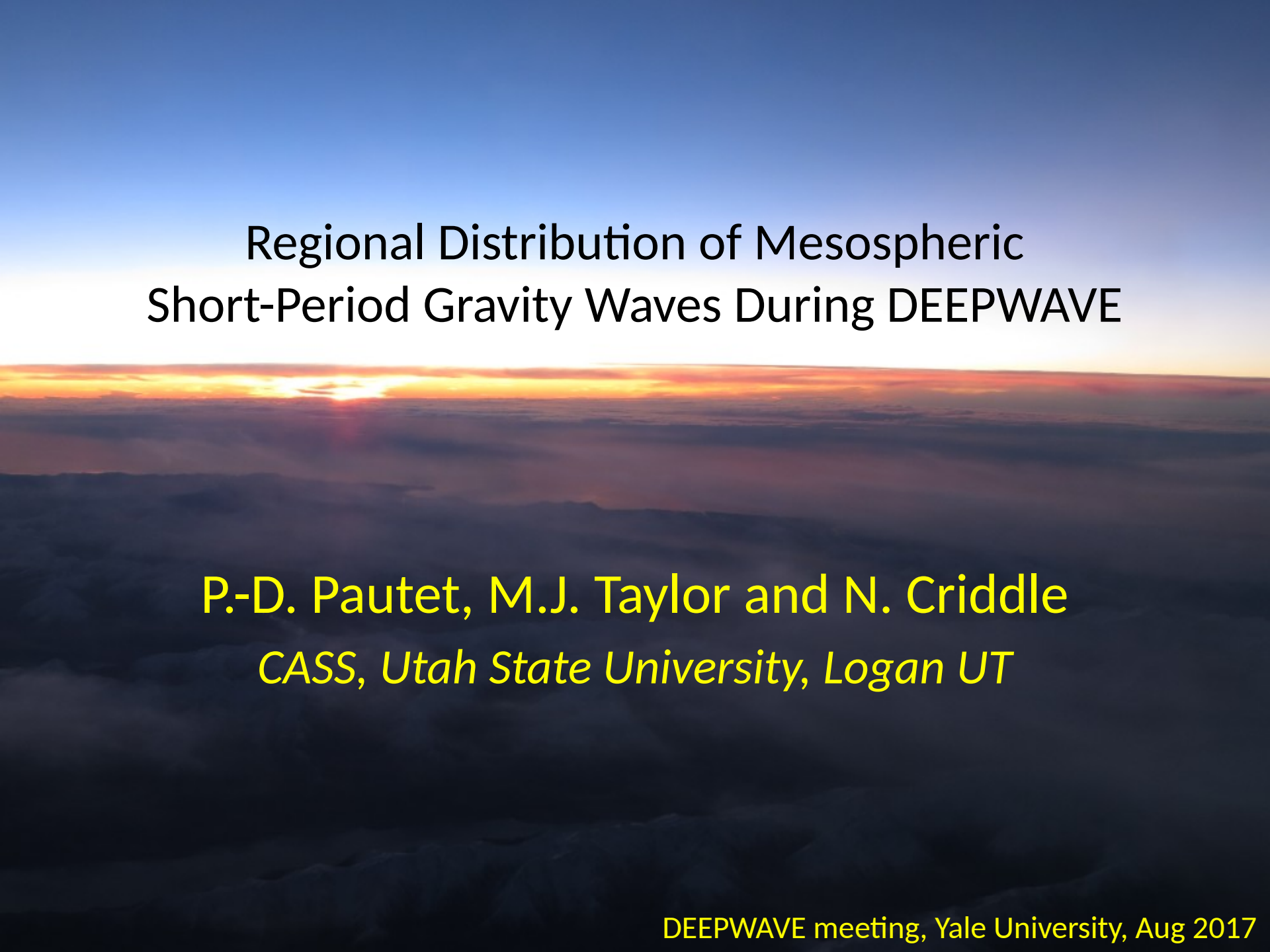


Regional Distribution of Mesospheric Short-Period Gravity Waves During DEEPWAVE

P.-D. Pautet, M.J. Taylor and N. Criddle

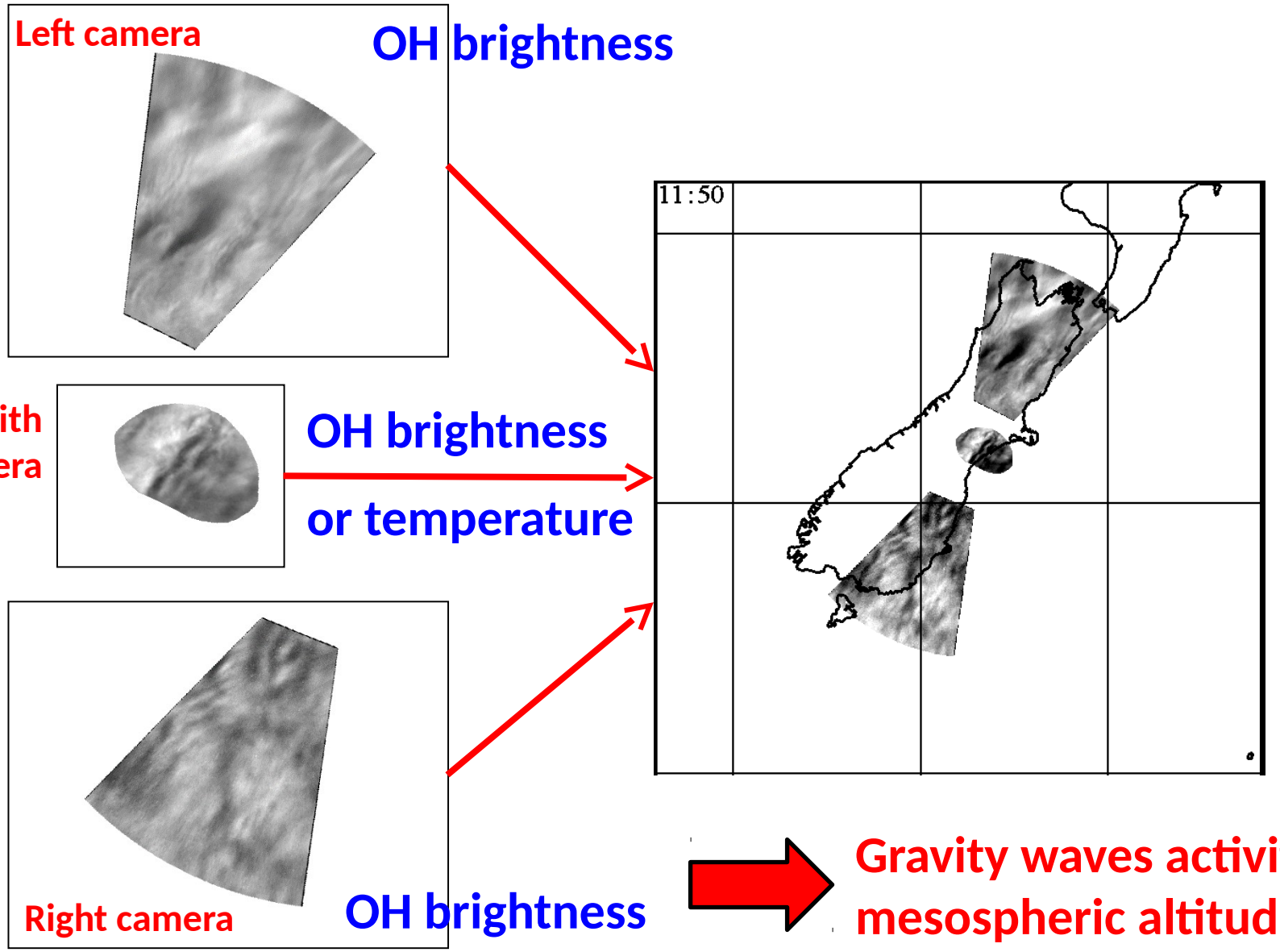
CASS, Utah State University, Logan UT

DEEPWAVE meeting, Yale University, Aug 2017

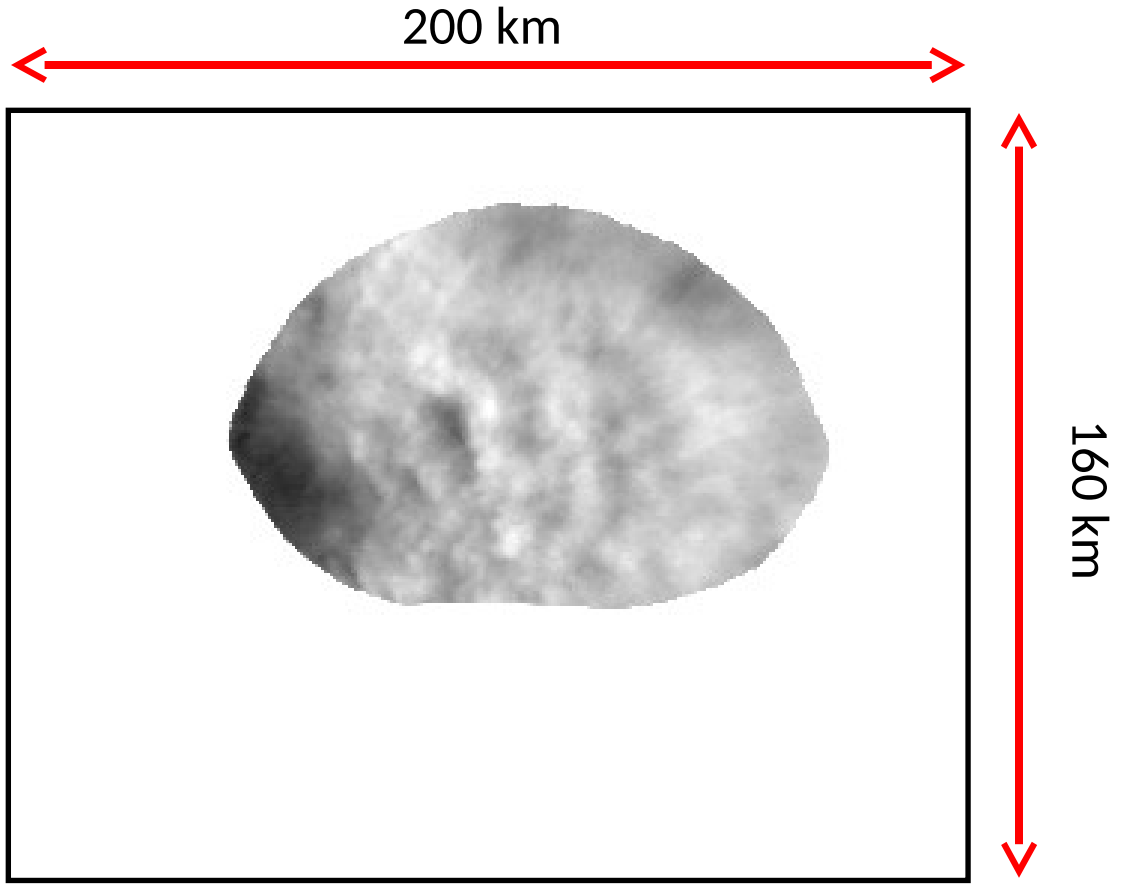
GV Upper Atmosphere Imagers

1 zenith imager (temperature + OH intensity)
+ 2 side cameras (just OH intensity)

