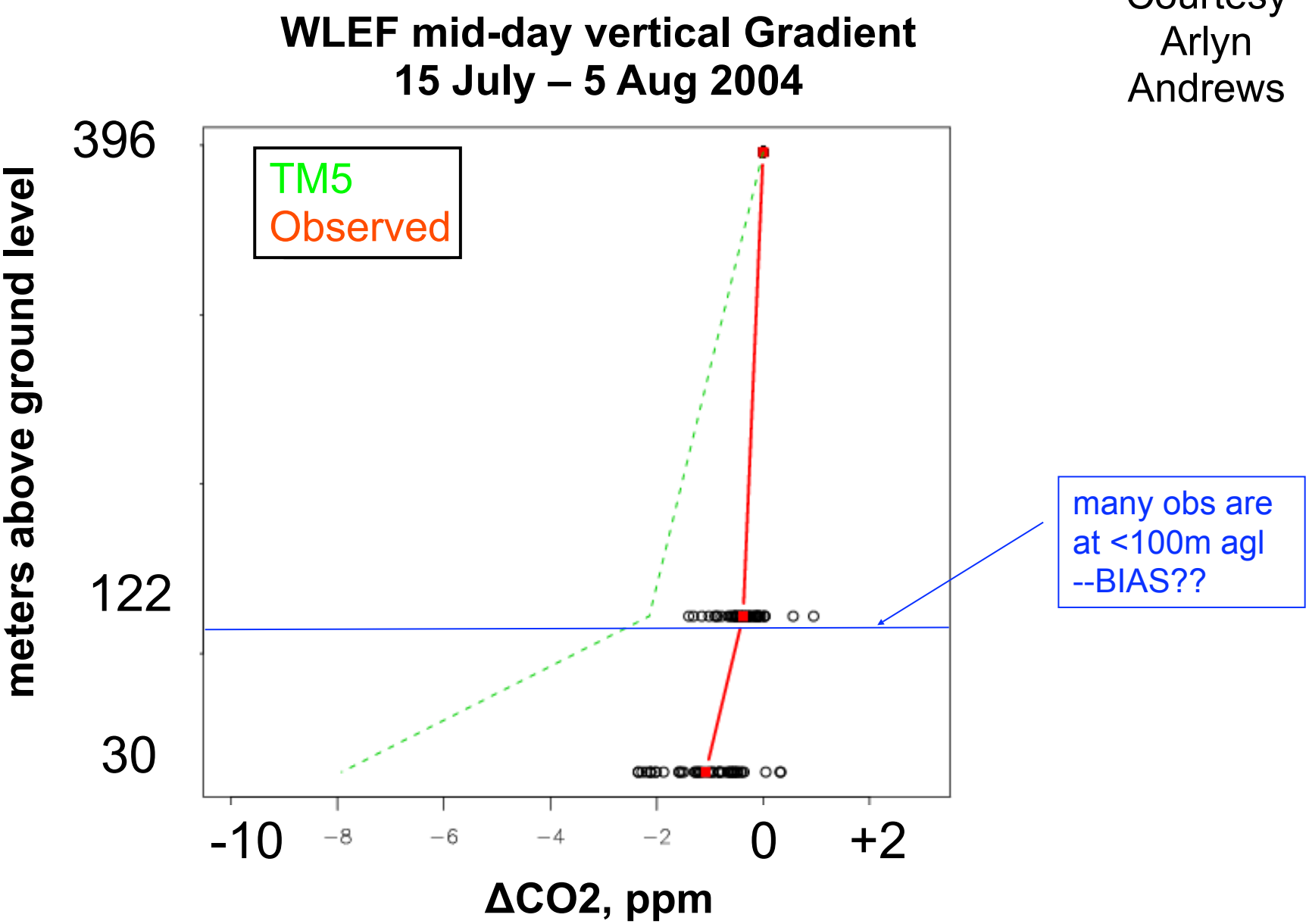
TM5 Sampling Issue

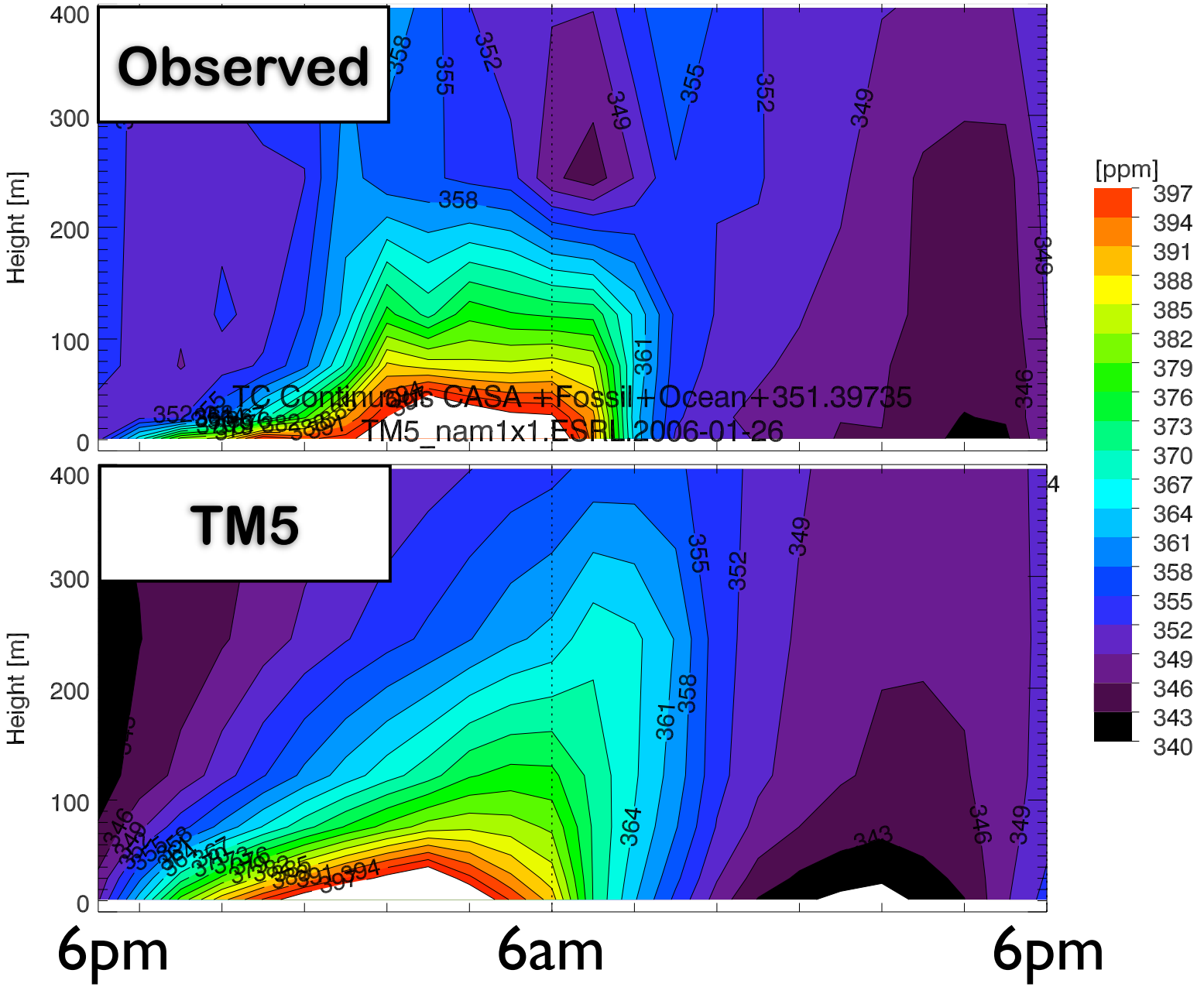
What's wrong with the simulated surface layer?

