

SUMMARY RECOMMENDATIONS
IGS 2014 WORKSHOP
PASADENA, CA, USA
23-27 JUNE 2014

Recommendations

1. Reference Frame Working Groups <i>Paul Rebischung</i>	2
2. Data Center WG <i>Carey Noll</i>	3
3. Infrastructure Committee <i>Ignacio Romero</i>	4
4. GNSS Working Group <i>Oliver Montenbruck</i>	5
5. Real-Time Working Group <i>Loukis Agrotis</i>	6
6. RINEX Working Group <i>Ken McLeod</i>	7
7. Bias and Calibration Working Group <i>Stefan Schaer</i>	8
8. Antenna Working Group <i>Ralf Schmid</i>	9
9. Space Vehicle Orbit Dynamics Working Group <i>Marek Ziebart</i>	10
10. Ionosphere Working Group <i>Andrzej Krankowski</i>	12
11. Troposphere Working Group <i>Christine Hackman</i>	13
12. IGS TIGA Working Group <i>Tilo Schöne</i>	14
13. Session: Celebrating 20 Years of Operational IGS <i>Markus Rothacher</i>	15
14. Session: Applications <i>Norman Teferle</i>	16

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

*Session/Splinter Meeting Title: **Reprocessing & Reference Frame***

Co-chairs: Paul Rebischung & Bruno Garayt

Rapporteur: Paul Rebischung

Key Issues, Session / Discussion Highlights:

Several ACs presented the analysis strategies used for their second reanalysis campaigns (repro2) and assessed the quality of their repro2 products. Some analysis specificities and their impacts on the AC repro2 products received particular focus, like the time-variable gravity field used by GRGS (Loyer et al.) or the a priori solar radiation pressure model used by ESA (Springer et al.). Preliminary orbit combination results showed an improved inter-AC consistency compared to repro1 (Deng et al.).

Oral and poster presentations from JPL emphasized the potential of using GPS data collected by LEOs to improve the origin of GPS-derived terrestrial frames, as well as to determine the terrestrial scale in an absolute sense via calibrations of the GPS satellite phase center offsets.

Recommendation 1:

Finalize the repro2 effort and the IGS contribution to ITRF2013.

- Perform daily SINEX combinations using the two-step procedure recommended at the IGS 2012 Workshop.
- Provide feedback to ACs.
- Build modernized cumulative IGS solution based on a revised discontinuity list and an extended parameterization (seasonal signals, post-seismic relaxation).
- Provide the AWG with reevaluated satellite phase center offsets.
- Evaluate the intrinsic scale rate of the repro2 solutions and its potential contribution to the ITRF2013 scale rate.

Recommendation 2:

Involve station operators in the selection of the future IGS13 Reference Frame stations, and especially of the IGS13 core stations, in view of securing the long-term stability of the IGS13 Reference Frame.

Recommendation 3:

Start considering truly multi-GNSS IGS final products and the related issues (orbital arc lengths, impact of non-GPS constellations on station positions and EOPs...).

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: IGS Data Center Working Group

Chair: Carey Noll

Rapporteur: Carey Noll

Key Issues, Session / Discussion Highlights:

The main issues discussed at the Data Center Working Group splinter meeting revolved around supporting RINEX V3 and integrating the MGEX archive into the operational IGS archive. Two main topics were addressed: merging RINEX V3 data into the archives and accepting data using the new RINEX V3 filename format.

The current parallel structure found at the DCs supporting MGEX limits the motivation of the ACs to switch to the RINEX V3 format. Integration of the two data archives will promote use of multi-GNSS data and the new format. The MGEX working group has suggested development of a transition plan for adding the MGEX data, and hence RINEX V3 data, to the operational archives. Participants agreed that members of the IGS infrastructure (DCs, the IC, ACs, etc.) should develop this transition plan. It was proposed to include three six-month phases: a preparation phase, followed by an implementation phase and a finalization phase, with full integration of RINEX V3 into the archives by the end of 2015. RINEX V2 for MGEX stations and stations capable of generating RINEX V3 would end at this time.

