Tidal and near-inertial waves over the Reykjanes Ridge

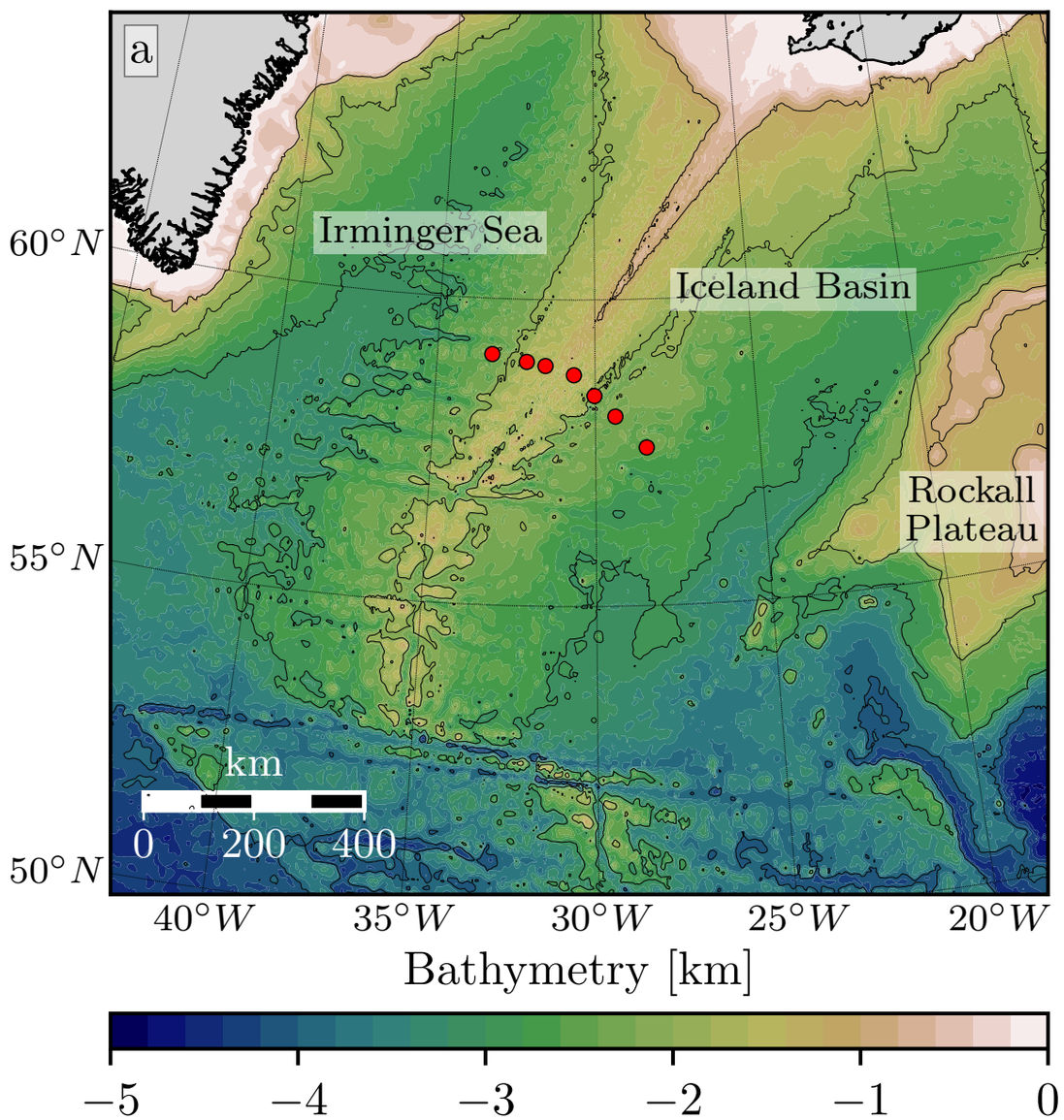
Clément Vic, B. Ferron, V. Thierry, H. Mercier, I. Salaün and P. Lherminier

