VLA Test Memo. No. 227

Holographic repeatability and accuracy

C.L. Carilli

National Radio Astronomy Observatory

Socorro, NM, 87801

September 5, 2001

Abstract

Holographic measurements at 43 GHz of surface panel deviations on the VLA antennas from February 2000 and February 2001 show that surface measurements are repeatable on yearly timescales, and can be measured to an rms accuracy of about 0.11 mm for a standard observation. This rms is of similar magnitude to the accuracy to which the mechanics can adjust the panels.

1. Introduction

Interferometric holographic measurements of surface panel deviations have been made at the VLA since 1992. These measurements are then used as guides for panel readjustments (Kestevan VLA Test Memo 169, 1993). Adjustments have been made at the VLA based on observations at 8 GHz, 22 GHz, and 43 GHz.[1] The process has been shown to improve the aperture efficiency by a factor of two, or more, at 43 GHz. The ultimate goal is to have most of the antennas with efficiencies between 30% and 40% at 43 GHz.

In this memo I investigate the repeatability of surface deviation measurements on yearly timescales, and determine the limits to the accuracy of such measurements using standard holographic observations at 43 GHz.

2. Observations and Results

Observations were made at 43 GHz in the CnB array on Feb 14, 2000, and in the BnA array on Feb 22, 2001. In both cases the phase stability was excellent. An example of the phase solutions from the BnA array observation is shown in Figure 1. The array was essentially phase stable on hourly timescales on 20 km baselines.

The total observing time was five hours. A 33x33 raster was made of 3C273 (1229+020), with phase calibration every 6 minutes and 8 GHz reference pointing every hour. For the CnB array observations one reference antenna was chosen on each arm, while for the BnA array two or three reference antennas were used on each arm.

The results for the surface panel deviations for Antenna 8 are shown in Figure 2. The

---

[1]see: http://www.aoc.nrao.edu/ ccarilli/ccarilli.shtml for a summary of the status as of Spring 2001 and future plans.

panels on antenna 8 were adjusted using 43 GHz holographic measurements in March 1996. This antenna remains one of the better antennas at 43 GHz, with a aperture efficiency $\sim 30 - 35\%$. The upper left panel shows the results from Feb. 2000, and the upper right panel shows the measurements from Feb. 2001. The rms of the deviations is about 0.22 mm in both cases (excluding the diffraction regions around the feed legs). Careful inspection shows that surface structure repeats between the two epochs (eg. the positive deviations in the lower right quadrant). The lower panel shows the difference between the two images. Clearly the larger deviations are significantly reduced, and the rms of the difference image is 0.16 mm.

The results for the surface panel deviations for Antenna 19 are shown in Figure 3. The panels on antenna 19 were adjusted using 22 GHz holographic measurements in Nov. 1999. Antenna 19 has somewhat lower efficiency at 43 GHz ($\sim 20 - 25\%$), and this is reflected in the large, systematic surface deviations seen in Figure 3. The rms of the deviations is about 0.38 mm in both 2000 and 2001, and there is a clear correlation between the deviations seen at both epochs. Differencing the two images results in an rms of 0.20 mm (lower panel).

3. Conclusions

These observations show that holographic measurements of surface deviations are repeatable from year to year, and that once panel adjustments are made the antennas retain their surface for years.

I assume that the results on the good antenna (antenna 8) are an indication of the measurement noise level that can be reached in a reasonable amount of observing time on a bright (7 Jy) source at 43 GHz. The residual rms for antenna 8 after differencing the results from the two epochs was 0.16 mm, implying a noise level for each measurement a factor root two lower, or 0.11 mm. The antenna mechanics (Broilo, Thunborg, Serna, Molina) say that they can make meaningful adjustments to the antennas at the level of a few thousands of an inch, corresponding to ~ 0.1 mm.[2]

[2]The panel bolts have 13 threads per inch, such that 1 screw turn = 0.077in = 2 mm.

