A REPORT ON

THE SECOND INTERNATIONAL TOVS STUDY CONFERENCE

Igls, Austria

February 18-22, 1985

Sponsored By:

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Austrian Solar Energy and Space Agency (ASSA)
World Meteorological Organization (WMO)

(Prepared by W. P. Menzel
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The Second International TOVS Study Conference

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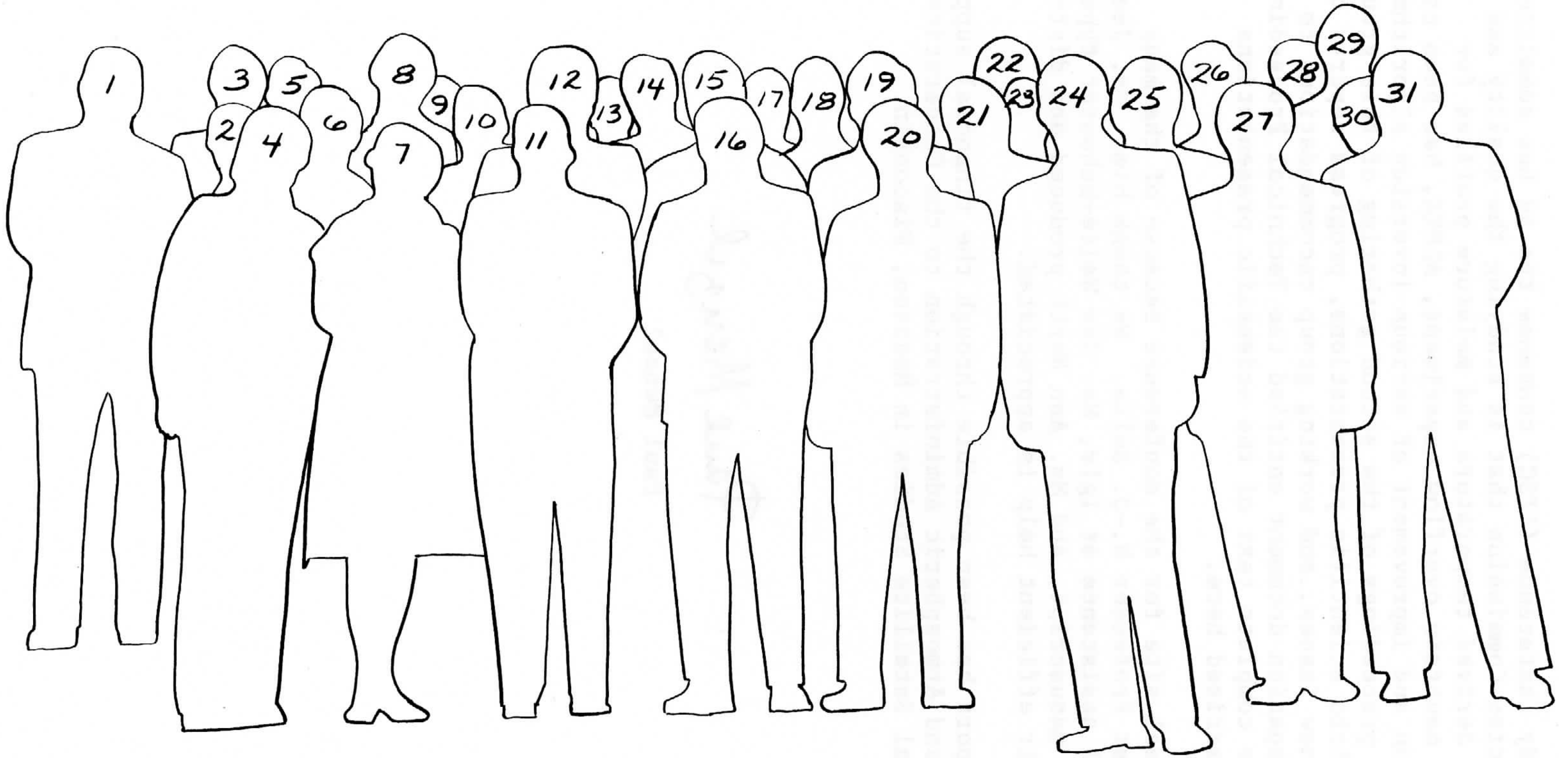
TABLE OF CONTENTS


KONGRESSZENTRUM IGLS



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4. M. Putsay
5. D. Steenbergen
6. H. Böhm
7. N. Scott
8. T. Phulpin
9. G. Cannizzaro
10. R. Juvanon du Vachat
11. A. Chedin
12. R. Rizzi
13. P. Lloyd
14. H.-J. Bolle
15. J. Pedersen
16. F. Prata
17. H. Koriem
18. J. Eyre
19. C. Hayden
20. E. Sarukhanian
21. H. Woolf
22. M. Steffensen
23. T. Aoki
24. P. Menzel
25. T. Kleespies
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FORWARD

The International TOVS Study Conference (ITSC) convenes the ad hoc committee 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. This report summarizes the proceedings of the second gathering of this group. The conference is divided into scientific presentations, progress reports on old issues, discussion of new issues, and working group recommendations to the TOVS user community. A companion document entitled the Technical Proceedings of ITSC-II will contain the complete text of the scientific presentations which are only briefly summarized here.

Igls continues to be an ideal site for the conference because of the many efforts of our gracious host Professor H.-J. Bolle. We thank him. Ms. Jean Slavin provided secretarial assistance at Igls, Ms. Jan Waite-Schuster typed the several drafts of this manuscript, and Ms. Ann North produced and distributed the many copies. Their efficient help is appreciated.

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Madison, 17 May 1985

Paul Menzel

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I. EXECUTIVE SUMMARY

A. Introduction

The Second International TIROS Operational Vertical Sounder (TOVS) Study Conference (ITSC-II) was held in Igls, Austria from 18-22 February 1985. Forty-three scientists from nineteen countries participated. This included experts from Australia, Austria, Canada, Denmark, France, Federal Republic of Germany, Hungary, Italy, Iran, Israel, Japan, New Zealand, Norway, Poland, Sweden, Republic of China-Taiwan, Union of Soviet Socialist Republics, United Kingdom, and United States of America. More than half of the participants had attended the ITSC-I conference held in 1983. The increased participation in ITSC-II reflects the rapidly expanding user community of direct readout TOVS data in research and operations. There are currently well over 100 direct readout stations capable of receiving TOVS data.

The ITSC-II focused its activities on the following issues: (1) objective assessment of the accuracy of different TOVS retrieval methodologies, (2) the treatment of clouds in TOVS processing, (3) the optimization of a standard TOVS data processing software system, the International TOVS Processing Package (ITPP), (4) the organization of a baseline system for routine validation and calibration of TOVS sounding products, (5) special considerations to enhance the use of TOVS data in the numerical weather analysis and forecasting, (6) the development of microcomputer software for ITSC research and potentially for operational applications, and (7) the global dissemination of direct readout TOVS data products. It was evident from the scientific presentations and from the reports of the working groups that considerable progress has been achieved in these areas during the intervening two years since the ITSC-I.

In particular, a quantitative TOVS retrieval validation software system has been constructed to enable objective intercomparison and assessment of results of prior and future TOVS processing techniques. As discussed in Section II, several additions to the validation system are recommended in order to enhance future intercomparisons.

Also, substantial progress has been made by several countries on the incorporation of 1 km resolution AVHRR data in the TOVS data processing in order to improve the product in cloudy sky conditions. Although these techniques for cluod clearing are still being refined, it appears that the algorithm using AVHRR in TOVS data processing will be fully defined and tested within the next year or two.

The optimization of the International TOVS Processing Package received considerable attention. Important developments since ITSC-I were reported concerning analytically direct algorithms for the simultaneous retrieval of surface and atmospheric temperature and water vapor profile parameters. The theoretical basis and empirical results of these techniques, especially for water vapor profiling, make them attractive candidates for an internationally acceptable physical algorithm for TOVS retrievals.

The requirements of the World Meteorological Organization (WMO) baseline system for validating and calibrating TOVS data products were more clearly defined. There was a strong desire for the utilization of a common radiosonde system at the baseline stations.

Refinements in TOVS data processing procedures and product types to enhance their utility in numerical weather prediction (NWP) were noted. Rapid progress is being made by the NWP research community in the direct utilization of sounding radiances in numerical analysis procedures.

