

Final project report

<i>Project ID</i>	2002/7.05
<i>Title</i>	Cosmic rays in Antarctica
<i>Principal investigator</i>	Marisa STORINI
<i>Institution</i>	CNR/INAF-IFSI
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<i>Duration</i>	2 years
<i>Assigned funding</i>	51.600,00 Euro

Activities and results

The aim of the project was to continue the Chile/Italy collaboration for the detection of the cosmic ray nucleonic component in the austral side of the American Sector (Antarctica: **LARC subproject** and Chile: **OLC subproject**), not covered by other neutron monitors of the world-wide network.

The *Antarctic Laboratory for Cosmic Rays* (**LARC subproject**; location: $\sim 62^{\circ}\text{S} - 58^{\circ}\text{W}$; 40 m a.s.l.) is based on a Chile/Italy collaboration started in November 1993 to run a 6NM-64 detector with Boron counters. The obtained data [(URL: http://www.dfi.uchile.cl/ec_web/htm/datos.htm)] are used to investigate solar extreme events, such as energetic solar particles in the terrestrial environment (the so-called GLE events) and induced effects. Part of the instrumentation operating at LARC (high voltage power supplies, barometers, relative humidity and temperature transducers) was already supplied by Italian counterpart as well as the multichannel analyzer through which the performance of the Boron (BP-28 type) counters have been annually tested during the Antarctic summer campaigns.

The *Los Cerrillos Observatory* (**OLC subproject**; location: $\sim 33^{\circ}\text{S} - 289^{\circ}\text{E}$; 570 m a.s.l.) is the result of a Chile/Italia collaboration via a PNRA/INACH agreement. Instruments sent to Santiago of Chile during the year 2000 allowed the build up of a 6NM-64 at Los Cerrillos "Comuna", located in Santiago of Chile [(URL: http://www.dfi.uchile.cl/ec_web/htm/datossccl.htm)].

The combined data of both observatories allows to check on hourly basis the incoming cosmic radiation in the energy range of 3-10 GeV. Moreover, the identification of Ground Level Enhancements (generally detected on 5-min basis) permits to estimate the ionization produced by the associated solar protons, particularly in polar areas where the variability of several minor atmospheric components is closely related. Special attention was paid on the preparation of the RA.C.-ANT database, made up by solar-terrestrial parameters useful to investigate several relevant open questions (see, for results, references reported in the next sections).

Finally, the design of a new standard detector based on helium counters (LND 25373 type) was completed; it was built up and tested in Rome. During the Antarctic Campaign of 2006–2007 the new Italian 3NM-64 with helium counters was added inside LARC building to increase the recorded counting rate of more than 50%.

Products

A – papers in scientific magazines

1. Laurenza M., Storini M., Moreno G., Fujii Z., Reliability of the interplanetary magnetic field polarities inferred from north-south cosmic ray anisotropy and geomagnetic data, *J. of Geophys. Res.*, Vol.109, 1-12, A06103, doi: 10.1029/2003JA010323, 2004.
2. Storini M., Kudela K., Cordaro E.G. and S.Masseti, *Ground-level enhancements during solar cycle 23: results from SVIRCO, LOMNICKY STIT and LARC neutron monitors*, *Adv. Space Research*, 35, pp.416-420, 2005.

