Puzzling, very slow oscillations of the air pressure in Europe

Herbert Weidner, Am Stutz 3, 63864 Glattbach, herbertweidner@gmx.de

If one compares long-term recordings of the air pressure measured by neighboring barometers, one observes synchronous oscillations at certain frequencies for which there is no known cause. Are they excited by gravitational waves?

1 Introduction

The regular measurement of air pressure is a basis of weather observation. The attractive forces of the nearby celestial bodies moon and sun generate tides with repetition times of about 12 hours, which are superimposed by short-term oscillations without recognizable regularity. Are there also slower oscillations? Historical records of closely neighboring stations in Europe, whose mutual distances are substantially smaller than the circumference of the earth, serve as data basis. The goal is to find and analyze common oscillations with oscillation durations longer than 24 hours.

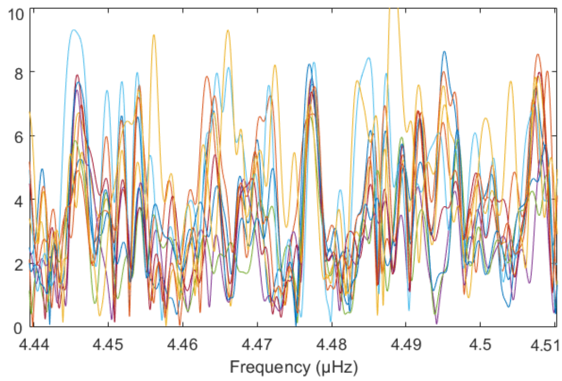

Figure 1): *The superimposed spectra of atmospheric pressure measured in the European capitals of Amsterdam, Berlin, Brussels, Bern, Budapest, Dublin, Paris, Vienna, London, and Stockholm during the period 1990-01-01 to 2022-07-01.*

Figure 1 shows that the air pressure in Central Europe changes with the same strength at certain frequencies. Adding the raw data *before* calculating the spectrum shows that the air pressure changes are synchronous. These results are hardly affected by the design of the barometers, the height of the measuring point above sea level, or the local weather. What common cause makes the ground pressure of the air mass pulsate throughout Central Europe?

How could the oscillations with the frequencies 4.477 μHz, 5.5 μHz, and 6.316 μHz be generated?

- The excitation could come from the Earth's interior. The *Slichter mode* is the triplet oscillational mode of the 3-D translation of the Earth's solid inner core within the fluid outer core. The resonances are thought to occur in the range between 45 μHz and 78 μHz, but have not yet been demonstrated [2].

- The gravitational forces from the Sun and the planets deform the Earth and also the air envelope. Periodic motions with particularly strong amplitudes are called tides and have known frequencies that are approximately multiples of 11.6 μHz. All known excitation frequencies are calculated and tabulated [3]. None of the near-Earth celestial bodies produce measurable oscillations in the range between 4.1 μHz and 7.45 μHz.

- Strong earthquakes excite the earth to damped natural vibrations, which are detectable only for a short period of time. The lowest natural frequency of the earth ($_0S_2$) is at 300 μHz [5].

In the solar system there is no known source which could excite the air mass over Europe to permanent oscillations with frequencies around $f \approx 5$ μHz. Therefore, the source must be sought outside. Are they gravitational waves emitted by nearby binary systems? For comparison: The binary system V Puppis has an orbital period of 35 hours.

2 Frequency drift measurement

The IGETS Potsdam [4] stores data sets measured by superconducting gravimeters. In parallel, air pressure is also recorded every minute. Weather archives [1] are also suitable data sources, provided that air pressure was recorded at least once per hour. Multi-year records allow sufficient spectral resolution. This analysis is based on data series recorded between 1990-01-01 and 2022-07-01 in Amsterdam, Berlin, Brussels, Bern, Budapest, Dublin, Paris, Vienna, London, and Stockholm. The addition of these records improves the S/N.

First, a narrow frequency range around one of 4.477 μHz or 5.5 μHz or 6.316 μHz is reduced by an IQ mixer to the intermediate frequency $f_{IF} = 200$ nHz. Subsequent decimation to $T_s = 72$ hours produces short file lengths that can be quickly analyzed.

In radio engineering, a high receive frequency f_0 is reduced to a lower value f_{IF} by mixing it with a locally generated frequency f_{Osz} to increase the ratio f_{MOD}/f_0. For the frequencies, $f_{IF} = |f_0 - f_{Osz}|$ is valid.

Normally, the value f_{Osz} is constant so as not to change the frequency drift or modulation content of the signal. Here, the opposite is true: we remove the drift and all known modulations to reduce the bandwidth. Therefore, we modulate the frequency f_{Osz} with the goal of obtaining a *constant* difference frequency f_{IF}. When the drift of the received signal and the oscillator match, f_{IF} is constant and we can reduce the bandwidth to improve the S/N.

$$f_{Osz} = sin(2\pi t(f_{IF} + f_0 + t \cdot \dot{f})) \tag{1}$$

Starting with the initial values $f_{IF} = 0.2$ μHz, f_0 and $\dot{f} = 0$, we get:

- $f_0 = 4.4779(6)$ μHz (date = 1990-01-01) and $\dot{f} = 9.38 \times 10^{-18} s^{-2}$

- $f_0 = 5.4999(0)$ μHz (date = 1990-01-01) and $\dot{f} = 3.69 \times 10^{-18} s^{-2}$
- $f_0 = 6.3142(7)$ μHz (date = 1990-01-01) and $\dot{f} = 1.34 \times 10^{-18} s^{-2}$

Due to the poor signal-to-noise ratio, no modulation can be identified, nor were any clues found as to where the signals might be coming from. The results open a new frontier for experimentalists to explore and theorists to explain.

References

[1] Historical Weather API, https://open-meteo.com/en/docs/historical-weather-api

[2] Hao Ding, H., Chao, B., The Slichter mode of the Earth, J. Geophys. Res.Solid Earth, 120 (2015)

[3] Hartmann and Wenzel, Tidal potential catalogue, (1995), https://publikationen.bibliothek.kit.edu/160395

[4] IGETS Datenbank, GFZ Potsdam, https://isdc.gfz-potsdam.de/igets-data-base/

[5] Harvard Seismology, Resources, Normal-Mode Observations, http://www.seismology.harvard.edu/downloads/mode.html