Projection on a Geographical Map

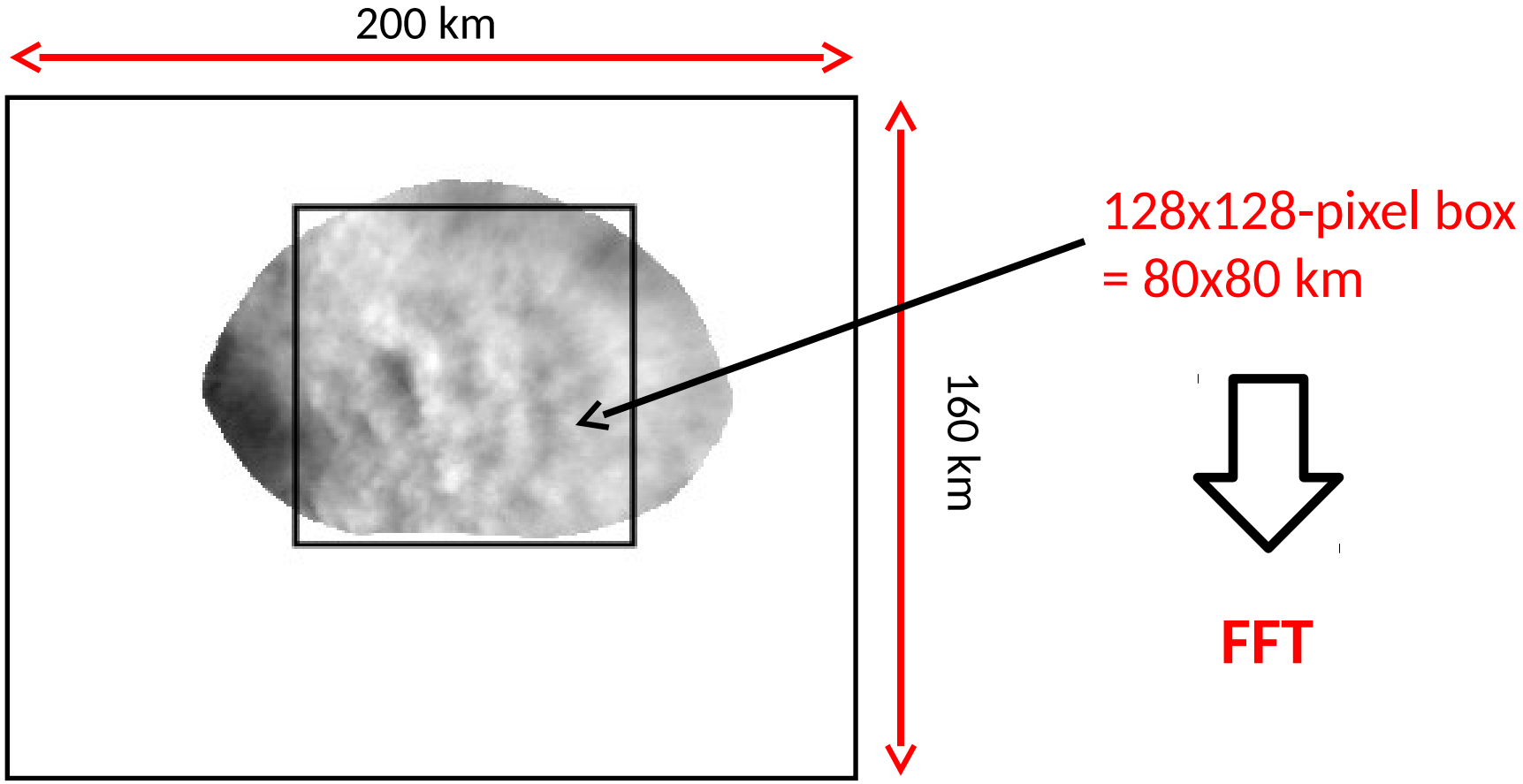


Quantifying the GWs Observed With the Zenith Imager

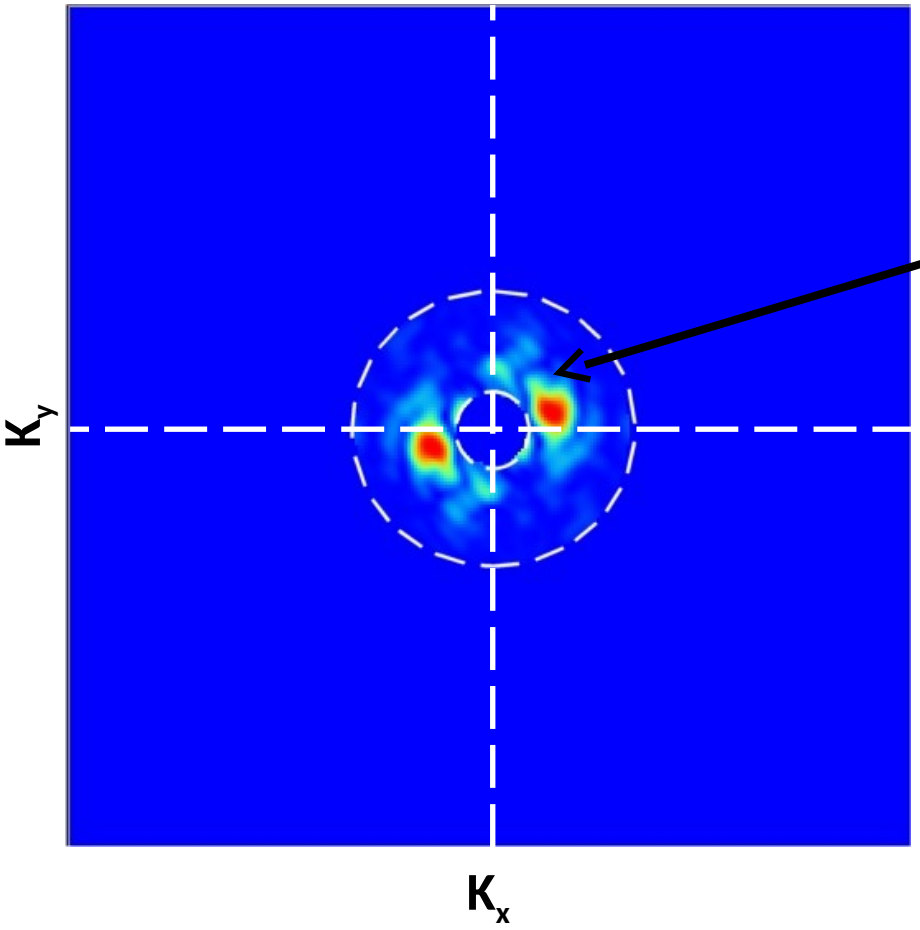


Irregular shape for the field-of-view of the zenith camera

Quantifying the GWs Observed With the Zenith Imager



Small-Scale GW Power Spectrum



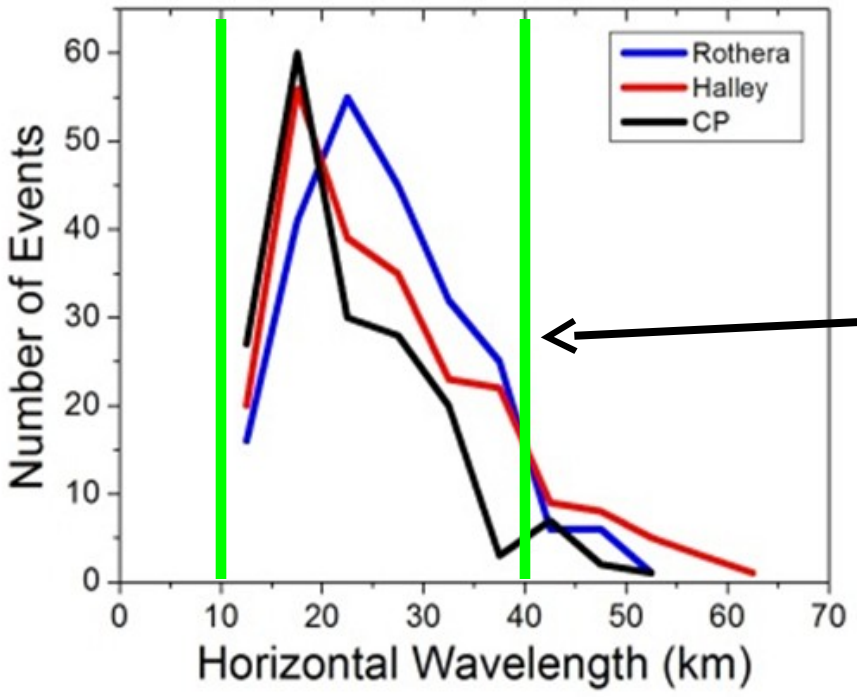
Integration of the power between the 2 circles
This power corresponds to the average temperature perturbation generated by the GWs

GWs with horizontal wavelength between 10 and 40 km

Small-Scale GW Power Spectrum

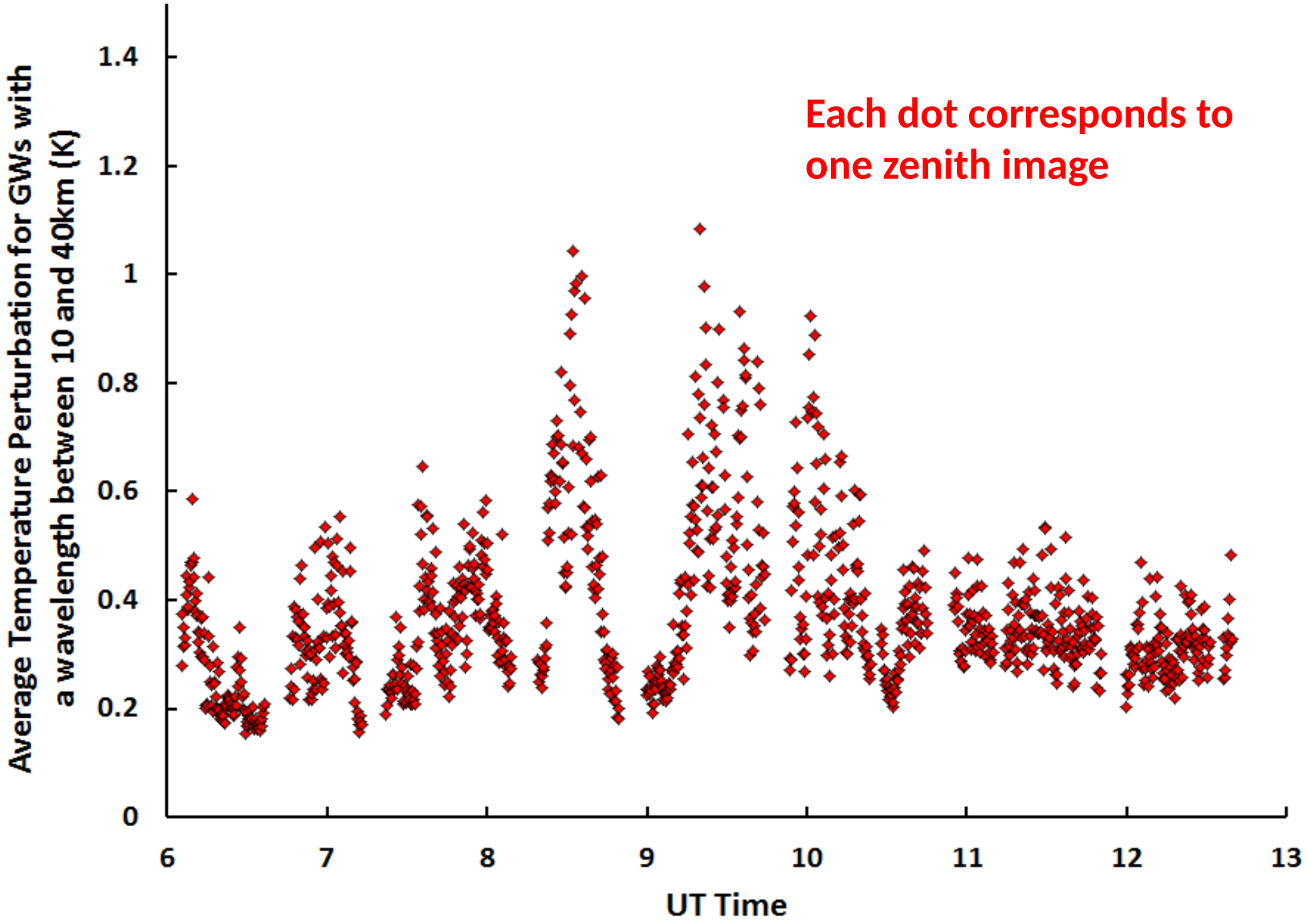
Short range of wavelengths, but:

- <10km, probably instabilities
- >40km, difficult to measure because of the small field-of-view (only 80km)
- Still representative of small scale GWs :



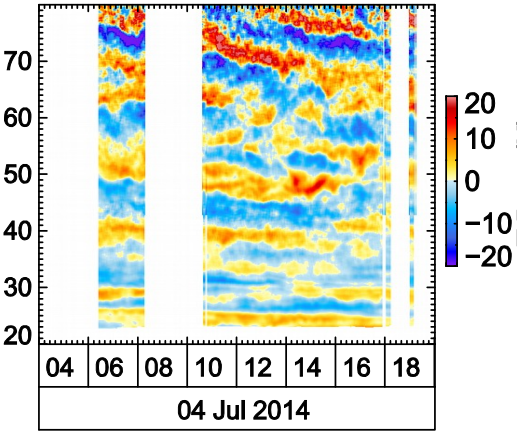
Typical horizontal wavelength distributions obtained using all-sky imagers at high (Rothera, Halley) and low (Cachoeira Paulista) latitudes (Nielsen et al., 2009)

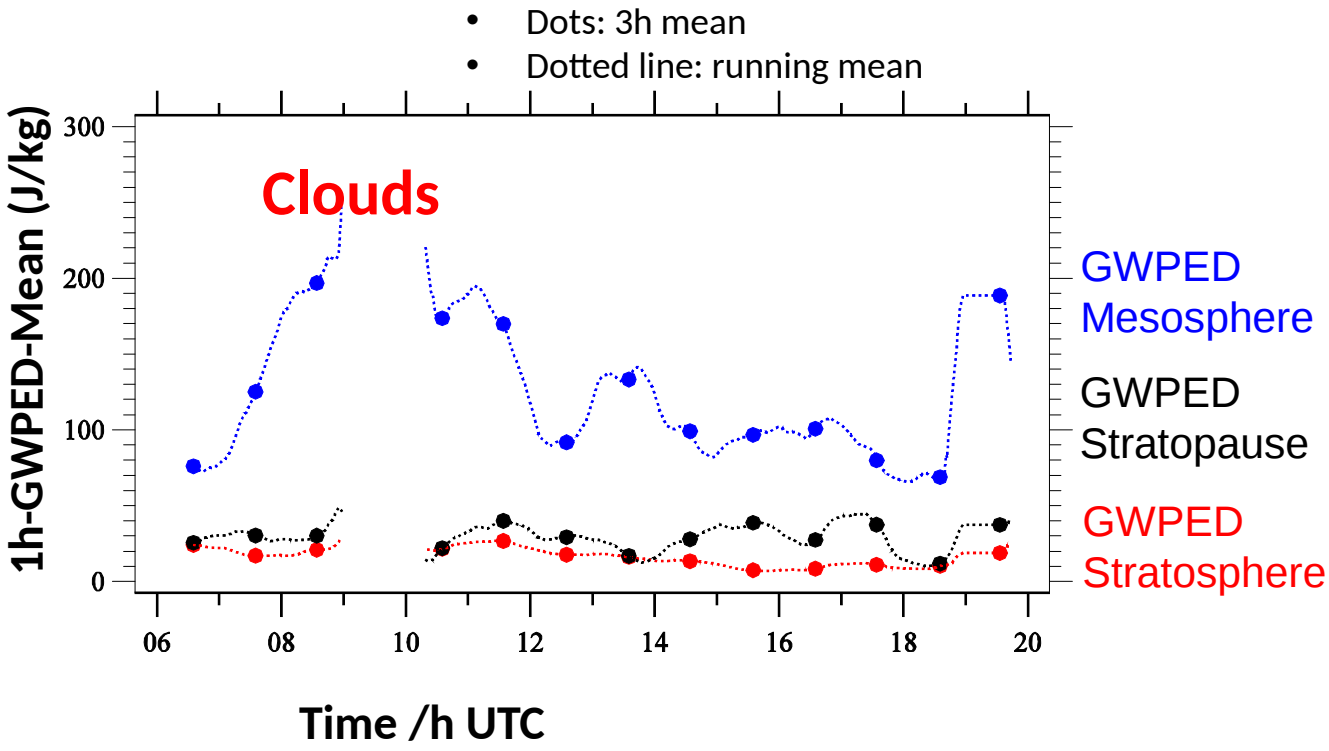
Power vs Time - Example: RF16



Ground-Based Data (Courtesy M. Bramberger)

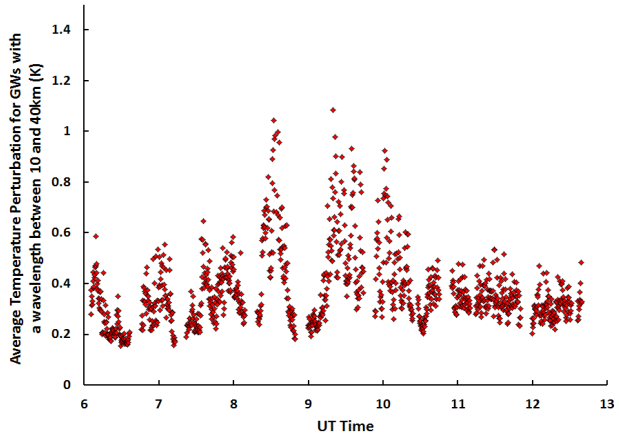
$$E_p(z) = \frac{1}{2}\frac{g^2}{\overline{N^2(z,t)}}\overline{\left(\frac{T'(z,t)}{T_0(z,t)}\right)^2}$$

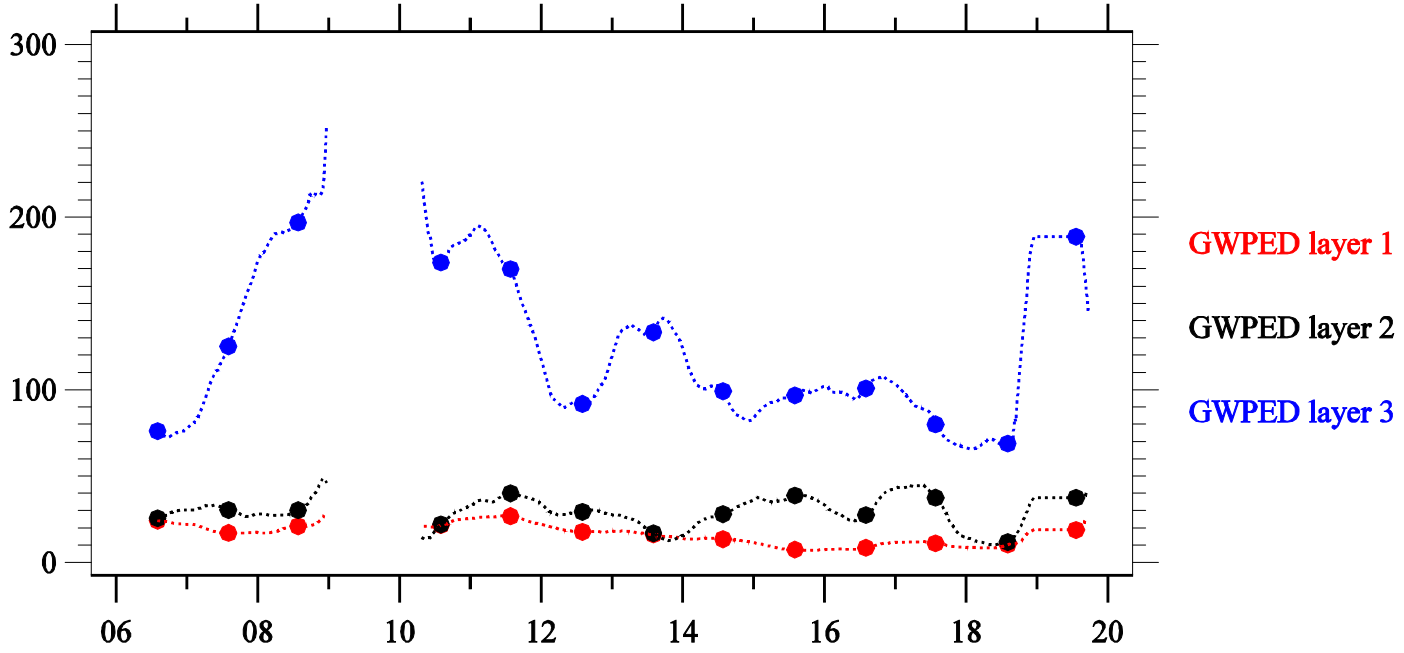




Between 06 and 12 UTC mesospheric gravity wave activity seems to be uncoupled from Stratosphere

