Magnetic repeat station results 2004 for Tristan da Cunha, South Atlantic Ocean

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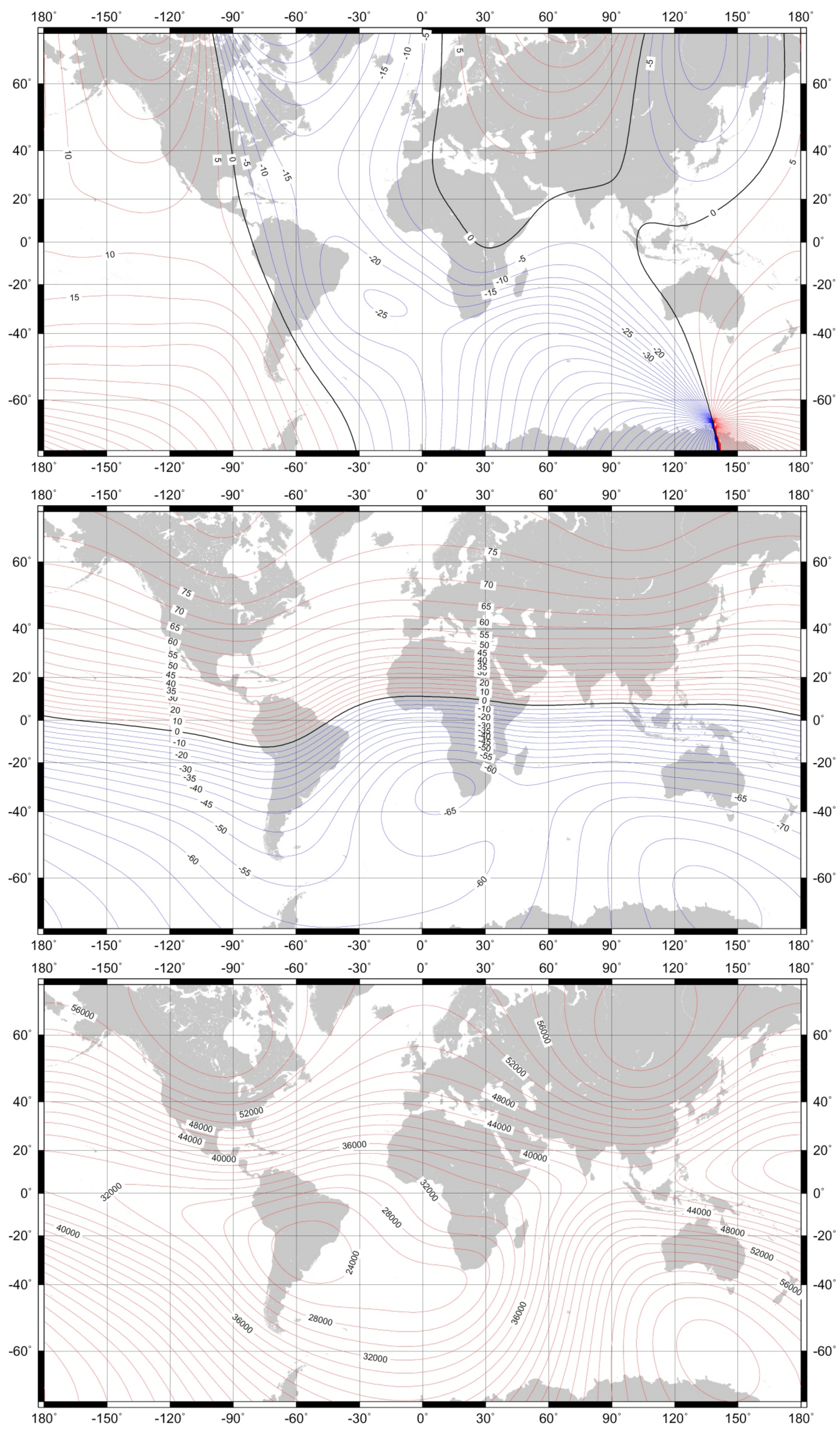
INTRODUCTION

