# Langmuir Parameterizations

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In preparation for continued research with
Keith Julien, CU-Boulder; Greg Chini, UNH; E. Knobloch, UCB

13th CCSM Meeting--OMWG Session
Thurs. 6/19/08 11:25-11:40

# Langmuir, What?

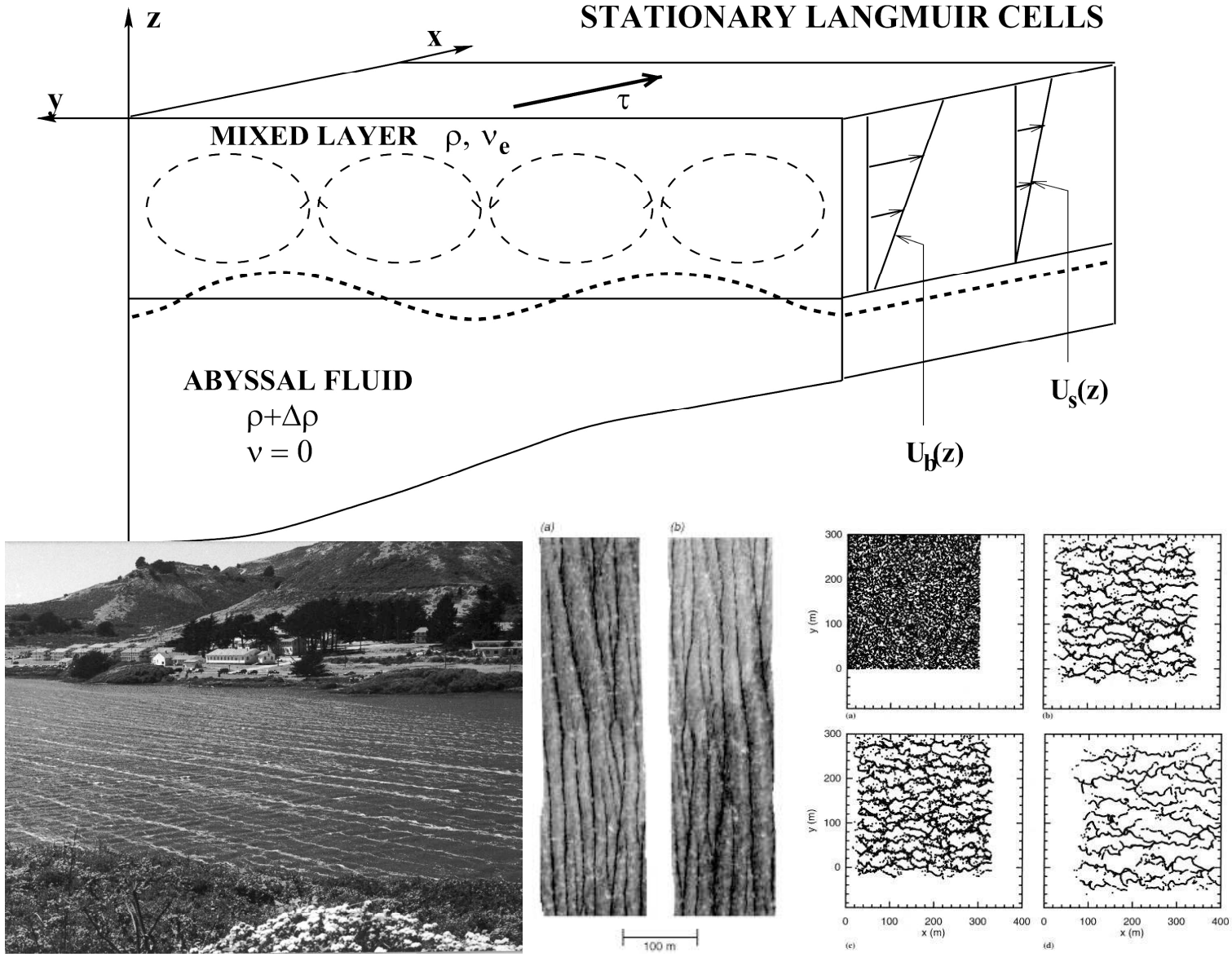



FIGURE 1: Images of Langmuir circulation windrows: (a) a photograph of Rodeo Lagoon in CA (from Szeri, 1996), (b) an infrared image of the surface of Tampa Bay (courtesy of G. Marmorino, NRL, D.C.), and (c) the evolution of surface tracers in a LES of Langmuir turbulence (McWilliams et al., 1997). Reproduced from Chini et al. (2008).