The conference recognized the continued need for fast statistical algorithms to process data in real time on small computer systems. Rapid advances in personal computer (PC) technology since ITSC-I were discussed at ITSC-II and a strong desire was expressed to utilize this technology to coordinate future international research and to process the TOVS data locally in real time. The PC is envisaged as a key component of a low cost ground station. Because of the rapid proliferation of personal computers which possess a common disk-based operating system, the utilization of this technology would be cost effective and provide a convenient means for scientific software exchange and development.

Finally, because of the great utility of real-time direct readout TOVS data, there is an urgent desire for the development of a means to globally disseminate locally produced products. The use of existing geostationary weather satellite data collection and transmission systems may enable global dissemination of locally processed data in a cost effective manner.

Other issues considered at the ITSC-II included the retrieval of cloud parameters from TOVS to validate geostationary satellite estimates that are part of the International Satellite Cloud Climatology Program (ISCCP), the use of TOVS for surface temperature and boundary layer flux estimation, and the formalization of the TOVS group under the International Radiation Commission of IAMAP. It was obvious to all the participants that there would be a long term need for the international TOVS scientific group to facilitate new uses of TOVS data and to formulate alternate scientific approaches to processing data from new sounding sensors as they are implemented aboard future NOAA satellites.

The agenda for the ITSC-II is provided in the appendices. Status reports concerning issues raised at ITSC-I are summarized in Section III. The recommendations of the working groups are summarized in Section II and more detailed reports are given in Section IV. The abstracts of Section V summarize the scientific presentations of the participants of the conference. The complete text of the scientific presentations will be available in the Technical Proceedings of the ITSC-II.

B. Conclusions

In broad summary there are nine conclusions from the ITSC-II. They are

1. The quantitative intercomparison study using broadscale ECMWF analyses and colocated RAOB data have shown that operational and research groups from a large number of countries have the capability to produce accurate temperature and moisture soundings from the TOVS case study data sets. To extend this study to gauge the mesoscale information contained in these satellite derived products will require the production of detailed mesoscale analyses from both conventional and satellite data which can be used for intercomparison.

2. The demonstrated quality of TOVS products indicates that it would be beneficial to extend the intercomparison studies to impact studies. Incorporation of the higher spatial resolution satellite data at the analysis level should impact forecast skill.

3. A major outcome of the conference has been the endorsement of combining TOVS and AVHRR data. Important advances in cloud clearing are possible using this approach. Additionally, the derivation of accurate cloud parameters, inclusive of cloud moisture, should be possible using this strategy. Because of the microwave capability on polar orbiter satellites, potentially superior products to those obtainable from present geostationary satellites are possible. A comparison of these cloud products with data produced by the ISCCP is desirable.

4. Benefits would derive from documentation and modularization of the International TOVS Processing Package (ITPP). Specifically, users wishing to incorporate alternate procedures (retrieval schemes, cloud clearing techniques, transmittance models) in the software package for research evaluation would be encouraged to make such amendments if modularity was achieved.

5. Strong endorsement was given to the WMO concept of a Baseline Upper Air Network. The value of incorporating additional rocketsonde stations was stressed. A particular concern was the variability in the accuracy of radiosondes used in atmospheric sounding. The point has been reached where the uncertain quality of radiosonde products limits their value for assessing satellite data. Standardization of sonde data transmissions and processing schemes requires attention.

6. Numerical weather prediction would benefit from the availability of radiance information for direct use in analyses.

7. The continued development of software packages for microcomputer systems was strongly supported. Standardization of processing packages and data sets would be essential. Low cost work stations were thought to have a vital role in expanding research activities to the wider user community, and in the development of education and training programs. The initiatives taken by CIMSS in hardware and software repackaging were given strong endorsement.

8. In the longer term, the need emerges for enhancement of global communication networks for the dissemination of satellite data sets, software and products. The development of low cost ground receiving stations for reception of products via communication satellite links was one solution. Implicit in such an initiative was the need for a definition of an internationally acceptable transmission standard for TOVS and AVHRR data and products derived from the HRPT data.

9. Evident at both ITSC-I and ITSC-II was the intense and growing interest in the research and operational use of polar orbiter sounding data. The continuing role for TOVS products to improve operational forecasts and its clear potential to contribute to climatic studies suggests profitable continuation of the international TOVS study conferences. Status was a significant issue in the interaction with other agencies and groups for the

purpose of data exchange, comparison studies and the planning of future experiments or joint studies. Operation under the IRC with WMO participation was an acceptable basis for continuation. Dissemination of the ITSC research outcomes would be improved if the conference report were prepared and distributed through the sponsoring agency.

C. Future Concerns

A number of important issues which emerged during ITSC-II discussions were identified 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 was in the process of documentation. Amendments should include NOAA-9 information. Transmittance calculations and their validation will require consideration of latitudinal adjustment to parameters.

2. Benefits to further research would derive from ITPP version 4 being structured on a modular basis with more machine-dependent data structures, the incorporation of quality control flags, and the specifications of intermediate products. Standards for these developments are in need of definition.

3. A requirement was identified for an additional case study that emphasizes impact upon forecasting. Such a data set should include AVHRR and geostationary data and be supported by a mesoscale analysis.

4. Planning for the new Advanced Microwave Sounding Unit (AMSU) scheduled for the 1990s requires the development of a new processing package. In particular, a transmittance module structured along the lines of the MSU module must be specified and developed.

5. The future role of satellite sounding data in climate research should be pursued. A status report on achievements to date would be beneficial. Agencies with responsibilities for collecting HRPT data should be encouraged to archive material for climate research purposes.

6. As planning for geostationary sounding satellites progresses, the issue of compatibility of instrumentation and data transmissions with existing polar orbiting satellites needs consideration. The international forum for evaluation of geostationary sounding products and the standardization of processing of these data is an issue for review at ITSC-III.

II. RECOMMENDATIONS

Important issues arising from recommendations of the ITSC-I meeting were addressed by specialist working groups. Topics given specific attention included (a) data intercomparisons, (b) cloud filtering, (c) processing package and algorithm developments, (d) baseline systems, (e) numerical weather prediction (NWP) considerations, (f) low cost workstations, and (g) global dissemination in real-time of sounding data and products.

Major recommendations which emerged from the working group discussions are provided below. Further details on working group deliberations, recommendations and action items are contained in the reports at Section IV of this document.

A. The following recommendations emerged from the data intercomparisons and subsequent discussions.

1. Existing ALPEX and USA case studies should be the subject of further research supported by a high resolution analyses. An additional case study should be identified with preference given to a complex synoptic situation in which an impact study could be undertaken.

2. Review the possibility of constructing a synthetic data set against which various retrieval schemes could be evaluated and their sensitivity to first guess, the surface constraint, cloud clearing scheme, etc. could be identified.

B. With regard to cloud filtering procedures the conference identified the following priorities.

3. Progress to date arising from combining the TOVS and AVHRR data for cloud clearing purposes has been encouraging and continuation of these efforts is endorsed.

4. A need has emerged for the performance of the various cloud filtering techniques to be compared systematically under clear, partially cloudy, and overcast conditions.

5. The potential of the research on cloud parameters has suggested that a formal liaison with the ISCCP may be beneficial in the near future.

C. With the number of users of the ITPP continuing to grow, redevelopment of the processing package and associated algorithms is necessary to better support the more remote users. The next two recommendations reflect this.

6. The restructuring of the ITPP on a modular basis would be an important encouragement to further research and an aid to information exchange on alternate processing algorithms. More machine-independent data structures as well as new modules for the incorporation of AVHRR pre-processing and

alternate cloud clearing schemes should be incorporated in future versions of the ITPP.

7. To date progress on procedures for the simultaneous retrieval of temperature and moisture profiles has been encouraging and further effort in that direction was strongly endorsed. Differences in transmittance models were thought to be a major contributor to differences in retrievals; the inclusion of the TIGR data base as an ITPP module would help address this problem.

D. WMO initiatives on the Baseline Upper Air Network were considered and the following recommendations on specific features of the scheme were supported.

8. Considerable value would be derived from the Baseline Upper Air Network, particularly if a wide diversity of air masses were embraced by the system including polar and tropical in both hemispheres and oceanic and continental areas. If possible, ozone profiling, for use in locating the tropopause height, should be included in the Network.

