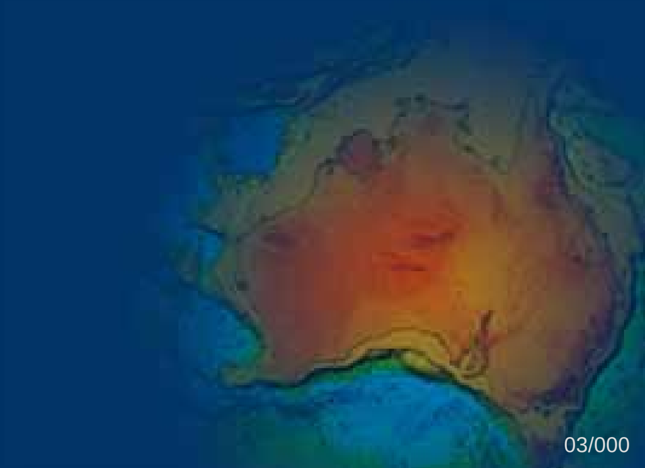
Australian Government

Geoscience Australia

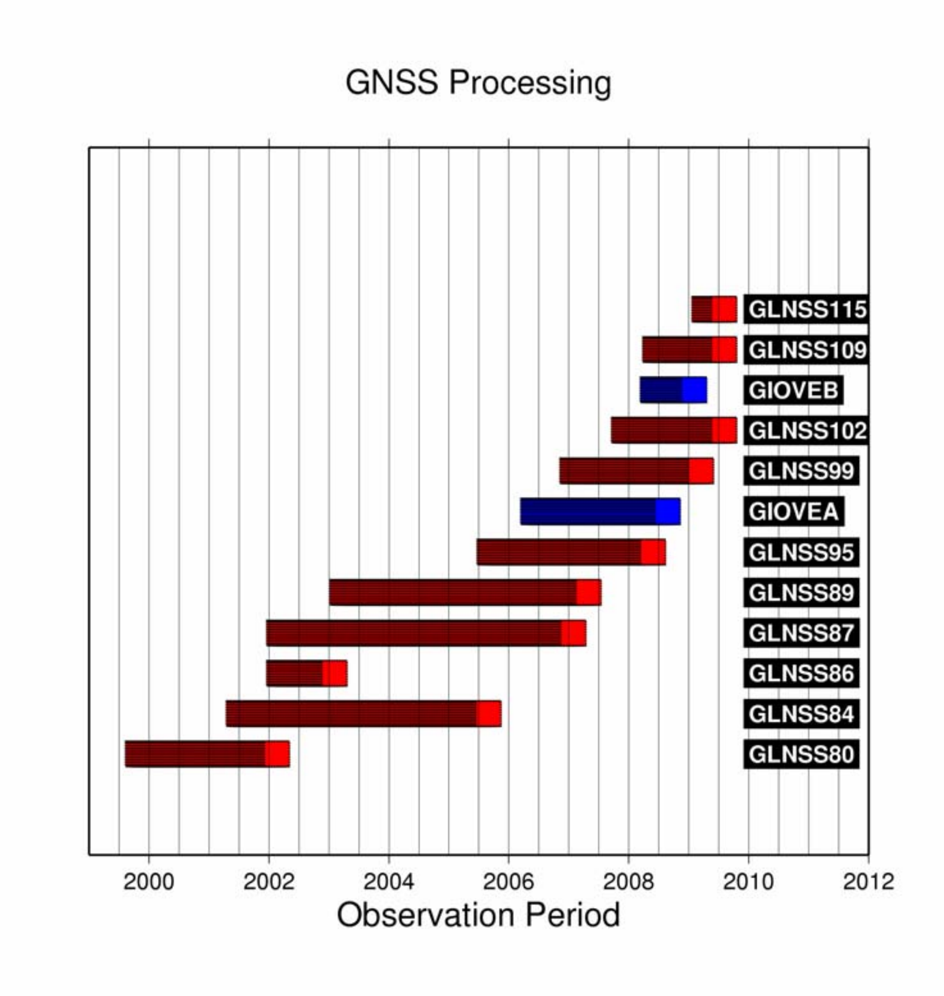
An Assessment of the Value of SLR Observations to GNSS

Ramesh GOVIND

ILRS Workshop on SLR Tracking of GNSS Constellations, 14th – 18th September 2009, Metsovo, Greece.



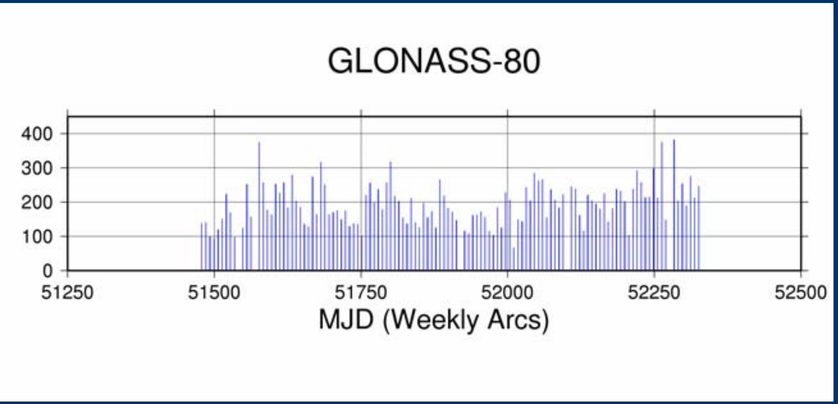
Inventory of GNSS Data Processed 9910 -- 0908



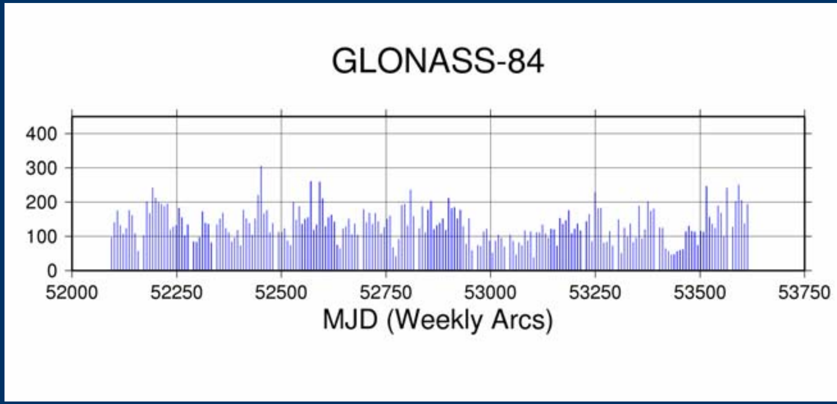
Assessment Measures

- Orbit Quality –
  - WRMS of Fit
  - SRP Scale -- consistency
- SLR Products -- Benchmark solution
  - GA ITRF2008 submission + 2009 Weekly solutions
  - Geocentre from degree one coefficients
  - XPOLE, YPOLE, LOD
  - Minimally Constrained
- Single Number Description of Assessment

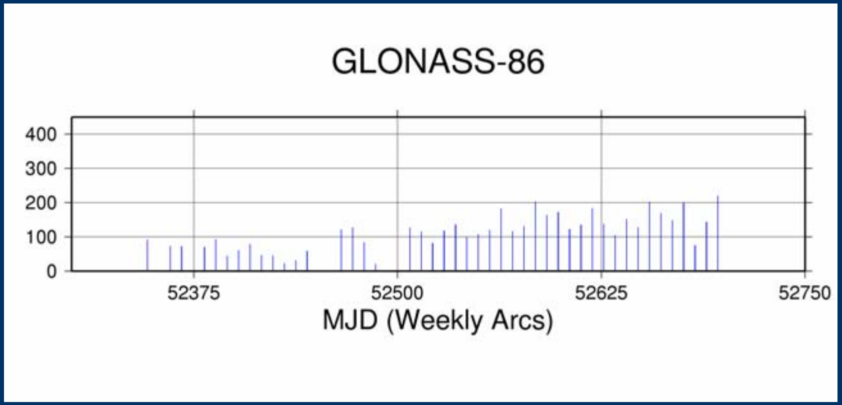
Number of Observations per satellite – per 7-day arc



