Long-term evolution of the power spectrum of galactic cosmic ray variability

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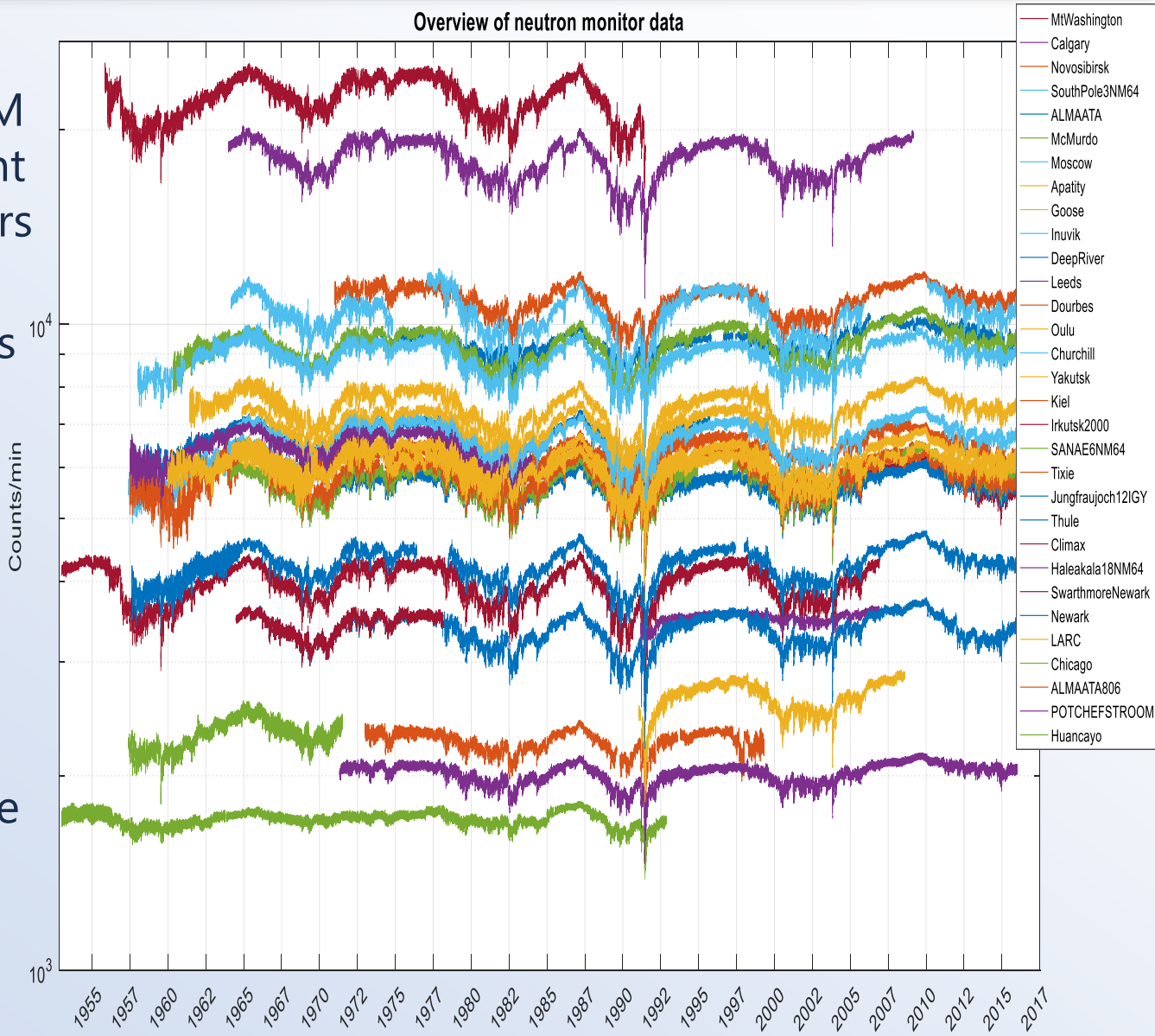
Data overview

We studied the power spectral densities of NM counts from 31 different monitors spanning years 1953-2016.

Data jumps and outliers (+ most GLEs) were excluded.