9. The poor quality control on radiosondes, particularly with respect to moisture measurements, identified the need to establish calibration standards and suggested the value of deploying radiosondes from a single manufacturer in the Baseline Upper Air Network. An important issue was the need to investigate if the radiosonde launch times could be made coincident with the twice-per-day satellite over passes.

E. The impact of satellite retrievals on numerical weather prediction is a major concern of the conference. Several recommendations on this matter came forth.

10. The quality of objective analysis schemes would improve with incorporation of satellite-determined horizontal radiance fields and the corresponding error structure functions.

11. Fast transmittance calculation schemes remain a constraint on the effective utilization of satellite radiances directly in the NWP.

12. Improvements to schemes for limb correcting radiances and for producing accurate moisture fields in cloudy areas would increase the value and utilization of satellite products in NWP.

F. The implication of the availability of low cost personal computer work stations, for the developing countries in particular, was significant and led to the following outcomes.

13. Considerable benefit would derive from CIMSS making operational information including sensor status, regression coefficients and empirical transmittance adjustments available to the international TOVS community via a personal computer-based dial-up system.

14. Existing users of the ITPP who were contemplating the use of microcomputers in processing of satellite data should ensure that systems purchased are compatible with the IBM PC in programming code data structures and floppy disk format.

15. The efforts by CIMSS in developing processing packages on personal computers were given strong endorsement by the conference. Financial support for continuation of these CIMSS initiatives was essential and should be addressed by users and agencies who plan to derive benefits from these developments.

G. In the future, a mechanism for the global dissemination of selected TOVS data and products in real-time would require attention.

16. If HRPT products are to be disseminated globally, the restrictions imposed by the global network of geostationary satellites, the specific products for transmission, data rates and data formats will require further investigation. A widespread distribution of low cost ground receiving and transmitting stations for ensuring global coverage of the data base is implicit in this concept.

III. STATUS REPORTS ON ITSC-I ISSUES

A. Calibration (presented by G. Rochard)

1. Introduction

Several issues concerning calibration were raised at ITSC-I; they are differing calibration techniques, spectral band corrections, registration of AVHRR and TOVS, and distribution and maintenance of a standard set of TOVS/AVHRR information. Calibration by continuous interpolation through the data gap has been accepted as the preferred technique that does not introduce any discontinuities. The information available to TOVS users is listed below.

- NOAA Technical Memo NESS 107, Appendix B for TIROS-N (November 1979)
- Errata for Appendix B for TIROS-N (1/21/80)
- Appendix B for NOAA-6 (1/21/80), NOAA-7 (10/19/81), NOAA-8 (4/18/83)
- Draft of Appendix B for NOAA-9 (10/29/84)
- NOAA Polar Oribiter Data Users Guide (February 1984).

Misinformation and confusion still exists in some areas.

2. Problems

a. For NOAA-7, the HIRS filters, specified by 30 values for each of channels 1 to 19 in Appendix B, do not correspond with the central wavelengths (ν_c) and band correction coefficients (b,c) given also in Appendix B. This observation holds for channels 1-5, 7, 8, 11, 12, 14-19. Channels 6, 9, 10, 13 are all right. A specific example follows. The channel 16 filter given in Appendix B has only one maximum near 2261 cm^{-1}. The ν_c, b,c values of this channel correspond with another filter (obtained by CMS/-Lannion from NOAA/Washington) which has 2 maxima at 2265 cm^{-1} and 2277 cm^{-1}. The computation of radiances using the two different spectral responses yields differences corresponding to about 1°C. Channels 12, 16 and 19 present the largest differences. It seems that the correct description is given by ν_c, b and c thus the filters from Appendix B for NOAA-7 are wrong (except 6, 9, 10, and 13). They should be corrected.

b. NOAA-9 is presently three times as noisy than the preceding HIRS instruments, mainly channels 1, 2, 3, 4, 5, 6, 7, 11, 12. It is suggested that the SSU on NOAA-9 is degrading the HIRS performance.

c. CMS/Lannion has observed some problems in the comparison between MSUX calibrated radiances and MSU calibrated radiances using NESS 107 and Appendix B. CMS/Lannion will soon compare those results with those of International TOVS Processing Package version 2 and the conclusion will be given in the future report on calibration.

d. The AVHRR nonlinearity error is poorly defined. The true temperature is assumed to be given by linear calibration between two reference points plus an error correction indicated by a table in Appendix B. The space radiance

(N_{sp}=0) is used as a reference through NOAA-8, but for NOAA-9 an artificial space radiance (N_{sp}≠0) is employed. This leads to some confusion. For example for channel 4 viewing a scene of 305° Kelvin, for NOAA-9 the error correction is 1.5°C for N_{sp}=0 but 0.9°C for N_{sp}=-3.384; for NOAA-7 it is 1.1°C for N_{sp}=0 but 0.8°C for N_{sp}=-1.176. These differences are large enough to cause concern; the artificial space radiance needs to be clarified.

3. Recommendation

A list of several specific problems concerning calibration will be forwarded to NESDIS (G. Rochard to R. Popham, H. Woolf, and K. Kidwell, May 1985). The NESDIS response will be copied for the ITSC participants (P. Menzel, June 1985).

B. Angular Correction (presented by T. Phulpin)

1. Introduction

Little progress has been made regarding angular correction. Therefore the conclusions and recommendations of the previous meeting remain unchanged. The conclusions announced at the ITSC-I indicated that angular corrections are needed:

- to display raw TOVS image data. (It has been demonstrated that only after careful correction of the viewing angle meteorological patterns emerge in the images).
- to retrieve temperature and humidity profiles by statistical methods with the desired accuracy.
- for the combined use of data from different sensors (e.g., scatterometer and TOVS for turbulent fluxes, computations or Meteosat and TOVS for sea surface temperature).

Regarding the inversion techniques the need of angular correction is alleviated for physical retrievals (3I method, ITPP version 2). In statistical retrieval schemes, there are two general approaches to the angular correction. In ITPP version 2, the profiles are retrieved using an independent set of coefficients on radiances corrected to the nadir view. The measurements are corrected using a set of regression coefficients. In the Japanese software, regression coefficients are a function of viewing angle on uncorrected radiances. They are empirically determined.

As the statistical regression technique continues to be used widely, it was recommended that a study of the precision of the different angular correction techniques be undertaken. In response to this recommendation two works have been presented. Aoki showed for the Japanese method that the precision of the retrievals is degraded for large scan angles. He proposed to use two different sets of coefficients for small and large scan angles, thus improving the accuracy of the retrieved temperature profiles. Weinreb et al. showed for ITPP version 1 that angular correction for NOAA-6 channel 9 is underestimated and they attributed this error to the transmittance model used to computer the regression coefficients. Their results have been improved by using coefficients computed with the LOWTRAN transmittance model.

2. Recommendation

Regarding the use of the statistical retrieval method for mesoscale applications, two recommendations have been made:

- the coefficients should be determined regionally for different climatological situations;

- the cloud filtering must be done before the angle correction.

C. Earth Location Report (presented by B. Taylor)

1. Background

Difficulty has been noted in using the Brouwer mean elements transmitted in part IV of the TBUS message for earth location of AVHRR imagery. Work by G. Rochard suggests that predictions become unuseable within four days of the epoch of TBUS IV.

It is important that this problem be investigated since the same orbital prediction software is widely used in TOVS processing, where location errors are less likely to be discovered than in imagery applications. Any such mislocation will contribute to retrieval errors determined in radiosonde comparison, etc.

CIMSS is unable to confirm these results, in spite of using Brouwer mean elements up to ten days old. Their source of data is not the TBUS message itself, but rather the data base from which the TBUS is constructed.

2. Recommendation

It is proposed therefore that the CIMSS investigate this problem by comparing the two sets of orbital elements and resulting predictions up to 10 days ahead of epoch with accurately known satellite positions (such as given in TBUS I).

D. Transmission Function Standard (presented by A. Chedin)

1. Workshop Information

Intercomparison of Transmittance and Radiance Algorithm (ITRA) has been established as a program. A transmittance/radiance model comparison study is being conducted under the auspices of the IAMAP/IRC, by the Working Group on "Remote Sensing: Direct Problems". In order to compare results and develop a preliminary report, a workshop will be held in the latter half of October at the Goddard Space Flight Center in Greenbelt, Maryland.

