

High Resolution Inertial Earth Sensing with Large Sagnac Interferometers

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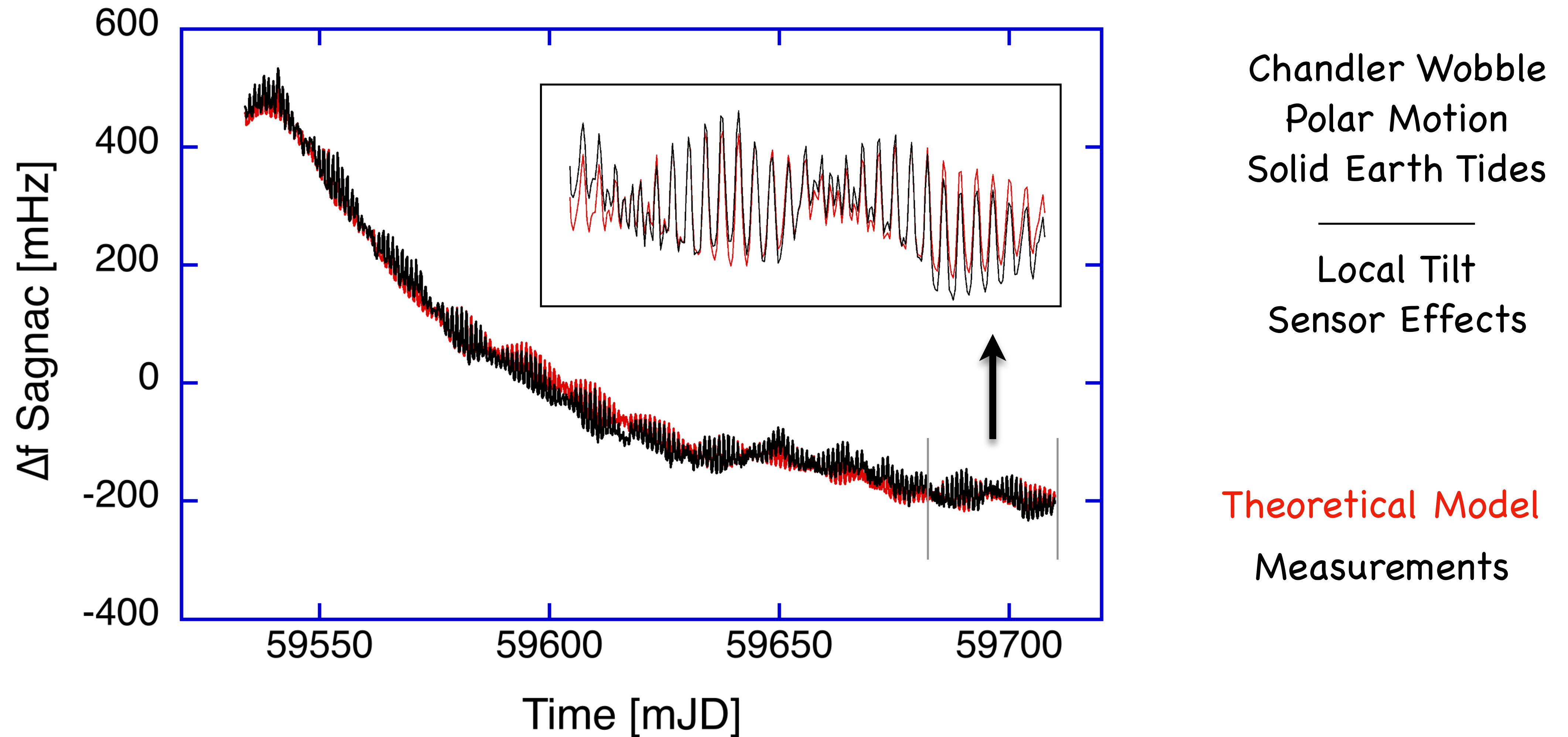
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Ring lasers are now resolving the rate of rotation of the Earth with 8 significant digits. Technically they constitute a Sagnac interferometer, where a traveling wave resonator, circumscribing an arbitrary contour, defines the optical frequency of two counter-propagating resonant laser beams. Subtle non-reciprocal effects on the laser beam however, cause a variable bias, which reduces the long-term stability. Over the last two years, we have improved the performance of the G ring laser to the point that we obtain long-term stable conditions over more than 50 days. Advances in the modeling of the non-linear behavior of the laser excitation process as well as some small but significant improvements in the operation of the laser gyroscope are taking us now right to the doorstep of the periodic part of the Length of Day signal. In this talk we outline the current state of the art of inertial rotation sensing in the geosciences. Furthermore we discuss the next steps for an enhanced stability. At this point in time there is no apparent fundamental limit of this technique in sight.

