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An Investigation of the Role of Current and Future Remote Sensing Data Systems in Numerical Meteorology

for the period of

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submitted by

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1. Introduction

A fundamental element in the design and implementation of any satellite radiometric sensor is the investigation of the potential of the instrument in an operational framework. Such investigations provide insight into what kinds of observations the instrument will and will not be capable of and how its measurements will blend into an already operational database of atmospheric observations from a variety of existing observing systems, each with its own characteristics.

This NASA-sponsored work has taken the first steps in addressing the question of the potential impact of the Advanced Microwave Sounding Unit (AMSU) on numerical analyses and forecasts and what advantages it will have over its predecessor the Microwave Sounding Unit (MSU). The work described here has been the precursor to a series of Observing System Simulation Experiments (OSSEs), which will be conducted for the AMSU and other new observing systems under continuing NASA support.

2. Simulated AMSU Radiances

The AMSU is a twenty-channel radiometric receiver capable of sensing the passive emission of radiation by the earth-atmosphere system in the microwave portion of the electromagnetic spectrum. It has been selected to replace the four-channel MSU in future polar orbiting satellites and will be a continuing part of the TIROS series of NOAA satellites.

Under this NASA program we have developed the capability to synthesize AMSU radiances from gridded fields of atmospheric state variables produced from the CIMSS Subsynoptic Scale Model (SSM) as a precursor to performing AMSU retrievals and analysis/forecast experiments from these simulated data. The AMSU forward radiance model is outlined in Eyre and Woolf (1988). In cooperation with the MSFC we have also developed procedures to make synthetic imagery from the AMSU channels. Synthetic satellite imagery is developing as a new diagnostic tool for providing information on the structure of the atmosphere and its time evolution and will be of great benefit in diagnosing forecast model deficiencies in a previously unexplored manner.

3. Retrieval Methodology

Central to the discussion of the impact of information to be obtained from a new radiometric sensor is the retrieval algorithm to be employed in transforming radiation measurements into meteorological observations. Although a wide variety of inversion methods could be applied to the problem, this investigation and continuing work focuses on the technique of one-dimensional optimal interpolation retrieval developed by Eyre (1988). Under this NASA program the Eyre method, originally developed for the TOVS, was expanded to AMSU application and preliminary AMSU retrieval sets were produced from the synthetic radiances described in the previous section. Some examples of these retrievals are shown in Figures 1-4. In each of these examples the "mesotruth" atmospheric profile is from SSM output and has been used to produce "truth" synthetic AMSU radiances at the location. Figures 1 and 2 show general retrieval quality at several locations. In these cases the "background" profile means the profile which has been produced by adding errors to the mesotruth profile. In these two cases the retrieval has improved the background profile by bringing it into closer agreement with the mesotruth profile in both temperature and moisture.

Figures 3 and 4 show similar tests for the HIRS with and without the AMSU channels also included in the retrieval. In these two examples the primary impact of the combination AMSU/HIRS appears to be in the designation of low and mid level atmospheric moisture.

The Eyre retrieval method is unique in that it will retrieve not only atmospheric temperature and moisture information from AMSU radiances, but also surface microwave emissivity and, when HIRS channels are included, the cloud height and its fractional coverage. The cloud retrieval accuracy has been shown to be comparable to that of CO_2 slicing methods (Eyre and Menzel; 1988). The retrieval method also has natural advantages for OSSEs because the statistical error characteristics of the background fields for retrieval can be easily varied and the results on the retrieval observed. This will provide important information about where and when the AMSU can be expected to provide useful improvements over a forecast background field.

4. LAMPS Model Forecasts from SSM Analyses

In this program an effort has been made to combine the strong features of two different analysis/forecast systems, the SSM and LAMPS. The SSM has a superior analysis package, recently updated to an optimal interpolation incremental scheme, while the LAMPS forecast model has more complete physical parameterizations. Software has been developed to transform SSM analyses to LAMPS forecast model input format and execute LAMPS forecasts on the Marshall Cray from this input. We expect that this capability will be valuable in subsequent OSSEs where comparisons of two different forecast models running from the same analysis will be required.

