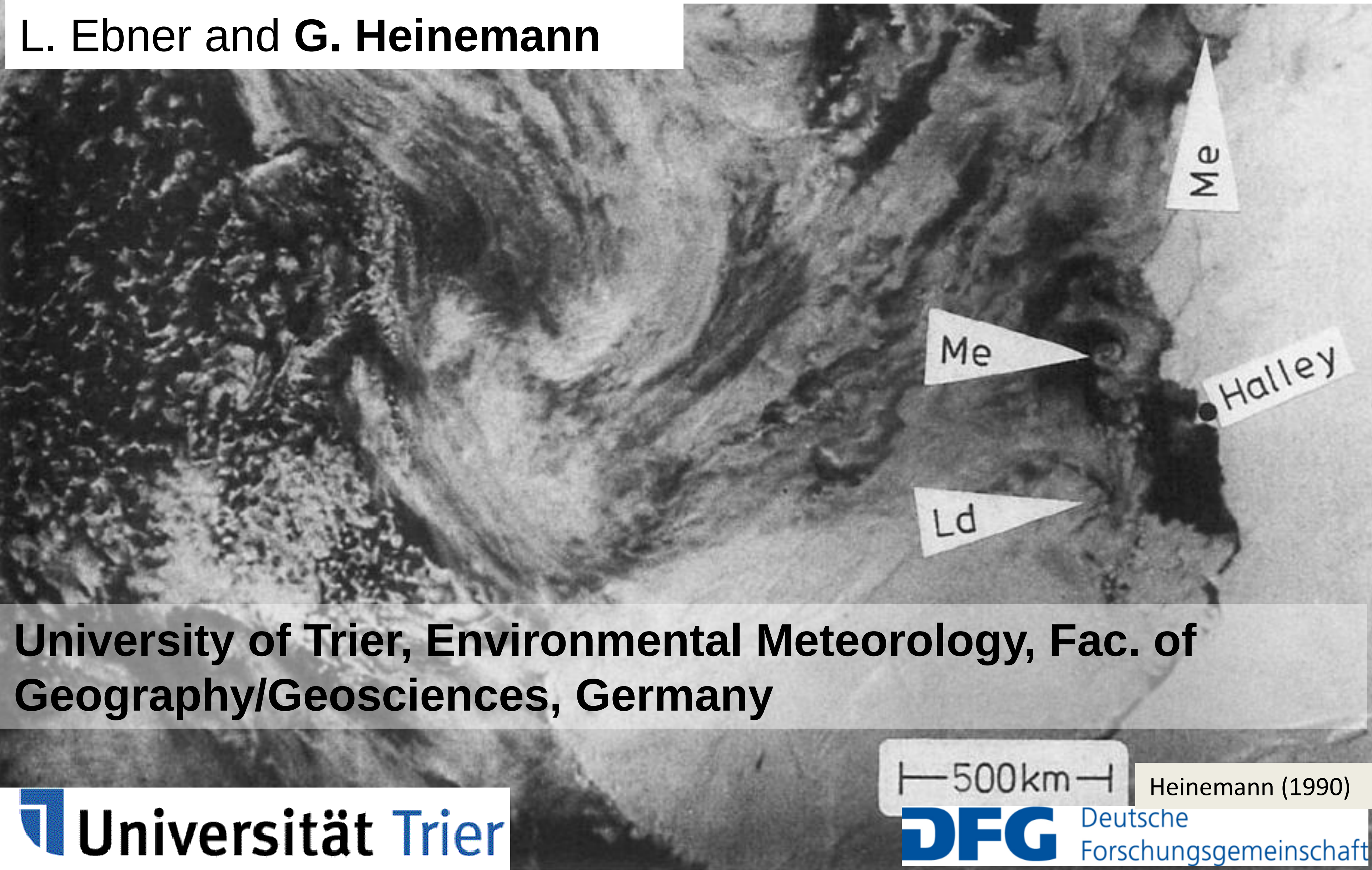
Cyclone and mesocyclone tracking in the Antarctic region and southern polar ocean

L. Ebner and **G. Heinemann**



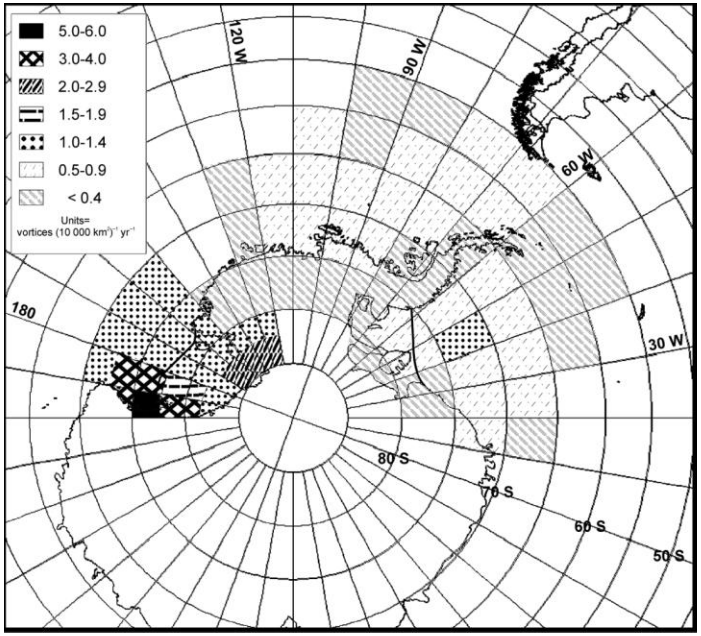
Heinemann (1990)

University of Trier, Environmental Meteorology, Fac. of Geography/Geosciences, Germany

