SIGNIFICANT SURFACE CURRENT VELOCITY CHANGES MEASURED BY THE OCEAN HIGH-FREQUENCY RADAR AFTER THE GREAT 2011 JAPAN TSUNAMI

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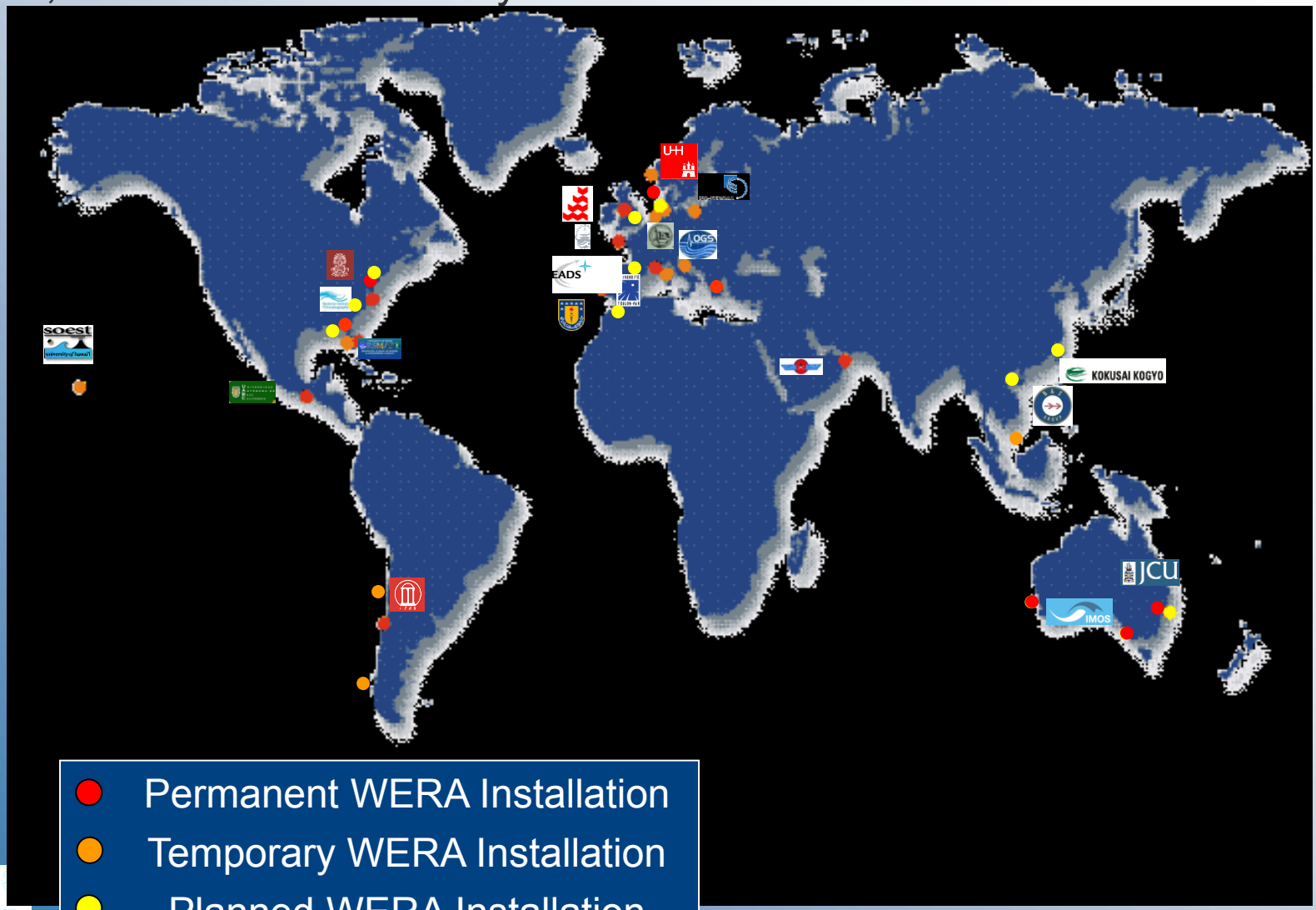
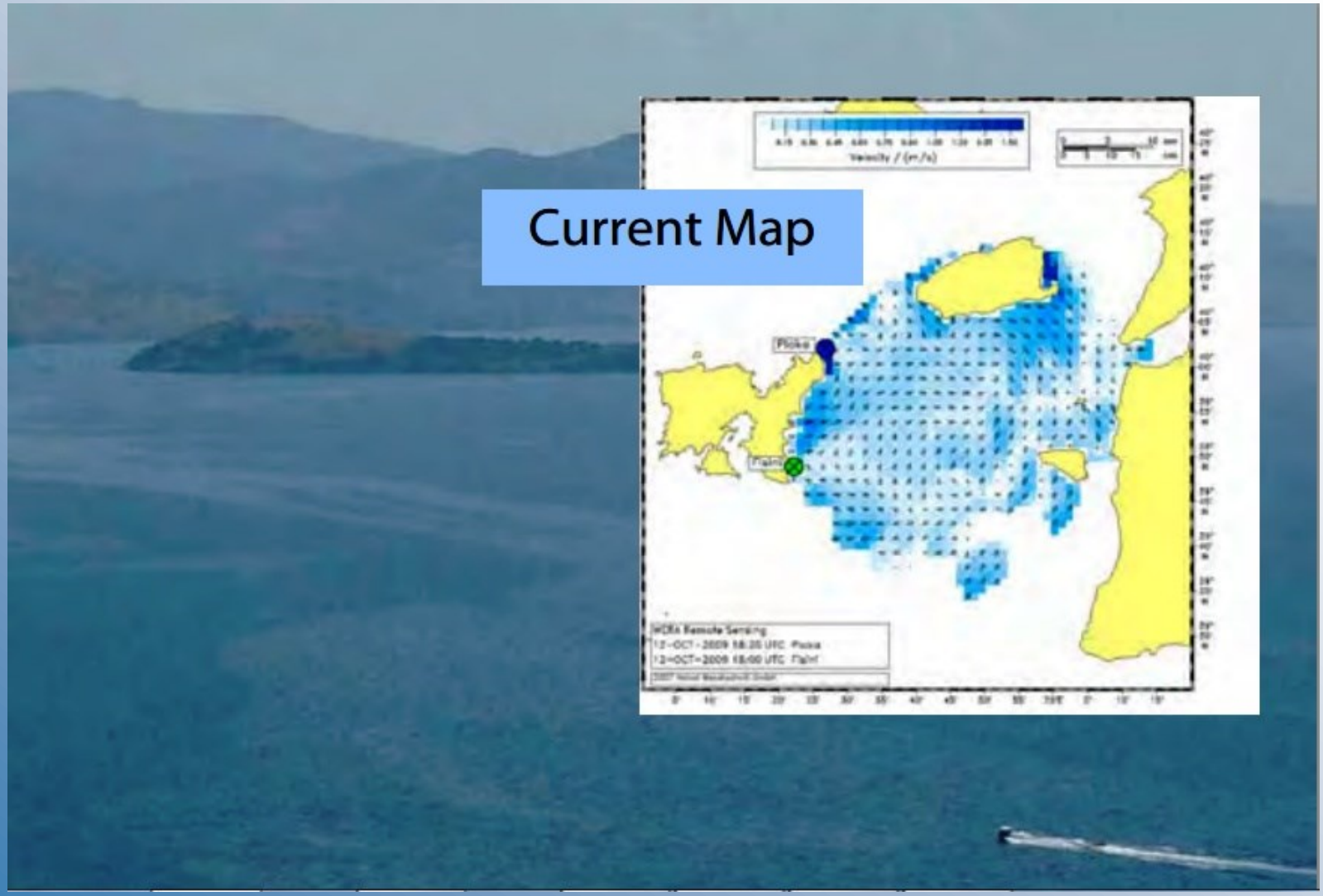
WERA Ocean HF Radar Installations

Since 1999, more that 50 WERA systems have been installed.

