Measuring the Correlation Scale of Turbulence ?

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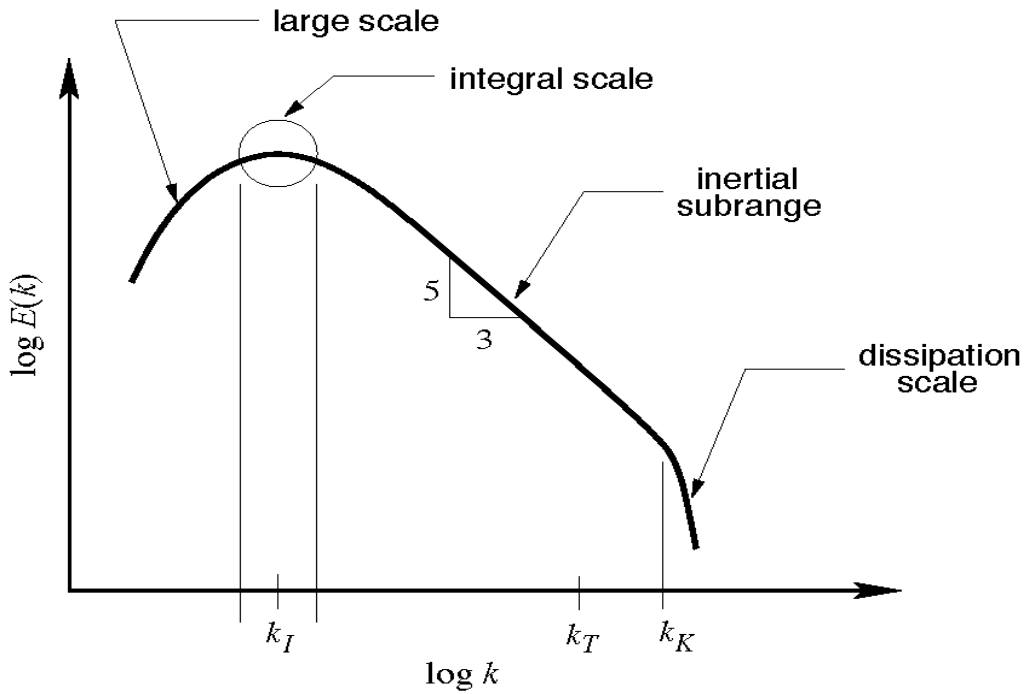
scales of turbulence

- Outer (driving) scale - energy input
- Taylor scale - gradient fluctuation scale
- Inner (dissipation) scale - requires E and hi-res particle measurements (Solar Orbiter?)



scales of turbulence

λ ~ 1100 Mm (186 Re)
λ_t ~ 2500 km

If inertial range is scale-free, this analysis is constrained by the measurement time…

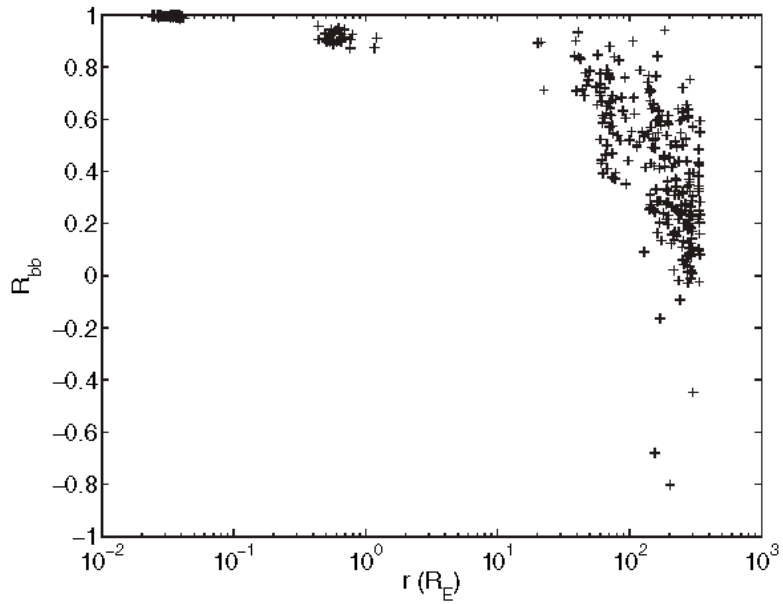


FIG. 2. Estimates of correlation function from ACE-Wind data (as in Fig. 1), supplemented by two sets of Cluster data, a set (1) with separations 0.4–1.2 R_E from data in 2003, and a set (2) with smaller separations 0.02–0.04 R_E, from 2004 data.

