Rotational variations in space-based TSI observations

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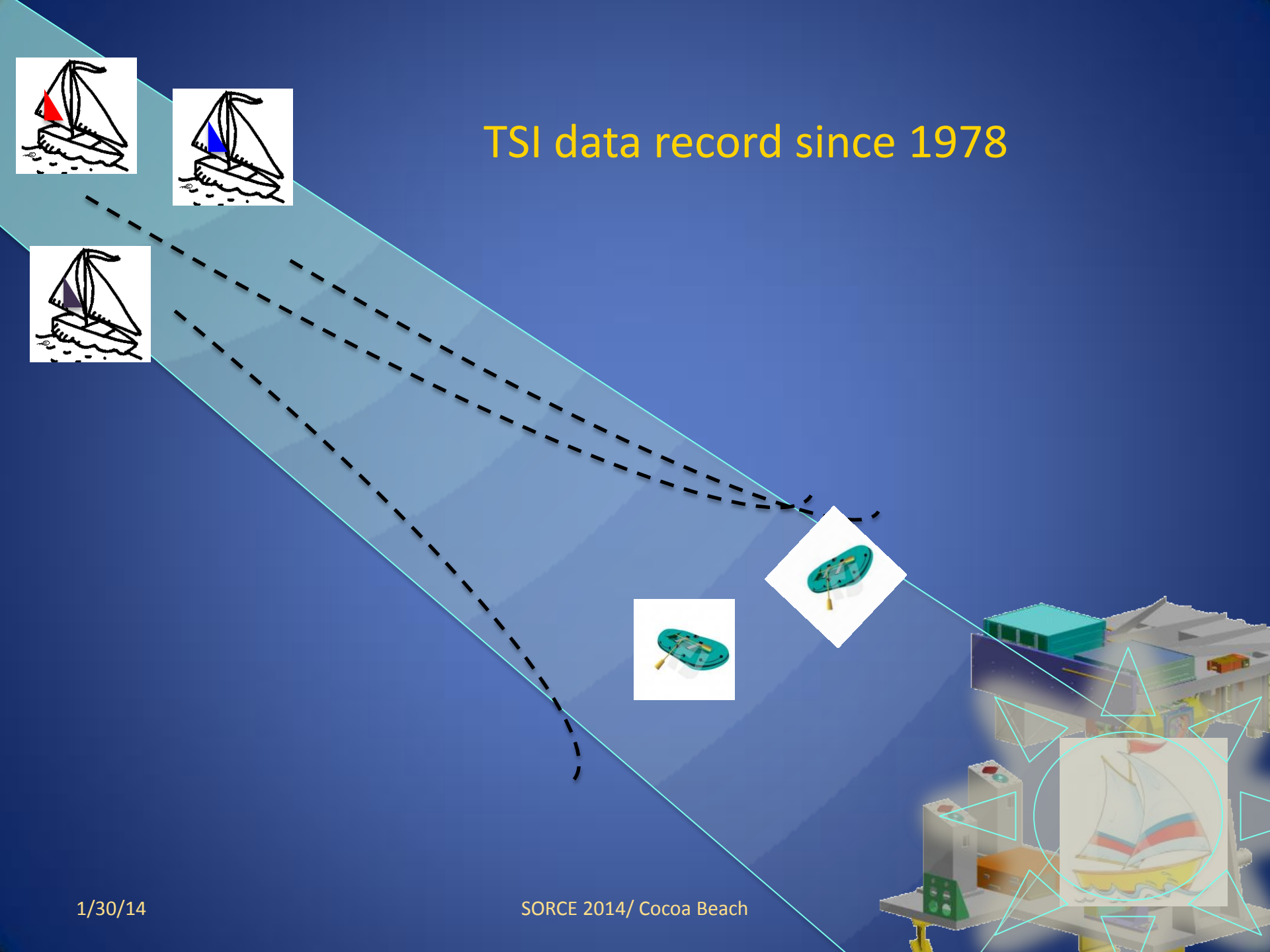
Motivation

- need for the solar climate data record, observed since 1978
- existing TSI observational Record:

  SORCE/TIM, ACRIM III, and SOHO/VIRGO are cross calibrated to obtain the TSI record during

  SORCE period
- consistent enough to determine the rotational variations in TSI?

