UNIVERSITY OF BIRMINGHAM

Detection and assessment of severe, damage prone wind fields caused by severe cyclones in mid-latitudes, tropics and polar regions

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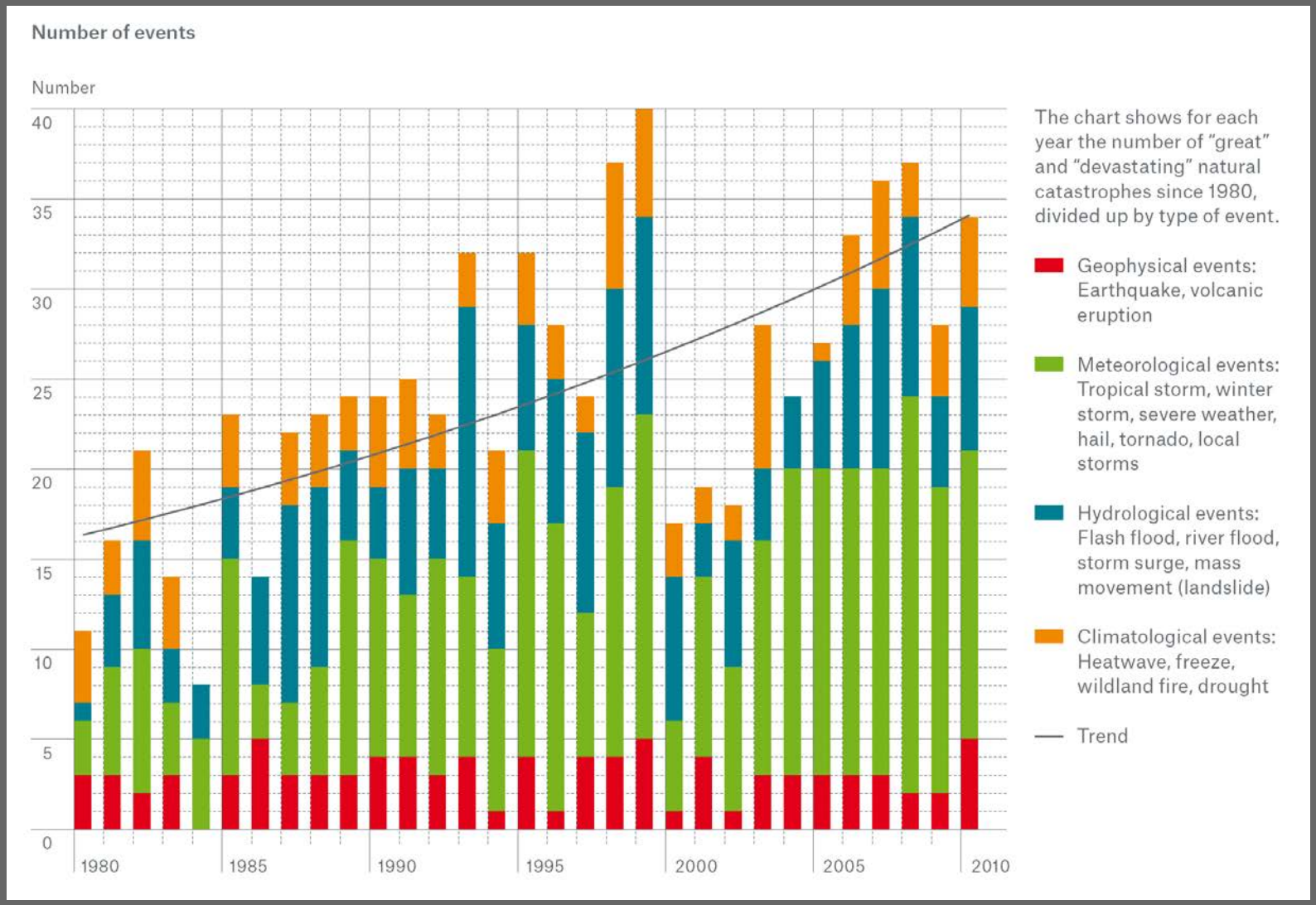
Outline

1. Introduction / Motivation
2. Basic considerations and definition of the severe wind field tracking (WTRACK) and the related Storm severity measure (SSI, Storm Severity Index)
3. Mid-latitude tracking of winter storms (ERA-Interim based)
4. Tropical cyclones and Hurricanes
5. Severe Polar Lows
6. Applications
7. Summary / Conclusion

1. Introduction

Number of devastating natural catastrophes (1980- 2010)



Source: Munich Re, 2011

1. Introduction

Question:

In how far storms will change by given decadal variability and potential changed future climate conditions?

Is it possible to give estimations on changed characteristics, e.g. the

- **frequency,**
- **intensity,**
- **spatial extent,**
- **longer pathways,**
- **shifted pathways,**
- **duration (total vs. local),**
- **travelling speed**

1. Introduction

Development of an objective storm identification, tracking and severity measure assessment, incorporating parameters to assess these characteristics

Application to

Ranalysis data and model data of different spatial resolution (GCM and RCM simulations)

2. WTRACK & SSI Concept

- Basic concept was inspired by the work of LAMB & FRYDENDAHL (1991, 2004):

- The "severity" of a storms is given by mainly 3 factors:

1. Magnitude of wind speed
2. Area affected by the storm
3. Duration of the storm

Lamb & Frydendahl used historical observations, i.e. station data, to assess theses parameters

2. WTRACK & SSI Concept

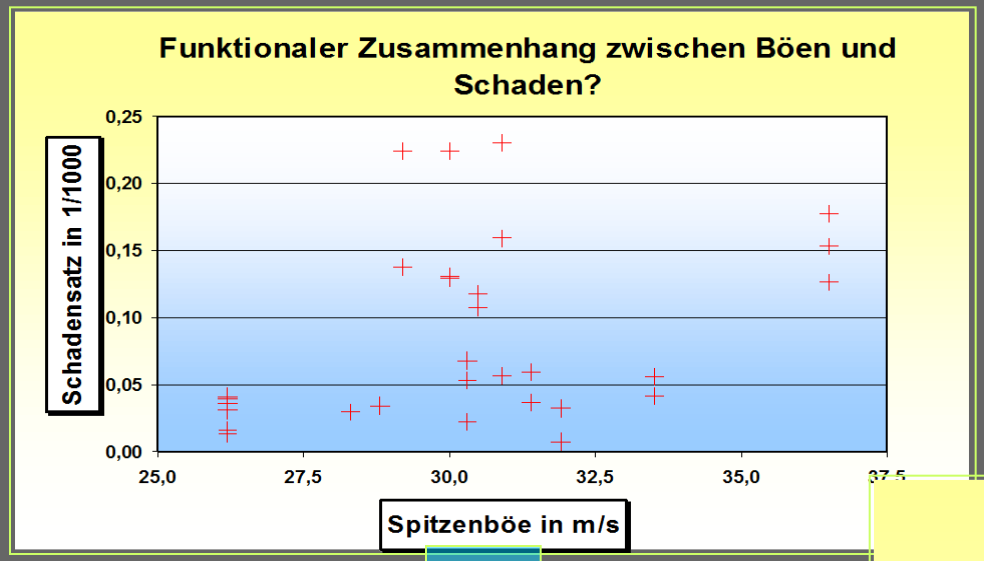
Some shortcomings might arise from this approach:

- **Difficulties to assess the correct spatial extent of storm systems due to the lack of station observations**
- **L&F used a fixed threshold of the wind speed to define a storm event: 21 m/s without any spatial differentiation**

Here, some amendments are introduced, in order to:

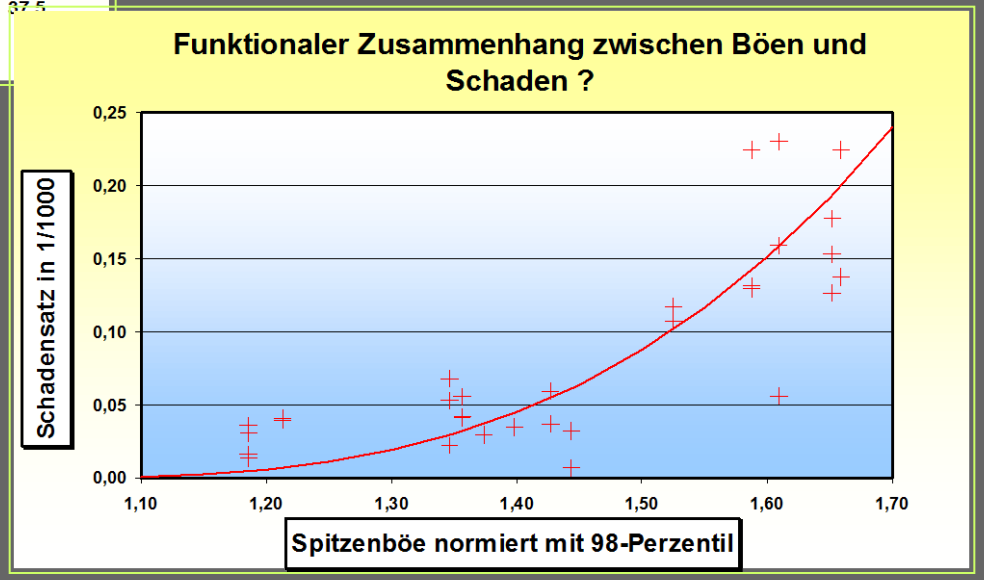
1. **apply the severity measure to gridded data sets**
2. **to account for the spatial heterogeneity of the impact of high wind speeds**

