Towards GGOS Stations in New Zealand

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Auckland University of Technology

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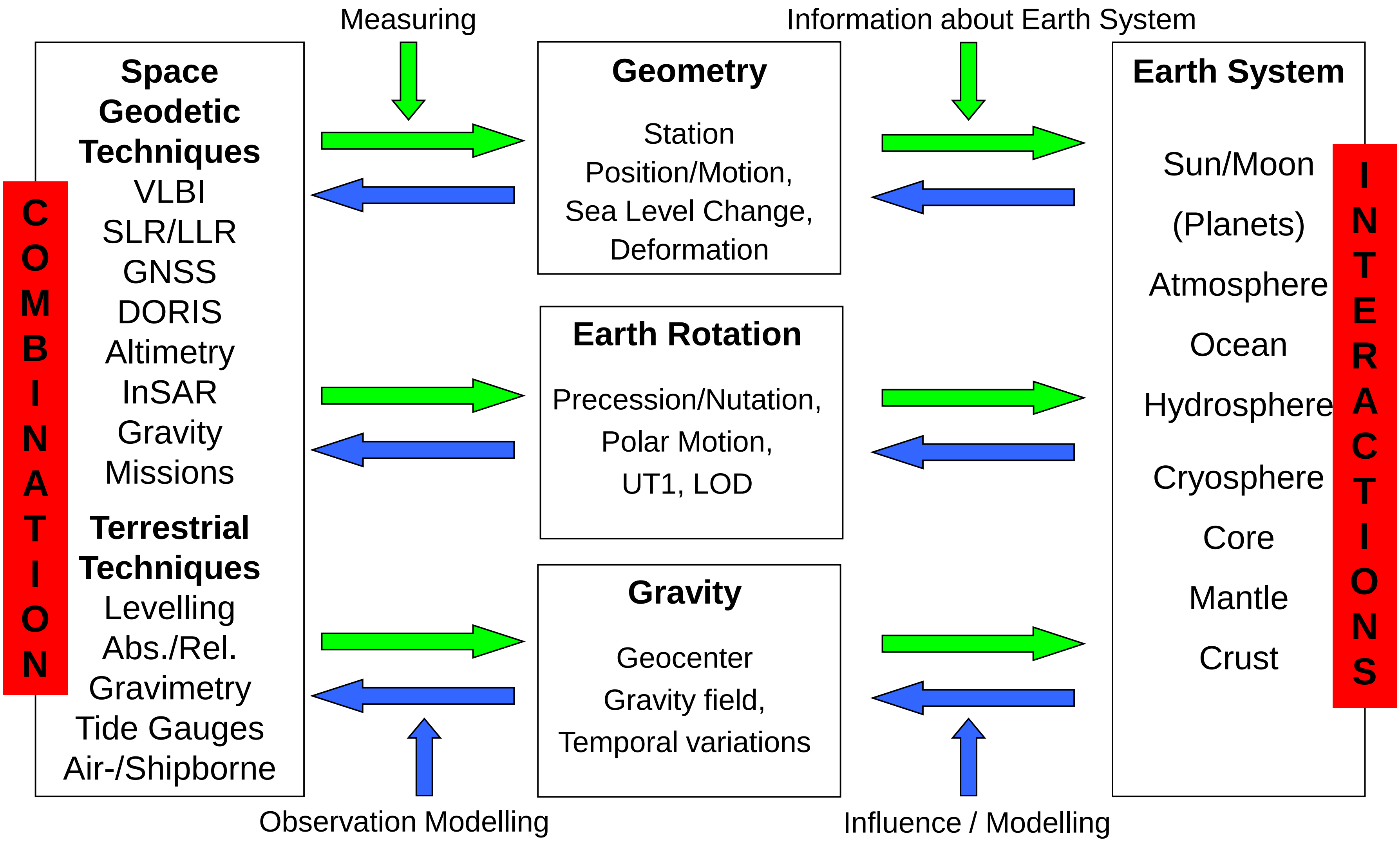
Land Information New Zealand, Wellington, 1 December 2014

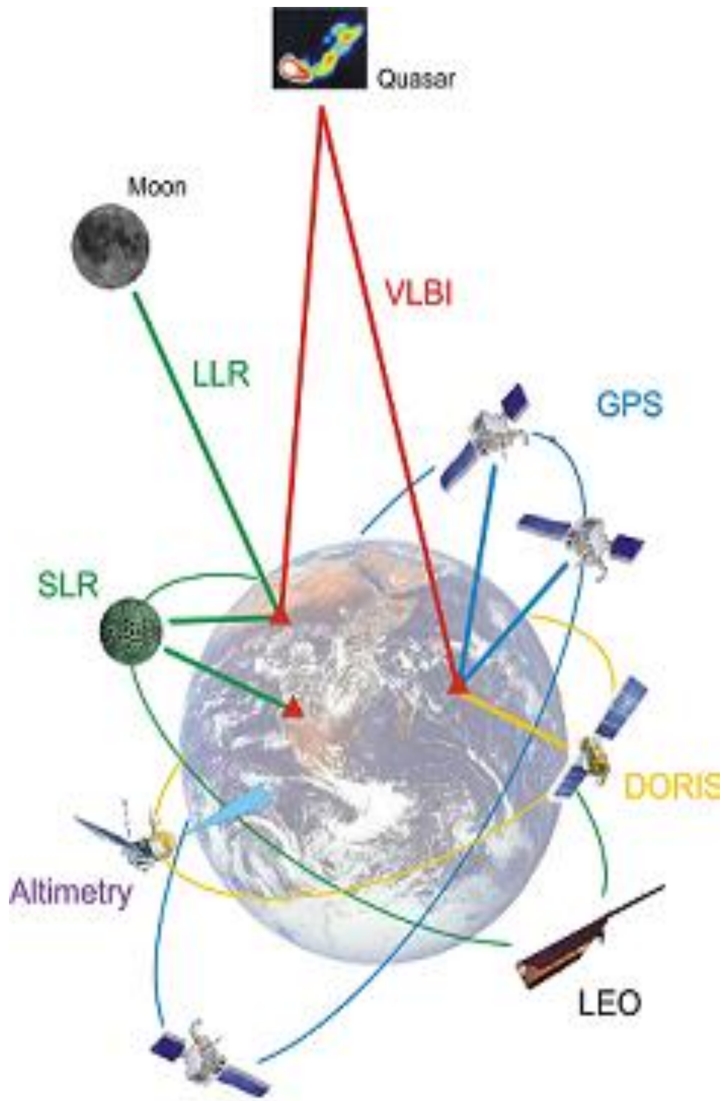
Space Geodesy is aimed

- To study Earth motions (rotation, irregularities of rotation, precession, nutation, polar motion, tectonic plate motion, intra-plate motions);
- To measure Earth parameters: scale (radius), position of the Earth centre (geocentre);
- To establish and support the International Celestial Reference Frame (VLBI only);
- To establish and support the International Terrestrial Reference Frame
- To determine coordinates of geodetic stations and variations of the coordinates and baselines (linear, seasonal signal, discontinuities).

Space Geodesy techniques



Space Geodesy techniques



http://www.ggos-d.de

Space Geodesy techniques

	Parameter Type	VLBI	GNSS	DORIS/ PRARE	SLR	LLR	Alti- metry	
ICRF	ICRF	X						
	Nutation	X	(X)		(X)	X		Earth Rotation
	Polar Motion	X	X	X	X	X		
	UT1	X						
	Length of Day (LOD)		X	X	X	X		
ITRF	Coord+Veloc (ITRF)	X	X	X	X	X	(X)	
	Geocenter		X	X	X		X	Gravity Field
	Gravity Field		X	X	X	(X)	X	
	Orbits		X	X	X	X	X	
	LEO Orbits		X	X	X		X	
Atmosphere	Ionosphere	X	X	X			X	
	Troposphere	X	X	X			X	
	Time/Freq.; Clocks	(X)	X		(X)			

(from Zuheir Altamimi, Presentation at the Fourth Meeting of the International Committee on GNSS, St. Petersburg, 14-18 Sept, 2009)

Space Geodesy techniques

Mix of techniques is fundamental to realize a frame (ITRF) that is stable in origin, scale, and with sufficient coverage

Technique Signal Source Obs. Type	**VLBI** Microwave Quasars Time difference	**SLR** Optical Satellite Two-way absolute range	**GPS** Microwave Satellites Range change	**DORIS**
Celestial Frame & UT1	**Yes**	No	No	No
Polar Motion	Yes	Yes	**Yes**	Yes
Scale	**Yes**	**Yes**	No (but maybe in the future!)	Yes
Geocenter ITRF Origin	No	**Yes**	Future	Future
Geographic Density	No	No	**Yes**	**Yes**
Real-time & ITRF access	Yes	Yes	**Yes**	Yes
Decadal Stability	**Yes**	**Yes**	Yes	Yes

(from Zuheir Altamimi, Presentation at the Fourth Meeting of the International Committee on GNSS, St. Petersburg, 14-18 Sept, 2009)

GGOS

- GGOS aims:
  - by using and integrating
    advanced geodetic observing techniques
    1) accuracy of < **1 mm** for position
    2) accuracy of < **0.1 mm/yr** for velocity

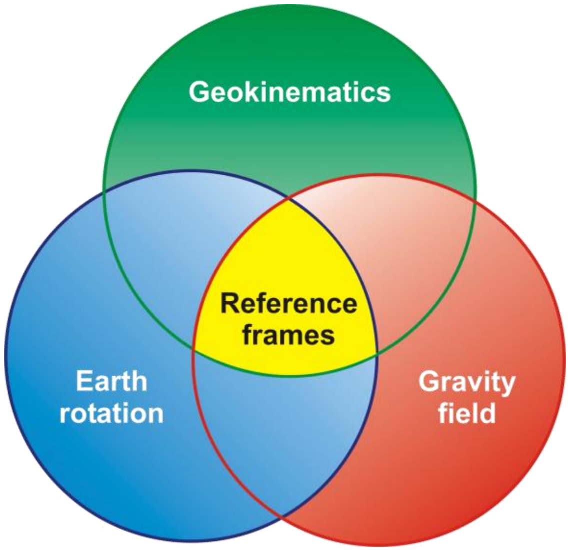


Fig. 1. SLR, VLBI, and DORIS Networks
Highlighting Sites with SLR, VLBI, GNSS and in some cases DORIS Co-locations