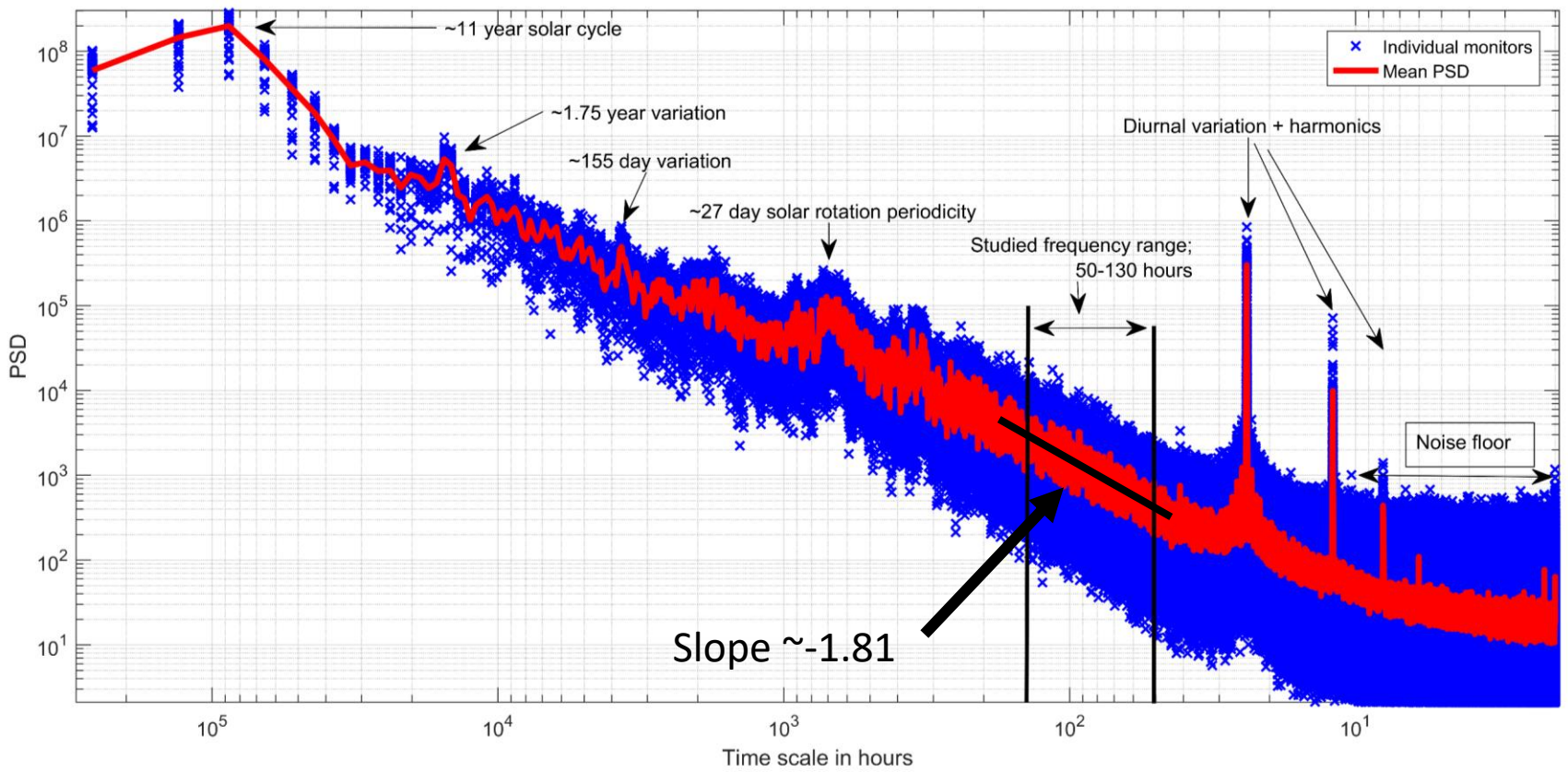
Data coverages are nearly 100% for most NMs for their time of operation.

Excluding Forbush decreases was not done here, but will be done later.



PSD overview

The PSD of all data for the whole period shows some specific features: the 11-year solar cycle, the 27-day solar rotational periodicity and the diurnal variation and its harmonics, as well as peaks at 1.75 years (Midterm Quasi-periodicity) and at 155 days (Rieger periodicity).