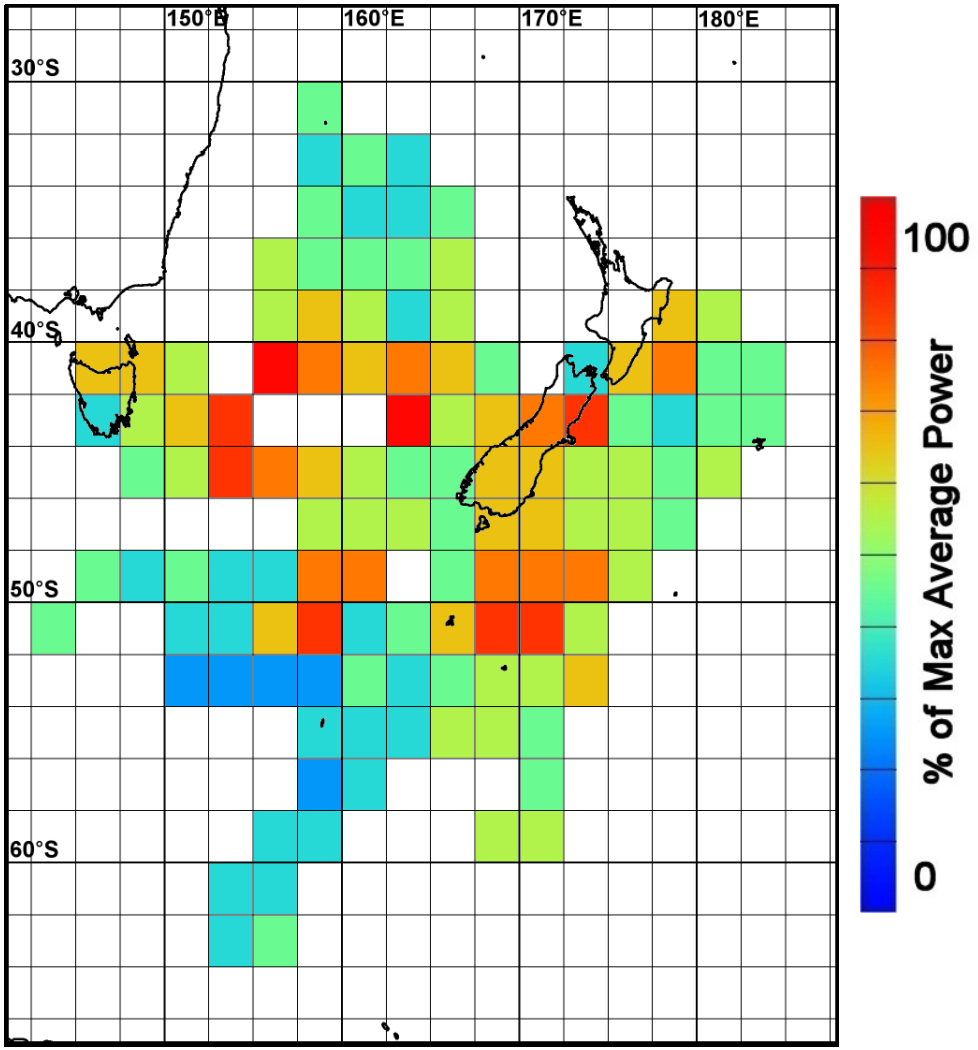
Comparison AMTM Power vs Lidar GWPED



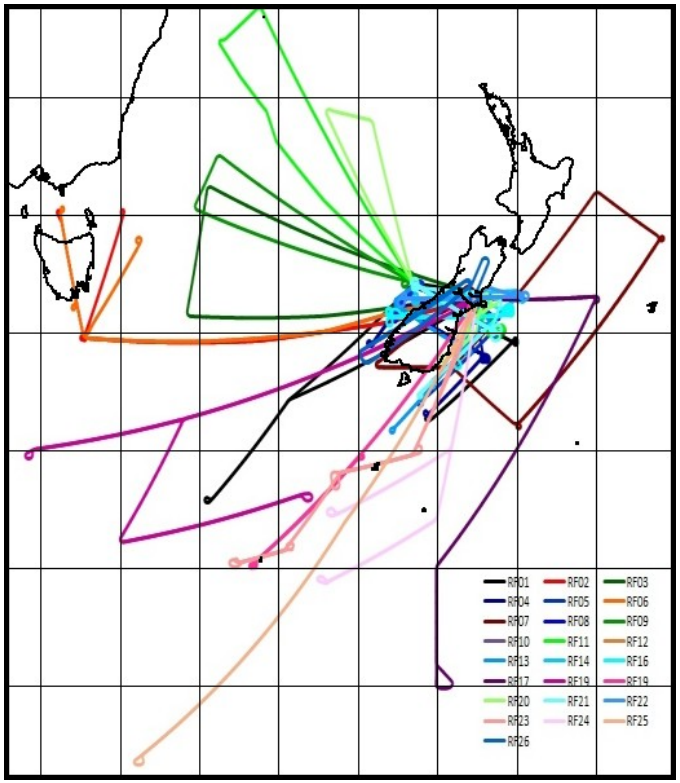


Small-Scale GW Power Regional Distribution

Average power



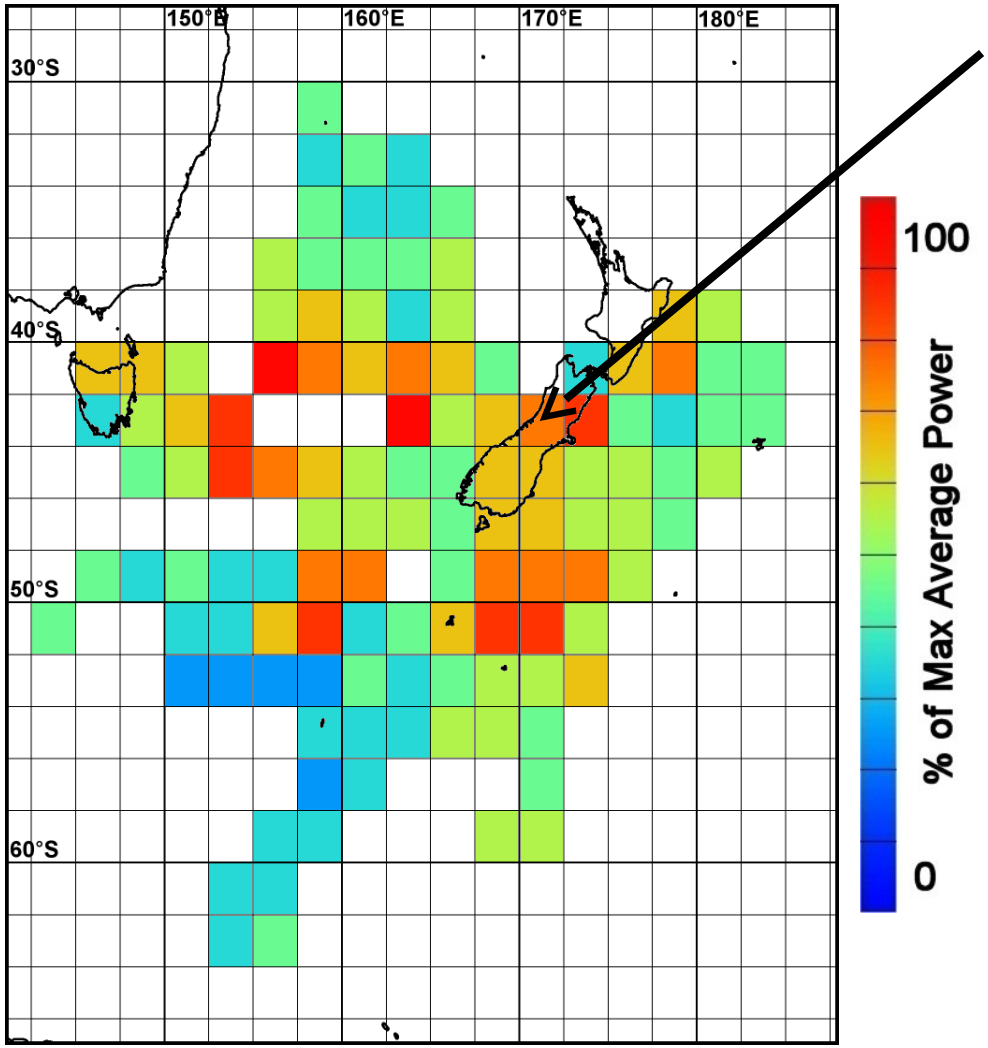
25 nighttime flights



Each square is 2.5° (longitude) x 2° (latitude)

Small-Scale GW Power Regional Distribution

Average power

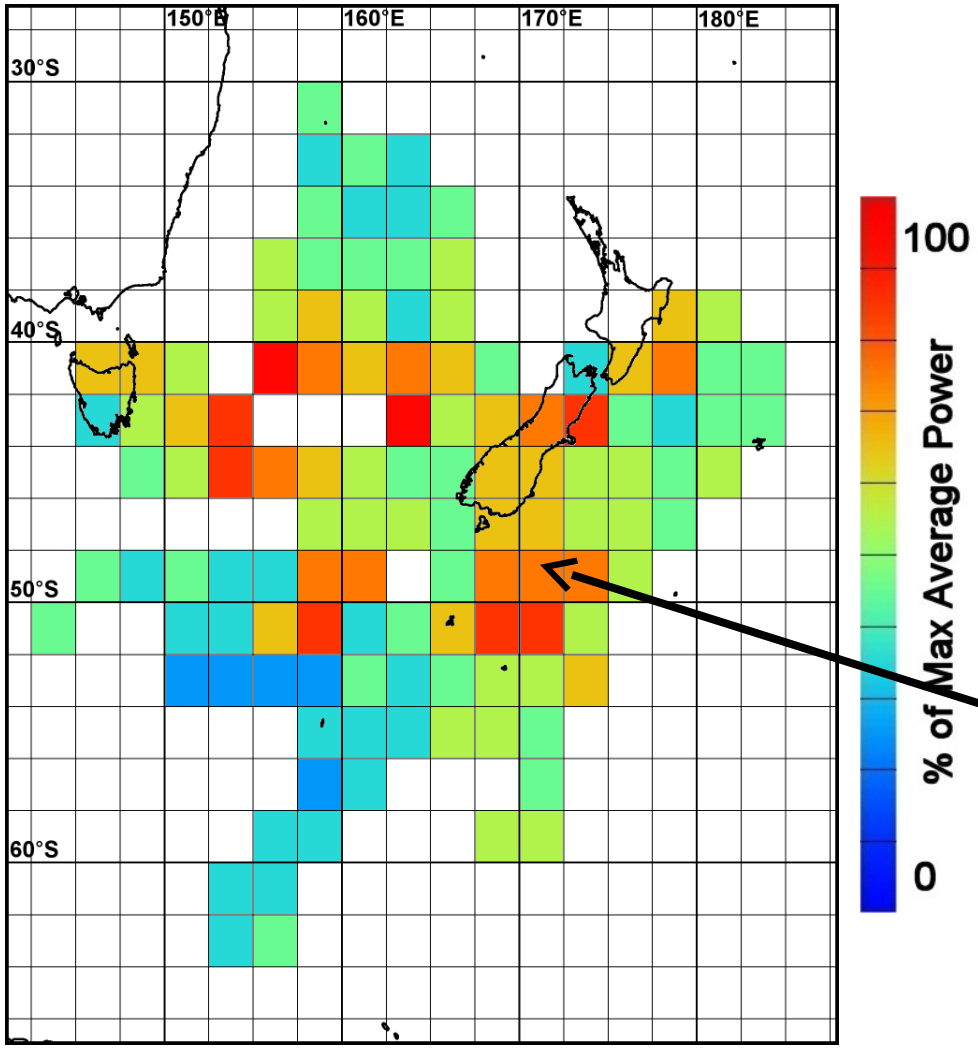


Large over NZ

Each square is 2.5° (longitude) x 2° (latitude)

Small-Scale GW Power Regional Distribution

Average power

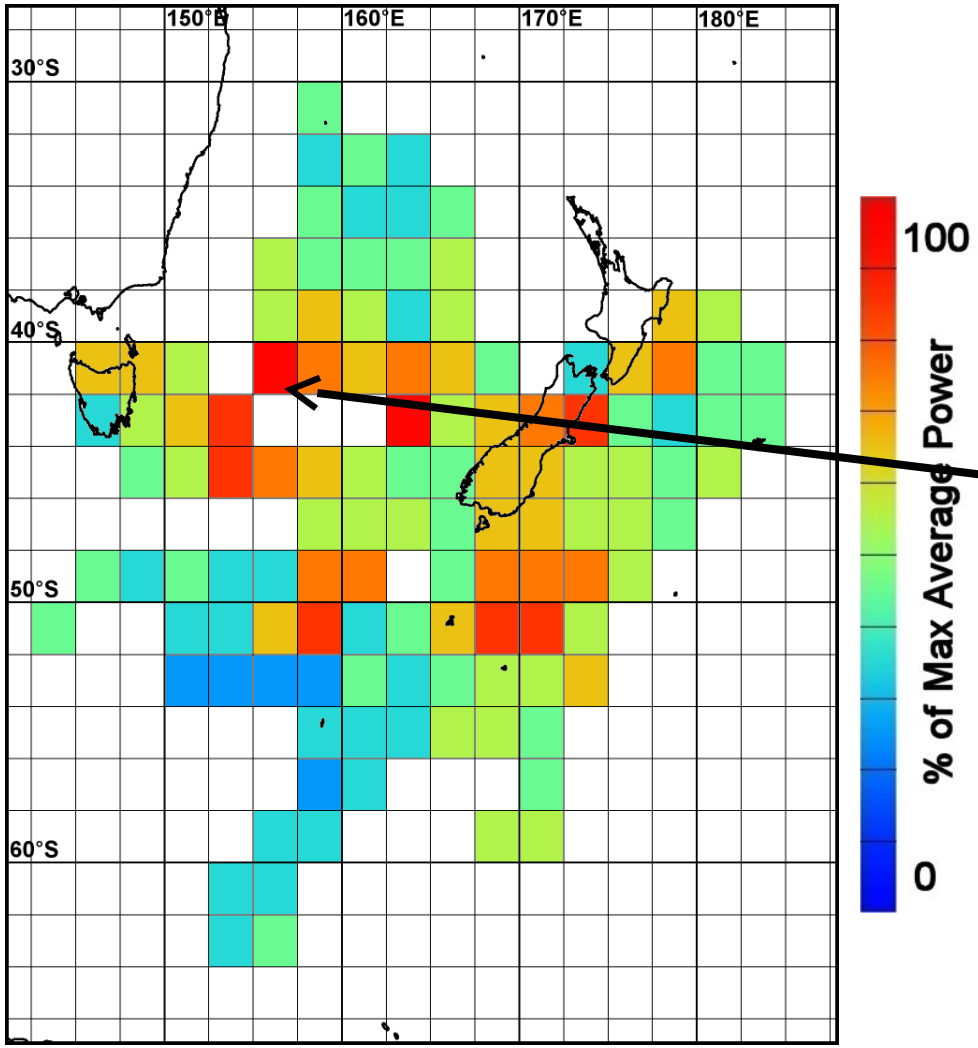


Trailing waves +
Auckland Island effect
(Pautet et al., 2016)

