Inertial Rotation Measurements for Geodetic Applications

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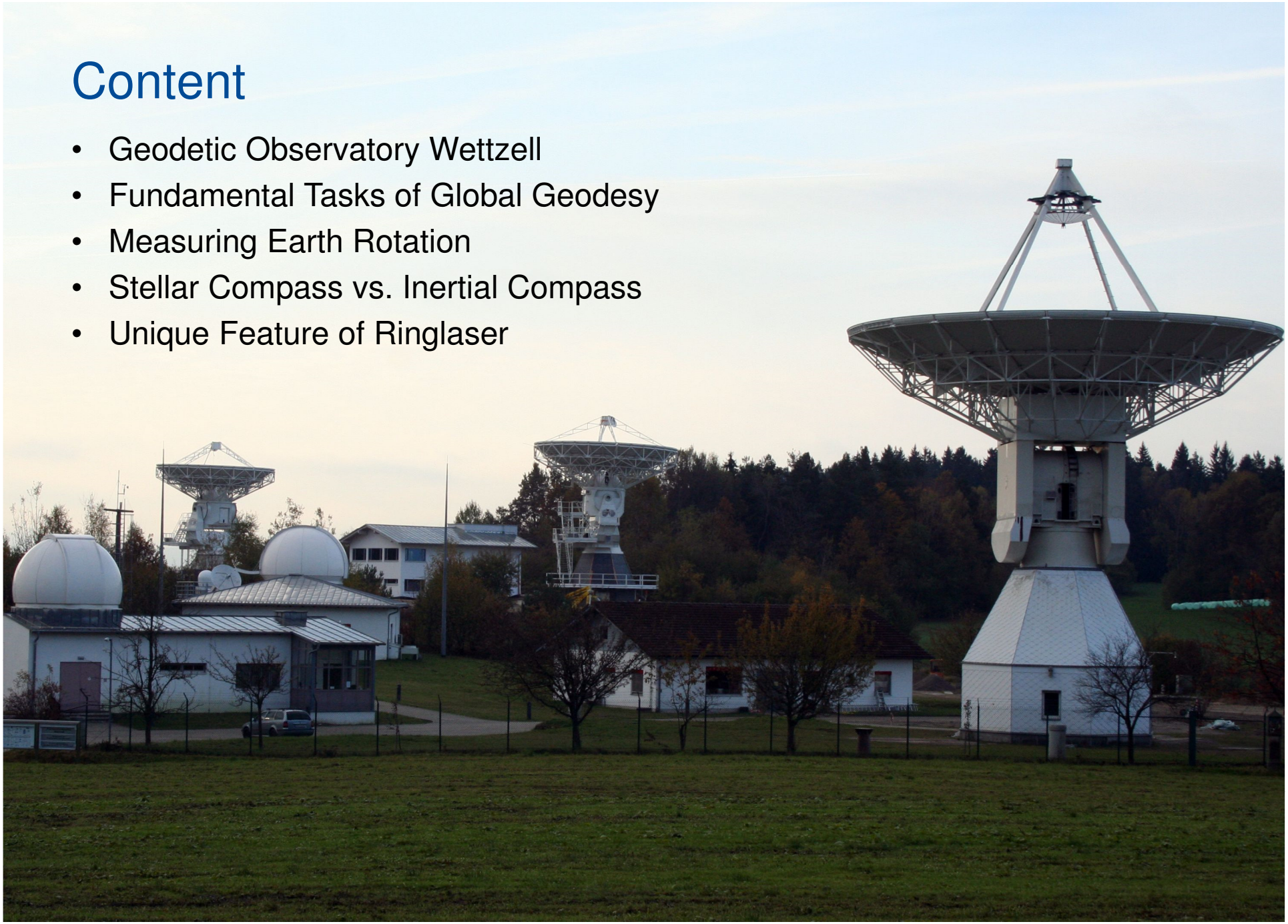
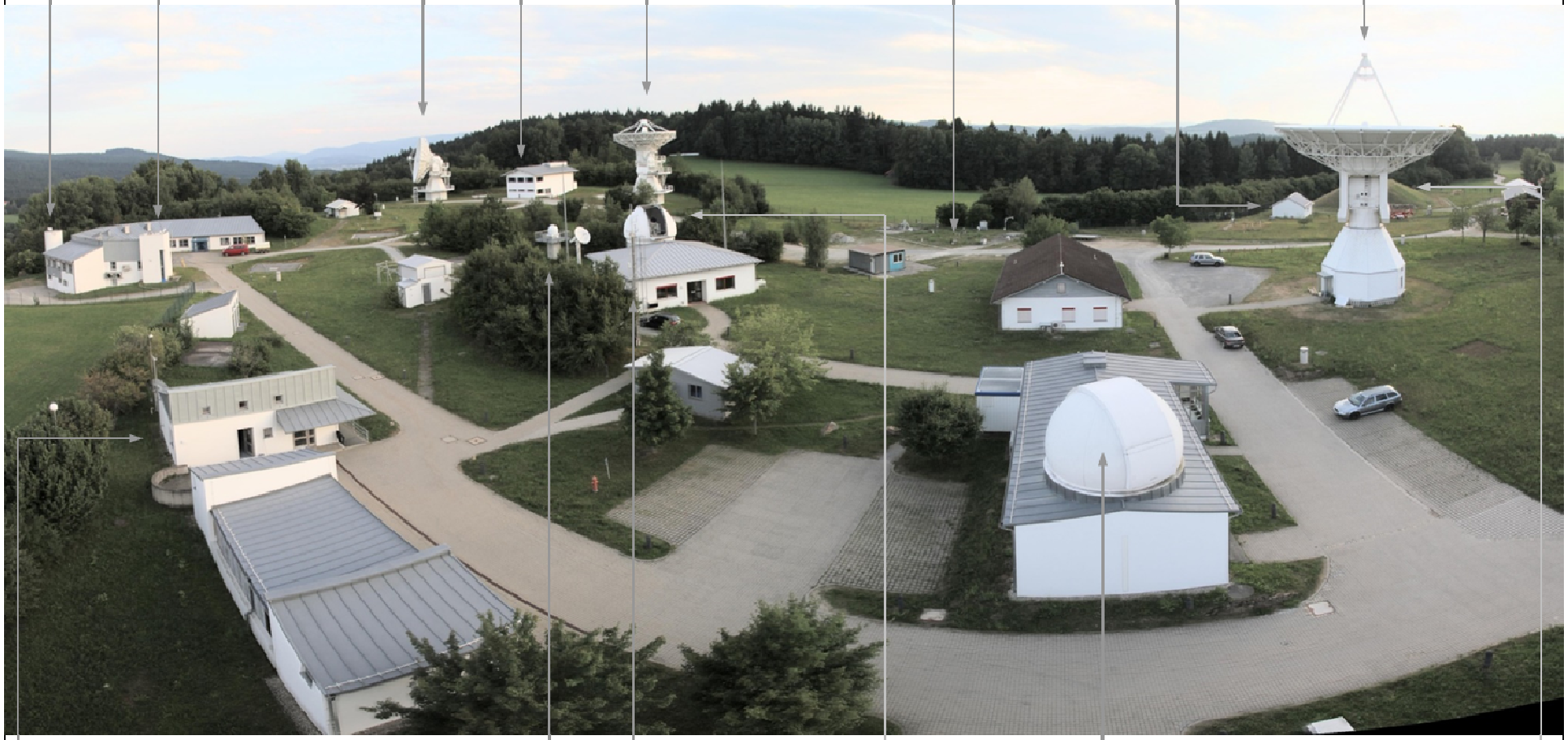
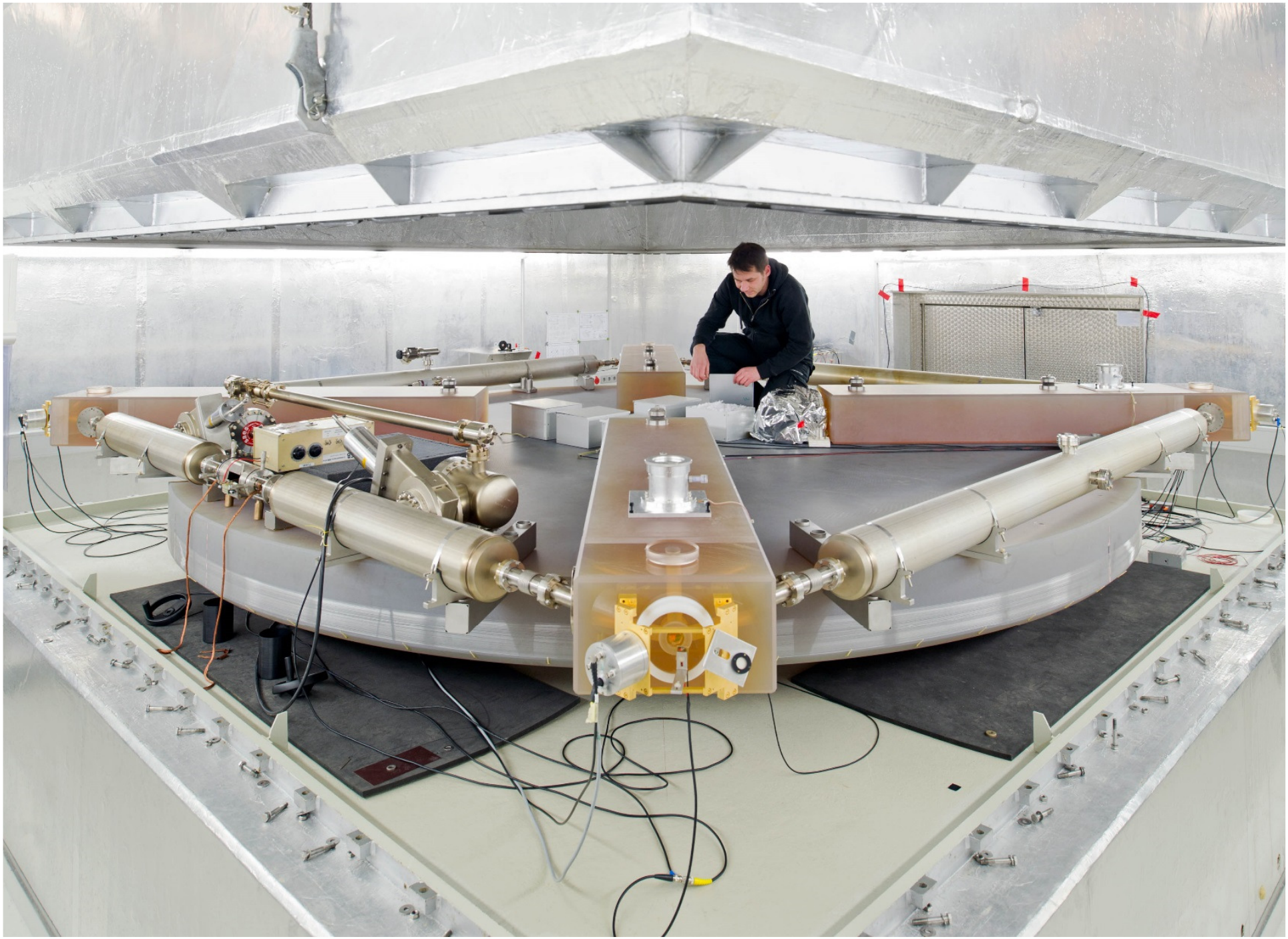


