Intensified internal tides in Explorer and Dangeard Canyons (Celtic Sea shelf edge) observed by a deep ocean glider

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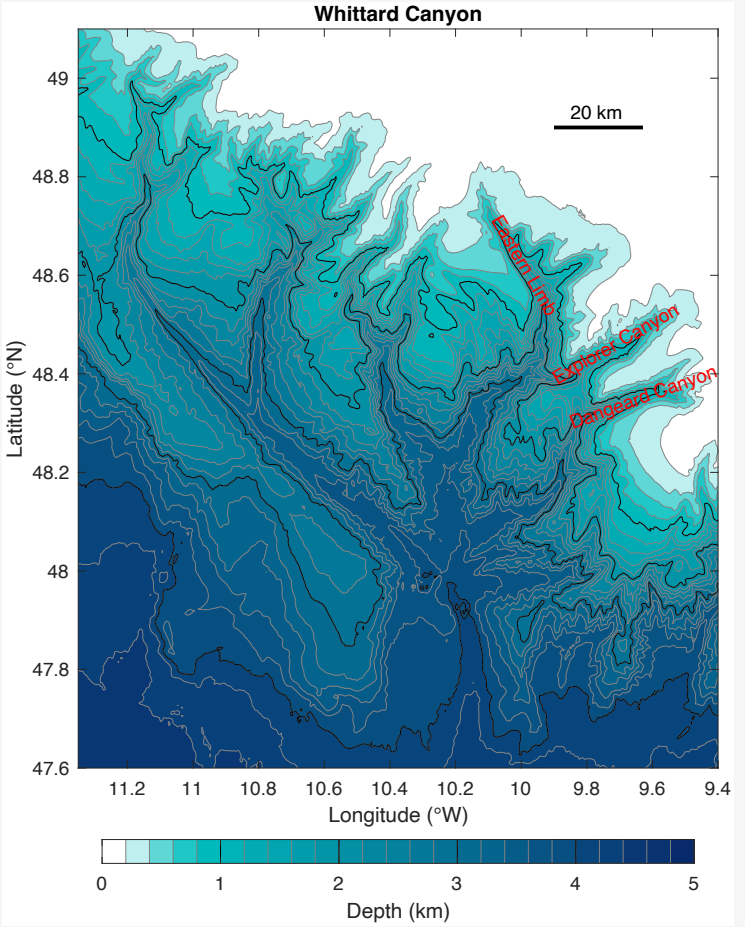


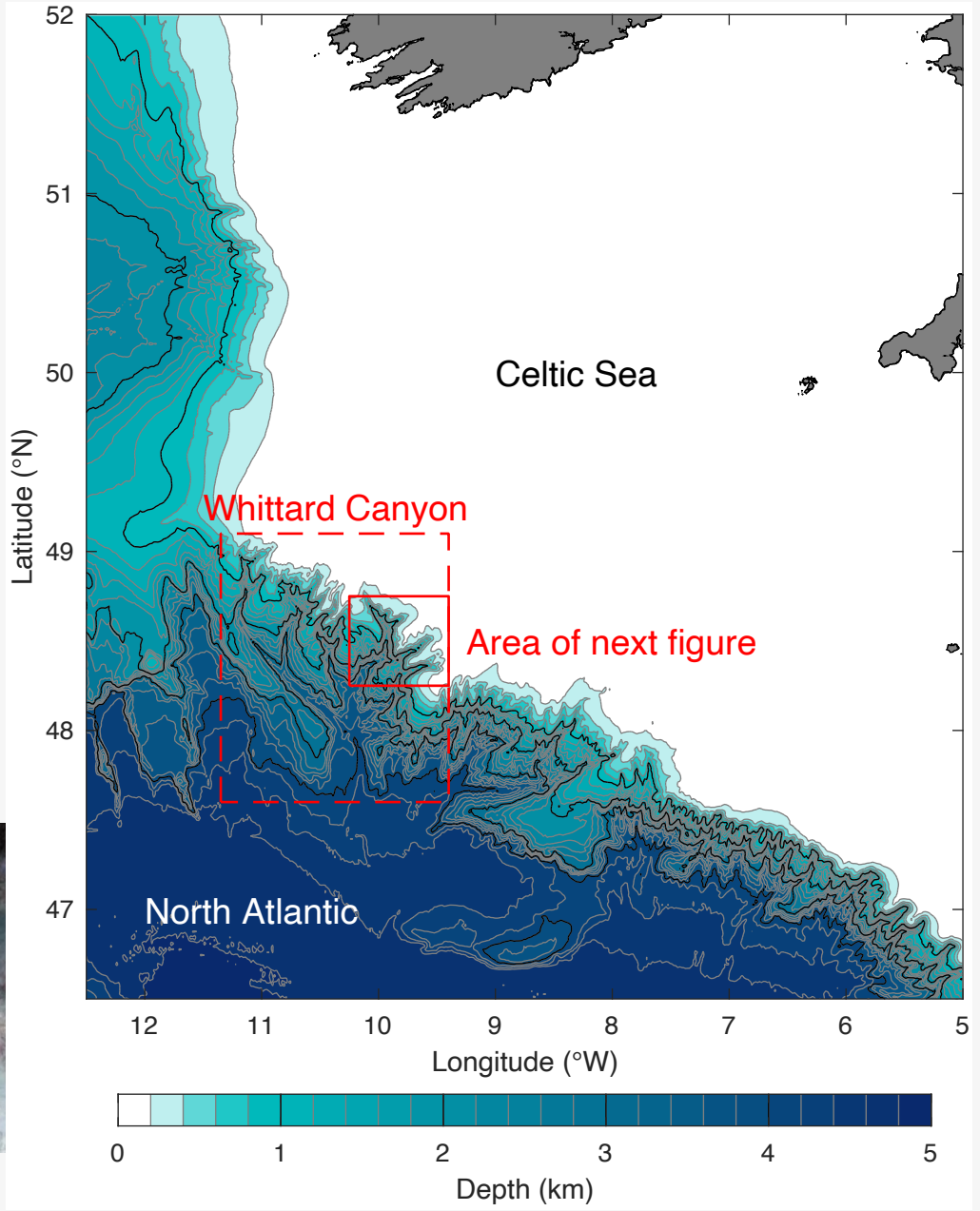
Motivation

Explorer and Dangeard Canyons are named limbs of the dendritic Whittard Canyon system that incises the Celtic Sea continental slope

System know to feature large, but spatially heterogeneous semidiurnal internal tides

These are thought to have a variety of environmental impacts, from benthic faunal distribution to triggering turbidity currents

Lophelia pertusa – Huvenne et al. (2011, PLoS ONE)



Data and methods

8 Seaglider virtual moorings (2015)
- ~1.5 days each
- 2 to 3-hour dives
- 800 to 1000 m

7 DeepGlider virtual moorings (2022)
- 2 to 4 days each
- 2.5 to 8.5-hour* dives
- 800 to 2200 m

M_2 harmonic fits to vertical isopycnal displacement
- Amplitude → Available Potential Energy (APE)
- Phase

