



IGS

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# International GNSS Service (IGS) Troposphere Products and Working Group Activities

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# Agenda

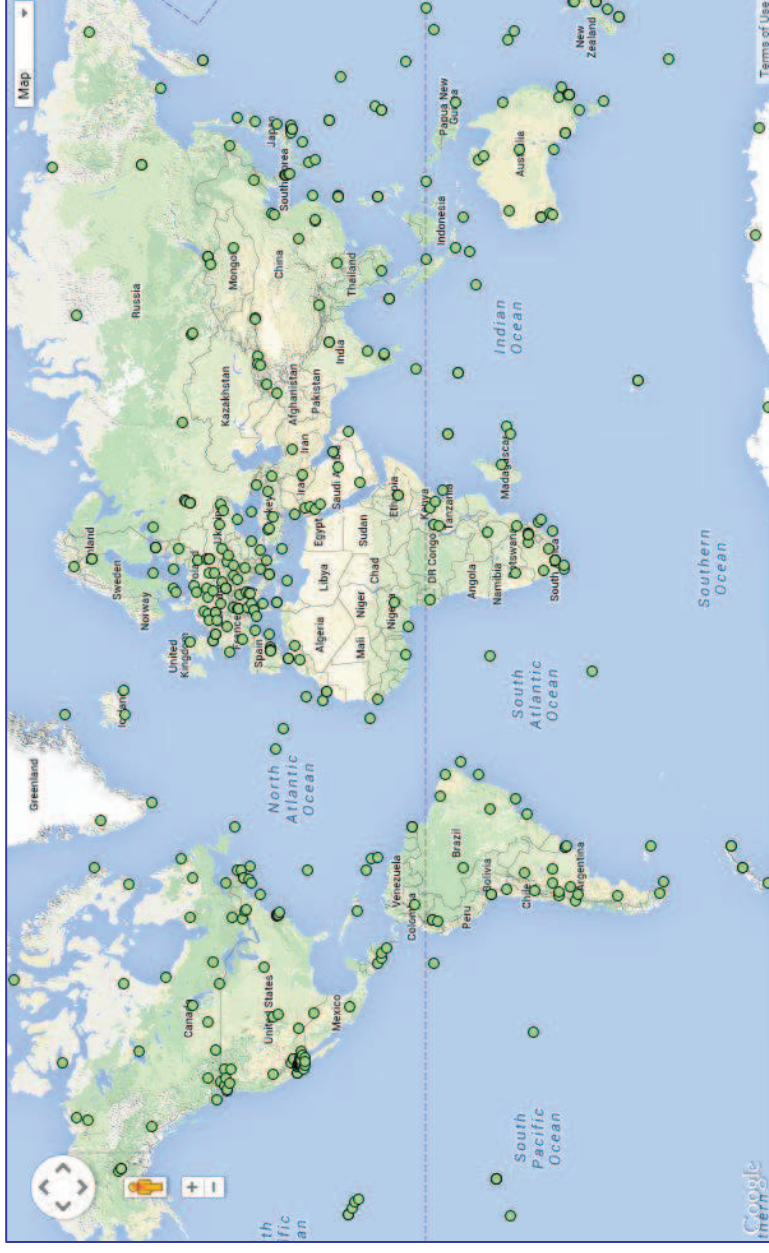
- IGS overview: mission, receiver network
- Why IGS estimates troposphere delay
- IGS Final Troposphere Estimates: generation, usage
- IGS Troposphere Working Group: structure, meetings, projects, how to join

## IGS overview (founded 1994)

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- **Mission:**
  - provide highest-quality GNSS data, products, services...
  - in support of applications benefiting science, society (e.g., terrestrial reference frame, PNT, earth-science research)...
  - openly-available basis
- **Activities:**
  - coordinate global GNSS-receiver network, archiving of its data
  - produce estimates from those data: GNSS satellite orbits, receiver coordinates, earth rotation parameters, sat/receiver clock values, iono/tropo values...
  - working groups: improve science to improve estimates
- **To learn more:** <http://igs.org>

