# Modeling of the Wegener–Bergeron–Findeisen process—implications for aerosol indirect effects



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# Corrigendum

## Modeling of the Wegener–Bergeron–Findeisen process—implications for aerosol indirect effects

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We have found some errors in one of the model simulations analyzed in the letter 'Modeling of the Wegener–Bergeron–Findeisen process—implications for aerosol indirect effects' by Storelvmo *et al* (2008b). The errors were related to the simulation including a new treatment of the Wegener–Bergeron–Findeisen (WBF) process ($AER_{WBF}$), and correcting these errors caused a general reduction in the efficiency of the WBF process. This can be seen in figure 1, where the cloud fraction dominated by the WBF process is reduced compared to the corresponding figure 3 in Storelvmo *et al* (2008b). As can be seen from table 1, the corrected present-day $AER_{WBF}$ simulation now yields a larger (i.e. more negative) shortwave cloud forcing than the uncorrected one, because the total water path (the sum of the liquid and ice water paths) is increased. Further, the aerosol indirect effect in this simulation was significantly altered after the errors had been corrected. The somewhat puzzling reversal of the

**Table 1.** Modeled and observed annual global mean cloud microphysical and radiative properties. Total cloud cover observations are obtained from surface observations (Hahn *et al* 1994), the International Satellite Cloud Climatology Project (ISCCP) (Rossow and Schiffer 1999) and MODIS data (King *et al* 2003). The LWP observations are from SSM/I (Ferraro *et al* 1996, Greenwald *et al* 1993, Weng and Grody 1994) and IWP is derived from ISCCP data (Storelvmo *et al* 2008a). The shortwave and longwave cloud forcing (SWCF and LWCF) estimates are from Kiehl and Trenberth (1997) and the effective droplet radius observations are from Han *et al* (1994).

| Simulation | $AER_{WBF,Orig}$ | $AER_{WBF,Corr}$ | Observations |
|---|---|---|---|
| Cloud cover (%) | 64.1 | 64.5 | 62–67 |
| Liquid water path (g $m^{-2}$) | 99.2 | 104.9 | 50-84 |
| Ice water path (g $m^{-2}$) | 32.9 | 31.9 | 29.4 |
| SWCF, TOA (W $m^{-2}$) | −50.4 | −54.5 | −50 |
| LWCF, TOA (W $m^{-2}$) | 31.8 | 33.1 | 30 |
| Effective droplet radius ($\mu$m) | 14.0 | 13.6 | 11.4 |
| Total precipitation (mm/day) | 2.77 | 2.78 | 2.74 |
| Convective precipitation (mm/day) | 1.83 | 1.92 | — |
| Stratiform precipitation (mm/day) | 0.93 | 0.85 | — |

