Revisiting the critical turbulence hypothesis in the upwelling region off NW Iberia

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Motivation

By controlling the vertical displacements of phytoplankton, turbulence determines their exposure to sunlight. The Critical Turbulence Hypothesis (CTH, Huisman et al., 1999) proposes that if turbulence is low enough, phytoplankton in the well-lit surface layer could bloom independently of the thickness of the mixed layer. The CTH has been very difficult to verify in the field, as the quantification of turbulence require microstructure observations.

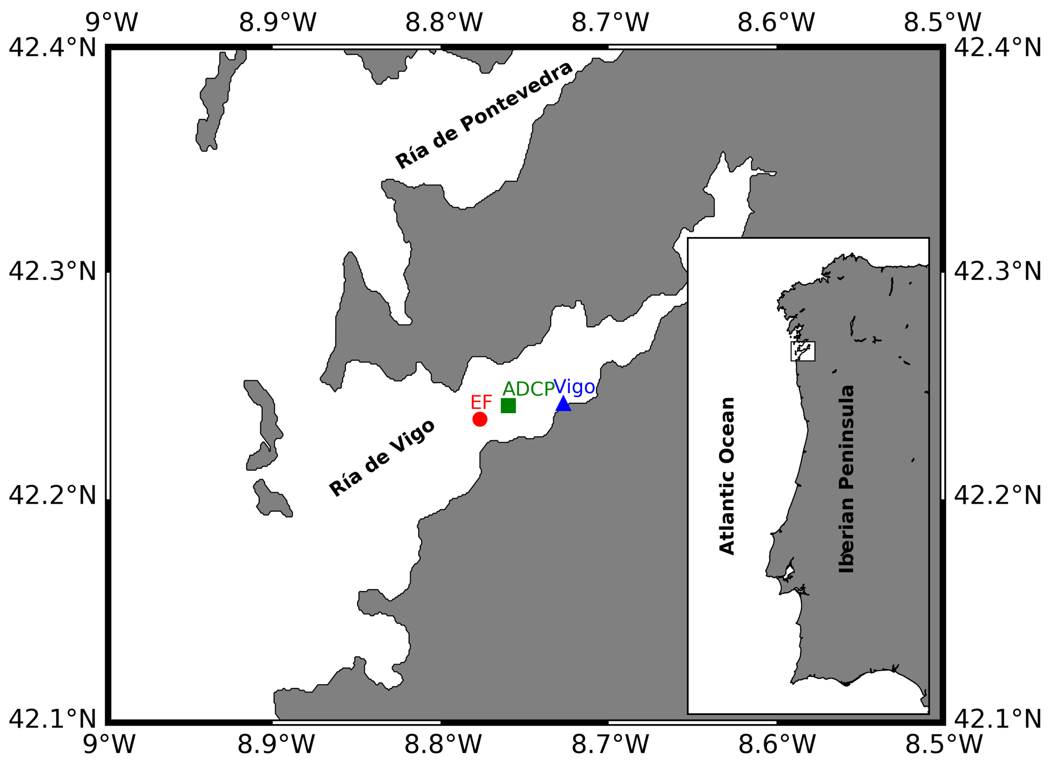
Hypothesis

The CTH explains phytoplankton bloom formation in the Ría de Vigo.

