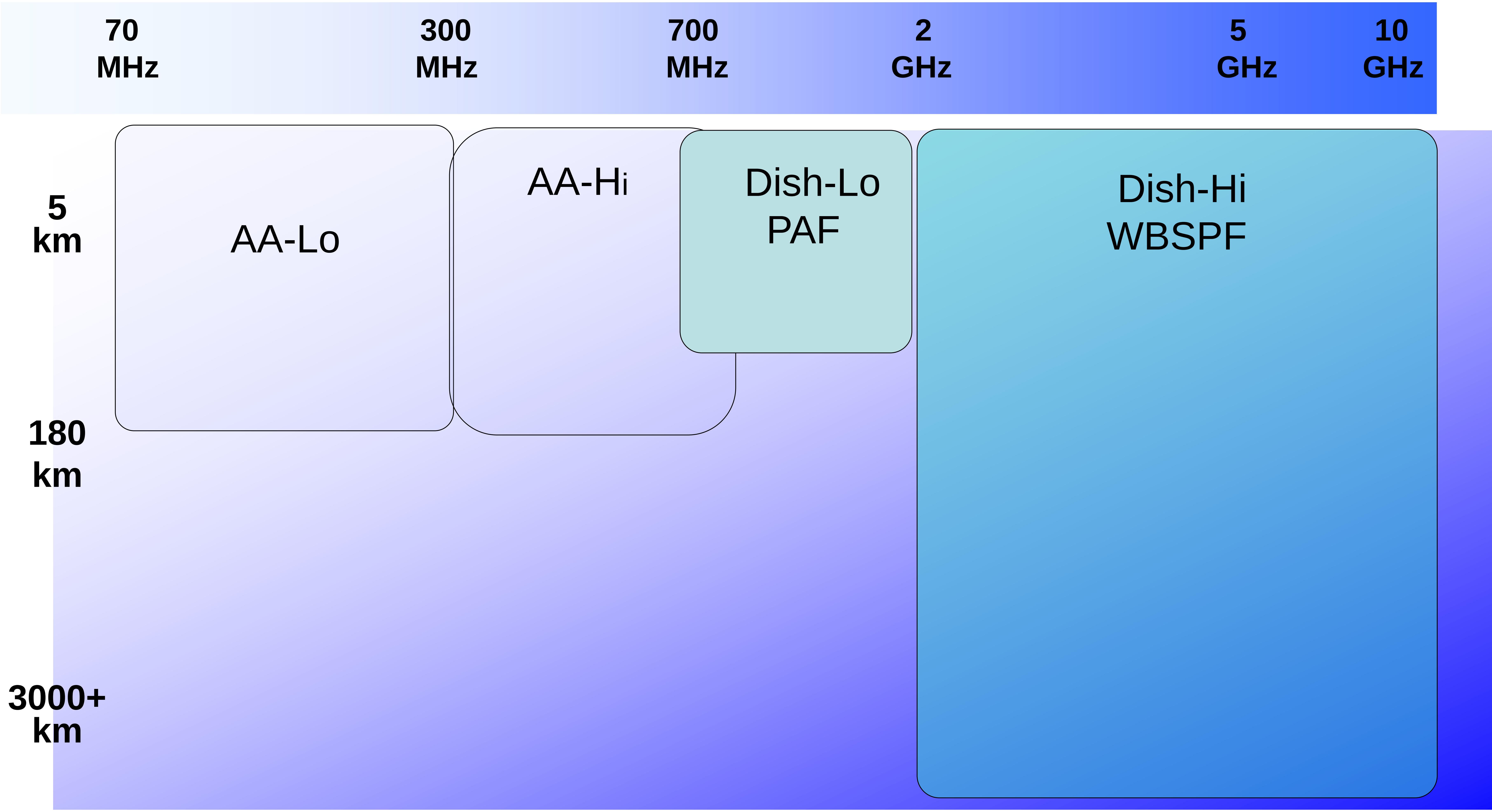

SKANZ 2012
CONFERENCE
Auckland, New Zealand
InterTronic Antennas
Creating solutions in communications and science
CSIRO
SKA
SQUARE KILOMETRE ARRAY
AUT
UNIVERSITY
anzska
INSTITUTE FOR
RADIO ASTRONOMY & SPACE RESEARCH
AN INSTITUTE OF AUT UNIVERSITY

Australasian VLBI:
SKA and NZ Agenda

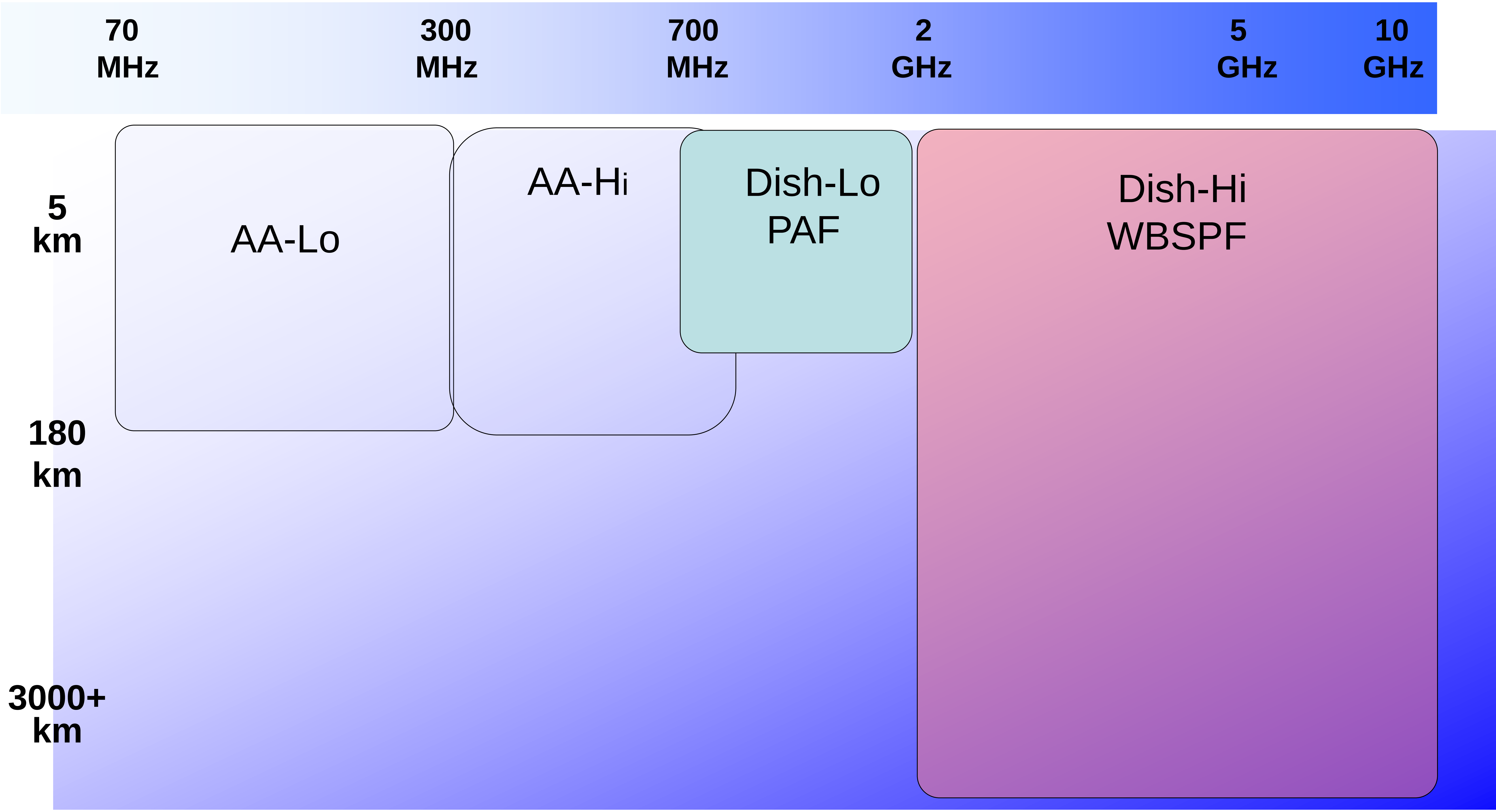
Sergei Gulyaev
AUT University

SKA Common Framework



Credit: R. Schilizzi

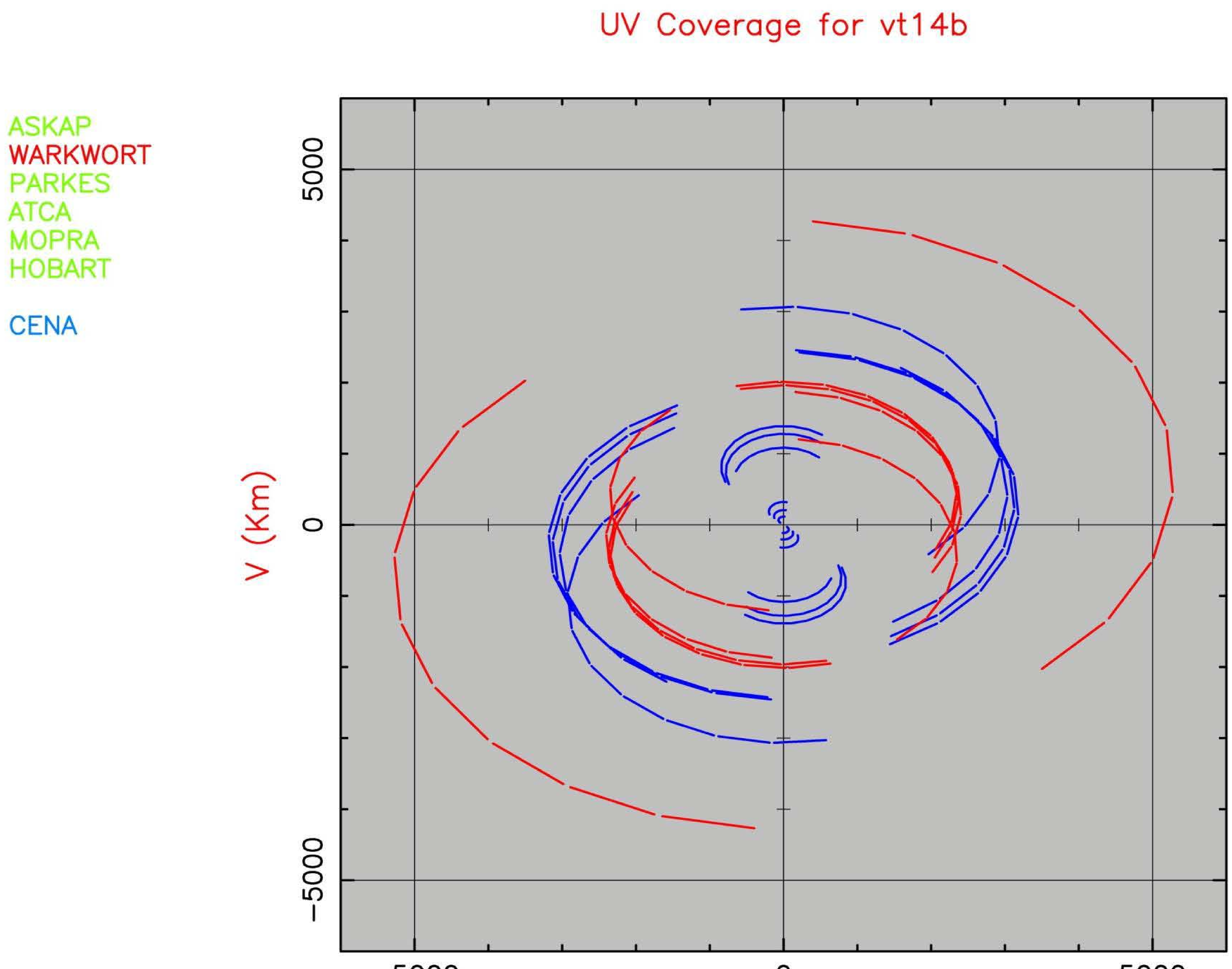
SKA Common Framework



Credit: R. Schilizzi

ASKAP--LBA--NZ VLBI, April-May 2010

Credit: Brian Boyle/CSIRO/ANZSKA



http://cira.ivec.org/dokuwiki/doku.php/correlator/records/2010

Memo 135

Very High Angular Resolution Science with the SKA

L. Godfrey

H. Bignall

S. Tingay

International Centre for Radio Astronomy Research, Curtin University, Bentley, WA, Australia

May 2011

Very High Angular Resolution Science with the Square Kilometre Array

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Accepted for publication in PASA: November 24, 2011

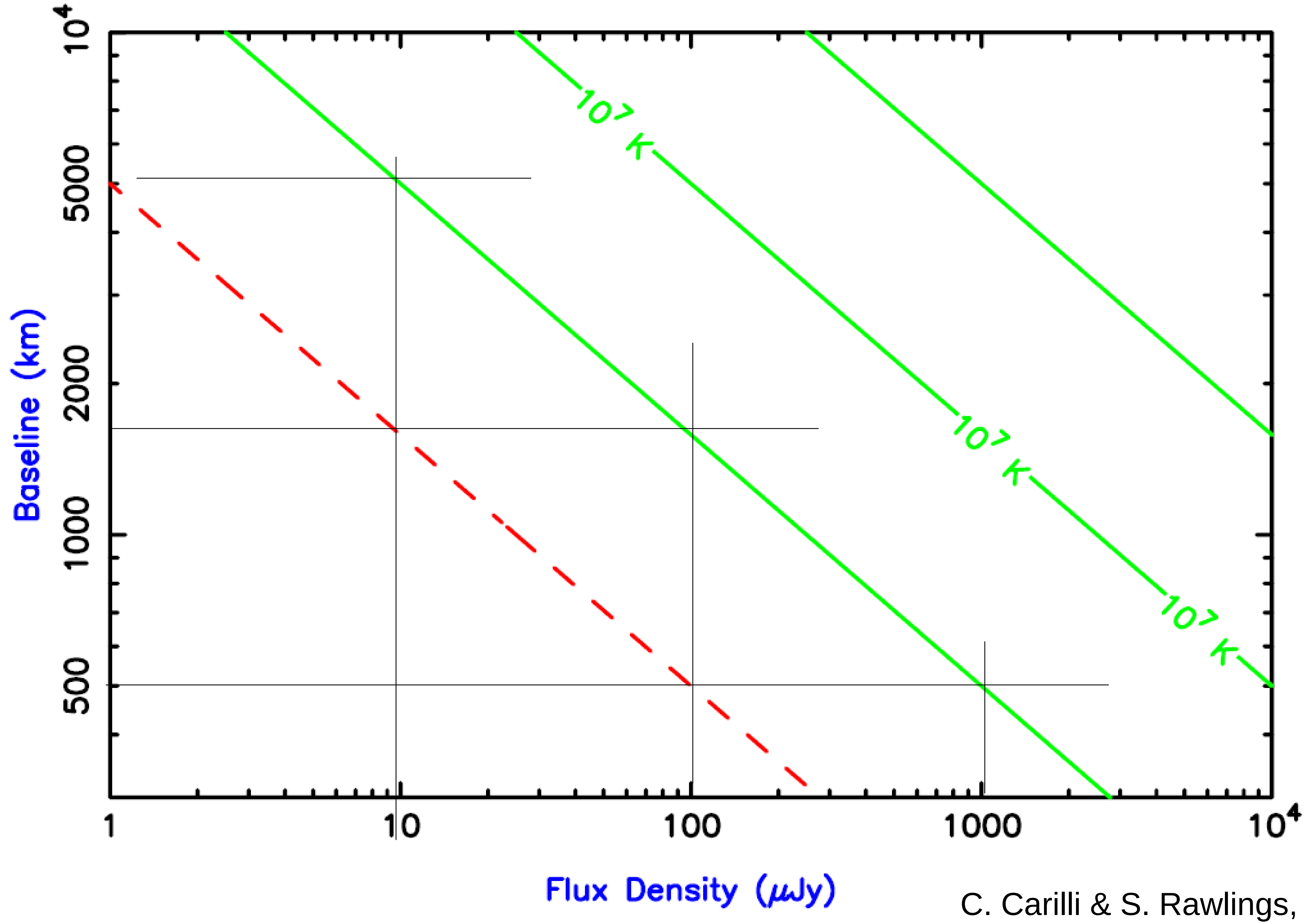
Abstract:
Preliminary specifications for the Square Kilometre Array (SKA) call for 25% of the total collecting area of the dish array to be located at distances greater than 180 km from the core, with a maximum baseline of at least 3000 km. The array will provide angular resolution $\theta \lesssim 40 - 2$ mas at $0.5 - 10$ GHz with image sensitivity reaching $\lesssim 50$ nJy/beam in an 8 hour integration with 500 MHz bandwidth. Given these specifications, the high angular resolution component of the SKA will be capable of detecting

Project	KSP	Frequencies [GHz]		Band
Pulsar Astrometry to enable projects including: **- Strong field tests of gravity** **- Tomographic Mapping of the Galactic magnetic field** **- Mapping the ionized ISM**	Strong field tests of gravity Cosmic Magnetism	1.4 -- 8	> 300 MHz (ionosphere correction)	>
Imaging Proto-planetary disks (continuum)	Cradle of Life	5 -- 10	> 500 MHz (sensitivity)	>
Resolving AGN and star formation in galaxies	Galaxy Evolution, Cosmology and Dark Energy	0.5 -- 8	1 GHz	>
The first supermassive black holes	Probing the dark ages and the epoch of re-ionization	1.4	~ 300 MHz would be sufficient	>
Binary Supermassive Black Holes		5 -- 10	TBD	>

andwidth

Project	Max Baseline Length	Image Sensitivity	Survey Speed	
Pulsar Astrometry to enable projects including: - Strong field tests of gravity - Tomographic Mapping of the Galactic magnetic field - Mapping the ionized ISM	> 3000 km	---		
Imaging Proto-planetary disks (continuum)	> 1000 km	< 0.1 μJy/beam		
Resolving AGN and star formation in galaxies	> 3000 km	< 6 μJy/beam	1000 m^4 K^{-2} deg^2	1000 deg^2
The first supermassive black holes	> 4000 km	> 10 μJy/beam		
Binary Supermassive Black Holes	> 5000 km	---	> 50,000 sources in the order of a few months	

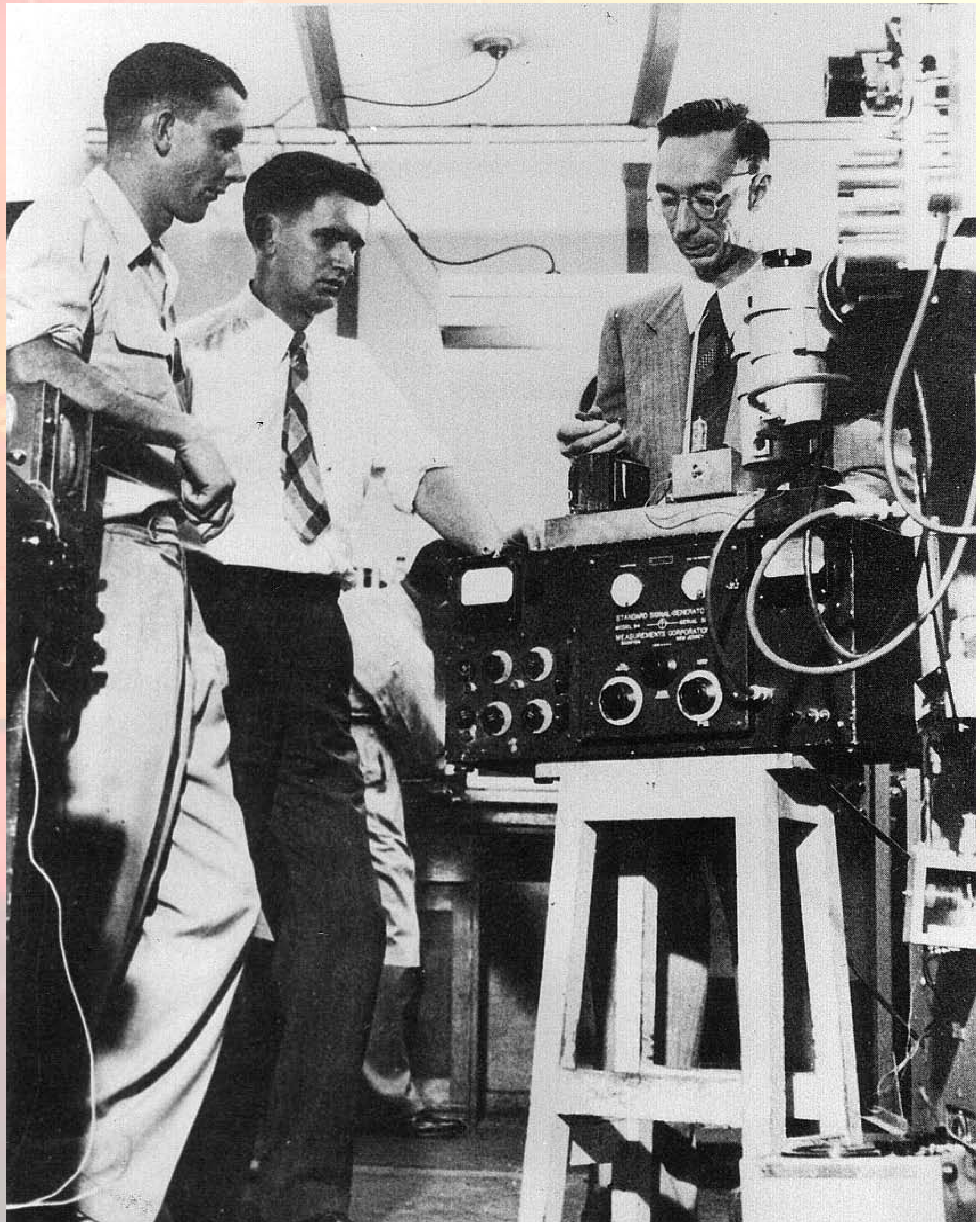
Project	…eld of View	Num. of Beams (FoV sampling)	Dynamic Range	Phase Referencing	Ae/…
Pulsar Astrometry to enable projects including: - Strong field tests of gravity - Tomographic Mapping of the Galactic magnetic field - Mapping the ionized ISM	> 4 beams (phase referencing	> 1000	Yes	~ 10,000 (assumed value i… Smits et al. 2011…	
Imaging Proto-planetary disks (continuum)	~ 4 beams (phase referencing)	Moderate to high dynamic range - complex source structure	Yes	~ 10,000	
Resolving AGN and star formation in galaxies	---	< 10,000	Yes	---	
The first supermassive black holes	~ 4 beams (phase referencing)	10,000 would be sufficient	Yes	1000 would be sufficient	
Binary Supermassive Black Holes	~ 4 beams (phase referencing	TBD	Yes	TBD	