Courtesy Arlyn Andrews

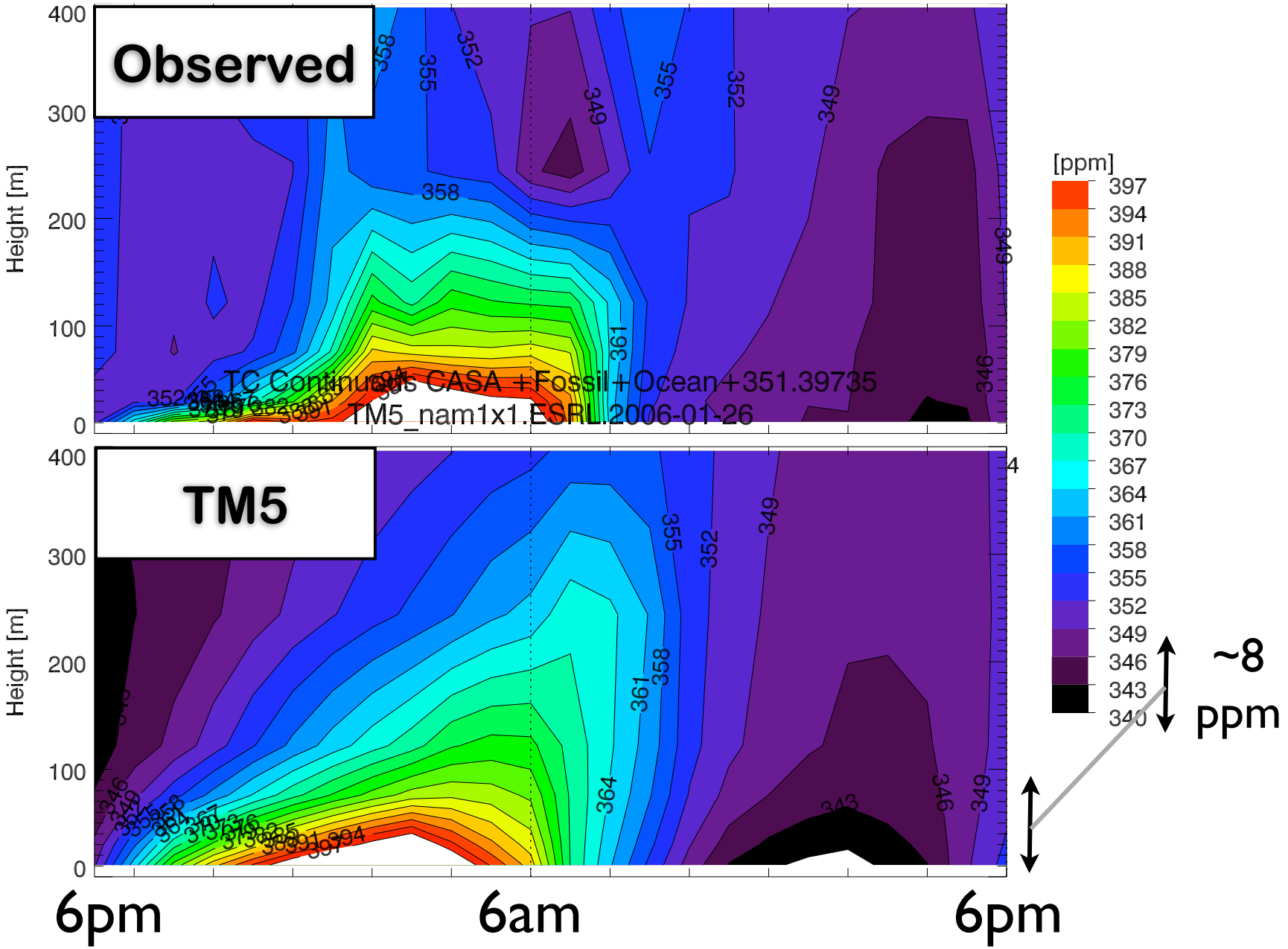


- TM5 overestimates vertical gradient from 30 – 400m by factor of 4 near the surface

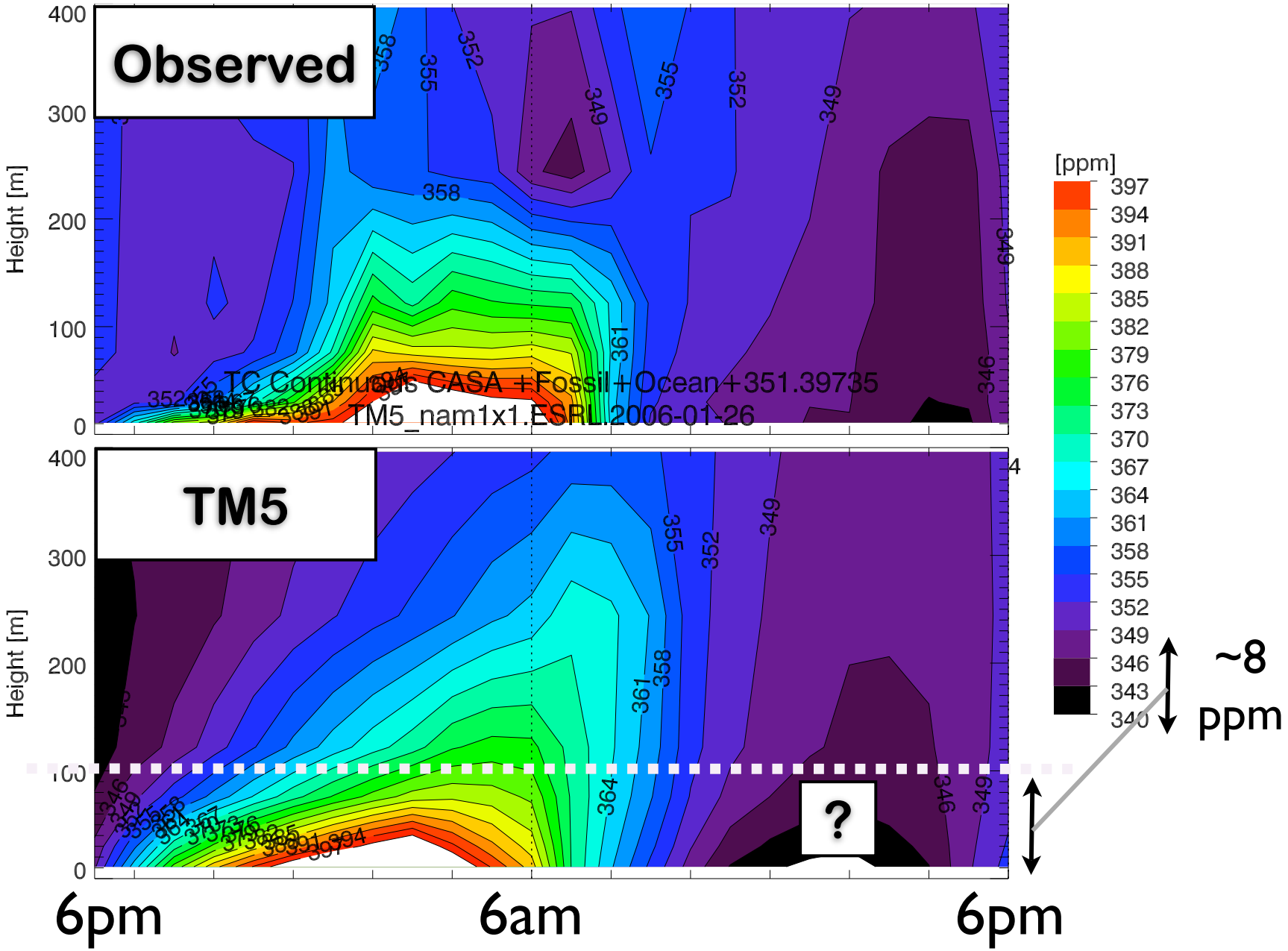
Diurnal cycle of CO_2, June-10th-2002



Diurnal cycle of CO_2, June-10th-2002



Diurnal cycle of CO_2, June-10th-2002



Hypotheses

A) The vertical diffusion is not fast enough in TM5 to wipe out the near-surface gradient

B) The way in which emissions are added (including setting the slope) leaves too much CO2 near the surface and not enough at higher levels.

