

Parkes Wind Loading - Calibration

M.Kesteven

April 29, 2002

Abstract

Data has become available allowing us to calibrate the elevation drive currents in terms of the elevation torque. From this data we can infer the actual wind loading on the Parkes antenna.

1 The Data

The observations were carried out by Harry Fagg in April, 2000. In stage 1 he drove the antenna between elevations 31 and 40 degrees. He then added a 200 kg load to the focus cabin and repeated the drive sequence. He obtained 4 datasets: the motor currents while driving UP and driving DOWN, with and without the additional 200 kg load. The drive rate was 6 degrees/minute.

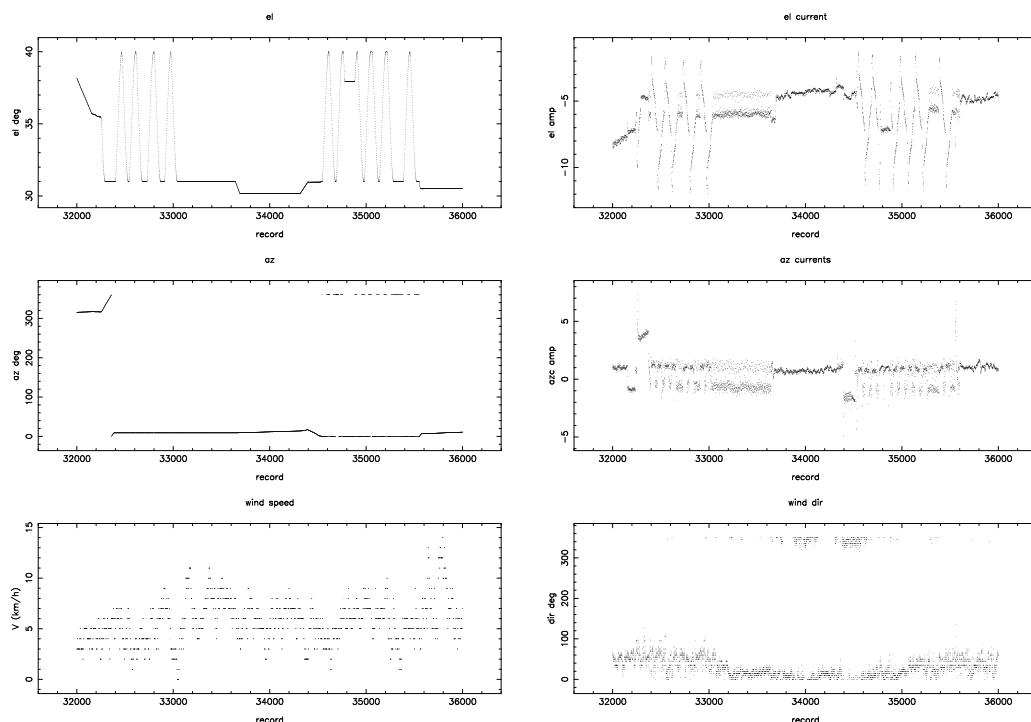


Figure 1: The observations. The top row shows the elevation and the elevation drive currents as a function of time. The second row has the azimuth and azimuth currents. The bottom row has the wind speed and direction

The data are shown in figure 1. The figure shows the elevation as a function of time (top left panel); the corresponding currents are shown in the top right panel. The figure also shows the azimuth and the azimuth currents, the wind speed and direction.

It will be noted that the wind speeds are low, and should not affect the torque calibration.

2 Analysis

Plots of drive current as a function of elevation are shown in figures 2 and 3. The main features to note:

- The higher the elevation, the higher the current required. That is, the greater the torque.
- The drive direction is important: the torques are less when driving towards the zenith. The counterweight torque assists the drive when driving up. The difference, at any elevation, between the UP and the DOWN currents is twice the drive losses.
- The "hooks" evident at the scan starts are presumably the acceleration currents, and not a structural effect.

