Effect of Surfactants on Concentration Fluctuations Due to Turbulence and Wind Stress

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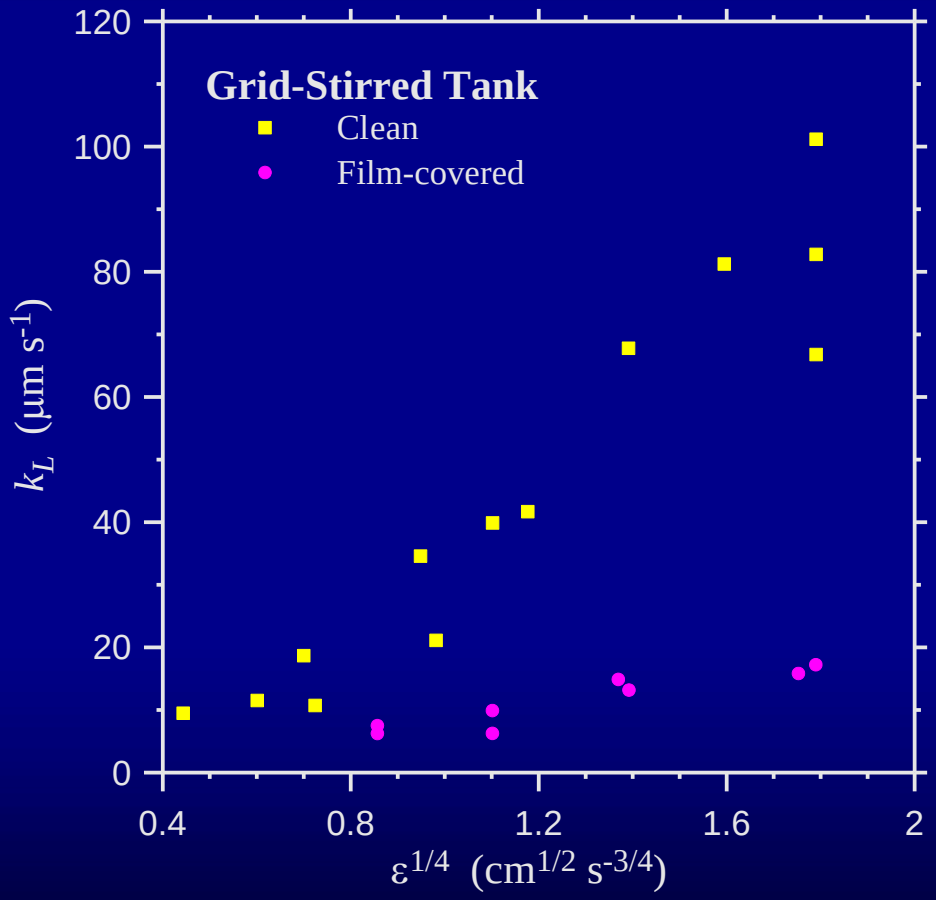
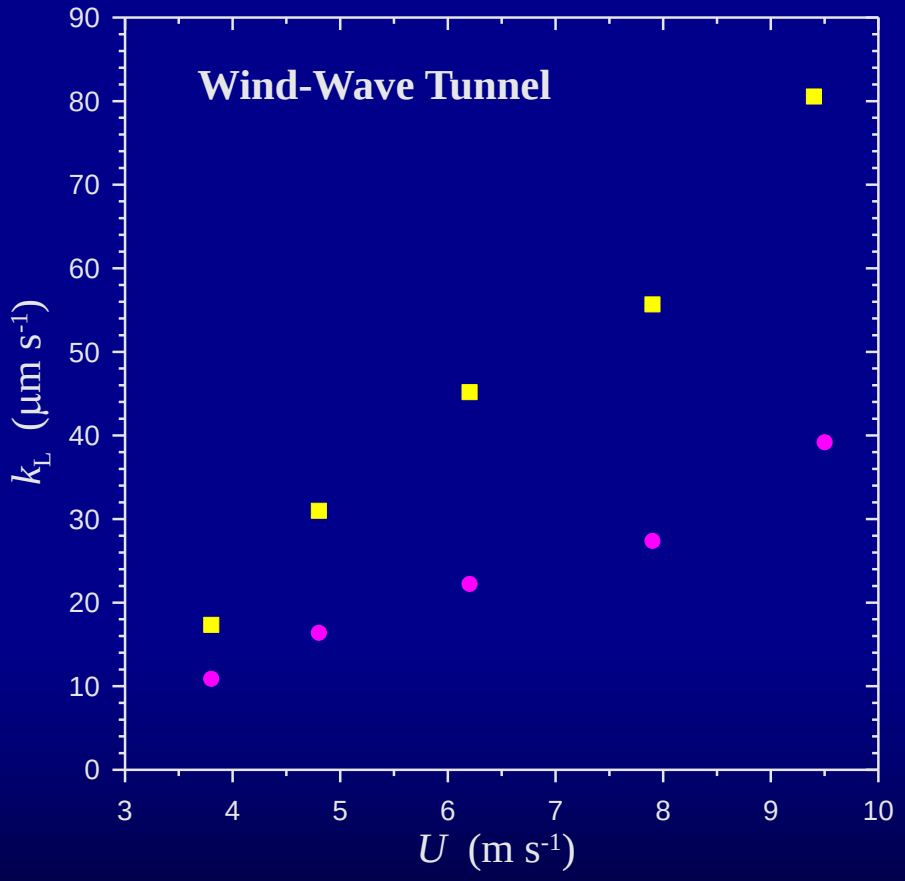
Surface films decrease *k*L, all other things being equal



