Chinaflux第十五次通量观测理论与技术培训

Eddy Covariance Experiment

Applications, Design, and Site Selection

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Topics will be covered

1. Eddy covariance applications
2. Concept of flux footprint and fetch requirement
3. Designing and implementation of EC experiment
    - Tower height
    - Location of the tower

Applications

- Climate change research

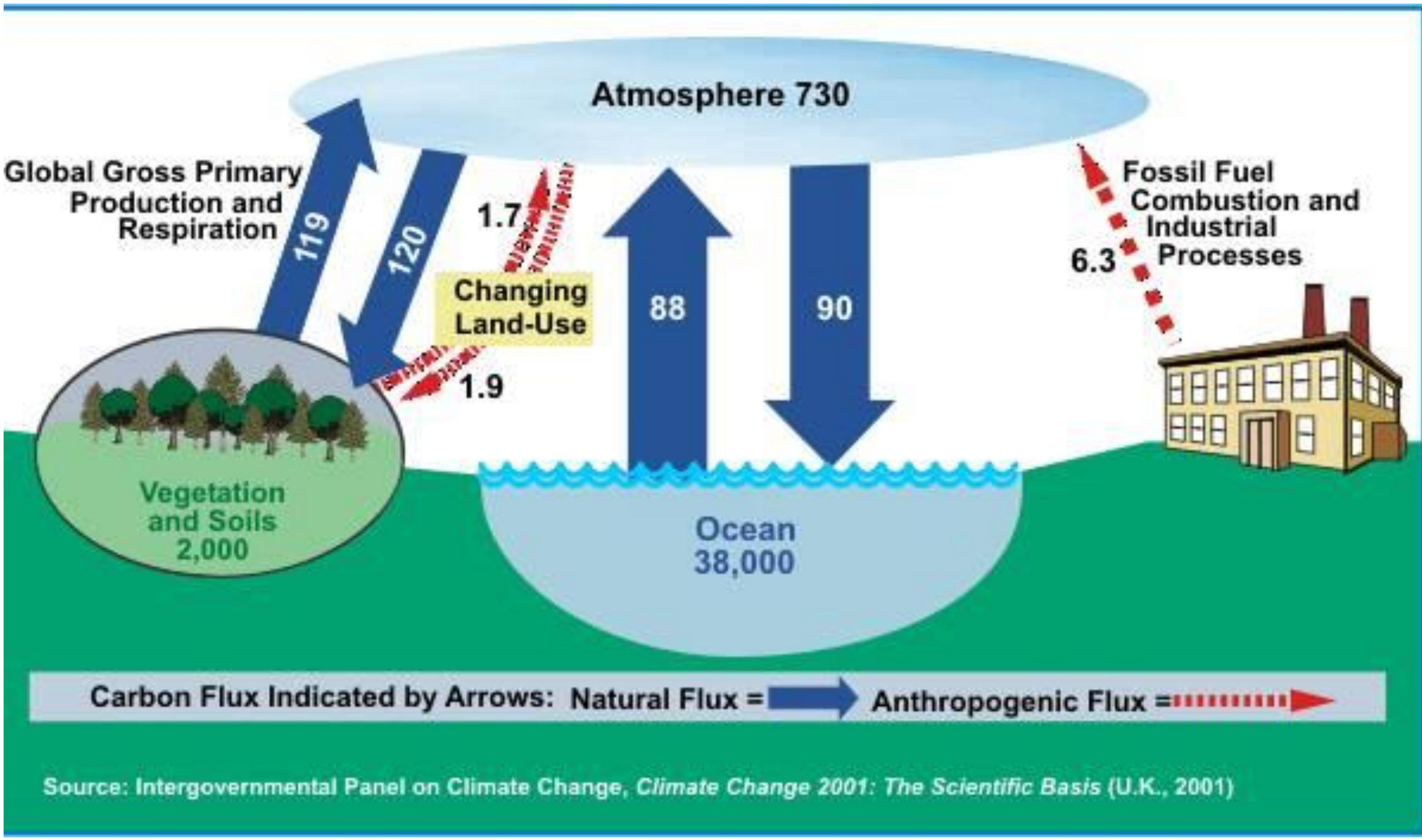
  Global Carbon Cycle

- Agricultural applications

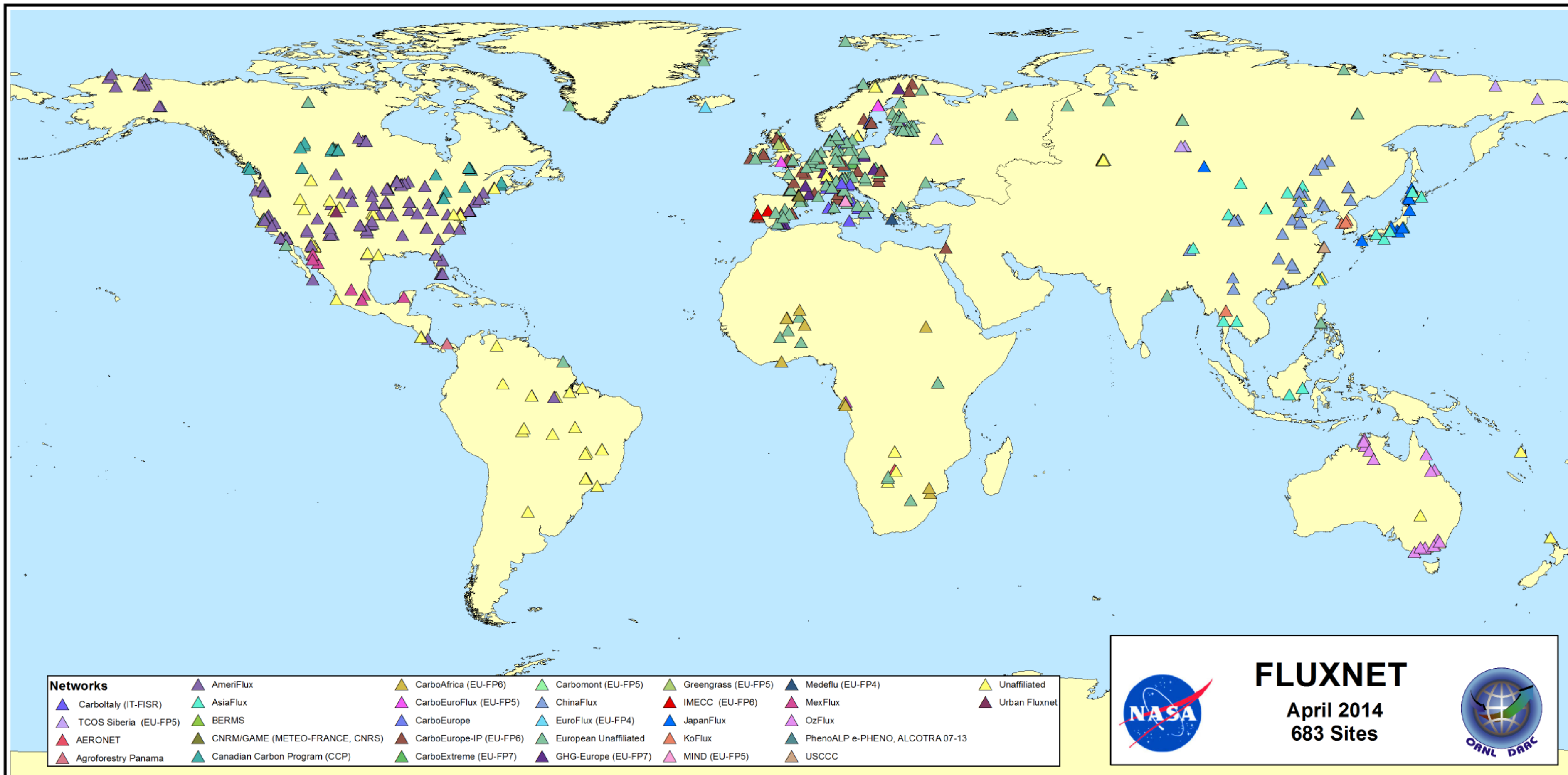
  Other GHG fluxes, N_2O, CH_4, $^{13}CO_2$ etc

