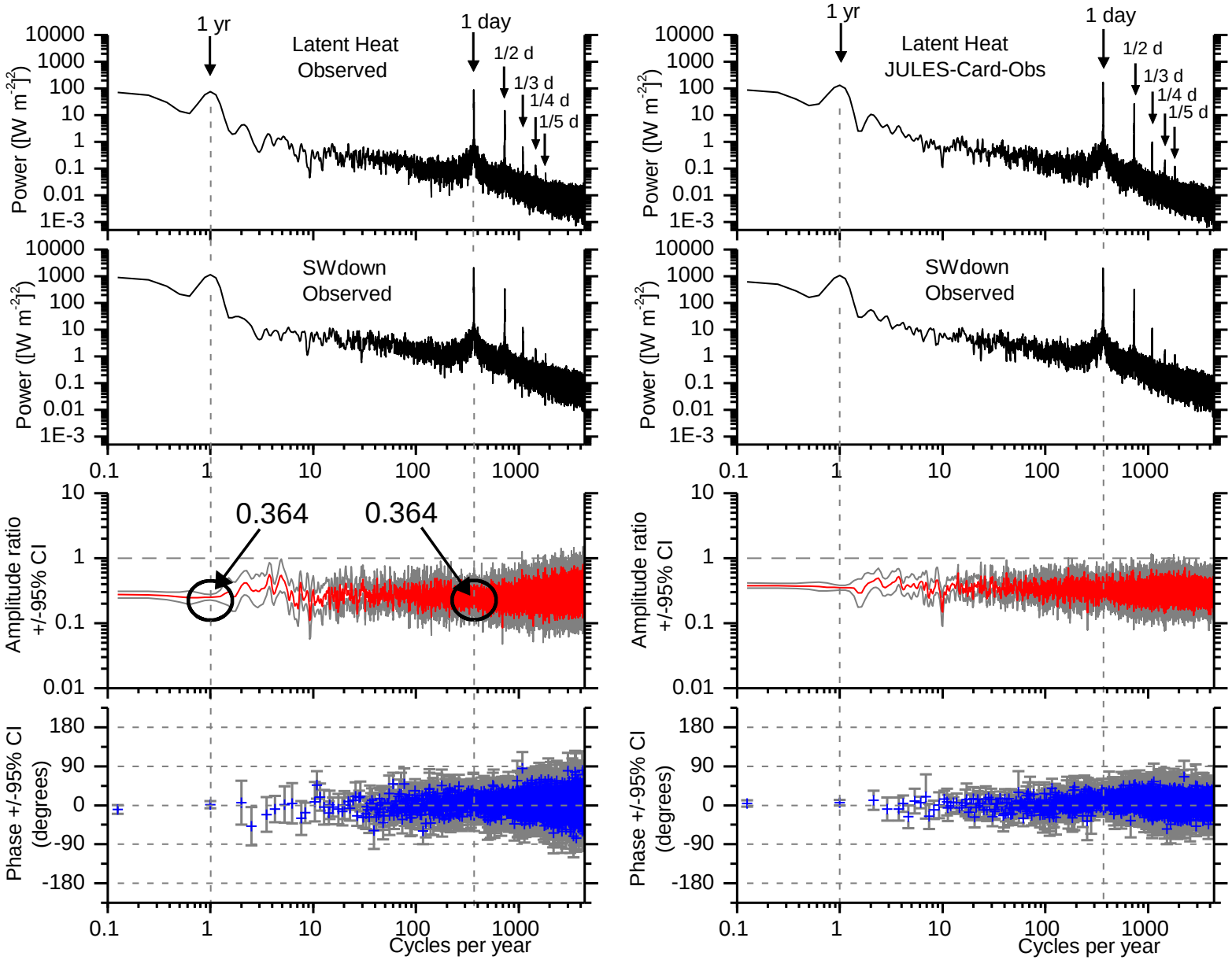
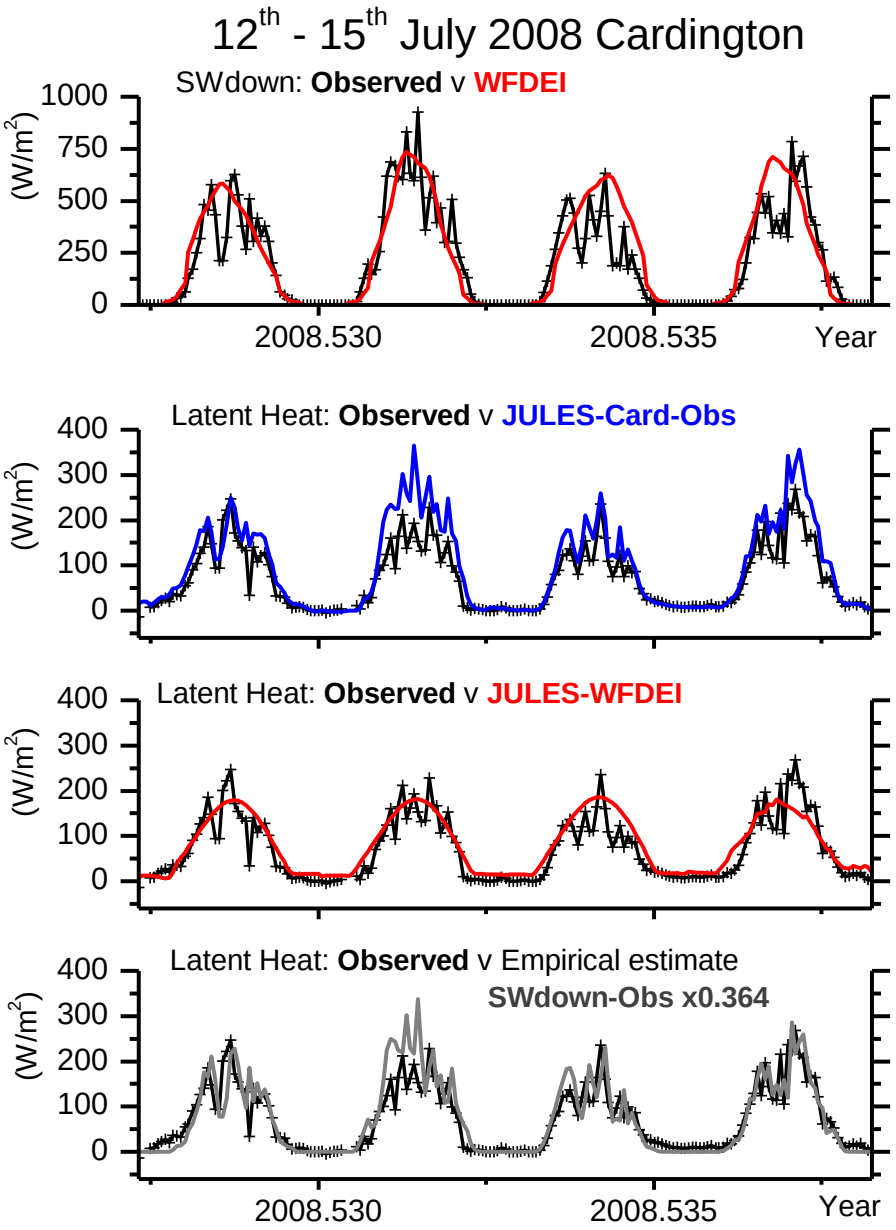
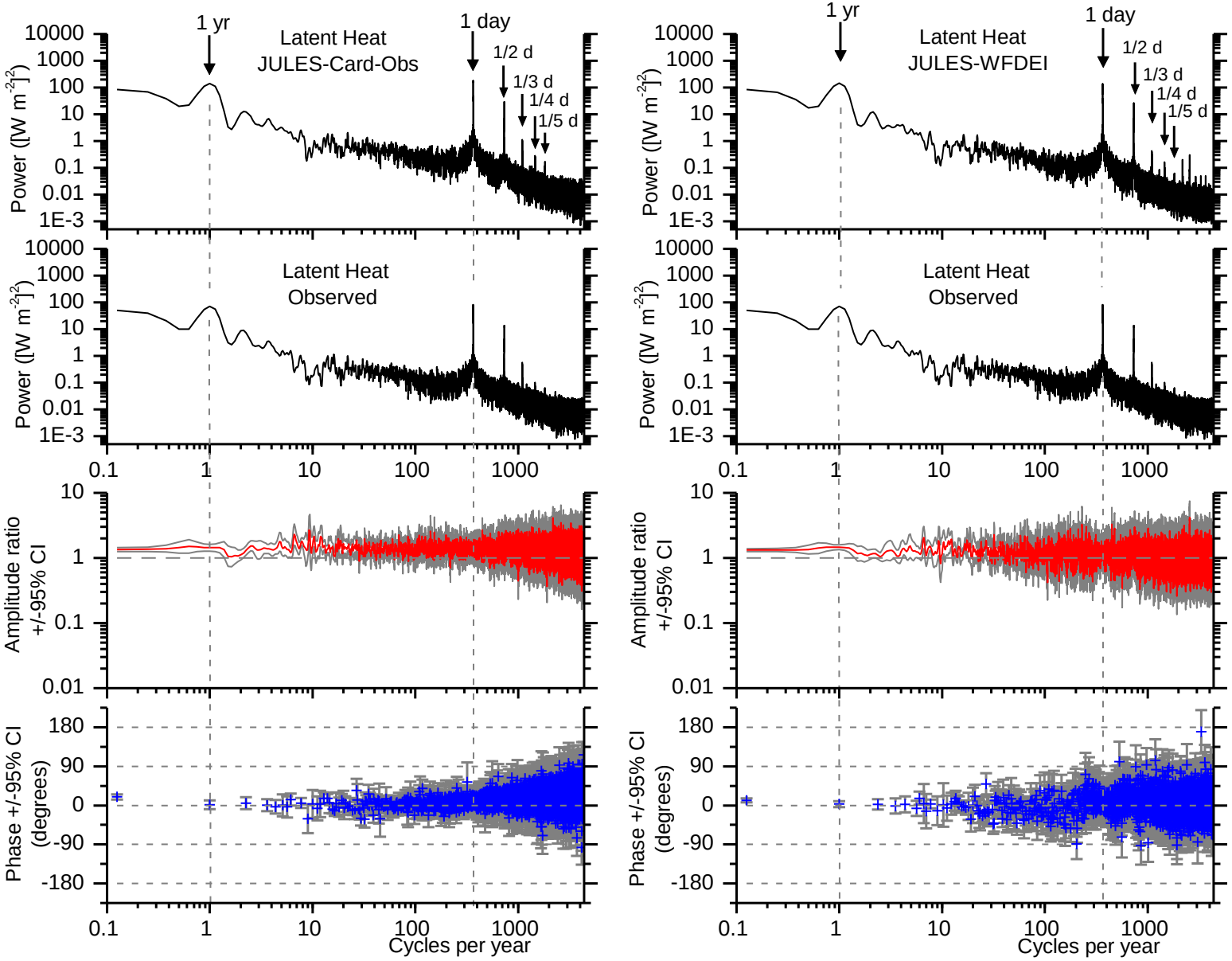
Cardington Transfer functions
Latent Heat v Downwards shortwave flux

