On the accuracy of the Platzman's charting for loading estimations

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Abstract:

The Platzman M_2 tidal map synthesized from normal modes of the world ocean is used to compute the gravimetric ocean loading and attraction effects. The calculations are made at several continental stations and are compared with results obtained by using the Schwiderski map and with observations. These comparisons show that the Platzman maps are not appropriate to estimate indirect effects.

Plan

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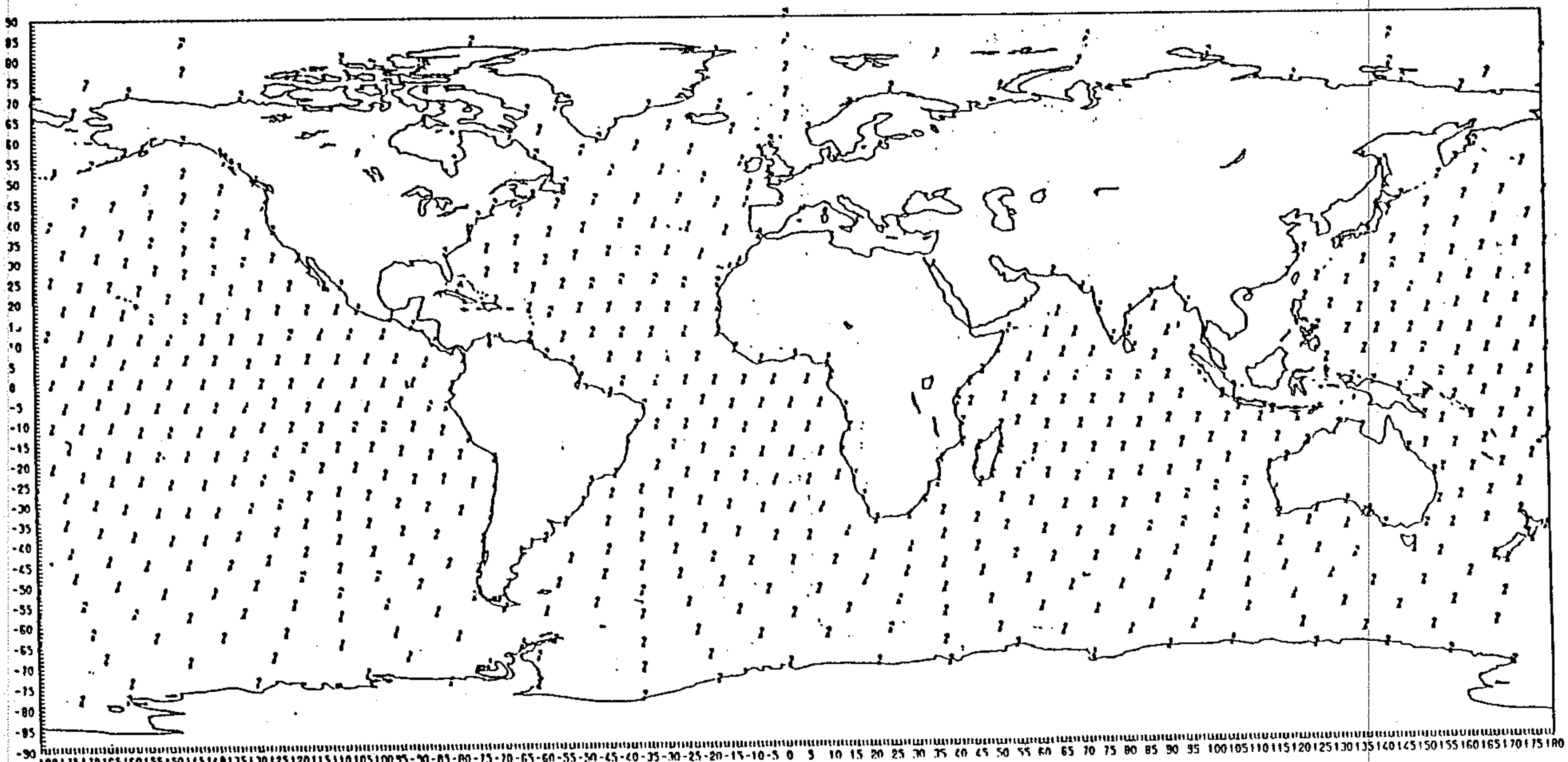


Figure 1 : Platzman map. Localisation of the 743 nodes.

