Climatology of Extratropical Complex Systems using a SLP based cyclone detecting and tracking method

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Talk Outline

- **Introduction**
- **TRG Method**
  - Cyclone Identification
  - Cyclone Tracking
  - Further filtering – elimination criteria
  - Cyclones in the Northern Hemisphere
- **Extreme Events and Impacts**
- **TRG_CS Method**
- **Conclusions**

Cyclone Identification and Tracking

I - Cyclone Identification

Pressure minima based cyclone detecting and tracking scheme

- first developed for the Mediterranean region [Trigo et al. 1999; 2002] and

- later extended to a larger Euro-Atlantic region [Trigo 2006]

- now extended to whole NH and SH

Cyclone Identification and Tracking

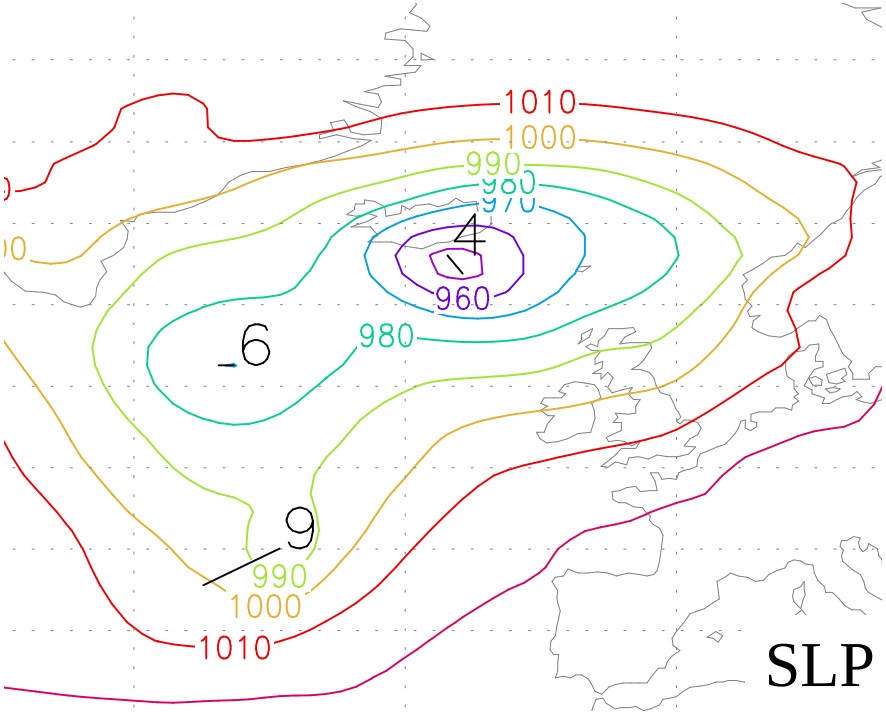
I - Cyclone Identification

Search for **Z1000 minima** fulfilling the conditions:

- corresponding central pressure < 1020 hPa;

- Grad (SLP) _ [averaged over 1000x1000km] ≥ 0.55 hPa /100 km;

- closed and open systems are considered



Cyclone Identification and Tracking

II - Cyclone Tracking

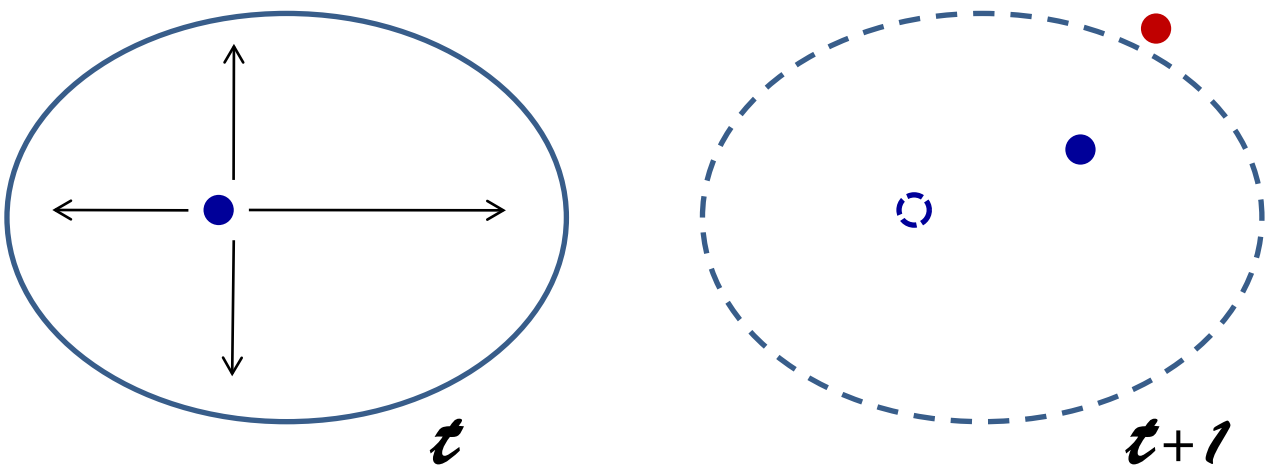
Based on a **nearest neighbour** search in the previous chart;

⇓

if not found within the area defined by **MAX** Cyclone velocity:

- 50 km/h westwards;
- 120 km/h eastwards;
- 90 km/h in any other direction;

⇒ **Cyclogenesis is assumed**



Cyclone Identification and Tracking

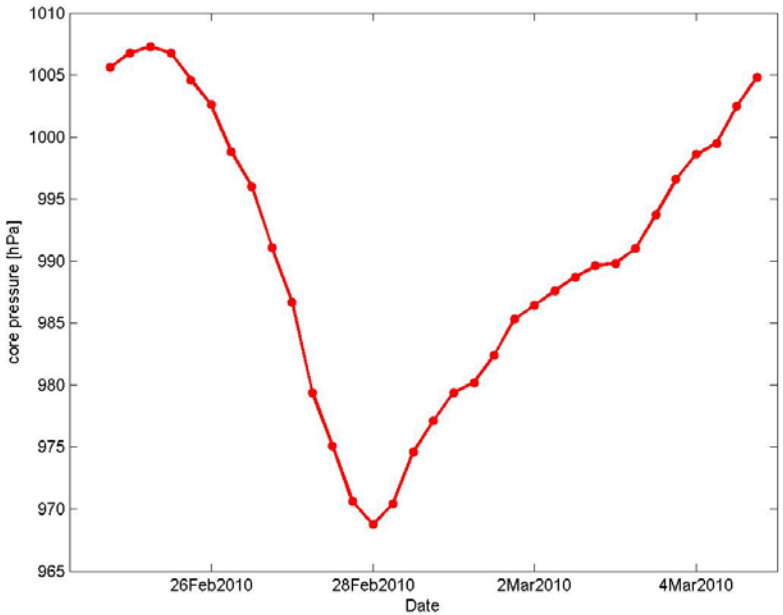
III - Further **filtering** discards events

- lasting < **Tmin** (**Tmin**=12h, **Tmin**=24h, ...)

(cyclones must have a lifetime of at least 24 hours)

- with **minimum pressure** (whole lifecyle) < 1010 hPa

(cyclone intensity must be lower than 1010 hPa at least once during lifetime)



Cyclone Databases

Applying the methodology to reanalysis available:

- NCEP/NCAR
- ERA-40
- ERA-Interim
- 20CR

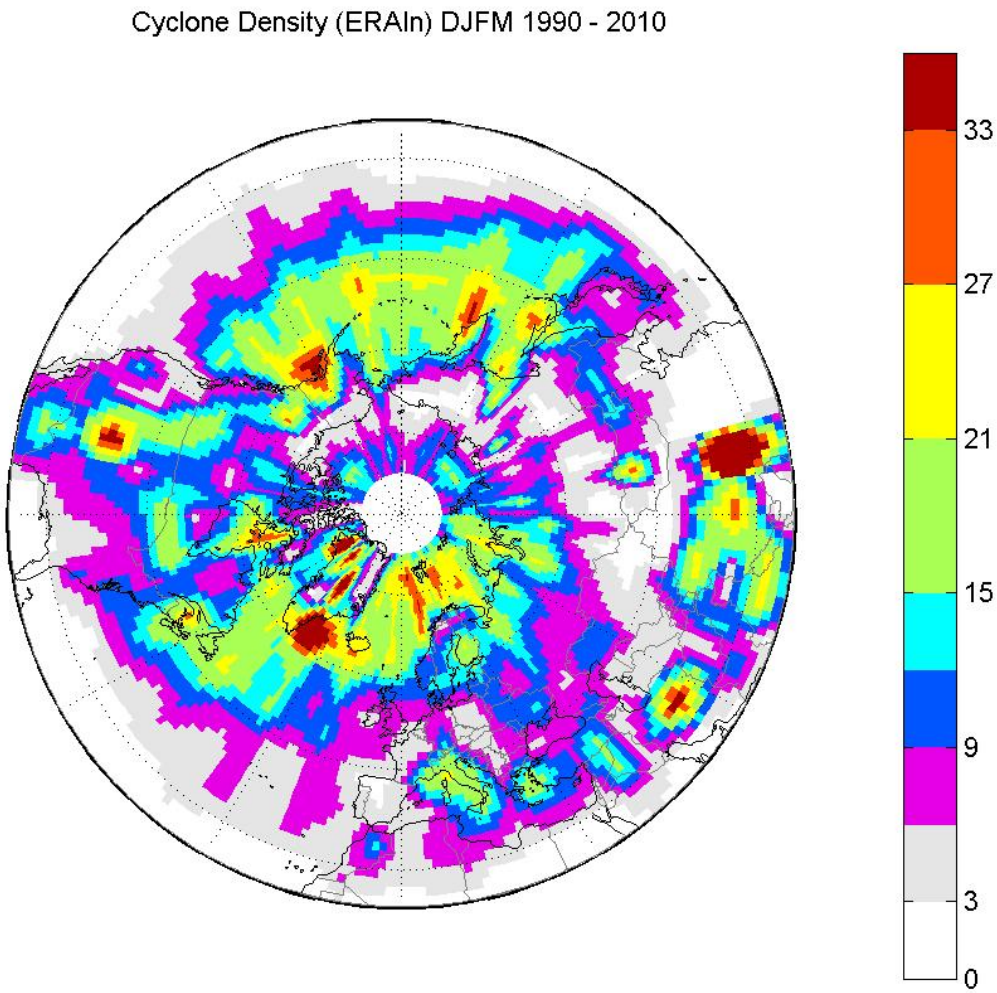
[Trigo 2006]

