Inspection of Flatfields from the Decontamination Monitoring Programme

ESO Wide Field Imager

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Contents

1 Preamble

In November 1999 the CCD dewar of the ESO Wide-Field Imager (WFI) was dismounted and cleaned of contaminants that had accumulated on the CCDs. The 2p2 Team undertook a monitoring programme through the weekly collection and measurement of dome flats in $UBVRIZ$. Here, we examine those frames, concentrating on those in B and I.

2 Analysis

Raw flatfields were taken on the dates in Table 1 by various members of the 2p2 Team and passed through the MIDAS procedure `Weekly_Health_Check` written by Thomas Augusteijn. This makes a ratio of each flat with its immediate predecessor and bins the resulting image by a factor of 4. It also produces a postscript contour plot with cuts at the appropriate levels. The resulting image and its plot were kept on disk; the raw images cleared but stored on tape.

Table 1: Dates upon which $UBVRIZ$ dome flats were taken by the team.

1	1999-12-01	6	2000-01-15	11	2000-03-04	16	2000-04-11
2	1999-12-02	7	2000-01-17	12	2000-03-04	17	2000-04-24
3	1999-12-23	8	2000-01-24	13	2000-03-11		
4	2000-01-02	9	2000-02-03	14	2000-03-15		
5	2000-01-09	10	2000-02-12	15	2000-04-01		

To derive some quantative measure I converted the ratio images to FITS and measured the level in the *full* binned pixel set of four chips (CCDs 57, 51, 55, 53) using a purpose-written IRAF script. Table 2 summarises the areas sampled. These levels were tracked across all dates for each filter.

Table 2: Image regions sampled of the 4×4-binned ratio images.

Chip Number	Region Sampled
57	`[10:255,10:510]`
51	`[282:525,527:1026]`
55	`[546:790,10:510]`
53	`[817:1061,525:1026]`

3 Flatfield Appearance

The pages towards the end show 16 of the 17 contour plots produced by Thomas's program for each B and I, in chronological order. The last was dropped for space reasons, without loss of generality. I examined the actual ratio images rather than the contour plots, which, as might be expected, do not show the more subtle features. Several points are worth noting.

- The first image in the set for both B and I (`19991201`) shows the first post-decontamination flat divided by a pre-decontamination flat. It shows the classic contamination pattern of a ring around the edge of the mosaic, and beyond (on the side where the tracker chip is located). None of the images thereafter show the ring, which is encouraging since it suggests that contamination has not re-appeared.
- The general distribution of illumination has changed between different weeks. The same shape is seen through all flats taken on a given day, irrespective of the filter used. The obvious conclusion is that 2.2 m dome flats fail to pass the most basic test of reproducibility. Clearly this limits what we can conclude from any changes in level from week to week. Observe that these changes were happening *both* before and after the procedure of checking the alignment of the screen and telescope tube by eye was started in January 2000.
- The `20000109` image in B shows a bright LH-edge and matching dim RH-edge of equal size ($\sim 1/6$ chip-width), both with a sharp boundary. The corresponding flat in I does not show these but shows rounded corners, suggesting some sort of vignetting. These features are apparent only on the images themselves and are not as well shown by the contour maps.
- Some of the plots show no detail in any of the chips apart from some strong bad columns in chips 50 and 57 (LHS). These images are remarkable for their uniform structure, quite unlike that of other flats. Despite their differences in structure, both image types carry ratios near unity. Images that are *completely* flat (*i.e.* $\leq 0.2\%$, according to the contour levels) are those from `20000212` and `20000304`, in both filters. It is *these* few cases where dome flat reproducibility has been achieved.
- Images `20000124` and `20000203` in both I and B are noteworthy for the profusion of dust donuts seen on both – presumably from the original image common image. None of the other ratios show anywhere near as many donuts. This leads to the suggestion that maybe telescope focus plays a more important role in flatfield reproducibility than had been assumed when we commenced the monitoring programme. Furthermore, the donuts are on optics other than filters, as a comparison between the B and I contour plots of `20000124` demonstrates, where both have donuts in common.
- The flats of `20000311` show a curious but different structures in each filter. In the B flat, a close-packed diagonal pattern of wavy lines affects all 8 chips in the mosaic, the likes of which I have never seen in any telescope flatfield elsewhere. This pattern can be seen on the contour plot, although not as clearly as it appears on the image. In I, this pattern is not present but the illumination pattern has a strong circular geometry, particularly noticeable in the mosaic corners. `20000401` is another I flat ratio with this corner geometry.
- The I-band ratios were examined for high-frequency structures (such as CCD fringing) that may have remained after division. None were found, suggesting that either such structures are very stable over ~ 1 week timescales, or that there is no fringing present at all. I suspect it is the latter, since the incident light is not monochromatic in this case.

