Programma Nazionale di Ricerche in Antartide (PNRA)

Final project report

Project ID	2002/3.02
Title	Antarctic Reference Model -2
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Duration	2 years
Assigned funding	30 987.41 €

Activities and results

After the first phase of the project Antarctic Reference Model (ARM) covering the years 1999-2001, the satellite missions CHAMP and Ørsted, launched in 1999 and 2000, respectively, have opened new perspectives to the ARM model, thanks to the uniform distribution of data and complete coverage of the continent. The validation and the use of these data was the main point of the next phase of the project (the so-called ARM2; 2002-2003), contributing to define the best reference model for Antarctica. The research was therefore carried out in three phases: collection and validation of all new data, with particular attention to the recent satellite data, development of the new updated version of ARM, and its comparison with global models. Despite of the greater accuracy of the model ARM compared with the IGRF, the use of observatory data only was insufficient, because of their lack of regional coverage. The data from the Boomerang mission (measurements collected by a sensor installed on a stratospheric balloon that flew over Antarctica during December 1998-January 1999) have helped to avoid such inconvenience. The different types of data were compared each other and with the older version of ARM and some statistical tests permitted to us to reject the observations that deviated too much from the average behaviour. The external magnetic contamination possibly present in the satellite data has been strongly reduced taking into account only magnetically quiet days and specific threshold values for the magnetic activity indices Kp, Dst and AE, and also looking for the lowest value for the By component of the interplanetary magnetic field. Another step has only considered the inclusion of measures taken during the austral winter for the minor contribution of magnetosphere currents.
All the data in the form of X, Y, Z components and total intensity F, were analyzed and modelled according to the observation point (geographic coordinates, height, epoch) with Spherical Cap Harmonic Analysis (SCHA). This technique is based on the expansion of the geomagnetic potential in spherical cap harmonics with integer order but usually non integer degree. The SCHA appears to provide the best results when the geomagnetic field is mapped on a limited area of the Earth's surface and had already been applied to generate the preliminary versions of the ARM model. The regional model, synthesized on a regular grid in the Antarctic area in different epochs, was compared with the IGRF model, improving the performance with respect to the main field and to the secular variation. The complete definition of ARM will be particularly useful for improving the next generations of global models over Antarctica, and for the process of compiling a new version of the map of magnetic anomalies for Antarctica in the framework of the Antarctic Digital Magnetic Anomaly Project (ADMAP). A web page was built during the first ARM and continuosly updated shows details and progresses of the project.

Products

A – papers in scientific magazines

1. Torta, J.M., Gaya-Piqué, L.R., Riddick, J.C., Turbitt, C.W., A Partly Manned Geomagnetic Observatory In Antarctica Provides A Reliable Data Set, *Contributions to Geophysics and Geodesy,* 31, 225-230, 2001.
2. Calcara M., Beranzoli L., Braun T., Calore D., De Santis A., Etiope G., Favali P., Frugoni F., Gasparoni F.,

Montuori C., Smriglio G. - MABEL: a multidisciplinary benthic laboratory for deep sea long-term monitoring in Antarctic environment, *Terra Antarctica*, 8 (2), 115-118, 2001.