(Matthaeus et al, PRL, 2005)

outline

- IMPACT/MAG and ~~SWAVES/APM~~ and Wind 3DP/SWE data
- early orbit - separations 4.7 to 5800 Mm
- Haar wavelet transform
- cross-correlations vs separation for different wavelet scales
- correlation length vs ‘wavelength’

IMPACT/MAG data

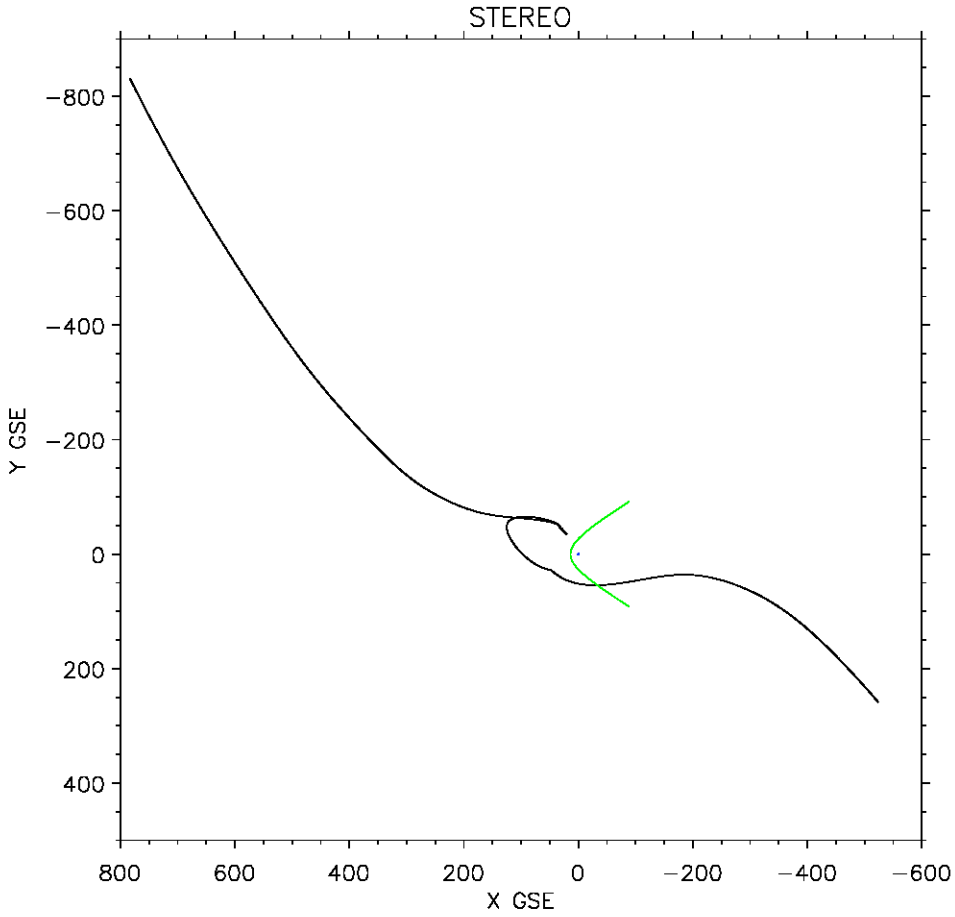
- magnitude |B| - a so-called 'passive scalar' in ideas about turbulence
- boxcar-averaged down to 3 seconds (for later correlative studies with Wind/MFI)

Wind/SWE and 3DP data

- solar wind velocity to 'deconvect' the data
- proton densities to calibrate S/WAVES APM

orbit

- early orbit data - Dec 14, 2006 to March 28, 2007
- separations from 4.7 to 5800 Mm (0.7 to 900 Re)
- separation along the mean Parker spiral



