A REPORT ON

THE THIRD INTERNATIONAL TOVS STUDY CONFERENCE

Madison, Wisconsin

13-19 August 1986

sponsored by

Cooperative Institute for Meteorological Satellite Studies (CIMSS)

International Association of Meteorology and Atmospheric Physics (IAMAP)

National Oceanic and Atmospheric Administration (NOAA)
Office of External Relations

World Meteorological Organization (WMO)

(prepared by W. P. Menzel
and M. J. Lynch)

First Draft
5 September 1986

Final Draft
28 October 1986

FORWARD

The International TOVS Study Conference (ITSC) convenes the ad hoc Working Group of the International Radiation Commission that is studying the quality and applicability of satellite derived temperature and moisture profiles for operational purposes. This report summarizes the proceedings of the third gathering of this group. As before, the conference is divided into scientific presentations, progress reports on previous issues, discussion of new issues, and working group recommendations to the TOVS user community. A companion document entitled the Technical Proceedings of ITSC-III will contain the complete text of the scientific presentations which are only briefly summarized here.

Madison, Wisconsin proved to be a good site for the conference because of the many opportunities that the University of Wisconsin-Madison campus offers for enjoyable recreation and quiet scientific discussion. The Space Science and Engineering Center kindly volunteered their facilities; the capabilities of McIDAS (Man-computer Interactive Data Access System) were ably demonstrated by Felicia Chen, the numerous xeroxing tasks were completed in a timely fashion by Susan Pfefferkorn, and assistance during registration was given by Linda Leeg. We thank them for their contributions. On-site secretarial support was performed by Laura Beckett. Those of you who attended know that she efficiently handled the considerable logistics and ensured a smoothly run conference. A special thank you goes to her.

We also thank Santa Barbara Research Center and International Telephone and Telegraph who set up demonstrations relating their efforts in satellite instrumentation. Many conference attendees commented on the useful information exchange with Leon Goldshlak of SBRC, and William Knorr and Robert Koczor of ITT.

We also gratefully acknowledge that the publication of this report has been possible through the financial support from the NOAA/NESDIS Office of External Relations to the Cooperative Institute for Meteorological Satellite Studies in Madison, Wisconsin.

And finally, a quick sports report is in order: the non-cricket playing attendees edged out the cricket playing attendees in the first official ITSC Cricket Championship. However, in the follow-up soccer match the tally was reversed and revenge was had.

Madison, 27 August 1986

Paul Menzel

Paul Menzel

The Third International TOVS Study Conference

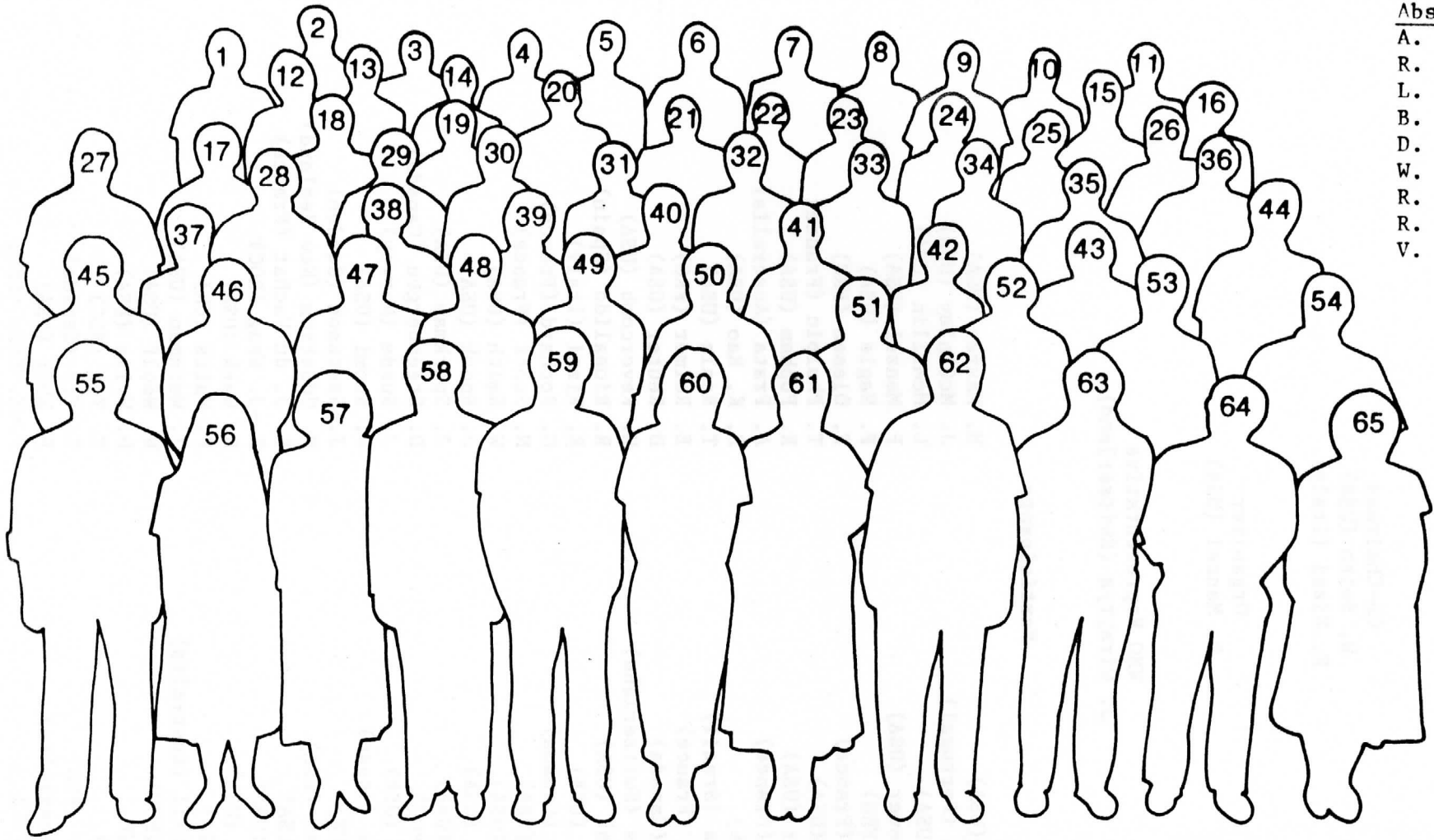
Co-Chairman
W. Smith (USA)
R. Rizzi (Italy)

Organizer
P. Menzel (USA)

WMO Representative
J. Giraytys (Switzerland)

Participants

T. Achtor (USA)
A. Arriaga (Portugal)
J. Bates (USA)
D. Birkenheuer (USA)
T. Boehm (FRG)
A. Chedin (France)
R. Curran (USA)
R. Dedecker (USA)
Y. Durand (France)
J. Eyre (UK)
M. Ferreira (Brazil)
J. Flobert (France)
L. Garand (Canada)
J. Giraytys (Switzerland)
L. Goldshlak (USA)
B. Goodman (USA)
B. Greaves (Canada)
C. Hayden (USA)
L. Herman (USA)
D. Hillger (USA)
B. Howell (USA)
A. Huang (ROC)
D. Johnson (USA)
K. Kageyama (Japan)
G. Kelly (UK)
T. Kleespies (USA)
W. Knorr (USA)
R. Koczor (USA)
D. LaPorte (USA)
K. Leap (USA)
J. Le Marshall (Australia)
G.-R. Liu (ROC)
P. Lloyd (UK)
C. Lo (USA)
F. Loechner (FRG)
M. Lynch (Australia)
X.-L. Ma (PRC)
H. Maurer (USA)
J. McGinley (USA)
L. McMillin (USA)
P. Menzel (USA)
F. Nagle (USA)
F. Olesen (FRG)
T. Phulpin (France)
R. Popham (USA)
A. Prata (Australia)
P. K. Rao (USA)
T. Reale (USA)
E. Reimer (FRG)
D. Reuter (USA)
H. Revercomb (USA)
R. Riosalido (Spain)
R. Rizzi (Italy)
G. Rochard (France)
N. Scott (France)
W. Smith (USA)
J. Snook (USA)
J. Sparkman (USA)
D. Steenbergen (Canada)
J. Sunde (Norway)
V. Suomi (USA)
J. Svensson (Sweden)
M. Uddstrom (New Zealand)
R. J. du Vachat (France)
H.-J. Wang (ROC)
D. Wark (USA)
P. Watts (UK)
J. Weinman (USA)
H. Woolf (USA)
D. Wylie (USA)
T. Yen (ROC)
T. Yip (Canada)
F. Zbar (USA)
F.-X. Zhou (PRC)



Absent
A. Arriaga
R. Curran
L. Goldshlak
B. Howell
D. Johnson
W. Knorr
R. Koczor
R. Popham
V. Suomi

1) H. Revercomb
2) D. Hillger
3) P. K. Rao
4) H. Maurer
5) J. Bates
6) R. Rizzi
7) D. Wark
8) D. Steenbergen
9) C. Lo
10) B. Greaves
11) P. Menzel
12) D. Reuter
13) J. Svensson
14) J. Sparkman
15) T. Phulpin
16) F. Loechner
17) G. Rochard
18) R. Riosalido
19) R. du Vachat
20) J. Giraytys
21) A. Chedin
22) N. Scott
23) Y. Durand
24) B. Goodman
25) A. Huang
26) E. Reimer
27) F. Zbar
28) J. Sunde
29) M. Uddstrom
30) J. LeMarshall
31) J. McGinley
32) D. Birkenheuer
33) F. Nagle
34) P. Watts
35) J. Snook
36) D. Wylie
37) X.-L.Ma
38) M. Lynch
39) L. McMillin
40) F. Olesen
41) J. Flobert
42) F.-X. Zhou
43) G. Kelly
44) T. Achtor
45) T. Boehm
46) L. Herman
47) H. Woolf
48) J. Eyre
49) T. Kleespies
50) W. Smith
51) J. Weinman
52) R. Dedecker
53) G.-R. Liu
54) D. LaPorte
55) K. Kageyama
56) T. Yip
57) H.-J. Wang
58) T. Yen
59) T. Reale
60) P. Lloyd
61) M. Ferreira
62) L. Garand
63) A. Prata
64) K. Leap
65) L. Beckett


THE UNI

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

A. Introduction

The Third International TIROS Operational Vertical Sounder (TOVS) Study Conference (ITSC-III) was held in Madison, Wisconsin, USA, from 13-19 August 1986. Seventy-four scientists attended representing seventeen countries which included Australia, Brazil, Canada, France, Federal Republic of Germany, Italy, Japan, New Zealand, Norway, Peoples Republic of China, Portugal, Republic of China-Taiwan, Spain, Sweden, Switzerland, United Kingdom, and United States of America. The participation in the ITSC has risen dramatically with each successive conference as new scientists, often from previously unrepresented countries, participate. The user community of direct readout TOVS data continues to expand in both the research and operational environments. The International TOVS Processing Package (ITPP) continues to be the main vehicle for extracting meteorological parameters and information from the TOVS data stream. The ITSC serves as a forum for scientific information exchange and planning for the future.

The ITSC convenes as an ad hoc Working Group of the International Radiation Commission that is studying the quality and applicability of satellite-derived temperature and moisture profiles for operational purposes. The mountain overflow experiment, ALPEX, has been used as a test bed for evaluation and improvement of various inversion algorithms. The previous two Conferences focused on the quantitative intercomparison of the processed ALPEX data sets and improved cloud clearing through incorporation of AVHRR data in the sounding process. The proceedings of the previous gatherings of this Working Group made several recommendations to the World Meteorological Organization regarding use of sounding data and came a long way toward achieving the central objective of defining an optimal approach for TOVS profile retrieval. ITSC-III saw presentations of further refinements of TOVS temperature and water vapor profiling algorithms, improved cloud clearing techniques, retrieval of cloud parameters, and the use of TOVS derived information in synoptic weather forecasts.

The ITSC-III heard presentations on the NASA and NOAA perspectives of the future satellite programs in this century and the WMO plans for utilizing the satellite retrieved meteorological information. A level of international cooperation for combined instrumentation efforts on future spacecraft is already apparent and growing. The need for coordinated infrared and microwave instrumentation on the same platforms was stressed. The possible role of higher vertical resolution information attainable with the newly tested interferometer sounders was presented.

The effective use of satellite sounding data in numerical weather prediction (NWP) models remains a high priority. Assimilation schemes using processed retrievals or observed radiances directly are both showing promise. The advent of improved computer power will soon enable models to achieve greater vertical and horizontal resolutions than the satellite can immediately provide. Future instruments must meet these improved requirements to remain compatible with planned finer mesh NWP models.

The International TOVS Working Group has selected several approaches to TOVS profile retrieval (statistical regression, simultaneous physical retrieval, and

improved initialization inversion), with the optimal approach depending on the specific application intended. Continued quantitative intercomparisons of these techniques was encouraged as a mechanism for further algorithm refinement for existing members of the TOVS community and for evaluation of data processing for new members. A new emphasis on intercomparison of clear only soundings also emerged, so that retrieval accuracy can be evaluated apart from cloud clearing skill.

The continued efforts of NOAA to provide high quality sounding data on a global scale were noted. The Satellite Calibration Center (SSC) in Lannion, France has volunteered collaboration for monitoring the quality of TOVS calibration. The European Center for Medium range Weather Forecast (ECMWF) continues to evaluate TOVS sounding data in their data assimilation system. More direct communications from these centers with NOAA operations were suggested. In addition, the ITSC offered the ITPP to the NESDIS Sounding Research Panel for scrutiny into its possible utility in NOAA operations.

The ITPP has proven to be an advanced and successful retrieval package which serves as the framework for operational implementation, permitting adjustment to local environments, and for research improvements. The ITPP has been packaged into a modular form to facilitate addition of recently developed techniques as new software modules. These efforts are taking place at many centers and the ITPP has truly become an international package. CIMSS continues to be the clearing house for modifications to and distribution of the ITPP. In the near term, the most important addition to the ITPP will be the use of AVHRR data in accounting for the effects of clouds on infrared measurements.

The cloud clearing techniques incorporating AVHRR data continue to show success. The derived cloud products are proving to be very useful. In order to validate the clear column radiances and cloud products, participation in international experiments, comparison with expert analyses of imagery, and simulation of cloudy radiances was encouraged.

The ITSC fully supported the WMO Baseline Upper Air Network initiative as an essential step in the improvement of global meteorological products. It further encouraged the complementary utilization and evaluation of B/UAN data and satellite products. Specifically, the ITSC was concerned that the WMO ensure that effective geographical and climatic coverage are achieved in the B/UAN.

Personal computer (PC) technology is starting to facilitate international scientific software exchange and development. The PC activities within the ITSC community are rapidly progressing. These systems are demonstrating great potential for TOVS processing (in a stand-alone mode), for case study data distribution and analysis, and for educational programs. The Chinese, French, Australian and U.S. delegates are already exchanging satellite data and display software on floppy disks. Many other countries will soon be joining in. The PC version of the ITPP is almost ready and ability to process TOVS data locally on one of these systems is at hand (the Chinese plan to implement PC systems at several of their HRPT direct readout sites). The ITSC recommend a common set of components for compatibility of disk based operating systems and established a newsletter for regular communication.

Global dissemination of locally produced TOVS products has not yet been accomplished. The Global Telecommunications System is not well-suited for

distributing satellite sounding data that satisfies NWP requirements. Alternate mechanisms have not yet been pursued. However, the ITSC did note that the NOAA Electronic Bulletin Board is proving to be an invaluable tool for distributing satellite information and general TOVS communications.

Finally, the Working Group suggested a broader scope for itself; ITOVS has been redefined to represent International Terrestrial Observing Vertical Sounders to indicate the growing interest in geostationary satellite observations in addition to the polar orbiting TOVS.

With the conclusion of the third ITSC, it is apparent from the interest and reaction of the delegates that these meetings are providing a valuable mechanism for the exchange of information and resolution of problems. With respect to the original Working Group brief from the IRC, substantial progress has been made in understanding and improving the retrieval process. Further, it is apparent from the ITSC that delegates have identified increasingly important roles for satellite-derived products in numerical weather prediction and climatological studies. Continued meetings were unanimously favored.

A review of ITSC goals at the present meeting concluded that this and future conferences should focus effort on the following five objectives: (1) improving satellite products via calibration refinements, retrieval method comparisons, verification, and case studies; (2) expanding the ITPP user community through distribution of the processing software, information exchange, and development of software for low cost processing systems; (3) investigating the growing number of applications of satellite products in numerical weather prediction and climate studies; (4) making recommendations to national agencies regarding the development of future satellite sounding instruments for both polar and geostationary platforms, and (5) encouraging an effective level of international cooperation on the above goals for the mutual benefit of the participating countries.

The ITSC agreed that these goals should be achieved by the following specific activities: (1) further case studies for evaluation of refinements to the ITPP or for impact studies, (2) improved information exchange and data dissemination among users of the ITPP, (3) formation of specialist working groups in areas where problems have been identified or where expanded areas for application of products are emerging, (4) communication of the outcomes of the ITSC to the IRC and other concerned national and international agencies, and (5) regular ITSC meetings.

At the ITSC-III meeting, nine Working Groups were established to review and recommend on a range of scientific and technical matters. They are:

- ITPP software,
- Transmittance Calculation Improvements,
- Sensor Calibration, Satellite Navigation, and Information Dissemination,
- Cloud Clearing and Cloud Products,
- PC Processing Systems,
- Future Instruments,
- Satellite Sounding Data in the NWP,
- Climate Applications, and
- Baseline Upper Air Network.

The Reports of the Working Groups are incorporated in Section IV of this document. The key conclusions and recommendations of the ITSC-III have been extracted and are summarized below.

The agenda for the ITSC-III is provided in the appendices. Status reports concerning issues raised at ITSC-II are summarized in Section III. The abstracts of Section II summarize the scientific presentations of the participants of the conference. As before, the complete text of the scientific presentations will be available in the Technical Proceedings of the ITSC-III.

B. Recommendations and Conclusions

The Working Group on ITPP software concluded that:

C1. The ITPP is an advanced and successful retrieval package which serves as the framework for operational implementation permitting adjustment to local environments, and for research improvements through addition of new software modules.

And further they recommend:

R1. The ITPP should be submitted to the Sounding Research Panel of NOAA/NESDIS for scientific evaluation and its utility to the international community in the NOAA operational processing scheme should be assessed.

R2. The NOAA Electronic Bulletin Board is an important vehicle for distributing ITPP information and new software developments. A separate ITPP category should be set up (as described in the Working Group report of section IV).

With regard to Transmittance Calculation Improvements it was concluded that:

C2. While fast code transmittance calculations have become sufficiently fast for use in physical retrievals and in radiance calculations in NWP models, they remain a significant source of error. The advent of the High resolution Interferometer Sounder (HIS) now offers the opportunity for infrared emission data at quarter wave number resolution which can guide adjustment in line parameters, particularly shapes.

The Working Group recommended that:

R3. Efforts must be made to incorporate these new data and to better verify the newly calculated transmittances. Data from the HIS experiment at Kitt Peak should be made available to ITRA (including emission spectra collected from high altitude aircraft overpasses of Kitt Peak, absorption spectra as a function of airmass measured using the McMath Solar Telescope, and special radiosonde profiles).

The ITSC-III concluded with regard to Sensor Calibration, Satellite Navigation, and Information Dissemination that:

C3. Most of the questions concerning TOVS calibration have been resolved through the combined effort of the Satellite Calibration Center (SCC) in Lannion, France (Guy Rochard) and NESDIS (Bob Popham). The remaining

problems will continue to receive combined attention. As a service to users, SCC will make available a pair of tapes, one of raw HRPT data and the other of calibrated earth located AVHRR, HIRS, MSU, and SSU data, for all satellites from NOAA-6 onward. This will enable users to compare locally processed data with SCC reference data.

Further it was recommended that:

R4. The SCC should monitor any changes or problems in TOVS calibration in collaboration with NOAA. Other HRPT users should refer any problems or questions to the SCC and should designate one (or more) HRPT stations within each country to act as a focal point. The Electronic Bulletin Board should be used to disseminate this information.

