# 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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Bloomfield, H. et al., 2018: Environmental Research Letters

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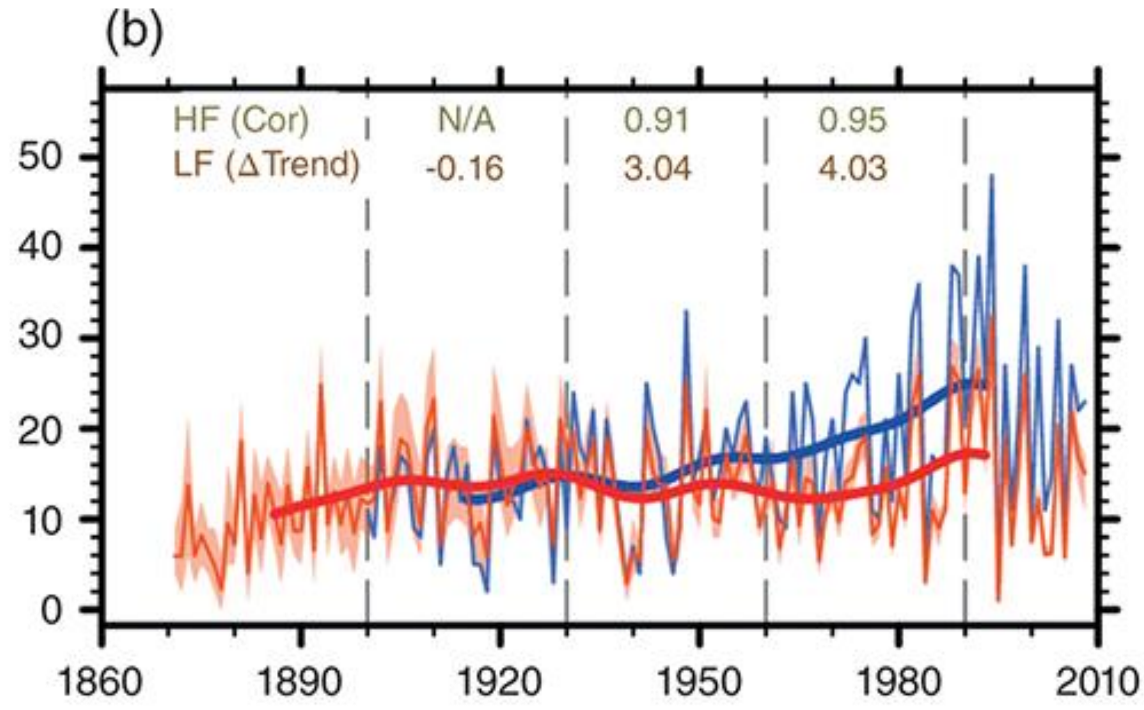
# Discussion at the 2017 European Windstorm Workshop on the 20th century trend in NH storminess:




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).

# Previous studies on storminess

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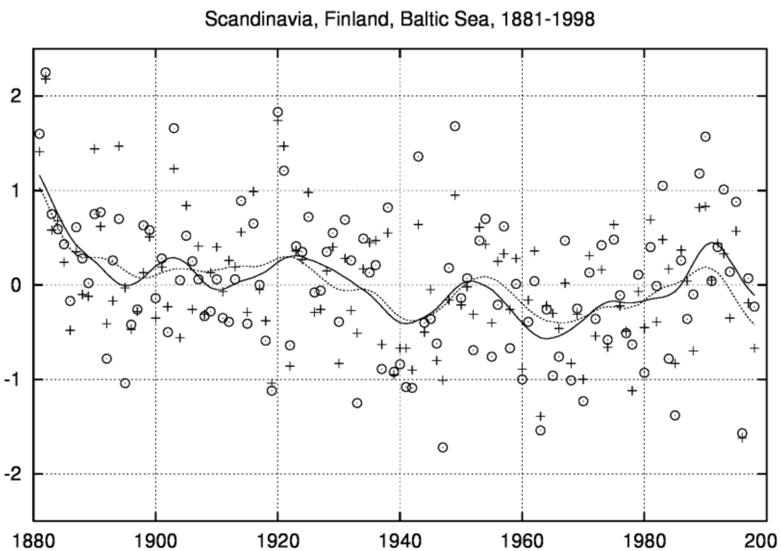
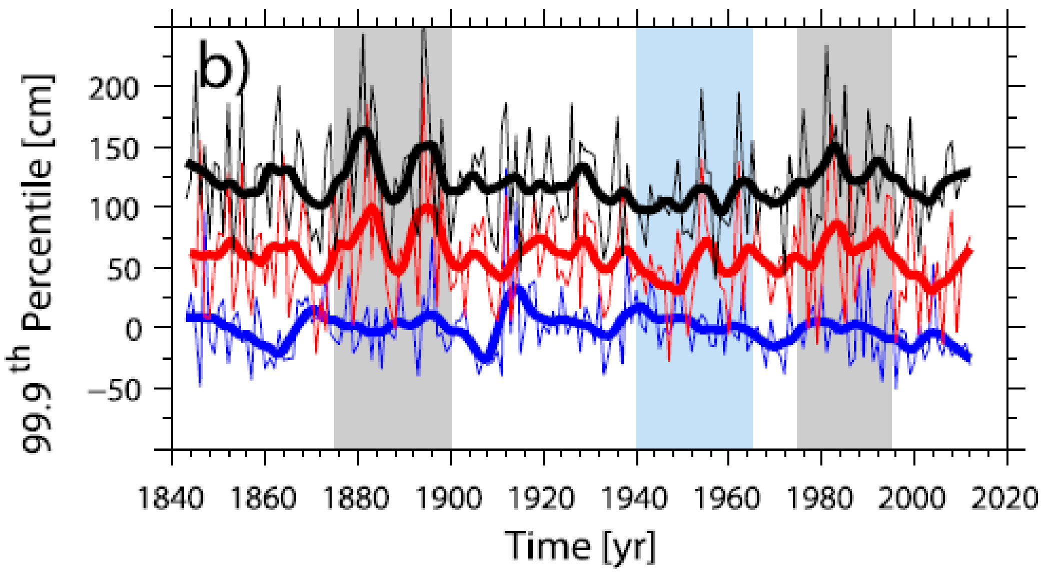
## Many studies have found no or small trends in storminess:

