THE TRIESTE-GRAZ SOLAR SURVEILLANCE NETWORK PROGRESS REPORT 2001

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ABSTRACT

We describe the progresses in the development of the Trieste-Graz Solar Surveillance Network (TGSSN), an observational network aimed to performing a continuous multi-wavelength surveillance of the solar electromagnetic emissions via a set of geographically-distributed dedicated instruments, which was conceived to provide relevant information in Space Weather monitoring and forecasting.

1. INTRODUCTION

The observational network integrates facilities for high speed multi-band solar imaging at optical wavelengths (Sonnenobservatorium Kanzelhöhe, Austria; KSO) as well as facilities for ultra-high speed multi-band solar radiometry and polarimetry at radio wavelengths (INAF-Trieste Astronomical Observatory, Italy), which will be able to automatically detect and identify solar activity transients and issue near real-time alerts and warnings. In fact, an operational scheme to provide observed and predicted solar activity indicators to Space Weather (SpW) forecasters was originally set up in 1998 [1] and has been developing since then. In the following sections, we give an overview of the recent developments related to the following functional sub-systems: (a) the observing sub-systems, such as the Kanzelhöhe Hα and the Na-D Intensity-Velocity-Magnetic-Field high speed imaging ones for the detection of optical flares, and the Trieste Solar Radio System for the detection of radio flares; (b) the image segmentation sub-system for automatic flare recognition in Hα images; (c) the significant statistical analysis of flare features performed on very large observational datasets.

2. THE KSO OBSERVING PROGRAM

A Multi-Spectral Solar Surveillance Program is routinely carried out at KSO based on: (a) Full Disk Hα Time Series with 1 min temporal resolution; increased resolution and quasi-simultaneous additional images in line wings during high Solar activity; (b) Full Disk Na-D Time Series with 1 min temporal resolution, simultaneous Dopplergrams, Magnetograms and Intensitygrams; increased resolution during high Solar activity; (c) White Light Photoheliograms to accomplish the Debrecen Photoheliographic Results; (d) Sunspot Drawings; (e) Full Disk Ca-K Time Series with 1 min temporal resolution (starting in Spring 2002); (f) Full Disk Continuum Time Series in several bands and white light (starting in Spring 2002). All data are archived and available on request; real-time Hα images and daily synoptic images are directly accessible via WWW (*http://www.solobskh.ac.at*). The Kanzelhöhe Electronic Archive System is part of SOLARNET and will be linked to the European solar archives grid. KSO is one of 3 observing stations of the Global High Resolution Hα Network, which provides high spatial and temporal resolution images with 24 hours coverage and participates in the chief observer team of MaxMillenium. It supports the NOAA Geophysical Data Center (Boulder, Co.), the Sunspot Index Data Center (Brussels) and the Debrecen Photoheliographic Results (Hungaria) with observations on a regular base and supported several campaigns of SOHO experiments with coordinated ground-based observations.

3. THE NA-D MOF FULL DISK IMAGER

The Na-D Magneto-Optical Filter (MOF) Full Disk Imager designed by A. Cacciani has an aperture of

