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GLOBAL AURORAL IMAGING FOR THE DYNAMICS EXPLORER MISSION

NAG5-483

SUMMARY OF RESEARCH

November 01, 1984 — January 31, 1998

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The two Dynamics Explorer spacecraft, DE-1 and DE-2, were launched on August 3, 1981, into polar coplanar orbits at different altitudes for the purpose of studying interactive processes within the atmosphere-ionosphere-magnetosphere system. The DE-1 spacecraft (high-altitude mission) used an elliptical orbit that was selected to allow (1) measurements extending from the hot magnetospheric plasma through the plasmasphere to the cool ionosphere; (2) global auroral imaging, wave measurements in the heart of the magnetosphere, and crossing of auroral field lines at several earth radii; and (3) measurements for significant periods of time along a magnetic field flux tube.

The orbit of Dynamics Explorer 1 offered an opportunity to obtain global images of Earth's dayglow and auroral luminosities and to acquire consecutive images of the entire auroral oval during the growth, onset, expansion, and recovery phases of substorms. Initial orbital parameters at launch on August 3, 1981, were an inclination of 90° , perigee and apogee altitudes of 570 km and 3.65 Earth radius, respectively, and an orbital period of 6.83 hours. The initial latitude of apogee at 78.2° N provided excellent viewing of the northern auroral oval, and the precession rate of 0.218° per day allowed similar viewing of the southern polar regions in 1983. Apogee returned to the northern polar region in the autumns of 1984 and 1987.

The University of Iowa's Spin-scan Auroral Imaging (SAI) instrument, was on-board DE-1. SAI was activated in orbit and placed in routine operation on September 23, 1981, and has provided outstanding new contributions in the fields of auroral, magnetospheric and geocoronal physics, introduced a powerful tool for the study of global atmospheric ozone, and initiated the first search from space for marine bioluminescence on the surface of the global ocean.

The SAI instrumentation consists of three imaging photometers, two for visible wavelengths and the third for vacuum-ultraviolet wavelengths equipped with primary catoptric optics with superpolished mirror surfaces. The primary focusing element is an off-axis section of a parabolic mirror that is used to provide an optical path completely free of support structures for the mirrors. SAI met or exceeded all design specifications and functioned normally with no degradation to electronics, sensors, optics or electromechanical devices.

A spacecraft malfunction on 1 June 1982 deprived the three imaging photometers of their primary (normal) source of nadir reference pulses. Operations continued using the alternate (advanced) source of three reference nadir pulses with a 60° phase shift in the imaging fields for multiple-photometer operation. The spacecraft contractor (RCA) speculated at the time that output gates from the spacecraft nadir generator may have latched in a non-

recoverable mode of operation. On 21 November 1982 it was discovered that the primary nadir pulses were again present. The reason for this spontaneous return is unknown.

The loss of a spacecraft analog data channel on 23 June 1984 had no operational impact upon the imaging instrumentation and resulted in no loss of scientific information. Routine (normal) imaging operations continued until the spacecraft intermittently stopped accepting commands starting on 17 November 1990. DE-1 operations were officially terminated on 28 February 1991. From the start of operations to the official termination, the SAI imagers acquired 1,250,000 images of the aurorae, dayglow, geocorona, and comets at ultraviolet and visible wavelengths.

DATA PROCESSING and ARCHIVING

GSFC continued to decommutate SAI imaging data and forward these data to Iowa until the turnoff of the Sigma-9 computer in September 1991. 100% of image processing was completed for all imaging data at Iowa which is processible.

All decommutated data tapes received from GSFC were read and logged upon receipt to verify that the data could be extracted and that the tape label correctly identified the contents of each tape. The tape number and contents were entered into a computer file. The orbit and attitude data from GSFC were received separately and handled in a similar manner.

