VLB ARRAY MEMO No. 144

Nov. 12 1982

To: VLBA Configuration Group

From: R. C. Walker

Subject: Fast quality measure

In the September meeting of the Configuration Group, we decided to use the quality measure of Mutel and Gaume (VLBA memos 84 and 124) to test arrays.
During recent efforts to find a 'final' configuration it has become clear that the capability to examine a very large number of possible configurations in a short time would be valuable. Attempts to examine roughly 200 arrays using Mutel and Gaume's program took on the order of 20 hours of cpu time on a VAX 11/780. It was clear that a much faster program was needed, even if it didn't provide as sharp a test as those in current use.

I have developed a program called ARTEST which meets the need. It is specifically designed to run large numbers of arrays. It saves large amounts of time by precalculating station positions as a function of time and by using a quality measure that does not require a search through the u-v plane. ARTEST takes about 1.9 seconds of cpu time on a VAX 11/780 per configuration.

The quality measure used by ARTEST involves simply counting the number of cells of two special u-v grids in which data points fall. Both grids are specified in radial and angular coordinates. In the angular coordinate, both grids use uniform spacing. In the radial coordinate, the main grid uses uniform spacings in the central region and exponential spacings in the outer region. The secondary grid uses only uniform spacings and only covers the inner region of the u-v plane. Two grids seem to be needed in order to select arrays that provide good coverage over full range of spacings of the VLBA. This is a need that may be shared by Mutel and Gaume's scheme since many of the arrays selected with their program have large holes near the center. The parameters of the grids that I am currently using are given in Table 1. The numbers of cells sampled by each array at each of our eight standard declinations (not including -44) are normalized by the values found for the first array calculated in order to equally weight all declinations (The first array is just a convenient source of numbers of about the right magnitude) and summed over declinations. After all arrays are analyzed, the results spread into the range 0-1000 for the main grid and 0-500 for the inner grid. These results are added and the list is sorted on the sum. The values used for the cell sizes and the weighting in adding the main and inner results were derived from repeated trials and examination of u-v plots of the resulting arrays. I make no claim that these are the best values, but they seem to work reasonably well.

The quality measure depends on the fact that arrays that have large holes in one region probably have redundancy in others. Also, in the presence of CLEAN, the complexity of a source that can be mapped may depend on the the number of u-v cells sampled, so this measure may be closely related to the capabilities of an array. More theoretical and empirical work needs to be done along these lines. The nature of the grids insures the central condensation that we consider desirable.

The results of a test of about 2850 arrays are presented in Tables 2 and 3. The program analyzes 10 station arrays consisting of four fixed stations and one station from each of six groups. The stations in Groups 5 and 6 are treated as matched pairs. Table 2 presents the stations and coordinates used in the search. All sites were assumed to be able to see all of the sky above 80 deg ZA. Table 3 presents the top 20 arrays. Included is the average result (not including dec -44) for each array from Mutel and Gaume's program. The ordering of arrays based on the two programs is different, probably because of differences in the emphasis on the inner regions and on the low declinations. Plots of the u-v coverage of the top 6 arrays plus arrays 14 and 16 are presented in Figures 1-8. From this run, I have selected array AR31-14 as the array that I feel can form the most promising basis for a final array. Details are presented in a separate memo.

ARTEST, plus the general considerations that we have derived from huge numbers of arrays examined so far that allow selection of possible sites, should allow derivation of good arrays in a relatively short time if we are presented with a different set of boundary conditions. This will prove important if we decide Puerto Rico is too wet or that we can use Canada and/or Mexico.

Table 1.

Parameters of ARTEST Grids

Parameter	Main Grid	Inner Grid
Number of angular cells (half plane)	30	16
Uniform spacing	100 km	50 km
Outer boundary of uniform cells	2000 km	800 km
Percent of u-v distance for outer cells	5	-
Outer boundary of grid	>8000 km	800 km
Weighting in quality measure	1.0	0.5

Table 2.

Stations used in ARTEST run.

Abbr.	Location	Lat.	Long.
Fixed Stations:			
HAWAII	Near Mauna Kea	19.8	155.5
OVRO	Owens Valley CA.	37.05	118.28
HSTK	Haystack Obs. MA.	42.43	71.49
ARECIBO	Puerto Rico	18.34	66.75
Group 1:			
LRDO	Laredo, Texas	27.5	99.5
FDVSNEW	Fort Davis, Texas	30.47	103.95
Group 2:			
IOWA	North Liberty Radio Obs.	41.58	91.57
ILLN	Vermillion River Obs.	40.06	87.57
NRAONEW	Green Bank WV.	38.25	79.84
Group 3:			
MISSOULA	Montana	46.8	114.0
FARGO	North Dakota	46.8	96.7
BND	Bend, Oregon	44.0	121.2
WENATCH	Wenatche, WA	47.4	120.3
BOIS	Boise, ID	43.6	116.2