C) Interpolation of the CO2 profile to the surface is done incorrectly because rzm slopes are used (linear and large)

D) The operator splitting and the way we sample within it causes biases from including one sample directly after sources.

Hypotheses

A) The vertical diffusion is not fast enough in TM5 to wipe out the near-surface gradient

B) The way in which emissions are added (including setting the slope) leaves too much CO2 near the surface and not enough at higher levels. (2)

C) Interpolation of the CO2 profile to the surface is done incorrectly because rzm slopes are used (linear and large) (1)

D) The operator splitting and the way we sample within it causes biases from including one sample directly after sources. (6)

(B) Emissions added incorrectly?

- One could distribute emissions through levels 1-3 instead of only having them affect level-1
- Currently, we set the slope of the tracers in the do_add_2d routine to have maximum mixing ratios near the surface after emissions, even further skewing the profile

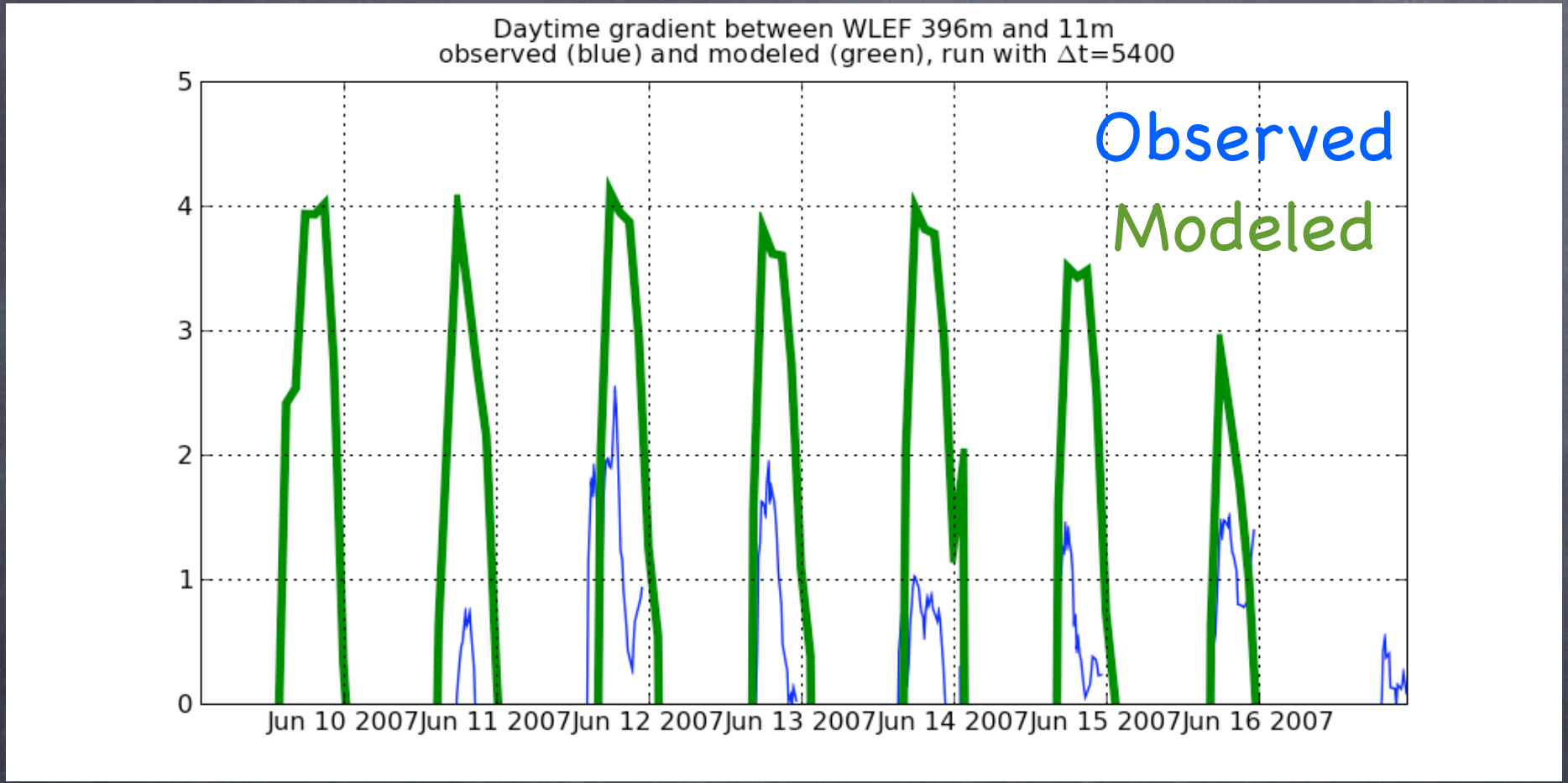
(C) Interpolation during sampling introduces biases?

- Results from TransCom Continuous intercomparisons demonstrated large sensitivity to sampling method
- Not only horizontal interpolation, but also vertical interpolation is important contributor
- Many observations are at surface, hence extrapolation is used from few points in profile