Regarding Cloud Clearing and Cloud Products, it was concluded that:

C4. The cloud clearing techniques incorporating AVHRR data continue to show success. Techniques for accurate collocation of AVHRR and HIRS footprints are well documented. The derived cloud products are receiving considerable attention and proving to be very useful. The validation of clear column radiances and cloud products remains as a major need requiring participation in international experiments, comparison with expert analyses of imagery, and simulation of cloudy radiances.

The recommendation was that:

R5. In order to evaluate variances of profile retrievals apart from cloud clearing skill, a quantitative intercomparison of only clear radiances for the ALPEX case study should be conducted.

R6. A case study should be chosen for intercomparison of clear radiances resulting from different cloud clearing schemes using AVHRR data. This study should attempt to establish a preferred processing technique and to validate the AVHRR cloud products.

The group working on PC Processing Systems concluded that:

C5. The PC activities within the ITSC community are rapidly progressing. These systems are demonstrating great potential for TOVS processing (in a stand-alone mode), for case study data distribution and analysis, and for educational programs.

Further it was recommended that:

R7. The ITSC PC activities should be coordinated as much as possible through active use of the NOAA Electronic Bulletin Board. CIMSS should continue to be the source of information regarding standardization, documentation, and distribution of PC/ITPP software with scientific contributions from other agencies funnelled through CIMSS.

Regarding Future Instruments it was concluded that:

C6. A number of agencies in different countries are formulating plans for new sounding instruments for the 1990's and beyond. The benefits from a high level of international cooperation on these activities are many, but most

importantly they include more effective use of national resources and the avoidance of duplicated effort. A division of effort (e.g. between future microwave and infrared sounders) might be a worthy goal and should receive further consideration by national agencies. To some degree, the duplication of effort between LANDSAT and SPOT is a case where cooperation rather than duplication may have been a preferred alternate strategy.

The Working Group made the following recommendations:

R8. The possibility of international agencies cooperating on the planning, development and evaluation of future satellite sounding instruments should be investigated.

R9. A major goal of future instruments should be an all-weather sounding capability which necessitates infrared and microwave instrumentation on the same space platform.

R10. Significant improvements to the quality of satellite-derived products and to their utility in numerical weather prediction models should be pursued through the increased vertical resolution associated with the new high spectral resolution instruments.

The ITSC-III recognized the important role of Satellite Sounding Data in the NWP models and concluded:

C7. Improvements in the assimilation of satellite soundings into NWP models are being sought through treating the data according to their true characteristics rather than as "poor-quality radiosondes." Early results are encouraging, but much more work is required.

Among the several recommendations from this group were:

R11. For continued improvement of operational implementation of TOVS products, it is essential that users of NESDIS retrievals feed back quality control information to the source agency in a timely manner. Telex or telephone communications to NESDIS operations within the same day should be vigorously pursued.

R12. NESDIS should consider dissemination of global high resolution (3x3 HIRS field of view) TOVS retrievals and clear column radiances where data communication systems permit.

R13. Careful selection of an ITSC case study for evaluation of TOVS impact on NWP should be made. This could focus on a northern Atlantic data set where the NWP might show positive impact in a revised analysis and forecast.

R14. The optimal orbit configuration and overpass timing for the polar orbiting satellites should be reviewed to ensure maximum impact of the data in NWP.

The use of TOVS data in Climate Applications was discussed and the following recommendations emerged:

R15. A data processing audit trail of the TOVS data should be initiated that indicates processing approach and ancillary data used. A common tape format for future archiving should be suggested to facilitate data exchange.

R16. The continued cross calibration of different instruments (satellite and non-satellite) is strongly urged. A program of periodic aircraft under flights and sonde launches during satellite overpasses with standard instrumentation should be considered.

The WMO initiative for a Baseline Upper Air Network (B/UAN) received considerable attention, from which it was concluded:

C8. The ITSC fully supports the WMO Baseline Upper Air Network initiative as an essential step in the improvement of global meteorological products. The complementary utilization and evaluation of B/UAN data and satellite products is highly desirable. To maximize the scientific impact of this effort, the WMO was asked to ensure that effective geographical and climatic coverage is achieved in the B/UAN.

C. Future Concerns

ITSC-III raised a number of important issues during discussions which were not readily solvable and were tabled for further consideration. Several of these will be addressed at the next ITSC to be held in approximately 18 months time.

1. The ITPP version 3 documentation, prepared by CIMSS in 1985, needs further distribution and review. Amendments should include NOAA-10 information. Feedback from the Sounding Research Panel of NESDIS is especially desirable. All improvements derived from ITPP version 4 will be added on in a modular form as new options.

2. A requirement was identified for an additional case study that emphasizes impact upon forecasting. ALPEX is not suitable for this application; data over the North Atlantic is most appropriate. Such a data set should include AVHRR and geostationary data and be supported by a mesoscale analysis.

3. An AMSU Working Subgroup needs to be formed. This group would review existing documentation, apprise NESDIS of data processing preferences, and prepare guidelines for the incorporation of AMSU into the ITPP.

4. ITSC has an increasing interest in new instruments, particularly in the impact of their products on NWP models. It is evident that probable improvements in NWP models will place increasing demands on the horizontal resolution of satellite derived sounding. The requirement for improved vertical resolution has consequences for the higher spectral resolution and broader spectral coverage now available through interferometric techniques. The inclusion of both infrared and microwave sensors on the same platform is viewed as mandatory. ITSC will prepare a position paper embracing these issues. International cooperation in new instrument planning and development is strongly encouraged.

5. The potential role of TOVS sounding products in climate research has been identified. ITSC will pursue future collaboration with climatologists and plan a demonstration of data utility via an audit trail.

6. Global TOVS data dissemination remains an issue with no immediate solution in sight. ITSC delegates will continue to alert their respective national agencies of their concerns.

7. ITSC is electing two new chair persons who will nominate a new organizer and venue for ITSC-IV. Dissemination of ITSC findings will be pursued through the sponsoring agencies (WMO, CIMSS, and IAMAP). Publication of a resume of the first three ITSC's in BAMS is planned.

II. ABSTRACTS FROM ITSC-III

Abstracts of presentations at the meeting are appended. The full text of presented papers is available in the Technical Proceedings of the Third International TOVS Study Conference, ITSC-III.

TOVS PROCESSING IN BANGLADESH

Thomas Achtor
CIMSS-University of Wisconsin
Madison, Wisconsin 53706
USA

The Space Research and Remote Sensing Organization (SPARRSO) in Dhaka, Bangladesh recently received the capability for direct readout of polar orbiter HRPT data. The International TOVS Processing Package (ITPP) was part of the software provided to the VAX/IIS interactive videographic computer system located at SPARRSO. Harold Woolf of CIMSS converted the ITPP software to VAX format as part of the University of Wisconsin (UW) involvement.

Initial efforts to study intense tropical cyclones in the Bay of Bengal focused on the 22-25 May 1985 case. Retrievals for these days were made at SPARRSO and the UW. An intense upper tropospheric anticyclone was found to develop above the cyclone during the period. Lower tropospheric fields did not indicate the strength of the cyclone. Future collaboration between SPARRSO and the UW is anticipated to investigate how TOVS data can be used to improve cyclone, monsoon depression and other severe weather forecasting in Bangladesh.

PLANS FOR TOVS IN PORTUGAL

Arlindo Arriaga
Instituto Nacional de Meteorologia e Geofisica
Rua C do Aeroporto
1700 Lisboa, Portugal

The HRPT satellite station of the National Institute of Meteorology and Geophysics in Lisbon, regularly receives the AVHRR. A brief description of the actual system configuration is presented, and reference is made to the use of AVHRR for operational purposes. The acquisition and processing of TIP data is planned for the near future.

OCEANOGRAPHIC AND CLIMATE APPLICATIONS OF TOVS DATA

John J. Bates
Climate and Remote Sensing Group
Scripps Institute of Oceanography
La Jolla, California 92093
USA

The Climate and Remote Sensing Group is involved in the applications of TOVS data to the remote sensing of the ocean surface fluxes including the shortwave

flux, the longwave flux, the sensible heating and the latent heating. We are also involved in possible climate applications of TOVS products including analysis of TOVS-derived SST, temperature, moisture, winds, and cloud data. The ITPP-III processing package has recently (Spring, 1986) been implemented on a VAX-750 computer. Computer facilities also include a Jupiter video display, optical disk mass storage, and PC-AT microcomputer smart terminal. The Scripps Satellite Oceanographic Facility (SOF) maintains an HRPT direct-readout site and archive of data from 1981 to the present. Initially, the ITPP-III package will be used to process archived data during past oceanographic research experiments so that comparisons can be made between the remotely sensed and in-situ data.

RECENT PROGRESS IN THE DETERMINATION OF METEOROLOGICAL PARAMETERS FROM THE SATELLITES OF THE TIROS-N SERIES

A. Chedin[1], N. A. Scott[1], C. Claud[1], J. F. Flobert[1], N. Husson[1], C. Levy[1], P. Moine[1], G. Rochard[2], J. Quere[2] and T. Phulpin[3]

[1]Laboratoire de Météorologie Dynamique du CNRS,
Ecole Polytechnique, 91128 Palaiseau Cedex, France

[2]Centre de Météorologie Spatiale de Lannion
P.O. Box 147, 22302 Lannion, France

[3]Centre National de Recherches Météorologiques/EERM
42, avenue Coriolis, 31057 Toulouse Cedex, France

Since the First International TOVS Study Conference (ITSC) held in Igls, Austria, 1983, the 3I (Improved Initialization Inversion) method has demonstrated its capability to accurately derive atmospheric parameters. Quantitative intercomparisons studies using ECMWF analyses and collocated RAOB data have been made (J. Le Marshall, 1983).

The 3I algorithm has been revised recently:

- optimization of the cloud detection algorithm, owing to, among other things, a better handling of the surface characteristics (quality of the terrain);
- improved specificity in the search for the closest element(s) in the TIGR data set owing to an optimized description of the air mass types;
- optimization of the surface temperature estimation method;
- optimization of the rejection tests based upon an improved filtering of the results;
- extension of the temperature profiles to the upper stratosphere owing to the use of the SSU data.

Newly derived results, using this revised version of the 3I code, have been submitted for comparisons studies (ITSC-III). They concern: temperature profiles, geopotential heights at standard pressure levels, cloud amounts, cloud-top pressure and temperature, H_2O content profiles, geostrophic winds.

The already demonstrated quality of the results (ITSC-II) has led us to extend the intercomparison studies to impact studies on forecasts (Chedin et al., 1986) and to the treatment of the satellite observations over polar regions.

Moreover, we have developed a very fast radiance calculation scheme (3R) to permit the effective utilization of satellite radiances directly in the numerical weather prediction schemes.

The ongoing development of this work concerns the combination of TOVS and AVHRR data and preparation for the processing of the coming AMSU data.

References:

Chedin, A., et al., to come.

LeMarshall, J.: The Technical Proceedings of the Second International TOVS Study Conference, Igls, Austria, February 18-22, 1985 (CIMSS, University of Wisconsin).

NEW DEVELOPMENTS OF THE FRENCH MESOSCALE ANALYSIS SCHEME USING RAW SATELLITE DATA

Y. Durand and R. Juvannon du Vachat
Direction de la Meteorologie SIEM/EERM
2 Avenue Rapp
75007 Paris, France

A mesoscale analysis has been developed in the French Weather Service to provide the initial conditions for a short-range numerical weather prediction model over France (PERIDOT project, mesh size = 35 km). Since we do not have classical data in the upper layers of the atmosphere, we make use of TOVS data whose resolution is approximately the mesh size of the model, and we insert these data directly into the analysis, without retrieval procedures. Since February, 1985 the PERIDOT model has been run operationally with this analysis and the ØZ data. Regular insertion of TOVS data received by CMS/Lannion from the NOAA9 satellite nighttime pass was begun in April, 1985. Since May, 1986 the analysis program has been used in an intermittent data assimilation 12 hour cycle. The guess field comes from a 12 hour forecast model. We also plan to insert raw satellite data at 12Z in September, 1986.

The new improvements since the Second International TOVS Study Conference concern the use of HIRS and AVHRR data estimating cloudy radiances. The statistics concerning NOAA9 errors have been produced and an experiment with systematic comparisons of analyses, with and without satellite data and the associated forecasts, has been performed during Spring, 1985.

TOVS RETRIEVALS IN THE U.K.: PROGRESS AND PLANS

J. R. Eyre, R. W. Pescod, P. D. Watts
Meteorological Office Unit
Hooke Institute for Atmospheric Research
Clarendon Laboratory, Oxford, U.K.

P. E. Lloyd
Department of Atmospheric Physics
Hooke Institute for Atmospheric Research
Clarendon Laboratory, Oxford, U.K.

W. Adams and R. J. Allam
Meteorological Office
London Road, Bracknell, U.K.

The Satellite Meteorology Branch of the Meteorological Office at Bracknell runs a scheme called LASS (Local Area Sounding System) to provide retrievals from locally-received TOVS data in real-time for use in operational weather forecasting and in particular for inclusion in the data assimilation of the regional forecast model. At the Hooke Institute for Atmospheric Research in Oxford, activities include research on improved methods for processing TOVS data which, if successful, are introduced into the operational system at Bracknell.

We review here developments to the operational system since the Second International TOVS Study Conference. These include the improved monitoring of biases between measured and calculated brightness temperatures and between retrieved profiles and radiosondes, and the assessment of scan-dependent biases in MSU data. The inversion scheme used operationally is still a regression method, but now uses regression coefficients generated locally rather than those obtained from NESDIS.

We also discuss aspects of current research. These include the development of a new cloud-clearing scheme and the use of AVHRR data both to validate the new (TOVS-only) scheme and to explore improvements to it. A cloud-clearing scheme which uses both TOVS and AVHRR data is described and some preliminary results presented. Research continues on a new inversion scheme which retrieves temperature and humidity profiles simultaneously and uses a forecast first-guess profile and its error covariance to constrain the inversion. The theory of the first-guess dependence of TOVS retrievals is discussed, and some preliminary results from the new scheme are presented. It is shown to improve significantly on both the current operational (regression) scheme and a minimum variance scheme used with a climatological first guess. However, when retrievals from the new scheme are compared with collocated radiosonde profiles over Europe, they do not yet show a consistent improvement over the forecast itself. It is shown that typical 12-hour forecast errors of tropospheric temperature (for the European/North Atlantic area) translate into errors in forecast TOVS brightness temperature which are quite small (around 0.5-1.0 K). These errors are comparable with those in the measured (pre-processed, cloud-cleared) brightness temperatures used in the inversion. Further work is required to reduce the errors introduced through the cloud-clearing and pre-processing stages, and plans for a new approach to MSU pre-processing are described. The effect of ozone on HIRS longwave channels is also discussed.

TOVS AND RELATED ACTIVITIES IN BRAZIL

Marlene Elias Ferreira
Departamento de Meteorologia
Instituto de Pesguisas Espaciais (INPE)
Caixa Postal 515
12200 Saõ José dos Campos SP
Brazil

Activities concerning meteorological satellites in Brazil are mainly conducted at the Space Research Institute (INPE), a civilian federal organization under the Ministry of Technology.

A program of major importance is the Complete Space Mission, established with the objective of designing, assembling, launching and operating a series of scientific satellites in low quasi-equatorial orbit for meteorological and remote sensing purposes. The first launch is planned for 1989. Research in Meteorology (Climatology, Numerical Modelling, Synoptic Meteorology, Satellite Meteorology and Oceanography) and Remote Sensing (of the ocean and land surfaces) is in the realm of the Space Research Program.

INPE has been receiving meteorological satellite data since 1969, when an APT station was designed and assembled at the Institute. Presently, the following facilities are operated on a routine basis (Elias, 1980; Meira Filho et al., 1981):

- TIROS-N (APT/AVHRR/TOVS) Station (since 1980).
- GOES (stretched VISSR) Station (since 1978).
- WEFAX Stations; one unit was installed at the Comandante Ferraz Station, the Brazilian research basis in Antarctic.
- ARGOS Receiving Station plus a network with ten ARGOS Data Collection Platforms designed at INPE and installed in the Amazon Region for hydrological support.
- Imagery Transmission Devices which use telephone lines to connect several users in the country.
- Interactive Imagery Devices which operate in conjunction with the GOES Station and provide the capabilities of displaying, storing and processing digital imagery.
- Remote Interactive Imagery Devices, installed in several meteorological offices.

Satellite data are used for research and operational purposes. AVHRR imagery has been particularly useful in the following research areas: Synoptic Meteorology, Oceanography, Forestry and Fishing. An algorithm to determine sea surface temperature, already developed, is presently undergoing a series of improvements.

TOVS data are processed on an experimental basis with ITPP-II implemented in 1986 on a Burroughs 6800 (48 bits) computer. The preliminary results are very promising.

Future prospectives include: continued operational reception of meteorological satellite data; expansion of the present interactive capabilities to treat

digital data; application of the TOVS retrievals in several case studies, especially in Numerical Modelling; and implementation of ITPP-III.

References:

Elias, M. Relatório de Acompanhamento Técnico (Final): Plataforma de Coleta de Dados. INPE, São José dos Campos, Ago. 1980. (INPE-1856-RA/127).

Meira Filho, L. G., Elias, M., Oliveira, J. R. Relatório de Acompanhamento Técnico (Final): Recepcão de Satélites Meteorológicos de Terceira Geracão. INPE, São José dos Campos, Mai. 1981. (INPE-2059-RA/150).

REMOTE SENSING OF SURFACE AIR AND DEW POINT TEMPERATURE IN CLOUDY ATMOSPHERES FROM CLOUD PATTERN-DEPENDENT RELATIONSHIPS

Louis Garand
Recherche en Prevision Numerique
Dorval, Quebec

A detailed cloud classification for oceanic areas has been developed. The method utilizes GOES visible and infrared imagery with a scale of analysis of 128x128 km. The 20 classes separate the various boundary layer regimes, including mesoscale cellular patterns (rolls, open cells), and thin cirrus, multi-layered systems and cumulonimbus. It is established that a strong relationship which is class dependent, exists between the apparent cloud base temperature, Tb (the infrared treshold corresponding to the cloud fraction) and the air and dew point temperature observed at the surface (Ta and Td). The difference between the sea surface temperature and Tb is also found to be an important predictor of Ta and Td. The standard deviations for single retrievals are, depending on the class, 2.5-4K for Ta and 3-5K for Td, about half the climatological standard deviations for the region studied (Gulf Stream area). The retrieval in each box is done independently of any content. It is argued that the results quoted above could further be improved from spatial and temporal consistency checks.

Thus, a new method, based on pattern recognition of cloud fields, is proposed for the remote sensing of Ta and Td in cloudy atmospheres. The method appears promising for application to vertical retrievals, in conjunction with radiative transfer techniques.

THE APPLICATIONS OF AVHRR DATA TO FINE SCALE TEMPERATURE AND MOISTURE RETRIEVALS OBTAINED FROM NOAA SATELLITES

Christopher M. Hayden and Leroy D. Herman
NOAA/NESDIS Systems Design and Applications Branch
Madison, Wisconsin 53706
USA

The mechanics of the amalgamation of AVHRR with TOVS data have been implemented. Techniques for applying the AVHRR to determine scene characteristics have been tested successfully although further fine tuning needs to be carried out. Initial investigations of the effect of the AVHRR on the retrieval accuracy have been made. It appears that on the synoptic scale there is minimal impact. On

the mesoscale, however, there is a strong indication that the impact is significant. This is primarily because the AVHRR permits confidence in single FOV HIRS retrievals even in partly cloudy areas. This means that the horizontal resolution of temperature/moisture soundings can be reduced to approximately 30 km. Detail of at least this scale is necessary for analysis of mesoscale features.

THE APPLICATION OF TOVS DATA TO THE CAROLINA TORNADO OUTBREAK OF 28 MARCH 1984

D. W. Hillger[1], J. F. W. Purdom[1,2], and T. H. Vonder Haar[1]
[1]Cooperative Institute for Research in the Atmosphere (CIRA)
[2]NOAA/NESDIS Regional and Mesoscale Meteorology Branch
Colorado State University
Fort Collins, Colorado 80523
USA

An analysis of satellite-derived soundings is presented for the 28 March 1984 Carolina Tornado Outbreak. The ability of the TIROS Operational Vertical Sounder (TOVS) to detect significant differences in water vapor profiles over small horizontal distances is shown. Temperature and water vapor profiles were retrieved in cloud-free areas at single field-of-view resolution of approximately 35 km without the aid of surface observations or other ancillary data. Significant differences in resultant profiles occur over horizontal distances of less than 200 km.

