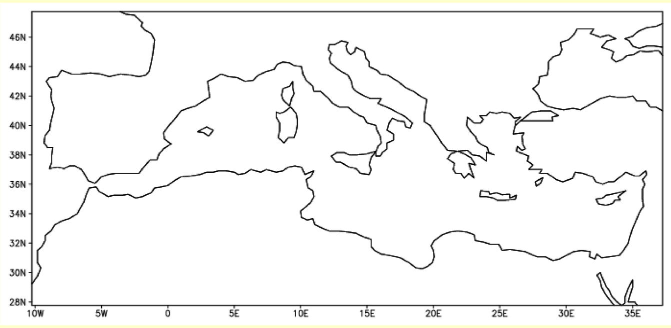
The Mediterranean storms play an important role in weather and climate. Their influence in determining the local weather is known; heavy precipitation systems and strong wind cases are often related to the presence of a cyclone in the Mediterranean. From a large-scale point of view, the Mediterranean storm track has importance in the vertical and horizontal transfers of heat and water vapour towards the Eastern regions. For all of these reasons, any future change related to the intensity, frequency or tracks of these storms can be important for both the local weather and local climate, at least, in the countries around the basin.

In spite of the fact that probably the existing automatic procedures include some large scale assumptions, which may not the best for the correct detection and tracking the Mediterranean storms, these procedures can provide a first and almost necessary step, from a statistical/climatological point of view, specially taking into account both the current resolution of the existent global re-analysis series and global climatic models and the state-of-the art about Mediterranean cyclones.

A cyclone detection and tracking procedure, originally designed for the description of Mediterranean storms, has been applied to the low resolution (1.25 degrees lat-lon) outputs of the JMA-GSM climate general circulation model. Preliminary results are here presented. Two different periods have been analysed. The first period, covering 1979-2002 has been compared with the previously computed ERA-40 climatology of cyclones. Results agree reasonably well with those obtained from ERA-40, providing confidence to the current climate simulation of JMA-GSM. Once validated the model from the perspective of cyclonic climatology under current climate conditions, the same procedure is applied to a scenario period (2075-2099) to investigate possible changes in cyclonic activity linked to climate change.



Time: 00, 06, 12, 18
Domain: lat[26.25N:48.75], lon[11.25W:37.50E]
Methodology of cyclone detection: Picornell et al. (2001)

Resolution and External Forcings of the used Datasets

	ECMWF ERA-40 (1957-2002) (Uppala et al., 2005)	JMA-GSM (Mizuta et al., 2006)	
Target time	20 Century Climate 1979-2002	20 Century Climate 1979-2002	End of 21th Century 2075-2099
Horiz. Resolution ~120-125 km	3D-Var analysis T_L159L60 1.125º	AGCM T_L159L40 1.25º	AGCM T_L159L40 1.25º
SST	HadISST1 (b. Nov. 1981) weekly NOAA/NCEP 2D-Var	Observation HadISST	Observation + Change (WCRP CMIP3 MME)
Greenhouse gases	IPCC (1995)	Observation	A1B scenario
Aerosol	Fixed geographical distribution	CTM climatology (1991-2000)	CTM climatology (1991-2000)

