Response to Referee #3 (D. Fitzjarrald)

We thank the referee for his constructive comments. The referee's comments are in italics, our responses in plain font.

Having labored in the Amazon rainforest environment at intervals during a period of 30 years, I can well appreciate the remarkable effort that went into the making of this facility.

I have worked personally with many of the authors on other projects. I think that too many topics and indeed, many separate potential papers or notes, were combined in this mighty one-hundred-and-twenty-seven-page manuscript. This is more than an "Overview", but less than a proper publication for each topic. Releasing these half-results now runs the risk of preventing the original scientists from presenting their specialized work separately.

Given the large number of studies ongoing at ATTO, we feel that the most effective way of providing an overview is to present a relatively short text and one or a few plots for each program component. This is the "standard" way of producing an overview paper for a special issue. There would be no objective basis for arbitrarily excluding some of the ATTO subprojects. The authors see no risk of this publication precluding future specialized papers. The overview is also intended to provide a broad context for readers unfamiliar with work in the disciplines other than their own.

This is compounded by the distinct impression this journal gives that the paper is essentially already accepted, even as it remains in some odd limbo as it awaits some correction and blessing.

It appears that the reviewer is not familiar with the two-stage publication and open review process of ACPD/ACP. Please see

http://www.atmospheric-chemistry-and-physics.net/peer_review/interactive_review_process.html

One mystery about this paper it may be too soon to report on results from ATTO, since no data has been obtained from the ATTO centerpiece, the 325 m tower. Why is this paper with preliminary results coming out before the tall tower is commissioned? Why not simply describe the project, justify its siting, instrumentation and height, and pass lightly over both the boilerplate justification and early finding from the smaller towers?

We apologize for not having made the purpose of this paper more transparent. As pointed out in the response to Reviewer 1, the Amazon Tall Tower Observatory is actually more than just the tall tower itself, rather, it comprises several smaller towers for pilot and process studies as well as the ecosystem surrounding the towers. This paper is intended to provide the scientific context of ATTO and to serve as an overview paper for the pilot studies. A future paper will discuss the details of the tall tower. We have added a paragraph at the end of the introduction that makes it clear that this paper is intended as an introduction and overview for a special issue.

The justifications as to why there is a need for long-term continuous measurements in the first thirteen pages are not clearly focused on the ATTO concept. The authors take side trips to explain details of the importance of the Amazon Basin to global biodiversity and climate change; these should be dealt with by references to other review articles already in the literature.

The introduction serves to introduce the reader of the special volume to the scientific background and context of the ATTO project. Therefore, it is written as a "mini-review", to provide this background to a broad range of scientists from many disciplines. It is also meant as a common point of reference for the specialized papers in the special issue. While the need for long-term measurements may be well known, it is nevertheless important to emphasize it for a site that is intended to operate for decades.

The reader deserves a more specific argument—more than generalities highlighting the importance of the Amazon Basin—that defends the idea that a 328-m tall tower be installed in such a hostile environment. It is necessary, but not sufficient to note that there are other tall towers monitoring the lower atmosphere at other parts of the world. The reader deserves to know why the ATTO tower was sited at this particular, relatively remote site.

The introduction now contains a section discussing the motivation and concept of the tall tower, the site selection criteria, and an improved description of the objectives.

What is the purpose of the smaller towers around the tall one? (The local canopy data presented in this paper all come from these towers.)

They were established to conduct process studies with minimal disturbance of the forest ecosystem, as is unavoidable with a large structure such as the tall tower, and to begin research

during the time that it took to get the tall tower constructed. This enabled about four years of process studies and pilot research at the ATTO site, which are being introduced in this overview.

Why is the local topography and map of adjacent water bodies only included deep into the manuscript, as part of one finding about gravity waves? These topics need to be presented right at the beginning, so that this paper can serve its rightful purpose as a reference to papers that follow, so that this information need not be endlessly repeated.

We agree, and have added a map with local topography and a brief discussion of the soils and geology earlier in the paper (Section 2.1).

To repeat: The authors would be well served to make a short description of the vertical structure of the atmosphere—and its diurnal variability—is presented. Such at least would allow the reader to understand why one has to make such a tall tower.

Boundary-layer phenomena that can be investigated using the tall tower are now discussed in the introduction. For a description of the boundary layer behavior we included a reference to Fisch et al. (2004).

The reader sees no reference to the successes and difficulties that have occurred at other tall tower installations (BAO, Cabauw, ZOTTO in Russia).

