



Combination of the reprocessed IGS Analysis Center SINEX solutions

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 - Coordinates
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Introduction

- Main Objective:
 - Improve products consistency to better meet users requirements
- Original SINEX products:
 - AC contribution started in early 1996 (Wk 0837)
 - Combinations:
 - GNAACs (mit & ncl) combination since 1996
 - Pilot Project ~1999 (Wks 0999 – 1049)
 - Official since ~2000 (Wks 1050 – Now)
- Latest SINEX products:
 - Reprocessed:
 - 1994.0 - 2008.0 (Wks 0730 – 1459)
 - Official (Included for completeness):
 - 2008.0 - 2010.1 (Wks 1460 – 1566)





Contributing Agencies

- co[d1] Center for Orbit Determination in Europe, University of Bern, Switzerland
- em[r1] Natural Resources, Canada
- es[a1] European Space Operations Center, ESA, Germany
- gf[z1] GeoForschungsZentrum, Germany
- gt1 GeoForschungsZentrum, Germany (Tiga)
- jp[l1] Jet Propulsion Laboratory, USA
- mi[t1] Massachusetts Institute of Technology, USA (AC + GNAAC)
- nc[l1] Newcastle, England (GNAAC)
- ng[s1] National Oceanic and Atmospheric Administration / NGS, USA
- pd1 GFZ Potsdam/IPG Dresden, Germany
- si[o1] Scripps Institution of Oceanography, USA
- ul1 University of La Rochelle, France (Tiga)

11 ACs + 2 GNAACS





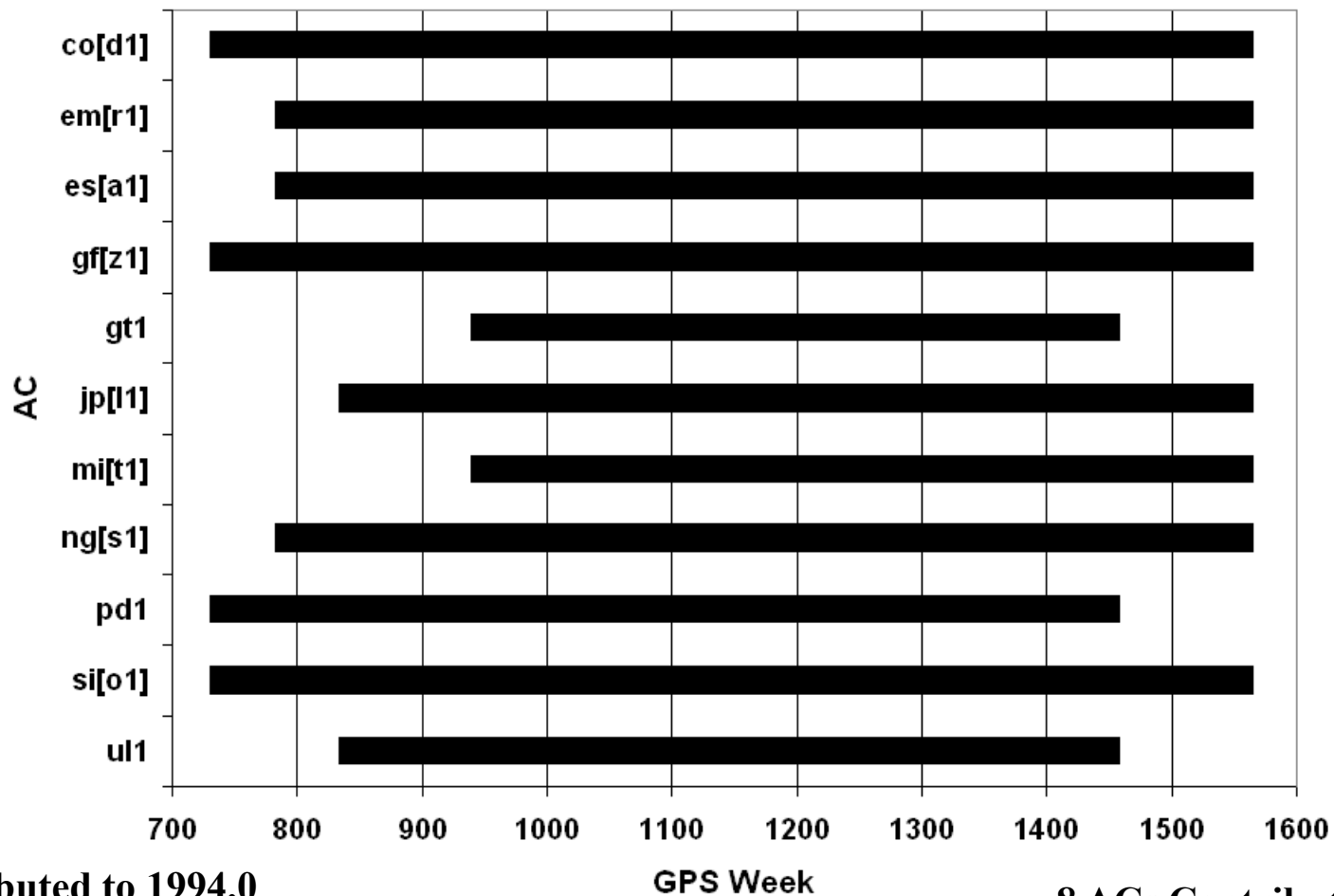
Contributed Solutions

AC (11)	Software (6)	Data span	# of Stations	Comments
co[d1]	Bernese	1994.0 - 2010.0	322	Excluded ERPs
em[r1]	Gipsy	1995.0 - 2010.0	229	
es[a1]	NAPEOS	1995.0 - 2010.0	418	
gf[z1]	EPOS	1994.0 - 2010.0	299	Excluded apparent geocenter
gt1	EPOS	1998.0 - 2008.0	390	Excluded apparent geocenter
jp[l1]	Gipsy	1996.0 - 2010.0	413	
mi[t1]	Gamit	1998.0 - 2010.0	700	
ng[s1]	Page	1995.0 - 2010.0	436	Excluded pole position (1994.0 - 2000.0)
pd1	Bernese	1994.0 - 2008.0	201	Excluded LOD
si[o1]	Gamit	1994.0 - 2010.0	422	Excluded pole rate (2008-2010)
ul1	Gamit	1996.0 - 2007.0	275	Excluded apparent geocenter (no ERPs)
GNAAC(2)				
MIT		2008.0 - 2010.0	632	Comparison only.
nc[l1]		2000.0 - 2010.0	355	Comparison only





Weekly AC Contributed Solutions



4 ACs Contributed to 1994.0

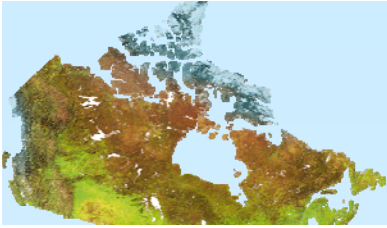
GPS Week

8 ACs Contributed to 2010.0

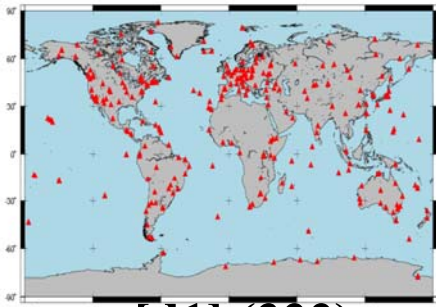
3 ACs Contributed the entire period

Contribution to ITRF2008 (1997.0 – 2009.5) 492 stations

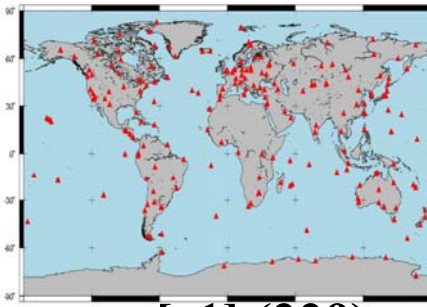




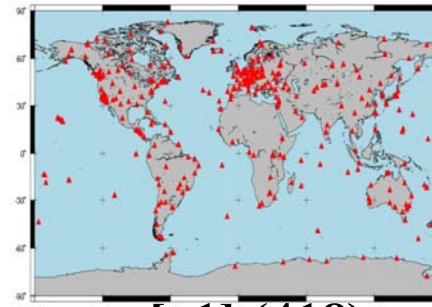
AC Networks (Total # of stations)



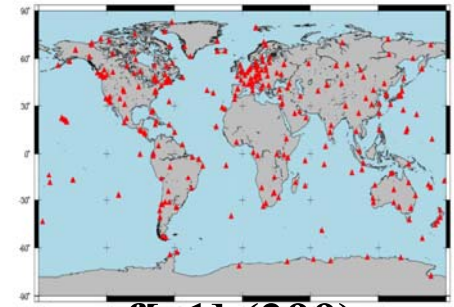
co[d1] (322)



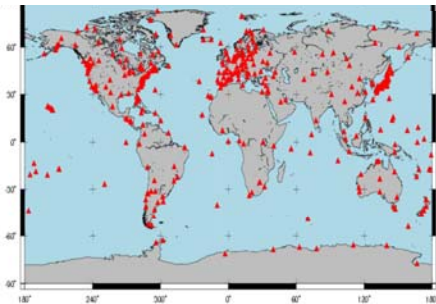
em[r1] (229)



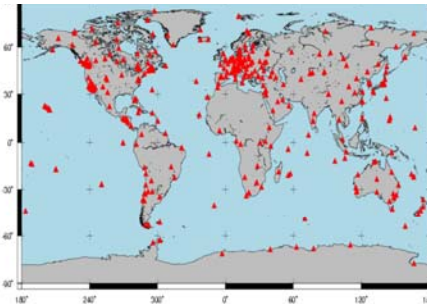
es[a1] (418)