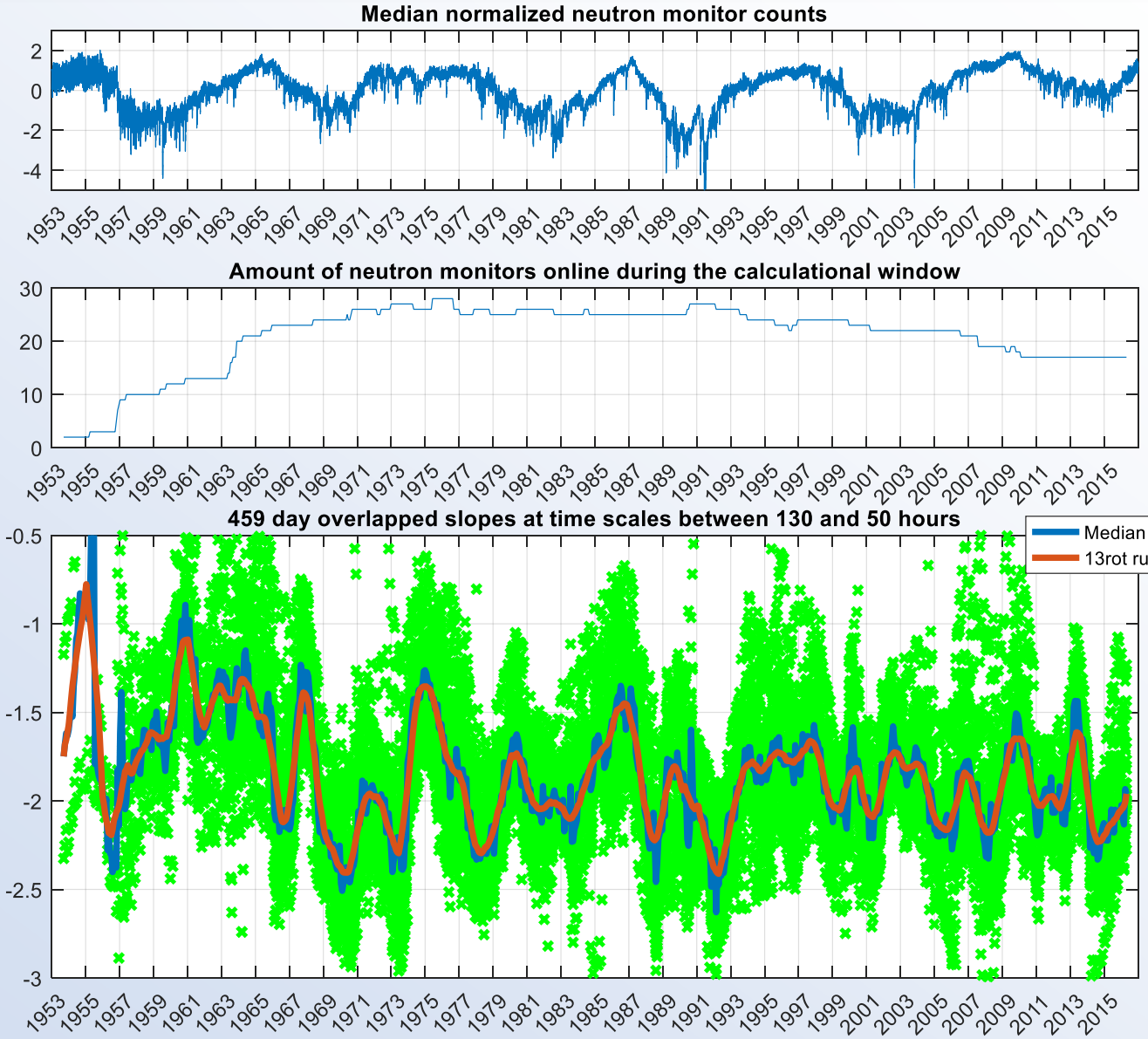


The main results

At steps of 27 days, the PSD was calculated using 17 rotations of data and the slope was calculated for time scales between 50 to 130 hours.

The resulting slope values are presented alongside NM counts and amount of active monitors.

To note:
-peaks at solar minimum,
-smaller peak(s) inbetween,
-steepest slopes during declining phase.



Solar cycle phase dependency

We also studied the solar cycle dependency by separating the results to different solar cycle phases, and calculating their mean and standard error separately.

