A Re-examination of the Relationship between Empirical Maximum Potential Intensity of Tropical Cyclone and SST

Kelvin Sai-cheong Ng, Man Hoi Lee, Yongqiang Zong
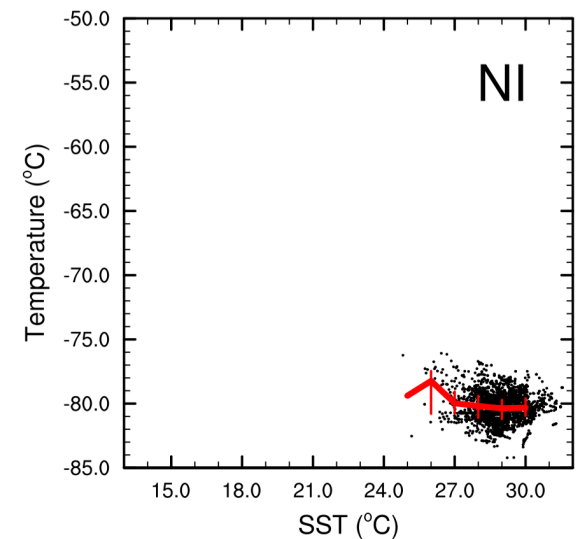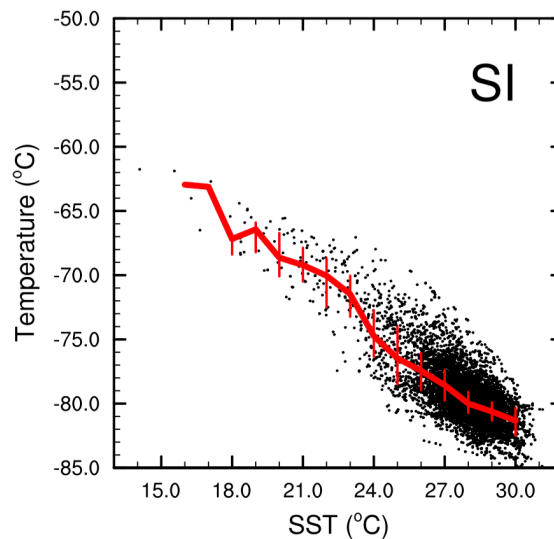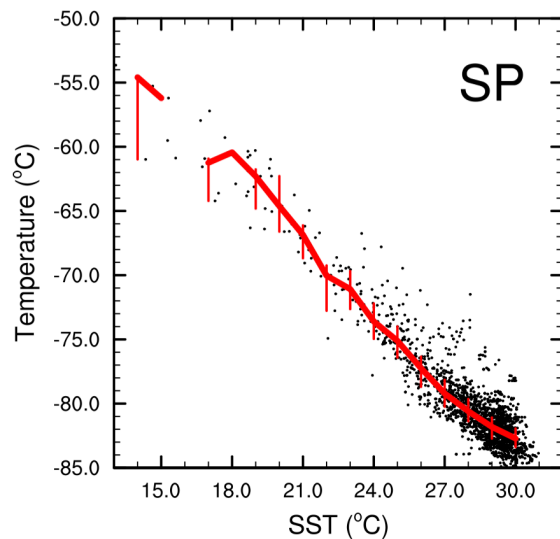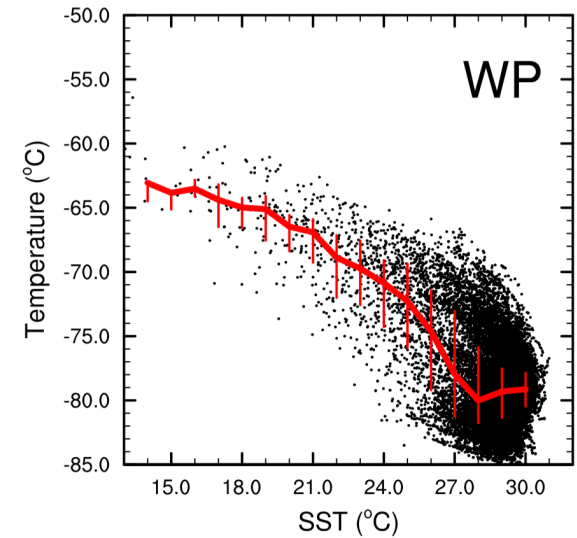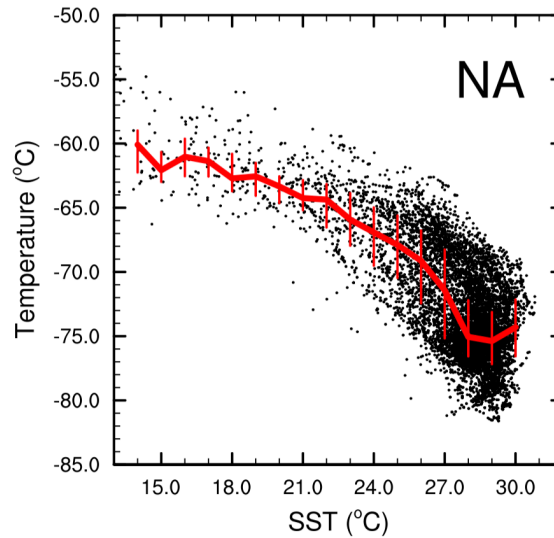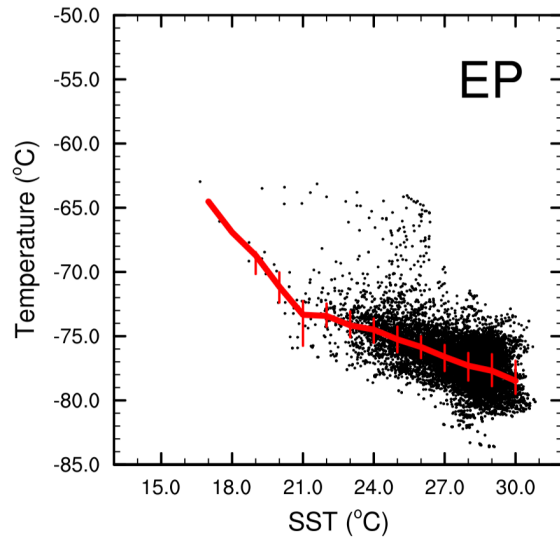The University of Hong Kong

Theoretical MPI
(e.g. Bister and Emanuel 1998)

$$V_{\max}^2 = \frac{C_k}{C_D} \frac{SST - T_0}{T_0} \left(h_0^* - h^* \right)$$

Thermodynamic Efficiency

Thermodynamic Disequilibrium

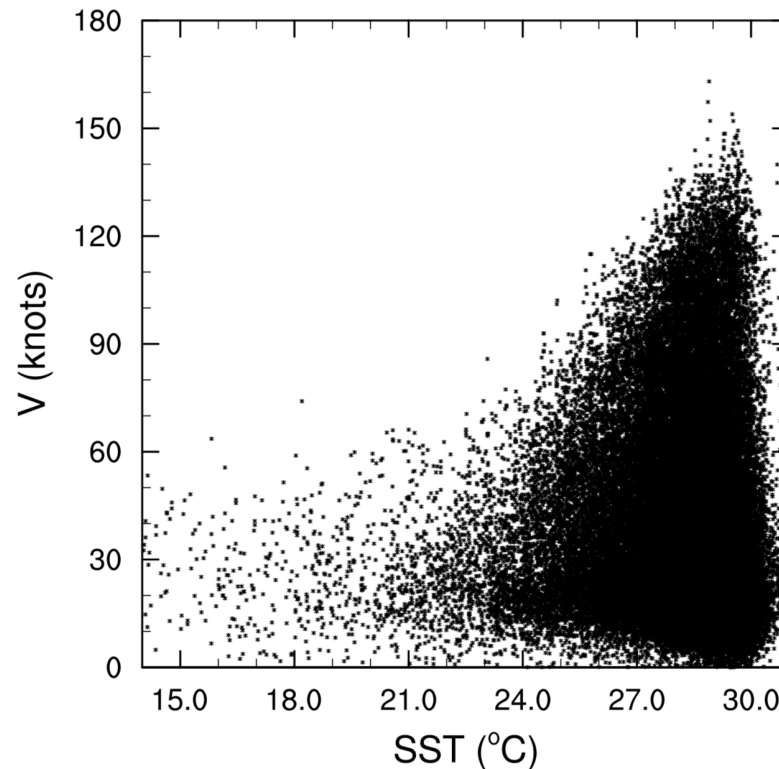# 100 hPa Temperature vs SST at TC locations

