MMA Visibility from Hilo and Topographical Shadowing

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1 Introduction

Mauna Kea is becoming a more likely site for the proposed NRAO Millimeter Array (MMA). One major concern is the visual impact of a large array of antennas on the 12,000 foot plain as seen from Hilo, 40 km away from the summit at 17° south of east. An 8 meter antenna as seen from Hilo would be 0.″7, or just unresolved by typical human eyes. However, when the dish faces towards Hilo, each antenna would be clearly visable as an unresolved white dot. The compact arrays would be visible as a white splotch.

In order to reduce the visual impact of a large number of radio antennas, it has been suggested that the compact arrays be located behind (to the west of) the puus at the southern edge of the proposed MMA site. To determine if this is feasible, this memo shows what parts of the mountain cannot be seen from Hilo.

If we place antennas close to topographical features to hide them from Hilo, we might also hide astronomical sources from the array. We also study the topographical shadowing of astronomical sources.

2 Obstructing Hilo's View of the Array

Figure 1 shows the elevation contours of Mauna Kea in meters. (The summit is the western blob with no contours: aips only permits 30 contour levels, and I decided it was more important to show a few contours on the puus than to show th summit.) South is down, west is left. The grey scale in Figure 1 represents the maximum height, up to 40 meters, of an object such that it would not be visible from Hilo. The three southern puus would prevent detection of the compact arrays and the control buildings from Hilo. The light band between the two easternmost puus has a minimum of 20 meters. Assuming the antennas will not be higher than 20 meters, it is possible to place an array with maximum north-south distance of almost 700 meters in the protection of these two puus. There is ample space for tall control buildings as well.

There is also a flat area to the northeast of the summit which would accommodate a 1000 meter array out of sight from Hilo. An access road to this region, cutting north across the plain just east of the summit, could take advantage of the 5 and 10 meter shadowing due to the low gradients, further reducing the visual impact. This location would also hide th compact arrays from many of the coastal communities which lie to the north of Hilo.

3 Obstructed View of Astronomical Sources

If we place the array near some puus to block Hilo's view, we might also block the array's view of part of the sky. The same software can be used to calculate the shadowing of astronomical sources by the local topography. We have produced shadowing maps for sources at 10° elevation and $n45°$ azimuth, for n ranging from 0 to 7, and they are shown in Figure 2. The main problem with topographical shadowing is that a large part of the A array would be shadowed by the Mauna Kea summit as sources set into the west. Figure 3 shows the topographical shadowing of an astronomical source at elevation 20°, azimuth 270°, indicating that this western shadowing is only a problem for sources below 20° for the A array. Atmospheric phase fluctuations would become very much worse at such elevations, and one would not choose to observe so low unless one had no choice, as for a very southerly source (which won't have bad topographical shadowing), or for a VLBI experiment.

Figure 1: Contours of Mauna Kea's elevation taken from the USGS *Digital Elevation Model* with a grey scale of Hilo view obstruction. The grey scale indicates if an object of a given height would not be seen from Hilo. The maximum height for which the obstruction was calculated is 40 meters, the grey scale pixel range is set to 80 meters to allow the elevation contours to be visible.

Figure 2: Contours of Mauna Kea's elevation taken from the USGS *Digital Elevation Model* with a grey scale of topographical shadowing of astronomical sources. The grey scale indicates if an object of a given height would be shadowed by the local topography when observing a source at elevation $10°$ and azimuth $n45°$, for n ranging from 0 to 7. The maximum height for which the obstruction was calculated is 20 meters, the grey scale pixel range is set to 40 meters to allow the elevation contours to be visible.

Figure 3: Same as in Figure 2, but for elevation = $20°$, azimuth = $270°$.

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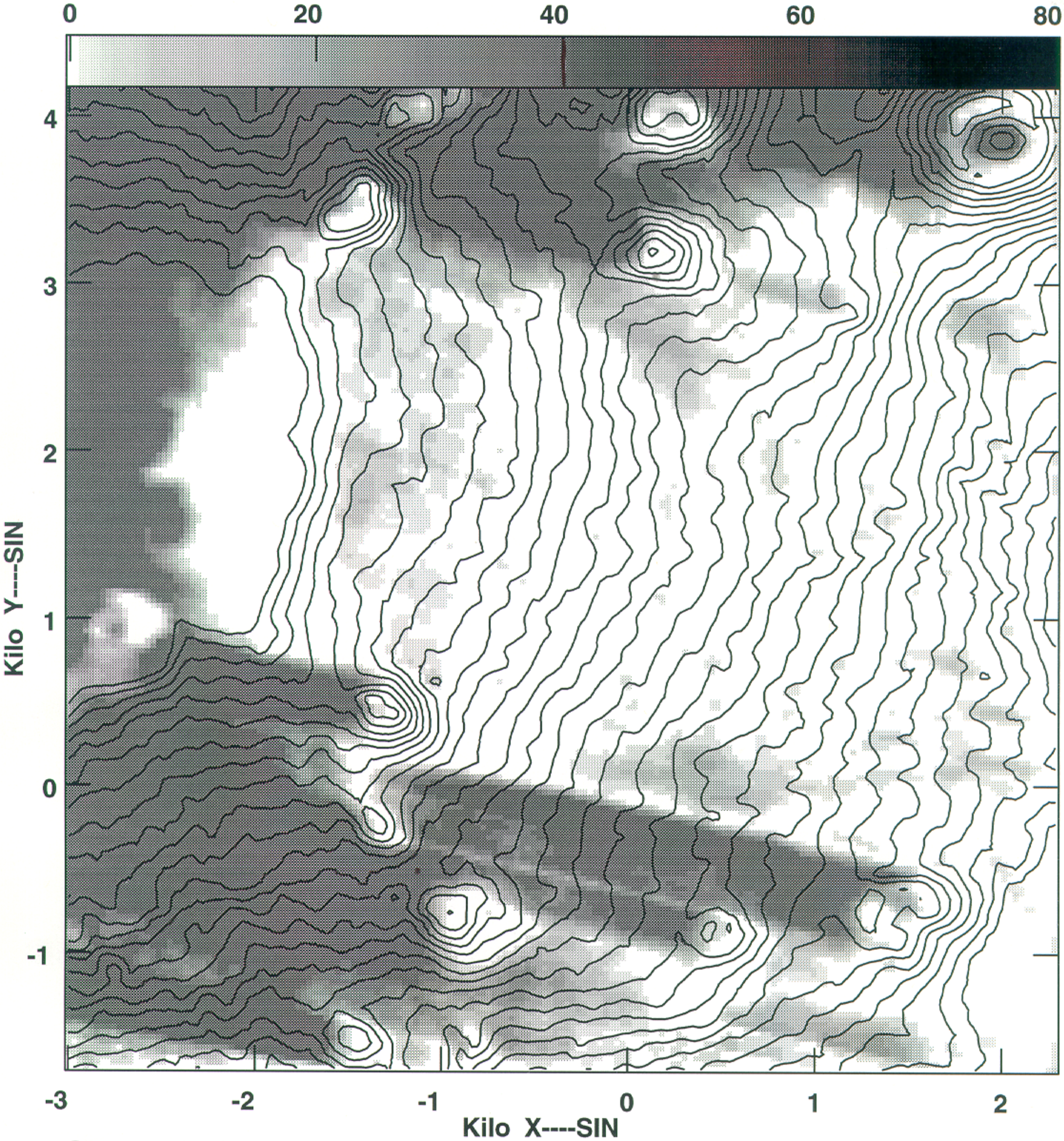
GREY: ? MK.SHAD.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 80.0

