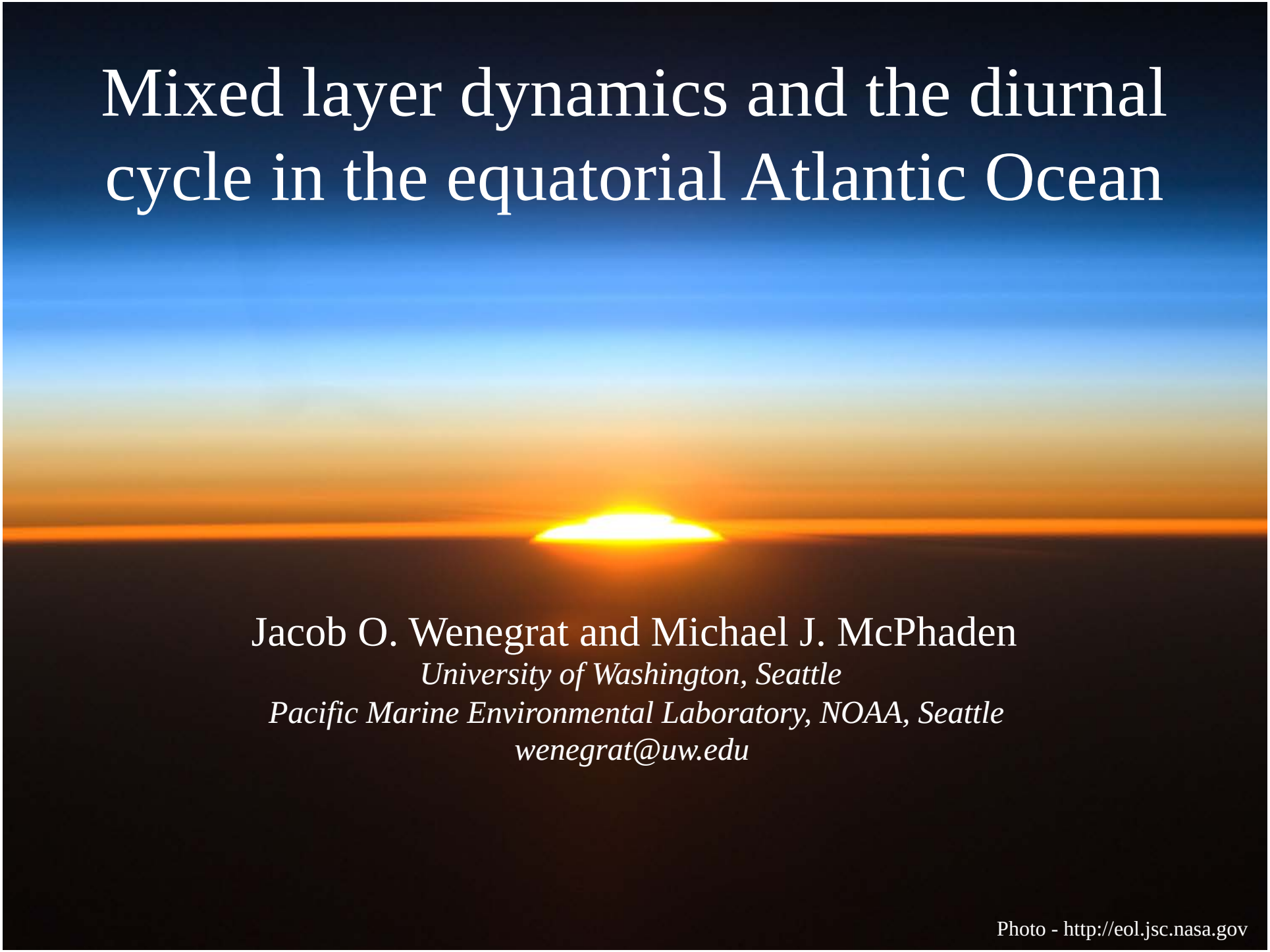
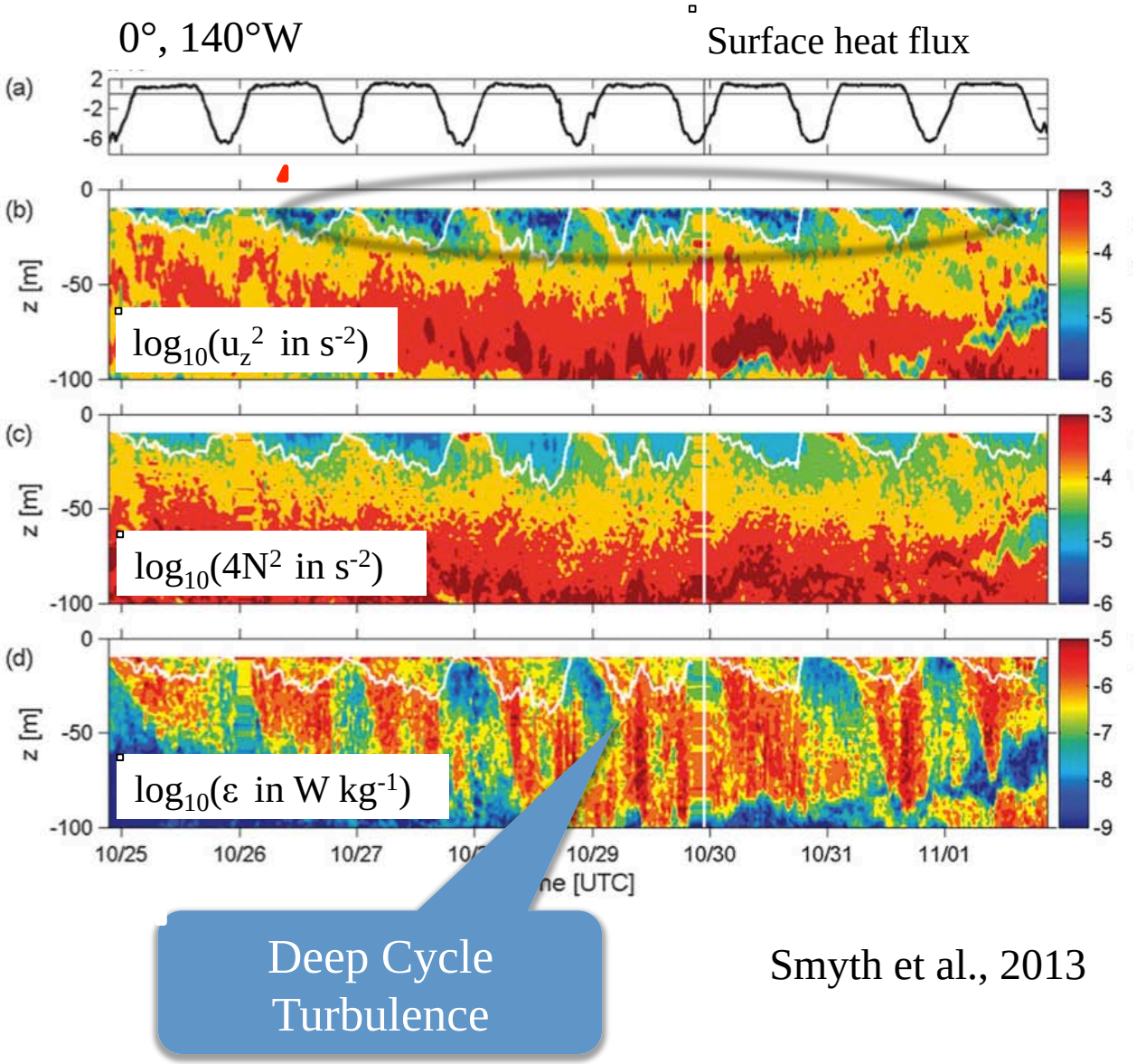
Mixed layer dynamics and the diurnal cycle in the equatorial Atlantic Ocean