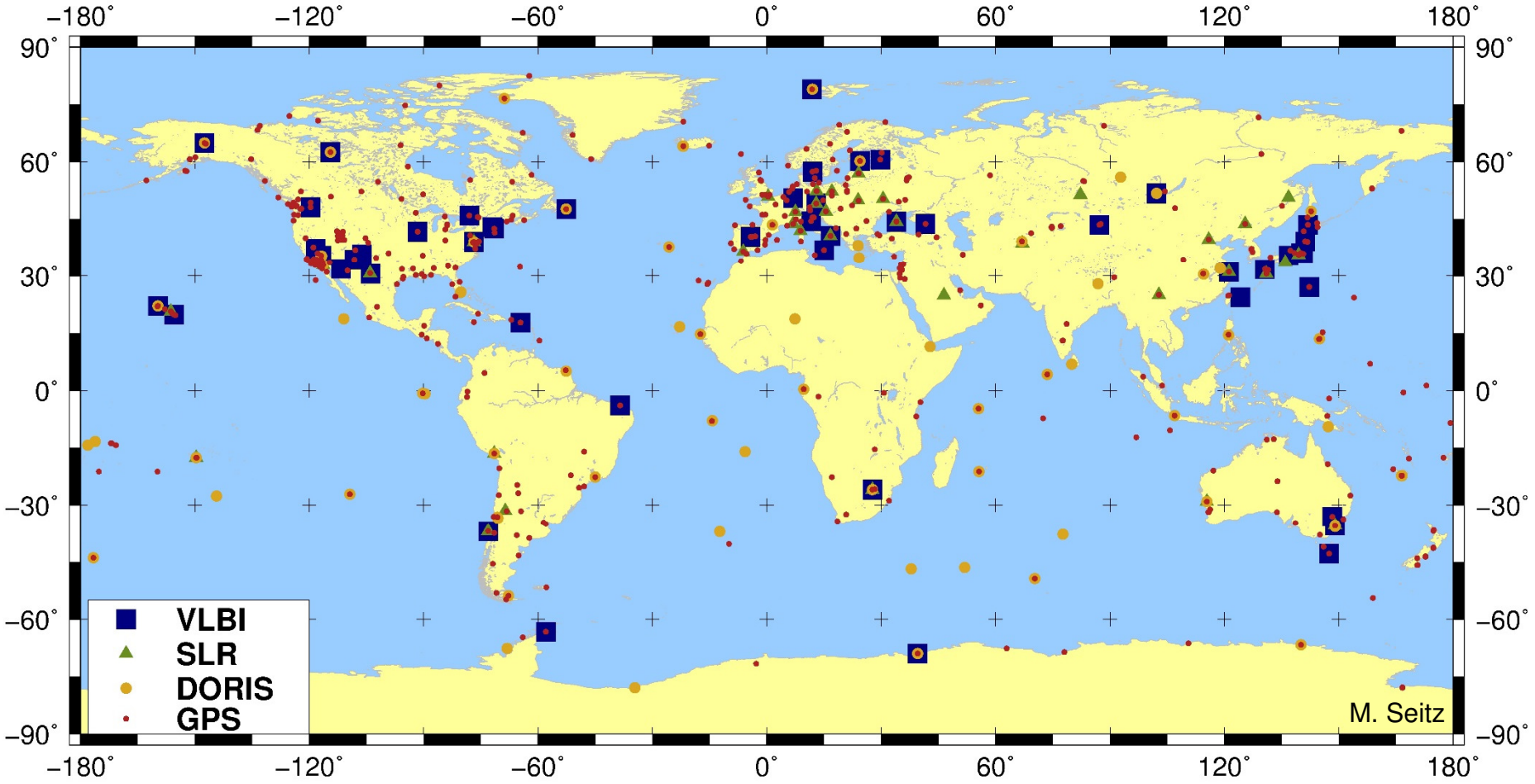
Geodetic Observatory Wettzell



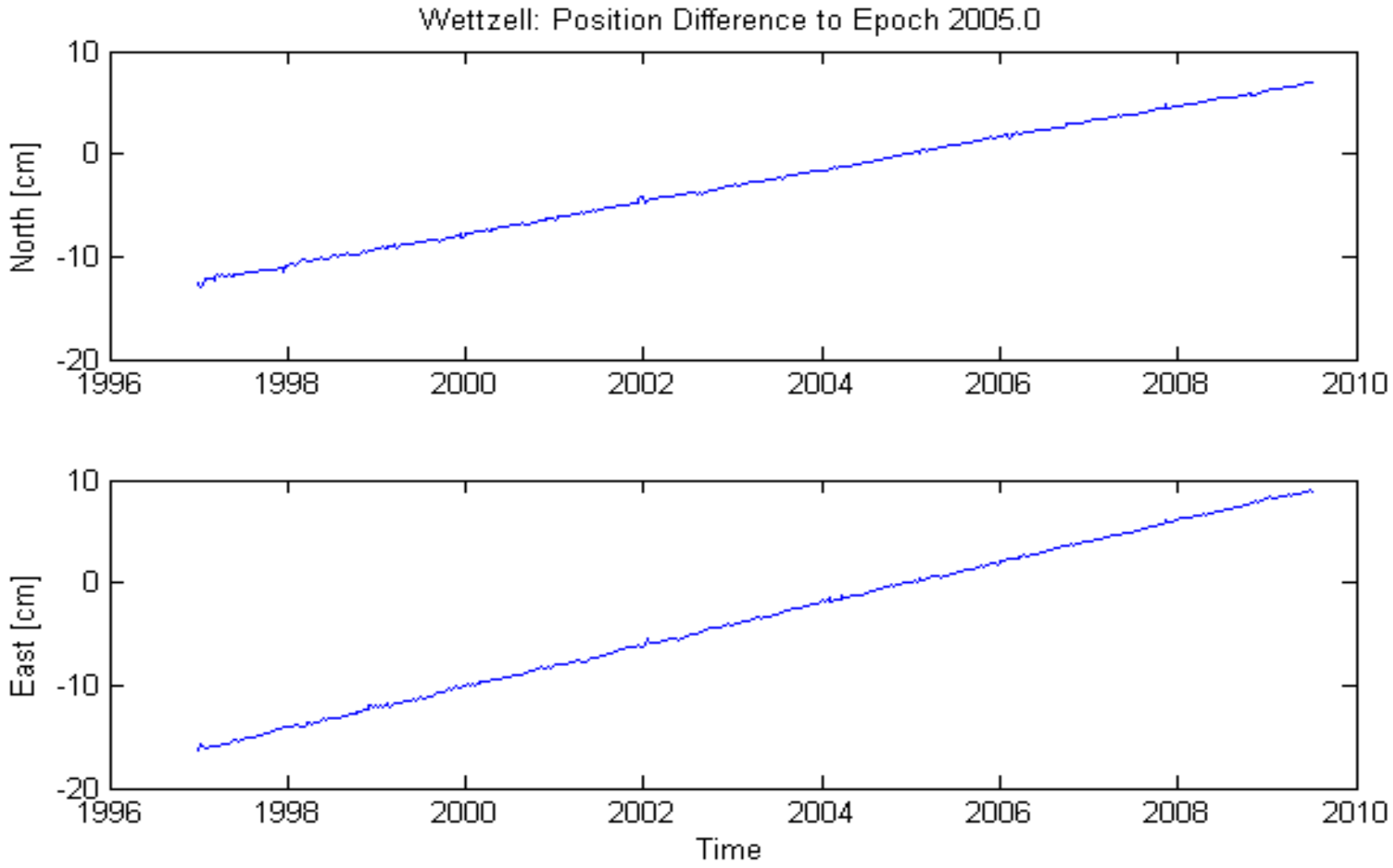


Tasks of a Geodetic Observatory

- Network of Geodetic Measurement Stations

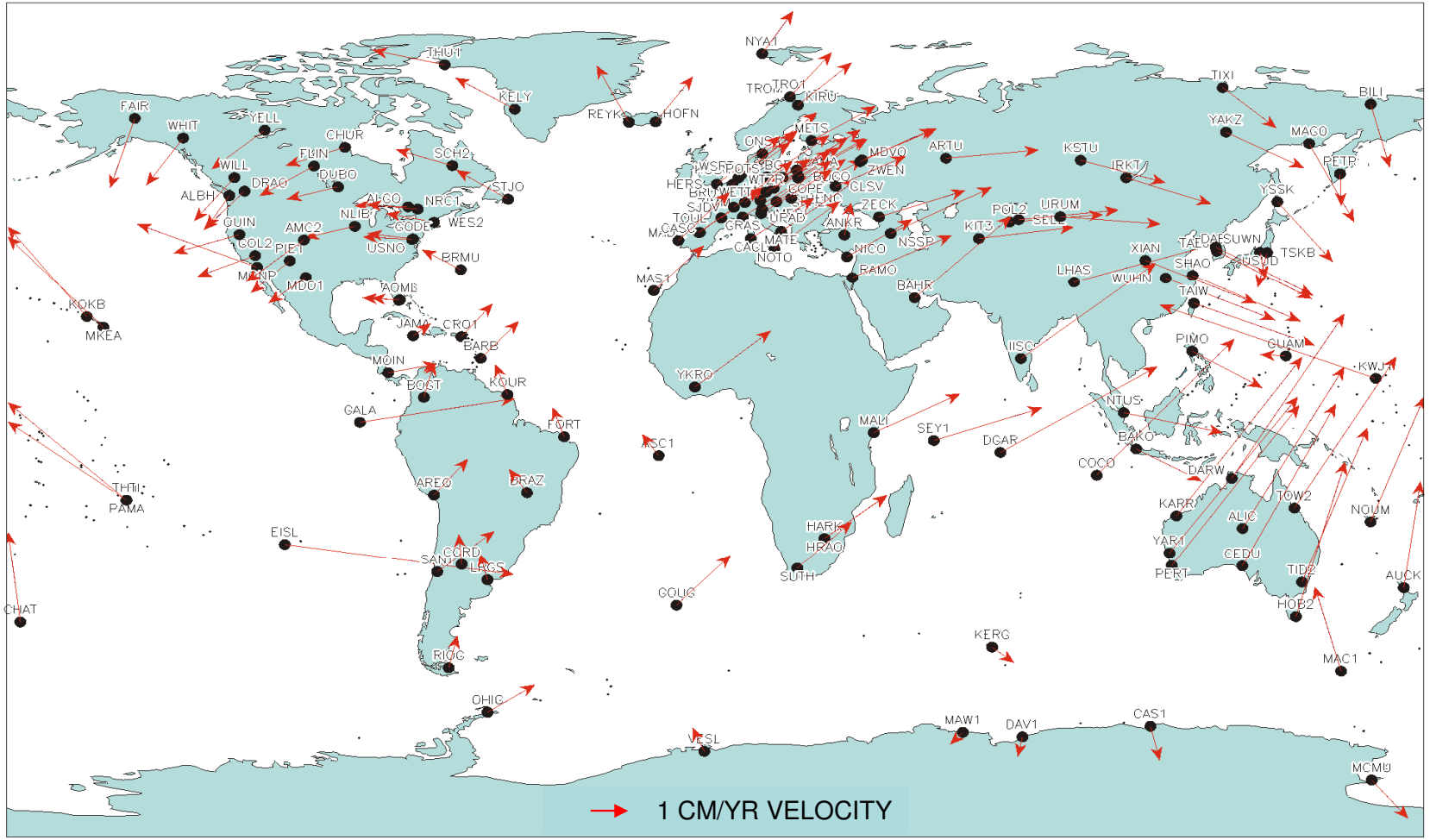


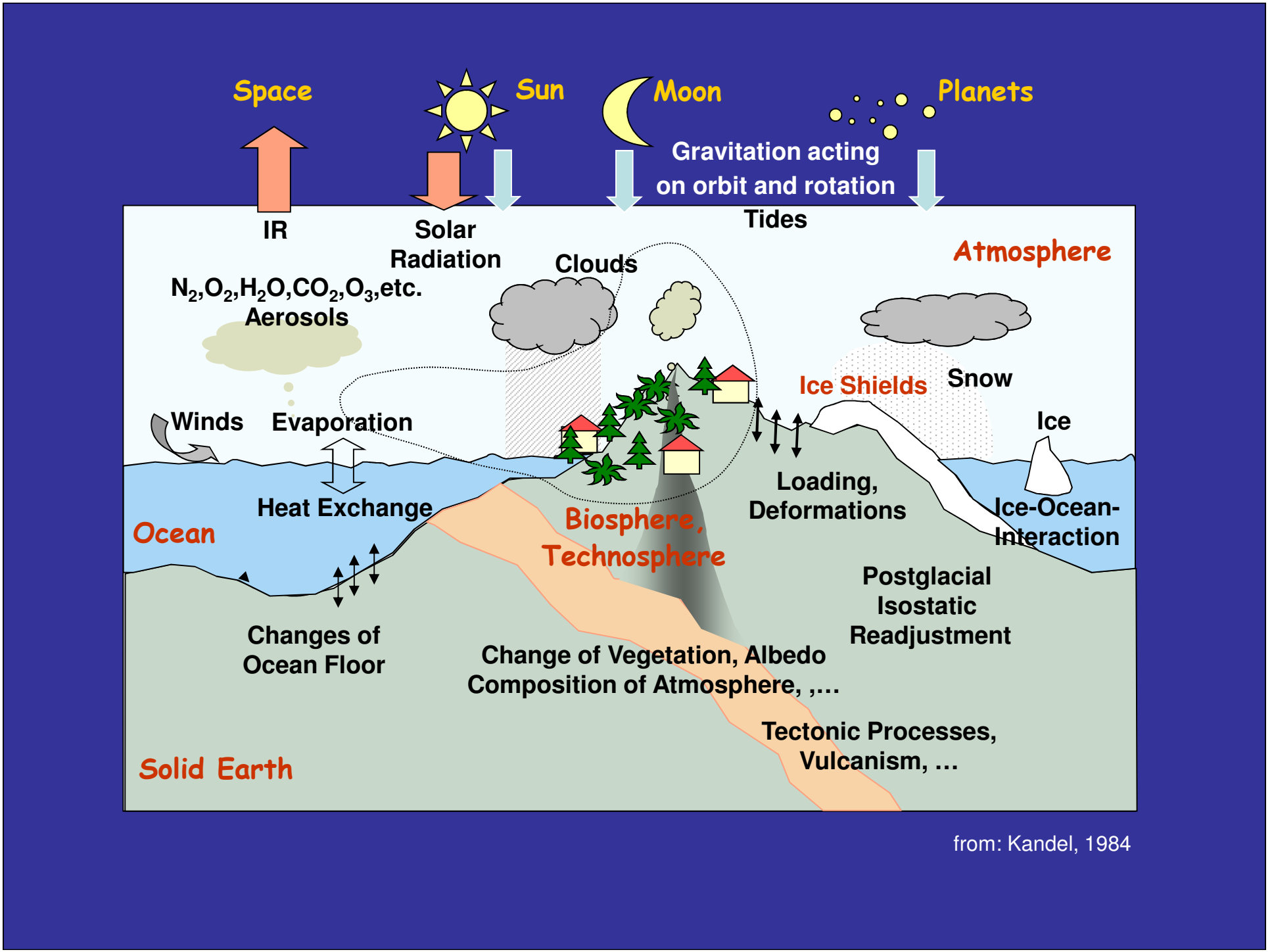
Tasks of a Geodetic Observatory



Tasks of a Geodetic Observatory

- Global Reference Frame