TSI data record since 1978

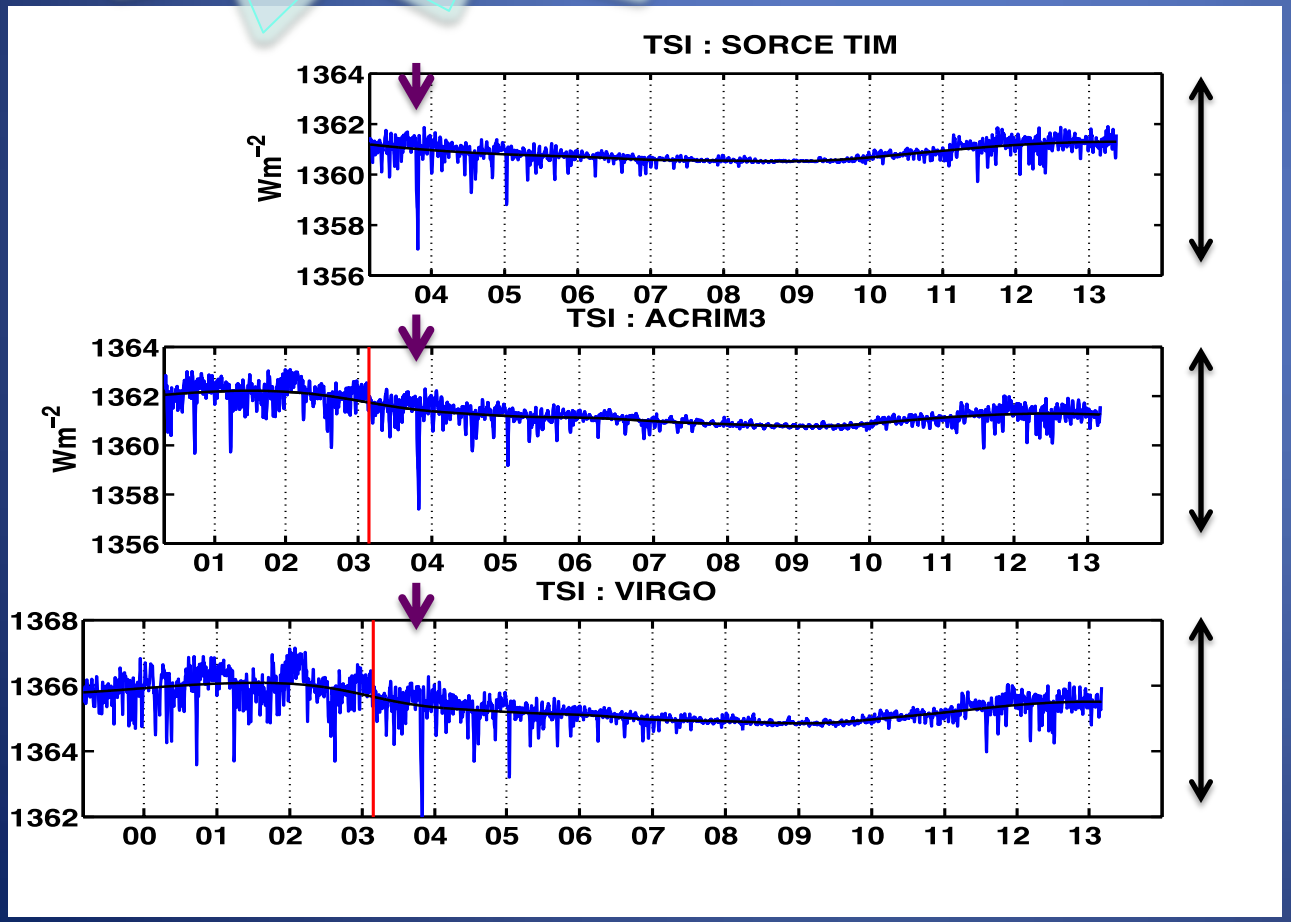


TSI Mode Decomposition

TSI ($I = \underline{I} + \tilde{I} + I_R + \langle I \rangle$)	
$\underline{I}$: Mean of TSI	
$\tilde{I}$: Low Frequency Variation	
I_R : Rotational Variation : $I_R = I_{R54} + I_{R27} + I_{R13}$	
I_{R54} : 54 day Variation	high Frequency Variation
I_{R27} : 27 day Variation	
I_{R13} : 13.5 day Variation	
$\langle I \rangle$: Short term Variation : $\langle I \rangle = I^* + \delta i$	
I^* : Solar Noise(f <13.5 day)	
δi : Calibration and Scaling Errors	