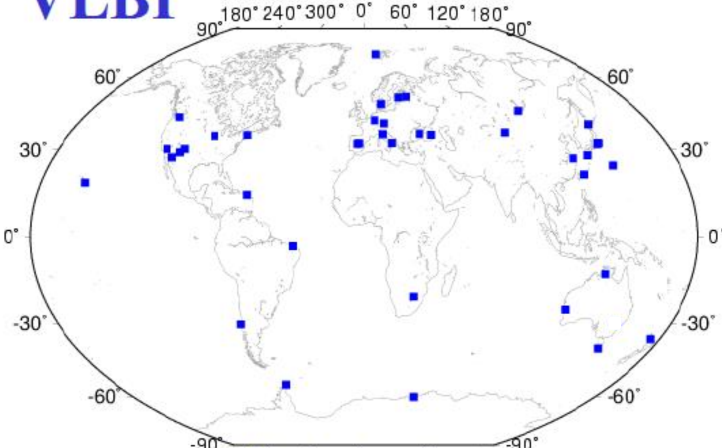
Warkworth

has capability to become a core site

Important contribution to geometrical distribution

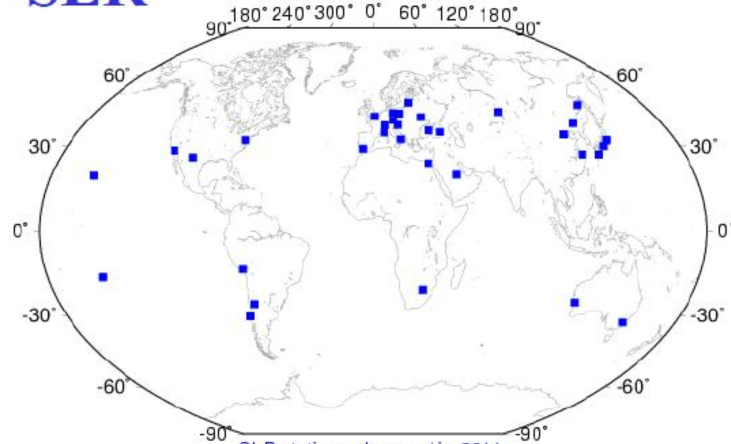
GGOS

VLBI



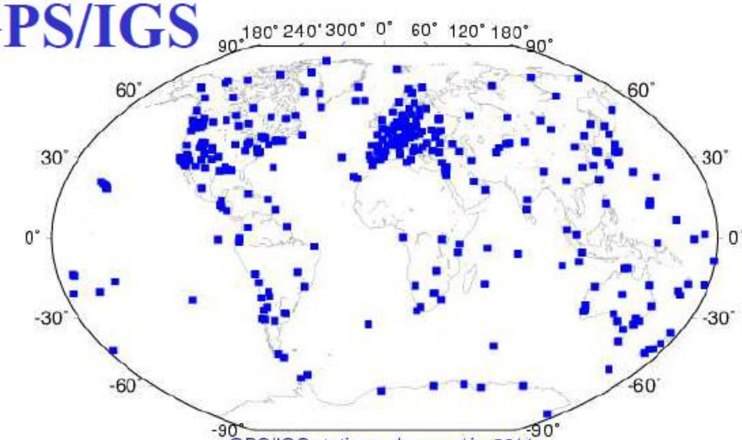
VLBI stations observed in 2011

SLR



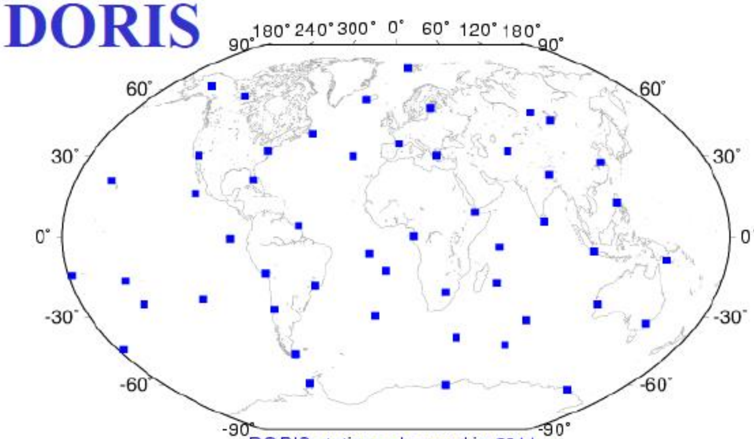
SLR stations observed in 2011

GPS/IGS



GPS/IGS stations observed in 2011

DORIS



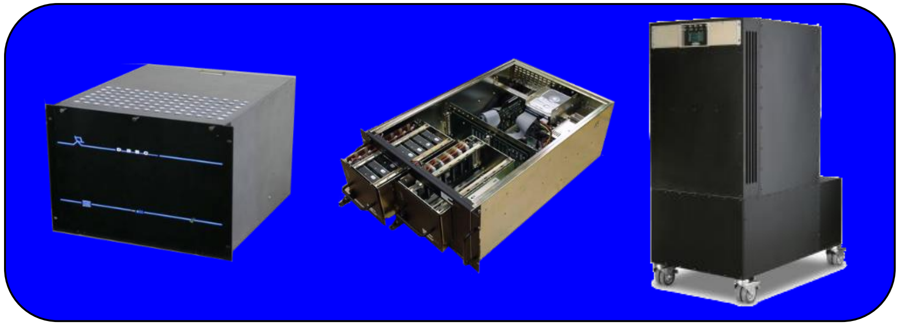
DORIS stations observed in 2011

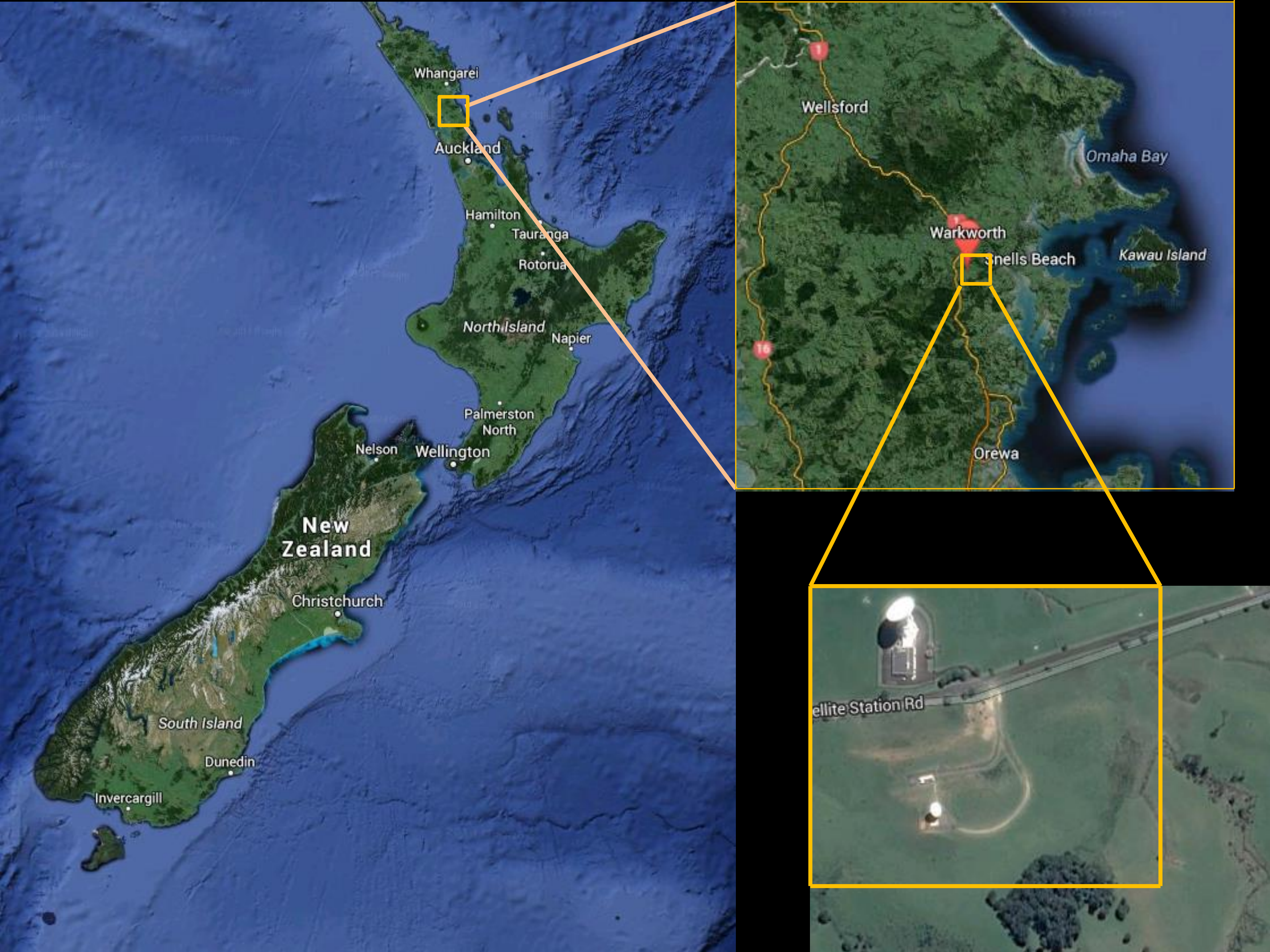
Zuheir Altamimi, Presentation at the Fourth Meeting of the International Committee on GNSS, St. Petersburg, 14-18 Sept, 2009

Geodetic 12m RT

WARK12M

- Warkworth 12m radio telescope
  - Launched on October, 2008
  - Participates in the IVS sessions since the beginning of 2011





Whangarei
Auckland
Hamilton
Tauranga
Rotorua
North Island
Napier
Palmerston North
Nelson
Wellington
New Zealand
Christchurch
South Island
Dunedin
Invercargill
1
Wellsford
Omaha Bay
Warkworth
Snells Beach
Kawau Island
16
Orewa
ellite Station Rd


Satellite Station Rd

The 30m RT at Warkworth

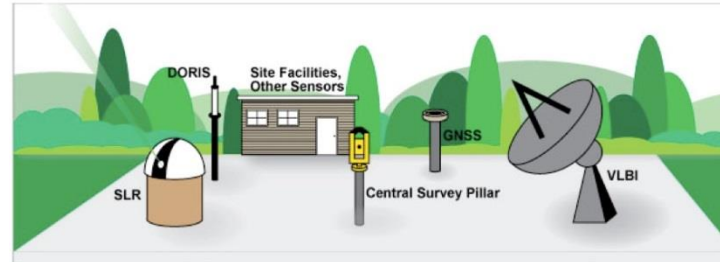
Thanks to Telecom

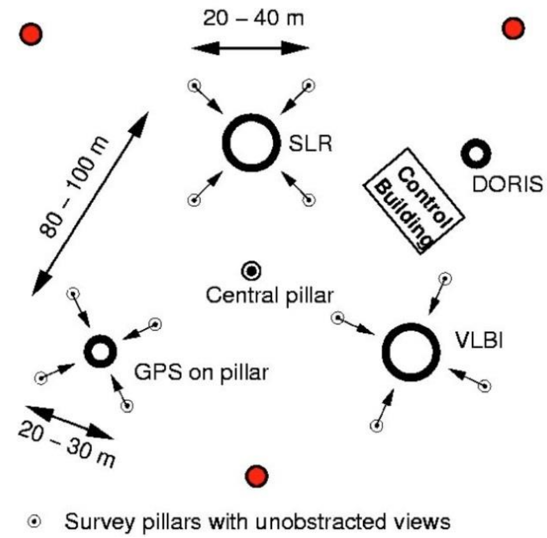
Cost of new 30m RT would be US$25-30m


HAZARD

To make a GGOS core site

- ✧Stable results
  - ✧Make an appropriate model
    - ✧ atmospheric delay
    - ✧ ocean tide loading
    - ✧ environmental loads, etc
  - ✧assistance observation
    - ✧Groundwater,
      Soil moisture, etc.
  - ✧Cooperation with other institutes
    - ✧periodical local survey
      - ✧to realize the local tie between VLBI and GPS
      - ✧LINZ and GNS Science





"Site Requirements for GGOS Core Sites"

Land-sea data for Warkworth

full resolution coastline
of GMT package

Shuttle Radar Topography Mission
The Mission to Map the World

Version 2 : SRTM3
World 3 arc-seconds
(90m)

The 2012 Warkworth Observatory Local Tie Survey

Land Information New Zealand
Record A1387321

Land Information New Zealand
Toitū te whenua

Department of Sustainability and Environment
Geodetic Survey, Office of Surveyor-General Victoria

Australian Government
Geoscience Australia

AUT UNIVERSITY
AUCKLAND, NEW ZEALAND

Azimuth Observations (5 targets)

The elevation axis was fixed in a vertical setting. The azimuth axis was rotated in 20 degree increments starting from 340 degrees backward through to 0 degrees. One set of observations was completed to all visible targets on the radio telescope for each 20 degree rotation.

Figure 6.2: Target placement on the front (left and top right) and back (bottom right) on telescope for the azimuth observations.

Elevation Observation (4 targets)

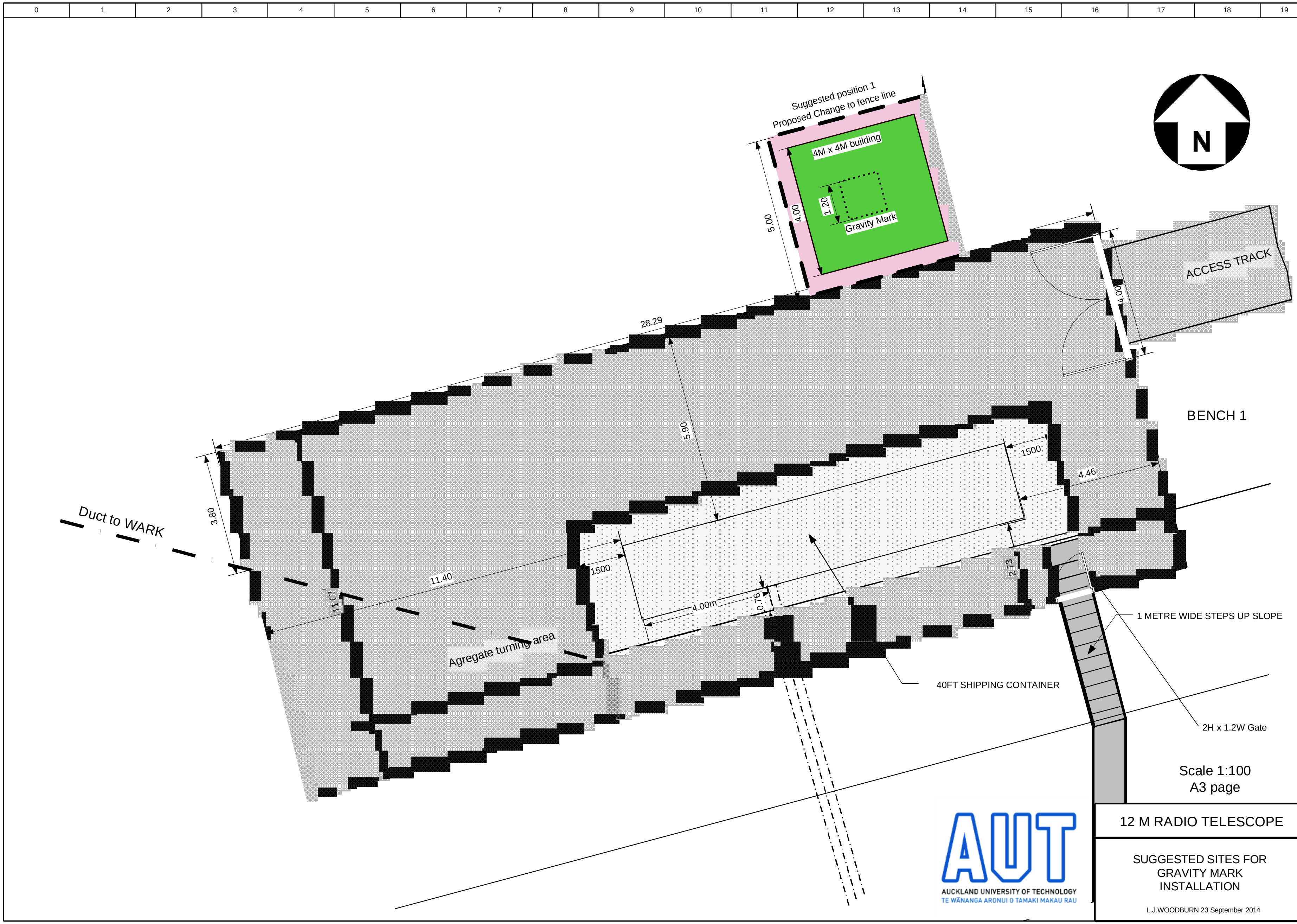
The azimuth axis was fixed in a horizontal orientation of 13 degrees and 130 degrees, to be orthogonal to the total station line of sight. The elevation axis was set to 85 (due to the bearing issue could not be set to 90) and lowered in 10 degree increments down to 10 degrees.