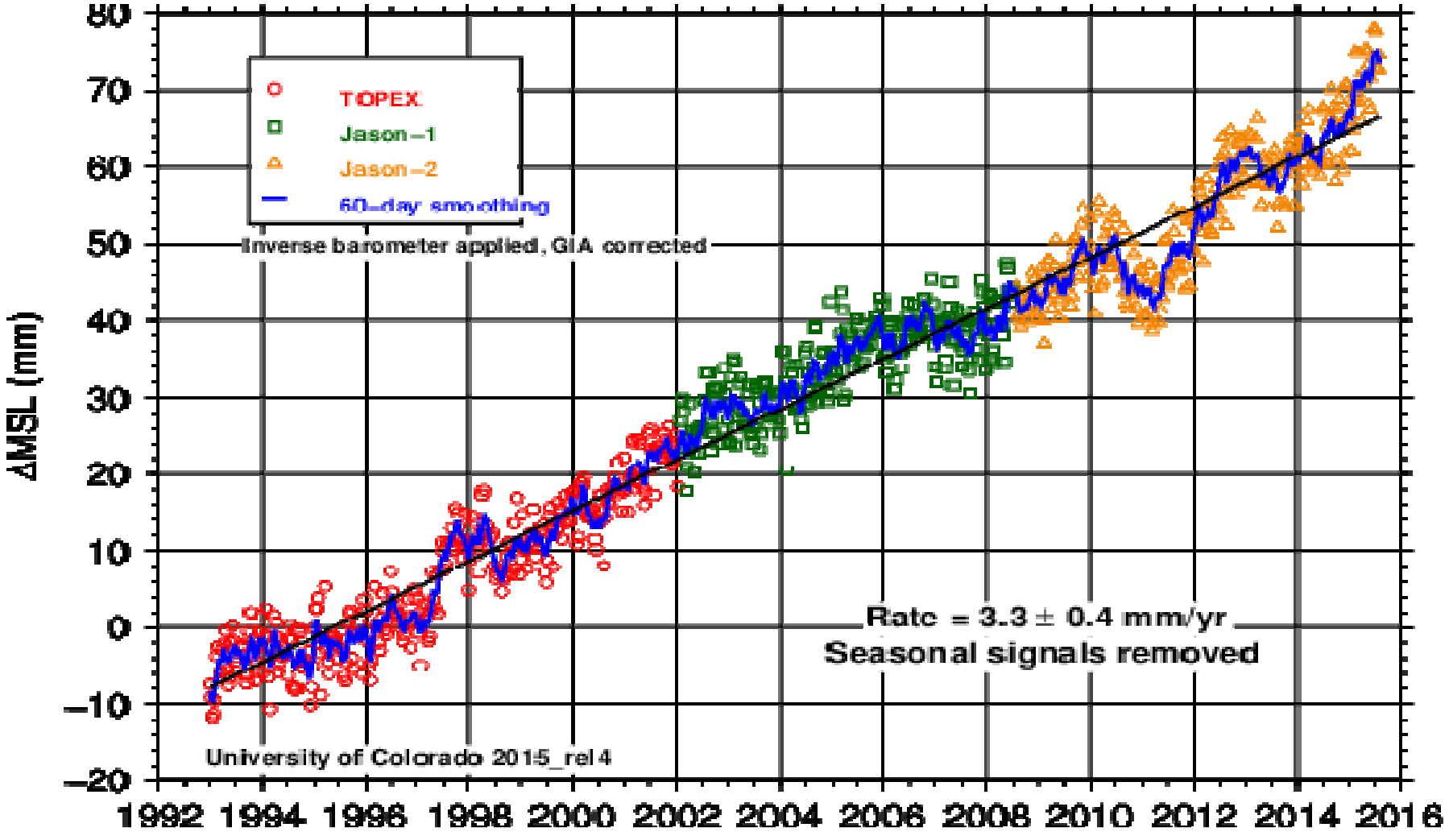




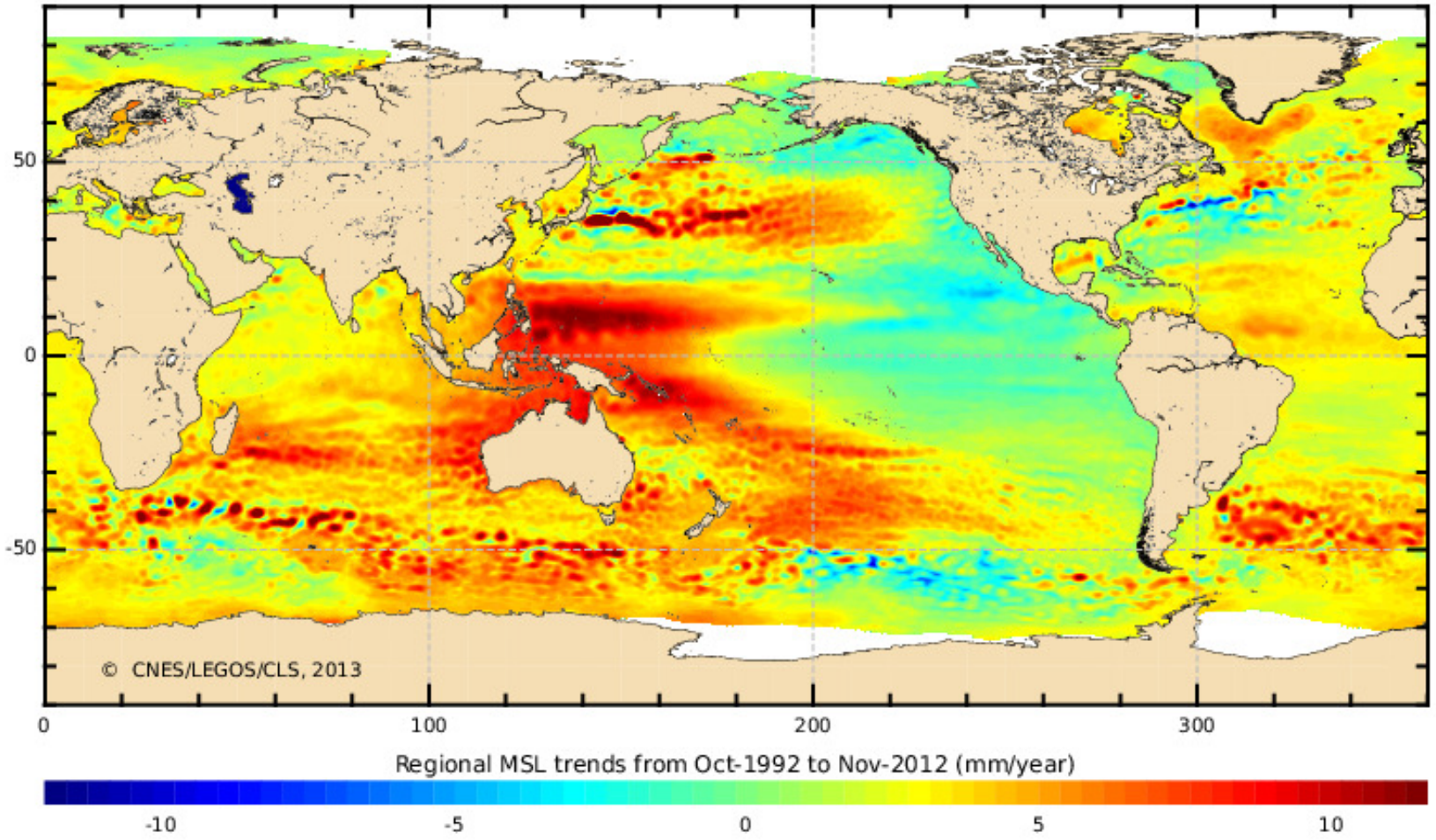
from: Kandel, 1984

Understanding of Key Processes in the System Earth

Mean Sea Level Rise

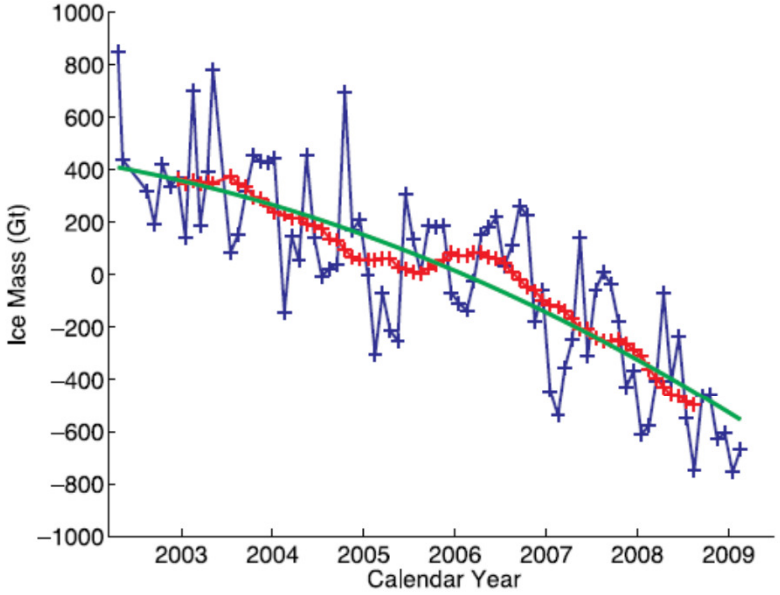


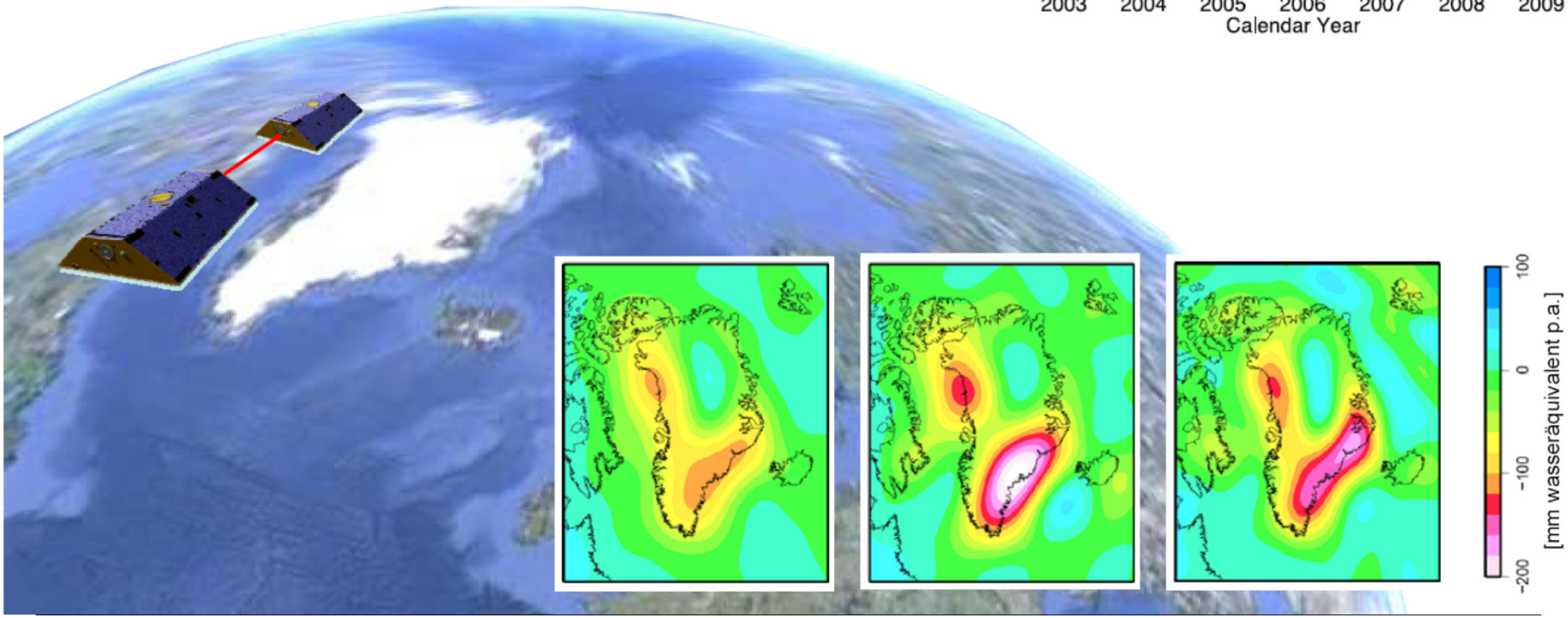
Regional Differences in Sea Level Rise



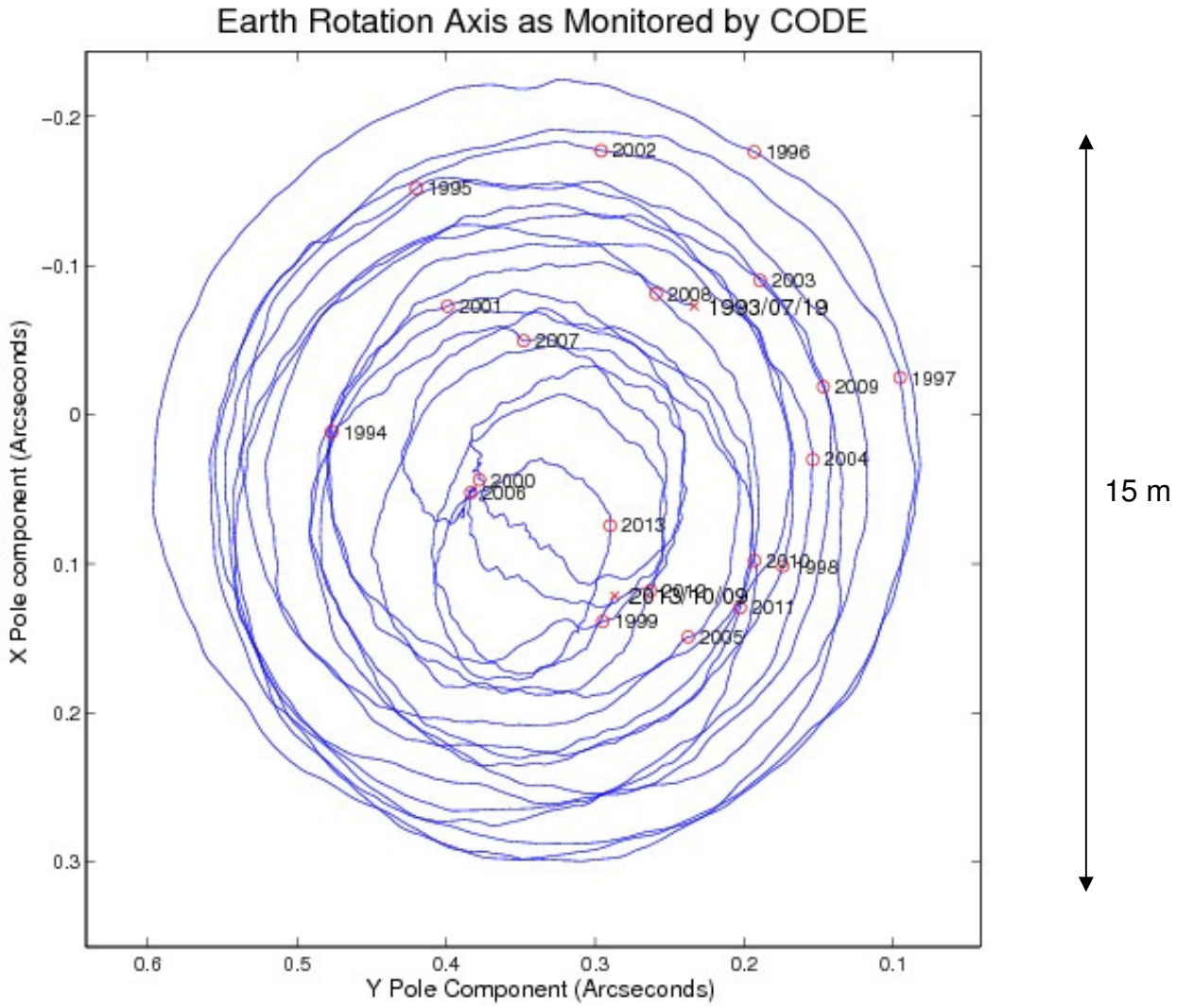
Deglaciation of Greenland

