Demonstration of Well Response Functions

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Abstract

abstract text

1 Introduction

Load the packages

```
library(signal, warn.conflicts = FALSE)
## Loading required package:  MASS
library(kitagawa, warn.conflicts = FALSE)
## Loading required package:  kelvin
## Loading required package:  Bessel
## Loading required package:  Rmpfr
## Loading required package:  gmp
##
## Attaching package:  'gmp'
##
## The following object is masked from 'package:base':
##
##    %*%, apply, crossprod, matrix, tcrossprod
## Loading C code of R package 'Rmpfr': GMP using 64 bits per limb
##
## Attaching package:  'Rmpfr'
##
## The following object is masked from 'package:stats':
##
##    pnorm, print.integrate
##
## The following object is masked from 'package:base':
##
##    cbind, pmax, pmin, rbind
##
## Loaded kelvin (1.2.2) - Solutions to the Kelvin differential equation.
## Loaded kitagawa (2.0.2) - Spectral response of water wells
```

2 Sealed well response

2.1 Strain: Kitagawa (2011)

Kitagawa et al. (2011)

3 Open well response

3.1 Strain: Rojstaczer (1988)

Rojstaczer (1988b,a)

```
# Some dummy parameters
z <- 1
Trans <- 1
Stor <- 1
Diffus <- Trans/Stor
# Nondimensional frequencies
Q <- 10^seq(-3, 2, by = 0.1)  # == z**2 omega / 2 D
omega <- omega_norm(Q, z, Diffus, invert = TRUE)  # == Q * 2 * Diffus / z**2
wrsp <- open_well_response(omega, T. = Trans, S. = Stor, z. = z, model = "rojstaczer",
    as.pressure = FALSE)
crsp <- wrsp[, 2]
#
lQ <- log10(Q)
# Amplitude
As <- 0.05  # cm/nE
Gain <- Mod(crsp)
# Phase
Phs <- Arg(crsp)  # will wrap to -pi/pi
uPhs <- signal::unwrap(Phs, tol = pi/30)
```

References

Kitagawa, Y., Itaba, S., Matsumoto, N., and Koizumi, N. (2011). Frequency characteristics of the response of water pressure in a closed well to volumetric strain in the high-frequency domain. *J. Geophys. Res.*, 116(B8).

Rojstaczer, S. (1988a). Determination of fluid flow properties from the response of water levels in wells to atmospheric loading. *Water Resources Research*, 24(11):1927–1938.

Rojstaczer, S. (1988b). Intermediate period response of water levels in wells to crustal strain: Sensitivity and noise level. *Journal of Geophysical Research: Solid Earth*, 93(B11):13619–13634.

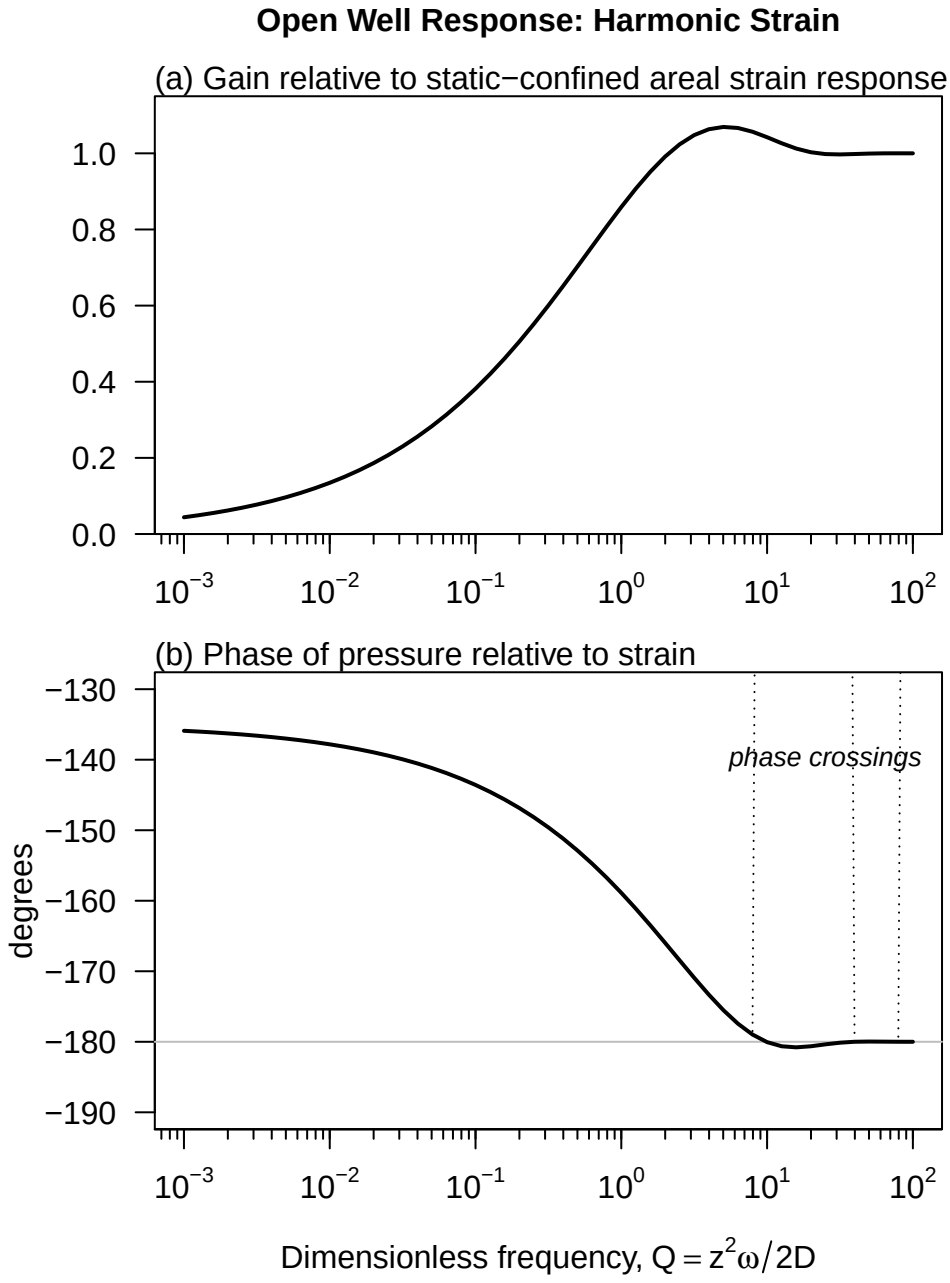

Figure 1: The response of an open well to harmonic areal strain using the Rojstaczer model. Modified from Rojstaczer (1988b, Fig. 3). Frequency is dimensionless, based on the well-depth z and the diffusivity D.