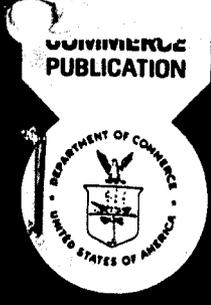


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# ESSA Technical Memorandum NESCTM 10

U.S. DEPARTMENT OF COMMERCE  
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION  
National Environmental Satellite Center

## Annotated Bibliography of Reports, Studies, and Investigations Relating to Satellite Hydrology

D. R. BAKER, A. F. FLANDERS, and M. FLEMING

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Supplement No. 1. Characteristics of Direct Scanning Radiometer Data, Edward G. Albert, April 1969. (PB-183 965)
  
- NESCTM 8 Operational Utilization of Upper Tropospheric Wind Estimates Based on Meteorological Satellite Photographs. Gilbert Jager, Walton A. Follansbee, and Vincent J. Oliver, October 1968. (PB-180 293)
  
- NESCTM 9 Meso-Scale Archive and Products of Digitized Video Data From ESSA Satellites. Arthur L. Booth and V. Ray Taylor, October 1968. (PB-180 294)

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ESSA Technical Memorandum NESCTM 10

ANNOTATED BIBLIOGRAPHY OF REPORTS, STUDIES,  
AND INVESTIGATIONS RELATING TO SATELLITE HYDROLOGY

D. R. Baker, A. F. Flanders, and M. Fleming



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July 1970

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# **National Oceanic and Atmospheric Administration TIROS Satellites and Satellite Meteorology**

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## PREFACE

In March of 1968 there was established through the efforts of Mr. Allen F. Flanders (Weather Bureau's Office of Hydrology) and Dr. E. Paul McClain (Director of Environmental Sciences Group) a satellite hydrology program within NESC's Office of Research. The objective of this program is to develop applications of satellite data to hydrologic problems confronting ESSA's mission. In the course of this activity considerable literature has been reviewed and the following annotated bibliography includes the papers and reports deemed to be of importance to the program.

## ACKNOWLEDGMENT

The authors express their appreciation for the review of this manuscript to Dr. E. Paul McClain, Mrs. Sheila Fleming, and Lt. Gordon Tornberg.

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016	Special subject bibliography
551.5	Meteorology
.507.362.2	Satellites
.579	Hydrometeorolgy
556	Hydrology

ANNOTATED BIBLIOGRAPHY OF REPORTS, STUDIES,  
AND INVESTIGATIONS RELATING TO SATELLITE HYDROLOGY

D. R. Baker, A. F. Flanders, and M. Fleming

1960

Wark, D. Q. and R. W. Popham, "TIROS I Observations of Ice in the Gulf of St. Lawrence," Monthly Weather Review, Vol. 88, No. 5, pp. 182-186, 1960.

...Describes the comparison of a pass of TIROS I photography over the Gulf of St. Lawrence to the Canadian Meteorology Service aircraft ice observations.

1962

Fritz, S., "Satellite Pictures of the Snow Covered Alps During April 1960," Archiv Fur Meteorologie, Geophysik und Bioklimatologie, pp. 186-198, 1962.

...Describes the identification of snow in the Alps with TIROS I photographs. One of the first articles that treats the identification of snow by satellite photographs. Discusses the use of a contour surface chart as a tool in locating snow-covered areas on satellite photographs in conjunction with a cloud-cover map. The contour surface chart is useful in defining basin shape while the cloud-cover chart shows cloud-free areas.

Fritz, S., "Snow Surveys from Satellite Pictures, in Wexler, H. and J. E. Caskey, Jr., ed.," Proceedings of the First International Symposium on Rocket and Satellite Meteorology, 1962, Washington, D.C., New York, John Wiley and Sons, pp. 419-421, 1962.

...Treats the identification and mapping of snow cover using TIROS IV photography. Selected photographs of the Alps, Rockies, and Andes are used. Discusses hydrologic requirements for better snow cover information as a means in determining potential water volume. Examples for identifying snow-covered areas in the mountains are shown.

Nagle, R. E. and R. H. Blackmer, Jr., "The Use of Synoptic Scale Weather Radar Observations in the Interpretation of Satellite Cloud Observations," Final Report for the Air Force Cambridge Research Lab. under Contract AF 19(628)284, Project 6698, Task No. 66982, Stanford Research Institute, Photos., figs., maps, 255 pp., 1962.

...Forty comparisons between TIROS cloud observations and simultaneous radar-detected precipitation areas. No characteristics were found that would allow specific determination of clouds of precipitation nature. It was found that precipitation associated with vortices occur in spiral-banded configuration.

Wark, D. Q. and R. W. Popham, "The Development of Satellite Ice Surveillance Techniques," Wexler, H. and J. E. Caskey, Jr., ed., Proceedings of the First International Symposium on Rocket and Satellite Meteorology, 1962, Washington, D.C., New York, John Wiley and Sons, pp. 415-418, 1962.

...Describes the photographs from each of the TIROS, as they came along, and the comparison to ground and/or aircraft observations. Conclusions were to wait for Nimbus with it's earth orientation and quasi-polar orbit.

Wark, D. Q. and R. W. Popham, "Ice Photography from Meteorological Satellites TIROS I and TIROS II," Meteorological Satellite Laboratory Report No. 8, NESG, ESSA, U.S. Dept. of Commerce, Photos., charts, refs., 68 pp., 1962.

...Describes the cooperative study of TIROS ice photography versus aircraft observations and photographs. Contains satellite and aircraft photograph mosaics and ice charts.

Wark, D. Q., R. W. Popham, W. A. Dotson, and K. S. Colaw, "Ice Observations by the TIROS II Satellite and by Aircraft," Arctic, Vol. 15, No. 1, pp. 9-26, 1962.

...Describes the comparison study between TIROS II ice photography and aircraft photography and observations. These were simultaneous satellite-aircraft observations.

Winkler, E. M., "Relationship of Airphoto Tone Control and Moisture Content in Glacial Soil," Proceedings of the Second Symposium on Remote Sensing of Environment, 1962, University of Michigan, Ann Arbor, Michigan, pp. 107-118, 1962.

...A step-by-step description of a test to compare gray tones to the moisture content of the soil. The conclusions: Organic content of soils unknown and water content gradient unknown.

1963

Cronin, J. F., "Terrestrial Features of the U.S. as Viewed by TIROS," prepared for the Meteorology Research Laboratory Air Force Cambridge Research Laboratories, Hanscom Field, Bedford, Massachusetts, by Aracon Laboratories, Concord, Massachusetts, photos., tables, 35 pp., 1963.

...Considers the problems of identification of the earth's surface from satellite photographs. A map was compiled portraying the U.S. as its surface features appear from TIROS. The ground patterns are those of late winter and early spring with descriptive comments on the nature of these features. Covers such features as forests, deserts, lava beds, terrain types, and snow line.

Fritz, S., "The Variable Appearance of the Earth From Satellites," Monthly Weather Review, Vol. 91, pp. 613-620, 1963.