Functional relation between wind speed and realised damages; e.g. storm „Lore“, 28.01.1994



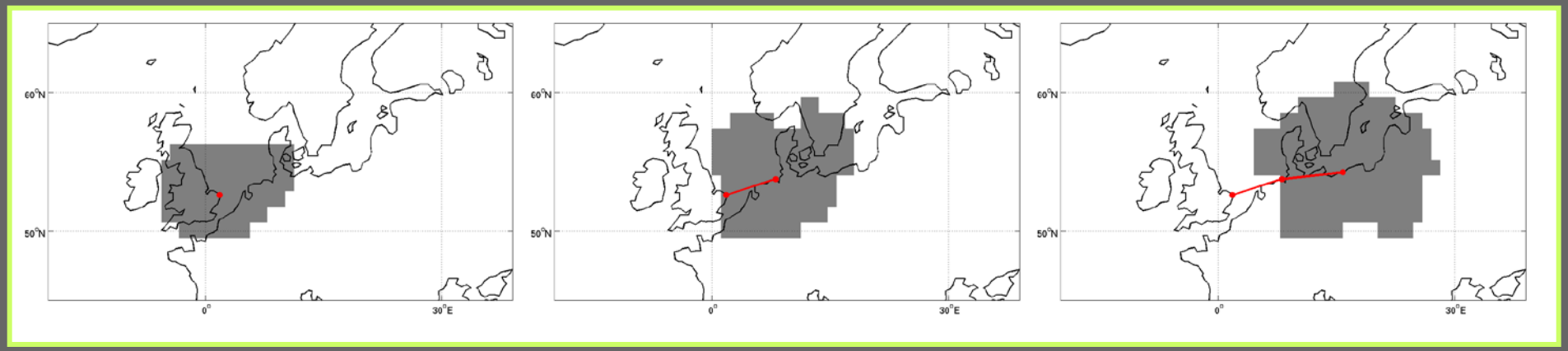
Only in the upper 2% of the measured wind speeds, damages occur.

Normalization with 98th percentile



2. WTRACK & SSI Concept

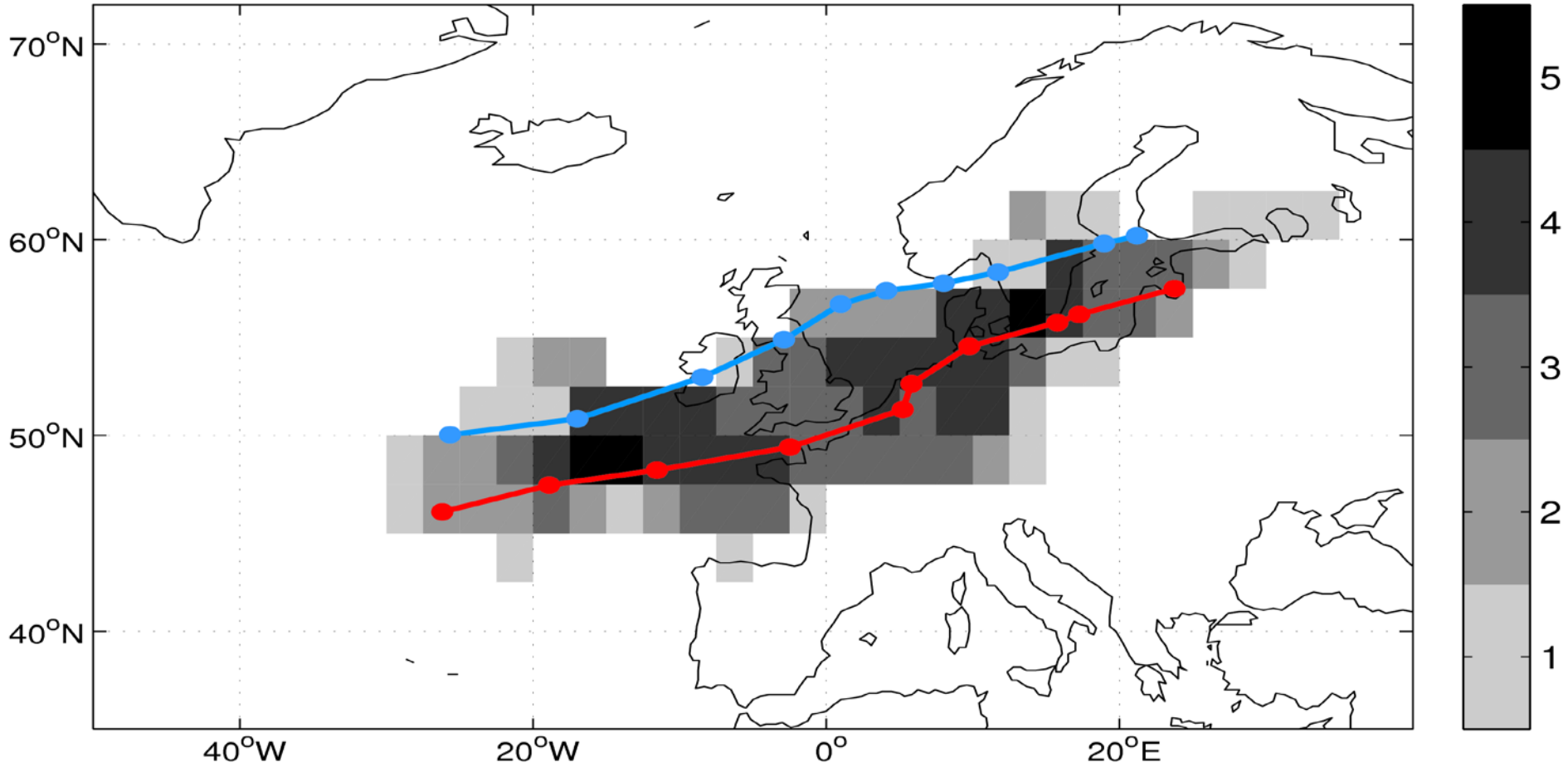
Basic Concept: Leckebusch et al. 2008 (2011 in prep.)



1) **Identification** of
- spatial coherent cluster of local exceedances of the
- 98th percentile of wind speed (e.g. in 10m, 850hPa, Sigma level),
- minimum area affected (e.g. 400x400 km^2)

2) **Tracking** of theses clusters:
- Nearest-Neighbour-Algorithm with a max. cluster travel distance, and
- minimum life time of the track (e.g. 18h)

