A global climatology of explosive cyclones using a multi tracking approach

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1. Background

Explosive cyclones (or so-called **"meteorological bombs"**, hereafter ***EC***) are among the most intense ***cyclones***. They are characterized with respect to ***ordinary cyclones*** (hereafter ***NEC***) by a ***strong deepening rate*** over ***a certain latitude*** in a relative ***short time range***. EC are identified through the ***"Normalized Central Pressure Deepening Rate" (NDR_c)*** defined as :

$$NDR_c = (\Delta P/24h)*\sin(60^o)/\sin(\varphi) \qquad (1)$$

where ***ΔP*** is the variation of pressure over a period of 24h, ***φ*** is the latitude of cyclone and ***60º*** is the reference latitude. When ***NDR_c*** >1, the system is deemed to be EC.

2. Purpose of the work

- to derive a ***new and comprehensive climatology of EC*** in both hemispheres using ***the multi tracking scheme (CTDM) approach*** of the ***IMILAST project.***
- ***to compare characteristics*** of ***explosive cyclones*** among ***target regions in both hemispheres,*** with particular ***emphasis on intensity , extremes*** and ***trends.***

3. Data and Methods

- ***Original data***: List of cyclones from the IMILAST dataset and derived applying different tracking schemes to the 6-hourly ERA-Interim 1979-2009 Mean Sea Level Pressure (MSLP) fields.
- ***Equation (1)*** has been used to separate cyclones in ***EC*** and ***NEC*** in those lists providing the intensity of cyclones in terms of MSLP (Table 1), 2 datasets per method.
- ***The resulting lists contains the time evolution of the EC (NEC)*** in function of ***its position, its intensity*** in terms of MSLP***, various metrics describing the intensity of deepening process as deepening rate (DR), adjusted geostrophically DR (ADR) , NDR_C*** and two numerical values (0 and 1) pointing out the time step where cyclone becomes ***EC*** and where it shows ***the maximum deepening rate. All the systems with a maximum speed <=150 km/h are considered in this work.***

Table 1 **Method** selected from the IMILAST dataset **(first column, Neu et al., 2013)**, **NEC** and **EC** detected in each list in the Northern Hemisphere and Southern Hemisphere **, and after removing all the systems with a max speed >= 150 km/h**

Method	Northern Hemisphere		Southern Hemisphere	
	All	Max speed<=150 km/h	All	Max speed<=150 km/h
M02	65712/5182	62973/4781	52318/9518	49747/8581
M06	79015/3284	78969/3282	85904/7554	85836/7553
M08	46538/2968	46535/2968	40081/4461	39998/4461
M09	95293/3068	93024/2960	51071/4207	49942/4035
M10	39322/3042	39151/2994	45209/6777	44969/6609
M16	57938/3747	50669/2753	44772/5082	40336/3710
M20	61139/2520	60774/2468	38304/3117	38071/3068
M22	63201/3246	63152/3244	40148/4325	39932/4320