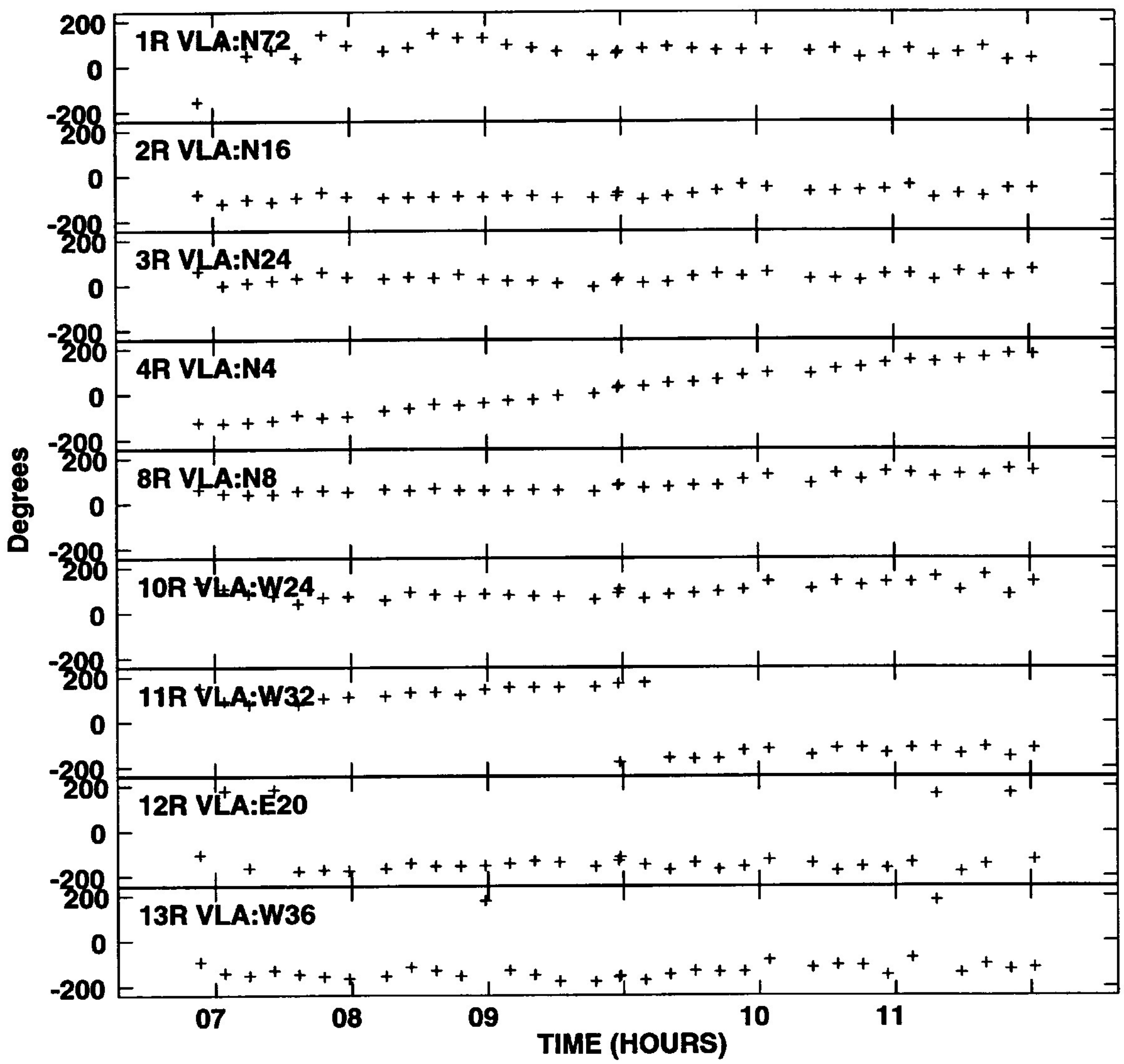

Fig. 1.— Antenna-based phase solutions versus time for the February 2001 observation at 43 GHz.