*Dives >3 hours require longer virtual moorings

Yo-yo CTD/LADCP station (2022)
- 13 hours, eight ~1.6-hour casts
- 2000 m

Yo-yo CTD/LADCP station (2012)
- 13 hours, twelve ~1-hour casts
- 850 m

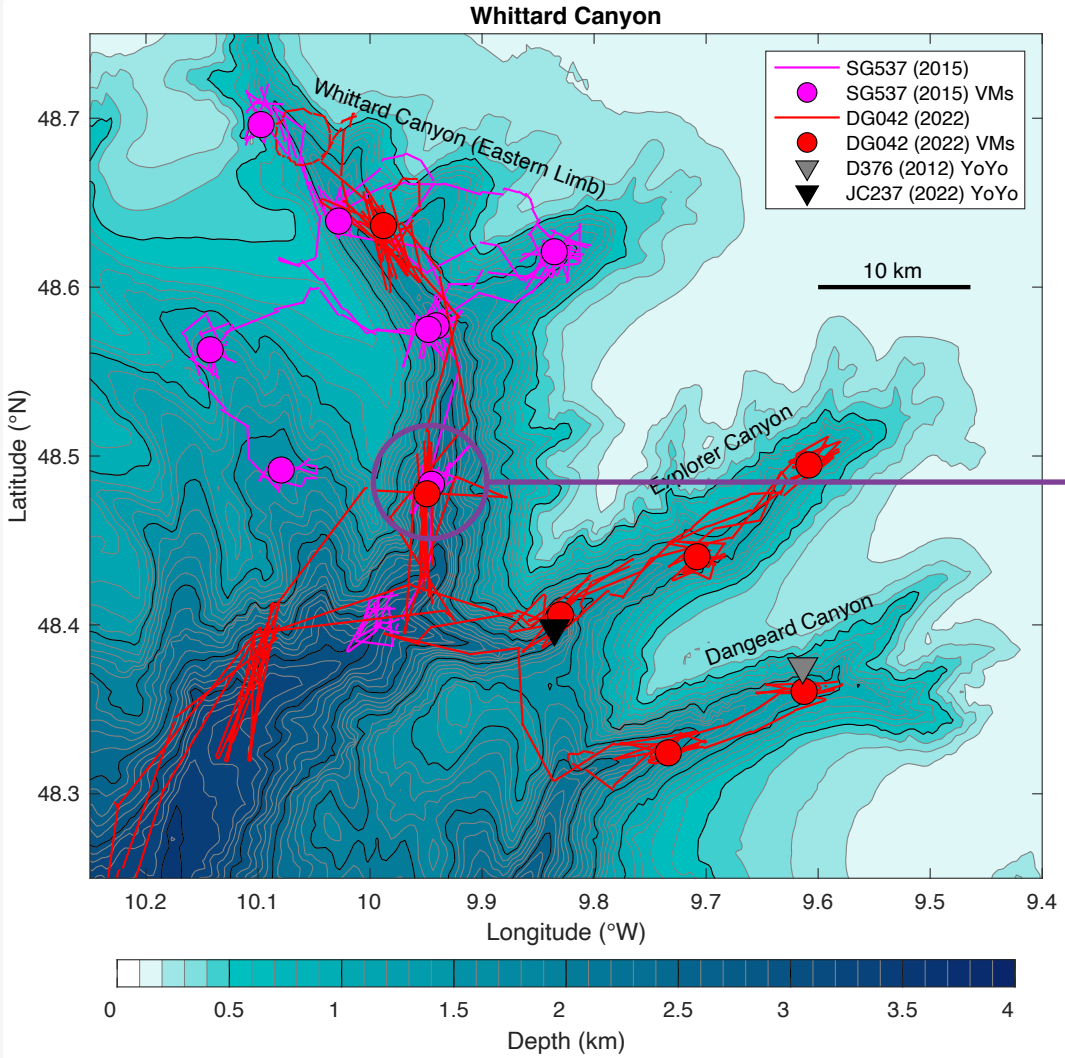
M_2 harmonic fits to vertical isopycnal displacement and baroclinic horizontal velocity
- APE, Horizontal Kinetic Energy (HKE), and energy flux = $\langle \mathbf{u}'p' \rangle$ (e.g. Nash et al. 2005)

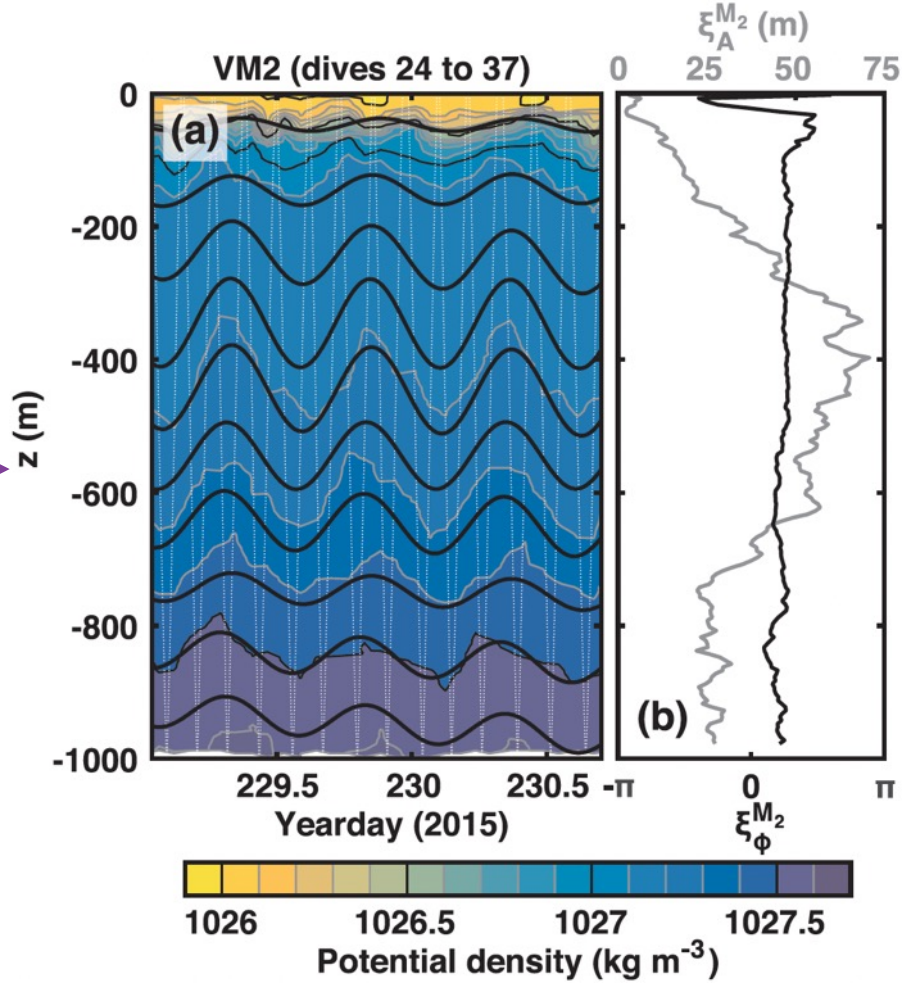
Internal spring-neap cycle removed using a TPXO-derived scaling following the method of Hall et al. (2017, Deep-Sea Res I)