→ ca. 250 Gt/Jahr



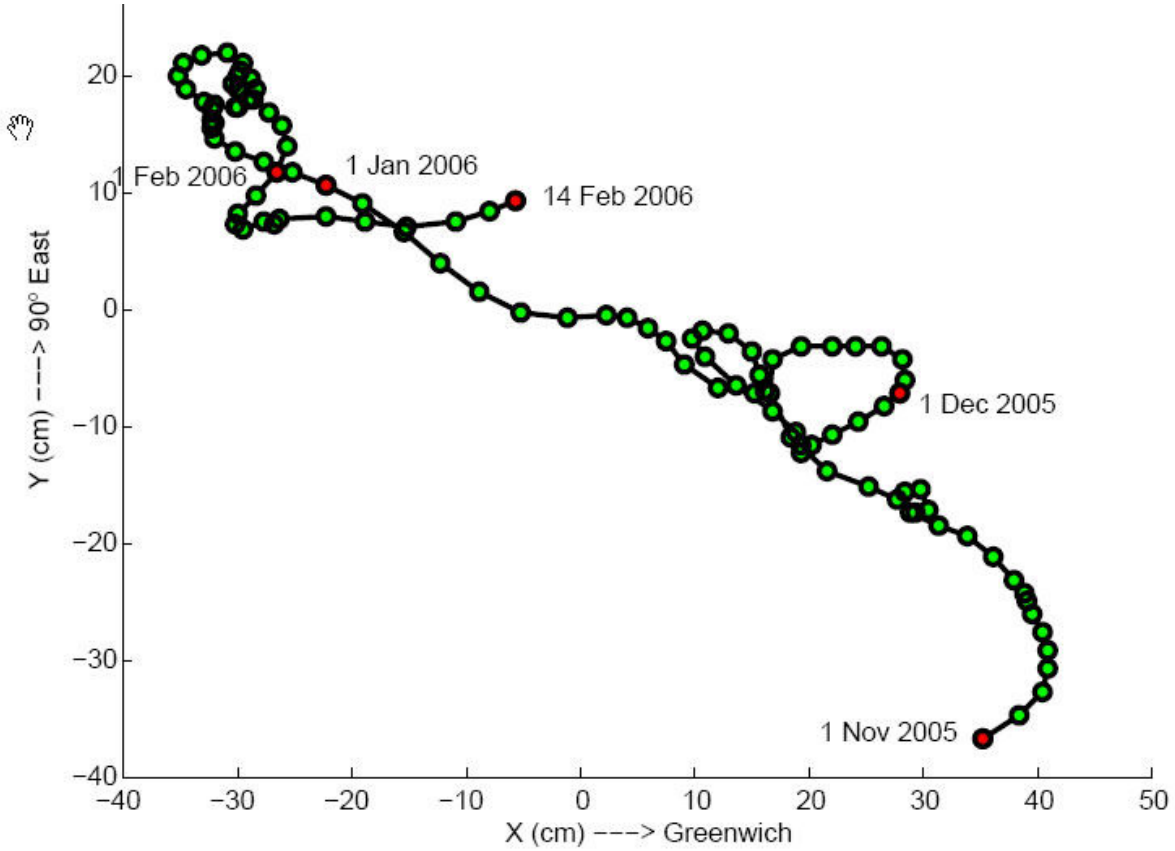


Polar Motion



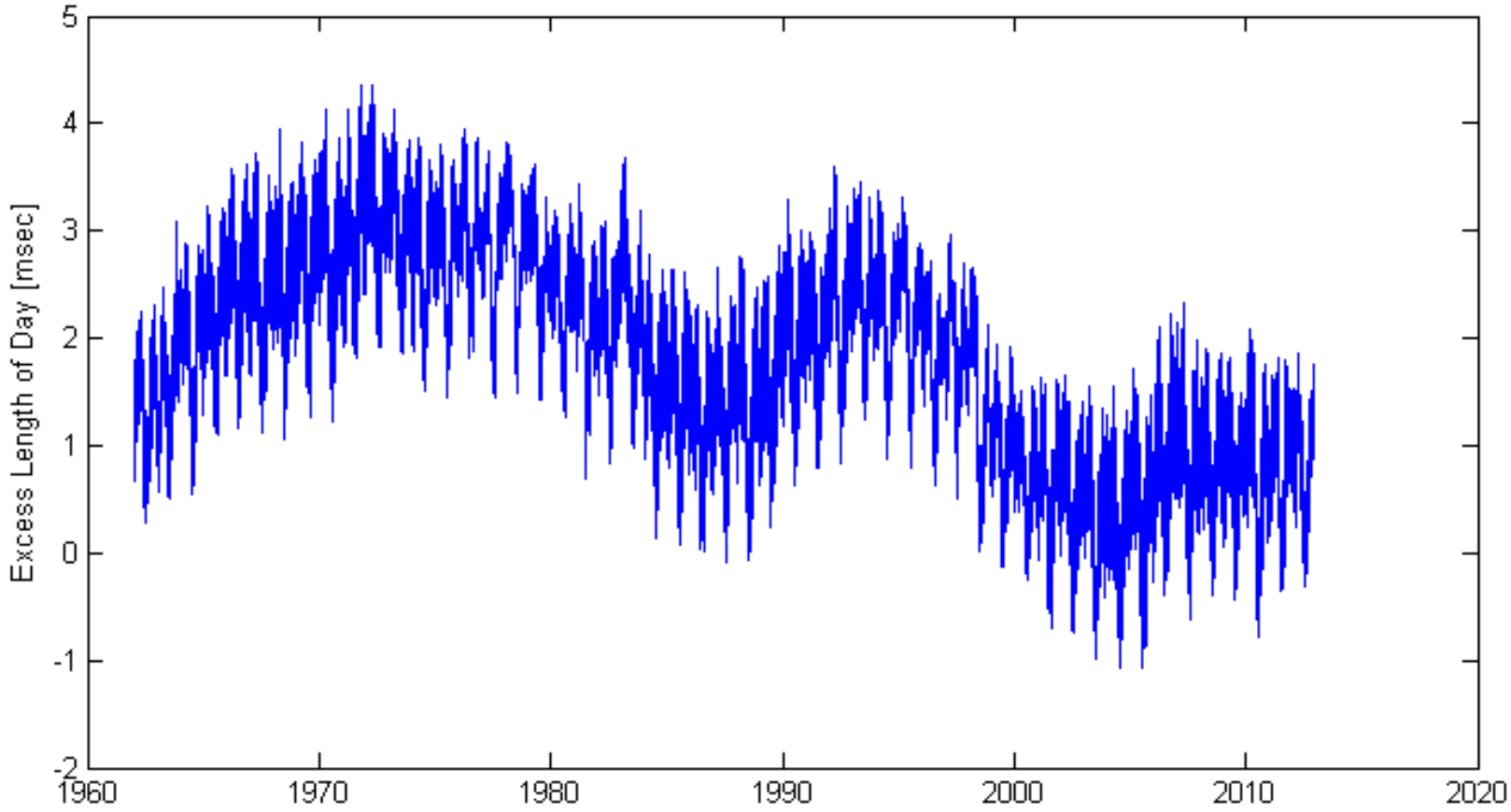
Polar Motion

- Polar motion around new year 2005/06



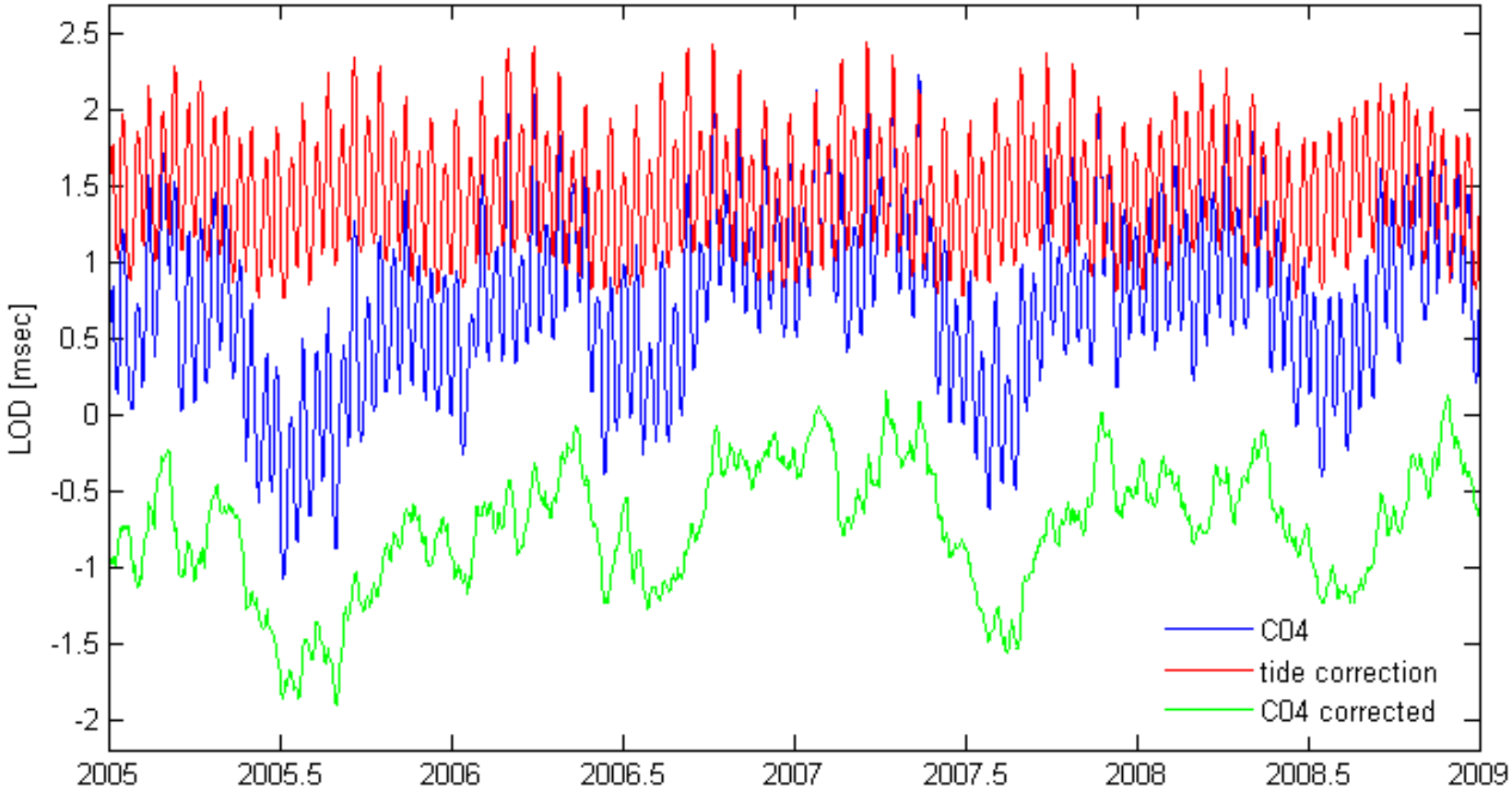
Earth Rotation

- Excess Length of Day



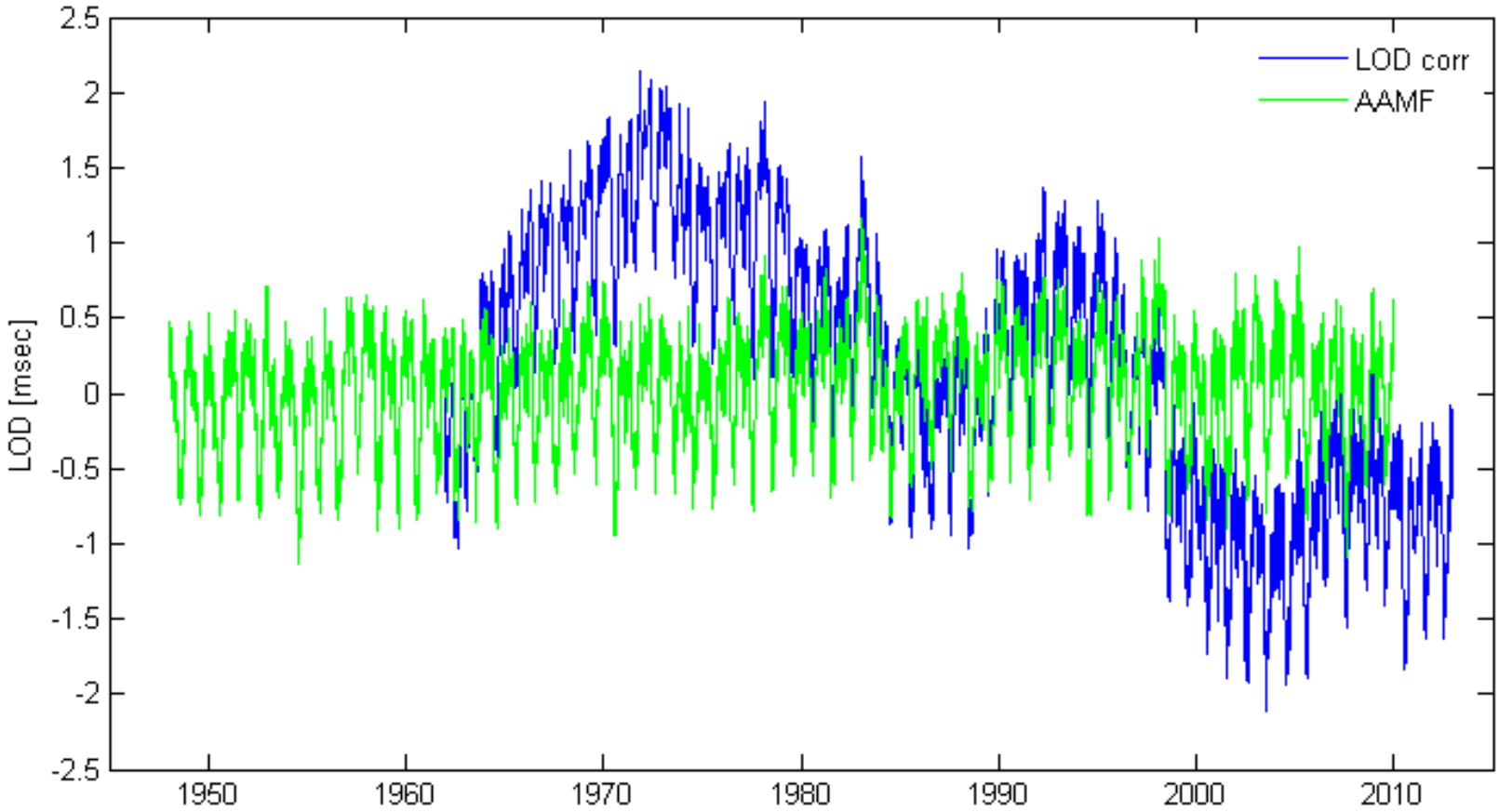
Earth Rotation

- Measured Length of Day corrected by tidal variations.