Those ACs attending the DCWG meeting agreed to utilize the filenaming convention specified in the RINEX V3 documentation. The DCs, however, will need software tools to create these new filenames from RINEX V2 filenames until stations and receiver manufacturers can create the new filenames directly. Tools also need to be made available to the DCs for data QC and metadata extraction as well as tools for the ACs and users to convert RINEX V3 to RINEX V2.

The RINEX V3 format should also address navigation files. The current format documentation specifies one file per station for observation data; therefore, the format should specify one file per station that includes navigation messages from all GNSS constellations. A tool may need to be developed for this capability rather than depend upon generation in the receiver.

Recommendations :

Develop a transition plan that will integrate RINEX V3, including the V3 filename convention, into the operational IGS archives by the end of 2015. (IC, DCs, ACs, MGEX WG)

Provide software tools that DCs can use to continue to provide needed QC and metadata extraction enabling creation of data status information.

Provide software tools to support data conversion (e.g., RINEX V3 to RINEX V2. RINEX V3 filename creation) that both DCs and ACs can use.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: Infrastructure Committee

Chair, Co-Chairs: Romero, Schmid, MacLeod

Rapporteur: Nacho Romero

Key Issues, Session / Discussion Highlights:

RF stations – to remind everyone that if a station is to be upgraded/changed configuration to check the IGS08 reference station list and ask IC/RF WG in case so that the number of stations dropping from the RF network is minimized.

NBS – to start the process of collecting NBS files from existing participating stations

Metadata for GNSS – station logs, NANU, satellites, the regional efforts in metadata storage and maintenance, there are several efforts around the world and they should all talk to the IGS SLM, an activity coordinating the existing databases with the IGS SLM will be promoted.

RINEX3 QC – Anubis, BQC, the QC of Rinex 3 is on its way, but the DC should guide what is needed so that the repository can decide on the storage. Extracting repository metadata should drive the QC need of Rx3 at this point.

RINEX 3 NAV – there is no letter in the 8.3 filenames to store the Beidou ephemerides messages so they are not generated! Tell manufacturers one of the free letters that they can use to write the information from Beidou ephemerides.

RINEX 3 CNAV – soft extension to retain the purely navigation format or an all-encompassing format, no clear direction yet.

Recommendations:

- 1) To start the process to have an IGS NBS data service using the existing shared resources, to support the in-space GNSS radio occultation community.
- 2) To adopt and promote the IGS SLM for station metadata management and to encourage the NC/CB that all existing GNSS metadata databases (GA, EPN, GFZ, etc) can talk to the IGS SLM to exchange and maintain the metadata correctly.
- 3) To contribute to the development of the Rinex 3 transition plan with the MGEX, NC, DC WG, etc for approval in the Dec 14, 2014 GB meeting.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: Multi-GNSS Experiment

Chair, Co-Chair: Montenbruck, Perosanz

Rapporteur: Montenbruck

Key Issues, Session / Discussion Highlights:

MGEX has made substantial progress over the past two years. Network has grown to approximately 110 stations offering global/regional coverage of BeiDou, Galileo, and QZSS in addition to GPS/GLONASS and includes a large fraction of real-time stations. Orbit and clock products from two or more ACs are available for Galileo, QZSS, and most lately BeiDou. Accuracy is at the level of 10-20 cm for GAL and BDS(MEO/IGSO) to 0.5-1.0 m for QZSS and BDS(GEO). Other MGEX products include a cumulative daily Broadcast Ephemerides and a multi-GNSS, multi-signal DCB product. Split of MGEX network and IGS network as well as quality/consistency of MGEX RINEX files constitute a major concern.

