



HAL
open science

First demonstration of transcontinental SQUID magnetometry

C. Fourie, P. Febvre, Elisabeth Pozzo-Di-Borgo, G. Waysand, D. Gouws, E. Saunderson, S Henry, Stéphane Gaffet, Lucas J. Janse van Vuuren, E. Lochner, et al.

► **To cite this version:**

C. Fourie, P. Febvre, Elisabeth Pozzo-Di-Borgo, G. Waysand, D. Gouws, et al.. First demonstration of transcontinental SQUID magnetometry. AGU Fall Meeting, Dec 2013, San Francisco, United States. . <hal-01336461>

HAL Id: hal-01336461

<https://hal.science/hal-01336461v1>

Submitted on 30 Jan 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

First demonstration of transcontinental SQUID magnetometry

C. J. Fourie¹, P. Febvre², E. Pozzo di Borgo³, G. Waysand⁴, D. Gouws⁵, E. Saunderson⁵, S. Henry⁶,
S. Gaffet⁴, L. J. Janse van Vuuren¹, E. Lochner¹, T. Matladi^{1,5}, C. Kwisanga¹, W. Agenbag¹

1) Department of Electrical and Electronic Engineering, Stellenbosch University, South Africa

4) Laboratoire Souterrain à Bas Bruit, LSBB, UMS CNRS 3538 UNS/UAPV/AMU/OCA, La Grande Combe, 84400 Rustrel, France

2) Laboratoire Hyperfréquences et Caractérisation – UMR 5130 CNRS, University of Savoie, France

5) South African National Space Agency: Directorate Space Science, Hermanus, South Africa

3) Université d'Avignon et des Pays de Vaucluse, INRA, EMMAH UMR1114, F-84914 Avignon, France

6) University of Oxford, Department of Physics, Oxford OX1 3RH, United Kingdom

Overview

We present the first simultaneous measurements from an ultra-sensitive dual-node transcontinental SQUID magnetometer network, available in real time on the internet.

A three-axis low temperature SQUID sensor at LSBB Underground Research Laboratory, Rustrel, France (43.841 N, 5.484 E) and a two-axis high temperature SQUID sensor at SANSA Space Science in Hermanus, South Africa (34.424 S, 19.223 E), form the sensitive nodes of the network.

Data are measured and GPS time stamped continuously at 125 Hz and 500 Hz (LSBB). The low-T_c SQUID at LSBB URL (known as a [SQUID]² system) is inside a shielded steel capsule underneath 500 meters of karstic rock, which allows a low magnetic noise floor. The less sensitive high-T_c SQUID at SANSA Space Science is completely unshielded, and housed only in a magnetically clean hut, 50 metres from a calibrated fluxgate node of the INTERMAGNET network.