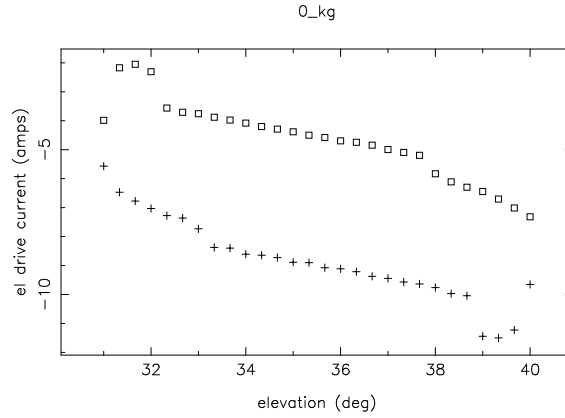


Figure 2: The drive current - elevation function, under normal conditions. The symbols distinguish the drive direction: "o" when the antenna was driving towards the zenith, "+" when driving towards the horizon

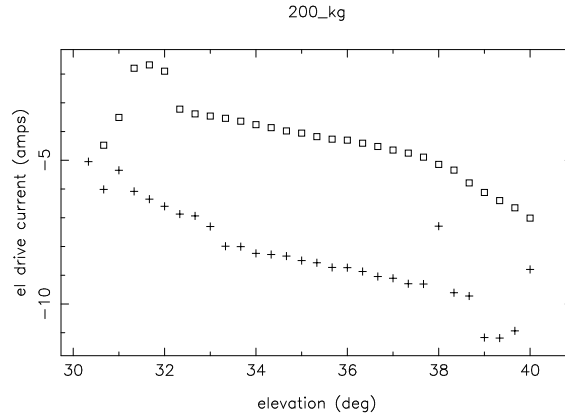


Figure 3: The drive current - elevation function, with a 200kg load added to the focus cabin

The difference between the unloaded and loaded experiment is small, but very clear - about 0.375 amps - see figure 4.

We can now calibrate the drive currents: the focus cabin is 26.3 m above the vertex, and 35.6 m above the elevation axis. The additional torque is therefore: $\text{Torque} \sim 7120 \cos(\text{el}) \text{ kg-m}$

The current difference (corresponding to an increased torque) of 0.375 Amp means that our calibration factor is thus

$$T_f = \mathbf{15.5 \text{ tonnes-m/amp}}$$

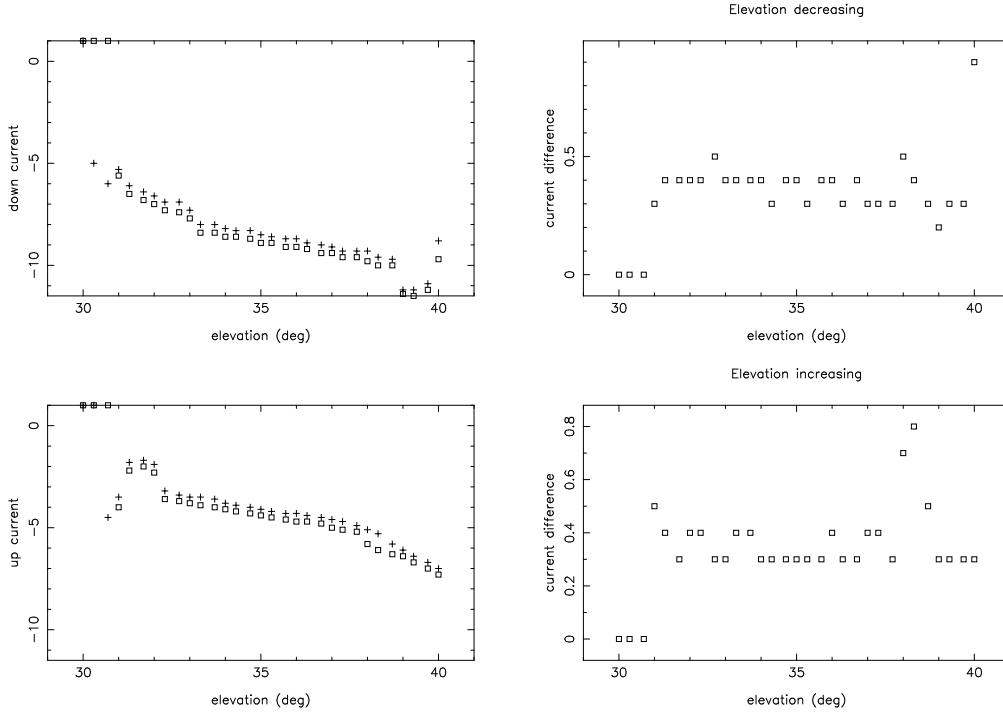


Figure 4: The left hand panels show the raw data, with the "o" symbols denoting the unloaded case, and the "+" symbols for the loaded case. The right hand panels show the difference due to the 200 kg load

3 Wind loads

Motor current and wind data have been monitored and logged for the past few years. Figure 5 shows the elevation drive currents as function of elevation for days with low wind speed. Figures 6 and 7 are the corresponding plots for times when the wind speeds were in the range 25-30 km/hr. (These figures are based on a representative subset data - a comprehensive analysis of the full dataset is planned).