Each square is 2.5° (longitude) x 2° (latitude)

Small-Scale GW Power Regional Distribution

Average power

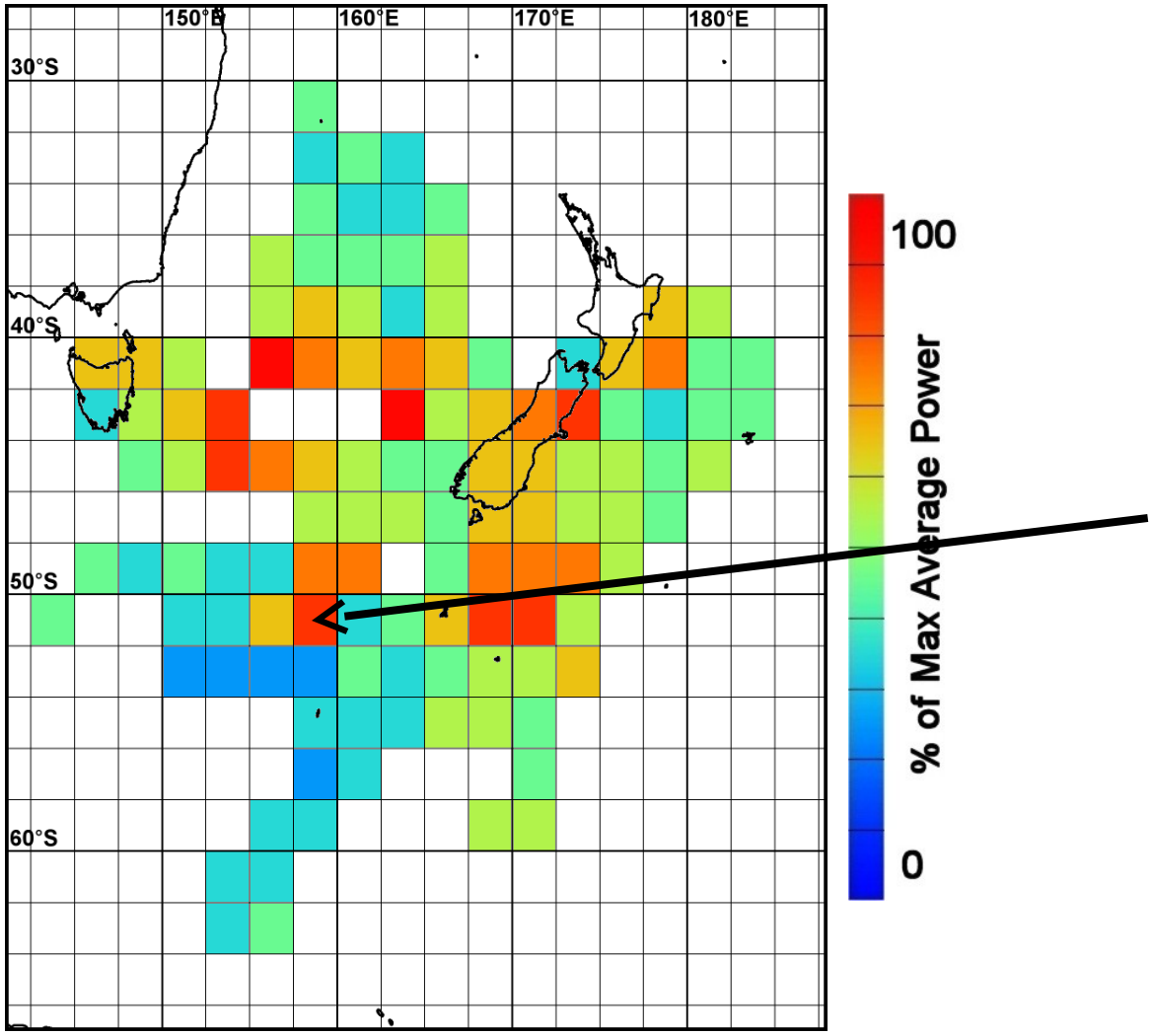


Lots of small scale GWs over the Tasman Sea, east of Tasmania

Each square is 2.5° (longitude) x 2° (latitude)

Small-Scale GW Power Regional Distribution

Average power

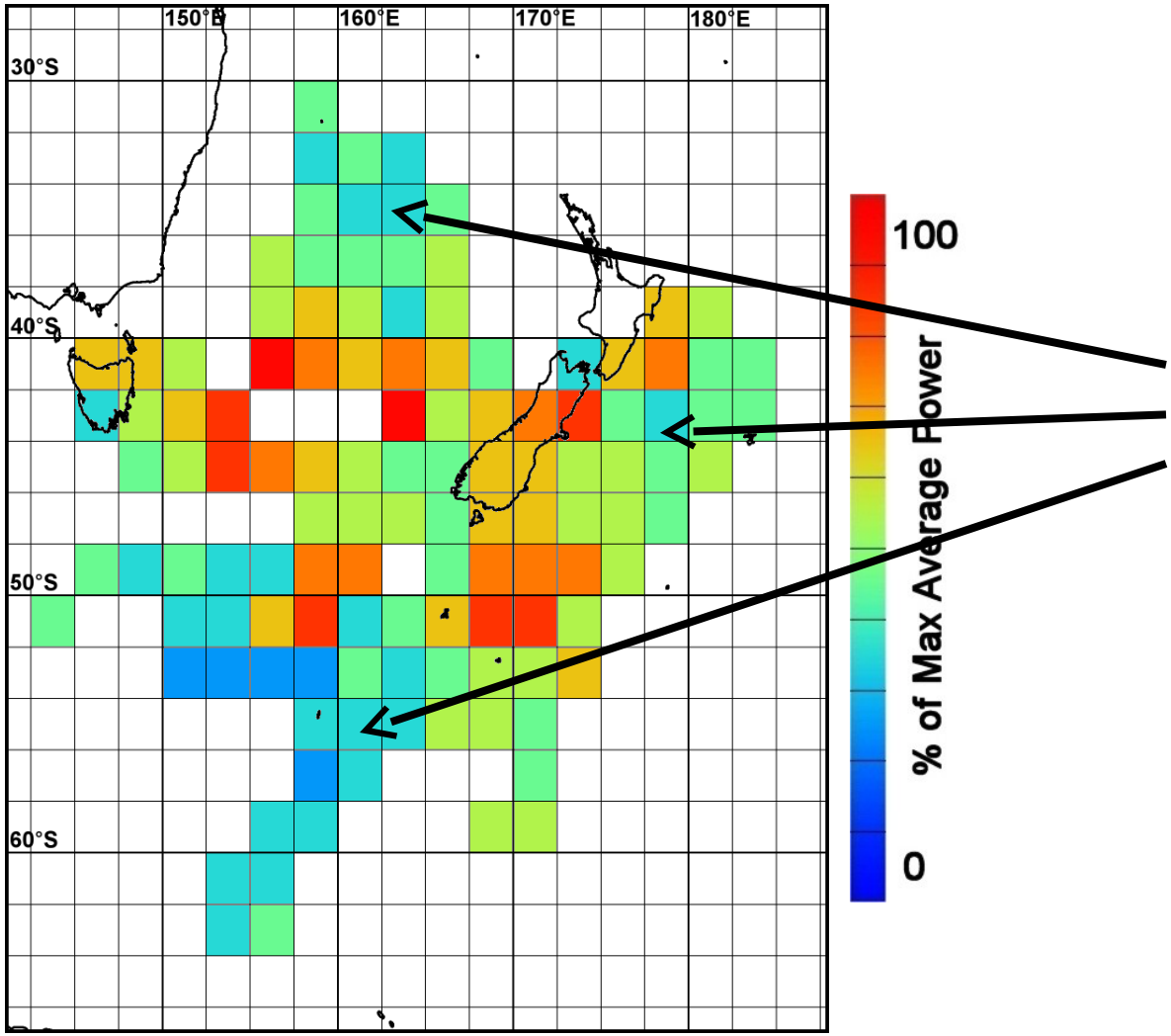


Only due to
one flight (RF01)

Each square is 2.5° (longitude) x 2° (latitude)

Small-Scale GW Power Regional Distribution

Average power

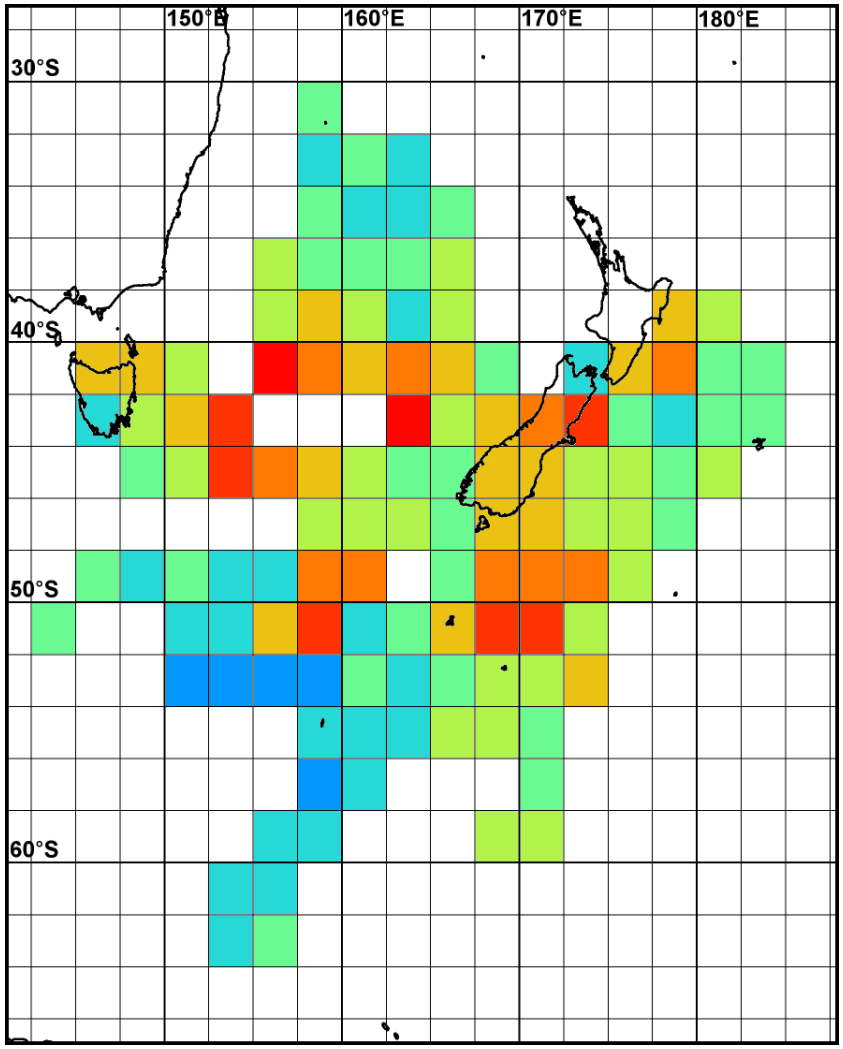


Not much over the North of Tasman Sea, Pacific Ocean and Southern Ocean

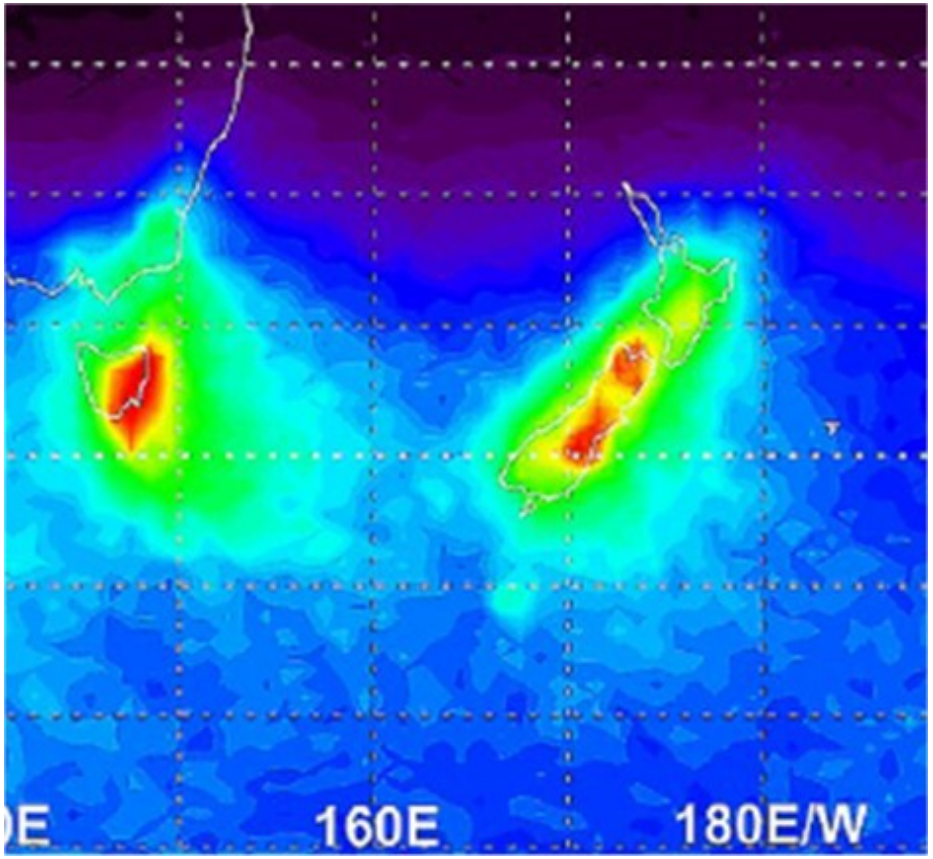
Each square is 2.5° (longitude) x 2° (latitude)

