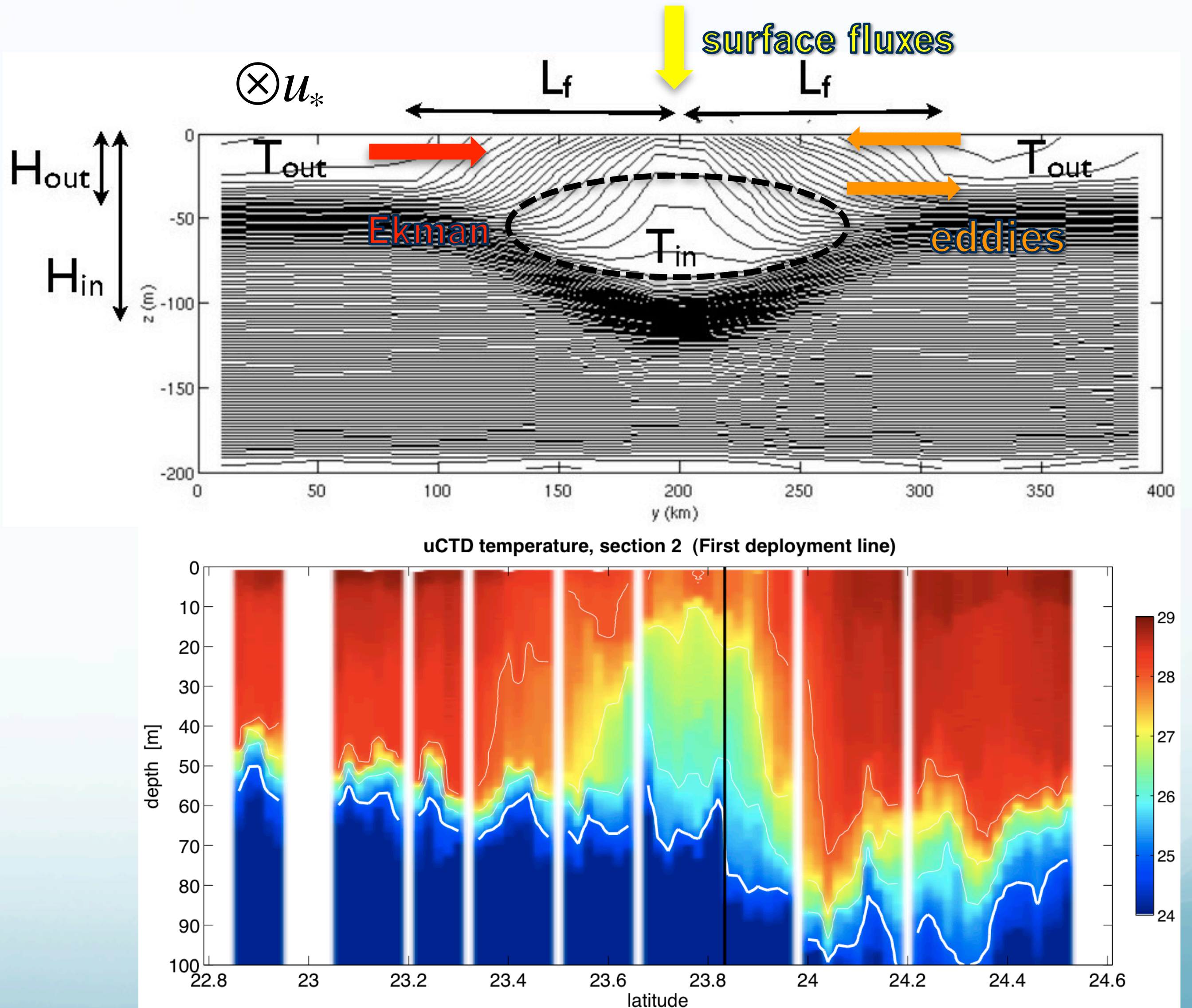
Hurricane Wake Restratification Mechanisms

Haney S.[1,2], B. Fox-Kemper[1,2], S. Bachman[1,2], B. Cooper[1], S. Kupper[1], K. McCaffrey[1,2], L. Van Roekel[2,3], S. Stevenson[1,2,4], A. Webb, R. Ferrari[5]

1. University of Colorado, Boulder, CO
2. Cooperative Institute for Research in Earth Sciences (CIRES), Boulder, CO
3. Northland College, Northland, WI
4. University of Hawaii Honolulu, HI
5. Massachusetts Institute of Technology, Cambridge, MA

How does a wake warm back up?