Asher and Pankow, 1986

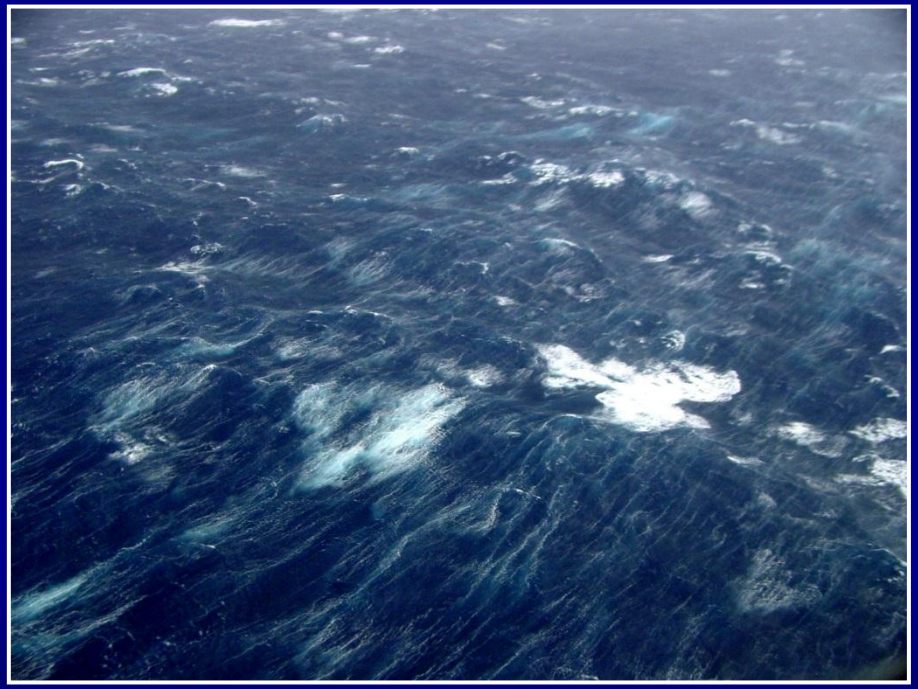


Zappa et al., 2001

Common Wisdom:
Surface films are mostly a factor at low wind speeds

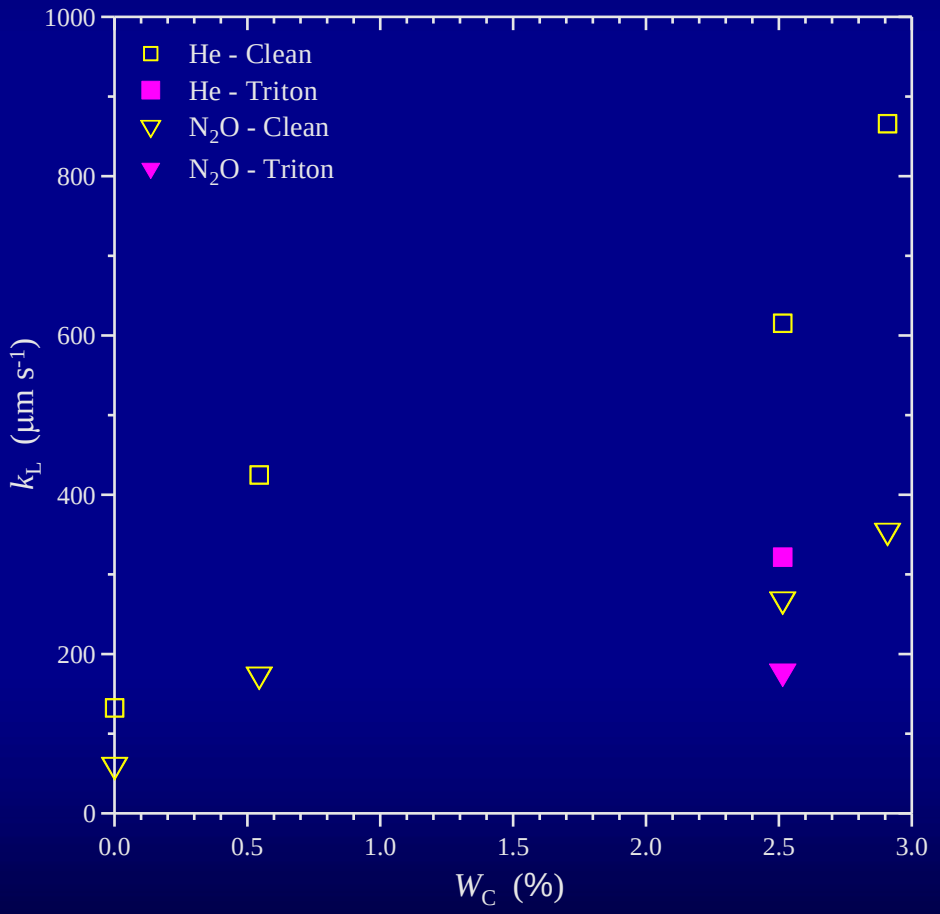
This

Not this

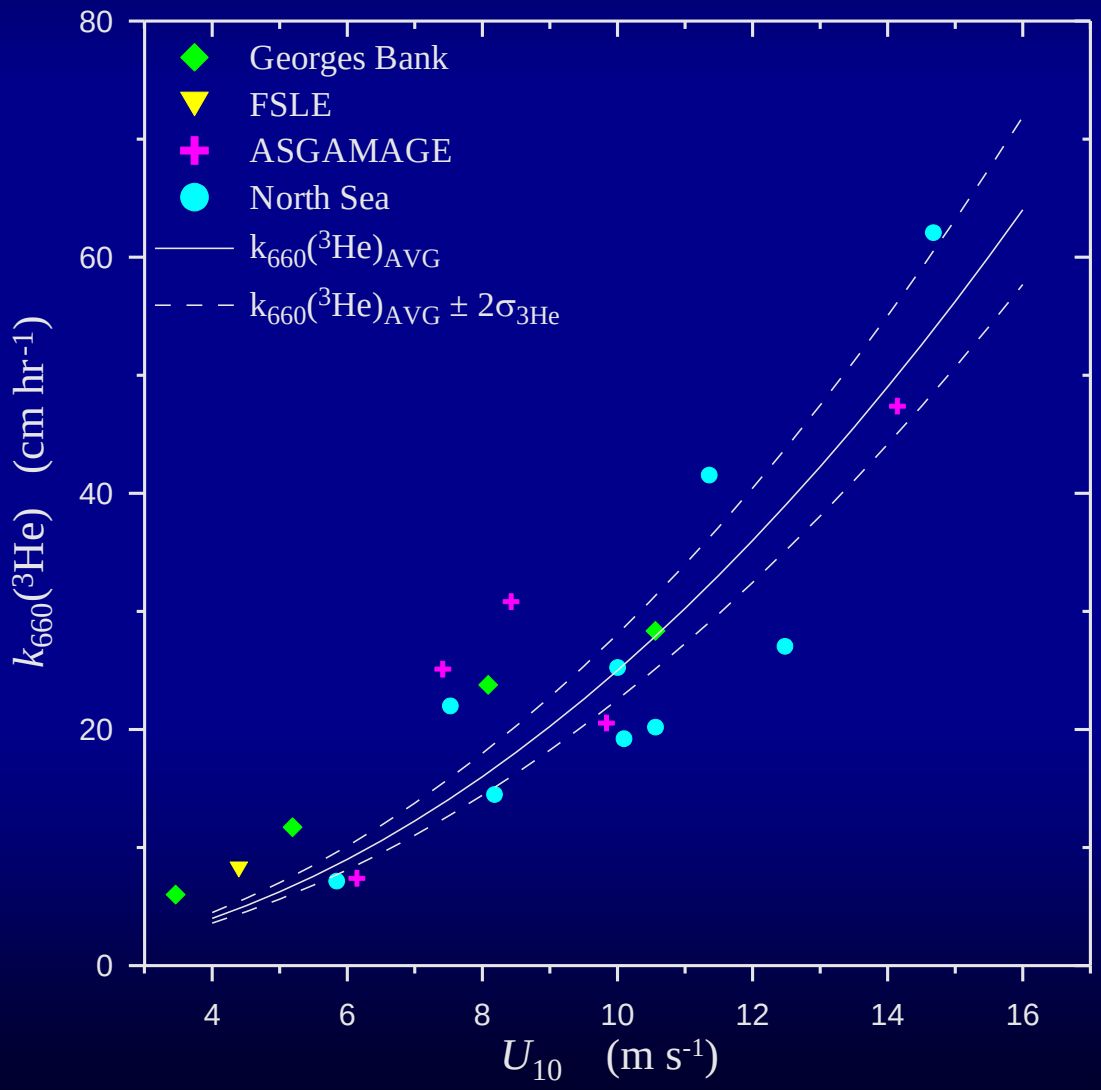


And yet: There is evidence surfactants effect exchange in the presence of breaking waves

