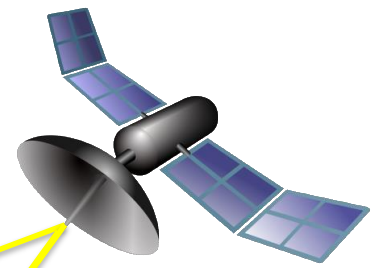
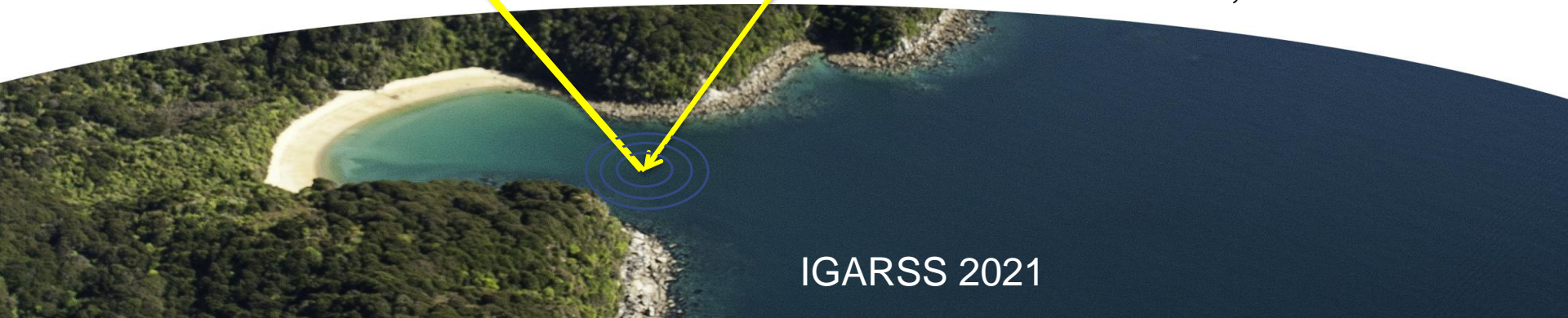


OPERATIONAL AIRBORNE GNSS-R ABOARD AIR NEW ZEALAND DOMESTIC AIRCRAFT



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Background

- CYGNSS Mission
 - NGRx Development
- Project Collaboration
 - Air New Zealand, CYGNSS, and NZ research orgs (University of Auckland and University of Canterbury)
- Coverage and Flight Simulations
- Instrument Calibration Plans and Soil Moisture cal/val
- Summary



CYGNSS Mission Overview

- Original Mission Objectives

- Measure ocean surface wind speed in all precipitating conditions with sufficient frequency to resolve tropical cyclone rapid intensification

- Flight Segment Design

- Eight satellites in low earth orbit at 35° inclination, each carrying a modified GPS receiver for bistatic radar measurement of GPS signals surface reflections

- Mission Status

- Launch 15 Dec 2016. All 8 s/c operating nominally. Mission objectives expanded to include measurements of soil moisture and inland water body extent from GPS surface reflections over land.



NASA IIP Next Gen GNSS-R Receiver (NGRx)

- Ruf PI

Engineering Design

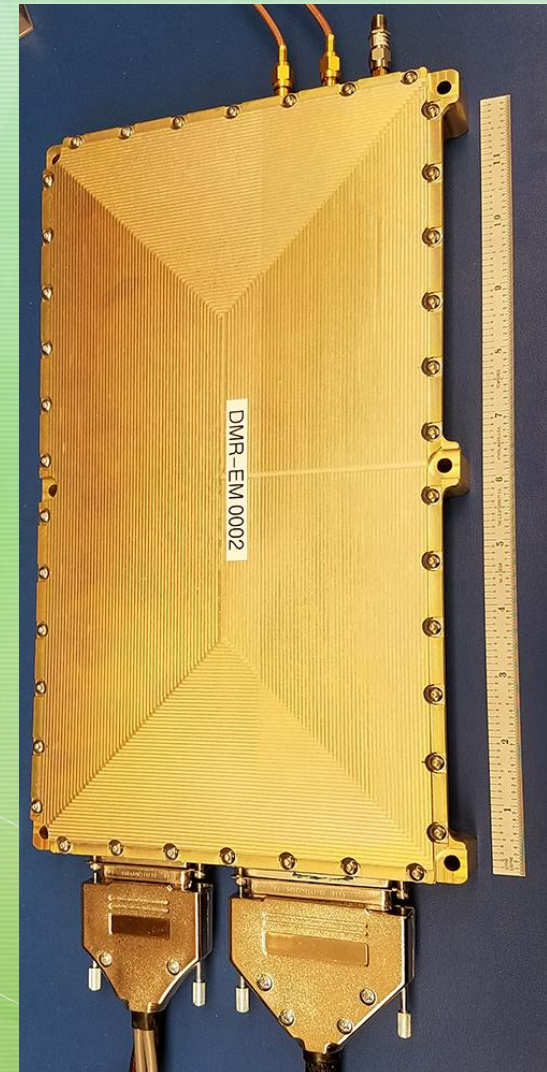
- GPS L1&L5, Galileo E1&E5
- 20 simultaneous receive channels
- Co- and X-pol antenna