When the imaging and orbit data were available for a full operations sequence (spacecraft turn-on to shut-off), image processing commenced. The image processing comprised three tasks: image reconstruction, nadir corrections and orbit-attitude merge. Routine image reconstruction was performed only for 30° Earth-centered images. Nadir corrections were necessary to correct irregularities in performance of the spacecraft spin-phase reference pulse generation. Production information was filed in computer files.

A library was created of menu-driven software which allowed outside investigators to quickly become adept at using the DE image catalog. This on-line data catalog provided a user with detailed information concerning 1) commands scheduled for the auroral imaging instrumentation, 2) status of data processing, 3) lists of images, by mission analysis file (MAF) numbers, created at imaging processing, and 4) estimated imaging geometry for times specified by the user. These catalogs were available on SPAN. Images were stored on high-quality, high-density tapes and 35-mm survey slides were created for all images.

Transfer of auroral imaging data to the optical disks began in January 1990—one set of disks for the NSSDC and a second set for the University of Iowa archives. These sets comprised approximately 272,000 images.

DESAI image data was provided upon request via 35-mm survey slides, glossy prints, reproduction-quality transparencies or prints, and electronically in formatted graphics files, to numerous research facilities, universities, publishers, TV stations, and interested individuals. Raw image data files were provided to researchers on magnetic tape or via

computer network. Assistance with the use of SAI data was available and provided at the University of Iowa throughout the grant period of performance.

The recent procurement of a RAID controller to manage expansion hard drive space, an X-Terminal workstation and a network switch, provides permanent data access to DESAI UV photometer images via the WWW. Survey views of all ultraviolet auroral images from 1981 to 1991 are available on the WWW at

<http://www-pi-physics.uiowa.edu/www/desai/>

COMPREHENSIVE SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

- **Measurement of polar cap areas.**
The area is observed to increase following a southward turning of the INTERPLANETARY MAGNETIC FIELD and to contract with substorm onset. Variations in this area are directly related to the energy content of the flaring section of the geomagnetic tail.
- **Measurements of the latitudinal motions of the aurora in the midnight sector following substorm onset.**
The aurora moves poleward at an average speed of approximately 200–350 m/s, with complex features on time scales of approximately 15 minutes. The optical signature of a 'poleward leap' has not been detected.
- **Direct comparison of observed auroral emission intensities with simultaneous radar observations of ionospheric electrodynamics and inferred auroral emission intensities.** (Guest Investigator Program)
- **Discovery of the theta aurora.**
- **Established that the transpolar arc of the theta aurora exists simultaneously in the two polar caps.**
- **Observations of Comet Halley.**
Unique images of Comet Halley were obtained in the light of solar Lyman- α radiation resonantly scattered by the comet's coma of neutral hydrogen gas. The observation periods were from mid-December 1985 through 29 January 1986, prior to perihelion, and from 25 February through 21 March in the post-perihelion period. From these observations the production rate of hydrogen is established for heliocentric distances approximately 0.64 to 1.2 AU.
- **Magnetic mapping between the source region for auroral kilometric radiation (AKR) and the discrete aurora.**
A joint investigation using DE-1 plasma-wave observations and auroral images demonstrated that the AKR source region at altitudes of 1–2 earth radii is located on magnetic field lines which thread bright, discrete auroral forms. While this mapping

has been assumed based on other, earlier work, this investigation provided definitive proof.

