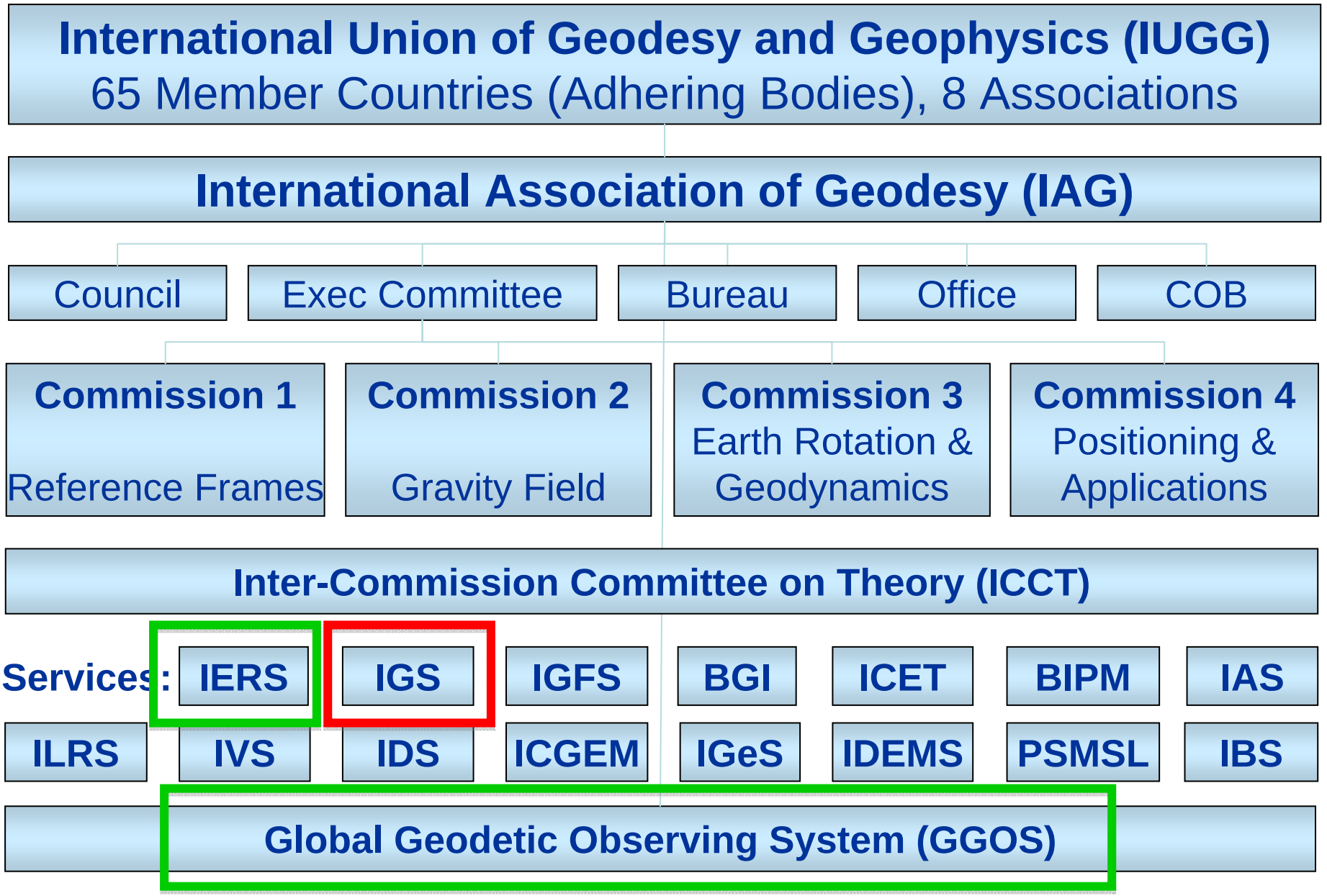
The IGS: A Multi-GNSS Service

Chris Rizos, Urs Hugentobler, Ruth Neilan

IAG Structure



International GNSS Service (IGS)

The IGS is a *voluntary federation* – more than 200 worldwide agencies in more than 90 countries – that pool resources and permanent GNSS station data to generate precise IGS

IGS products are critical to ITRF definition, maintenance & its accessibility

Reliability through *redundancy.*

Improvements in signals, receivers and computations have led *to progressive improvements in product quality.*