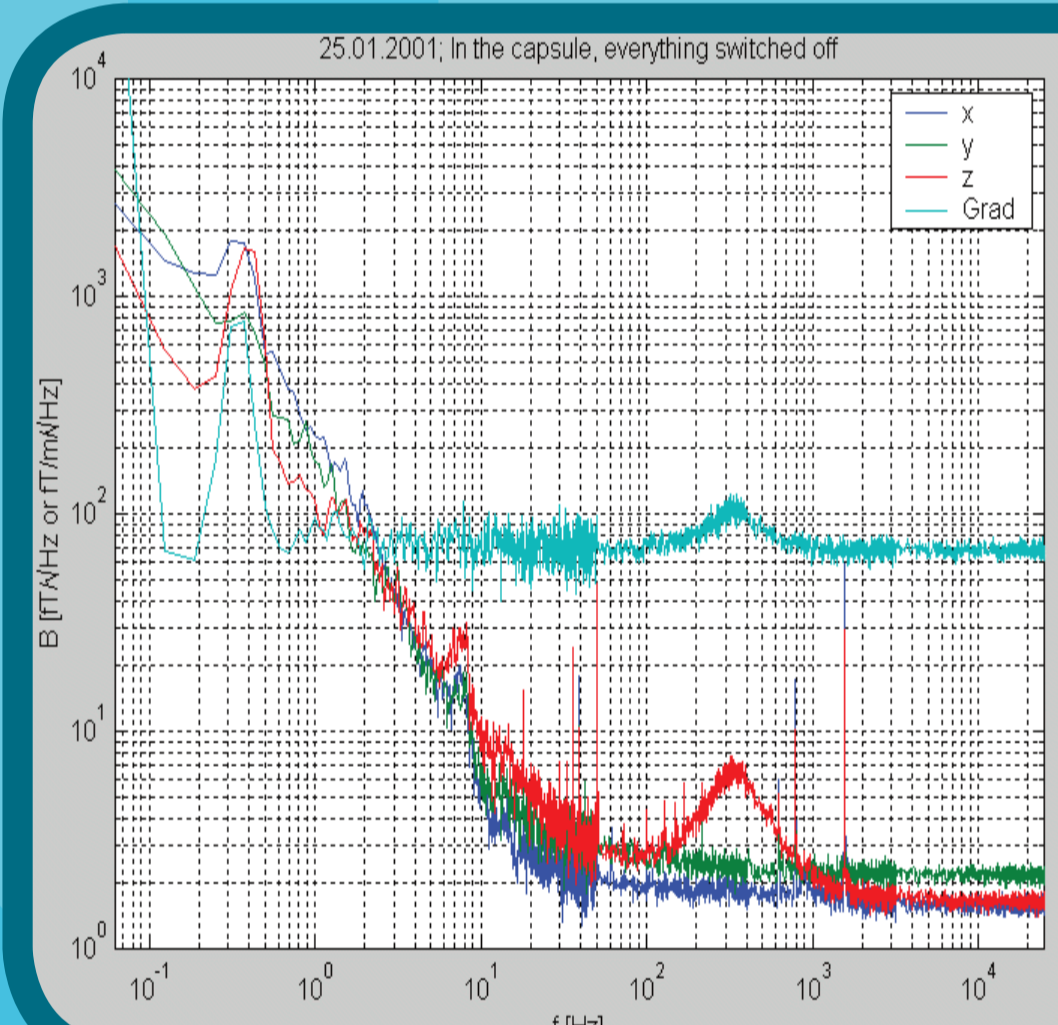
The network, which is more sensitive than observatory fluxgate magnetometers, detects Earth's magnetosphere pulsations, Schumann waves, mesopause resonance, breathing modes of the Earth and oceanic swell. Our goal is further to extract directional or polarization information if earthquake precursors are observed again, as with the Sichuan-Wenchuan earthquake on 12 May 2008 [1].

In the medium term, we are exploring the possibility to extend the network with more spatially distributed SQUID sensors, such as at the South African National Antarctic Expedition's SANAE IV base in Antarctica.

