Comment on Biondi et al. (hereafter B16), **A novel technique including GPS radio occultation for detecting and monitoring volcanic clouds**.

As the title accurately states, this paper attempts to demonstrate that GPS-RO profiles may manifest a signal that suggests existence and height of volcanic cloud tops. B16 take advantage of their prior works that characterize organized (and horizontally large) convective cloud systems with GPS-RO data. Given that the volcanic eruption clouds in which they are presumably interested are also convective in nature, it is reasonable for them to hypothesize that a similar GPS-RO signal may be evident. If this effect is verified, the accurate, global, continuous, and fairly dense network of GPS-RO observations may well provide a new way of detecting and monitoring volcanic clouds.

My concern is that B16 has several fundamental weaknesses. Their current analysis is irreconcilable with the prior Biondi et al. papers' focus on active, opaque thunderstorm convective clouds. Moreover, B16 implicitly expand the definition of "cloud" beyond the active volcanic-convective eruption column to residual, optically thinner stratospheric sulfate and ash "clouds" that may last for weeks to months. This expansion of cloud scope comes without a consistent physical argument on how GPS-RO bending angle and temperature data would be impacted by this array of aerosol plumes and water-ice clouds.

The foundational papers by Biondi et al. make a very specific and limited claim; that widespread active convective water-ice cloud tops extending into the upper troposphere or overshooting into the stratosphere might be systematically accompanied by anomalously cold temperature. This cold anomaly owes to the fact that the top of the convective column represents the top of the moist adiabatic convective updraft with occasional excursion above the level of neutral buoyancy. Hence there could be a cold anomaly at the cloud-top altitude that is roughly proportional to the moist instability, vigor of the convection, and the horizontal scale (in order for it to be resolvable by GPS-RO measurements). These papers were careful to present independent cloud data with unassailable cloud top altitude resolution (e.g. CALIPSO) to prove the existence of the organized convection coincident with GPS-RO measurements. Their physical argument is that GPS-RO is neither directly nor deleteriously impacted by clouds or water vapor at UTLS altitudes; it is sensitive only to temperature and would show evidence of anomalously low temperature in relation to climatology at the cloud top. The stronger the anomaly (in T or bending angle), the more robust the evidence for water-ice cloud. The stronger the convective vigor and overshoot, the stronger the temperature anomaly. The inherent high vertical resolution of the GPS-RO data then is used to provide a precise estimate of the cloud-top altitude. Presumably in the absence of strong UTLS convective clouds the GPS-RO bending angle and temperature profile would not differ significantly from climatology, and the GPS-RO-determined tropopause height would coincide well with radiosondes and even gridded analyses. Moreover, even if there is vigorous, large-area, overshooting convection, **the effect would be local to the convective cloud cluster**. I.e. one would not expect the cold anomaly to persist in enough strength outside the cloud perimeter or after the cloud dissipates. This is my understanding of the principles argued in the Biondi et al. foundation papers. The prior papers did not venture into the subject of dust, sulfate, or ash-plume-top estimation with GPS-RO; neither does B16. They state in the abstract "an anomaly technique recently developed for detecting cloud tops of convective cloud systems can also be applied to the volcanic clouds." As they did in their prior papers, B16 need to show specific GPS-RO measurements collocated with and simultaneous to active volcanic-convective water-ice eruption clouds in order to be convincing. They did not make that case in this paper.

Part of Figure 2 is a detailed analysis near the Nabro location and eruption time. The pre- and post-Nabro panels of Figure 2 display GPS-RO profiles within a tight 5x5 lat/lon box centered on the volcano. The presumed intent of the tight cropping is an analysis similar to the prior Biondi et al. papers (and a presumed hypothesis consistent with their prior findings of a cooling at cloud top), focusing on the volcano-convective water-ice cloud. The pre- and post-Nabro GPS-RO signatures are essentially identical from the bottom to ~15 km, and above ~20 km. In between it appears that almost every post-Nabro profile is perturbed w.r.t. pre-Nabro. This is highly perplexing, for the following reasons. This small box does not represent the footprint of Nabro's continental-size plume footprint between 12-20 June, according to Clarisse et al. (2014) http://www.atmos-chem-phys.net/14/3095/2014/). Fromm et al. (2014) (http://onlinelibrary.wiley.com/doi/10.1002/2014JD021507/full) showed that the active Nabro eruption column top was near the tropopause only on 12-13 and 16 June and that the high-altitude eruption cloud in the volcano's vicinity was consistently situated northwest of the volcano (i.e. just a fraction of the box). Hence it is very perplexing to see that essentially all of the post-Nabro GPS-RO profiles in that box exhibit a UTLS anomaly with respect to pre-Nabro, and that all the perturbations are warming (rather than the cooling that a high convective water-ice cloud might give). Given the larger context of the injection-height chronology and the plume advection laid out in the above-mentioned papers, it would seem that the prescribed box and time interval would not contain such a stark, wholesale volcano-caused perturbation. If the post-Nabro assemblage of profiles in this box is correct, then I suspect that the anomaly must be attributable to non-volcanic forcing.

Regarding Puyehue, the ash map in Fig. 1 makes clear that the "cloud" that is being monitored reaches far beyond the range of the volcano's eruption column. Hence it is unconvincing that "an anomaly technique recently developed for detecting cloud tops of convective cloud systems" would have applicability. Moreover, B16 do not present a physical argument as to why volcanic ash would cool the surrounding atmosphere. As for Nabro, the Puyehue GPS-RO results are curious but unfounded on any physical argument. Hence the results here have insufficient substance to be convincing.

What I understand about the localized radiative impact of volcanic sulfates and ash is that they would **both** lead to **warming**, ash primarily through absorption of incoming solar radiation and sulfates via absorption of terrestrial IR radiation. Therefore one would expect both plume types to give the same sign of temperature impact. In either case the amount of GPS-RO-detectable warming would be strongly tied to the plume's physical size and concentration. In the absence of a fuller, alternate physical explanation for the cause-effect of these two plume types, the current explanations seem dubious. Moreover, making the case cannot be based on the assumptions and physical context embodied in the foundational Biondi et al. papers.