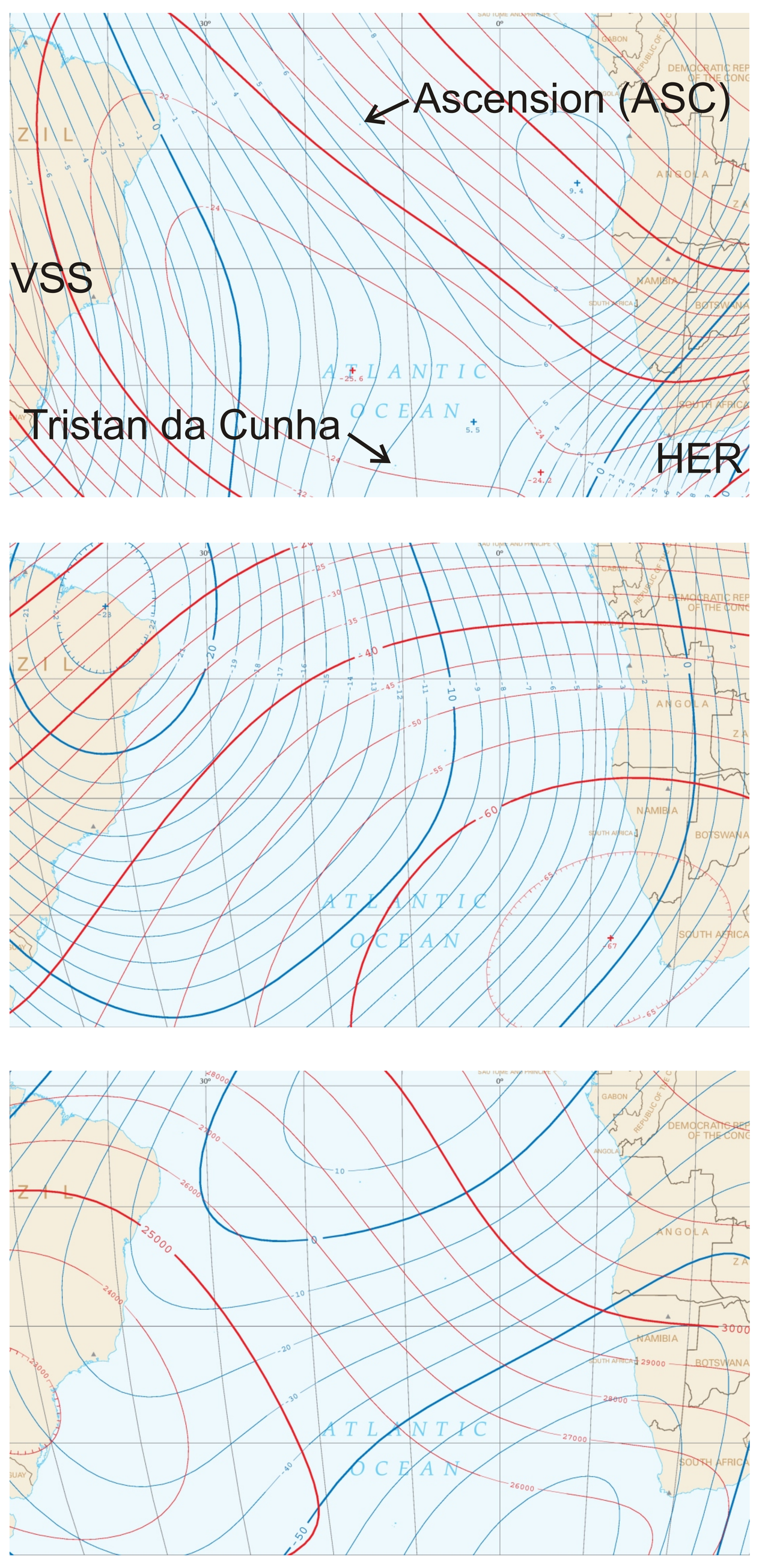
In this study, we present repeat station measurements from a location that has distances of some 3000 km to the nearest observatories. We are taking advantage of the rather quiet magnetic field during the measurements and use models of the solar quiet daily variation to extrapolate our results to quiet night time values of the magnetic field. Our data gives us some confidence in this extrapolation, which can be used for repeat stations where the employment of on-site variometers or night time measurements is logistically impossible.

