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TECHNICAL PROGRESS REPORT

for research entitled

INVESTIGATION OF THE ROLE OF GRAVITY WAVES IN THE GENERATION OF EQUATORIAL BUBBLES

under the direction of

Francis S. Johnson, Principal Investigator
&
William R. Coley, Co-Investigator

Report covers the period of

1 May 1994 through
28 February 1995

for

NASA Grant No. NAGW-4002

From

The University of Texas at Dallas
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Progress Report on

Nasa Grant NAGW-4002

INVESTIGATION OF THE ROLE OF GRAVITY WAVES IN THE GENERATION OF EQUATORIAL BUBBLES

Francis S. Johnson, Principal Investigator
William R. Coley, Co-Investigator

Software development is proceeding for the examination of F-region gravity-wave power using in-situ data from Atmosphere Explorer E (AE-E). AE-E data are available in three forms. The first is easily accessible 15-second-resolution data from the Unified Abstract (UA) files that contain geophysical measurements from all three AE-E instruments of interest at the moment. Currently, UA files covering 1975-79 are in-house and the 1980-81 data are on order from the NSSDC. Higher resolution (4 second) neutral wind and density measurements are available via the NATE Geophysical Unit (GU) files. NATE GU data covering 349 days are available and software to display the data has been written. Ion velocity data from the Ion Drift Meter (IDM) can be produced directly from the satellite telemetry data at either 2/3-s (5-km) or 4-s (30-km) resolution, depending on the instrument mode of operation that was in effect.

San Marco data look increasingly attractive for the study of the initiation and growth of bubbles, particularly when the satellite passes through the early evening hours at relatively high altitudes. Because of the low inclination of the orbit, several successive orbital passes may pass over the same area, giving a series of measurements at intervals of about 98 minutes. Tinsley et al. (Images of Transequatorial F-Region Bubbles in 630- and 777-nm Emission Compared with Ionospheric Morphology, in preparation) have followed the progressive development of bubbles using San Marco data and airglow observations made in Hawaii. The airglow observations permit the unambiguous identification of bubbles having lifetimes of several hours. We have also found some good cases in the AE-E data base where the same area is observed on successive passes under conditions favorable for the development of bubbles. Figure 1 (00:26-00:40 UT day 89, 1977) shows ion drift and concentration data just prior to the development of bubbles, which are seen about an hour and a half later in Figure 2 (02:00- 02:13 UT)

We have found many cases in the AE-E records of bubbles that are descending relative to their surroundings. Generally, the surroundings are also descending, but less rapidly than the bubble, indicating the presence of a large-scale westward directed electric field. This suggests that the field inside the bubble is enhanced relative to that in the surroundings because of the reduced conductivity there, thus enhancing the downward velocity. This would be just the inverse of the enhanced electric field in bubbles during their development phase leading to enhanced upward velocities, even supersonic. The association of reduced concentration with enhanced downward velocity in these cases is most impressive. An example appears in Figure 3 from 17:05 to 17:11 UT on day 209, 1980. The next step is to explore how well this concept fits with conventional theory for growth rates.

Another promising development is the observation of distinct well formed waves at about 400 km altitude in the equatorial region, also shown in Figure 3 (16:38-17:04 UT). These are seen in the ion drift, most clearly in the vertical component or the in-out drift of the flux tubes. The horizontal wavelengths are a few hundred kilometers. They look very much like waves seen over the polar cap that are attributed to internal gravity waves in the neutral atmosphere driving ionization up and down the magnetic field lines. The equatorial waves show no modulation of the total ion concentration. This was sometimes true in the case of polar cap waves, where it could be attributed to a near-zero rate of change of concentration with altitude at the satellite altitude in the ambient ionosphere. In the equatorial region, any upward motion of a magnetic tube of force involves expansion of the tube and of the plasma within it, and one would expect to see modulation of the ion concentration. The answer appears to be that ionization is being driven up the field lines by the horizontal component of motion of the internal gravity waves. Thus the outward motion of the tube appears to be driven by the flow of ionization up the field tube, inflating the field tube as it rises. And conversely as it sinks. This requires that the tubes not be firmly anchored in the lower ionosphere by current flow along the field lines, closed by Pedersen currents in the lower F region or E region.