...Discusses the changes in brightness and in tone observed on the surface of the earth using TIROS photographs resulting from interactions between geographical, seasonal, and meteorological factors. Attention is called to fog and stratus conditions, unstable cloud development, mountain waves, snow and cyclone systems. Some discussion is also given to use of infrared data.

Markham, W. E. and R. W. Popham, "A Report on Operational Satellite Ice Reconnaissance and Surveillance TIROS V and VI," Department of Transport, Toronto, Ontario, Canada, photos., charts, 11 pp., 1963.

...Describes comparison study made of TIROS V and VI ice observations with Canadian ice charts of the same period covering the Gulf of St. Lawrence. Mentions operational problems that will arise with the large volume of satellite ice data when weather satellites are placed into quasi-polar orbits.

Tarble, R. D., "Areal Distributions of Snow as Determined From Satellite Photographs," Publication #65, I.A.S.H., pp. 372-375, 1963.

...A brief summary on the applications and potentials of satellite photography in determining snow distribution for water supply and river forecasting. TIROS photographic examples are used. Discusses techniques for identifying snow-covered regions, particularly in mountainous areas.

1964

Barr, S. and M. Lawrence, "A Comparison of Large-Scale Vertical Motion and Satellite Observed Cloud Systems," Master of Sciences Thesis, Massachusetts Institute of Technology, photos., charts, refs., 70 pp., 1964.

...Studies the relationship of large-scale vertical motion to cloud patterns photographed by TIROS. Two cases were compared computing quasi-geostrophic, 10-level numerical models for vertical motion.

Fritz, S., "Pictures from Meteorological Satellites and Their Interpretation," Space Science Reviews, tables, pictures, pp. 541-579, 1964.

...Traces the history of the applications and interpretations made of photographs from TIROS satellites. Describes the video and infrared systems on the TIROS satellite. Results are shown of meteorological applications made of photographs in understanding the cloud forming process, storm development, location of the jet stream, tropical disturbances and severe local storms. Briefly discusses snow and ice photographs.

Lethbridge, M. D., K. S. Park, and H. A. Panofsky, "Synoptic Applications of Window Radiation from TIROS III," Final Report for U.S. Weather Bureau Grant No. WBG-14, Pennsylvania State University, maps, figs., 17 pp., 1964.

...Report summarizes synoptic applications of a quantity DV (effective radiating window temperature minus the surface temperature). Part of report deals with summer DV over U.S. compared with precipitation.

1965

Camerson, H. L., "Radar as a Surveying Instrument in Hydrology and Geology," Proceedings of the Third Symposium on Remote Sensing of Environment, 1964, University of Michigan, Ann Arbor, Michigan, pp. 441-451, 1965.

...Discusses the results of high resolution radar photography from 41,000 ft. as it relates to land features.

Cooper, C. F., "Snow Cover Measurements," Photogrammetric Engineering, Vol. 31, No. 4, pp. 611-619, 1965.

...Describes a field to compare snow depth measurements obtained from field measurements and from photogrammetric methods. The ground height was measured when clear of snow cover, and this value was subtracted from the snow surface height to derive the depth of snow. At 1:6,000 photo scale the standard deviation was 0.78 and the photo-derived depth was greater than the ground truth value.

Conover, J. H., "Notes on the Flora and Snow Cover Distribution Affecting the Appearance of Northeastern United States as Photographed by TIROS Satellite," Monthly Weather Review, Vol. 93, No. 10, pp. 644-646, 1965.

...Short article on the tonal changes in TIROS photographs as related to the season and to the forestation.

Morrison, A. and J. B. Bird, "Photography of the Earth from Space and Its Non-Meteorological Applications," Proceedings of the Third Symposium on Remote Sensing of Environment, 1964, University of Michigan, Ann Arbor, Michigan, pp. 357-367, 1965.

...Covers the application photographs of earth from space in non-meteorological fields. Photographs from sounding rockets, ESSA, Nimbus, and manned Mercury satellites are discussed.

Mueller, George E., "Statement Before the Committee on Aeronautical and Space Sciences," U.S. Senate, tables, 50 pp., 1965.

...A review of the status of manned space flight planning for the post-Apollo period is presented by the Associate Administrator for Manned Space Flight. A good source for an outline of the Apollo Applications Program that ranges from earth-orbital flights to follow-on programs after the lunar landing. Purpose is to provide information which will form the basis for decisions on future courses of action in the national space program. Missions range from earth-orbital through lunar experiments to deep space probes.

Pascalar, H. G. and R. T. Sakamoto, "Microwave Radiometric Measurements of Ice and Water," Proceedings of the Third Symposium on Remote Sensing of Environment, 1964, University of Michigan, Ann Arbor, Michigan, pp. 803-811, 1965.

...Describes an experiment of ice measurements with a passive microwave radiometer. Discusses the equipment design and the data. Data indicates that ice thickness can be obtained.

Phleger, F. B., "Study of River Effluents from Space Vehicles," Oceanography from Space, Woods Hole Oceanographic Institute, Ref. No. 65-10, pp. 425-426, 1965.

...Suggests use of satellites for large-scale mapping of river effluents by photographs and temperature sensing means on a world-wide basis.

Popham, R. W. and R. E. Samuelson, "Polar Exploration with Nimbus Meteorological Satellite," Arctic, Vol. 18, No. 4, photos., maps, pp. 246-255, 1965.

...Presents satellite photographs and HRIR imagery and compares them with ice charts of polar region.

Sanders, F., "Large-Scale Vertical Motion and Satellite Cloud Photographs," Final Report for U.S. Weather Bureau, Contract CWB-10843, by Dept. of Meteorology, Massachusetts Institute of Technology, maps, photos., ref., 36 pp., Dec. 1965.

...TIROS cloud photographs and fine-scale quasi-geostrophic calculations of vertical motion are used in an attempt to gain understanding of the evolution of large-scale cloud masses and to explore the usefulness of the pictures in diagnosis of the vertical motion.

U.S. Department of Interior, "Scope, Importance, and Resolution Requirements of Geoscience Problems to be Attacked by Orbital Remote-Sensor Measurements," Preliminary Report by U.S. Geological Survey to National Aeronautics and Space Administration, 85 pp., 1965.

...Describes some applications of measurements from remote sensors, indicates their economic and scientific importance, and discuss their "resolution" and "resolving power" requirements in the fields of cartography, geology, mineral resources, hydrology, and geography.

U.S. National Aeronautics and Space Administration, "Space Science and Applications Program," NASA Publication NFB 8030.2, listings, about 200 pp., 1965.

...An annual summary of all approved space flight investigations and experimental and theoretical supporting research. The names of participating individuals, universities, and agencies are listed. Covers Astronomy, Solar Physics, Particles and Fields, Ionospheres and Radio Physics, Planetary Atmospheres, Planetology, Bioscience, Meteorological Programs, Communications

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and Navigational Programs, and Conferences and Supporting Activities. Reports on the objectives of each of the above areas and the work performed, including techniques and instruments.