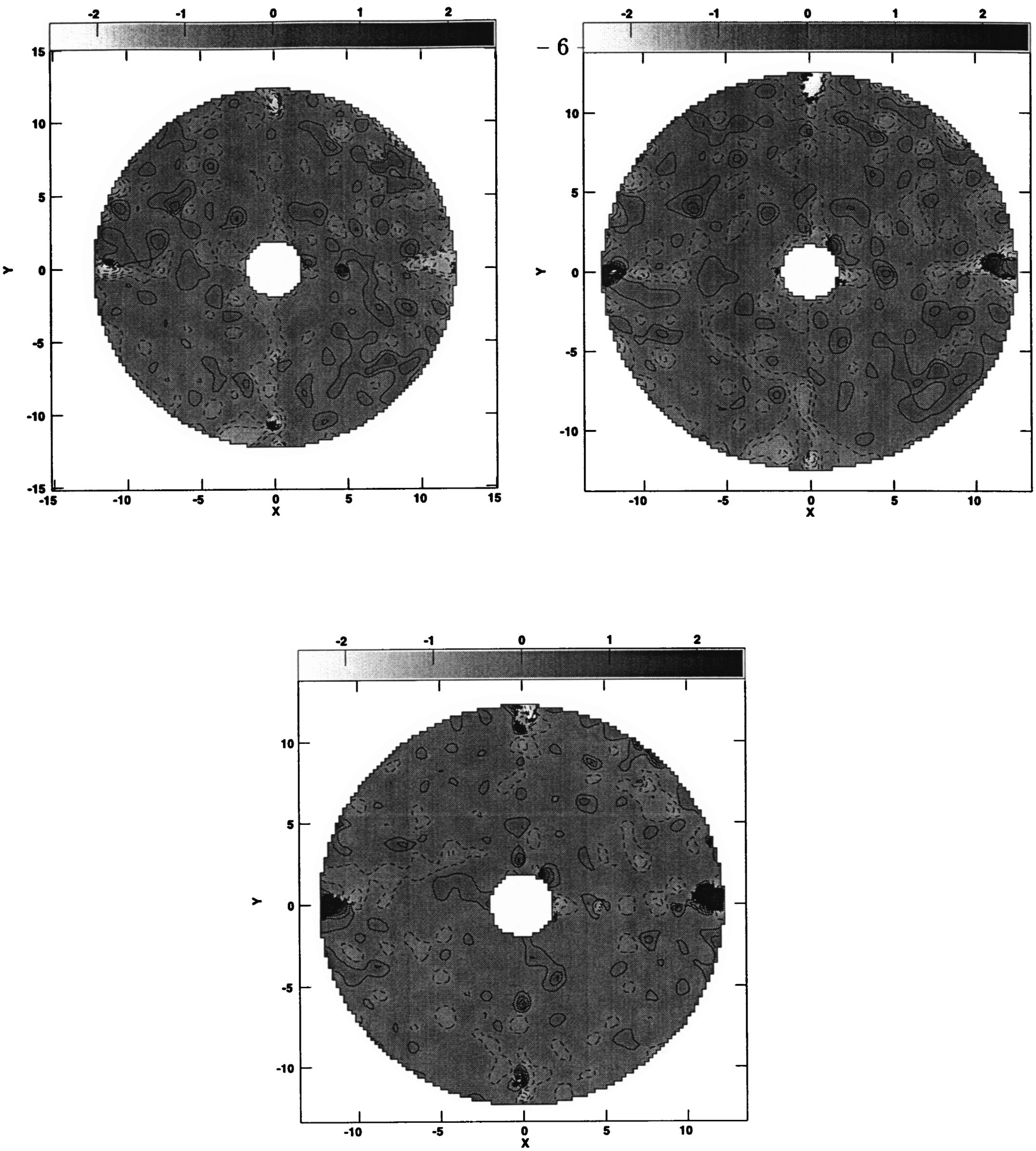

Fig. 2.— Antenna 8: Upper left = February 2000, Upper right = February 2001, Lower = Difference. In all three cases the contour levels are: -1.1, -0.8, -0.5, -0.2, 0.2, 0.5, 0.8, 1.1 mm. The greyscale range is -2.5 mm to +2.5 mm

