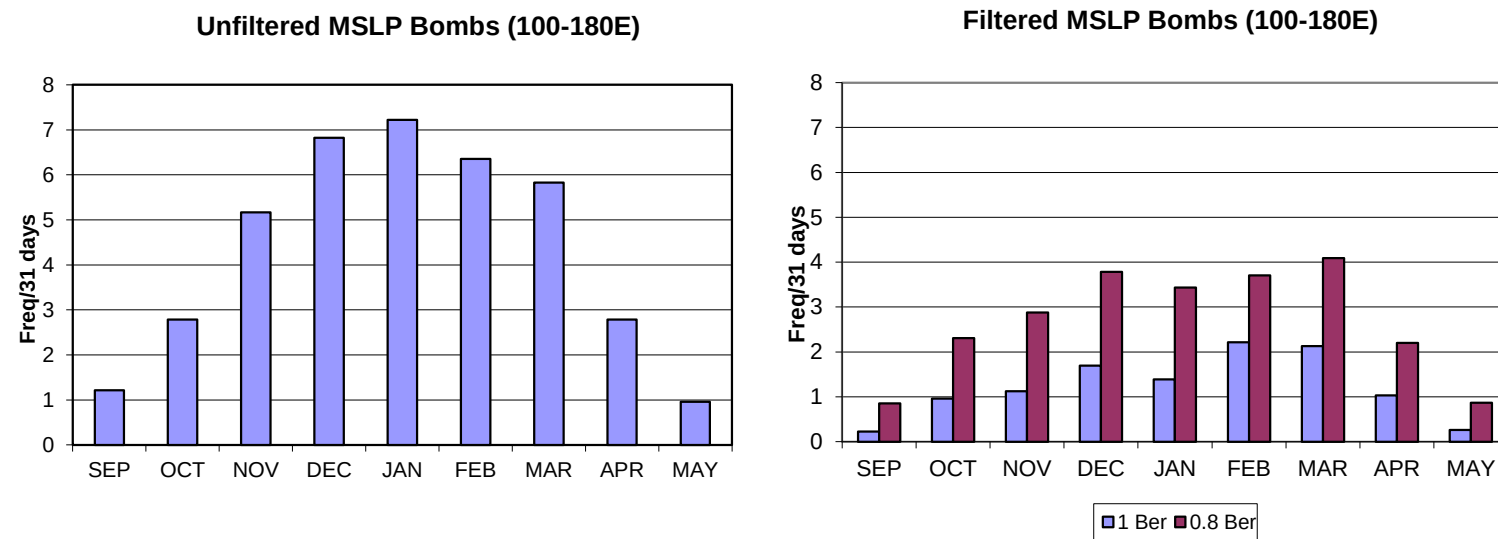


I. INTRODUCTION

Motivation

- Cyclones are responsible for much of the high impact weather in the mid-latitudes
- Many objective algorithms have been developed to track cyclones and compile cyclone statistics
- Nakamura (1992): mid-winter minimum in Pacific storm track activity (in terms of variance)
 - Seasonal cycle of frequency of “bombs” depend on definition of cyclones
 - Peak in January if defined by total MSLP
 - Indications of mid-winter minimum if defined as perturbations



Goals

- Tracks winter cyclones based on minima in MSLP
- Explore the impacts of the removal of a background field on cyclone statistics

