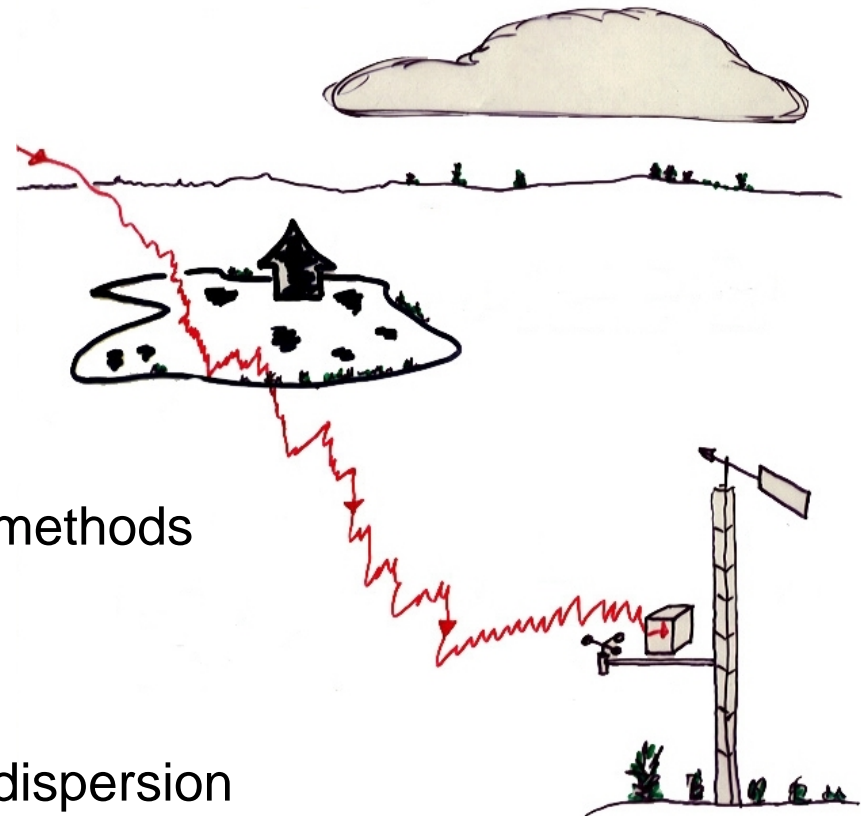


# Micrometeorological methods to determine methane emissions

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20 min,  
17 slides

- survey of micromet methods
- review IHF method
- review bLS inverse dispersion method