C. Carilli & S. Rawlings, 2004

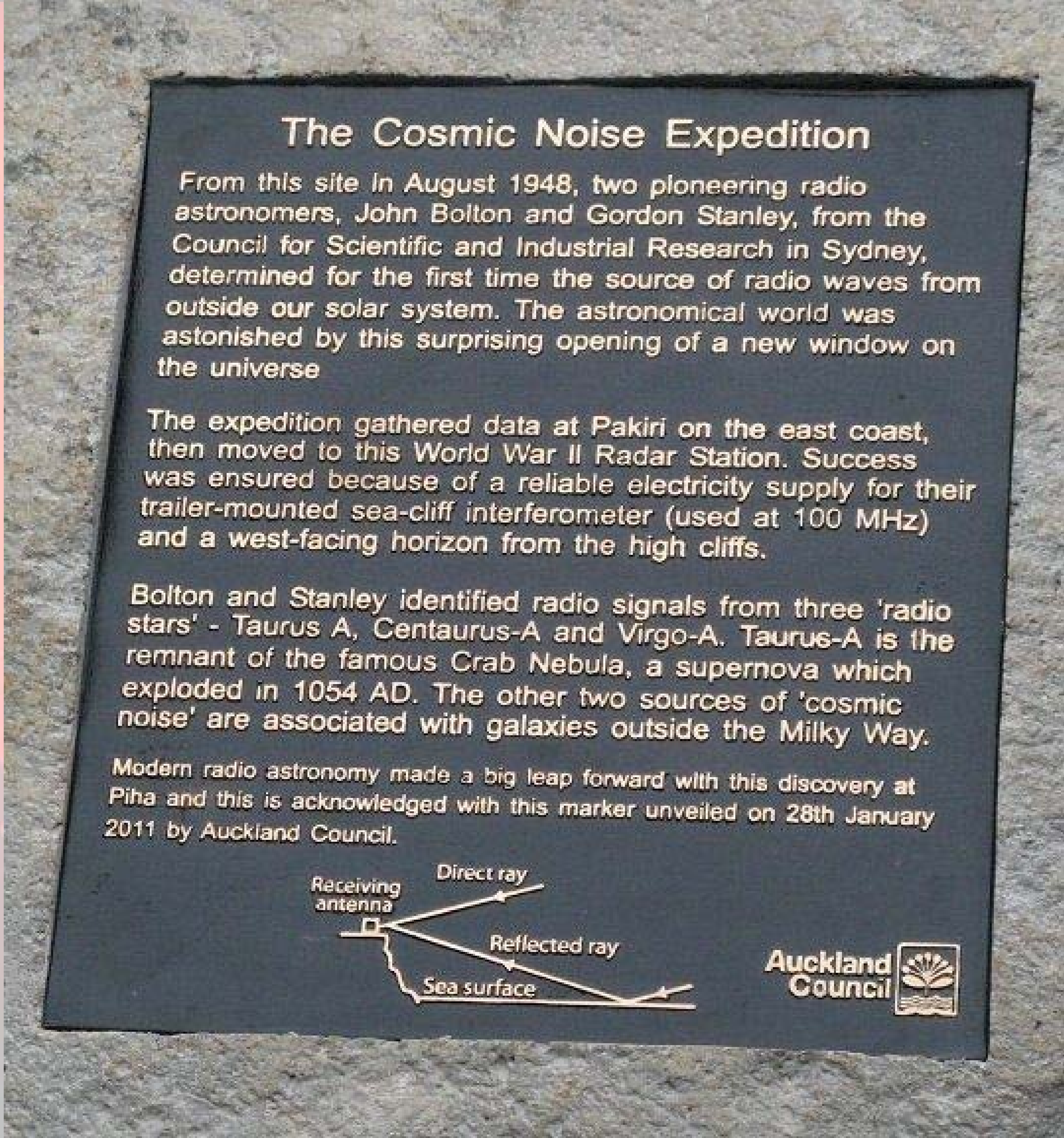
The range of baselines and flux densities needed to probe high brightness temperature components of AGN. It shows baselines needed to allow sources with certain flux densities to be identified unambiguously with AGN.

Australasian Interferometry



1948


The Cosmic Noise Expedition
From this site in August 1948, two pioneering radio astronomers, John Bolton and Gordon Stanley, from the Council for Scientific and Industrial Research in Sydney, determined for the first time the source of radio waves from outside our solar system. The astronomical world was astonished by this surprising opening of a new window on the universe
The expedition gathered data at Pakiri on the east coast, then moved to this World War II Radar Station. Success was ensured because of a reliable electricity supply for their trailer-mounted sea-cliff interferometer (used at 100 MHz) and a west-facing horizon from the high cliffs.
Bolton and Stanley identified radio signals from three 'radio stars' - Taurus A, Centaurus-A and Virgo-A. Taurus-A is the remnant of the famous Crab Nebula, a supernova which exploded in 1054 AD. The other two sources of 'cosmic noise' are associated with galaxies outside the Milky Way.
Auckland Council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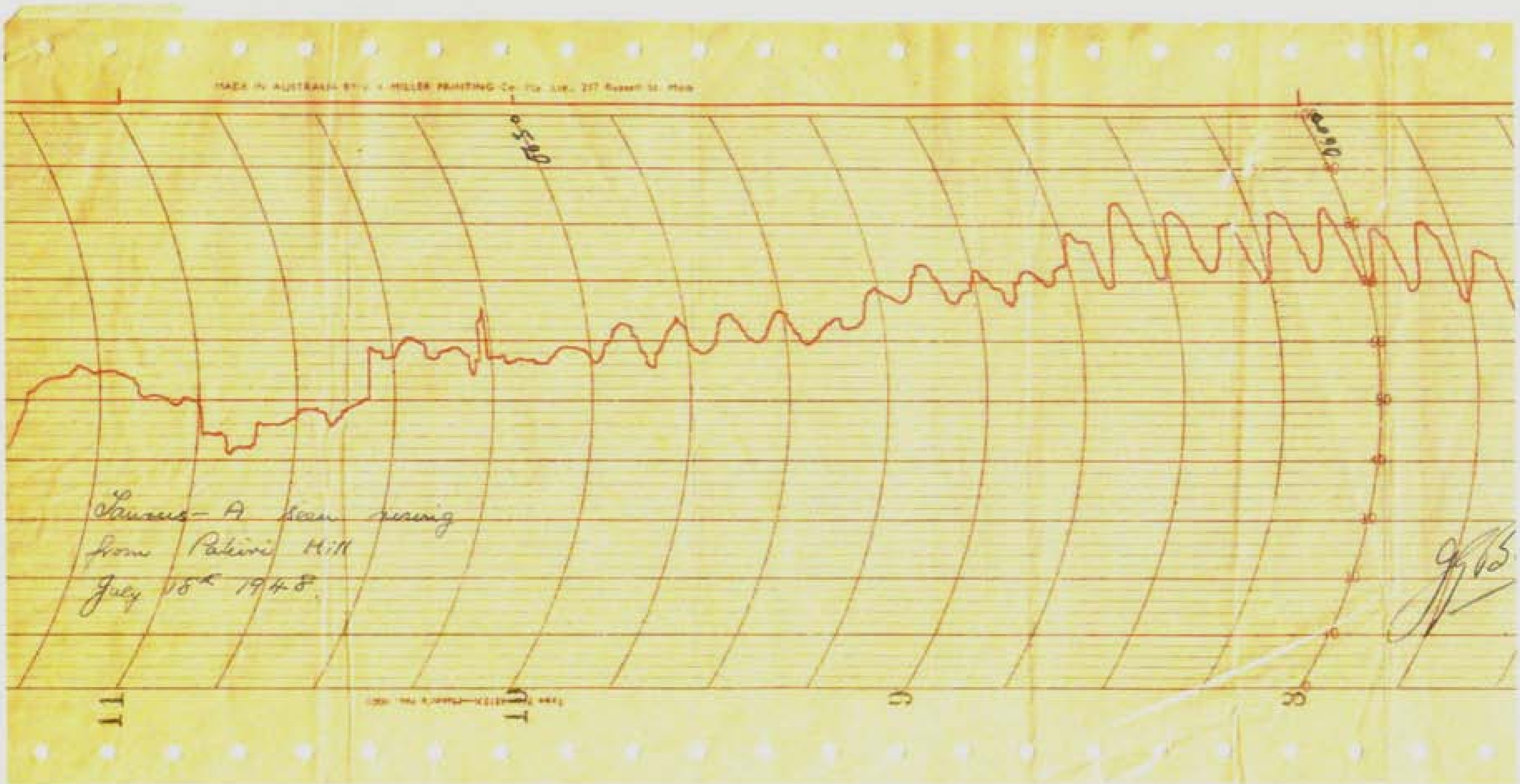
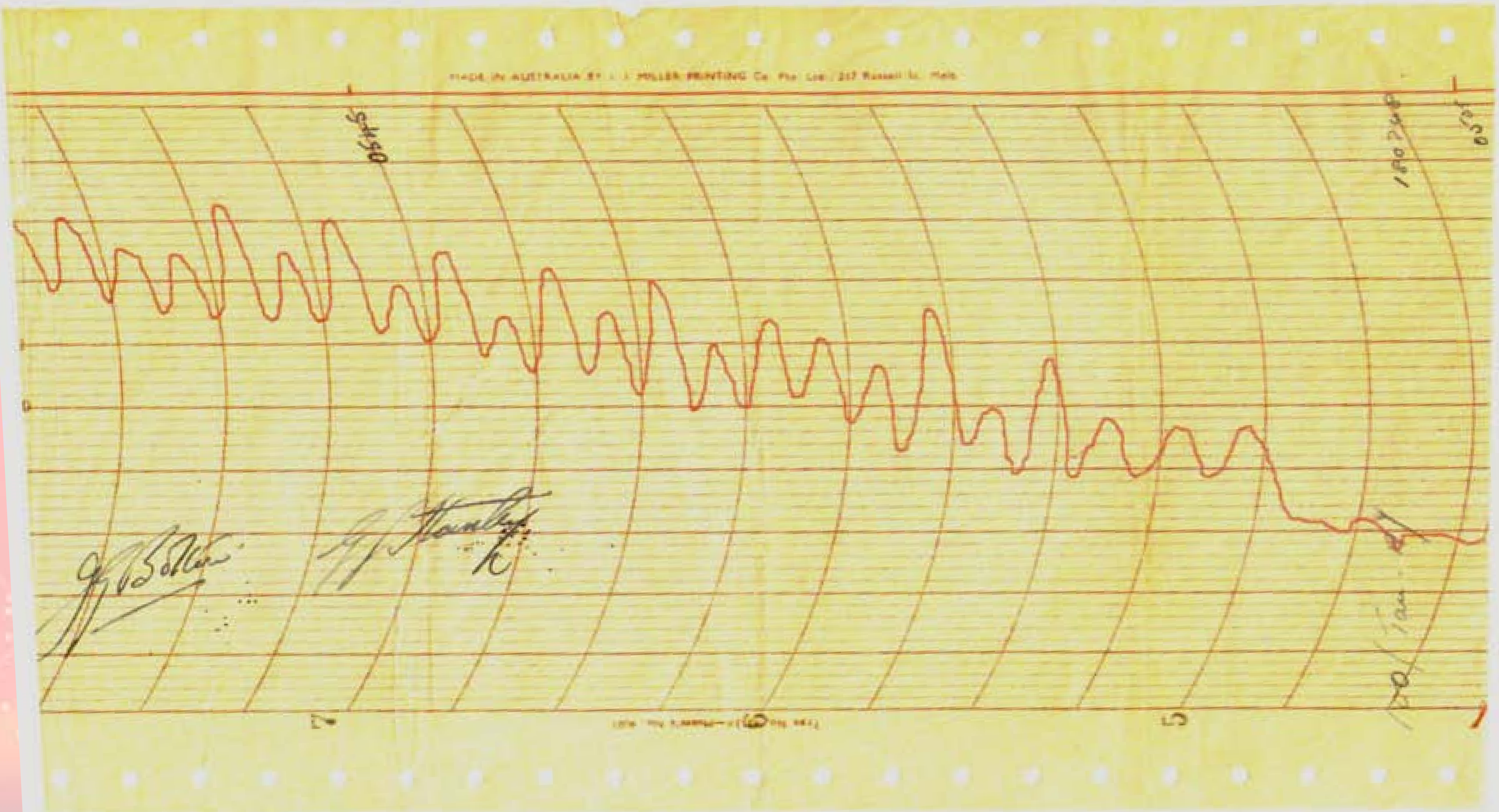
Modern radio astronomy made a big leap forward with this discovery at Piha and this is acknowledged with this marker unveiled on 28th January 2011 by Auckland Council.
Receiving antenna
Direct ray
Reflected ray
Sea surface
Auckland Council

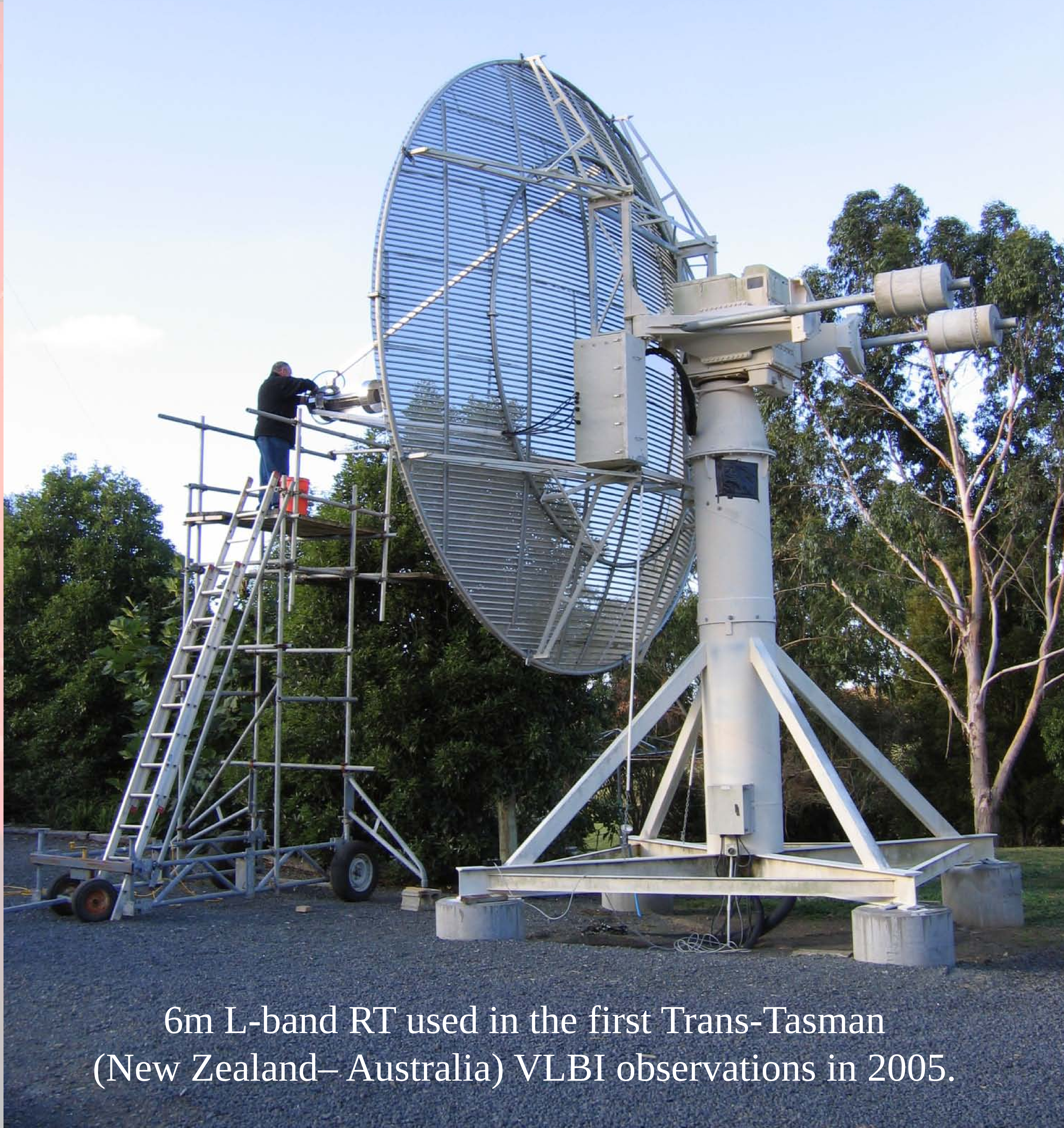


Greenwood. b. CCE....



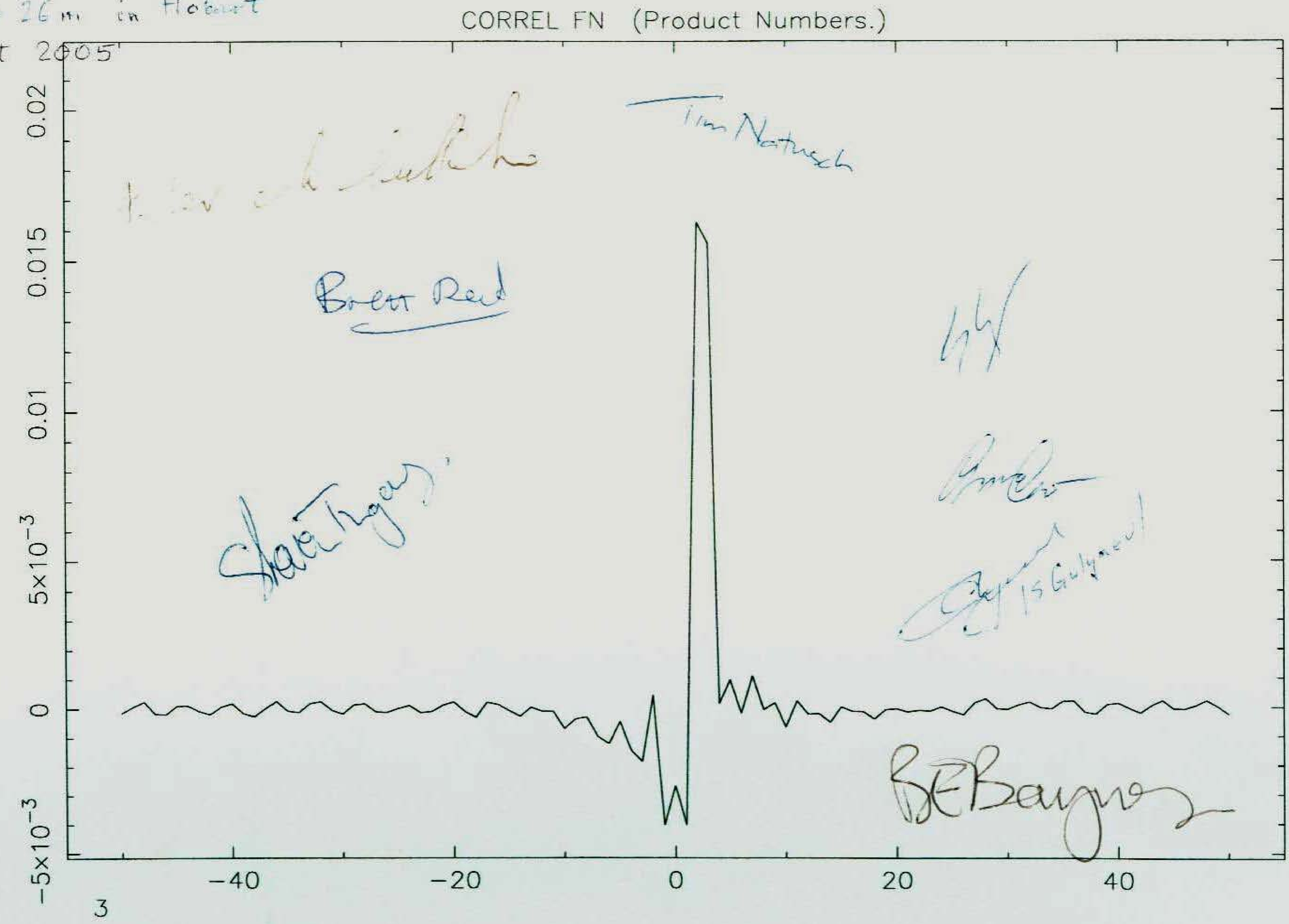
Greenwood .C.C....

