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FINAL REPORT

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SUPPORT OF DATA ACCESS FOR THE IMP-8 UMD EXPERIMENT

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SCIENCE SUMMARY

Our funding level was barely sufficient to cover our routine processing costs. We did use our IMP data to assess the state of the interplanetary medium, quickly and accurately, before analyzing events from other spacecraft and also used our IMP data to assist in the analysis of our ULYSSES and SOHO data sets.

Figure 1, one of our WWW plots, shows the instrument response during an active time period in April 2001. Note that the color-coding allows an easy, visual identification of the nominal position of the earth's bow shock and magnetopause. The A2 channel (see the Appendix for a definition of the rate channels) detects the presence of high energy protons from the solar flares on April 10, 15 and 18. The P5 rate shows the presence of a background caused by those penetrating particles. Also indicated in Figure 1 are the arrival times of three strong shocks detected during this IMP orbit; these shock times are from the UMd instrument on SOHO (http://umtof.umd.edu/pm/FIGS.HTML). Note that the P3 rate (~200 keV protons) has a local maximum during each of these shock passages.

Another example is provided in Figure 2, which shows (top panel) an increased flux of >20 MeV and >40 MeV protons caused by a solar flare on 28 Jan 2001. The middle panel of Figure 2 shows that the ~200 and 700 keV protons have a local maximum at the time of the flare-generated shock passage (bottom panel).

One of the advantages of the IMP-8/UMd instrument data set is its very long baseline, from late 1973 to the present. We have developed software that could allow us to explore the particle environment at 1 AU with this data set. In the following we present preliminary results from this effort, making use of the two very large geometry factor scintillator anticoincidence rates.

Figure 3 shows the entire ~ 27.5 year time interval as detected by the A1 rate (which has an integral response above about 40 MeV). The two traces represent the maximum and minimum values for A1, derived as follows. For each consecutive 30 day interval the 5 lowest and highest ten-minute averaged rate values are ignored (this was in order to reject occasional data-hits). The 5 next highest and lowest values were then averaged separately to form the quantities A1_max and A1_min. The A1_min trace in Figure 3 reflects the behavior of galactic cosmic rays, while the A1_max trace presents a record of the largest solar particle events. Two of the three largest solar events occurred relatively recently (July and November 2000), while the third occurred about 11 years earlier. During times of solar minimum (e.g., 1996) the *difference* between the two traces presumably represents the quiet-time solar system energetic particle intensity level; we note that the statistical errors in each of the data points is very small, of order 10^{-3}.

Figure 4 displays the 'min" values from both the A1 and A2 scintillators. The primary difference is the overall count rate, a reflection of their different geometry factors. There are however additional subtle differences, for example in their relative phases, that would be interesting to explore. Presumably these differences are caused by the different energy thresholds of the two rates (~ 20 and 40 MeV).

In order to explore the expected anti-correlation of A1_min with solar activity Figure 5 displays the Monthly (Unsmoothed) Sunspot Number and a quantity that is anti-correlated with A1_min: (475 – A1_min)/2, which for convenience we call the A1-trace. The Figure confirms the expected anti-correlation of galactic cosmic ray intensity with solar activity. Note that both the Sunspot Number and A1-trace are lower in Cycle 23 (with maximum in the year 2000) than in the previous 2 Cycles. The expected phase-lag of cosmic ray intensity relative to solar activity is also evident, although interestingly this hysteresis effect appears strongest in Cycle 21.

Finally, in Figure 6 we compare the behavior of A1_min with the University of Chicago Climax Neutron Monitor data set. The Climax data responds to energies above about 3 GeV. Note the different scales for the 2 traces: the A1_min scale (left axis) is logarithmic while the Climax axis (right) is linear. The peak-to valley ratio for A1_min is about a factor of 3, while for the Climax data it is only about 50%. This difference presumably reflects the different threshold values of ~ 40 MeV and ~ 3 GeV. There are also small differences in phase between the two traces. These differences would be interesting to explore in future work.