- Industrial applications

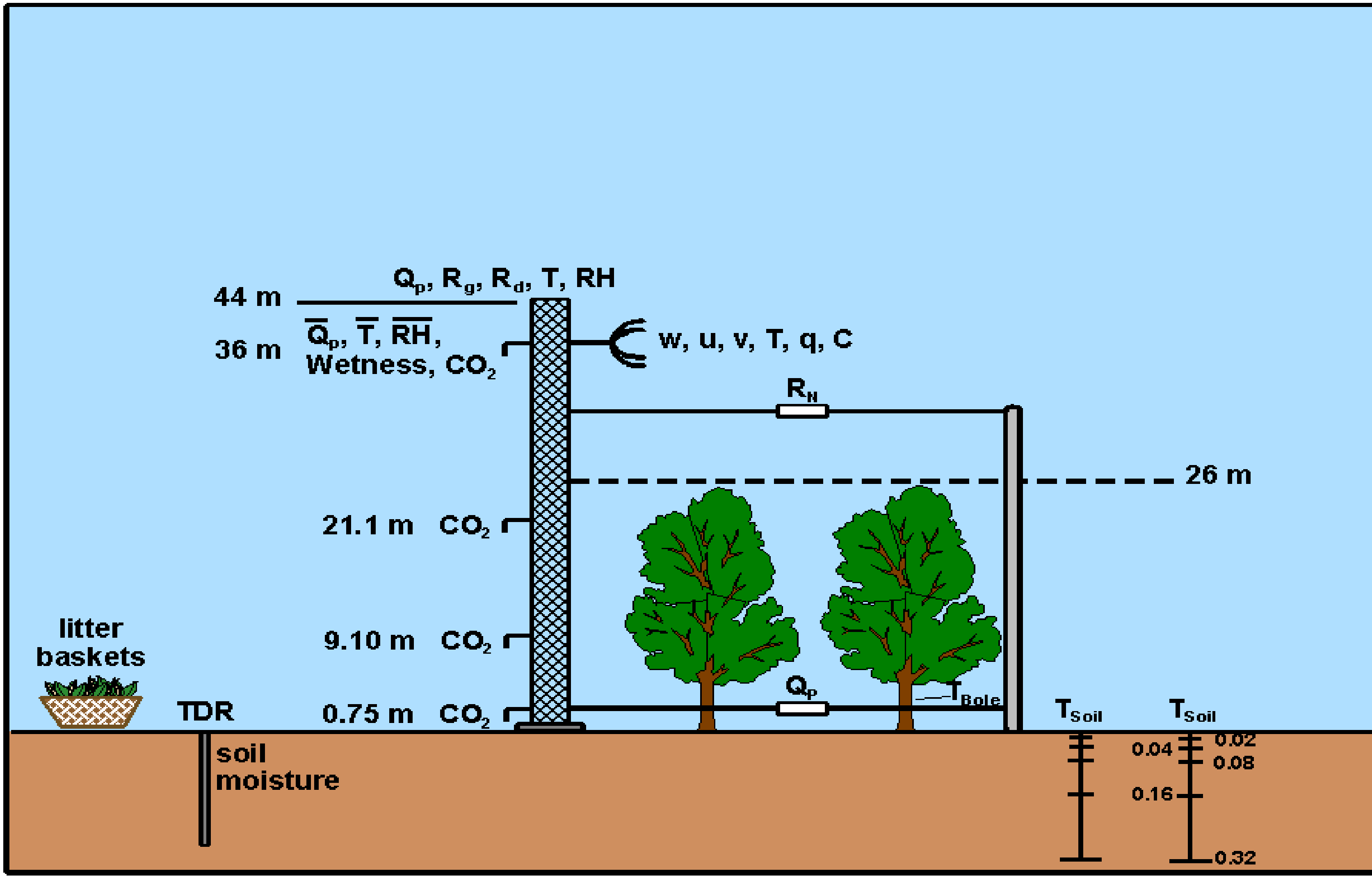
Global Carbon Cycle



Ecology, Carbon Cycle



Typical setting for a flux station



ET or *NEE* = f (precipitation, temperature, soil moisture, *VPD*, radiation, diffuse radiation, *LAI*, vegetation type, etc.,)

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model validation, ground truth for remote sensing