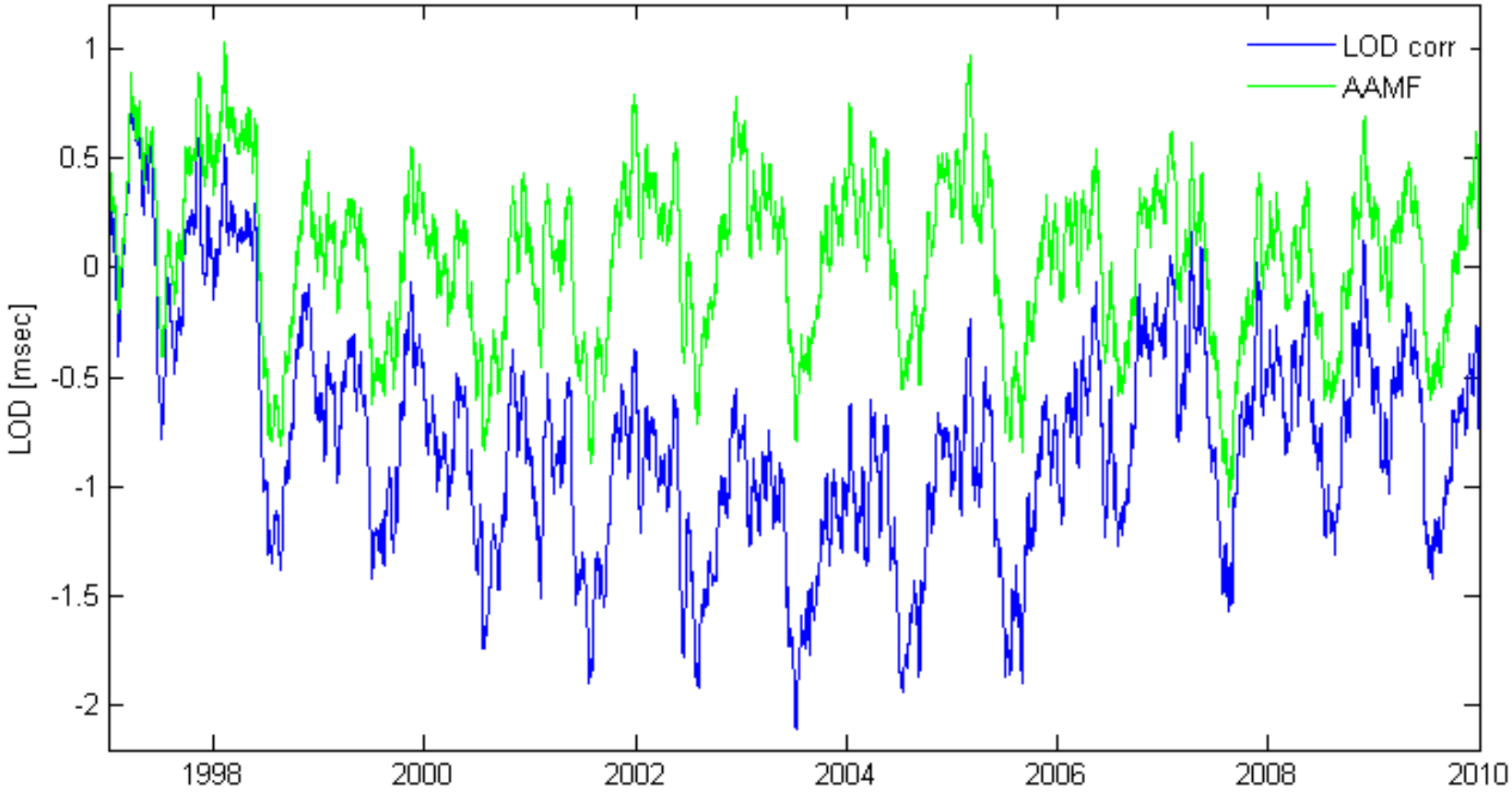
Earth Rotation

- Measured LOD and Atmospheric Angular Momentum from Weather Model

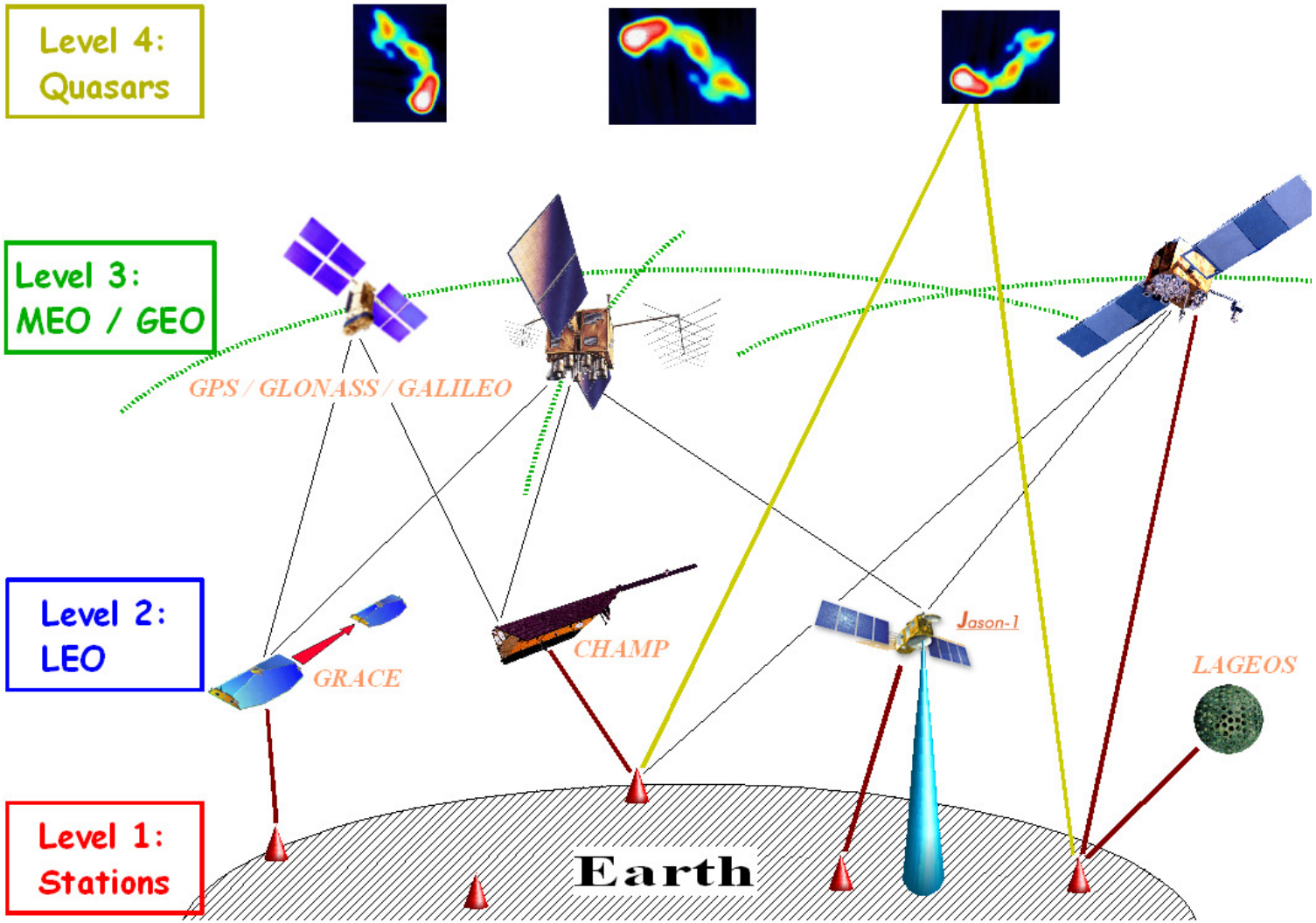


Earth Rotation

- Measured LOD and Atmospheric Angular Momentum from Weather Model



Combination of Geodetic Measurement Techniques

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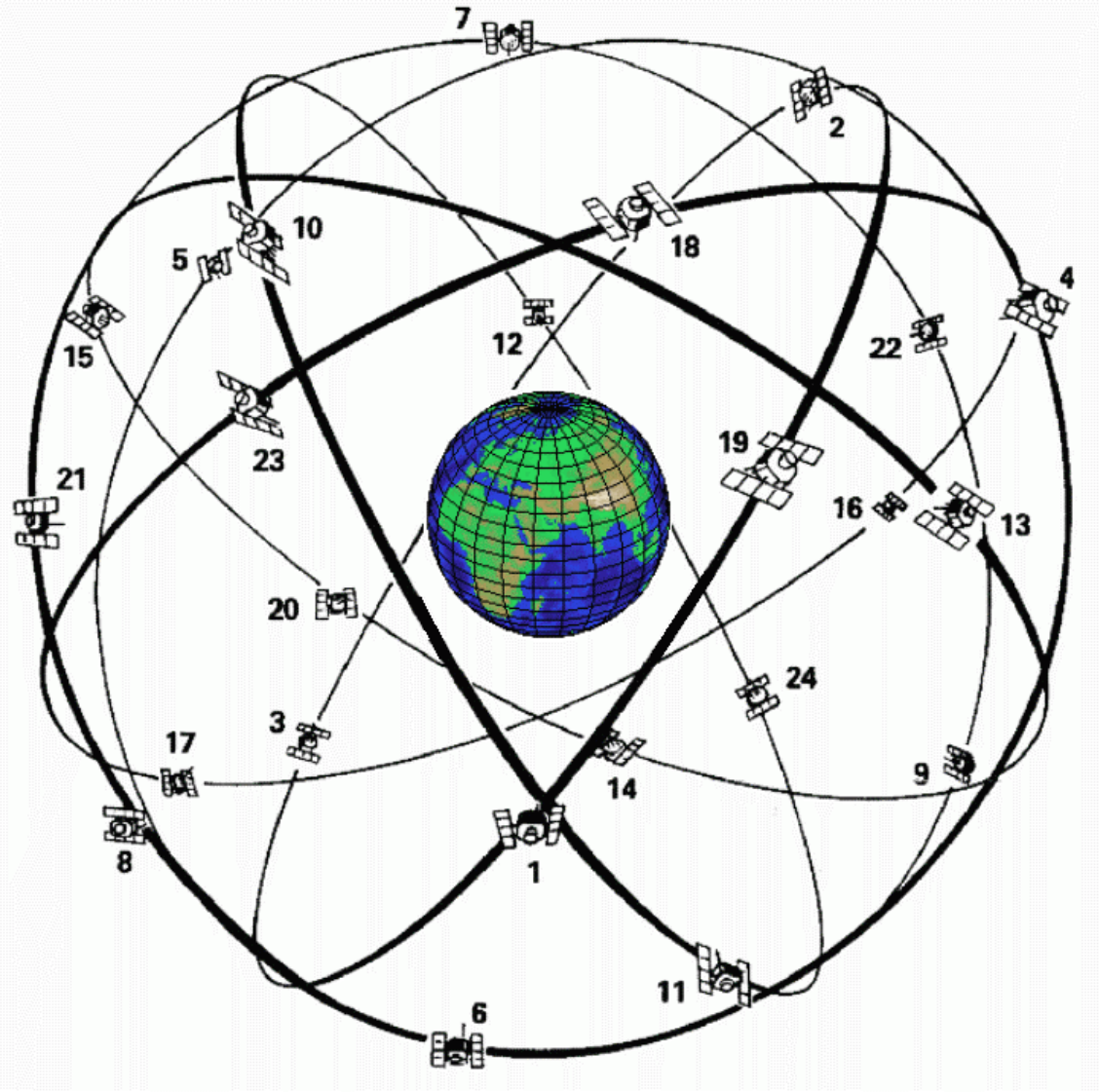
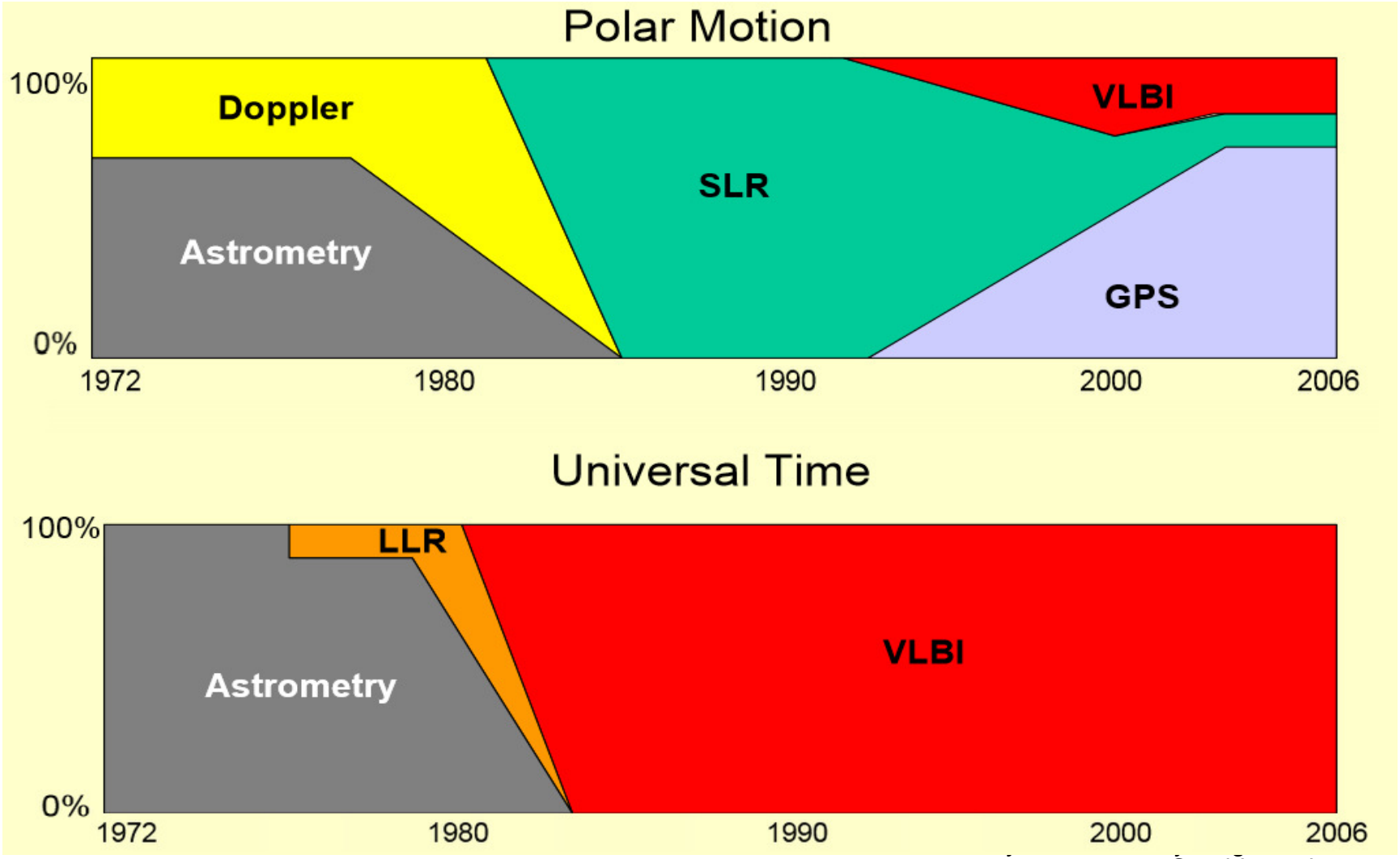
Measurement of Earth Rotation with GNSS



Contribution of Space Geodetic Techniques



Gambis et al., 2006

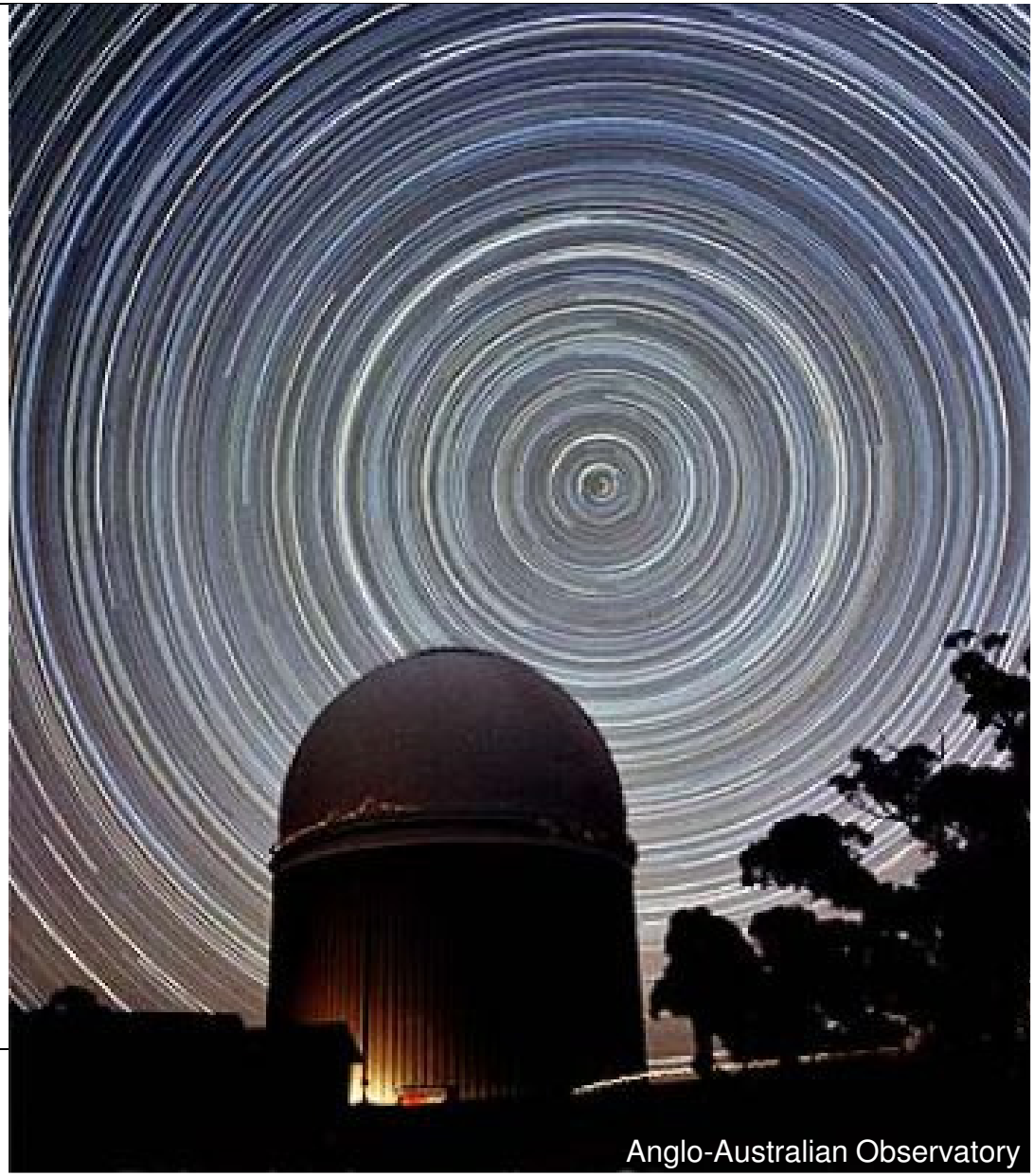
Stellar Compass vs Inertial Compass

- All current space geodetic techniques measure Earth rotation kinematically.
- Measurement of directions to stars or satellites

→ Stellar Compass

Ringlaser:

