

TRENDS AND PERIODICITIES IN NIGHTTIME LF RADIO WAVE REFLECTION HEIGHTS

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LF reflection height estimations at Collm (51.3N, 13E)

Low frequency 177kHz radio waves from the Zehlendorf (near Berlin) commercial radio transmitter are registered at Collm Observatory east of Leipzig, Germany, distance to transmitter 150 km). The virtual reflection heights are estimated using measured travel time differences between the ground wave and the reflected sky wave by means of phase comparisons in the modulation frequency range on 1.8 kHz of the amplitude modulated LF radio wave (Kürschner *et al.*, 1987).

The reflection height measurements have started in September 1982 and, as well as wind measurements (e.g., Jacobi *et al.*, 1997), are carried out continuously since.

References

- Kürschner, D., R. Schminder, W. Singer, and J. Bremer, 1987: Ein neues Verfahren zur Realisierung absoluter Reflexionshöhenmessungen an Raumwellen amplitudenmodulierter Rundfunksender bei Schrägeinfall im Langwellenbereich als Hilfsmittel zur Ableitung von Windprofilen in der oberen Mesopausenregion. *Z. Meteorol.* **37**, 322 - 332.
- Jacobi, Ch., R. Schminder, und D. Kürschner, 1997: Measurements of mesopause region winds over Central Europe from 1983 through 1995 at Collm, Germany. *Contrib. At-mos. Phys.* **70**, 189 - 200.