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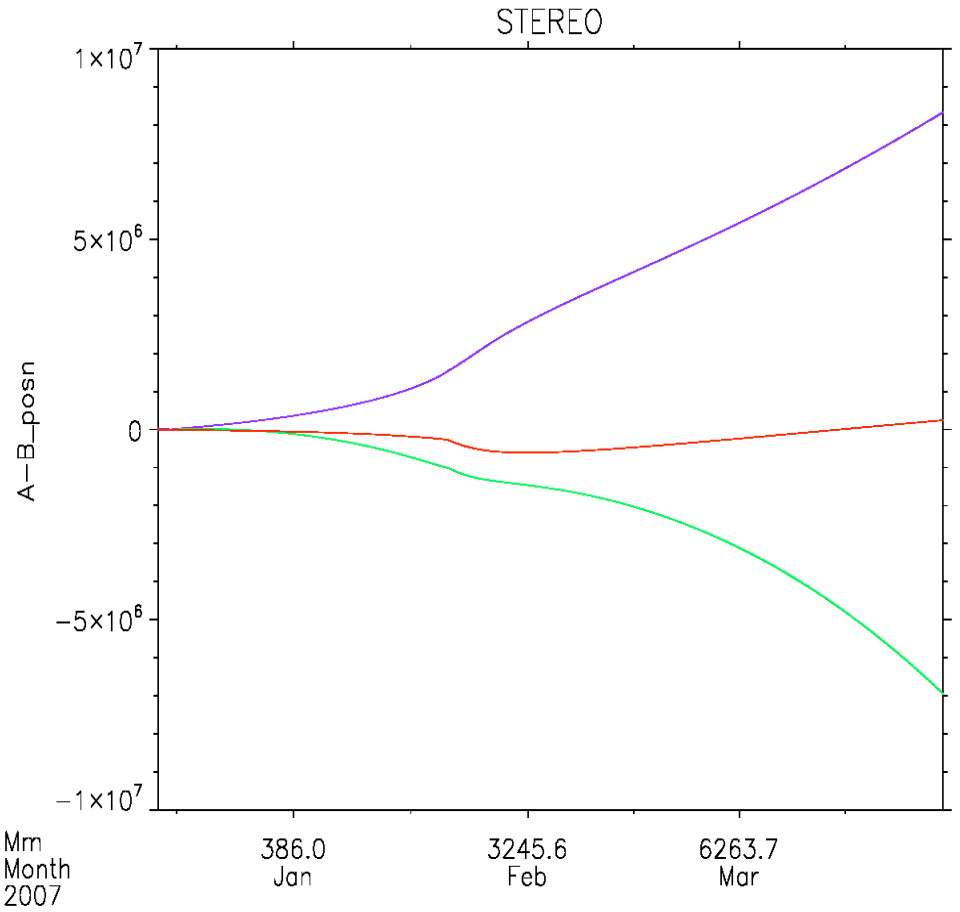
