

Passive Subsurface Characterisation (PSC)

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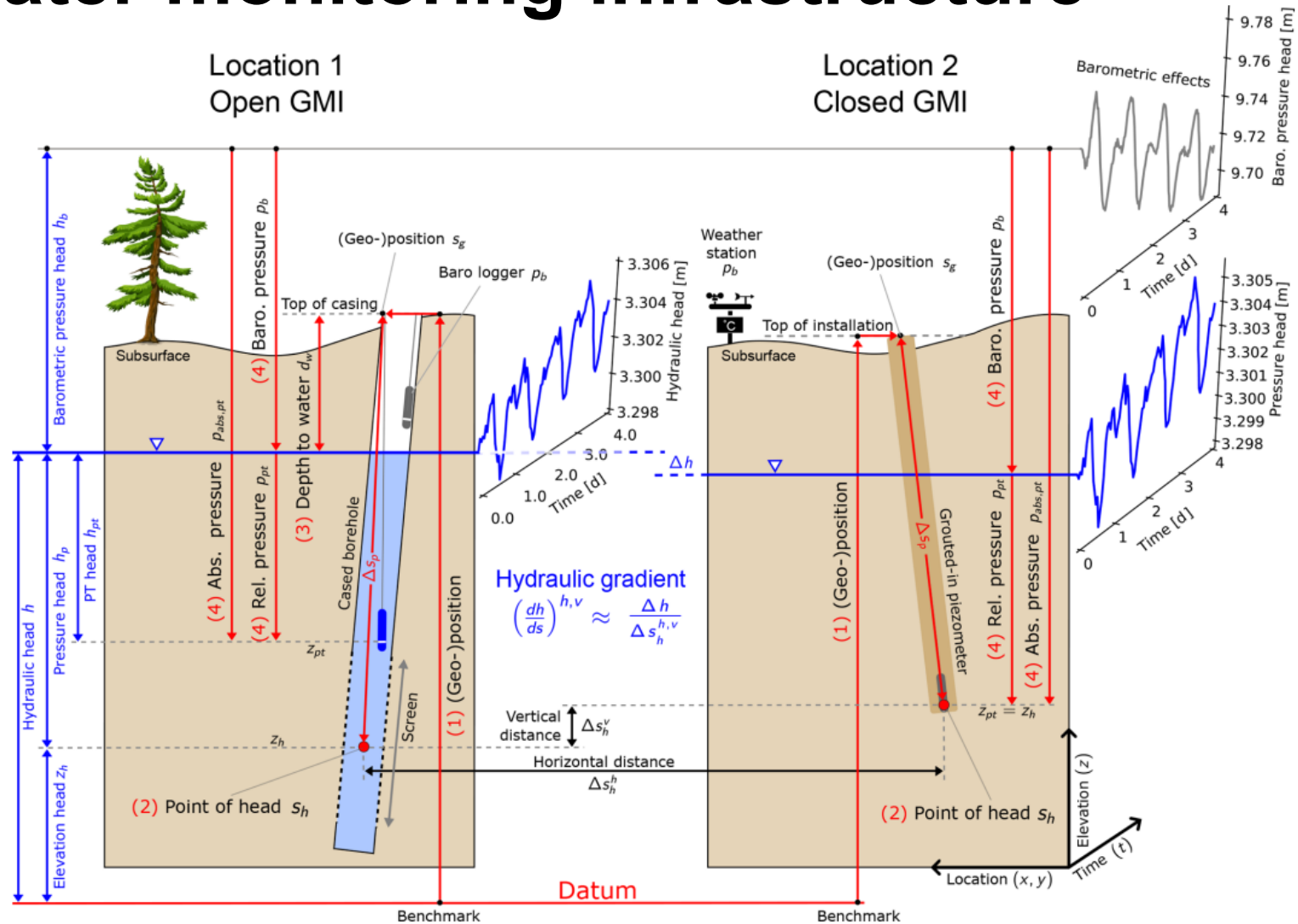
Institute of Applied Geoscience - Department of Engineering Geology



Aims

- Overview of groundwater response to tidal forces
- Interpreting the groundwater responses to Earth and atmospheric tides
- Quantifying subsurface properties using the groundwater responses to Earth and atmospheric tides

