IGS Reference Frame Maintenance

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Summary

- Objectives
- Station Products Combination
- TIGA Overview
- Orbit/Clock Products Combination
- Recommendations

Objectives

- Review Existing Procedures
- Identify Potential Weaknesses
- Recommend Practical Improvements

Station Products Combination

- Internal Limitations
  1. Validation
  2. Unconstraining
  3. Transformation/Alignment
  4. Comparison
  5. Combination

Station Products Combination (1. Validation)

- SINEX version 1.00 Compliance
- Use file igs.snx as template
- Apply corrections as needed (use *.acn):
  - Pole Tide
  - LODR-> LOD
  - LOD Bias (w.r.t. to Bull A)
  - Antenna height

  (depends on correctness of info from ACs!)
- **Keep Analysis Strategy summary files (*.acn) up to date**

Station Products Combination (2. Unconstraining)

- Provided AC SINEX files:
  - Rotated to ITRF frame realization
  - Not translated, not scaled.
- Occasional Matrix conditioning needed
- Within an AC, multiple station coordinates solutions combined (one DOMES# ➔ one solution)
- The AC should provide solutions with loose constraints or unconstrained on **all** parameters (not limited to reduced normals)
- For a test period (TBD) the ACs will be asked to provide unconstrained weekly SINEX solutions

Station Products Combination (3. Transformation/Alignment)

- Use latest IGS realization of ITRF (IGb00) for all intermediate and final alignment
- ERP's referred to the origin
- Current procedure uses unweighted (robust) transformation (7/14 parameters)

- Review effects of the covariance information on the estimated transformation parameters

Station Products Combination (4. Comparison)

- Estimated and applied variance factor to AC solutions
- Pair wise solutions comparison to detect and reject outliers:
  - AC / GNAAC / IGb00 / igs $_{wk-1}$ / IGS $_{wk-1}$

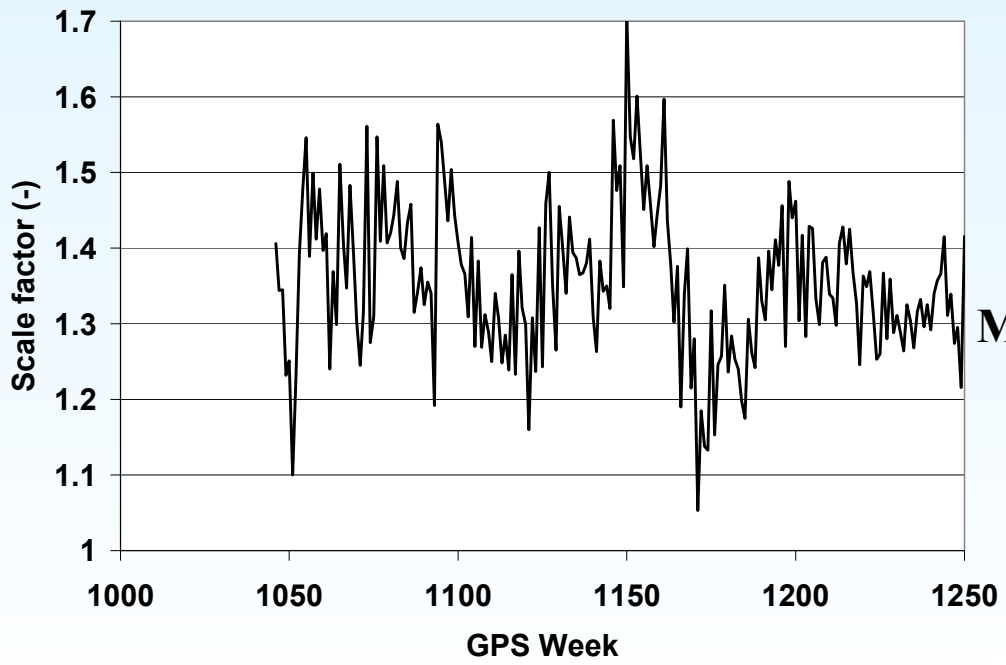
    Newly added stations sometimes require special attention
- Current rejection threshold (5 sigmas / 50mm)

- Optimize the rejection thresholds and procedure

Station Product Combination (5. Combination)

