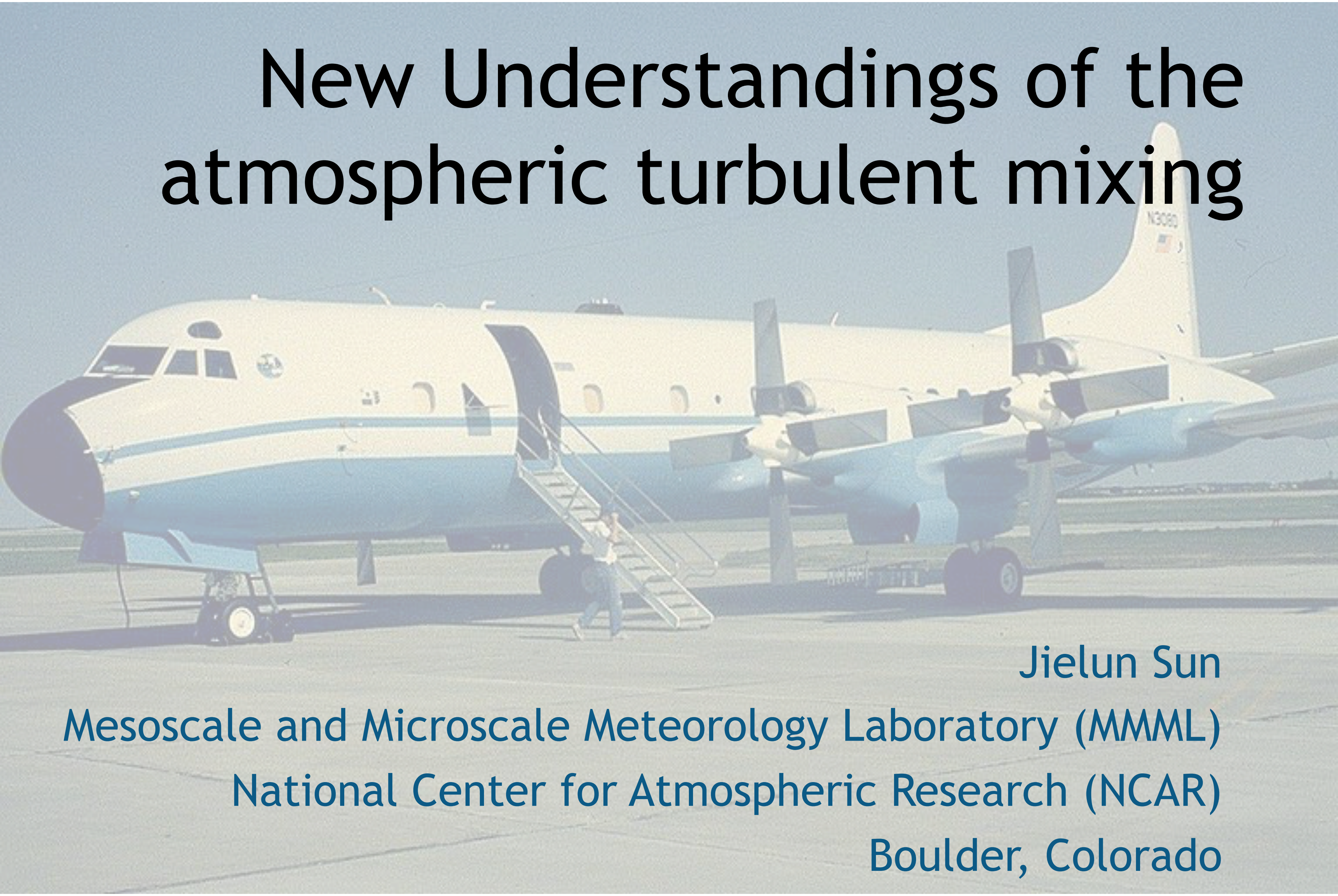

New Understandings of the atmospheric turbulent mixing

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What I learned from BOREAS