Some of this work has been done in collaboration with Sardul Singh at the University of Ilorin, who intends to visit us for a few months during the coming year.

Figure 1

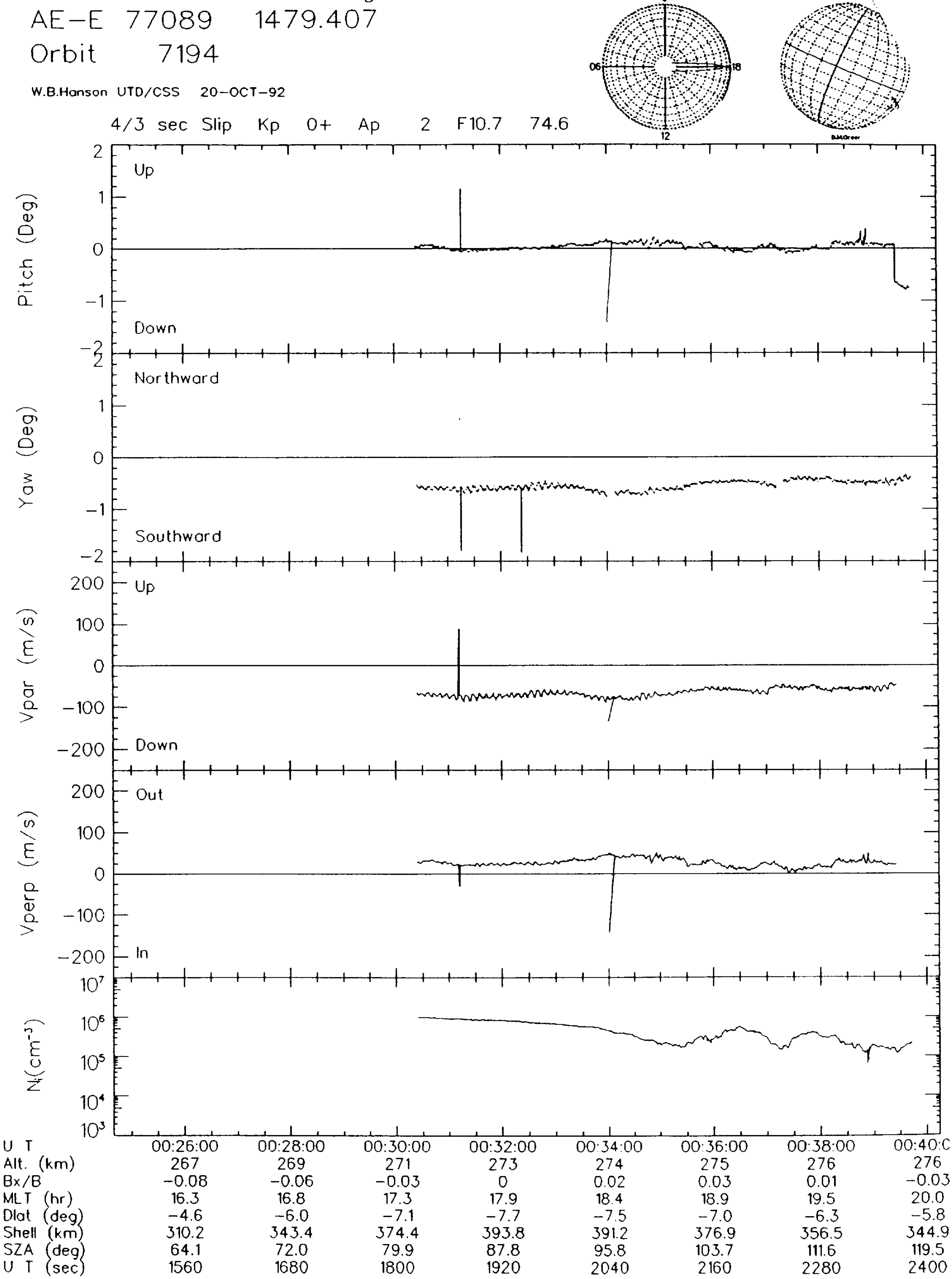

AE-E 77089 1479.407
Orbit 7194
W.B.Hanson UTD/CSS 20-OCT-92
4/3 sec Slip Kp 0+ Ap 2 F10.7 74.6
0
06
18
12
Pitch (Deg)
Up
Down
Yaw (Deg)
Northward
Southward
Vpar (m/s)
Up
Down
Vperp (m/s)
Out
In
$N_i(cm^{-3})$
U T 00:26:00 00:28:00 00:30:00 00:32:00 00:34:00 00:36:00 00:38:00 00:40:0
Alt. (km) 267 269 271 273 274 275 276 276
Bx/B −0.08 −0.06 −0.03 0 0.02 0.03 0.01 −0.03
MLT (hr) 16.3 16.8 17.3 17.9 18.4 18.9 19.5 20.0
Dlat (deg) −4.6 −6.0 −7.1 −7.7 −7.5 −7.0 −6.3 −5.8
Shell (km) 310.2 343.4 374.4 393.8 391.2 376.9 356.5 344.9
SZA (deg) 64.1 72.0 79.9 87.8 95.8 103.7 111.6 119.5
U T (sec) 1560 1680 1800 1920 2040 2160 2280 2400