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3. Kudela K., and Storini M., *Cosmic ray variability and geomagnetic activity: A statistical study*, Journal of Atmospheric and Solar-Terrestrial Physics, 67, pp.907-912, 2005.
4. Diego P., Storini M., Parisi M., and Cordaro E.G., *AE variability during corotating fast solar-wind streams*, Journal of Geophysical Research, Vol.110, A06105, doi: 10.1029/2004JA010715, 2005.
5. Laurenza M., Storini M. and Moreno G., *Use of the cosmic ray measurements to identify the sector polarities of the interplanetary magnetic field*, International Journal of Modern Physics A, Vol.20, No.29, 6708-6710, November 2005.
6. Kudela K., Storini M. Possible tools for space weather issues from cosmic ray continuous records, Advances in Space Research 37, 1443-1449, 2006.
7. Berti R., Laurenza M., Moreno G. and Storini M., Interplanetary magnetic field polarities derived from measurements of the northern and southern polar geomagnetic field, J. of Geophysical Research 111, A06109, doi:10.1029/2005JA011325, 2006.
8. Berti R., Laurenza M., Moreno G. and Storini M., Correction to "Interplanetary magnetic field polarities derived from measurements of the northern and southern polar geomagnetic field", J. of Geophysical Research 111, A10110, doi:10.1029/2006JA012073, 2006.
9. Storini M., Hofer M.Y., and Šýkora J., Towards the understanding of coronal hole occurrence during the Schwabe Cycle, Advances in Space Research 38, 912-920, 2006.
10. Damiani A., Storini M., Laurenza M., Rafanelli C., Piervitali E. and Cordaro E.G., Southern ozone variations induced by solar particles events during 15 January-5 February 2005, J. of Atmospheric and Solar-Terrestrial Physics 68, 2042-2052, 2006.
11. Amata E., Berrilli F. Candidi M., Centrone M., Cantarano S., Consolini G., Contarino L., Criscuoli S., De Lauretis M., Del Moro D., Egidi A., Ermolli I., Francia P., Giordano S., Giorni F., Oliviero M., Magrí M., Marcucci F., Massetti, Messerotti M., Parisi M., Perna C., Pietropaolo E., Romano P., Severino G., Spadaro D., Storini M., Vellante M., Villante U., Zlobec P. and Zuccarello F., *SINERGIES, the Italian Network for Ground-Based Observations of Sun-Earth Phenomena*, Mem.S.A.It. Suppl., Vol.9, 79-81, 2006.
12. Amata E, Candidi M, Centrone M., Consolini G., Contarino L., Criscuoli S., De Laurentis M., Diego P., Ermolli I., Francia P., Giorgi F., Laurenza M., Magrí M., Marcucci F., Massetti S., Messerotti M., Oliviero M., Penza V., Perna C., Pietropaolo E., Romano P., Severino G., Spadaro D., Storini M., Vellante M., Villante U., Zlobec P. and Zuccarello F., *SINERGIES (Sun, INterplanetary, EaRth Ground-based InstrumEntS) or the potential of the Italian Network for Ground-Based Observations of Sun-Earth Phenomena*, Mem.S.A.It. Suppl., Vol.9, 82-84, 2006.
13. Messerotti M., Candidi M., Storini M. and Zuccarello F., *COST Action 724: The Italian Contribution*, Mem.S.A.It. Suppl., Vol.9, 117-119, 2006.
14. Damiani, A., Storini, M., Laurenza, M., Rafanelli, C., Piervitali, E., Cordaro, E.G., *Erratum to "Southern ozone variations induced by solar particle events during 15 January – 5 February 2005"*, J. Atmosph. Solar-Terrestrial Phys. 69, 628-630, 2007.
15. Damiani, A., Benedetti, E., Storini, M., Rafanelli C., *Italian polar data center for capacity building associated with the IHY*, J. Adv. Space Res. (ScienceDirect online: 31 January 2007), doi:10.1016/j.asr.2007.01.046.

B – book chapters

1. Piervitali E., Damiani A., Benedetti E., Castorina M., Di Bono M.G., Martinelli M., Ravanelli C., Salvetti O., Storini M., Testa L., and Vitale V. The Italian research in Antarctica information system project, In Conference Proceedings – 10th Workshop Italian research on Antarctic Atmosphere and SCAR Workshop on Oceanography, edited by M. Colacino, Roma 22-24-October 2003, SIF, Vol.89, pp.3-11, Bologna, 2004.
2. Moro F., Storini M., Signoretti F., and Parisi M., ³He-Counter tests for A ³He-Neutron monitor section: results from a preliminary evaluation, In Conference Proceedings – 10th Workshop Italian research on Antarctic Atmosphere and SCAR Workshop on Oceanography, edited by M. Colacino, Roma 22-24-October 2003, SIF, Vol.89, pp.13-20, Bologna, 2004.
3. Diego P., and Storini M., Interplanetary induced effects: a case study for April 2003, In Conference Proceedings – 10th Workshop Italian research on Antarctic Atmosphere and SCAR Workshop on Oceanography, edited by M. Colacino, Roma 22-24-October 2003, SIF, Vol.89, pp.21-29, Bologna, 2004.
4. Laurenza M., Moreno G., and Storini M., Geomagnetic activity and IMF polarities inferred from Vostok observations, In Conference Proceedings – 10th Workshop Italian research on Antarctic Atmosphere and SCAR Workshop on Oceanography, edited by M. Colacino, Roma 22-24-October 2003, SIF, Vol.89, pp.241-249, Bologna, 2004.

