Frequency and Intensity of Tropical Cyclones in Southeastern China Seas

Camilla Liu

EAS 4480

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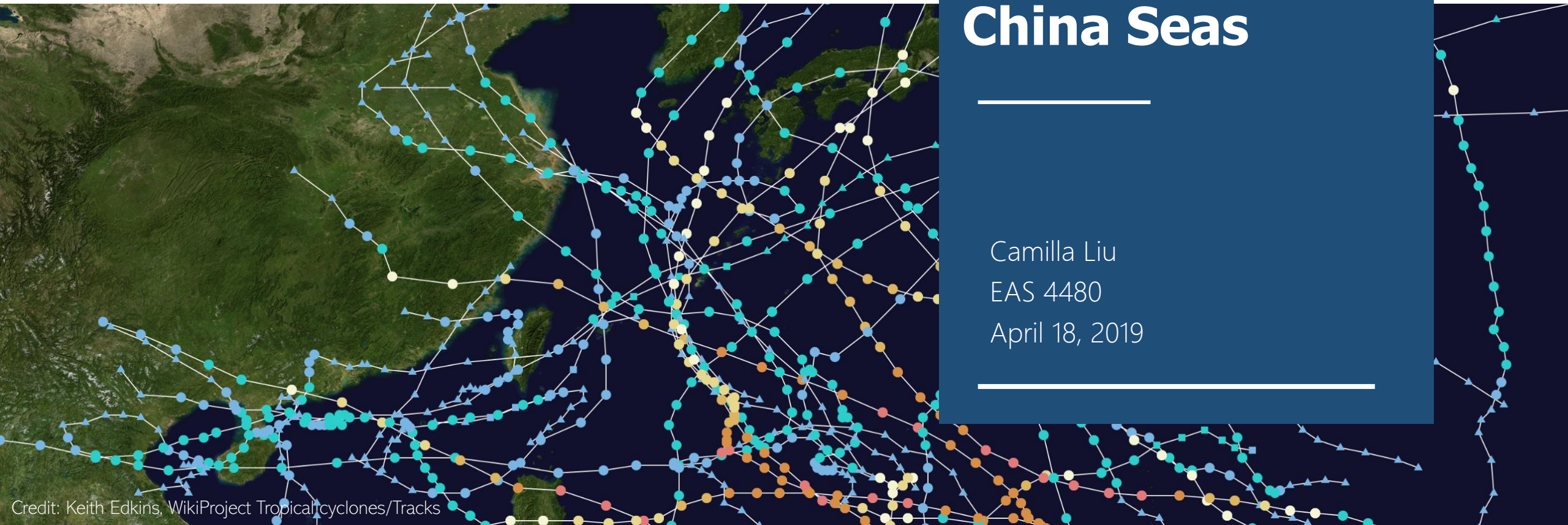
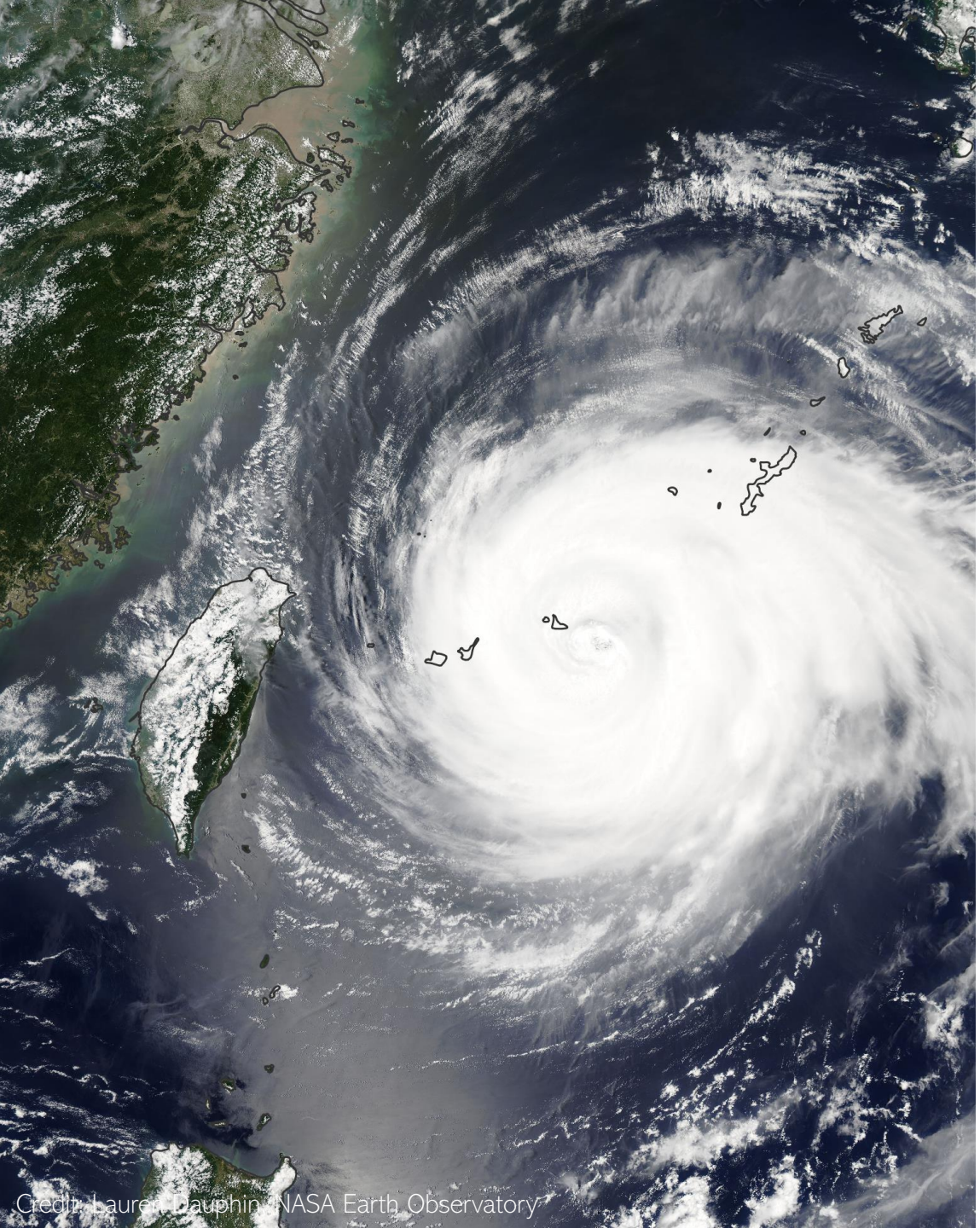


Credit: Keith Edkins, WikiProject Tropical cyclones/Tracks



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Background information

Tropical Cyclone

- Typhoon: tropical cyclones that form over the western North Pacific Ocean.
- Formation
  - Warm ocean water (≥26.5 °C/80 °F)
  - Upper-level low pressure (tropical upper tropospheric troughs)
- Damage: horizontal wind, tornadoes, storm surge, rainfall, etc.