- The ultraviolet spin-scan photometer provided the most extensive series of geocoronal images to date. The extent of this imaging campaign in terms of observation time and range of viewing geometries allowed accurate determinations of the parameters for a spherical Chamberlain [1963] model, a search for temporal variations during a fraction of a solar cycle, and an image of the atomic hydrogen geotail.
- The discrete aurora observed with the DE-1 auroral images has been mapped to the plasma sheet boundary layer observed simultaneously with plasma instrumentation on the ISEE spacecraft. The magnetic mapping used the model field of Tsyganenko and Usmanov.
- Observed that the latitudinal and local time distributions of atmospheric 'holes' in the VUV-wavelength dayglow are similar to those for meteoric impacts.
- Interpretation of atmospheric 'holes'.
Localized, transient depressions in the brightness of the atmospheric dayglow at vacuum-ultraviolet wavelengths have been interpreted as the optical signature of the infall of approximately 20 small ($\sim 2 - 4 \times 10^7$ gram each) comets per minute into Earth's atmosphere.
- The localized transient decreases in VUV-wavelength dayglow observed with the VUV auroral imager on DE 1, and interpreted as the optical signature of infalling small comets, has been observed in the Viking VUV images. The analysis was carried out at Iowa after a brief visit to the University of Calgary.
- A Master's thesis and oral examination were completed by J. B. Sigwarth. The thesis title is "Imaging of Absorption and Emission Features of Water-Vapor Clouds Associated with Small Comets as Observed with Dynamics Explorer 1".
- Participated in the Third Environmental Reactions Induced by Comets (ERIC) rocket flight from Wallops Island on 10 September 1988.
- Successful measurement of the diffuse UV radiation (Fix et al., 1988) from galactic and extragalactic sources.
- An extensive investigation of the zodiacal light was carried out at UV wavelengths during the spacecraft maneuver from the orbit-normal position.

PRESENTATIONS

Scientific Meetings Attended for which DE-1 Auroral Imaging Results were presented.

1. 1984 Fall Meeting of the American Geophysical Union, 3-7 December 1984, San Francisco, CA.

Craven, J. D. and L. A. Frank, An Apparent Signature of Modifications to the Upper Atmosphere During Aurora Substorms, EOS, 65(45), 1021, 1984.

Frank, L. A., J. D. Craven, C. T. Russell and E. J. Smith, Variations of Magnetotail Energy in Response to Fluctuations of the Interplanetary Magnetic Field, EOS, 65(45), 1050, 1984.

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Reiff, Patricia H., J. L. Burch, J. D. Winningham, W. K. Peterson, J. D. Craven and L. A. Frank, Simultaneous Measurement of Auroral Electrostatic Potential Differences from High and Low Altitudes, EOS, 65(45), 1058, 1984.

Sigwarth, J. B., L. A. Frank and J. D. Craven, Asymmetric Distribution of Atmospheric Holes Possibly Associated with Meteors, EOS, 65(45), 1020, 1984.

Vondrak, R. R., R. M. Robinson, J. D. Craven and L. A. Frank, Simultaneous Measurements of Ionization by the Chatanika Radar and Optical Emissions by the DE-1 Spin-Scan Auroral Imager, EOS, 65(45), 1020, 1984.

2. 1985 Spring Meeting of the American Geophysical Union, 27-31 May 1985, Baltimore, MD.

Craven, J. D., L. A. Frank, M. S. Gussenhoven, D. A. Hardy, D. S. Evans and H. H. Sauer, On the Simultaneous Existence and Motion of the Theta Aurora over the Two Polar Caps, EOS, 66(18), 345, 1985.

Frank, L. A., J. D. Craven, R. P. Lepping, N. C. Maynard, C. T. Russell and E. J. Smith, Global Auroral Imaging with DE-1: Large Auroral Substorms, Theta Auroras and Attempts at Stereoscopy, EOS, 66(18), 345, 1985.

3. IUGG/IAGA XVIII General Assembly, 5-17 August 1985, Prague, Czechoslovakia.

Craven, J. D. and L. A. Frank, Auroral, Geocoronal and Atmospheric Imaging with Dynamics Explorer. (Poster)

Frank, L. A., Auroral Observations from the Atmosphere and Dynamics Explorer Satellites.

Huang, C. Y., L. A. Frank, J. D. Craven, W. K. Peterson, D. J. Williams, W. Lennartsson, D. G. Mitchell, R. C. Elphic and C. T. Russell, Filamentary Structures in the Magnetotail.