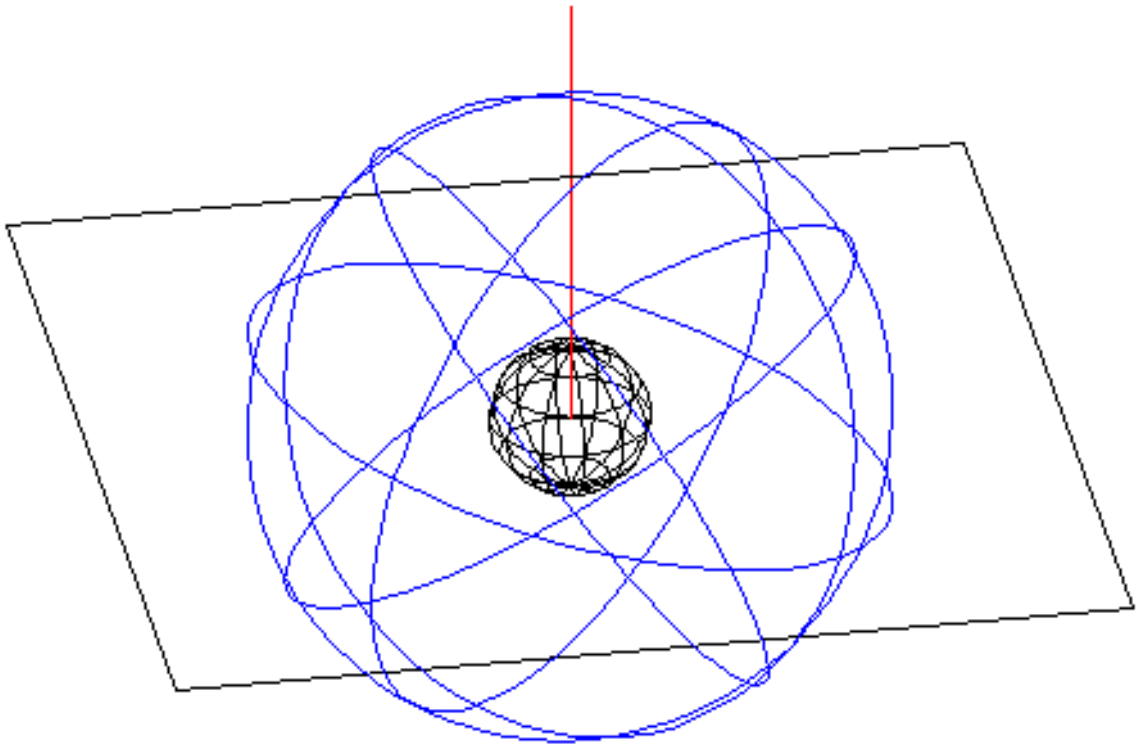
→ Inertial Compass



Ringlaser Measures Instantaneous Rotation Axis

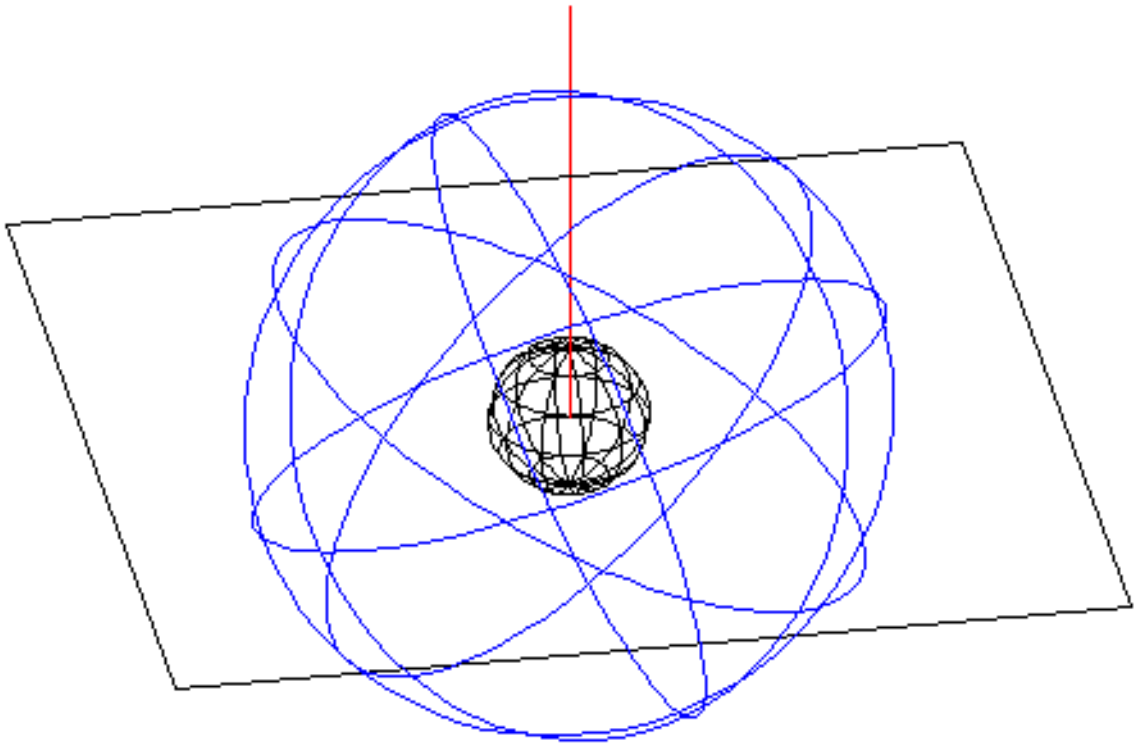
$$\Delta f = \frac{4A}{\lambda L}\mathbf{n}\cdot\boldsymbol{\Omega}$$