Objective

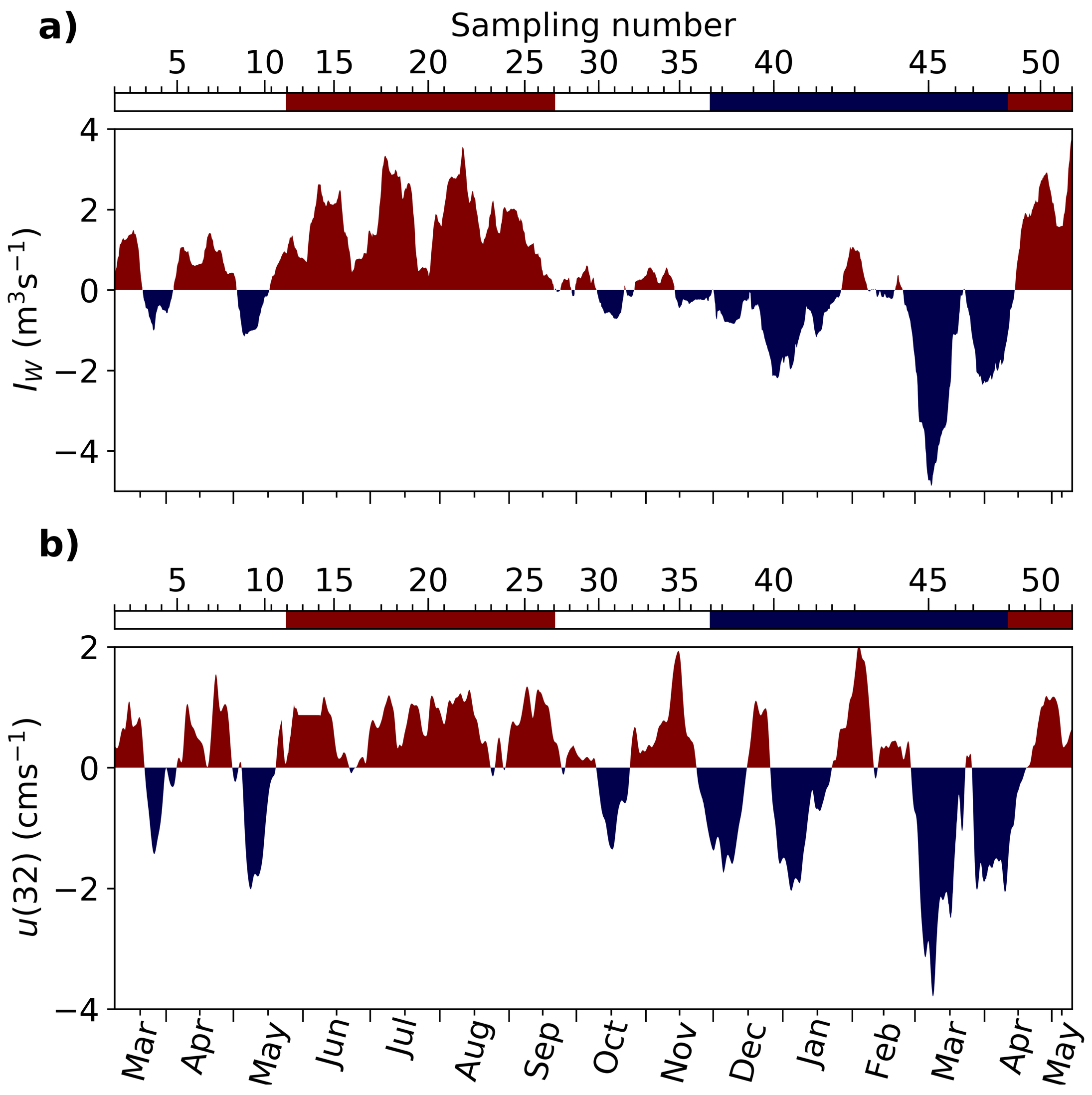
To describe the variability in phytoplankton growth and turbulent mixing in the Ría de Vigo over a seasonal cycle.