# Langmuir, do we care?

Maybe:

## Role of Langmuir Circulation in the Deepening of the Ocean Surface Mixed Layer

Ming Li,* Konstantin Zahariev, Chris Garrett

Helical motions, known as Langmuir circulation, are a key physical process in the upper ocean but have not yet been incorporated into ocean models. Here, surface mixed layer deepening by Langmuir circulation was added to that due to convection or velocity shear; Langmuir circulation is more important than shear if the velocity difference across the mixed-layer base is less than about 1 percent of the wind speed. In an upper ocean data set, evidence was found for the deepening of the mixed layer by both mechanisms. Thus, Langmuir circulation influences upper ocean diurnal and seasonal changes in stratification.

Maybe Not:

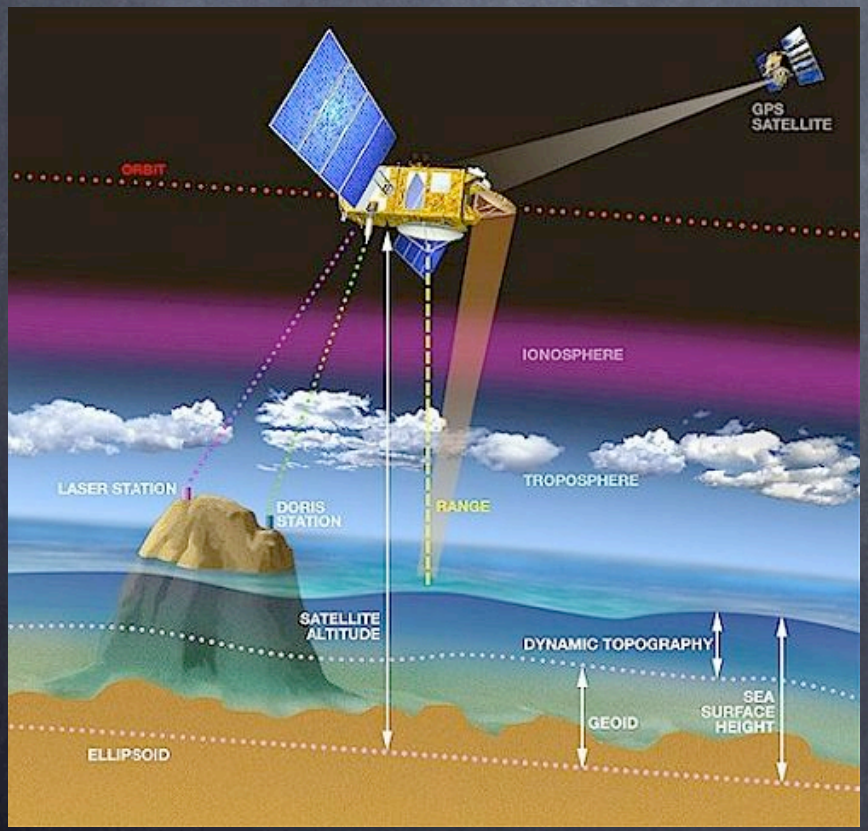
## Langmuir circulation within the oceanic mixed layer

ROBERT A. WELLER* and JAMES F. PRICE*

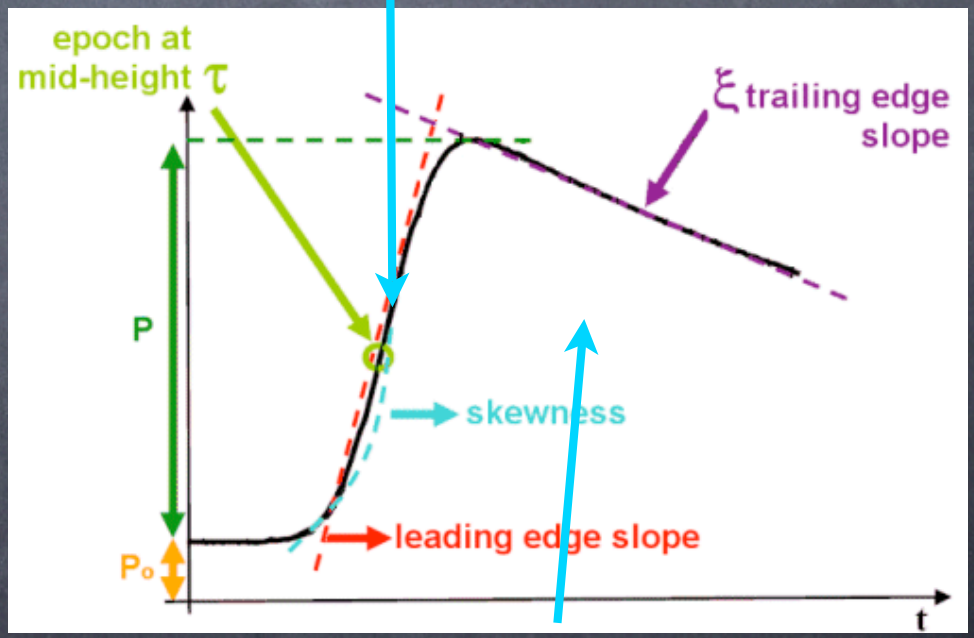
some occasions, when Langmuir cells appeared suddenly, they were able to mix the weak near-surface stratification that had formed in reponse to diurnal heating. They could also maintain large shears in the well-mixed fluid near the surface. They did not, however, penetrate with strength to the base of relict mixed layers observed during summer-like conditions or to the base of deeper, more isothermal, mixed layers observed during stormy conditions.