Group 4:

KITT	Kitt Peak, AZ	31.96	111.6
TUSC	Tucson, AZ	32.3	111.0
GREENRV	Green River, UT	39.0	110.2
OMAHA	Nebraska	41.3	96.0
NPLAT	North Platte, Nebraska	41.3	101.0
DULUTH	Minnesota	46.7	92.3
FARGO	North Dakota	46.8	96.7
AMARILLO	Texas	34.6	101.8
FDVSNEW	Fort Davis, Texas	30.47	103.95
BLYTHE	California	33.6	114.6
MOAB	Utah	38.5	109.6
GRJCT	Grand Junction, CO	39.1	108.5
SIOUXN	North of Sioux Falls, SD	44.0	97.0
PUEBLO	Colorado	38.3	104.5
BLDR	Boulder, CO	40.00	105.26
PROVO	Utah	40.2	111,7
JKHOLE	Jackson Hole, WY	43.4	110.7
PHNX	Phoenix, AZ	33.5	112.1

Group 5 - Group 6: Matched Pairs - Near VLA

SCHOLLE	South of Albuquerque	34.4	106.5
GALLUP	NM	35.5	108.7
QUEMADO	West of VLA on Rt 60	34.35	108.49
LASL	Los Alamos, NM	35.9	106.4
RT107NM	South of Socorro near I25 and Rt107	33.66	107.13
LVNM	Las Vegas, New Mexico	35.6	105.2
HORSESP	Horse Springs (SW of Datil, NM)	33.93	108.25
SANYSID	San Ysidro, NM	35.5	106.8
SCHOLLE		34.4	106.5
LASCRUCE	Las Cruces, NM	32.3	106.75

Table 3

ARTEST Results - Puerto Rico Arrays

All arrays include HAWAII, OVRO, HSTK, and ARECIBO

Name	Stations						O	I	Sum	MG
AR31-1	FDVSNEW	IOWA	WENATCH	KITT	RT107NM	LVNM	967	378	1345	281.7
AR31-2	LRDO	IOWA	FARGO	AMARILLO	QUEMADO	LASL	989	347	1336	291.4
AR31-3	FDVSNEW	IOWA	WENATCH	TUSC	RT107NM	LVNM	958	361	1319	281.9
AR31-4	FDVSNEW	IOWA	MISSOULA	KITT	RT107NM	LVNM	903	411	1314	288.2
AR31-5	FDVSNEW	IOWA	MISSOULA	TUSC	RT107NM	LVNM	900	400	1300	288.7
AR31-6	LRDO	IOWA	MISSOULA	PHNX	SCHOLLE	GALLUP	1000	299	1299	281.0
AR31-7	LRDO	IOWA	FARGO	BLYTHE	QUEMADO	LASL	968	324	1292	289.4
AR31-8	FDVSNEW	IOWA	WENATCH	PHNX	RT107NM	LVNM	909	377	1286	282.1
AR31-9	FDVSNEW	ILLN	MISSOULA	KITT	RT107NM	LVNM	876	407	1283	291.9
AR31-10	FDVSNEW	IOWA	MISSOULA	PHNX	RT107NM	LVNM	863	414	1277	288.9
AR31-11	LRDO	IOWA	FARGO	AMARILLO	SCHOLLE	GALLUP	970	298	1268	291.2
AR31-12	LRDO	IOWA	MISSOULA	BLYTHE	SCHOLLE	GALLUP	975	293	1268	280.3
AR31-13	LRDO	IOWA	FARGO	PUEBLO	SCHOLLE	GALLUP	942	322	1264	290.4
AR31-14	FDVSNEW	ILLN	WENATCH	KITT	RT107NM	LVNM	884	377	1261	286.1
AR31-15	LRDO	NRAONEW	FARGO	AMARILLO	QUEMADO	LASL	971	287	1258	293.7
AR31-16	FDVSNEW	IOWA	WENATCH	AMARILLO	QUEMADO	LASL	887	369	1256	282.6
AR31-17	FDVSNEW	ILLN	MISSOULA	AMARILLO	QUEMADO	LASL	870	381	1251	292.1
AR31-18	LRDO	ILLN	MISSOULA	BLYTHE	SCHOLLE	GALLUP	959	291	1250	284.4
AR31-19	LRDO	IOWA	MISSOULA	PHNX	RT107NM	LVNM	961	288	1249	279.5
AR31-20	LRDO	IOWA	BOIS	PHNX	TR107NM	LVNM	896	346	1242	293.6

(The "Measure:" label is printed in the header row above the O, I, Sum and MG columns.)

The measures are:

O: The number of cells sampled in the main grid, normalized to typical values for each declination, added across declinations and spread over the range 0-1000. The declinations used are 65,44,30,18,6,-6, -18,and -30 degrees.