DATA SUMMARY

The most recent DECOM data set received from GSFC was DECOM 2526, ending on October 26 2001. The most recent encyclopedia that has been generated is 9815, ending October 26 2001. The most recent summary that has been generated is summary 70, ending on October 26 2001. This summary was retrieved by Goddard via anonymous FTP on April 12, 2002. This is a total for the complete mission of approximately 2500 decoms received, 815 encyclopedias generated, and 70 summaries generated and given to GSFC.

DATA PROCESSING

Originally much of our data processing was done on an IBM 3108 system, at GSFC, where we processed the decom tapes to create encyclopedia tapes containing one orbit (approximately 13 days) of data. Because of the replacement of the IBM 3108 system at Goddard by an IBM 9021, the encyclopedia generating software was rendered inoperative. In view of the prospect of further changes in the Goddard system, the encyclopedia generation program was transferred to our DEC VAX station. This involved extensive modification of the FORTRAN code to deal with the different forms of numerical representation used by DEC, and to allow the program to function on a system with far fewer tape drives. Several modules of the original encyclopedia generator were written in IBM assembly language, and were rewritten in FORTRAN to allow them to function on a DEC system. Finally, the encylopedia generator was moved onto a Compaq Alphastation 250 4/266, (imp8.umd.edu), where all IMP processing software now resides. This involved rewriting of the Fortran code to eliminate tape drive use altogether. Recent encyclopedias now reside on the Alphastation as files, rather than existing as tapes.

Other processing done at UMD using our DEC VAX station system included using encyclopedia files to generate summary files, These files originally contained approximately 6 months of data, but were later shortened to a 2 month length. The encyclopedia files were also used to generate ten-minute orbital counting rate plots routinely used in data analysis. The VAX station was also used to generate printouts and plots for time periods selected for special analysis. We have written software to allow the selection and printing of any or all rates, for any time period on an encyclopedia tape. Time resolution can be varied from the ultimate time resolution of the instrument up to 30 minutes or more. The summary tapes were 1) copied and sent to NSSDC and 2) used as input for a program, running on VAX station, which generated tapes that were also sent to the NSSDC. We wrote a program to print rate data from the summary tape. It allowed the user to select the rates, interval, and time resolution, much as the rate-printing program, above. We have automated the production of plots on the World Wide Web.

Other changes to the IMP data processing programs were made to endure Y2K compliance, to improve the user interface, and to filter out spurious data points caused by telemetry problems. Data formats were also changed to make the data easier to use. New programs were written to extract minimum and maximum values of the A1 and A2 scintillator rates and to facilitate worldwide web processing.

Due to the new tape formats necessitated by the change of systems, several of these IMP data processing programs had to be modified. During the period February 1999 to January 2002, 258 decoms were received from NASA/GSFC.

