# Compact Array Pointing
# Thermal Effects

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## Summary

**We have made a sequence of antenna pointing measurements over a 24 hour period and confirmed earlier measurements (Nelson and Kesteven, 1987) of a strong correlation between elevation pointing error and ambient temperature. Our measurements show that the six antennas differ markedly in the thermal effect on their pointing. We find antenna specific variation in the thermal coefficient and have measured values of up to 2.5"/K with correlations up to 0.8. The typical diurnal temperature range at Narrabri of 15°C induces elevation pointing errors over a 35"range in some antennas. At present we do not know the origin of the differences between antennas.**

## Intoduction

For some time it has been obvious that the pointing is not very stable over the period of about a week at the 10–20 second of arc level. It has been difficult to quantify the nature of this unstability, and in an attempt to discover if there was any diurnal effect, or if there were any longer term drifts, we reserved two 24 hour observing periods (one week apart) during the August '93 shutdown to monitor pointing changes.

Measurements made by Nelson & Kesteven (1987) have characterised the thermal induced tilts on one antenna. *Talyvel* electronic levels were used to measure changes in antenna tilt with temperature over a period of several days. The antenna was held in the stowed position throughout the measurements. Thermal coefficients of 0–2"/K were observed and there was marked hysteresis in the tilt changes over the dirnal temperature cycle. The measurements described here differ from those of Nelson & Kesteven in that they are made by observing radio sources at a variety of elevations and that they are made on all six Compact Array antennas.

## Pointing

Antenna pointing is imperfect. We estimate corrections to the pointing for each antenna using an expression which models the known physical effects leading to pointing errors. In order to calculate the model – determine parameter values for the expression – we measure pointing errors for a number (10 – 20) of radio sources (pointing calibrators) which are widely spread

| Antenna | No temperature fit | | With temperature fit |
|---|---|---|---|
| | $\sigma(\epsilon_{Az})$ | $\sigma(\epsilon_{El})$ | $\sigma(\epsilon_{El})$ |
| 1 | 6.9 | 7.1 | 6.5 |
| 2 | 4.4 | 12.4 | 6.4 |
| 3 | 4.3 | 12.7 | 7.3 |
| 4 | 4.9 | 11.6 | 6.6 |
| 5 | 4.1 | 6.5 | 5.3 |
| 6 | 6.1 | 11.2 | 6.8 |

Table 1: Standard deviations of pointing errors

in azimuth and elevation. We refer to this series of measurements as *"pointing observations"*. The standard pointing model (Kesteven and Calabretta, 1986) has 10 parameters. We usually reduce data from pointing observations by fitting for four of these.

## Observations

Because of hardware failure, the second of our observing periods was unavailable, so we were only able to evaluate the diurnal effects. A standard pointing run had been done two weeks prior to the observations, so the effects reflect the effects that an observer would be suffering from.

The observations were conducted as a series of runs that, individually, mimicked the standard pointing observations, *ie* a series of 10 pointing observations done on sources spread widely in azimuth and elevation. The shortest baseline was 30m which meant that the elevation range towards the east and the west was limited by antenna shadowing.

## Reduction

Each run was individually processed, using the standard parameters (antenna tilts, and encoder offsets): the rms errors on each antenna after reduction was around 6″. However, when all the data were combined a number of antennas had standard deviations in their elevation errors of around 12″(table 1).

On antennas with large rms errors, the correlation between temperature at the site weather station and elevation error was large (figure 1). On the antennas where the effect was most pronounced it amounted to about 2.5″/K. It also demonstrated that, in this regard, there are significant differences between antennas

Assuming that this effect is caused by the thermal expansion and contraction of the main members of the antenna structure, there should be some delayed between a given temperature (and possibly its derivative) and the effect that it causes on the pointing. We tried finding the lag most appropiate for each antenna (figure 2). This also seems to vary for different antennas.