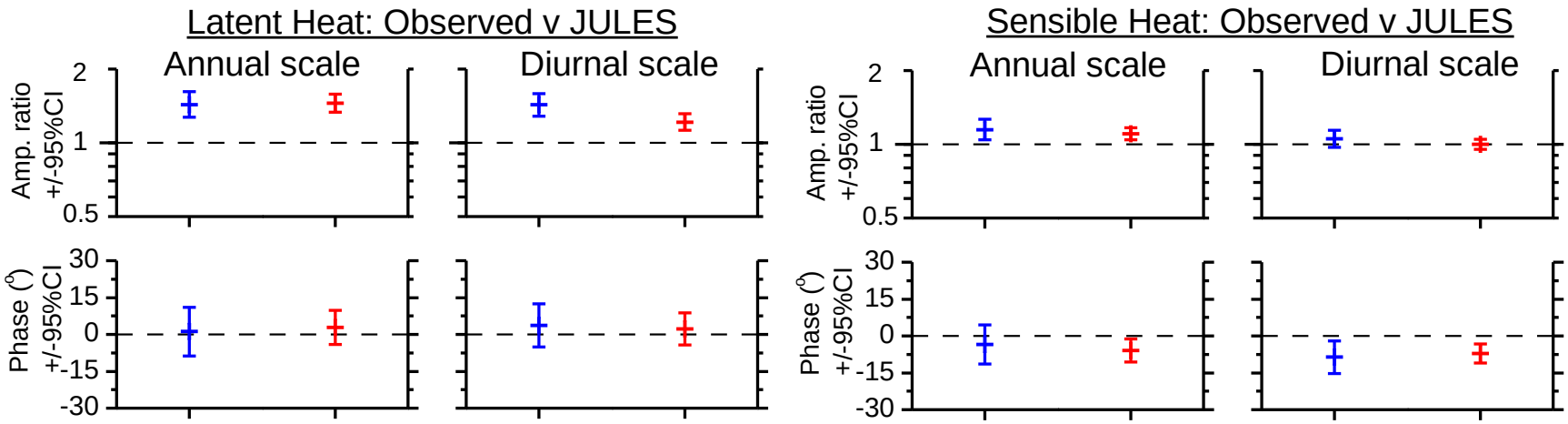



12th - 15th July 2008 Cardington
SWdown: Observed v WFDEI
1000
750
500
250
0
(W/m2)
2008.530
2008.535
Year
Latent Heat: Observed v JULES-Card-Obs
400
300
200
100
0
(W/m2)
Latent Heat: Observed v JULES-WFDEI
400
300
200
100
0
(W/m2)
Latent Heat: Observed v Empirical estimate
SWdown-Obs x0.364
400
300
200
100
0
(W/m2)
2008.530
2008.535
Year