4. Chapman Conference on Magnetotail Physics, Applied Physics Laboratory, Johns Hopkins University, 28–31 October 1985, Laurel, MD.

Craven, J. D., L. A. Frank and T. E. Eastman, Latitudinal Motions of Auroras in the Midnight Sector During Substorms.

5. 1985 Fall Meeting of the American Geophysical Union, 9–13 December 1985, San Francisco, CA.

Craven, J. D., Comparisons of Plasma–Sheet Boundary Motions with Auroral Oval Dynamics Using DE 1 and ISEEs 1, 2, and 3, EOS, 66(46), 1028, 1985. (Invited)

Craven, J. D., L. A. Frank, C. T. Russell and R. P. Lepping, Onset of the Classical Auroral Substorm, EOS, 66(46), 1047, 1985.

Elphic, R. C., M. Sugiura, J. D. Craven, L. A. Frank and W. K. Peterson, Simultaneous Measurements of Field–Aligned Currents at High and Low Altitudes: ISEE and DE Observations, EOS, 66(46), 998, 1985.

Frank, L. A., Recent Imaging Results from the Dynamics Explorer Mission, EOS, 66(46), 1047, 1985. (Invited)

Gombosi, E., T. L. Killeen, R. W. Eastes, J. D. Craven, L. A. Frank, J. D. Winningham, R. A. Heelis and N. W. Spencer, On the Relationship Between the Dynamics of the Polar Thermosphere and the Morphology of the Visible Aurora, EOS, 66(46), 998, 1985.

Gussenhoven, M. S., J. D. Craven, L. A. Frank and D. N. Baker, Highly Asymmetric Response of the High Latitude Magnetosphere for B_z Northward, EOS, 66(46), 1033, 1985.

Hoffman, R. A., M. Sugiura, N. C. Maynard, L. A. Frank and J. D. Craven, Electrodynamics of the Polar Region During Extremely Quiet Periods, EOS, 66(46), 1001, 1985. (Poster)

Rairden, R. L., L. A. Frank and J. D. Craven, Images of the Geocorona from Dynamics Explorer, EOS, 66(46), 1003, 1985.

- Robinson, R. M., R. R. Vondrak, J. D. Craven, L. A. Frank and K. L. Miller, Comparison of Dynamics Explorer Auroral Imaging Data with Chatanika Radar Measurements of Electron Density, EOS, 66(46), 991, 1985.
- Sigwarth, J. B., L. A. Frank and J. D. Craven, Latitudinal and Longitudinal Distribution of Atmospheric Holes Associated with Meteors, EOS, 66(46), 1005, 1985.
- Saflekos, N. A., J. L. Burch, J. D. Winningham, J. D. Craven and L. A. Frank, Dynamics of the Polar Cusp During a Strong Magnetic Substorm, EOS, 66(46), 1034, 1985.
6. Chapman Conference on Ionospheric Plasma in the Magnetosphere, 3-7 February 1986, Yosemite National Park, CA.
- Robinson, R. M., Y. T. Chiu, J. R. Sharber, J. D. Winningham, J. L. Burch, J. D. Craven and L. A. Frank, A Study of Auroral Particle Fluxes at Three Altitudes.
7. 1986 Spring Meeting of the American Geophysical Union, Baltimore, MD, 19-22 May 1986.
- Ackerson, K. L., J. D. Craven and L. A. Frank, Mapping the Auroral Oval into the Magnetosphere, EOS, 67(16), 336, 1986.
- Craven, J. D., L. A. Frank, R. L. Rairden and M. R. Dvorsky, The Hydrogen Coma of Comet Halley Before Perihelion: First Observations with Dynamics Explorer 1, EOS, 67(16), 330, 1986.
- Frank, L. A., J. B. Sigwarth and J. D. Craven, On the Influx of Small Comets into the Earth's Upper Atmosphere, II. Interpretation, EOS, 67(16), 299, 1986.
- Sigwarth, J. B., L. A. Frank and J. D. Craven, On the Influx of Small Comets into the Earth's Upper Atmosphere, I. Observations, EOS, 67(16), 299, 1986.
8. XXVI Plenary Meeting of the Committee on Space Research (COSPAR), 30 June-11 July 1986, Toulouse, France.
- Calvert, W. J., J. D. Craven, R. L. Huff, M. R. Dvorsky, L. A. Frank and D. A. Gurnett, Magnetic Mapping of the AKR Source to the Aurora.
- Craven, J. D., The Role of the Dynamics Explorer Auroral Imagers in Multi-point Magnetospheric Investigations.
- Craven, J. D., L. A. Frank and M. R. Dvorsky, Integrated Lyman- α Emission Rates from Comet Halley as Observed with Dynamics Explorer 1 - Early Results.

