**Discussion:** **Flux correction for cross-contamination**

## Open Path / Closed Path IRGA comparison

1. Before measuring: practical considerations for open paths

2. Application of WPL correction and comparison with closed path

3. Recommendations

Historical review of WPL density correction:

Fuehrer and Friehe (2002) Flux corrections revisited,
BLM 102, 415-457.

*Scott Miller and Mike Goulden (UC Irvine)*

## Practical Considerations for Open Path

Advantages:

- Low Power
- Co-located with sonic
- No high frequency corrections/delays

Disadvantages

- Density corrections can swamp true fluxes
- Performance in rain?
- Dirt on windows

# Considerations from First Principles

1. In terms of molar density, $\rho_c$ (measured by open path)

$$F_c = \overline{\rho'_c w'} + \overline{\rho_c}\ \overline{w}$$

Correction term proportional to background CO2 concentration - need to know the mean accurately.

- Use well-calibrated sensor that doesn't drift
- Calibrate a drifty sensor regularly
- Use simultaneous with well-calibrated nearby reference sensor

## Considerations from First Principles

1. In terms of molar density, $\rho_c$ (measured by open path)

$$F_c = \overline{\rho'_c w'} + \overline{\rho_c}\ \overline{w}$$

$$F_c = \overline{\rho'_c w'} + \overline{\rho_c}\left[0.54\,\lambda\, E + 2.80\, H\right]\times 10^{-6}$$

Correction is ~5 times more sensitive to sensible heat flux than it is to latent heat flux. In theory, sites with small Bowen ratio will have smaller corrections.

Also, since correction is independent of CO2 flux, the correction is relatively smaller for sites with large CO2 fluxes.

## Considerations from First Principles

1. In terms of molar density, $\rho_c$ (measured by open path)

$$F_c = \overline{\rho'_c w'} + \overline{\rho_c}\ \overline{w}$$

2. In terms of mixing ratio, $c = \rho_c / \rho_a$

$$F_c = \overline{\rho_a}\ \overline{c' w'}$$

Requires simultaneous measurement of dry air molar density, $\rho_a$

- Fast response, co-located temperature measurement

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## Sample by Sample dry air molar density, $\rho_a$

$$\rho_a = \frac{P_a}{RT}$$

$$P_a = P - P_v$$

$$P_v = \left(\frac{\rho_v}{M_v}\right) R_u \, T$$

$$T \approx \frac{T_s}{1 + 0.32 \, P_v / P}$$

| | |
|---|---|
| $P$ | - total air pressure |
| $P_a$ | - partial pressure dry air |
| $P_v$ | - partial pressure water vapor |
| $R_u$ | - gas constant |
| $T$ | - "dry" temperature |
| $T_s$ | - "sonic temperature" |

Water vapor density measured by open path

# Considerations from First Principles

$$\rho_c = c\,\rho_a$$

measured by open path

For constant mixing ratio, $c$

$$\delta\rho_c = c\;\delta\rho_a$$

Spurious fluctuation in measured density due to air density fluctuation

Correction will be smaller for species with large fluctuations relative the the background concentration value.

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# EFFECT OF DIFFERENT HARDWARE

**Using closed path to calibrate open path**

# Performance in Rain

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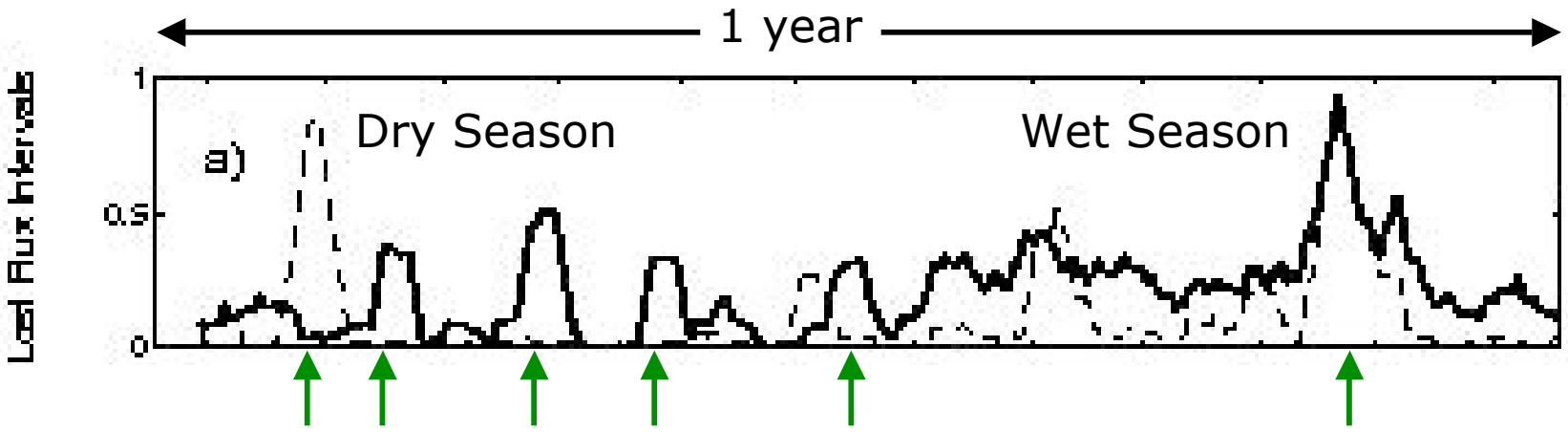
2000 mm rain $yr^{-1}$