Seaglider virtual moorings

2015

M_2 maximum displacement amplitude
Whittard Canyon: **85 m**



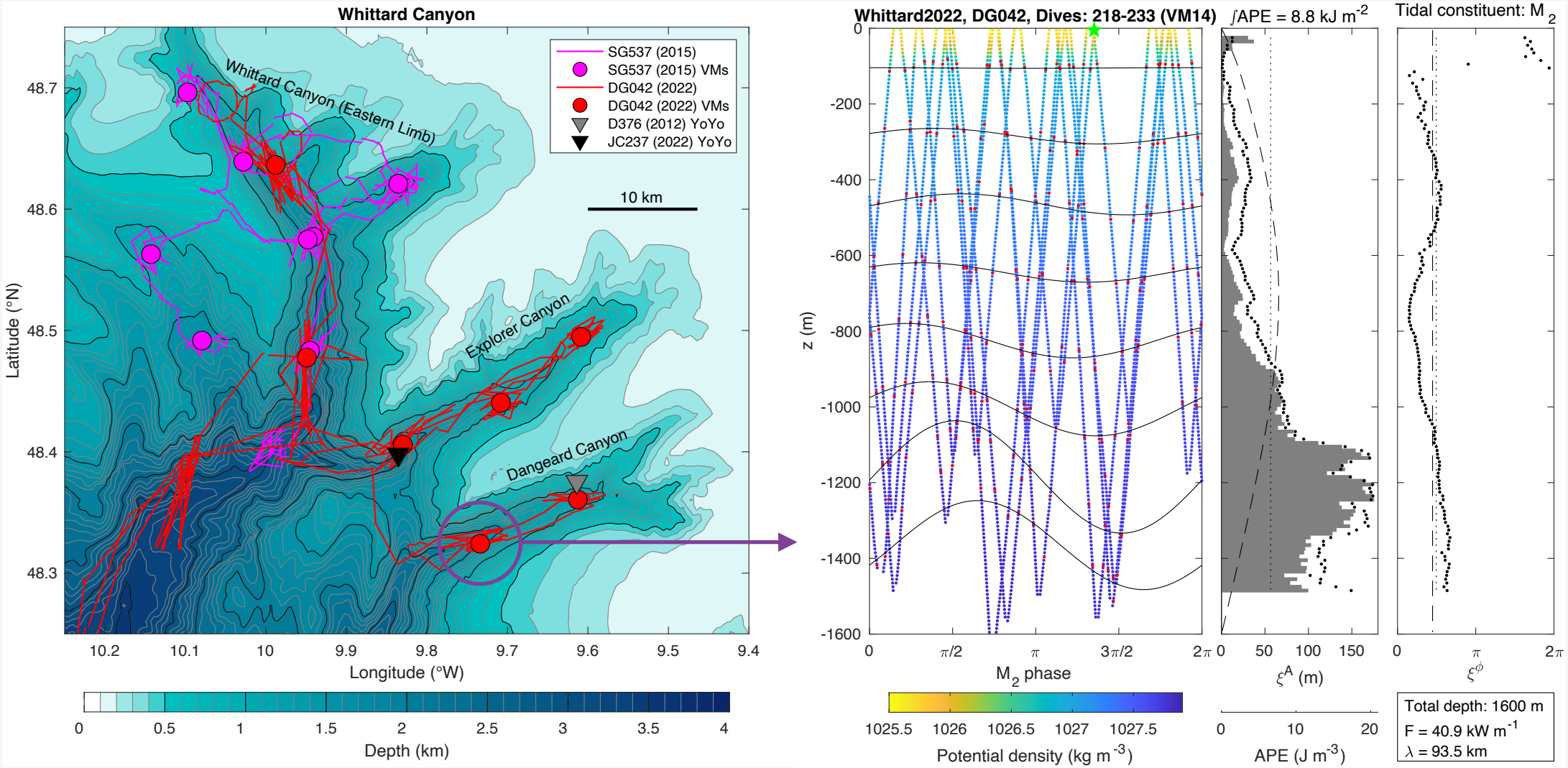


Hall et al. (2017, Deep-Sea Res. I)

