Answers to the first reviewer

Major Comments and recommendation

Well-done study based on a novel approach to PBL (planetary boundary layer) definitions of EI and SBI. First, variability of these PBLs by season is given. Then, concentrations of ozone, CO and water vapour from IAGOS data are produced within these PBL layers to create climatologies better suited for comparisons to models. In the case of ozone ozonesonde data from stations near IAGOS airports are also used. The paper should be published after addressing a few comments and after correcting many instances where English grammar or usage needs improvement.

We thank the reviewer for his/her comments and corrections. In the revised manuscript, we took into account all his/her suggestions. In the following, the comments are in blue and the answers in black.

Minor Comments

Page 2, Line 14. It is not accurate to say that in-situ data are lacking at altitude. In addition to IAGOS are literally hundreds of aircraft campaigns over many continents in which ozone, RH, CO profiles have been measured since the late 1980s and early 1990s. The data reside in many open archives such as in European databases and at NASA's Langley and Ames Research Centers.

Indeed, many aircraft campaigns have been organized over the last decades. However, complete vertical profiles starting from the surface in the lower troposphere are more limited, and in comparison to the surface, the amount of in-situ data in altitude is much lower in altitude. We still modified the sentence as follows : "Over the last decades, a continuous effort was put to collect in-situ observations in the troposphere, mainly with commercial/research aircraft and sondes, and to a lesser extent with instrumented mats and tethered balloons. However, the amount of in-situ data available in altitude remains relatively low compared to the surface (both in terms of quantity of data and number of species). In particular, profiles throughout the entire PBL (i.e. starting from the surface and extending to the free troposphere) are relatively sparse. This limits our ability to properly describe and understand how pollution is vertically distributed within the PBL. One consequence is the difficulty of many state-of-the-art models to reproduce accurately the vertical stratification of the pollution in this part of the troposphere. Although some high-resolution chemistry-climate models (CCMs) with interactive stratospheric and tropospheric chemistry can show encouraging results at the episodic scale (e.g., Lin et al., 2012, 2015), several initiatives of models inter-comparison depicted substantial errors on the ozone (O_3) and carbon monoxide (CO) vertical distribution over longer periods of time (Elguindi et al., 2010; Solazzo et al., 2013). More recently, Travis et al. (2017) highlighted the difficulty of the GEOS-Chem chemistry-transport models (CTM) to reproduce sharp O_3 vertical gradients in the first kilometre above surface of the Southeast United-States (during both clear-sky and low-cloud conditions), attributed to excessive top-down mixing in the model."

Page 2, Line 18. GEOS-Chem is considered a CTM (global chemistry-transport model) not an "Air Quality" model. The latter typically has higher horizontal

resolution, a more limited vertical range and different approaches to emissions inputs and chemical mechanisms.
Indeed, we modified the sentence accordingly.

Typo/Grammar Fixes on Petetin, Sauvage, Smit et al.
Page 1, Line 14 should have a comma before ozone instead of "and"
Modifications applied.

Page 1, Line 20 at the end, "novel" is a more appropriate word than original, makes a better impression ; Page 1, Line 33 Instead of "Contrary" begin the sentence with "In contrast," ...
Modifications applied here and in the entire document.

Page 1, Line 35 use "in" the presence of snow ; Page 2, Line 9 better to say "numerous processes interacting in the PBL" ; Page 2, lines 18 and 19. Insert "the" before GEOS and before Southeast United States
Modifications applied.