**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**

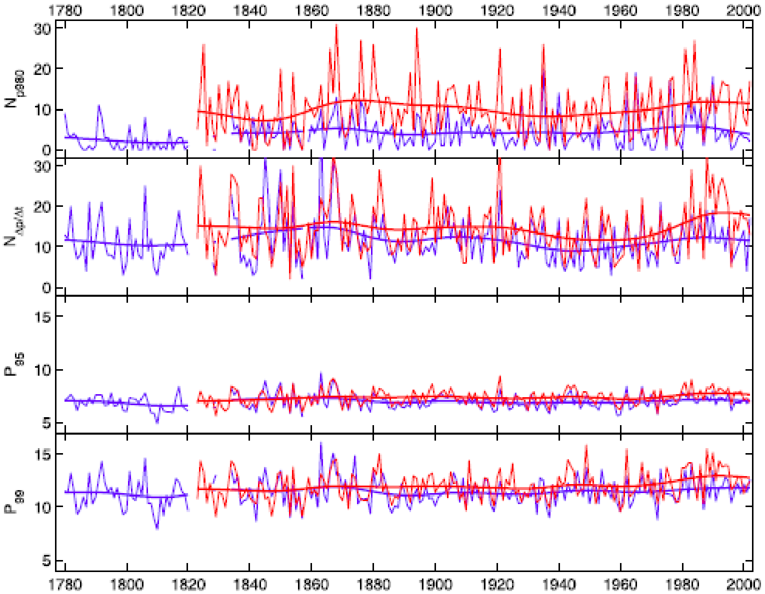



Normalized (i.e., the long-term average has been removed) annual (black) and seasonal [red is October–March (ONDJFM); blue is April–September (AMJJAS)] time series of the 99.9th storm surge percentiles. Dangendorf et al (2016).

# Previous studies on storminess

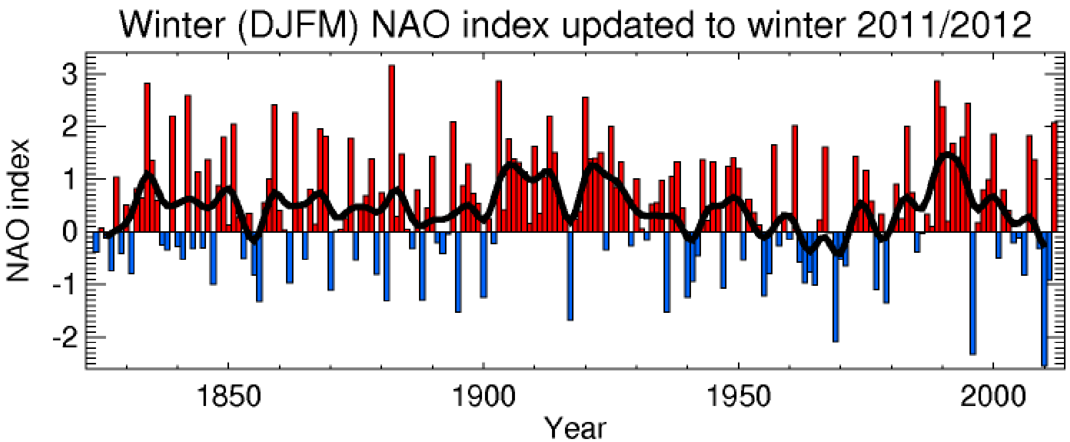
## Many studies have found no or small trends in storminess:

**Pressure extremes from weather station records**




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

**Long term observations of the North Atlantic Oscillation**




DJFM NAO time-series (updated Jones *et al.*1997 time-series, courtesy of Tim Osborn)