Winds blowing into the dish increase the torques; winds from behind reduce the torques. It is clear that at low elevations there is little freedom: the currents are indeed close to zero when driving towards the zenith, at winds around 30 km/hr.

In effect, at 30 degrees elevation, with no wind, there is a nett torque of about 5 Amps (mean of UP + DOWN) required to hold the dish steady. The torque due to a 27.5 km/hr wind together with the driving losses (both equivalent to about 2.5 A) combine to reduce the loading on the bull gear to zero.

Figures 8 and 9 show the change in currents due to the windloading, expressed in tonnes-m, based on the calibration factor derived earlier. Also shown on these figures are the predictions based on the JPL wind tunnel data. The predictions are given in table 1.

The agreement is fair - rather better than one might have expected given the many uncertainties that entered the calculations. However, they do suggest that the predictions (as in table 1) do provide a basis for estimating the additional windloading which will follow the panel upgrade.

4 Discussion

- It is clear that the predictions do not map well the actual elevation dependance : the observations are essentially neutral to elevation, whereas the predictions have greater torques at high elevation.

This may arise because the predictions make no allowance for a possible height profile in the

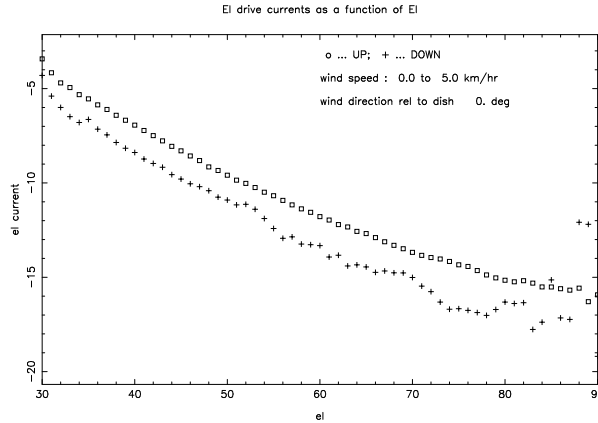


Figure 5: This shows the full current - elevation function, under low wind speed conditions

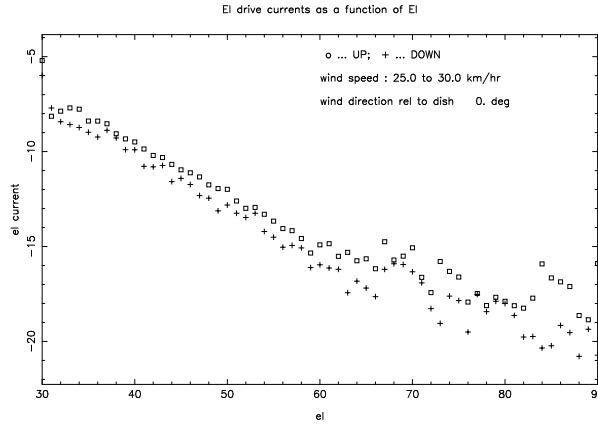


Figure 6: The current - elevation function, wind blowing into the dish, for wind speeds in the range 25 to 30 km/hr

wind velocity.

It may have implications for the vulnerability to wind stow after the panel upgrade.

- The plots shown in figures 2 and 3 suggest that the acceleration away from low elevations may introduce a short period of backlash.
- There is a period of drive "chatter" evident in figure 1 (in the interval record 33000 to 33700). It is present in both azimuth and elevation. A similar burst is shown in figure 10; in this example the antenna is slewing in azimuth. It might be wise to check that this has no adverse consequences.
- The main message from the drive current - elevation curves is that the counterweight is no longer optimally set. The ideal (and designed - see D. Yabsley's report) would ensure that the peak torque occurred at an elevation of about 60 degrees. At present the peak occurs at elevation ~ 120 degrees.

The weight above the elevation axis is about 800 T; the torque at zenith is 16.5 A, or 256 T-m, which puts the centre of mass at :

$$x = 32 \text{ cm}$$

$$y = 18 \text{ cm}$$

relative to the elevation axis.

A mass of about 30 T is required to restore the centre of mass to its designed location, with the peak torque at 60 degrees.

