THE DYNAMICS AND STRUCTURE OF THE SOLAR ATMOSPHERE AS OBTAINED FROM COMBINED SUMER/SOHO AND TIP2/VTT OBSERVATIONS

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ABSTRACT

We present combined SUMER/SOHO and TIP2/VTT observations of the active region NOAA 10763 obtained on 19 May 2005. The SUMER spectrograph aboard SOHO provided high spatial, spectral and temporal resolution spectra of several lines formed at transition region temperatures (4.2 < log (T/K) < 5.6), while the TIP2 spectropolarimeter on the VTT telescope was acquiring spectra of the chromospheric He I 1083.0 nm line and the photospheric Si I 1082.7 nm line in the four Stokes parameters. These data allow us to study the relationship between the structures and flows observed in transition region with the full magnetic vector at the chromospheric and photospheric levels as obtained from the inversion of the spectropolarimetric data.

1. INTRODUCTION

Solanki et al. (2003), Lagg et al. (2004) and Wiegelmann et al. (2005), have shown that it is possible to trace magnetic structures such as loops and to detect current sheets using the full Stokes measurements of the He I 1083 nm triplet. These studies have also revealed the presence of highly supersonic flows at many locations in the upper chromosphere (Aznar Cuadrado et al., 2005; Lagg et al. 2005).

However, to fully understand the dynamics and structuring of the solar magnetised atmosphere it is necessary to find the relationship between the magnetic structures in the photosphere (as obtained by VTT and MDI) and in the upper chromosphere (VTT) with EUV radiance images (TRACE, EIT) of the 1 MK corona and velocities measured in EUV lines formed at transition region and coronal temperatures (SUMER). In this way it is possible to uncover the transition region and coronal signatures associated with the magnetic field at different layers in the atmosphere. Since the magnetic field is already very close to force free at the level where the He 1083.0 triplet is formed (in contrast to the photosphere, where most observations are carried out), the magnetic structure deduced from this line should be much more closely related to transition region and coronal structures and dynamics. The relation between the photospheric and chromospheric magnetic structure and flows measured by SUMER in different transition region lines will also be of great interest (as will the relation between flows seen with SUMER and in the He 1083.0 line).

2. OBSERVATION AND INSTRUMENTATION

The Tenerife Infrared Polarimeter (**TIP2**) at the Vacuum Tower Telescope (**VTT**), Izaña Observatory, Tenerife is a spectropolarimeter with a spectral resolution of 15 mÅ per pixel and a pixel size of 0.17″. The observed wavelength range, from 1082.5 to 1083.6 nm, contains the two photospheric lines of Si I (at 1082.9 nm) and Ca I (at 1082.93 nm) and the chromospheric He I triplet (lines at 1082.909 nm, 1083.025 nm, and 1083.034 nm). Observations here presented consist of a raster scan of active region NOAA 10763 started at 08:21:33 UTC. The area was covered in 299 steps of 0.35″, exposing each spectrum for 8 seconds. In order to increase the signal-to-noise level theTIP2 data were binned over 2 in the x-direction and over 4 in the y-direction.

The SUMER instrument (Wilhelm et al. 1995) aboard SOHO is a normal incidence spectrograph. Since May 2004 detector A has started showing a deterioration of the ADC resulting in the loss of a progressively increasing number of detector rows. Only pixel rows up to 46 were still useable at the time of the observations here discussed. All data were acquired using the narrow 0.3″×120″ slit on the bottom part of detector A. The observations presented here consist of a raster scan starting at 07:48 UTC and covering an area of 110″x40″ in 98 steps of 1.13″ each.. Five selected spectral windows including Cont. 1557, Si II 1533, C IV 1548, C IV 1550 and Ne VIII 770.

3. DATA ANALYSIS

SUMER and TIP2 data were carefully aligned by correlating the 155.7 nm continuum image (SUMER) and the Si I Stokes V map (TIP2). We believe the alignment to be accurate within 1" to 2".