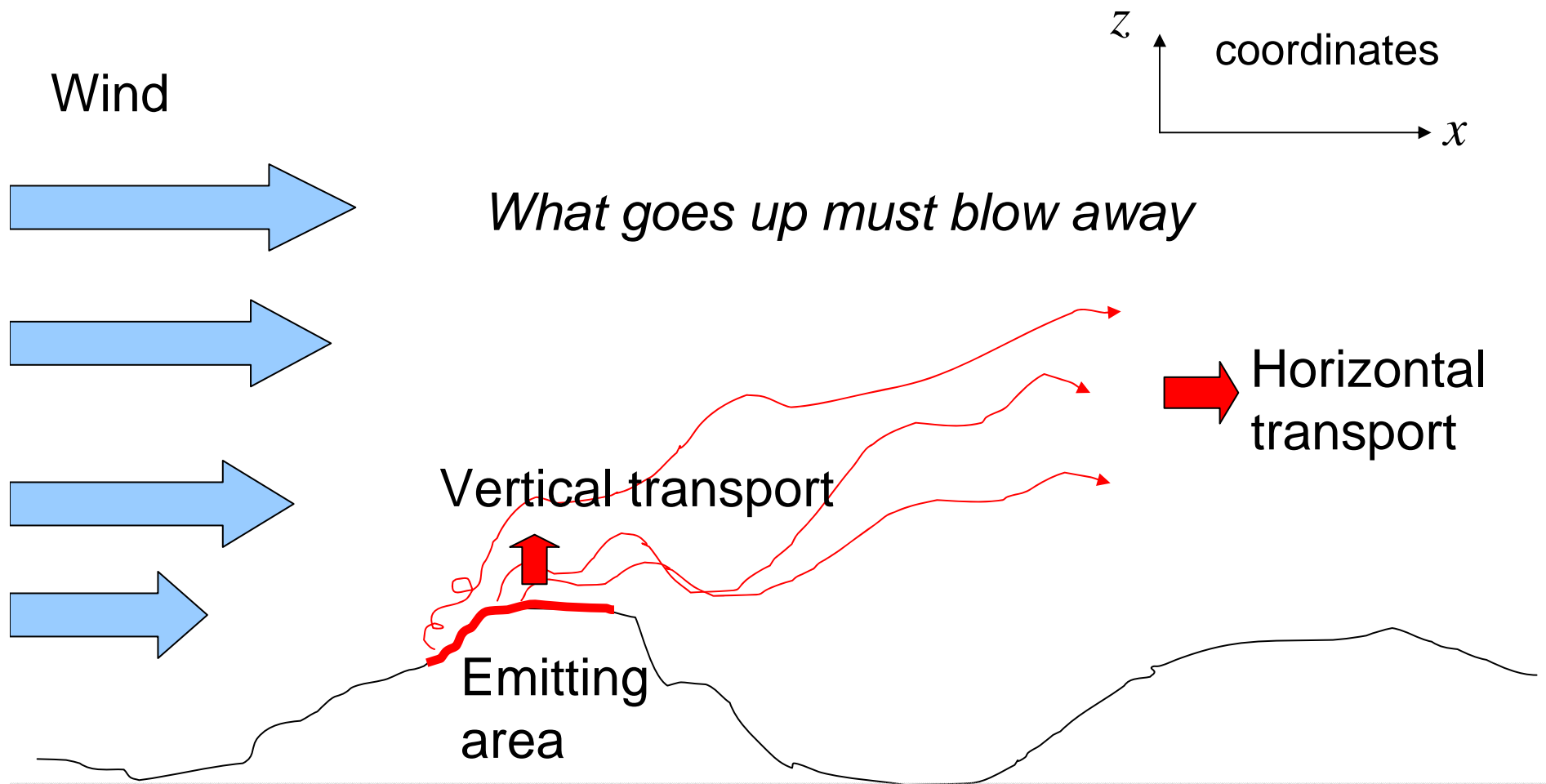
~~20 min~~

- ~~demonstrate bLS using WindTrax~~

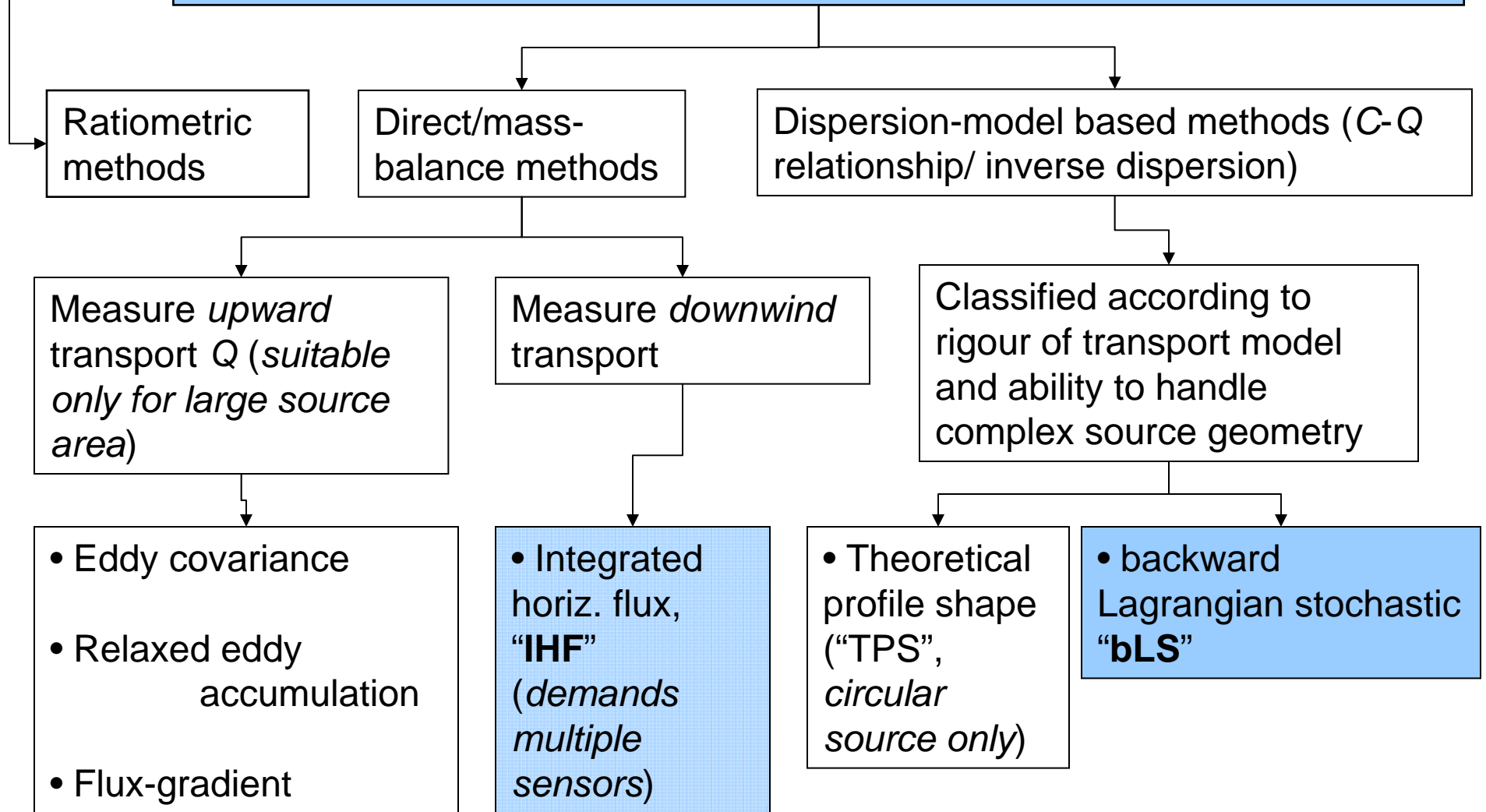
Banff2010.ppt  
J.D. Wilson, presented at GGAA  
Banff, Oct. 2010  
(Comments added subsequently for  
posting to web site)

Micro-meteorological methods estimate gas entering the atmosphere (as opposed to observing what goes missing from the substrate).

- Because they fluctuate, winds and gas transfer rates necessarily must be averages, over a period of something like 15 – 60 min.