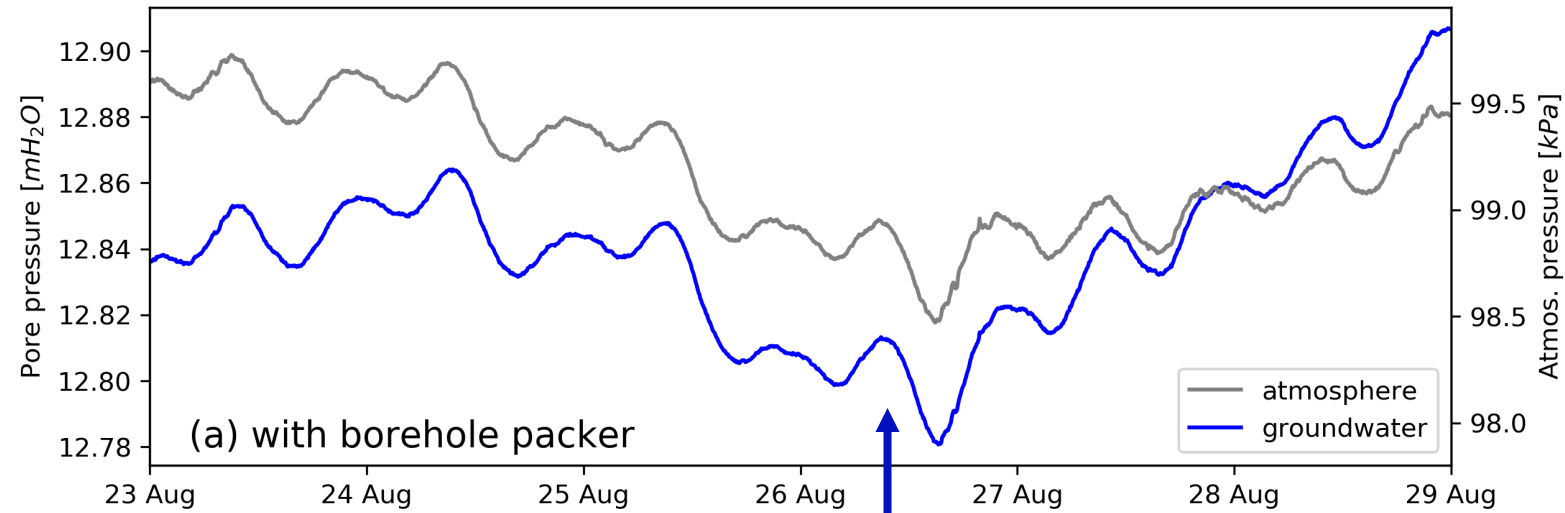
Groundwater monitoring infrastructure



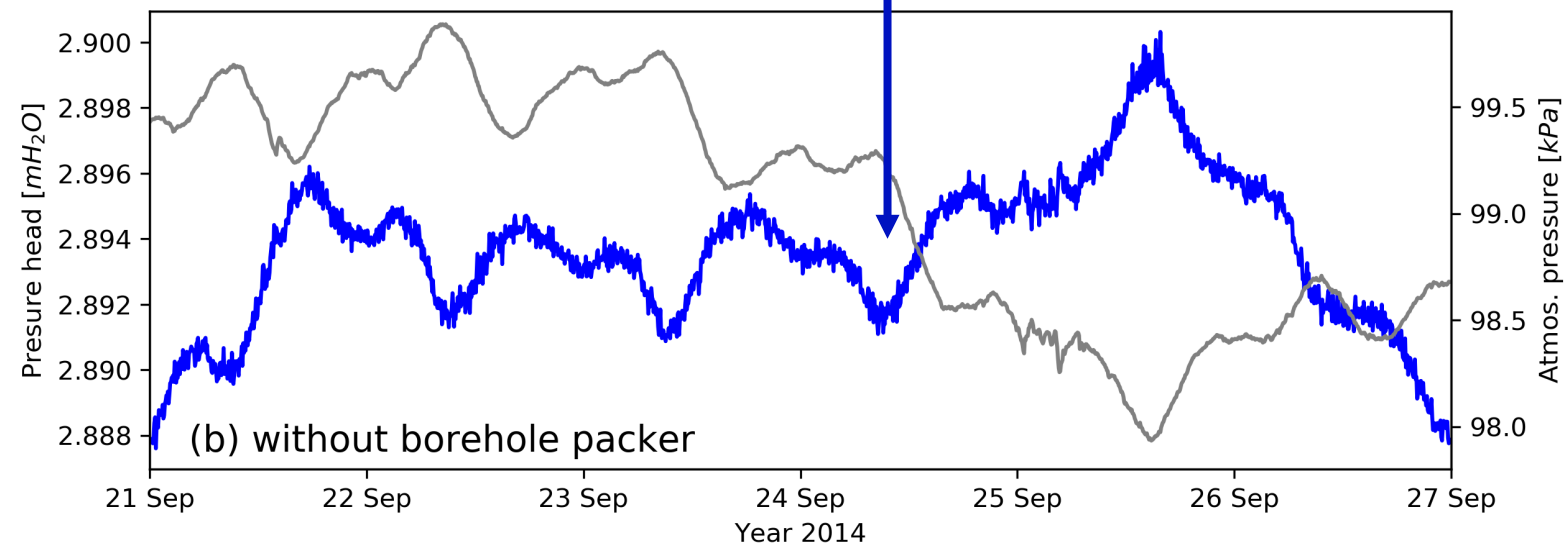
Rau et al. (2019)

