

Reconstructing the solar spectral irradiance

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INTRODUCTION/BACKGROUND

We present a new method to reconstruct the spectral solar irradiance by utilizing the formation height of the spectral lines and continuum and an increase in active area over height. This leads to a more realistic model of the irradiance specifically in the extreme UV. Solar irradiance variation is an important forcing component in climate models as it is known that the climate reacts to a changing solar irradiance. As Rozanove et al. (2002) has shown, the Lyman-alpha is of particular importance to chemical reactions in the upper atmosphere. To reconstruct the climate of the past, spectra as a function of time are needed. Following the approach of Wenzler (2005) the spectral reconstruction is based on a four component model with filling factors for the area of quiet sun, sunspots, plague and network. Wenzler extracts the filling factors using MDI magnetogram data and images of the visible sun.

This model does works well for modeling the total solar irradiance. However, it does not well reproduce the variability in the extreme UV (EUV) spectrum, notably the Ly-alpha emission line at 1215.6 Angstrom. Using Non-LTE calculations improves the model significantly. Even so Haberreiter (2005) still fails to reproduce the variability of the first hydrogen line (Ly-alpha, 1216.5 Angstrom) by a factor of two. We present a new method to reconstruct the spectrum of Ly-alpha by introducing a modification to the filling factor or the active regions.

THE SOLAR PHOTOSPHERE AND CHRONOSPHERE – METHODS

The photosphere is a 300km thick layer of the sun where the visible part of the spectrum is formed. Its average temperature is about 6000K. Above the photosphere lies the chromosphere and the transition region to the corona with temperatures up to 1 Mio.°C. The formation height of the EUV differs from that of the visible part of the spectrum. The visible light is formed in the photosphere while the EUV and lines are formed under hotter temperatures in the chromosphere.

Figure 1 shows the Ly-alpha formation height, which is several thousand kilometers above the photosphere. A widening of the active area with respect to height above the photosphere is evident, when looking at images of the sun.

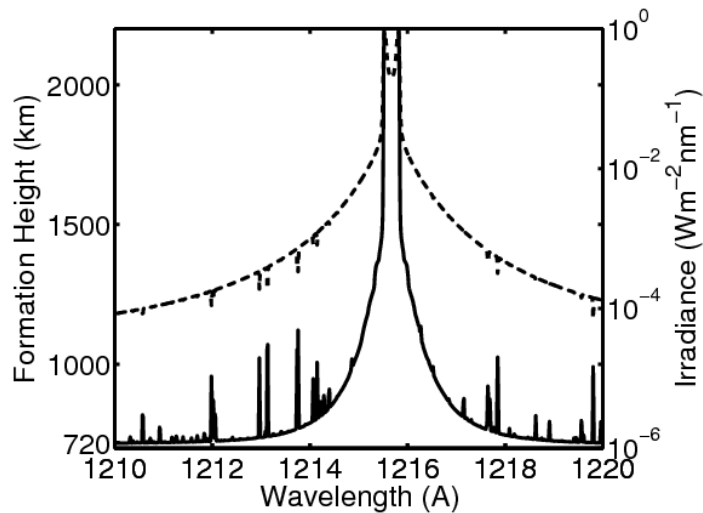


Fig. 1: Left (solid): Formation Height of the corresponding wavelength. The Ly-alpha goes up to 2000km above the photosphere and the EUV continuum in this region is about 800km above the photosphere. Right (dashed): Spectral irradiance in $\text{Wm}^{-2}\text{nm}^{-1}$ of the quiet sun Ly-alpha

THE MODEL – RESULTS AND OUTLOOK

From images extracted from the SOHO SUMER instrument, a high-resolution spectrograph with imaging capabilities, an increase in the active area of about a factor of two compared to MDI magnetograms is observed (Figure 2).

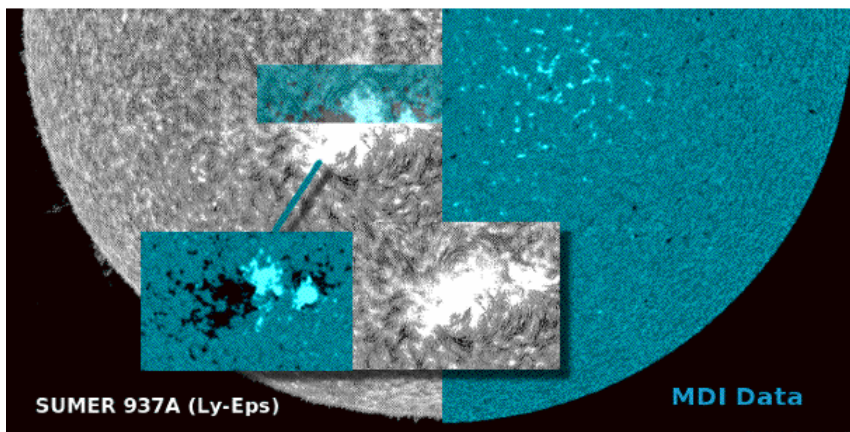


Fig. 2: Comparison of SUMER 937A (left, Ly-epsilon, SUMER ATLAS) with MDI magnetogram data (right, SOHO Datacenter). The SUMER pictures show an increase in area of about a factor 2. Images from SUMER ATLAS and the SOHO Data Archive

As a first approximation of the area expansion over height, a quadratic function of the area is constructed. The constraints are an expansion factor of unity at the photosphere and an expansion factor of two for the active area at the Ly-alpha formation height. We apply this area enlargement to all wavelengths of the spectrum by calculating the corresponding factor from the formation height of optical depth unity at this wavelength. The result are frequency dependent filling factors $\alpha_{\text{Model}}(\lambda, t)$ leading to a more accurate spectral solar irradiance in the EUV region. This new filling factor is used to reconstruct the spectrum. From this work in progress we show the reconstructed Ly-alpha compared to measurements in Figure 3.

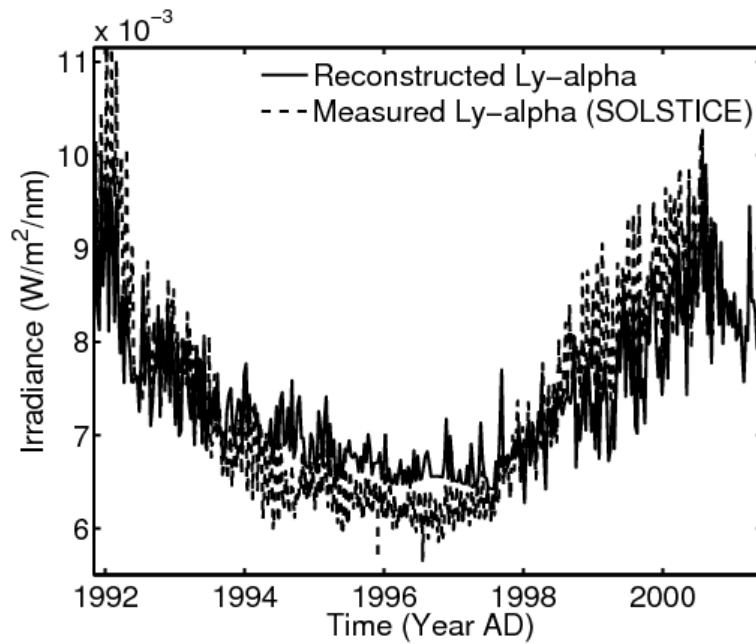


Fig. 3: Reconstruction of the Ly- α over time using both the active area expansion and the network. The variability of the reconstructed Ly- α is within 75% of the measured one

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