

A new Python package to estimate hydraulic and poroelastic groundwater properties using standard pressure records

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What is this about?

- Automated collection of groundwater levels is expanding over time
- Natural forcing (atmospheric pressure, Earth tides) is commonly observed in these time series, which can overwhelm important responses, such as groundwater withdrawals and recharge events
- Our package removes responses to natural forcings, which allows for improved identification and quantification of groundwater responses
- An additional benefit is the ability to quantify subsurface hydraulic and geomechanical properties using the observed responses to natural forcing

Why do we need new software?

- While existing software (e.g., BETCO, HEADCO, KGS_BRF) are available for removing the effects of natural perturbations on observed groundwater levels, these codes do not provide collaborative opportunities for adding new methods and features
- A dynamic, community-based code is needed that (a) removes noise (natural signals) from observed water levels, and (b) uses this noise to estimate subsurface features, events, and processes (FEPs) for the development and evaluation of conceptual site models
- This fills a vital gap that incorporates needed metadata (geo-location (WGS84), borehole dimensions, construction details, hydrostratigraphic information) to deliver location-based aquifer hydraulic and poroelastic properties that can then be used during model development

What is it and what does it do?

- The new Python software is called HydroGeoSines (HGS) and is currently available on GitHub
- Sines is the acronym for Signal-in-the-Noise-Exploration-Software
- HGS uses the versatile Python programming language, and is open source and open access
- Package inputs require time series of groundwater hydraulic heads, atmospheric pressure, and Earth tides
- Package outputs include adjusted head, Barometric Response Functions (BRF, used to assess groundwater confinement), Barometric Efficiency (BE, used to assess the poroelastic response), hydraulic conductivity (K), and specific storage (Ss)

How does HGS work?

- HGS builds on the functionality of existing Python packages (e.g., Numpy, Pandas, matplotlib, mpmath, etc.)
- Automatically converts arbitrary units into SI
- Allows import of data from multiple boreholes at each field site
- Provides pre-processing capabilities (dataset alignment, interpolation, gap filling where possible)
- Applies a range of peer-reviewed time and frequency domain methods to estimate hydraulic and poroelastic properties
- Wraps around PyGTide (Rau, 2018) to calculate theoretical Earth tide potential, gravity or strain
- Applies the Discrete Fourier Transform (DFT) as well as Harmonic Least-Squares (HALS) to quantify harmonic properties of tidal components
- Applies flexible regression deconvolution to dataset derivatives
- Returns standardized containers for plotting and export of results

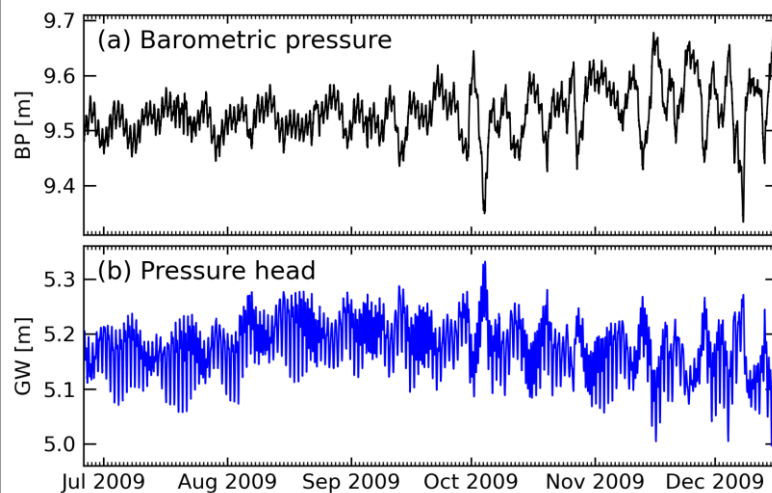
Where is HGS? How can I get involved?

- The package is located at:
<https://github.com/HydroGeoSines/HydroGeoSines>
- Includes example datasets from different field sites
- Examples are included as IPython notebooks
- Note that the package is still under development, and additional testing is needed
- Future versions of HGS will include additional methods, such as the ability to estimate poroelastic parameters from responses to Earth and atmospheric tides
- We hope that you will join us in making this the go-to groundwater analysis platform of the future

Overview of HydroGeoSines (HGS)

Input

	A	B	C
1	Datetime[UTC+0.0]	BLM-1[m]	Baro[m]
2	25/06/2009 22:00	5.0916988	9.4947857
3	25/06/2009 22:15	5.0912636	9.4934414
4	25/06/2009 22:30	5.0970486	9.4904733
5	25/06/2009 22:45	5.0970669	9.4896618

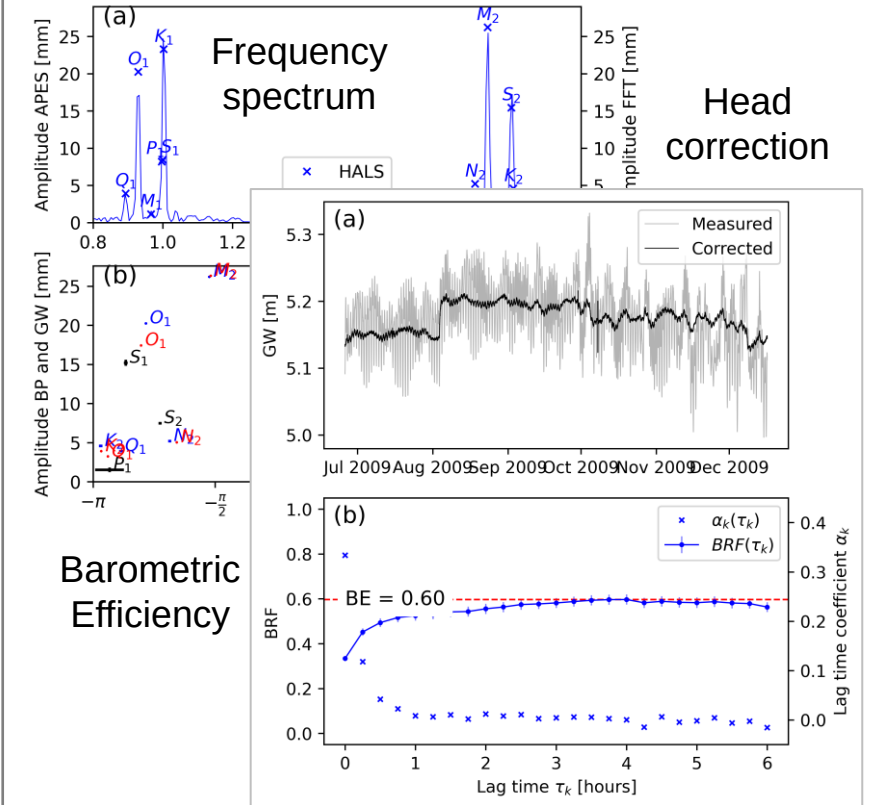


23	26/06/2009 03:15	5.1894092	9.490251
24	26/06/2009 03:30	5.1930667	9.4890337
25	26/06/2009 03:45	5.1957117	9.4924764
26	26/06/2009 04:00	5.1989326	9.4906642
27	26/06/2009 04:15	5.2010186	9.4923802
28	26/06/2009 04:30	5.2024473	9.4953557

Time series,
geo-location (WGS84),
borehole dimensions



Output



Hydraulic conductivity, Specific storage,
poroelastic properties