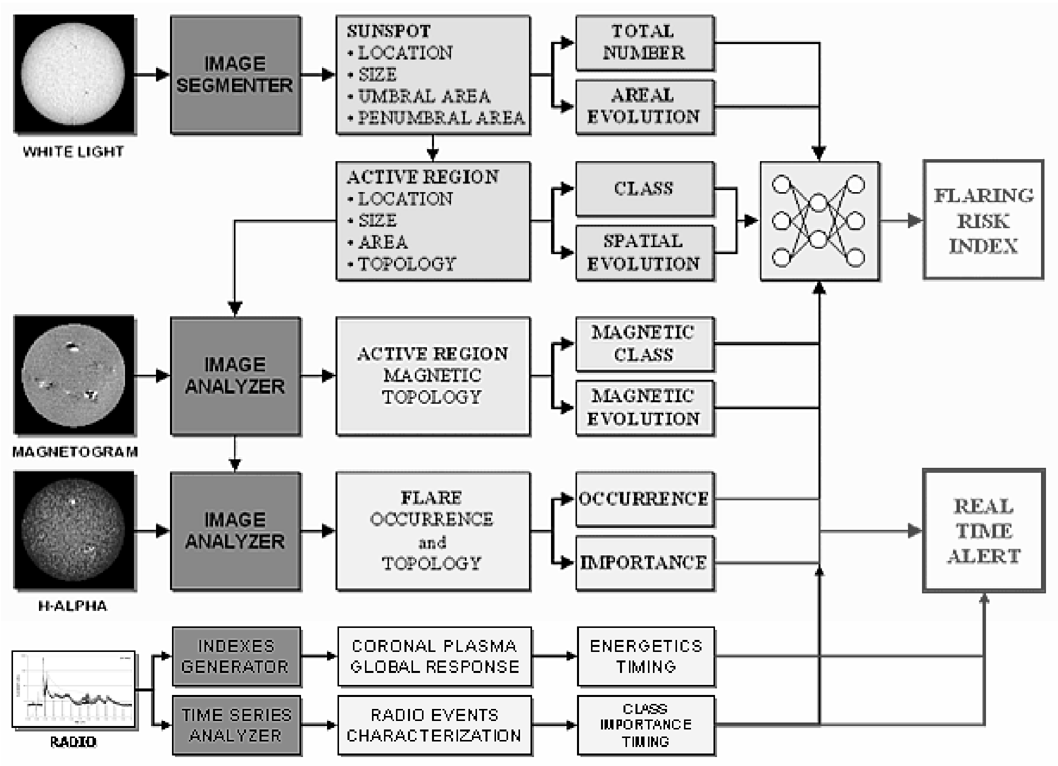

Figure 1. Operational scheme of TGSSN.

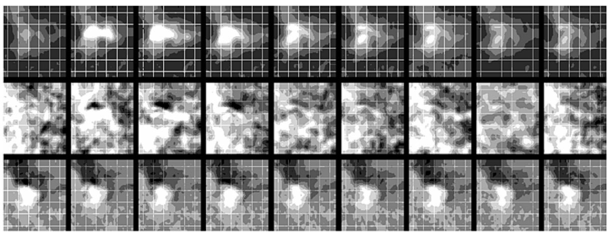

Figure 2. Intensity (top), velocity (middle) and longitudinal magnetic field maps (bottom) obtained on 1 June 2000 in the Na-D lines.

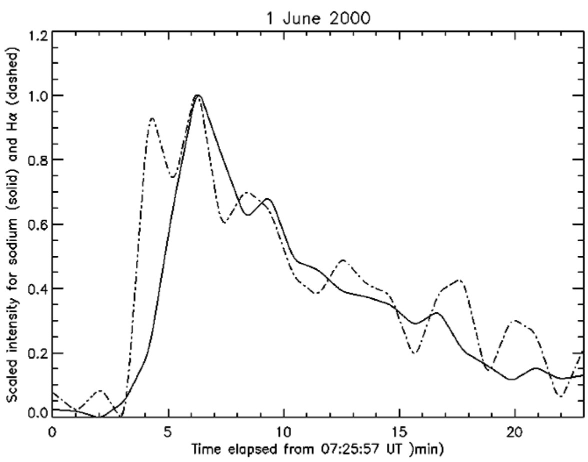

Figure 3. Intensity brightenings detected on 1 June 2000 in simultaneous Na-D (solid) and Hα (dashed) observations.

5 cm, which achieves a resolution of 4.3 arcsec/px in the present configuration. In synoptic mode it produces 1 set of images per minute, i.e., an Na-D intensitygram, a Dopplergram and a longitudinal magnetogram, with a resolution in velocity of 5 $(m/s)/px$ and a magnetic field range from 20 to 2800 G; the maximum time cadence is 1 set per 160 ms. Figure 2 depicts a selection of the intensity (top), velocity (center) and longitudinal magnetic field maps (bottom) obtained on 1 June 2000 in the Na-D lines; time goes from left to right at 2 min step starting from 07:25:57 UT; velocity is black if downward and a $20''$ x $20''$ grid is superimposed. Planned developments are the increase of the aperture to enhance the resolution and the upgrade of the software to automatically detect the clouds. Such instrument is a fundamental tool in the analysis of pre-flare and flare activity, e.g. from simultaneous Sodium and Hα images taken on 1 June 2000, intensity brightenings in the Na-D lines and in Hα were detected and compared (Figure 3). The Hα pulse precedes the Na one by 90 s. The intensities, normalised to the mean central one, span from 1.1 to 2.1 and from 1.0 to 3.2 for the Na and Hα respectively [2].

4. THE Hα FAST DIGITAL IMAGER

The Digital Full-Disk Hα Patrol System has been routinely in operation since 2000 with the following features: (a) Telescope: 10 cm aperture, 200 cm focal length; (b) Band: 656.3 nm Wavelength, 0.07 nm FWHM; (c) Detectors: 1K x 1K x 8 bit CCD, 2K x

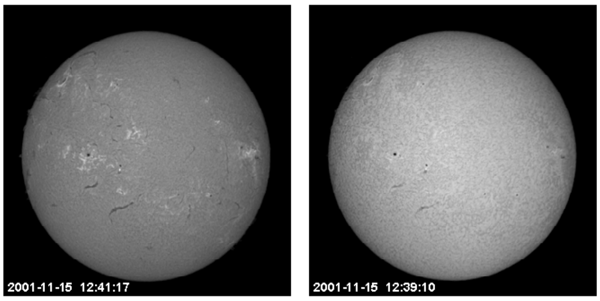

Figure 4. Hα full-disk images taken at KSO on 15 November 2001 in line center (left) and in a line wing (right).