Location



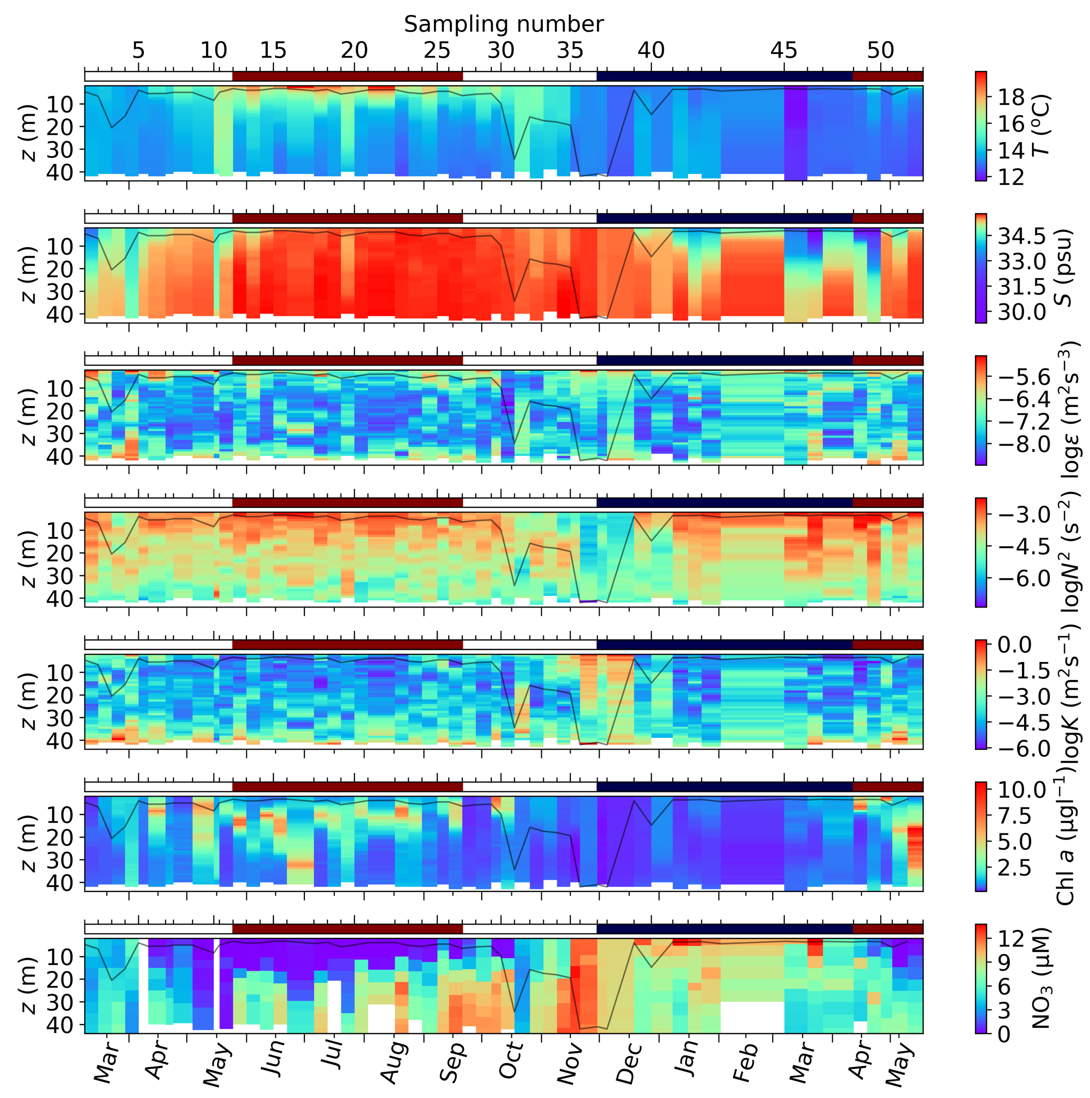
(1) 52 weekly hydrografic sampling (●) and continuous ADCP currents recording (■) was conducted in the Ría de Vigo from 09/03/17 to 10/05/18.