LSBB, Rustrel, France



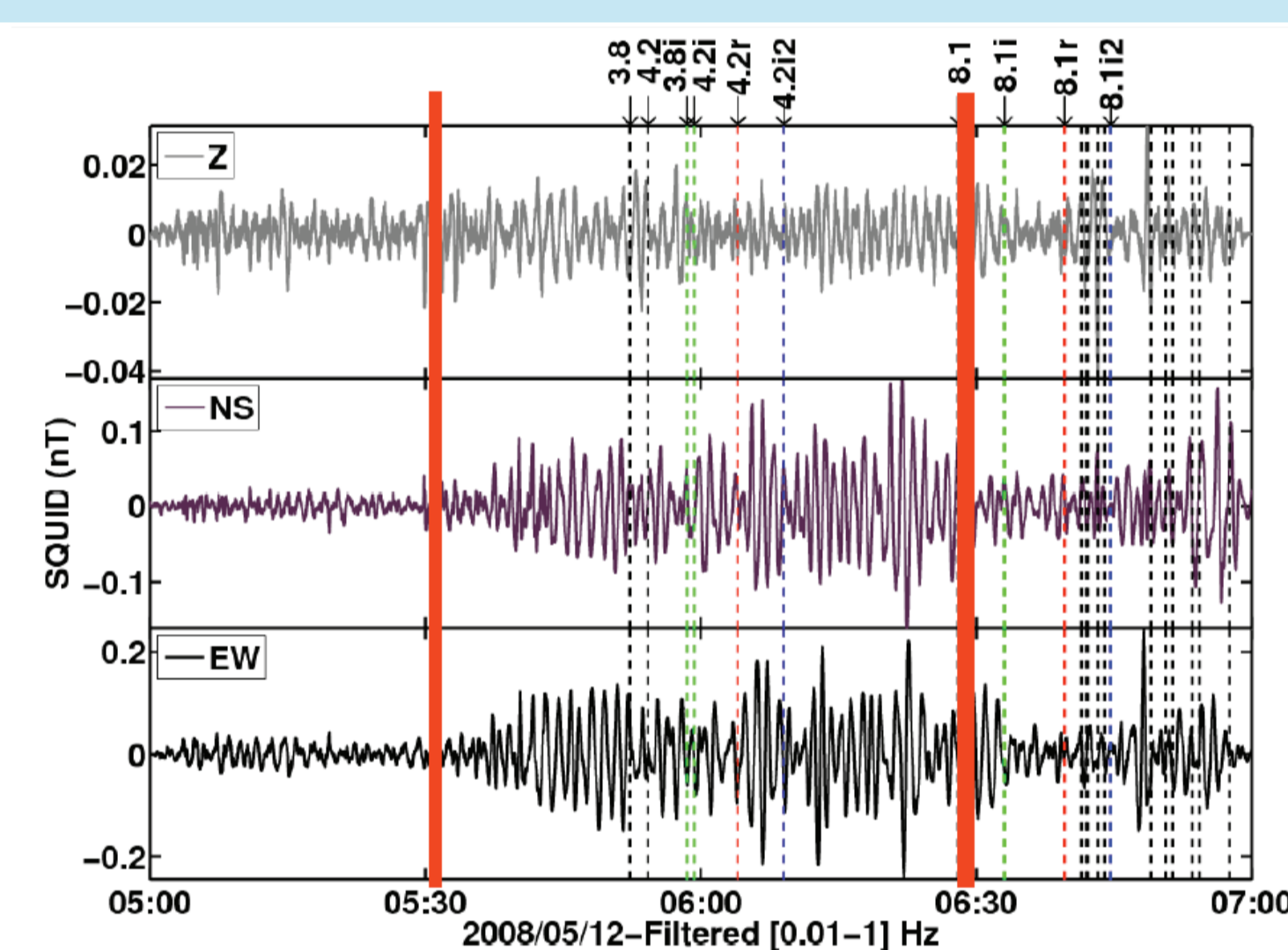
SANSA Space Science, Hermanus, South Africa



LSBB SQUIDS: Shielded with 518 m karstified rock & capsule ([SQUID]² - SQUIDS in Shielding Qualified for Ionospheric Detection).

Acts as low pass filter under 30 Hz.

Residual noise < 2 fT/√Hz above 40 Hz.



Sichuan-Wenchuan earthquake of 2008: precursors in LSBB SQUID-data start at 05:30 (initiation of mesopause resonance). Quake occurs at 06:30 [1].