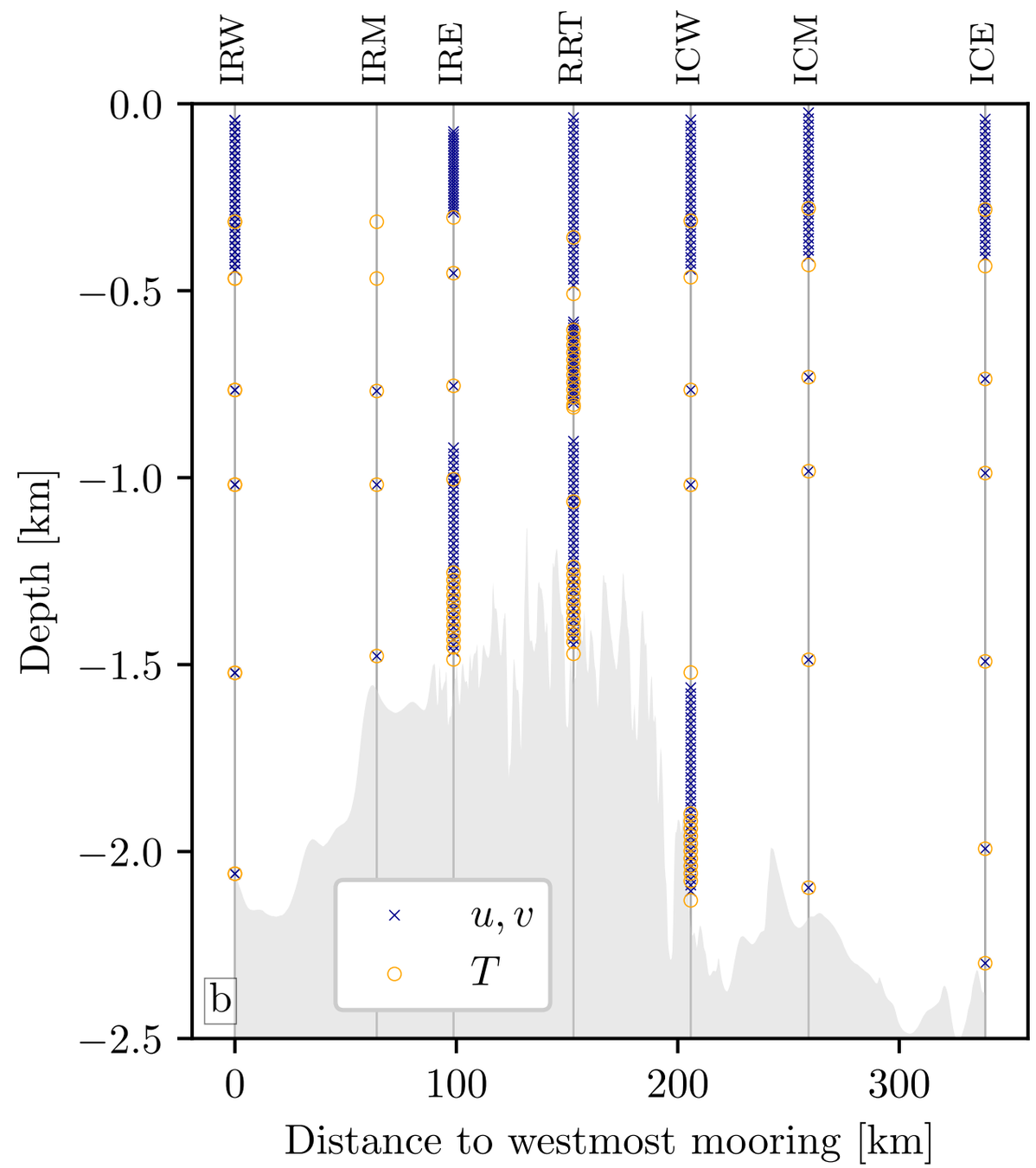
Laboratoire d'Océanographie Physique et Spatiale, Plouzané, France

EGU (locked down) General Assembly — May 2020

Context and data

2+ years of data from an array of 7 moorings across the Reykjanes Ridge at ~59°N





Science questions

Variability of semi-diurnal internal tides

- Cross-ridge variability
- Spring-neap cycle
- Clear propagation patterns

Variability of near-inertial waves

- Wind generation
- Seasonal cycle — winter intensification
- Vertical propagation

Tools

SD: Semi-Diurnal and NI: Near-Inertial

Mooring data

Kinetic energy $E_{\mathrm{SD}} = \frac{1}{2}\rho_0 |\mathbf{u}'_{\mathrm{SD}}|^2$ and $E_{\mathrm{NI}} = \frac{1}{2}\rho_0 |\mathbf{u}'_{\mathrm{NI}}|^2$

Energy fluxes $\mathbf{F}_{\mathrm{SD}} = \int_{-H}^{0} \mathbf{u}'_{\mathrm{SD}} p'_{\mathrm{SD}} \, \mathrm{d}z$ and $\mathbf{F}_{\mathrm{NI}} = \int_{-H}^{0} \mathbf{u}'_{\mathrm{NI}} p'_{\mathrm{NI}} \, \mathrm{d}z$

[Nash et al JAOT 2005]

Semi-analytical model

Barotropic-to-baroclinic tidal energy conversion $C = \mathrm{function}(N, f, U_{\mathrm{tide}}, h(x, y))$

[St Laurent & Garrett JPO 2002, Vic et al JPO 2018]

Mooring and wind data

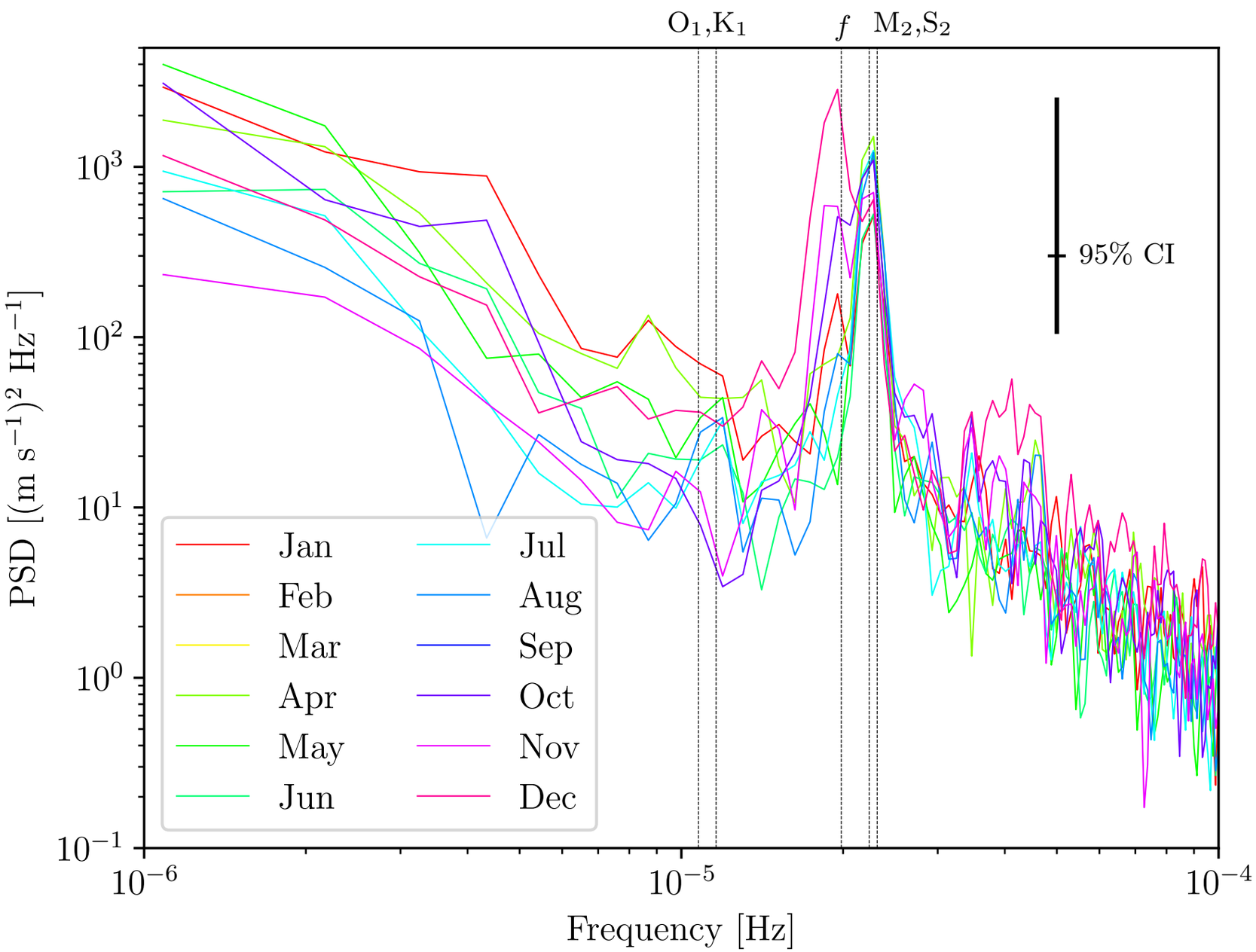
Wind work to NI motions $W_{\mathrm{NI}} = \tau_{\mathrm{NI}} \cdot \mathbf{u}_{\mathrm{NI}}$