This will be included in a future paper specifically addressing the tall tower.

One important issue is the likely percentage of good turbulence data that has been obtained from tall towers in other 'remote' sites. This reader sees no reference to what degree the preliminary measurements have been continuous. (In the preliminary results, many findings based on 2-3 weeks of work are presented at representative.)

Continuous micrometeorological measurements have been made since September 2012, with some interruptions due to technical problems. This information has been included in Section 3.3.

What this reader found here resembles a forced marriage collection of 'white papers' written over some time to accompany meetings planning this tower and/or (perhaps) selling the concept to funding agencies.

In fact, all the text contained in this manuscript was specifically written for this paper.

In short, the reader gets a heavy dose of interesting, perhaps important facts, but facts that are tangential to the issue at hand. The authors need to describe the site, explain why it was placed where it was, and what peculiarities it exhibits. I'm thinking of vegetation diversity, geographical diversity, and behavior of local wind systems. As one example, does proximity to the large Balbina dam and reservoir perturb any measurements? How would the authors know?

We have described the site in quite some detail and have now added additional detail on site selection and characteristics. Vegetation diversity is described in 4.1.1; geomorphology in section 2.1 (new text); local wind systems in 4.2.1. The influence of the Balbina Reservoir has not been detected in chemical tracers (e.g., CH_4) or wind measurements.

Perhaps the size of the text is merely a symptom of the enthusiasm that led to the tower's construction, but the founds ought to be restrained a little, to avoid the hubris that leads to 'monumental science'. There is not yet enough output to justify a celebration. The reader deserves to receive an overview that discusses ATTO, not an encyclopedia of everything all shoved together as it would be in a loosely gathered notebook. If the fifty-six authors want to write such a tome, they should write a book, with chapters for the sundry specialties OR they should commandeer a journal for a dedicated issue.

In fact, this is a paper that introduces just such a dedicated issue, and that is intended to serve as a common reference for the specialized papers.

I hope that in revision the paper more closely resembles a reference work that allows the reader to understand why the tower was placed where it was, how the height of the tower was determined, what thinking went behind the construction of the smaller, satellite towers.

This has been included in the revised manuscript (see above).

I imagine that the revised paper will make a reasonable assessment of the percentage of time that continuous measurements can be achieved.

Such an assessment would be different for all the variables measured at the site and would dramatically increase the size of this already large paper.

Such a paper would lighten the load of the many authors who will follow and report on their new findings. The justification for the ATTO and how it came to be at this site can simply be referred to. Only some of these findings—perhaps long-term concentration measurements of

trace gases and aerosols—will be relevant to the Basin as a whole; many more will be of necessity local area case studies.

Indeed, ATTO is meant to be both a site for long-term measurements and local process studies.

Specific comments.

1. Any subsequent drafts should provide line numbers to aid the harried reviewer.

We don't understand. The ACPD version has both line and page numbers.

p. 7. "Efforts to upscale local measurements to larger scales have also lead to inconclusive and often contradictory results." Where do the authors explain how adding a single point measurements will improve this situation?

This statement is part of a general discussion on carbon cycle investigations. We did not imply that ATTO by itself would be the answer to this problem. But the establishment of long-term mid-continental baseline stations has been shown to significantly reduce uncertainties in the carbon budget. See the paper by Gloor et al. (2001), now discussed in the Introduction section 1.5.

p. 8. "Seen together, these studies suggest that the Amazon Basin teeters on a precarious balance…" Again, these generalizations would be interesting if they were not distracting from the mission at hand. They belong in an overview paper; perhaps they come from one.

This is the overview paper.

p. 8. "While remote sensing can provide important information on the response of the Amazon forest to changing climate and ecological factors, the recent controversy about the effects of seasonal change and drought on the "greenness" of the forest illustrates how important long-term ground based observations are to our understanding of the Amazon system…" This is a true statement, as far as it goes. Much of this 'green-up' controversy has to do with the situation further east in the Basin, where the dry season is more intense and prolonged. The authors are 'selling' the utility of a tall tower in the central Basin. They are justifying it in much the same way as one would justify having a much smaller tower, of the type that is in use in this region already. What they need to do is emphasize the scientific riches that are in store for those who

have long-term observations at 325 meters, about one fourth of the thickness of the daytime convective boundary layer.

This is now discussed in section 1.5, and will be included in more detail in a forthcoming paper specifically addressing the tall tower.