BART -6
Karaka, South Auckland
2005

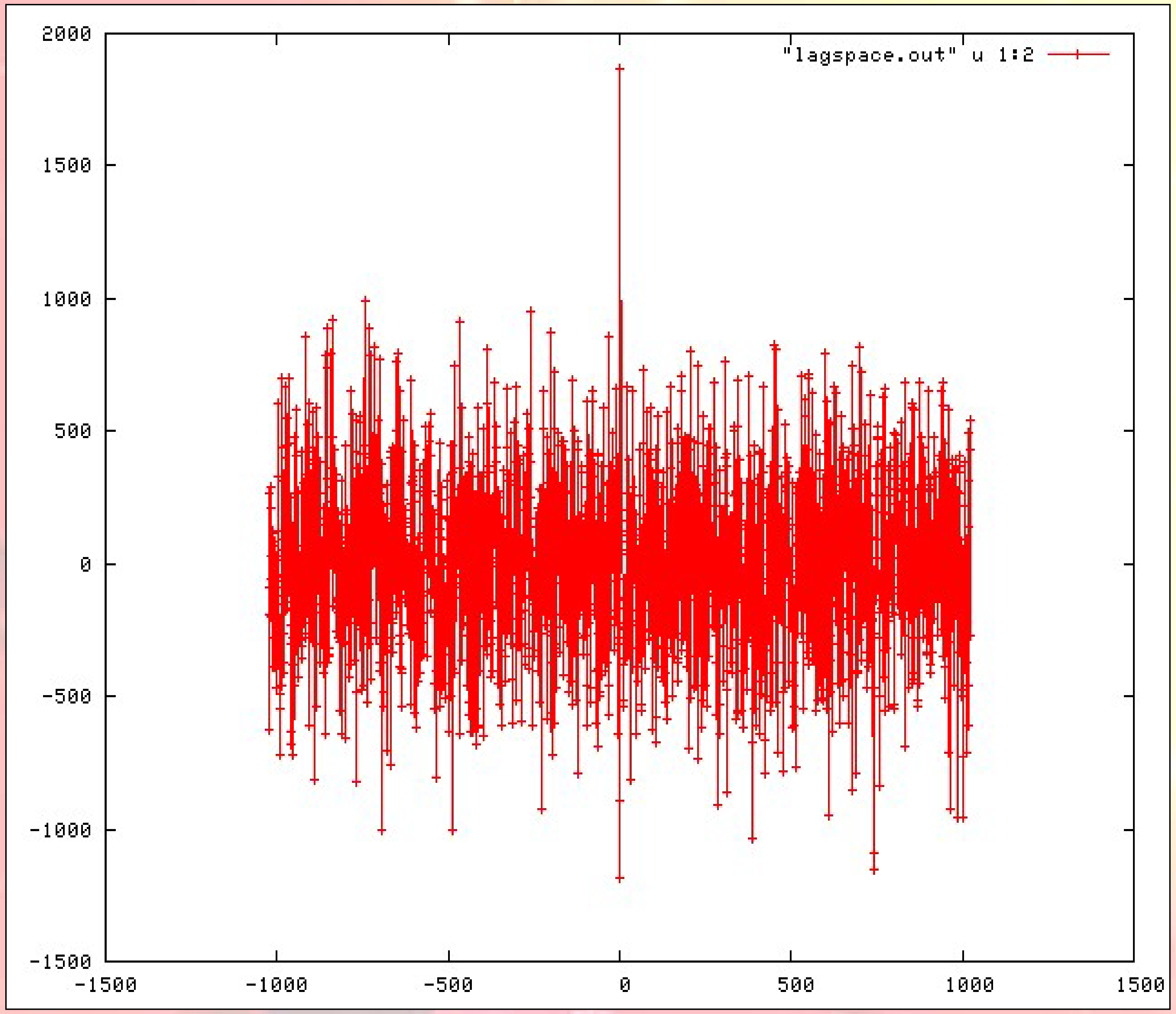


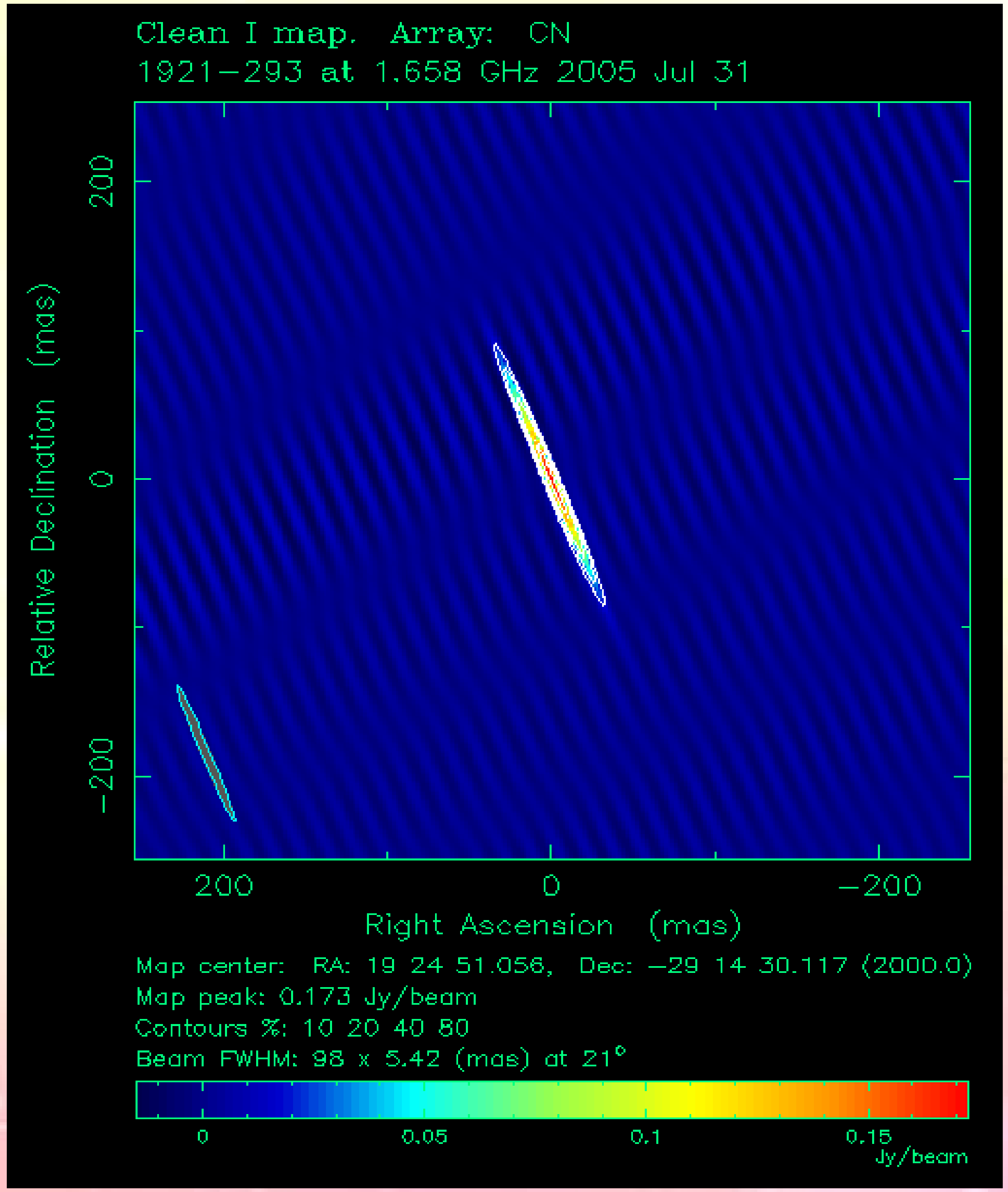
6m L-band RT used in the first Trans-Tasman
(New Zealand– Australia) VLBI observations in 2005.

Taurus: First fringes
14 m + 26 m in Hobart
25 August 2005



NZ – ATCA: 31 July 2005





The first fringe and the image of PSK1921-231 obtained from Australia—New Zealand VLBI.

(Credit: Adam Deller and Steven Tingay)

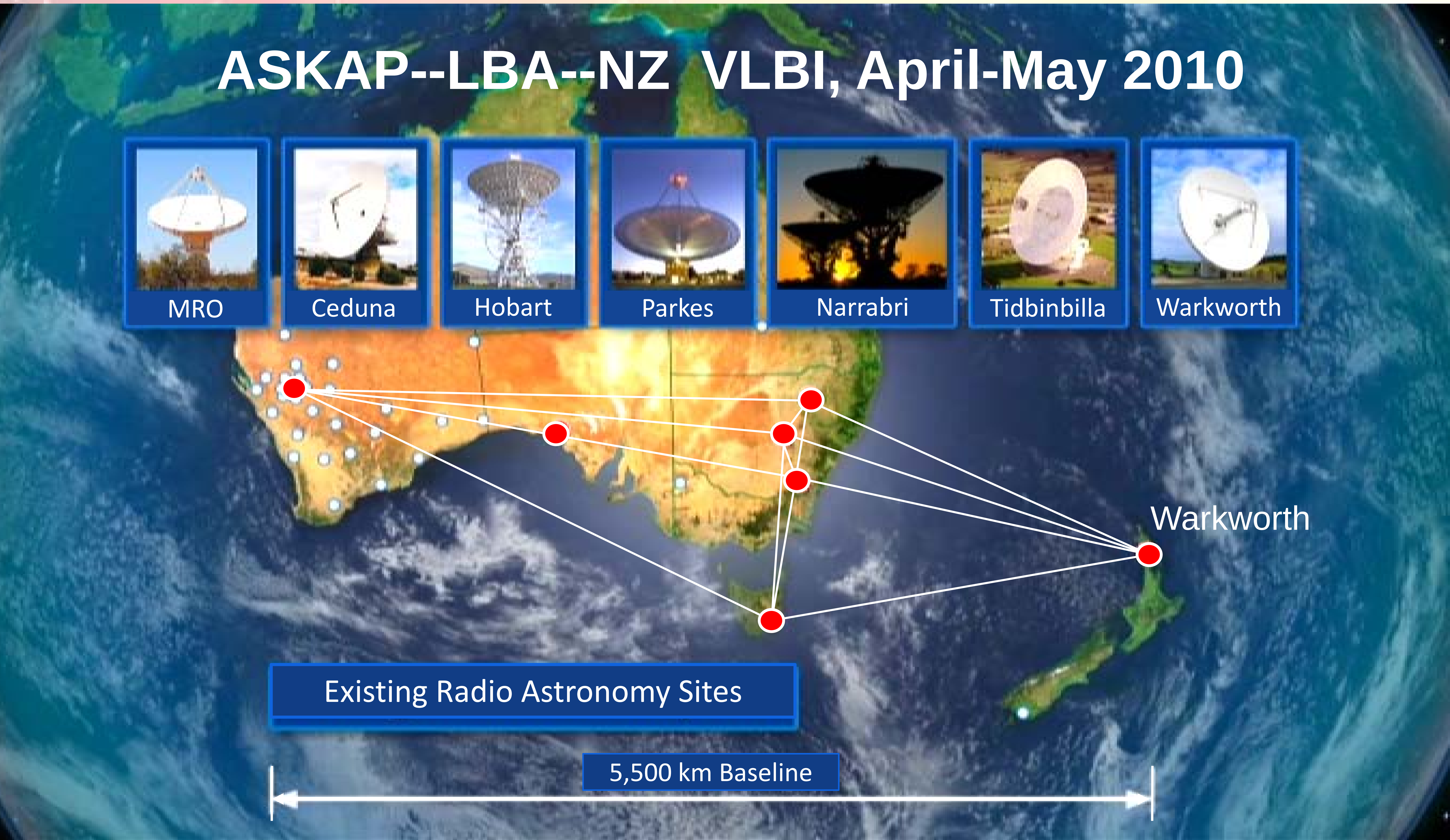
- Diameter: 12.1 m
- Manufacturer: Patriot/Cobham
- Shaped Cassegrain
- Slewing: 5 deg/s Az

  1 deg/s El
- Surface: 0.35 mm (rms)
- Bands: S/X dual polarisation;

  L-band (InterTronics)
- H-maser (Symmeticom, US)
- Mk5B+ , Mk5C:

  9 chassis x 8 disks x 1 TB
- DBBC (Gino)
- 1 Gbps International Connectivity
- Controlled remotely

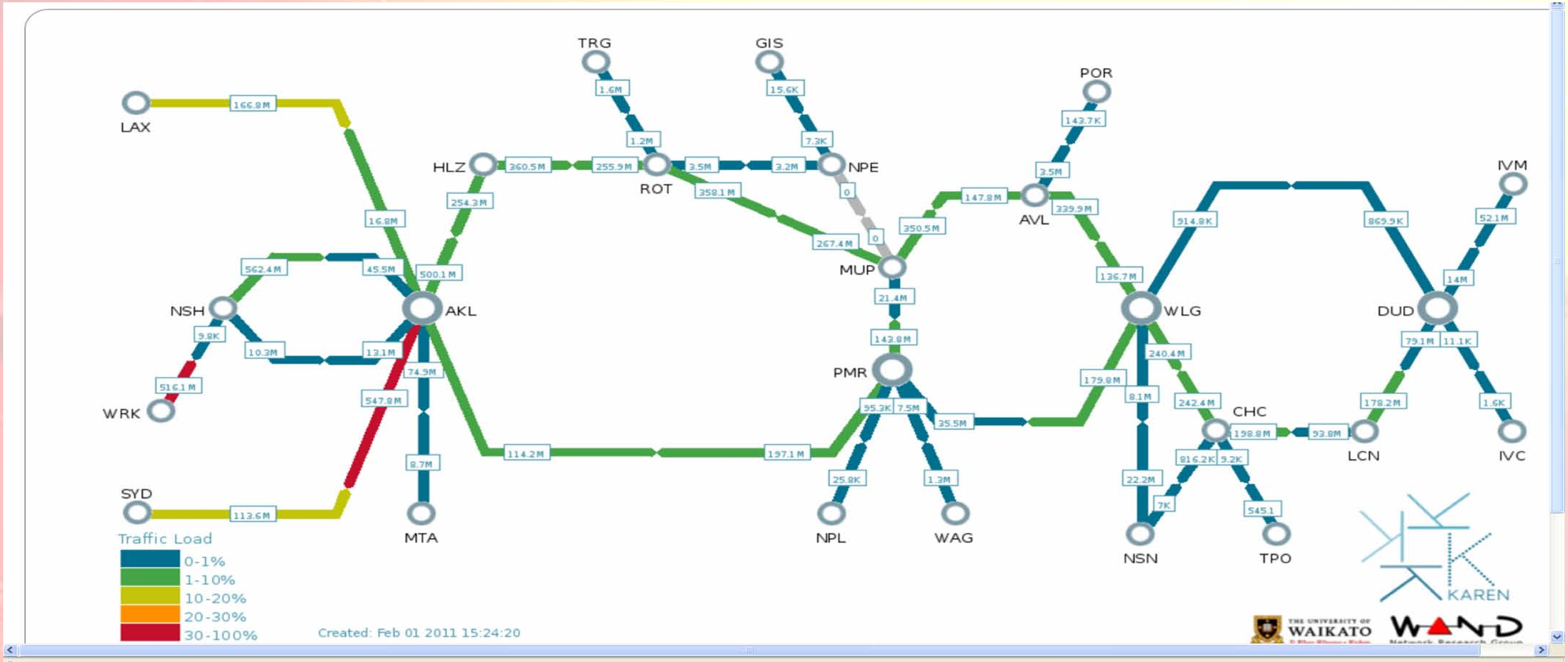
ASKAP--LBA--NZ VLBI, April-May 2010



Credit: Brian Boyle/CSIRO/ANZSKA

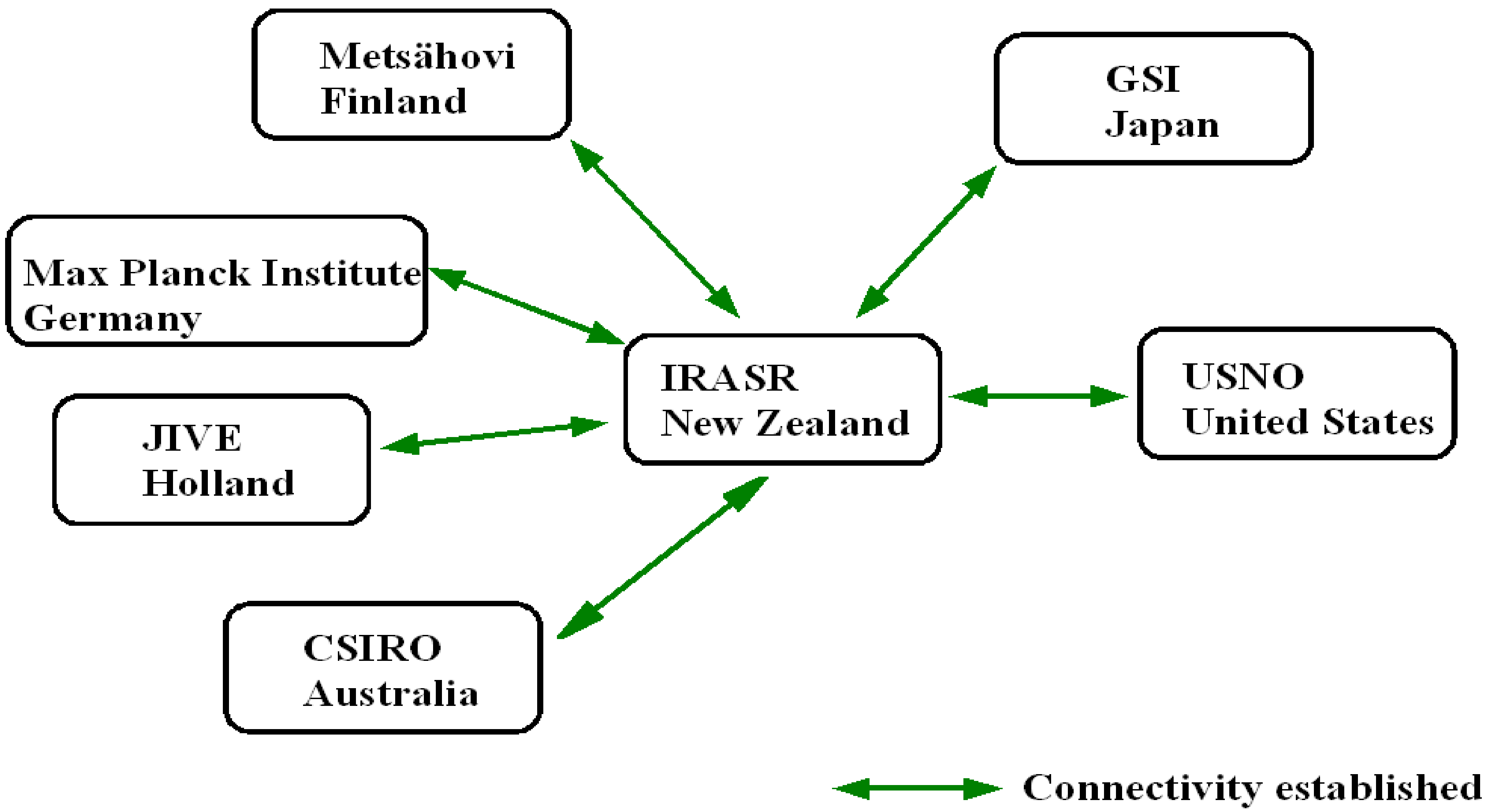
The 1st real-time eVLBI ASKAP—LBA—NZ June 2011

KAREN – Kiwi Advanced Research and Education Network



WRK – The end node to the Warkworth Radio Astronomical Observatory

IRASR collaborates with a number of international partners

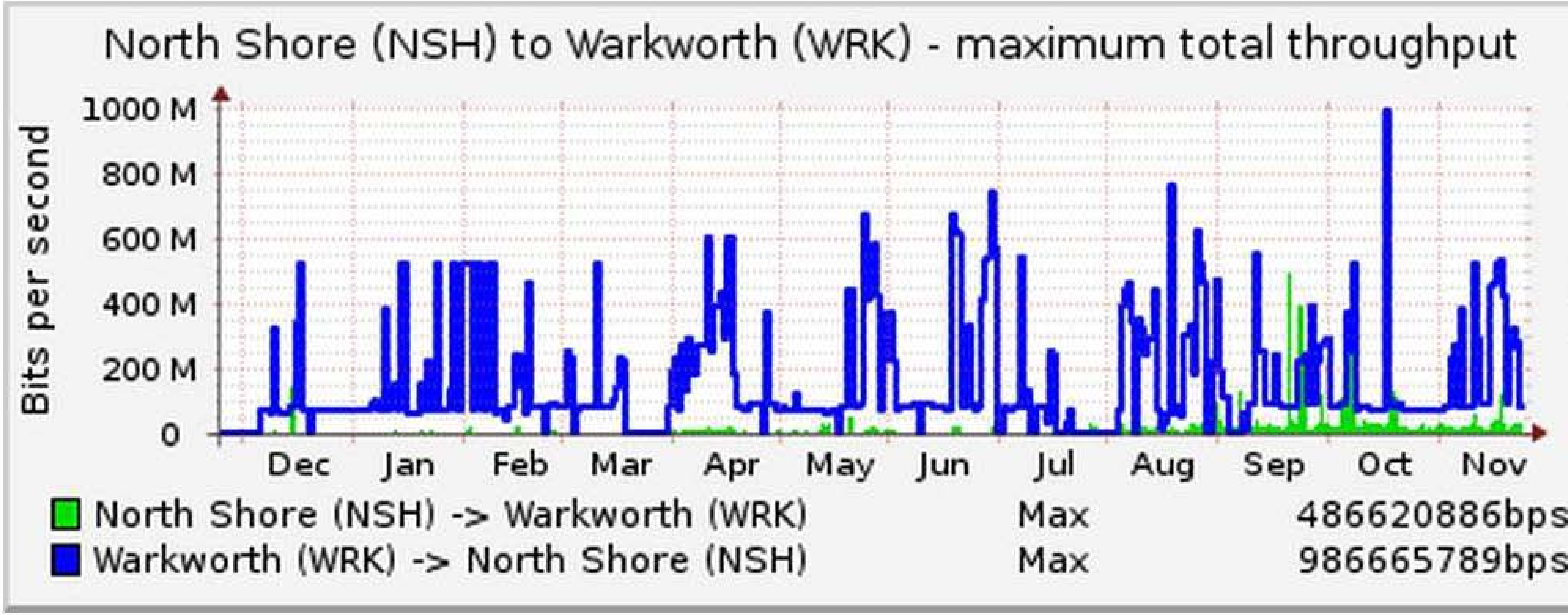


S.Weston et al, 2011

NZ development towards eVLBI

Image: Blue Marble Next Generation. Courtesy: NASA Visible Earth

North Shore (NSH) to Warkworth (WRK): Last Year



Network connectivity

- Southern Cross Cables:
  - NZ – Australia: 2 Tbps
  - NZ – USA: 2 Tbps
- KAREN: Kiwi Advanced Research and Education Network
  - Inside NZ: 10 Gbps
  - NZ – Australia: 1 Gbps
  - NZ – USA: 1 Gbps
- Warkworth Observatory GigaPoP: connection to KAREN at 1 Gbps