[Flexas et al JGR 2019, Renault et al JAMES 2020]

Results — overview

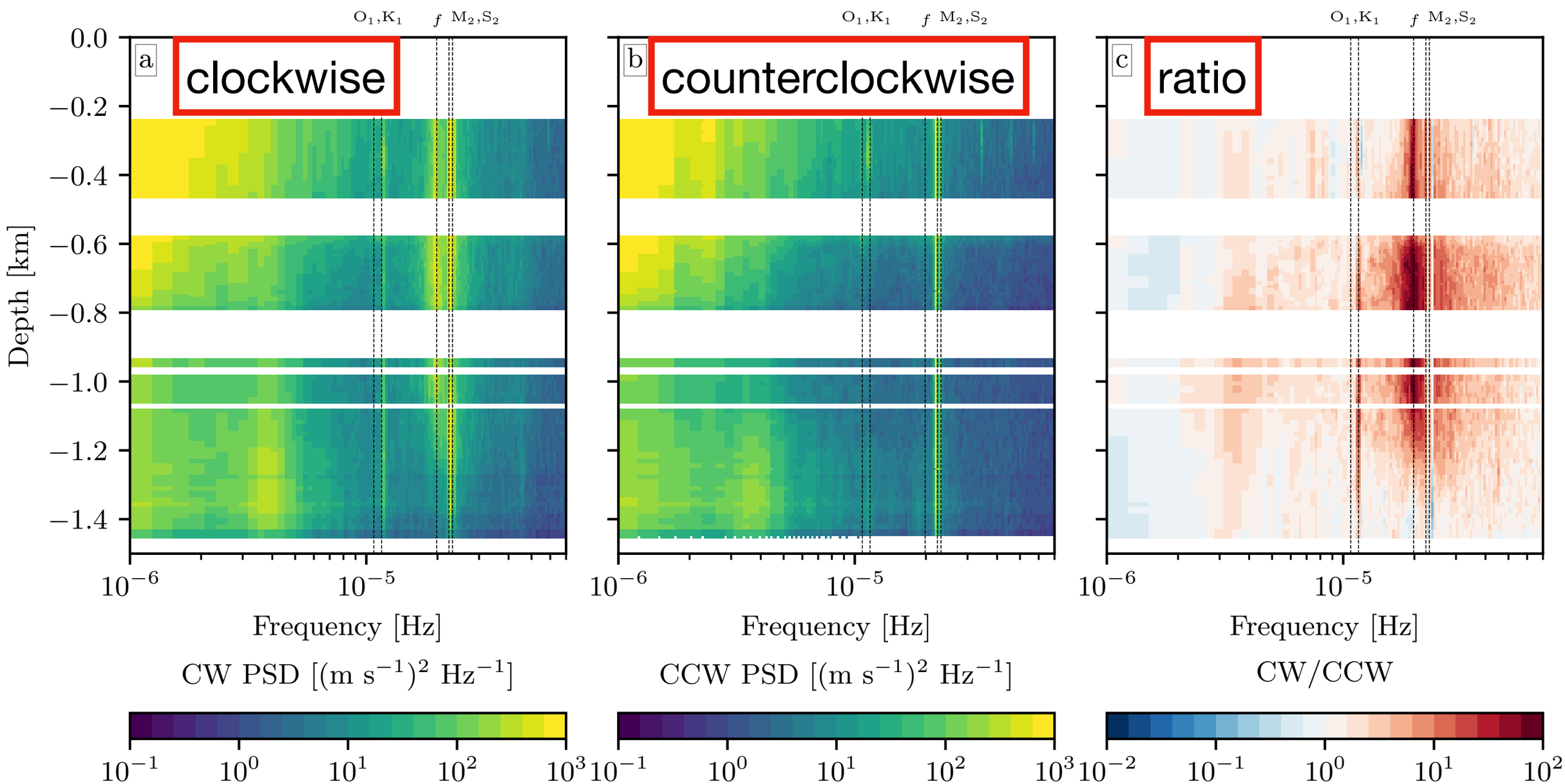
Results — overview

Strong seasonality in near-inertial energy: wind generation

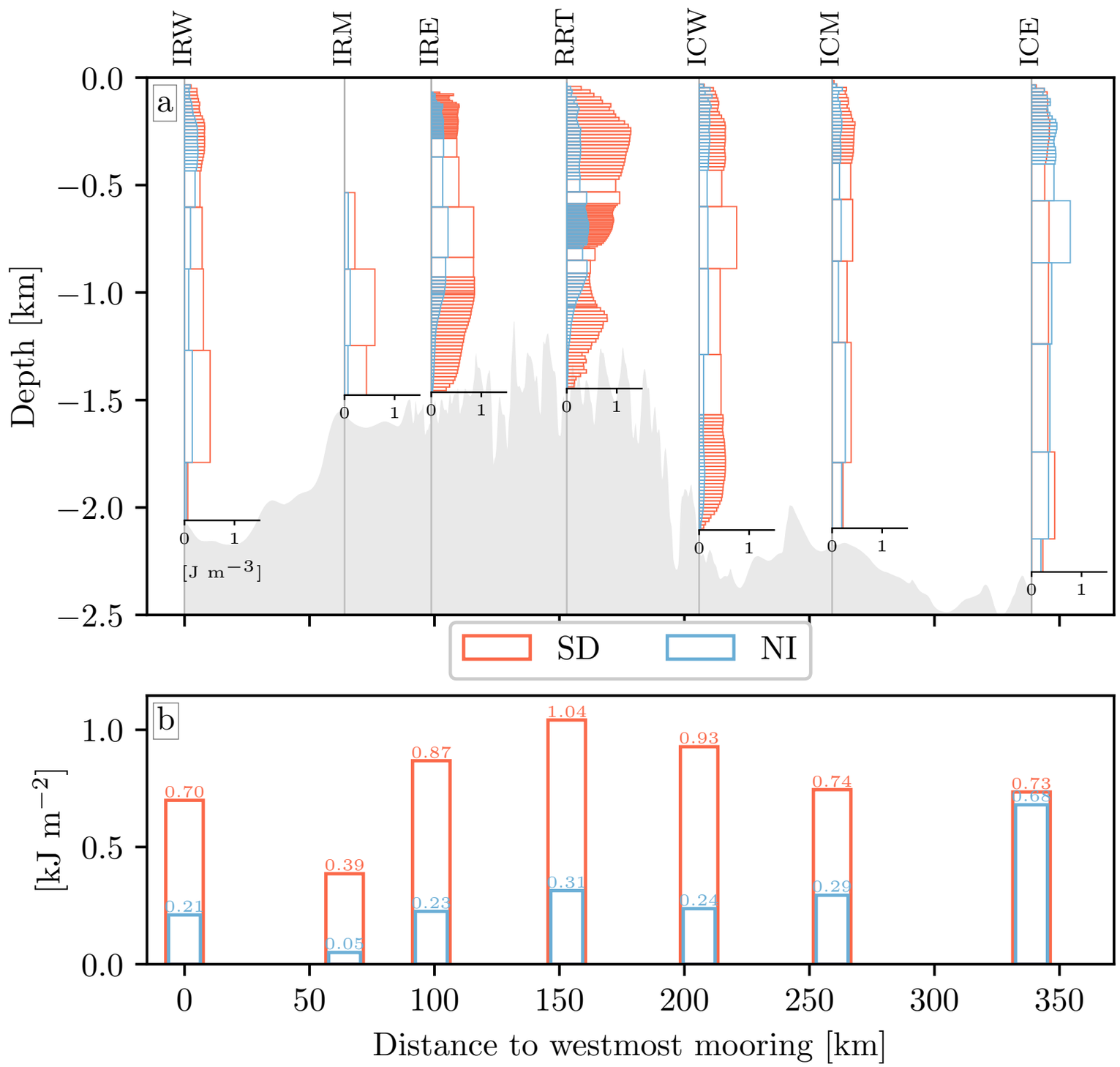


Results — overview

Penetration of near-inertial energy down to 1000 m