Different **resolutions** but also different characteristics of the **integration models** and **assimilation schemes** used for each reanalysis

Cyclones in NH - DJFM Climatology

Cyclone Density

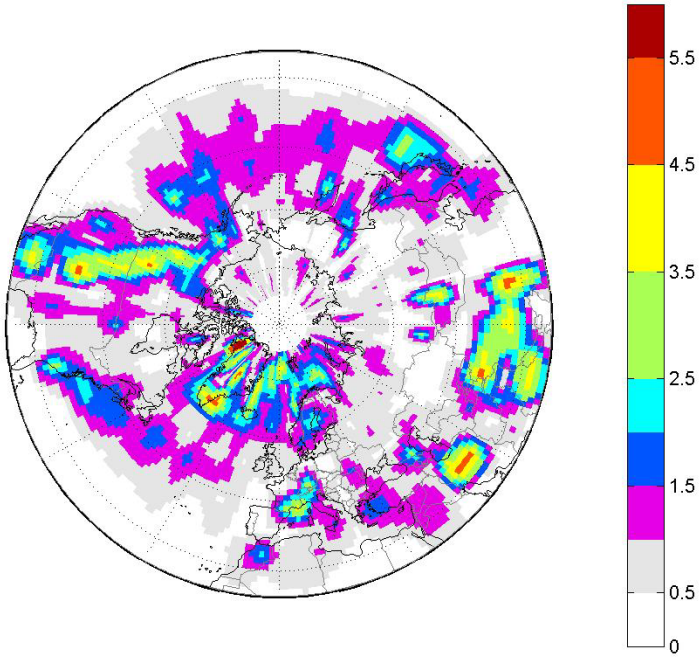
ERA Interim

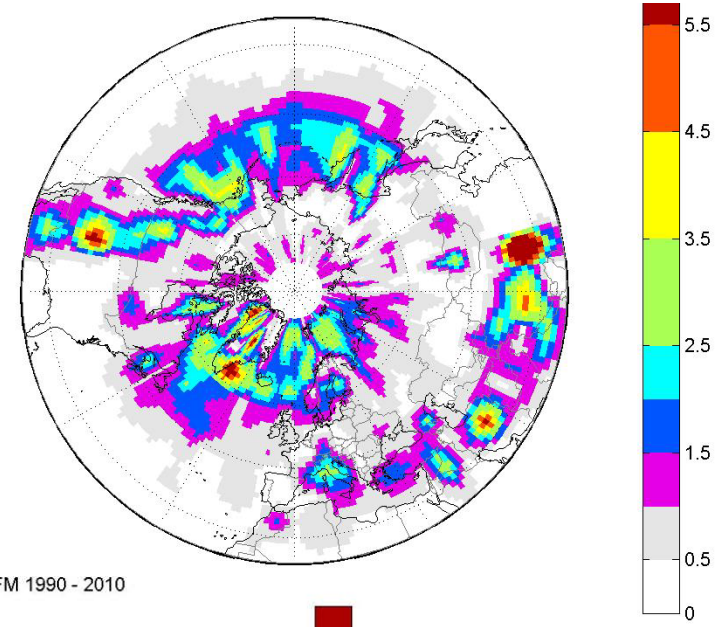


Cyclones per winter

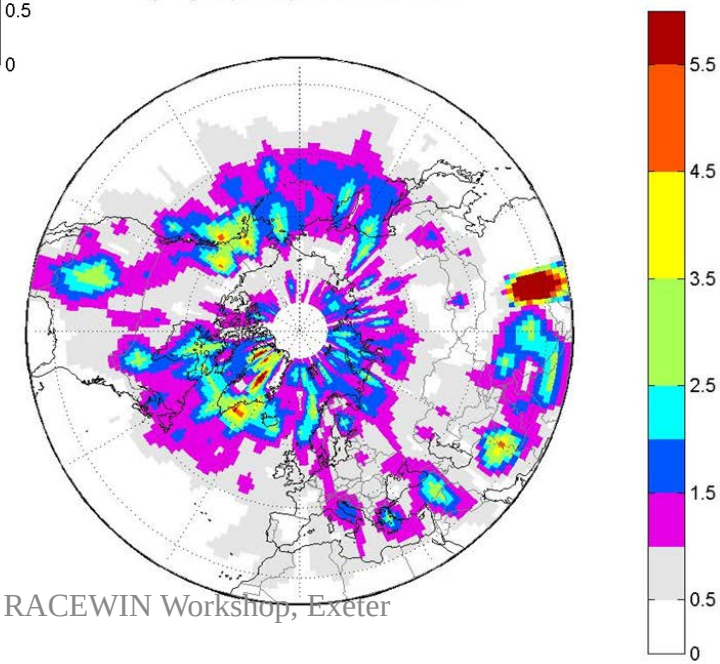
Cyclone Genesis, peak intensity, lysis

Cyclogenesis (ERAIn) DJFM 1990 - 2010





Cyclolysis (ERAIn) DJFM 1990 - 2010



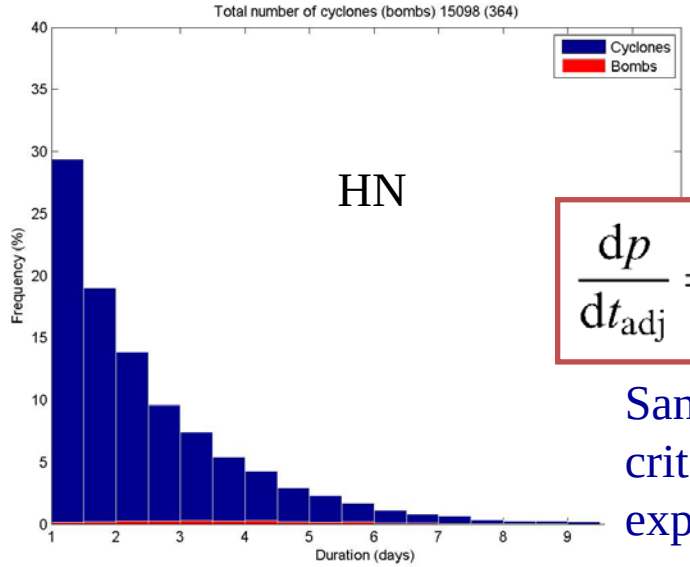
Cyclones per winter

Cyclone Statistics - lifetime

DJFM

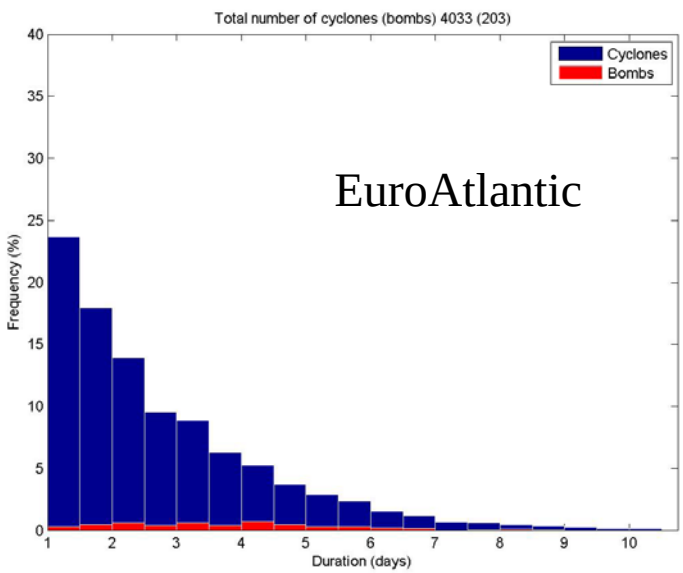
< 1010 hPa

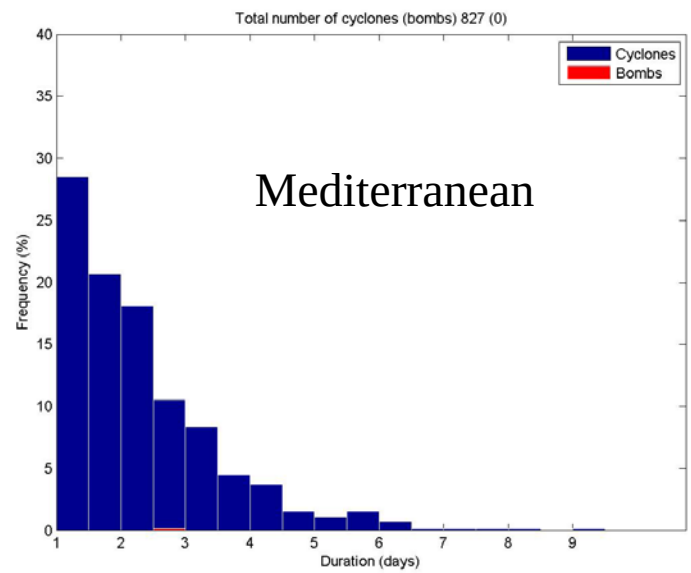
Duration (days)



$$\frac{\mathrm{d}p}{\mathrm{d}t_{\mathrm{adj}}} = \frac{\mathrm{d}p}{\mathrm{d}t}\frac{\sin\varphi_{\mathrm{Ref}}}{\sin\varphi} \leq -24\,\mathrm{hPa}/24\,\mathrm{h}$$

Sanders and Gyakum (1980) criterion: storms are classified as explosive cyclones (bombs)