Peak contour flux = 4.1980E+03

Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

Figure 1

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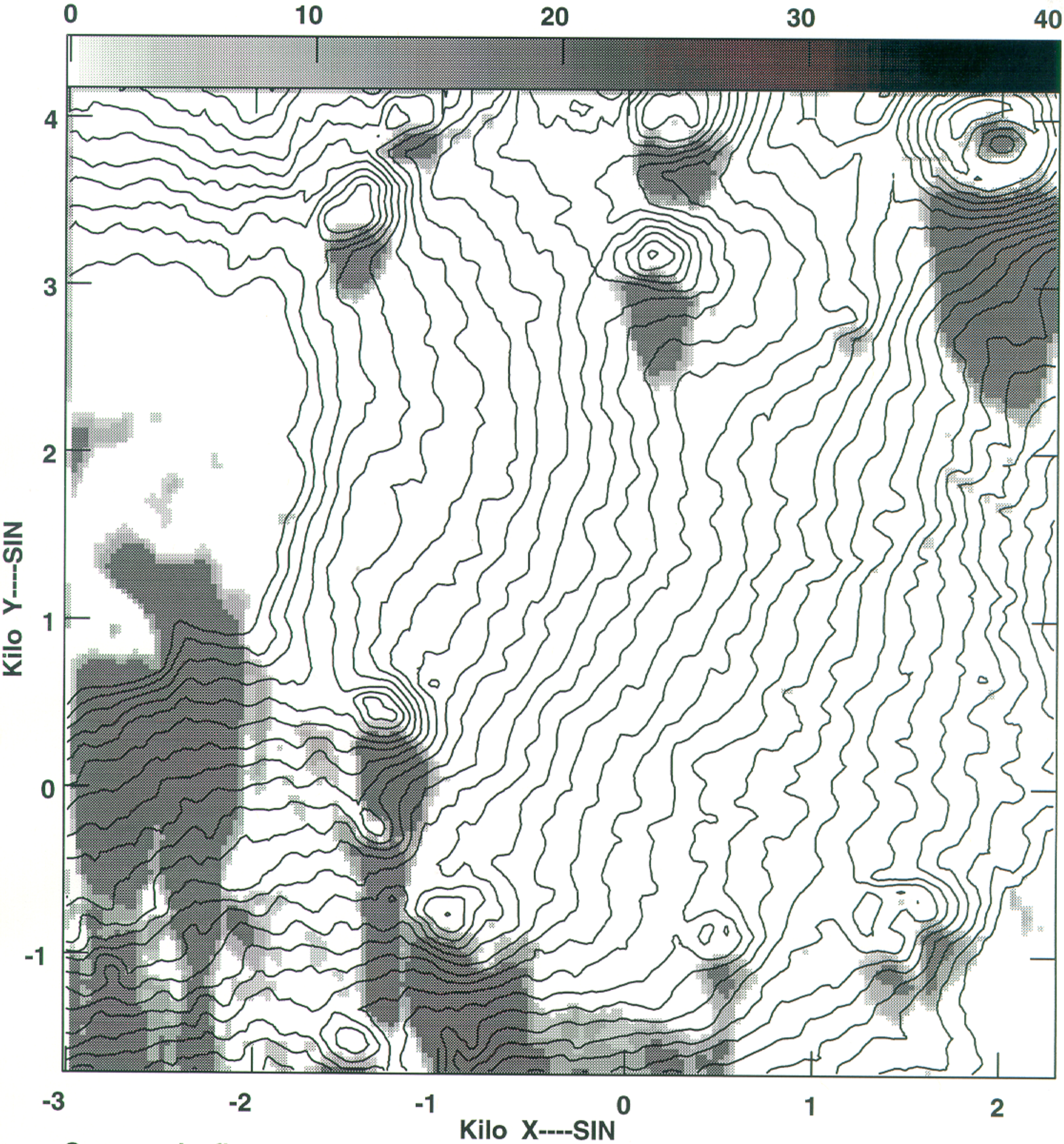
GREY: ? MK-SHAD.A0.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0