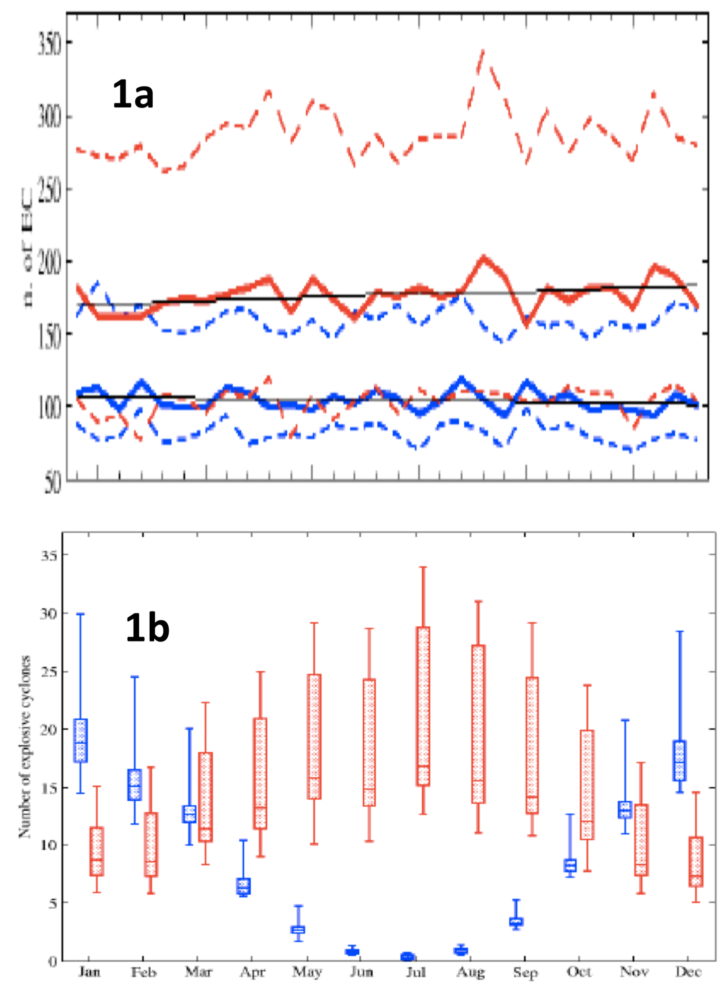

Fig.1 (a) Multi method mean (thick line) of the annual number of **EC in the NH and SH.** Dashed line marks the spread of data in each hemisphere **(b) Intermonthly mean number of EC in NH and SH** The upper and lower limits of the boxes correspond to 25th and 75th percentiles, whiskers the min and max value, – represents the median of the methods.

4. EC spatial and temporal variability

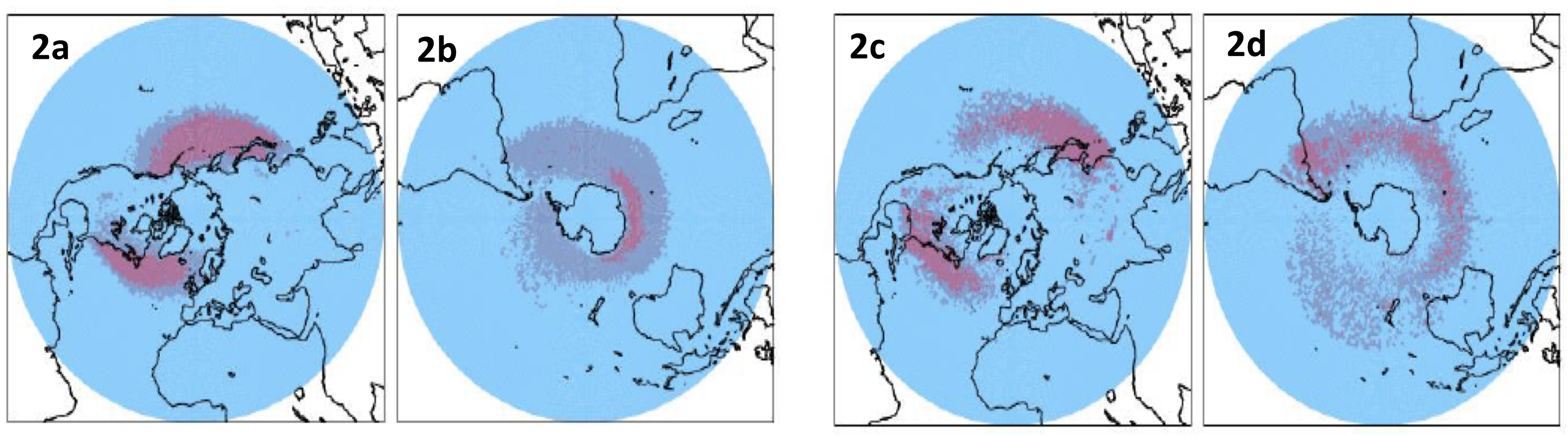

Fig.2 Multi method mean frequency (in %) of: (a,b) **EC track** crossing each cell of 1.5˚, (c,d) **cyclogenesis** occuring in each cell of 1.5˚

Despite a huge spread among methods, the analysis shows that :

- **EC represent a small percentage** with respect to the total number of cyclones detected by each method **(5-11% in NH and SH respectively).**
- ***the multi method mean*** (Fig. 1 a) exhibits **a negative tendency (not significant** according to Mann Kendall test, 90%) in **NH**, and a **positive and significant** according to Mann Kendall test, 90%) in the **SH .**
- **EC** activity is **high** during **the cold season (Fig.1b)** in both hemispheres in particular in ***January (NH) and July (SH)***. In the ***SH*** activity is ***less seasonal*** with respect to ***NH.***
- The multi method mean shows that **EC storm track** has **its maxima** along the **Atlantic/Pacific storm track** and around the ***Antartica (Fig.2a,b).***
- The **cyclogenesis** has **its maxima** in the area of **Eastern American/Japan coastline** and off the **Southern American coastlines** and surrounding the **Antartica *(Fig.2c,d).***