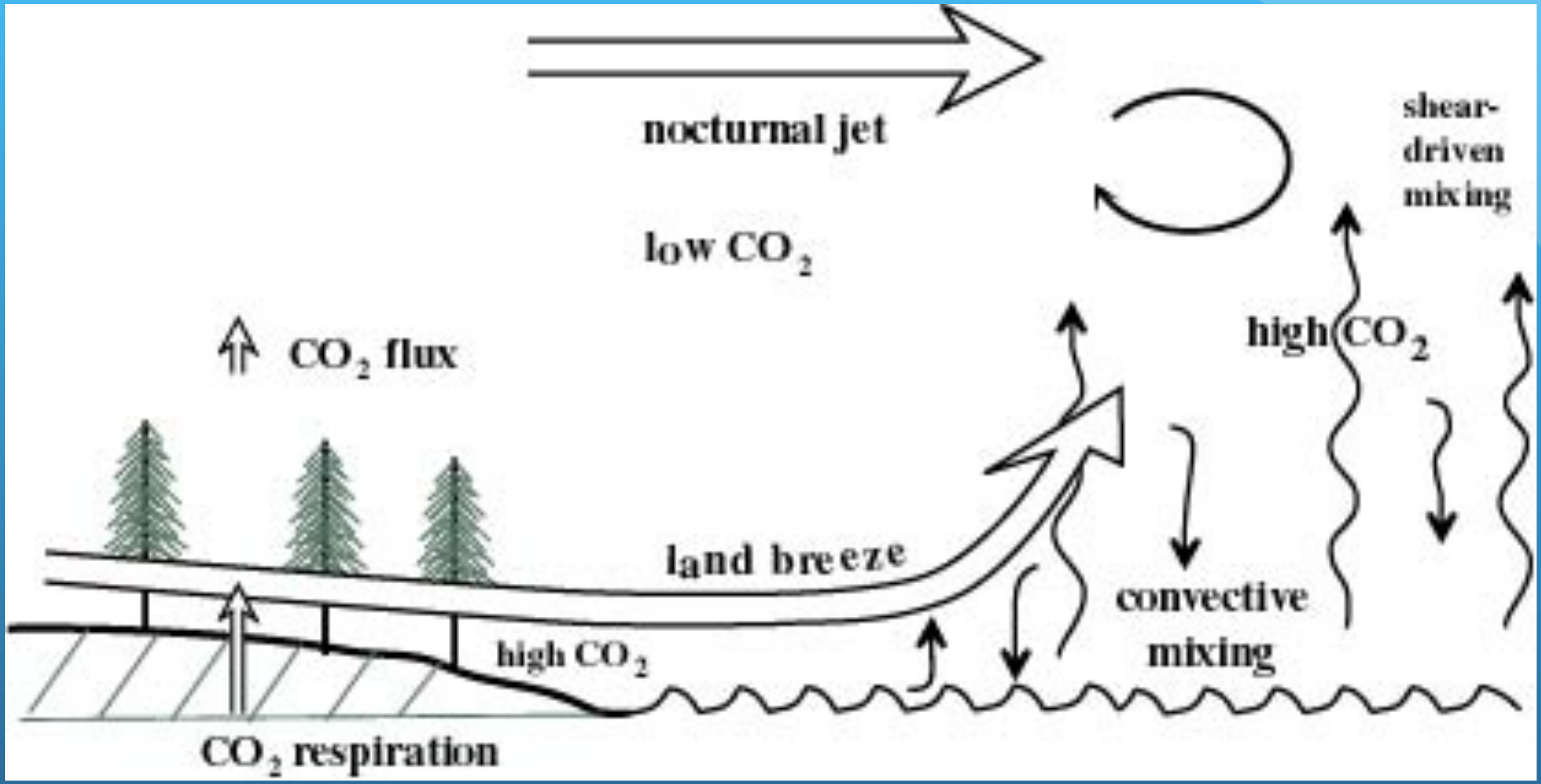
- The first CO_2 advection experiment (nighttime CO_2 chimney)
- skin temperature vs. aerodynamic temperature