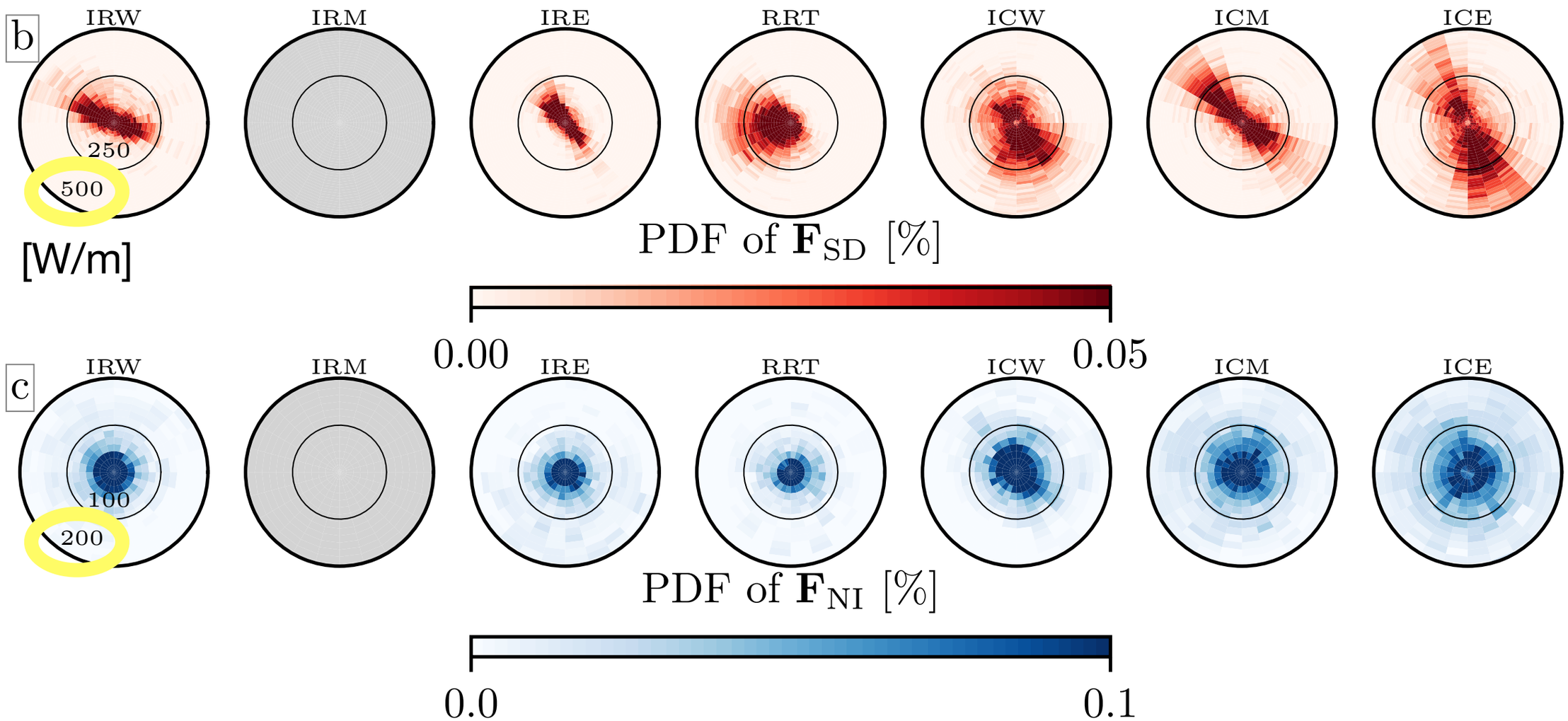
Results — time-mean kinetic energy



- $E_{\mathrm{SD}} \sim 2 - 3 \times E_{\mathrm{NI}}$
- Little depth-dependence of energy

- E_{SD} decays at a similar rate on both flanks
- E_{NI} consistent between moorings except ICE