II. DATA AND METHODS

Data

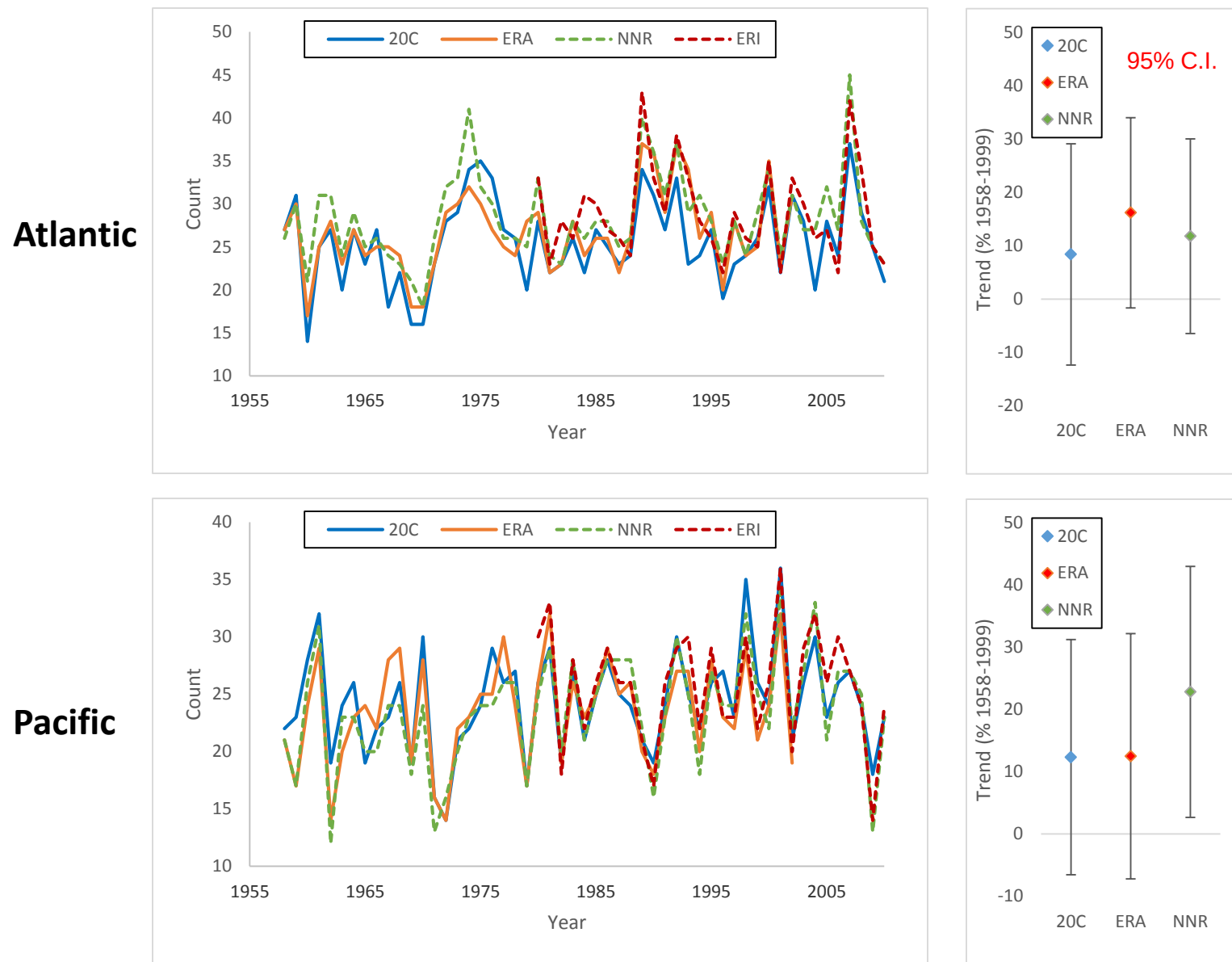
- 20th Century Reanalysis (20C)
 - ERA-40 (ERA)
 - NCEP/NCAR Reanalysis (NNR)
 - ERA-Interim (ERI), 1979/80 to 2009/10 DJF MSLP
 - GPCP monthly mean precipitation
- 1957/58 to 1998/99 DJF MSLP