Besides temperature and mixing ratio profiles, various sounding parameters such as stability indices and buoyant energies were computed. These parameters help accentuate the differences in the profiles retrieved in the various air masses surrounding the tornado outbreak area.

AN EXTENSION OF THE SIMULTANEOUS TOVS RETRIEVAL ALGORITHM - THE INCLUSION OF CLOUD PARAMETERS

Hung-Lung Allen Huang[1] and William L. Smith[2]

[1]Satellite Ground Station
Central Weather Bureau
Taipei, Taiwan, Republic of China

[2]Cooperative Institute for Meteorological Satellite Studies
Madison, Wisconsin 53706
USA

An extension of the simultaneous retrieval algorithm is formulated to improve the retrieval of temperature and water vapor profiles, and surface skin temperature in cloudy situations. The modification enables the simultaneous retrieval of cloud amount and cloud top temperature with the atmospheric profiles from polar orbiting satellite TIROS Operational Vertical Sounder (TOVS) spectral radiance observations. The modified algorithm includes physics to account for the influence of clouds in the process of inverting the transfer equation.

The results have been compared with those of the original simultaneous retrieval algorithm for Alpine Experiment (ALPEX) orbits (March 4 and 5, 1982) under investigation by the ITSC. The comparison between analyses of retrieval results and those of the European Center for Medium Range Weather Forecasting (ECMWF) for radiosonde data indicate significant improvements in temperature profile accuracy for both regression and climatological first guess conditions. The results of the extended simultaneous retrieval method based on a regression first guess also show varying levels of improvement for different cloudy conditions: (1) clear or low cloud; small improvement (<0.1°C); (2) moderate cloudiness; moderate improvement (as much as (0.5°C); and (3) heavy cloudiness; large improvement (as much as 0.7°C), depending upon atmospheric level.

ECMWF ANALYSIS/DATA ASSIMILATION

G. A. Kelly
ECMWF
Shinfield Park
Reading, Berkshire RG29AX
United Kingdom

The ECMWF operational analysis is used as a reference for intercomparison of TOVS retrieval methods. The analysis has recently been rewritten with various improvements incorporated. The horizontal resolution of the analysis is now performed in the Gaussian grid of the forecast model (currently 110 km), and the improved method for the moisture analysis forecast model's vertical resolution has been extended to 19 levels. This paper also includes results (with and without TOVS profiles) from some forecast impact experiments in the Northern hemisphere during FGGE.

THE OPERATIONAL AND RESEARCH PROCESSING OF TOVS DATA IN THE AUSTRALIAN BUREAU OF METEOROLOGY

J. F. Le Marshall and G. A. Kelly
Bureau of Meteorology
Melbourne, Australia

Since the launching of the TIROS-N Series satellites in 1978, the Bureau of Meteorology in Australia has used data generated from the second generation sounders on these spacecraft. In the Australian region, these data are received and processed locally. This paper describes the present operational TOVS direct readout processing system used by the Bureau of Meteorology and the products it provides. It briefly describes the recently implemented ARM (Australian Region McIDAS) system, which has facilitated the interactive processing of TOVS data. It also briefly details the statistical and physical retrieval systems incorporated into this system which are now the basis of a significant amount of operational development and research.

SATELLITE SOUNDING ACTIVITIES AT THE W.A. INSTITUTE OF TECHNOLOGY

M. J. Lynch
School of Physics and Geosciences
WAIT, Bentley, Western Australia

Status reports are provided on a number of research projects in progress at our Institute. Specifically, current activities include, (i) tropical cyclone studies using MSU data,* (ii) the application of TOVS retrievals to refractive index production for microwave and radar propagation studies. Some difficulties are identified in using the physical retrieval scheme without surface data in coastal areas where a more complex boundary layer regime exists. (iii) a cloud top heights measurement program using the multispectral CO_2 technique with lidar verification, (iv) an evaluation of TOVS and AVHRR products over the ocean using verification data from an Indian Ocean scientific cruise.

Briefly reviewed are plans for a new NOAA HRPT station and Perth involving both state and federal agencies.

Preliminary plans for a meteorological and oceanographic instrument on the Australian geostationary platform (AUSSAT) are outlined.

*jointly with Dr. A. J. Prata et al. See paper elsewhere in this volume.

A PHYSICAL MODEL FOR RETRIEVING TOTAL OZONE FROM THE NOAA SATELLITE AND PRELIMINARY RESULTS OVER CHINA

Ma Xia-Lin and Zhang Feng-Ying
Satellite Meteorology Center
State Meteorological Administration
Beijing, People's Republic of China

A physical model is presented for calculating the total ozone amount from HIRS radiance measurements on the TIROS-N/NOAA satellites. The total ozone distribution charts over China are obtained according to this physical model calculation. Comparisons of analyses are presented for real time physical ozone retrievals versus analyses of conventional sounding total ozone data at Beijing and Kunming. These comparisons show that the total ozone amount can be retrieved with an accuracy of better than 3%. Also, this paper reveals that high (or low) values of total ozone usually correspond to the low (or high) at 500 hpa height.

SOME MODIFICATIONS TO THE NESDIS OPERATIONAL CLEAR COLUMN RADIANCE PROCEDURE

Larry McMillin
NOAA/NESDIS Satellite Experiment Laboratory
Washington, D.C. 20233
USA

Several incremental improvements to the cloud clearing algorithm are presented, as well as a modified method for obtaining cloud amounts and heights. The improvements stem from the recognition that many cloud fields consist of clouds

for which cloud amount and cloud height are correlated. This lack of independence causes a bias rather than a random error in derived clear column radiances, and methods that rely only on statistical approaches such as averaging to remove the errors will be affected by the bias. To remove the bias, some means of filtering is needed, and the NESDIS procedure is designed to filter out cases of mixed cloud heights. After filtering, many of the statistical procedures are useful as additional steps.

A new cloud algorithm has also been implemented. In doing so, the definition of the TOVS cloud height and amounts have been changed. When the present processing system was designed, there was interest in a dynamic indicator of retrieval accuracy for retrievals derived from clear column radiances. Cloud amount and height for the spots going into the retrieval provide some limited information about the reliability of the resulting retrievals. Since that time, we know of no user who has used these quantities as accuracy indicators, and there has been considerable interest in cloud amounts and heights. For these reasons, these parameters have been modified to represent the average of all the spots in a retrieval box, rather than just the spots used in deriving clear column radiances. The current cloud amounts and heights being produced by NESDIS provide useful meteorological information and are in better agreement with conventional measurements of these quantities.

CLOUD TOP PRESSURES AND AMOUNTS USING HIRS CO_2 CHANNEL RADIANCES

W. Paul Menzel and Don Wylie
Cooperative Institute for Meteorological Satellite Studies
Madison, Wisconsin 53706
USA

The CO_2 technique has been applied to HIRS and VAS data to determine cloud top pressures and effective cloud amounts (emissivities). Cloud top pressures are determined from the ratio of CO_2 channel radiances in a radiative transfer equation formulation. Effective cloud amounts are then calculated from infrared window channel observations. CO_2 technique derived height and amount assignments have been found to be reliable in all cloud types, including thin cirrus clouds where other techniques have been inconsistent. Cloud statistics have been calculated for 4-5 March 1982 of ALPEX using the HIRS data and are presented. Statistics of cloud characteristics over North America during winter of 1985-86 have also been calculated using the VAS data. Cirrus reports were found 25% of the time. It is suggested that ISCCP would benefit from using the CO_2 technique with TOVS data in performing its cloud climatology.

USE OF AVHRR PRODUCTS GIVEN BY ESTHER FOR TOVS PROFILES RETRIEVALS

T. Phulpin
ESSI/CNRM Toulouse
France

The ESTHER procedure (a two-dimensional histogram method) has been applied to the ALPEX orbit 3587 AVHRR data. The study of the results has shown that there are not enough AVHRR pixels within a HIRS footprint to obtain statistically reliable parameters.

Thus, the ESTHER results have been screened by means of several tests, which differ for "sea" or "land." The parameters provided by ESTHER, which can be used to improve the quality of TOVS profiles, are then listed. A method for clear column radiance retrieval using ESTHER products is proposed.

OBSERVATIONS OF TROPICAL CYCLONES IN WESTERN AUSTRALIA USING COMBINED TOVS AND AVHRR RADIANCES

A. J. Prata*, M. J. Lynch†, R. Hille**, and L. Van Burgel**

* CSIRO, Division of Groundwater Research, Perth, WA
† Western Australian Institute of Technology, Perth, WA
** Bureau of Meteorology, Perth, WA

Observations of tropical cyclones off the northwest shelf region of WA are presented from analyses of TOVS and AVHRR radiance measurements. The warm core anomaly is derived from MSU channel 3 measurements and is shown to be correlated with the central pressure drop in mature cyclones. A combination of MSU channels 3 and 4 is shown to provide better sensitivity for mature cyclones with upper level cooling. Vertical misalignment is assessed using synthetic and real data measurements and the importance of correcting for limb effects is demonstrated. The problem of horizontal misalignment and the effects of the MSU antenna gain pattern are also investigated. Collocated MSU and AVHRR measurements allow discrimination between horizontal and vertical misalignment problems. Cloud top temperatures derived from AVHRR channel 4 brightness temperatures are also presented for several tropical cyclones.

NUMERICAL FINE MESH ANALYSIS AND INCORPORATION OF HIGH RESOLUTION TOVS

E. Reimer
Institut für Meteorologie
FU Berlin

For the cyclogenesis of 4 to 5 March, 1982, the use of high resolution TOVS from NOAA 7 has been tested. Radiation fields are first transformed to a fine mesh grid. Afterwards, the physical retrieval software (Smith) is used at all grid points to update the fine mesh analysis of conventional data. By use of the synoptic cloud observations it is obvious that the infrared soundings fail in regions of translucent higher clouds and partial cloudiness with high convection. However, by use of microwave soundings and the numerical analysis as first guess, the update of a 3-dimensional portion of analysis or forecast seems to be possible.

ACCURACY AND FIRST GUESS DEPENDENCE OF CONSTITUENT RETRIEVALS PRODUCED BY THE GLA PHYSICAL RETRIEVAL PROCESS

Dennis Reuter and Joel Susskind
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
USA

The physically based constituent retrieval method used at the Goddard Laboratory for Atmospheres (GLA) is described and results are presented for some selected cases. In the case of water vapor retrievals, an additional study is described in which a poor first guess is used in the retrieval scheme in order to determine the sensitivity of the results to first guess accuracy.

For the case presented here, the accuracy of the water vapor retrievals is roughly comparable to that of the first guess in the lower troposphere and somewhat better in the upper troposphere. However, when a degraded first guess is used (i.e., 70% relative humidity through the atmosphere) it is found that the retrievals improve upon the first guess at all levels of the atmosphere and, in fact, have roughly the same RMS differences, with respect to radiosondes as do the retrievals based upon the six hour forecast first guess. This is not to be taken as implying that the retrievals are first guess independent, but rather that differences between retrievals produced using quite different initial guesses are much less pronounced than the differences between the guesses themselves. Since the forecast is probably most accurate in the vicinity of the radiosondes, because the radiosondes were used in the analysis to produce the forecast initial conditions, it is seen that the possibility of significant improvement upon the forecast values exists over most of the planet.

The results of the total ozone retrievals are shown for both a monthly mean field and for a shorter period in March 1979. When compared to TOMS values, it is found that the values produced using the infrared retrieval system are very similar to those produced using the ultraviolet instrument. Problems do exist,

however, in regions where there is little thermal contrast between the surface temperature and the air temperature in the region of the peak of the ozone concentration. It must be mentioned that a latitudinal adjustment is made to the total ozone retrieved by the HIRS/MSU system by adding to the retrieved total ozone the latitudinal mean difference between the TOMS and the HIRS for the period ten days previous to the time of the retrieval. This cannot alter longitudinal gradients, but may alter latitudinal gradients. Currently, it is not clear if the accuracy of the ozone retrievals is sufficient to monitor small changes in ozone amount. It is clear, though, that the ozone retrievals have great promise as an air mass indicator. This information may be extremely useful in improving the sounding accuracy of the other products produced by the retrieval system.

COMPATIBILITY BETWEEN HIGH DENSITY CONVENTIONAL AND SATELLITE TEMPERATURE FIELDS

Rolando Rizzi, Ennio Tosi, Marina Berti
Dipartimento di Fisica
Universita di Bologna
Bologna, Italy

An isentropic high resolution objective analyses scheme has been applied to conventional and satellite temperature data in order to quantify and determine possible causes of the differences observed among the analyzed fields. Greatest attention has been paid to the lowest levels of the atmosphere which are most affected by the presence of rough terrain. The r.m.s. difference in the lower troposphere between the conventional and satellite analyses are smaller by about half a degree with respect to the difference between the ECMWF operational analysis and satellite retrievals indicating the closer agreement of high resolution satellite and conventional products. The retrieved temperature field in the layer 1000 to 700 mbars has a great horizontal consistency mostly due to the cloud detection algorithm used. Since small, but detectable differences are found over large areas, some examples are shown of (1) differences involved by the cloud cover preventing the use of lower troposphere infrared channels, and (2) differences which are to be considered as due to true atmospheric features not detected by the conventional network over the central Mediterranean areas.

NOAA AMSU PLANS

James K. Sparkman, Jr.
NOAA/NESDIS
Washington, D.C. 20233
USA

A new all-weather microwave sounding instrument is now in fabrication for launch aboard NOAA-K in 1990. This instrument, an assembly of two major sub-units, AMSU-A and -B, has its roots in imagers and sounders dating back to the early NIMBUS program. It advances the art of microwave atmospheric sounding through the use of higher frequencies and spatial resolution. Its fields of view vary with frequency from 15 to 45 km. Since the AMSU will replace both the present SSU and MSU, and in time, perhaps the HIRS as well, considerable redundancy of parts is being designed into the unit to insure reliability. AMSU-B is provided to the NOAA polar spacecraft by the United Kingdom Meteorological Service.

Changes are also planned for the AVHRR imager to upgrade its channels. Some changes in the scheduling of platforms for NOAA sensors are also possible in the years 1989-1995.

SIMULTANEOUS RETRIEVAL OF TEMPERATURE AND RELATIVE HUMIDITY USING EMPIRICAL ORTHOGONAL FUNCTIONS

J. David Steenbergen, Brian T. Greaves, and Tsoi-Ching Yip
Atmospheric Environment Service
Downsview, Ontario, Canada

Preliminary tests of the use of empirical orthogonal functions of temperature and relative humidity as basis functions for a simultaneous retrieval scheme have shown some encouraging results. Because the scheme does not yet account for the effects of cloud, the tests were carried out using a small sample of manually screened clear radiance measurements and collocated radiosonde data. RMS layer mean temperature differences ranged from 1.0K for 50-70 kPa to 2.4K for 20-30 kPa. The retrievals were able to account for a significant part of the variation in tropopause height in the radiosonde sample using a constant first guess.

The comparisons showed that the algorithm had skill in retrieving layer mean relative humidity above 85 kPa. However, 85-1000 kPa layer mean relative humidities from retrievals and radiosondes were almost uncorrelated even though the retrievals explained 80% of the mixing ratio variance in the radiosonde sample for that layer.

PROCESSING OF TOVS - INFORMATION AT THE NORWEGIAN METEOROLOGICAL INSTITUTE

J. Sunde
Meteorological Institute
Box 320 - Blindern
0314 Oslo 3, Norway

Norway benefits strongly from the polar orbiting system. 20-25 orbits/day can be received from a twin satellite system. Operational systems for receiving and processing HRPT-information have been in place since the late 1970's, and have been modified and improved since then.

Our main effort has been concentrated on investigations of the AVHRR and DCP (ARGOS) information. The TOVS activity has been concentrated solely on the MSU data. The future extended TOVS processing hopefully will benefit from our present AVHRR and DCP products. Our main purpose will be to contribute to an improvement of TOVS retrievals in arctic and subarctic regions.

ESTIMATING THE CORRECT DEGREE OF SMOOTHING IN THE SIMULTANEOUS RETRIEVAL METHOD

Jan Svensson
The Swedish Meteorological and Hydrological Institute (SMHI)
Norrköping, Sweden

The International TOVS Processing Package, version 3 (ITPP3) has been implemented on the VAX 8600 computer at SMHI. ITPP3 has been tested and compared with ITPP2. The test shows a significant improvement in temperature profiles in this new version, especially for cloudy retrievals. A subjective estimation of the regularization parameter is done in the original inversion method of ITPP3. The generalized cross-validation (GCV) is an automatic method of choosing the regularization parameter. The GCV is implemented in ITPP3 and some preliminary results are shown.

SYNTHETIC AND REAL DATA APPLICATIONS OF THE TYPICAL SHAPE FUNCTION SIMULTANEOUS PHYSICAL RETRIEVAL ALGORITHM

Michael J. Uddstrom
New Zealand Meteorological Service
Wellington, New Zealand

Recently, a number of important advances have been made in the specification of linear measurement models for the radiative transfer equation. However, because the retrieval problem is fundamentally ill-posed, additional ancillary data must always be supplied to retrieval estimators. The purpose of this paper is to outline the characteristics of a physical simultaneous retrieval algorithm which utilizes the method of Typical Shape Function (TSF) classification. The advances made in both the selection of the first guess profile and constraints, and measurement specification models, are incorporated in this new algorithm. The essential element of TSF classification is that it enables the development of a non-linear retrieval scheme, without recourse to relaxation or iterative techniques. Instead, local domains in both radiance and retrieval parameter space are defined, in which the constituent atmospheres are in some sense linearly related. Within each TSF domain, linear retrieval methods may be applied without the usual consequences associated with the application of linear perturbation theory to strongly non-linear problems. In addition to providing a good estimate of the first guess profile, the TSF classification method also provides covariance constraints which define the "shape" of each TSF atmospheric class. This additional information is important and may be utilized in an appropriately specified retrieval algorithm.

The full TSF retrieval algorithm, which includes *a priori* temperature classification, radiance discrimination, cloud detection and correction, and simultaneous maximum *a posteriori* retrieval estimators, is applied to synthetic data and two NOAA-7 passes over the New Zealand region in July 1984. The TSF retrieval results are subjectively compared with operational NWP analyses, and output from the New Zealand Meteorological Service's operational retrieval scheme, which is a version of the NOAA/NESDIS Systems Design and Applications Branch - Cooperative Institute for Meteorological Satellite Studies (CIMSS) regression retrieval software found on the ITPP.

VALIDATING A TOVS CLOUD CLEARING SCHEME USING AVHRR DATA

P. D. Watts and J. R. Eyre

Meteorological Office Unit
Robert Hooke Institute for Cooperative Atmospheric Research
Clarendon Laboratory
Oxford, U.K.

A sensitive method for validating HIRS (High-resolution Infrared Radiation Sounder) cloud clearing schemes is described. The method uses AVHRR (Advanced Very High Resolution Radiometer) data collocated with the HIRS field of view. Cloud is identified with high spatial resolution with the AVHRR data and the clear window channel radiance appropriate to the HIRS field of view estimated. This is used as the "truth" for assessing the performance of a new cloud clearing scheme which uses TOVS data only.

With this method of validation, the performance of the new scheme is compared with that of the existing scheme used operationally by the U.K. Meteorological Office. Normally the error characteristics of the cleared radiances are obscured by larger errors inherent in the validation system. Many interesting features of cloud clearing infrared radiances become apparent when an accurate "truth" is available and these are demonstrated. Some of these results have prompted further improvements to the scheme and these are described briefly.

A PRELIMINARY STUDY OF TOVS RETRIEVAL IN TAIWAN, R.O.C.

T-C. Yen and H-J. S. Wang
Meteorological Satellite Ground Station
Central Weather Bureau
Taipei, Taiwan
Republic of China

The International TOVS Processing Package from the Cooperative Institute for Meteorological Satellite Studies was modified for implementation on a PDP-11/70 computer in the Meteorological Satellite Ground Station of the Central Weather Bureau, R.O.C. A preliminary study of the TOVS retrievals was made on a mesoscale convective system occuring June 4-5, 1986. The root mean square difference of temperature between TOVS retrieval and radiosonde and the thickness of 1000-500 mb comparison were shown. While preliminary results are encouraging, coniderable effort is still needed to improve the TOVS retrievals over the Taiwan area.