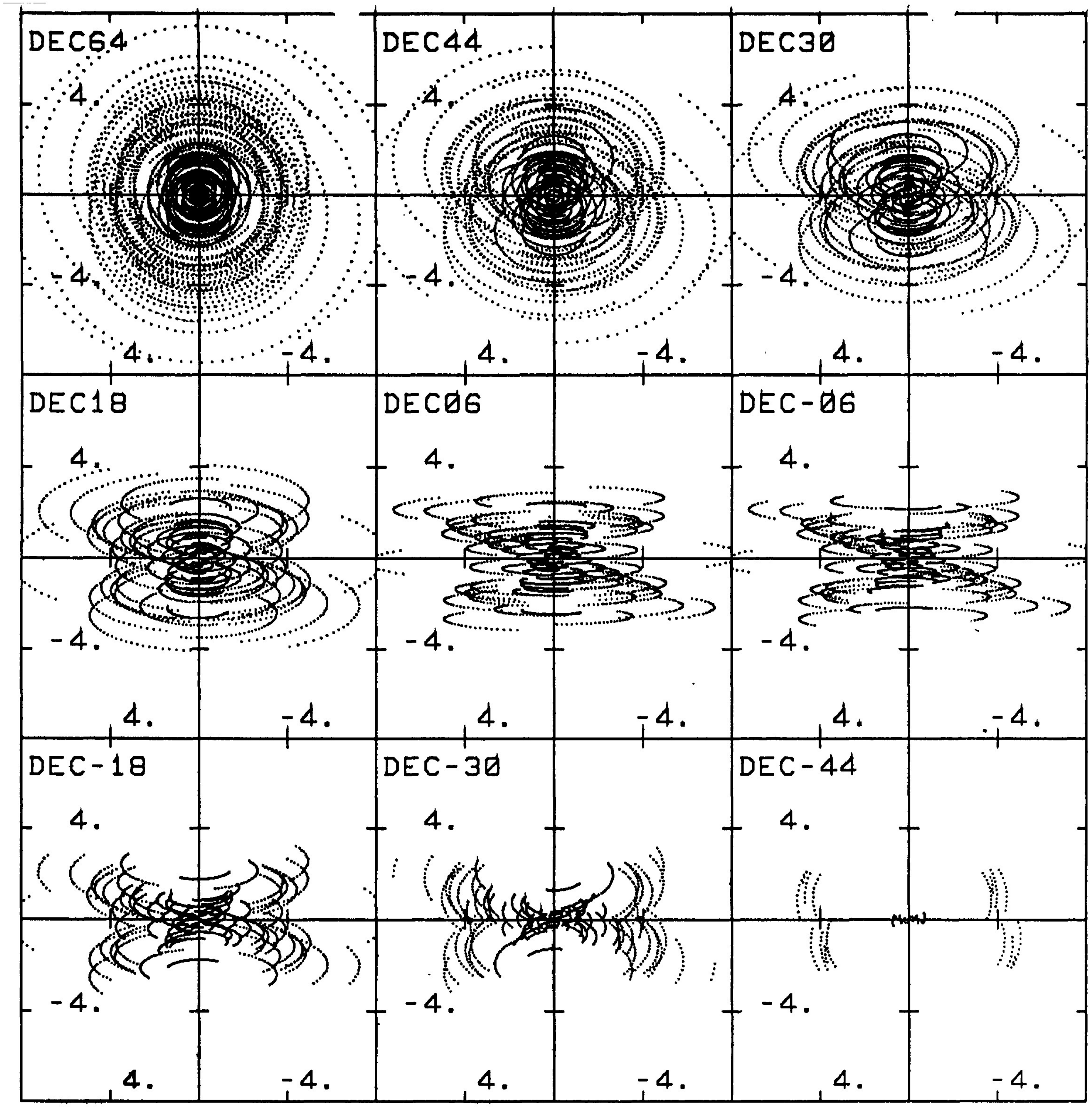
I: A similar number to O but for the inner grid.

