Satellite-Based Midlatitude Cyclone Statistics Over the Southern Ocean -- Tracks and Surface Fluxes

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August 19, 2009

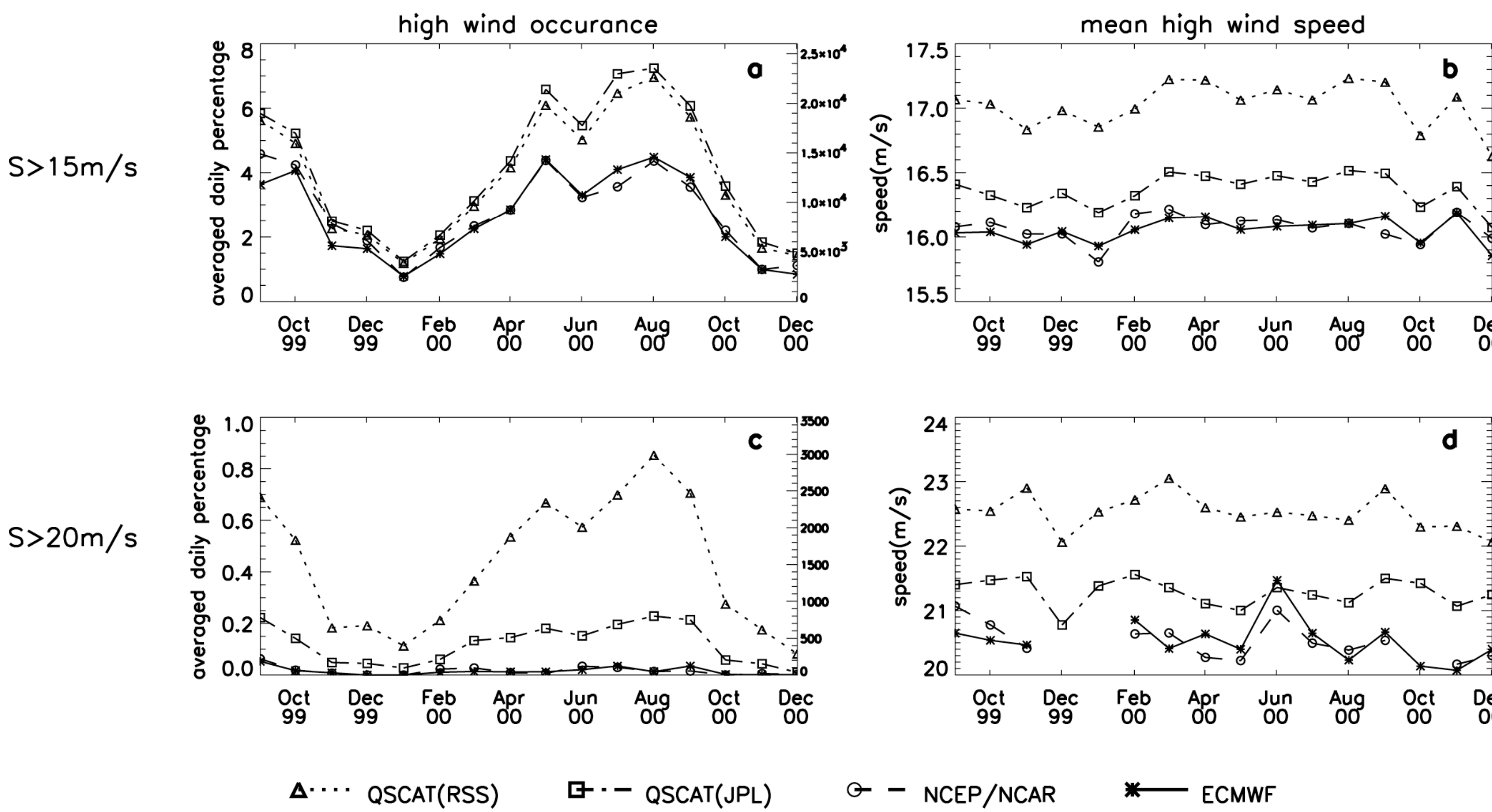
In collaboration with Jérôme Patoux at University of Washington and *Cuihua Li at Lamont-Doherty Earth Observatory, Columbia University*

Jerome Patoux[2], Xiaojun Yuan[1], Cuihua Li[1], Satellite-Based Midlatitude Cyclones Statistics Over the Southern Ocean. Part I: Scatterometer-Derived Pressure Fields and Storm Tracking. *J. Geophys. Res*., vol 114, D04105, doi:10.1029/2008JD010873, 2009.

Xiaojun Yuan[1], Jerome Patoux[2], Cuihua Li[1], Satellite-Based Midlatitude Cyclones Statistics Over the Southern Ocean. Part II: Tracks and Surface Fluxes. *J. Geophys. Res*., vol 114, D04106, doi:10.1029/2008JD010874, 2009.

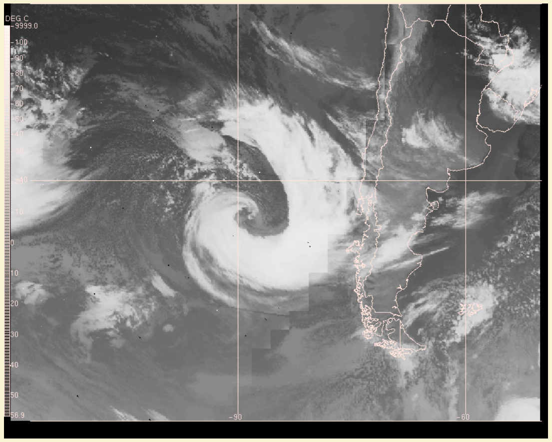
High Wind Assessment with Scatterometer Measurement

In the Southern Ocean



Yuan (2004)

SOUTHERN OCEAN CYCLONE TRACKS AND FLUXES



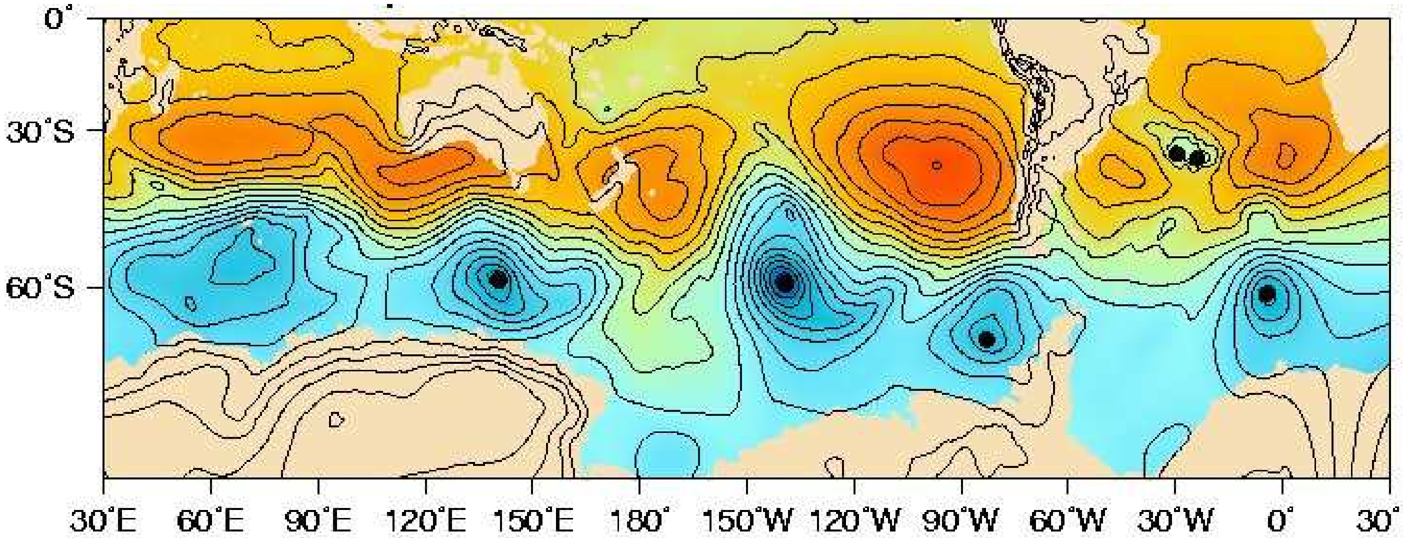
Main scientific question:

What is the impact of midlatitude cyclones on the Southern Ocean in terms of fluxes (momentum, sensible and latent heat) ?

Related questions:

- What is the impact of mesoscale cyclones (*i.e.* 3-4 days or less)?
- Are they captured by numerical models over the Southern Ocean?
- Do scatterometer winds contain information about cyclones that is not assimilated in the models?

