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The Repeat Station Network and Estimation of Secular Variation in the Australian Region

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Introduction

The repeat station network run by the Australian Geological Survey Organisation is a cost-effective way of supplementing data from the permanent magnetic observatories for the estimation of secular variation in the Australian region.

The existing five observatories (Fig. 1) on continental Australia have an average spacing of about 2000 kilometres, which is greater than the apparent wavelength of the secular variation. The observatories are therefore too few and too far apart to provide adequate information on the secular variation by themselves. It is too expensive to improve the coverage by installing more observatories. The repeat station network, on the other hand, is a relatively inexpensive method of providing more closely spaced data for estimation of secular variation and development of reference field models. The network has been designed to supplement the observatories, which record the magnetic field continuously, by infilling the gaps between observatories and extending the coverage beyond the observatories with some eighty-three repeat stations, that are occupied on a regular basis.

Uses of Secular Variation

Direct surveying of the magnetic field is very expensive, but can give the best representation of the magnetic field at the time of the survey. However the magnetic field changes with time, as indicated by the change of some 13 degrees in the magnetic declination at Hobart since Abel Tasman's measurements in 1642 A.D. Currency of survey data can be extended by applying secular variation corrections, determined from a small number of evenly distributed stations. The secular variation is estimated from analysis of data from the permanent magnetic observatories and the network of repeat stations (Fig. 1). Secular variation measurements are therefore used to update survey data to a common epoch, to adjust data recorded over a long time to a common epoch and to assist in studies of the origin and behaviour of the magnetic field. Furthermore, accurate secular variation data are required for the production of reference field models, and can be used for verifying such models.

The study of geomagnetism world-wide is biased by the density of stations in the northern hemisphere, particularly in Europe. The region covered by the observatory and repeat station network of AGSO represents almost one eighth of the surface of the Earth. Australia therefore makes a significant contribution to the global understanding of the secular variation. The density of the repeat stations within Australia equates with the density of magnetic observatories in Europe.

History

The network had its beginnings with the Carnegie Institute of Washington in the latter part of last century, and still contains stations that were occupied by them in their early systematic magnetic surveys of the globe, e.g. Suva (re-occupation of the HMS Waterwich station established in 1896), Eucla, Hobart, Port Lincoln and Mildura 1911. Re-occupations were spasmodic until the 1940s. Since 1946, when this work became the responsibility of the Federal Government, regular, approximately five-yearly re-occupations have been undertaken. During this time the network has been modified and improved to provide better coverage of the Australian region. The network now extends to Australian offshore islands, Papua New Guinea and south west Pacific islands.

Measurement Requirements

Measurement of the magnetic field for estimation of secular variation is an exacting task. During magnetic repeat station surveys, four vector components of the magnetic field, including total intensity, are measured at each station over a period of three to four days. Methodology is stringent to ensure that measurements are calibrated to absolute levels, that the exact location can be re-occupied in future, and that the immediate magnetic environs remain unchanged for years, even decades. Other considerations are the inherent need to standardise instruments, and to remove 'noise', such as diurnal and magnetic storm disturbances, to ensure that the estimation of secular variation is accurate.

Effect of External Fields

External fields vary continuously. Diurnal variation is the cyclic change of the magnetic field throughout the day, whereas magnetic storms cause large scale irregular fluctuations. The regular diurnal change is most evident between 9 am and 3 pm local time, and is generally larger in summer than winter with peak-to-peak magnitudes of 4 to 15 minutes of arc for D, 15 to 70 nT for F, 20 to 80 nT for H and 15 to 70 nT for Z. Field disturbances during a magnetic storm can vary greatly depending on the severity of the storm and may last from less than a minute to several days. For example, over an interval

of 15 minutes, during the storm of 13 July 1982 the field in Canberra changed by 55 minutes of arc in D, 620 nT in H and 220 nT in F. Estimation of secular variation by first differences, which are small compared to natural fluctuations (may be less than a few nanotesla per year), is not therefore an easy task.