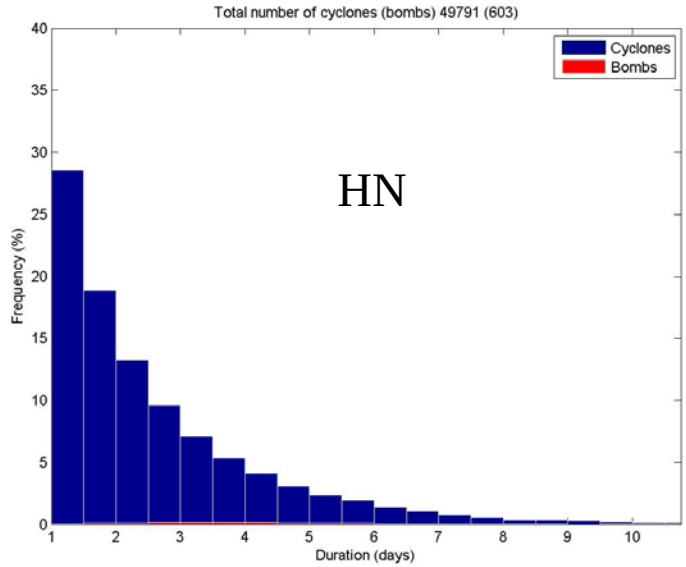


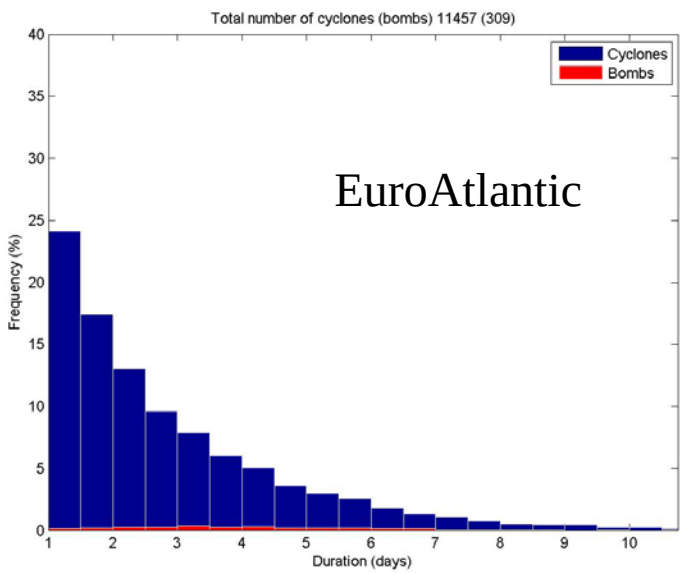
Cyclone Statistics - lifetime

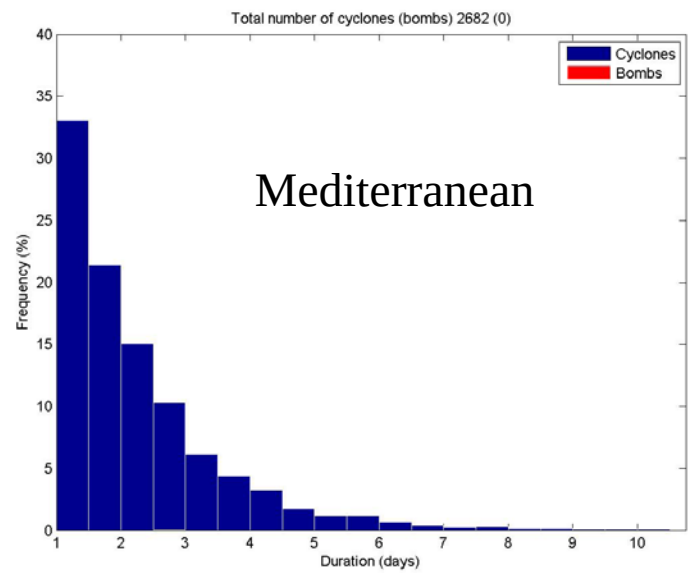
Annual

< 1010 hPa

Duration (days)



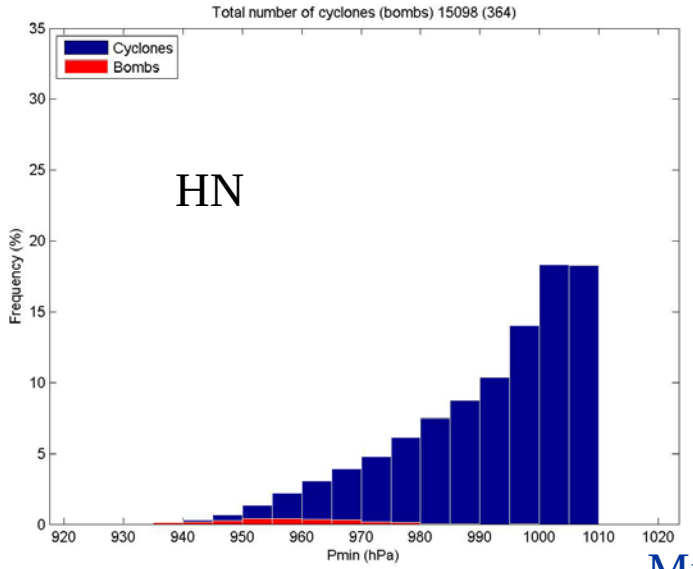




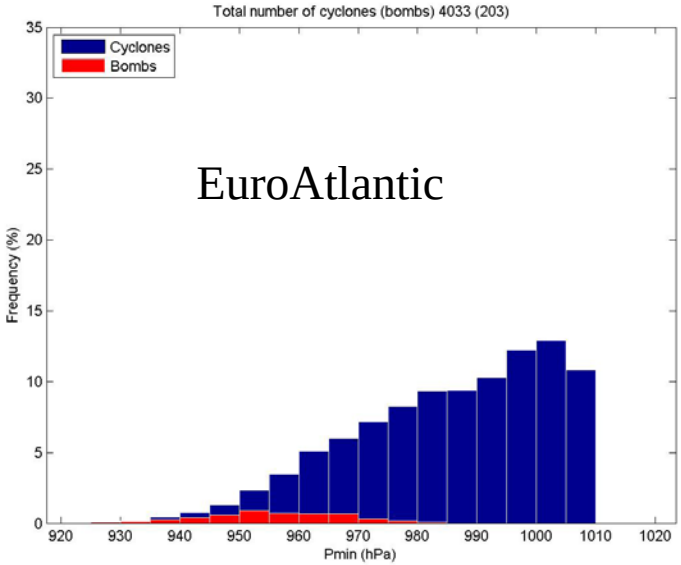
Cyclone Statistics - intensity

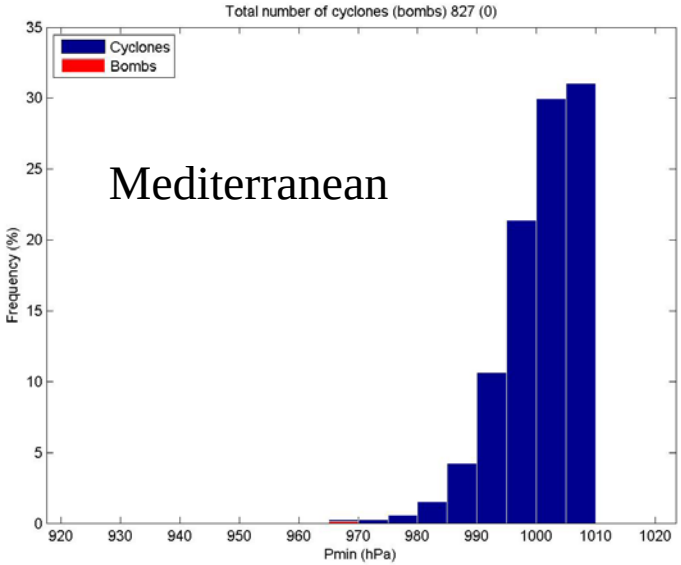
DJFM

< 1010 hPa



Minimum Central Pressure (hPa)

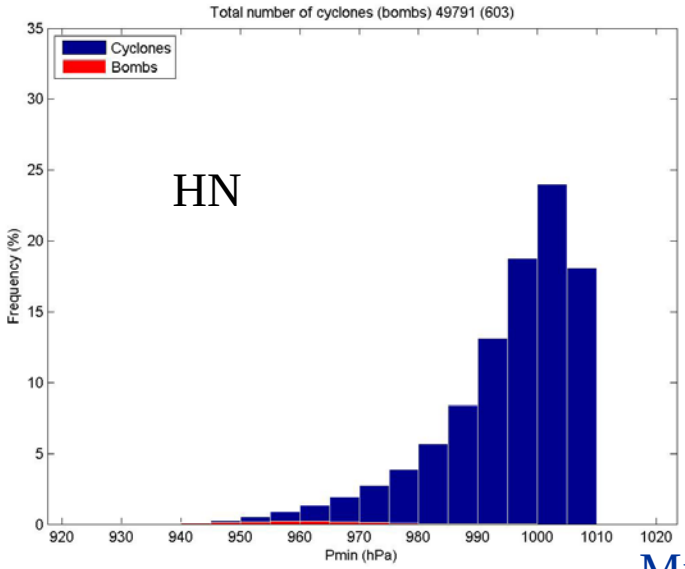




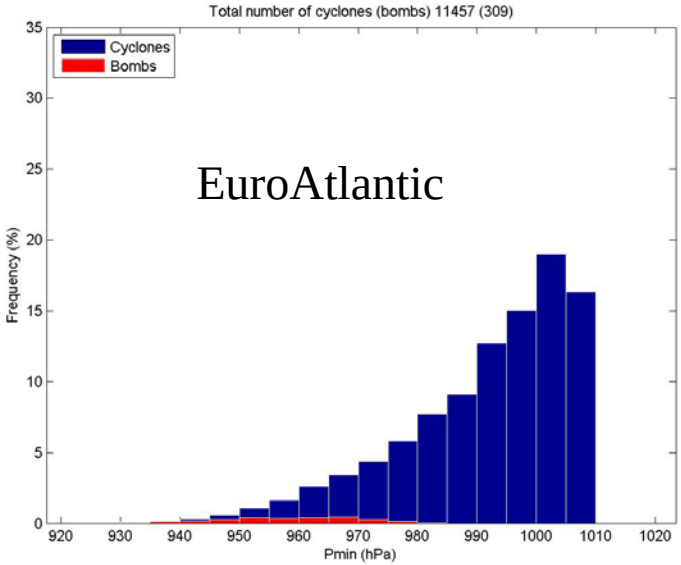
Cyclone Statistics - intensity

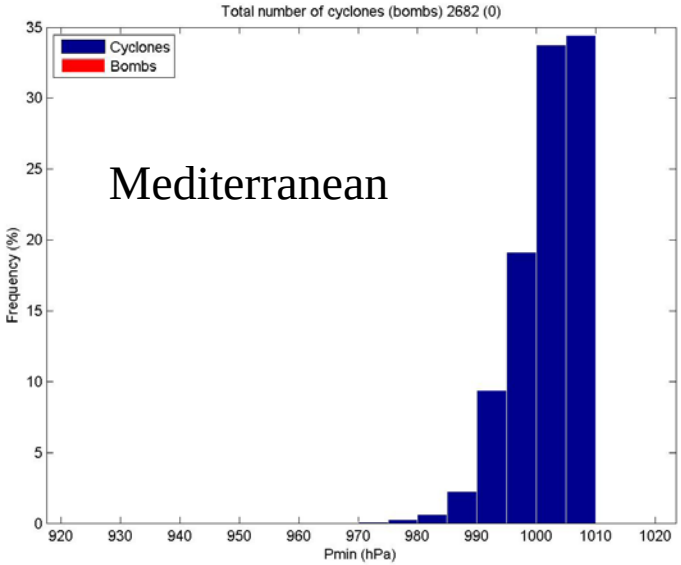
Annual

< 1010 hPa



Minimum Central Pressure (hPa)