All IGS data and products are available *free of charge.*

Evolution of a Multi-GNSS Service

- Mission, structure & governance

IGS Mission

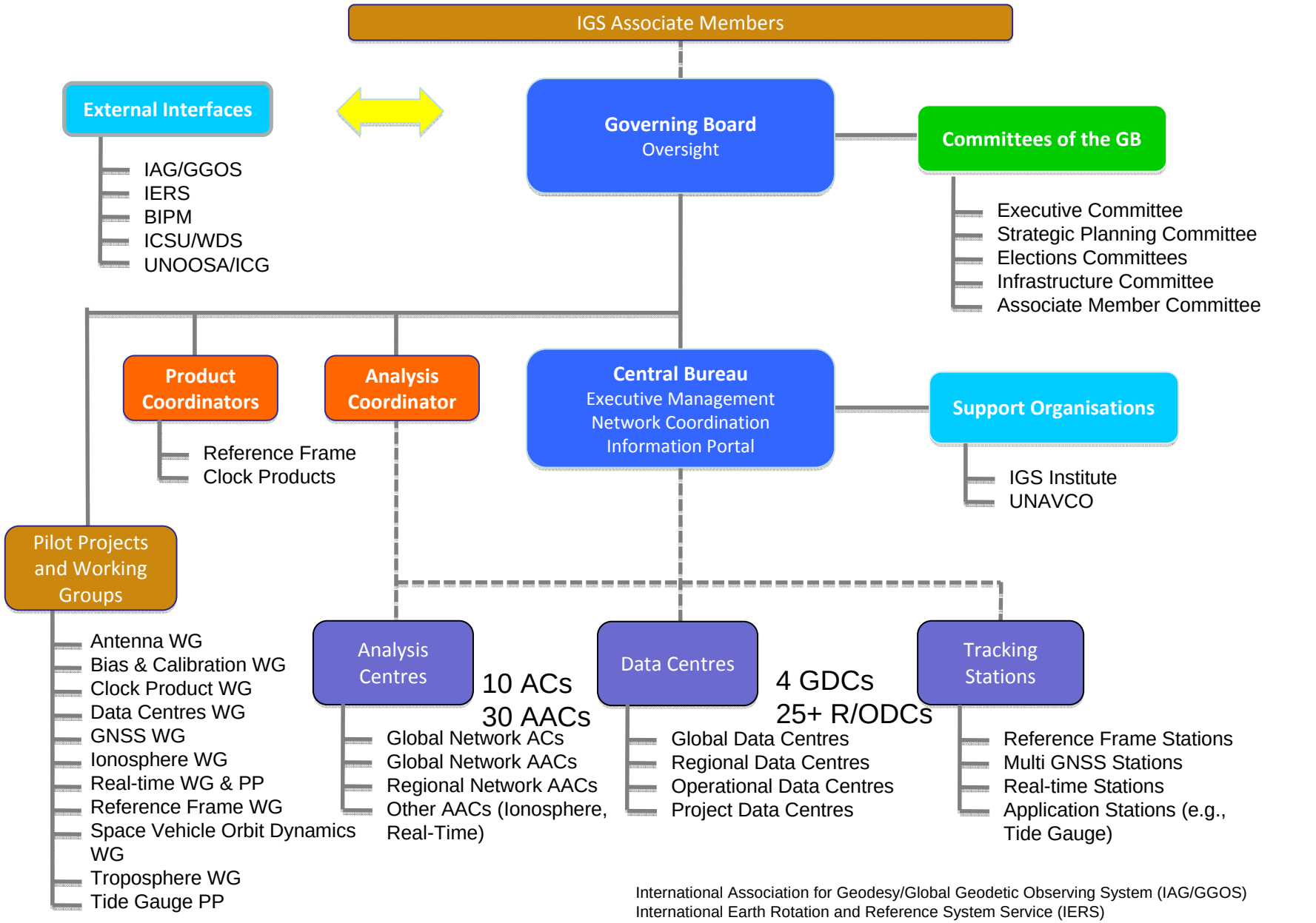
*"The International GNSS Service provides the highest-quality GNSS data, products, and services in support of the Earth observations and research, positioning, navigation and timing, the terrestrial reference frame, Earth rotation, and other applications that benefit society."**

**From IGS Strategic Plan 2008-2012*

IGS Mission

*"The International GNSS Service provides the **highest-quality GNSS data, products, and services** in support of the Earth observations and research, positioning, navigation and timing, the terrestrial reference frame, Earth rotation, and other applications that benefit society."**