Empirical MPI
(e.g. DeMaria and Kaplan 1994)
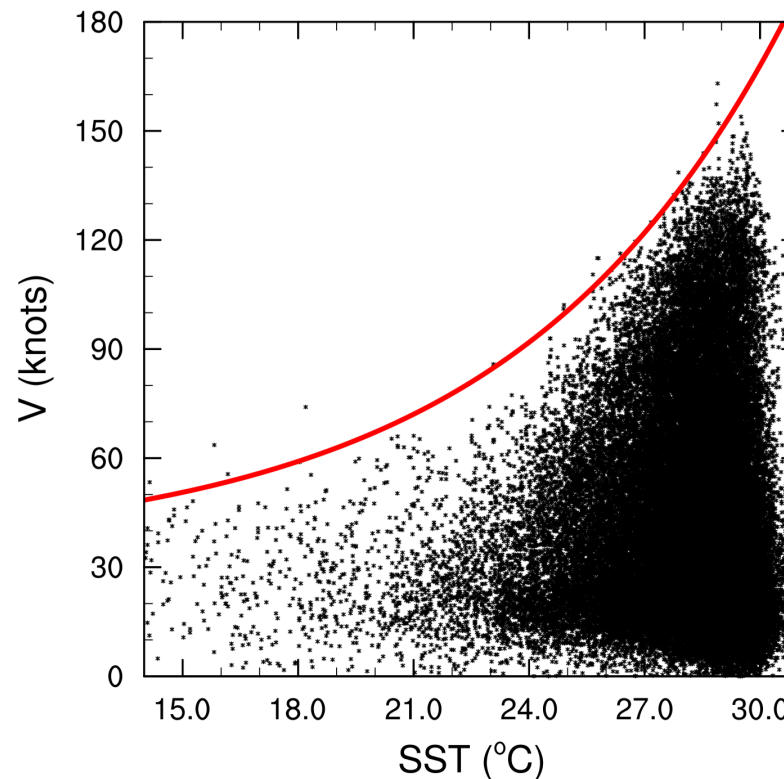
$$V_{\max} = A + B \exp\left[C\left(SST - 30\right)\right]$$

GLOBAL

Empirical MPI
(e.g. DeMaria and Kaplan 1994)

$$V_{\max} = A + B\exp\left[C\left(SST - 30\right)\right]$$

GLOBAL

Outline

1. Are the regional MPI-SST relations truly different?(e.g. DeMaria and Kaplan 1994, Whitney and Hobgood 1999, Zeng et al. 2007)