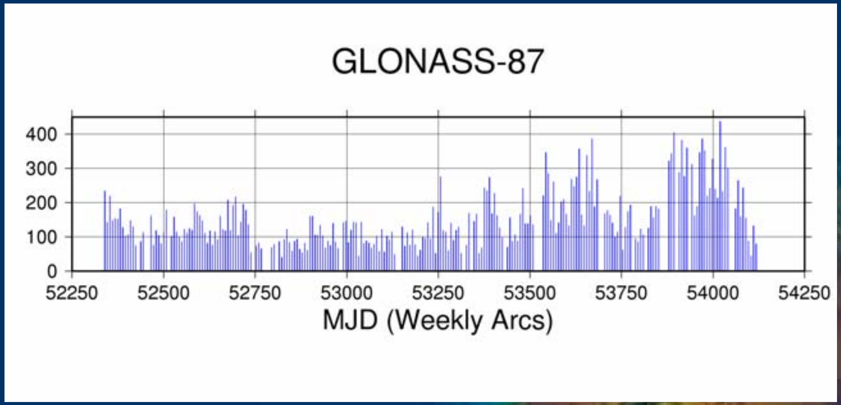
Median = 185



Median = 105

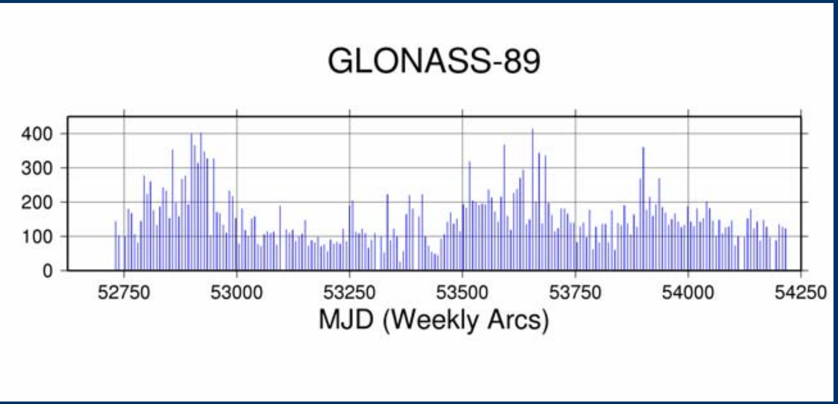


Median = 117

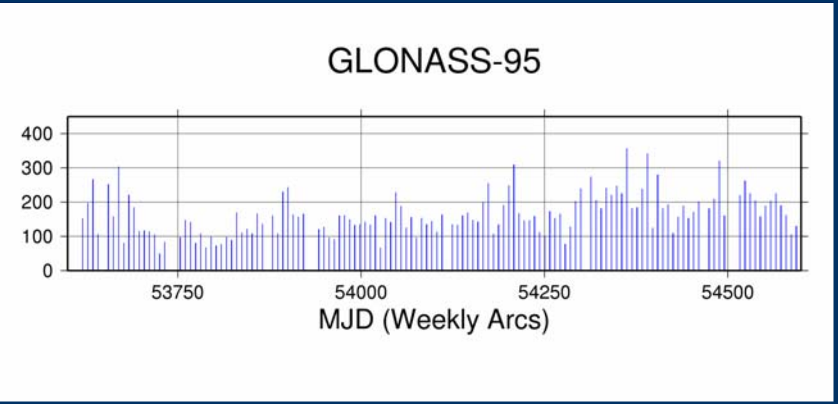


Median = 130

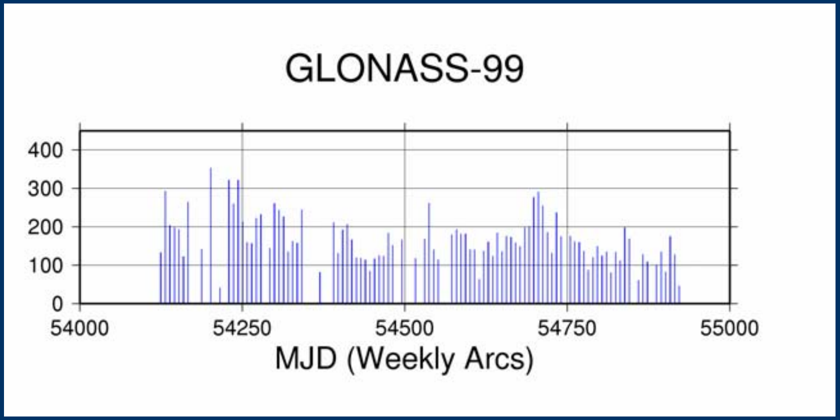
Number of Observations per satellite – per 7-day arc



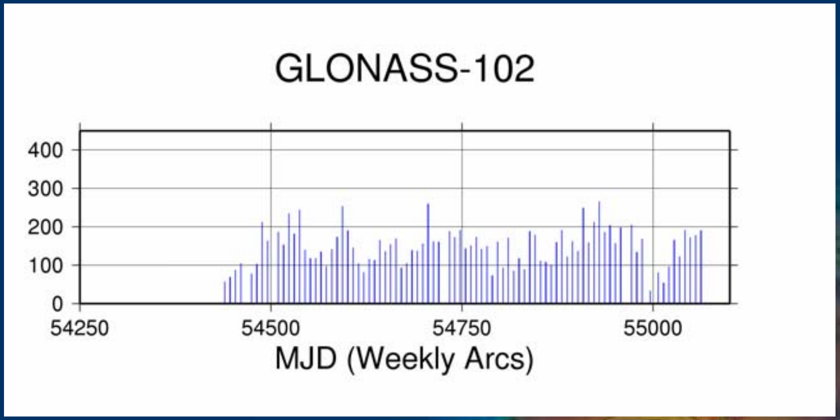
Median = 142



Median = 157

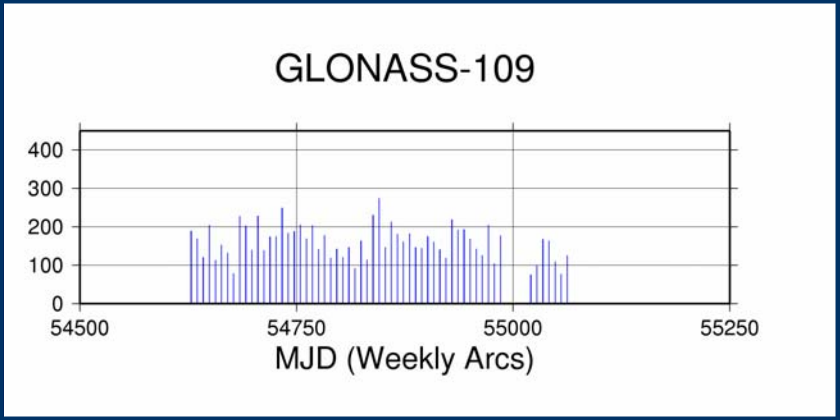


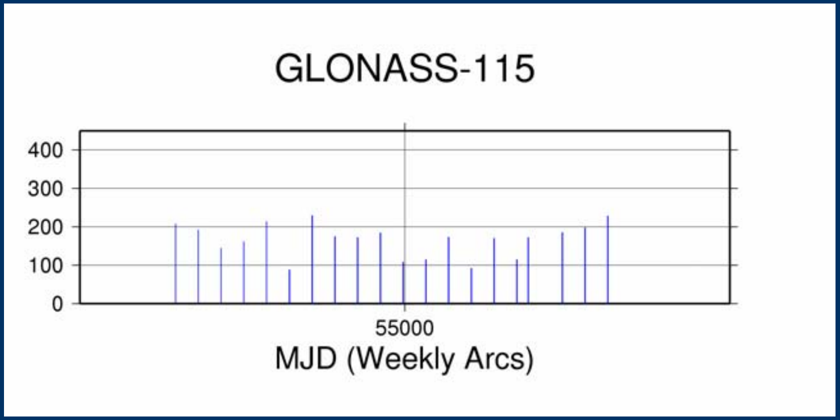
Median = 160



Median = 152

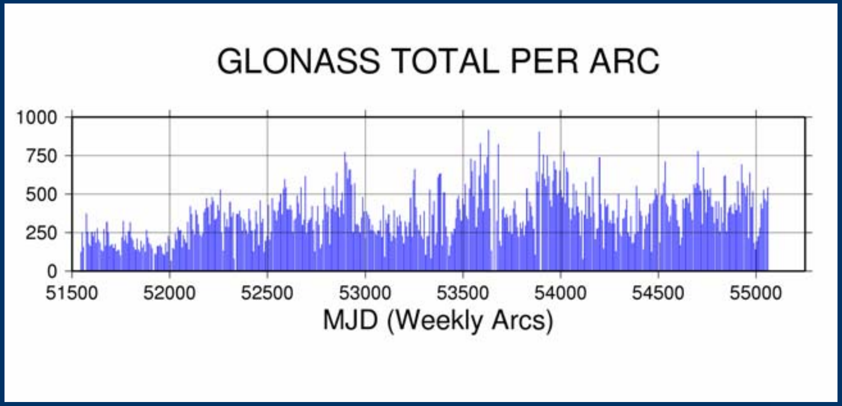
Number of Observations per satellite – per 7-day arc