Jacob O. Wenegrat and Michael J. McPhaden
University of Washington, Seattle
Pacific Marine Environmental Laboratory, NOAA, Seattle
wenegrat@uw.edu

Photo - http://eol.jsc.nasa.gov

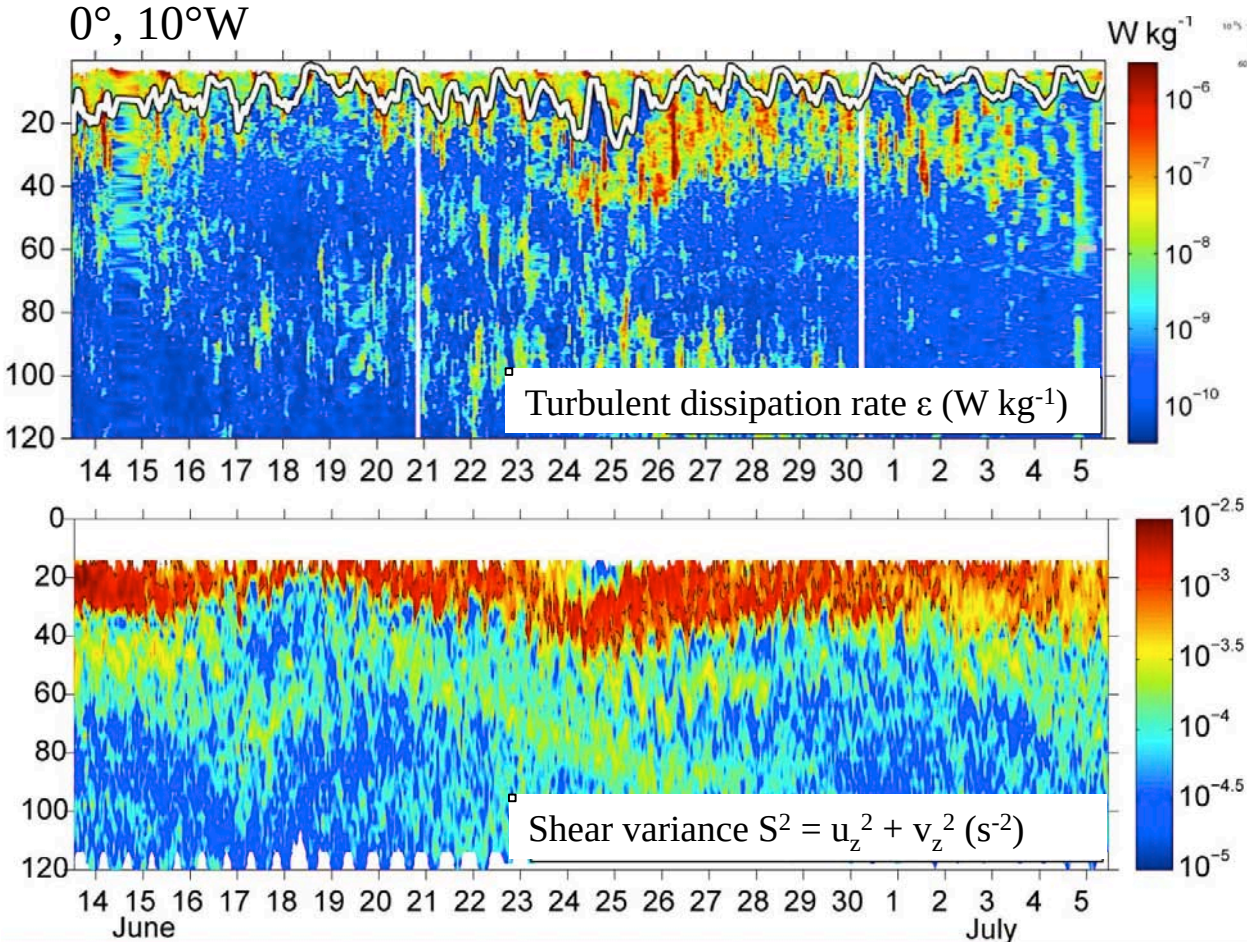
Deep Cycle Turbulence in the Equatorial Pacific