Zotimov, N. V., "A Surface Method of Measuring the Water Equivalent of Snow by Means of Soil Radioactivity," Transactions of the State Hydrologic Institute, Trudy GGI, No. 130, 1965.

...Describes the use of natural radioactivity of the ground for measuring the water equivalent of snow and some other hydrometeorological elements.

#### 1966

Badgley, P. C., "Current Status of NASA's Natural Resources Program," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 547-570, 1966.

...A status report of NASA supported R&D in those areas of remote sensing from earth-orbiting spacecraft. Contains information on NASA's aircraft program and a matrix on sensor versus earth science application. Also contains a list of on-going experiments with names of individuals and/or investigating agency.

Barnes, J. C. and C. J. Bowley, "Snow Cover Distribution as Mapped from Satellite Photography," Final Report ESSA Contract 11269, Allied Research Associates, Inc., figs., 103 pp., 1966.

...Satellite photographs were analyzed to determine if snow cover distributions in the Missouri and Upper Mississippi River Basin areas could be usefully mapped. Results indicate that snow cover can be reliably identified from satellite photographs, with snow depths of one-inch or more generally appearing as continuous snow cover with an accuracy of about +20 miles. Sufficient detail in the snow pattern can be recognized to allow mapping of individual river basins as small as 400 sq. miles.

Barringer, A. R., "The Use of Multi-Parameter Remote Sensing as an Important New Tool for Mineral and Water Resource Evaluation," Proceedings of the Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 313-325, 1966.

...Describes the testing and development of multi-sensor system for remote sensing from aircraft for high quality geology maps from aircraft surveys. Mentions that the detection of water indicates area of gravel for possible aquifers.

U.S. National Aeronautics and Space Administration, "Earth Resources Survey Program," tables, 13 pp., 1966.

The stated objective of this program is to develop the technology for surveying the Earth's resources from space. The major areas of interest are: Agricultural and Forestry Resources; Geography, Cartography, and Cultural Resources, Geology and Mineral Resources; Hydrology and Water Resources; and Oceanography and Marine Resources. The report expands on each of the above categories listing areas of applications; discusses economics and benefits.

Hoffer, R. M., R. A. Homes, and J.R. Shay, "Vegetative Soil and Photographic Factors Affecting Tone in Agricultural Remote Multi-Spectral Sensing," Proceedings of Fourth Symposium on Remote Sensing of Environments, 1966, University of Michigan, Ann Arbor, Michigan, pp. 115-134, 1966.

...A ground truth comparison to multi-spectral photography.

Hope, J. R., "Path of Heavy Rainfall Photographed from Space," American Meteorological Society, Bulletin, Vol. 47, No. 5, photos., figs., tables, and refs., pp. 371-373, May 1966.

...Discusses the dark area in one of the series of photographs taken at 101.9 stat. mi. altitude during the Gemini 4 flight of June 2-7, 1965. It is concluded that the dark area is the result of the previous heavy rain. Article suggests possible applications of such observations.

Huang, C., M. D. Lethbridge, and H. A. Panofsky, "Satellite Radiation Measurements and Synoptic Data," ESSA/WB Grant No. WEG 48-ESSA, Dept. of Meteorology, Pennsylvania State University, tables, 27 pp., 1966.

...Two periods, March and June 1962, U.S. TIROS 4 data (window temperature and water vapor channel temperature) were compared to ground observations of ceiling, relative humidity at ground level and cloud cover percentages. Discusses determining precipitation probabilities from the two temperatures.

International Business Machine Corporation, "ORL Experiment Program, Vol. B, Part II, Geology/Hydrology," NASA Contract NASw-1215, Rockville, Maryland, tables, graphs, 144 pp., 1966.

...The study was designed to lay the ground work for the large-scale NASA Orbiting Research Laboratories effort required to implement a meaningful earth-orbital experiment program. It is a four-volume task. Volume A is user-oriented, defines scientific and technical areas for experimentation, and presents a method of synthesizing the program. Volume B illustrates the application of the synthesis approach. Volume C interrelates the experiment programs and identifies the equipment and flight characteristics common to the experiment areas. Volume D summarizes the study results. In Volume B 12 areas of study are identified and method of solutions discussed to determine feasibility and value. Six of these areas concern flooding, snow, river ice, soil moisture, stream flow and basin patterns. Suggested modes (microwave, etc.) spectral bands and resolutions needed are listed for the experiments including specifications for related equipment. A summary describes the investigations being conducted in the geology area.

Kennedy, J. M. and R. T. Sakamoto, "Passive Microwave Determination of Snow Wetness Factors," Proceedings of the Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 161-171, 1966.

...Short text on determining free water content of natural snow by passive microwave measurements using various frequencies, polarization, and angle of incidence.

Leestma, R. A., "Applications of Air and Space Borne Sensor Imagery for Study of Natural Resources," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 111-113, 1966.

...U.S. Army Corp of Engineers compiled an atlas from satellite data. The atlas includes the atmosphere, hydrosphere, biosphere, lithosphere, and culture sphere.

McClain, E. P., "On the Relation of Satellite Viewed Cloud Conditions to Vertically Integrated Moisture Fields," Monthly Weather Review, Vol. 94, No. 8, pp. 509-514, 1966.

...Mean relative humidity in the layer 1,000-500 mb is related statistically to cloud cover and type obtained from TIROS satellite pictures.

Meier, M. H., W. J. Campbell, and R. H. Alexander, "Multi-Spectral Sensing Tests of South Cascade Glacier, Washington," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 145-159, 1966.

...A review of test data from a nine-lens multi-spectral camera, a scanning radiometer, a profiling radiometer, a four-frequency passive microwave radiometer and a side-looking radar. The article projects future applications of the above systems.

Meyer, M. A., "Remote Sensing of Ice and Snow Thickness," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 183-192, 1966.

...A high resolution monocyclus V.H.F. radar readily measured snow and lake-ice deposits to an accuracy of the order of 1 cm. Radar measurements were made from helicopter and on the ground. Ice water interfaces gives good returns whereas snow is smeared out, indicates a gradual change in dielectric constant.

Morain, S. A. and D. C. Simonett, "Vegetation Analysis with Radar Imagery," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 605-622, 1966.

...A comparison of vegetation maps versus K band and ANQ-56 radar imagery for development of radar echo mapping.

Meyers, V. I., C. L. Wiegand, M. D. Heizman, and J. R. Thomas, "Remote Sensing in Soil and Water Conservation Research," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 801-814, 1966.

...Describes application of optical and thermal remote sensing to certain soil and water problems. Subjects discussed are: (1) some reflectance properties of plants, (2) photographic detection of moisture stress, (3) thermal detection of moisture stress, and (4) photographic detection of salinity.

Popham, R., A. Flanders, and H. Neiss, "Second Progress Report on Satellite Applications to Snow Hydrology," Proceedings of the 23rd Annual Meeting of Eastern Snow Conference, pp. 109-119, 1966.