Reflection height time series

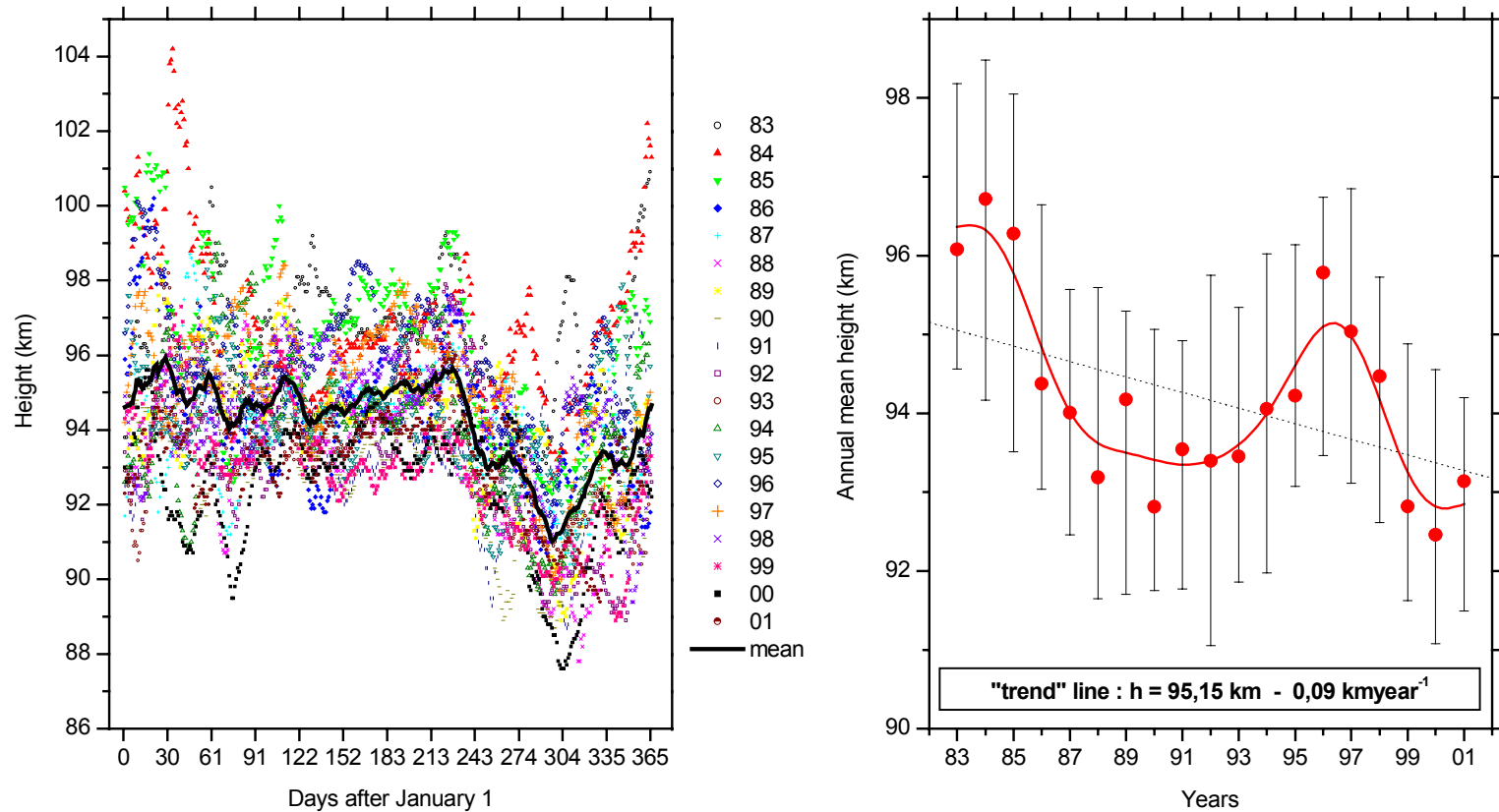


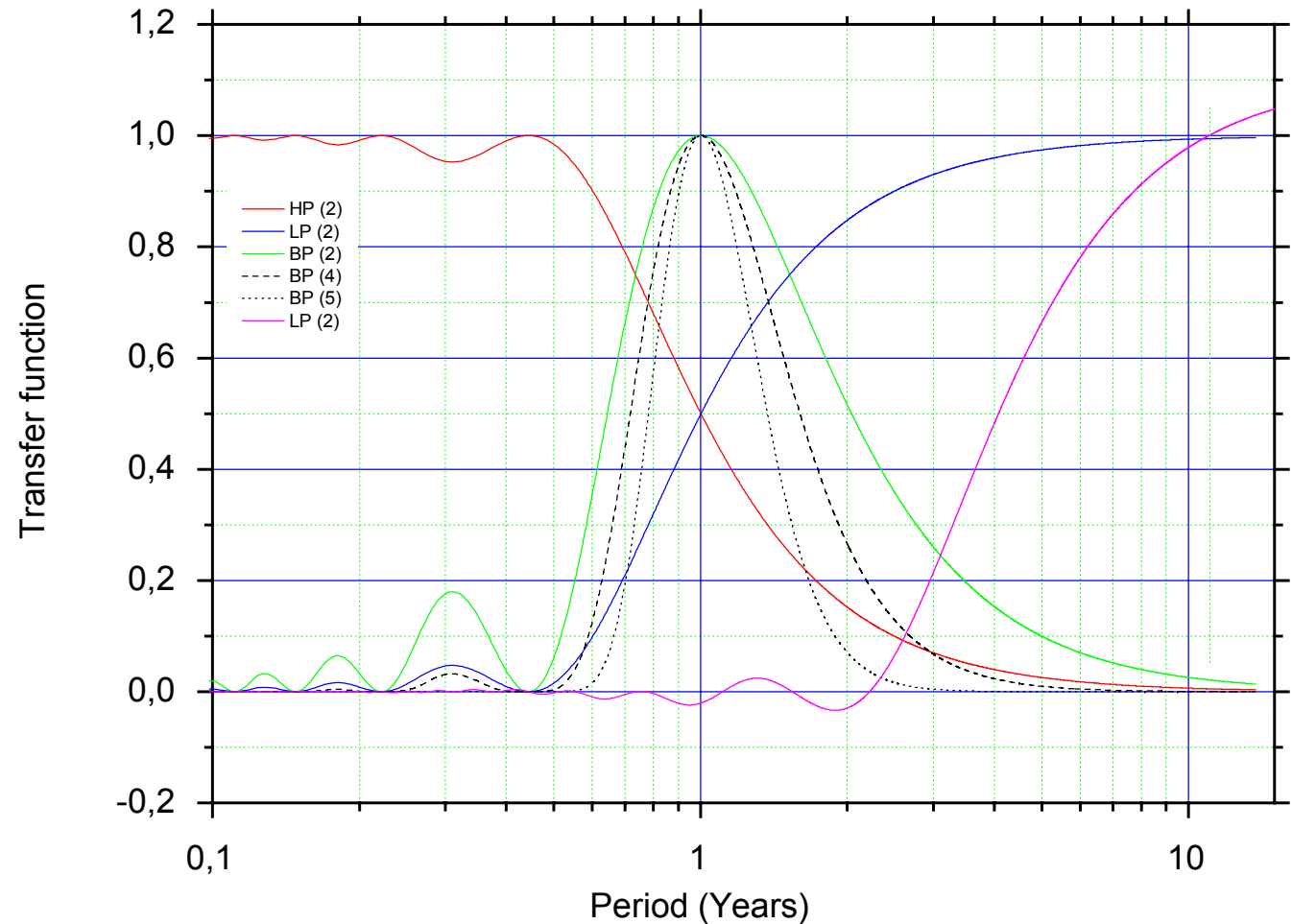
Figure 1: Left panel: 15-day mean reflection heights 1/1983 – 12/2001, and 19-year averages (black line). Right panel: Annual mean reflection heights 1983 – 2001. The amplitude of the “error bars” is mainly determined by the seasonal cycle of the reflection height.