**From IGS Strategic Plan 2008-2012*

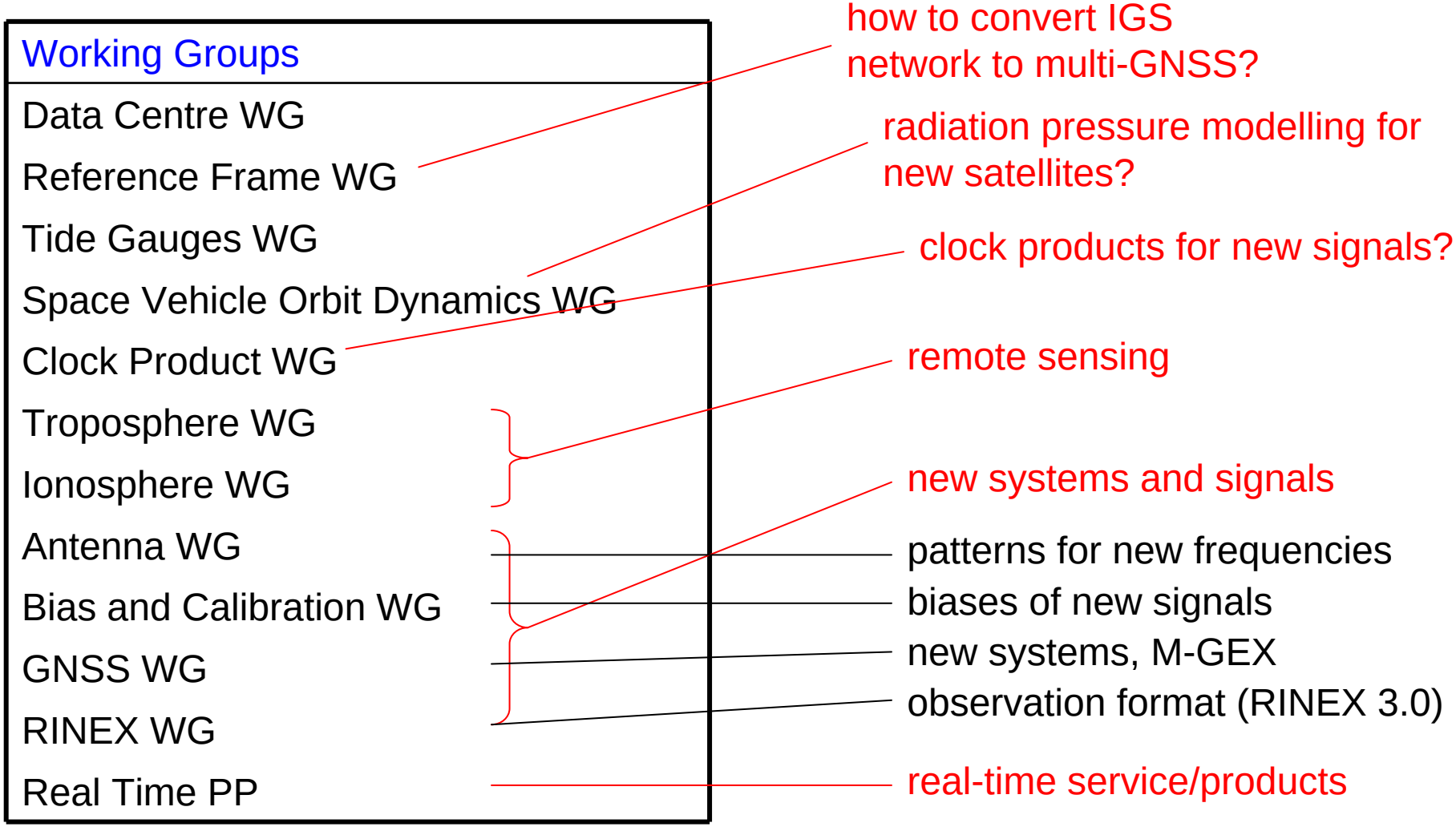


International Association for Geodesy/Global Geodetic Observing System (IAG/GGOS)
International Earth Rotation and Reference System Service (IERS)
Bureau International des Poids et Mesures (BIPM)
International Council for Science/Word Data Systems (ICS/WDS)
United Nations Office for Outer Space Affairs/International Committee on GNSS (UNOOSA/ICG)
Analysis Centre (AC)
Associate Analysis Centre (AAC)