Figure 6.3: Placement of targets on dish for the elevation observations

Gravity

http://www.microglacoste.com/

http://www.gwrinstruments.com/



Scale 1:100
A3 page

AUCKLAND UNIVERSITY OF TECHNOLOGY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

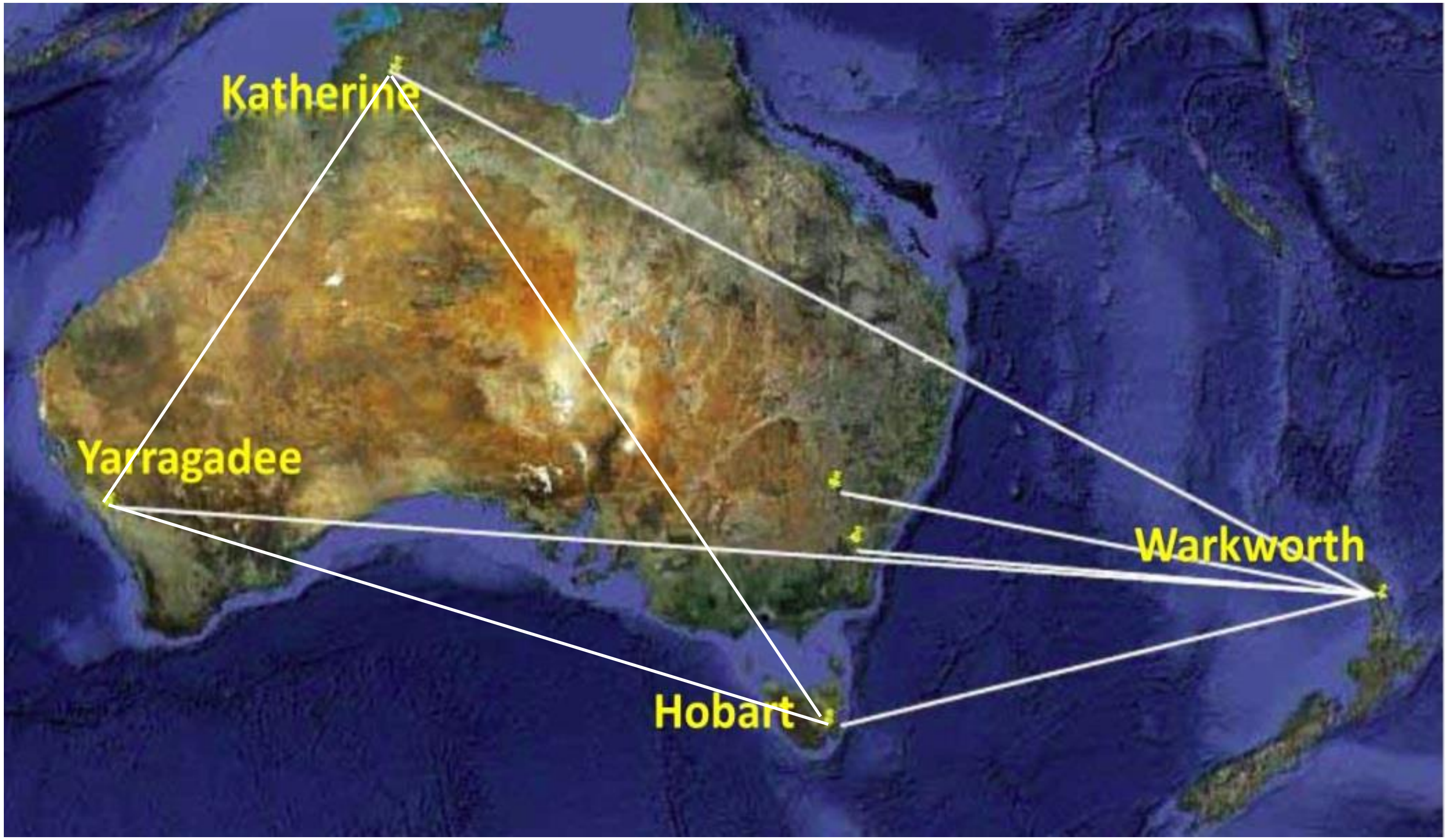
12 M RADIO TELESCOPE

SUGGESTED SITES FOR GRAVITY MARK INSTALLATION

L.J.WOODBURN 23 September 2014

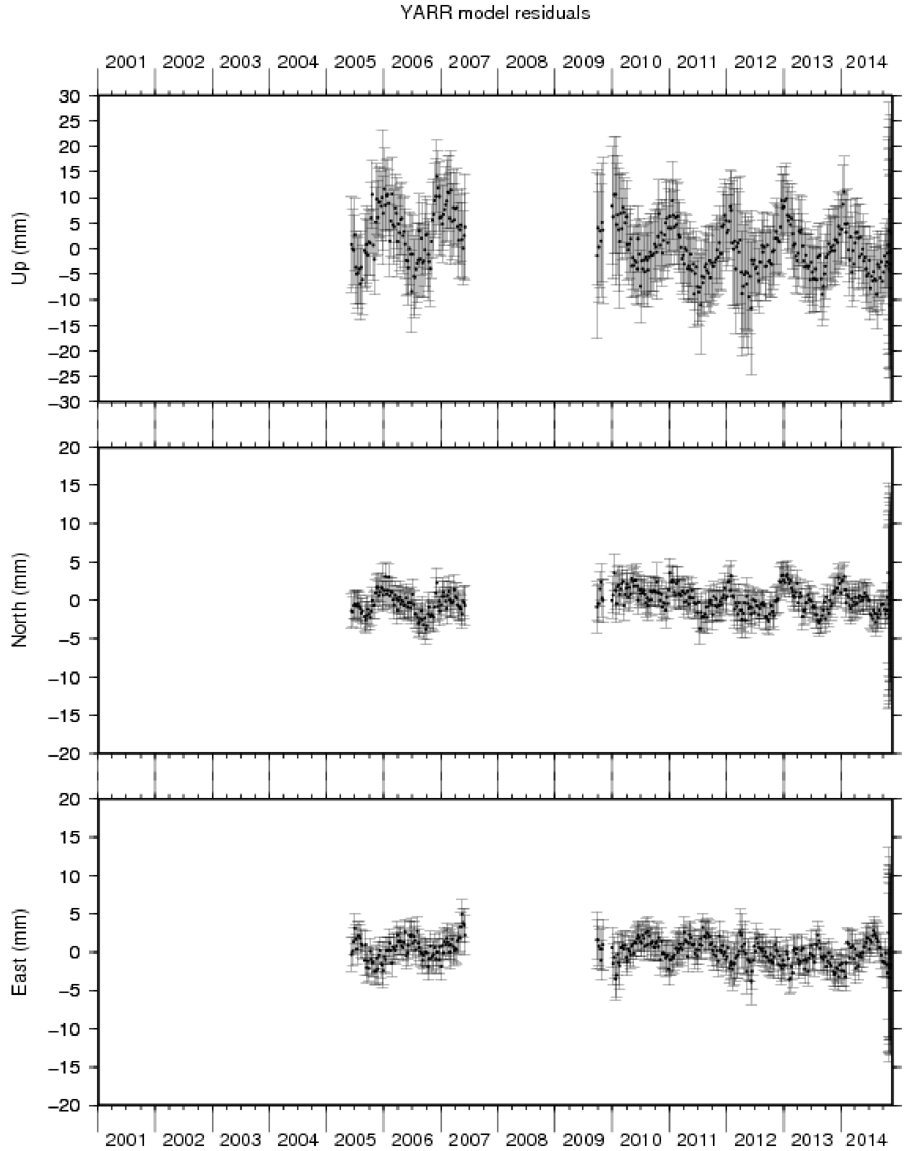
AuScope

AuScope

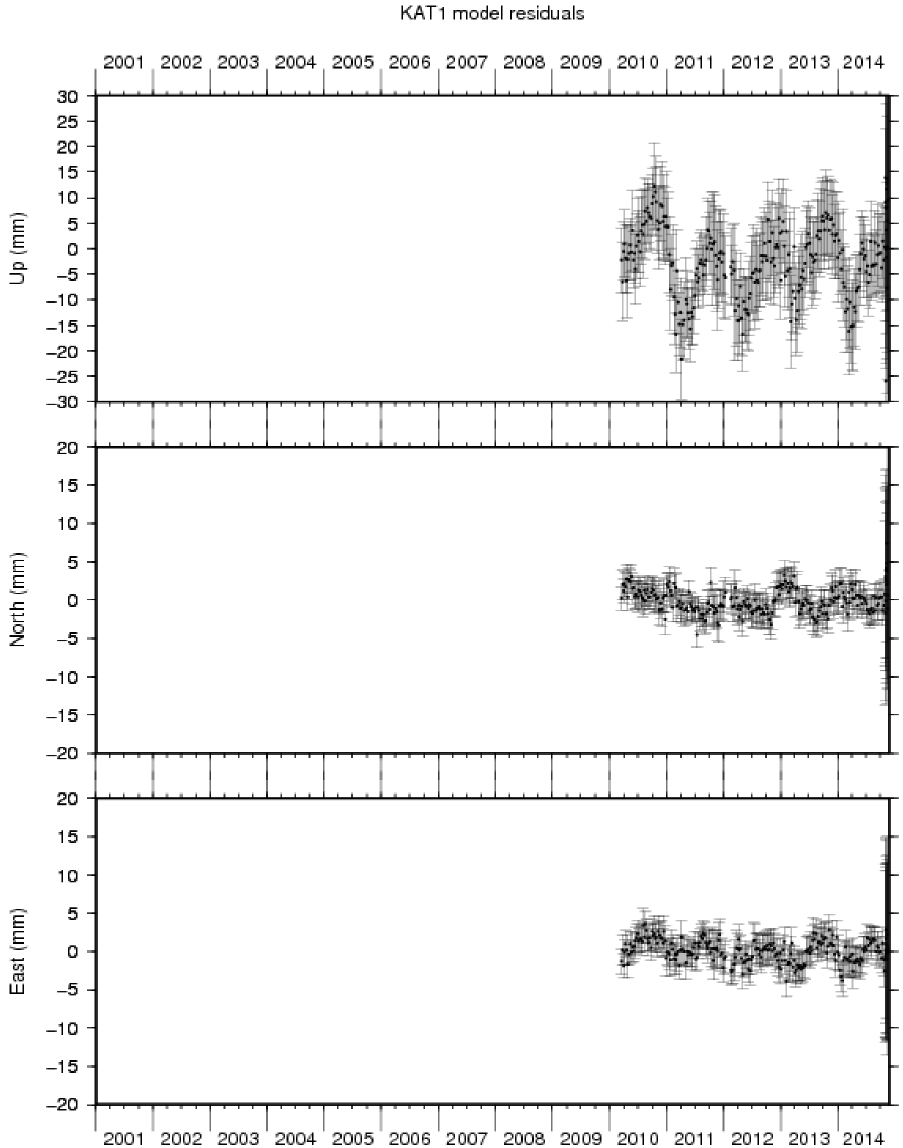


GGOS stations in Australasia.