Methods

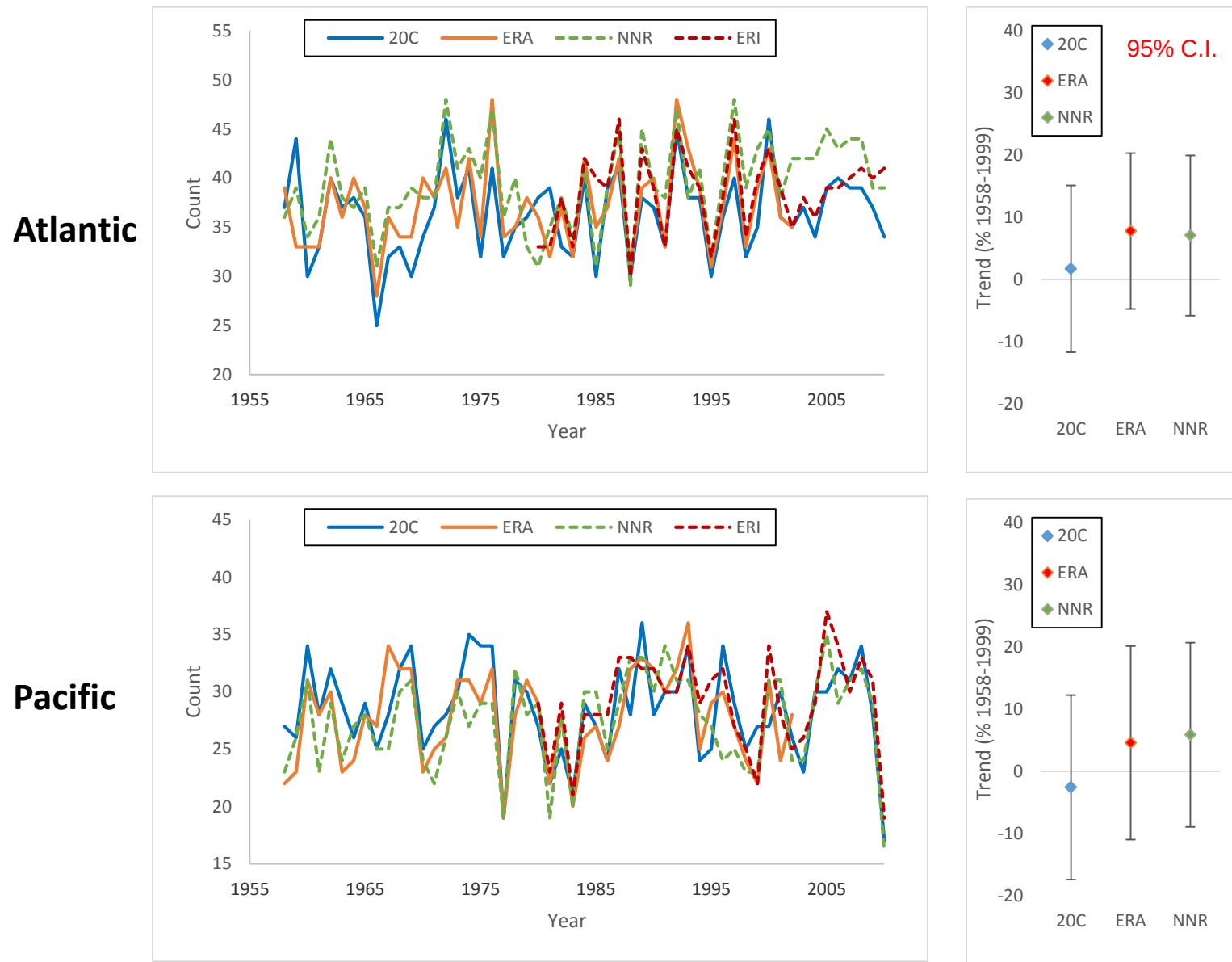
- Objective cyclone tracker on MSLP from Hodges (1999)
- Two different definitions of cyclones:
 - Unfiltered cyclones, defined as the local minima in the total MSLP data (T0-70)
 - Filtered cyclones, defined as the minima in pressure perturbation after removing a large scale, low frequency background field from the MSLP data (T5-70, remove seasonal mean)
- Cyclone counting method:
 - If the track is longer than 1000km and 2 days
 - If the lowest pressure center along the track is:
 - < 975 hPa for unfiltered cyclones
 - > 25 hPa for filtered cyclones
 - If the lowest pressure center is inside the area of interests:
 - Pacific (155E to 130W, 20-80N)
 - Atlantic (80W-30E, 20-80N)
 - If all of the above criteria are satisfied, the track is incremented by 1 in that season