DeepGlider virtual moorings

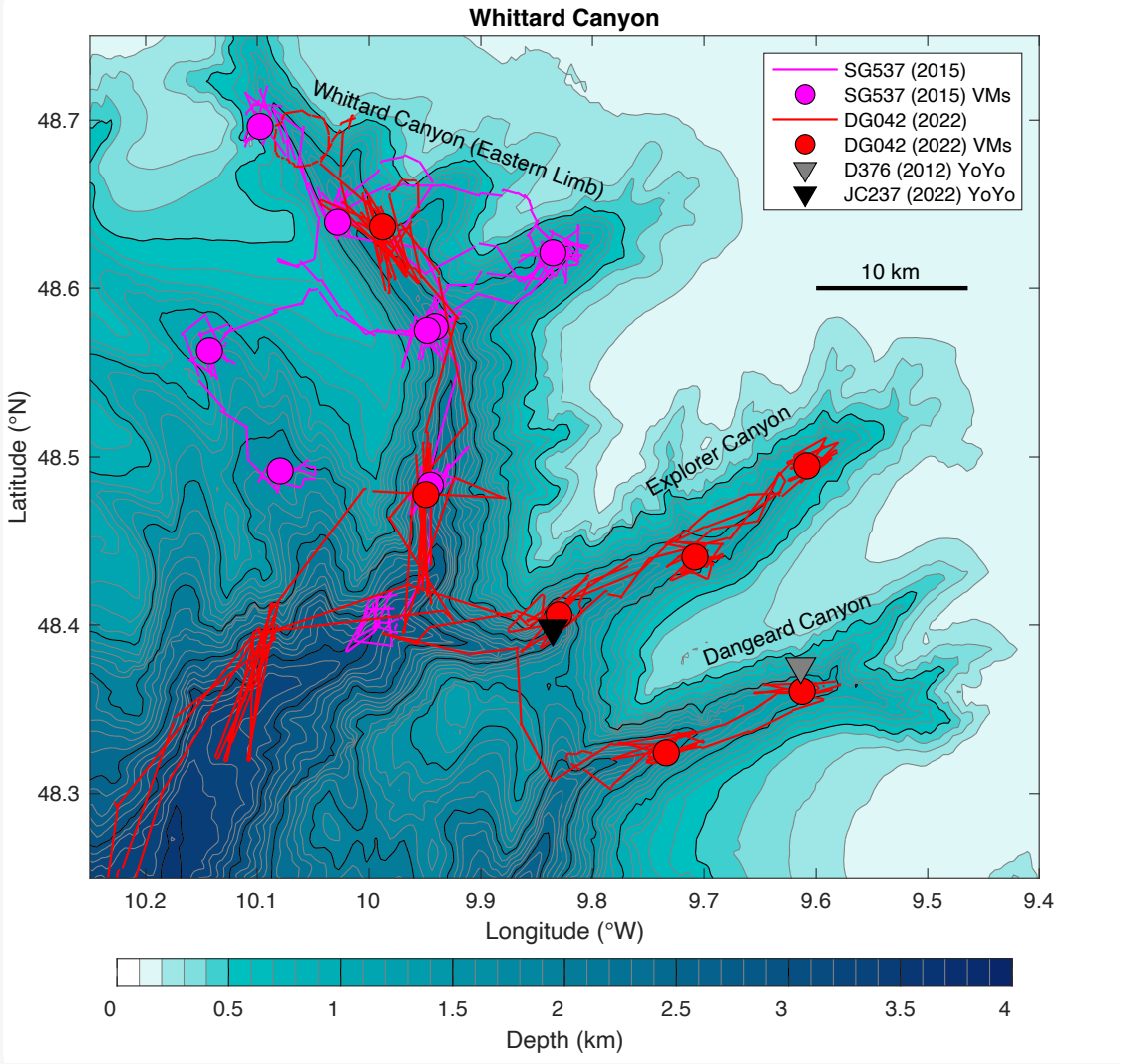
2022

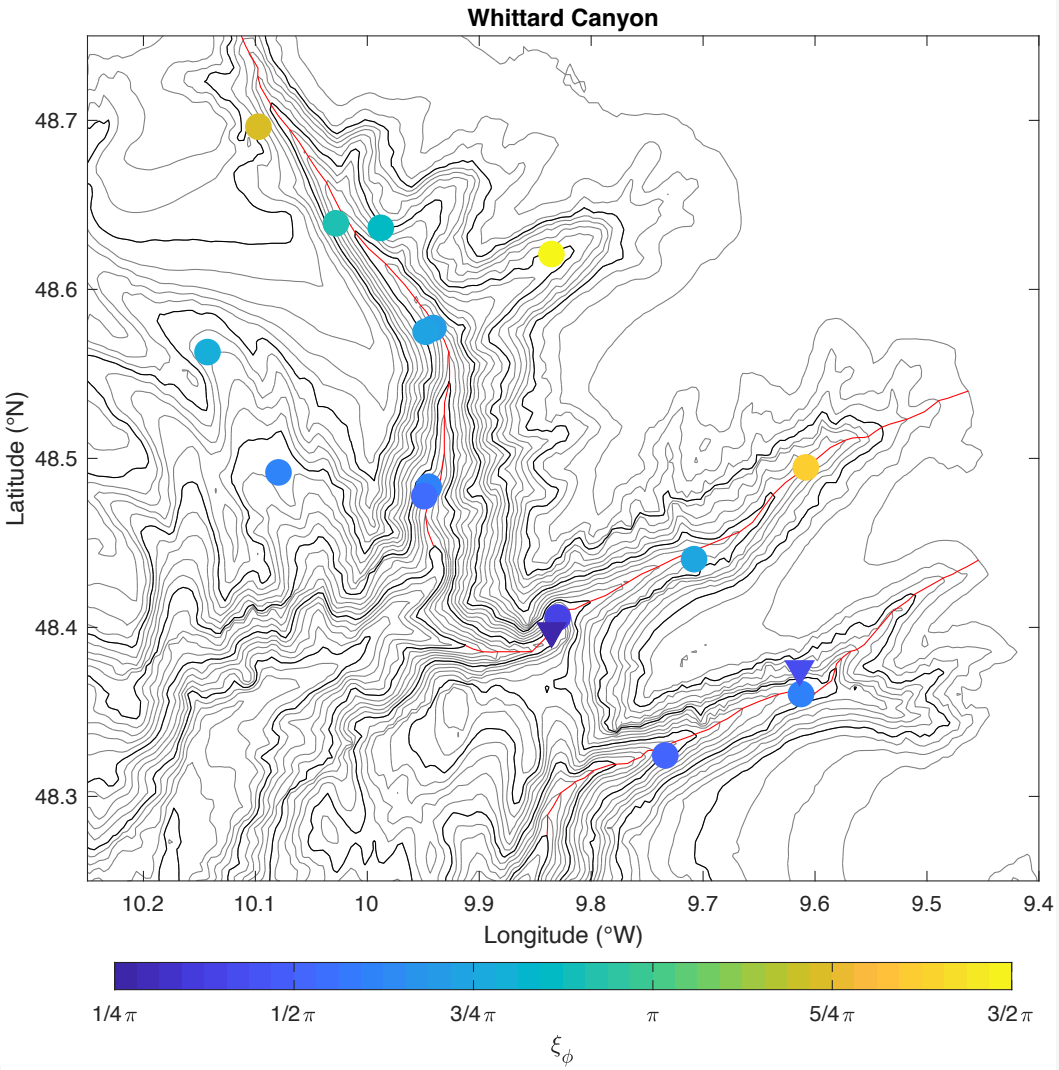
M_2 maximum displacement amplitude
Explorer Canyon: **115 m**
Dangeard Canyon: **130 m**