Evolution of a Multi-GNSS Service

- Mission, structure & governance
- Innovation, experimentation & expertise

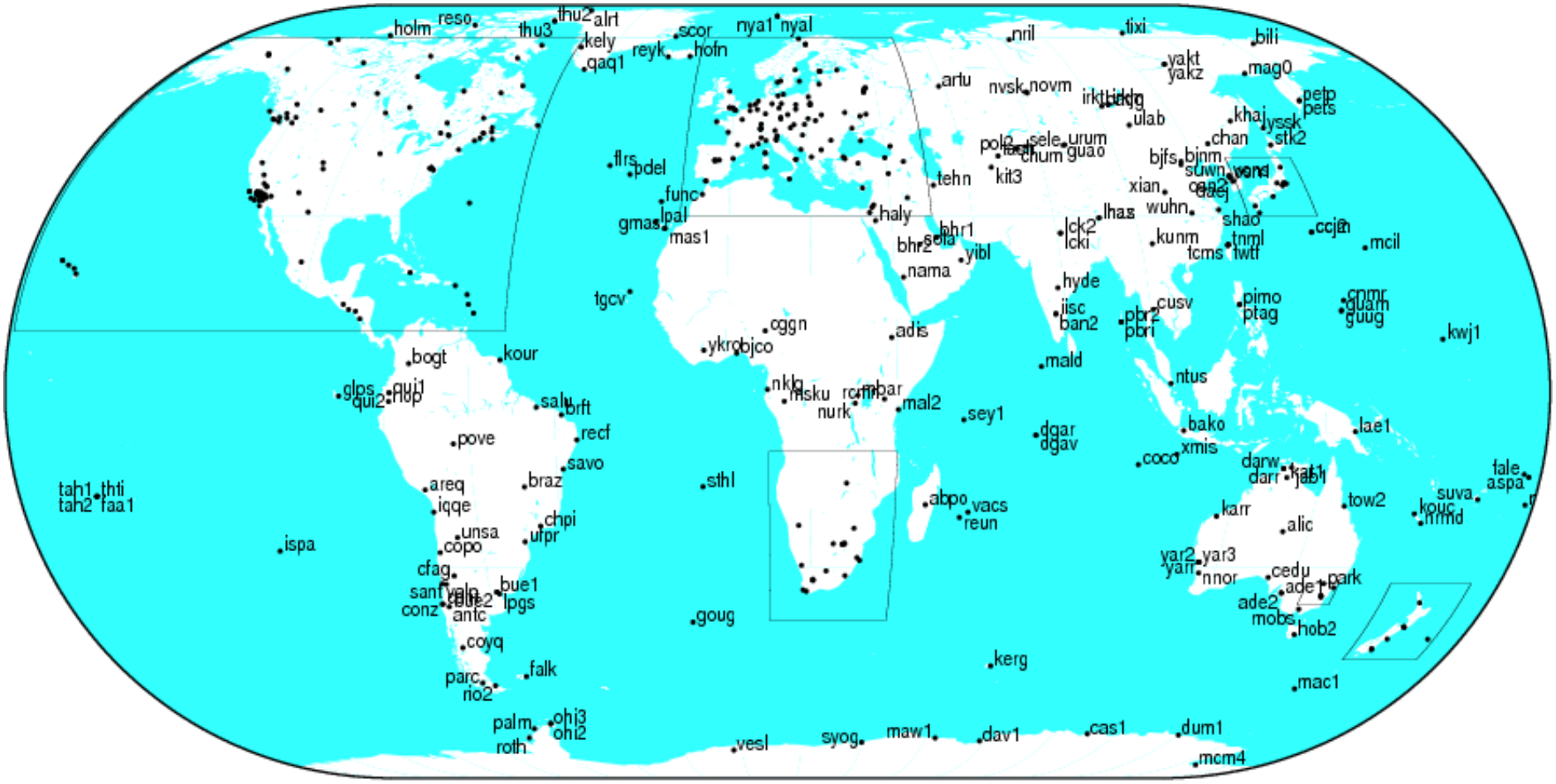
IGS Working Groups & M-GNSS