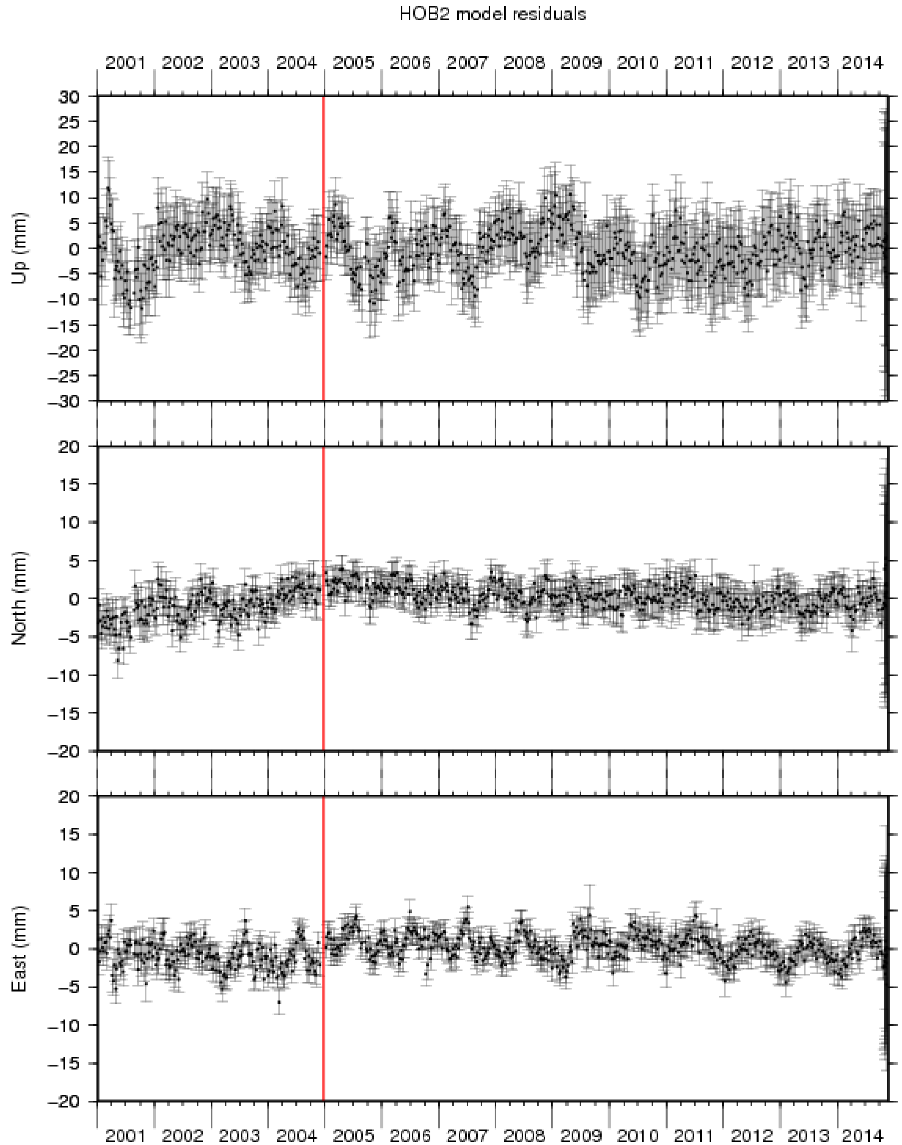
GNSS coordinate variations – YARR



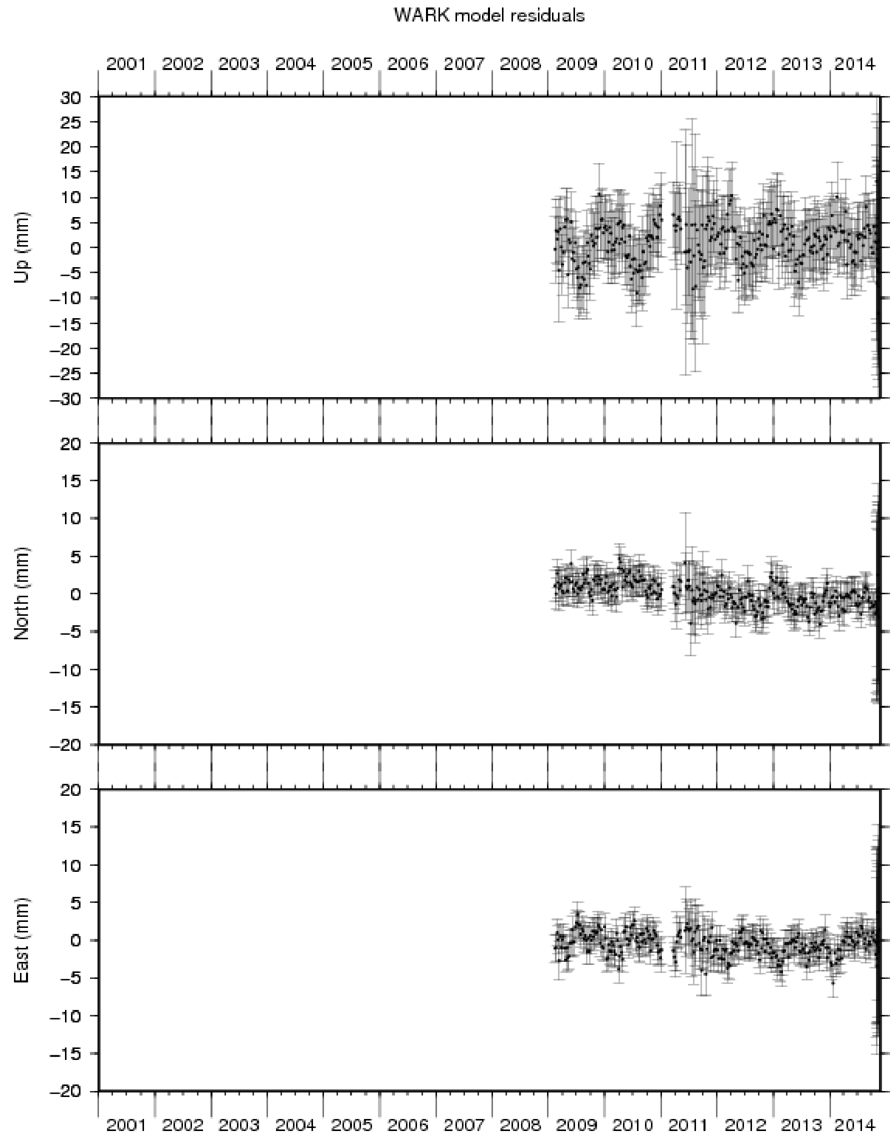
GNSS coordinate variations – KAT1



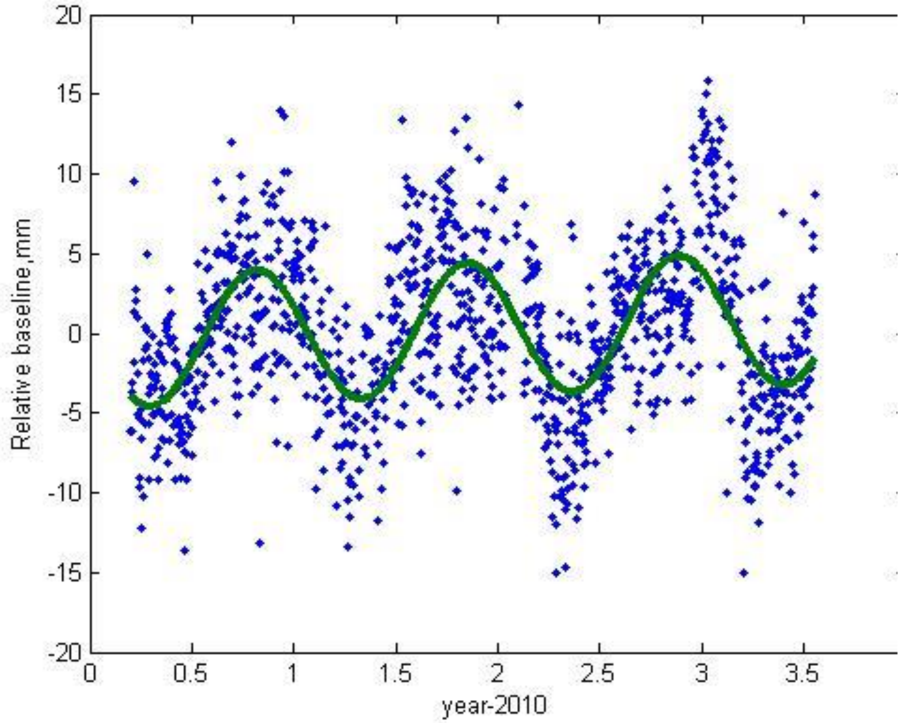
GNSS coordinate variations – HOB2

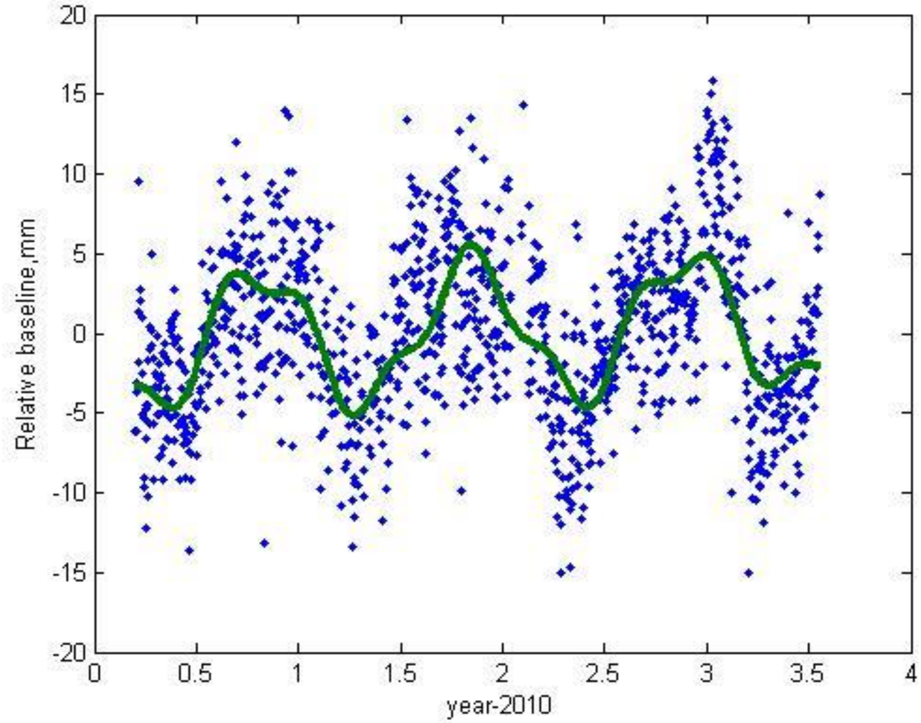


GNSS coordinate variations – WARK



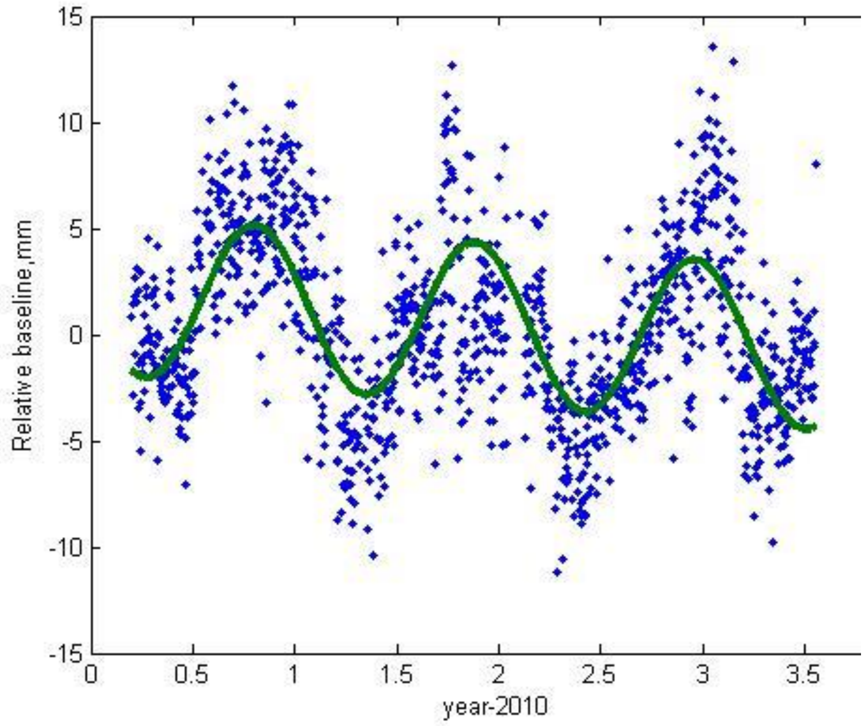
GNSS baseline variations

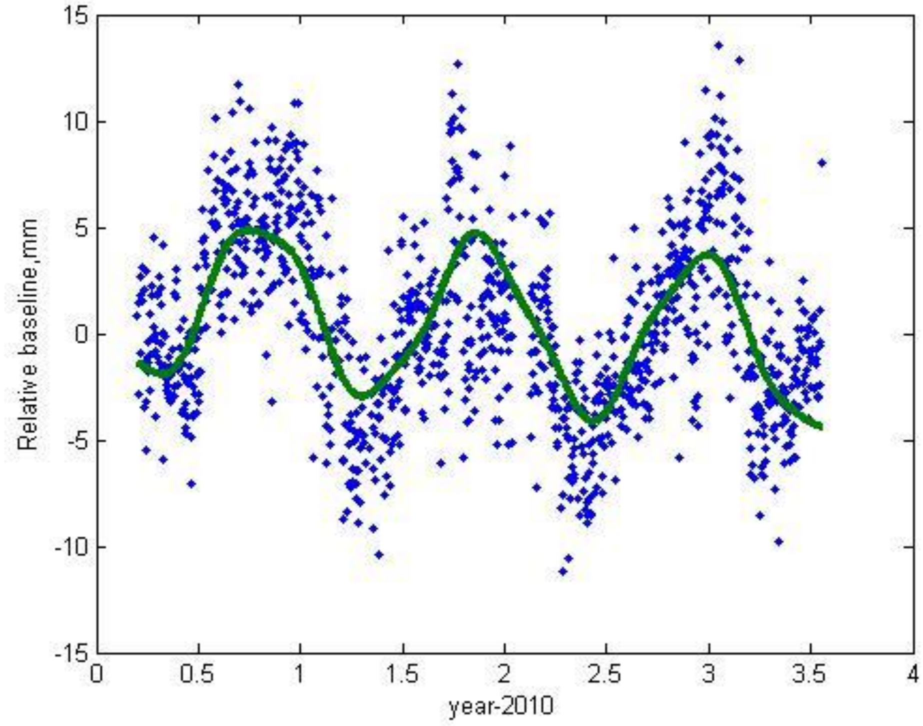




Ho-Ka GNSS baseline

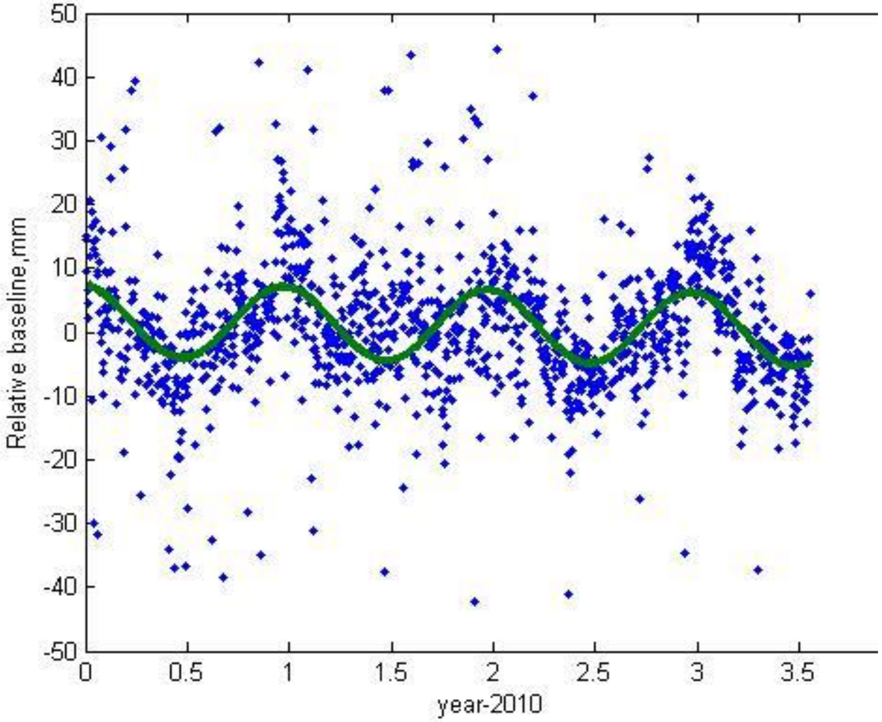
GNSS baseline variations

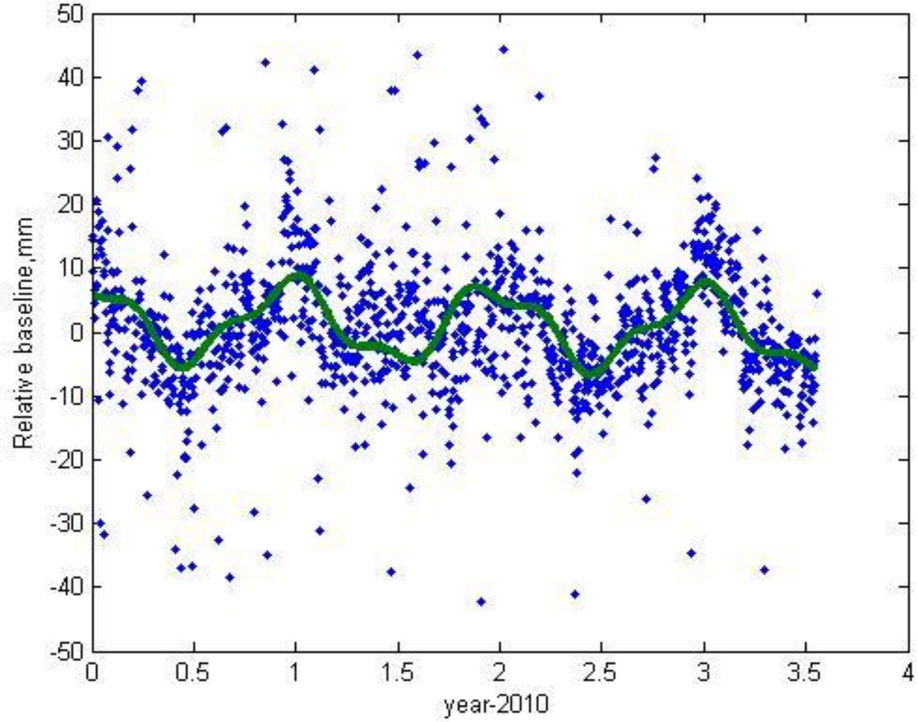




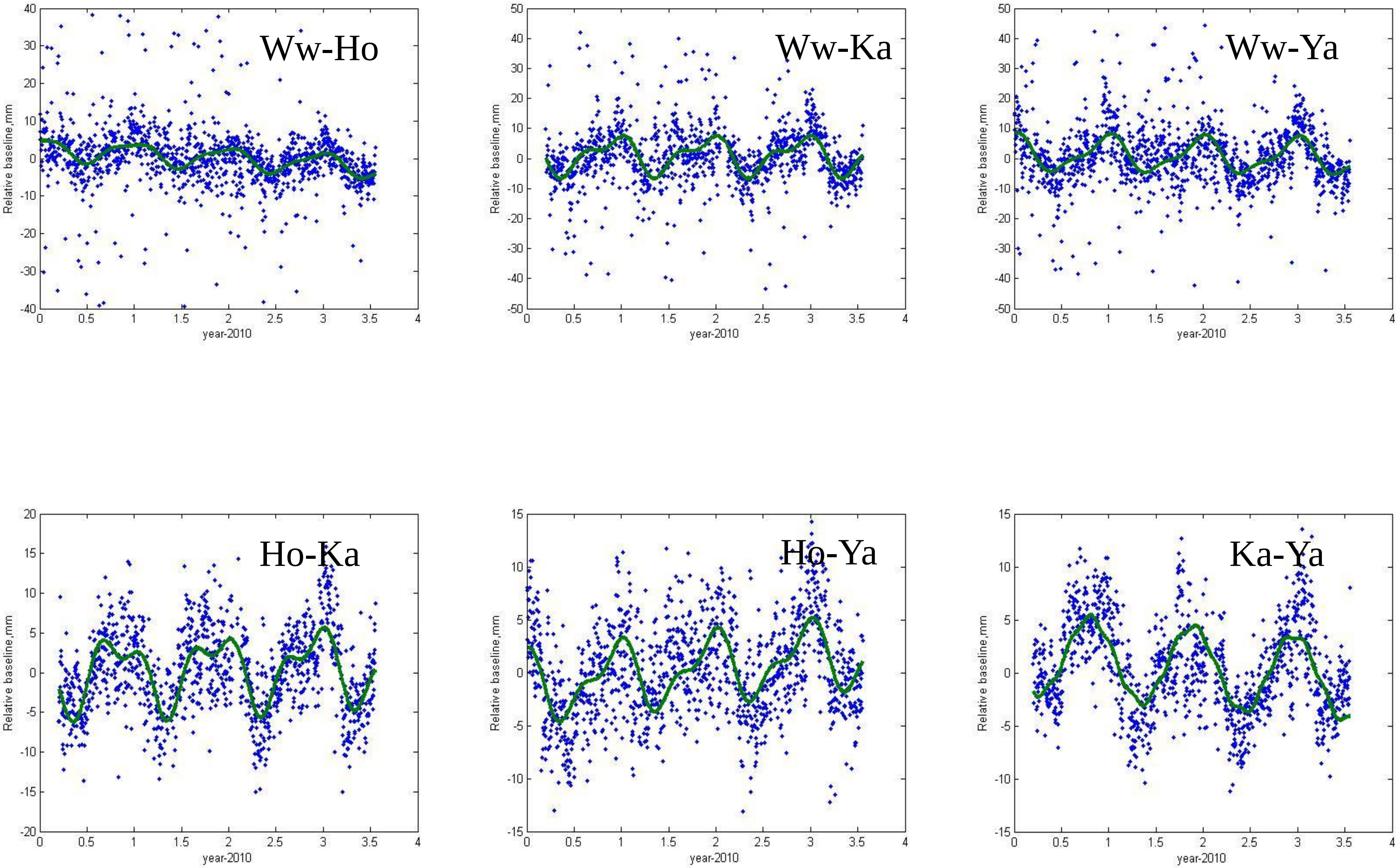
Ya-Ka GNSS baseline

GNSS baseline variations



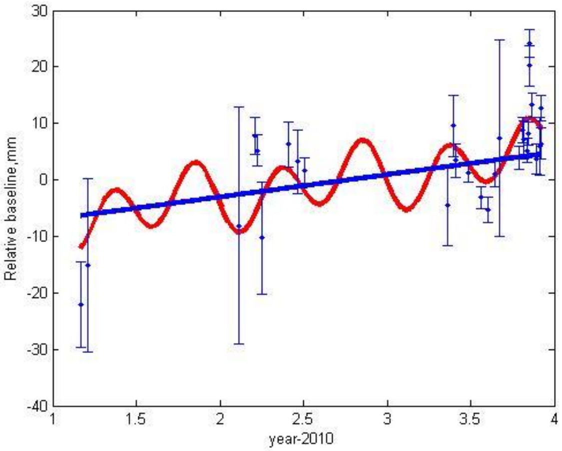


Ww-Ya GNSS baseline