Recommendations :

- Adopt new SP3d format (for >85 satellites) within IGS
- Adopt GPS-style s/c axes conventions for GAL/BDS/QZSS to achieve consistent handling of yaw steering mode across all constellations and satellites; orbit normal mode needs to be „translated“ consistently. ACs shall implement constellation-specific nominal attitude modes (yaw steering and orbit normal mode)
- Populate IGS ANTEX file with transmit antenna PCOs for new constellations and anechoic chamber calibrations of receive antenna for new frequencies.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: IGS Real-Time Service on the way to FOC

Chair, Co-Chair: Caissy, Agrotis

Rapporteur: Caissy

Key Issues, Session / Discussion Highlights:

- Need to have additional RTAC's contributing GLONASS clocks.
- Need to improve the reliability of the broadcast ephemeris stream used by RTAC's.
- RTWG Activity: MGEX Pilot within RTWG involving ACs. One key objective is that all RTACs become able to use MSM streams in their routine RTS processes.
- RTWG Activity: Participation in SSR interoperability testing – for example ambiguity fixing and ionosphere.

Recommendation #1

The RTWG recommends that RTAC's who are not contributing GLONASS clocks to the real-time service be asked to confirm their intentions for future contributions. This can be done immediately in the form of a letter/email to these ACs.

Recommendation #2

old: The RTWG recommends that the IGS encourage and coordinate member organizations to establish protocols and develop a system for an Indo-Pacific moderate density GNSS network, real-time data sharing, analysis centers, and advisory bulletins to the responsible government agencies in accord with the IAG's Global Geodetic Observing System (GGOS) Theme #2 for natural hazards applications.

The IGS encourages and coordinates member organizations to establish protocols and develop a system for establishment of moderate density GNSS network (e.g. in Indo-Pacific), real-time data sharing, analysis centers, and advisory bulletins to the responsible government agencies in accord with the IAG's Global Geodetic Observing System (GGOS) Theme #2 for natural hazards applications.

Recommendation #3

It is recommended that the RTWG implement a process to monitor BRD EPH streams that are used by RTACs and that rt-station operators be contacted and encouraged to deliver, when possible, a minimum of two streams to separate independent real-time data centers/casters.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: **RINEX Working Group**

Chair: MacLeod

Rapporteur: MacLeod

Recommendations:

Develop RINEX 3 Transition Plan, to cover:

- Acceptance of the Rinex 3.02 format
- Adopt the new naming convention limiting the rec and ant number to 00 for starters
- To continue to support 2.11 parallel files from MGEX stations for a period of time
- To confirm and support the tools to write Rx2.11 from Rx3 files to aid in the AC and user transitions
- To confirm and support a naming translator between Rx3 names to Rx2.11 and vice versa
- To define together with the DC WG the minimum QC of Rx3 files so that the repository daily metadata can continue to be generated

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: **Bias and Calibration Working Group**

Chair: Schaer

Rapporteur: Schaer

Key Issues, Session / Discussion Highlights:

- Bias SINEX format (version 0.01)
- Status concerning the cc2noncc utility
- New MGEX DCB prototype product generated by DLR
- IGS Bias Workshop 2015 planned to be held at ESA/ESOC in Darmstadt, Germany
- GNSS receiver test data collection at NRCAN for the purpose of bias monitoring

Recommendations:

- Define and adopt Bias SINEX Version 1.00 (including features, such as OBS1-only, handling time-varying biases, maybe extensions concerning phase-related biases).
- Start to provide GPS DCB information in Bias SINEX 1.00 (in addition to Bernese DCB format).
- cc2noncc, currently maintained by I. Romero (ESA/ESOC), will not to be extended to RINEX-3. Users are encouraged to handle this information in their analysis S/W.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: **Antenna Working Group**

Chair: Schmid

Rapporteur: Schmid

Recommendation #1

z-offsets of all GPS and GLONASS satellites will be reestimated from repro2 SINEX files in order to compensate for AC orbit modeling changes (albedo, antenna thrust) affecting the orbit scale.

