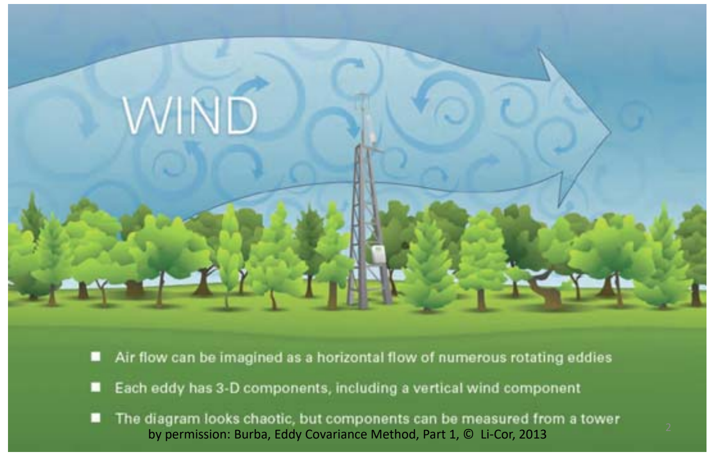
Eddy Covariance Method

Most of these slides are from:

Burba, G., 2013. Eddy Covariance Method for Scientific, Industrial, Agricultural and Regulatory Applications: A Field Book on Measuring Ecosystem Gas Exchange and Areal Emission Rates. LI-COR Biosciences, Lincoln, NE, 331 pp.

www.licor.com/env/products/eddy_covariance/resources.html

Airflow in Ecosystems



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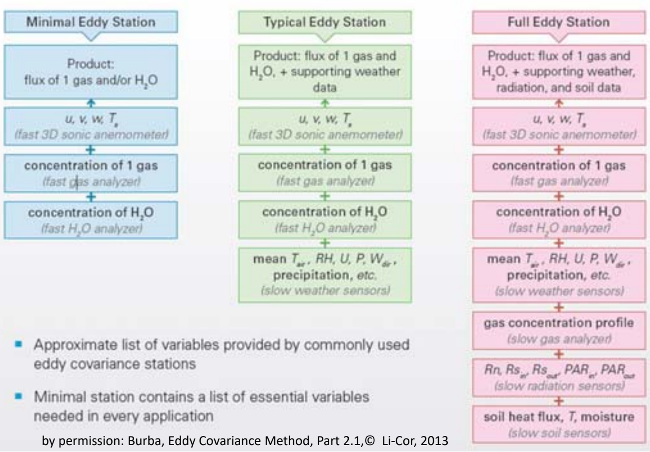
Typical Variables



- Approximate list of variables provided by commonly used eddy covariance stations
- Minimal station contains a list of essential variables needed in every application

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Major Assumptions

- Measurements at a point can represent an upwind area
- Measurements are done inside the boundary layer of interest
- Fetch/footprint is adequate – fluxes are measured from the area of interest
- Flux is fully turbulent – most of the net vertical transfer is done by eddies
- Terrain is horizontal and uniform: average of fluctuations of *w'* is zero, air density fluctuations, flow convergence and divergence are negligible
- Instruments can detect very small changes at high frequency
- Air flow is not distorted by the installation structure or the instruments

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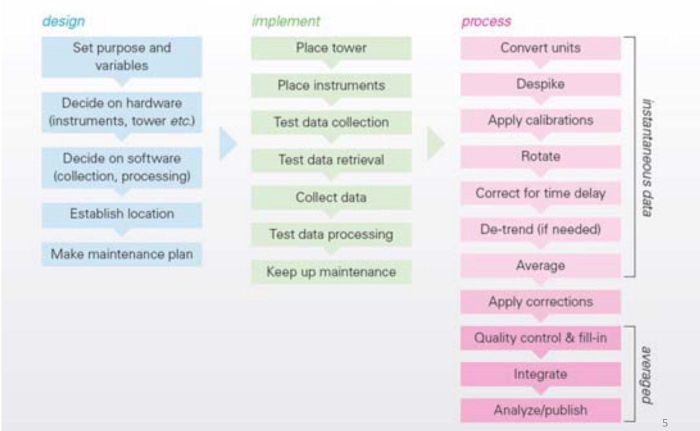
Typical Workflow