Barometric pressure response

Pore pressure



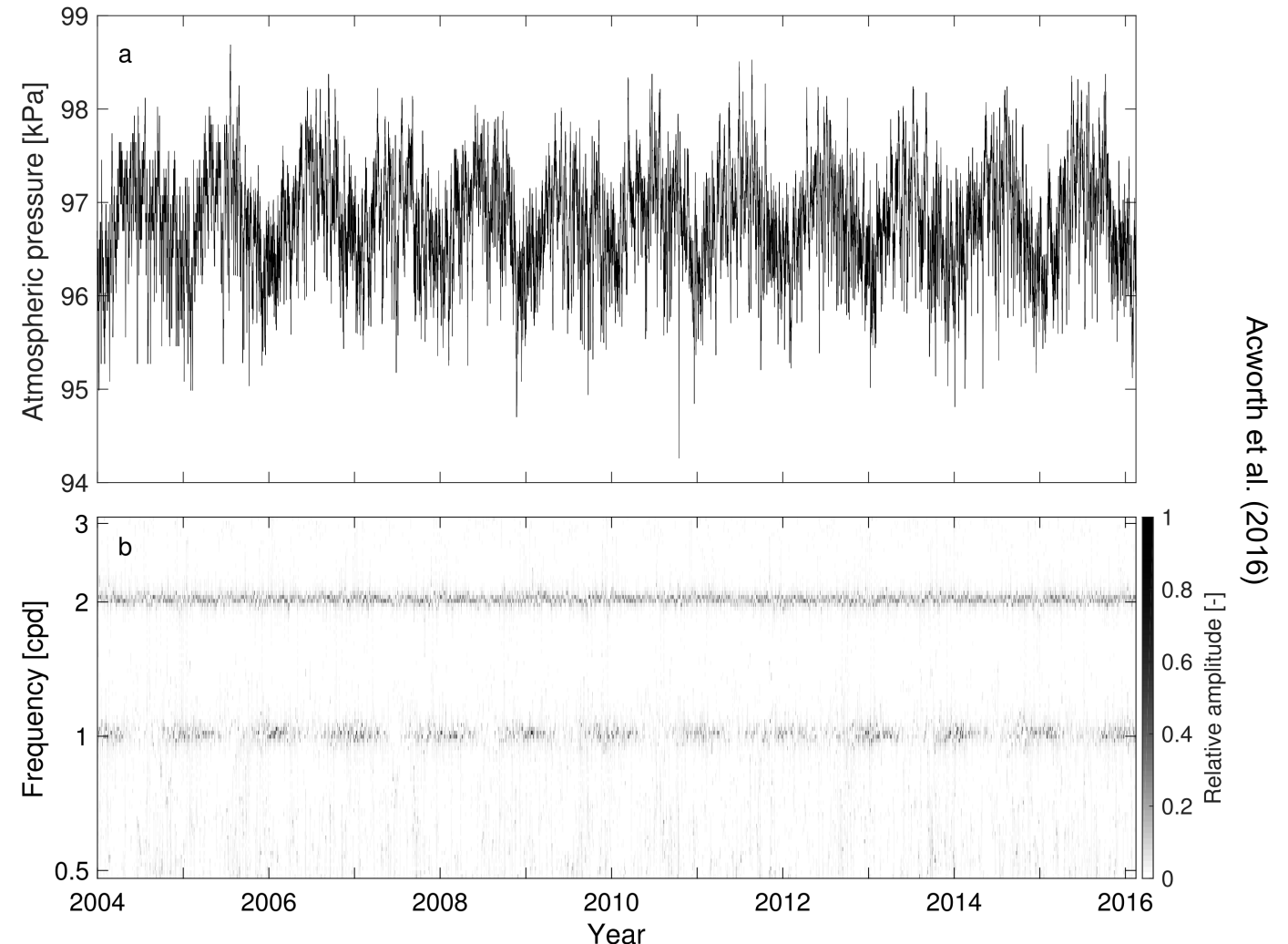
Well water level



McMillan et al. (2019)

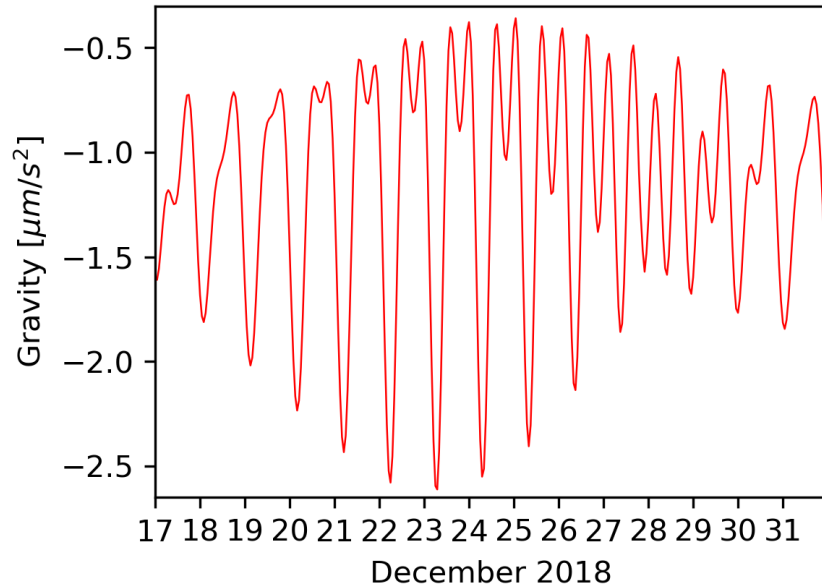
Atmospheric tids (AT) and groundwater

- Periodic changes in atmospheric pressure
- Widely recognised in the atmospheric sciences
- Atmospheric pressure is a standard measurement
 - Baro logger
 - Weather station



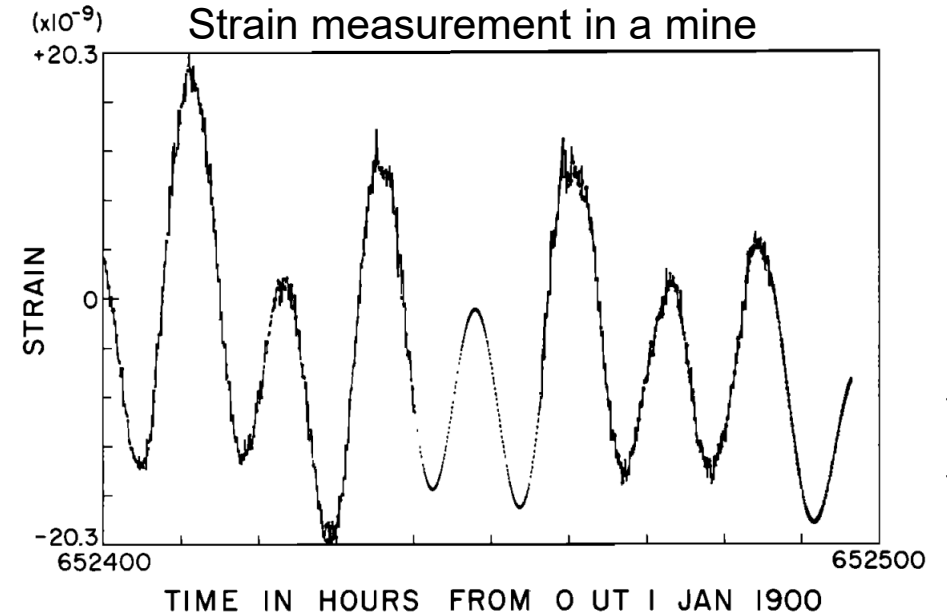
Earth tide (ET) and groundwater

Gravity measurement at Membach station

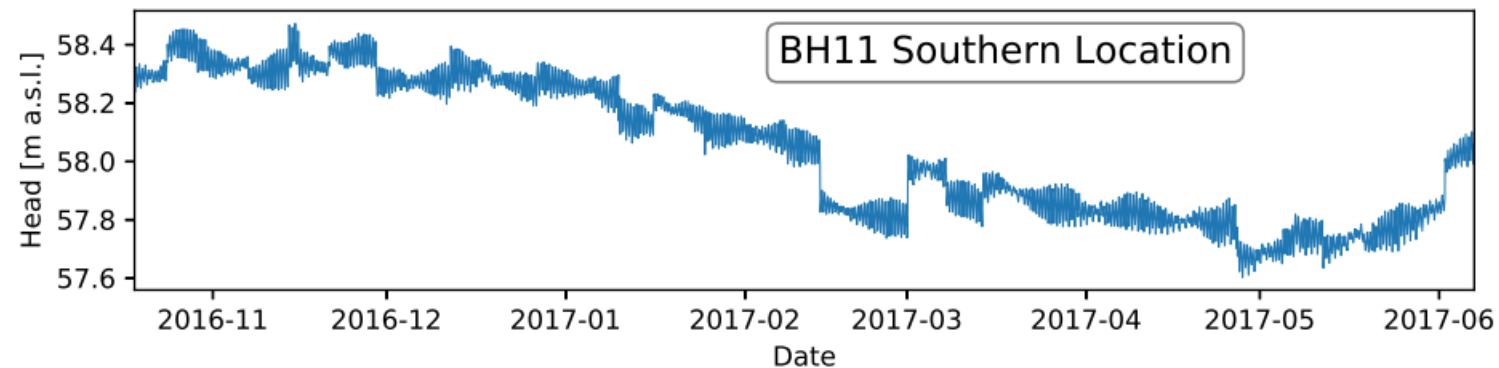


Royal Observatory of Belgium (2019)