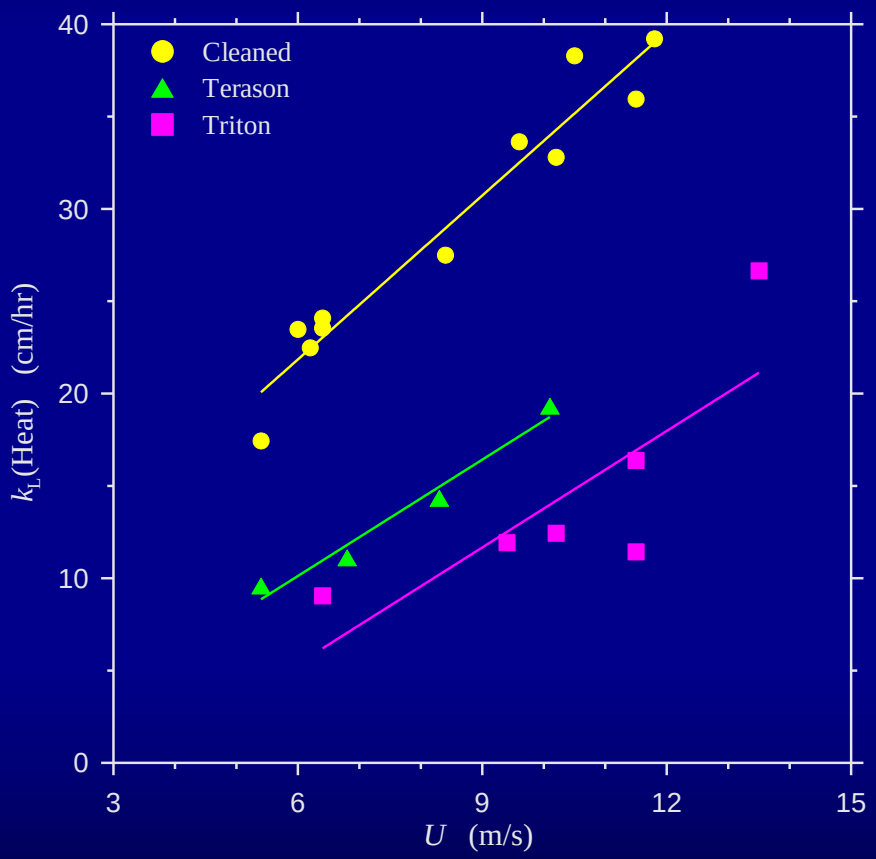
Hurricane Harbor
Wild Rivers Water Park
Irvine, California