(D) Operator splitting and sampling

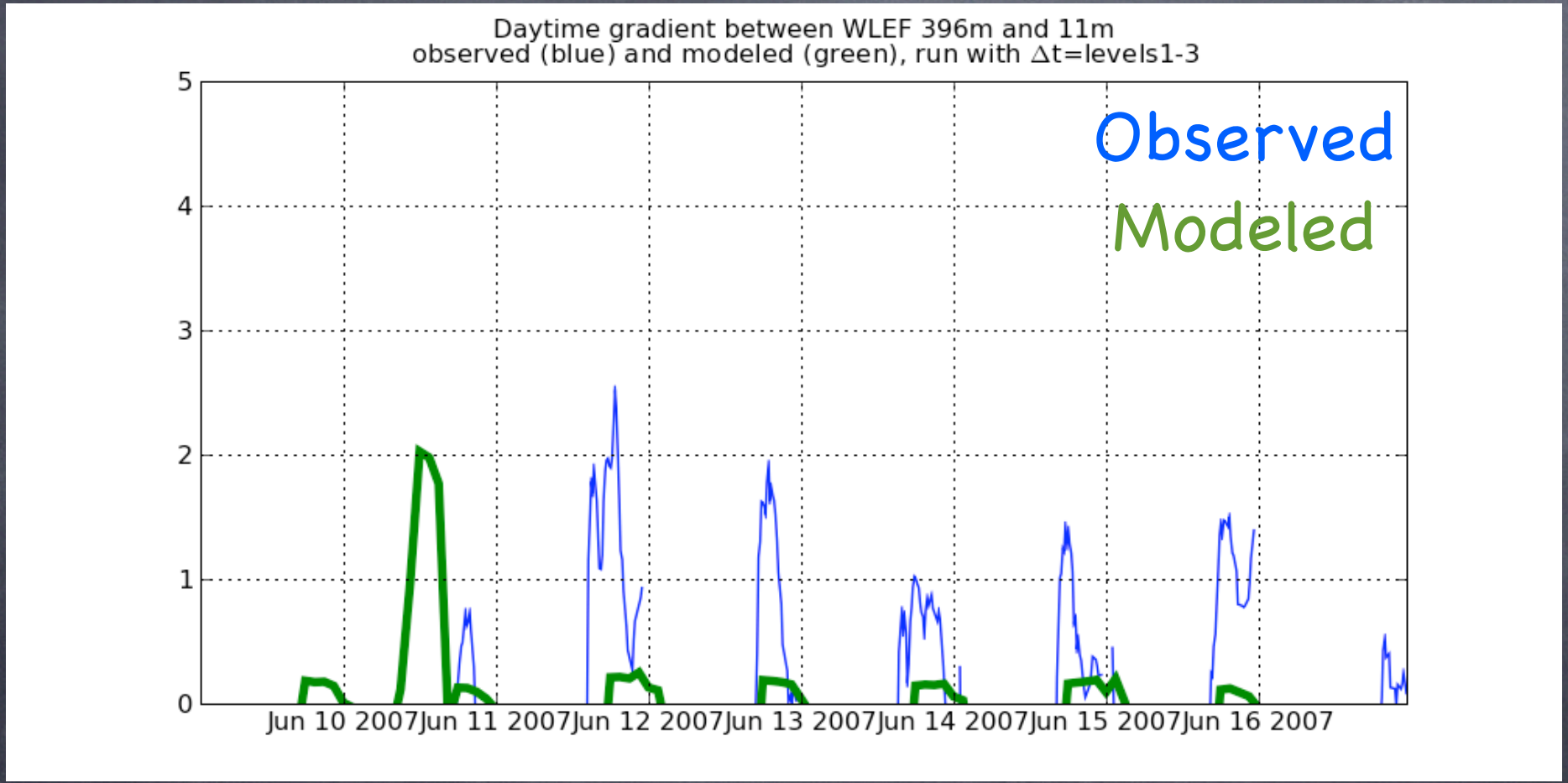
- We currently sample (*) twice per sequence:
  - *XYZVSC - *CSVZYX
- and average the result. One sample is after tracer updates by S and C, what if these tendencies are really large?
- Small time step avoids numerical inaccuracies
- Smart sampling too?

