Geo-spatial Information Science
Vol. 4, No. 2, p. 47~51 June 2001

THE COMPILATION OF A DTM AND A NEW SATELLITE IMAGE MAP FOR KING GEORGE ISLAND, ANTARCTICA

Matthias Braun
Jefferson Cardia Simões
N. Blindow
Steffen Vogt
U. F. Bremer
M. Pfender
H. Saurer
F. E. Aquino
F. A. Ferron

KEY WORDS King George Island; Antarctic Peninsula; GIS; digital terrain model; satellite image map; glacier retreat; environmental management

ABSTRACT An improved topographic database for King George Island, one of the most frequently visited regions in Antarctica, is presented. A first step consisted in combining data from differential GPS surveys gained during the austral summers 1997~1998 and 1999~2000, with the current coastline from a SPOT satellite image mosaic, topographic information from existing maps and from the Antarctic Digital Database. From this data sets, a digital terrain model (DTM) was generated using Arc/Info GIS. In a second step, a satellite image map at the scale 1:100 000 was assembled from contour lines derived from the DTM and the satellite mosaic. A lack of accurate topographic information in the eastern part of the island was identified. Additional topographic surveying or SAR interferometry should be used to improve the data quality in that area. The GIS integrated database will be indispensable for glaciological and climatological studies and administrative and scientific purposes. In future, the application of GIS techniques will be mandatory for environmental impact studies and environmental monitoring as well as for management plans on King George Island.

1 Introduction

At present, King George Island (KGI) is one of the most frequented sites in Antarctica. In total, 9 permanent research stations are in operation and several research cabins have been constructed. Due to the easy access via the Chilean air strip the number of the island's inhabitants rose to more than 500 (1989 ~ 1990) during summer months and at least 85 persons overwintered in the same year[1]. Furthermore, the rich wildlife on the permafrost areas attract an increasing number of tourists. The record of the International Association of Antarctic Tour Operators (IAATO, 1999) shows an increase of the tourist visits on King George Island from 3 275 in 1989~1990 to 4 227 in 1998~1999 (Fig. 1). Altogether, the activities of tourists, scientists, station personnel and the related logistic operations have considerable impact on the local ecosystems. Sites of Special Scientific Interest (SSSI) and the first Antarctic Specially Managed Area (ASMA) have therefore been desig-

Matthias Braun, Ph. D, Institut für Physische Geographie, Albert-Ludwigs-Universität Freiburg, Werderring 4, D-79085 Freiburg, Germany
E-mail: mabra@ipg.uni-freiburg.de

nated on the island.

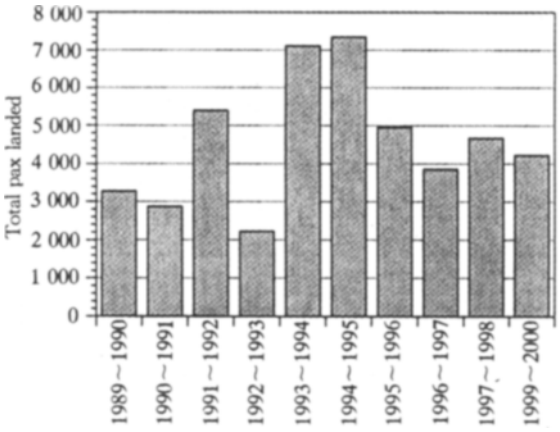

Fig. 1 Total numbers of passengers landed on various sites on King George Island in the summers 1989 to 1999

Although all these activities require up-to-date mapping, there is still a lack of an accurate topographic database for considerable parts of the island. Cartographic work started with the discovery of the island in 1819 by William Smith, resulting in some sketches of the area. A first Argentinean aerial survey was undertaken in 1952 covering almost the entire island. Ground surveys by the Falkland Island Dependency Survey accompanied by aerial photography (1956) led to the first detailed maps of King George Island. In recent years, large-scale maps have been published by various nations for the ice-free areas of the island (e. g. for Fildes Peninsula, Admiralty Bay, Potter and Barton Peninsula, and Lions Rump). However, the need for a continuous, digital topographic database for the entire island, especially for the main ice field, at a scale larger than 1∶200 000 remained. Harris has called for an easily accessible GIS as database to support environmental monitoring and management in this area[2]. So far, only a few internationally uncoordinated attempts have been made by different groups. In 1998, the Working Group of Geodesy and Geographic Information (WG-GGI) of the Scientific Committee of Antarctic Research (SCAR) started an initiative for the implementation of a GIS of King George Island, the KGIS project.

