Signal extraction through higher-order statistics

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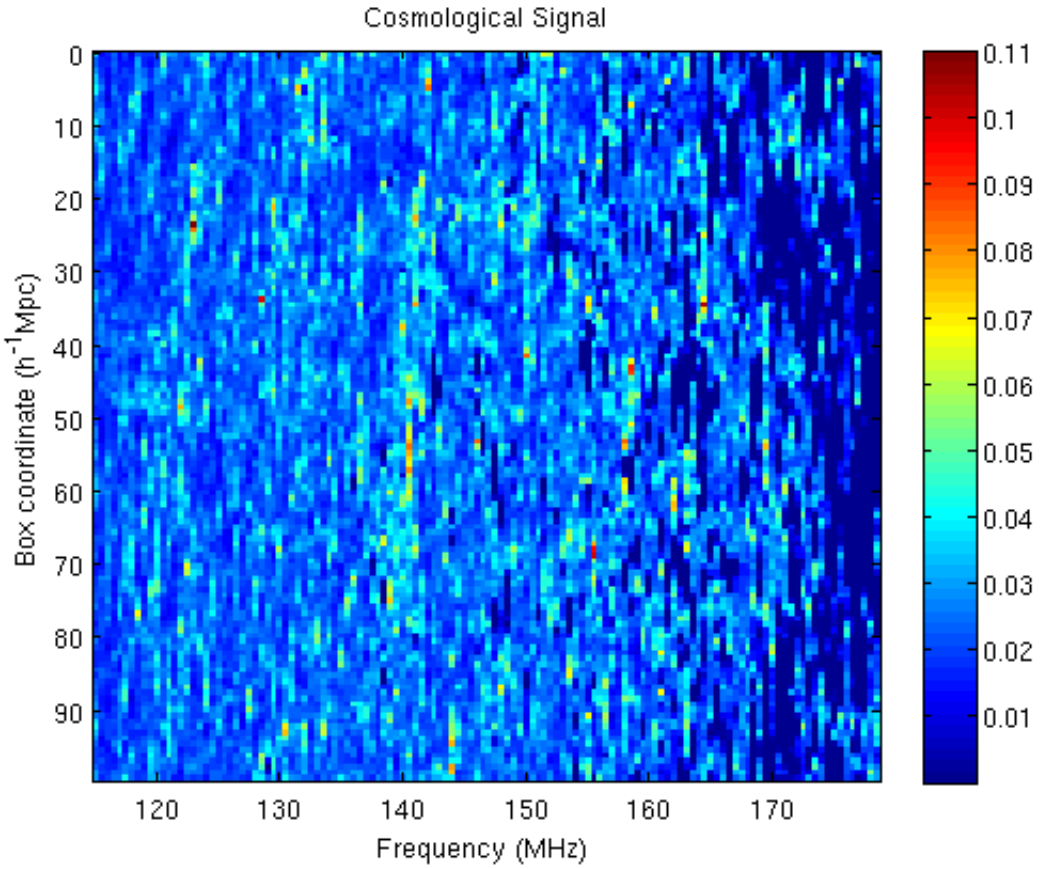
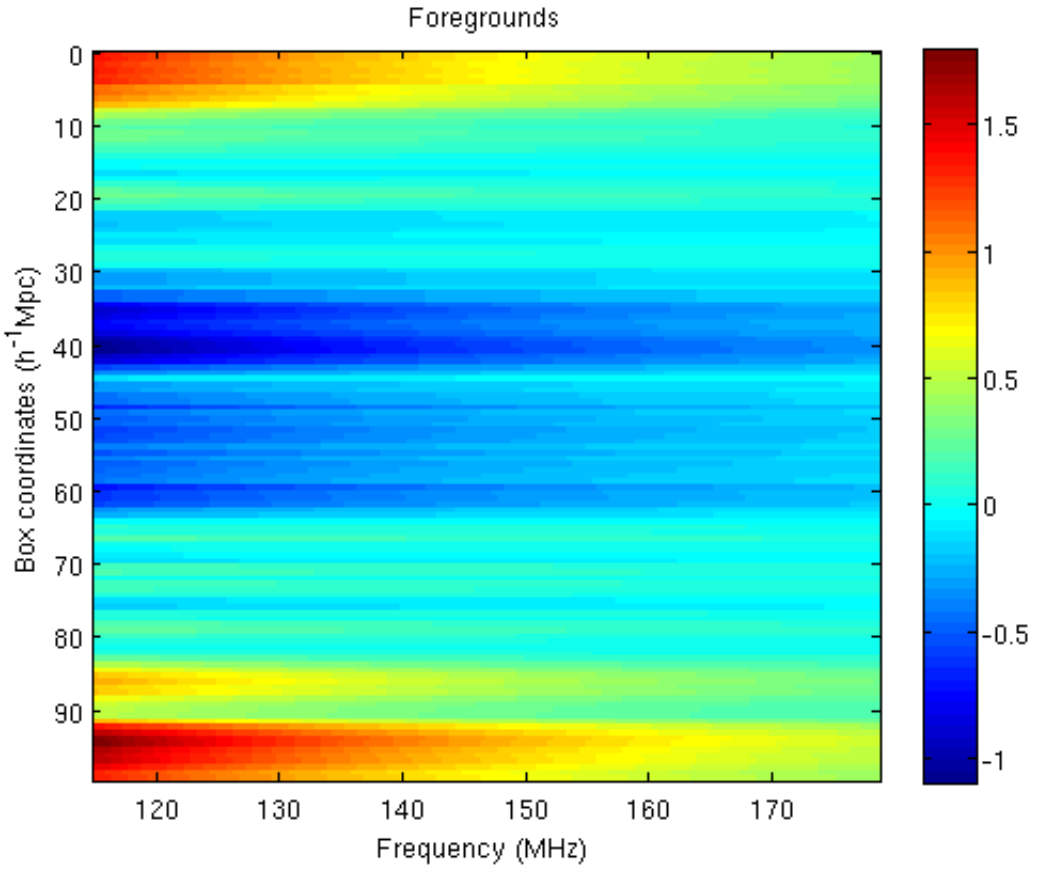
The problem