New Understandings of the atmospheric turbulent mixing

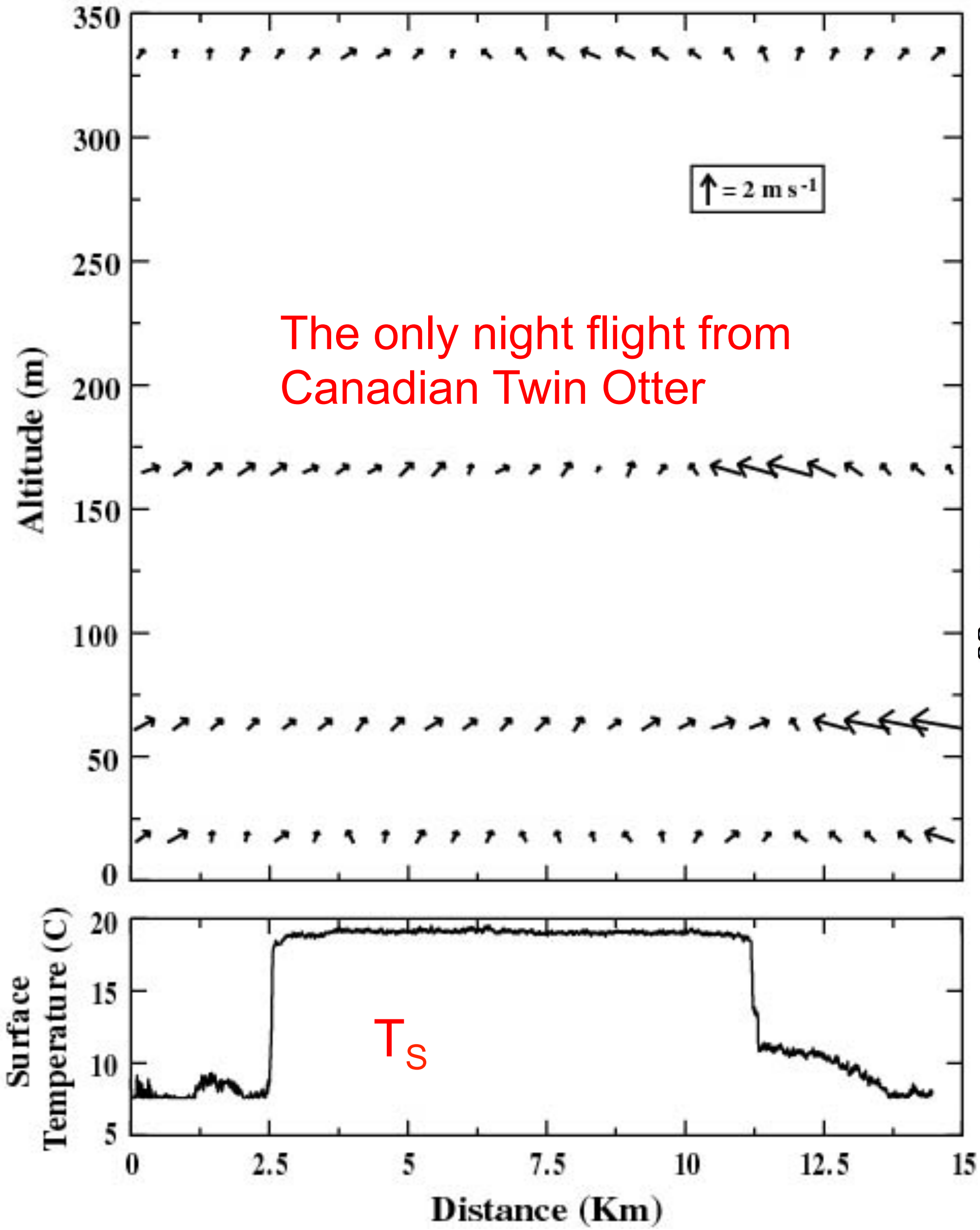
- Molecular diffusion vs. turbulent mixing
- MOST vs HOST

