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TWO DIMENSIONAL SPECTRAL TIME SERIES

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Abstract. We analyze two dimensional time series of solar photospheric spectrograms in order to study the dynamics of solar fine structures and their evolution. The two dimensional images were obtained by scanning over the photosphere. Spectrographic data of this type include a much higher information than ordinary images.

1. Introduction

The solar photosphere is dominated by convective overshooting motions. The study of these fine structures requires excellent seeing conditions since the elements are $\leq 1''$ size. In the low photosphere the convection dominates whereas in the higher photosphere the influence of oscillations is dominant. This was studied by many authors, among them e.g. Leighton et al. (1962) or Canfield and Mehltretter (1973) or Hanslmeier et al. (1990, 1994), Kučera et al. (1995). A comparison bewteen previous observational results and theoretical 2-d simulations can be found in Gadun et al. (2000).

Why is it so interesting to study the dynamics of the photosphere? There are several reasons for that: first the photosphere is the deepest layer that is directly visible and hence constitutes a boundary layer for solar models. Second it is well known that in these layers turbulent motions are agitated which are responsible for the heating of the above lying chromosphere and corona. The questions however is, where are these motions located and how is the disturbance propagating upwards.

The best way of studying a dynamic phenomenon is of course using time series. Photospheric spectrograms, taken in spectral ranges with lines of different formation heights provide a tool for studying the dynamics in different layers of the photosphere.

2. Data

The data were taken with the 70 cm VTT at the Observatorio del Teid at Izana, Tenerife. A more detailed description of this telescope can be found in Schröter et al. (1985) . We obtained during an observing campaign in 1999 two dimensional spectral scans, where the space interval $\delta x = 0.4''$ and the total number of scans was 50. In total an area of 20" was scanned. The time step between two successive images was $2.5\,s$. Thus one 2-d scan lasted for slightly more than 2 minutes. The spectrograms contained the two FeI lines:

- $Fe\,I$ at $630.1508\,nm$ and $W_\lambda = 127\,m\mathring{A}$, $EP = 816\,eV$ and $g_{eff} = 1.6$.
- $Fe\,I$ at $630.2499\,nm$ and $W_\lambda = 83\,m\mathring{A}$, $EP = 816\,eV$ and $g_{eff} = 2.5$.

From these data the following spectral line parameters were calculated in the usual way:

- continuum intensity
- line center residual intensity
- line center velocity
- equivalent width

8 images each separated by 130 s were analyzed to study the evolution of the structures.