- Extract a cosmological signal from a datacube, the three axes of which are x and y positions, and frequency.
- Consider three components:
  - The cosmological signal itself;
  - Astrophysical foregrounds;
  - Noise.
- Should the signal have any special properties which should enable us to tease it out?

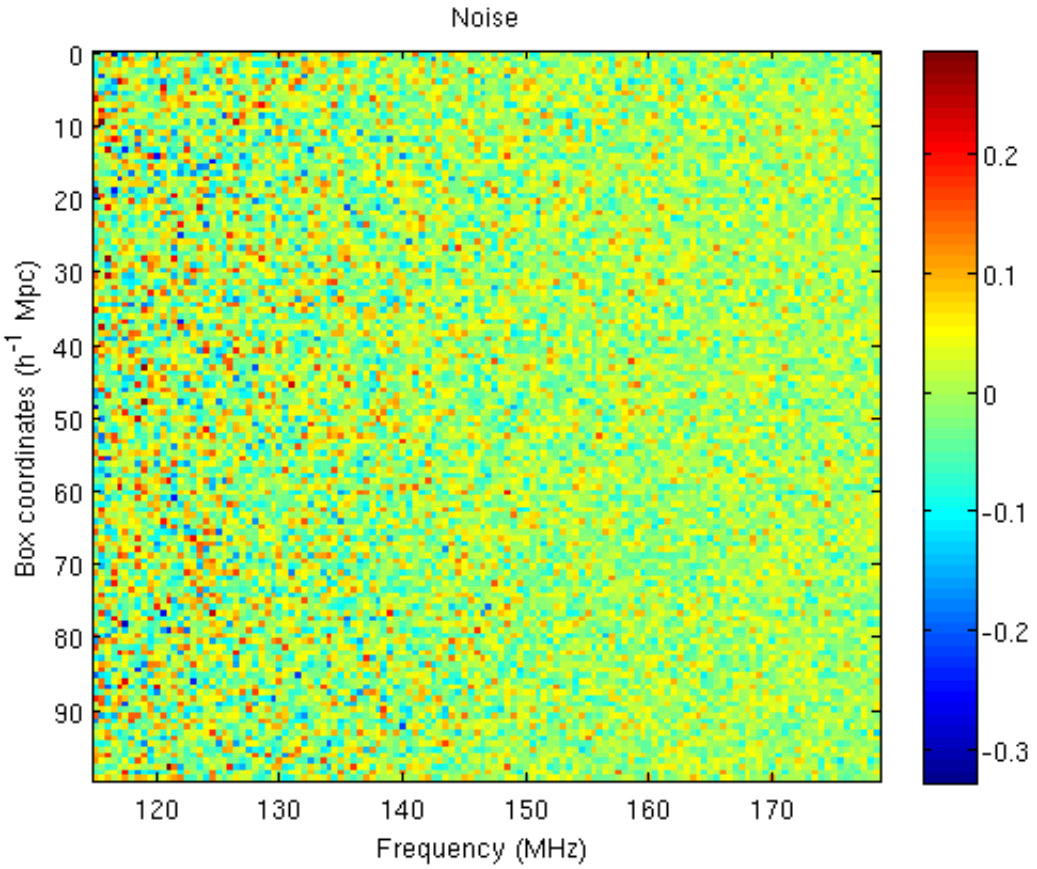
Cosmological signal



Foregrounds

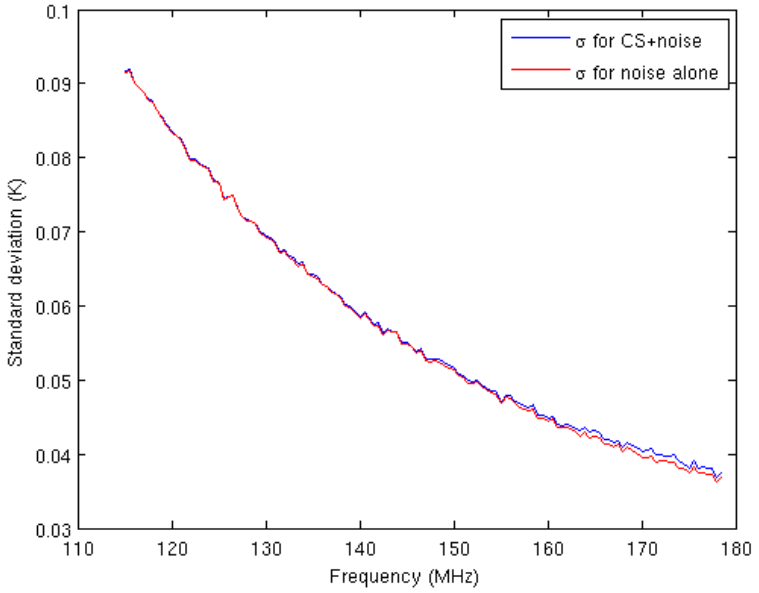


Noise

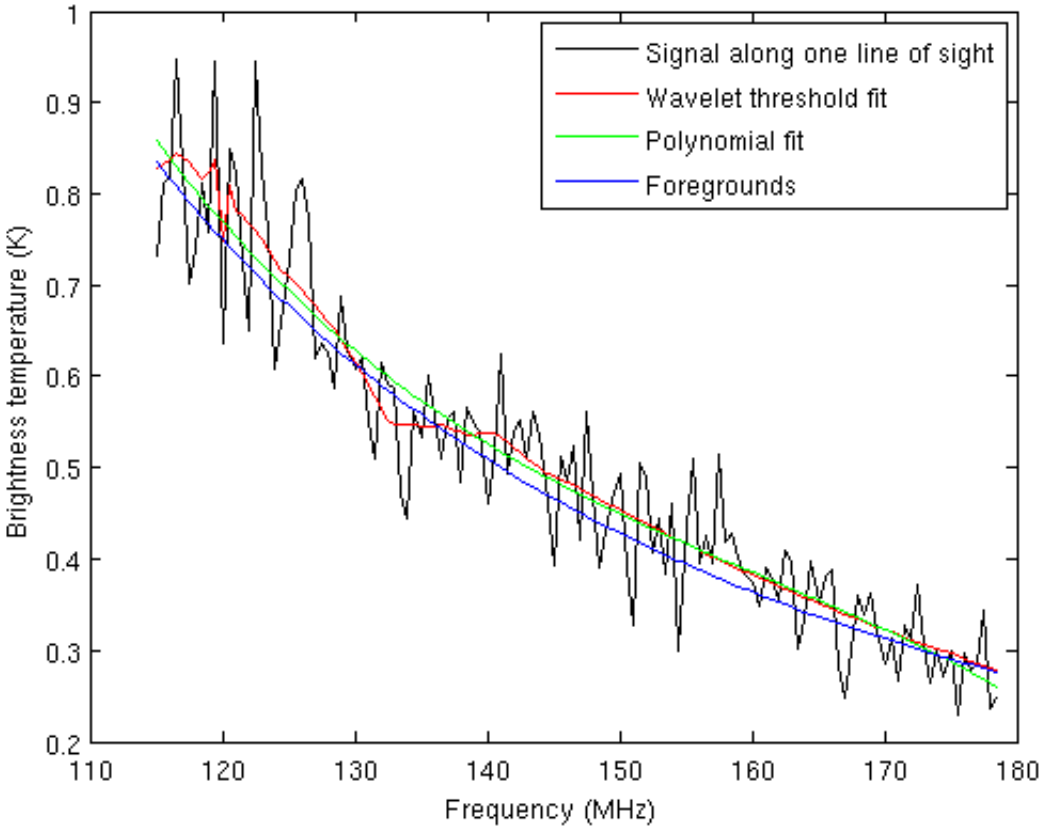

Noise
0
10
20
30
40
50
60
70
80
90
Box coordinates (h^{-1} Mpc)
120
130
140
150
160
170
Frequency (MHz)
0.2
0.1
0
-0.1
-0.2
-0.3

Detecting excess variance