C - proceedings of international conferences

1. Storini M., Laurenza M., Cliver E.W., *Comparing the 11-yr and 22-yr cycles in cosmic ray modulation*, ICRC 2005, 29th Int. Cosmic Ray Conf.: <http://icrc2005.tifr.res.in/>, folder: Submitted Papers (also on CD).
2. Storini M., Kudela K., Diego P., *Testing cosmic ray continuous records for Space Weather*, ICRC 2005, 29th Int. Cosmic Ray Conf.: <http://icrc2005.tifr.res.in/>, folder: Submitted Papers (also on CD).
3. Kudela K., and Storini M., Can we use cosmic ray continuous records to forecast enhanced geomagnetic activity levels?, Geophysical Research Abstracts, Vol.6, 07269,2004, SRef-ID: 1607-7962/gra/EGU04-A-07269 – European Geosciences Union, Nizza, 2004

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4. Kudela K. and Storini M., Useful tools for space weather issues from cosmic ray continuous records, 35th COSPAR Scientific Assembly, Paris, France, 18-25 July, 2004, Abstract number: COSPAR 04-A-00378 – paper number: D1.3/E2.4-0054-04
5. Diego P., Storini M., Parisi M., Relationship between the midnight equatorward auroral oval boundary and the geomagnetic activity level for different solar wind regimes, Geophysical Research Abstracts, Vol. 6, 04207, 2004, SRef-ID: 1607-7962/gra/EGU04-A-04207 – European Geosciences Union, Nizza, 2004.
6. Storini M., Laurenza M., Moreno G., Daily interplanetary magnetic field polarities near the Earth, Eos Trans. AGU, 85(17), Jt. Assem. Suppl., Abstract SH21A-07, 2004 Joint Assembly, Montreal, Canada, 17-21 May, 2004.
7. Kudela K. and Storini M., Useful tools for space weather issues from cosmic ray continuous records, 35th COSPAR Scientific Assembly, Paris, France, 18-25 July, 2004, Abstract number: COSPAR 04-A-00378 – paper number: D1.3/E2.4-0054-04.
8. Storini M., Hofer M.Y., and Sykora J., Towards the understanding of coronal hole occurrence during the Schwabe cycle, 35th COSPAR Scientific Assembly, Paris, France, 18-25 July, 2004, Abstract number: COSPAR 04-A-00741 – Paper number: E2.2-0047-04.
9. Storini M., Kudela K., and Cordaro E.G., Ground-level enhancements during solar cycle 23: results from SVIRCO, LOMNICKY STIT and LARC neutron monitors, 35th COSPAR Scientific Assembly, Paris, France, 18-25 July, 2004, Abstract number: COSPAR 04-A-00740 – Paper number: D2.1/C2/E3.1-0067-04.
10. Storini M., Anav A., Damiani A., Piervitali E., Rafanelli C., Search of solar induced effects in Antarctica General Belgrano base on total ozono data: 1995-2003, 28th SCAR Open Science Conference, Bremen, Germany, 25-31 July, 2004- Abstract: S16/O04.
11. Storini M., Laurenza M., Diego P., The October-November 2003 solar-terrestrial relation as a case study for space weather and climate, 28th SCAR Open Science Conference, Bremen, Germany, 25-31 July, 2004- Abstract: S18/P.
12. Laurenza M., Storini M., Moreno G., Use of cosmic ray measurements to identify the sector polarities of the interplanetary magnetic field, 19th European Cosmic Ray Symposium, Florence, Italy, 30 August-3 September, 2004.
13. Storini M., Solar Particle Emission inside WG1-CA 724, in COST Action 724 - 3rd Management Committee Meeting & 1st Meeting on Advance in Space Weather Research: The Earth Radiation Environment, Trieste, Italy, 10-13 October 2004.
14. Storini M., *Cosmic rays inside the heliosphere: Research topics for the century*, IV Convegno della Ricerca Italiana in Fisica Solare e Relazioni Sole-Terra, Trieste, 18-20 Ottobre 2005.
15. Damiani A., Storini M., Laurenza M., Rafanelli C., Piervitali E., *Evaluation of TOC variability during January 15-February 5, 2005*, Contribution: IAGA2005-A-00832, Session JSMA03, Toulouse - July 18-29, 2005.
16. Piervitali E., Benedetti E., Damiani A., Storini M., and Rafanelli C., *The Information System for documenting data and disseminating information of Italian research in Antarctica*, Contribution: IAGA2005-A-00676, Session GAIV05, Toulouse - July 18-29, 2005.
17. Storini M., Damiani A., Rafanelli C., *Search of solar induced effects on the ozone layer: 1996-2004*, Contribution: IAGA2005-A-00833, Session JSMA0306, Toulouse - July 18-29, 2005.
18. Storini M., Cliver E.W., and Svalgaard L., *Connecting solar activity with the long-term geomagnetic activity trend*, Contribution: IAGA2005-A-00676, Session IDV01, Toulouse - July 18-29, 2005.
19. Damasso M., Galliani M., Parisi M., Storini M., *More on solar energetic particle events*, IV Convegno della Ricerca Italiana in Fisica Solare e Relazioni Sole-Terra, Trieste, 18-20 Ottobre 2005.
20. Diego P., Storini M., *On the solar wind-auroral electrojet variation during recurrent high-speed streams*, IV Convegno della Ricerca Italiana in Fisica Solare e Relazioni Sole-Terra, Trieste, 18-20 Ottobre 2005.
21. Storini M., Kudela K., Diego P., and Bucik R., *Continuous cosmic ray records for space weather studies*, EGU – Vienna, 2-7 April 2006, Session ST5.6, ABSTRACT EGU06-A-05876, 2006.
22. Laurenza M. et al., *Solar energetic proton events and soft x-ray flares*, Space Weather Week, Boulder, 25-28 April 2006.
23. Benedetti E., Damiani A., Rafanelli C., Castorina M., Salvetti O., M. Storini, Testa L., Vitale V., Martinelli M., *Information System for the Italian Polar Research*, Atti del "21st Polar Libraries Colloquy". Roma, 8-12 May 2006.
24. Damiani A., Diego P., Storini M., and Rafanelli C., *Search for the Ozone Variability related to SEP events during the current solar cycle*, 36th COSPAR Scientific Assembly, Beijing, 16–23 July 2006, Poster TC-0011 COSPAR2006-A-02800, C2.1-0038-06.
25. Damiani A., Benedetti E., Storini M., and Rafanelli C., *Italian Polar Data Center for capacity building associated with the IHY*, 36th COSPAR Scientific Assembly, Beijing, 16–23 July 2006, Poster TC3-0272 COSPAR2006-A-02812 PCB1-0016-06.
26. Damiani A., Storini M., and Rafanelli C., *Polar ozone variability during January 2005*, SCAR XXIX/COMNAP XVIII, Hobart, 9-19 July 2006.
27. Rafanelli C. et al., *Italian Polar Data Center*, SCAR XXIX/COMNAP XVIII, Hobart, 9-19 July 2006.
28. Storini M., *Neutron Monitor Network*, IVOSEC Meeting, Roma, 22 June 2006.
29. Storini M., Damiani A., *Effects of the January 2005 GLE/SEP Events on minor atmospheric components*, 30th Int. Cosmic ray Conf., Abstract ID: 1009, Mérida (Yucatán), 3-11 July, 2007.
30. Diego P., Storini M., *Medium and long-term periodicities in geomagnetic parameters*, IUGG XXIV General Assembly, ASV039/PN 69, Perugia, 2-13 July, 2007.