Severe Cyclones and Impacts

KLAUS

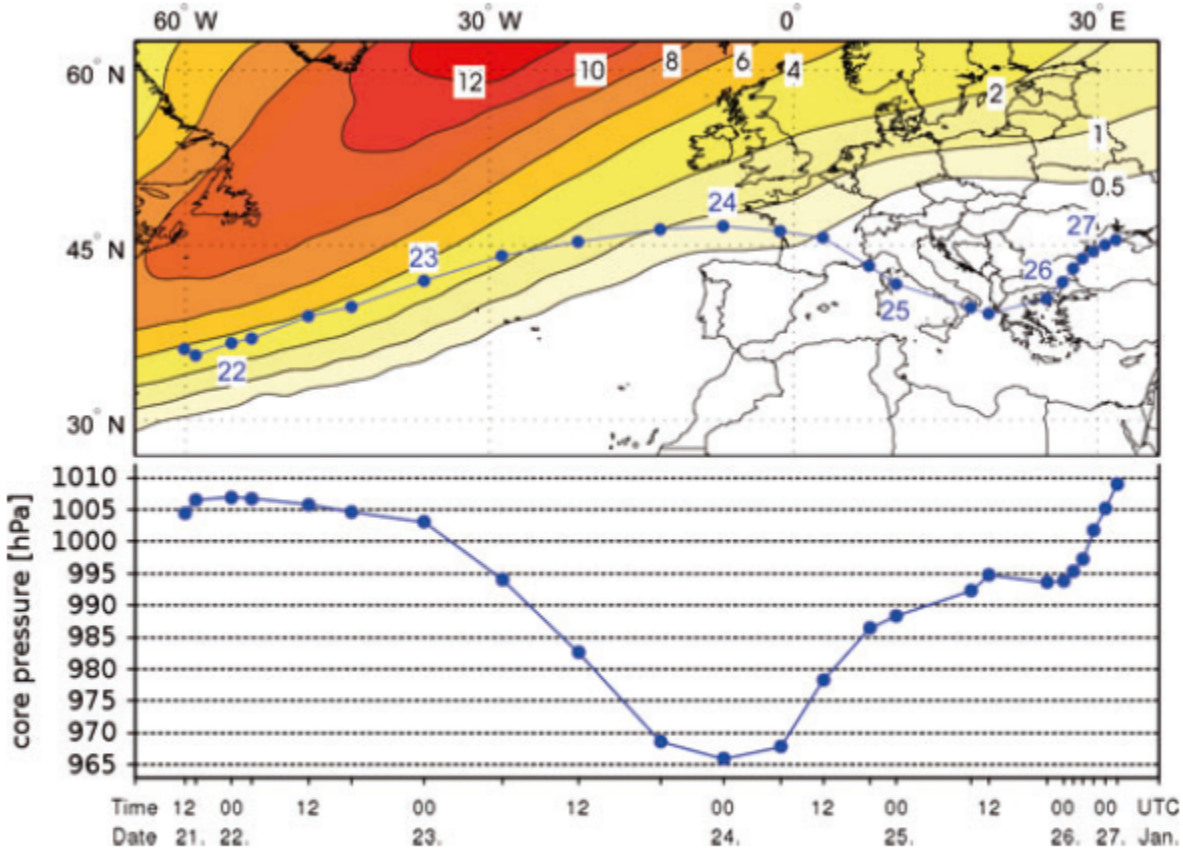


Figure 1. Surface track of Klaus. The position of the storm at six-hourly intervals is marked with a filled circle. The corresponding core MSLP data are shown in the bottom panel for the period 1200 UTC 21 January 2009 to 0600 UTC 27 January 2009. Contour lines represent the track density of the major (extreme) cyclones (cyclone days/winter) over the NA European sector (adapted from Pinto et al., 2009, their Fig. 4).

Liberato et al. 2011

Severe Cyclones and Impacts

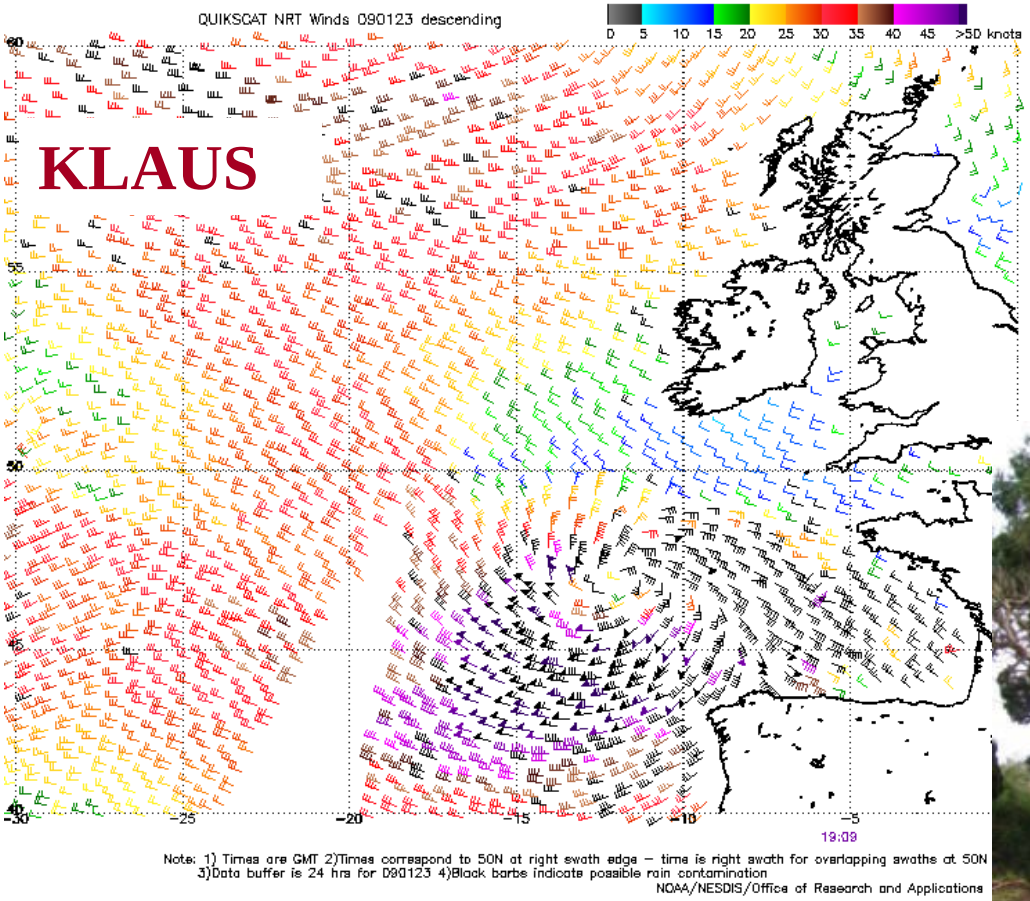


Figure 4. Example of damage associated with Klaus, near Corunna, northern Spain. (Photograph courtesy of Pablo Herrero Isasi.)

QUIKSCAT NRT winds

(23-01-2009)