Flux Footprint Concept

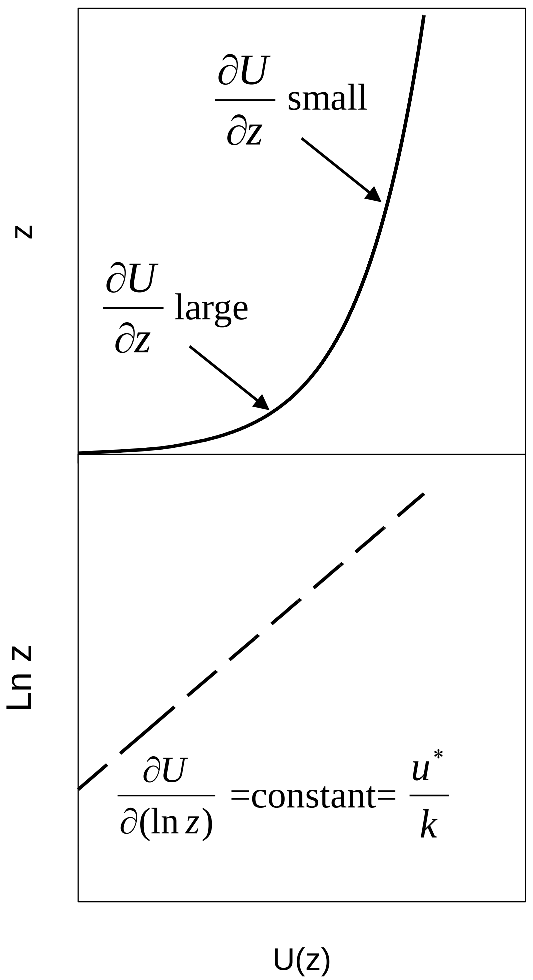
For

EC Experiment Design

Friction Velocity – *u**

Typical wind profile

Smooth surface and neutral stability



$$U_{(z)} = \frac{u^*}{k}\ln\frac{z}{z_0}$$

$U_{(z)}$ – horizontal wind speed at z

u* - friction velocity $u^* = \sqrt{-\overline{u'w'}}$

k – von Karman constant (0.41)

z – height

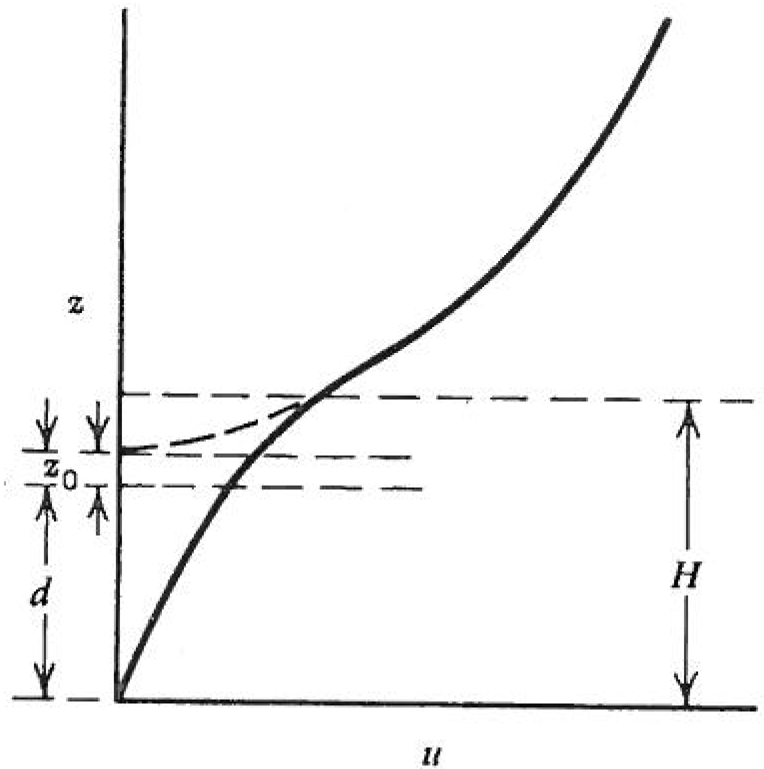
z_o – roughness length

Roseberg, et al., 1983, Microclimate: The Biological Environment

Friction Velocity – *u**

Typical wind profile

-Rough surface and neutral stability



$$U_{(z)} = \frac{u^*}{k} \ln \frac{z-d}{z_0}$$

$U_{(z)}$ – horizontal wind speed at z

u* - friction velocity

k – von Karman constant (0.41)

z – height

z_o – roughness length

d – zero plane displacement, (d ≈ 0.66 h)

H– canopy height

Roseberg, et al., 1983, Microclimate: The Biological Environment

Atmosphere Stability, Richardson number R_i

$$R_i = \frac{\frac{g}{\bar{\theta}}\frac{\partial\bar{\theta}}{\partial z}}{(\frac{\partial\bar{u}}{\partial z})^2}$$

$\frac{\partial\bar{\theta}}{\partial z} > 0$ R_i>0; stable

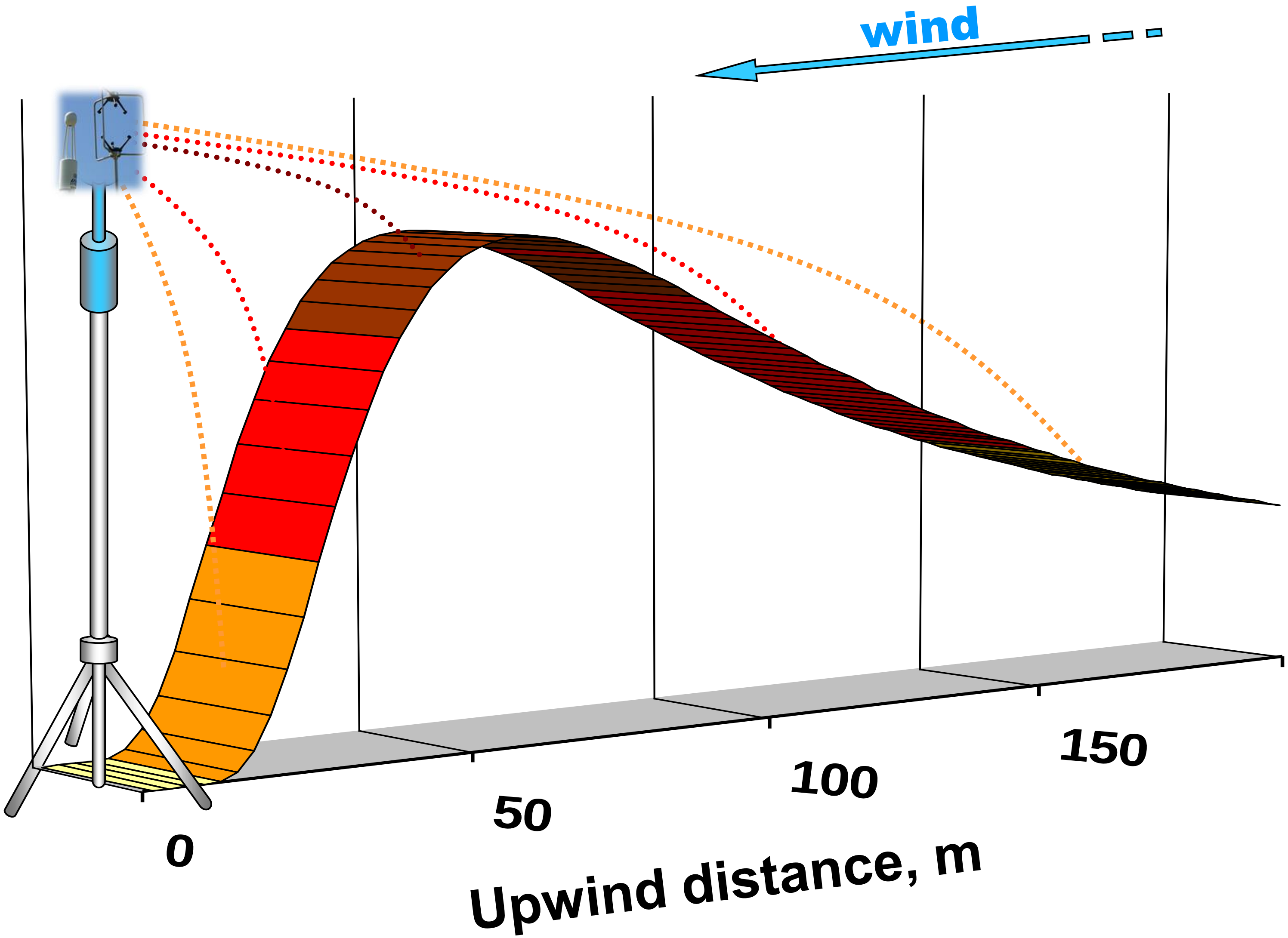
$\frac{\partial\bar{\theta}}{\partial z} = 0$ R_i=0; neutral