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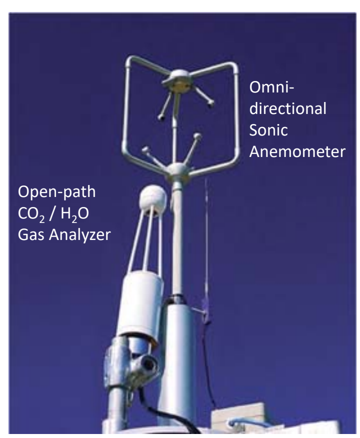
Instrumentation – Sonic Anemometer



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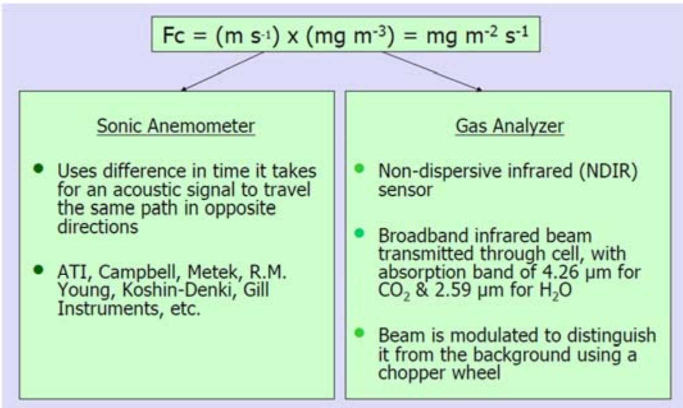
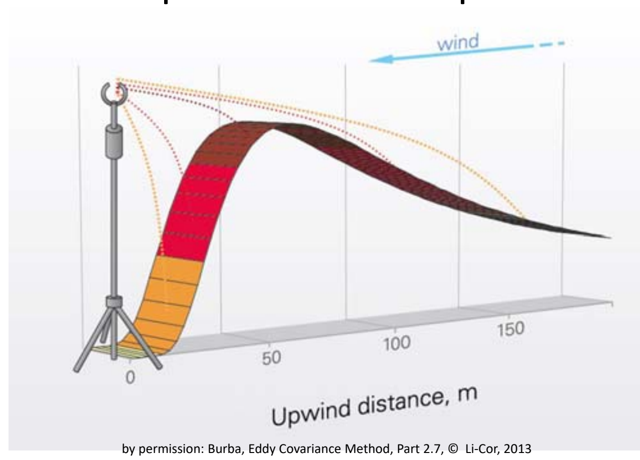
Measurement Principles



by Permission: Burba & Anderson, Intro to the EC Method, Li-Cor, 2010

Importance of Footprint



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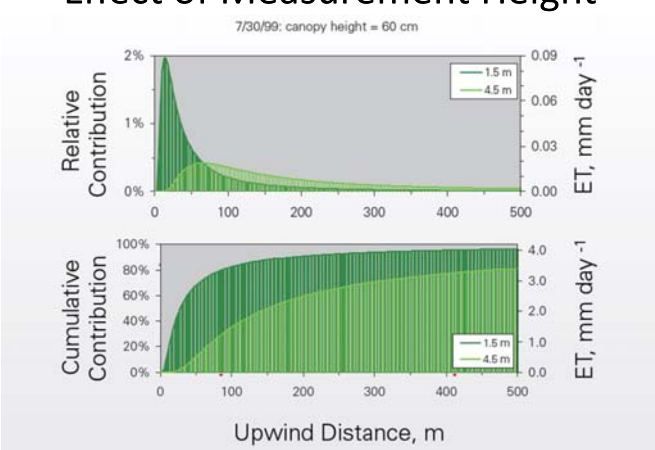
Effect of Measurement Height



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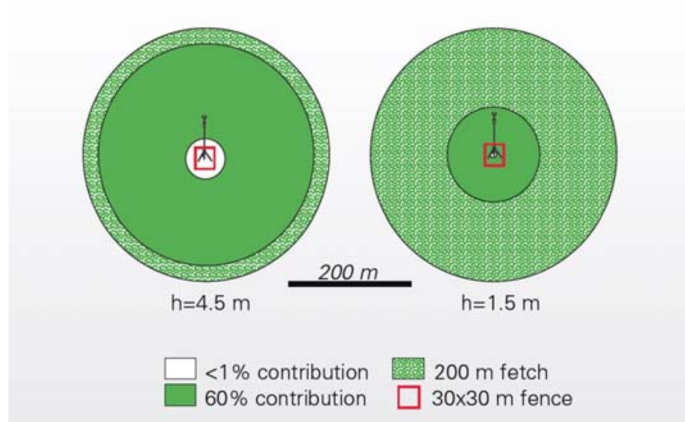
Effect of Station Height