Peak contour flux = 4.1980E+03

Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

Figure 2

Az = 0°

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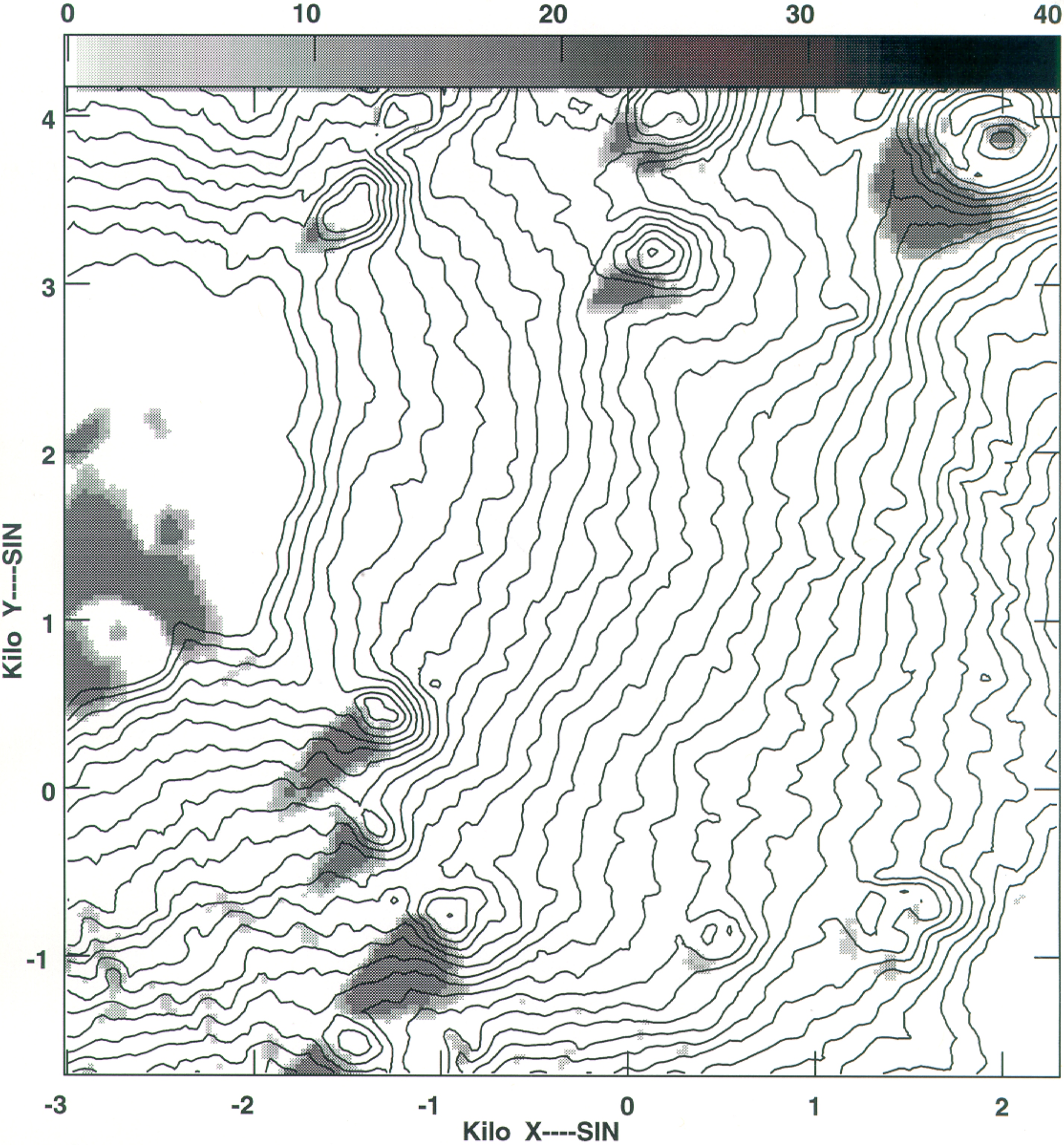
GREY: ? MK-SHAD.A45.1
CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0
Peak contour flux = 4.1980E+03
Levs = 1.0000E+01 * (340.0, 342.0, 344.0,
346.0, 348.0, 350.0, 352.0, 354.0, 356.0,
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370.0, 372.0, 374.0, 376.0, 378.0, 380.0,
382.0, 384.0, 386.0, 388.0, 390.0, 392.0,
394.0, 396.0, 398.0)

