Densification of the ITRF through the weekly combination of regional and global GNSS solutions

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Introduction

The IAG WG “Integration of Dense Velocity Fields in the ITRF” (2011-2015) is the follow up of the IAG WG “Regional Dense Velocity Fields” (Bruyninx et al. 2012, in press). The objective of the WG is to provide a dense, unified and reliable velocity field globally referenced in the ITRF (International Terrestrial Reference Frame) and useful for seismological and geophysical interpretations based on regional GNSS-based velocity fields. The WG is embedded in Sub-Commission 1.3 “Regional Reference Frames” where it coexists with the Regional Reference Frame Sub-commissions AREF (Africa), APREF (Asia & Pacific), EURREF (Europe), NAREF (North America), SIRGAS (Latin America & Caribbean). The IAG Regional Reference Frame sub-commissions are responsible to provide the GNSS-based weekly solutions for their region.

To obtain such velocity field, the WG will combine the weekly solutions and then stack these weekly combined solutions in order to derive a cumulative position and velocity solution as well as residual position time series. This poster focuses on the preliminary combinations of the individual weekly solutions to derive weekly combined solutions.

Data Set

Each solution submitted by regional sub-commissions (AFR, EUR, AUS, UGS, NGS, GSB, SIR) consists of:
- the weekly SINEXs (cleaned or with the list of the outliers),
- the cumulative solution and the associated residual series time,
- the position and velocity discontinuities that should be used for the cumulative solution,
- the station site logs if available.

Five of the seven solutions have a global coverage.

Table: List of the weekly solutions submitted to the WG.

<table>
<thead>
<tr>
<th>AC</th>
<th>Solution</th>
<th>Data span</th>
<th>Data span</th>
<th>Antenna</th>
<th>Velocity</th>
<th>Latitude</th>
<th>Longitude</th>
<th>RMS of all stations</th>
<th>RMS of all stations</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS</td>
<td>Global</td>
<td>2005-2013</td>
<td>2006-2013</td>
<td>521</td>
<td>900</td>
<td>123</td>
<td>56</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>AREF</td>
<td>Global</td>
<td>2013-2013</td>
<td>2014-2013</td>
<td>516</td>
<td>890</td>
<td>124</td>
<td>56</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>APREF</td>
<td>Global</td>
<td>2015-2015</td>
<td>2016-2016</td>
<td>516</td>
<td>890</td>
<td>124</td>
<td>56</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>EURREF</td>
<td>Global</td>
<td>2012-2012</td>
<td>2013-2013</td>
<td>268</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>NAREF</td>
<td>Global</td>
<td>2013-2013</td>
<td>2014-2014</td>
<td>268</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>SIRGAS</td>
<td>Global</td>
<td>2013-2013</td>
<td>2014-2014</td>
<td>268</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2005-2013</td>
<td>2012-2014</td>
<td>1489</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

Solutions:

1) Individual cumulative solutions: Estimation of individual cumulative solutions (Pos., Vel. & time series) based on the individual weekly SINEXs using the information (discontinuities, outliers) given by the regional sub-commissions.
2) Weekly solution combination: Combination of the weekly SINEXs.
3) Cumulative solution of the combined SINEXs: Estimation of a cumulative solution based on the combined weekly SINEXs using a harmonized set of discontinuities.

Combination of the weekly solutions

Each week, the available individual SINEXs are combined with CATREF Software (Altamimi et al. 2007). Seven Helmert parameters are estimated to aligned the individual solutions to the IGS solution.

Tests realized / Experience Gained / Remaining Issues

Weighting of Weekly Solutions, Special Care to Regional Solution

- Several weighting schemes of the weekly covariance matrices have been tested but no conclusion has been reached yet.
- EURREF and SIRGAS solutions have a regional coverage. Covariance matrices for regional solutions are always more optimistic than global solutions. Usual covariance matrix rescaling with chi-square factor is not given satisfactory results so far.
- In regional solutions, the border stations are degraded compared to the other stations, but necessary to reduce the network effect (Legrand et al. 2012). Border stations should be used but calibrated to reduce their impact on the combined solution.

Metadata Check and Antenna Calibration

- To avoid the mix of antenna calibration model, preliminary combinations are stopped at week 1630 (505:atc to 505:atc switch), nevertheless:
  - some solutions are using 505:atc, while others are using 505:atc (Table 1),
  - EURREF is using individual calibrations when available.
- Large systematic biases (few mm to several m) probably due to wrong antenna eccentricity and small systematic biases (few mm) between solutions have been observed. The latter seems to be linked to the different antenna calibration models.
  - We will performed a systematic verification of the antenna installed at the station, the antenna type and the antenna model used in the analysis.
  - If necessary, position offsets (505:505) will be applied if available (Rebschung et al. 2012), or will be estimated to account for different calibration used.
  - Systematic meta-data verification will be done but for the same station, information contained in site logs can differs depending on the considered network! It is necessary to check site logs first!
  - Harmonisation of discontinuities between solutions is necessary before the combination of the cumulative solution. Discontinuities will be cross checked with Antenna/Receiver changes, earthquakes...

Conclusion

The IAG WG “Integration of Dense Velocity Fields in the ITRF” aims at densifying the ITRF velocity field by combining weekly individual solutions to derive a cumulative (Pos., Vel. & time series) solution.

Remaining issues such as the stabilization of the regional (EURREF and SIRGAS) solutions and verification of the meta data and the antenna calibration model used.

The preliminary weekly combinations performed within the WG, contains 1530 additional stations compared to the ITRF2008 and includes 7 individual solutions. The agreement between the solutions is promising and leads to weekly RMS of about 4 mm.

References

Altamimi et al. (2007) CATREF software. Combination and Analysis of Terminated Reference Frames, LARES Technical, Od, France