...A brief summary of the efforts to date by ESSA to use satellite photographs. Concerns mostly TIROS photography and some Nimbus. Covers in-house investigations and contract work directed toward development of techniques for mapping snow cover from satellite pictures.

Popham, R. W. and M. Baliles, "TIROS Cloud Free Atlas," prepared for National Environmental Satellite Center, ESSA, by Walter A. Bohan Co., Park Ridge, Ill., 3 Vols., photos., maps, 125 pp., 1966-67.

...Atlas contains cloud free photographs of the U.S. with prominent earth features identified for use by those working with satellite pictures. Pictures were collected over several years but show the Northern Hemisphere as it appears during the Spring (March 20-June 21). Features identified are salt flats, deserts, coral reefs, ice, and snow.

Rinker, J. N., S. Evans, and G. Robins, "Radio Ice-Sounding Techniques," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 793-800, 1966.

...During summer of 1964 a cooperative research project team traversed on the surface some 450 miles of Greenland Ice Cap to evaluate two V.H.F. band radar systems for measuring ice thickness and contouring bedrock profile at the ice/rock interface.

Robinove, C. J., "A Preliminary Evaluation of Airborne and Spaceborne Remote Sensing Data for Hydrologic Uses," NASA Tech. Letter 50, prepared by USGS for NASA under Contract R-09-020-009, tables, 4 pp., 1966.

...Defines the USGS hydrology program for improving its resource data collecting from airborne and spaceborne remote sensors. Includes a table of sensor versus problem areas. Briefly discusses relative value of remote sensors in hydrology and future research needed.

Robinove, C. J., "Remote-Sensor Application in Hydrology," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 25-32, 1966.

...Paper describes the present use of remote sensors in hydrology, assess the potential problem areas in hydrology, in which remote sensors may be useful and attempts to match the problems to sensing devices to develop a priority of investigations of remote sensing instruments for hydrologic purposes.

Sanders, P. M. and C. H. Wilkens, "Precise Airborne Radiation Thermometry," Proceedings of the Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 815-826, 1966.

...Reduction of the problems of relating remotely sensed temperature to the true temperature.

Schotland, R. M., "Some Observations of the Vertical Profile of Water Vapor by Means of a Laser Optical Radar," Proceedings of the Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 273-283, 1966.

...Theory, calculations, and measurements of the vertical profile of atmospheric water vapor utilizing a thermally tuned ruby laser is present. Author states that quantitative measurements cannot be made from cloud-free or sub-cloud areas until accurate data are obtained on the structure of the water vapor line.

Thompson, A. H. and P. W. West, "The Use of Satellite Cloud Pictures to Estimate Average Relative Humidity Below 500-mb," Final Report for Contract CWB-11247 for ESSA/NESC, Texas A&M University, Dept. of Meteorology, College Station, Texas, photos., charts, figs., refs., 28 pp., 1966.

...Relative humidities for ocean areas were computed using a coefficient determined from cloud types taken from satellite cloud photographs. The correlation coefficient was 0.78.

U.S. Department of Interior, "Objectives, Instrumentation, and Flight Time Recommendations of User Agencies and Cooperating Scientists Involved in the NASA Natural Resources Program," Space Applications Program Office, NASA, letters, tables and graphs, about 54 pp., 1966.

...Summarizes the requirements of the user agencies in the NASA's Natural Resources Program covering four major application areas:

1. Agriculture Forestry (USDA).
2. Geography/Cartography (USGS).
3. Geology/Hydrology (USGS).
4. Oceanography/Marine Technology (U.S. Navy).

The first three of these agencies have agreements with NASA to define requirements and the needs of the entire discipline involved, including the needs of other federal agencies. Tables and graphs show instruments and list the investigators; covers applications and resolutions expected or to be determined from experiments; includes specifications of the instruments employed.

University of Michigan, "Peaceful Uses of Earth Observation Spacecraft," NASA Contract NASw-1084, Washington, D.C., 3 Vols., tables, graphs, 430 pp., 1966.

...The University of Michigan, as a subcontractor for IBM, conducted a three-month study of the potential applications of Earth-viewing spacecraft. Volume I is an introduction and summary of the work performed. Volume II contains a comprehensive survey of potential applications and anticipated benefits. Volume III describes some of the requirements to be met by the orbital sensing devices. This reference material suggests results obtainable from a variety of sensors used to measure or detect selected parameters.

Williamson, A. N., "Laboratory Investigations of the Gamma-Ray Spectral Region for Remote Determination of Soil Trafficability Conditions," Proceedings of Fourth Symposium on Remote Sensing of Environment, 1966, University of Michigan, Ann Arbor, Michigan, pp. 623-633, 1966.

...Laboratory tests of gamma-ray radiation of soil samples.

#### 1967

Blackmer, R. H., Jr. and S. M. Serebreny, "Relationship Between Marine Precipitation Radar Echoes and Cloud Cover Viewed by Satellite in Polar Orbit," Final Report for Contracts Navy N62306-1642 and ESSA/WB CWB-11091, Stanford Research Institute, Menlo Park, California, 2 Vols., figs., charts, 41 pp., 1967.

...Analyses of concurrent radar data and TIROS 9 cloud photographs were made to develop techniques for determining areas of precipitation and severe weather within a given satellite-observed cloud situation. From the resulting examples a model of the probable distribution of precipitation within and around a typical maritime cyclone was constructed.

Bock, P., "Applications of Space Data to Water Resources," Presented at the 13th Annual Meeting of the American Astronautical Society, Dallas, Texas, 10 pp., 1967 (preprint).

...A discussion of the need for the application of space-derived data to the problems encountered in water resources. Broad areas of study are suggested. Stresses the need for studies concerned with the global hydrologic cycle. Briefly covers related efforts being undertaken by international organizations and by federal agencies at the national level.

Catoe, C., W. Nordberg, P. Thaddeus, and G. Ling, "Preliminary Results from Aircraft Flight Tests of an Electrically Scanning Microwave Radiometer," NASA Goddard Space Flight Center, Report X-622-67-352, 13 pp., 1967.

...Describes electrically scanning microwave radiometer and its operation during Convair 990 flights. Briefly describes data compared with terrain and cloud cover.

Fischer, W. A., "Satellite Detection of National Resources," Practical Space Applications, Vol. 21, pp. 399-408, 1967.

...Discusses the global surveying capabilities of satellites, both high-orbital speed types for full earth coverage and earth-synchronous types. Article describes the USGS work on mapping faults and its relation to earthquake prediction.

Lethbridge, M. D., "Precipitation Probability and Satellite Radiation Data," Monthly Weather Review, Vol. 95, No. 7, pp. 487-490, July 1967.

...TIROS radiation (channels 2 and 5) data were compared with the hourly precipitation for various periods following the satellite pass.

MEVA Corporation, "Pilot Program for Pilot River Basin," Final Report by MEVA (a subsidiary of Hughes Aircraft) under USGS Contract 14-08-0001-10474, tables, graphs, 101 pp., 1967.

