USING BAYTAP-08 TO ISOLATE TRANSIENTS

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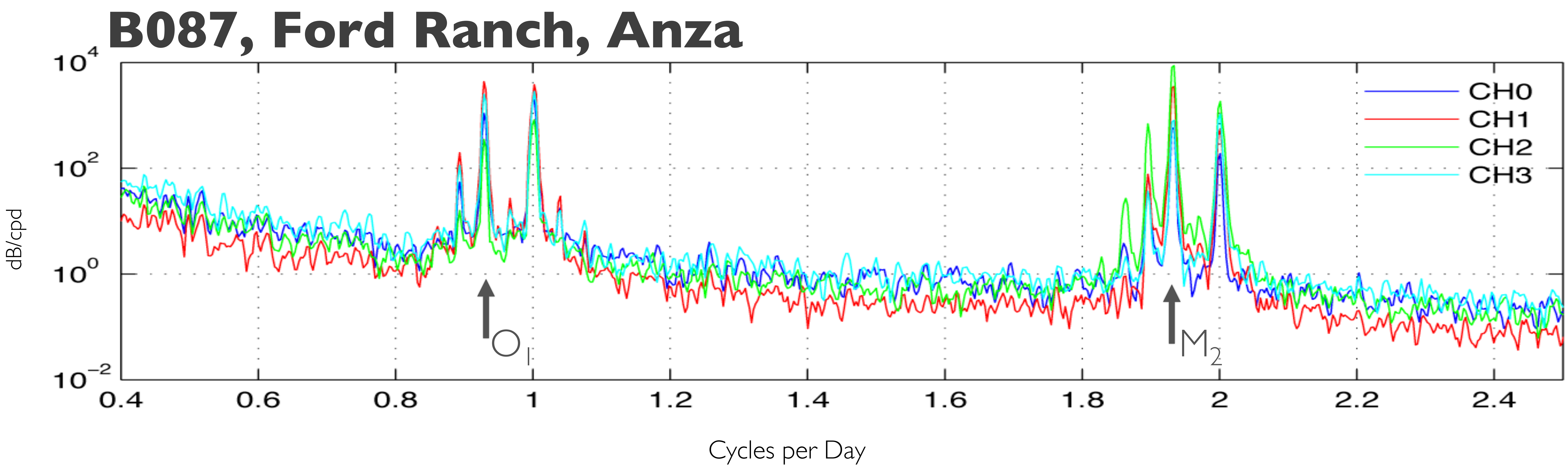
2018 Strainmeter Short Course

TIDES

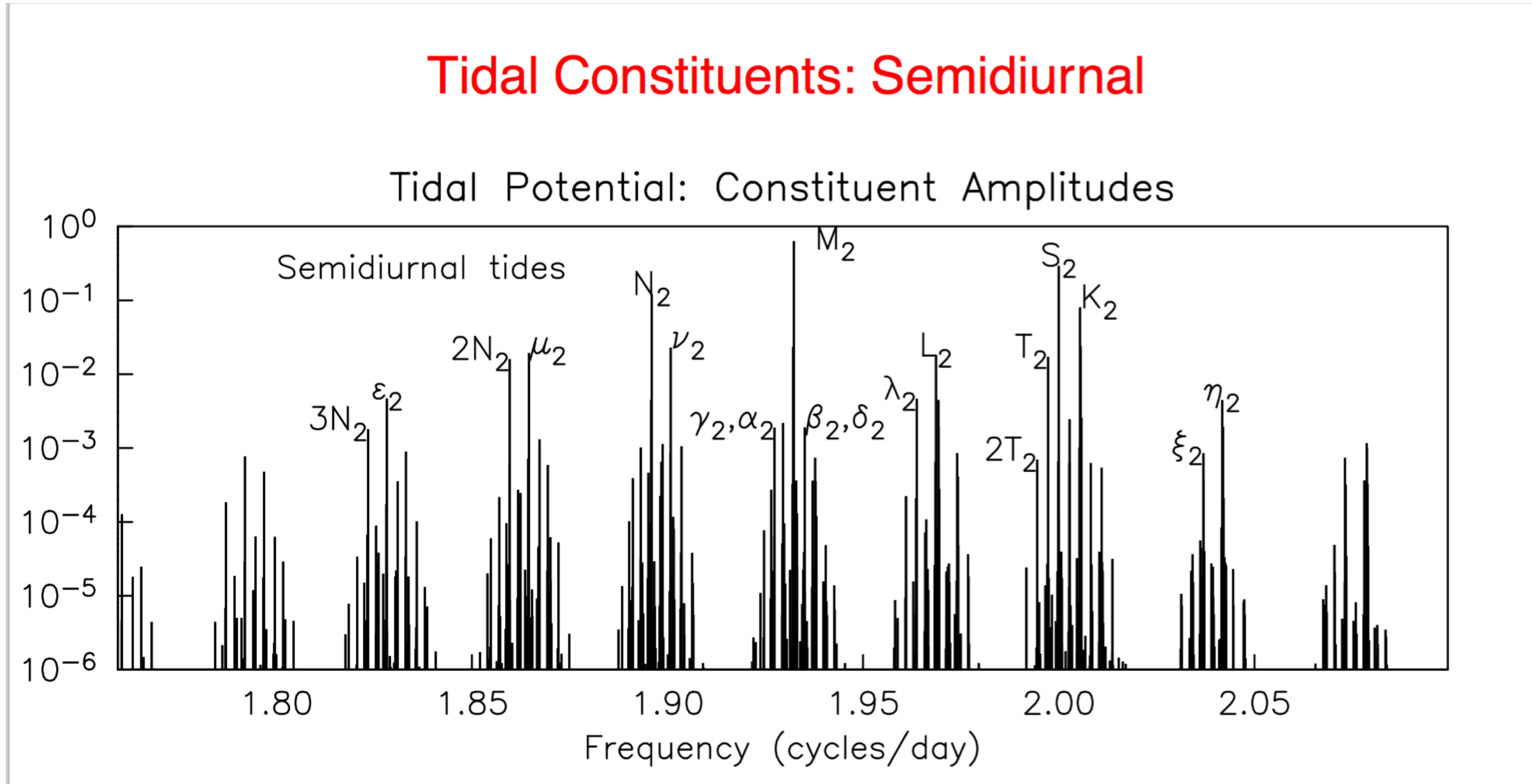
- To isolate tectonic strains the tidal signal must be identified and removed
- Tides also provide
  - A known signal against which to calibrate
  - A way to monitor state of health