# Micromet methods to determine gas flux to atmosphere\*\*

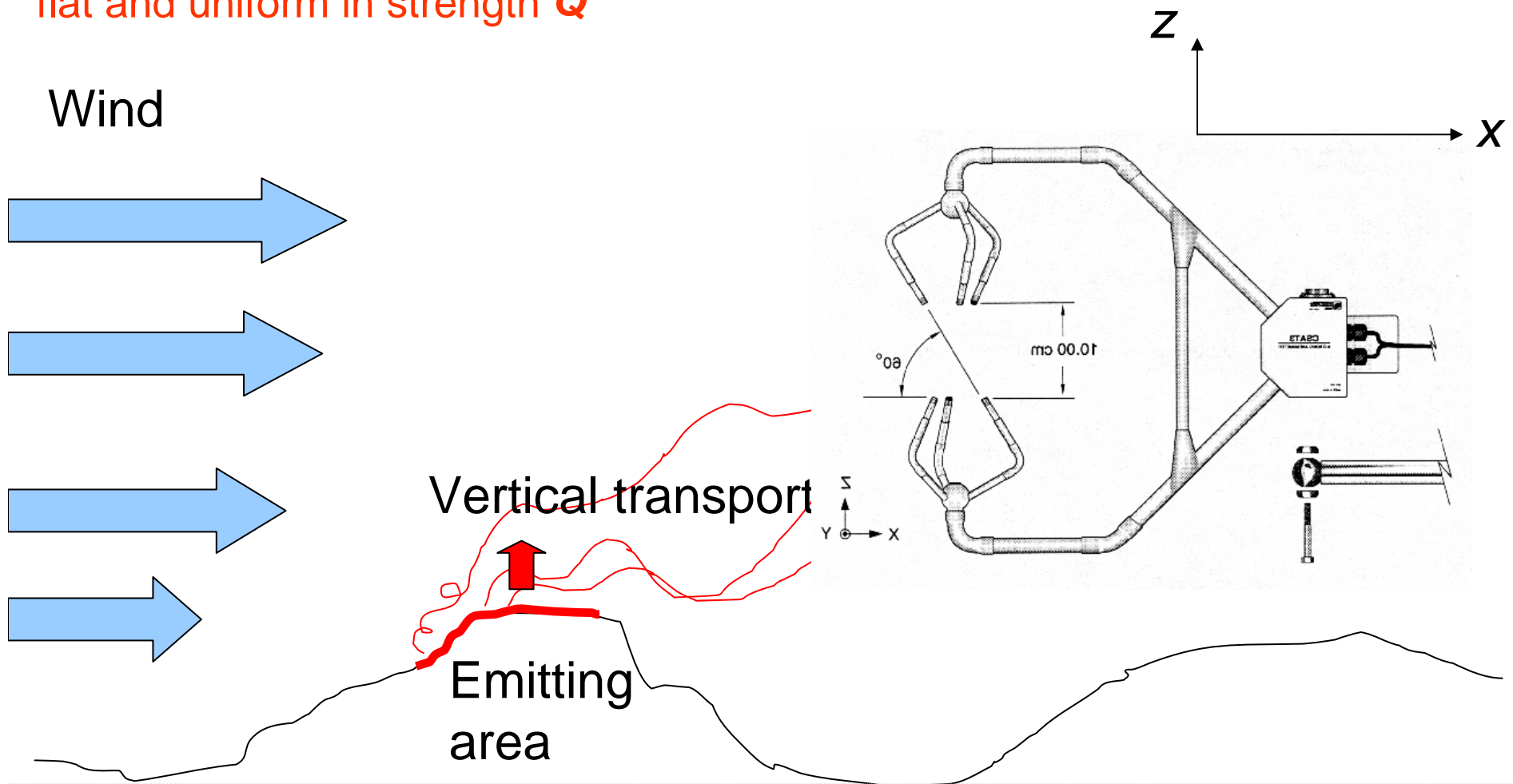


\*\*Classification is arbitrary; not all variants of main methods are indicated

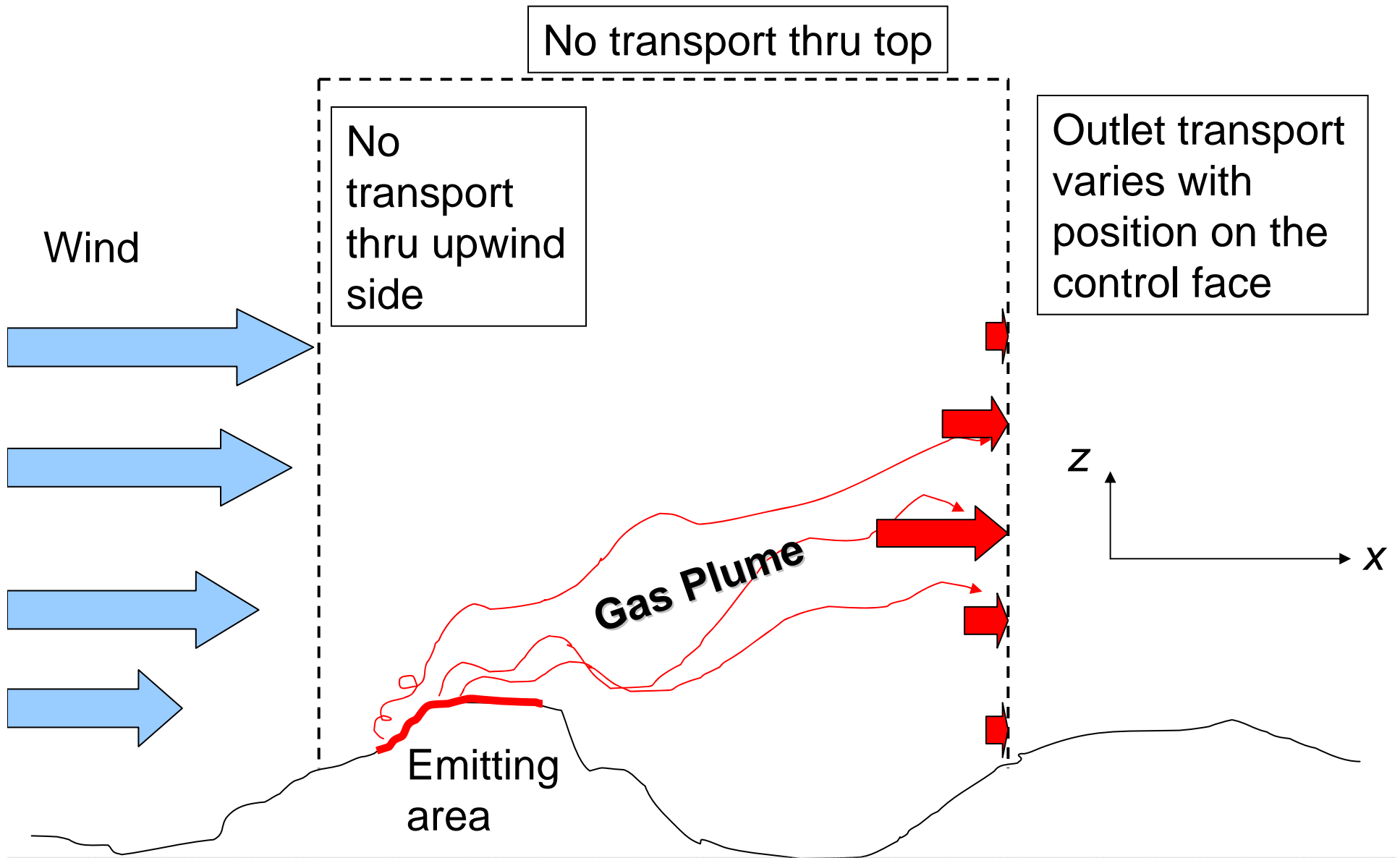
• will concentrate on IHF & bLS

May focus on measuring the vertical transport (e.g. by eddy covariance) or on measuring the horizontal transport