The island of Tristan da Cunha, a Dependency of the British Overseas Territory St. Helena located between South Africa and South America, is a geomagnetic repeat station of global importance. The present-day geomagnetic field in the South Atlantic Ocean is characterised by the so-called South Atlantic Anomaly, an area where it is considerably weaker than elsewhere and is highly inclined. Declination is westerly by some 24°. Repeat station measurements on the island have been made by British and South African institutions in 1958, 1960, 1986 and 2002, but otherwise there is a clear lack of reliable ground vector data for the area. The nearest observatories are some 3000 km away. In September 2004 measurements were made at the most recently established repeat station using a D/I-fluxgate theodolite and proton magnetometers. We present the results of these measurements and comment on the effects of external field contamination using the Sq-model of Campbell (2003) and a Sq-model from CM4 (Sabaka et al., 2004).

RIGHT: Charts of the South Atlantic Magnetic Anomaly, photographs of the repeat station.



Total intensity (F) at 2005.0 from the World Magnetic Model (WMM2005). Contour interval is 2000 nT and projection is Mercator. This is an example of an isodynamic chart. Credit: British Geological Survey (Natural Environment Research Council).



Tristan da Cunha - a repeat station in the South Atlantic Magnetic Anomaly

Very left panels show global charts for D, I, and F (from top to bottom, plots from WMM 2005) to highlight the South Atlantic Magnetic Anomaly.

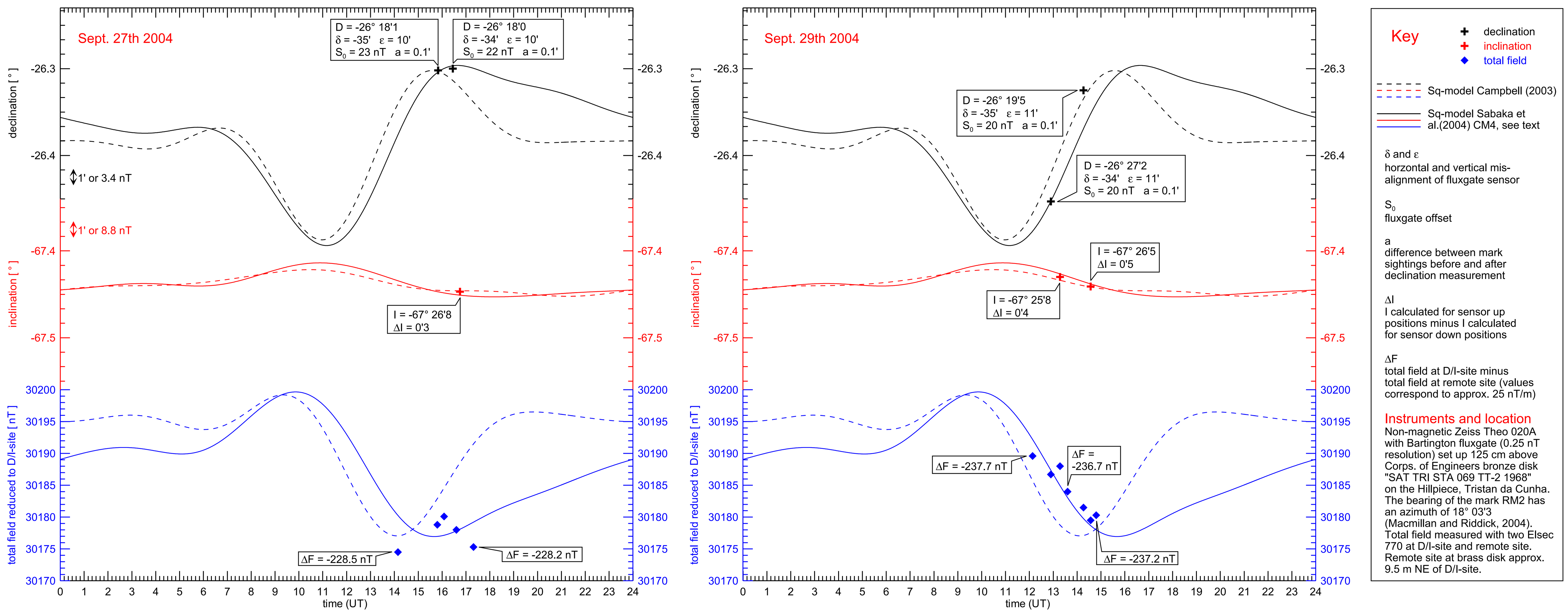
Left panels show D, I, and F (red isolines in degrees or nT) and their secular variation (blue isolines in minutes of arc or nT per year) for the South Atlantic region calculated from the IGRF 2000 model (plots from Rukstales and Quinn, 2001). The islands Tristan da Cunha and Ascension (with a BGS magnetic observatory, ASC) and the observatories Hermanus (HER) and Vassouras (VSS) are indicated.

