

Solar Irradiance: Modes of Variations

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Empirical Mode Decomposition

(Huang et al., 1998)

1. *FFT* :

$$x(t) = \Re \sum_j a_j e^{i\omega_j t} \quad \Rightarrow \quad \phi(\omega)$$

2. *HHT* :

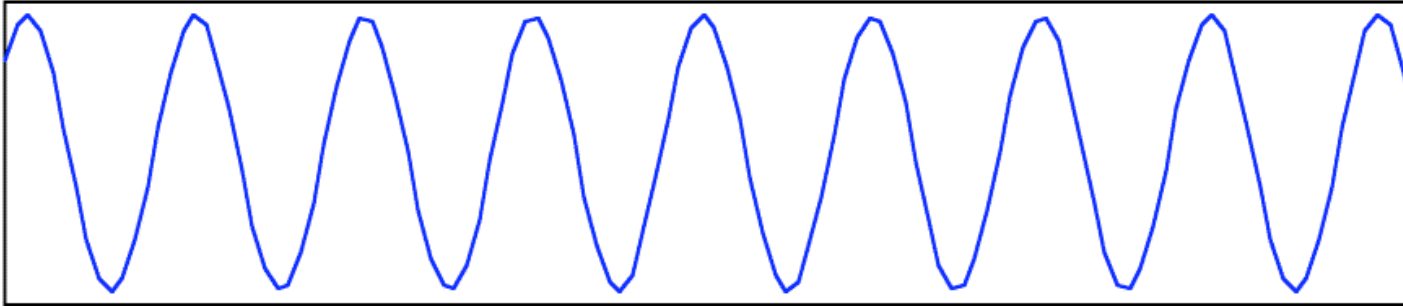
$$x(t) = \Re \sum_j a_j(t) e^{i \int^t \omega_j(\tau) d\tau} \quad \Rightarrow \quad H(\omega, t)$$

EMD is:

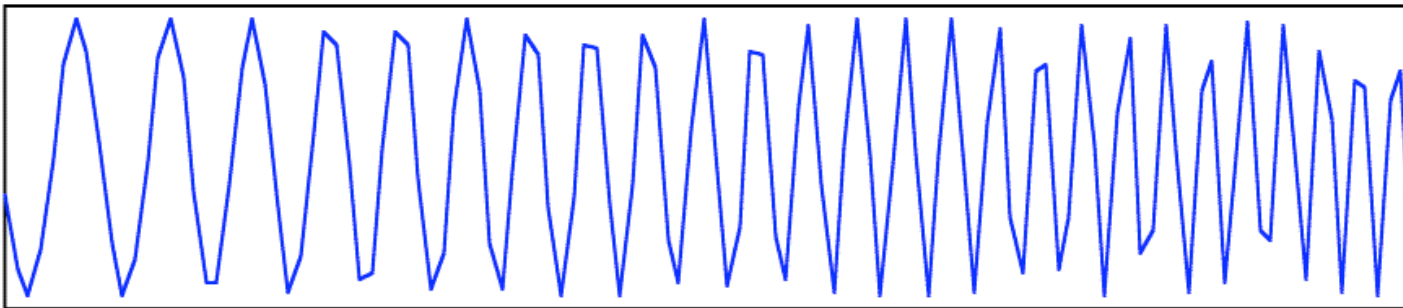
Adapted to data natural filter (not like Fourier or wavelet)