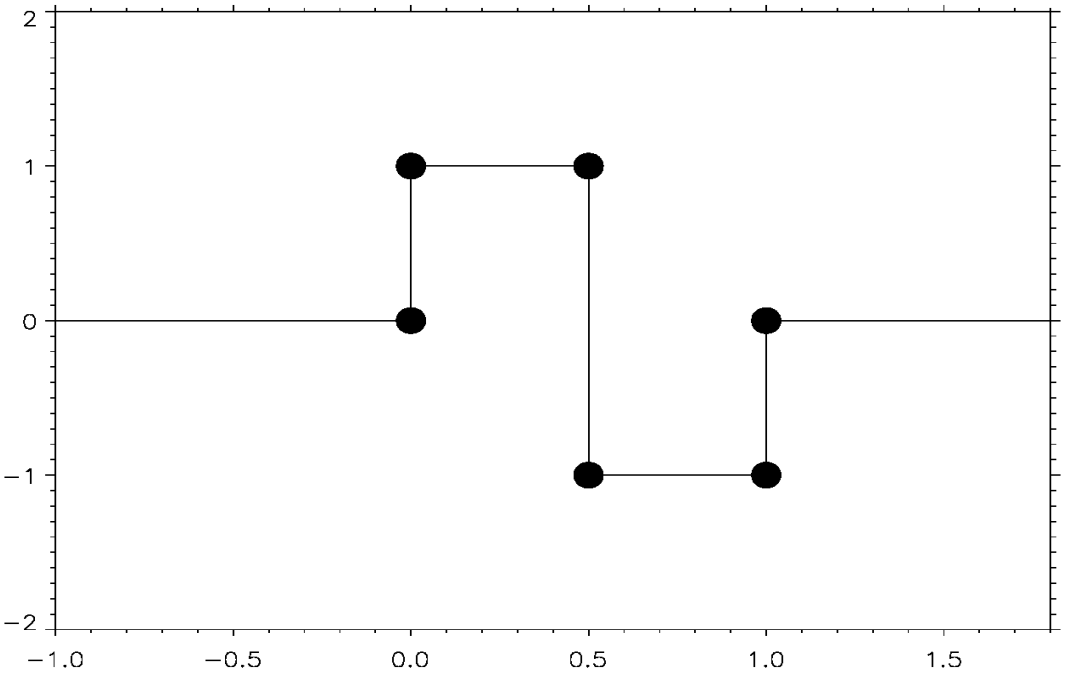
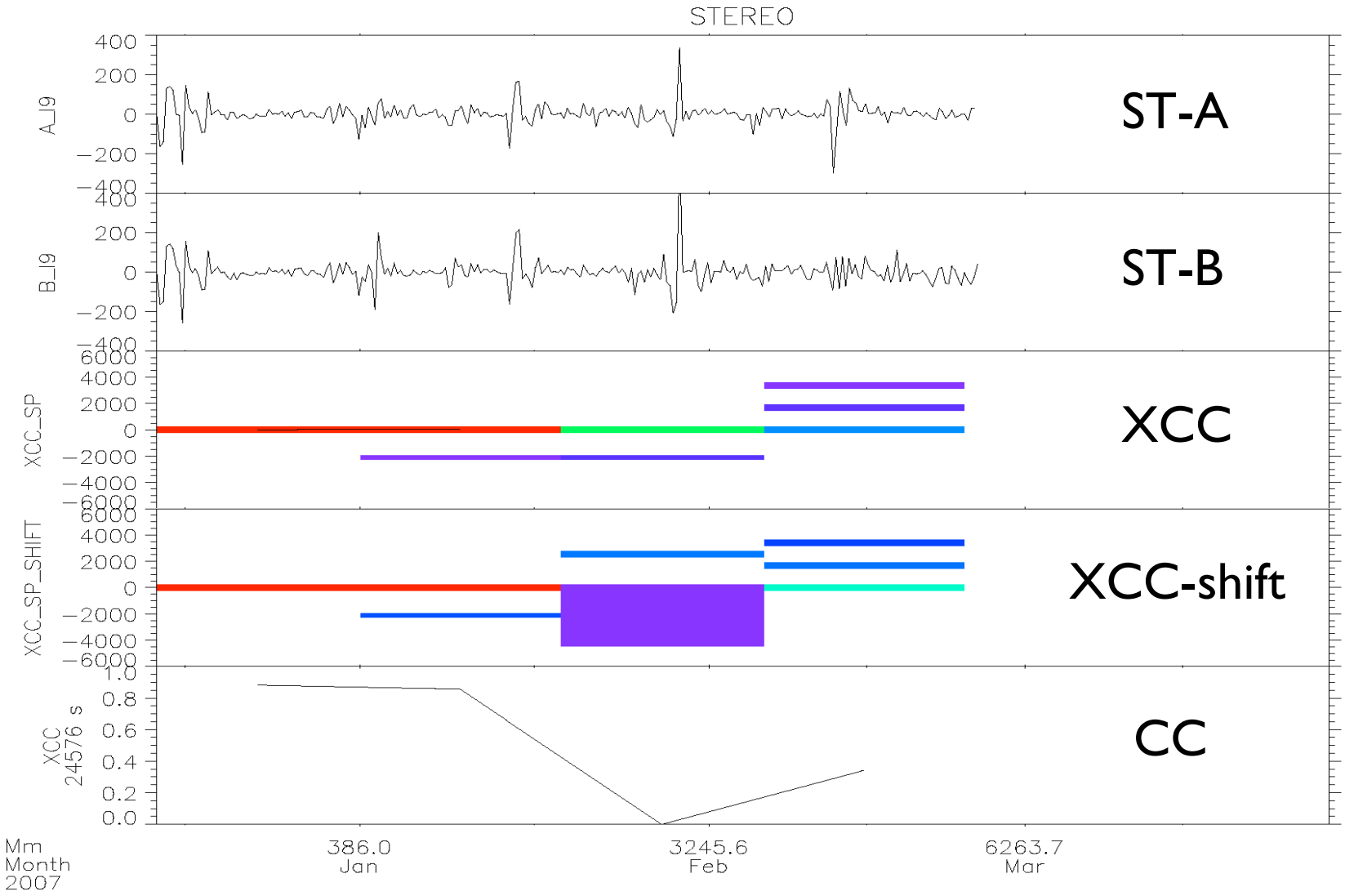