Strain measurement in a mine



Levine and Harrison (1976)



Foppen et al. (2019)

PyGTide - Theoretical Earth tides

- A few different (and clunky) software packages are available
- ETERNA PREDICT is the gold standard in Geodesy
- Integration of latest tidal catalogue (Kudryavtsev, 2003)
- A modernised Python module enables automated ET calculation

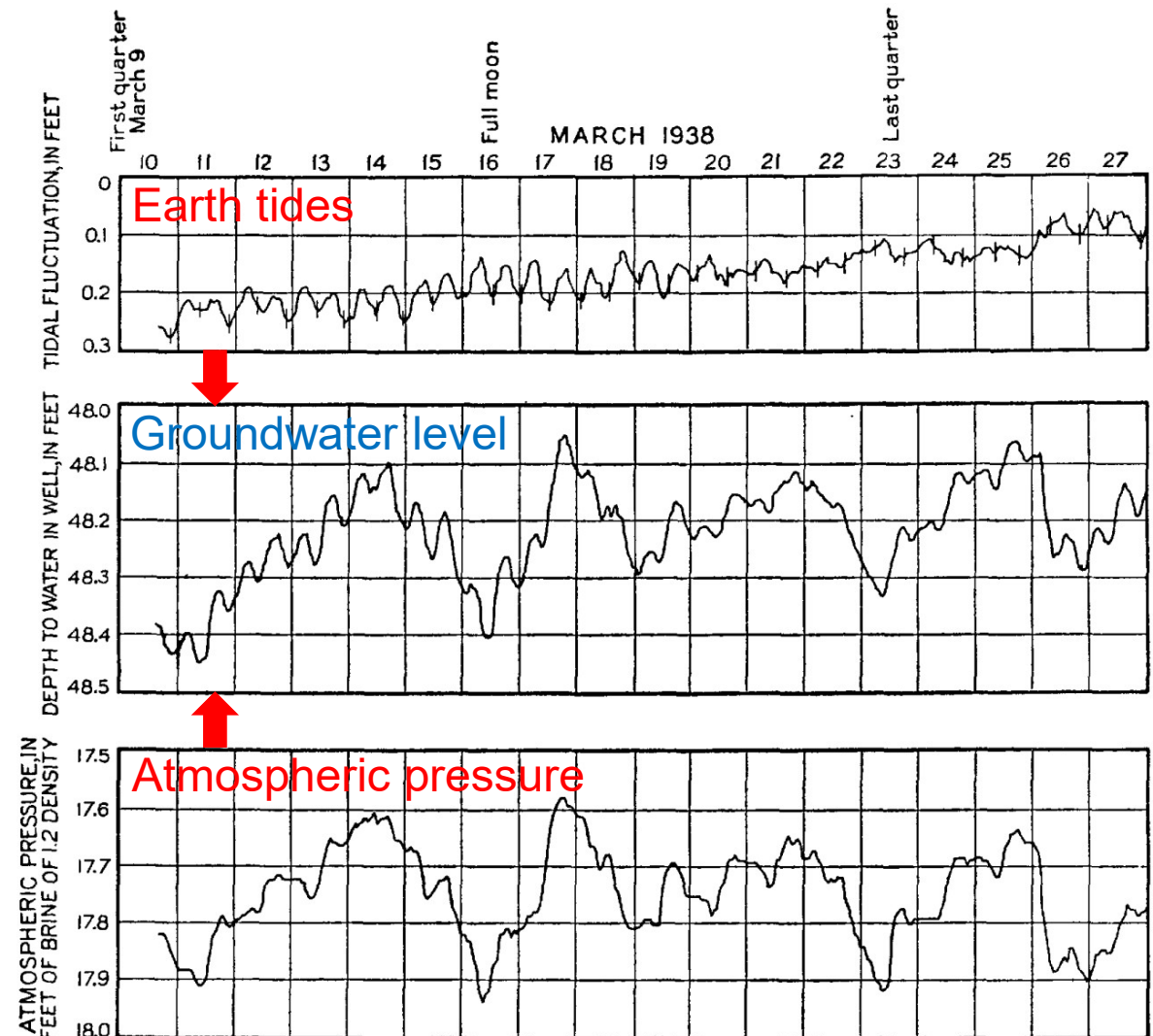
Rau, G C (2018) *PyGTide: A Python module and wrapper for ETERNA PREDICT to compute gravitational tides on Earth*, Zenodo, doi:10.5281/zenodo.1346260.

GitHub, <https://github.com/hydrogeoscience/pygtide>

GitHub

Groundwater responds to tidal forces

- Early observations of periodic discharge in an underground mine (Klönne, 1880)
- More observations by pioneers in Geology in the following decades
- Very prominent example by Meinzer (1939)