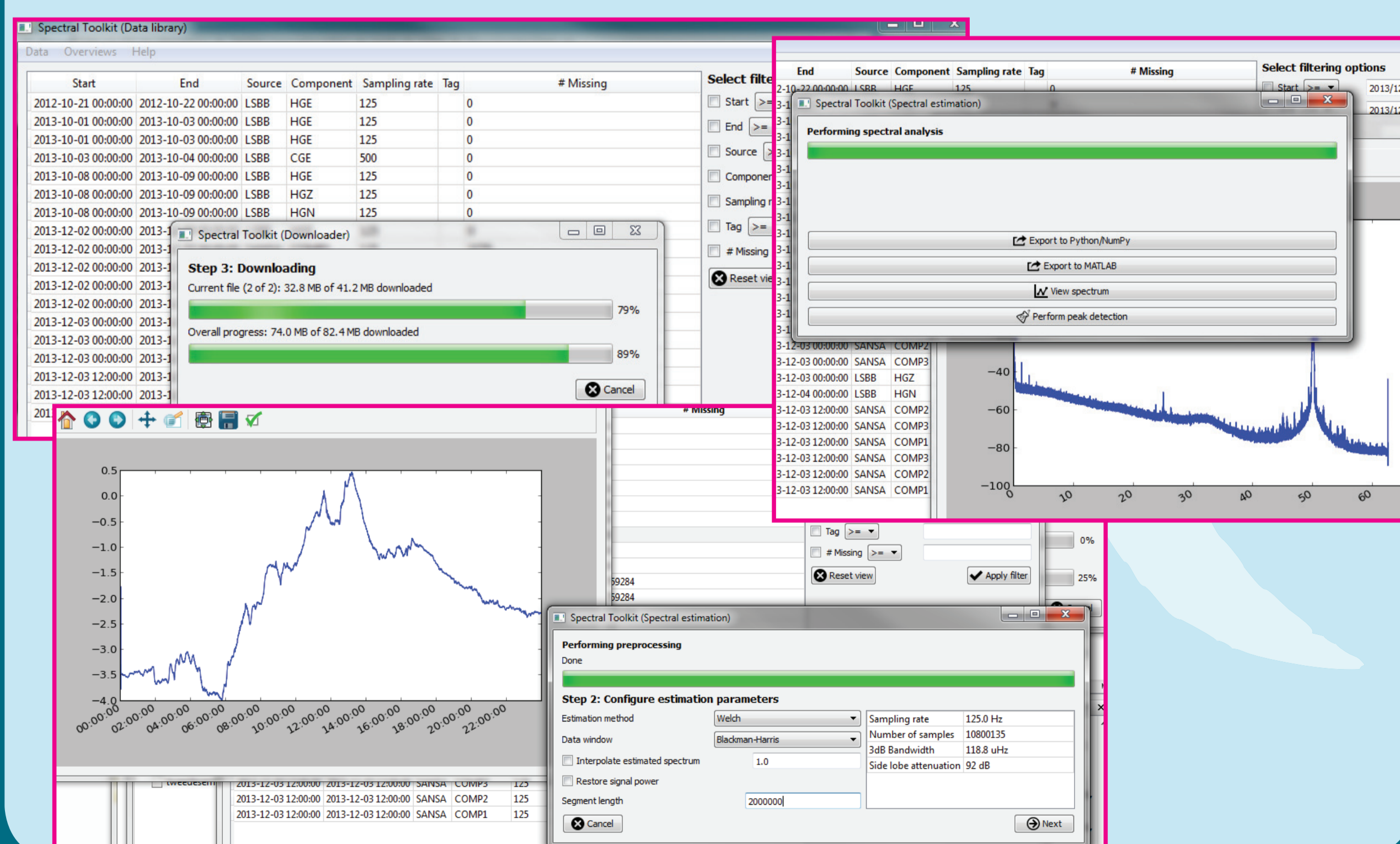
[1] Waysand G, et al. (2009) ULF magnetic ionosphere precursor of Sichuan Earthquake detected by [SQUID]² system in LSBB-Rustrel – AGU Fall Meeting Poster session S53B-1838.

System and tools

Data from both sensor nodes openly available in real-time and archived on servers on the internet.

Custom-developed open-source tools allow seamless access (download) of LSBB and SANSA SQUID data, and standardized data processing through Fast Fourier Transforms with a range of windowing functions.