Upwelling-downwelling regimes



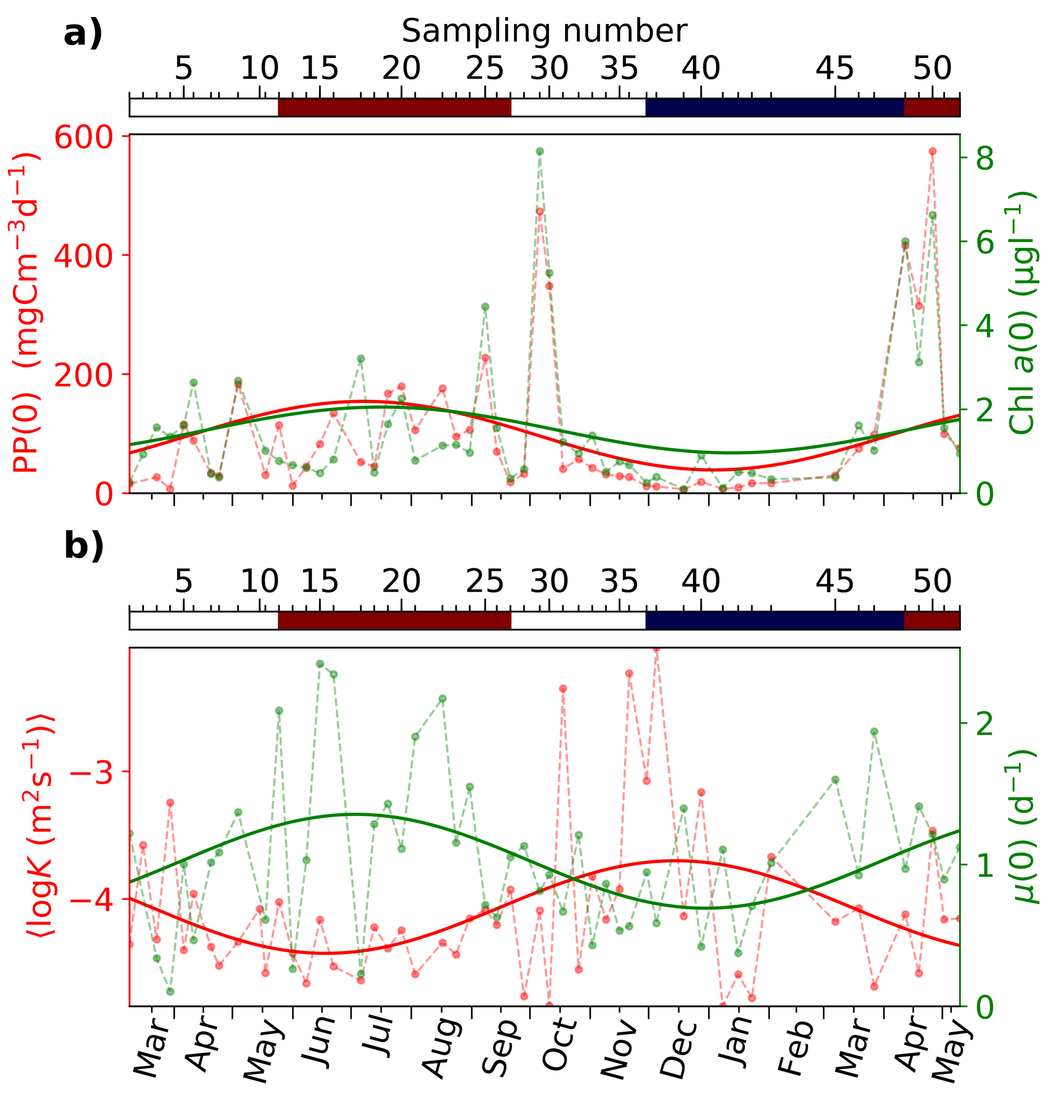
(2) Upwelling (red), downwelling (blue) and transitional (white) periods were identified based on **a)** the upwelling index (I_W) and **b)** current velocity recorded at 32 m ($u(32)$).