This study presents the compilation of a digital terrain model (DTM) and a satellite image map at a scale of 1∶100 000. The improved topographic information was based on DGPS data, digitised contour lines from existing large scale maps and data from the Antarctic Digital Database (ADD). The present-day coastline was derived from a SPOT mosaic which was also used to increase the topographic information content and to distinguish between ice and permafrost areas. This data set may form a first base for the KGIS on entire King George Island.

2 Database and DTM compilation

The compilation of the map can be subdivided in six major steps:

1) generation of a satellite image mosaic,
2) preparation of the different input data layers,
3) compilation of the DTM,
4) selection of place names,
5) composition of the satellite image map,
6) final layout.

The satellite image mosaic consists of 3 multispectral SPOT scenes. An image from 23 February 2000 extends over almost the entire island whereas for the easternmost parts a scene from 29 March 1995 was used. The adjacent Nelson Island was covered by a scene from 26 November 1994. Georeferencing was first done for a scene from November 1994 using ground control points in Admiralty Bay, Fildes Peninsula and Stigant Point. A total rout mean square (RMS) error of the geo-rectification process of 1. 2 pixel (24 m) was achieved. Subsequently, all other images where co-registered to this master scene with values for the RMS errors of 1 to 2 pixels (20 to 40 m). Finally the images were merged to the present satellite image mosaic.

The DTM was generated using data from various sources. An overview of the different data layers is given in Fig. 2. Precise elevation information from two mobile DGPS surveys in the years 1997～1998 and 1999～2000 forms the base in the central parts of the Arctowsky Icefield. For Fildes Peninsula and Admiralty Bay digitised contour lines of the large scale maps published by the Instituto Geográphico Militar de Chile (1996) and the Nakladem Instytutu Ekologii (1990) were included. Furthermore, elevation information from a DTM from Potter Peninsula was also available as well as digitised con-

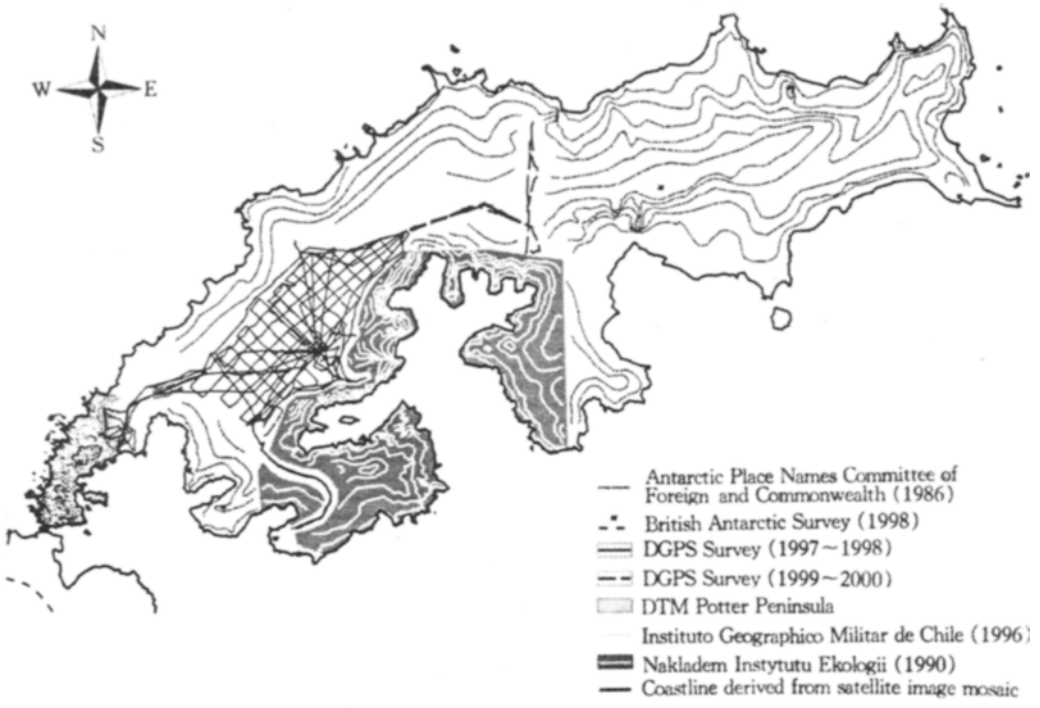

Fig. 2 The different data layers used for the generation of the DTM

tour lines from a map of the Antarctic Place Names Committee of Foreign and Commonwealth Office (1986). Single spot heights and altitudinal information for Nelson Island were taken from the ADD. The current coastline was derived from the satellite image mosaic. Priority was given according to the data accuracy. Consequently, data of minor accuracy was clipped in areas with data overlap. All data sets were assembled and converted to Lambert conic conformal projection as suggested by Sievers and Bennat (1989). The DTM (Fig . 3) was compiled using the Arc/Info TOPOGRID module. This module is especially suitable for the generation of hydrologically correct DTMs from heterogeneous data sets. A horizontal cell size of 100 m was chosen for the King George Island DTM. More details about the map and DTM compilation as well as on possible applications is given by Braun, *et al*.