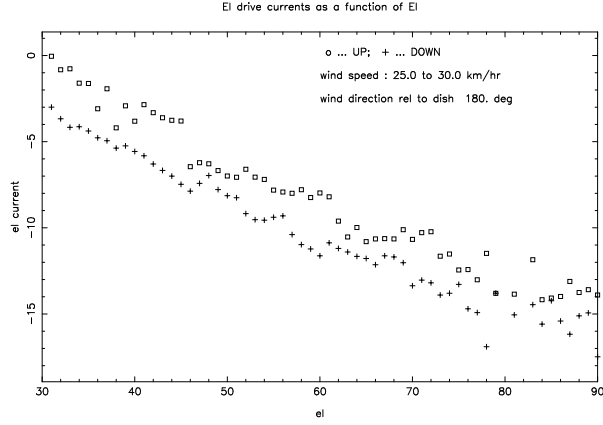


Figure 7: The current - elevation function, wind blowing into the back of the dish, for wind speeds in the range 25 to 30 km/hr

elevation	22m perforated (tonnes-m)	27m perf (tonnes-m)	
30.	-24.	- 29.	wind into dish
60.	-42.	-50.	wind into dish
90.	-50.	-60.	
60.	55.	66.	into back
30.	23.	27.	into back

Table 1: The predictions of the torques about the elevation axis, based on the JPL wind tunnel data. Two cases are examined : perforated panels out to 22 m, the present configuration; and perforated panels out to 27 m, the planned upgrade. Each case is a model with perforated panels out to the specified radius, then mesh out to 32 m radius

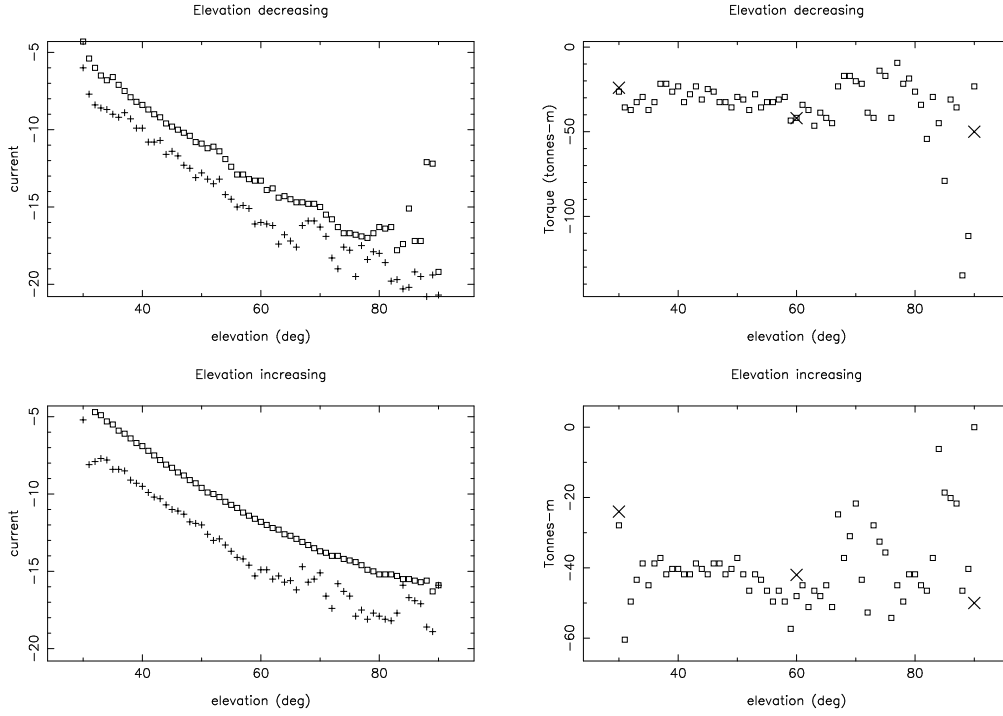


Figure 8: The wind loading as a function of elevation for winds in the range 25-30 km/hr, into the dish. The panels on the left show the zero-wind data as "o", and the 25-30 km/hr wind data as "+". The right hand panels show the difference in the currents (high wind - zero wind) converted to torques. The torque predictions, based on the JPL data, are shown as "X"

