Response to reviewers for the ACPD manuscript:
"Overview of the Manitou Experimental Forest Observatory: site description and selected science results from 2008–2013" by J. Ortega et al. (ACP-2013-685)

We sincerely appreciate the reviewers for agreeing to thoroughly review our manuscript and thank them for their helpful comments. To guide the review process we have copied the reviewers' comments in black font below. Our responses to their points are listed below in regular blue font. Where appropriate, we have listed the changed text in **bold blue font**.

Comments from anonymous Referee #1

This document an on Overview of the Manitou Experimental Forest Observatory is a very basic description of a very important and extremely multidisciplinary trace gas field site. It is much on the order of the Hyytiala site in Finland, Blodgett forest in California, Harvard Forest and the Prophit site at the University of Michigan, so it is relatively rare. If one is to judge this descriptive paper on if the work is new and novel, I'd give it a luke warm grade, as it is a site characterization paper. But I have had many conversations with colleagues making long term flux measurements and I appreciate the importance of producing a site description paper, as documentation for ensuing papers, and this is that paper. So I think it has merit, especially in ACP where this group continues to publish products of their research. So given the paper has merit how can it be improved. I am a huge fan of producing more, better and extensive site meta data on the vegetation and soils. The information on site meta provided is sketchy at best. More information on physiological variables would be nice as I know Peter Harley measured these at the site; in fact the paper states 'Physiological parameters (e.g.sapflow, photosynthesis, and BVOC emissions) were measured on all trees within the experimental plot. Similar to the speciation seen in ambient air, branch-level measure20 ments showed that the BVOCs emitted in the highest concentrations were methanol, 2-methyl-3-buten-2-ol, and monoterpenes'.. I want to know more about stand inventory, disturbance history and its spatial variation of plant biomass, as deduced from remote sensing, eg Landsat or Ikonos. I want to know more about the flux footprint climatology and the representativeness of the site for making eddy covariance flux measurements. Information on soil moisture and rain and temperature climate is satisfactory. But sunshine climatology is important too, the daily integral of incoming solar radiation. And I want to see more basic soil and topography information

The organization and content could be improved. The goals of the paper are 'This article describes the Manitou Experimental Forest Observatory, presents on-going research at the site and highlights some initial findings. More specific scientific results and publications can be found in the publication list (Table S2) and within the individual articles as part of this special issue of Atmospheric Chemistry and Physics' Yet, If this is an overview on the site why the digression on some case study data.

We need to have this paper focus on its intent and not be duplicative of data that may be published in a more specific analysis. So climatology on the atmospheric chemistry, eg ozone levels and nox leves would be ideal. Focus on the ecophysiology, biometeorology, atmospheric chemistry climatology of the site and leave the case study material for other papers. Coupled chemistry modeling is a diversion too.

So clean up the paper and remove material that is in other papers and just describe the site in gory and gritty detail.

There were numerous discussions regarding whether or not this manuscript should include case study data in an overview. While we see the reviewer #1's argument that it goes beyond the scope of just a site description, many of the co-authors were strongly in favor of including specific gas- and particle-phase data in this paper in addition to the basic site description. We did our best to come up with a compromise and believe that including specific data strengthens the manuscript. Part of this includes simplifying the manuscript and attempting to put the entire text in "one voice" (the 1st author's).

To address the reviewer's comment regarding solar radiation and eco-physiology, a new figure (2) has been added that shows net radiation, sensible heat flux, latent heat flux and CO2 fluxes in the 4 seasons. The following paragraph has been added to section 1.2.

Like much of Colorado, the site has a high frequency of sunny days during most of the year. During mid-day in July 2011, approximately 90% of the days had PAR values (photosynthetically active radiation between 400 and 700 nm) above the canopy that exceeded 2100 umol m-2 s-1, and part of every day reached a PAR value of at least 2000 umol m-2 s-1. Frequent afternoon thunderstorms can temporarily reduce the solar insolation, but rarely for more than three hours. Figure 2 shows the diel cycles of net longwave and shortwave radiation, latent heat flux, sensible heat flux and net CO2 flux (calculated using the eddy covariance method) from four representative months during 2011. Each point represents the 30 minute average for that time period. The net radiation is calculated from the difference between the downwelling radiation and the upwelling radiation from the radiometers at the top (28 m) of the chemistry tower. It is interesting to note the net carbon uptake in the spring (April) and autumn (October) during the day, and the large nighttime respiration flux in July.