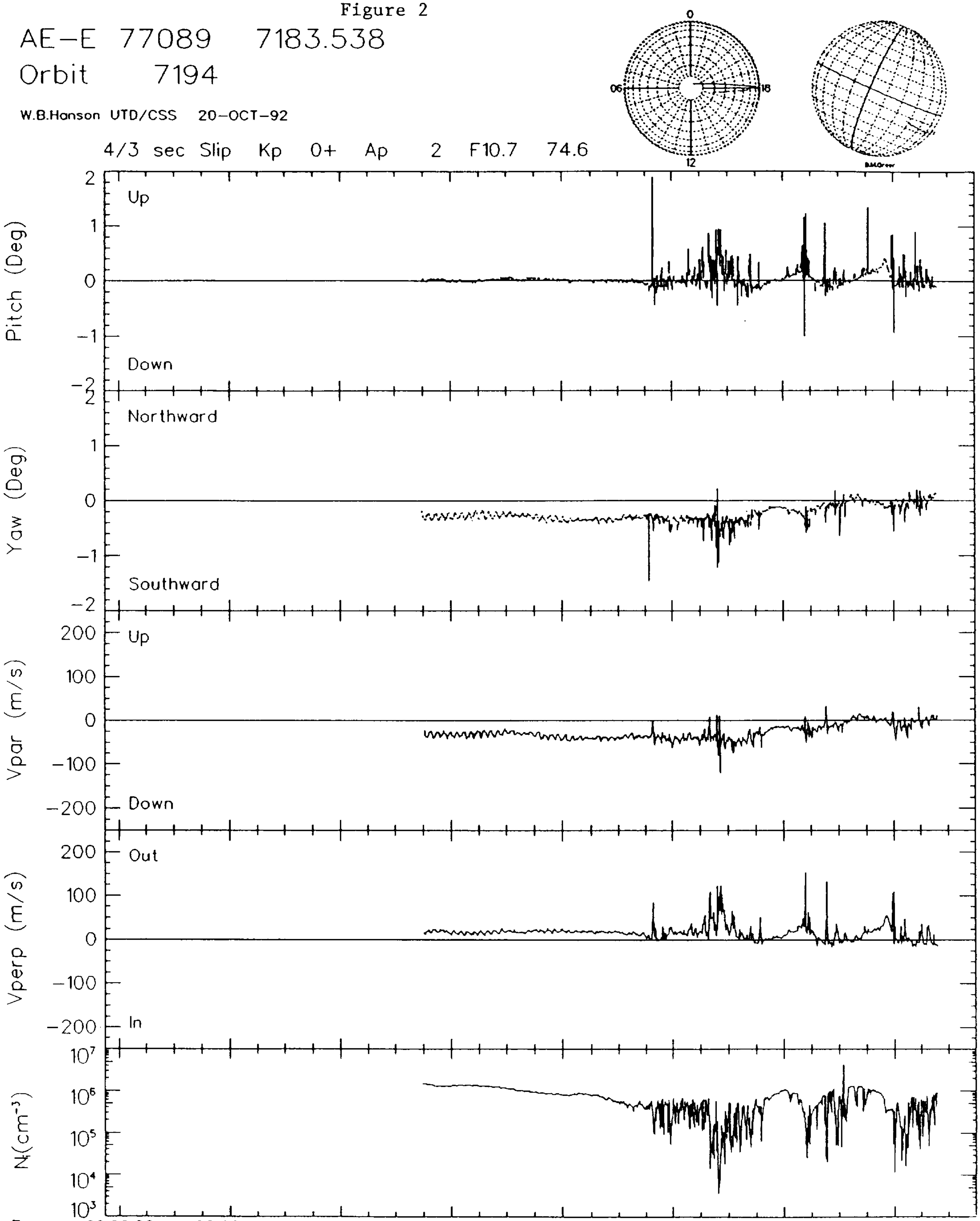
Figure 2

AE–E 77089 7183.538

Orbit 7194

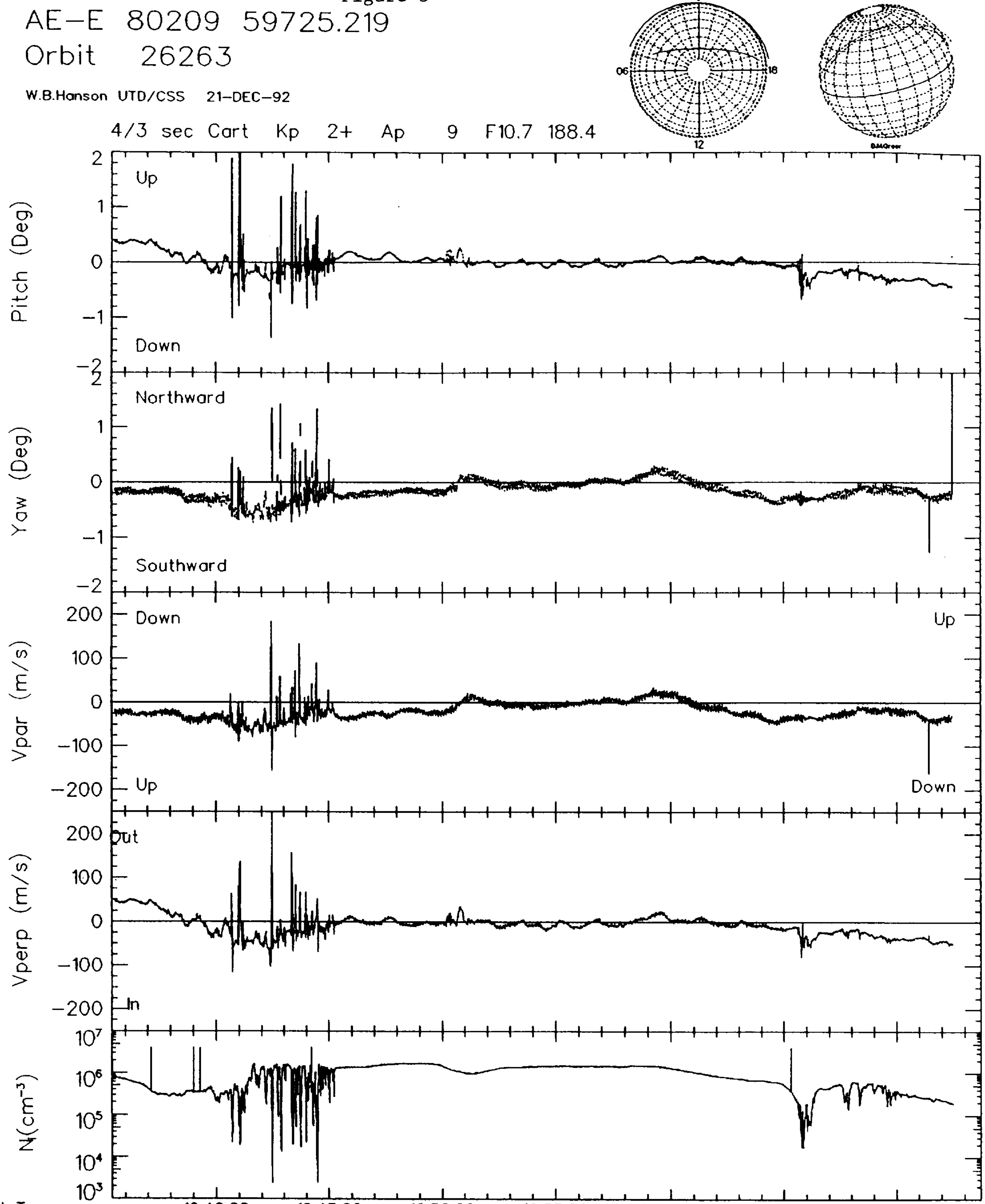
W.B.Hanson UTD/CSS 20–OCT–92

4/3 sec Slip Kp 0+ Ap 2 F10.7 74.6



U T	02:00:00	02:02:00	02:04:00	02:06:00	02:08:00	02:10:00	02:12:00	02:14:00
Alt. (km)	272	273	275	275	276	276	275	274
Bx/B	−0.02	0.02	0.05	0.09	0.12	0.14	0.15	0.11
MLT (hr)	17.5	18.0	18.6	19.1	19.7	20.2	20.7	21.3
Dlat (deg)	−10.3	−11.2	−11.6	−11.5	−10.8	−9.4	−7.6	−5.9
Shell (km)	492.3	534.0	556.0	551.8	518.6	456.2	395.1	345.9
SZA (deg)	81.7	89.6	97.6	105.5	113.4	121.3	129.2	137.0
U T (sec)	7200	7320	7440	7560	7680	7800	7920	8040

Figure 3



U T	16:40:00	16:45:00	16:50:00	16:55:00	17:00:00	17:05:00	17:10:00
Alt. (km)	402	403	403	403	403	403	403
Bx/B	0.21	0.10	0	−0.10	−0.19	−0.24	−0.20
