Background

The collective effort of the working group participants is to generate the official IGS station coordinates and velocities, Earth Rotation Parameters (ERP) and geocenter estimates along with the appropriate covariance information. The estimated parameters are aligned to the International Terrestrial Reference Frame (ITRF). The group strives for consistency, reliability, accuracy and timeliness of the above products.

Besides operational products, the RFWG also generates station coordinates and ERP solutions on the occasion of each IGS reprocessing campaign. The reprocessed products constitute the IGS contribution to the successive ITRF releases.

The RFWG finally specifies and selects globally distributed sets of GNSS stations from the ITRF solutions to realize the successive IGS Reference Frames (RF). New RF realizations are issued at irregular intervals, usually synchronized to new ITRF releases. The reliability and consistency of individual RF stations must be continuously monitored and occasional updates announced to users.

The RFWG is composed of one coordinator, the Director of the IGS Central Bureau, the IGS Analysis Center Coordinator, the IGS Network Coordinator, the chair of the IGS Infrastructure Committee, the chair of the IGS Antenna Working Group, one representative from each AC, GNAAC and RNAAC, one from the ITRF/IERS section, and the members of the IGS RF team at IGN, France. Other members may be added as required. The RFWG reports to the IGS Governing Board. Modifications to the goals and working plan will be done through consultation among the working group.

Operational Activities

The final daily station coordinates and ERP solutions from the Analysis Centers (ACs) are combined to generate the IGS official products. Solutions from the Global Network Associate Analysis Centers (GNAAC) are used to validate the combination. The daily combined IGS solutions are made available on a weekly basis, by each Friday, with a delay up to 13 (for the last day of the week) to 19 (for the first day of the week) days. They include station coordinates, ERPs and geocenter estimates and are aligned in origin and orientation to the current IGS RF. A weekly combined solution is also produced by stacking the daily combined solutions.

The daily combined station position time series are monitored and occasional discontinuities caused by equipment changes, earthquakes or other causes are reported in the IGS discontinuity list (ftp://igs-rf.ign.fr/pub/discontinuities/soln.snx).

The weekly station coordinate solutions are added to a cumulative solution to form a continuously evolving secular GNSS RF with linear station velocities. This cumulative solution contains successive sets of positions and velocities for each station, each set being valid over the time period between two discontinuities.

An accumulated series of daily ERP is also updated weekly. It includes the pole coordinates, their rates and the excess length of day. While other ERP files are also generated by the Analysis Center Coordinator from the various IGS orbit combination processes, the weekly final ERPs from the RF combination are the definitive IGS products.

Occasional Activities

Reprocessing campaigns are occasionally organized by the IGS with the purpose of providing improved consistent sets of GNSS geodetic products based on the latest available models and methodology. One major goal of the reprocessing campaigns is to provide the IGS inputs to the successive ITRF releases. For that purpose, the Reference Frame Working Group combines, compares and validates the station

coordinates and ERP solutions provided by the ACs in the course of the reprocessing campaigns. The combined solutions from the IGS 2nd reprocessing campaign were the IGS input to ITRF2014. The ongoing 3rd reprocessing campaign will provide the IGS input to ITRF2020.

After each new version of the ITRF is released, the Reference Frame Working Group works in close co-operation with the Antenna Working Group to define of a new framework for the IGS products based on the latest ITRF release. The procedure involves the following steps:

- selection of globally distributed, stable IGS stations from the latest ITRF solution to realize the new IGS RF,
- re-evaluation of the GNSS satellite radial phase center offsets (z-PCOs) based on the scale of the latest ITRF solution,
- update of the ground antenna calibrations in the IGS ANTEX file based on newly available measurements,
- computation of the expected impact of the ground antenna calibration updates on station positions.

This procedure leads to the publication of a new RF and ANTEX file (e.g., IGS14 and igs14.atx), which become the IGS standards until the next ITRF version.

Between ITRF releases, new discontinuities inevitably make the number of available RF stations decrease. When the situation becomes such that a precise and stable alignment of the IGS products to the RF is jeopardized, an update to the IGS RF is published. The latest such update and current IGS RF is IGb14.

Plans and Future Developments

Website. To facilitate dissemination and use of the IGS Reference Frame products, a dedicated website had been set up to include all necessary documentation and results and to illustrate the IGS RF combination results (https://webigs.ign.fr/tfcc/en/general-info). The information on this website has however not been updated for years due to lack of human resources and is now largely outdated. We will therefore thrive to update the whole website as soon as possible.

Characterization and mitigation of systematic errors. Noting the tremendous progress achieved by the IGS Analysis Centers (ACs) over the past decades, we believe that there are still areas where progress could be made to improve the accuracy of the IGS products. Systematic errors, such as spurious periodic signals in station position time series, imprecise geocenter estimates or LOD biases, indeed still affect the IGS station position and ERP products. The RFWG will work in collaboration with the ACs and the ACC to characterize these systematic errors and their differences among ACs, with the aim of identifying and mitigating their sources.

Densified combination. The daily combinations of the IGS AC solutions only include stations processed by the ACs and do usually not cover the whole IGS network. In order to provide daily coordinates for all IGS stations, but also for regional densification stations, the project of daily densified IGS combinations will be studied. The project would involve regional IAG sub-commissions such as EUREF, SIRGAS, APREF…, some of which already contribute to the IGS as Regional Network Associate Analysis Centers (RNAACs). Daily regional solutions provided by the contributing RNAACs would be combined with the legacy daily IGS solutions to form densified IGS solutions.

Combination of satellite PCOs. The feasibility of rigorously combining the daily satellite PCO estimates provided by the ACs as part of their final solutions, simultaneously with station positions and ERPs, will be studied.

Galileo-based terrestrial scale. The release of the Galileo satellite antenna phase center offsets (PCOs) by the European Global Navigation Satellite Systems Agency (GSA) opens the way, for the first time in GNSS history, to an independent determination of the terrestrial scale with GNSS. Based on the AC solutions from the 3rd IGS reprocessing campaign which make use of Galileo, the Reference Frame Working Group will carefully study the terrestrial scale information implied by the Galileo satellite PCOs, how it compares with other techniques (SLR, VLBI) and how precisely it can be propagated to the pre-Galileo era.

Monitoring of RF stations. Interaction and communication with the IGS Network Coordinator and Infrastructure Committee will be enforced in order to follow the performance and behaviour of the IGS stations over time, and in particular the RF stations that are crucial for the stability of the IGS RF. In coordination with the IGS Network Coordinator and Infrastructure Committee, communication with station operators will be established to inform of possible abnormal station behaviours that could be detected in time series analysis.