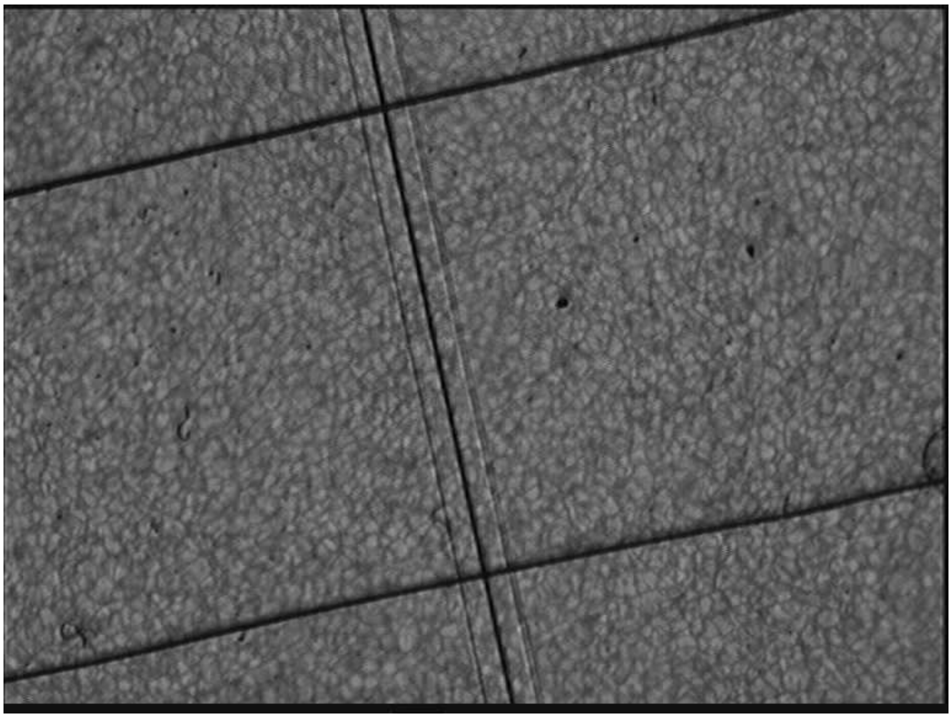

Figure 1: Uncorrected slit jaw image

3. Results

In Fig. 1 we show a slit jaw image which was not corrected for flat field and seeing.

In Fig. 2 we can follow the time evolution of the continuum intensity and line center residual intensity over 7 different timesteps.

In Fig 3 we can follow the time evolution of the line center velocity fluctuations and the full width at half maximum variations over 7 different timesteps.

We calculated the correlation coefficients for the individual 2-D images of the time series. This was done in two ways: a) we calculated the correlation coefficients for subsequent images and b) the decay of the correlation was calculated by comparing the correlations of the images $n > 1$ with image 1. This was done for all four spectral