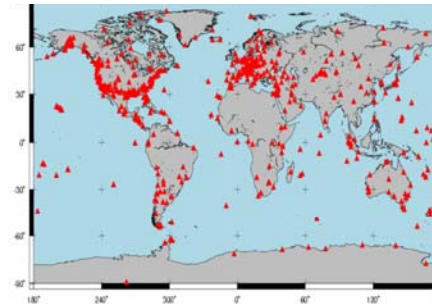
gf[z1] (299)



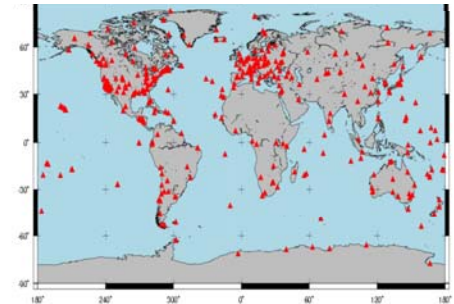
gt1 (390)



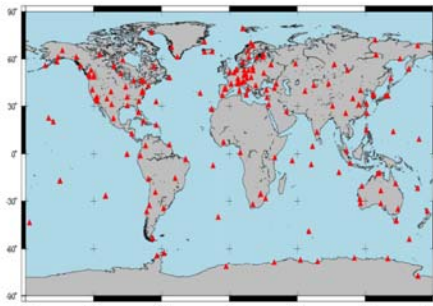
jp[l1] (413)



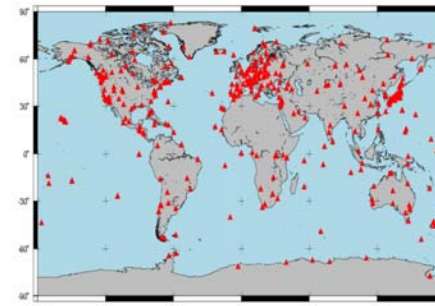
mi[t1] (700)



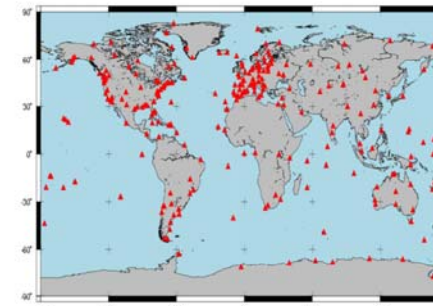
ng[s1] (436)



pd1 (201)



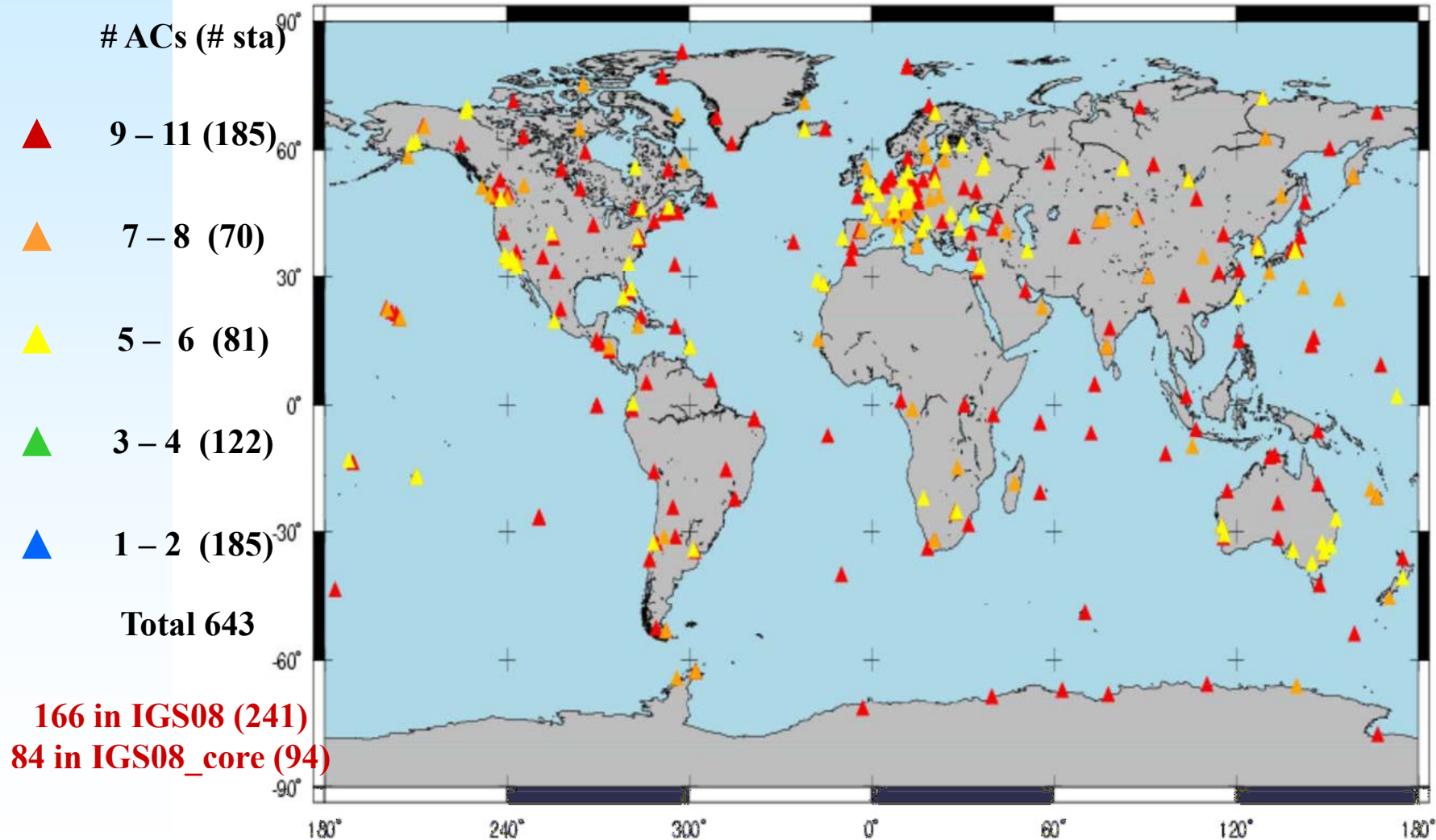
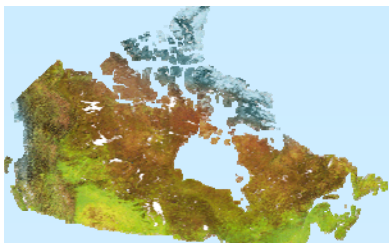
si[o1] (422)



ul1 (275)



Stations Usage by the ACs for at least 2 years



Stations Data Span



Years of Data (# sta)

▲ 14.0 – 16.0 (78)

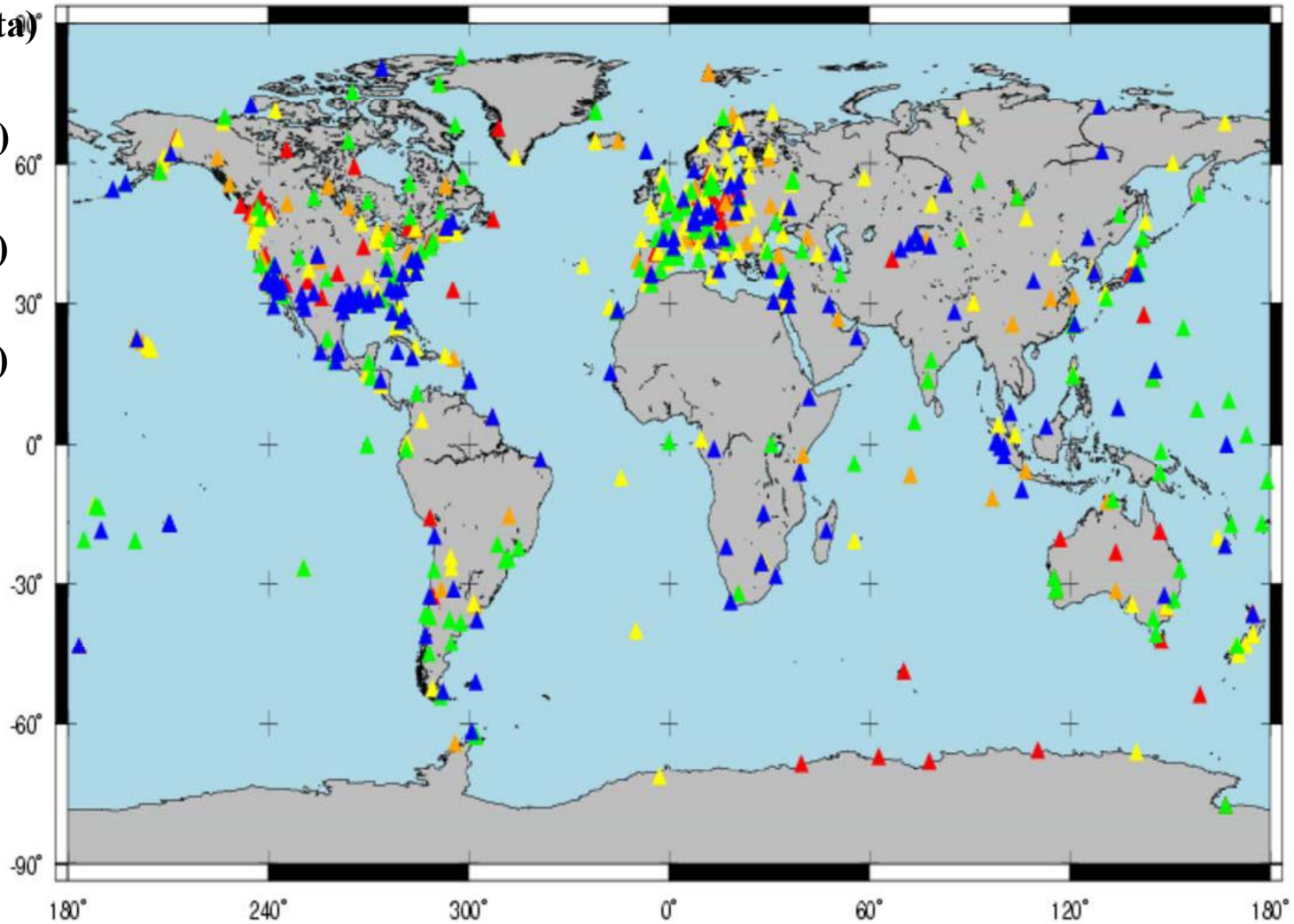
▲ 11.0 – 14.0 (81)

