STATISTICAL STUDY OF MEDITERRANEAN CYCLONES IN A CHANGING CLIMATE

DELEGACIÓN TERRITORIAL DE AEMET EN ILLES BALEARS

PROYECTO: "ESTUDIO ESTADÍSTICO SOBRE CICLONES EN CLIMA FUTURO"

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AEMet

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気象庁

Japan Meteorological Agency

ESTUDIOS METEOROLÓGICOS DEL MEDITERRÁNEO

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INTRODUCTION

JMA-GSM is an atmosphere general circulation model which has been developed in the Earth Simulator, Japan.
From the output of the climate model JMA-GSM, scenario A1B, we focus on how climate change can affect spatial and temporal cyclone frequencies, and their preferred tracks.

The cyclone detection algorithm by Picornell *et al.* (2001) has been adjusted to JMA-GSM grid characteristics in orden to get their climatology.

First of all, we verify the present time of JMA-GSM using the reanalysis from ECMWF “ERA-40” and afterwards we look for the future time (2079-2099).

CLIMATE MODEL: JMA-GSM

- **LOW RESOLUTION (1,25º): LON~[-65, 50] , LAT~[15,65] , Z=9 + surface , nx=93, ny=41**
  - **VARIABLES:**
    - **SLP (Sea level pressure “Pa”)**
    - **U (Zonal velocity “m/s”)**
    - **V (Meridional velocity “m/s”)**
    - **T (Temperature “K”)**
    - **Q (Specific humedity “kg/kg”)**
    - **Z (Geopotential heigh “M^2/S^2”)**
    - **CWC (Cloud water content “kg/kg”)**
    - **OMEGA (Vertical Pressure velocity “Pa/s”)**

CLIMATE MODEL: JMA-GSM

- **HIGH RESOLUTION (0,1875º): LON~[-64.5,49.3125] , LAT~[15.086,44.883] , nx=608, ny=160**
  - **VARIABLES:**
    - **SLP (Sea level pressure “Pa”)**
    - **ua (Surface velocity, zonal component “m/s”)**
    - **va (Surface velocity, meridional component “m/s”)**
    - **ta (Surface air temperature “K”)**
    - **precipi (Precipitación total “kg m^{-2} s^{-1})”)**
    - **u850, u300 (Zonal velocity in 850 & 300 HPa “m/s”)**
    - **v850, v300 (Meridional velocity in 850 & 300 hPa “m/s”)**
    - **t700, t500, t300 (Temperature in 700, 500 & 300 hPa “K”)**
    - **Omg700, omg500 (Vertical pressure velocity in 700 & 500 hPa “Pa/s”)**

CYCLONE DETECTION ALGORITHM

- **Before applying this algorithm the pressure field has been smoothed using the Cressman filter (r0=200 km), that performs a weighted average for each grid point with the neighbouring when r<r0:**

  Weight ~ $(r0^2 - r^2)/(r0^2+r^2)$

  - **This removes noise and smooths the pressure and vorticity fields.**

It detects a minimum of sea level pressure (SLP) rejecting weak cyclone using an additional criterium where the grandient of preassure is lower than (0,5 Hpa/100 Km) at least in 3 out of 8 directions .

The domain of the cyclone is found in the vorticity field, extending to all grid points with “ξg >0” plus other limiting constraints.

CYCLONE TRACK ALGORITHM

TRACK: Once a cyclone is found, we look for it in the next analysis (+6h) in a domain bounded by three ellipses with a fixed size whose main axis has the same direction than the geostrophic wind in 700 hPa.

$$x^2+(c/b)y^2 - (c-b)x = bc$$

- **Ellipse 1 :(b1= 160 km) c1=max (170 km, 0.5 D)**
- **Ellipse 2: (b2=170 km) c2=max (170 km, 0.8 D)**
- **Ellipse 3: (b3= 180 km) c3=max (180 km, D)**

where: D=1,2*[V(700HPa)*6h] V(km/h)

DOMAIN OF STUDY

LON~[-11.25, 37.5] & LAT~[26.25, 48.75]

CLASIFICATION BY CIRCULATION (ff) AND SEASONS

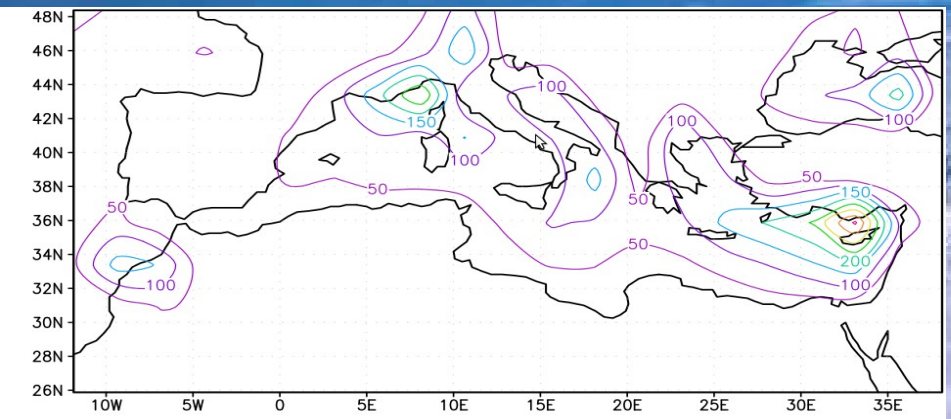
JMA-GSM [1979-1999]: Nº CICLONES	WINTER	SPRING	SUMMER	AUTUMN	TOTAL
WEAK ($ff<2*10^7$)	1016	2047	3365	1600	8028
MODERATE ($2*10^7<ff<6*10^7$)	6027	10118	11408	7517	35070
INTENSE ($6*10^7<ff<12*10^7$)	1973	1632	612	696	4913
VERY INTENSE ($ff>12*10^7$)	17	3	1	1	22
TOTAL	9033	13800	15386	9814	48033

