

Extra-tropical cyclone activity in the ensemble of 20th Century Reanalysis (20CRv2)

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Abstract

An objective cyclone identification/tracking algorithm is applied to the 6-hourly SLP fields of each of the 56 runs of the 20th Century Reanalysis (20CR) for 1871-2008 (138 years), and to the ensemble mean 6-hourly SLP fields, to infer extra-tropical cyclone activity and historical trends therein. The analysis is done for the northern and southern hemispheres (NH and SH), separately. The presentation includes ensemble mean and spread of cyclone counts and intensity. A preliminary assessment of temporal homogeneity and trend of the 20CRv2 cyclone activity index is also presented. The discontinuities are accounted for in the estimates of cyclone climatic trends (see the main conclusions below).

For the recent half century, the 20CR is found to be comparable to modern reanalyses (see the other poster by Wang et al.), although it uses surface pressure data only.

Data – global 6-hourly MSLP from

- 1) 20CR: the ensemble (56 runs) of 20th Century Reanalysis for 1871-2008 (20CRv2), 2°-by-2° lat-long grid (Compo et al. 2010)

Cyclone identification/tracking algorithm

- Adopted from Serreze (1995) and Serreze et al. (1997)
- 6-hourly MSLP data are first interpolated onto a (200km)² EASE grid [also (250km)² in Fig. 2]

Terminology

- Cyclone: a single low pressure center identified at a specific location and time → **cyclone counts (Cnts)**
- Cyclone track: consists of a cyclone and its trajectory during its lifetime (usually lasts more than one observing interval (6 hours in this study)).
- Cyclone **intensity (Inten)**: local Laplacian of pressure. Unit: 10⁻⁵ hPa km⁻².
- Cyclone **activity index (CAI)** = counts * mean-intensity
- Strong (deep) cyclones**: those of intensity >= 15 units

Temporal homogeneity test procedure

- (1) The FindU.wRef function in the RHtestsV3 software package (Wang and Feng 2010, Wang 2008) was applied to the time series of the ensemble spread (std), using the mean of the std series as reference series, to find sudden changes in the std series, which were then taken as potential Type-0 changepoints (Wang 2008) in the corresponding CAI series.
- (2) Apply the FindU function in the RHtestsV3 to the CAI series to find Type-1 changepoints (Wang 2008)
- (3) Combine the lists of changepoints obtained in (1) and (2), and then use the StepSize function in the RHtestsV3 to test the statistical significance of the changepoints in the combined list; delete the insignificant changepoint one by one, until all the changepoints in the list are significant at the nominal level.

Main conclusions:

- (1) The ensemble mean 6-hourly fields are not suitable for identifying/tracking cyclones, especially for periods/areas that have much fewer observations (Fig. 2).
- (2) The 20CR is found to be homogeneous over 100+ years for several NH regions (Highlat_NA, Midlat_NA, NEurope, CEurasia, Central_NAM). It contains discontinuities in data sparse regions/periods, such as the Canadian Arctic (CanArctic) and Siberia (NE_Asia) in the earlier periods (Fig.3).
- (3) After accounting for the discontinuities, cyclone activity trends are characterized by increased intensity of strong cyclones in the high latitude areas in the cold season of both hemispheres, which was also accompanied by an increase in strong cyclone counts in all high latitude regions except CanArctic (Fig. 4).

Major references

1. Compo et al., 2010: The Twentieth Century Reanalysis Project. *Quart. J. Roy. Meteor. Soc.* (accepted subject to revision).
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7. Wang, X. L. and Y. Feng, 2010: *RHtestsV3 User Manual*. Climate Research Division, Environment Canada, 28 pp. Available at <http://cccma.seos.uvic.ca/ETCCDMU/software.shtml>

Fig. 3: Annual trends in the ensemble mean series of cyclone activity index (see Fig. 1 for the regions)