5. SSM Forecasts on the Marshall Cray

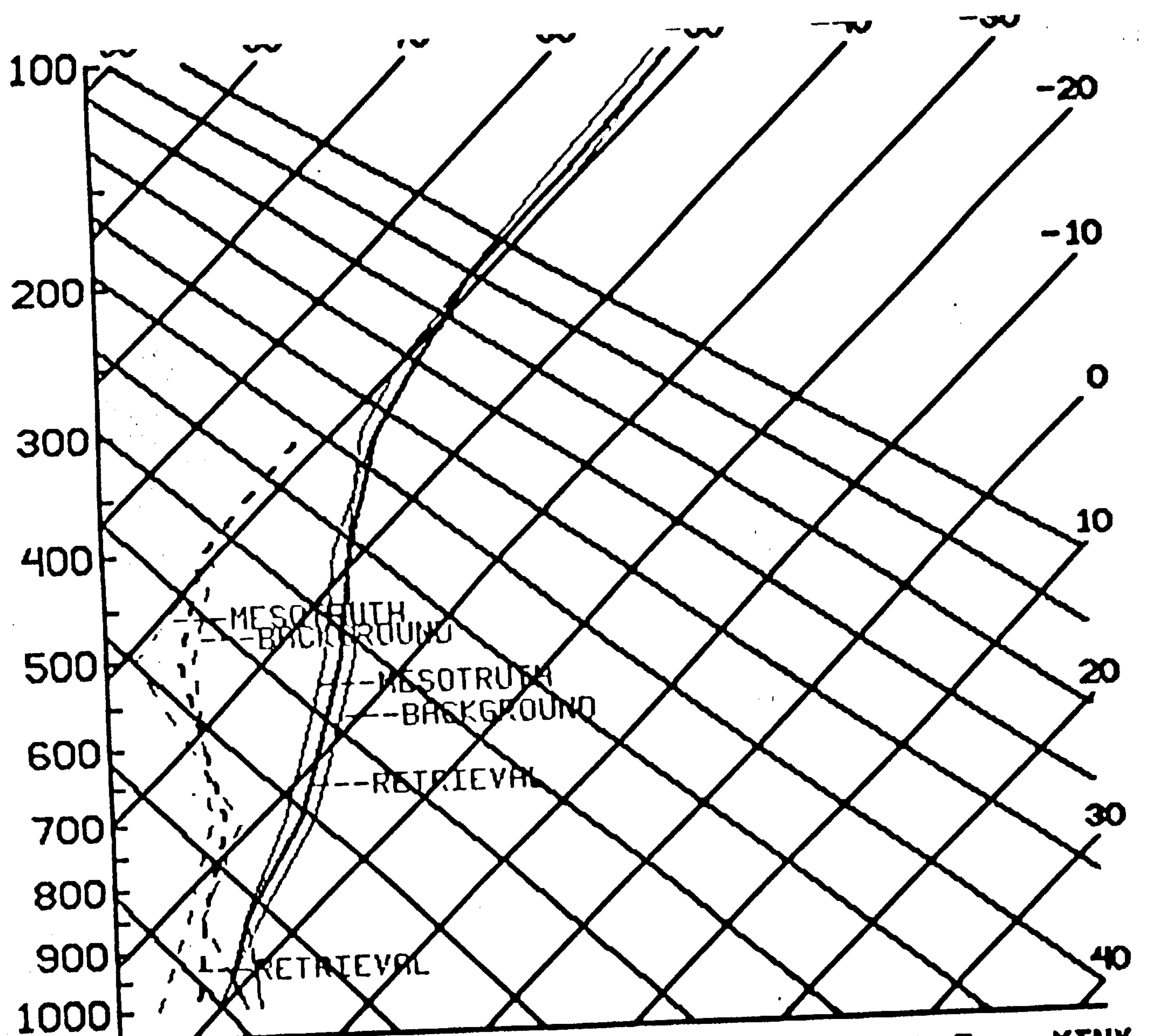
Due to the limited memory and CPU capabilities of the Wisconsin IBM-McIDAS, it is desirable to have the capability to run the SSM forecast model on the Marshall Cray. To this end, the SSM forecast code has been installed on the Cray. Some problems remain however because of inefficient facilities for transferring large SSM analysis data sets between the Wisconsin McIDAS and the Cray.

References

Eyre, J.R. and H.M. Woolf, 1988: Transmittance of atmospheric gasses in the microwave region: a fast model, Appl. Optics,27,3244-3249.