Track of wind storm "Daria" (24.01.1990–26.01.1990), and its Footprint



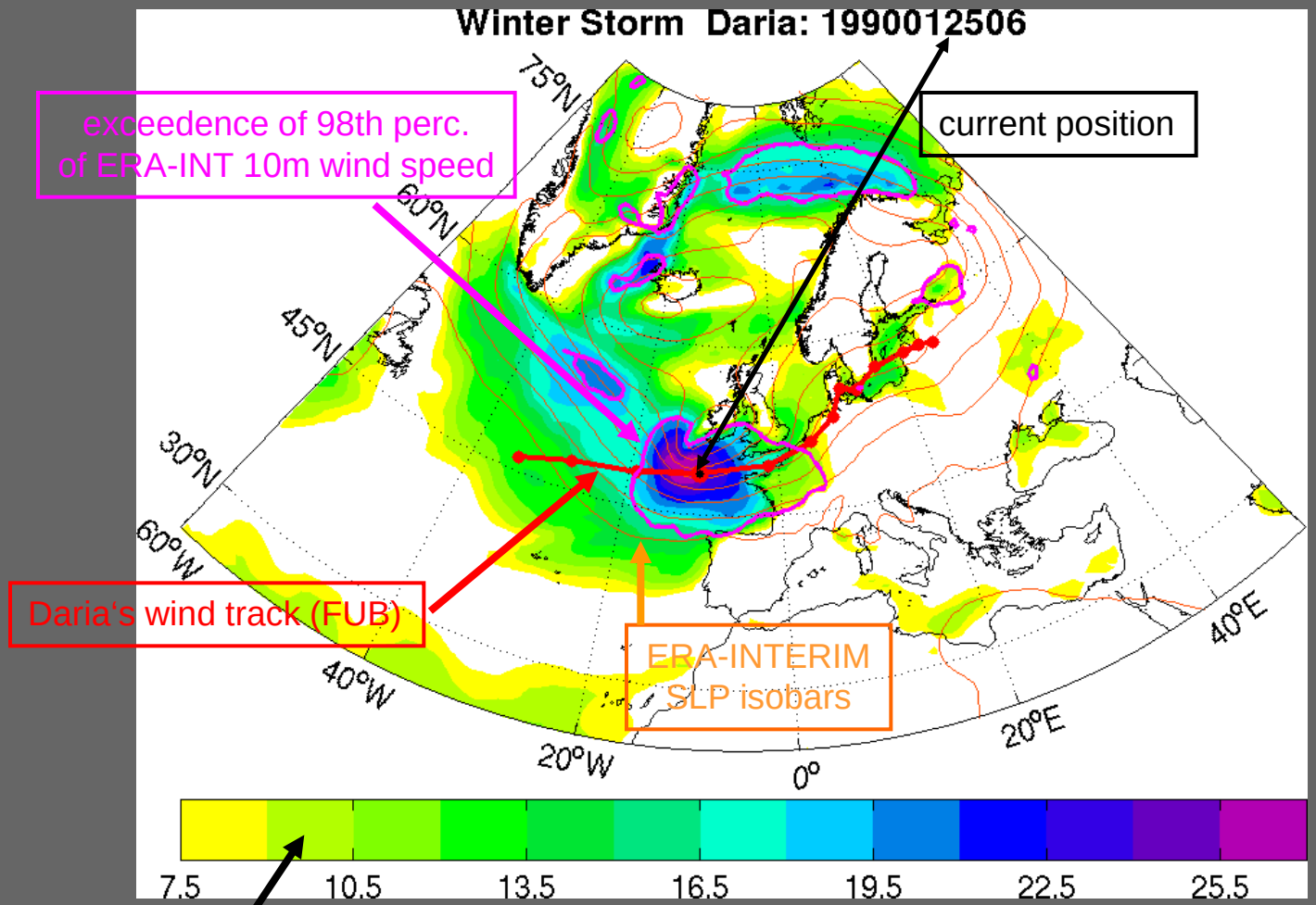
based on wind speed (red) and affected area (shading)
Shading: number of times a grid box was affected

Leckebusch et al., 2008

Specific settings for NH mid latitudes

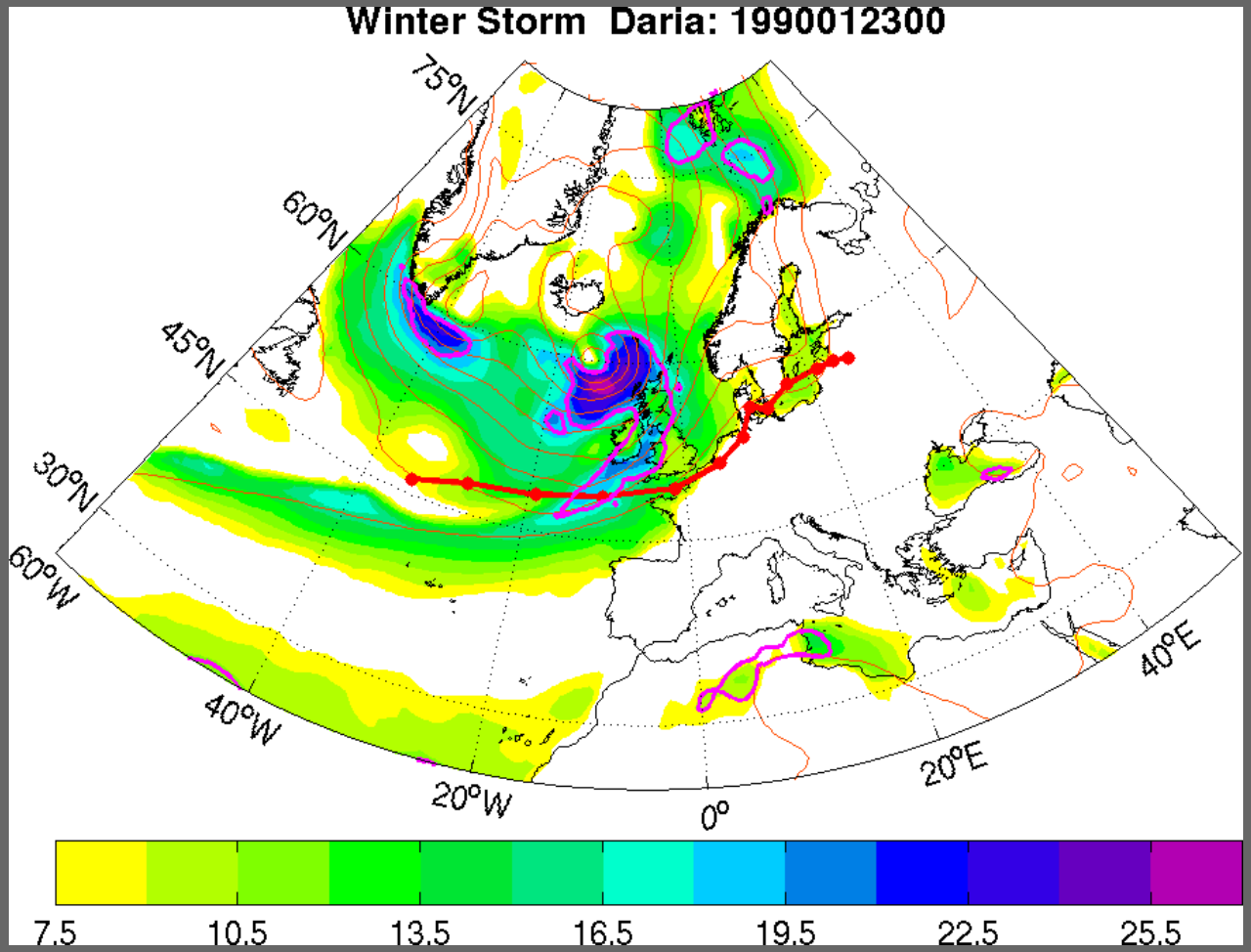
- minimum size of wind storm field > 150,000 km²
  - approx. 390 x 390 km²
- max. system translation velocity of 100km/h
  - (+ storm size dependant parameter for internal shift of storm centroid, e.g. maxdist = 600km + 0,5*R => R = Storm area – radius = max (R_t , R_{t+1}))
- minimum life time of 18h
  - min. track length of 4 time steps

Case study: e.g. "Daria"