Ring Laser observations of nearly 200 days



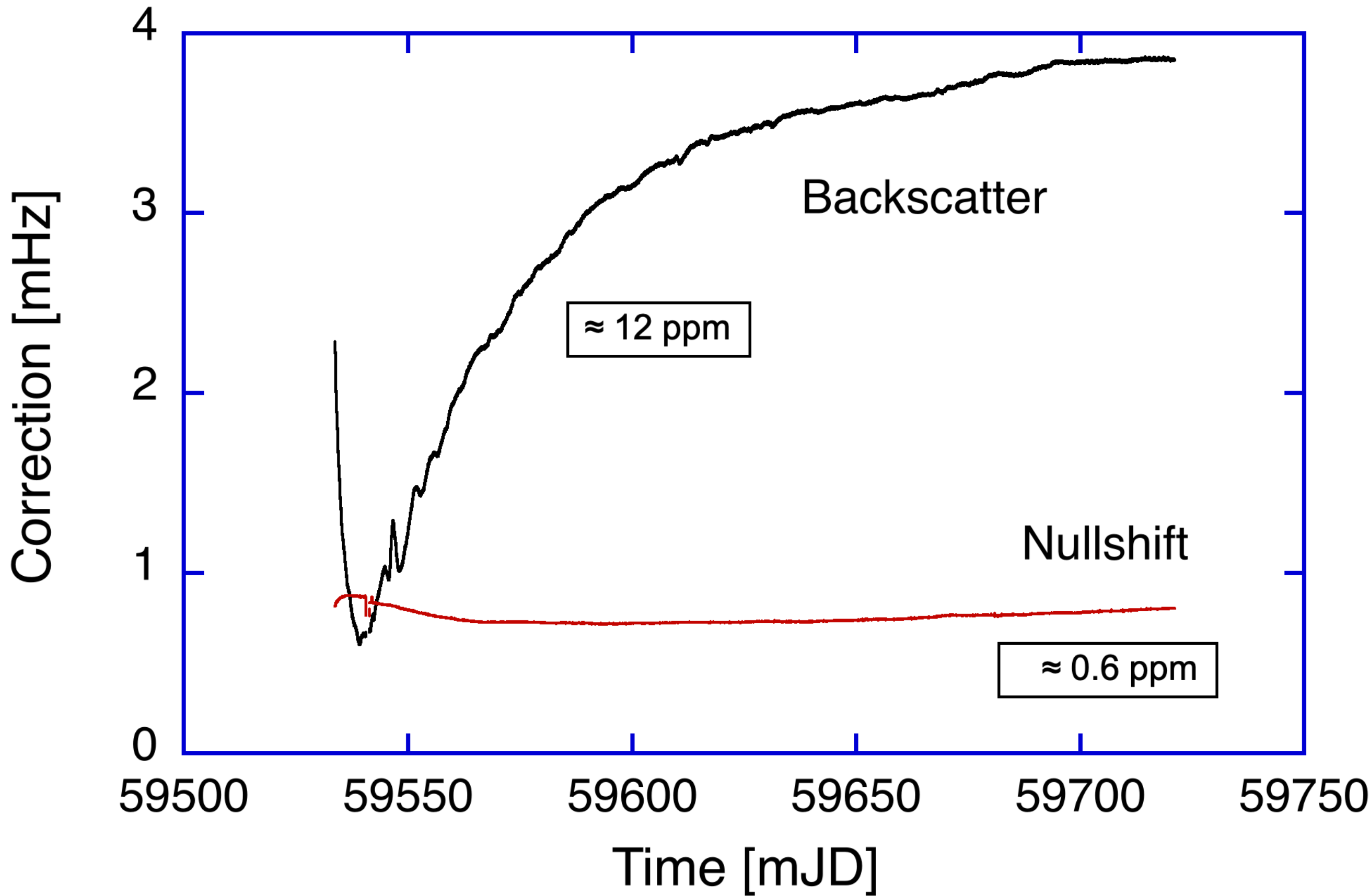
The Earth rate causes a beat note of 348.516 Hz \rightarrow 1 ppb \approx 0.3 μ Hz