Results — energy fluxes

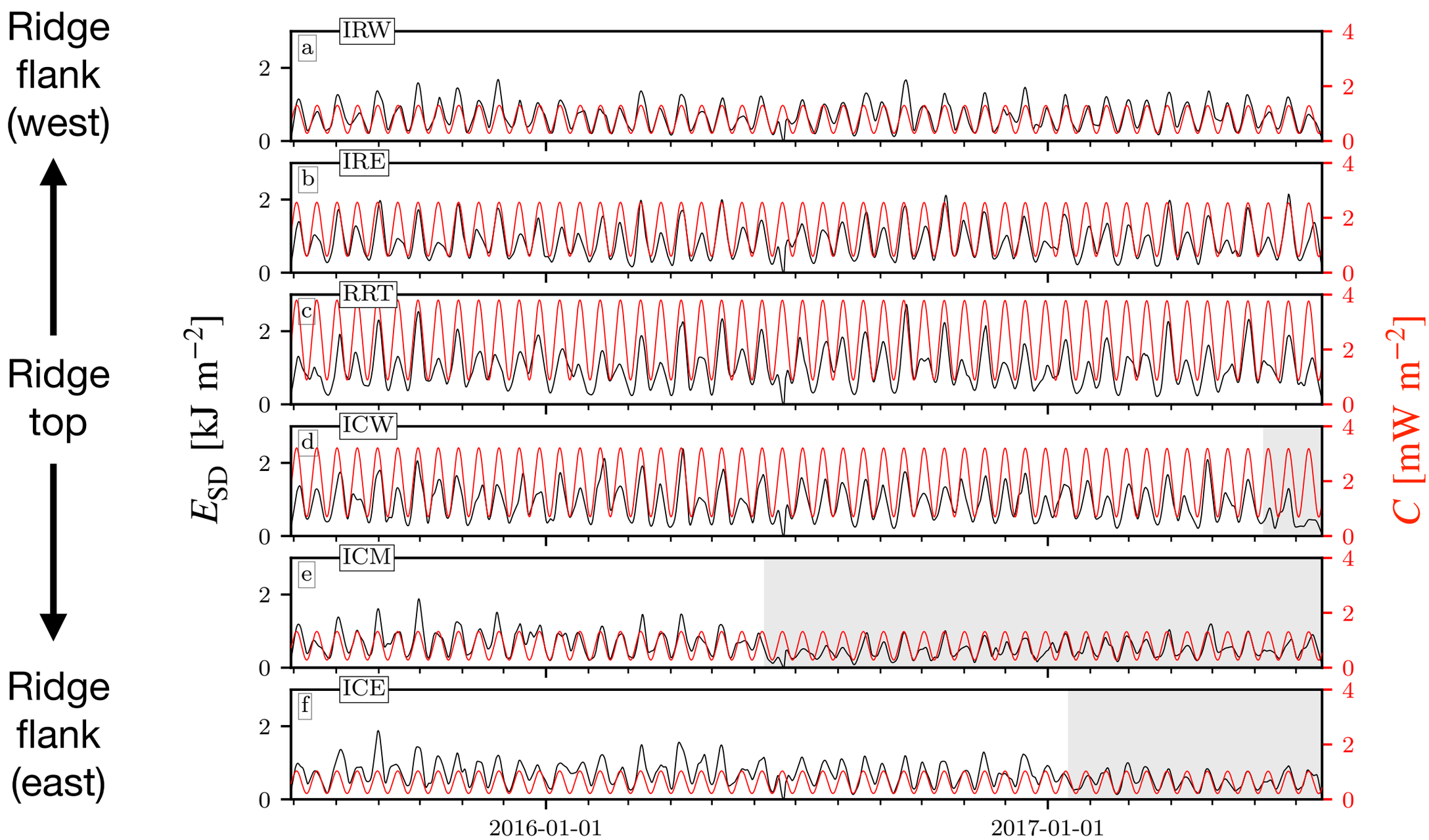


- $\mathbf{F}_{SD}$ is polarized in the cross-ridge direction but has little cross-ridge variability
- $\mathbf{F}_{NI}$ smaller (factor 2-3) and much variable in direction.
  No noticeable equatorward propagation