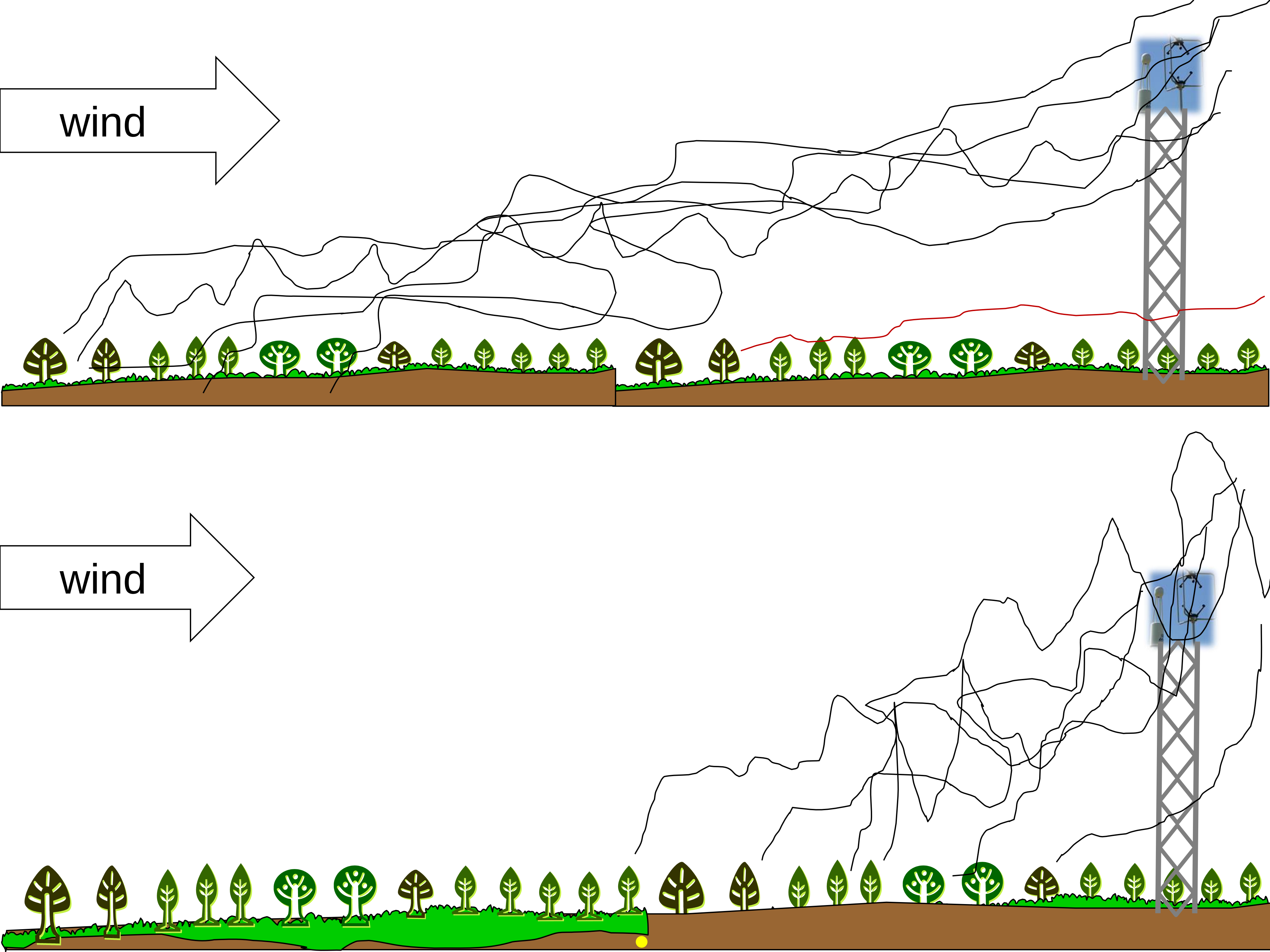
$\frac{\partial\bar{\theta}}{\partial z} < 0$ R_i<0; unstable