# Waves+Wind != Wind

- Langmuir is 'in' KPP, but only based on wind
- Really Langmuir depends on both u* and $u_s$
- Is there data? Altimeters do both simultaneously




Leading Slope->Swell




Inverse Area->Capillaries

Thus, Local wind

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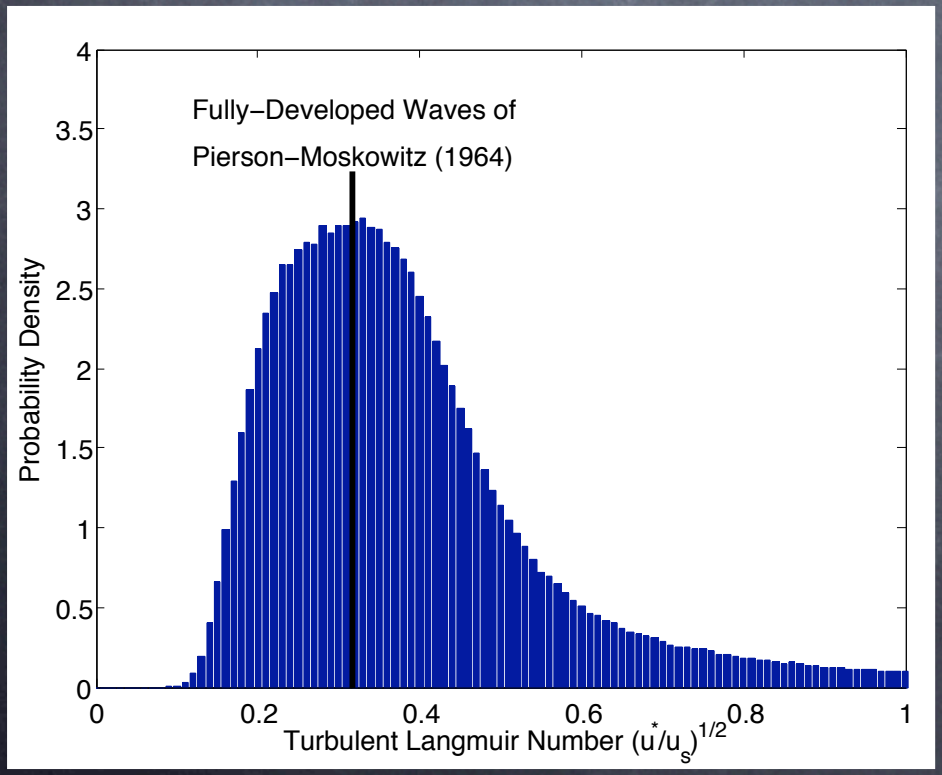
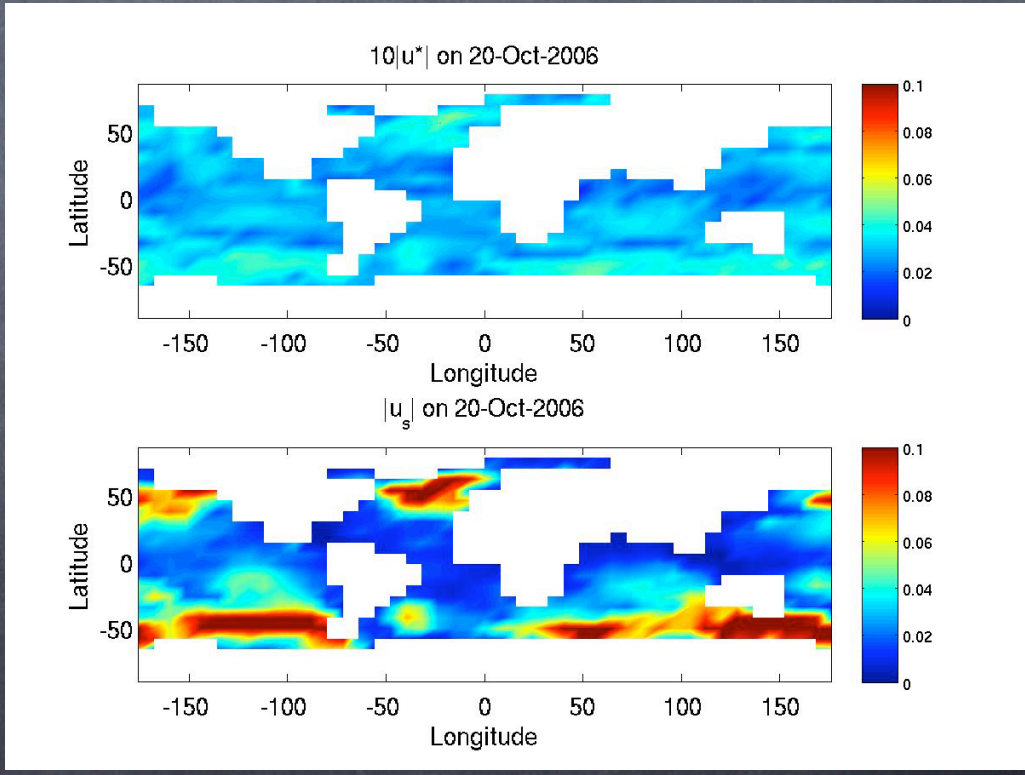