- **Goal:** make simple scalings for 1D, 2D, and 3D processes that restratify cold hurricane wakes.
- Scalings depend on readily available observations from satellites, profiling floats, and reanalysis data.
- Scalings for both the thin surface layer and for the sub-surface bolus are derived.



A cross section of the Typhoon Fanapi wake temperature. Image courtesy of Dr. Steve Jayne and the ITOP Group.

Surface Scalings

$$\tau_{Ekman} = K_1 \frac{fH_{out}L_f}{u_*^2}$$

$K_1 = 2$

Ekman buoyancy fluxes
(Thomas & Ferrari, 2008)

$$\tau_{SF} = K_2 H_{out}$$

$K_2 = \frac{\rho C_p}{\lambda} \sim 1\left(\frac{days}{m}\right)$

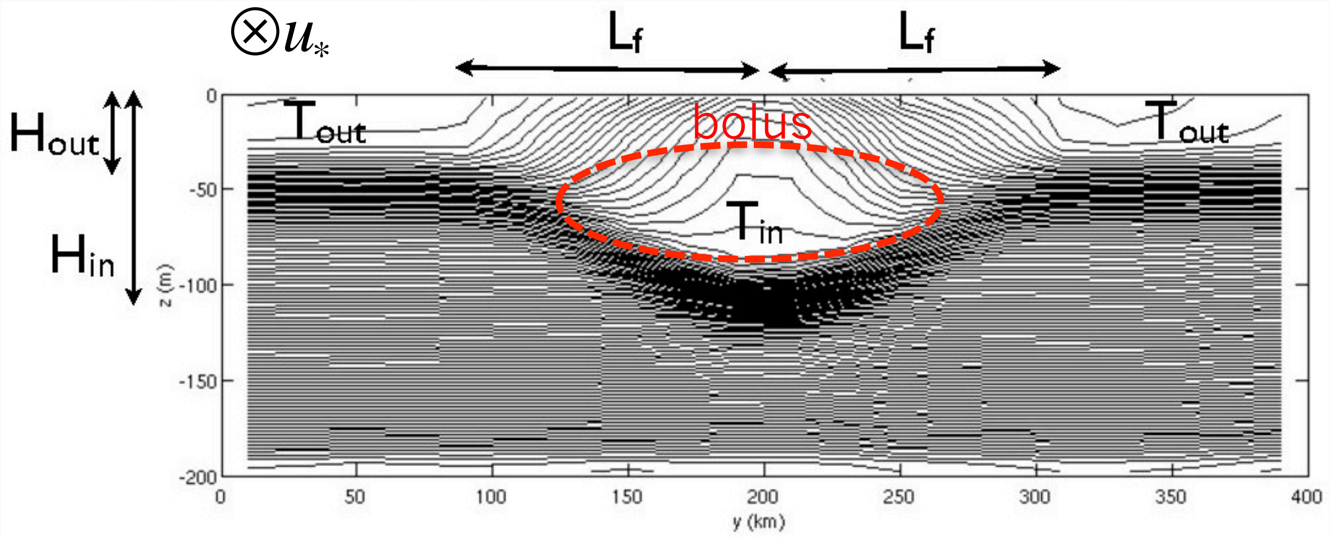
surface, and penetrating solar
buoyancy fluxes
(Price et al., 2008, Kraus & Turner, 1967)

$$\tau_{eddy} = K_3 \frac{L_f^2 \left|f\right|}{H_{out}\Delta T}$$

$K_3 = \frac{0.2 C_e}{g\alpha} \sim 6\left(\frac{s^2 K}{m}\right)$

eddy buoyancy fluxes
(Fox-Kemper & Ferrari, 2008)

Sub-Surface Bolus Scalings



$$\tau_{sb} = K_4 \frac{(H_{in} - H_{out})\Delta T}{\int_{-H_{in}}^{-H_{out}} \left(I_1 e^{k_1 z} + I_2 e^{k_2 z} \right) dz}$$

$$K_4 = \frac{\rho C_p}{S_0}$$

solar in the sub-surface bolus

$$\tau_{eb} = K_5 \frac{L_f^2 |f|}{\Delta T \left(H_{in} - H' \right)}$$

$$K_5 = \frac{1}{7.11 C_e g \alpha}$$

eddies in the sub-surface bolus

Ekman buoyancy fluxes are fastest

Surface Timescales

Cyclone	τ_{Ekman} (days)	τ_{SF} (days)	τ_{eddy} (days)
Frances	6	30	525
Igor	2	26	287
Katrina	2	15	163