...Under authority of Bureau of the Budget Circular "A-67" the USGS contracted with the MEVA Corp. to study the application of advanced technology to water data collection. A study of the data systems was made, including sensors, communications, data processing and data uses. This ranged from long-line systems through meteor burst technology. The purpose of this study was to determine the data users requirements on communications. Part of this report is a separate 200-page index that contains engineering analyses of each system. Worthwhile material for anyone concerned with communications in the earth resources field.

Oliver, V. J., "Some Applications of Space Observations to Meteorology, Oceanography, and Hydrology," Presented at Fourth Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Anaheim, California, 10 pp., pictures, 1967 (preprint).

...A brief description of the current status and application being made of satellite photographs and infrared data to these sciences. The paper covers the use of satellite pictures

Oliver, V. J., 1967, Cont.

in detection and tracking of storm systems, identification of cloud formations, frontal locations, and wind regimes for meteorological purposes. Discusses application in oceanography of satellite data for tracking ice fields and of infrared data in the mapping of sea-surface temperatures. Describes uses made of satellite pictures for mapping snow cover and identification of soil moisture for hydrologic purposes.

Thompson, A. H., J. F. Morrisette, and C. W. Bell, "On the Statistical Relationship Between Nimbus II MRIR and Lower Tropospheric Moisture Content," Final Report for ESSA/NESC under Grant No. E-63-67(G), Texas A&M University, Department of Meteorology, charts, tables, refs., 35 pp., 1967.

...A statistical study of the relationship between satellite-measured reflected and long-wave radiation and the moisture content of the atmosphere.

U.S. House of Representatives, "The National Space Program - Its Values and Benefits," Staff Study for the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, U.S. House of Representatives, Ninetieth Congress, First Session, GPO, 66 pp., 1967.

...The impact of the U.S. space program on Americans is reviewed with views on its contribution in the future. Economic, international and national values are discussed including benefits. The report also briefly treats the spectrum of space efforts ranging from weather satellites to nuclear power--included is a section on NASA's Earth Resources Program. A good reference that summarizes U.S. space efforts with selected references to efforts of other nations.

U.S. National Aeronautics and Space Administration, "A Survey of Space Applications for the Benefit of All Mankind," NASA SP-142, 135 pp., 1967.

...This document was prepared as a basic contribution to the projected 1967 summer study on space applications. The stated objectives of this survey are to focus attention on the real and potential applications of space technology to civil needs and to summarize work done to date, effort underway, and program plans; to identify policy and technical problems yet to be resolved. The survey includes a thorough review of communications, earth resources, geodesy, meteorology, and navigation with bibliographies on each area. Also covers future applications.

U.S. National Aeronautics and Space Administration, "Earth Resources Program-Ground Truth Session," Final Report by NASA Test and Operations Office, Science & Applications Directorate, Houston, Texas, figs., graphs, and tables, 171 pp., 1967.

...A summary is presented of ground truth data collected for agricultural, geologic, radar, oceanographic, and remote sensing surveys. Each section on the above topics treats many subareas. In agriculture for example, crop and soil identification and soil moisture measurements are discussed. Measurements are made through optical, infrared, and ground probe techniques which were performed from aircraft and mobile vans. Signature responses are also disclosed for the various instruments employed with suggestions for space flight experiments. Contains useful background information.

U.S. National Aeronautics and Space Administration, "Opportunities for Participation in Space Flight Investigations," NHB 8030 1A, about 100 pp., 1967.

...The stated purpose of the handbook is to communicate information to potential investigators concerning the space research and exploration programs of NASA. Includes basic information on the development of proposals including the names of NASA individuals to be contacted regarding specific opportunities. Programs include automated and manned spacecraft, research aircraft, and data analysis of concern to hydrology. Future investigations and missions are also discussed.

U.S. National Aeronautics and Space Administration, "Prospectus 1967-- Appendix A. Goals and Objectives." Office of Space Science and Application, Washington, D.C., 171 pp., 1967.

...Report compiled for planning purposes only. Section VIII is the goals and objectives of the programs for the Application of Space Technology. A portion of this section is Earth Resources Survey Program. The overall objective of this Program is to develop the technology for surveying the Earth's resources from space. This involves the selection and testing of appropriate observational procedures, instruments, subsystems, and interpretive techniques. The five major areas of interest are: Agricultural and Forestry Resources; Geography, Cartography, and Cultural Resources; Geology and Mineral Resources; Hydrology and Water Resources; and Oceanography and Marine Resources. The primary role of the Earth Resources Survey Program is to determine those

U.S. National Aeronautics and Space Administration, 1967, Cont.

Earth resources data which can best be acquired by spacecraft and to test and develop spaceborne instruments which can contribute significantly to the discovery, development, conservation, and management of these resources.

The Prospectus notes the following with respect to Hydrology and Water Resources: Water resources management requires data on a continuing basis of the water regimens of glaciers, snow fields, icecaps, rainfall runoff, and water retention and runoff in river basins. Space surveys could provide an operational method to obtain data for the inventory of the water resources of the nation and the world.

In the long run the acquisition of hydrologic data from space should produce significant economic benefits; however, these benefits cannot be stated in terms of dollars at this time. Direct benefits will accrue from improvements in present data-collection capabilities and for operational decisions in water management. Indirect benefits will be derived from the application of increased knowledge about the hydrologic cycle, regionally and worldwide.

The total existing capital investment in water-resources facilities of all types in the United States is about \$235 billion. To service this capital investment, some \$40 million is spent each year for routine collection of basic hydrologic data almost entirely by Federal agencies. These data are far from adequate; many important areas of investigation necessarily cannot foreshorten the time required to gather serial data for statistical analysis and long-range forecasting of hydrologic events, it should produce more data for long-range use and more timely data for short-range use. It is estimated that data collection by ground and aerial surveys would be more expensive than space surveys by factors ten to one-hundred.

#### 1968

Barnes, J. C. and C. J. Bowley, "Operational Guide for Mapping Snow Cover from Satellite Photographs," Final Report by Allied Research Associates, Inc., under ESSA Contract No. E-162-67(N), figs., maps, photos., and refs., 116 pp., 1968.

...This is an operational guide to users of satellite photographs for analysis of snow cover. The primary area of application is in the upper Mississippi and Missouri river basins, for this

Barnes, J. C. and C. J. Bowley, 1968, Cont.

area has minimum forestation. Techniques of snow identification, differentiation from clouds, and optimum methods for transferring the photograph information to work maps are included.

Bristor, C. L., "Computer Processing of Satellite Cloud Pictures," ESSA Technical Memorandum NESCTM 3, diagrams, 11 pp., 1968.

...Describes the basic operational computer processing of satellite pictures. Also covers the command, data acquisition, input data, processing, earth location, picture gridding, data mapping, computer products and is finished with a few cautionary remarks on these products. This paper is necessary background information for users of the NESCTM satellite data.