Figure 2
Az = 45°

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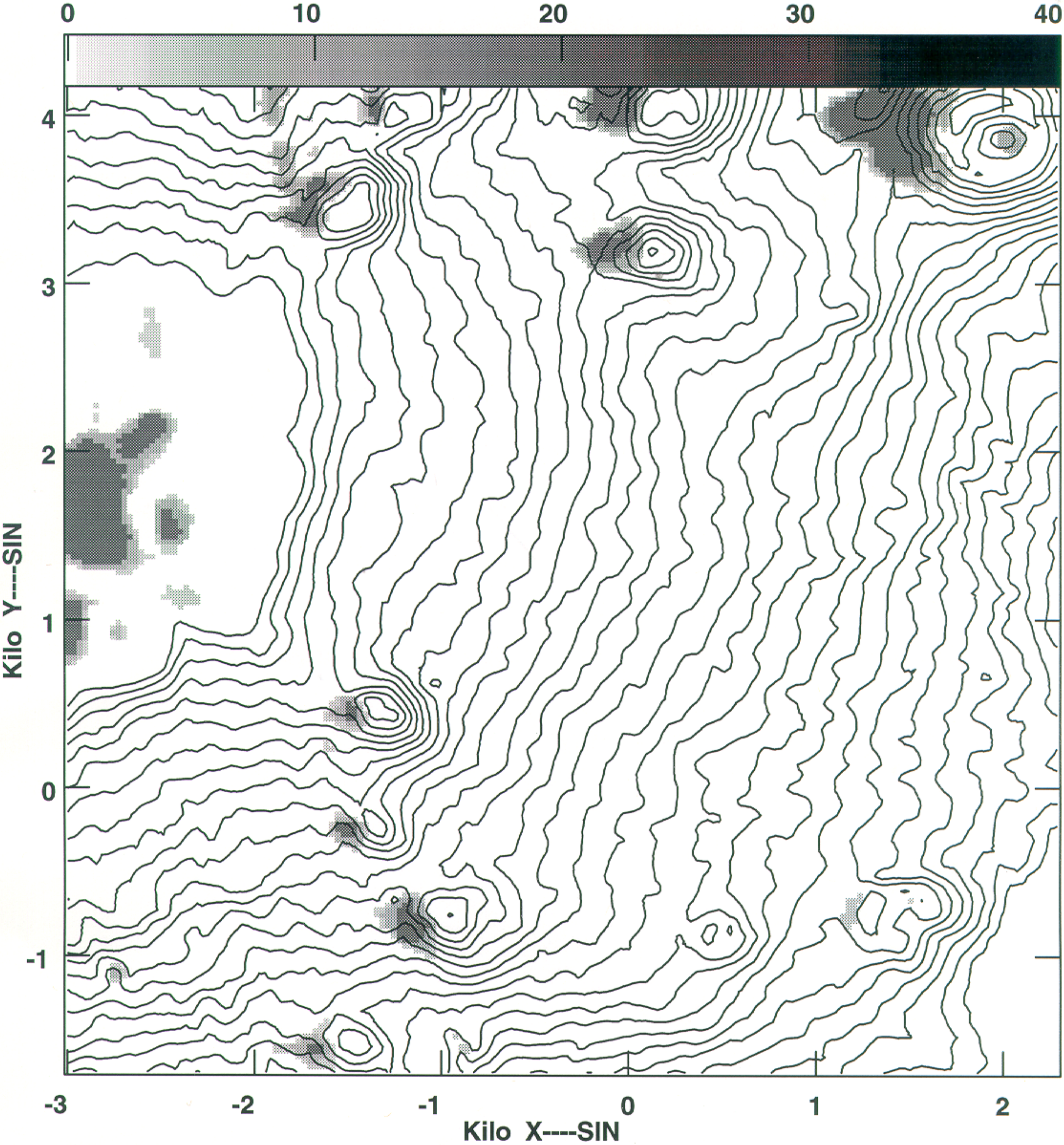
GREY: ? MK-SHAD.A90.1
CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0
Peak contour flux = 4.1980E+03
Levs = 1.0000E+01 * (340.0, 342.0, 344.0,
346.0, 348.0, 350.0, 352.0, 354.0, 356.0,
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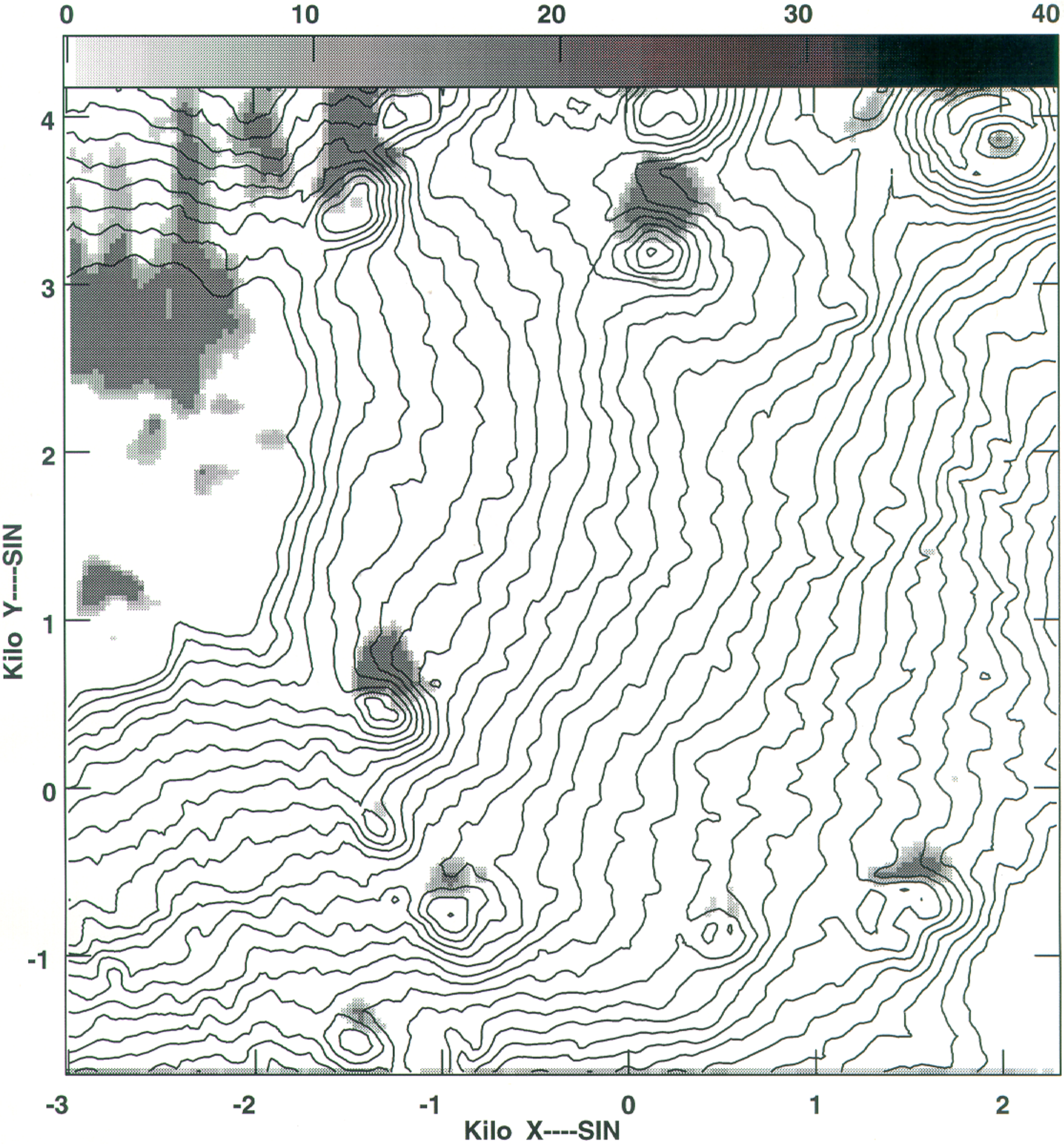
382.0, 384.0, 386.0, 388.0, 390.0, 392.0,
394.0, 396.0, 398.0)