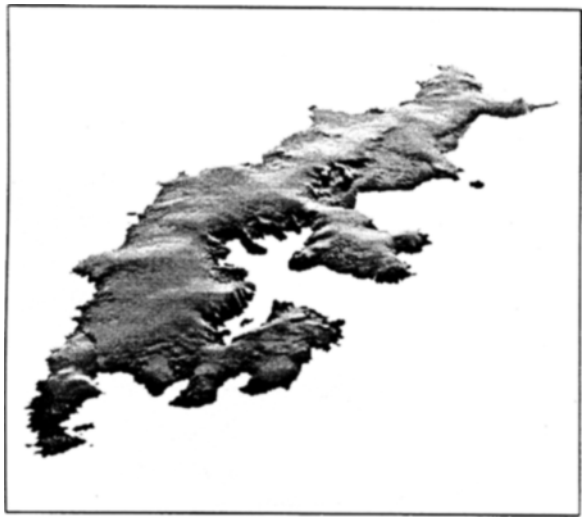

Fig. 3 3D-view of the DTM with superimposed satellite image mosaic from southwest

3 The new satellite image map of King George Island

An overview of the satellite image map is given in Fig. 4. The contour lines were computed from the DTM in 50 m intervals and superimposed on the satellite image mosaic. Similarly, the coastline was included as a vector layer. Since a very heterogeneous data set forms the base of this new map, special attention was paid to give the user as much as possible information on the data accuracy and compilation. Additionally to the information on the projection and map datum, the map annotation includes metadata on the satellite image map, a table of estimated accuracies (Table 1), a figure showing the different data input layers and text on the place name selection criteria. To meet the requirements of users from various nations the map legend and an-

notations are given in four languages (English, German, Portuguese and Spanish). From the combination of the accuracy table (Table 1) with the location diagram of the different input data layers (Fig. 2) an accuracy map can be constructed by the user. As a result of the low precision input data the accuracy of the DTM and map is lowest in the eastern parts of the island. More accurate data from ground surveys or radar interferometry is needed to overcome this problem.

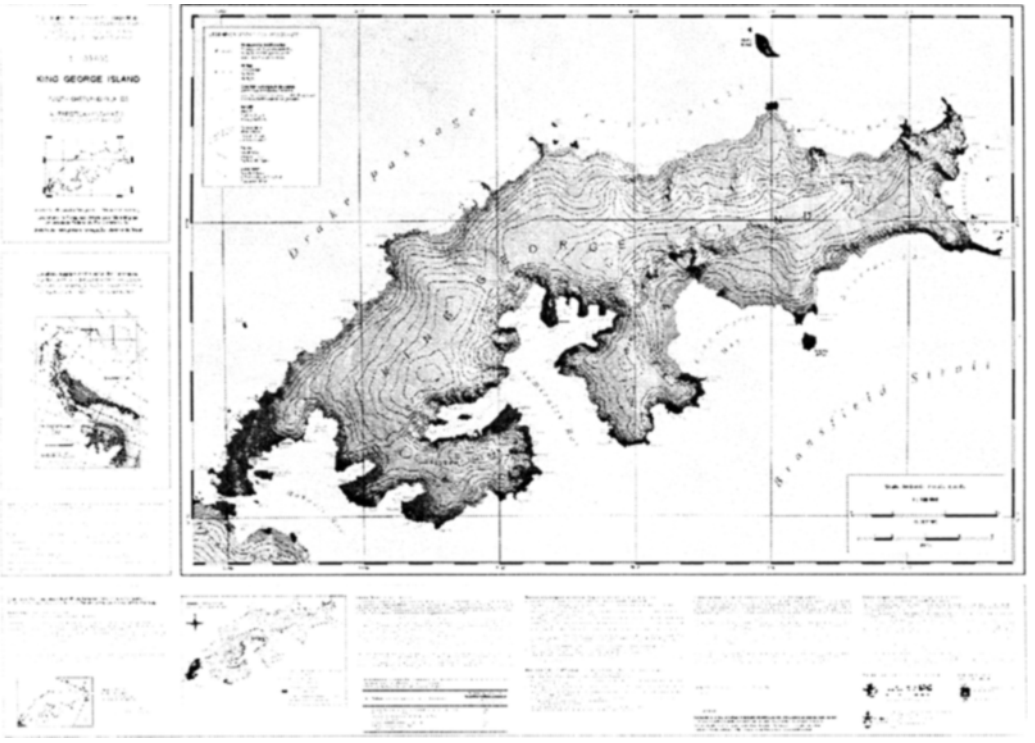

Fig. 4 The new satellite image map of King George Island

Table 1 Estimated accuracies of the different data layers used for the DTM compilation