Bunting, J. and D. Lamb, "Heavy Snow in the Chicago Area as Revealed by Satellite Pictures," ESSA Grant CWB WBG-34, Satellite and Mesometeorology Research Project (SMRP), Research Paper No. 75, Dept. of Geophysical Sciences, University of Chicago, Chicago, Illinois, pp. 1-49, 1968.

...Weather data and snow cover data are compared with satellite photographs in the area of Chicago during and after the "Great Chicago Snowstorm of 1967." Discusses techniques for differentiating clouds from snow.

Chapurskiy, L. I., V. V. Klemin, N. I. Andreyeva, and M. V. Startseva, "Spectral Brightness of Clouds and Landscape Objects in the Visible and Near Infrared Sectors of the Spectrum," Sputnikovaya Meteorologiya, G.G.O. Trudy 221, Hydrometeorological Press, Leningrad, NASA Technical Translation (TT-F 589), pp. 225-239, 1968.

...Nadir measurements of the spectral brightness of five types of cloudiness and six types of underlying surface were made from aircraft with elevations of the sun from 0-50°. The instrument was calibrated in absolute unital brightness. The equipment made it possible to control the stability of its characteristics in time. The authors explain the spectral variations of their brightness from the point of view of reflecting properties of natural formations. All the results of the measurements and calculations are represented in the form of graphs and tables.

Edgerton, A. T., R. M. Mandl, G. A. Poe, and J. E. Jenkins, "Passive Microwave Measurements of Snow, Soil, and Snow-Ice Water Systems," Tech. Report No. 4, Space Division of Aerojet-General Corp. for Office of Naval Research, Contract No. NONr 4767(00), NR 387-033, Feb. 15, 340 pp., 1968.

...This report summarizes field and laboratory investigations conducted to determine the microwave emission characteristics of a number of natural materials. These experiments showed a useful relationship between the microwave brightness temperature and the moisture content of the soil and sediment. The laboratory tests on ice-water systems demonstrated that a definite relationship existed between the microwave brightness and the thickness of the ice layer. Experiments were conducted using ice formed from both fresh and salt water.

Greaves, J. R., P. E. Sherr, and A. H. Glaser, "Use of Cloud Statistics in Planning Remote Sensing Missions," Allied Research Associates, Inc., Concord, Massachusetts, 7 pp., 1968.

...Describes the program and use of their "World Cloud Data Bank" to determine the statistical probability of clouds in an area at a given month.

Ketchum, R. D., Jr. and W. I. Whittmann, "Infrared Scanning the Arctic Pack Ice," Informal Report, IR No. 68-115, Naval Oceanographic Office, photos., 25 pp., 1968.

...This report presents the infrared imagery and the vertical photography taken by the Navy during their first IR scanning experiment in the Arctic. Several over-flights of ARLIS II ice station are used for ground truth comparisons.

Kuettner, J. P., "Man's Geophysical Environment - Its Study from Space," Report to Administrator of ESSA, Rockville, Maryland, tables, 132 pp., 1968.

...A task force "report" representing all disciplines within ESSA that looked five years ahead for the purpose of appraising the potential utilization of manned and unmanned space platforms for the environmental sciences. The report contains proposals for experiments in support of ESSA's service and research missions and includes discussion of proposed sensors to be employed and parameters to be measured along with suggested resolution. Also covers work that has been accomplished to date in many of these areas.

Llaverias, R. K., "Bibliography of Remote Sensing of Earth Resources for Hydrological Application, 1960-1967," U.S. Geological Survey under NASA Contract No. R-146-09-020-011, Task 160 75-01-60-10, 71 pp., 1968.

...A preliminary bibliography to acquaint hydrologists with the basic literature on remote sensing as applicable to their work.

Panofsky, H. A., M. D. Lethbridge, J. A. Zak, and C. Huang, "Satellite Radiation Measurements and Synoptic Data," Interim Report III, ESSA Grant WBG-48, by Pennsylvania State University, 28 pp., 1968.

...This report concerns several investigations relating satellite radiation amounts in the water vapor window to synoptic characteristics. Of particular interest are those by Huang and earlier work by Lethbridge comparing infrared radiation amounts and precipitation. Tables are presented showing probability of precipitation as a function of window temperature. Combined cloud brightness and window radiation values as related to precipitation are also discussed.

Popham, R. W., "Satellite Application to Snow Hydrology," Project Report No. 7, World Meteorological Organization, International Hydrological Decade, Secretariat of the World Meteorological Organization, Geneva, Switzerland, 9 pp., 1968.

...Report summarizes satellite snow surveillance activities, reviews existing and future satellite instrumentation applicable to snow hydrology and suggests needs and solutions for future systems.

Potocksy, G. J., "Use of Satellite Photographs to Supplement Aerial Ice Information," IR No. 68-72, Naval Oceanographic Office, 11 pp., 1968.

...A short report on the use of satellite photographs to supplement aerial ice reconnaissance. It lists the advantages and disadvantages between satellite and aerial observations, and concludes they should be used together.

Robinove, C. J., "The Status of Remote Sensing in Hydrology," Proceedings of Fifth Symposium on Remote Sensing of Environment, 1968, University of Michigan, Ann Arbor, Michigan, pp. 827-830, 1968.

...A short review of remote sensing in hydrology (1968) with suggested direction of future work. Small bibliography (1966-1967).

Singer, S. F. and G. F. Williams, Jr., "Microwave Detection of Precipitation over the Surface of the Ocean," Journal Geophysical Research, Vol. 73, No. 10, pp. 3324-3327, 1968.

...Preliminary report on the detection of precipitation over the ocean by means of passive microwave radiometry. Discusses the problems encountered and results obtained during experimentation in October 1966 and February 1967 using the 15.8 GHz microwave channel from an altitude of about 3 km on a NASA 926 aircraft over the Florida straits. Other frequencies are also discussed.

Smith, W. L., "An Improved Method for Calculating Tropospheric Temperatures and Moisture from Satellite Radiometer Measurements," Monthly Weather Review, Vol. 96, No. 6, pp. 387-396, June 1968.

...Describes an improved method for calculating tropospheric temperature and moisture from satellite radiometer measurements. The computations required are only ten percent of those required by a previous method.

U.S. House of Representatives, "Earth Resources Satellite Systems," Report for the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, U.S. House of Representatives, Ninetieth Congress, Second Session, Serial W, GPO, Washington, D.C., 28 pp., 1968.

...Covers the purpose of an Earth Resources Satellite System and reviews the history of the development of ERTS.

U.S. National Academy of Sciences, "Space Applications Summary Study, 1967 Interim Report, Vol. 1," Prepared by National Academy of Sciences, National Research Council for NASA, 60 pp., 1968.