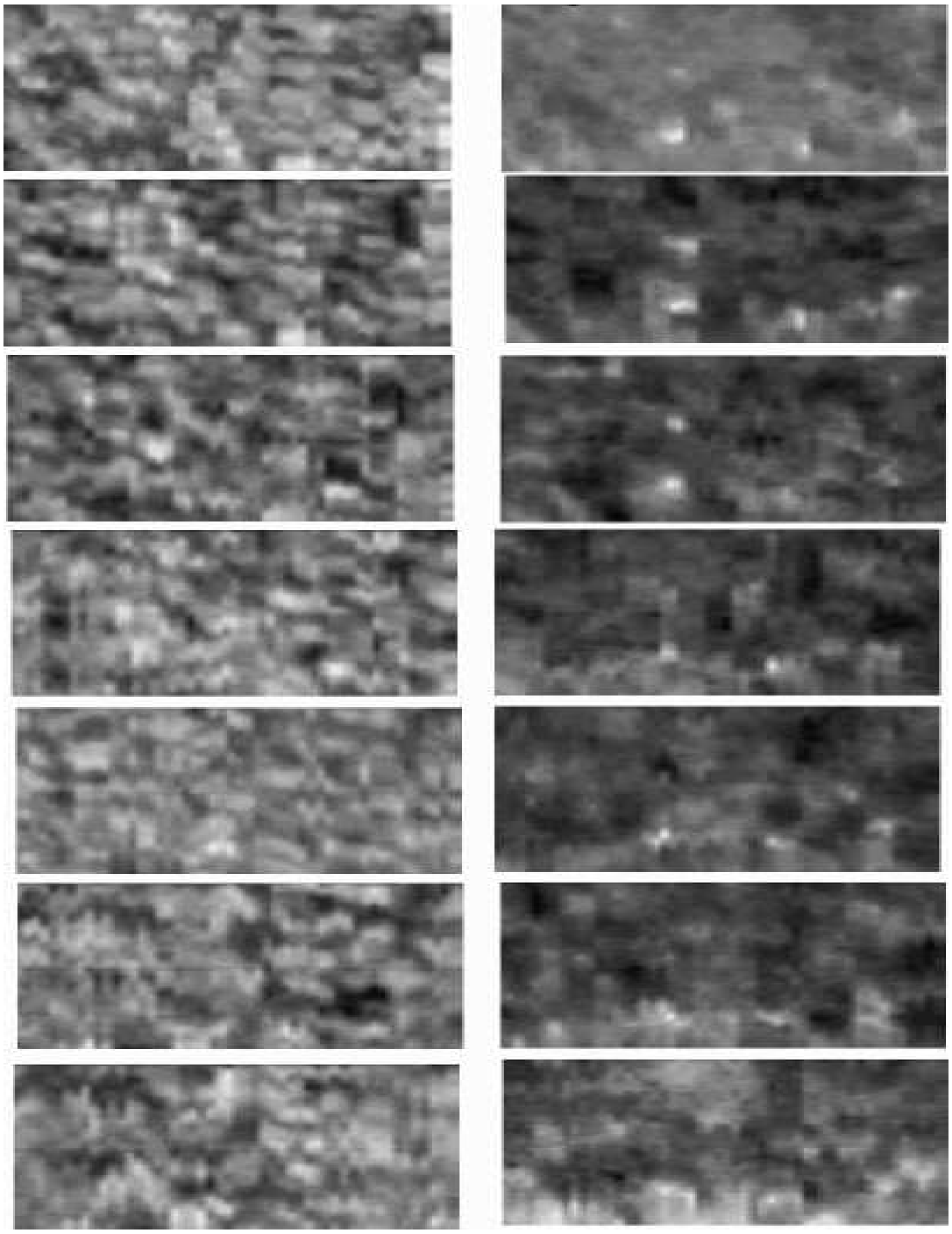

Figure 2: Variation of continuum intensity (left) and line center residual intensity (right) as a function of time (line I)

