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Upward velocities of the reconnection points and coronal magnetic field strengths in flaring regions derived from the GOES X-ray light curves

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Abstract. From Yohkoh and SoHO observations, the magnetic reconnection is considered as a main energy release mechanism of the solar active phenomena. In this study, we try to reproduce GOES X-ray light curves (1–8 Å) of solar flares using a model incorporating the radiative and conductive cooling and the magnetic reconnection heating.

1. The method and results

In this paper, we try to reproduce the maximum flux ($F_{\rm X}$) and the rise time ($D_{\rm t}$) of GOES X-ray light curves of 21 solar flares. The radiative loss rate (1-8 Å) was calculated using the CHIANTI code (Landi *et al.* 2006). For radiative and conductive coolings, we need lengths, volumes, and temperatures of the flare loops.

Typical scales and magnetic field strengths of these loops are evaluated from surface areas and vector magnetograms (Mitaka/NAOJ) of flare regions. To define the flare areas TRACE and SoHO/EIT images were used. Here we introduce the first free parameter, P_1, which manipulates coronal field strengths and coronal typical scale lengths from the magnetic flux conservation. $B_{\rm co} = B_{\rm ph} P_1$, $L_{\rm co} = L_{\rm ph}/\sqrt{P_1}$, where B is the magnetic field strength, L is the typical scale length, and subscripts 'ph' and 'co' mean photospheric and coronal values. It is assumed that a flare loop consists of 10 multiple loops. X-ray light curves of constituent loops are calculated and summed to obtain the X-ray light curve of the flare loop (Fig. 1a). These loops are assumed to have fan-like expansion upwards (e.g. Švestka *et al.* 1998; McKenzie & Hudson 1999). The loop lengths are calculated taking this fan-like geometry into account.

The temperature of a single loop is derived from the temperature scaling law (Shibata & Yokoyama 1999, 2002) based on $B_{\rm co}$ and $L_{\rm co}$. The pre-flare number density is assumed to be 10^9 cm^{-3}. The number densities of flare loops are obtained by assuming plasma $\beta =$ 1 in flare volumes. The loop heating (increase in temperature and number density) is assumed to proceed from the lowest loop to the highest loop. The upward velocity of the propagation of the loop heating, $V_{\rm up}$, was assumed to be as follows; $V_{\rm up} = V_{\rm A} P_2$, where $V_{\rm A}$ is the Alfven velocity, and P_2 is the second free parameter. The values of P_1 and P_2 consistent with the observed values of $F_{\rm X}$ and $D_{\rm t}$ were derived (Fig. 1b).

Fig. 1c shows one example of fitted profiles. In Fig. 1d, our calculated temperatures are different from the observed temperatures by factor of less than 3.

More precise study will be presented in our future paper.

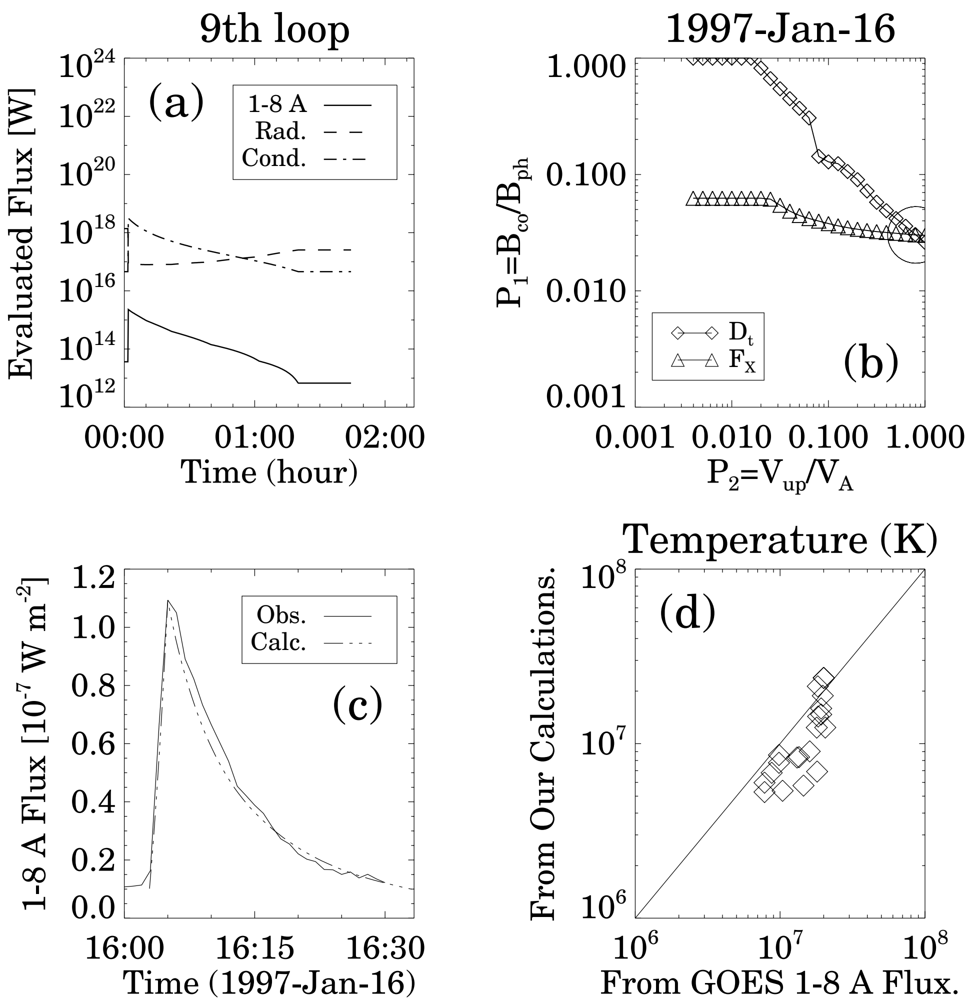

Figure 1. (a) Conductive and radiative flux profiles in one loop of a B1 class flare. (b) P_1 and P_2 consistent with F_X ($\triangle$) and D_t ($\diamond$). (c) GOES 1-8 Å flux profile and our calculated 1-8 Å flux profile. (d) Temperatures derived from GOES fluxes and our calculations of 21 flares.

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