Smyth et al., 2013

- Diurnal stratification inhibits vertical transfer of momentum.
- Sheared diurnal jet.
- Descent of the diurnal shear layer can initiate deep cycle turbulence. [Smyth et. al, 2013]
- Large associated heat flux. [Moum et al. 2013]

Deep Cycle Turbulence in the Equatorial Atlantic?



- A similar deep cycle turbulence picture is emerging, but…
  [Hummels et al., 2013, 2014]
- Very sparsely sampled.

M. Dengler, Ocean Sciences Meeting 2014

Open issues in the equatorial Atlantic

Provide a description of the near-surface diurnal cycle in the equatorial Atlantic Ocean.

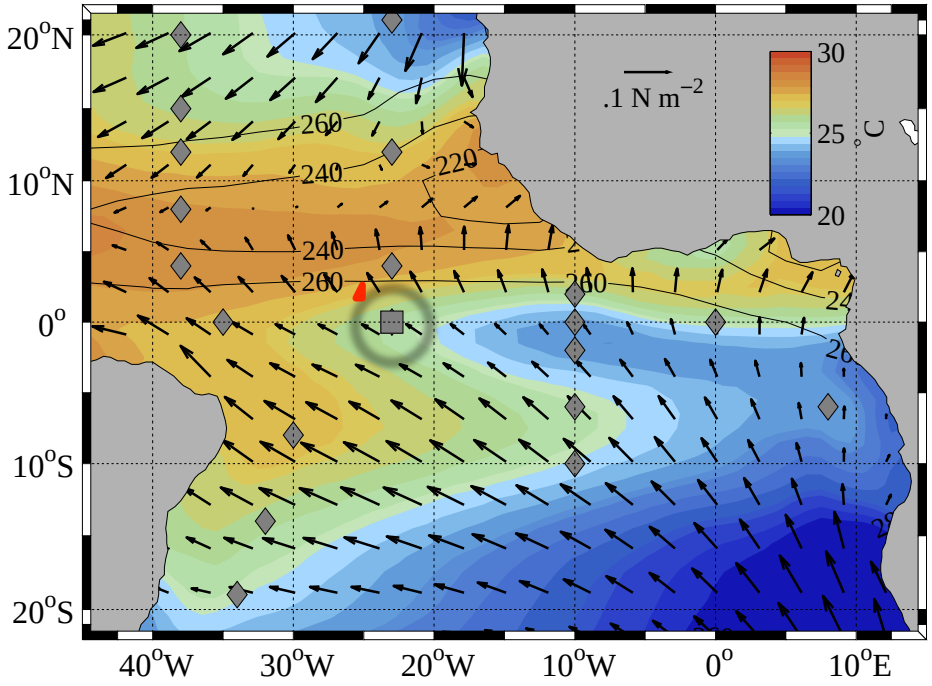
What is the role of ocean dynamics?

Do we observe descending diurnal shear layers?

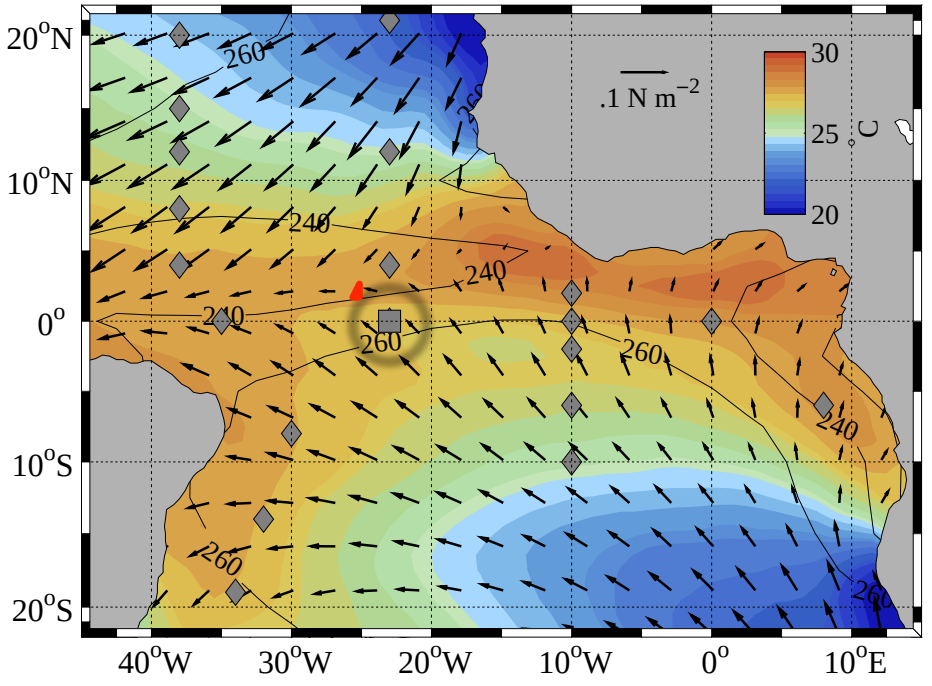
Is there evidence of deep-cycle turbulence in the central equatorial Atlantic?