STORM CHASING

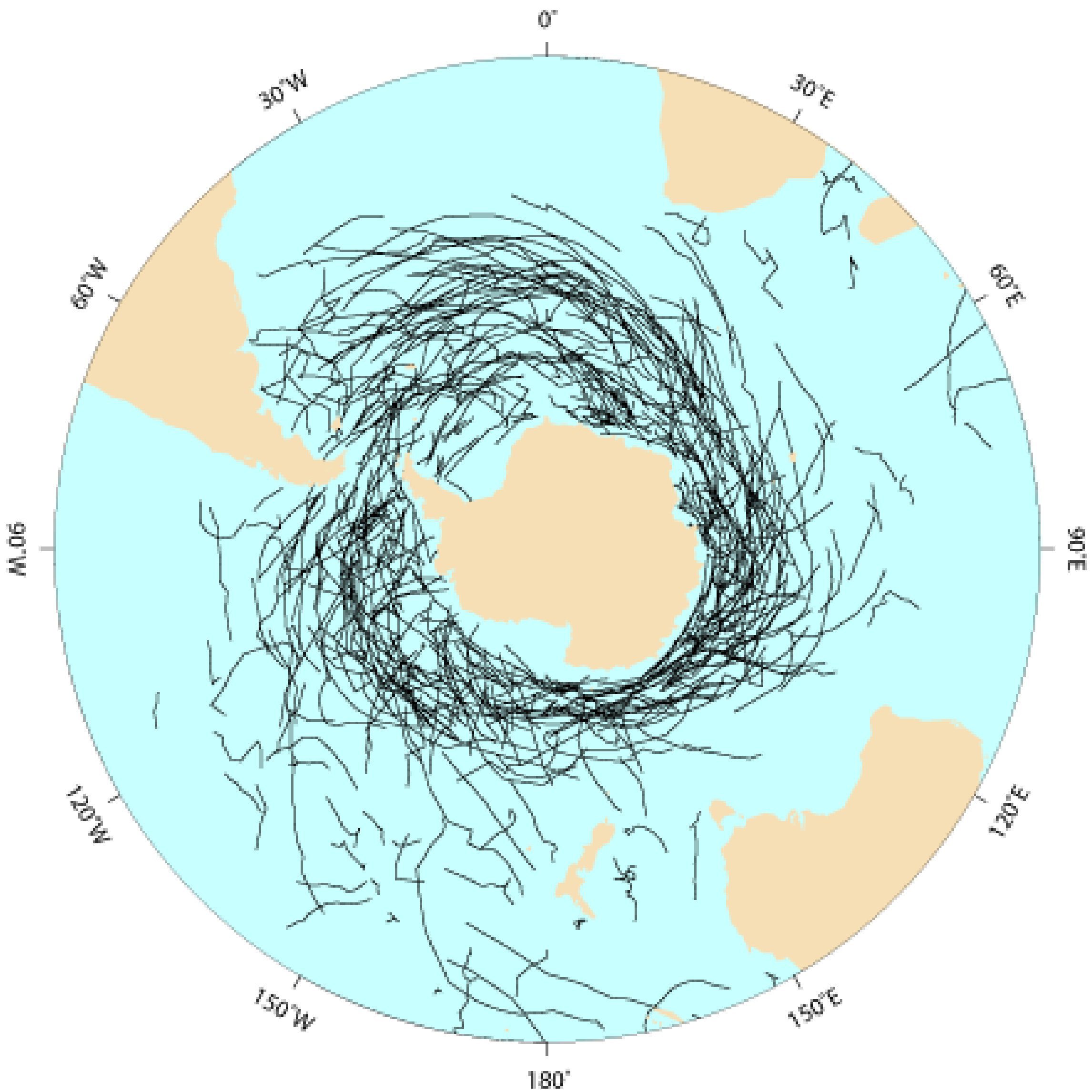


Systematic detection of low pressure centers

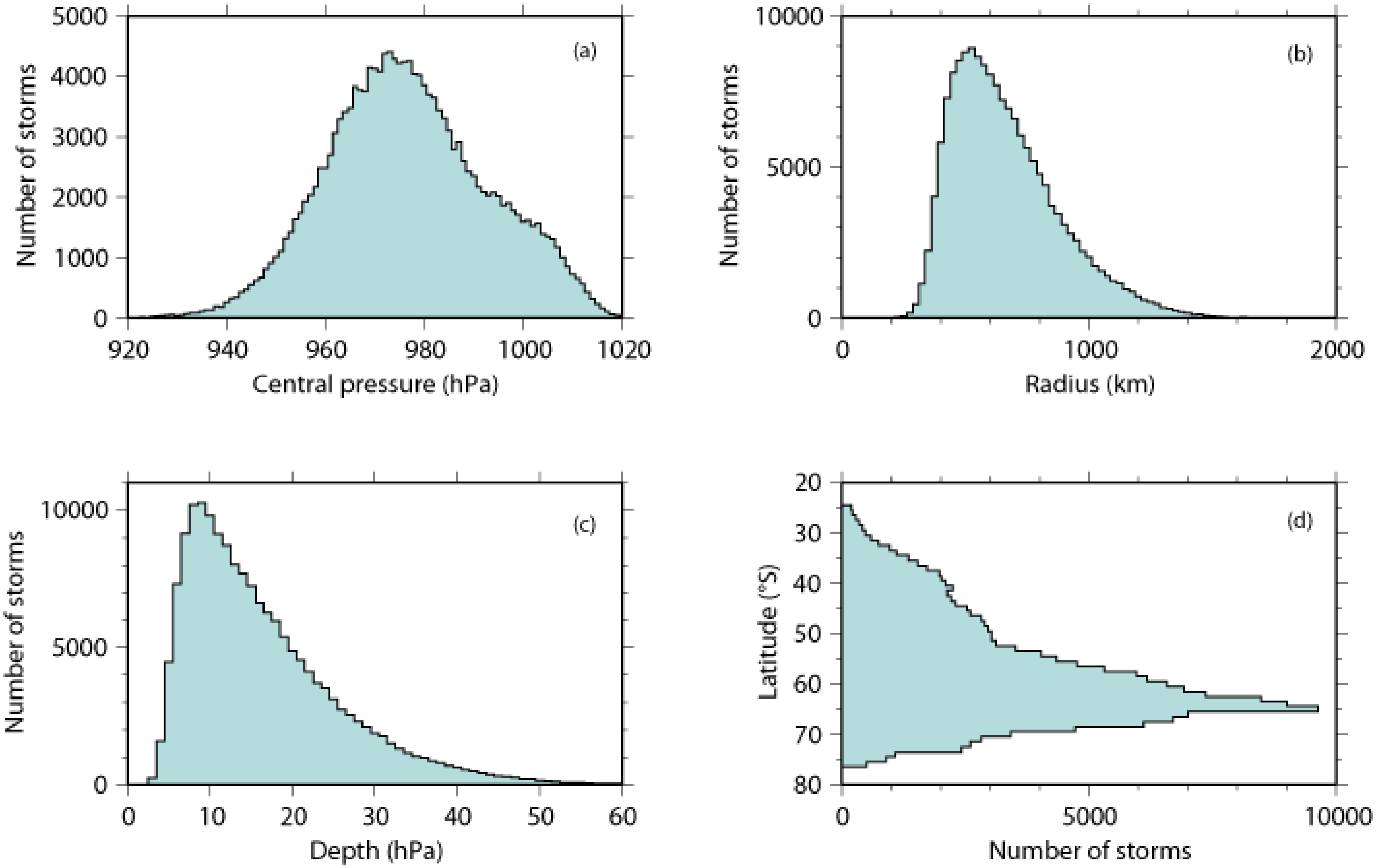
- ECMWF sea-level pressure, July 1999 – June 2006
- 4 synoptic periods per day (00:00, 06:00, 12:00, 18:00 UTC)
- Based on kinematic criteria:
  - local pressure minimum
  - a 1-hPa pressure difference between the local minimum and the surrounding pressure (averaged over ±2° lon/lat)
  - mean surrounding vorticity (averaged over ±2° lon/lat) greater than $5\times10^{-11}\ s^{-1}$

…and reconstruction of storm tracks.

(Storm tracking scheme by Ian Simmonds and Kevin Keay, University of Melbourne.)