Database	Estimated vertical accuracy/m
Antarctic Place Names Committee of Foreign and Commonwealth (1986)	100
British Antarctic Survey (1998)	30
Mobile DGPS measurements 1997～1998 and 1999～2000	2
DTM Potter Peninsula	10
Instituto Geographico Militar de Chile (1996)	10
Nakladem Instytutu Ekologii (1990)	50
Coastline from SPOT mosaic	20

Thematic information in the map comprises the location of the permanent research stations, refuges, the air strip near Frei station and the major gravel roads. Multi-naming is a very frequent phenomenon on King George Island. Therefore, in order to avoid confusion, only one place name per feature was selected in accordance with the suggestions of Sievers and Thompson (1995). They gave priority to the first recorded name. The Gazetteer Antarctica (Working Group on Geodesy and Geographic Information 1999) formed the reference of formal approval. The history of place names was mainly obtained from Hattersley-Smith (1991).

4 Conclusion and outlook

A significant improvement of the topographic database on King George Island could be achieved by integrating a satellite image mosaic and elevation information from various sources. The compilation in a GIS enables an easy update and the new data set will have a wide range of potential applications, ranging from glaciological studies to administrative purposes. In particular those studies that require spatially distributed modelling and environmental management will find a suitable database in the

new map and the DTM. It is the authors' intention to make these data available for other working groups. The DTM and the various other input layers and satellite images may form a first base for the entire King George Island in a KGIS, as suggested and intended to be implemented in the future by the SCAR WG-GGI. The new satellite image map will be printed and distributed by the Brazilian Hydrographic Survey.

Acknowledgements

The authors would like to thank the Brazilian Antarctic Program, the Alfred Wegener Institut für Polar- und Meeresforschung (AWI), the Instituto Antárctico Argentino (IAA) and the Instituto Antárctico Chileno (INACH) for their logistic support. This study was financed by the Deutsche Forschungsgemeinschaft (DFG), under contract SA 694/1-1/2, and the Brazilian National Council for Scientific and Technological Development (CNPq) under the project 49.0047/99. Special thanks to our friends Marcelo Krings (Sao Paulo, Brazil) and Andres Zakrajsek (IAA) who did the translation of the legend and annotation text into Spanish.

References

1 Harris C M. Environmental effects of human activities on King George Island, South Shetland Islands, Antarctica. *Polar Record*, 1991, 27(162): 193~204

2 Harris C M. Environmental management of human activities on King George Island, South Shetland Islands, Antarctica. *Polar Record*, 1991, 27(163): 313~324

3 Antarctic Place Names Committee Foreign and Commonwealth Office. APC Misc 64, South Shetland Islands, Sheet 1 King George Island, 1:100 000, 10th ed. 1986

4 British Antarctic Survey. Antarctic digital database, Version 2.0. manual and bibliography. Scientific Committee on Antarctic Research, Cambridge, 1998. 74

5 Hattersley-Smith G. The history of place-names in the British Antarctic Territory. British Antarctic Survey, Natural Environmental Research Council, Cambridge, British Antarctic Survey Scientific Reports, 1991, 113(1/2)

6 International Association of Antarctic Tour Operators. http://www.iaato.org/, 1999

7 Instituto Geográfico Militar de Chile. Isla Rey Jorge-Península Fildes (Sheet 1 and 2, 1:10 000), 1996

8 Nakladem Instytutu Ekologii. Admiralty Bay, King George Island. Warszawa, 1990

9 Scientific Committee on Antarctic Research. Antarctic Digital Database Version 2.0. Cambridge, 1998. 74

10 Sievers J, Bennat H. Reference systems of maps and geographic information systems of Antarctica. *Antarctic Science*, 1989, 1(4): 351~362

11 Sievers J, Thomson W. Adopting one name per feature on maps of Antarctica: an experimental application-Topographic Map (Satellite Image Map) 1:250 000 Trinity Peninsula SP21-22/13. *Polarforschung*, 1998, 65 (3): 123~131

12 Working Group of Geodesy & Geographic Information. Composite Gazetteer of Antarctica, http://www.pnra.it/SCAR-GAZE, 1999

13 Braun M, Simões J C, Vogt S, *et al*. An improved topographic database for King George Island——compilation, application and outlook. *Antarctic Science*, 2001, 13(1): 41~52