# Previous studies on storminess

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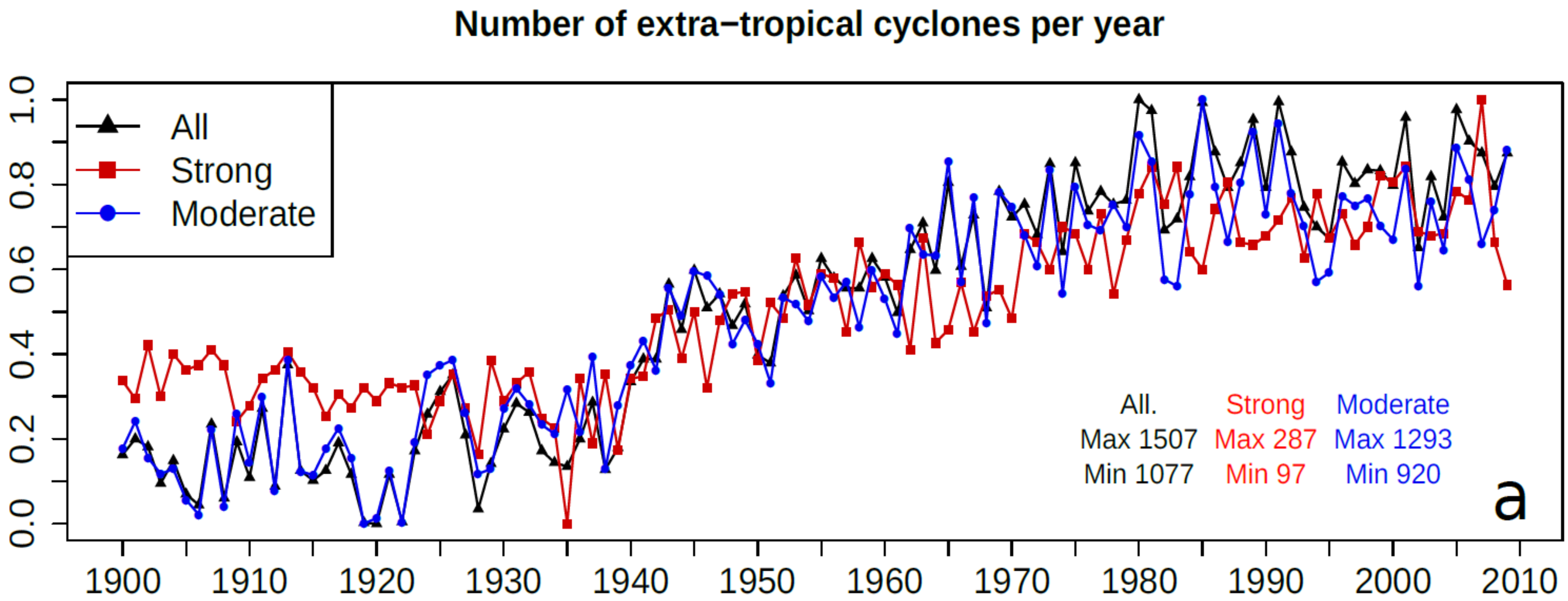
## But can we dismiss the results from ERA20C?

- 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)

# What are atmospheric reanalysis?

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**Atmospheric reanalysis optimally combine observations and weather forecast models**

Pros: Best estimate of the state of atmosphere; spatially homogenous global output

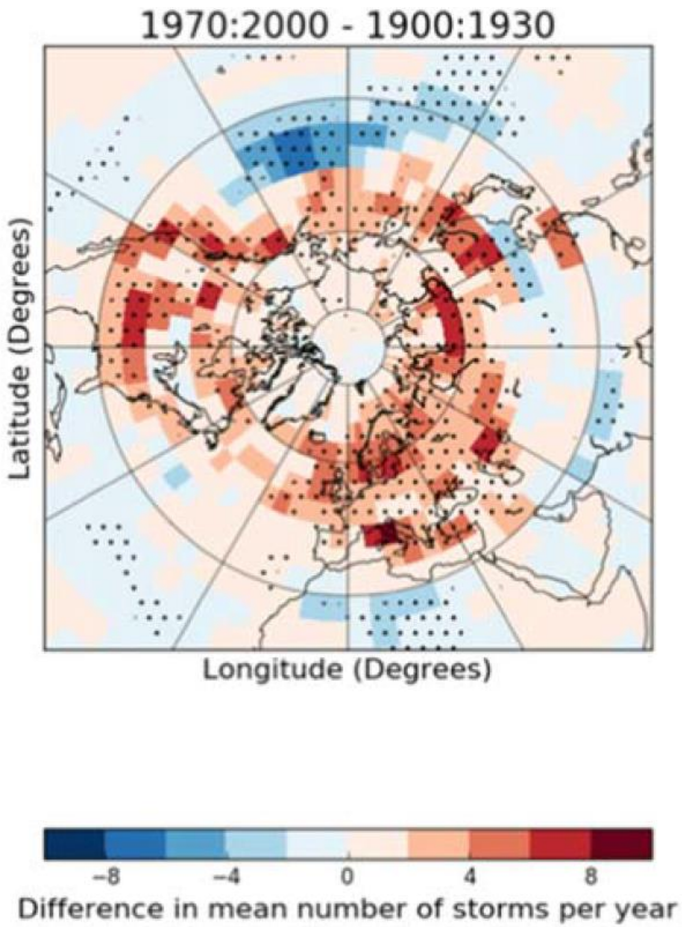
Cons: Will default to model when observations are sparse