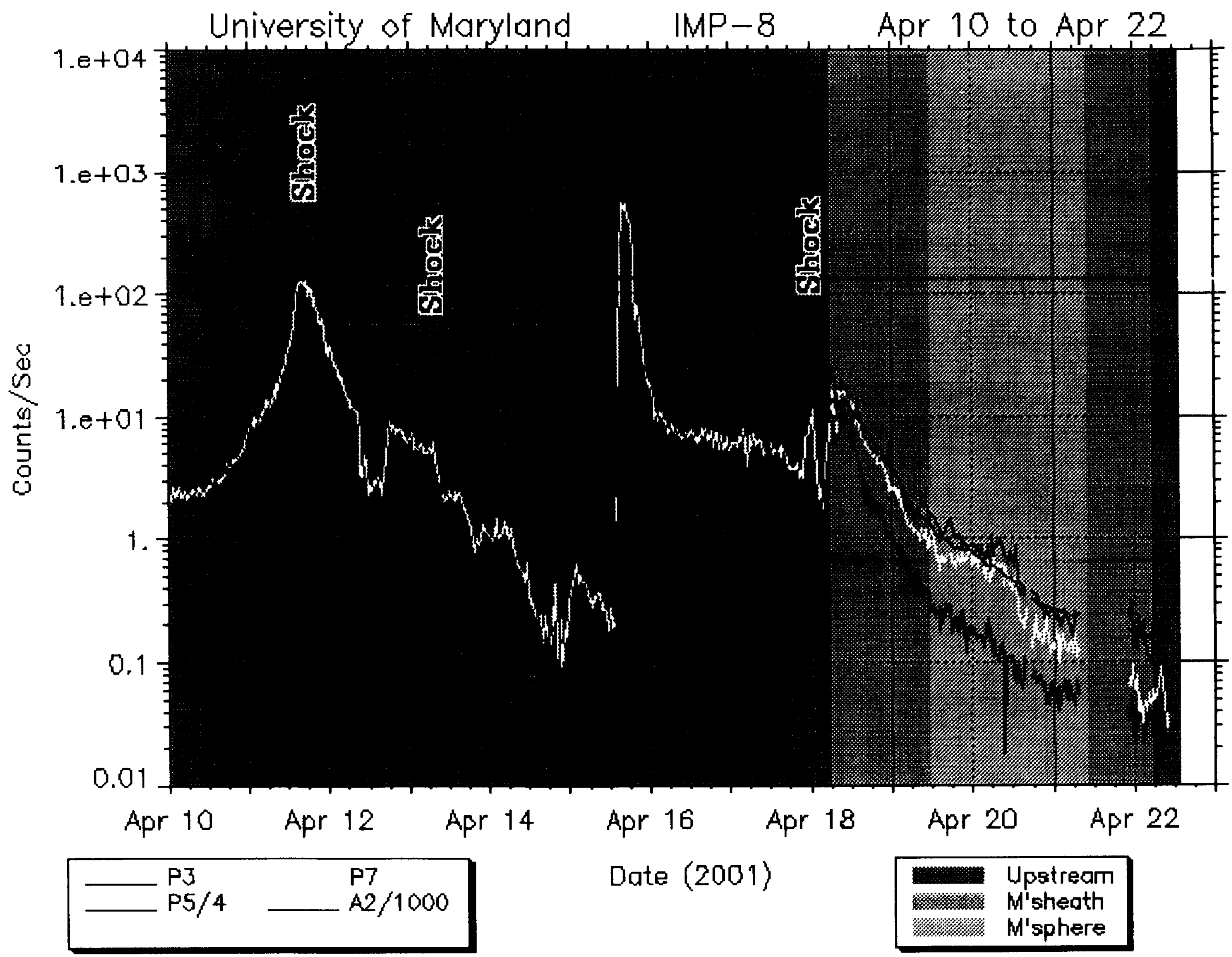
We automated almost all of the IMP data processing. Decom files were transferred automatically from GSFC. When sufficient files had been accumulated to generate an encyclopedia file, the encyclopedia was generated automatically. Then when sufficient encyclopedias have been accumulated to produce a summary, that too, was generated automatically.