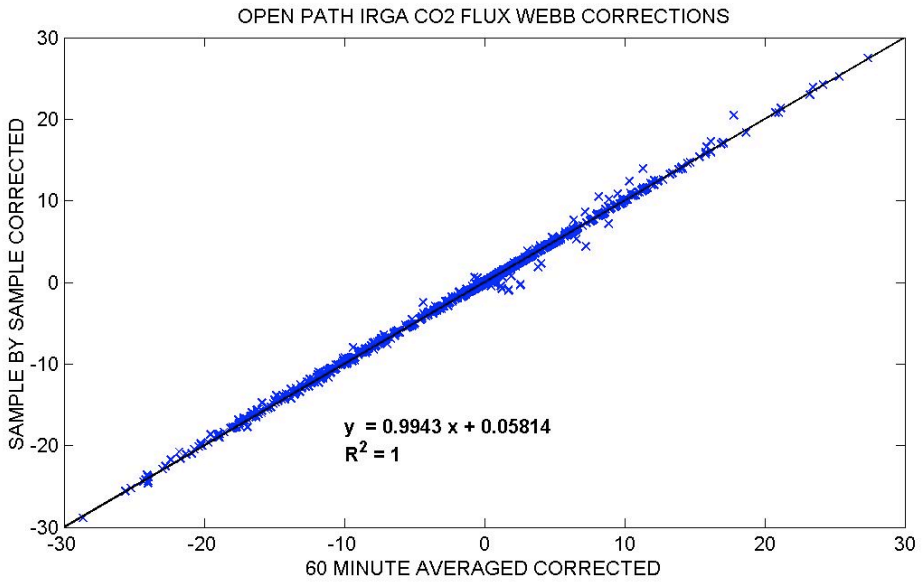
Open path: solid
Closed path: dashed

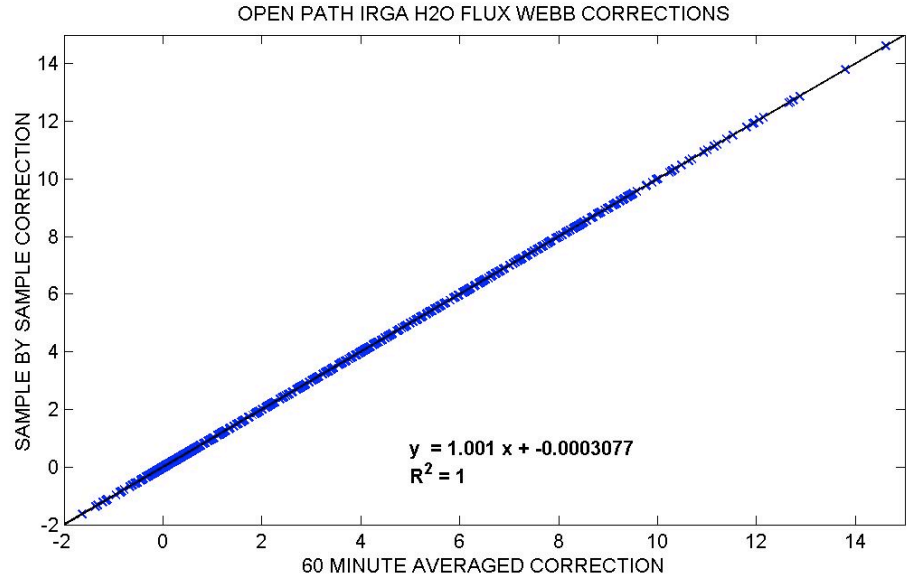



peaks are system downtime

## Results

Applying WPL correction sample by sample or using 30 minute covariances are equal.