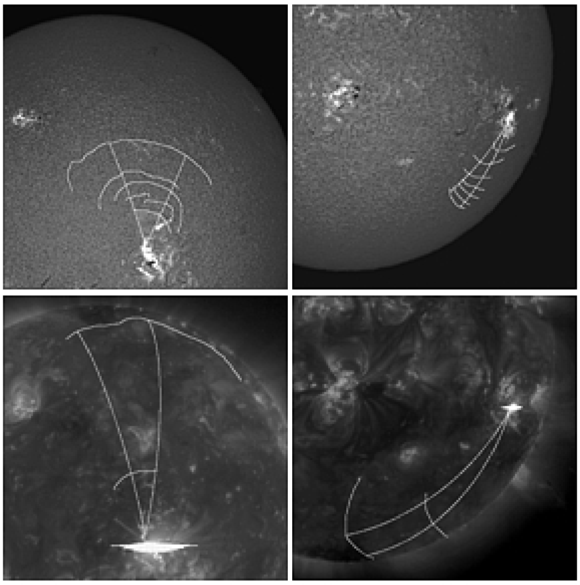

Figure 5. Two flare wave events observed in Hα at KSO (top) and in EUV by SOHO/EIT (bottom panels). Overplotted are the wave fronts and parts of great circles along which the distances from the supposed origin of the disturbance were measured.

2K x 14 bit CCD; (d) Resolution: 2.2 arcsec/pixel, 1.1 arcsec/pixel; (e) Cadence: 1 image/1 min (synoptic); (f) Archive: Digital on CD-R. A frame selection algorithm is used in order to achieve the maximum resolution. In November 2001 the Hα filter was upgraded with a computer-controlled stepping motor which shifts the filter passband rapidly into the wings of the line in order to rapidly obtain frames both in Hα line center and off-band (Figure 4): (a) one image triplet (center & both wings) per minute with frame selection or four triplets without; (b) shift of passband up to +/− 0.1 nm; (c) either continuous observations or only during flare mode. High-cadence off-band observations are a must in SpW-related observations. In fact, events relevant to SpW are often associated with filament eruptions, flare sprays and Moreton waves and these phenomena can show large line-of-sight velocities and may vanish from Hα line center; moreover, Moreton waves and sprays develop on short timescales.

The relevance of flare waves for SpW (especially regarding SEPs) was shown for EIT waves by different authors. In this framework the Hα Fast Digital Imager allows to study the association of flare waves in different wavelengths, and we currently focus on Hα (Moreton) and EIT waves (Figure 5)[3]. A search of several Hα data archives has shown that Moreton waves are only rarely observed in line center (only 12 pronounced events have been found thus far for the period of 1997-2001). Our first results show that Moreton waves and their associated EIT waves are caused by the same disturbance. With the new off-band observing capability, we expect to observe more Moreton events during the next years.

5. SOLAR FLARE RECOGNITION

A procedure for automatic and quasi real-time recognition and identification of solar flares in Hα full-disk images is under development. The main objectives are the automatic detection of the flare onset and the extraction of relevant flare parameters, such as, e.g., flare position, flare area and intensity as function of time.

Preliminary results of the developed procedure applied to time series of full-disk Hα images from the KSO are depicted in Figure 6, which shows the time evolution of the May 2, 1998, 3b class flare. The flare recognition is based on a combination of region and edge based segmentation methods [4]. In this frame an advanced edge detection technique is needed. We applied the Canny edge detector, which is optimized with respect to the edge detection, the edge localization, and the one-response to edges.

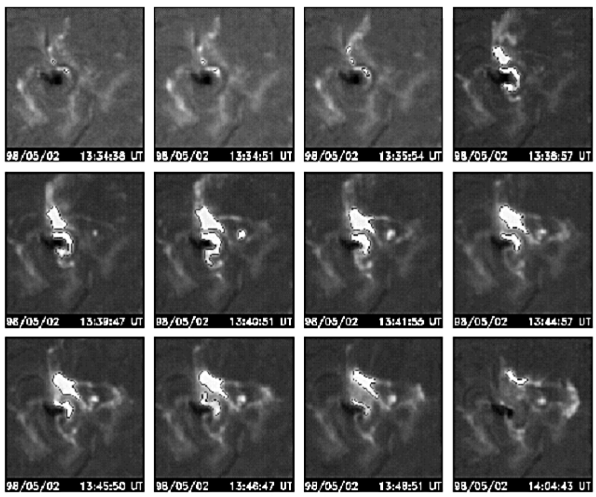

Figure 6. Contour lines of the flare area in the time evolution of a flare observed on 2 May 1998.