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

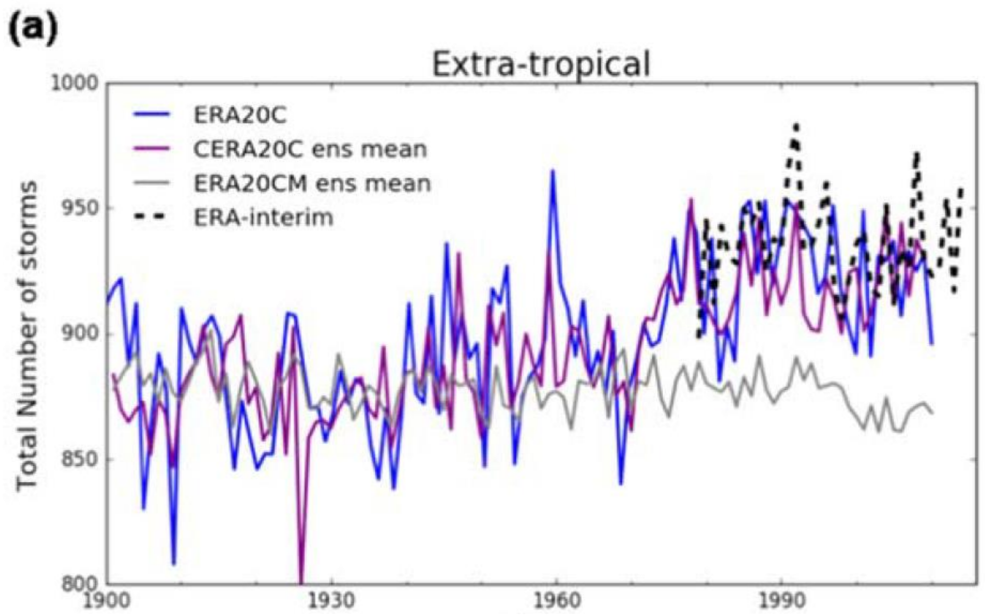
20C reanalyses use limited surface observations (ERA20C uses sea-level pressure, temperature and ocean winds)