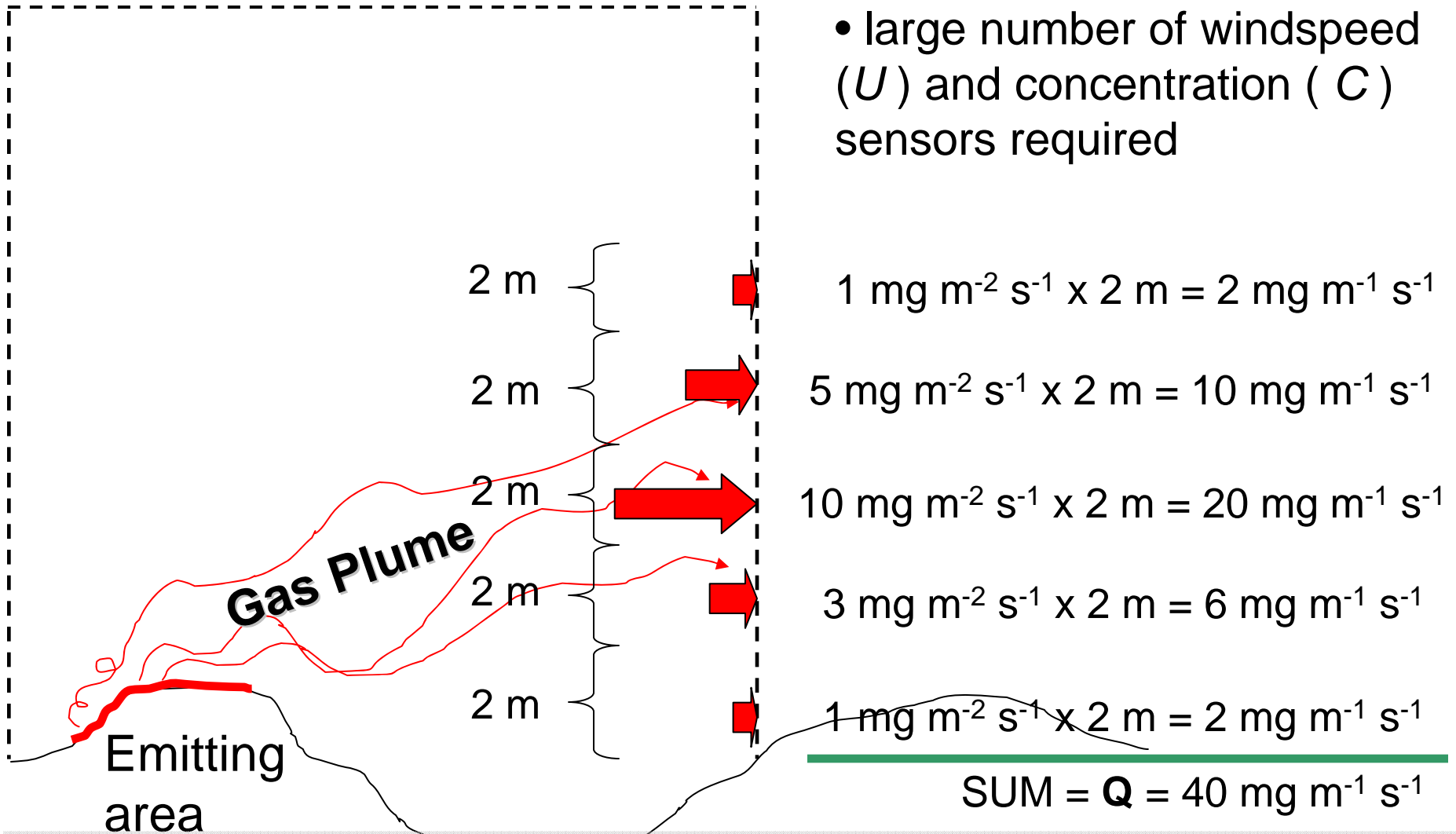
- quantifying the vertical transport rate problematic unless symmetry prevails: require uniformity of wind and of the source – in effect source must be large, flat and uniform in strength  $Q$



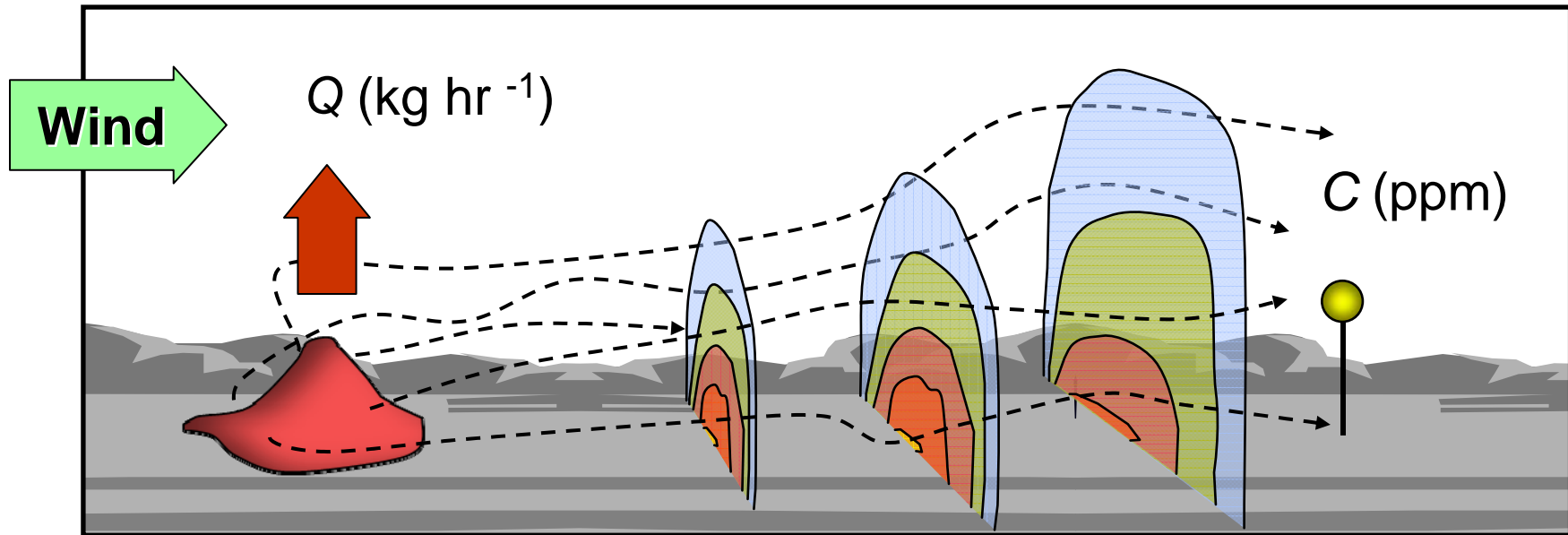
# Mass balance (IHF) approach – illustrated in two dimensions



Mass balance approach demands summation of the outlet transport, because the latter varies with position on the control face