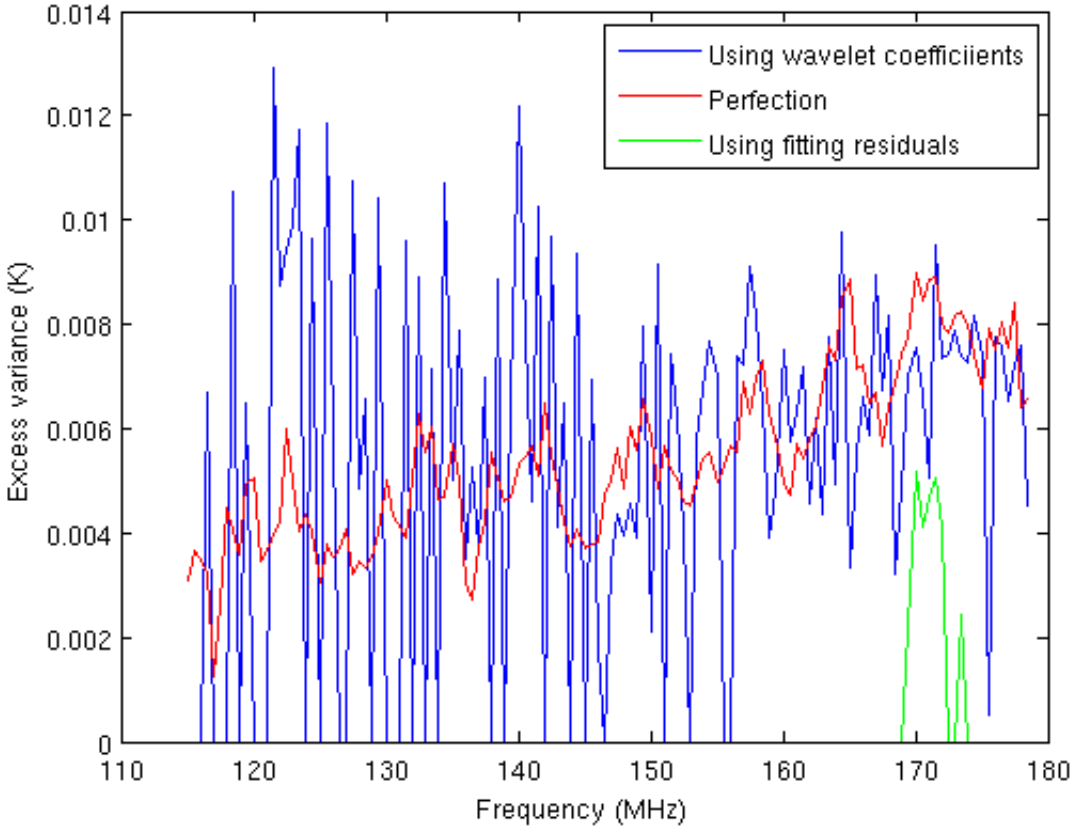
- Fit the (smooth) foregrounds as a function of frequency for each line of sight.
- Calculate the variance of the residuals.
- Subtract the (presumed known) noise variance.
- Alternatively: estimate the variance of CS+noise from fine-scale wavelet coefficients, then subtract the noise variance.