"Super" Repeat Stations

Five-yearly occupations of repeat stations have, in some cases, proved insufficient for accurate estimation of secular variation in areas of rapid change. In areas of rapid secular variation change, deriving the secular variation by first differences for data four to five years apart can lead to erroneous estimates of secular variation. To overcome this problem, the concept of "super" repeat station has been introduced. A few strategically located stations have been designated as Class A (super repeat station) (Fig. 1). AGSO intends to re-occupy these annually. It is expected that these, together with the permanent observatories, will provide data adequate in time and space to track the secular variation accurately. The remainder of the existing repeat stations will be occupied five yearly (Class B) or ten yearly (Class C), to cover the off-shore areas and to provide additional detail between the onshore Class A stations.

References

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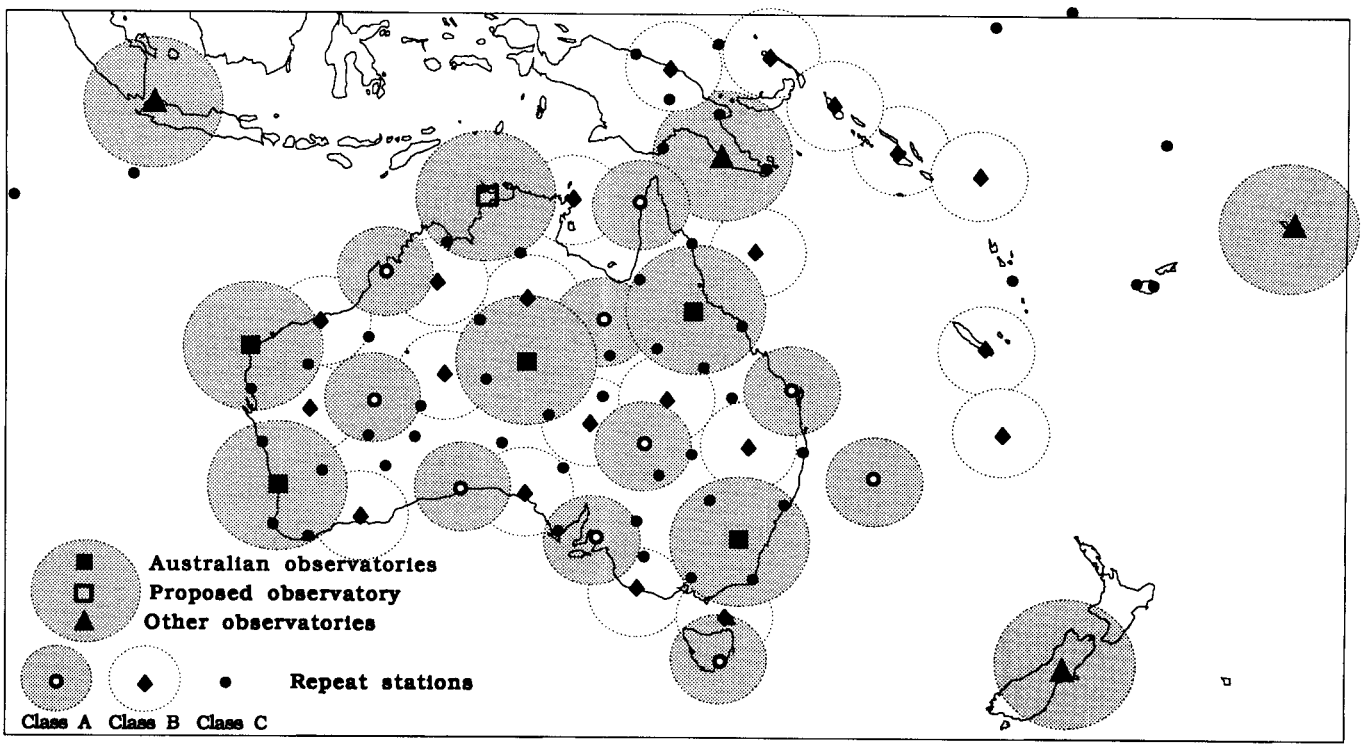

FIGURE 1
Magnetic observatories and repeat stations in the Australian Region. The New Zealand and Indonesian repeat stations are not shown.