REVISITING THE SVERDRUP HYPOTHESIS IN THE UPWELLING REGION OFF NW IBERIA

M. Pérez-Lorenzo[1]*, B. Mouriño-Carballido[1], P. Chouciño[1], E. Fernández[1], B. Fernández-Castro[2], A. Fuentes-Lema[1], E. Nogueira[3], M. Villamaña[1]

[1]Universidad de Vigo (Spain), [2]Instituto de Investigacións Mariñas-CSIC (Spain), [3]Instituto Español de Oceanografía-Vigo (Spain); *mplorenzo@uvigo.es

MOTIVATION

In 1953 Sverdrup proposed the Critical Depth Hypothesis, a simple phytoplankton growth model which used the depth of the mixed layer to predict the onset of the North Atlantic spring bloom. This model assumed a thoroughly mixed layer where turbulence is strong enough to evenly distribute the phytoplankton cells. Following attempts to verify this hypothesis have generally forgotten this assumption and used the mixed-layer, defined as a layer homogenous in density, as the equivalent of a turbulent layer. For the first time, by using microstructure turbulence observations, we use the theoretical framework of the Sverdrup hypothesis to investigate phytoplankton bloom initiation in a coastal upwelling system (Ría de Vigo, NW Spain).

HYPOTHESIS

The critical depth hypothesis explains phytoplankton bloom formation in the Ría de Vigo

OBJECTIVE

To describe the variability in phytoplankton growth and turbulent mixing in the Ría de Vigo over a seasonal cycle