Median = 163

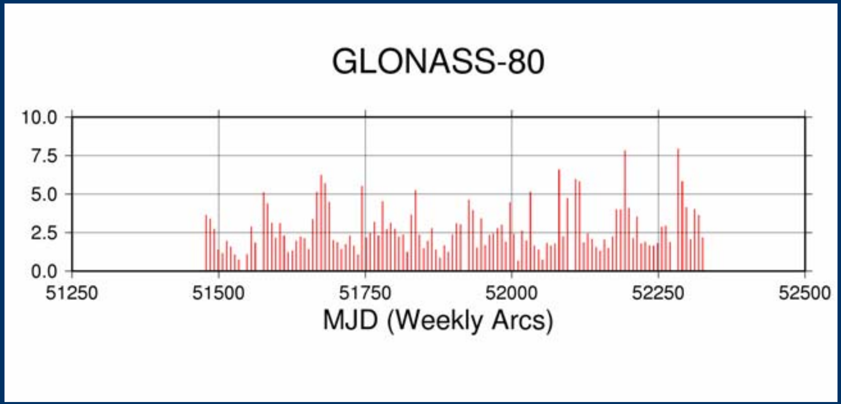
Median = 170



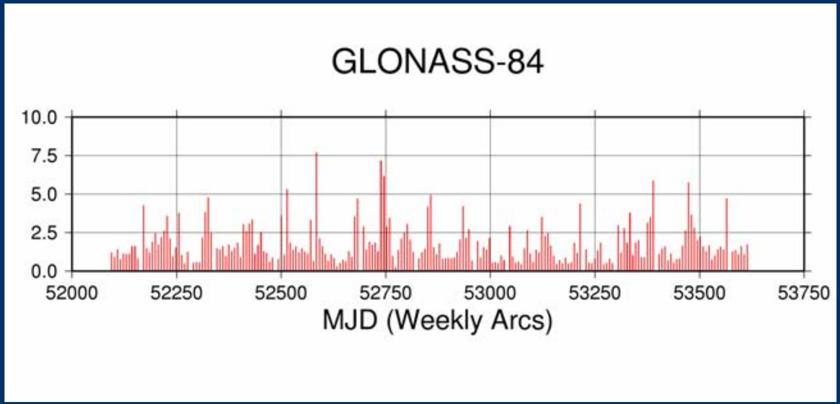
Number of Stations observing per 7-day arc

	Minimum	Median	Maximum
GLNSS-80	5	11	21
GLNSS-84	3	9	15
GLNSS-86	3	8	15
GLNSS-87	3	9	16
GLNSS-89	4	12	18
GLNSS-95	4	10	18
GLNSS-99	5	10	16
GLNSS-102	3	9	16
GLNSS-109	3	9	16
GLNSS-115	6	10	17

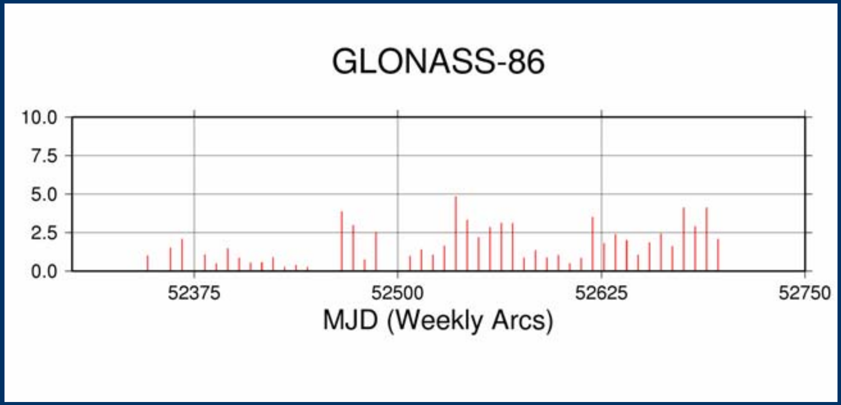
POD Results: RMS of Orbit Fit (cm)