To accomplish this study three subgroups were established: one oriented towards satellite nadir-type applications, one oriented towards satellite limb-type applications, and one oriented towards the microwave spectral region.

The convenors for these three sub-groups, Dr. D. Spankuch (nadir), Dr.H. Fischer (limb), and Dr. K. Kunzi (microwave) are preparing the documents organizing the first step of the ITRA program.

The calculations requested in each document should be competed by August 1, 1985 and will be presented and discussed during the workshop. It is anticipated that the results will help in defining the most appropriate strategy for future activities, which should be oriented towards comparisons with real data (measurements).

The workshop will last for three days, and will most likely be held during the week of October 21-25. The final dates will be selected to coordinate this meeting with a similar workshop of the ICRCCM (Inter Comparison of Radiation Coded for Climate Models). One of the 3 days may be a joint meeting with ICRCCM, in view of the clearly overlapping interests. The two co-organizers of the workshop are Drs. A. Arking and A. Chedin.

2. Recommendation

The ITSC-III should be informed of the results of this workshop.

E. AVHRR (presented by T. Aoki and W. Smith)

1. Introduction

The retrieval of clear radiance is an important problem in the inversion problem. By incorporating the AVHRR data within the HIRS spots the clear radiance retrieval of HIRS channels will be improved in accuracy. However, the AVHRR and HIRS are separate scanning instruments and we have to determine the collocation of the pictures of both instruments. In determining the collocation of two pictures of AVHRR and HIRS, there are several factors that induce errors:

- The AVHRR lines are not synchronous with those of HIRS because the scanning time of AVHRR and HIRS are 1/6 and 6.4 seconds, respectively.
- The response function of HIRS spot is not known and may not be uniform.
- The fields of view of each channel of HIRS are slightly displaced with respect to each other (it is on the order of half of an AVHRR field of view at maximum), so that for precise data processing it is necessary to obtain the collocation table for each channel of HIRS.

2. Recommendation

Because of the sources of error in attempting to register HIRS and AVHRR data, it is suggested that the AVHRR data be used to identify the radiances from the cloud filled and cloud-free portion of the HIRS field-of-view (FOV), but not its fraction of cloud cover. The cloud fraction can be computed from the HIRS radiance, given the uniform scene radiance contributions diagnosed from the AVHRR data (i.e., $N = R_{HIRS} - R_{clr}/R_{cld} - R_{clr}$). It is suggest that the fractional cloud cover for three spectral domains be determined: (a) visible, using HIRS-20 and AVHRR-1, (b) shortwave infrared, using HIRS-19 and AVHRR-3, and (c) longwave infrared, using HIRS-8 and AVHRR-4. In the performance of cloud clearing using N-Star, the required clear and cloud condition equivalence of the two spatially independent FOV's should be checked using the AVHRR R_{clr} and R_{cld} values before its application.

F. Retrieval Quality Information (presented by J. Eyre)

1. Background

It is desirable for the user to have access to as much information as practicable on the probable error characteristics of the retrieval product and the method by which it has been obtained. To have a knowledge of the error characteristics of an observation is almost as important as having the observation itself. We can expect an increase in the number of Centres producing and disseminating satellite sounding products, with each Centre using a different retrieval procedure with different error characteristics. Also, as analysis methods become more sophisticated and seek to exploit the special strengths of the satellite products (whilst allowing for their the observations are to be used to best effect. Various types of "quality" information are possible depending on the type of retrieval method (and the capacity of the transmission and storage media used to handle the products), including:

a. Satellite identifier, e.g. NOAA-7, -8, -9, etc.

b. Instrument identifier, e.g. HIRS+MSU, MSU-only, etc.

c. Retrieval scheme identifier such as a code number which can be used (with the appropriate message description) to direct the reader to a complete and up to-date description of the retrieval scheme and an assessment of its error characteristics.

d. Retrieval path identifier (where appropriate) such as a code number which identifies the path through the retrieval scheme followed to obtain the "observation", e.g. cloud-free sounding, partly cloudy sounding, etc.

e. Confidence indicator such as a value indicating the relative confidence associated with this "observation". The retrieval scheme description should indicate how this value is obtained and how it is expected to be related to retrieval product accuracy.

f. Estimates of errors, either as a vector indicating the probable error at each level of the retrieved profile (or for each channel in the clear column radiance vector), or as a multiplier to be used with a documented description of the characteristic error profile.

g. Retrieval first guess and constraint information. The first guess profile used in the retrieval, either explicitly (e.g. from a forecast model) or implicitly (e.g. the mean climatological profile in some statistical retrieval schemes), should be given in the message, or identified by a code number and supporting documentation if it takes only a limited number of values. If the retrieved profile, $\bar{x}$, is obtained by a process which can be represented:

$$\bar{x} = x_o + D \cdot (y_m - y_c \{x_o\})$$

where x_o is the "first guess" profile,

y_m is the radiance or brightness temperature measurement vector,

$y_c \{x_o\}$ is the corresponding vector calculated from the first guess,

and

D is the retrieval "constraint" matrix,

then it is also desirable for the constraint matrix (or some good approximation to it) to be made available or documented. Knowledge of x_o and D allows the analysis centre to make best use of the retrieval, $\bar{x}$, and to judge and correct for the (undesirable) correlations which may exist between retrieval and first guess errors. Without this information it may be preferable for the analysis centre to use the clear column radiances directly. Even with the present SATEM system, it would be useful for the message to contain information identifying the regression coefficients used, allowing the date at which they changed to be monitored.

2. Discussion

Several points emerge from a consideration of the above list:

a. Apart from the information transmitted in the message, considerable documentation should be made available to the user community on the retrieval scheme and its error characteristics if the products are to be used properly.

b. A "retrieval path identifier" is appropriate for several current schemes. However, some future developments, such as those which seek to obtain improved, horizontally consistent, clear radiance field, may complicate this matter and make other means of quality indication more appropriate.

c. "Confidence indicators" are of little value unless the user knows how they have been derived and what information they convey.

d. All retrievals make use of "first guess" and "constraint" information. This information must be known to the analysis centre if it is to account correctly for undesirable components or correlations in the retrieved profiles.

e. Requirements for products are likely to become more diverse in the future, e.g. some analysis centres may prepare to use clear column radiances rather than retrieved profiles, particularly if the retrieval scheme has made use of another centre's forecast model.

3. Conclusion

It is difficult to be prescriptive at this stage about standards for quality indicators and related information, with such diversity in retrieval scheme properties and user requirements. Further discussion is required within the retrieval community and the user community to establish what level of commonality exists or should be sought. The above ideas may serve as a basis for such a discussion.

IV. WORKING GROUP DISCUSSIONS

A. Data Intercomparisons (chaired by J. LeMarshall with C. Hayden, F. Löchner, M. Lynch, R. Rizzi, and N. Scott contributing)

1. Introduction

At the first International TOVS Study Conference (ITSC-I) in Igls, Austria in 1983 (Menzel and Lynch, 1983), it was concluded that a quantitative comparison of temperature and moisture soundings derived by the participants was a vital part of the intercomparison which still remained to be done. As a first step in this task, temperatures, layer mean temperatures, thickness and precipitable water observations derived from satellite radiances have been compared to ECMWF fields and colocated radiosonde data. A representative subset of this comparison data, which includes those fields nominated for comparison at ITSC-I was presented at ITSC-II.

2. The Participants in the Intercomparisons

Fourteen sets of sounding data have been provided by the eleven institutions involved in this intercomparison study and several more will be included in the study shortly after the conference. The participants and a summary of the data sets they have provided are given in Table 1. The entries in Table 1 are grouped according to the case studied, i.e., the ALPEX, Tasman Sea or US. A description of the processing techniques used in the production of the soundings for the study can be found in the Technical Proceedings from ITSC-I (Menzel, 1983) and ITSC-II (Menzel, 1985).

3. The Intercomparisons

Temperature at the fifteen standard levels as well as the fields nominated for comparison at ITSC-I (the thickness of the layers 1000 to 700 millibars (mb), 700 to 500 mb, 500 to 300 mb, 300 to 100 mb and 1000 to 500 mb and the precipitable water in the layers 1000 to 400 mb, 850 to 400 mb, 700 to 400 mb and 500 to 400 mb) have been compared to their respective ECMWF fields interpolated to the sounding position and also to colocated (within 150 km) RAOB data. Standard differences, biases, and root mean square differences have been analyzed between the satellite observations and the related ECMWF and RAOB data. The standard deviation of standard level temperature data have also been examined; satellite, ECMWF, or RAOB data are calculated about their respective mean from data located at the satellite sounding points. In addition, correlation coefficients also have been tabulated.

