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INFLUENCE OF THE SOLAR RADIATION ON EARTH'S CLIMATE USING THE LMDZ-REPROBUS MODEL

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Abstract. The atmospheric response to the 11-year solar cycle is studied using the fully interactive 3-D coupled chemistry-climate model LMDz-REPROBUS (CCM). We show a comparison between two series of 20-year runs, one in maximum of activity and the other in minimum. The stratosphere-troposphere system indicates partly significant response to a solar cycle enhancement of UV radiation. We show how the changes in stratospheric ozone, temperature and zonal wind are connected.

1 Introduction

The impact of solar irradiance variations on the terrestrial atmosphere has long been seen as an important issue. Despite the fact that it is one of the main drivers for Earth's climate, the mechanism by which its short-term variation influences atmospheric parameters is controversial and difficult to prove. During the 11-year solar cycle, the Total Solar Irradiance varies from less than 0.1%. However, about 30% of the radiation changes over a solar cycle occur below 250 nm (Lean 1989). Moreover, photodissociation is an essential component of ozone formationand the stratospheric ozone modulated by the solar cycle could be at the origin of changes in the Brewer-Dobson circulation (Shindell et al. 1999 and references herein). The polar night jet could also be affected as shown by Kodera & Kuroda (2002), Matthes et al. (2006) and Haigh & Blackburn (2006).

2 Stratospheric response to solar forcing

LMDz-REPROBUS is a CCM including full representations of dynamical, radiative, and chemical processes in the atmosphere and their interactions, specially feedbacks of the chemical tendencies on the dynamics : in particular, ozone is strongly affected by dynamics and transport. Details are included in Jourdain et al. (2008) and references herein. Solar variability is forced explicity in the model through changes in the photolysis rates: two 20-year runs, one in maximum of activity and the other in minimum, are computed and we show here results concerning a comparison between these two series by computing the mean difference between them.

Preliminary results for the temperature, the zonal wind and the ozone concentration are shown in Figure 1. We only plotted graphes for the Northern winter months where the solar signal is strongly zonally asymmetric. The stratosphere is generally warmer of about 0.5 to 1 K at maximum, accompanied by a slight cooling at low latitude in the troposphere, suggesting a dynamical origin. At higher latitudes, the response is well marked with a reversal of the temperature difference. The temperature anomalies are associated to zonal wind ones with a positive anomaly of u in January. A clear ozone increase is visible in the stratosphere at solar maximum, with a peak at 10 hPa in the equatorial band.

3 Discussion and conclusions

These results correspond to a reinforcement of the polar vortex in January with a destabilization in February, under solar maximum conditions (SMC). The temperature response is consistent with the observations in the

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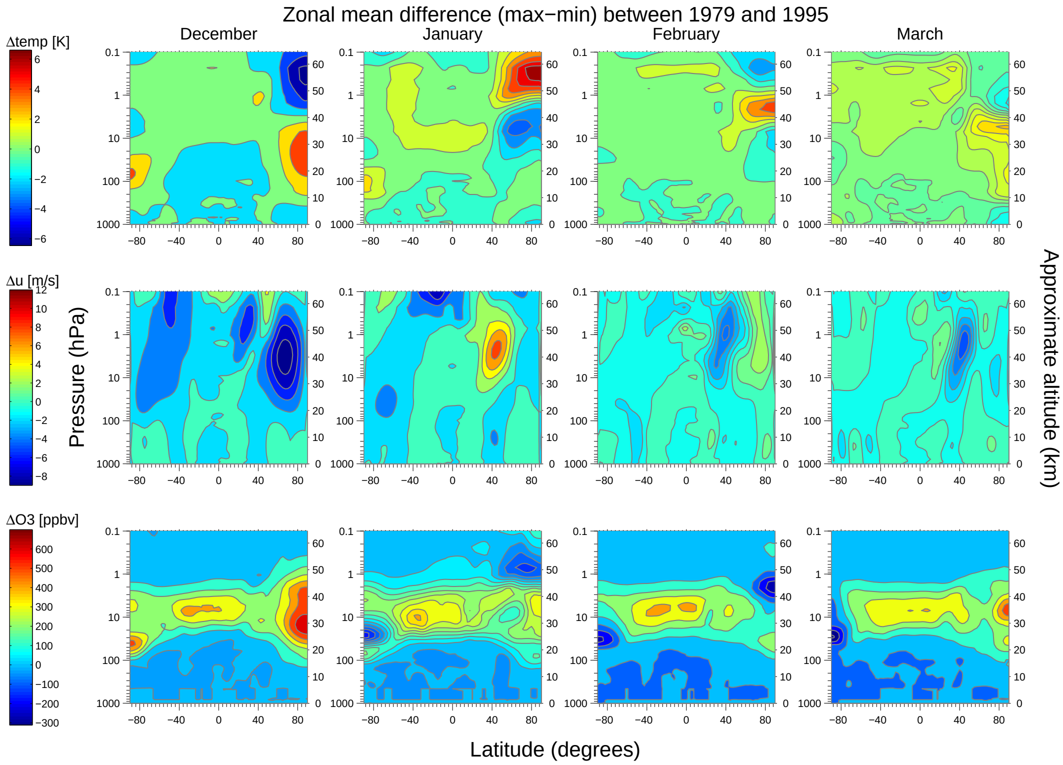

Fig. 1. Zonal mean difference (max-min) for the temperature *temp* (top), the zonal wind u and the ozone concentration O_3, in the atmosphere for the Northern winter months (December to March).

upper stratosphere-lower mesosphere (direct effect on ozone) as shown by Keckhut et al. (2005). By a study concerning SSU temperature measurements and ERA-40 zonal wind response to solar cycle, Claud et al. (2008) also demonstrated that in the lower stratosphere, temperatures are generally warmer for low- and mid-latitudes under SMC, and that, at high latitude, the polar vortex is stronger with the exception of February and to a lesser extent March in the northern hemisphere. main circulation. In particular, Kodera & Kuroda (2002) has argued that changes in the winter polar stratosphere brought about by anomalous solar heating may influence the passage of upward propagating planetary waves and thus their deposition of momentum that will influence the strength of the mean overtuning of the stratosphere. Gray et al. (2001) also demonstrated that zonal wind anomalies in the sub-tropical upper stratosphere can influence the timing and amplitude of sudden stratospheric warmings, events during the polar winter in which enhanced planetary wave activity disturbs the cold polar vortex. which will permit to investigate the interaction of the planetary waves. Moreover, In a next future is planned the analysis of a run with a real solar signal as input for the irradiance.

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