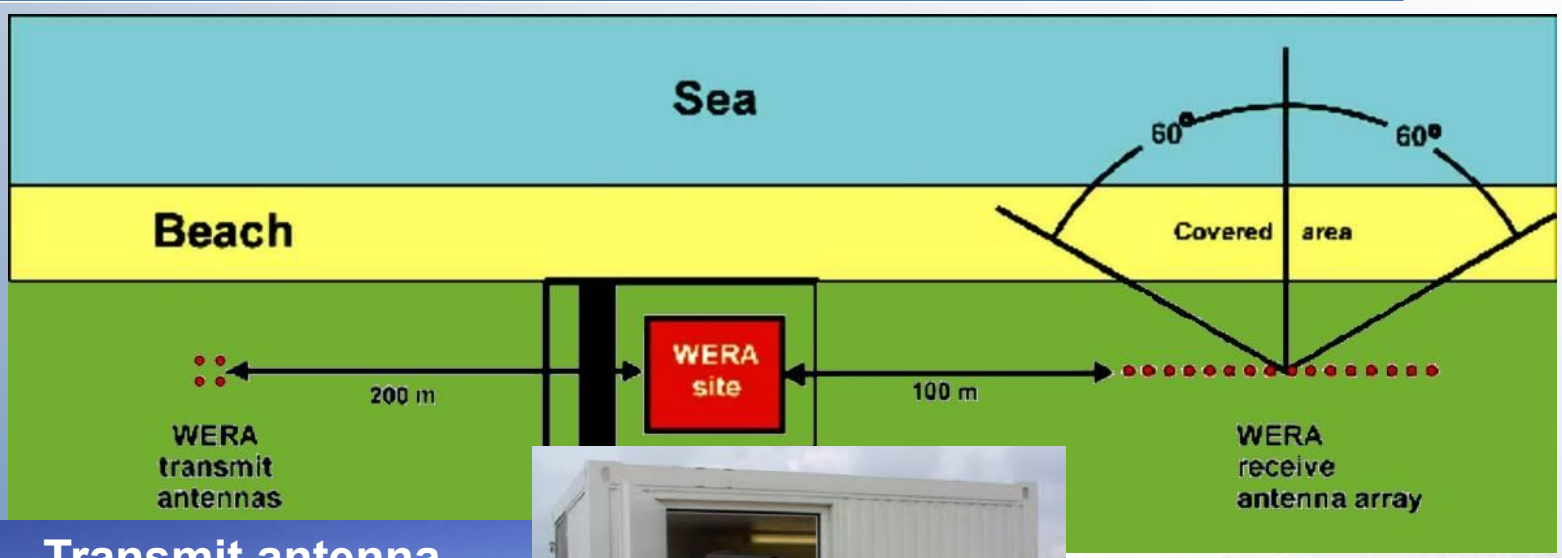


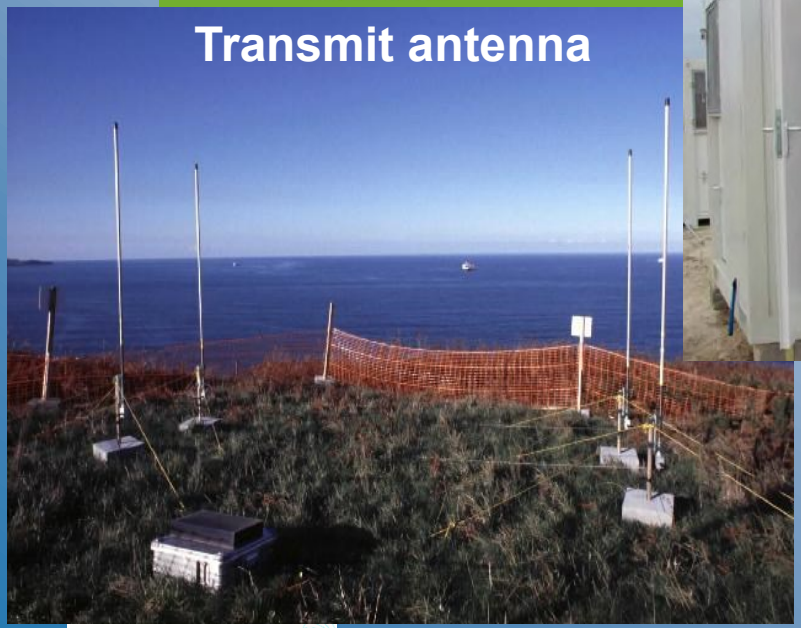
HF Radar WERA Installation in Greece

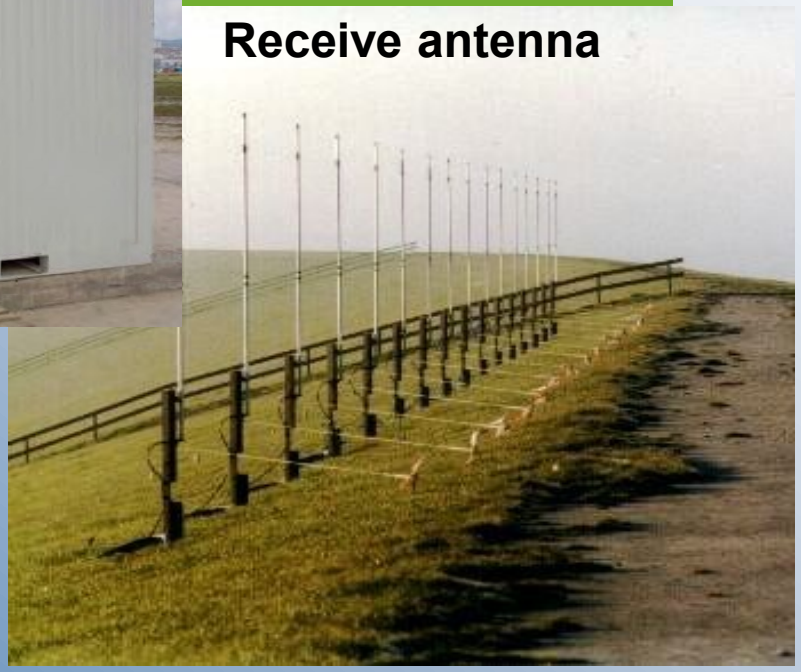
HF Radar WERA Installation in Greece



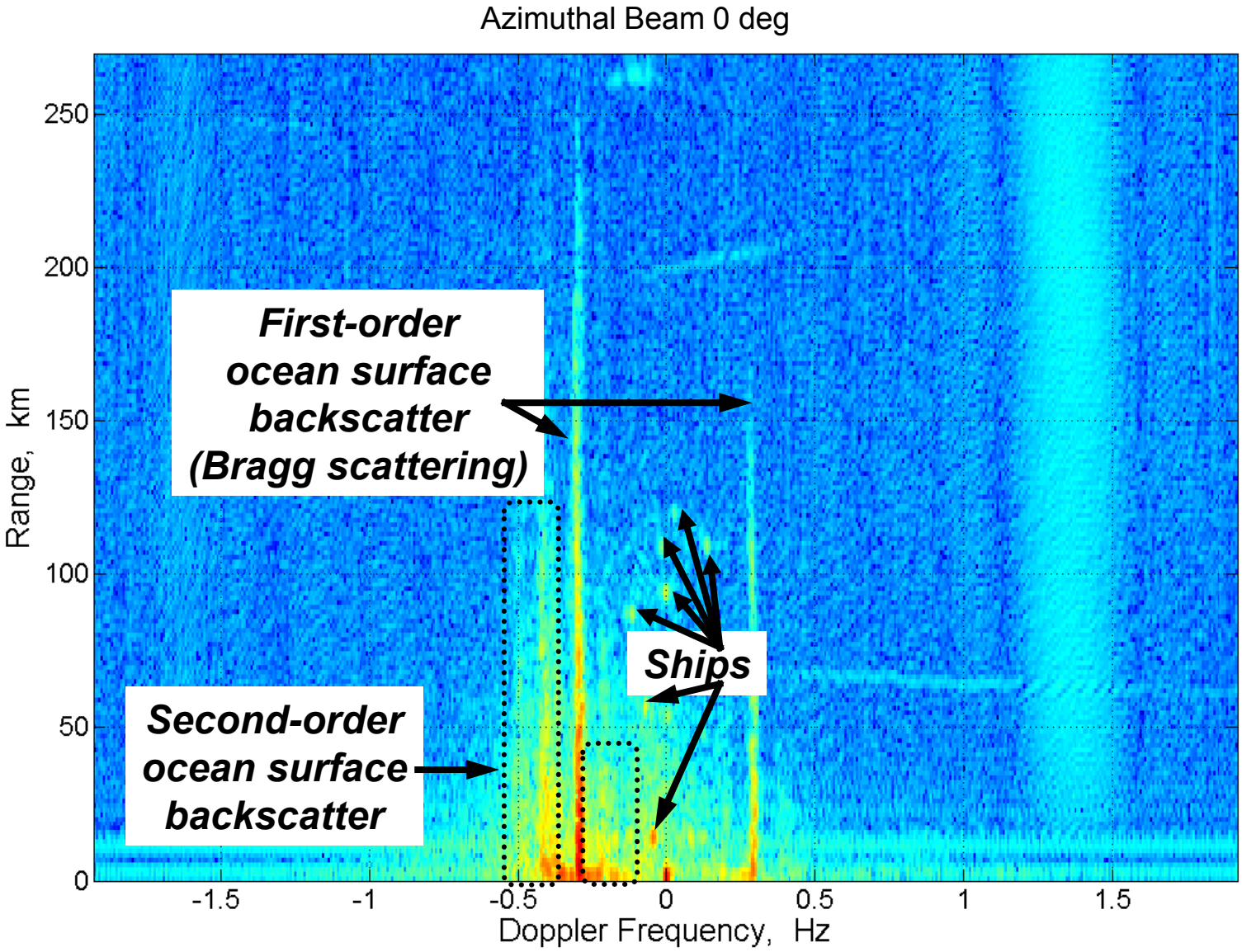
Ocean HF Radar Installation







HF Radar Spectrum at 8-MHz Operating Frequency



WERA in Continuous Operation Mode

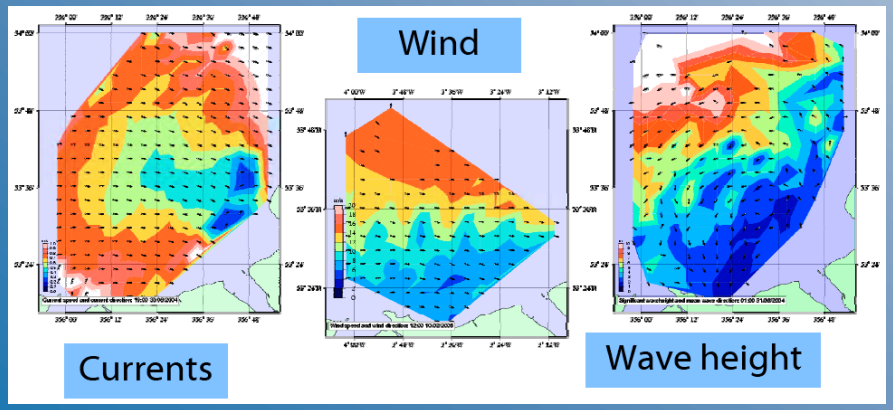
WERA radar — Operating continuously (24/7)