Sensor Error Contributions

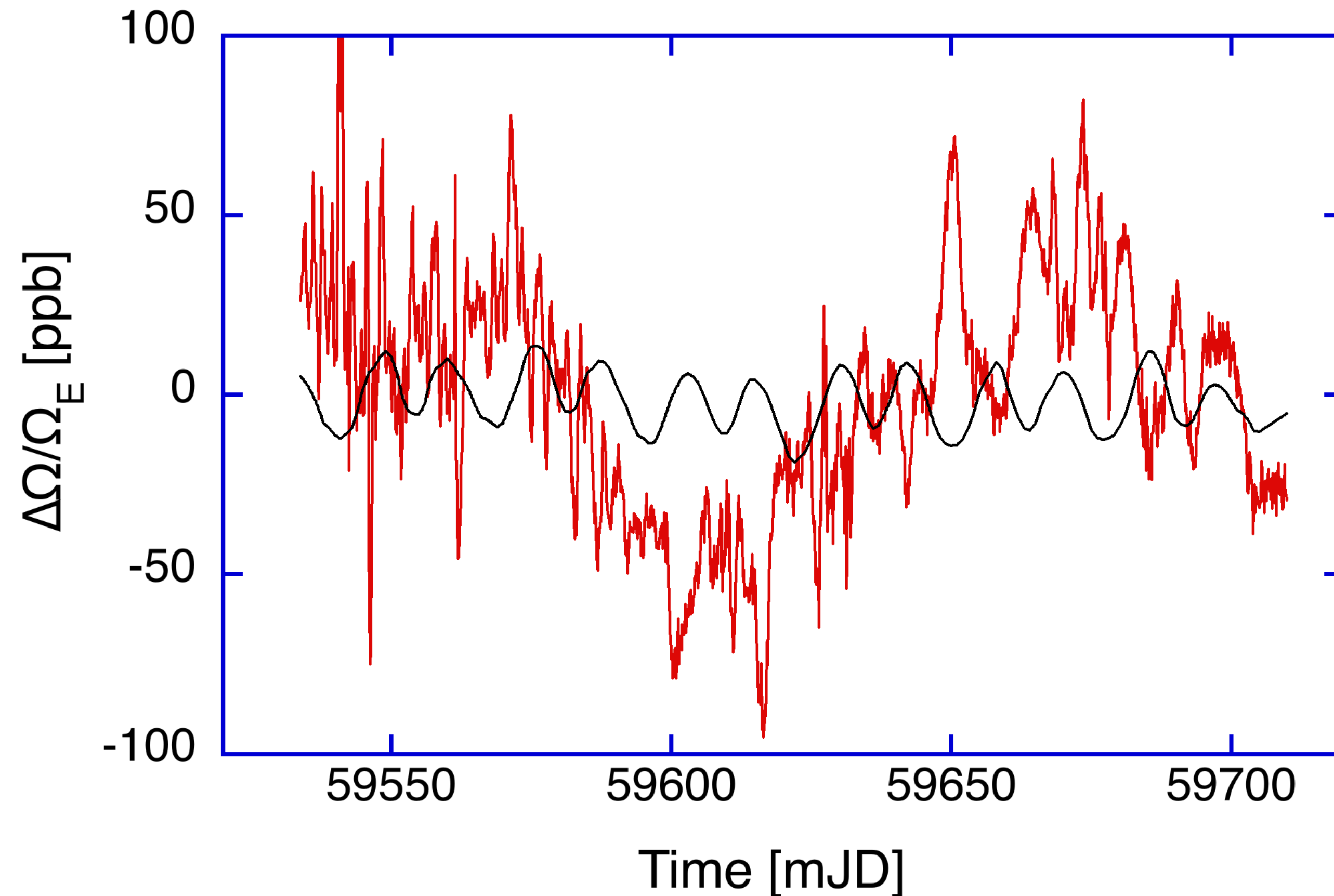
Scale Factor

Effect	Value for G	Error (ppb)
Goos Hänchen Displacement	$1 + 8.78\text{e-}8$	1.6
Refractive Index	$1 - 6.616\text{e-}7$	1.6
Dispersion from Mirrors and Plasma	$1 - 2.527\text{e-}7$	0.2
Beam Abberation	$1 + 4.11\text{e-}8$	0.3