6. SOLAR FLARE STATISTICAL ANALYSIS

Including the time span from 1975-2000 a large set of Hα flare events comprising about 75000 single events taken from SGD (Solar Geophysical Data) was analyzed. The results are given in Figure 7, which presents median values of the evolution steps of flare events divided into the importance classes S, 1 and > 1 with a 95% confidence interval. It is clearly revealed that the duration as well as the rise and decay time increase with the importance class. By analyzing these flare parameters additionally as a function of solar activity we obtained also changes during the solar cycle. A significant change of duration and decay time to higher values during solar maximum was calculated whereas the rise times did not show noticeable variations [5].

With a further statistical analysis of the duration of a sample of about 7800 flare events observed in the time span from 1994-1999 (SGD) we optimized the rate of the data acquisition in the frame of Hα flare patrol observations at the Kanzelhöhe Solar Observatory (KSO). For a suitable identification and classification of a flare event the criterion is to cover the flare at least at 3 times during its evolution. Thus the loss of flare events with respect to different time cadences of observation were calculated. We obtained a result of about 0.5% loss for a 1 minute cadence whereas for 2 minutes the ratio of missed data jumped up to about 18%. A cadence of 4 minutes even would only cover less than 50% of Hα flares. As a consequence the data acquisition rate for Hα patrol at the KSO was set to 1 image per minute.

Imp.	Duration	Rise time	Decay time
S	14.0 ± 0.1	3.0 ± 0.1	10.0 ± 0.1
1	28.0 ± 0.5	5.0 ± 0.1	22.0 ± 0.5
>1	57.0 ± 3.2	8.0 ±0.6	45.0 ± 2.9
T	15.0 ± 0.1	3.0 ± 0.1	11.0 ± 0.1

Figure 7. Duration (end-start), rise (max-start) and decay time (end-max) given in minutes. S=Subflares, 1=Importance 1, >1=Importance 2, 3 & 4.

7. THE TRIESTE SOLAR RADIO SYSTEM

The Trieste Solar Radio System is fully integrated in TGSSN and provides both solar radio indexes (Figure 8) and automatic warnings when a radio flare is in progress. Extended operational details are described elsewhere in these proceedings [6].

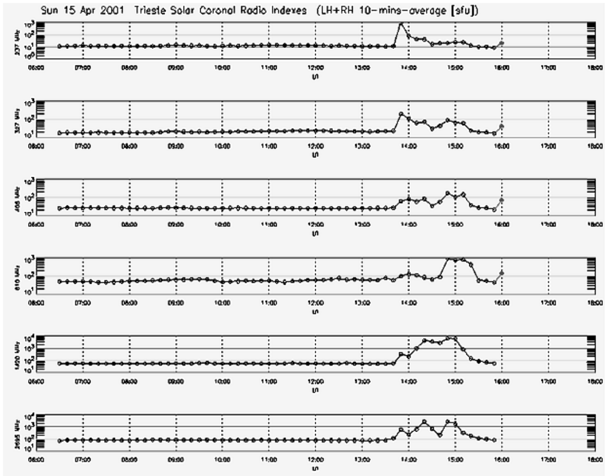

Figure 8. Time evolution of the decimetric to metric (bottom to top) coronal radio indexes on 15 April 2001, which indicate the occurrence of a radio flare.

8. CONCLUSIONS

The Trieste-Graz Solar Surveillance Network is in an advanced phase of development and plays an important role in the detection of solar activity transient phenomena. High time cadence data and indexes are made available in near-real-time on Internet to constitute a tool in SpW nowcasting and forecasting.

ACKNOWLEDGMENTS

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REFERENCES

1. Messerotti M., et al. The Solar Surveillance Program at the Kanzelhöhe Solar Observatory: New Facilities for High Speed Digital Imaging and Dynamic Event Tracking, ESA WPP, 155, 321, 1999.
2. Moretti P.F. et al., Simultaneous Hα and Sodium Observations at the Kanzelhöhe Solar Observatory 2001, ESA SP-477, 2001.
3. Warmuth A. et al., Evolution of two Hα/EIT Moreton Waves, Ap. J. Lett., 560, 105, 2001.
4. Veronig A. et al., Automatic image segmentation and feature detection in solar full-disk images, ESA SP-463, 2000, 455.
5. Temmer M. et al., Statistical analysis of solar Hα flares, Astron. Astrophys., 375, 1049, 2001.
6. Messerotti M. and Zlobec P., The Trieste Solar Radio System as a Near Real-Time Monitor of Coronal Radio Emissions, these proceedings.