Online data — Update every 33 sec

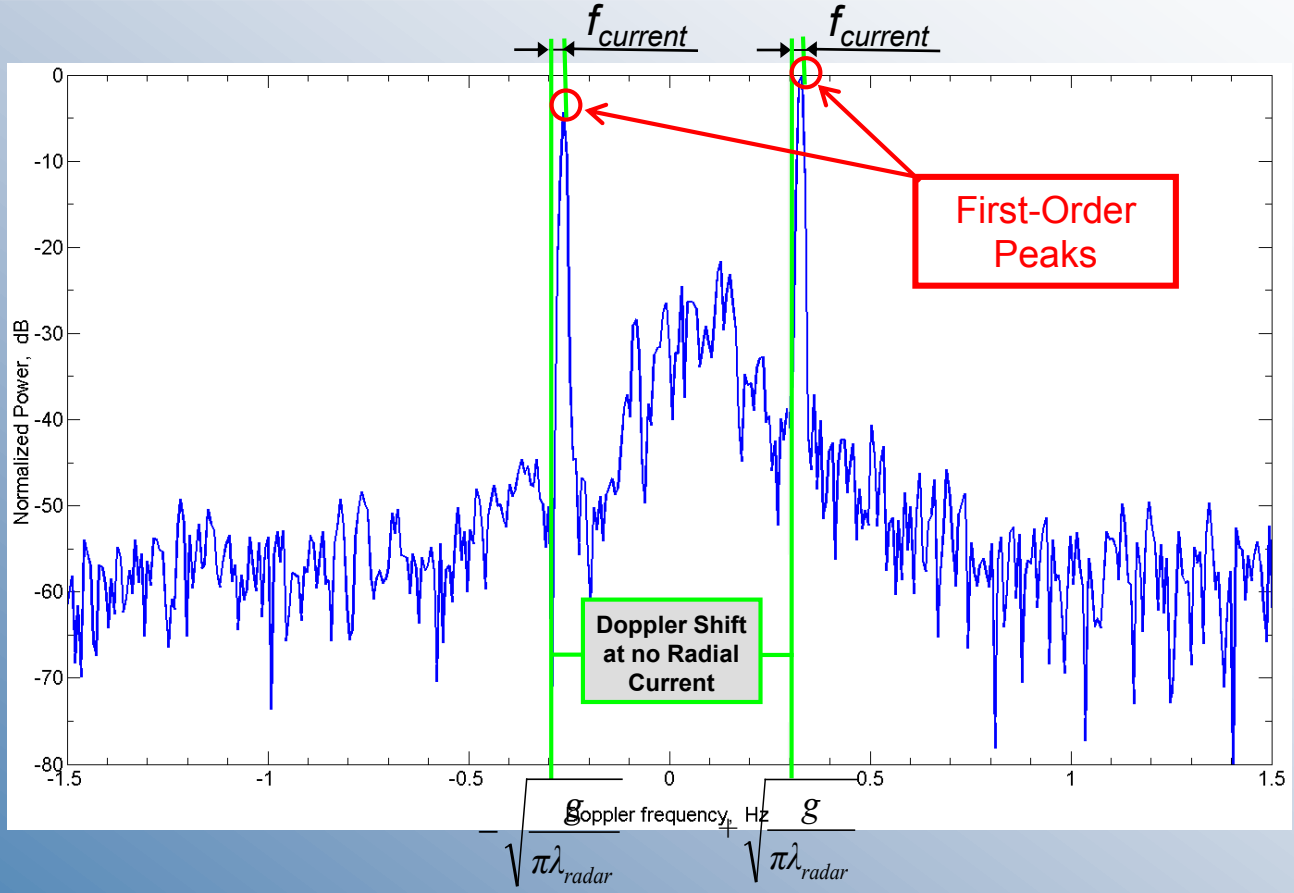
Signal Processing — Spectrum analysis

Oceanography

Detection, Tracking



Main Focus: Ocean Surface Current Estimation



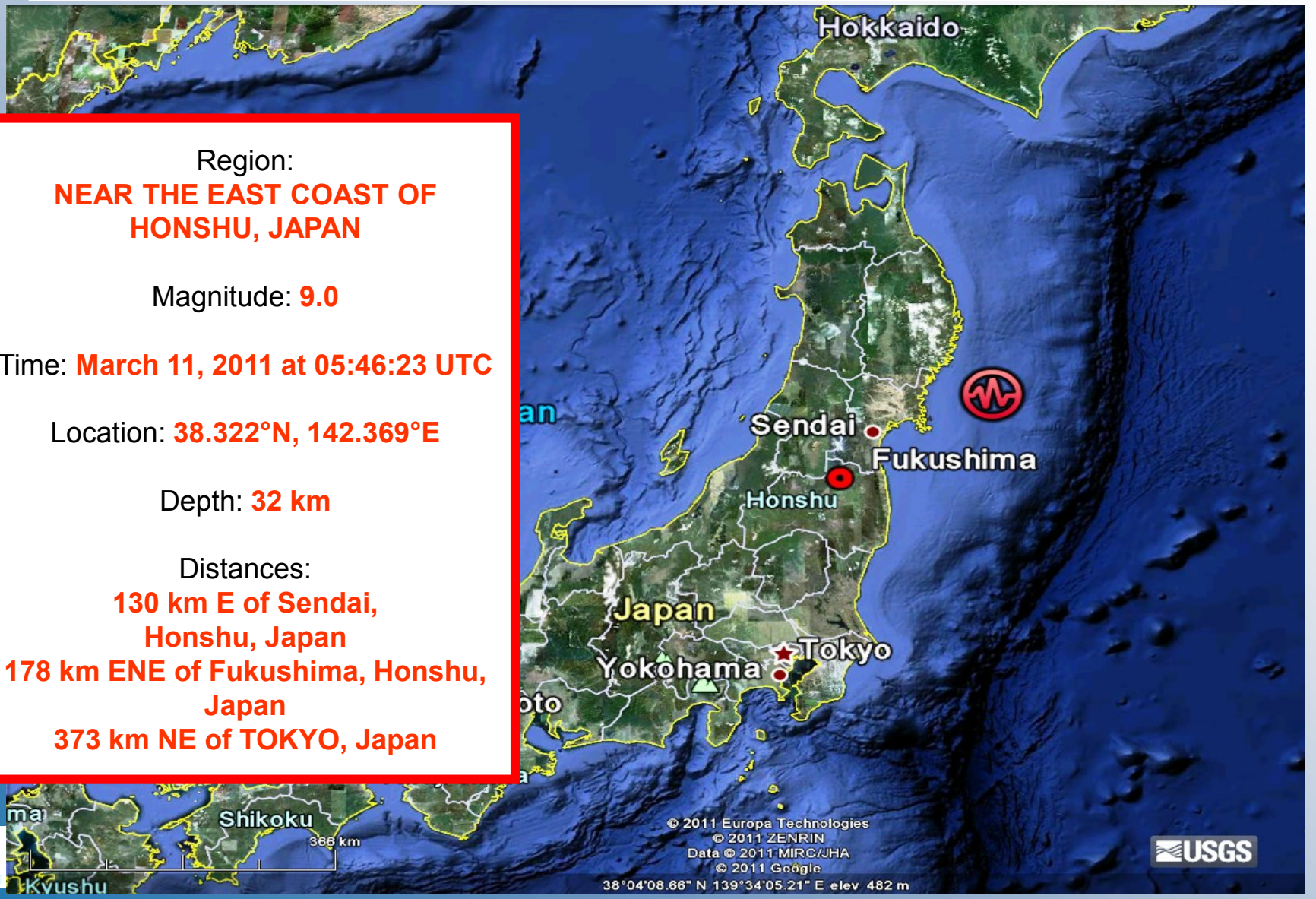
Bragg scattering law:

$$\lambda_{wave}=\lambda_{radar}/2$$

Radial surface current velocity:

$$v_{radcurr} = f_{current}\frac{\lambda_{radar}}{2}$$

Underwater Earthquake near Japan, March 11, 2011



Region:
NEAR THE EAST COAST OF HONSHU, JAPAN

Magnitude: **9.0**

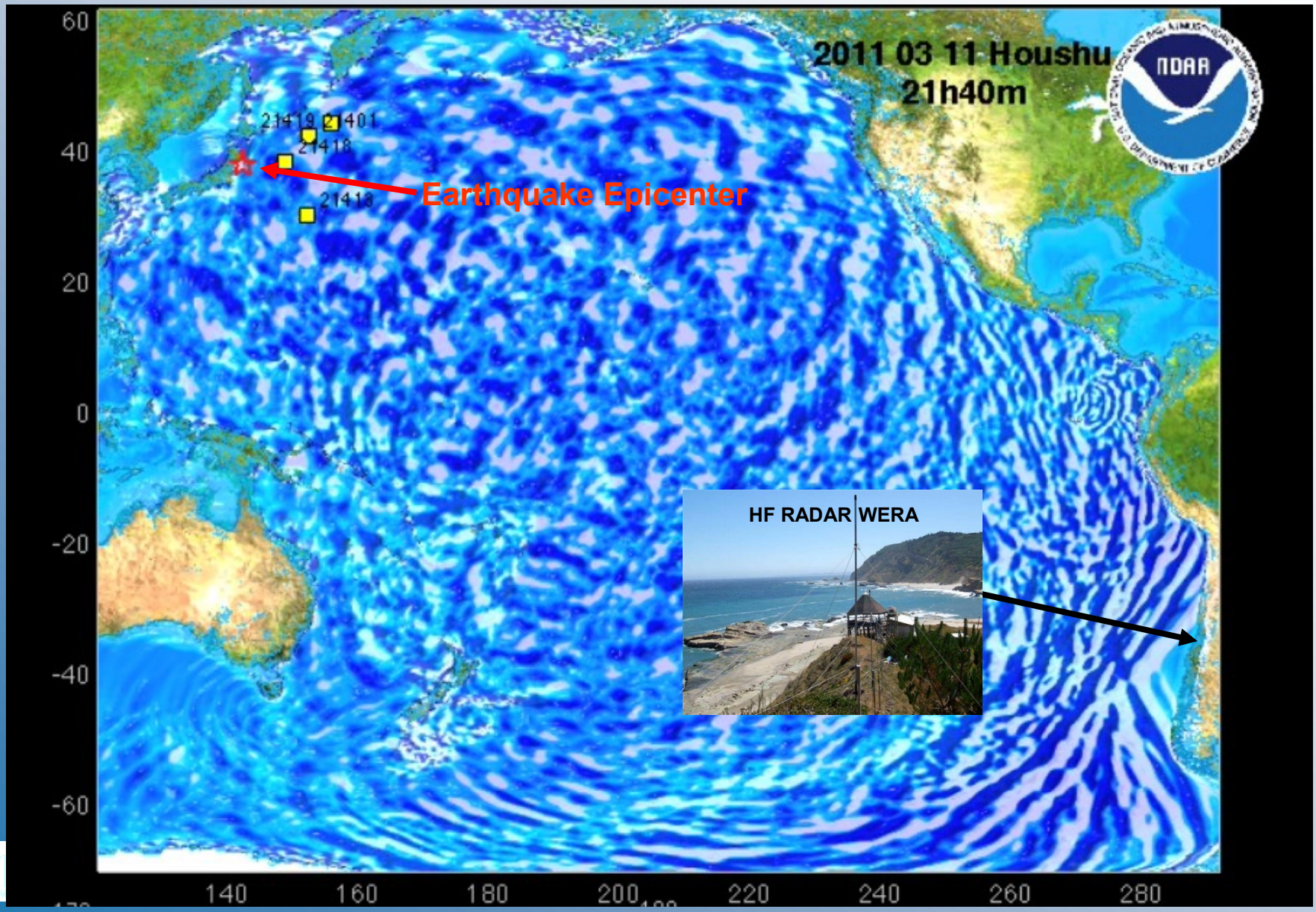
Time: **March 11, 2011 at 05:46:23 UTC**