openclosedcompare.m, WebbCompare.p1, 17-Jan-2002

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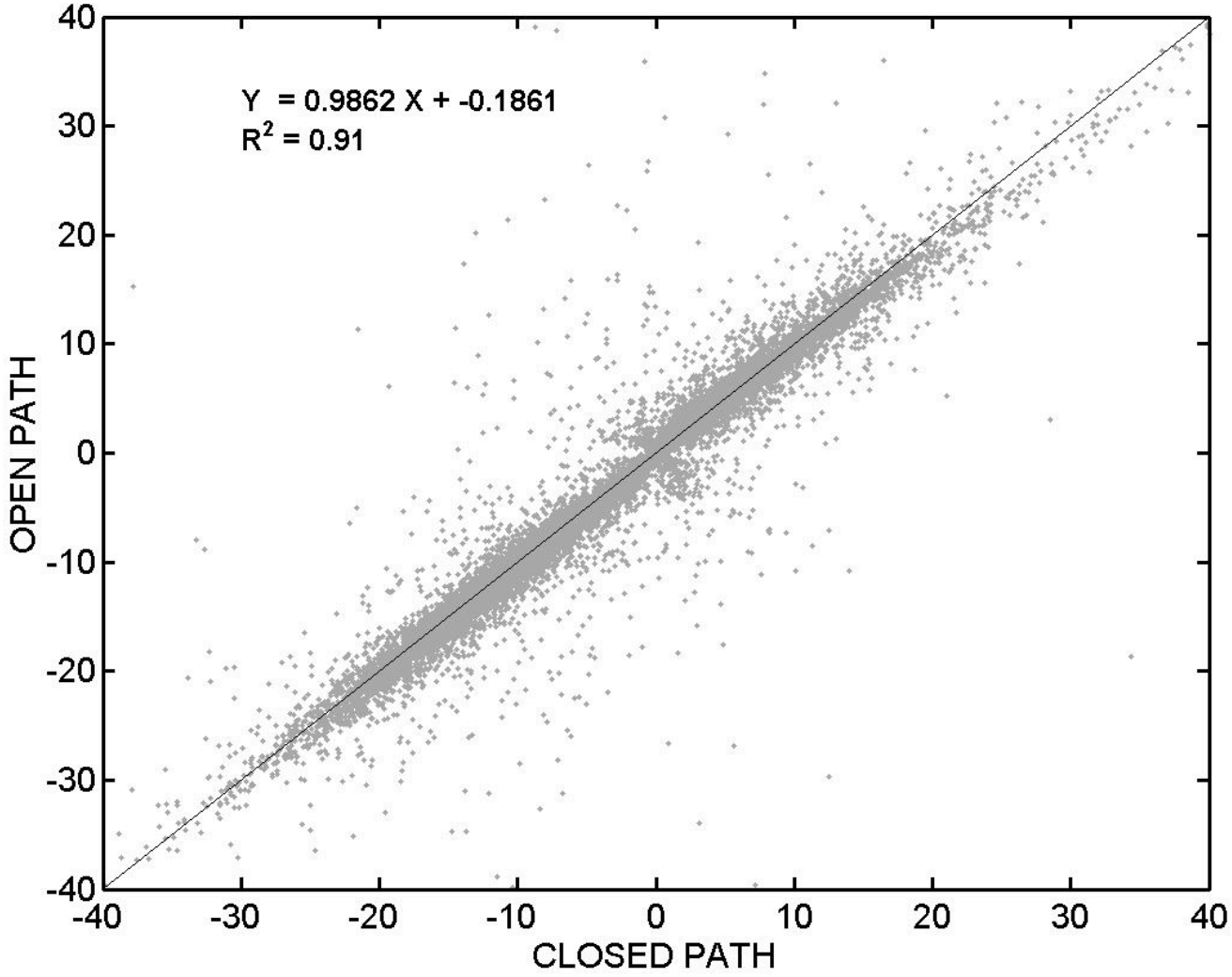
## Open Path - Closed Path regression of CO2 flux



Averaged over 22 months...

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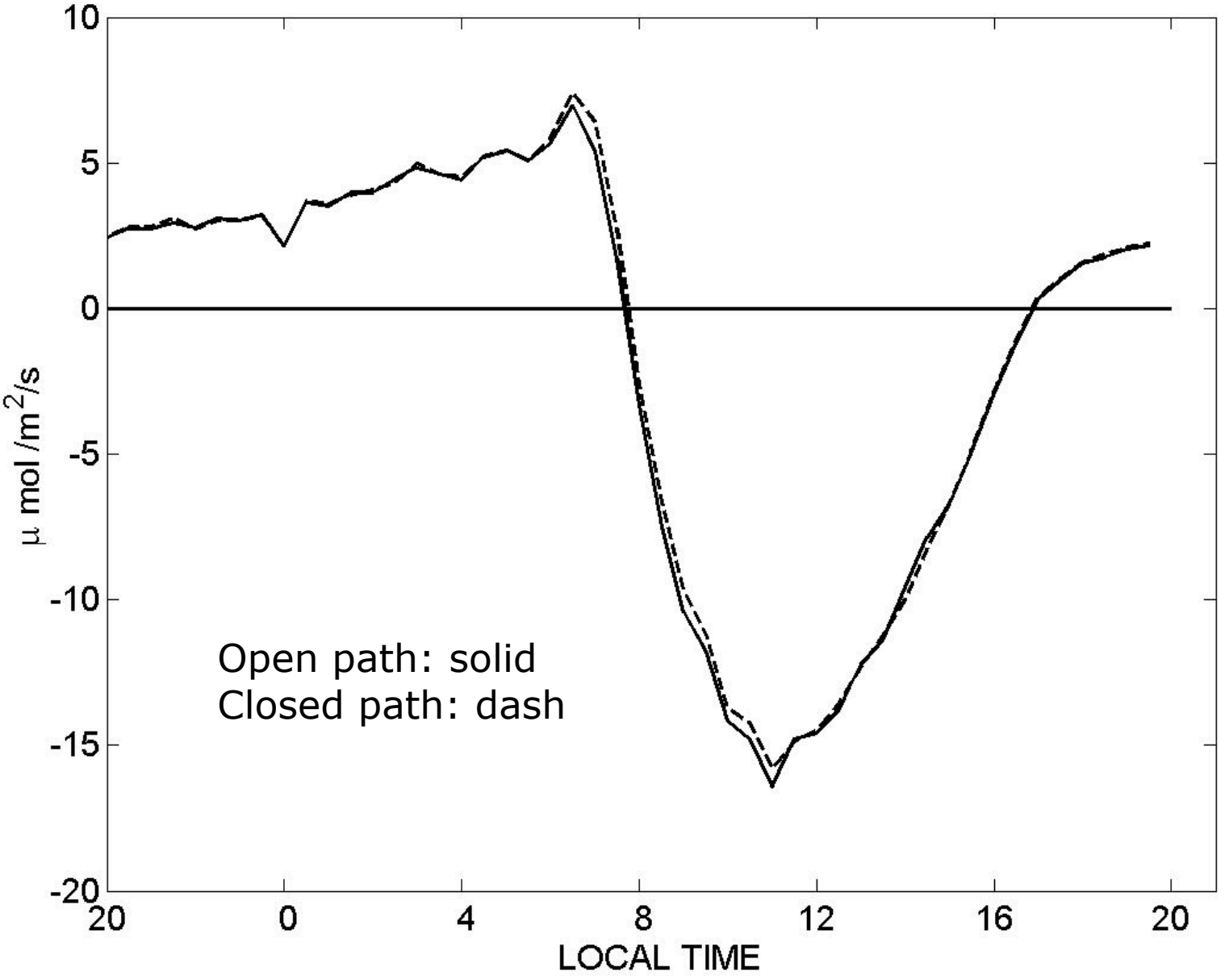
Fco2