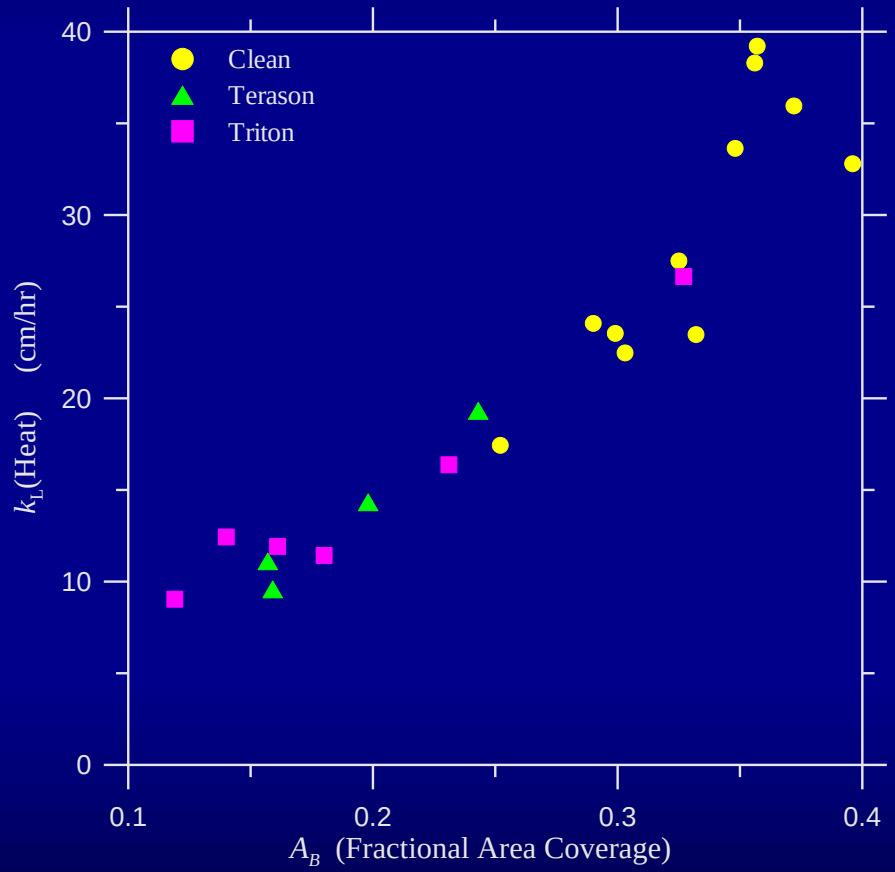


Circumstantial evidence that surfactants influence gas exchange in the ocean

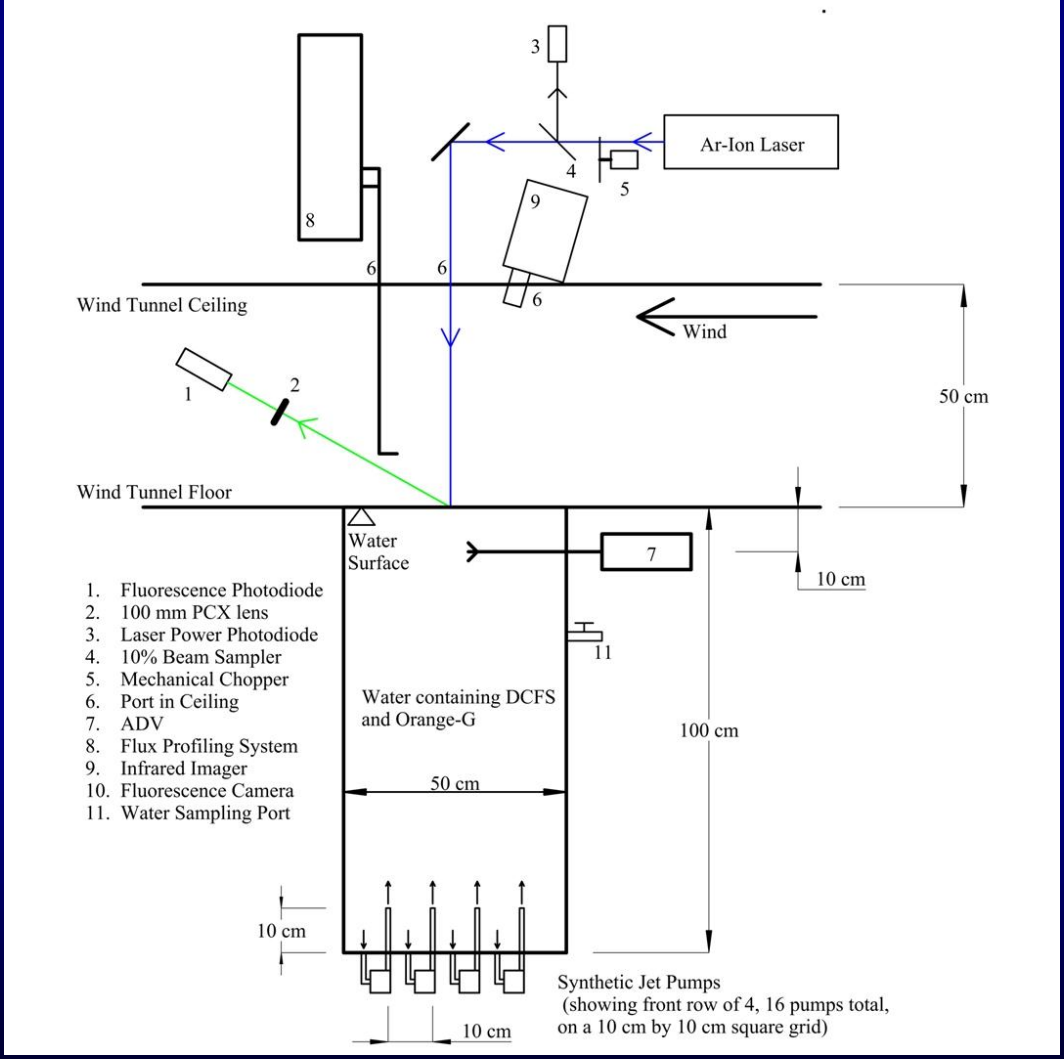


It might be possible to scale *k*L for clean and dirty surfaces

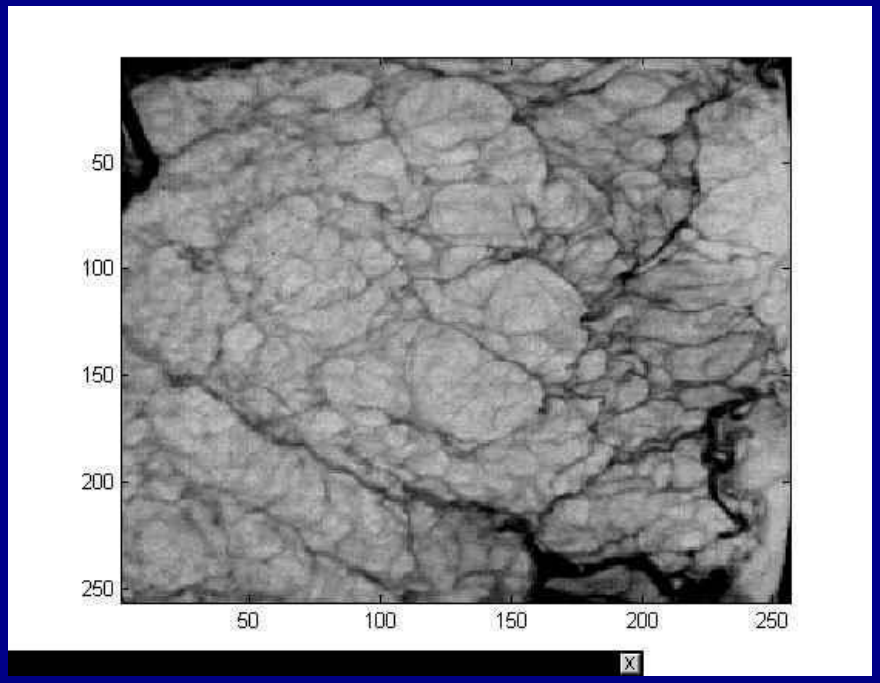




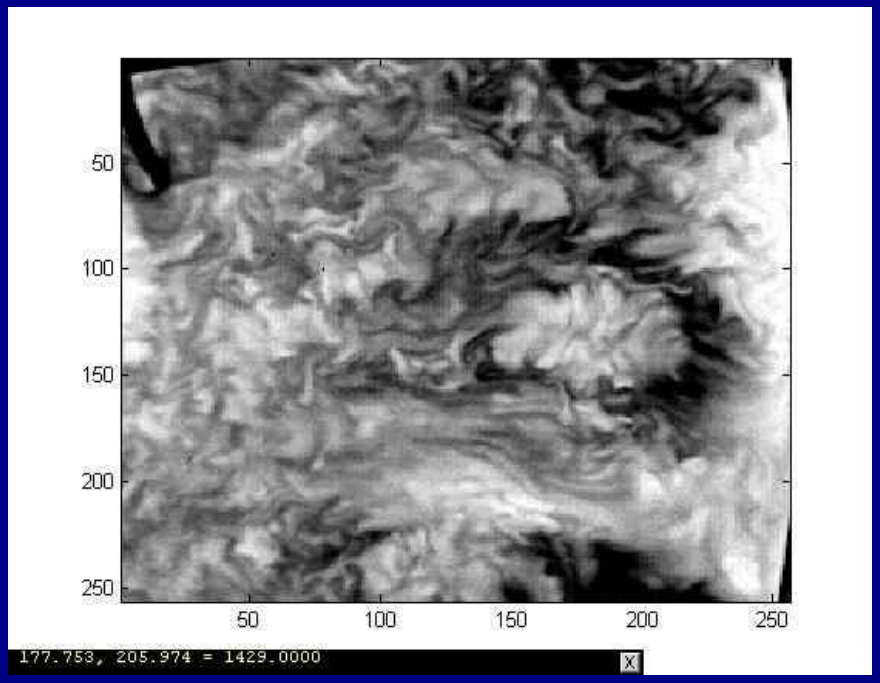
The Synthetic Jet Array Tank



The effect of surfactants on near-surface motions: A qualitative look using IR imagery



