

Interactive comment on “Mobile water vapor Raman lidar for heavy rain forecasting: system description and validation” by Tetsu Sakai et al.

Anonymous Referee #2

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The manuscript by Sakai et al. mainly describes the design and the performances of an automatic Raman lidar system designed for the measurement of water vapor mixing ratio profile during daytime and nighttime conditions. According to the authors, the final goal of the work is to show the positive impact that water vapour Raman lidar measurements may potentially have if assimilated in a heavy-rain forecasting system.

The manuscript is sufficiently well written and outlines in detail the experimental setup of the Raman lidar. The stability of the Raman lidar calibration is assessed over the test period of the instruments, while the correction for the system incomplete overlap is calculated using radiosounding data from a nearby station. Intercomparison statistics versus radiosoundings and GNSS measurements for both the profile and the integrated water vapor content are used to validate the Raman lidar measurements.

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Regardless of my specific concerns about the conclusions presented by the authors to support the validation of the Raman lidar measurements, more in general, I think that this manuscript does not demonstrate what the title would like to claim, i.e the positive impact of the Raman lidar measurements on an heavy rain forecasting model.

Focussing on the section where the comparison with high resolution local analysis data is reported, the authors' expectation is to demonstrate, from the Observation-minus-Background (O-B) comparison on a limited time period (less than 5 months), that the Raman lidar can improve the rain forecasting system because it is able to reveal an evident bias in the analysis model output. This is indeed a demonstration of the well known value of Raman lidar measurement to assess the performance of the model analysis output. To demonstrate the impact of lidar observations on any forecasting system a data assimilation experiment or alternatively an Observing System Simulation Experiments (OSSE) must be carried out. Various examples are available in literature of lidar data assimilation experiments (e.g. Wulfmeyer et al., 2006, <https://journals.ametsoc.org/doi/10.1175/MWR3070.1>). The authors state that they are currently studying the impact of using lidar data with a nonhydrostatic mesoscale model for simulating heavy rainfall in the Kanto area in Summer 2016, citing a paper in Japanese: to my opinion the outcome of these experiment must be embedded in the manuscript by Sakai et al. because it could be the only possibility to add more substance to the manuscript and create a real scientific interest in the readers.

In addition, the lidar described in the manuscript does not add new knowledge about innovative, more advanced technological solutions than the other home-made and commercial Raman lidars operating around the world. Besides, also about the intercomparison of Raman lidar measurements with radiosoundings, GNSS, MWR and FTIR, many other papers are available in literature using more robust approaches (Bhawar et al., 2011, <https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/qj.697>; Beherendt et al., 2007, <https://journals.ametsoc.org/doi/full/10.1175/JTECH1924.1>).

The authors themselves, when trying to assess of the Raman lidar system performance

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which should be able to provide continuous profile of the water vapor mixing ratio, they do clearly show that during daytime the lidar has very limited performance, providing measurements with an uncertainty lower than 30% up to about 1.0-1.5 km above the ground level, which is also the region where the overlap correction is applied. These performances are even lower than a few of commercial Raman lidars and for sure does not allow to achieve the desired impact on a data assimilation system. However, as I said before the impact must be concretely demonstrated and the considerations provided in the manuscript are not sufficient to this purpose. I must also note that the authors honestly acknowledge that the maximum measurement altitude achievable with the Raman lidar system is limited during the daytime and that, though in theory this does not prevent the data assimilation (though I am concerned about the total uncertainty budget in this region), there are the limited information provided by the lidar in the boundary layer and obviously above. This pushes the authors to state that the development of a diode laser-based differential absorption lidar (ongoing) will allow to improve the range and the quality of the measurement for their rain forecasting system. This statement sounds like a "certification" of the insufficient performance of the Raman lidar for the proposed objective.

Therefore, I'd propose the manuscript rejection, but I hope to see the authors submitting soon a new manuscript showing concrete results related to the impact of DIAL measurements or, at least, of the current night time Raman lidar measurements on a rain forecasting system.

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