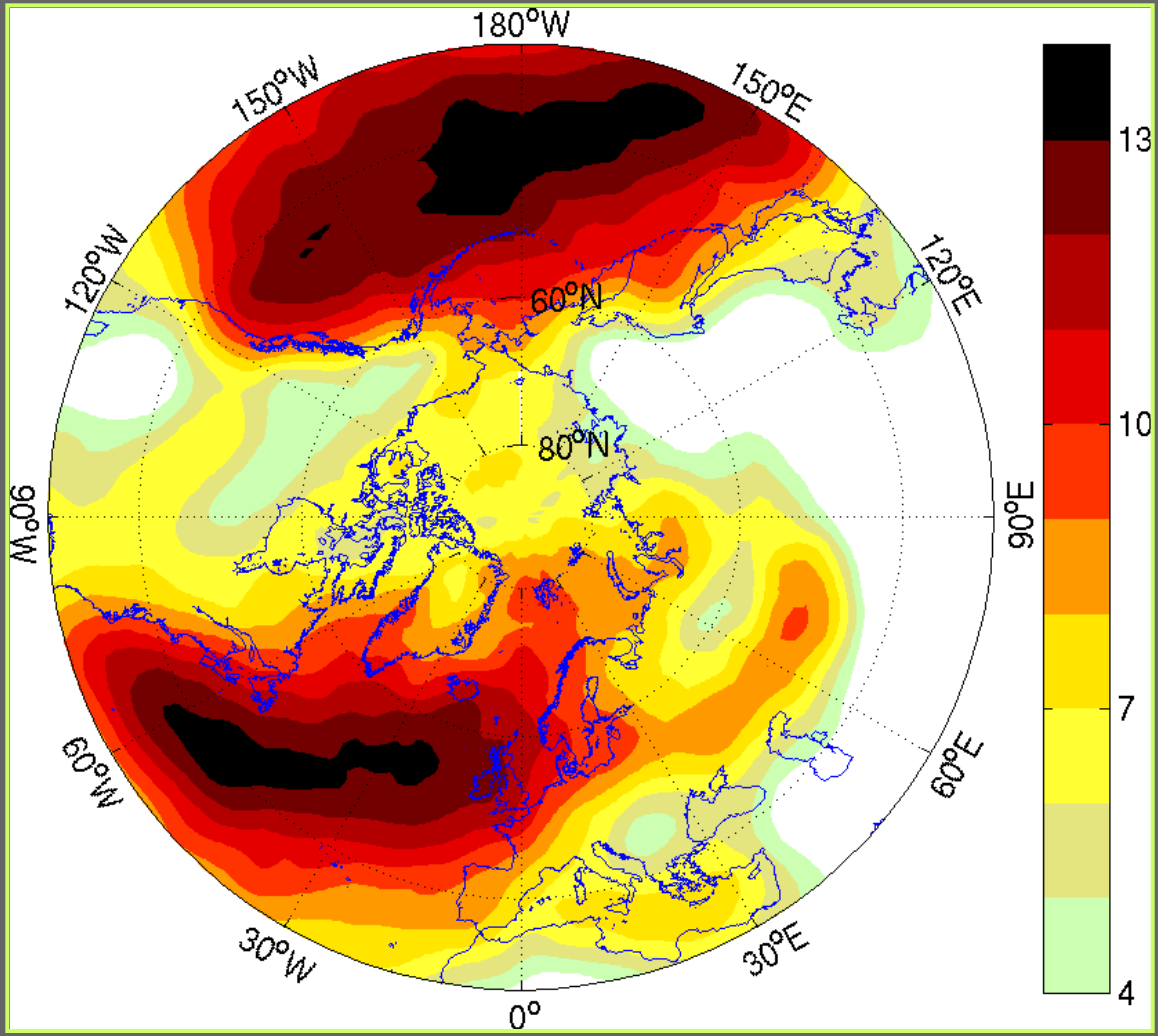
10m wind speed in ERA-INTERIM

Case study: e.g. “Daria”



Trackdensity

- ERA-INTERIM
- ONDJFM 1989/90-2009/10
  - **mean no. of wind storm tracks within vicinity of 500km**
  - **Unit: systems per winter**



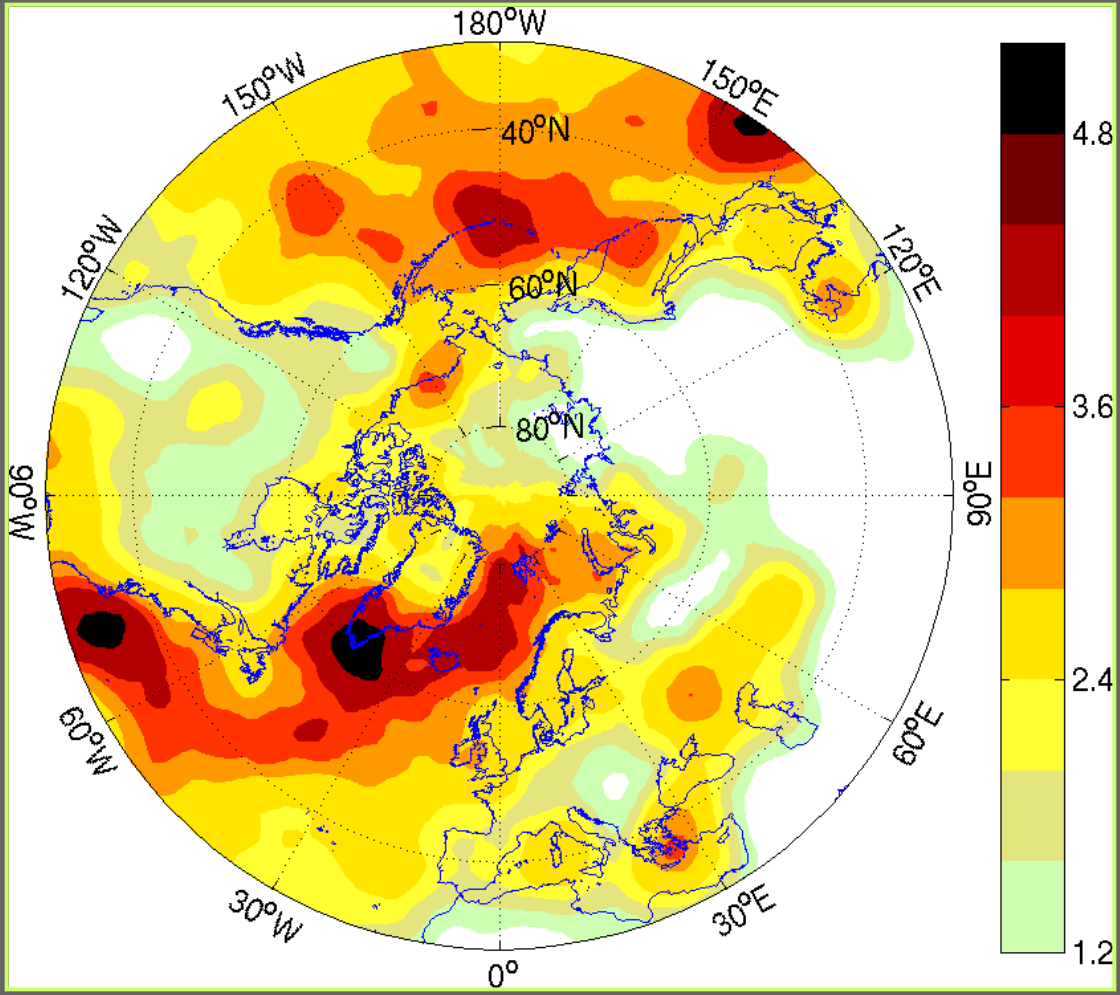
3. Mid-latitude tracking

Genesis

- ERA-INTERIM
- ONDJFM, 1989/90-2009/10

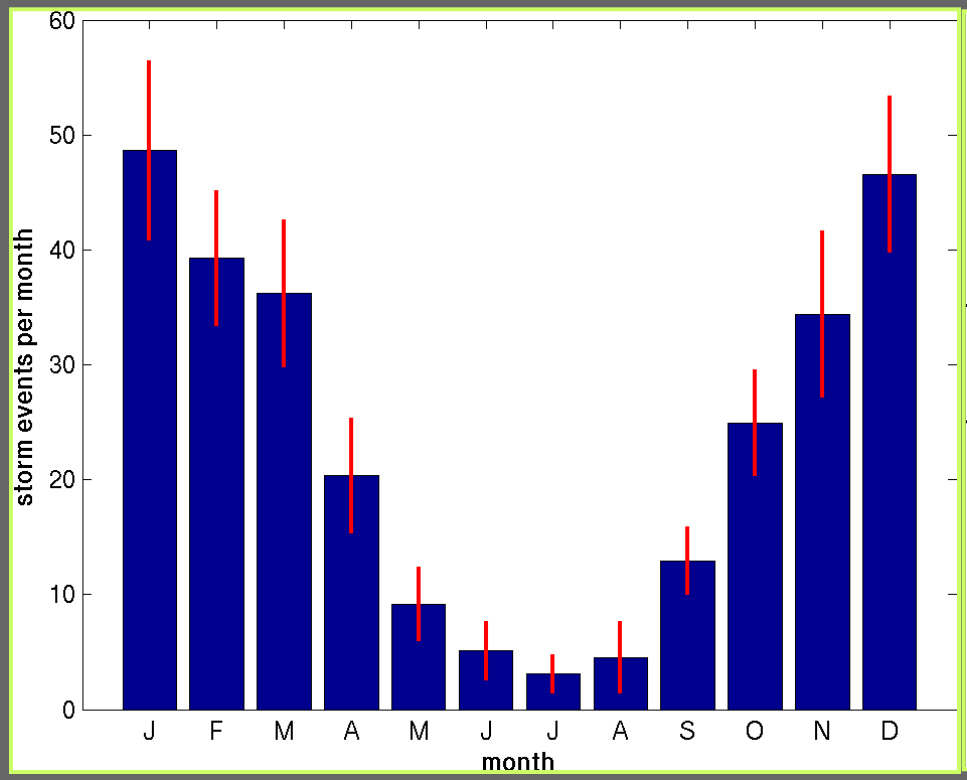
Genesis of wind storm tracks within vicinity of 500km