CHARACTERISTICS OF STORMS

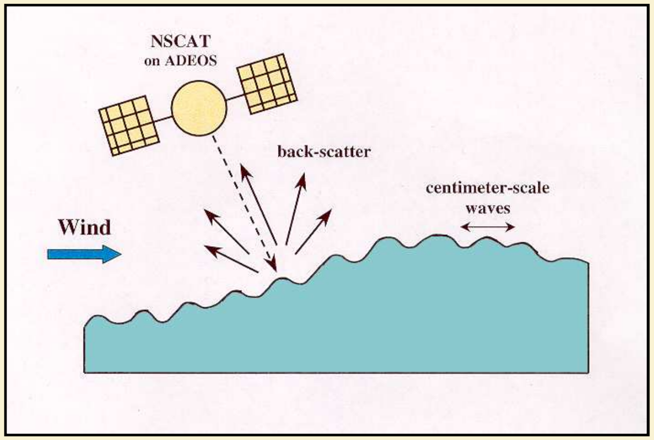


SeaWinds-on-QuikSCAT

July 1999 to present

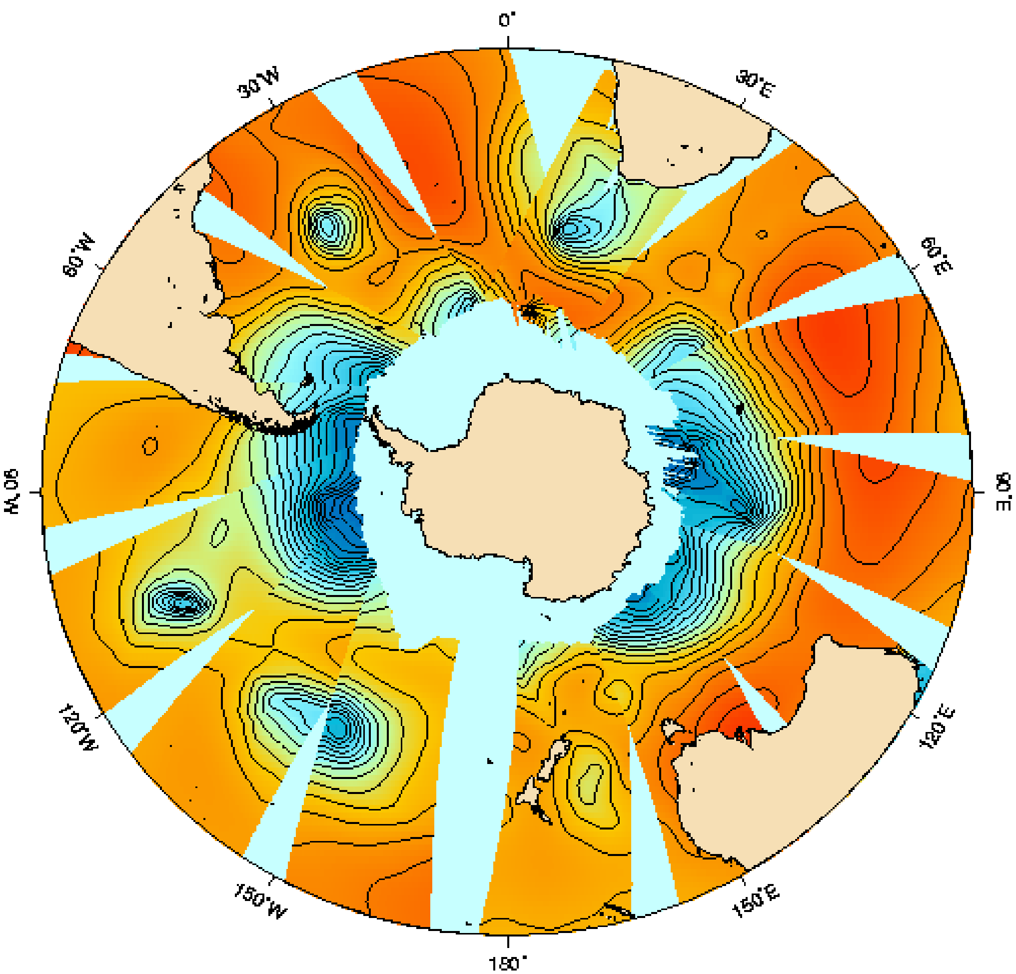
Now beyond its original mission requirements

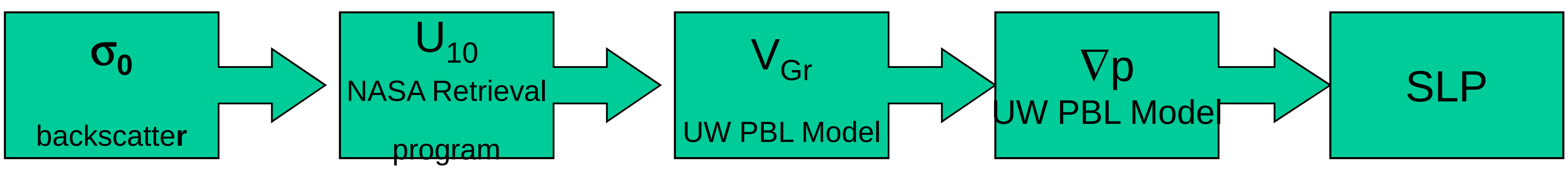
(3-year lifetime to bridge the gap between NSCAT and SeaWinds)

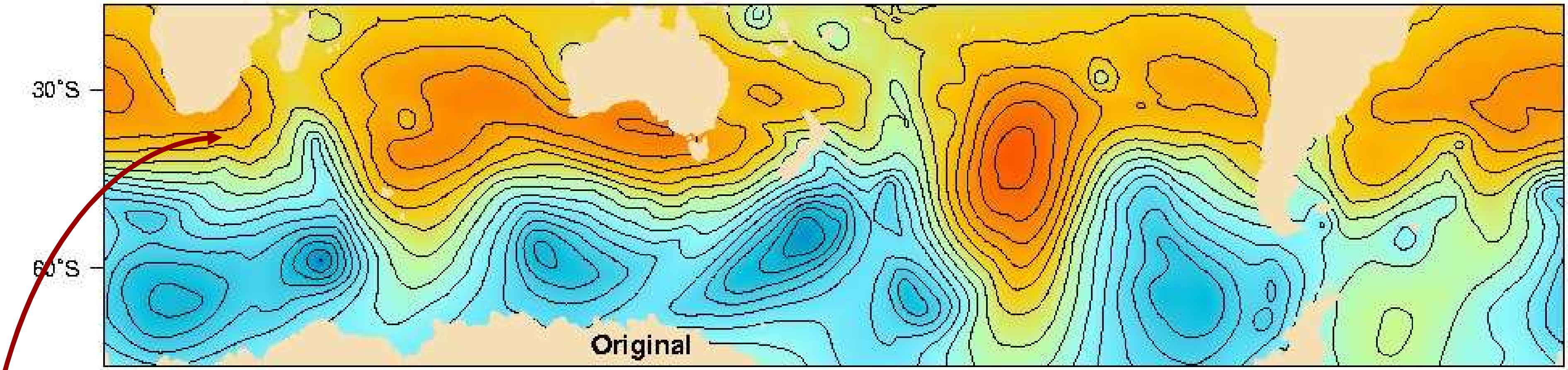


Scatterometer winds are stronger than reanalysis surface winds particularly in high wind bands in the Southern Ocean (Yuan, 2004)

1 August 99 - 12:00 UTC



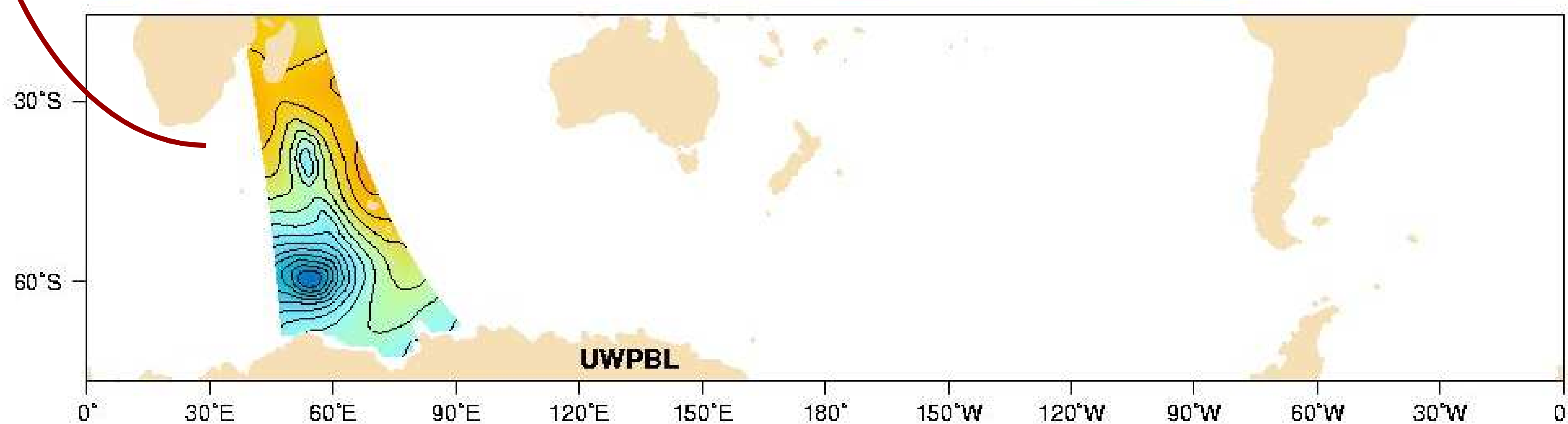


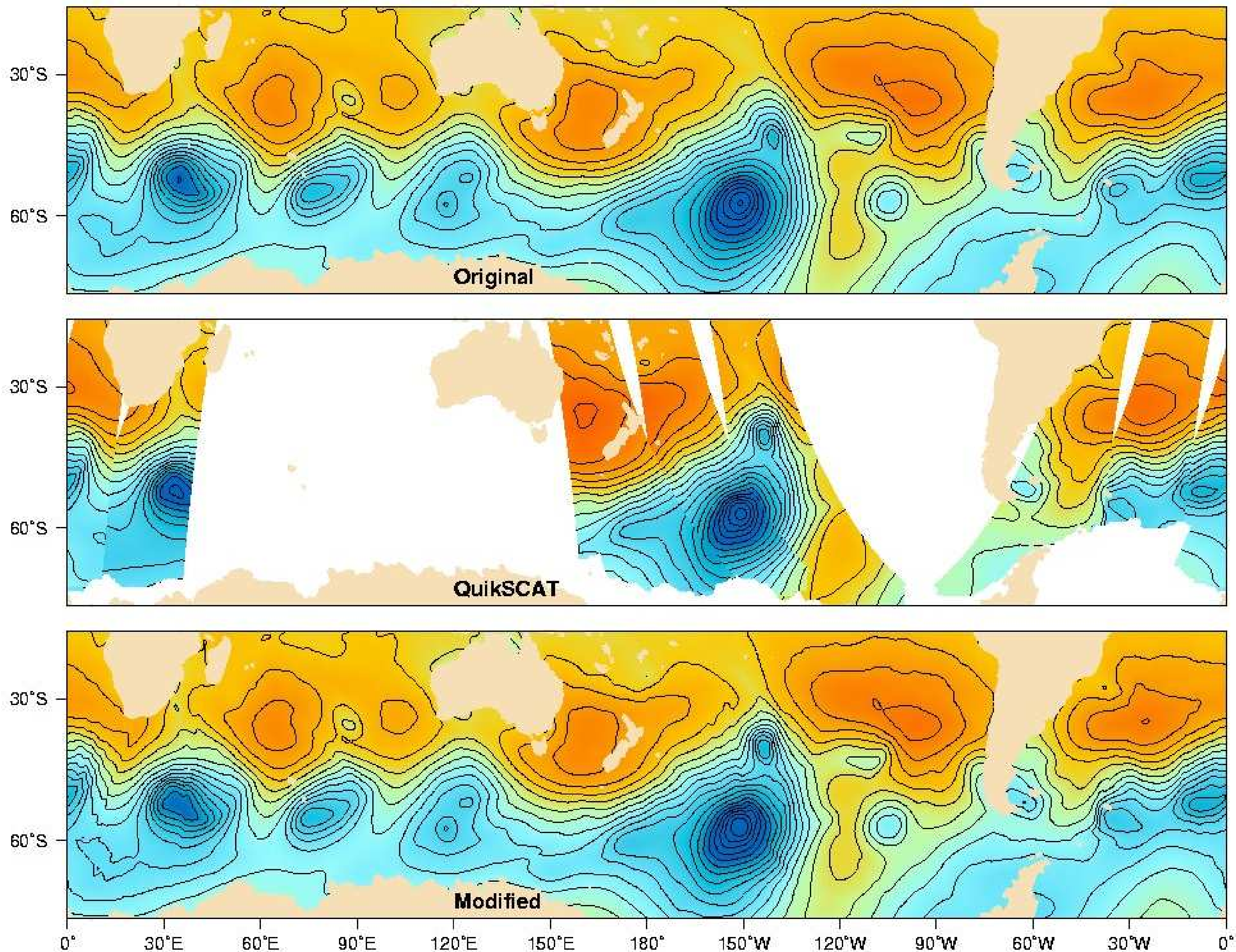


ECMWF sea-level pressure – 27 Jan 2003 – 00:00 UTC

injecting the mesoscale detail from a QuikSCAT swath into an ECMWF sea-level pressure analysis