- Craven, J. D., L. A. Frank and G. K. Parks, Simultaneous Observations of the Plasma Sheet Boundary Layer and the Aurora – Spatial and Temporal Relations.
- Elphic, R. C., M. Sugiura, J. D. Craven, L. A. Frank and W. K. Peterson, Simultaneous DE and ISEE Observations of Field-Aligned Currents in the Midnight Auroral Zone.
- Frank, L. A., On the Significance of Satellite Auroral Imaging for Magnetospheric Physics.
- Sojka, J. J., R. W. Schunk, L. A. Frank, J. D. Craven, J. D. Winningham and J. R. Sharber, Ionosphere's Response to an Auroral Storm Based Upon the Dynamics Explorer SAI and LAPI Data Bases.
9. 20th ESLAB Symposium on the Exploration of Halley's Comet, 27–31 October 1986, Heidelberg, W. Germany.

Craven, J. D. and L. A. Frank, Neutral Hydrogen Production Rates for Comet Halley: Early Estimates with Dynamics Explorer 1.
 10. 33rd Annual Meeting of the American Astronautical Society, 26–29 October 1986, Boulder, Colorado.

Fix, J. D., J. D. Craven and L. A. Frank, Measurement of the Diffuse Ultraviolet Background Using the Dynamics Explorer Spacecraft.

Frank, L. A., The Hydrogen Coma of Comet Halley: A Review of Early Work with Dynamics Explorer 1.
 11. 1986 Fall Meeting of the American Geophysical Union, 8–12 December 1986, San Francisco, CA.

Craven, J. D., L. A. Frank, K. L. Ackerson and G. K. Parks, Auroral Imaging as a Monitor of Magnetotail Dynamics, EOS, 67(44), 1134, 1986.

Frank, L. A., Global Imaging of the Aurora with Dynamics Explorer 1, EOS, 67(44), 1133, 1986. (Invited)

Frank, L. A., J. B. Sigwarth, J. D. Craven, K. L. Ackerson and R. L. Rairden, On the Influxes of Small Comets into the Earth's Upper Atmosphere: Recent Results, EOS, 67(44), 1134, 1986.

Huff, R. L., W. Calvert, J. D. Craven, L. A. Frank and D. A. Gurnett, Magnetic Mapping of AKR Sources to the Aurora, EOS, 67(44), 1161, 1986. (Poster)

Keating, G. M., M. C. Pitts, W. E. Bressette, J. D. Craven and L. A. Frank, Spin-Scan Ozone Images from DE-1, EOS, 67(44), 1133-1134, 1986.

McCarthy, M., G. K. Parks, K. C. Clark, J. Craven, L. A. Frank and D. Baker, Ionospheric Trigger of an Auroral Substorm, EOS, 67(44), 1139, 1986. (Poster)

12. 169th American Astronomical Society Meeting, 4-8 January 1987, Pasadena, CA.