Severe Cyclones and Impacts

KLAUS

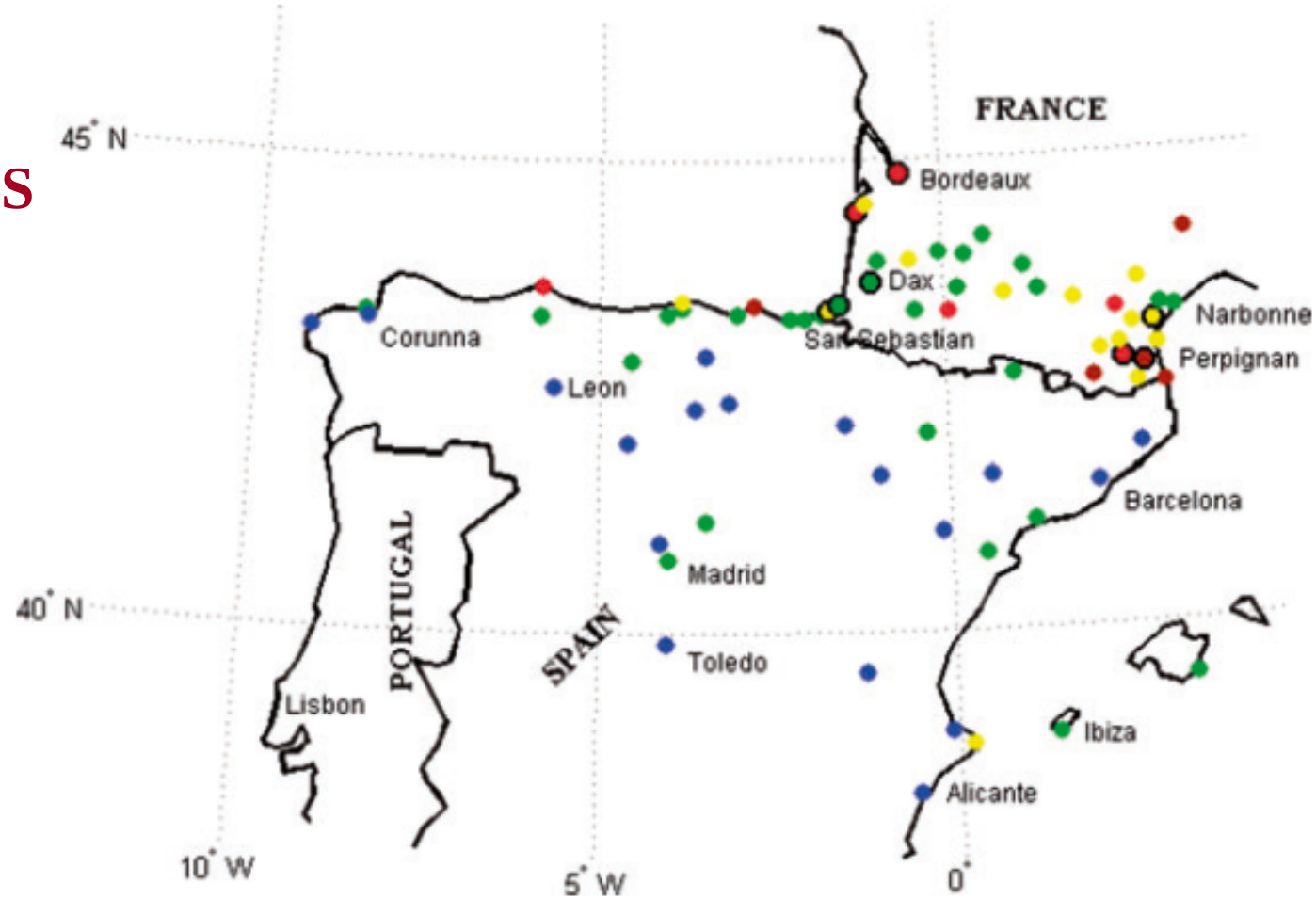
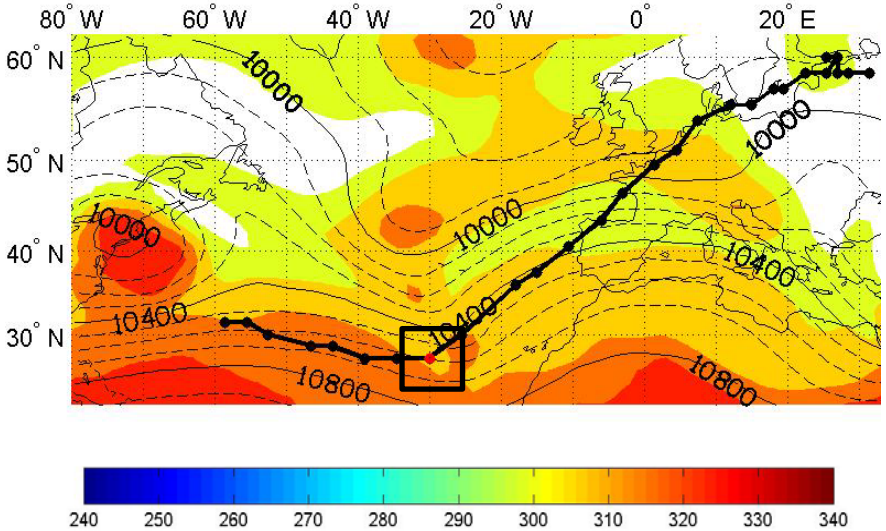


Figure 3. Maximum gusts measured at Spanish and French meteorological stations. Blue: 28–33 ms⁻¹ (54–65kn); green: 33–39ms⁻¹ (65–76kn); yellow: 39–44ms⁻¹ (76–86kn); red: 44–50ms⁻¹ (86–97kn) and brown >50ms⁻¹. A black circumference is included around those stations where previous long-term records of wind speed were surpassed.

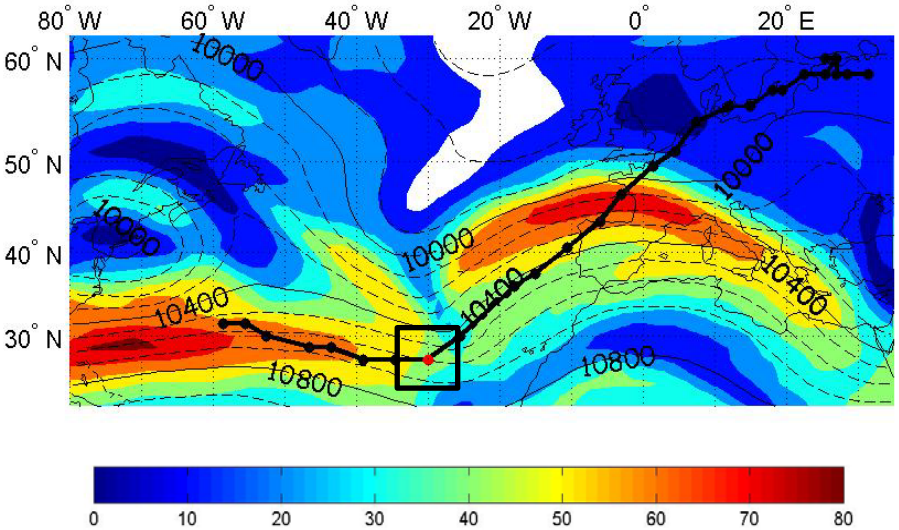
Liberato et al. 2011

Severe Cyclones and Impacts

Xynthia



a) equivalent potential temperature field at 850 hPa (shaded; K) and the 500 hPa geopotential height (contours every 80 gpm)



b) wind (shaded; m s-1) at the 250 hPa level)

Panels show the situation for 12 UTC 26 February 2010. Cyclone track is displayed in black and position at corresponding time is marked with a square and red dot.

Severe Cyclones and Impacts

Xynthia

a)

b)

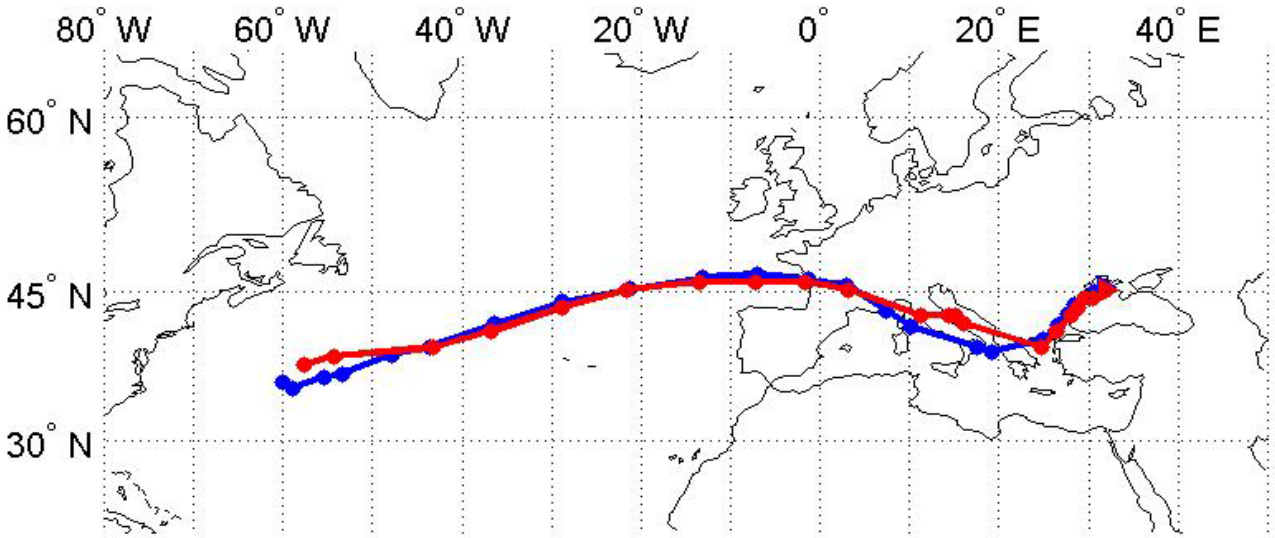
c)

d)

a) A Guarda, Spain 27 Feb. 2010; b) Arlanzon, Spain 28 Feb. 2010; c) La Faute-sur-mer, France 28Feb2010; d) Aiguillon Sur Mer, France 28 Feb. 2010.