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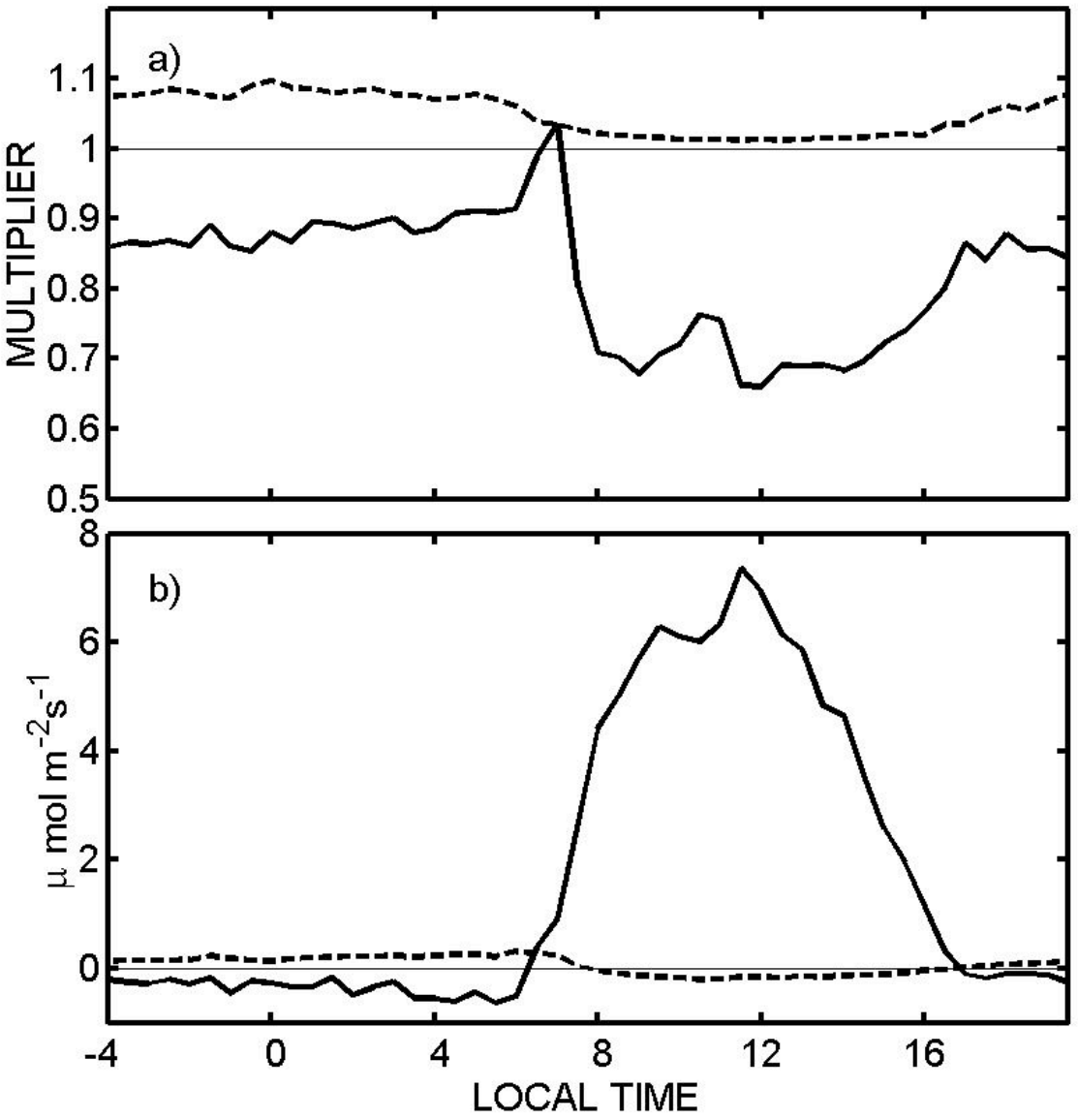
## How Big are Flux corrections?