▲ 8.0 – 11.0 (158)

▲ 5.0 – 8.0 (157)

▲ 2.0 – 5.0 (169)

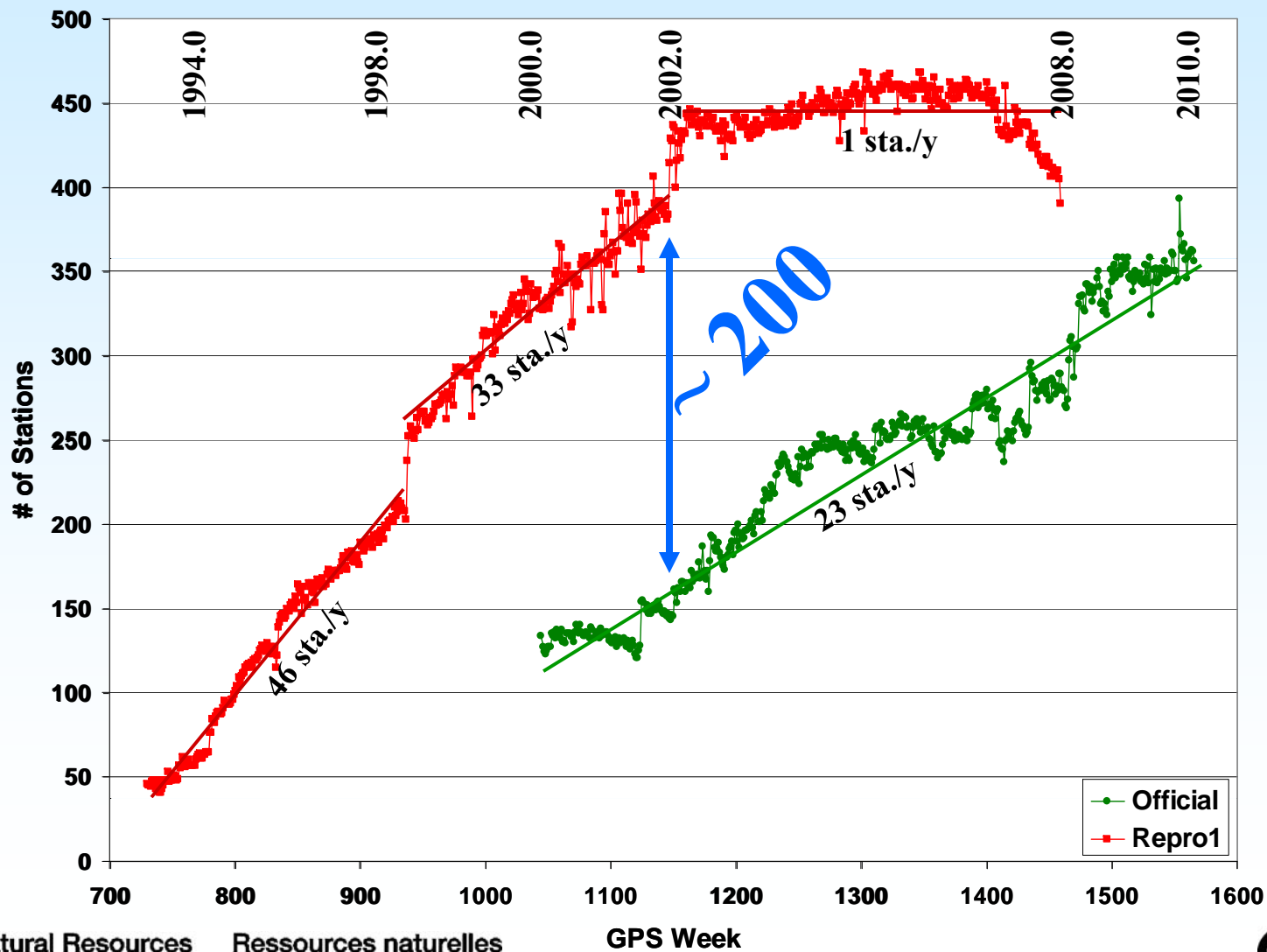
Total 643



Natura
Canada

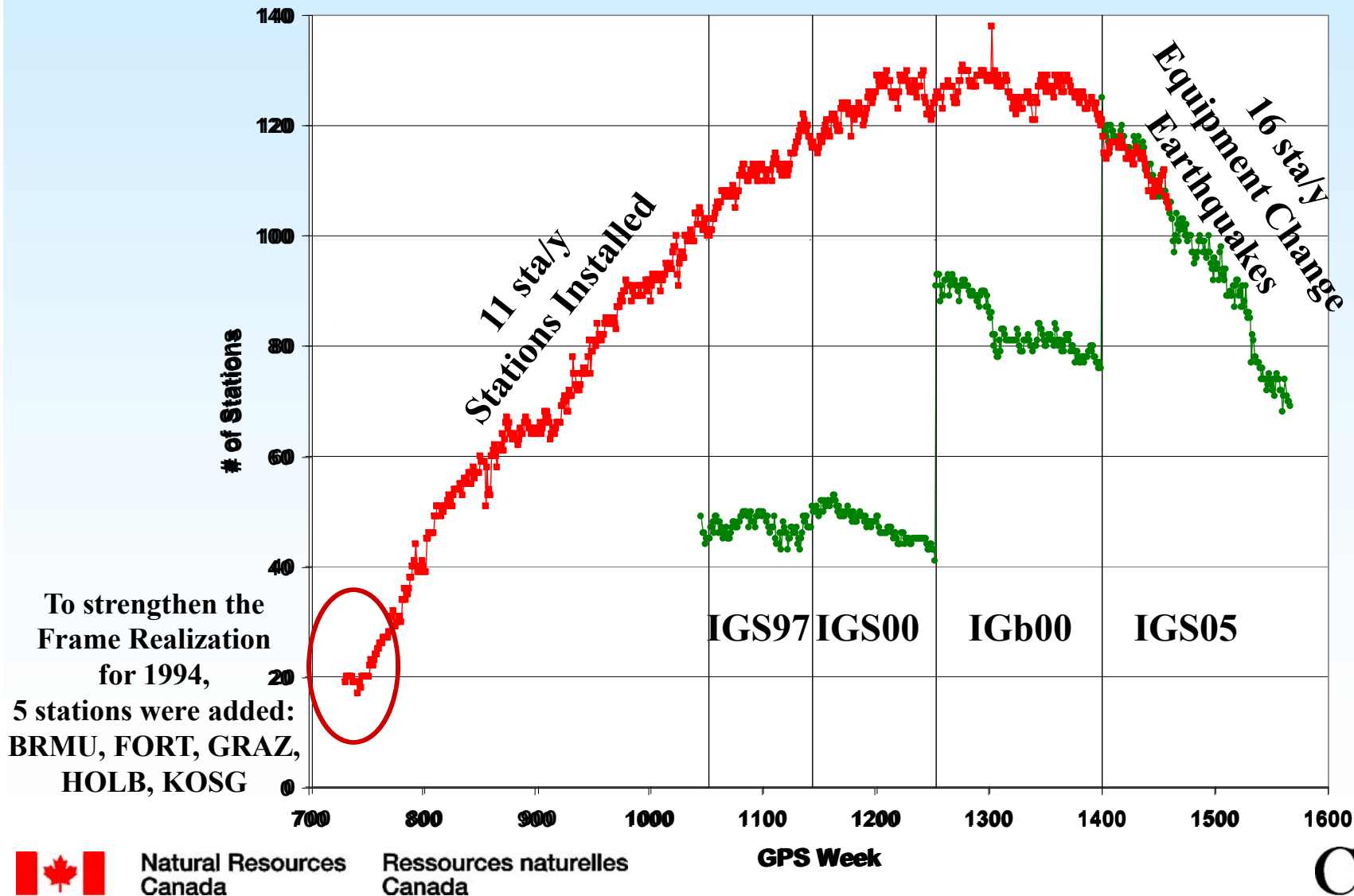


Stations in the IGS Weekly Combination



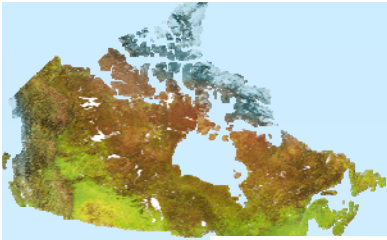


Reference Frame Stations in the Weekly Combinations



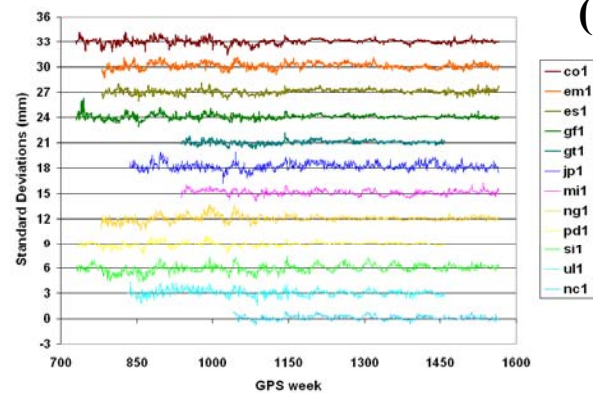
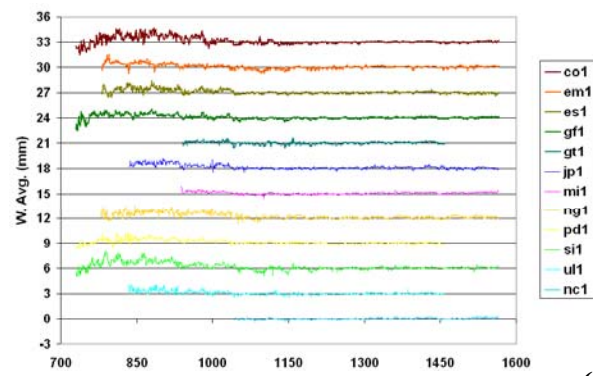
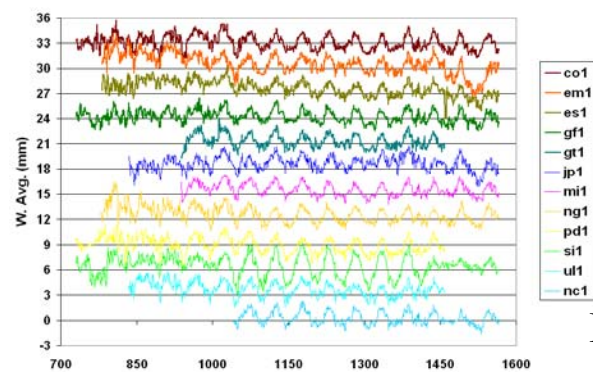
ACs Coordinates Residuals

Avg. & Std. w.r.t. IGS05



Annual Signal Amplitude ~1mm

Avg. (mm)



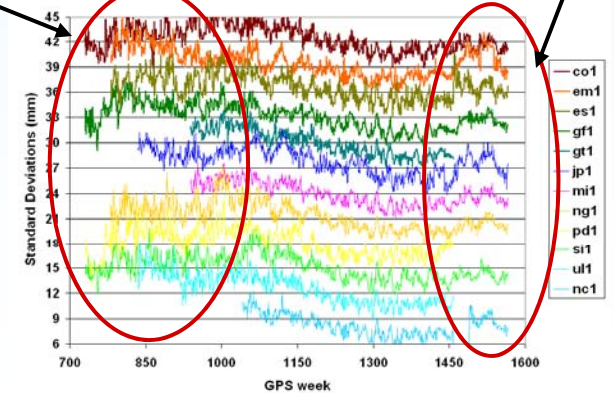