Filter technique

Figure 2:

Transverse filters
 LP (low pass), HP
 (high pass) and
 combined BP
 (band pass) for
 2nd, 4th and 6th
 order (2), (4), (6)
 as examples for
 used filter techni-
 que.

Resonant period
 chosen is one
 year. LP (2) for
 11-year period is
 also added.



Filtered time series

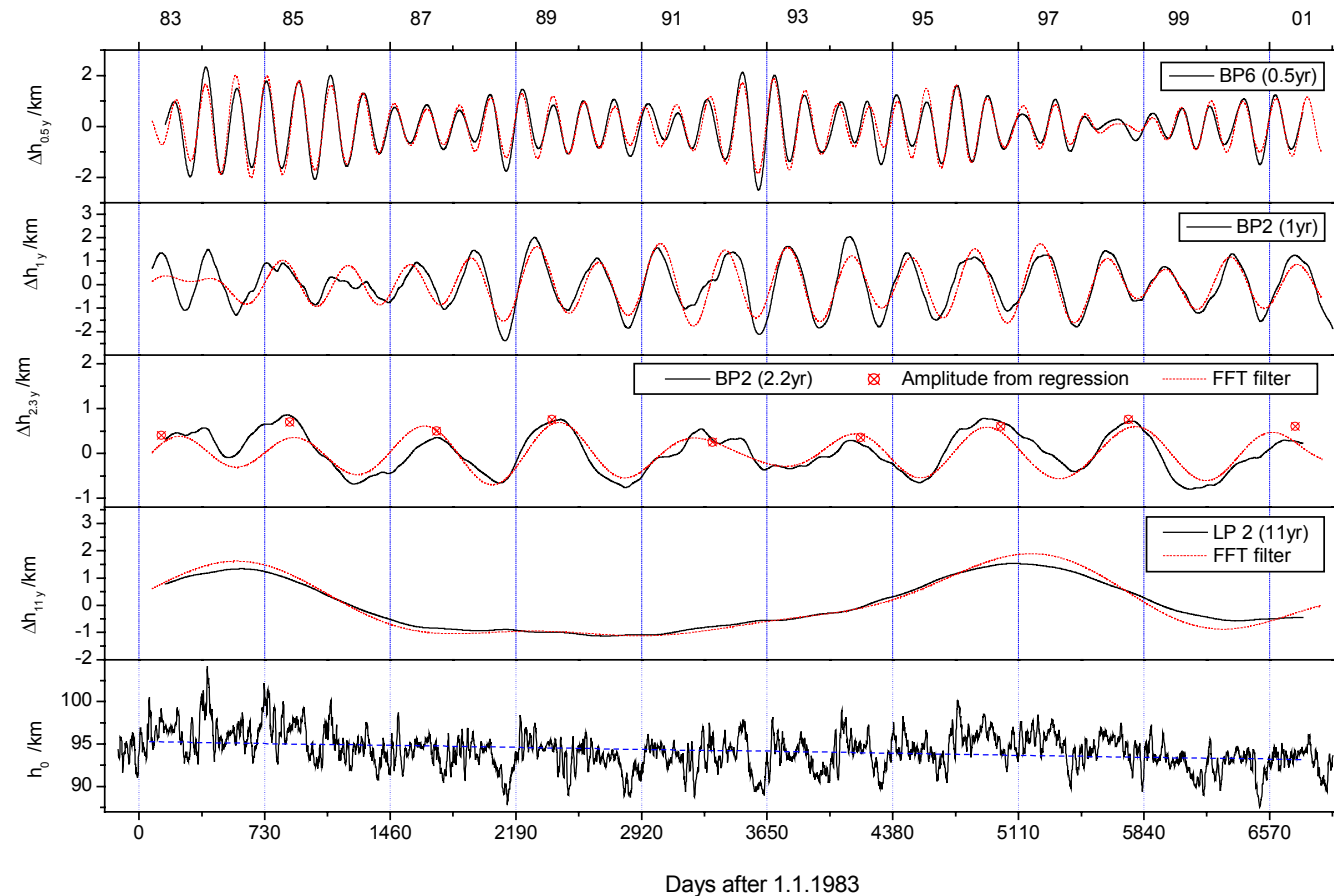


Figure 3: Filtered time series using different filter windows: 0.5 yr (0.4 – 0.6 yr, uppermost panel), 1 yr (0.9 – 1.9 yr, second panel), 2.2 yr (1.5 – 3 yr, middle panel), 11 yr (high pass, 4 yr cut off, 4th panel), original time series with linear regression (lowermost panel).

