The status and evolution of Antarctic archives.

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ABSTRACT

Antarctic exploration began in the 18th century with the circumnavigation of Captain Cook, then came a grey period where whalers and various explorers gathered data without formally publishing it. Scientific exploration really began with the Belgica wintering of 1898 and the International Polar year of 1908 where scientific teams collected and archived systematically observational data. A global observational strategy was for the first time implemented in the International Geophysical Year of 1957-1958 and on its subsequent sequels as stations became permanent. The data was then published in standard reports, the original raw data being kept on paper support in the original laboratories. The digital age started later in Antarctica compared to other continents due both to the difficulty of operating computer equipment on location and now to the complexity of establishing digital high-rate communications inside Antarctica and between Antarctica and the mid-latitudes. The current historical and new born digital data bases will be described as well as proposals for future data distribution and preservation in relation with the planetary exploration programs.

Keywords: Antarctica ,history, data, data centres.

INTRODUCTION

Antarctica is a major element of the earth system, the continent is basically a huge quasi circular plateau covered with thick ice, it is estimated that the melt of the Antarctic polar cap would rise the oceans by about one hundred meters, transforming the planet in a water world with a few dramatically reduced continents and archipelagos. Knowledge of Antarctic history and present trends becomes extremely relevant to present climate studies.

EARLY HISTORY: ARE THERE DOCUMENTS BEFORE MODERN TIMES?

The historical data bases are unfortunately up to now useless to describe Antarctica. However, ancient navigators as the Phocean Greeks and middle age Chinese were not scared by the open ocean, Pytheas of Massilia reached the Arctic Circle. Pytheas was never believed until the modern times when the coherence of his geographical descriptions with his latitudes was put in evidence. Pytheas gave a description of arctic pancake ice as his maximum latitude (66°?) is still speculated. The Massaliotes unfortunately allied successively with Carthage and with the Celts in trying to prevent the Roman conquest of Southern Gaul and their scientific works are known only by fragments in the books of later geographers. Similarly, a Chinese fleet in the 15th century crossed several time the Indian ocean under the command of admiral Zhen He, despite the recognition these expeditions got in China, they were stopped at his death at sea and their record is uncertain. The Chinese ships had certainly the capability to reach and cross the Cape of Good Hope and venture further south or in the Atlantic. Chinese maps of the time were incredibly accurate and seem to indicate America and a Southern continent. (http://www.digitalhistory.uh.edu/learning_history/1492/1492_zhenghe.cfm). References to these Chinese

expeditions are constantly evolving as Chinese historians are progressing very fast in understanding this part of the Chinese past.

Figure 1: Integrated map of Zheng He of 1418 showing the West Coast of Africa and possible representations of the coasts of America and an austral continent, the representation of Europe suggests contacts with European and Arab geographers. Chinese maps were probably known to the Venetian geographer Fra Mauro who inspired Columbus and his brother the cartographer Bartolomeo Colon.

In the 15th century, European navigators progressed rapidly, mapping the entire coast of Africa and culminating into repeated crossings of the Atlantic and the exploration of the American coasts until the treaty of Tordesillas in 1494 which divided all new lands between Spain and Portugal, this treaty is still invoked by Argentina to substantiate its claims to the Falkland islands and Antarctic territories.

This Western European success came as a surprise to the Turkish naval authorities who thought that Columbus had had access to secret ancient maps. Admiral Piri Reis[1] began in the early sixteenth century to systematically interrogate Spanish prisoners and collect maps to find Columbus' source and possibly to discover also a new continent. This led to a collection of maps found back in the 20th century in the Topkapi palace in Istanbul, one of them show the details of the coasts of West Africa, parts of South America and an almost unreadable coast of a Southern continent with resemblances to the Queen Maud Land coasts. Most current geographical historians admire these maps but think that any coincidence with an Antarctic feature is coincidental. This map attaches also South America to Antarctica and thus does not predict the discovery of the Magellan strait. Piri Reis attributed these maps to a compilation of maps coming from Alexander the Great and maps from more recent sources including a 1508 lost map of Columbus, the Alexander connection points to the map collection of the Alexandria library transferred to Constantinople at the time of Arab conquest.

This effort was continued by Ali Macar Reis [1] who produced in 1567 a maritime atlas including a world map which clearly drew attention to an unknown austral continent.