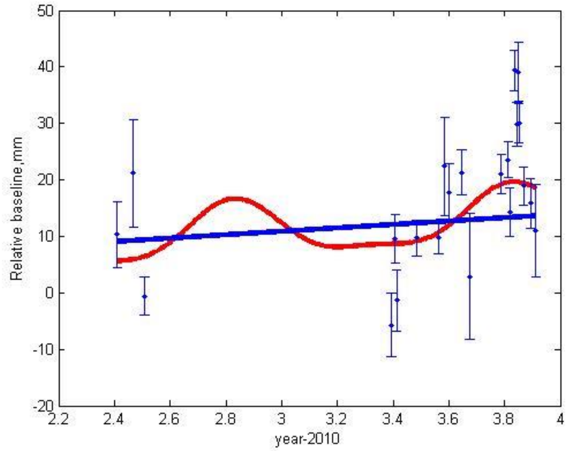

Ww-Ho
Ww-Ka
Ww-Ya
Ho-Ka
Ho-Ya
Ka-Ya
Relative baseline,mm
year-2010

VLBI baseline variations

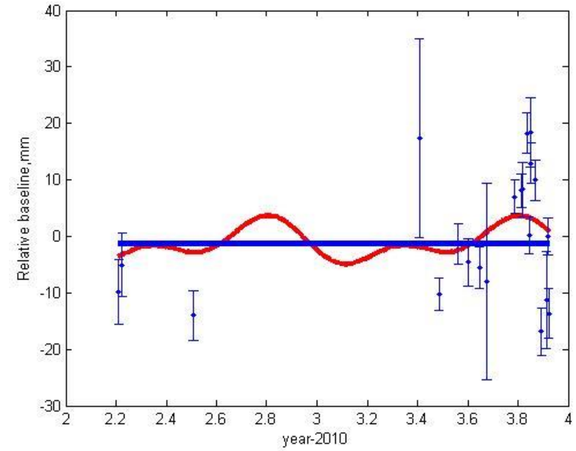
Ww-Ho



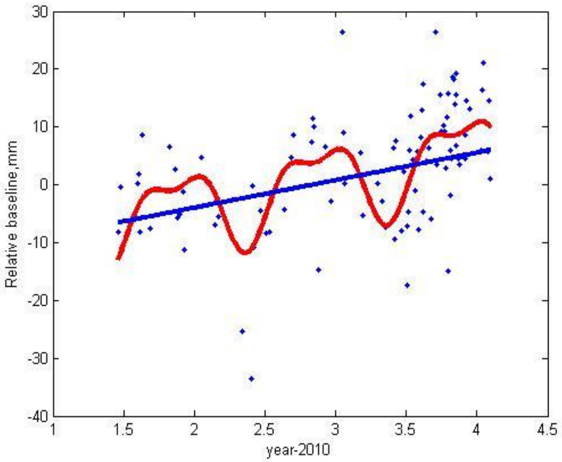
Ww-Ka



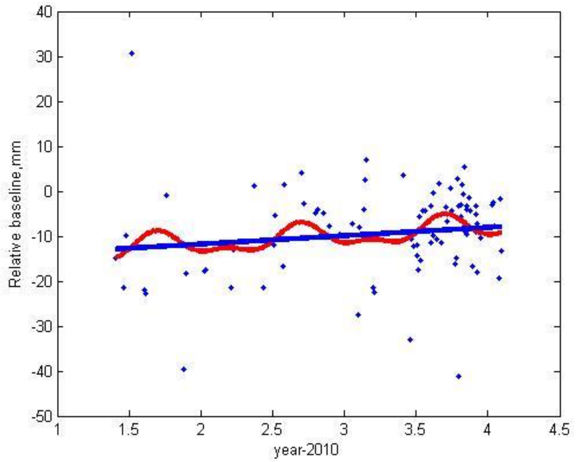
Ww-Ya



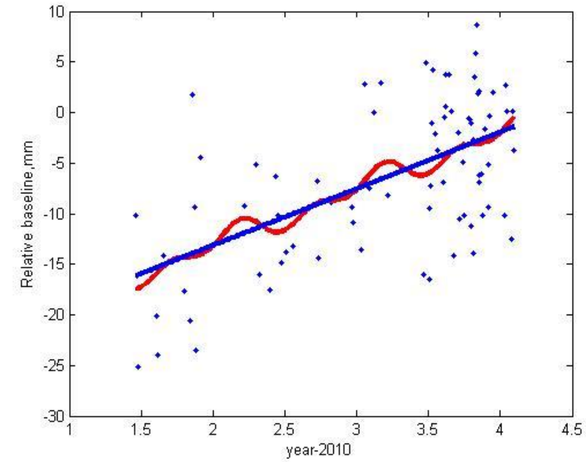
Ho-Ka



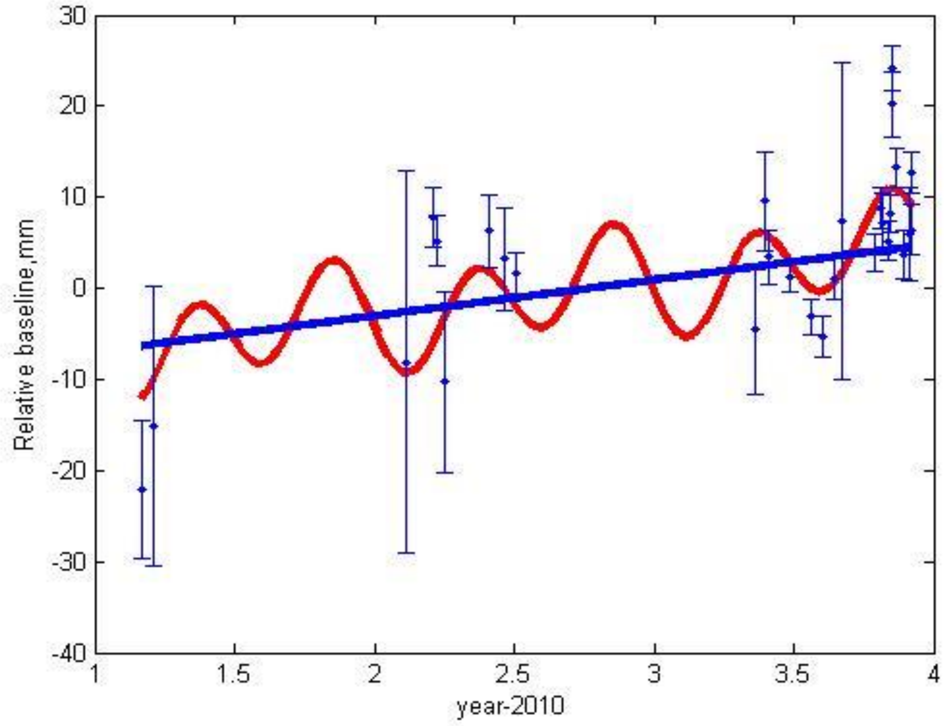
Ho-Ya



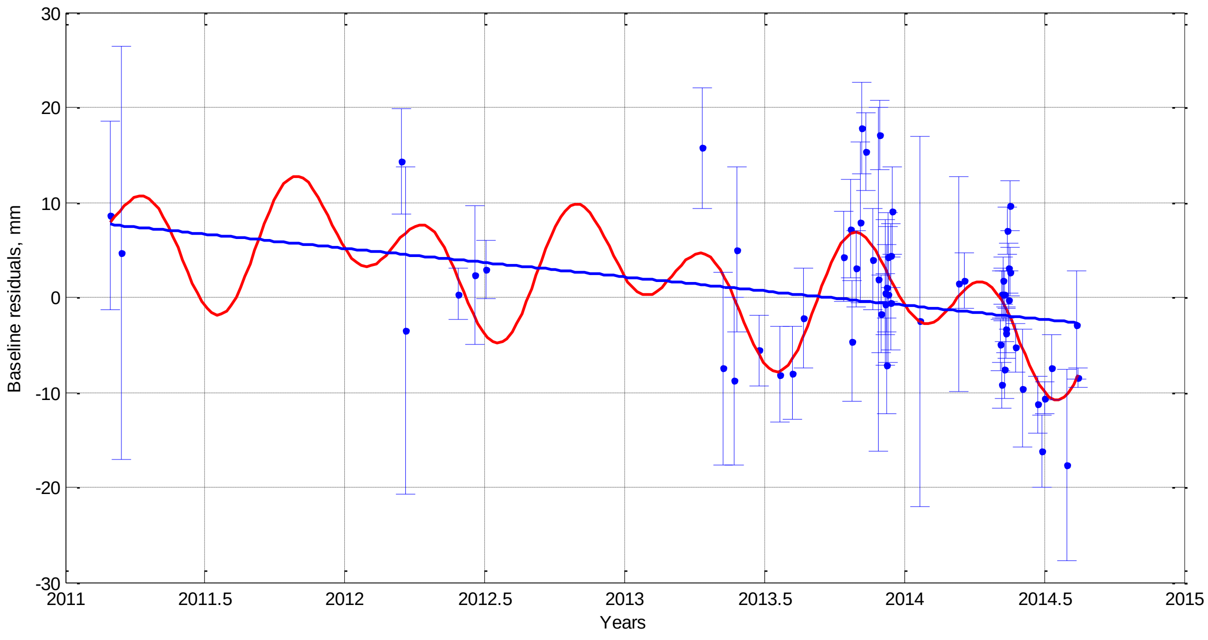
Ka-Ya



Ho-Ww

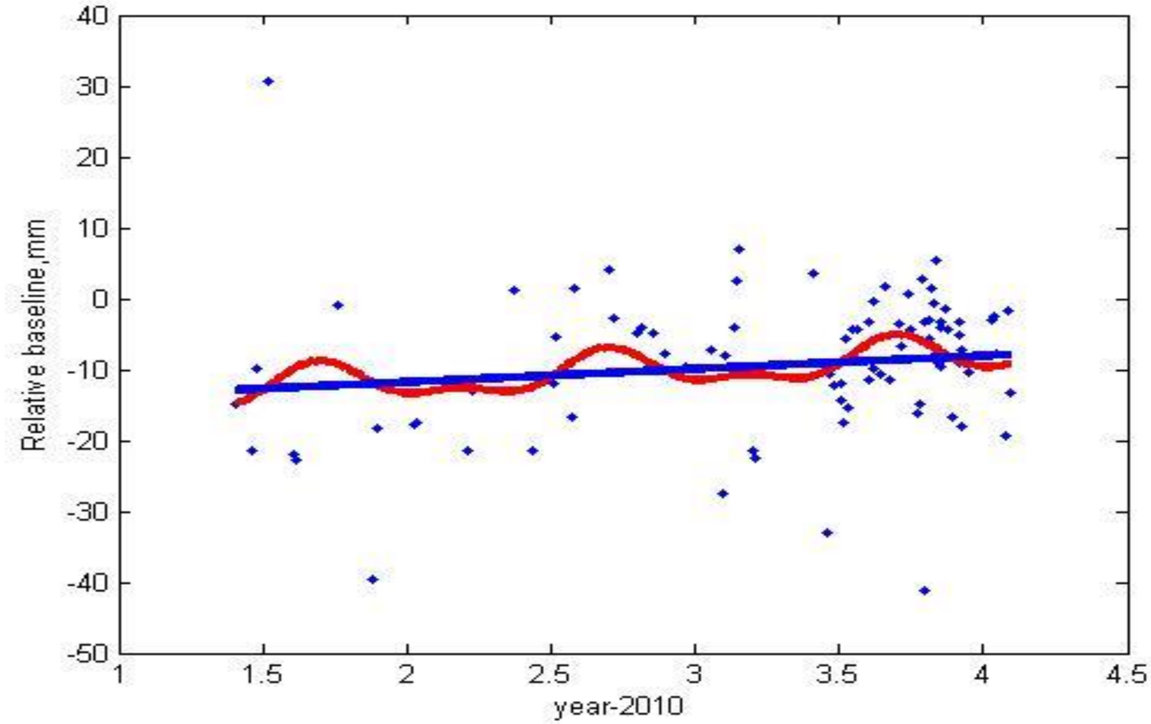


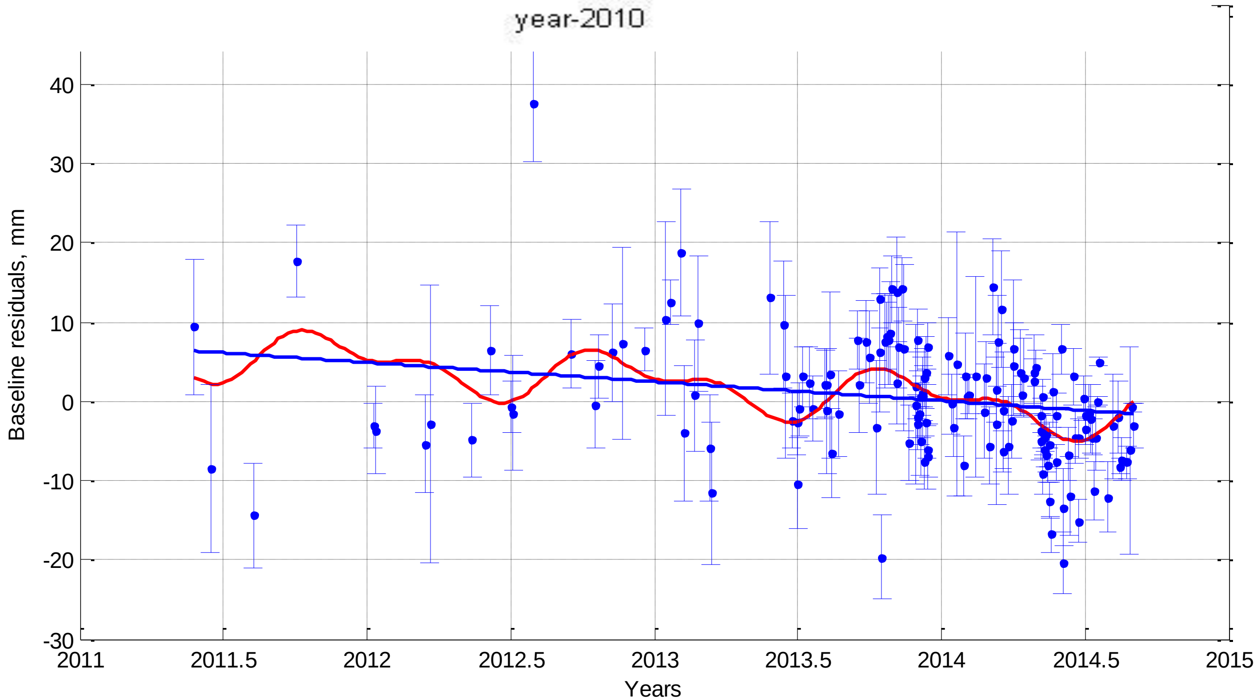
Relative baseline,mm
year-2010
30
20
10
0
-10
-20
-30
-40
1
1.5
2
2.5
3
3.5
4



Baseline residuals, mm
Years
30
20
10
0
-10
-20
-30
2011
2011.5
2012
2012.5
2013
2013.5
2014
2014.5
2015

Ho-Ya

