# Spectral Analysis of Lake Balaton Seiche

## Data Processing and Methodological Framework

Zalán Horlik

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# 1. Introduction: The Seiche Phenomenon

- **What is a Seiche?**
  - A standing wave in an enclosed or semi-enclosed body of water.
  - Triggered by wind forcing or atmospheric pressure variations.
- **Why Lake Balaton?**
  - Shallow depth and elongated geometry make it highly susceptible.
  - Even moderate wind events induce noticeable fluctuations.
- **Relevance:**
  - Harbor dynamics, shoreline flooding risks, and ecological processes.

# 2. Data Acquisition

## Data Source

- Source: General Directorate of Water Management (OVF).
- Period: **2008 – 2014**.

## Temporal Resolution Issues

- **5-minute resolution:** Available for Balatonfűzfő, Keszthely, and Siófok.
- **15-minute resolution:** Available for all other stations.
- **Challenge:** The 5-minute datasets exhibited systematic vertical measurement shifts (inconsistencies).

# 3. Data Preprocessing Results

**Correction Method:**

- Monthly aggregation was used to identify offsets.
- **Siófok** was used as the reference station for leveling.
- Short gaps ($< 3$ hours) were filled via linear interpolation.

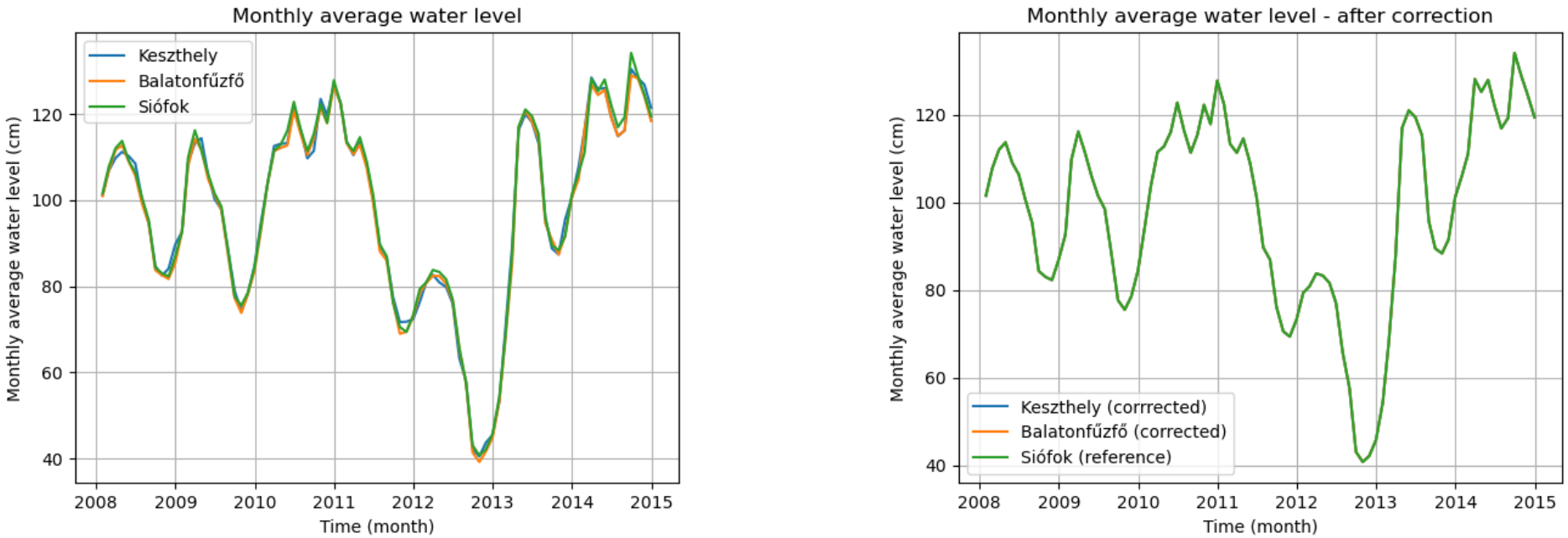


Figure: Comparison of 5-minute Keszthely, Balatonfűzfő and Siófok water level records, before and after the correction.

# 4. Methodology: Spectral Analysis Tools

To analyze the dynamics, the following mathematical tools will be applied:

1. **Power Spectral Analysis:** To identify the natural frequency ($f_0$) of the seiche.
$$P(f) = |X(f)|^2$$
2. **Cross-Spectral Analysis:** To determine phase relationships between stations (e.g., Keszthely vs. Balatonfűzfő).
$$\gamma_{xy}^2(f) = \frac{|S_{xy}(f)|^2}{S_{xx}(f)S_{yy}(f)}$$
3. **Wavelet Analysis:** To capture the temporal evolution and damping of transient seiche events.

# 5. Future Work and Goals

The immediate next steps focus on specific spectral investigations:

- **High-Resolution Comparison:** Compute energy spectra for 1-week storm events to compare resolution limits ($T > 10$ min vs. $T > 30$ min) against the theoretical transverse seiche mode.
- **Spectral Analysis (Basin-wide):** Identify the dominant longitudinal oscillation modes across the entire dataset.
- **Q-Factor Estimation:** Quantify the damping characteristics (ratio of stored to dissipated energy) of the system.
- **Cross-Spectral Analysis:** Investigate spatial correlations to map the phase relationships between stations.

# Summary

- **Status:** Data from 2008-2014 has been cleaned, corrected for vertical shifts, and interpolated.
- **Key Result:** A high-quality, continuous dataset (Feb 2011 - Mar 2013) is ready.
- **Next Phase:** Implementation of Fourier and Wavelet analysis to model the physical properties of the Balaton seiche.

# AI Disclosure

In accordance with academic integrity guidelines, I disclose that **Gemini (Google)** was used as a thought partner and technical assistant for:

- **Source Analysis:** Interpretation of hydrodynamic and spectral literature.
- **Technical Support:** Debugging LaTeX code and visualization scripts.
- **Structuring:** Developing the study's outline and presentation flow.