Results — internal tides

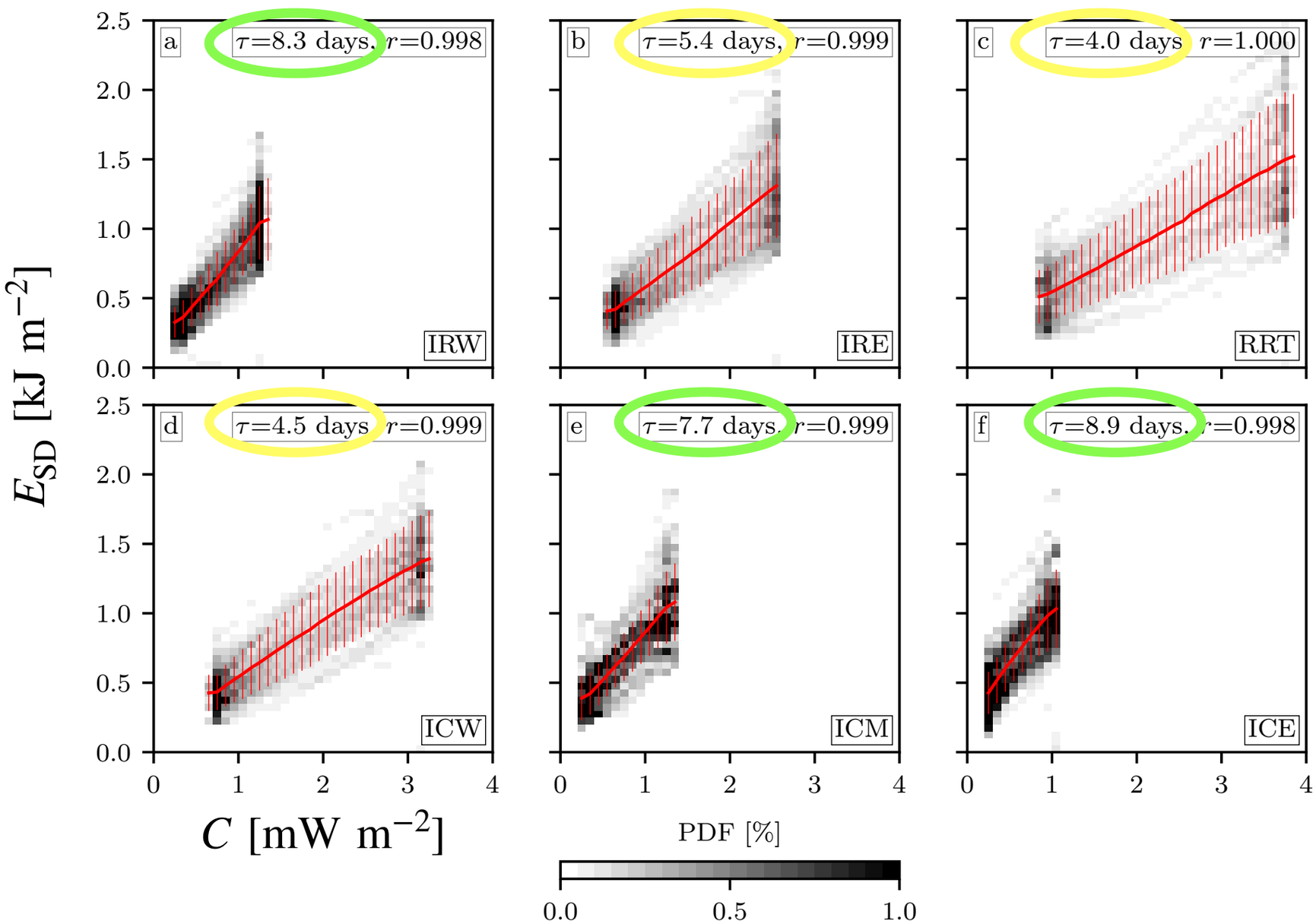
Results — internal tides

- E_{SD} is phase-locked to energy conversion C for the spring-neap cycle regardless of mooring location over the ridge —> near local energy source



Results — internal tides

- Linear relationship between E_{SD} and C, $E_{\mathrm{SD}} = \tau \times C$, with τ a 'replenishment time scale', representative of how local the dynamics are.

