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Geol 495

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**Assignment 1: Lectures 1-3**

Problem 1: Geodesy is the science of measuring the Earth’s shape, gravity field, and rotation. The three pillars of geodesy are the Earth’s time-dependent shape (geokinematics), Earth rotation, and the gravity field.

Problem 2: A geodetic reference system is a system that is used in order to define a reference frame. In Geodesy there are many reference systems, some examples are: the International Celestial Reference System (ICRS), and the International Terrestrial Reference System (ITRS).

Problem 3: The International Terrestrial Reference System (ITRS) and the World Geodetic System (WGS), they are linked by the rotation of the Earth. The IERS and the ICRF are the two systems accepted by the IAG and IAU and also linked through the rotation of the Earth. Both the IAG and the IAU maintain both systems.

Problem 4: For the ITRF

1. Unlike the ICRS, the realization of the ITRS through the ITRF is based on a combination of results from several space geodetic techniques, and local survey measurements between reference points of geodetic instruments (so-called local ties)\index{local ties} co-located at the same sites. The combination is coordinated by the IERS, while the observational aspects for each individual technique involved are coordinated by technique-specific Services. Co-location sites (where two or more instruments are operating in close vicinity), are key elements in the ITRF combinations. While any individual space geodesy technique (VLBI, SLR, DORIS, GNSS) is able to provide necessary information for the ITRF, only the combination of the independent techniques allows for the complete determination of ITRF (origin, scale and orientation).
2. In principle, the particular strengths of one observing method can compensate for weaknesses in others if the combination is properly constructed, suitable weights are found, and accurate local ties in co-location sites are available. The conventions for both the ITRS and ICRS and their realizations are detailed in the \index{IERS!Conventions}IERS Conventions \cite[e.g.,][]{mccarthy+pet2004}. As accuracy requirements evolve and technical and modeling capabilities increase, these conventions are modified and developed under the auspice of IERS in a continuous process with support from the broad geodetic science community.
3. In the conventions, the motion of the reference points in ITRF currently is described by a linear model, thus reducing the information necessary to determine the motion of the reference points relative to their coordinates at a reference epoch and a constant velocity. This representation is no longer appropriate to accommodate possible future user requirements to have access to the actual instantaneous point position over the Earth surface and new representation and models are being discussed (see Chapter~\ref{s-futureref}). The coordinates and constant velocities of the points that define a particular reference frame depend on the points, techniques, models, and analysis tools used in the determination of these quantities. Therefore, for any given reference system, there can be a multitude of reference frames realizing the system at various degrees of accuracy.
4. For global terrestrial reference frames, the ITRS is increasingly used as the underlying system, thus gaining importance for practical applications. For example, the U.S. Government and the European Commission agreed to align the reference frames of the \ac{GPS} and GALILEO as close as possible to ITRS \cite[]{europeancom2004}. In practice, this goal is achieved by aligning the GNSS reference frames to the ITRF, which is the most accurate realization of ITRS.

Problem 5:

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| **Phase and duration** | **Key characteristics** | **General idea** |
| A: From 200 BC up to the middle of the 17th century | Radius of a spherical Earth | Simple geometrical form.  |
| B: From the middle of the 17th century to the middle of the 19th century | Oblateness of a rotational ellipsoid | Geometrical form resulting from rotational dynamics.  |
| C: From the middle of the 19th century to the middle of the 20th century | Geoid | Gravitational field in addition to a purely geometrical form.  |
| D: Since the middle of the 20th century | Dynamics of the Earth's surface and relativistic models of the Earth system | Changes in the shape instead of mean shape; dynamical instead of static view.  |

Problem 6: Today we know that the shape of the Earth is very close to that of an oblate rotational ellipsoid flattened along the axis from pole to pole and elongated in the equatorial (circular) plane. A conventional reference ellipsoid is used to approximate this overall shape (see below). Local topography deviates from this reference ellipsoid by about +8,848 m and about -10,911 m (Figure 3.1). With only 17% of the radius, these deviations are small, and a reference ellipsoid is a good approximation for many studies and mathematical modeling.

Problem 7: Endogenic processes are more on the scale of millions of years, these are processes driven by internal forces in the Earth, i.e. plate tectonics, etc. Exogenic processes, like wind, water, glacial loading, storm surges, etc. are all on a much shorter (relative) time-scale.