# Changes in ERA20C

## Long-term changes in Oct-Mar storminess in ERA20C:



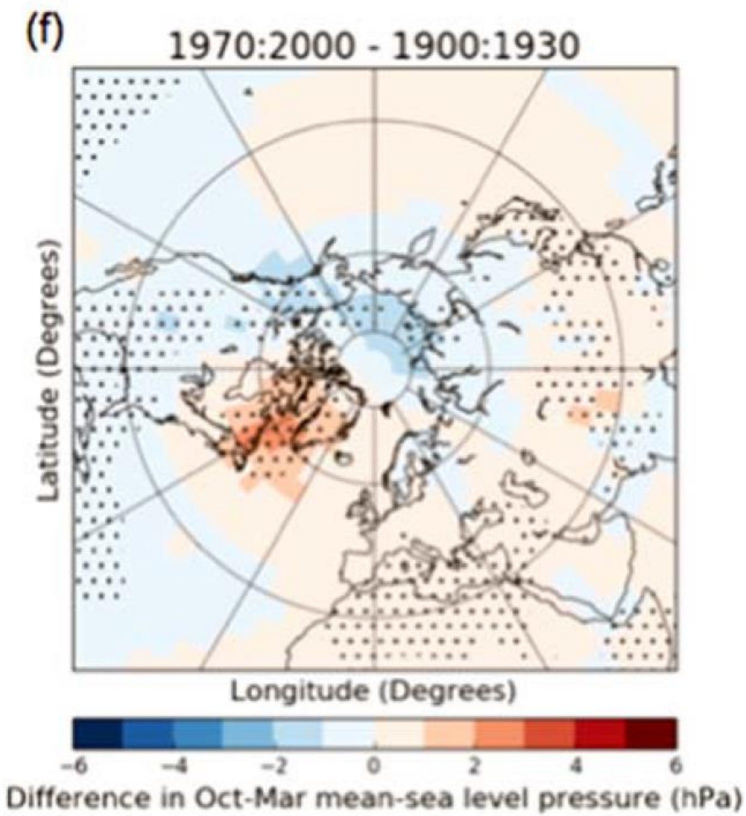

**Spatial change in Oct-Mar storminess (1970-2000) minus (1900-1930)**



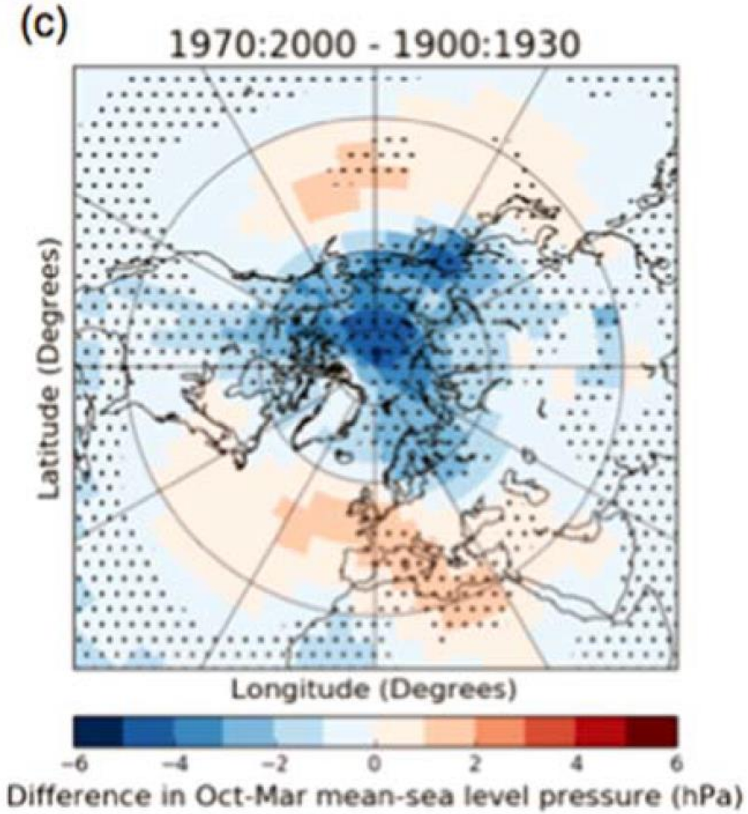

Using Hodges (1995) tracking an increase in NH storminess in ERA20C is also found, mostly over Europe and North America

# Changes in sea level pressure

## Long-term change in Oct-Mar sea level pressure 1970-2000 minus 1900-1930:




**HadSLP2 gridded weather station observations**




**ERA20C atmospheric reanalysis**

# Changes in sea level pressure

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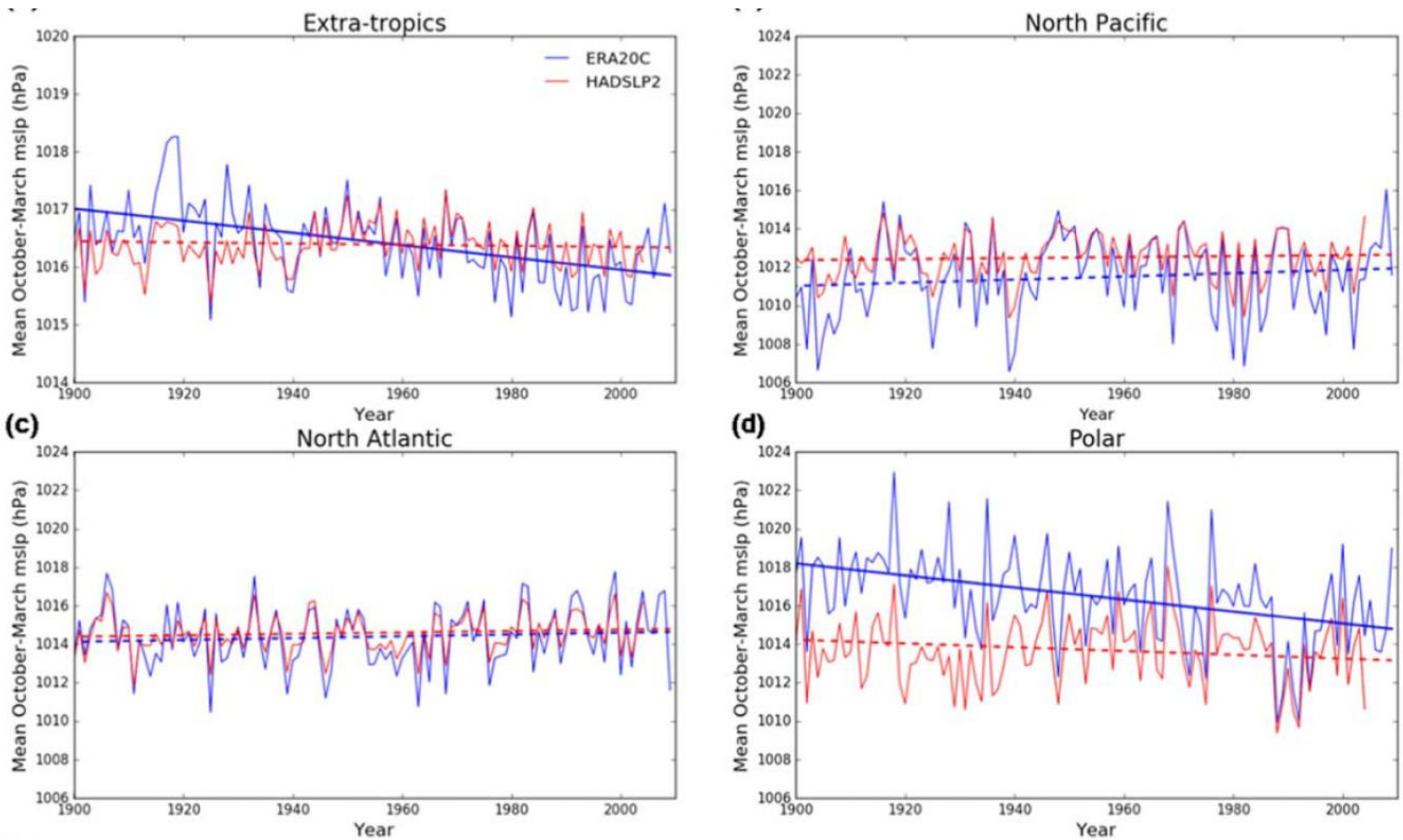
**Timeseries of Oct-Mar sea level pressure for selected regions:**