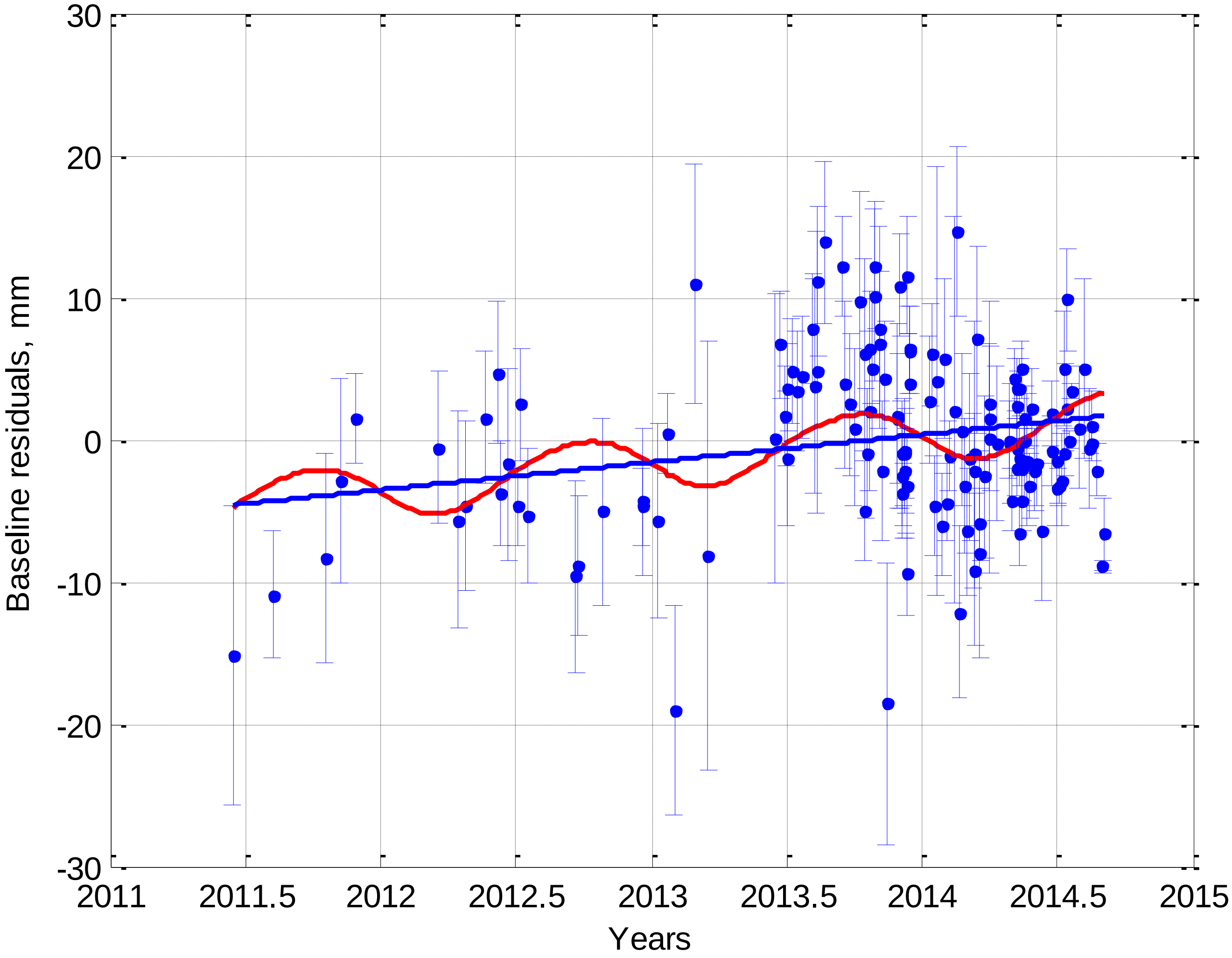

Relative baseline,mm
year-2010
40
30
20
10
0
-10
-20
-30
-40
-50
1
1.5
2
2.5
3
3.5
4
4.5


Baseline residuals, mm
Years
40
30
20
10
0
-10
-20
-30
2011
2011.5
2012
2012.5
2013
2013.5
2014
2014.5
2015

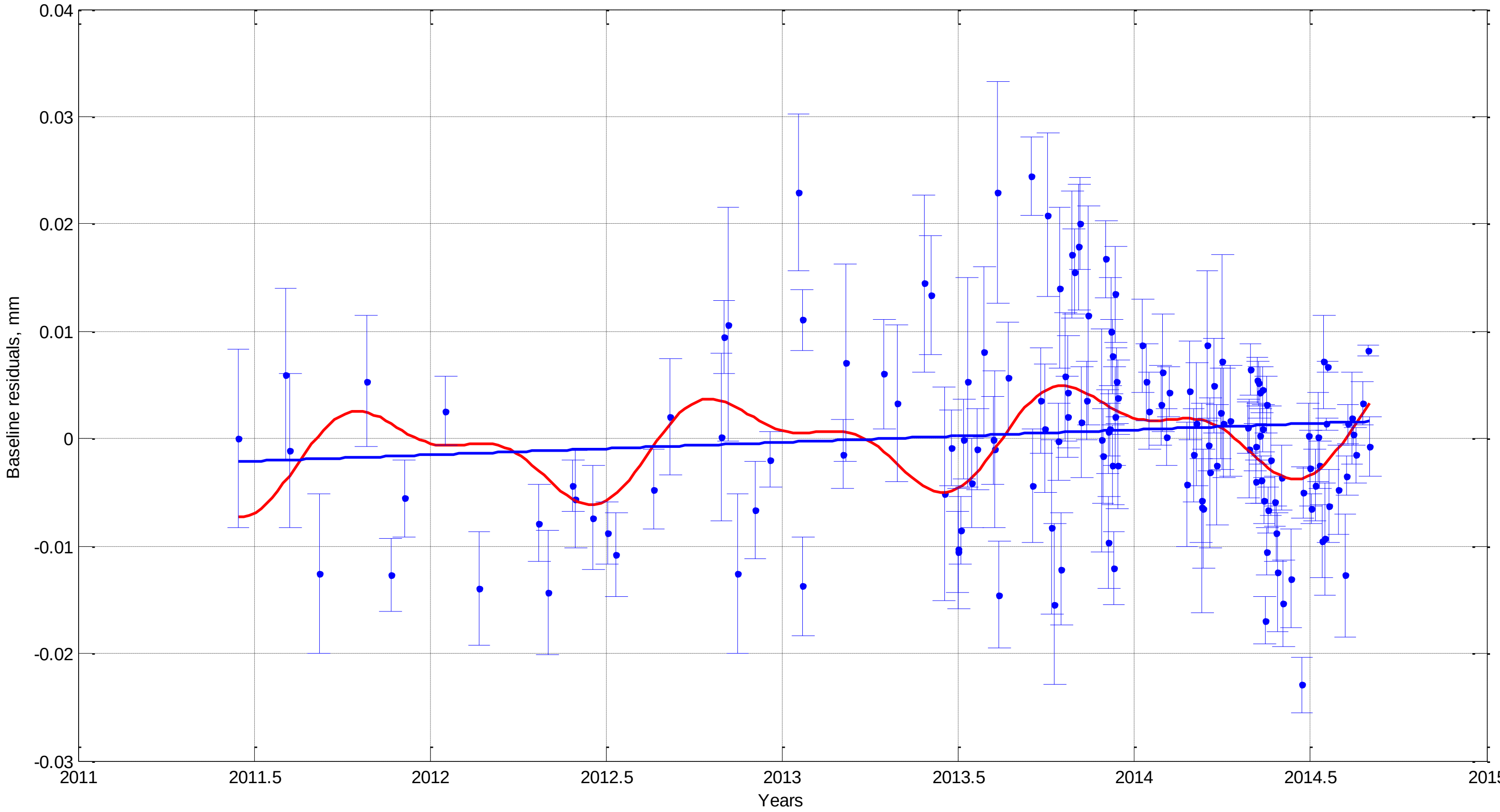
Coefficients	Table 1. GNSS baseline fitting parameters					
	WwHo	WwKa	WwYa	HoKa	HoYa	KaYa
x1(1)	2.75	5.47	5.49	4.03	2.86	3.50
x1(2)	-0.02	-0.10	-0.03	-0.13	-0.06	-0.12
x1(3)	2.78	1.17	1.73	-0.14	-1.36	2.25
x1(4)	-1.45	-0.02	-0.41	0.31	0.93	-0.78
x1(5)	0.59	2.82	1.94	2.18	1.37	1.20
x1(6)	-0.09	-0.93	-0.19	-0.17	0.06	-0.17
resnorm	7.5e+04	9.1e+04	1.1e+05	1.9e+04	1.7e+04	1.2e+04
stdev_resid	7.84	9.01	9.37	4.09	3.77	3.32
stdev_y	8.26	10.04	10.31	5.28	4.50	4.34

