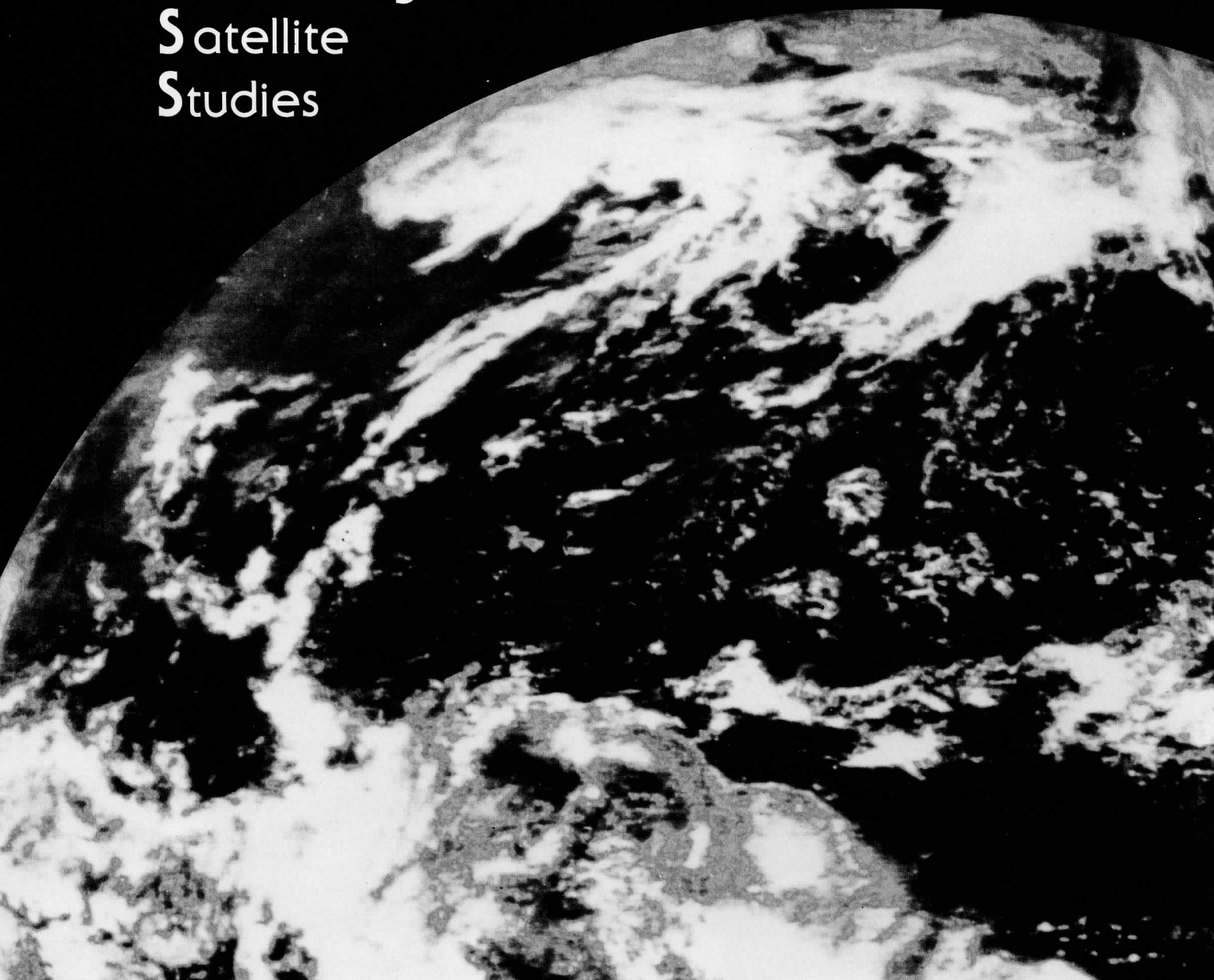
Space Science and Engineering Center
University of Wisconsin-Madison

BOARD OF DIRECTORS REPORT
COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES
JUNE 5 1990

A REPORT from the

Cooperative Institute for Meteorological Satellite Studies



BOARD OF DIRECTORS REPORT
COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES
JUNE 5 1990

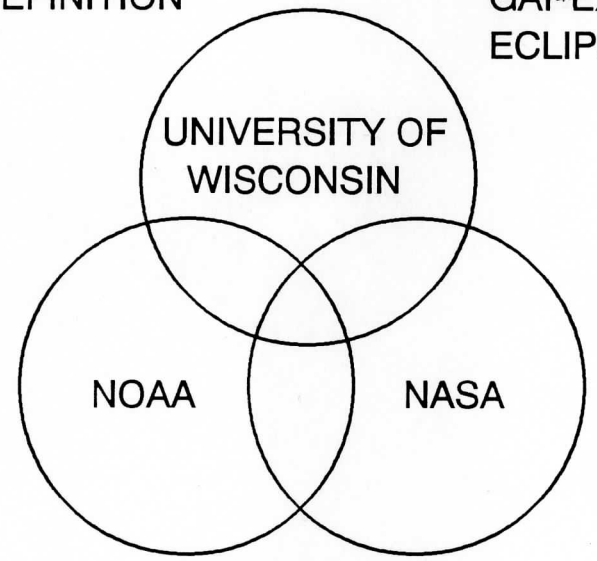
REMOTE SENSING APPLICATIONS TO WEATHER AND CLIMATE

MAJOR PROGRAMS

- REMOTE TEMPERATURE/ MOISTURE SOUNDING
- TRACE GAS PROFILING
- WIND DETERMINATION
- DATA ASSIMILATION
- INSTRUMENT DEFINITION