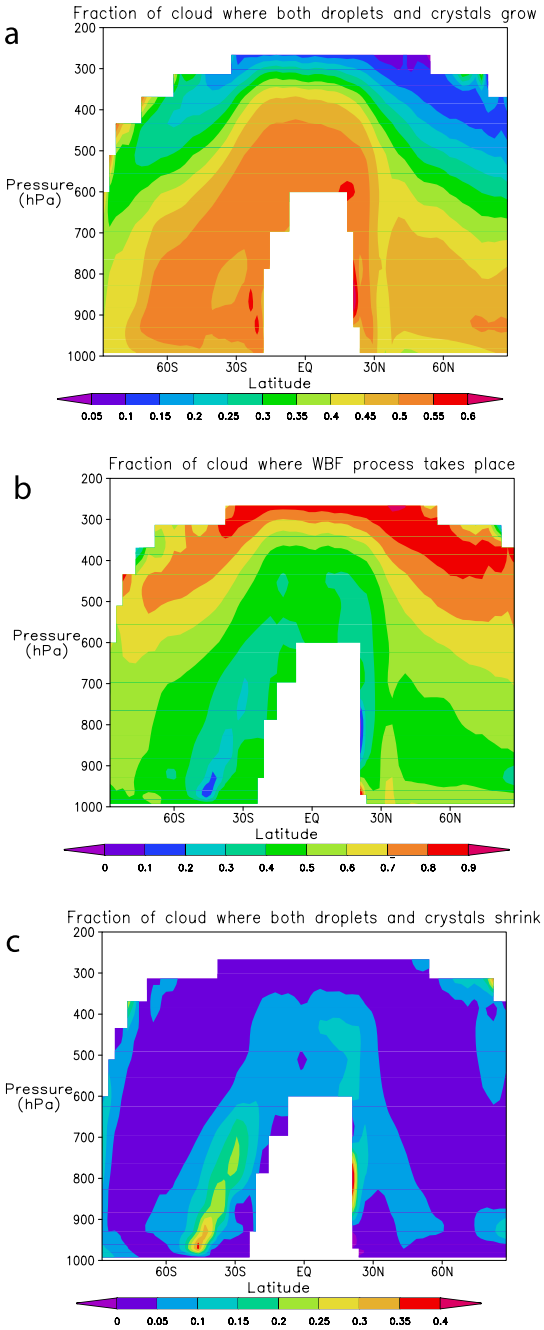


**Figure 1.** Simulated cloud fractions dominated by (a) regime 1 (i.e. simultaneous growth of droplets and ice crystals), (b) regime 2 (i.e. ice crystal growth at the expense of cloud droplets) and (c) regime 3 (i.e. sublimation of ice crystals and evaporation of cloud droplets).

 

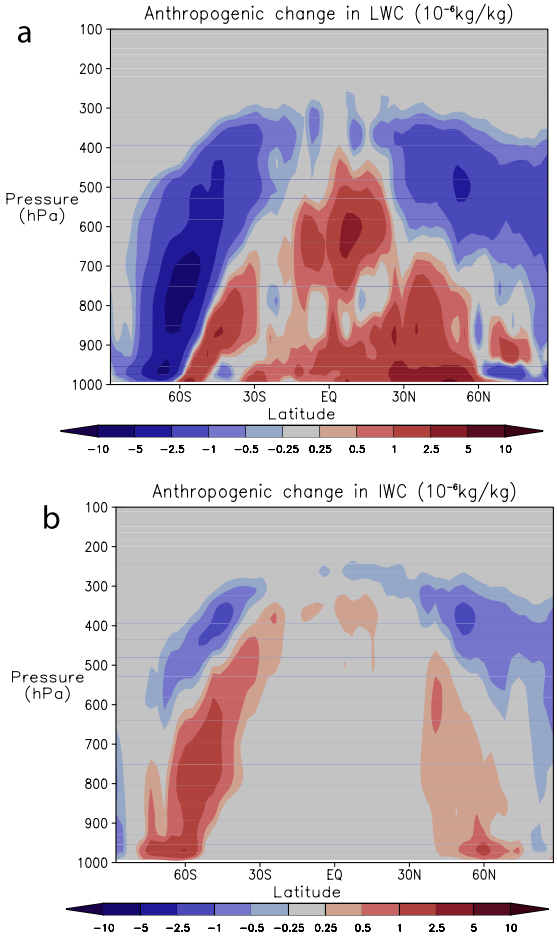


**Figure 2.** Zonally averaged anthropogenic change in (a) liquid water content (kg kg$^{-1}$) and (b) ice water content (kg kg$^{-1}$), both from the simulation $AER_{WBF}$, calculated by subtracting the preindustrial values from the present-day values.

cloud lifetime effect found in $AER_{WBF}$ is now much less pronounced. Table 2 shows the anthropogenic changes in cloud microphysical and radiative properties in the new and corrected $AER_{WBF}$ simulation, compared to the corresponding properties as given in Storelvmo *et al* (2008a, 2008b) ($AER_{WBF,Orig}$ and $AER_{WBF,Corr}$, respectively). Evident is the significantly reduced change in liquid water path (LWP) in the corrected simulation. However, the change is still negative, contrary to most simulations of aerosol effects on cloud lifetime and horizontal/vertical extent. The anthropogenic changes in ice and liquid water content from $AER_{WBF,Corr}$ are shown in figure 2, which corresponds to figure 4 in Storelvmo *et al* (2008a, 2008b). Because the anthropogenic reduction in liquid water is now much smaller in magnitude, the total aerosol indirect effect is no longer positive, but rather a modest negative forcing of −0.81 W m$^{-2}$.

Other changes between the original and the corrected simulations are largely insignificant, and the main conclusions from Storelvmo *et al* (2008b) still hold.

**Table 2.** Annual global mean changes in cloud microphysical and radiative properties from preindustrial to present-day.

| Simulation | $AER_{WBF,Orig}$ | $AER_{WBF,Corr}$ |
|---|---|---|
| Cloud cover (%) | −0.25 | −0.11 |
| Liquid water path (g m$^{-2}$) | −6.9 | −0.84 |
| Ice water path (g m$^{-2}$) | 0.20 | 0.55 |
| Shortwave radiation, TOA (W m$^{-2}$) | 1.13 | −0.49 |
| Outgoing longwave radiation (W m$^{-2}$) | −1.08 | −0.32 |
| Net radiation, TOA (W m$^{-2}$) | 0.05 | −0.81 |
| Effective droplet radius ($\mu$m) | −0.89 | −0.93 |
| Precipitation (mm/day) | 0.011 | −0.011 |

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