SINERGIES

(Sun, INterplanetary, EaRth Ground-based InstrumEntS)

or the potential of the Italian Network for Ground-Based Observations of Sun-Earth Phenomena

Amata E., Candidi M., Centrone M., Consolini G., Contarino L., D e Lauretis M., Diego P., Ermolli I., Francia P., Giorgi F., Lau renza M., Magri M., Marcucci F., Massetti S., Messerotti M., Oliviero M., Penza V., Perna C., Ro mano P., Severino G., Spadaro D., Storini M., Vellante M., Villante U., Zlobec P., Zuccarello F.

IFSI-INAF; INAF-OAC; INAF-OAC; INAF-OAR; CVS@INAF-OAR; INAF-OATs; Dipartimento di Fisica, Università dell'Aquila; Consorzio Area di Astrogeofisica, L'Aquila; Dipartimento di Fisica e Astronomia, Catania.

The Italian Network for Ground-Based Observations of Sun-Earth Phenomena, whose instruments monitor the Sun, the Interplanetary Space, and the Earth's Magnetosphere, has recently started to operate in a coordinated scheme. The effort of integrating all the network 's instruments must be even more pursued and supported in the future, because the joint acquisition and use of data from two or more of the network instruments is not only useful in researches of solar physics, geophysics and Space-Weather, but also represents a *value added* to the individual data .

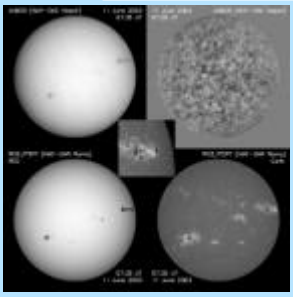
In this poster, we will describe few significant examples of this coordination effort.

1) During the year 2003, several coordinated observational camp aigns were carried out by using simultaneously the VAMOS instrument, located at the INAF-OAC in Naples, and the PSPT telescope, installed at the INAF-OAR in Monteporzio Catone (Rome). These observations were used to study the solar photospheric dynamics by means of the cross spectral analysis between the fluctuations of the 5 observed quantities (4 intensities and one velocity).

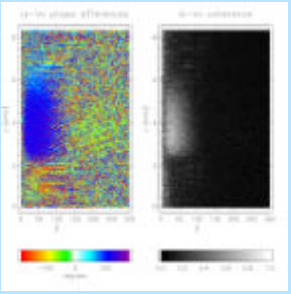
2) Reconstruction of TSI in time, for periods spanning from a so lar rotation up to the whole current solar cycle, using data p roduct of both PSPT and OACt synoptic observing programs.

3) Extreme solar events occurring during the late October – early November 2003 produced coronal mass ejections, flares, solar energetic particles, and interplanetary shocks of strong intensity. Such structures arrived at the Earth's orbit causing huge geomagnetic field disturbances. These events were observed at six network 's nodes, i.e. at INAF-OACt (WL and H images), at INAF-OATS by the Trieste Solar Radio System, through the SEGMA array (geomagnetic field measurements), and by the world-wide network of neutron monitors (including the ones operated in partnership by IFSI/INAF: SVIRCO, LARC; OLC and ESO), by the SuperDARN ionospheric radars and ITACA² twin high-latitude auroral monitors (INAF-IFSI, PNRA).

VAMOS and PSPT Coordinated Campaigns



An example of the VAMOS and PSPT joint observations. Top panels represent intensity and velocity, respectively, obtained by VAMOS in the KI D1 resonance line. Lower panels represent two PSPT intensity images in the red continuum and in the CaII resonance line, respectively. In the center a blow-up of the active region visible at the right limb of the Sun where a flare is developing.

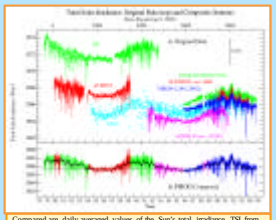


Left panels represent the -ν phase difference and coherence diagrams, respectively, between the intensity fluctuations observed with PSPT and the velocity fluctuations observed with VAMOS. is the spherical harmonics degree and ν is the temporal frequency. The color bar indicates the phase values ranging from -180° to +180°.
The grey bar represent the coherence values ranging from 0 to 1. The reported data refer to a ten hour long series of simultaneous observations. The phase difference values close to 90° on the p-modes, between 2mHz and 6mHz, where coherence is maximum, indicate that oscillations are evanescent in the photosphere and low chromosphere with some non adiabatic behaviour which deserves a more detailed studies.

