

The relationship between the potential and actual intensities of tropical cyclones on interannual time scales

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Abstract

The thermodynamic theory for the physics of a mature tropical cyclone (TC) tells us that the cyclone's intensity cannot exceed an upper bound; the potential intensity (PI). This combined with an empirical result due to Emanuel leads to a prediction of average TC intensity change, given the change in PI. The authors use best track data for the North Atlantic and western North Pacific, combined with PI computed from reanalysis data sets, to test these predictions.

Theoretically predicted slope for actual wind speed vs. PI:

-1.0, when computing PI along tracks, including all storms except those whose max. wind speed exceed the PI at that point

-0.5, when computing PI along tracks, including hurricanes only

Methods

Wind speeds from the best track (from NHC & JTWC) tropical cyclone and PI data (calculated according to the method of Emanuel (1995) from NCEP/NCAR reanalysis) were averaged to create time series of yearly average values. Methods of sampling:

1. The first point at which each storm's max intensity occurred, averaged all such values in a single year; for all storms, and then the subset of all storms reaching hurricane intensity

2. Average the PI over a specific region and peak season for each year: the MDR (10-20N, 80-20W) for the Atlantic and the region 5-25N, 100-160E for the Western North Pacific.

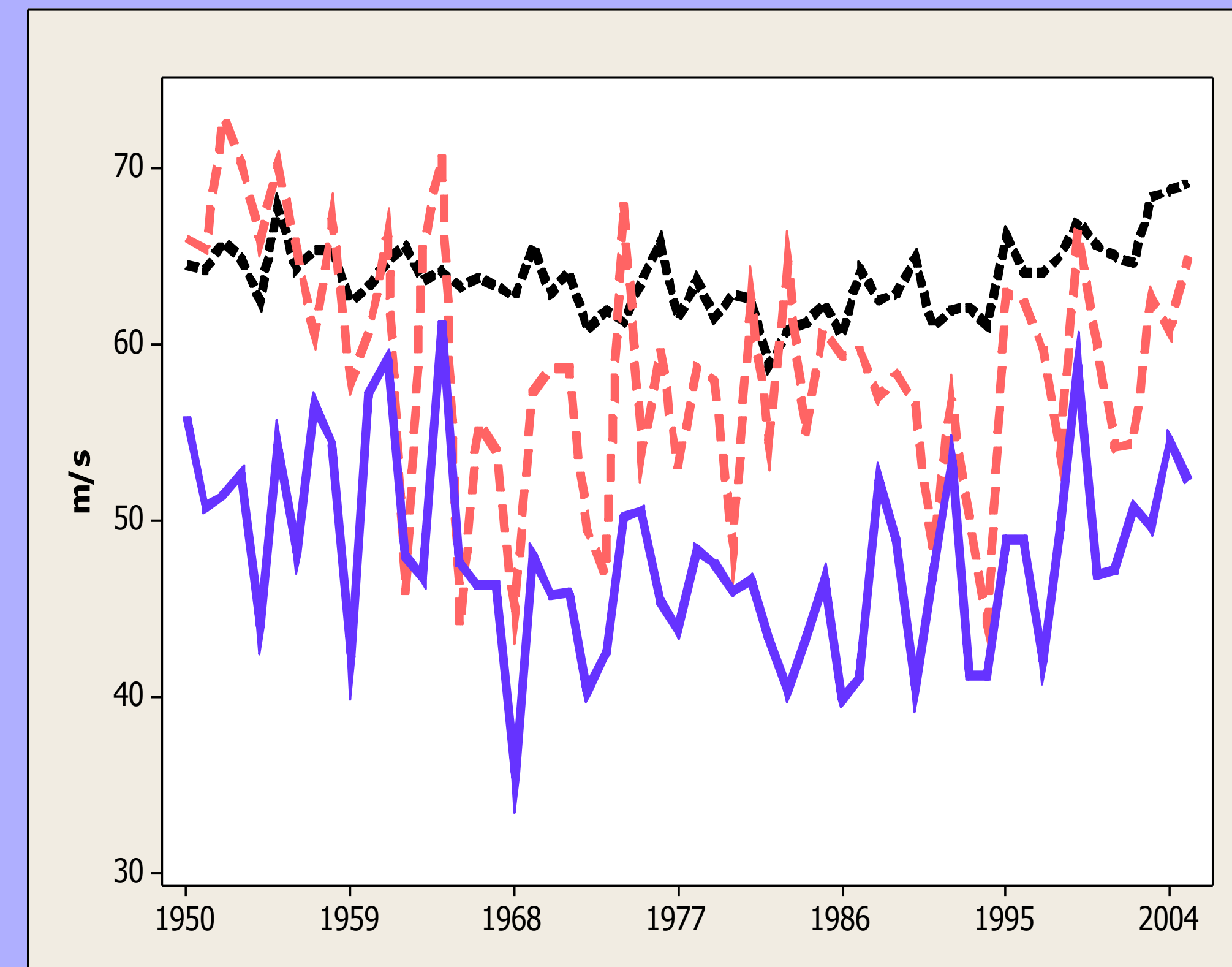


Figure 1a: North Atlantic

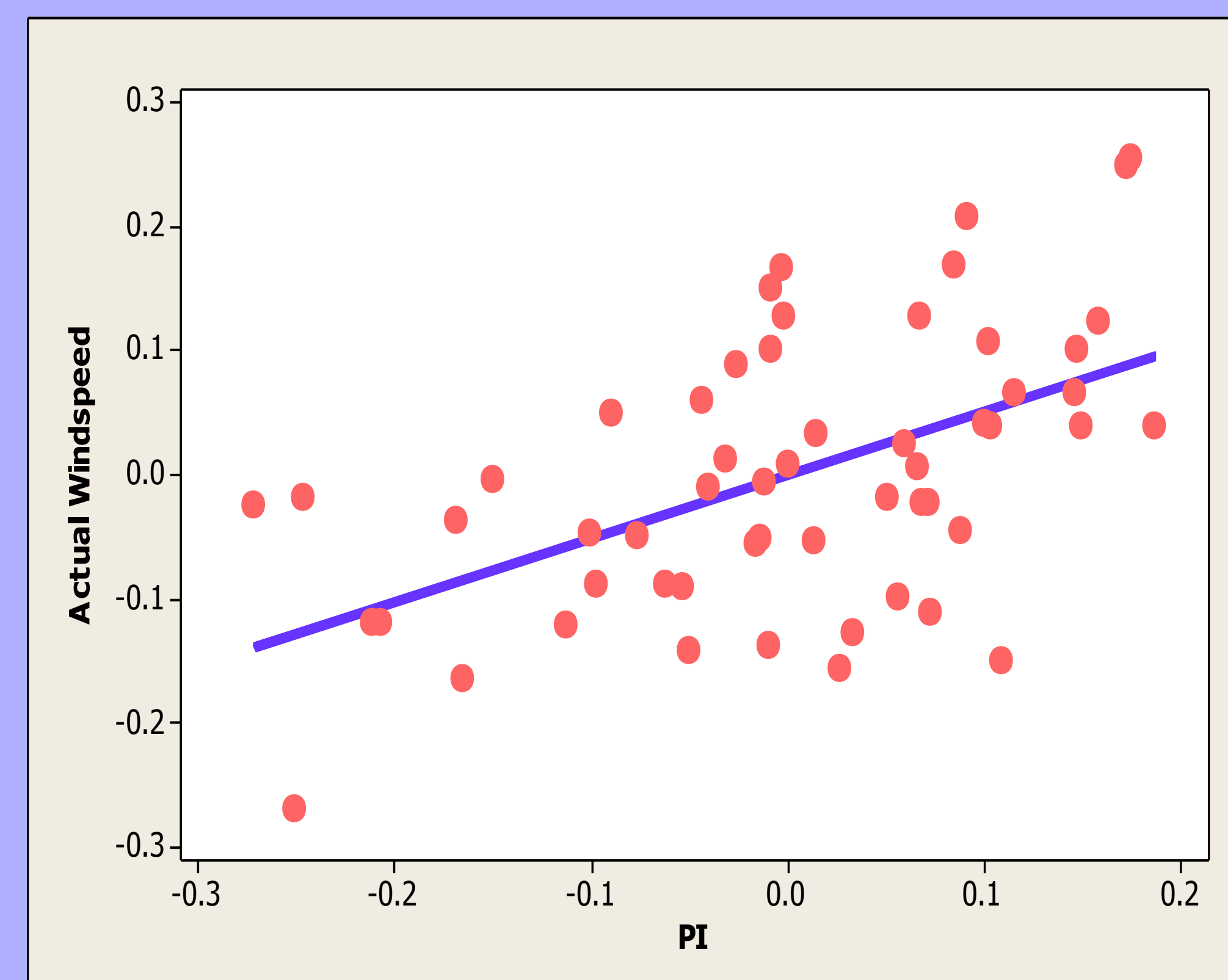


Figure 2a: North Atlantic

Figure 1: Time series of

- max. wind speeds
- - PI along tracks at points of max wind speed, for hurricanes
- PI averaged over main development region and peak season