Page 2, line 23. "The possible error compensations" is awkward and meaning is not clear
We modified the sentence as follows : "However, a common difficulty in the evaluation of CTMs relies in the fact that several error sources may compensate each other and therefore hide specific model deficiencies. Such error compensations are often complex to identify. In particular, although closely linked, both PBL heights and pollutant concentrations (at the surface and/or along vertical profiles in the PBL) are often evaluated separately, which limits the significance of the drawn conclusions. "

Page 2, Line 25. Do you mean "the significance of any conclusions drawn from case studies"?
No we mean that pollutant mixing ratios at the surface and PBL heights are often evaluated separately, usually because no or sparse observations of the PBL height are available for comparisons. This is the case in model evaluations conducted both on the long-term or during case-studies. We simply argue here that as the surface mixing ratios are closely linked to the PBL height (among other parameters), it is tricky to get firm conclusions about the ability of a model to reproduce the surface mixing ratios when its ability to correctly simulate the PBL height has not been assessed simultaneously, or only at one or few locations (that may in addition not correspond to the locations where the chemical composition measurements are performed).

Page 2, Lines 26-27. Remove "with" on l 26. Line 27 should read "mixing would imply that its..."
We modified the sentence as follows : "For instance, a model may well reproduce the concentrations of a specific chemical compound at the surface but overestimate the PBL height and/or the vertical mixing ; in this case, this would suggest that its sources are actually overestimated."

Page 2, Line 29 "included" not "including"

Modifications applied here and in the entire document.

Page 2, Line 35. Remove "the" before relative humidity
Modifications applied.

Page 2, Line 39. Replace "on which" with "from which"
We divided the sentence in two parts : "We first implement an algorithm for automatic estimation of the PBL height from both sonde and airborne profiles. Based on these estimates of PBL height, we derive a climatological description of the vertical stratification of the O_3, CO, RH and θ within the PBL and at the interface with the FT. "

Page 3, Line 6. PBL-FT interface. (End sentence - remove phrase in ()) Page 3, Line 8. "Vertical distributions of O3, CO and RH" - is more clear. At the end of Line 8 modify to "the study and additional perspectives"
Modifications applied.

Page 3, Line 18. "IAGOS aircraft used in this study are the barometric"; Page 3, Line 30. Calibrated for RH with respect to liquid
We modified the sentence as follows : "In this study, we used the barometric altitude, temperature, pressure, calibrated RH with respect to liquid, O_3 and CO volume mixing ratios measured on-board IAGOS aircraft."

Page 3, last line. Uses ozonesonde observations (remove "the") ; Page 4, line 4. ("fewer" than 10% not "less" than 10%) ; Page 4, Line 7. Factor "of" 3-5 ; Page 4, Line 24. Less problematic because the vertical variability (not "as") Page 4, Line 34 spelling United ; Page 4, Line 35. Insert "the" Middle East ; Page 4, Line 38. "allows smoothing of the vertical" is better ; Page 6, Line 8. Allows "us" to maximize the number of profiles taken into account (remove "then") ; Page 6, Line 19 EIs are found "in" 16%... ; Page 7, Line 15 top "of" the EIs
Modifications applied.

Page 7, Line 20. Characteristics "exhibits" or "displays" is more acceptable word than "depicts"
Modifications applied here and in the entire document.

Page 13. In "Summary and conclusion" standard usage is NOT to refer to Figure numbers again.
We removed them.

Page 13, Line 19 replace "performed" by "archived"
We replaced "performed" by "measured".

Page 13, Line 21 78% IAGOS profiles, 22% sonde profiles. (Remove "of" and singular sonde, not sondes) ; Page 13, Line 23. "Strongly vary throughout the day" not "along" ; Page 13, Line 24. "The results" or "Our results" Page 13, Line 27. .."approach allows us to" ; Page 13, Line 30. EIs "displayed" not "depicted" ; Page 13, Line 39. Top, "which supports out ability" is correct ; Page 14, Line 30. Processes "at work" not "at stake" ; Page 14, Line 31. "Interesting way" is weak .... "Better

way" or "superior way" or "more meaningful way" ; Page 14, Line 34. "resolution" not "resolutions" Replace "deeply" with "thoroughly" ; Page 14, Line 39. Replace "interesting" with "rich" or "significant"

Modifications applied.