- Simultaneous combination of station coordinates + ERP's + apparent geocenter
- Processing noise 1mm/3mm (hori/vert); compared to NCL, MIT
- AC solutions correlation approximately accounted for by estimating a V.F. on the IGS weekly combined solution (30-40% rescaled). (Keep as is)

Estimated IGS Scale Factor (sqrt (variance Fact))



Mean 1.36

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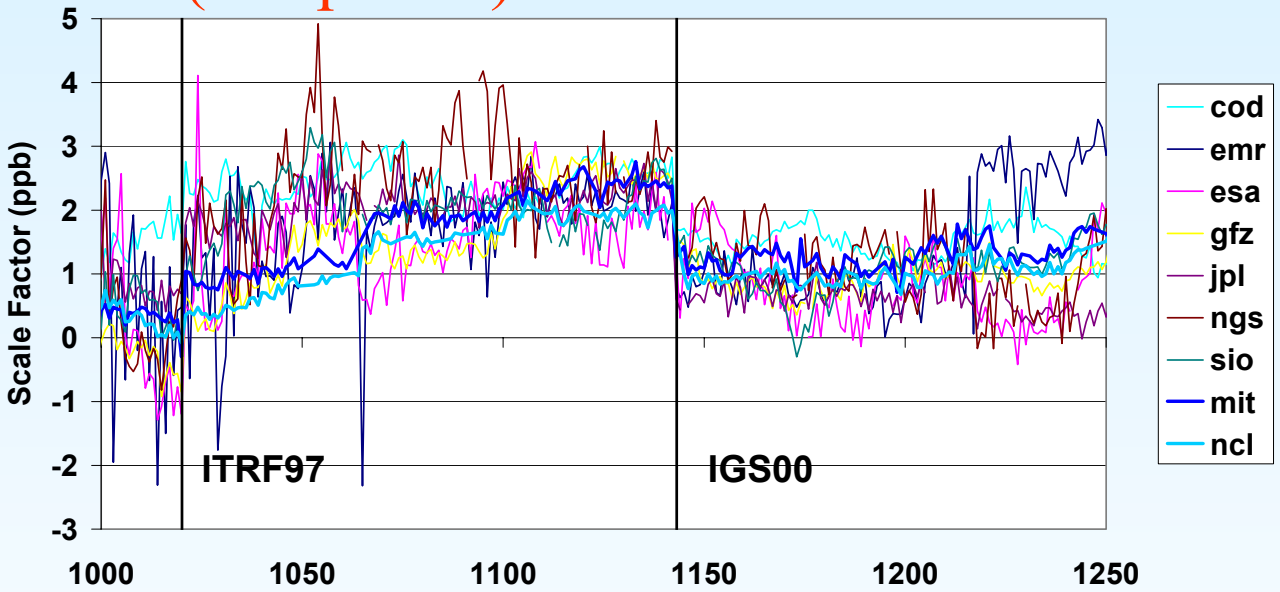
Station Product Combination (5. Combination)

- Alignment to ITRF(IGb00), translations reported as 'apparent geocenter'
- Cumulative solution updated weekly, past weeks residuals become approximate. (Keep as is)

Estimated ACs & GNAACs Transformation Scale



- Add an estimated IGS transformation scale (IGS to ITRF) to the weekly reports
- Investigate/Resolve AC&GNAAC systematic differences