ERA-40 [1979-1999]: Nº CICLONES	WINTER	SPRING	SUMMER	AUTUMN	TOTAL
WEAK ($ff<2*10^7$)	319	894	1359	596	3168
MODERATE ($2*10^7<ff<6*10^7$)	5835	9317	8549	6248	29949
INTENSE ($6*10^7<ff<12*10^7$)	2101	1561	387	769	4818
VERY INTENSE ($ff>12*10^7$)	17	3	0	0	20
TOTAL	8272	11775	10295	7613	37955

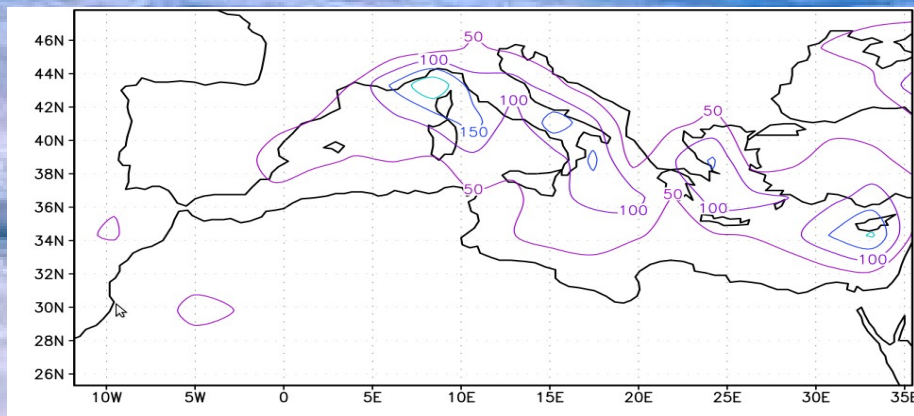
JMA-GSM [2079-2099]: Nº CICLONES	WINTER	SPRING	SUMMER	AUTUMN	TOTAL
WEAK ($ff<2*10^7$)	909	2014	4145	1624	8692
MODERATE ($2*10^7<ff<6*10^7$)	5137	9932	14780	7731	37580
INTENSE ($6*10^7<ff<12*10^7$)	1429	1422	770	630	4251
VERY INTENSE ($ff>12*10^7$)	6	5	0	0	11
TOTAL	7481	13373	19695	9985	50534

LOCATION OF CYCLONES BY SEASONS I: PRESENT TIME,(1979-1999)