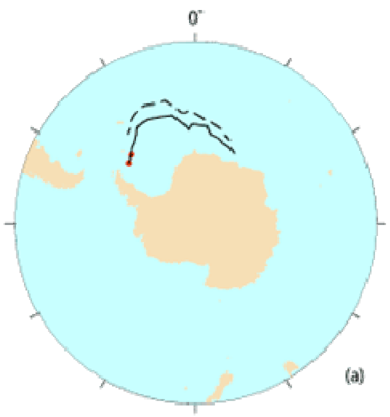
QuikSCAT sea-level pressure – 27 Jan 2003 – 02:56 UTC





30°S
60°S
Original
QuikSCAT
Modified
0°
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W

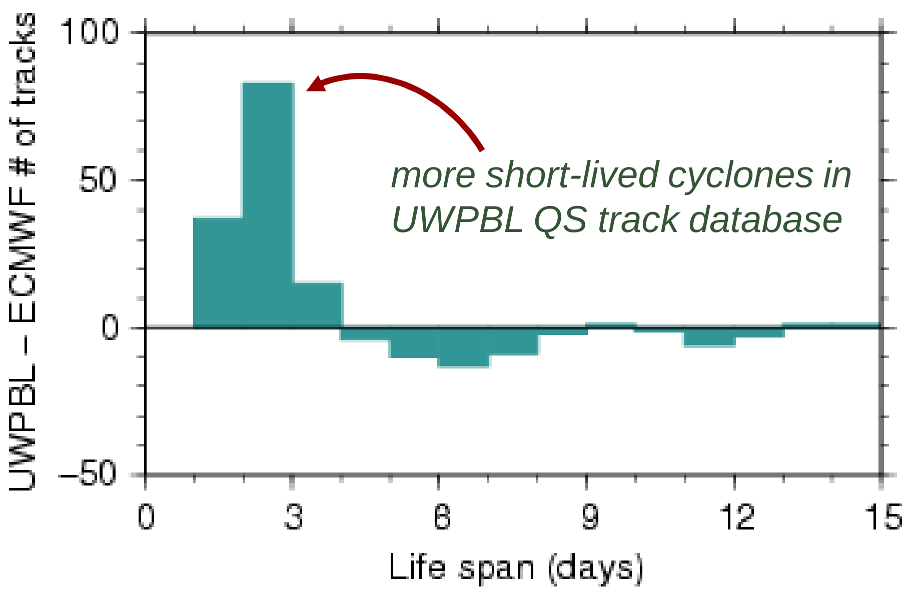
IMPACT OF THE SCATTEROMETER



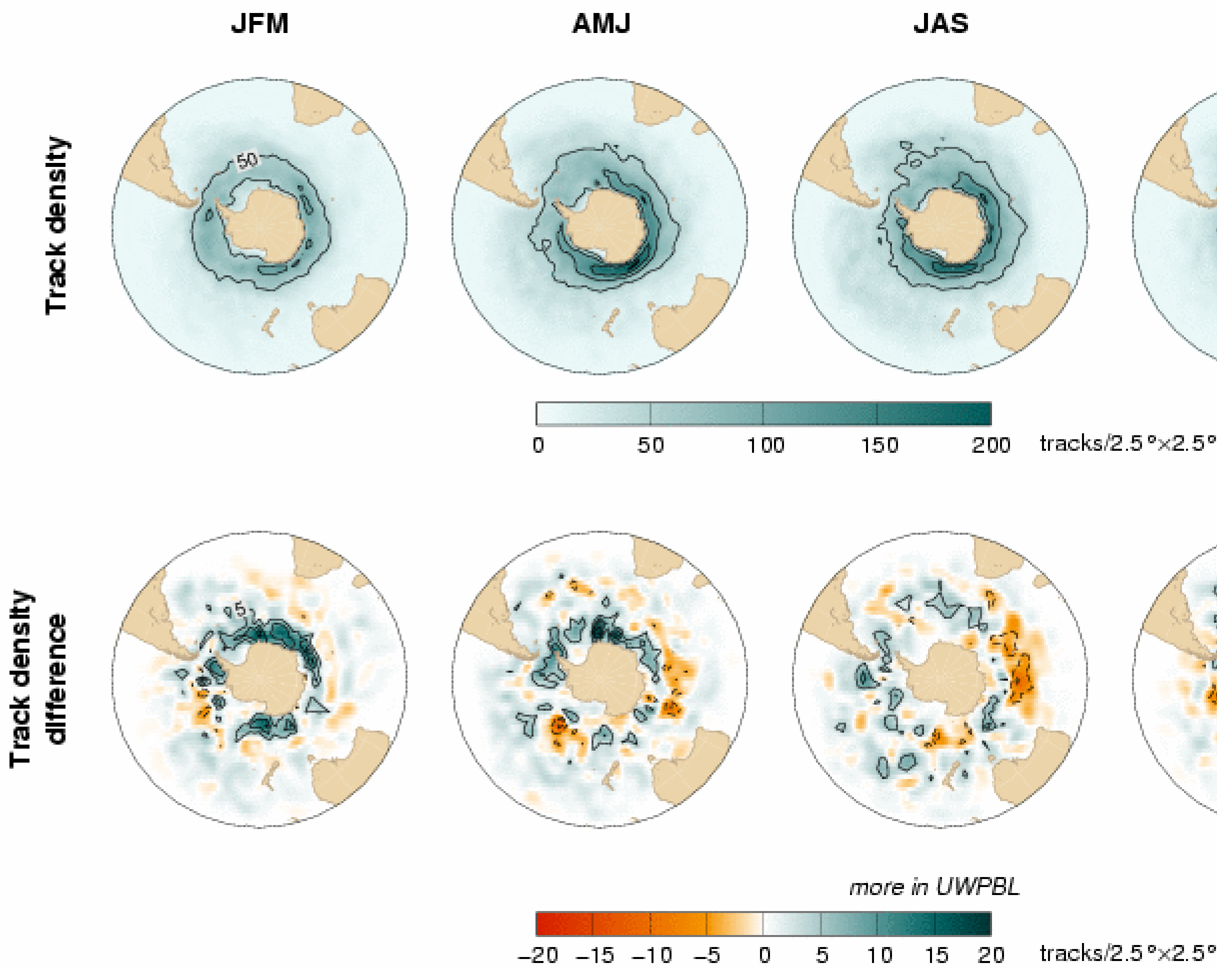
Over the 7-year study:

- 663 “QS” tracks were initiated at least 6 hours earlier than the “EC” cyclones.
- 557 were extended by at least 6 hours.

- …and the “QS” database contained 141 more short-lived cyclones (4 days or less).