FIELD PROGRAMS

- GALE
- ERICA
- COHMEX
- GTE/ABLE
- FIRE
- GAPEX
- ECLIPSE



CIMSS

NOAA PROGRAMS

- VDUC
- GOES I/M
- STORM
- GUFMEX

NASA PROGRAMS

- EOS
- GEOPLATFORM
- ERBE

BOARD OF DIRECTORS REPORT

COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES

5 JUNE 1990

1. CIMSS PERSONNEL AND FINANCIAL SUMMARY

2. CIMSS RESEARCH PROGRAMS

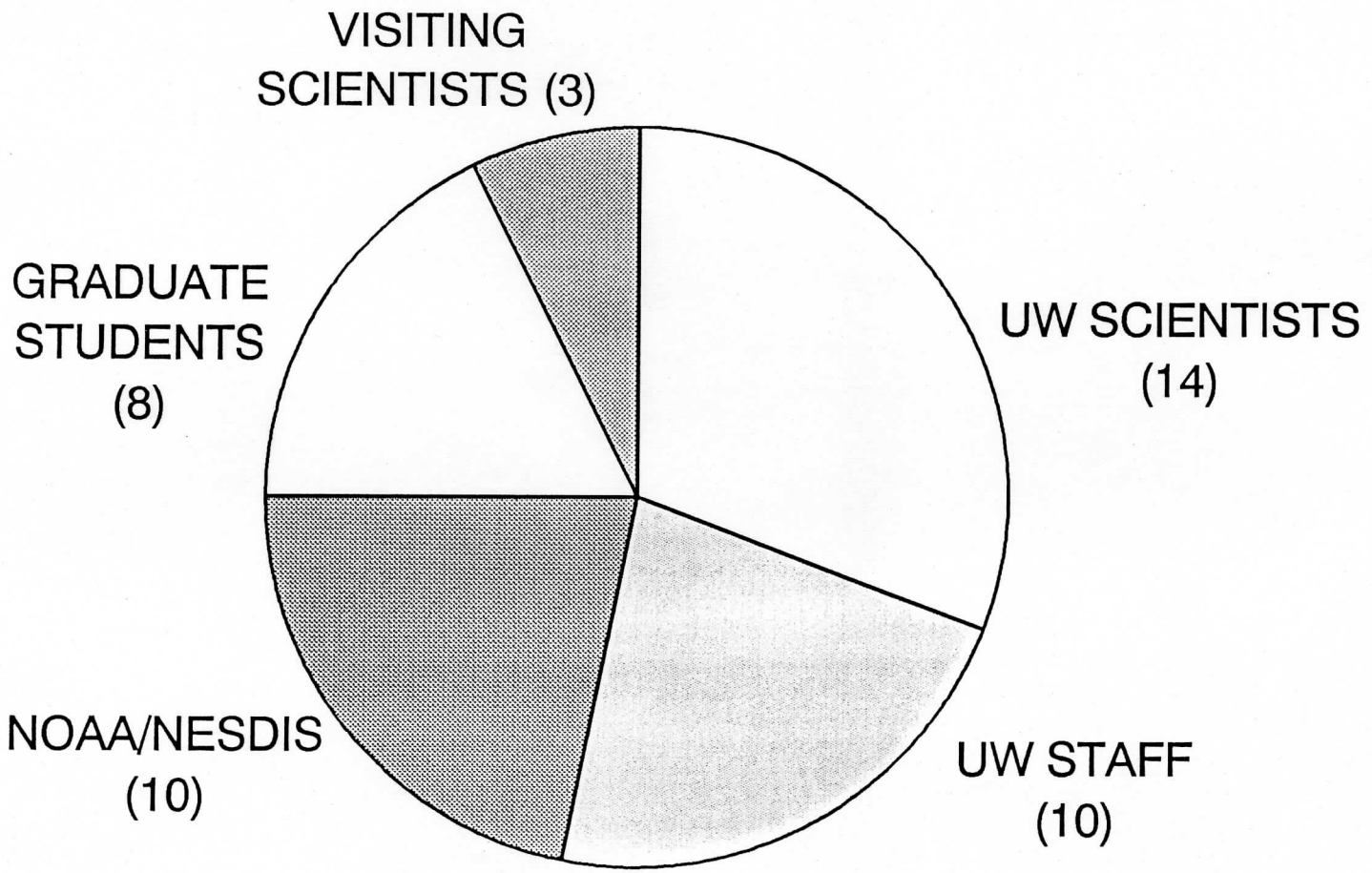
3. CIMSS PROPOSAL SUMMARY

4. VISITING SCIENTISTS

5. SUMMARY OF CIMSS PUBLICATIONS

CIMSS PERSONNEL 1990

TOTAL OF 45 ASSOCIATES



CIMSS ASSOCIATES

Board of Directors
Francis Bretherton
Christopher Hayden
John Kutzbach
Thomas Pyke
William Smith
Shelby Tilford
John Wiley

John Anderson (participant)
Robert Fox (participant)
Donald Johnson (participant)
Verner Suomi (participant)

Council Members
John Anderson
James Dodge
Robert Fox
Christopher Hayden
Paul Menzel
Donald Miller
P. Krishna Rao
Henry Revercomb
William Smith
Roland Stull

UW Scientists
Steve Ackerman
George Diak
Rob Knuteson
Robert Merrill
Chris Moeller
Bill Olson
Bill Raymond
Tony Schreiner
Chris Velden

UW Staff
Thomas Achtor
Laura Beckett
Felicia Chen
Ralph Dedecker
Richard Frey
Scott Lindstrom
Barry Rowe
Tim Schmit
Kathy Strabala
Mark Whipple

NOAA NESDIS
Bob Aune
Geary Callan
Leroy Herman
Ben Howell
Fred Nagle
Cecil Paris
Gary Wade
Hal Woolf

Post Doctors
Allan Huang
Lynn McMurdie

Visiting Scientists
Elen Cutrim
Xia-Lin Ma
Bob Rabin

CIMSS Associates
Ed Eloranta
Dave Martin
Don Wylie

Graduate Students
Arlindo Arriaga
Murthy Divakarla
Peter Keehn
Szu Chia Lee
Walt McKeown
Yanni Qu
Xiangquian Wu
Hai Yan Zhang