KAREN connectivity

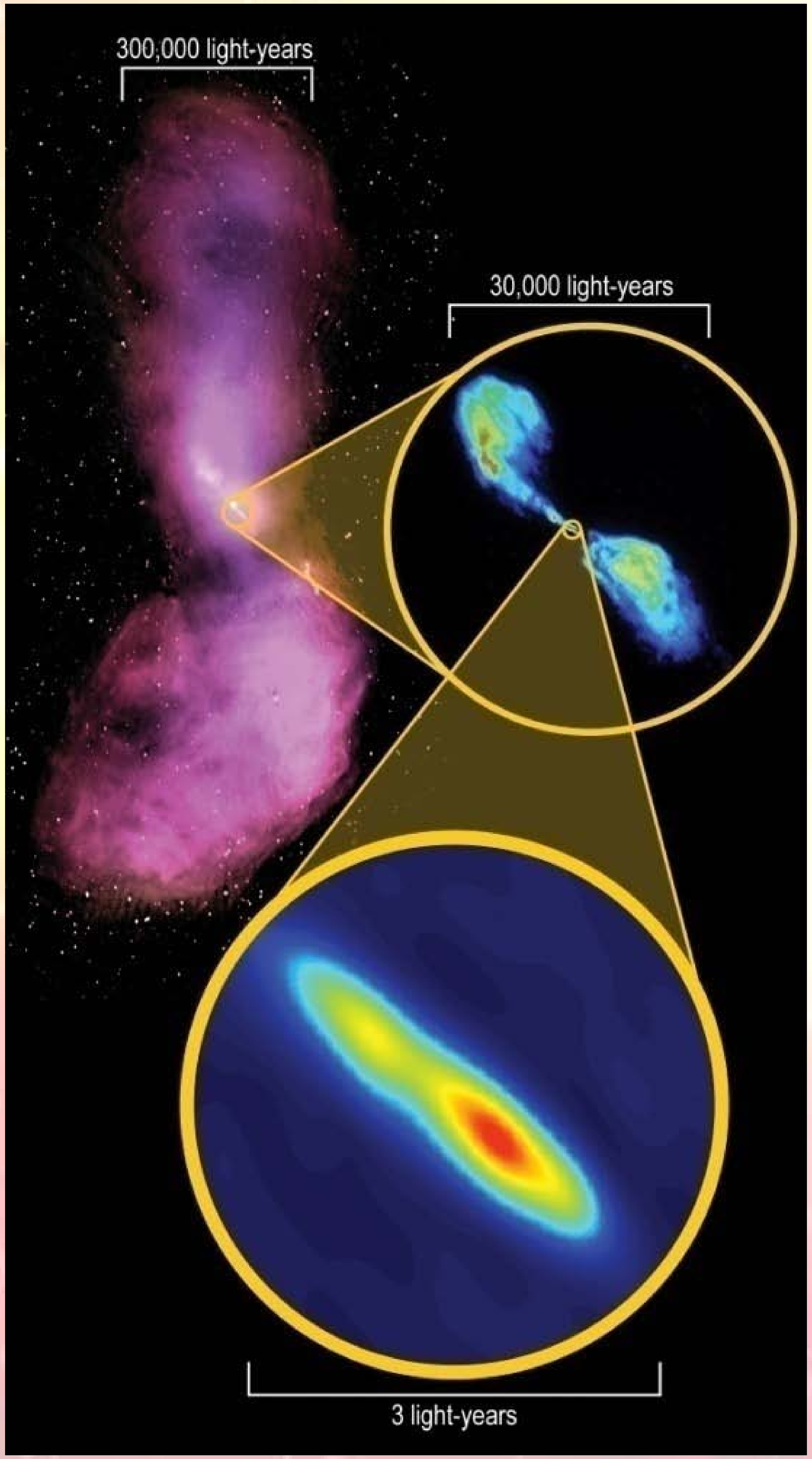
Professor John Raine, Chair of KAREN:

“SKA-like real-time observations are a great achievement by New Zealand and Australian researchers. KAREN which provides the data network for New Zealand’s research institutions intends to be an anchor tenant on a new international cable that, if built, will provide international connectivity of 40 Gbps by 2014, scaling through 80Gbps in 2017 to 160 Gbps by 2022 – more than enough to link the New Zealand and Australian parts of SKA.”

- **2012: 10 Gbps**
- **2014: 40 Gbps**
- **2017: 80 Gbps**
- **2022: 160 Gbps**

Radio galaxy Centaurus A

ASKAP antenna

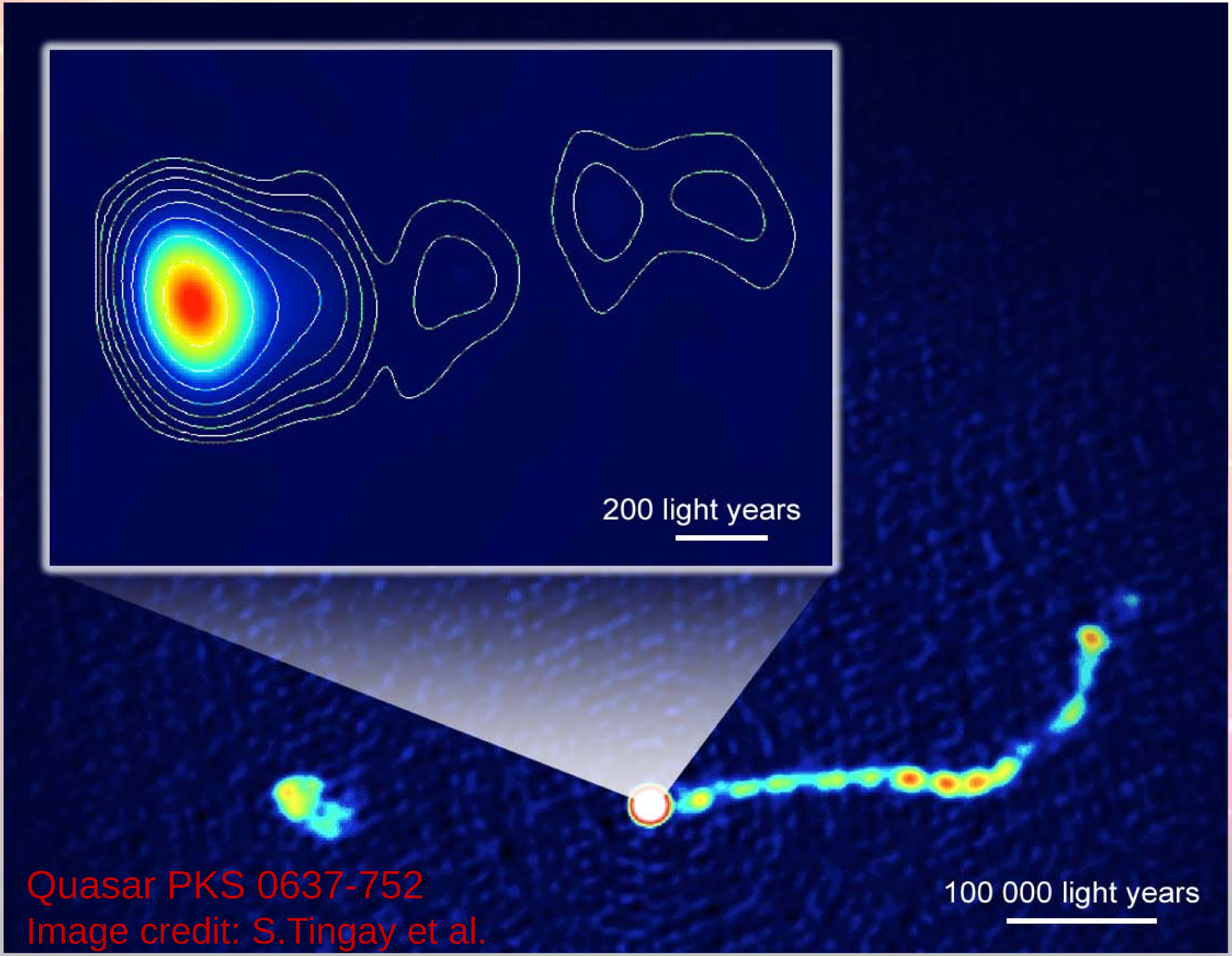


NZ radio telescope

Image credit – Whole galaxy: I. Feain, T. Cornwell & R. Ekers (CSIRO/ATNF); ATCA northern middle lobe pointing courtesy R. Morganti (ASTRON); Parkes data courtesy N. Junkes (MPIfR). Inner radio lobes: NRAO / AUI / NSF. Core: S. Tingay (ICRAR) / ICRAR, CSIRO and AUT

The 1st real-time eVLBI ASKAP—LBA—Warkworth

June 2011



Quasar PKS 0637-752
Image credit: S.Tingay et al.

The Astronomical Journal, 140:1506–1510, 2010 November doi:10.1088/0004-6256/140

EVOLUTION OF THE PARSEC-SCALE STRUCTURE OF PKS 1934−638 REVISITED: FIRST SCIENCE WITH THE ASKAP AND NEW ZEALAND TELESCOPES

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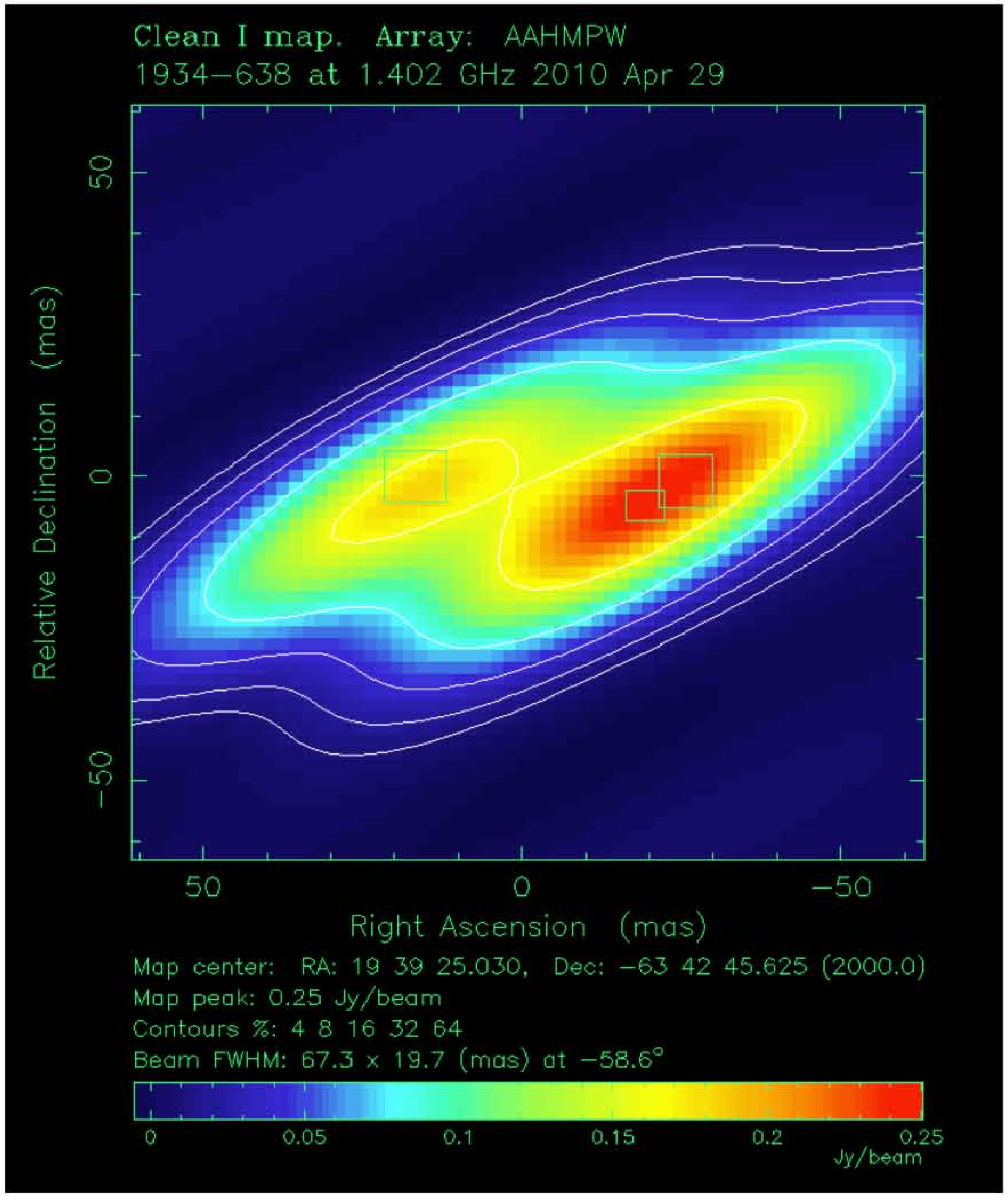
Received 2010 June 8; accepted 2010 September 7; published 2010 October 15

ABSTRACT

We have studied the archetypal Gigahertz Peaked Spectrum radio galaxy, PKS 1934−638, using the Australian Long Baseline Array augmented with two new telescopes that greatly improve the angular resolution of the array. These very long baseline interferometry observations represent the first scientific results from a new antenna in New Zealand and the first antenna of the Australian SKA Pathfinder. A compact double radio source, PKS 1934−638 has been monitored over a period of 40 years and the observation described here provides the latest datum, eight years after the previous observation, to aid in the study of the long-term evolution of the source structure. We take advantage of these new long baselines to probe PKS 1934−638 at the relatively low frequency of 1.4 GHz in order to examine the effects of optical depth on the structure of the radio source. Optical depth effects, resulting in the observation of frequency-dependent structure, may have previously been interpreted in terms of an expansion of the source as a function of time. Expansion and frequency-dependent effects are important to disentangle in order to estimate the age of PKS 1934−638. We show that frequency-dependent structure effects are likely to be important in PKS 1934−638 and present a simple two-dimensional synchrotron source model in which opacity effects due to synchrotron self-absorption are taken into account. Evidence for expansion of the radio source over 40 years is therefore weak with consequences for the estimated age of the radio source.

ASKAP & NZ VLBI of 1934-638

Normal LBA at 1.4 GHz



LBA with NZ and ASKAP

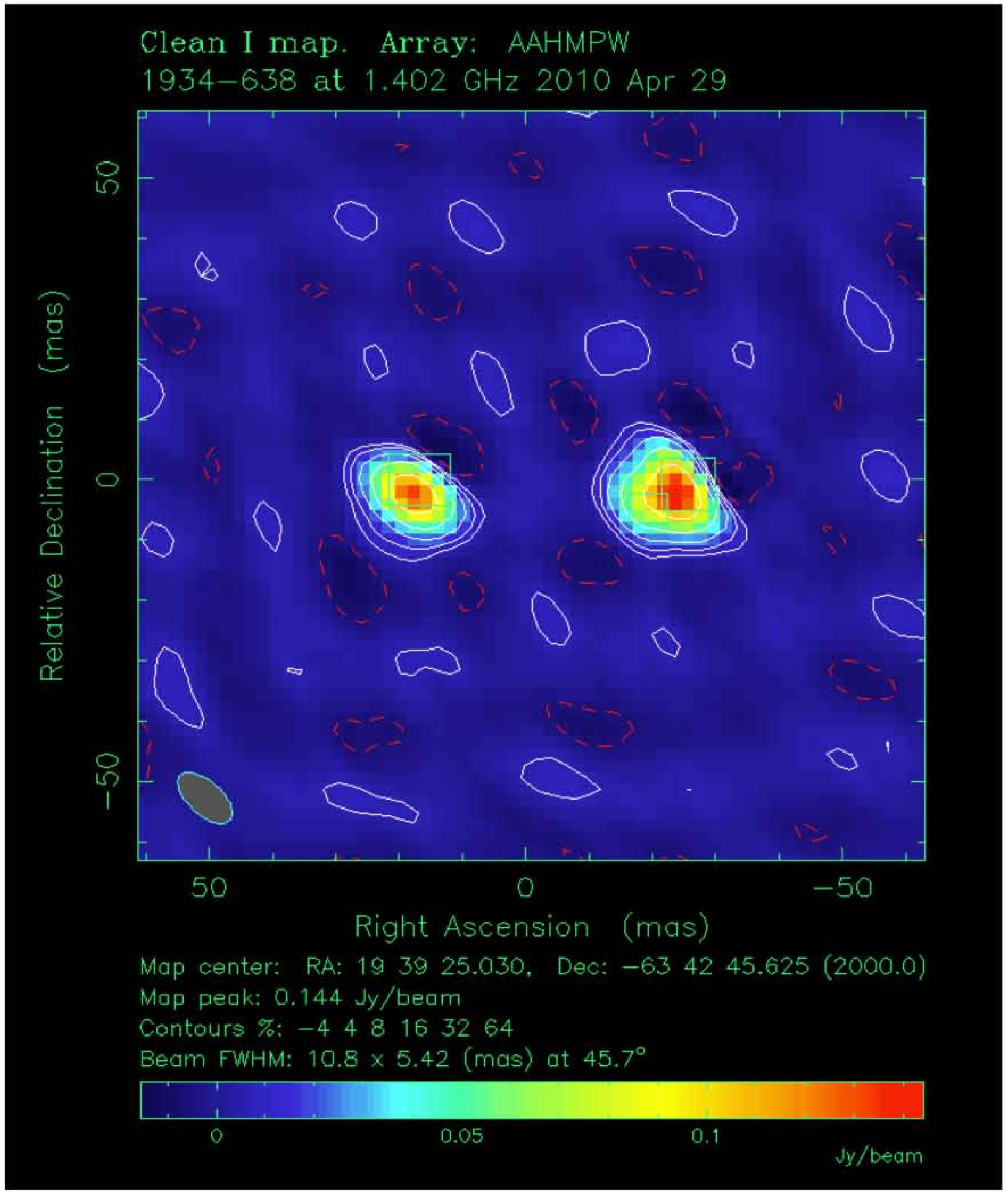
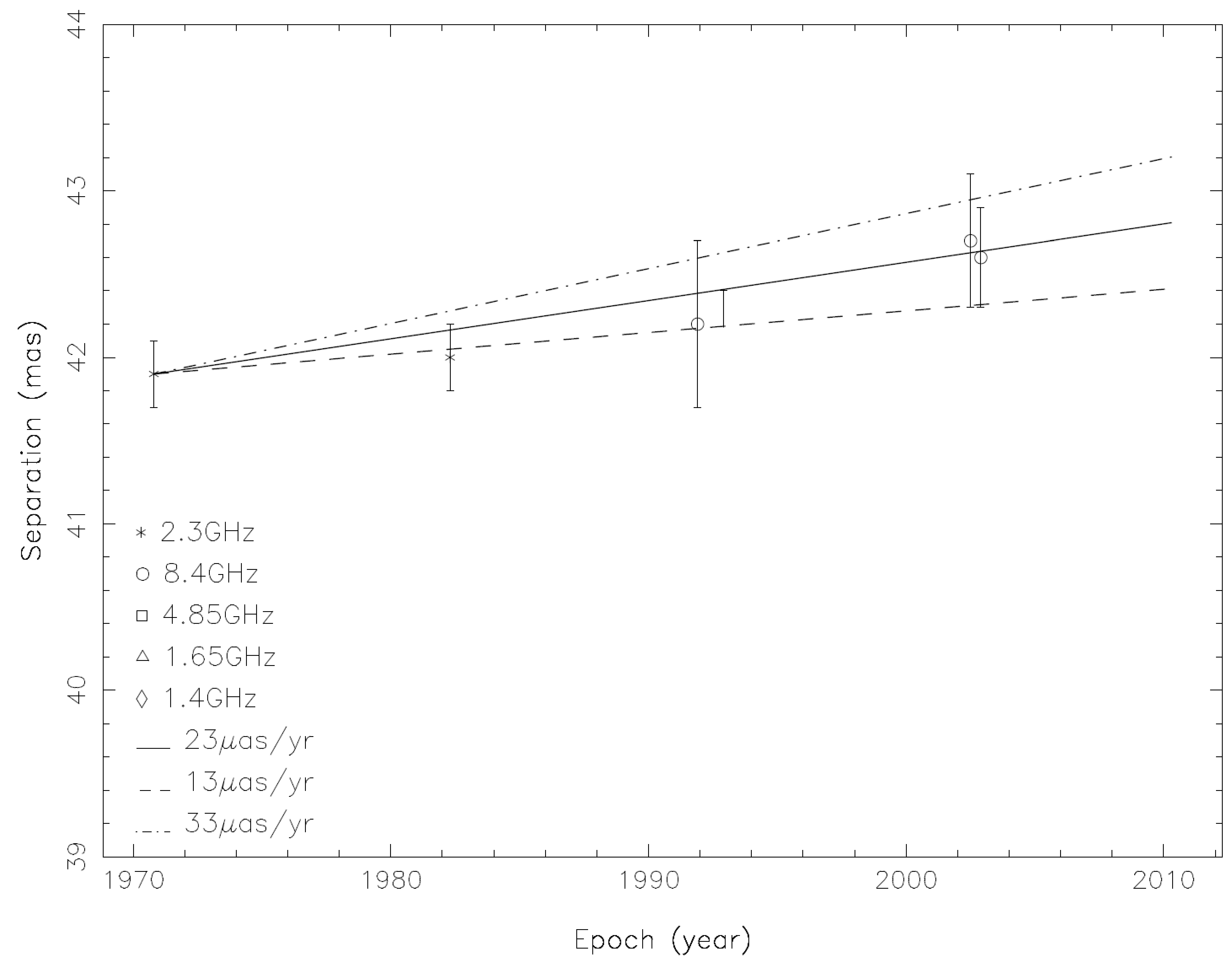
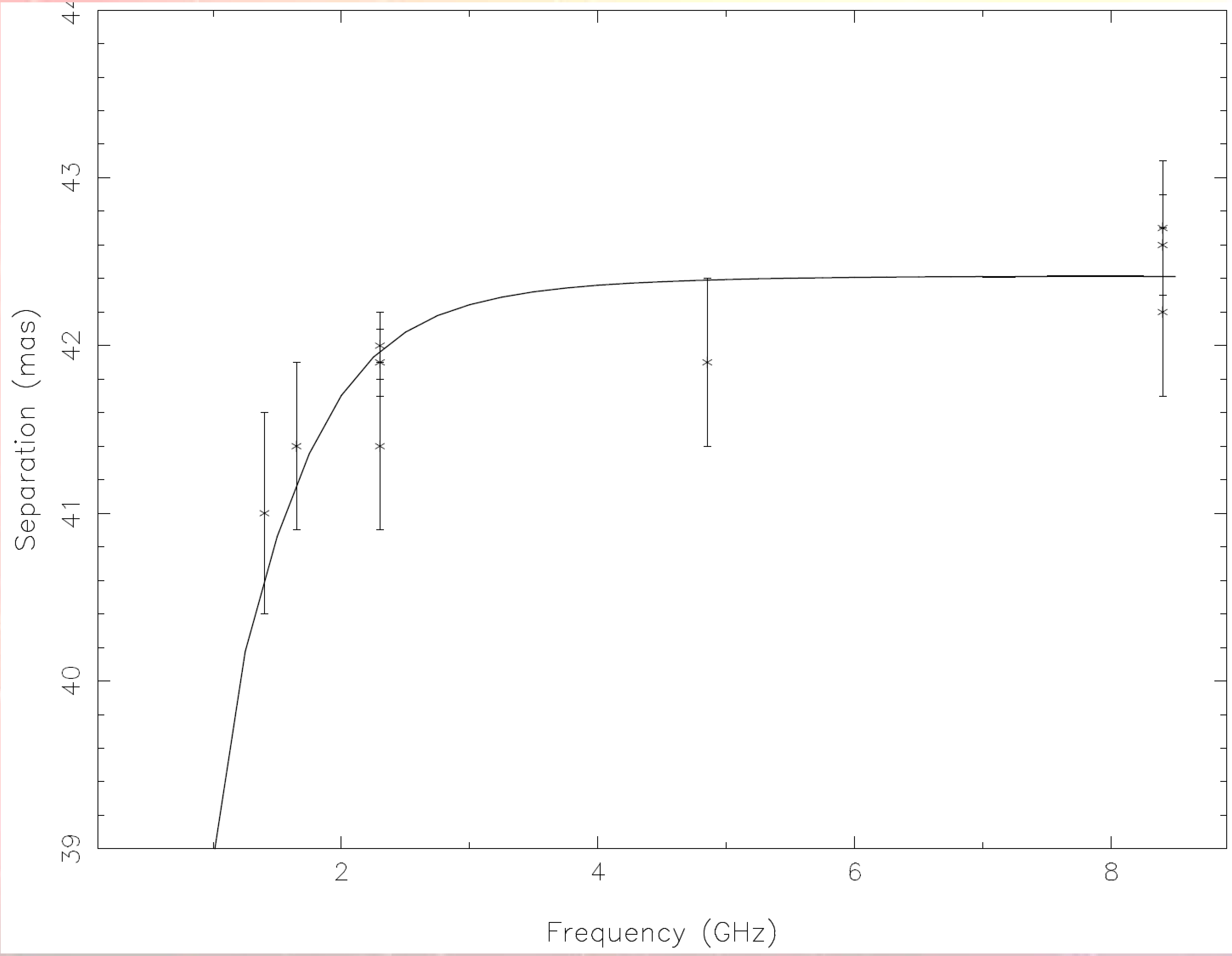