COMPARISON OF ECMWF AND QS TRACKS



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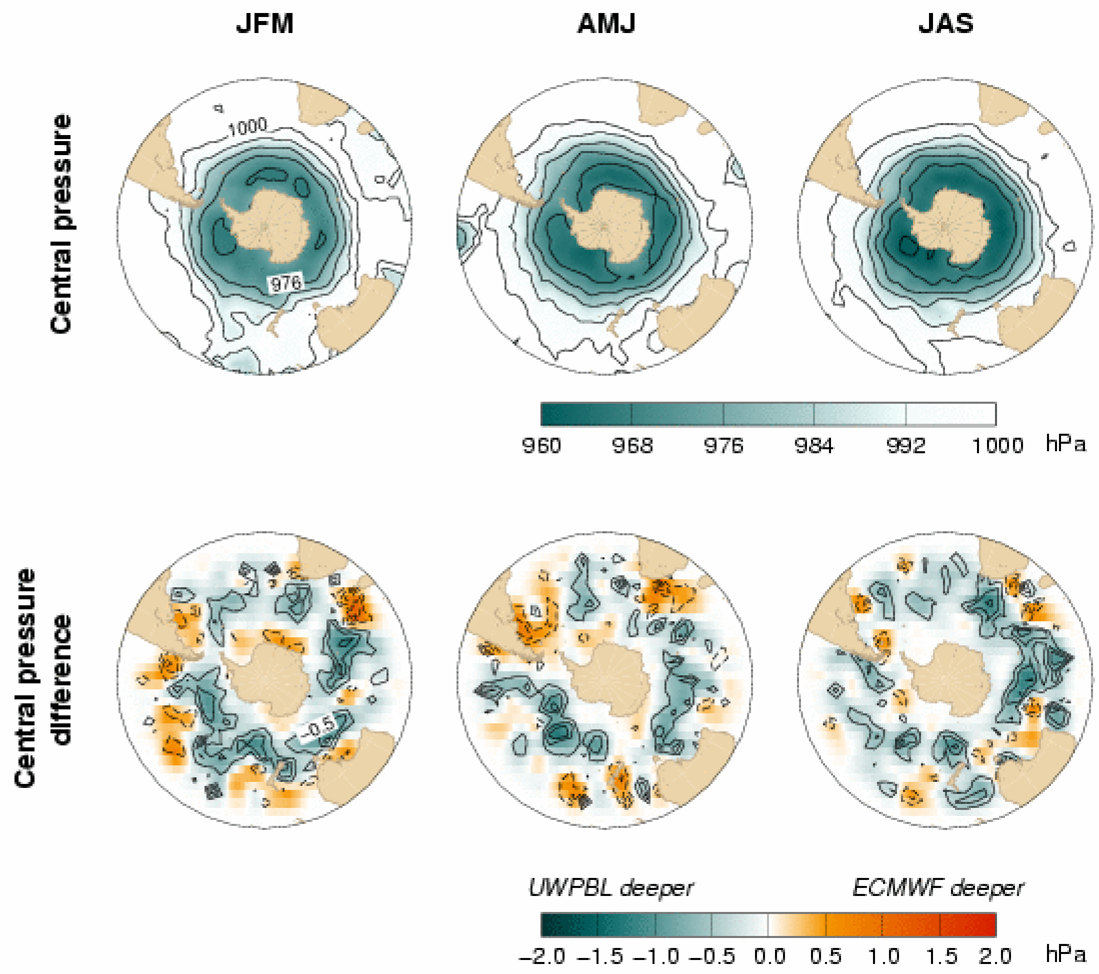
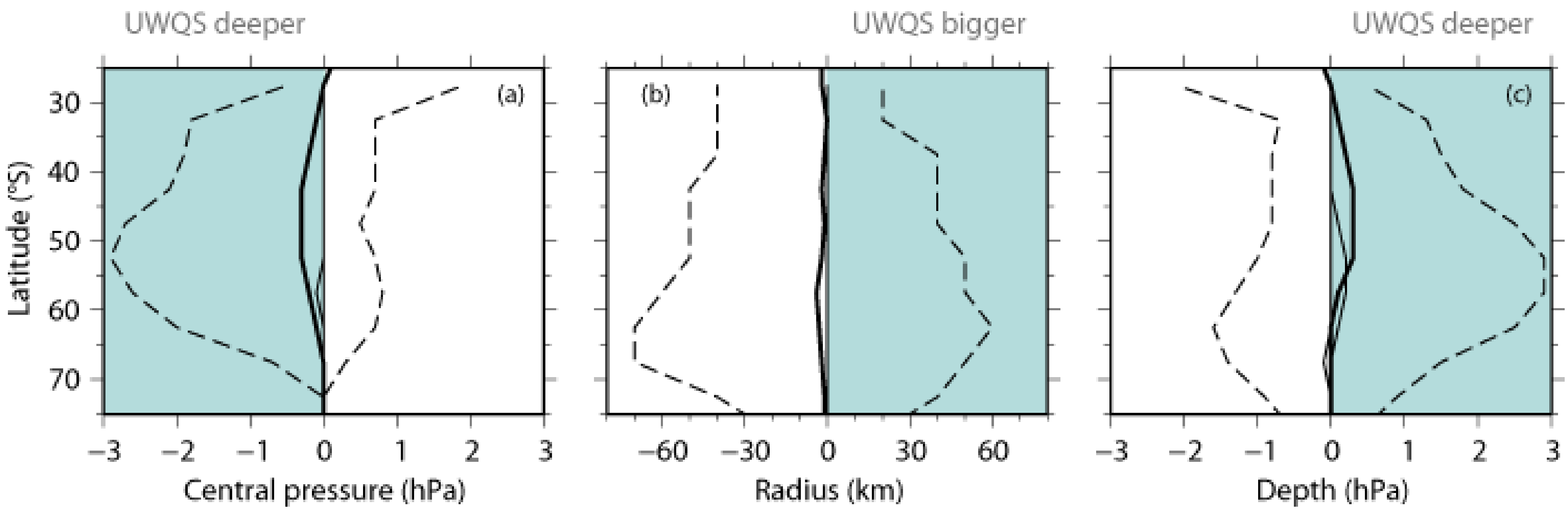
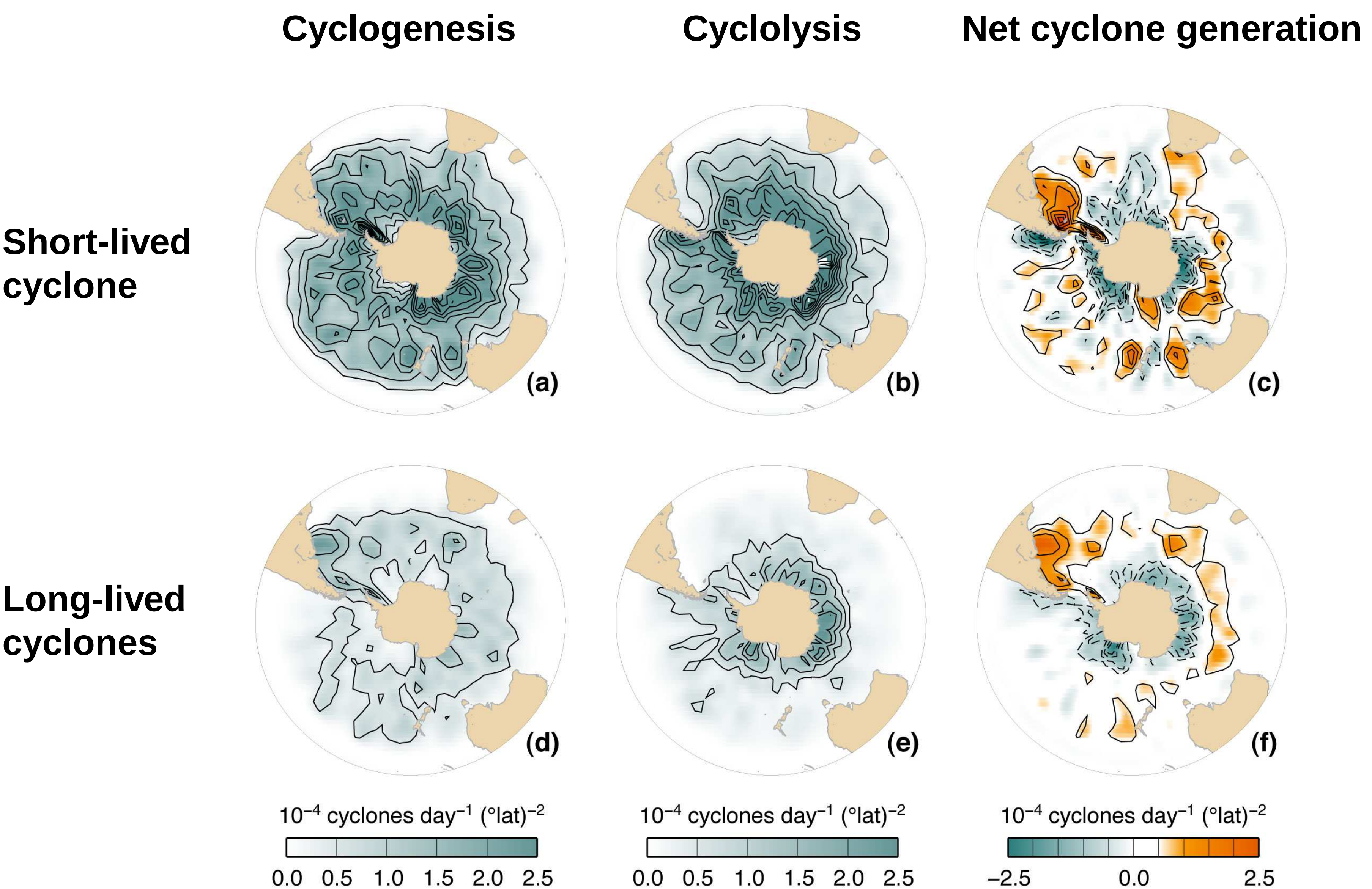