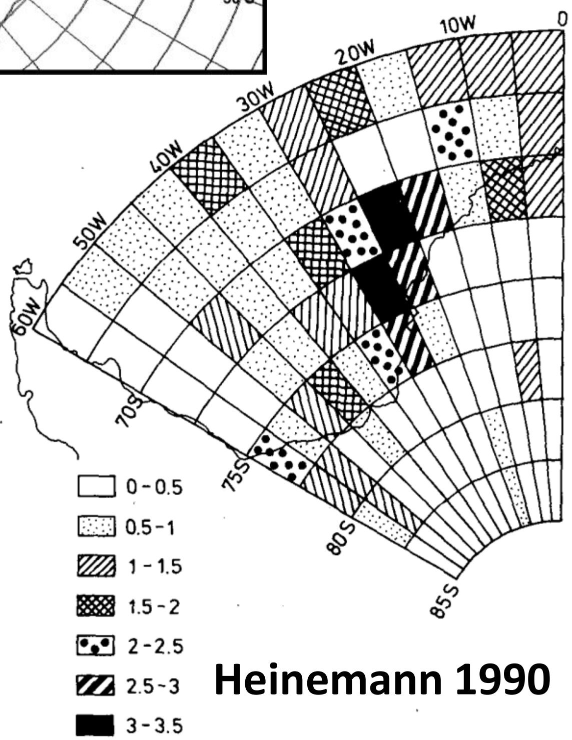
Universität Trier

DFG Deutsche Forschungsgemeinschaft

Satellite-based MC studies

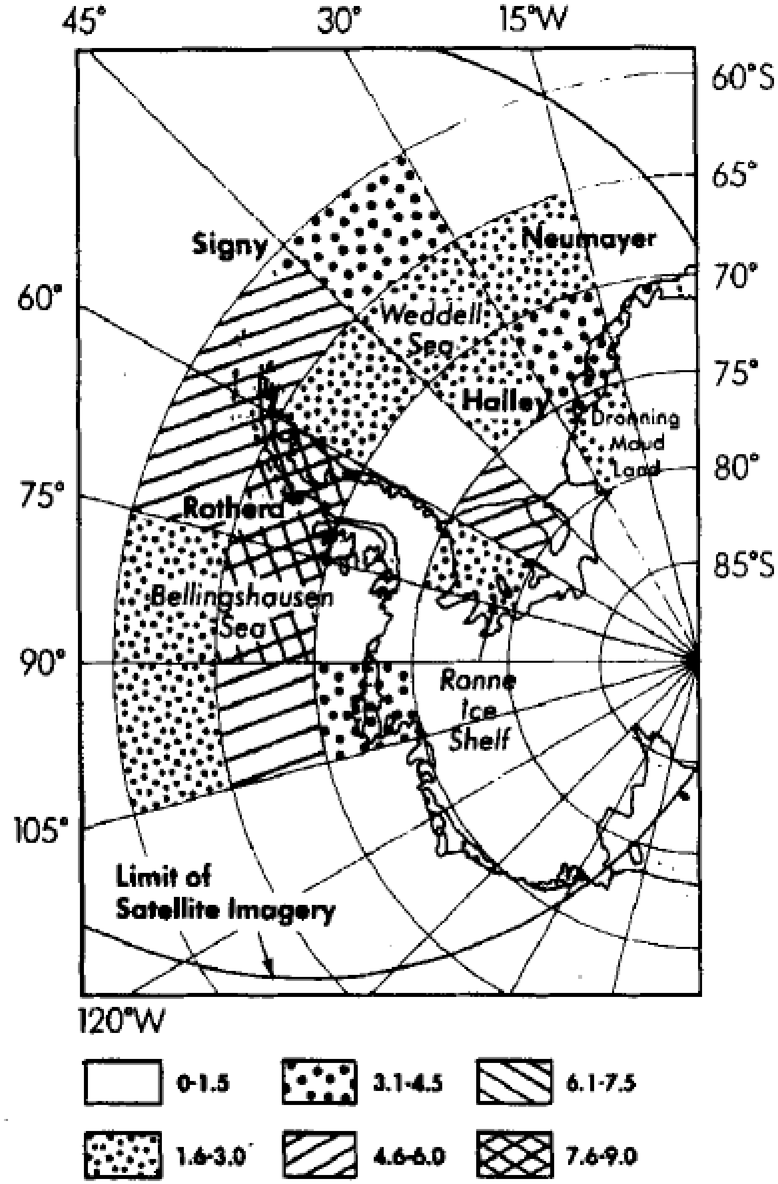


Carrasco et al. 2003
Jan.-Dec. 1991

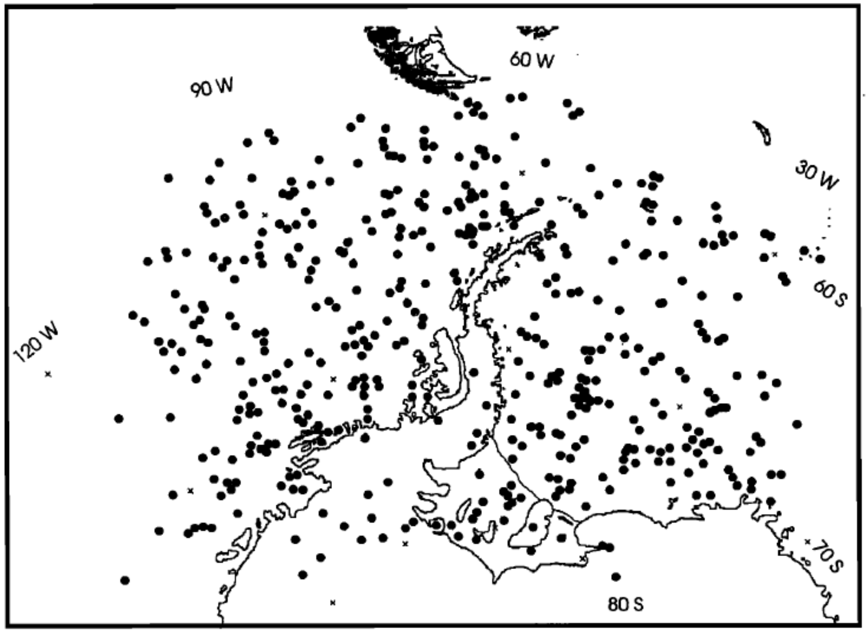


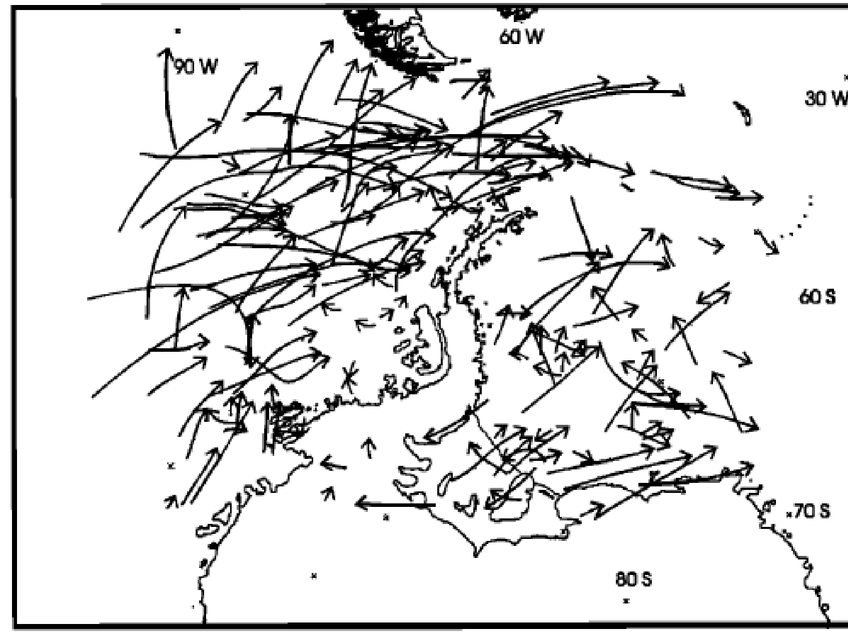
Jan./Feb.
83-88

Heinemann 1990

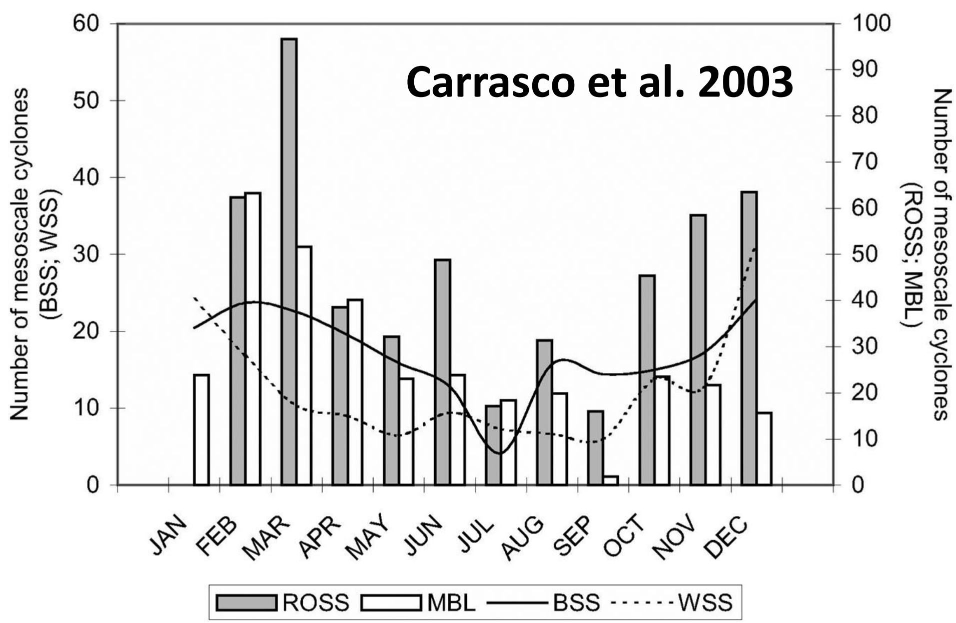


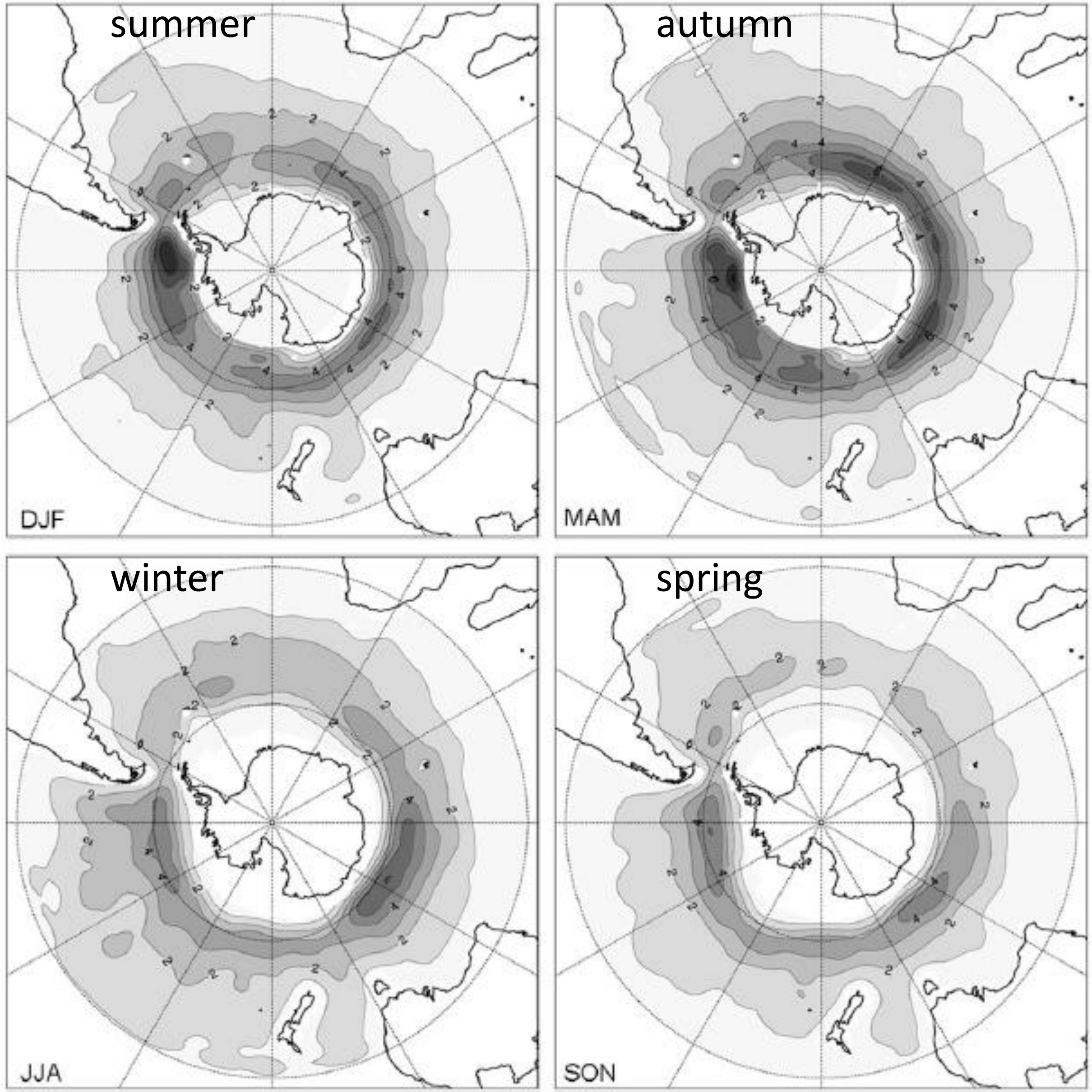
Turner and Thomas 1994
Dec./Jan./Feb. 83-84





Carrasco et al. 1997

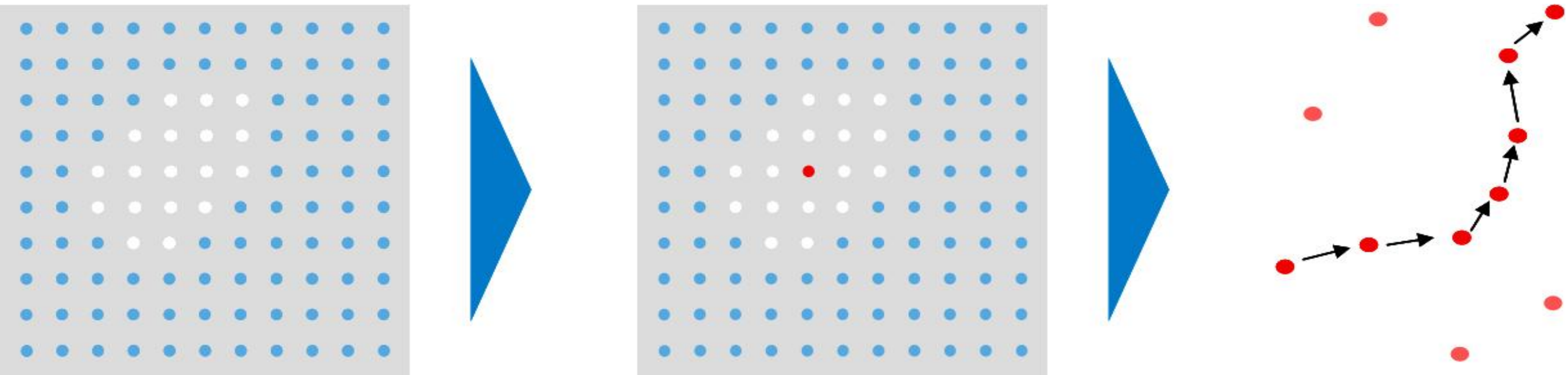




Irving et al. 2010

MC system density = mean number of cyclones (unit: 10^{-3} per $(°lat)^2$ area per analysis), 1999-2008. Data: Surface pressure fields (0.5° x 0.5°) derived from **QuikSCAT** surface wind (25 km resolution)

TRACK(ing algorithm) Hodges 1994



segmentation — feature point detection — Tracking using a minimized cost function

Illustration of the TRACK method by Hodges (1994, 1995)

Data:

GME (25-40km) for 2007-2011

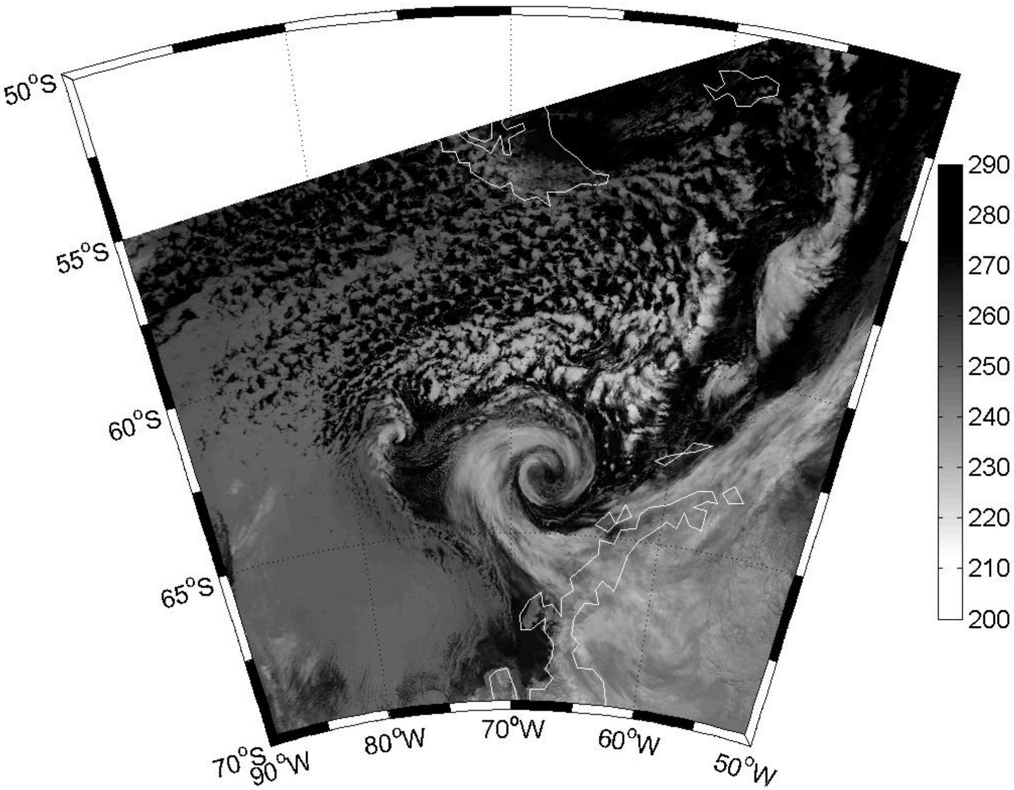
ERA-Interim (80km) 1979-2011

MC tracking

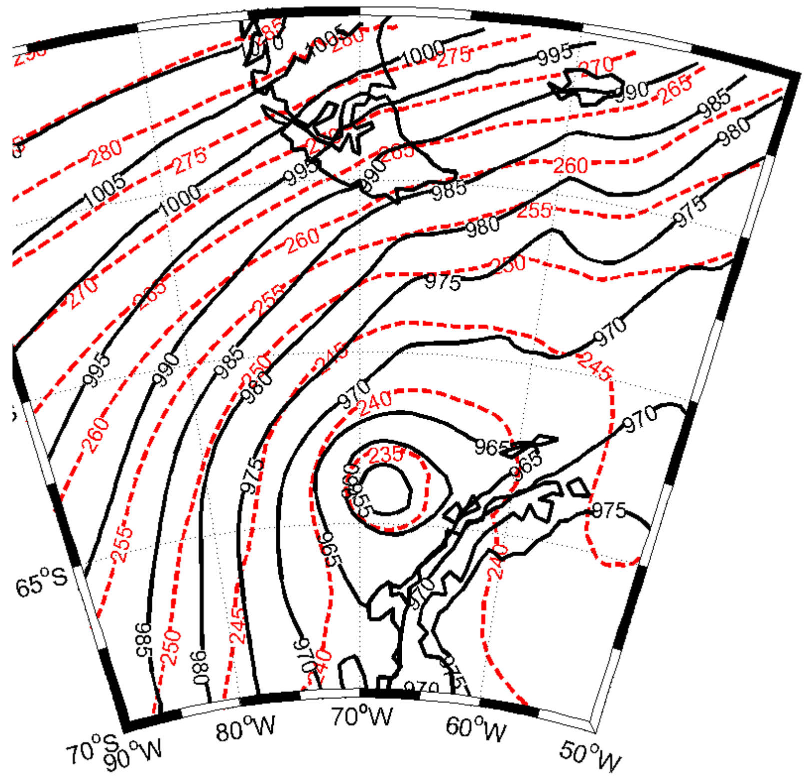
- calculation of vorticity (850 hPa)
- spectral filtering (wave number for MCs 40-100)
  - → 65°S (170 km – 500 km)
  - →tracking (optional parameters)
- post processing (polar lows requirements, regarding topography, surface pressure, …)