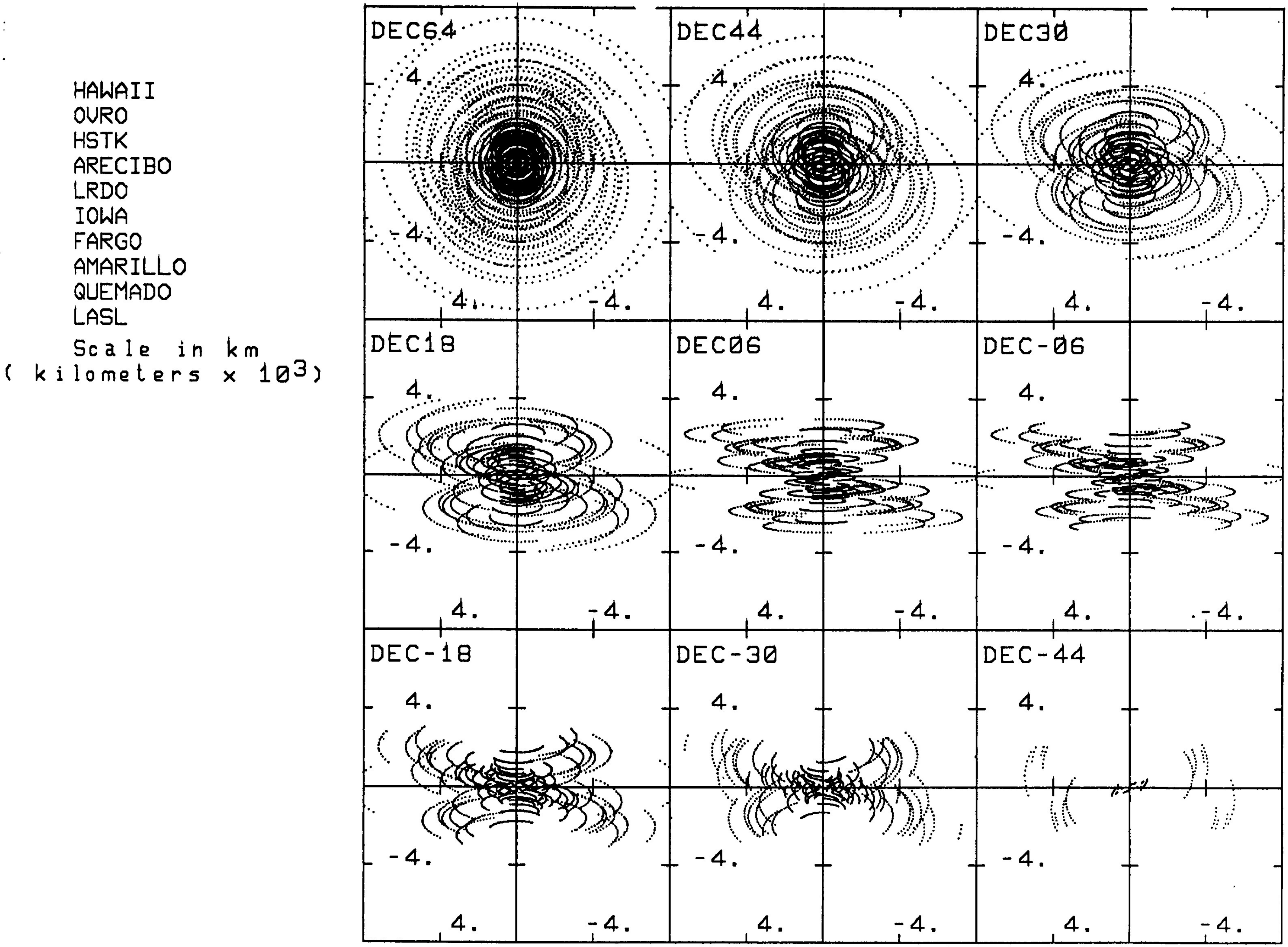
S: The sum of the above two measures and the one used for ranking.

MG: Mutel and Gaume's sum not including -44 degrees.

HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
IOWA
WENATCH
KITT
RT107NM
LVNM