Coefficients	Table 2. VLBI baseline fitting parameters					
	WwHo	WwKa	WwYa	HoKa	HoYa	KaYa
x1(1)	2.13	4.79	2.87	6.65	2.34	0.82
x1(2)	-0.27	-0.17	-0.24	-0.13	-0.30	0.12
x1(3)	-10.96	1.78	-1.33	-13.49	-15.53	-24.35
x1(4)	3.95	3.03	0.02	4.76	1.86	5.60
x1(5)	5.13	-1.48	-2.20	-2.94	-1.23	-0.81
x1(6)	0.36	0.08	0.07	9.86	-0.06	-0.05
resnorm	1.1e+03	2.1e+03	2.1e+03	6.2e+03	8.5e+03	2.9e+03
stdev_resid,	6.36	9.64	10.21	8.15	9.94	6.22
stdev_y	9.59	12.06	11.33	10.45	10.23	7.72

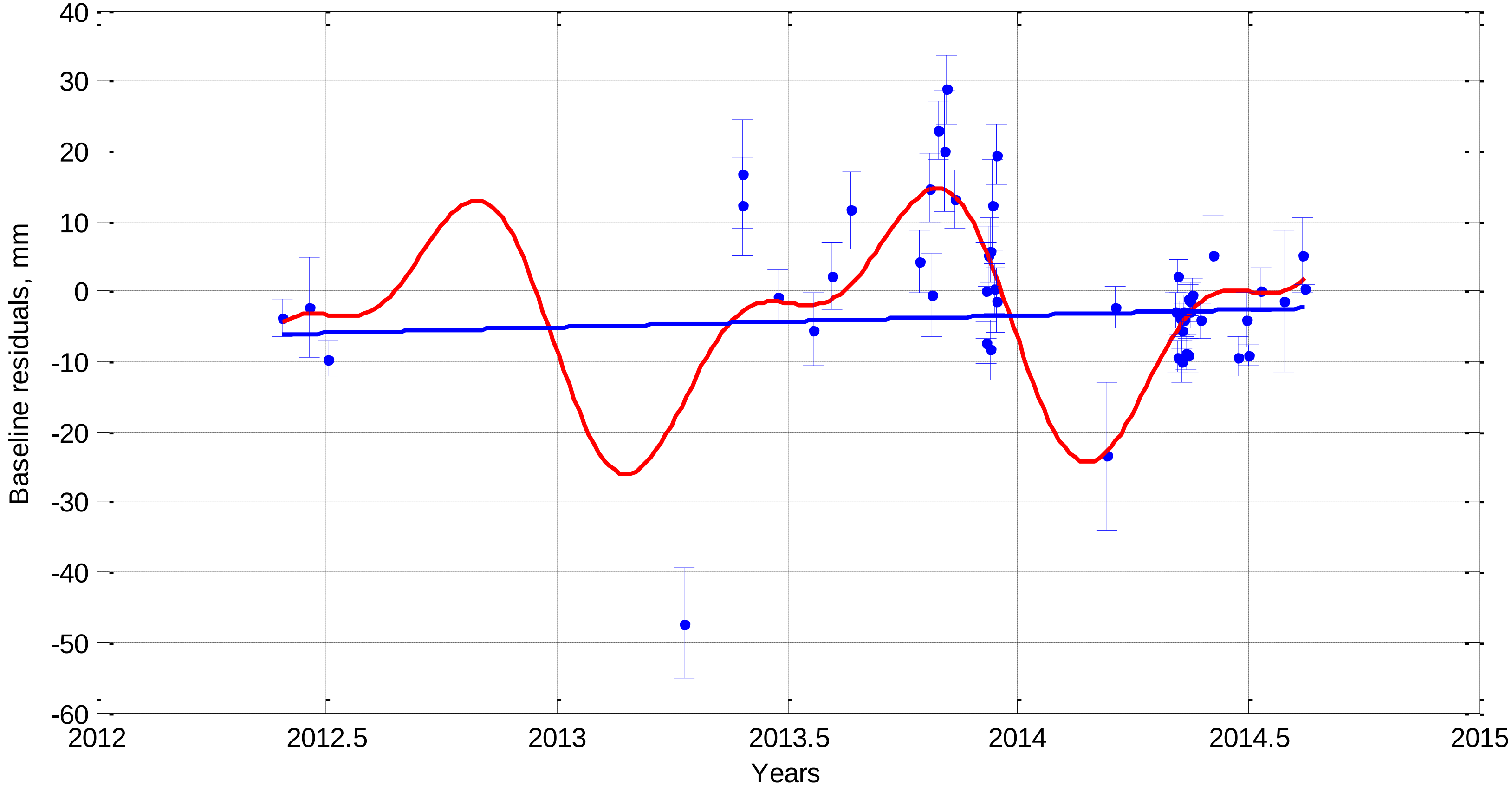
KaYa


30
20
10
0
-10
-20
-30
Baseline residuals, mm
2011
2011.5
2012
2012.5
2013
2013.5
2014
2014.5
2015
Years

Ho-Ka

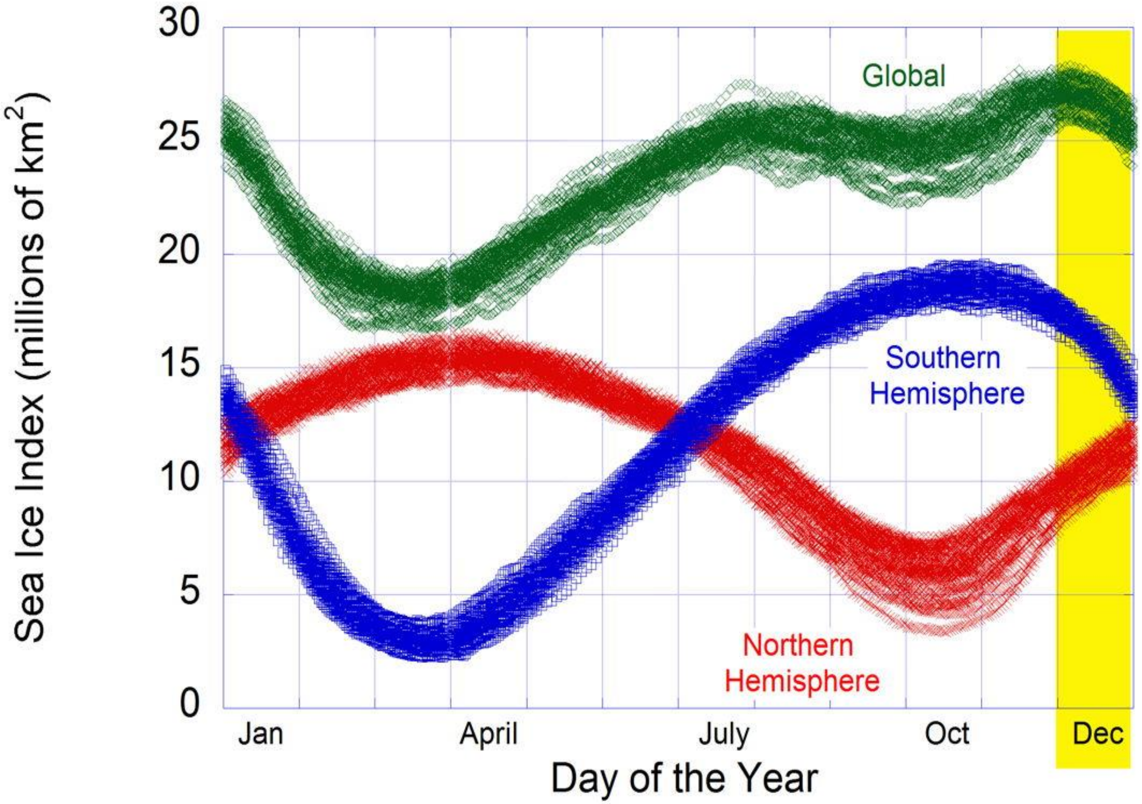

0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
Baseline residuals, mm
2011
2011.5
2012
2012.5
2013
2013.5
2014
2014.5
2015
Years

Ww-Ka



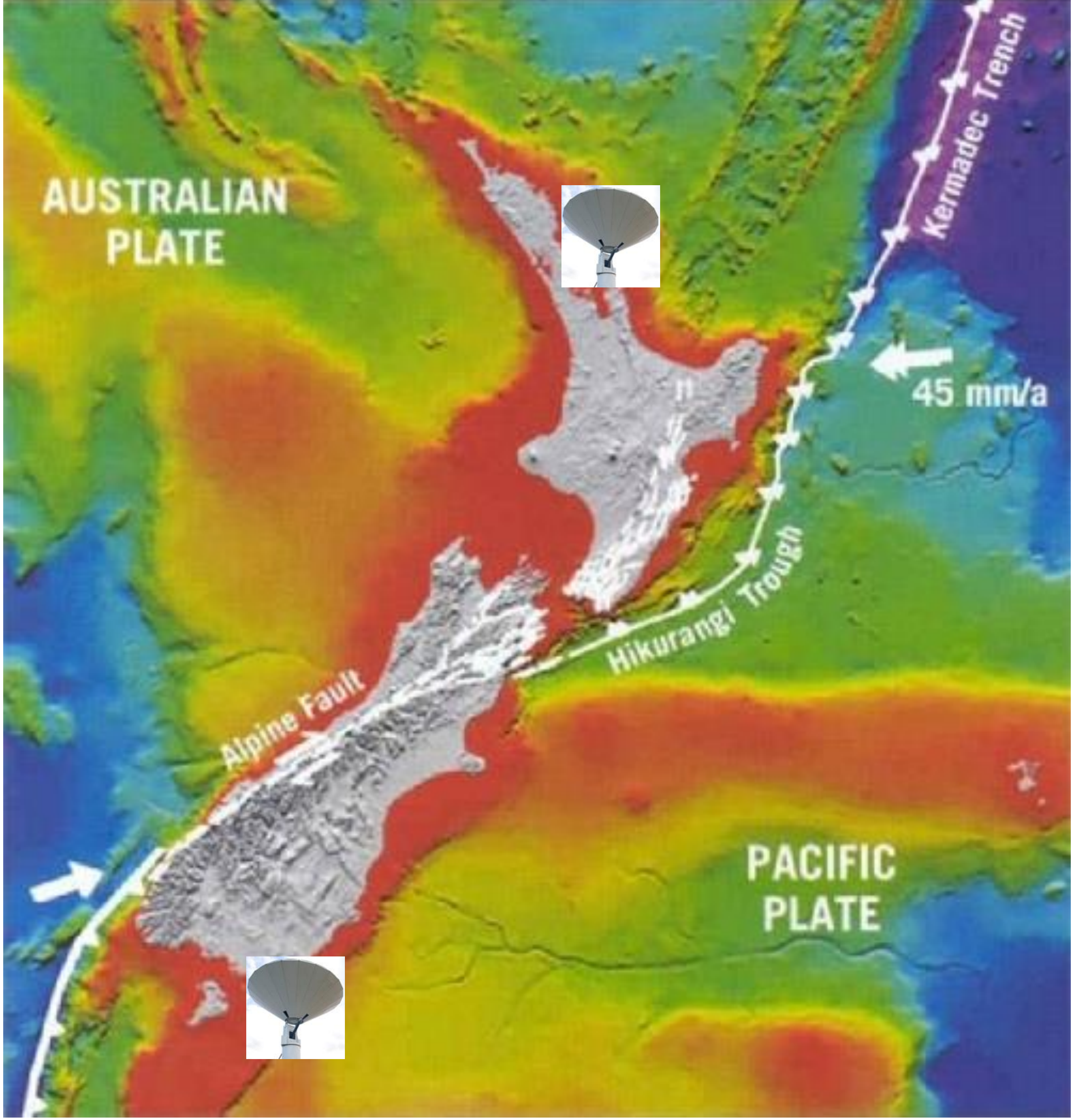
40
30
20
10
0
-10
-20
-30
-40
-50
-60
2012
2012.5
2013
2013.5
2014
2014.5
2015
Years
Baseline residuals, mm