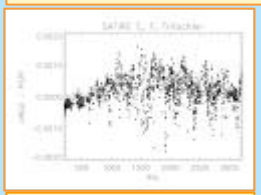
Total and Spectral Irradiance Variability Studies

Regular space-based measurements of solar total and spectral irradiance reveal variations on time scales from minutes to decades. Circumstantial evidence suggests that variations on yet longer time scales, which are of special interest for climate studies, are also possible. About 90% of the measured irradiance variations are reproduced by recent models assuming both evolution of the observed magnetic regions over the solar disk and results of atmospheric models computation.

These approaches have successfully reproduced with high accuracy the total and spectral irradiance measured by VIRGO on SOHO, but has so far been restricted to MDI (Krivova et al. 2003) and PSPT (Ermolli et al. 2004) data, available only since 1996, i.e. for less than a solar cycle.



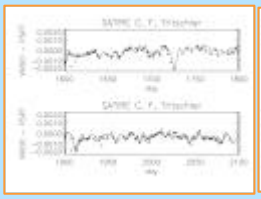
Compared are daily averaged values of the Sun's total irradiance TSI from radiometers on different space platforms since November 1978. The data are plotted as published by the corresponding instrument teams . Note that only the results from the three ACRIMs and VIRGO radiometers have inflight corrections for degradation. Lower Panel: the PMODcomposite TSI as computed by Fröhlich and Lean (2000), available at http://www.pmodwrc.ch.

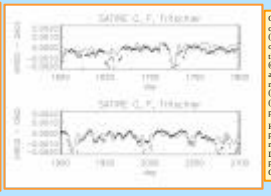


Compared are daily values of the solar total irradiance TSI measured by VIRGO on SOHO from July 1996 to December 2004 (gray) and result of the irradiance modelling based on atmosphere model computations and Rome-PSPT image analysis (black).

To extend the application of these approaches back in time we started to analyze the great amount of information stored in the solar data archives of the Roma and the Catania Observatories.

Existing measurements of magnetic region properties show systematic differences and gaps, but seem not to prevent the compilation of a complete and cross-calibrated time series useful for irradiance studies.





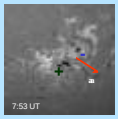
Compared are daily values of the total solar irradiance (Wm⁻²) measured by VIRGO on SOHO (line) and result of the irradiance reconstruction (diamond) based on atmosphere models and measurements of both Rome (PSPT, left) and Catania (OACt, right) synoptic programs.

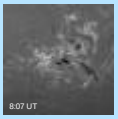
Here the resuls obtained for periods spanning several months, from May to December 2000 (upper panel) and from March to October2001 (lowerpanel).

Study of the X17.2 eruptive flare on 28 October 2003

On 28 October 2003 GOES registered a flare of X17.2 class in the active region 10486, with beginning at 9:51 UT, peak at 11:10 UT and end at 11:24 UT.

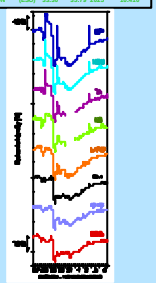
Images acquired at INAF-OACt 90 minutes before the flare showed the eruption of a filament characterized by negative magnetic helicity , as inferred from its reverse S-shape (Rust, 2003) and its chirality (Martin, 2003). Images at 1600 Å and 195 Å acquired by TRACE during the main phase of this eruption, showed a left helical flux rope structure which suggested a kinked configuration of the filament (Chae, 2001).

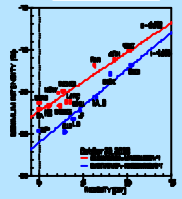




Using MDI/SOHO magnetograms we calculated, over the entire active region from 27 October at 12:00 UT, the photospheric velocity fields by using the local correlation tracking (LCT) method (November and Simon, 1988) and the magnetic helicity transport rate by using the method proposed by Chae (2001). We inferred that the negative magnetic helicity played a key role in the evolution of the filament eruption and of the subsequent flare. The whole active region showed a monotonic negative trend of the accumulation of magnetic helicity (- 3.5 x 10^{40} Mx² in less than 2 hours) and the highest rates of magnetic helicity transport were located in the same areas where the first brightenings of the flare occured.