Aviso Merged Satellite Dataset, 11/12/05-05/27/08

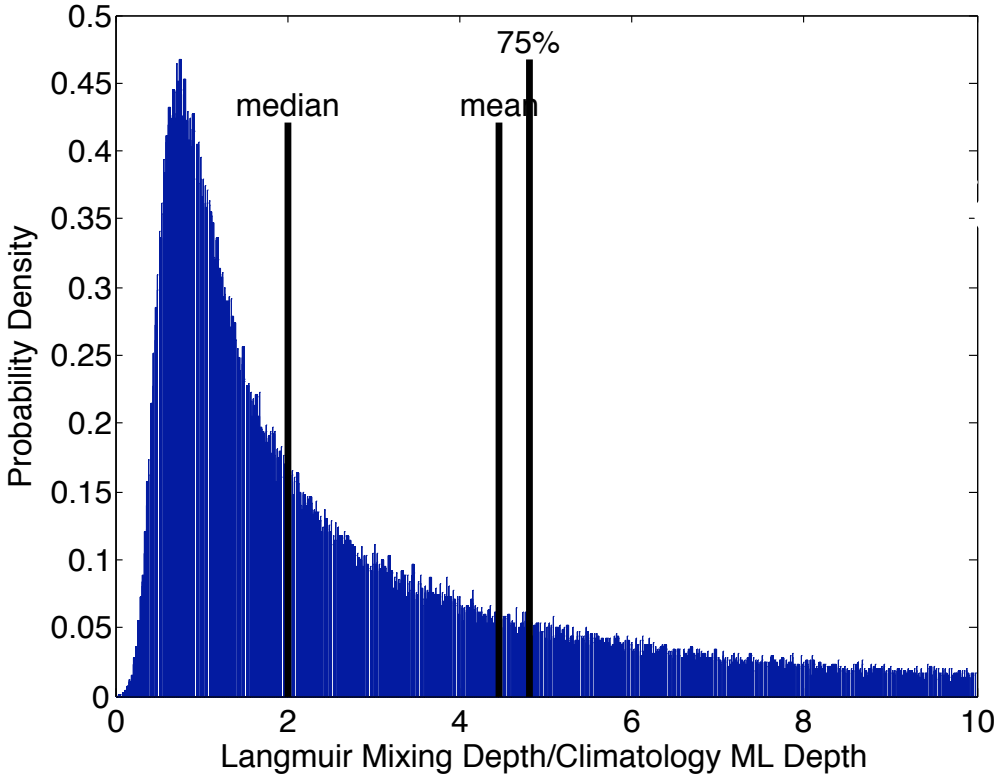
# Estimate Importance from LES scalings

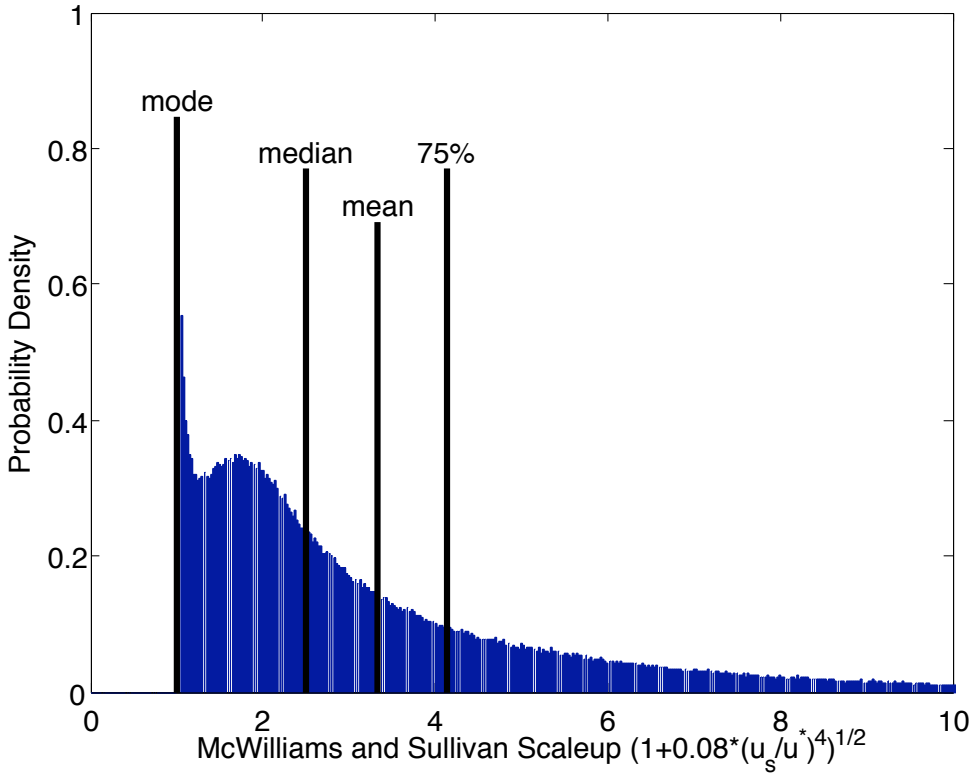
Li and Garrett (1997)