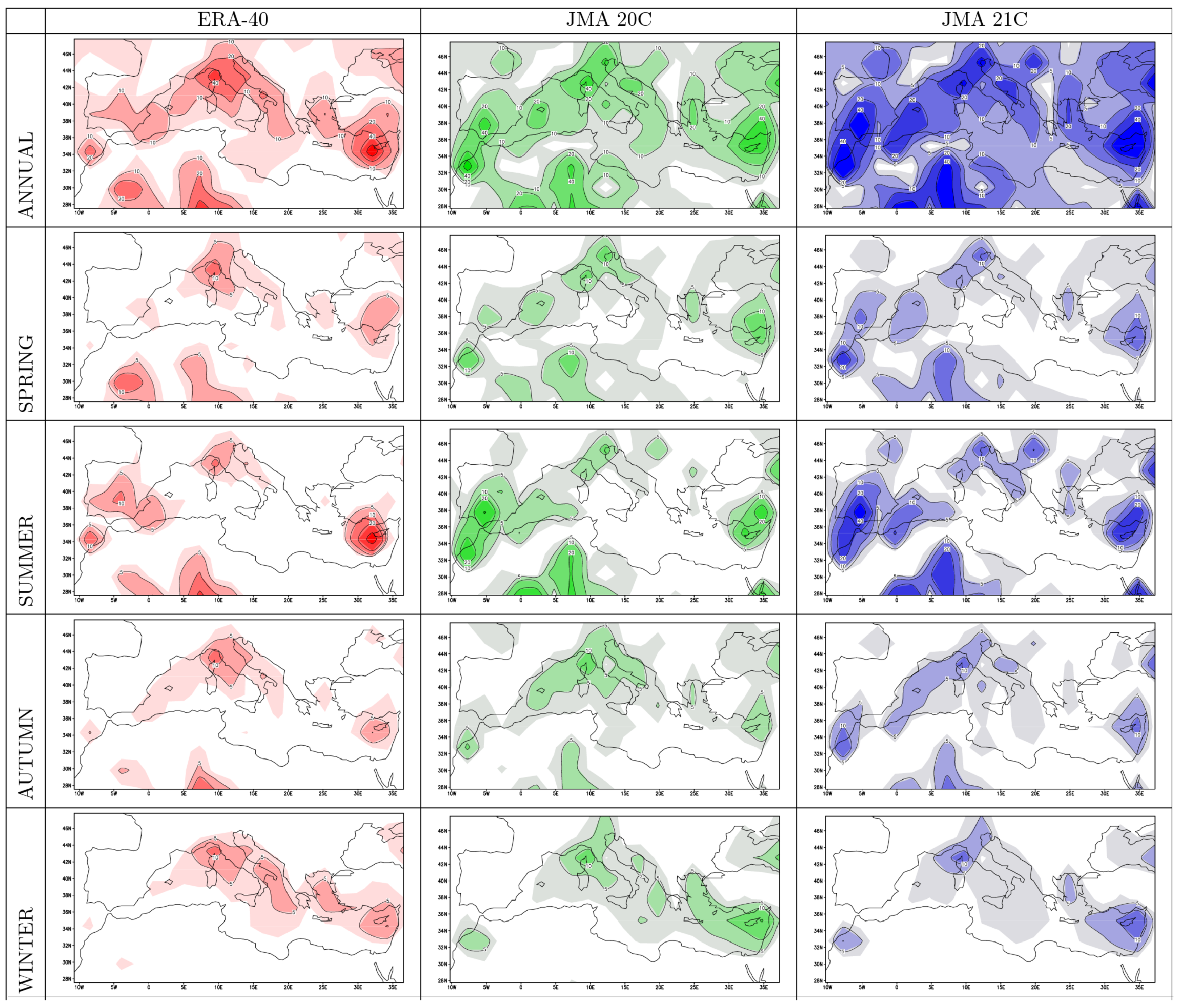


Fig.1 Annual/Seasonal frequency of cyclonic centres. Annual contour intervals: 5 (only shaded), 10, 20, 40, 60.
Seasonal intervals: 2.5 (only shaded), 5, 10, 20, 40.

Radius	ERA-40	JMA 20C	JMA 21C
Median	512	462	453
Mean	514	462	528
Max	822	912	819

Intensity	ERA-40	JMA 20C	JMA 21C
Median	3.7	3.3	3.2
Mean	4.0	3.6	3.5
Max	14.7	14.7	14.9

Lifetime	ERA-40	JMA 20C	JMA 21C
Median	12.0	6.0	6.0
Mean	14.2	13.1	13.0
Max	186	162	198

Track length	ERA-40	JMA 20C	JMA 21C
Median	537	541	536
Mean	655	654	637
Max	3935	3398	3161

Fig.2 Some statistical parameters for radius (in km), intensity (geostrophic circulation, in cgu), lifetime (in hours) and track length (of at least 300 km, in km) of cyclone centres. [1 cgu= 10^7 m^2 s^{-1}].

	ERA-40	JMA 20C	JMA 21C
intense	47.5	53.4	45.0
moderate	451.4	512.7	547.6
72 hours	7.4	7.0	6.8
48 hours	29.6	30.7	32.6
24 hours	137.2	154.0	152.3
non-stationary	156.4	173.8	159.7
non-stationary + 48 hours	29.1	24.9	30.8

Fig.3 Mean number of cyclone centres per year for intense (GC ≥7 cgu), moderate (7 > GC ≥ 3 cgu), 72/48/24 hours (lifetime ≥ 72/48/24 h),non-stationary (track length ≥ 300 km) and non-stationary and lifetime of at least 48 h, cyclones.