Figure 2
Az = 90°

Plot file version 1 created 31-MAR-1994 14:25:38

GREY: ? MK-SHAD.A180.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0

Peak contour flux = 4.1980E+03

Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

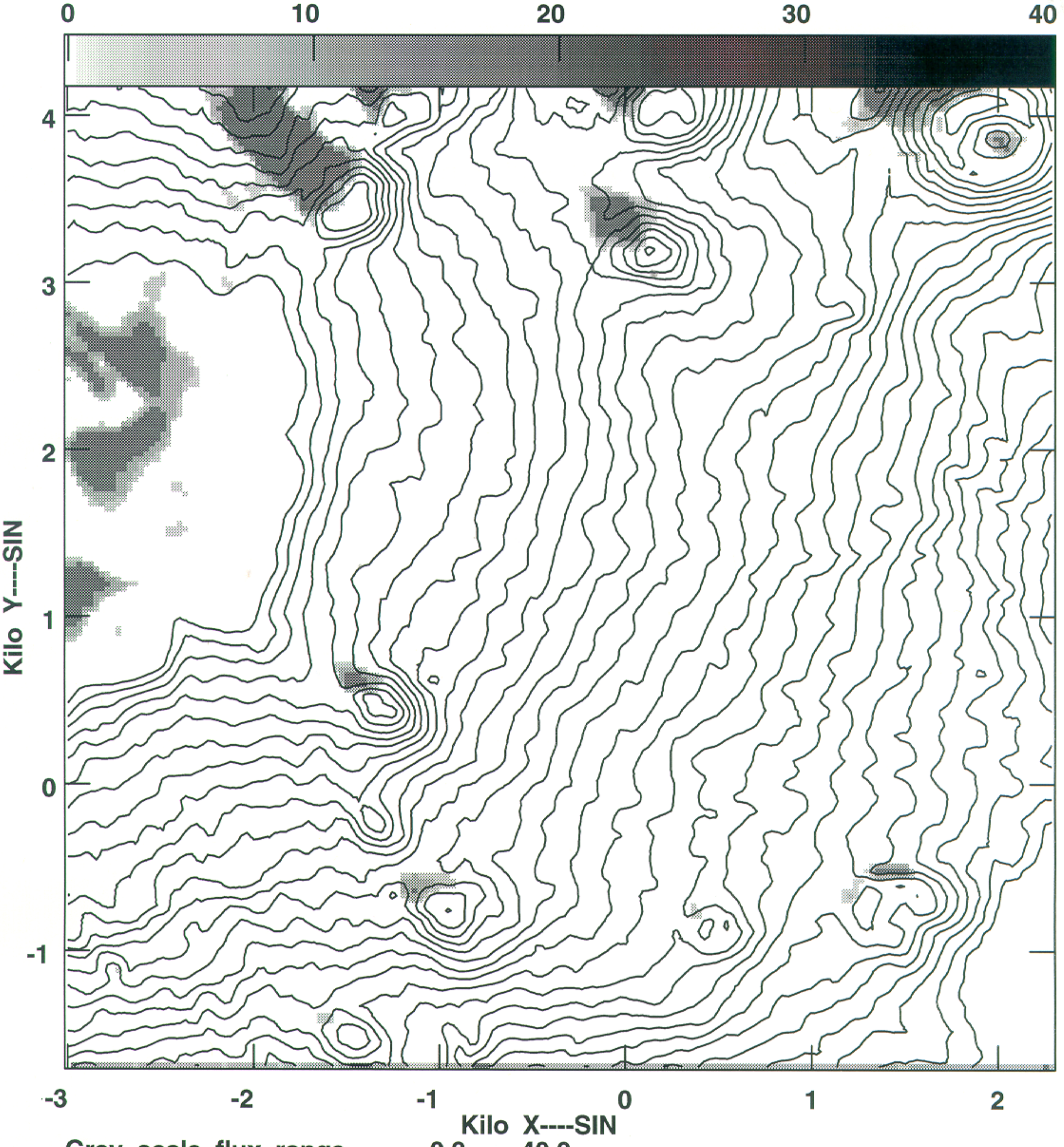
Figure 2

Az= 180°

Plot file version 1 created 31-MAR-1994 14:24:36

GREY: ? MK-SHAD.A135.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0

Peak contour flux = 4.1980E+03

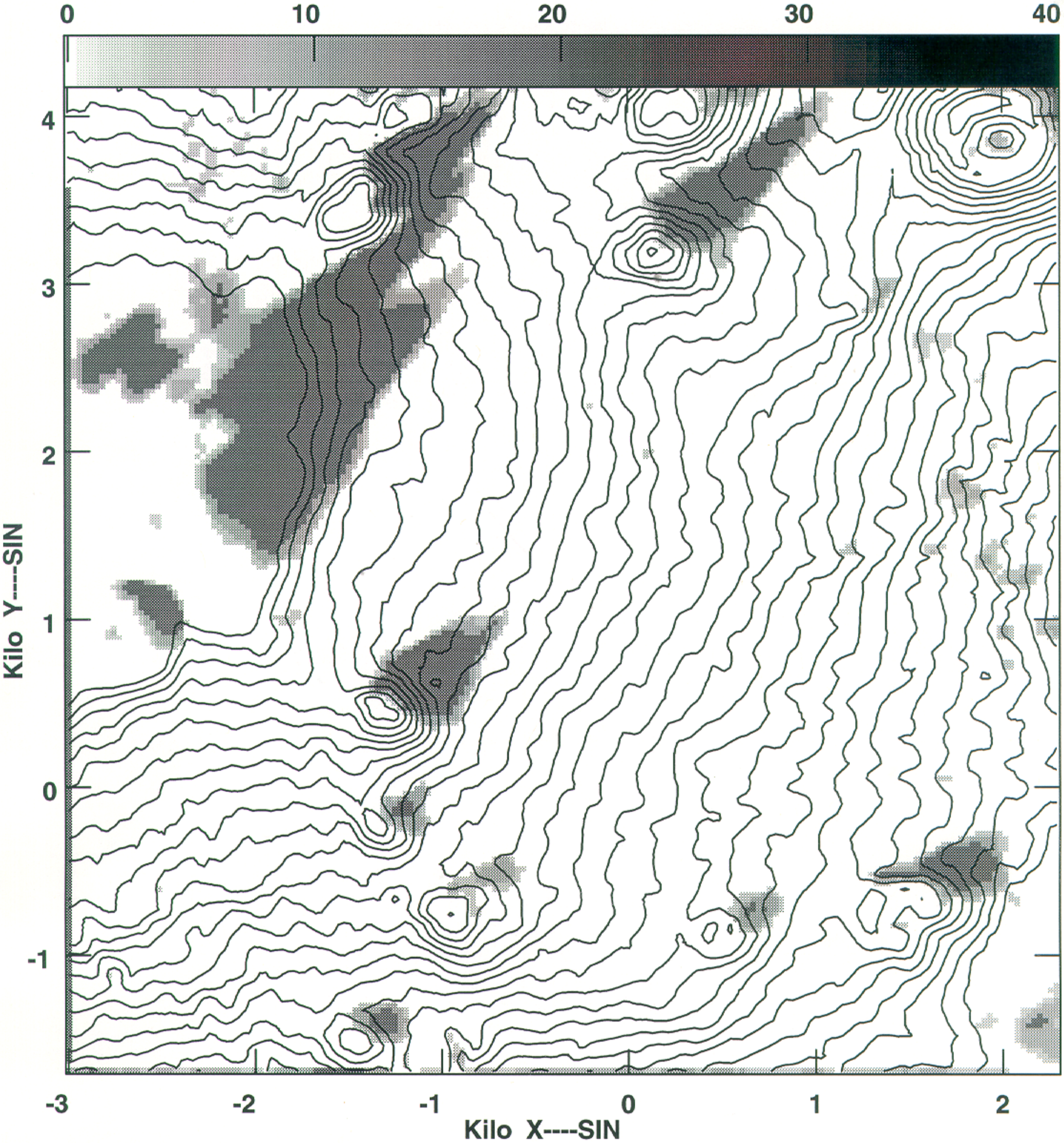
Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