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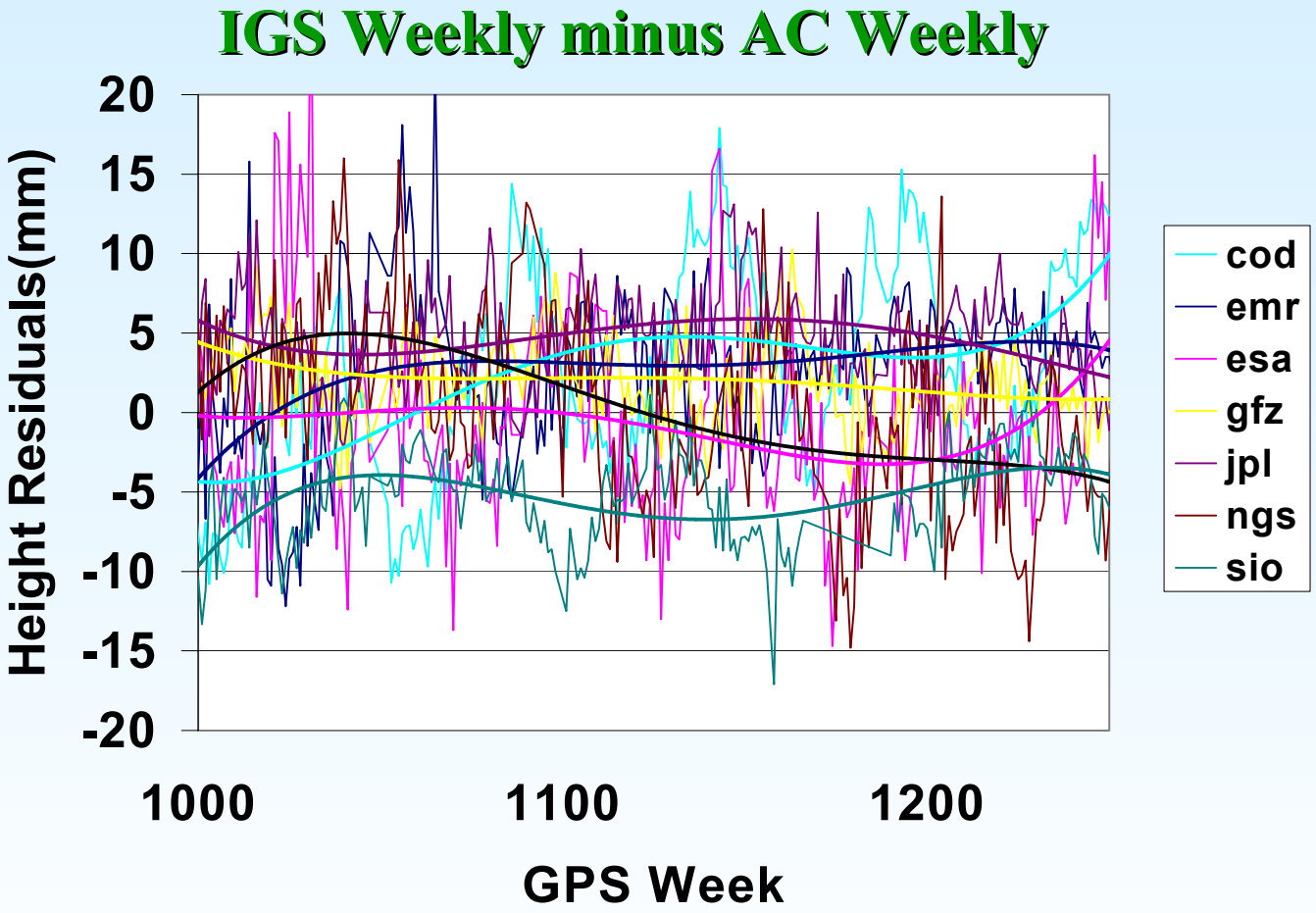
Weekly Height Residuals at YELL
Time Series (example)



Systematic effects btw. ACs

Hori.: 1-2 mm

Vert.: 5-10 mm

Missing ACs may generate artificial jumps in IGS time series

Note : Smooth lines are 4th order polynomial fit on the residuals time series.