Original and reconstructed amplitude spectra

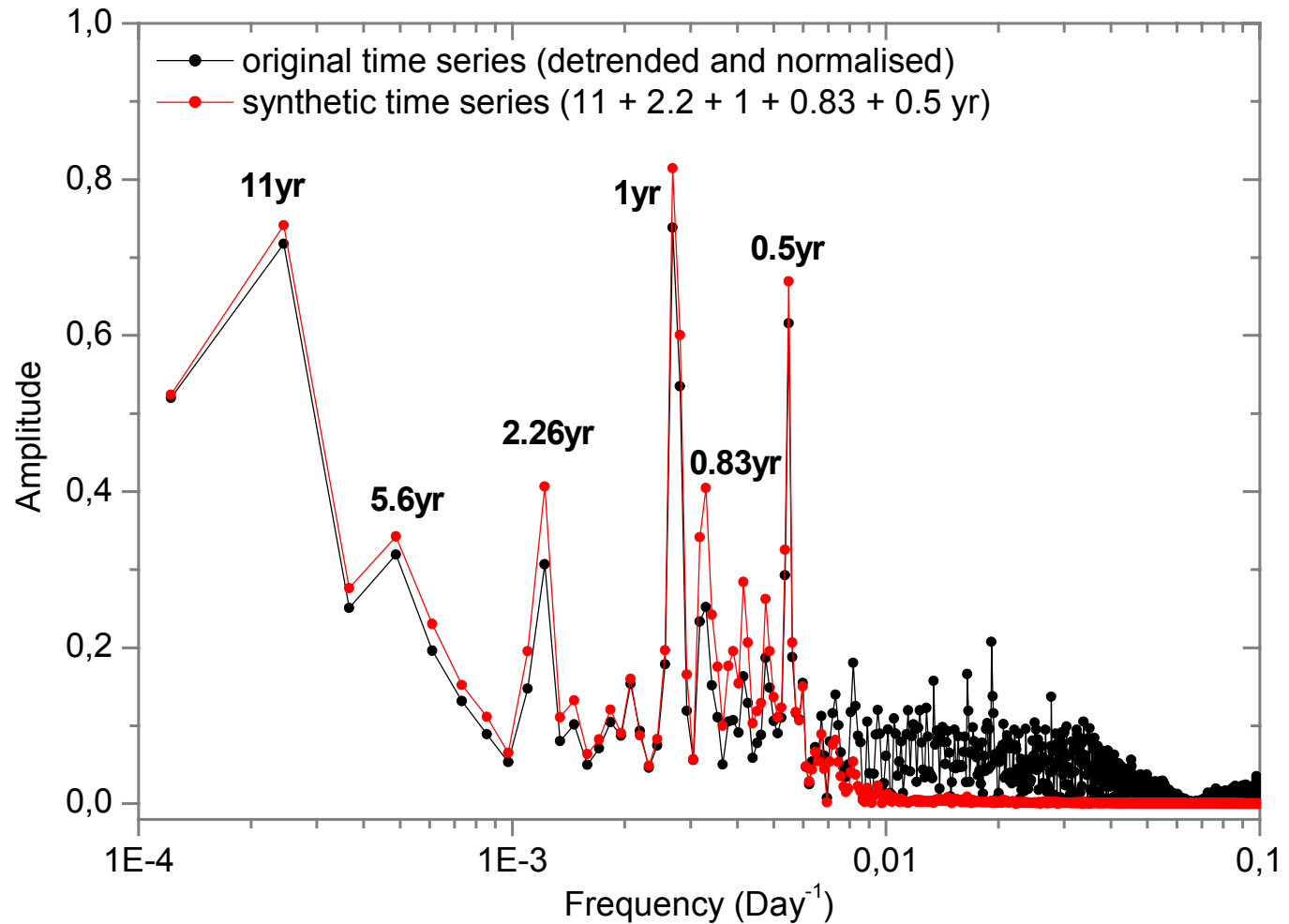


Figure 4: Amplitude spectra of original and synthetic time series.