To address the reviewer's comments regarding soil properties, we added additional information about soils and topography in section 1.2:

Soils underlying the tower site and in surrounding area are classified as deep, well-drained sandy loams and sandy gravelly loams largely existing as alluvial deposits weathered from underlying arkosic sandstone formations as well as nearby granite formations (Soil Conservation Service, 1992). Although numerous outcroppings of partially-weathered sandstone exist around the site, the average depth to bedrock is estimated to be between 1-1.8 m (36-60 inches) below ground surface. Soil acidity ranges from slightly acidic to moderately alkaline (pH 6.1-7.8) with little organic matter content (1-4%)

and rooting depths reported to be in excess of 1.3 m (40 inches). Soil permeability on undisturbed soils is characterized as moderately rapid (approx. 50-150 mm hr-1). However rapid runoff generation and sediment transport has been observed at the site on compacted road surfaces, and other areas void of significant ground vegetation. The tower site is on an alluvial bench, formed by the erosion of underlying granite. It is situated in a broad, shallow valley approximately 1 km west of an intermittent creek. The terrain slope is asymmetric across this valley with the east side of the valley being steeper and the west side being more gradual (gradient between 3-8%).

To address the reviewer's concern about flux footprint, we have provided the following information in section 1.3.

The suitability of these towers for making eddy covariance flux measurements in the surrounding landscape was analyzed by Kaser et al. (2013b). Briefly, the flux footprint was found to extend to 900 m for unstable boundary layer conditions and to 2500 m for stable conditions. However, because there is more heterogeneity in the forest composition and proximity to former burn areas inside the 2500 m radius, a practical limit of 1850 m beyond the tower was used as the criteria for valid flux data. A paved road ~ 500 m east of the site caused data to be eliminated if wind direction was from that sector.

To address the reviewer's concern about physiological parameters, we have included additional information in Section 1.3. Just prior to this insertion, we have also emphasized that ponderosa pine is the only significant type of woody biomass surrounding the observatory.

Leaf-level gas exchange was measured during peak sun exposure (9am - 2pm) on sunlit needles ~ 10m above the ground. Each measurement was made on 6-10 mature needles. Mature needles were defined as needles that been on the branch through at least one winter. Gas exchange measurements were made using an LI-6400 portable gas exchange system (LI-COR Biosciences, Lincoln, NE) and photosynthesis, stomatal conductance, and transpiration calculations were made using total leaf area (measurement as described in Eller et al., 2013). The effects of high solar insolation, warm temperatures, and low humidity just prior to monsoon precipitation are demonstrated by the low stomatal conductance and photosynthesis values in July.