Severe Cyclones and Impacts

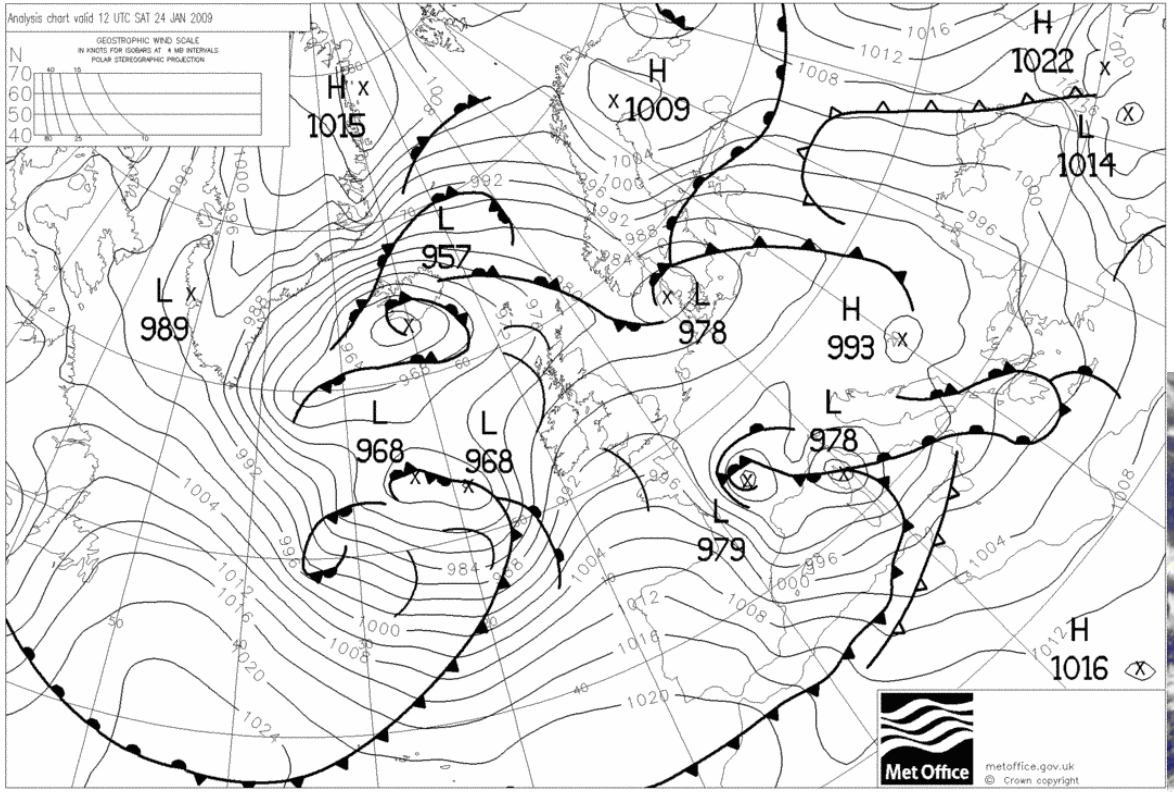
Track intercomparison



KLAUS

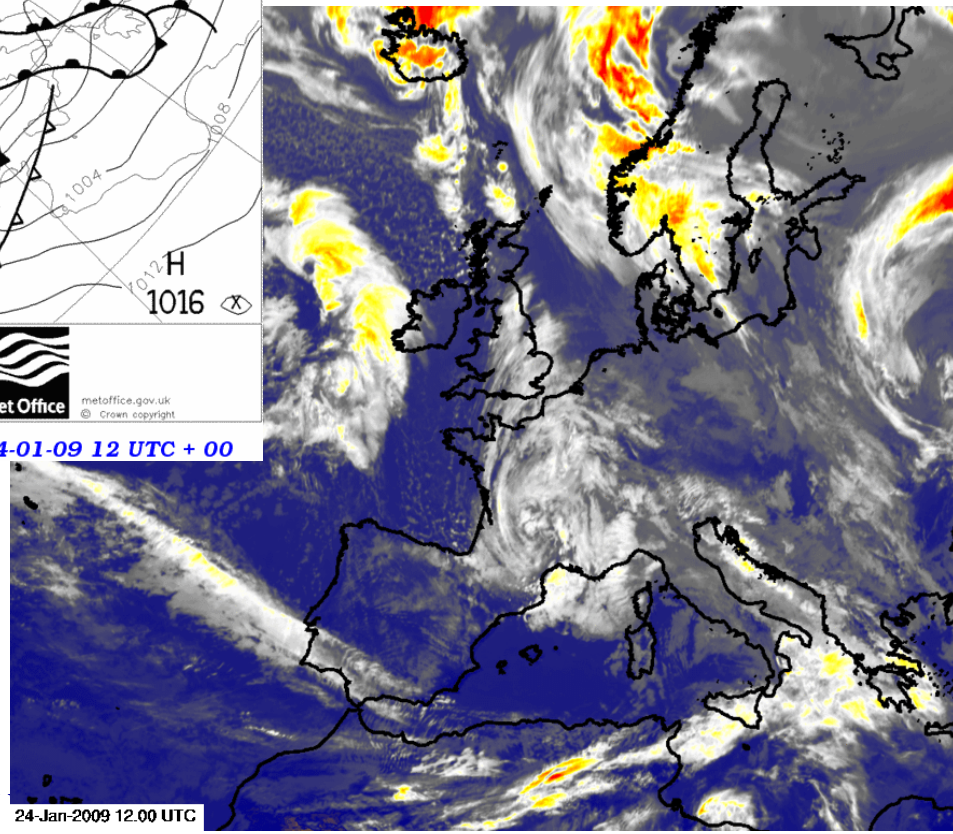
M08 (TRG, based on the identification of minima in the SLP field) vs **M02** (MSI, based on Laplacian of the SLP field)

Severe Cyclones and Impacts



http://www.wetter3.de/fax

24-01-09 12 UTC + 00



KLAUS

Cyclone Identification and Tracking

Cyclone Tracking of complex systems

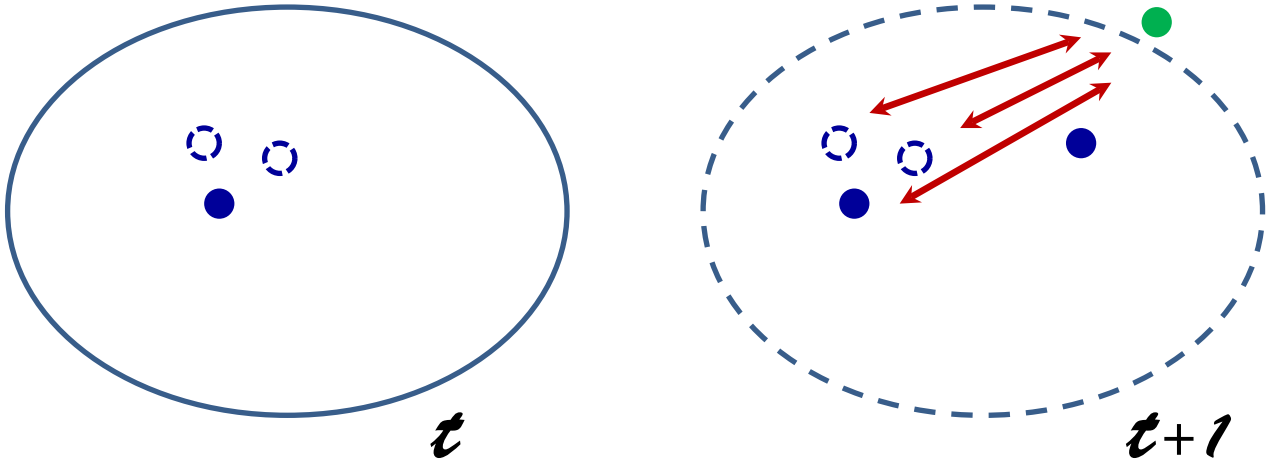
Based on a **nearest neighbour** search in the previous chart;

⇓

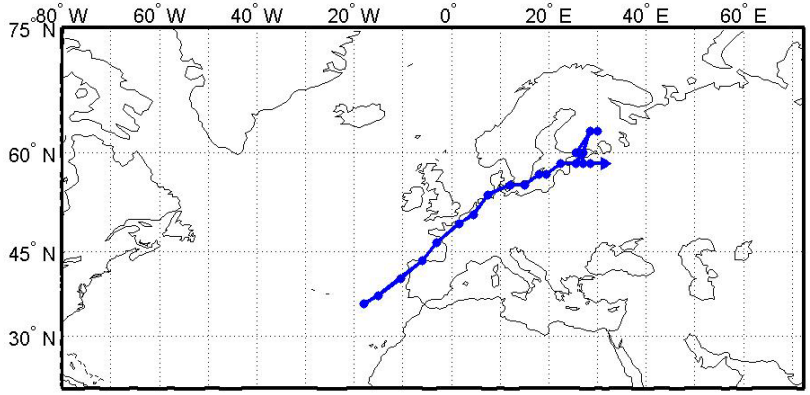
if not found within the area defined by **MAX** Cyclone velocity:

- 120 km/h eastwards;
- 50 km/h in any other direction;