Comparison with Stratospheric Measurements

Average power

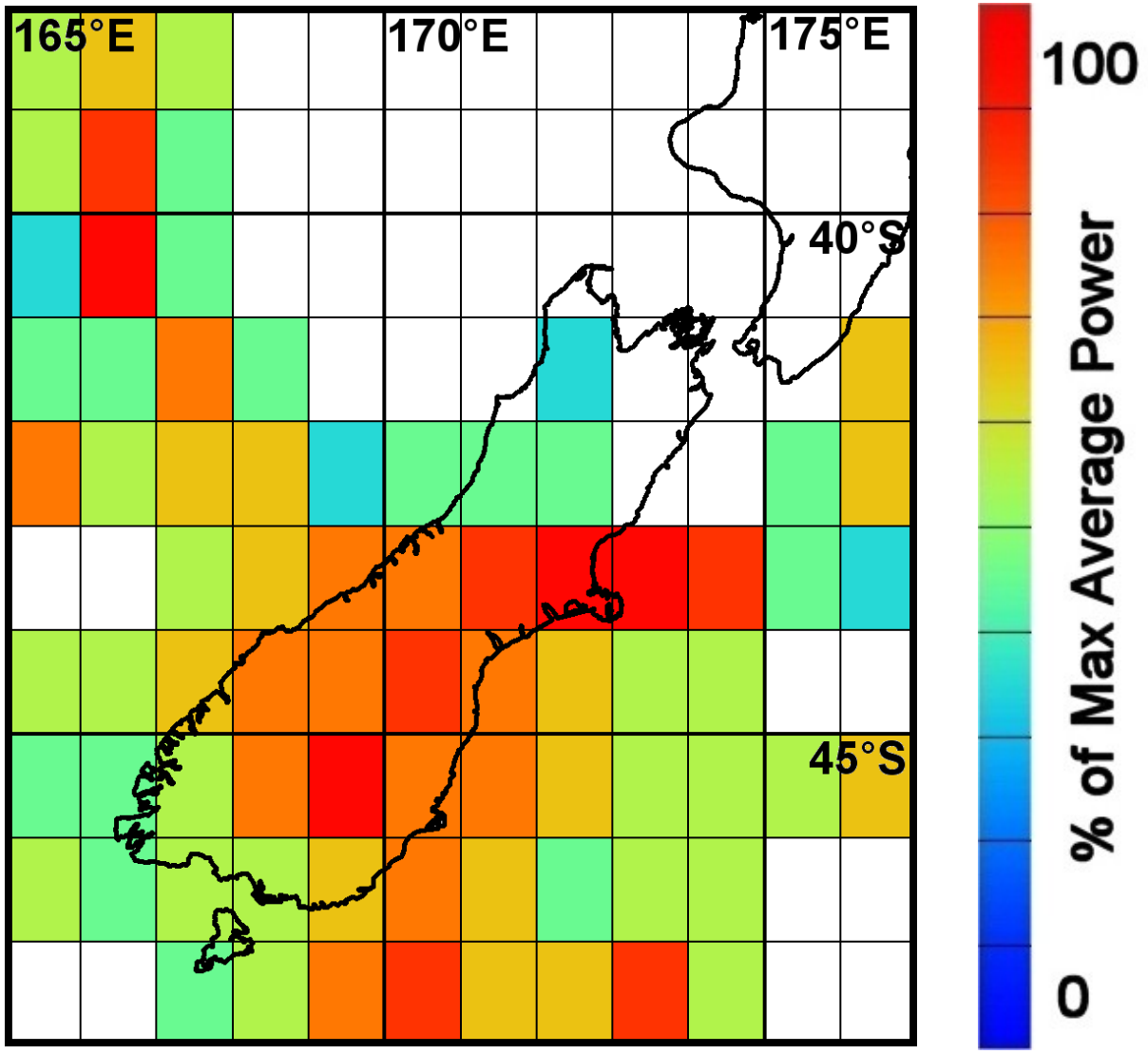


Each square is 2.5° (longitude) x 2° (latitude)

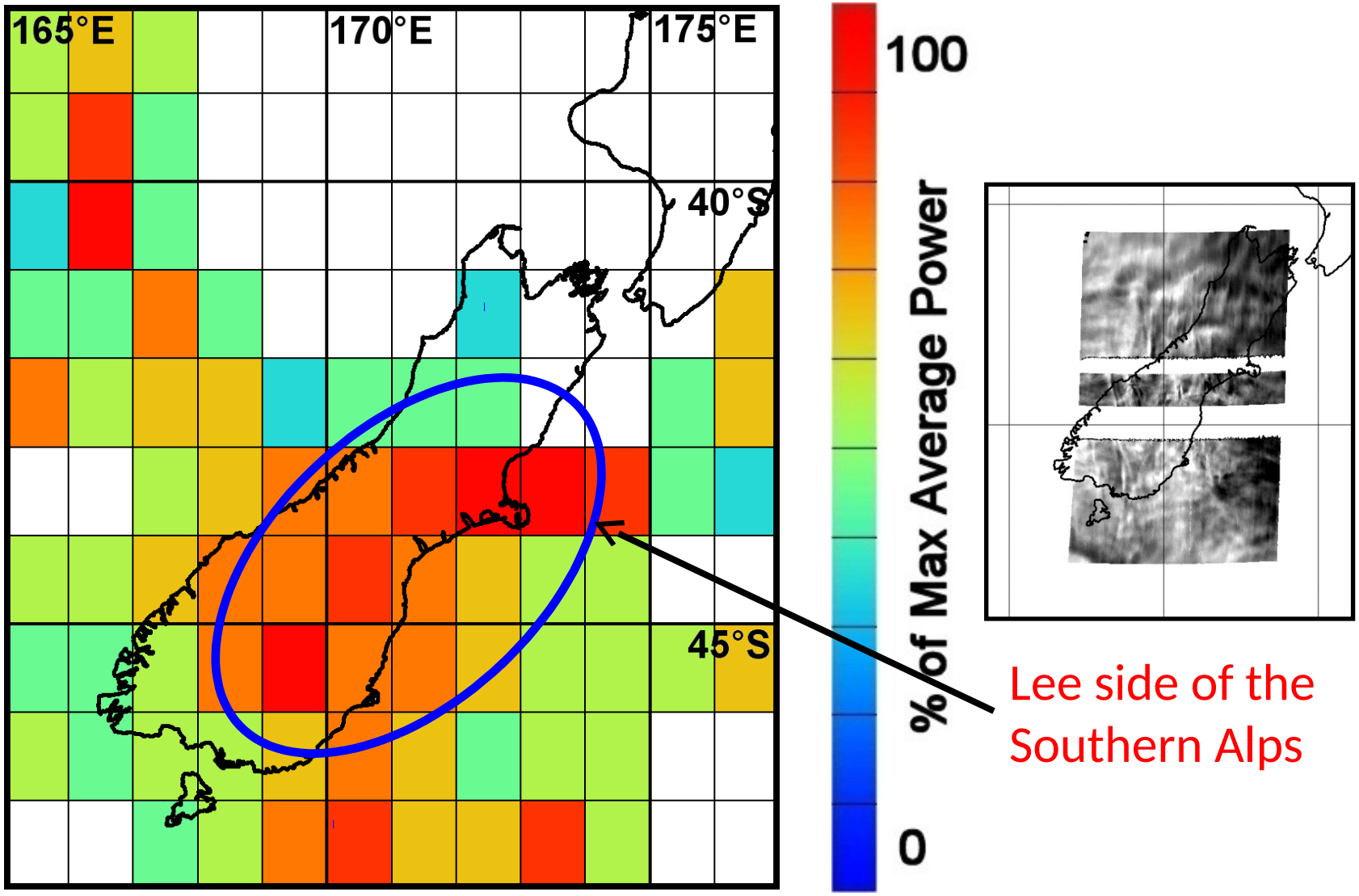


AIRS GW RMS brightness temperature during July 2003-2011 at 2 hPa (~41 km, courtesy Steve Eckermann)

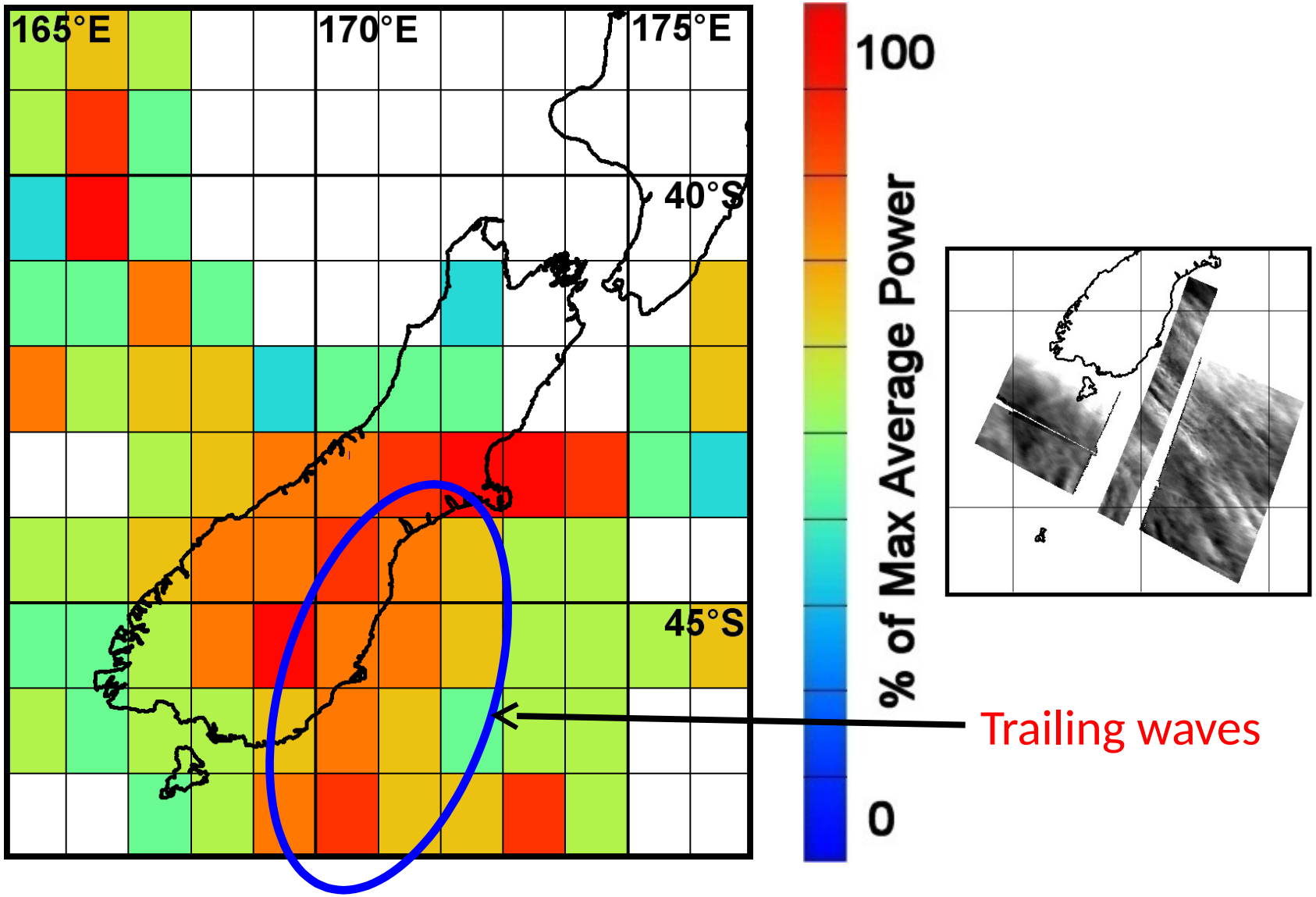
Small-Scale GW Power Over NZ (1°x1°)



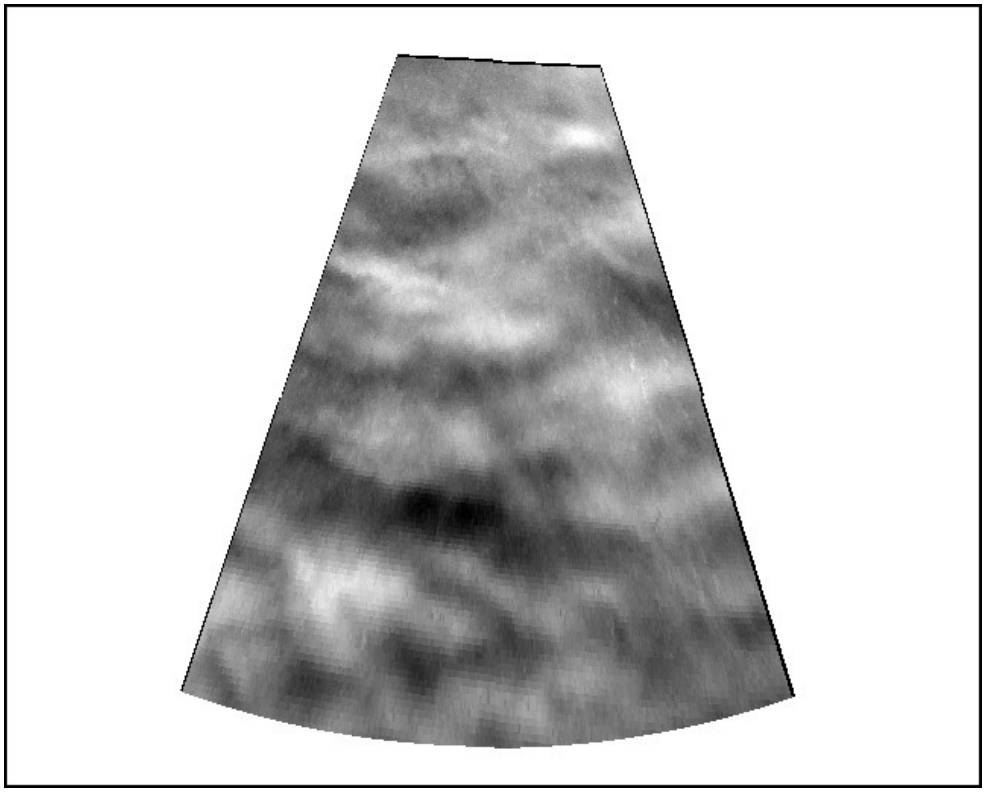
Small-Scale GW Power Over NZ (1°x1°)



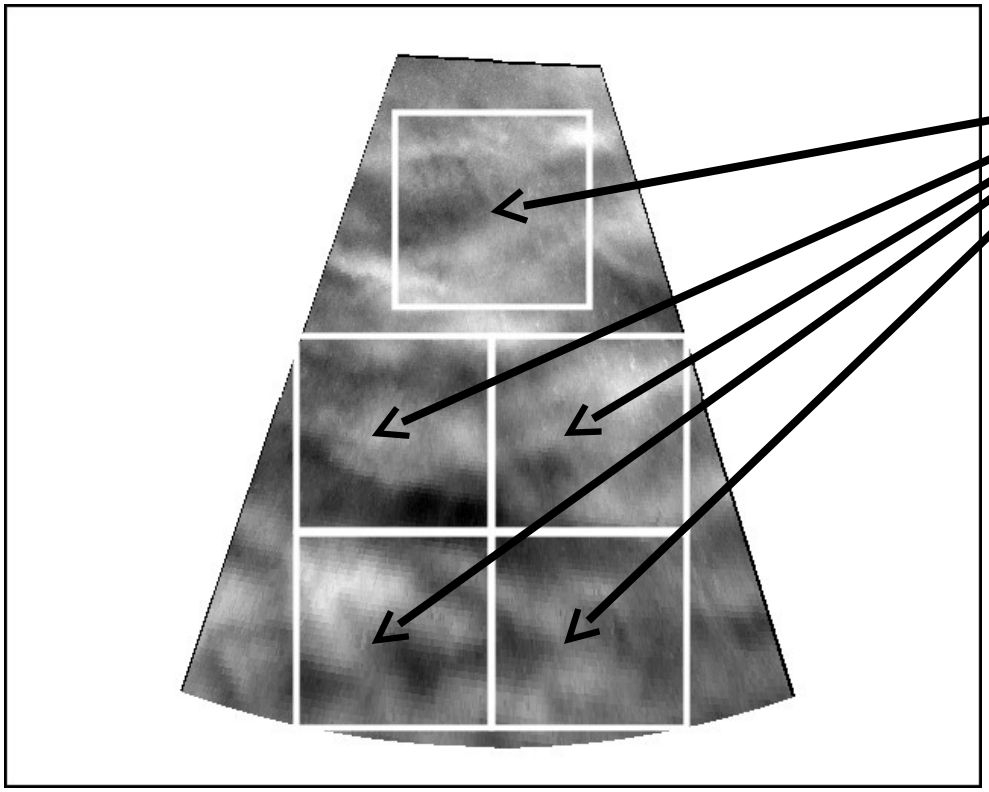
Small-Scale GW Power Over NZ (1°x1°)