# IGS receiver network, data analysis



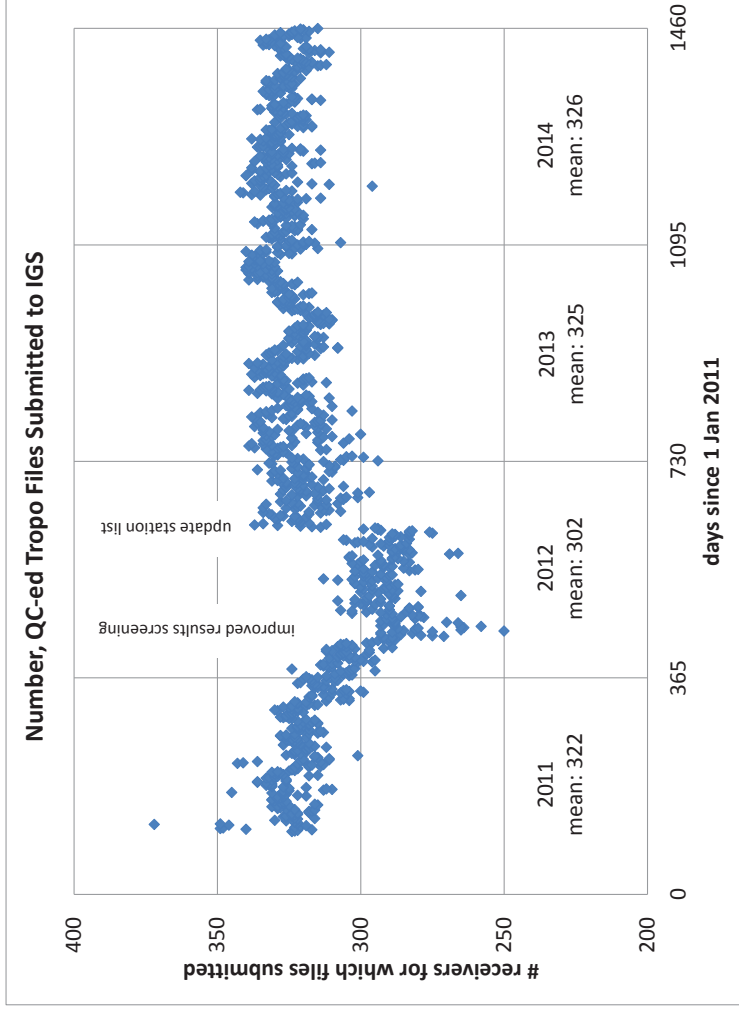
- 400+ permanent continuously-operating dual-frequency carrier-phase receivers
- Record one or more of: GPS, GLO, GAL, BeiDou, QZSS, SBAS
- Data archives (publicly-accessible):
  - Four global IGS data centers
  - Regional data centers
- IGS analysis centers process measurements, contribute “products” (e.g., orbits) to IGS AC Coordinator, who produces official IGS products:
  - ultras (NRT); rapids (24-h later); finals (best)

- Original reason: “nuisance parameter” – must estimate to achieve cm- or mm-level GNSS positioning
  - 2.2 m @ zenith; tens of m @ low elevation (e.g., 15 or 7 deg)
  - $ZTD_{GNSS} = ZTD_{dry} + ZTD_{wet}$
  - $ZTD_{dry}$ : ~2 m, can model
  - $ZTD_{wet}$ : 0.1-0.25 m, changes too quickly/locally to model -> must estimate from GNSS or get from, e.g., WVR
- But now: use  $ZTD_{GNSS}$  ->  $ZTD_{wet}$  -> PWV
- Atmospheric science!
  - Low-latency, high-density PWV: **weather forecasting**
  - Decades-long record, 300+ sites worldwide, values every five minutes: **climate studies**

# IGS Final Troposphere Estimates



- USNO/Dr S Byram generates
- One 24 hr file per IGS station
  - ZTD, gradients every 5 min
  - 325-6 stations/d, 2013-4
- Computed using *Bernese GPS SW*, GMF, PPP using IGS Final Orbits/EOPs/SV clocks
- Thus ~ 21 d latency
- Used by scientific researchers as reference (e.g. Wang *et al.* 2013\* radiosonde study)
- 12.3 M downloads in 2014
- <ftp://cddis.gsfc.nasa.gov/gps/products/troposphere/zpd>