Science data products (NGRx Mission)

- 5 km resolution
- 2 hr mean revisit (8 s/c constellation)
- Co- and X-pol scattering cross section
- $O(10\text{ cm})$ sea surface height uncert.

Enabling science applications

- Ocean surface wind speed (w/ improved temporal/spatial res)
- Land surface soil moisture (w/ improved temporal/spatial res and improved vegetation discrimination)
- Sea level height/tsunami detection
- Sea ice draft/sea ice mass



The NASA/NZ Partnership

- Air New Zealand's will certify, install and fly the NgRx
 - Initially restricted to domestic aircraft – Options Q300. or ATR
 - Safety assessment
 - No interference to operations or need to maintain
 - Compatible with Air New Zealand's sustainability program commitment
 - NASA supported customization of the hardware for automated airborne operations
 - New Zealand government support for engineering calibration and terrestrial science retrieval calibration and validation (in collaboration with US colleagues)
- ***TRL Advancement to 6***
 - ***Unique science records to advance terrestrial and coastal retrievals***
 - ***High temporal sampling***
 - ***High resolution/high SNR***
 - ***Long duration records***

Air New Zealand Q300 Aircraft



A Unique International Partnership



The screenshot shows a web browser displaying a news article. At the top, the NASA logo is visible on the left, and the New Zealand Herald logo is in the center. Below the newspaper logo, the Air New Zealand logo is featured, including the text 'AIR NEW ZEALAND' and '80 YEARS YOUNG'. A navigation bar contains links for 'Plan', 'Book', 'Experience', 'Airpoints™', and 'Help', along with a search bar and links for 'Manage booking' and 'Check in'. The article title is 'Air New Zealand joins NASA climate science mission'. The sub-headline reads: 'In a world first, Air New Zealand and NASA are working together to monitor climate change impacts, with the airline to collect unique environmental data during domestic flights.' The date '25 February 2020' is at the bottom left of the article content.

New Zealand Herald

AIR NEW ZEALAND 80 YEARS YOUNG

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Media releases >

Air New Zealand joins NASA climate science mission

In a world first, Air New Zealand and NASA are working together to monitor climate change impacts, with the airline to collect unique environmental data during domestic flights.

25 February 2020



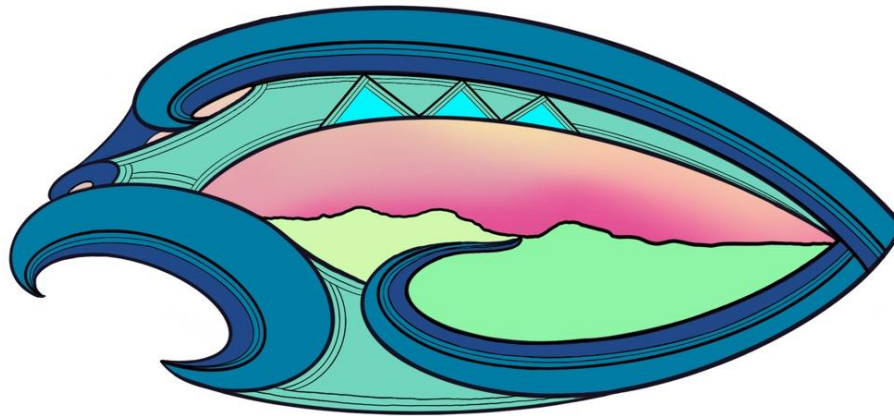
Spacecraft: Air New Zealand operates 23 Q300 aircraft across its network. Photo / Supplied, Air New Zealand

NZ Herald

Rongowai

Our mission name: Rongowai.