Figure 2

Az = 135°

Plot file version 1 created 31-MAR-1994 14:26:38

GREY: ? MK-SHAD.A225.1
CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0
Peak contour flux = 4.1980E+03
Levs = 1.0000E+01 * (340.0, 342.0, 344.0,
346.0, 348.0, 350.0, 352.0, 354.0, 356.0,
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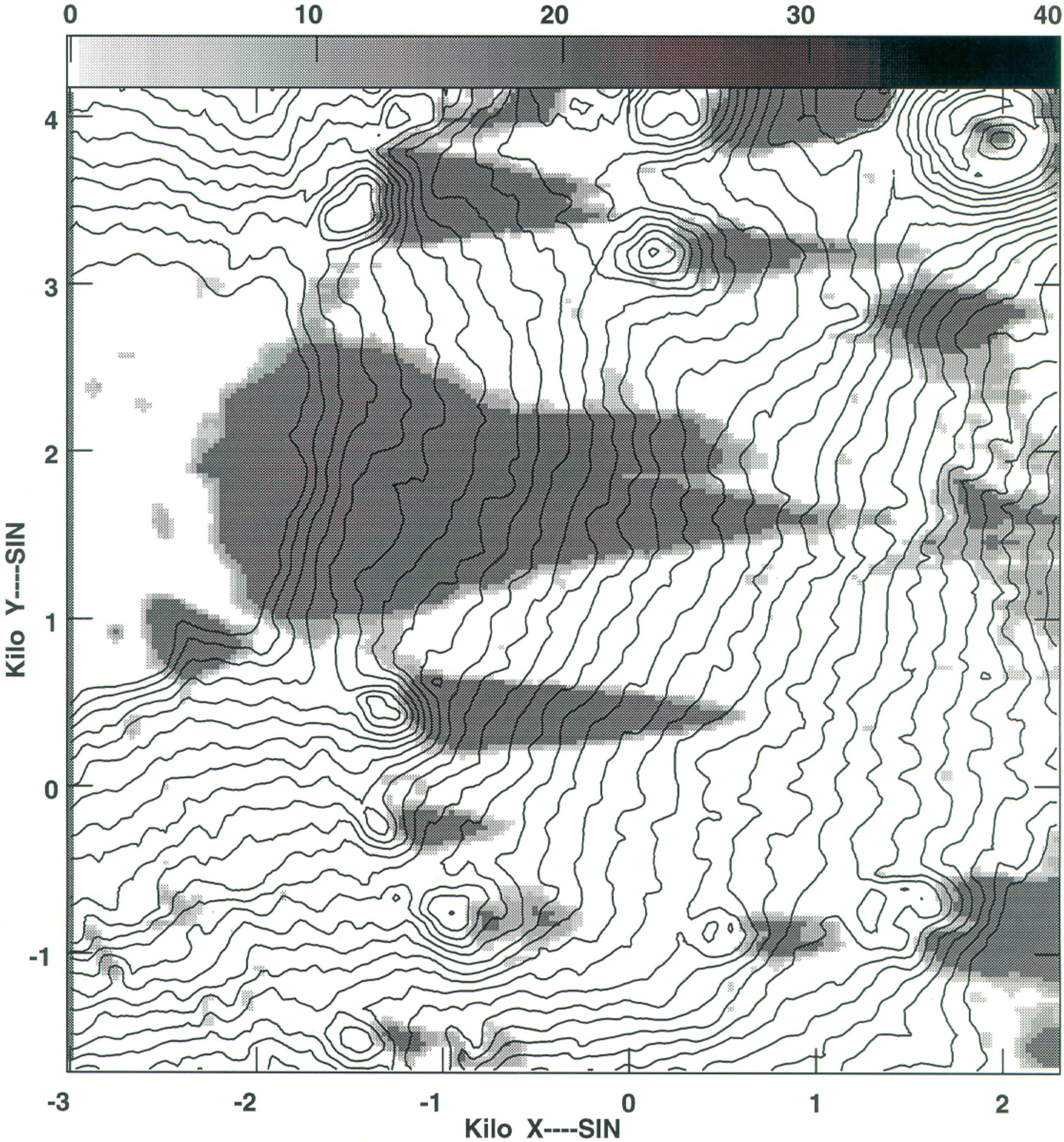
382.0, 384.0, 386.0, 388.0, 390.0, 392.0,
394.0, 396.0, 398.0)

Figure 2
Az = 225°