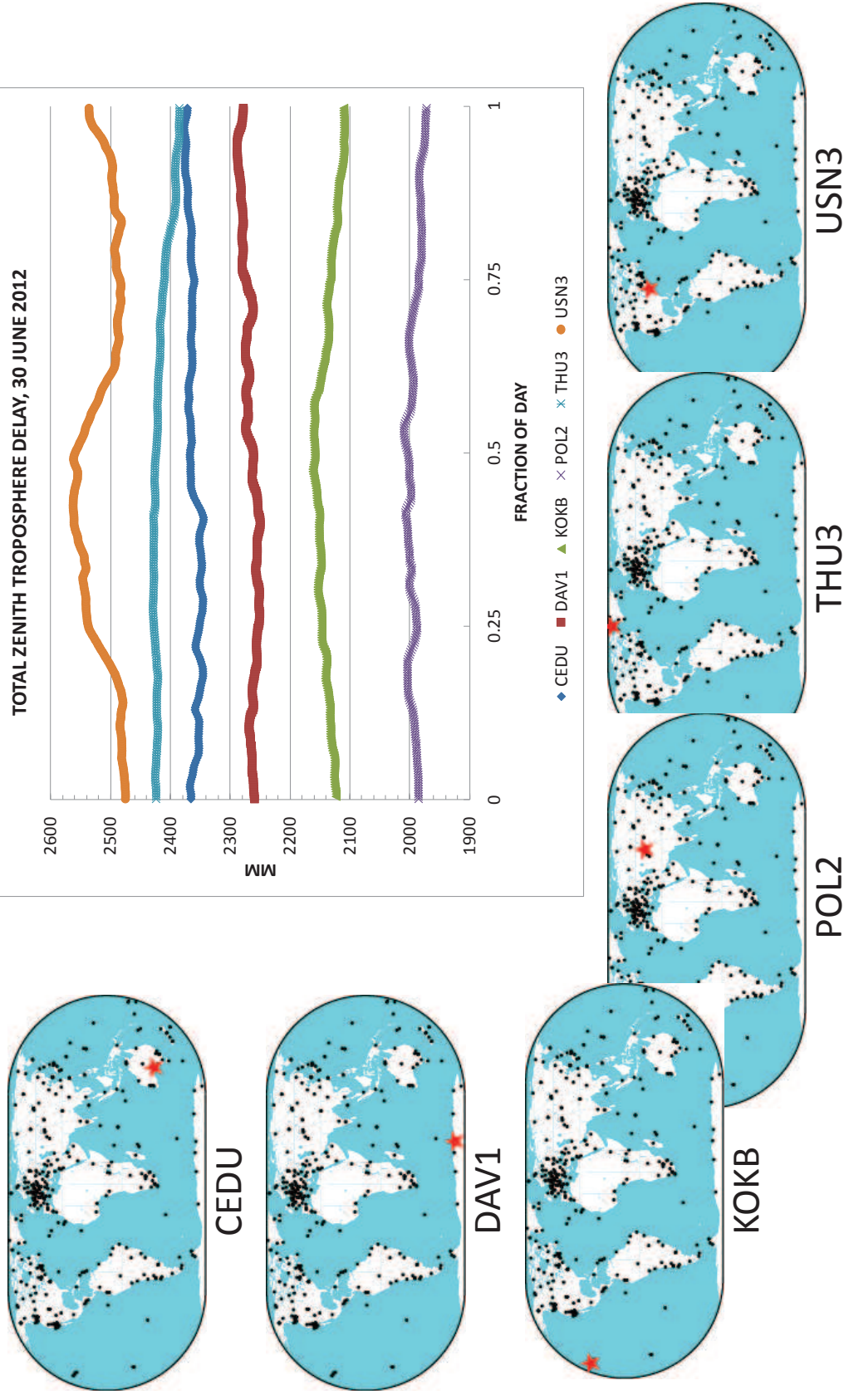
*Number of quality-checked IGS Final Troposphere Estimate files submitted to IGS per measurement day.*

\*Wang, J. et al., "Radiation dry bias correction of Vaisala RS92 humidity data and its impacts on historical radiosonde data," *J Atmosph and Oceanic Tech*, 30:197-214, 2013.