$$Fr = \frac{W}{NH} \approx \frac{V}{1.5NH} \approx \frac{\sqrt{u_s u^*}}{1.5NH} \approx 0.6$$

McWilliams & Sullivan (2000)

$$\kappa \rightarrow \kappa \left(1 + 0.08 \frac{u_s^2}{u^{*2}}\right)^{1/2}$$




N, MLD Based on Argo Climatology (Speer & Wienders)

Aviso Merged Satellite Dataset, 11/12/05-05/27/08, Assuming 120m Wavelength

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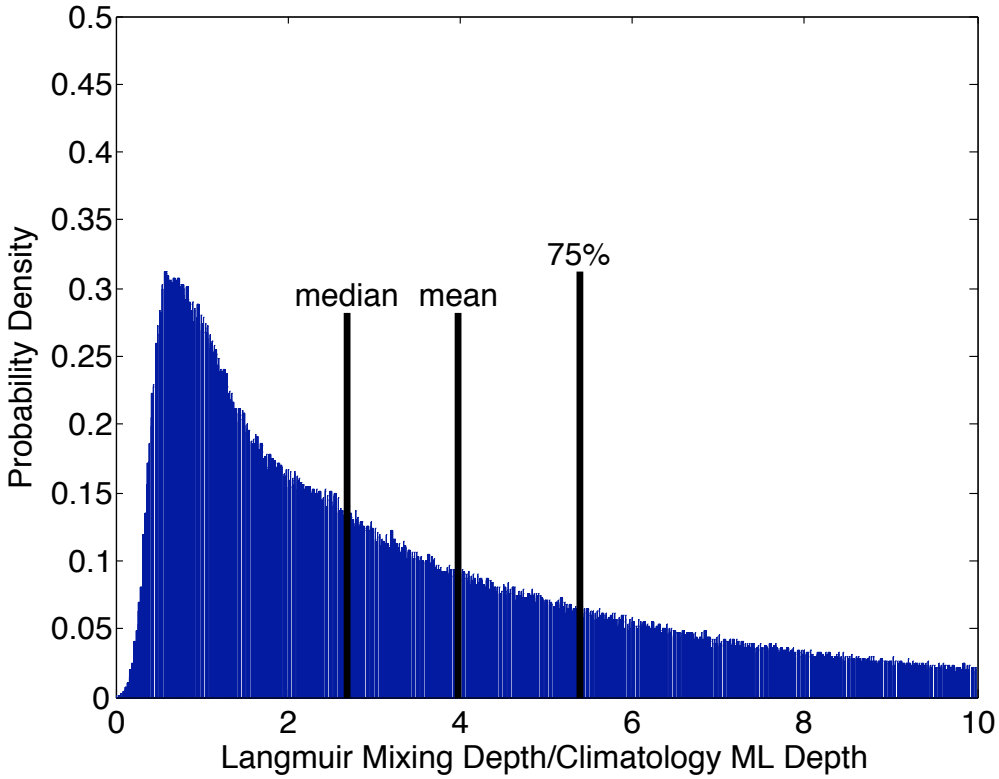
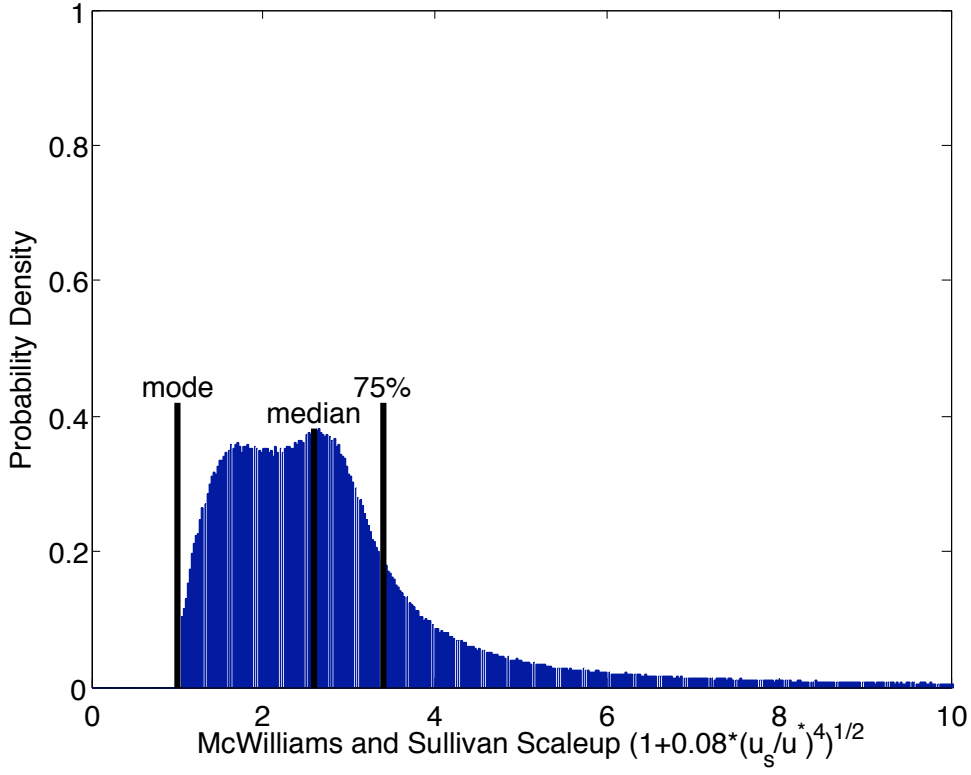
McWilliams & Sullivan (2000)