Plot file version 1 created 31-MAR-1994 14:27:36

GREY: ? MK-SHAD.A270.1
CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0
Peak contour flux = 4.1980E+03
Levs = 1.0000E+01 * (340.0, 342.0, 344.0,
346.0, 348.0, 350.0, 352.0, 354.0, 356.0,
358.0, 360.0, 362.0, 364.0, 366.0, 368.0,
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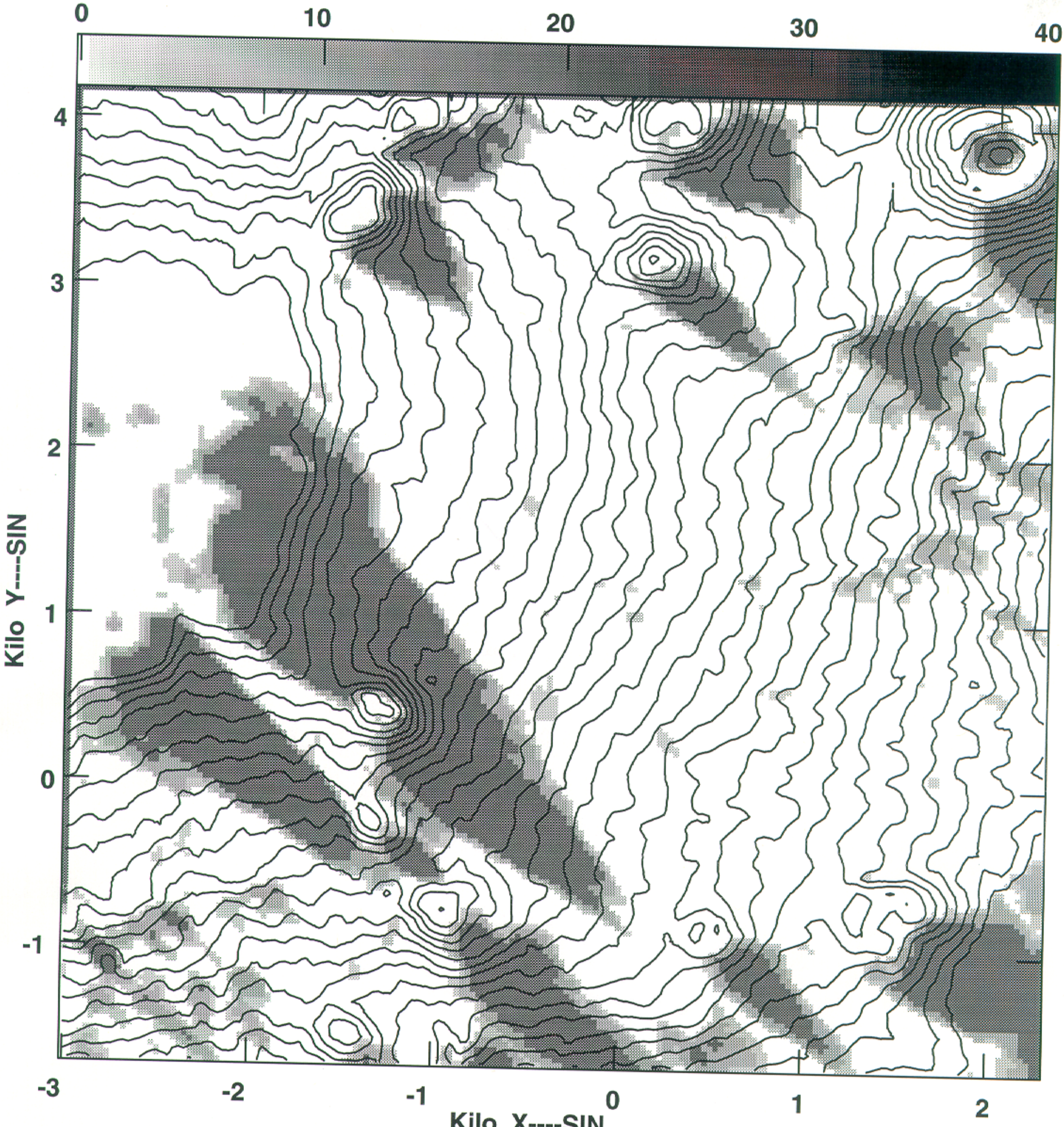
382.0, 384.0, 386.0, 388.0, 390.0, 392.0,
394.0, 396.0, 398.0)