III. STATUS REPORTS ON ITSC-II ISSUES

CALIBRATION PROBLEMS AND PROGRESS

Guy Rochard
Centre de Meteorologie Spatiale
Lannion, France

In accordance with the recommendations of ITSC-II, a list of 25 specific problems were forwarded to NOAA/NESDIS. Most of them have been resolved with considerable assistance from R. Popham of NESDIS, but others arise.

With regard to calibration problems (see the Report on ITSC-III, pp. 8-9), the following comments summarize recent progress.

1. The AVHRR nonlinearity correction is well-defined, but it is documented differently in the NOAA/NESDIS table (Appendix B of the NESS Technical Report 107, Mar 86) and O. Brown et al. (Journal of Geophysical Research, Vol. 90, Nov 85). Which one is correct? R. Koczor of ITT is being asked to help.

2. NOAA-7 filters for HIRS-2, given in 30 points in Appendix B (10/19/81) are correct only for channels 6, 9, 10 and 13. The 15 others are incorrect. The central wavelengths and band correction coefficients of the same Appendix are correct for all channels.

3. Several other corrections to the NESS Technical Report 107 and its Appendix B have been established (see the Technical Proceedings of ITSC-III for details).

4. By matching AVHRR and HIRS-2, the practical field of view of HIRS-2 is found to be 1.4 degrees. The corrections for misalignment between AVHRR and HIRS-2 are now well-known at the precision of about ±1 pixel an AVHRR line.

5. For MSU, several problems have been resolved. A new approach to MSU preprocessing is given by J. Eyre et al. in their ITSC-III report "TOVS Retrievals in the UK: Progress and Plans." F. Prata of CSIRO in Perth has suggested an improved MSU calibration of NOAA-9 channel 3. Results of matching AVHRR and MSU will be available soon from F. Prata, but antenna pattern and limb correction problems remain. A residual scan dependent correction for the MSU is proposed by J. Eyre and R. Pescod in the UK Met Office 0.19 Branch Memorandum No. 78. P. Swanson at JPL is a new contact regarding MSU.

6. For SSU data, the precision of the data has been obtained. S. String at the UK Met Office is a new contact regarding SSU.

The detailed calibration report will be published in the Technical Proceedings of ITSC-III. However, as some remaining problems exist and new problems will likely emerge, the calibration working group of ITSC will remain active to resolve these issues (and the related problems of earth location and archival format).

EARTH LOCATION: A DESCRIPTION OF PREDICTION ERRORS AND A CORRECTIVE PROCEDURE ASSOCIATED WITH THE T-BUS-4 NAVIGATION MESSAGE

Frederick W. Nagle
NOAA/NESDIS Systems Design and Applications Branch
Madison, Wisconsin 53706
USA

The instantaneous positions of the NOAA-x orbiting satellites predicted by means of the T-Bus orbital parameters have been subject to considerable error. After tracking the error for many months, several points can be noted. Firstly, there is an overall tendency toward degradation in that the predicted positions generally fall further and further behind with time. Secondly, the degradation occurs at a rate which is by no means uniform, for certain sets of parameters tend to produce strings of predicted positions which degrade much more rapidly than other strings produced by other sets. Thirdly, the prediction error for any given epoch is not continuous. The discontinuities are obvious and occasionally very large. Finally, the error is frequently non-trivial even at the time of epoch (the origin). It should be recalled that this navigation is being used to locate the AVHRR data where an error of even a few kilometers is objectionable. Although its precise cause is unknown, it appears possible to introduce corrections which greatly reduce it. The correcting algorithm makes use of the fact that the Equator-to-Equator orbital period of a NOAA-x satellite is highly predictable, and this periodicity can be employed to stabilize the predicted positions by adjusting the along-track predictions to correspond to the known times of Equator crossing. Details of the correction algorithm will appear in the Technical Proceedings of ITSC-III.

DATA INTERCOMPARISONS REVISITED

John LeMarshall
Bureau of Meteorology
Melbourne, Australia

Fields of temperature, thickness and precipitable water, derived from common sets of TIROS Operational Vertical Sounder (TOVS) radiance data have been intercompared. These fields were produced by a variety of institutions using different retrieval techniques. The fields have been derived over three regions. The region associated with the Alpine Experiment (ALPEX) in 1982, the Tasman Sea and the United States of America (US). Basic statistics have been produced for these derived fields by comparing them to analyses produced by the European Centre for Medium Range Forecasting (ECMWF) and with collocated radiosonde (RAOB) data.

In most cases, both physical and statistical retrieval techniques exhibited root mean square (RMS) temperature differences of near two degrees Kelvin (2K) in the mid-troposphere (700 to 400 millibars (mb)) when compared to ECMWF analysis or collocated radiosonde data. Near the tropopause the differences rose to be near 3K or 4K. These figures include significant contributions due to radiosonde error, collocation differences, analysis error and other factors. Larger differences, which were contributed to by different vertical resolutions among the compared fields were evident near the tropopause and the surface.

Near the surface the differences appeared more a function of the use of ancillary data or constraints rather than the retrieval scheme.

Overall, the differences found in this study indicate an almost uniformly high standard of retrieval skill has been established on a international level. This suggests that the goal of satellite sounding producers to optimize and standardize TOVS processing procedures so as to provide accurate and uniformly consistent soundings to the meteorological community is rapidly being achieved.

The skill shown by the statistical techniques suggests that their further development is important to provide fast, efficient and accurate retrievals requiring limited computing resources. There are several areas in which the retrieval process would clearly benefit from such development. These include limb correction, which could be done after cloud clearing or avoided by using regressions associated with a particular angle. The use of ancillary data, such as surface data and surface elevation, would also benefit many schemes. The statistical schemes are comparatively simple and efficient and require limited computing resources, making them particularly suitable for use by groups establishing direct readout stations.

The clear advantages of the physical retrieval schemes include explicit treatment of skin temperature, emissivity, elevation, and the limb effects in obtaining a temperature profile. Appropriately developed versions of these schemes are favored for future operational use considering these advantages combined with those of using the characteristics (such as baroclinicity or the detailed structure) of a numerically predicted first guess field, and the easy use of the ancillary data. In particular, there are indications of increased skill in the moisture retrievals, which make their development a priority given the importance of moisture distribution in both nowcasting and numerical weather prediction. Furthermore, the requirement for coincident RAOB/satellite data is substantially lessened in comparison to the statistical schemes.

The direct use of radiances in numerical analysis schemes themselves shows some promise. These schemes have the advantage of using the first guess fields, ancillary data, and radiances in a statistically optimal way. They also facilitate horizontal consistency in the resultant temperature and moisture fields. The wide spread use of these schemes relies on several factors, particularly the generation of a suitable statistical data set for use in these analysis schemes and the production of high quality limb correct radiances.

A NEW CASE STUDY FOR ITSC

Rolando Rizzi
Dipartimento di Fisica
Universita di Bologna
Bologna, Italy

A second ALPEX case study was suggested, the intensive observing periods from March 17-21, 1982. This period affords the opportunity for numerical impact study since it is long enough to include 24 hours for initialization and 48 hours for the subsequent forecast. TOVS and AVHRR data from 24 overpasses are archived

at Lannion, so that the improved cloud clearing techniques using AVHRR can be tested. Also, Meteosat images exist for March 18 at Darmstadt, thus enabling satellite derived winds to be included in the initial data set.

After some consideration, ITSC decided not to pursue this new case study, but to consider a time period from the upcoming Operational World Weather Watch Systems Evaluation in the North Atlantic. It was felt that a case study with TOVS and AVHRR data over the data void Atlantic Ocean would better represent the potential impact on numerical forecast.

DATA PRODUCTS FOR THE INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY PROJECT (ISCCP)

Donald Wylie
Space Science and Engineering Center
University of Wisconsin-Madison
USA

ISCPP is currently in the process of assembling a global data set for a cloud climatology. The program plans to collect five years of data from all available geostationary satellites and the NOAA polar orbiting satellite. These data will be calibrated to a standard radiometer and analyzed for cloud information. Two types of products will be produced and distributed to the general scientific community: (1) radiance data from satellite imagery, and (2) an analysis of cloud cover.

ISCCP started collecting data in July of 1983. Three years of geostationary data have been collected to date. The program started with GOES-East, GOES-West, Meteosat and GMS. These satellites covered the entire globe except for a small part of the Indian Ocean. In 1984, GOES-East failed and GOES-West was moved to cover North America. This left small gaps in coverage in the central Pacific and Atlantic Oceans. Future plans call for a return to two GOES satellites and participation by the Indian government with INSAT.

The satellite imagery are reduced in both time and spatial resolution for ISCCP. Imagery are sampled once every three hours in time and approximately 30 km in space. This sampling is done to reduce the data volume to a manageable size.

Imagery from all satellites have been compared to a standard radiometer. This was originally the AVHRR on NOAA-7. Since the inception of this program NOAA has changed to satellite 9, some overlap in satellites has allowed a relative calibration between the satellites. In addition, global average radiances from the NOAA satellites have been continuously monitored for tracking drifts in the satellite's radiometers. The comparison of the geostationary imagery to the NOAA polar orbiter also is an ongoing function that is done to detect drifts in the satellites and changes between satellites.

ISCCP is compiling data from the visible and window infrared channels on the satellites. Other channels such as the 6.5 micron water vapor or the CO_2 sounding channels of HIRS or VAS are not used because they are not present on all of the satellites.

The reduced resolution data set is called the "B3" data. These data are radiances (visible channel) and brightness temperatures (infrared) that have been reduced to the standard radiometer. Its resolution is approximately 30 km in space and three hours in time as previously mentioned. The length of B3 record varies between satellites. The most complete record is Meteosat, however, efforts are being made to process all satellites at the same rate.

Cloud analyses of the B3 data will begin operational processing in January 1987. The cloud analysis algorithm is currently being refined. It will produce statistics on total cloud cover, cloud to pressure, radiance temperature, optical thickness, and the fraction of low, middle and high cloud categories. The cloud analysis will be archived as the "C3" data set.

ISCCP encourages use of both the B3 and C3 data sets. For more details contact:

Dr. William Rossow
NASA Goddard Institute for Space Studies
2880 Broadway
New York, NY 10025
Telephone: 212-678-5567

The First ISCCP Region Experiment (FIRE) will complement ISCCP by making detailed studies which are not feasible for the global ISCCP product. FIRE will study the radiative properties of clouds and also the atmospheric dynamics that produce and dissipate the clouds. This program will study only two special cloud forms: cirrus and marine stratus. A combination of intensive observation programs and long-term monitoring are planned. The first cirrus intensive field observations will be made in October 1986 in Wisconsin. The first marine stratus intensive observations are scheduled for the eastern Pacific Ocean along the coast of southern California in July 1987. For more information on FIRE contact:

Mr. David McDougal
Mail Stop 483
NASA Langley Research Center
Hampton, VA 23665
Telephone: 804-865-4342

THE INTERNATIONAL TRANSMITTANCE WORKING GROUP OF THE IRC

Alain Chedin
Laboratoire de Meteorologie Dynamique du CNRS
Ecole Polytechnique
91128 Palaiseau Cedex, France

In 1982, the International Radiation Commission of IAMAP through its Remote Sensing Working Group, initiated an international program of comparison of transmittance and radiance codes in order to determine the accuracy which can be achieved with the different calculation methods and to emphasize the problems which still limit the understanding of related research. The first organized exercise compared well-documented laboratory spectra of CO_2 in the 15 μm region to synthetic spectra. A report is available which gives the details of this

study. A brief summary of this comparison was presented at the business meeting of the Commission (IUGG 18th General Assembly in Hamburg). This activity was favorably received and plans for its development in the coming months were adopted at that time.

According to these plans, the second step of the international intercomparison program will follow three main directions:

1. "Nadir viewing" exercise.

   A subgroup has been organized with the charter to intercompare transmittance/radiance codes designed for simulating atmospheric transmittance an upwelling radiances in view of applications to satellite experiments sounding at nadir (e.g. those on board the satellites of the TIROS-N series). Dr. Spänkuch (Postdam, DDR) accepted the responsibility of leading this group. The starting point consisted in modelling transmittances/radiances for very simple atmospheric and "instrumental" conditions and to intercompare the results. Simulation of realistic conditions and comparisons with experimental data would be the objective of a second step.

2. "Limb viewing" exercise.

   A subgroup has been organized in the same spirit as the preceding one for simulation studies of satellite or balloon experiments looking at limb (like those flying on board Nimbus-7 or the coming UARS mission). Dr. Fischer (Munich, FRG) will head up this group.

3. "Microwave" exercise.

   Taking into consideration the rapidly growing impact of microwaves in the remote sensing of geophysical parameters, this subgroup has been organized to tackle those problems encountered at microwave wavelengths. Dr. Kunzi (Bern, Switzerland) accepted the leadership of this group.

Several initial studies were begun. The nadir group studied simulations of TOVS (TIROS-N Operational Vertical Sounder) channels around 15 μm in several atmospheric conditions (two isothermals, U.S. Standard atmosphere 1976, mean tropical and subarctic winter atmospheres). The limb group studied the spectral regions around 15 μm and 6.3 μm in three atmospheric conditions. The microwave group studied the AMSU (Advanced Microwave Sounding Unit to be flown on the TIROS-next platforms) channels in the same conditions as the nadir group. Three documents have been produced and sent to the interested parties. The calculations suggested by each study were completed by March 1, 1986 and presented during a workshop last spring.

About 30 scientists participated in this first ITRA Workshop held at University of Maryland, 12-14 March 1986. Seven countries were represented: USA (20 participants), Federal Republic of Germany (2), France (2), Great Britain (2), Japan (1) and Switzerland (1). Very active an constructive discussions were conducted within the three subgroups: Nadir, Limb and Microwave. The final report is in preparation and a first draft was discussed at the COSPAR Meeting in Toulouse in July. Dr. A. Arking, Head of Climate and Radiation Branch, Laboratory for Atmospheres, NASA/GSFC co-organized the workshop. The final report should be ready by the end of 1986.

COMPRESSION OF THE TIGR DATA SET

Alain Chedin and Noelle Scott
Laboratoire de Meteorologie Dynamique du CNRS
Ecole Polytechnique
91128 Palaiseau Cedex, France

The 3I algorithm has been designed with the purpose of retrieving geophysical parameters from space radiometric measurements and oriented towards the processing of the TIROS-N series observations made by the TOVS (TIROS-N Operational Vertical Sounder) instruments: HIRS-2, a 20 channel infrared radiometer, and MSU, a 4-channel microwave radiometer.

The 3I procedure is a physico-statistical type method which relies upon an a priori knowledge of the observations as well as of the parameters. This a priori knowledge is contained in a large data set, the TIGR (TOVS Initial Guess Retrieval) data set, created once and for all possible observing conditions (viewing angle, surface pressure, surface emissivity) and for about 1200 atmospheric situations covering the whole globe. It contains the transmittance profiles and associated brightness temperatures for each of the TOVS channels and the partial derivatives of these brightness temperatures with respect to a given atmospheric parameter. Provided the observed brightness temperatures correspond to clear areas or have been properly "cleared," the 3I procedure follows two principal steps.

a. Retrieval of the initial guess solution: the observed clear column radiances are first used to retrieve the best initial guess solution in a statistical sense. The procedure makes use of the TIGR data set. The selected set of observed brightness temperatures is compared with each of the computed sets of brightness temperatures and the closest is retained. This search for the closest archived situation may be carried out by considering either all the HIRS-2 and MSU channels or more restricted brightness temperature sets emphasizing a given property in the atmosphere; for example, a set of channels most insensitive to clouds.

b. The basis for the retrieval of the "exact" solution is a maximum probability estimation procedure aimed at minimizing the differences between the brightness temperatures associated with the initial guess and the observed ones. Use is made of the Jacobian associated with the retrieved initial guess in the TIGR data set.

At the time of the previous International TOVS Study Conference, the TIGR data set volume was close to 130 megabytes. A first compression, eliminating the Jacobian matrices (computed on line very rapidly) and compressing information through the use of 16 bits integer numbers, has resulted in a new volume of 35 megabytes. Further compression could be considered based upon principal component analysis.

The TIGR data set and associated software which strives for the best initial guess solution and then the exact solution of the radiative transfer equation inversion problem (the so-called ψ-method) is available from the authors upon request.

EMPIRICAL ADJUSTMENTS TO TRANSMITTANCES

Larry McMillin
NOAA/NESDIS Satellite Experiment Laboratory
Washington, D.C.
USA

If satellite retrievals are to be made with physical, not statistical, retrieval methods, then a method of calculating atmospheric radiances rapidly as well as accurately is required. Since the development of the successive layer adjustment method for fixed gases by McMillin and Fleming in 1976 and the extension of the method to gases with variable mixing ratios in 1979 as well as the development of the method to apply homogeneous-path transmittance models to inhomogeneous atmospheres by Weinreb and Neuendorffer in 1973, the ability to match results produced by more extensive line-by-line models has exceeded the accuracy of the line-by-line models themselves, particularly for gases with fixed mixing ratios. The papers by Spänkuch and Dohler (1985), Weinreb et al. (1981), and McMillin et al. (1980) provide summaries of the models and their accuracies, as well as reference lists.

In the past few years, alternatives to the rapid transmittance algorithms have been suggested. Unfortunately, they have not been compared on a common data set, similar to the comparison done by McMillin et al. (1980), and as a result, the relative accuracies are not known. As time goes on, there will undoubtedly be others. This is especially true for water vapor and other variable gases since it is more difficult to calculate transmittances for variable gases than it is for fixed gases, and much less has been done in terms of model comparisons. Therefore, there is an increasing need to:

a. Select a standard set of atmospheres to be used for comparing fast techniques. This set should be divided into a training set to be used to generate empirical factors, and an independent evaluation set to be used for the comparisons.

b. Have one of the centers calculate line-by-line data for selected channels for the set of atmospheres.

c. Select a center to distribute the data sets and to collect results.

Although the fast transmittance models provide a means of calculating radiances for a given instrument channel, a line-by-line model has been required to calculate coefficients for a new channel, and this has limited the number of people with capabilities to look at new spectral regions. With the arrival of Personal Computers (PC's) the number of people with access to computer resources has greatly increased, and a PC-based ability to calculate transmittances would provide a similar increase in ability to do sounding research. A major advantage of PC's is the portability offered by the large number of compatible machines. To promote this exchange, NESDIS has generated a capability to calculate transmittances on PC's. The method is based on the work of McMillin et al. (1976), but has gone through an evolution where parts have been done by NESDIS at Madison and others by NESDIS at Washington. Programs and data consist of:

a. the famous set of 1200 atmospheres along with programs to graph and use the data;

b. the programs necessary to calculate transmittances and radiances for TOVS instruments, given the correct coefficients for the satellite in question (i.e. NOAA-8 is different from NOAA-9);

c. line-by-line programs for the microwave region and programs to produce coefficients for the fast code and to execute the fast code,

d. programs to calculate infrared radiances at 0.1 cm^{-1} and convolute the result with any arbitrary filter;

e. coefficients for d for the region 600-2700 cm^{-1}.

Unfortunately, step e requires 36-360 k floppies to store the data even though any one channel may require only one or two. The whole package can be put on 11-1.2 meg. floppies. For the time being, a limited number of copies are available through NESDIS at Madison. It is anticipated that in a year to two, the sounding community can agree to exchange data on one of the high density media now appearing on the market, and the data volume will no longer be a problem.

References:

McMillin, L. M., H. E. Fleming, A. Arking, and D. Chesters, 1980: Accuracies of three computationally efficient algorithms for computing atmospheric transmittances. App. Opt., 19, 2267-2269.

Spankuch, D. and W. Dohler, 1985: TOVS transmittances: is there an optimum spectroscopic data set? The Technical Proceedings of the Second International TOVS Study Conference, Igls, Austria, 254-259.

Weinreb, M. P., H. E. Fleming, L. M. McMillin, and A. C. Neuendorffer, 1981: Transmittances for the TIROS Operational Vertical Sounder. NOAA Technical Report, NESS 85, Washington, D.C.