Evolution of a Multi-GNSS Service

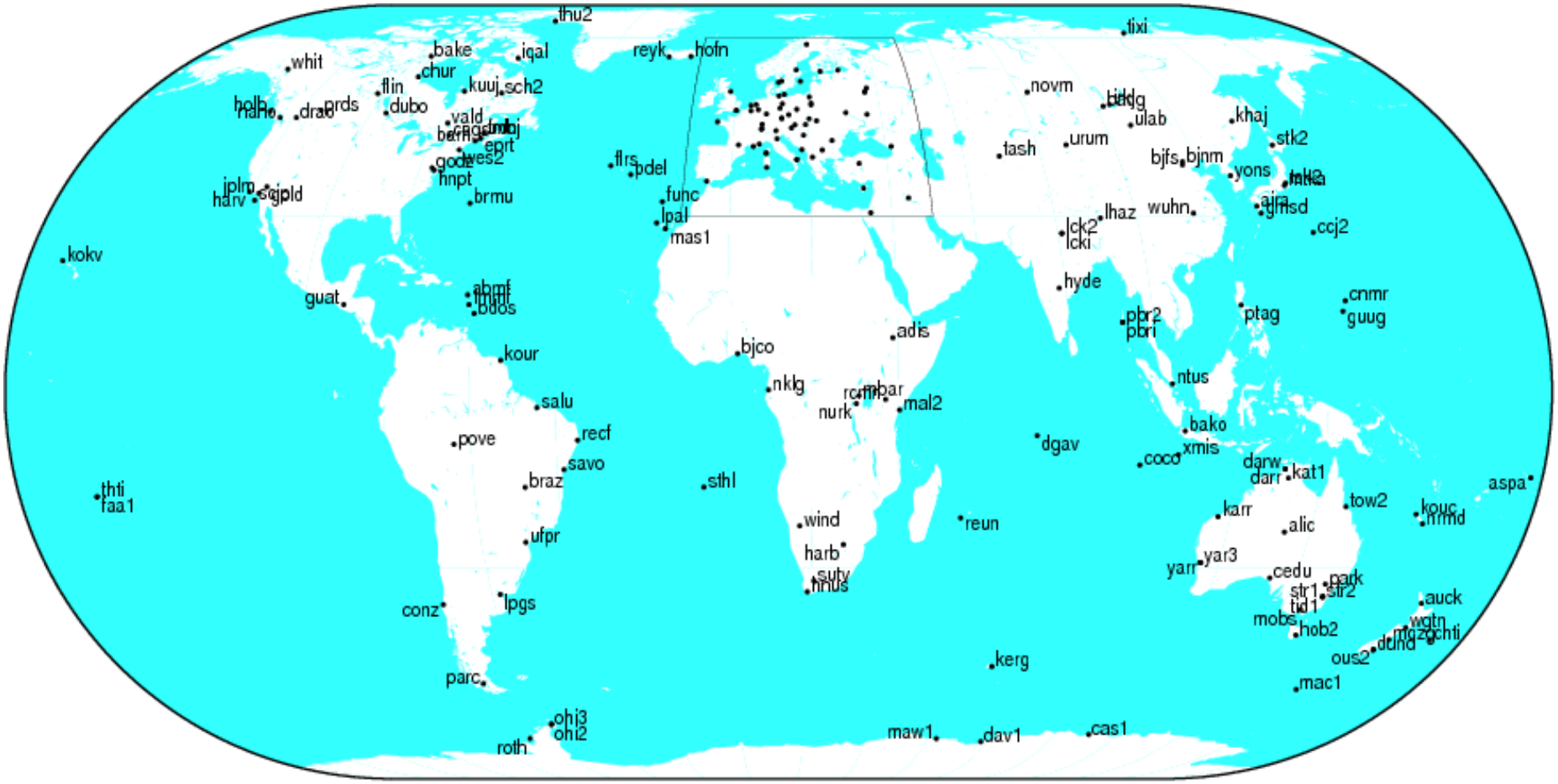
- Mission, structure & governance
- Innovation, experimentation & expertise
- Network infrastructure