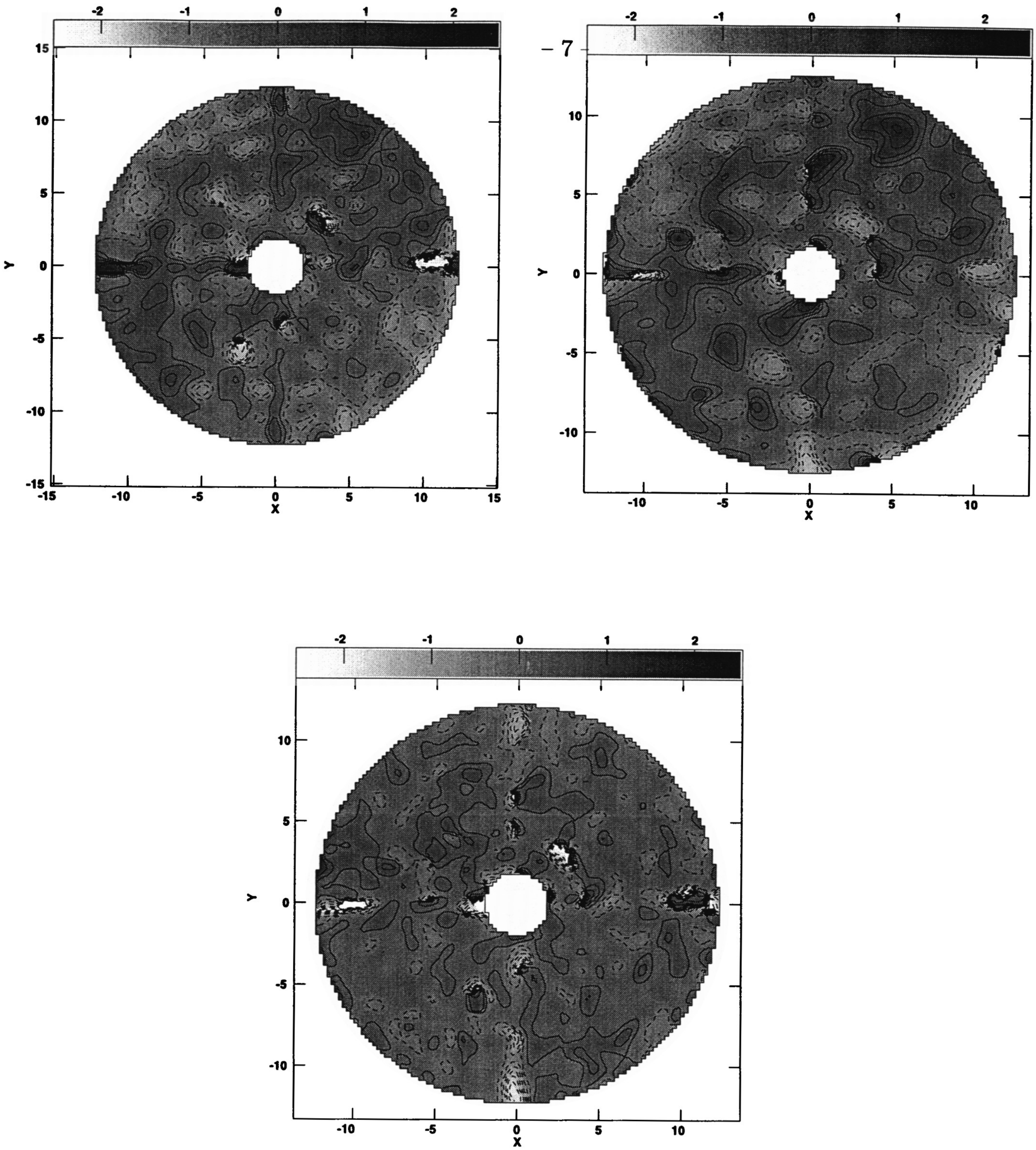

Fig. 3.— Antenna 19: Upper left = February 2000, Upper right = February 2001, Lower = Difference. The contour and greyscale levels are the same as Figure 2.