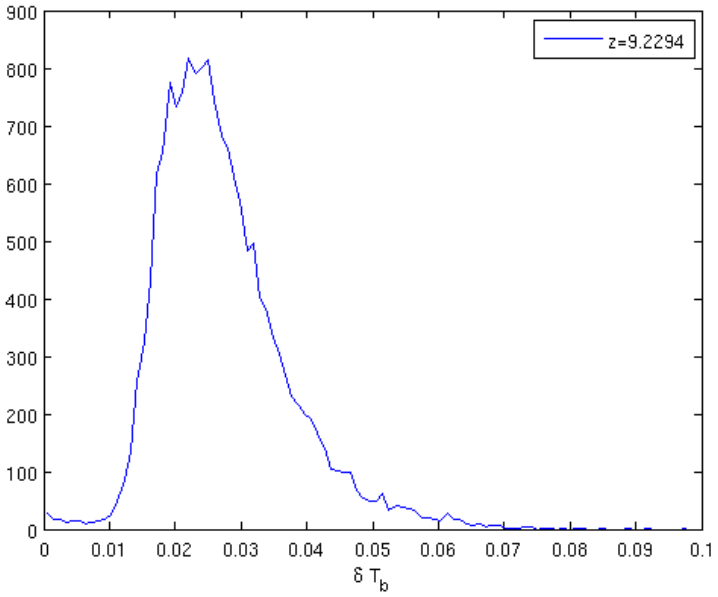
One line of sight

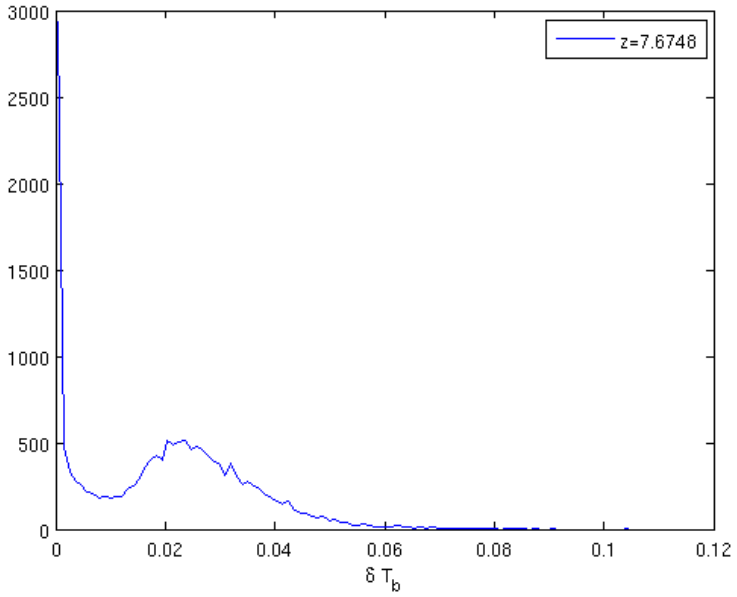


Comparison

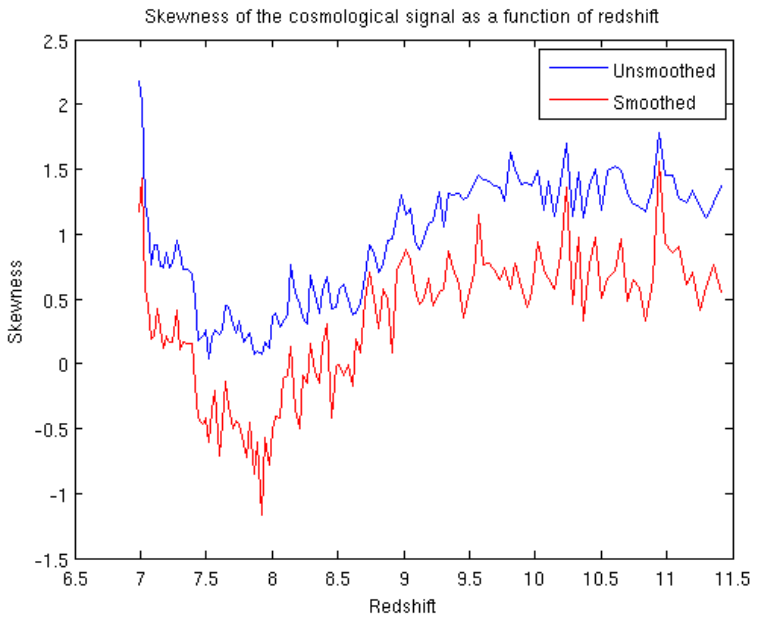

Using wavelet coefficiients
Perfection
Using fitting residuals
Excess variance (K)
Frequency (MHz)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
110
120
130
140
150
160
170
180