The Stokes profiles were inverted (using a method described in Lagg et al. 2004) to obtain the full magnetic vector and the line-of-sight velocity in the photosphere (Si I 1082.7 nm line) and in the upper chromospheric (where the He I multiplet at 1083.0 nm is formed).

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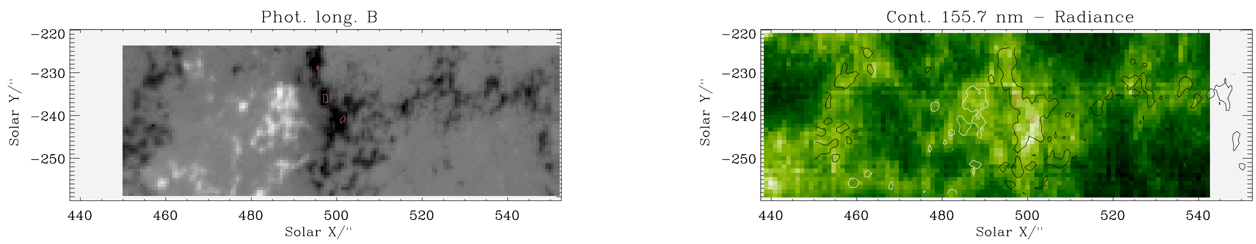

Figure 1. Left: photospheric longitudinal magnetic field (from Si I 1082.7), displayed from -700 to 700 gauss. Right: square-root radiance map of the 155.7 nm continuum with superimposed the isocontours of the longitudinal flux at levels of 300 G (white) and − 300 G (black). On both panels the isocontours of the radiance of the visible continuum are shown in magenta, outlying some small pores.

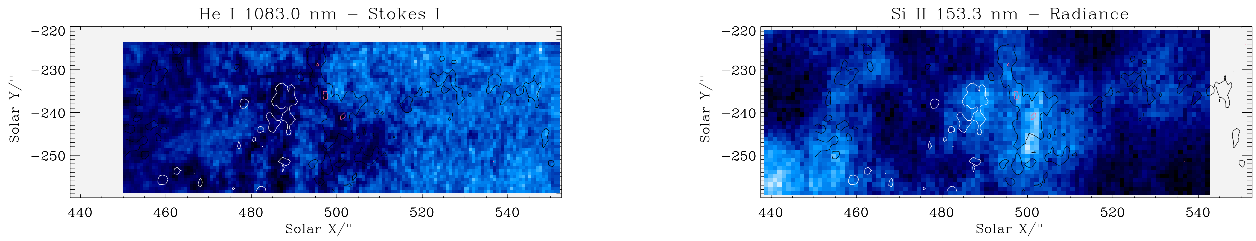

Figure 2. Left: radiance map of the chromospheric He I 1083.0 nm line (Stokes I). Right: square-root radiance map of the Si II 153.3 nm line. On both panels the isocontours of the radiance of the visible continuum are shown in magenta, outlying some small pores. The isocontours of the longitudinal flux at levels of 300 G (white) and -300 G (black) are also shown.

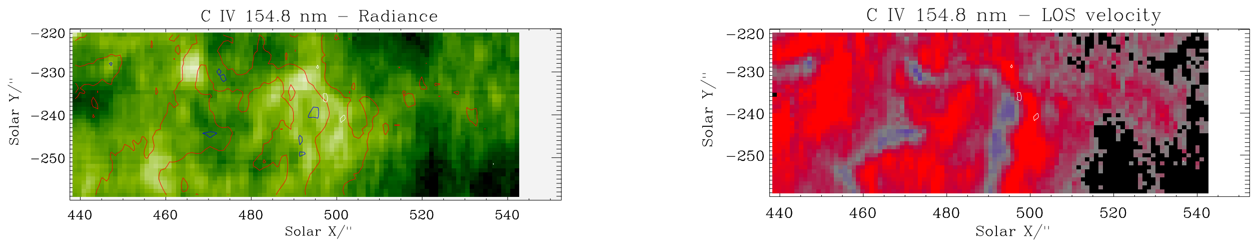

Figure 3. Left: square-root radiance map of the C IV 154.8 nm line with superimposed the: line of sight (LOS) velocity isocontours at levels of 10 km/s (red) and −3 km/s (blue). Right: LOS velocity map obtained by fitting the C IV line profiles. The velocity is displayed between −5 and 20 km/s. On both panels the isocontours of the radiance of the visible continuum are shown in white, outlying some small pores.