Example

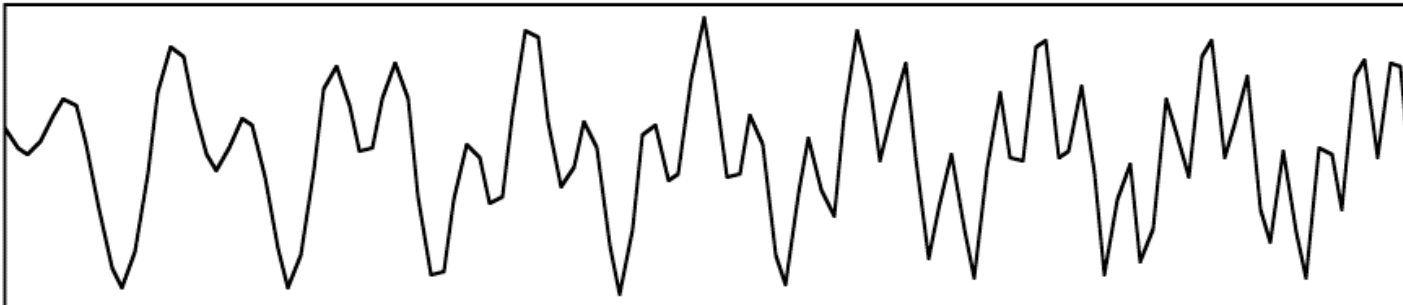
tone

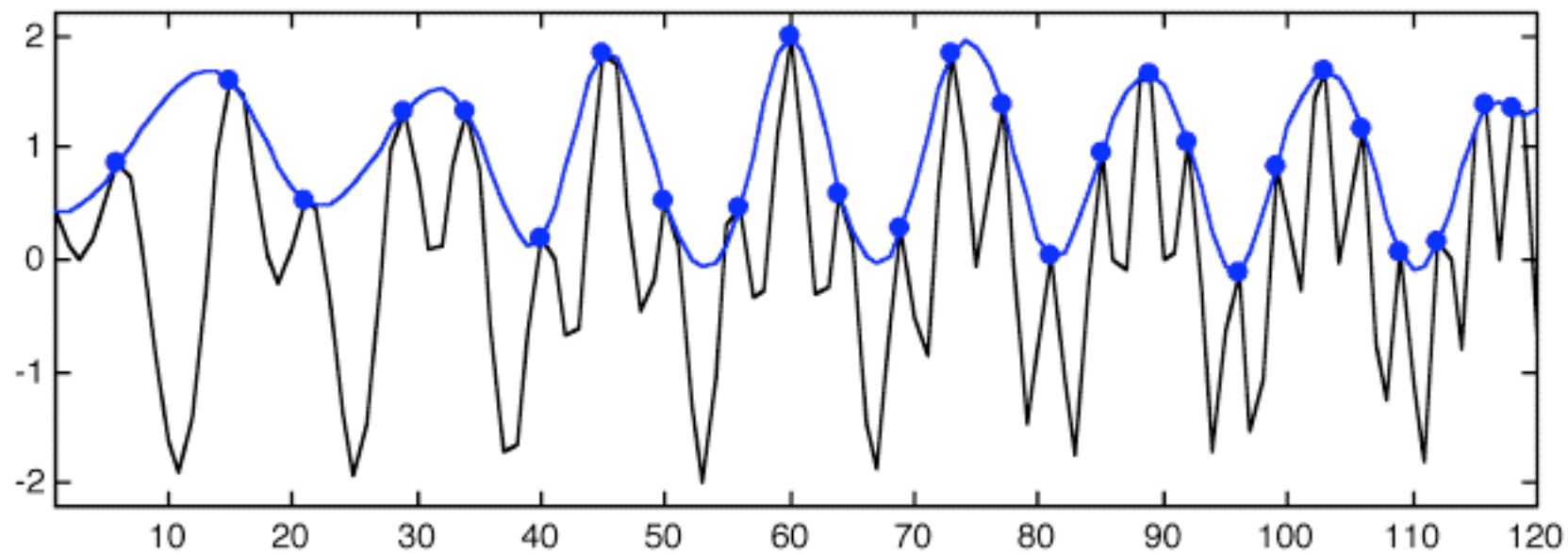


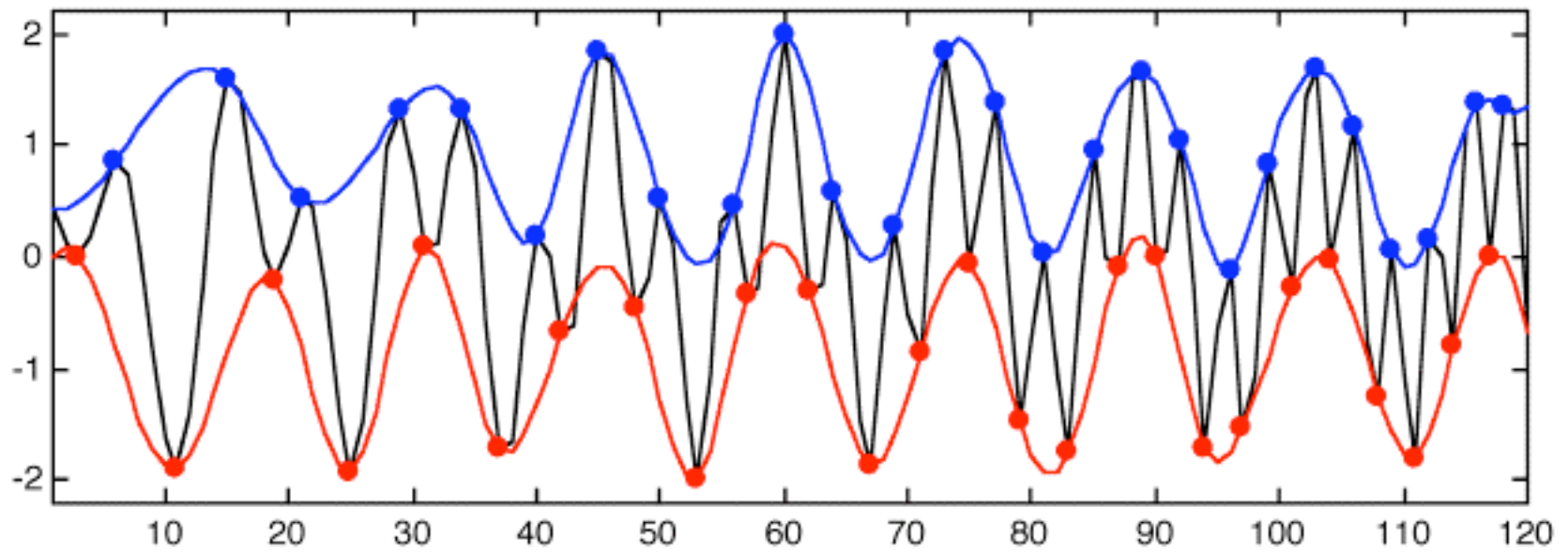