VISITING SCIENTISTS TO CIMSS: 1989-90

Marilena Perrone
EUMETSAT
Darmstadt, FRG
February 13-17, 1989
March 5-7, 1990

Elen M. Cutrim
Department of Meteorology
University of Belem
Brazil
September 1988/September 1989

H. J. Lutz
Universitat zu Koln
Koln, FRG
April 17-21, 1989

Mr. Luigi De Leonibus
Italian Meteorological Service
Rome, Italy
May 30-June 2, 1989

Tom Lachlan-Cope
UK Met Office
British Antarctic Survey
Bracknell, UK
June 5-9, 1989

Merv Lynch
Curtin University of Technology
Perth, Australia
July 11-22, 1989

Tony Hollingsworth
ECMWF
Reading, England
October 5-6, 1989

Rolando Rizzi
Department of Physics
Bologna, Italy
October 12-13, 1989

Akiyoshi Mita
Meteorological Satellite Center
Tokyo, Japan
January 22-26, 1990

Robert Rabin
NOAA/NSSL
Norman, OK
January 17, 1989 to present

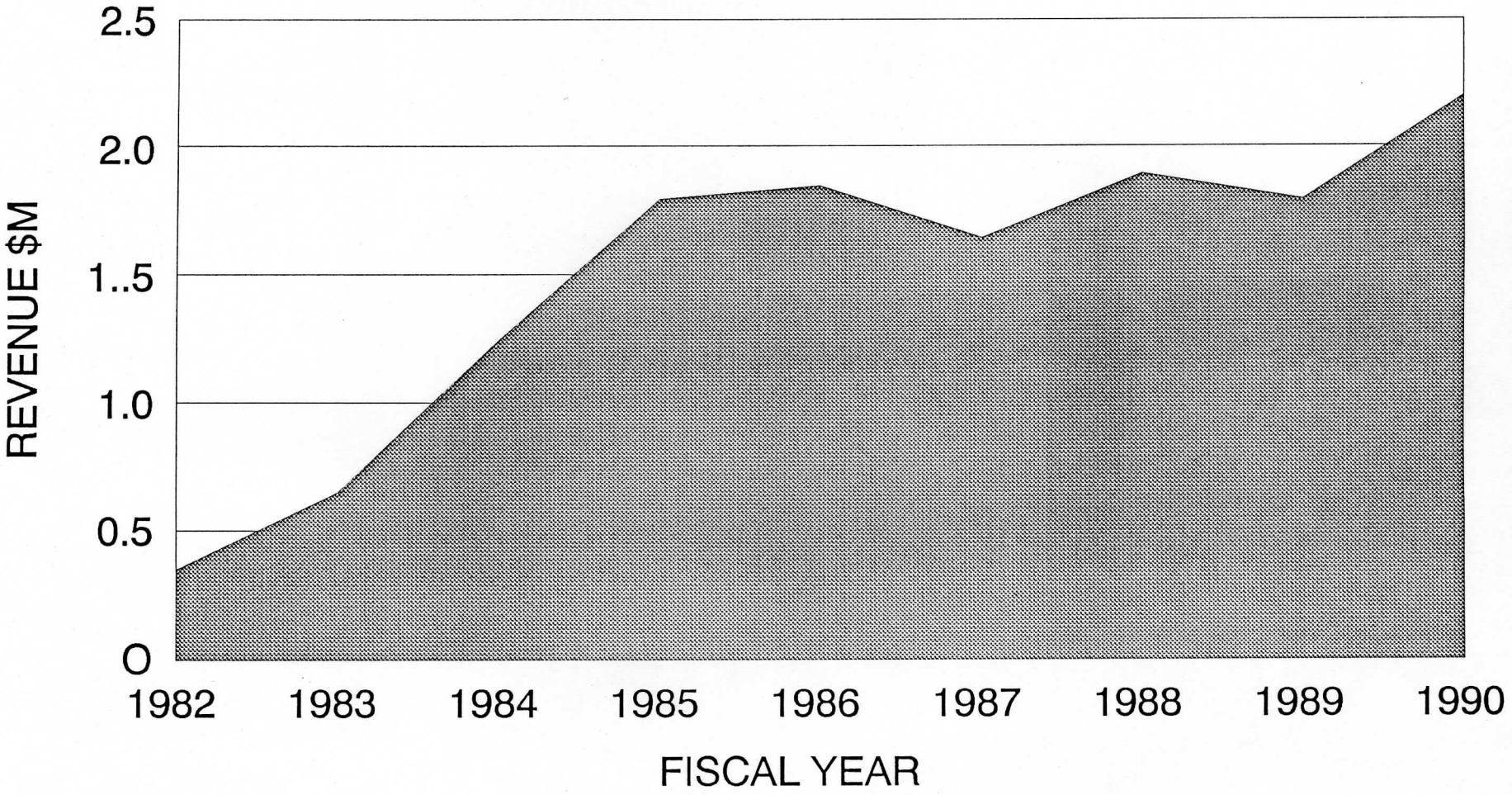
L.V.G. Rao
National Institute of Oceanography
Goa, India
March 12-13, 1990

Klaus Schaefer
Heinrich-Hertz Institute
Berlin, FRG
March 19-April 1, 1990

Johannes Schmetz
Kenneth Holmlund
Meteosat Exploitation Project
European Space Agency
Darmstadt, FRG
March 26-30, 1990