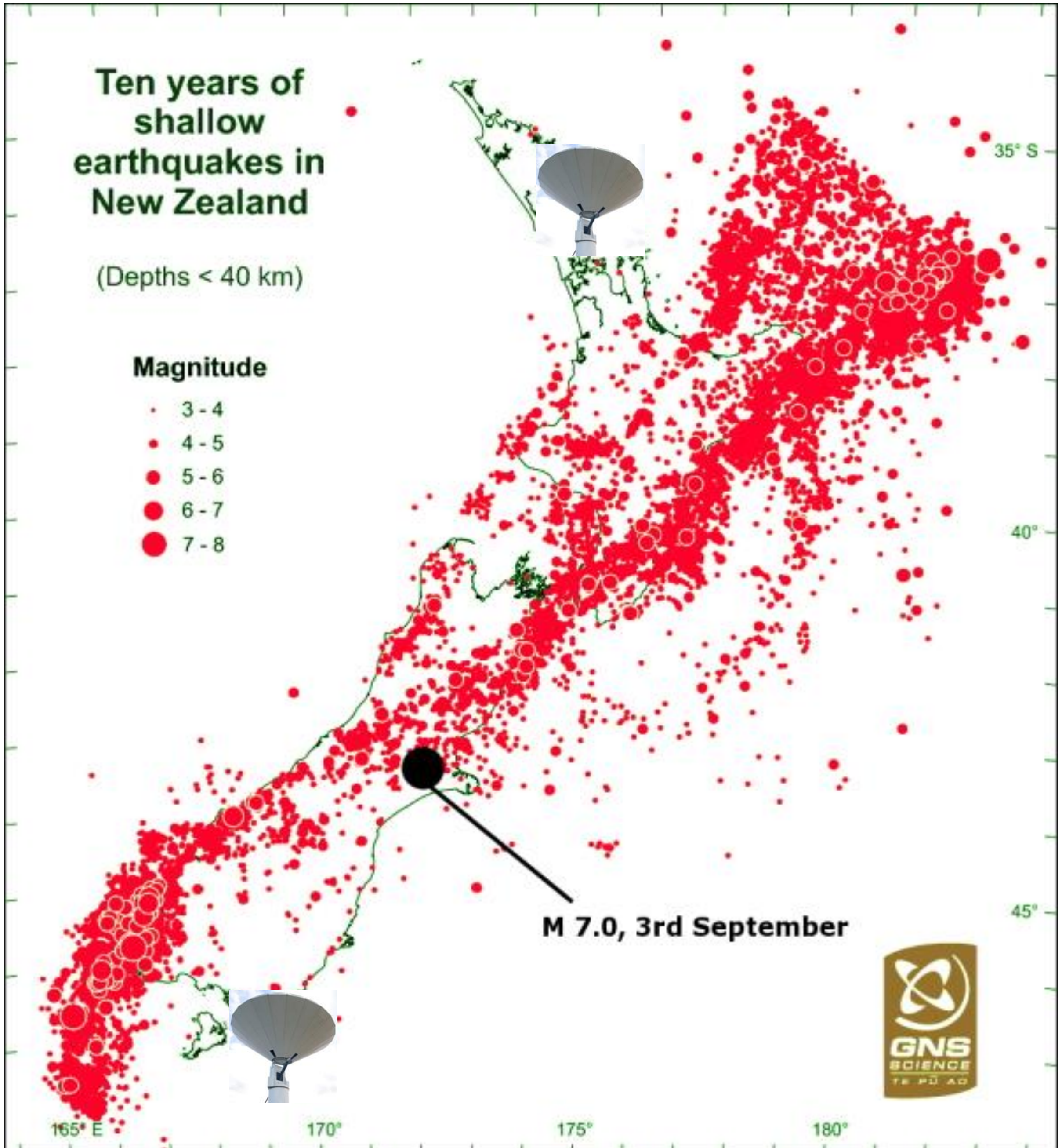
Sea ice extent



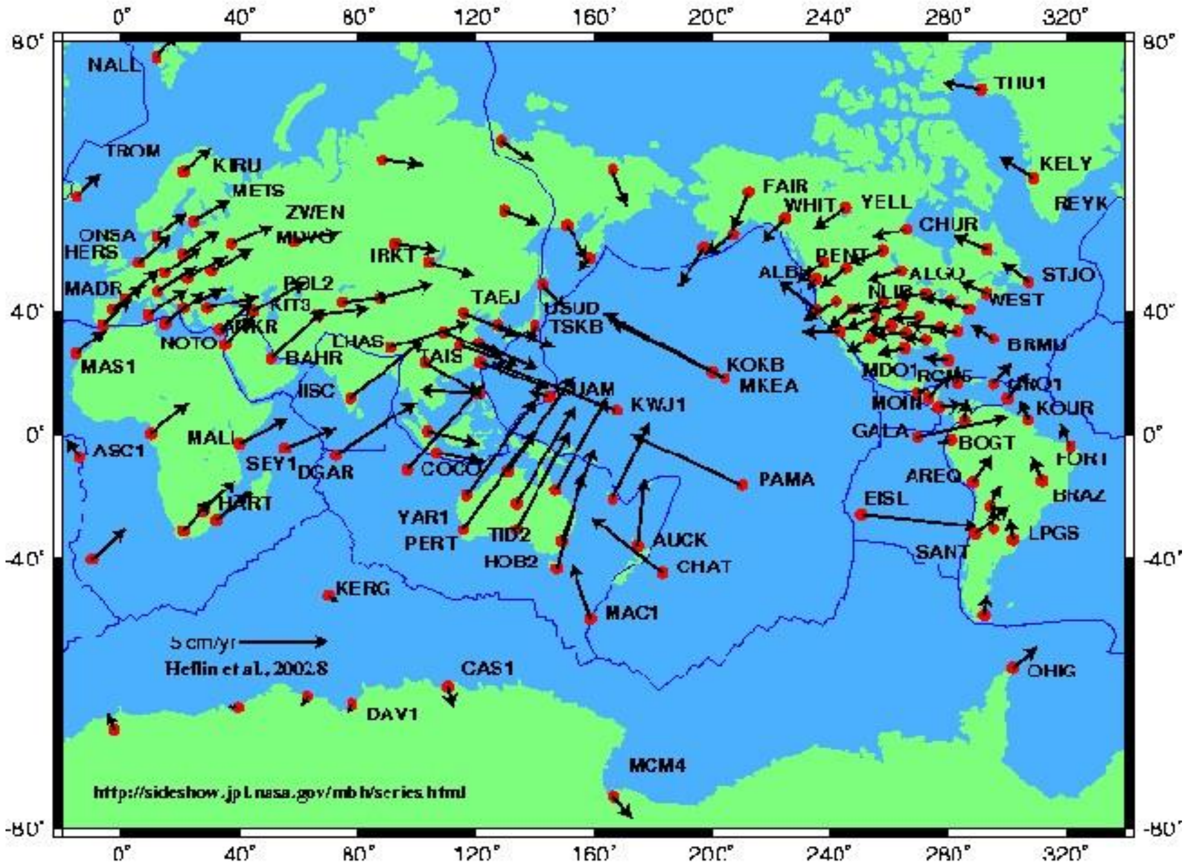
Data from US NSIDC showing the northern hemisphere, southern hemisphere and global sea ice extent plotted versus the day of the year. Based on 50 years observations


US Dept of State Geographer
© 2014 Google
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

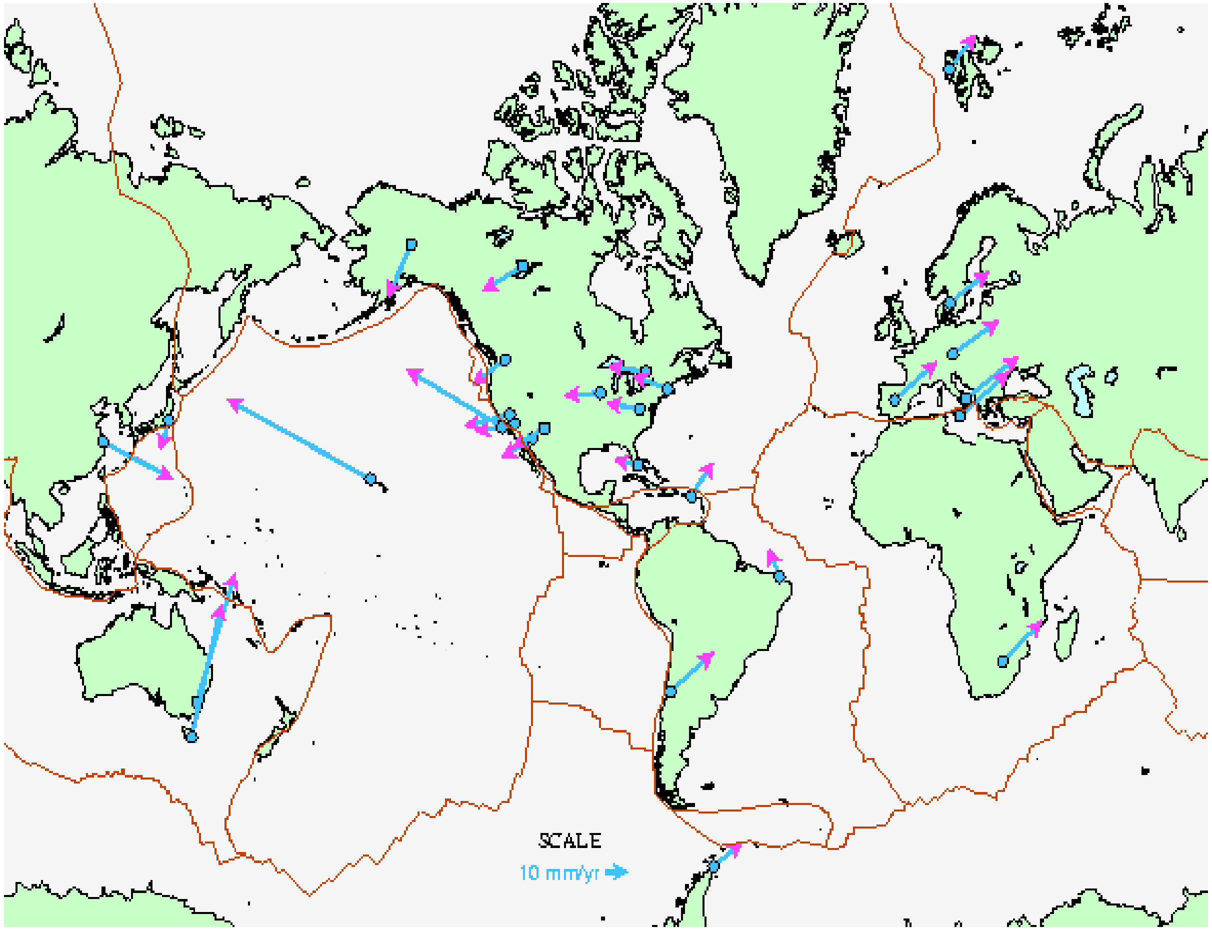

AUSTRALIAN
PLATE
Kermadec Trench
45 mm/a
Hikurangi Trough
Alpine Fault
PACIFIC
PLATE


Ten years of shallow earthquakes in New Zealand
(Depths < 40 km)
Magnitude
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
35° S
40°
45°
165° E
170°
175°
180°
M 7.0, 3rd September
GNS SCIENCE
TE PŪ AO

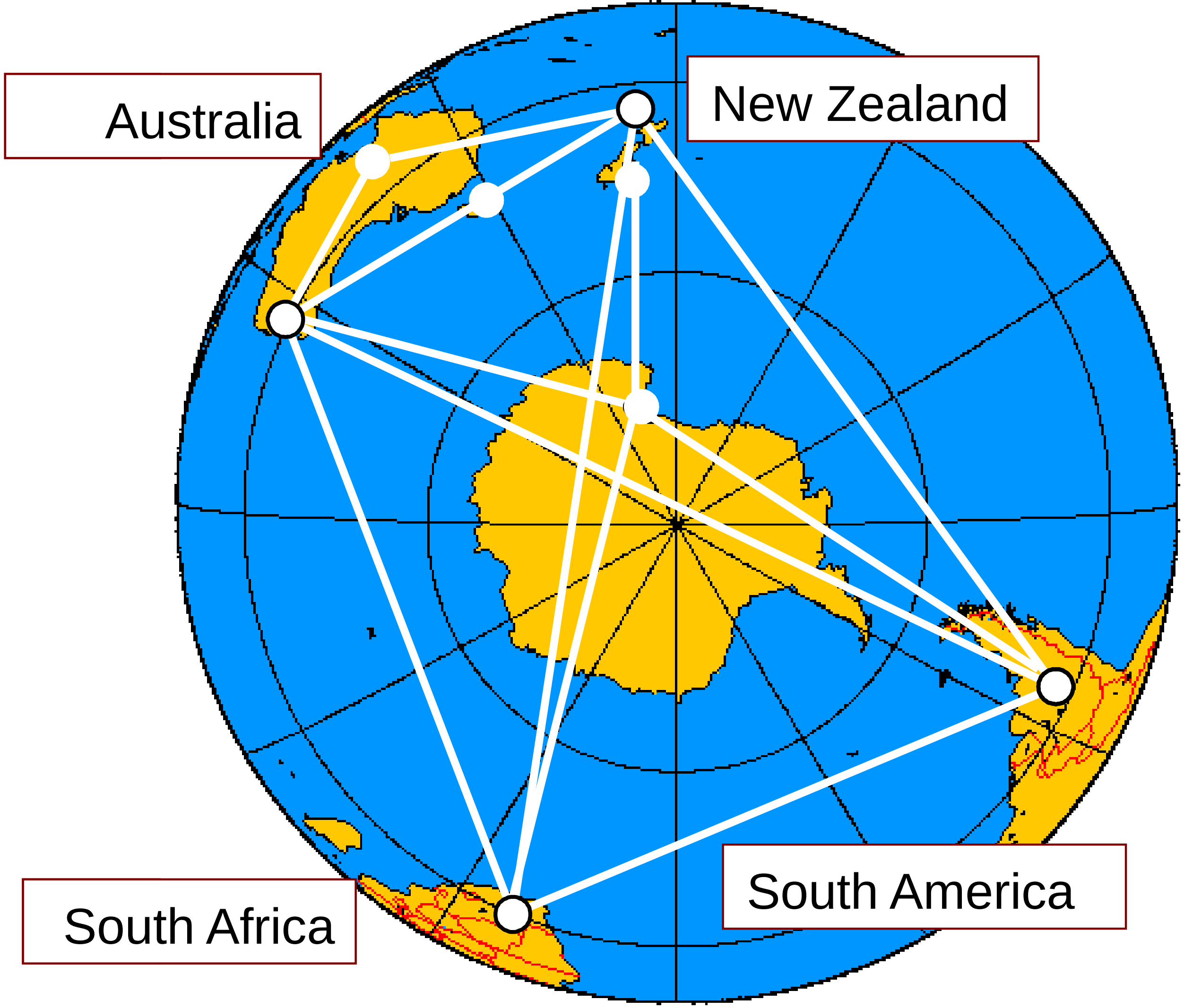
EOLSS - MANTLE DYNAMICS AND PLATE KINEMATICS



Motions of tectonic plates based on GNNS observations. The plot was compiled by Heflin et al., 2002 using the NASA database *http://sideshow.jpl.nasa.gov/post/series.html*



Annual movement of radio telescopes, measured by geodetic VLBI. The Hartebeesthoek telescope moves North-East at 2.5 cm per year. Tectonic plate boundaries are shown as brown lines.
http://www.hartrao.ac.za/summary/sumeng.html



Geographical distribution of GGOS stations – Australia, New Zealand, South Africa, South Ametica. Locations of possible antennas in NZ South Island and in NZ Scott Base (Antarctica) are indicated. Projection: polar orthographic.

Thank you !