## Recommendations

We need to do a similar observation and determine if the effects were repeatable. (The next time that there is the option for 24 hour pointing runs is in the December '93 maintanance period. Both the temperature and diurnal temperature range will be greater.) We intend to persue the following points:

- make measurements with an array without antenna shadowing problems;
- make measurements with temperature probes located at selected positions on several antennas;
- consider mechanisms which might account for the differences between antennas.

## Reference

Kesteven M J and Calabretta M, Australia Telescope technical notes AT/25.1.1/029, 1986.

(a) (b)

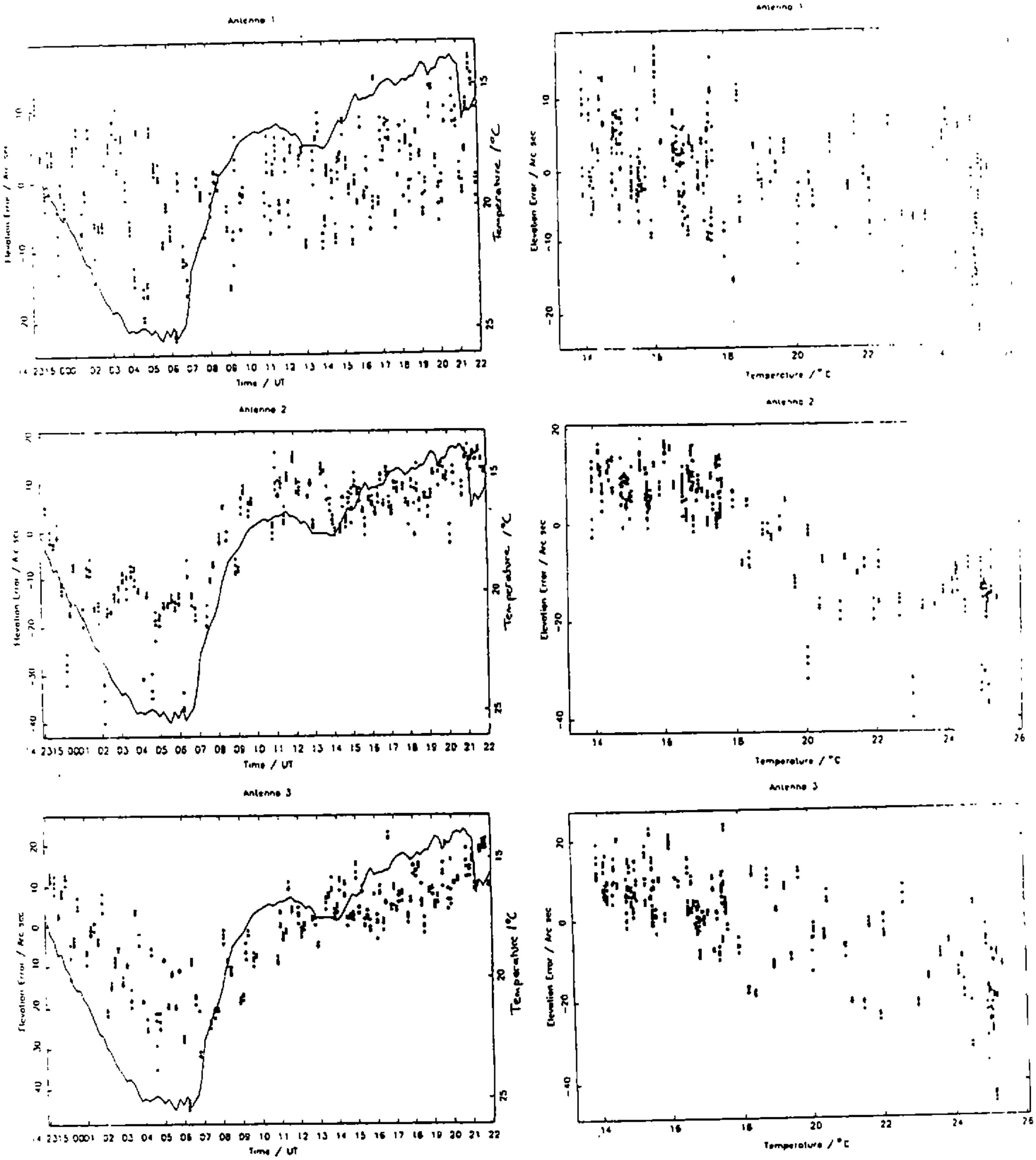


FIGURE 1 Antennas 1, 2, 3

(a) Elevation error and ambient temperature vs. time

(b) Elevation error vs. ambient temperature.