11 years of TSI observation

2003 Halloween
Solar Proton Event



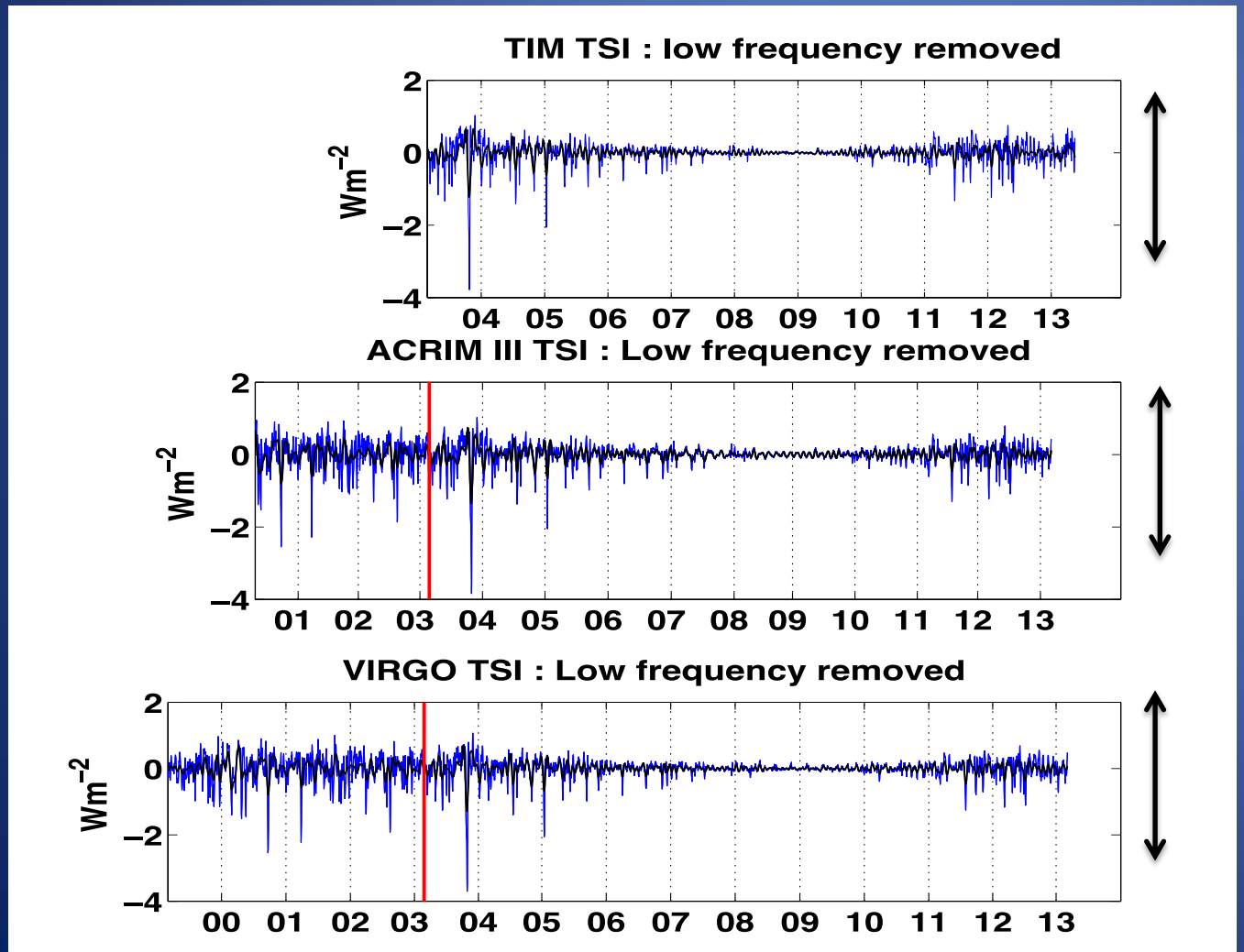
SORCE TIM

ACRIM III

SOHO/VIRGO

*** TRF adjusted VIRGO TSI exists but not available, yet.**

High Frequency mode of TSI



SORCE TIM

ACRIM III

SOHO/VIRGO

EEMD (Ensemble Empirical Mode Decomposition)