Sub-Surface Bolus Timescales

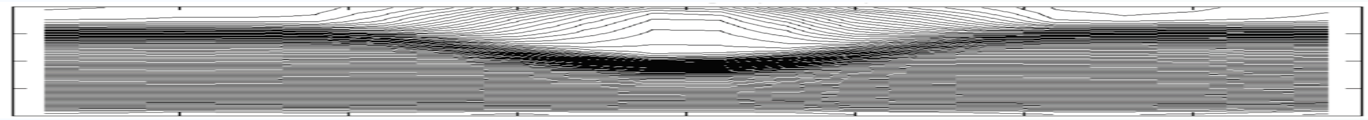
Cyclone	τ_{eb} (days)	τ_{sb} (days)
Frances	122	435,000
Igor	39	325,000
Katrina	23	1,650

Who Wins Under What Conditions?

surface fluxes beat wind

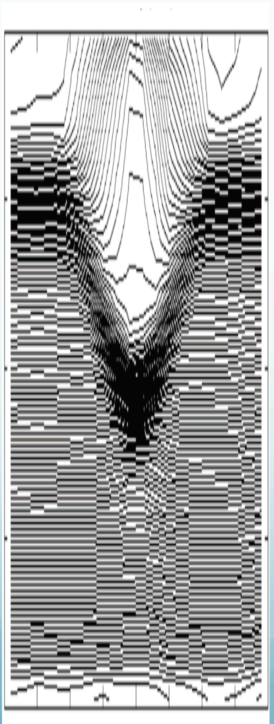
$$\frac{\tau_{Ekman}}{\tau_{SF}} = \frac{K_1}{K_2}\frac{fL_f}{u_*^2} > 1$$

$\otimes u_*$



eddies beat surface fluxes

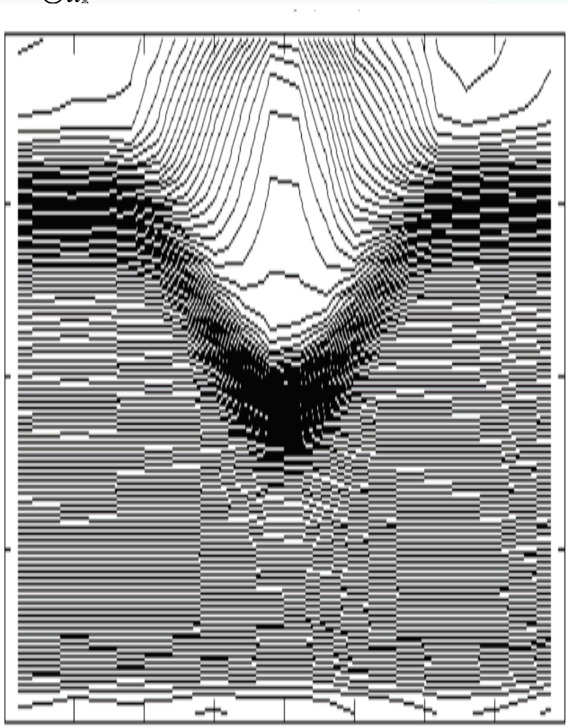
$\otimes u_*$



$$\frac{\tau_{SF}}{\tau_{eddy}} = \frac{K_2}{K_3}\frac{H^2 \Delta T}{L_f^2 f} > 1$$

eddies beat wind

$\otimes u_*$



$$\frac{\tau_{Ekman}}{\tau_{eddy}} = \frac{K_1}{K_3}\frac{H^2 \Delta T}{L_f u_*^2} > 1$$

Conclusions

- Restratification by Ekman buoyancy fluxes is the fastest mechanism in the thin surface layer for the wakes considered
- Restratification by eddy buoyancy fluxes is the fastest in the subsurface bolus.
- In the subsurface bolus restratification is generally slower, so temperature anomalies will persist
- Who wins may easily change if L_f, H, ΔT, u_*, f change
- Eddies are particularly sensitive to H and L_f.

References

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