2. The problem with using maximum

Data

- TC positions and intensities from IBTrACS v03r05
- SST and temperature from monthly JRA-55
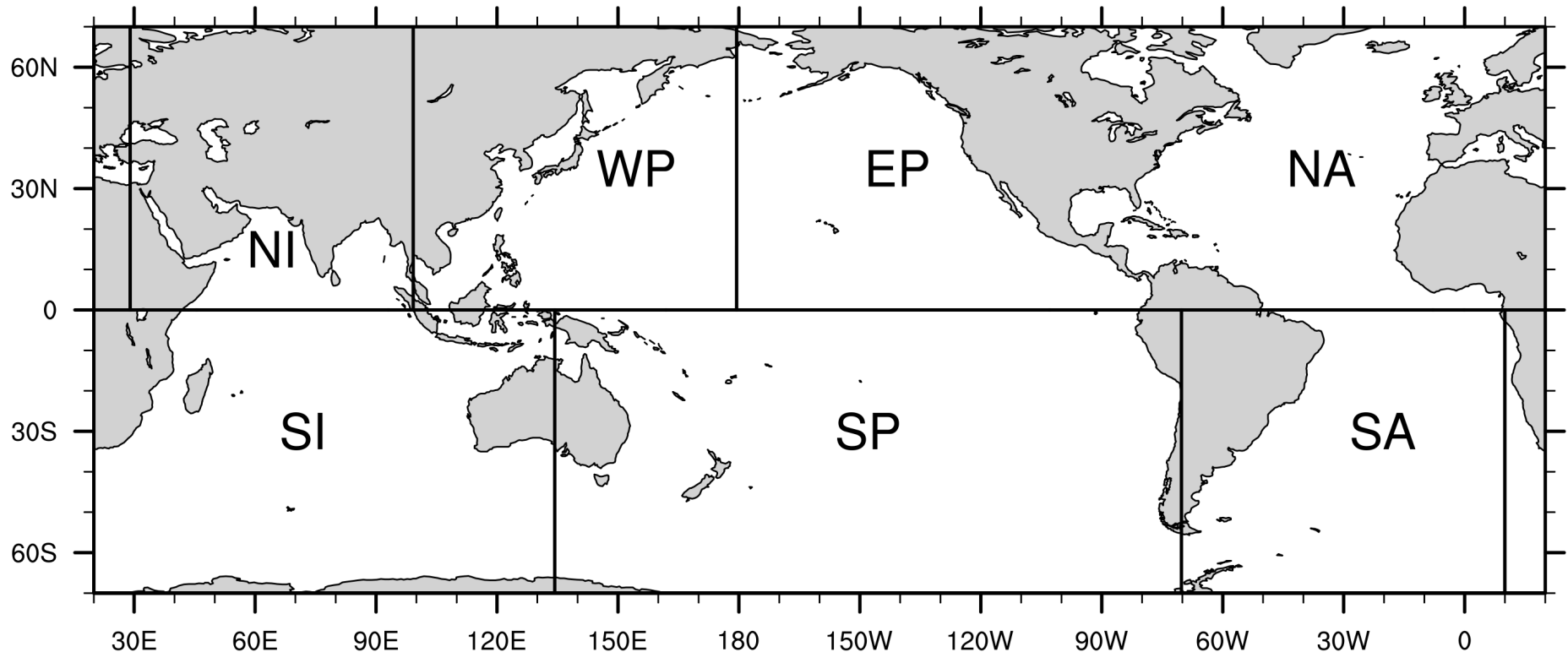
Scatter plots of IBTrACS wind and JRA-55 SST
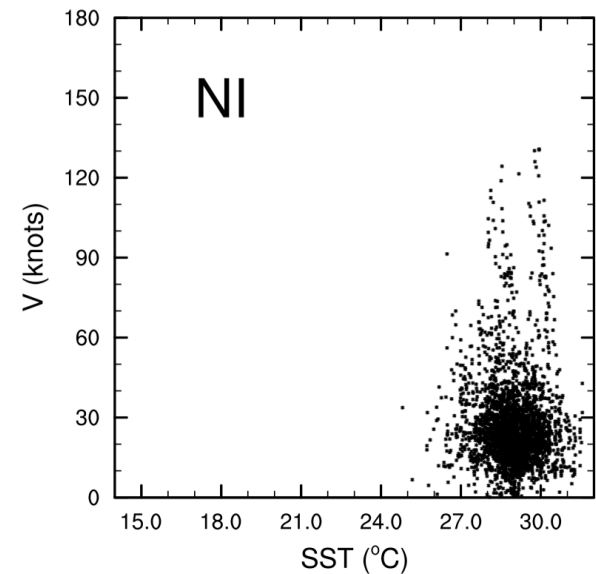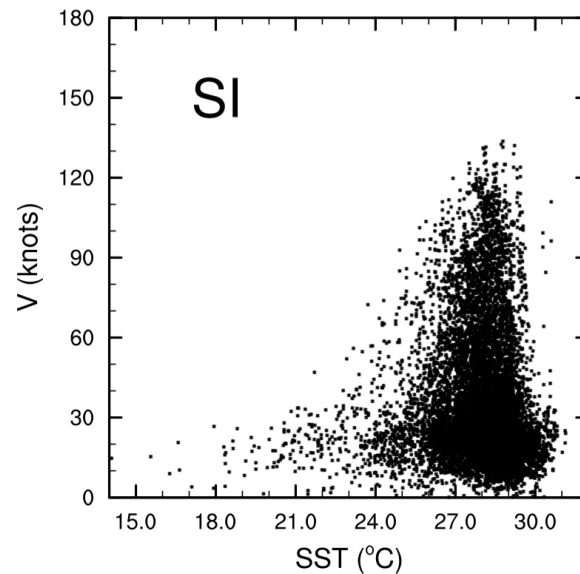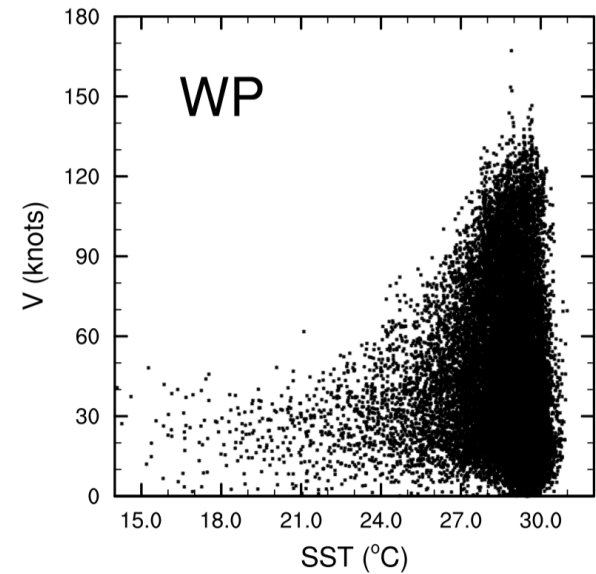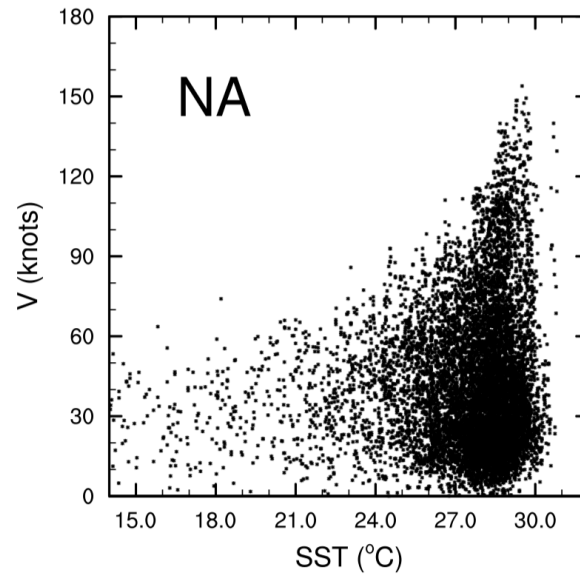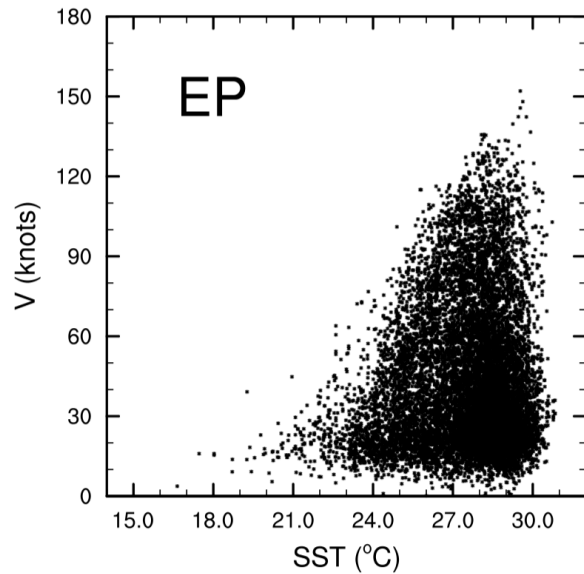