III. CYCLONE TRACKING STATISTICS

Unfiltered Cyclones

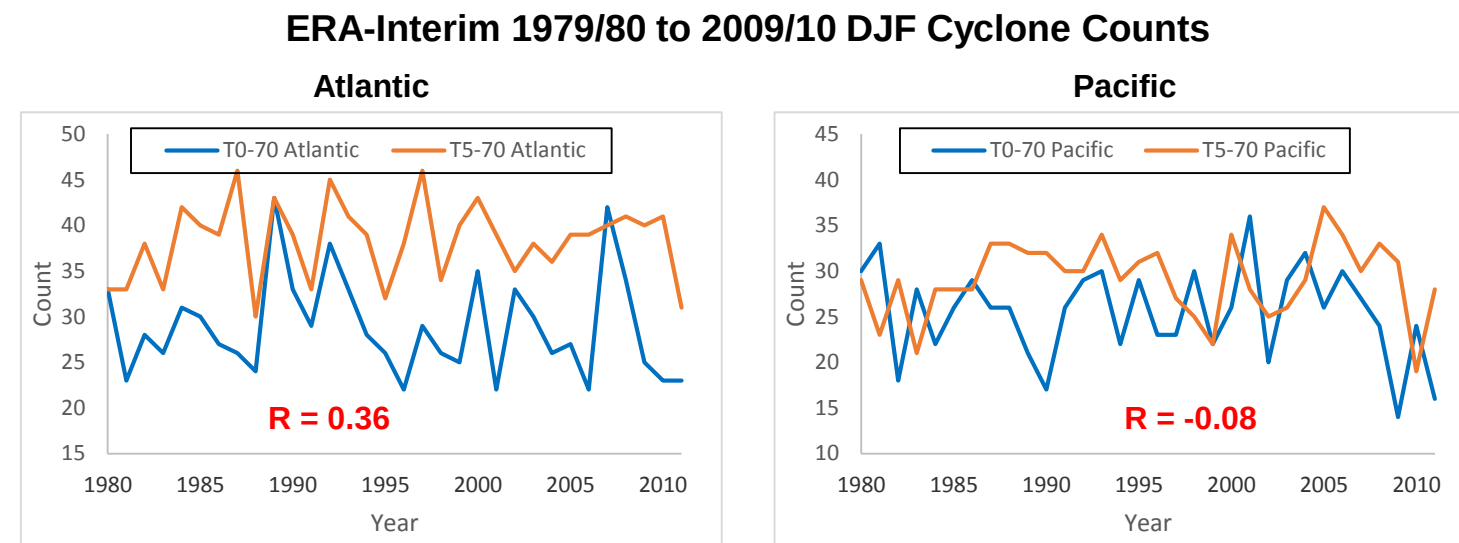


Filtered Cyclones

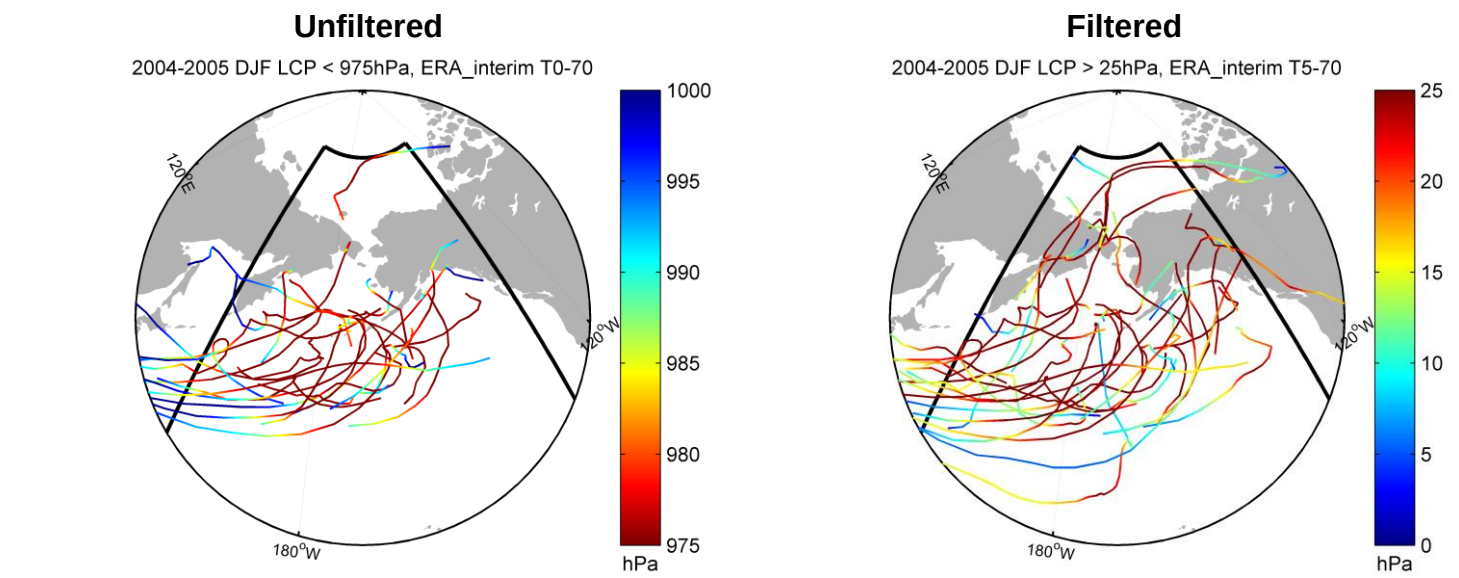


- Cyclone counts from different reanalysis datasets are consistent
- All cyclone counts have small but statistically insignificant trends except:
 - NNR unfiltered cyclones in Pacific
 - 22.8±20.2% increase from 1957/58 to 1998/99 DJF
 - 16.0±15.0% increase from 1957/58 to 2009/10 DJF
 - Consistent with Graham and Diaz (2001)