Location: **38.322°N, 142.369°E**

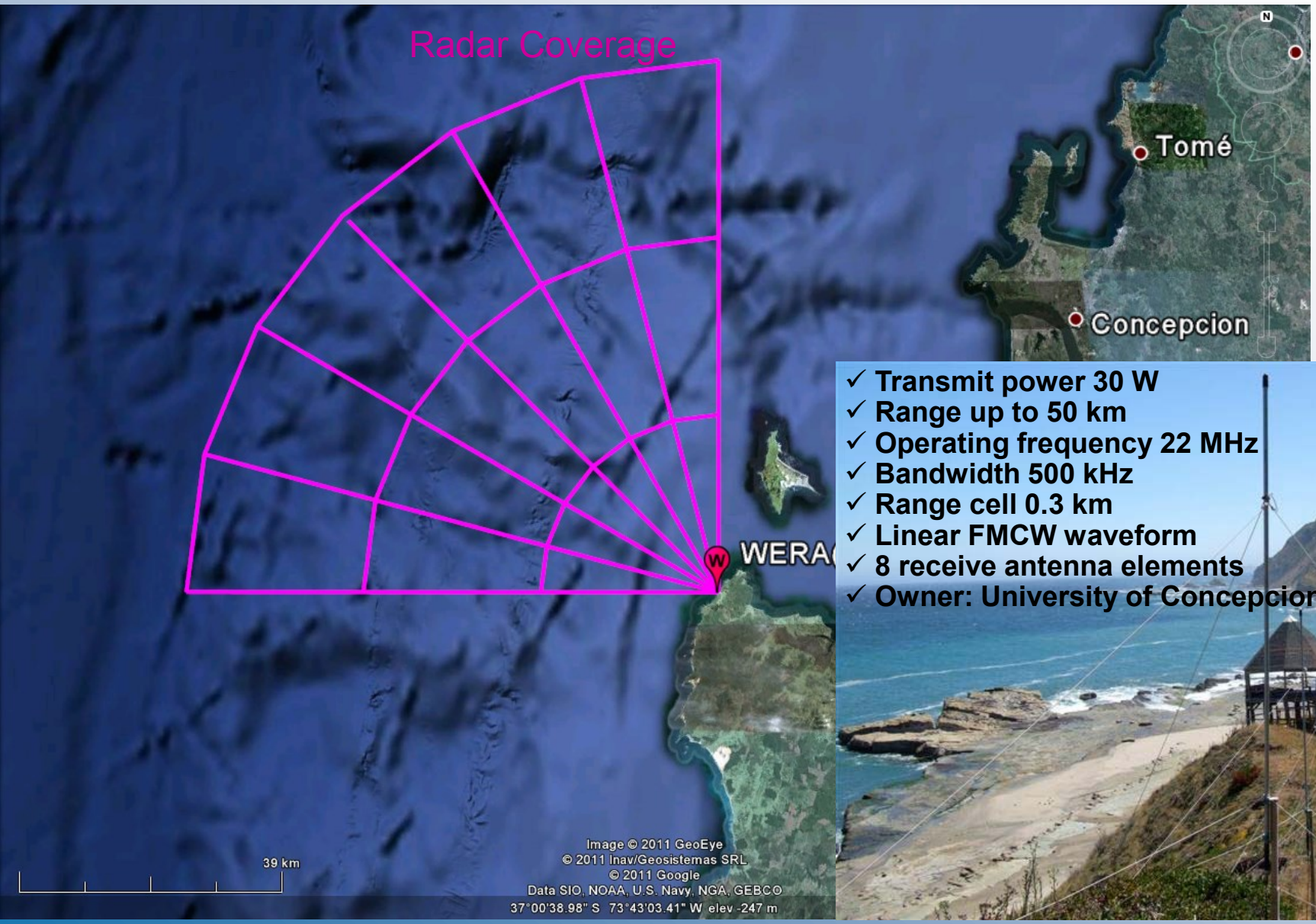
Depth: **32 km**

Distances:
130 km E of Sendai, Honshu, Japan
178 km ENE of Fukushima, Honshu, Japan
373 km NE of TOKYO, Japan

HF Radar WERA Installed in Chile

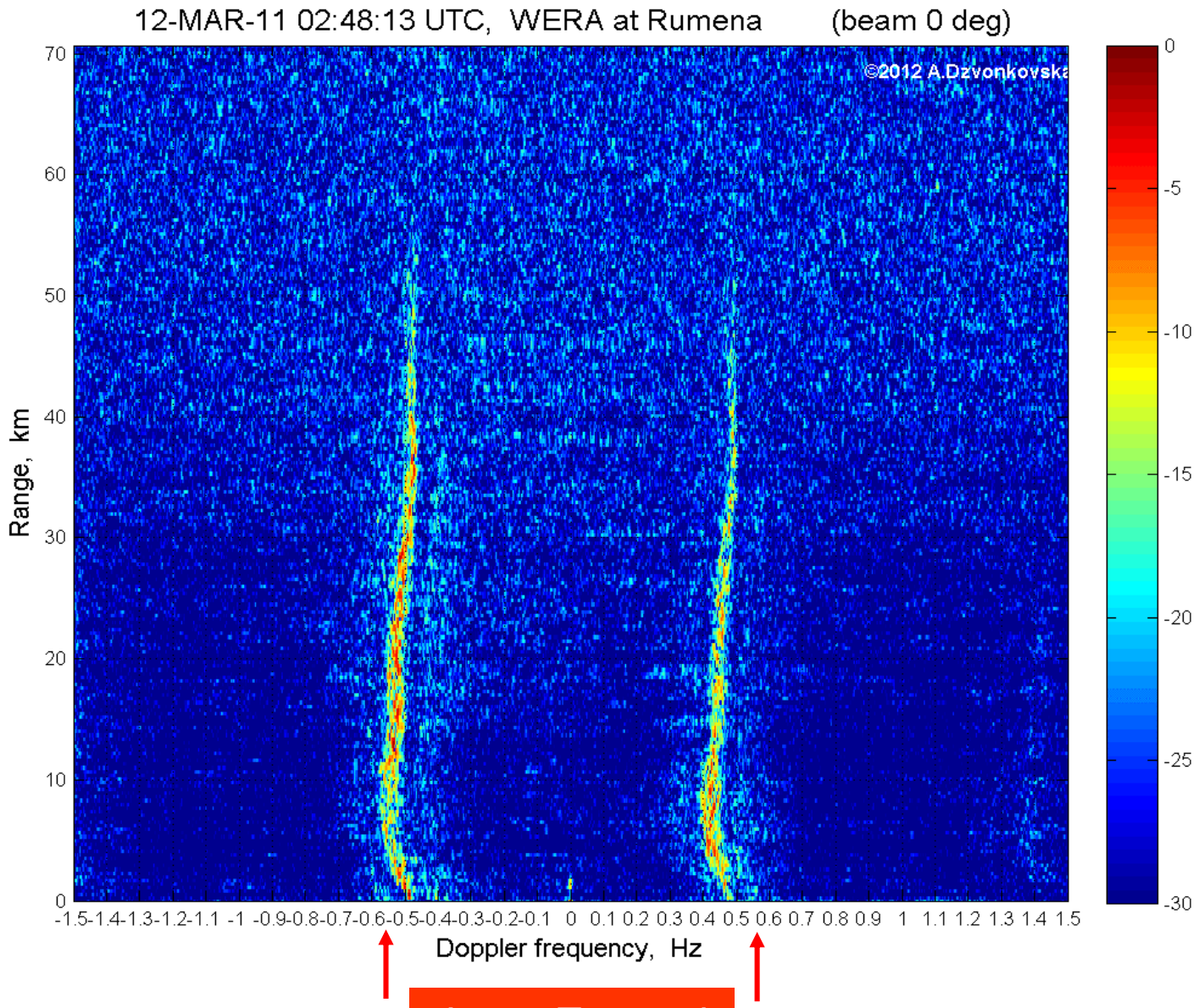


HF Radar WERA Installed in Chile

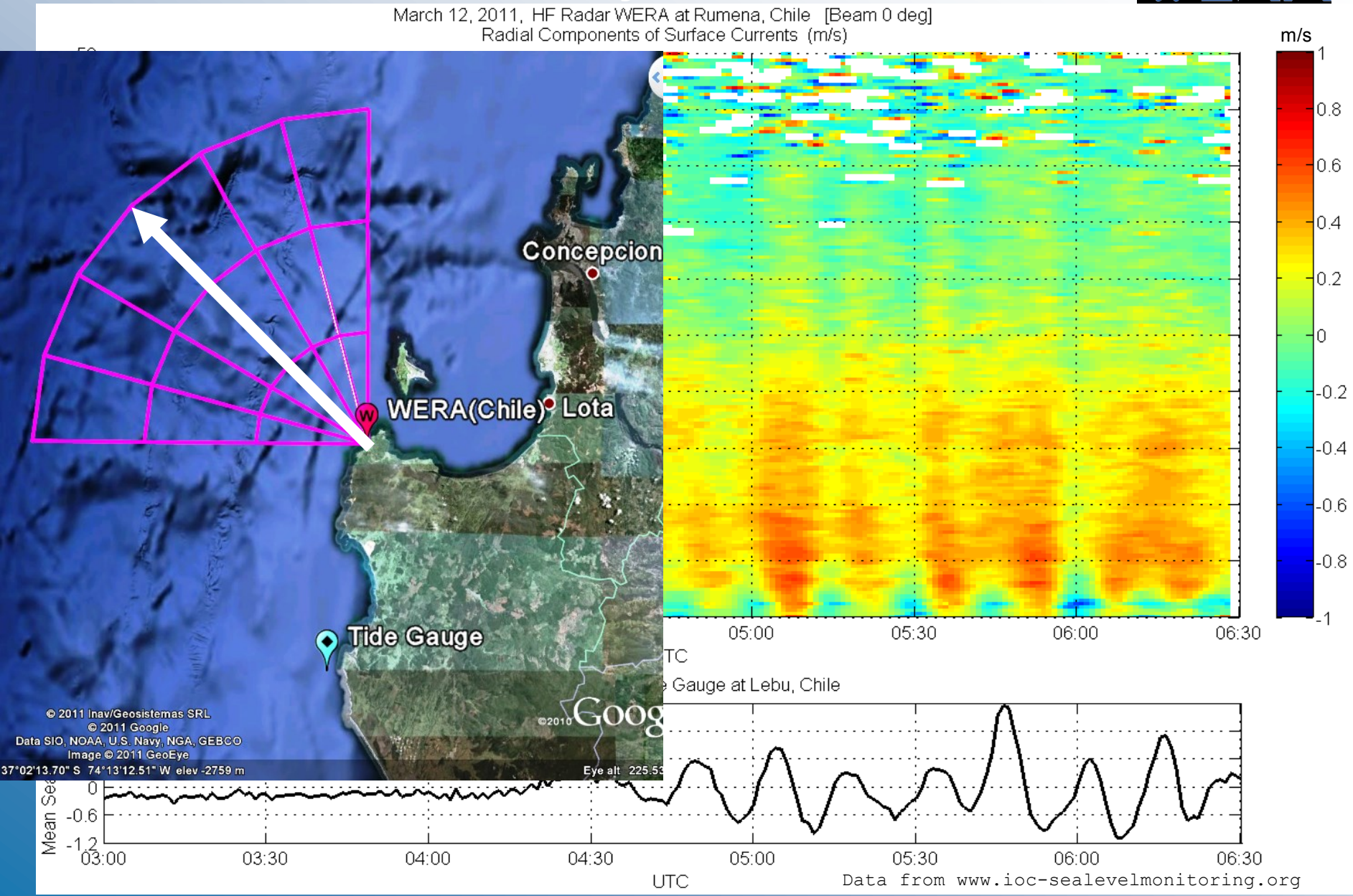


- ✓ Transmit power 30 W
- ✓ Range up to 50 km
- ✓ Operating frequency 22 MHz
- ✓ Bandwidth 500 kHz
- ✓ Range cell 0.3 km
- ✓ Linear FMCW waveform
- ✓ 8 receive antenna elements
- ✓ Owner: University of Concepcion, Chile