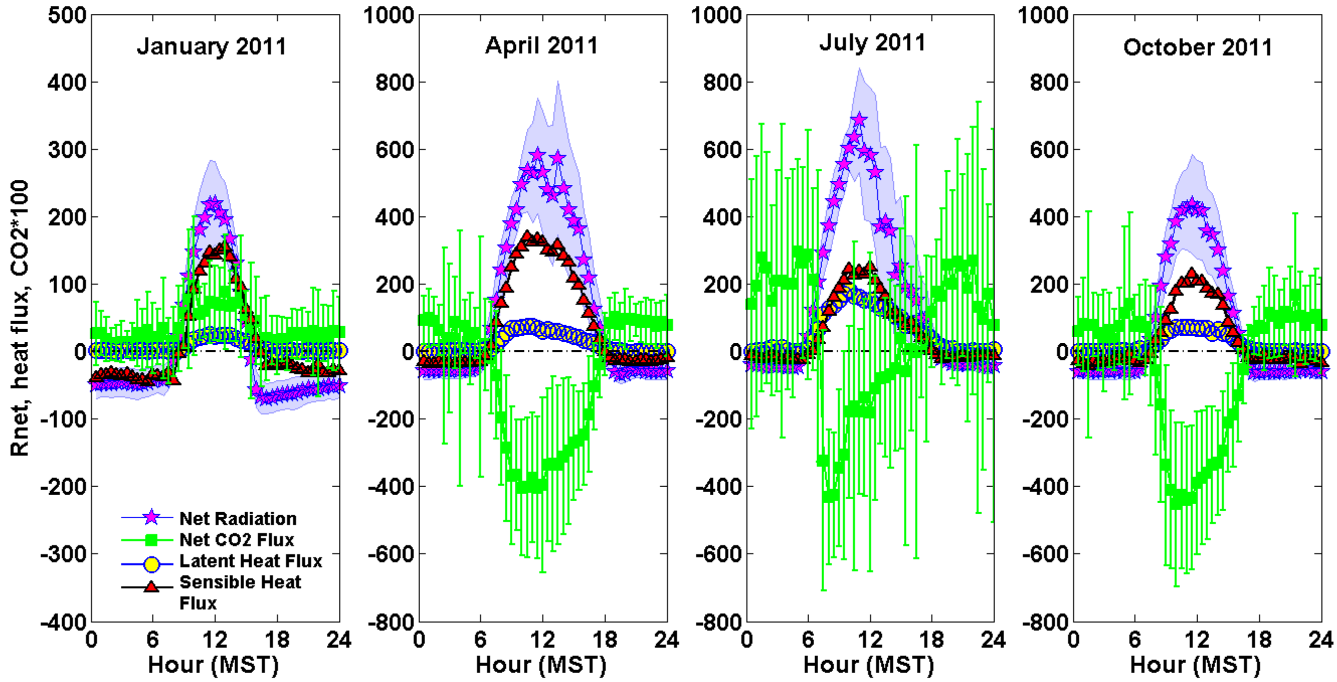
Table 1: Mean values for needle-level gas exchange measured on mature *P. ponderosa* needles at the Manitou Experimental Forest Observatory. All calculations are based on total, rather than projected, leaf area. Values in parentheses give the range of dates (2011 day of year) when measurements were made. Standard deviations are given in italics (n=3).

	May (136-149)	June, July (178-185)	August (230-233)	September (263-265)

Net Phosynthesis (A)	2.9	0.9	3.2	3.5
µmol CO_2 m^{-2} s^{-1}	*0.6*	*0.6*	*0.8*	*0.2*
Stomatal conductance(g_s)	28	7	29	30
mmol H_2O m^{-2} s^{-1}	*9*	*5*	*12*	*6*
Transpiration	0.49	0.35	1.00	0.64
mmol H_2O m^{-2} s^{-1}	*0.13*	*0.28*	*0.22*	*0.07*

Since another figure was added to an already long manuscript, we have removed the original Figure 3. We have simplified the meteorology section (1.4).

Figure 2: Average diel net radiation (downwelling minus upwelling), latent heat flux, sensible heat flux and net CO_2 flux for four representative months. All properties were measured from 28 m at the top of the chemistry tower in 2011. Each data point represents a 30 minute average for that time period. The y-axis limits are the same for each plot except for January, where the scale is ½ of the other three months. The shaded area for net radiation and error bars for CO_2 flux represent ± 1 standard deviation. Error bars for sensible and latent heat fluxes have been omitted for clarity.



Comments from anonymous Referee #2

This article provides an in depth overview about the conceptual design, implementation, site characteristics, and brief summary of key research findings of the Manitou Experimental Forest Observatory. Compared to a number of other overview articles that I have read, this manuscript impresses with the detail of the topics that are addressed. Sections of the article obviously were written by different contributing authors, but they have been nicely merged to yield a cohesive and well readable article. One could question if an overview article should go as deep into providing instrumental operating variables etc as done in this work.

Where are the data from these experiments deposited? A short section on data policy Interactive and data sharing would be a good addition. A few minor suggested corrections are given below. I see no further need for content changes or additions.
Please check for consistent consecutive numbering of Tables and Figures and that all figure graphs are mentioned and discussed in the text.

We agree that the manuscript goes into more details regarding instrumentation and results than typical site description or "overview" papers. Many of the co-authors were strongly in favor of including specific gas- and particle-phase data in this paper in addition to the basic site description. We did our best to come up with a compromise and believe that including specific data to augment the basic site description strengthens the manuscript.

