SCAR fellowship report

Natalia Tilinina, Antarctic "missing" mesoscale cyclones representation in new reanalyses comparing to the satellite imagery

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Project Objectives:

- Creation of the database of mesocyclones over the Southern Ocean for one winter using satellite imagery mosaics
- Verification of the representation of mesocyclones into the modern reanalyses

Background and Rationale:

Mesocyclones in high latitudes are maritime atmospheric phenomena that are still not well documented and studied as they have relatively small size (<1000km in diameter) to be well observed in existing meteorological observational network. At the same time, mesocyclones influence large scale ocean circulation through the deep water formation (Condron and Renfrew, 2013) and often associated with extreme winds when the special class of mesocyclones, known as polar lows (Rasmussen and Turner, 2003), occurs. Number of studies were focused on mesocyclones in both Northern and Southern Hemispheres high latitudes (Ahern 2015; Irving et al., 2010;), all this studies use reanalysis or numerical models data. (Xia et al. 2012) proposed adaptation of traditional tracking algorithms typically used for midlatitudinal cyclones to track polar lows using combination of criteria. However even being adequately adapted for small scale short living mesocyclones tracking algorithms applied to reanalyses underestimate mesocyclones' activity. This can be especially dangerous in Southern Hemisphere where observational network coverage is pour. However being not directly observed, even with satellite data assimilated in reanalysis model, mesocyclones tend to be missed or to have smaller than in reality imprint in reanalysis (Condron et al. 2006) sea level pressure and vorticity fields. (Harold et al., 1999 part I and part II) produced satellite based dataset for North-East Atlantic and Nordic

Seas during the 2-year period, they found more than 4000 mesocyclones on satellite imageries, this is twice more than number of mesoscale circulation signatures in ERA-40 reanalysis (Condron et al. 2006). (Harold et al., 1999 part I and part II) work provides a reference dataset of mesoscale cyclones that can be used for verification of both reanalyses datasets and tracking algorithms. To fill the gap in Southern Hemisphere mesocyclones' studies we have developed a new database of Southern Hemisphere mesocyclones for one winter of 2004 (June, July, August September). For this purpose the methodology of manual tracking of mesocyclones was developed and the paper is under submission not to *Geophysical Research Letters*.

Methodology:

Satellite data has a big potential for identification and tracking of mesocyclones, however this procedure is - can be done for short periods of time. Only one season of 2004th(JJAS) was taken due to complexity and time-consuming manual tracking procedure. Production of 4-month dataset took roughly ~500hours of manual tracking of Antarctic satellite mosaics.

Data

Mesocyclones were derived from AMRC satellite infrared (10.3 – 11.3 μm) mosaics that cover polar region inside 40 s.h. with 3-hourly time and 5 km spatial resolution. Base synoptic features were overlaid as ERA-20 Reanalysis sea level pressure field.

Three high-quality reanalysis data were examined on mesocyclones reproduction quality: ERA-Interimdataset with spatial resolution .75°x.75°, NCEP CFSR on .5°x.5° grid and Antarctic Mesoscale Prediction System(AMPS) with 30x30 km resolution for all Antarctic domain, with temporal resolution 6 hours. Detailed (25x25 km) wind speed field from QuikSCAT (SeaWinds) were obtained twice a day.

Manual tracking

Mesocyclones were defined as short-living (less than 48 hours, more than 3) maritime cyclonic vortexes whose diameter varies between 100 and 1000 km. We analyzed all cloud systems with cyclonic curvature, observed over ocean. Following parameters were recorded: date and time, diameter, latitude and longitude of its center, cloud shape and large scale conditions at cyclogenesis moment. Cyclones' diameter and center coordinates were determined using criteria specified in (Harold et al., 1999), 5 main cloud forms were allocated after [Rasmussen and Turner, 2003] for each system, not for different stages of it's life: comma, spiral, comma-to-spiral, cloud train and merry-go-round (Figure 1 - one example).

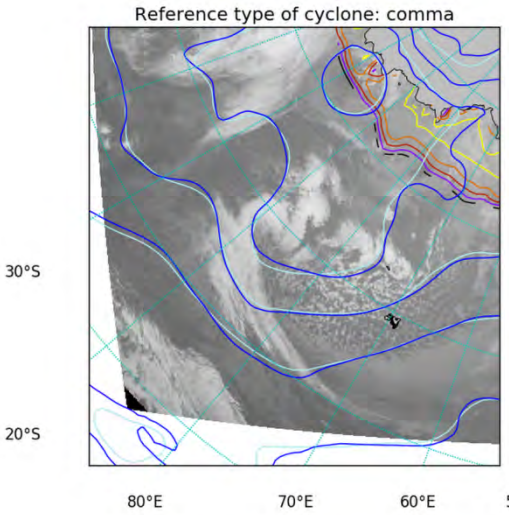
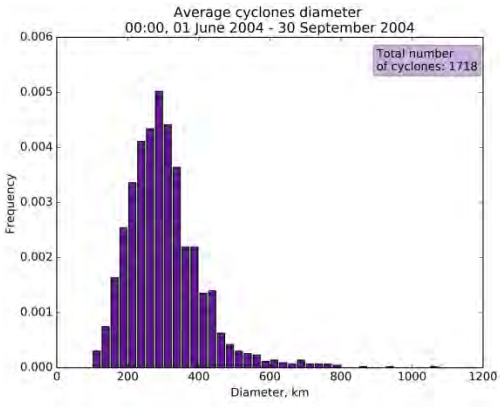


Figure 1. An example of comma type mesocyclones overlaid with SLP contours from ERA Interim and NCEP CFSR reanalyses. 03:00/13June/2004.