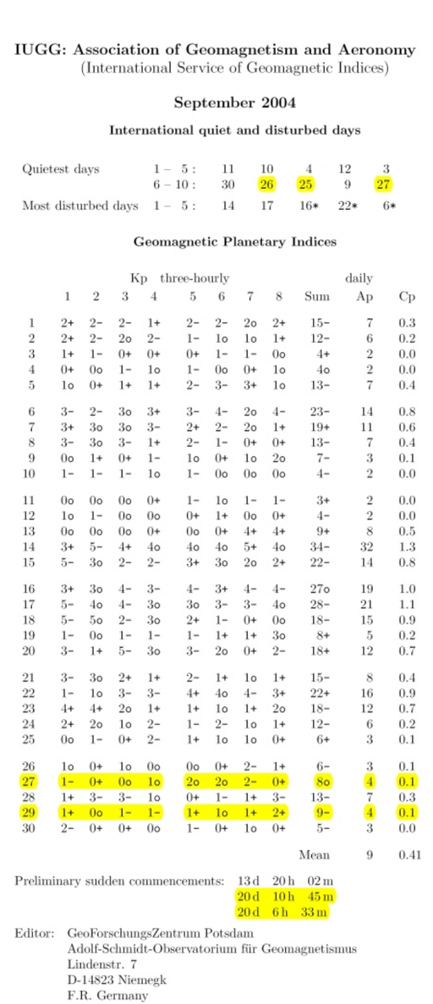
The right top panel shows the reference mark for true north (with James Glass). The photo below shows the repeat station with the tripod and theodolite. Behind the proton magnetometer (at the remote site) is the location of the reference mark (1.9 km distance) and parts of the settlement can be seen. The photo on the bottom shows the repeat station with a view to the south.

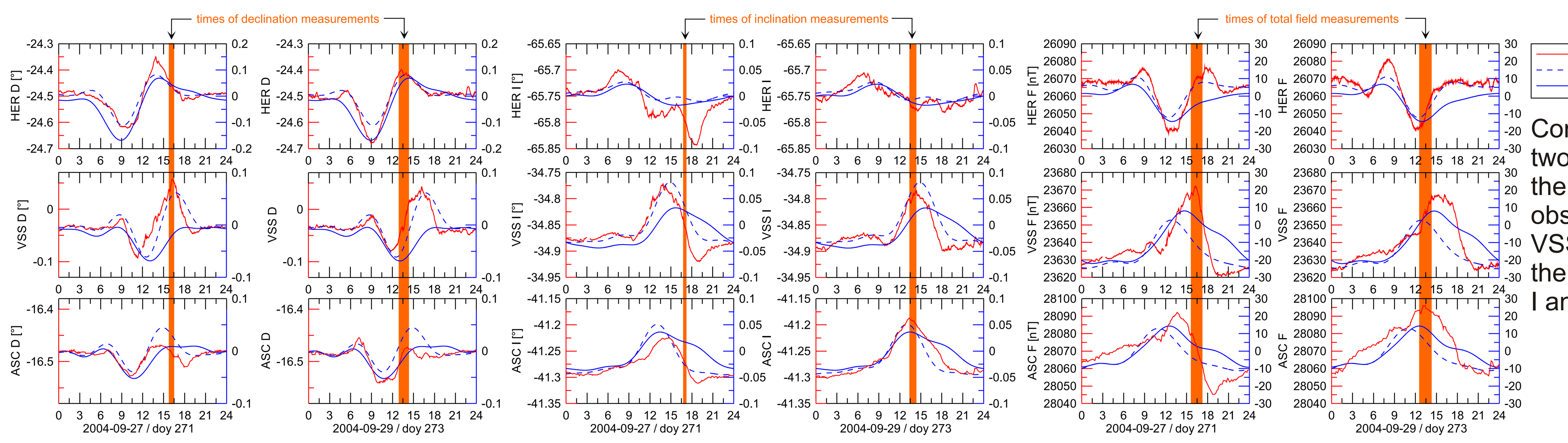
RESULTS: The measurements and external biasing fields