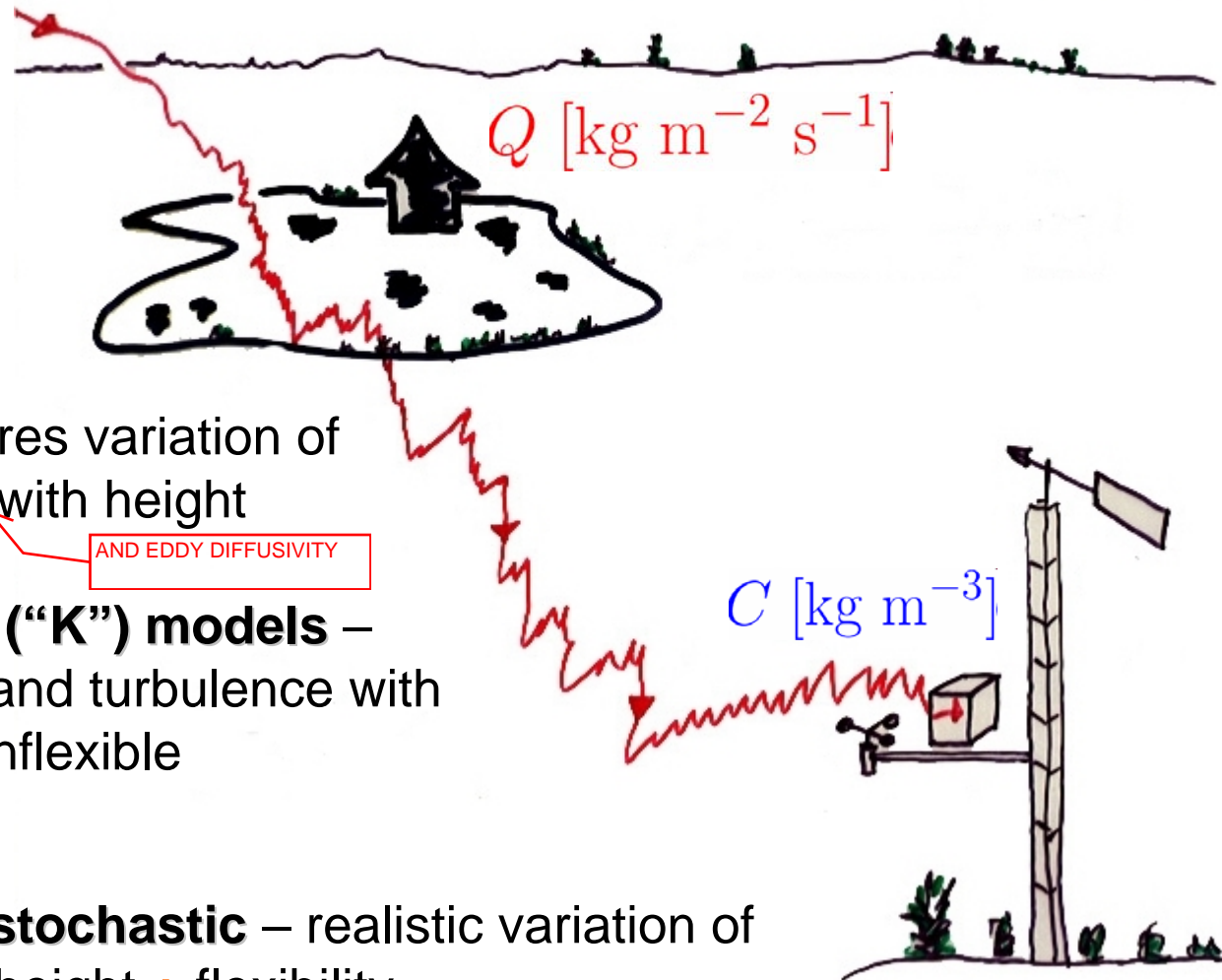
## Inverse Dispersion method to deduce Gas Emissions



- Atmospheric dispersion model relates downwind concentration **C** to emission rate **Q** for prevailing regime of wind & turbulence
- Measurement of **C** (minus background) + model permits to infer **Q**

+ simple, remote measurement + unrestricted source geometry  
+ no disruption of operations

## Fidelity of the atmospheric model providing C-Q relationship?



- **Gaussian plume** – ignores variation of wind speed and direction with height
- **other “eddy diffusion” (“K”) models** – realistic variation of wind and turbulence with height, but cumbersome/inflexible
- **backward Lagrangian stochastic** – realistic variation of wind and turbulence with height + flexibility

# Feedlot Emissions (Texas, spring 2005; 40, 000 cattle)



pens cover 0.8 km x 1.1 km

“MO-bLS” – effects on the wind of obstacles (cattle, mounds, fences) neglected, i.e. Monin-Obukhov description of wind & turbulence