Typhoon in China

- Season: July to September, peak in August
- Region: Islands of Hong Kong and Taiwan, Guangdong and Fujian Provinces on the mainland.
- Scale
  - Tropical depression-severe tropical storm: 6-11 (39-117 km/h)
  - Typhoon: 12-15 (117-183 km/h)
  - Super typhoon: 16-17+ (≥184 km/h)

Climatic variation

- Increase in SST could increase maximum TC intensity.
- Increase in global temperature could decrease TC frequency due to change in upper level wind.
- El Niño and La Niña impact vertical wind shear and SST.

Super Typhoon Mangkhut

- Category 5-equivalent super typhoon occurred in mid-September, 2018
- The third-strongest tropical cyclone worldwide in 2018 and the strongest typhoon to affect Hong Kong since Ellen in 1983.
- Caused 6 death and a total damage of $1.99 billion in China and broke several windows at my parents' apartment.

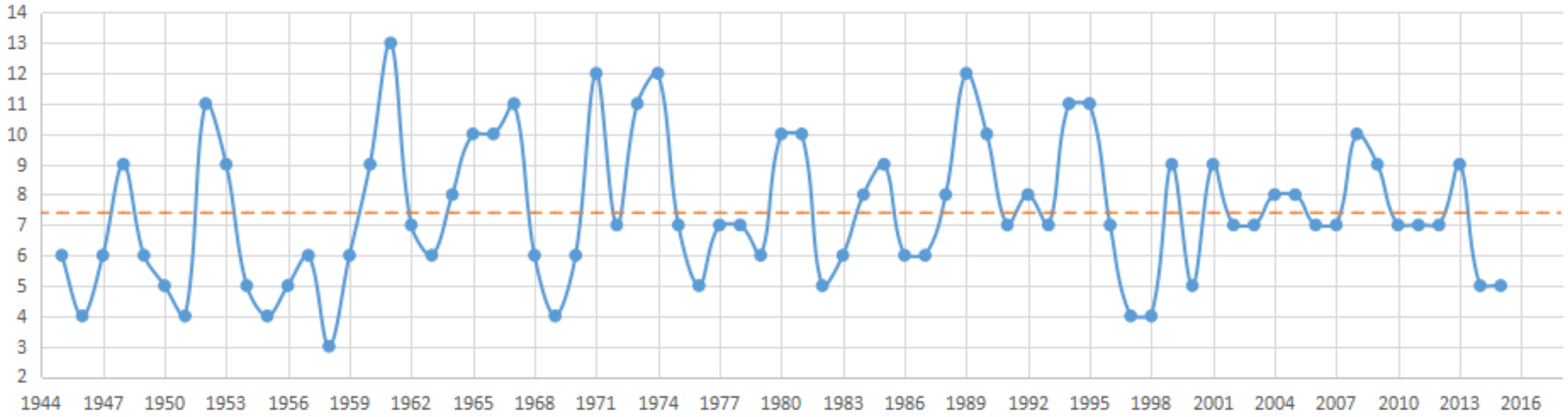
Data set

STWC

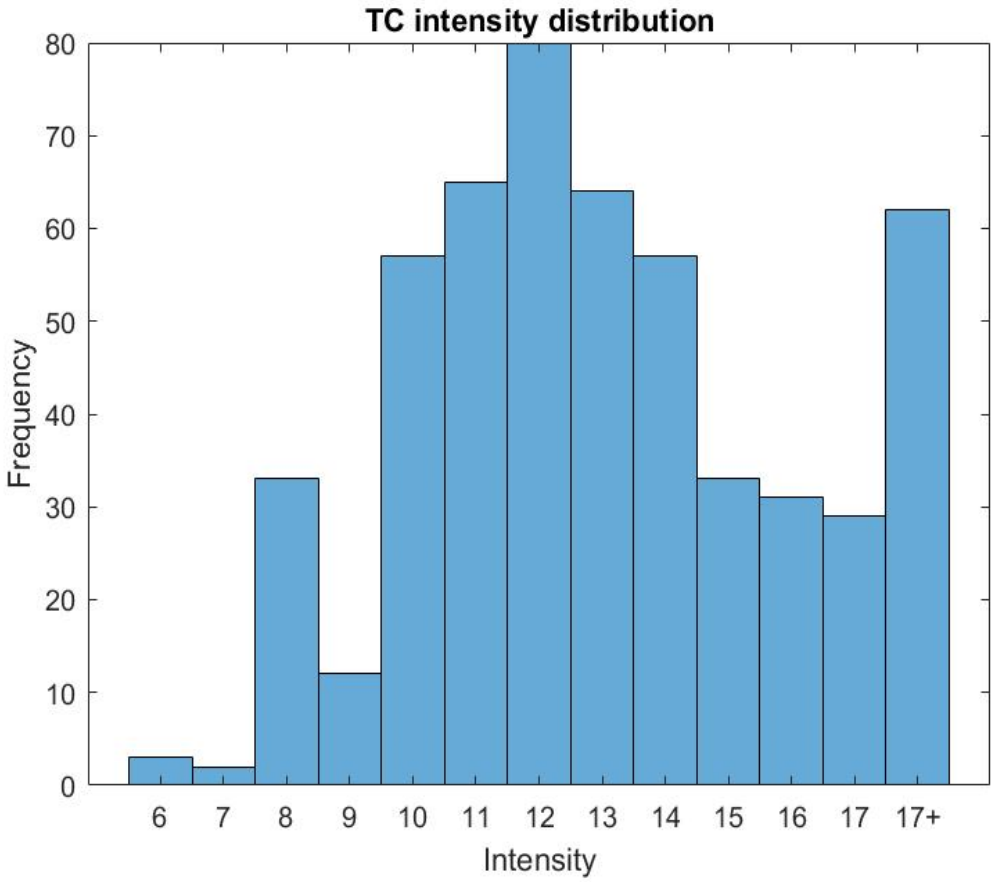
- Recorded 528 TCs that made landfall in China from 1945-2015
- Information on landfall location & time, peak & landfall intensity (based on revised Beaufort scale)

HadISST1

- Hadley Centre SST data set
- Time: July to October, 1945-2015
- Location: 17-30N, 107-127E
- Yearly anomaly: value - mean