Measurements at the repeat station "The Hillpiece" on Tristan da Cunha were conducted on Sept. 27th (doy 271) and Sept. 29th (doy 273) 2004. The individual measurements at the repeat station are shown in two graphs, each containing the results for D, I and F at the corresponding time of the measurements (BIG PANELS TO THE RIGHT). Additional information on the repeat station and parameters for the quality of the measurements are given in these graphs and their key, too. The individual results for each component do not vary by more than 10 nT, except for declination (0.128° or 26 nT). However, most of this variation is explained by the Sq-models calculated for the location of Tristan from Campbell (2003) (dashed lines) and CM4 by Sabaka et al. (2004) (full lines). The CM4 Sq-variation was calulated from the magnetospheric field, the induced magnetospheric field, the primary ionospheric field, the induced ionospheric field and the actual 3-monthly mean of F10.7 data for the period including September 2004 (solar cycle modulation of Sq). Dst was not used in the computations using CM4 as the point of the excercise is to establish the quiet field at these locations, and Dst includes the non-quiet field. Whilst Dst also includes the quiet field (i.e. the effect of the ever-present ring current) it only contributes an offset that is fairly constant for the period of the observations (with the exception of the small contribution from the ever-present partial ring current on the night-side). There is already an unknown offset for the main field which cannot be estimated by CM4 for September 2004, and for the local crustal field. Additionally, we want to compare like with like when we compare Campbell's Sq model with that output by CM4, and Campbell's Sq model does not include Dst. Note that the Sq-models give variations only and that their absolute values in the graphs were adjusted to fit the measured data.

Using the Sq-models is not only justified by the good fit between our data and the models, but is also supported by observatory data from the region. First of all, geomagnetic planetary indices indicate rather low external geomagnetic disturbance during these measurements (MARKED YELLOW IN THE FORM TO THE RIGHT). Magnetic observatory data from the region (PANELS TO THE RIGHT) is quite comparable to Campbell's (2003) estimate for Sq daily variation as well as the Sq-model from CM4 (Sabaka et al., 2004). Although the observatories are too distant for reducing our observations at Tristan, both models are shown to be more or less valid for the region. A first inspection suggests that the observatory data is better fit by the Campbell (2003) model. For the limited data at hand for Tristan, no clear preference for one or the other model can be given. Since CM4 attempts to make a more complete separation between internal and external fields than Campbell's Sq-model, we prefer this model for reducing the measurements to quiet night time level and adopt the following values for quiet night time: D = -26° 22', I = -67° 27' and F = 30190 nT.


Sept. 27th 2004
D = -26° 18'1
δ = -35' ε = 10'
S0 = 23 nT a = 0.1'
D = -26° 18'0
δ = -34' ε = 10'
S0 = 22 nT a = 0.1'
1' or 3.4 nT
1' or 8.8 nT
I = -67° 26'8
ΔI = 0'3
ΔF = -228.5 nT
ΔF = -228.2 nT
declination [°]
inclination [°]
total field reduced to D/I-site [nT]
time (UT)
Sept. 29th 2004
D = -26° 19'5
δ = -35' ε = 11'
S0 = 20 nT a = 0.1'
D = -26° 27'2
δ = -34' ε = 11'
S0 = 20 nT a = 0.1'
I = -67° 26'5
ΔI = 0'5
I = -67° 25'8
ΔI = 0'4
ΔF = -237.7 nT
ΔF = -236.7 nT
ΔF = -237.2 nT
Key
declination
inclination
total field
Sq-model Campbell (2003)
Sq-model Sabaka et al.(2004) CM4, see text
δ and ε
horzontal and vertical mis-alignment of fluxgate sensor
S0
fluxgate offset
a
difference between mark sightings before and after declination measurement
ΔI
I calculated for sensor up positions minus I calculated for sensor down positions
ΔF
total field at D/I-site minus total field at remote site (values correspond to approx. 25 nT/m)
Instruments and location
Non-magnetic Zeiss Theo 020A with Bartington fluxgate (0.25 nT resolution) set up 125 cm above Corps. of Engineers bronze disk "SAT TRI STA 069 TT-2 1968" on the Hillpiece, Tristan da Cunha. The bearing of the mark RM2 has an azimuth of 18° 03'3 (Macmillan and Riddick, 2004). Total field measured with two Elsec 770 at D/I-site and remote site. Remote site at brass disk approx. 9.5 m NE of D/I-site.