Glider synthesis: displacement phase progression

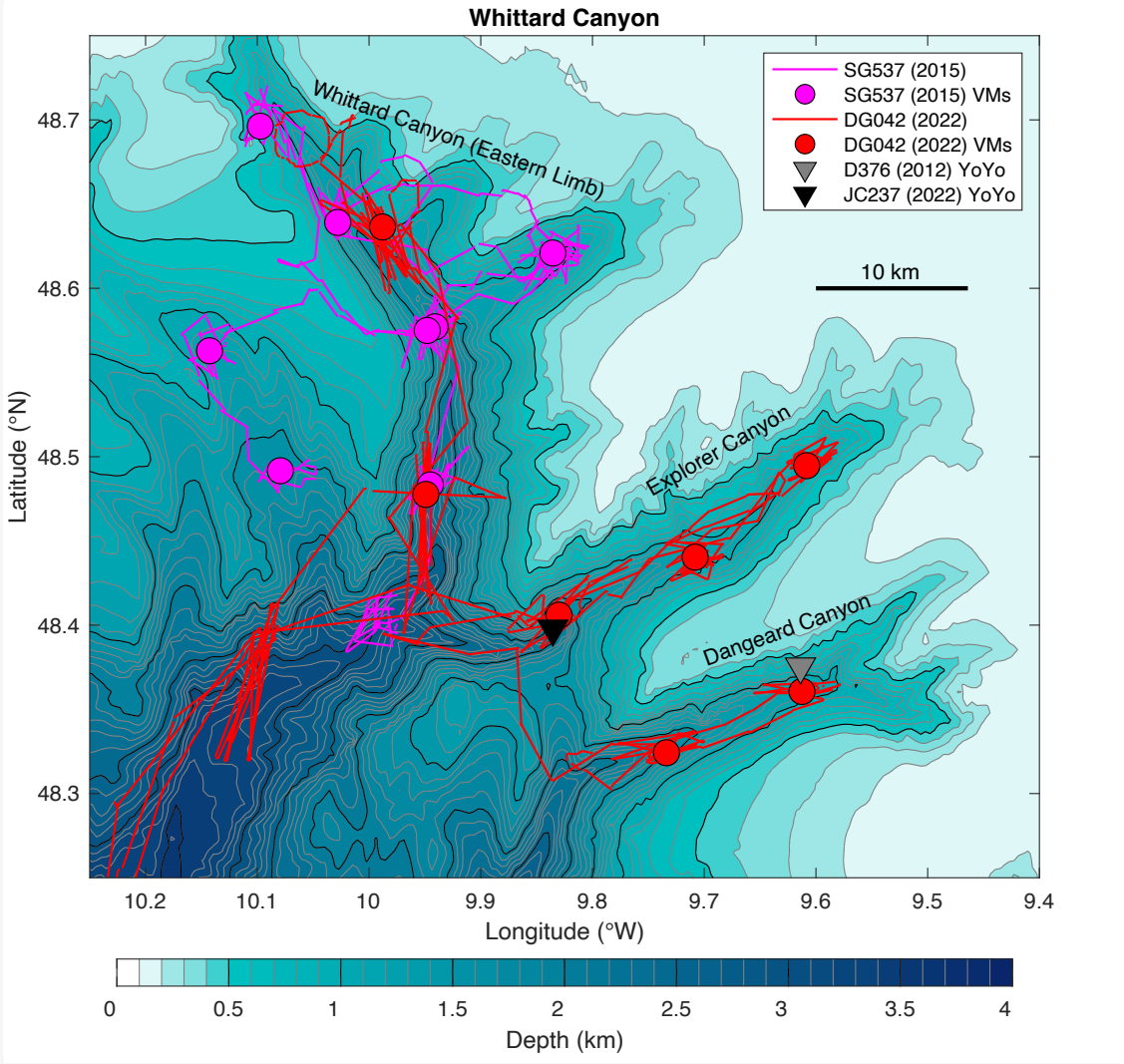
All 2015 and 2022 virtual moorings

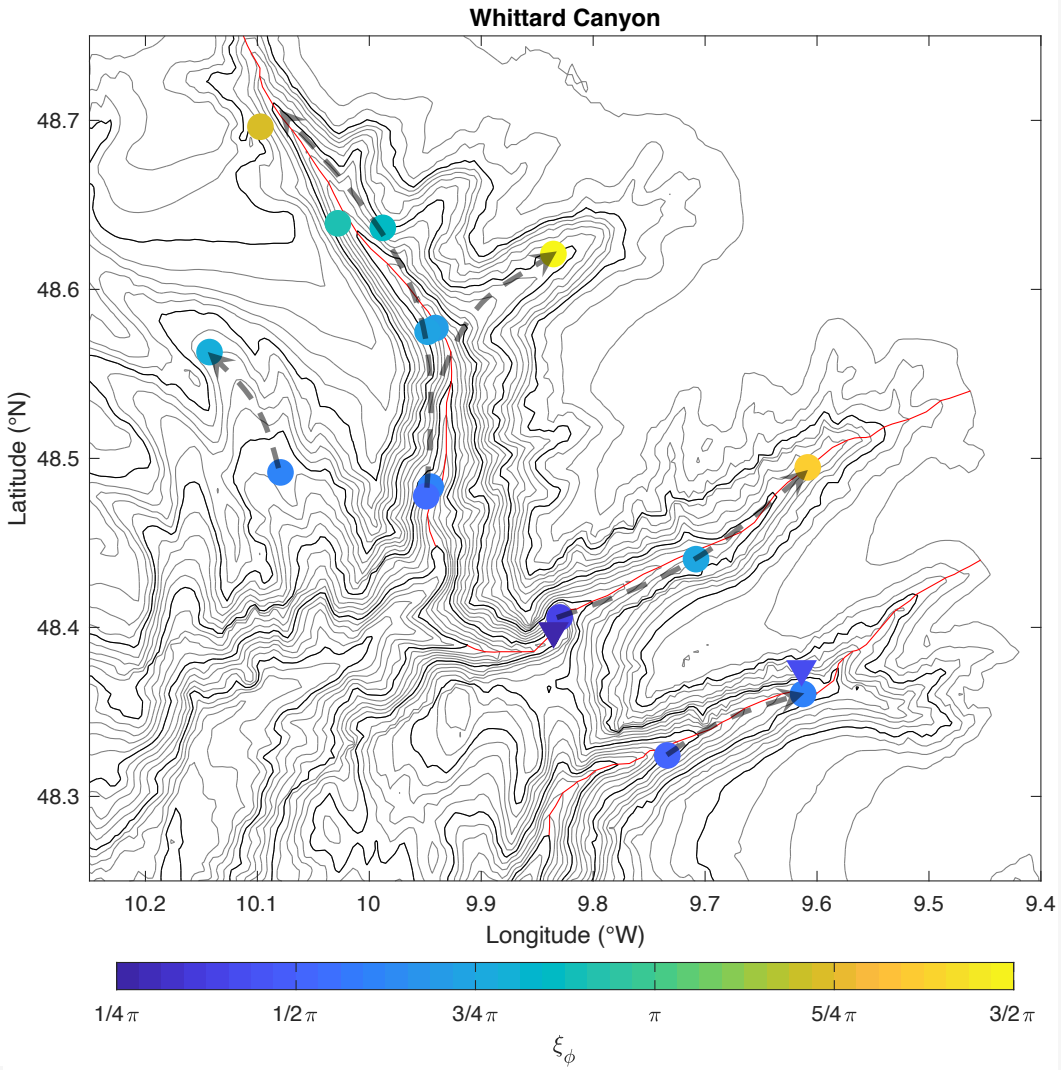




Glider synthesis: displacement phase progression