4. Summary

Details of the intercomparison study are presented in the Technical Proceedings of ITSC-II. A very brief summary of the conclusions is given below.

a. Near the surface and to a significant extent near the tropopause, where vertical resolution of the satellite measurements is limited, the differences appear to be a function of the use of surface data or constraints rather than a particular retrieval scheme.

ORIGIN	CASE	ABBREV.	CONTENT	RET. SCHEME
ALPEX				
Meteorological Office (United Kingdom)	1	ALPEX ALUK	T,Z,Q	Statistics
CIMSS (USA)	2	ALPEX ALWI	T,Z,Q	Physical
DFVLR (West Germany)	3	ALPEX ALDF	T,Z,Q	Physical
Laboratoire de Meteorologie Dynamique (France)	4	ALPEX ALFR	T,Z	Physical/ Statistical
NASA (USA)	5	ALPEX ALNA	T,Z,Q	Physical
NOAA/NESDIS (USA)	6	ALPEX ALNE	T,Z	Statistical
University of Bologna (Italy)	7	ALPEX ALIT	T,Z,Q	Physical
Western Australia Institute of Technology (Australia)	8	ALPEX ALWA	T,Z,Q	Statistical
TASMAN				
Bureau of Meteorology (Australia)	9	TASMAN TAAU	T,Z,Q	Statistical
CIMSS (USA)	10	TASMAN TAWI	T,Z,Q	Physical
New Zealand Meteorological Service (New Zealand)	11	TASMAN TANZ	T,Z,Q	Statistical
NOAA-NESDIS (USA)	12	TASMAN TANE	T,Z	Statistical
US CASE				
Atmospheric Environment Service (Canada)	13	US USCA	T,Q	Statistical
Meteorological Office (United Kingdom)	14	US USUK	T,Z,Q	Statistical

Table 1: Summary of contributors to the intercomparison. (Note T represents temperature data, Z represents thickness data, and Q represents moisture data.)

b. In the mid troposphere (between 700 and 300 mb) the satellite temperature soundings, regardless of retrieval scheme, generally exhibited RMS temperature differences near 2 degrees Kelvin.

c. Verifications using radiosondes as opposed to the ECMWF analyses show some differences particularly near the tropopause because of the different scales represented by these standards.

5. Recommendations

Studies thus far have focussed on a comparison of the retrieval schemes used by the participating groups with ECMWF and RAOB data. However, it now remains to address the comparison of data on a scale closer to that of the TOVS retrieval data, to concentrate on moisture and cloud retrievals, and to conduct some model impact studies. As a result, the following recommendations were made.

a. ALPEX, Tasman, and the US case studies should be completed and should include an examination of first guess fields with additional ALPEX radiosonde data and ECMWF analyses (J. LeMarshall, June 1985).

b. A new ALPEX case study should be selected which has a good data base of conventional, AVHRR, and Meteosat data. Preference should be given to a complex synoptic situation which affords opportunity for a numerical impact study (R. Rizzi and C. Hayden, June 1985). Data tapes should be distributed to interested parties (H. Woolf, November 1985).

c. The case study tape format should be expanded to include additional variables for quality control, data screening, surface constraints, cloud data, and intermediate products (J. LeMarshall, June 1985).

d. High resolution analyses should be produced for the ALPEX, the US and the new case study. This is to be done using available conventional data and cloud and water vapor drift winds generated at high resolution. This should be used as a basis for statistical intercomparison studies, taking account of data density scale and other factors (E. Tosi, R. Rizzi, C. Hayden, J. LeMarshall, November 1985).

e. Moisture retrievals should be intercompared after analysis of the retrieval data, with special attention to the space and time interpolation of these highly variable fields (J. LeMarshall, December 1985).

f. Intercomparison of cloud parameters should commence before ITSC-III (J. LeMarshall, December 1985).

g. Because of some unresolved questions in the intercomparison of retrieval techniques using observed data case studies, consideration should be given to the formation of a synthetic data base. This data base would provide an exact "truth" against which to measure the merits of various retrieval methods for different first guess constraints, cloud clearing techniques, and surface temperature sensitivity. Initial investigation of this will be reported at ITSC-III (F. Löchner, C. Hayden, June 1985).

6. References

Menzel, W. P., 1983: Technical Proceedings of the First International TOVS Study Conference, Igls, Austria, The Cooperative Institute for Meteorological Satellite Studies, 352 pp.

Menzel, W. P. and M. J. Lynch, 1983: A Report on the First International TOVS Study Conference, Igls, Austria, the Cooperative Institute for Meteorological Satellite Studies, 32 pp.

B. Cloud Filtering (chaired by B. Taylor with T. Aoki, H. Billing, P. Lloyd, T. Phulpin, F. Prata, and G. Rochard contributing)

1. Introduction

In order to obtain temperature and water vapor soundings of the atmosphere, clear-column radiances are generally required. Methods are therefore needed to identify and remove the effects of clouds in HIRS field of view (FOVs). It was concluded in the executive summary of the First International TOVS Study "that improved cloud filtering to reconstruct clear-column radiance values using the higher horizontal resolution AVHRR data (should be investigated)". It has been confirmed by results presented at this conference that AVHRR data lying within a HIRS FOV can be identified and hence used to discriminate between clear HIRS FOVs and those with single or multiple cloud layers.

2. Techniques Employing AVHRR Data

a. Identification of clear HIRS FOVs benefits from using AVHRR data.

- Thresholds in infrared and visible channels during daytime can be applied to establish clear areas. The thresholds may be determined, for example, by climatology (over the sea) or ancillary surface data.

- The multi-channel capability of the AVHRR can be used to eliminate FOVs containing cloud types often not rejected by threshold tests. Intercomparison of channels 3 and 4 may be used for nighttime detection of fog and stratus; channels 4 and 5 may be compared for the detection of cirrus. These tests rely on the wavelength dependence of the emissivity of these cloud types.

- The standard deviation of channel 4 (channel 3 by night) can be used in comparison with some empirical threshold determined by the nature of the underlying surface. This test identifies uniform scenes; it will identify scattered cloud but does not discriminate between uniform cloud and clear surface.

b. In partly cloudy FOVs the AVHRR may be used to determine the temperature/radiance of both cloud and surface for use in a retrieval. Techniques currently under investigation include spatial coherence methods, two dimensional histogram methods, and methods more usually associated with pattern recognition.

c. Rejection of multi-layer clouds is best done by fitting a curve to a scatter diagram of channel 3 against channel 4 radiances and rejecting scenes with non-linear components exceeding a suitable threshold.

3. Clear Column Radiance Determination

Clear column-radiance determination is currently performed in one of three main ways:

a. Adjacent FOV techniques, such as the N-star, are well known.

b. The Psi Method (Chedin et al.) provides the brightness temperatures for cloud-contaminated spots that would have been obtained under clear sky conditions for HIRS/2 channels (3 to 6, 14 and 15). The method uses MSU observations and eventually the TIGR data set. These pseudo channels are then used in the retrieval scheme.

c. Optional Estimation makes better use of information in spots that are not necessarily adjacent. A maximum likelihood estimator is used to sequentially derive clear radiances from all of the available information including AVHRR, N-star and MSU data.

4. Recommendations

a. Recognizing that the combined application of the AVHRR and the HIRS is desirable, the satellite operator should be encouraged to publish, in an appendix to NOAA Technical Memorandum NESDIS 107, a description of the scanning geometry of the two sensors, and for each satellite, parameters necessary for their colocation. Also software should be made available to the TOVS user community to generate the lookup table necessary for identifying HIRS-colocated AVHRR spots.

b. Given the large amount of data and the heavy computer load associated with the statistical treatment of AVHRR data, it is desirable to determine a small number of useful parameters for the cloud-filtering operation. Investigations should be undertaken to select these parameters and efficient methods of determining them.

c. Single-spot retrieval techniques which fully utilize the cloud-filtering techniques discussed above should be investigated.

d. It is desirable that the group be informed of the progress of the ISCCP with respect to cloud recognition.

e. The various cloud filtering techniques should be tested under clear, partly cloudy, and overcast conditions, and the results should be compared in order to select the most appropriate method.

