Title: Global Geodetic Reference Frames

Brief Description: With the *International Terrestrial Reference Frame* (ITRF), the *International Celestial Reference Frame* (ICRF), and the *Earth Rotation Parameters (ERP)*, the *Global Geodetic Observing System* (GGOS) provides the metrological basis for all Earth observations independent of the specific *Societal Benefit Area* (SBA). These reference frames depend on considerable global infrastructure comprising not only the global *in situ* networks of several space-geodetic techniques (with up to 400 stations in more than 80 countries) and gravimetric techniques, but also the Global Navigation Satellite Systems and, increasingly, dedicated satellite missions (see the Figure below). Maintaining a terrestrial reference frame at the level necessary to meet the user requirements, for example, with respect to the determination of global sea level changes, seismic displacement fields associated with large earthquakes, timely early warnings for earthquakes, tsunamis, landslides, and volcanic eruptions, as well as the monitoring of mass transport in the Earth system (in particular, the global and regional water cycle), requires an Earth system approach encompassing all Earth sciences. In the frame of GEO, GGOS carried out a strategy process (denoted as GGOS 2020) with the goals (1) to establish the relevant user requirements across the nine SBAs, and (2) to provide the basis for the implementation of a geodetic observing system that will meet the requirements of the society at large and the SBAs of GEO in particular.

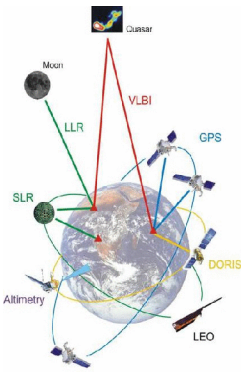

Figure: Infrastructure contributing to GGOS. The combined infrastructure allows the determination and maintenance of the global geodetic reference frames, and the determination of Earth's gravity field and rotation. The ground networks and navigation satellites (currently in particular GPS) are crucial in positioning, with applications to all SBAs. In particular, they allow the monitoring of volcanoes, earthquakes, tectonically active regions and landslide-prone areas. The *Low Earth Orbit* (LEO) satellites monitor sea level, ice sheets, water storage on land, atmospheric water content, high-resolution surface motion, and variations in the Earth' gravity field. The latter are cause, to a large extent, by regional and global mass transport in the hydrological cycle.

Added Value: GEO is an appropriate forum for the dialog on the development of an intergovernmental approach to the implementation of the infrastructure, in particular the operational core, required for maintenance of the global geodetic reference frames in a way appropriate for maximum benefit of GEO. The GEO Committees and Tasks foster new links between GGOS and Participating Organizations and institutions in Member Countries that are stakeholders in geodetic observations, products, and applications. GEO also provides for the links to users in a wide range of applications across all SBAs.

Relevance to GEO: Geodetic observations and products are relevant at least for the GEO SBAs of Water, Disasters, Energy, Weather, Climate, Health, and Agriculture. Thus, GGOS is a major component in the architecture of GEOSS. The GGOS 2020 process, which is integrated in the Task AR-07-03, facilitated the assessment of the cross-cutting GEO requirements for the reference frames and for monitoring of mass transport particularly in the water cycle (including sea level, ice sheets, water storage on land, and atmospheric water content). The process also provided an assessment of the status of GGOS and the identification of current and potential future gaps (particularly in the sea level, ice sheets, and water cycle monitoring system).

Participants: IAG (represented by GGOS), CEOS (represented by CNES), Germany, Italy, South Korea, EC.

Current Status and next Steps: After completion of the GGOS 2020 process, the next steps are (1) to enter a dialog concerning the appropriate intergovernmental frame for the implementation of the recommendations, (2) to discuss with the space agencies steps towards implementation of the recommended space components, and (3) to reach out to the SBAs to ensure maximum benefit of the geodetic observations and products for the users. A major goal will be on the stability of an operational core infrastructure and the closure of spatial gaps in the global *in situ* networks.