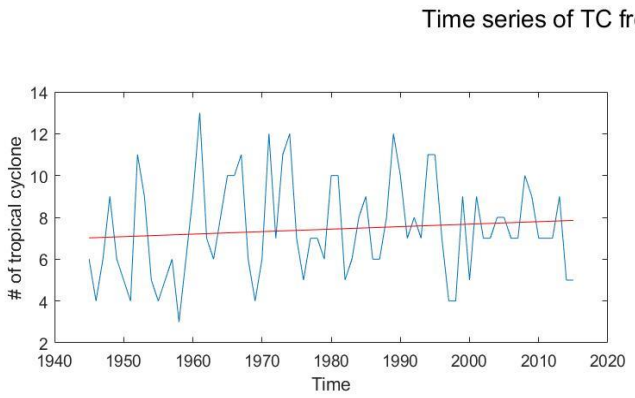
Credit: STWC

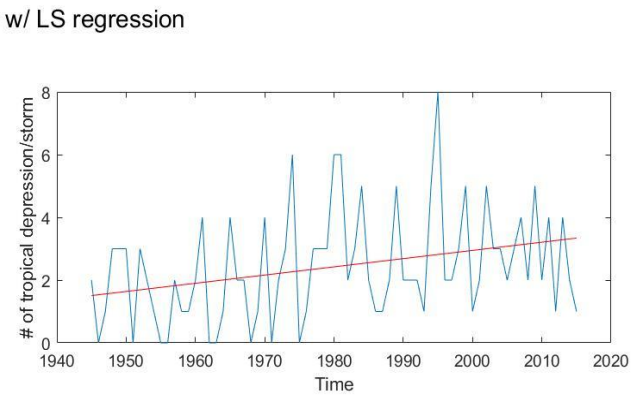


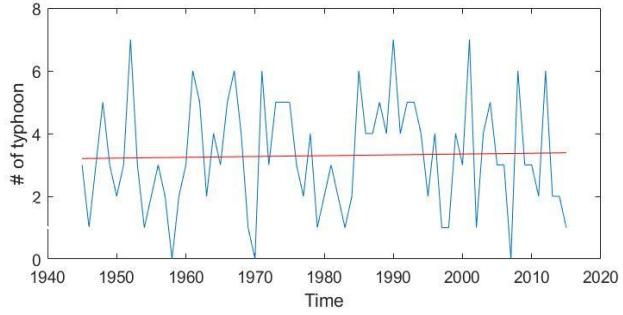
Histogram

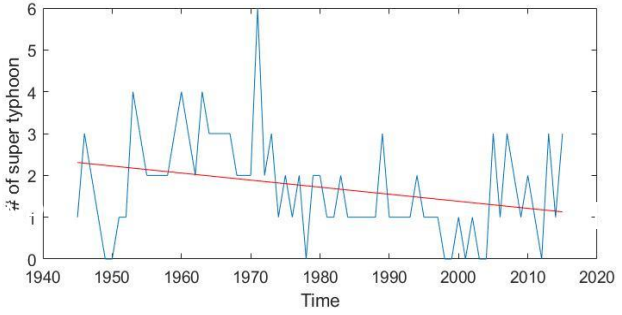
- Overall, Scale 12 typhoon (Category 1 hurricane) is the most frequent and tropical depression (Scale 6-7) is the least frequent.
- Within the super typhoon group, the most powerful Scale 17+ typhoon (Category 5 hurricane) dominates.
- Severe tropical storm (Scale 10-11), typhoon (Scale 12-13) and severe typhoon (Scale 14-15) form a symmetrical distribution.