Image credit: Steven Tingay
(see also Tzioumis et al. AJ, 140, 2010)



44
43
42
41
40
39
Separation (mas)
1970
1980
1990
2000
2010
Epoch (year)
∗ 2.3GHz
○ 8.4GHz
□ 4.85GHz
△ 1.65GHz
◊ 1.4GHz
23μas/yr
13μas/yr
33μas/yr

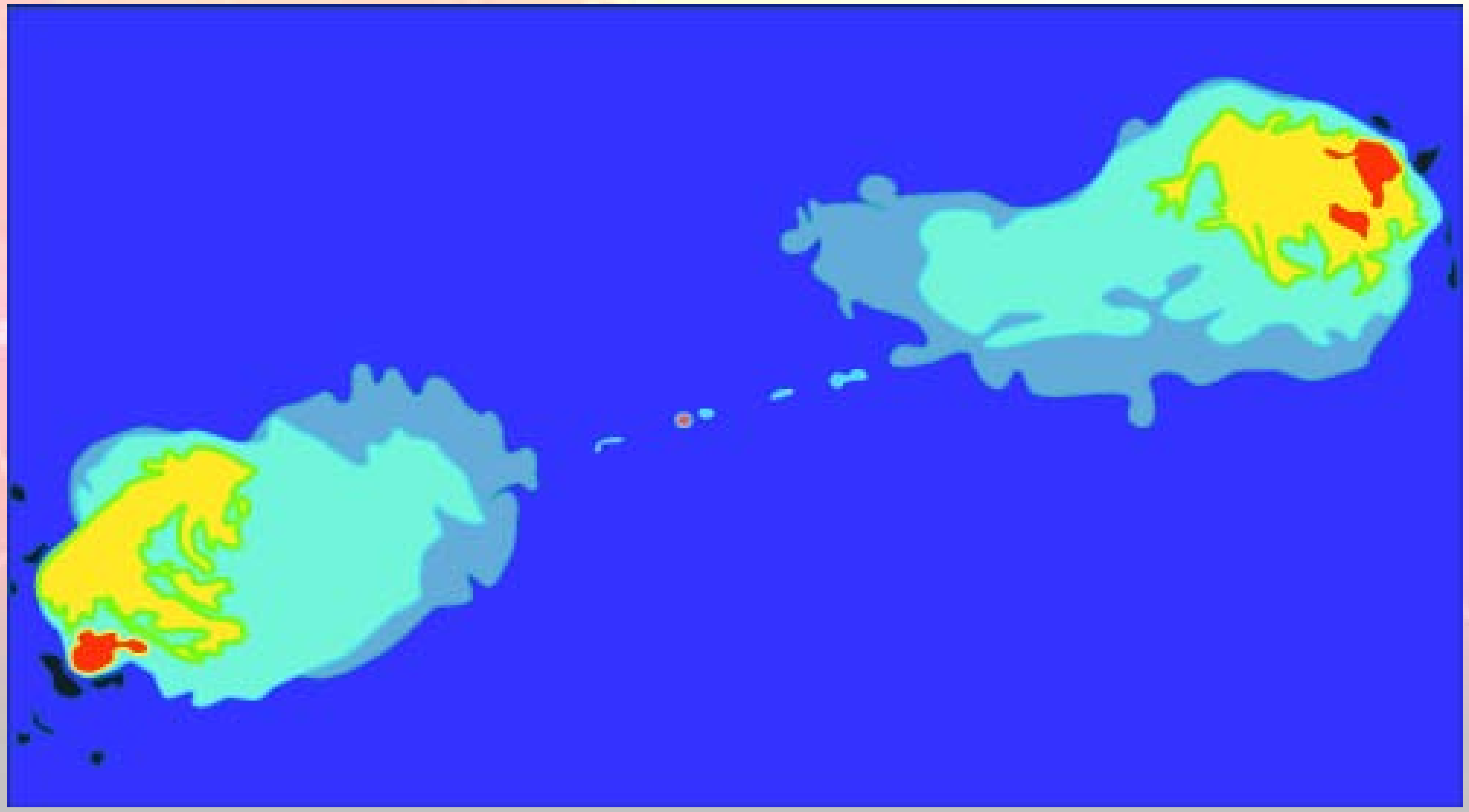


Separation (mas)
Frequency (GHz)
39
40
41
42
43
44
2
4
6
8

- A two-dimensional synchrotron source model takes into account opacity (optical depth) effects associated with synchrotron self-absorption

$$\rho(x, z) = \begin{cases} \rho_0 \exp\left[-\frac{(|x|-x_0)^2+z^2}{r_0^2}\right], & |x| < x_0, \\ 0, & \text{otherwise}, \end{cases}$$

- A “cutoff” Gaussian profile represents the shock front at the jet working surface and the corresponding backflow from the shock region



CSIRO PUBLISHING

publish.csiro.au/journals/pasa *Publications of the Astronomical Society of Australia, 2011,* **28(2)**, *107–116*

First geodetic observations using new VLBI stations ASKAP-29 and WARK12M

Leonid Petrov[A,G], *Chris Phillips*[B], *Tasso Tzioumis*[B], *Bruce Stansby*[C], *Cormac Reynolds*[C], *Hayley E Bignall*[C], *Sergei Gulyaev*[D], *Tim Natusch*[D], *Neville Palmer*[E], *David Collett*[F], *John E Reynolds*[B], *Shaun W Amy*[B], *Randall Wayth*[C], *Steven J Tingay*[C]

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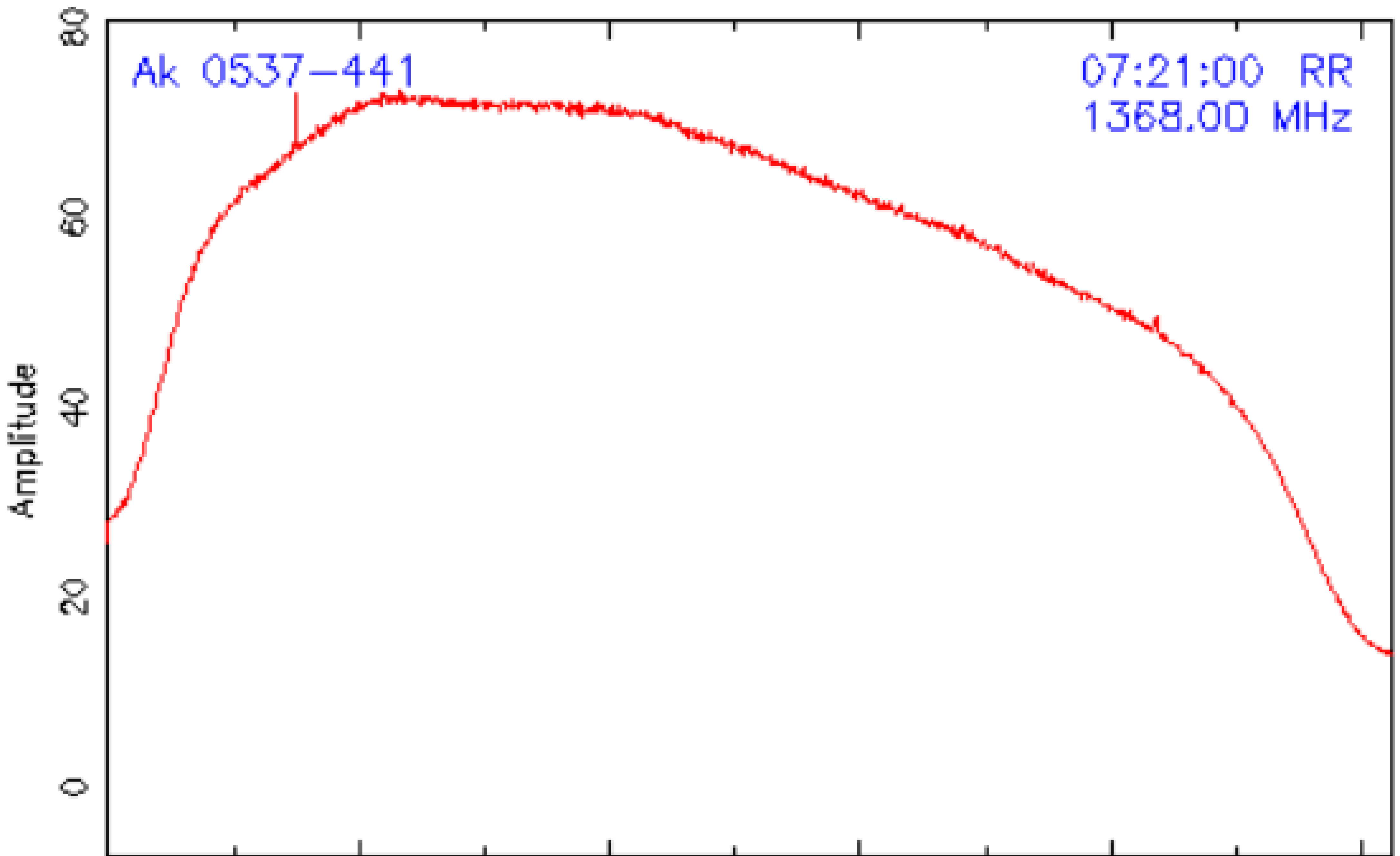
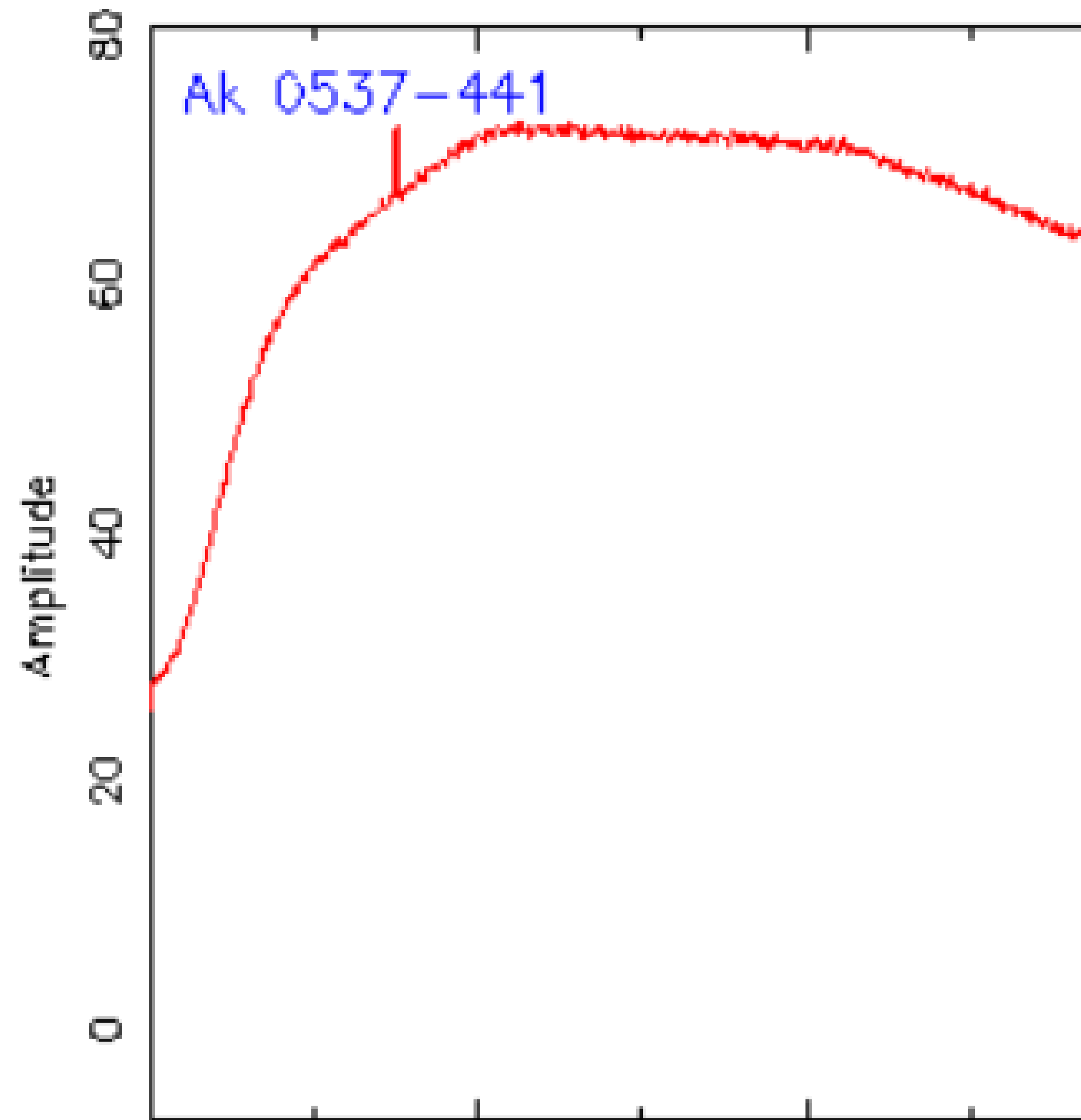
Australian-NZ observations in 2010-11 demonstrated that

- NZ has a strong observational basis for VLBI and e-VLBI
- NZ is capable of electronically transferring large amounts of data in real-time
- NZ has excellent radio-quiet zones

RFI in Western Australia desert (ASKAP)

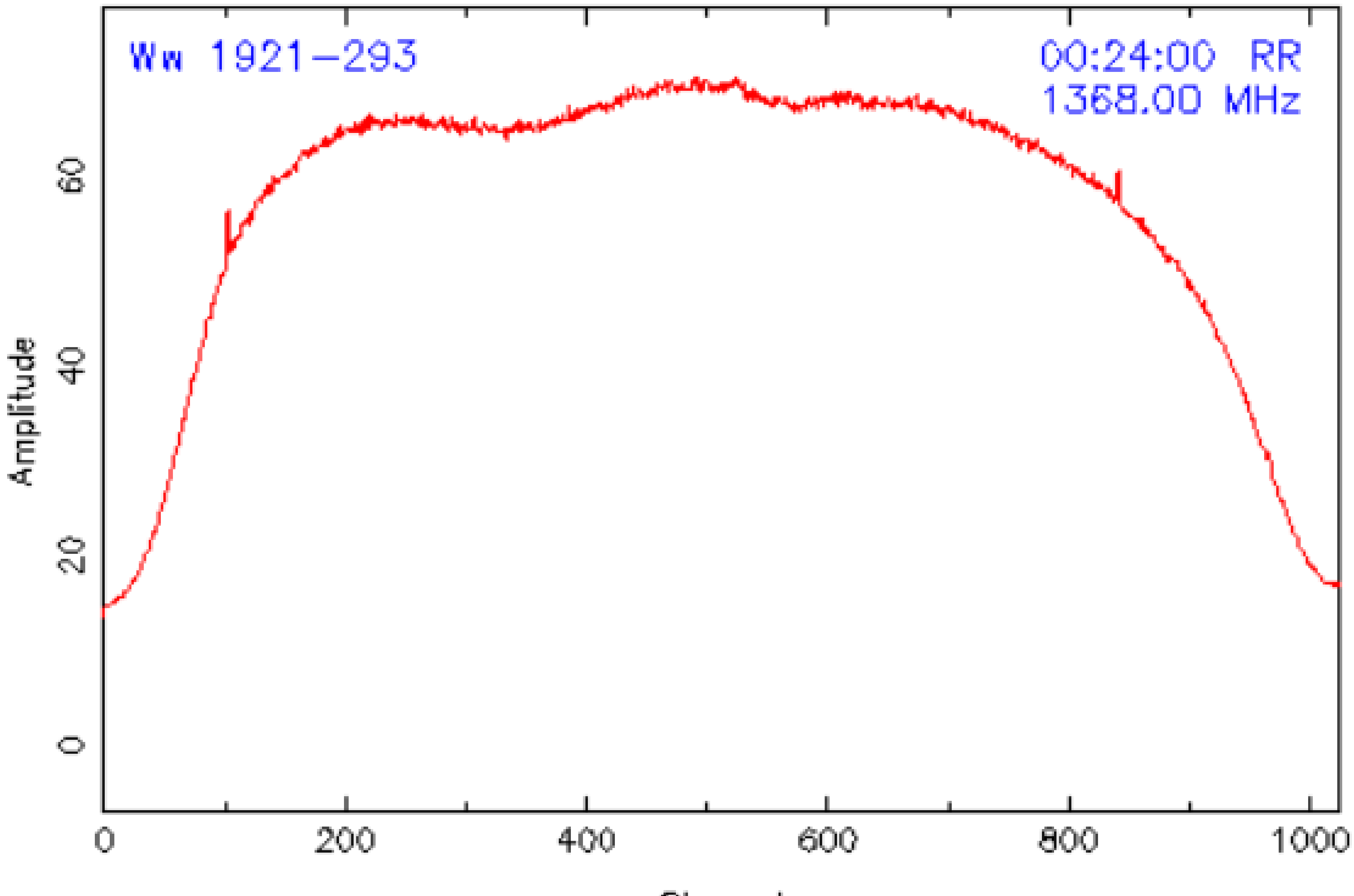
	Ak	Ho	Mp	Ww
Ak	1368	-	1368	-
Ho		-	-	-
Mp			1368	-
Ww				-

