

Geosci. Model Dev. Discuss., author comment AC1  
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## Reply on RC1

Matthias Göbel et al.

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Author comment on "Numerically consistent budgets of potential temperature, momentum, and moisture in Cartesian coordinates: application to the WRF model" by Matthias Göbel et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-171-AC1>, 2021

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Thank you very much for your positive review and your comments!  
Here are our replies:

**1. Line 235. It would be good to mention the length of the simulation here as this surface flux would only be reasonable for a period of a few hours.**

We added the simulation time (4 h) in the following paragraph.

**2. Figure 2 caption. Should this be Eq. 8 instead of 6?**

Eq. 6 is correct. It refers to the budget equation in the terrain-following coordinate system as it appears in the WRF model equations.

**3. Line 292-295. Some orders of magnitude here seem ten times too large compared to Figures 1 and 2.  $10^{-3}$  and  $10^{-4}$  look more accurate.**

The  $\pm 1e-2$  numbers refer to SGS and resolved contributions, respectively. These are not shown separately in any figure. Fig. 2 only shows the decomposition into total turbulent (resolved + SGS) and mean advection.

The total tendency close to the ground above the ridge can be seen in the solid green line in Fig. 3. It is about  $0.04e-3=4e-5$ . This is why we wrote on the order of  $1e-5$ .

**4. 5. and 7.:**

Thanks for pointing us to the wrong equation references. After removing an equation, we forgot to update the hard-coded references in the figures and table. This is now fixed.

**6. Line 303. Is this the lowest level only?**

At the lowest mass level ( $\sim 3$  m agl) the tendency in the green dashed line is positive, at the second level ( $\sim 9$  m agl) it is strongly negative, and at the third level ( $\sim 15$  m agl) it is strongly positive again. But also higher up the differences between the two green lines are rather large, at least up to the 15th vertical level ( $\sim 100$  m agl). The AGL height on the y-axes of Fig. 3 and 4 had a small error in the computation. We have corrected these figures.

**8. Line 318. References to Eq. 15 and 14 should be 16 and 15.**

The references to Eq. 15 and 14 are correct here.

**9. Line 339. Maybe "total" is better than "final" here.**

ok

**10. Figure 2. Comment: This large difference is interesting and I would like to have a better conceptual idea of why. Is it because the Cartesian representation is somehow less sensitive to coordinate motion? In Fig. 2b are we looking at the expansion of the coordinate layers with heating?**

What we see in Fig. 2b is the LHS of Eq. 6. This is not the  $\rho \cdot \theta$  tendency on constant model levels, but the tendency of  $\rho \cdot z_{\eta} \cdot \theta$  (governing equation in WRF) normalized with  $\text{mean}(\rho \cdot z_{\eta})$ .

If we would plot the  $\rho \cdot \theta$  tendency on constant model levels (1st term on LHS of Eq. 8) it would look very similar to Fig. 2a. So yes, the difference between Fig 2a and 2b arises mainly from the expansion of the coordinate layers with heating (magnitude of  $z_{\eta}$  increases with time). And yes, the representation in Fig. 2b is more sensitive to coordinate motion.