Open path: solid

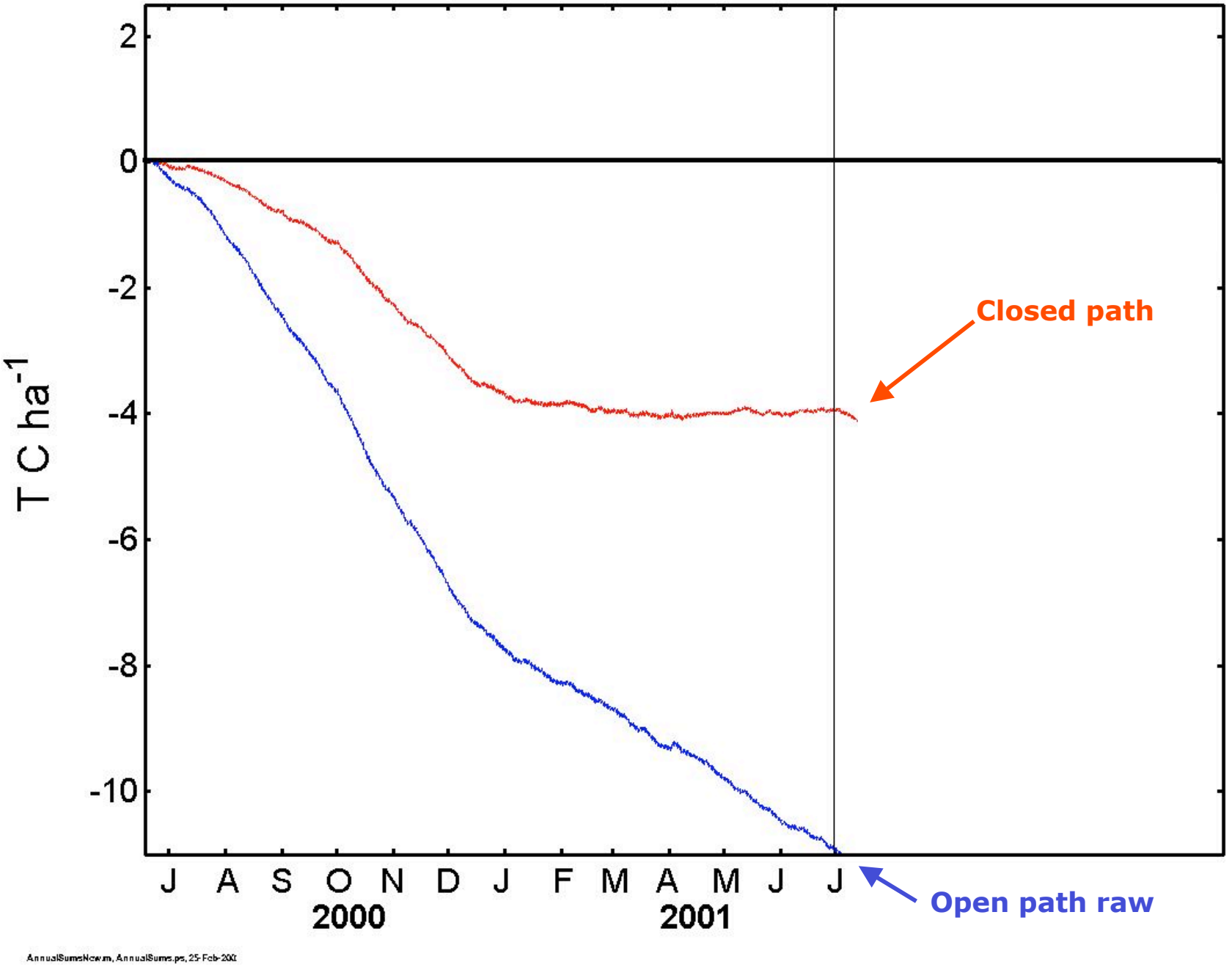
Closed path: dash

Expressed as gain to the raw flux.