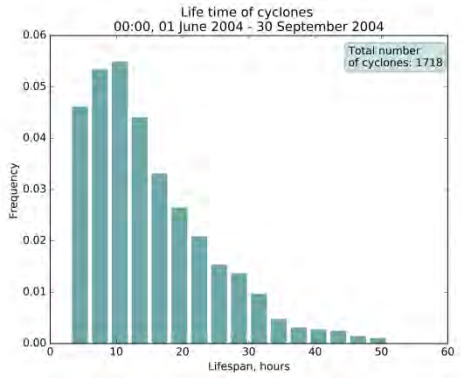
Since PL could not be distinguished using only satellite data we estimate if observed cyclone could be PL looking on type and brightness of associated cloud system, and also note it as a characteristic of MC.

Lifecycle statistics

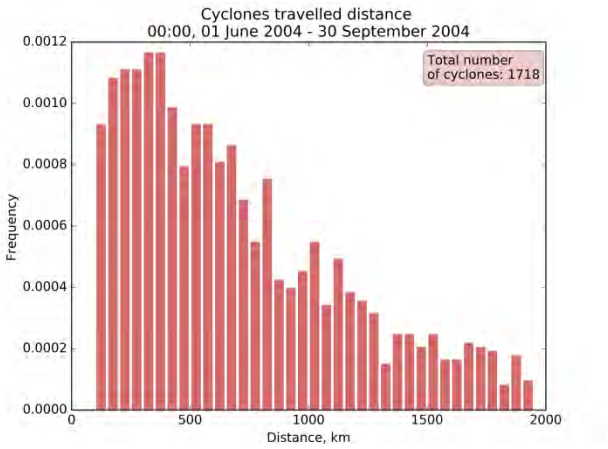
Using the newly created database we calculated basic statistics: distributions of diameter:



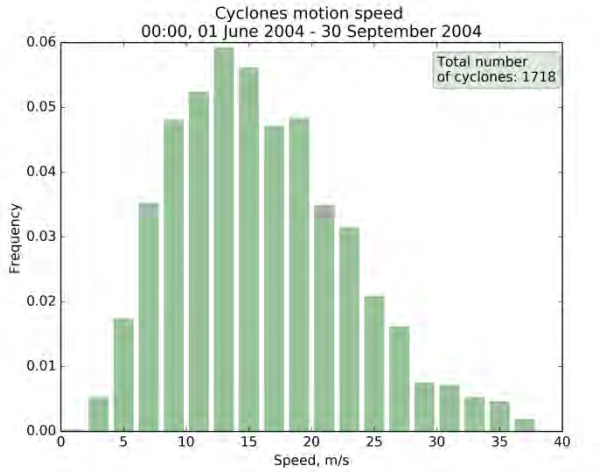
lifetime:



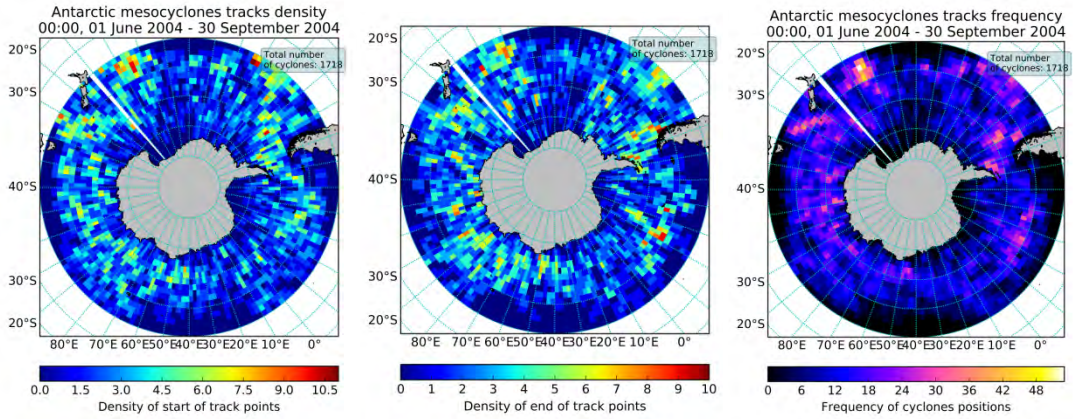
travelled distance:



and motion speed of cyclones:



Frequency of cyclones' locations and density of genesis/lysis points and tracks were mapped using circular grid with 1° mesh:



To avoid the "loss" of cyclones characterized by high motion speed, for tracks density and frequency calculations cyclones' locations were linearly interpolated on 10 minutes intervals.

Project Outcomes and Budget:

- Two working visits to prof. Ian Renfrew at University of East Anglia, Norwich:
  1) February 2012 - 34 days
  2) June 2015 - 32 days

- New computer

- Participation and presenting results at 13th European Polar Low Working Group meeting 25-26 April 2016, Paris, France.

- Paper "Mesocyclone activity representation in modern reanalysis over the Southern Ocean comparing to satellite infrared mosaics for winter 2004" is under submission to *Geophysical Research Letters.*

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