chirp

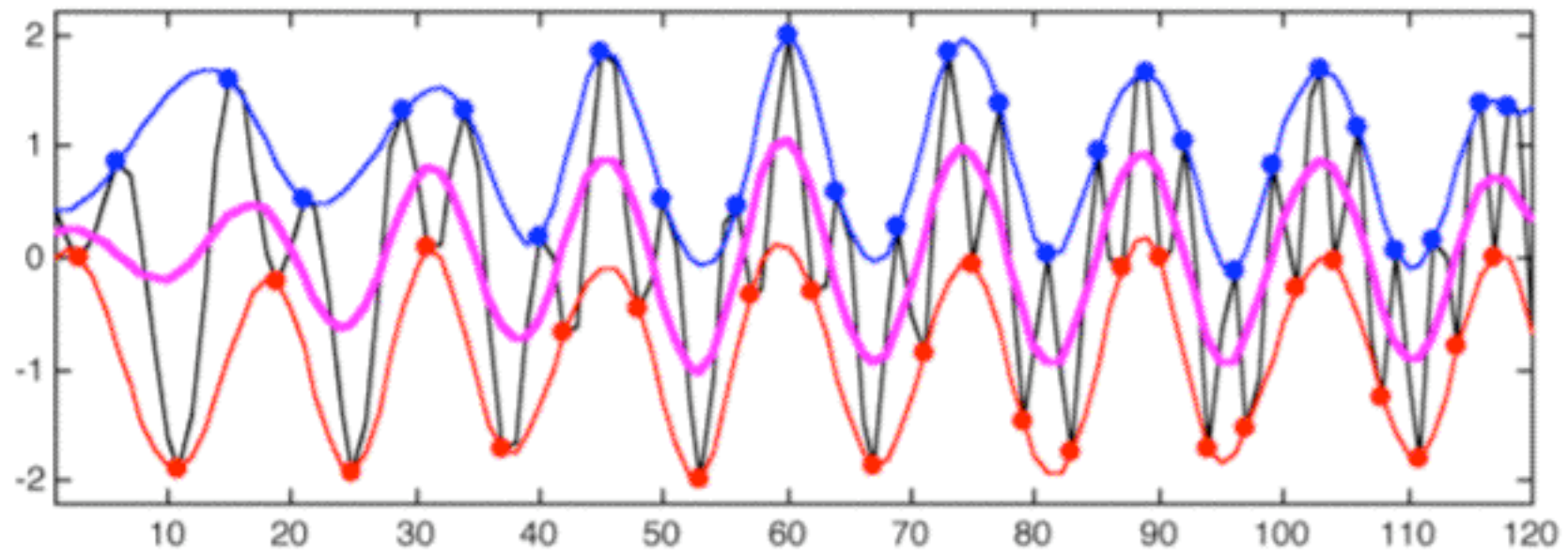


tone + chirp

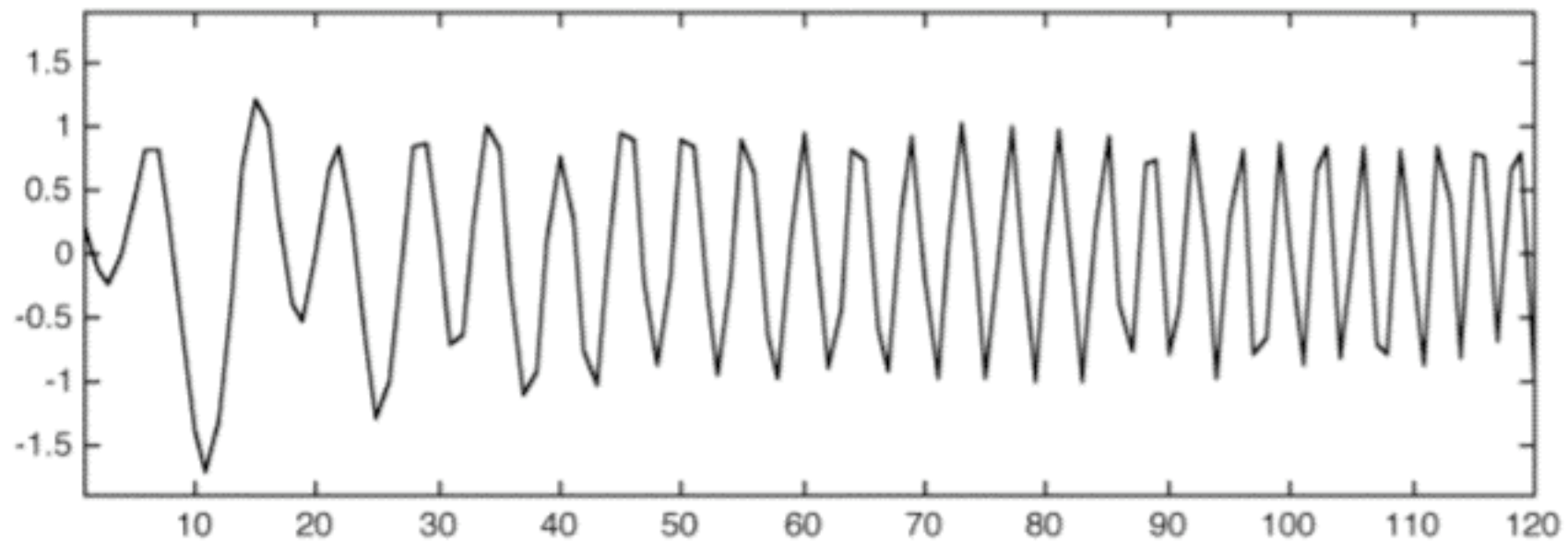