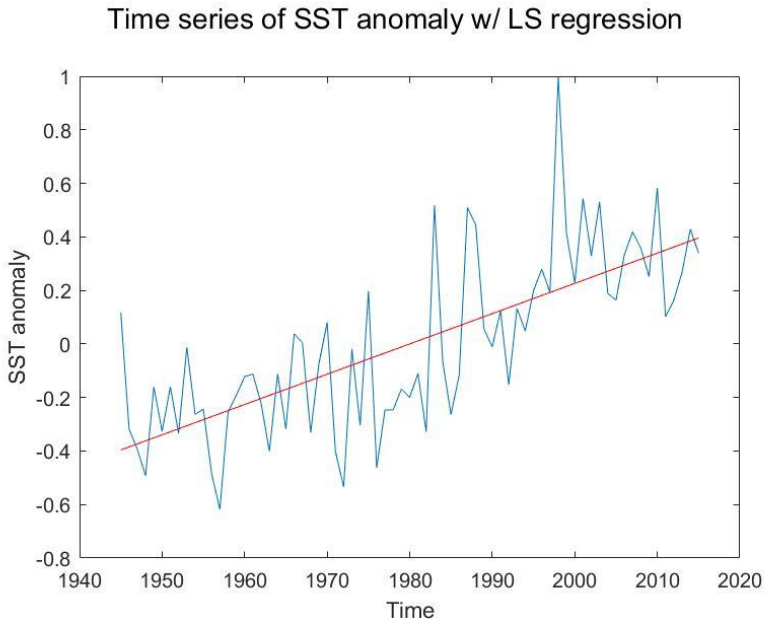
Time-series plot







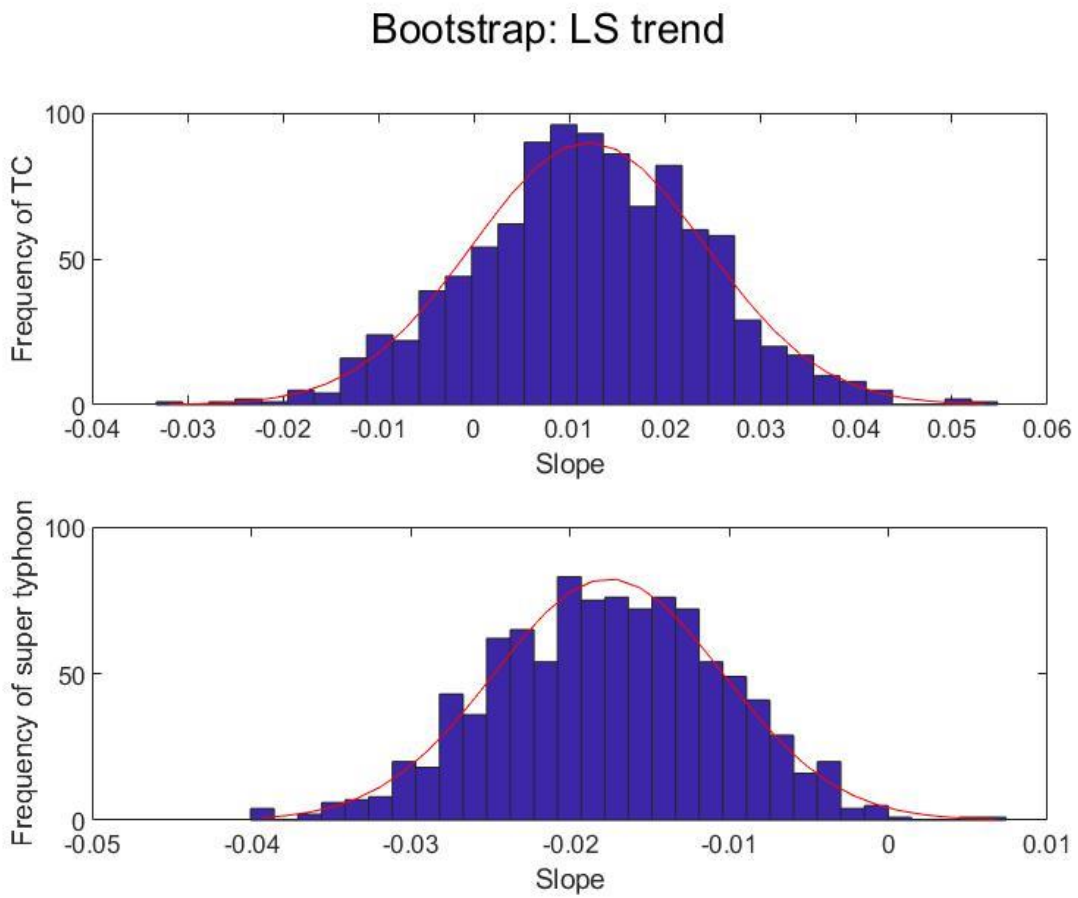




Data analysis

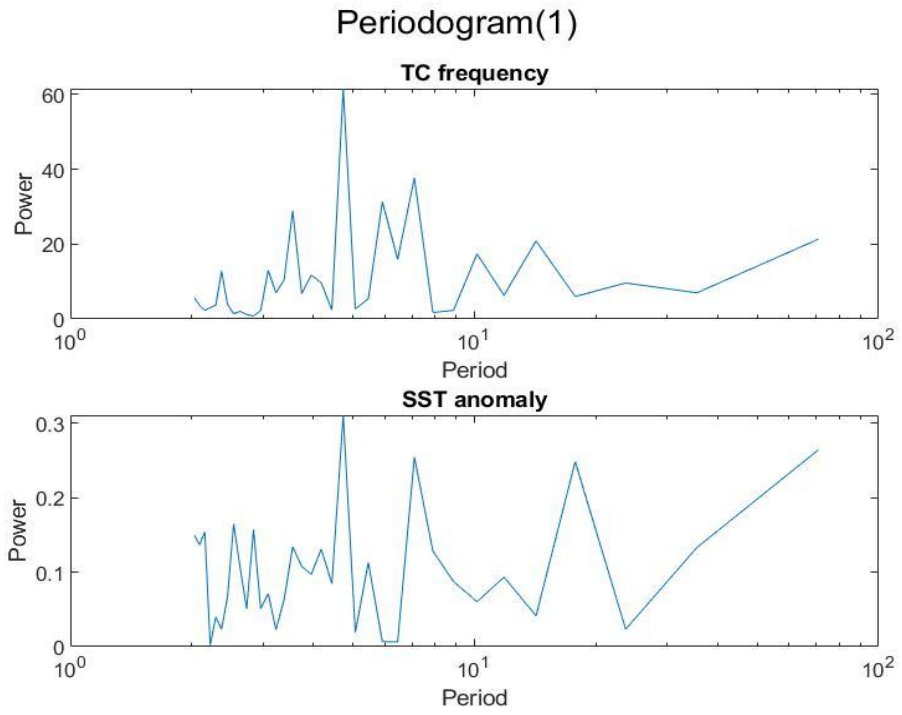
- TC frequency slope = 0.0119; TD/TS frequency slope = 0.0262; TP frequency slope = 0.0026; ST frequency slope = -0.0169.
- SST anomaly slope = 0.0113.