5. p. 15. Suggested changes to the objectives, all designed to rein in hyperbole:

The Objectives have been tightened up and rewritten.

1) To understand the carbon budget of one specific site in the Amazonian rain forest under changing climate conditions and anthropogenic influences.

Actually, because the tall tower has a CO_2 concentration footprint on the order of 10^6 km^2, it represents more than one specific site. See new text in Section 1.5.

2) To continuously observe anthropogenic and biogenic greenhouse gases in the lower troposphere, within the planetary boundary layer by day and outside it at night, in order to help constrain inverse methods for deriving continental source and sink strengths and their changes over time.

Changed as suggested.

3) To continuously measure trace gases and aerosols for improvement of our understanding of atmospheric chemistry and physics in the Amazon and further allow a continuous assessment of the effects of land use change that occur upwind of ATTO on the atmosphere and climate.

Now part of the newly formulated Objective 1.

4) To simultaneously measure anthropogenic and biogenic trace gases, contributing to our understanding of natural and anthropogenic effects on the atmosphere and climate. Measurements of isotopic composition will be made to help distinguish anthropogenically and biologically induced fluxes.

OK

5) To investigate key atmospheric processes, with emphasis on the atmospheric oxidant cycle, the trace gas exchange between forest and atmosphere, and the life cycle of the Amazonian aerosol.

6) To determine vertical trace gas and aerosol gradients from the tower top to the ground to estimate biosphere-atmosphere exchange rates.

7) To study turbulence and transport processes in the lower atmospheric boundary layer, as well as to understand the extent and characteristics of the roughness sublayer over the forest.

8) To develop and validate dynamic vegetation models, atmospheric boundary layer models, and inverse models for the description of heat, moisture, aerosol, and trace gas fluxes.

9) To provide single-point ground truth to help evaluate satellite estimates of greenhouse gas concentrations and temperature and humidity profiles

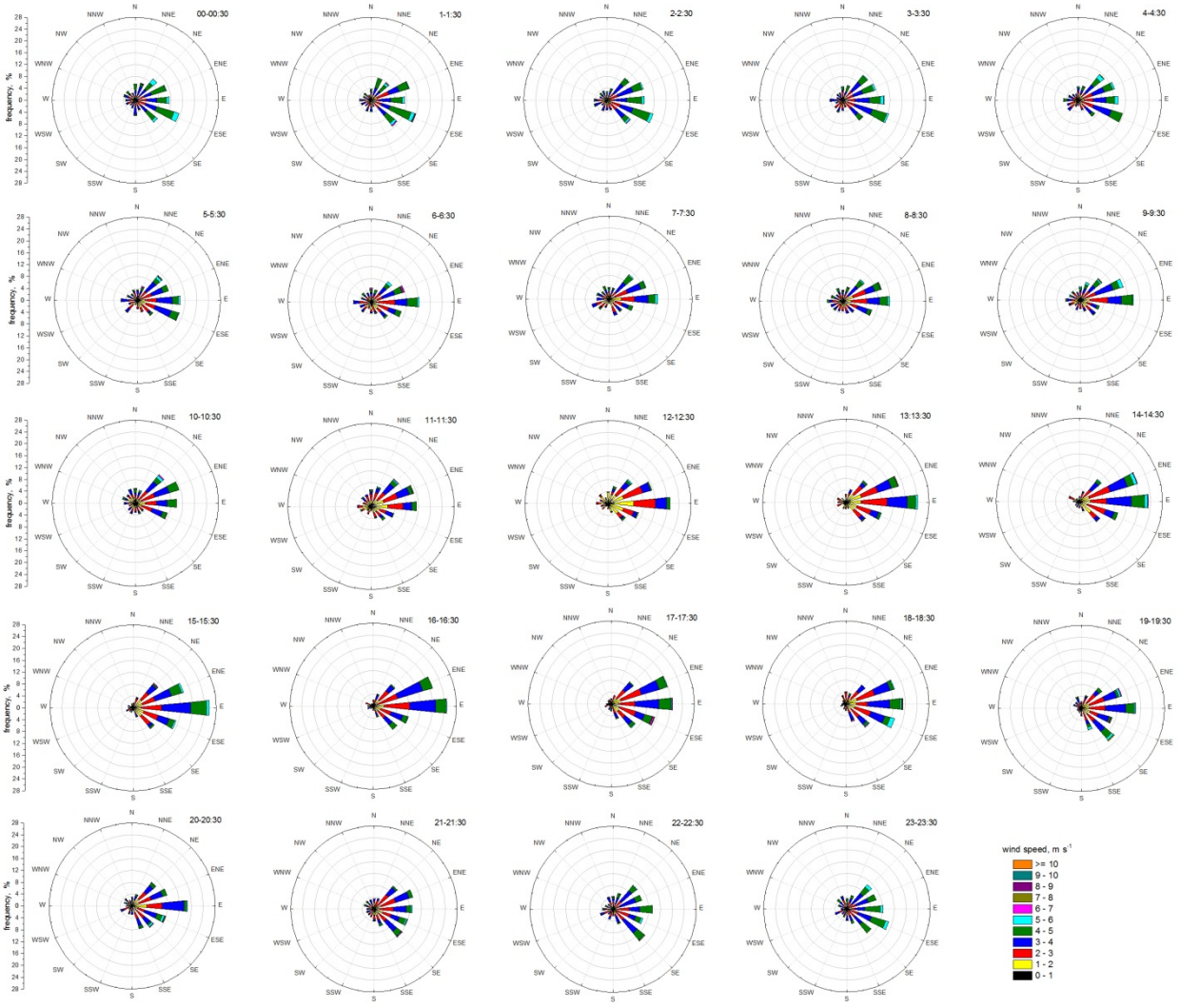
Modified to reflect the point that this is one site.