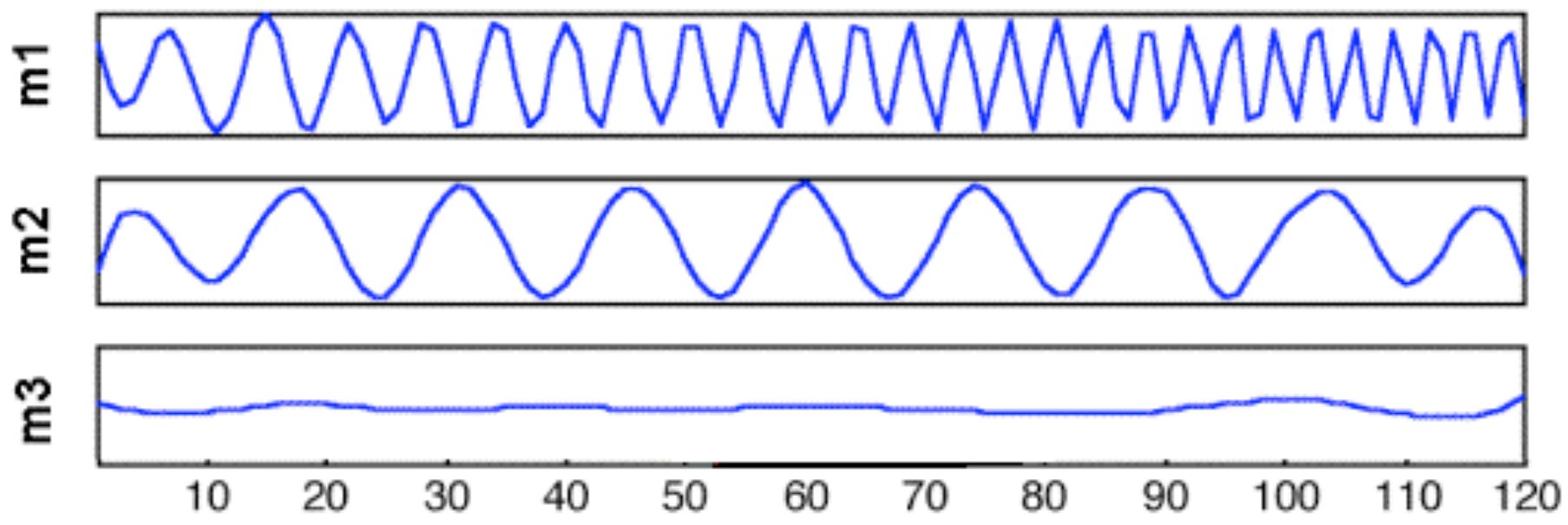






residue

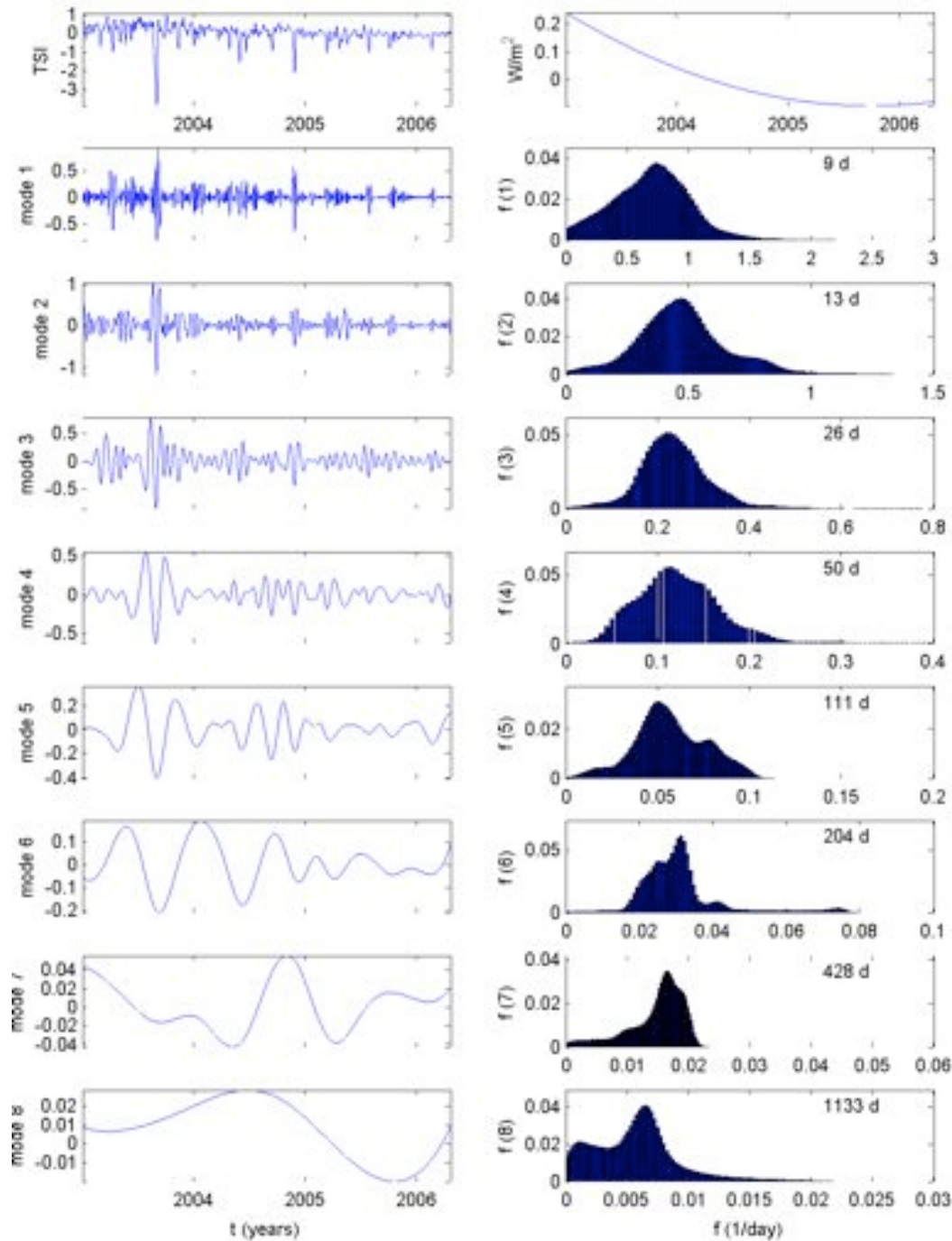




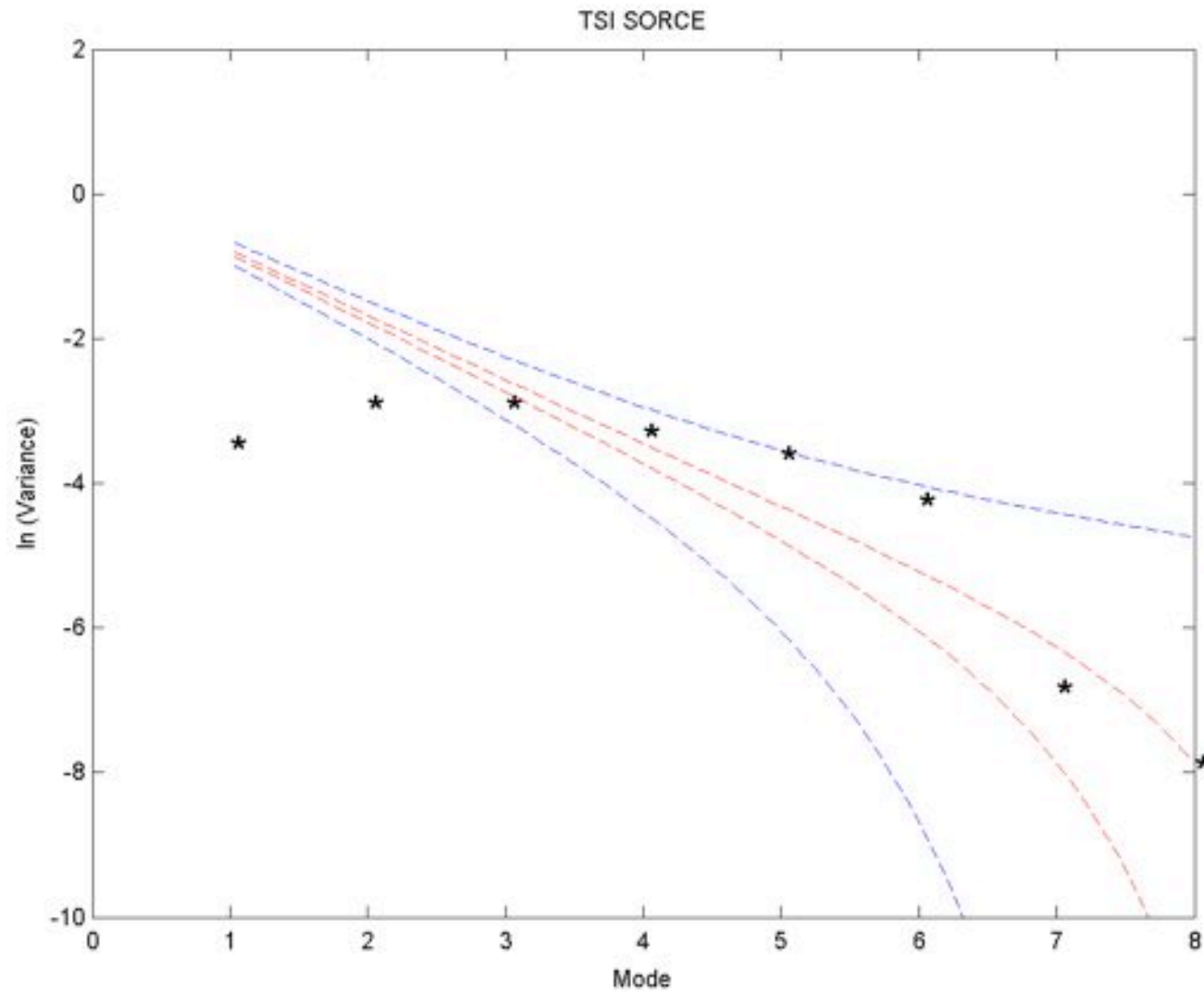
Benefits

- Non-stationarity and non-linearity are well treated
- No leaks from one mode to another
- Nonlinear trend appears as the last mode