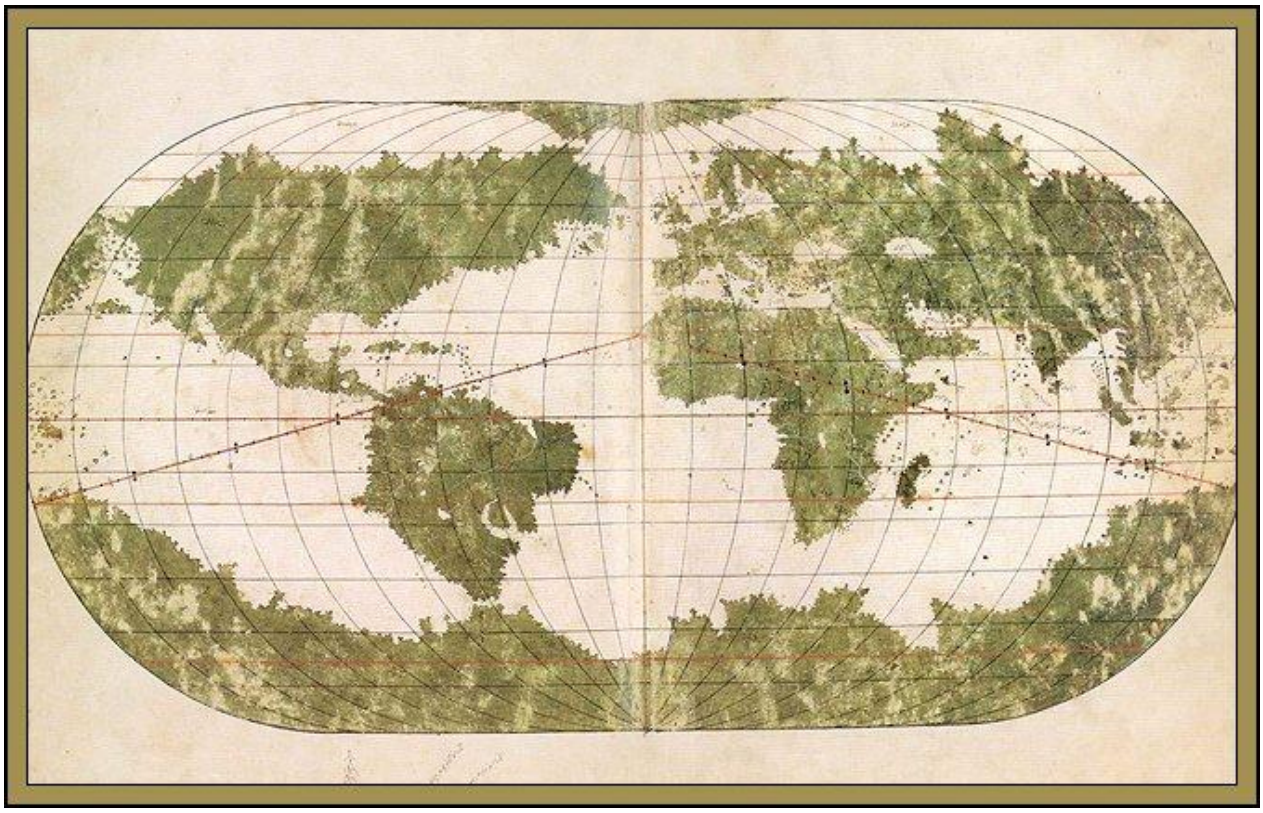

Figure 2: World map of Ali Macar Reis of 1567 , this map shows a tremendous improvement of the coasts of America compared with the 1513 Piri Reis map; it implies an austral continent but does not modify the Antarctic continent of Piri Reis. This point indicates that no new Antarctic data came between 1513 and 1567, except that the austral continent was not connected to any other known land body.

In conclusion, nor the ancient cartographers, nor archaeology prove an antique exploration of Antarctica. Claims that the Piri Reis maps indicate the coast of an ice free Antarctica are of course absurd because melting the Antarctic ice would dramatically modify coastal lines everywhere including Antarctica. However, the Chinese navigation archives should be searched for any evidence of a medieval Chinese expedition in the Southern hemisphere. If the records were found, these data will be invaluable and would have to be integrated with the more modern data.