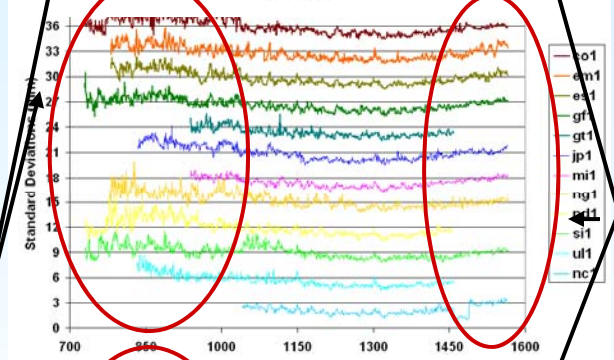
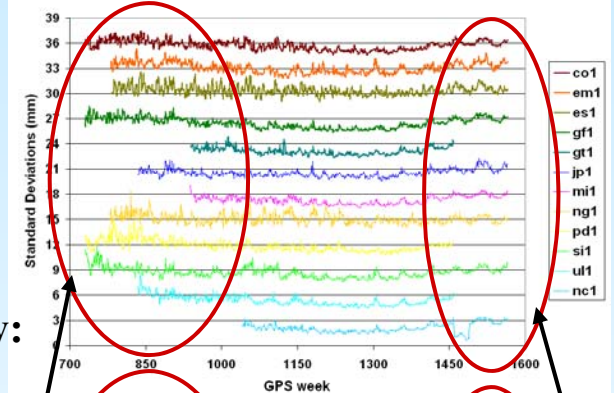
N

Best Consistency:
N&E ~2.5mm
H ~7mm

E

Older=noisier
(solns. & IGS05)

H



IGS05 Std. (mm)

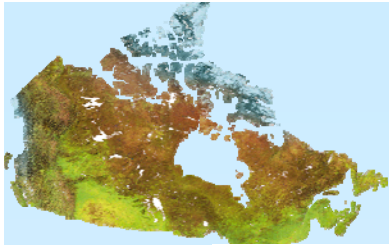


Natural Resources Canada

ressources naturelles Canada

Time series shifted by multiples of 3 mm.

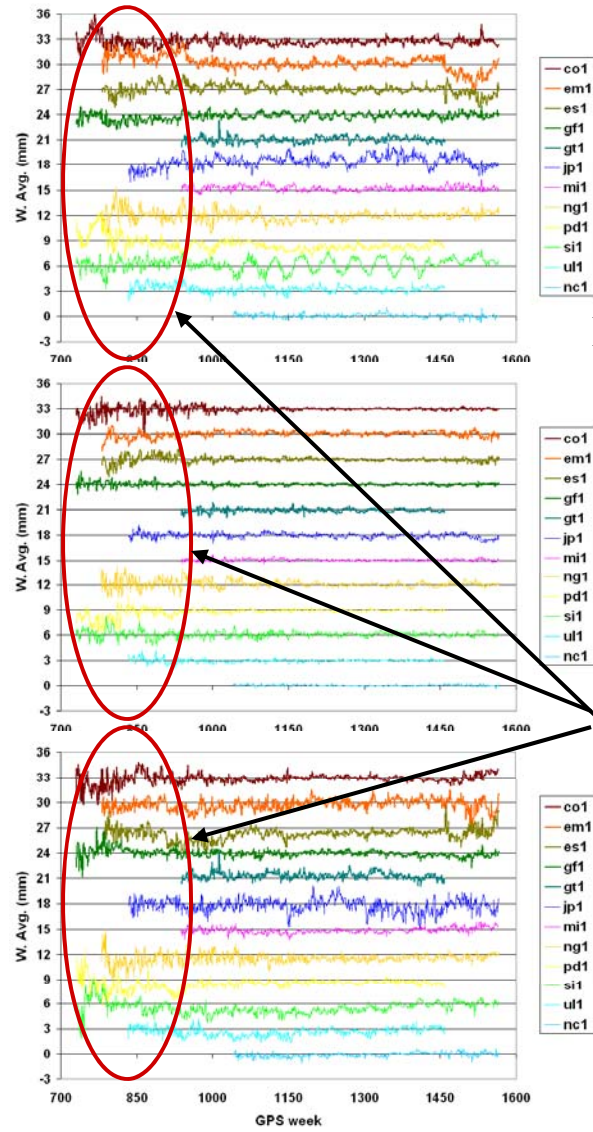




ACs Coordinates Residuals

Avg. & Std. w.r.t. IGS Weekly

Avg. (mm)



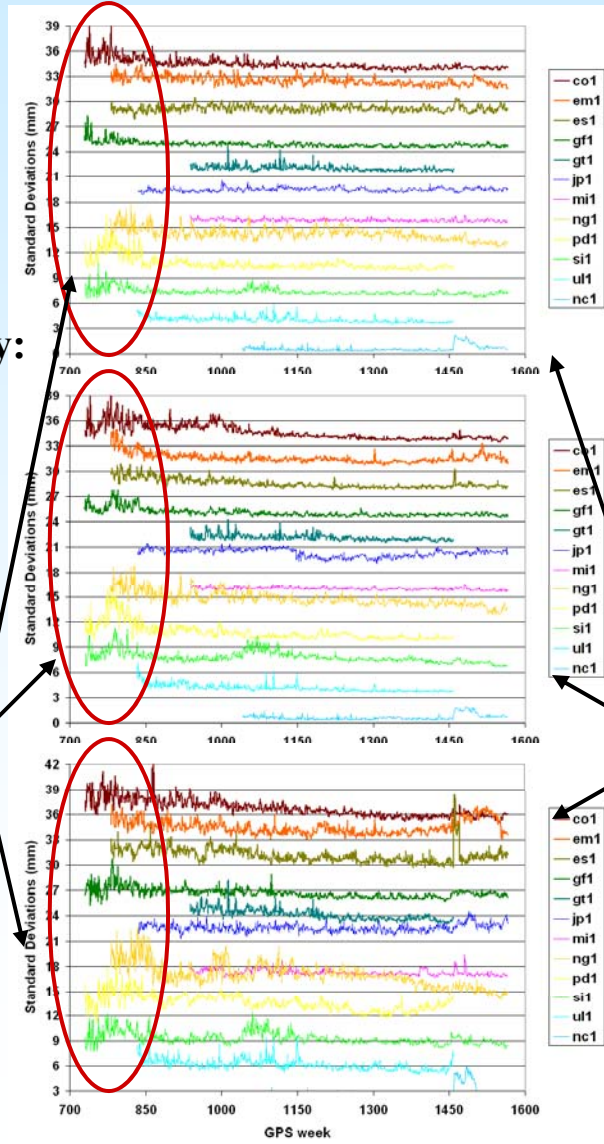
N

Best Consistency:
N&E ~1mm
H ~ 2.5 mm

E

Older=noisier

H



Std. (mm)