θ is potential temperature

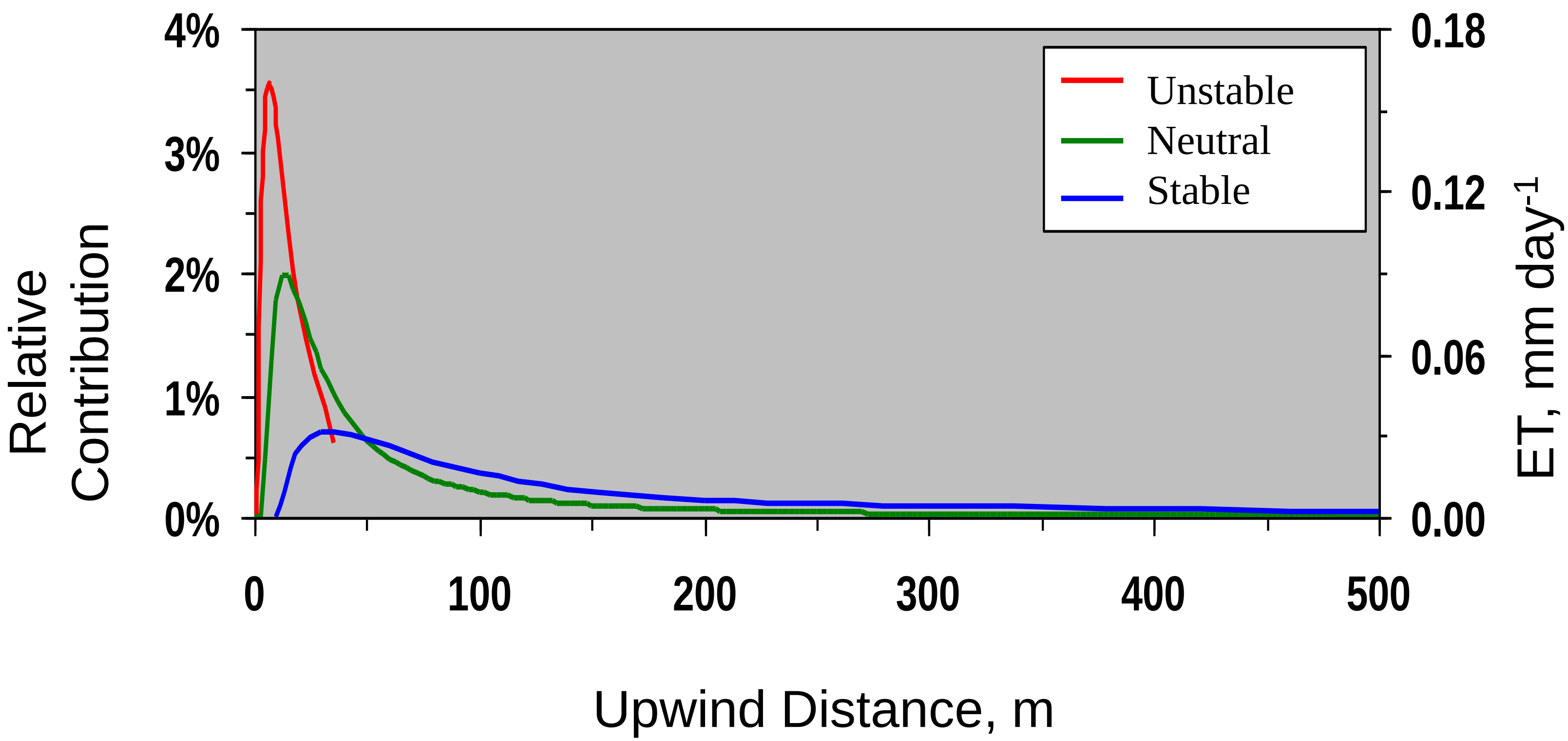
Fetch Requirement

The footprint is defined as the relative contribution at different location (in the upwind direction) to the measured vertical flux




wind
wind

Instrument height 1.5 m, and canopy height 0.6 m



Adopted from Leclerc and Thurtell (1990)

For near-neutral conditions:

$$CNF(x_L) = -\int_0^{x_L} \frac{U(z-d)}{u_* k x^2} e^{-\frac{U(z-d)}{u_* k x}} dx = e^{-\frac{U(z-d)}{u_* k x_L}}$$

CNF is Cumulative Normalized contribution to Flux measurement, %
x_L is distance from the tower, m
U is mean integrated wind speed, m s^{-1}
z is measurement height, m
u_* is friction velocity, m s^{-1}
d is zero plain displacement, m
k is von Karman constant (0.4)

$$U^* = \sqrt{-\overline{u'w'}}$$

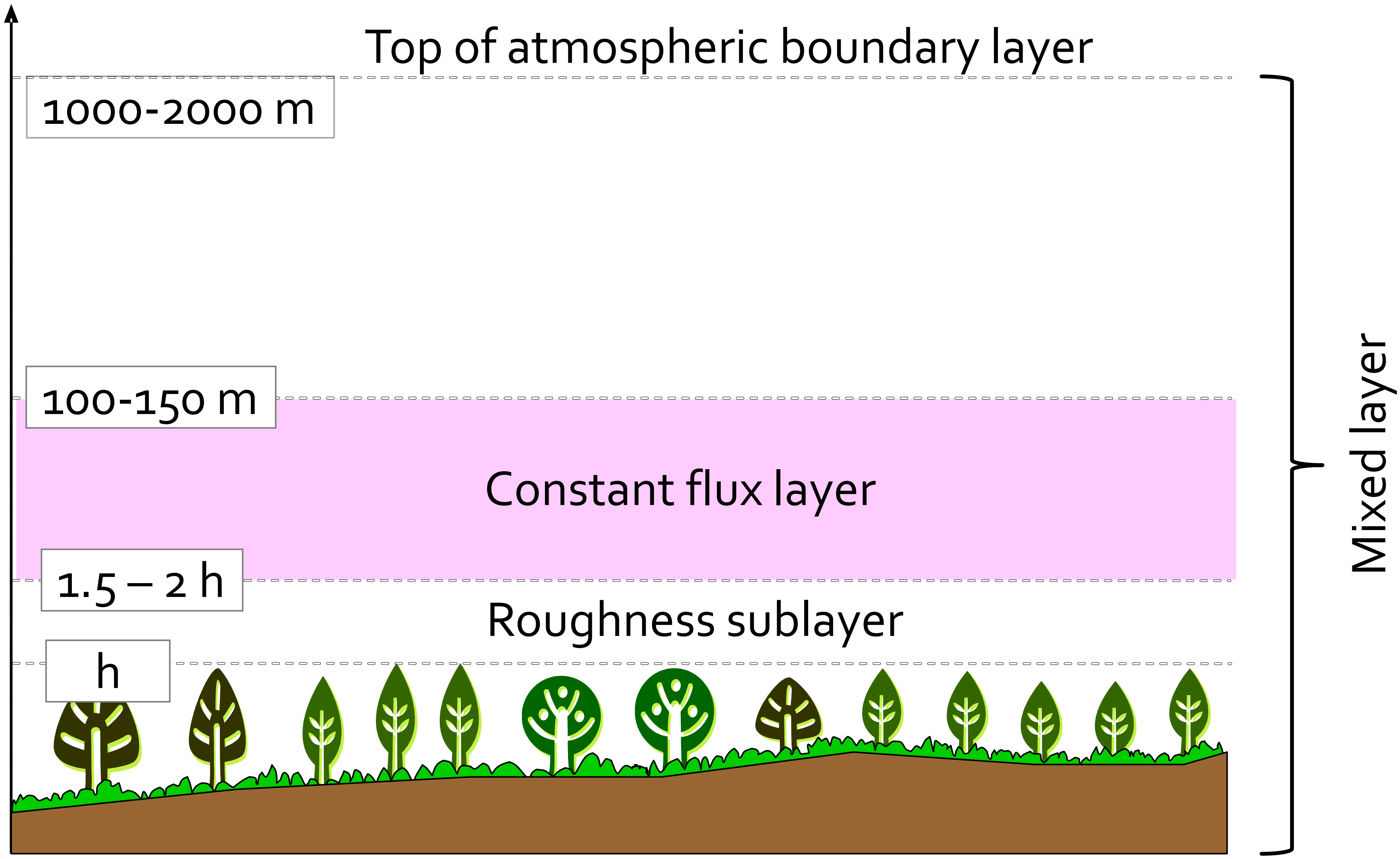
Schuepp, P.H., Leclerc, M.Y., Macpherson, J.I., and R.L. Desjardins (1990)
'Footprint prediction of scalar fluxes from analytical solution of the diffusion equation'