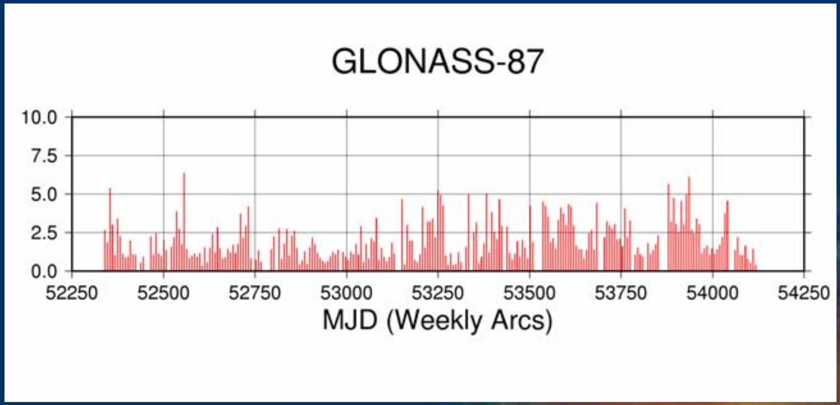
Mean WRMS = 2.74



Mean WRMS = 1.75

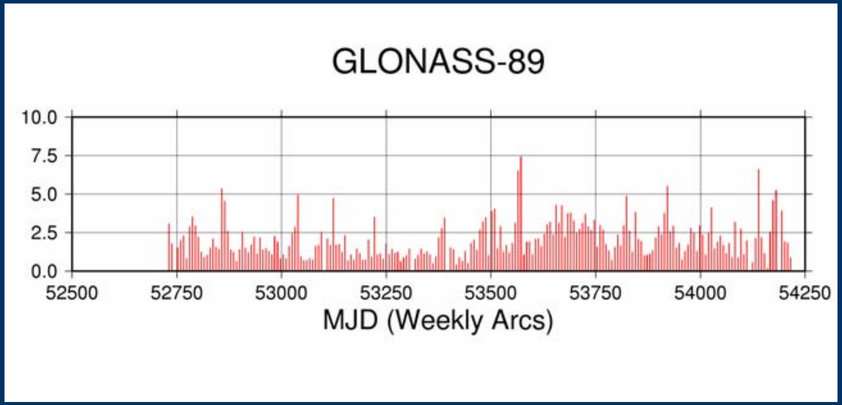


Mean WRMS = 1.79

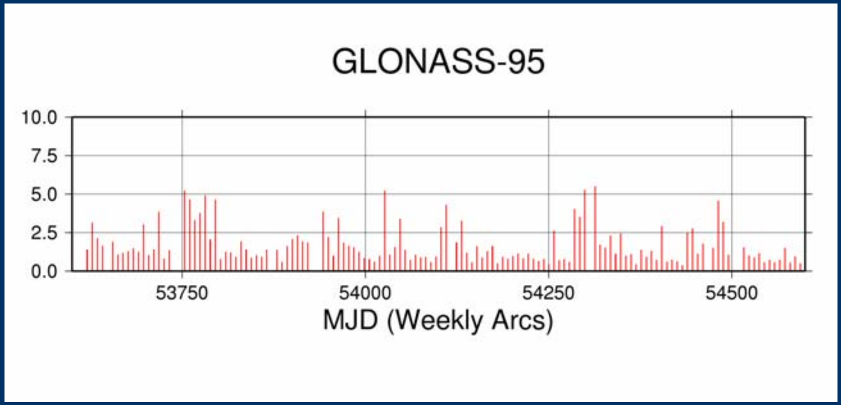


Mean WRMS =2.00

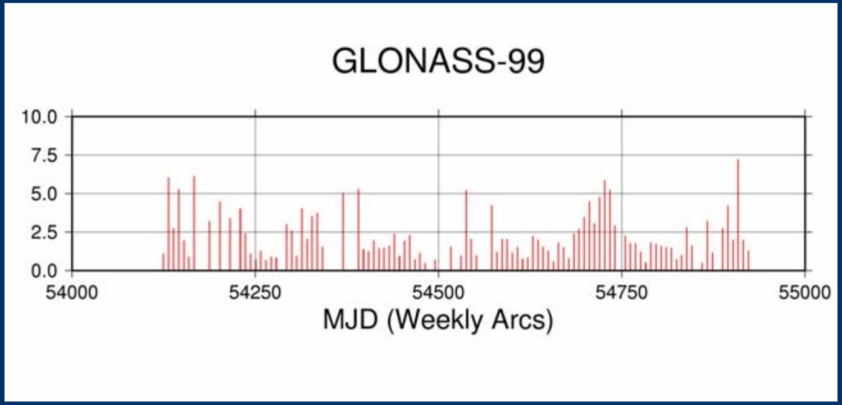
POD Results: RMS of Orbit Fit



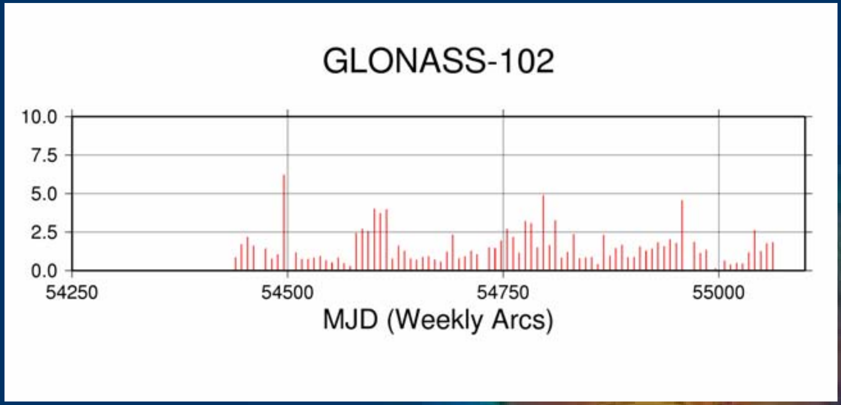
Mean WRMS = 2.04



Mean WRMS = 1.68

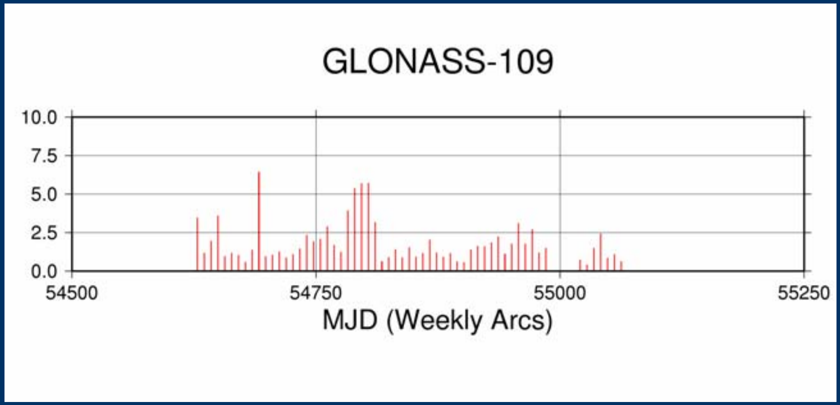


Mean WRMS = 2.26

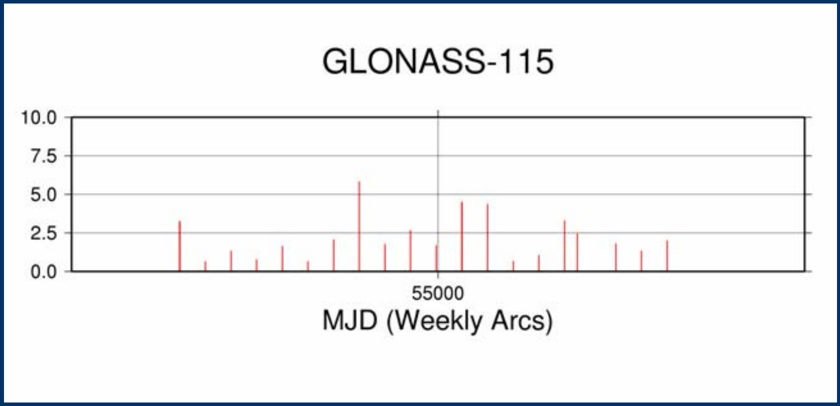


Mean WRMS = 1.55

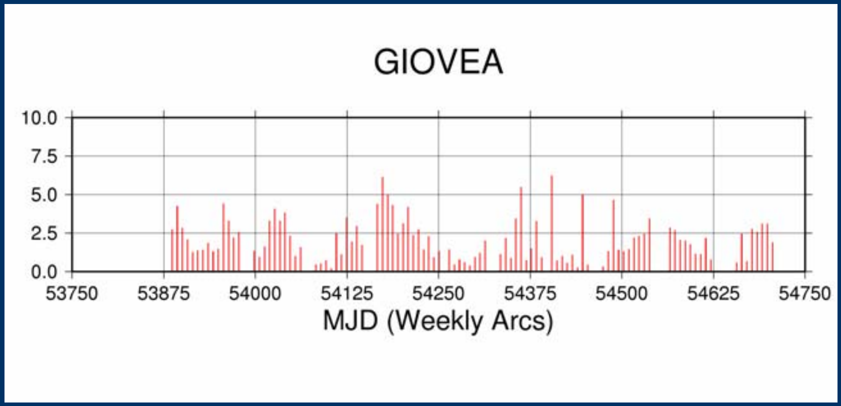