ΔCO2 (396m–11m) at WLEF



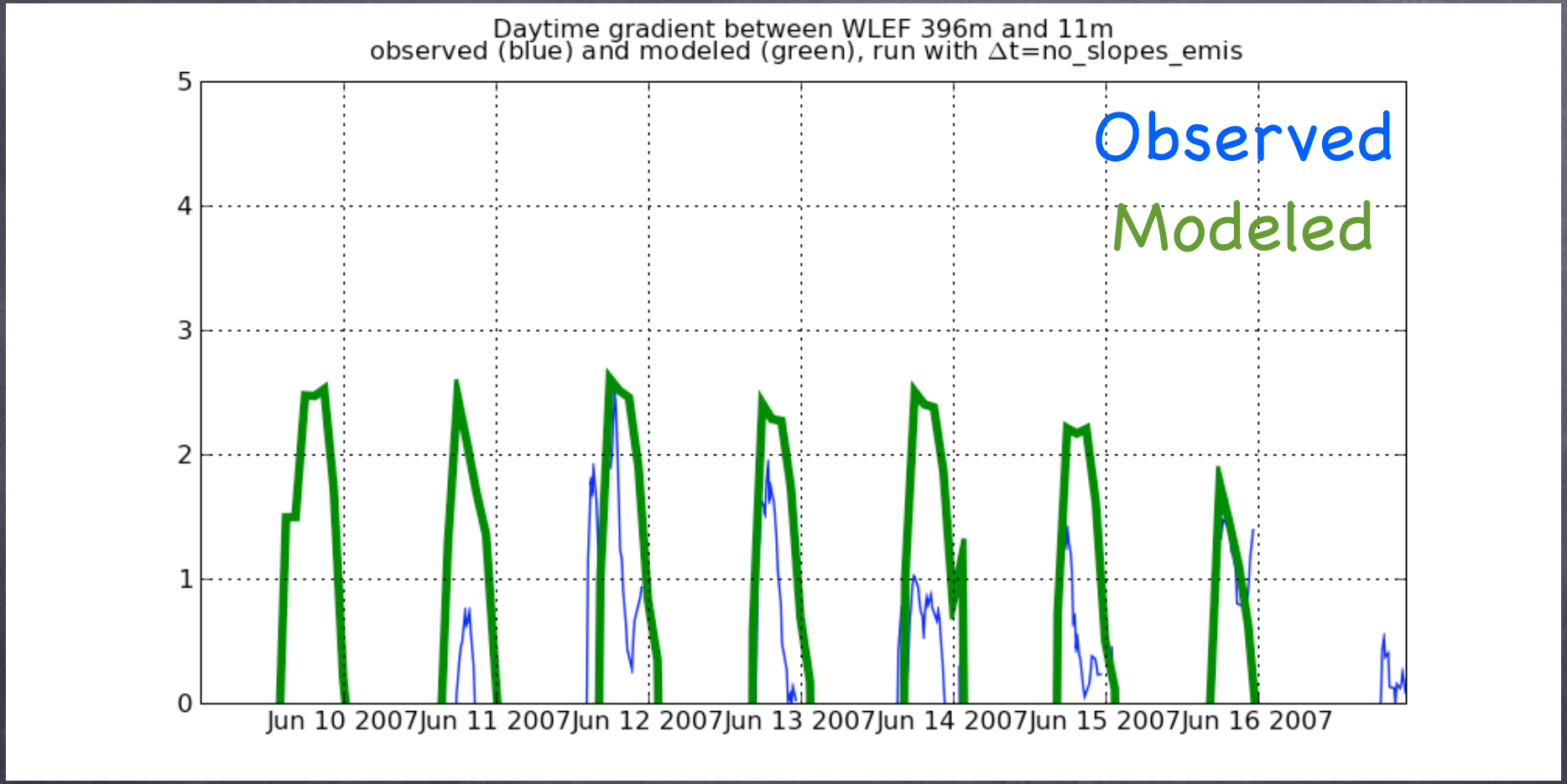
Δt = 5400 seconds

ΔCO2 (396m–11m) at WLEF



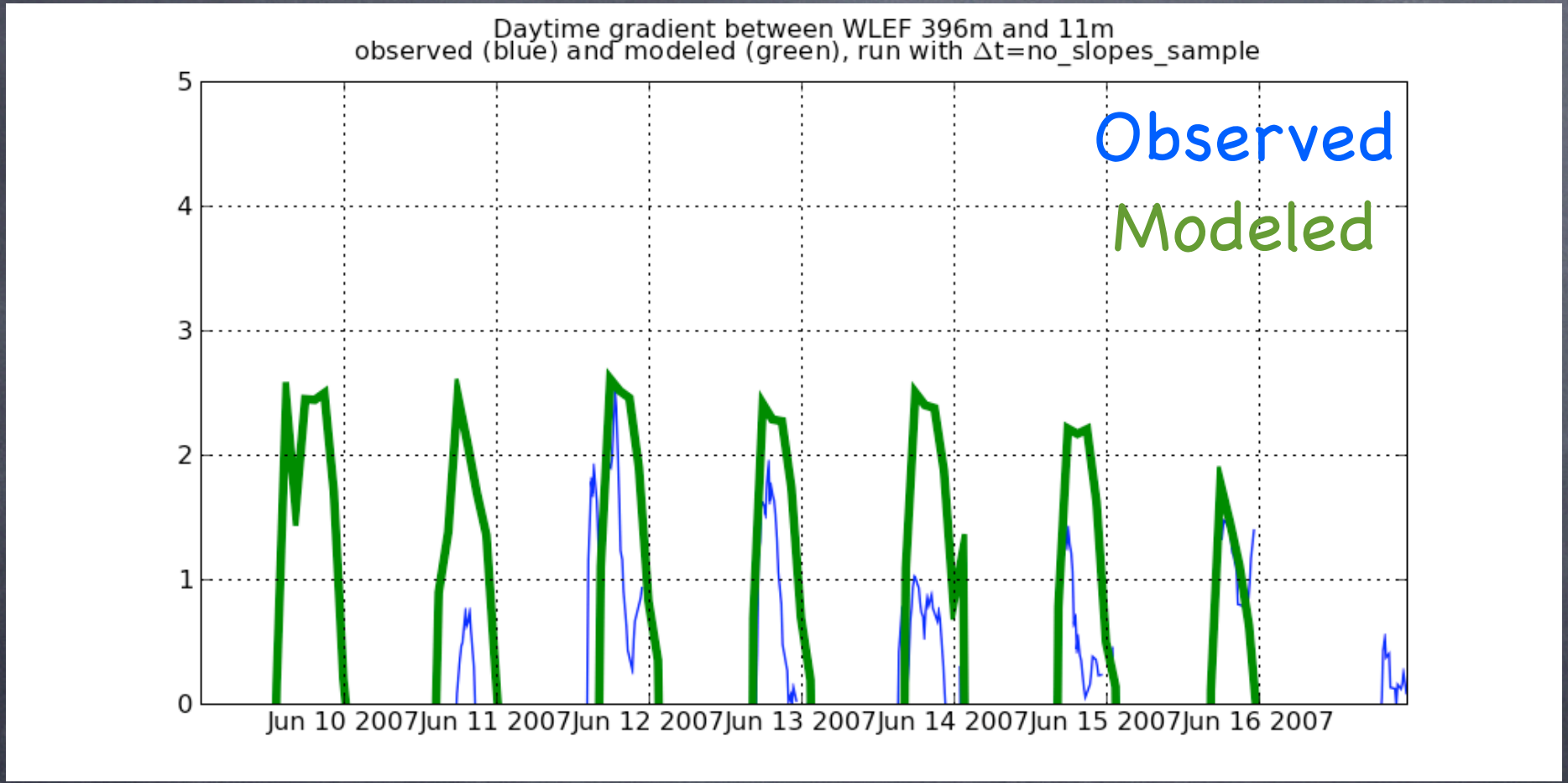
emissions in levels 1–3 (mass-weighted)

ΔCO2 (396m-11m) at WLEF



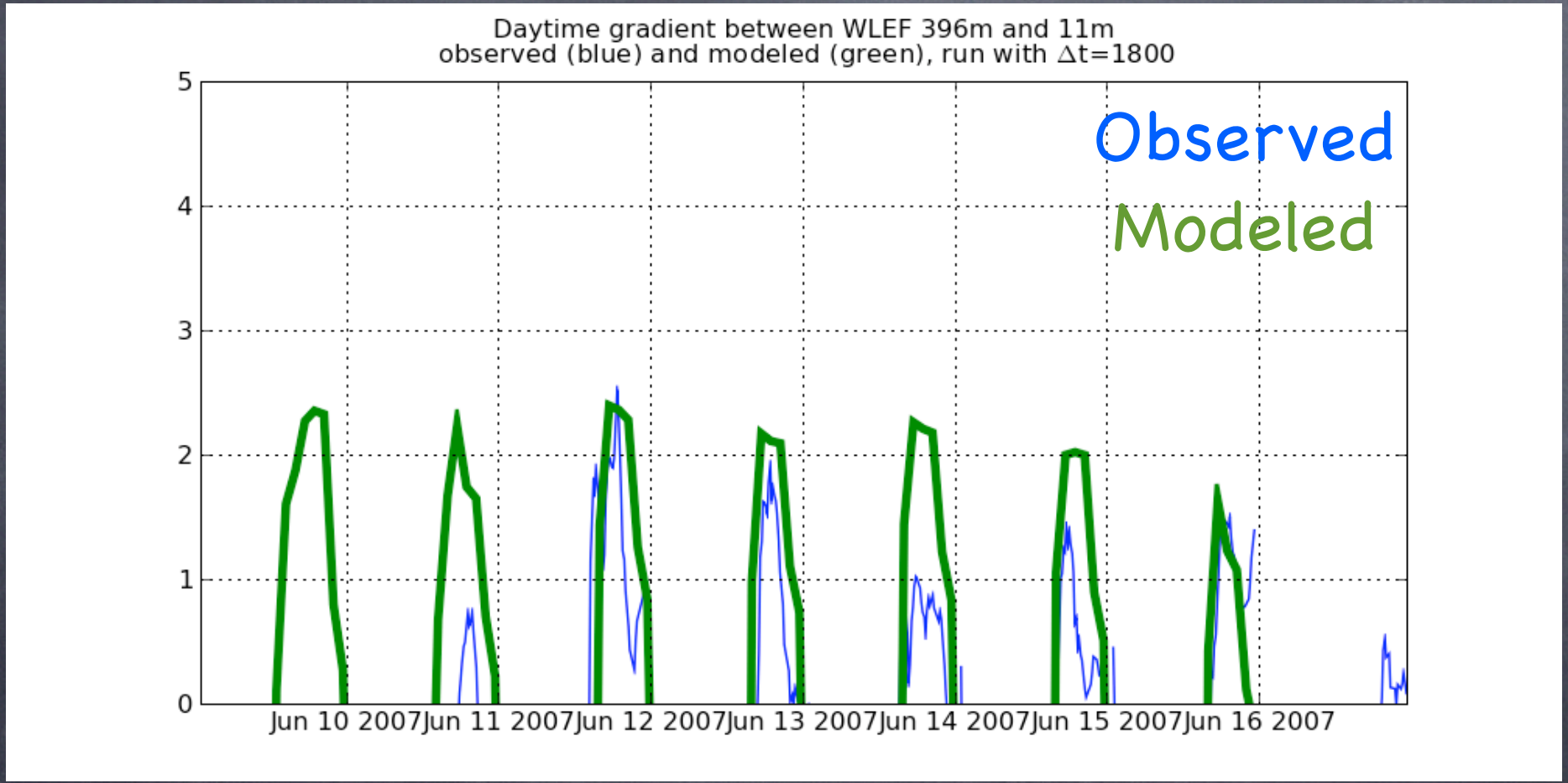
no slopes setting in emissions (do_add_2d)