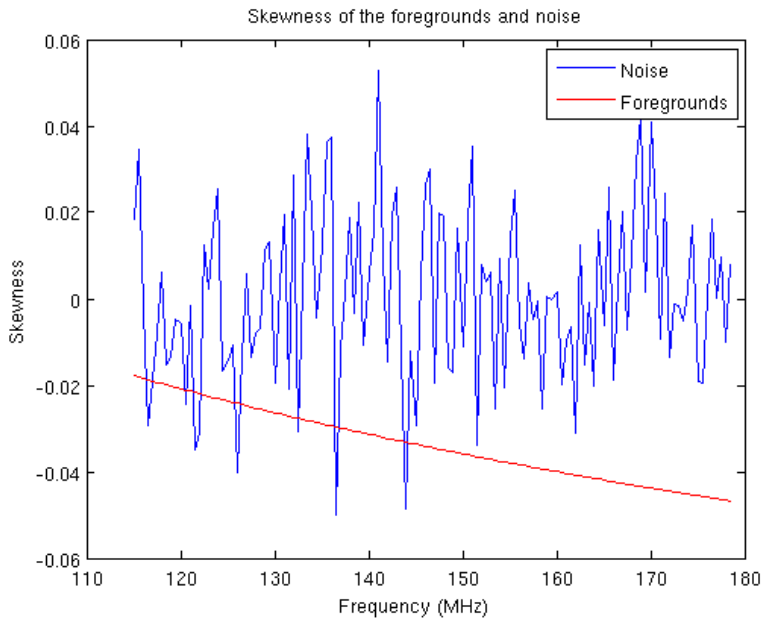
One-point distribution for the cosmological signal