Location

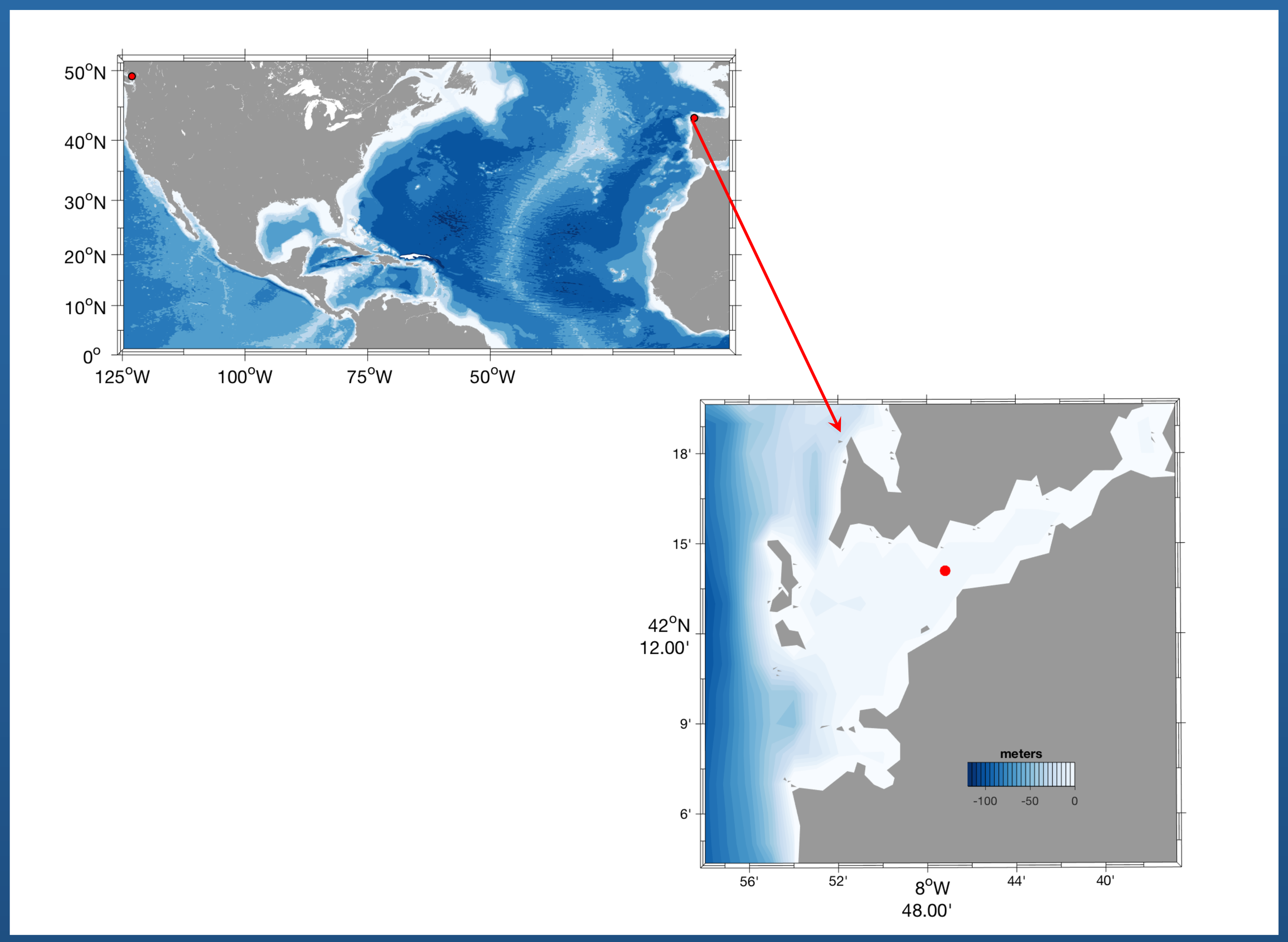

Figure 1. A station located in the Ría de Vigo was weekly sampled from 9/03/17 to 26/04/18 (50 occasions).

Methods

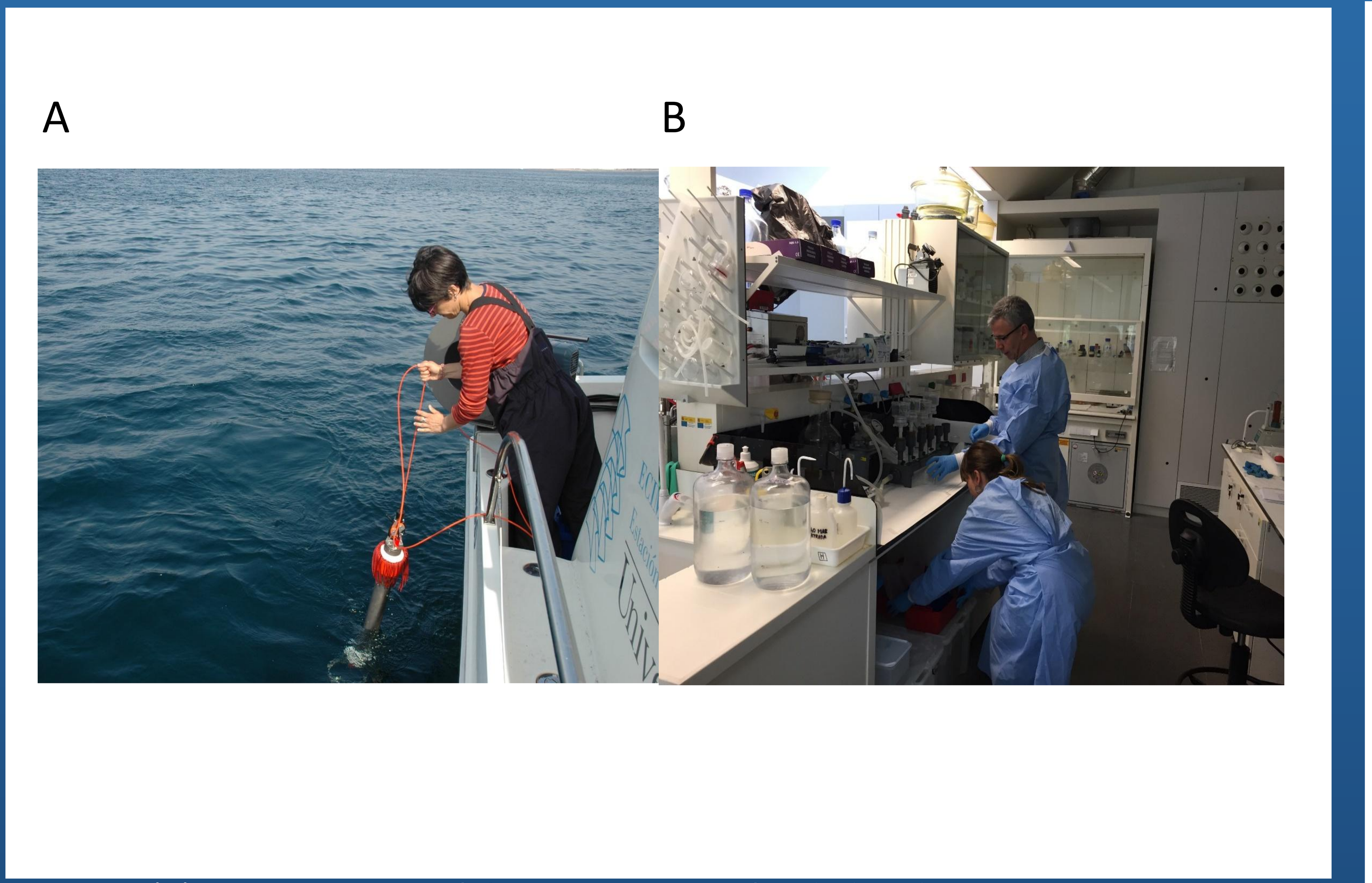

Figure 2. (A) Measurements of dissipation rates of turbulent kinetic energy were carried out with a microstructure profiler. (B) Phytoplankton growth rates were derived from estimates of chlorophyll-a-phytoplankton biomass and ^{14}C phytoplankton uptake experiments.