Haar wavelet

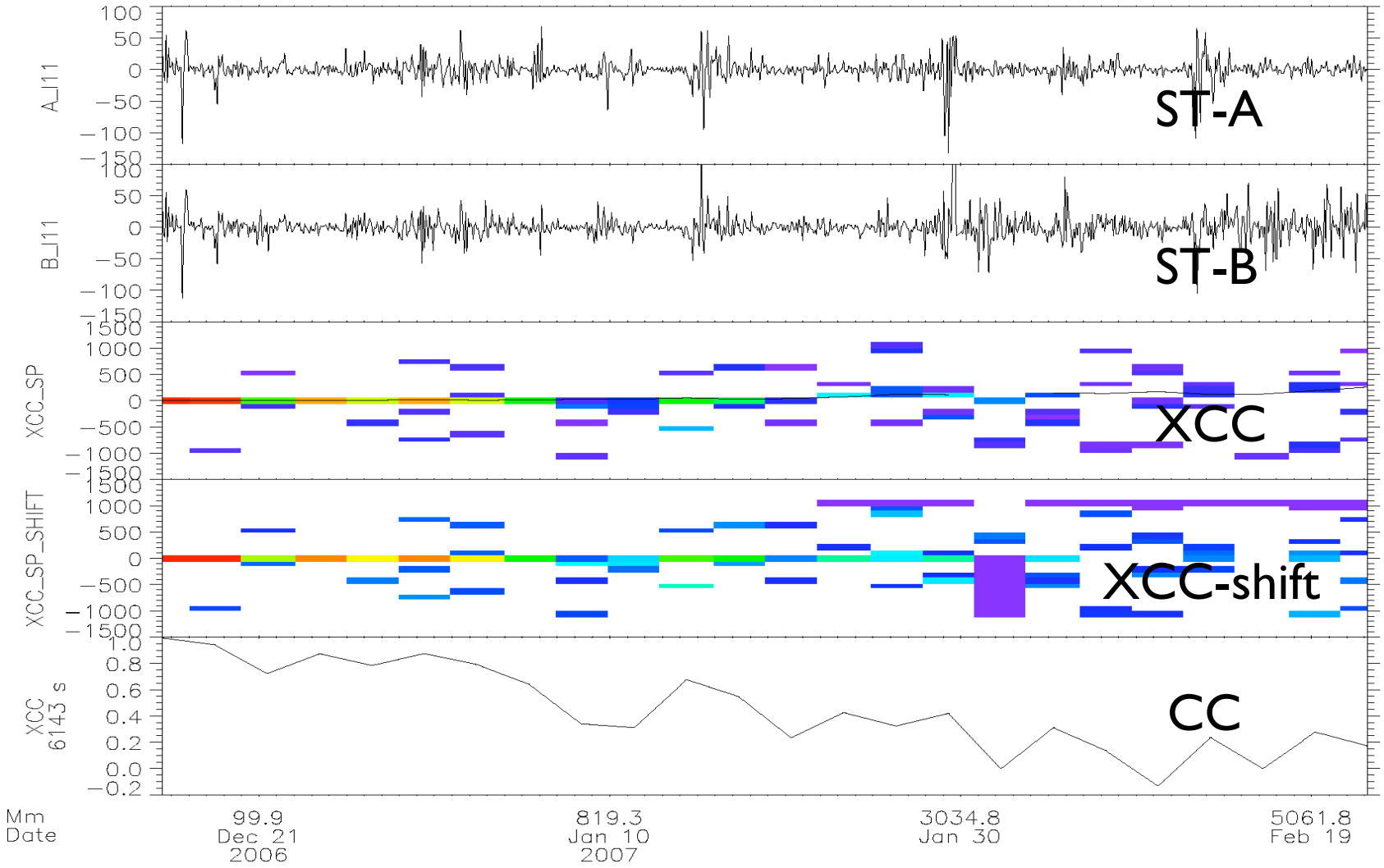


- sums and difference
- orthogonal
- 13 (pseudo-log) wavelet scales
  - from 16s to 65536s (16s to 18h)