IGS GNSS Tracking Network



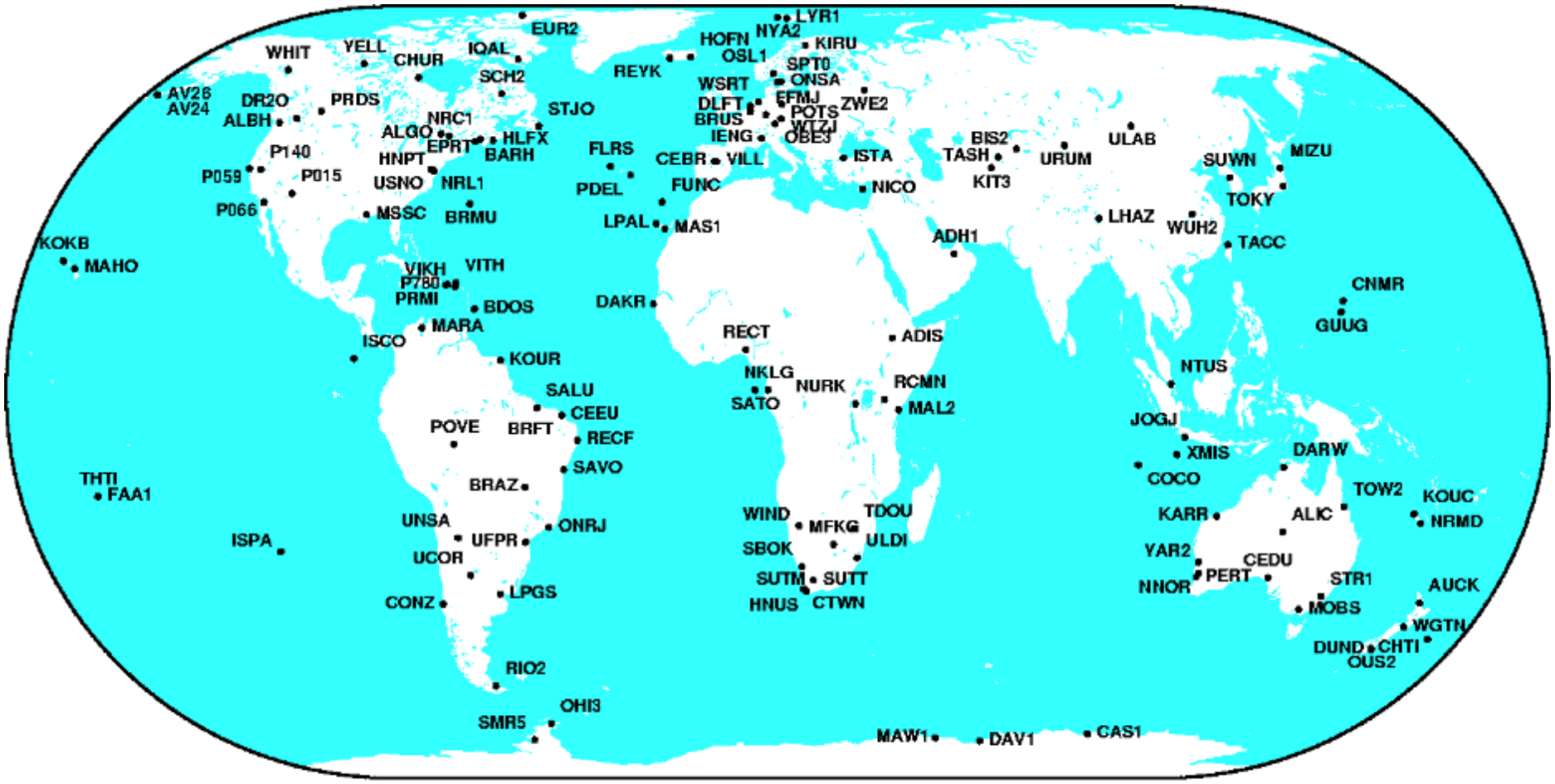
GMT 2012 Oct 03 16:45:32

GPS+GLONASS Network



GMT 2012 Oct 03 16:46:27

IGS Real-Time Network



GMT 2012 Jun 6 13:33:53

~180 Stations streaming data to ACs

Evolution of a Multi-GNSS Service

- Mission, structure & governance
- Innovation, experimentation & expertise
- Network infrastructure
- Improved product suite

Current IGS Products

- Precise GNSS orbits (post-processed & predicted):
  - GPS (2-5 cm, 3Dwrms), predictions (<5-10 cm)
  - GLONASS (~5-10 cm, 3Dwrms)
- GNSS clock corrections (satellite & stn: sub-ns)
- Earth rotation parameters (polar motion, PM rate, LOD)
- Ground positioning (sub-cm), definition, maintenance & *access* to ITRF
- Ionospheric delay mapping (VTEC)
- Tropospheric parameters (integrated water vapour)
- Tracking data from IGS stations (RINEX files, or real-time data streams)

http://igs.org/components/prods.html

(GPS Broadcast Values Included for Comparison)

GPS SATELLITE EPHEMERIDES/ SATELLITE & STATION CLOCKS		ACCURACY	LATENCY	UPDATES	SAMPLE INTERVAL
Broadcast	Orbits	~100 cm	real time		daily
	Sat. clocks	~5 ns			
Ultra-Rapid (predicted half)	Orbits	~5 cm	real time	4x daily	15 min
	Sat. clocks	~3 ns			15 min
Ultra-Rapid (observed half)	Orbits	<3 cm	3 hours	4x daily	15 min
	Sat. clocks	~0.15 ns			15 min
Rapid	Orbits	<2.5 cm	17 hours	daily	15 min
	Sat. & Stn. clocks	75 ps			5 min
Final	Orbits	<2.5 cm	~12 days	weekly	15 min
	Sat. & Stn. clocks	<75 ps			5 min
Real Time Combination	Orbits	~10 cm	25 sec	10 sec	10 sec
	Sat. clocks	<0.3 ns			
Real Time AC Streams	Orbits	~10 cm	8-20 sec	5-10 sec	5-10 sec
	Sat. clocks	~0.3-2 ns			

Note 1: IGS accuracy limits, except for predicted orbits, based on comparisons with independent laser ranging results. The precision is better.
Note 2: The accuracy of all clocks is expressed relative to the IGS timescale, which is linearly aligned to GPS time in one-day segments.
Note 3: Real Time products are provided on an experimental basis. See http://www.rtigs.net/index.php and http://igs.bkg.bund.de/ntrip/orbits.
Note 4: The methods used by some RT Analysis Centres result in high clock biases for individual satellites. Clock standard deviation, which is the more important metric for Precise Point Positioning, is typically of the order of 0.1 ns.