IMPACT OF THE SCATTEROMETER

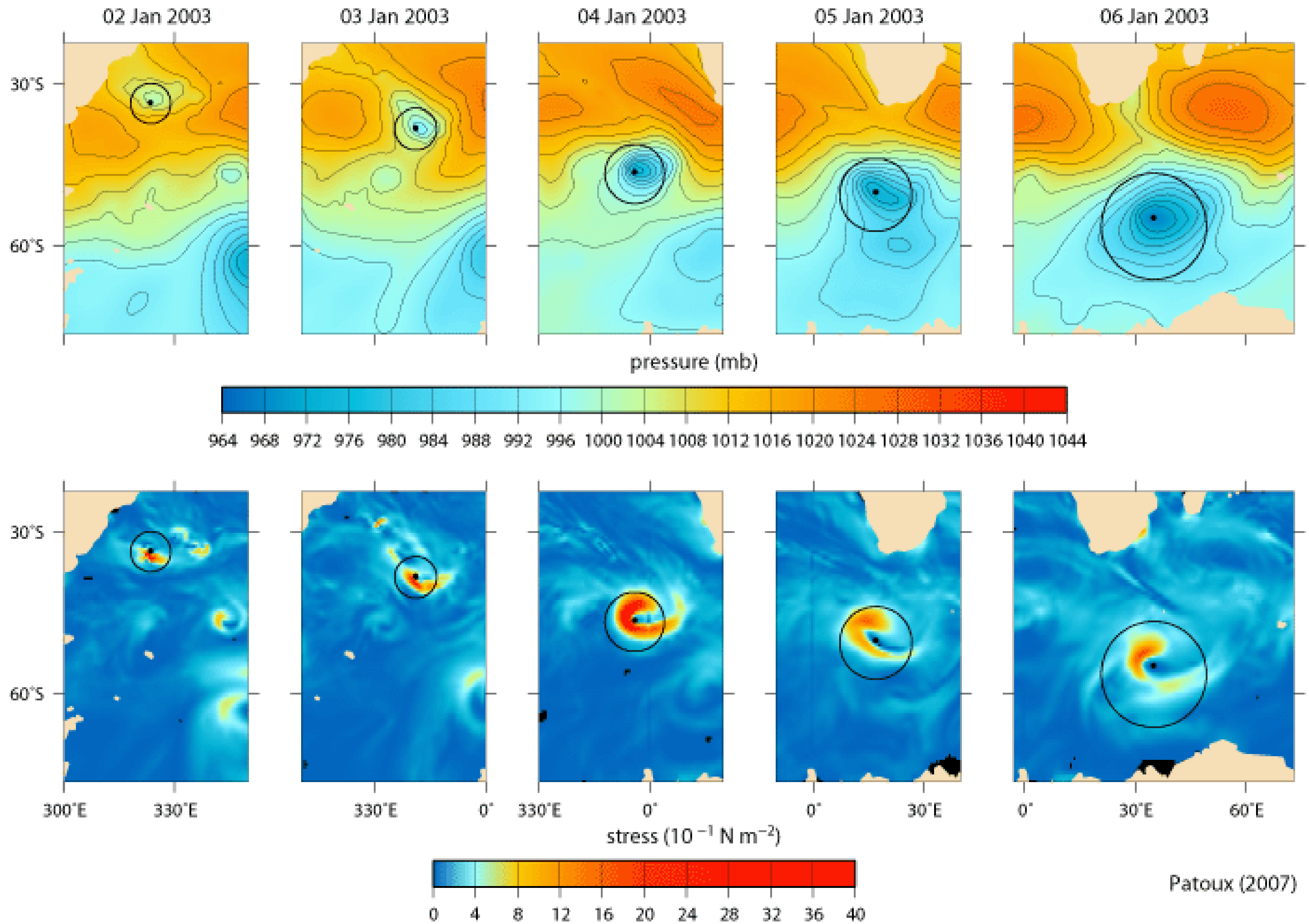
Statistics of the difference in central pressure, radius, and depth between the ECMWF and the QuikSCAT storms:



CONTRIBUTION FROM STORMS OF DIFFERENT LIFE SPANS

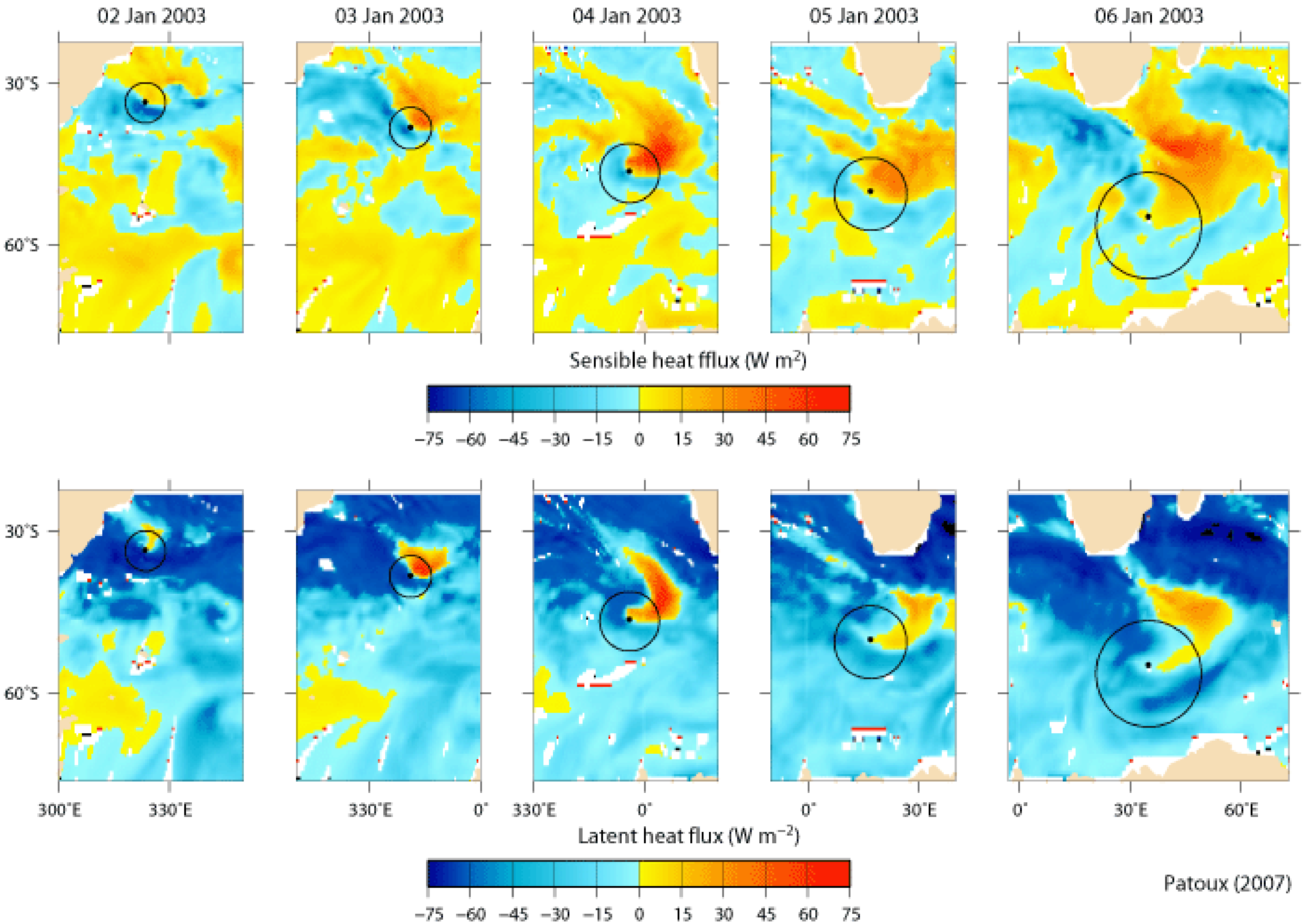


FLUXES IN STORMS



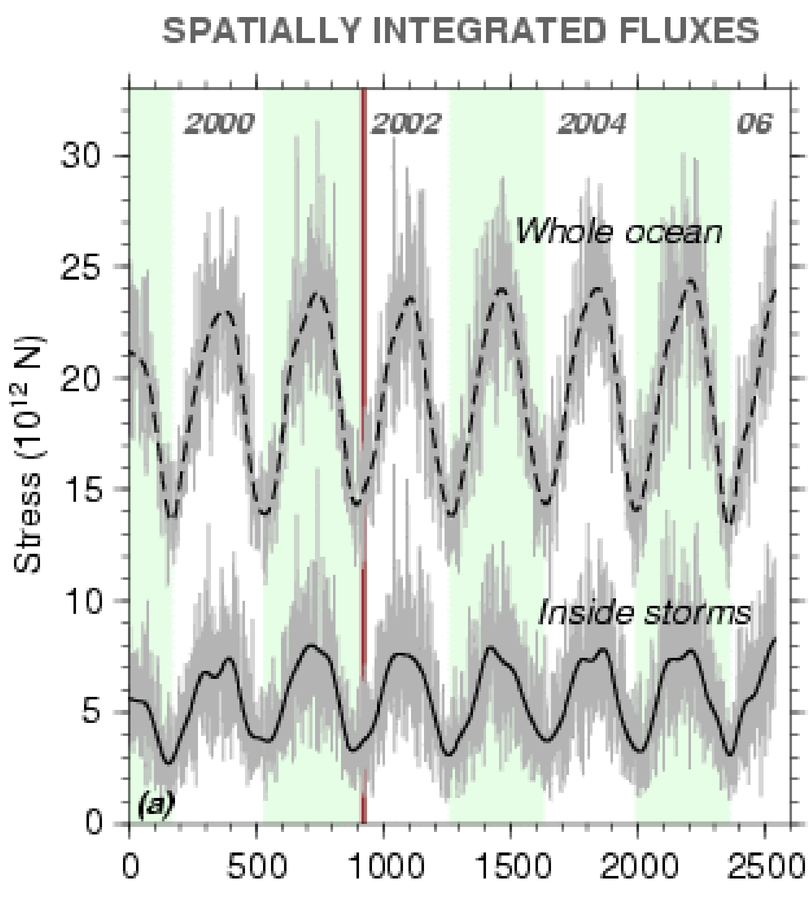
Patoux (2007)