No AC dominates the combination

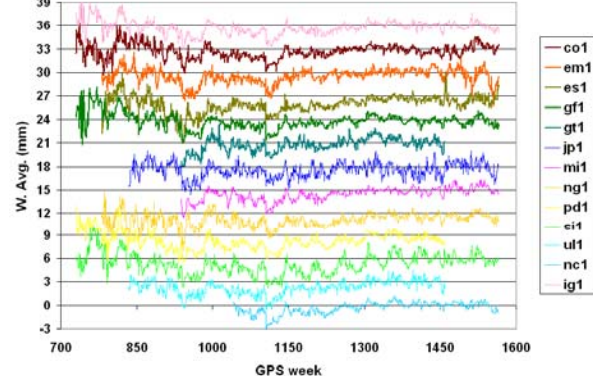
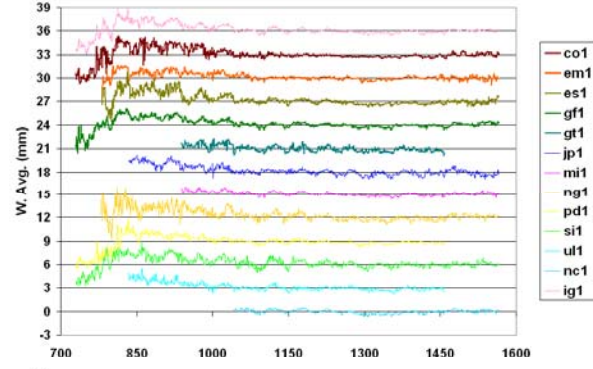
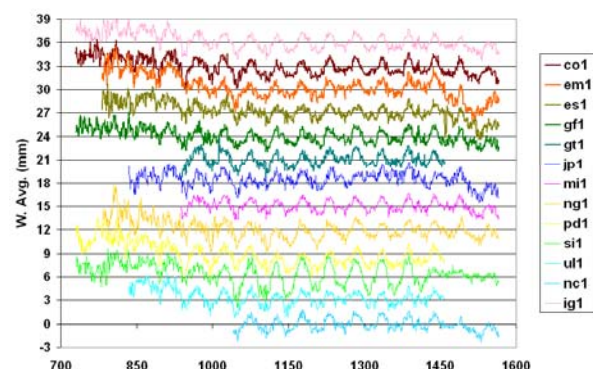


ACs Coordinates Residuals

Avg. & Std. w.r.t. IGS Cumulative

Annual
Signal
Amplitude
~1mm

Avg. (mm)



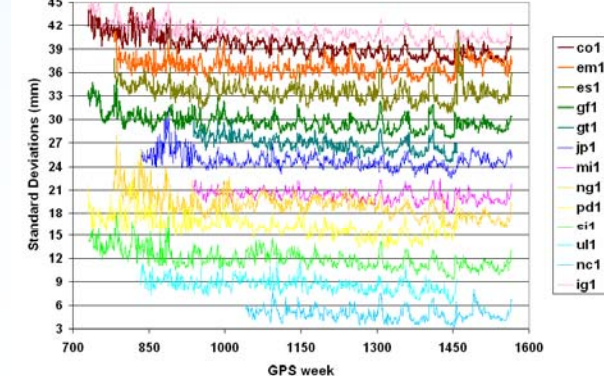
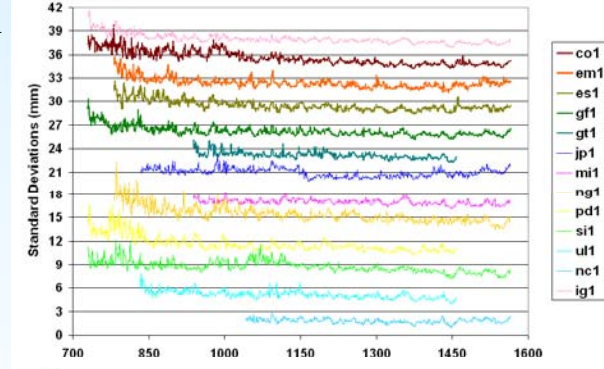
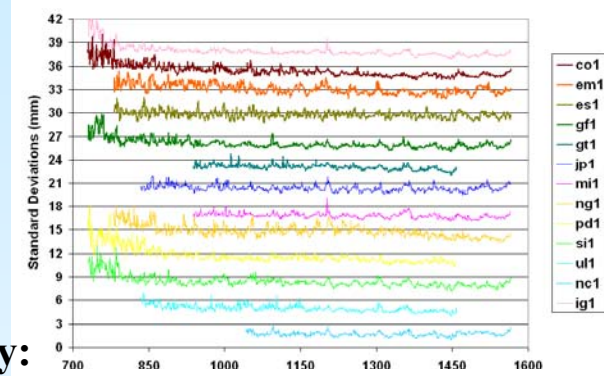
N

Best Consistency:
N&E ~ 1.5mm
H ~ 5mm
Older=noisier

E

Again,
Older=noisier

H

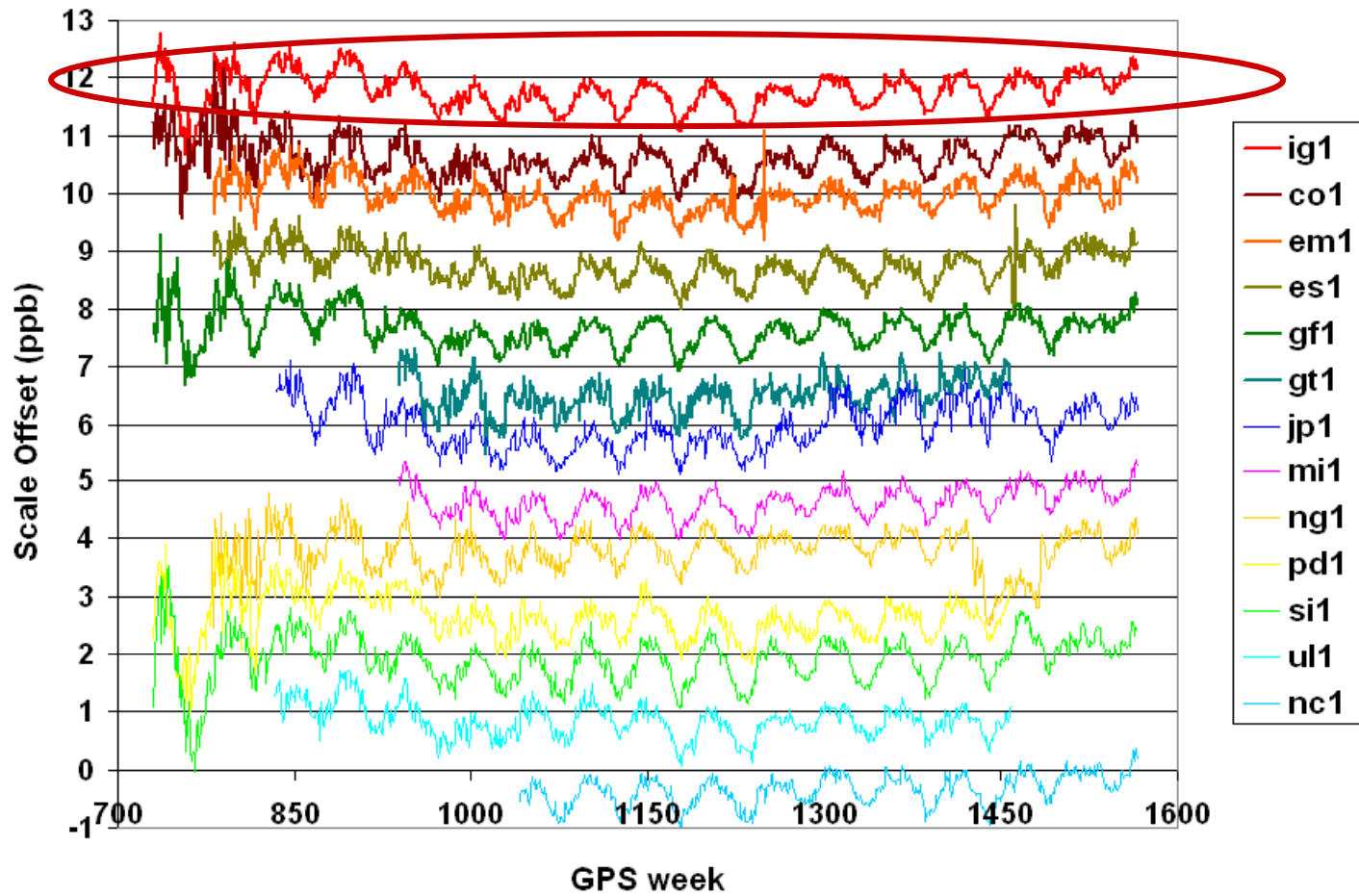


Std. (mm)