GLONASS SATELLITE EPHEMERIDES					
Final		5 cm	12-18 days	weekly	15 min

GEOCENTRIC COORDINATES OF IGS TRACKING STATIONS (>130 SITES)					
Final Positions	Horizontal	3 mm	12 days	weekly	weekly
	Vertical	6 mm			
Final Velocities	Horizontal	2 mm/yr	12 days	weekly	weekly
	Vertical	3 mm/yr			

EARTH ROTATION PARAMETERS					
Ultra-Rapid (predicted half)	Polar Motion	0.2 mas	real time	4x daily	4x daily
	Polar Motion Rate	0.3 mas/day			
	Length-of-day	0.05 ms			
Ultra-Rapid (observed half)	Polar Motion	0.05 mas	3 hours	twice daily	twice daily (00 & 12 UTC)
	Polar Motion Rate	0.25 mas/day			
	Length-of-day	0.01 ms			
Rapid	Polar Motion	<0.04 mas	17 hours	daily	daily (12 UTC)
	Polar Motion Rate	<0.2 mas/day			
	Length-of-day	0.01 ms			
Final	Polar Motion	0.03 mas	~13 days	weekly	daily (12 UTC)
	Polar Motion Rate	<0.15 mas/day			
	Length-of-day	0.01 ms			

Note: The IGS uses VLBI results from IERS Bulletin A to calibrate for long-term LOD biases.

ATMOSPHERIC PARAMETERS				
Final tropospheric zenith path delay	4 mm	<4 weeks	daily	5 min
Ionospheric TEC grid	2-8 TECU	~11 days	weekly	2 hours; 5 deg (lon) x 2.5 deg (lat)

Occasional "reprocessing"…

Evolution of IGS

From experimental to operational products... *a*
Self-improvement & competitive culture... *leads*
Address new user requirements... *new data & products supporting science & societal needs*
GPS to GPS+GLONASS to multi-GNSS...

Evolution of a Multi-GNSS Service

- Mission, structure & governance
- Innovation, experimentation & expertise
- Network infrastructure
- Improved product suite
- From service focused on post-processing applications, to real-time products

IGS Real-Time Products

- **Real-time product generation is part of IGS Strategic Plan**, started 2002
- Infrastructure:
  - More than 180 active real-time stations, streaming data using NTRIP
  - Close link to RTCM...*joint WG established to develop standards*
- Analysis:
  - 8 real-time Analysis Centres
  - Real-time orbit & sat clock combination...*can support RT-PPP*
- Users tap into product streams from NTRIPcaster via internet link
- Future:
  - Real-time Beta service (late 2012)...*initially GPS-only*
  - Satellite clock corrections, orbits, ionosphere corrections (later)
  - **Progressively include new systems and signals**
  - **New derived products, e.g. integrity monitoring & assessment**

IGS Real-Time Network

Larger than any private network, and more redundancy...
Will support readily available RT-PPP (& other services)