STATION	ACRON	LAT	LONG	HEIGHT (m)	RIGIDITY (GV)
SOUTH POLE	(SP)	-90.00	0.00	2820	0.05
McMURDO	(McM)	-77.85	166.72	48	0.00
TERRE ADELIE	(TA)	-66.65	140.01	45	0.00
KERGUELEN	(KG)	-49.35	70.25	33	1.14
ROME (SVIRCO)	(RM)	41.86	12.47	0	6.27
LOS CERRILLOS	(OLC)	-32.45	289.46	579	10.14
ALMA ATA B	(AA_B)	43.14	76.60	3300	6.69
CLIMAX	(CLI)	39.37	106.18	3400	3.03
JUNGFRAUJOCH	(JF)	46.55	7.98	3570	3.60
LOMNICKY STIT	(LS)	49.11	20.13	2634	4.00
MEXICO CITY	(MEX)	19.33	260.82	2274	8.53
ATHENS	(ATH)	37.97	23.72	40	8.72
MOSCOW	(MOSC)	55.47	37.32	200	2.46
NEWARK	(NEW)	39.70	284.40	50	2.91
NOVOSIBIRSK	(NOVO)	54.84	83.23	163	2.31
IRKUTSK	(IRKU)	52.10	104.00	453	1.65
MT.HERMON	(ISSO)	33.30	35.79	2025	10.810



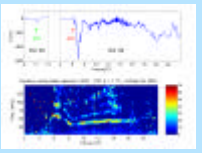


A very intense decimetric radioflare (TENFLARE) was observed by the Trieste Solar Radio System (total peak flux at 2695 MHz: 8,506 sfu (solar flux units) at 11:15 UT) accompanied by a very intense metric radioflare (type IV burst) (total peak flux at 237 MHz: 16,222 sfu at 11:03 UT).

We investigated the period from 27 October 2003 to 4 November 2003 during which a Forbush decrease (FD) and three ground level enhancements (GLEs) occurred, all arising from the active region on the Sun AR0486. Left panel shows the response of five neutron monitors located at different latitudes (Table) in Antarctica and 3 NM in the northern hemisphere: GLEs are identified from the spikes on 28, 29 October and 2 November. The start of the CR decrease phase (FD reaches the minimum intensity of about -24.61 % at McM station) coincides with the shock arrival at the Earth (an SSC is observed in the geomagnetic records).

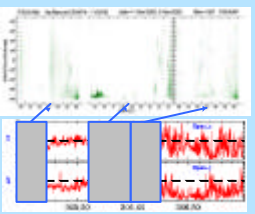
It is known that the sensitivity of CR observatories depends on the rigidity threshold; we analyzed the Forbush decrease (FD) on 29 October 2003 for 18 observatories. A high linear correlation exists between the recorded minimum intensity (percentage of the pre-increase level) and the local rigidity value. In particular, we found two slopes for low (height < 600 m) and high (height > 2000) altitudes (the correlation coefficient being r ~ 0.95 for both correlations).

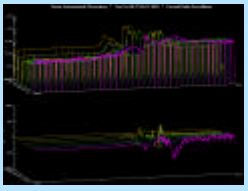
Following the intense solar flare occurring on October 28 at 11:10 UT, a coronal mass ejection leaved the Sun in the Earth's direction. On October 29 a huge geomagnetic storm started on the ground (SSC at 06:10 UT) in response to the solar event. Top figure shows the time behaviour of the north-south component of the geomagnetic field at L'Aquila (the lowest latitude station of SEGMA). Note the clear bay-like signature (SFE) at ~11:00 UT in correspondence to the flare occurrence. The storm onset is characterized by a sharp SSC and a strong field decrease of ~ 600 nT.

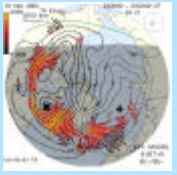


A significant ULF wave activity is also observed during the storm development From the ULF waves recorded at the SEGMA array we have investigated the temporal variation of the local geomagnetic field line resonance (FLR) frequencies during the storm development. This allows to monitor corresponding variations of the field aligned plasma density. The bottom figure shows the time behaviour of the FLR frequencies (bright traces) at L = 1.7 during October 29. Soon after the SSC the FLR frequencies show a significant decrease to unusually low values. This corresponds to an increase of the plasmaspheric density presumably due to heavy ions (O^+) outflowing from the ionosphere.

The upper panel shows the Northern hemisphere SuperDARN Cross Polar Cap Potential on 1st November 2003.
The lower panel shows the SuperDARN convection map for 23:20-23:22 UT (corresponding to the centre of the red bar in the previous figure). Ny-Ålesund (see keogram on the top-left) appears to be close to the centre of the dawn convection cell.







Combined ITACA-NAL keograms (upper panel) showing the high-latitude auroral green emission @ 557.7 nm, during 1-2 November 2003. This was the most active period recorded by ITACA-NAL, between 28 October and 3 November. The IMF B_y and B_z data, recorded by the ACE satellite at L1, is shown in the lower panel. The shaded areas with blue arrows mark the periods that match the observed auroral activity. This activity was produced by a series of poleward expansions of the auroral oval, during intense *geomagnetic substorms* that were triggered by the NOAA 10486 active region, after the flare. The ionospheric currents associated to the substorm activity between 23:20-23:22 is visible in the SuperDARN convection maps.