C. Algorithm Development (chaired by J. Eyre with A. Chedin, W. Smith, J. Svensson, and H. Woolf contributing)

1. Introduction

The name of the "Export Package" has been changed to the "International TOVS Processing Package", ITPP, in order to reflect the international contributions to this software system.

The following issues concerning the ITPP were considered:

- general principles which should influence future development of the Package,
- lines of research presented at the ITSC-II conference in which further development should be encouraged,
- specific suggestions for algorithms which might be developed for inclusion in the Package.

2. Recommendations

a. The ITPP should evolve to incorporate modular and flexible data structures. As far as practicable, scientific operations on the data which are logically separate should be in separate modules in order to assist exchange of modules between research groups and implementation of improved modules within existing systems.

To allow flexibility in interfacing new software modules to the system, the data structures should be redesigned. They should allow for all information required with current and planned algorithms, and also for future expansion. Exchange of modules developed within this framework by different research groups should be encouraged. Proposals should be prepared for new standard data structures and modular software (H. Woolf and J. Eyre, September 1985). Based on feedback, new data structures will emerge in ITPP version 4. (H. Woolf, June 1986).

b. Some specific aspects of the scientific algorithm require additional attention.

- Performance of the current location algorithm should be reviewed and, if necessary, improvements should be sought. The possibility of creating a flexible routine which can use TBUS or other elements should be investigated. (H. Woolf and B. Taylor, June 1985). An independent check on location accuracy should be performed and results distributed. (G. Rochard, December 1985).
- With regard to preprocessing, the separation of different aspects of the MSU corrections (for limb effects, surface emissivity, and antenna gain pattern) should be investigated to provide more flexibility. (H. Woolf, December 1985). An improved method of limb correction should be sought. (W. Smith and H. Woolf, December 1985). An improved method for mapping MSU data to HIRS spots should be sought. (C. Hayden, December 1985).

- To improve its cloud clearing capability, the ITPP should be modified to allow the inclusion of AVHRR products if available. (H. Woolf, September 1985). Research on new cloud-clearing algorithms which provide horizontally consistent radiance fields should be encouraged. Such a routine should be provided for the ITPP as soon as possible.
- Studies of inversion methods which simultaneously solve for all meteorological variables show promising results and should be encouraged. The use of library data bases such as TIGR should also be encouraged. The feasibility of disseminating and compressing the TIGR data should be studied. (A. Chedin, December 1985).

c. Studies should continue on the use of ancillary data sources such as forecast fields and surface observations/analyses. It is recognized that considerable improvements are possible in the accuracies of the retrieval profiles using these data, but that corrections to the resulting analysis/forecast model errors will require careful study.

D. Baseline Upper Air Network (chaired by E. Sarukhanian with T. Böhm, T. Kleespies, M. Putsay, and M. Steffensen contributing)

1. Introduction

A considerable effort has been made by the scientific community to compare satellite-derived soundings and soundings made by the global upper air network. In reality, these two systems observe the state of the atmosphere in different fashions and on dramatically different scales. The present upper air network has several deficiencies when used for intercomparisons; not only is there an error structure in the radiosondes, but this error structure varies widely among the different manufacturers of radiosondes. Thus the present upper air network is inadequate for the purposes of comparison with satellite data. The Committee for Baseline Systems (CBS) of the WMO is contemplating the establishment of a Baseline Upper Air (B/UA) Network of radiosondes that addresses these issues. The ITSC-II supports this initiative and offers the following recommendations.

2. Recommendations

a. Inter-network calibration standards and tests should be established to ensure that all B/UA stations operate at a consistent high standard of performance. To ensure consistent operation, all radiosondes in the B/UA Network should be from the same manufacturer. If the use of different instruments is necessary, then techniques should be established for providing compatible output data. The development of these techniques will draw heavily on the results of radiosonde intercomparisons conducted by CIMO. Quality control of the B/UA Network should be performed by one of the centers of expertise in satellite data processing. This center would also prepare a monthly schedule of launch times for each of the network stations.

b. Some of the stations in the B/UA Network should be at rocketsonde locations. If possible, cloud cover and total ozone amount should also be measured at these stations. Furthermore, an effort should be made to improve the accuracy of the radiosonde instruments used in the B/UA Network. Particular attention should be paid to the humidity sensor.

c. It is important that the radiosonde launch time in the B/UA Network should be as coincident with the satellite overpass as possible. These launches should be scheduled with the orbits that are most directly overhead (two per day). If possible, rocketsonde and radiosonde launches should be nearly simultaneous. The radiosondes in the B/UA should report from the surface to at least 10 mb.

d. The baseline network should include a wide diversity of climatological air masses, from polar to tropical, in both hemispheres. Stations should be not only in oceanic regions, but also over continental areas so as to guarantee a broad diversity of air masses.

e. Consideration should be given to making the radiosonde launches coincident with the satellite overpass during future experiments in which high resolution (less than 100 km spacing) radiosonde observations are made.

E. Numerical Weather Prediction (chaired by G. Kelly with J. Quere, E. Reimer, and R. J. du Vachat contributing)

1. Introduction

A most important goal of the satellite sounding program is an improved forecast of weather by objective numerical techniques. The effective incorporation of TOVS-derived products into numerical weather prediction models will require consideration of many issues. Some of them are:

a. Horizontal and vertical error structure information is important for most objective analysis methods. The horizontal and vertical error structure as a function of retrieval method is required.

b. Geostrophic adjustment theory must be studied down to the scale of the TOVS radiances in order to determine the coupling of mass and wind fields as a function of scale. It is important that thermal wind not be calculated at a scale which is not valid.

c. Moisture observations from satellites are most important due to the comparative incompleteness of radiosonde measurements. There should also be an increased effort made to determine moisture profiles in cloudy areas. The first guess surface and boundary layer moisture could be provided by the numerical forecast system.

d. Fast radiance calculations must be provided for numerical modeling. The current transmittance models are too slow even on machines such as the CRAY-XMP. Radiance may be calculated using deviations from the first guess field.

e. Limb corrected radiances are important for some objective analysis system and improved limb correction methods are important.

f. Objective analysis methods require first guess and sounding data quality information with all satellite retrievals.

g. Forcing of model divergence using cloud data. Work done by Krishnamurti in the USA has shown this may be an important method for model adjustment.

h. The suitability for NWP of the various retrieval methods need to be evaluated using a data assimilation systems.

2. Recommendations

a. Work on the error structure of satellite retrievals and a comparison of retrieval methods in NWP should be coordinated. (G. Kelly, June 1986).

b. Work on geostrophic adjustment theory and the forcing of model divergence using cloud data should be started. (E. Reimer and R. Juvanon du Vachat, December 1985).

c. Objective analysis of clear radiance data should be studied. (R. Juvanon du Vachat, December 1985).

3. Summary

Studies on vertical and horizontal structure of TOVS are important to determine the information content. Multivariate objective analysis methods using satellite and other data types are required to reduce redundancy in data so that the resulting analysis is optimum.

Further work is required to be able to calculate wind shear and divergence at the resolution of the TOVS data. Normal mode initialization may be a useful tool. Moisture, particularly in cloudy areas, is most important for mesoscale forecasting. Fast radiance calculations are required.

F. Low-Cost Work Station (chaired by P. Menzel with L. Baranski, S. Haga, H. Rott and D. Steenbergen contributing)

1. Introduction

A large number of TOVS receiving and processing systems have been set up around the world. In general, these systems run on expensive hardware so that new users (both for operations and research) are discouraged by the high cost in labor and hardware of setting up a TOVS system. A contributing factor to the set-up cost is that users have had to develop their own software for displaying data and results. A related problem is that the time and effort involved in exchanging data, software, and results among TOVS users on magnetic tapes is too large.

The explosion in microcomputer technology has reached a point where a significant TOVS receiving and processing capability can be achieved at relatively low cost. CIMSS has developed a system based on IBM PC (or PC-compatible) technology which can access TOVS data, display the data in image form, derive and display meteorological products, and display the products in combination with conventional weather data. The development of this system represents a significant investment of time and money (about four programmer-years) by CIMSS.