Huang et al (1996)

Ruzmaikin et al (2007)

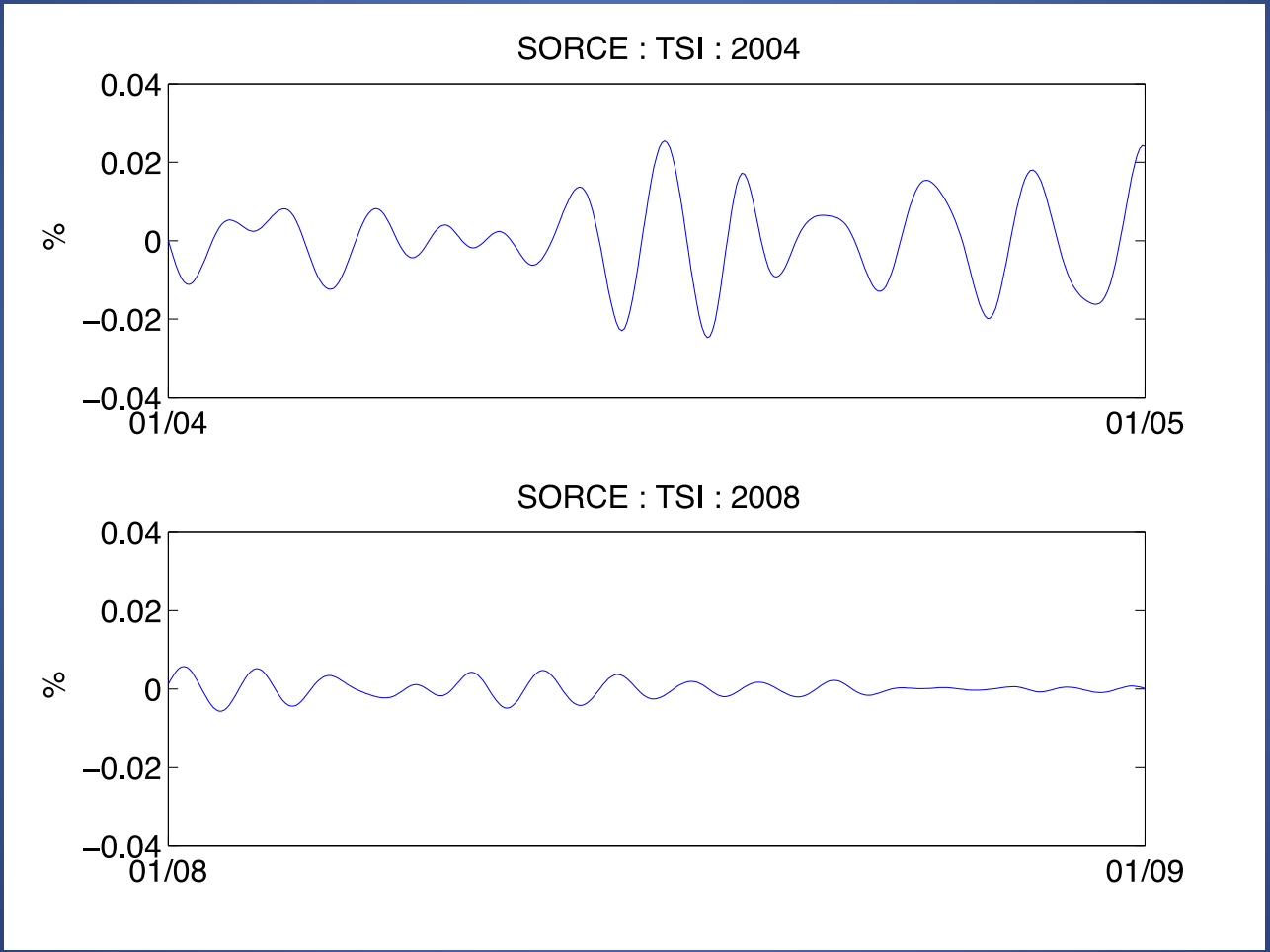
Evolutionary spectral analysis

FFT