...A study of the peaceful application of satellites was initiated in January 1967 by the NAS at the request of NASA. The first phase of this summer study was carried out in 1967 and the final phase scheduled for 1968. Participants, under the general chairmanship of Dr. W. Deming Lewis, President of Lehigh University, numbered about 90 and represented a variety of backgrounds and experience. About an equal number of other specialists participated on a one- or two-day basis. Panels treated the subjects of meteorology, hydrology, oceanography, forestry-agriculture-geography, geology, geodesy, cartography, point-to-point communications, broadcasting, and navigation and traffic control. A Central Review Committee of about ten people reviewed presentations from each panel. The study treats the probable future usefulness of satellites in practical

U.S. National Academy of Sciences, 1968, Cont.

earth-oriented applications, and the nature and scope of the R&D programs believed necessary to provide the technology needed to achieve these applications. It also examined technical feasibility, costs, and benefits.

U.S. National Aeronautics and Space Council, "Report to the Congress from the President of the United States," Executive Office of the President, Washington, D.C., 145 pp., 1968.

...A resume of the U.S. Aeronautics and Space Program in 1967 with contributions from twelve participating agencies. The report is sectioned by agency with a brief paragraph describing their projects. Included is an appendix with historical data on launches, budget, and space vehicles. Contains much useful information on committees concerned with aeronautics and space activities.

Waltz, D. M., "Technological Base for Planning of Spaceflight Missions to Obtain Data on the Earth's Resources," presented at the Fifth Annual AIAA Meeting, Philadelphia, Pennsylvania, TRW Doc. No. 8800.8.10-32, TRW Group, One Space Park, Redondo Beach, California, 26 pp., September 1968.

...Covers the system requirements and sensors that may have application to the earth's resources space program. Concludes that the present technological base is potentially accurate for acquiring valuable data on earth resources from spacecraft during the 1970's; and that the data management problem is likely to be the pacing element in developing the program.

Whitney, M. B., R. C. Doolittle, and B. Goddard, "Processing and Display Experiments Using Digitized ATS-1 Spin Scan Camera Data," ESSA NESCTR 44, figs., tables, 60 pp., 1968.

...Results of experiments conducted with the digital data from the ATS-1 spin scan camera system are shown. Resolution, response characteristics, and dynamic range are discussed. The report also concerns itself with gridding, attitude determination, image brightness, and location problems. Display devices employed are described along with communications.

Zotimov, N. V., "Investigation of a Method of Measuring Snow Storage by Using the Gamma Radiation of the Earth," Soviet Hydrology: Selected Papers, Issue No. 3, pp. 254-266, 1968.

...Discusses the principle of Earth's gamma radiation to measure snow storage. The M-100 instrument is compared against the conventional snow-weighting snow-survey method.

### 1969

Amsbury, D. L., "Geological Comparison of Spacecraft and Aircraft Photographs of the Potrillo Mountains, New Mexico and Franklin Mountains, Texas," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, Vol. I, pp. 493-516, 1969.

...Color photos from Apollo 6, 7, and 9, high- and low-altitude aircraft flights were compared by photo-interpretative methods, in addition to limited field checking, to determine resolution requirements and optimum scales for mapping several types of geological features.

Barnes, J. C. and C. J. Bowley, "Satellite Surveillance of Mountain Snow in the Western United States," Final Report for NASA Contract No. E-196-68, Allied Research Associates, Inc., figs., 78 pp., 1969.

...The application of satellite snow-mapping techniques to mountainous-terrain regions is investigated. Principal data are ESSA-3 AVCS photographs (winter 1967) and a few APT photographs. A sample of high-resolution color photography from Gemini manned space flights are compared to AVCS for an indication of data from future earth-resources satellite systems. Results of the investigation indicate that mountain region snow mapping can be done. Geographic positioning can often be made by characteristic shapes of the mountain snow pattern due to the terrain contours.

Barnes, J. C., D. T. Chang, and J. H. Willand, "Use of Satellite High Resolution Infrared Imagery to Map Arctic Sea Ice," Final Report for NASA/NAVOCEANO Spacecraft Oceanography Project, Contract No. N62306-68-C-0276, prepared by Allied Research Associates, Inc., figs., photos., maps, refs., 109 pp., 1969.

...This report is an evaluation of High Resolution Infrared (HRIR) imagery for Arctic sea-ice mapping. Night HRIR film strips are used because they are available at a near real-time basis, hence are most suitable for operational ice mapping. In this study full resolution digitized data were also analyzed. HRIR imagery was compared with the United Kingdom Meteorological Office 10-day composite ice chart, the U.S. Navy "Bird-Eye" aerial ice reconnaissance flights, and satellite ice photography. Daytime HRIR was used in conjunction with radiometric measurements of other spectral intervals (MRIR). This provides unique signatures for geophysical features.

Bilello, M. A., "Surface Measurements of Snow and Ice for Correlation with Aircraft and Satellite Observations," Cold Regions Research and Engineering Laboratory Special Report No. 127, Hanover, New Hampshire, maps, refs., 13 pp., 1969.

...Describes network of ground stations that records snow and ice data in the Canadian and American Arctic.

Booth, A. L., and V. R. Taylor, "Meso-scale Archive and Computer Products of Digitized Video Data from ESSA Satellites," Bulletin of the American Meteorological Society, Vol. 50, No. 6, charts, pp. 431-438, 1969.

...Describes computer products derived from the archived mesoscale digitized video data.

Bowley, C. J., "Use of Nimbus II APT to Determine the Rate of Ice Disintegration and Dispersion in Hudson Bay," Technical Report No. 8 for NASA Goddard Space Flight Center under Contract No. NAS 5-10343 by Allied Research Associates, Inc., photos., maps, 39 pp., 1969.

...Describes results of investigation of the Nimbus II APT data to determine the rate of ice disintegration and dispersion over Hudson Bay, May-July 1966.

Colwell, R. N. and J. D. Lent, "The Inventory of Earth Resources on Enhanced Multiband Space Photography," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, 1969, Univ. of Michigan, Ann Arbor, Mich., Vol. 1, pp. 133-144, 1969.

...Apollo 9 and high altitude aircraft multiband photographs were optically or electronically combined and color enhanced so that the enhanced composite images might be compared with corresponding Infrared Ektachrome photos in terms of ease and accuracy with which various earth resources might be identified from them. Additional research is needed to: (1) determine which wavelengths of the electromagnetic spectrum are most useful for identifying each earth resource feature of interest; (2) determine which color combinations, of that many that can be used in producing image enhancements, are most easily and accurately discerned by the image analyst; (3) determine the net gain resulting from the use of such image enhancement techniques.

Edgerton, A. T. and S. Sakamoto, "Microwave Radiometric Investigations of Snowpacks," Interim Report No. 1, U.S. Geological Survey Contract 14-08-001-11828, by Aerojet-General Corporation, 88 pp., 1969.

...Report on measurements and analysis of radiometric data taken at Mt. Rainier and Crater Lake. Snow depths ranged from 46 cm to 184 cm during study period. Study shows that the relative importance of environmental conditions influencing microwave emission by snowpack varies with observational wavelength, antenna polarization, and antenna viewing angle. Experiment demonstrated that microwave of 13.4 and 1.4 GHz could penetrate greater than 180 cm dry compacted snow, whereas 37 GHz wavelength was more strongly attenuated by the dry snow. No quantitative relationships established for radiometric "temperature" and free water content.