⇒ **Cyclogenesis is assumed**

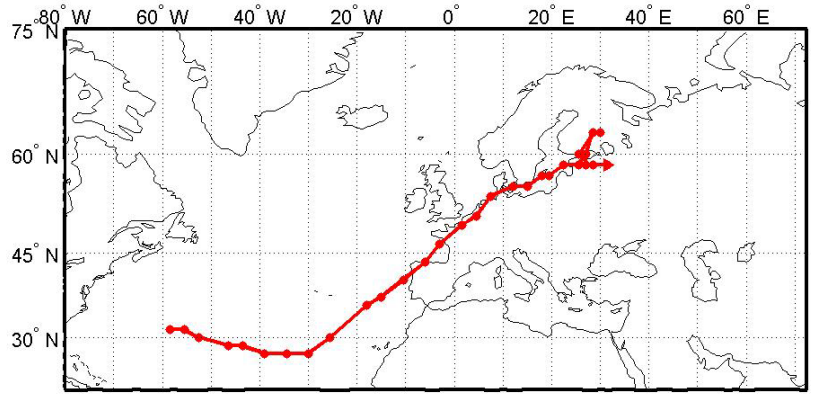


Case studies

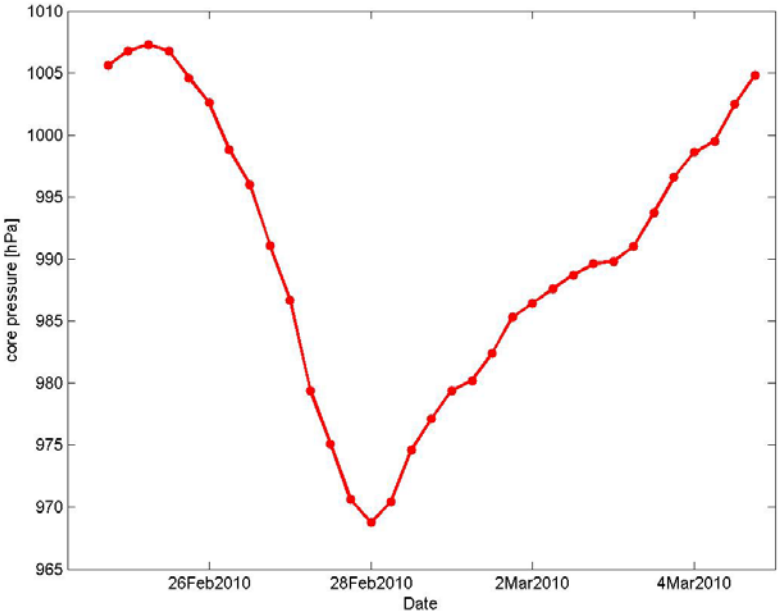


Xynthia

TRG

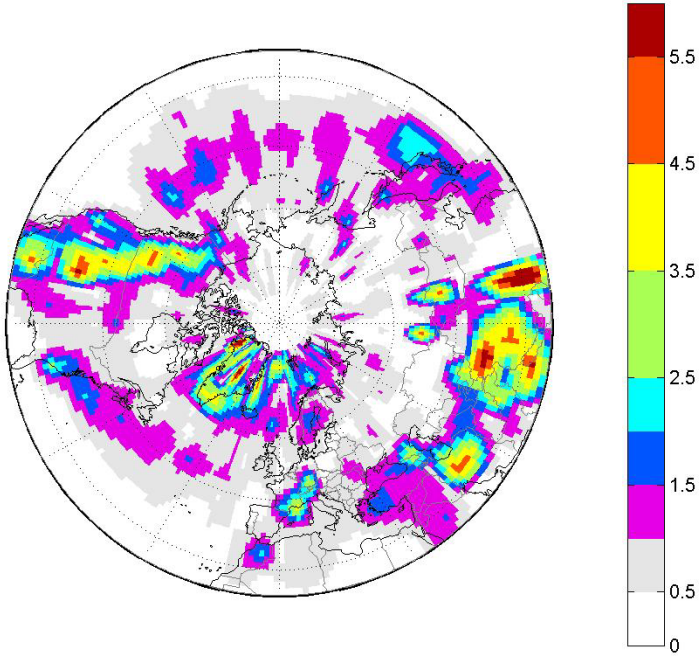


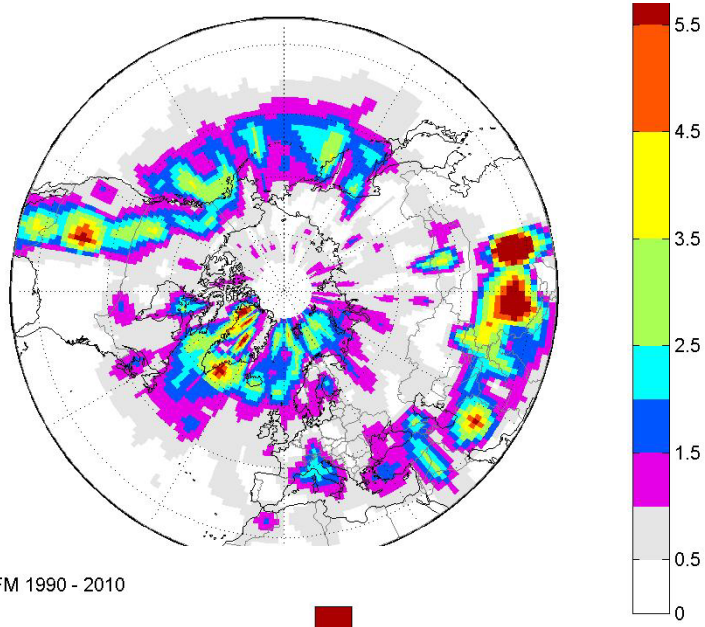
TRG_CS



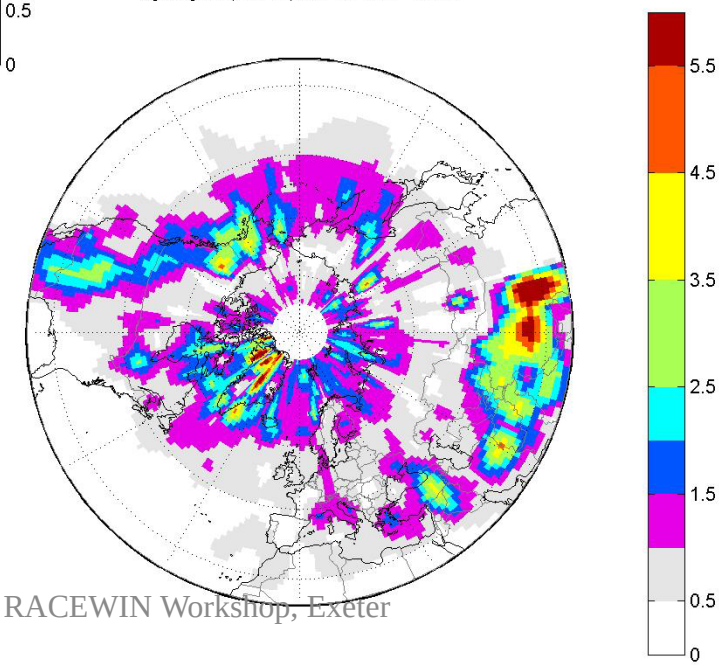
Cyclone Genesis, peak intensity, lysis

Cyclogenesis (ERAIn) DJFM 1990 - 2010





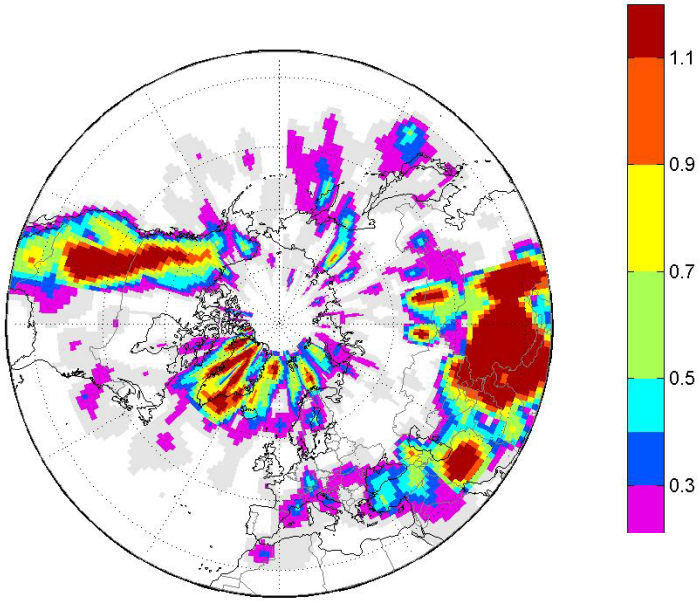
Cyclolysis (ERAIn) DJFM 1990 - 2010

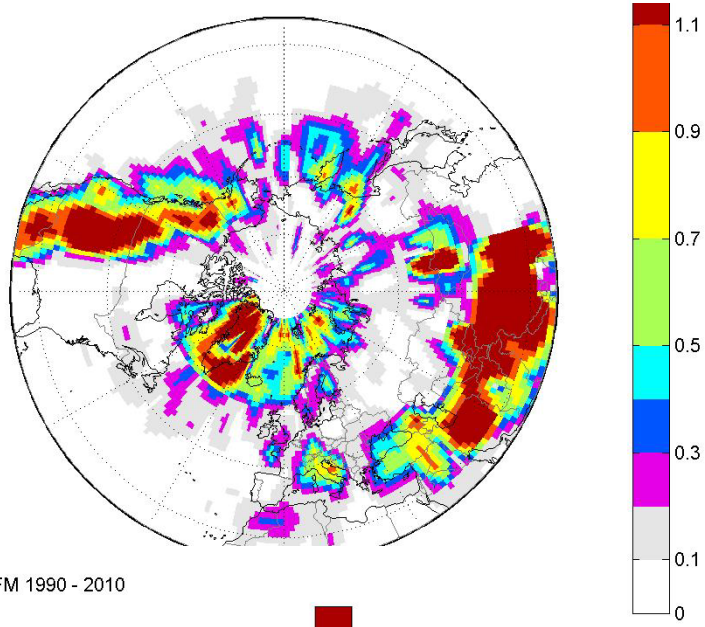


Cyclones per winter

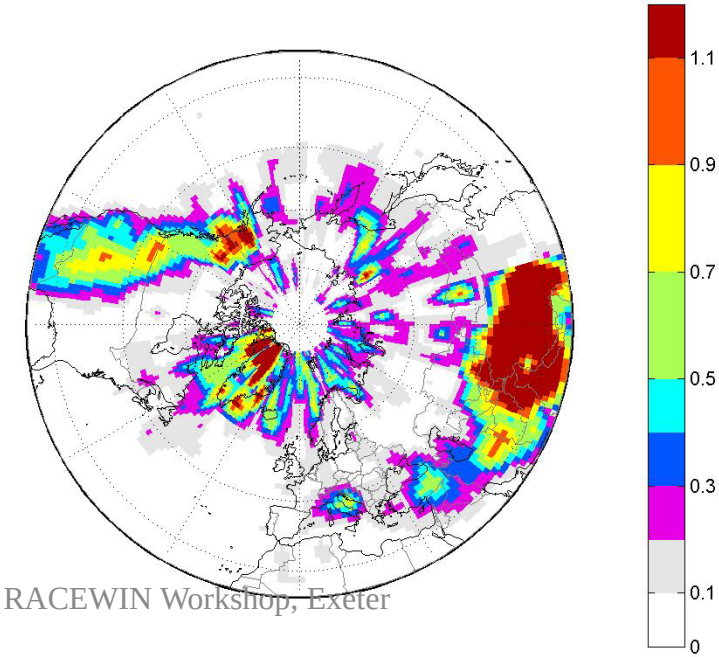
Cyclone Genesis, peak intensity, lysis

Cyclogenesis (ERAIn) DJFM 1990 - 2010





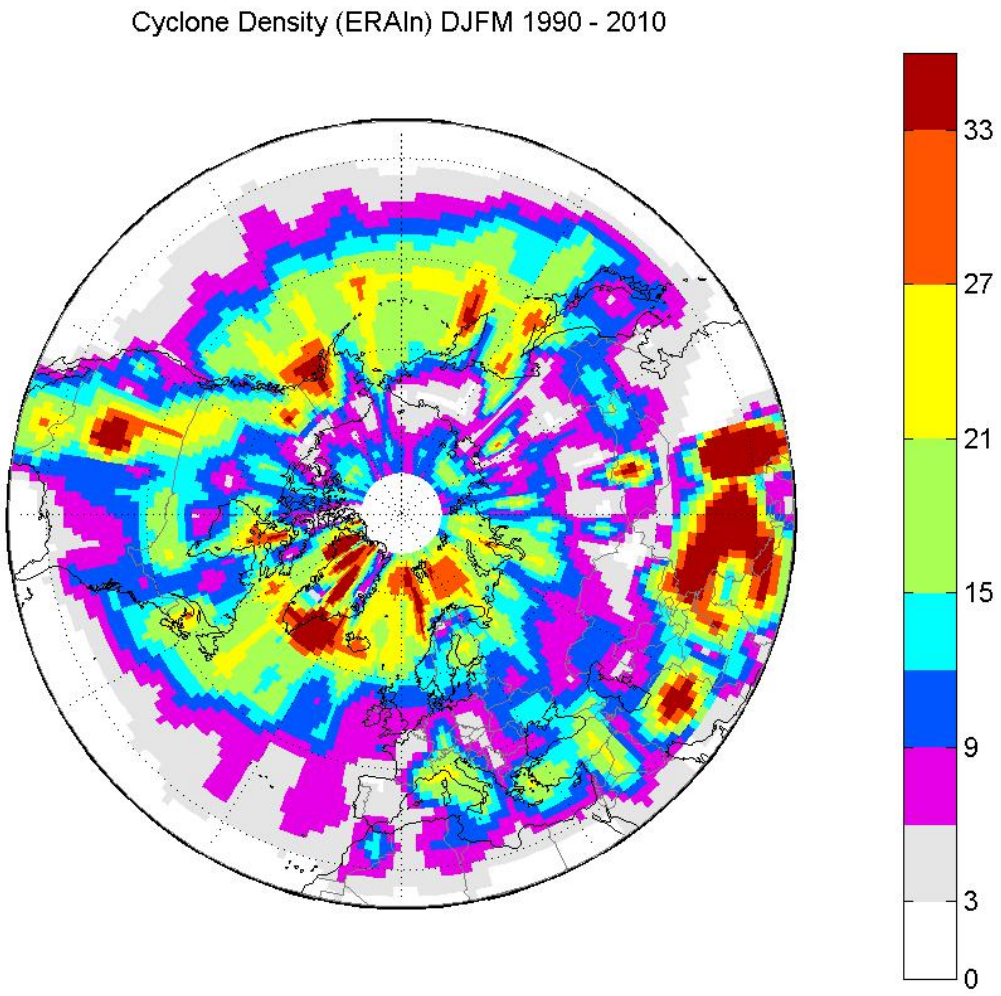
Cyclolysis (ERAIn) DJFM 1990 - 2010



Only complex systems

Cyclones per winter

Cyclones in NH - DJFM Climatology



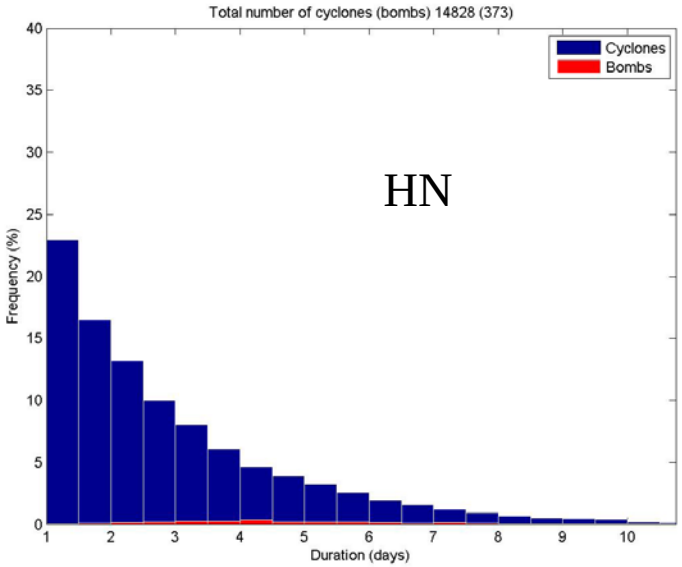
Cyclones per winter

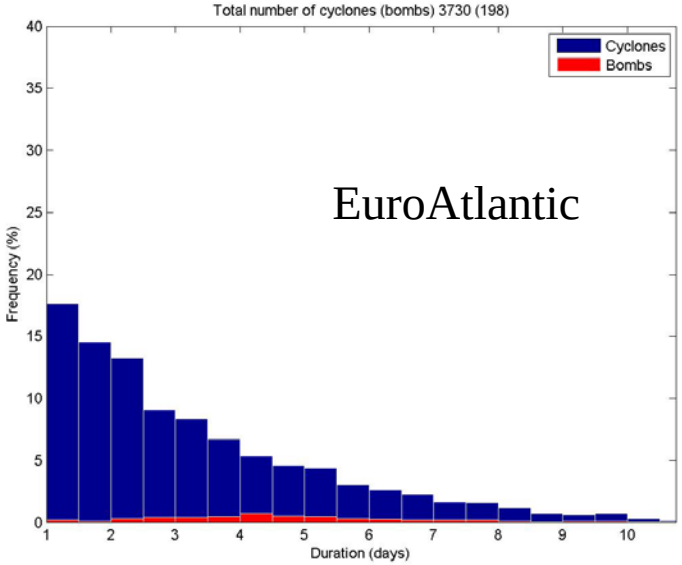
Cyclone Statistics - lifetime

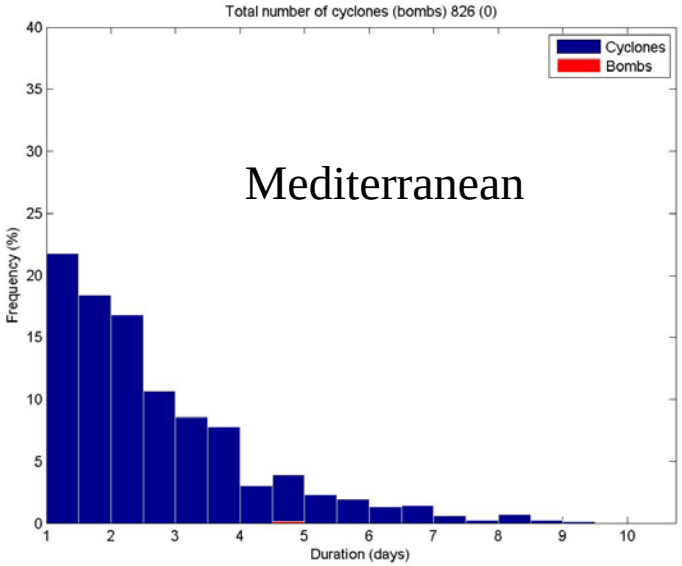
DJFM

< 1010 hPa

Duration (days)



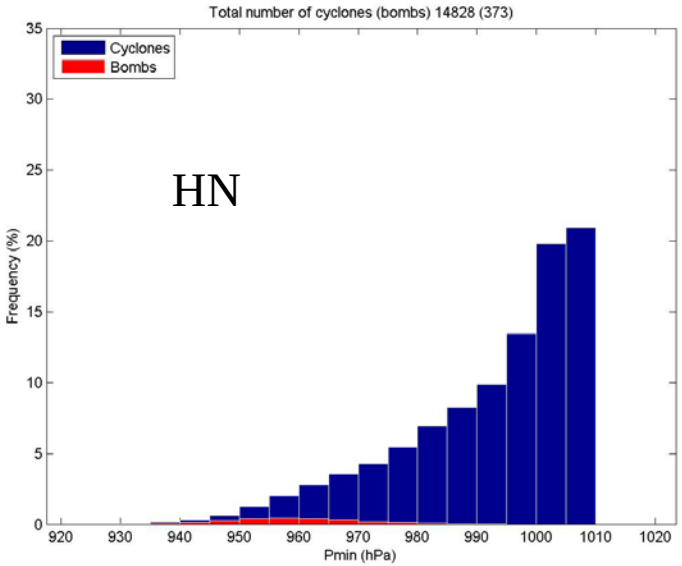




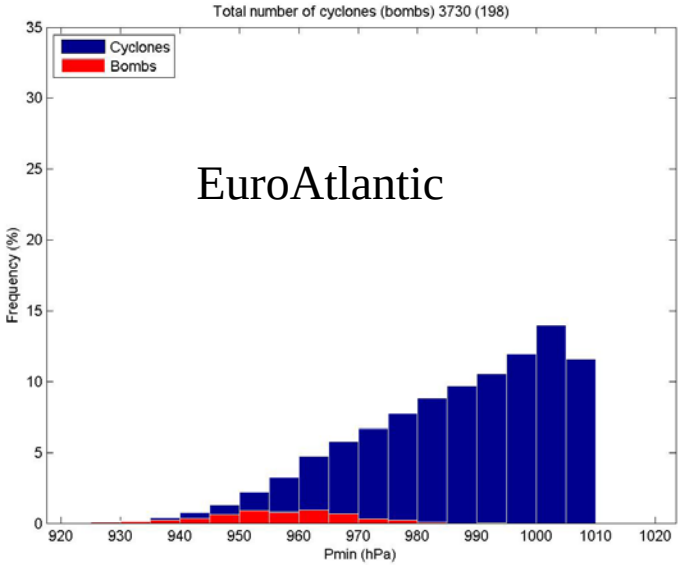
Cyclone Statistics - intensity