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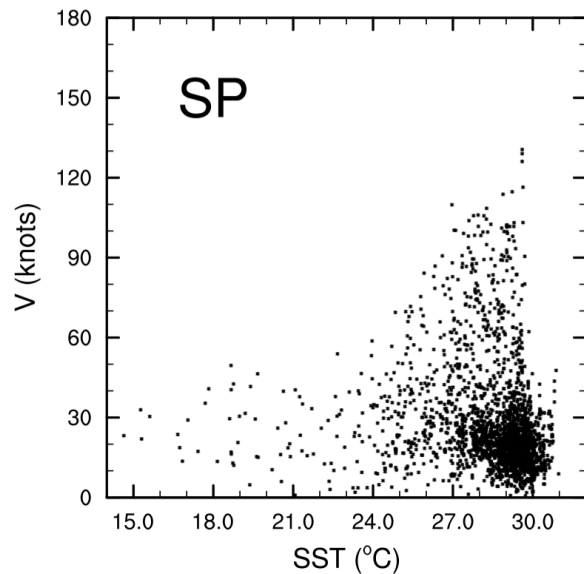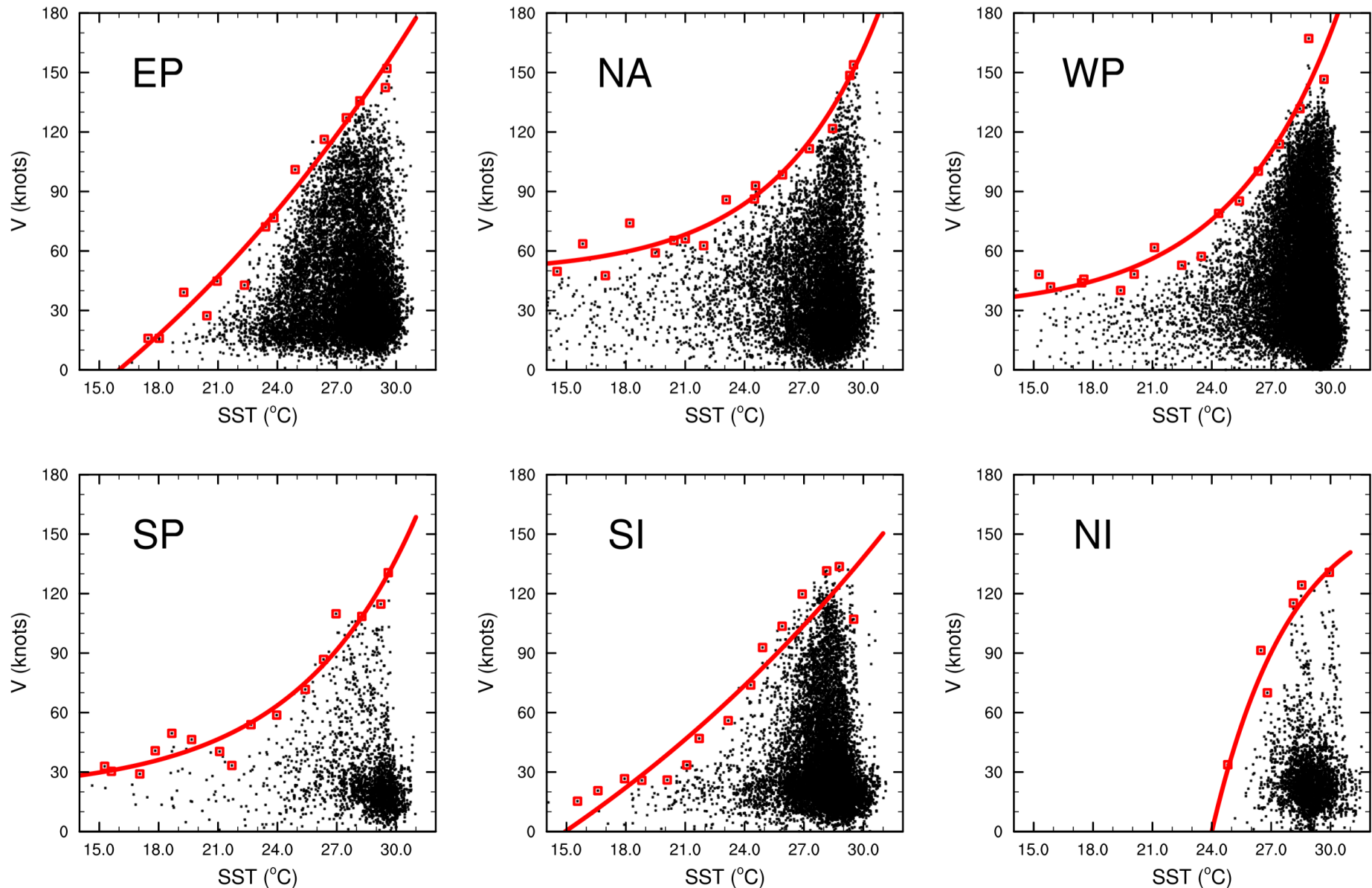
MPI-SST relations in different basins derived from ERA-I and JRA-55 SST
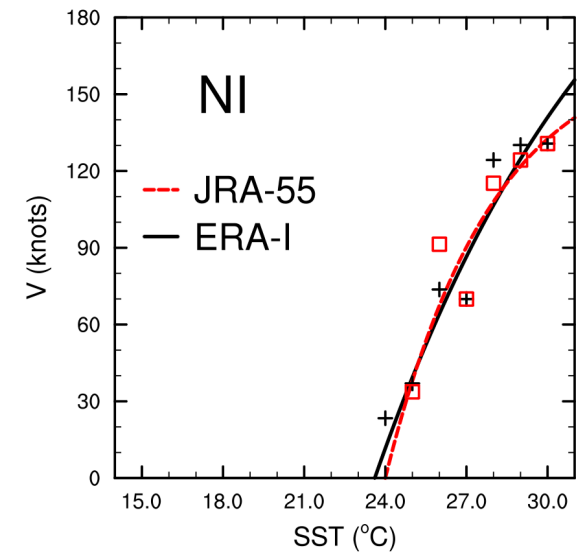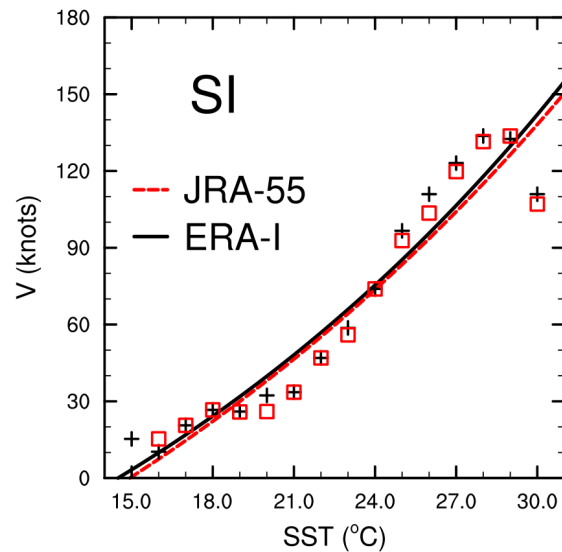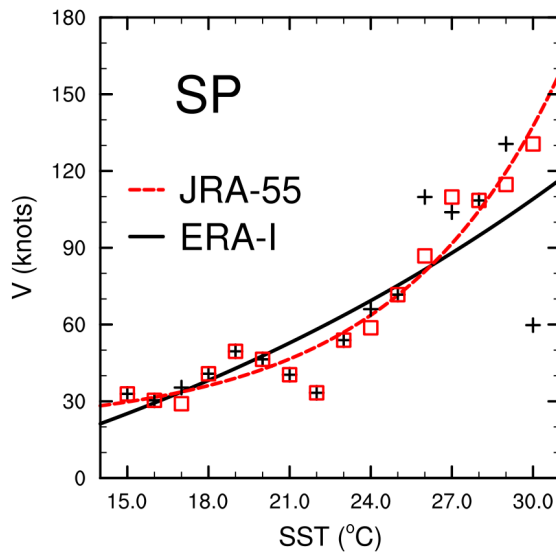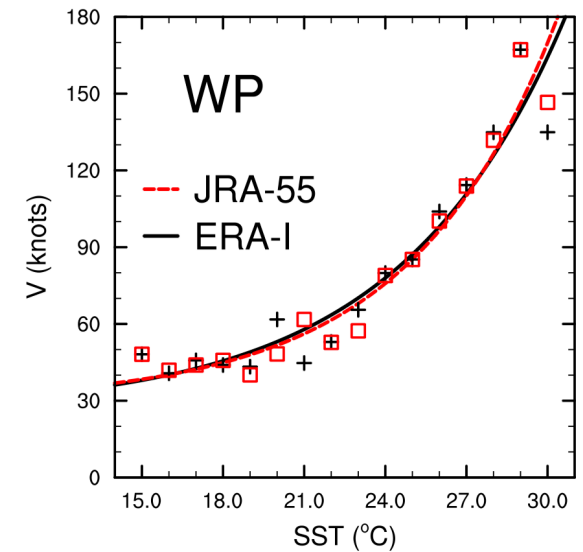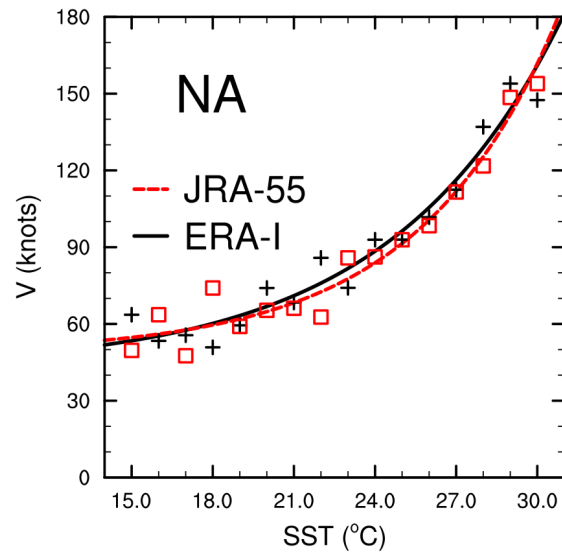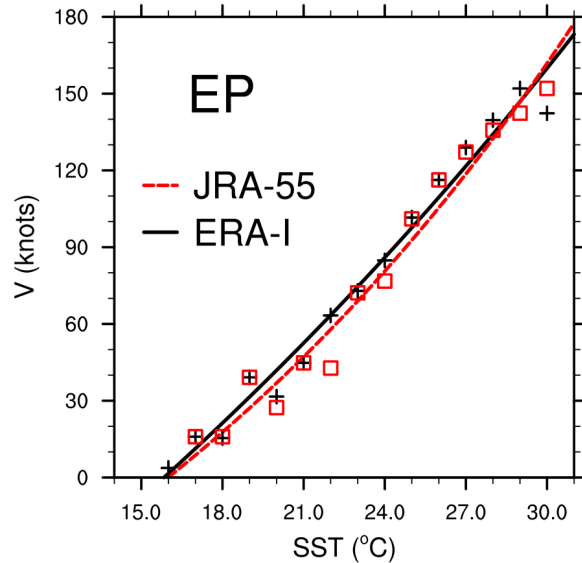
