Notes on Gonzi et al., Quantifying pyroconvective injection heights using observations of fire energy, ACPD, September 2014.

We read with interest your paper on pyro-convective injection heights. We would probably all agree that more work is needed on both the observational and the modeling sides before we can reach a truly satisfactory way of representing smoke injection heights in climate models. However, we seem to have reached different conclusions about whether an embedded 1-D plume-rise model or a statistical summary of satellite-derived injection heights would be a better choice for this application, given current capabilities. In any case, here are a few notes on the ACPD article, for your consideration.

Be well. Ralph Kahn and Maria Val Martin

1. P 22550, lines 10-13. *Val Martin et al*. [2012] vertically distribute the smoke emissions using *the same* 1-D physical plume-rise model of *Freitas et al*. [2007; 2010] that is used in the current study. The physics in this prognostic model includes the dynamical heat flux at the lower boundary, the atmospheric stability structure, parameterized entrainment, and latent heat. The point of the *Val Martin et al*. paper is to test the sensitivity of this leading plume-rise model to input parameters and to the underlying parameterizations, using MISR plume-height retrievals for validation.

   Although we agree this model does not treat explicitly the role of storm systems in pyro-convection, we conclude in *Val Martin et al*. [2012] that there are fundamental uncertainties in the plume-rise model even when storm-related factors do not represent major energy sources for the plume. Specifically, uncertainties in available dynamical heat flux constraints, derived from the most widely used FRP and fire area methods, remain limiting factors in model predictive ability, and even more importantly, the entrainment parameterization itself might dominate the factors contributing to model indeterminacy.

2. P22551, line 7 ff. You might consider referencing (1) *Peterson et al*. [*Remt. Sens. Env. 129*, 262-279, 2013], where they go beyond earlier studies in analyzing and refining the bi-spectral approach for deriving FRP from partly filled MODIS pixels and accounting for atmospheric transmittance, and/or (2) *Peterson et al*. [*JGR* 2014, doi: 10.1002/2013JD021067], where they apply this technique, and additionally demonstrate the role of upper-level moisture in fire energetics.

3. P22556, lines 2-6. We find from MISR stereo-height observations that if smoke is injected above the boundary layer, it tends to accumulate in layers of relative stability in the free troposphere [*Kahn et al., JGR* 2007; *Val Martin et al*., *ACP* 2010].

4. P22559, lines 2-4. As you know, this depends quantitatively on the atmospheric stability structure as well as the heat flux.

5. P22559, lines 6-18. The description of *Val Martin et al*. [2012] here is not quite accurate. The plume height climatology used in our paper was derived from MISR stereo height retrievals using the MINX algorithm [*Nelson et al*., *Remt. Sens. 5*, 4593-

4628, 2013], not from MODIS, covering the years 2002 and 2004-2007. The MISR-retrieved heights were used to test injection heights calculated by the *Freitas et al*. [2007; 2010] model, initialized with values from all combinations of four widely used methods for deriving fire heat-flux, and four widely used methods for deriving fire area, most of which rely upon MODIS data one way or another.

We found that the *dynamic range* of model-derived heights tends to under-predict the observations, i.e., the model sometimes over-predicts for low injections, and nearly always under-predicts for high injections [See Figure 2 of *Val Martin et al*., 2012], similar to the model result for CO in your Section 4.2. Our conclusion covers the range of injection heights over both the boundary layer and the free troposphere.

To your statement: "… that finding a robust relationship with injection height may well be as uncertain as using the plume rise model itself," we agree that there is uncertainty in the measurement-derived statistics due to limited coverage of smoke injection height from stereo-imaging observations (and even more so from other techniques, such as lidar), especially diurnal sampling. However, we concluded that given current plume-rise model uncertainties, simply using a statistical summary of the relationship between satellite-observed fire properties and stereo-derived plume heights (which you refer to as a look-up table) would probably be preferable, for global climate model applications, compared to running an embedded, state-of-the-art plume-rise model with currently available constraints and parameterizations. And we provided the best statistical relationship we could from the five years of North American plume data in our study, with the understanding that similar relationships would need to be derived for other fire regimes.

6. P22559, lines 18-19. Looking case-by-case, we concluded that the parameterization of entrainment is also likely to make a leading contribution to uncertainty in the plume-rise model. (Also relevant here: P22562, last 2 lines + P22563, lines 1-3, where you introduce a parameterization for entrainment in the CO plume.)

7. P22560, lines 7-13. We think *Val Martin et a*l. [2012] instead of *Val Martin et al*. [2010] is the intended reference here.