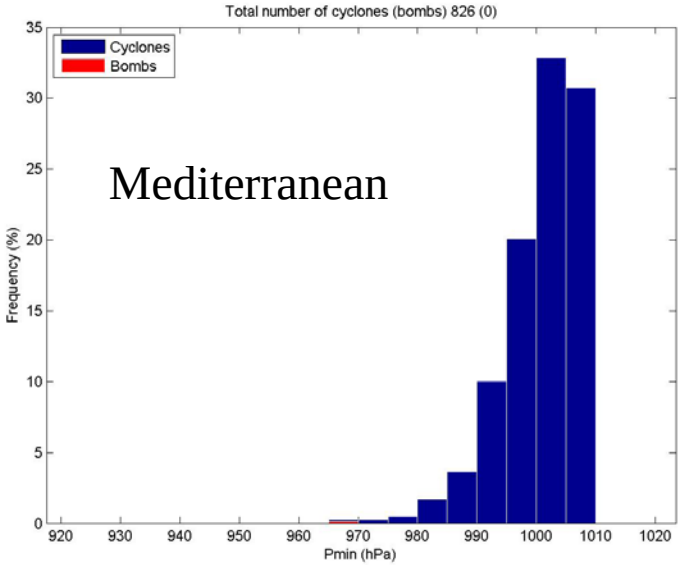
DJFM

< 1010 hPa



Minimum Central Pressure (hPa)





Conclusions

- An objective methodology (TRG detecting/tracking algorithm, Trigo 2006) is applied to **ERA-Interim reanalyses** to build a **storm-track dataset** for the **Northern Hemisphere** spanning the period January 1989-December 2010.

- Even though there are discrepancies in the number of storms from previous datasets (NCEP/NCAR, ERA40), mainly resulting from differences in the resolution of the sub-daily SLP field, **results agree on the main cyclone activity areas** (formation, minimum central pressure and cyclolysis) and **general characteristics** (minimum pressure, lifetime) which are distinct namely between Atlantic and Mediterranean systems.

- TRG detecting/tracking algorithm (Trigo 2006) was adapted in order to **identify complex low-pressure systems**, namely those characterized with **more than one SLP minima**.

- DJFM cyclone density plots and cyclone activity areas (formation, minimum central pressure and cyclolysis) show good agreement with previous datasets.