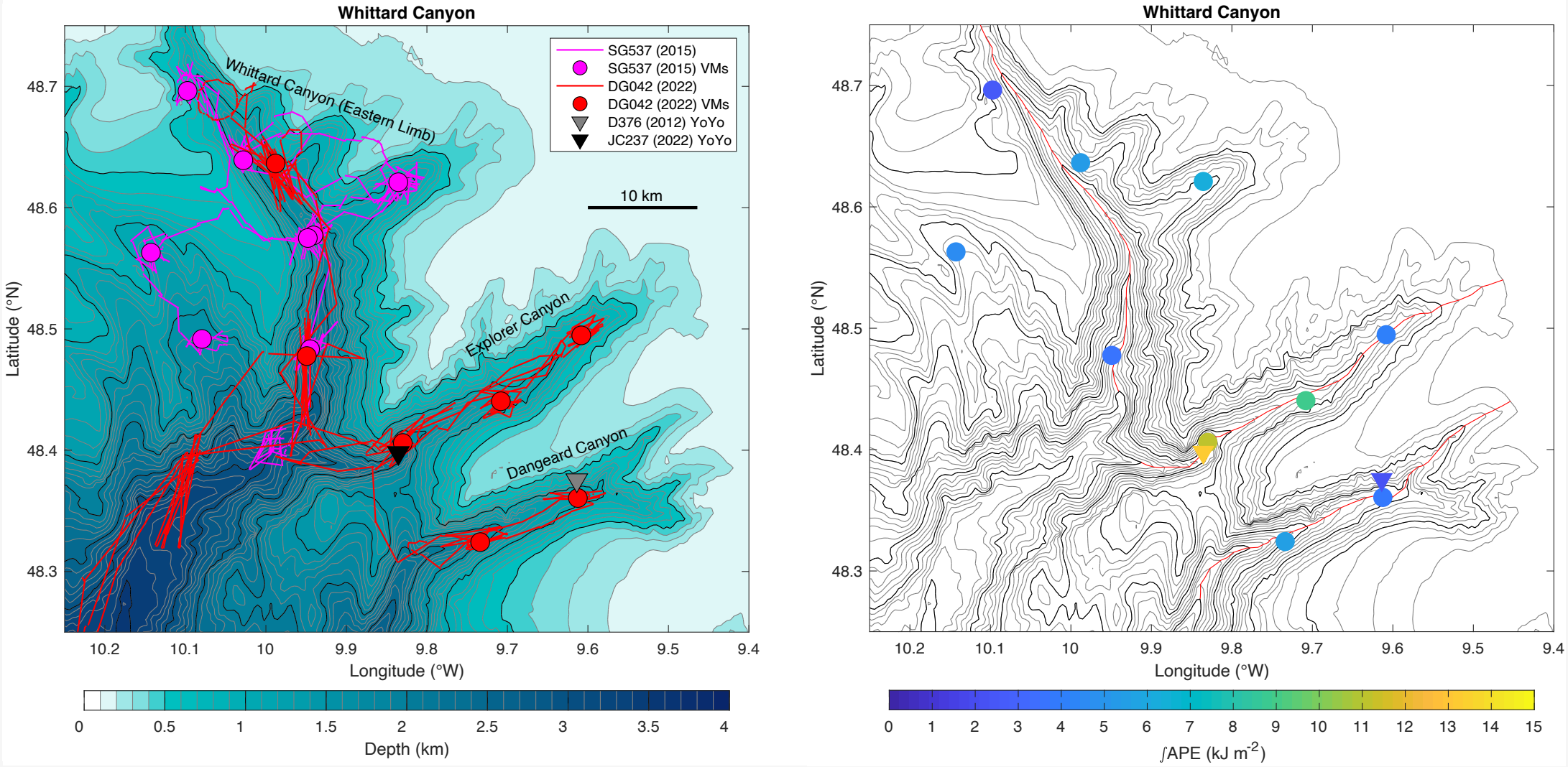
All 2015 and 2022 virtual moorings





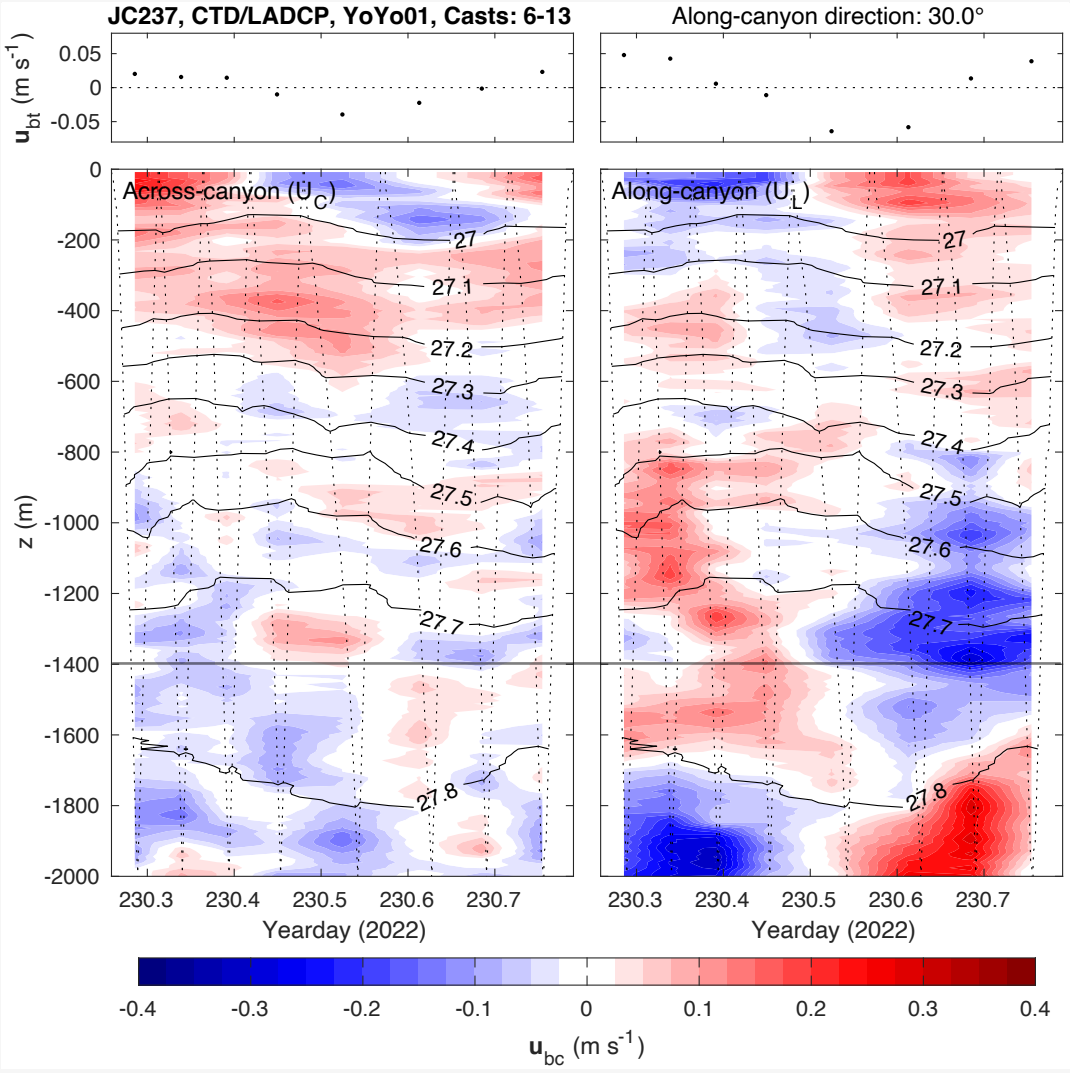
Glider synthesis: depth-integrated APE

2015 and 2022 virtual moorings >75% full-depth