Original and reconstructed time series

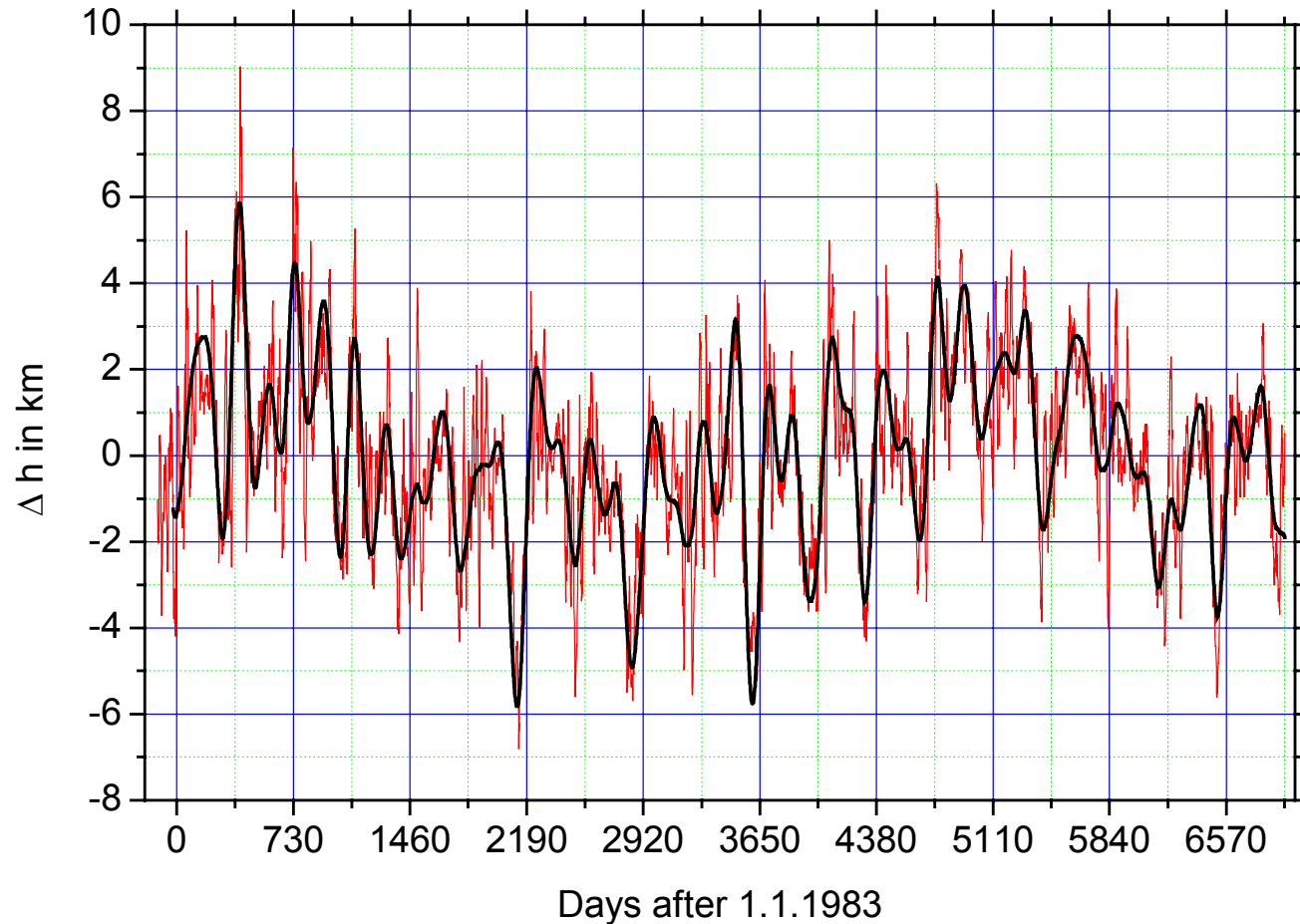


Figure 5: Original detrended and normalised time series (red line) and synthetic time series, constructed as the sum of the components 11, 2.2, 1, 0.83 and 0.5 yrs.