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31. Diego, P., Storini, M., *Comparing Sargent III and Levitin et al. methods to identify time intervals characterized by recurrent solar wind structures*, IUGG XXIV General Assembly, ASV039/PN 70, Perugia, 2-13 July, 2007.
32. Damiani, A., Storini, M., Rafanelli, C., Laurenza, M., *Atmospheric chemical changes in polar caps during December 2006*, IUGG XXIV General Assembly, JMS021, Perugia, 2-13 July, 2007.
33. Storini, M., Diego, P., Laurenza, M., *Prehistory and history of the December 2006 GLE*, SEE 2007 Symposium: Fundamental Science and Applied Aspects, COSPAR Colloquium, Abstract booklet p. 28, Athens, 24-27 September, 2007.
34. Storini, M., Signoretti, F., Diego, P., Laurenza, M., Cordaro, E.G., Olivares, E.F., *A new detector added to the Antarctic Laboratory for Cosmic Rays*, SEE 2007 Symposium: Fundamental Science and Applied Aspects, COSPAR Colloquium, Abstract booklet p. 81, Athens, 24-27 September, 2007.
35. Diego, P., *Space Climate inferred from ground-based data*, Fourth European Space Weather Week, Brussels, November 5-9, 2007.

D – proceedings of national meetings and conferences

1. Storini, M., Signoretti, F., Diego, P., Laurenza, M., *LARC-upgrade for solar activity cycle n. 24*, XI Workshop – Fisica e Chimica dell'Atmosfera Antartica, CNR, Roma, 10-12 Aprile 2007.