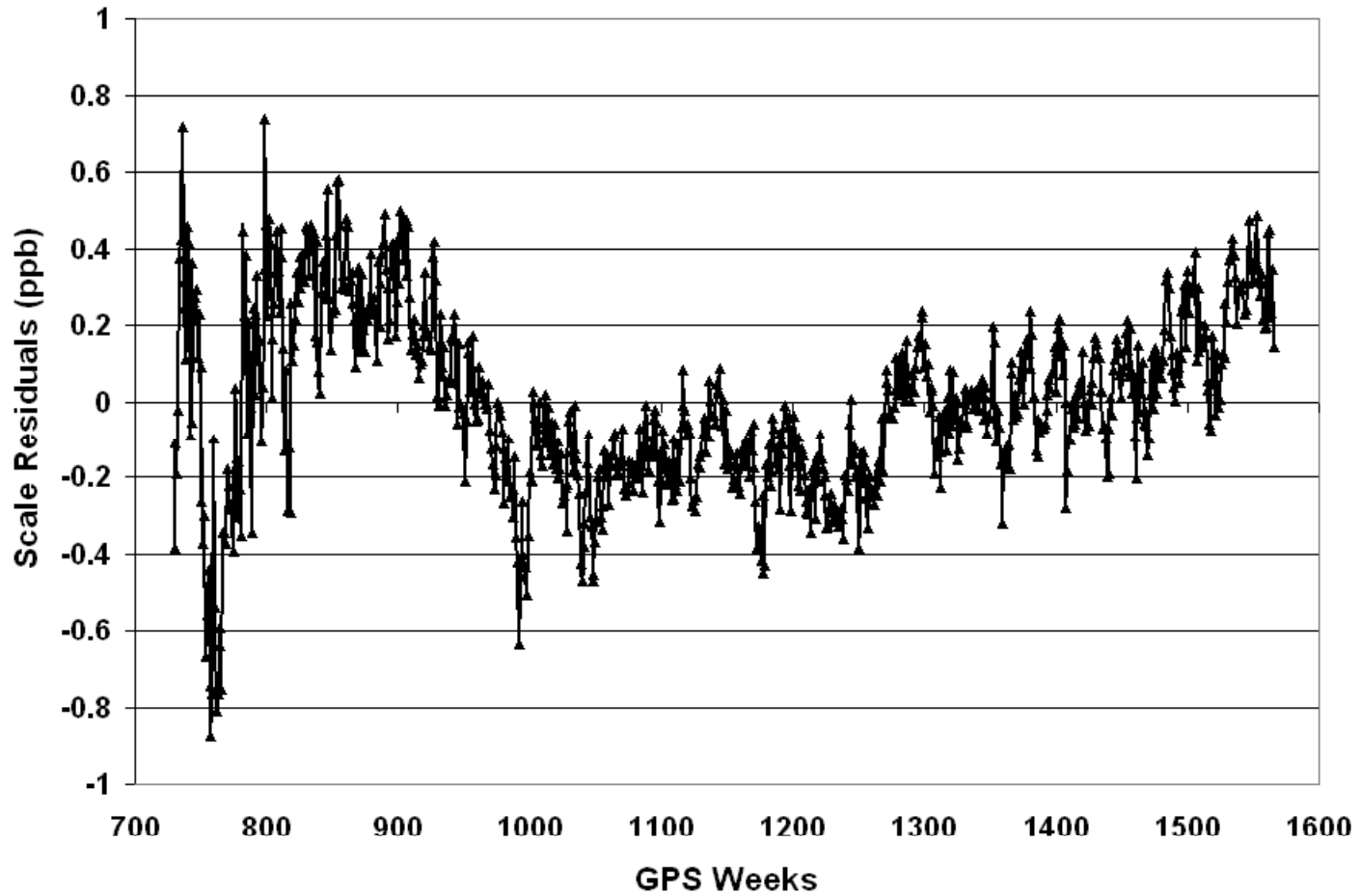
ACs Scale offset





IGS Scale Offset

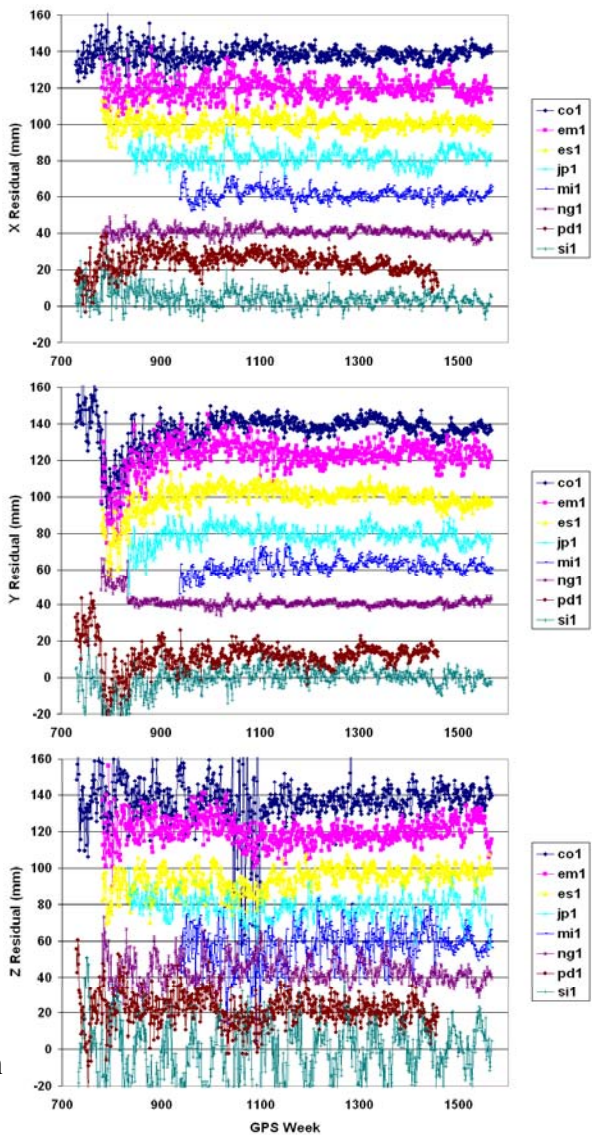
Bias = -0.2ppb
Drift \approx 0.000 ppb/y
Annual signal Amplitude = 0.3ppb



AC Apparent Geocenter Weekly Residuals and Formal Uncertainty



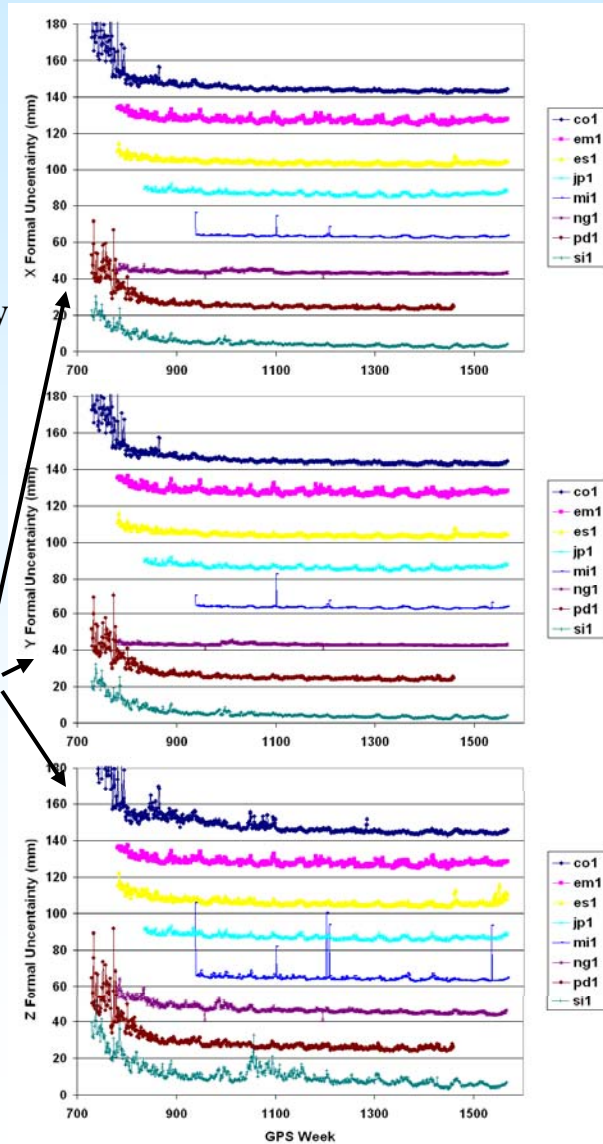
Residuals (mm)



mi1 A~5mm
ng1 A~7mm
si1 A~15mm

X
Best Consistency
X&Y ~1mm
Z ~3mm
Older=noisier

Y
Z No AC Dominates
the Combination



Formal Uncertainty (mm)

Time series shifted by multiples of 20 mm.

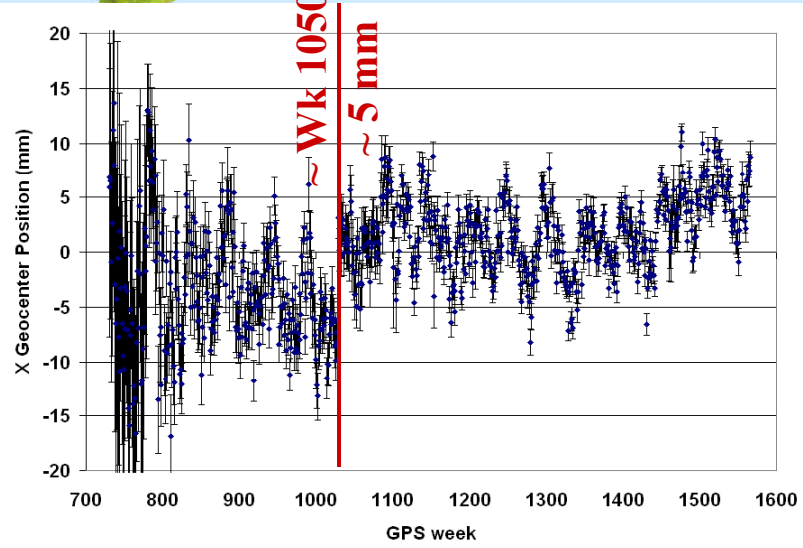




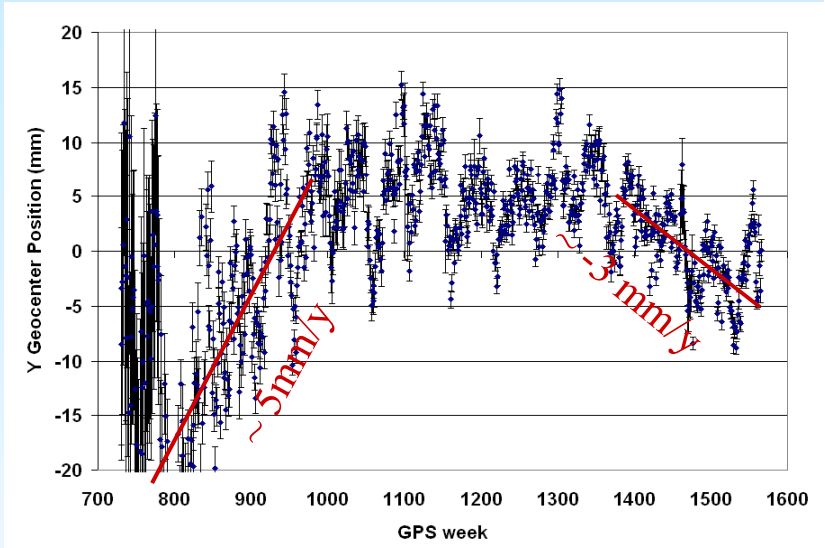
IGS10, Newcastle upon Tyne • England , 28 June – 2 July , 2010