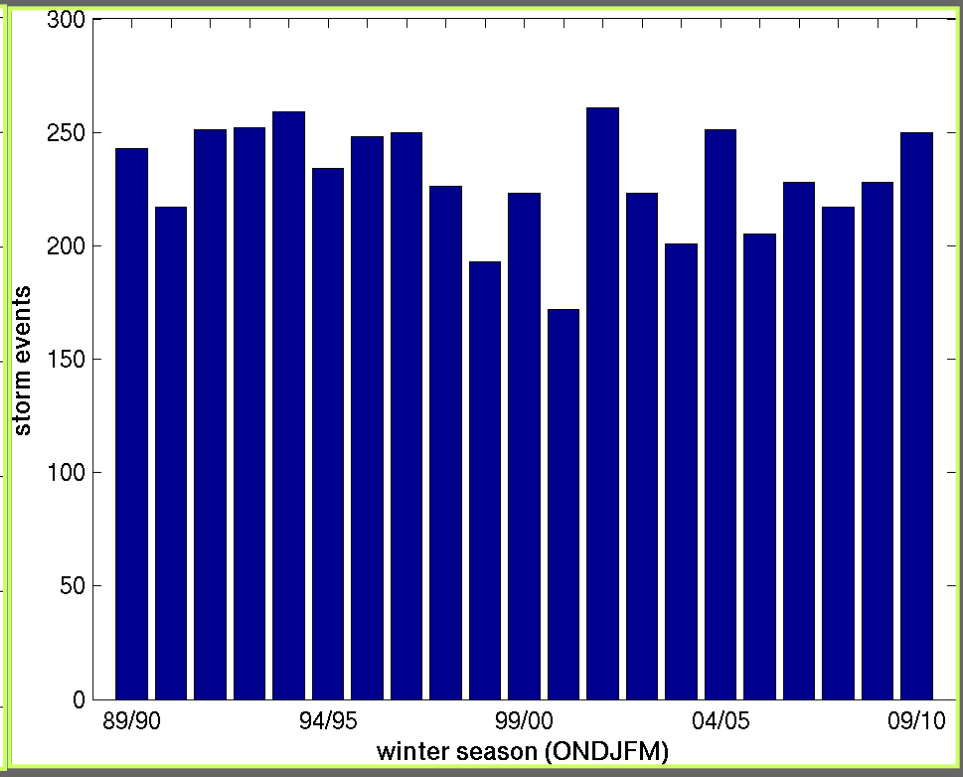
– Unit: Systems per winter



3. Mid-latitude tracking

Intra- and Interannual Variability
Synoptic scale NH extratropical (25°-90°N) storms

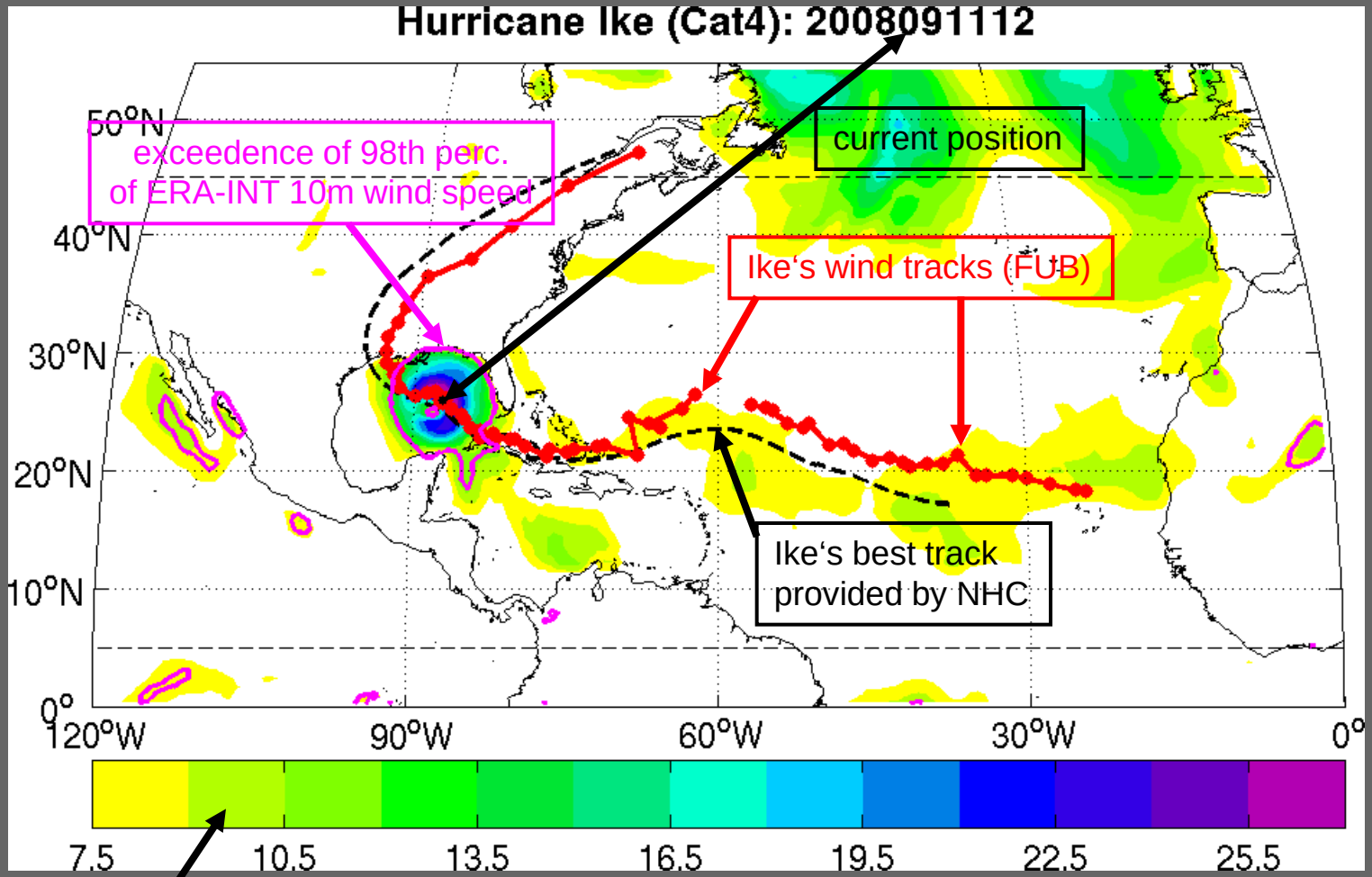




Identification and Tracking of tropical cyclones and hurricanes

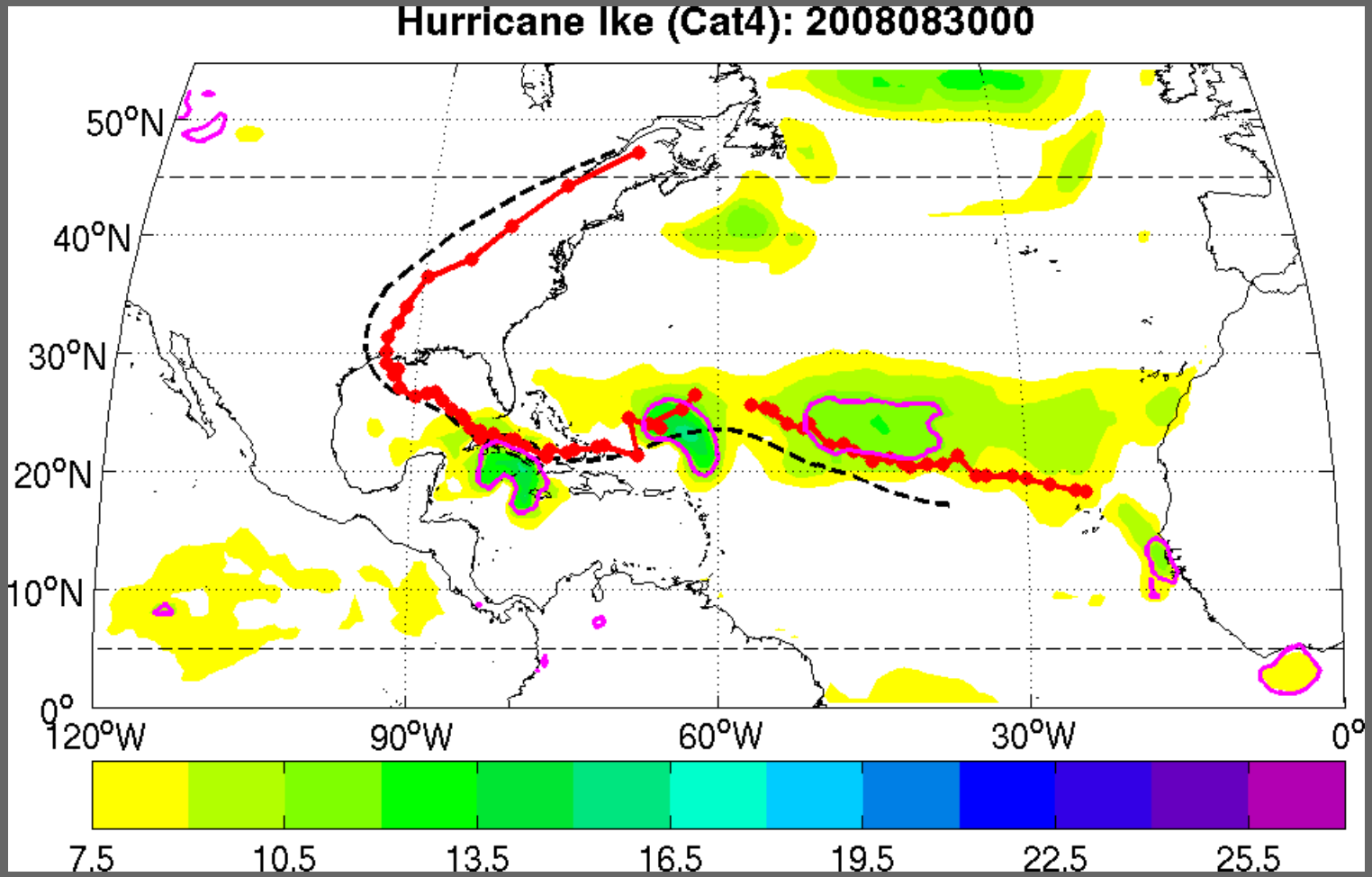
- Specific settings:
  - minimum size of wind storm field > 36000km²
    - approx. 190 x 190 km²
  - max. system translation velocity of 66km/h
    - (+ storm size dependant parameter for internal shift of storm centroid)
  - minimum life time of 18h
    - min. track length of 4 time steps