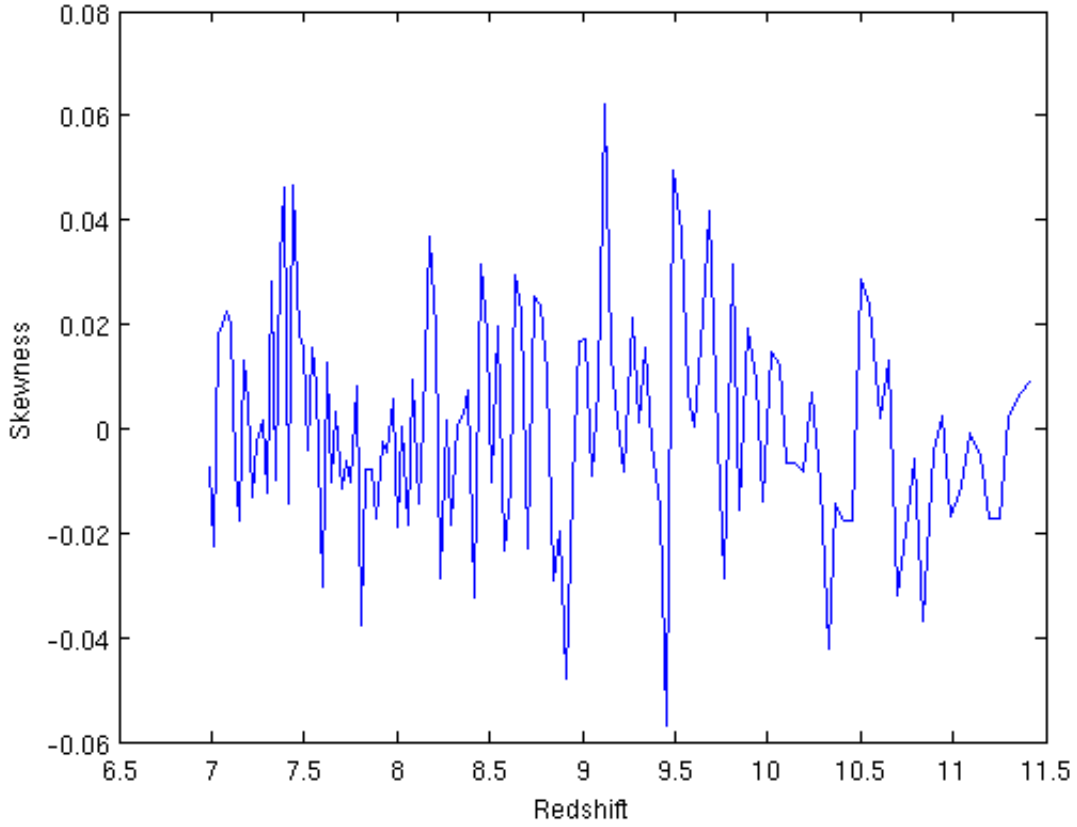


Skewness of the cosmological signal, foregrounds and noise





Skewness of the fitting residuals



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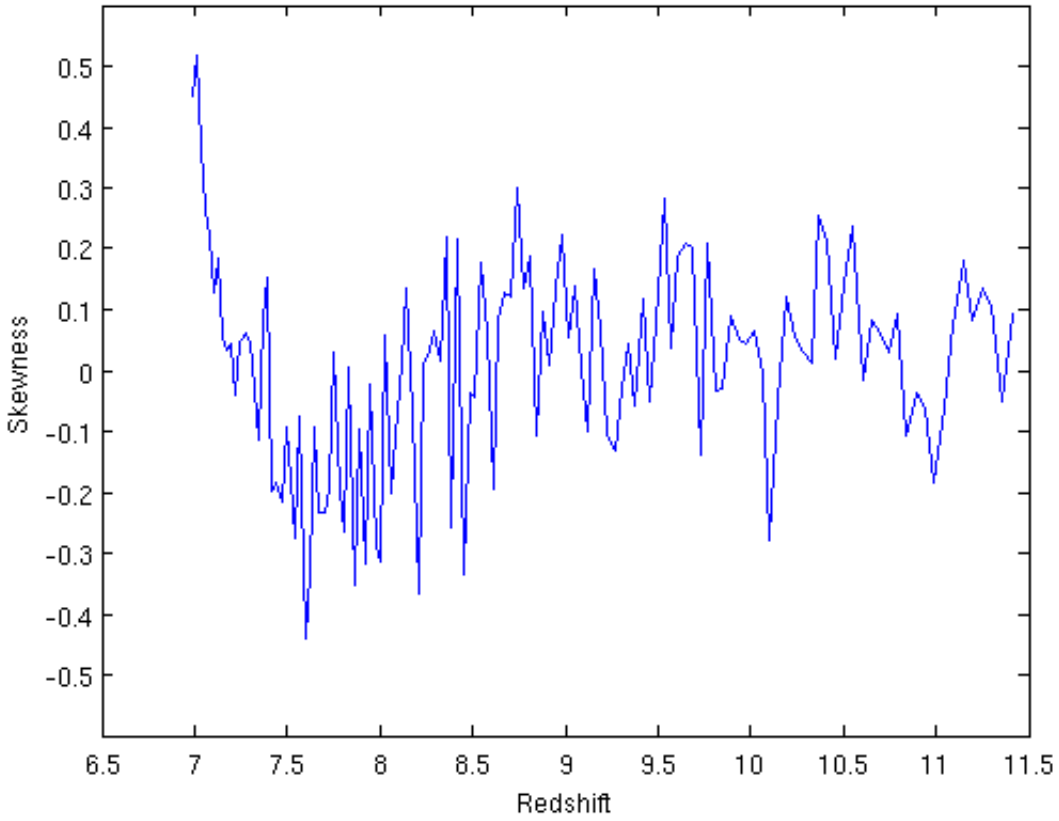