1. CO_2 advection

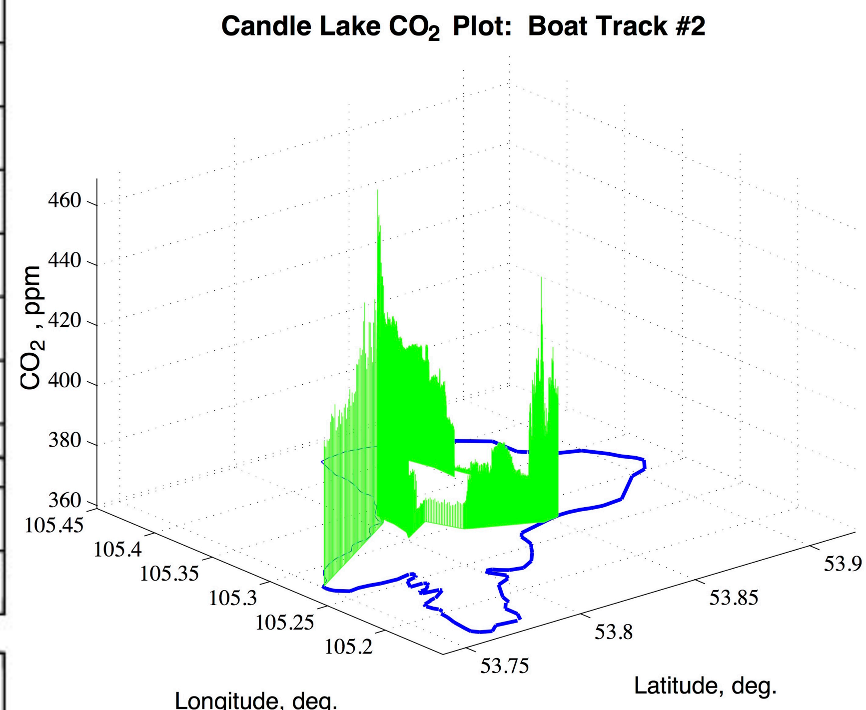
Sun, Desjardins, Mahrt, MacPherson (1998, JGR)



Marc Aubinet just won the award for outstanding achievement in biometeorology "for significant contributions,... to apply the eddy covariance method to atmosphere-biosphere interactions and to the problem of advection"