Even though IBM PC hardware is not available everywhere in the world, the IBM PC is one of the most widely available and maintainable microcomputer systems. There has also been a proliferation of IBM-compatible hardware from other manufacturers which could run the CIMSS software (although some modifications might be necessary). In many cases, interfaces between the PC (or PC-compatible systems) and the hardware used by present TOVS users already exist. It is not likely to be too difficult to develop such an interface when necessary. Taking advantage of current microcomputer technology and the CIMSS investment in software is clearly the most cost-effective, short-term solution to the problem. The lifetime of this solution is about five years because current microcomputers will be obsolete by then and because major software changes will be needed to cope with the Advanced Microwave Sounding Unit (AMSU).

2. Recommendations

a. New and existing TOVS users who are contemplating a microcomputer purchase are encouraged to choose a system compatible with the CIMSS TOVS software for the IBM-PC/XT.

b. CIMSS should establish a pilot program for data and information exchange on PC format floppy disks. Possibilities include ALPEX data and results, export package software, and experimental retrieval software. CIMSS should continue the packaging of TOVS processing and display software into a user-friendly (e.g., menu-driven, documented) system for PC or PC-compatible hardware. TOVS users who foresee immediate benefits to themselves from such a system should investigate ways of providing financial support to CIMSS to carry out the necessary work.

c. Potential TOVS users should be made aware of the capacity of the microcomputer version of the CIMSS TOVS software and of the potential availability of the software. CIMSS should arrange for the international distribution of a report on the system through NESDIS and the WMO.

d. NESDIS should make operational TOVS information such as sensor status, regression coefficients, and empirical transmittance adjustments available to the international TOVS community via a low-speed dial-up computer link.

G. Global Dissemination of TOVS Real Time (chaired by R. Popham with G. Cannizzaro, J. Fischer, H. F. Olesen, J. Pedersen, and T. Yen contributing)

1. Introduction

As of February 1985, about 100 HRPT stations are in operation in 44 countries. About 20 of these countries are currently using, or planning to use, TOVS data.

Collecting and retransmitting raw TOVS data as a part of a global TOVS data acquisition and dissemination scheme is not practical, because the required data rate is too high. However, it is technically possible to send data at a reduced rate via the Data Collection System (DCS) of the geostationary environmental satellites.

2. Recommendations

a. A standard HRPT/TOVS software package, agreeable to each station operator, should be developed that could reduce the TOVS data in the same way for all stations, to a level of no more than 3 to 4 kilobits per second.

b. Techniques for retransmission of reduced or compressed data via the DCS should be developed and tested.

c. A network of specific HRPT/TOVS stations should be identified that could and would receive data so that overlap areas could be avoided.

d. It is desirable that this working group draft and distribute to the international TOVS members a plan for implementing these recommendations in the next six months. The WMO should be made aware of, and probably approve, the above recommendations before the working group is directed to proceed with a draft plan.

V. ABSTRACTS FROM ITSC-II

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

CHARACTERISTICS OF ERRORS IN RETRIEVED VERTICAL TEMPERATURE

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There has been no big change in data processing system of MSC since the ITSC-I in fall of 1983. The atmospheric parameters are obtained by regression equations. Angular correction is made on the regression coefficients, but not on the clear radiances. The clear radiances are obtained with the use of AVHRR data.

The characteristics of errors have been examined for the vertical temperatures routinely obtained. It has been found that a monotonic variation of both mean and rms errors exist through the range of cloud amount from 0.0 to 1.0.

The errors are generally larger at the limb. This error has been decreased significantly by determining the regression coefficient separately for two scanning angle ranges.

THE INITIAL PROCESSING OF TOVS DATA USING A MERA-60 MICROCOMPUTER

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In the Institute of Meteorology and Water Management in Krakow, the system for receiving Direct Sounder Broadcast TIP data and processing meteorological information was established. This instrumentation is capable of pre-processing of TOVS data and calculating vertical soundings. The software for initial processing was completed at the end of 1984. The first temperature and moisture profile retrievals are planned for 1985 from NOAA satellites.

A FULL RESOLUTION DISPLAY OF TOVS DATA

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At the Free University of Berlin, the forecast meteorologist can display AVHRR images and loops made of the last four hours of Meteosat images. The 20 HIRS and 4 MSU channels can be displayed after calibration and limb correction. The temperature ranges can be color enhanced interactively.

For testing the retrieval technique, each HIRS element is processed so that small scale features in the temperature and moisture field can emerge. All retrievals are allowed to pass through. The failure flags, the type of retrieval, the cloud fraction are also mapped.

For the 4 March 1982 case study, it has been found that only the lowest levels are influenced by clouds, while higher levels yield more continuous results. For a large number of cloud fields, the TOVS derived fractional cloud cover corresponds quite well to AVHRR evaluations.

IAMAP ACTIVITIES

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The International Association for Meteorology and Atmospheric Physics represents the individual scientists working in the broad field of atmospheric sciences. IAMAP is organized in ten commissions which collaborate closely with WMO and COSPAR. The International Radiation Commission of IAMAP formed the Working Group on Inversion Procedures which convenes these International TOVS Study Conferences.

Initiatives in the next few years will involve the World Climate Research Program where TOVS data are beginning to play an important role over the oceans, the International Satellite Cloud Climatology Project where TOVS data can contribute to cloud retrieval algorithms, and the International Satellite Land Surface Climatology Project where TOVS data are useful for global skin temperature determinations. The unsolved problem of early detection of climate change could benefit from TOVS research also.

Such applications of temperature and water vapor soundings enter new fields of research to which IAMAP Commissions may address themselves in the future. The Joint Scientific Committee for the WCRP is currently inviting nations and international organizations to participate in the WCRP projects which are defined in the Scientific Plan for the WCRP (ICSU-WMO WCRP Publications Series No. 2, 1984; WMO TD-No. 6). IAMAP is ready to respond to this challenge and to join with WMO in stimulating and coordinating the necessary efforts.

TELESPAZIO ACTIVITIES ON TOVS DATA PROCESSING AND APPLICATIONS

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The remote sensing branch of Telespazio is presently carrying out the following activities:

- Acquisition (Fucino Station), archiving, pre-processing, and distribution of first and second generation LANDSAT satellite data.

- Research and development activities on calibration, atmospheric and geometric correction, image processing of data from different satellites for thematic applications (surface temperature, land cover/use maps, agricultural inventories, etc.).

At present no TOVS data processing is performed. The feasibility of the use of TOVS data in the following fields is being investigated:

- Atmospheric correction of window sensors in the thermal infrared (AVHRR, LANDSAT Thematic Mapper).

- Radiance calculations for climatological applications.

THE "3I" PROCEDURE APPLIED TO THE RETRIEVAL OF METEOROLOGICAL PARAMETERS FROM NOAA-7 AND NOAA-8

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The 3I (Improved Initialization Inversion) method has been designed for retrieving meteorological or climatic parameters from satellite vertical sounders. It was first applied to NOAA-7, the third of the TIROS-N operational weather satellites series. The 3I algorithm has already been described in some detail in several publications: Chedin and Scott (1984), Chedin et al. (1985), Scott et al. (1984a), Wahiche et al. (1984). This approach to the radiative transfer equation problem directly pertains to pattern recognition theory as it has been shown by Chedin and Scott (1985). The first purpose of the present paper is to present an overview of the 3I method: initialization of the inversion problem including cloud detection and cloud clearing, atmospheric temperature retrieval, cloud parameter retrieval, atmospheric water vapor retrieval and surface temperature retrieval. The second purpose of this paper is to discuss the results of two applications of the algorithm, one to NOAA-7 for the March 4-5, 1982 during the ALPEX (ALPine EXperiment) IOP (Intensive Observing Period) and the other to NOAA-8 for June 7, 1984 during cyclogenesis over the United States. From the latter case, a "cold pool" has been detected along 90° longitude and between latitudes 40° to 45°.

DEVELOPMENTS OF A MESOSCALE ANALYSIS USING RAW SATELLITE DATA

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A mesoscale analysis has been developed in the French Weather Service to provide the initial conditions for a short-range numerical weather prediction model of 35 km horizontal resolution over France (PERIDOT Project). Since we lack of classical data in the upper layers of the atmosphere, we are making use of TOVS data whose resolution is comparable to the mesh size of the model. The analysis scheme uses clear HIRS radiances directly, without retrieval procedures, together with classical observations in a three dimensional multivariate optimum interpolation method. A first guess of meteorological fields is provided by a large-scale forecast and is modified by linear combination of observed and forecast values. The discrimination between clear and cloudy radiances is mainly based on HIRS information (and forecast surface temperature) but can use AVHRR cloudiness determinations when available. The use of radiances implies the creation of guess radiances with the CIMSS provided International TOVS Processing Package and the forecast profiles of temperature and humidity.