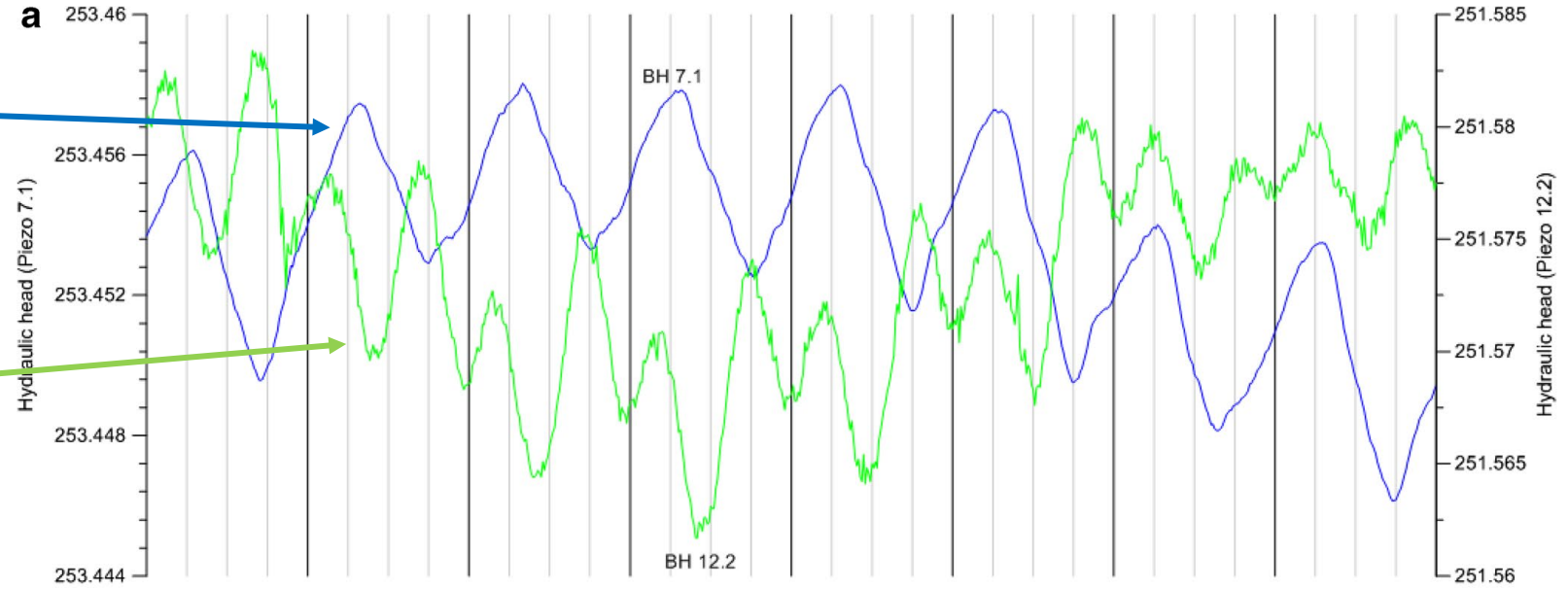


Meinzer (1939)