3. De Santis A., Torta J.M., Gaya-Piqué L.R., The first Antarctic geomagnetic Reference model (ARM), *Geophysical Research Letters*, 29, Art. No. 1192, 2002.
4. Gaya-Piqué L.R., De Santis A., Torta J.M., The first geomagnetic main field and secular variation model for Antarctica, Proceedings *3ª Asemblea Hispano-Portuguesa de Geodesia y Geofísica*, vol. I (S08), pp. 652-656. Valencia, Spain, 2002.
5. Gaya-Piqué L.R., Torta J.M., Curto J.J., Analysis of magnetic variations from external sources measured at Livingston Island Observatory (Antarctica), *Proceedings della III Asemblea Hispano-Portuguesa de Geodesia y Geofisica*, vol. I (S08), pp. 666-670. Valencia, Spain, 2002.
6. Gaya-Piqué L.R., Torta J.M., Curto J.J., Sanclement E., Marsal S., Solé J.G., Altadill D., Ugalde A., De Santis A., Apostolov E.M., Alberca L.F., García A., Livingston Island Geomagnetic Observations, Antarctica. 2000, 2001 and 2001-2002 Survey, *Boletín del Observatori de l'Ebre*. Roquetes, Spain, 2002.
7. Torta J. M., A. De Santis, M. Chiappini, R.R.B. von Frese, A model of the secular change of the geomagnetic field for Antarctica, *Tectonophysics*, 347, 179-187, 2002.
8. De Santis, A., Gaya-Piqué, L.R., Dominici, G., Meloni, A., Torta, J.M., Tozzi, R., 2003. ITalian Geomagnetic Reference Field ITGRF: update for 2000 and secular variation model up to 2005 by autoregressive forecasting. *Annals of Geophysics*, vol. 46, 3, 491-500, 2003.
9. Marsal S., Torta J.M., Gaya-Piqué L.R., Curto J.J., Sanclement E., Solé J.G., Altadill D., Ugalde A., De Santis A., Apostolov E.M., Alberca L.F., García A., Livingston Island Geomagnetic Observations, Antarctica. 2002 and 2002-2003 Survey. *Ebre Observatory Bulletin*. ISSN 1579-8313. Roquetes, Spain, 2003.
10. Gaya-Piqué L.R., Analysis of the Geomagnetic field in Antarctica from near-surface and satellite data. *PhD Thesis. Observatori de l'Ebre*, Spain, 2004.
11. Kim H.R., von Frese R.R.B., Taylor P.T. , Gaya-Piqué L.R., Golynsky A.V., and Kim J.W., Champ, Ørsted and Magsat anomalies of the Antarctic Crust, *Geophysical Research Abstracts* 6, 04382. European Geosciences Union, 2004.
12. Duka B., Gaya-Piqué L.R., De Santis A., Bushati S., Chiappini M., Dominici G., A geomagnetic Reference Model for Albania, Southern Italy and Ionian Sea from 1990 to 2005, *Annals of Geophysics*, 47, 5, 1609-1615, 2005.
13. Kim H.R., Gaya-Piqué L.R., von Frese R.R.B., Taylor P.T., Kim J.W., CHAMP magnetic anomalies of the Antarctic crust, *II Champ Mission Results for Gravity, Magnetic and Atmospheric Studies*. Potsdam, Germany, 2005.
14. Meloni A., Gaya-Piqué L.R., De Michelis P., and De Santis A., Some recent characteristics of geomagnetic secular variation in Antarctica, in *Antarctica: Contributions to global earth sciences,* Futterer DK et al. (Eds), 377-382, Springer-Verlag, Berlin, 2006.
15. Gaya-Piqué L.R., Ravat D., De Santis A., Torta J.M., New model alternatives for improving the representation of the core magnetic field of Antarctica*, Antarctic Science*, 18(1), 101-109, 2006.

B – book chapters

1. Gaya-Piqué L.R., De Santis A., Torta J.M., Use of Champ magnetic data to improve the Antarctic Geomagnetic Reference Model, *Earth Observation with CHAMP*, (eds) Reigber C. Et al., Springer Berlin Germany, pp. 317-322, 2005.
2. Torta, J.M., L.R. Gaya-Piqué, A. De Santis, Spherical Cap Harmonic Analysis of the Geomagnetic Field with Application for Aeronautical Mapping, (eds.)Rasson, J.L. and Delipetrov, T., *Geomagnetics for aeronautical safety: a case study in and around the Balkans.* NATO security through Science series - C, 291-307 Springer, Netherlands (2006)