POD Results: RMS of Orbit Fit

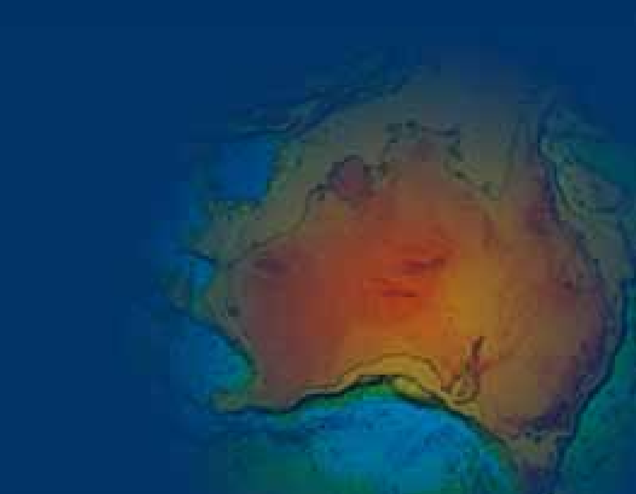


Mean WRMS = 1.81

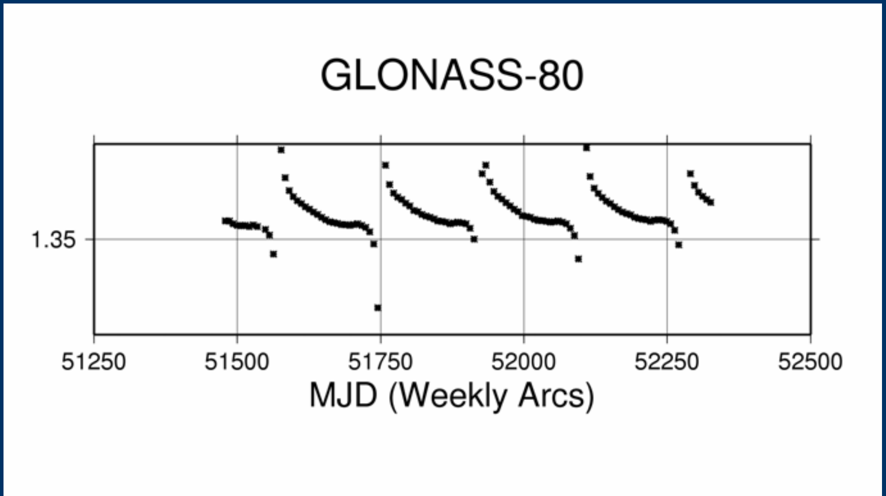


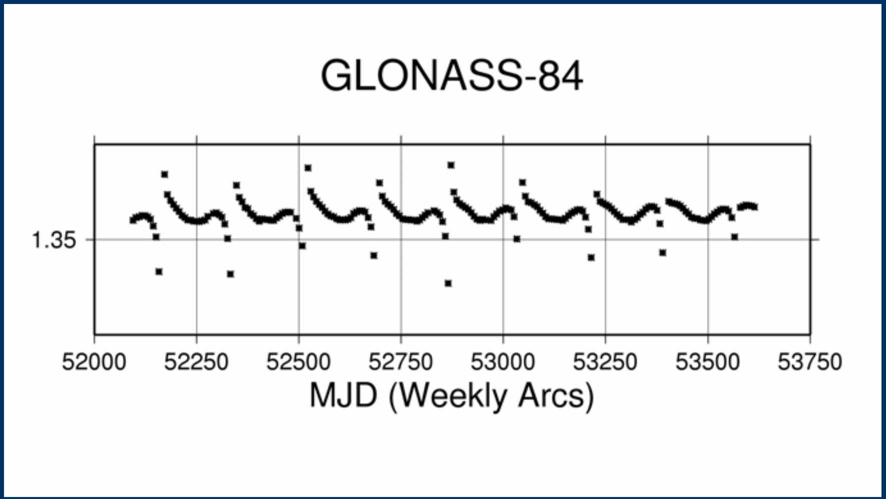
Mean WRMS = 2.17

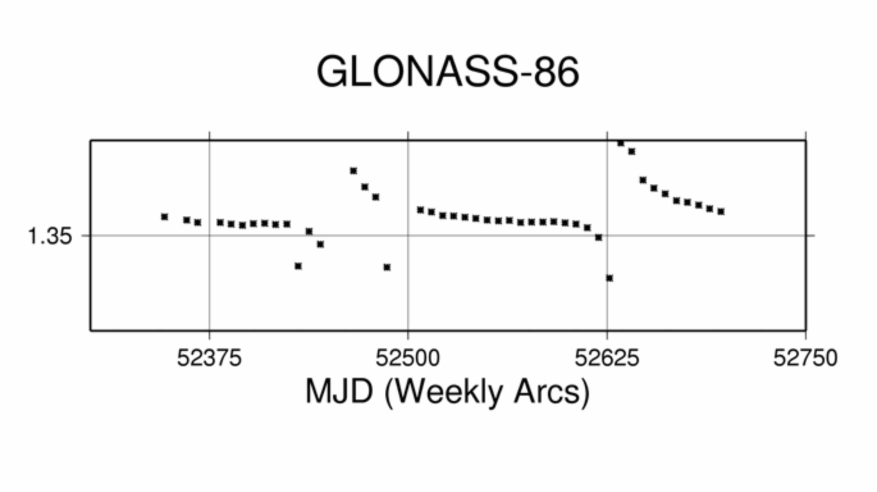


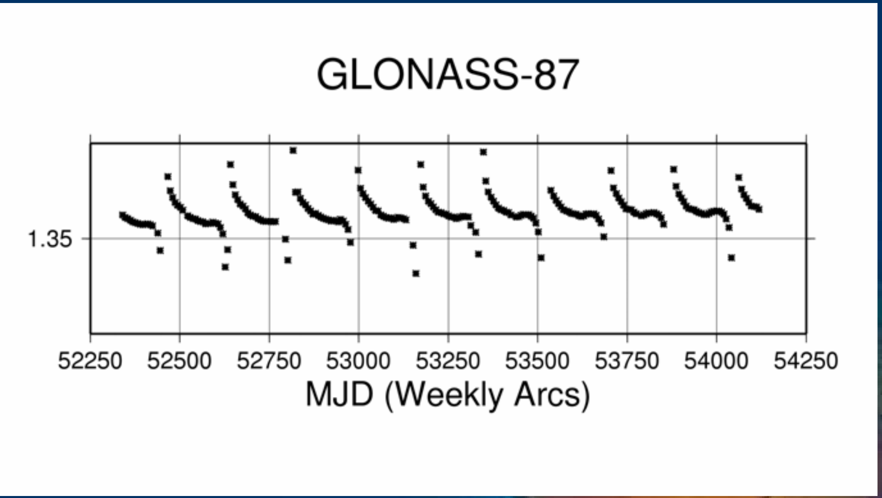


POD Results: SRP Scale Factor

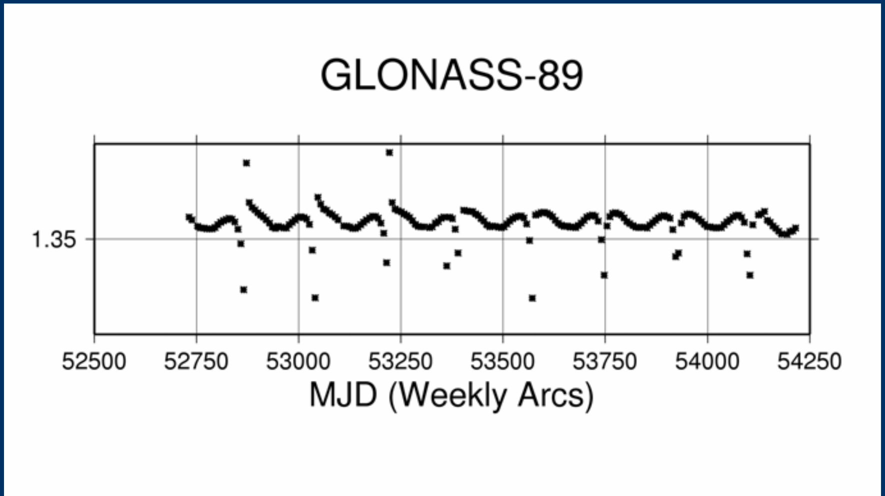


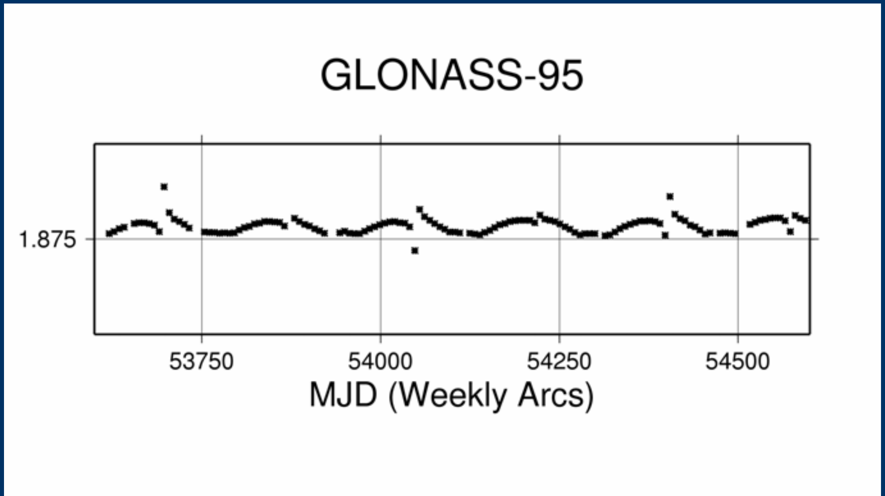


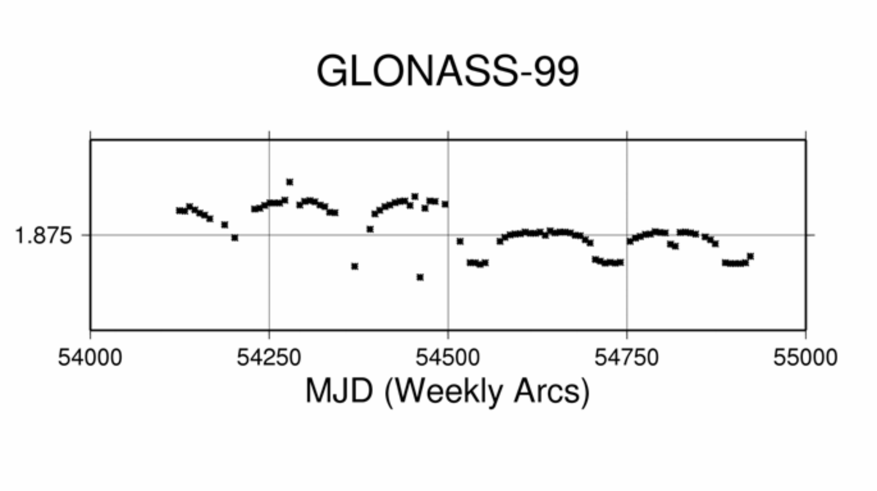


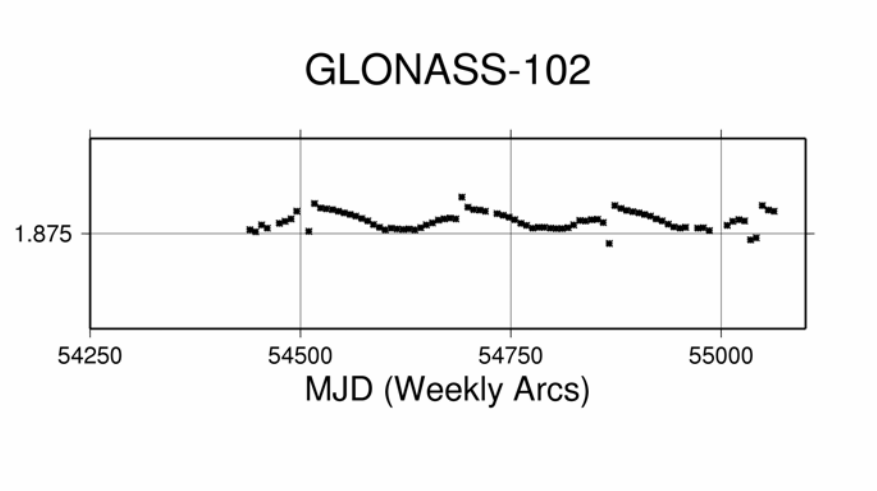


POD Results: SRP Scale Factor