Decadal oscillation

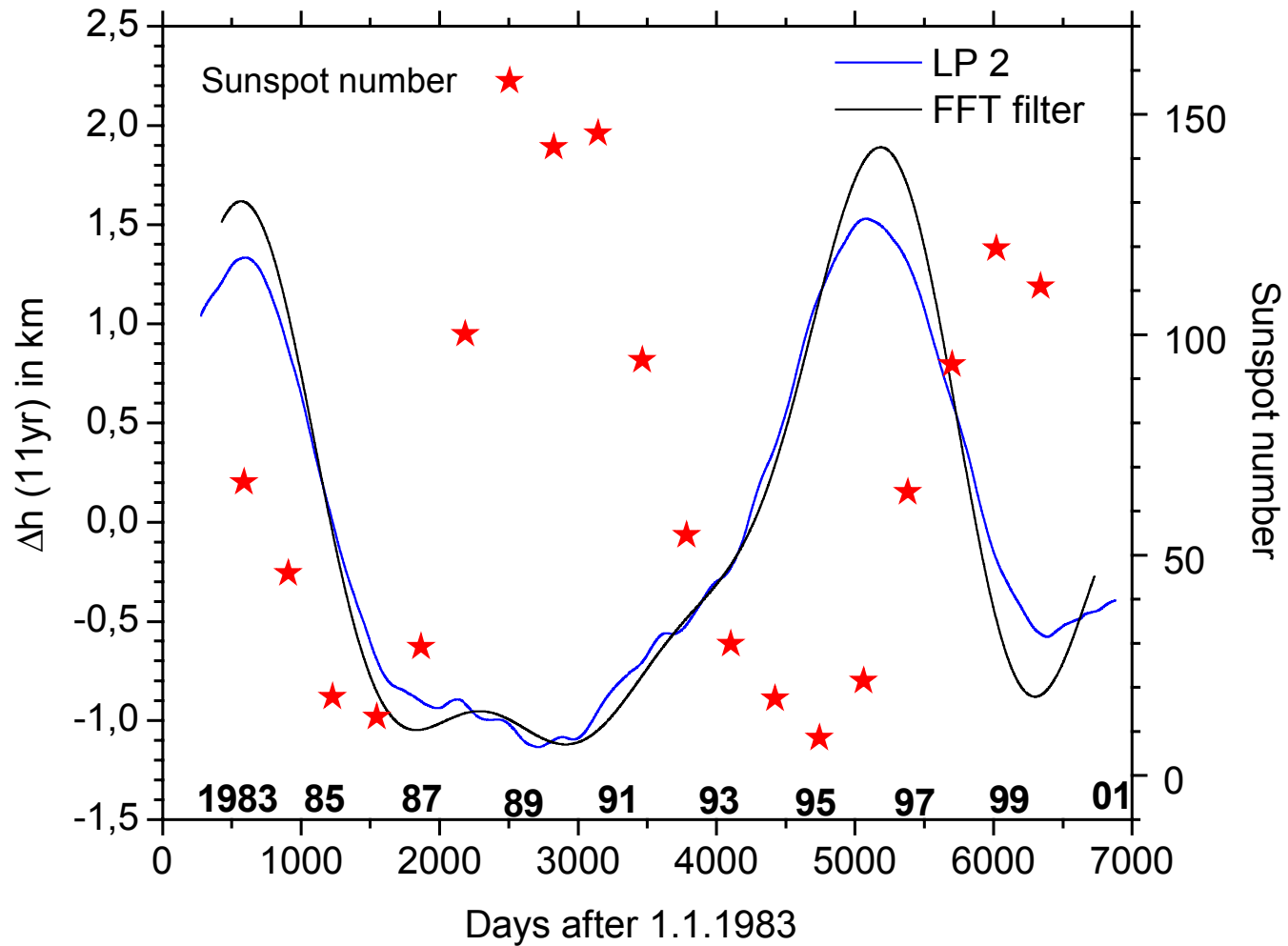


Figure 6: Time series of low pass filtered reflection heights and annual mean sunspot numbers.