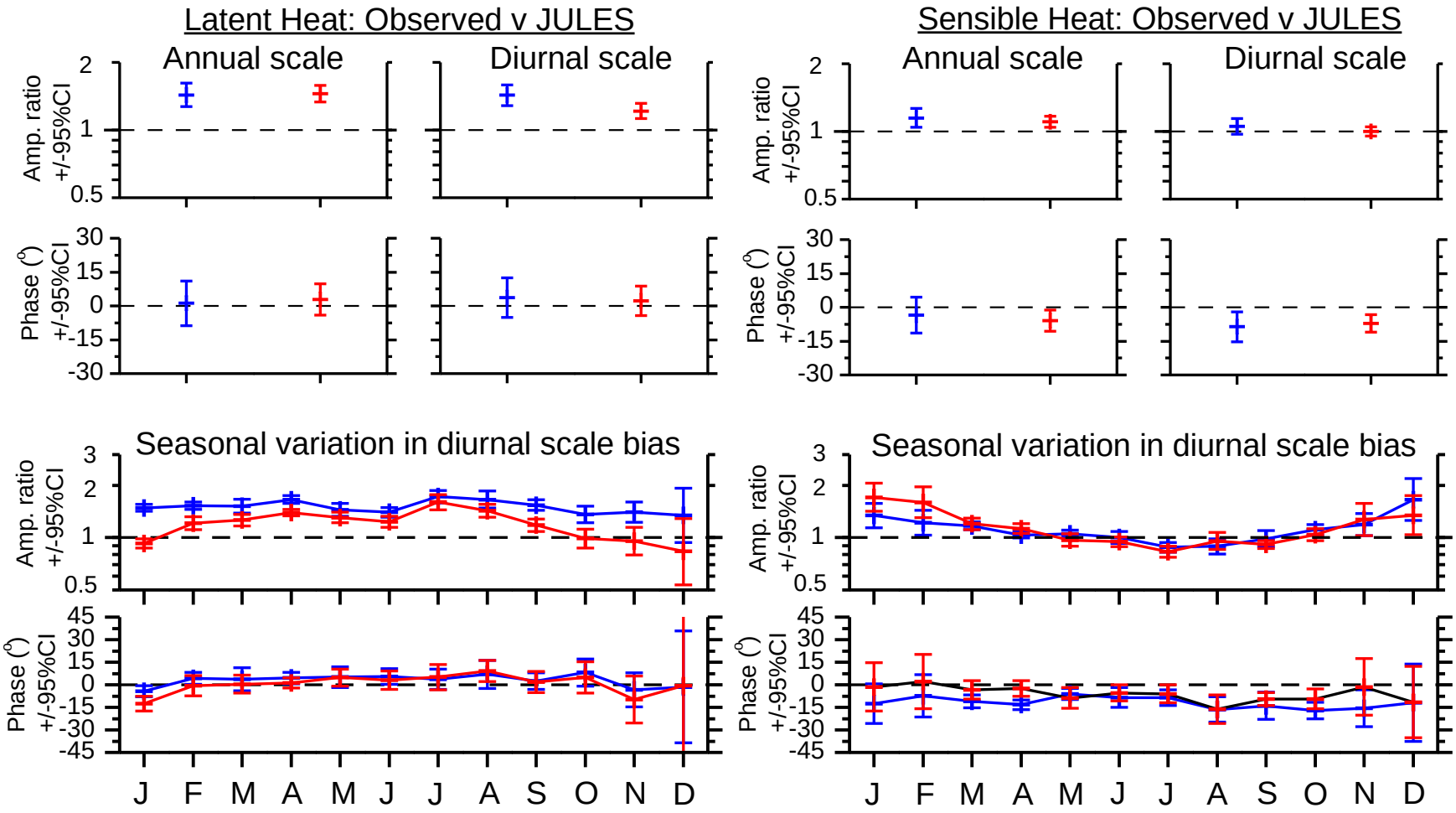
Cardington Evaluation of output variable JULES Latent Heat v Observed Latent Heat



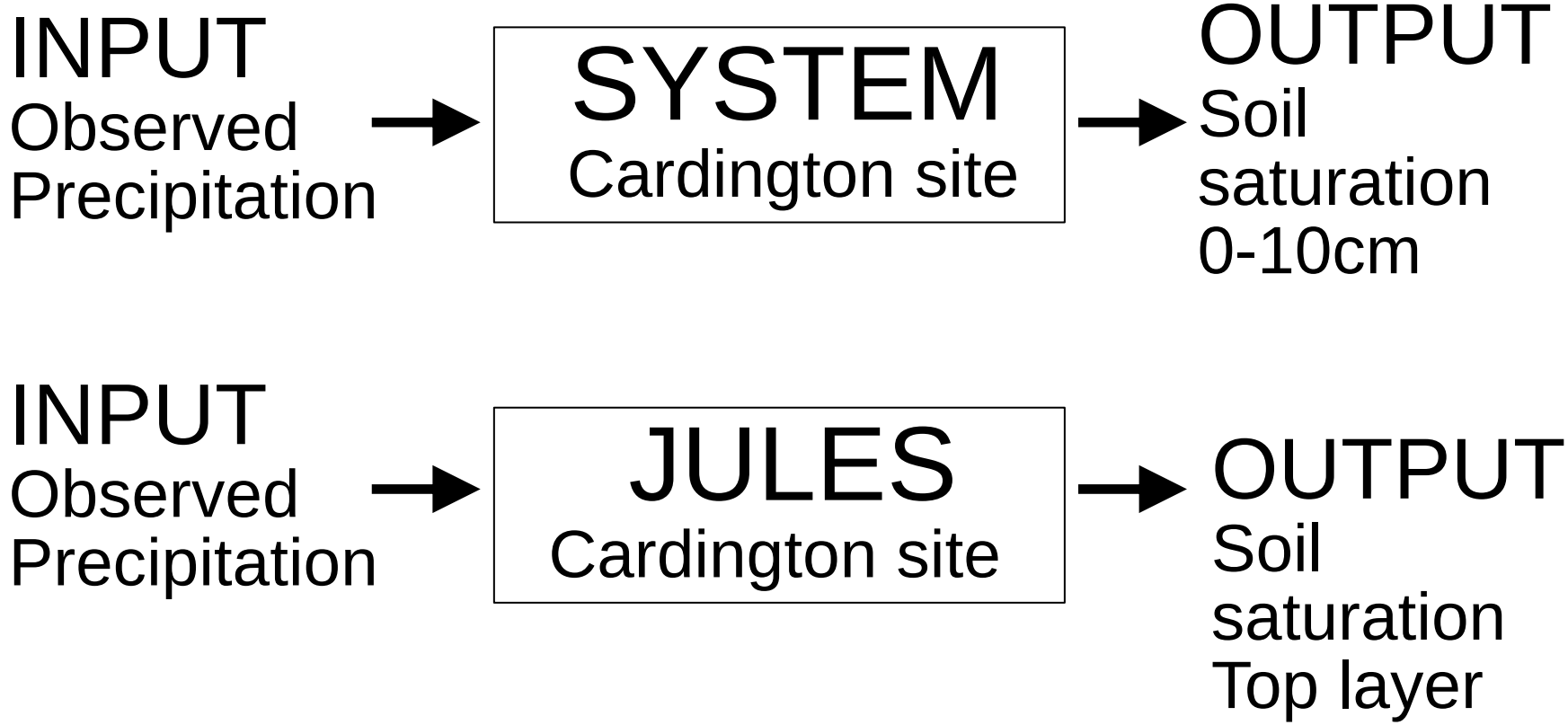
Comparing bias according to forcing data: **JULES-Card-Obs** and **JULES-WFDEI**