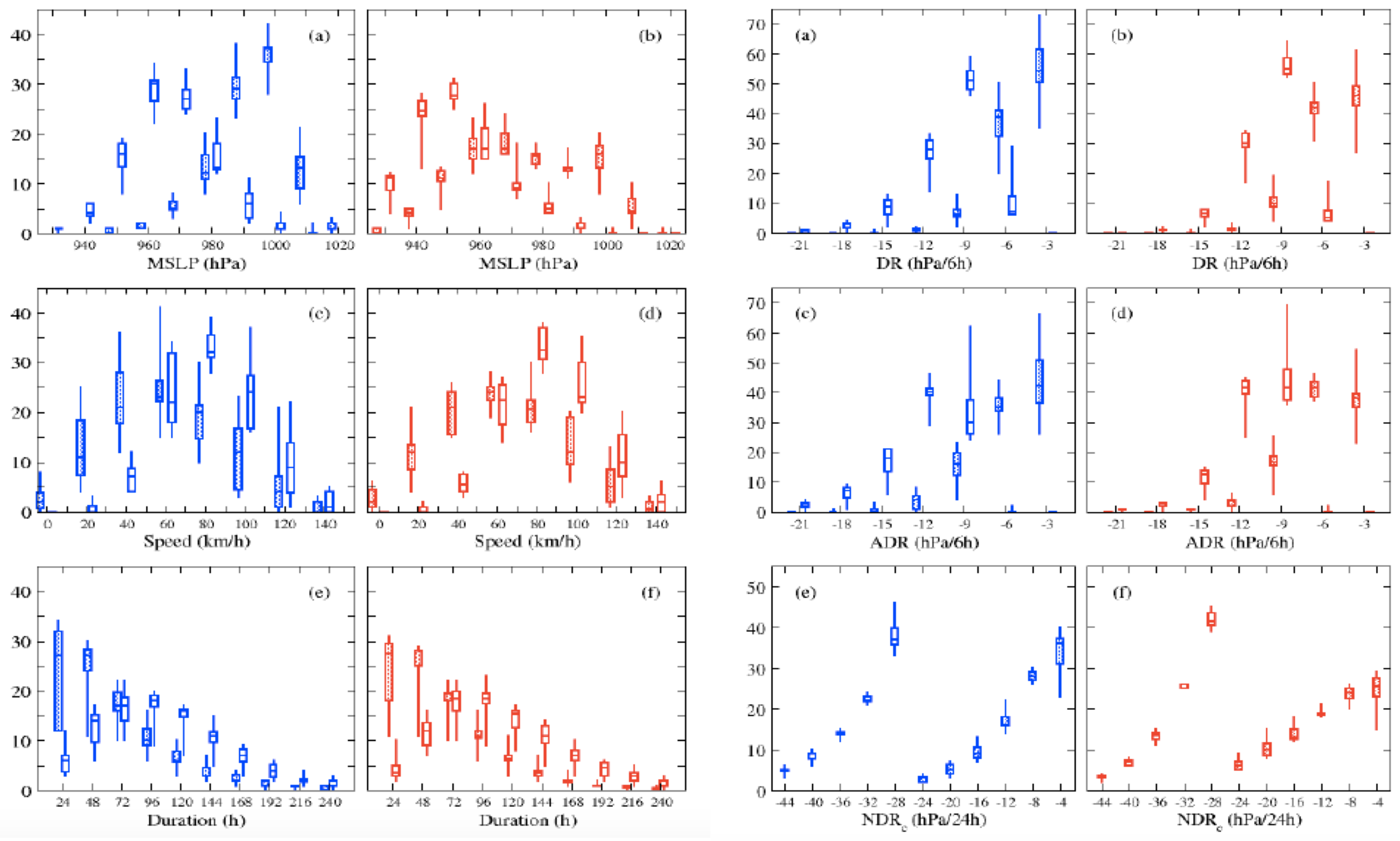

Fig.3 Relative frequency (in %) of NEC (full box) and EC (empty box) in function of their metrics describing dynamics and intensity in NH and SH . The upper and lower limits of the boxes correspond to 25th and 75th percentiles, the whiskers represents the min and max, – represents the median of the methods.

- ***EC*** tend to ***be deeper, faster and long lasting*** with respect to NEC (**Fig.3**). ***EC in the SH are still deeper, faster and long lasting with respect their NH counterparts***. Looking at **deepening metrics in EC** these are usually ***more negative*** in ***NH*** with respect their ***SH*** counterparts **(Fig.3).**

5. Regional EC analysis

An analysis of **EC characteristics** has been performed in some selected areas of both Hemispheres gathering EC themselves in three categories ([0,50p],[50p,75p],[75p,100p] according to three percentile thresholds (25p,50,75p) computed on hemispheric scale . The season considered is **ONDJFM** in **NH** and **AMJJASO** in **SH** which account in both cases for **> 60% of EC detected** in all the lists.