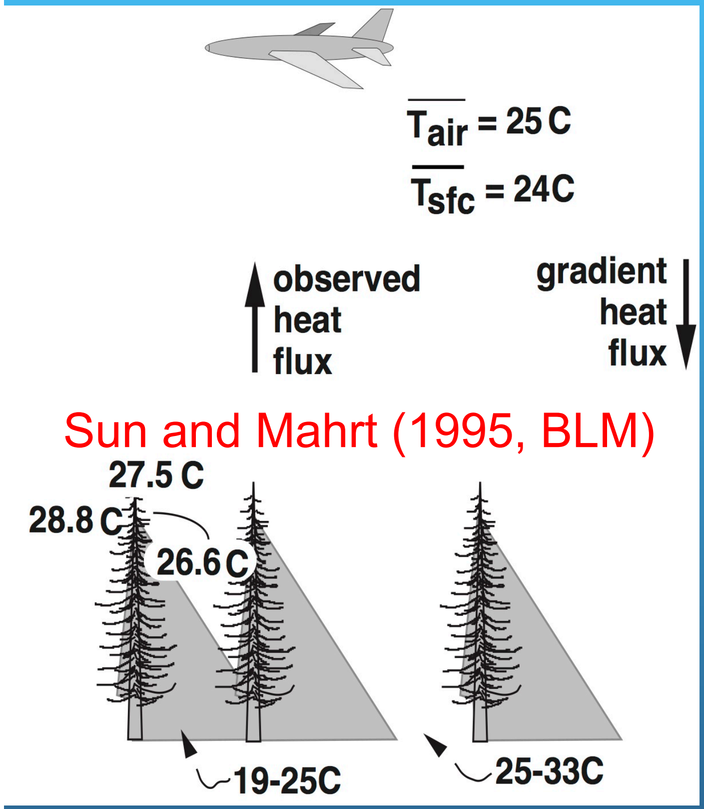


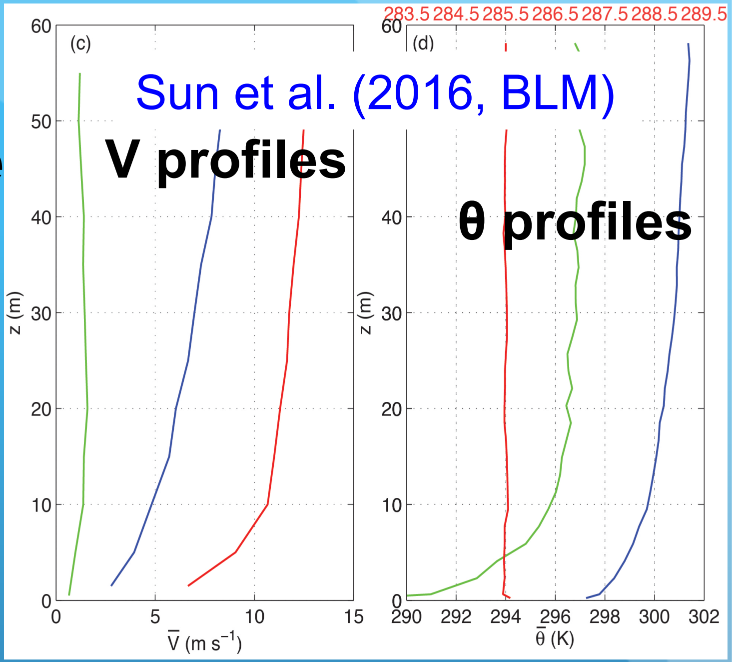
350
300
250
200
150
100
50
0
Altitude (m)
= 2 m s-1
The only night flight from
Canadian Twin Otter
20
15
10
5
Surface
Temperature (C)
T_S
0
2.5
5
7.5
10
12.5
15
Distance (Km)



Candle Lake CO2 Plot: Boat Track #2
460
440
420
400
380
360
CO2 , ppm
105.45
105.4
105.35
105.3
105.25
105.2
Longitude, deg.
53.75
53.8
53.85
53.9
Latitude, deg.

2. Surface skin temperature vs. aerodynamic temperature



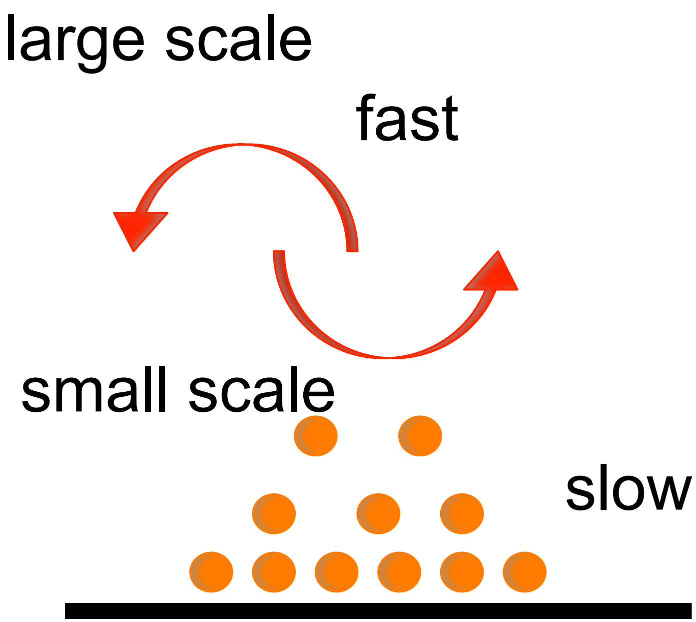


$H=C_hV(T_a-T_0)$ ✔

$H=C_hV(T_a-T_s)$ ✗

Using the skin temperature (T_s) in parameterization of H can lead to the run-away cooling

Molecular diffusion vs. turbulent mixing (1)

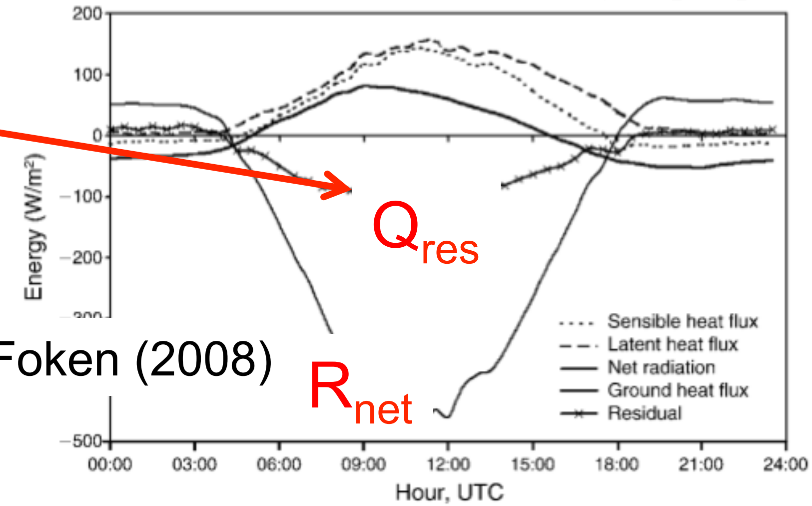


turbulent mixing (MOST-
Monin-Obukhov similarity theory)