ΔCO2 (396m–11m) at WLEF



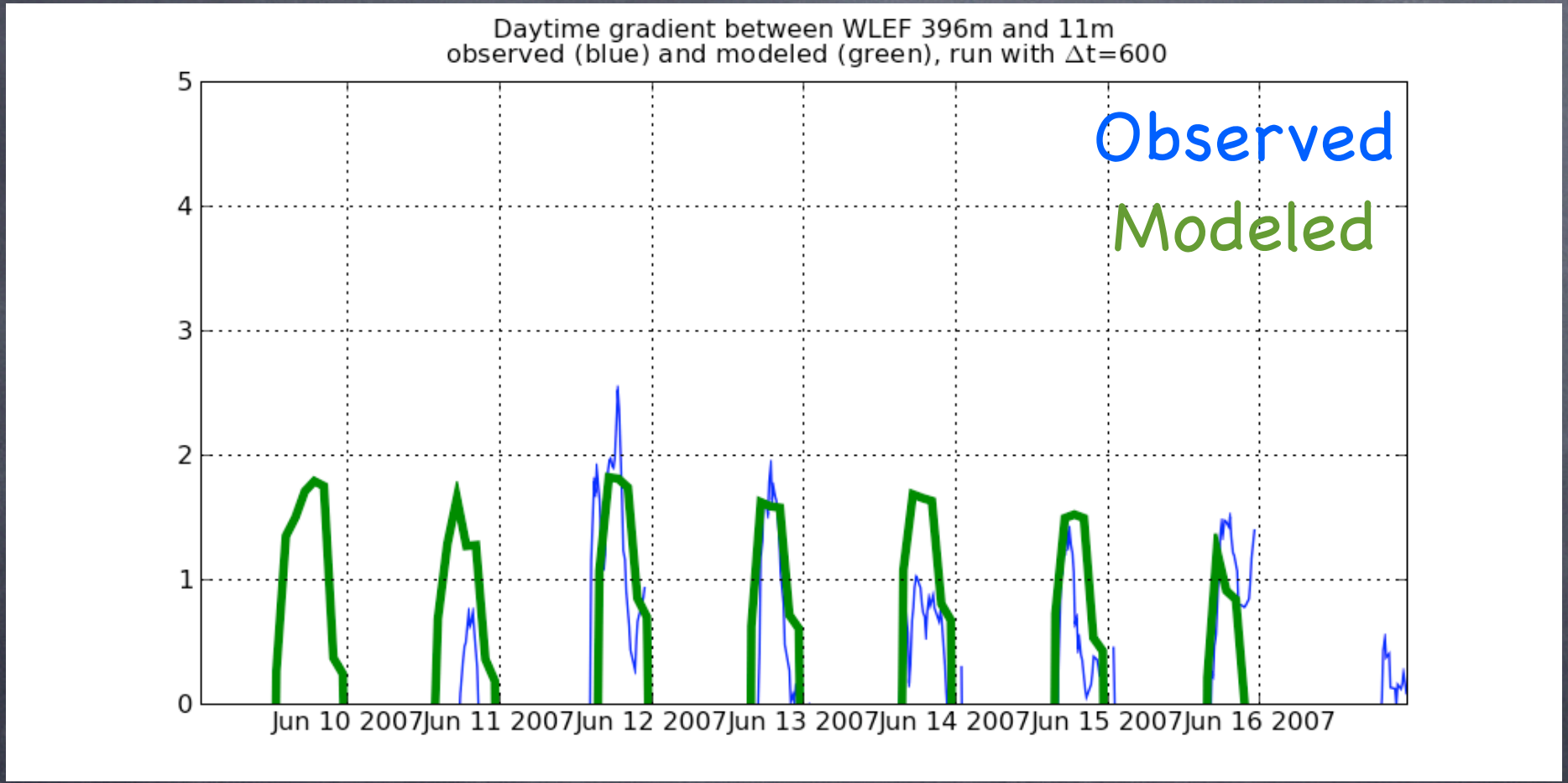
no vertical slopes in sampling

ΔCO2 (396m–11m) at WLEF



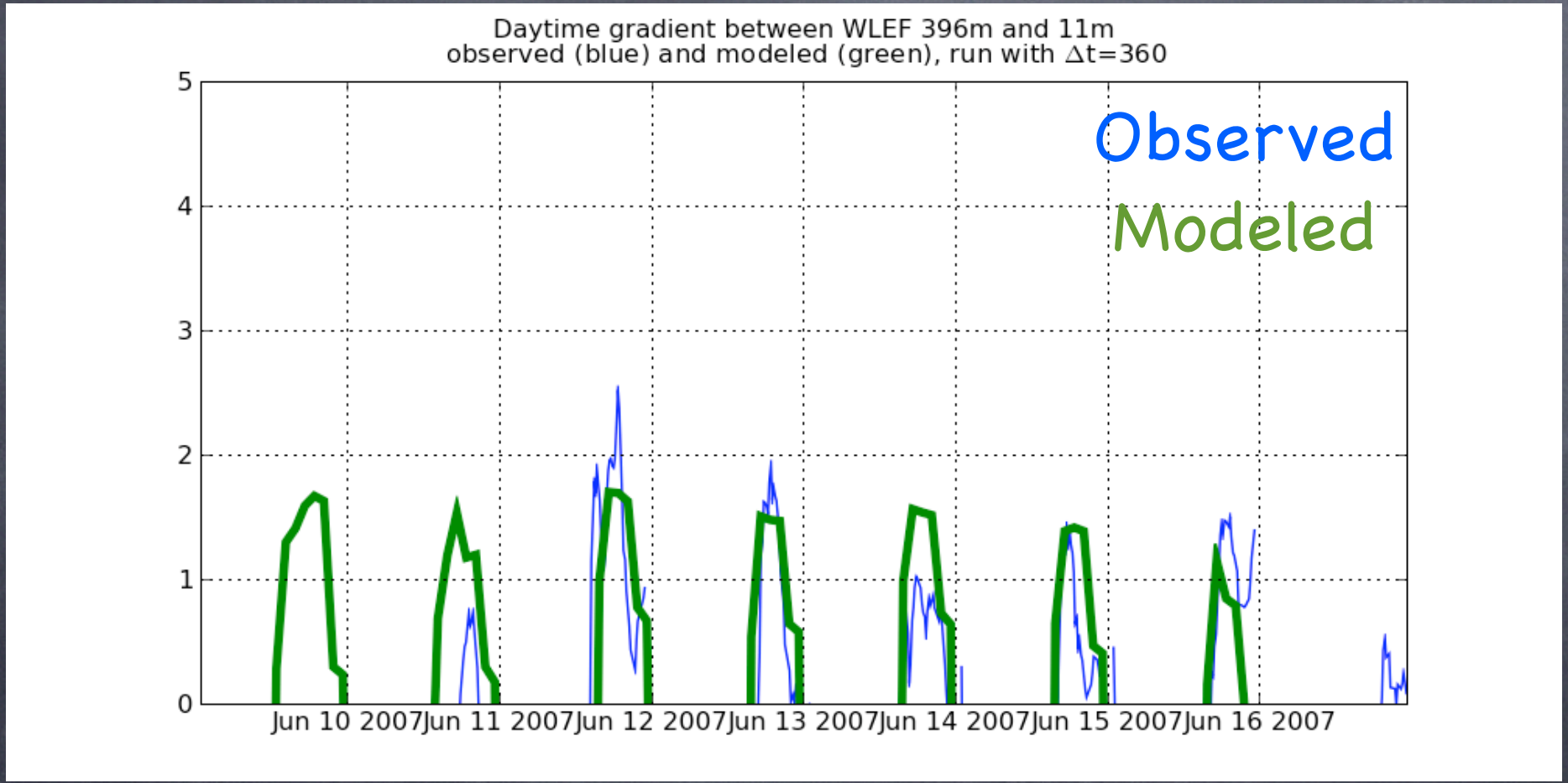
Δt = 1800 seconds

ΔCO2 (396m–11m) at WLEF



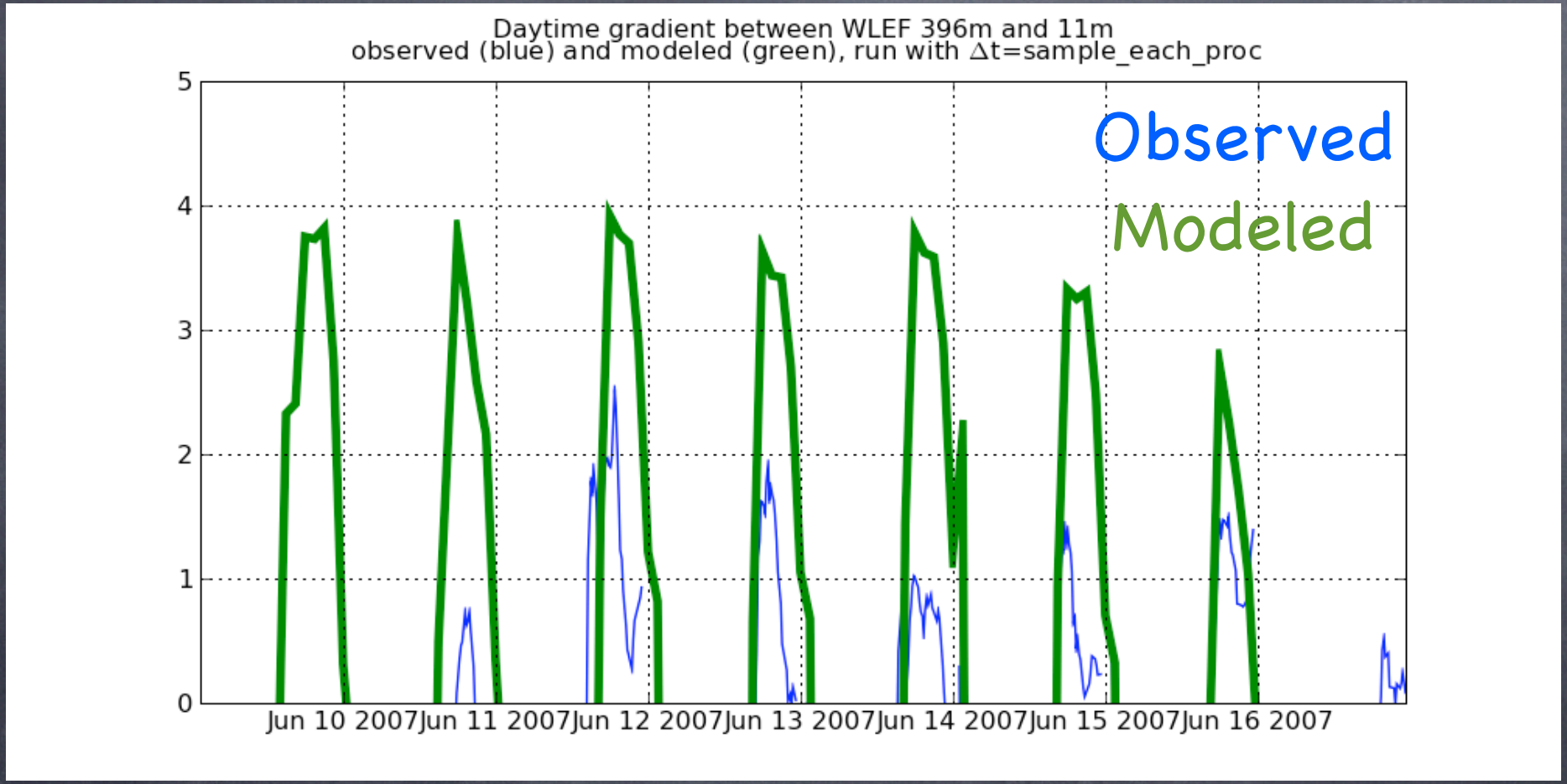
Δt = 600 seconds

ΔCO2 (396m–11m) at WLEF



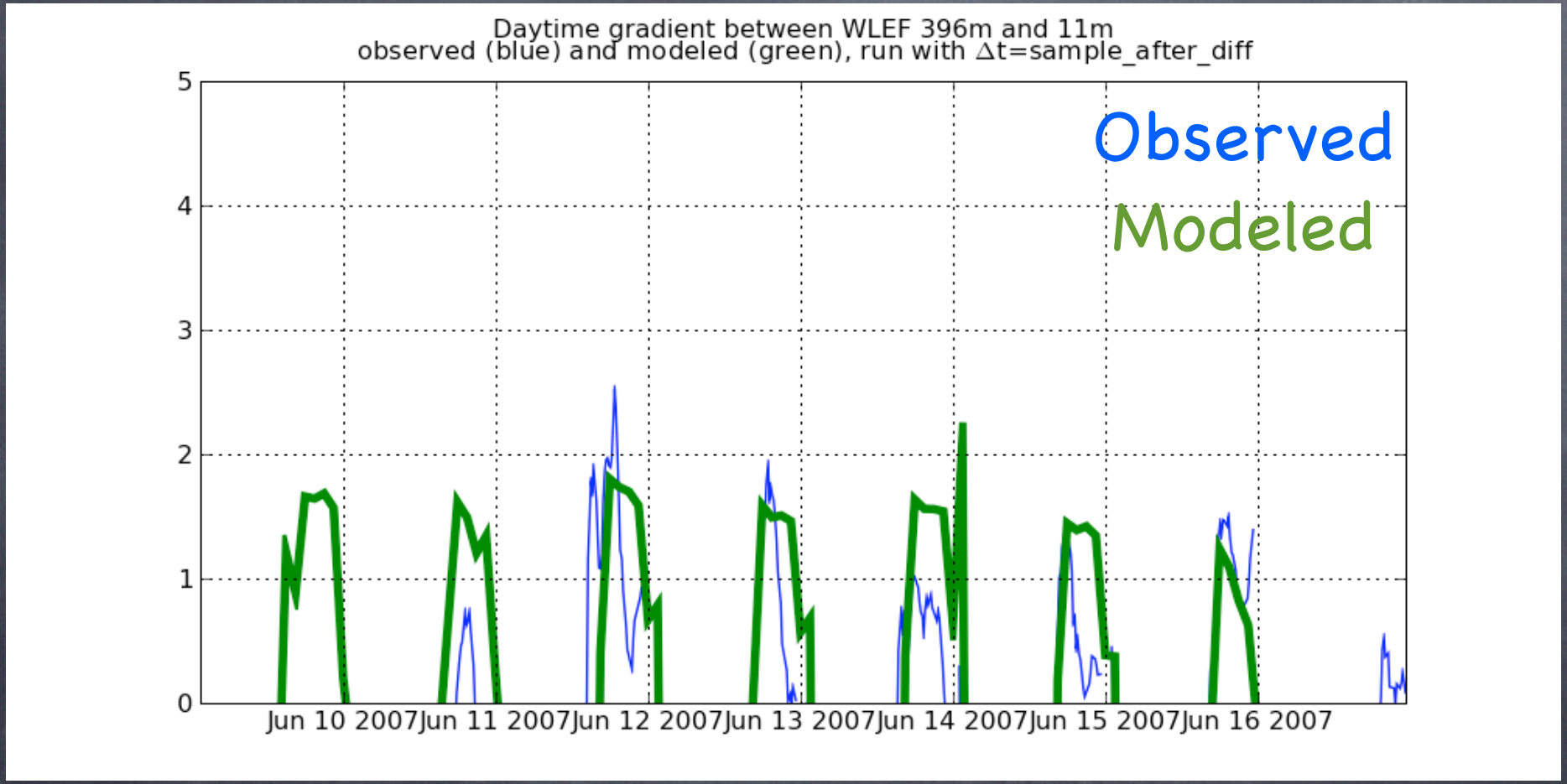
Δt = 600 seconds

ΔCO2 (396m–11m) at WLEF



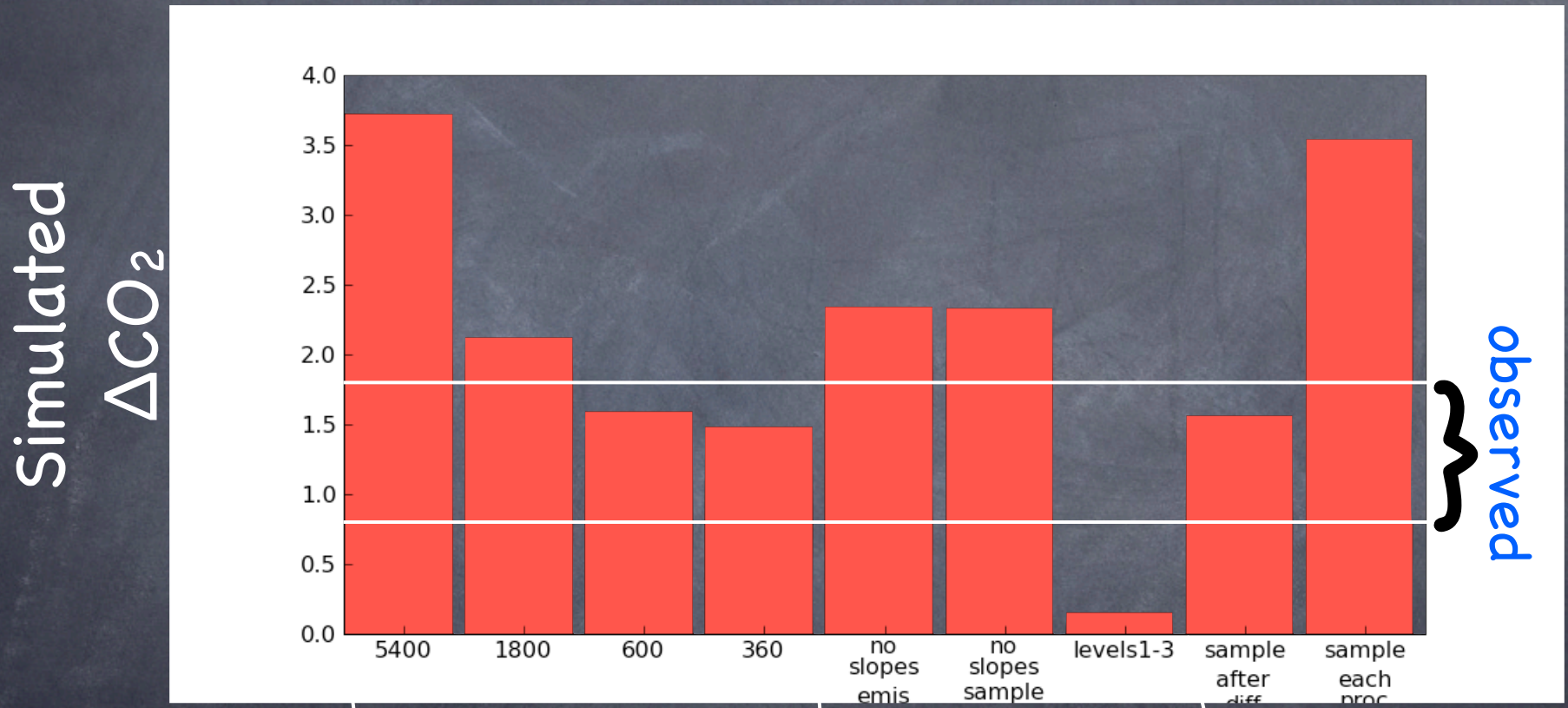
Sample after each process (X*Y*Z*V*S*C*)