In short, while the dome flats for both B and I ratio to near unity in all cases, they are highly nonreproducible, with a variety of structures and illumination patterns present.

4 Flatfield Levels

Figure 1 shows the evolution of the ratio values over time, on a chip-by-chip basis, for both the B and I image sequences. Different line-styles are used to trace the ratios in the different chips. The chip-to-chip variation is remarkably small – $\sim 5\%$ or less, in all images except the 'unlucky' 13th measurement in B (`20000311`). This is the image with the woeful diagonal pattern discussed before. Otherwise, the variety of dome flat structures do not account for much change in level between chips on individual frames.

The variation between frames taken at different times is much larger – of order $\sim 10 - 20\%$, or even greater if we include 4 outlier points. For all measurements, exposure times and lamp voltages were kept as uniform as could be managed with the set-up we have. This is not to say that the lamp does not carry some sort of intrinsic variation. However, it is difficult to believe that this alone would be responsible for shifts of up to 40%.

A change in decontamination would produce a steady decline in throughput, and this we do not see. Furthermore, the variations are seen in both bands are more or less similar, indicating the absence of any colour effect.

5 Conclusions

The conclusions we can draw are as follows:

- Dome flats from 2.2 m are not reproducible and should probably be avoided altogether for use with science data. The best hypothesis I can suggest is that the flatfield screen is not large enough to account for reproducibility of the dome position, as it is provided by the TCS. Alternatively, it could be that focus is more critical in making a good dome flat than we originally assumed. This would be interesting if it turned out to be the case, given that a dome flat is going to be an out-of-focus image in any case, no matter how much you shift the secondary.

- Despite our best efforts in maintaining constant exposure times and lamp voltages, variation the illumination *level* reaching the CCD are not ruled out. However, variations of 40% as seen in the trace would not be due to this alone. Variations in lamp voltage *would not* make for the variable structures and patterns, only a shift in the illumination *level*.

- The corollary of this is that tolerances of the dome flatfield set-up are insufficient to provide reliable calibrations. At the moment, any attempt to set tolerances on the repeatability of low spatial frequency structures would be in vain.

- Decontamination does not appear to have returned to the dewar. Throughput levels have remained constant over the past few months, so far as we can judge from the dome flats and their variable structure.