Laser Dynamics

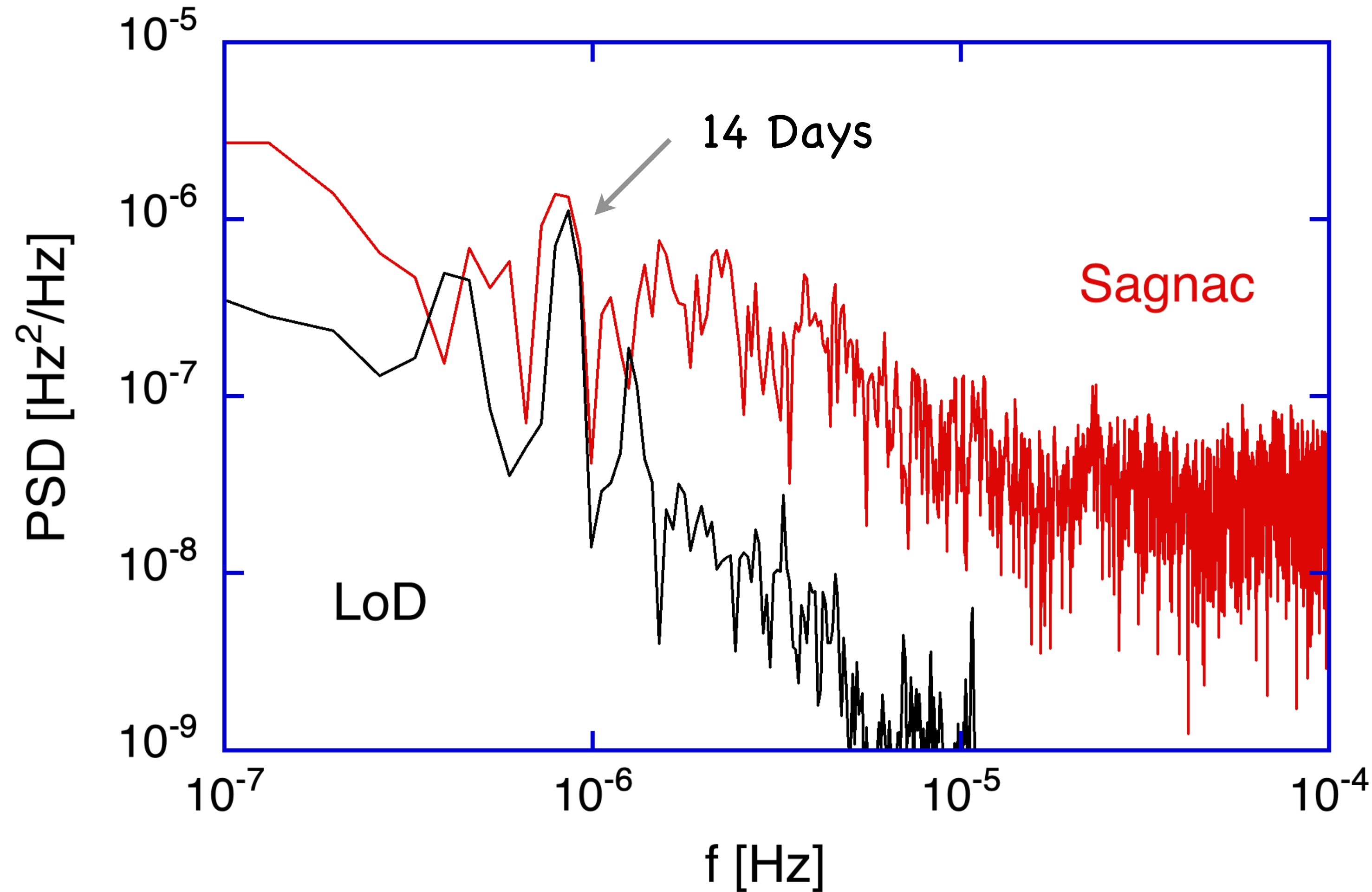


Global versus local Measurements (time domain)



- Measurements 1 data point in 3 hours
- LoD signal derived from IERS daily finals
- As long as we have only one well performing sensor, we are not sure if the low frequency component is a real signal or not.
- A candidate for the residual trends are non-reciprocities from birefringence in the coating

Global versus local Measurements (spectral domain)



In the spectral domain we can already see the LoD signal, but the SNR is not yet sufficient.