$$\kappa \rightarrow \kappa \begin{cases} \left(1 + 0.08 \frac{|\mathbf{u_s}|^4}{(\mathbf{u}^* \cdot \mathbf{u_s})^2}\right)^{1/2} & \forall : \mathbf{u}^* \cdot \mathbf{u_s} > 0 \\ 1 & \forall : \mathbf{u}^* \cdot \mathbf{u_s} < 0 \end{cases}$$

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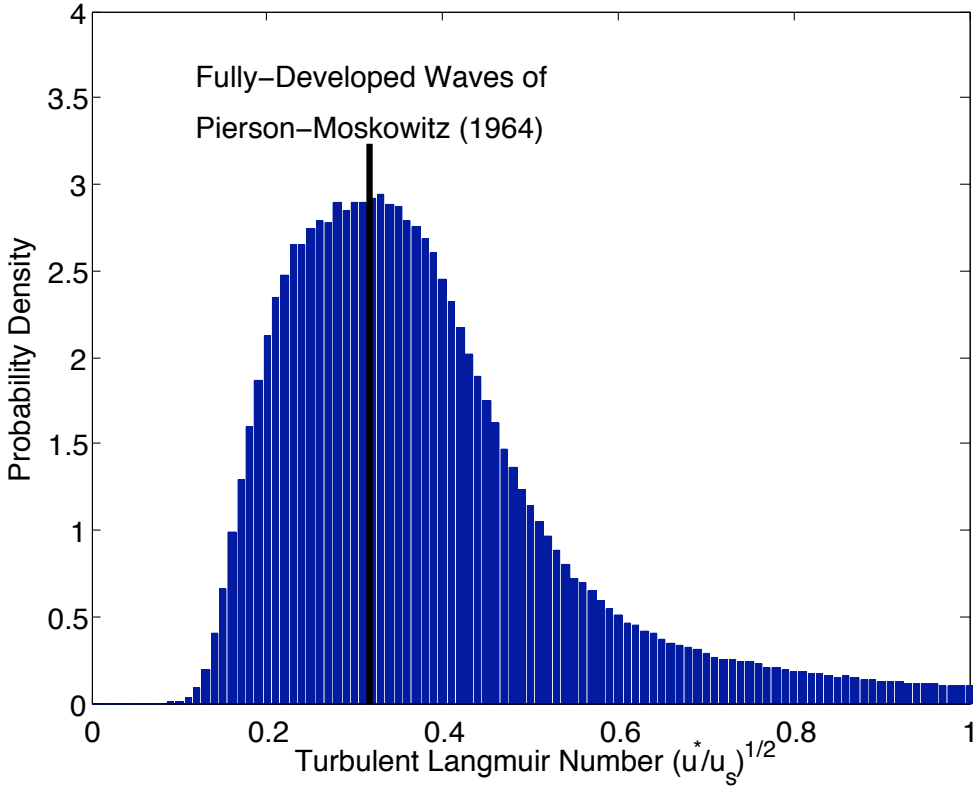
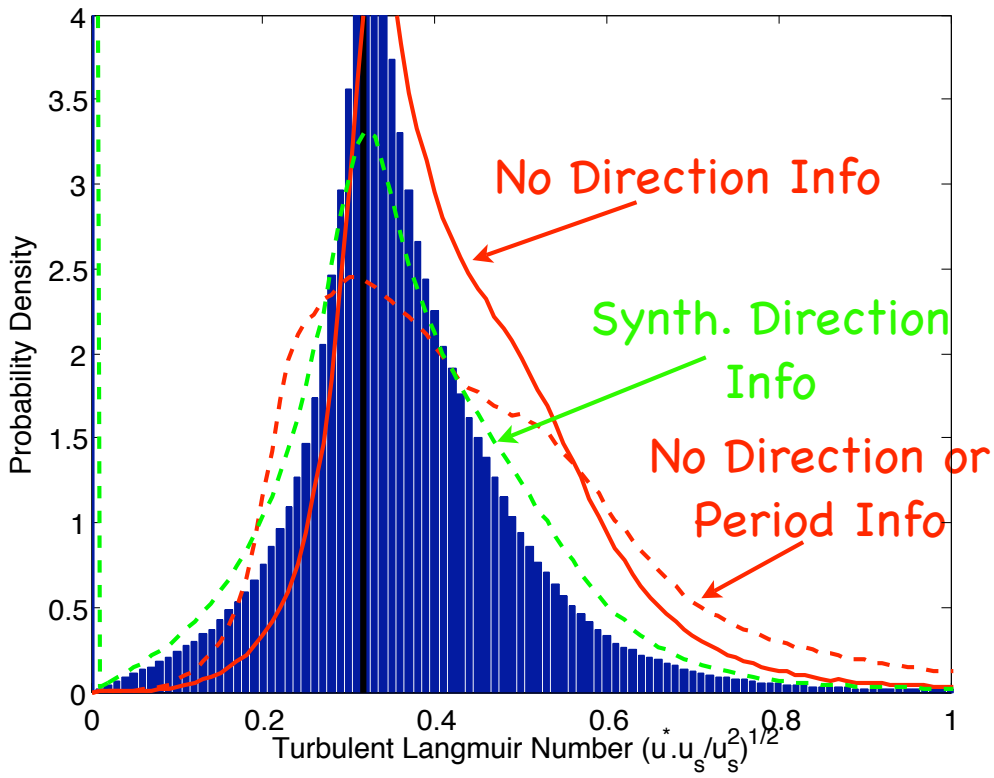
# Satellite versus Model

Stokes' Drift is *sensitive* to wave period.

$$u_s \approx \frac{\pi^3 H_s^2}{g T_w^3}$$




Aviso Merged Satellite Dataset, 11/12/05-05/27/08

WaveWatch III Data-Assimilating Wave Model
(attempted to rescale find surface wind-stress)