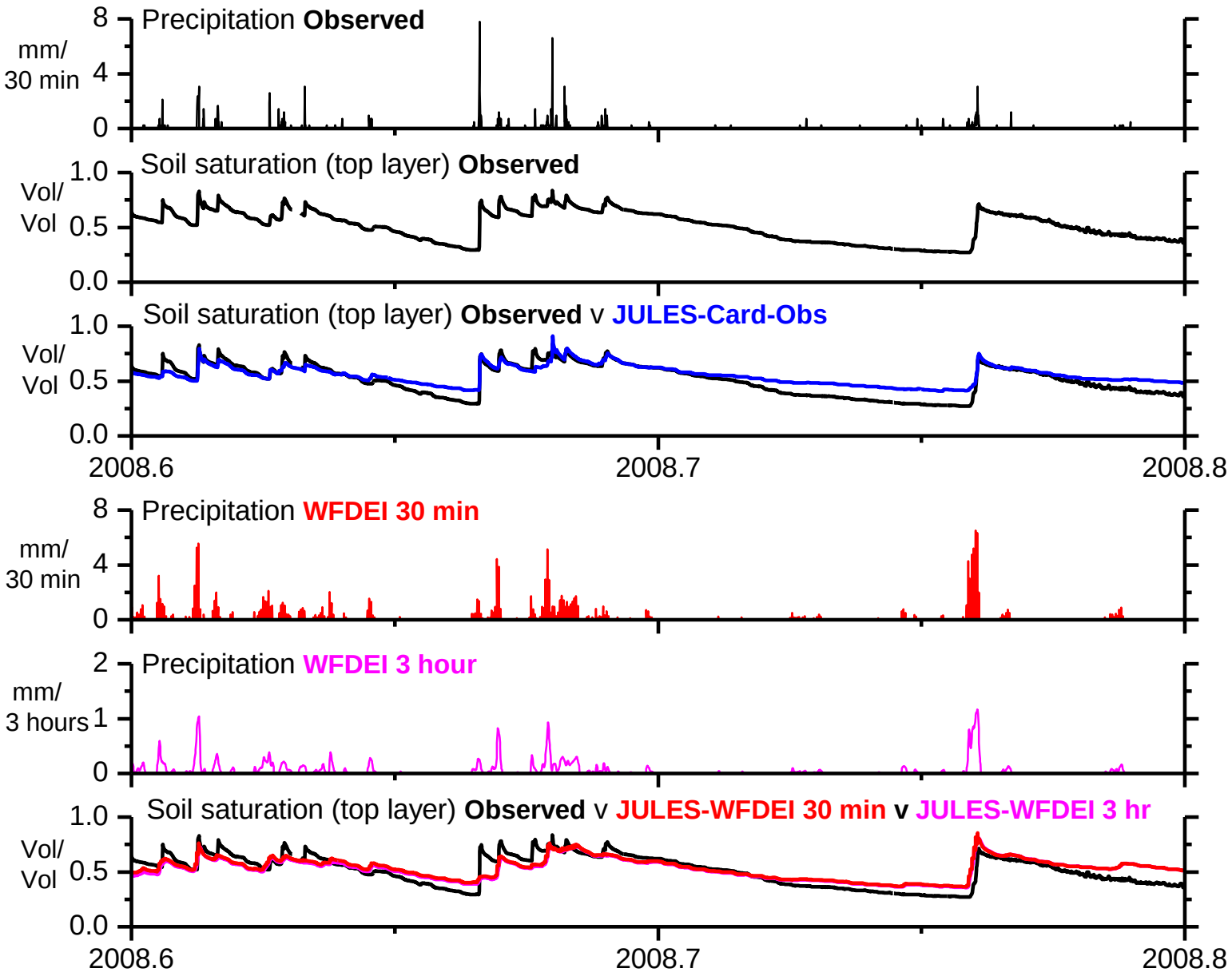
Comparing bias according to forcing data: **JULES-Card-Obs** and **JULES-WFDEI**



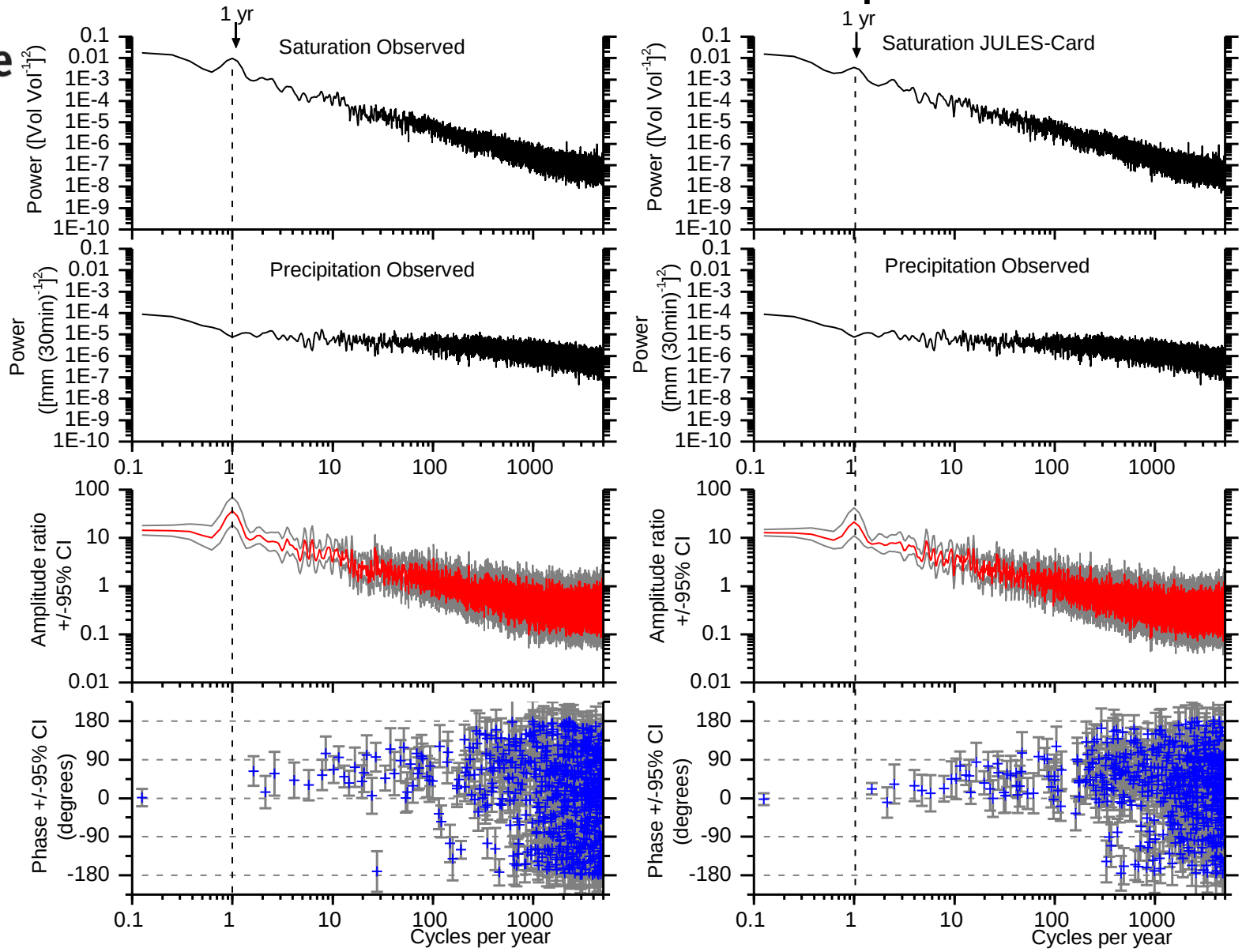
Frequency response from the spectral transfer function