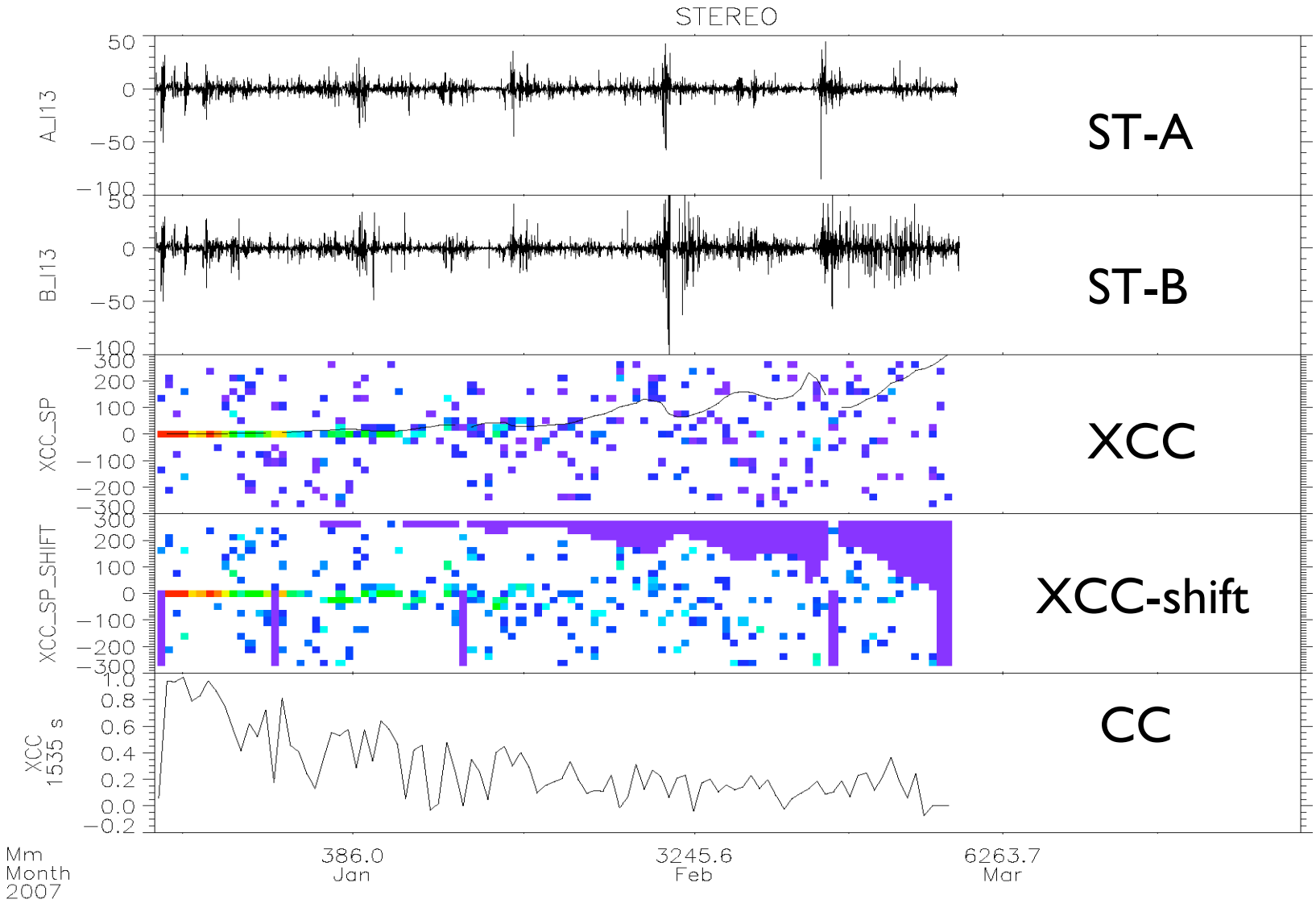
cross-correlations - 24756 s



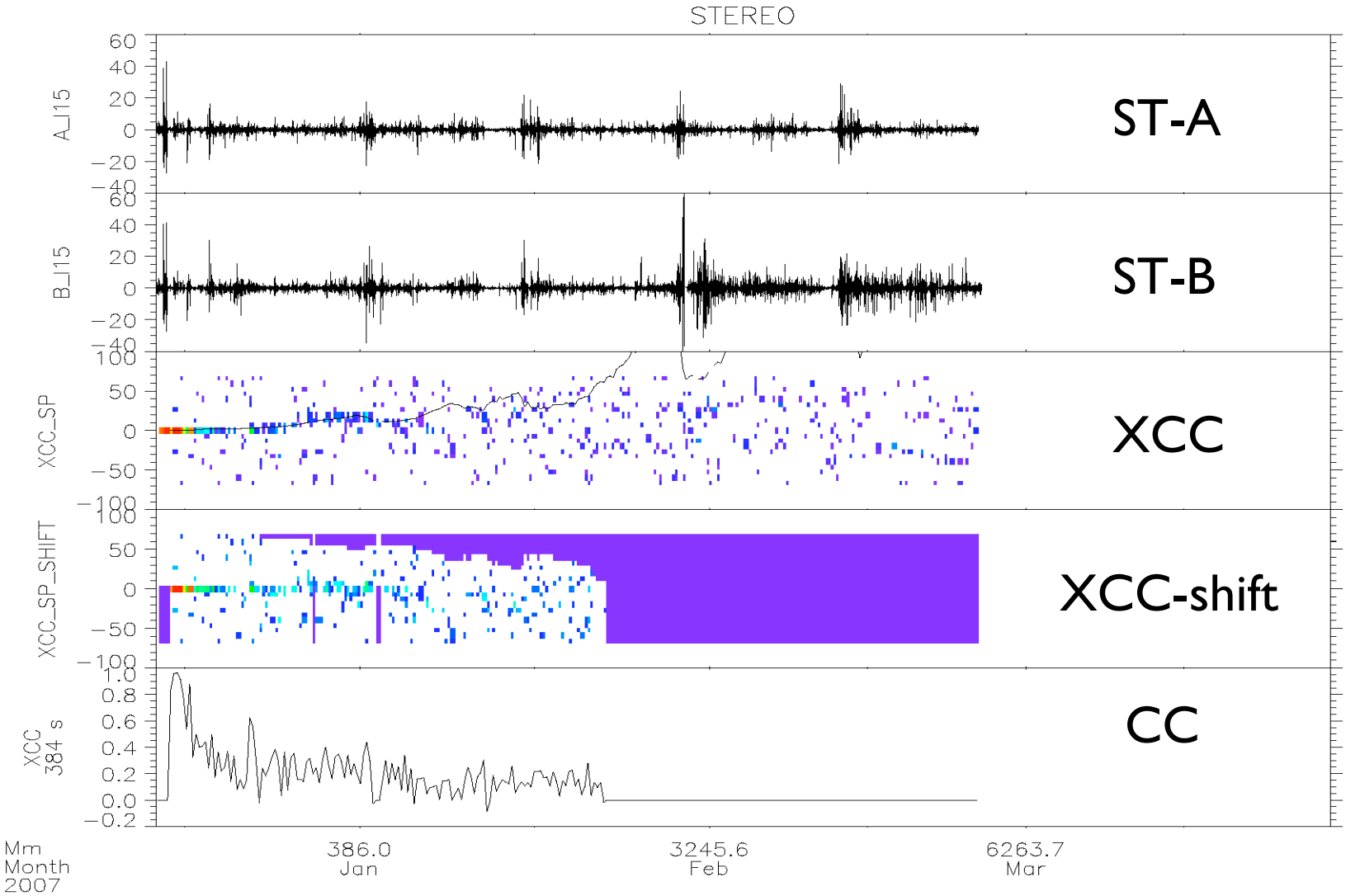
cross-correlations - 6143 s



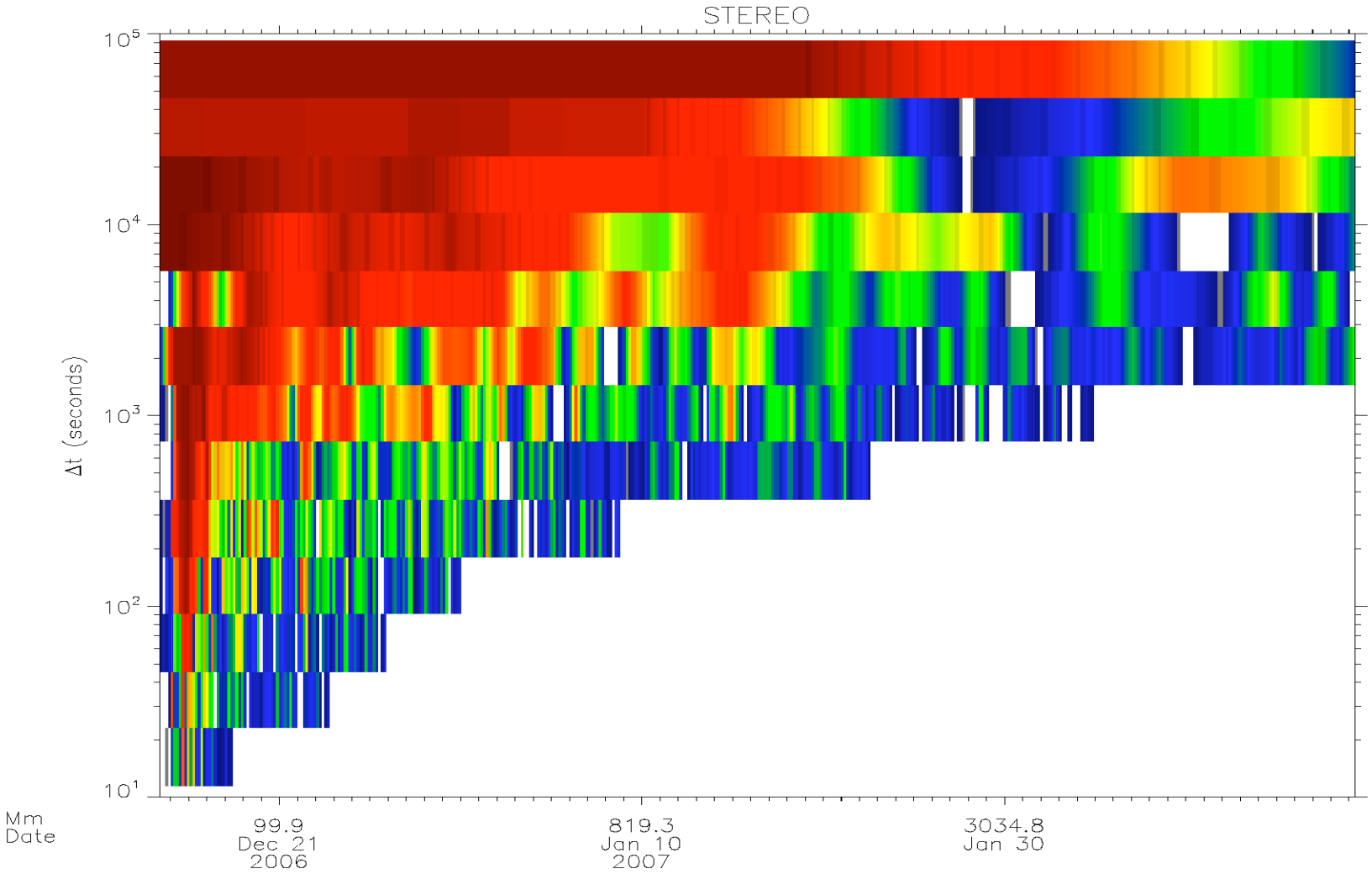
cross-correlations - 1535 s



cross-correlations - 384 s



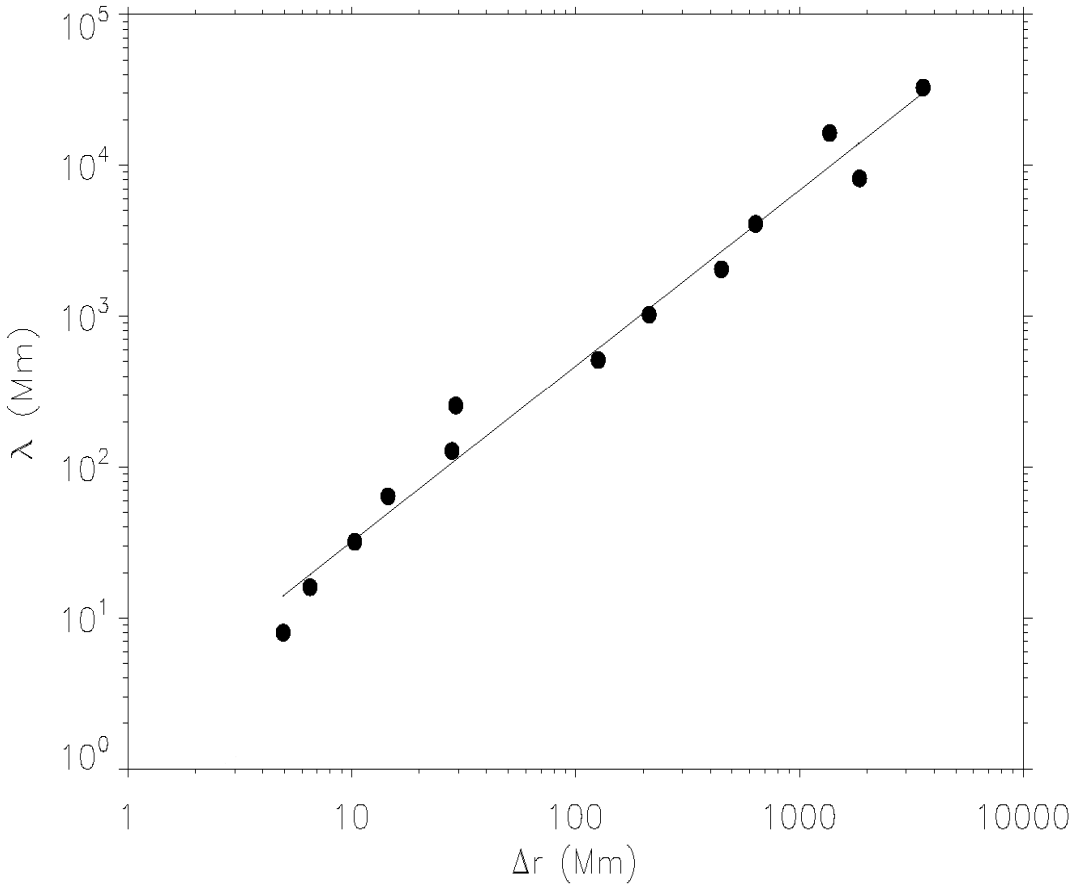