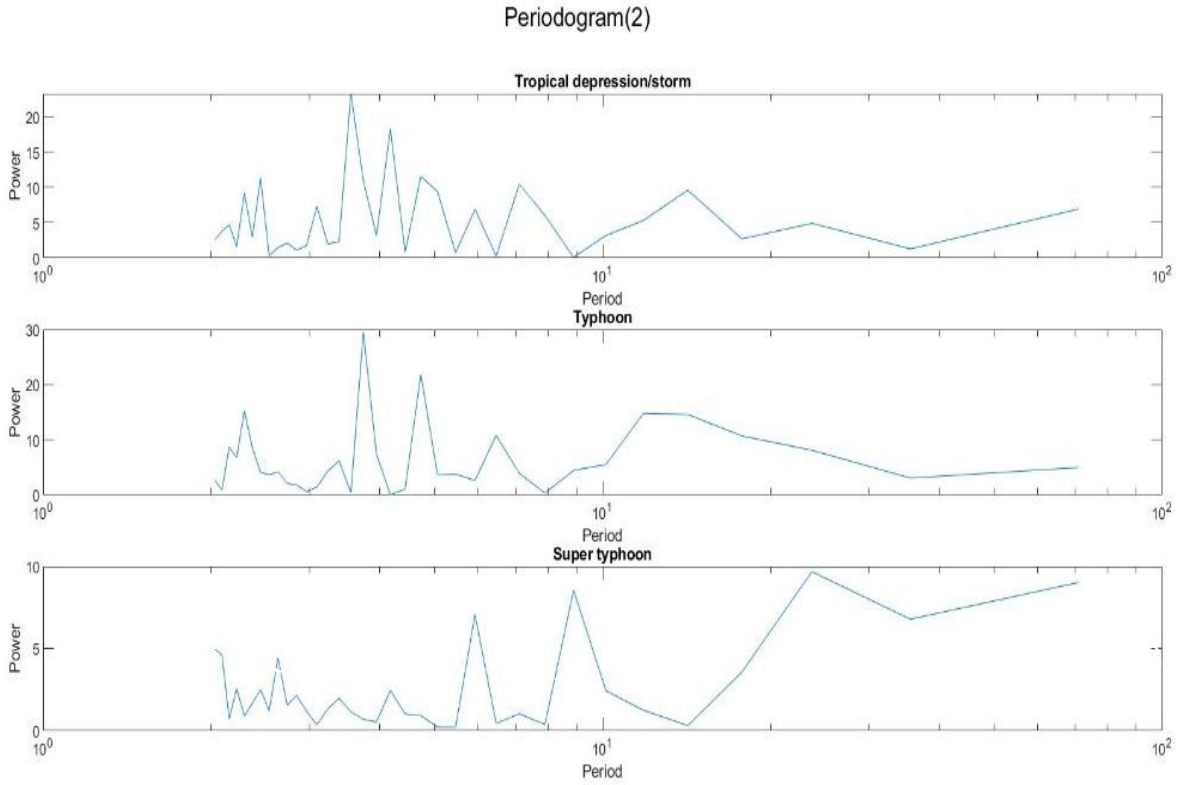
Significance of trend



- The generated LS slope distribution of super typhoon frequency failed the chi-squared test of normality.
- 95% CI for TC frequency: [-0.0119,0.0359], a range including negative slopes. Suggesting that there has been no real appreciable trend in TC occurrence over the time interval.

Periodogram

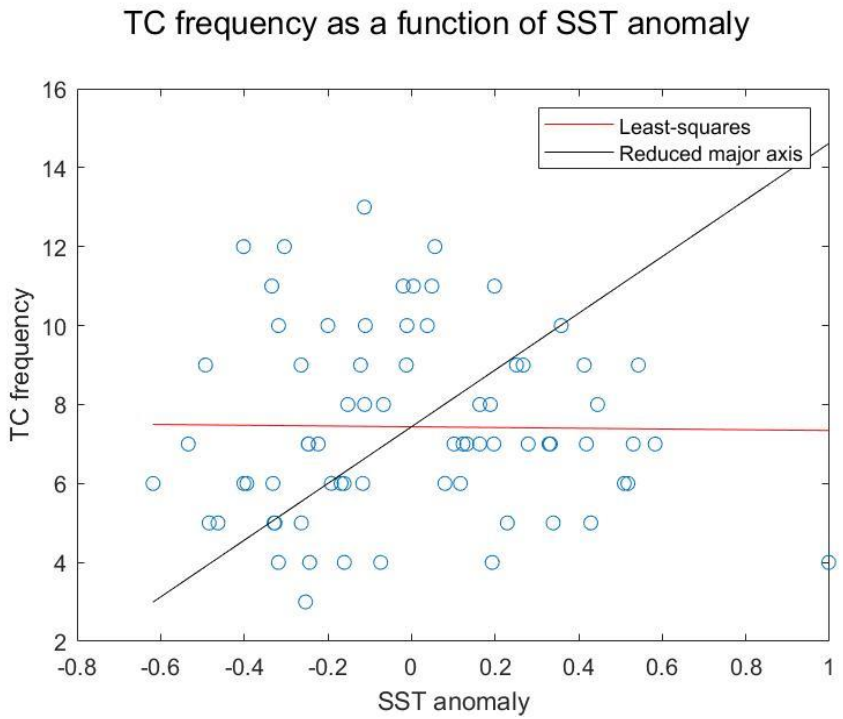


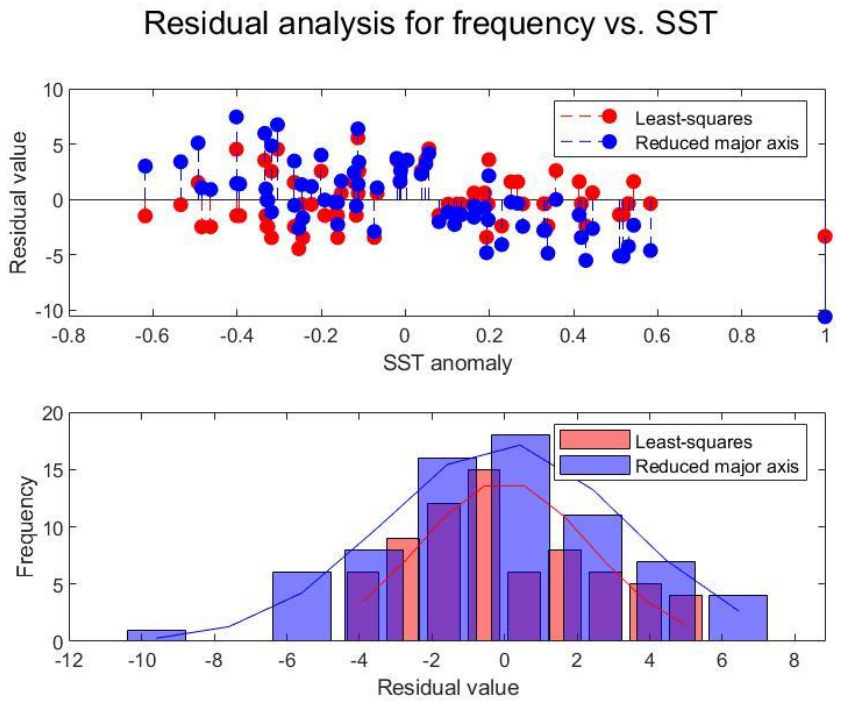


Data analysis

- Both TC frequency and SST anomaly peak at 4.733 years, coinciding with ENSO cycle.
- TD/TS and TP show a cycle of about 3.65 years while super typhoon has a larger periodicity.