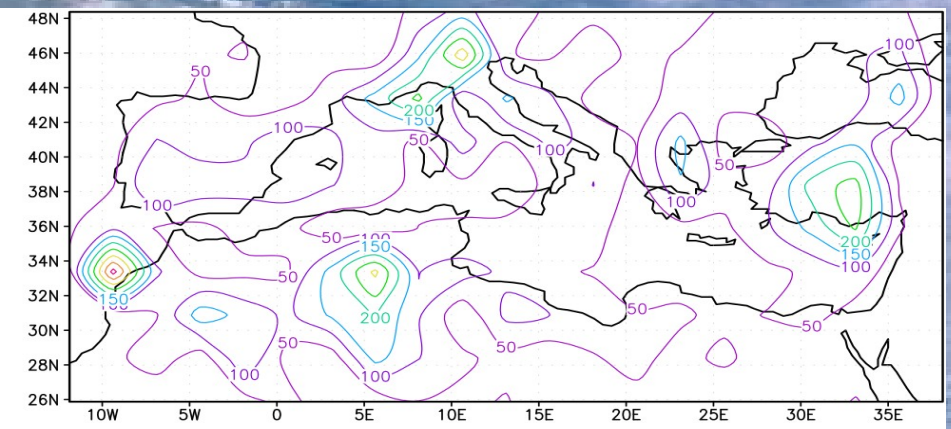
JMA-GSM: WINTER



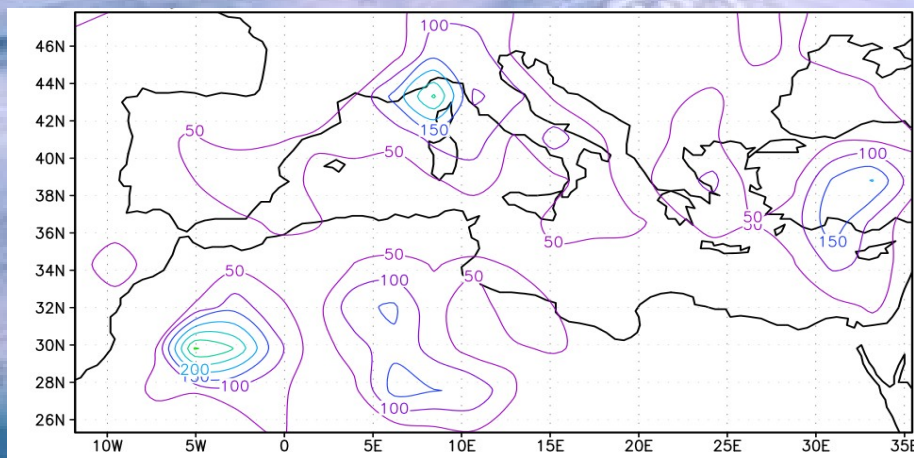
ERA-40:WINTER



JMA-GSM: SPRING

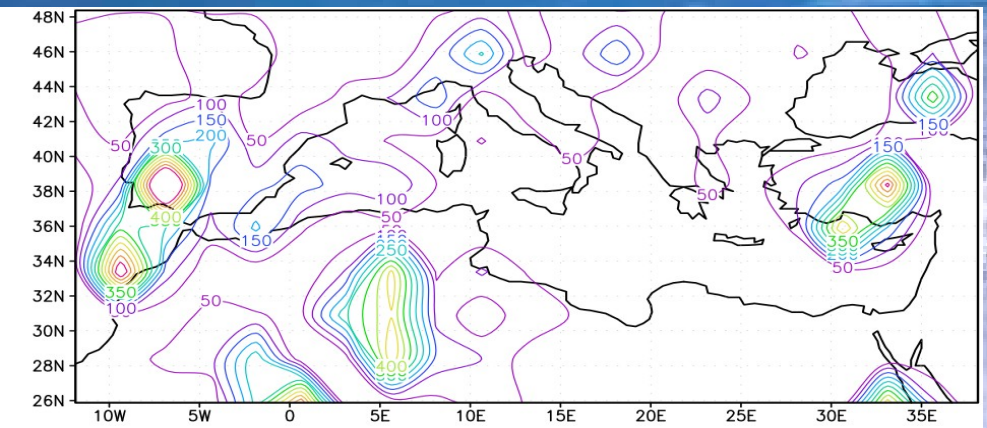


ERA-40:SPRING

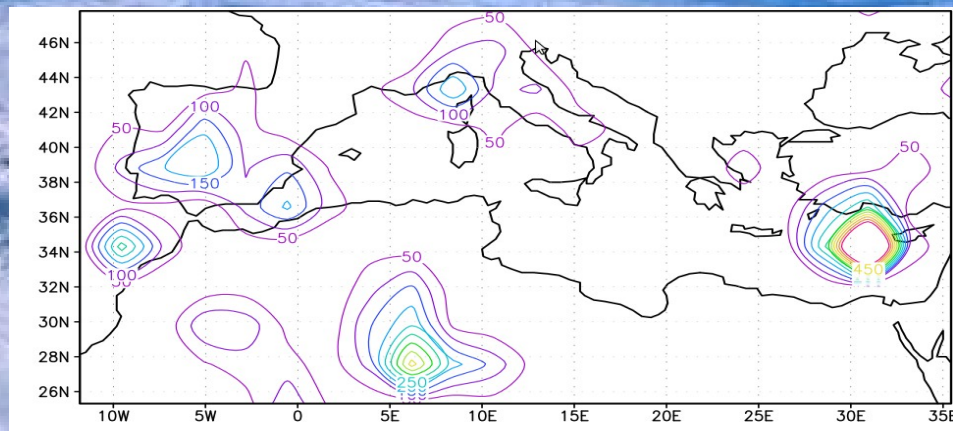


LOCATION OF CYCLONES BY SEASONS I: PRESENT TIME,(1979-1999)