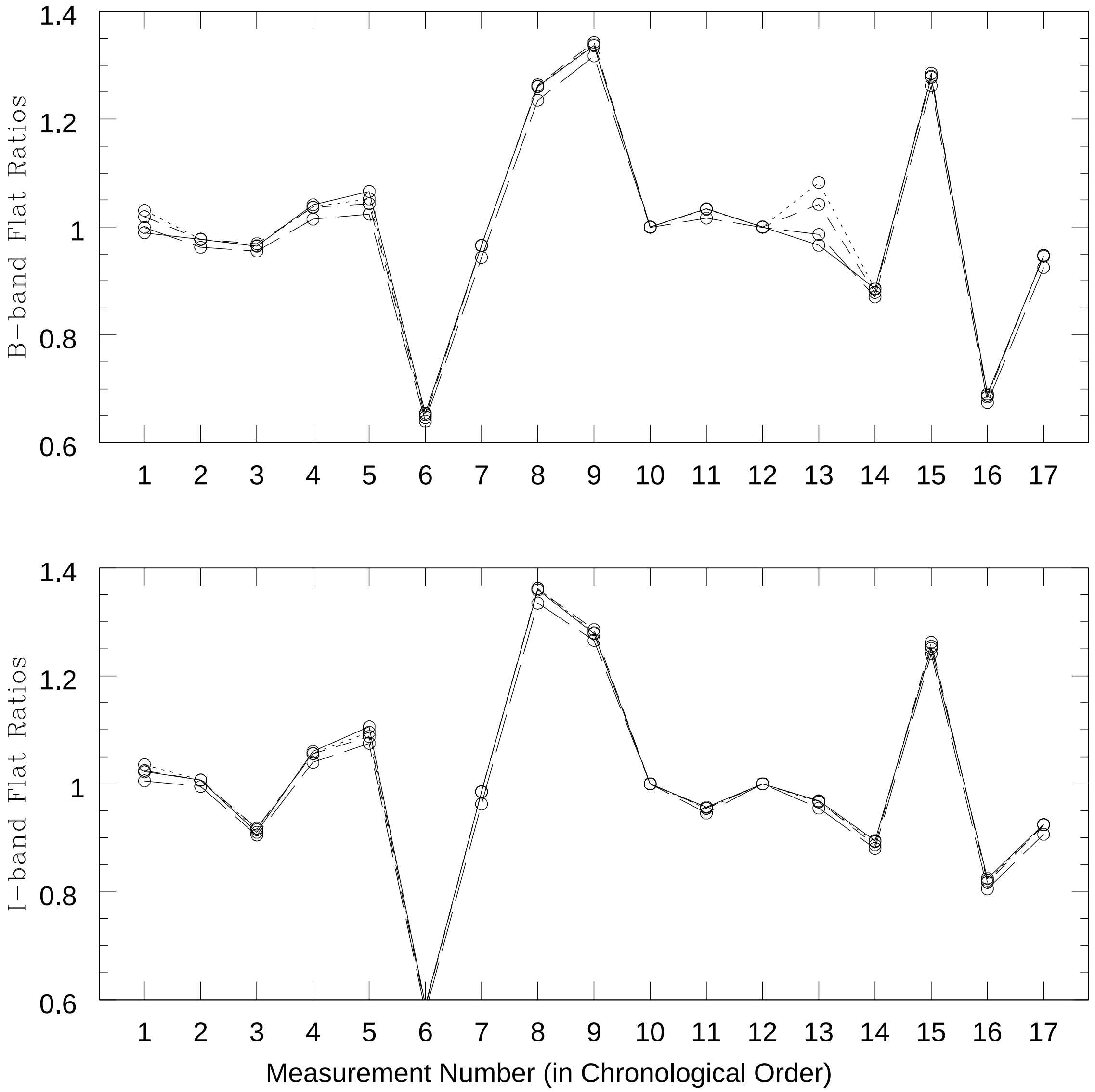

Figure 1: Variation in the dome flatfield ratio with time for B (*top*) and I-band (*bottom*). The traces for CCDs 57, 51, 55 and 53 are indicated by *solid*, *dotted*, *short-dashed* and *long-dashed* lines respectively. The measurement numbers correspond to those used in Table 1.

- High frequency structures are not present in I band, implying that they either divide out perfectly, or do not exist on the flats at all. I suspect it is the latter.

6 Further Questions and Tests: Can You Help Us?

The decontamination monitoring programme was designed with a specific question in mind, namely the change in throughput of the WFI system after contamination had been removed. A couple of questions could not be resolved by these data.

Observers: If you have dome and/or twilight flats from your run which you think might be useful to answer one/more of the following, we'd like to hear from you. Send an email to the Team Coordinator at `2p2team@eso.org` and he/she will arrange to `ftp` your flatfield data from `w2p2drs` to our team PC.

1. *Are twilight flats any better than those taken in the dome?* Some dome flats taken on the same day both in the dome and during twilight would answer this question in fairly short order. It is likely the twilight flats will show some sky gradient, but the behaviour of this should be easier to account for than the structures seen in the domes. Observer obserrvations/comments welcome.
2. *Is the non-reproducibility of dome flats due to imprecision in the dome preset position?* An easy test would be to take a few flatfields in short succession, moving away and then re-presetting between each. Everything else would remain unchanged.
3. *How important is focus?* Perhaps a less-useful test would be to take a series of dome flats in one filter (say I) through a range of focus settings. (I'd be very surprised if this turned up anything, but it's worth a try.)
4. *Is the lamp stability an important consideration?* The dome flatfield lamp is on a regulated voltage supply but it has never been measured with the CCDs. A time series taken over a couple of hours through the one filter and at the same voltage setting would give some indication.