Introduction

At the International Center for Earth Tides (ICET), the Schwiderski cotidal and corange maps for Q_1, O_1, P_1, K_1, N_2, M_2, S_2, K_2 and M_f are used to compute the ocean loading effects. They are at the present day the best global maps because they provide, world wide, the closest results to the observations (Melchior, 1981).

In a series of papers (Platzman 1978, 1983, 1985, Platzman and al. 1981) Platzman has described the development of a finite element barotropic model of the normal modes of the world ocean and, from these normal modes, he has synthesized the tides for the world ocean for O_1, K_1, M_2, S_2, M_1, S_1, N_2 and L_2 components. This procedure to construct the cotidal maps is quite different from the usual method which consists to solve the Laplace's tidal equation using tide-gage data as constraints.

The goal of our paper is to compare the gravity load vectors computed from the M_2 cotidal maps of Schwiderski and Platzman with the observed residues and so to check the validity of the Platzman maps for loading estimations. Indeed, if the results for the M_2 map are satisfactory ones could hope that the M_1, S_1 and L_2 Platzman maps which are not computed by Schwiderski should have the same accuracy.

1. Description of the Platzman maps

The maps contain 743 nodes (figure 1) where elevation amplitude and phase for the tidal constituents are given. From these nodes, I covered the world ocean by a triangular grid of 1299 elements. Except near the coasts, the triangles are approximatively equilateral and have an average side length of 6.9 degrees. They cover an area of 3.29×10^6 km^2 and have an average area equal to that of a 4.5° equatorial square. The maps do not cover the North Sea, Baffin Bay, the Gulf of Mexico and Caribbean Sea, the Bering Sea, and all of the marginal seas on the east Asian coasts (Platzman and al., 1981).

2. Gravity load computation

In the first step, the surface and the barycentre are computed for each spherical triangle. In the second one, the values of the amplitude and the phase converted to two components in quadrature of the tidal M_2 constituent are interpolated at the barycenter using the data at the three vertices. Two different methods of interpolation were applied. The first method was a simple linear interpolation (as Platzman advised in a personnal communication to Melchior in 1986): the plane which contains the three vertices is constructed and then the values of the phase and the amplitude are evaluated at the barycenter.