Case study Hurricane "Ike"

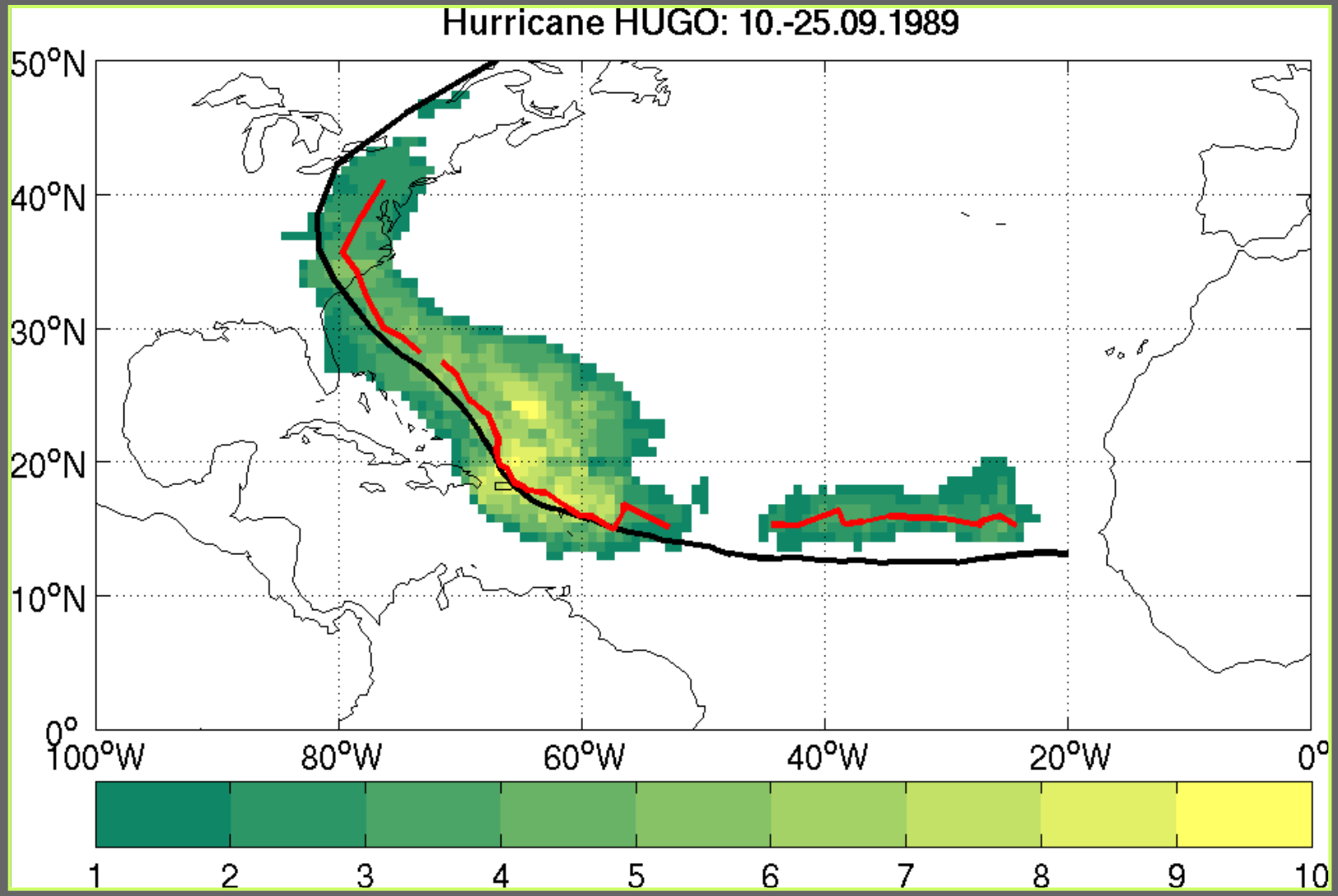


10m wind speed in ERA-INTERIM

Case study Hurricane "Ike"



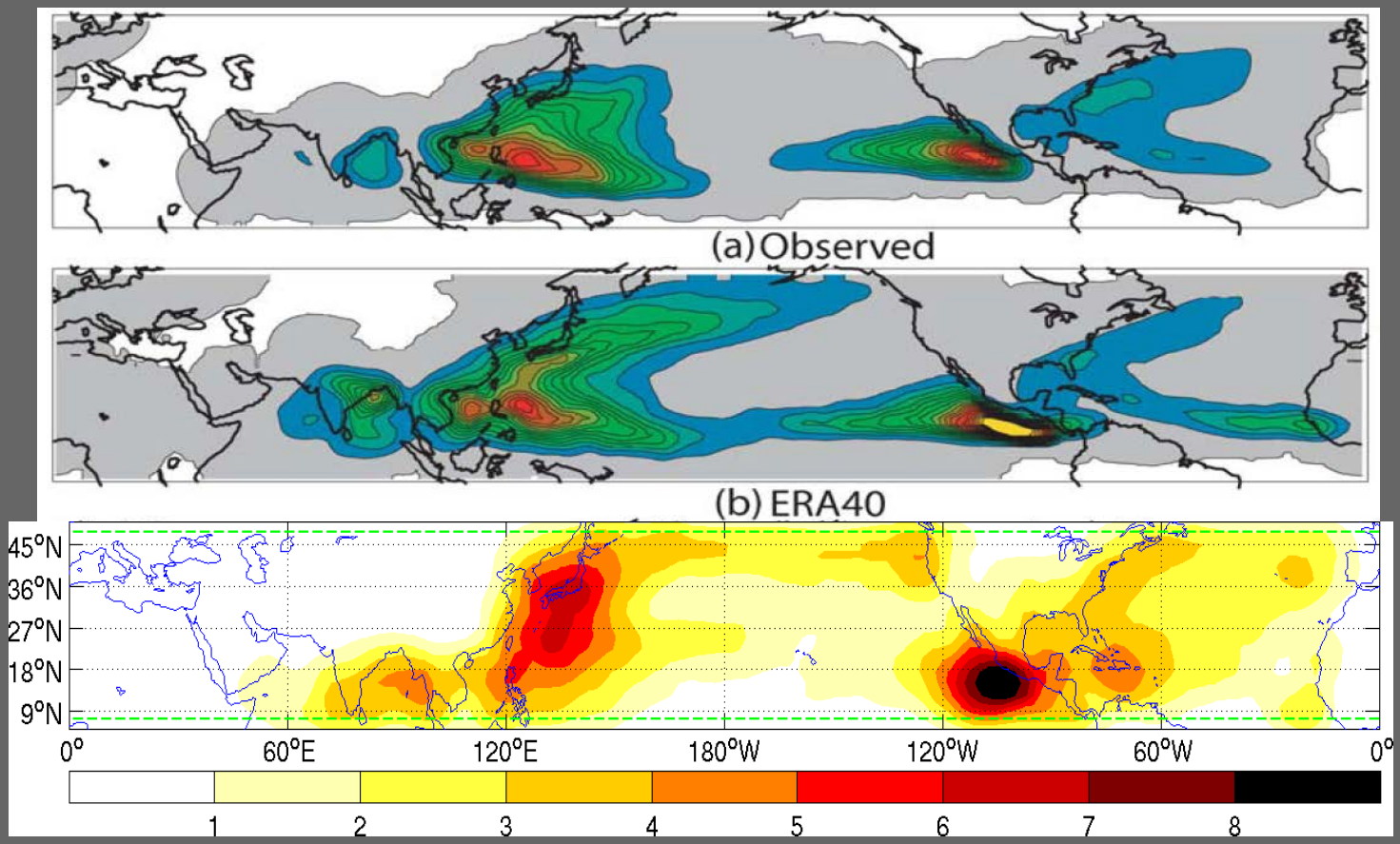
Footprint assessment and analysis: Hurricane “Hugo”