Information regarding data policy has been augmented in section 1.3. The following text was added:

Campaign data and long-term observations are available at the following web site:
http://www2.acd.ucar.edu/campaigns
Other long-term data is available upon request from the corresponding author.

We have double-checked for consistency in the numbering of tables, and figures, and that it is consistent with the text.

1657/17: ..data are available
Thank you for noticing the error. See above for re-wording of this section regarding data availability**.**

1658/20: : : :show very little
We have corrected the typographical error (thank you for catching it).

1663/21: Please double-check and mention, where appropriate, what substrate/variable was measured/investigated (i.e. ambient air, fluxes, emission samples, leaf litter, ..)
This observation was in ambient air using the PTR-TOF-MS. The sentence now reads:

The PTR-MS showed that ambient concentrations of several other BVOC (including cymene, camphor, nopinone, pinonaldehyde and sesquiterpenes) were also elevated after this vegetation disturbance.

1664/17: Provide trees species that were investigated.
The only tree species at the site is Ponderosa pine. This has been added to the sentence to make it clear.

1666/12: Has MEFO been defined?
The MEFO abbreviation was introduced in the abstract as well as in the introduction and again in section 1.3.

1676/17: Mean and standard deviation results should be given with same number of significant and decimal digits. Please double-check standard deviation result. 5.2 ppbv seems amazingly low. Does this result reflect the variability of hourly mean values? Or maybe daily mean values?
The value given of 5.2 ppb was mistakenly calculated using an incomplete data set. It has been re-calculated using the complete month (August 2011) and found to be 27 ppb. This has been corrected in section 4.1. We appreciate the mistake being brought to our attention. The rest of that section has

been changed to be more consistent with units and significant figures for NO_x, SO_2, CO and ozone concentrations.

1677/23: Front Range Urban ???
The word “area” has been added after “urban”.

1678/23: ..in Indiana, USA : : :
A comma has been inserted between “Indiana” and “USA”.
1695: Inconsistency in figure formatting, i.e. font size of axis titles, legends, titles, date and time format should be corrected.
We have done our best to clean up some of the figures to make them more clear and consistent.

1701: Discussion of data should be in the text not in the figure caption. Figure caption should explain the figure.
Discussion has been removed from the figure caption.

1702: Are there any thoughts on the large disagreement between the modeled and measured HCHO flux? There seems to be a large discrepancy in these results that is not really addressed in the text?

On page 1666 (section 3.1), we state that "The missing HCHO source is thus consistent with oxidation of VOCs with light- and temperature-dependent emission profiles. The strength of HCHO fluxes cannot be accounted for by the oxidation of measured MBO and terpenes (also see Sect. 3.2)." A detailed analysis of this issue is presented in DiGangi et al. (2011). We have referenced DiGangi et al. (2011) in this section to emphasize the point.

The following sentence was added at the end of section 3.1: **A detailed analysis regarding HCHO sources and oxidation is discussed in DiGangi et al. (2011).**

Comments from anonymous Referee #3

This is a detailed overview paper summarizing initial efforts of the BEACHON project at the recently developed Manitou Experimental Forest research site in the Colorado Rocky Mountains. The paper details the long-term measurements at the site and provides highlights of results from several intensive observation campaigns already conducted at the site. The paper makes a useful contribution to the literature by providing a central reference point for the site that is and will (hopefully) continue to be a focal point for mountain forest systems research in the United States. The paper does a good job of both highlighting the published work from the site and laying the groundwork for ongoing work. It is suitable for publication in ACP after some corrections. These necessary changes are described below.

In section 1.3, there is an apparent discrepancy here regarding the current status of the micrometeorological measurements at the site. Much of the text and the paragraph here indicate this is an active site (present tense). However, the following paragraph on page 1656 states that measurements were discontinued in 2012. Have measurements since been reinitiated? If not, are they expected to be? It would be very unfortunate if long-term measurements have been discontinued. If that is the case, the manuscript should be modified throughout to better reflect the temporary nature of the site.

The initial draft of this manuscript reflected what was thought to be a temporary hiatus in long-term trace gas measurements. Due to a variety of factors and other obligations, these long-term continuous measurements were not continued. In the future, NCAR is planning to carry out limited (season-specific) measurements in an effort to continue year-round coverage without the requirements of having to be there every day of the year. The meteorological data on the chemistry tower has been running mostly continuously.