Estimation of Subdaily EOPs with GNSS



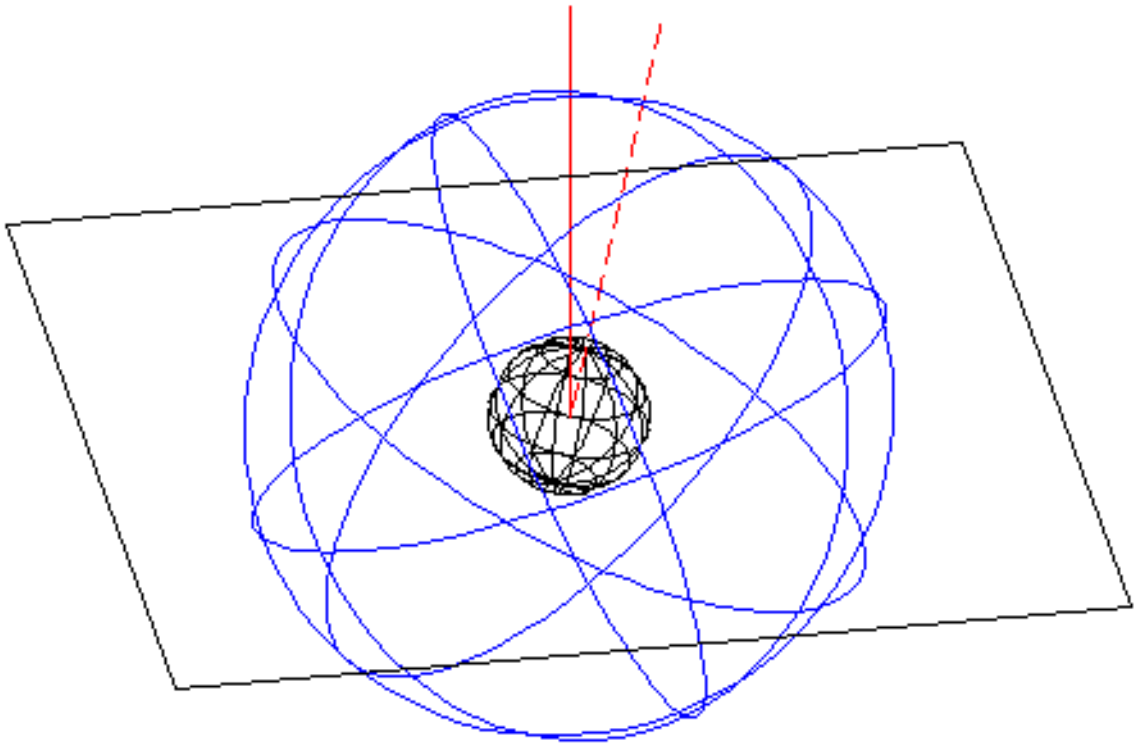
Estimation of Subdaily EOPs with GNSS

- Rotation of orbital planes

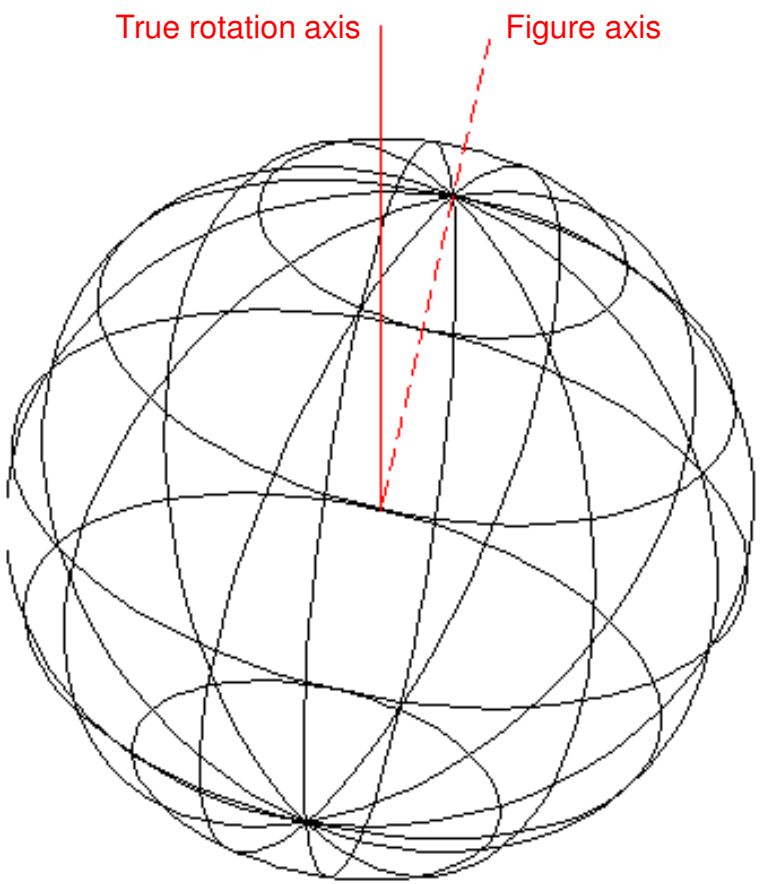


Estimation of Subdaily EOPs with GNSS

- Compensated by rotation of the Earth

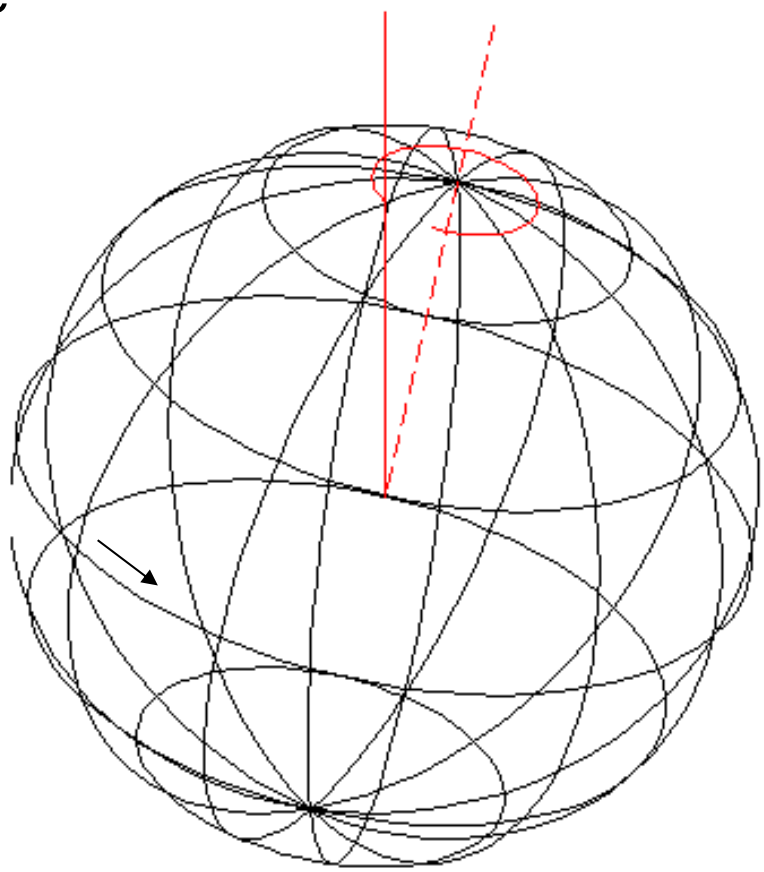


Estimation of Subdaily EOPs with GNSS

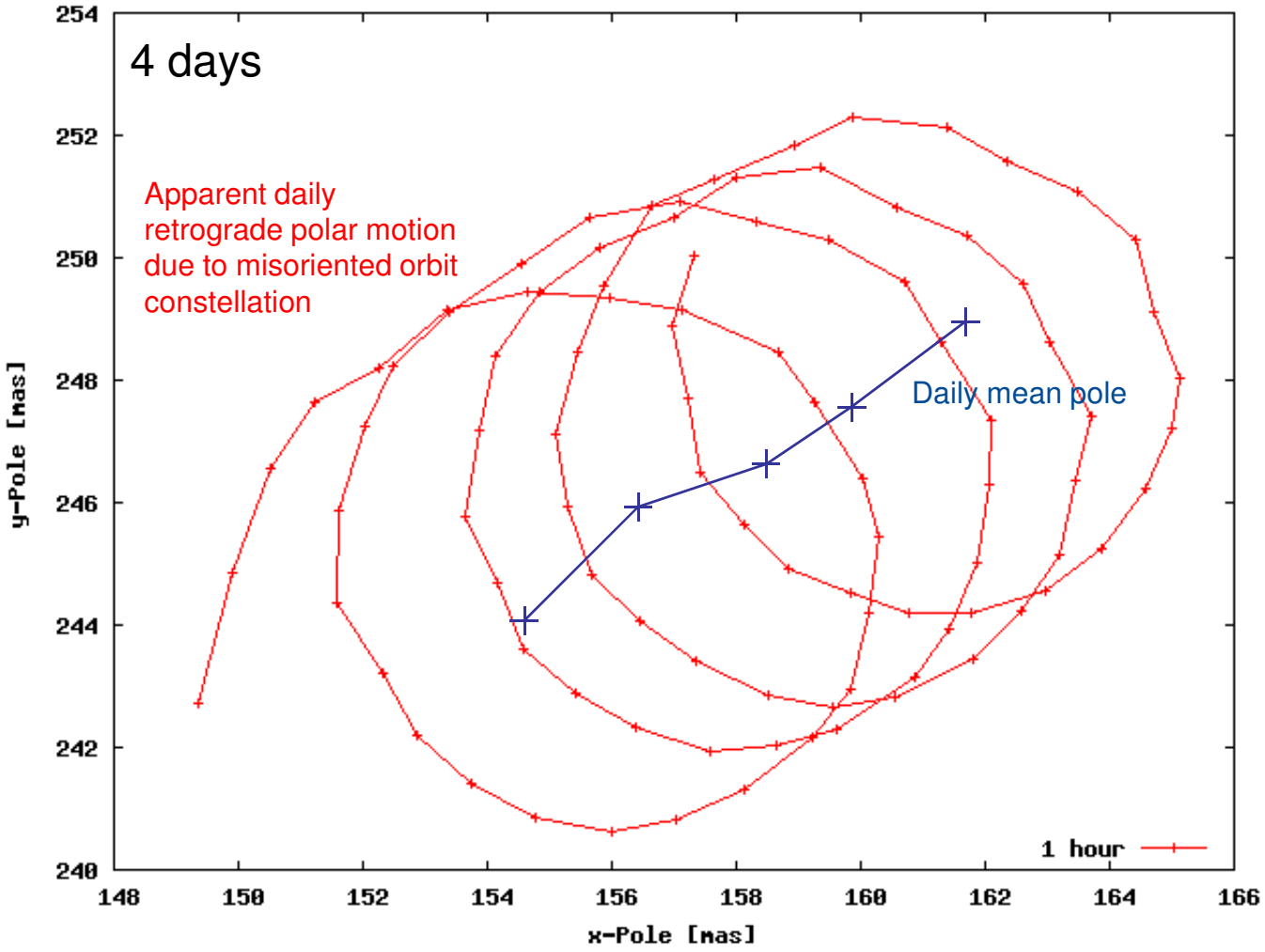


Estimation of Subdaily EOPs with GNSS

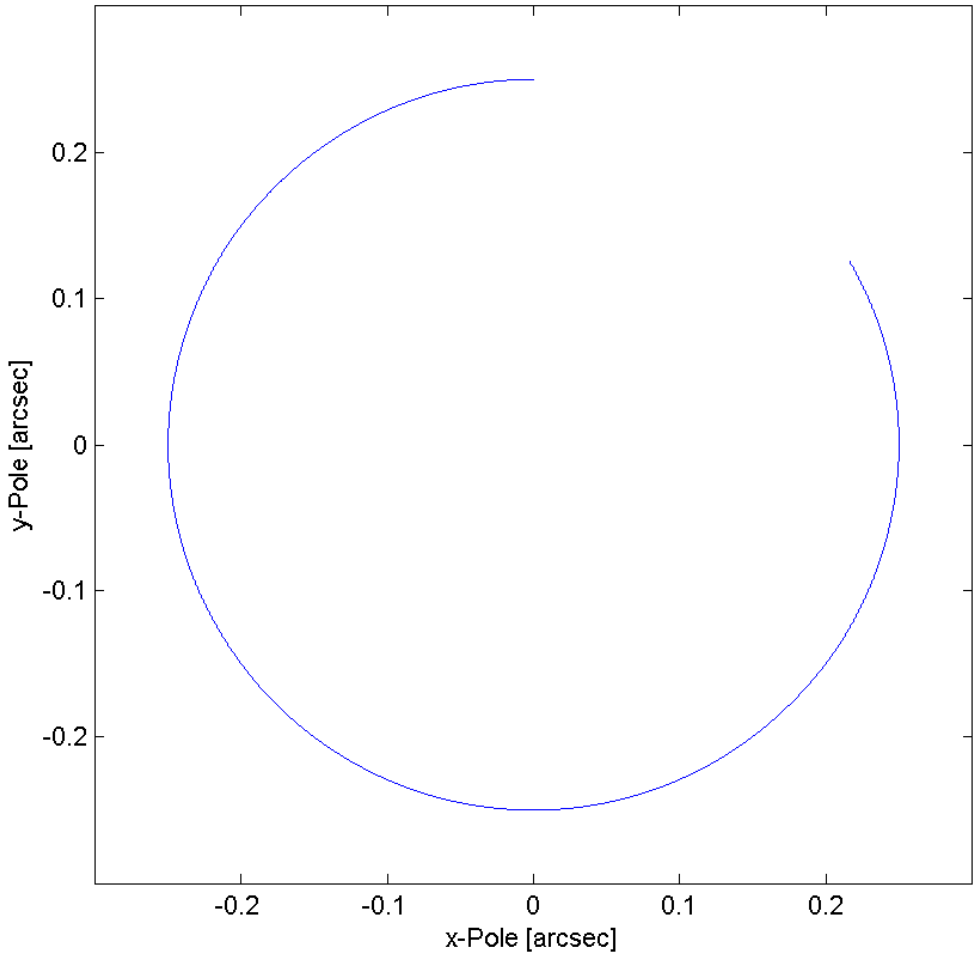
- Daily retrograde rotation of pole



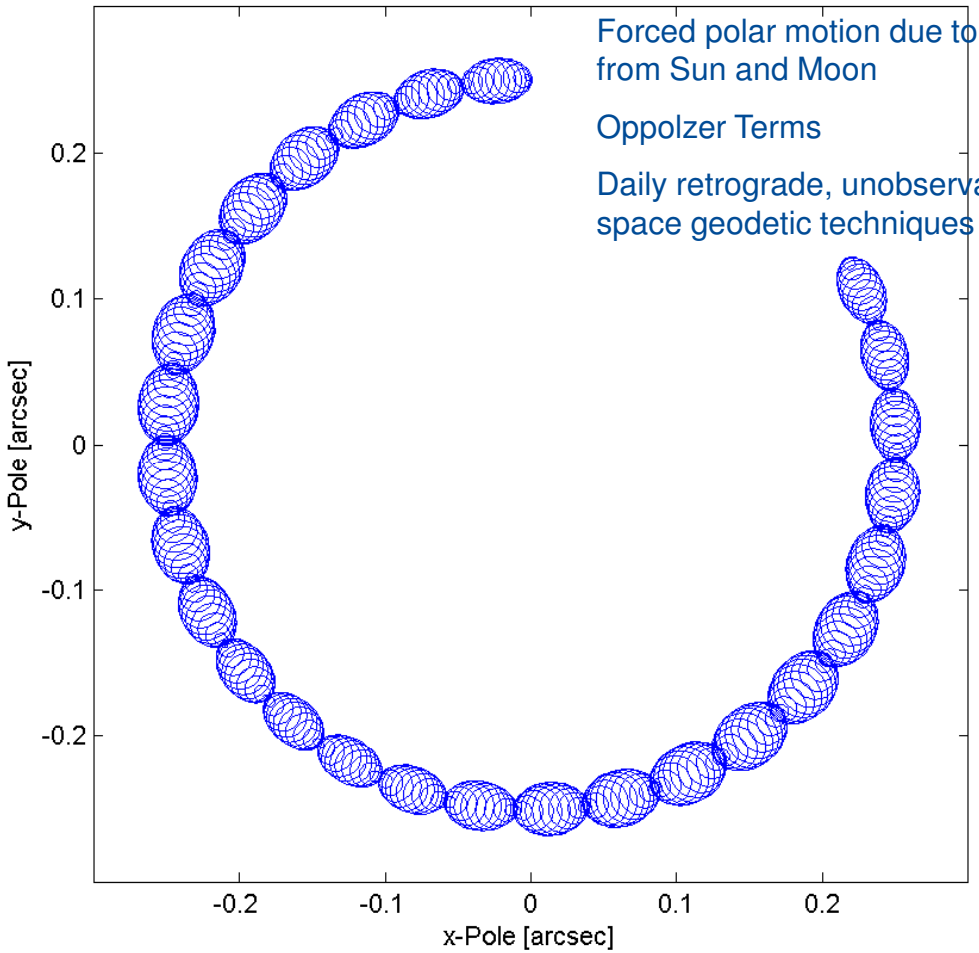
Estimation of Subdaily EOPs with GNSS



Free Polar Motion



Forced Polar Motion

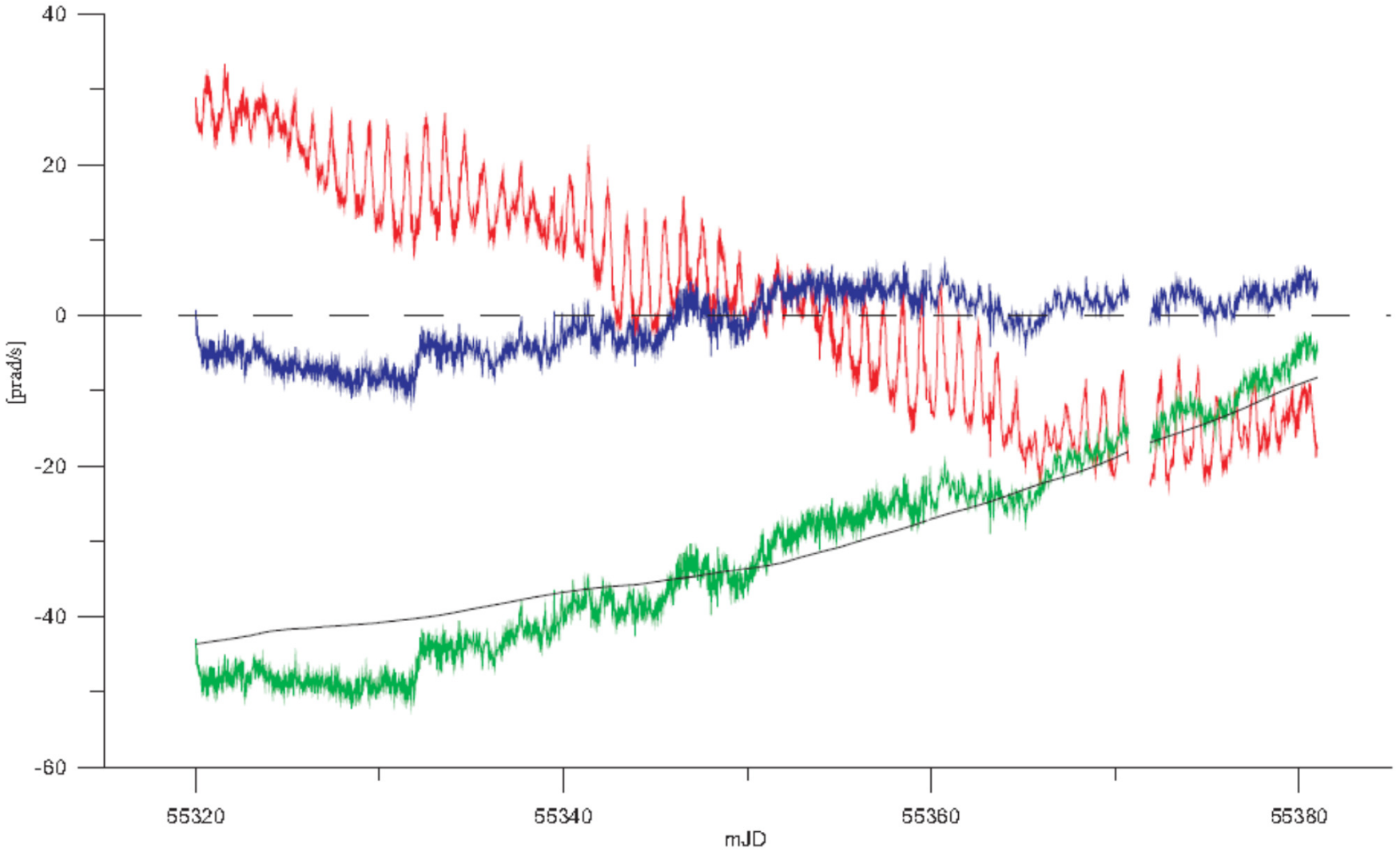


Forced polar motion due to torques from Sun and Moon

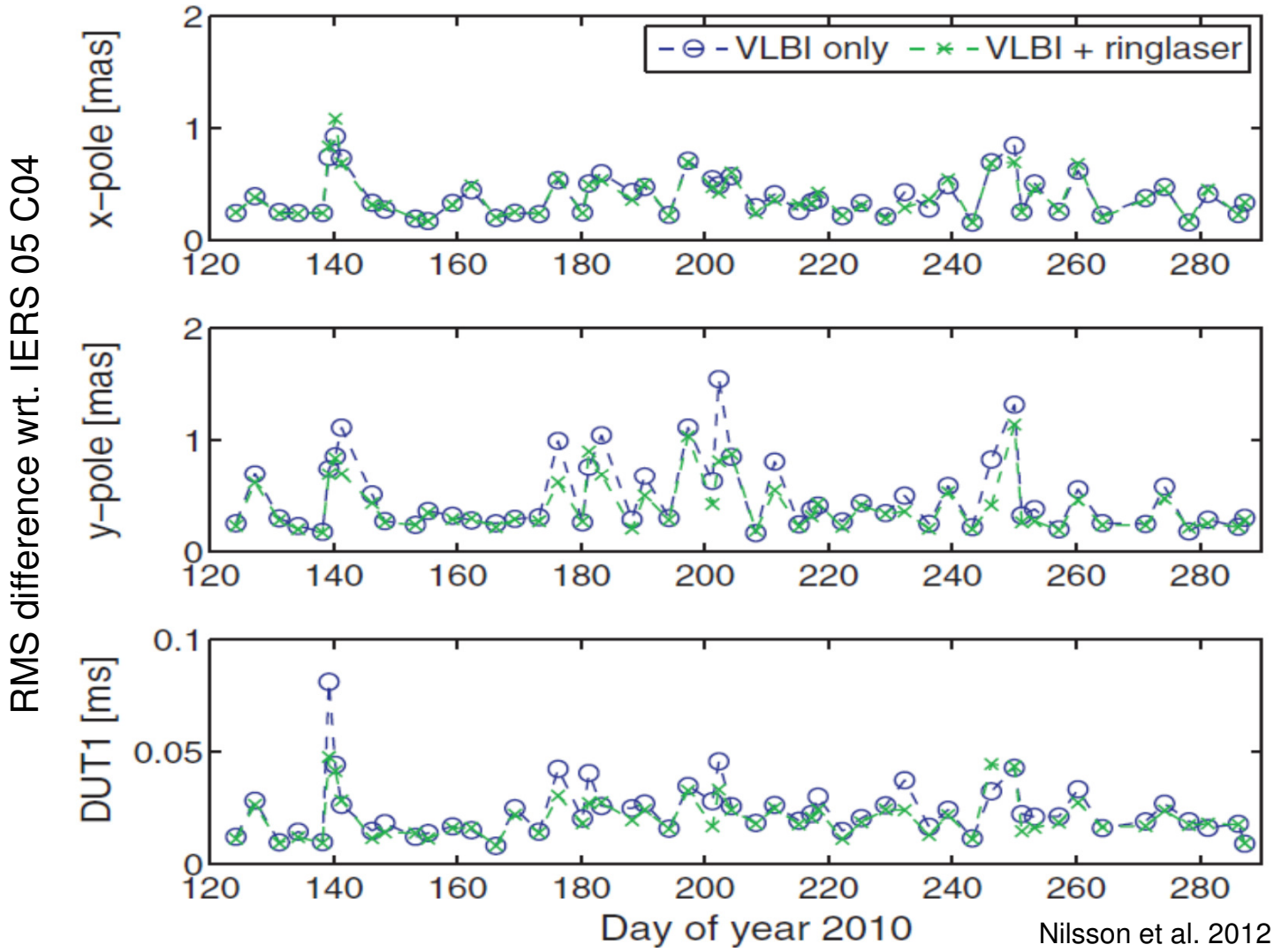
Oppolzer Terms

Daily retrograde, unobservable with space geodetic techniques

Ringlaser Measures Polar Motion

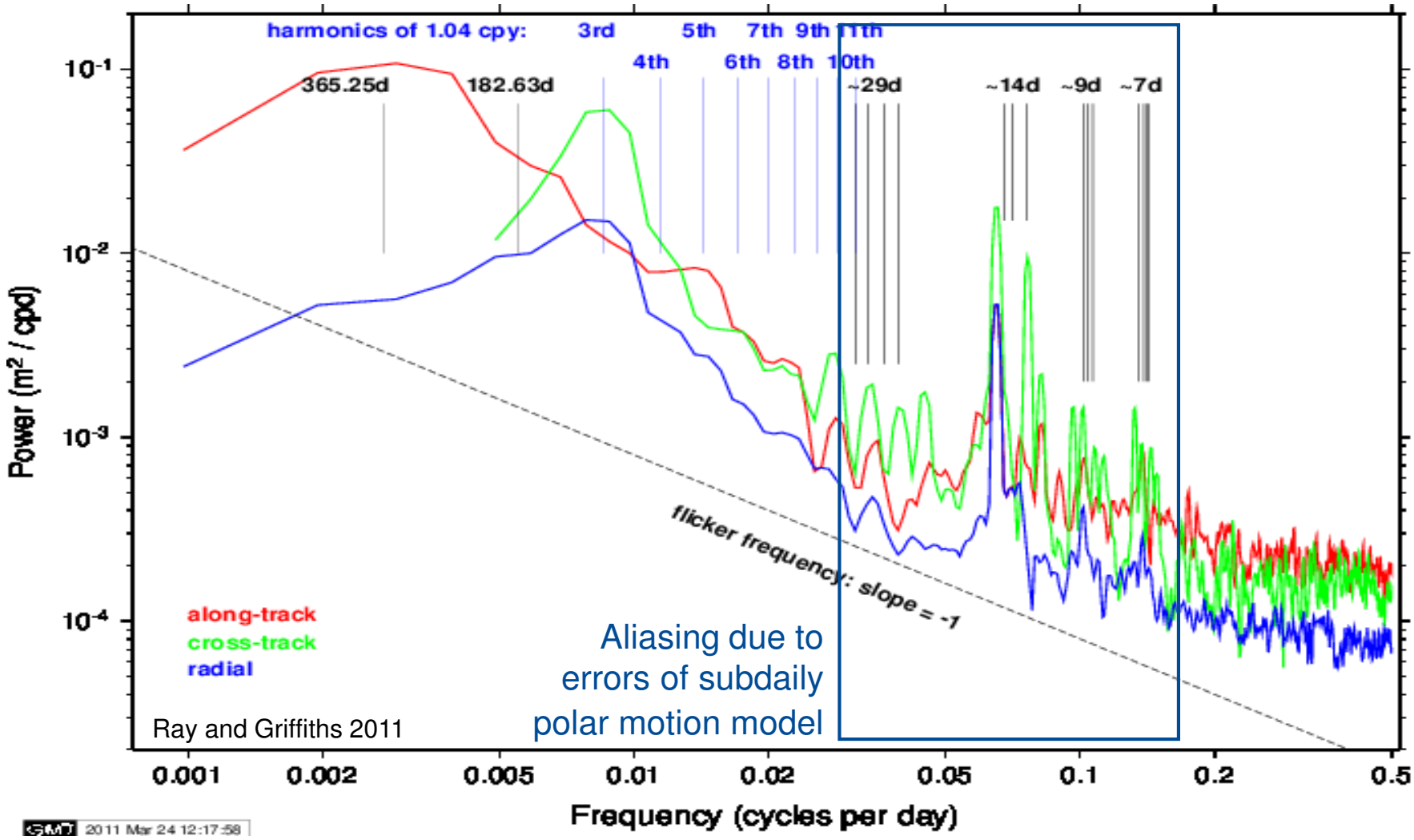


Combination of VLBI and Ringlaser



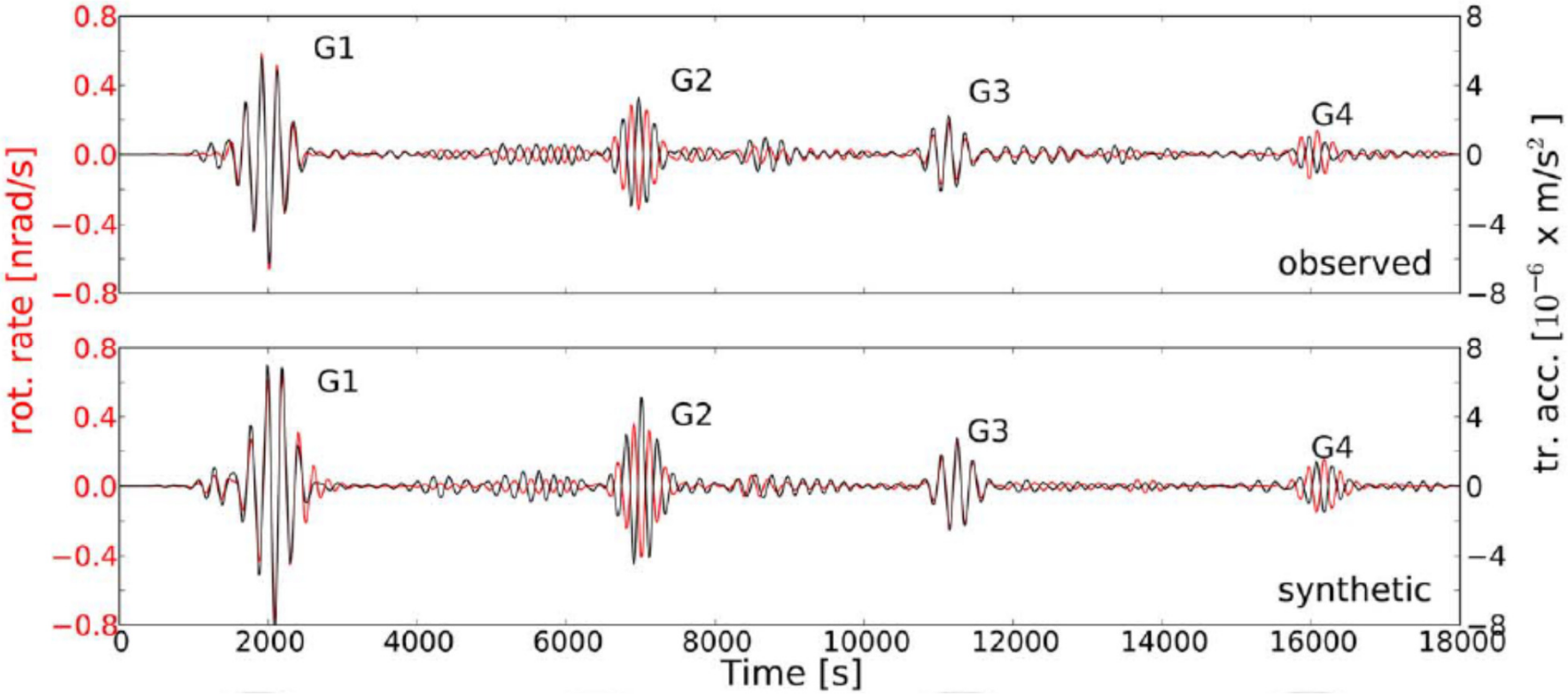
Nilsson et al. 2012

Power Spectra of IGS GPS Orbit Discontinuities



Ringlaser Measures Earthquakes

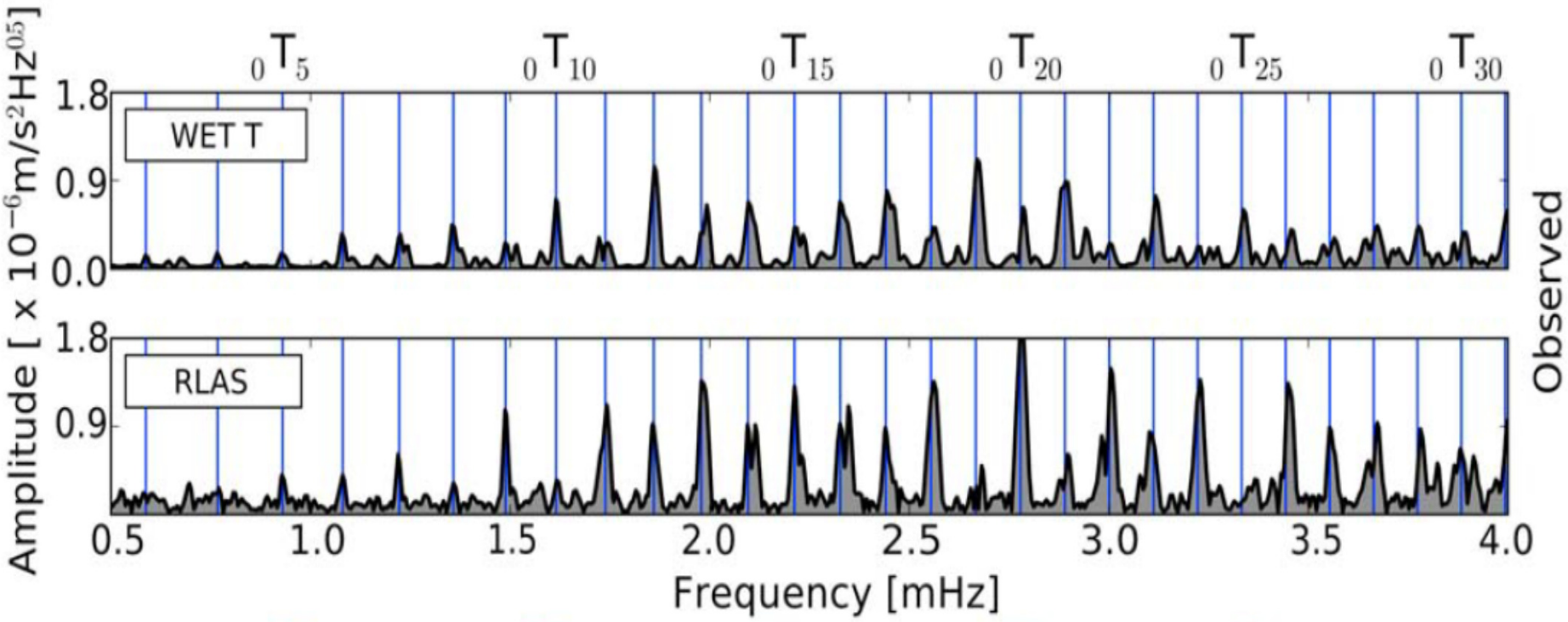
- Love waves from the 9.0 magnitude 2011 Tohoku-Oki earthquake, travelling several times around the Earth



Igel et al. 2011

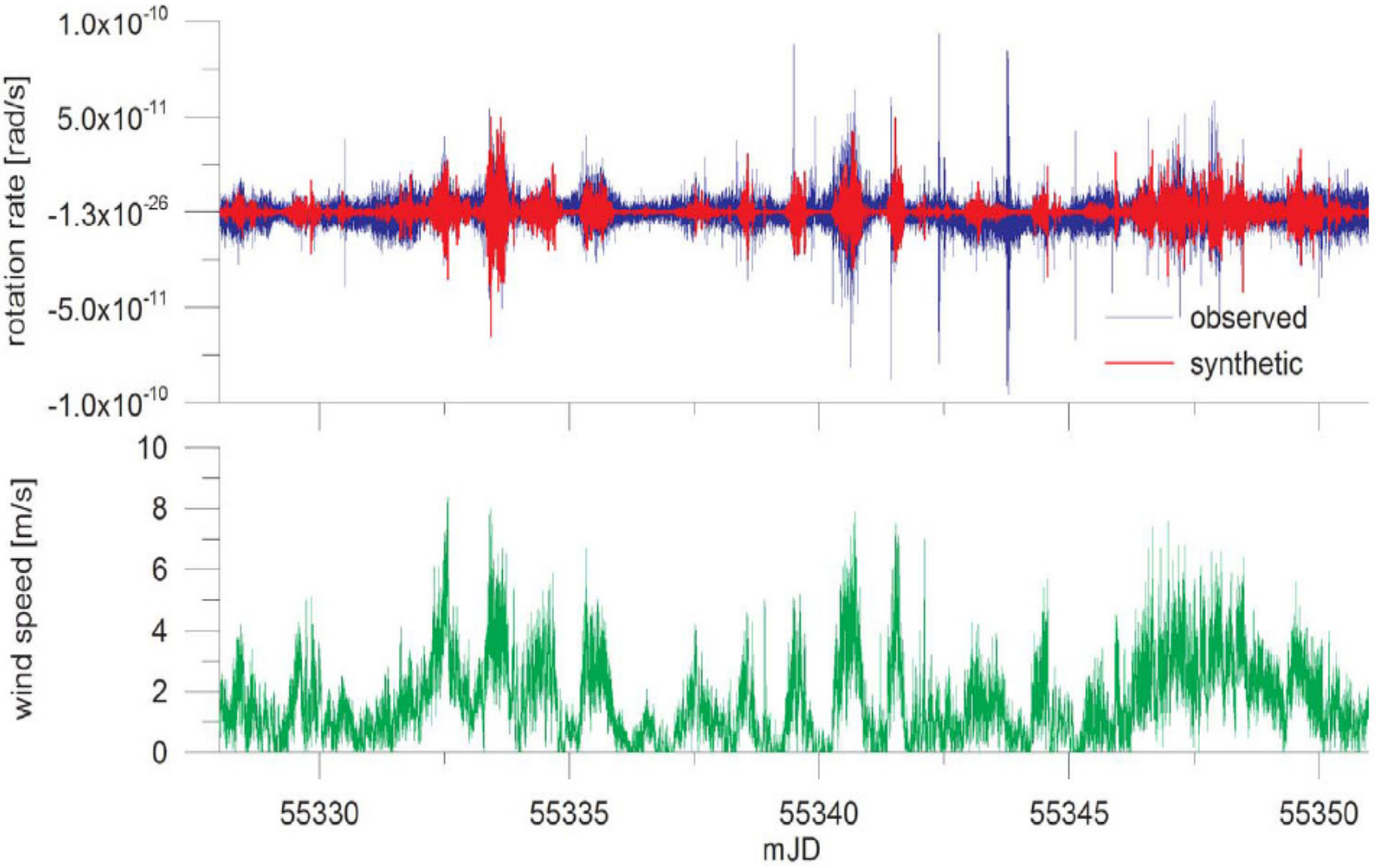