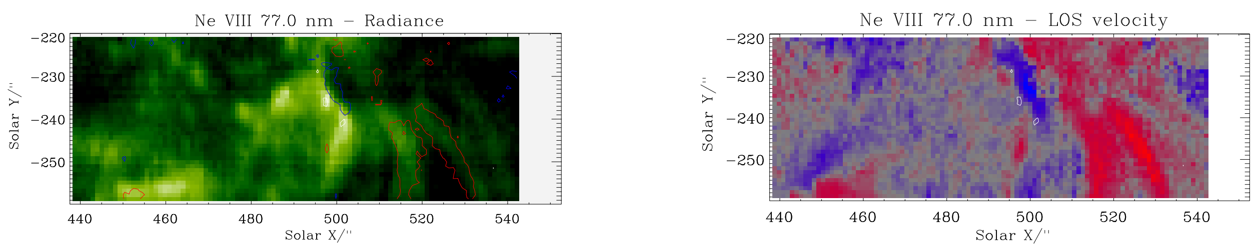

Figure 4. Left: square-root radiance map of the Ne VIII 77.0 nm line with superimposed the line of sight (LOS) velocity isocontours at levels of 10 km/s (red) and −10 km/s (blue). Right: LOS velocity map obtained by fitting the Ne VIII line profiles. The velocity is displayed between −20 and 20 km/s. On both panels the isocontours of the radiance of the visible continuum are shown in white, outlying some small pores. Note the downflowing loops around X=520".