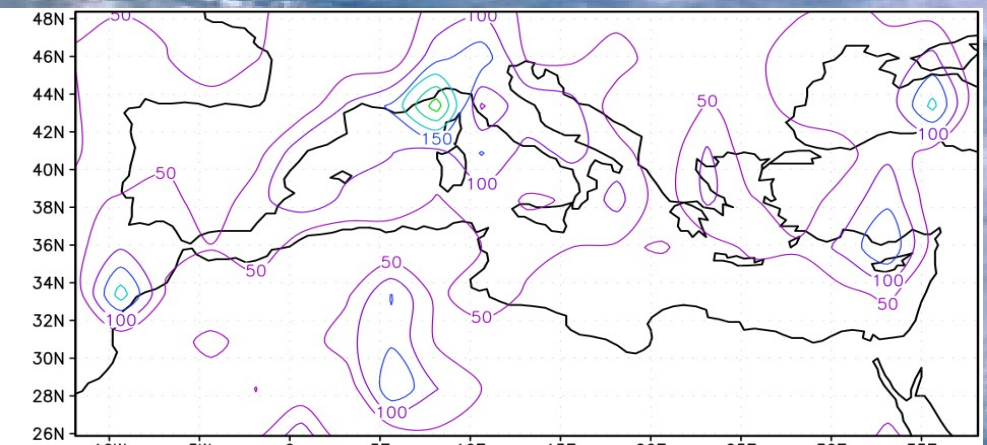
JMA-GSM: SUMMER



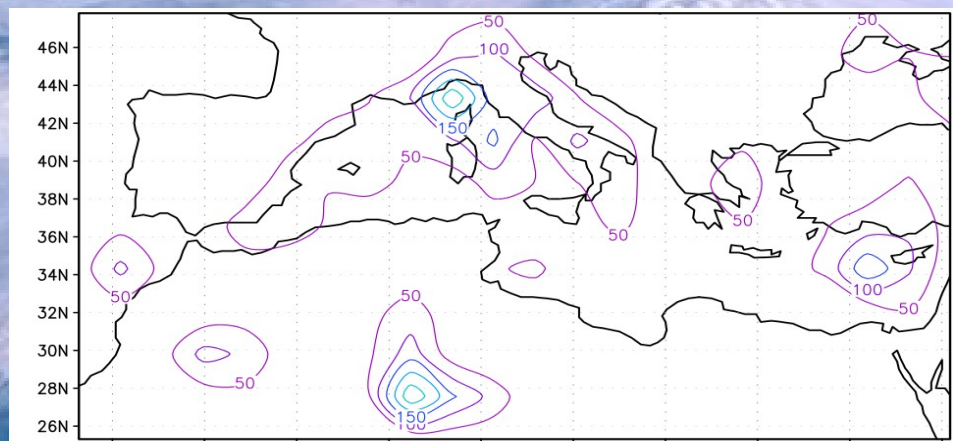
ERA-40: SUMMER



JMA-GSM: AUTUMN

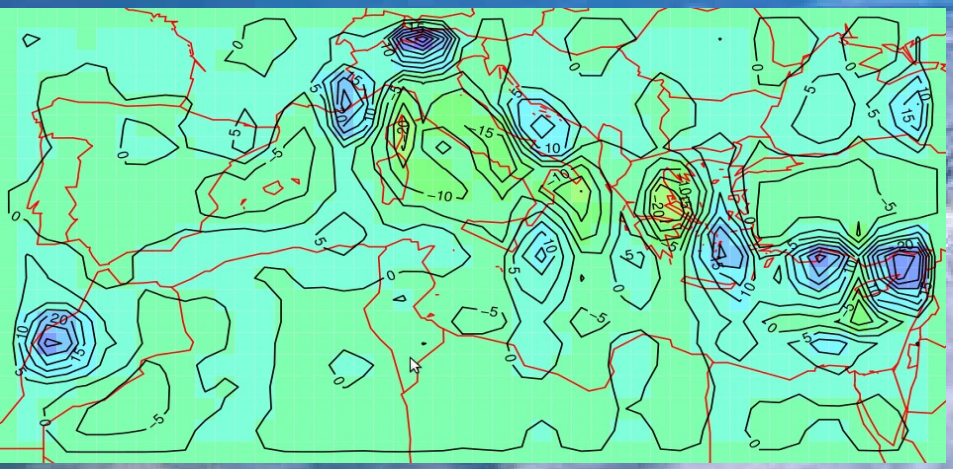


ERA-40:AUTUMN

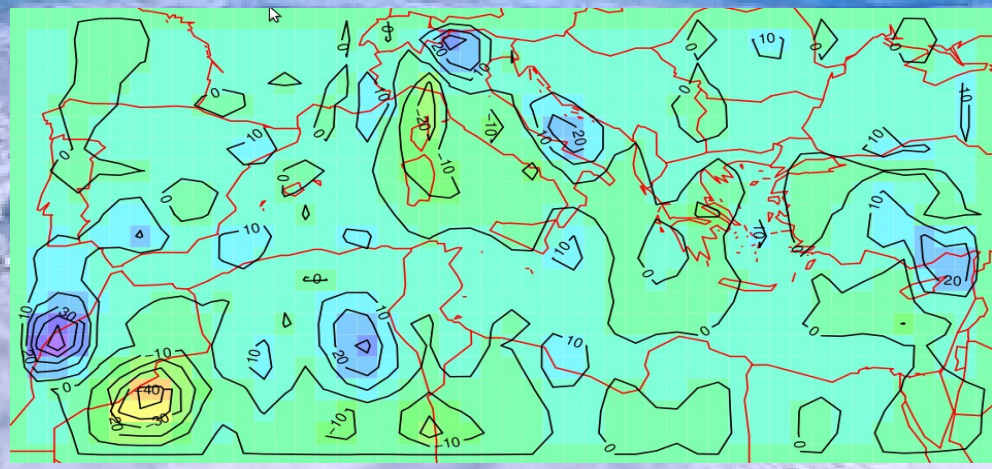


DIFFERENCE BETWEEN JMA-GSM AND ERA-40 (PRESENT TIME)