Through both the comments of observers and our own tests, we hope to build up some sort of collective experience about the nature of flatfields taken with the ESO Wide Field Imager.

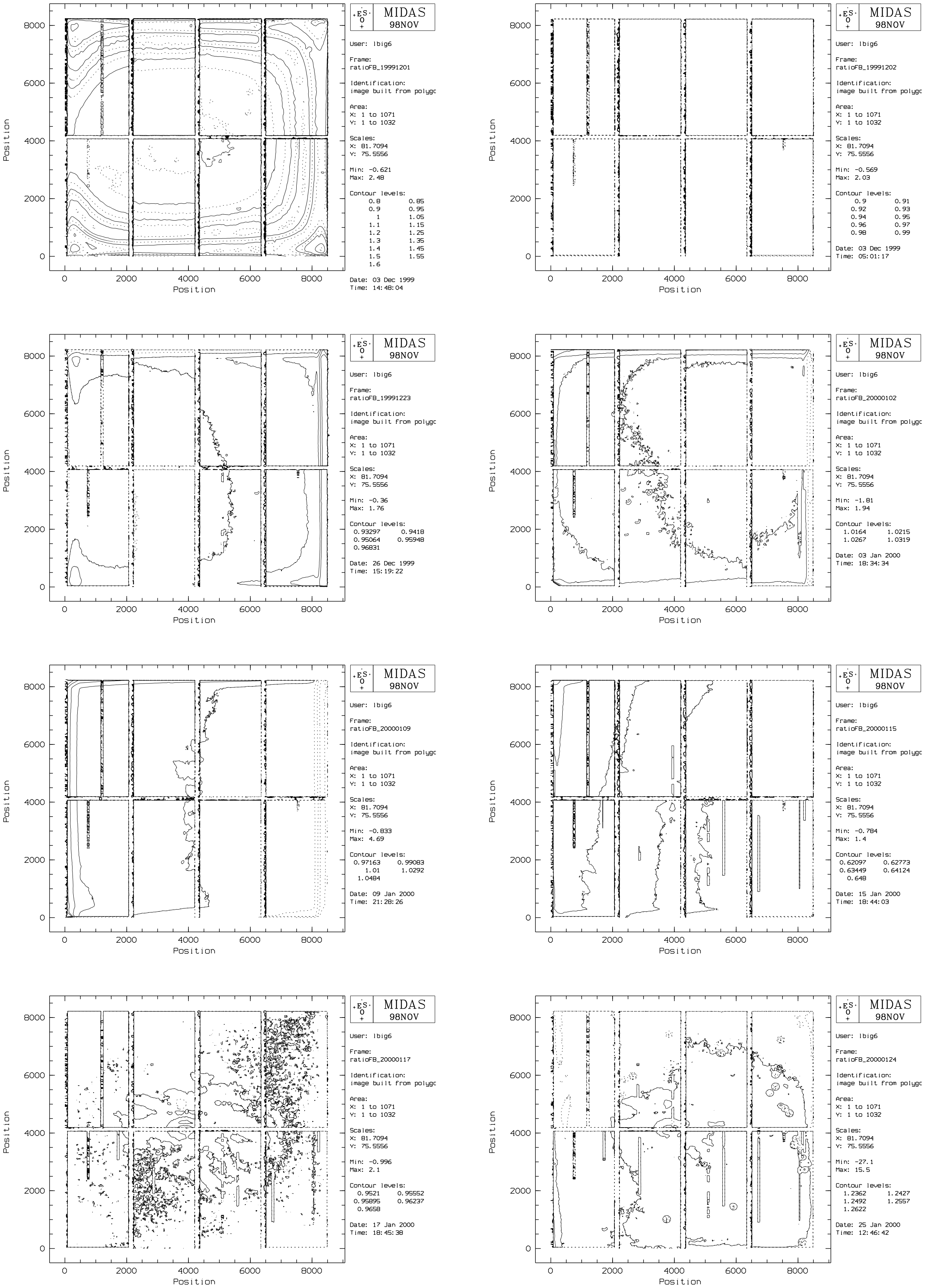

Figure 2: B dome flat ratio images (19991201 – 20000124).