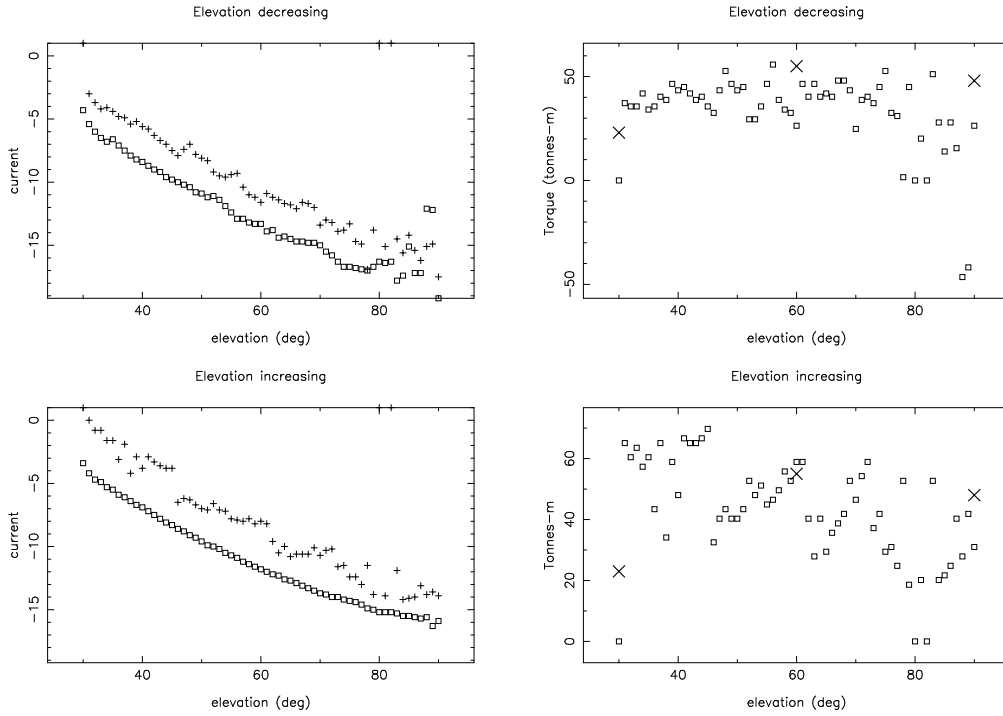


Figure 9: The wind loading as a function of elevation for winds in the range 25-30 km/hr into the back of the dish. The predictions based on the JPL data are shown as "X"

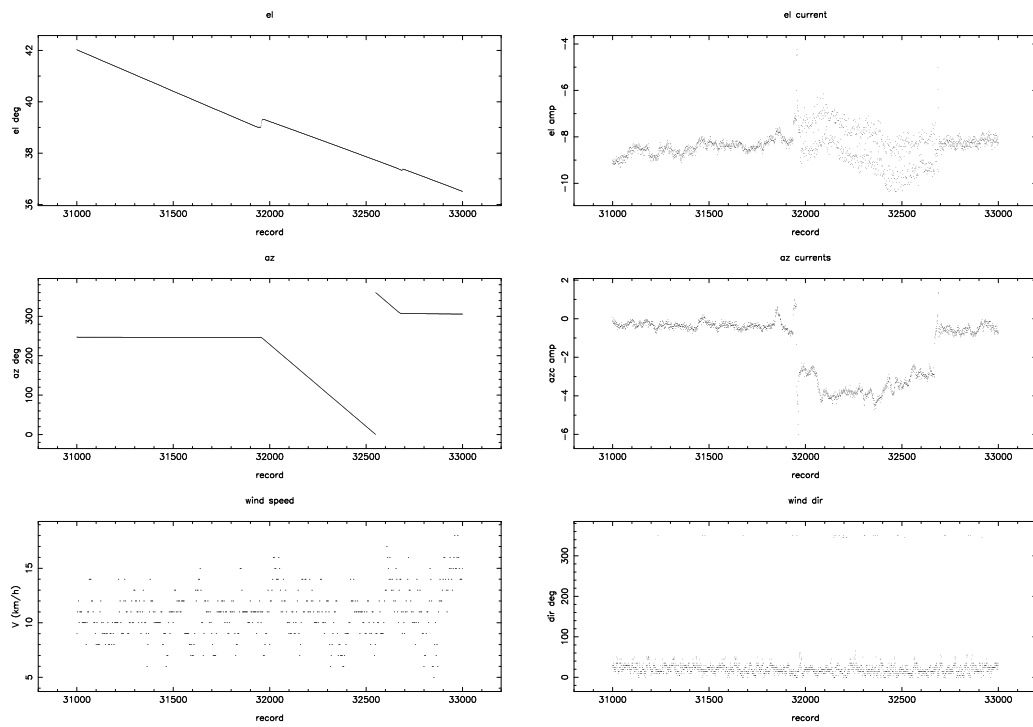


Figure 10: This is a second example of apparent chatter in the elevation drive. It occurred during a rapid azimuth slew, seen in the central panel. This event occurred on April 3, 2000