Quantifying the GWs Observed With the Side Imagers

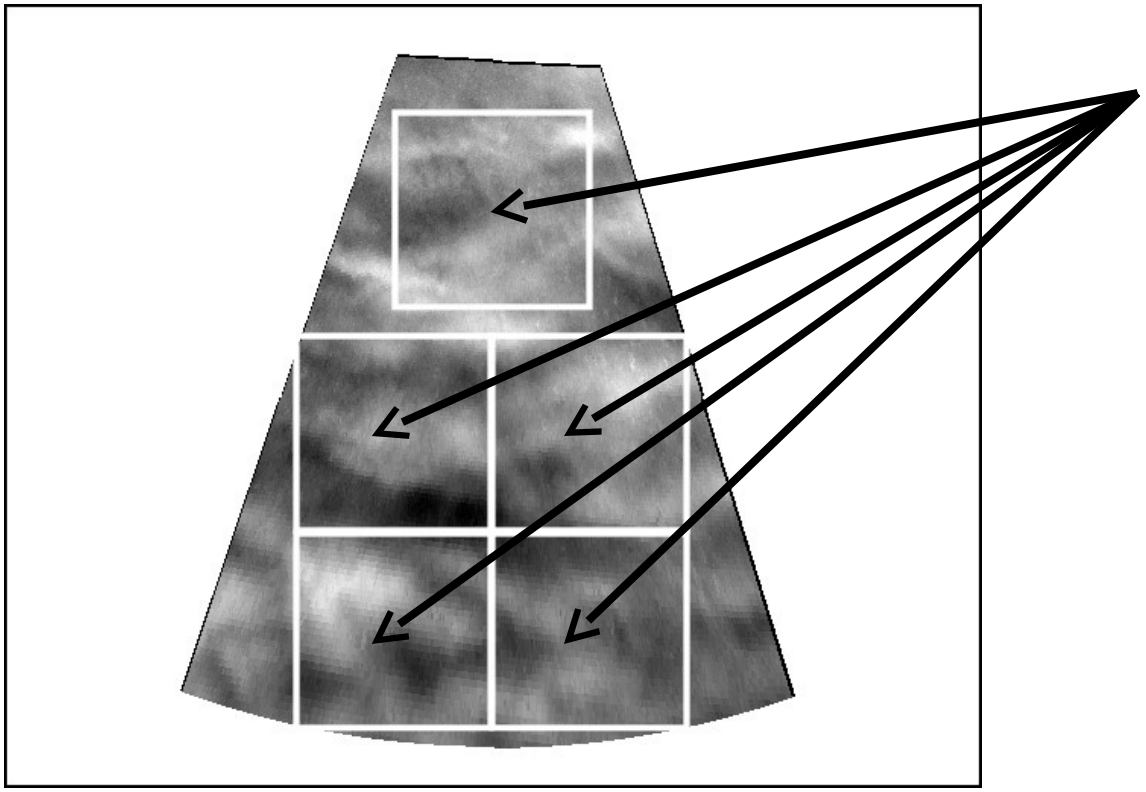


Quantifying the GWs Observed With the Side Imagers



Five 128x128-pixel boxes (80x80 km)

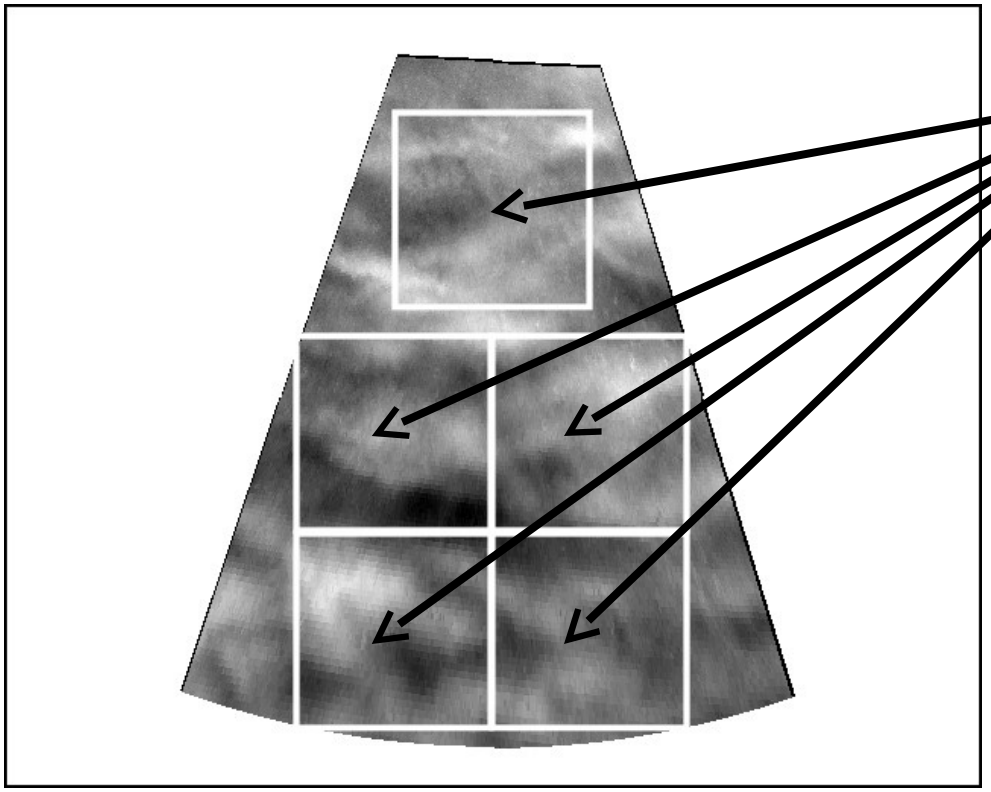
Quantifying the GWs Observed With the Side Imagers



Five 128x128-pixel boxes (80x80 km)

FFT

Quantifying the GWs Observed With the Side Imagers

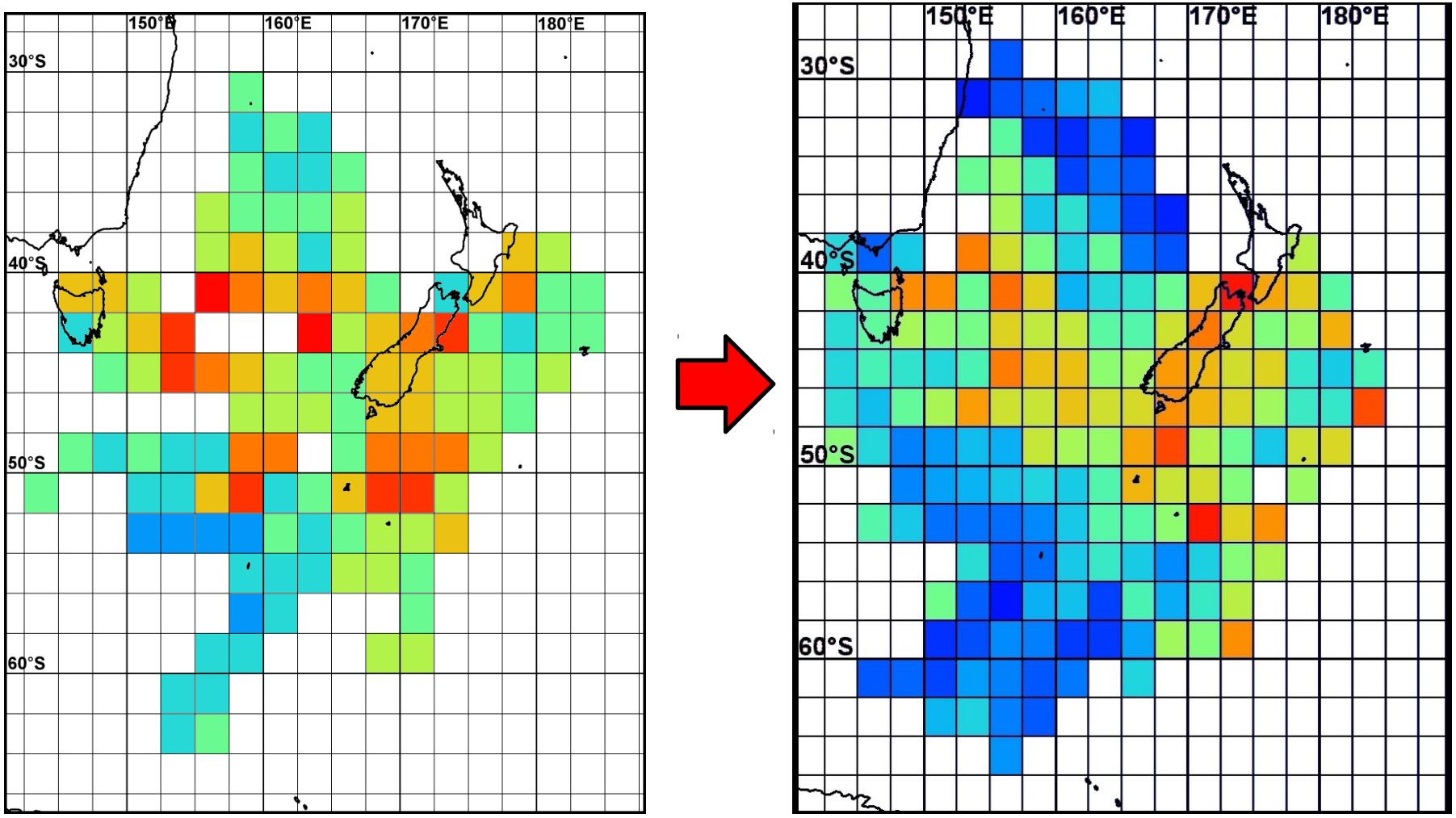


Five 128x128-pixel boxes (80x80 km)

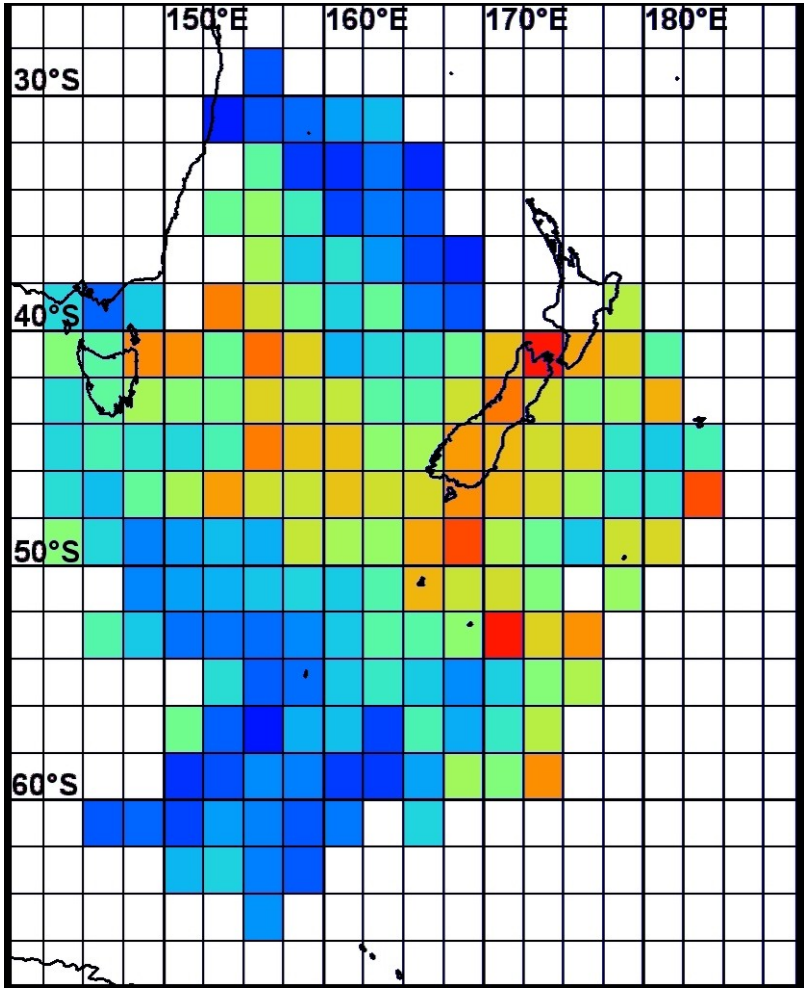
FFT

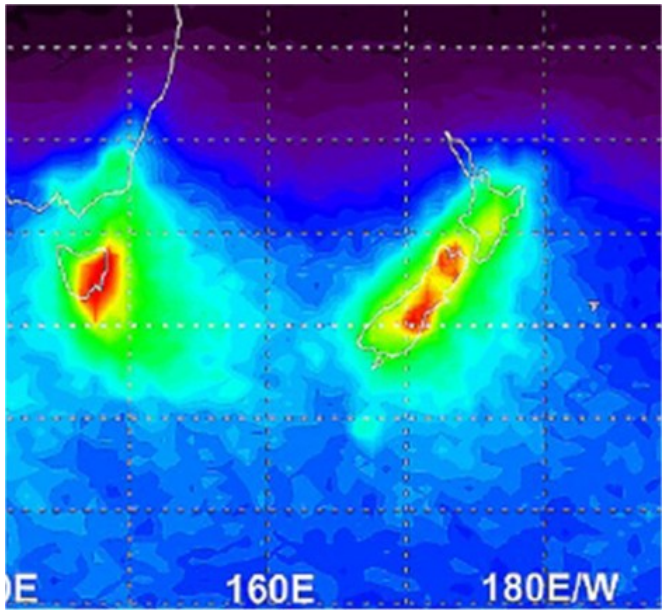
Power for GWs with $10<\lambda_x<40$ km

Small-Scale GW Power Regional Distribution with 3 Cameras



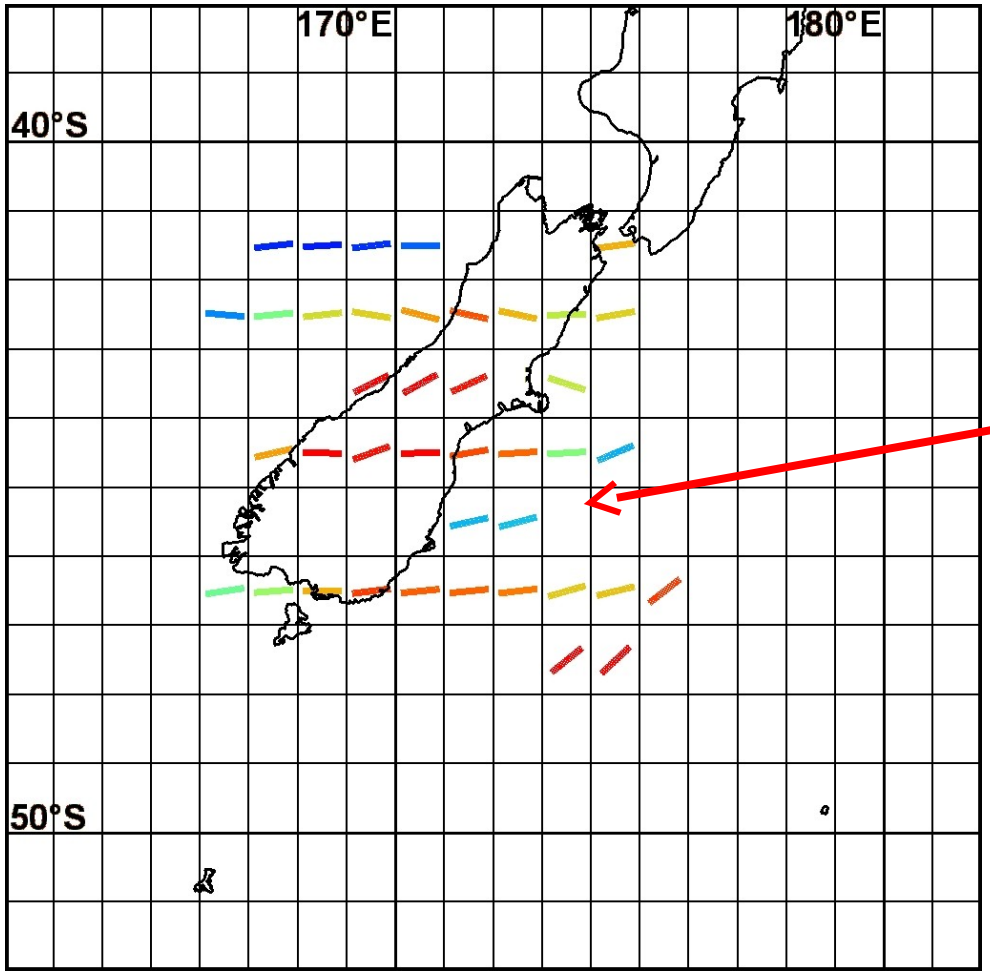
Small-Scale GW Power Regional Distribution with 3 Cameras