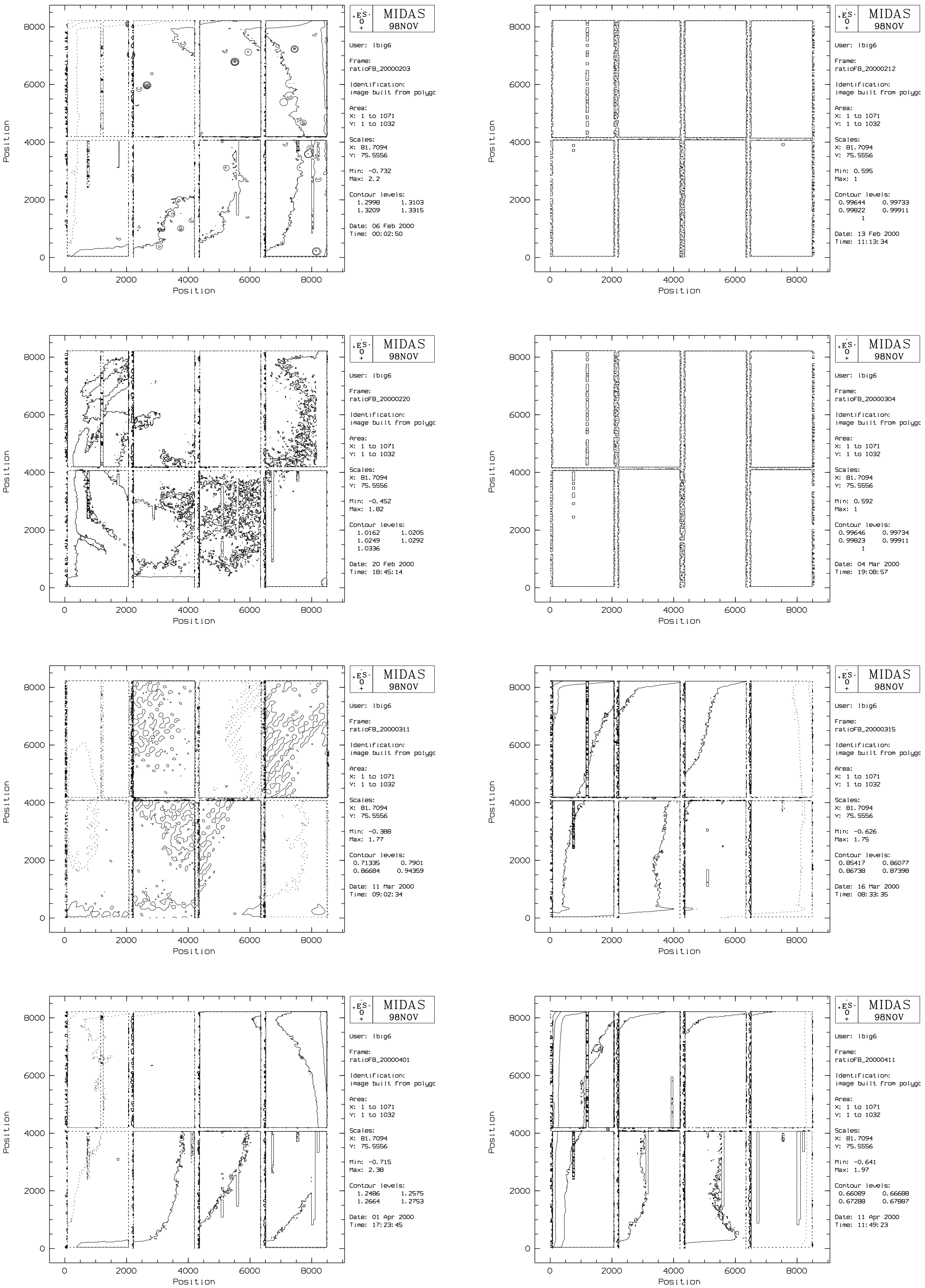

Figure 3: Continuation of the B dome flat ratio images (20000203 – 20000411).