Frequency vs. SST: linear regressions

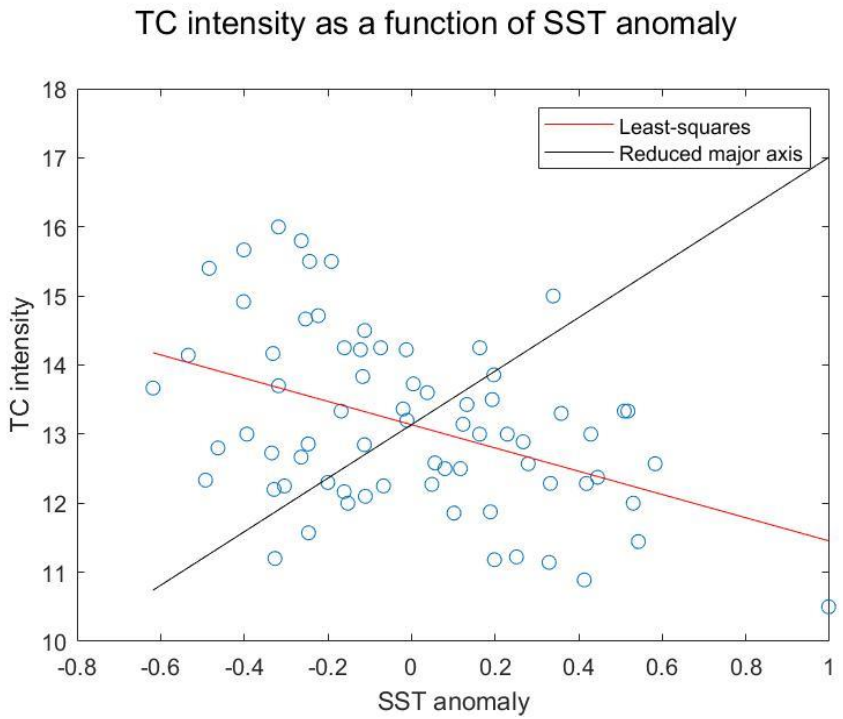


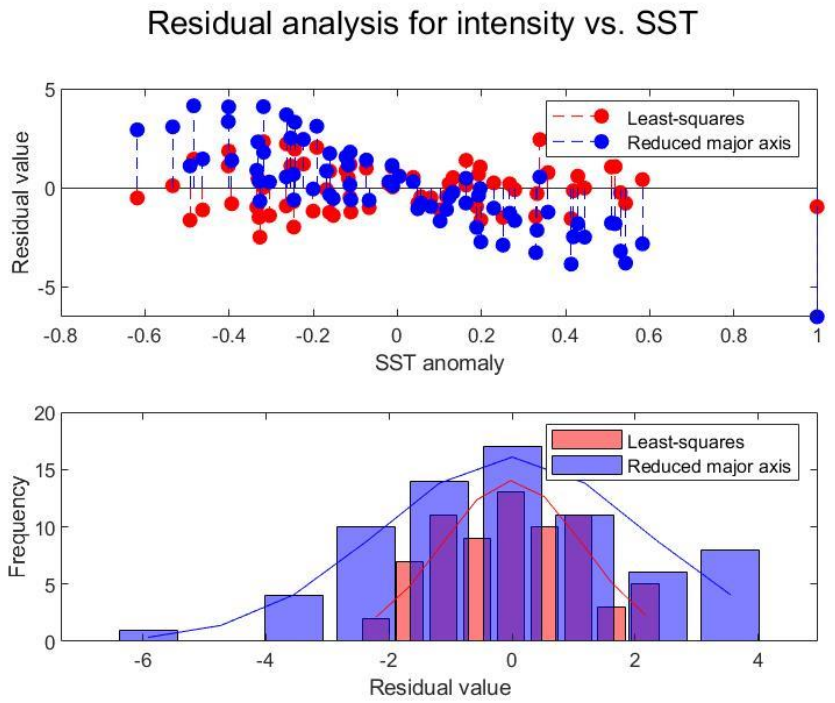


Data analysis

- LS slope = -0.0949; failed chi-squared test of normality of residual. (13.1565>12.5916)
- RMA slope = 7.1865; passed chi-squared test of normality of residual. (5.4057<12.5916)

Intensity vs. SST: linear regressions

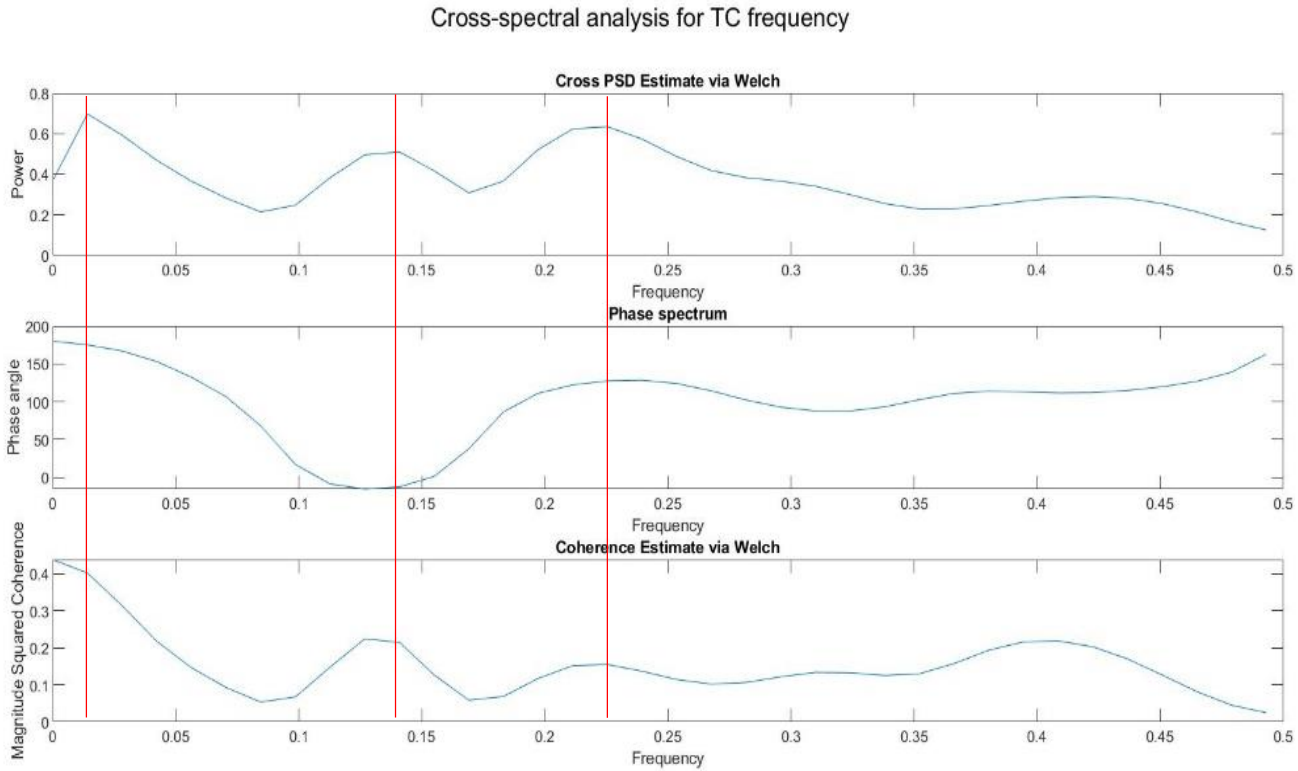




Data analysis

- LS slope = -1.6845, R^2 = 0.1889; passed chi-squared test of normality of residual. (7.6719<12.5916)
- RMA slope = 3.8757; passed chi-squared test of normality of residual. (8.0748<12.5916)