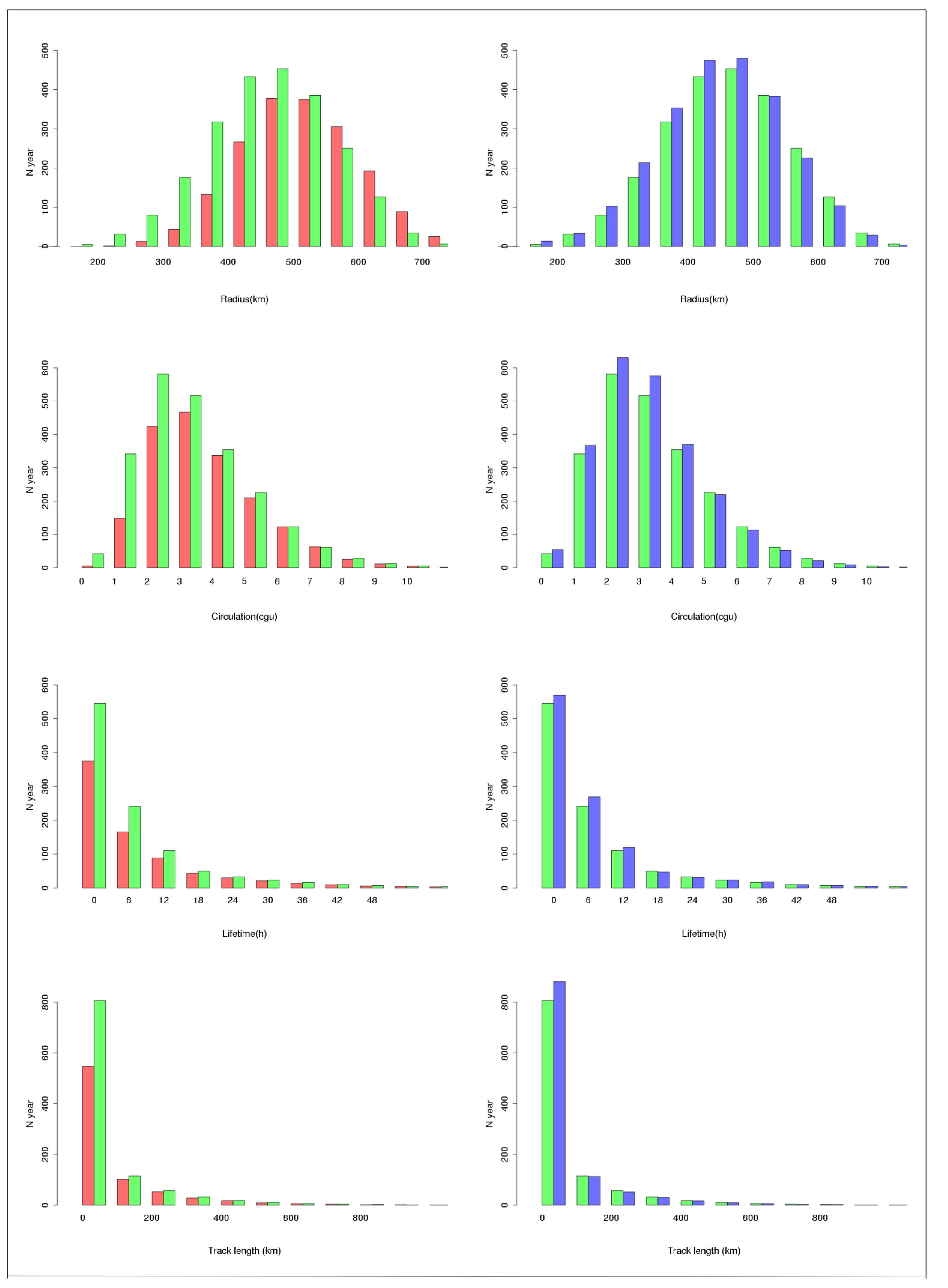


Fig.4 Histograms (number per year) of mean radius (km), geostrophic circulation (cgu), lifetime (h) and track length (km) of all the cyclone centres. Red bars are ERA-40, green are JMA-GSM 20C and blue are JMA-GSM 21C.

		ERA-40	JMA 20C	JMA 21C
N year	**Annual**	**767**	**1051**	**1207**
	Spring	237	301	324
	Summer	236	368	485
	Autumn	152	208	227
	Winter	145	177	177
R mean	**Annual**	**514**	**462**	**528**
	Spring	517	466	458
	Summer	474	435	430
	Autumn	514	465	456
	Winter	558	498	492
GC mean	**Annual**	**4.0**	**3.6**	**3.5**
	Spring	4.1	3.8	3.7
	Summer	3.2	3.1	3.2
	Autumn	3.9	3.5	3.4
	Winter	4.9	4.4	4.2

Fig.5 Values of number of cyclone centres per year/season (N year) in all domain, the mean radius (R mean, in km) and mean geostrophic circulation (GC mean, in cgu), in ERA-40 (red), JMA 20C (green) and JMA 21C (blue).