Hydrography



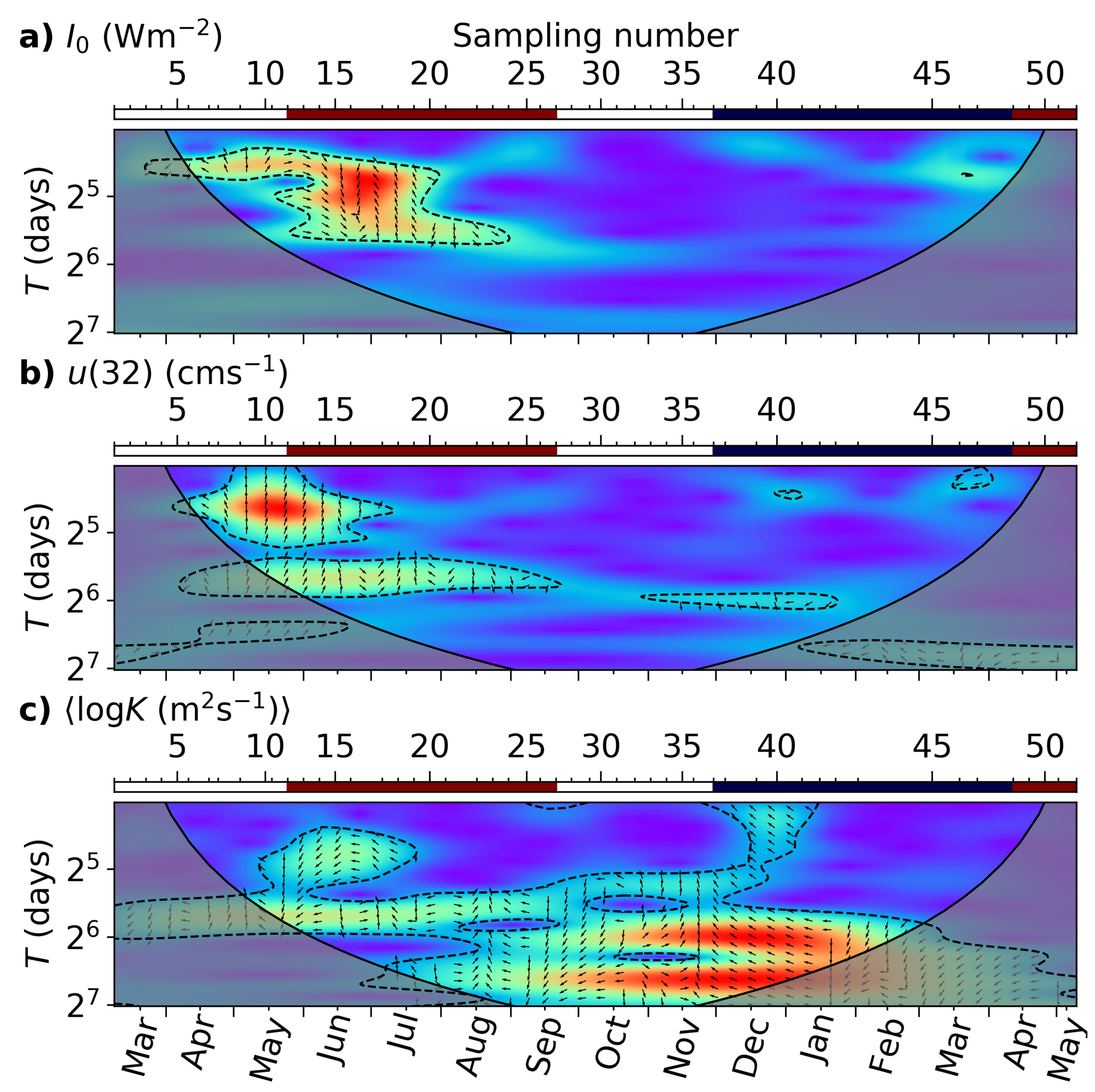
(3) Time series of temperature (T), salinity (S), dissipation (ϵ), buoyancy frequency (N), turbulent diffusivity (K), chlorophyll a (Chl a) and nitrate (NO_3). The black line denotes the mixed layer depth.