TIDES

M_2 and O_1 tidal bands should stand well above the background noise



TIDES



Agnew (2013) BAYTAP08 User's Manual

Tides are clustered around 0, 1 , 2 cycles per day frequency,
called "species".

Within each species tides are separated into groups separated at 1 cycle per month.

Tides within groups are separated at 1 cycle per year.

TIDAL ANALYSIS

- We will use BAYTAP08 to :
  - identify the amplitudes and phases of the larger tides
  - estimate the barometric response coefficient

BAYTAP

BAYTAP-G

Tamura, Y., T. Sato, M. Ooe, and M. Ishiguro (1991), A procedure for tidal analysis with a Bayesian information criterion, Geophys. Journ. Int., 104, 507–516.

BAYTAP08 rewritten by Duncan Agnew

http://igppweb.ucsd.edu/~agnew/Baytap/baytap.html

BAYTAP

BAYTAP

- Estimates tidal amplitudes and phases.
- Determine the "drift" or "trend" and calculate its power spectrum using an ARMA model.
- Includes in its modeling the effect of partially correlated data, such as atmospheric pressure.

BAYTAP

Assume each tide can be represented by $P\cos(2\pi ft + \varphi)$ where,

P is the amplitude ,

f is the frequency,

φ is the phase w.r.t. the local potential

$$\begin{aligned} P\cos(2\pi ft + \varphi) &= P\cos\varphi \cdot \cos(2\pi ft) - P\sin\varphi \cdot \sin(2\pi ft) \\ &= A\cos(2\pi ft) + B\sin(2\pi ft) \end{aligned}$$

BAYTAP

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$$= A\cos(2\pi ft) + B\sin(2\pi ft)$$

BAYTAP

Assumes a strain signal y_i at time i can be represented as

$$y_i = t_i + d_i + c_i + s_i$$

t_i = tidal signal

d_i = long term trend (drift)

c_i = response to other effects (e.g., barometric pressure)

s_i = data offsets

TIDAL SIGNAL

$$y_i = t_i + d_i + c_i + s_i$$

$$t_i = \sum_{m=1}^{M} (A_m C_{mi} + B_m S_{mi})$$

C_{mi} and S_{mi} are the theoretical values of the tidal groups (known)