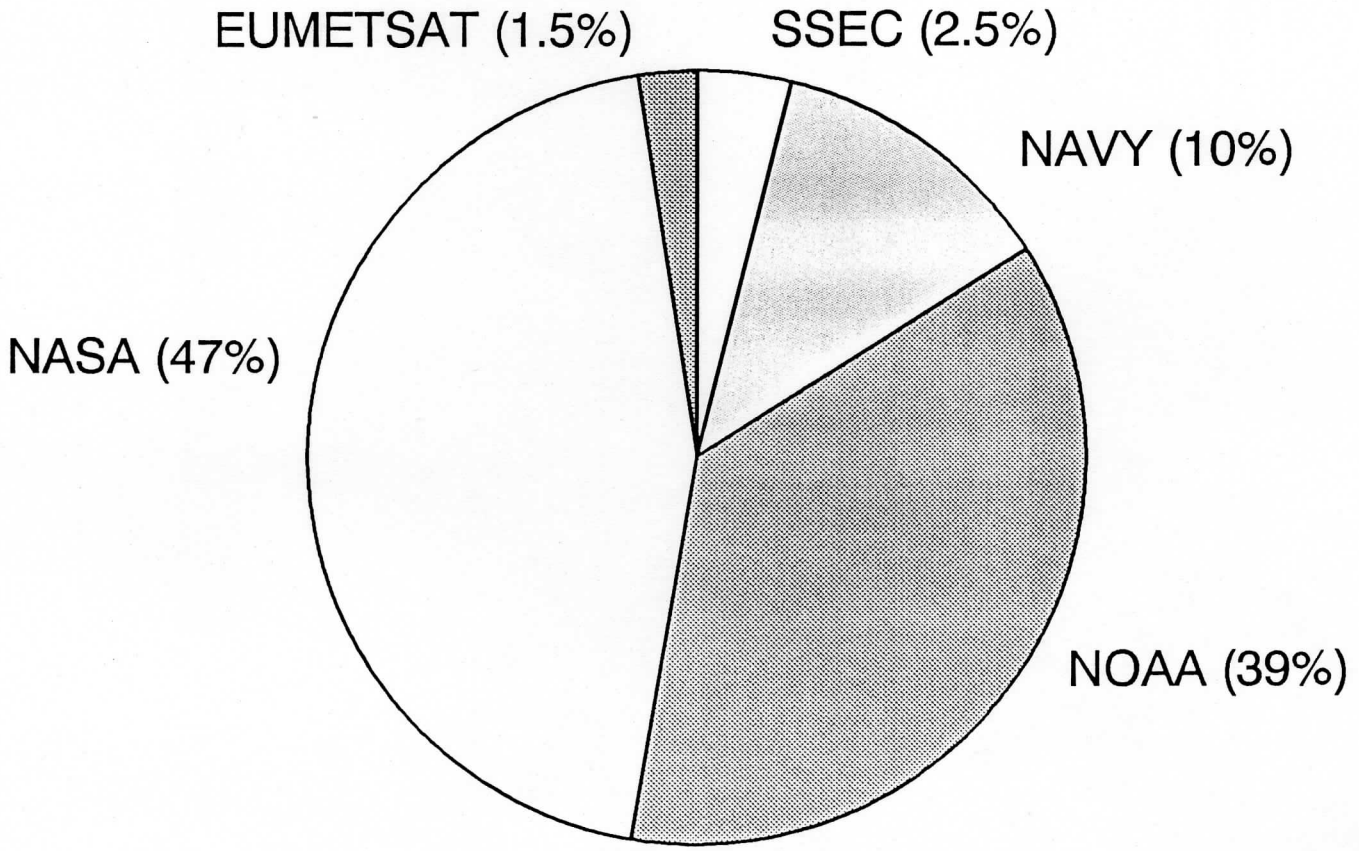
Ma Xia-Lin
State Meteorological Center
Beijing, PRC
March 5, 1990 to present