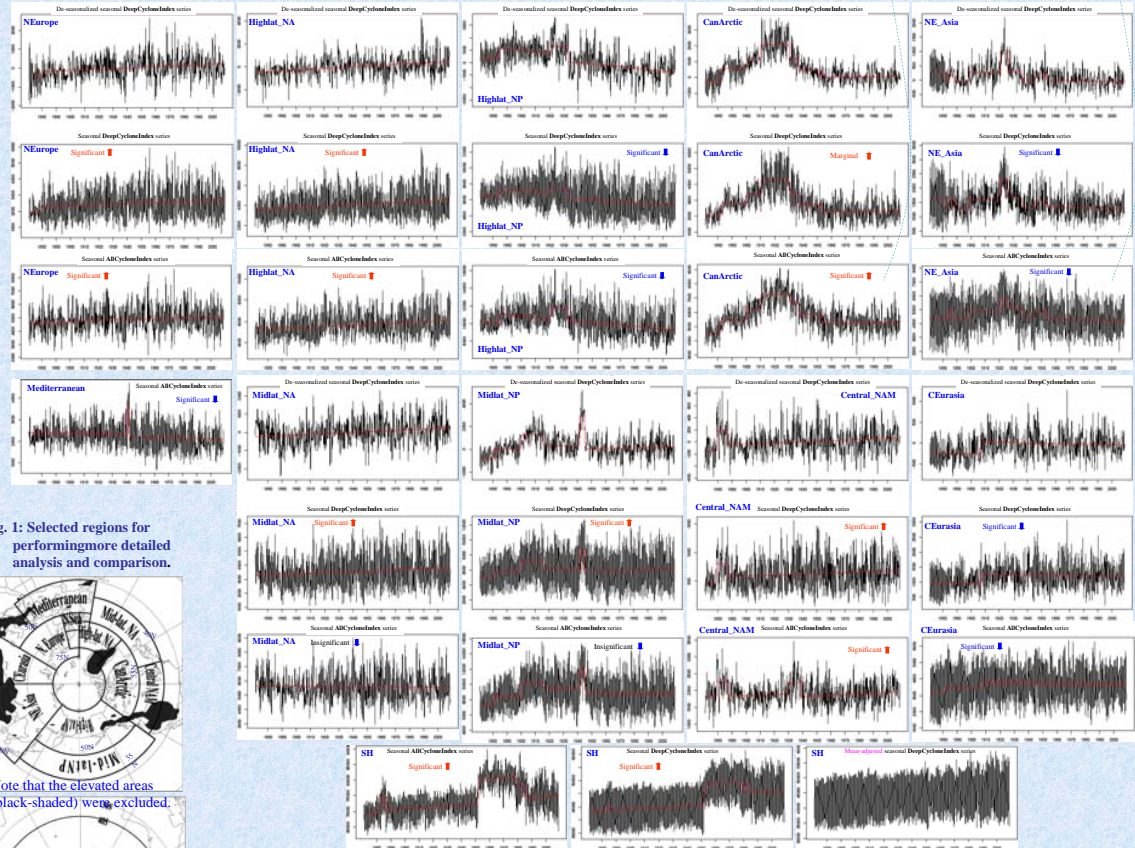


Fig. 1: Selected regions for performing more detailed analysis and comparison.

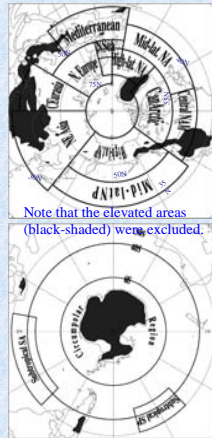
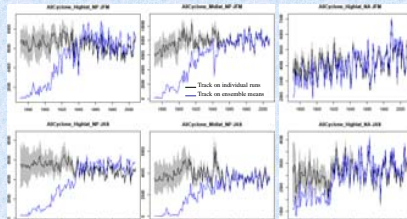


Fig. 2 Examples showing that the ensemble mean 6-hourly fields are not suitable for identifying/tracking cyclones, especially for periods/areas that have much fewer observations. [(250km)² EASE grid for both]



Black – Ensemble means of the 56 CAI series obtained from tracking the 56 runs individually
Blue – CAI time series obtained from tracking the ensemble mean 6-hourly SLP field series

Fig. 4: Trends in the ensemble means of JFM & JAS strong cyclone activity (grey shading – 95% interval; red: ↑, blue: ↓)