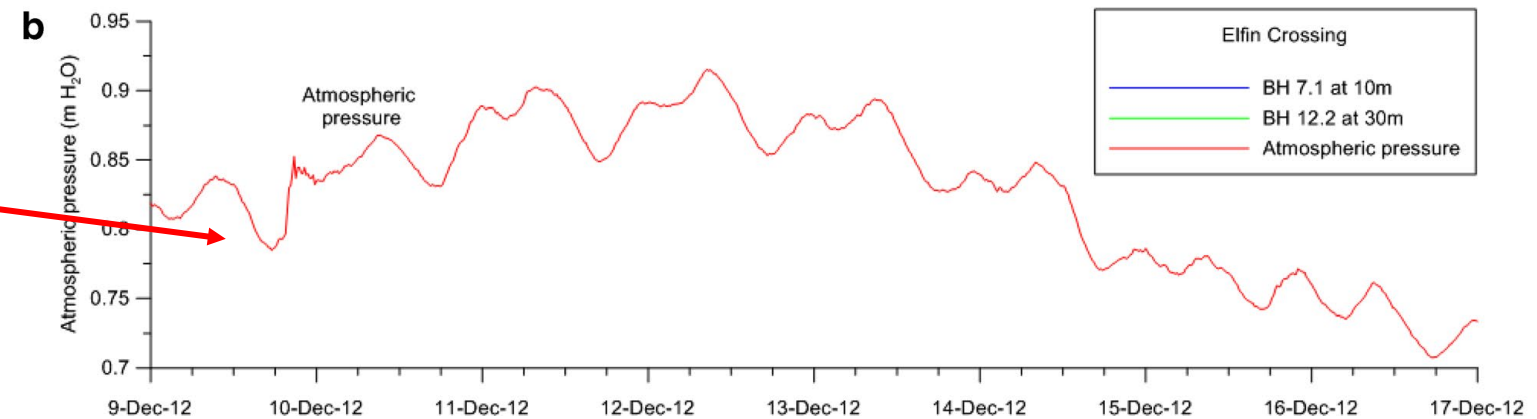
Periodic signals in measurements

Shallower system:
Evapotranspiration

Deeper system:
Tidal forces



Atmospheric pressure

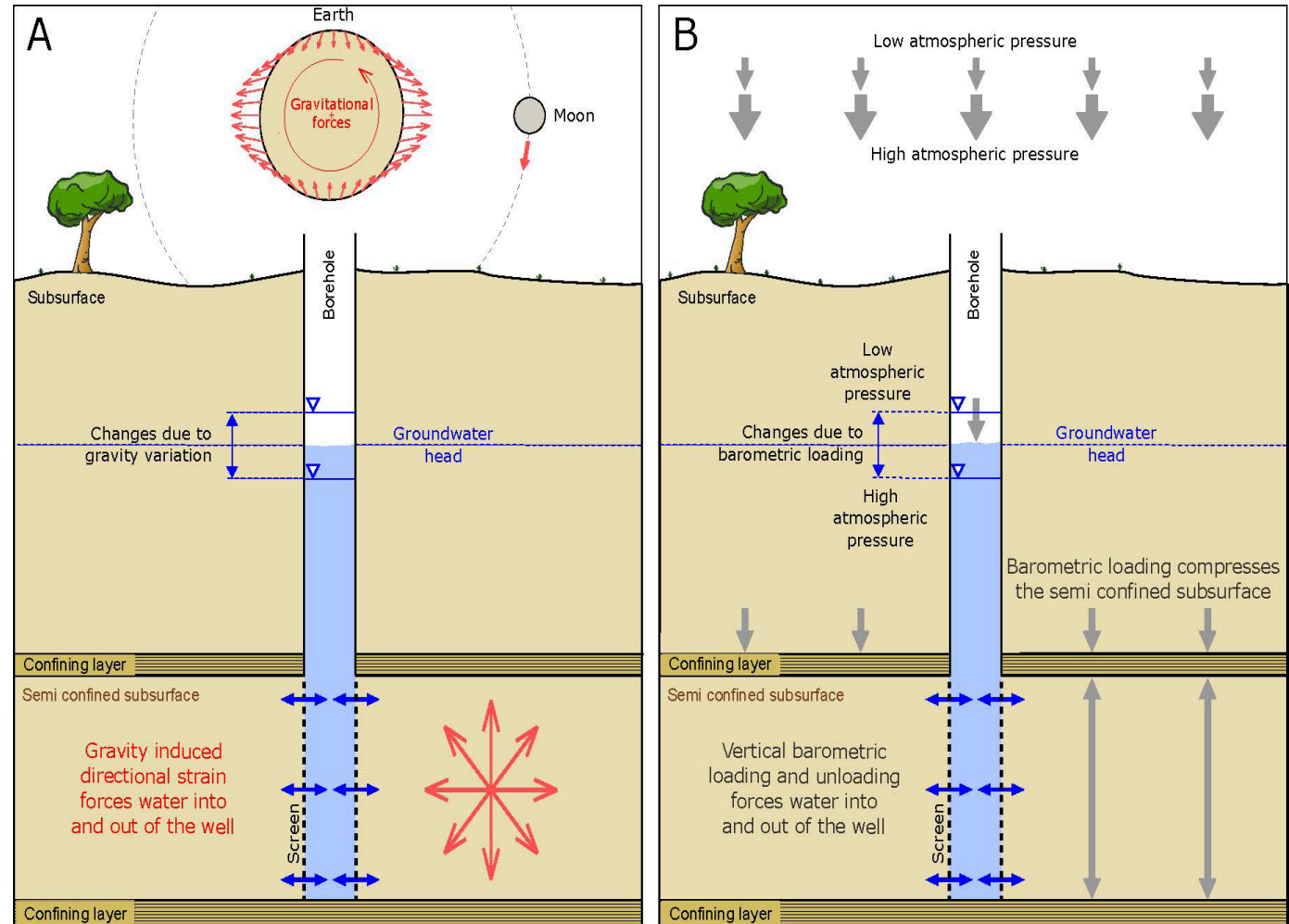


Acworth et al. (2014)

Groundwater response to EAT

- **(A) Earth tides**
 - Plane stress & strain
 - Signal can be synthesised with software, e.g.
 - *TSoft* (van Camp and Vauterin, 2005)
 - *PyGTide* (Rau, 2018)

- **(B) Atmospheric tides**
 - Uniaxial stress & strain
 - Recorded by barometric loggers or weather stations



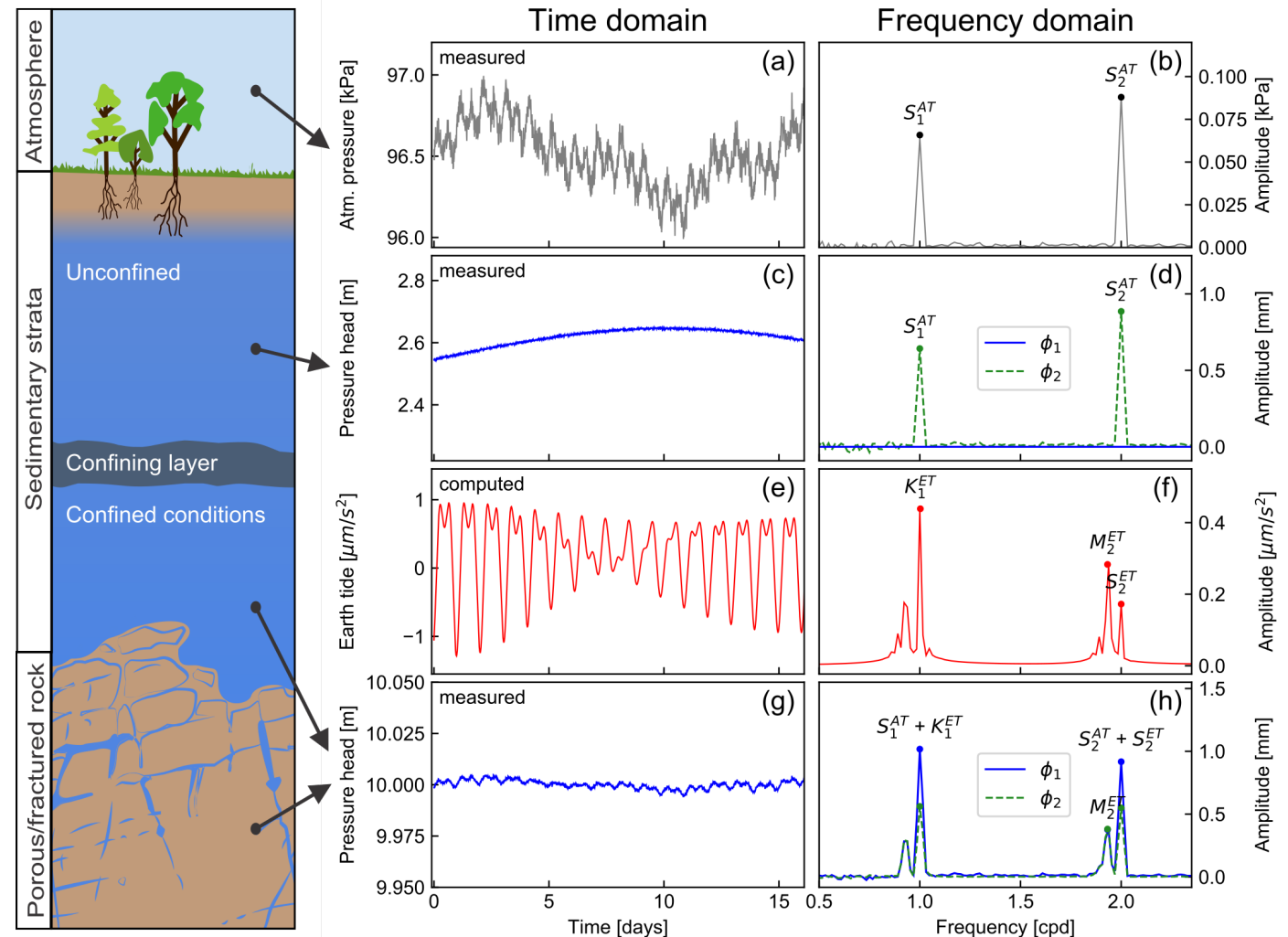
McMillan et al. [2019]

Spectral „finger print“ as screening tool

- Standard datasets
 - **Well water levels** (measured)
 - **Baro pressure** (measured)
 - **Earth tides** (calculated)