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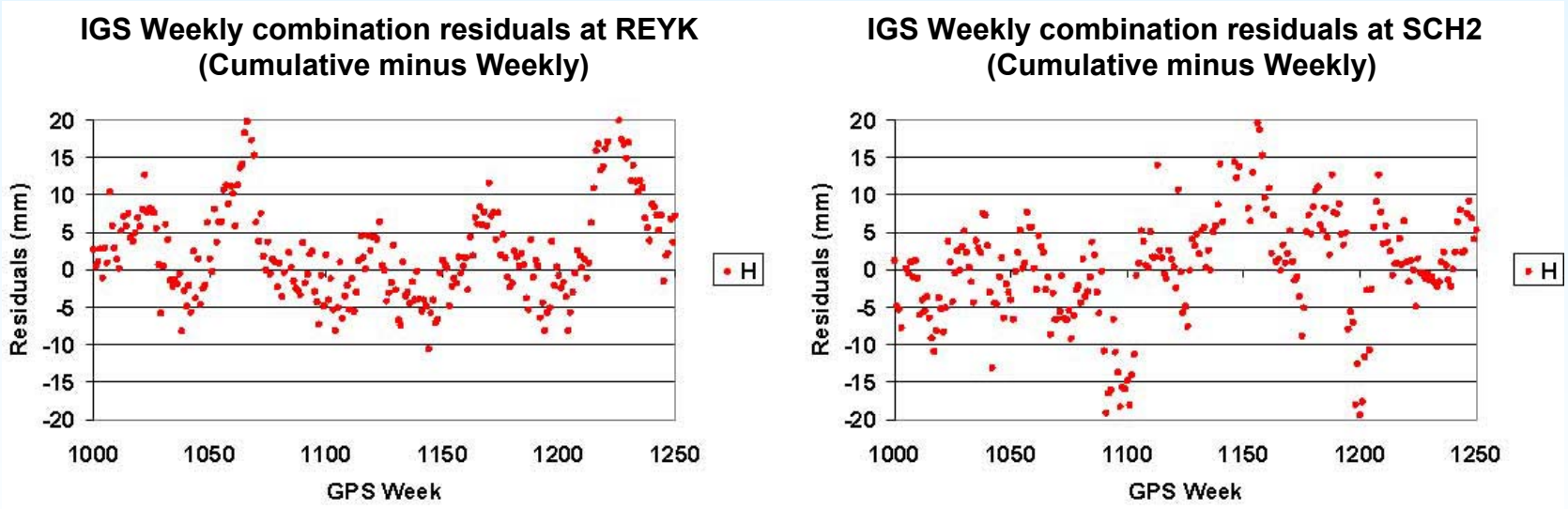
Combination Products
Time Series

- Table & Graphics updated weekly
- Combination Summary :
  - ftp : macs.geod.nrcan.gc.ca /pub/requests/sinex/sum
  - Web : Coming soon
- Combination Residuals :
  - ftp : macs.geod.nrcan.gc.ca /pub/requests/sinex/res
  - Web : Coming soon
- Station Coordinates : (Coming soon)

Station Products
Time Series Discontinuities (1)

- Larger discontinuities already included
- Most small discontinuities still not included