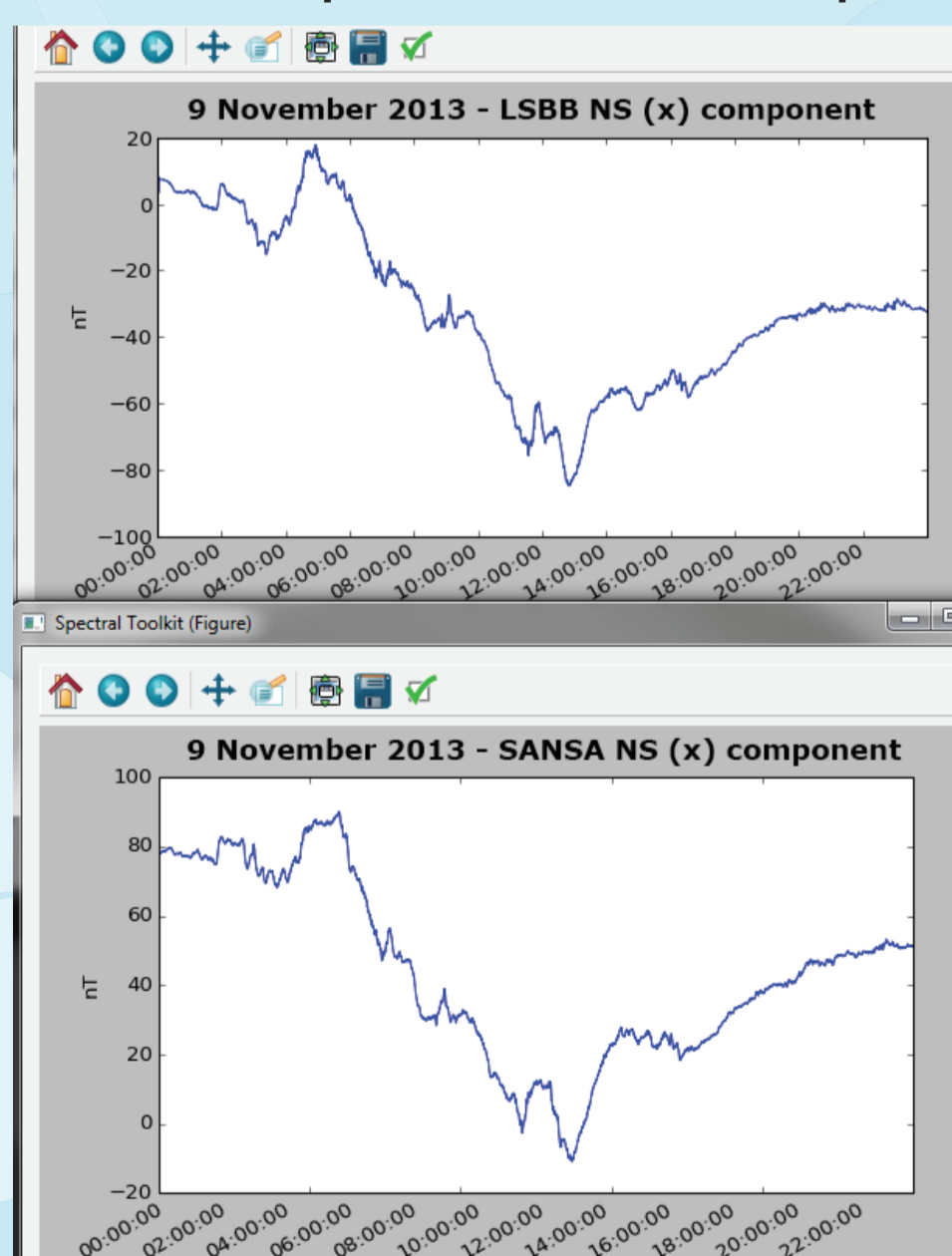
<https://github.com/wiehan-a/spectral-toolkit>