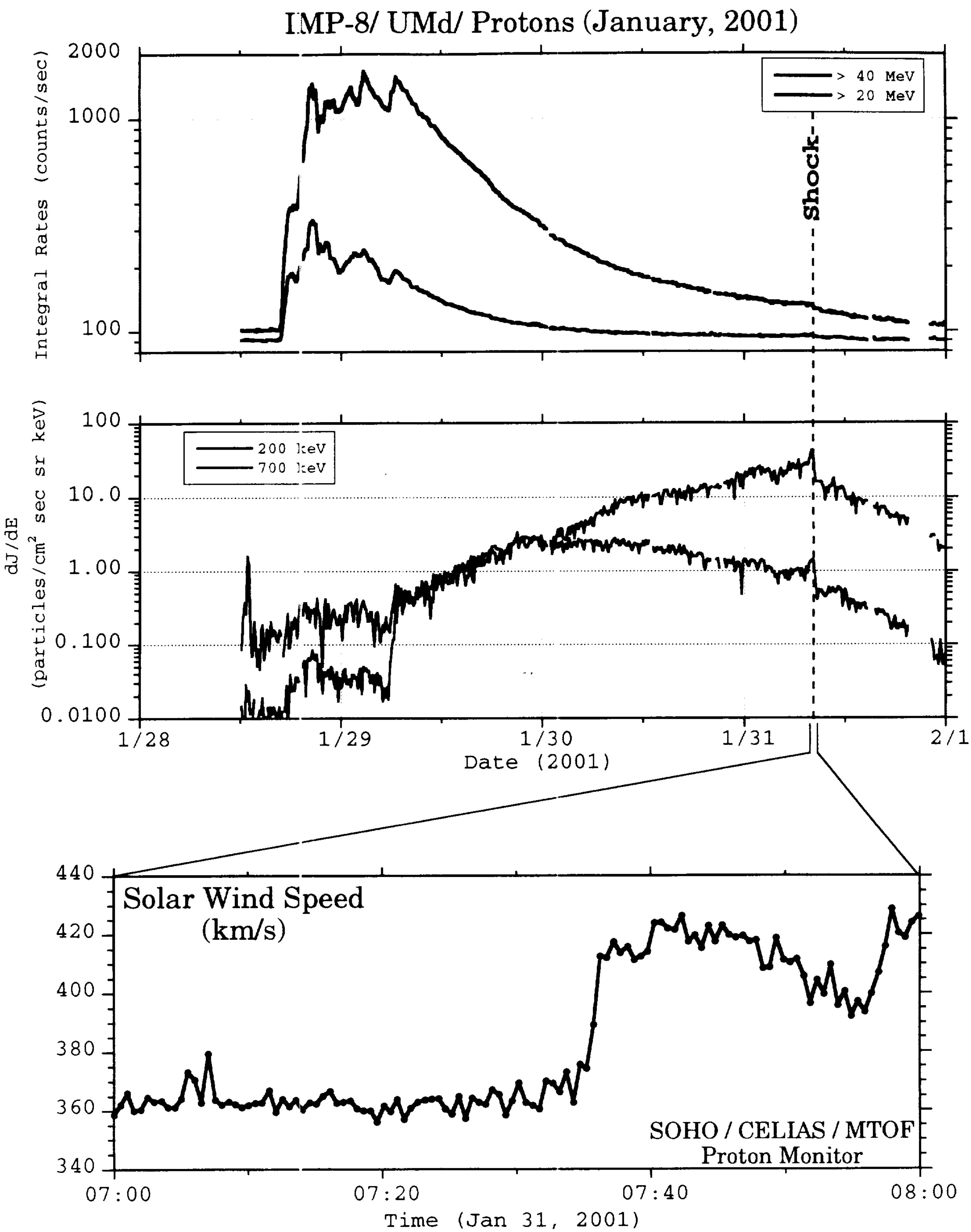
DATA SUBMISSION TO NSSDC

Originally, data submission was done by hand. A summary tape was actually carried over to GSFC. This system was replaced some years ago by electronic transfer. When a summary is completed, the resulting file was automatically placed in the anonymous FTP area of our IMP8 computer, and an email message was automatically sent to NSSDC, notifying personnel there that the summary is available for retrieval via anonymous FTP.