The text describing the meteorological tower has been changed to past tense. The following text has been added to section 1.3 after the description of the chemistry tower trace gas instruments:

The Waldo Canyon fire in June 2012 forced the removal of the trace gas instruments from the chemistry tower at the same time instruments were removed from the micrometeorological tower mentioned above. Fortunately, the fire did not directly affect the site, and meteorological measurements from the chemistry tower have been running continuously (see Table S1). Since the two towers had generated 3-4 years of data and the instruments were required for other projects and field sites, it was decided to stop continuous measurements. Measurements at the Manitou Experimental Forest Observatory are now planned on a seasonal basis to continue long-term measurements that capture each of the seasons. The intent here is to continue the time series, but with fewer resources than are required for continuous year-round coverage.

2. The label “Chemistry Tower” is sometimes capitalized and sometimes not. Capiltalization does not seem necessary, but either way it should be consistent.

The label “chemistry tower” has been changed to lower case throughout the manuscript.

3. As other reviewers have noted, the contributions of several different authors is clear in the writing. This occasionally affects the organization of the overall work; there are places where material is presented in a section where it does not fit. The most obvious example is the chemical data presented with the meteorology in section 1.4, but this issue occurs occasionally throughout the manuscript.

The discussion of NO_x in section 1.4 with meteorology has been simplified and the original Figure 3 has been removed.

4. In section 3.1, the cited paper by Zhao et al. describes the TAG system, but not it's coupling to an aerosol mass spectrometer. Is there a better reference available? Has the described work from the MEF site been peer-reviewed and published?

A new publication by Williams et al., 2014 has been added. The relevant text has been modified in the following way:

A newly developed Thermal desorption Aerosol Gas chromatograph - Aerosol Mass Spectrometer (TAG-AMS) was deployed and analyzed semi-volatile VOCs (~C14-C25) on a bihourly timescale. The sample collection, thermal desorption and chromatography systems have been described previously by (Zhao et al. (2013), however the 2011 BEACHON-RoMBAS campaign was one of the first to couple it to the AMS as a detector (Williams et al., 2014).

5. Most of the results presented in the paper are described only briefly, because they are based on previously peer-reviewed and published work. This is an appropriate approach for an overview paper. However, in some cases results of advanced measurements and analyses are presented that have not been previously peer-reviewed. This is the case, for example, for the results presented in Figs. 9 and 10. Since these are 'new' results, the scrutiny for review is higher, and significantly more detail about the measurements and analysis is required. This detail is not provided in Section 3.3, nor are the appropriate papers cited for readers to understand how the results were attained. Similar concerns exist for Figs. 12 and 13 in section 4.2. The authors need to provide sufficient detail that these new results can be fully evaluated, or they should cite appropriate companion papers that contain the details, or these parts of the manuscript should be removed.

To support the OH and HO2 measurements, the following references were added:

Edwards, G. D., Cantrell, C. A., Stephens, S., Hill, B., Goyea, O., Shetter, R. E., Mauldin, R. L., Kosciuch, E., Tanner, D. J., and Eisele, F. L.: Chemical ionization mass spectrometer instrument for the measurement of tropospheric HO2 and RO2, Analytical Chemistry, 75, 5317-5327, 10.1021/ac034402b, 2003.

Hornbrook, R. S., Crawford, J. H., Edwards, G. D., Goyea, O., Mauldin, R. L., Olson, J. S., and Cantrell, C. A.: Measurements of tropospheric HO2 and RO2 by oxygen dilution modulation and chemical ionization mass spectrometry, Atmospheric Measurement Techniques, 4, 735-756, 10.5194/amt-4-735-2011, 2011.

Mauldin, R. L., Eisele, F. L., Cantrell, C. A., Kosciuch, E., Ridley, B. A., Lefer, B., Tanner, D. J., Nowak, J. B., Chen, G., Wang, L., and Davis, D.: Measurements of OH aboard the NASA P-3 during PEM-Tropics B, Journal of Geophysical Research-Atmospheres, 106, 32657-32666, 10.1029/2000jd900832, 2001.

For more clarification on the particle size distribution measurements used for Figure 8, we have added the following text in the beginning of section 3.3.