Ringlaser Measures Eigenmodes of Earth

- Observed eigenmodes of the ringing Earth, stroked by the Tohoku-Oki earthquake



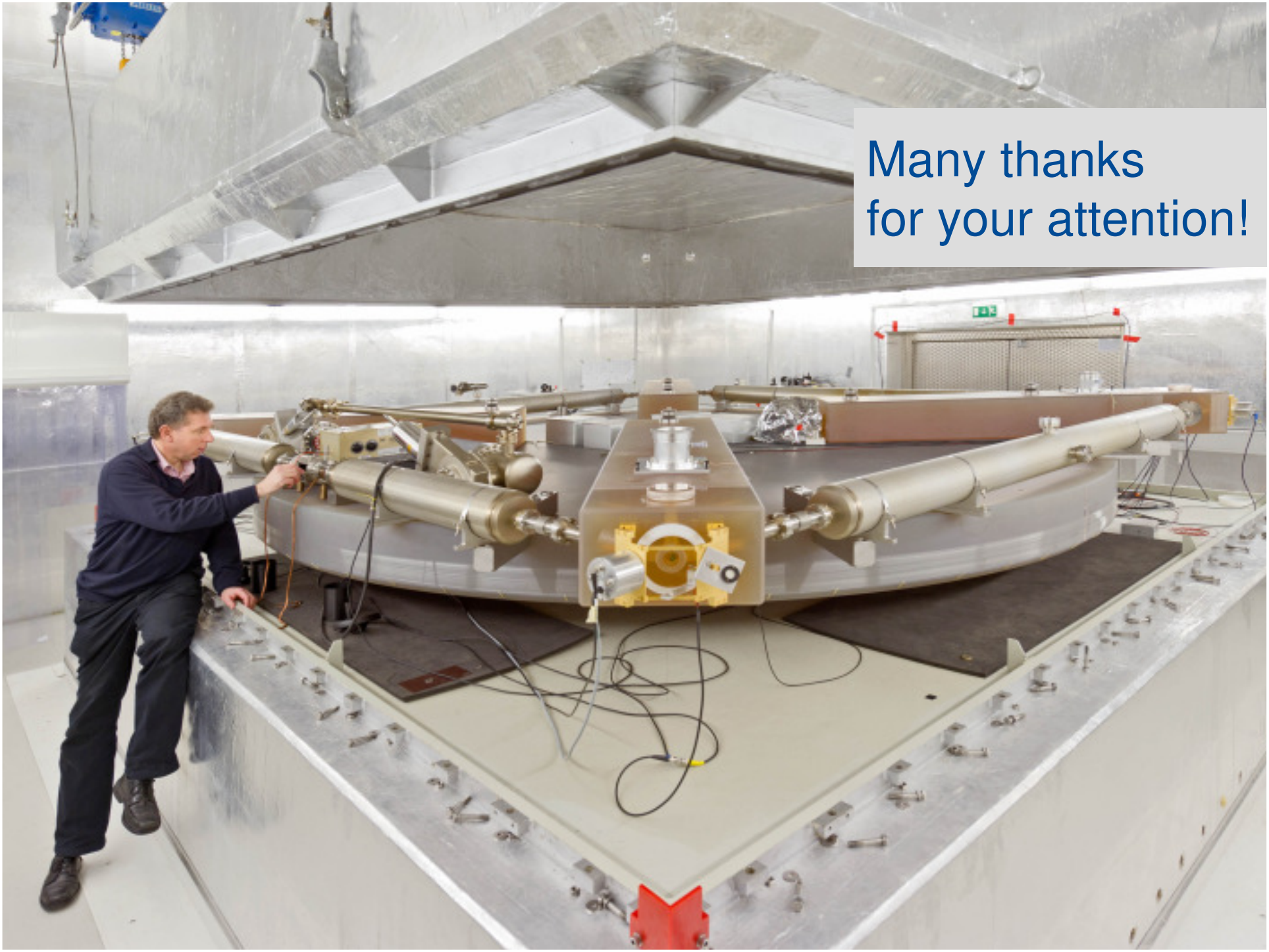
Igel et al. 2011

Ringlaser Measures Local Wind Stress



Conclusions

- Geodetic observatories such as Wettzell play a key role as anchor points for a longterm-stable global reference frame as the basis for the understanding of processes in the system Earth.
- Precise measurement of Earth‘s rotation is one of the core tasks of global geodesy. Earth rotation is an integral measure for mass processes on the surface and inside the Earth.
- The ringlaser gyroscope represents an inertial compass while all other space geodetic techniques for measuring Earth rotation are versions of a stellar compass. This unique feature of allows it – differently to the other techniques - to measure the instantaneous rotation axis and thus subdaily polar motion.
- Combination of ringlaser with VLBI measurements shows improvement of Earth orientation parameters in particular when low a number of VLBI stations participate in a session.
- The ringlaser is a local sensor. It measures seismic rotational signals, microseismic noise, wind stress induced local rotations. A global network of ringlaser gyroscopes should be envisage to decouple local and global effects.


Many thanks
for your attention!