TABLE I

Name	long.	lat.	Without mass correction: Schwiderski Ampl.	Without mass correction: Schwiderski Phase	Without mass correction: Platzman Ampl.	Without mass correction: Platzman Phase	With mass correction: Schwiderski Ampl.	With mass correction: Schwiderski Phase	With mass correction: Platzman Ampl.	With mass correction: Platzman Phase	Observed residues Ampl.	Observed residues Phase
Asia												
Tashkent	69.30	41.33	0.3154	-97.71	0.4406	68.24	0.5070	-102.60	0.4344	7.10	1.35	-124.7
Frounze	74.62	42.83	0.2395	-105.01	0.4944	70.62	0.4296	-112.23	0.3681	10.43	0.60	-123.6
Novosibirsk	83.30	54.90	0.0339	-101.06	0.4865	78.54	0.2193	-133.14	0.1707	14.48	0.40	-60.3
Talgar	77.38	43.27	0.2053	-108.36	0.5348	70.33	0.3944	-177.26	0.3496	14.08	0.37	-89.2
Irkutsk	104.41	52.36	0.1530	38.22	0.8094	47.64	0.1242	128.50	0.3507	35.32	0.36	8.8
Lanzhou	103.85	36.10	0.2282	-1.53	1.7716	41.79	0.0158	-20.37	1.2677	35.09	0.76	-55.1
Urumqi	87.60	43.81	0.0013	-110.87	0.7487	63.91	0.2655	-136.69	0.3944	32.61	0.56	-34.6
Europe												
Bruxelles	4.36	50.80	1.6570	70.97	1.0759	126.94	1.0797	63.07	1.4862	110.58	1.76	61.4
Kiev	30.60	50.40	0.5039	29.20	0.2811	118.00	0.6314	11.04	0.5132	57.50	1.06	12.5
Potsdam	13.07	52.38	0.9706	56.42	0.5131	117.68	1.1426	45.69	0.0025	09.07	0.99	44.6
Africa												
Bangui	18.55	4.43	1.6601	75.31	1.0342	105.64	1.6997	67.30	1.3999	06.05	2.59	41.6
Lwiro	28.60	-2.18	2.1719	77.02	0.6728	117.00	2.1169	70.63	0.0610	79.74	2.02	86.8
Butare	29.75	-2.59	2.2818	76.78	0.6395	120.51	2.2160	70.60	0.7932	79.55	2.26	69.1
North America											1.95	-11.9
Pittsburgh	-79.73	40.47	2.1536	-2.45	2.6159	35.13	1.8062	-3.00	2.1097	26.05	2.30	5.7
Ottawa	-75.72	45.38	2.1395	-14.07	2.3142	29.99	1.0706	-16.06	1.0090	21.40	1.72	-25.4
Holland Hills	-75.65	45.75	2.1136	-13.89	2.2638	30.06	1.8440	-15.07	1.7607	21.42	1.41	-18.3
South America												
Campo Grande	-54.62	-20.46	1.2869	46.78	2.8503	74.50	1.3095	57.90	2.5034	07.08	1.02	68.4
Cuiaba	-56.13	-15.61	1.5631	47.84	2.5399	79.29	1.5720	57.16	2.3052	93.29	1.89	82.4
Manaus	-59.83	-3.17	2.3997	49.64	1.9050	91.36	2.3760	56.05	1.7400	110.44	1.50	26.8
Iquitos	-73.24	-3.73	2.4882	57.18	1.1643	77.40	2.3735	63.14	0.6560	101.43	2.24	88.8
Australia												
Alice Springs	133.83	-23.71	0.8035	-72.47	2.5374	22.11	0.5420	-70.06	1.9423	30.29	0.75	-43.3
South Pole												
		-90	0.7091	-63.35	0.8303	-130.03	0.7303	-45.60	0.5720	176.70	0.35	-31.1

Note: All amplitudes are given in microgals and all phases in degrees.
A negative phase corresponds to a lag.

The second method was a cubic spline interpolation (Inoue, 1986). This last method was rejected because instability appeared for some triangles.

In the third and last step, the response of the Earth to ocean loading effects at a given station is computed by a convolution of the Green's functions derived by Farrell (1972) for the Gutenberg-Bullen A model with the mass (surface x amplitude) of each spherical element from the Platzman map. To obtain the total response, the direct or newtonian attraction of each mass is added. For this last effect, the altitude of the stations is taken into account (Melchior and al., 1980).

3. Numerical results.

The gravity load vectors have been computed for several continental stations over the five continents (table 1). They were not computed for coastal stations because the results will be certainly not reliable due to the low resolution of the Platzman map. Indeed, the side of the triangles have a length of about 700 km and it is not physically realistic therefore to calculate the loading effects at a station close to the ocean.

In the table 1, the results of computation performed with a mass correction (Melchior and al., 1980) in order to conserve the total mass of the world ocean are also presented. All the results computed with the Platzman map are compared with those obtained by using the Schwiderski map. Obviously the observed tidal residues are fitting better to the load vectors obtained from the Schwiderski map. In order to try to understand the difference between the two maps, they are compared for an area of 30° x 30° in the North Pacific (figure 2).

There is no similarity between the both maps and then it is not surprising that the results are quite different.

If one makes a comparison continent by continent, one can conclude that the gravity load vectors obtained from the Platzman map disagree very much in phase with the observed residues except in Africa and in amplitude except in North-West America. In general, phases and amplitudes always disagree and when seldom one of them is in agreement the other disagrees.

Conclusion

The computation of the gravimetric ocean loading and attraction effects shows that the Platzman maps are not appropriate for estimation of indirect effects. The reasons are that the resolution of these maps are too low and that Platzman did not take account of ocean loading and self attraction as well as tide-gage data to compute his maps (Platzman personal communications to Melchior 1986 and 1987).