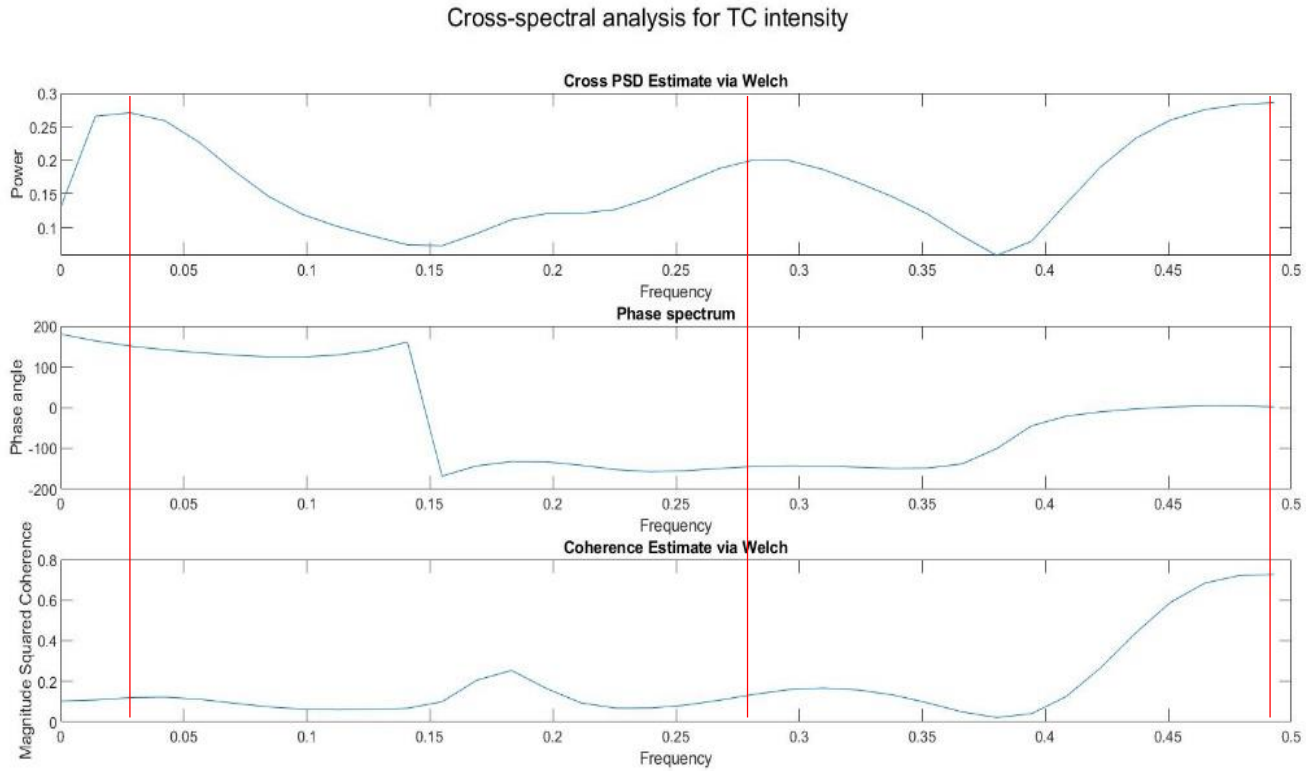
Frequency vs. SST: cross spectral analysis



Data analysis

- At f = 0.01408, phase lag = 175.0391, year lag = 34.5237, coherence = 0.402.
- At f = 0.1408, phase lag = -12.5439, year lag = -0.2474, coherence = 0.2147.
- At f = 0.2254, phase lag = 127.4706, year lag = 1.5709, coherence = 0.155.

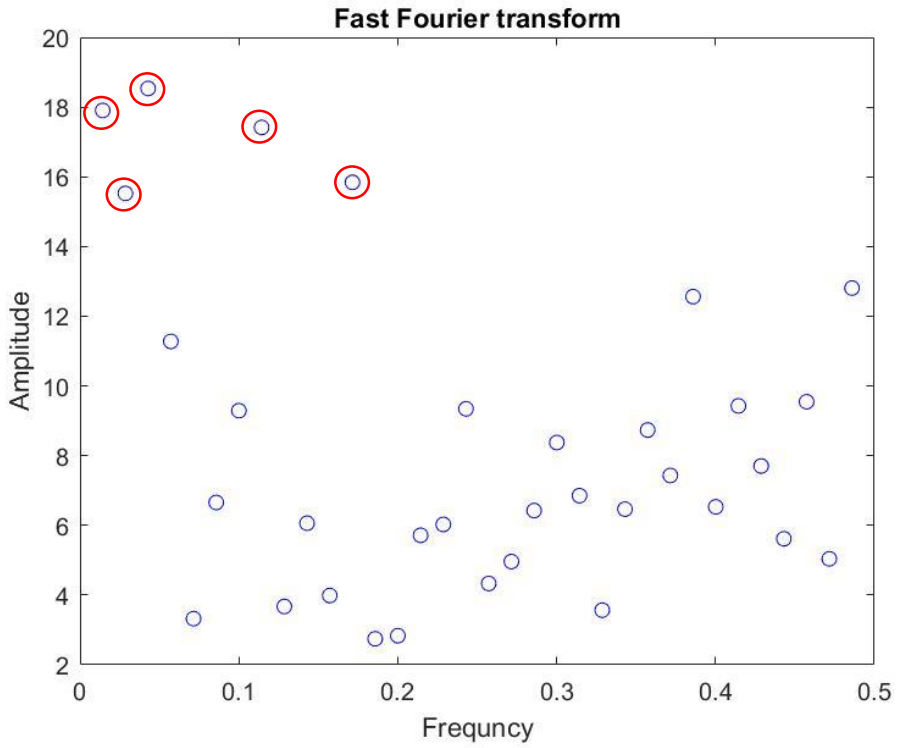
Intensity vs. SST: cross spectral analysis