HF Radar Spectrum Changes During Tsunami Runups



Radial Surface Current Velocity Measured by WERA in Chile



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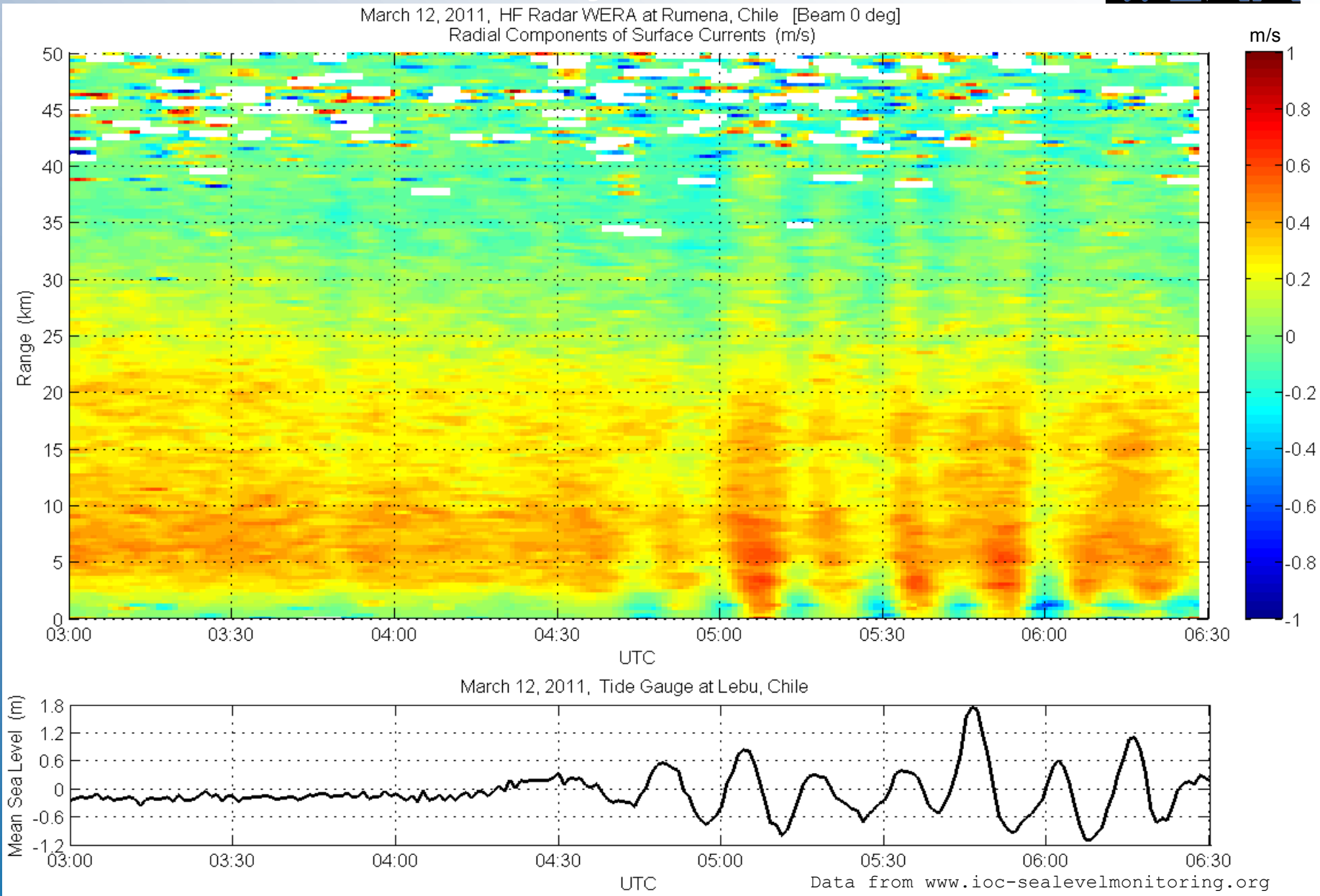
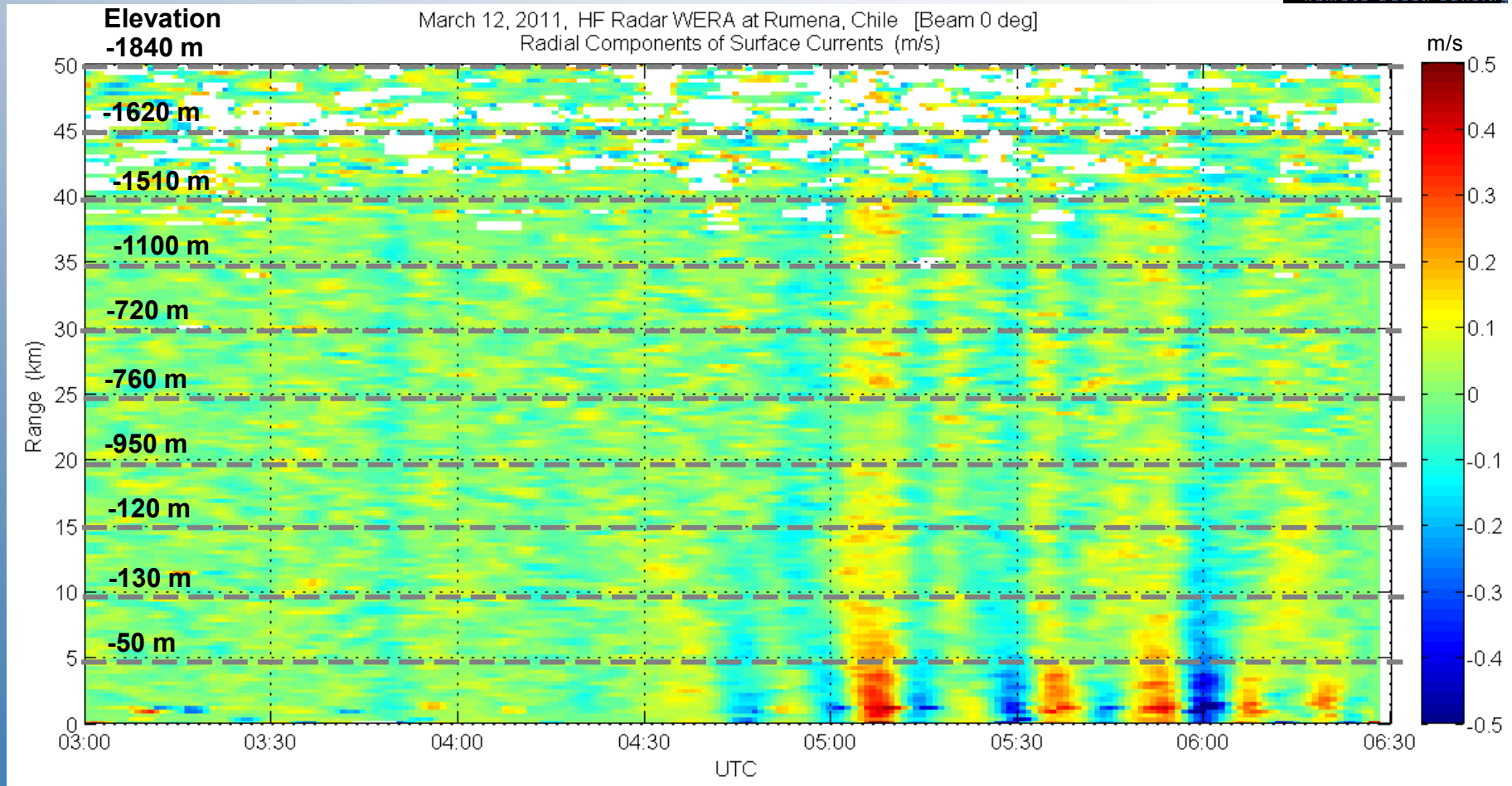
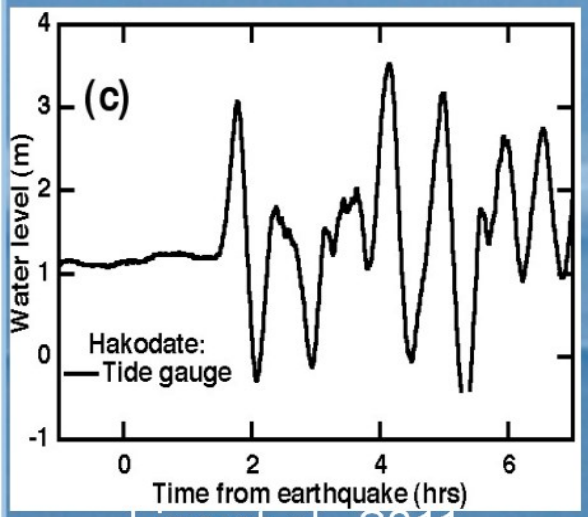