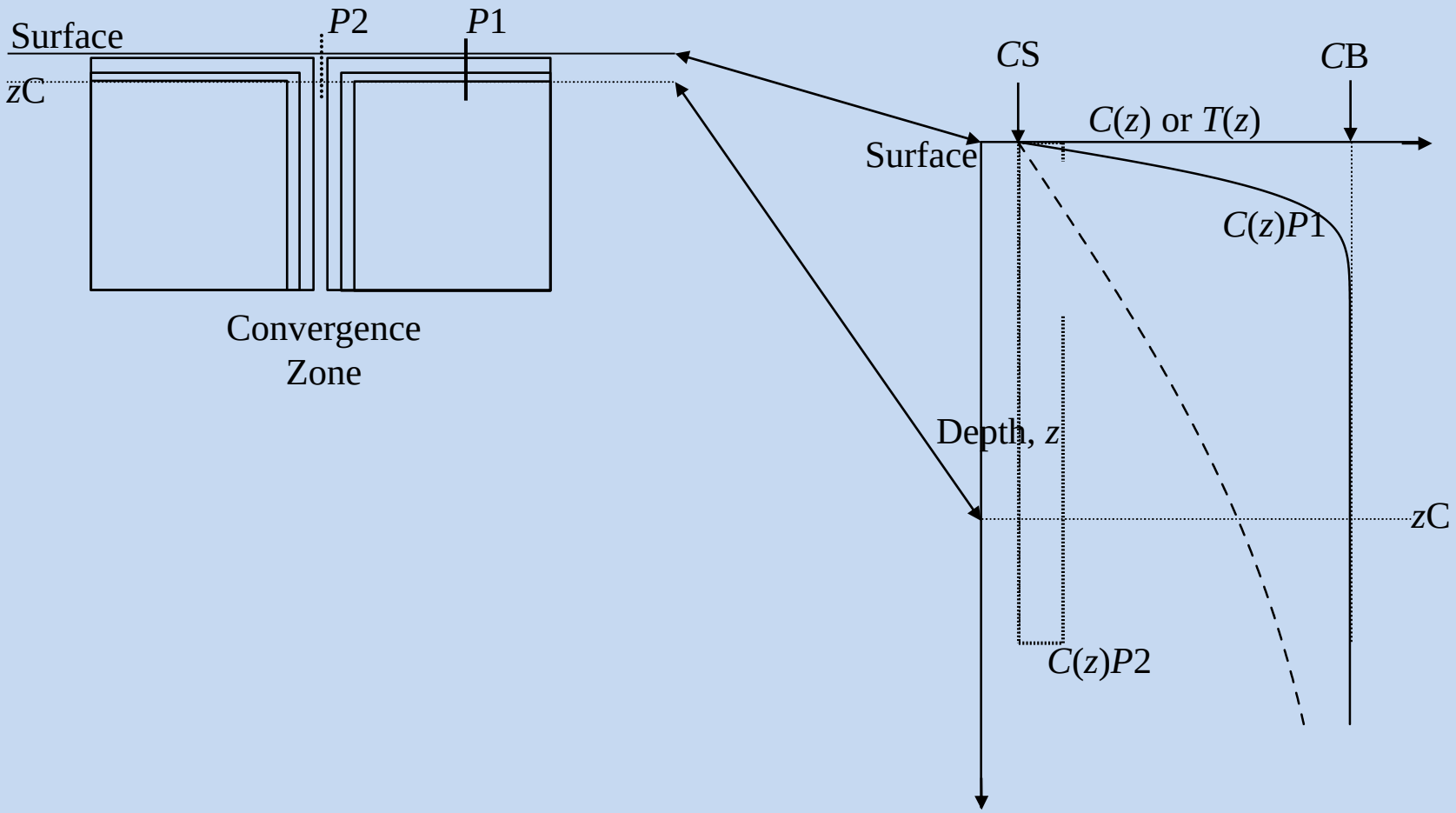
Clean Surface



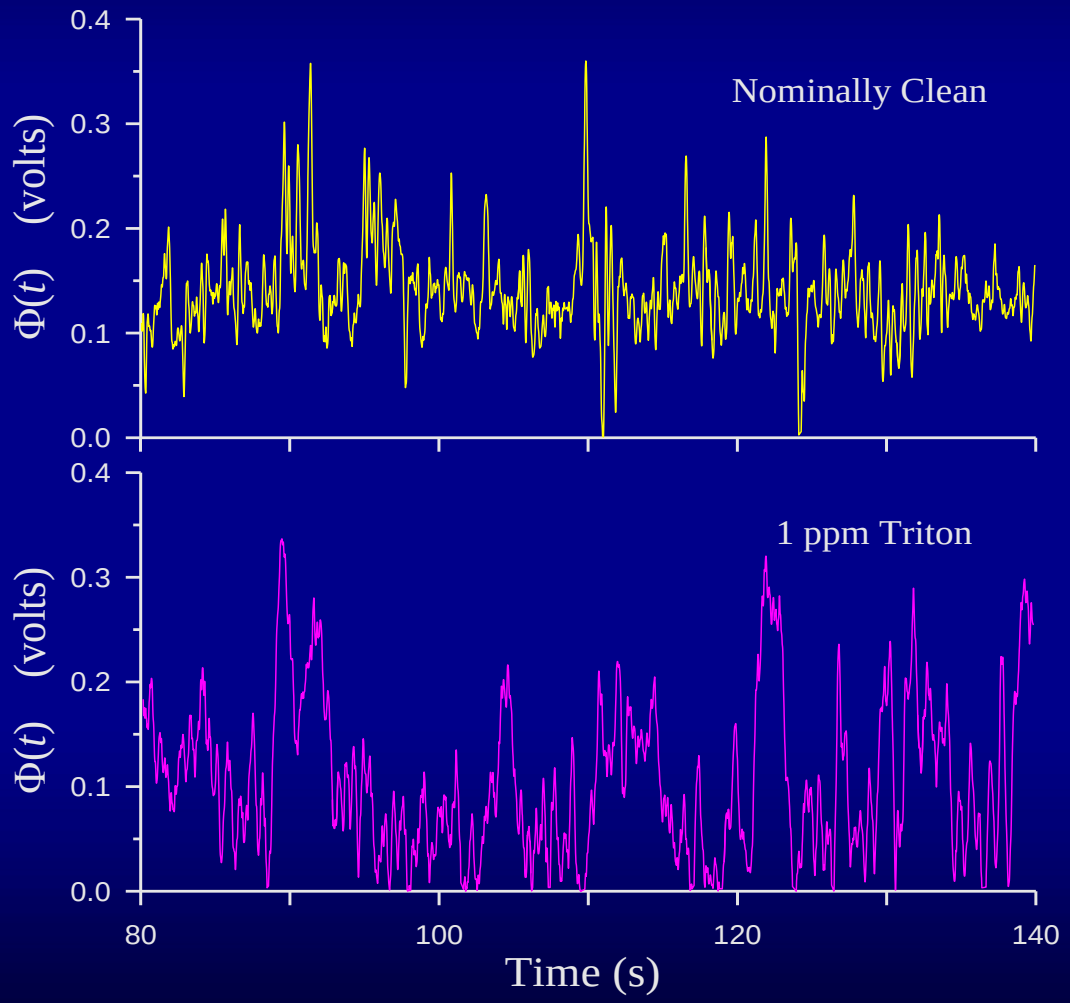
Surfactant-Influenced Surface
1 ppm (by weight) Triton X-100

APL-UW, SJAT, 2007

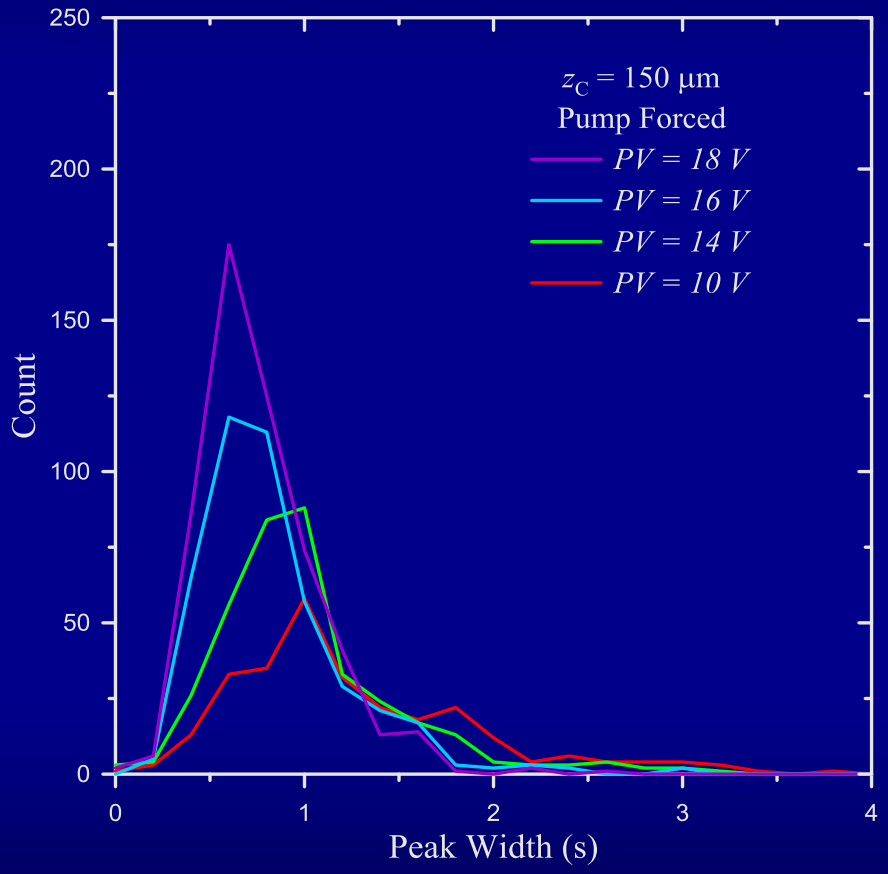
What causes the dark and light features?