A_m and B_m contain the tidal amplitudes and phases we want to find

BAROMETRIC RESPONSE

$$y_i = t_i + d_i + c_i + s_i$$

$$c_i = b_i\, a_i$$

b_i is the barometric response coefficient

a_i is the barometric pressure

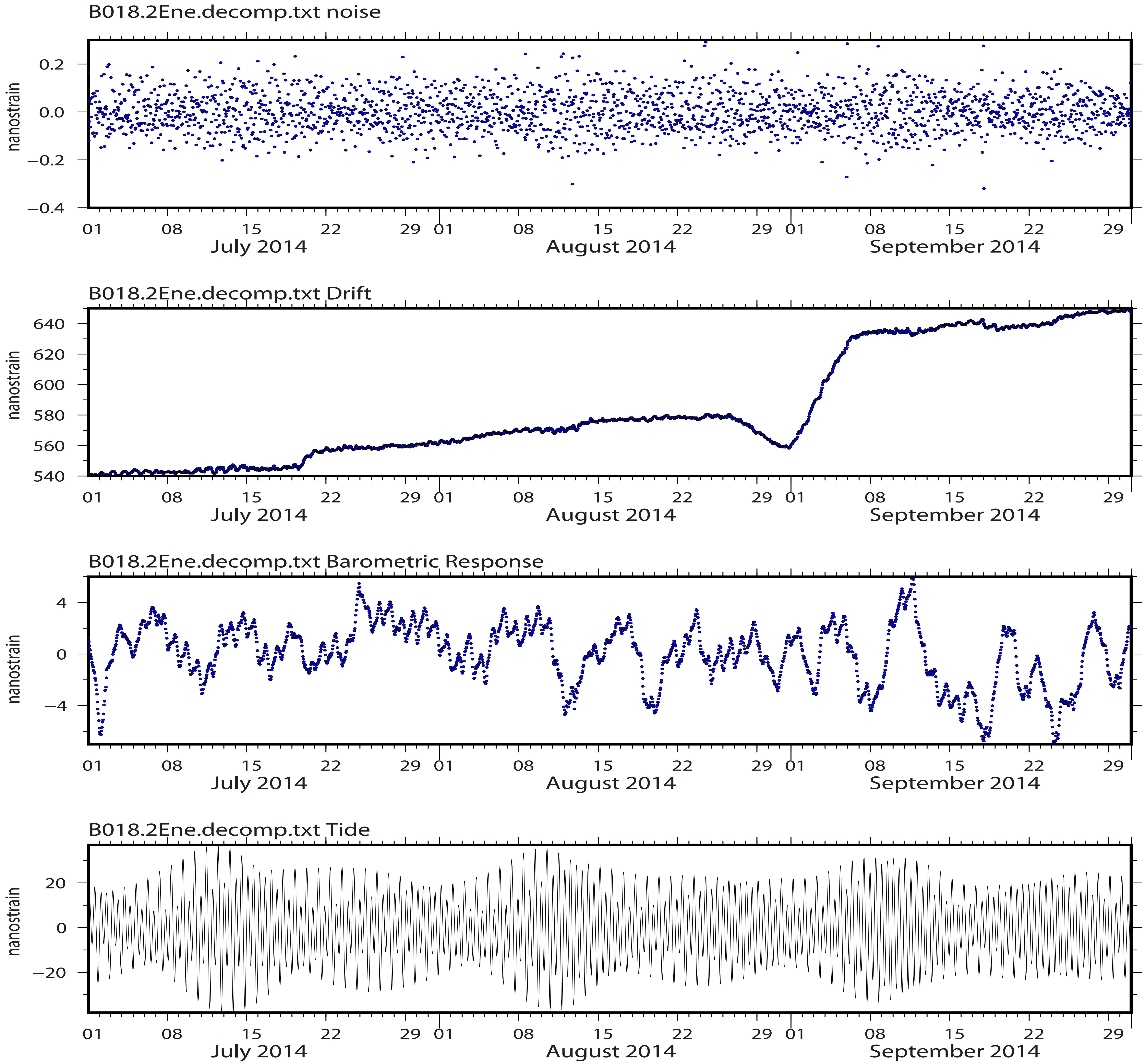
- We assume a linear response coefficient between strain change and barometric pressure change.

BAYTAP

The residual series, or noise, is the misfit of the model to the data

$$r_i = y_i - (t_i + d_i + c_i + s_i)$$

BAYTAP



Residual (r_i)

Drift (d_i)

Barometric Response (c_i)

Tide (t_i)

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The program solves for the parameters by minimizing $\boldsymbol{S}$

$$S = \sum_{i=1}^{N} \left[y_i - \left(t_i + d_i + c_i + s_i \right) \right]^2$$

Residual term

$$+ D^2 \sum_{i=1}^{n} \left(d_i - 2d_{i-1} + d_{i-2} \right)^2$$

$$+ W^2 \sum_{m=2}^{M} \left(A_m - A_{m-1} \right)^2 + \left(B_m - B_{m-1} \right)^2$$

BAYTAP

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Forces a smooth variation in trend

- D is an input parameter
- Larger D => a smoother series
- Very large D -> a drift linear with time

BAYTAP

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$$+ D^2 \sum_{i=1}^{n} \left(d_i - 2d_{i-1} + d_{i-2} \right)^2$$

$$+ W^2 \sum_{m=2}^{M} \left(A_m - A_{m-1} \right)^2 + \left(B_m - B_{m-1} \right)^2$$

A_m and B_m are the tidal amplitudes and phases we solve for.

W controls how much the tidal admittance can vary over frequency bands.