Combined Apparent Geocenter Position w.r.t. IGS05

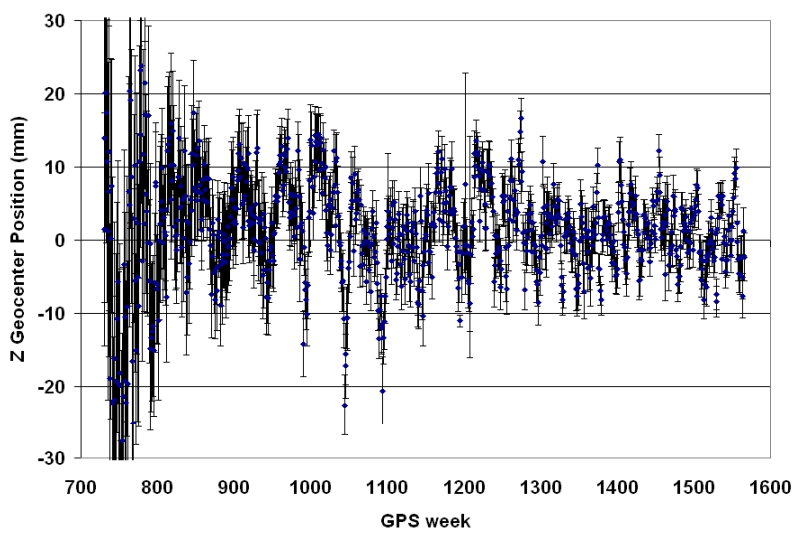
X



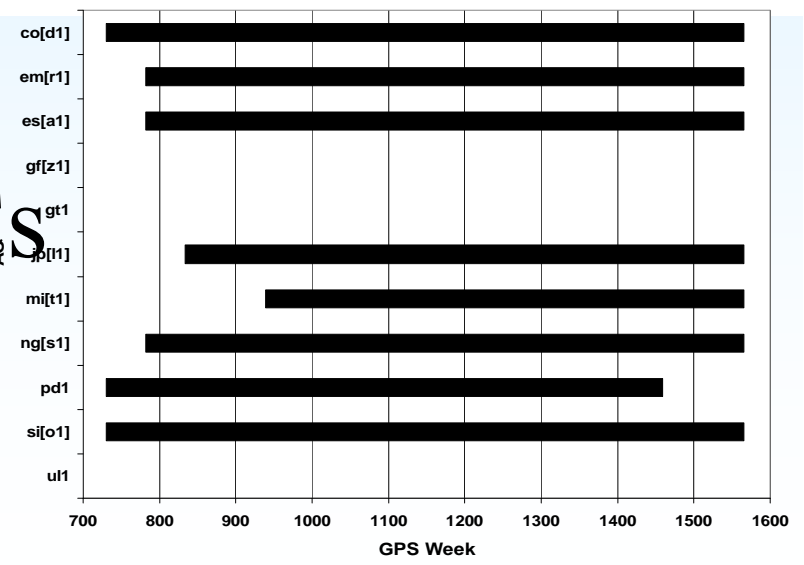
Y



Z



ACS



Natural Resources Canada

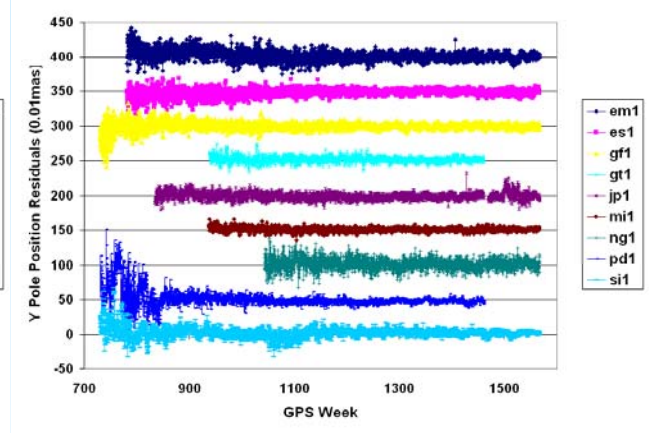
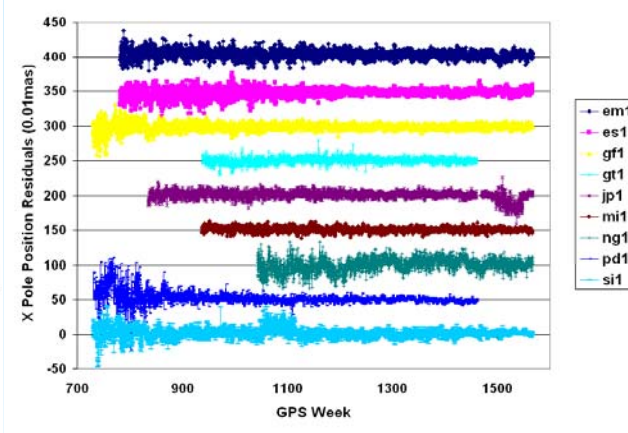
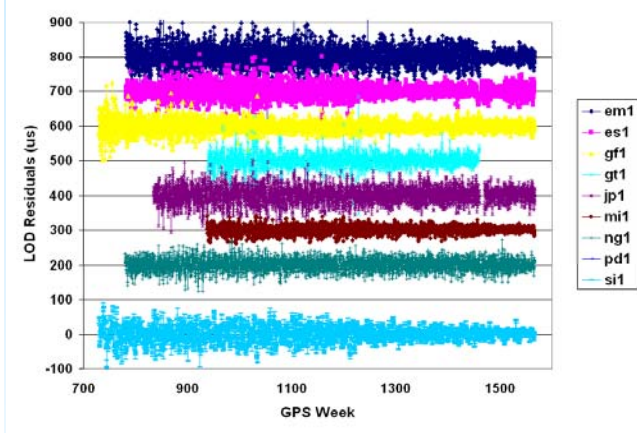
Ressources naturelles Canada

Canada



ACs Daily ERPs Residuals w.r.t. the IGS Combined

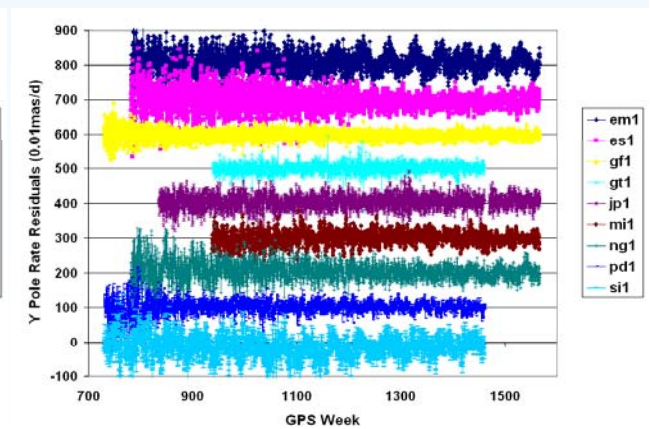
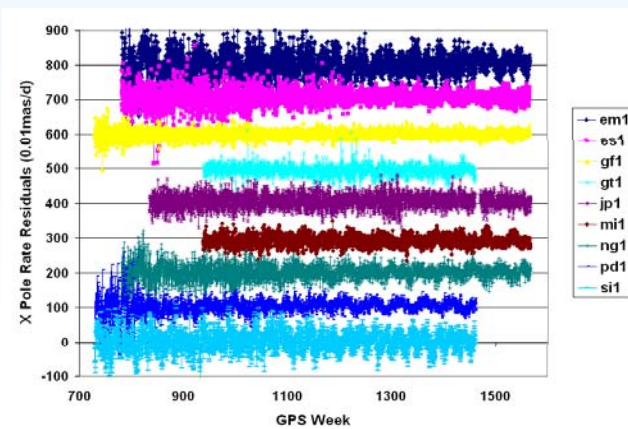
X_p Y_p



X_{pr}

Y_{pr}

Consistency:
 LOD $\sim 10\mu s$
 [XY] $_p \sim 0.03mas$
 [XY] $_{pr} \sim 0.10mas/d$
 (Older=noisier)





Daily ERPs STD

	LOD	XPO	XPOR	YPO	YPOR
em1	25.7	5.7	33.4	7.0	26.6
es1	17.3	5.4	21.0	4.8	29.0
gf1	14.9	4.7	10.3	5.5	11.9
gt1	19.2	3.7	13.9	3.8	12.6
jp1	23.0	5.5	18.3	4.6	18.2
mi1	10.0	3.0	13.3	2.6	18.6
ng1	17.0	9.0	20.7	7.6	26.6
pd1		8.9	20.7	12.0	20.4
si1	22.5	7.1	28.6	7.2	31.4