THE INTERNATIONAL TOVS PROCESSING PACKAGE

Harold Woolf
NOAA/NESDIS Systems Design and Applications Branch
Madison, Wisconsin
USA

The International TOVS Processing Package (ITPP), developed by CIMSS at the University of Wisconsin-Madison, is available to international users to produce retrievals of vertical temperature and moisture profiles, surface skin temperature, and total ozone. Version-3 of this package has been available for over a year. The main features of the system include: (a) selective removal of longwave HIRS channels and/or suppression of shortwave HIRS channels under cloudy conditions; (b) use of TOVS initial (synthetic) coefficients or long-term climatic means for first guess profiles; and (c) a simultaneous solution regularization retrieval method using as basis functions selected channel weighting (i.e. transmittance) functions.

ITPP-3 exists in an IBM and a VAX compatible form. The VAX form has been documented in a CIMSS Report entitled "Documentation of the TOVS Bangladesh Data Processing Software" (Nelson, 1985). To date, ITPP-3 has been sent to 37 users. The list of recipients and country affiliation follows (I stands for IBM and V stands for VAX):

Aoki	I & V	Japan (Tokyo)
Baranski	V	Poland (Warsaw)
Bates	V	California (Scripps, San Diego)
Billing	V	West Germany (Berlin)
Boehm	V	West Germany (Offenbach)
Cannizzaro	V	Italy (Rome)
Diaz	I	Chile (Santiago)
Eyre	V	United Kingdom (Oxford)
Farrelly	V	Norway (Bergen)
Ferreira	I & V	Brazil (INPE)
Hillger	V	Colorado (Fort Collins)
Hoque	V	Bangladesh (Dhaka)
Huang/Yen	V	R.O.C. (Taipei)
Kalb	I	Alabama (MSFC, Huntsville)
Kelly	I	United Kingdom (ECMWF)
Khanna	V	India (New Dehli)
Kleespies	V	Massachusetts (AFGL, Bedford)
Lai	I	Singapore (Met Service)
Le Marshall	I	Australia (Melbourne)
Loechner	I	West Germany (Oberpfaffenhofen)
Lynch	V	Australia (Perth)
Ma Xia Lin	I	P.R.C. (Beijing)
Murthy	I & V	India (Ahmedabad)
Pedersen	V	Norway (Tromso)
Putsay	V	Hungary (Budapest)
Quere	I & V	France (Lannion)
Riosalido	I	Spain (Madrid)
Rizzi	V	Italy (Bologna)
Sarukhanian	V	Switzerland (WMO, Geneva)
Shin	V	Canada (Univ. of British Columbia, Vancouver)
Steenbergen	I	Canada (Atmospheric Env. Service, Toronto)
Steffensen	V	Denmark (Copenhagen)
Sunde	I	Norway (Oslo)
Svensson	V	Sweden (Norkoping)
Taylor	V	New Zealnd (Wellington)
Young	I	Louisiana (Louisiana State Univ., Baton Rouge)
Zhou	I & V	P.R.C. (Beijing)

BASELINE UPPER AIR NETWORK

Frederick S. Zbar
NOAA/National Weather Service
Silver Spring, Maryland
USA

The WMO Commission for Basic Systems (CBS) decided, at the Extraordinary session at Hamburg, FRG in October 1985, that there be a feasibility study performed prior to the operational implementation of a global upper air baseline network. The U.S. agreed to formulate a plan, carry out studies for a six-month period, and report to the WMO. The Technical Proceedings of ITSC-III provides a report describing progress in developing the plan, identifying the requirements for and operation of the network, identifying a candidate set a globally distributed stations, organizing the participants for the evaluation, and a tentative schedule of the activities.

TOVS DATA DISSEMINATION

Paul Menzel
NOAA/NESDIS Advanced Satellite Products Project
Madison, Wisconsin
USA

The suggestion was made by Luigi Fusco of ESRIN/ESA that TOVS data be provided in the Landsat CCT format so that earth observation research could easily benefit from both AVHRR and TOVS data. Currently, the data are in different formats and the TOVS data is not provided along with the AVHRR. TOVS data would be extremely useful to perform atmospheric corrections.

On the other hand, Guy Rochard of SCC, Lannion has proposed a new format which includes AVHRR, HIRS, and MSU data for easier dissemination of case study tapes.

The issue of a generally accepted format for TOVS data dissemination was discussed by the International TOVS Working Group, but no easy solutions were available. Many centers already have substantial archives of NOAA data in formats that would not be compatible with these newly suggested formats. A conversion to a uniform format, while very desirable, would be costly and the most appropriate format is not yet known.

IBM PC PACKAGE FOR TOVS PROCESSING AND DISPLAY

Fengxian Zhou and Yanni Qu
System Development Laboratory
Institute of Atmospheric Physics, Academia Sinica
Beijing, People's Republic of China

An IBM PC package for TOVS data ingestion, preprocessing, retrieval, and display is available now. This package is based on previous work done by CIMSS scientists. Our major effort was concentrated on TIP data ingestion and retrieval display software.

IV. WORKING GROUP DISCUSSIONS

A. ITPP Software (chaired by T. Reale with M. Ferreira, F. Loechner, X. L. Ma, D. Steenbergen, J. Svensson, M. Uddstrom, H. Wang, and T. Yen contributing)

1. Introduction

The International TOVS Processing Package (ITPP), developed by CIMSS at the University of Wisconsin-Madison, is available to international users to produce retrievals of vertical temperature and moisture profiles, surface skin temperature, and total ozone. The main features of the system include: (a) selective removal of long wave HIRS channels and/or suppression of short wave HIRS channels under cloudy conditions; (b) use of TOVS initial (synthetic) coefficients or long-term climatic means for first guess profiles; and (c) a simultaneous solution regularization retrieval method using as basis functions selected channel weighting (i.e. transmittance) functions. This represents one of a large variety of methods currently under development and/or available internationally.

2. Issues

The following issues concerning the ITPP and and its role in the user community were discussed:

a. The general philosophy as to whether the ITPP should reflect the latest advances in retrieval methods or instead represent a baseline system for further development upon receipt by the international community.

b. The problem of communication, assimilation of ideas and software exchange between the principal research contributors associated with the ITPP and the international user community and the role of the NOAA Electronic Bulletin Board (EBB).

c. Adequate documentation of the ITPP including descriptions of file structures.

d. The contributions of the international community to the NESDIS operational global retrieval system.

e. Specific suggestions for further development of ITPP within the current framework of the package.

Considerable discussion was focussed on the status of the ITPP in the realm of ongoing international research. One of the most active areas of recent research has been the development of pattern recognition or classification techniques for determining a very accurate first guess (Chedin and Scott, 1983) or both the first guess and statistical constraints (Uddstrom and Wark, 1985). The global representative data sets which have been developed as part of this work are a very valuable resource.

Accounting for the effects of clouds on infrared measurements is another area in which a large improvement over present techniques is possible. The use of AVHRR data has been identified as a promising approach. Several workers have contributed to solving the problem of matching HIRS and AVHRR data (Aoki, 1983;

Phulpin et al., 1983; Hayden et al., 1985; Lloyd et al., 1985). The software required to carry out the matching would be an important addition to the ITPP.

The list of potential improvements for ITPP-3 is extensive. The working group concluded that it would not be reasonable to ask CIMSS to increase its level of support for the ITPP-3 to the extent that would be necessary to include latest research capabilities as an integrated part of a system. Instead, it recommended that the capabilities be made available directly to potential users by the original developers if they were willing to do so. The EBB would facilitate such exchanges.

A number of groups have now used the CIMSS software as a starting point for the development or adaptation of new retrieval schemes. Several improvements to the ITPP-3 were identified which would facilitate these applications. These included improved documentation on the file structures and common blocks.

3. Recommendations

a. The ITPP represents an advanced and successful retrieval procedure which in its current form constitutes an important and valuable contribution to the international community. This is reflected, for example, by its successful implementation in Bangladesh. Some alternative methods, particularly in the areas of cloud clearing (or lack of) and first guess procedures, are attractive. However, procedures surrounding such methods are numerous and in many cases still incomplete. The ITPP-4 package should remain basically unchanged from ITPP-3, except for some modifications within the current framework as described below (Action: Woolf).

b. It is important to set up a mechanism for making available software developed within the international community in order to facilitate the experimentation with different approaches to the retrieval problem. An important vehicle for this is the NOAA Electronic Bulletin Board. We propose that a separate category under ITPP be set up. Within this category, seven subcategories would appear (Preprocessing, Radiance Adjustments, Cloud Clearing, Filtering, First Guess Data Sets, First Guess Procedures and Retrieval Methods). Items of research under each category would appear along with the key personnel, a short description of the research and an address and phone (and telex or fax) number where the key person can be reached. An example with a preliminary list of some of the subcategories and associated methods and key people defined by the group are in Table 1 (Action: Popham/Chedin/Eyre/Reale).

c. Documentation of the ITPP is necessary so that users can interact with the package, particularly in the area of file structure. The documentation that accompanied the Bangladesh system (Nelson, 1985) is a good starting point. Further upgrading will be done at Madison and the final version will be made available to all involved with the ITPP system (Action: Woolf).

d. The ITPP package will be reviewed. Upgrades will be considered to (1) separate the various corrections done in the preprocessor such that users can choose which corrections they want to apply; (2) include the option of applying the NESDIS updated coefficient data base (CDB) in place of initial coefficients for the first guess for the current operational NOAA satellites and additional

1. First Guess Data Sets

Name	Key Person	Address & Phone	Description
TIGR	Chedin	France	to be provided by nominated key person
PDS-1200	Reale	USA/NESDIS	
TSF	Uddstrom	New Zealand	
Clim ITPP	Woolf	USA/CIMSS	
RR-7000	Uddstrom	New Zealand	
Fleming 108	Fleming	USA/NESDIS	
McMillin	McMillin	USA/NESDIS	

2. First Guess Procedure

Name	Key Person	Address & Phone	Description
TSF	Uddstrom	New Zealand	to be provided by nominated key person
ITPP	Woolf	USA/CIMSS	
Classification	McMillin	USA/NESDIS	
3I	Chedin	France	
TOVS Global	Reale	USA/NESDIS	
Forecast	Eyre	UK	
	Reuter	USA/NASA	

3. Retrieval Methods

Name	Key Person	Address & Phone	Description
Physical-B Spline	Svensson	Sweden	to be provided by nominated key person
Physical-Basis Functions (ITPP-3)	Woolf	USA/CIMSS	
Physical-TSF, MAP, Sequential	Uddstrom	New Zealand	
Physical-Minimum Variance Estimator	Fleming	USA/NESDIS	
Physical-NWP Error Covariance	Eyre	UK	
Physical-Iterative (ITPP-2)	Woolf	USA/CIMSS	
Physical-Iterative	Susskind, Chahine	USA/NASA	
Physical-Minimum Variance	Fleming	USA/NESDIS	
Physical-3I	Chedin	France	
Regression-ITPP1	Woolf	USA/CIMSS	
Regression-TOVS Global	Reale	USA/NESDIS	
Regression-Classification	McMillin	USA/NESDIS	

TABLE 1: Key areas of development within the ITPP software with identified key personnel.

CDB data sets for the other satellites (i.e., NOAA-8, NOAA-7, etc.); (3) include cloud parameters and ozone in the simultaneous solution; and (4) include an MSU only processing option (Action: Woolf/Reale).

e. A study of quality control algorithms for the ITPP-3 package to flag bad data within the orbital processing stream. Action at this time consists of the distribution of available documentation of such procedures to the user community (Action: Reale/Woolf).

f. Development of more timely and routine procedures to input user feedback into the quality control of NESDIS global products particularly during the implementation of new procedures and satellites is recommended. Also better communication is needed to the international community on current NESDIS operational sounding procedures and plans for upgrades (Action: Kelly/Reale).

g. The ITPP-3 should be submitted to the Sounding Research Panel (SRP) of NOAA/NESDIS for scientific evaluation. Its utility in the NOAA operational global processing scheme and also the utility of endorsed international research should be assessed. The development of dedicated procedures within NOAA/NESDIS to routinely execute and evaluate new sounding algorithms on a global basis would be a valuable asset (Action: McMillin/Reale).

References:

Aoki, T., 1983: Clear radiance retrieval of HIRS channels with use of AVHRR data. Technical Proceedings, First International TOVS Study Conference.

Chedin, A., and N. A. Scott, 1983: Improved initialization procedure ("3I"). Technical Proceedings, First International TOVS Study Conference.

Hayden, C. M., W. L. Smith, H. M. Woolf, and B. F. Taylor, 1985: An application of AVHRR data to TOVS retrievals. Technical Proceedings, Second International TOVS Study Conference.

Lloyd, P. E., J. J. Barnett, and J. R. Eyre, 1985: Investigation of AVHRR data to improve HIRS retrievals. Technical Proceedings, Second International TOVS Study Conference.

Nelson, J. P., 1985: Documentation of the TOVS Bangladesh Data Processing Software. A Report from the CIMSS.

Phulpin, T., M. Derrien, and A. Brard, 1985: CMS contribution to the use of AVHRR data in TOVS data processing. Technical Proceedings, Second International TOVS Study Conference.

Uddstrom, J., and D. Q. Wark, 1985: A classification scheme for satellite temperature retrievals. J. Clim. Appl. Meteor., 24, 16-29.

B. Transmittance Calculation Improvements (chaired by N. Scott with T. Kleespies, L. McMillin, and H. Revercomb contributing)

1. Introduction

Atmospheric transmittance calculations for satellite retrievals have been refined over the years. Line-by-line calculations are at the point where they very closely can approximate laboratory and in-situ observations over much of the spectrum. Fast transmittance models have been developed which match the line-by-line model results with an accuracy which is better than the variations among the different line-by-line models. The fast code models are now several thousand times faster and thus are sufficiently fast for use in physical retrieval schemes and in calculating radiances in numerical weather prediction (NWP) models. Nevertheless, there is room for improvement in some areas of transmittance calculations, since uncertainties in transmittance still contribute some errors to retrievals.

The impact of improved transmittance calculations on TOVS processing will be most noticeable in physical retrievals and in limb corrections. Current methods used for TOVS processing in major centers are sufficiently good that transmittance errors are not a dominant source of retrieval error. However, there may be some retrieval packages in use which could be improved by updated transmittance models. Also, improved knowledge of transmittances will be important to any future improved TOVS or other sounding instruments.

2. Identified Problems

Several problems have been noted that still require further attention. They are:

a. Unresolved errors in the calculation of transmittance in the infrared window regions, particularly near the 668 cm^{-1} and 720 cm^{-1} Q-branches, and in other regions of strong absorption related to problems in handling the continuum, line shape modeling, line mixing, and temperature dependence of line widths.

b. Discrepancies between calculated and observed radiances in the microwave channels of MSU.

c. Problems of calculating microwave transmittance through clouds and precipitating areas.

d. Imprecisely known influence of aerosols in radiative transfer calculations.

e. Inadequate in-situ verification above radiosonde measurements, and for ozone profiles.

f. Radiosonde measurement inaccuracy arising largely from the uncorrected influence of radiative coupling.

3. Recommendations

a. We concur with the International Transmittance Working Group (ITRA) regarding items in 2a. - 2c. above (see Status Report in section III). We recommend that their work be continued and that their conclusions be communicated to operational groups (Action: Chedin).

b. Furthermore, we feel it is especially important that efforts be made to collect and use high quality ground truth observations for verification of calculated transmittances. Data from the High resolution Interferometer Sounder (HIS) experiment at Kitt Peak should be made available to ITRA (including emission spectra collected from high altitude aircraft overpasses of Kitt Peak, absorption spectra as a function of airmass measured using the McMath Solar Telescope, and special radiosonde profiles) (Action: Smith).

c. Gammas and deltas used in TOVS processing should be updated more frequently and air mass and/or latitude dependences should be used. In doing this, potential radiosonde errors should be identified and removed, since they may be a major cause of the remaining differences between calculated and observed transmittances (Action: Woolf).

d. With the increasing dependence on microwave observations, problems with microwave transmittances in clouds and in areas of precipitation will be more important. The ITSC should be informed about efforts to understand and resolve these difficulties (Action: McMillin).

e. Little is known about the influence of aerosols on physical retrievals. Greater efforts should be made to quantify their effect on atmospheric transmittances (Action: McMillin).

C. Sensor Calibration, Satellite Navigation and Information Dissemination (chaired by G. Rochard with B. Greaves, P. Lloyd, A. Prata, J. Snook and T. Yip contributing)

1. Introduction

Most of the questions on calibration arising at ITSC-II are set out in the Status Report included in this document. Several questions still remain to be answered and new problems have arisen though discussions during ITSC-III. Guy Rochard of CMS Lannion will be the focal point for remaining questions and any new problems in calibration and earth location which arise in the next 18 months. Results will be reported at ITSC-IV, at which point these activities may be transferred to NOAA.

Continuation in association with SCC/ISCCP, in Lannion, of intercalibration between HIRS2 channel 20, AVHRR channel 1, and the visible channels of GMS, Meteosat and GOES.

2. Recommendations

a. SCC Lannion should make available to users one tape of raw HRPT data and another tape containing calibrated earth location AVHRR, HIRS, MSU and SSU data. This should apply for all satellites from NOAA-6 onward. This would enable users to compare locally processed data with SCC reference data (Action: Rochard).

b. SCC Lannion should monitor any changes or problems in calibration in collaboration with NOAA (Bob Popham) who will put a note to Electronic Bulletin Board, if necessary. Also, other HRPT users should refer any problems or questions to CMS Lannion. A letter (drafted by Fred Prata and reprinted in Appendix C) should be sent to all HRPT users to inform them of this recommendation and to request users to designate one (or more) HRPT stations to act as focal points for calibration questions in each country. This will be carried out for a test period of 18 months and the results reported at the next ITSC (Action: Rochard/Popham).

c. Additional information regarding instrument performance should be sought. Problems concerning HIRS/AVHRR data should be brought to ITT's attention (Action: Rochard). More detailed information about the MSU antenna grid pattern should be requested of JPL (Action: Eyre).

d. It is also recommended that the status report and recommendations be presented at the International AVHRR Users Workshop in Melbourne in October 1986 by the chairman of this Working Group or his representative (Action: Rochard/Prata).

e. New users (or those updating existing operations) should select an existing format for data storage, and one or more reference formats should be provided by major HRPT operations (e.g. NESDIS, Lannion) (Action: Rochard/Popham).

f. Research into improved preprocessing for MSU should be encouraged with the intent to improve the mapping of MSU and HIRS/AVHRR. In particular, it is recommended that the limb correction of MSU should be done separately from the antenna pattern connection. This should be treated as a calibration problem (Action: Rochard/Prata).

g. Information concerning the new TBUS package should be put on the EBB (Action: Popham).

D. Cloud Clearing and Cloud Products (chaired by T. Phulpin, with F. S. Olesen, J. Sunde, and P. Watts contributing)

1. Cloud-Clearing Techniques and Accuracy

Cloud-clearing techniques generally consist of two distinct stages: first detection of cloud and then correction for their effect. Considerable work has been undertaken to incorporate AVHRR data into both stages with some success. Progress has also been made with TOVS-only schemes. Further work has been done to include the cloud-clearing as part of the temperature/humidity retrieval by obtaining first guesses of the cloud parameters.

a. TOVS-Only Schemes

The adjacent FOV technique and its extensions have been improved, but only for a synoptic scale operation. Too many FOVs are necessary for successful cloud clearing for it to apply to mesoscale retrievals. The horizontal consistency in radiance fields has been utilized to improve overall accuracy. The damaging effect of biases in various regressions used in cloud filtering is recognized and some attempts have been made to correct for them.

A validation system using AVHRR data has been developed for application to a TOVS-only scheme. Unfortunately, it cannot be used to validate a cloud filtering scheme assisted by surface data.

Work into TOVS-only schemes is important despite the proven advantages of including AVHRR data because many regional centers do not have access to AVHRR data or to the computing power required to process it.

b. TOVS and AVHRR Schemes

Detection within AVHRR data is fairly well established with generally a high degree of confidence in the pixels determined as clear. However, there is a danger that some HIRS channels may be affected by clouds not seen in AVHRR. All available cloud detection tests should be retained even with an AVHRR-aided cloud clearing scheme.

It is not fully established how the AVHRR data should aid the HIRS cloud clearing. Certainly, the surface brightness temperature obtained can be used in the inversion procedure but utilizing the cloud information is more difficult. The use of parameters such as cloud type and cloud coverage to improve the search of the closest profile in TIGR is under study, and work to utilize AVHRR parameters in the determination of clear column radiances is in progress.