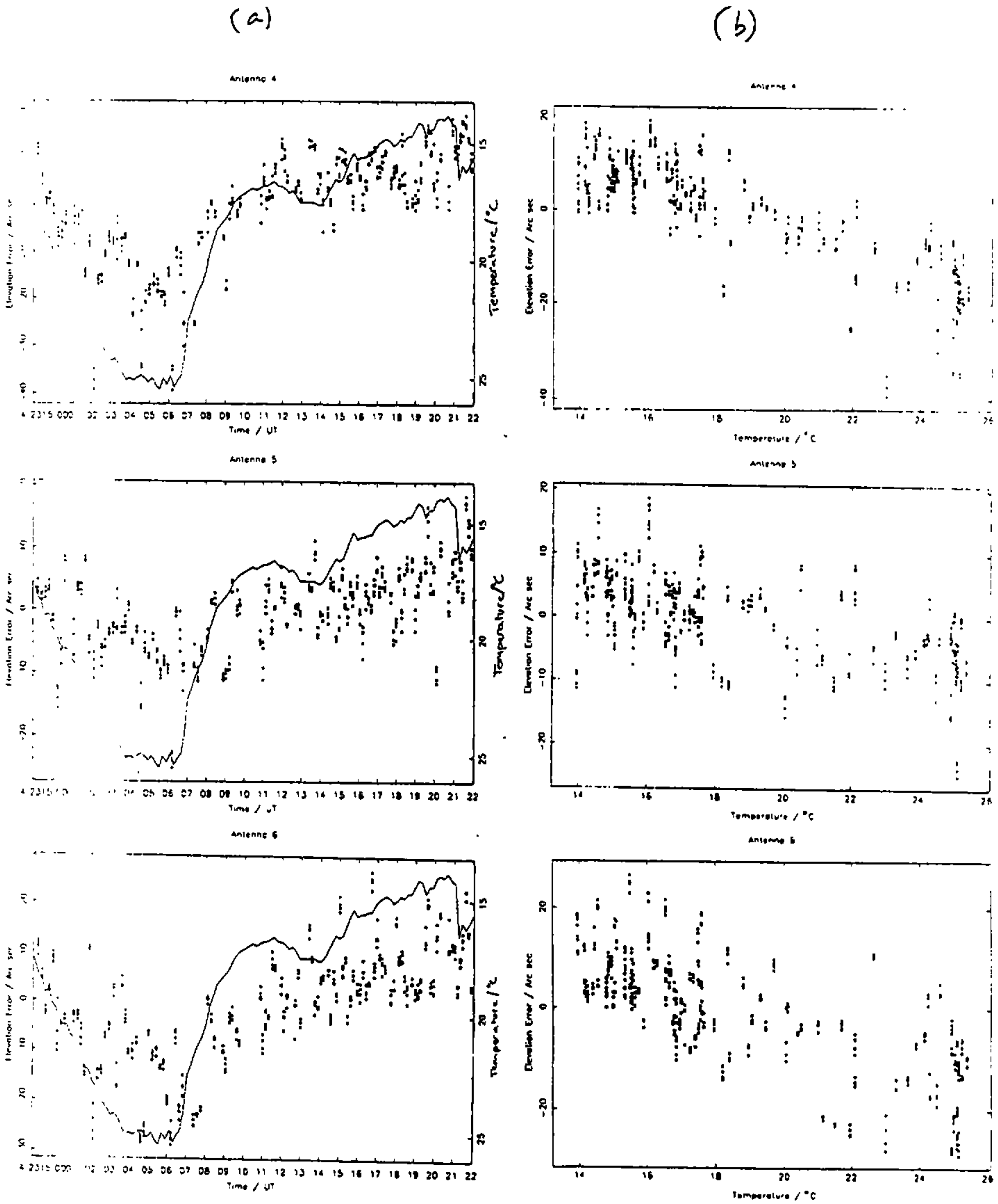


FIGURE 2 Antennas 4, 5, 6
(a) Elevation error and ambient temp. vs time
(b) Elevation error vs temperature.