CIMSS FUNDING 1982-1990

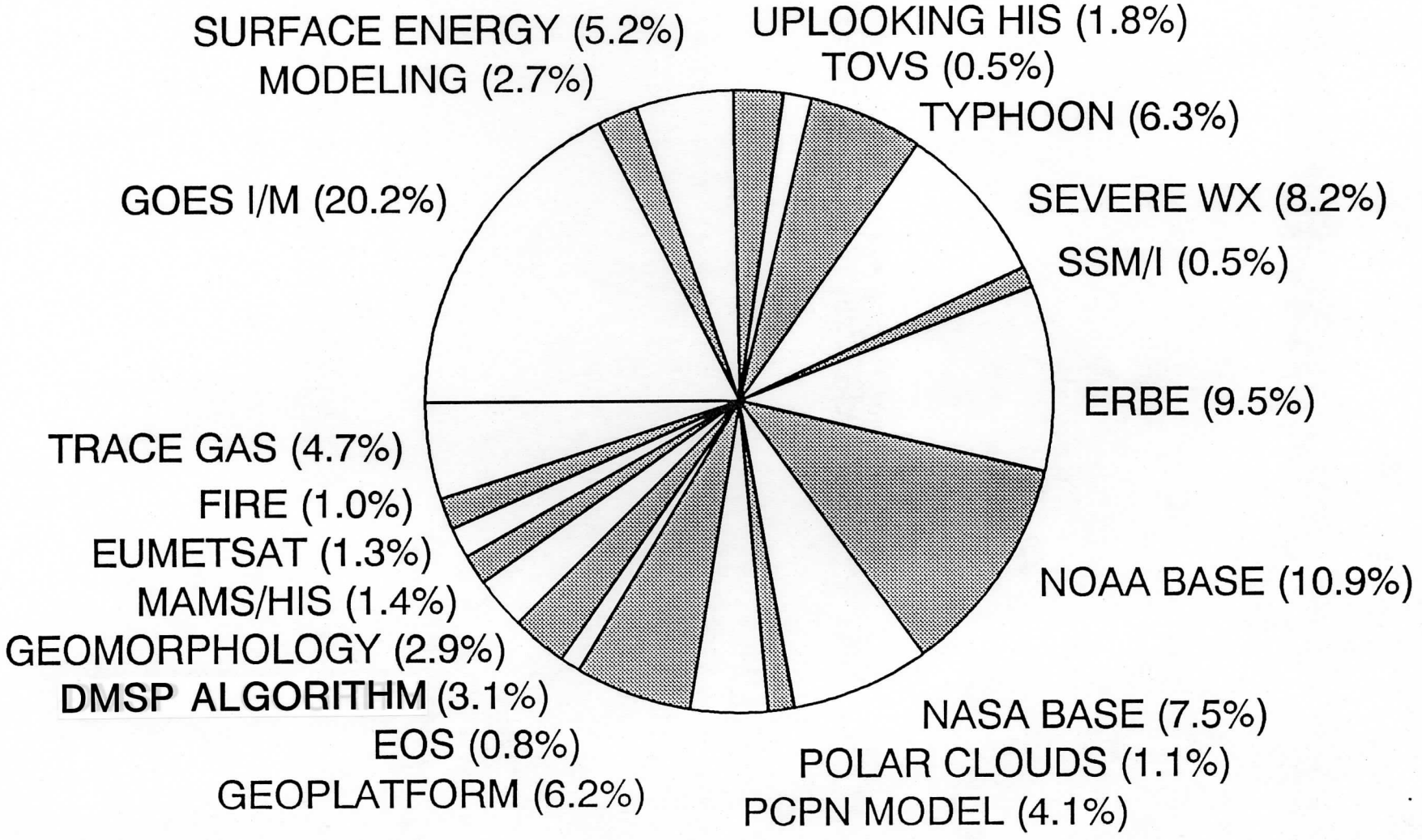


CIMSS PROGRAM FUNDING 1990

AGENCY PARTICIPATION



CIMSS PROGRAM FUNDING



SUMMARY OF CIMSS RESEARCH PROGRAMS: 1988-1990

Key to Program Information:
G = Geostationary
P = Polar orbiter
H = HIS
M = MAMS
F = Field experiment
L = Modeling

	Investigation Title	Principal Scientists	Agency

1. INSTITUTIONAL SUPPORT

GPH L **NASA Base** Smith, Achtor NASA

- Institutional support for seed programs, graduate students, post doctoral positions, visiting scientists and seminars.
- Measurement of water vapor, methane and nitrous oxide from ground based HIS measurements (Phd thesis)
- Support for Madison Uplooking HIS data analysis

GPH L **NOAA Base** Smith, Achtor NOAA

- Institutional support for seed programs, graduate students, post doctoral positions, visiting scientists and seminars.
- Develop HIS temperature/moisture retrieval algorithm (Phd thesis)
- Support for investigation of satellite signitures of explosive North Atlantic cyclogenesis (MSU, SSM/I,VAS)

2. OPERATIONAL SUPPORT

G **GOES I/M** Menzel, Hayden, Schmit NOAA

- Implementation of processing system, retrieval products and algorithm development for GOES I
- Development and implemenation of improved automated wind vector derivation scheme (with CO_2 heights) at VDUC
- Develop new cloud height algorithm for GOES I (MS thesis)
- Cloud defination studies to supplement ASOS and ISCCLP indicate good quality of VAS CO_2 cloud heights
- Tropical cyclone deep-layer-mean satellite wind analysis transferred to operations at VDUC

P **TOVS-Bangladesh** Achtor, Schreiner NASA/GSFC

- Installation of ITPP in Dhaka, Bangledesh; Cyclone and severe weather cases
- Taught two week course in satellite meteorology and use of ITPP
- In collaboration with NASA/GSFC and USAID

3. WEATHER AND CLIMATE APPLICATIONS

P **Typhoon** Merrill/Velden NAVY/ONR
- Estimate of Typhoon intensity from TOVS Microwave radiances
- Participation in Navy Tropical Cyclone Motion Experiment (8/90)

G F **GUFMEX** Hayden, Wade NOAA/NSSL
- Field experiment/data analysis to better understand the role of return flow from the Gulf of Mexico
- Moisture fields from VAS and SSM/I have shown ability of satellite to accurately depict return moist flow

P **ERBE** Ackerman, Herman NASA/LANGLEY
- Study the radiative impact of dust on regional climate
- Scanner vs non-scanner instrument comparisons
- GOES-6 VAS observations of OLR found to be highly correlated with ERBE OLR measurements
- ERBE - HIS radiance comparisons in good agreement

HM **HIS/MAMS-COHMEX** Smith, Menzel NASA/MSFC
- HIS retrievals depict high resolution PBL moisture gradients, strongly correlated with cumulus cloud presence/absence
- HIS/MAMS radiance comparisons show strong agreement
- MAMS/VAS derived precipitable water matches well with cloud field

M **Geomorphology** Menzel, Moeller NASA
- MAMS flights over Louisiana coastline
- 100 m resolution suspended sediment and sea surface temperature maps
- Short term (<1hr) variation observed during cold frontal passage
- Comparison of 11 um with AVHRR shows additional structure in MAMS

G F **Amazonia** Martin, Cutrim, Menzel NSF
- Estimate evapotranspiration over Amazon durng GTE/ABLE-2B
- Demonstrate ability of VAS to estimate hydrologic cycle parameters
- Results summarized in several publications and latest CIMSS View

G **Biomass Burning** Menzel, Cutrim NOAA-INPE
- Monitor burning and aerosol transport in Amazon region
- Demonstrate ability of VAS to estimate extent of burning
- Improved understanding of number, size and diurnal cycle of fires

P **Polar Clouds** Ebert NASA
- Analysis of Polar clouds using AVHRR radiances and pattern recognition algorithm
- Assembly of winter and summer, Arctic and Antarctic, data sets for ISLCCP

4. REMOTE SENSING TECHNIQUES

P **SSM/I Rainrate** Olson NAVY/ONR
- Validate original rainrate algorithm for SSM/I radiances
- Develop improved rainrate algorithms for operations
- Evaluate potential for physical retrieval rainrate technique

P **DMSP Algorithm** Smith, Woolf, Olson NAVY/NOARL
- Develop physical retrieval algorithm using SSM/T and /I radiances
- Validate algorithm with case studies

GP **VAS plus MSU** Schreiner NAVY/NOARL
- Comparison of VAS, TOVS and VAS+MSU retrieval algorithms with GALE radiosonde data set
- VAS+MSU showed more complete coverage and improved temperature and moisture analyses