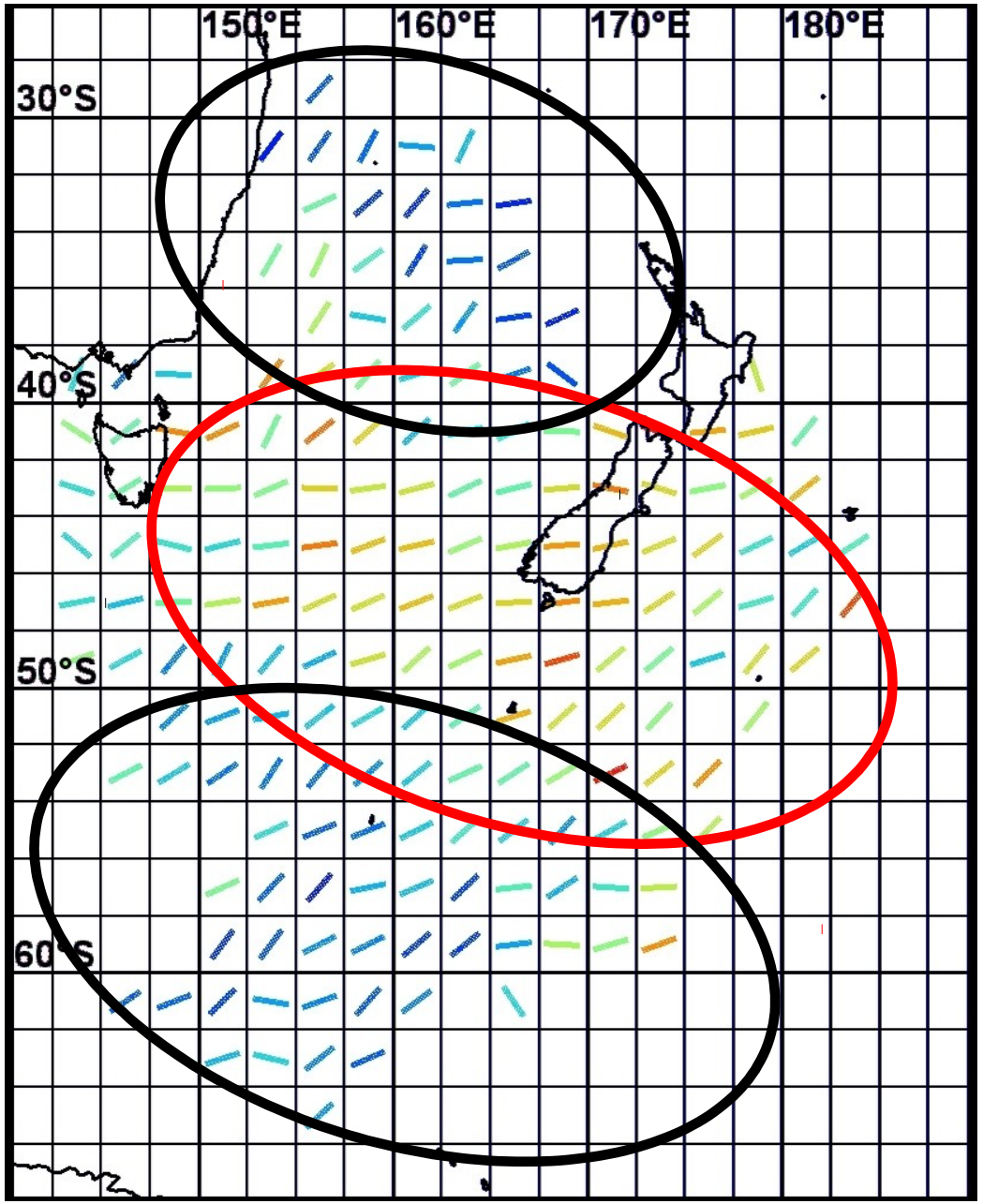
- Using only OH brightness, not temperature
- Similar distribution over a larger region
- Regions with larger power better defined

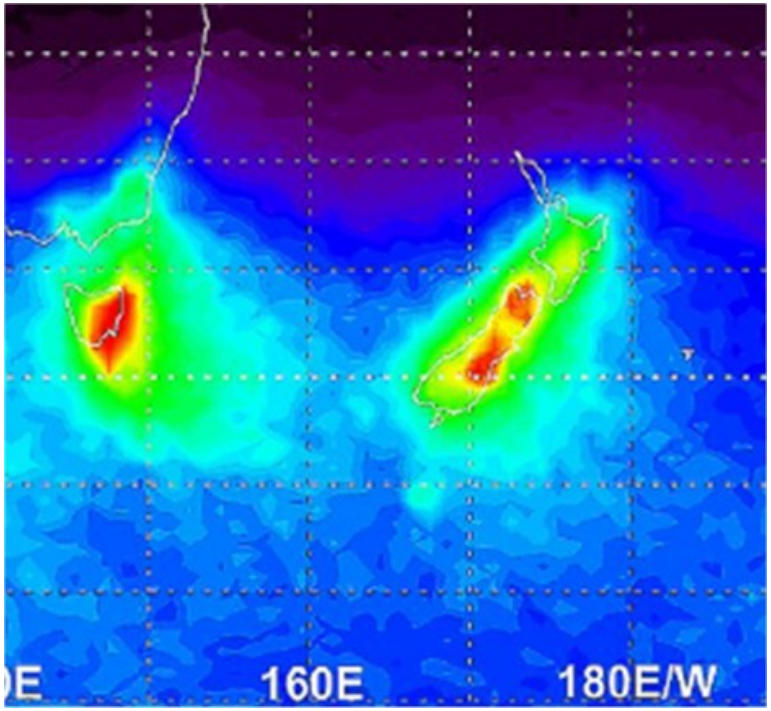
GWs Direction – Example: RF16

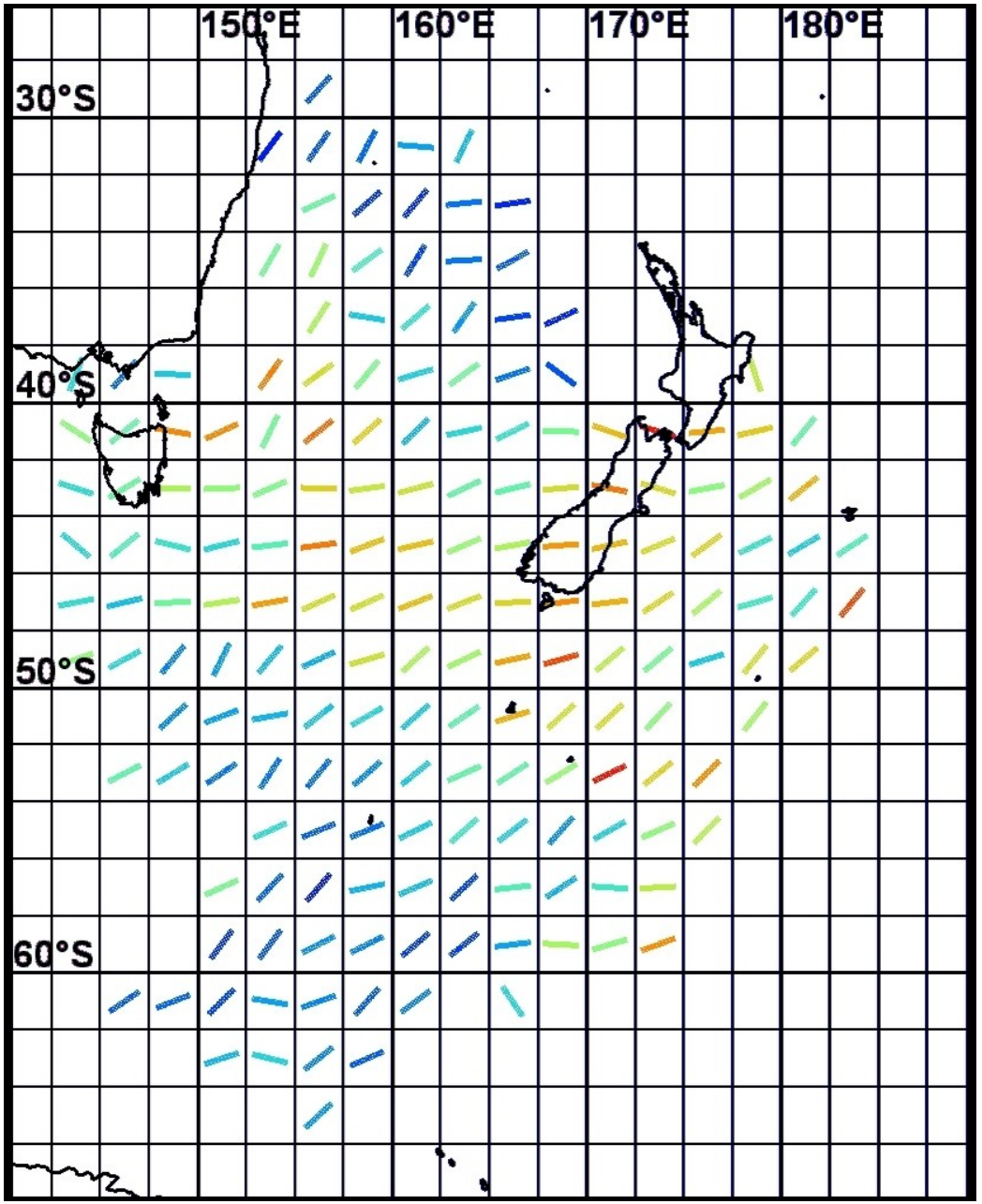


It's also possible to use the spectrum to look at the main direction of propagation by integrating over the 10-40km range and looking at the distribution vs angle.
For RF16, the highest power (red) was just above the mountains and most of the GWs propagated in the East-West direction (since we use only single images, there is a 180° ambiguity and we cannot tell if they were going towards the East or the West with this method).

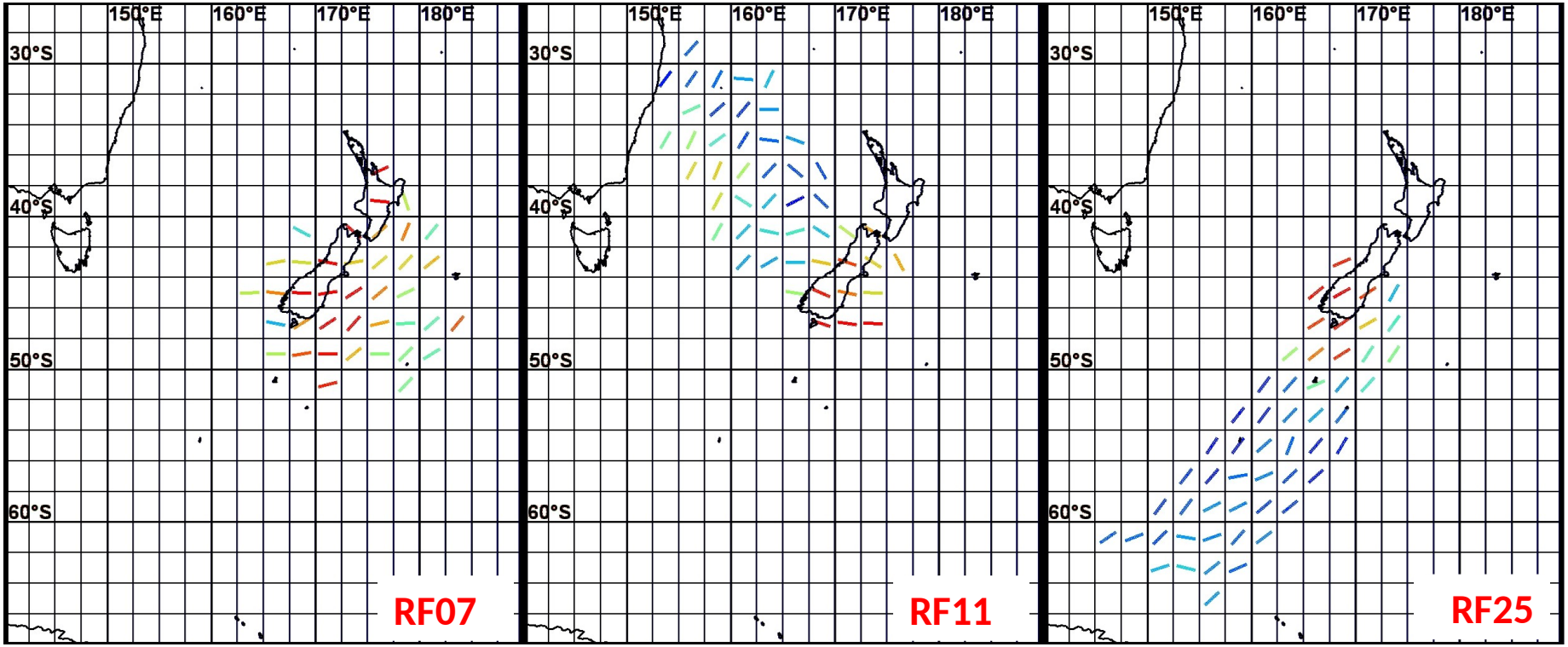
Small-Scale GWs ($10<\lambda_x<40$km) Power and Direction for all 25 Flights




160E
180E/W

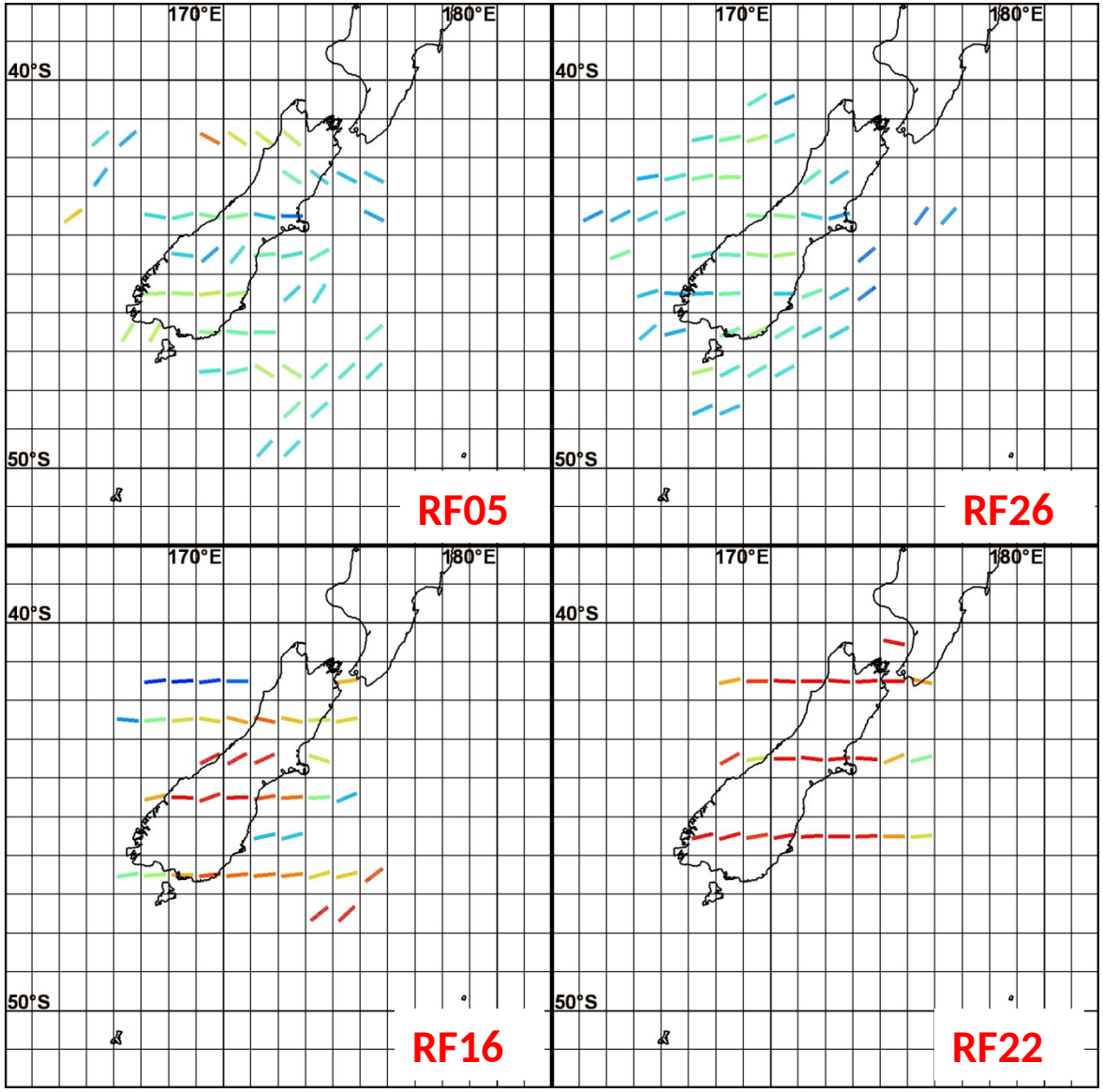

150°E
160°E
170°E
180°E
30°S
40°S
50°S
60°S

Mountains vs Oceans



- Strong difference land vs ocean during the same flight, usually in power, sometimes in directionality