VALIDATION: ERA-40 & JMA 20C

Spatial distribution is quite well represented. Zones of maximum frequency of cyclone centres in ERA-40 are also reproduced in JMA 20C: Gulf of Genoa, Cyprus, Aegean Sea, Iberian Peninsula and Sahara. These two last zones have more cyclone centres in JMA 20C, especially in summer (see the annual distribution). These lows are mostly thermal lows which form in summer, over the warm land, and have short lifetime and small radius.

Radius and circulation distributions are similar, but cyclone centres are a little shorter and weaker in JMA 20C. Nevertheless, extreme values are greater or the same in JMA 20C. Lifetimes and track lengths are smaller.

If we discard short length and short lifetime events, the number of cyclones is similar in both models. Intense cyclones and cyclones with a long track are more frequent in JMA 20C.

PREDICTION: JMA 20C & JMA 21C

According to JMA-GSM model, spatial distribution will be similar as present one. The number of events will increase, specially in summer. In Fig.1, the contoured zones (of at least 10 cyclonic centers per year) in the annual distribution cover the most part of the region.

Future cyclones are bigger. Intensity, lifetime and track length are quite similar.

If we discard short length and short lifetime events, the trends change. The number of intense cyclones will decrease, but the number of moderate cyclones will increase. The frequency of cyclones with a track of at least of 300 km will decrease, but the number of the ones which their lifetime is of at least 48 hours increases.

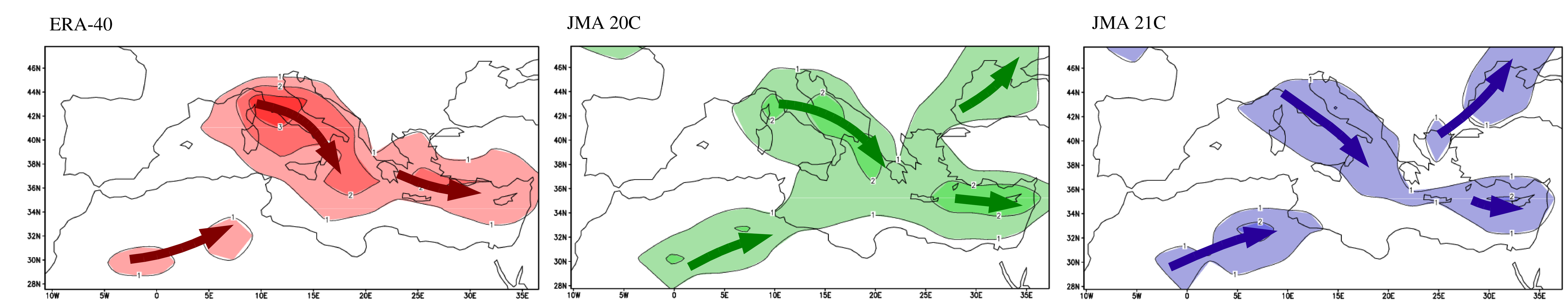


Fig.6 Track density for cyclones with an intensity of at least 7 cgu, movement of at least 300 km and lifetime of at least 18 h.

TRACKS: ERA-40 , JMA 20C & JMA 21C

One difference between ERA-40 and JMA 20C is the dispersion of cyclones in JMA 20C around Italy. Cyclones originated in Gulf of Genoa move preferently to Ionian Sea and cyclones originated in Aegean Sea move to Cyprus, in both datasets.

African lows in ERA model are more stacionary than in JMA 20C, but their preferent path is the same.

The most important difference is near the Black Sea. In JMA 20C, there is an important path to northeast direction not present in ERA-40 .

In the future, there will be less intense cyclones, but their preferent paths will be very similar to the present: a decrease is observed in Genoa and an increase in North Africa.

VALIDATION:

- The most important differences between ERA-40 and JMA 20C is that the number of cyclones is larger in JMA 20C, and they are smaller and with a shorter lifetime (mostly thermal lows).

- Statistical parameters are consistent.

- Principal genesis zones and tracks are similarly represented.

PREDICTION:

- The number of cyclones tend to increase in the future, but they will be smaller and weaker.

- Preferent tracks of intense cyclones are nearly the same now and in the future, but a decrease on track density is forecasted in Genoa whereas an increase appears in North Africa.

- These results complement previus ones obtained with longer scale global models (see Lionello et al. (2002) and Anagnostopoulou et al. (2006)).

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Aknowments.

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