Chapter 8: The future geodetic reference frames

Thomas Herring, Hans-Peter Plag, Jim Ray,
Zuheir Altamimi

Status

- The method of realizing the geodetic reference frame is still being debated.
- Current sections:
  - 8.1 Concepts of frame and system
  - 8.2 Reference frame formulation
  - 8.3 Linking geodetic measurements
  - 8.4 Potential field and geometric frames
  - 8.5 Time variation of reference frame
  - 8.6 Components needed for reference frame
  - [8.7 Solar system dynamic reference frames?] -- Should be included in 8.1, and 8.3.

8.1 Concepts

- Two systems needed: Terrestrial rotating system and external inertial system.
- The terrestrial reference system is based on potential. Given a Cartesian frame, time dependent mass elements are assigned to each X,Y,Z coordinate. The integrals of potential for this system are divided into solid-Earth, fluid core and outer fluid envelope.
- Surface coordinates correspond to surface mass elements. The problem is how to detemine the motion of the mass elements?

Concepts

- Ideally, all forces and rheologies of system would be known and motions can be computed.
- Earth rotation variations would be the degree 0 toroidal components, averaged over a specific region, such as crustal layer, of the deformation field.
- Many of these forces are ready well known (e.g., tides), others such as plate tectonic forces can be approximated, and others are not well known but can be inferred from geodetic measurements (hydrographic loading)
- Develop a reference system that allows inputs from different geodetic components to realize the frame. Example next slide.

Example Concept

- Hydrographic loading:
  - Gravity missions such as GRACE measure changes in gravity which are interpreted as surface load changes.
  - The mass changes in the fluid envelope cause deformations in the solid Earth
  - The instantaneous realization of the reference frame would incorporate the loading deformations associated with the gravity changes accounting for the effects of the loading on the satellite tracking and EOP.
- This would be one effect of many. Other effects would be earthquake generated signals, atmospheric loading, internal stress changes in the Earth.

8.2 Reference Frame Formulation

- Temporal variations of site coordinates will be complex in general and as more is learned about the Earth, the motion complexity will increase.
- Sites would be divided into two types:
  - “Frame realization” sites that would have “simple, well characterized motions” (plate motion, GIA, loading not too effected by ocean effects).
  - Reference frame sites that could have more complicated motions (e.g., earthquake postseismic) but are needed to allow user local access to the reference frame.
- Anomalous station motion would be defined as a deviation of observed motion from predicted motion.
- Enough redundancy in the frame realization sites is needed to allow the detection of anomalous motion.

8.3 Linking geodetic measurements

- Section to discusses issues of linking ground geodetic systems to satellite and celestial systems
- Linkage of geodetic systems e.g., collocation of ground systems versus linkage through orbits (corner cubes in satellites)
- Inertial frame from quasars and solar system dynamics

8.4 Potential and Geometric reference frames

- Orthometric heights versus ellipsoidal heights
- In reference system definition, the gravimetric concept is imbedded however spatial resolution may not be adequate? Depends on future missions

8.5 Time variations of reference frame

- Summary of the magnitudes of changes expected from various signals:
  - Plate tectonics
  - Glacial isostatic adjustment
  - Tidal (earth and ocean and ocean loading)
  - Loading atmosphere, hydrology, fluid core
- Document effects on position, rotation and gravity
- Most of this information is in other chapters

8.6 Components needed

- Section looks at temporal, spatial resolutions and latency need from frame resolution.
- Temporal and spatial resolution possible with future gravity missions