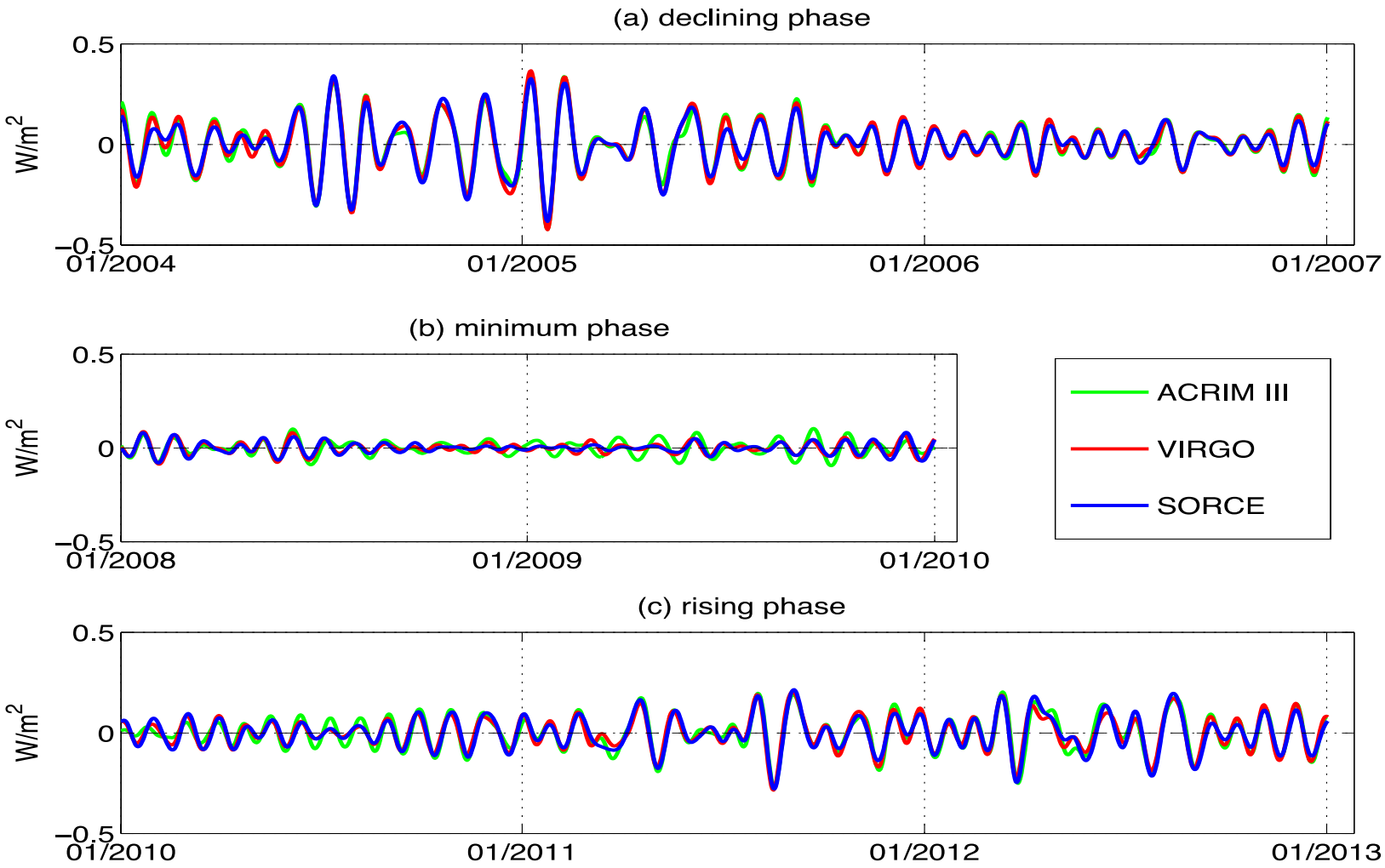
$$X(t) = \sum_j A_j(\omega, t) e^{i\int_t \omega_j(\tau)d\tau} \longleftrightarrow X(t) = \sum_j A_j e^{i\omega_j t}$$