TSI SORCE 2004-2007

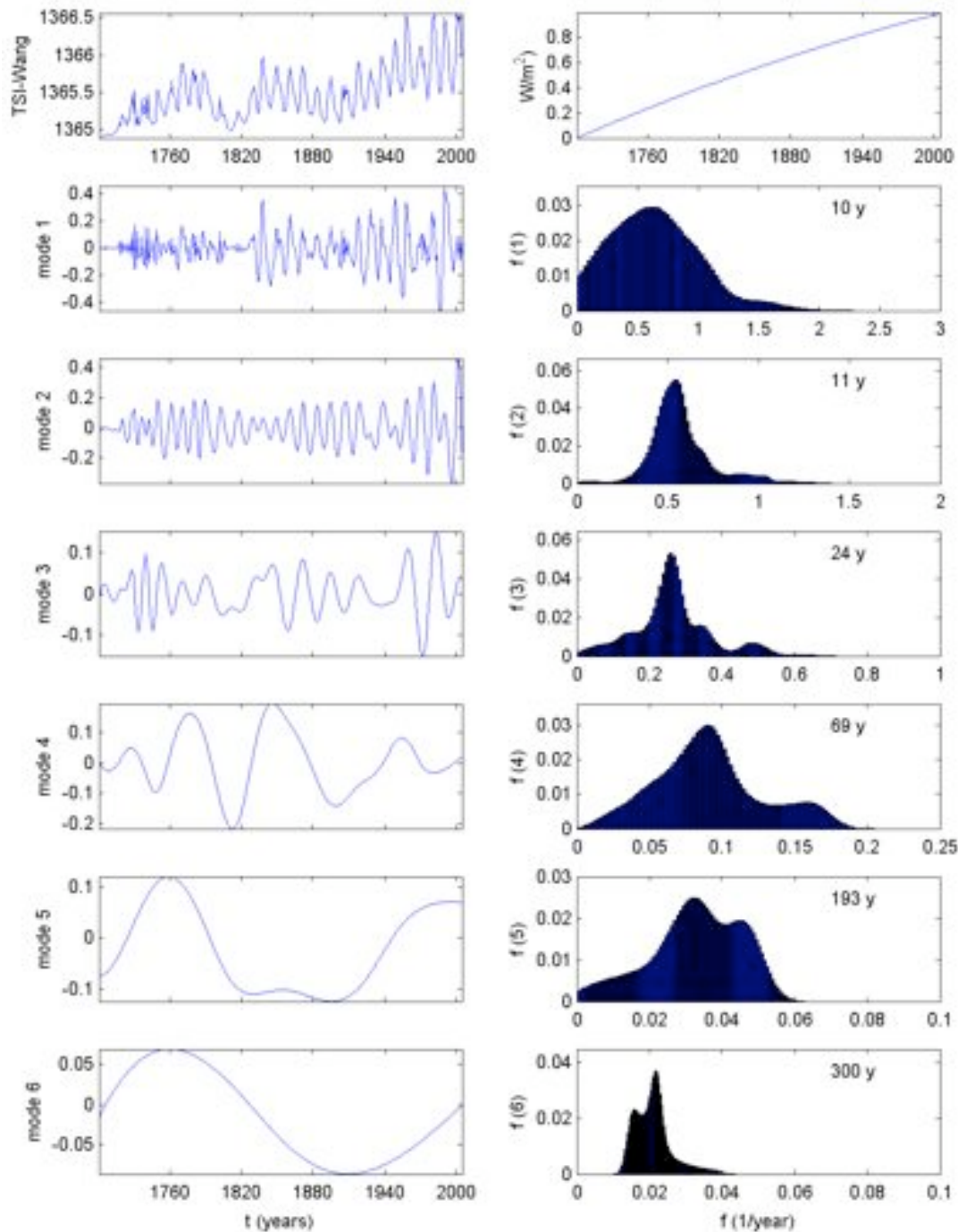


TSI SORCE: STATISTICAL SIGNIFICANCE



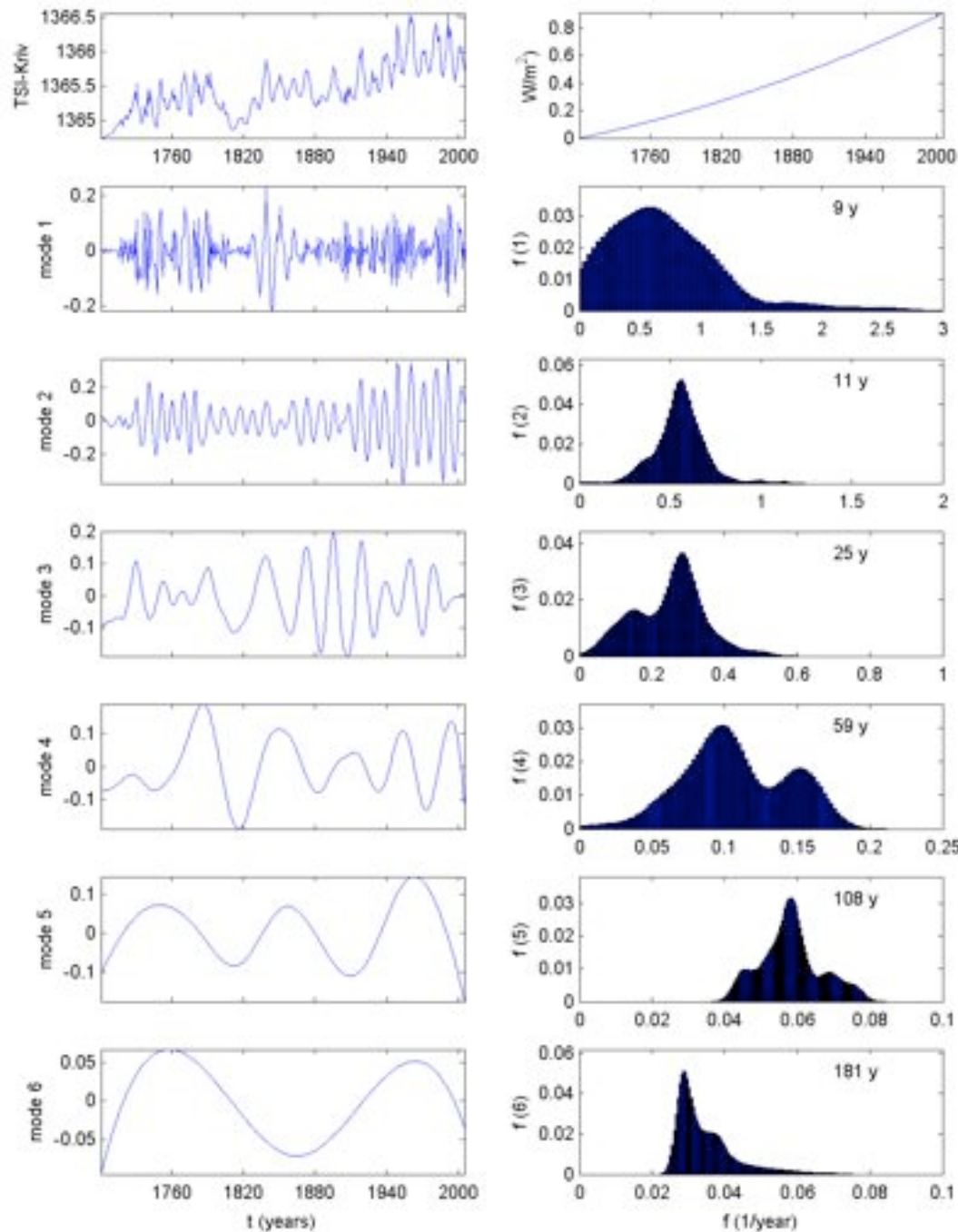
TSI
RECONSTRUCTIONS
1700-2000
Wang et al