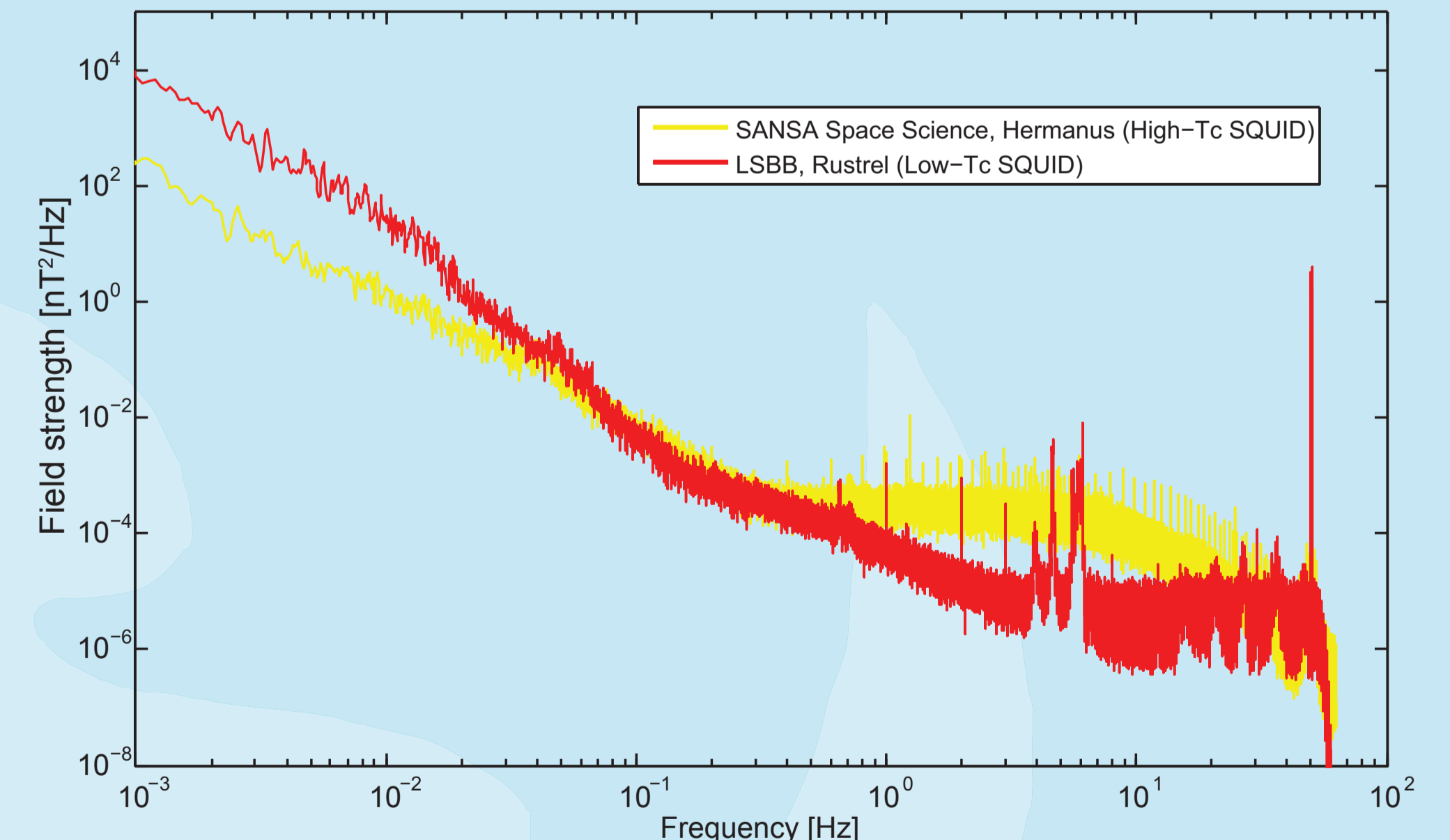
Simultaneous measurements

Simultaneous measurement at both locations needed for a better understanding of the sources of ultra-low-frequency magnetic fields; all measurements in near-field configuration.

Time-stamped, indexed, open data storage allows this. See data for 9 November 2013 below.



Geomagnetic field x-component Power Spectral Density for 9 November 2013 (highest K-index of 4)



Project website:
www.squidmagnet.org

SANSA data:
geomagnet.ee.sun.ac.za

LSBB data:
lsbb.oca.eu

Future improvements

SANSA SQUID sensor soon to be upgraded to a full 3-axis instrument with a 3 times lower noise floor.

LSBB SQUID to be operated in higher sensitivity mode.