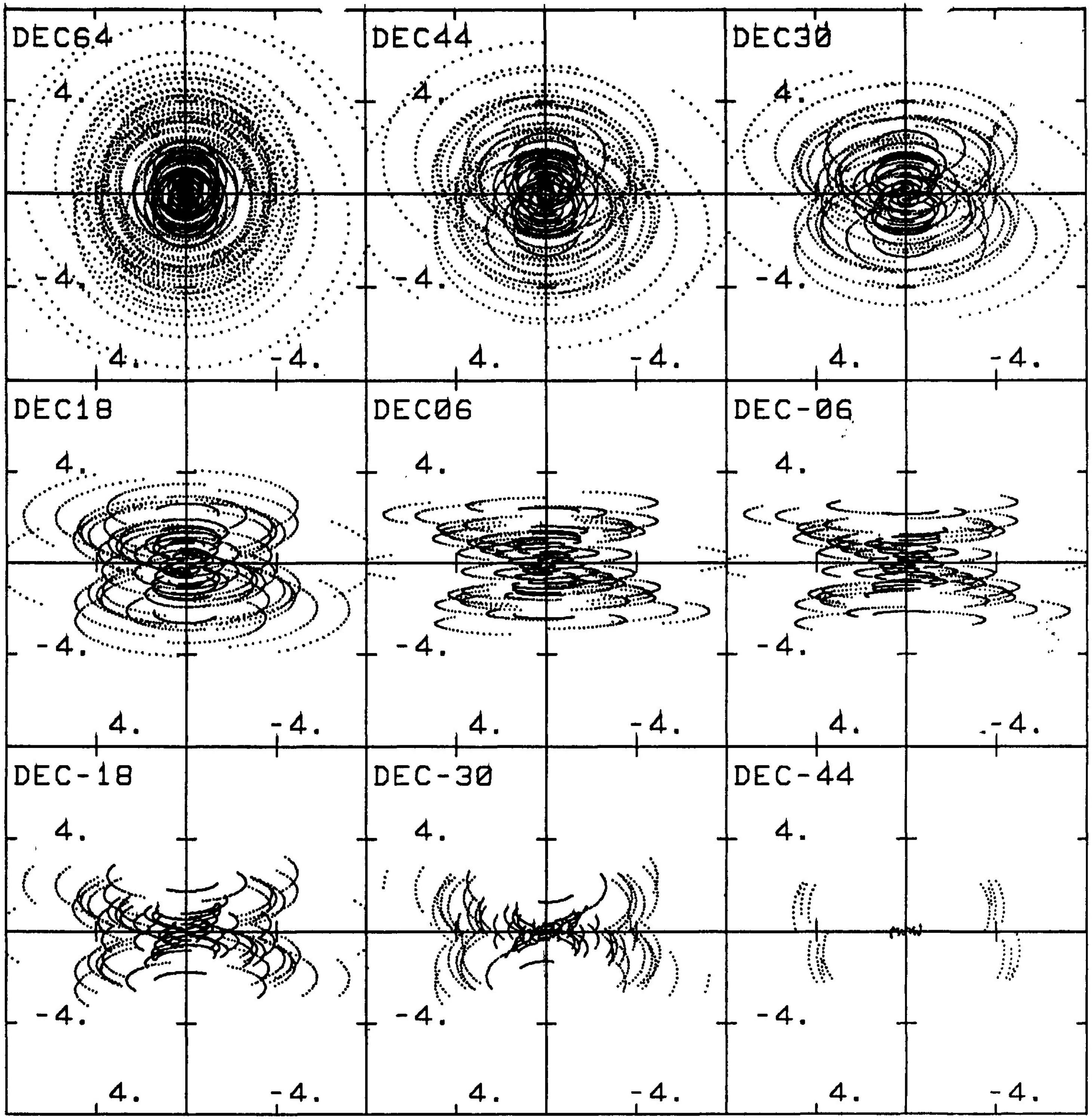
Scale in km
(kilometers x 10^3)