Alternative spectral filtering
MC1: wave number 30-100, at 65°S: 170 km – 570 km
MC2: wave number 15-30, at 65°S: 570 km – 1100 km

A case study: 28 April 2009

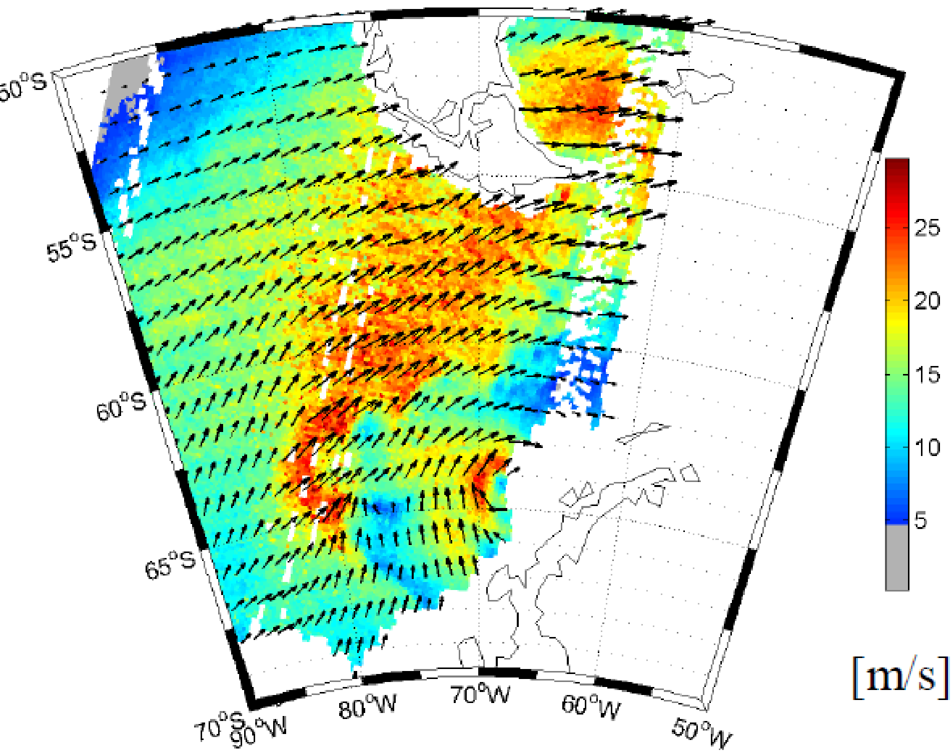


AVHRR IR 0159 UTC 28 April 2009

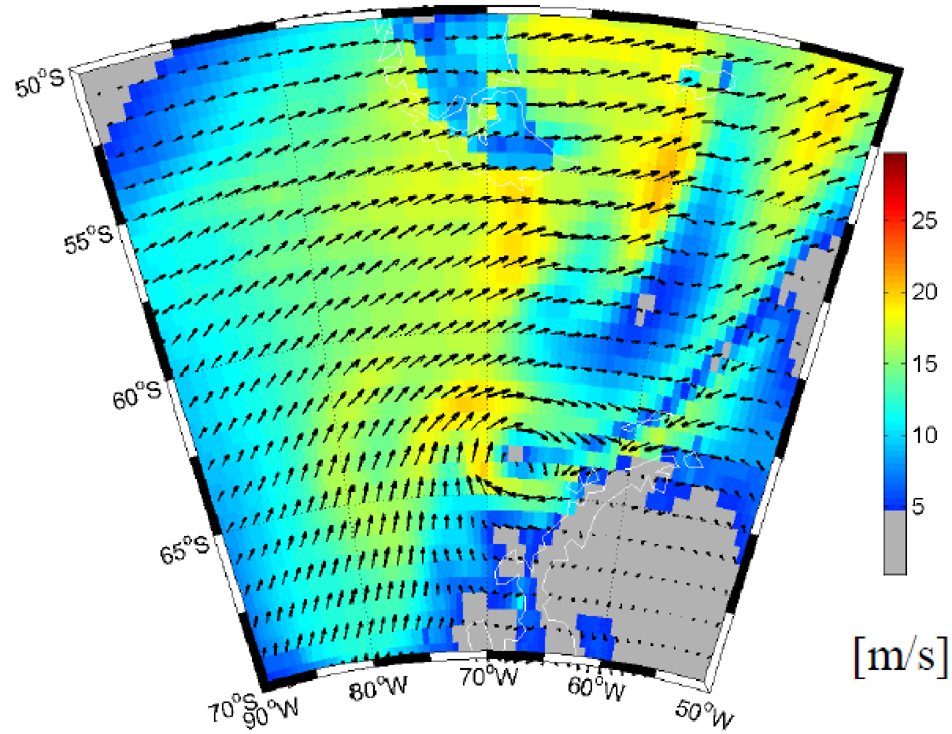


GME: MSLP (black, isolines 5 hPa) and 700hPa geopotential (red, gpdm) for 0000 UTC 28 April 2009

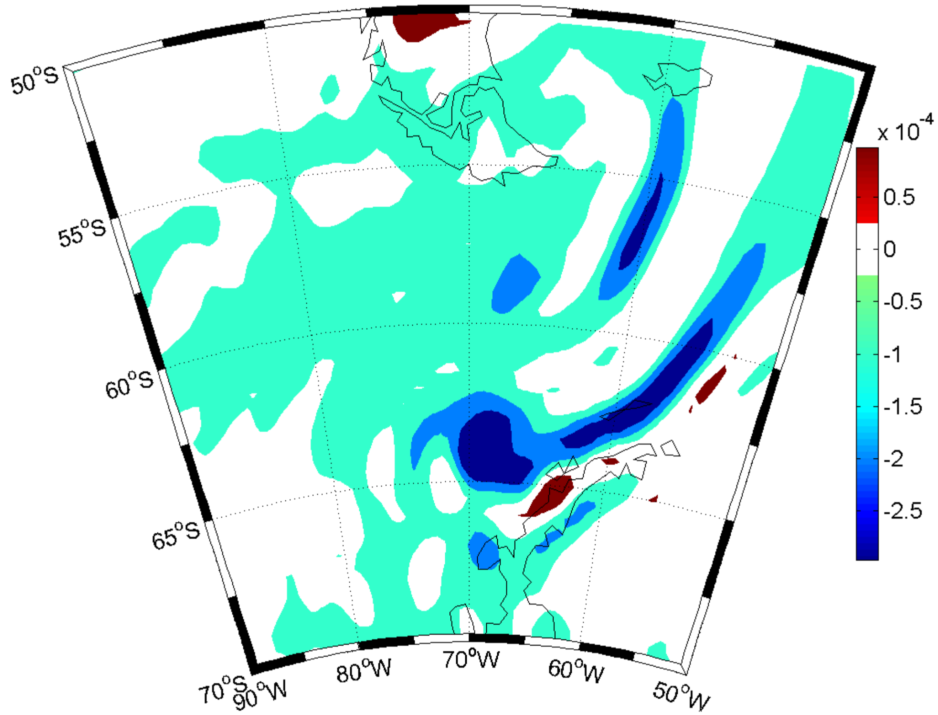
Ebner et al. (2010)



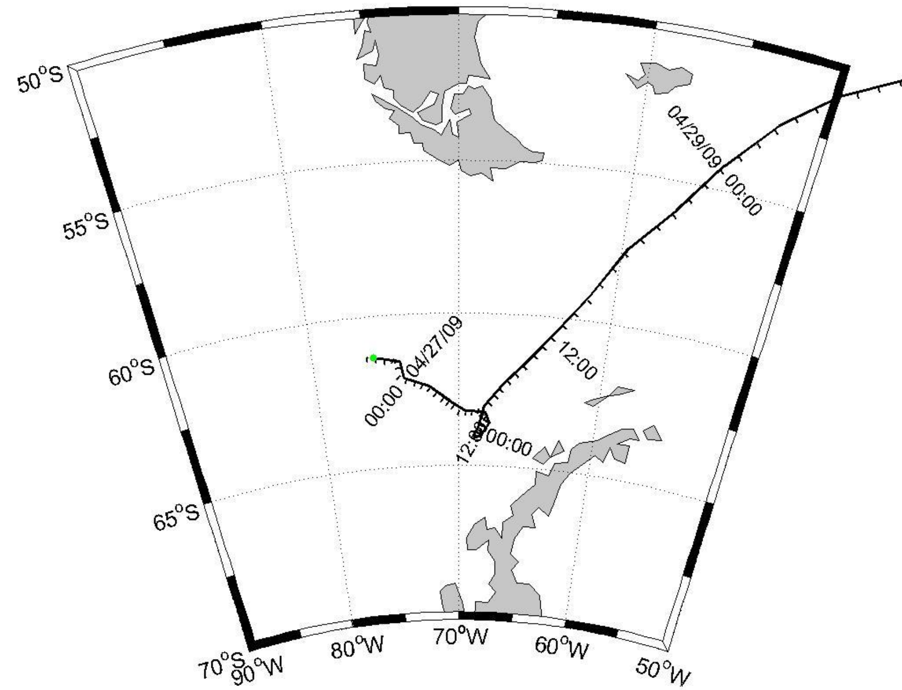
QuickSCAT: 10m wind for 2220 UTC 27 April 2009



GME: 10m wind for 0000 UTC 28 April 2009



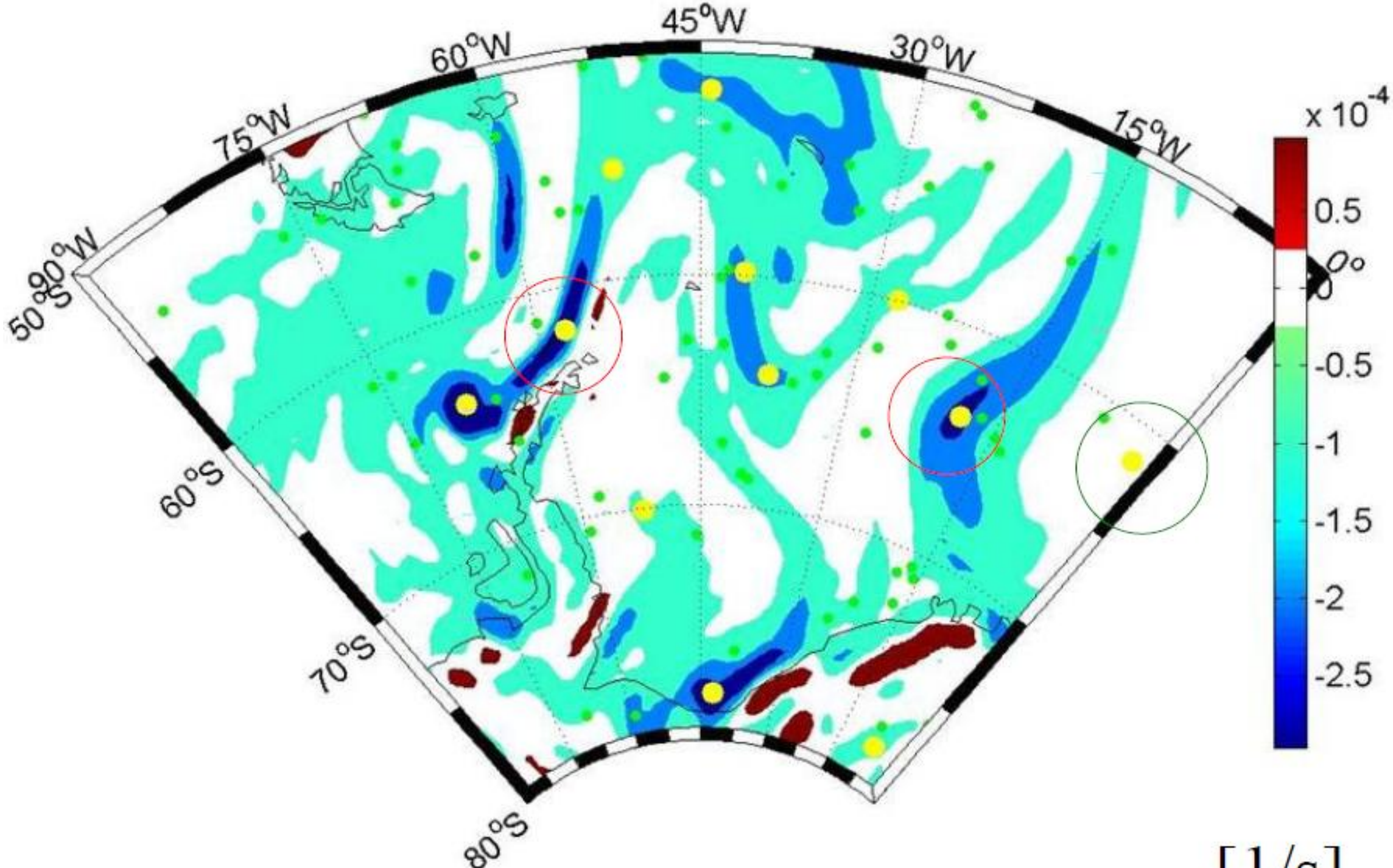
GME 850 hPa vorticity 0000 UTC 28 April 2009, red: anticyclonic, blue: cyclonic