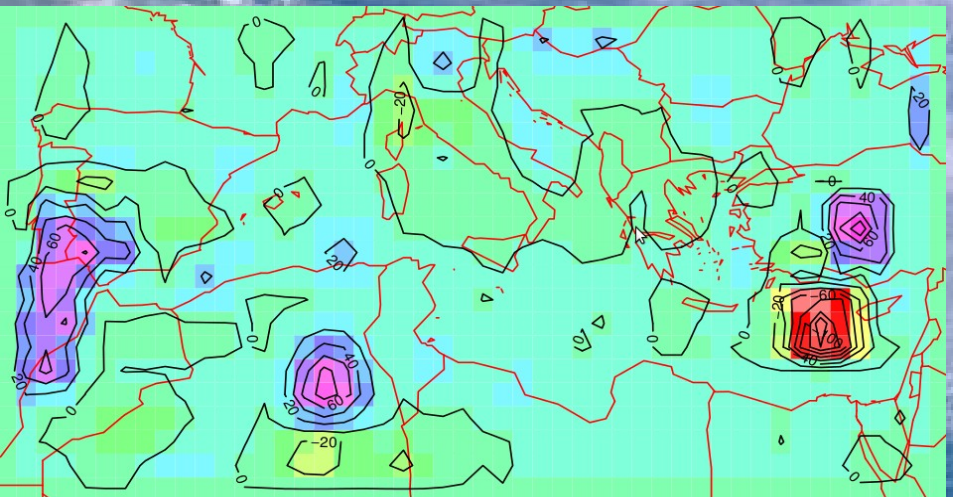
WINTER



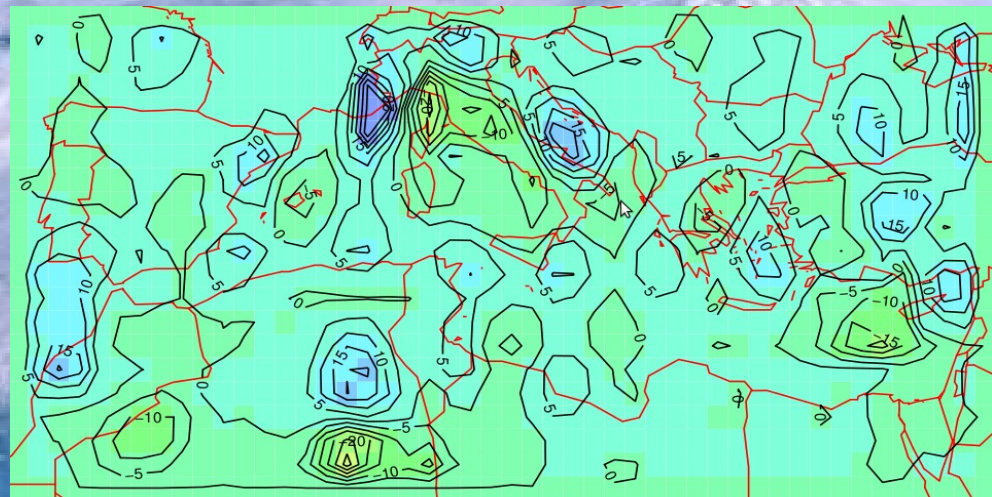
SPRING



SUMMER

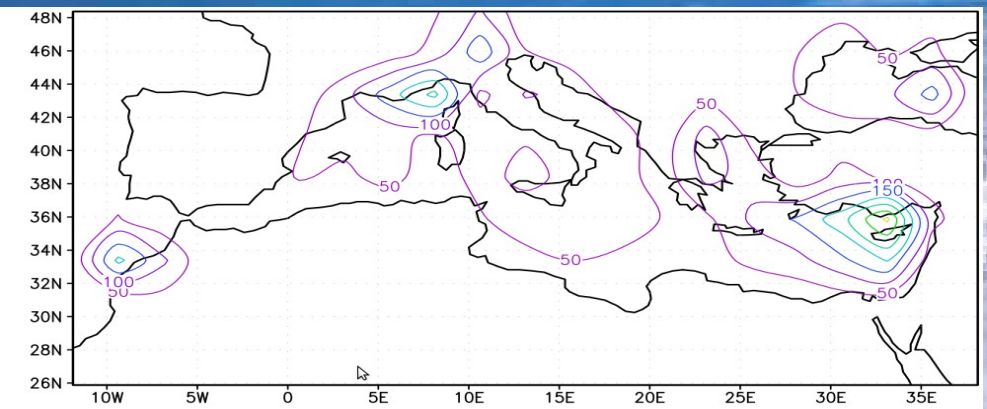


AUTUMN

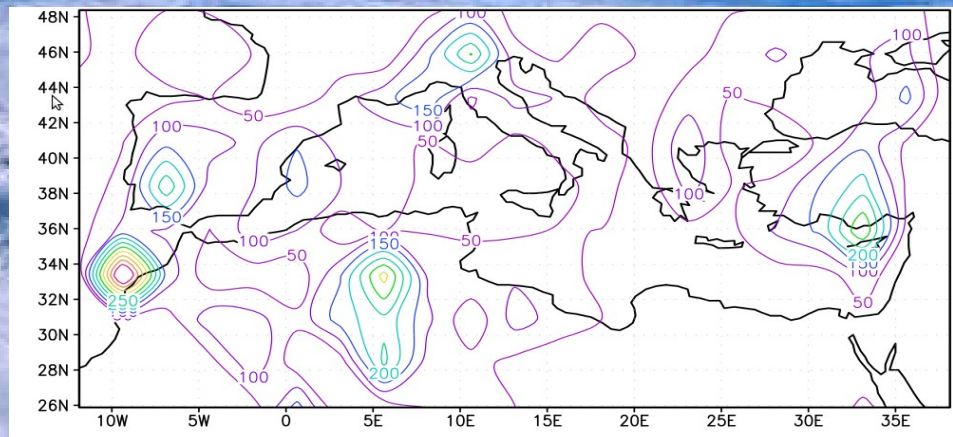


LOCATION OF CYCLONES BY SEASONS II: FUTURE TIME,(2079-2099)