Difference Between Unfiltered and Filtered Cyclones



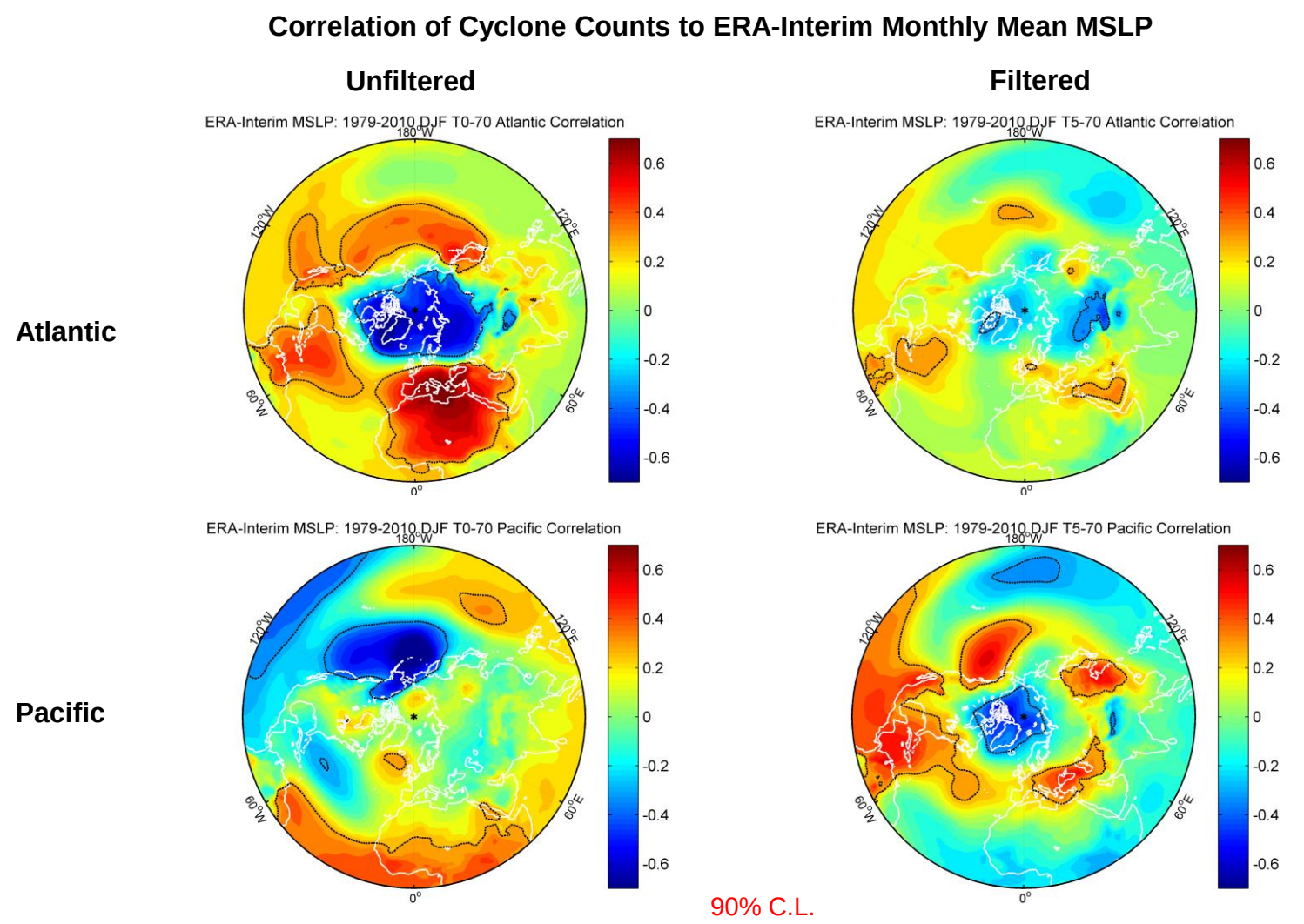
- Over the Atlantic, the unfiltered cyclones and filtered cyclone counts are positively correlated
- Over the Pacific, they are slightly anti-correlated, and often show a significant difference in the track patterns



- For example, in 2004/05, the Pacific unfiltered cyclones have 26 tracks while filtered cyclones have 37 tracks, the filtered cyclone tracks are longer and more scattered than the unfiltered tracks