Figure 2
AZ = 270°

Plot file version 1 created 31-MAR-1994 14:28:36

GREY: ? MK-SHAD.A315.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0

Peak contour flux = 4.1980E+03

Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

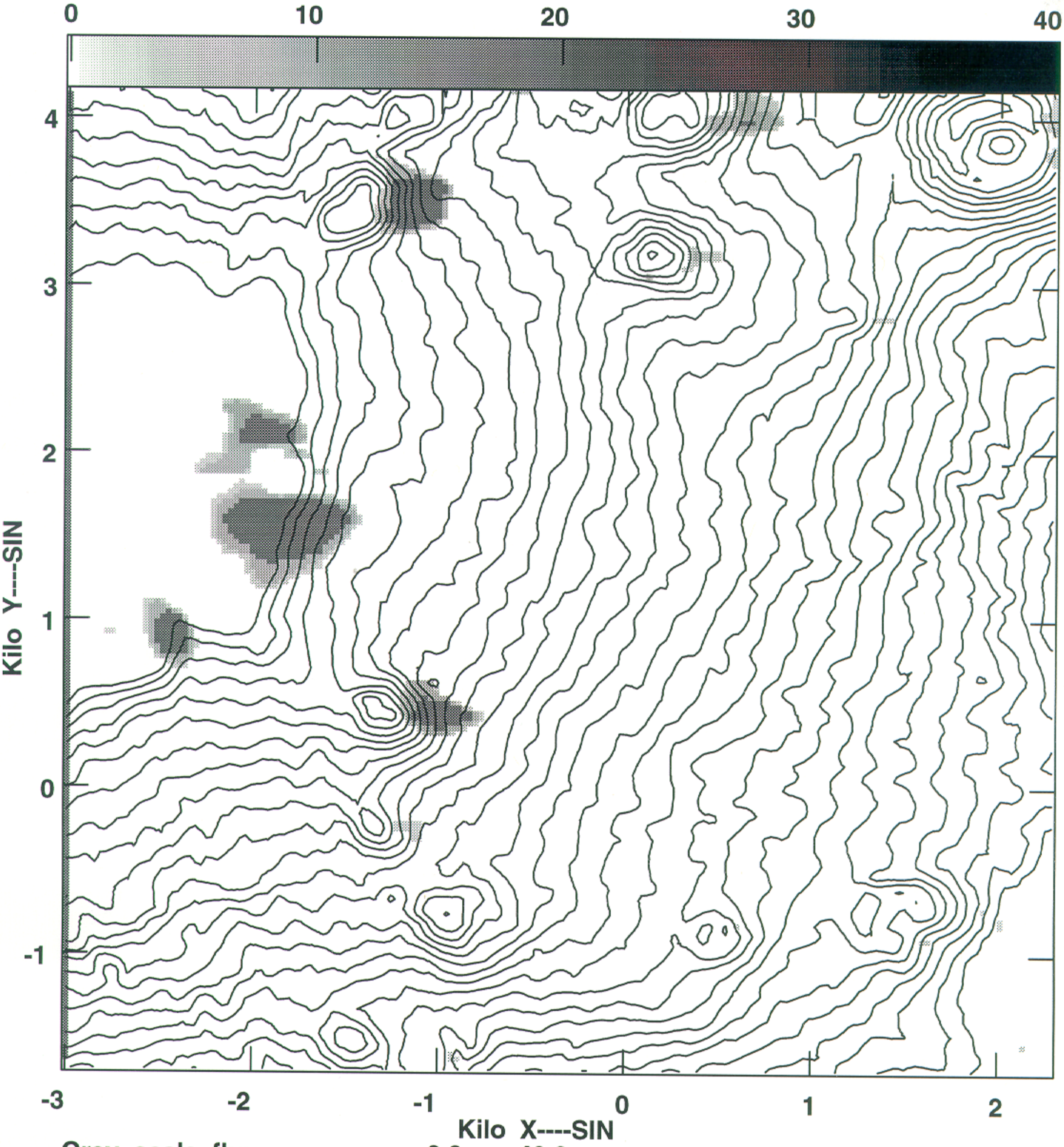
Figure 2

Az = 315°

Plot file version 1 created 31-MAR-1994 14:54:05

GREY: ? MK-SHAD.270E20.1

CONT: ? MK.MAP.1



Grey scale flux range= 0.0 40.0

Peak contour flux = 4.1980E+03

Levs = 1.0000E+01 * (340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0, 356.0, 358.0, 360.0, 362.0, 364.0, 366.0, 368.0, 370.0, 372.0, 374.0, 376.0, 378.0, 380.0, 382.0, 384.0, 386.0, 388.0, 390.0, 392.0, 394.0, 396.0, 398.0)

Figure 3

AZ = 270°

EL = 20°