$$\delta\text{TSI} = 1.00 \text{ W/m}^2$$

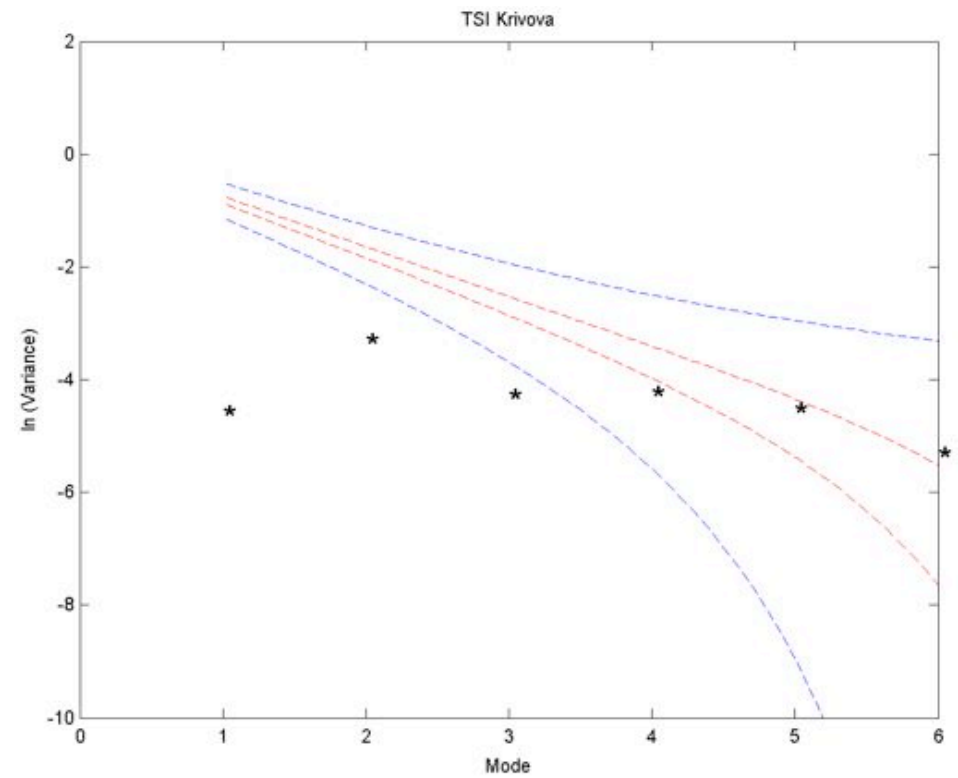
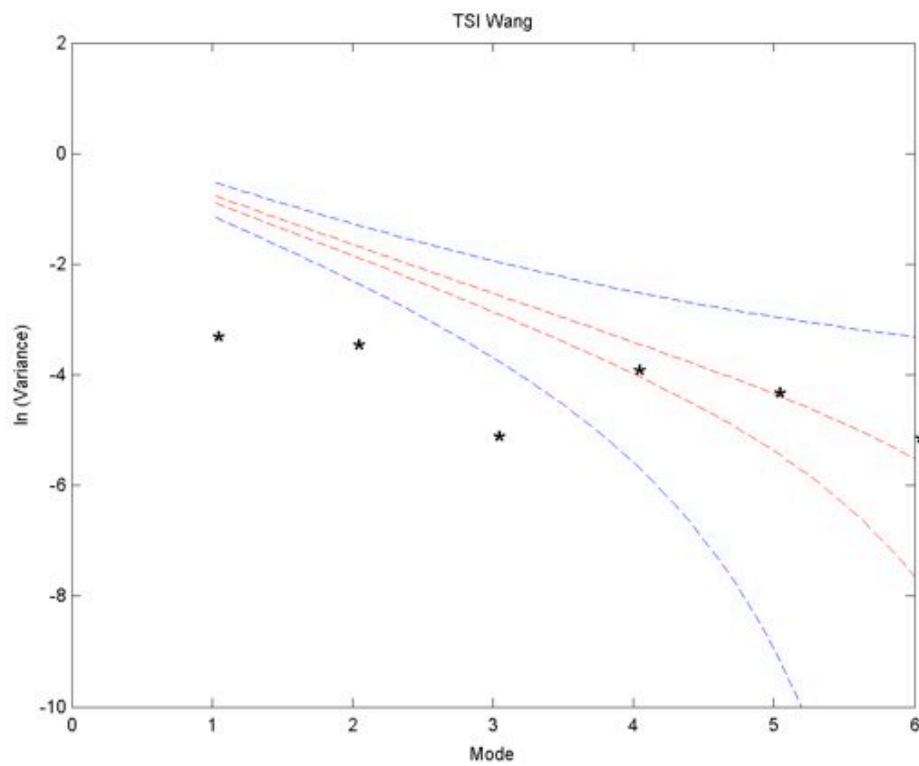