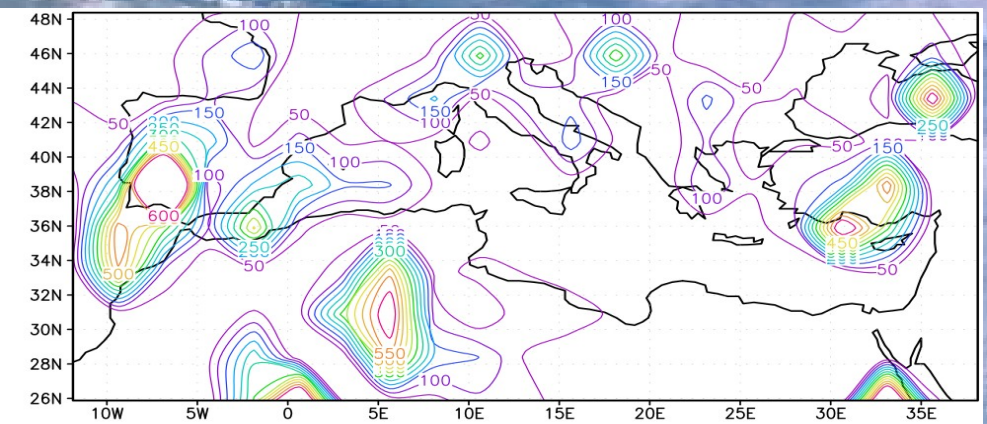
WINTER



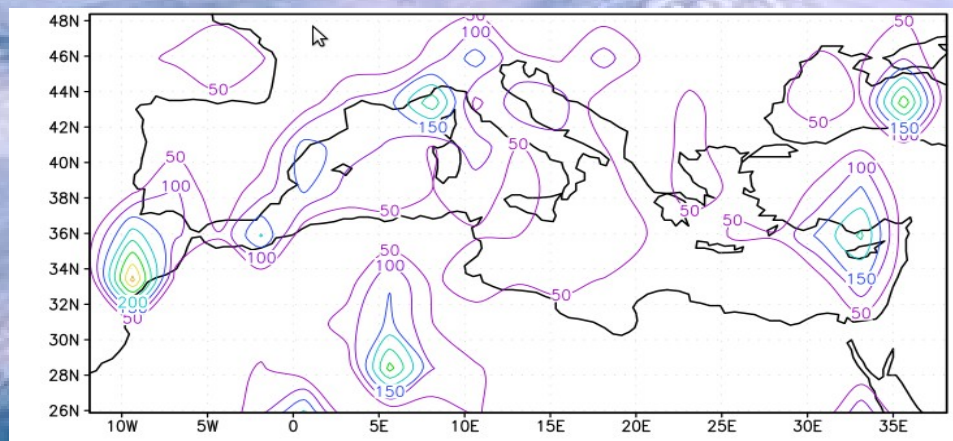
SPRING



SUMMER

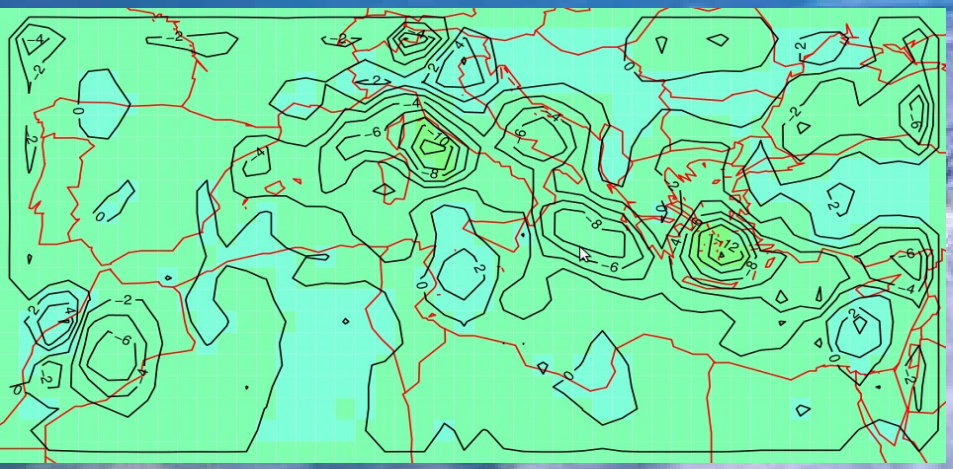


AUTUMN

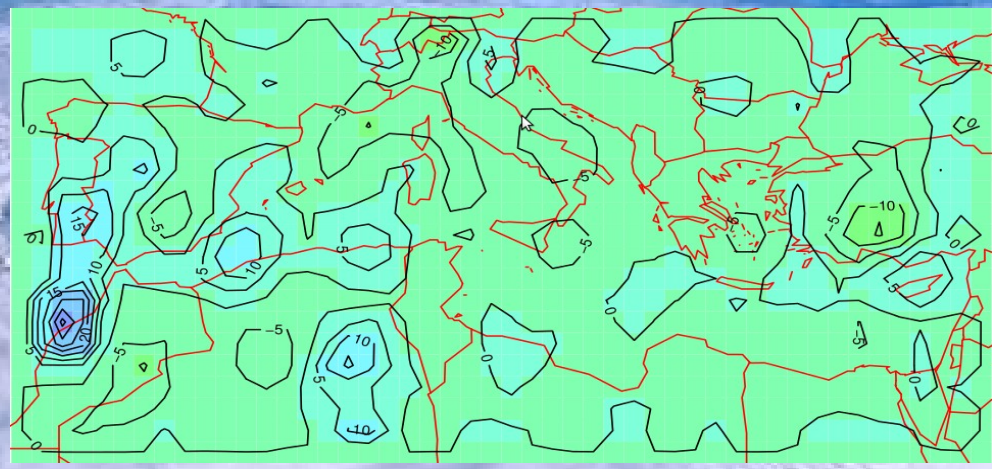


JMA-GSM: DIFFERENCE BETWEEN FUTURE AND PRESENT TIME

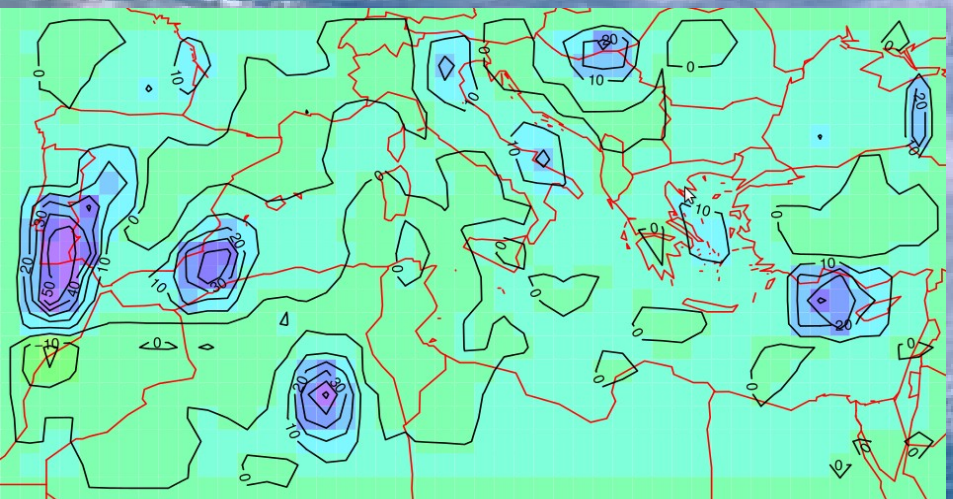
WINTER



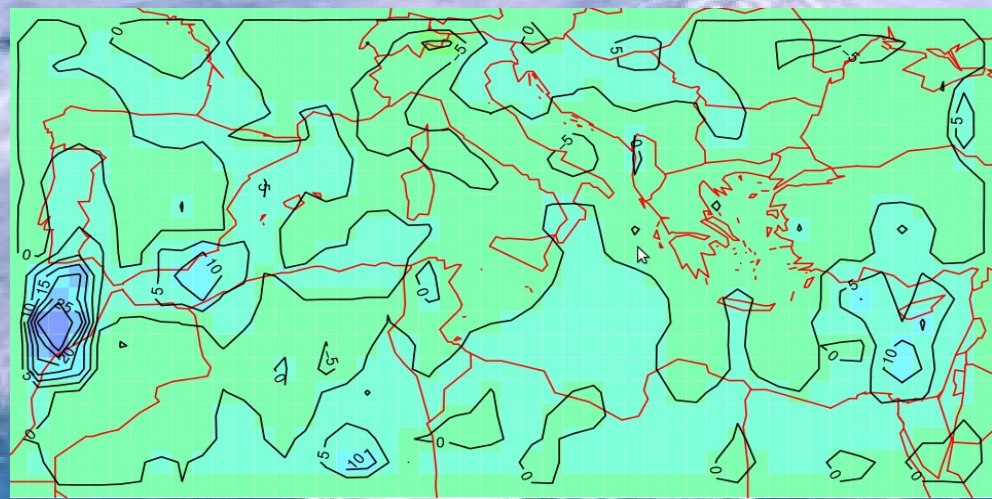
SPRING



SUMMER

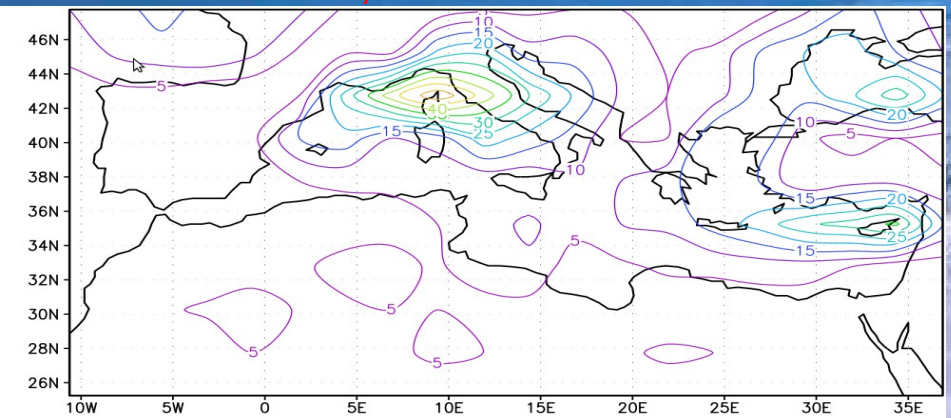


AUTUMN

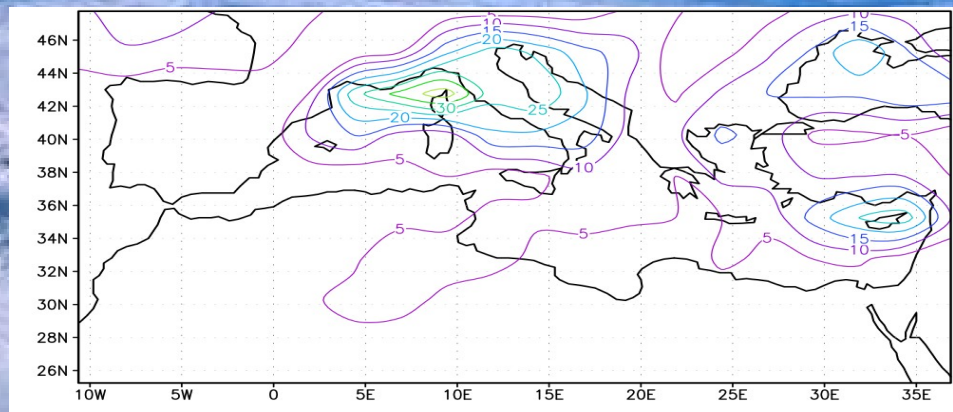


JMA-GSM: TRACKS (PRESENT AND FUTURE TIME) I

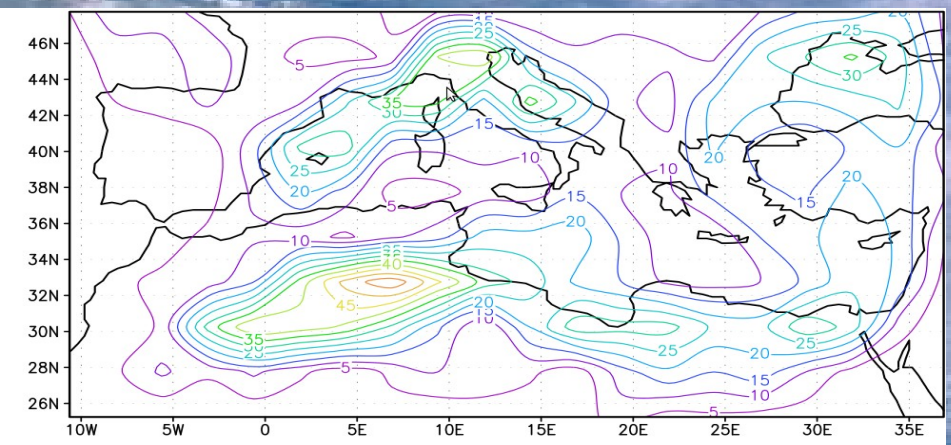
WINTER, PRESENT TIME



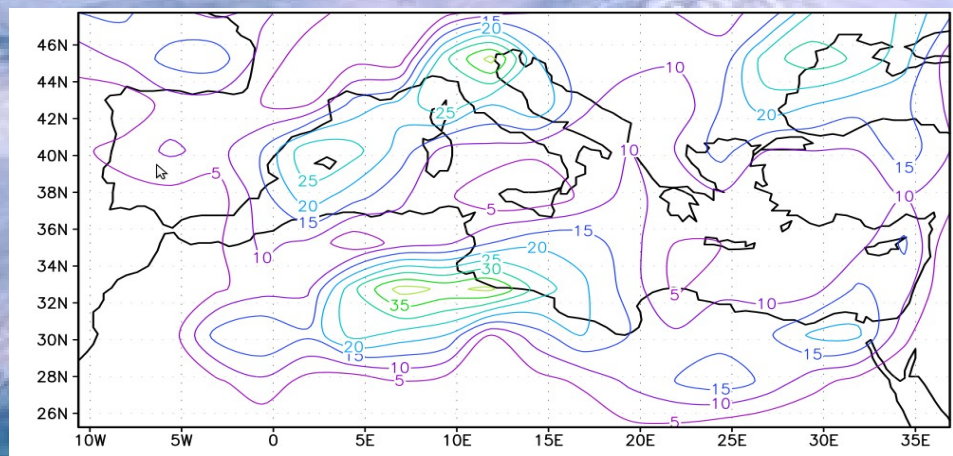
WINTER, FUTURE TIME



SPRING, PRESENT TIME

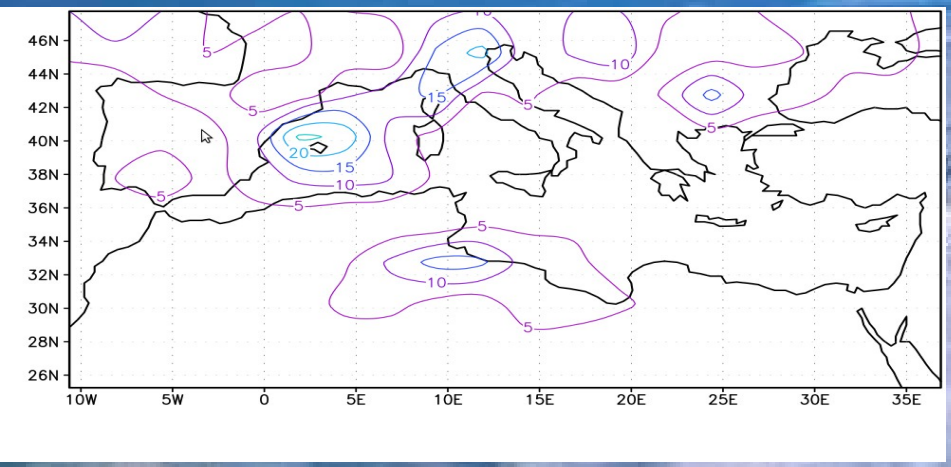


SPRING, FUTURE TIME

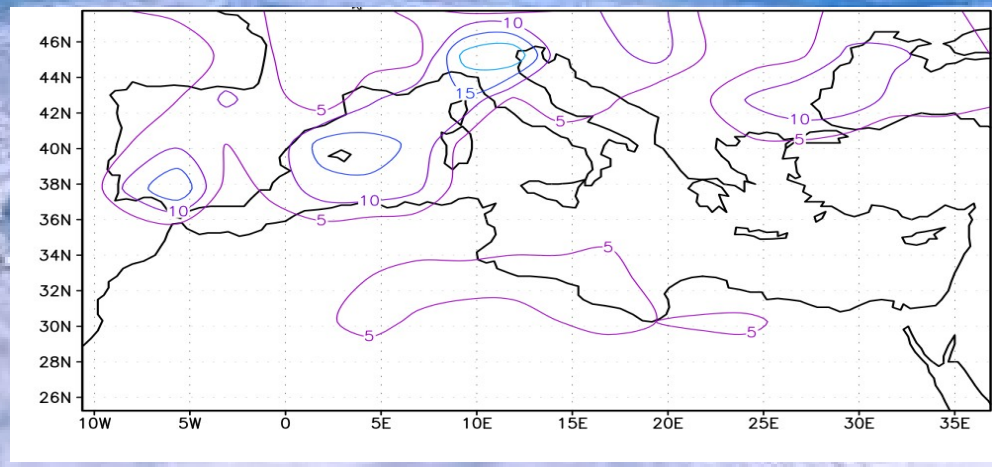


JMA-GSM: TRACKS (PRESENT AND FUTURE TIME) II

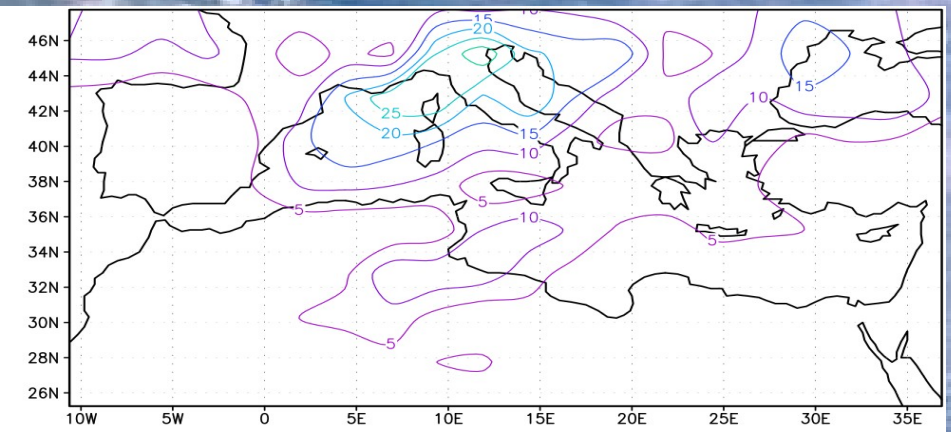
SUMMER, PRESENT TIME