Corresponding track calculated by TRACK

Ebner et al. (2010)

wave number for MCs 40-100



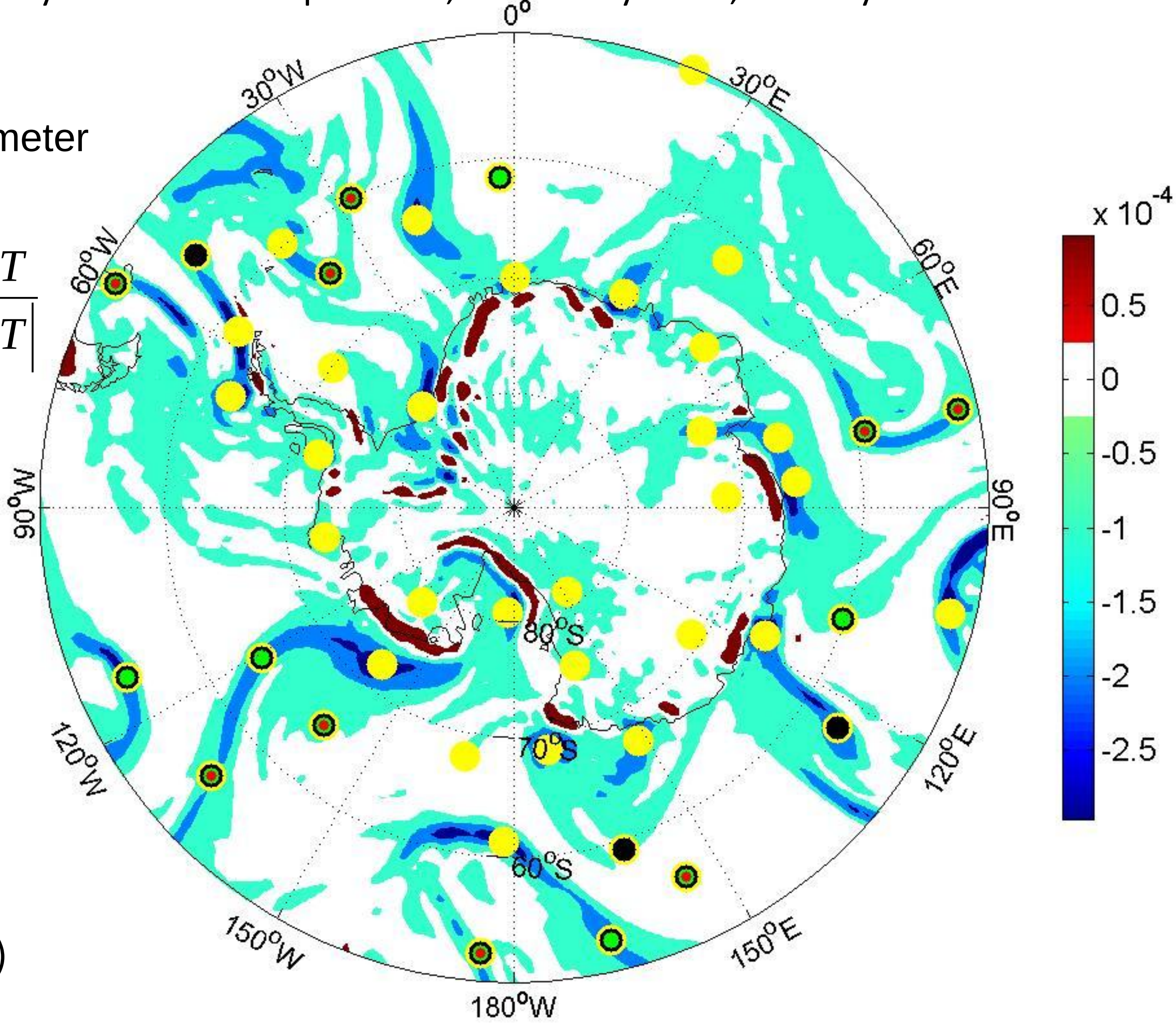
GME 850 hPa vorticity 0000 UTC 28 April 2009, red: anticyclonic, blue: cyclonic, track points yellow

Bauer (2010)

GME 850 hPa vorticity 0000 UTC 28 April 2009, red: anticyclonic, blue: cyclonic

thermal front parameter (TFP)

$$TFP = -\vec{\nabla}\left|\vec{\nabla}T\right| \cdot \frac{\vec{\nabla}T}{\left|\vec{\nabla}T\right|}$$

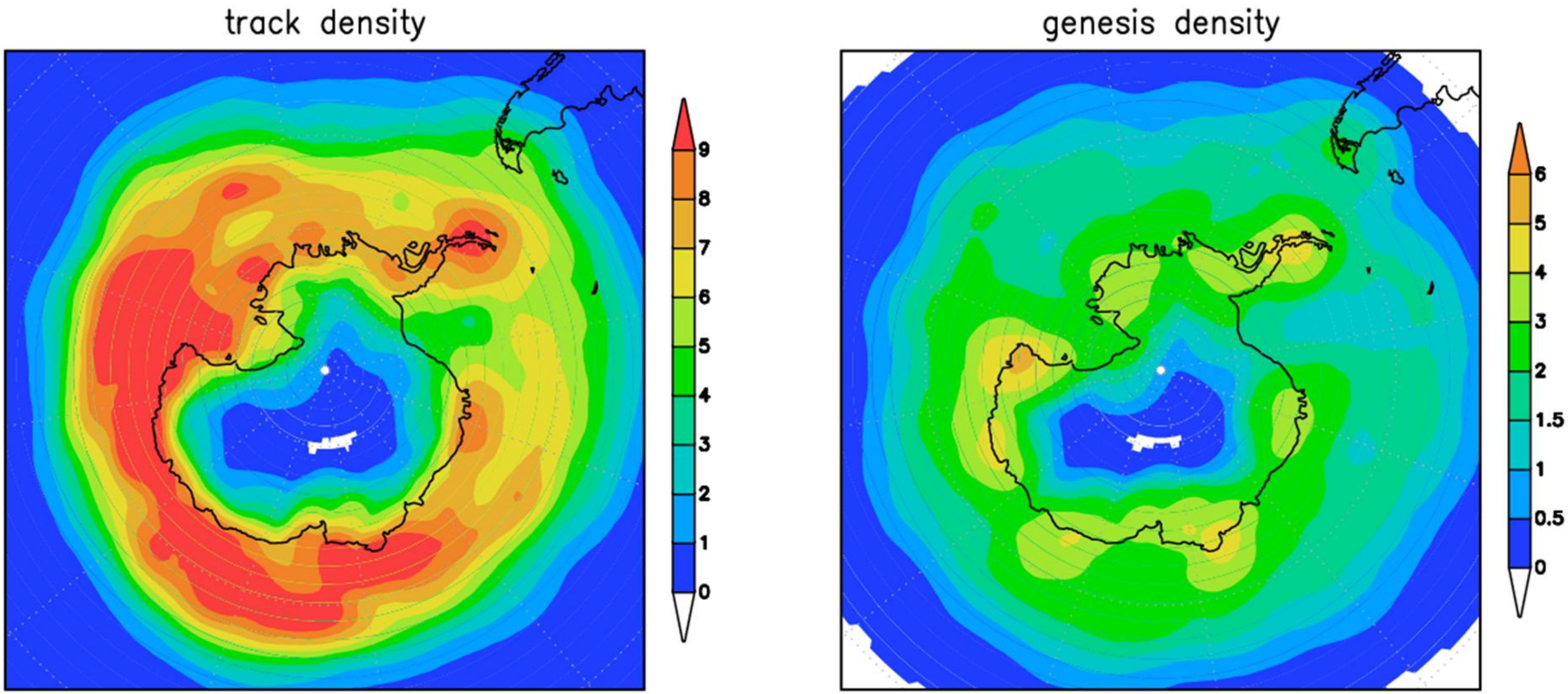


Ebner et al. (2010)

Dots: track positions with filter conditions (yellow: windspeed >13.9 m/s, black: plus TFP < 15 * 10^{-10} K/m^2, green: TFP < 10 * 10^{-10} K/m^2, red: TFP < 7 * 10^{-10} K/m^2)