Ascending phase ~-1.95,

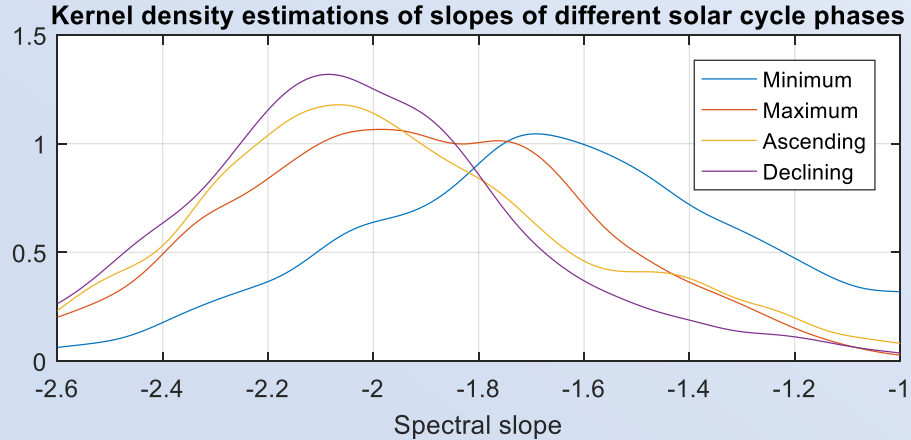
Maximum phase ~ -1.93

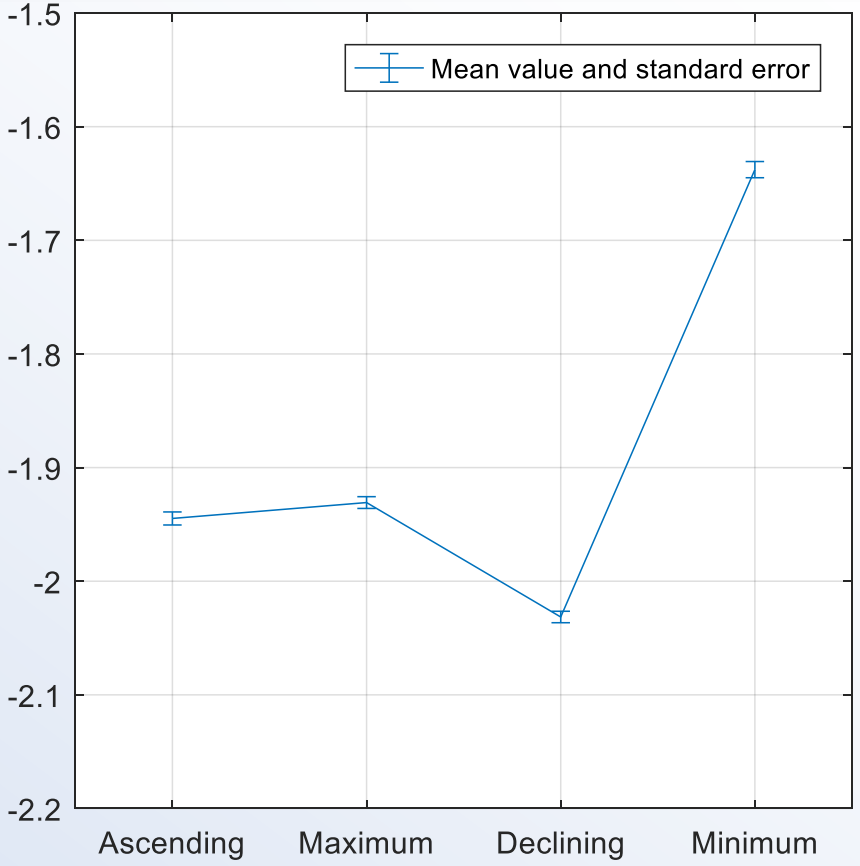
Declining phase ~ -2.03.

Minimum phase ~ -1.64 (~Kolmogorov)

The difference between minimum times compared to other solar cycle phases could be caused by effects of CMEs and CIRs which are more frequent during the other phases.

=> GCR modulation is driven by the diffusion on "normal" turbulence of the SW during solar minima.
During solar maxima (and other phases) either the turbulence spectrum is changed or the modulation switches to propagation-barrier type and the information on SW turbulence is lost in the CR data.





(Note: these values are different from the poster, where an error in the time vector affected some of the selected years.)

Conclusions

- We used 63 years of NM data from 31 different stations to calculate PSD estimates and spectral slopes for time scales between 50 and 130 hours.
- The resulting slope times series indicates that the spectral slopes are related with the solar cycle. Slopes from individual monitors reach values of -0.5 to -1.5 at solar minimum, while values of -2 to -3 are observed during declining phase times.
- We speculate that the slope behaviour at solar minimum is the baseline behaviour, and that other behaviour is the results of enhanced CME and CIR activity outside solar minimum which usually have periodicities that are at the studied frequencies.