Residuals of Measured Radial Velocities



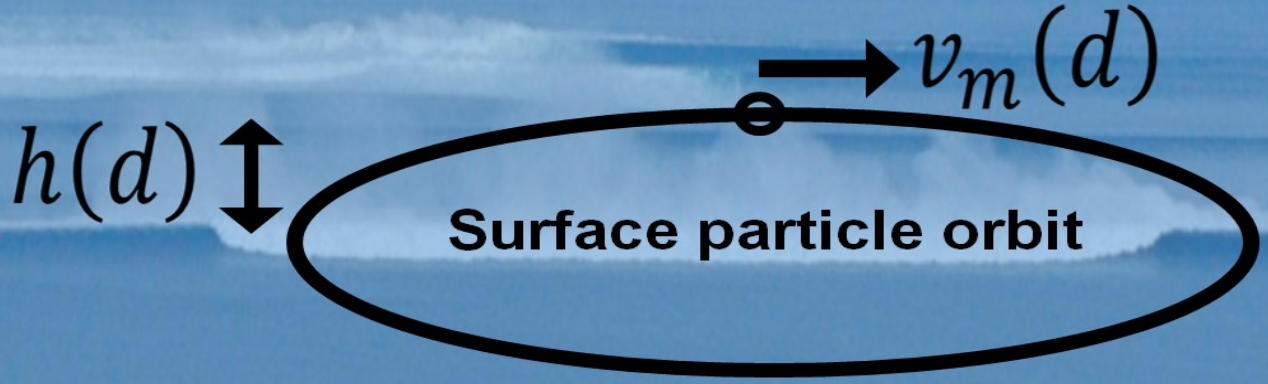
Linear Wave Theory

Phase Velocity $v_p = (gd)\,½$



Lipa et al., 2011

Max Surge Velocity



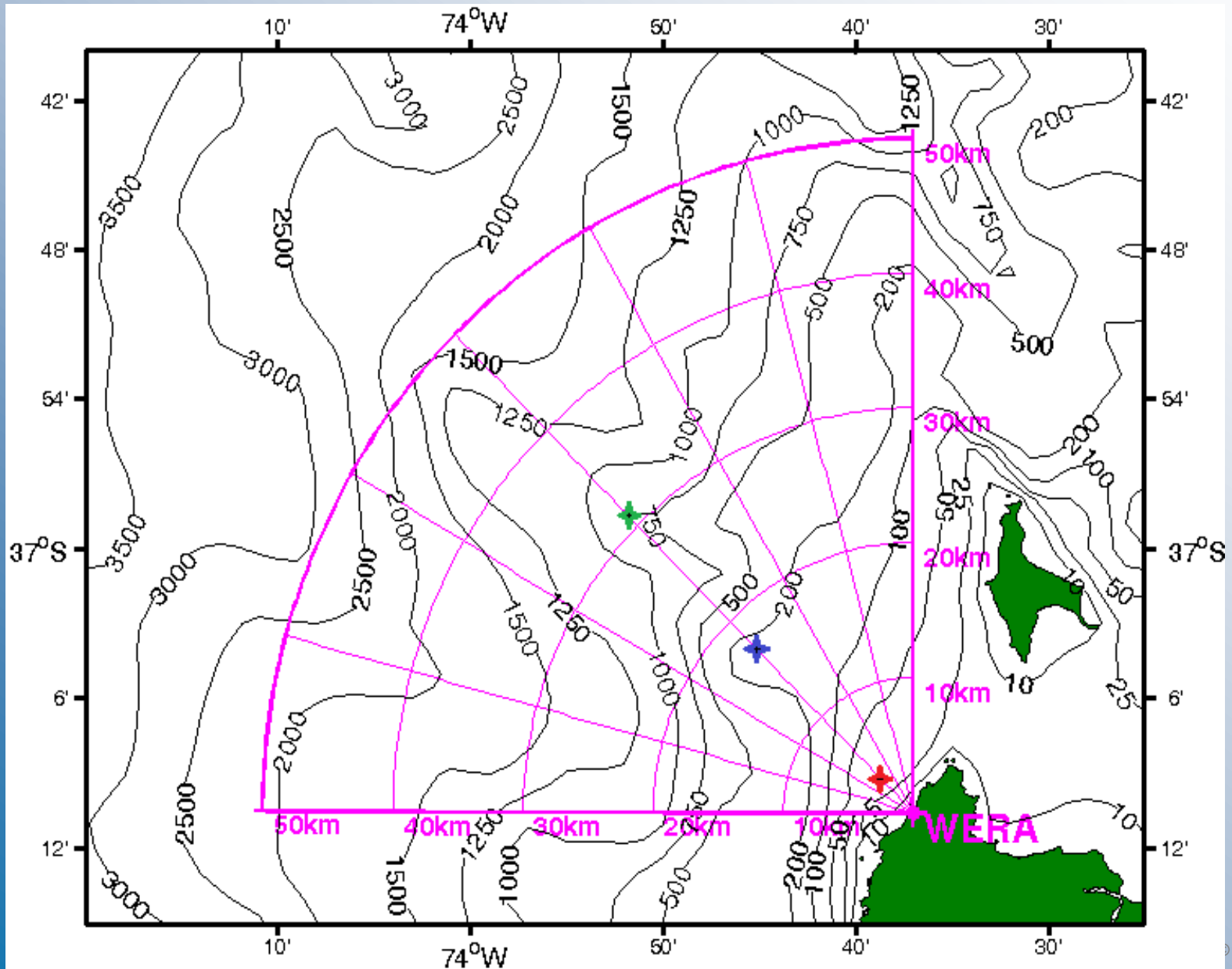
$$h(d) = h(D)\left(\frac{D}{d}\right)^{1/4}$$

=

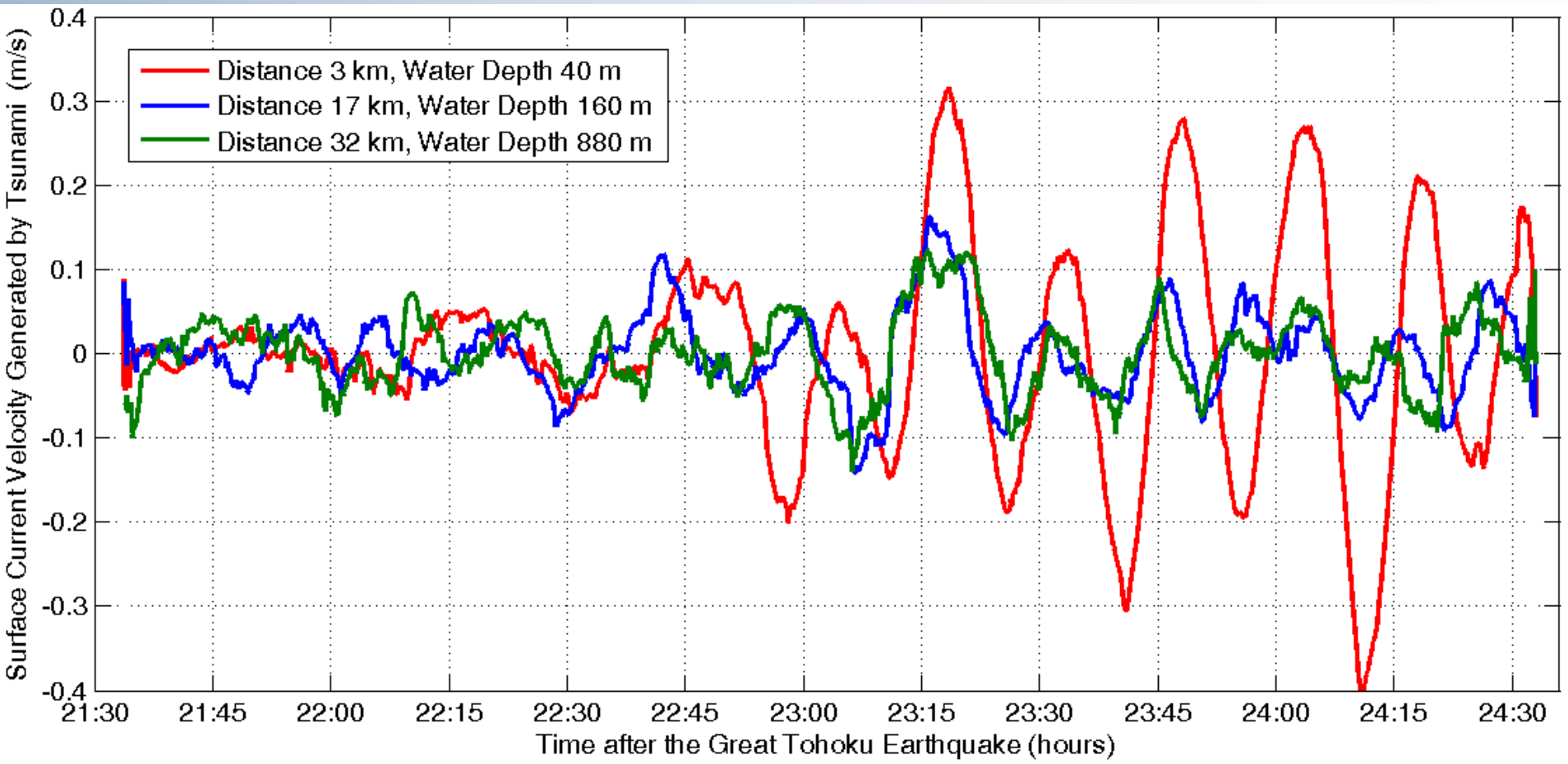
$$v_m(d) = v_m(D)\left(\frac{D}{d}\right)^{3/4}$$

Kinsman, 1965

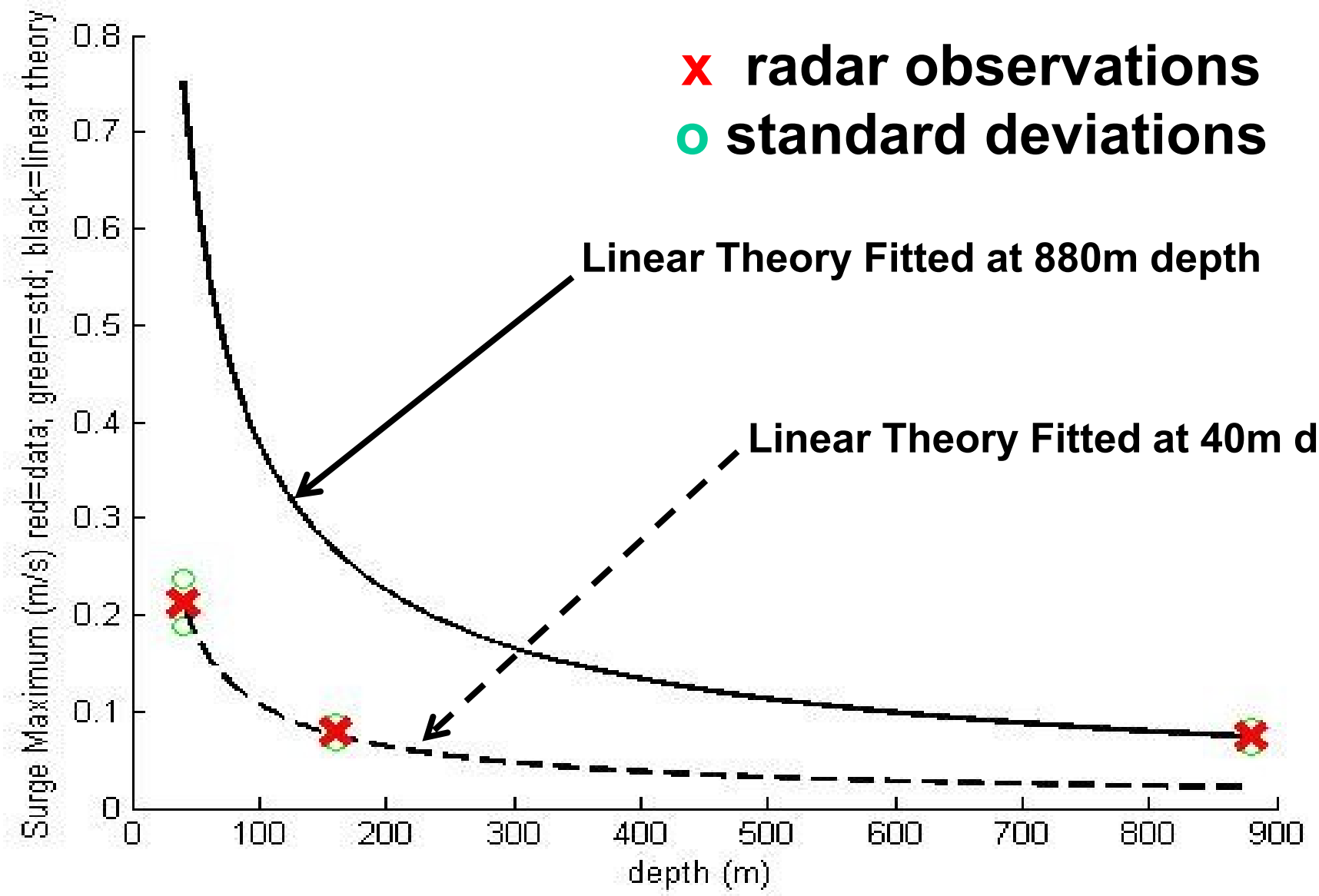
Bathymetric Contours within Radar Coverage



