Terrestrial Reference Frames: Definition, Determination, and Usage

*Richard S Gross[1]

1. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA

We measure and monitor the Earth's environmental system (its oceans, ice, land, atmosphere) not only to understand the processes of global change, but to also enable educated decisions on how to cope with these changes. Space agencies like NASA are heavily investing in satellites to make these measurements. Many of these depend on a highly accurate and stable terrestrial reference frame (TRF) within which to interpret the data and understand trends in the processes of change.

The terrestrial reference frame is the foundation for virtually all space-based, airborne and ground-based Earth observations. Positions of objects are determined within an underlying TRF and the accuracy with which objects can be positioned ultimately depends on the accuracy of the reference frame. The TRF allows different spatial information, such as imagery from different space and airborne platforms, to be geo-referenced and aligned with each other. It plays a key role in modeling and estimating the motion of the Earth in space, in measuring change and deformation of all components of the Earth system, and in providing the ability to connect measurements made at the same place at different times, a critical requirement for understanding global, regional and local change. Providing an accurate, stable, homogeneous, and maintainable terrestrial reference frame to support numerous scientific and societal applications is one of the essential goals of the International Association of Geodesy's (IAG's) Global Geodetic Observing System (GGOS).

The terrestrial reference frame is determined and maintained though a global network of ground sites with co-located SLR, VLBI, GNSS, and DORIS stations and is realized as the international standard through the ITRF (International Terrestrial Reference Frame). Requirements for the ITRF have increased dramatically since the 1980s. Today, the most stringent requirement comes from critical sea level programs: a global accuracy of 1.0 mm, and 0.1 mm/yr stability is required. This is a factor of 5 to 10 beyond current capability. Current and future satellites will have ever-increasing measurement capability and should lead to increasingly sophisticated models of the processes that they are observing. The accuracy and stability of the terrestrial reference frame needs to dramatically improve in order to fully realize the measurement potential of the current and future generation of Earth observing satellites.

Different groups are taking different approaches to improving the TRF. At JPL, we are developing a sequential estimation approach wherein station positions are combined on a daily basis to determine the frame. This daily approach allows the origin of the frame to be defined at nearly the instantaneous (daily) position of the Earth system's center-of-mass. And while station positions can be constrained to move linearly in order to produce linear frames for comparison with others, they can also be allowed to more realistically follow the observed station motion by applying appropriate levels of smoothing. Thus, more realistic estimates of frame parameter and station position time series can be determined by the sequential estimation approach being developed at JPL.

Keywords: TRF