Fits of maximum for different regions
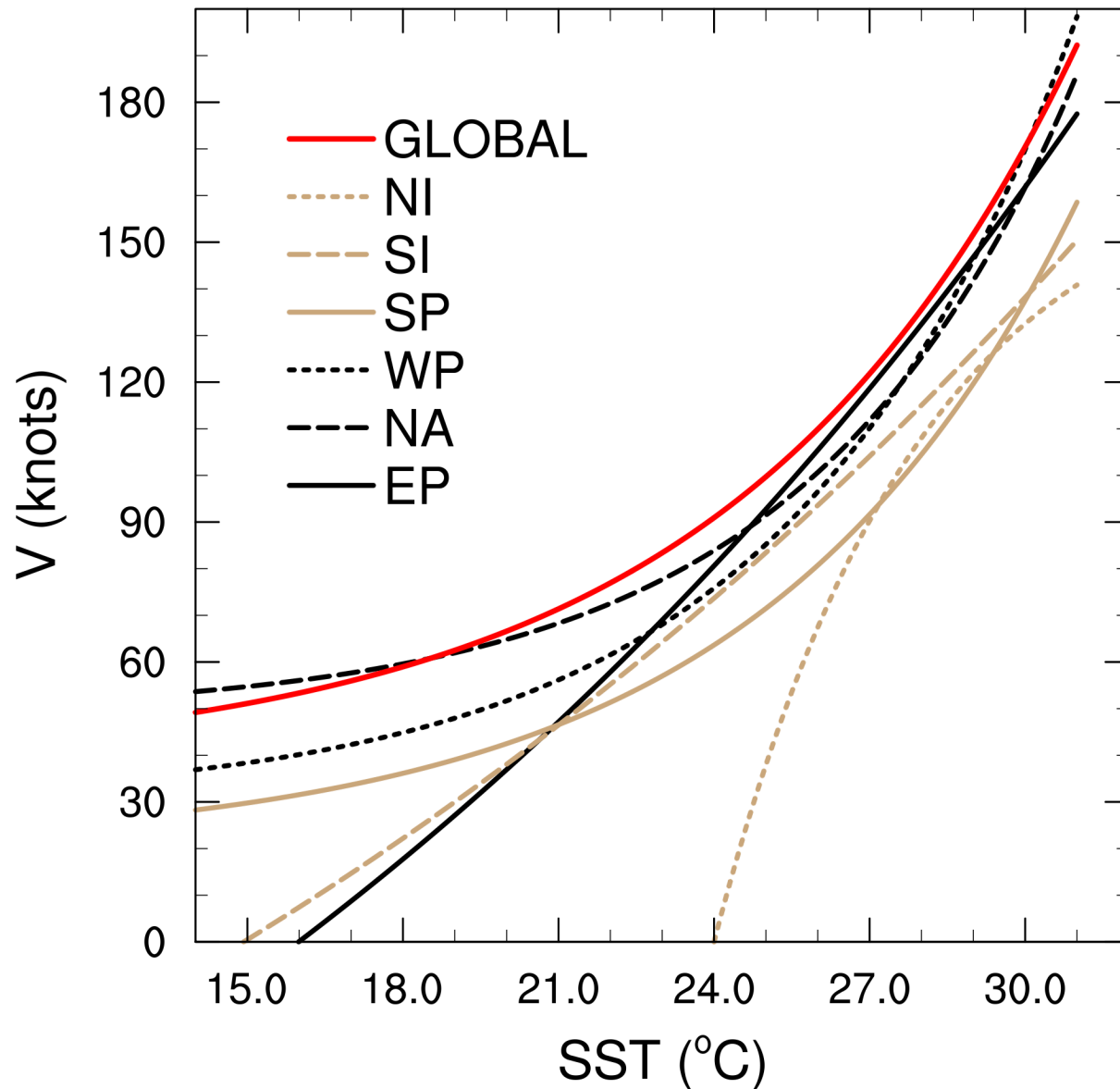
100 hPa Temperature vs SST for Max. Intensity
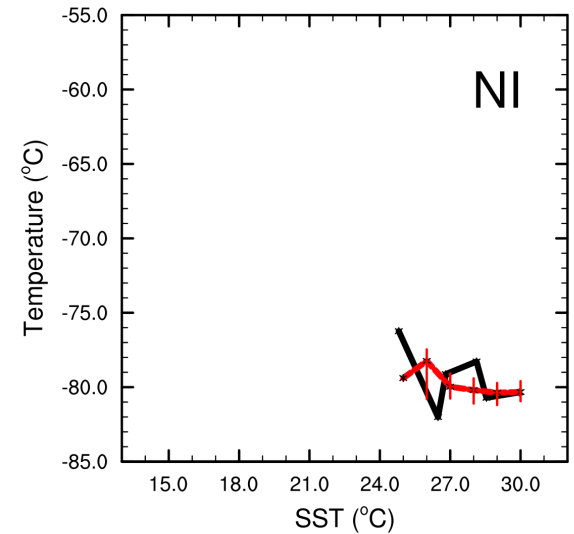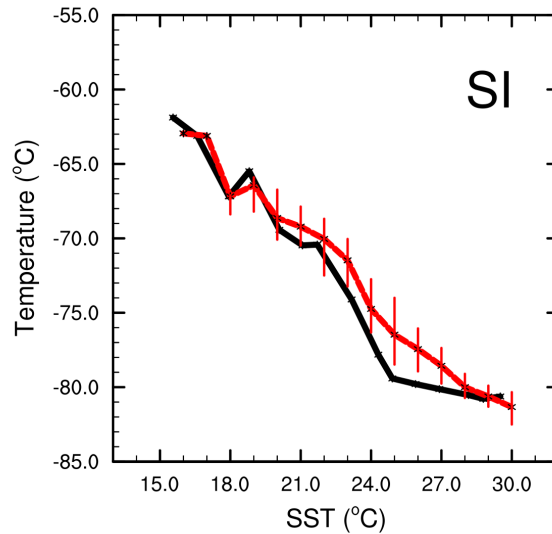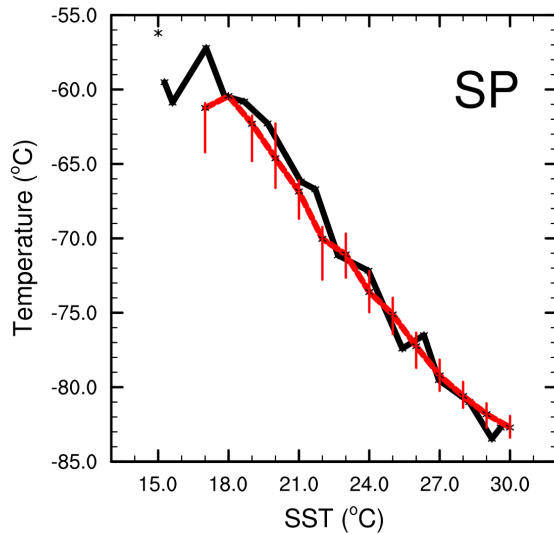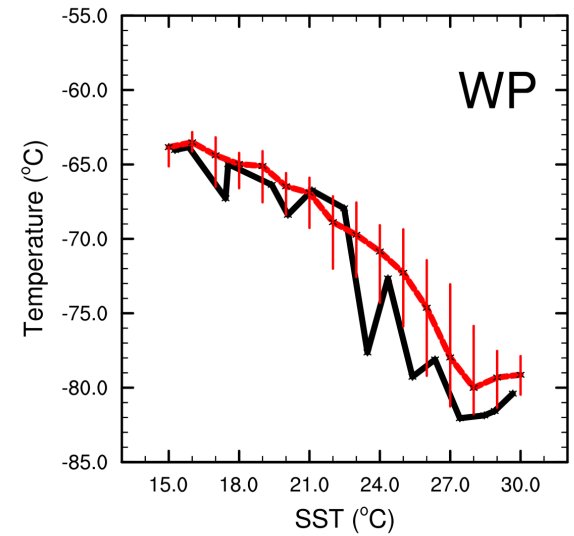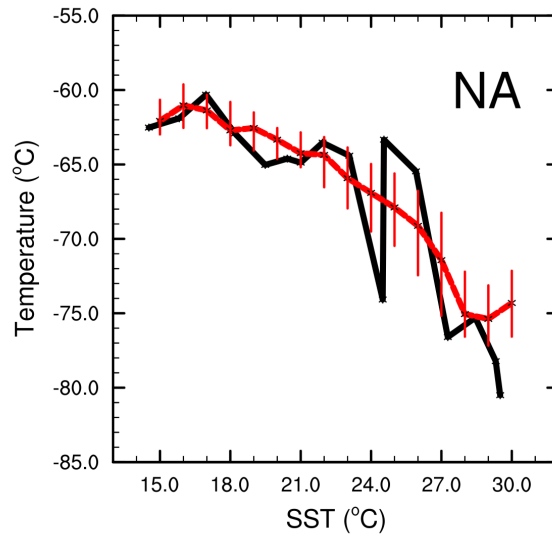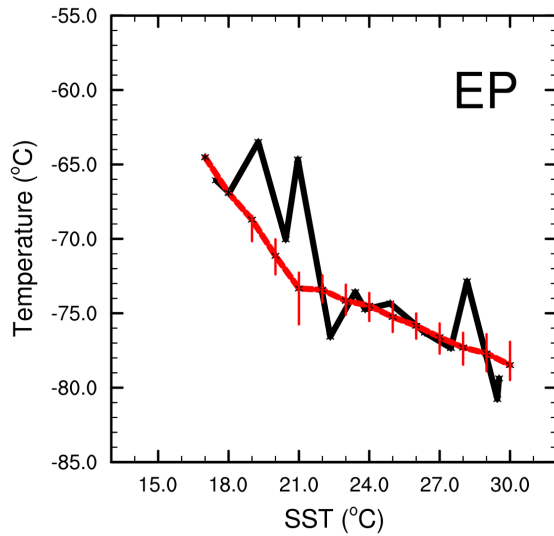
Problem with maximum