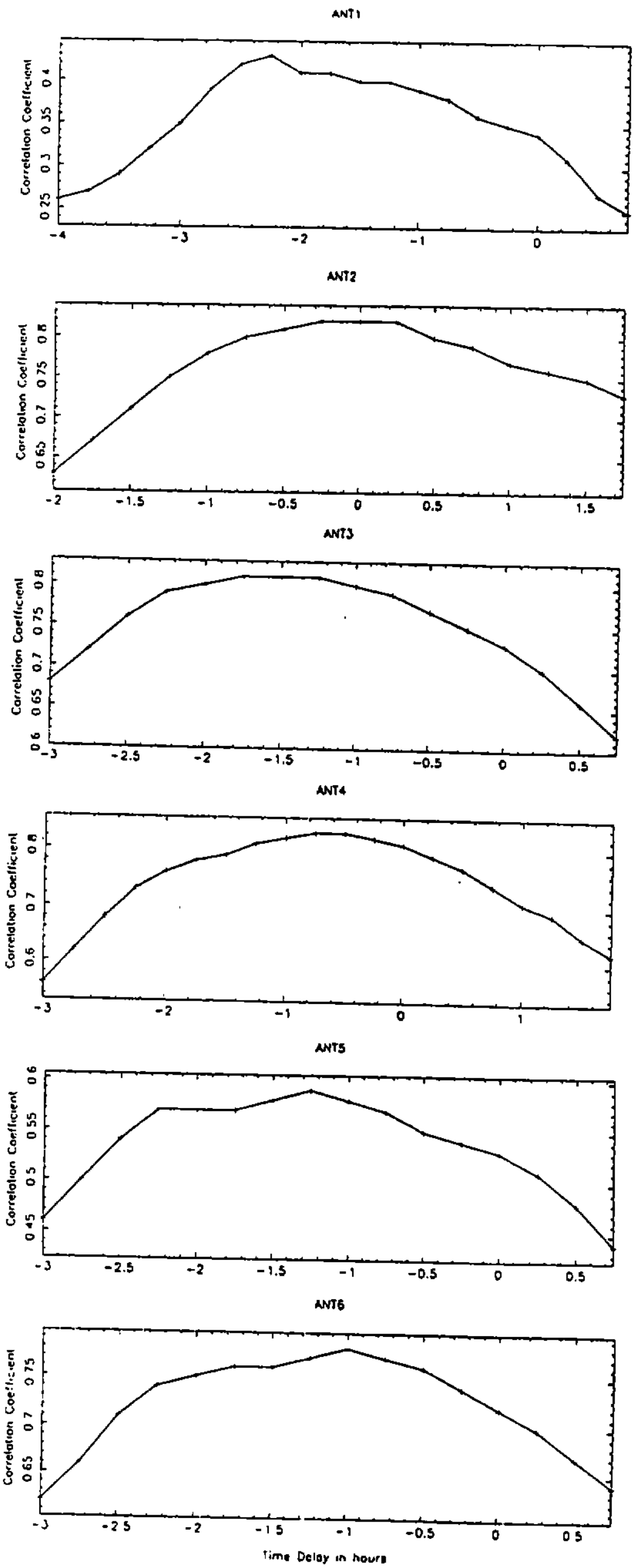
ANT1
ANT2
ANT3
ANT4
ANT5
ANT6
Correlation Coefficient
Time Delay in hours

FIGURE 3