Fix, D. J., J. D. Craven and L. A. Frank, Measurement of the Diffuse Ultraviolet Background Using the Dynamics Explorer Spacecraft. (Poster)

13. Quantitative Modeling of Magnetosphere-Ionosphere Coupling Processes, 9-13 March 1987, Kyoto, Japan.

Craven, J. D., Auroral Morphology in Quiet and Actual Periods.

14. 1987 Spring Meeting of the American Geophysical Union, Baltimore, MD, 18-21 May 1987.

Baker, D. N., J. D. Craven, R. C. Elphic, L. A. Frank, J. H. King, H. Singer, J. A. Slavin and R. D. Zwickl, A Detailed Analysis of the 0738 UI Substorm on 28 January 1983: CDAW-8, EOS, 68(16), 389, 1987.

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Fairfield, D. H., D. N. Baker, R. D. Zwickl, J. D. Craven, L. A. Frank, R. C. Elphic, J. F. Fennell, I. G. Richardson, J. A. Slavin and B. T. Tsurutani, Substorms, Plasmoids, Flux Ropes and Magnetotail Flux Loss on March 25, 1983: CDAW-8, EOS, 68(16), 388, 1987.

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Parks, G., M. McCarty, K. Clark, J. Craven, L. Frank, D. Baker and G. Rostoker, New Observations of an Isolated Substorm, EOS, 68(16), 391, 1987.

Singer, H. J., W. J. Hughes, J. D. Craven and L. A. Frank, DE-1 Auroral Images and Ground-based Magnetic Observations at Substorm Onset: CDAW-8, EOS, 68(16), 389, 1987.

Slavin, J. A., E. J. Smith, D. N. Baker, R. D. Zwickl, J. D. Craven, L. A. Frank, R. C. Elphic, D. H. Fairfield, W. J. Hughes, R. H. Manka, I. G. Richardson, T. R. Sanderson, D. J. Sibeck, D. G. Mitchell and H. J. Singer, CDAW-8 A & G Plasmoid Events: Magnetic Islands, Fluxropes or Large Amplitude Waves?, EOS, 68(16), 388, 1987.

15. Cambridge Workshop in Theoretical Geoplasma Physics, July 1987, Cambridge, Massachusetts

Craven, J. D., and L. A. Frank, Dynamics of the Aurora and the Magnetotail: Recent Contributions from dynamics Explorer 1.

16. IUGG/IAGA XIX General Assembly, 9-22 August 1987, Vancouver, Canada.

Baker, D. N., J. D. Craven, R. C. Elphic, L. A. Frank, J. H. King, H. J. Singer, J. A. Slavin and R. D. Zwickl, A Detailed Analysis of the 0738 UT Substorm on 28 January 1983: CDAW-8.

Cattell, C. A., D. N. Baker, J. D. Craven, L. A. Frank, C. Huang, R. C. Elphic, D. H. Fairfield, W. J. Hughes, R. H. Manka, T. J. Rosenberg and D. L. Carpenter, CDAW-8 Observations of Pi2 Pulsations and Associated Substorm Processes on the Ground, at 6.6 R_E and at 9 R_E .

Craven, J. D., and L. A. Frank, Atomic Hydrogen Production Rates for Comet Halley: Early Estimates from Dynamic Explorer 1. (Poster)

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Fairfield, D. H., D. N. Baker, R. D. Zwickl, J. D. Craven, L. A. Frank, R. C. Elphic, J. F. Fennell, I. G. Richardson, J. A. Slavin and B. T. Tsurutani, Substorms, Plasmoids, Flux Ropes and Magnetotail Flux Loss on March 25, 1983: CDAW-8.