MODERN EXPLORATION

The serious exploration of the Antarctic continent began in the 18th century; it was at the time an element of maritime folklore that Spanish vessels which had lost their routes while passing Cape Horn had seen lands much to the South of any known islands. In the same way, a French expedition led by Captain Kerguelen found a vast expanse of land which he called "France Australe" without being able to survey it. But the first verified accounts were the explorations of James Cook who took fresh water at the islands found at the location indicated by Kerguelen and choose to name them Kerguelen Islands; Cook reached the pack ice but could not find a safe passage towards the land. His logs make constant mention of whales and seals sightings but have never been analysed to study the evolution of Antarctic biodiversity. Later, as early as 1815, Argentine seal hunters claimed to have reached the continent. The first confirmed sightings of the continent were however made by the Russian expedition of von Bellingshausen in 1818. Antarctica was then already considered by the British authorities as dependencies of the Falkland Islands which diverging interpretations of the

1713 Peace of Utrecht attributed either to Great-Britain or Spain represented later by its successors in South-America: Chile and Argentina. The interest of Great-Britain was then to keep open the route South of Cape Horn where the storms were weaker and avoid a conflict if narrow straits were to be discovered. This political history point has significance for Antarctic data of the 20th century as to substantiate their claims; the different countries had to prove occupation which could be done conveniently through the establishment of permanent bases issuing meteorological and scientific reports [2]. Antarctica got also interest in the nineteenth century from the U.S. and Scandinavian whaling industries while French explorations took also an important role with the expeditions of Dumont d'Urville. The first detailed Antarctic survey of the coasts and pack ice was due to the expedition of Ross in 1839 to 1844 which mapped the limits of the continent. The historical British data have been scattered in different locations but the British government has currently a plan to unify the different catalogues and the Antarctic and Arctic archives can be accessed through: http://yourarchives.nationalarchives.gov.uk/index.php?title=Arctic_and_Antarctic_Expeditions . The most important elements these discovery travels contain are on cartography and the meteorological logs of the ships. Unfortunately, most of these data are not on line and the Kew National Archives which keep the British records have to be consulted to know if a collection has already been digitized or microfilmed.

The first expedition to winter in Antarctica was the Belgian led expedition of Adrien de Gerlache in 1897-1898 which had purely scientific purposes. The crew was truly international and included seven scientists: Henrik Arctowski, Antoine Dobrowolski, Emile Racovitza, Frederick Cook, Georges Lecointe, Emile Danco and Adrien de Gerlache himself. Meteorology and glaciology were covered by the two Polish scientists who later founded Polish geosciences. The presence of two geodesists in this team also avoided the localisation contestations which had characterised a lot of earlier and later expeditions.

The data were composed of hand written logs, drawings, photographs and samples, the only data which can be easily digitized are the positioning and meteorological records. Meteorological recording was following the rules set by Adolphe Quetelet in Brussels as one of the founders of meteorological statistics. At the time meteorological and geodetical observations had already began to unify and since the beginning of the electric telegraph, synchronisation was marking the beginning of network science. In the case of the Belgica, of course, the time was given by carefully maintained maritime chronographs.

The meteorological results of this expedition contain the first observation of pressure temperature and wind during the Belgica drift, this took place between 69°28' and 71°36' of latitude and 80°30' W and 96°40' W longitude. This record has been commented by Arctowski [3] The combination of temperatures and wind direction shows that the Belgica was in a mass of very cold (-20° to -30°) air with mainly Western winds from July 8 1898 up to September 15 where the temperature rapidly rose and reached values close to 0°. The coldest period occurred in the beginning of September and let Actowski to make what was found a posteriori to be the first description of the Antarctic vortex currently involved in the mechanics of the ozone hole. His fellow meteorologist Dobrowolski wrote also an apparent description of a polar stratospheric cloud.

The data from this first scientific wintering were carefully collected and published in several books during the next 10 years. Most of these books are now available on line at the library of the " Vlaams Instituut voor de Zee" in Ostend (http://www.vliz.be) , unfortunately, these books are available in PDF form and digitisation of the data has yet to be attempted.

A similar situation exists for the larger scientific campaigns later led by Germany during the 1908 polar year, the British Empire, the U.S. and others, most interestingly, the Scott record of the British

1910 expedition gave also a description of a polar stratospheric clouds. As some stations were operated only as tokens of sovereignty, their records are probably still buried in archives if not lost. Again, for the sake of global change studies, it would be worth searching for these data and giving them the benefit of a contemporary analysis.