## Site surveying

- Lowry Harper recording coordinates of lagoon corners at hog farm, Utah



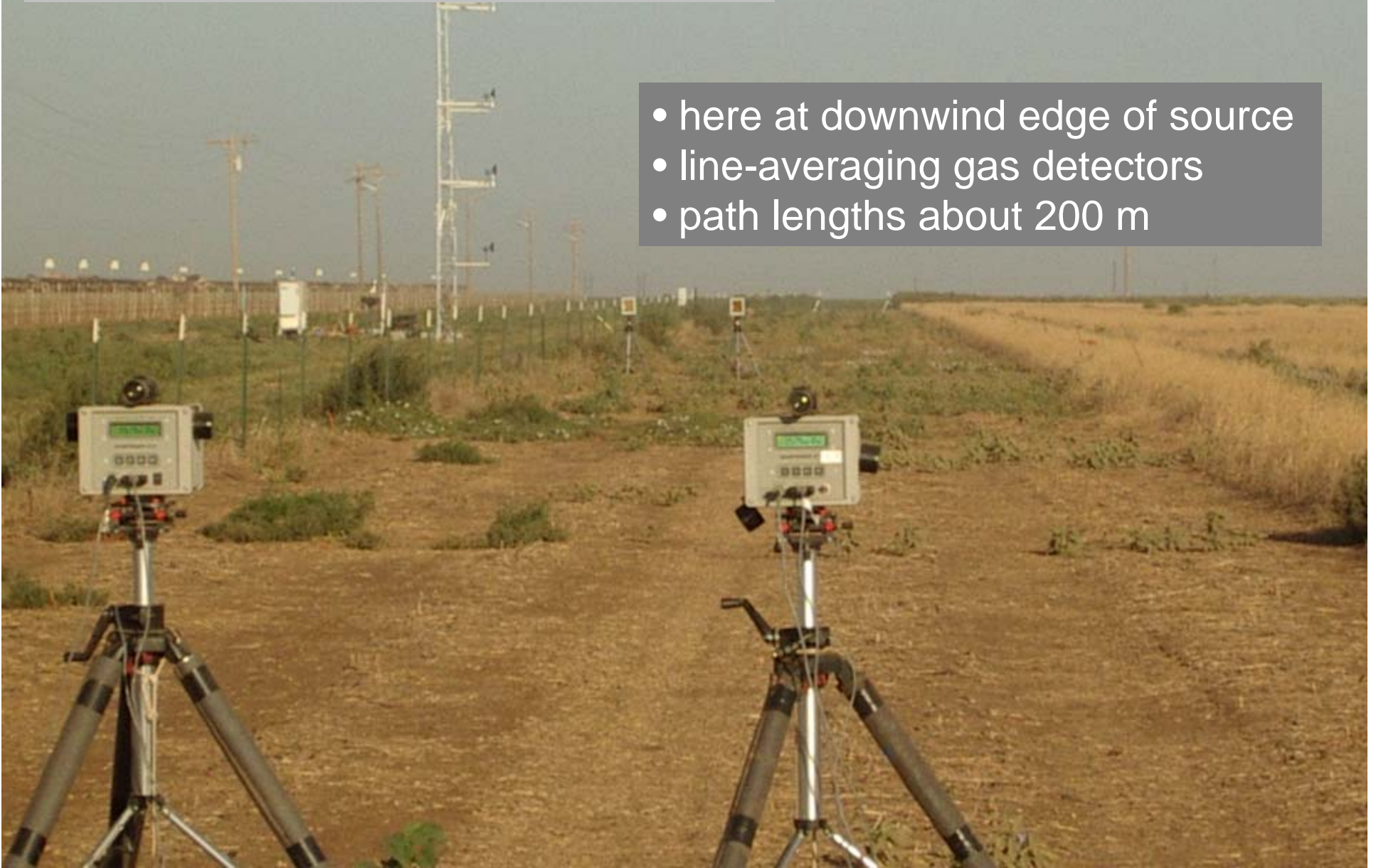
## Wind & turbulence – a sonic anemometer



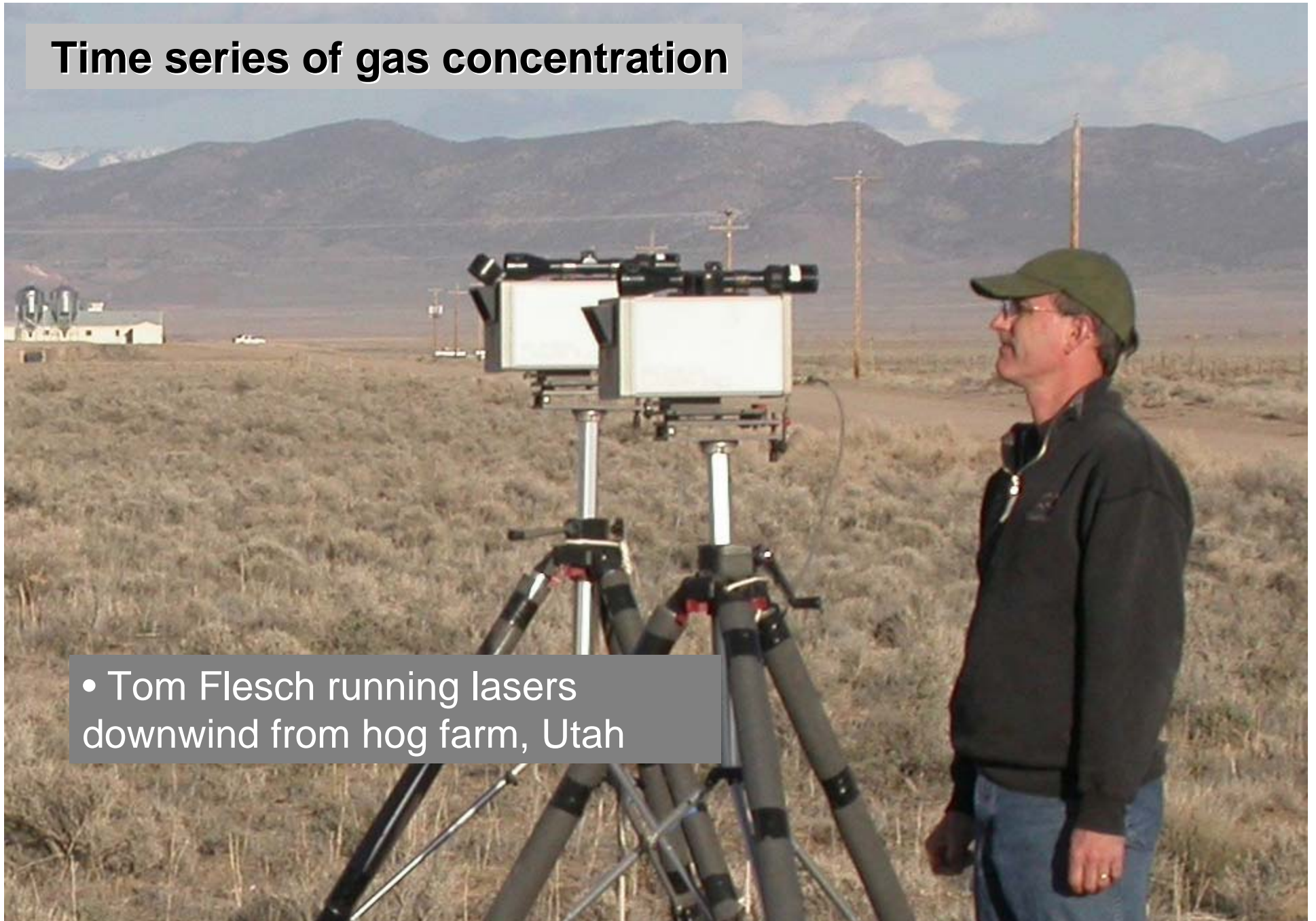
– positioned to give spatially representative wind statistics