Work has been done to identify cloudy HIRS FOV suitable for N-Star type clearances using various methods. For detecting multi-layer cloud not suitable for N-Star, it has been shown that spatial coherence techniques are more useful than the relationship between channels 3 and 4. Two groups have reported that if decisions are based on AVHRR data then very few suitable N-Star pairs are found. On the contrary, some TOVS-only work has suggested that N-Star errors are not as high as expected from inhomogeneous and multi-layer cloud.

A good validation scheme for cloud filtering techniques that use AVHRR data is needed. The detection of cloud in AVHRR can be validated interactively by eye but the usefulness of such data on the clear HIRS radiance retrieval is not easy to monitor. Comparison of clear radiances to those derived from an NWP analysis is unsatisfactory because the latter are generally in error to a similar degree to the cleared radiances. A suggestion is to simulate clear and cloudy radiances from radiosonde observations and the cloud field and to use this data to test various cloud filtering schemes. Another basic suggestion to evaluate the accuracy of cloud clearing techniques is the intercomparisons of the clear radiances in a future case study.

2. Cloud Products

Cloud products can be divided into two categories; those derived from AVHRR processing which are useful for the clear column HIRS radiance retrieval, and those which result from the TOVS cloud clearing techniques themselves (CO_2 technique, iterative methods, N-Star) or are deduced as a final result of the inversion (3I).

The cloud parameters which are useful in the clear column radiance retrieval are (1) the cloud coverage or effective cloudiness in the FOV spots, (2) the cloud type, (3) the cloud temperature or the cloud height, and (4) the cloud spectral emittance and reflectance.

The cloud cover is generally well-determined by taking advantage of the high resolution of the AVHRR. Cloud type can be quite well identified as well using the multispectral capabilities of this instrument. However, the determination of the cloud top temperature and spectral properties of the cloud can only be made in restricted conditions (non-overlapping clouds, thick clouds, ...). Much progress remains to be made to retrieve these parameters in all conditions. The concerns are shared by the Cloud Algorithm Working Group of ISCCP and it is suggested that we share information and collaborate with this group.

The cloud parameters resulting form the TOVS data processing are (1) the effective top temperature, (2) the effective cloudiness, (3) the cloud height.

From all these cloud products, subproducts may be derived that can more easily be validated; for example, the liquid water content or the cloud thickness.

Until now, satellite cloud products have rarely been accurately validated. Therefore, participation is encouraged in experiments such as FIRE and FIFE which will produce a large number of direct cloud measurements.

3. Recommended Procedures

The required accuracy of the cloud clearing techniques differs between the global retrieval problem (synoptic scale) and the regional retrieval problem (mesoscale). However, in both cases a good evaluation of the performances of the different techniques remains to be performed.

In the case of the global retrieval, the problem of clouds is less acute since the required resolution is poorer and the singular profiles due to poor cloud clearing may be discarded. Nevertheless, important progress has been presented which could benefit the NESDIS operational clear column radiance procedure.

For regional applications, the problem of clouds is more acute. Despite the improvements of some of the techniques, no one procedure emerges and thus none will be recommended. It is therefore suggested that validation tests be added to the various schemes.

- Even if AVHRR data are used in the cloud clearing procedure, conventional tests that HIRS channels are not actually contaminated are recommended.
- If TOVS techniques are used, it is recommended that AVHRR data be used to verify the quality of the cloud clearing (e.g., synthesized channel 8 technique).

- If AVHRR is not available, the absence of thin cirrus or low level homogeneous clouds must be confirmed by adding new tests (e.g., differences between channel 8 and 19 or 18, or thresholds derived from auxilliary data, etc.)

4. Recommendations

Most of the recommendations of the previous ITSC meetings on clear column radiance retrieval can be further endorsed by ITSC-III plus a few recommendations have emerged.

a. Single spot retrieval techniques that fully utilize the available cloud filtering techniques available should be pursued (Action: Watts).

b. Cloud parameters derived from AVHRR should be used in TOVS clear radiance retrievals (Action: Lloyd).

c. Cloud detection and classification techniques using AVHRR could be validated by data sets derived by expert analysis of imagery. Such validation data sets should be available to the scientific community (Action: Rochard).

d. A study of the effect of aerosols on radiances should be undertaken (Action: McMillin).

e. The quantitative intercomparison for the ALPEX case study should be repeated for clear only radiances so that variances of different profile retrieval techniques can be evaluated apart from cloud clearing techniques (Action: LeMarshall).

f. An intercomparison of clear radiances resulting from different schemes should be performed. A case study has to be chosen and the processing method established. This ought to be done in the framework of the previous quantitative intercomparisons (Action: ITSC delegates/ LeMarshall).

g. AVHRR cloud products should be validated. Three methods are proposed:

- participation in appropriate international experiments
- comparison to expert analysis of imagery
- simulation of cloudy radiances

(Action: Phulpin/Eyre).

E. PC Processing Systems (chaired by F. X. Zhou with R. Dedecker, D. Hillger, B. Howell and R. Riosalido contributing)

1. Introduction

Meeting delegates expressed strong interest in the development of low cost systems for processing TOVS data (PC/ITPP). The scope of interest included:

a. Use of PCs associated with direct readout facilities.

b. Downloading data sets to PCs from mainframes where preprocessing, calibration, etc. has been undertaken on the larger systems.

c. Use of PCs in an off-line mode with data sets provided via low cost media (e.g. floppy disk).

d. Role of PC systems in meteorological satellite applications, education and training programs.

2. Status of Developments

Progress on PC-based TOVS processing since the ITSC-II meeting has been considerable. CIMSS and the PRC in the main have been active in pursuing the development of software for a number of the purposes outlined above. Much more remains to be done in order to establish communications between users of PC systems regarding standards for data files, documentation, identification of areas for further effort, etc.

3. Recommendations

Accordingly, the following recommendations were made to expedite the PC-based processing package development.

a. A newsletter for ITSC participants should be published twice a year (Action: Smith).

b. PC/ITPP News & Information should be established on NOAA's Electronic Bulletin Board (Action: Popham).

c. The ITSC should compile brief summaries regarding the current status and plans for PC/ITPP system developments of the various national groups (Action: PC/ITPP users should direct written responses to Dedecker).

d. Sources of funding should be explored to support the standardization, documentation, exchange, and distribution of PC/ITPP software (Action: Smith).

F. Future Instruments (chaired by A.Chedin with D. La Porte, M. Lynch, R. Rizzi, W. Smith, and D. Wark contributing)

1. Introduction

The working group noted that the evolution of satellite sounding systems is approaching a crucial time. The United States is currently defining candidate infrared and microwave sounding experiments for a polar platform and GOES-NEXT. Europe has undertaken design studies of a microwave sounding capability with a companion high spectral resolution infrared sensor for their next generation Meteosat. Japan, India, and Australia have also shown interest in enhancing their current meteorological or communication satellite systems with an advanced remote sounding capability.

The ITSC-III has brought together an international body of experts deeply concerned about the future implementation of recently developed remote sensing technology. The working group stressed the need for international coordination of future developments to insure cost effective system designs through a minimization of redundant national development efforts and to promote the similarity of the sounding systems eventually implemented on national satellites.

The working group discussed the following issues:

a. Identification of national groups and available reports concerned with future instruments.

b. Problems with current instruments which need to be addressed in new instrument designs (e.g. vertical resolution).

c. New requirements to be addressed by operational instruments.

d. International collaboration on new instruments concepts and their evaluation.

e. Changes to the NOAA-K, L, M satellites.

2. Recommendations

a. The advantages of deploying infrared and microwave (millimeter) temperature and humidity sounders on the same platform should be stressed to space agencies, since these provide complementary capabilities superior to either component by itself (Action: Chedin/Rao/Rizzi/Lynch).

b. International cooperation amongst space agencies should be encouraged to provide consolidated use of available resources as required for the implementation of both an advanced infrared and microwave sounding capability on national geostationary satellites (Action: Chedin/Rao/Rizzi/Lynch).

c. Because operational mesoscale meteorological analysis/forecast systems planned for the 1990's and beyond will be severely limited by the vertical resolution of current sounding instruments, space agencies should be encouraged to develop a high vertical resolution sounding capability at a pace which will allow its implementation as close to 1990 as is practically possible (Action: Chedin/Rao/Rizzi/Lynch).

d. Space agencies should be encouraged to implement several lower IR tropospheric sounding channels with 1 km or better resolution imaging radiometers on future satellites which will also carry the AMSU (Action: Eyre/Smith).

e. The high spatial resolution sounder should serve as a replacement to HIRS only after an improved vertical resolution IR sounder provides the other cloud, surface, ozone, and water vapor information currently provided by IR spectral data (Action: Chedin/Rizzi/Smith).

f. A position paper from the ITOVS Working Group on future sounding instruments should be prepared (Action: Chedin/Rizzi/Smith).

g. Changes to the infrared channels on the NOAA K, L. and M polar orbiter satellites would be beneficial. Specifically advised were: (1) Channel 10 should be shifted to 813 cm^{-1}, (2) Channel 12 should be shifted to a more absorbing part of spectrum, (3) Channel 16 should be eliminated, and instead, (4) four channels should be located in the spectral region now covered by channels 13, 14, 15 (Action: Wark).

References:

Chedin, A., D. Pick and R. Rizzi: Definition study and impact analysis of a microwave radiometer on a geostationary spacecraft. European Space Agency, March, 1985.

Chedin, A., D. Pick and R. Rizzi: Definition study of the infrared component of the meteosat infrared and microwave sounder. European Space Agency, November, 1985.

Koffler, R., E. Friday, Jr., F. Zbar and J. Hussey: Envirosat-2000 report, U.S. weather watch: a composite system. National Oceanic and Atmospheric Administration, July, 1985.

Schwalb, A., D. Cotter and W. J. Hussey: Envirosat-2000 report, GOES-Next overview. National Oceanic and Atmospheric Administration, September, 1985.

SBRC: A design feasibility study for the High-resolution Interferometer Sounder (HIS). Santa Barbara Research Center (Contract No. 871R55 5), July 10, 1981.

Smith, W. L., H. E. Revercomb, H. B. Howell, and H. M. Woolf: HIS - A satellite instrument to observe temperature and moisture profiles with high vertical resolution. Proceedings of the Fifth Conference on Atmospheric Radiation, 31 October-4 November, 1983, Baltimore, MD. Published by American Meteorological Society, Boston, Massachusetts.

G. Satellite Sounding Data in NWP (chaired by J. Eyre with Y. Durand, J. Flobert, B. Goodman, D. Johnson, G. Kelly, E. Reimer and R. Juvanon du Vachat contributing)

1. Numerical Weather Prediction (NWP) Models

TOVS and other satellite sounding data are already used widely in a range of operational and experimental NWP models. These range from (a) global and hemispheric models with horizontal resolutions of the order of 100-200 km used principally to provide short-medium range forecasts (1-10 days), to (b) regional models with horizontal resolutions of about 50-100 km for forecasting in the short range (1-3 days), to (c) mesoscale models of 10-50 km resolution for very short range forecasting (< 24 hours). They are run by national meteorological services (mainly the larger centers, but increasingly the smaller ones for limited areas), by international agencies such as ECMWF, and by meteorological research centers and university groups.

These models have developed rapidly over the last decade and will continue to do so over the next in many respects, some of which have important implications for satellite sounding products. Firstly, the continuing rapid progress in computer technology is making possible the development of models of higher resolution both in the vertical and horizontal. The implications for satellite sounding

instruments and their products are discussed below. Secondly, major changes are occurring in the data analysis and assimilation techniques used by these models.

2. Satellite Sounding Data

TOVS data are already made available in several forms for use in NWP: NESDIS global operational products, national (regional) operational products and the output of experimental/research systems. The various forms of products and their means of dissemination are described later. In addition to TOVS, data from VAS on the USA's geostationary satellite (GOES) give coverage over the American continent and adjacent ocean areas. The USA's military weather satellites (DMSP) also carry sounding instruments with potential for contributing to the total sounding system.

In the future, significant advances in instrumentation and subsequent products are foreseen (as discussed in the report of the Working Group on Future Instruments). These include the Advanced TOVS (ATOVS) complement of AMSU plus HIRS, currently planned for NOAA-KLM. This will considerably improve sounding performance in cloudy areas and the horizontal resolution of products. Plans are underway to improve the sounding system on the GOES satellites, and to initiate such systems (including microwave components) on geostationary satellites such as second generation Meteosat. Recent instrument developments, such as interferometers for atmospheric sounding, also offer the hope of significantly improved vertical resolution.

3. Interaction Between Sounding Data and NWP Models

a. Retrieved profiles

Until recently, operational models have only had available to them sounding products from NESDIS. Global products at about 500 km resolution have been distributed on the GTS. NESDIS have recently started to produce soundings at 80 km resolution. These are sent to NMC where they are reduced in resolution to about 250 km. They are used by NMC and are also transmitted to ECMWF and to the UK Met Office. Operational systems providing regional retrieved products for use in NWP are in place in Australia, New Zealand and the UK. Many other countries have similar plans.

b. Radiances and other products

All the above modelling applications currently make use of sounding products in the form of temperature and humidity profiles or products derived from them (thicknesses, precipitable water contents, etc.). However, there is growing interest in the use of radiance data directly in the model assimilation in order to avoid some of the problems introduced by the inversion process. Experiments are in progress or planned in several centers, some involving the assimilation of clear-column radiances and others the original "cloudy" radiances. Such a system is already used operationally in France. These schemes demand that the assimilation algorithms include an accurate forward model which allows the radiances corresponding to the forecast model state to be calculated.

There is also growing interest in the assimilation of information on clouds derived from the sounding data to improve the initial humidity and cloud fields within the model.

c. Model output

Forecast fields are used in several centers to provide a first-guess for the inversion process. This is one approach to obtaining an appropriate linearization point for the inversion. More generally, forecast and analyzed fields can provide useful quality control information and assist the satellite data processing agencies in minimizing the distribution of erroneous products.

4. Problem Areas

a. Error characteristics of satellite sounding products

Satellite sounding products tend to have rather subtle error characteristics which must be properly understood if the data are to be used to best effect in NWP. Most damaging are those errors which are systematic over large areas. Such errors arise for a number of reasons:

(1) Calibration errors lead to biases and continued effort is required to minimize these. Two particular problems at present concern the scan-dependent errors in MSU data and the inter-calibration errors between TOVS and VAS data.

(2) The limb correction process used by many systems leads to errors which are highly correlated in the horizontal, and this leads to the conclusion that, unless limb correction errors can be reduced below 0.1 K, the process is to be avoided if possible in generating products for NWP applications.

(3) Clouds lead to a variety of error problems, particularly with infrared data. Continued efforts are required to minimize and charaterize these errors.

(4) The inversion process itself introduces errors; not only does it propagate radiance errors into the retrieved products, but it also introduces errors which originate in the first guess used in the inversion. Compensation for the latter may be made in the subsequent analysis if the first guess and constraints used in the inversion are known. Alternatively, this problem may be avoided by direct assimilation of radiances.

(5) The forward model is another source of error, usually in the form of a bias equivalent to a calibration error. This problem must be addressed through improved forward models and empirical corrections to them. A particular problem for forward calculations from model fields concerns the appropriate extrapolation of the stratosphere above the uppermost model level.

Insufficient attention has been given in the past to the characterization of these various sources of error and to their effects in NWP. We note particularly that it is highly desirable that the problems discussed above be taken into account when designing the data processing systems to be used with AMSU data.

b. Quality control

In general, it is less harmful to provide models with no data rather than data containing gross errors or errors with characteristics which are unsuited to the analysis techniques used on them. For this reason, improved monitoring of the quality and characteristics of satellite sounding products is encouraged by agencies both disseminating and using the data. Improved communication is also required in order that data problems are identified, notified and rectified as soon as possible.

c. Timeliness

For short-range forecasts to be useful, they must be made with as little delay after the measurements as is practicable. Continued efforts are required to streamline the systems used for acquiring the data from the satellite and for disseminating the products.

d. Asynoptic data

Initial efforts to utilize satellite products required them to be analyzed by schemes designed to handle data acquired only at main synoptic hours. Satellite sounding products are intrinsically asynoptic and some of the current developments in analysis techniques represent a response to the problem of how to use usch data most effectively. We note that, in the past, decisions on the local times for the satellite orbits have been influenced by the desire to have "synoptic" data in critical areas. Such concepts are rapidly becoming outdated, and a review of the optimal orbital pattern to suit data assimilation methods of the 1990s would be useful.

e. Resolution

With continuing rapid growth of computer power, the horizontal resolution of present and planned models in major forecast centers is higher than was anticipated a few years ago. There has not been comparable improvement in the horizontal resolution of planned operational instruments, and this may become a limiting aspect for the forecasting systems of the future. Moreover, the vertical resolution of sounders is controlled by the width of the weighting functions and is lower than that desired for current modelling applicatons. No amelioration of this problem is foreseen in the near future, but in the longer term, instruments of higher spectral resolution providing products of higher vertical resolution offer the best approach to this problem.

f. Assimilation of humidity products

We note the problem inherent in infrared systems of producing humidity profiles biased towards clear air regions. A more sophisticated treatment of cloud products together with sounding products is required to alleviate this problem. Also, with AMSU and HIRS it should be possible to separate to some extent the characteristic profiles of clear and cloudy areas.

g. Incorporation of wind fields

We note that the advantage of high resolution temperature analyzes can be partly lost if the model's initial wind field does not represent these scales. We encourage developments in satellite wind derivation which lead to more observations (including "water vapor" winds) at higher resolution.

5. Case Studies

The Group noted that the case studies undertaken so far by ITSC have been useful as diagnostic exercises for assessing the performance of a retrieval scheme and for comparing it with other schemes. However, they have not been particularly useful for assessing the impact of TOVS data on forecasts; the ALPEX case study was in a data-dense area where little impact can usually be expected, and the Tasman Sea case study was in a data-deficient area where verification of forecast impact is a problem. A more productive study might entail the processing of several passes of data over the Atlantic to study the effect on subsequent forecasts over Europe.

It was also noted that there was growing interest in the potential of TOVS data in the tropics. A tropical case study would be worthwhile and some period within the Australian Monsoon Experiment was identified as a candidate. Careful thought would need to be given to the objective and design of such a study; large scale aspects would be of most interest in NWP studies, whereas a limited area study focussing on smaller scales wold be better suited to retrieval scheme validation or studies of tropical weather phenomena.

6. Recommendations

a. It was noted that there are current developments in several centers to improve the assimilation of satellite soundings into NWP models by treating the data according to their true characteristics rather than as "poor-quality radiosondes." However, more work is required to improve assimilation techniques for these data. ITSC should remain informed on developments in this area (Action: Durand, Kelly, Eyre).

b. The development of new sounding instruments with higher vertical resolution is of primary importance for future NWP applications. This should be emphasized to the space agencies (Action: Chedin/Rizzi/Rao/Smith/Lynch).

c. NESDIS should explore with major forecasting centers improved methods for acquiring, communicating and acting on quality control information (Action: Reale/Kelly).

d. It is recognized that the present GTS is not considered an adequate means of distributing satellite sounding data for NWP requirements. Therefore, it is recommended that WMO adopt the data compression system currently under consideration (Action: Giraytys).

e. NESDIS should consider the dissemination of global high resolution (3x3 HIRS field-of-view) TOVS retrievals and clear column radiance where data communication systems permit (Action: Reale).

f. NESDIS (and other agencies disseminating retrievals) should add indicators to retrieval messages from which the first guess profile used in the inversion can be inferred (Action: Reale).

g. Wider dissemination of VAS products should be considered (Action: Menzel).

h. It was noted that (often unnecessary) errors introduced into sounding data through pre-processing are particularly damanging for NWP applications. In particular, it is recommended to NESDIS that for future processing systems the errors introduced by any limb correction procedures should not exceed 0.1K in any channel (Action: McMillin).

i. It is proposed that the optimal orbital configuration for the polar orbiting satellite system be reassessed in light of recent and continuing developments with NWP analysis schemes to make better use of asynoptic data (Action: Rao).

j. It is proposed that the ITSC promote (1) another mid-latitude case study (using data from a future date to be determined) designed specifically to assess the impact of TOVS data on forecasts (Action: Kelly) and (2) a tropical case study, possibly associated with the Australian Monsoon Experiment (Action: LeMarshall).