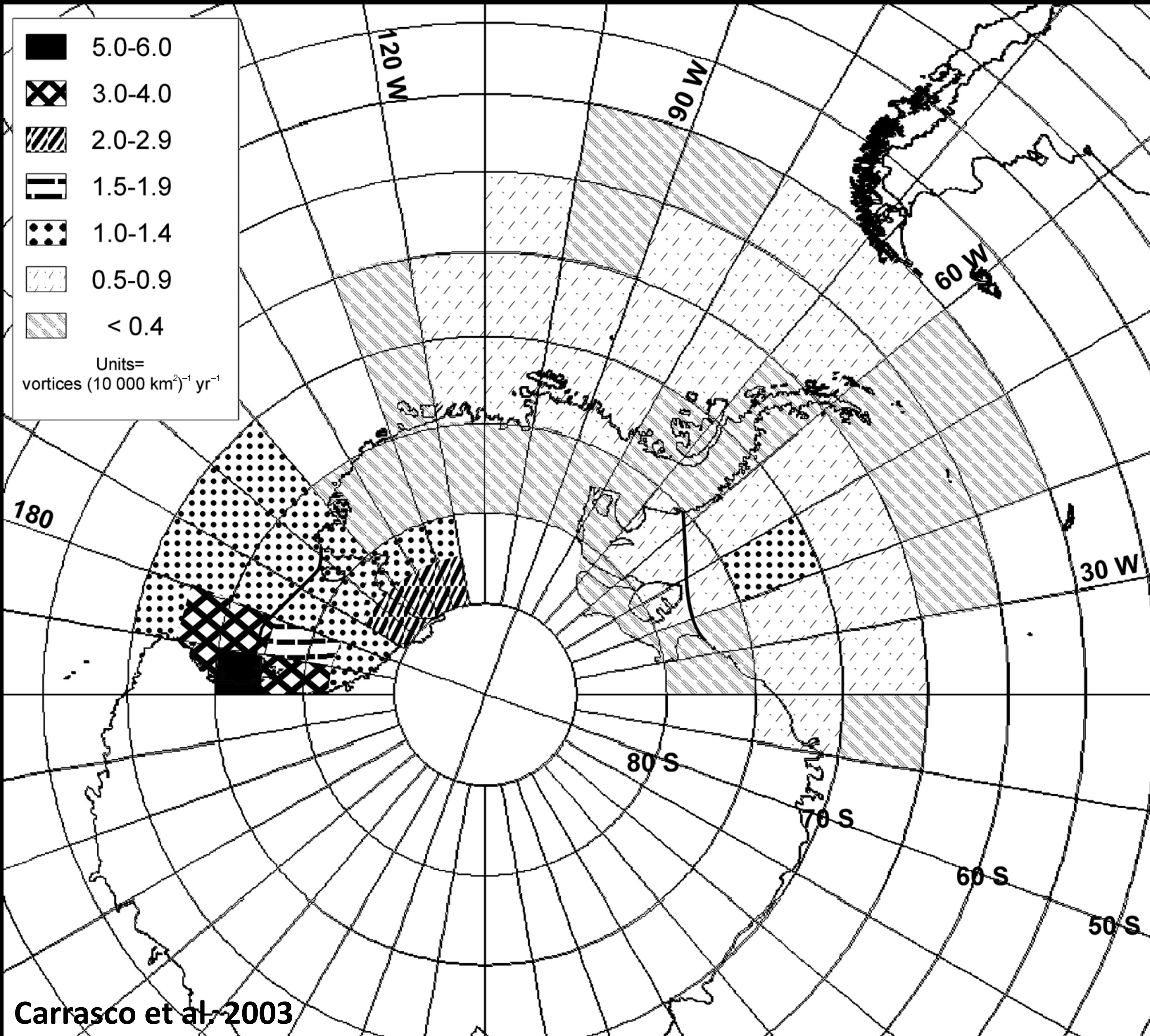
wave number for MCs 40-100

GME: MC statistics for 2007-2010



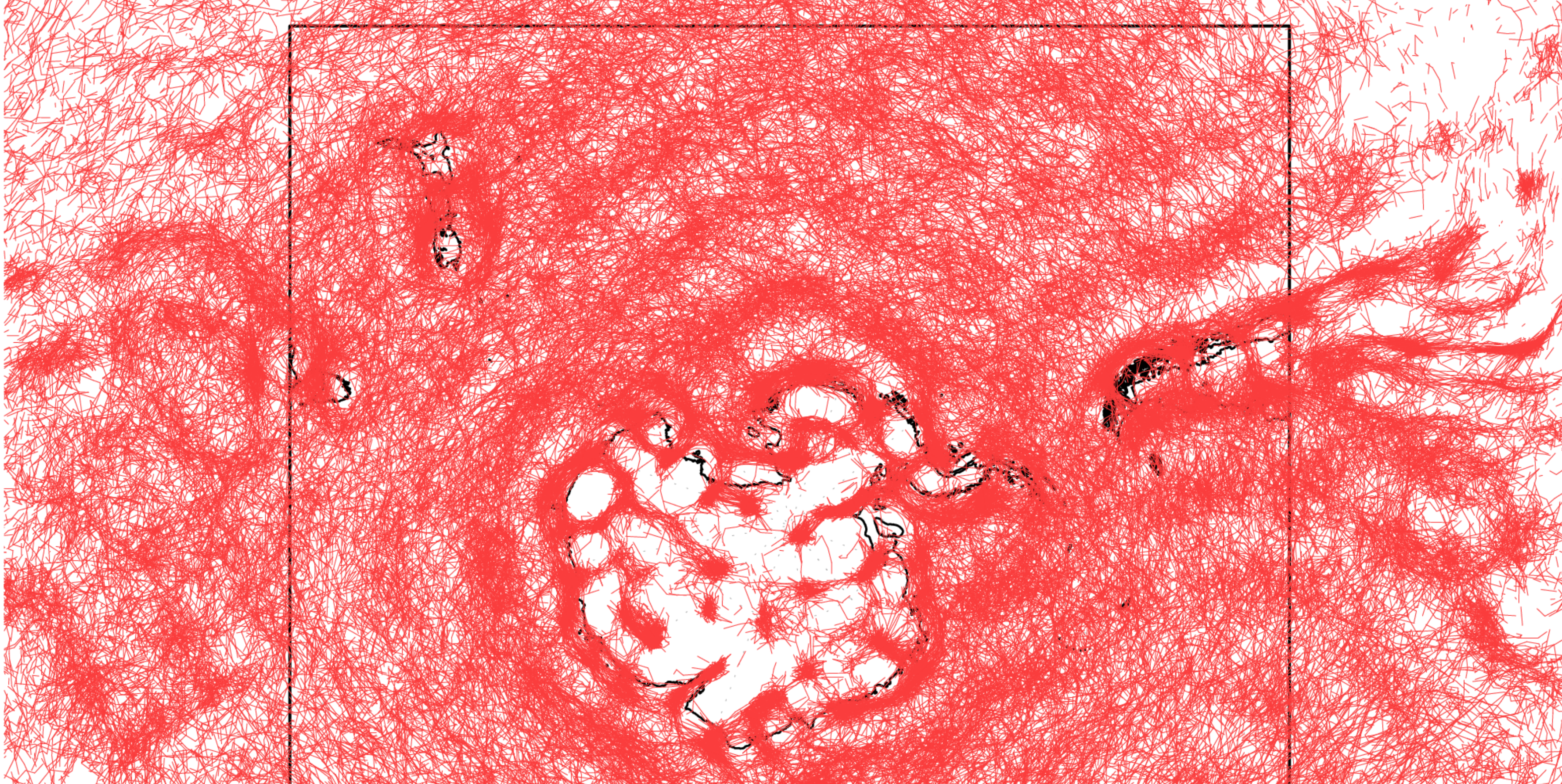
GME: MC statistics for 2007-2010 (numbers per year and per 10000km²). Track density (left), genesis density (middle) for **winter** (June, July, August).

1991



Carrasco et al. 2003

ERA-Interim 1991: all MC tracks without filtering

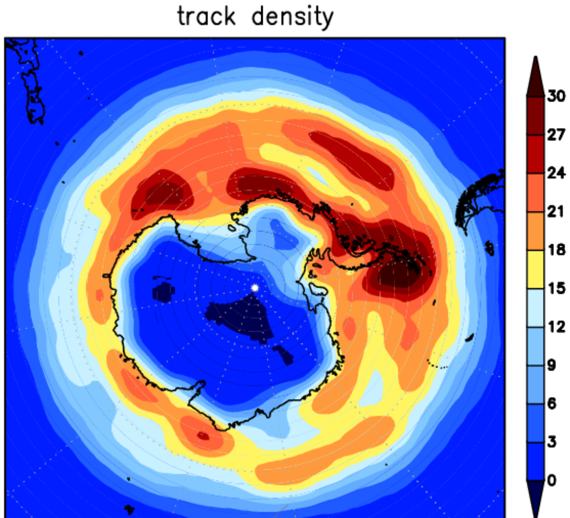


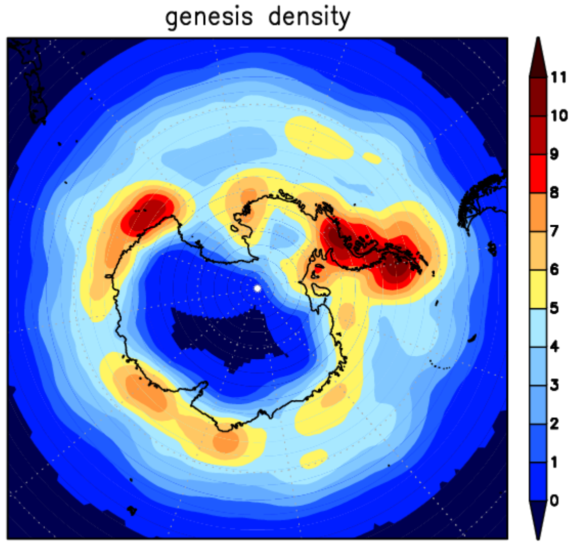
Filtering

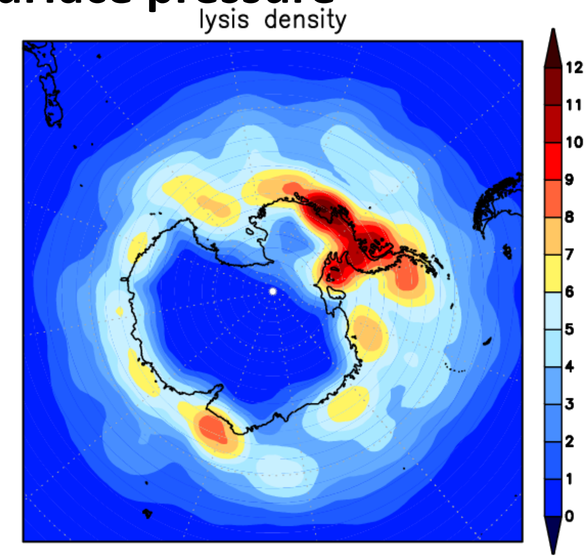
- Vorticity < $-0.5x10^{-4}$ once during the lifetime
- Wind > 15 m/s once during the track
- TFP < $5x10^{-10}$ always
- no tracking, if surface pressure < 850 hPa within 1° distance

MC1 (Wn 30-100)
All MCs south of 55°S (first sighted)
> 24h life time

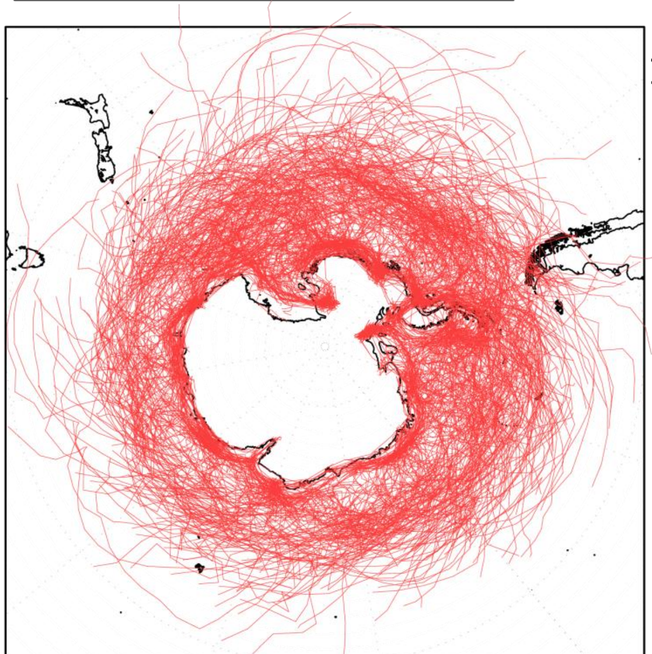
Filtering:
1°lat distance to 850hPa surface pressure