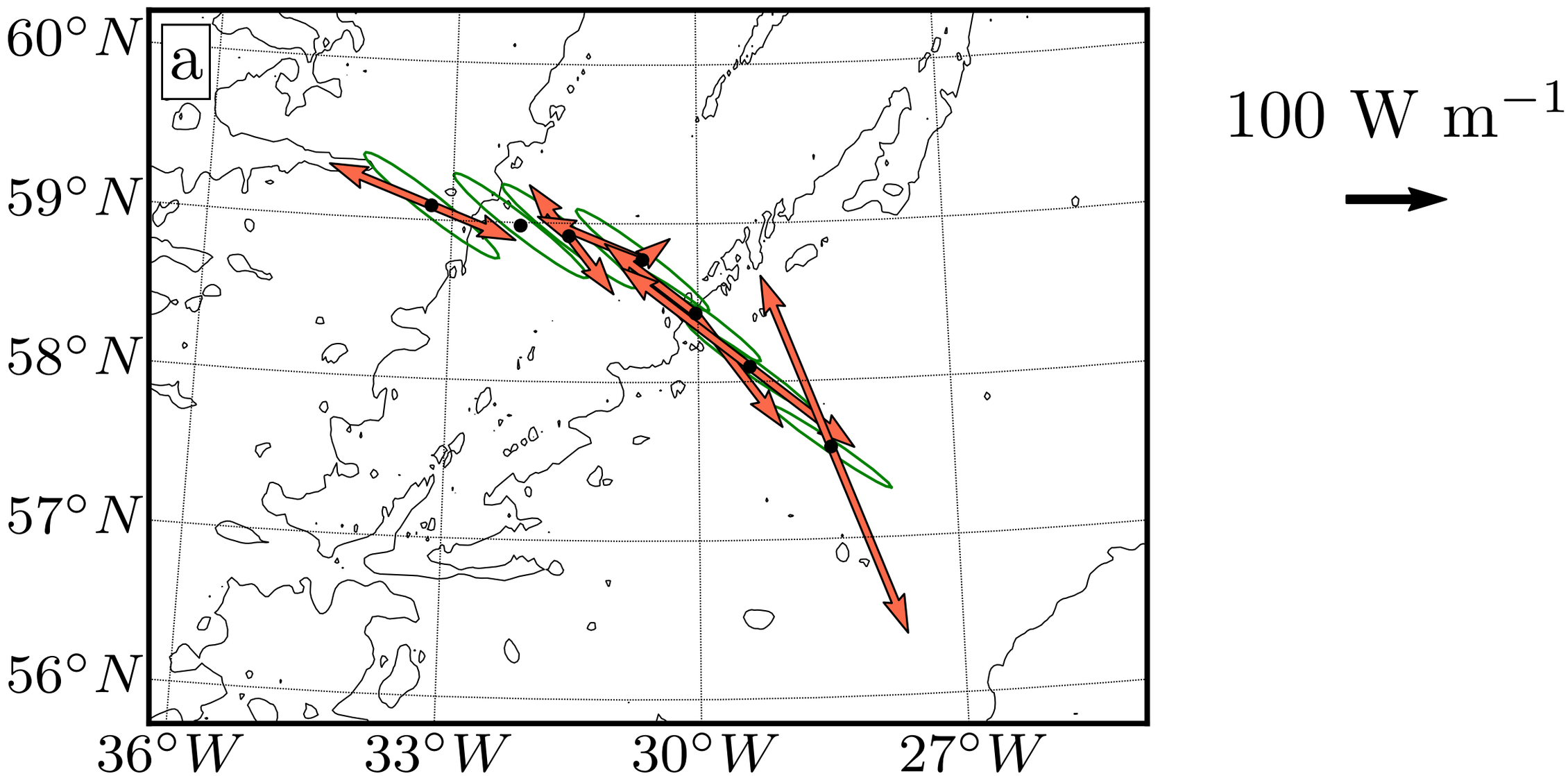


- On the ridge top, $\tau \sim 4 - 5$ days $\ll$ spring-neap cycle, local energy source dominate

- On the ridge flanks, $\tau \sim 8 - 9$ days, energy partially comes from sources around

Results — internal tides

- Cross-ridge redistribution of energy is supported by energy fluxes' direction



Results — near-inertial waves

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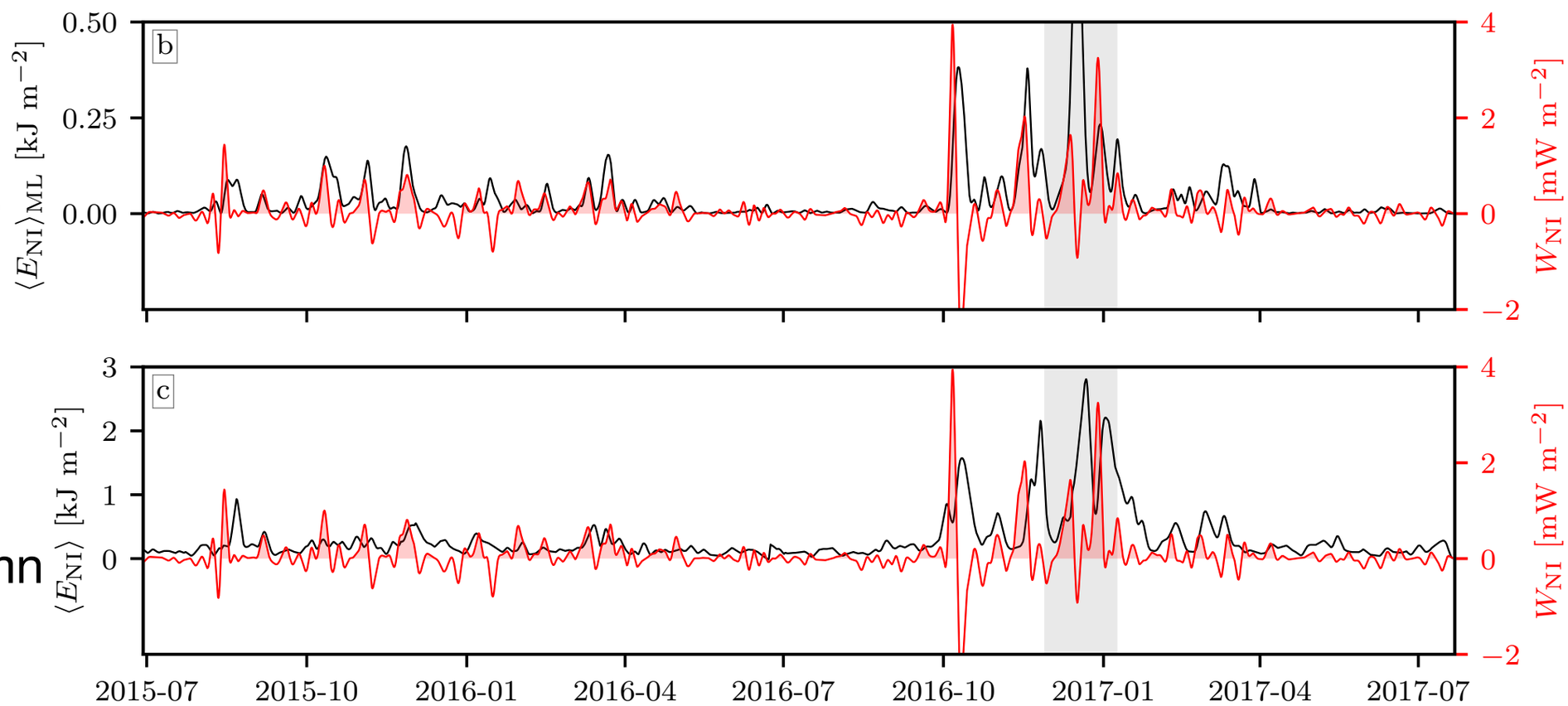
- Seasonal cycle in near-inertial kinetic energy. Variability at weekly time scales, ‘bursts’ of KE