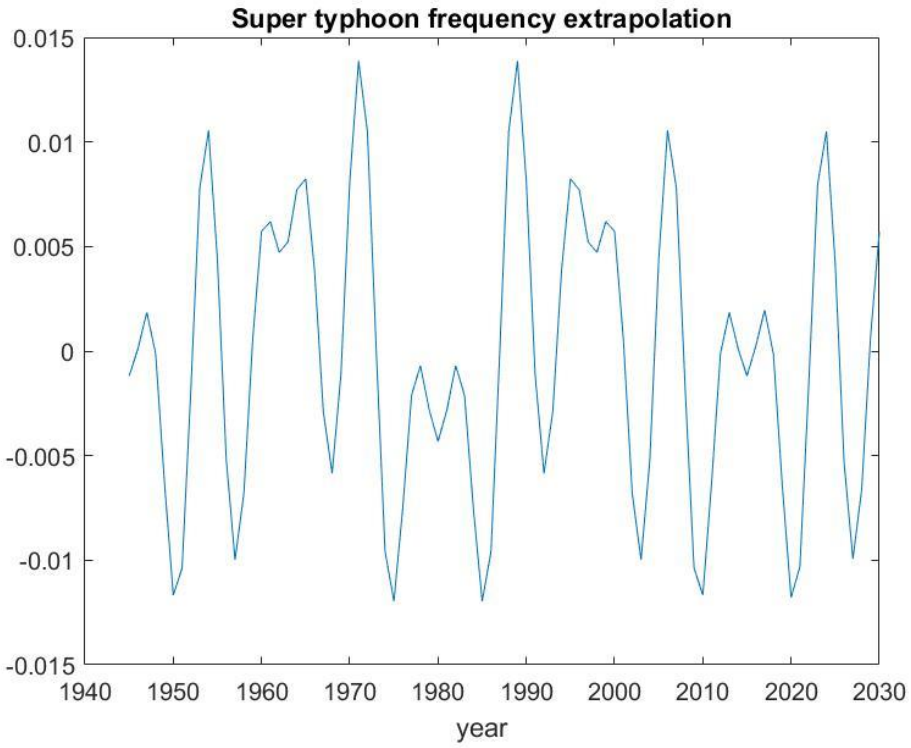


Data analysis

- At f = 0.02817, phase lag = 150.7319, year lag = 14.8633, coherence = 0.1196.
- At f = 0.2817, phase lag = -144.4782, year lag = -1.4247, coherence = 0.1362.
- At f = 0.493, phase lag = 1.6506, year lag = 0.0093, coherence = 0.7274

FFT and IFFT analysis



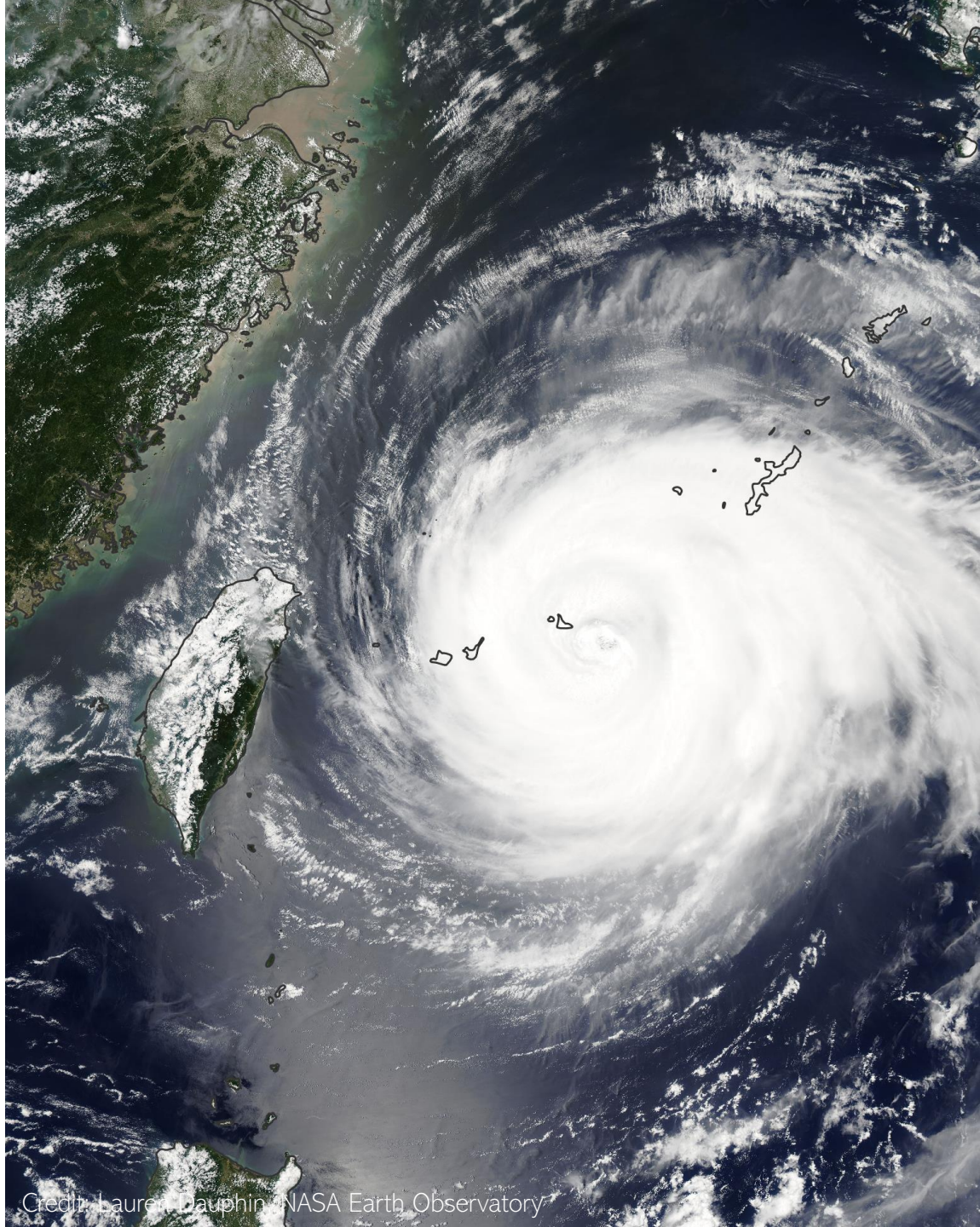


Data analysis

1. Performed IFFT on 5 data points with most prominent frequency from FFT of detrended data.
2. Used nonlinear regression to output estimated coefficients (A,φ) for year vs. IFFT result.
3. Sum up the 5 sine waves generated from $y = Asin(2\pi tf + \varphi)$ over extended time period.
4. Y-axis: more positive→larger frequency; more negative→smaller frequency?

Conclusion

- Temporal trends
  - No real trend for TC or ST occurrence over the 70yr period.
  - TC frequency and SST anomaly seem to follow a ~5yr cycle, while ST has a longer periodicity than weaker TCs.
- Correlation with SST
  - TC frequency may increase and intensity may decrease as ocean water warms up.
  - There might be (weak) cause and effect relationship between SST and TC frequency at period of 7.1 years, and between SST and TC intensity at period of 3.5 years.
- Predict super typhoon
  - Few or no super typhoon in the near future but frequency will likely increase within the next 5 years.



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