A critical assessment of the long term changes in the wintertime surface Arctic Oscillation and Northern Hemisphere storminess in the ERA20C reanalysis

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Discussion at the 2017 European Windstorm Workshop on the 20th century trend in NH storminess:

Befort et al. 2016, ASL: Number of cyclones with pressures < 970hPA over Northern Hemisphere from the 20th Century reanalysis (red) and the ERA20C reanalysis (blue). See also Chang et al. (2016), Wang et al. (2016).
Many studies have found no or small trends in storminess:

Geostrophic winds from weather station records

Time-series of wintertime European storminess beat the Baltic Sea, Alexandersson et al. (2000). See also Feser et al. (2015)

Storm surge from Tidal gauges in the North Sea

Normalized (i.e., the long-term average has been removed) annual (black) and seasonal [red is October–March (ONDJFM); blue is April–September (AMJJAS)] time series of the 99.9th storm surge percentiles. Dangendorf et al (2016).
Many studies have found no or small trends in storminess:

Pressure extremes from weather station records

Long term observations of the North Atlantic Oscillation

Pressure extreme records at Lund (red) and Stockholm (blue) since about 1800 (Barring and Von Storch, 2004)

Winter (DJFM) NAO index updated to winter 2011/2012

DJFM NAO time-series (updated Jones et al. 1997 time-series, courtesy of Tim Osborn)
But can we dismiss the results from ERA20C?

• Decadal variability appears realistic (Varino et al. 2018)
• Where does the trend come from?

Normalised timeseries of DJF NH cyclone counts for all, strong and moderate storms (Varino et al. 2018)
Atmospheric reanalysis optimally combine observations and weather forecast models

Pros: Best estimate of the state of atmosphere; spatially homogenous global output
Cons: Will default to model when observations are sparse

Typically start in 1979 (with the advent of satellite data) and use as many observations as possible

20C reanalyses use limited surface observations (ERA20C uses sea-level pressure, temperature and ocean winds)
Long-term changes in Oct-Mar storminess in ERA20C:

Using Hodges (1995) tracking an increase in NH storminess in ERA20C is also found, mostly over Europe and North America.
Changes in sea level pressure


HadSLP2 gridded weather station observations

ERA20C atmospheric reanalysis
Changes in sea level pressure

Timeseries of Oct-Mar sea level pressure for selected regions:
Long-term change in Oct-Mar Arctic Oscillation:

HadSLP2 gridded weather station observations

ERA20C atmospheric reanalysis
Long-term change in Oct-Mar Arctic Oscillation:

Time-series of Oct-Mar Arctic Oscillation from HadSLP2, Thompson and Wallace (2000) and ERA20C. Lower figure difference between ERA20C minus Thompson and Wallace (black) and ERA20C minus HadSLP2 (red)
Changes in ERA20C


ERA20C meridional surface pressure gradient

ERA20C storminess
• A significant increase in NH storminess is seen in the ERA20C reanalysis, which is not seen in observational studies or in the NOAA 20CR reanalysis

• There is a significant decrease in polar sea level pressure in ERA20C not seen in HadSLP2 gridded observations

• The spurious decrease in ERA20C polar sea-level pressure increases the meridional pressure gradient and is associated with an increase in NH storminess

• The ERA20C 20\textsuperscript{th} century trends seen in storminess and sea level pressure are most likely spurious, and should be treated with caution
Substantial change in the density of the observational network in ERA20C:

Previous studies have also shown similar issues with the Southern Hemisphere storm track (Simmons and Keay, 2000; Hines et al 2000)

Would need to perform additional sensitivity experiments with ERA20C (e.g. keeping polar observational network constant over 20\textsuperscript{th} Century) to identify the specific problem
Summary

- A significant increase in NH storminess is seen in the ERA20C reanalysis, which is not seen in observational studies or in the NOAA 20CR reanalysis.

- There is a significant decrease in polar sea level pressure in ERA20C not seen in HadSLP2 gridded observations.

- The spurious decrease in ERA20C polar sea-level pressure increases the meridional pressure gradient and is associated with an increase in NH storminess.

- The ERA20C 20th century trends seen in storminess and sea level pressure are most likely spurious, and should be treated with caution.