MLT (hr)	19.9	21.3	22.6	23.9	1.2	2.5	3.8
Dlat (deg)	7.3	11.6	12.5	11.6	8.5	3.3	−1.5
Shell (km)	513.0	689.3	735.7	688.2	553.5	425.7	407.7
SZA (deg)	109.5	123.7	135.5	142.1	140.9	132.3	119.7
U T (sec)	60000	60300	60600	60900	61200	61500	61800

UTD

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CENTER FOR SPACE SCIENCES
PHYSICS PROGRAM

22 February 1995

NASA Headquarters
Two Independence Square Building
300 E Street S. W.
Washington, DC 20546-0001

Attention: Adriene Y. Woodin, Grant Officer
Code HWG

Reference: Technical Progress Report
NASA Grant No. NAGW-4002
UTD Account No. 29811-961

Dear Ms. Woodin:

Please find enclosed the original progress report for the above referenced grant covering the period from 1 May 1994 through 28 February 1995. Note that the budget covering the second year funding of $58,000 has not changed from the original proposal and that all required certifications were included with the original proposal.

If additional information is required from our office at this time to facilitate the second year funding, please contact me at the above referenced address or at phone no. 214/883-2852 or facsimile no. 214/883-2761. (Please note that effective 2/1/95, all university telephone/fax prefixes changed to "883" which spells out "UTD". Our letterhead stationery does not yet reflect these changes.)

Sincerely,

Jan Cox

Janice F. Cox
Administrative Services Officer

cc: M. M. Mellott/Program Official
√ CASI
UTD Office of Sponsored Projects
F. S. Johnson
W. R. Coley
C. R. Lippincott