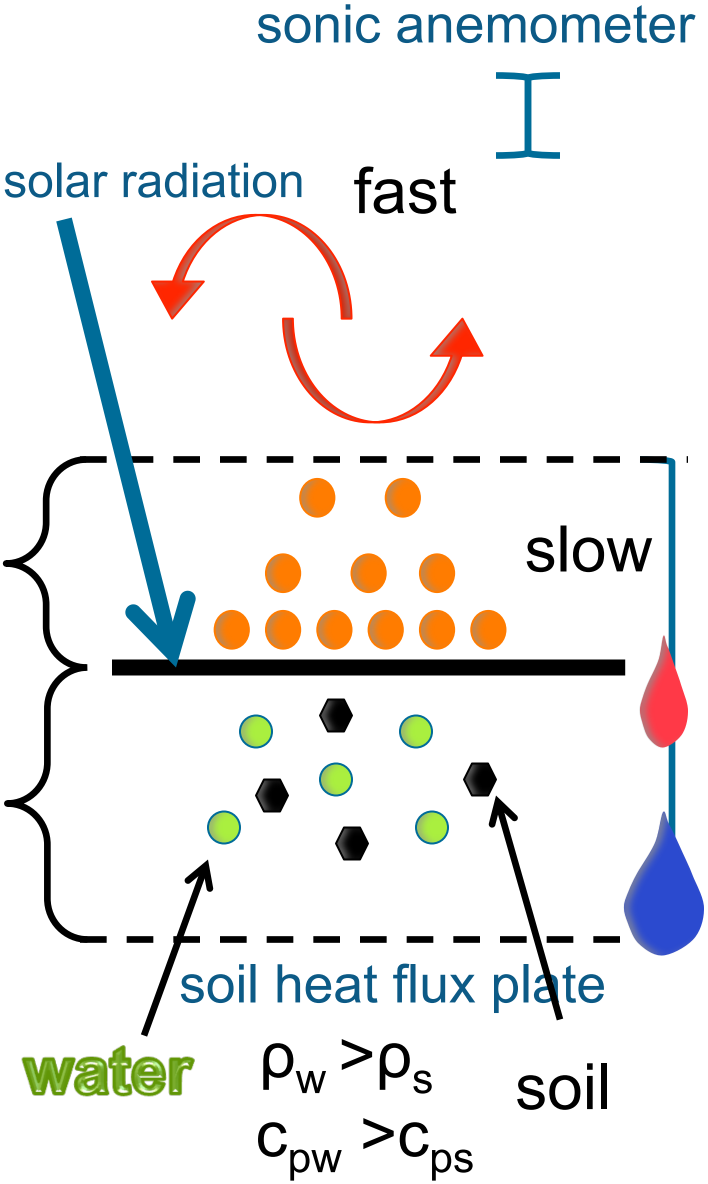
molecular diffusion

Molecular diffusion vs. turbulent mixing (2)

surface energy imbalance



Foken (2008)