Hydrography

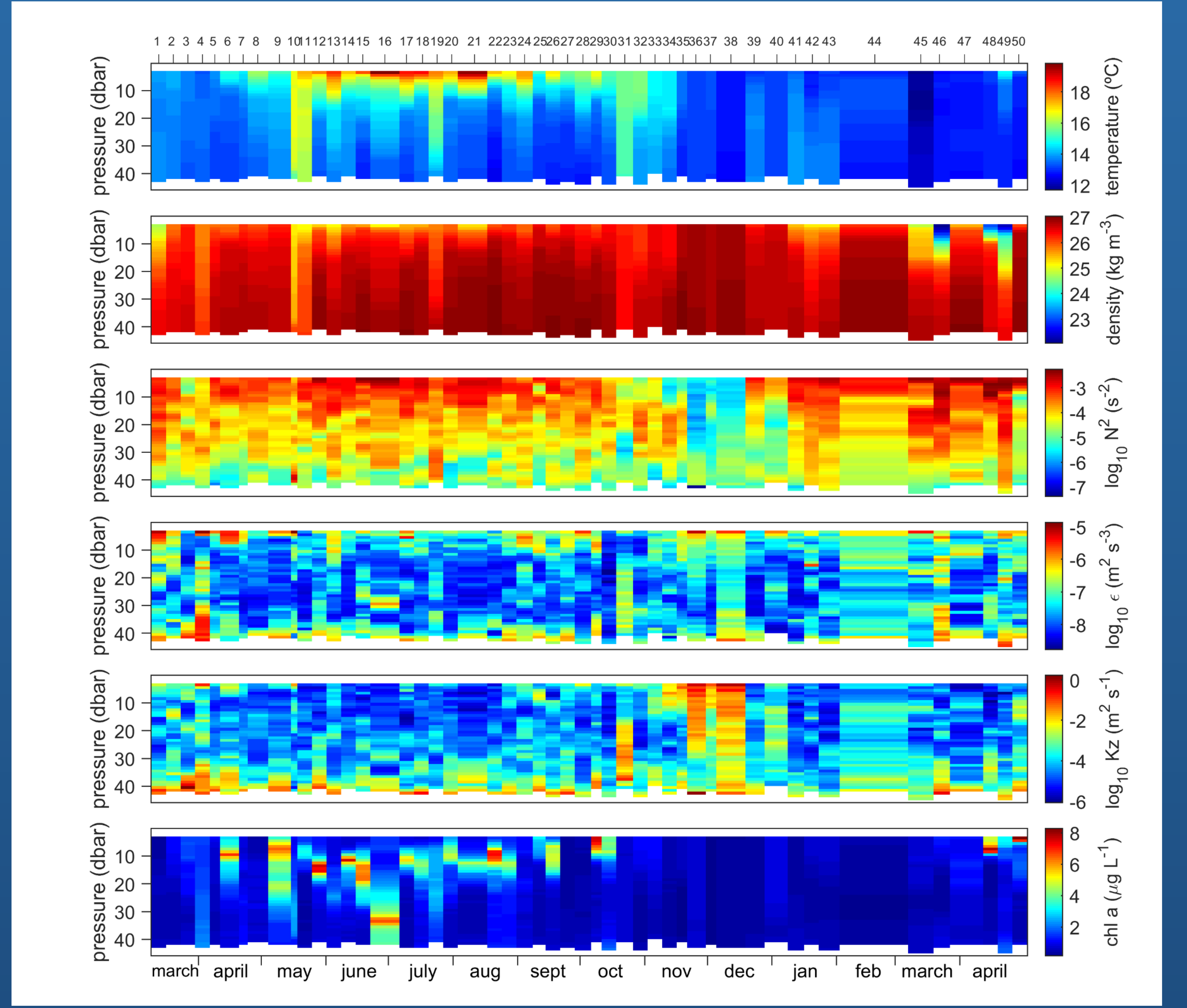

Figure 3. Vertical distribution of temperature, density, Brunt-Väissälä frequency (N^2), dissipation rates of turbulent kinetic energy (ε), diapycnal diffusivity (K_ρ) and chlorophyll-a measured with a microturbulence profiler.