H. Climate Applications (chaired by J. Bates with D. Reuter and D. Wylie contributing)

1. Introduction

Historically, the TOVS data has been under utilized for climate applications. While much of the neglect may be explained by the poor interface between the remote sensing and climate research communities, there are specific areas where improvements in the data base and its products would enhance utilization. These areas include error uncertainties, calibration and first guess dependence of products. A demonstration of data integrity via an audit trail would be a beneficial action.

2. Recommendations

a. A data processing audit trail should be initiated. It should feature (1) an expanded data header record, (2) an itemized list of options (i.e., cloud clearing, initial guess) using the NESDIS list as prototype, (3) the NESDIS electronic bulletin for updates (Action: Bates/Reuter).

b. A literature search should be conducted to identify applications and constraints of TOVS data for climate problems (Action: Bates/Wylie/Lynch).

c. Individual organizations should be urged to continue cross calibration of different instruments (satellite and non-satellite) including: cross calibration during different satellite overlaps, periodic aircraft underflights with standard instrumentation, and sonde launches during satellite overpasses (Action: Rochard/Kelly/Reale).

I. Baseline Upper Air Network (B/UAN) (chaired by J. Giraytys with T. Boehm, J. LeMarshall, K. Rao and F. Zbar contributing)

1. Background

The First International TOVS Study Conference (ITSC-I), 29 August - 2 September 1983, recommended the establishment of an independent baseline sounding capability from radiosondes (recommendation 10, page 6, Final Report). ITSC-II (18 - 22 February 1985) gave strong support to the concept of a baseline upper air network (conclusion 5, page 3, Final Report). The WMO Executive Council XXXVII (1985) invited the President of CBS in consultation with the Secretary-General to complete the definition of a baseline network (Paras 3.1.32 - 3.1.35, General Summary, EC-XXXVII).

A preliminary study on the definition of the Baseline Upper Air Network (B/UAN) was prepared by J. Le Marshall (Australia) on secondment to the WMO Secretariat in August 1985. The study notes that there are two principal reasons for establishing a B/UAN: (1) to provide high quality, intercalibrated, and at times contemporaneous, set of radiosonde and rawinsonde sounding data for verifying and optimizing the quality and utility of satellite temperature and moisture vertical sounding data, and (2) to provide a standard which would be the basis for obtaining uniformly high quality data throughout the global upper-air sounding programme.

The Extraordinary Session of the Commission for Basic Systems held in 1985 (CBS/Ext(85)) agreed that there should be an evaluation effort prior to full-scale implementation of the baseline upper-air network. The USA agreed to formulate the plan for such an evaluation and to carry out studies. The plan has been drafted and is being reviewed prior to requesting the WMO to enlist the support of members. The plan envisions a six month evaluation which would be conducted during 1987.

2. Need for the B/UAN

The ITSC-III gave special attention to the need for an orderly development in the operational use of satellite data. While satellite sounding data are used routinely in the operational analyses at all major processing centers, there important questions remain to be answered on its quality and stability, and on the interrelationships between satellite and other data. Further, the ability to process sounding data nationally has grown dramatically over the past few years, in part due to the availability and use of the ITPP. Some 10 to 12 countries currently have "on line" capability to produce soundings. Finally, ITSC-III noted the changes in satellite instrumentation and data processing which are expected over the coming decade. It is imperative, therefore, that careful attention be given to (1) determining the relationship between satellite retrievals and other data and (2) providing a mechanism for monitoring these relationships as changes are made in both the surface and space-based subsystems.

The ITSC-III agreed that the B/UAN was essential and that an evaluation of the concept was valuable. The evaluation plan should be (1) both technically feasible and oriented toward specific objectives, and (2) practical for countries to carry out. While the plan is being proposed by the US for the Commission for Basic Systems, the ICTS-III felt it would be useful, given the

unique expertise of the ITSC participants, for it to generate recommendations for consideration.

3. Recommendations to WMO Concerning the Evaluation of the B/UAN

The ITSC-III was informed that the draft B/UAN evaluation plan was not yet ready for circulation to appropriate people and organizations. The ITSC-III realized that many of the following recommendations likely have been incorporated into the planning. It wished, however, to make the following general statements based on its current understanding of the overall guidelines for the evaluation because ITSC-IV likely would not be held before the B/UAN evaluation started.

a. An ad hoc group of ITSC be asked to make a technical review of the plan for the B/UAN and provide comments and suggestions to the WMO Secretariat with a copy to F. Zbar. (Action: LeMarshall/Kelly/Chedin/Eyre). A copy of the plan should be sent to these people when the plan is received by the WMO Secretariat (Action: Giraytys).

b. The B/UAN, at least during the evaluation phase, should include lidar and rocketsonde observations and ozone measurements to obtain stratospheric data. These should be collocated with radiosonde soundings if at all possible. It may be necessary to establish special periods when maximum effort will be made to obtain coincident soundings from radiosondes, lidar, rocketsondes and satellites (Action: Giraytys).

c. During the evaluation phase of the B/UAN, it is essential that a balanced data set be obtained. Careful attention should be given to geographical (e.g. land and ocean) coverage and climatic variability, including polar climates (Action: Giraytys/Zbar).

d. Radiosonde soundings coincident with satellite overpasses are not required on a continuous basis for the regular operation of a B/UAN. However, it is important to have a sufficient sample of coincident soundings so that the influence of such factors as the local time-of-day, geography, climate and season can be analyzed (Action: Giraytys/Zbar).

e. During the proposed six month evaluation period the number of coincident soundings should be higher than for routine operation. The percentage should be on the order of 60-70% of all soundings for each participating station during the evaluation (Action: Giraytys/Zbar).

f. The evaluation phase should be conducted for one year rather than the six months proposed to obtain a full cycle of seasons at each station (Action: Giraytys).

g. As part of the B/UAN evaluations, WMO members should be asked to (1) investigate the B/UAN with respect to both physical and statistical retrieval techniques; (2) investigate the impact of moisture and temperature variations on tuning retrievals, and (3) take appropriate steps to reduce this impact (Action: Giraytys).

h. During the evaluations, it is essential that participating groups be advised routinely of the performance of their systems. It will be important that one (or two) centres be asked to provide special reports on

data quality, reception (etc.) from the surface-based systems. Similarly, one (or two) centres (not necessarily the same as above) should be asked to provide status reports on the performance of the sounders (Action: Giraytys/Kelly/Zbar).

i. Careful attention should be given to close coordination between the evaluation of the B/UAN and the OWSE-NA. Much of the results of the B/UAN likely will be directly applicable to the OWSE-NA. Conversely, the OWSE-NA will be implementing ocean systems (e.g. ASAP and drifting buoys) which can provide essential data for the B/UAN evaluations (Action: Giraytys).

j. As a part of reviewing the results of the B/UAN evaluation, the ITSC-III recommended that special attention be given to the utility of the B/UAN in the evaluation of new satellite instruments (Action: Giraytys).

k. A special B/UAN data archive should be established to operate in real-time so that vital information (such as first-guess analysis fields) are not lost. It likely will be necessary to generate a standard data set for use of the planners for the B/UAN (Action: Giraytys/LeMarshall/Kelly/Eyre).

4. Recommendations Relating to Intra-Network Calibration and Accuracy

The ITSC recommended strongly that intra-network calibrations (i.e. between radiosondes, satellites, lidars and rocketsondes) be conducted for the B/UAN on a regular basis. It is especially important to set up standard procedures for such calibration during the evaluation of the B/UAN. Recommendations were:

a. Primary emphasis be given to stations using sondes compared during the CIMO intercomparisons (Action: Giraytys/Zbar).

b. For any of the systems (radiosondes, lidars, and rocketsondes) used in the B/UAN, a written description of the entire sounding process, including data processing, should be provided (Action: Giraytys).

c. A set of standard adjustments to both satellite and surface-based data should be prepared for use as guidance to those people making satellite retrievals and preparing evaluations of the B/UAN. Such adjustments might include long and short wave radiation effects, factors derived from the CIMO intercomparisons, and factors based on calibration of, or experience with, various satellite data channels. Such adjustments would not be applied by the data producers, but would be available for use by data processors (Action: LeMarshall/Kelly/McMillin).

d. As part of the B/UAN evaluations, a study should be undertaken to separate sonde and satellite errors. The previous three recommendations are essential as a basis for such a study (Action: LeMarshall/McMillin).

5. Recommendations to ITSC Participants

The ITSC-III recognized that the formal evaluation of the B/UAN is to be carried out through the WMO (i.e. by the Commission for Basic Systems) and by WMO Members.

ITSC, however, does bring together people with unique expertise for satellite soundings, who should be considered a valuable resource for the B/UAN evaluations. Table 2 shows the possible relationship for the evaluations. In preparation for making effective use of this expertise, the ITSC-III made the following recommendations for the participants in anticipation of the formal request to Members from the WMO Secretariat:

a. The participants should make certain that appropriate distribution is made of the ITSC-III considerations in their national organizations, including the expected B/UAN timetable (six months, during 1987) (Action: ITSC delegates).

b. Based on the ITSC-III recommendations, ITSC should assist in the identification of potential stations, data processing schemes, etc (Action: ITSC delegates).

c. ITSC should consider what ancillary data is required and/or could be added by their service/organization (e.g., ozone, cloud information, surface moisture, etc.) (Action: ITSC delegates).

d. ITSC should consider how individual countries could take advantage of the B/UAN data set in conducting national case studies. This might be coordinated closely with the OWSE-NA, as appropriate (Action: ITSC delegates).

e. ITSC should consider what part of the overall set of responsibilities might be assumed by their country/organization:

- providing surface based-soundings
- providing retrievals
- preparing archived data sets
- preparing standard adjustment tables
- providing ancillary data sets
- preparing national evaluations including those associated with the OWSE-NA
- preparation of routine performance reports on system operation (surface-based and/or satellite)
- conducting special coincident soundings and their evaluation (e.g. with lidars)
- investigations into the impact of moisture and temperature variations on tuning the retrievals
- investigations into the differing impacts (if any) of the B/UAN data on physical as opposed to statistical retrievals
- investigations into the use of the B/UAN for evaluating new satellite instruments
- preparation of descriptive material on data processing techniques (Action: ITSC delegates).

	Planning	Operations	Report
CBS Evaluation	• US prepares plan • WMO asked to recruit Members to participate	• US provide coordination and appropriate notification on network activities • An organization and/or Member(s) provide performance information to participating stations • Same for establishing and maintaning a B/UAN archive	• US will provide report for consideration of CBS • CBS prepare recommendations on need for B/UAN
MEMBERS	• Members consider the appropriate level of support which can be provided • Members consider what additional national efforts are useful, e.g. case studies in coordination with the OWSE-NA	• Members carry out national studies • Members provide support to operations as they agreed	• National reports issued
ITSC	• Provides expert recommendations on technical considertions	• Individuals carry out studies using B/UAN data base	• Scientific and technical reports issued

Table 2: Possible Relationships of Potential Participants

APPENDIX A. Agenda for the Third International TOVS Study Conference
Madison, Wisconsin
13 - 19 August 1986

Wednesday, August 13 (at Wisconsin Center, Room 313)

7:45 - 8:30 a.m.	Registration	
8:30 - 9:00 a.m.	Welcome and Opening Remarks (Smith)	
9:00 - 9:30 a.m.	NASA Perspective of Future Satellite Programs (Curran)	
9:30 - 10:00 a.m.	NOAA Plans for the 90's (Rao)	
10:00 - 10:30 a.m.	WMO and Satellites (Giraytys)	
10:30 - 10:50 a.m.	Coffee Break	
10:50 - 11:00 a.m.	Agenda Approval (Menzel)	
11:00 - 12:20 p.m.	Presentation of Participants (chaired by Menzel)	
11:00 a.m.	AUSTRALIA	LeMarshall
11:20 a.m.		Prata
11:40 a.m.		Lynch
12:00 noon	BANGLADESH	Achtor
12:20 - 1:30 p.m.	Lunch	
1:30 - 3:10 p.m.	Presentation of Participants (chaired by Rizzi)	
1:30 p.m.	BRAZIL	Ferreira
1:50 p.m.	CANADA	Steenbergen
2:10 p.m.	CHINA (PRC)	Zhou
2:30 p.m.		Ma
2:50 p.m.	CHINA (ROC)	Yen
3:10 - 3:30 p.m.	Coffee Break	
3:30 - 4:50 p.m.	Presentation of Participants (chaired by Rizzi)	
3:30 p.m.		Huang
3:50 p.m.	FRANCE	Durand
4:10 p.m.		Phulpin
4:30 p.m.		Chedin
5:00 - 7:00 p.m.	Wine and Cheese Gathering (poster presentations by ITT and SBRC)	

Thursday, August 14 (at Wisconsin Center, Room 313)

8:30 - 10:30 a.m.	Presentation of Participants (chaired by Chedin)	
8:30 a.m.	FRG	Reimer
8:50 a.m.	ITALY	Rizzi
9:10 a.m.	NEW ZEALAND	Uddstrom
9:30 a.m.	NORWAY	Sunde
9:50 a.m.	PORTUGAL	Arriaga
10:10 a.m.	SPAIN	Riosalido
10:30 - 10:50 a.m.	Coffee Break	
10:50 - 12:30 p.m.	Presentation of Participants (chaired by Chedin)	
10:50 a.m.	SWEDEN	Svensson
11:10 a.m.	UK	Eyre
11:30 a.m.		Watts
11:50 a.m.		Lloyd
12:10 p.m.	USA	Herman
12:30 - 1:40 p.m.	Lunch	
1:40 - 3:00 p.m.	Presentation of Participants (chaired by Eyre)	
1:40 p.m.	USA	Menzel
2:00 p.m.		McMillin
2:20 p.m.		Reuter
2:40 p.m.		Hillger
3:00 - 3:20 p.m.	Coffee Break	
3:20 - 4:00 p.m.	Presentation of Participants (chaired by Eyre)	
3:20 p.m.	USA	Bates
3:40 p.m.		Garand
4:00 - 5:20 p.m.	Presentation of Supporting Organizations (chaired by Eyre)	
4:00 p.m.	NOAA TOVS Support	Popham
4:20 p.m.	NOAA AMSU Plans	Sparkman
4:40 p.m.	ECMWF Activities	Kelly
5:00 p.m.	USAID	Maurer
7:00 - 10:00 p.m.	Banquet	

Friday, August 15 (at Wisconsin Center, Room 313)

8:30 - 10:30 a.m.	Status Reports (chaired by LeMarshall)	
8:30 a.m.	Calibration	Rochard
8:50 a.m.	Earth Location	Nagle
9:00 a.m.	Data Intercomparisons Revisited	LeMarshall
9:20 a.m.	Expanded Tape Format	LeMarshall
9:30 a.m.	New Case Study	Rizzi
9:50 a.m.	ISCCP	Wylie
10:10 a.m.	ITRA	Chedin
10:30 - 11:00 a.m.	Group Photo & Coffee Break	
11:00 - 12:20 p.m.	Status Reports (chaired by LeMarshall)	
11:00 a.m.	TIGR Compression	Chedin
11:20 a.m.	Empirical adjustments to transmission	McMillin
11:40 a.m.	ITPP	Woolf
12:00 noon	B/UA network	Zbar
12:20 - 2:00 p.m.	Lunch	
2:00 - 3:00 p.m.	Status Reports (chaired by Lynch)	
2:00 p.m.	WWW and WCRP	Giraytys
2:20 p.m.	TOVS data dissemination	
2:40 p.m.	PC Demonstrations	Zhou/Dedecker
3:00 - 3:20 p.m.	Coffee Break	
3:20 - 4:30 p.m.	General Discussion and Working Group Formation (chaired by Lynch)	

Saturday, August 16

Sailing
Farmer's Market
Arboretum Tour
Bicycle Ride
Working Group Meetings

Sunday, August 17

Working Group Meetings
2:00 - 6:00 p.m. Picnic

Monday, August 18 (at SSEC, Room 811)

8:30 - 12:00 noon	Working Group Meetings McIDAS Demonstrations
12:00 - 1:30 p.m.	Lunch
1:30 - 3:30 p.m.	Reports of the Working Groups (chaired by Hayden)
3:30 - 4:00 p.m.	Coffee Break
4:00 - 5:30 p.m.	Drafting Executive Summary and Recommendations McIDAS Demonstrations

Tuesday, August 19 (at SSEC, Room 811)

8:30 - 12:00 noon	Discussion of Executive Summary and Recommendations (chaired by Giraytys)
12:00 - 12:30 p.m.	Discussion of Future Plans and Adjournment (chaired by Menzel)

APPENDIX B. LIST OF ACRONYMS

ALPEX	-	Alpine Experiment
AMSU	-	Advanced Microwave Sounding Unit
	-	Austrian Solar Energy and Space Agency
ASAP	-	Automated Shipboard Aeronautical Program
AVHRR	-	Advanced Very High Resolution Radiometer
B/UAN	-	Baseline Upper Air Network
CBS	-	Commission for Basic Systems (WMO)
CDB	-	Coefficient Data Base
CIMO	-	Commission for Instruments and Methods of Observation (WMO)
CIMSS	-	Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison, Wisconsin, USA
CIRA	-	Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, Colorado, USA
CIRRUS	-	Cirrus Intensive Field Operation of FIRE
CMS	-	Centre de Meteorologie Spatiale, Lannion, Cedex, France
DCS	-	Data Collection System
DFVLR	-	Deutsche Forschungs -und Versuchanstalt fur Luft -und Raumfahrt, Oberpfaffenhofen, Germany
DSB	-	Direct Sounder Broadcast
EBB	-	Electronic Bulletin Board
ECMWF	-	European Centre for Medium range Weather Forecasting Bracknell, Berkshire, UK
FIFE	-	First ISLSCP Field Experiment
FIRE	-	First ISCCP Regional Experiment
FOV	-	Field of view
GARP	-	Global Atmospheric Research Program
GLAS	-	Goddard Laboratory for Atmospheric Science, NASA, Greenbelt, Maryland, USA
GOS	-	Global Observing System
GTS	-	Global Telecommunications System
HIRS	-	High resolution Infrared Spectrometer
HIS	-	High resolution Interferometer Sounder
HRPT	-	High Resolution Picture Transmission
IAMAP	-	International Association of Meteorology and Atmospheric Physics
ICSU	-	International Council of Scientific Unions
3I	-	Improved Initialization Inversion
IRC	-	International Radiation Commission
ISCCP	-	International Satellite Cloud Climatology Project
ISLSCP	-	International Satellite Land Surface Climatology Project
ITSC	-	International TOVS Study Conference
ITRA	-	International Transmittance Working Group (IRC)
ITPP	-	International TOVS Processing Package
JSC	-	Joint Scientific Committee
LBL	-	Line-by-line
LFM	-	Limited Finemesh Model
LMD	-	Laboratoire de Meteorologie Dynamique
MSU	-	Microwave Sounding Unit
McIDAS	-	Man-computer Interactive Data Analysis System

NESDIS	-	National Environmental Satellite, Data, and Information Service
NMC	-	National Meteorological Center
NOAA	-	National Oceanic and Atmospheric Administration, U.S. Department of Commerce
NWP	-	National Weather Prediction
OWSE-NA	-	Operational World Weather Watch Systems Evaluation-North Atlantic
PC	-	Personal Computer
PC/ITPP	-	Personal Computer/International TOVS Processing Package
RAOB	-	Radiosonde Observation
RMS	-	Root Mean Square
RTE	-	Radiative Transfer Equation
SCAMS	-	Scanning Microwave Spectrometer
SCC	-	Satellite Calibration Centre (Lannion)
SMHI	-	Swedish Meteorological and Hydrological Institute
SSEC	-	Space Science and Engineering Center, University of Wisconsin-Madison, Wisconsin, USA
SSU	-	Stratospheric Sounding Unit
TIGR	-	TOVS Initial Guess Retrieval
TIP	-	TIROS Information Processor
TOMS	-	Total Ozone Mapping Spectrometer
TOVS	-	TIROS Operational Vertical Sounder
TSF	-	Typical Shape Functions
VHF	-	Very High Frequency
WCRP	-	World Climate Research Program
WEFAX	-	Weather Facsimile
WGRS	-	Working Group on Remote Sensing
WMO	-	World Meteorological Organization
WWW	-	World Weather Watch

APPENDIX C.