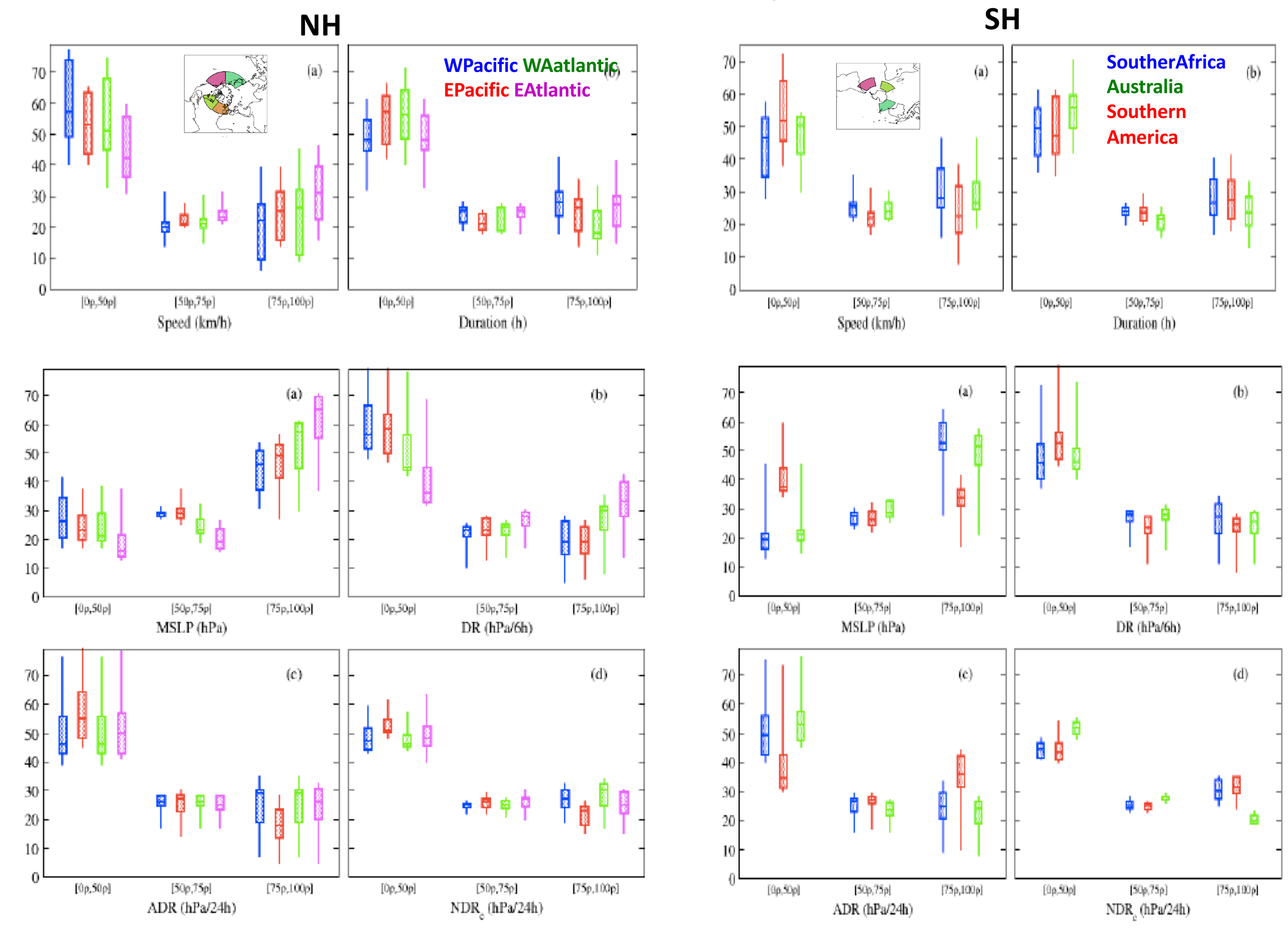

Fig.4 As Fig.3 but for only EC in selected areas of the NH and SH .

- In the **NH, EC are usually faster, deeper and with higher DR_{max} and ADR_{max} in the Atlantic than in the Pacific. EC $NDRC_{max}$ is higher in the western areas than in the eastern areas.**
- **EC close to Southern Africa and Australia are usually faster, deeper and with higher DR_{max} with respect those close to Southern America .**
- **EC close to Southern America and Southern Africa are characterized by higher ADR_{max}, $NDRC_{max}$ and duration with respect EC close to Australia.**

6. Future developments

- **Sensitivity** of the statistics to the **dimension** of areas selected.
- **Analysis** of the source of the spread among the methods.
- **EC trends and features** in the ***future climate scenarios***.

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Bibliography: Reale M, Liberato MLR , Lionello P, Pinto JG , Salon S, Ulbrich S ***(2018)*** **A global climatology of explosive cyclones using a multi-tracking approach** (submitted to Tellus A)