# Changes in the Arctic Oscillation

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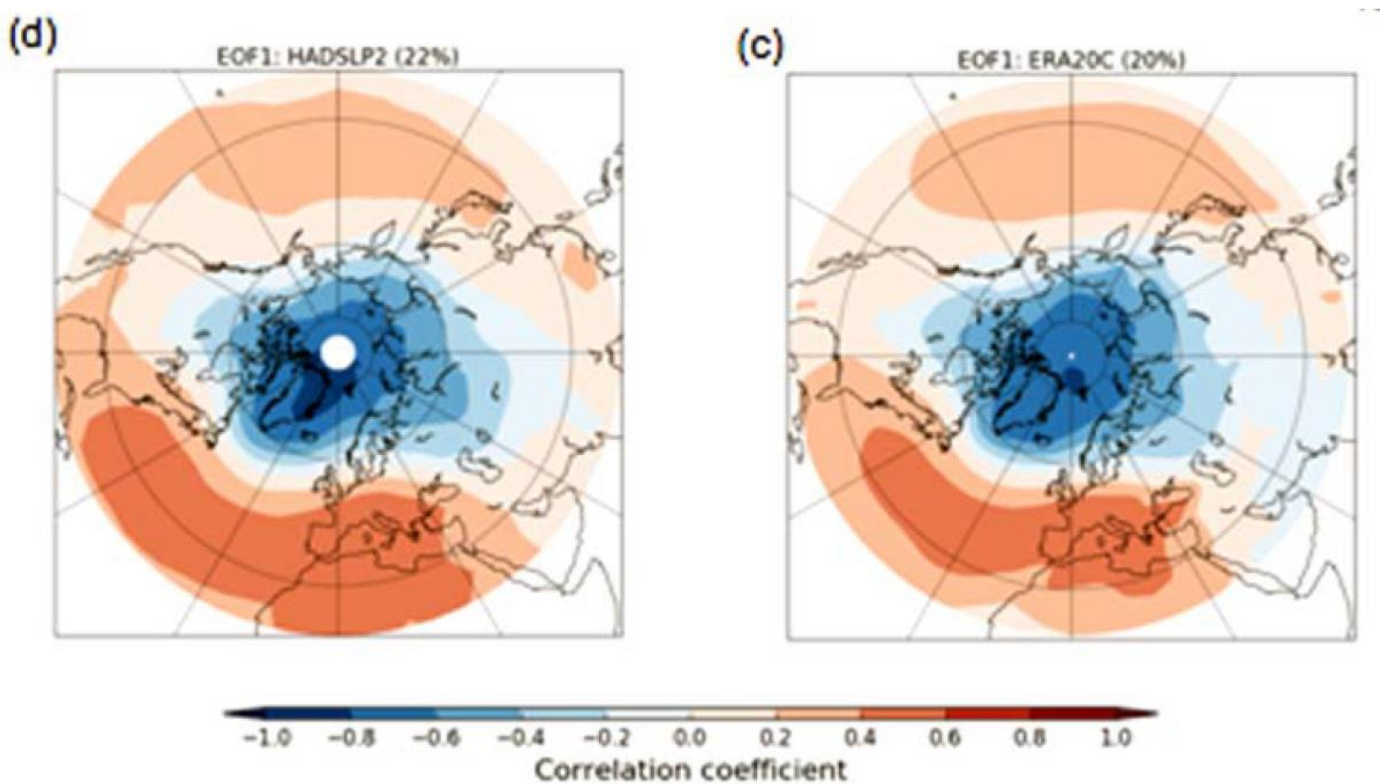
## Long-term change in Oct-Mar Arctic Oscillation:




**HadSLP2 gridded weather station observations**

**ERA20C atmospheric reanalysis**

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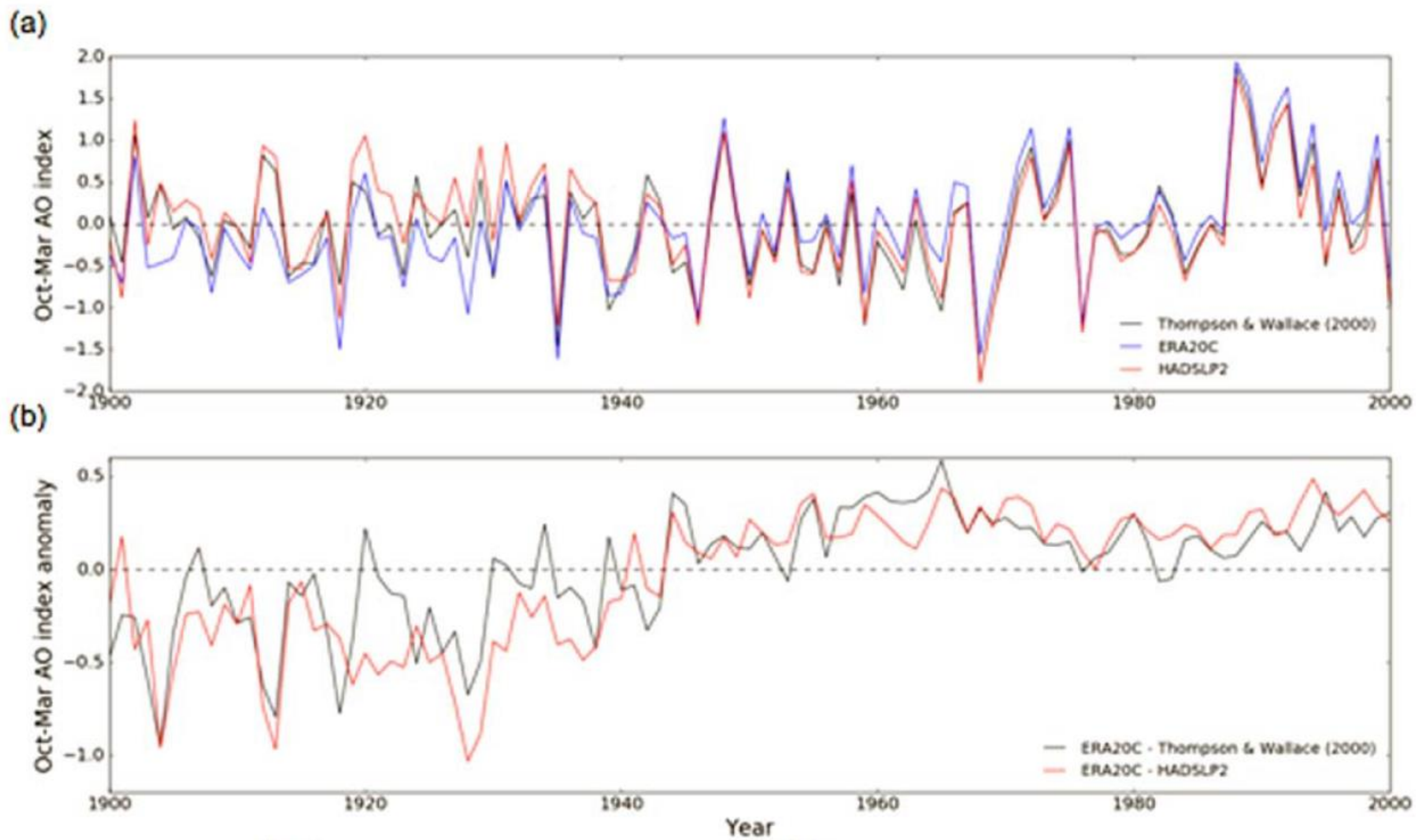


**Time-series of Oct-Mar Arctic Oscillation from HadSLP2, Thompson and Wallace (2000) and ERA20C. Lower figure difference between ERA20C minus Thompson and Wallace (black) and ERA20C minus HadSLP2 (red)**