## Time series of gas concentration

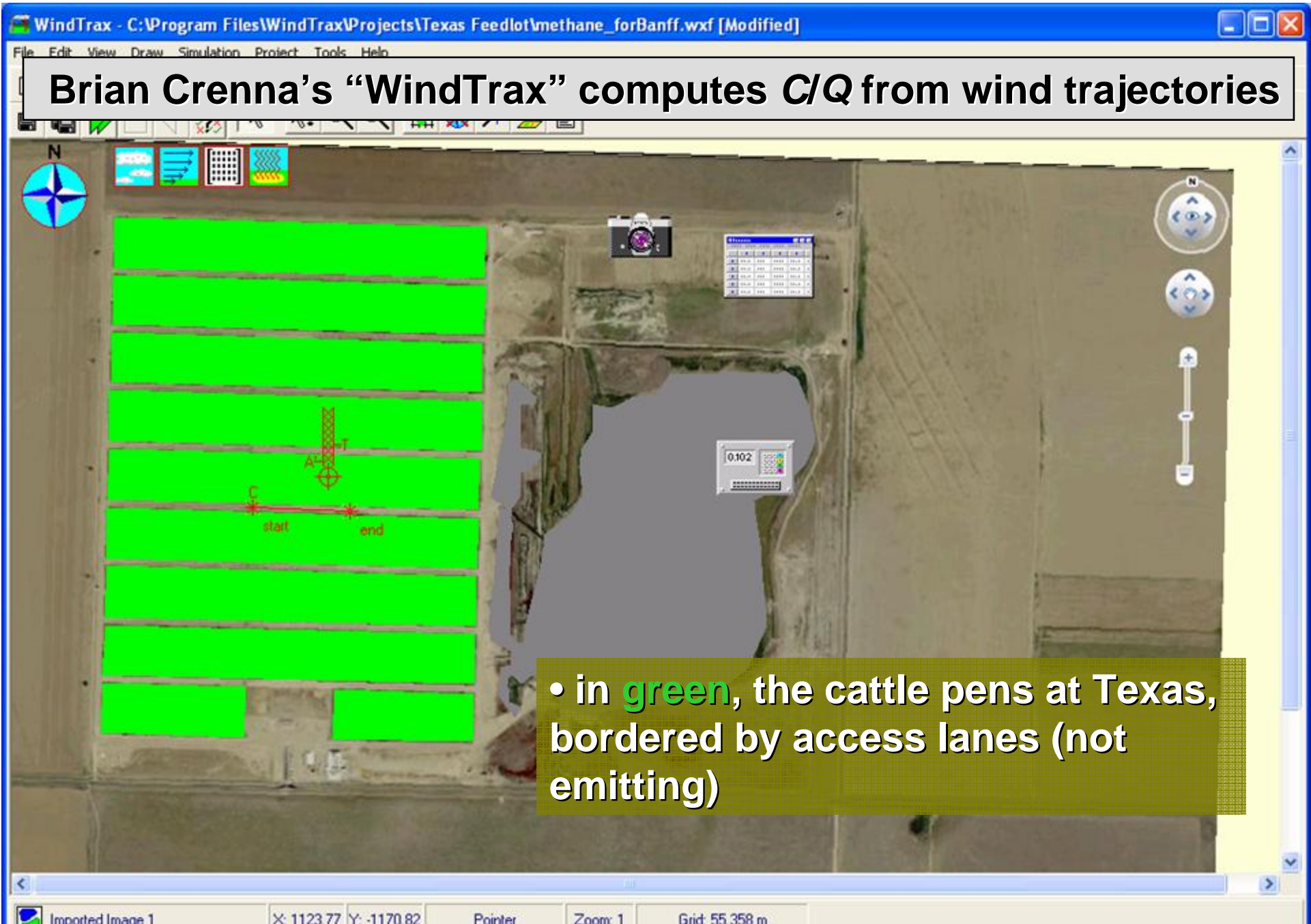
- here at downwind edge of source
- line-averaging gas detectors
- path lengths about 200 m



## Time series of gas concentration



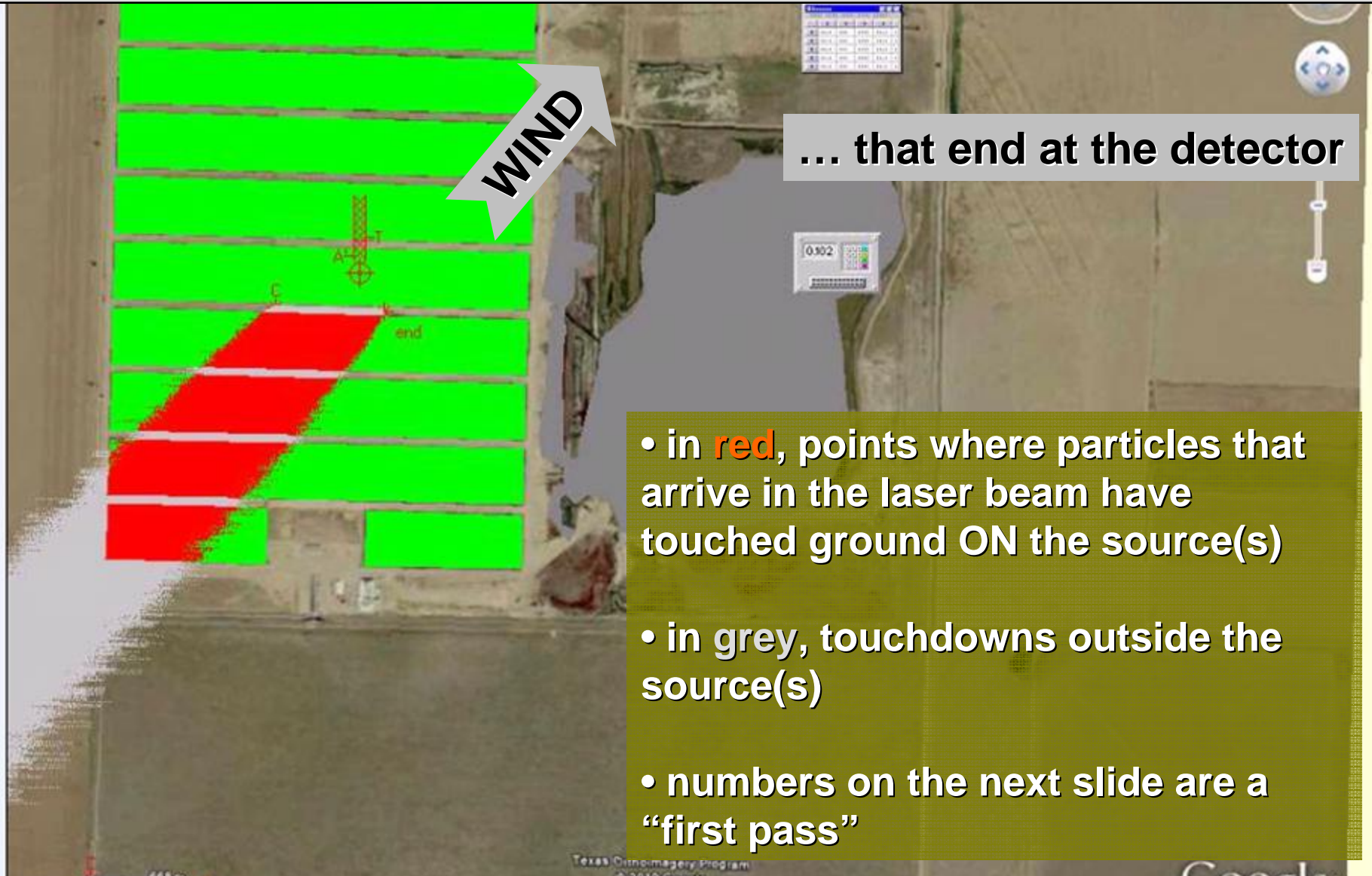
- Tom Flesch running lasers downwind from hog farm, Utah