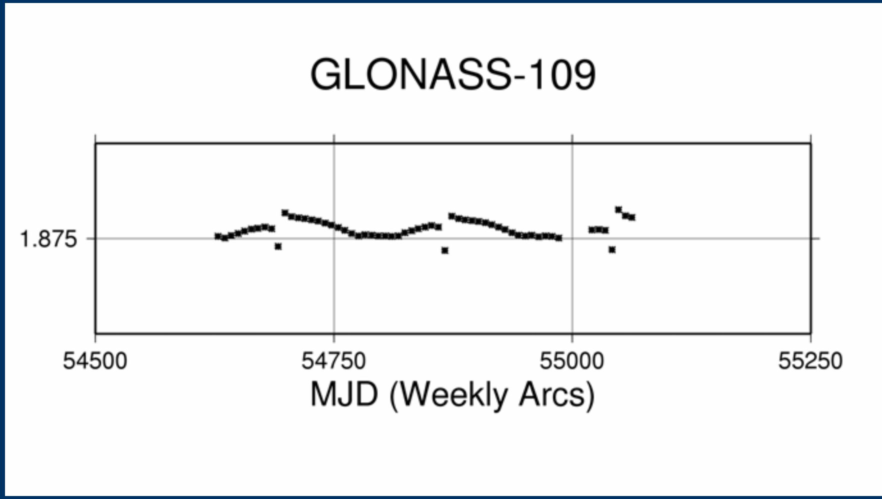


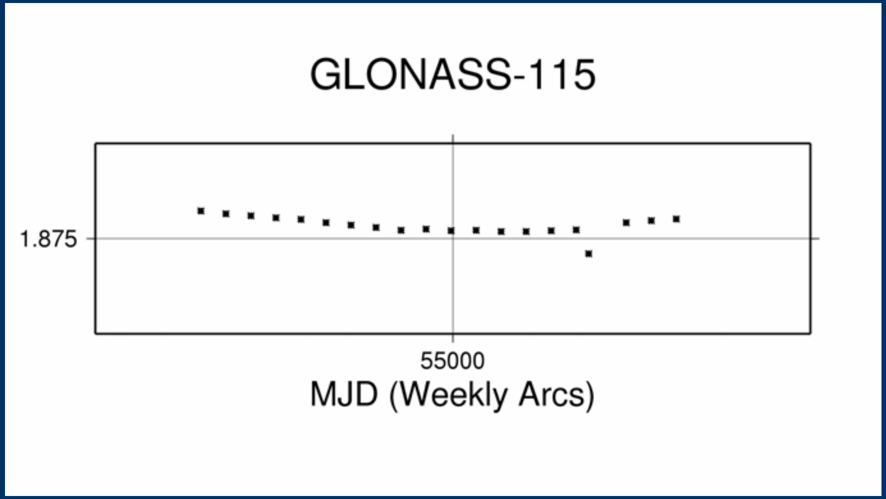






POD Results: SRP Scale Factor





SRP Scale Factor

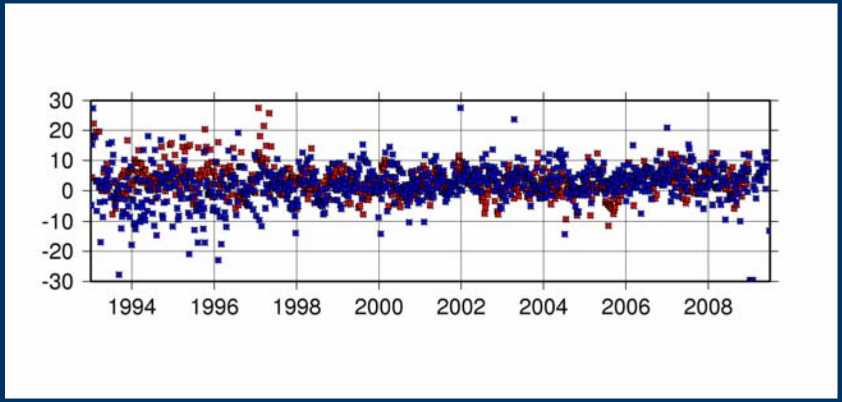
1.3 for GLONASS 80 – 89; 1.8 for GLONASS 95-115

Two Different Spacecraft – Mass, Surface Area, SRP Model ?

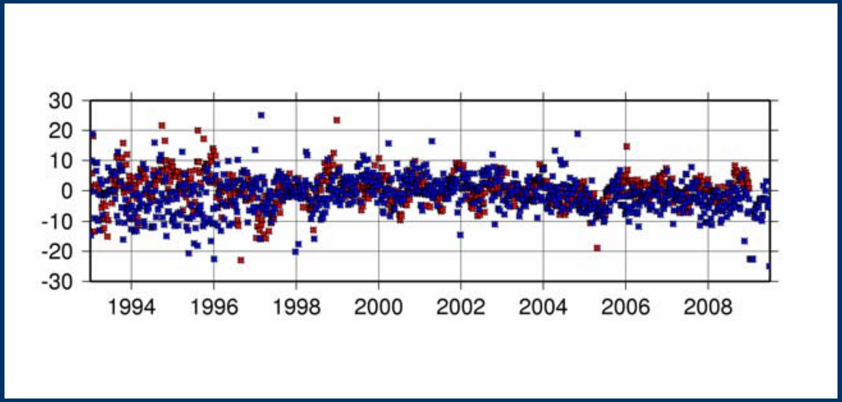
Slow Attitude change, Changing Orientation of Solar Panels ?

180-day Jumps ?

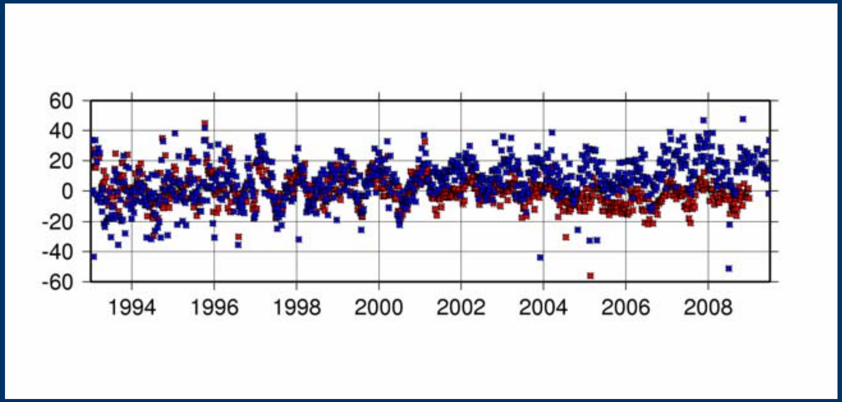
Results: COM Benchmark Solution



X-Geocentre (mm)



Y-Geocentre (mm)