FLUXES IN STORMS

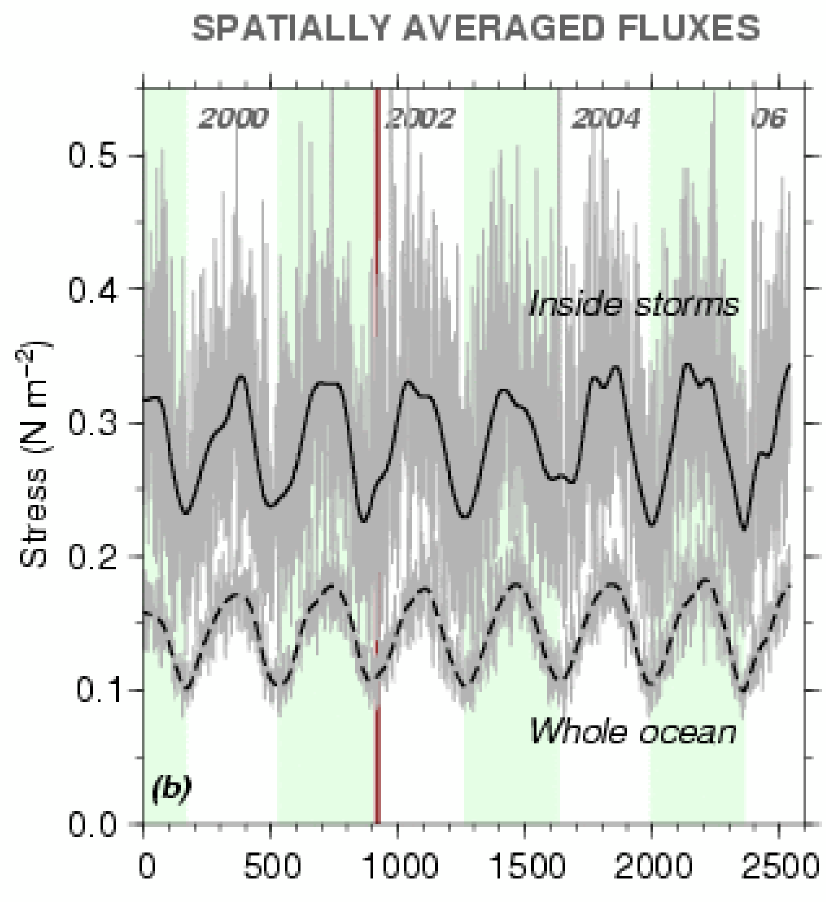


Patoux (2007)

INTEGRATION OVER THE SOUTHERN OCEAN



days



days

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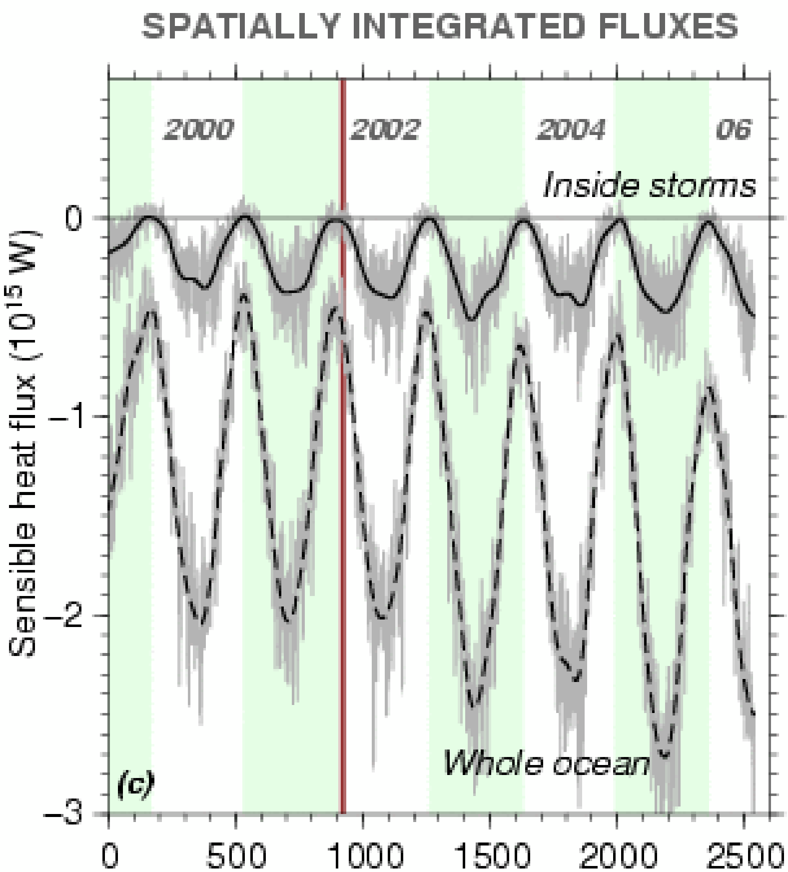