Seasonal variability



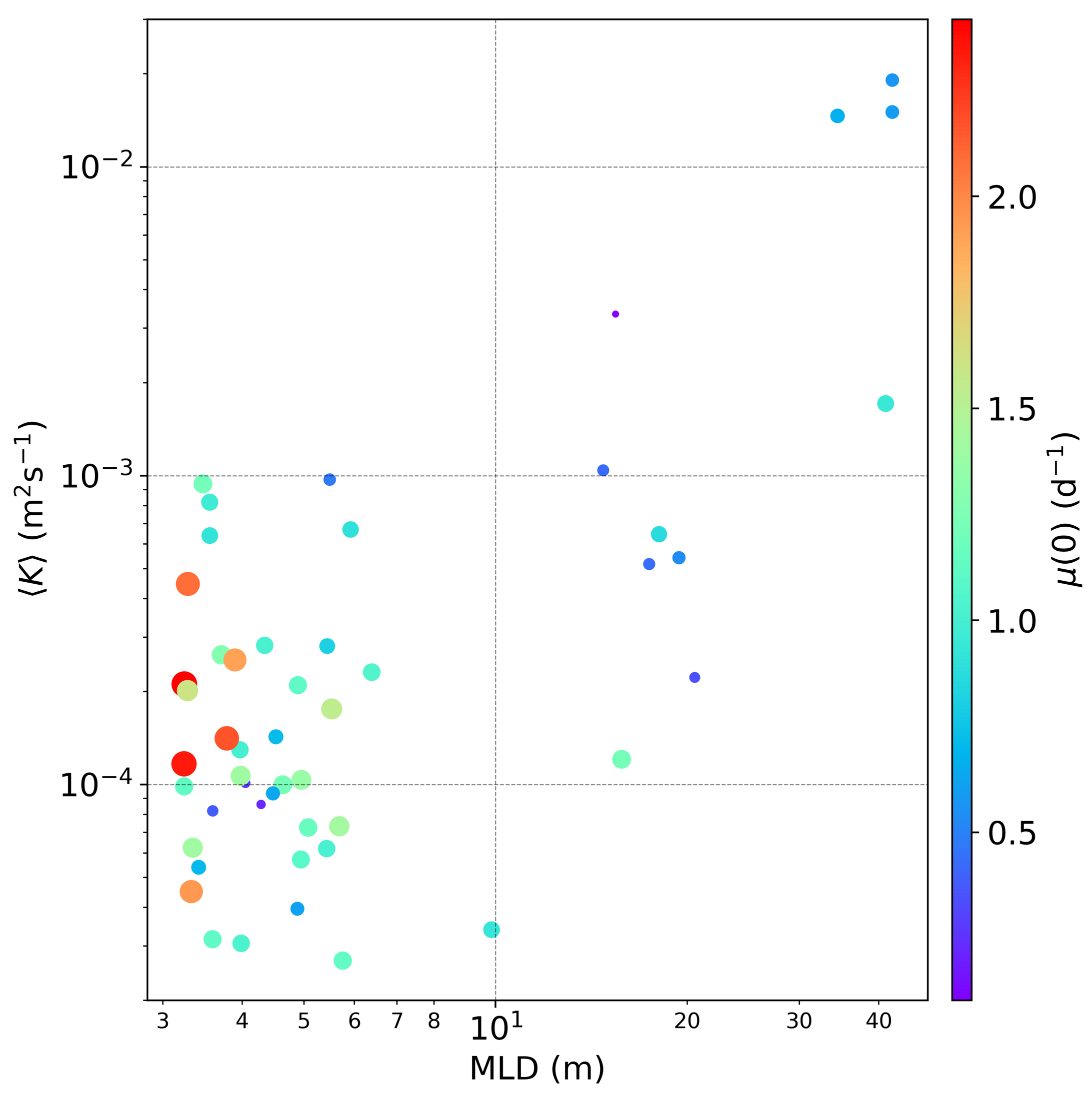
(4) Temporal evolution of **a)** surface Chl a and ^{14}C primary production (PP), and **b)** phytoplankton growth rates (μ) and depth-averaged K.

Wavelet analysis



(5) Wavelet cross spectrum between μ and **a)** surface irradiance (I_0), **b)** $u(32)$ and **c)** depth-averaged K.

Critical Turbulence Hypothesis



(6) μ versus mixed layer depth (MLD) and depth-averaged K.

Conclusions

1. Phytoplankton growth rates (μ) ranged from $\sim$0.1 d^{-1} to 2.4 d^{-1}, and maximum (minimum) values were quantified in spring-summer (autumn-winter).
2. The seasonal maximum of μ coincided with shallow mixed layer depths (MLD) and relatively weak turbulent mixing (K).
3. The wavelet analysis showed three maxima of covariance between μ and K at: $\sim$29-35 days (high frequency variability during the upwelling), $\sim$55-62 days (present through most of the year), and $\sim$100-110 days (autumn growth decline).
4. Our results partially agree with the CTH and show the coupling of K and μ at different temporal scales.

Acknowledgments

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To know more

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