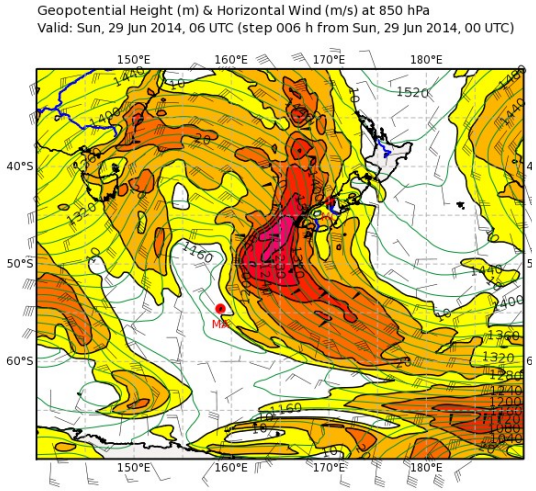
Mountain Flights – Small vs Large Power

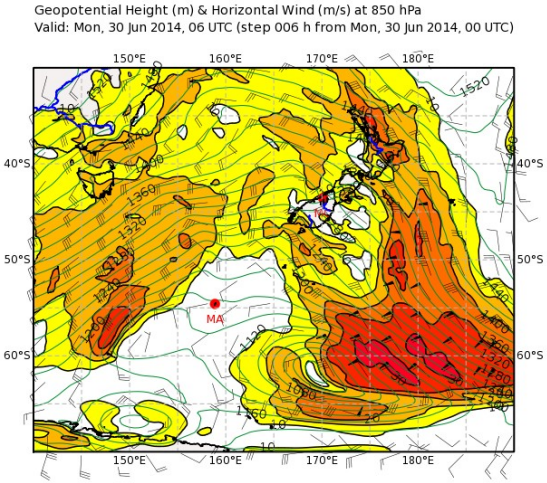


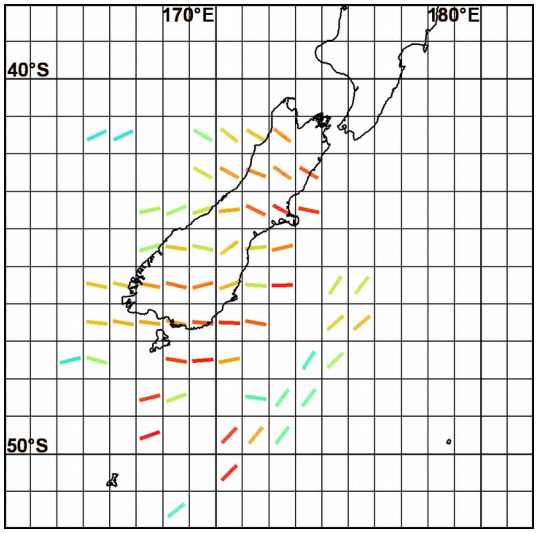
- Weak GW power
- Direction ~NE
- Similar cases: RF04 and RF21

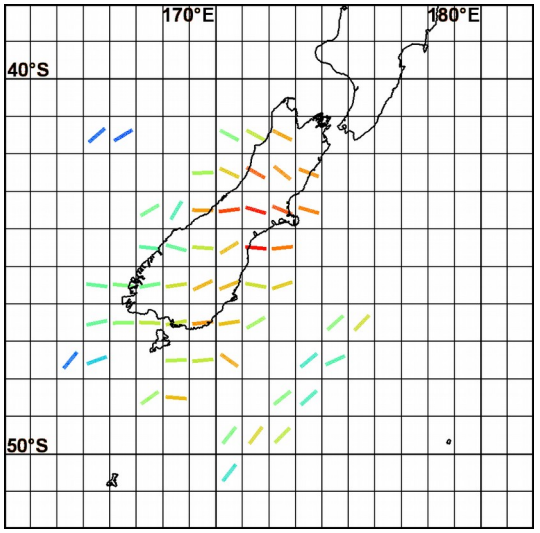
- Larger GW power
- Direction ~E or ~SE
- Similar cases: RF08, RF10, RF12, RF13, and RF14

RF12 vs RF13

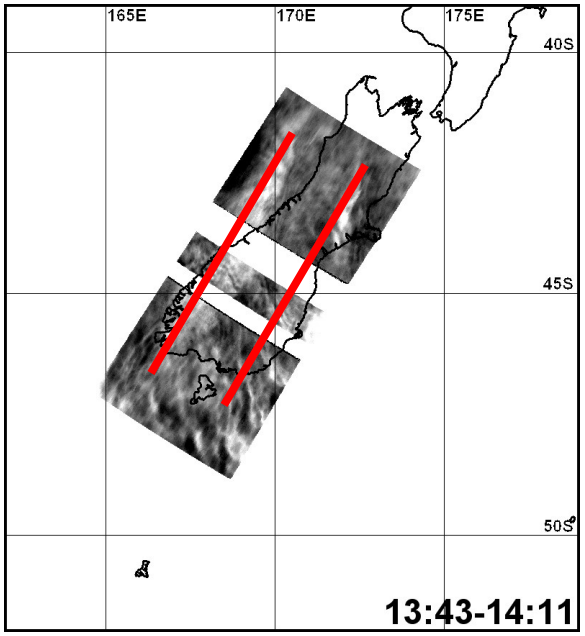




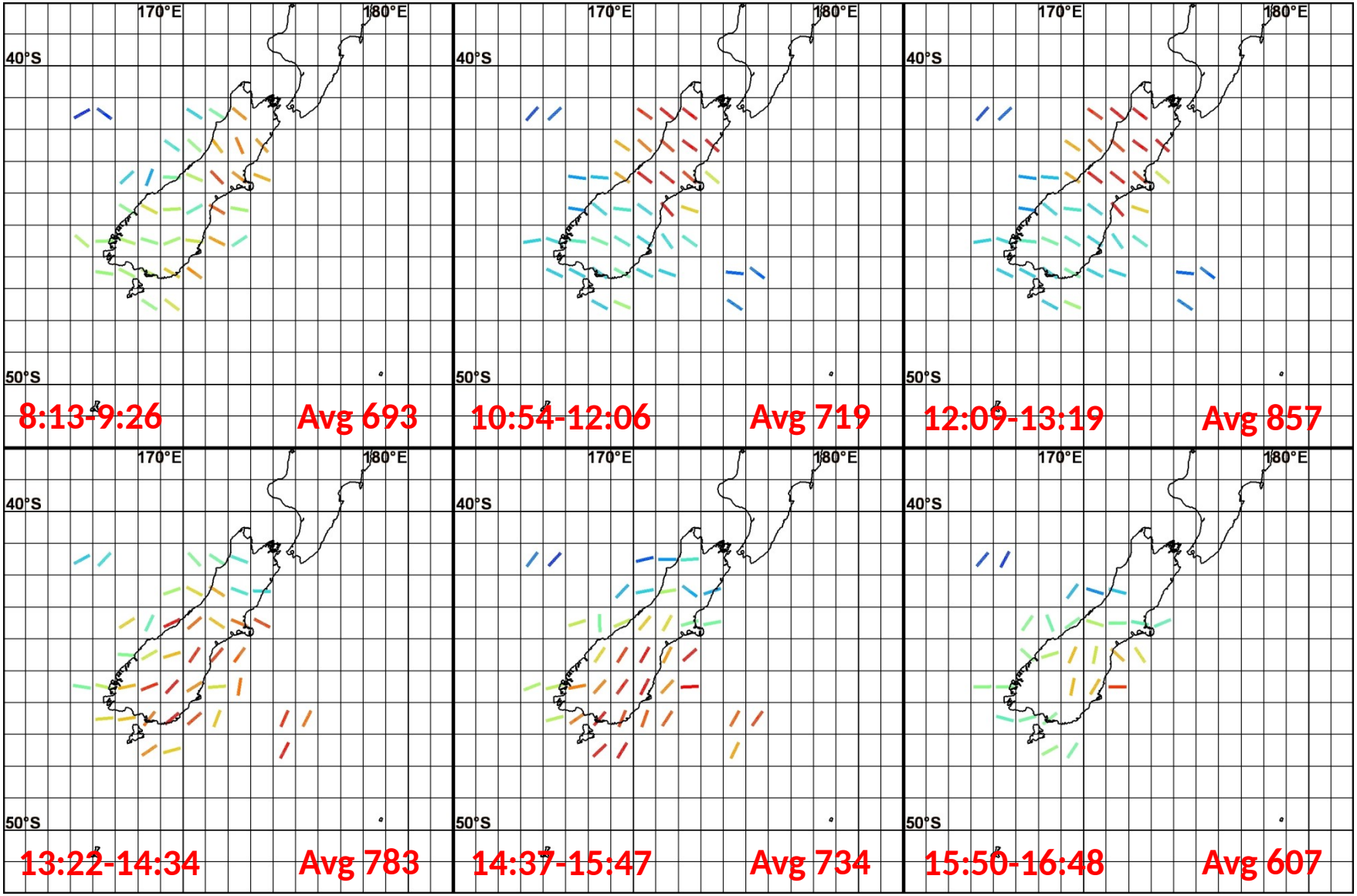




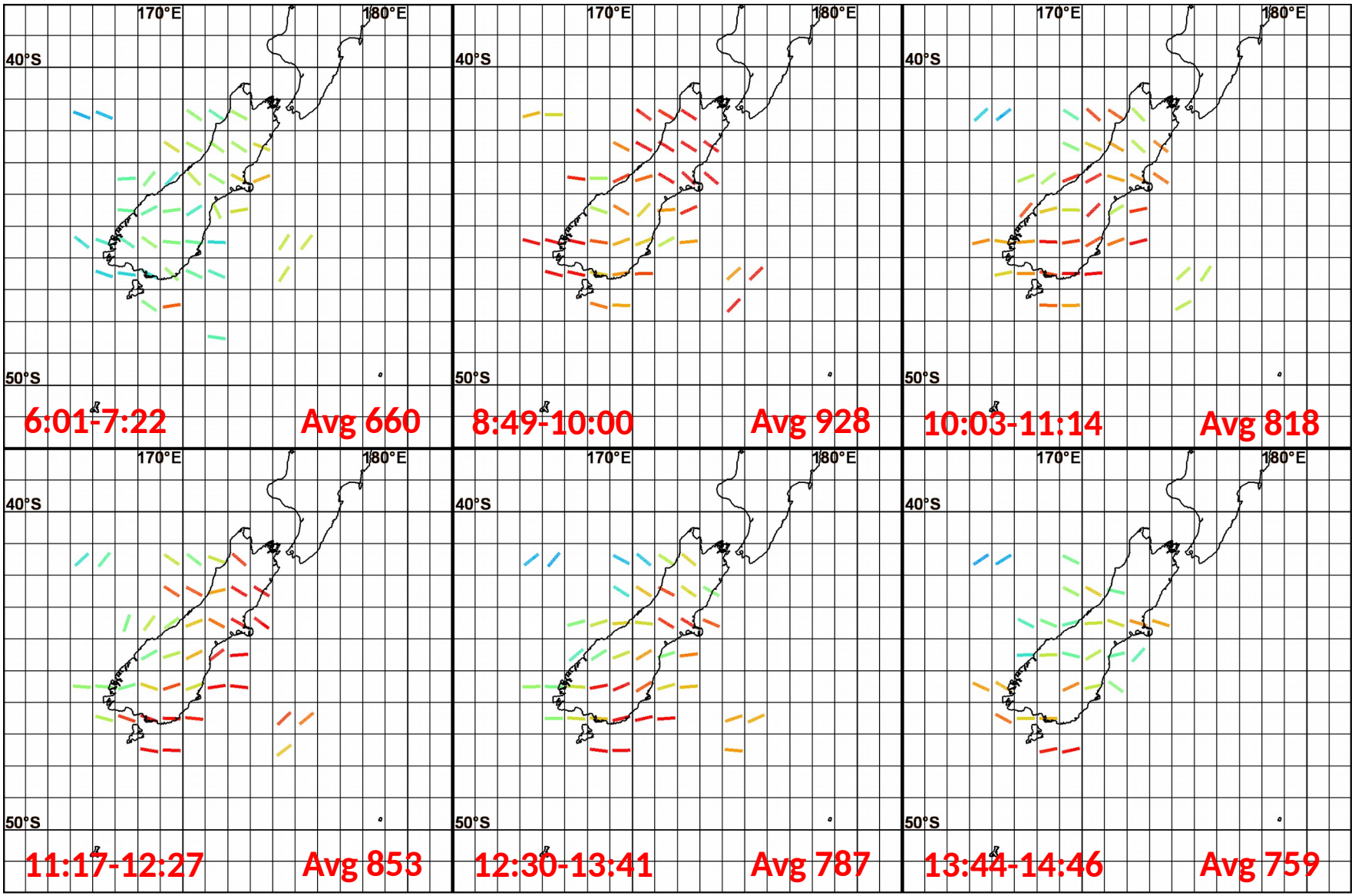
- Strong forcing during RF12, weaker forcing during RF13
- Still, strong GW activity in AMTM data during RF13
- Delayed appearance (~15hrs) of long-period waves at MLT altitude (Portele et al., 2017) ?



Evolution Power/Direction RF12



Evolution Power/Direction RF13



Small-Scale GWs Power

- Small-scale GWs ($10<\lambda_x<40$km) power and direction (180° ambiguity)
- Comparison lands vs oceans: average power and direction different if over land or over ocean, even during the same flight
- High variability over NZ SI, depending on forcing but also on other parameters…
- Possibility to follow the evolution of power and direction during a single flight

Future Work

- Separate by legs instead of RFs (see Smith et al., 2016).
- Separate MW vs Ocean RFs/legs.
- Classify by tropospheric forcing, stratospheric dissipation/breaking, MLT activity.
- Ray-tracing?
- Similar study for Lauder, data focusing on MW activity.
- Confirmation with models?