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- Rees, D., T. J. Fuller-Rowell, J. D. Craven, L. Frank and H. Rishbeth, Post-Magnetic Storm Mid-Latitude Depletions of Atomic Oxygen UV Emissions: Simulations of Fossil Changes in Thermospheric Composition Using a Global Thermospheric Model.
- Singer, H. J., W. J. Hughes, J. D. Craven and L. A. Frank, DE-1 Auroral Images and Ground-based Magnetic Observations at Substorm Onset: CDAW-8.
- Slavin, J. A., E. J. Smith, D. N. Baker, R. D. Zwickl, J. D. Craven, L. A. Frank, R. C. Elphic, D. H. Fairfield, W. J. Hughes, R. H. Manka, I. G. Richardson, T. R. Sanderson, D. J. Sibeck, D. G. Mitchell and H. J. Singer, CDAW-8 A & G Plasmoid Events: Magnetic Islands, Fluxropes or Large Amplitude Waves?
- Sojka, J. J., L. A. Frank and J. D. Craven, Global Scale Auroral Imagery, An Essential Tool for Ionospheric Simulation and Prediction.
17. Workshop on Magnetosphere - Ionosphere Coupling and Substorm Phenomena, October 1987, Fairbanks, Alaska.
- Craven, J. D., and L. A. Frank, Dynamics of the Aurora and the Magnetotail: Recent Contributions from Dynamics Explorer 1.
18. 1987 Fall AGU Meeting, 7-11 December 1987, San Francisco, CA.
- Craven, J. D., L. A. Frank, C. Y. Huang and G. K. Parks, Concerning the Latitude of the Discrete Aurora and the Thickness of the Plasma Sheet, EOS, 68(44), 1424, 1987.
- Dyson, R. L., J. D. Craven, C. Y. Huang, L. A. Frank, E. J. Smith and B. T. Tsurutani, Auroral Substorms and Magnetic Signatures in the Distant Magnetotail, EOS, 68(44), 1424, 1987.
- Frank, L. A., and J. D. Craven, Auroral Substorms as Viewed with Dynamics Explorer 1, EOS, 68(44), 1420, 1987. (Invited)
- Frank, L. A., J. B. Sigwarth, and J. D. Craven, On the Influx of Small Comets into the Earth's Upper Atmosphere, EOS, 68(44), 1343, 1987. (Poster)
- Walker, M. G., C. R. Clauer, R. Samadani, J. D. Craven and L. A. Frank, Automated Analysis of Auroral Images, EOS, 68(44), 1436, 1987. (Poster)
19. American Astronomical Society, January 1988, Pasadena, CA.
- Frank, L. A. J. B. Sigwarth and J. D. Craven, On the Influx of Small Comets into Earth's Upper Atmosphere.

20. 1988 Spring AGU Meeting, 16–20 May 1988, Baltimore, MD.

Craven, J. D., C. Y. Huang, L. A. Frank, and G. K. Parks, Mapping the Discrete Aurora into the Near-Earth Magnetotail, EOS, 69(16), 440, 1988. (Invited)

Dyson, R. L., J. D. Craven, C. Y. Huang, L. A. Frank, E. J. Smith, B. T. Tsurutani and R. D. Zwickl, A Comparison of the Plasma Sheet in the Distant Magnetotail for Quiet and Active Auroral Conditions, EOS, 69(16), 434, 1988.

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Mendillo, M., J. Sigwarth, J. Craven, L. Frank, J. Holt, D. Tetenbaum and J. Buchau, The ERIC-2 Experiment: An Attempt to Create Signatures of Comet-Like Objects in the upper Atmosphere, EOS, 69(16), 422, 1988.

21. International Conference on Auroral Physics, 11–15 July 1988, Cambridge, England.

Craven, J. D., Diagnosis of Auroral Dynamics Using Global Auroral Imaging with Emphasis on Large Scale Evolutions.

22. XXVI COSPAR Meeting, 18–29 July 1988, Espoo, Finland.

Craven, J. D., and L. A. Frank, A Signature in the UV Dayglow of Modifications to the Upper Atmosphere During Auroral Substorms. (Invited)

Craven, J. D., and L. A. Frank, Auroral Response to Variations in the Solar Wind and Interplanetary Medium. (Invited)

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Dr. Frank reviewed this article.

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