Surface Loading effects on the LHC tunnel

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May 5, 2016

0.1 Introduction

Some thoughts and a theoretical framework are gathered here to quantify the circumference changes due to surface loading induced deformations of the bedrock.

0.2 Horizontal deformations due to surface loading

0.3 LHC circumference changes due to horizontal surface deformations

Assumptions:

- ring is positioned horizontally (it is not but to first order it is)
- Horizontal deformations in and around the ring can be linearized wrt to the center point.

Circumference changes of the(a) LHC ring, ΔL, may be computed by a path integral of the horizontal deformations, $\vec{h}$ along a circular path:

$$\Delta L = \oint_{ring} \vec{h} \cdot \frac{d\vec{s}}{|d\vec{s}|} \tag{1}$$

For a circular ring we may parameterize the ring in terms of a fixed radius, r_{lhc} and an azimuth angle α:

$$\Delta L = \int_0^{2\pi} \begin{bmatrix} h_{north}(\alpha, r_{LHC}) \\ h_{east}(\alpha, r_{LHC}) \end{bmatrix} \cdot \begin{bmatrix} -\sin\alpha \\ \cos\alpha \end{bmatrix} d\alpha \tag{2}$$

When the ring is relatively small we may linearize the deformation

0.3.1 Hydrology and atmospheric induced LHC circumference changes from GRACE data

0.3.2 LHC circumference changes due to water level changes