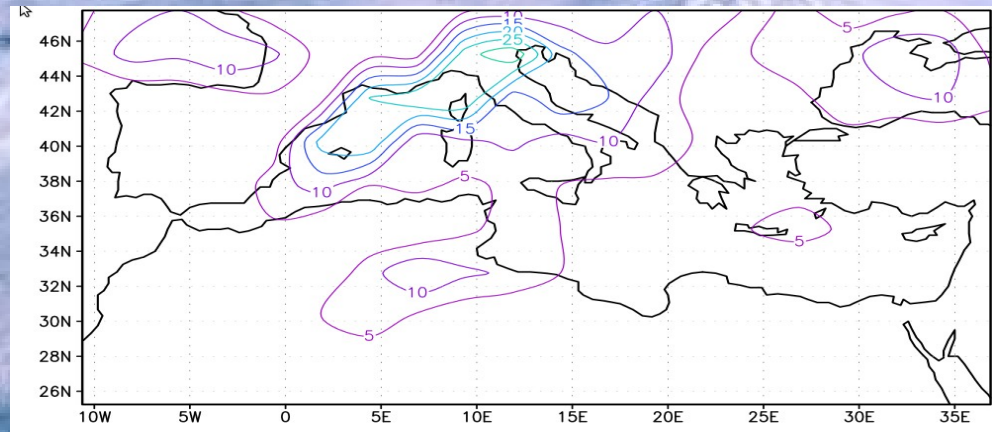
SUMMER, FUTURE TIME



AUTUMN, PRESENT TIME



AUTUMN, FUTURE TIME



CONCLUDING REMARKS:

Present time:

- The cyclones number found is higher in JMA-GSM than ERA-40, specially in summer “thermal lows”.

- For the climate model and the reanalysis, cyclone frequencies are located in the same regions: “Cyprus, Gulf of Genoa, Sahara, Iberian Peninsula and Atlas” but in some cases the maximum positions are in differents locations highlighting the Atlas region.

Future time:

- Seasonaly, there is a not main variation of cyclones numbers in winter, spring and autumn but it is found an increase of events in summer which is due to the global warming.

TRACKS: In the future the preferent tracks will be similar, some of the cyclones origined in Gulf of Genoa move towards the Ionian Sea and the cyclones originated in the Agean sea move preferently to Cyprus.

FUTURE WORK

- Complete the present study (low resolution of JMA-GSM) : cyclone life in the domain, focus in local tracks, distance traveled by cyclones ...

- Local studies with the data available from high resolution (0,1875º) of JMA-GSM

- Three dimensional structure of cyclones in the Mediterranean basin (Campins *et al.* 2005)

- Studies of cyclones symmetry using the Hart Diagram (Hart *et al.* 2001)

REFERENCES:

- Campins J, A. Genovés, M.A.Picornell and A.Jansá. 2010. Climatology of Mediterranean cyclones using the ERA-40 dataset. *International Journal of Climatology.*

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- Picornell M.A., A.Jansá, A. Genovés y J. Campins. 2000. Automated database of mesocyclones from the Hirlam(INM)-0.5 analyses in the western mediterranean. *International Journal of Climatology*