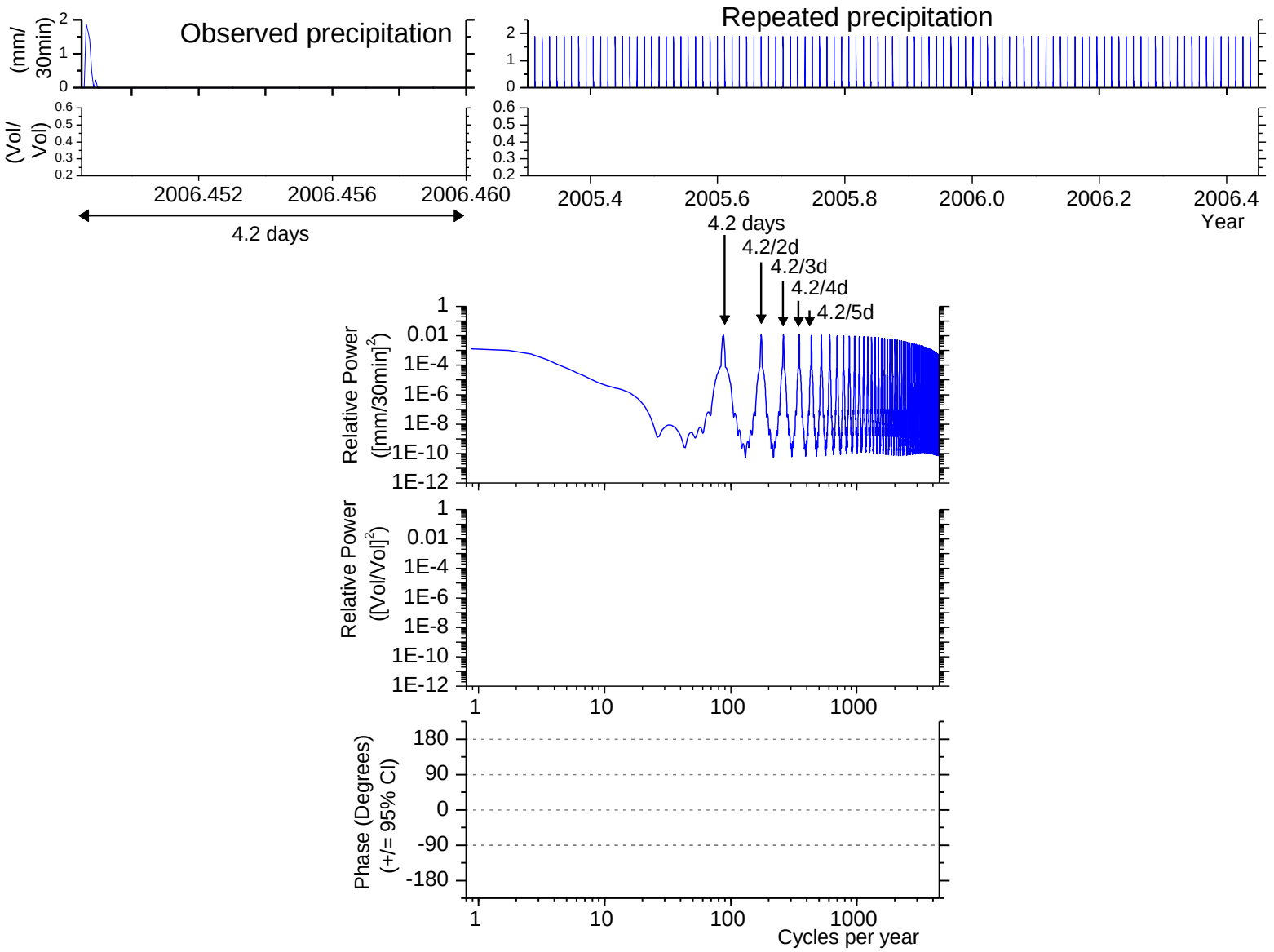
Precipitation and top-layer soil saturation



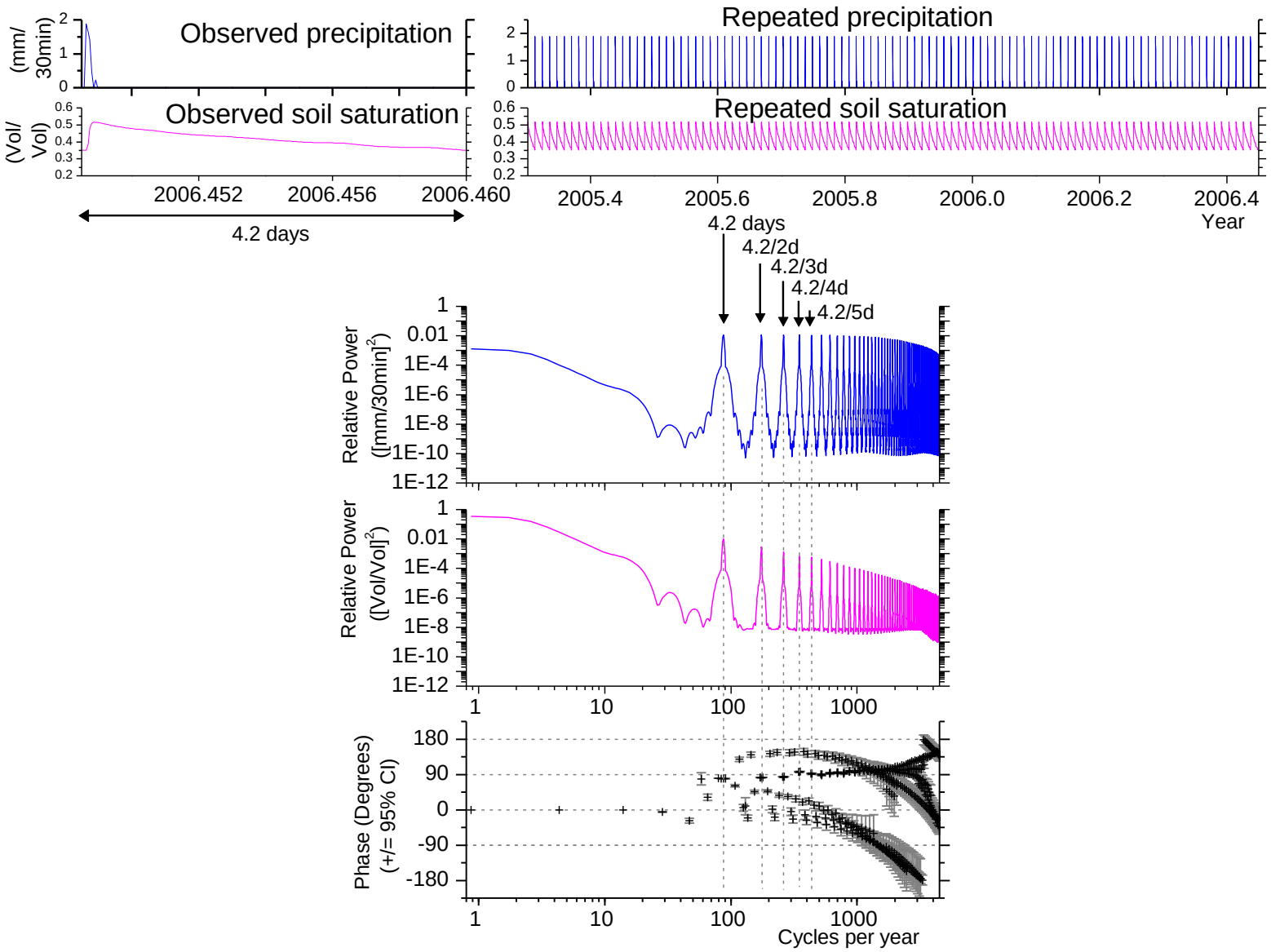
Cardington Transfer functions
Soil saturation v Precipitation