- Equipment related discontinuities will be problematic at multi-techniques sites (IERS)



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Station Products
Time Series Discontinuities (2)

- **Example of Proposed format inventory:**

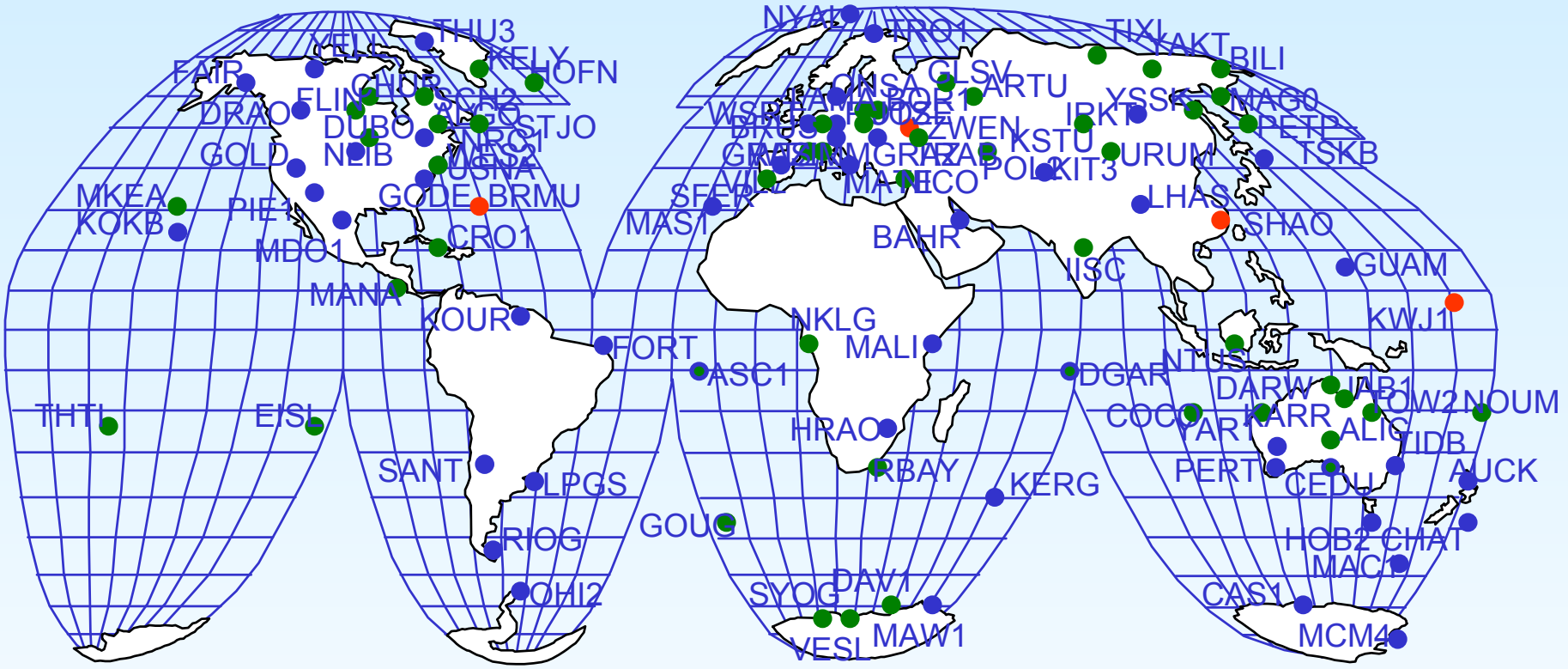
```
+ SOLUTION/DISCONTINUITY
*CODE PT SOLN T _DATA_START_ __DATA_END__ _________COMMENTS__________
 BRMU  A    2 P 03:071:69300 00:000:00000 Antenna & Receiver Changes
 FAIR  A    2 P 02:308:00000 00:000:00000 Denali earthquake
- SOLUTION/DISCONTINUITY
```