H **Trace Gas** Knuteson, Revercomb NASA
- Quantify measurement characteristics important to retrieval
- Develop algorithms for mixing ratio profile retrieval
- Validate algorithms with real data

G L **Surface Energy Balance** Diak NASA
- Improved techniques for remote sensing of land surface energy balance and soil moisture
- Determine improved skin temperature method
- Techniques to determine the diurnal fluctuation of the PBL height

5. MODEL APPLICATIONS

P L **Precipitation Modeling** Raymond, Olson NASA
- Improvements to initialization fields in mesoscale forecast models using rainrate estimates from SSM/I
- Study model sensitivity to initial moisture fields

L **Data Assimilation** Diak, Aune NASA/MSFC
- Examine the potential of new satellite data sources for NWP (AMSU, HIS)
- Develop techniques for incorporating satellite-measured parameters into and their impact upon short-term mesoscale forecasts
- Wind impact tests with NMC and ECMWF

GP L **Severe Weather** Hayden, Schreiner, Aune NOAA/ERL
- Participation in STORM program
- Definition of improved sounding instruments and techniques
- 4 dimensional data assimilation experiments
- Performance evaluation of HIRS - HIS spectral channels (MS thesis)
- Support for GUFMEX involvement

6. INSTRUMENT STUDIES

G H **Geoplatform** Smith/Bretherton/Menzel NASA/MSFC
- Provide thermal and atmospheric constituent profiles in the lower troposphere
- Investigate the radiative effects of Greenhouse gasses
- Study the complimentarity of GOES-N and Geoplatform
- Study the data system requirements for Geoplatform

G H **GOES/N** Smith, Revercomb NOAA
- Offers improved vertical temperature and moisture soundings
- Completed Phase A study of GOES L/M modification
- Primary candidate for GOES-N advanced sounder

H **EUMETSAT/HIS** Smith, Knuteson EUMETSAT
- Interferometer sounder feasibility study

7. FIELD PROGRAMS

HMFL **COHMEX** Velden, Diak NASA/MSFC
- Participatation with HIS and MAMS data gathering flights
- Collect and assemble satellite data set
- Data assimilation experiments with CIMSS model

H F **FIRE** Smith, Ackerman NASA
- HIS aircraft observations over Wisconsin in fall 1987
- Study cirrus cloud microphysical properties with HIS data set
- Effects of cirrus upon satellite temperature retrieval techniques

H F **GAPEX** Smith, Revercomb NOAA/WPL-SSEC
- Field experiment at Denver, CO in November 1988
- Low-cost interferometer compares closely to aircraft HIS in measurement accuracy
- Acquire and analyze atmospheric temperature and moisture profiles
- Demonstrated high quality HIS data as ground based profiler

H F **ECLIPSE** Revercomb, Knuteson SSEC
- Madison experiment; Nov 1989 to acquire coincident upwelling and downwelling radiation, for data analysis with lidar measurements
- Data reduction in progress

CIMSS PROPOSAL SUMMARY: 1988-1990

Date	Title	Agency	Amount	PI	Status
10/7/88	Continuation of CIMSS Basic Funding	NOAA	$240,229	Smith/ Achtor	Funded
10/10/88	Analysis of Cirrus Optical Properties with Data from the NASA ER2 High-resolution Interferometer Spectrometer (HIS)	NASA	45,760	Smith/ Ackerman	Funded @ $25K
10/28/88	Storm Research Program; Ground-based Atmospheric Profiling Experiment (GAPEX)	NOAA	135,166	Smith/ Schreiner	Funded @ $35K
12/13/88	Surface Energy Balance	NASA	411,911	Diak	Funded
12/13/88	Microwave (SSM/I) Estimates of the Precipitation Rate to Improve Numerical Atmospheric Model Forecasts	NASA	178,000	Raymond/ Olson	Funded
12/15/88	Atmospheric Trace Gas Vertical Concentration Profiling - Source, Sink and Flux Observations	NASA	480,058	Smith	Unfunded
12/15/88	Participation in the ONR Tropical Cyclone Motion Initiative	ONR	13,660	Merrill/ Velden	Funded
1/10/89	Complete Calibration/Validation Work for SSM/I Rainfall Rate Estimation	ONR	50,000	Smith/ Olson	Funded
2/15/89	Memorandum of Understanding Among the NOAA, NASA, and Board of Regents of the Univ. of Wisconsin	NOAA/ NASA/ UW-MSN		Cooperative Agreement	Signed
5/2/89	Arctic Radiation and Chemistry Experiment	NOAA	14,594	Smith	Funded

5/15/89	Environmental Influences on Tropical Cyclone Convection	NSF	367,227	Merrill	Unfunded
5/18/89	NASA Base	NASA	165,000	Smith/ Achtor	Funded
5/25/89	Continued Support of the Storm Research Program	NOAA	180,600	Smith	Funded
6/2/89	Trace Gas Retrieval Program	NASA	599,197	Smith	Funded
6/2/89	Investigations in Support of the Development of the NASA Geoplatform Program	NASA	999,739	Smith	Funded @ $269K
6/29/89	Participation in the FIRE Phase II Program	NASA	349,252	Smith	Funded $TBD
7/17/89	Application of Non-local Mixing Concept to Model Initialization and Forecasting	NSF	231,846	Raymond	Pending
8/2/89	HIS Spectral Surface Studies	Univ. of MD	305,570	Smith/ Revercomb	Funded $TBD
8/22/89	HIS Participation in TOGA COARE	NSF	148,200	Smith	Unfunded
9/12/89	Continuation of CIMSS Basic Funding	NOAA	240,382	Smith/ Achtor	Funded
9/15/89	Typhoon Monitoring Supplement	ONR	93,658	Merrill	Funded
10/13/89	EUMETSAT-Meteosat Interferometer Sounder: Tradeoff Study	EUMETSAT	28,982	Smith	Funded
10/19/89	A TOVS/VHF Ground Receiving Station	Ahmed Jaffet Company	305,742	Smith	Pending
11/29/89	Participation in FIRE Phase II Program	NASA	50,000	Smith	Funded