C - proceedings of international conferences

1. De Santis A., Torta J.M., Gaya-Piqué L., Chiappini M., Von Frese R.R.B., Progress On The Geomagnetic Reference Field Model For Antarctica, *Spring Meeting Program of the American Geophysical Union,* Boston (USA), 29 May-2 June 2001.
2. De Santis A., Chiappini M. , Torta J.M., Gaya-Piqué L., Von Frese R.R.B., An Improved Geomagnetic Secular Change Model For Antarctica To Facilitate Merging Different Magnetic Data Sets, *IAGA IASPEI VIII General Assembly,* Hanoi (Vietnam), 18-30 August 2001.
3. De Santis A., Chiappini M., Gaya-Piqué L.R., Torta J.M., von Frese R. R. B., A model of the geomagnetic field over Antarctica, *IAGA IASPEI VIII General Assembly,* Hanoi (Vietnam), 18-30 August 2001.
4. De Santis A., Gaya-Piqué L., Dominici G., Meloni A., Torta J.M., Tozzi R., ITalian Geomagnetic Reference Field ITGRF: update for 2000 and secular variation model up to 2005, *II International Workshop on Geo-Electro-Magnetism*, LERICI (La Spezia) 26-28 September, 2001.
5. De Santis A., Tozzi R., D.R. Barraclough. Space time interconnection of the geomagnetic field. *II International Workshop on Geo-Electro-Magnetism,* LERICI (La Spezia) 26-28 September, 2001.
6. Gaya-Piqué, L.R., Torta, J.M., De Santis A., El primer modelo Magnético de Campo Principal y Variación Secular para la Antártida. *3rd Spanish- Portuguese Assembly of Geodesy and Geophysics,* Valencia 4 - 8 February 2002.
7. De Santis A., Torta JM., Gaya-Piqué L.R., A three-dimensional Antarctic Reference Model (ARM) of the geomagnetic field and its secular variation developed by means of SCHA for 1960-2005, *EGS XXVII General*

Assembly Nizza (France) 21-26 April 2002.

8. De Santis A., Gaya-Piqué, L.R., Torta, J.M., Caprara F., De Santis A., An online observatory and satellite-based model for the Geomagnetic Field in Antarctica and its secular variation. *American Geophysical Union Spring Meeting*, Washington DC 28 - 31 May 2002.
9. De Santis A., Gaya-Piqué L.R., Torta JM., Spherical cap harmonic model for the geomagnetic field and secular variation over Italy improved by the use of Oersted and Magsat satellite data, *4th Oersted International Science Team Conference,* Copenhagen (Denmark), 23-27 September 2002.
10. Gaya-Piqué L.R., De Santis A., and Torta J.M., Improvement of the Antarctic Geomagnetic Reference Model by using new sets of data, *IUGG 2003,* Sapporo (Japan), July 2003.
11. Gaya-Piqué L.R., De Santis A., Torta J.M., Use of Champ Magnetic Data to Improve the Antarctic Geomagnetic Reference Model *2nd Champ Scientific Meeting,* Potsdam (Germany), September 2003.
12. Kim H.R., Gaya-Piqué L.R., von Frese R.R.B., Taylor P.T., Kim J.W., CHAMP magnetic anomalies of the Antarctic crust, *2nd Champ Scientific Meeting,* Potsdam (Germany), September 2003.
13. Meloni A., L.R. Gaya-Piqué, P. De Michelis, De Santis A., Some recent characteristics of geomagnetic secular variation in Antarctica, *IX Meeting ISAES,* Potsdam (Germany), September 2003.

D – proceedings of national meetings and conferences

1. Gaya-Piqué L.R., De Santis A., Torta J.M, ARM: a geomagnetic model for Antarctica, *FIST Geoitalia IV Forum di Scienze della Terra*, Bellaria, 16 September 2003.
2. Meloni A., Gaya-Piqué L.R., De Michelis P., De Santis A., Some characteristics of the present geomagnetic secular variation in Antarctica, *FIST Geoitalia IV Forum di Scienze della Terra*, Bellaria, 16 September 2003.

E – thematic maps

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F – patents, prototypes and data bases

1. Official Website for ARM Project.
2. Software on the ARM website for automatic interrogation and providing magnetic components in Antarctica, period 1960-2005.

G – exhibits, organization of conferences, editing and similar

1. De Santis, Invited Chairman in the Workshop: Challenges for Geomagnetism and Seismology for the XXI century, Tortosa - Ebro, Spain, 28/9-1/10/2004, for the celebration of the centenary of the activities of the Geophysical and Astronomical Observatory of Ebro (Spain).

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

1. R. Tozzi, Variabilità del campo geomagnetico e dinamica non lineare del nucleo, Univ. di Bologna, PhD Thesis, (2002) - Tutor A. De Santis.
2. L.R. Gaya-Piqué, Analysis of the geomagnetic field in Antarctica from near-surface and satellite data, Universitat Ramon Llull, Barcellona, Spain, PhD Thesis, (2004) - Tutor A. De Santis.

Research units

Research Unit 1: Responsible, A.De Santis,other components: M. Chiappini, G. Dominici, R. Tozzi
Research Unit 2: Responsible J.M. Torta, other component: L.R. Gaya Piqué

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Notes