Recommendation #2

- a) Conventional MGEX satellite antenna phase center offsets for the new GNSS will be added to the IGS antenna phase center model igs08.atx taking into account the IGS-conventional axis definition related to the yaw-steering attitude mode.
- b) igs08.atx robot calibrations for the legacy GPS/GLONASS frequencies are extended with chamber calibrations provided by the University of Bonn for the new GNSS in order to support MGEX activities. Systematic differences between chamber and robot have to be reasonably small for the affected antennas, but cannot be completely avoided. Start to provide GPS DCB information in Bias SINEX 1.00 (in addition to Bernese DCB format).

Recommendation #3

antenna.gra will be extended with a definition for the so-called "north reference point". Station operators are asked NOT to touch active antennas immediately, in case the antenna orientation should not be according to the new IGS definition.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: Space Vehicle Orbit Dynamics Working Group

Chair: Ziebart

Rapporteur: Ziebart

Key Issues, Session / Discussion Highlights:

Overview of splinter

- 30 people attended splinter meeting, including Henry Fliegel and Gerhard Beutler
- Strong, lively discussion took place
- Several good ideas and news items emerged
- There is plenty of worthwhile work to pursue
- Question is..... What to do first?

Emerging technical ideas/questions

- Determining mass change of satellites from burn events
- Henry Fliegel suggested contacting John Berg through Christine Hackman to obtain mass history data
- What is the ideal arc length? Should we use a range of arc lengths? What would we gain?
- Accelerometers on GNSS satellites – should be a recommendation to ICG?
- Fred Vrba from Flagstaff has done some interesting photometry experiments on GPS satellites

News

- Box/wing models demonstrate powerful gains (SLR residuals, draconitics)
- Satellite structural and surface property data available from UCL via web portal
- UCL/JPL major test of new class of solar pressure models on GPS satellites underway – ESOC (Tim Springer) will also participate
- UCL have link with Wuhan University to develop Beidou force models – PhD starting this year, with structural and attitude data made available

Recommendation #1

- Marek and Tim to compile list of parameters needed to build SV surface force models for all MGEX satellites
- Pass this list to Zuheir. He will make representations at ICG to attempt to obtain the data

Recommendation #2

- Orbit Dynamics Working group must pool its resources to develop models for the MGEX satellites
- Marek will liaise with Oliver to keep him informed
- GLONASS/Beidou is where we will start – UCL already have substantial GLONASS information

Recommendation #3

- It is time to start using better a priori SV models, but augmented by appropriate empirical parameters
- In the first step models must be made available – UCL has committed to this and others may be made available
- In a second step, we should revisit what empirical parameters are appropriate

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

*Session/Splinter Meeting Title: **Ionosphere Modelling***

Chair: Krankowski

Rapporteur: Krankowski

Key Issues, Session / Discussion Highlights:

This Plenary Session has been a forum for discussing possible improvements of IGS ionospheric products, empirical models such as Nequick model, monitoring fluctuation and scintillation effects, in-situ and occultation measurements.

The Splinter session has also included a summary of the activities of the IGS Ionosphere Working Group, updates and future plans especially for introducing potential new IGS ionospheric product: TEC fluctuation maps over Northern Hemisphere and GNSS-based near-real time ionospheric monitoring. A new proposed format (SCINTEX) for slant ionospheric information (such as S4, sigmaPhi, ROT and STEC) has been recently proposed and it is under consideration in the IGS ionospheric community due to its significance for potential applications.

Announcements

1. Natural Resources Canada (NRCan) is resuming the activities on global VTEC modelling. After a performance evaluation period, NRCan can become again an IAAC (Reza Ghoddousi-Fard, beginning 2015)
2. The Institute of Geodesy and Geophysics (IGG), Chinese Academy of Sciences, Wuhan, China (Yunbin Yuan, beginning 2015) is computing on routinely basis global VTEC maps, and it can become a new IAAC after a performance evaluation period (Yunbin Yuan)
3. A new proposed format (SCINTEX) for slant ionospheric information (such as S4, sigmaPhi, ROT and STEC) has been recently proposed and it is under consideration in the IGS ionospheric community due to its significance for potential applications.