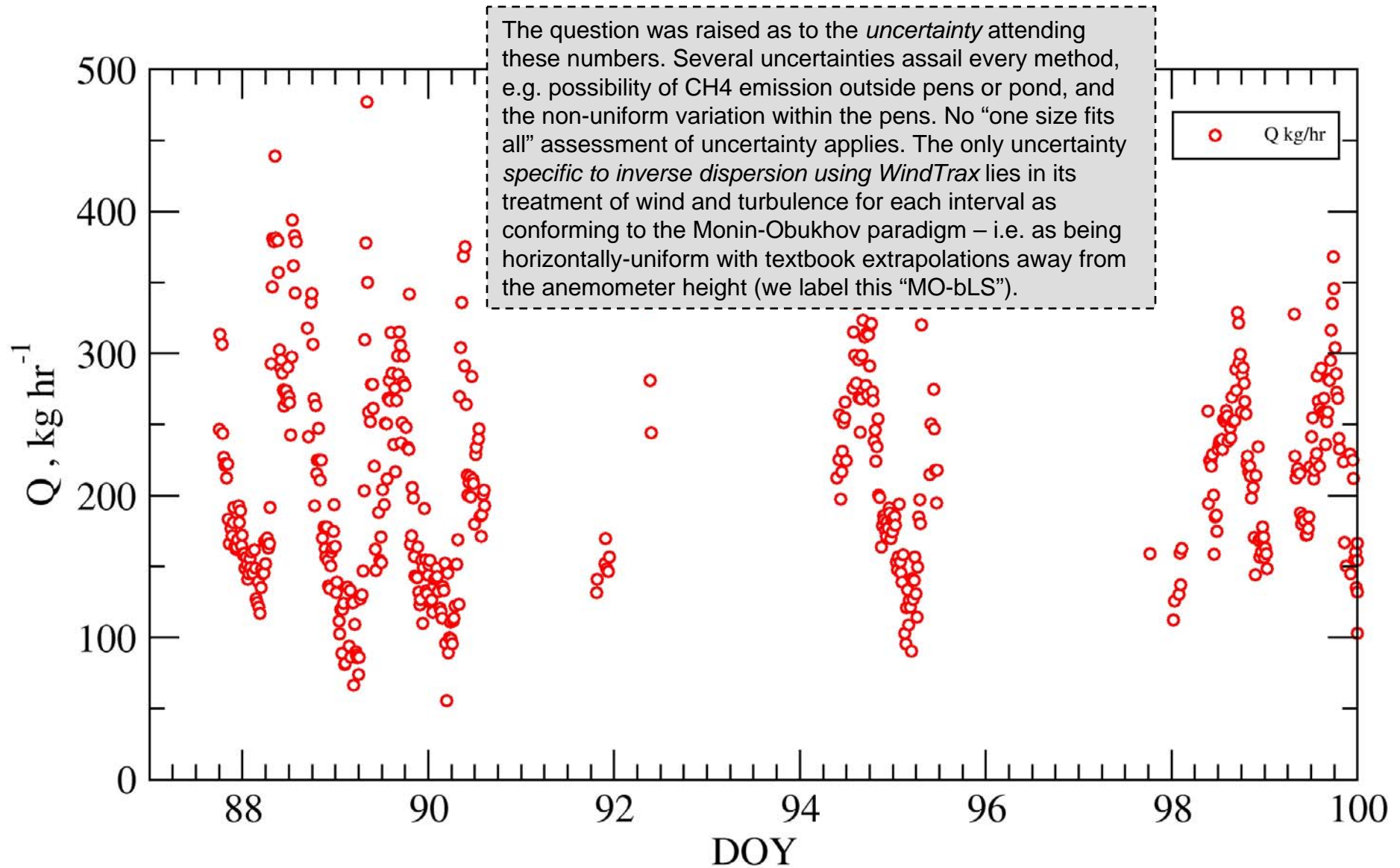
## Brian Crenna's "WindTrax" computes C/Q from wind trajectories

- in green, the cattle pens at Texas, bordered by access lanes (not emitting)

“WindTrax” computes C/Q from *backward (upwind)* paths...



# Methane flux, Texas feedlot (40,000 head)



## bLS method for inferring emission rate from measured concentration

- convenient; provides a time-resolved (but typically non-continuous) record with overall accuracy that (past experience suggests) converges to about +/- 10% to 20% when individual 15-min estimates are pooled (see relevant publications concerning cases where emission rate is independently known)
- experience so far suggests bLS is rather robust against deviation of setup from the ideal (Wilson et al. 2010, J. Appl. Meteorol. Climatol. **49**). *Even if wind is highly disturbed and concentration detector is near the obstacles, Q unlikely to be wrong by factor as large as 2.*
- requires
  - well defined background  $C^{bk}$  – or use two detectors & treat  $C^{bk}$  as unknown
  - that source area(s) can be delineated from non-source
  - detector placed close enough that concentration rise is resolved, yet in a configuration such that trajectories to the detector are in undisturbed wind