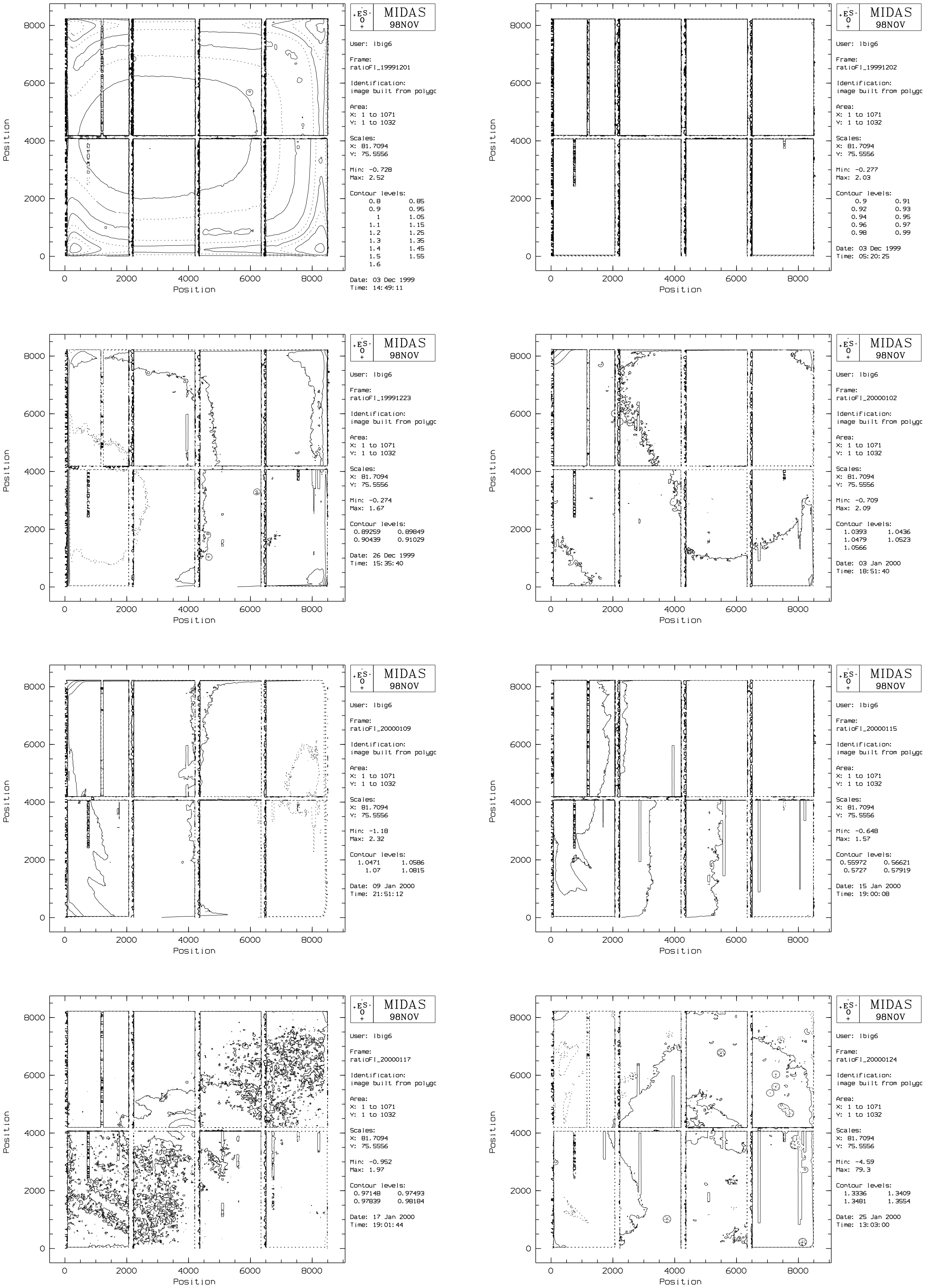

Figure 4: I dome flat ratio images (19991201 – 20000124).