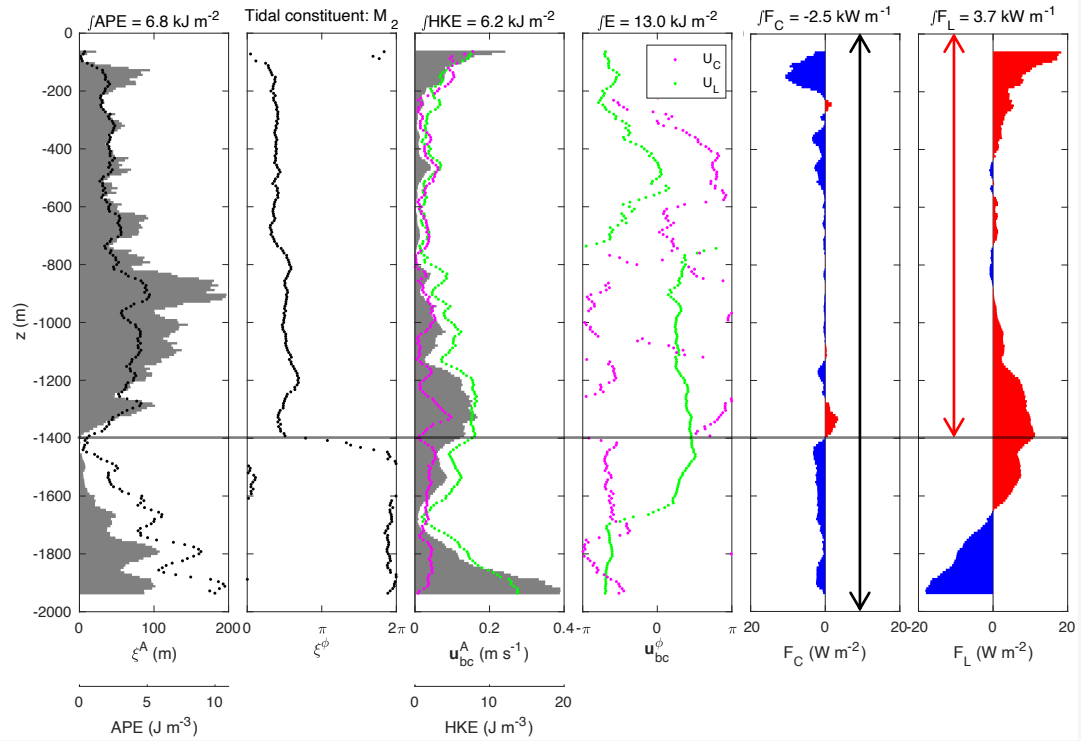
Yo-yo CTD/LADCP station (2022)

APE, HKE, and energy flux



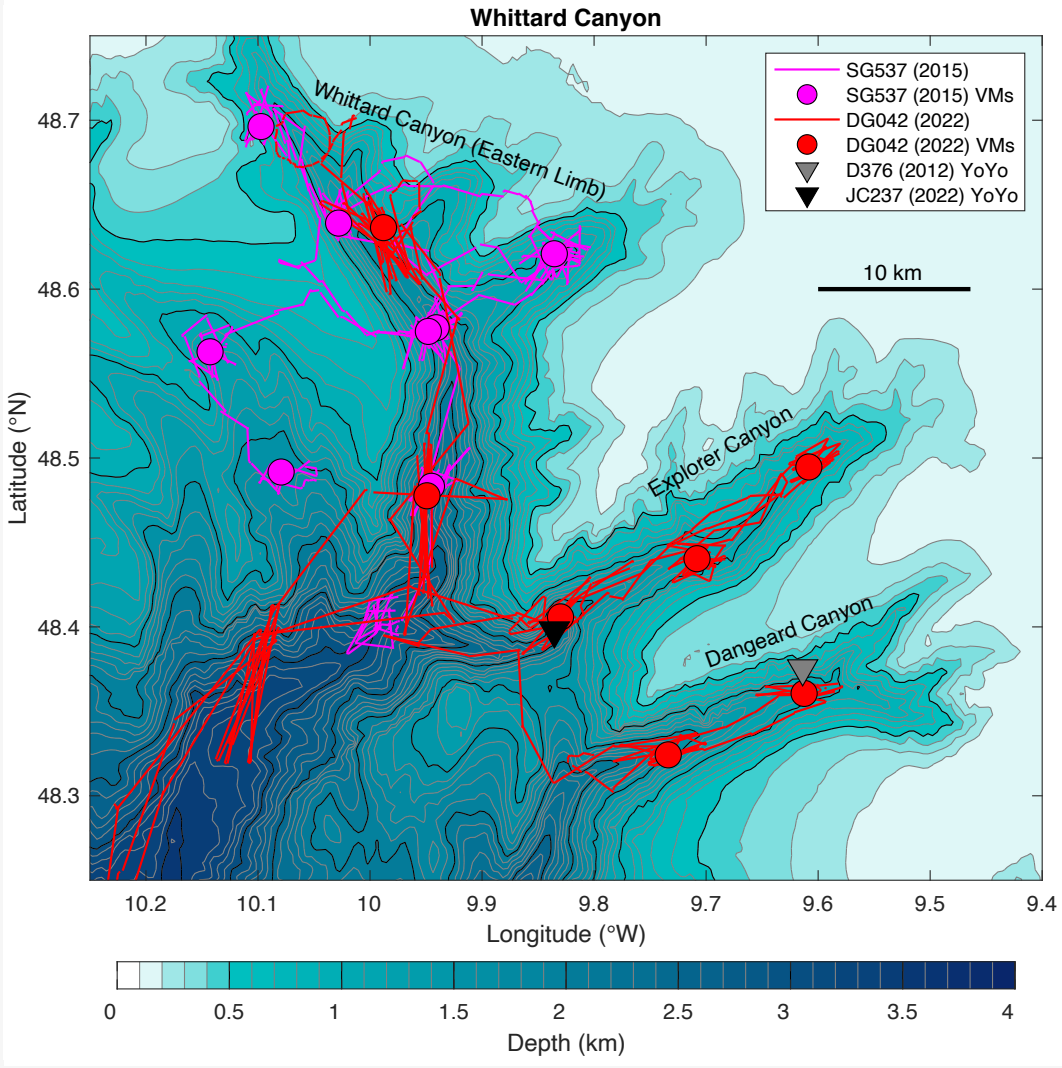
Explorer Canyon M_2 baroclinic energy flux: **8.2 kW m^{-1}**