~180 Stations streaming data to ACs

GMT 2012 Jun 6 13:33:53

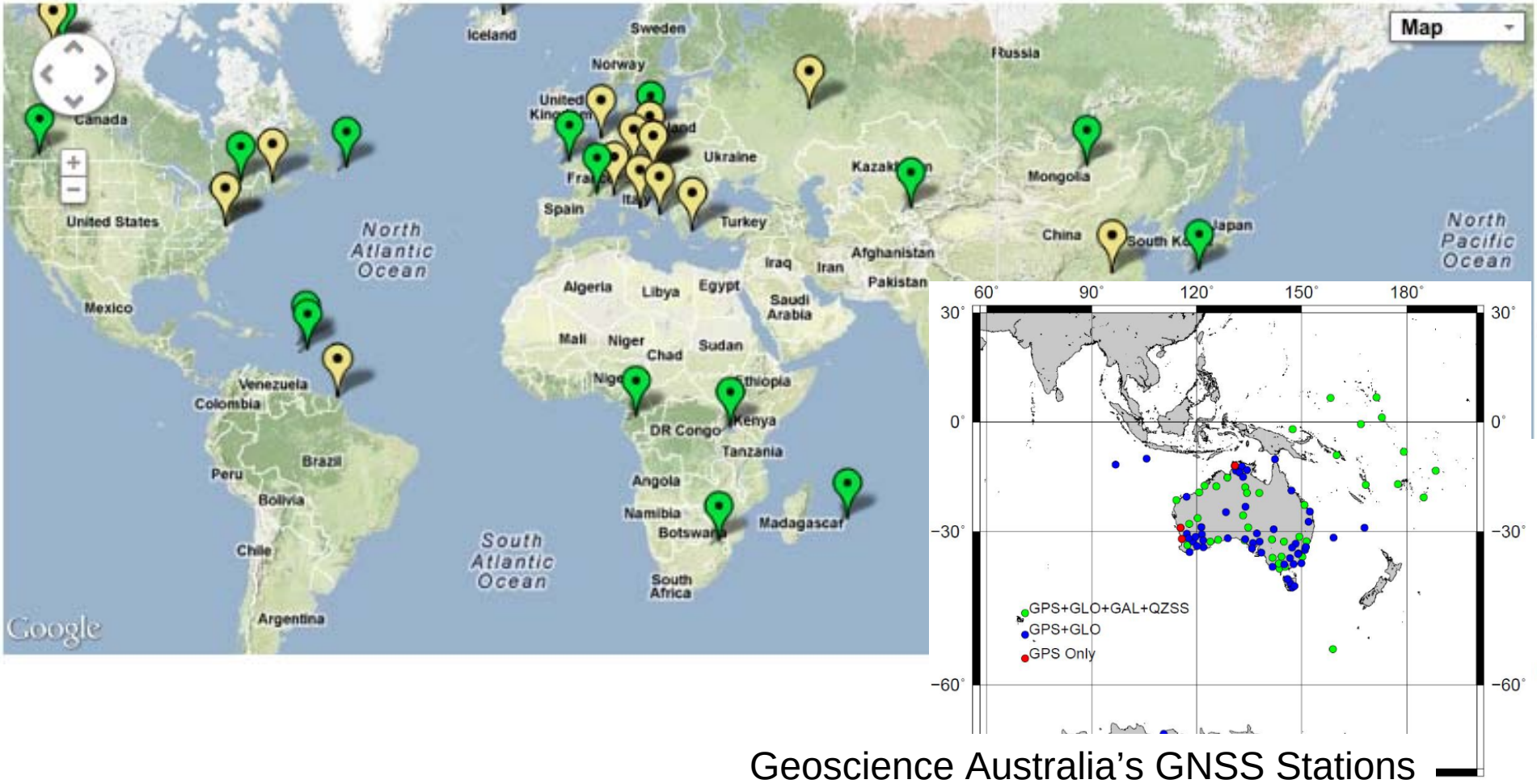
Evolution of a Multi-GNSS Service

- Mission, structure & governance
- Innovation, experimentation & expertise
- Network infrastructure
- Improved product suite
- From service focused on post-processing applications, to real-time products
- From GPS-only to multi-GNSS

IGS Multi-GNSS Experiment (M-GEX)

- Call for Participation to realise M-GNSS *global* network (Feb 2012).
- Include RT tracking and signal utilisation, coordinated by the IGS Real-Time WG.
- M-GEX will not disrupt daily IGS operations, and delivery of its current data and products.
- Analysis of data from multi-GNSS by IGS ACs to extend standard IGS product suite.
- Data and engineering analysis by *any* interested groups.
- Coordinated by IGS GNSS WG.
- *Initial phase of M-GEX to continue until end of 2013.*

M-GEX sites



Geoscience Australia's GNSS Stations

IGS Multi-GNSS Challenges

- Improve tracking network distribution.
- BeiDou, Galileo, IRNSS tracking data; global receiver stations; & signal/engineering specifications.
- Information on satellite antenna offsets & patterns, attitude modes, etc.
- Detailed modelling of observations on new GNSS signals, e.g. DCBs.
- Across-the-board upgrade of IGS AC processing capability.
- Upgrade of file formats, e.g. RINEX 3.0, ANTEX, etc.
- Ensure benefits of multi-GNSS propagate into variety of *standard* (e.g. ITRF, site time series, etc.) and *new* (e.g. RTS, integrity, etc.) IGS/GGOS products.

Evolution of a Multi-GNSS Service

- Mission, structure & governance
- Innovation, experimentation & expertise
- Network infrastructure
- Improved product suite
- From service focused on post-processing applications, to real-time products
- From GPS-only to multi-GNSS
- Concluding remarks...*the future IGS*

The IGS is working towards...

- An expanded IGS M-GEX tracking network...*the future M-*
- *r*
- *eful*
- Liaison with Signal Providers to ensure high product quality.
- Supporting ICG mission & objectives...*with growth in IGS expertise & reputation, by harnessing strong IGS culture.*

The IGS is transitioning to a full multi-GNSS service...

Several initiatives have been launched to address (current & new) user requirements