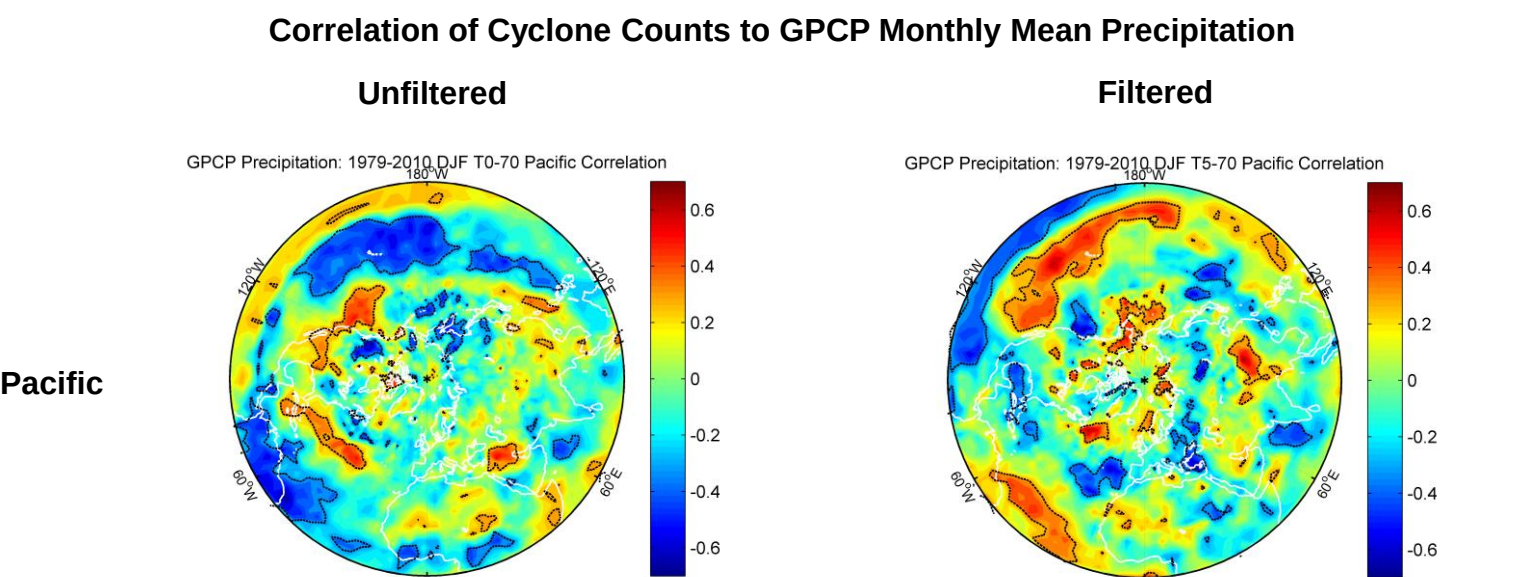
IV. RELATIONSHIP WITH MEAN FLOW / WEATHER

Monthly Mean Sea Level Pressure



- Correlation maps of ERA-Interim unfiltered cyclones with monthly mean MSLP resemble teleconnection patterns: NAO in Atlantic and PNA in Pacific
- Filtered cyclones in the Atlantic shows a much weaker pattern comparing to the unfiltered cyclones
- Filtered cyclones in the Pacific shows a nearly opposite pattern comparing to the unfiltered cyclones, which is expected because the cyclone counts are anti-correlated over the Pacific between two counting methods
- This can be shown more clearly in the precipitation data

GPCP Monthly Mean Precipitation



- The correlation map of unfiltered cyclones in the Pacific with GPCP monthly mean precipitation shows a typical PNA pattern in the winter
- However, the correlation map of filtered cyclones shows an inversed pattern with the unfiltered cyclones
- Which cyclone tracking methods is the better way to predict precipitation?

V. SUMMARY AND CONCLUSIONS

- Cyclone counts are consistent in different datasets, however NNR unfiltered cyclones in Pacific shows a slightly larger trend
- The filtered and unfiltered cyclones are positively correlated over the Atlantic, but slightly anti-correlated over the Pacific
- The correlation maps of unfiltered cyclones with monthly mean MSLP resembles NAO and PNA, while filtered cyclones in Pacific show an inversed pattern, which is more clearly shown in GPCP precipitation
- Remaining questions: Which cyclone tracking statistics is better related to high impact weather? Unfiltered or filtered? Why are they anti-correlated in the Pacific?
- Further results:** CMIP5 Multi-model projection, Chang (2013; talk A44C-03 on Thursday): Pacific intense cyclone activity decreases based on filtered cyclones, but increases based on unfiltered cyclones

VI. REFERENCES

- Chang, E.K.M., 2013: *Impacts of background field removal on CMIP5 projected changes in Pacific winter cyclone activity*. J. G. R., accepted.
- Graham, N.E. and H.F. Diaz, 2001: *Evidence for intensification of North Pacific winter cyclones since 1948*. Bull. Amer. Met. Soc.
- Hodges, K.I., 1999: *Adaptive Constraints for Feature Tracking*. Mon. Weather Rev.
- Nakamura, H., 1992: *Midwinter Suppression of Baroclinic Wave Activity in the Pacific*. J. Atmos. Sci.,