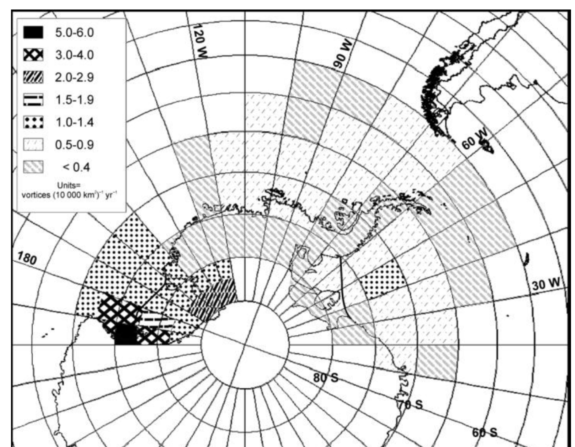




10000 km²

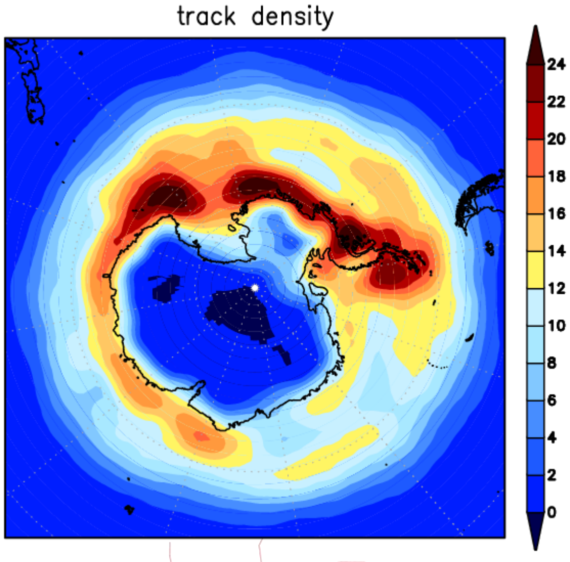


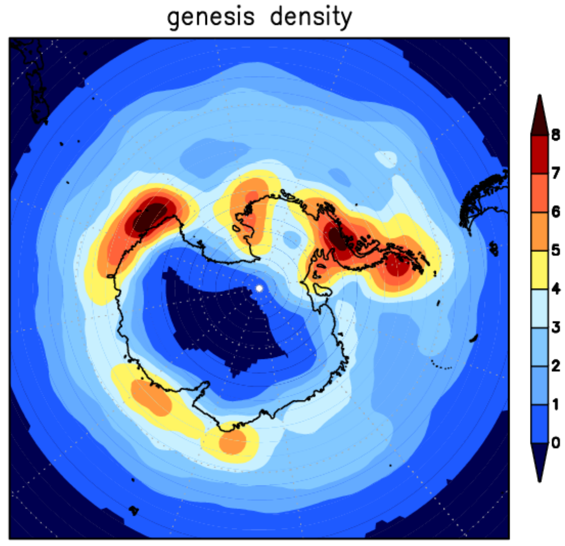
2698 Tracks for 1991

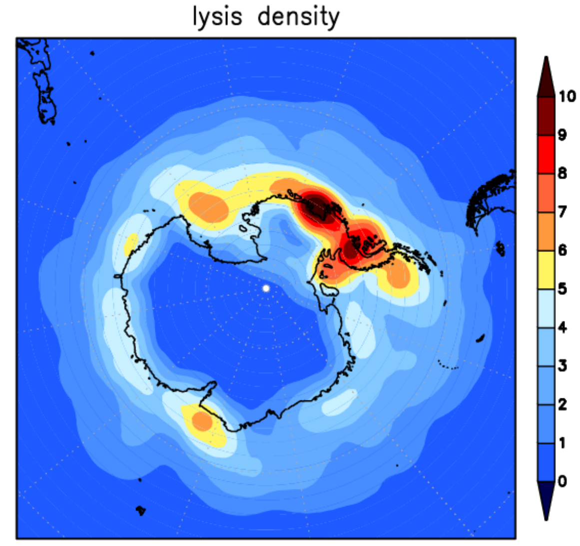


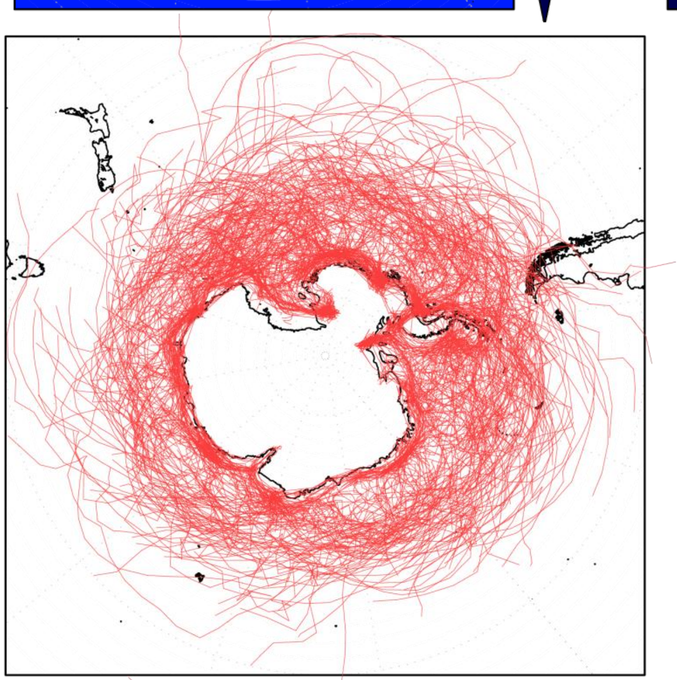
Carrasco et al. 2003: 1991

MC1 (Wn 30-100)
All MCs south of 55°S (first sighted)
> 24h life time





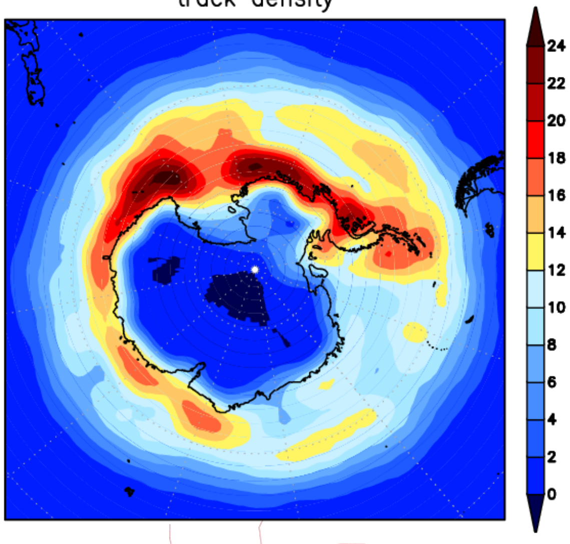


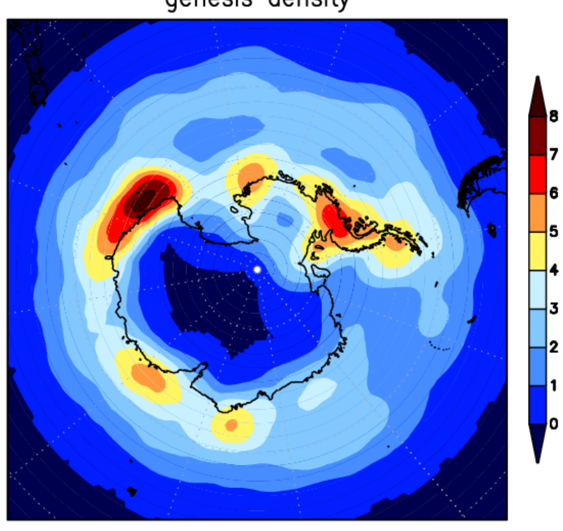


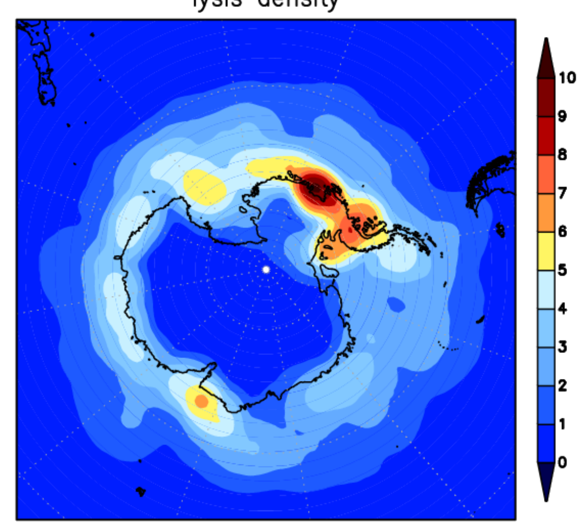
1790
Tracks
1991

Filtering:
1°lat distance to 850hPa surface pressure
Vorticity <-0.5x10^{-4}

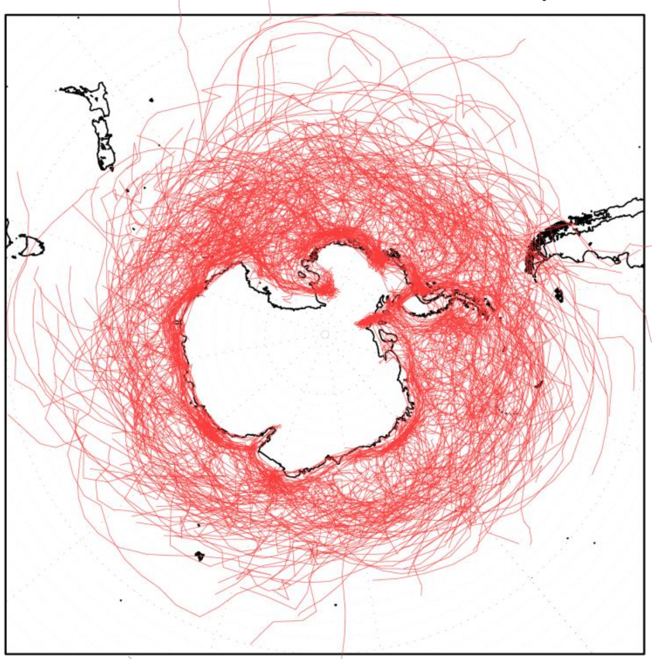
MC1 (Wn 30-100)
All MCs south of 55°S (first sighted)
> 24h life time







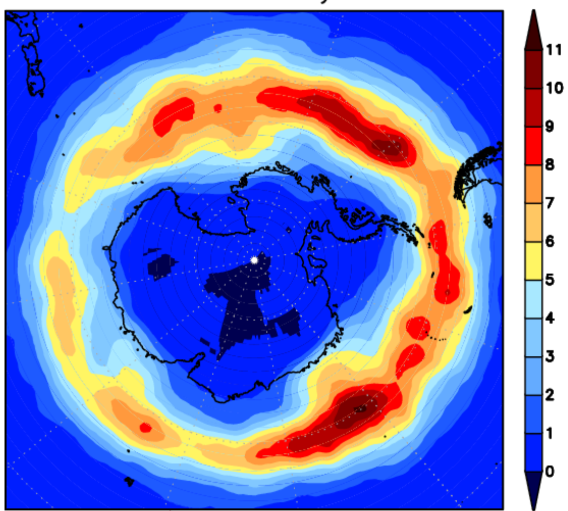
Filtering:
1°lat distance to 850hPa surface pressure
Vorticity <-0.5x10^{-4}
wind >15m/s



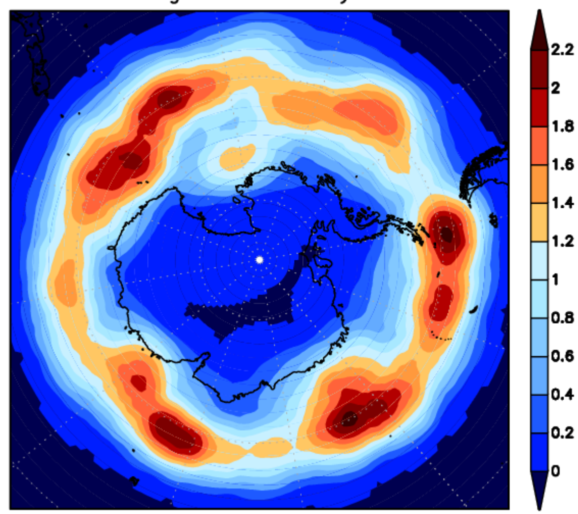
1581 Tracks 1991

MC1 (Wn 30-100)
All MCs south of 55°S (first sighted)
> 24h life time

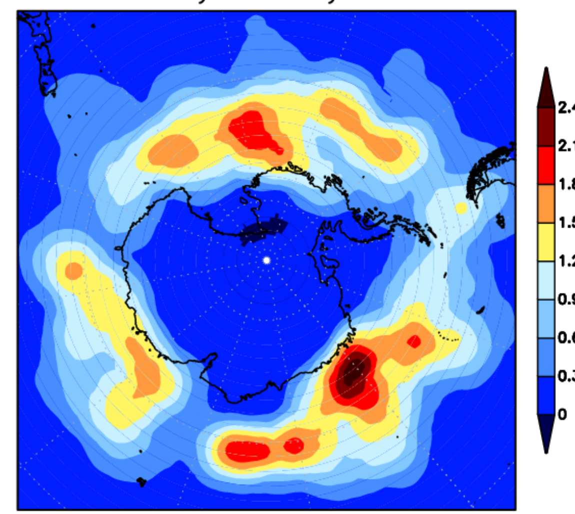
track density

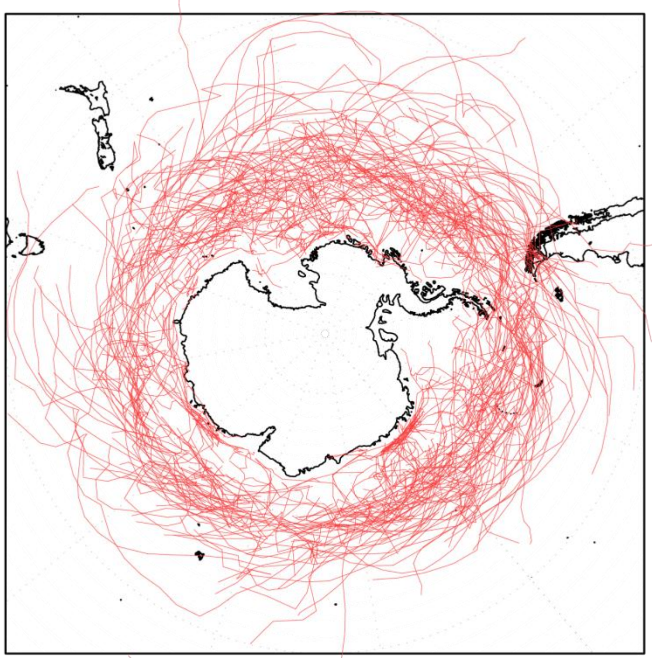


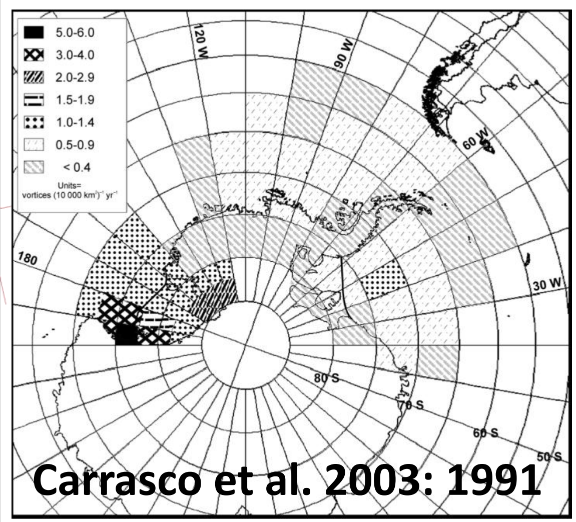
genesis density



lysis density







Filtering:

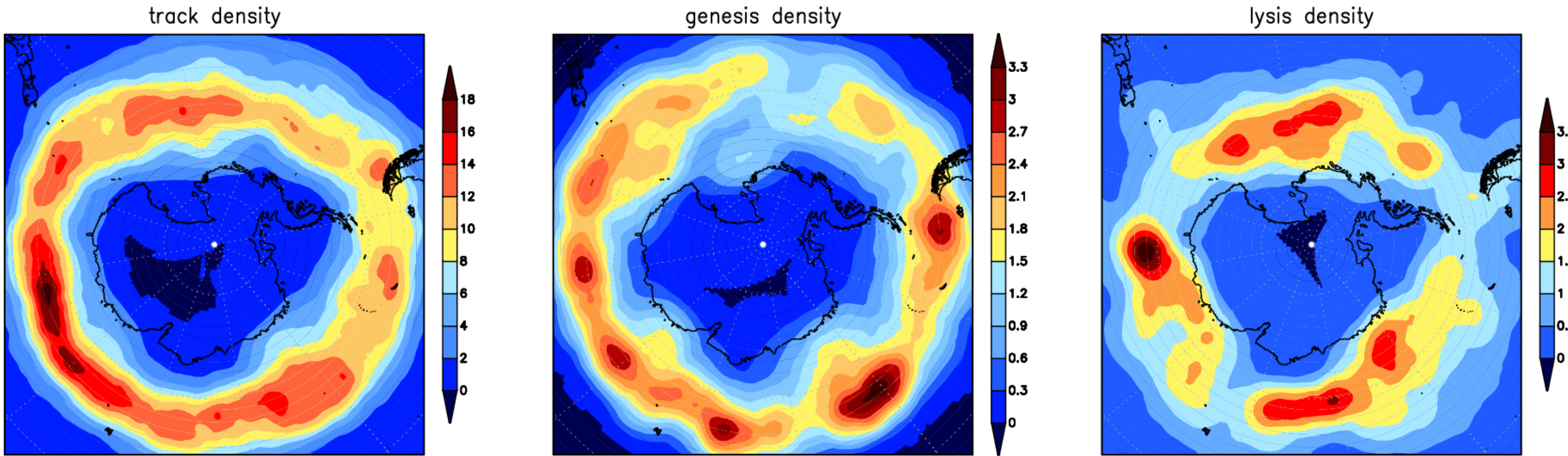
1°lat distance to 850hPa surface pressure