TSI RECONSTRUCTIONS 1700-2004 Krivova et al

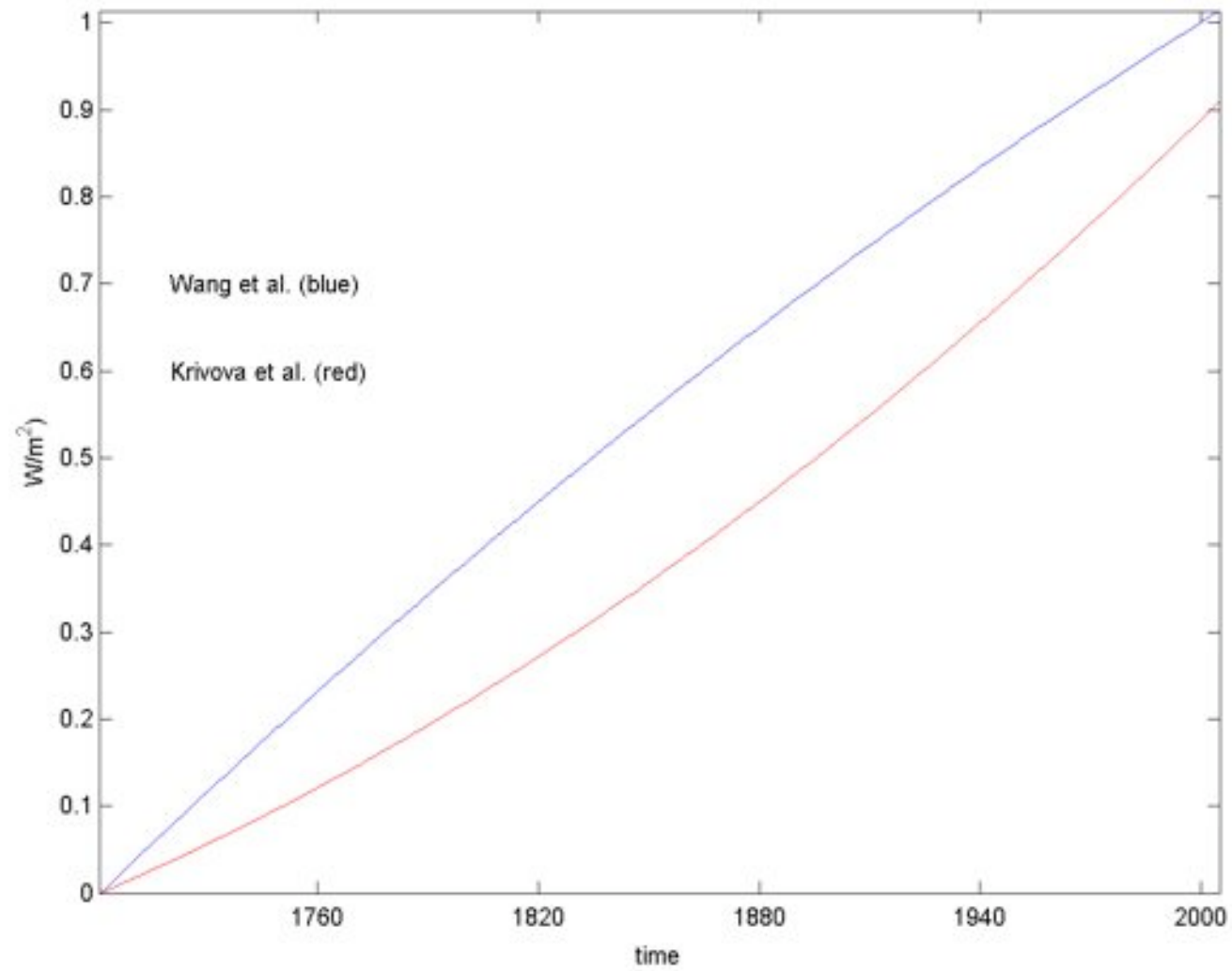
$$\delta\text{TSI} = 0.92 \text{ W/m}^2$$



TSI RECONSTRUCTIONS Statistical Significance



TSI Trends



CONCLUSION

- ❖ TSI is variable on many time scales
- ❖ SOURCE TSI shows 9, 13, 27-days, and 11-year variations
- ❖ Reconstructed TSIs have common 11, 22 year variations but differ on longer time scale variations and trends since Maunder Minimum