Flux Footprint Depends on:

Measurement height

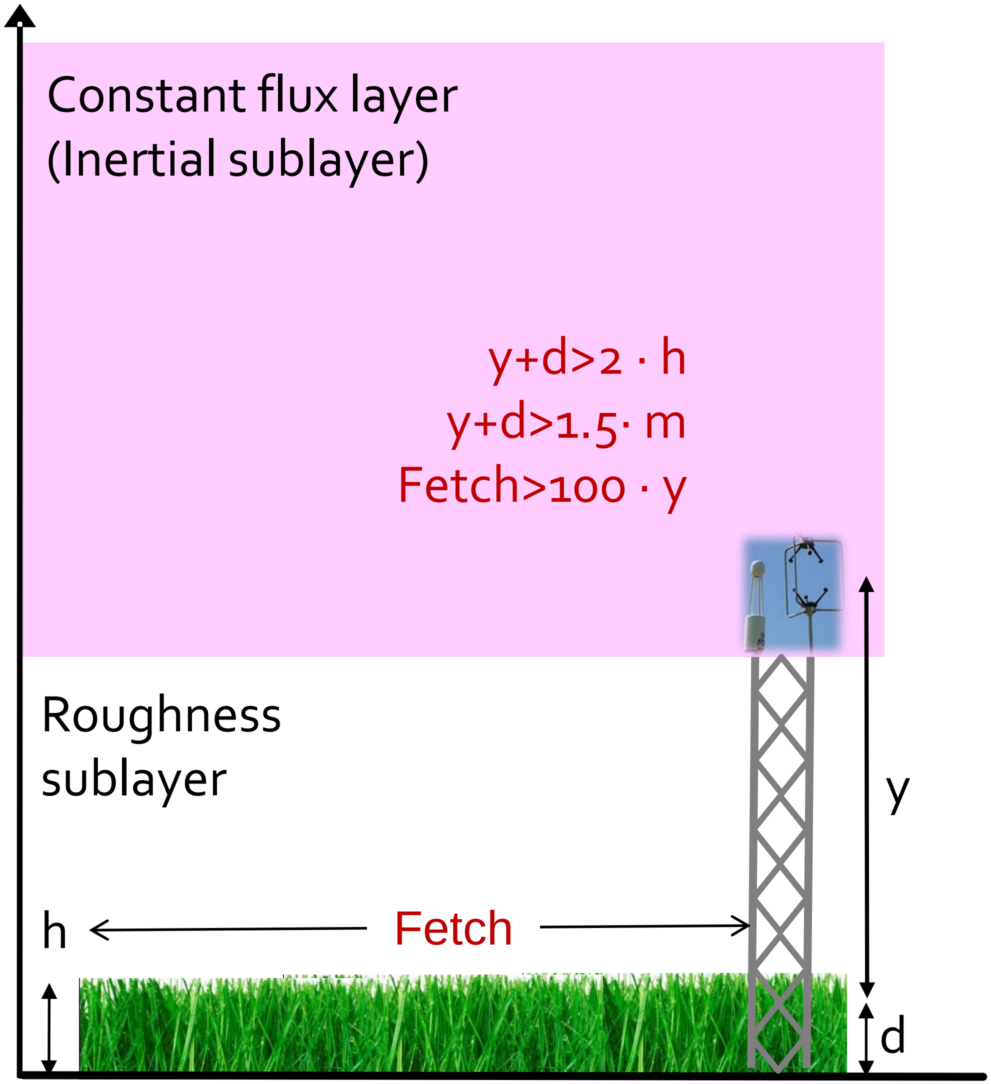
Mechanic mixing (dU/dz)

Thermal stability ($d\theta/dz$)



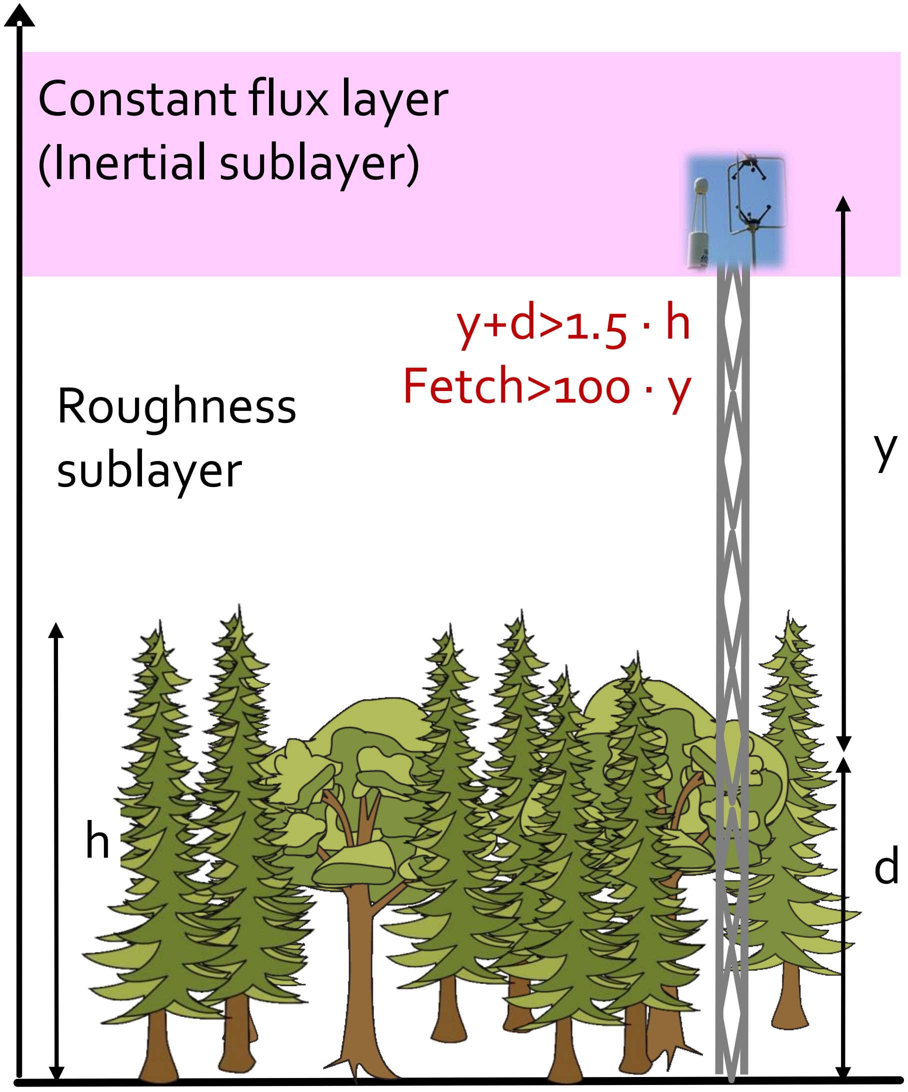
(layers are based on Stull, 1988; Denmead *et al*., 1996; and Oke, 2007)

