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Inferring the contribution of changes in shortwave atmospheric absorption to dimming and brightening from colocated surface and TOA observations in Europe and China

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The global energy balance has been studied for more than a century and recent studies provide quantitative estimates about the global annual mean energy fluxes in the climate system. It is, however, well documented that the amount of solar (shortwave, SW) radiation reaching the Earth's surface (SSR) underwent substantial decadal variations commonly known as "global dimming and brightening". From an energy balance perspective, it is apparent that a change in SSR implies that at least one other variable of the SW energy balance, namely the surface SW absorption, the top-of-the-atmosphere (TOA) net SW flux, or the atmospheric SW absorption must change as well. Here we bring together colocated long-term observational data from the surface and the top-of-the-atmosphere (TOA) to study the decadal changes of the SW fluxes at the surface, within the atmosphere and at the TOA in Europe and China from 1985-2015. Within this integrated observation-based shortwave energy balance framework, we show that increasing net shortwave radiation at the TOA and decreasing atmospheric absorption contribute each half to the observed "brightening" trends in Europe. For China, we find continued "dimming" until 2005 despite increasing TOA net radiation. After 2005, Chinese trends reverse and surface brightening occurs despite decreasing TOA net radiation. This indicates that changes in atmospheric shortwave absorption are a major factor of European brightening and the dominant cause for the Chinese surface radiation trends.