THE CURRENT AGE: AFTER THE INTERNATIONAL GEOPHYSICAL YEAR OF 1957-1958

After the large American expedition of 1947, it became evident that the study of Antarctica was to become essentially an international venture, the IGY was proposed by Lloyd Berkner, a U.S. scientist and engineer who had participated as responsible of radio-communications to the expeditions of Admiral Byrd, he had been instrumental in quantifying the role of the ionosphere and during world war two, his participation in the design and deployment of radar systems in the Pacific had earned him the rank of admiral. After the war, he had headed the U.S. expedition of 1947 and became the president of the International Council of Scientific Unions. It was in these capacities that the proposed in 1950 to transform the international polar year of 1957 into an international geophysical year. Twelve countries participated to this programme in Antarctica and signed in 1959 the Antarctic treaty solving the territorial dispute between Great-Britain, Chile and Argentina. From a scientific point of view, all scientific observations had to follow common procedures described in the IGY manuals. These procedures included also the recording of the data and the obligation to send standard reports to designated world data centres. These reports were then compiled into yearly volumes to which the libraries of the geophysical institutions would subscribe. The IGY implied during its two years the maintenance of permanent Antarctic stations, as an example, the U.S. established a station at the geographic South pole while the Soviet Union announced that it would put a station at the most inaccessible location which coincided in 1958 with the geomagnetic pole. Both of these stations are still operated now, radio-communication was still very difficult and analogue recording equipment was not qualified for Antarctic use. Digital techniques were so poor at the time that in 1959 during the NASA JPL Pioneer 4 mission to the moon, data had to be transferred from one computer to the other on punched paper tape. Digital techniques were thus certainly not available for Antarctic research at the time of IGY.

The momentum of IGY continues after its completion in 1958 and the standardised approach introduced by IGY constitutes its main legacy and allows to consider the data acquired since as a coherent collection.

An example: the Belgo-Dutch ozone data set of 1965-1967.

Ozone Dobson measurements were obtained in Antarctica at the Belgian "Base Roi Baudouin" (70°26' S, 24°19' E) in 1965 and 1966 during the last occupation of the station, together with other meteorological parameters and especially surface ozone. The original records were archived from the KNMI (Royal Netherlands Meteorological Institute) archives in De Bilt. The data was then left untouched after reporting to the Toronto ozone data centre. After the discovery of the ozone hole in 1984-1985, it was important to check for the presence of this phenomenon in data prior to 1979. There was a persistent rumour that observers eliminated anomalously low data in Antarctic spring when the sun was low as measurement errors, this had to be checked. Despite excellent treatment at the time by the meteorologists in charge at the KNMI [4], the original observers notes localised in 1989 were reanalysed using a digitisation of the original log books Happily, no systematic anomaly in the first analysis was found, meteorological data from the site together with Brewer-Mast ozone soundings concur that the conditions did not correspond either in 1965 nor 1966 to the current ozone hole (Farman et al, 1985) situation. However, the data yields excellent correlation with stratospheric temperature and shows in 1966 a clear November maximum in opposition to an October value around 344 Dobson units. The reanalysis of the data has been published at the International Ozone Commission symposium of Charlotteville (1992) [5] and these early data have become a proof of the chemical origin of the ozone hole.