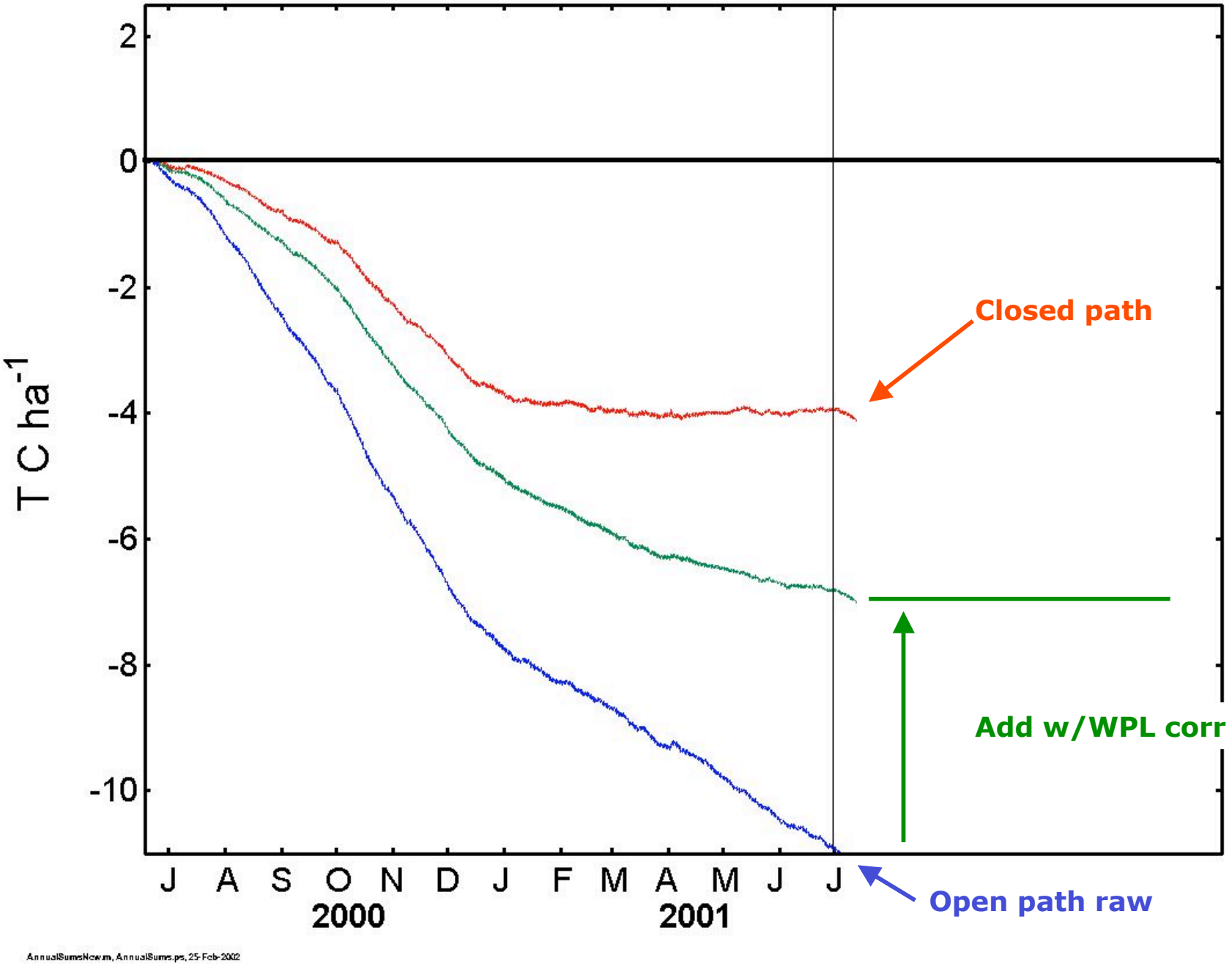
Expressed as additative correction to raw flux