4. Tropical tracking

Application of a spatial based post-processing

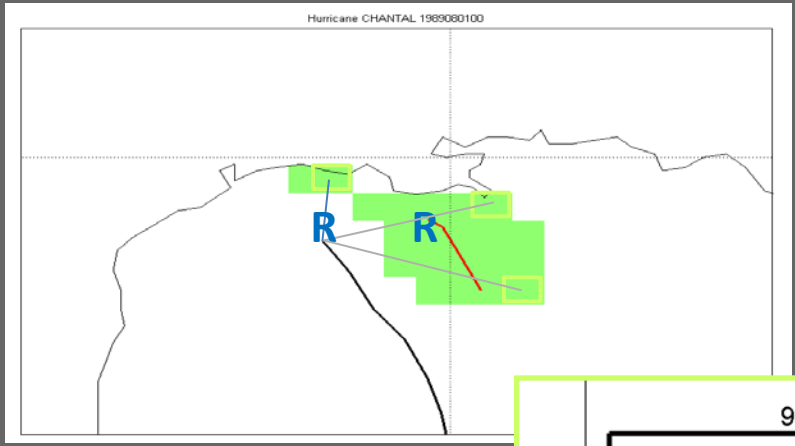
Comparison with Bengtsson et al., 2007:



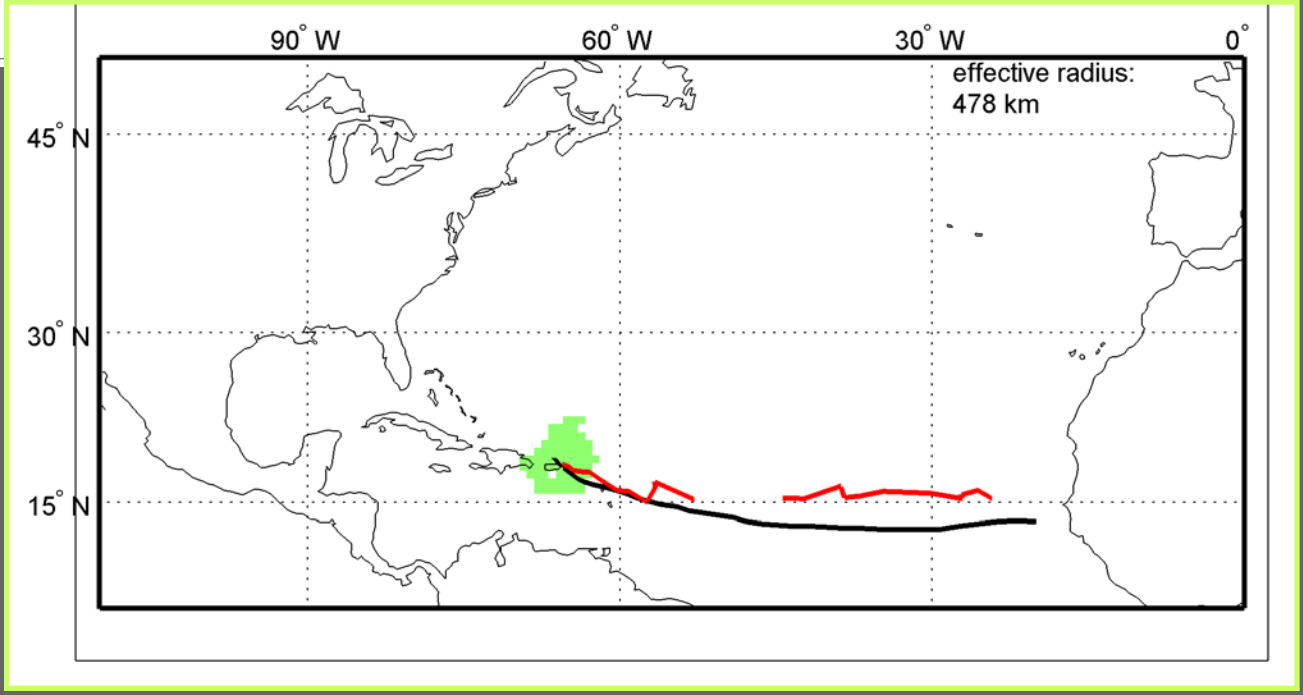
Bengtsson et al 2007: Tropical cyclones in a T159 resolution global climate model: comparison with observations and re-analyses. Tellus Series A-Dynamic Meteorology And Oceanography Vol.59, 396-416

4. Tropical tracking

Estimation of effective radius of impact:



HUGO, 18.09.89, 18 GMT

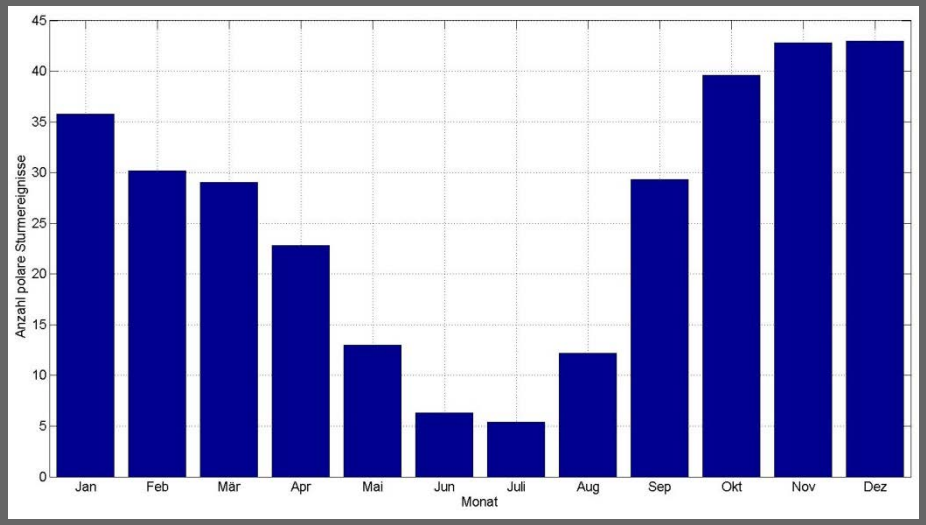


4. Tracking of Polar Low's

Polar Low Tracking:

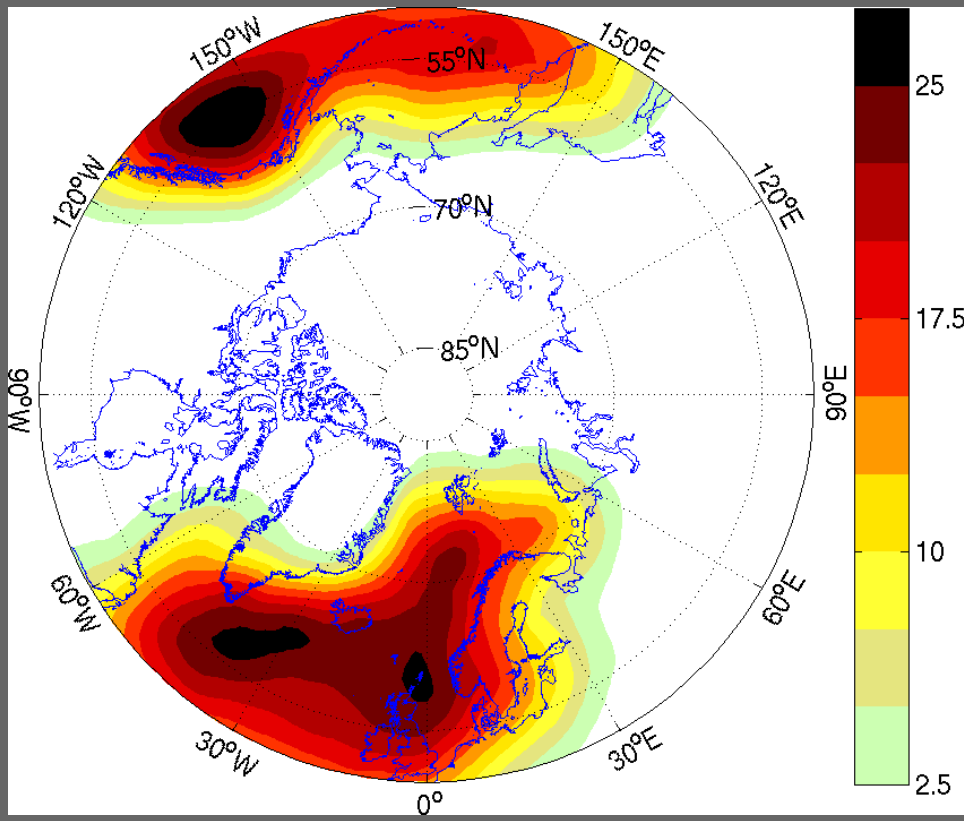
- Region: NH north of 40°
- minimum number of grid boxes affected: 2 ; equivalent to apr. 123 km in diameter circle
- minimum life time: 2 time steps (6h)

Number of Systems per month 1989-2007



Trackdensity 1989-2006.