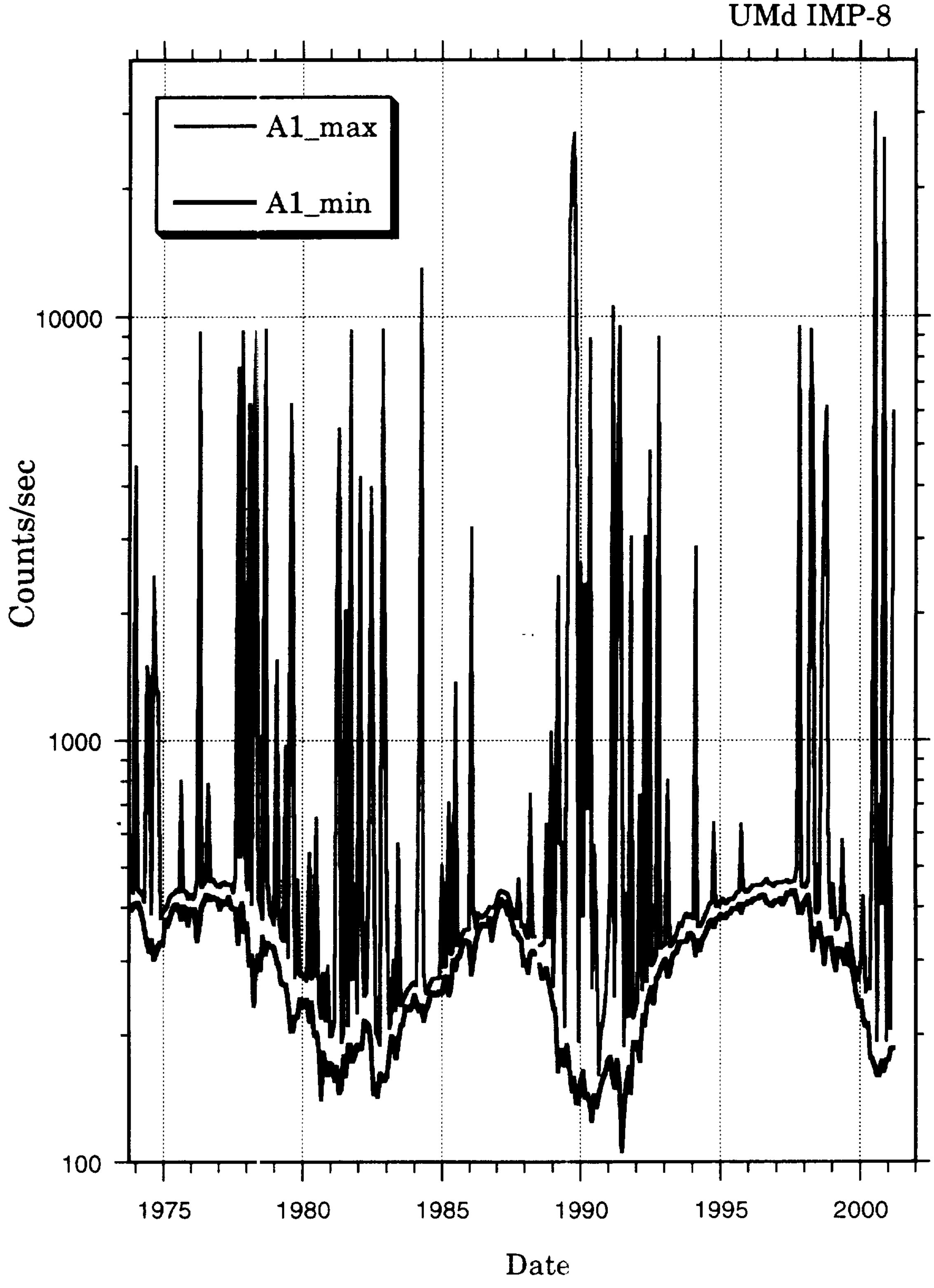
DATA AVAILABILITY ON THE WORLD WIDE WEB

We have constructed a world wide web page (its URL is http://imp8.umd.edu/imp/). This page contains an instrument description and 182 plots and the corresponding listing files, as well as a link to the overall IMP page at Goddard. Each plot/listing covers one orbit period, so there is nearly continuous coverage from August 1995 through the end of the mission in October 2001. The web page was continuously and automatically updated. As new encyclopedia files were generated, new plots and lists were created and a pointer to them was inserted into the web page, allowing relatively recent data to be available without the need for human intervention.