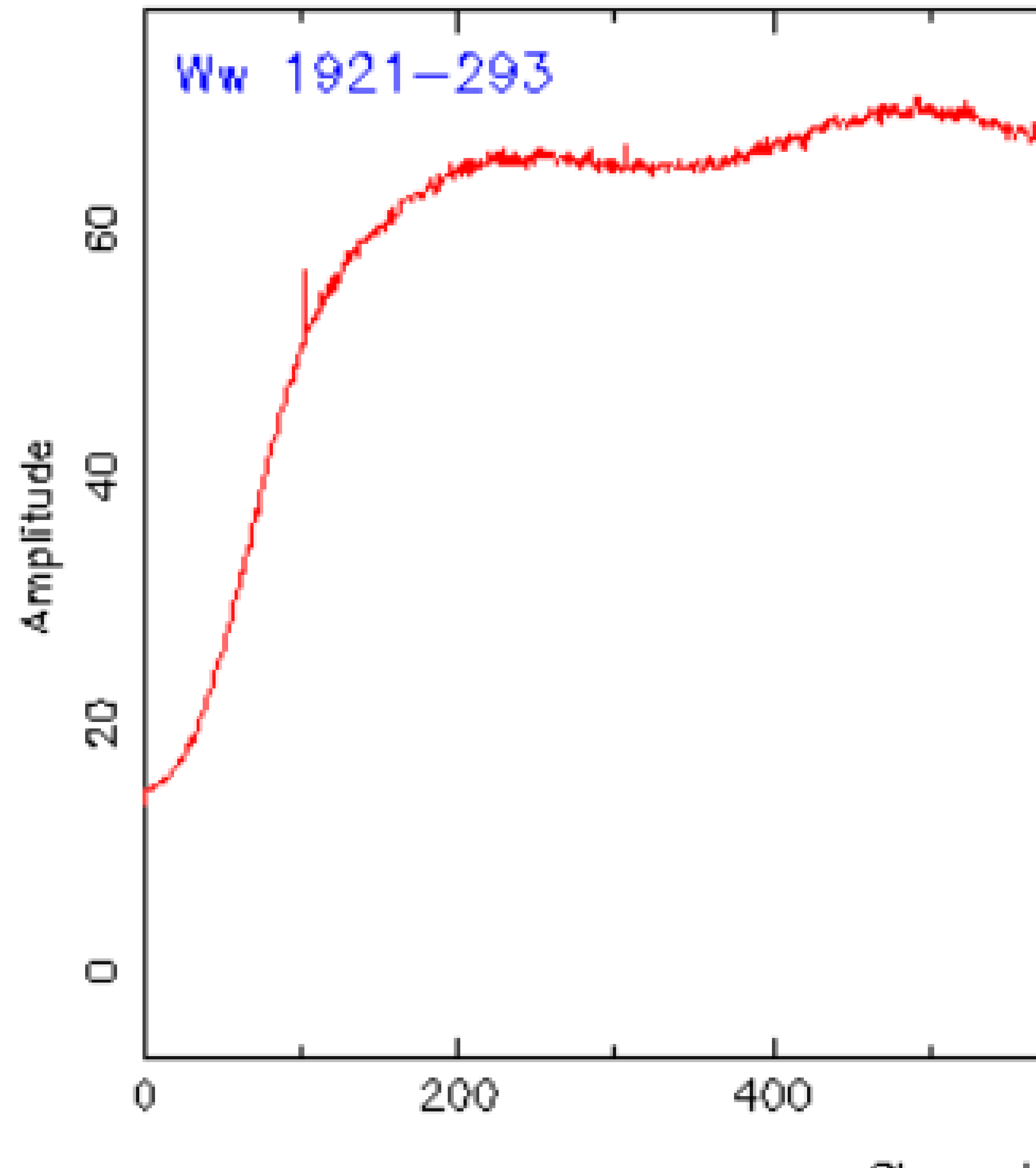




RFI in Warkworth radio quiet zone

	Ho	Mp	Ww
Ho	1368	1368	1368
Mp		1368	1368
Ww			1368



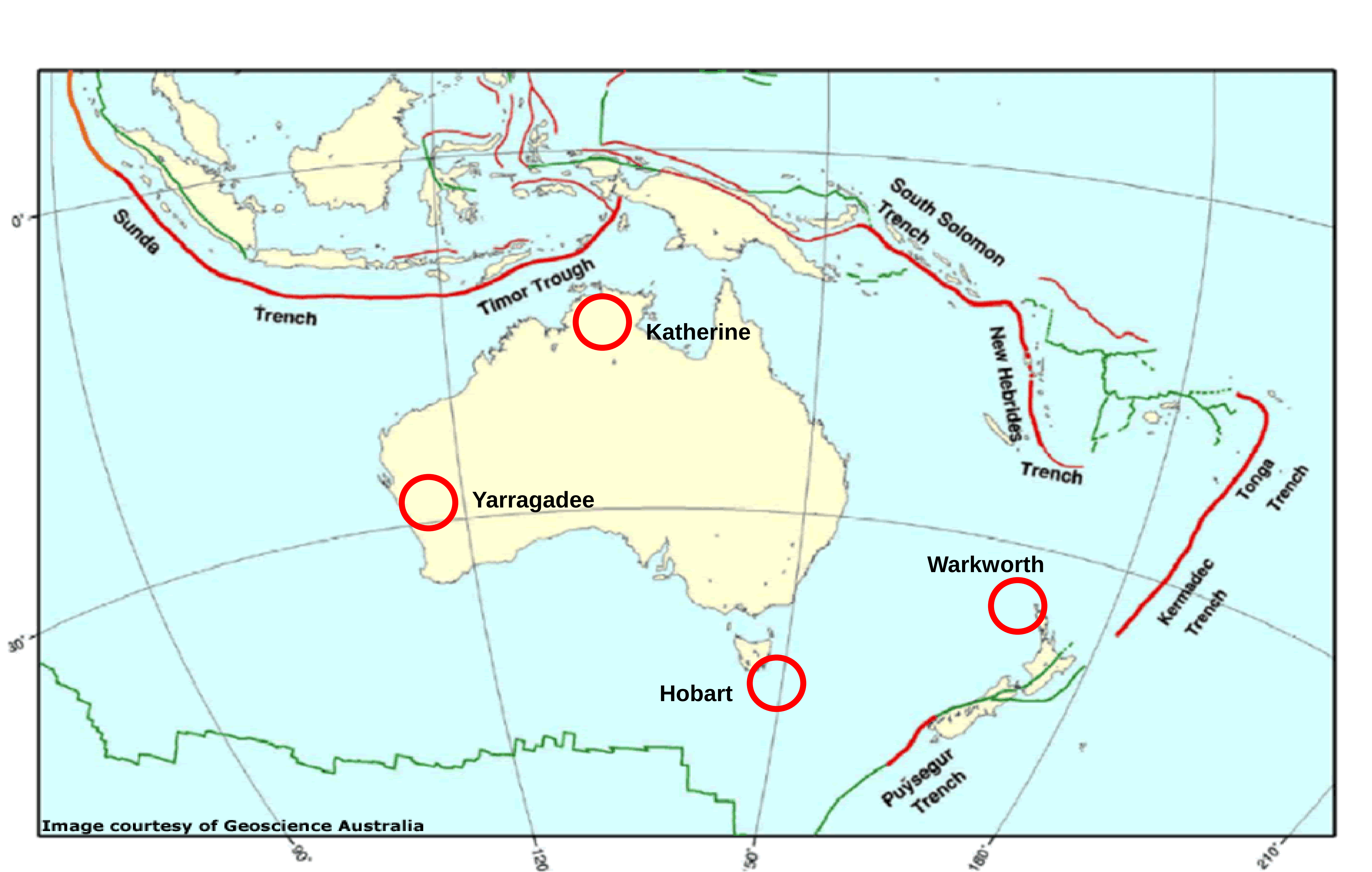


LBA meeting in February 2011

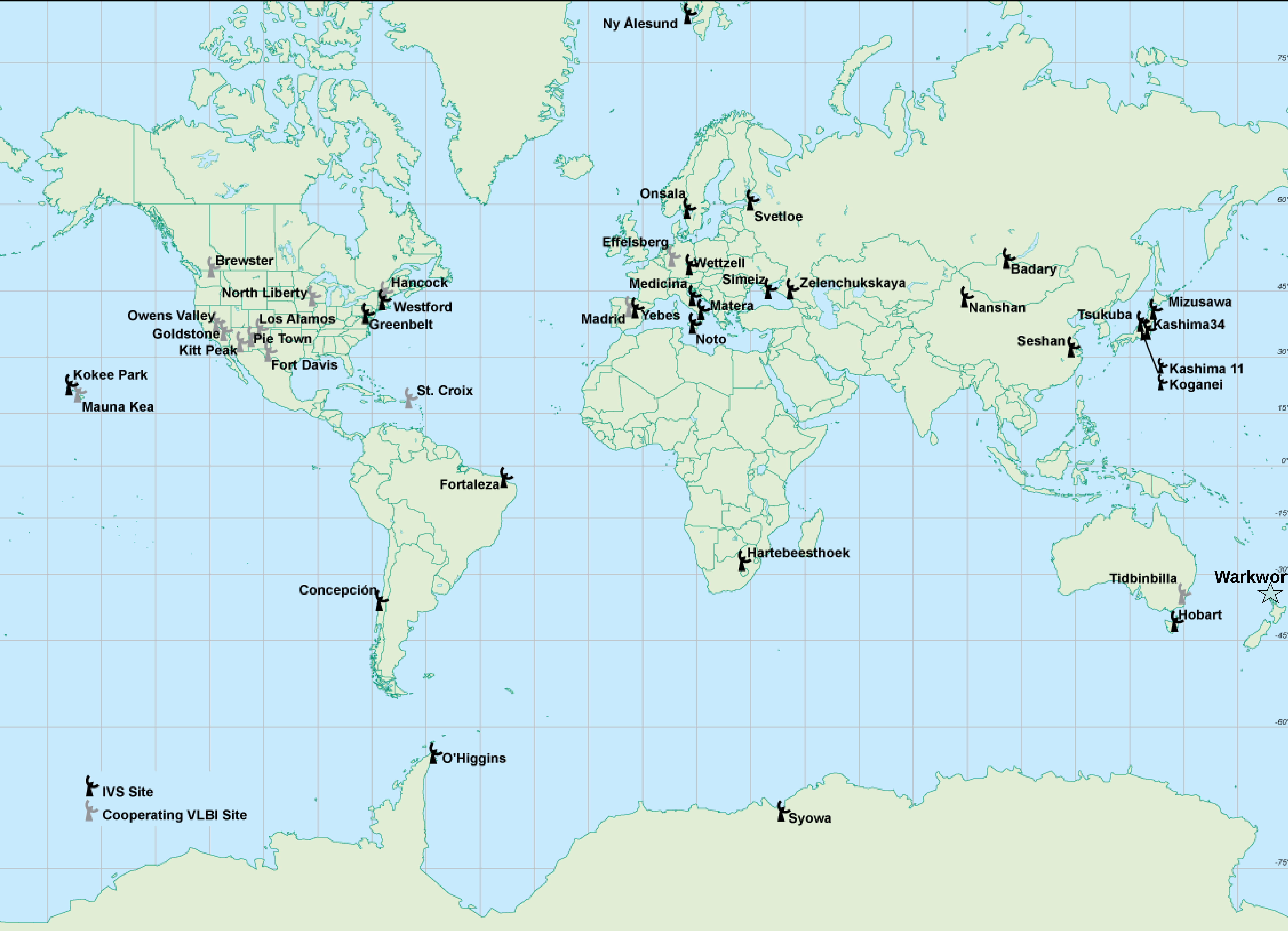
NZ joining LBA

AuScope

Study of Australian Tectonic Plate deformation



- Warkworth (WARK12M) is one of IVS network stations.
- Regular IVS observations started in February 2011


Ny Ålesund
Onsala
Svetloe
Effelsberg
Wettzell
Medicina
Simeiz
Zelenchukskaya
Madrid
Yebes
Matera
Noto
Badary
Nanshan
Mizusawa
Tsukuba
Kashima34
Seshan
Kashima 11
Koganei
Brewster
North Liberty
Hancock
Westford
Greenbelt
Owens Valley
Goldstone
Los Alamos
Pie Town
Kitt Peak
Fort Davis
Kokee Park
Mauna Kea
St. Croix
Fortaleza
Hartebeesthoek
Concepción
Tidbinbilla
Warkwor
Hobart
O'Higgins
Syowa
IVS Site
Cooperating VLBI Site

IVS Live

Calen…

i11031

Now observing session t2074

Go to now | Session Details | Webcams

Session Details | 2251+158 | 2145+067 | 0637-752 | 0119+115 | 1044+719

Session t2074

Start 2011-02-01 17:30:00

End 2011-02-02 17:30:01

Intensive No

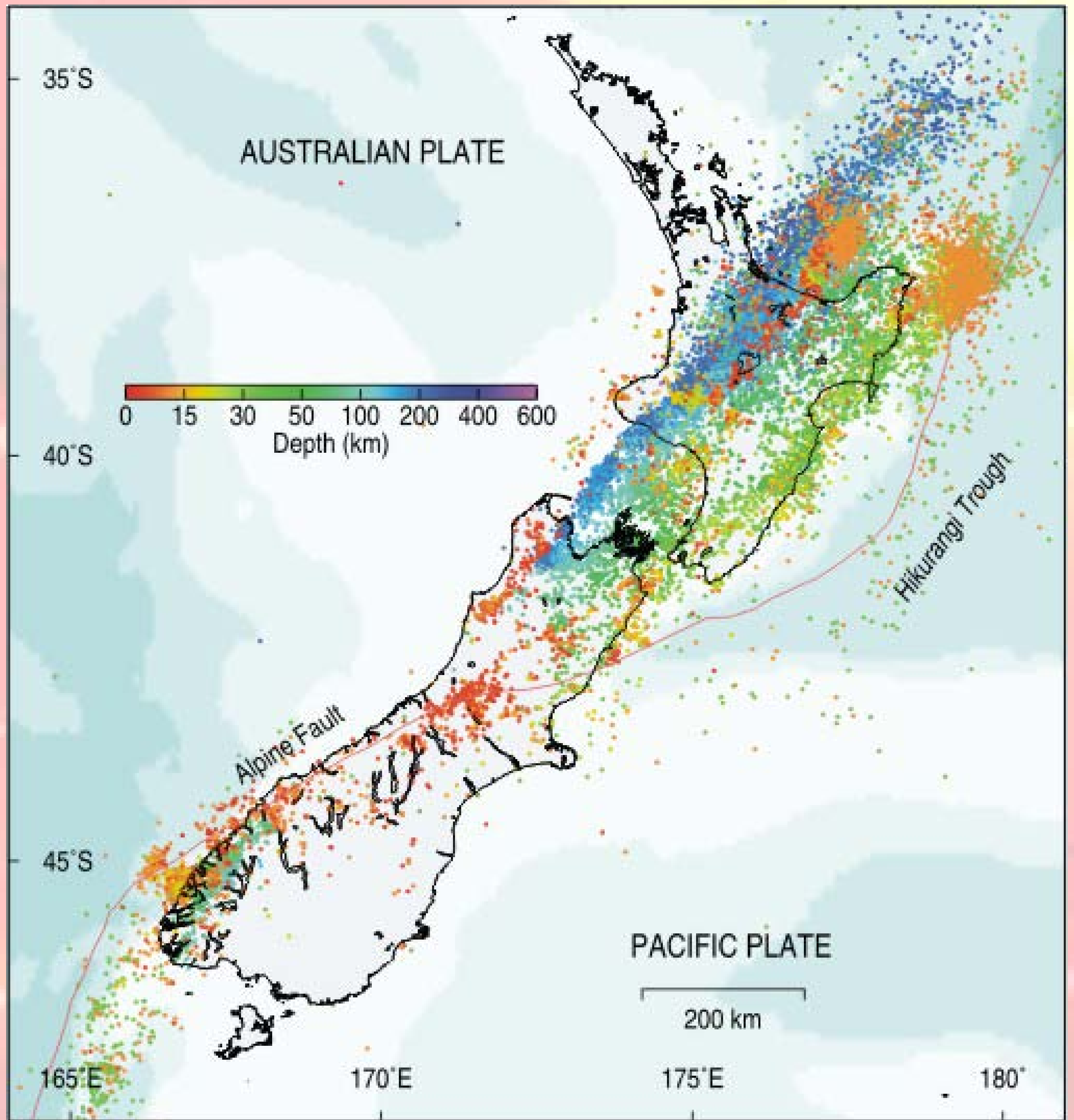
Sources (68) 0003-066, 0059+581, 0106+013, 0119+115, 0133+476, 0208-512, 0235+164, 0316+413, 0336-019, 0355+508, 0454-234, 052 0718+792, 0727-115, 0851+202, 0923+392, 0955+476, 1034-293, ... more

Stations (15) Aira, Chichijima, Crimea Simeiz, DSS13, Hartebeesthoek, Hobart 12m, Hobart 26m, Ishigakijima (VERA), Kokee Park, Mizusawa

TC]	Duration
00:46	663
01:29	378
05:50	68
07:44	216
08:53	129
09:30	149
10:45	40
11:24	92
16:42	720
19:32	366
26:14	133
27:09	131