- Maximum is not a robust statistics. It might change if more observations are available.

- In particular, maximum is not a good quantity when we only have few data points.

- Does maximum really exist in the wind distribution in the SST bin?

Exploring the robustness of maximum

Step 1:   Pick SST bin with the most data.

Step 2:   Randomly pick i) 10, ii) 30, iii) 100 data points from the SST bin, calculate and store the statistical measures
(e.g. maximum, n^{th} percentile)

Step 3:   Repeat *Step 2* 10,000 times and calculate the mean of the statistical measures.

Results of robustness study

Sample size	Statistical measure	True values	Means of measures	Standard Deviation	Percentage error
10	50th percentile	39.18	37.42	11.48	4.49
30			38.56	7.00	1.59
100			39.01	3.92	0.45
10	95th percentile	105.77	99.03	18.79	6.38
30			103.17	11.37	2.46
100			103.76	6.33	1.90
10	99th percentile	121.73	98.63	18.77	18.98
30			114.33	11.53	6.07
100			117.28	6.52	3.65
10	Maximum	167.17	98.91	18.57	40.84
30			114.17	11.62	31.71
100			124.41	8.54	25.58

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Wind speed distribution in selected SST bins
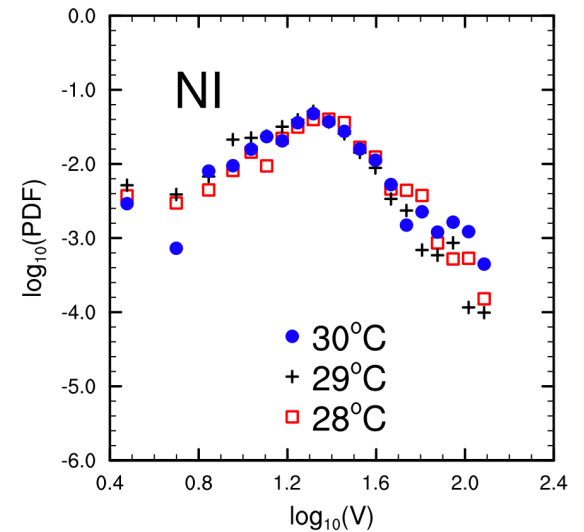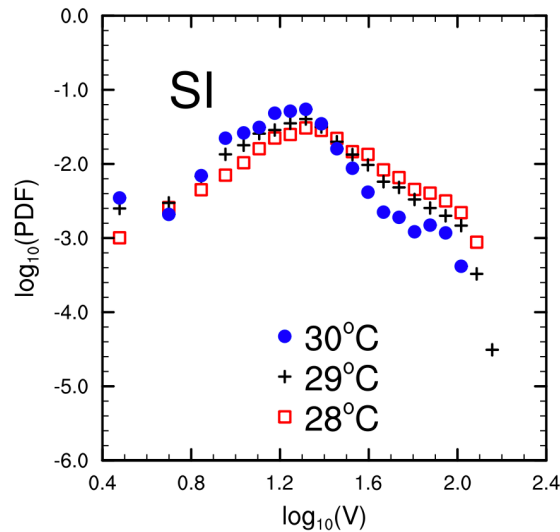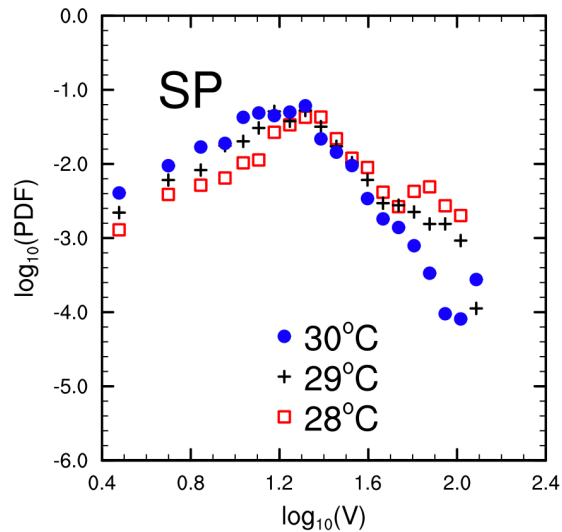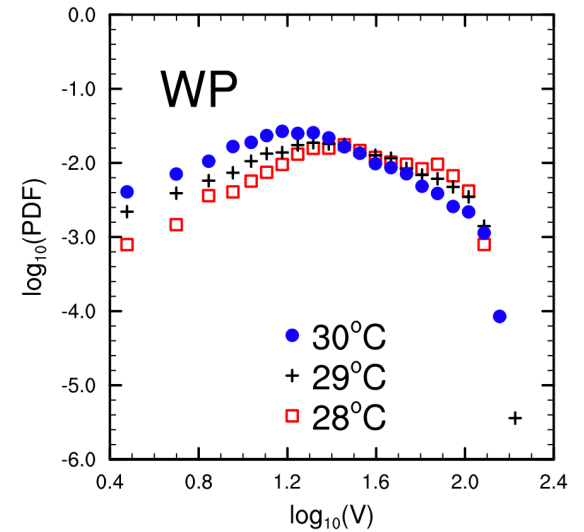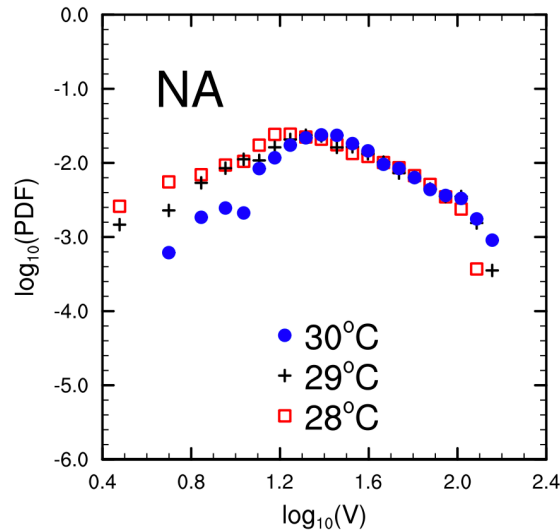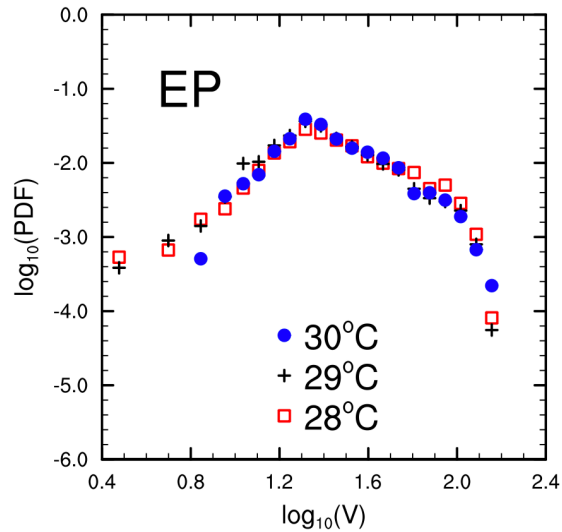
Comparison of fits of 99th percentile and fits of max for different regions