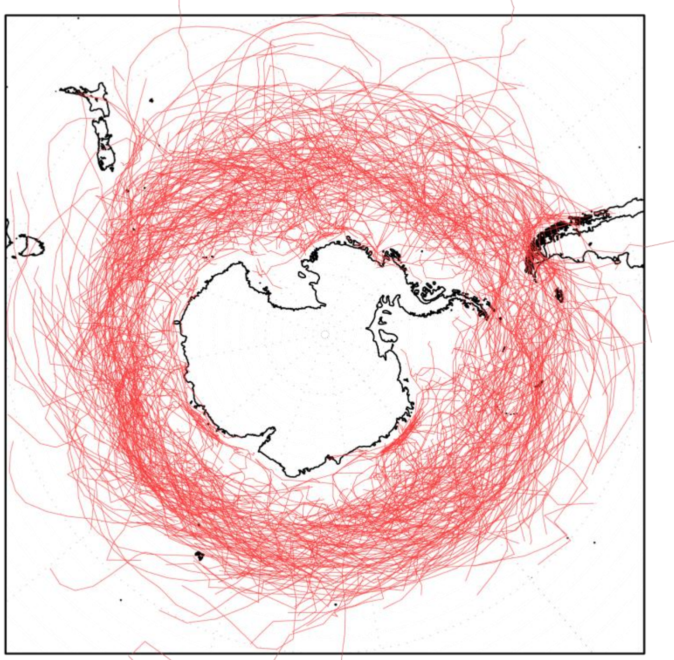
Vorticity <-0.5×10^{-4}

wind >15m/s

TFP < 5×10^{-10}

MC1 (Wn 30-100)
All MCs south of 50°S (first sighted)
> 24h life time





1026
Tracks
1991

Filtering:

1°lat distance to 850hPa surface pressure

Vorticity <-0.5×10^{-4}

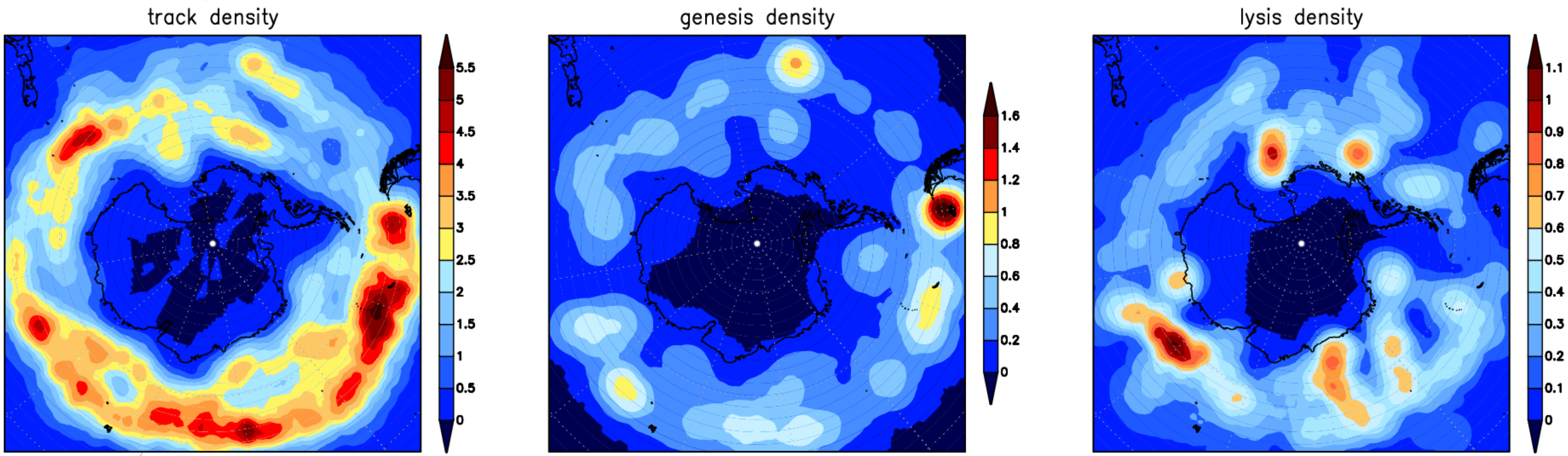
wind >15m/s

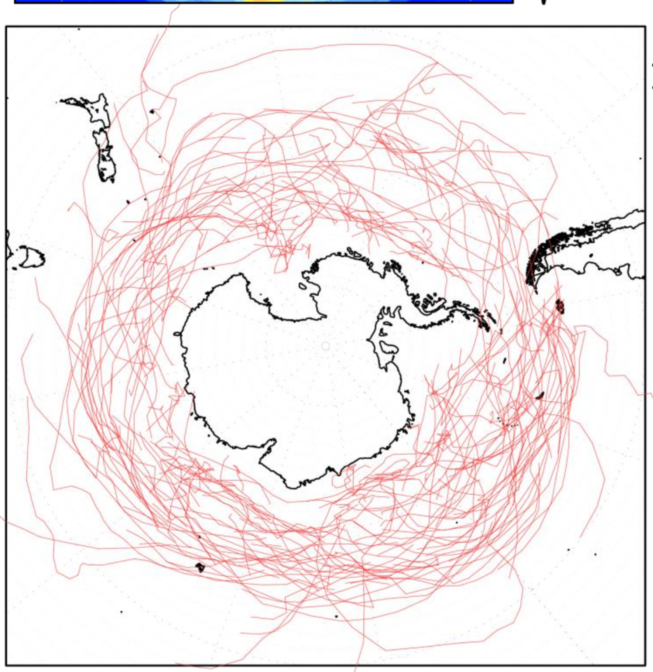
TFP < 5×10^{-10}

MC2 (Wn 15-30)

All MCs south of 50°S (first sighted)

> 24h life time





10000 km²

224 Tracks
1991

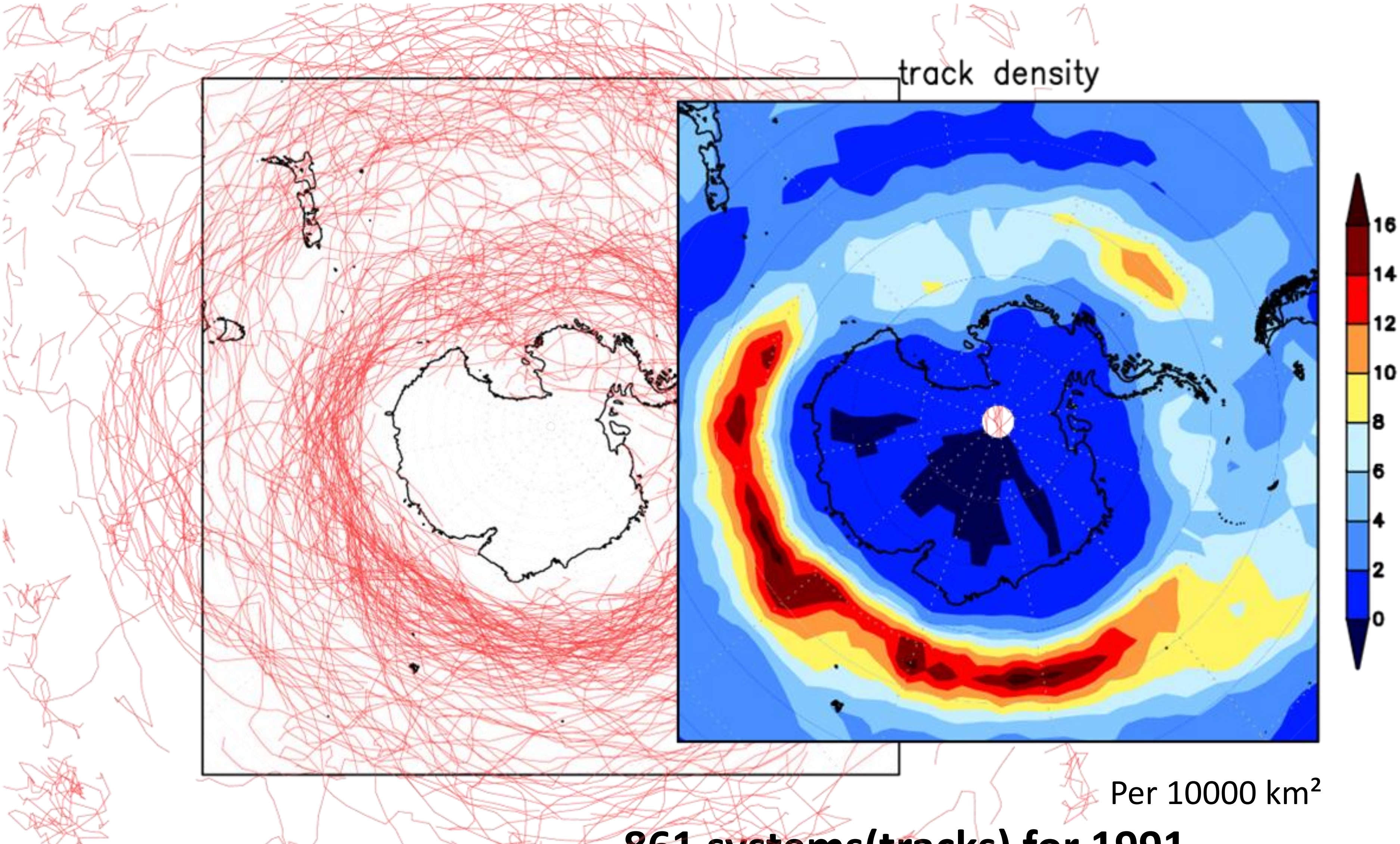
Filtering:
1°lat distance to 850hPa surface pressure
Vorticity <-0.5x10^{-4}
wind >15m/s
TFP < 5x10^{-10}

Synoptic cyclone tracking

- calculation of vorticity (850 hPa)
- spectral filtering (wave number for synoptic systems 5-15)
  → at 65°S: 1100 km – 3400 km

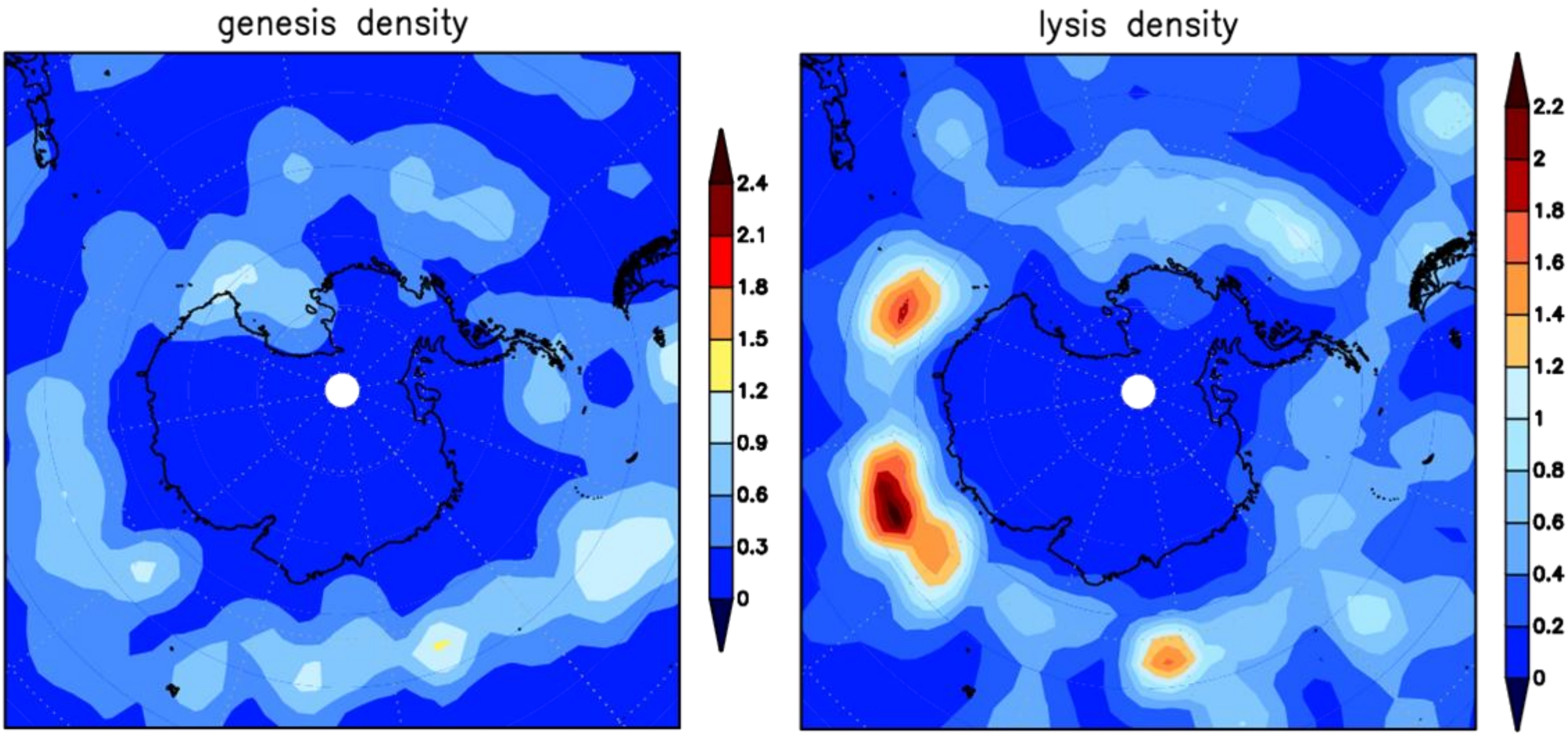
ERA-Interim, all SH cyclones
>48h life time