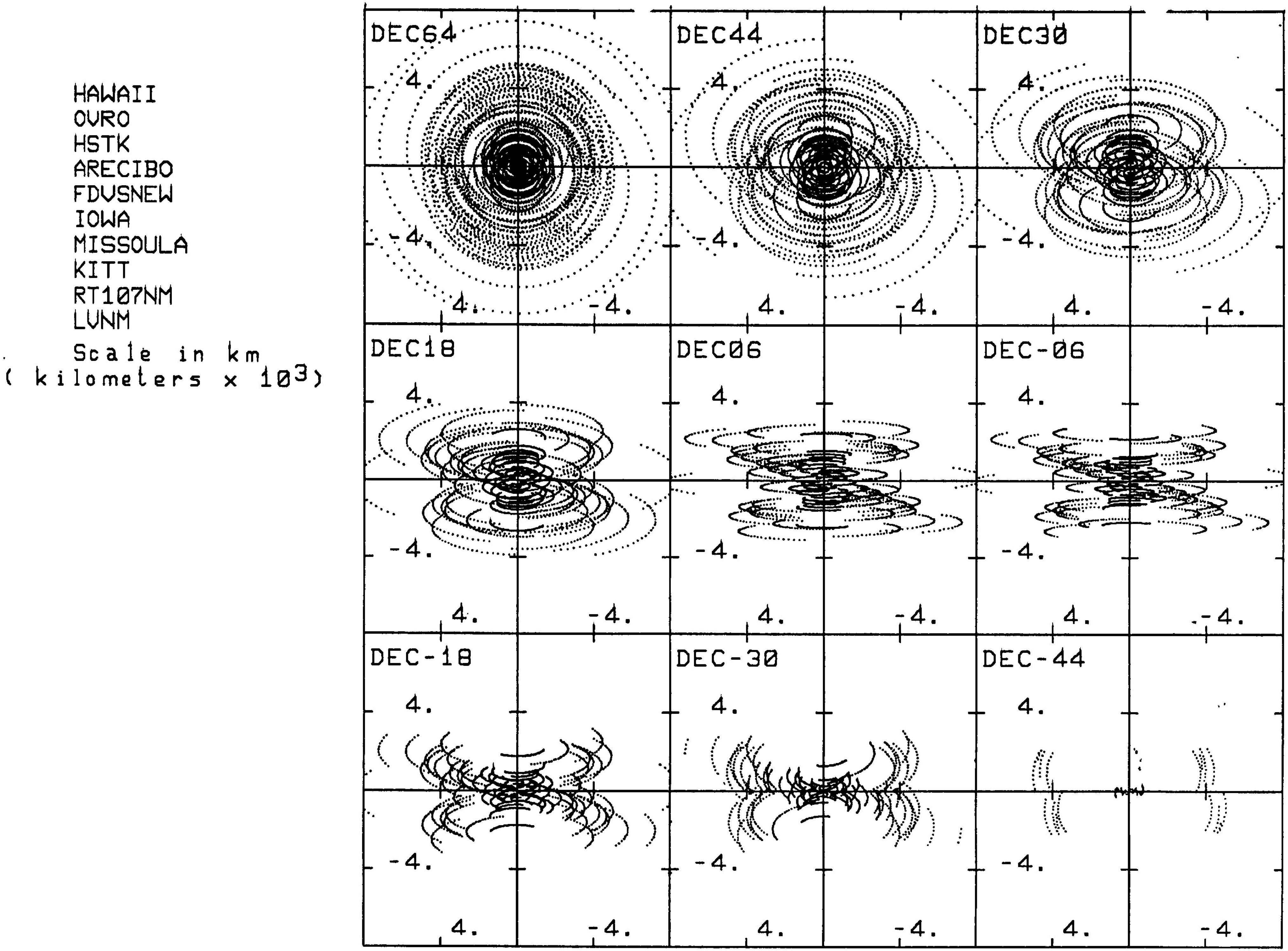



HAWAII
OVRO
HSTK
ARECIBO
LRDO
IOWA
FARGO
AMARILLO
QUEMADO
LASL
Scale in km
(kilometers x 10^3)
DEC64
DEC44
DEC30
DEC18
DEC06
DEC-06
DEC-18
DEC-30
DEC-44
4.
-4.

HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
IOWA
WENATCH
TUSC
RT107NM
LVNM

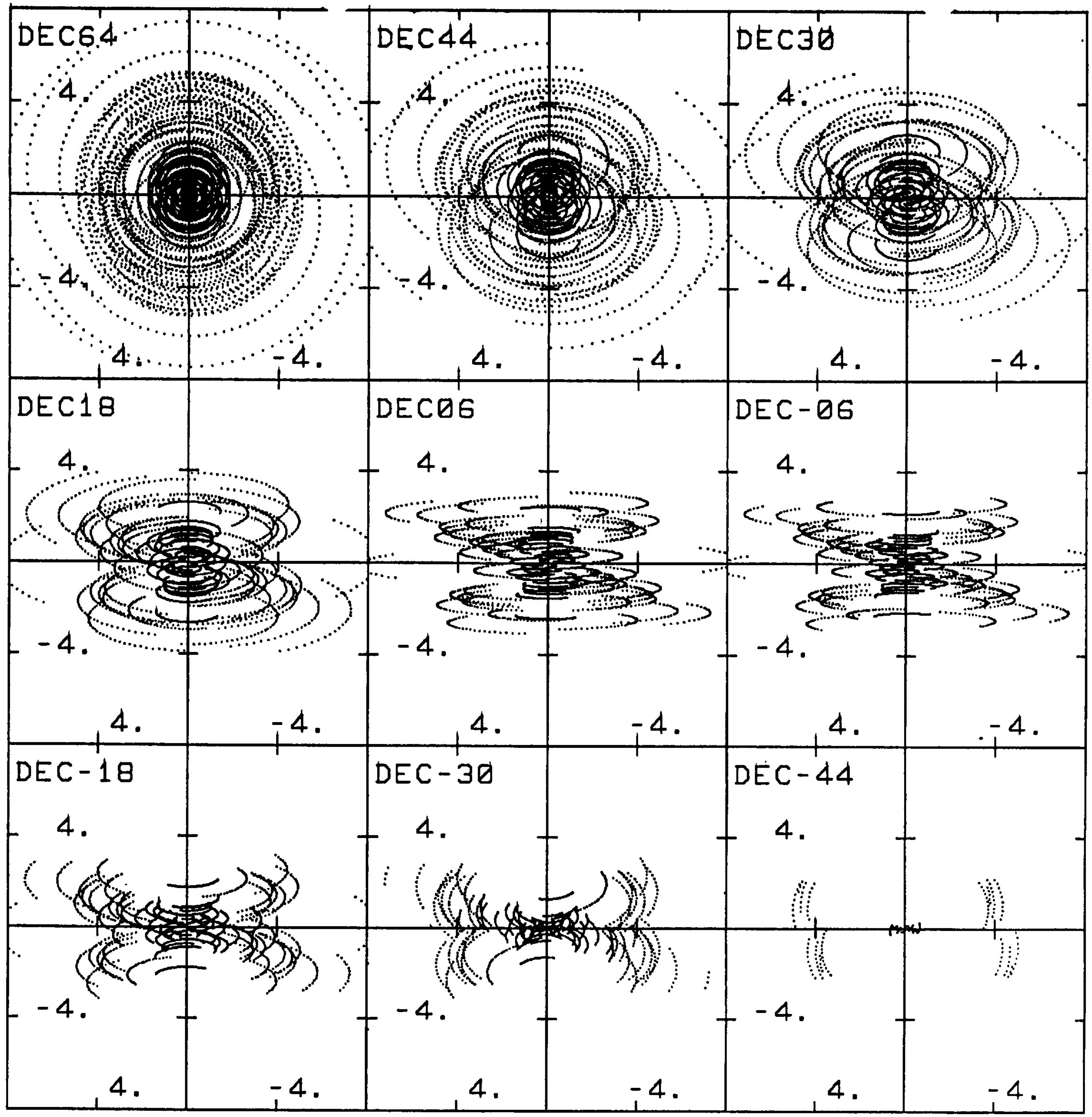
Scale in km
(kilometers x 10^3)




HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
IOWA
MISSOULA
KITT
RT107NM
LVNM
Scale in km
(kilometers x 10³)
DEC64
DEC44
DEC30
DEC18
DEC06
DEC-06
DEC-18
DEC-30
DEC-44
4.
-4.

HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
IOWA
MISSOULA
TUSC
RT107NM
LVNM

Scale in km
(kilometers x 10^3)



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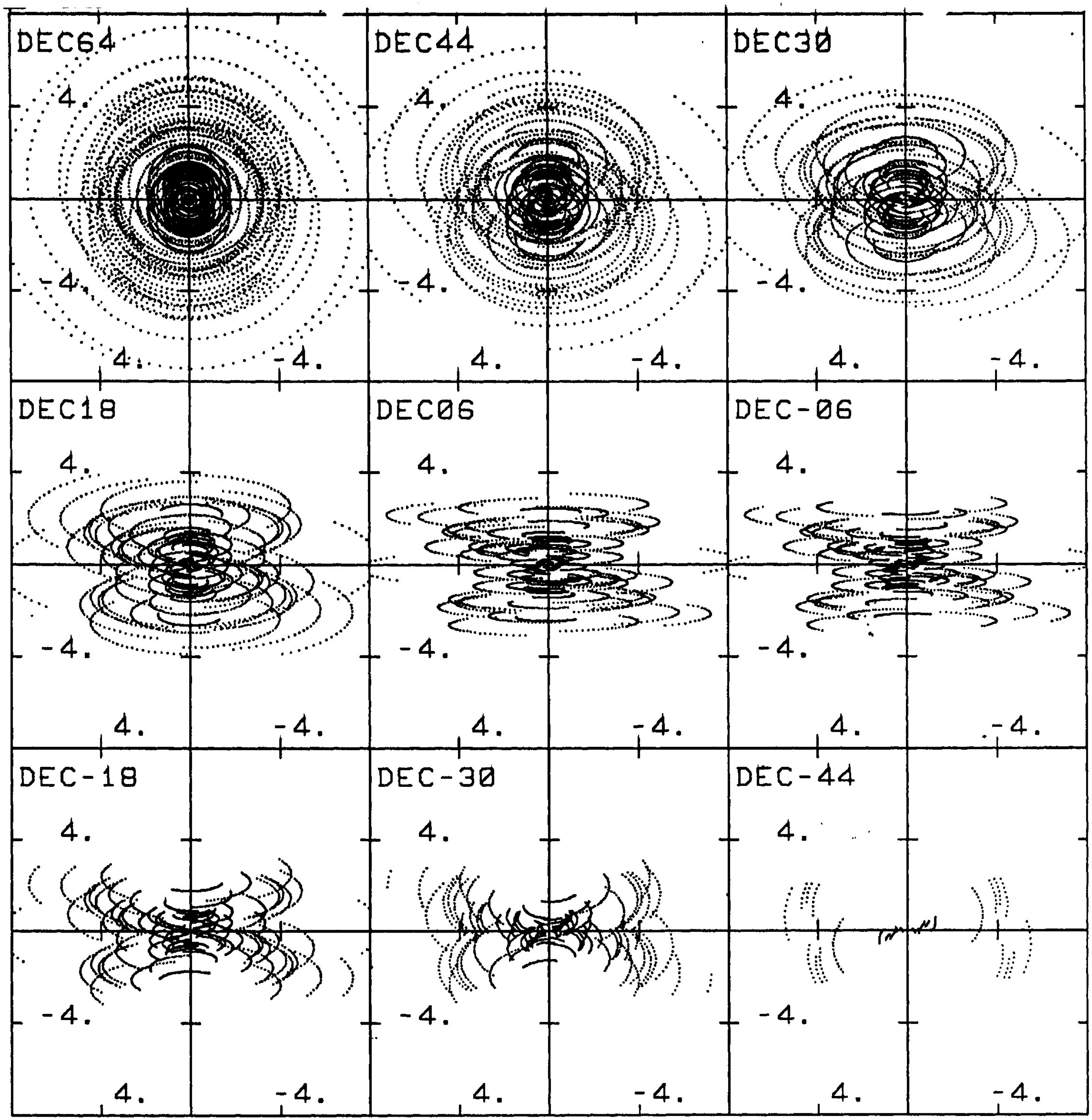