Intrinsic mode function

27 day variation in SORCE/TIM



Comparison : Solar 27day rotational mode



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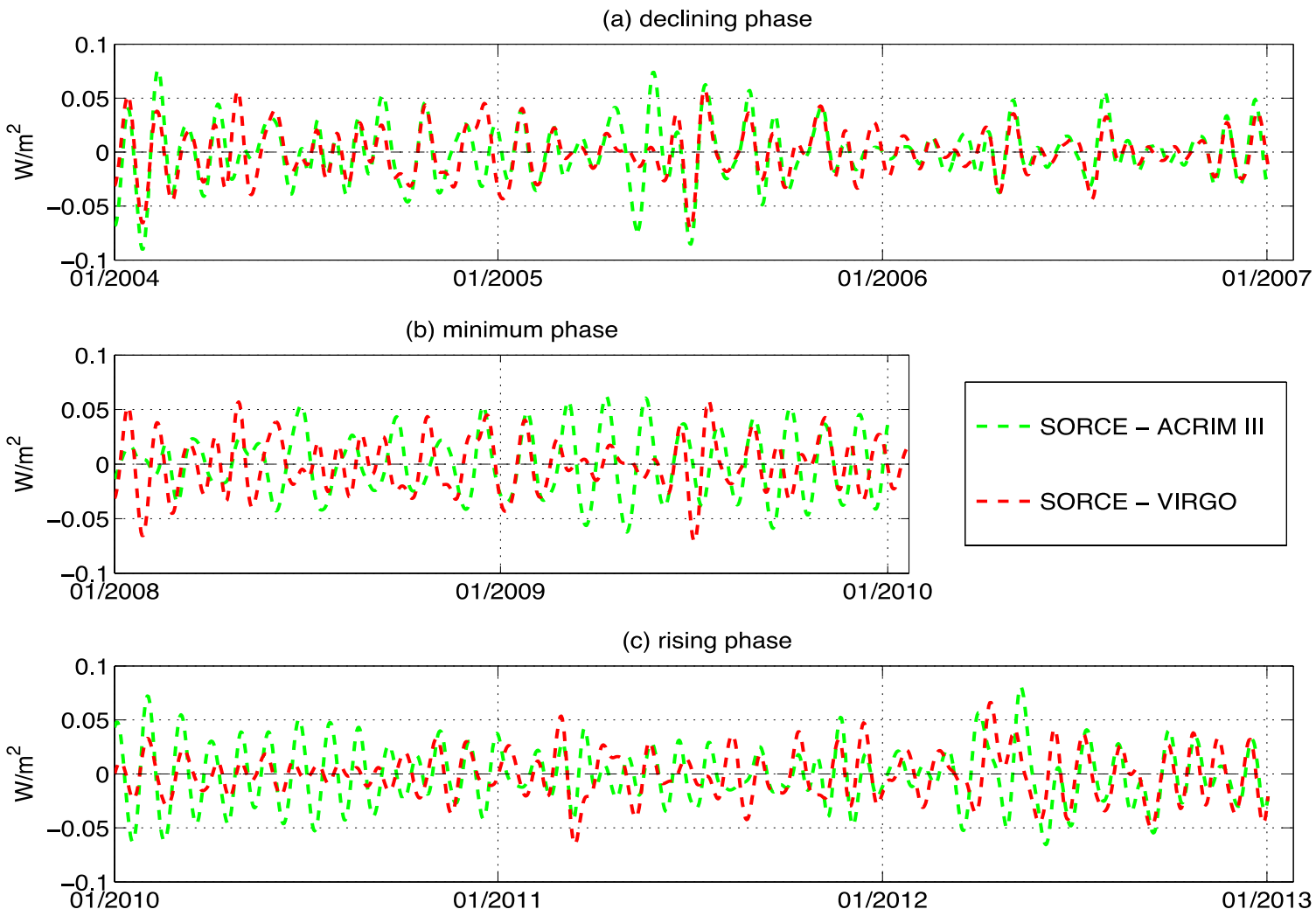
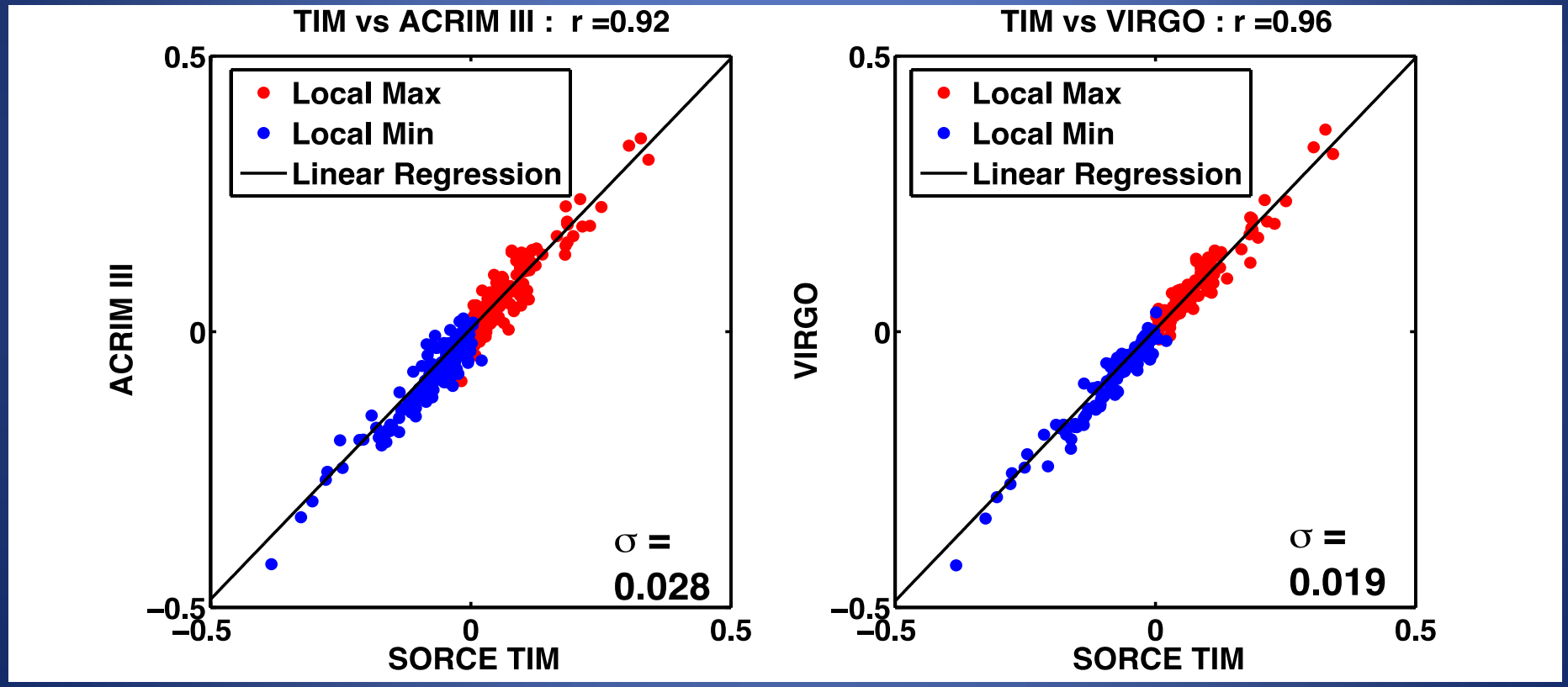
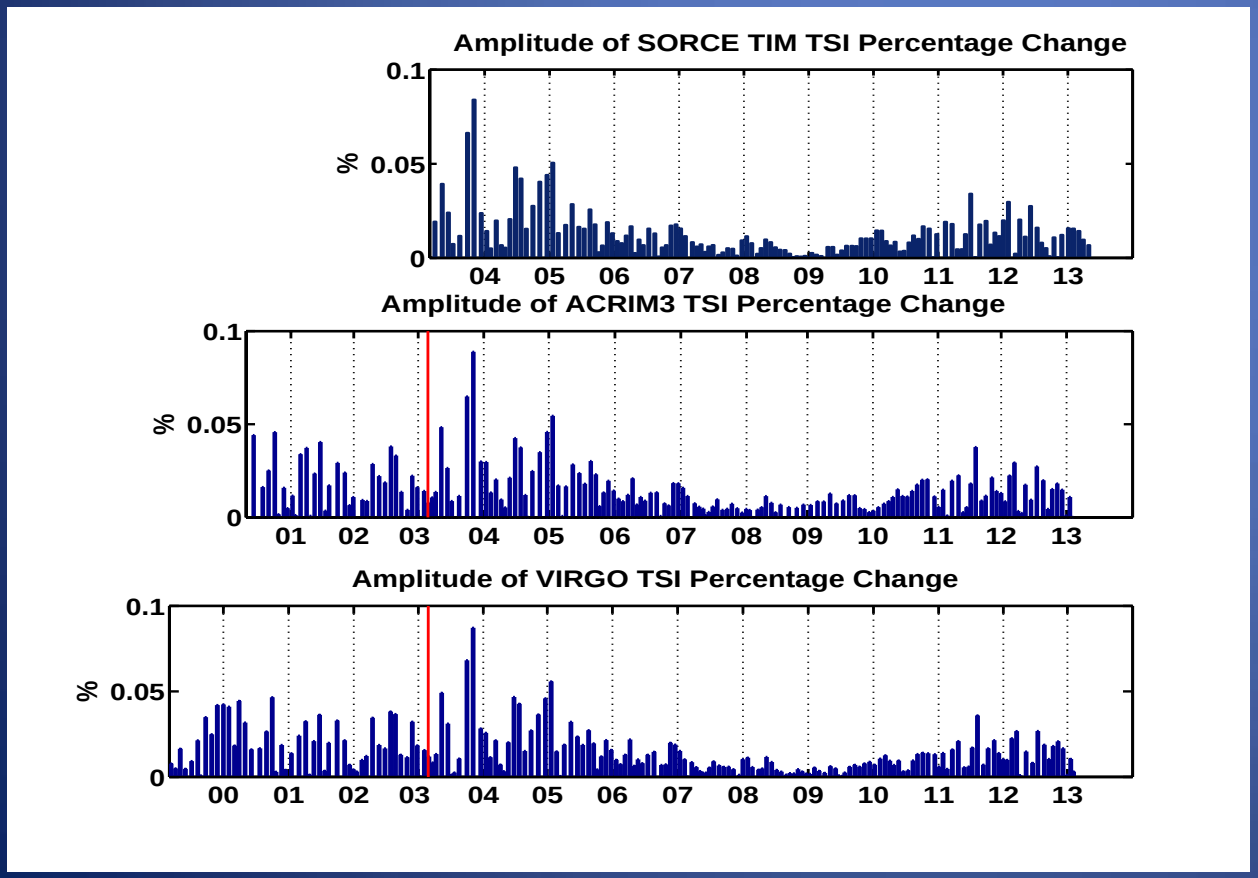