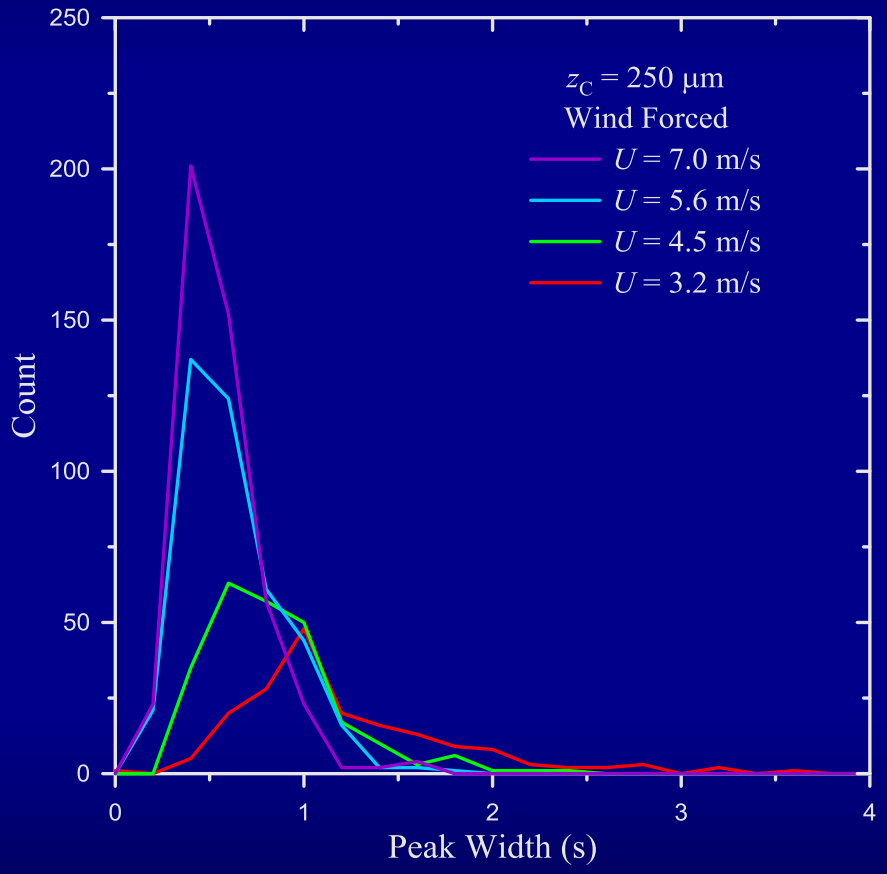


Can you see them in concentration fluctuations?
pH fluctuations due to CO2 evasion in the top 150 μm

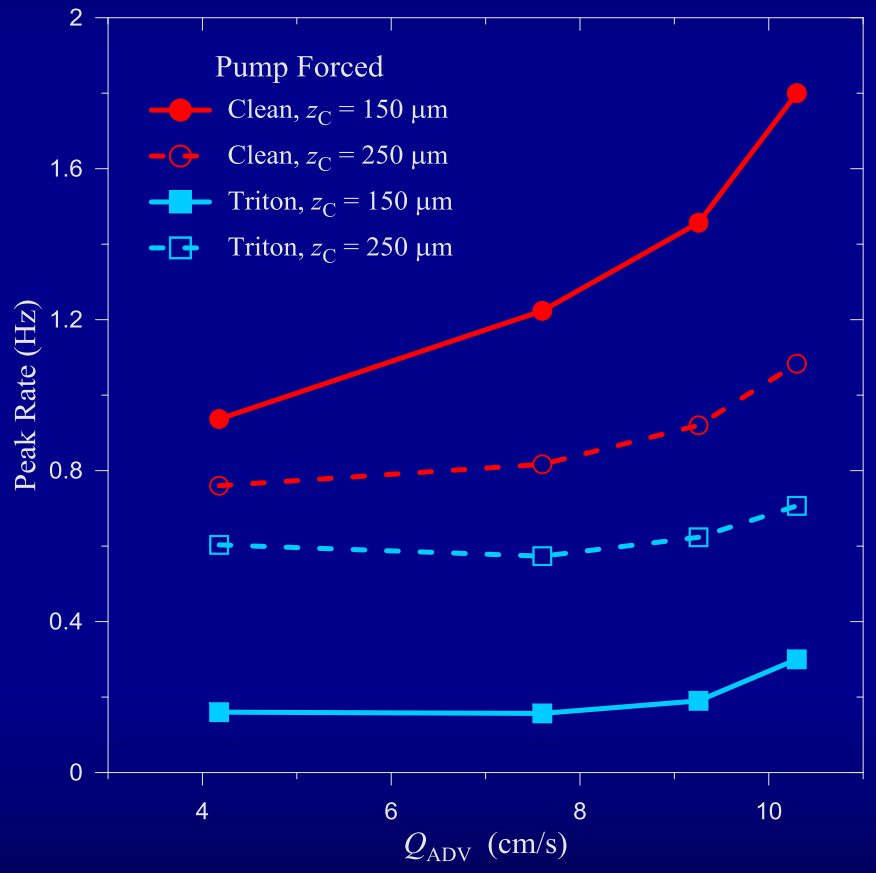


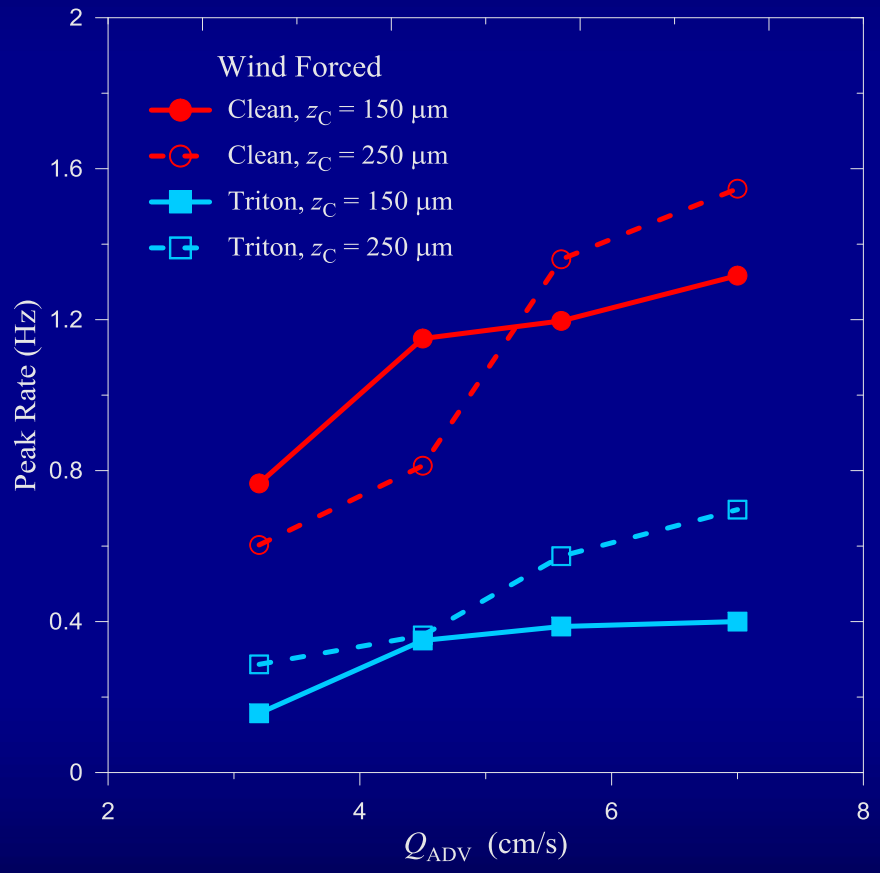
Simple analysis of statistics of these “peaks”
Distribution of the peak widths