Prediction and Research moored Array in the Tropical Atlantic - PIRATA

June/July/August



December/January/February

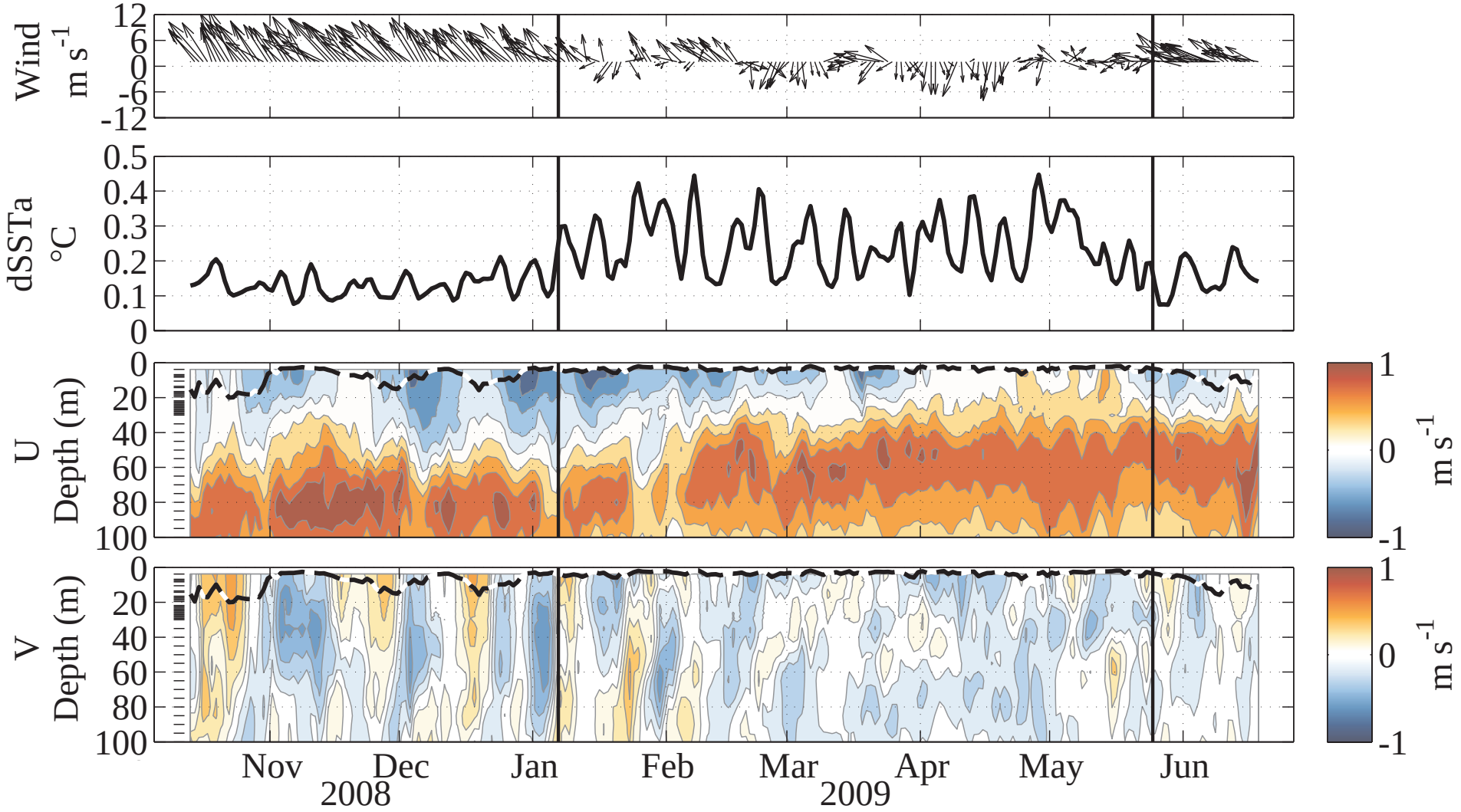


Subsurface Observations

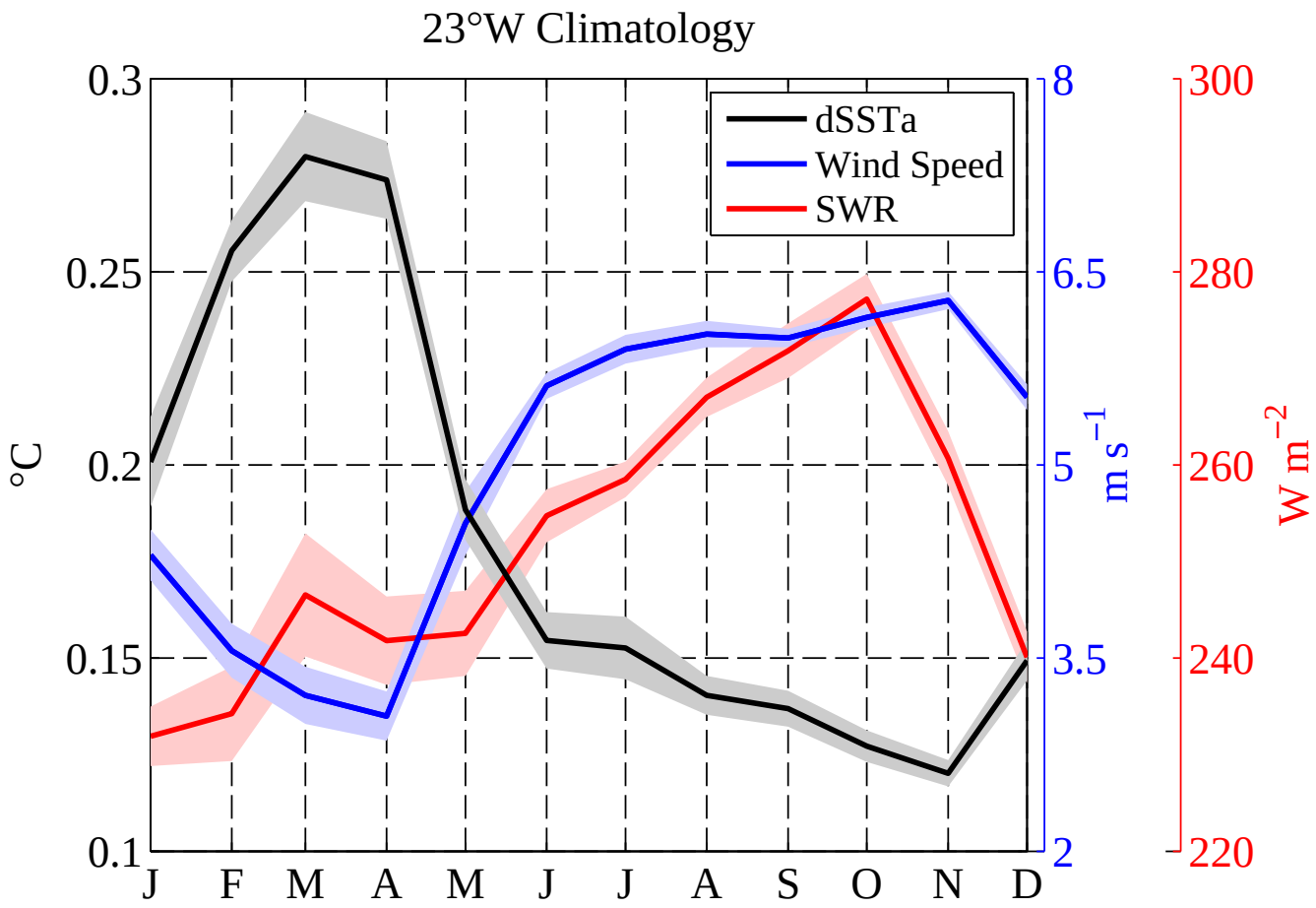
Observation	Depth (m)	Sampling Frequency
Temperature	1, 5, 10[b], 13[a], 20, 23[a], 40, 60, 80, 100, 120	10 minute
Salinity	1[b], 10[b], 20, 40, 60, 80, 100, 120	10 minute
600 kHz ADCP[a]	3.75 - 35 (0.75 m bins)[b]	Hourly (120×1 Hz ensemble)
150 kHz ADCP[a]	35 - 150 m (8 m bins)	Hourly (45×0.0125 Hz ensemble)