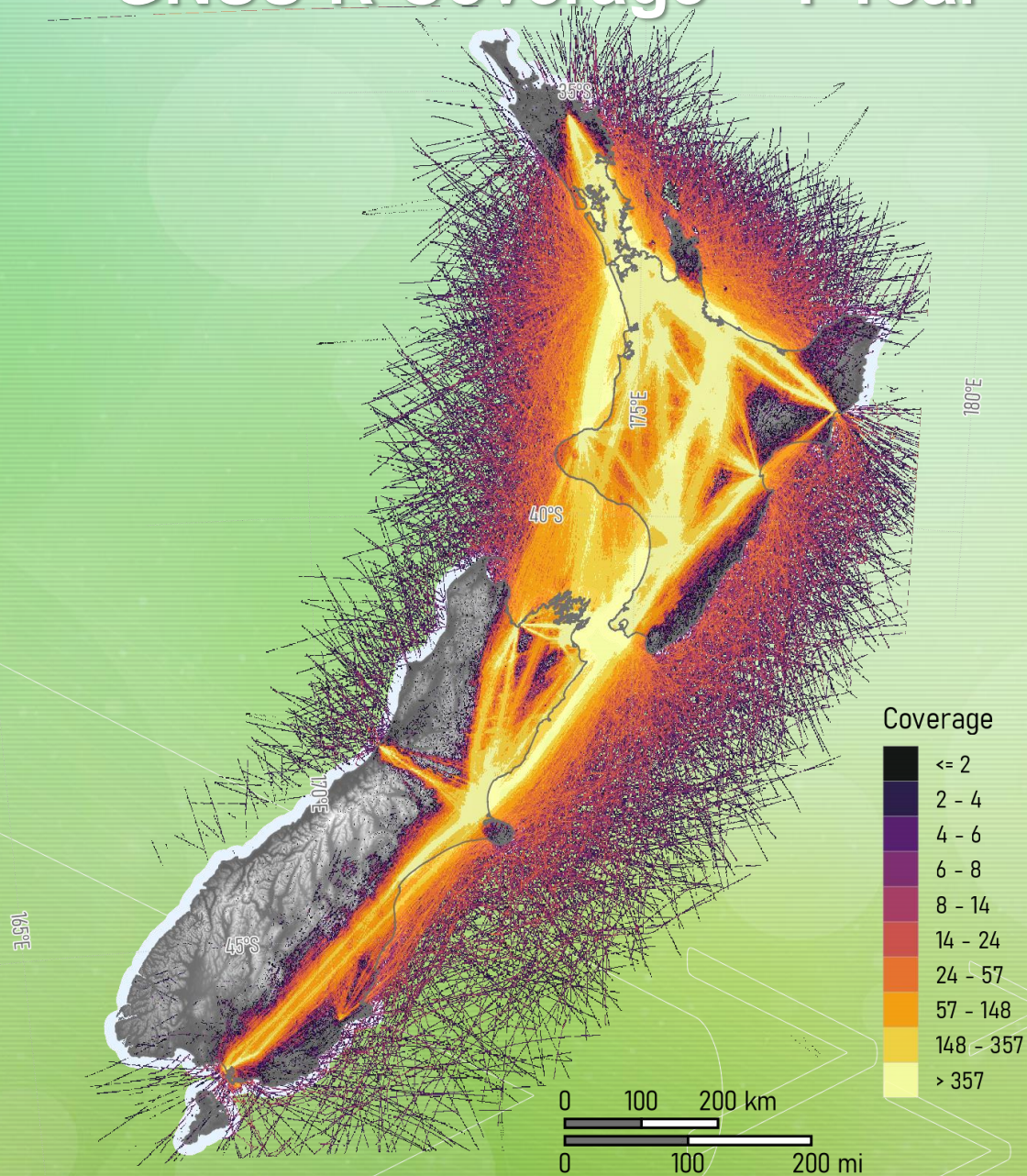
- In te reo Māori Rongo means to sense and wai means water



R O N G O W A I

GNSS-R Coverage – 1 Year

- 1 year of GNSS-R measurements for a single Q300 aircraft
- GNSS-R measurements (GPS & Galileo only) are assumed to be at 1 Hz
- Grid size is 800 m
- Line-of-sight obstruction due to topography accounted for
- Shows that, after one year, there is very good coverage except for the mountainous regions on the South Island and some areas obscured by topography