Energy in the mixed layer

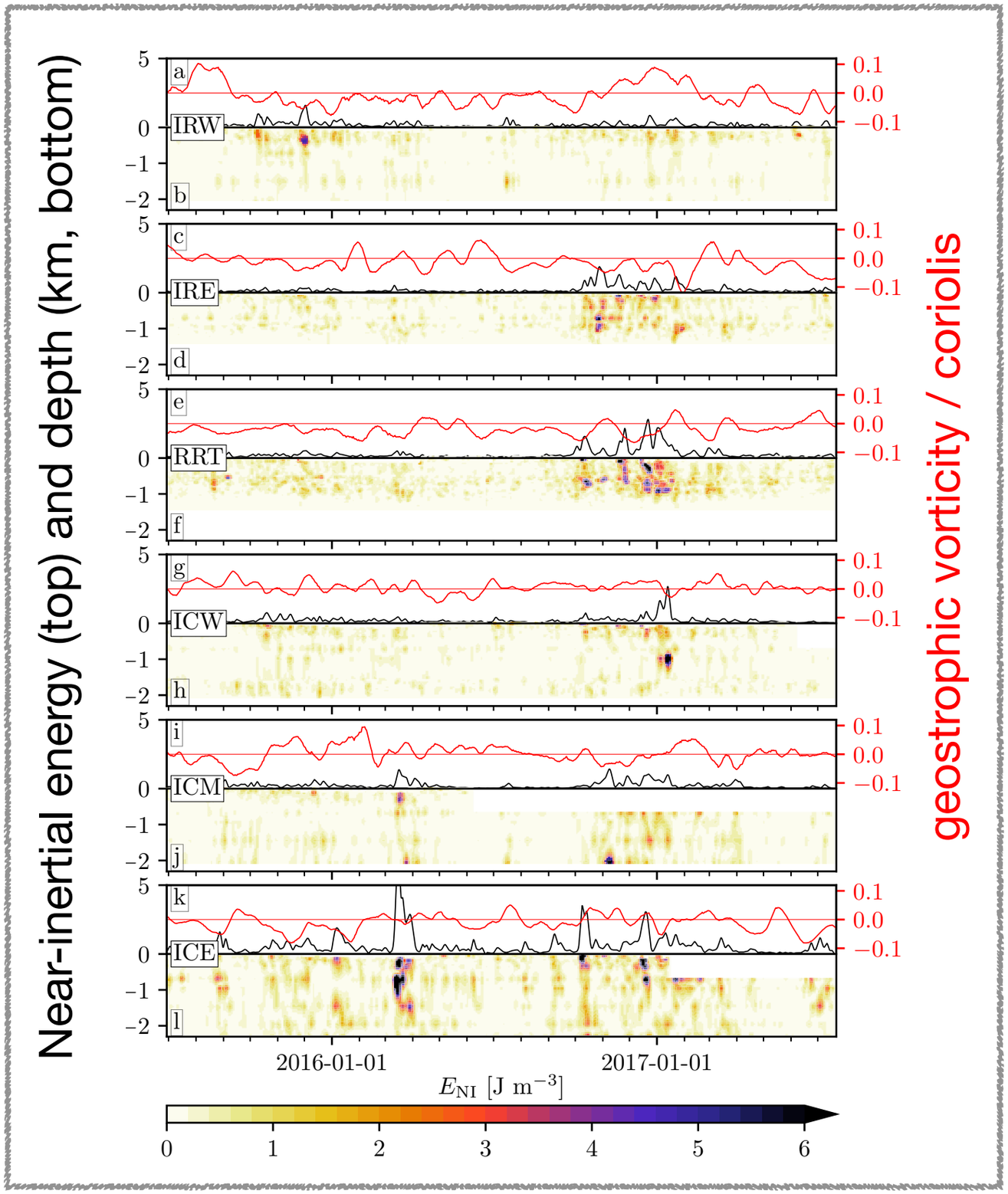
Energy in the water column



Work done by the wind

- $E_{NI} = \tau \times W_{NI}$, $\tau \sim 13 - 15$ days is a replenishment time scale [Alford & Whitmont 2007]

Results — near-inertial waves



- Coherence in time between moorings, E_{NI} has scales of ~200 km at least
- Strong year-to-year variability, weaker energy levels during the winter 2016 compared to winter 2017
- E_{NI} higher in anticyclones? (altimetry-derived vorticity)

Results — near-inertial waves

- E_{NI} is indeed higher in anticyclones
- Differences between cyclones and anticyclones are enhanced in the top 1 km, and for high levels of E_{NI}