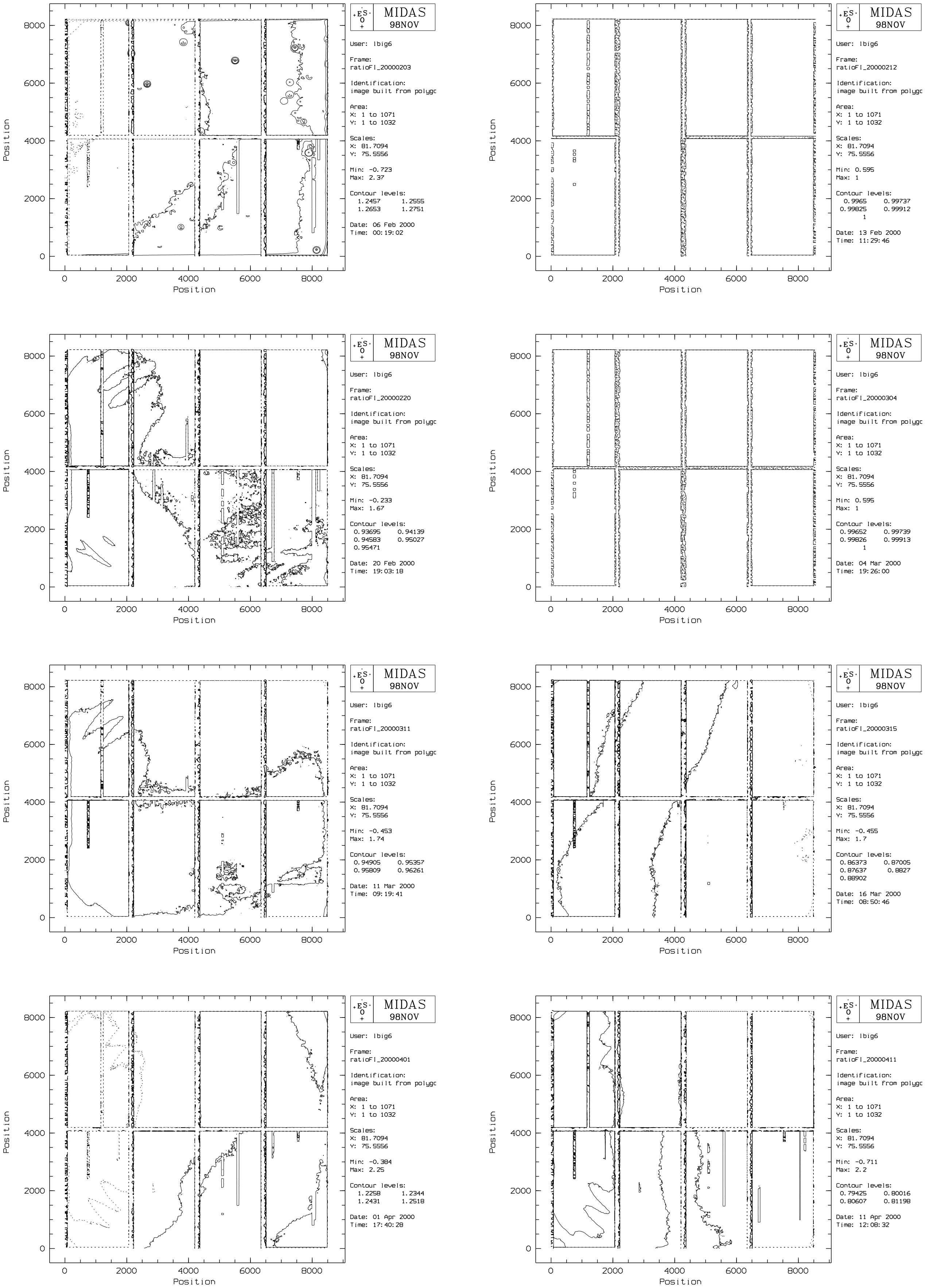

Figure 5: Continuation of the *I* dome flat ratio images (20000203 – 20000411).