# Example: IGS Final ZTD, 29 June 2012



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- “Reprocessing” campaigns:
  - IGS adopts new physical models -> changes ZTD estimates (though same atmosphere) -> complicates long-term studies
  - To address: reprocess entire timespan of IGS GNSS measurements using one, best-to-date model set
  - “Repro 1”: <ftp://cddis.gsfc.nasa.gov/gps/products/zpd/repro1>
  - “Repro 2”: will do when Repro 2 orbits/clocks/EOPs complete
- Upcoming improvements to IGS FTEs:
  - Reduce day-boundary discontinuities (non-physical few-mm ZTD-value jumps between end of one 24-hr file, beginning of next)
  - Upgrade to newer version of Bernese SW, newer models



- Mission: improve accuracy, usability of GNSS troposphere estimates
- Members: 50+ worldwide; all are welcome!
- Two meetings/yr (simulcast using [gotomeeting.com](http://gotomeeting.com)):
  - December: splinter @ Am. Geophysical Union Fall Meeting
  - Spring/Summer: either IGS Workshop or splinter @ EGU
- Major activities:
  - Working group projects (next page).
  - Coordinate technical sessions (plenary, poster) at IGS Workshop.
    - Plenary: three oral presentations, big-picture projects
    - Poster: goal = foster technical exchange -> seek maximum participation
    - *Links to 2014 IGS Workshop contributions in printed version of this presentation*

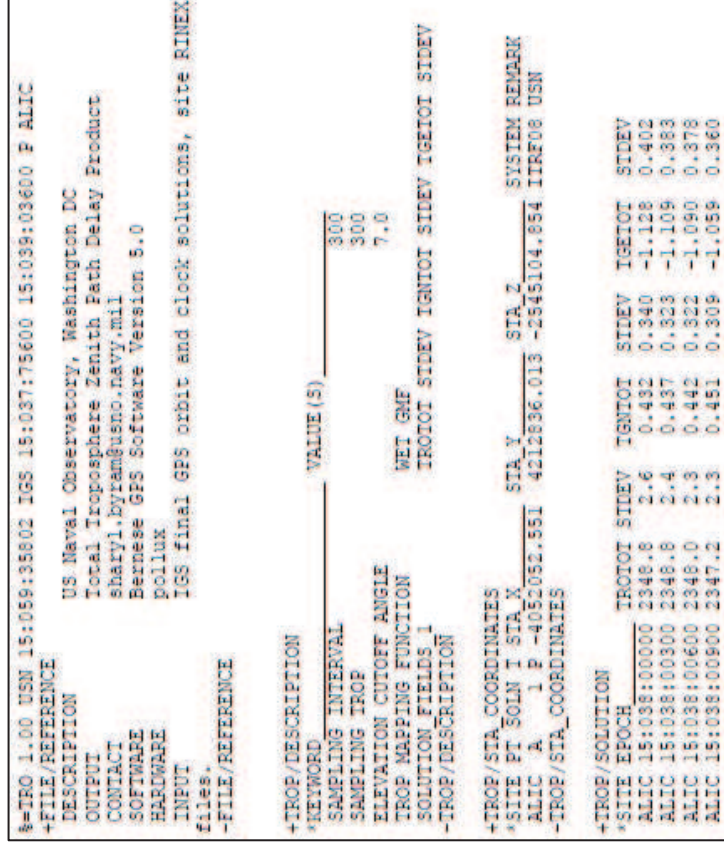
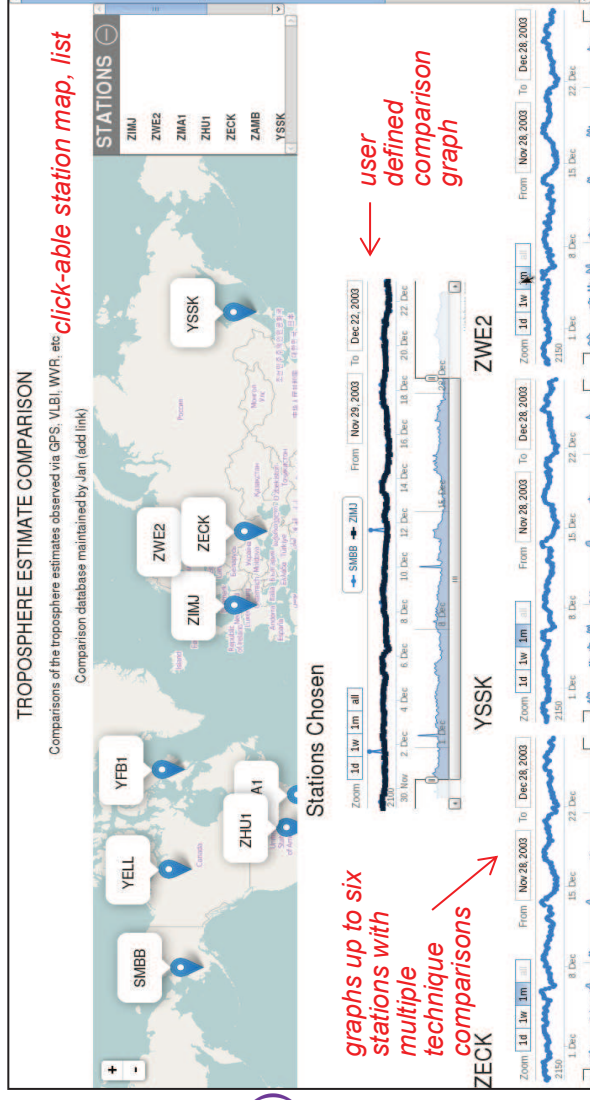
# IGS TWG projects