# Changes in ERA20C

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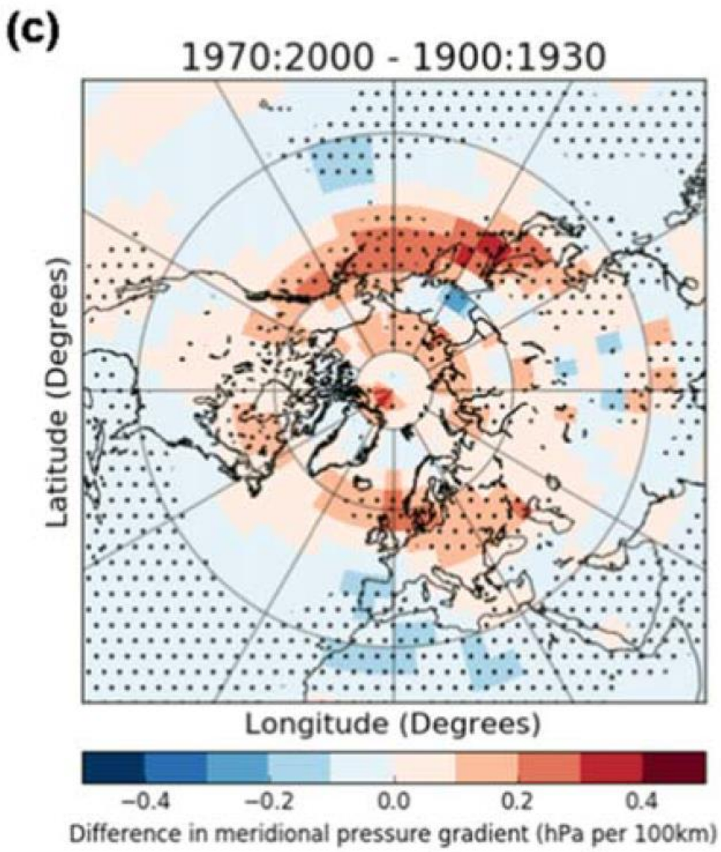
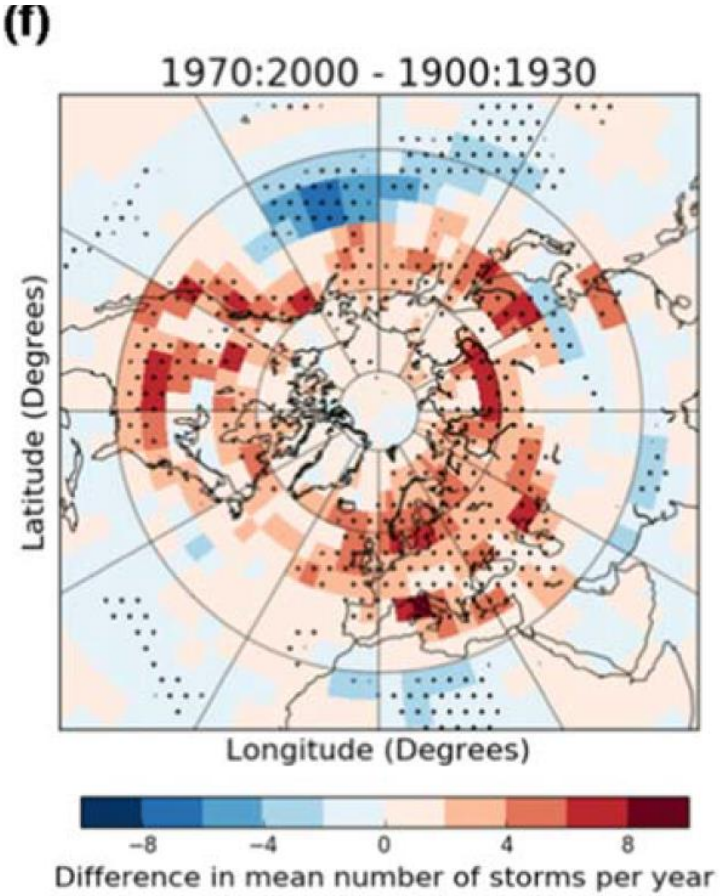
## Long-term change in Oct-Mar sea level pressure gradient and storminess, 1970-2000 minus 1900-1930:




**ERA20C meridional surface pressure gradient**




**ERA20C storminess**

# Summary

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- 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

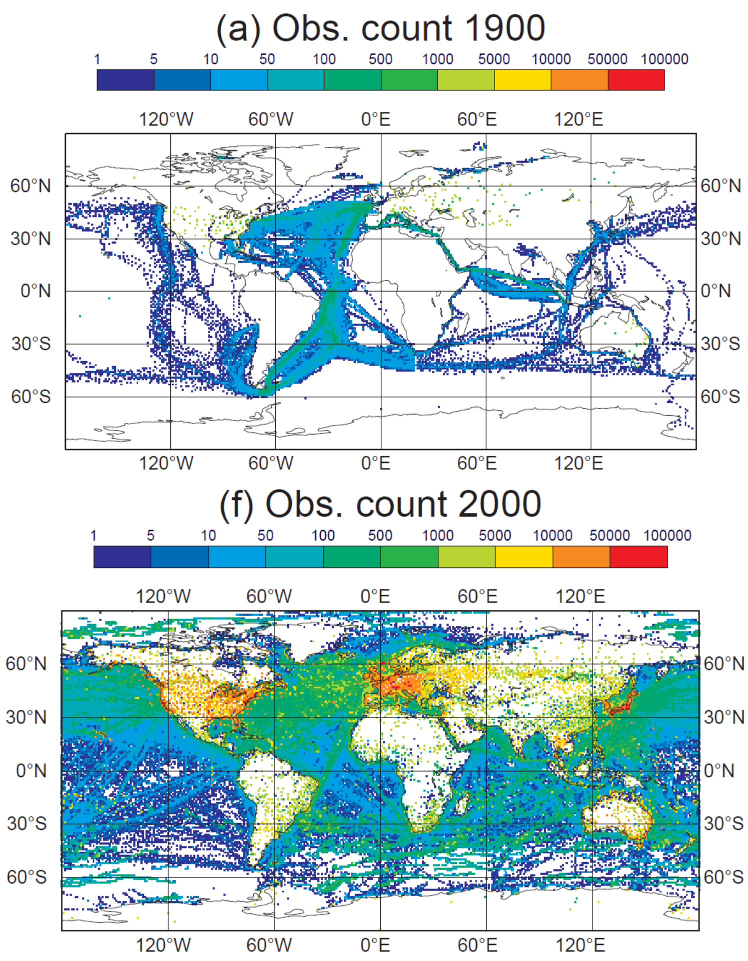
- The spurious decrease in ERA20C polar sea-level pressure increases the meridional pressure gradient and is associated with an increase in NH storminess

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

# What's wrong with ERA20C?



## Substantial change in the density of the observational network in ERA20C:




**Observational count 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$^{th}$ Century) to identify the specific problem

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