Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-1019-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Lagrangian matches between observations from aircraft, lidar and radar in an orographic warm conveyor belt" *by* Maxi Boettcher et al.

Josué Gehring (Referee)

josue.gehring@epfl.ch

Received and published: 26 November 2020

1 General comment

The authors investigate an orographic WCB with a very innovative Lagrangian matching involving ensemble WCB trajectories and in-situ measurements of a tracer released in the inflow of the WCB. This study presents at least three major novel aspects. The first one is the method: to my knowledge, it is the first time that Lagrangian trajectory computation of a WCB could be verified by measuring in the outflow region a tracer gas that was released in the inflow. This must have been a very challenging task in-

volving accurate ensemble trajectory predictions and strategic flight planning. More importantly, it shows that trajectory computation are reliable enough to plan in-situ aircraft measurements. The second aspect is the triple Lagrangian matching: to have measurements in the inflow, ascent and outflow of a WCB allows to better characterise the humidity conditions in these three different phases of the WCB and to evaluate the model performances along them. This is a crucial contribution for future studies on model verification. The third one is the orographic aspect of the WCB "T2". To my knowledge there has not been many studies mentioning the orographic contribution to the WCB ascent. This a nice example of a WCB ascent with significant orographic lifting. For these reasons, I strongly support the conclusions of this study and its publication in Atmospheric Chemistry and Physics, subject to minor revisions.

2 Minor comments

- P.6, L.178-179: could you briefly justify the choice of -30 C for the threshold between saturation with respect to liquid water and ice ?
- P.7, L. 201: "Only data outgoing from the instrument upward until a relative error of 100% is reached are used, [...]". I am not sure to understand this sentence, it means you compute the relative error with respect to the radiosounding measurement and when it reaches an altitude where it is greater than 100% you take this altitude as the maximum measurement height for this period? Do you think the horizontal displacement of the radiosounding could significantly contribute to this relative error (and maybe also to the calibration)?
- P.9, L.250: did you consider using the modification of this condition proposed by Binder2020 et al. 2020 (i.e. consider also trajectories that fulfil the 600 hPa ascent before 48h, but then descend)? Do you think that could impact the result

of this study? Maybe your WCB selection was performed before the study of Binder et al. 2020, in which case I totally understand that it was not used.

- P.10, L.294: "On a smaller scale, the strong westerly wind ahead of the cold front initiates a secondary lee cyclone [...]". Which figure and region are you referring to with this westerly wind? Do you mean the westerly wind over Spain in Fig. 2c? In this case the Piemont region is not in the lee of this flow. Or you mean the westerly wind over France in Fig. 2a or 3b? In this case it is not ahead of the cold front.
- P.15, L.363: "[...] facilitates aggregation and riming[...]". Supercooled liquid water favours riming, but not necessarily aggregation. It was the wind shear and turbulence below the WCB air masses, which promoted aggregation in Gehring et al. 2020.
- P.15, L. 384: "[...] is likely to sublimate or evaporate." Do you have an idea why sublimation is not simulated in ERA5?
- P.18, L.432: "[...] if the model is assumed to underestimate precipitation from the WCB [...]". Does the model underestimate precipitation from the WCB?
- P.19, L.461: "The moist bias in EDA does not seem to depend on the large-scale flow direction." Do you have an hypothesis on the reason for this moist bias in EDA?
- P.21, L.490: "[...] dynamically-driven ascent for T1 [...]". Do you know if the orography also significantly influenced the ascent of T1?
- P. 21, L.482: "[...] the orographic lifting coincided most likely with enhanced dynamical forcing for ascent [...]". The respective contribution of orographic and dynamic lifting in the ascent of the WCB is very interesting. Out of curiosity: do

you think it is possible to disentangle both effects to quantify what is the contribution from each? If yes, how would you suggest to do it?

- P.24, L.430-431: "Also, a technical issue concerning the manual time adjustment of the device cannot be completely excluded." From what you wrote on P.8, L.232-233 it seems that this issue was almost confirmed. Here it sounds as if it would be a possible issue that might have taken place. If this issue is likely as you mention on P.8, maybe it would be worth rephrasing this sentence and referring to P.8 (e.g. a technical issue [...] likely occurred as mentioned in Sect. 2.4). This would make it clear to the reader that it is an issue you likely had and not only a potential problem that you list among other possibilities explaining the time shift.
- P.27, L.617: "[...] with a more complete instrumental package [...]". If you could redo this campaign, which instruments would you add?

3 Technical corrections

- P.2, L.48: "[...] an unique airborne tracer [...]". Remove the "n" in "an".
- P.2, L. 84: "Oertel et al. (in preparation)". I think this article is in review in WCD discussion, so it would be better to cite it as such.
- P.3, L.87: "This brief summary reveals the importance of WCBs for understanding precipitation in and the dynamics of extratropical cyclones, [...]". Remove the "in".
- P. 10, L.284: "Within the westerly flow, WCB trajectories originating over the Atlantic are embedded that start to ascend prior to passing the lidar (Fig. 2b)." I do not understand this sentence, do you mean "[...] and start to ascend [...]"?
- P.15, L.366 "[...] (see blue line in Fig. 3a) [...]". You probably mean Fig. 3b.

- P.18, L.428 "[...] (Fig. 7a, between 16:00-19:00 UTC)." You probably mean Fig. 8a.
- P.19, L.475: "[...] (read and blue dots in Fig. 8c)". It seems that there are only asterisks on Fig. 8b,c, instead of asterisk for T2 and dots for WCB or non-WCB air. This makes it hard to read when you are referring to a single asterisk in the location of T2.
- P.21, L. 485: "[...] when the aircraft enters the region of high WCB probabilities (Figs. 5)". It should be Fig. 5 without "s".
- P.22, caption Fig. 8: add "N" after "46.15".
- P.22, Fig. 8c: the labels of the WCB probability are not very clear.
- P.25, L. 564: "[...] (ii) if a suitable [...]". Remove "if".

4 References

- Binder, Hanin, Maxi Boettcher, Hanna Joos, Michael Sprenger, and Heini Wernli. “Vertical Cloud Structure of Warm Conveyor Belts – a Comparison and Evaluation of ERA5 Reanalysis, CloudSat and CALIPSO Data.” Weather and Climate Dynamics 1, no. 2 (October 19, 2020): 577–95. https://doi.org/10.5194/wcd-1-577-2020.
- Gehring, Josué, Annika Oertel, Étienne Vignon, Nicolas Jullien, Nikola Besic, and Alexis Berne. “Microphysics and Dynamics of Snowfall Associated with a Warm Conveyor Belt over Korea.” Atmospheric Chemistry and Physics 20, no. 12 (June 25, 2020): 7373–92. https://doi.org/10.5194/acp-20-7373-2020.