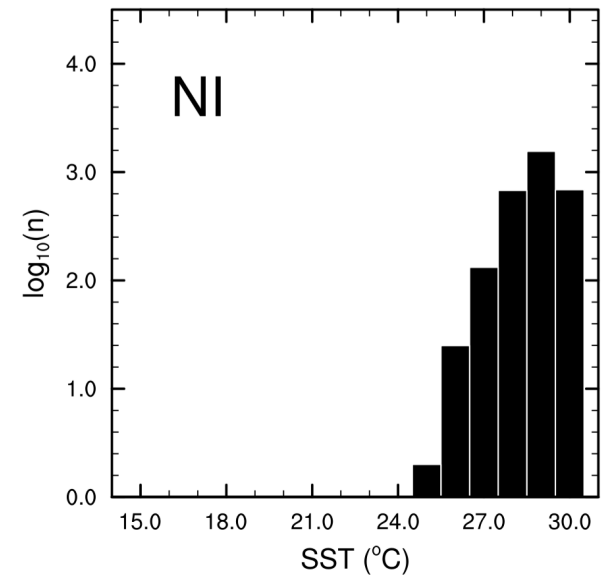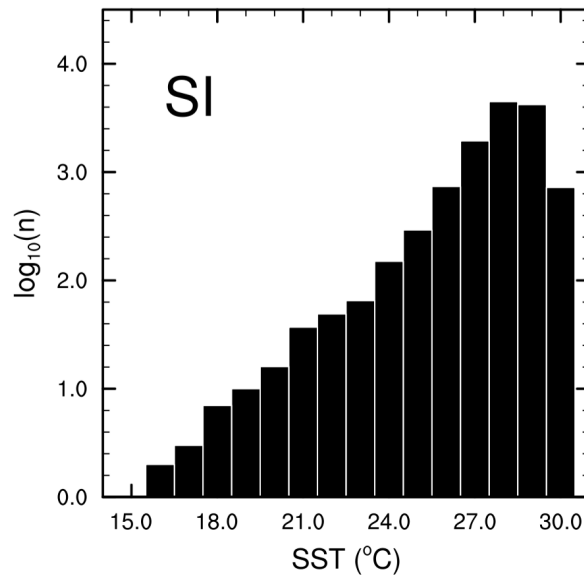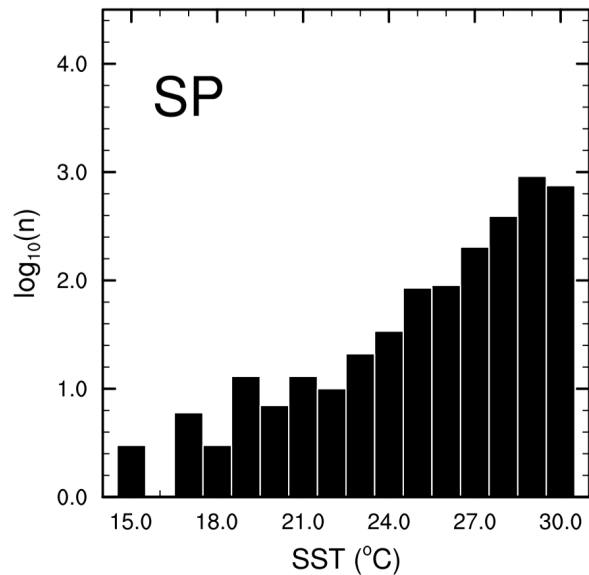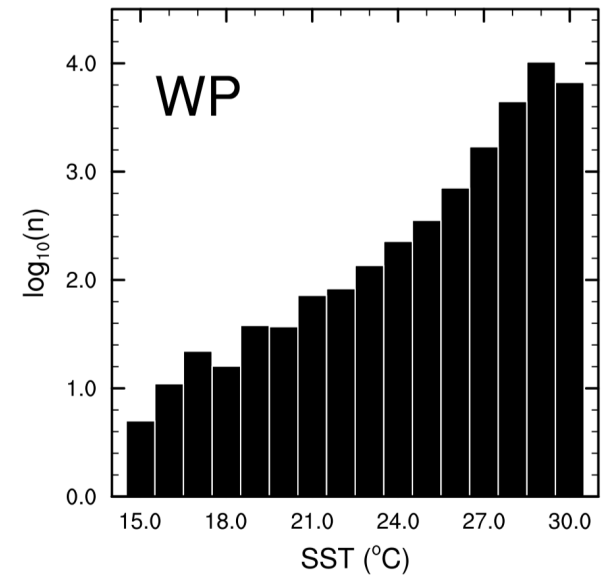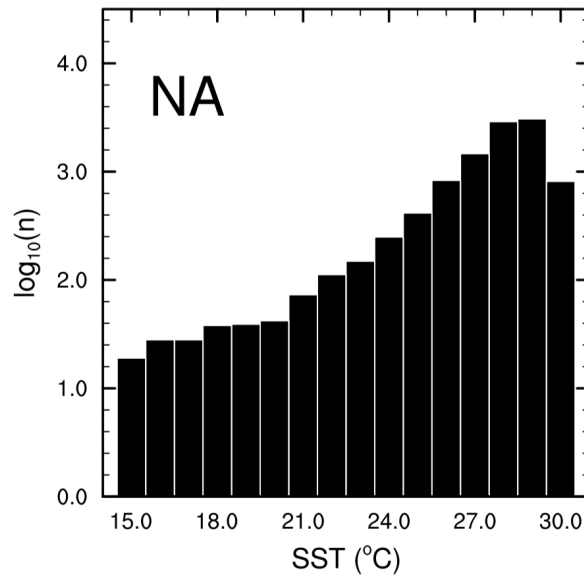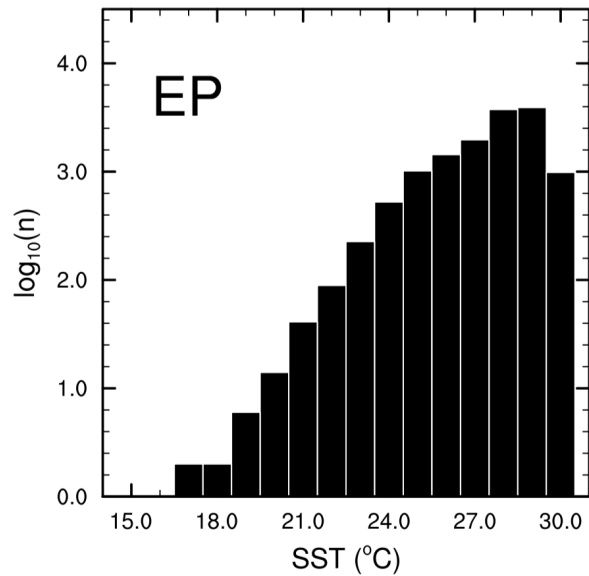