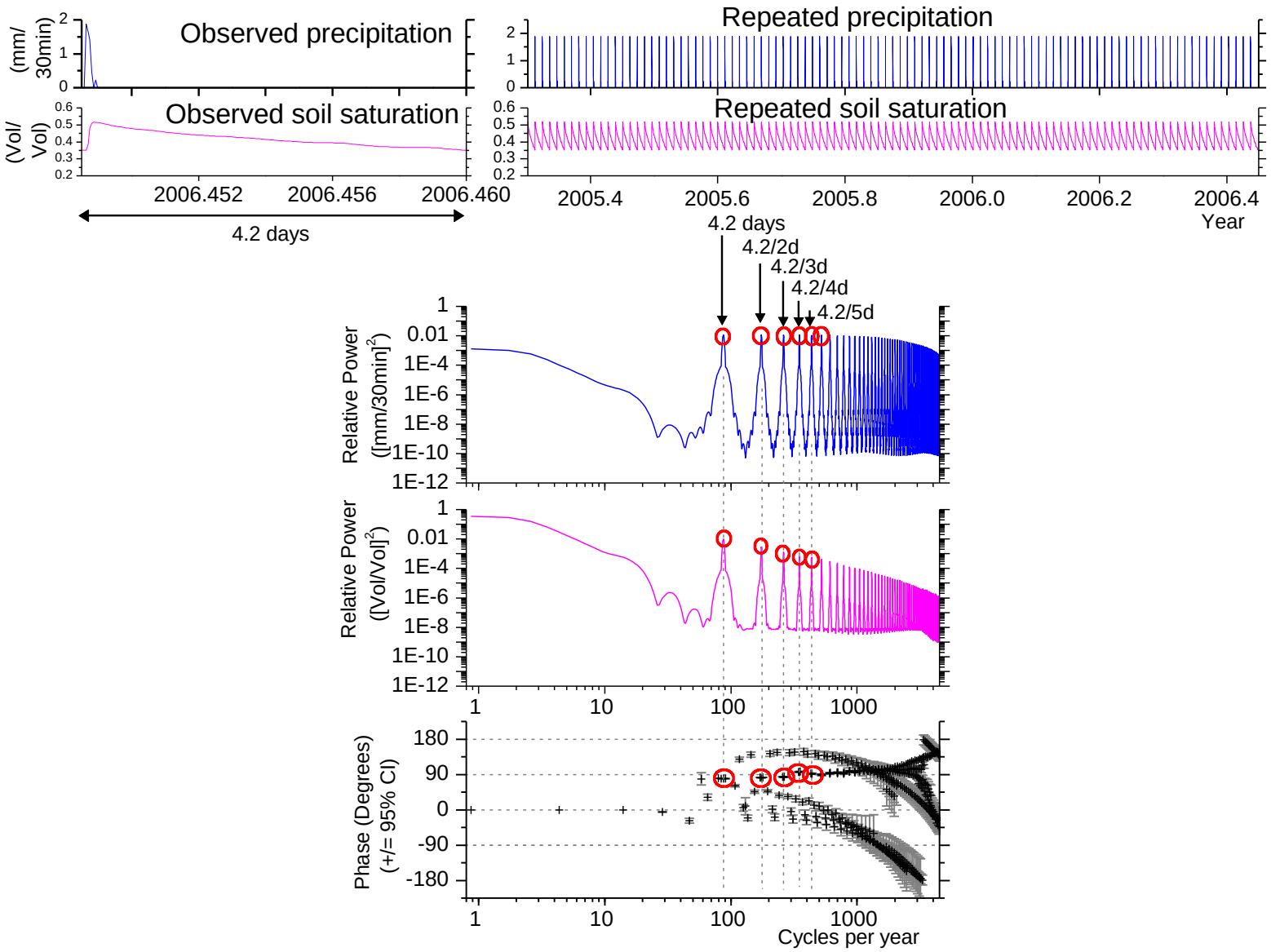
Investigating the phase of impulse v. response (soil saturation variations after precipitation events)