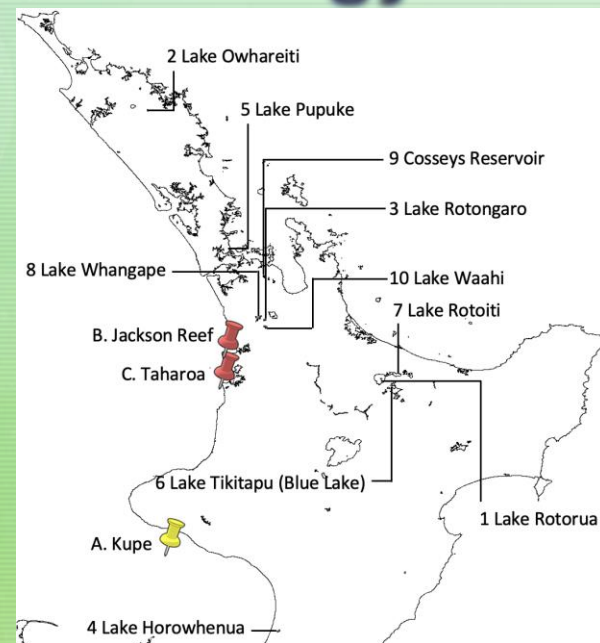
Example Flight Coverage

Single Flight from Auckland to Kerikeri (will overlap with CYGNSS Coverage)



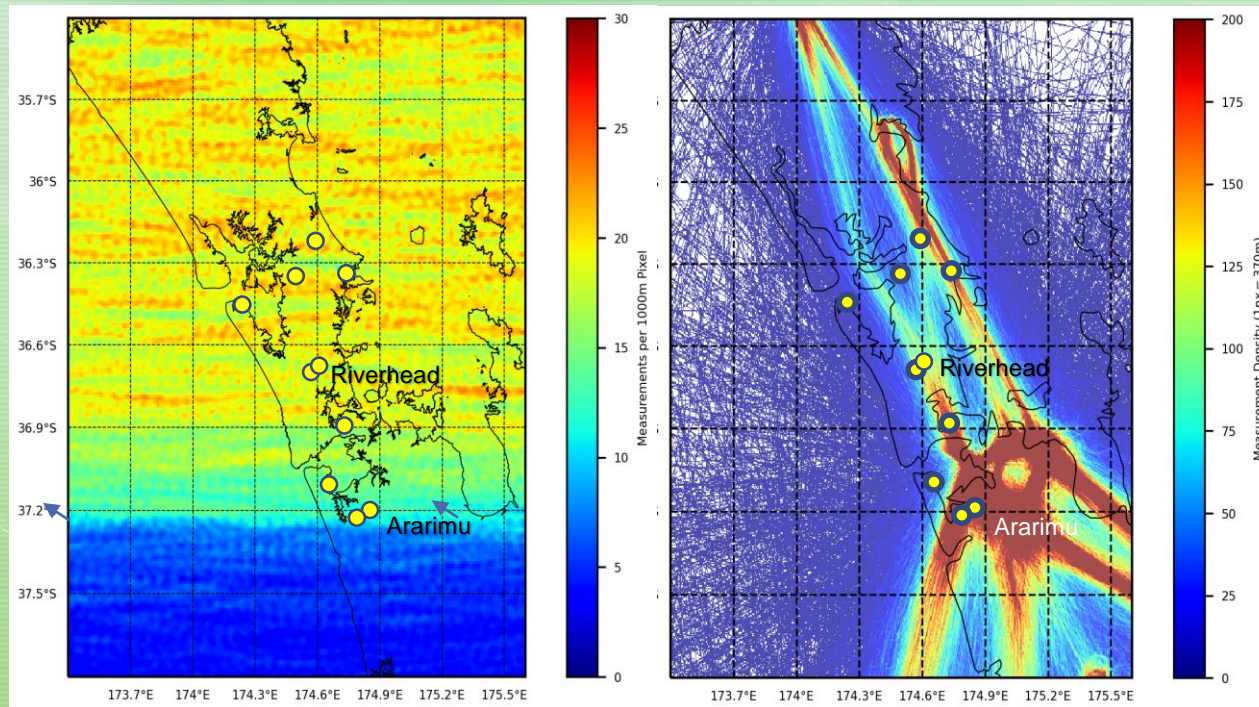
GNSS-R Calibration Strategy

- Antenna pattern comprehensively measured and characterized (ref?)
- During initial checkout refine and C=characterise antenna pattern in the presence of the aircraft
- Strategy: Use lakes and ocean as calibration targets
- The 153 lakes $>1 \text{ km}^2$ were prioritised in terms of coverage, shape index (roundness), Elevation standard deviation within 2 km (surrounded by flat land?) and forest cover within 500 m (wind breaks)
- Top 10 lakes provide comprehensive calibration opportunities
- 3 buoys identified (2 wind and one wind/wave)
- Can define geographic windows for likely calibration target specular