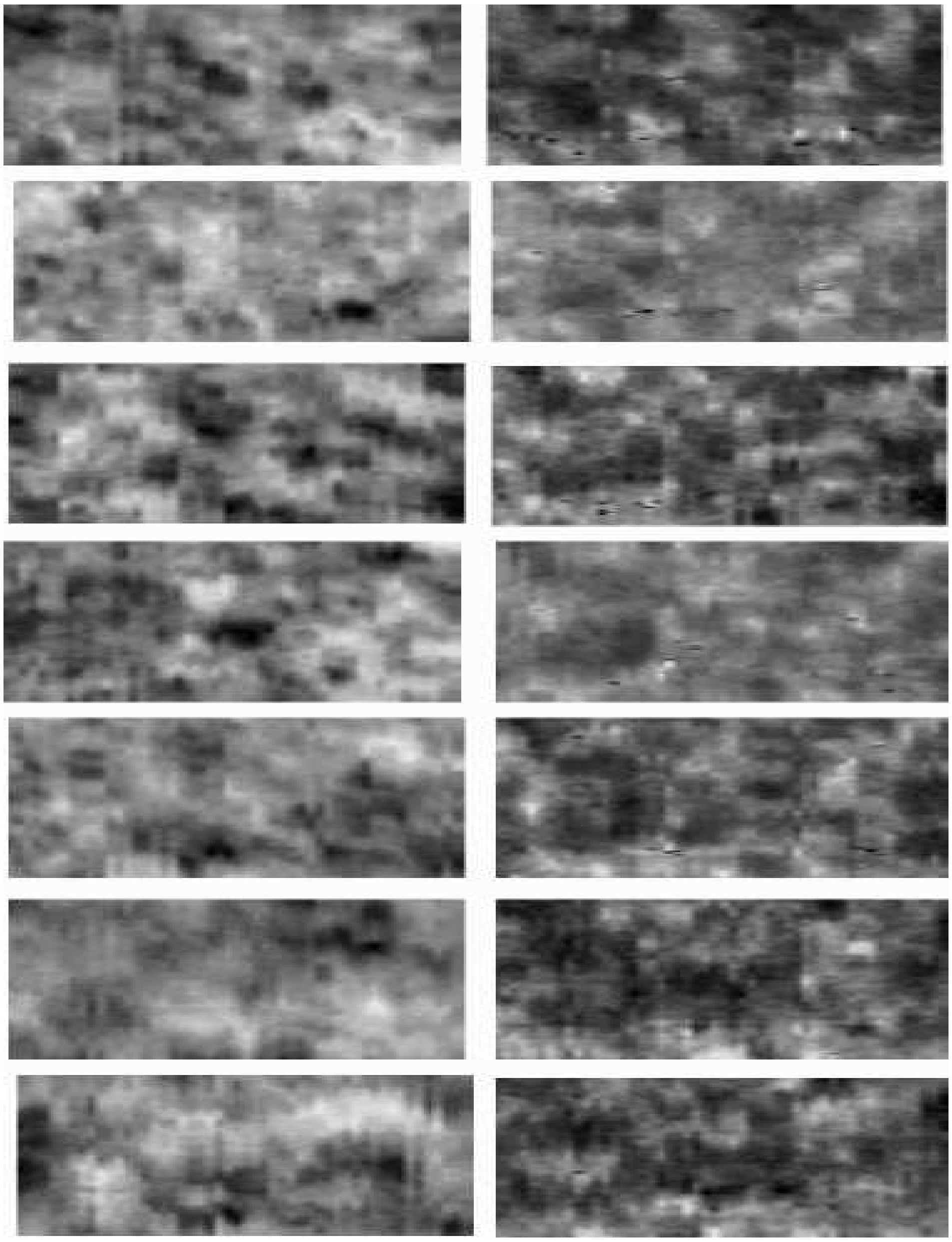

Figure 3: Variation of line center velocity fluctuations (left) and full width at half maximum variations (right) as a function of time (line I)

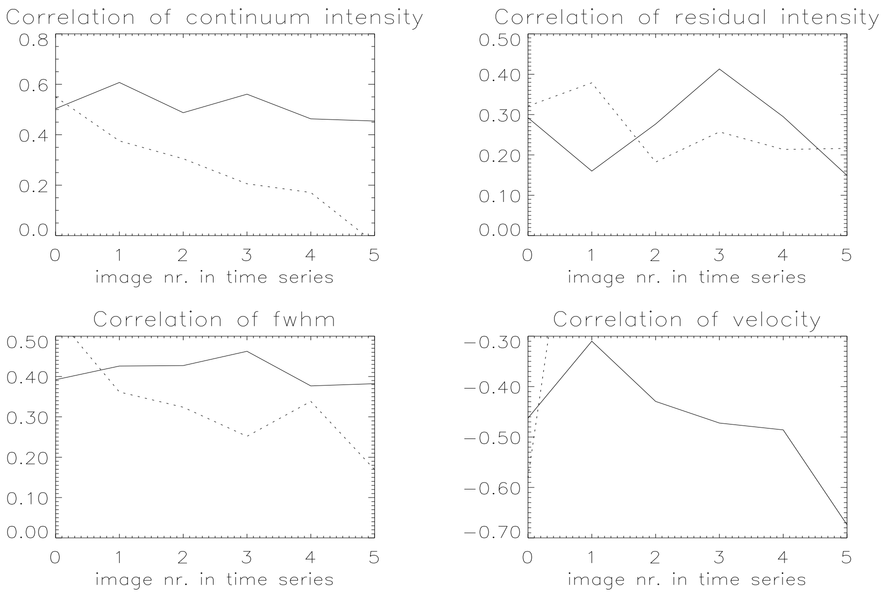

Figure 4: Correlation coefficients; full line: between subsequent images of the time series, dotted line: between the first image of the time series and the subsequent images

line parameters. The results are given in Fig. 4 the correlation between subsequent images remains relatively stable for the continuum intensity (correlation coefficient ~ 0.6) indicating slow evolution in the field. The correlation between the first image and the other images falls down in the case for continuum intensity and full width at half maximum due to the evolution of granular/ intergranular structures. The results are different for the residual intensity. For both types of correlations the values of correlation coeffiecients are low (around 0.3) and show no clear trend.

This may be explained by enhanced turbulence in these layers. Also the line center velocity shows low values for the correlations which are negative with a tendency to increase. This could be attributed to the influence of larger scale motions.

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