To all HRPT stations: August 19, 1986

At the last meeting of the International TOVS Study Conference (ITSC), August 13-19, 1986 in Madison, Wisconsin a working group was set up to examine problems associated with sensor calibration, satellite navigation and dissemination of information for the TOVS and AVHRR instruments. The working group noted that there were a number of problems which were reported at this and previous ITSC meetings which would be of interest to HRPT station operators and their users. Accordingly, this letter was drafted by ITSC Working Group on Sensor Calibration, Satellite Navigation and Information Dissemination.

In an effort to maximize the efficiency of disseminating information and coordinating users' problems and queries, the following recommendations were made:

(1) The Satellite Calibration Centre (SCC) at Lannion, France will gather all information regarding calibration and navigation from NESDIS and other sources as appropriate. All questions concerning sensor calibration and satellite navigation should be sent to Guy Rochard at Lannion and responses will be prepared in collaboration with NESDIS.

(2) Use of the Electronic Bulletin Board (EBB) is highly recommended. Information concerning use of the EBB is available now from Bob Popham at NOAA/NESDIS.

(3) A list of the known HRPT stations (as of August 1986) is attached. It is recommended that one station be nominated per country as a clearing house for problems and initial contact point. Questions should be sent in the first instance to the nominated HRPT station operator and then these questions should be put on the EBB and addressed to Guy Rochard with a copy to Bob Popham. In this way it is hoped to simplify exchange of information and avoid duplication. HRPT operators are requested to inform Guy Rochard of the contact point and supply names and addresses of HRPT stations not contained on the list. Those users who are awaiting EBB implementation should use the postal service in a similar fashion.

(4) It was recognized by the working group that a single tape format for TOVS and AVHRR data, although desirable, would probably be impractical. The working group has, however, decided to recommend use of an existing format (e.g. Bunrel et al., 1986, available on request from Lannion), particularly by new users to avoid increasing the total number of different tape formats used.

Users who have details of their tape formats should send these to Guy Rochard. The question of tape formats will be discussed at the International AVHRR Workshop in Melbourne (27-29 October 1986).

(5) For the purpose of validating calibration, two tapes will be available from the SCC on request. The first tape will contain one orbit of raw HRPT data and the second (or master) will contain calibrated and navigated data. The user should process the raw data and compare results with those on the master tape. Problems should be reported to the SCC or at future ITSC/AVHRR meetings.

The mechanisms for information exchange as described above will operate for a trial period of 18 months and will be reviewed at the next International TOVS Study Conference. Your cooperation in this will result in a more efficient and accessible information exchange. The executive summary of ITSC-III is appended to this letter for your information.

Sincerely,

Mr. R. Popham,
NOAA/NESDIS

Important addresses:

Dr. Guy Rochard
Satellite Calibration Centre
Centre de Météorologie Spatiale
B.P. 147, 22302 Lannion Cédex
France

Tel: 96 48 4433
Telex: 950256

Mr. Bob Popham
NOAA/NESDIS
FB-4, Room 3301
Washington, D.C. 20233
USA

Tel: 301-763-7289
Telex: 248376

References:

1. Brunel, P., M.Derrien and J. Quere: Format description of the AVHRR-TOVS magnetic tapes produced by the SATMOS Service, CMS, B.P. 147, 22302 Lannion Cedex, France, June 1986.

2. Status report and working group recommendations, Report on the Third International TOVS Study Conference, Madison, Wisconsin, 13-19 August 1986. Edited by W. P. Menzel and M. J. Lynch.

List of HRPT Users

	Country	Location
A.	Active	
		Antarctica (2)
		Canary Islands
		Greenland
		Hong Kong
	Australia	Melbourne
		Perth
	Bangladesh	Dhaka
	Brazil	Sao Paolo
	Belgium	Brussels
	Canada	Toronto
		Ottawa
		Prince Albert
		Vancouver
	Czechoslovakia	Prague
	Denmark	Copenhagen
		Birkeroed
	France	Lannion
	FRG	Offenbach
		Berlin
	India	New Delhi
		Secunderabad
	Indonesia	Djakarta
	Iran	Karadi
	Iraq	?
	Israel	Tel Aviv
	Italy	Ravenna
	Japan	Tokyo (4)
		Ibariki
	Korea	Seoul
	Malaysia	Jalan
	Mongolia	Ulan Bator
	Netherlands	De Biet
		Doetinchem
	New Zealand	Wellington
	Norway	Tromso
		Oslo (2)
	Poland	Krakow
	Portugal	Lisbon
	PRC	Beijing
	Saudi Arabia	Jeddah
		Dahran
	Singapore	Singapore
	South Africa	Pretoria
	Sweden	Norrkoping
		Bergen
	Switzerland	Lucarno-Mont
		Bern
	ROC	Taipei
	Thailand	Bangkok
	Tunesia	Tunis

UK	Dundee
	Lasham
	Crowborough
USA	Suitland, MD
	Wallops, VA
	Madison, WI
	Fairbanks, AK
	Redwood City, CA
	Greenbelt, MD
	Sioux Falls, SD
USSR	Moscow
Yemen	?

B. Planned

Chile	Santiago
Hungary	Budapest
Mexico	Mexico City
Spain	Madrid

APPENDIX D. Attendees of the International TOVS Study Conferences (or recipients of the International TOVS Processing Packages where I indicates IBM and V indicates VAX)

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Thomas Achtor Cooperative Institute for Meteorological Satellite Studies 1225 West Dayton Street Madison, Wisconsin 53706 USA			X	
Dr. Tadao Aoki Meteorological Research Institute Nagamine, Yatabe Ibaraki 305 JAPAN	X	X		I,V
Mr. Arlindo Arriaga Instituto Nacional de Meteorologia E Geofisica Rua C do Aeroporto 1700 Lisboa PORTUGAL (presently seconded to CIMSS)			X	
Dr. Les A. Baranski Satellite Data Receiving Centre, Institute of Meteorology and Water Management Piotra Borowego Str. 14 PL-30-215 Krakow POLAND	X	X		V
Dr. John J. Bates Scripps Institution of Oceanography Mail Code A-021 La Jolla, California 92093 USA			X	V
Dr. H. Billing Freie Universitat Berlin Institut fur Meteorologie Fachbereich 24, WE07 Podbielskiallee 62 D-1000 Berlin 33 FEDERAL REPUBLIC OF GERMANY	X	X		V
Dr. Daniel Birkenheuer NOAA/ERL/PROFS R/E23 325 Broadway Boulder, Colorado 80303 USA			X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Dip.-Met. Thomas Boehm Deutscher Wetterdienst - Zentralamt Frankfurter Str. 135 D-6050 Offenbach a.M. FEDERAL REPUBLIC OF GERMANY		X	X	V
Dr. H. J. Bolle Institut fur Meteorologie WE 07 im FB Geowiss Freie Universitat Berlin Dietrich-Schafer-Weg 6-8 D-1000 Berlin 41 FEDERAL REPUBLIC OF GERMANY	X	X		
Dr. Giovanni Cannizzaro Remote Sensing Applications Telespazio S.P.A. per le Comunicazioni Spaziali Via A. Bergamini, 50 00159 Roma ITALY		X		V
Dr. M. T. Chahine Jet Propulsion Laboratory California Inst. of Technology 4800 Oak Drive Pasadena, CA 91109 USA	X			
Dr. A. Chedin Laboratoire de Meteorologie Dynamique Ecole Polytechnique Route Departementale 36 F-91128 Palaiseau Cedex FRANCE	X	X	X	
Dr. Robert J. Curran Mail Code EET National Aeronautics and Space Administration 600 Indepenedence Ave., S.W. Washington, D.C. 20546 USA			X	
Mr. Ralph Dedecker Space Science and Engineering Center 1225 West Dayton Street, Room 405 Madison, Wisconsin 53706 USA			X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Eduardo Diaz NASA Station Director U.S. Embassy APO, Miami, FL 34033 USA CHILE				I
Dr. Yves Durand SCEM/PREVI/DEV 2 avenue Rapp 75007 Paris FRANCE	X		X	
Dr. John R. Eyre Meteorological Office Unit Hooke Institute for Atmospheric Research Clarendon Laboratory Oxford OX13PU UNITED KINGDOM	X	X	X	V
Dr. Brian Farrelly Geophysical Institute Department of Oceanography University of Bergen Allegt. 70, 5000 Bergen NORWAY				V
Ms. Marlene-Elias Ferreira Departmento de Meteorologia Instituto de Pesquisas Espaciais (INPE) Caixa Postal #515 12200 São José Dos Campos-SP BRAZIL			X	I,V
Dr. Herbert Fischer Meteorologisches Institut der Universitat Munchen Theresienstrasse 37 D-8000 Munchen 2 FEDERAL REPUBLIC OF GERMANY	X			
Mr. James C. Fischer NOAA/NESDIS Office of Systems Development E/SPD1 712 World Weather Building Washington, D.C. 20233 USA		X		

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. J. F. Flobert Laboratoire de Meteorologie Dynamique Ecole Polytechnique Route Departementale 36 F-91128 Palaiseau Cedex FRANCE			X	
Mr. Louis Garand Recherche en Prevision Numerique 2121 North Serrile Road Nous-Canada Highway Dorral, P. Quebec H9P1J3 CANADA			X	
Mr. James Giraytys World Weather Watch Department World Meteorological Organization 41 Guiseppe-Motta Case Postale No. 5 CH-1211 Geneve 20 SWITZERLAND	X		X	
Mr. Brian Greaves Atmospheric Environment Service - ARMA 4905 Dufferin Street Downsview, Ontario M3H 5T4 CANADA			X	
Mr. Svein Haga Norwegian Meteorological Institute P.B. 320 Blindern Oslo 3 NORWAY		X		
Dr. Christopher Hayden Chief, NOAA/NESDIS Systems Design and Applications Branch Code E/RA2 1225 W. Dayton Street Madison, Wisconsin 53706 USA		X	X	
Dr. Donald W. Hillger Cooperative Inst. for Research in the Atmosphere (CIRA) Colorado State University Fort Collins, Colorado 80523-0033 USA			X	V

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Raihan Hoque Space Research and Remote Sensing Organization (SPARSO) Agargaon, Sher-E-Banglanagar Dhaka, GPO Box 529 Bangladesh				V
Dr. Michael Kalb Code ED-43 Environmental Applications Branch NASA/Marshall Space Flight Center Hunstville, Alabama 35812 USA				I
Mr. Graeme A. Kelly European Centre for Medium Range Weather Forecasts Shinfield Park Reading, Berkshire RG2 9AX, UNITED KINGDOM	X	X	X	I
Mr. P. N. Khanna Satellite Meteorology Indian Meteorology Department Mausam Bhavan, Lodi Road New Delhi 110003 INDIA				V
Dr. Patrick King (ARMA) Atmospheric Environment Serv. Department of Environment 4905 Dufferin Street Downsview, Ontario M3H 5T4 CANADA	X			
Mr. Thomas J. Kleespies AFGL/LYS Hancom AFB Massachusetts 01731 USA	X	X	X	V

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Habib Taghizadeh Koriem Iranian Meteorological Organization P.O. Box 13185-461 Tehran-Mehrabad IRAN		X		
Dr. Woon Shih Lai Meteorological Service Singapore P.O. Box 8 Singapore Changi Airport Singapore 9181 REPUBLIC OF SINGAPORE				I
Mr. Dan LaPorte Santa Barbara Research Center 75 Caromar Drive Goleta, California 93017 USA (presently seconded to CIMSS)			X	
Mr. Ken Leap NOAA/ERL/PROFS R/E23 325 Broadway Boulder, Colorado 80303 USA			X	
Dr. John F. LeMarshall National Meteorological Analysis Centre Bureau of Meteorology P.O. Box 1289K Melbourne, Victoria 3001 AUSTRALIA	X	X	X	I
Professor J. Lenoble Universite des Sciences et Techniques de Lille Laboratoire d'Optique Atmospherique 59655 Villeneuve d'Ascq Cedex FRANCE		X		
Gin-Rong Liu Center for Space and Remote Sensing Research National Central University Chung-Li, Taiwan REPUBLIC OF CHINA			X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Ms. Philippa Lloyd Department of Atmospheric Physics Clarendon Laboratory Parks Road, Oxford OX1 3PU UNITED KINGDOM		X	X	
Mr. Cecil Lo Teletronics International, Inc. P.O. Box 1204 Bethesda, Maryland 20817 USA			X	
Dr. Frank Loechner Deutsche Forschungs- und Versuchsanstalt fur Luft-und Raumfahrt Oberpfaffenhofen D-8031 Wessling FEDERAL REPUBLIC OF GERMANY	X	X	X	I
Dr. Mervyn J. Lynch School of Physics and Geosciences Western Australian Inst. of Technology Kent Street, South Bentley 6102 AUSTRALIA	X	X	X	V
Xia-Lin Ma Satellite Meteorological Center State Meteorological Administration Beijing PEOPLE'S REPUBLIC OF CHINA			X	I
Dr. Harold Maurer Code 675, Bldg. 22 NASA/Goddard Space Flight Center Greenbelt, Maryland 20771 USA			X	
Dr. John A. McGinley NOAA/ERL/PROFS R/E23 325 Broadway Boulder, Colorado 80303 USA			X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Dr. Larry McMillin NOAA/NESDIS Satellite Experiment Lab E/RA21 FB-4, Room 3206 Washington, D.C. 20233 USA	X		X	
Dr. W. Paul Menzel NOAA/NESDIS Advanced Satellite Products Project 1225 West Dayton Street Madison, WI 53706 USA	X	X	X	
Dr. M. J. Munteanu Code 911 NASA/Goddard Space Flight Center Greenbelt, MD 20771 USA (deceased)	X			
Dr. D. G. K. Murthy Meteorology Division Space Application Centre Indian Space Research Organization Dept. of Space, Jodhpur Tekra Ahmedabad 380 053 INDIA				I,V
Mr. Folke-Soren Olesen D.F.V.L.R. - WT - DA Oberpfaffenhofen D-8031 Wessling FEDERAL REPUBLIC OF GERMANY		X	X	
Dipl.-Met. K. Paetzold Deutscher Wetterdienst Zentralamt Frankfurter Strasse 135 D-6050 Offenbach/Main FEDERAL REPUBLIC OF GERMANY	X			
Mr. Jan-Petter Pedersen Tromso Telemetry Station P.O. Box 387, N-9001 Tromso NORWAY		X		V

	ITSC-I	ITSC-II	ITSC-III	ITPP
Dr. T. Phulpin Centre Nationale de Recherches Meteorologiques CNRM/ESSI 42 avenue, Gustave Coriolis 31057 Toulouse FRANCE	X	X	X	
Mr. Robert W. Popham NOAA/NESDIS E/ER2 FB-4, Room 3301 Washington, D.C. 20233 USA		X	X	
Dr. A. J. Prata CSIRO Div. of Groundwater Research Private Bag P.O., Wembley Western Australia 6014 AUSTRALIA	X	X	X	
Ms. Maria Putsay Institute for Weather Forecasting Department of Remote Sensing Budapest XVIII Tatabanya Ter 5-7 HUNGARY		X		V
Mr. Joel Quere Centre de Meteorologie Spatiale B.P. 147 F-22302 Lannion Cedex FRANCE		X		I,V
Dr. P. Krishna Rao NOAA/NESDIS Office of Research and Applications E/RA 810 World Weather Building Washington, D.C. 20233 USA			X	
Mr. Anthony Reale NOAA/NESDIS E/RA23 FB-4, Room 3210 Washington, D.C. 20233 USA			X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Dr. Eberhard Reimer Freie Universitat Berlin Fachbereich Geowissenschaften-WE 07 Institut fur Meteorologie Dietrich-Schafter-Weg 6-10 1000 Berlin 41 FEDERAL REPUBLIC OF GERMANY		X	X	
Mr. Dennis Reuter Code 611 NASA/Goddard Space Flight Center Greenbelt, Maryland 20771 USA			X	
Mr. Ricardo Riosalido Instituto Nacional de Meteorologia Apt. 285 Madrid SPAIN			X	I
Dr. Rolando Rizzi Dipartimento di Fisica Viale B. Pichat 8 I-40127, Bologna ITALY	X	X	X	V
Dr. Guy Rochard Centre de Meteorologie Spatiale B.P. 147 F-22302 Lannion Cedex FRANCE	X	X	X	
Dr. Helmut Rott Institut fur Meteorologie und Geophysik Schopfstrasse 41 A-6020 Innsbruck AUSTRIA	X	X		
Dr. Edward I. Sarukhanian World Weather Watch Department World Meteorological Organization 41 Guiseppe - Motta Case Postale N5 CH-1211, Geneve 20 SWITZERLAND		X		V

	ITSC-I	ITSC-II	ITSC-III	ITPP
Dr. Noel Scott Laboratoire de Meteorologique Dynamique Ecole Polytechnique Route Departementale 36 F-91128 Palaiseau Cedex FRANCE	X	X	X	
Hae-Yong Shin Department of Oceanography University of British Columbia 6270 University Boulevard Vancouver, B.C., V6T 1W5 CANADA				V
Dr. William L. Smith Cooperative Institute for Meteorological Satellite Studies 1225 West Dayton Street Madison, WI 53706 USA	X	X	X	
Mr. John Snook NOAA/ERL/PROFS R/E23 325 Broadway Boulder, Colorado 80303 USA			X	
Dr. D. Spänkuch Meteorologischer Dienst der D.D.R., Met. Hauptobservat. Telegraphenberg 1500 Potsdam GERMAN DEMOCRATIC REPUBLIC	X			
Mr. James Sparkman NOAA/NESDIS E/SPD1 701 World Weather Building Washington, D.C. 20233			X	
Mr. David Steenbergen Aerospace Meteorology Division Atmospheric Environment Service 4905 Dufferin Street Downsview, Ontario M3H 5T4 CANADA		X	X	I

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Mickael Steffensen University of Copenhagen Institute for Theoretical Meteorology Haraldsgade 6, DK-2200 Copenhagen, DENMARK		X		V
Mr. Jens Sunde Norwegian Meteorological Institute P.B. 320 Blindern Oslo 3 NORWAY			X	V
Dr. Joel Susskind NASA Goddard Space Flight Center Greenbelt, MD 20771 USA	X			
Mr. J. Svensson Swedish Meteorological and Hydrological Institute S-60176 Norrkoping SWEDEN	X	X	X	V
Dr. Brian F. Taylor Ministry of Transport New Zealand Meteorological Service P.O. Box 722 Wellington 1 NEW ZEALAND	X	X		V
Dr. Ennio Tosi Dipartimento di Fisica Via Irnerio, 46 I-40126 Bologna ITALY		X		
Dr. Michael Uddstrom NZ Meteorological Service P.O. Box 722 Wellington NEW ZEALAND			X	
Dr. R. Juvanon du Vachat Centre de Recherche en Meteorologie Dynamique (CRMD) 2 Avenue Rapp 75007, Paris FRANCE	X	X	X	

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mrs. Hsiu-Jung Shen Wang M.S.G.S., Central Weather Bureau 64, Kung Yuan Road Taipei, Taiwan REPUBLIC OF CHINA			X	
Dr. David Q. Wark NOAA/NESDIS E/RA FB-4, Room 0130 Washington, D.C. 20233 USA			X	
Mr. P. D. Watts Meteorological Office Unit Hooke Institute for Atmospheric Research Clarendon Laboratory Oxford OX13PU UNITED KINGDOM			X	
Mr. Hal M. Woolf NOAA/NESDIS Systems Design and Applications Branch 1225 West Dayton Street Madison, Wisconsin 53706 USA	X	X	X	
Mr. Tai Chung Yen M.S.G.S., Central Weather Bureau 64, Kung Yuan Rd. Taipei, Taiwan REPUBLIC OF CHINA		X	X	V
Miss Tsoi Yip Atmospheric Environmental Service c/o ARMA 4905 Dufferin Street Downsview, Ontario M3H 5T4 CANADA			X	
Dr. Myron Young Center for Wetlands Study Louisiana State University Baton Rouge, Louisiana 70803 USA				I

	ITSC-I	ITSC-II	ITSC-III	ITPP
Mr. Frederick S. Zbar W/OM22 NOAA/National Weather Service 8060 13th Street Silver Spring, Maryland 20910 USA			X	
Ms. Feng-Xian Zhou Institute of Atmospheric Physics Academia Sinica Beijing PEOPLE'S REPUBLIC OF CHINA	X		X	I,V