1/11/90	Fellowship Proposal - Precise Determination of Sea Surface Temperature from Satellite	NASA	18,000	McKeown/ Smith	Pending
3/29/90	Continued Participation in the ERBE Program	NASA	486,829	Smith	Funded
4/11/90	Continued Support of the Storm Research Program	NOAA	280,473	Smith	Pending
4/16/90	High Spectral Resolution Radiation Measurements for the ARM Program	DOE	1,901,662	Revercomb	Pending
4/16/90	The Determination of Atmospheric Radiative Properties and Their Use in Parameterizing the Radiative Forecast in Climate Models	DOE	1,363,448	Smith/ Eloranta	Pending
4/18/90	Synoptic Analysis of the GUFMEX Field Phase of 10-12 March 1988	NOAA	26,944	Merrill	Pending
4/27/90	The Investigation of Cloud Properties, Atmospheric Stability and Total Ozone with MODIS-N	NASA	4,072,202	Menzel	Pending
4/27/90	Algorithm Development with HIS Data	NASA	3,021,724	Smith	Pending

Funding Summary: FY89-FY90

Total funding requested: all proposals	$17,163 M
Total funding of accepted proposals	$ 3,083 M
Total of unfunded proposals	$ 1,115 M
Total funding of pending proposals	$12,965 M

CIMSS PUBLICATIONS: 1988-1990

1988 REVIEWED LITERATURE

Ackerman, S. A., and S. K. Cox, 1988: Shortwave radiative parameterization of large atmospheric aerosols: Dust and water clouds. J. Geophys. Res., 93, 11063-11073.

Diak, G. R., and T. R. Stewart, 1988: Assessment of surface turbulent fluxes using geostationary satellite surface skin temperatures and a mixed layer planetary boundary layer scheme. J. Geophys. Res., 94, 6357-6373.

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

Green, R. N., F. B. House, P. W. Stackhouse, *X. Wu, S. A. Ackerman, W. L. Smith*, and M. J. Johnson, 1988: Intercomparison of scanner and nonscanner measurements for the Earth Radiation Budget Experiment (ERBE). Accepted for publication in J. Geophys. Res.

**Hayden, C. M.*, 1988: GOES-VAS simultaneous temperature-moisture retrieval algorithm. J. Appl. Meteor., 27, 705-733.

**LaPorte, D. D., J. D. Carpenter, and *H. E. Revercomb*, 1988: A radiometric Fourier transform spectrometer for the measurement of downwelling atmospheric emission. Microchimica Acta [Wien], II, 421-427.

**Lewis, J., *C. Hayden*, and J. Derber, 1988: A method for combining radiances and wind shear to define the temperature structure of the atmosphere. J. Atmos. Sci., 117, 1193-1207.

Liu, G.-R., *W. L. Smith, and T. H. Achtor*, 1988: The use of visible data in VAS temperature soundings. J. Appl. Meteor., Vol. 27, No. 12, 1309-1321.

Lynch, M. J., *W. P. Menzel*, and A. Chedin: 1988: Summary of the fourth international TOVS study conference. Bull. Amer. Meteor. Soc., 70, 42-45.

Merrill, R. T., 1988: Characteristics of the upper-tropospheric environmental flow around hurricanes. J. Atmos. Sci., 45, 1665-1677.

Merrill, R. T., 1988: Environmental influences on hurricane intensification. J. Atmos. Sci., 45, 1678-1687.

Raymond, W. H., and A. Garder, 1988: A spatial filter for use in finite area calculations. Mon. Wea. Rev., 116, 209-222.

Raymond, W. H., 1988: High-order low-pass implicit tangent filters for use in finite area calculations. Mon. Wea. Rev., 116, 2132-2141.

Raymond, W. H., 1988: Theoretical investigation of spiral features in meso-low circulations. Polar and Arctic Lows, P. Twitchell, E. Rasmussen, and K. Davidson, (Eds.), A. Deepak Publishing, Hampton, VA, 191-200.

*Revercomb, H. E., H. Buijs, H. B. Howell, D. D. LaPorte, W. L. Smith, and L. A. Sromovsky, 1988: Radiometric calibration of IR Fourier transform spectrometers: Solution to a problem with the High-resolution Interferometer Sounder (HIS). Appl. Optics, 27, 3210-3218.

*Revercomb, H. E., D. D. LaPorte, W. L. Smith, H. Buijs, D. G. Murcray, F. J. Murcray, and L. A. Sromovsky, 1988: High-altitude aircraft measurements of upwelling IR radiance: prelude to FTIR from geosynchronous satellite. Mikrochimica Acta [Wien], II, 438-444.

Revercomb, H. E., H. Buijs, H. B. Howell, R. O. Knuteson, D. D. LaPorte, W. L. Smith, L. A. Sromovsky, and H. M. Woolf, 1988: Radiometric calibration of IR interferometers: experience from the High-resolution Interferometer Sounder (HIS) aircraft instrument. RSRM '87: Advances in Remote Sensing Retrieval Methods, A. Deepak, H. Fleming, J. Theon (Eds.), A. Deepak Publishing, Hampton, VA.

Revercomb, H. E., H. Buijs, H. B. Howell, R. O. Knuteson, D. D. LaPorte, W. L. Smith, L. A. Sromovsky, and H. M. Woolf, 1988: Radiometric calibration of IR interferometers: experience from the High-resolution Interferometer Sounder (HIS) aircraft instrument. RSRM '87: Advances in Remote Sensing Retrieval Methods, A. Deepak, H. Fleming, J. Theon (Eds.), A. Deepak Publishing, Hampton, VA.

Revercomb, H. E., 1988: The dominant drive for the zonal circulation on Venus may not be solar heating in the clouds of the middle atmosphere. Adv. Space Res., in press.