ΔCO2 (396m–11m) at WLEF



Sample after diffusion only (XYZV*SC-CSV*ZYX)

Summary

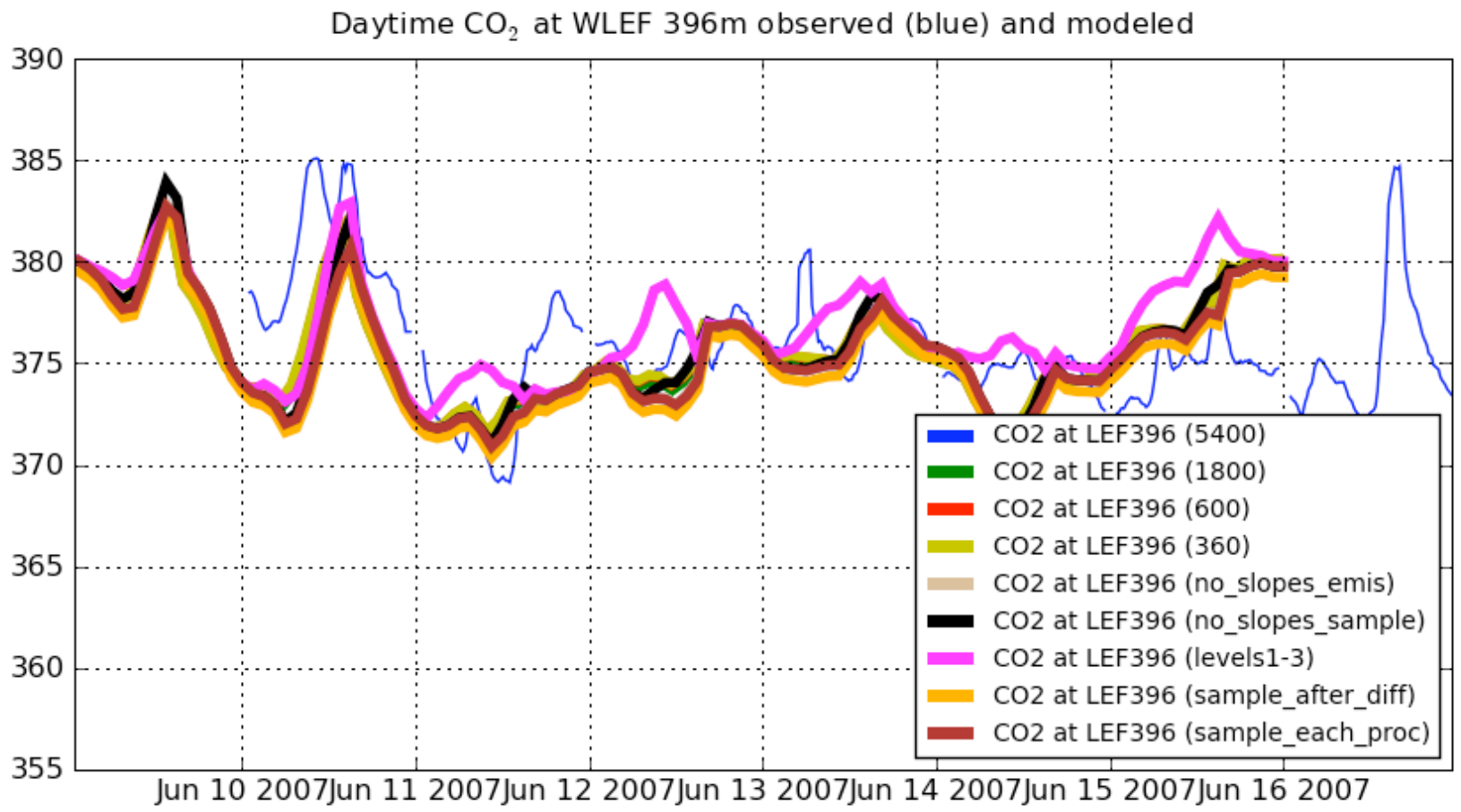


Influence of time step

Influence of slopes

Influence of splitting

And note:



Mixing ratios at 396m are hardly affected by any of the changes attempted!

Conclusions

- A dangerous time step dependence of the numerical results of TM5 exists, manifesting itself strongest near the surface
- Careful sampling is the best way to minimize these errors
- For now, it seems prudent to *stop* using vertical slopes in the emissions and sampling routines, at least near the surface
- Smarter sampling can help, but 'smart' is application specific and thus not easy to implement
- A more generic solution is under development (WUR: Maarten)
- This problem is not CO2 specific: it exists for all tracers, and especially for those with large tendencies in S or C !!!