# State of the Art:

## Fundamental Model Hierarchy

Wave Resolving 3d DNS

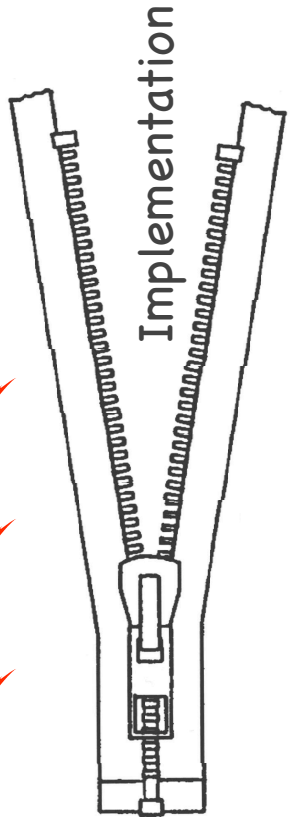
3d C-L LES ✓

Asymptotic-3d PDEs

Asymptotic-2d PDEs ✓

Single Mode PDEs

Equilibrated Scaling ✓




## Applied Model Hierarchy

Wave Resolving Model

C-L Equations

Full Wave Model

Simple Wave Model

Climatology Forcing

Wind-Only Forcing ✓

# Our Goal:

## Fundamental Model Hierarchy

Wave Resolving 3d DNS

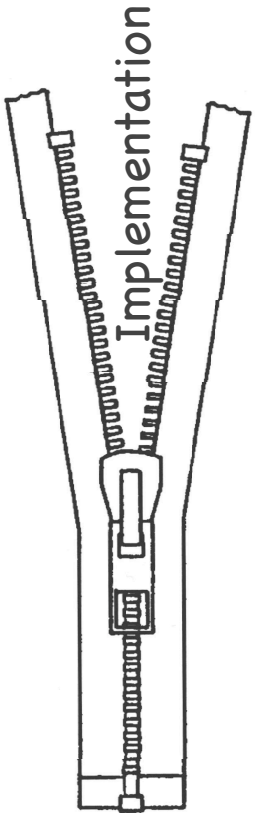
3d C-L LES ✓

Asymptotic-3d PDEs ✓

Asymptotic-2d PDEs ✓

Single Mode PDEs ✓

Equilibrated Scaling ✓