Smith, W. L., L. M. Leslie, G. R. Diak, B. M. Goodman, C. S. Velden, G. M. Callan, W. Raymond, and G. S. Wade, 1988: The integration of meteorological satellite imagery and numerical dynamical forecast models. Phil. Trans. R. Soc. Lond., A 324, 317-323.

Smith, W. L., and H. M. Woolf, and H. E. Revercomb, 1988: A linear simultaneous solution for temperature and absorbing constituent profiles from radiance spectra. Accepted for publication in Appl. Optics.

*Smith, W. L., H. M. Woolf, H. B. Howell, H.-L. Huang, and H. E. Revercomb, 1988: The simultaneous retrieval of atmospheric temperature and water vapor profiles - application to measurements with the High-resolution Interferometer Sounder (HIS). RSRM '87: Advances in Remote Sensing Retrieval Methods, A. Deepak, H. Fleming, J. Theon (Eds.), A. Deepak Publishing, Hampton, VA.

1988 CONFERENCE PAPERS AND REPORTS

Ackerman, S. A., 1988: Atmospheric radiative heating and cloud probability statistics. Poster presentation at the International Radiation Symposium, Lille, France, August 18-24.

Ackerman, S. A., H. Chung, S. K. Cox, *L. Herman, W. L. Smith, and D. P. Wylie*, 1988: Comparison of NOAA-9 ERBE measurements with cirrus IFO satellite and aircraft measurements. Presented at the FIRE Science Team Workshop, Vail, CO, July 11-15.

Clough, S. A., R. D. Worsham, *W. L. Smith, H. E. Revercomb, R. O. Knuteson, H. M. Woolf*, G. P. Anderson, M. L. Hoke, and F. X. Kneizys, 1988: Validation of FASCOD calculations with HIS spectral radiance measurements. International Radiation Symposium, Lille, France, August 18-24.

Cutrim, E. C., D. W. Martin, L. Castro, and M. Shipman, 1988: Satellite infrared estimates of wet season rainfall in Amazonia. American Geophysical Union Spring Meeting, Baltimore, MD, February 16-20.

Garstang, M., D. Fitzjarrald, P. L. S. Dias, C. A. Nobre, and *D. W. Martin*, 1988: The meteorological design of the ABLE-2B. American Geophysical Union Spring Meeting, Baltimore, MD, February 16-20.

**Hayden, C. M.*, and R. J. Purser, 1988: Three-dimensional recursive filter objective analysis of meteorological fields. Preprint Vol. 8th Conference on Numerical Weather Prediction, Baltimore, MD, February 22-26, 185-190.

Hayden, C. M., and R. T. Merrill, 1988: Recent NESDIS research in wind estimation from geostationary satellite images. Proceedings of the ECMWF Workshop on Data Assimilation and the Use of Satellite Data, Reading, UK, September 5-9.

Jedlovec, G. J., K. B. Batson, R. J. Atkinson, *C. C. Moeller, W. P. Menzel*, and M. W. James, 1988: Improved capabilities of the Multispectral Atmospheric Mapping Sensor (MAMS). NASA Tech. Memo. 100352, NASA Marshall Space Flight Center, Huntsville, AL.

Leslie, L. M., *C. S. Velden*, G. J. Holland, N. Davidson, and K. Puri, 1988: Numerical modelling of tropical cyclone motion. Abstracts of the International Conf. on Tropical Meteor., Brisbane, Australia, July 4-8.

Lutz, H. J., and *W. L. Smith*, 1988: TOVS over polar regions. Presented at Fourth International TOVS Study Conference, Igls, Austria, W. P. Menzel (Ed.), March 16-22, CIMSS Report, University of Wisconsin, Space Science and Engineering Center, Madison, WI.

Lynch, M. J., *W. P. Menzel*, 1988: A report on the fourth international TOVS study conference. CIMSS Report, University of Wisconsin, Space Science and Engineering Center, Madison, WI, June, 86 pp.

McMurdie, L. A., and K. B. Katsaros, 1988: On the interpretation of integrated water vapor patterns in mid-latitude cyclones derived from the Nimbus-7 scanning multichannel microwave radiometer. 3rd Conference on Satellite Meteorology and Oceanography, Anaheim, CA, Amer. Meteor. Soc., Boston, MA, January 31-February 5.

Menzel, W. P., 1988: The technical proceedings of the fourth international TOVS study conference. CIMSS Report, University of Wisconsin, Space Science and Engineering Center, Madison, WI, October.

Merrill, R. T., and G. S. Wade, 1988: GUFMEX: The Gulf of Mexico experiment. CIMSS View, Vol. 4, No. 1, Spring issue.

Nagle, F. W., 1988: Satellite navigation and de-navigation. Presented at Fourth International TOVS Study Conference, W. P. Menzel (Ed.), Igls, Austria, March 16-24, CIMSS Report, University of Wisconsin, Space Science and Engineering Center, Madison, WI.

Olson, W. S., 1988: Report of the science steering group for a tropical rain measuring mission (TRMM): Final draft. NASA/Goddard Space Flight Center, Greenbelt, MD, 131 pp.

Raymond, W. H., and A. Garder, 1988: Numerical procedures in semi-Lagrangian calculations. Preprint, 8th Conf. on Numerical Weather Prediction, Baltimore, MD, Amer. Meteor. Soc., Boston, MA, 507-512, February 22-26.

Schmit, T. J., L. Castro, *W. L. Smith, and W. P. Menzel*, 1988: Satellite infrared estimates of wet season rainfall in Amazonia. American Geophysical Union Spring Meeting, Baltimore, MD, May 16-20.

Schreiner, A. J., and C. M. Hayden, 1988: An evaluation of VAS satellite moisture retrievals and moisture bogus data in the Gulf of Mexico. University of Wisconsin-Madison CIMSS Report, Space Science and Engineering Center, Madison, WI, 16 pp.

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