6. p. 20. Are raw turbulence and trace gas data archived? Will these be available to the community?

Yes. This is now stated in section 3.3.

7. p. 31. "The variation of the wind roses between daytime and nighttime was insignificant." This reader doesn't believe this. Please present hourly hodographs to show possible breeze influences.

This statement was based on an initial analysis of wind roses for daytime and nighttime. We have now plotted hourly wind roses for each season (see Figure 1 below, time in UTC) and cannot detect a lake breeze system. Such a system would be characterized by dominant flows from the north-western sector (Balbina reservoir) during daytime, which is clearly not the case. However, the wind roses show a slight diurnal variation with small contributions from the North, West and South during nighttime, when the nocturnal boundary layer is decoupled, in both seasons. In contrast, during daytime the wind blows nearly all the time from the East (dry season) and Northeast (wet season) with much higher wind speeds.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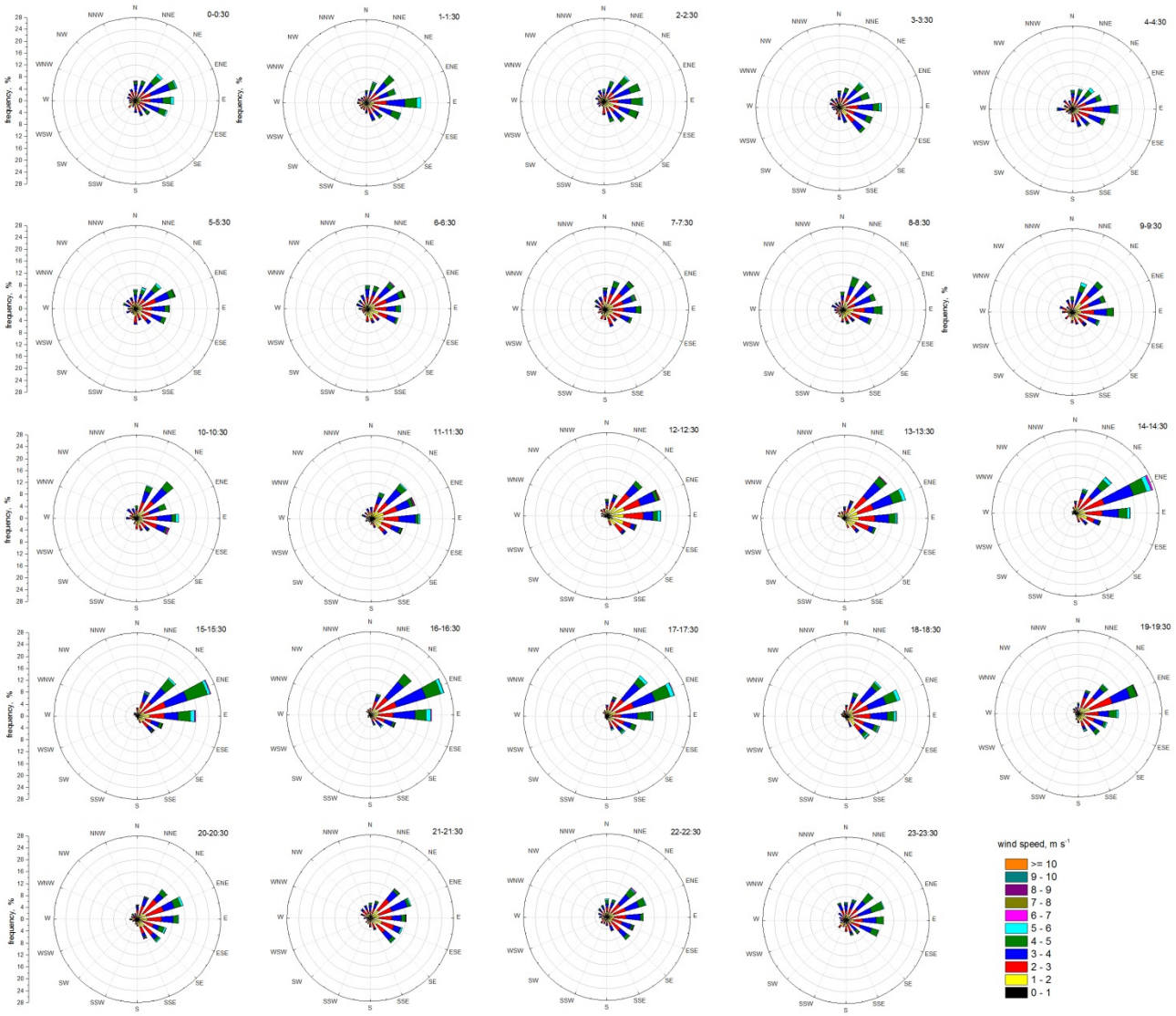