Seasonal variability

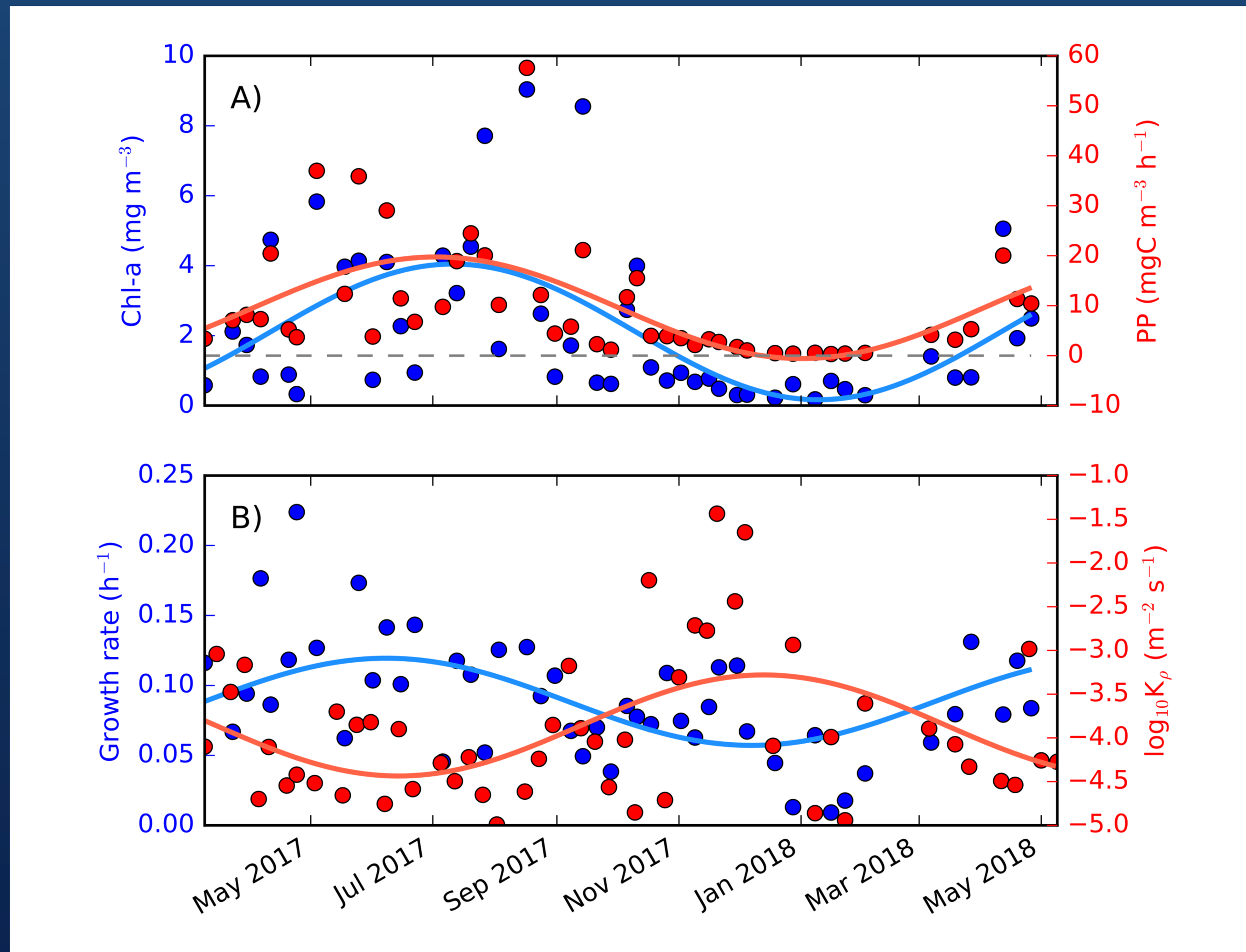

Figure 4. Temporal evolution of: (A) chlorophyll-a concentration and primary production derived from ^{14}C uptake experiments at 10 m depth, and (B) phytoplankton growth rates and depth-averaged (7-20 m) diapycnal diffusivity (K_ρ).