- Prepare inventory of discontinuities (two tables)
  1. Confirmed 2. Probable
- Recombine SINEX solutions to include discontinuities
- At each discontinuity restart new pos./vel. estimation
- Quality control of the solution with aux. information:
  - –Known offset / constant velocity / etc.
- Use auxiliary information in “derived products”.

Station Products
Reference Frame Realization

- Important Criterion Selection:
  - Usage/Performance
  - Geometry
  - Monumentation / Geology
  - Quality time series – Coordinates / velocity
  - Collocation (VLBI, SLR, DORIS, Time Labs,…)
- IGb00 (99 stations)
  - Transformation to IGS00 less than 1 mm

IGb00 Realization of ITRS



- Tracking Sites used for IGS00 but Removed for IGb00 (4)
- Tracking Sites Added to IGS00 (49)
- Tracking Sites used for IGS00 and IGb00 (47)

OHIG → OHI2
THU1 → THU3
TROM → TRO1

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AC Products Reanalysis (RINEX)

- The AC products currently available contain some inconsistencies due mainly to modeling updates.

- The objective is to produce fully consistent products by :
  1) Resolving current small AC solutions inconsistencies (*.acn)
  2) Gradual Reanalysis of older RINEX data
     (e.g.: before IGS00/IGb00)

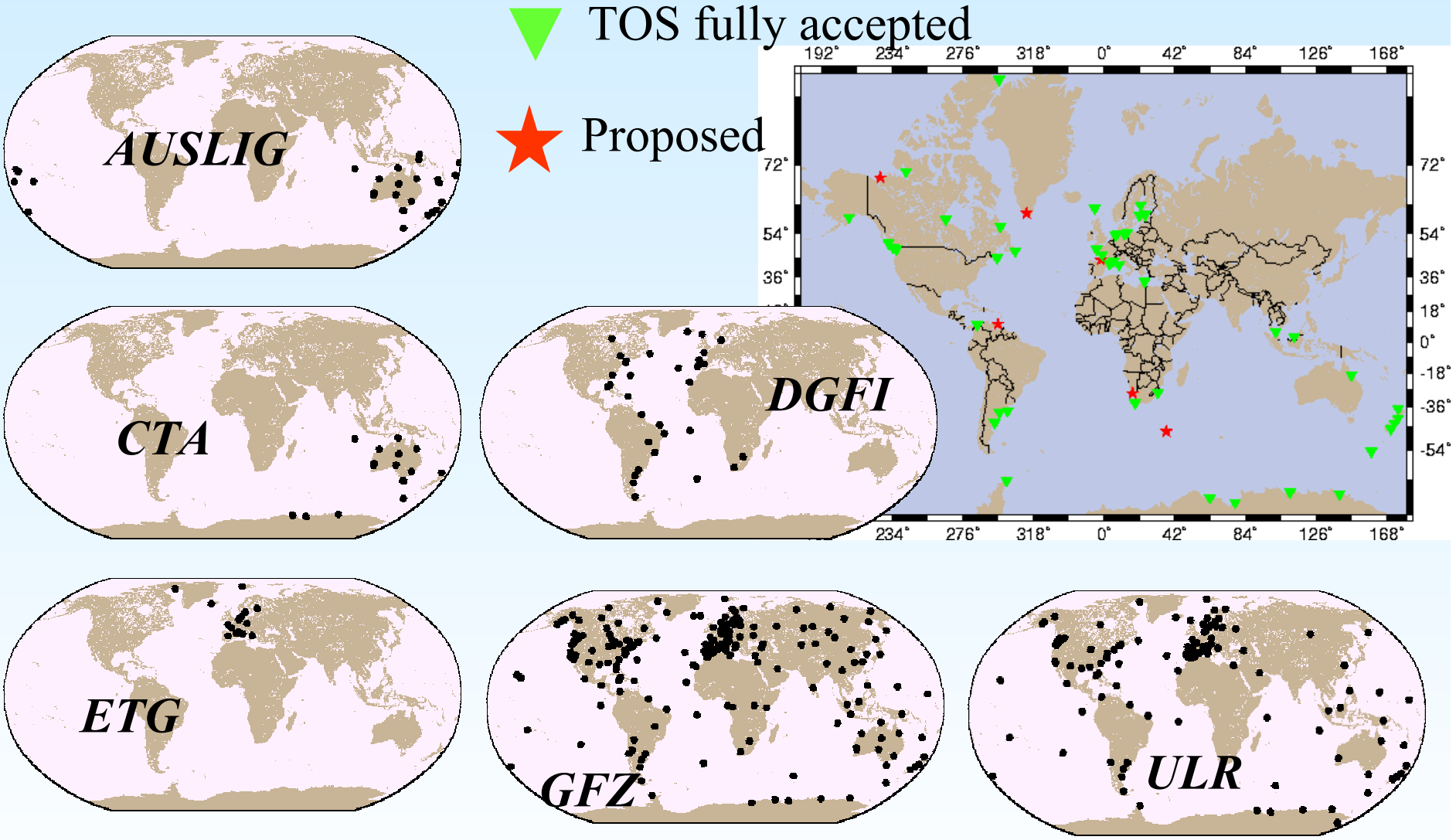
SINEX Combination Reanalysis (SINEX of AC & GNAAC)

- The main benefit is the availability of more accurate Coordinates/ERP's/Geocenter.
- Use of the currently available AC SINEX solutions
- Improvements:
  - Correction of various small problems that may have been missed during the production of the official SINEX products:
    - Station coordinate discontinuities
    - Antenna heights
    - etc
  - Addition of more solutions
  - Processing improvements

Tide Gauge Monitoring - TIGA (An Overview)

- 6 TIGA Analysis Centers (TAC)
- Current latency of 460 days
- Processing Strategy similar to the IGS ACs
- Differences between the TAC Networks
  - Global and Regional Networks
  - Stations at tide gauges not part of IGS included
- Overlap with the IGS network
  - Additionally IGS core stations are used in all TAC solutions