E – thematic maps

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F – patents, prototypes and data bases

1. F1 - prototype: 1 helium detector (3NM-64_³He)
2. F2 - database: **3** (LARC_6NM-64_¹⁰BF₃ ; LARC_3NM-64_³He ; OLC_6NM-64_¹⁰BF₃) + **2** (LARC_GLEs ; OLC_GLEs)

G – exhibits, organization of conferences, editing and similar

1. Storini, M. Raggi Cosmici in Antartide: Report di una campagna IFSI, Newsletter Interna IASF-IFSI, Issue 4, pubblicato on line: 31/03/2004.
2. Laurenza M., *Protoni solari relativistici rivelati da SVIRCO e LARC - ancora protoni relativistici dal Sole*, Newsletter interna IASF-IFSI, Issue 16, pubblicato on line: 01/02/2005.
3. Diego P., Rapporto della Campagna Antartica IFSI 2005, Newsletter interna IASF-IFSI, Issue 17, pubblicato on line: 20/04/2005.
4. **ICRC'07 Workshop** on *Fifty Years of Continuous records by the world-wide network of cosmic ray detectors*, Merida (Yucatan, Mexico), 4-5 July 2007. **Convener**: M. Storini (IFSI-Roma/INAF), Co-Conveners: K. Kudela (IEP/SAV-Kosice), R. Pyle (Delaware University/Bartol Res. Inst., Newark), **Scientific Secretariat**: S. Zampieri (INAF/IFSI-Roma).
5. **IHY/CIP 57** – Solar Minimum Watching with Italian SINERGIES and More by M. Storini (invited), Bad Honnef, 18-19 May 2007.
6. Storini, M., Raggi cosmici nelle zone polari (Legami con le misure in alta quota), Festival della Scienza, Genova, 26 Ottobre, 2007.
7. Diego, P., in *Rapporto sulla Campagna Antartica Estate Australe 2006-2007 Ventiduesima Spedizione*, a c. di M. Chiara Ramorino, MZS: Settore di Ricerca 7: Relazioni Sole-Terra ed Astrofisica, ISSN 1723-7084, pp. 35-36, 2007.

H - formation (PhD thesis, research fellowships, etc.)

1. *UNISiena, Scuola di Dottorato di Ricerca in Scienze Polari* – Piero Diego, Ricorsività nel mezzo interplanetario e climatologia dedotta da misure terrestri, XIX Ciclo, IFSI-Roma/INAF: M. Storini (tutor).
2. Assegno di ricerca - Dr. Piero Diego: *Studio della Fisica delle aree polari e subpolari mediante l'uso congiunto di dati di radiazione cosmica e parametri del sistema Sole-Terra*.

Research units

PEA2002: CAN-STO

(Head: Marisa STORINI)

Marisa STORINI	Coordinator/Senior Scientist	IFSI-INAF
Fabrizio SIGNORETTI	CTER	IFSI-INAF
M.P. ALLEMANDI	CTER	IFSI-INAF

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Francesco RE	Technician	IFSI-INAF
Monica LAURENZA	Post-Doctor.	IFSI-INAF
Piero DIEGO	Research contract/PNRA	IFSI-INAF
Giovanni MORENO	Associated Professor.	UNIRoma1
Karel KUDELA	Associated Professor.	SAV
Julius SYKORA	Senior Researcher	SAV
Mario PARISI	Associated Professor	UNIRoma3

PEA2003

CAN-STO.1: *Head:* Marisa STORINI (check of the experimental work and obtained data from neutron monitors; research for Solar-Terrestrial Relations/Space Weather)

Marisa STORINI	<i>Coordinator/Senior Scientist</i>	IFSI_INAF
Piero DIEGO	Research contract/PNRA	IFSI_INAF
Francesco RE	Technician	IFSI_INAF
Fabrizio SIGNORETTI	CTER	IFSI_INAF
Mario PARISI	Associated Professor	UNIRoma3

CAN-STO.2: *Head:* Fabrizio SIGNORETTI (design and experimental tests for an helium standard detector: $3\text{NM-64-}^3\text{He}$)

Fabrizio SIGNORETTI	<i>Head/CTER</i>	IFSI_INAF
Piero DIEGO	PhD student/Research contract	IFSI_INAF
Francesco RE	Technician	IFSI_INAF
Marisa STORINI	Senior Scientist	IFSI_INAF

CAN-STO.3: *Head:* Monica LAURENZA (database for Sun-Earth-Heliosphere System: RA.C.-ANT database)

Monica LAURENZA	<i>Head/PhD student</i>	IFSI_INAF
Marisa STORINI	Senior Scientist	IFSI_INAF
Alessandro DAMIANI	Research Contract	CNR_IDAC
Giovanni MORENO	Associated Professor	UNIRoma1
Karel KUDELA	Associated Professor	SAV-Kosice
Julius SYKORA	Senior Scientist	SAV-T.Lomnica

Date: 22 October 2008

Notes