## Applied Model Hierarchy

Wave Resolving Model

C-L Equations

Full Wave Model

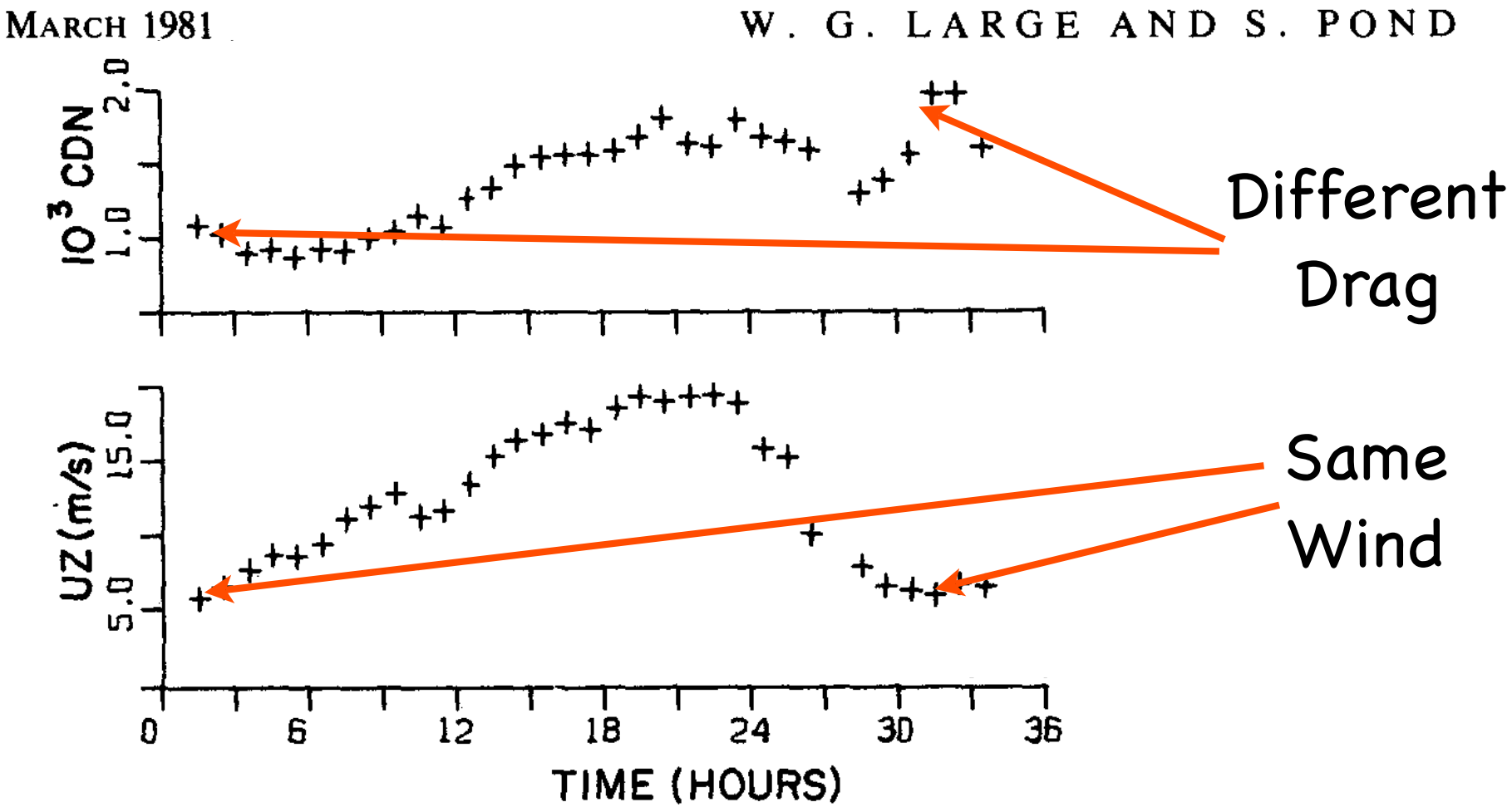
Simple Wave Model ✓

Climatology Forcing ✓

Wind-Only Forcing ✓

Satellite Altimeter Creation/Validation

# Other Effects of Wind+Waves != Wind



# Conclusions

- Langmuir turbulence may play an important role in mixed layer mixing and deepening
- Langmuir scaling requires wind & waves
- Proper parameterization requires development of theory, as well as implementation of a wave model
- Once we've got the wave model, it will be useful for other things!