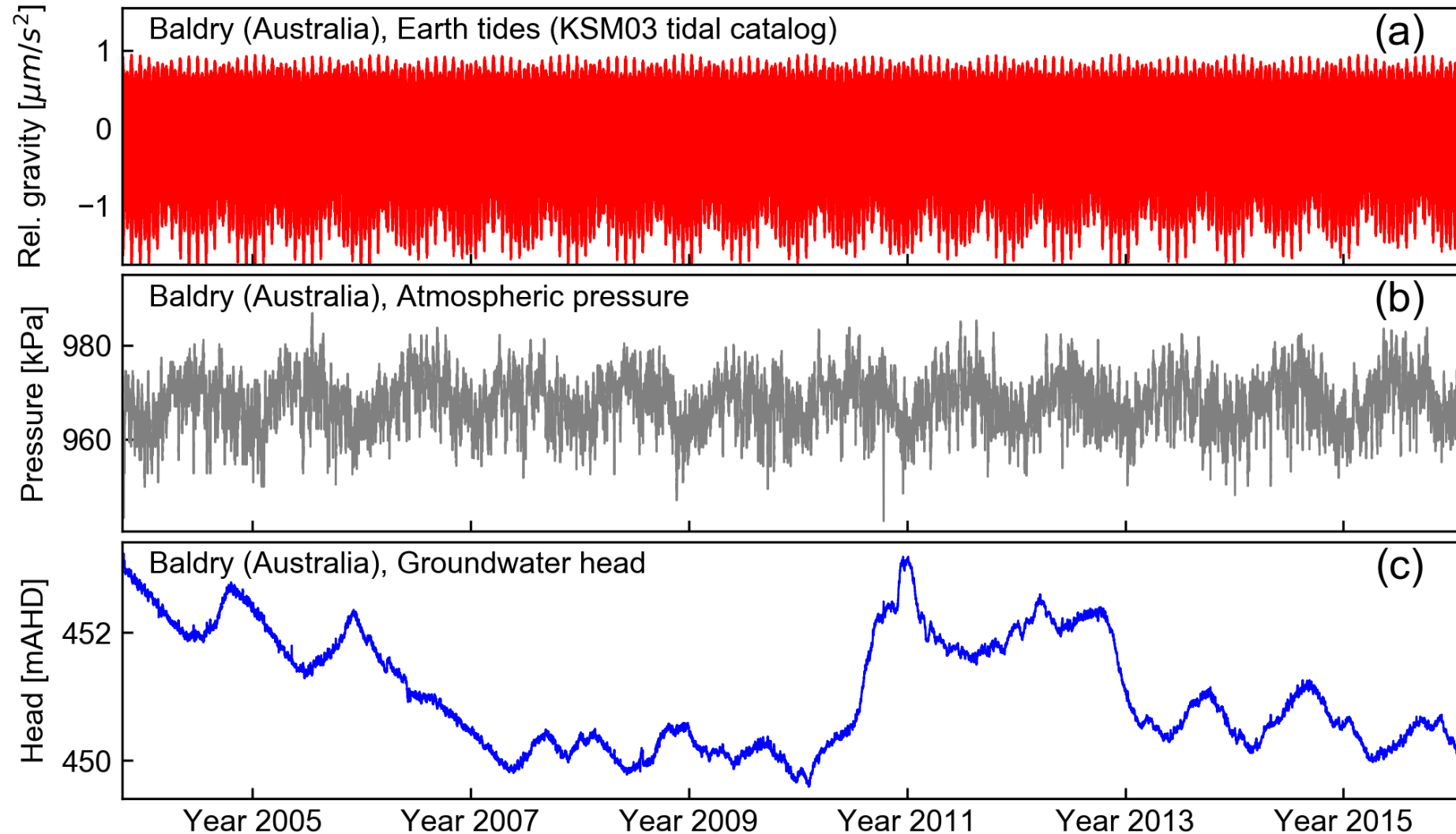
- Potential for PSC

- Summary in:
McMillan et al. (2019) in
Fachjournal *Reviews of Geophysics*



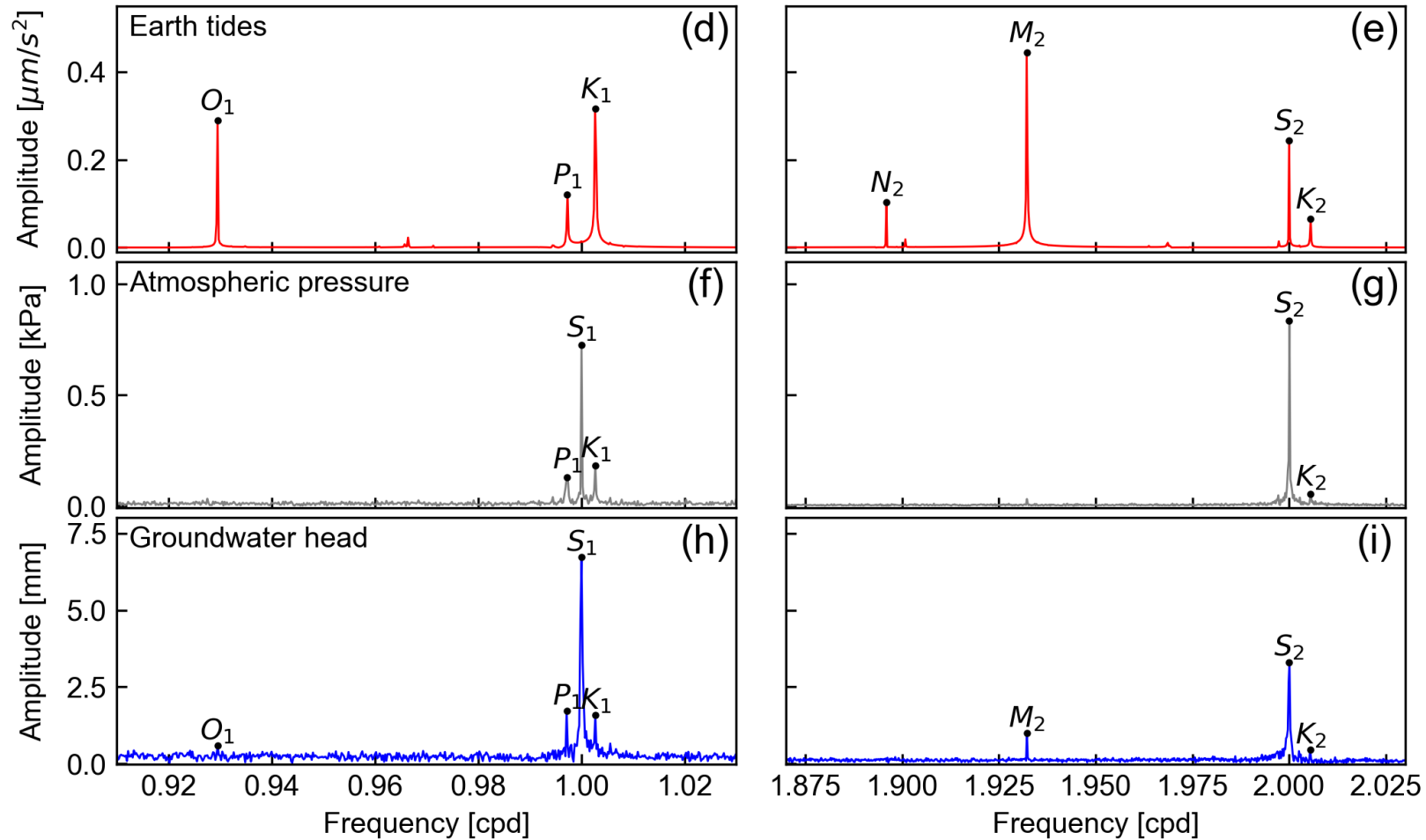
McMillan et al. (2019)