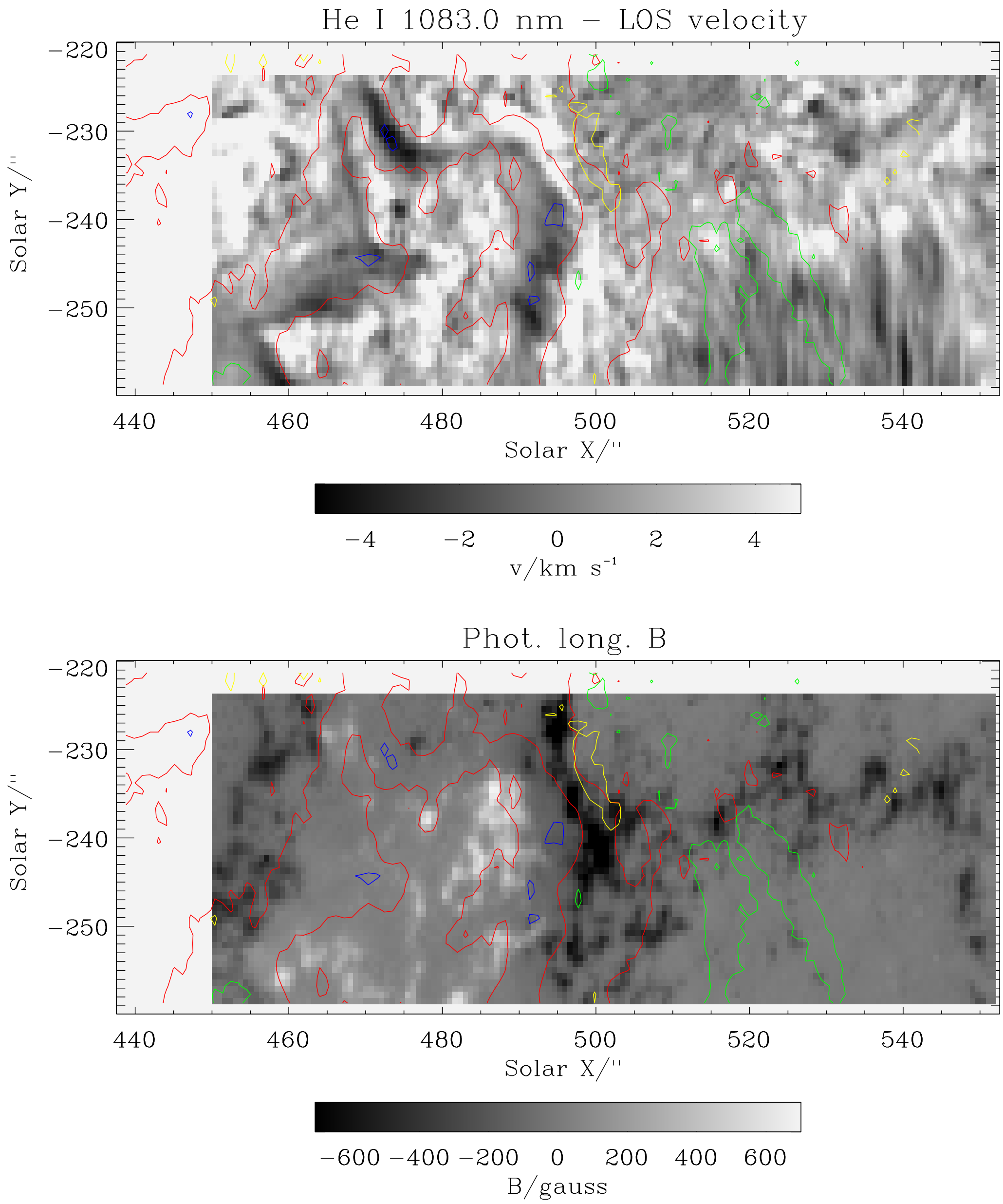

Figure 5. Top: LOS velocity map derived from the inversion of the Stokes parameters of the He I 1083.0 nm line. The velocity is displayed between −5 and 5 km/s. Bottom: photospheric longitudinal magnetic field (from Si I 1082.7), displayed from -700 to 700 gauss. On both panels isocontours of the C IV LOS velocity at levels of 10 km/s (red) and −3 km/s (blue) are shown while isoconturs in green and yellow, respectively, indicate LOS velocities of 10 km/s and −10 km/s as measured from the Ne VIII line. Note the downflowing Ne VIII loops (around X=520") that may be connected with areas that appear redshifted in the C IV and He I lines.

4. SUMMARY OF RESULTS

Our observations allow us to study the velocity field of the solar atmosphere from the photosphere to the low corona and its relationship with the magnetic field.

Figures 1 to 4 show the structures of the solar atmosphere from the photosphere (magnetic flux and visible continuum, Fig. 1 left) through the chromosphere (continuum at 155.7 nm, Fig. 1 right and line radiances of He I 1083.0 and Si II 153.3, respectively Fig. 2 left and right), the transition region (C IV 154.8, Fig. 3) up to the lower corona (Ne VIII 77.0, Fig. 4). From the top panel of Fig. 5, it can be seen that there is a good correlation between the velocities measured in upper chromosphere (He I

1083.0 nm, T ≈ 10 000 K) and those seen in the mid transition region (C IV 154.8 nm, T = 10^5 K).

On the other hand, no obvious relation was found between the brightness structures seen in He I and C IV and those seen in the upper transition region/low corona (Ne VIII 77.0 nm, T = 6.3×10^5 K). However, we also see a system of downflowing loops in the Ne VIII line (see Fig. 4 around X=520") whose footpoints could be connected with areas characterised by redshifts in C IV and He I (see Fig. 5, bottom panel).

A force free magnetic extrapolation will help in understanding the topology of the observed region.

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