IUGG: Association of Geomagnetism and Aeronomy
(International Service of Geomagnetic Indices)
September 2004
International quiet and disturbed days
Geomagnetic Planetary Indices
Editor: GeoForschungsZentrum Potsdam
Adolf-Schmidt-Observatorium für Geomagnetismus
Lindenstr. 7
D-14823 Niemegk
F.R. Germany



Comparison of the two Sq-models with the variation at the observatories HER, VSS, and ASC for the components D, I and F.

RESULTS: Comparison to previous results and recommendations

Although declination measurements at Tristan da Cunha were made by sailors for hundreds of years, proper repeat stations were established only in 1958 (TABLE TO THE RIGHT). Wiid and van Wijk (1960) give a detailed description of these repeat stations near the Flagstaff, which, in 1961, were covered by a huge lava flow. Later, repeat stations were established on the Golf Course and on Hillpiece. The locations are all a few km apart from each other and their results do not match the expected secular variation (GRAPHS TO THE RIGHT) since the local field gradients are larger than the secular variation. This is due to the islands magnetic anomalies, which arise from the strongly magnetised volcanic rocks.

The new repeat station on the Hillpiece was established in 2002 and the re-occupation in 2004 is described in this study. To determine the secular variation for this important repeat station in the South Atlantic Anomaly, the position of the repeat station has to be accurately reoccupied in the future. A potential problem might arise from lightning strikes, which might preferentially affect the elevated Hillpiece. Lightning strikes are known to change a rock's remanent magnetisation profoundly (e.g. Soffel, 1991). This in turn would affect the rock's bias field at the repeat station. It is therefore suggested to establish two more well separated repeat stations on Tristan da Cunha to cross-check for a change in the rock's biasing fields from lightning strike.

Observer	year	source	location	lat.	long.	D [°]	I [°]	F [nT]	
#	1958.33	database @ BGS		-37.047	-12.298	-28.083	-54.897	27531	
	1958.33	Wiid and Wijk, 1960	Flagstaff A	-37.05	-12.3	-28.083	-54.897	27531	
#	1958.33	database @ BGS		-37.047	-12.298	-28.173	-55.223	27781	
	1958.33	Wiid and Wijk, 1960	Flagstaff B	-37.05	-12.3	-28.173	-55.223	27781	
#	1960.22	database @ BGS		-37.047	-12.298	-27.895	-55.503	27629	
		Wiid and Wijk, 1960	Flagstaff B	-37.05	-12.3	-27.895	-55.504	27629	
#	1960.22	Wiid and Wijk, 1960	Flagstaff A	-37.05	-12.3	-27.91	-55.105	27452	
#	1960.22	database @ BGS		-37.047	-12.298	-27.968	-55.252	27567	
	1960.22	Wiid and Wijk, 1960	Flagstaff A	-37.05	-12.3	-28.025			
	1960.22	Wiid and Wijk, 1960	Flagstaff B	-37.05	-12.3				
##	1986.86	database @ BGS	Golf Course RM2	-37.065	-12.315	-20.04			
##	2001.5	database @ BGS	Golf Course RM1	-37.065	-12.315			27956	
##	2002.29	Macmillan and Riddick, 2004	TT-2* (Hillpiece)	-37.081	-12.322	-24.833	-67.15	30116	UT 15:24/9:54 doy 105/106
###	2004.74	this study	TT-2* (Hillpiece)	-37.081	-12.322	-26.3	-67.447	30178	UT 16:36 doy 271 Sept. 27th
###	2004.75	this study	TT-2* (Hillpiece)	-37.081	-12.322	-26.453	-67.43	30187	UT 13:06 doy 273 Sept. 29th
###	2004.75	this study	TT-2* (Hillpiece)	-37.081	-12.322	-26.325	-67.441	30181	UT 14:25 doy 273 Sept. 29th
###	2004.75	this study	TT-2* (Hillpiece)	-37.081	-12.322	-26.367	-67.45	30190	quiet night time value

symbol	observer
*	Wild and Wijk for HER, Hermanus
**	HMS Endurance Surveyors for BGS, Edinburgh
***	Matzka for FUR and LMU Munich