Caption to the figure 2

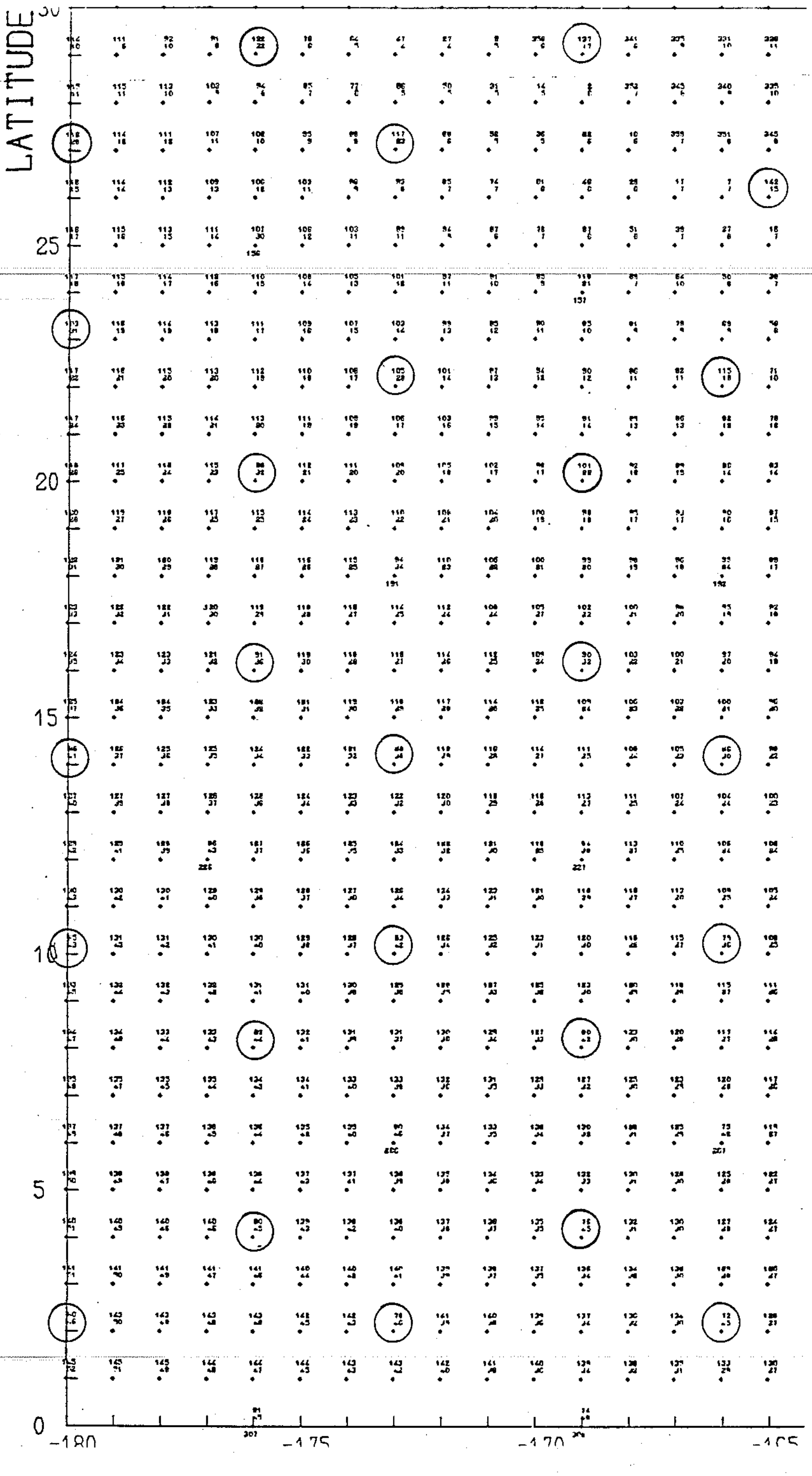
The Schwiderski and the Platzman maps are compared in this figure.

xxx
yyy xxx = phase (in deg.)
◆
zzz yyy = amplitude (in cm)

zzz = if zzz exists, it represents the number of the nodes from the Platzman map.

(◆) = it represents a point interpolated from the Platzman maps.