Example EAT impact on groundwater



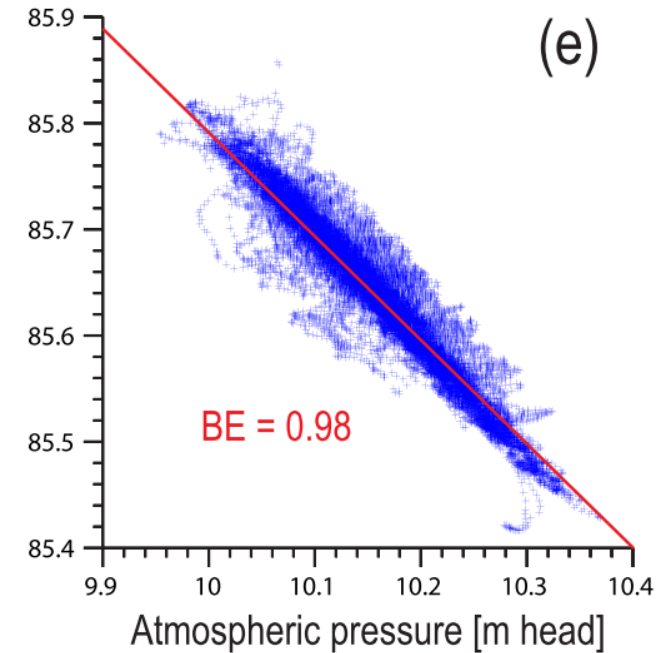
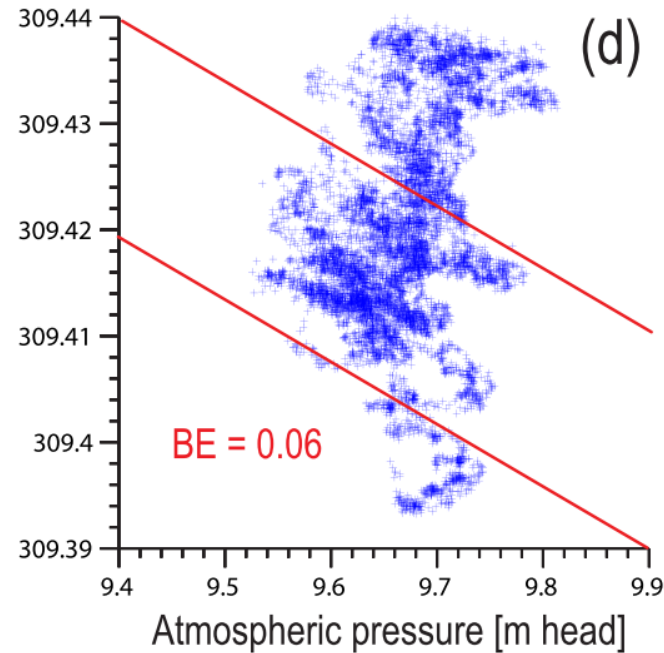
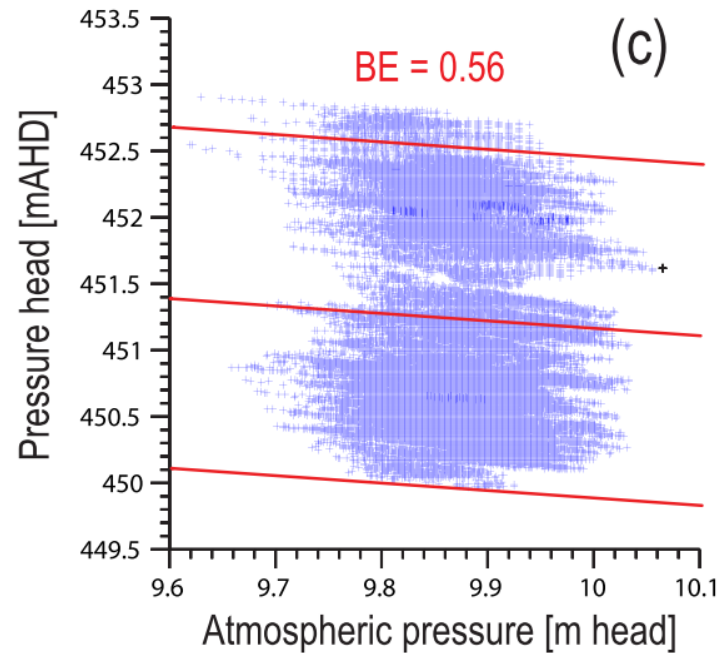
McMillan et al. (2019)

Spectrum reveals EAT impact



McMillan et al. (2019)

Estimating subsurface properties



Acworth et al. (2016)

HydroGeoSines



- A Python module to estimate subsurface properties from standard pressure datasets
- Goal: Easy analysis and interpretation
- Open source and access tool to be advanced by the community

<https://github.com/HydroGeoSines/HydroGeoSines>