TIGA Analysis Centers



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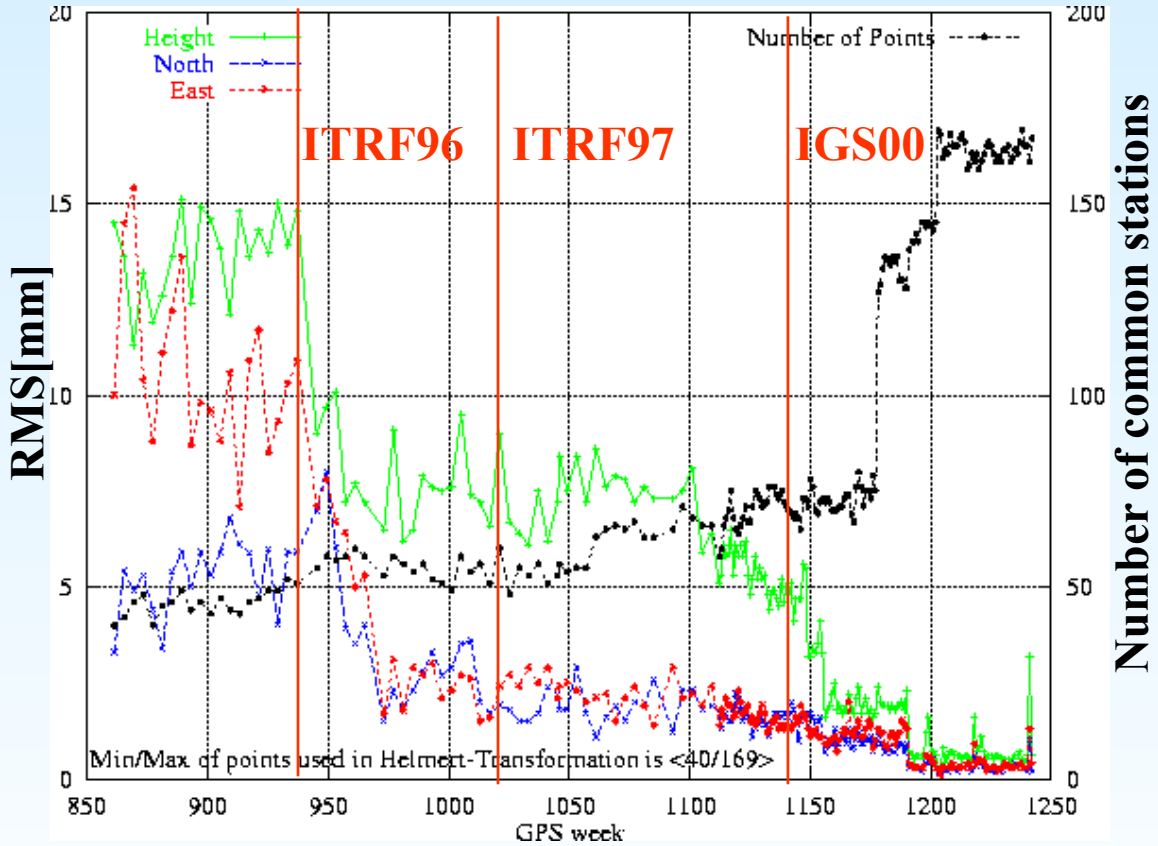
TIGA and the Reference Frame

- Vertical velocity precision objective ~1mm/y
- Requires a careful selection of the stations connecting to the Reference Frame for meaningful interpretation of the results
- Selection criteria:
  - Stability
  - Reliability
  - Data span

GFZ: AC versus TIGA(GFT)

RMS of coord. diff. btw. GFZ and transformed GFT



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(Ultra) Rapid Orbit Products and the Reference Frame Stability

- Orbit products may be significantly affected by errors between the adopted reference frame station coordinates and their "instantaneous" coordinates

- The AC and/or AC coordinator should:
  - Estimate/check station coordinates

    and/or
  - Use PPP to check the station coordinates

Effect of Fixed Reference Frame on Orbits and Clock Products

- Reference Frame shifted & fixed to new position
- Orbits will follow the RF shift only by:
  - (dx dy dz) ~ (10% 10% 20%) if amb-fixed solut. (90%)
  - (dx dy dz) ~ (40% 40% 50%) real amb solution

  →Orbits will stay in Center of Mass
- PPP using orbits and clocks. Station solution will follow the RF shift by:
  - (dx dy dz) ~ (90% 90% 100%)