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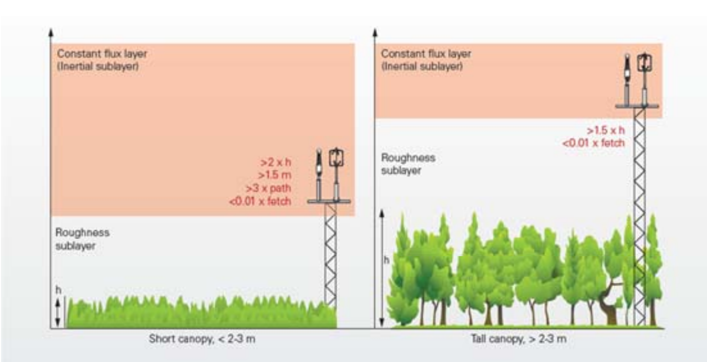
Instrument Placement – Rules of Thumb



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Practical Formulas

Any gas (CO_2, CH_4, N_2O, H_2O, *etc.*): $F = \overline{\rho}_d \overline{w's'}$ $\approx \overline{w'\rho_c'}$

Sensible heat flux: $H = \overline{\rho} C_p \overline{w'T'}$

Traditional H_2O flux: $E = \frac{M_w / M_a}{\overline{P}} \overline{\rho_d w'e'}$

Latent heat flux (H_2O flux in energy units): $LE \equiv \lambda E = \lambda \frac{M_w / M_a}{\overline{P}} \overline{\rho_d w'e'}$

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Eddy Covariance

Flux density: mol/m^2/s or J/m^2/s

$$F = \overline{\rho_a ws} \sim \overline{\rho_a} \cdot \overline{w' s'}$$

covariance term

$$s = \left(\frac{\rho_c}{\rho_a}\right)$$

where s is the mixing ratio of the density of CO_2 (ρ_c) to the density of dry air (ρ_a)

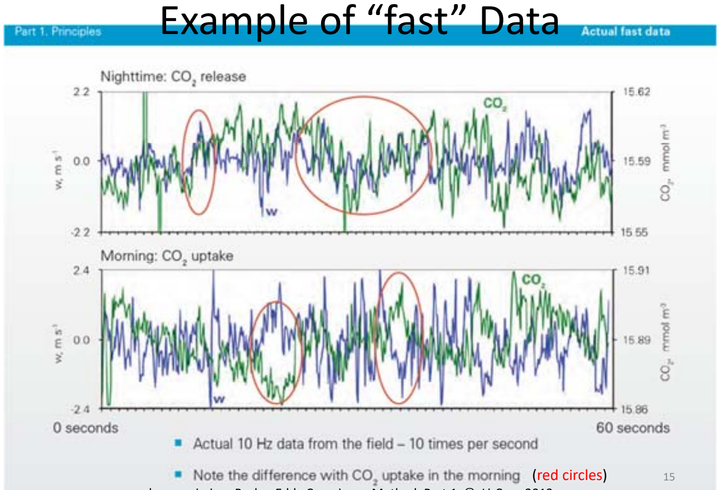
Reynolds Decomposition

$$\overline{\rho_a ws} = \overline{(\overline{w}+w')(\overline{s}+s')(\overline{\rho_a}+\rho_a')}$$

Flux Averaging Rules

$$\overline{xy} = \overline{x}\,\overline{y} + \overline{x'y'}$$
$$\overline{x'} = 0$$
$$\overline{x+y} = \overline{x} + \overline{y}$$

Example of “fast” Data



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Connecting Tower to Basin Flux Estimates

- Determine trunk density
- Measure Sap flow flux at several trees
- Study allometric relationships between tree size and trunk DBH (dia. @ breast height)
- More info: baskar mitra – UA postdoc

References

- The citation for 2013 Eddy Covariance book (most slides): “Burba, G., 2013. Eddy Covariance Method for Scientific, Industrial, Agricultural and Regulatory Applications: A Field Book on Measuring Ecosystem Gas Exchange and Areal Emission Rates. LI-COR Biosciences, Lincoln, USA, Hard- and Softbound, 331 pp. ISBN: 978-0-61576827-4”
- The citation for 2010 Eddy Covariance book (slide 7): “Burba, G., and D. Anderson, 2010. A Brief Practical Guide to Eddy Covariance Flux Measurements: Principles and Workflow Examples for Scientific and Industrial Applications. LI-COR Biosciences, Lincoln, USA, Hard- and Softbound, 211 pp. ISBN: 978-0-61543013-3”