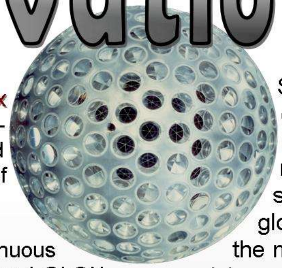
Space Geodesy: Underpinning Space-based Earth Observation

Space-based platforms are the most efficient, accurate and robust method of mapping and measuring our world.



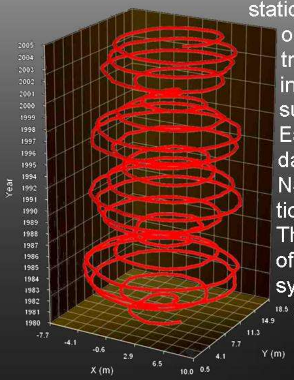
The UK NERC Space Geodesy Facility at Herstmonceux plays an active part in the ongoing international analysis effort towards the definition of a stable and robust reference frame and contributes space geodetic observations to two of the Services of the International Association of Geodesy (IAG):

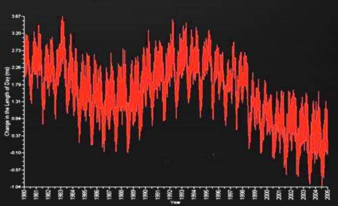
- Two **GPS receivers** (named HERS and HERT) are in continuous and autonomous operation, providing hourly and daily GPS and GLONASS tracking data to the International GNNS Service (IGS). Also provided is streaming specialist high-rate data and navigational information.
- The **Satellite Laser Ranging** (SLR) facility is operated, weather permitting, on a continuous basis. SLR is used to track those satellites that carry retro-reflector assemblies, and provides range measurements at mm-levels of precision. This technique is coordinated by the international Laser Ranging Service (ILRS). The high-precision, versatility and high productivity of the NSGF laser ranging facility places it among the top five or so best stations from a global network of some 40 stations.

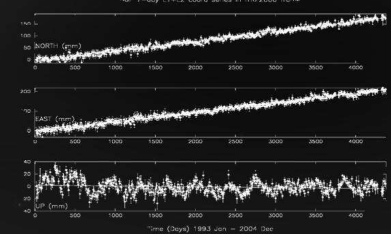
Sensors, including altimeters and SAR, are capable of monitoring global-scale changes of the solid Earth, oceans and ice fields at the cm-level of accuracy. Such disparate and temporally and spatially separated observations need to be placed on a global reference frame determined and maintained at the mm-level of accuracy. This is achieved by high precision observations of geodetic and navigational satellites from dedicated observatories worldwide of which the UK NERC Space Geodesy Facility at Herstmonceux is a leading example. In addition, the NSGF plays an active part in the ongoing international analysis effort towards the definition of a stable and robust reference frame At this level of accuracy, seasonal geocentre motions, hydrological loading effects, post-glacial rebound signals and Earth orientation changes forced, for example, by large earthquakes become apparent and are of great interest in their own right.

Fundamental Product

Space Geodetic observations and analyses define and maintain a global reference frame at the sub-cm level of precision called the International Terrestrial Reference Frame (ITRF) with an origin at the mass-centre of the Earth. It is realised through a catalogue of precise coordinates and velocities of multi-technique tracking stations, along with a consistent series of Earth orientation parameters and mathematical transformation algorithms. Studying changes in the ITRF yields scientifically interesting results. Shown below and left are time series of Earth orientation (polar motion) and length of day. Also below are weekly coordinates of NSGF Herstmonceux with plate tectonic motion and mm-level vertical motion of the site. The vertical motion reflects seasonal changes of a few mm in the mass centre of the Earth system driven by atmospheric, continental hydrological and oceanic processes.

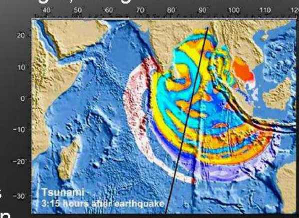


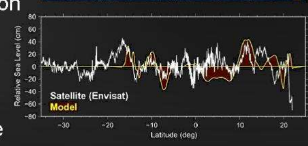




Monitoring Hazardous Events from Space

Satellites can observe events on the Earth's surface such as the large Indonesian Earthquake of 26th December 2004. In this region the Indian plate is subducting under the Burma plate at a rate of 6cm/year. Tsunami models (NOAA, USA) of the time-evolution of sea level changes in response to the earthquake are tested using satellite altimeter observations. Such a comparison is shown right, using data from ENVISAT, whose orbit is determined precisely by DORIS and laser tracking.