No.	Name	Total No. of SX
1	Lake Rotorua	306685
2	Lake Owhareiti	710
3	Lake Rotongaro	2003
4	Lake Horowhenua	2640
5	Lake Pupuke	939
6	Lake Tikitapu	777
7	Lake Rotoiti	51528
8	Lake Whangape	7500
9	Cosseys Reservoir	208
10	Lake Waahi	2868

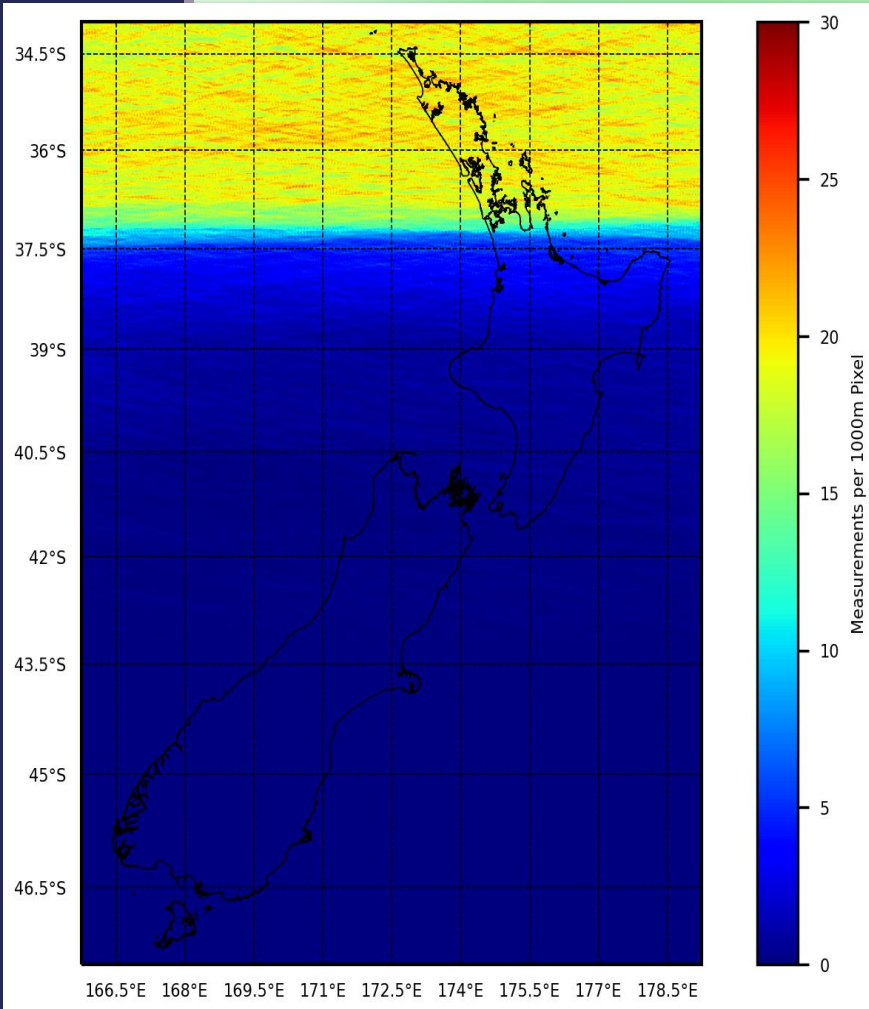
Auckland Region: AirCyGNSS and CYGNSS Coverage



- Overlapping coverage for cross-calibration
- Nine existing Auckland Council sites
 - Developing API access to data
- Augmenting Ararimu with SoilScape
- Riverhead additional SoilScape installation

CYGNSS New Zealand Coverage

CYGNSS Measurement Count (3yr)



- Far Northern peninsula. Unique geometry for electromagnetic modelling /validation
- Permission granted for SoilScape Installation in Wharekapua
 - On site weather station (wind speed/direction)
 - Installation planned for August
- Will also have complementary in situ soil-moisture monitoring network in Te Hiku forest

Summary

- Timeline:
 - NgRx Integration planned CY 2021
 - Shipping August
 - CYGNSS & Rongowai cal/val sites selected and permissions granted (ag and forest)
 - SoilScape field installations once final hardware is received.
- Plan developed using lakes and ocean for verifying and refining instrument cal
- Initial focus soil moisture
 - Ground campaigns and instrumentation
 - Establishing sites overlapping CYGNSS for mission cross calibration
 - Sites extending CYGNSS for expanded science will be next phase
- Additional opportunities to expand science sets include new airborne sensors including an L/P band polarimetric SAR and multispectral photogrammetry
- All capabilities coming on line this calendar year! Collaborations and participation welcome!