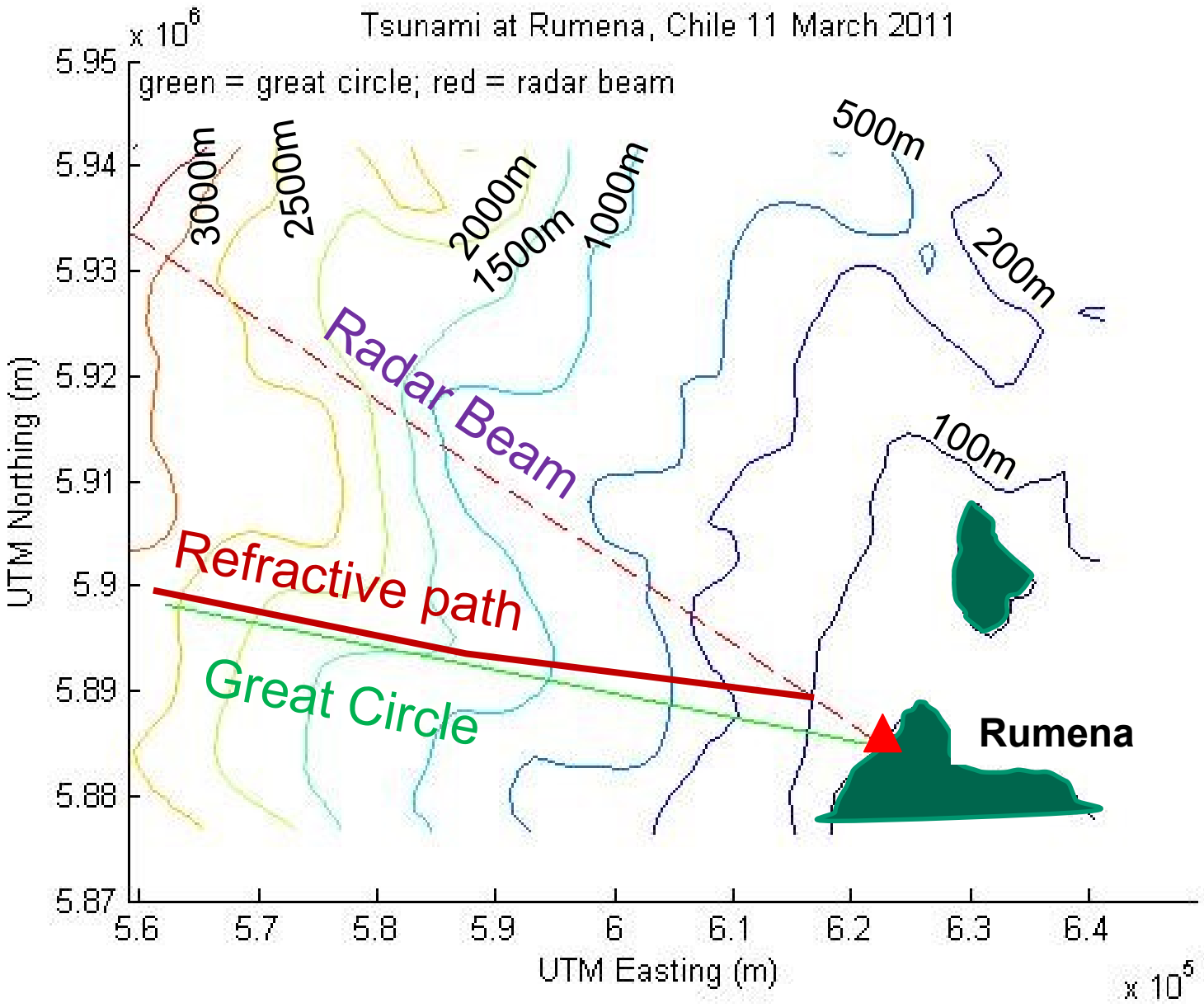
Residuals of Measured Radial Velocities



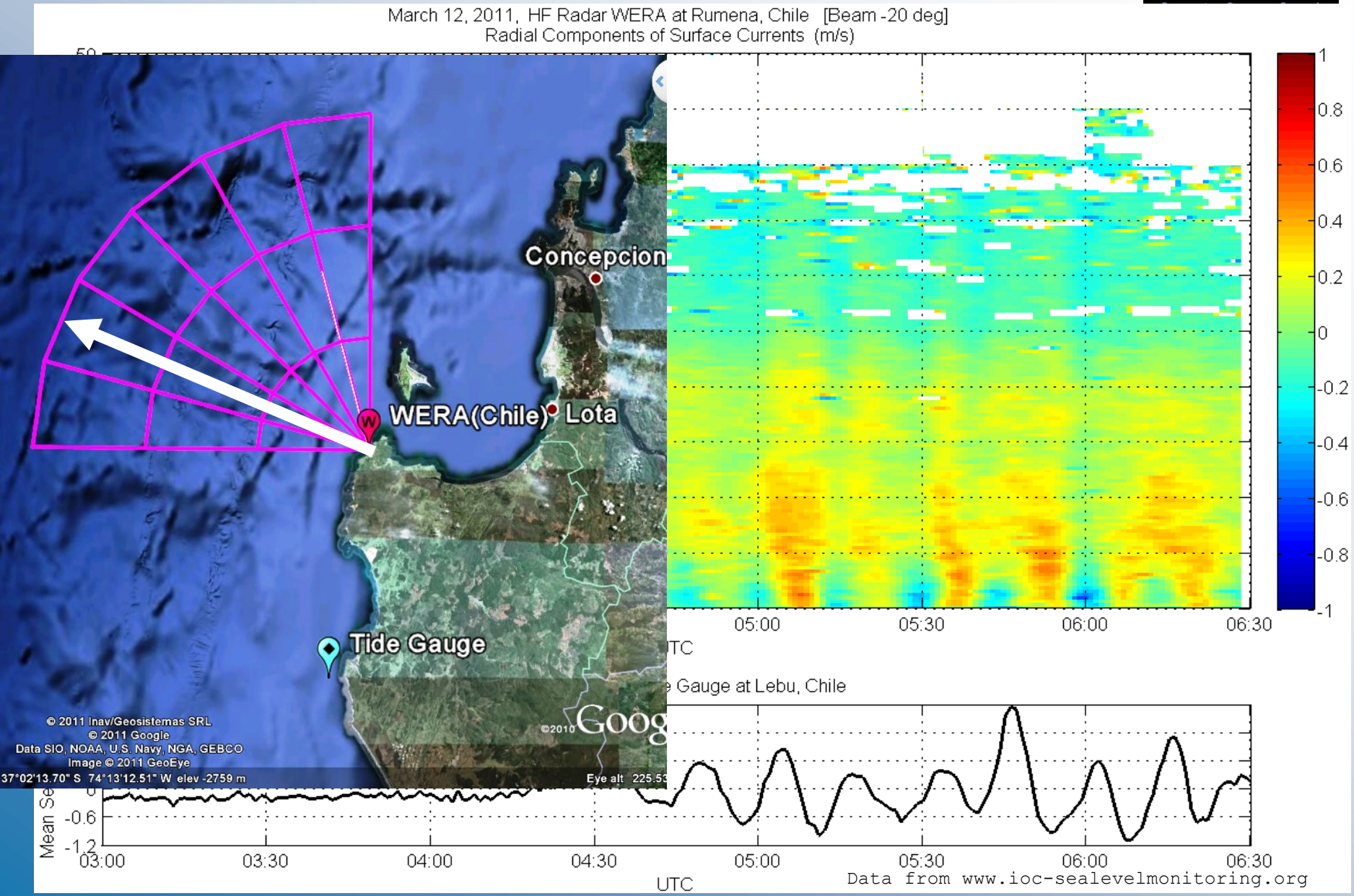
Linear Theory Results



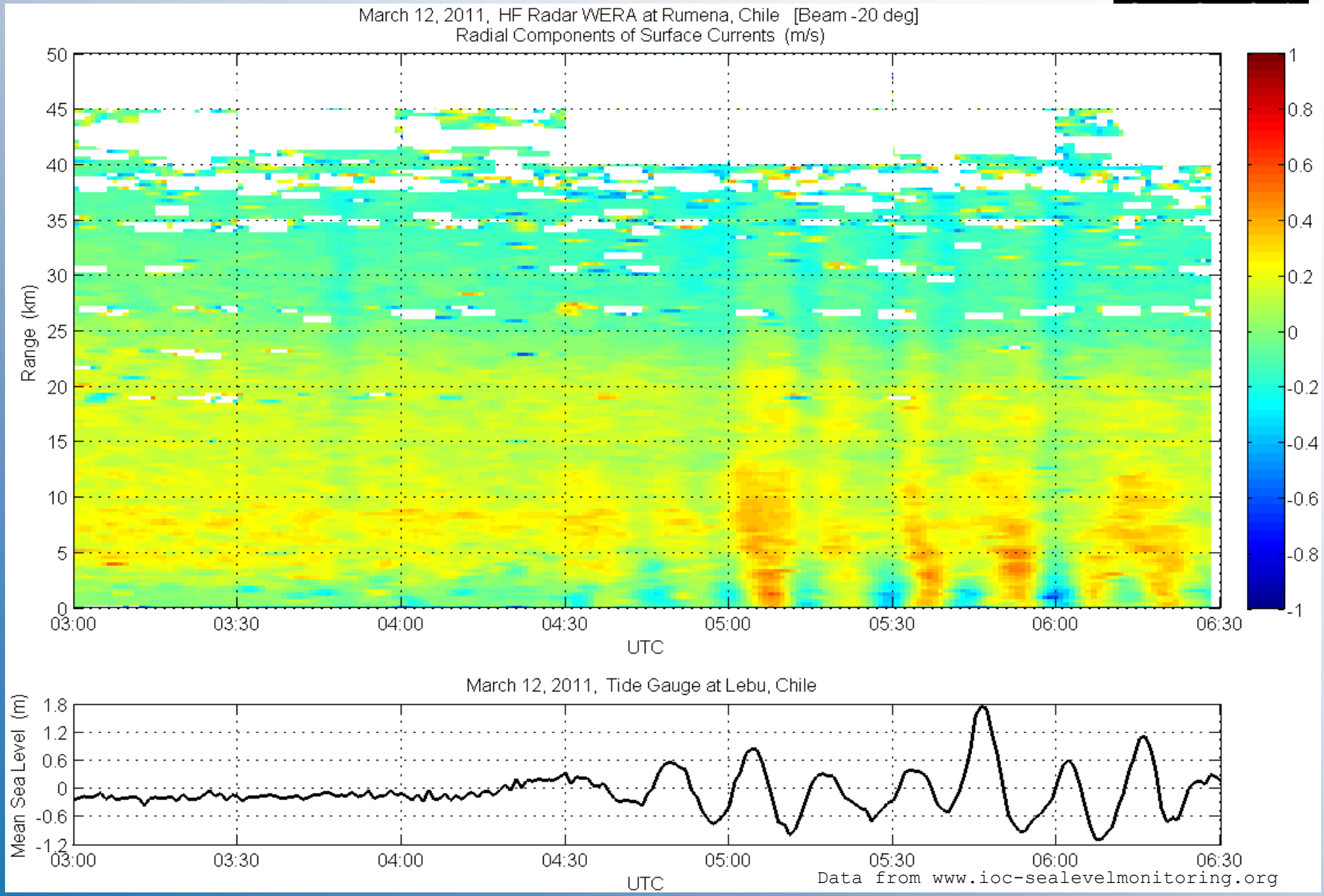
Direction of Tsunami Wave Arrival



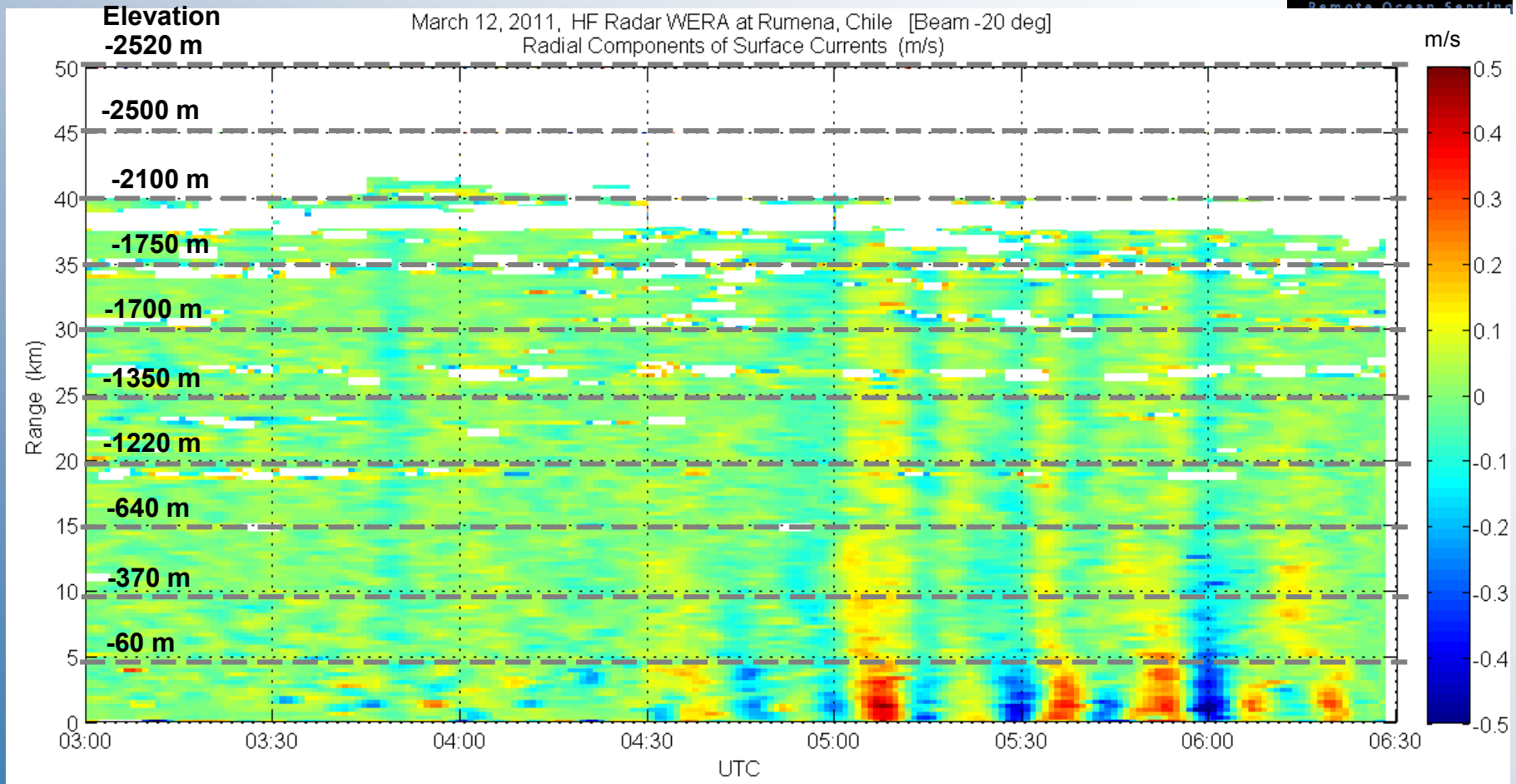
Radial Surface Current Velocity Measured by WERA in Chile



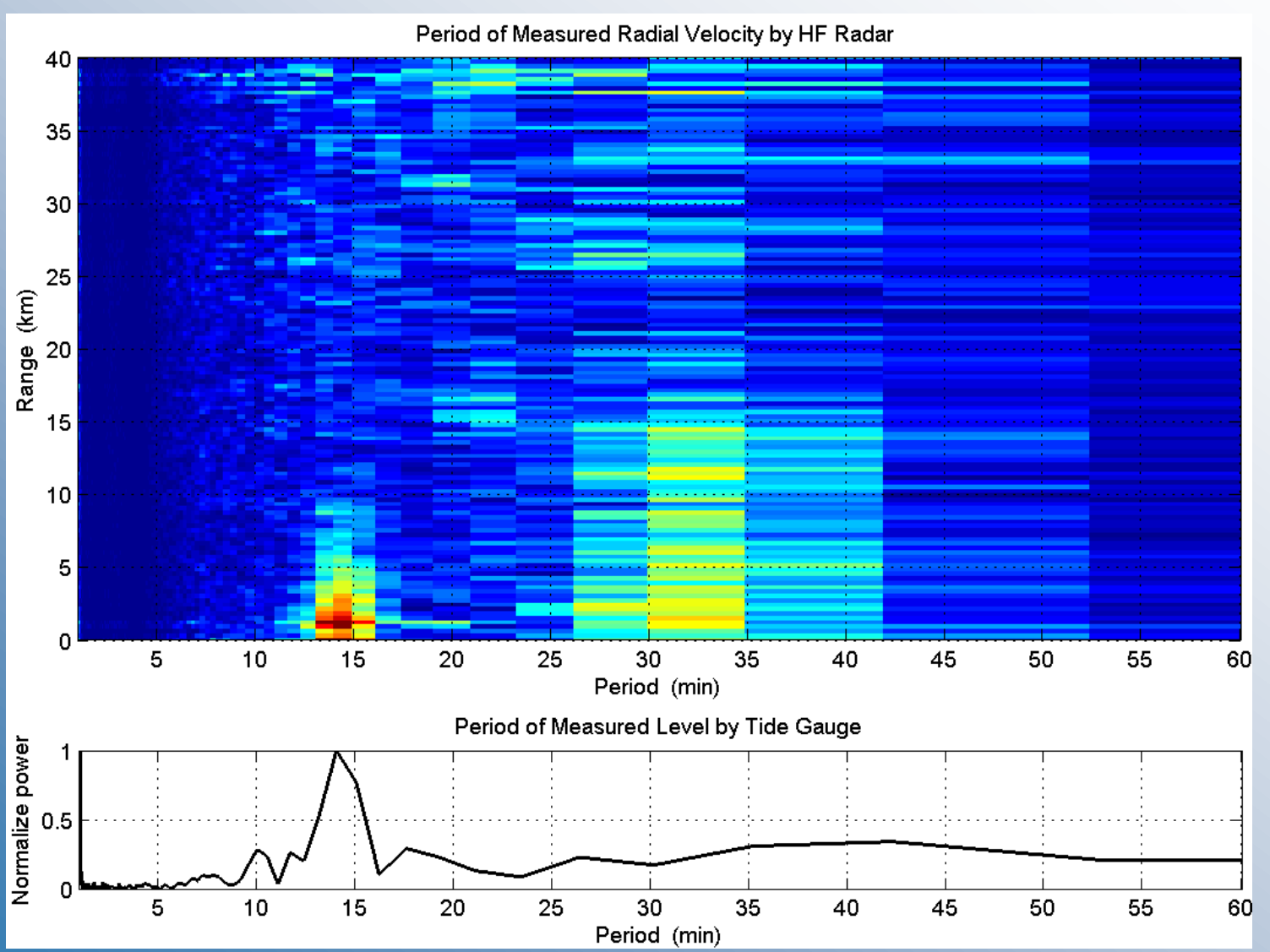
Radial Surface Current Velocity Measured by WERA in Chile



Residuals of Measured Radial Velocities



Tsunami Wave Period Estimation



Conclusions

✓ HF surface wave radars have a unique capability to monitor the coastal environment and could contribute to the development and improvement of tsunami early warning systems.

✓ The unique chance to observe a natural tsunami event using an HF radar showed that such radars are capable to measure tsunami surface current velocity in real-time.

✓ In case of the tsunami, large deviations in ocean surface current measurements were observed by the HF radar system. The tsunami wave train was clearly seen in radar measurements and it was compared with the water level measurements by the tide gauge.

✓ Tsunami currents can be observed beyond shelf area; therefore a good understanding about tsunami features is needed.

Acknowledgements

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