RULES OF THUMB

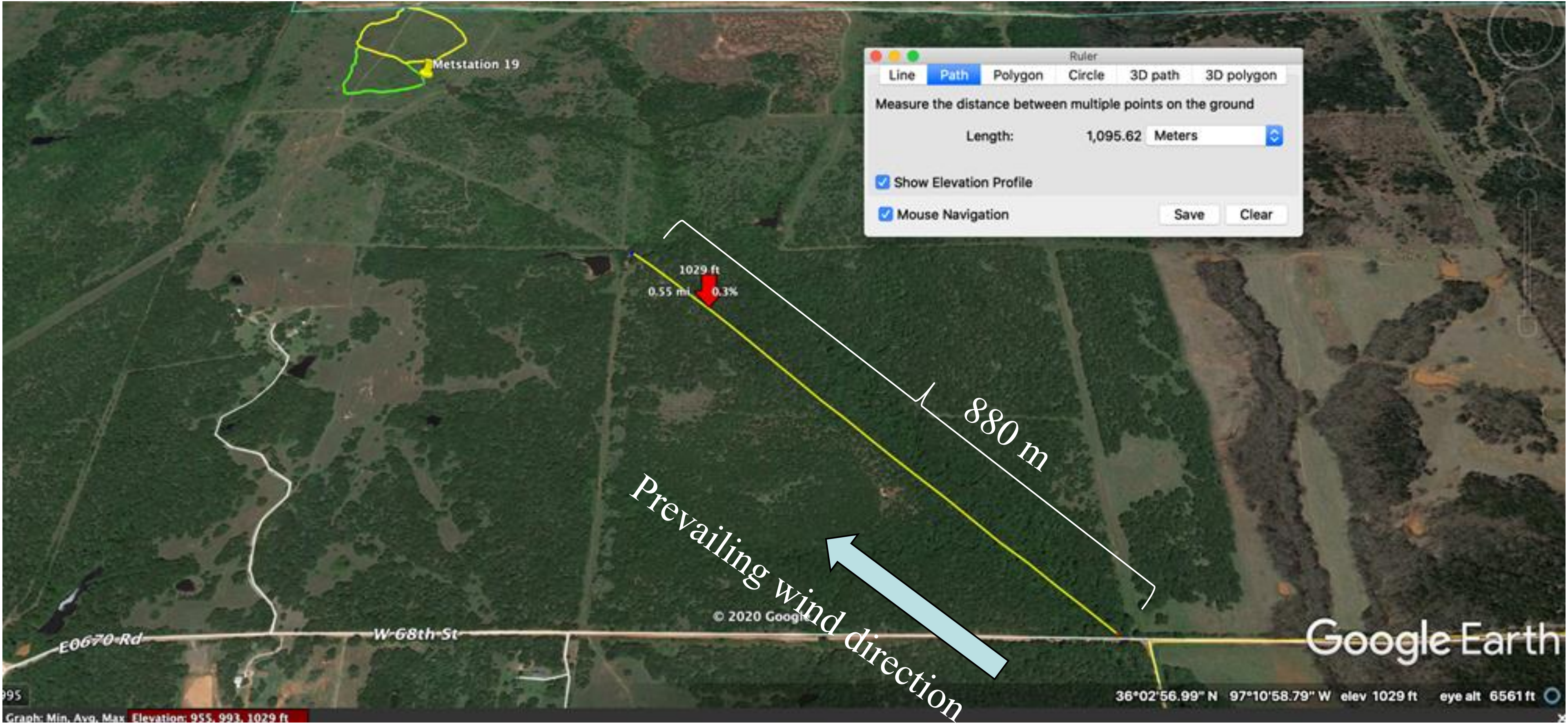


Short canopy, < 2-3 m

RULES OF THUMB



Tall canopy, > 2-3 m



An example:

UIUC research site:

Canopy height: 8-10 m

Instrument height: 15 m

y-d = 15 - 6.8=8.2 m

880 m >100 x 8.2 m

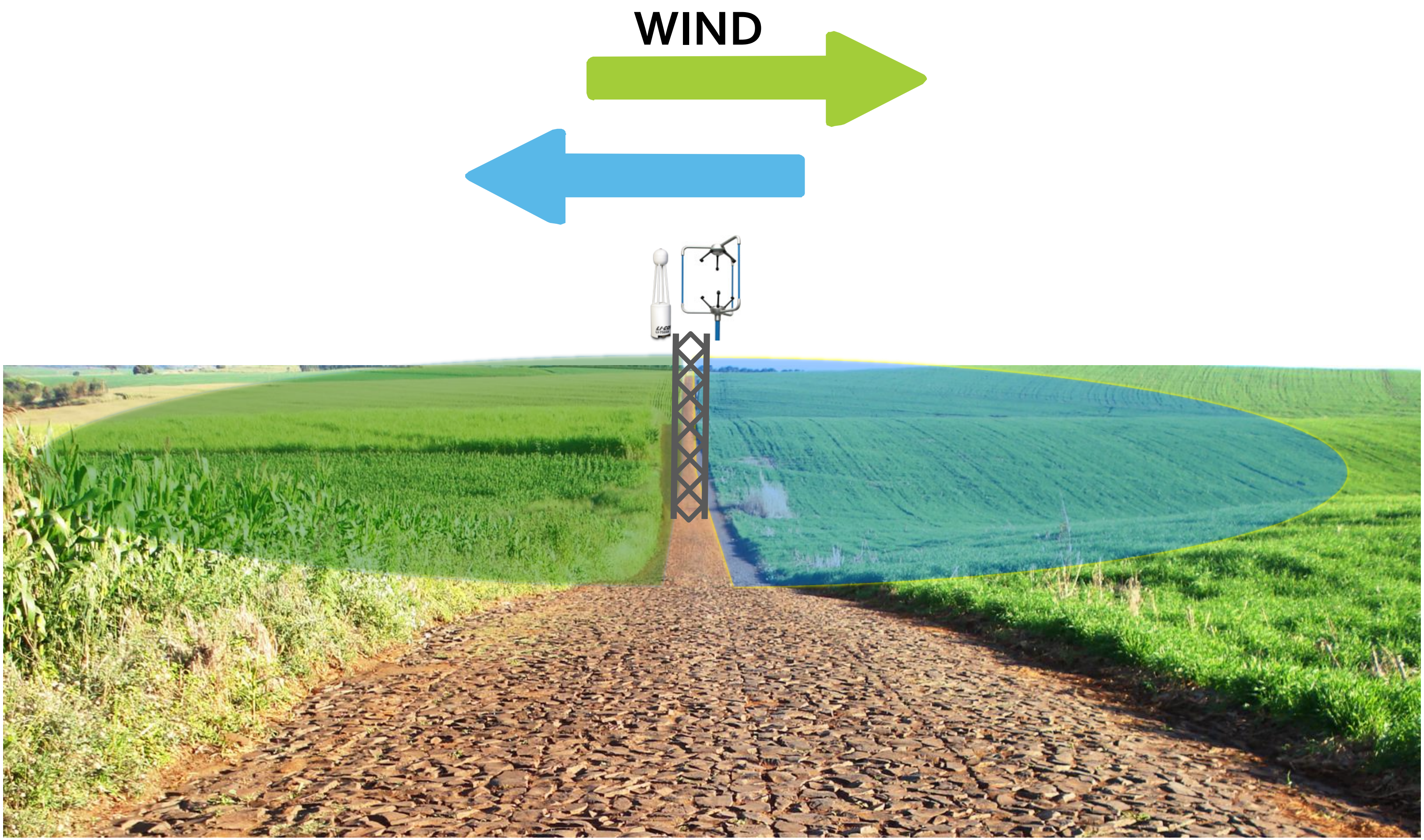
Criteria

y+d>1.5 · h

Fetch>100 · y

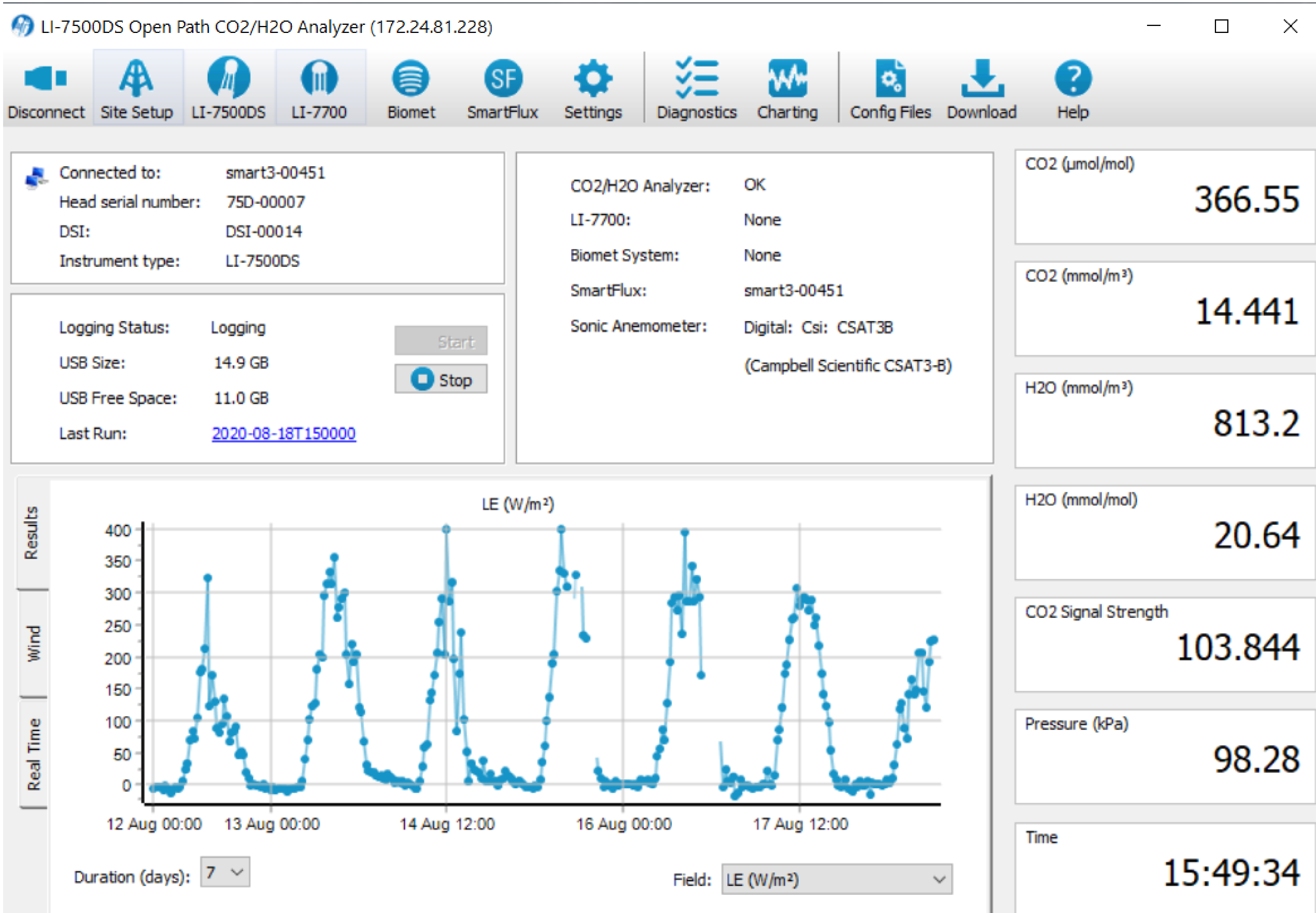
Tower Location

Tower Location?




Daytime wind

Look through all channels to make sure output values in reasonable ranges?



Compute flux with EddyPro
as soon as you get back from the field

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Do all the flux values make sense?
Do all the variables values make sense?

Analyze and look at your data right away!

Summary

- Applications
- Footprint and fetch concept
- Tower location
- An important advices

Questions ?