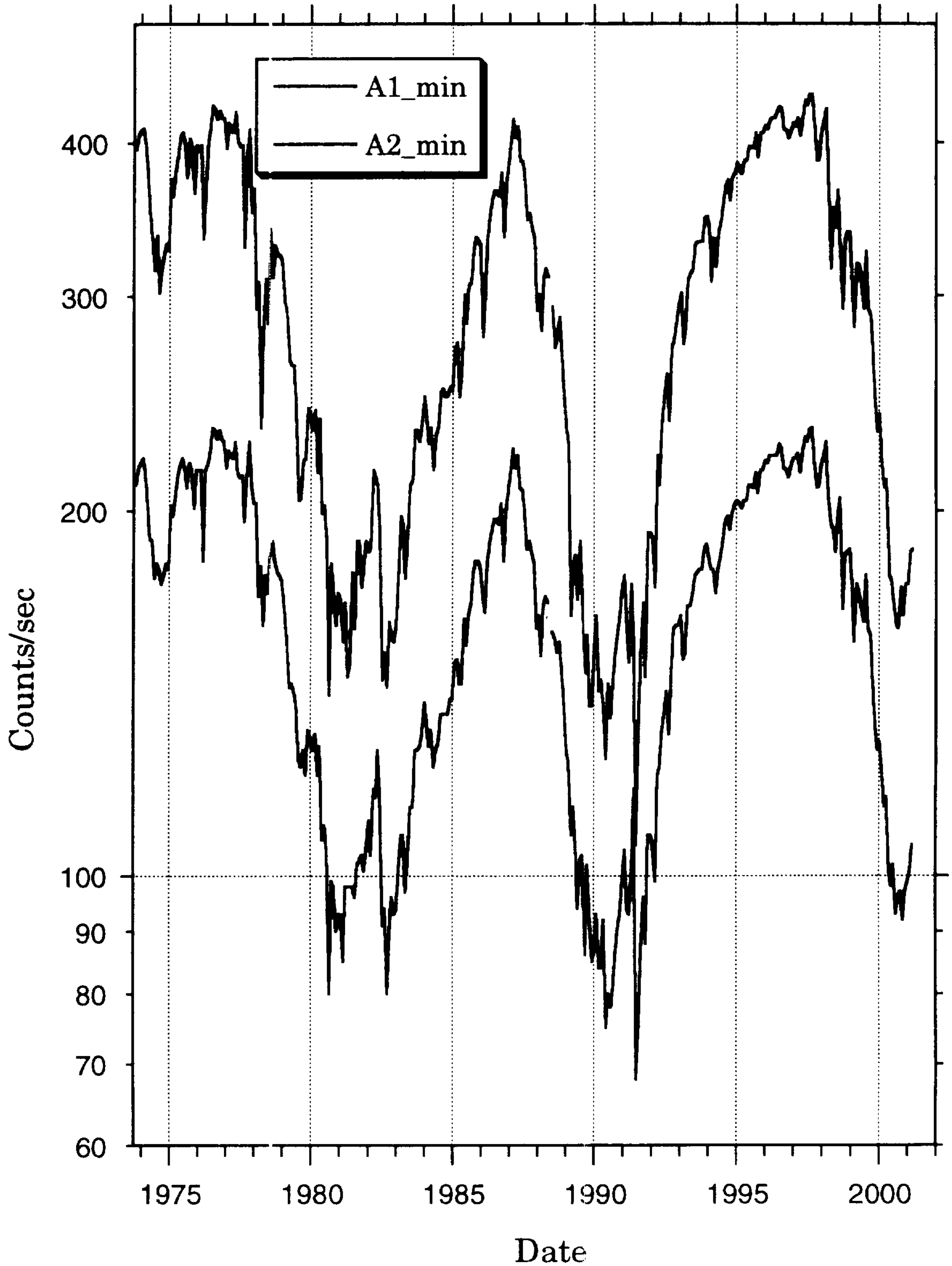

University of Maryland
IMP−8
Apr 10 to Apr 22
Shock
Shock
Shock
1.e+04
1.e+03
1.e+02
1.e+01
1.
0.1
0.01
Counts/Sec
Apr 10
Apr 12
Apr 14
Apr 16
Apr 18
Apr 20
Apr 22
Date (2001)
P3
P5/4
P7
A2/1000
Upstream
M'sheath
M'sphere