Recommendations:

1. Higher temporal resolution of IGS combined GIMs - the IAACs (UPC, JPL, ESA and CODE) agreed on providing their maps in IONEX format, with a resolution of 1 hour from October 1, 2014.
2. Starting a new potential official product – TEC fluctuation maps using ROTI over Northern Hemisphere to monitor the dynamic of oval irregularities (carried out by UWM (Krankowski), JPL (Pi) and UPC (Hernandez-Pajares) in next future to be started as official/routine product after performance evaluation period (end of 2014 or beginning 2015).
3. Close cooperation with National Central University from Taiwan regarding usage occultation measurements from Formosat/Cosmic mission for future validation IGS GIMs.
4. Cooperation with IRI COSPAR group for improving IRI TEC.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: IGS Troposphere Working Group

Chair: Hackman

Rapporteur: Hackman, Byram

Key Issues, Session / Discussion Highlights:

- General intro, status report re IGS Final Troposphere Estimates (C Hackman)
- Presentation/status report re development of intertechnique troposphere-estimate-comparison database/website (J Dousa)
- Presentation (R Pacione) and discussion of proposal to standardize tropo_sinex format. Though coordination of this activity would likely take place within the COST GNSS4SWEC action, its authors wanted to assess IGS support.
- Discussion: what should next big WG effort be? (Once dbase/website is complete.)

Recommendation #1

General support was expressed for tropo sinex standardization, so authors Pacione/Dousa plan to distribute a proposal for comment after further work on the draft.

Recommendation #2

Though several challenging ideas were put forward, the will of the people is to support providers of both real-time and post-processed troposphere estimates by comparing said estimates to the IGS Finals, and perhaps issuing regular comparison reports.

This would particularly assist the providers of NRT estimates in understanding, e.g., how helpful their inputs are to forecasting models.

Such comparisons will fortunately be made much easier with the completion of the troposphere-comparison database.

It is therefore likely (recommended?) that establishing/re-establishing such comparisons will be the next big effort of the IGS Troposphere WG.

Recommendation #3

Concern was expressed re the quality of the meteo sensor data recorded at IGS sites, e.g., are the instruments regularly calibrated? Bad P or T values can wreck ZTD-to-PWV conversion. Long-term, the group may need to work with the Infrastructure WG, perhaps creating a recommendation that IGS stations maintain/calibrate their meteo instruments, or even developing IGS site meteo-sensor standards.

Recommendation #4

Other potential long-term projects: addressing conversion of ZTD to IWV; INSAR support.

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: Tide Gauge Working Group

Chair: Schöne

Rapporteur: Schöne

Recommendations:

1. Encourage station operators to establish leveling to tide gauges
2. The inclusion of TIGA stations into the repro2 IGS combination as to be done with care as there are many stations with varying quality, monument stability and missing dome numbers.
3. Promote TIGA activities and results to non-geodetic and hydrographic communities

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

*Session/Splinter Meeting Title: **Celebrating 20 Years of Operational IGS***

Chair: Rothacher

Rapporteur: Rothacher

Key Issues, Session / Discussion Highlights:

Review presentations demonstrate the enormous success of the IGS in the last 20 years. There are major challenges ahead of the IGS, the most important being multi-GNSS.

Recommendation:

All IGS entities (ACs,DCs, WGs, ...) should actively consider the multi-GNSS world and work towards its realization

IGS WORKSHOP 2014
PASADENA/CA
SESSION SUMMARY AND RECOMMENDATIONS

Session/Splinter Meeting Title: Applications

Chair: Teferle

Rapporteur: Teferle

Key Issues, Session / Discussion Highlights:

Important role of GNSS for collocation ties

More applications will emerge with more accurate clocks onboard GNSS

Recommendation:

1. Taking into account temporal gravity variations in GNSS orbit determination.
2. Some applications benefit from long-term orbit arcs
3. Encourage more SLR observations to GNSS satellites