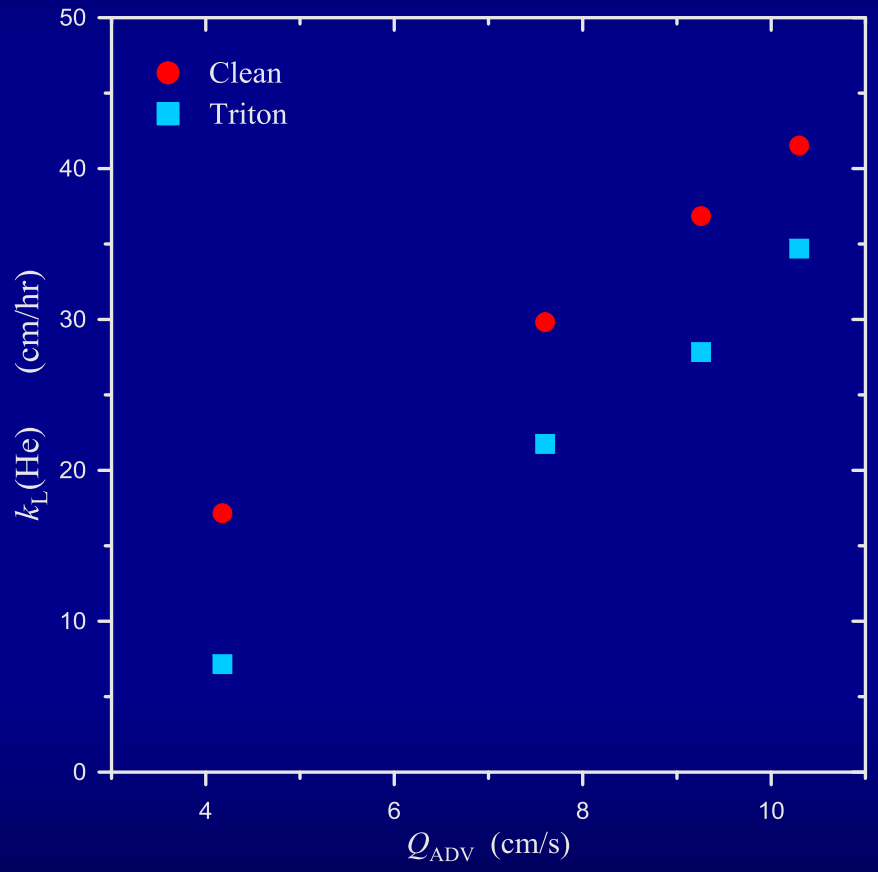


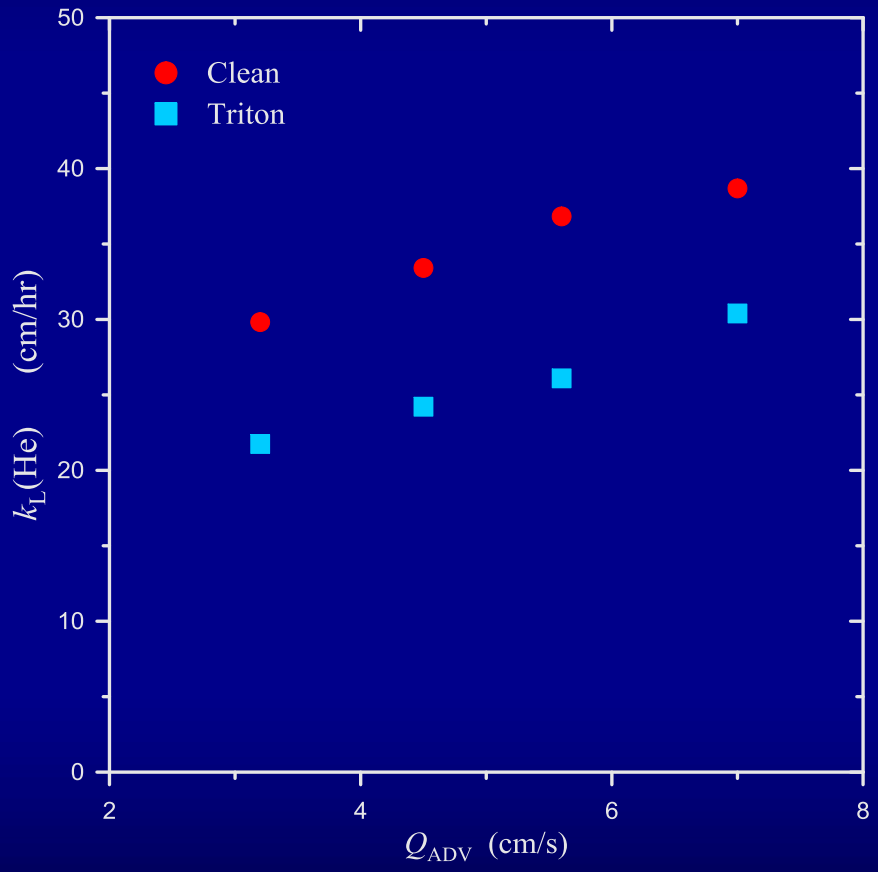
Even simpler statistical analysis: The rate at which these peaks are observed



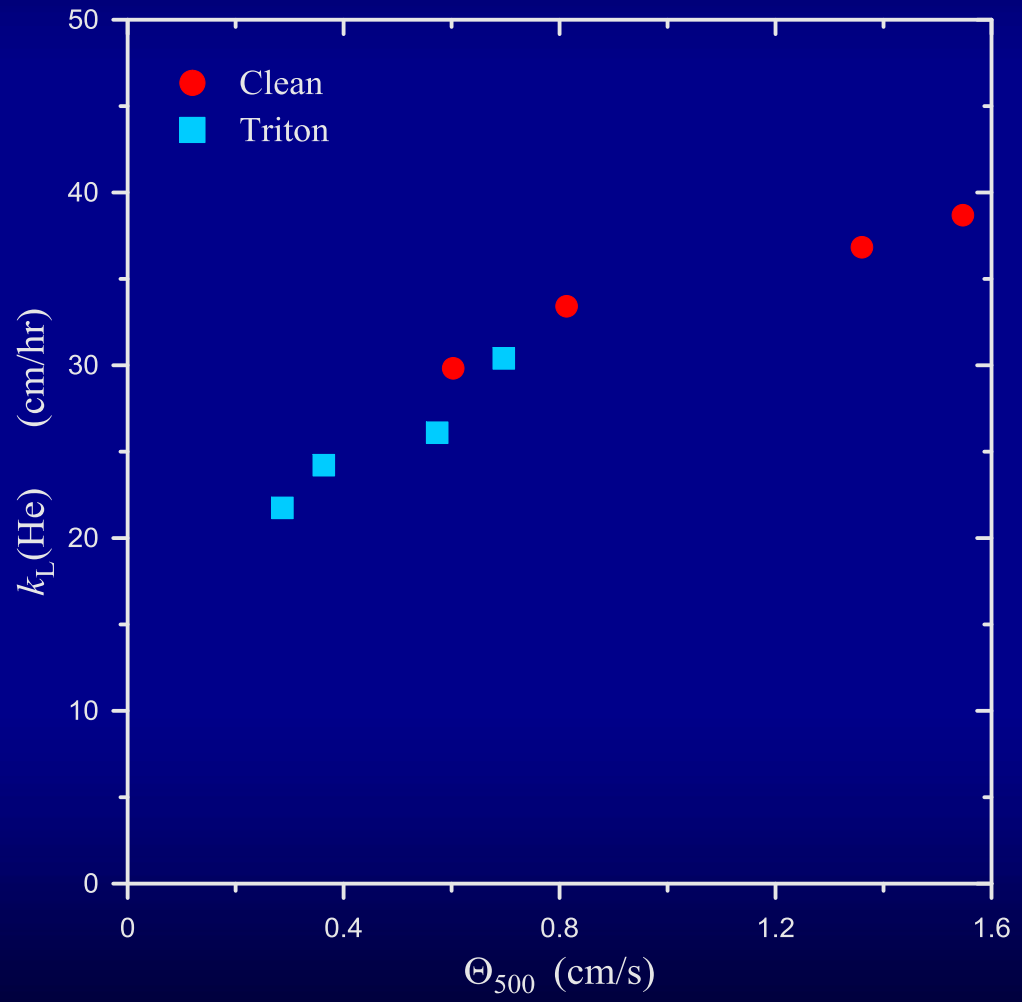


What the gas transfer velocity is doing:

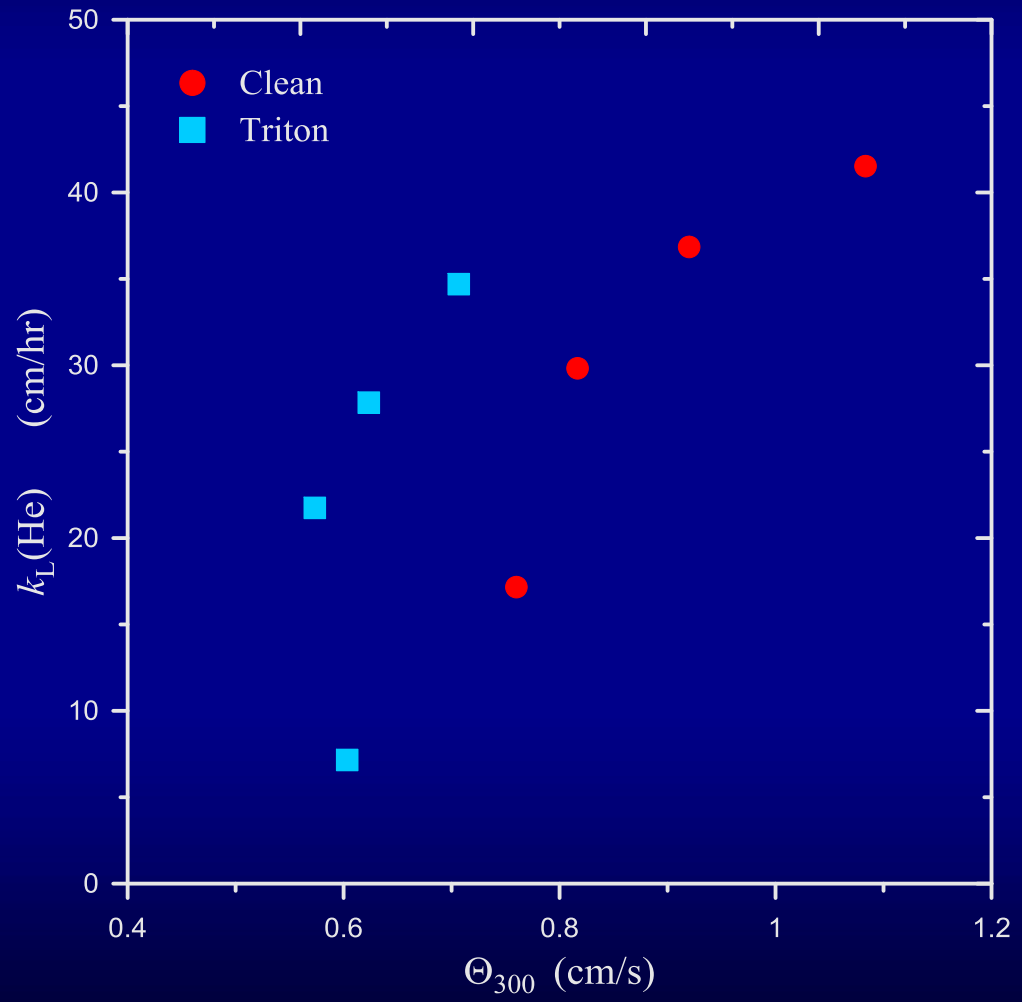




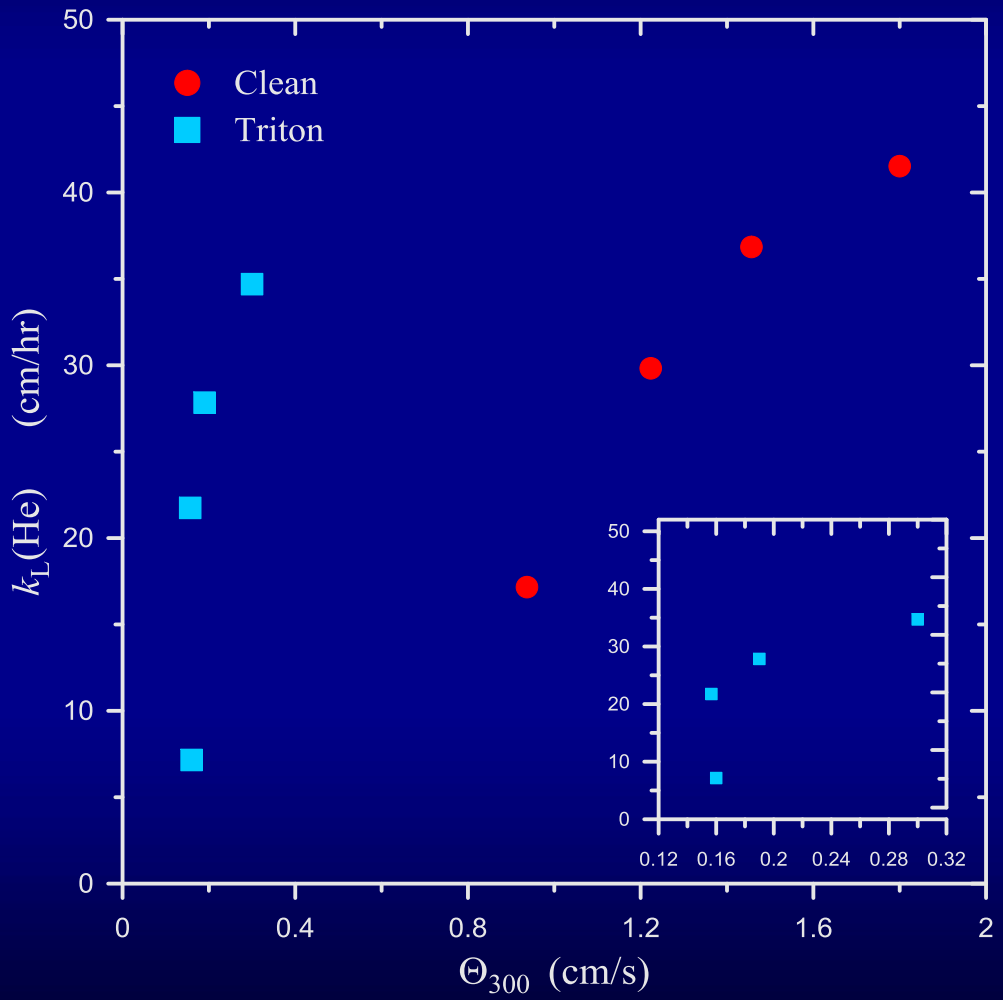
Does peak rate (Θ) correlate with *k*L?
Θmeasured in the upper 250 μm for wind forcing



Does peak rate (Θ) correlate with *k*L?
Θmeasured in the upper 250 μm for pump forcing



Does peak rate (Θ) correlate with *k*L?
Θmeasured in the upper 150 μm for pump forcing



You Call These Conclusions?

There does not seem to be a universal timescale that explains the dependence of *k*L on the surface divergence for clean and surfactant-influenced surfaces
Even if there were, it is unlikely that satellite-borne instruments will ever be able to detect surface divergences (or *A*B) from space

While there is a lot of circumstantial evidence around that surfactants are affecting gas transfer in the ocean, it is still unclear how you do anything about it in terms of estimating *k* from satellite data products

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Θmeasured in the upper 150 μm for wind forcing