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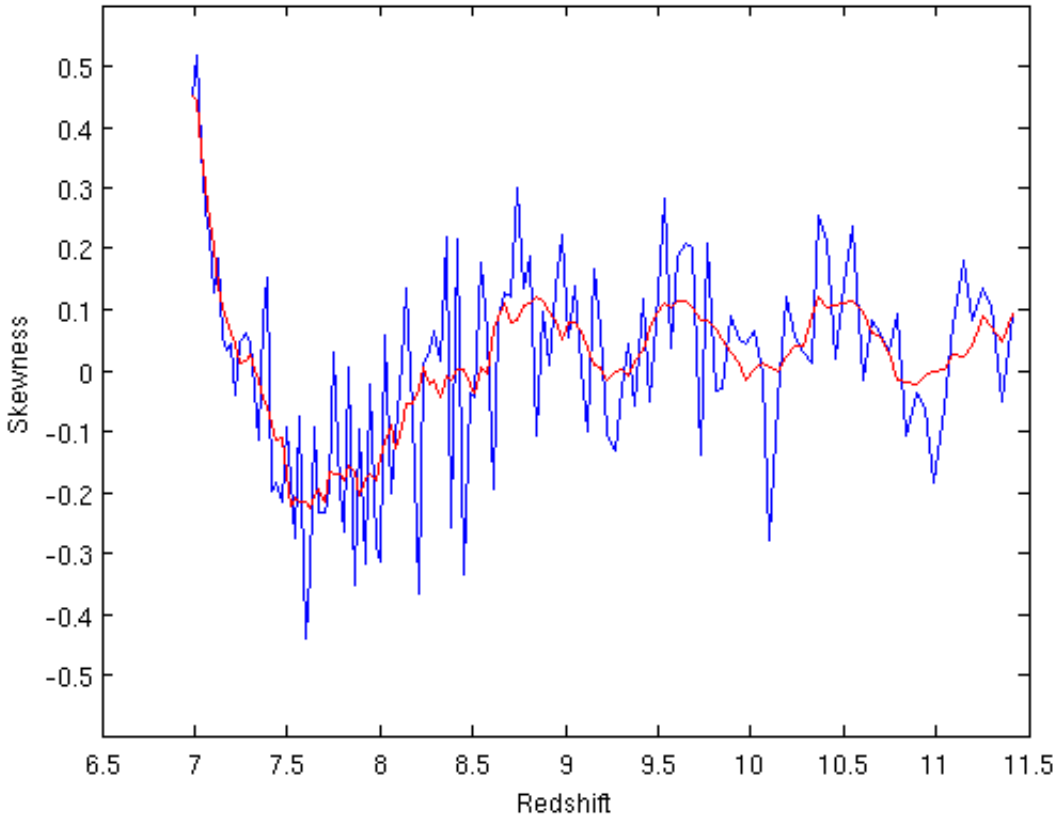
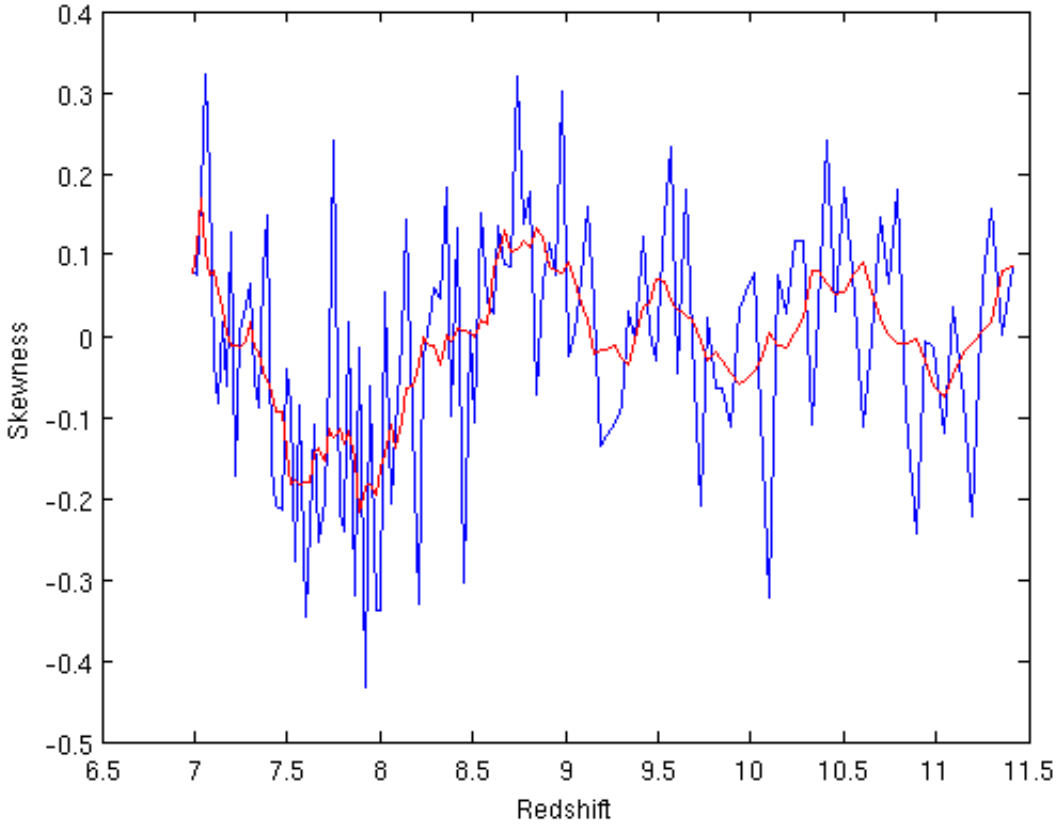


The same thing with wavelets…



Further work and questions

- Work with dirty maps and/or visibilities.
- Investigate other higher-order statistics.
- Check if the trends seen in these statistics and in the skewness are generic: more simulations required?
- Wavelets offer a lot of freedom in the analysis; might they offer a more robust or sophisticated route?
- Require larger boxes to avoid periodic repetitions.
- Can more realistic foregrounds affect extraction of higher order statistics?