[a] Enhanced Monitoring Period

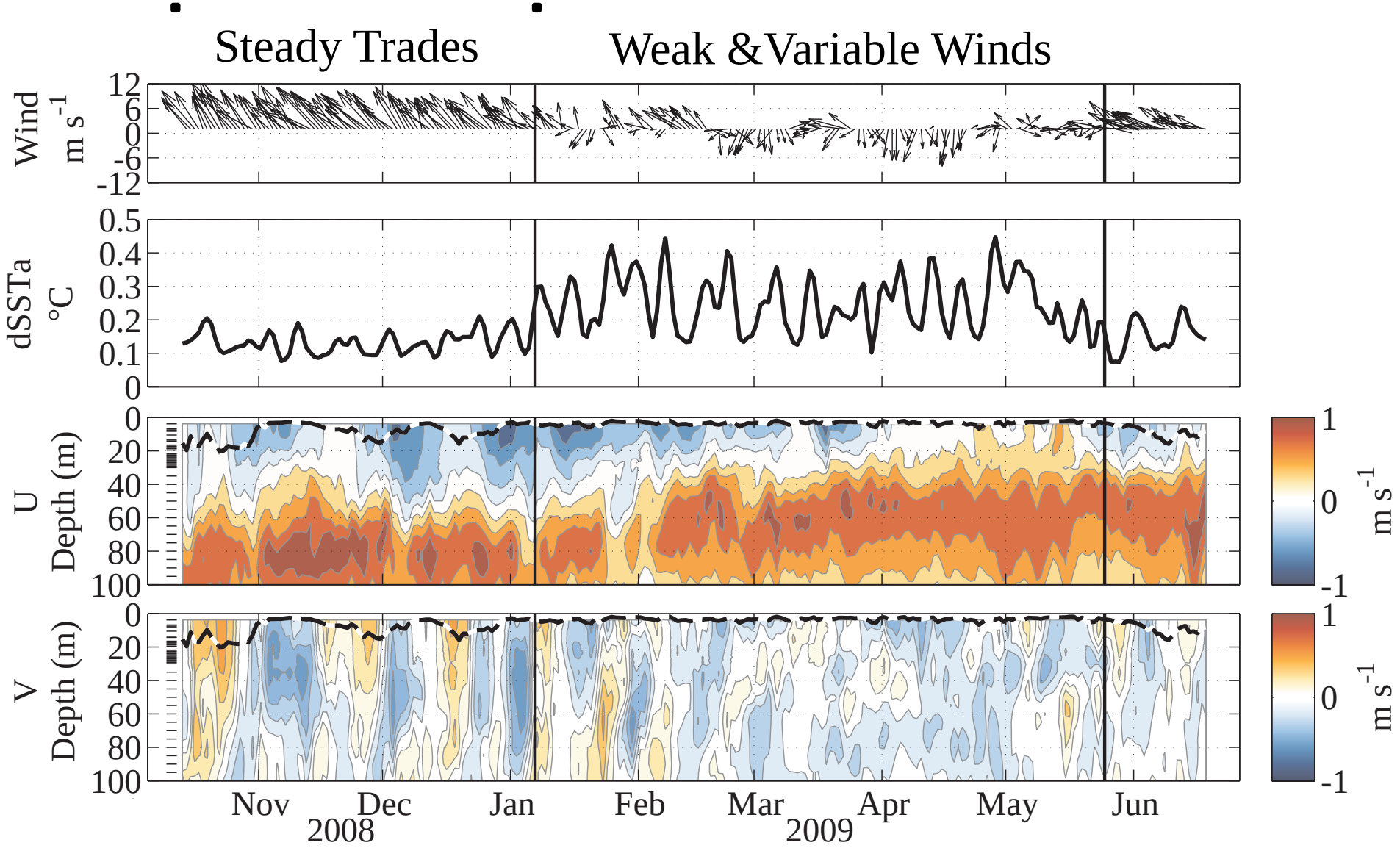
Overview of enhanced monitoring period



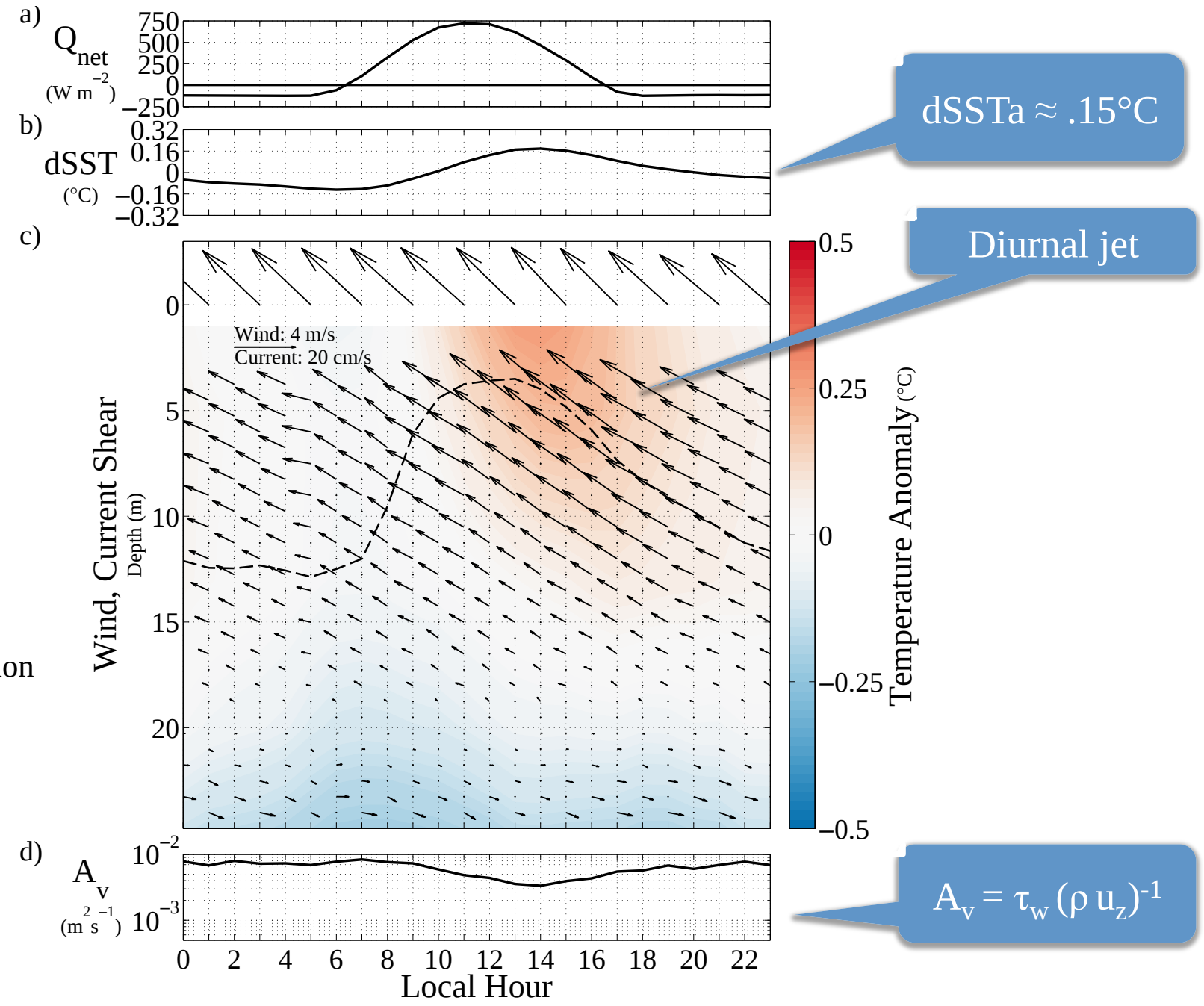
Climatology
1999-2014



Seasonal diurnal composites



Diurnal composite during steady trades

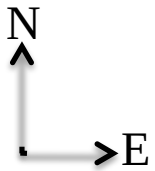


dSSTa ≈ .15°C

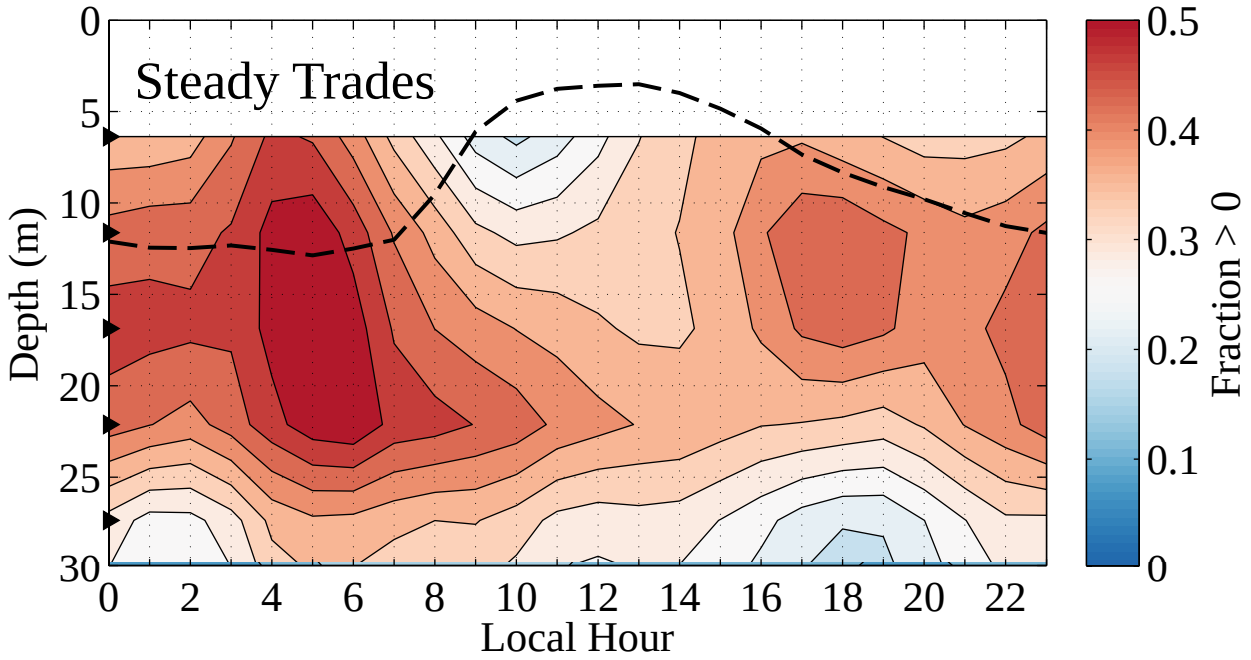
Diurnal jet

$A_v = \tau_w (\rho u_z)^{-1}$

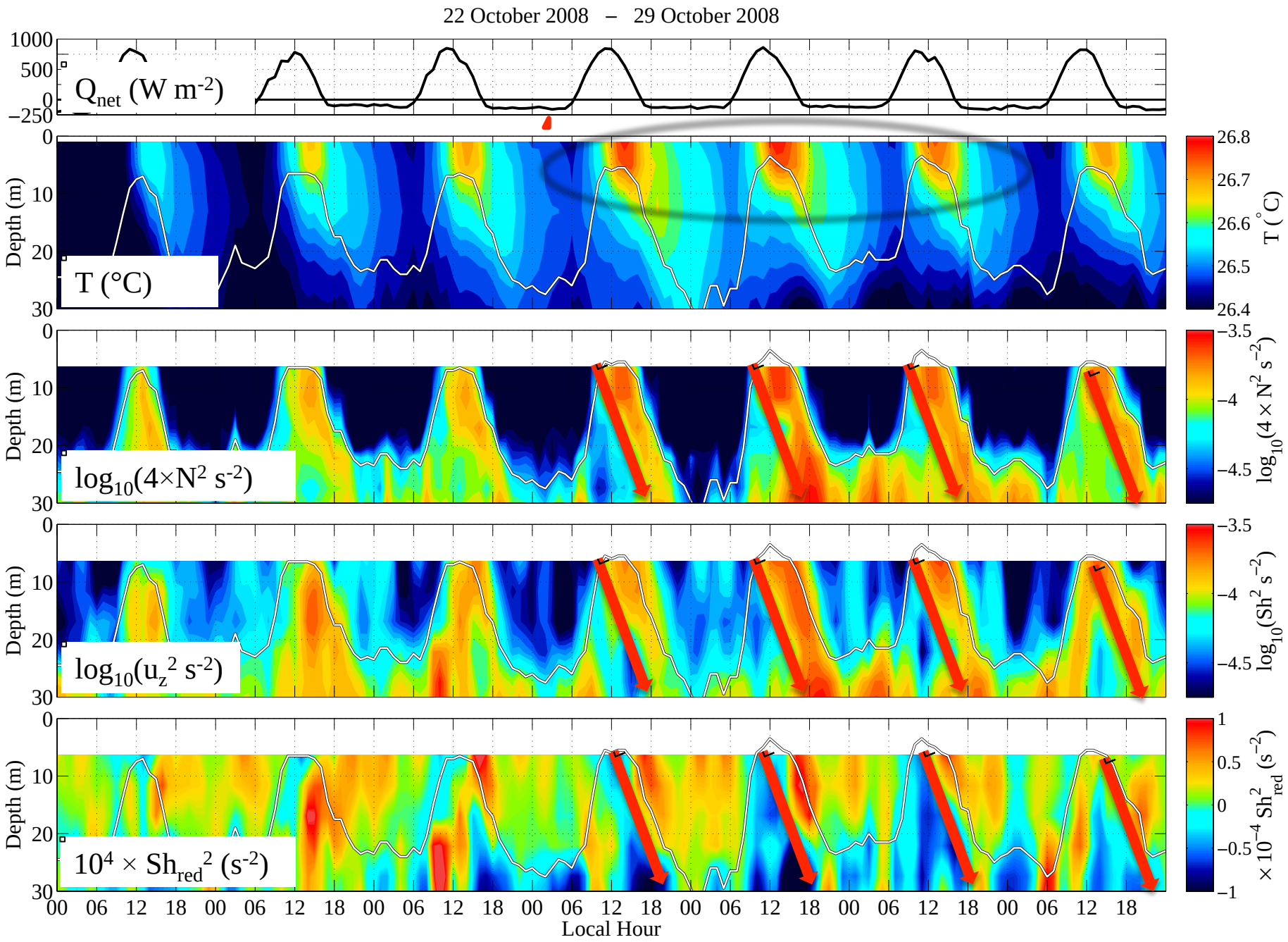
Vector Convention



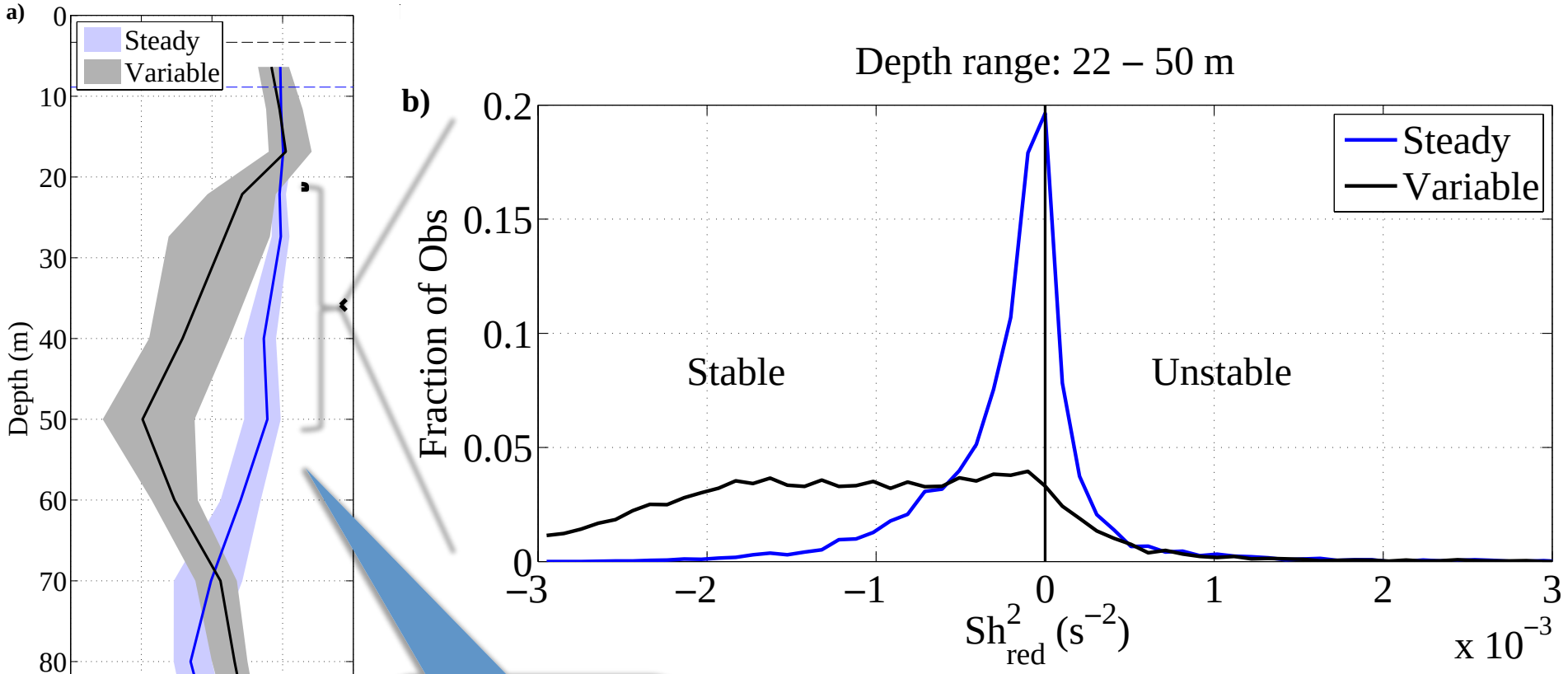
Diurnal cycle of stability: $Sh^2_{red} = u_z^2 - 4N^2$



Evidence of deep cycle turbulence?



Marginal Instability in the Atlantic



Evidence of seasonality in deep cycle of turbulence

Estimated turbulent dissipation rates:
Steady Trades: $\varepsilon \sim 10^{-6} – 10^{-7}$ W kg^{-1}
Variable Winds: $\varepsilon \sim 10^{-7} – 10^{-8}$ W kg^{-1}

[Using, Kunze et al., 1990, over the layer MLD + 20 - 50 m]

Summary of the diurnal cycle at 0°, 23°W

High resolution velocity observations provide a unique view into the dynamics of the near-surface equatorial Atlantic.

Ocean dynamic response is critical on diurnal timescales, and mixing controls the diurnal SST anomaly.

Descending diurnal shear layers are a regular feature during steady trade wind conditions, associated with subcritical Ri numbers.

Marginal instability and estimates of ε, indicate deep-cycle turbulence, comparable to the Pacific.

Wenegrat, J.O., and M.J. McPhaden, 2015: Dynamics of the surface layer diurnal cycle in the equatorial Atlantic Ocean (0°, 23°W), *J. Geosphys. Res.*, 120, 563–581, doi: 10.1002/2014JC010504.