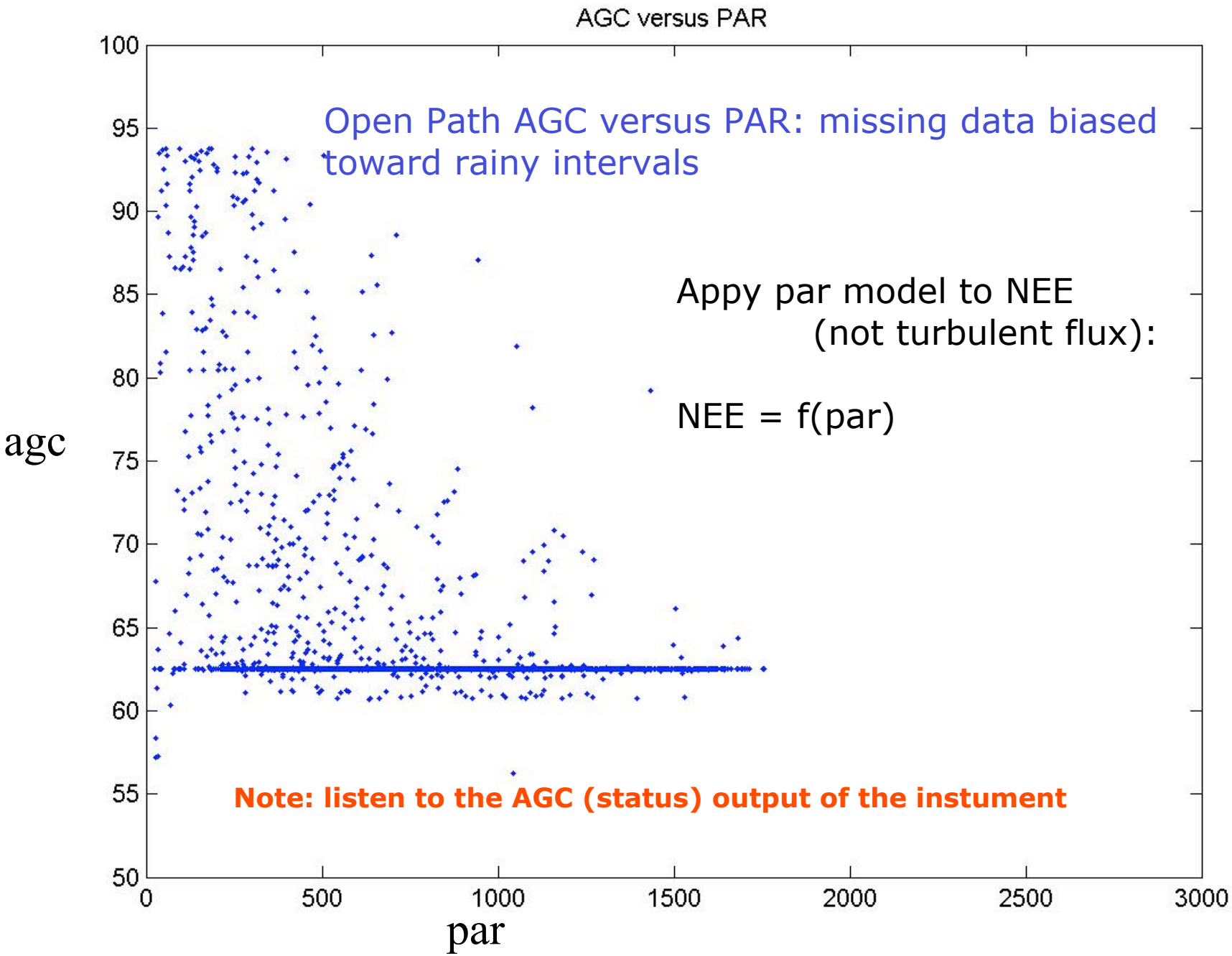


# Cumulative Sum for 1 Year (NOT $u_*$ FILTERED!)

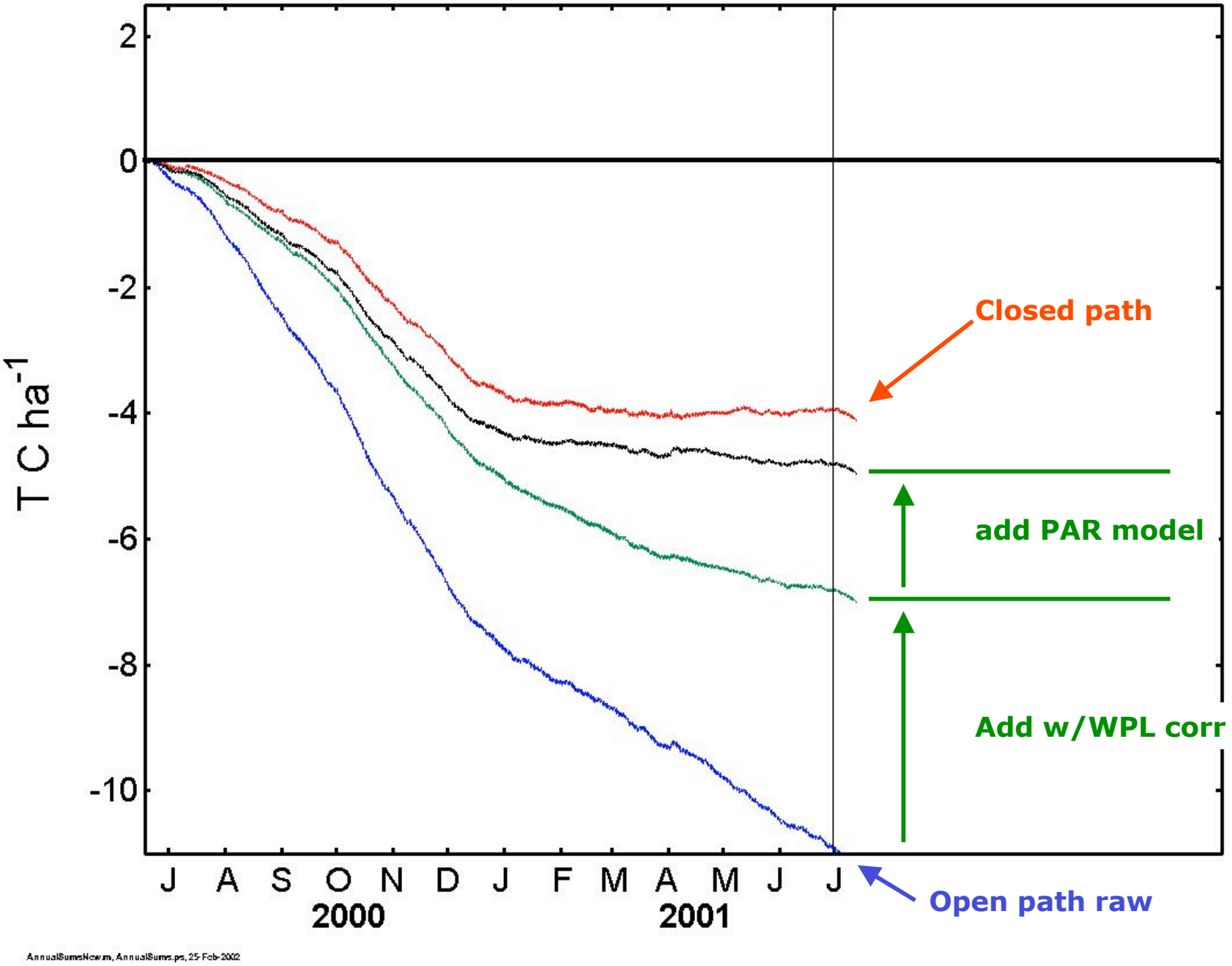


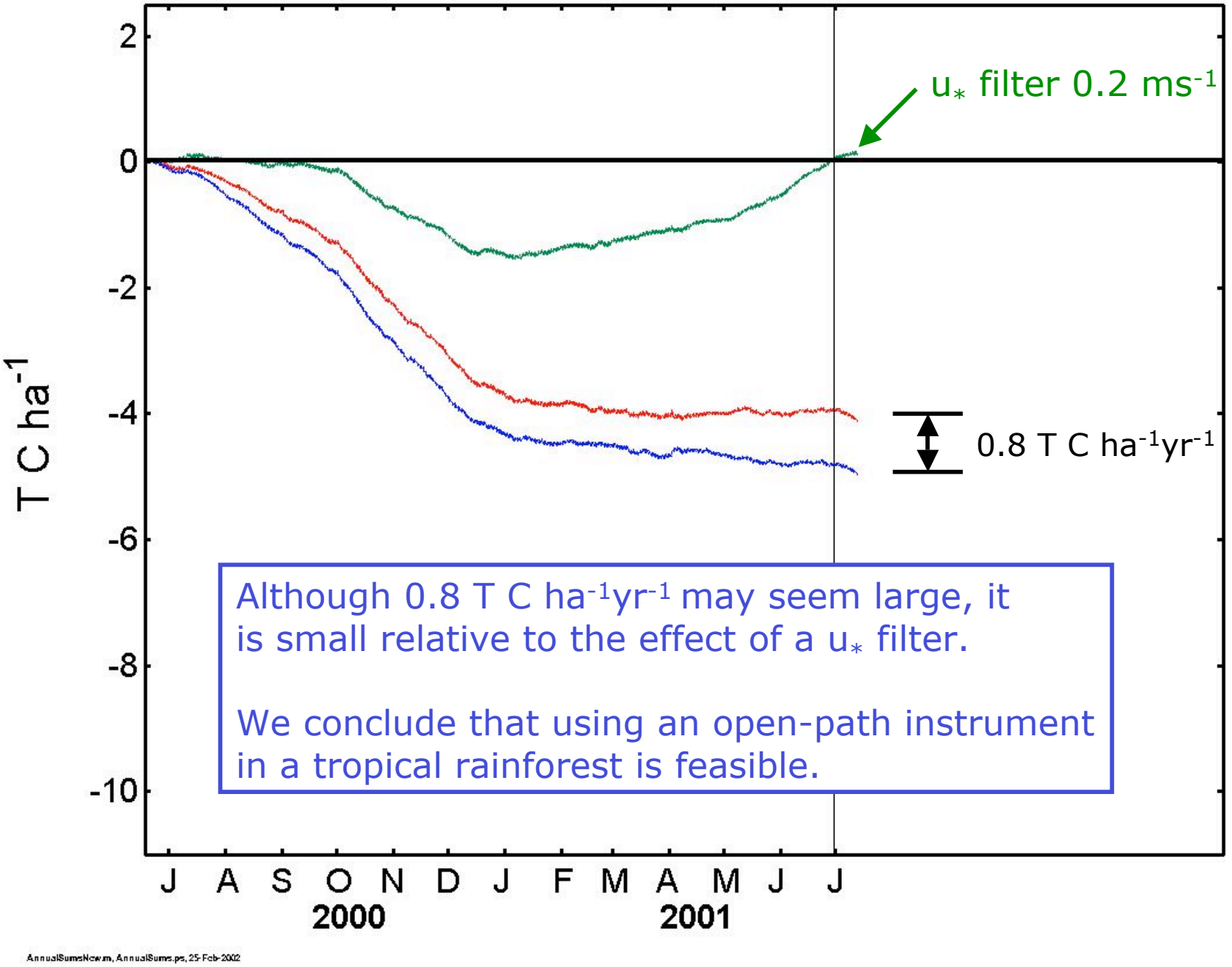
# Cumulative Sum for 1 Year (NOT $u_*$ FILTERED!)




AGC versus PAR
Open Path AGC versus PAR: missing data biased toward rainy intervals
Appy par model to NEE (not turbulent flux):
NEE = f(par)
Note: listen to the AGC (status) output of the instument
agc
par
100
95
90
85
80
75
70
65
60
55
50
0
500
1000
1500
2000
2500
3000

# Cumulative Sum for 1 Year (NOT $u_*$ FILTERED!)




2
0
-2
-4
-6
-8
-10
T C ha-1
u* filter 0.2 ms-1
0.8 T C ha-1yr-1
J A S O N D J F M A M J J
2000
2001
Although 0.8 T C ha-1yr-1 may seem large, it is small relative to the effect of a u* filter.
We conclude that using an open-path instrument in a tropical rainforest is feasible.
AnnualSumsNewm, AnnualSums.ps, 25-Feb-2002

Recommendations:

1. Keep well calibrated

2. Corrections decrease for high CO2 fluxes, small Bowen ratios, and when fluctuations are larger compared to background.

3. Ensure sonic temperature has sufficient response

4. Can apply correction either sample by sample or using 30 minute temperature and water vapor fluxes.

5. Make sure gap-filling is not biased toward sunny periods if missing flux intervals are correlated with cloudy periods.

30 MINUTES

u,v,w

Sonic T

CO2
open path (blue)
closed path (red)

H2O

w,CO2 cospectrum

w,co2 ogive

w,H2O cospectrum

w,h2o ogive