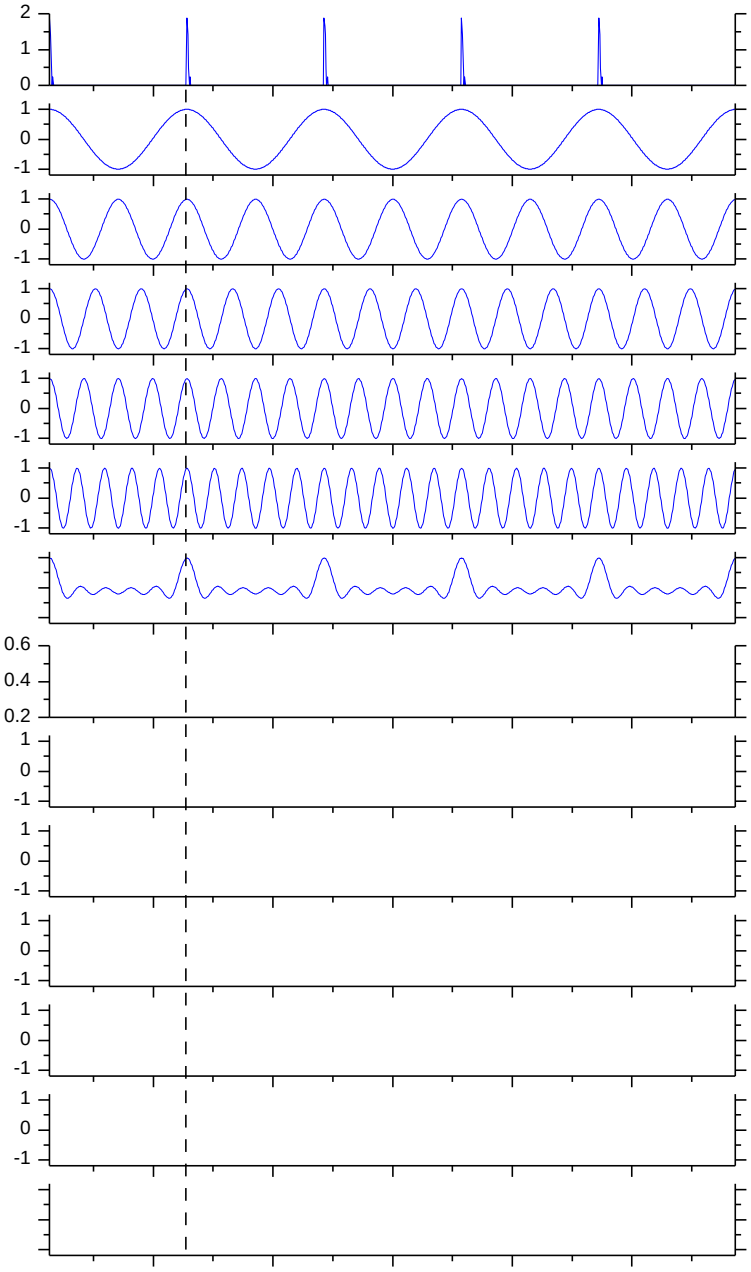


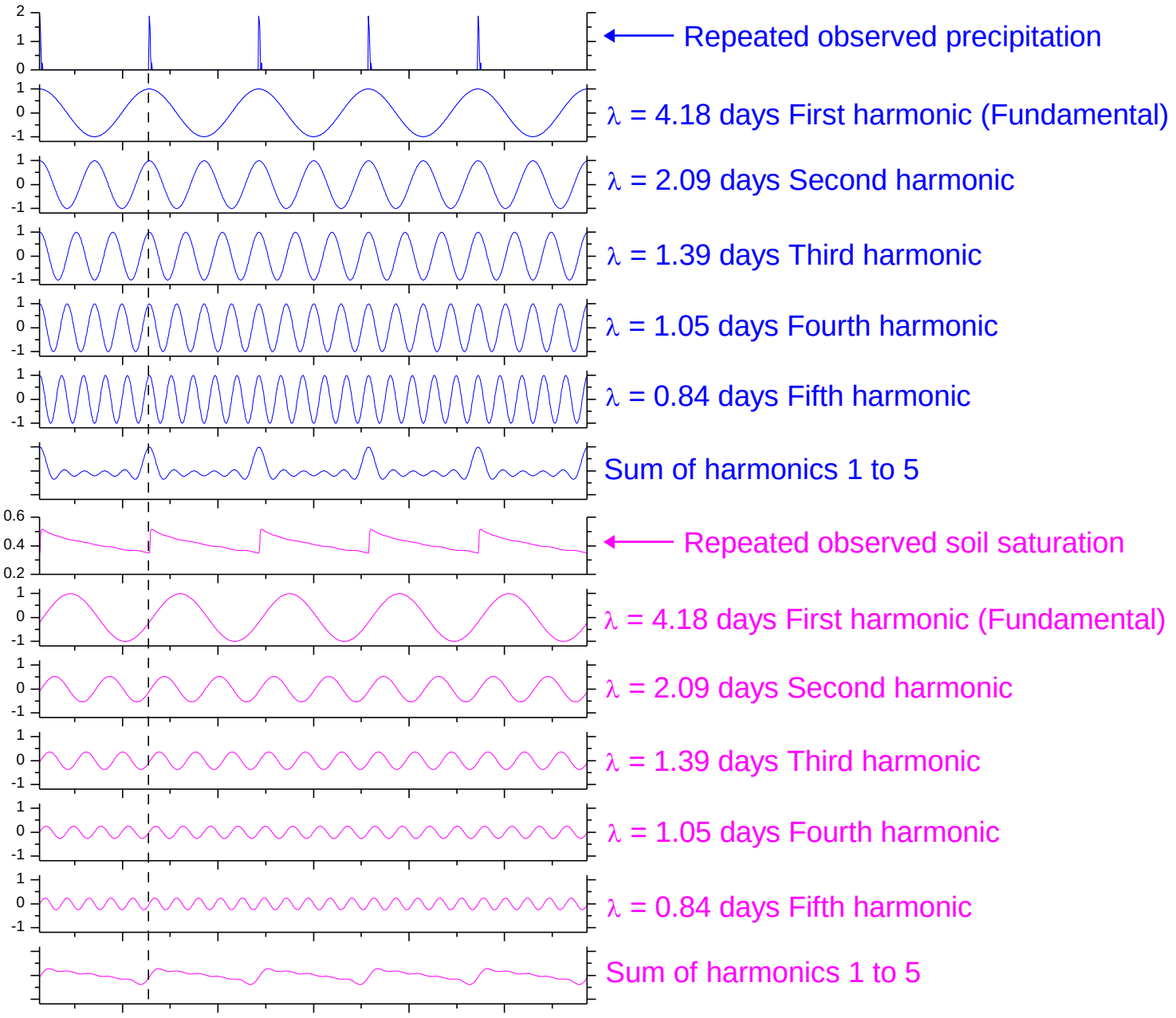
Investigating the phase of impulse v. response (soil saturation variations after precipitation events)