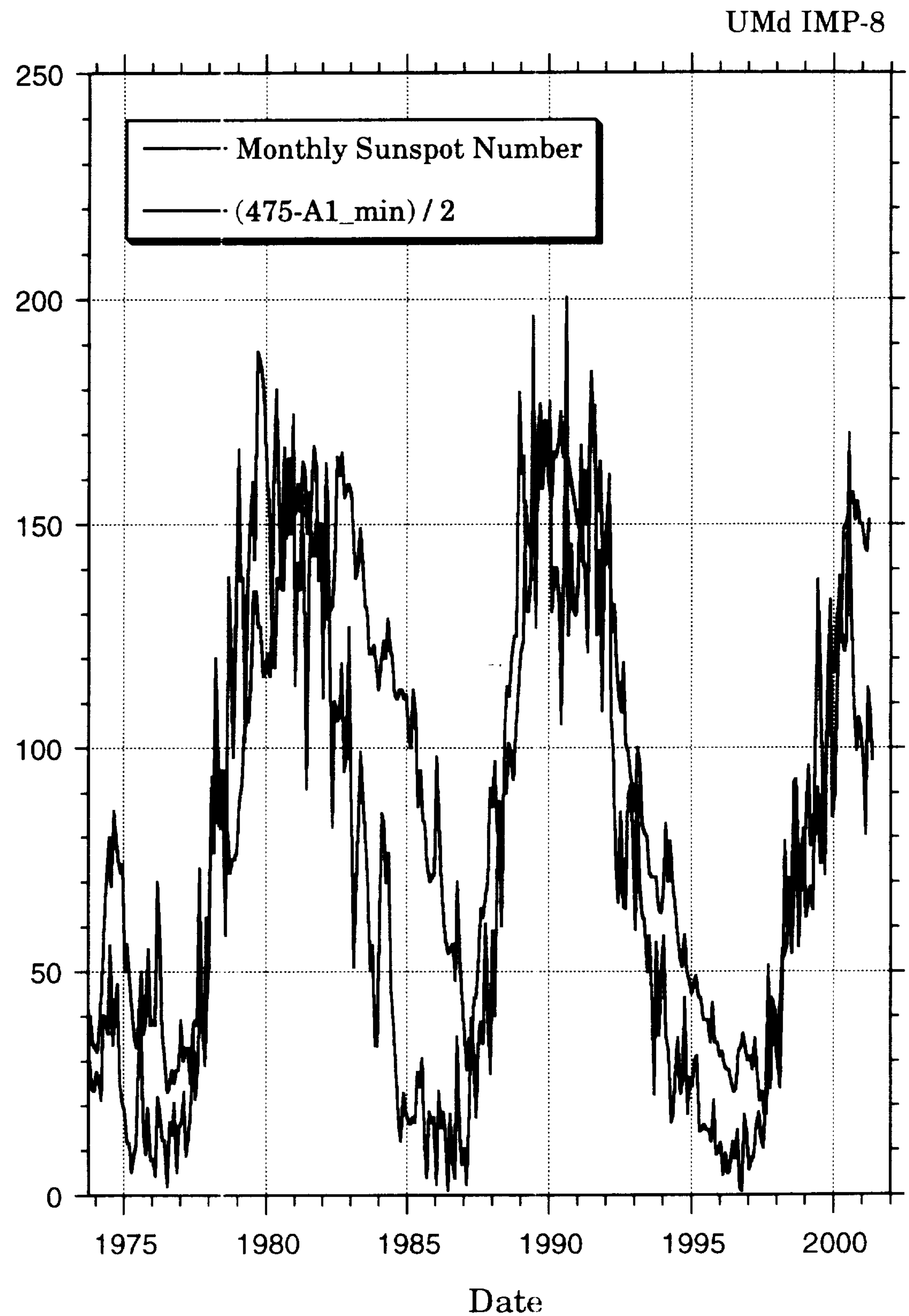
IMP-8/ UMd/ Protons (January, 2001)
Integral Rates (counts/sec)
2000
1000
100
> 40 MeV
> 20 MeV
Shock
dJ/dE
(particles/cm2 sec sr keV)
100
10.0
1.00
0.100
0.0100
200 keV
700 keV
1/28
1/29
1/30
1/31
2/1
Date (2001)
Solar Wind Speed
(km/s)
440
420
400
380
360
340
SOHO / CELIAS / MTOF
Proton Monitor
07:00
07:20
07:40
08:00
Time (Jan 31, 2001)