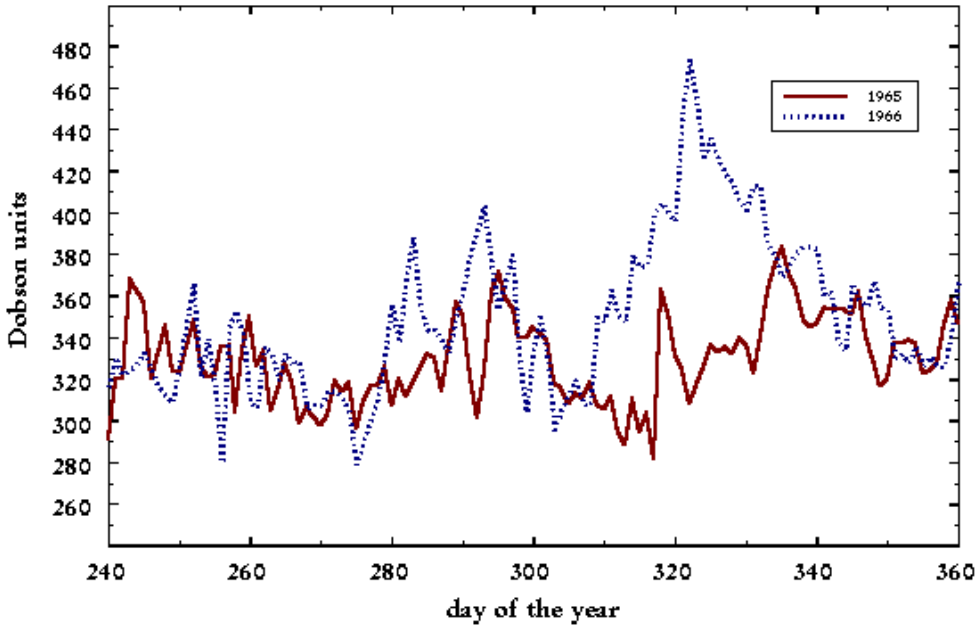

Figure 3: Daily means of the ozone total column for the last trimesters of 1965 and 1966 showing a November maximum in 1966 relating to a sudden stratospheric warming. These conditions correspond to the break-up of a stable polar vortex, however, no “ozone hole” appears in these data (the current ozone hole has the minimum ozone values around the beginning of October, days 300-320). Dobson units correspond to vertical columns of ozone, one hundred Dobson units being equal to 1 mm of pure ozone at normal conditions (1013 Hpa and 0° C).

Distribution of this example set.

In order to allow a preservation of the digitized data set, it was put on a secure server of the Belgian Institute for Space Aeronomy and can be accessed to the internet at http://ozonehistory.aeronomie.be/history.htm, this site gives both historical context and access to the entire data set including observers notes, allowing anybody to make an own reanalysis. These data are far from being dead as they could be entirely retreated if a calibration report of the Dobson spectrophotometer 51 after its return in Europe could be found, unfortunately, the instrument was decommissioned in 1971 when it was used as a test bench for automatic ozone data acquisition at the ETH in Zurich. After this task was completed, most of its documentation was lost and we still have to trust the declaration of Wisse and Meerburg [4] that after checking the instrument upon its return to the Netherlands, there was no reason to modify the parameters used in the initial analysis. To our knowledge this test case is the only data set of the time having received this treatment.

THE PRESENT: A COMMON PORTAL FOR ANTARCTIC DATA

NASA took the initiative to regroup the data concerning Global Change in Antarctica in the portal http://gcmd.nasa.gov/KeywordSearch/amd/nadc_portals.html which regroups portals of national institutions now active in Antarctica. This portal is not really integrated, the user has to browse through the national centres sited to really know if the required data is present; A progress would be for one the major players to make this portal a real service with an efficient search engine. The data sets collected show the very wide variety of records archived by the national institutions. A trail would be semantic web studies as the ones introduced in the FP-7 ULISSE test project of collecting and preserving the International Space Station results.

THE FUTURE: ARCHIVING AND DISTRIBUTION OF DATA FROM A CONNECTED ANTARCTICA.

Up to now, communications with Antarctica have been difficult, while the Arctic Ocean is well covered by Russian MOLNYA communication satellites with an eccentric elliptic orbit covering the North Pole, Antarctica will never benefit from a similar system because of the restrictions on economic activities put by the Antarctic treaty itself. Two civilian systems are currently used for navigation at high latitudes, the INMARSAT relay satellite and the IRIDIUM constellation, both are too expansive for science budgets and do not allow permanent high data rate transmission. However the increase in capability from the civilian geostationary satellites could lead soon to an improvement of data transmission. The new "Princess Elisabeth" polar station will be used in this respect to transmit its data using spare capabilities of the ASTRA commercial satellites to an operation centre in Brussels enabling both remote operations and direct archiving of the data. The similarities with space operations both on the International Space Station and in automatic planetary exploration programmes are evident and will allow developing new concepts where data analysis will influence operations.

Figure 4: the “Princess Elisabeth” station in Antarctica, this station operates on renewable resources and is unmanned during the polar night, making it a perfect candidate for the testing of remote operations and monitoring.

CONCLUSIONS

An integrated Antarctic data centre is yet to create, a reflexion should be initiated between the signatories of the Antarctic treaties to associate the provisions imposing scientific research with an obligation to archive and preserve the data. In the meanwhile, national authorities could initiate programmes based on the practice of space agencies concerning earth science data.

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