Flanders, A. F., F. V. Kohl, and T. W. Davis, "Hydrologic Communications Experiment on the Applications Technology Satellite (ATS-1)," Proceedings of Sixth International Symposium on Remote Sensing of Environment, 1969, University of Michigan, Ann Arbor, Michigan, pp. 197-204, 1969.

...Describes the joint experiment by ESSA/NASA to test data relay from hydrologic platforms via the VHF Transponder on the ATS-1 earth-synchronous satellite. Digital river and rainfall data were transmitted from Arkansas, California, and Oregon upon satellite interrogation through a readout station at Mojave, California, to the Weather Bureau's Office of Hydrology in Silver Spring, Maryland.

Hemphill, W. R. and G. E. Storetz, "Remote Sensing of Luminescent Materials," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, 1969, University of Michigan, Ann Arbor, Mich., Vol. I, pp. 565-586, 1969.

...Fraunhofer line-depth method is used. This is a comparison of a selected Fraunhofer line in the solar spectrum with same line in a spectrum reflected from a material suspected to luminesce. Results of tank, shipboard, and helicopter tests show that a prototype Fraunhofer line-discriminator responds to dye concentrations as small as 1 part per billion and suggests that this instrument may be operationally useful in time-of-travel and dispersion studies.

Hruby, R. J., B. Ragent, and A. Edgerton, "An Experimental Evaluation of the Basic Assumptions Used in the Analysis of Microwave Radiometric Ground Truth Data," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, 1969, University of Michigan, Ann Arbor, Mich., Vol. I, pp. 587-602, 1969.

...Presented are the results of an experimental program designed to test the validity of commonly made assumptions used in microwave radiometry. The emissivity and absorptivity data agreed with each other to a sufficient degree of accuracy to ensure confidence in the assumptions and analytical procedures used for rough radiometric applications such as gross imaging, but there were sufficient discrepancies from surface effects and procedures to raise some questions about interpretations of measurements of small temperature differences for moisture content analysis or geological structure.

Kriegler, F. J., W. A. Malila, R. F. Nalepka, and W. Richardson, "Preprocessing Transformations and Their Effects on Multispectral Recognition," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Mich., Vol. I, pp. 97-132, 1969.

...Automatic pattern recognition techniques have been applied to data sensed remotely by a multichannel optical-mechanical scanner. These techniques are based on likelihood decision rules using as inputs the "signatures" (i.e., the spectral profiles and covariance matrices) of the objects or material to be recognized.

McClain, E. P. and D. R. Baker, "Experimental Large-Scale Snow and Ice Mapping with Composite Minimum Brightness Charts," ESSA Technical Memorandum NESCTM 12, photos., charts, refs., 19 pp., 1969.

...Describes composite minimum brightness (CMB) charts, a computer product used to suppress transient cloudiness yet retain images of stationary features, Comparisons are made of CMB charts with snow cover maps and sea ice maps.

Norwood, V. T., "Optimization of a Multispectral Scanner for ERTS," Proceedings of the Sixth International Symposium on Remote Sensing of Environment, 1969, Univ. of Michigan, Ann Arbor, Michigan, Vol. I, pp. 227-236, 1969.

...Presented are the equations relating scanner and orbital parameters to performance along with the reasons for selecting the actual design values.

Sabatini, R. R. and J. E. Sissala, "Project NERO Nimbus Earth Resources Observations," Technical Report No. 7, for NASA Goddard Space Flight Center Contract No. NAS 5-10343, by Allied Research Associates, Inc., Concord, Massachusetts, photos., maps, figs., refs., 66 pp., 1969.

...This report is a survey of nonmeteorological investigations using Nimbus photographic and infrared data. These investigations cover the fields of oceanography, geology, geography, and hydrology. It summarizes the experiments planned for the future Nimbus satellites and their application to the Earth Resources Program.

U.S. National Academy of Science, "Useful Application of Earth-Oriented Satellites, Hydrology," Panel 3 of the Summer Study on Space Applications, Division of Engineering, National Research Council for NASA, Contract NSR 09-012-909, 73 pp., 1969.

...Panel 3 of NASA-NRC's Summer Study of Space Applications was on hydrology. The report reviews the status of space technology and of remote sensing as it pertains to hydrology. Report covers benefits and economics of pursuing such application of space-borne systems.

Yost, E. and S. Wenderoth, "Agricultural and Oceanographic Applications of Multispectral Color Photography," Proceedings of Sixth International Symposium on Remote Sensing of Environment, 1969, University of Michigan, Ann Arbor, Michigan, Vol. I, pp. 145-174, 1969.

...Presented are the theory, design, and application of a multispectral additive color photographic system.

1970

Barrett, E. C., "The Estimation of Monthly Rainfall from Satellite Data," Monthly Weather Review, Vol. 98, No. 4, pp. 322-327, 1970.

...Explores feasibility of using meteorological satellite data to obtain better rainfall maps for periods of one month or more, especially over ocean areas, than is possible with conventional data.

McClain, E. P., "Applications of Environmental Satellite Data to Oceanography and Hydrology," ESSA Technical Memorandum NESCTM 19, photos., charts, refs., 12 pp., 1970.

...A summary of recent research results in the areas of sea surface temperature mapping, sea surface roughness determinations, and the charting of major sea ice and snow boundaries. Brief discussion of relevant data expected from upcoming ESSA, Nimbus, GOES, and ERTS satellites.

Planet, W. G., "Some Comments on Reflectance Measurements of Wet Soils," Remote Sensing of Environment, Vol. 1, No. 2, pp. 127-129, 1970.

...Augstrom's explanation of observed visual darkening of wet natural soils was verified by laboratory measurements.

Ramey, E. H., "Study of the Use of Aerial and Satellite Photogrammetry for Surveys in Hydrology," ESSA Technical Memorandum NESCTM 14, photos., charts, refs., 22 pp., 1970.

...Analysis of various physical and economic factors in the use of aerial and satellite photogrammetry for surveys of snow cover, snow depth, and some other problems in hydrology.

Smigielski, F. J. and L. M. Mace, "Estimating Mean Relative Humidity from the Surface to 500 Millibars by Use of Satellite Pictures," ESSA Technical Memorandum NESCTM 23, photos., charts, refs., 12 pp., 1970.

...The experimental method and verification are described, and the subsequent operational procedures are briefly discussed.

Waite, W. P. and H. C. MacDonald, "Snowfield Mapping with K. Band Radar," Remote Sensing of Environment, Vol. 1, No. 2, pp. 145-150, 1970.

...An analysis of K-band imagery obtained from aircraft over snow fields and glaciers shown relatively high signal return from old snow or firm and very low return from glacier ice. The microwave energy of Ka-band frequency is capable of penetrating an appreciable depth of new-fallen snow.