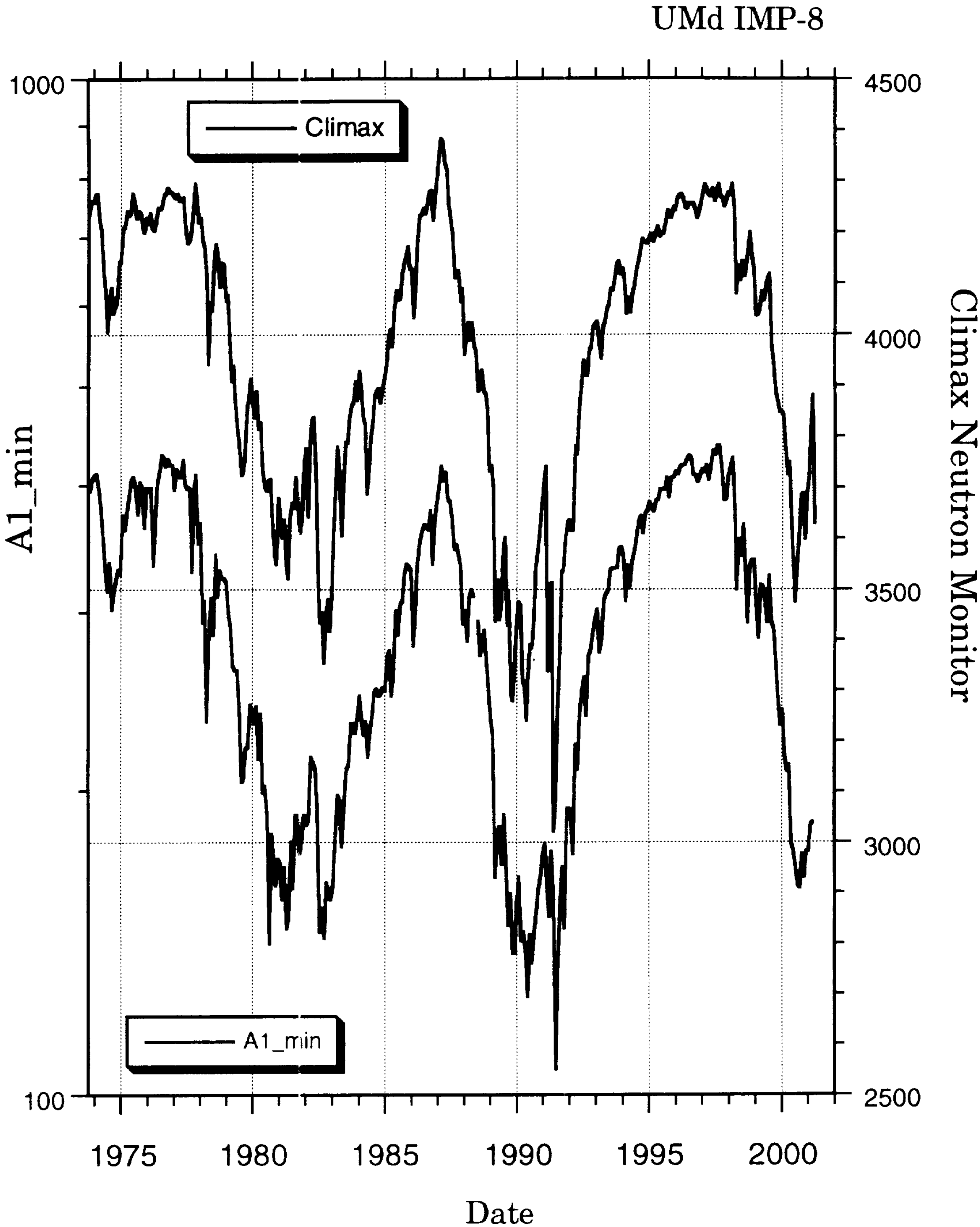

UMd IMP-8
A1_max
A1_min
Counts/sec
10000
1000
100
1975
1980
1985
1990
1995
2000
Date

UMd IMP-8



A1_min
A2_min
400
300
200
100
90
80
70
60
Counts/sec
1975
1980
1985
1990
1995
2000
Date


UMd IMP-8
Monthly Sunspot Number
(475-A1_min) / 2
250
200
150
100
50
0
1975
1980
1985
1990
1995
2000
Date


UMd IMP-8
Climax
A1_min
1000
100
4500
4000
3500
3000
2500
1975
1980
1985
1990
1995
2000
Date
A1_min
Climax Neutron Monitor