Figure 1: Half-hourly wind roses at 80 m at the ATTO site. The upper diagram shows the dry-season average, the lower diagram the rainy season average.

8. p. 32. (Figure 6) I don't see that the vertical spacing of temperature sensors is adequate to describe the stability regimes within the canopy. One cannot properly resolve the stability at canopy top and near the forest floor with the observation levels shown. How will this be addressed in the long term?

The referee is right in that the vertical spacing of the temperature sensors (6 levels throughout the canopy) might not be sufficient to resolve the shape of the temperature profile and, therefore, the exact heights of the diurnal maxima and minima. Nevertheless, the observed minima and maxima reflect the regimes of cooling and heating of the canopy as described in the text, which are in agreement with general observations in forest canopies. Nevertheless, our concept for upgrading the measurements within the framework of equipping the ATTO tower includes a higher vertical resolution of the profile throughout the canopy.

9. p. 40. Text following: "Figure 15a shows a topographic image of the experimental site with colors ranging from blue to red representing the altimetry values in meters above sea level." It turns out that the forest floor topography has an important influence on the CO2 balance, at length scales well smaller than 30 km, as the work of co-author Julio Tóta has shown. Somewhere in the site description this information should show up. Indeed, one shouldn't have to wait until p. 40 to learn of this site peculiarity.

We have added a new Figure (Fig. 1b) and some text in the manuscript (Section 2.1) to introduce this topic earlier in the revised version. The topography surrounding ATTO is actually not a site peculiarity, but the dominant landscape form in the central Amazon Basin. Regrettably, but unavoidably, this is not an ideal type of terrain from the perspective of micrometeorological flux measurements, because it induces significant upslope and downslope circulations (Tota et al., 2012). The effects of local topography on the local flux measurements from the small towers are the subject of ongoing investigations.

It must be pointed out, however, that the main objective of the tall tower with respect to greenhouse gas and aerosol monitoring is the measurement of concentrations above the level of local circulations. In this context, measurements from tall towers, such as ATTO, have the advantage of being less influenced by the surface layer variability due to diurnal changes in photosynthesis and respiration, as well as ecosystem and terrain heterogeneity. This results in smoothening of the large daily cycles of near-surface signals and efficiently integrates over daily cycles and small-scale heterogeneities, and facilitates the detection of long-term changes in the background atmospheric composition.

Tota, J., Fitzjarrald, D. R., and da Silva Dias, M. A. F., Amazon rainforest exchange of carbon and subcanopy air flow: Manaus LBA Site - A complex terrain condition: Scientific World Journal, 2012, 165067, doi:10.1100/2012/165067, 2012.