Winter (ONDJFM); Unit: Systems in 500km radius



6. Applications

1) Identifying the relevant systems in sub catchments like the Mediterranean; Matching with cyclone tracks
➔
Identification of damage relevant systems and their relation to large-scale variability pattern, as the NAO. (e.g. Nissen et al., 2010)

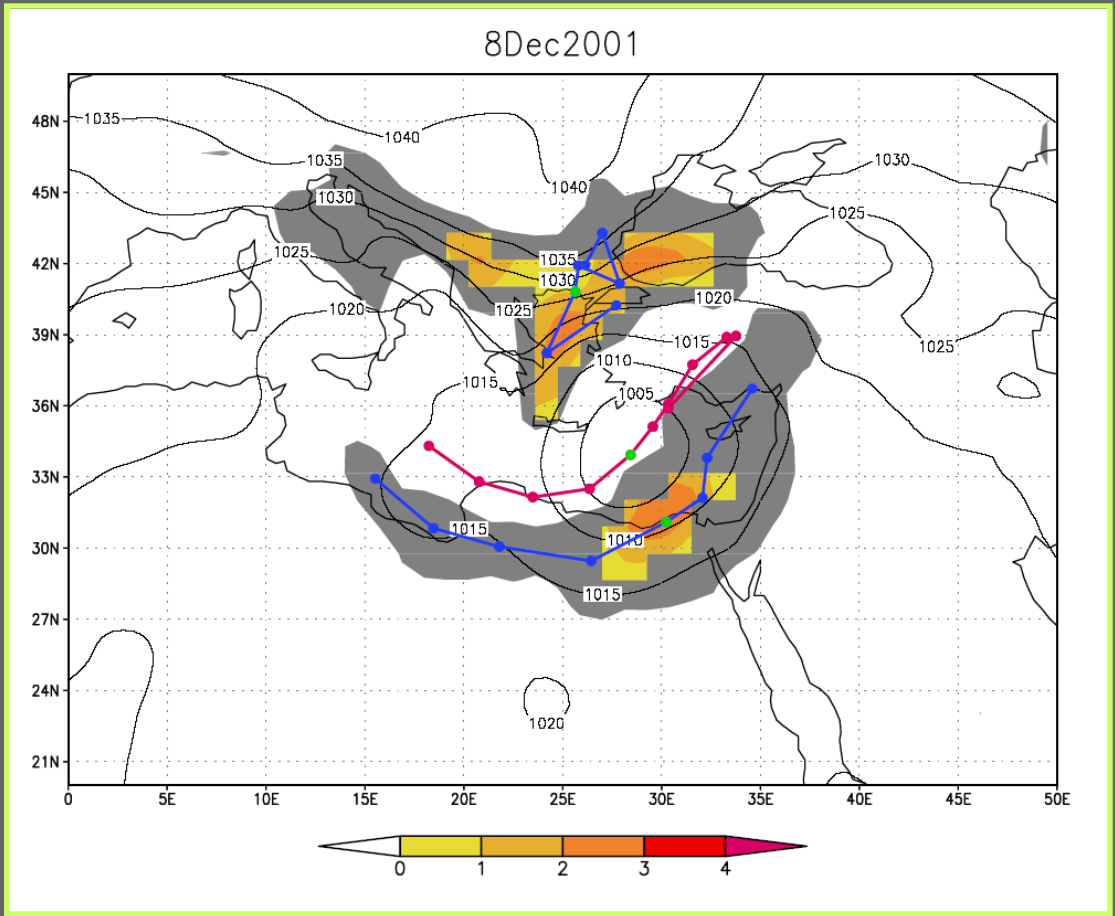
2) ACC signal detection in Climate model runs
(e.g. Leckebusch et al., 2008)

not shown here …

6. Applications

Relevant systems in sub catchments like the Mediterranean

➔ Matching with cyclone tracks



Matching algorithm developed in
Nissen, Leckebusch et al., 2010 (Nat Hazards Earth Syst., 10, 1379-1391)

6. Applications

Mediterranean Cyclogenesis:

NAO$^+$ - NAO$^-$ Phases
for cyclones associated with strong wind events in the Mediterranean

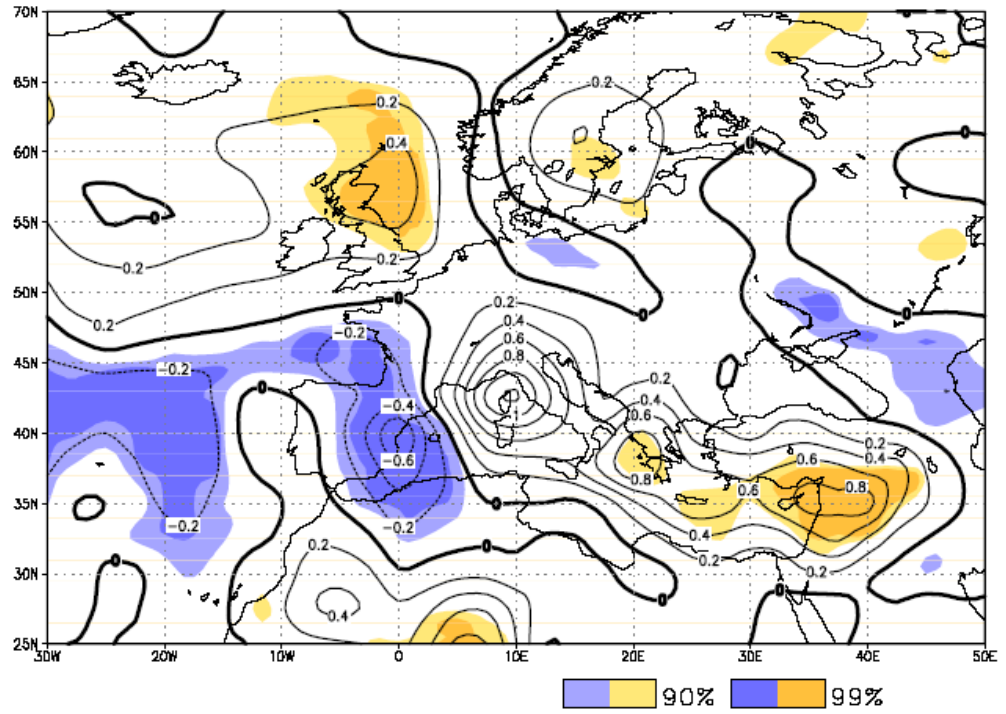


Fig. 11. Difference in cyclogenesis between positive and negative phase of the NAO for cyclones associated with wind events in the Mediterranean region. Calculated for extended winter season. Shaded are 90% and 99% significance levels. Contour lines denote change in number of events per extended winter season (ONDJFM) per (deg.lat.)^2.

Nissen, Leckebusch et al., 2010 (Nat Hazards Earth Syst., 10, 1379-1391)

7. Summary

- Development of objective severe wind storm identification method, related to the potential impacts of this event
- Tracking of severe wind fields with destructive potential, including different parameter and applications suitable for further event diagnostics (footprint, area, duration, effective radius, etc.)
- Identification and tracking method flexible:
  applicable to different geographical regions and different types of severe wind events (ETC, TC, Polar Lows)
- Applicable to all gridded data sets (GCM, Reanalysis)
- Ongoing efforts: application to regional climate model simulations: further development of the tracking algorithm
- Assessment of potential damages arising from tropical cyclones and hurricanes (decadal variability; ACC signal)