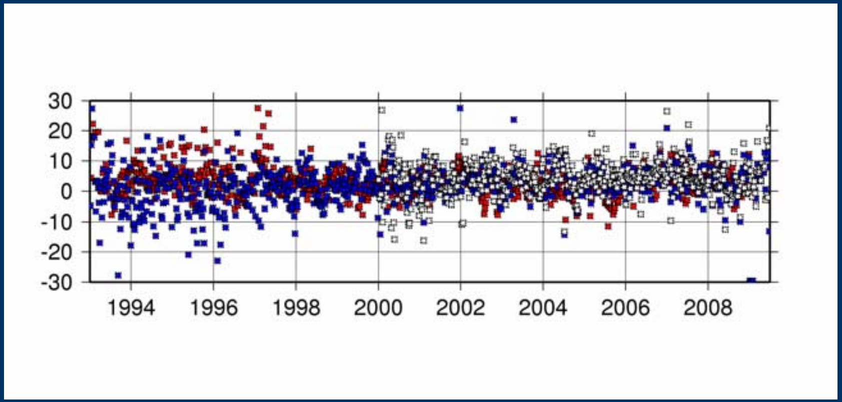


Z-Geocentre (mm)

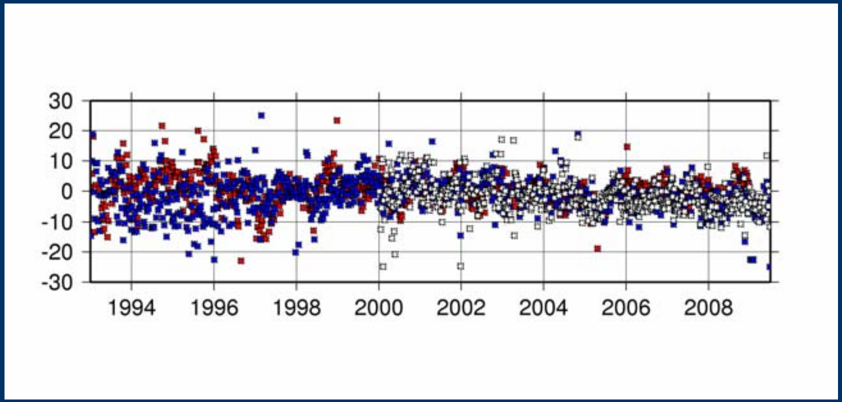
Blue = GA gravimetric solution

Red = GA ITRF2008 + Weekly

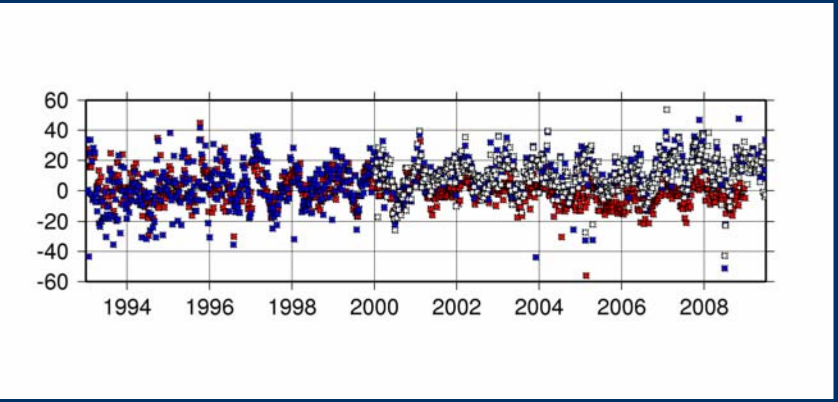
LAGET + GLNSS Geocentre



X-Geocentre (mm)



Y-Geocentre (mm)



Z-Geocentre (mm)

Assessment of CoM

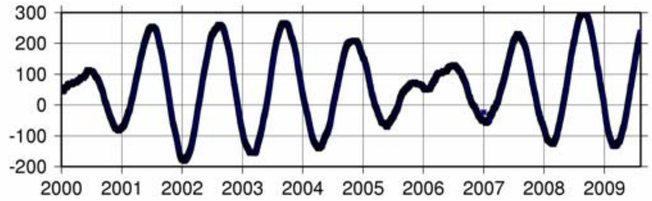
LAGET+GLNSS

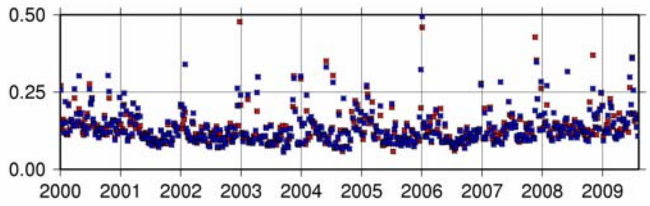
	Mean of Uncertainty (mm)	RMS of Uncertainty (mm)
X-com	2.01	9.92
Y-com	2.06	11.36
Z-com	3.97	14.46

LAGET

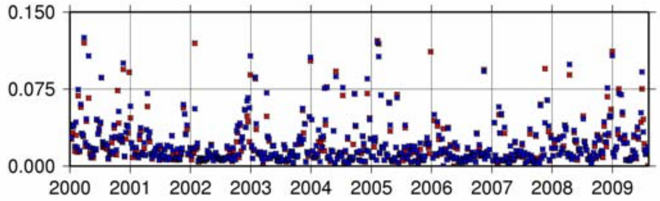
	Mean of Uncertainty (mm)	RMS of Uncertainty (mm)
X-com	2.02	9.20
Y-com	2.01	8.84
Z-com	3.54	14.00

XPOLE (mas)



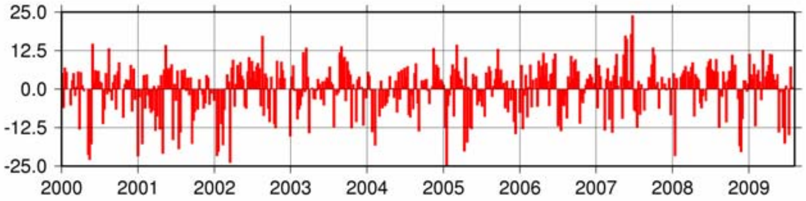


Mean uncertainty per arc



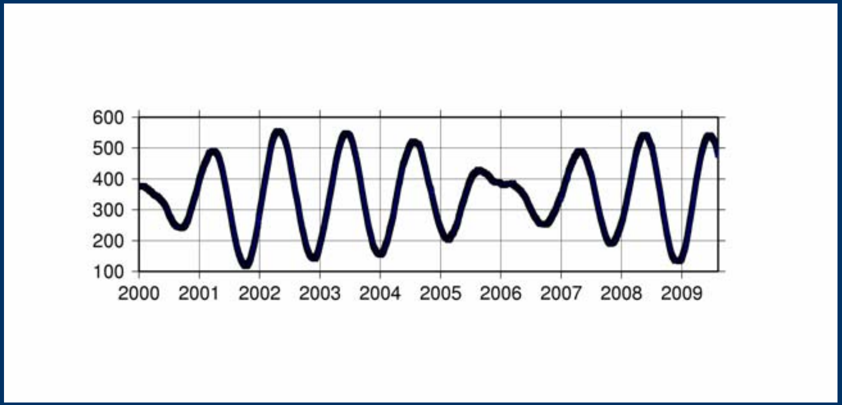
RMS of uncertainty per arc

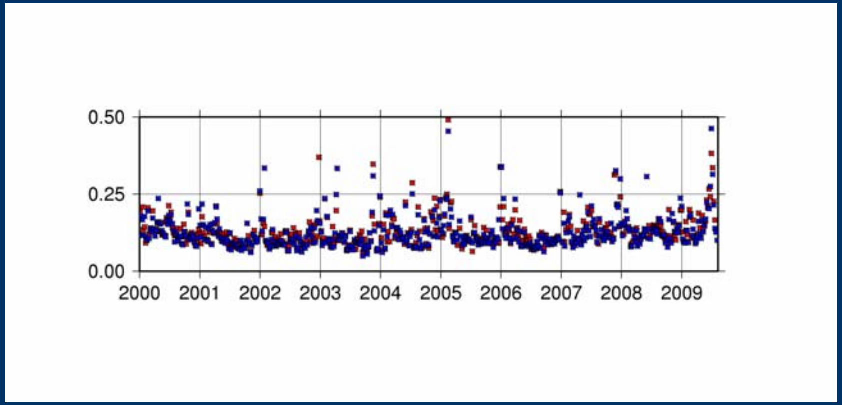
+VE = improvement



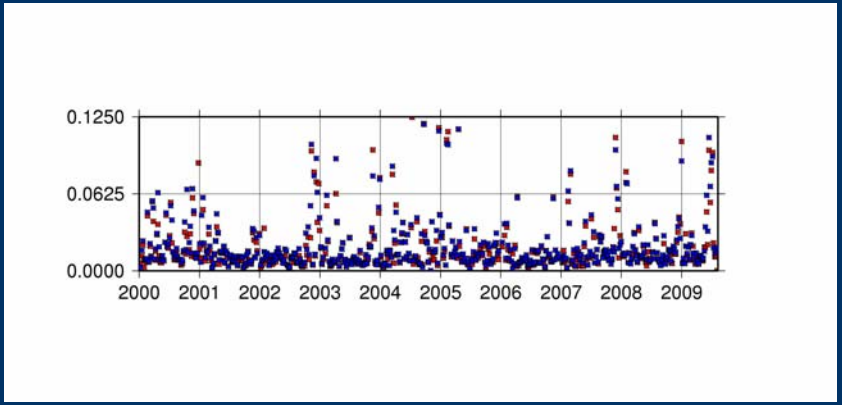
%difference in uncertainty

YPOLE (mas)