Correlation of local maximum and minimum



Amplitude of 27day variation

$$A = [I(local\ maximum) - I(preceding\ minimum)] / I(preceding\ minimum)$$



TIM

ACRIM3

VIRGO

TSI Modes Decomposition

$TSI\ (I = \underline{I} + \tilde{I} + I_R + \langle I \rangle)$	**Variance (%)**		
$\underline{I}$: *Mean of TSI*	TIM	ACRIM III	VIRGO
$\tilde{I}$: *Low Frequency Variation*	30.7%	41.6%	24.8%
I_R : *Rotational Variation :* $I_R = I_{R54} + I_{R27} + I_{R13}$	23.0%	13.3%	14.7%
I_{R54} : *54 day Variation*	5.6%	3.3%	3.5%
I_{R27} : *27 day Variation*	6.7%	4.0%	4.2%
I_{R13} : *13.5 day Variation*	10.7%	6.0%	7.0%
$\langle I \rangle$: *Short term Variation :* $\langle I \rangle = I^* + \delta i$			
I^* : *Solar Noise(f <13.5 day)*	7.9%	5.1%	6.0%
δi : *Calibration and Scaling Error*			

Conclusion

- Each rotational cycle in TSI can be identified with EEMD
- Rotational variations of TSI are in good agreement among three observations
  (0.92 with ACRIM III, 0.96 with VIRGO)
- Accounting 4 to 7% of the total variations during SORCE mission period
- Amplitude of solar rotation mode is higher during the declining phase of SC23 than the rising phase of SC24.

Acknowledgment

- SORCE, ACRIM, SOHO team
- NASA LwS program