Quasi-biennial oscillation

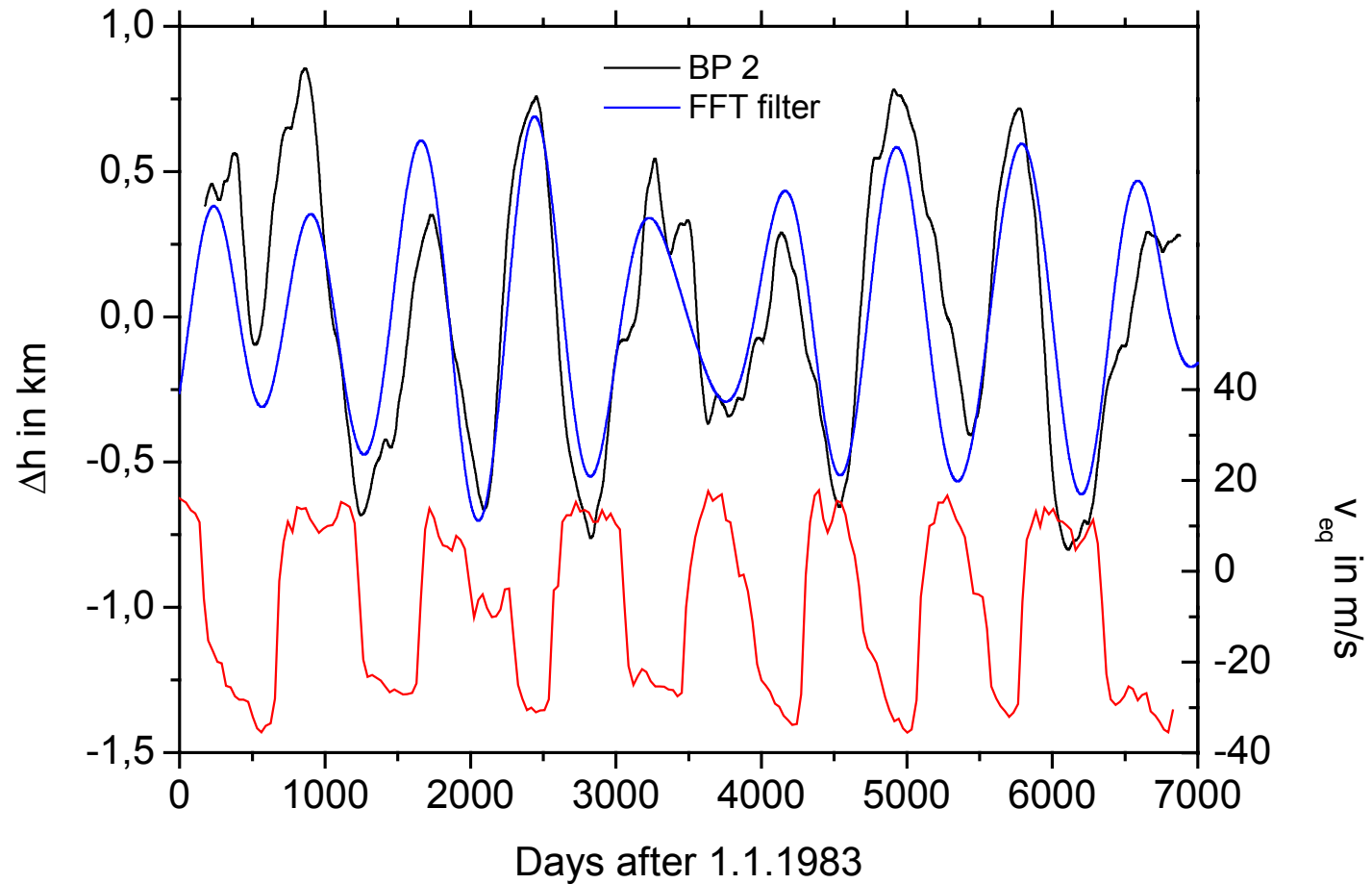


Figure 7: Time series of bandpass (2.2 years) filtered reflection heights (black and blue) curves, and equatorial winds at 30 hPa (red curve).

Results and Conclusions

The time series of the mean reflection height shows

1. a possible long-term negative trend, which is in correspondence with results from literature (Bremer and Berger, 2002), and
2. a clear quasi-biennial oscillation.

These characteristics indicate a response of the lower ionosphere region to the underlying neutral atmosphere.

3. A solar cycle dependence is also visible, which corresponds to literature results (e.g. Entzian, 1967) .

References

Bremer, J., and U. Berger, 2002: Mesospheric temperature trends derived from ground-based LF phase-height observations at mid-latitudes: comparison with model simulations. J. Atmos. Solar-Terr. Phys, in press.

Entzian, G., 1967: Der Sonnenfleckenzyklus in der Elektronenkonzentration der D-Region. Kleinheubacher Berichte 12, 309 - 313.

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