Variance spectral analysis

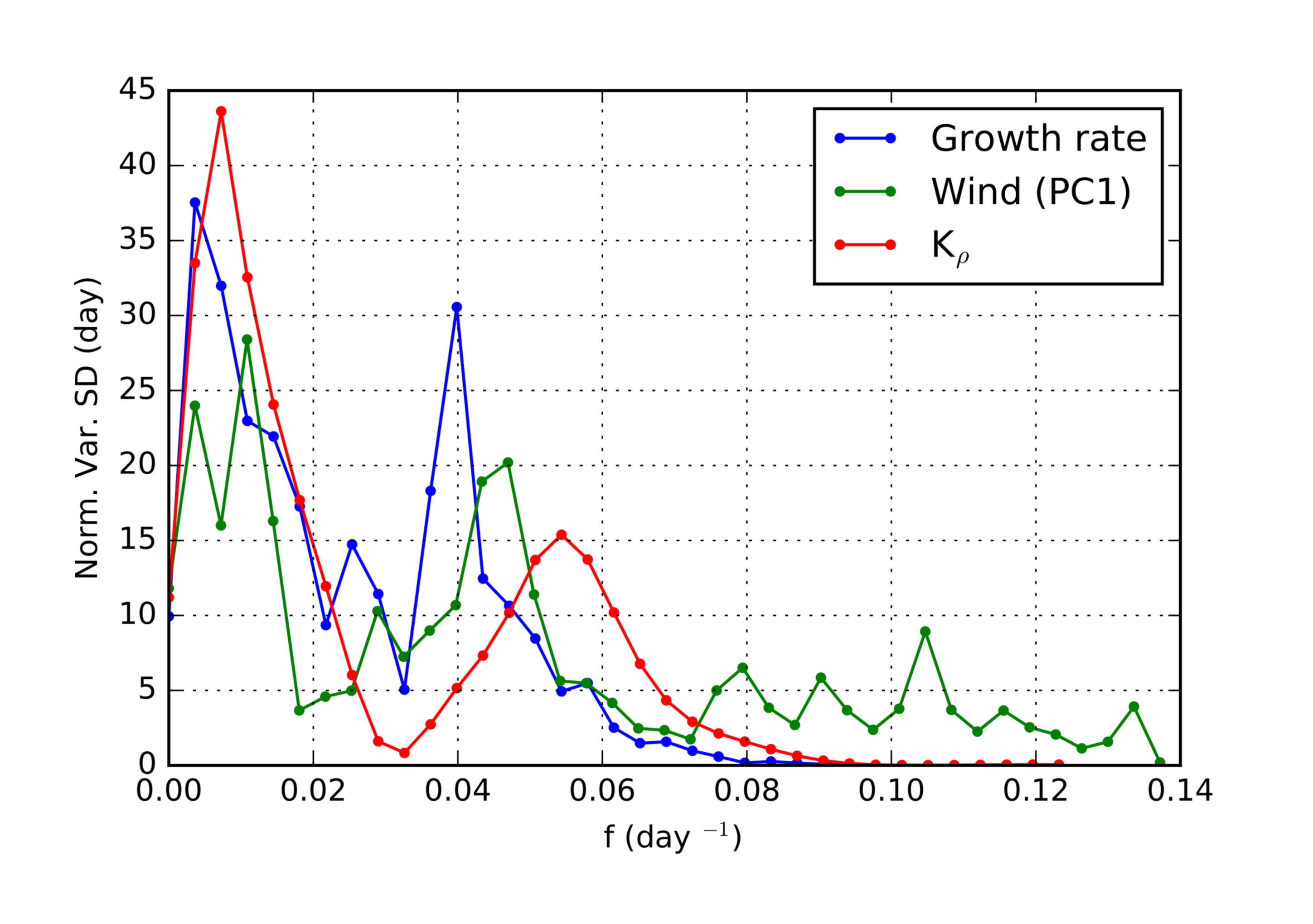

Figure 5. Spectral density of the normalized variance of growth rates (blue line), wind velocity (green line) and diapycnal diffusivity (red line).

CONCLUSIONS

1) Phytoplankton growth rates ranged from 0.01 to 0.22 h^{-1}, and maximum (minimum) values were quantified in spring-summer (autumn-winter).

2) The maximum seasonal phytoplankton growth rates coincided with the decrease in the intensity of turbulent diffusion, which ranged from 5.03 x 10^{-6} to 0.04 $m^2\ s^{-1}$.

3) Two peaks of variability in growth rates, mixing and wind were observed at seasonal (f<0.02 $days^{-1}$, period >50 days) and fortnightly-monthly frequencies (f ~ 0.03-0.06 $days^{-1}$, period ~ 15-33 days).

3) The seasonal variability in phytoplankton growth and mixing is consistent with the Critical Depth Hypothesis, whereas upwelling/downwelling events, related to the alternation of low-high pressure systems, could explain the variability at lower time scales.

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Acknowledgments

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