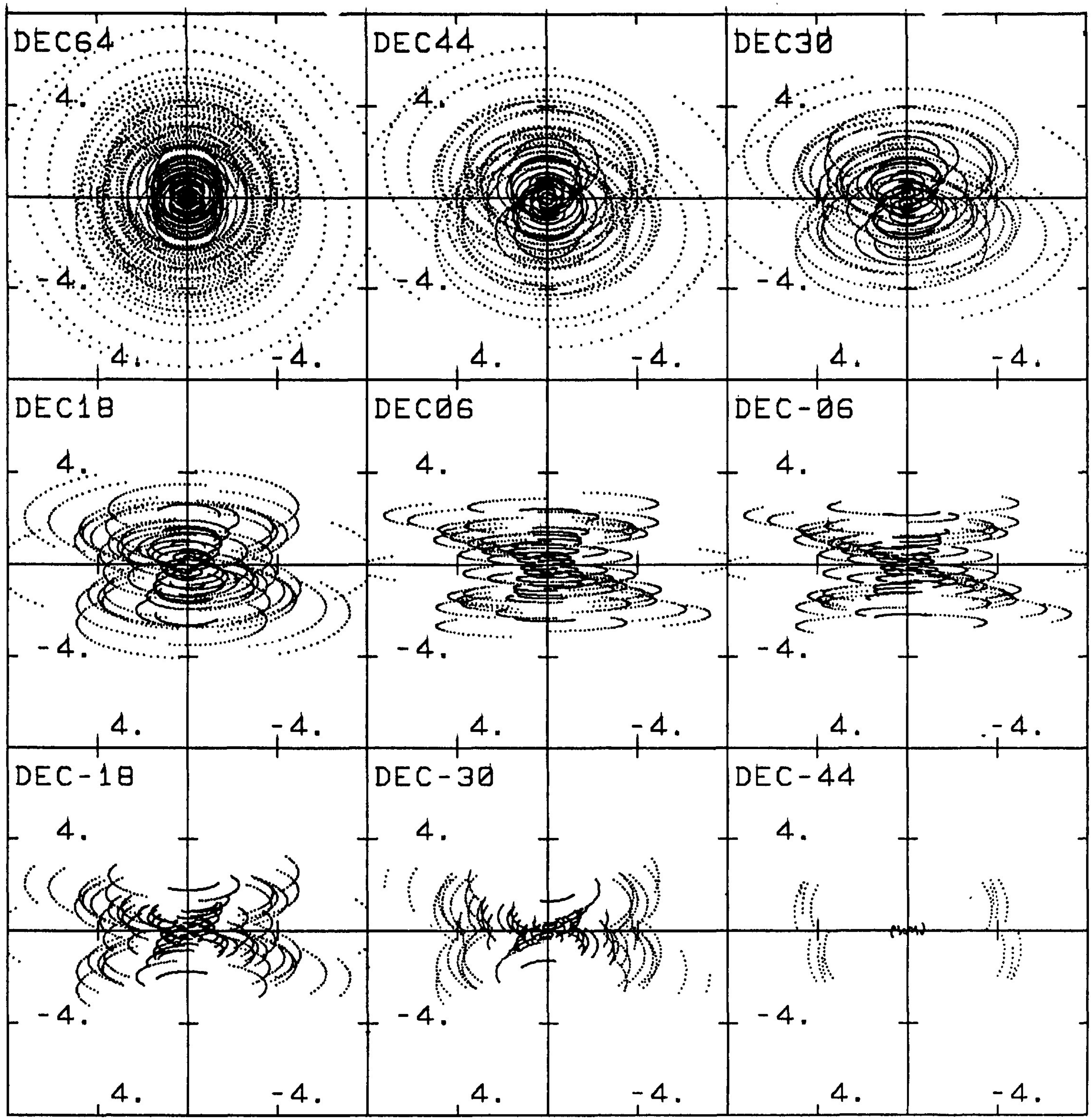
HAWAII
OVRO
HSTK
ARECIBO
LRDO
IOWA
MISSOULA
PHNX
SCHOLLE
GALLUP

Scale in km
(kilometers x 10^3)



HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
ILLN
WENATCH
KITT
RT107NM
LVNM

Scale in km
(kilometers x 10^3)



HAWAII
OVRO
HSTK
ARECIBO
FDVSNEW
IOWA
WENATCH
AMARILLO
QUEMADO
LASL

Scale in km
(kilometers x 10^3)