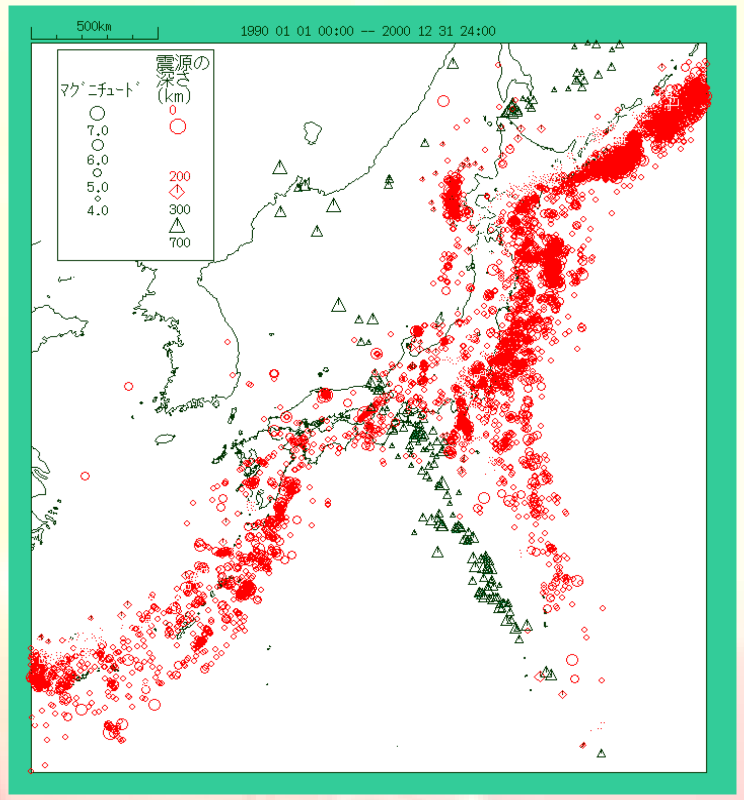
Plate boundaries & earthquakes

- NZ



22 February, 2011

- Japan

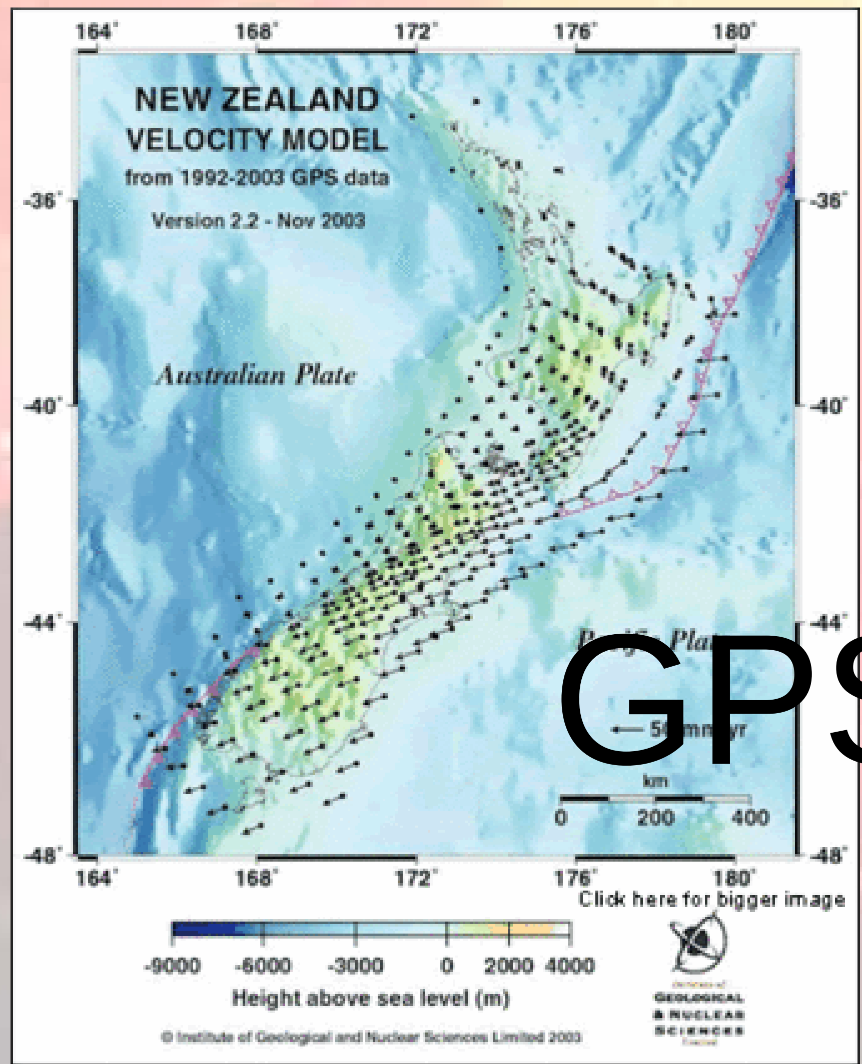


11 March, 2011

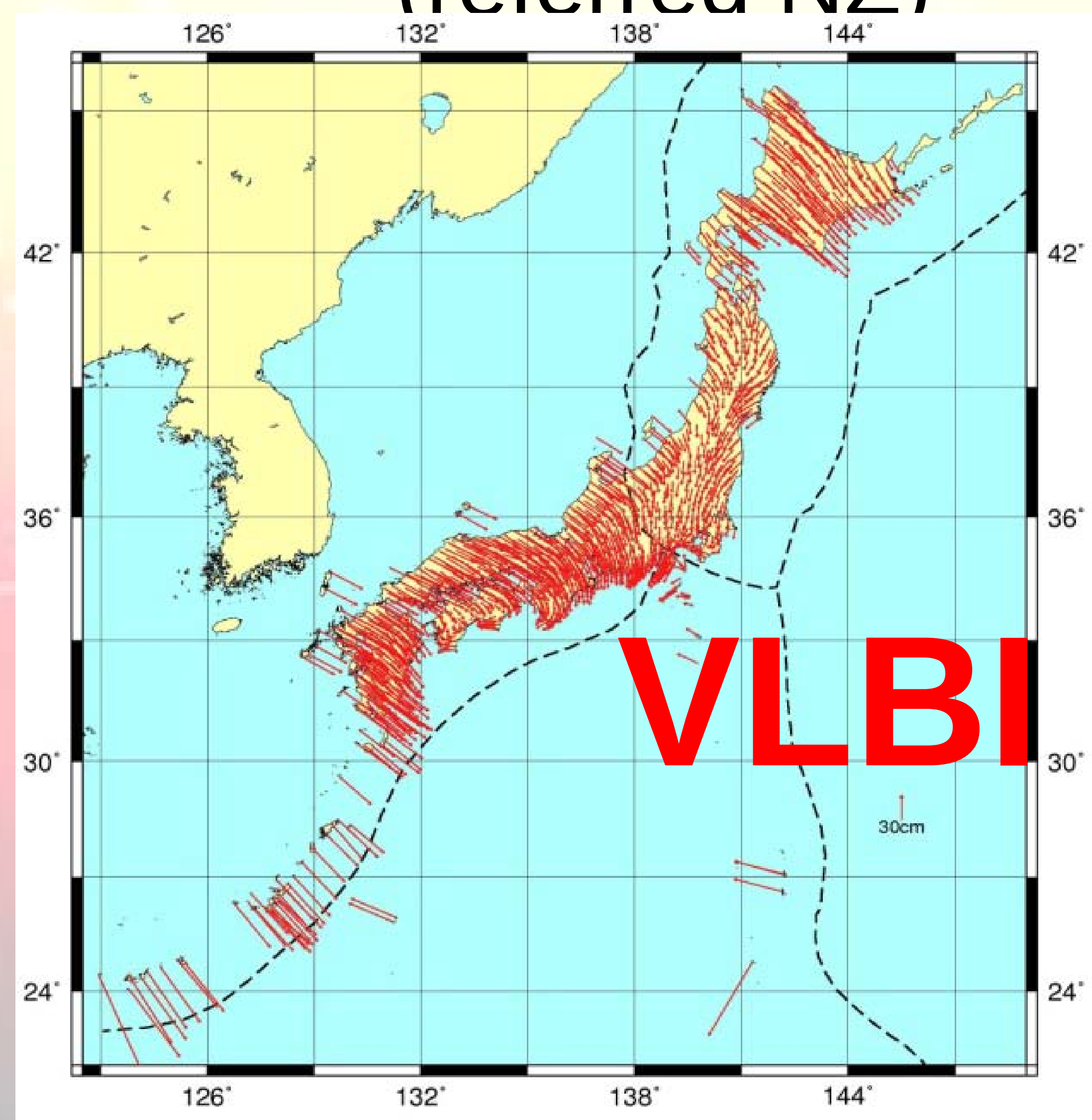
Space Geodesy

- NZ
  - NZGD2000 (1998)
    - ITRF96, 2000.0
    - Semi-dynamic system

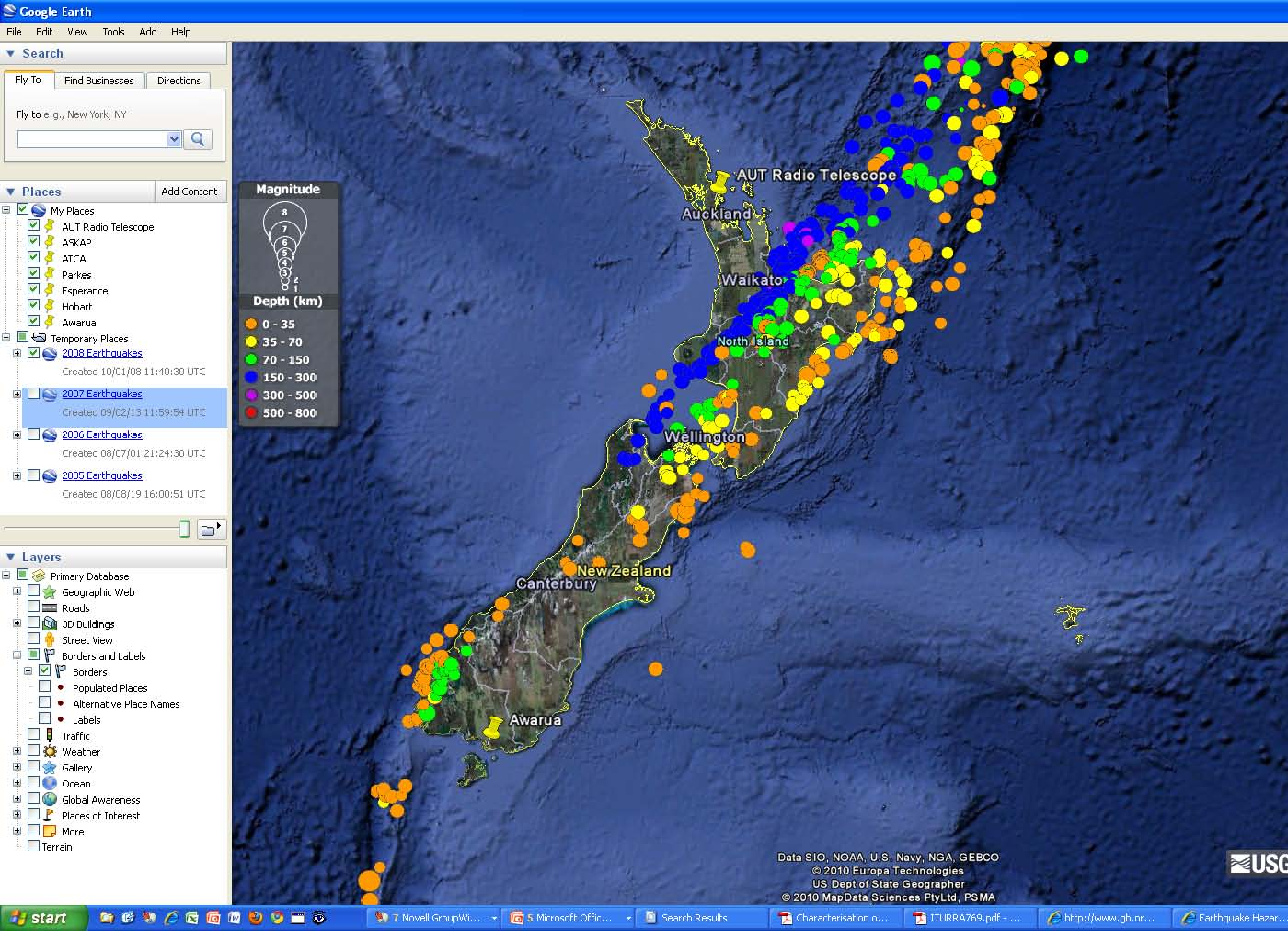
- Japan
  - JGD2000 (2002)
    - ITRF94, 1997.0
    - Static system
      + Semi-dynamic correction
      (referred NZ)



GPS



VLBI + GPS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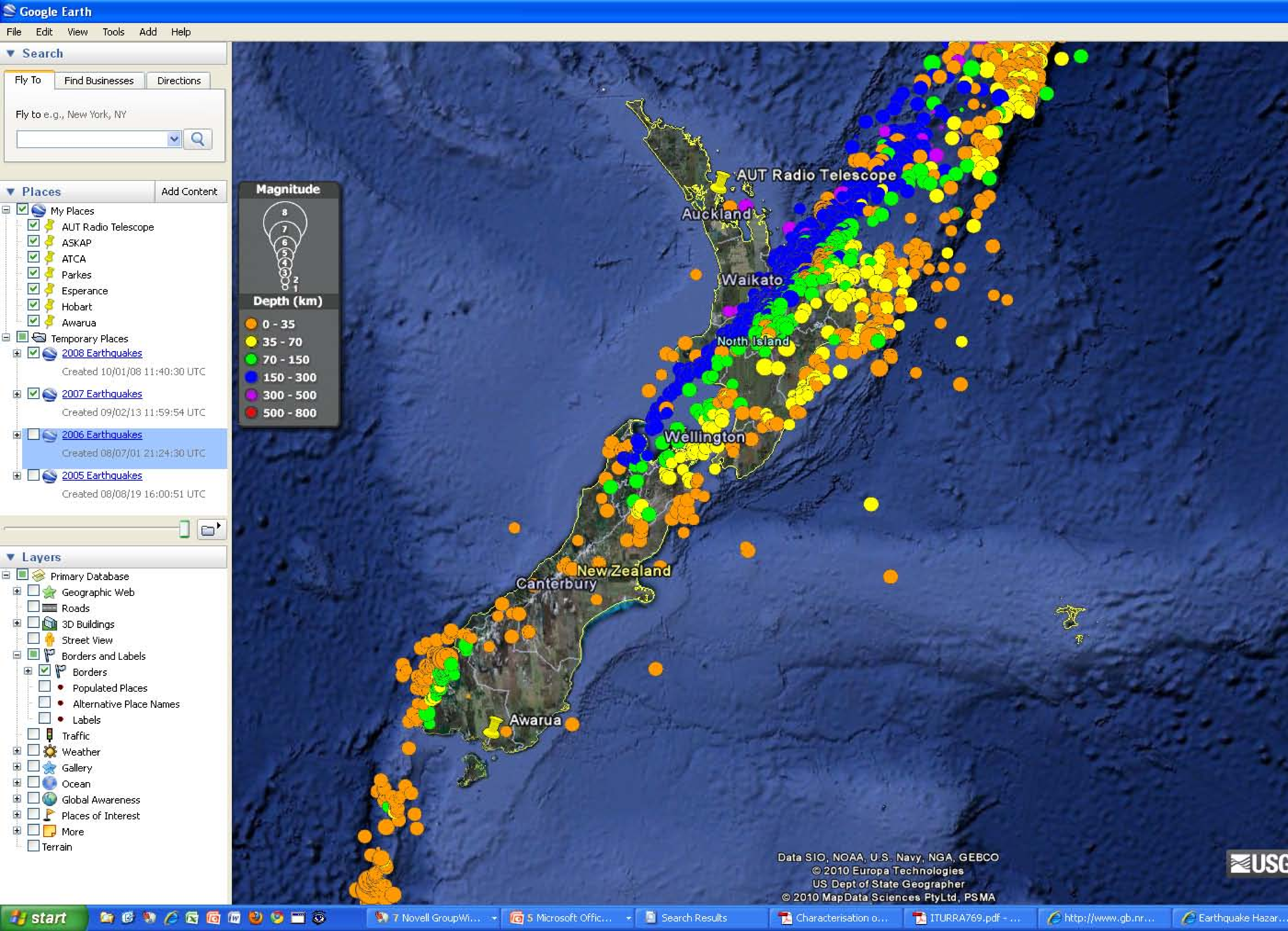

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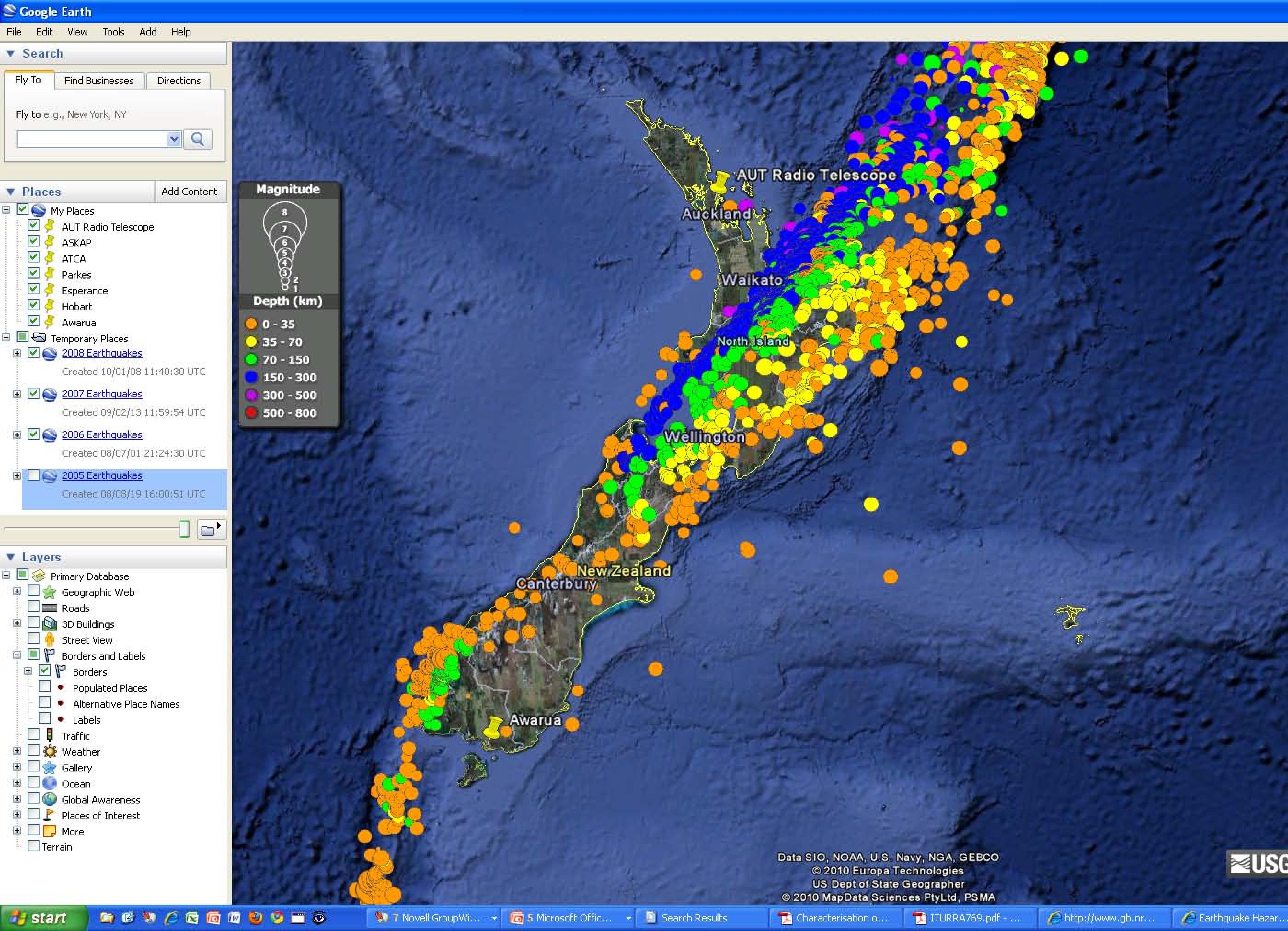
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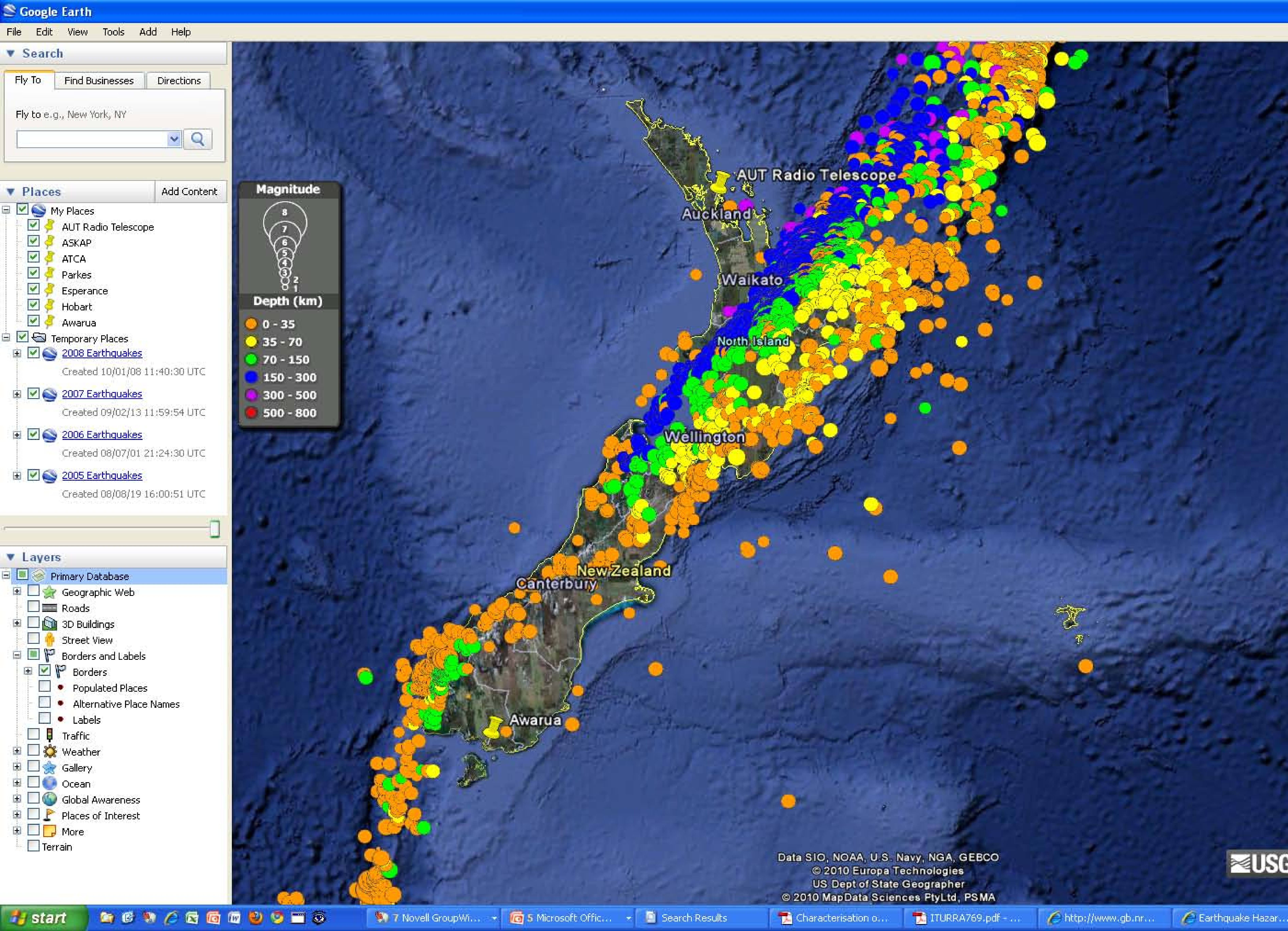
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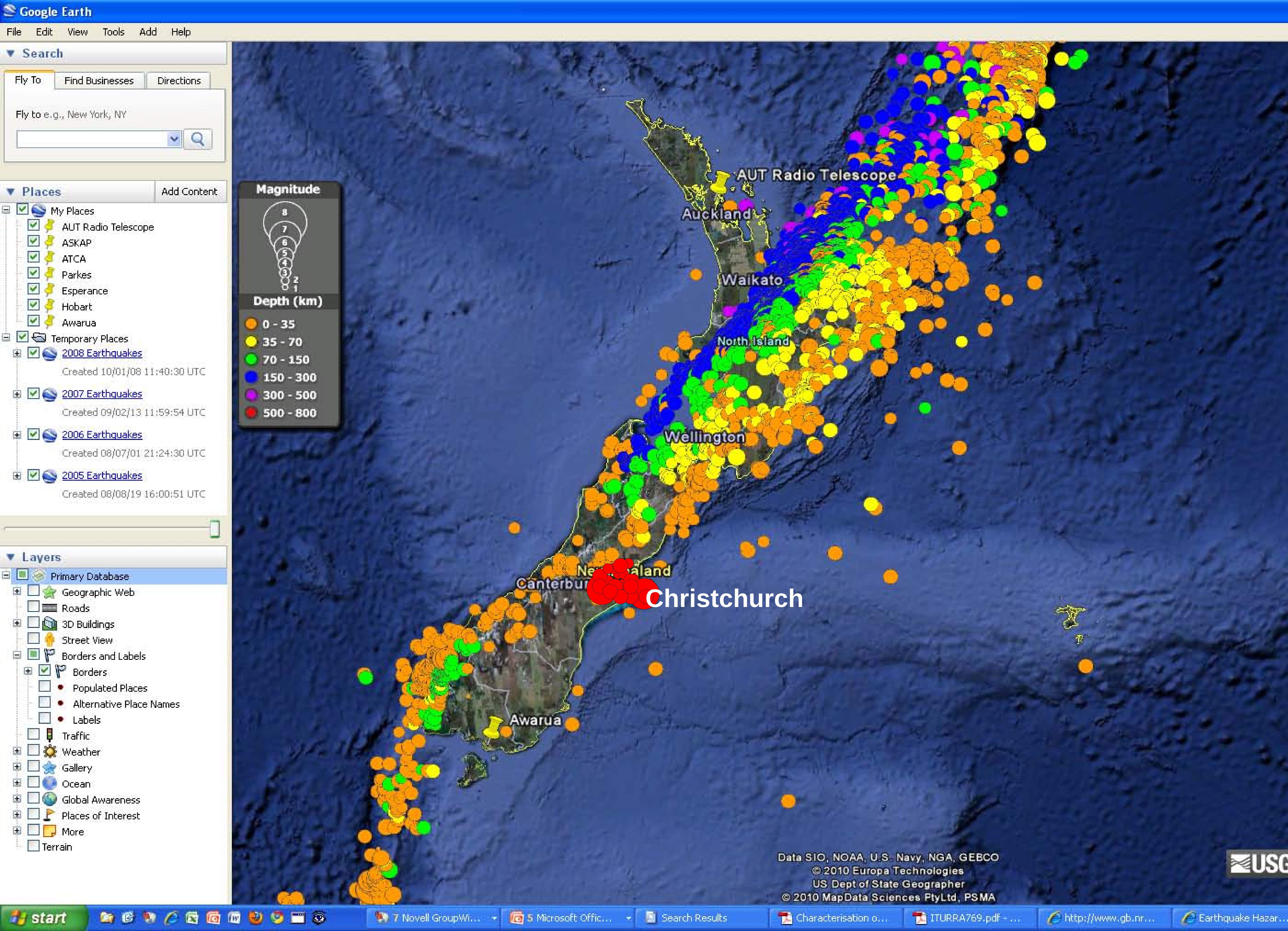