Fits of 99th percentile
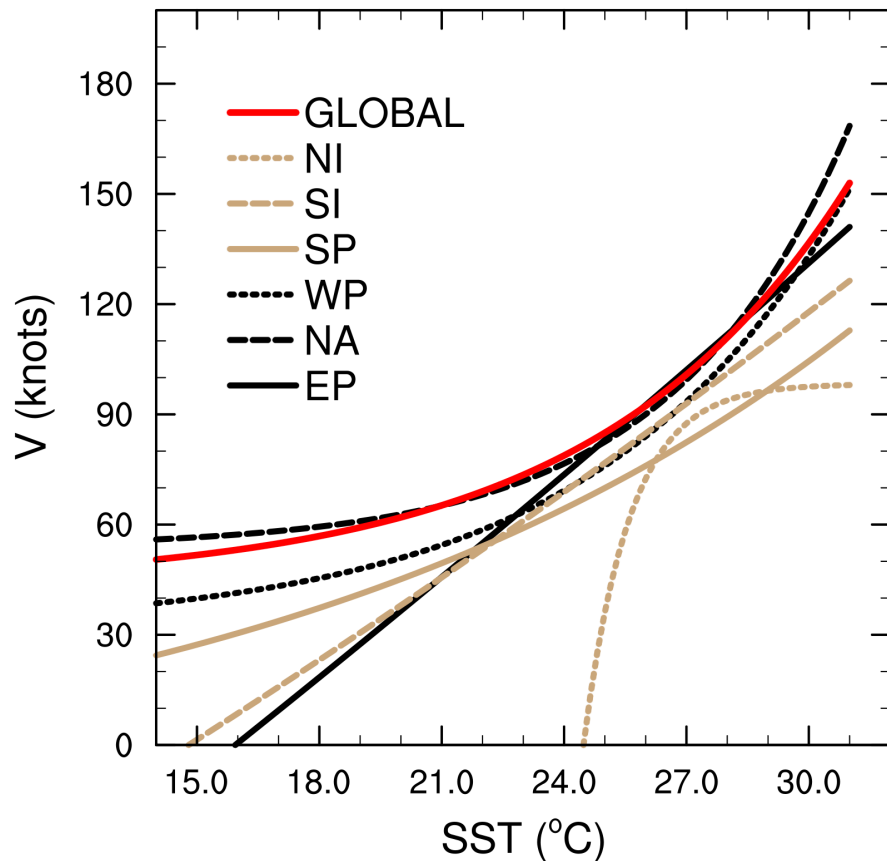
Fits of maximum
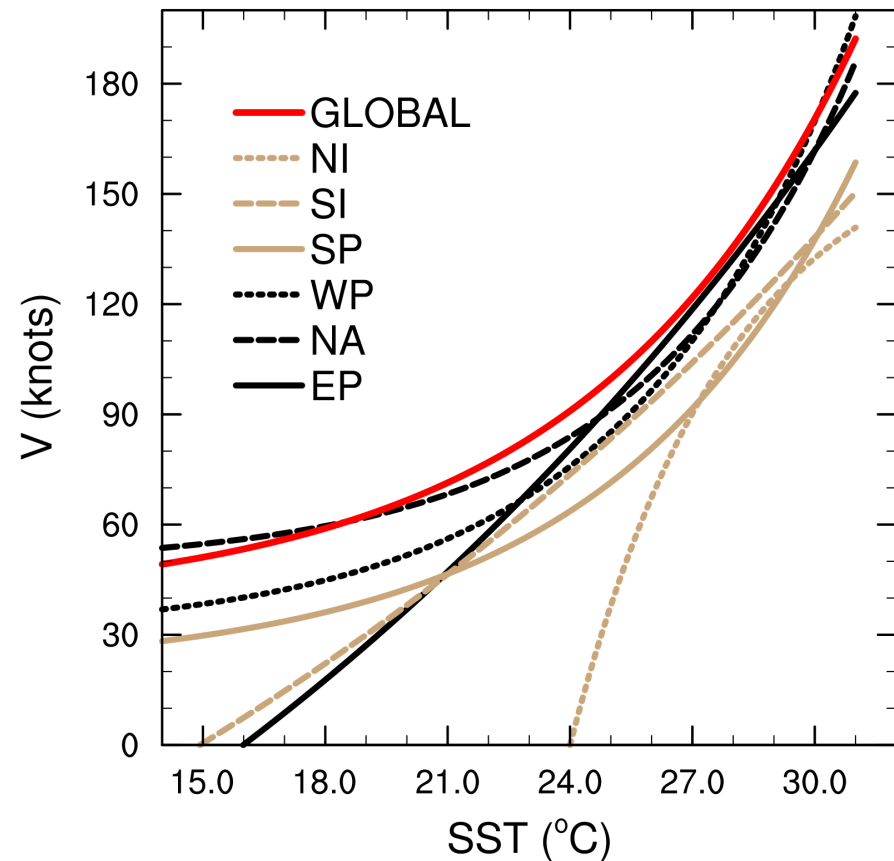
Summary

1. MPI-SST relation in different regions are truly different.
2. Outflow temperature does not seem to be responsible for the differences in the regional MPI-SST relations.
3. Sample maximum is <u>not</u> a good quantity to use because it is not robust. In the case of the lack of data, percentage error of the estimating maximum is <u>more than 40</u>.
4. 99th percentile should be used because it is more robust and it only has 1 in 100 chance of underestimating the wind speed.

Supplementary Slides

Number of observations in SST bins

100 hPa Temperature vs SST at TC locations