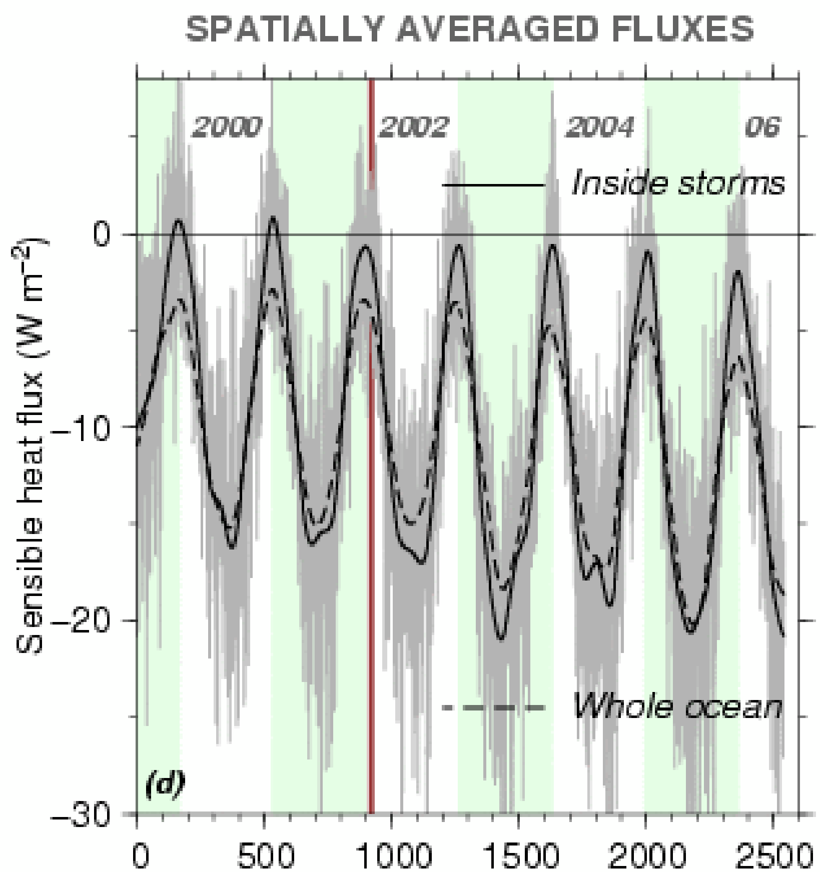

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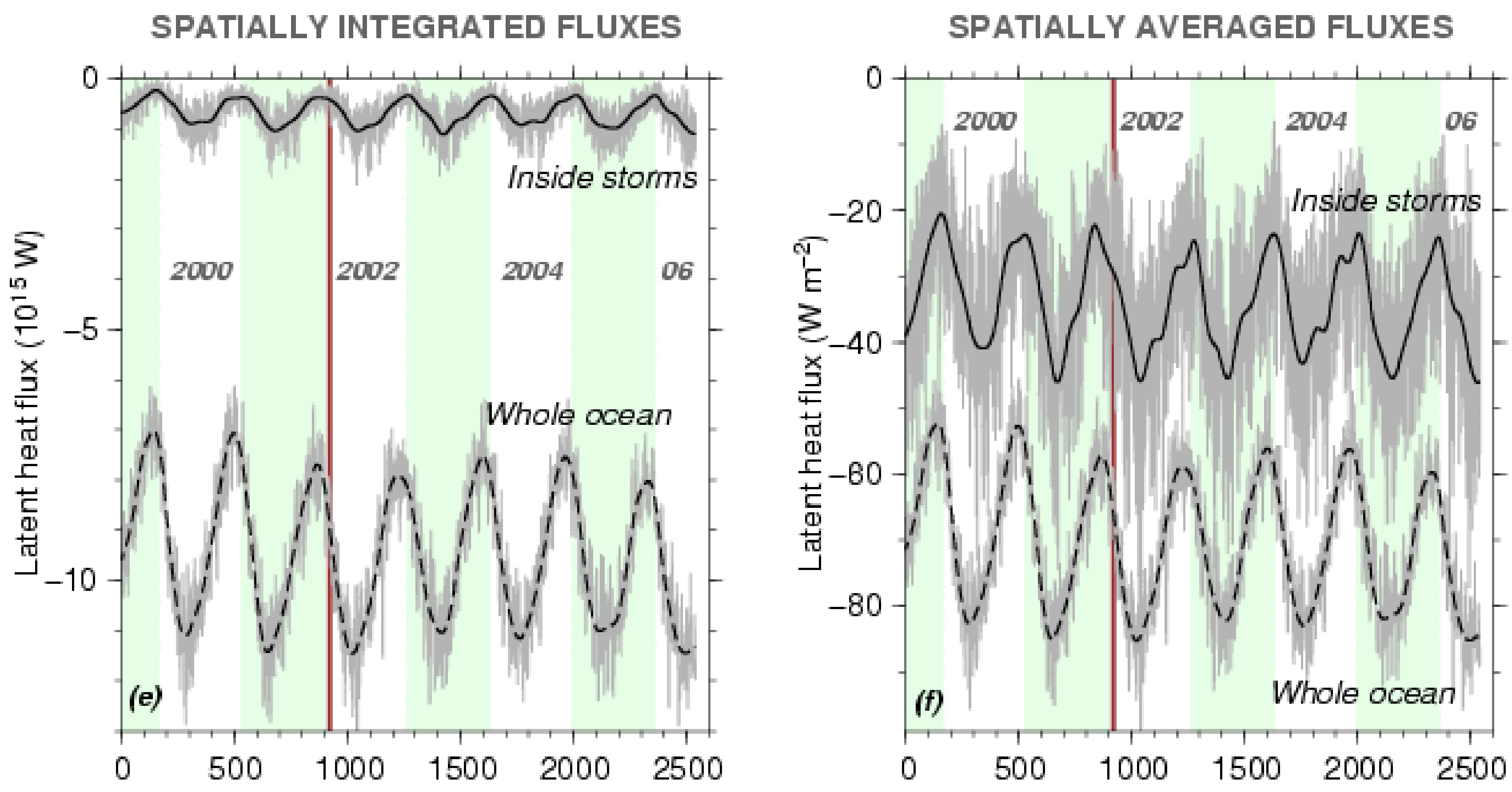
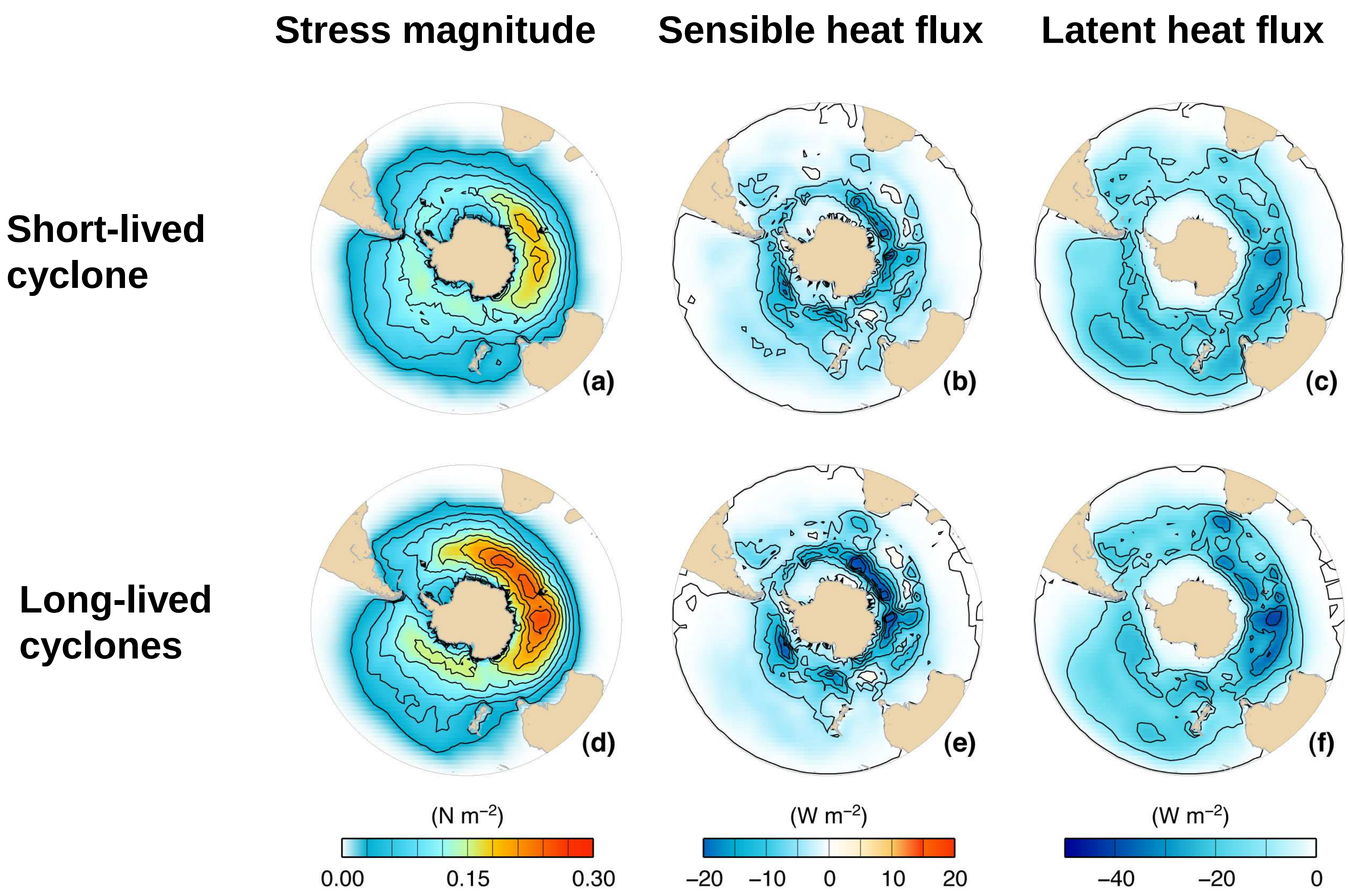


CONTRIBUTION FROM STORMS OF DIFFERENT LIFE SPANS

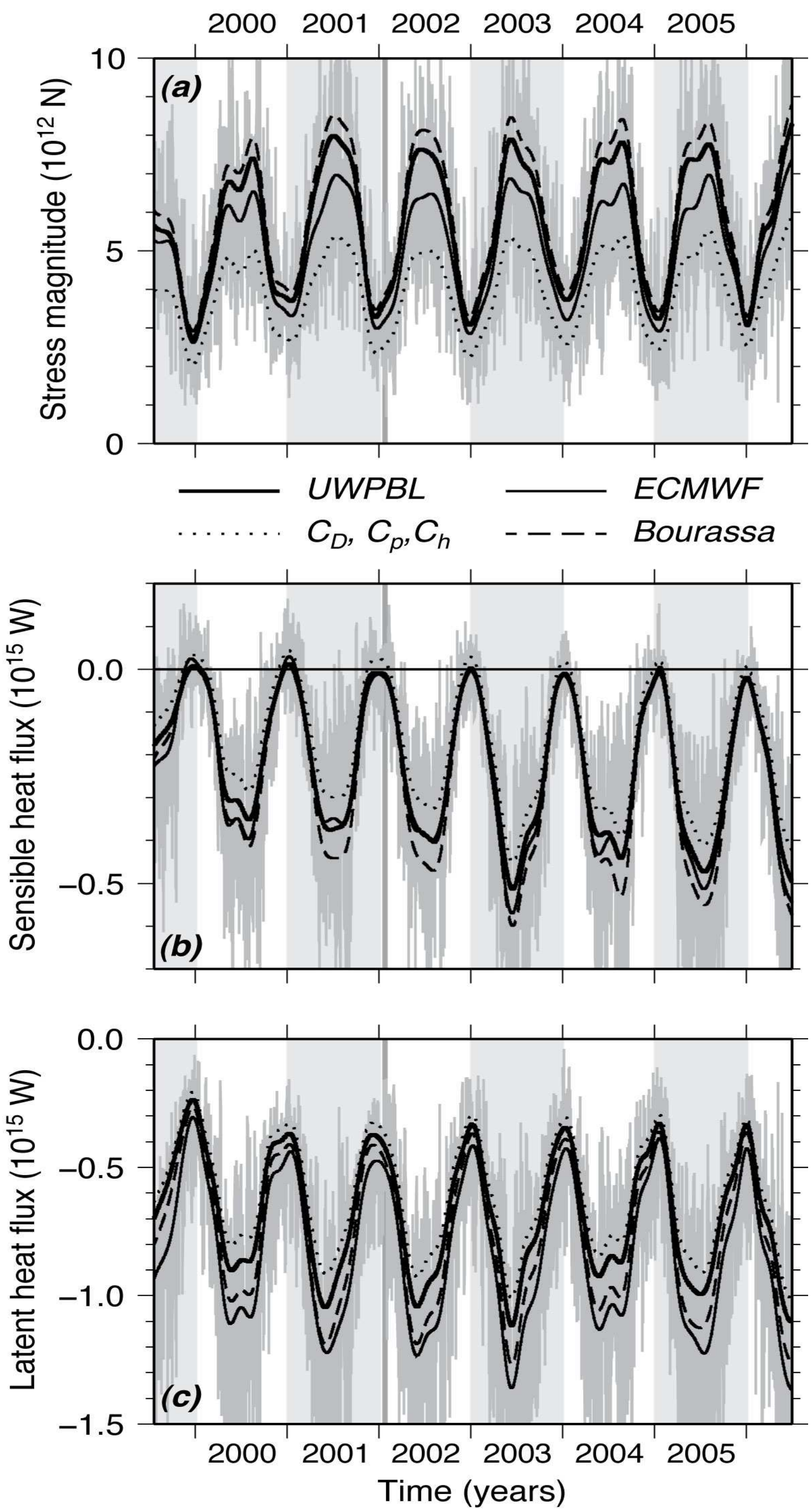
Winter mean fluxes



Impact of Parameterizations

On Spatial integrated fluxes for the whole ocean

- Standard bulk coefficient produce weakest fluxes.
- Bourassa's stress is the strongest (60% stronger than bulk coefficient stress in winter).
- UWPBL stress is about 15% stronger than ECMWF stress in winter.
- ECMWF sensible flux is comparable to, latent flux is stronger than UWPBL fluxes.
- Incorporating Scatterometer winds in ECMWF does not produce noticeable differences in fluxes.
- Flux differences among products are magnified in winter.



CONCLUSIONS

- Scatterometer enhanced pressure fields yield longer cyclone tracks and more mesoscale cyclones.
- Cyclones deliver 20% sensible heat and 10% latent heat of entire southern ocean in all weather condition heat transports from the ocean to atmosphere.
- Mesoscale cyclones (last shorter than 4 days) represent 75% of all cyclone tracks and 60% of all storm positions.
- Large storms tend to be generated in midlatitudes and die in high latitudes.
- Mesoscale cyclones tend to be generated and die in high latitudes.
- Mesoscale cyclones deliver comparable amount of sensible and latent heat fluxes as large storms even wind stress is usually stronger within large storms.


THANK YOU!