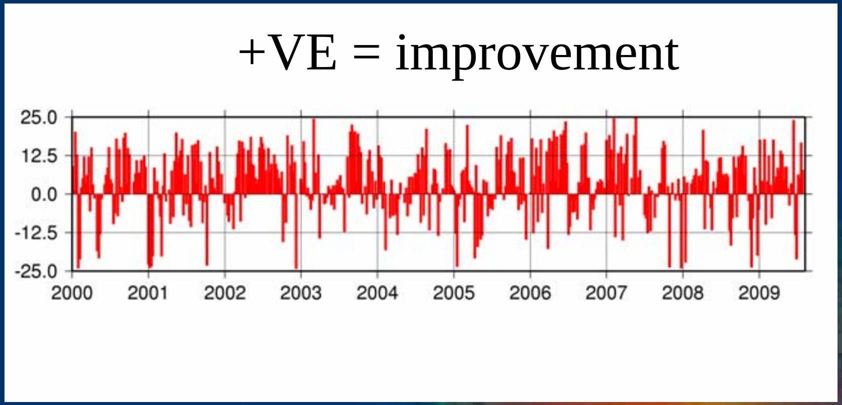




Mean uncertainty per arc

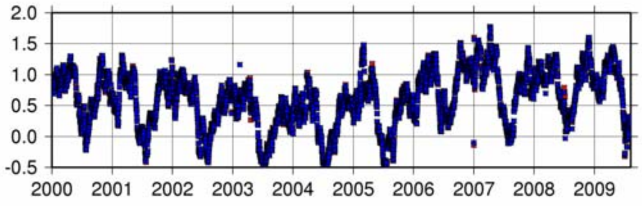


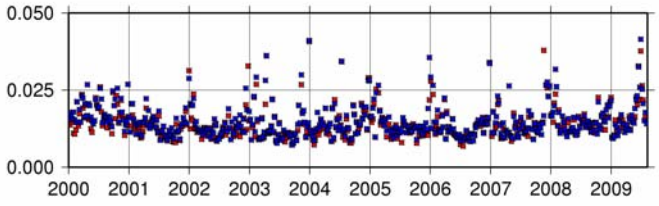
RMS of uncertainty per arc



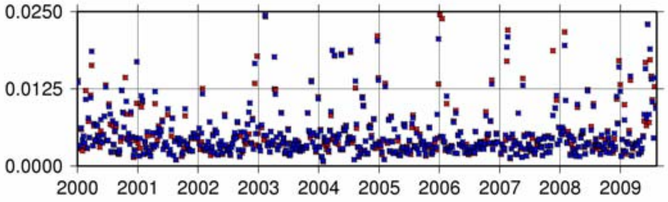
%difference in uncertainty

LOD: LARET vs. LARET+GLNSS (ms)



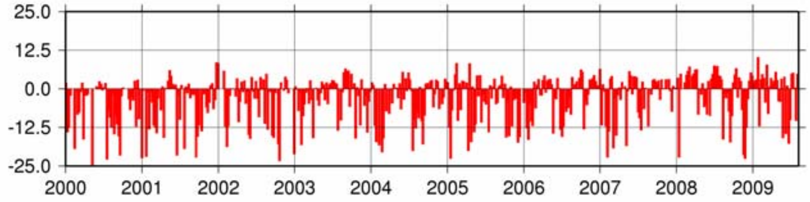


Mean uncertainty per arc



RMS of uncertainty per arc

+VE = improvement



%difference in uncertainty

Assessment: For 10% improvement

Arc 021027	#Obs	#Stns
GLNSS-84	118	8
GLNSS-86	131	9
GLNSS-87	119	8

Arc 060924	#Obs	#Stns
GLNSS-87	240	13
GLNSS-89	142	8
GLNSS-95	143	11

Arc 080727	#Obs	#Stns
GLNSS-99	150	10
GLNSS-102	106	8
GLNSS-109	79	5

Tables show the observation configuration of typical arcs where an improvement of ~10% was achieved in the uncertainties in XPOLE and YPOLE components.

Summary and Conclusions - 1

- The main aim of this study was to assess the potential of SLR observations to GNSS satellites to contribute to the improvement of, specifically, SLR products – Geocentre (for the Terrestrial Reference Frame definition) and Earth Orientation Parameters.
- For the purposes of this assessment, all available GLONASS SLR data for the period October 1999 (Start of GLONASS-80 data) to end August 2009 – comprising 10 satellites was processed for POD and combined with the standard Lageos and Etalon data over this period.

Summary and Conclusions - 2

- The combined solutions were compared with a benchmark solution – which was the Geoscience Australia contribution to the ILRSA combination for ITRF2008 – the parameters being the gravimetric (geocentre), XPOLE, YPOLE and LOD. The gravimetric geocentre was compared with the ILRSA determined translation components for consistency of the two methods.

Summary and Conclusions - 3

- The POD results showed a typical RMS fit for the orbit of 2 cm for each 7-day arc for all the satellites.
- The estimated Solar Radiation Pressure (SRP) scale factor gave mean values of 1.38 (for GLONASS 80, 84, 86, 87, 89) and 1.85 (for GLONASS 95, 99, 102 and 115). This identified them as different spacecraft GLONASS and GLONASS-M in their dimensions and construction. This information is not readily available apriori.

Summary and Conclusions - 4

- The estimated time series for the SRP scale factor showed a slowly changing attitude or orientation of the satellite or the solar panels with an "abrupt" adjustment every six months. This is consistent in the POD results for all 10 GLONASS satellites in this study. An attitude model to address this effect is also not available.

Summary and Conclusions - 5

- The addition of the GLONASS data in determining the gravimetric geocentre has little impact – the mean and RMS of the uncertainties in the z-component deteriorated by 0.4 mm. Although there was no significant change in the mean uncertainty of the y-component the RMS did deteriorate by a significant 2.5 mm.

Summary and Conclusions - 6

- The addition of the GLONASS data had a large impact on uncertainties of the EOP estimates. For both the x and y pole coordinate uncertainties, in each case there was an improvement in approximately 50% of the computed arcs and a detrioration in approximately 50% of the computed arcs. The uncertainty in the LOD estimates deteriorated for the majority of the computed arcs.

Summary and Conclusions - 7

- Although the study implies that there is potential for GNSS SLR observations to positively impact the quality of SLR products, some major and important issues of space segment information has been identified and needs to be addressed if GNSS ranging is to be a contributor to the enhancement of SLR TRF products.

Summary and Conclusions - 8

- Immediate Issue #1: Satellite Centre of Mass Offset.
  - The “instantaneous” offset between the satellite centre of mass and the LRA has to be provided for each (identified) satellite in an unambiguous form. This should comprise the nominal CoM offset and the “instantaneous” location of the CoM with respect to the origin of satellite’s the body fixed frame. This value has to be updated at least after every manoeuvre.

Summary and Conclusions - 9

- Immediate Issue #2: Solar Radiation Pressure
  - The physical dimensions (“instantaneous” mass and surface area) need to be provided for each satellite for SRP computations. The “instantaneous” mass should be provided with the location of the satellite CoM; at least after every manoeuvre.
  - If available, a SRP maromodel that may have been developed by GLONASS for each model of the constellation could be provided.

Summary and Conclusions - 10

- Immediate Issue #3: Attitude and Manoeuvres
  - An attitude model is required and the six-monthly re-orientation of the satellite explained.