The instrument used for these measurements consists of the following components:

- **Optical Particle Counter (200 – 2500 nm); Lasair model 1002 from Particle Measurement Systems (Boulder, CO),**
- **Regular scanning mobility particle sizer (SMPS; 30-300 nm): Custom sheath air and HV control unit combined with TSI model 3081 Differential Mobility Analyzer (DMA) and TSI model 3760 Condensation Particle Counter (CPC; TSI Inc., Shoreview, MN), and**
- **Nano SMPS (4-30 nm): Custom sheath air and HV control unit combined with TSI model 3085 DMA, and TSI model 3025a CPC.**

Particle size distributions started at midnight at exact 5 minute intervals for a total of 288 size distributions per day.

For more clarification on the measurements used for Figure 9, we have changed the appropriate text in section 3.3.
Previous text:
During the summertime 2011 BEACHON-RoMBAS study, AMS (Aerosol Mass Spectrometry) measurements showed average PM1 mass loadings of 2.5 μg m-3 (Figure 10). Also included in this figure is black carbon aerosol as measured with a single particle soot photometer (SP2, Droplet Measurement Technologies).

New Text:
During the August 2011 BEACHON-RoMBAS study, chemical speciation and mass loadings of non-refractory PM_1 aerosol were measured using a high resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS, Aerodyne Research, Inc., Billerica, MA; DeCarlo et al., 2006). Average mass loadings during the campaign were 2.5 μg m-3 (Figure 10). Also included in this figure is black carbon aerosol as measured with a single particle soot photometer (Droplet Measurement Technologies, Boulder, CO, model SP2).

Similar concerns exist for Figs. 12 and 13 in section 4.2. The authors need to provide sufficient detail that these new results can be fully evaluated, or they should cite appropriate companion papers that contain the details, or these parts of the manuscript should be removed.

The results presented here for the WRF-Chem model are based on already published model versions. The study on OA formation presented in Figure 12 is based on the WRF-Chem model simulations described in Fry et al. (2013). In that version, SOA formation from anthropogenic VOCs and semi/intermediate volatility compounds (S/IVOCs) is based on Hodzic and Jimenez (2011), whereas treatment of biogenic SOA follows Shrivastava et al. (2011).

The WRF-Chem simulations that were used to study the transport of anthropogenic pollutants to the site, as well as new particle formation and effect on CCN, are configured as described in Cui et al., 2014. This is now explained better in the manuscript:

These modeling studies focused particularly on organic aerosol (OA) formation from forest BVOC emissions, and the influence of anthropogenic pollutants transported to the site. To study OA formation, the WRF-Chem model was configured as described in Fry et al. (2013) using the SOA module based on Hodzic and Jimenez (2011) for anthropogenic precursors and Shrivastava et al. (2011) for biogenic precursors. To study the influence of anthropogenic pollution on aerosol formation, the WRF-Chem model was configured as described in Cui et al. (2014).

The following references have been added:

Hodzic, A.; Jimenez, J. L. Modeling anthropogenically controlled secondary organic aerosols in a megacity: A simplified framework for global and climate models. Geosci. Model Dev. 2011,4,901−917, DOI: 10.5194/gmd-4-901-2011.

Shrivastava, M., Fast, J., Easter, R., Gustafson Jr., W. I., Zaveri, R. A., Jimenez, J. L., Saide, P., and Hodzic, A.: Modeling organic aerosols in a megacity: comparison of simple and complex representations of the volatil- ity basis set approach, Atmos. Chem. Phys., 11, 6639–6662, doi:http://dx.doi.org/10.5194/acp-11-6639- 201110.5194/acp-11-6639-2011, 2011.

Cui, Y. Y., Hodzic, A., Smith, J. N., Ortega, J., Brioude, J., Matsui, H., Turnipseed, A., Winkler, P., and de Foy, B.: Modeling ultrafine particle growth at a pine forest site influenced by anthropogenic pollution during BEACHON-RoMBAS 2011, Atmos. Chem. Phys. Discuss., 14, 5611-5651, doi:10.5194/acpd-14-5611-2014, 2014.

6. Figures 8 and 10 do not resolve adequately for publication.
This should be resolved in the final on-line publication. Thank you for noticing.