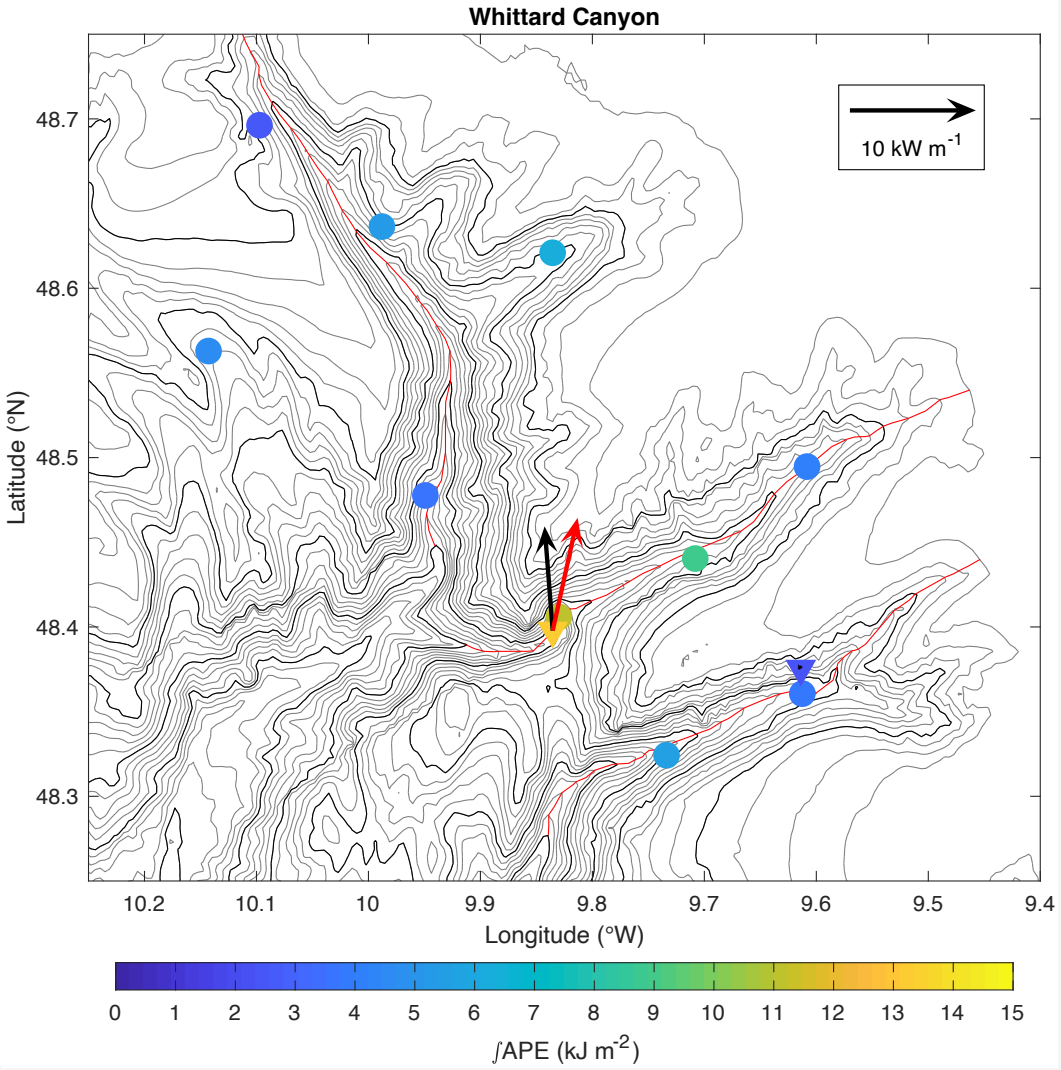
Monterey Canyon: up to 5 kW m^{-1} (Kunze et al. 2002)
Eel Canyon: 7.6 kW m^{-1} (Waterhouse et al. 2017)
Hawaiian Ridge: 1.3 to 39 kW m^{-1} (Rudnick et al. 2003)
Luzon Strait: up to 60 kW m^{-1} (Alford et al. 2011)



Yo-yo CTD/LADCP station (2022)

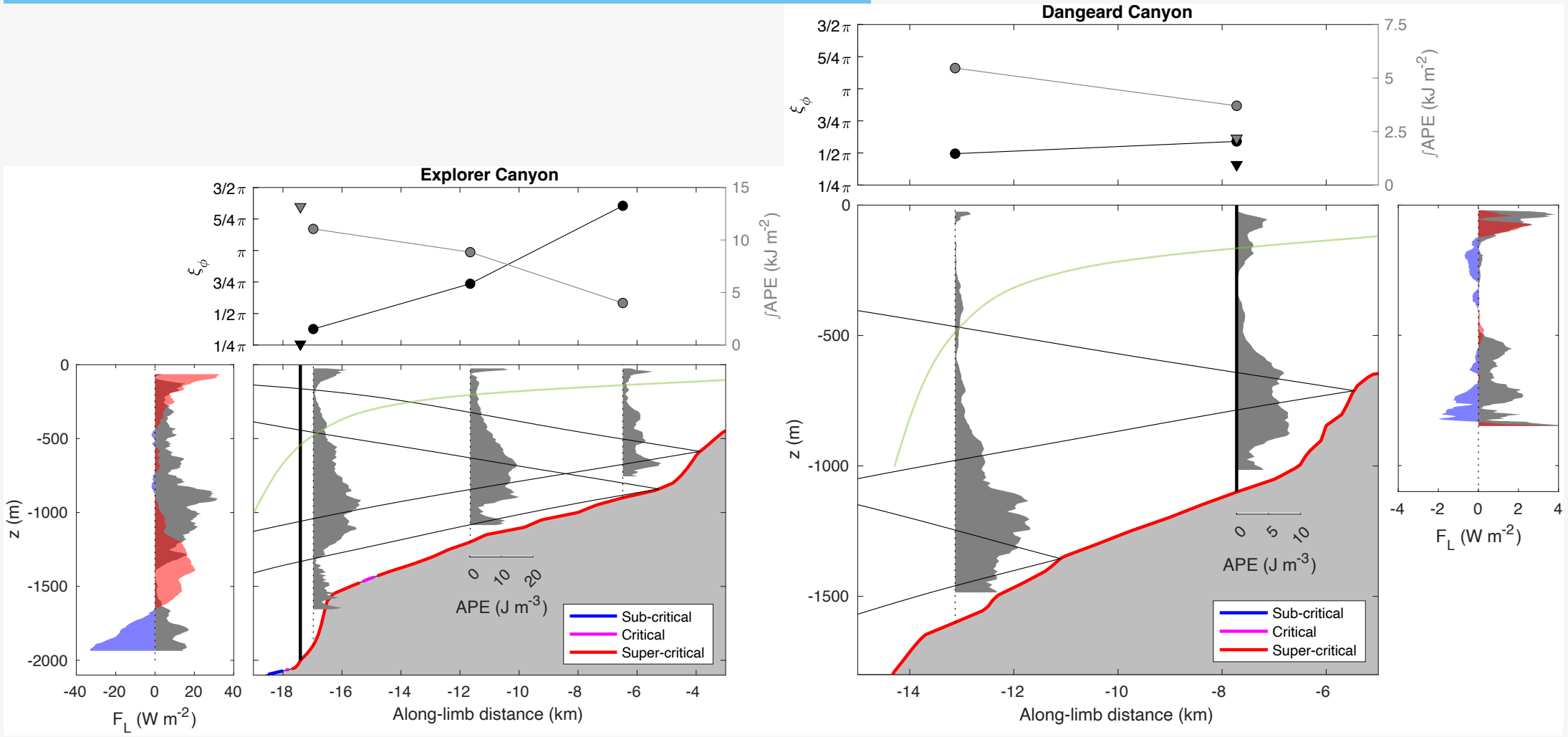
Depth-integrated energy flux and 0-1400 m energy flux





Along-canyon sections

APE intensification within the canyon volume



Summary

- Semidiurnal internal tides in Explorer and Dangeard Canyons are probably the largest in the Whittard Canyon system – M_2 maximum displacement amplitude: **130 m**
- Vertical oscillation of isopycnals progress up-canyon (not a fully-standing wave)
- APE is intensified within the canyon volume and decreases up-canyon
- M_2 baroclinic energy flux is **8.2 kW m^{-1}** at the mouth of Explorer Canyon
- Dissipation of internal tide energy within the canyon must drive elevated turbulent mixing, but currently there are no direct measurements (i.e. microstructure)

Processes drIving Submarine Canyon fluxES (PISCES) project will be making intensive observations of internal tides and turbulent mixing within the canyon (spring 2025)

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