Automated, continuous comparisons of tropo estimates from independent techniques (GNSS, VLBI, radiosondes...)

- Comparison of answers yields better uncertainty estimates -> improves accuracy
- Primary development @ GOP; contributions from GFZ, USNO, more
- Partially funding, CZ-US Kontakt II grant # LH14089
- Complete 2016

## Support of *tropo\_sinex* (ZTD-dissemination) format standardization

- Ad-hoc format evolution in different geodetic communities
- IGS Tropo WG members R Pacione, J Dousa spearheading COST Action GNSS4SWEC WG 3 effort to redefine/expand format
- Status: just started Fall 2014



# Conclusion: join us!

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## *For more information on...*

- IGS: <http://igs.org>
- IGS Final Troposphere Estimates:
  - Download here: <ftp://cddis.gsfc.nasa.gov/gps/products/troposphere/zpd>
  - Questions about them?
    - Dr Sharyl Byram: [sharyl.byram@usno.navy.mil](mailto:sharyl.byram@usno.navy.mil)
    - Dr Christine Hackman: [christine.hackman@usno.navy.mil](mailto:christine.hackman@usno.navy.mil)
- IGS Troposphere Working Group:
  - Questions: [christine.hackman@usno.navy.mil](mailto:christine.hackman@usno.navy.mil)
  - Website (under development): <http://igs.org/projects-working-groups/twg>
  - Join email list: <http://igscb.jpl.nasa.gov/mailman/igs-twg>

**Thank you for your attention!**

Extra stuff (as needed?)



# Troposphere Gradients

$$\delta\rho_{trp}(z, A) = \underbrace{f_h(z) \cdot \delta\rho_h^0 + f_w(z) \cdot \delta\rho_w^0}_{\text{hydrostatic delay (modelled)}} + \underbrace{N \frac{\partial f_w}{\partial z} \cos A}_{\text{wet delay (estimated)}} + \underbrace{E \frac{\partial f_w}{\partial z} \sin A}_{\text{NS and EW gradients (estimated)}}$$

Example:  
Gradient of 1  
mm

asymmetry of  
1 mm at  $z=38^\circ$

asymmetry  
15 mm at  
 $z=75^\circ$

