Global dimming and brightening - evidence and agricultural implication

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Introduction

The quantity and quality of solar radiation (sunlight) received at the Earth surface is critical for the growth of the biosphere in general and for agricultural production in particular. The amount of solar radiation received in the photosynthetic active range of the solar spectrum (PAR, between 400 and 700 nm) as well as the relative portion of direct and diffuse radiation therein distinctly affect the rate of photosynthesis (Mercado et al., 2009; Wild et al., 2012).

Global dimming and brightning

***Period 1960-1980**: Global dimming*

- *decline* in solar radiation due to increasing air pollution and associated increase in aerosol concentrations
- increase in the diffuse fraction in areas with strong dimming owing to increased cloudiness and/or aerosol loads (enhanced scattering in the atmosphere)

***Period 1980-2000**: Global brightning*

- characterized by *increasing* solar radiation
- in line with similar shift in atmospheric clear sky transmission determined from pyrheliometer (Fig.1) due to reduced aerosol emissions.

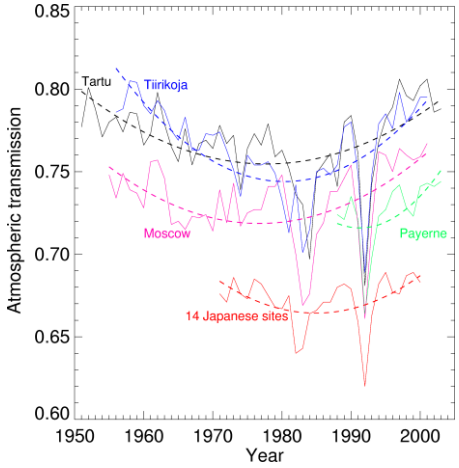

Figure 1. Time series of annual mean atmospheric transmission under cloud free conditions determined at various sites in Russia (Moscow), Estonia (Tartu-Toravere and Tiirikoja, Switzerland (Payerne) and Japan (average of 14 sites). From Wild et al. (2005).

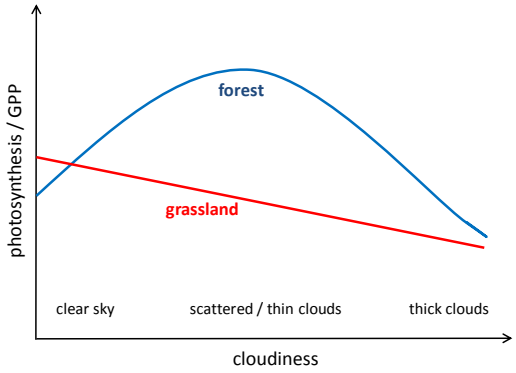

Figure 2. Schematic representation of cloud effects on photosynthesis or gross primary productivity (GPP) of forests (blue curve) and grassland (red curve). Clouds affect photosynthesis/GPP through the modulation of the total solar radiation as well as the diffuse/direct fraction received by the canopy.

Implications for plant photosynthesis and carbon uptake

- **Forests**: typically show enhanced CO_2 uptake with increased levels of diffuse PAR -> peak photosynthesis on partly cloudy days (Fig. 2)
- **Grassland**: is more susceptible to changes in total PAR than to changes in the diffuse fraction
- **Agricultural crop**: Photosynthesis and yield is affected positively by increased fractions of diffuse radiation.

Abstract

The amount of surface solar radiation has significantly changed during the last decades mainly due to trends in the aerosol burden. Increasing air pollution (scattering aerosols) and cloudiness alter the partitioning of surface solar radiation towards a higher relative portion of diffuse light. The diffuse ratio impacts on the plant photosynthesis. Photosynthesis of forests and agricultural crops generally profit from increased diffuse ratios whereas grassland is more susceptible to changes in total PAR.

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- Wild, M., Gilgen, H., Roesch, A., Ohmura, A., Long, C., Dutton, E., Forgan, B., Kallis, A., Russak, V., and Tsvetkov, A. (2005): From dimming to brightening: Decadal changes in solar radiation at the Earth's surface. *Science*, **308**, 847-850.
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