  →Clocks will be in the shifted RF

Orbit/Clock Products Combination

CoM : Center of Mass

–Keep all orbits in CoM

–Shift Final clocks to ITRF

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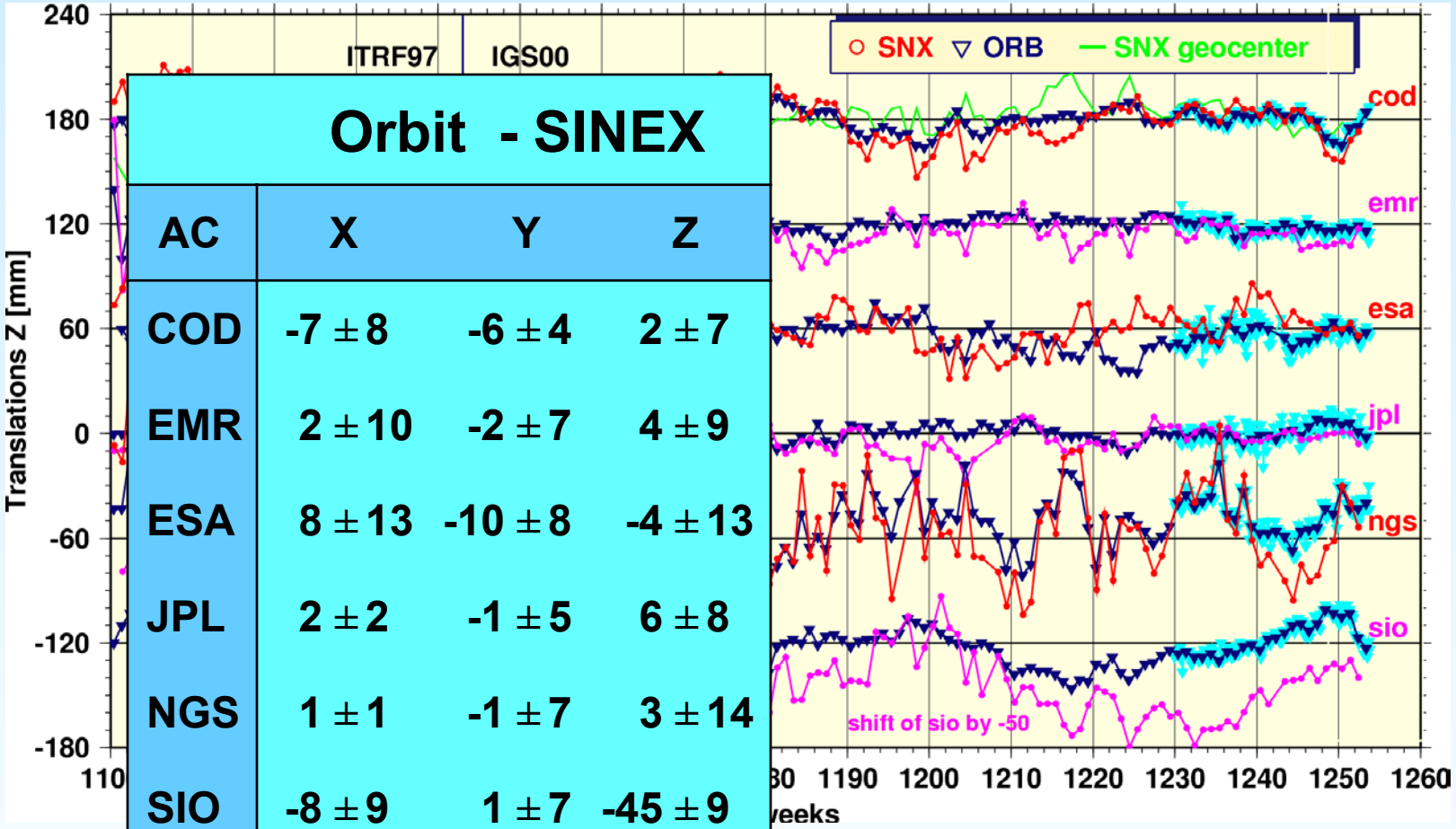
Apparent Geocenter (Z component)



Orbit - SINEX

AC	X	Y	Z
COD	-7 ± 8	-6 ± 4	2 ± 7
EMR	2 ± 10	-2 ± 7	4 ± 9
ESA	8 ± 13	-10 ± 8	-4 ± 13
JPL	2 ± 2	-1 ± 5	6 ± 8
NGS	1 ± 1	-1 ± 7	3 ± 14
SIO	-8 ± 9	1 ± 7	-45 ± 9

- No Clock correction during combination
- ACs should fix the RF while back-substituting for clk solutions

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Recommendations

- See Slides

Recommendations affecting the ACs:

1. AC provide unconstrained weekly SINEX solutions for a test period (TBD)
6. Summary/update AC processing (*.acn; ++)
7. Prepare inventory of discontinuities (Confirmed & Probable)
8. Check station position during (ultra)Rapid analysis
10. Gradual Reanalysis of older RINEX data
12. ACs generate Final Clocks in ITRF