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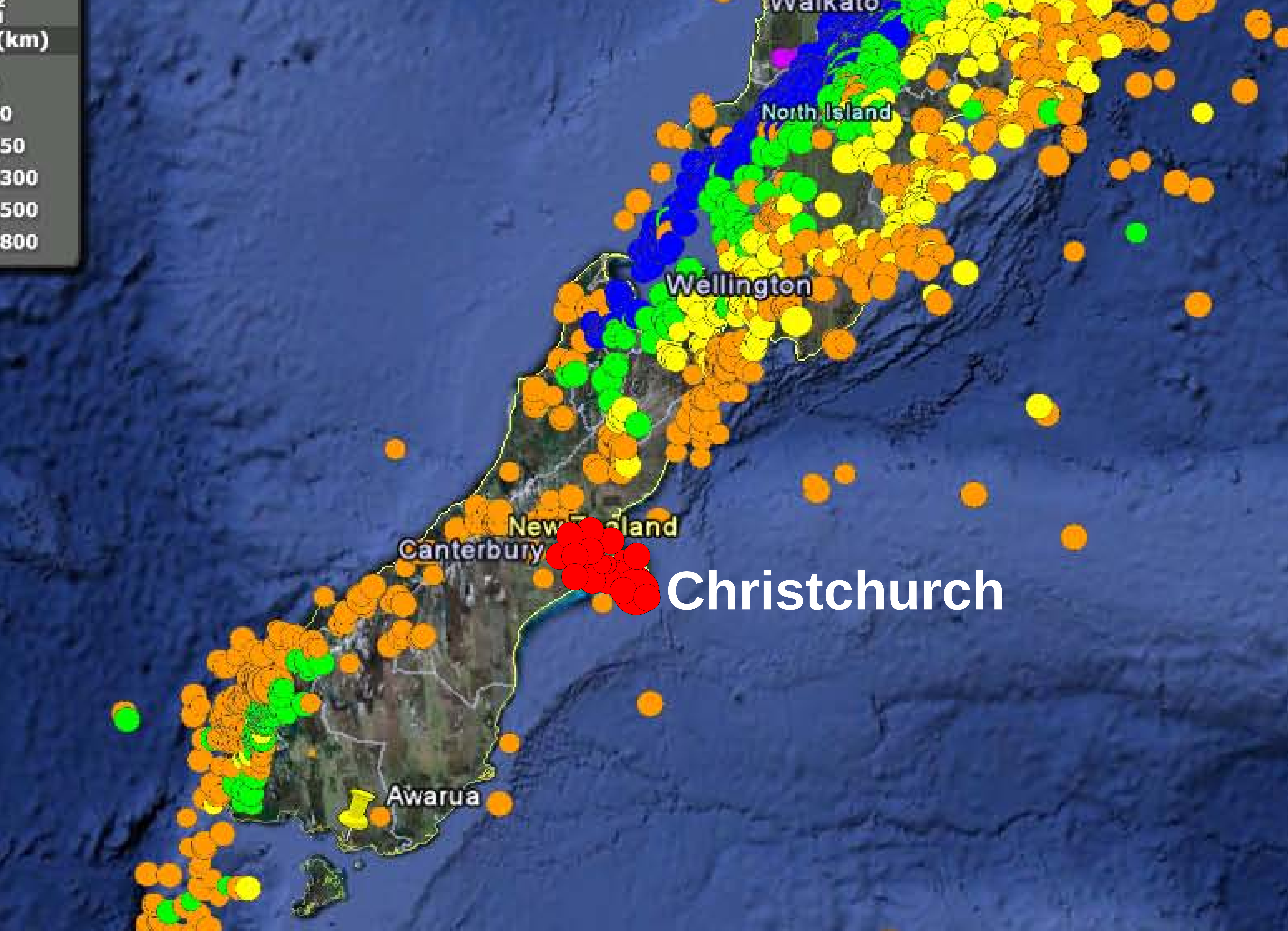

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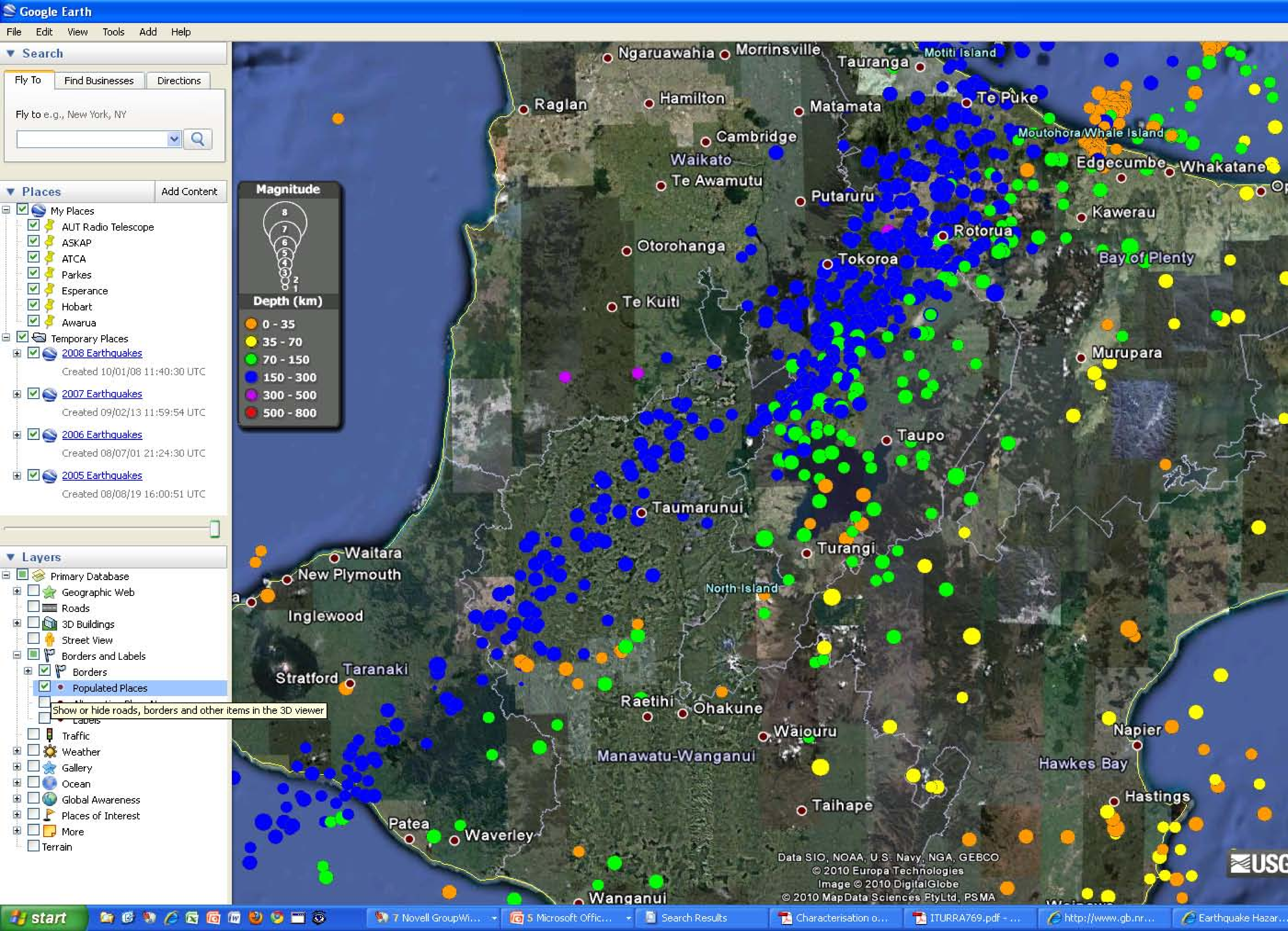
LEOPARD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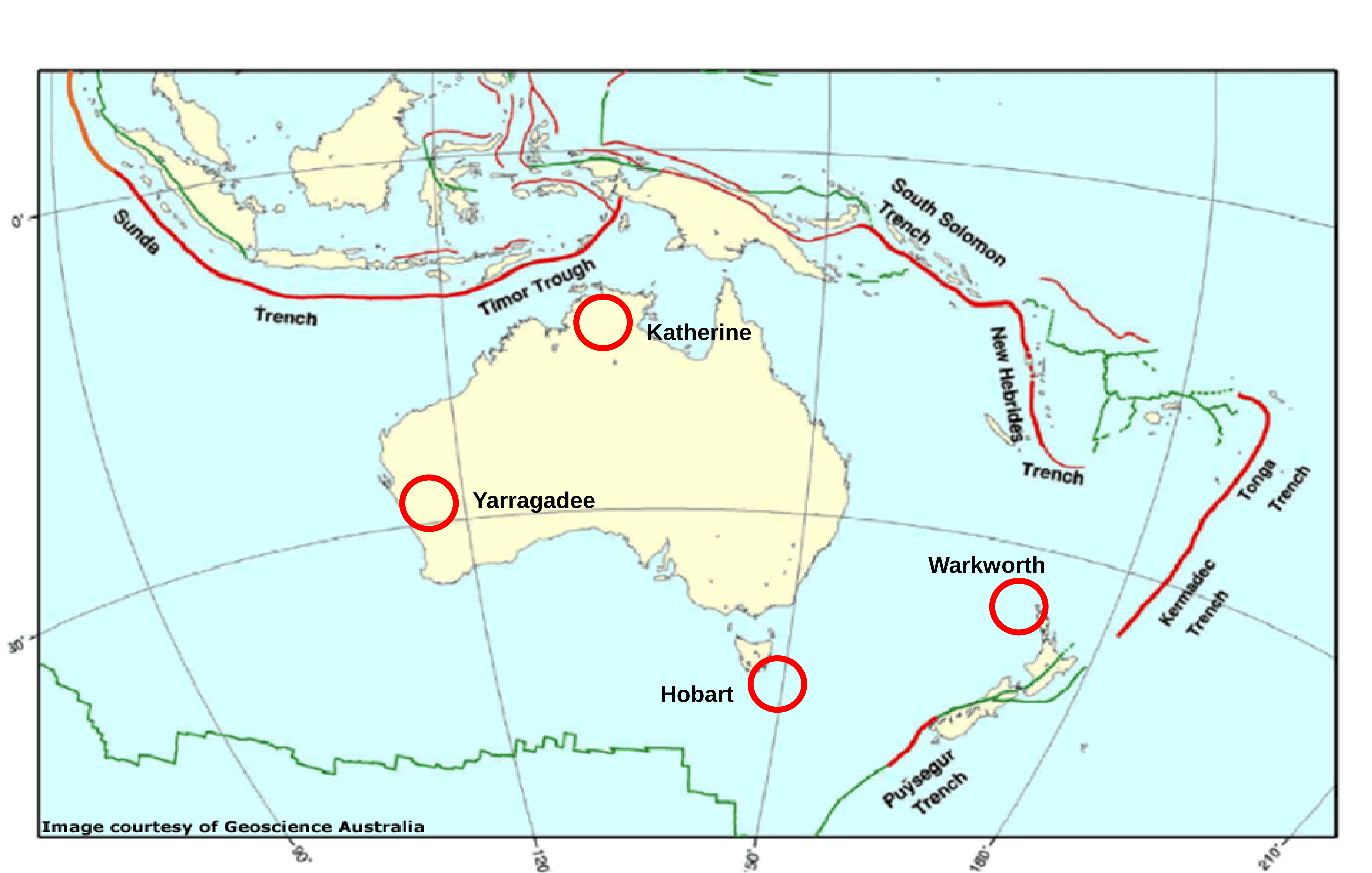
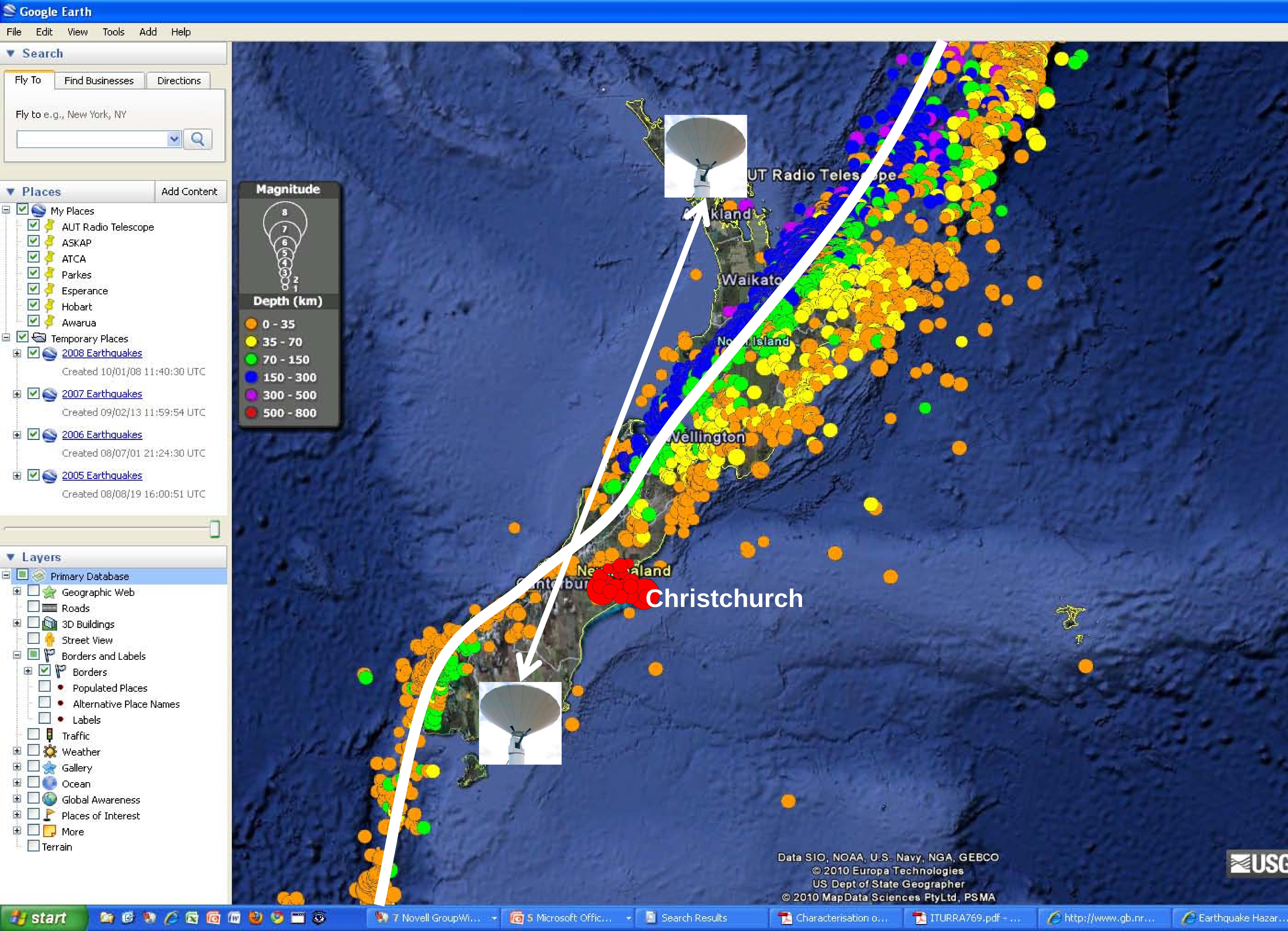
AuScope

Study of Australian Tectonic Plate deformation

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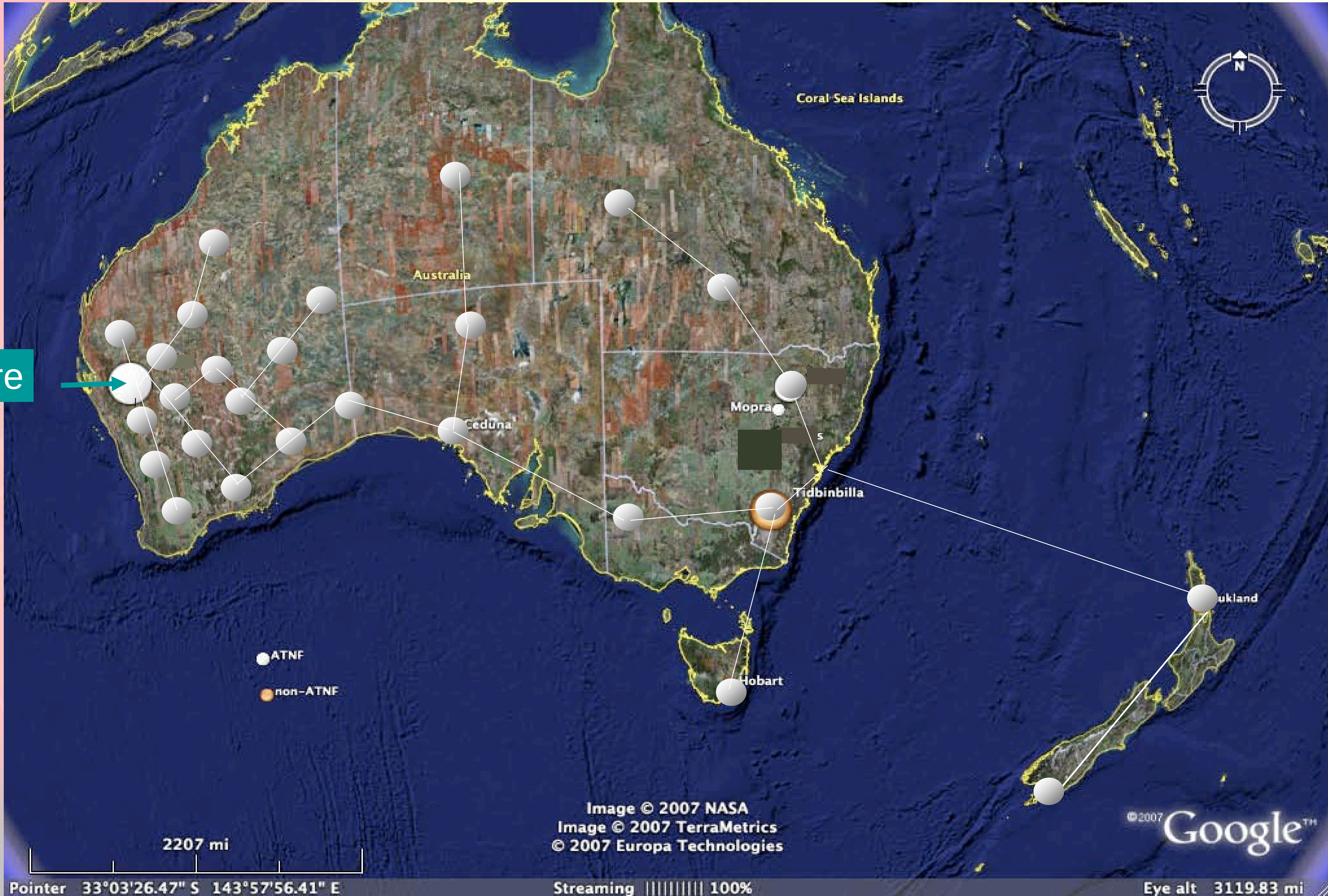
The Square Kilometre Array

SKA Core



THANK YOU !

Acknowledgements

- IRASR team
- CSIRO Astronomy and Space Science
- ICRAR team
- Curtin University group
- UWA group
- UTas radio astronomy group
- Swinburne University team