Note: the longitude and latitude of the points are not the same as those of the different maps. For example, all points of the Schwiderski map must move from 0.5° in latitude and longitude. But, for our purpose, there is not inconvenient.



LATITUDE
25
20
15
10
5
0
-180
-175
-170
-165

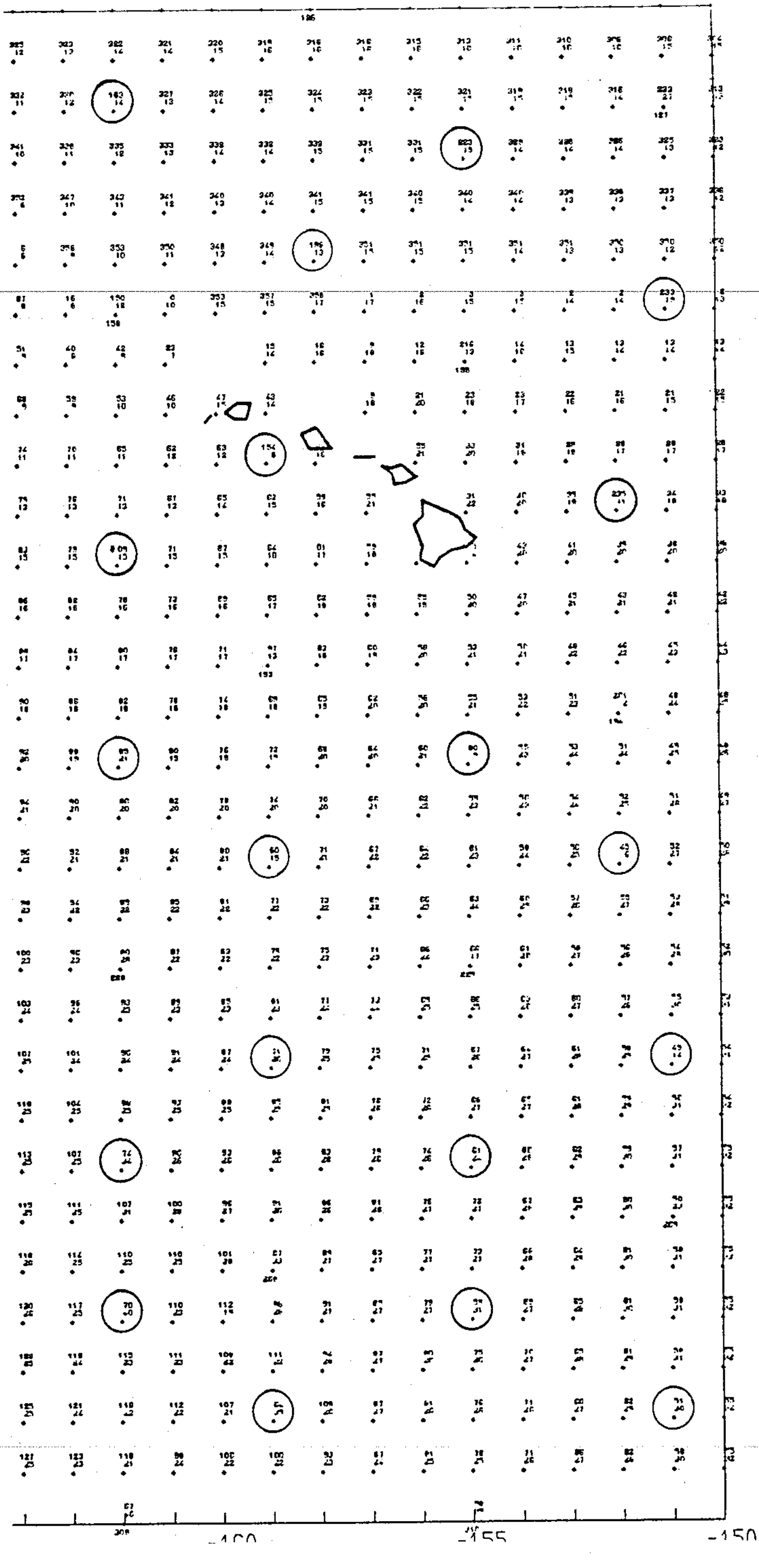


FIGURE 2

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