Figure 2: Scatter plots of wind speed vs. PI

-using max.intensity, for storms reaching hurricane strength; time series have been normalized and detrended

-Atlantic: correlation=0.53
slope=0.51

-Pacific: correlation=0.43
slope=0.61

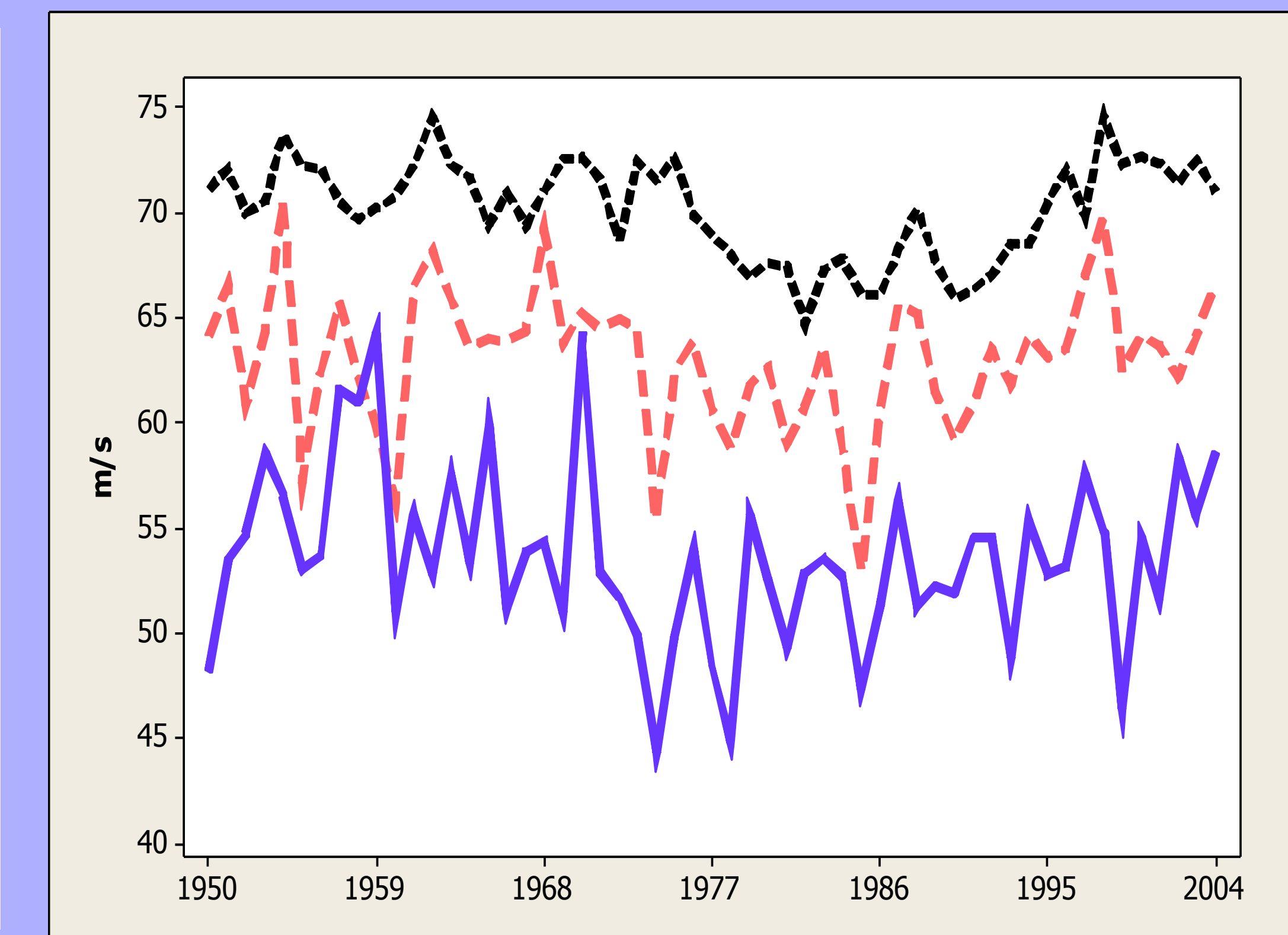


Figure 1b: Western North Pacific

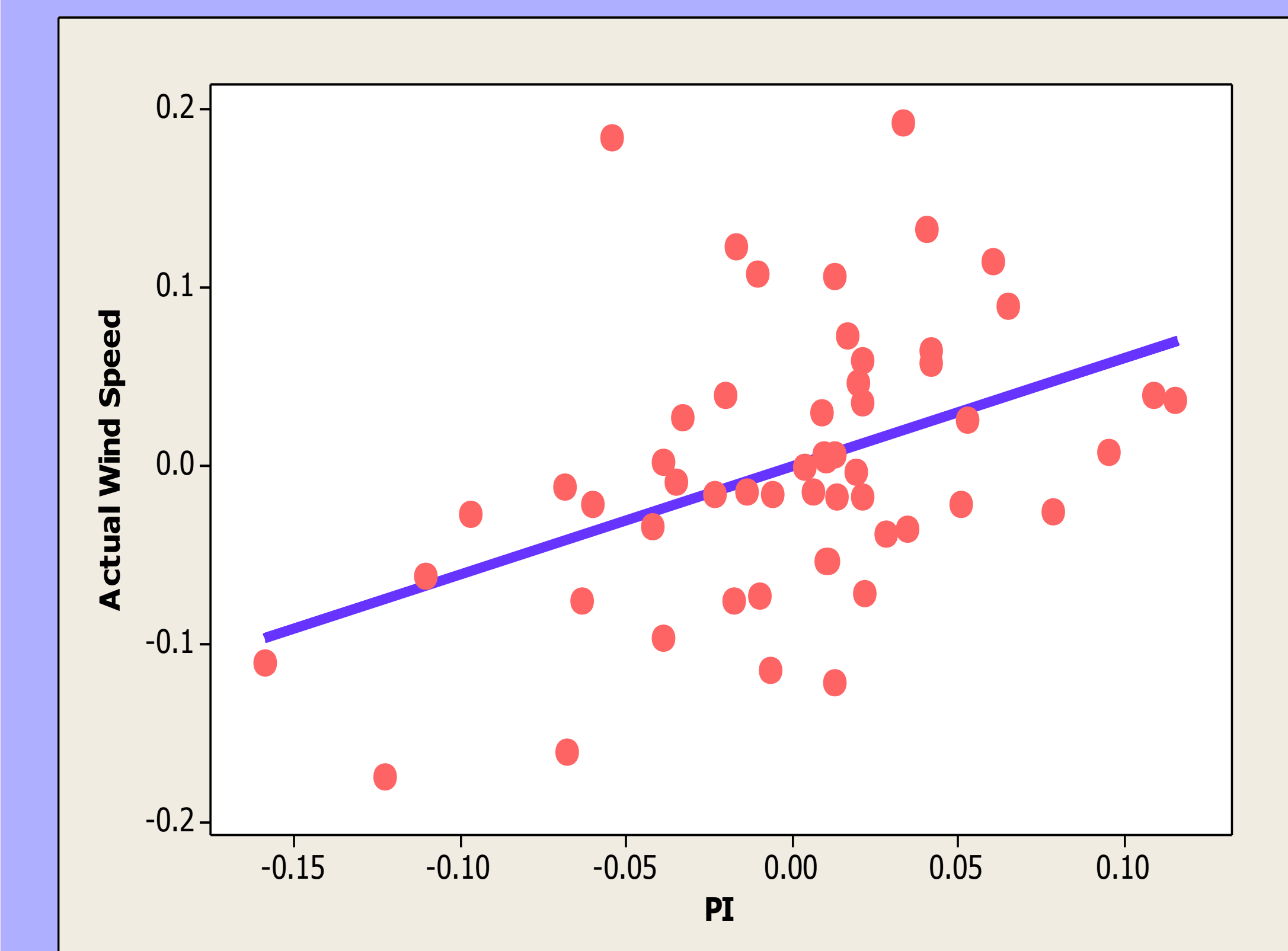


Figure 2b: Western North Pacific

- D I S C U S S I O N**
- Results show that observed interannual variations of maximum TC intensity are consistent with predictions of PI theory.
 - Modest fractions of variance in actual intensity are explained by PI variations
 - Much of the interannual variation in PI experienced by the storms comes from variation in TC tracks so that the storms in different years are likely to sample regions of high PI, rather than variations in PI at a fixed location.

References

Emanuel, K.A. (1995): Sensitivity of tropical cyclones to surface exchange coefficients and a revised steady-state model incorporating eye dynamics, J. Atmos. Sci., 52, 3969-3976
Emanuel, K.A.(2000): A statistical analysis of tropical cyclone intensity, Mon. Weather Rev., 128, 1139-1152

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