Wn 5-15



Per 10000 km²

861 systems(tracks) for 1991

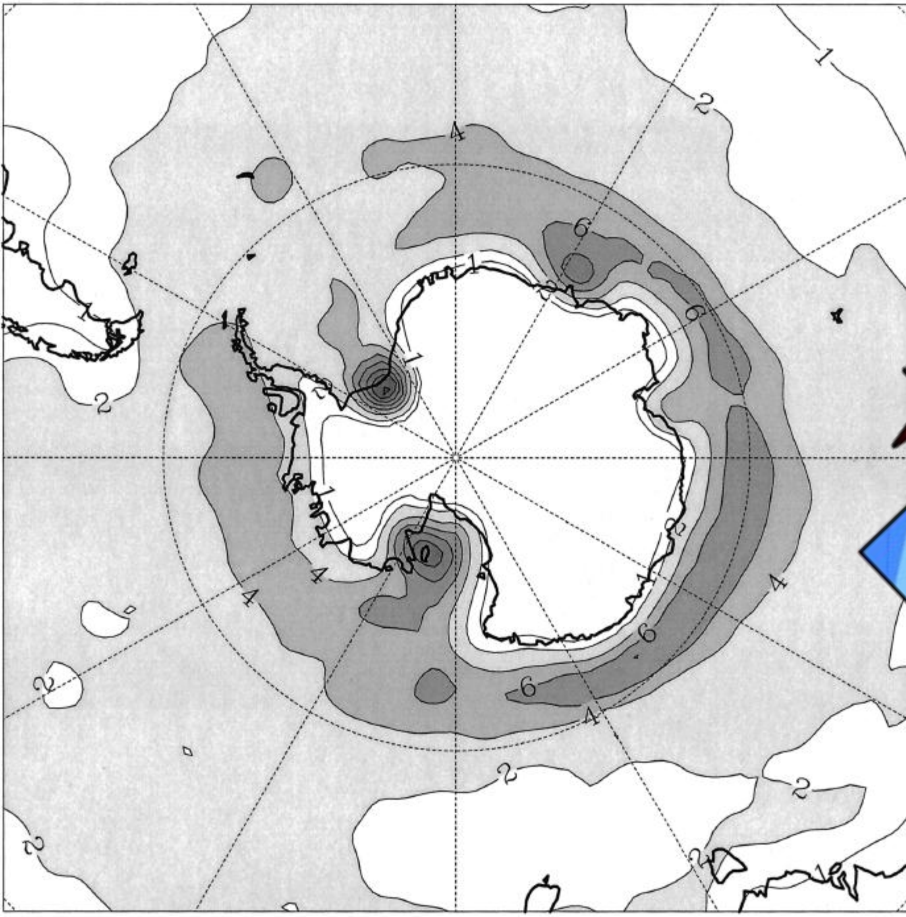


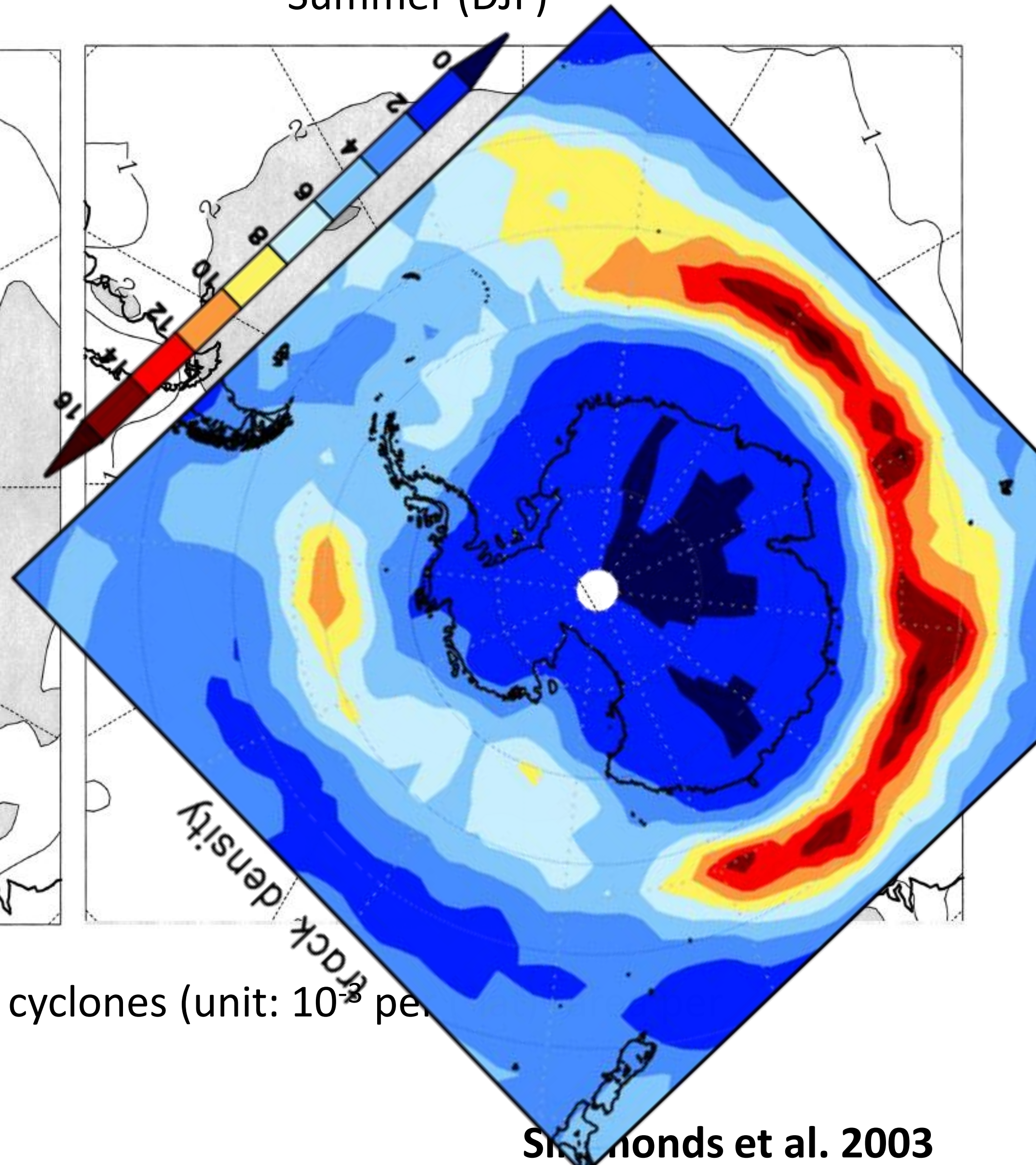
Per 10000 km²

NCEP2: 1979-2000

Winter (JJA)

Summer (DJF)



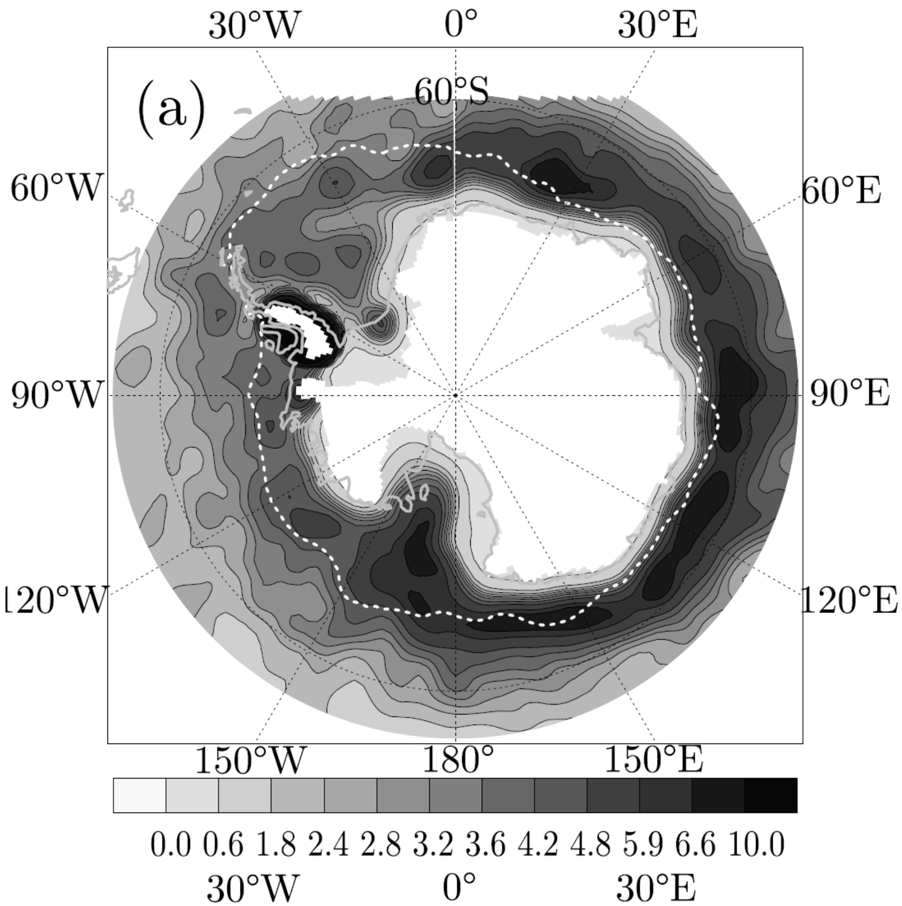


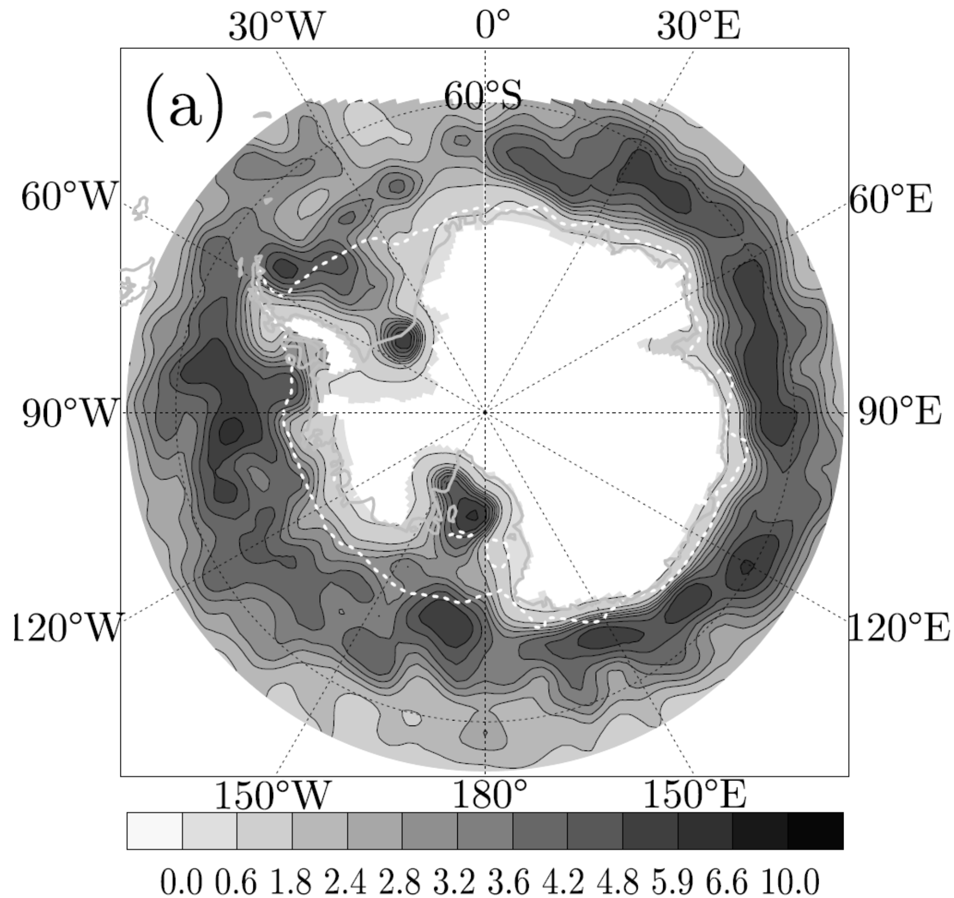
System density = mean number of cyclones (unit: 10^{-3} pe
analysis)

Si nonds et al. 2003

Winter (JJA)

Summer (DJF)





Uotila et al. 2009

AMPS System density 2001-2007 (mean number per (°lat)^2 area)

Conclusions

Objective methods are very sensitive to chosen parameters (tracking parameters, filtering)

GME data (25-40km) resolve MCs, but are available only since 2007

ERA-Interim data (80km) may miss some MCs

Defencies in tracking MCs over Antarctica (subjective and automated methods)

Need for long-term satellite-based climatologies