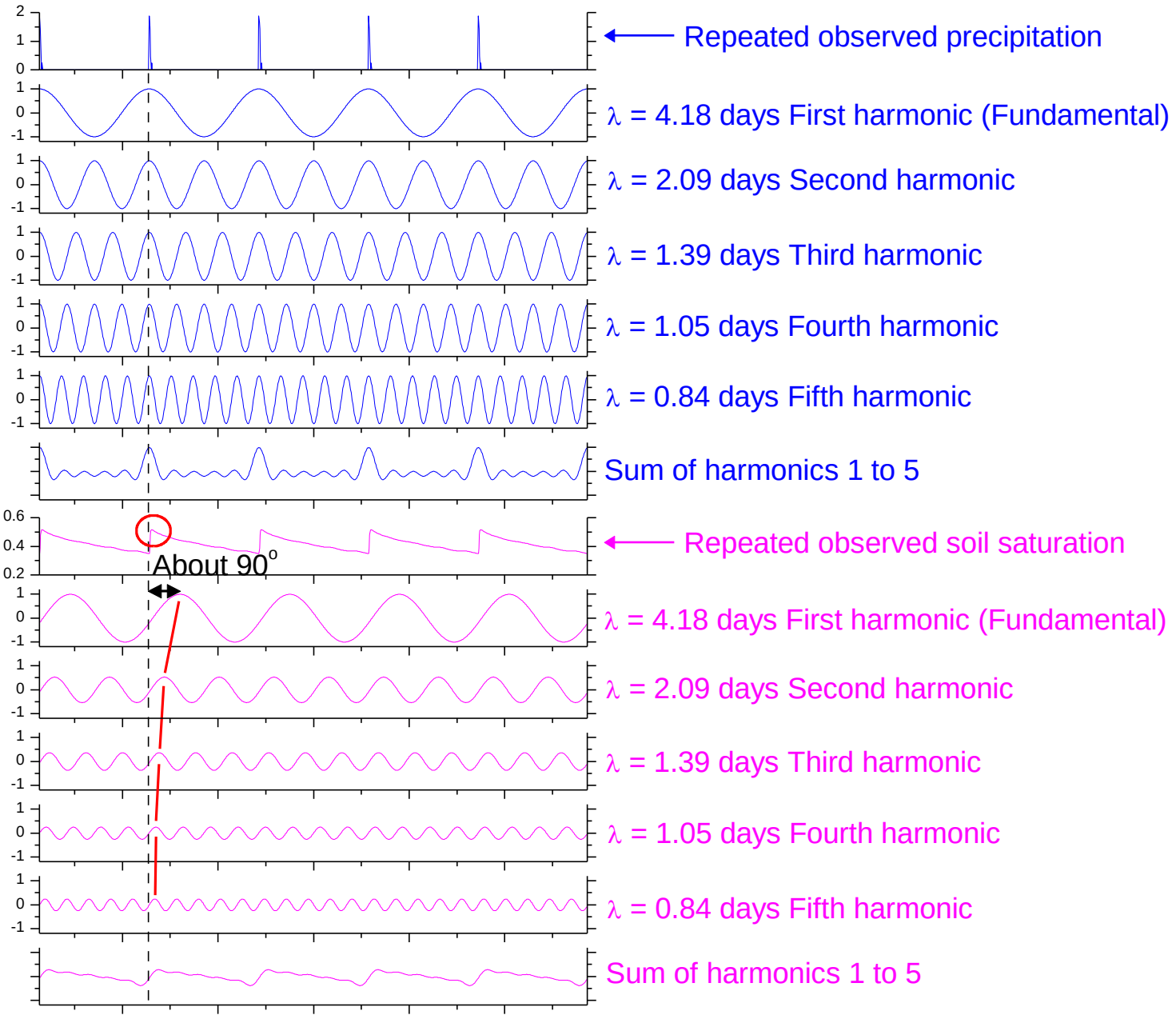


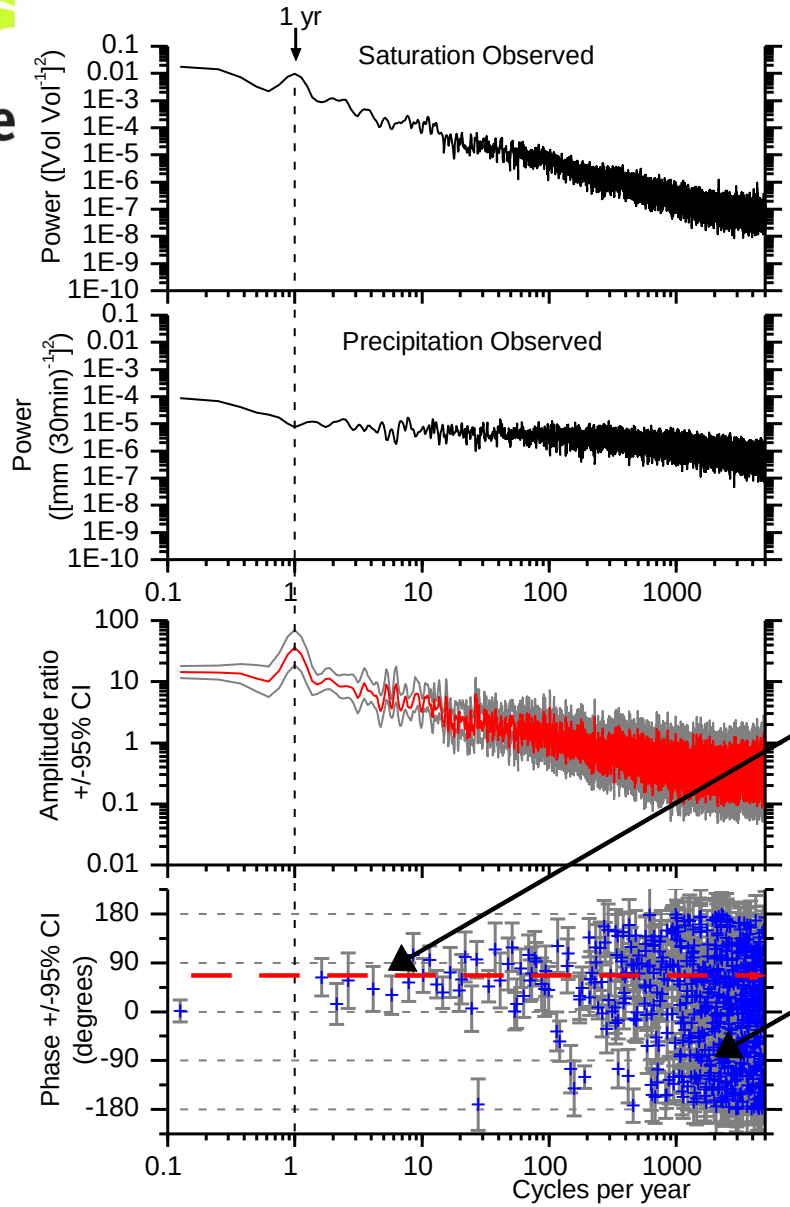
Investigating the phase of impulse v. response (soil saturation variations after precipitation events)




Repeated observed precipitation
λ = 4.18 days First harmonic (Fundamental)
λ = 2.09 days Second harmonic
λ = 1.39 days Third harmonic
λ = 1.05 days Fourth harmonic
λ = 0.84 days Fifth harmonic
Sum of harmonics 1 to 5


Repeated observed precipitation
λ = 4.18 days First harmonic (Fundamental)
λ = 2.09 days Second harmonic
λ = 1.39 days Third harmonic
λ = 1.05 days Fourth harmonic
λ = 0.84 days Fifth harmonic
Sum of harmonics 1 to 5
Repeated observed soil saturation
λ = 4.18 days First harmonic (Fundamental)
λ = 2.09 days Second harmonic
λ = 1.39 days Third harmonic
λ = 1.05 days Fourth harmonic
λ = 0.84 days Fifth harmonic
Sum of harmonics 1 to 5


Repeated observed precipitation
λ = 4.18 days First harmonic (Fundamental)
λ = 2.09 days Second harmonic
λ = 1.39 days Third harmonic
λ = 1.05 days Fourth harmonic
λ = 0.84 days Fifth harmonic
Sum of harmonics 1 to 5
Repeated observed soil saturation
About 90°
λ = 4.18 days First harmonic (Fundamental)
λ = 2.09 days Second harmonic
λ = 1.39 days Third harmonic
λ = 1.05 days Fourth harmonic
λ = 0.84 days Fifth harmonic
Sum of harmonics 1 to 5



"Expected" response:
Positive phase of about +90°.

"Intermittent" response:
Memo: Phase spectra give averages.
Negative phase due to a few, large precipitation events at a time spacing that matches many large dry-downs.
NB: Precip. events and dry-downs **NOT** coincident in time.

Conclusions:

1) Cross-spectral analysis, adapted for data with missing time steps, provides a useful way to investigate how a model (e.g. JULES) represents physical processes. In evaluations this is achieved by examining the mis-matches between observations and model output time series at different frequencies using amplitude and phase estimates.

2) The frequency responses of JULES for: a) energy fluxes (latent heat v SWdown) and b) soil moisture (saturation v. precipitation) are a good match to the real world frequency responses (unlike JULES running TRIP for Discharge v precipitation).