total energy conservation

$$c_p\, dT/dt + dE_k/dt = Q + v dp/dx + \varepsilon_T$$

momentum conservation

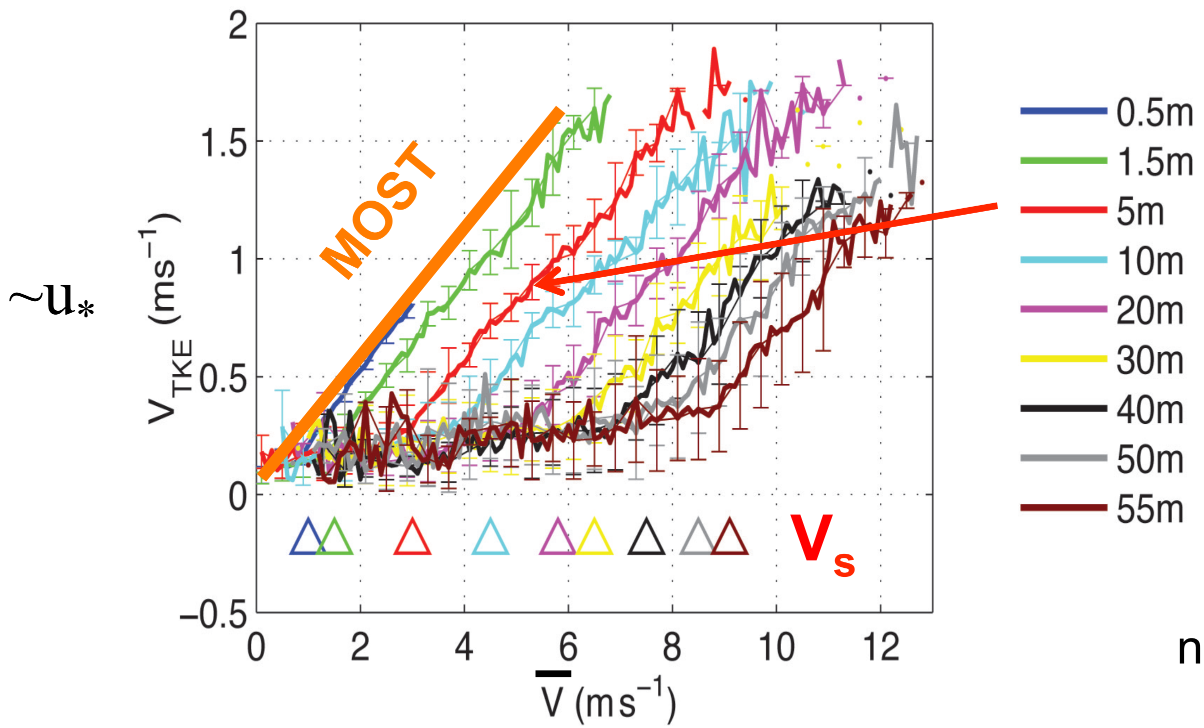
$$c_p\, dT/dt + \varepsilon = Q$$

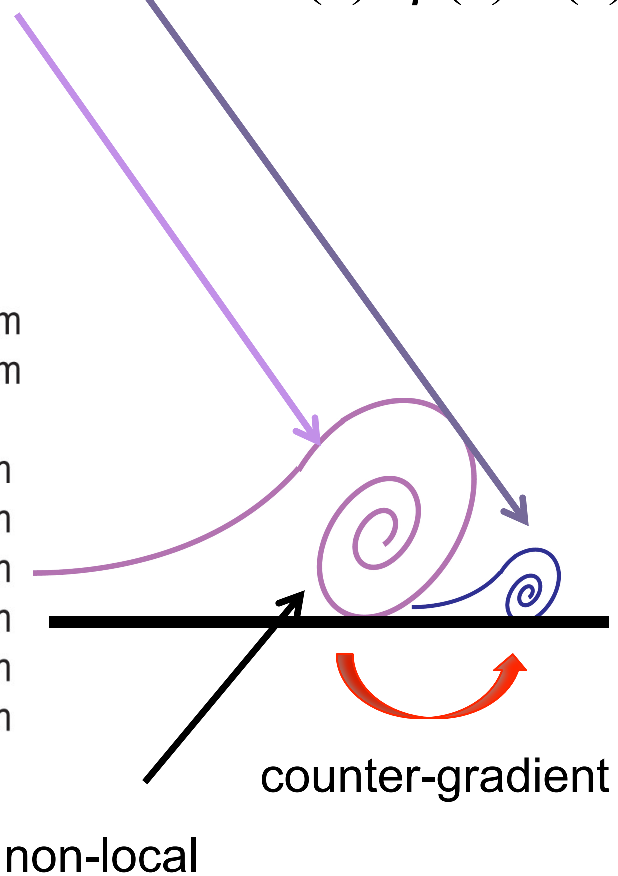
Surface energy balance involves the thermal energy balance associated with radiation and molecular diffusion only

turbulent mixing near the surface

$$u_* = |\overline{w'V'}|^{1/2} \sim \delta V/\delta z \begin{cases} \delta z \rightarrow 0,\ \partial V/\partial z & \textbf{MOST} \quad u_* \sim V(z)\ f(Ri,z) \\ \delta z = [0,z],\ [\frac{\partial V}{\partial z},\ \frac{V}{z}] & \textbf{HOST} \quad u_* \sim \alpha(z) + \beta(z) V(z) \end{cases}$$