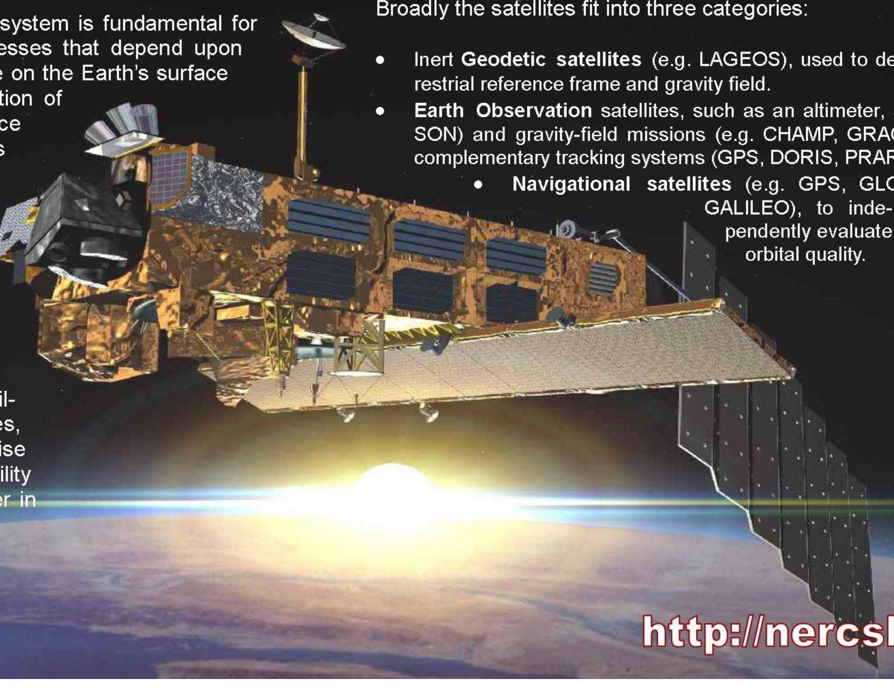
Apart from the shaking effect near the epicentre, any seismic event creates a permanent dislocation in the entire Earth. This re-distribution of mass slightly changes the Earth's inertia tensor and the Earth's rotation vector changes in accordance with the conservation of angular momentum. For the Indonesian earthquake, Gross and Chao (2005) predict a mean rotation pole shift of 0.8 milli-arcsec towards 145ºE. This should be present in the **geodetic results**. The long term polar motion 'spiral' shows a clear jump on 26th December 2004 in the y-coordinate of ~1.5 milli-arcsecs and (perhaps) zero in the x-component.

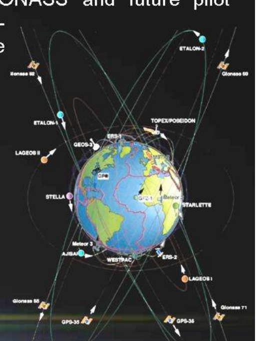
The resulting consistent reference system is fundamental for studying those Earth system processes that depend upon precise positioning, whether that be on the Earth's surface or through precise orbit determination of EO satellites. State of the art space geodetic techniques involved in this fundamental work are the Global Positioning System (GPS), Satellite and Lunar Laser Ranging (SLR, LLR), Very Long Baseline Interferometry (VLBI) and Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS).

The UK NERC Space Geodesy Facility features two of these technologies, GPS/GLONASS and SLR. Precise satellite observations from the Facility ensure that it is an important player in the definition of the ITRF.

Laser ranging is used to support precise orbit determination of a variety of satellites, orbiting the Earth at heights of from 500 to 20,000 Km. Broadly the satellites fit into three categories:

- Inert **Geodetic satellites** (e.g. LAGEOS), used to define and monitor the terrestrial reference frame and gravity field.
- **Earth Observation** satellites, such as an altimeter, SAR (e.g. ENVISAT, JASON) and gravity-field missions (e.g. CHAMP, GRACE), in combination with complementary tracking systems (GPS, DORIS, PRARE).
- **Navigational satellites** (e.g. GPS, GLONASS and future pilot GALILEO), to independently evaluate orbital quality.





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