Eyre, J.R., 1988: Inversion of cloudy satellite sounding radiances by non-linear optimal estimation: theory and simulation for TOVS. Accepted for publication Quart. J. Roy. Meteor. Soc.

Eyre, J.R. and W.P. Menzel, 1988: Retrieval of cloud parameters from satellite sounder data. Accepted for publication J. Appl. Meteor.



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271200	300	22	0	-12	-10	24	-28	2

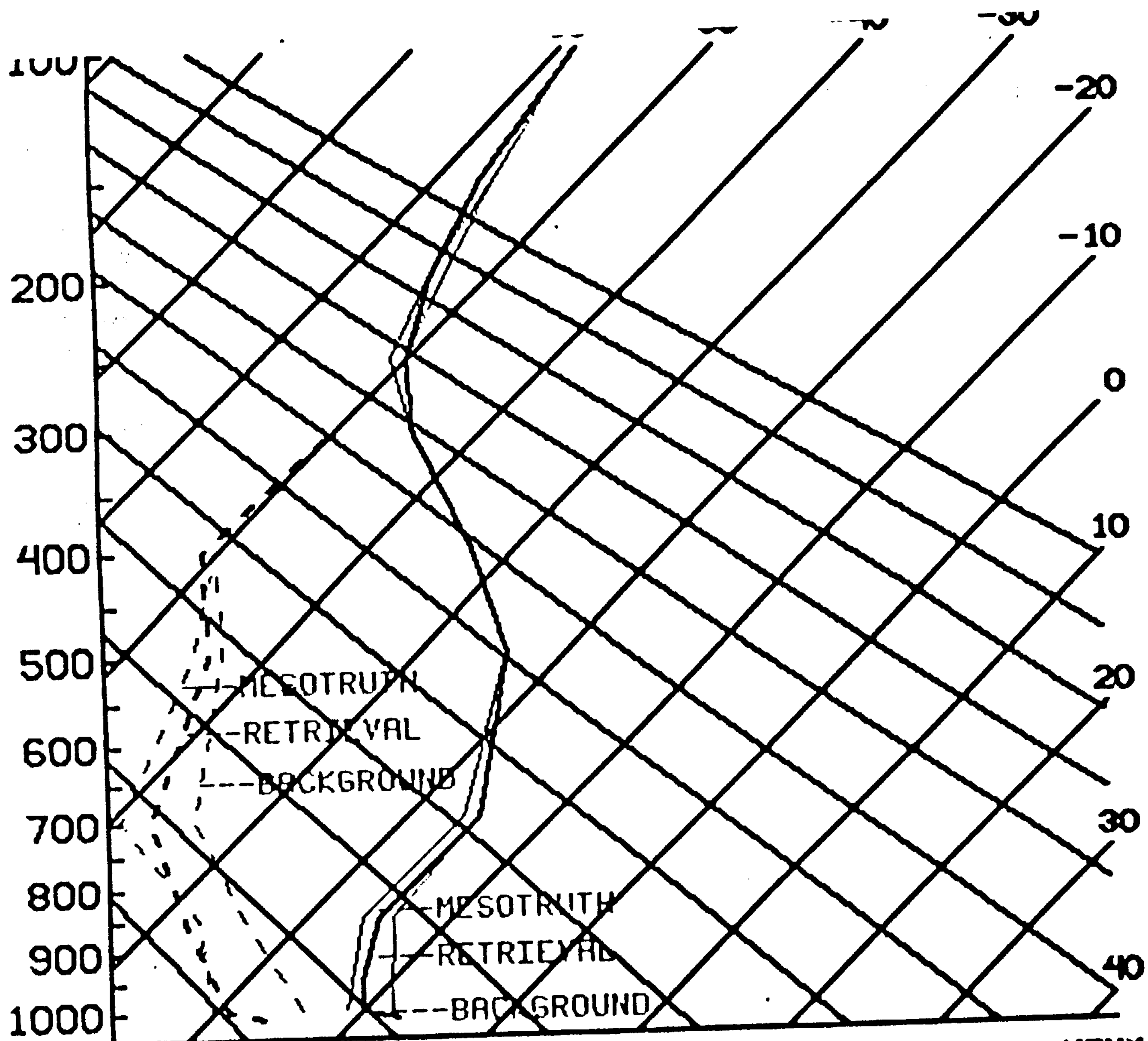

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FIG 2

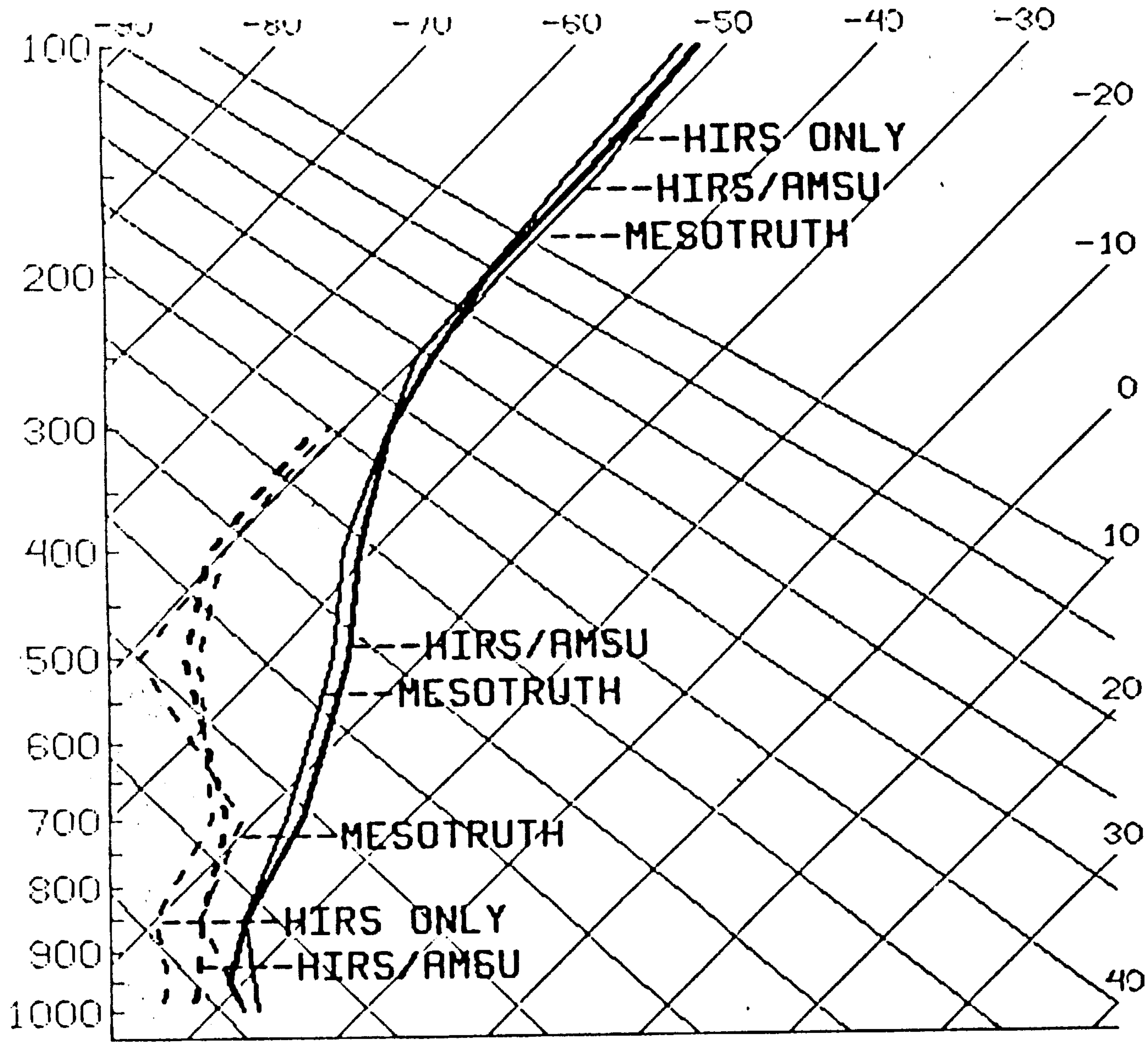

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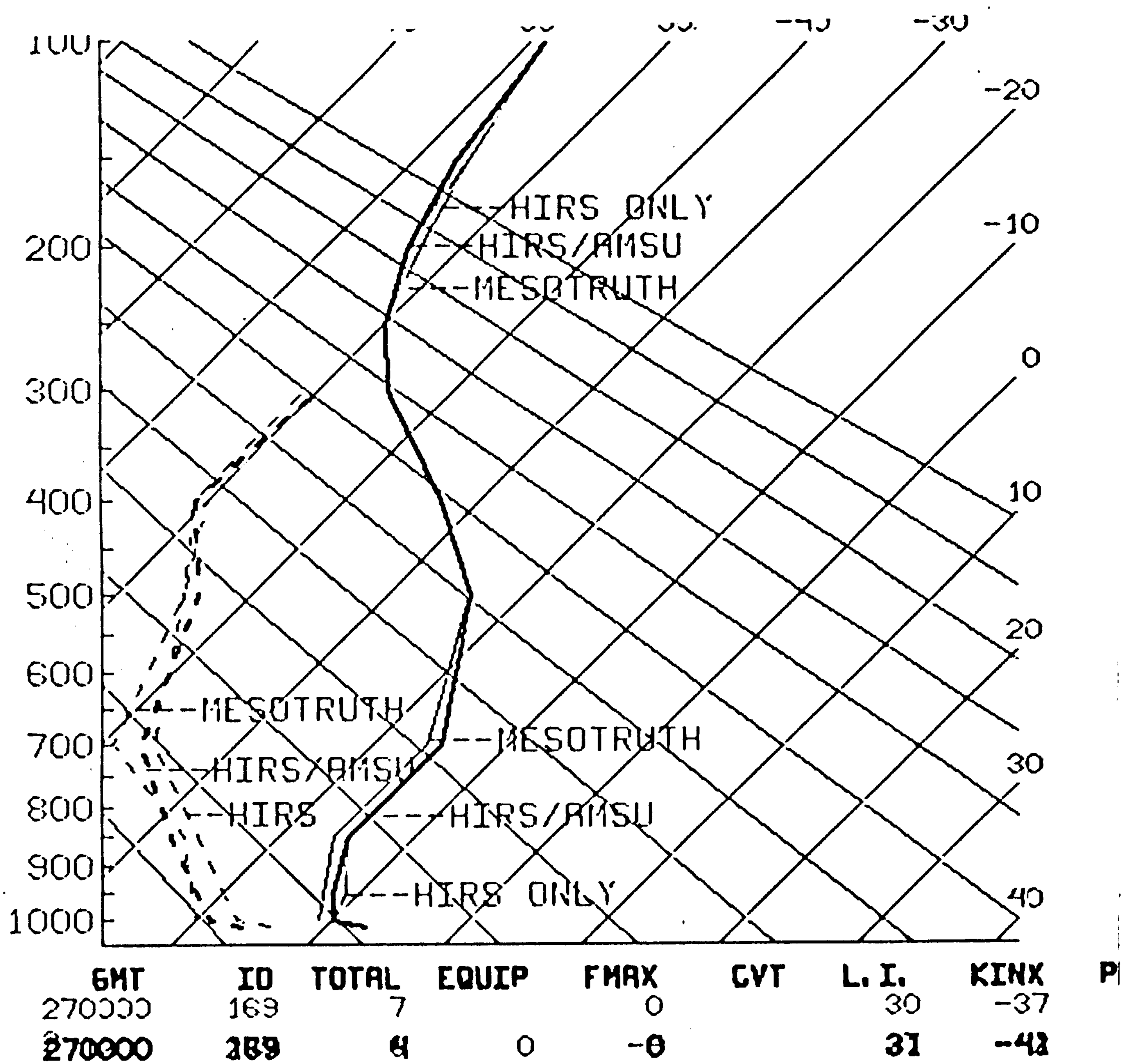
FIG 3


100
200
300
400
500
600
700
800
900
1000
-30
-20
-10
0
10
20
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40
--HIRS ONLY
--HIRS/AMSU
--MESOTRUTH
--MESOTRUTH
--HIRS/AMSU
--HIRS
--MESOTRUTH
--HIRS/AMSU
--HIRS ONLY
GMT
ID
TOTAL
EQUIP
FMAX
CVT
L.I.
KINX
270000
169
7
0
30
-37

FIG 4