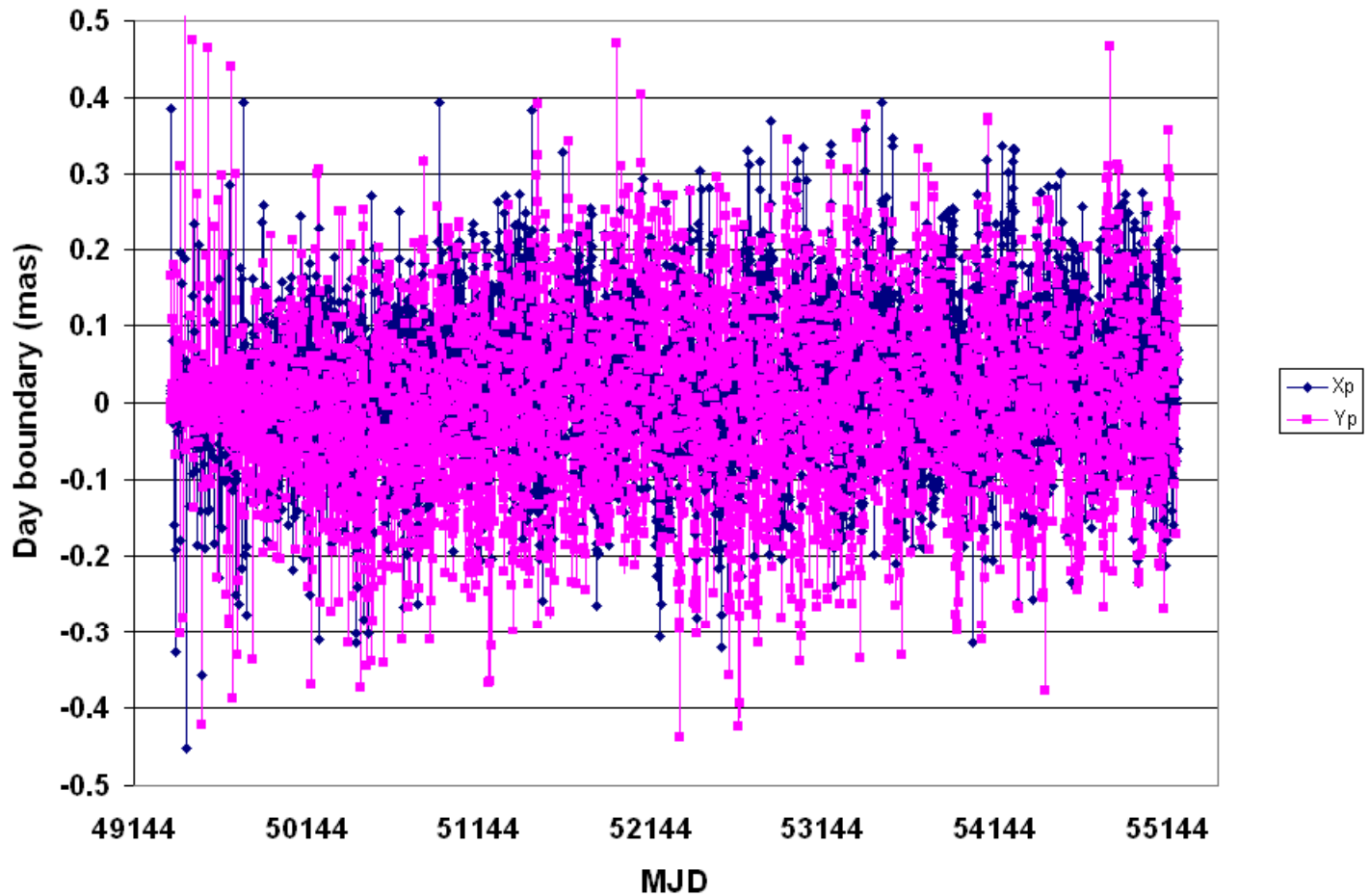
Red = Smallest STD

Green = Largest STD





Pole Position Misclosure at Day Boundary



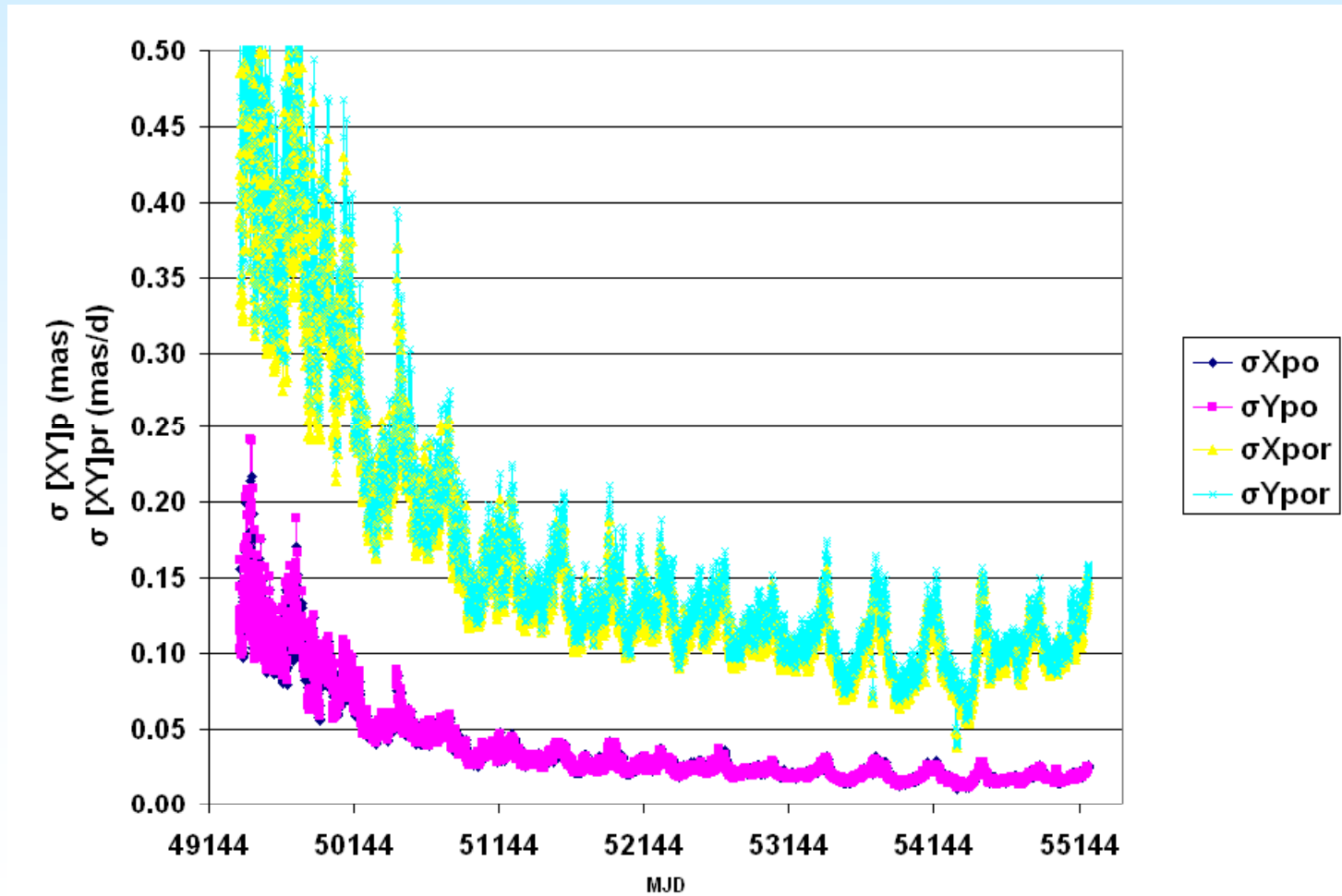
Std

X	0.10 mas
Y	0.11 mas





Pole Position and Rate Formal Uncertainty





Summary (1/2)

- Contributors :
 - 11 ACs
 - 2 GNAACs
- Time span:
 - Reprocessed: 1994.0 – 2008.0
 - Official: 2008.0 – 2010.1
 - No significant discontinuity observed at the reprocessed/Official solutions boundary
- Network:
 - All contribution : 900 + stations
 - With 2 years + : 643 stations





Summary (2/2)

- ACs products best consistency:
 - Coordinates w.r.t.:
 - IGS05 (N-E ~ 2.5 mm, H ~ 7 mm)
 - IGS Weekly (N-E ~ 1 mm, H ~ 2.5 mm)
 - IGS Cumulative (N-E ~ 2 mm, H ~ 5 mm)
 - ERPs:
 - LOD ~ 10us
 - ([XY]p ~ 0.03 mas; [XY]pr ~ 0.10mas/d)
 - Geocenter: X & Y ~1 mm Z ~ 3mm
 - Older (pre-1996) solutions consistency substantially worse





Recommendations

- Improve older combinations (pre-1996)
 - All Acs should contribute (Half have done it)
 - More stations ... if possible.
- All ACs should contribute all parameters
- All contributed Parameters should be unconstrained or at least unconstrainable.





Acknowledgements

- Co[d1] Center for Orbit Determination in Europe, University of Bern, Switzerland
 - Em[r1] Natural Resources, Canada
 - Es[a1] European Space Operations Center, ESA, Germany
 - gf[z1] GeoForschungsZentrum, Germany
 - gt1 GeoForschungsZentrum, Germany (Tiga)
 - jp[l1] Jet Propulsion Laboratory, USA
 - mi[t1] Massachusetts Institute of Technology, USA (AC + GNAAC)
 - nc[l1] Newcastle, England (GNAAC)
 - ng[s1] National Oceanic and Atmospheric Administration / NGS, USA
 - pd1 GFZ Potsdam/IPG Dresden, Germany
 - si[o1] Scripps Institution of Oceanography, USA
 - ul1 University of La Rochelle, France (Tiga)
-
- All Data/Products Centers
 - All Agencies and people that contributed station data.

