Decadal changes in surface radiative fluxes

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Recent evidence suggests that the radiative fluxes incident at the earth surface are not stable over time but undergo significant changes on decadal timescales. This is not only found in the thermal spectral range, where an increase in the downwelling flux is expected due to the increasing levels of greenhouse gases in the atmosphere and associated enhanced thermal atmospheric emission, but also in the solar spectral range. Surface based observations suggest that surface solar radiation, after decades of decline ("global dimming"), reversed into a "brightening" since the mid 1980s at widespread locations (Wild et al. 2005). These observations stem from two databases founded at ETH Zurich, the Global Energy Balance Archive (GEBA) and the Baseline Surface Radiation Network (BSRN). The changes in surface solar radiation are not only seen under cloudy, but also cloud-free conditions, in line with a partial recovery of atmospheric transparency since the mid 1980s (Wild et al. 2005, Norris and Wild 2007). This might be related to reduced aerosol loadings due to air pollution control and the breakdown of the industry in formerly communist countries. The variations in surface solar radiation, in addition to the changes in thermal radiation induced by alterations in greenhouse gases, cause changes in surface radiative forcings which may significantly affect surface climate.

This is for example seen in significant changes in diurnal temperature ranges over global land surfaces. They show, after decades of decline, a distinct tendency to level off since the mid 1980s (Wild et al. 2007). This suggests that daytime solar dimming did no longer counteract nighttime thermal warming since the 1980s, thereby no longer diminishing the diurnal temperature range. This implies that surface solar dimming was no longer present to effectively mask greenhouse warming after the mid 1980s. With the fade of solar dimming, the uncovered greenhouse effect started to reveal its full dimension, as manifested in a rapid temperature rise over land since mid 1980s (Wild et al. 2007). Current Global Climate Models (GCMs) used in the IPCC AR4 report are not able to fully capture these effects. They overestimate the observed temperature increase over land surfaces during the "dimming period" from the 1960s to the 1980s, and underestimate the temperature increase during the subsequent "brightening period" (Wild 2009b). This points to the lack of a proper representation of surface solar dimming and brightening in these models. Indeed the models show no trend reversal in the surface solar radiation over global land surfaces from 1960 to 2000, but rather a continuous slight decrease over the entire period. It is therefore crucial that models need to improve their surface radiative forcings in order to correctly reproduce the observed decadal variations in temperature as well as in other climate variables, such as the components of the hydrological cycle (Wild et al. 2009a). An analysis of the available observations on decadal changes in surface energy and water balance components suggests that global dimming and associated reduction in surface net radiation attenuated the strength of the hydrological cycle up to the mid-1980s over land surfaces. Thereafter, the reversal to brightening and the enhanced thermal greenhouse emission form the atmosphere lead to an

increase in surface net radiation and thereby to an intensification of the hydrological cycle (Wild et al. 2004, 2008).

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