Spectrum of shifted cross-correlations



correlation wavelength

correlation time δt
- 3dB of XCC

correlation wavelength
- $v_{sw} * \delta t$

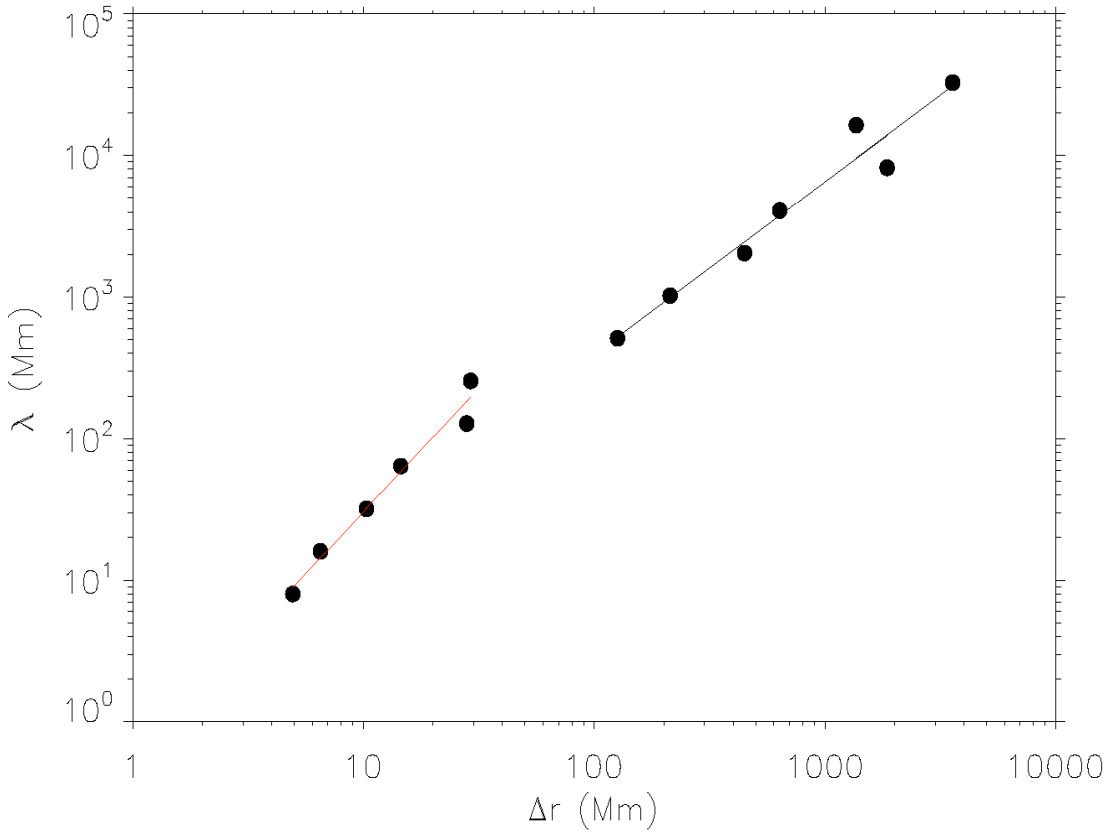


correlation wavelength

correlation time δt
- 3dB of XCC

correlation wavelength
- $v_{sw} * \delta t$

A broken power-law?



summary

- Conclusion: correlation length is a function of wavenumber - there is no apparent ‘single’ value

- Much more work to do…
  - vector B, S/WAVES APM
  - angle to Parker spiral
  - dynamic wavelength correction (for v_{sw})
  - interpretation…