* TT-2 also known as SAT TRI STA 069

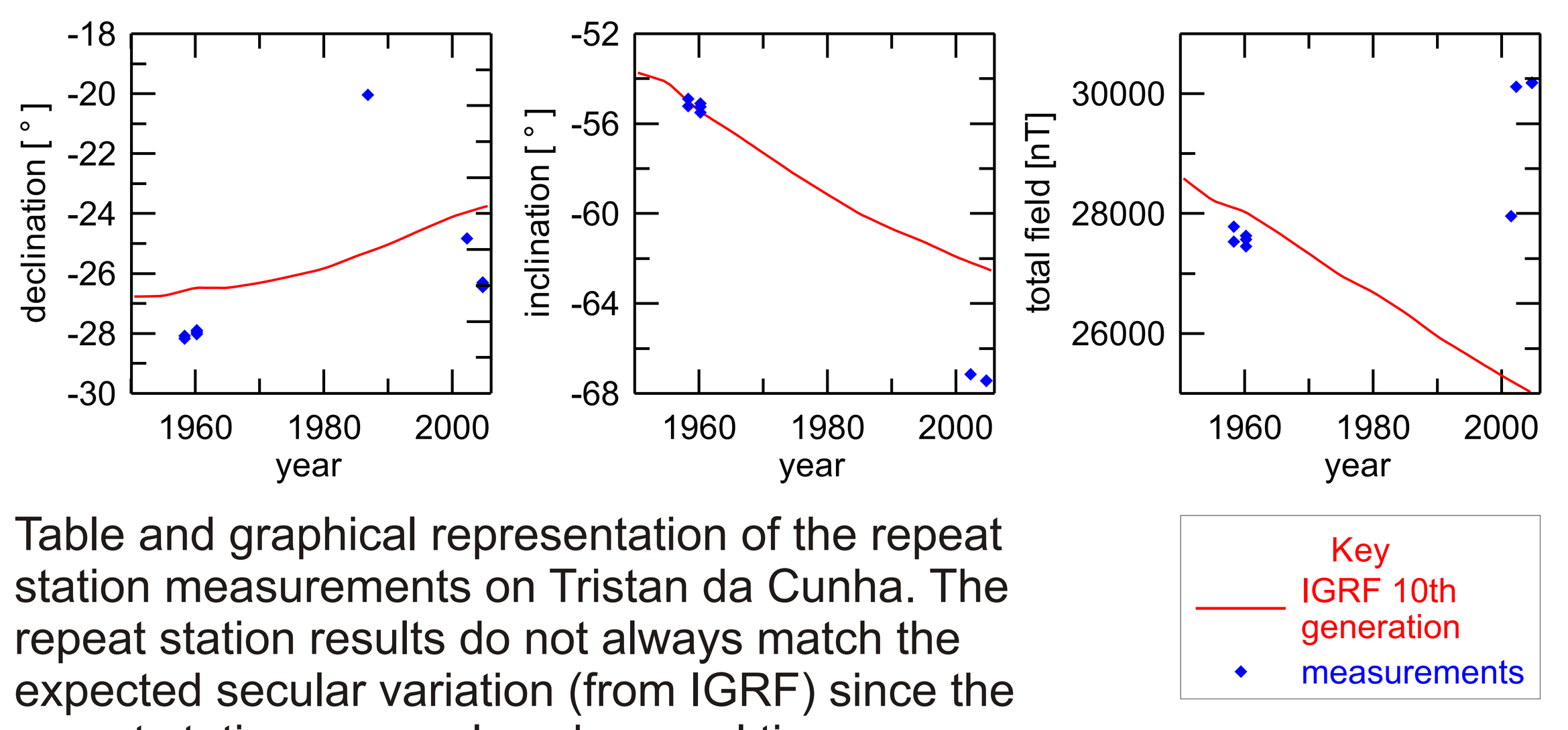


Table and graphical representation of the repeat station measurements on Tristan da Cunha. The repeat station results do not always match the expected secular variation (from IGRF) since the repeat station was replaced several times.

Acknowledgements

We would like to thank the Tristanians, the Administrators Mike Hentley and Bill Dickson, the Chief Islanders Anne Green and James Glass, and the Island Council for admitting us to their island and for the help with the measurements there. We thank the South African Department for Environmental Affairs and Tourism, Directorate Antarctica and Islands, and its Departmental Coordinating Officer Erik Buenk, and the Officers and Crew of SA Agulhas for taking us with them on their trip to Tristan da Cunha. We thank CHC Africa and especially Dick Hilland for the helicopter airlift to the island. We thank Pieter Kotze and Peter Sutcliffe from the Hermanus Magnetic Observatory for excellent support in South Africa.

The stay of JM on Tristan da Cunha was funded by DFG grant Ma 2578/2-1. The measurements were supported by funds of FUR.

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