HOckey-Stick Transition (HOST)

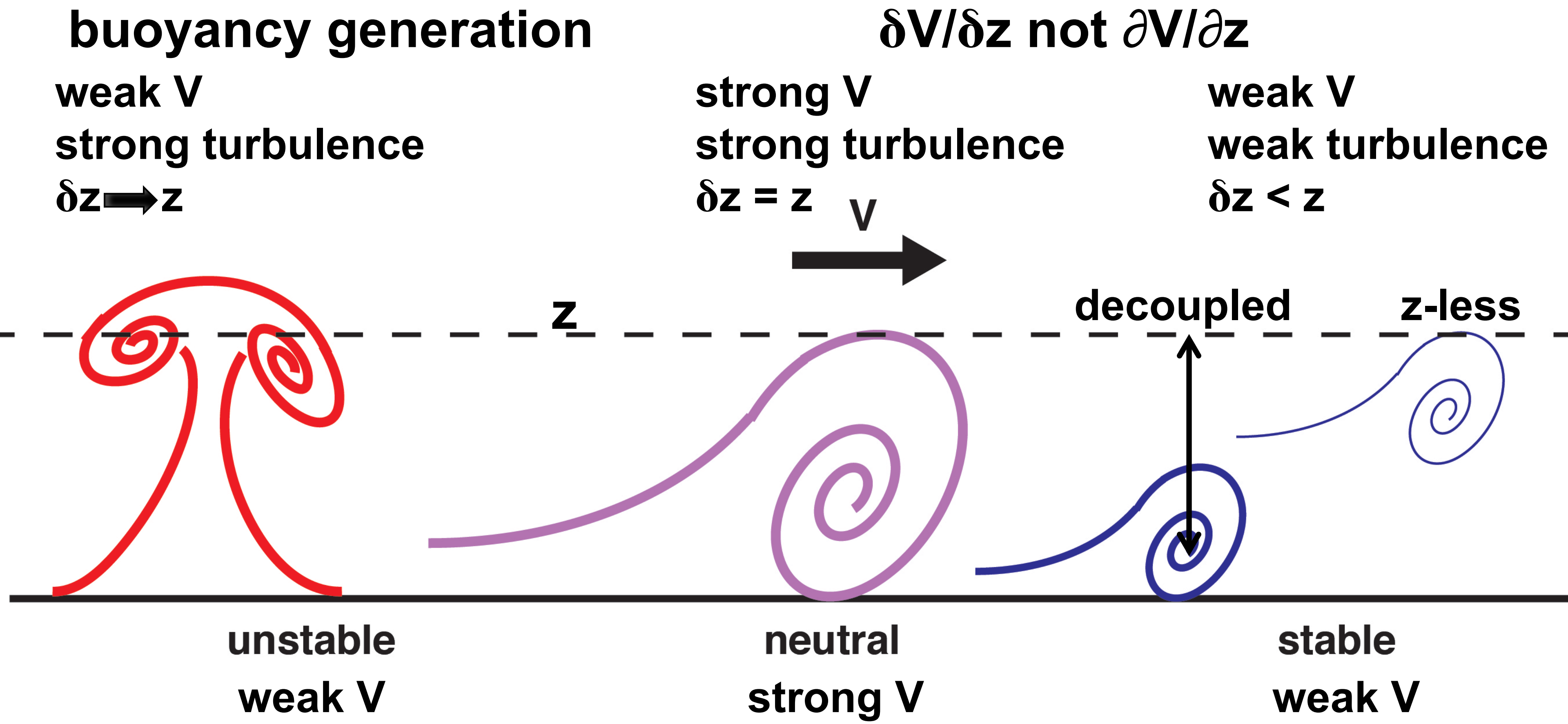




Sun et al. (2012)

HOST hypothesis:

1. turbulence generation is on a finite scale, δz
2. turbulence intensity is determined by the TKE and TPE partition as well as turbulence generation in the δz layer



summary

- **Need to understand aerodynamics (turbulent mixing, air-land interaction) in order to scale up from leaf to regions.**
- **New understandings of turbulent mixing (large coherent eddies controlled by the energy conservation) will shed light on how to keep track trace gases in the atmosphere-ecosystem interaction.**