The impact of these radiances data on this analysis has been evaluated for 12 cases in June 1984, by comparing the analysis with (A) and without (B) these data. To study the impact of this information on short-range forecasts, we have run the forecast model in four cases with an initial state defined by A and B. The impact has been found to be small but significant.

RESEARCH AND DEVELOPMENT ON TOVS RETRIEVALS IN THE UK

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The U.K. Meteorological Office has implemented a system to process locally received TOVS data for use in operational forecasting, both as plotted thickness charts and as temperatures at standard pressure levels for input to the numerical forecasting process. The development, monitoring, and use of the operational products are described. Minor improvements which have been made recently to the retrieval scheme are discussed. Research and development to improve several aspects of the retrieval scheme continues; recent activities and future plans in this area are outlined. Finally, some results from the TOVS data case study of 7 June 1984 are presented.

NOAA PLANS FOR FUTURE POLAR SATELLITES

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Washington, D.C. 20233
USA

The plans for the instrument payloads on the polar orbiting satellites remain constant through the launch of NOAA J. The SBUV and the SSU will only be aboard the afternoon satellite in this time frame. Beginning with NOAA K the polar orbiter will undertake a significant change. In the AVHRR a 1.6 micron channel will be incorporated and time shared with the 3.7 micron channel. Changes in gain and the spectral response will occur in channels 1 and 2 and only changes in gain will occur in channels 3B, 4 and 5. In the HIRS/2 the channel 20 will be changed from a visible channel to a broadband shortwave channel covering a 0.4 to 1.8 micron band.

In NOAA K the MSU and SSU will be replaced with the Advanced Microwave Sounder Unit (AMSU). This instrument will be a 20-channel instrument providing temperature, mositure, precipitation, and ice data. With the addition of AMSU on the spacecraft, the VHF beacon will be dropped from the spacecraft.

AN APPLICATION OF AVHRR DATA TO TOVS RETRIEVALS

C. M. Hayden, W. L. Smith, H. M. Woolf and B. F. Taylor
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USA

Multiple scene temperatures derived from the AVHRR colocated with HIRS are used to determine cloud conditions for the case study of 7 June 1984. Retrievals with AVHRR input are contrasted with those produced without AVHRR. It is shown that the high resolution data is useful in providing cloud-cleared radiances in and around cloudy areas, and that the field of low level moisture produced is greatly improved over that obtained without AVHRR. Sensitivity of the results to AVHRR filtering options is briefly discussed.

ECMWF ANALYSIS/DATA ASSIMILATION

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The analysis provided by ECMWF has been used as a reference atmosphere for intercomparison of TOVS retrievals. This currently has a horizontal resolution of 1.875° which is much larger than current TOVS retrievals of 1°, however, it has provided an important reference for the intercomparison of various retrieval methods. In the near future this multivariate analysis will have a variable horizontal resolution, which will enable intercomparison at a more realistic horizontal scale. The new multivariate analysis will enable the use of clear

column radiances as an optional future. This paper describes the current ECMWF analysis method.

THE IMPROVED AUSTRALIAN REGION TOVS PROCESSING SCHEME

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Australia

Since the First International TOVS Study Conference operational processing of TOVS data in the Bureau of Meteorology has continued with gradual refinement of retrieval algorithms. At present (January 1985) operational processing provides microwave based soundings from NOAA 6 and infrared and microwave based soundings from NOAA 9. The processing is done on the Bureau of Meteorology's mainframe computer, a FACOM M200, taking 15 minutes elapsed time per satellite pass. The products from the processing are distributed to the National Meteorological Centre and the Regional Forecast and Aviation Forecast Centres via the National Facsimile Network. The refinements to the retrieval algorithms include the use of forecast fields from the operational primitive equation forecast model the use of surface data in the retrieval scheme, and a refinement to the limb correction procedure particularly in the microwave region.

INVESTIGATION OF AVHRR DATA TO IMPROVE TOVS RETRIEVALS

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Hooke Institute
Clarendon Laboratory
Oxford, UK

J. R. Eyre
Meteorological Office Unit
Hooke Institute
Clarendon Laboratory
Oxford, UK

Studies have been initiated to develop techniques for extracting parameters from AVHRR data for use within TOVS retrieval schemes. The relative calibration and registration of the HIRS and AVHRR instruments are discussed. Potential methods for using AVHRR data to assist the HIRS cloud clearing process are outlined and some preliminary results presented.

STATUS OF SURFACE TEMPERATURE MEASUREMENT AND IMPACT UPON ATMOSPHERIC SOUNDING

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School of Physics and Geosciences
Perth, Australia

Accurate sea surface and land surface temperatures are important parameters not only for oceanographic and agricultural/forestry studies, but also they are equally important in studying the atmosphere. An accurate surface temperature enables a precise estimate of the clear column radiance to space and in turn permit improved atmospheric temperature retrievals, particularly in the near surface layers.

This paper reviews the status of surface temperature measurement and draws attention to the particular difficulties which are requiring of further attention. Finally, we address some of the benefits and overheads which would result from combining surface information from the AVHRR sensor with TOVS data for improved atmospheric profiling.

A LOW COST METEOROLOGICAL WORKSTATION

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Advanced Satellite Products Project
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USA

Considerable progress has been made in packaging a low cost interactive workstation with image and graphic displays for meteorological research and forecast applications. Standard off-the-shelf hardware from the IBM personal computer family was used to minimize costs and to facilitate easy international implementation. Software has been developed to provide the following capabilities: accessing the satellite data, display of satellite images and loops of images, derivation and display of meteorological products, and amalgamation with conventional weather data.

These developments make the TOVS data processing capability affordable to many more users (a workstation for roughly $7000 US, the tracking VHF antenna for roughly $15,000 US). This technology development needs the support and guidance of the international TOVS user community so that an organized transfer to new users in developing countries can be brought about.

READOUT AND PROCESSING OF NOAA DATA IN NORWAY

Jan-Petter Pedersen
University of Tromsoe
Norway

Norway has two HRPT direct readout stations; the Meteorological Institute of Norway, located at Oslo, supporting the meteorological users, and Tromsoe Telemetry Station. Data received at Tromsoe, covering the polar regions, are processed locally and distributed to other users. So far the use of the data from the NOAA-satellites has concentrated on the AVHRR data. However, use of the TOVS data on an operational basis are very interesting to Norway because there are many activities off the coast of Norway (fisheries, oil companies), and very few meteorological stations cover the area. Currently there are plans for use of the TOVS data on an operational basis both at Tromsoe Telemetry Station and at the Meteorological Institute, but they are awaiting installation of a retrieval system.

CMS CONTRIBUTION TO THE USE OF AVHRR DATA IN TOVS DATA PROCESSING

T. Phulpin, M. Derrien, A. Brard
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France

The two-dimensional procedure ESTHER (Phulpin, et al., JCAM, August 1983) has been improved with a better description of the cloudiness in each HIRS pixel. This program was tested for several selected situations and the clear column radiance retrieval using AVHRR data is now under study.

Presently, a gross description of the cloudiness is performed using AVHRR channel 4 data. Average brightness temperatures of the clouds and HIRS radiances are provided to the French Met Office to be incorporated in the fine mesh analysis of the short range forecasting project PERIDOT.

NOAA TOVS SUPPORT

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USA

NOAA offers several kinds of support to TOVS receiving station operators. Primary support is in the form of information dissemination, keeping operators informed of the status of operating satellites, future launches, and changes in the design or operating characteristics of sensors. NOAA distributes Information Notes, sends telexs, reports, APT predict messages with remarks on launches or systems failures, and holds conferences and workshops to encourage an exchange of information on uses of TOVS Direct Sounder Broadcasts and other types of satellite services.

In return, NOAA asks that TOVS users provide information on the status of their station and use of the data.

CLEAR COLUMN RADIANCES BY OPTIMAL ESTIMATION

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Western Australia

A method for estimating the clear column radiance for the measurements of the HIRS instrument is described. The basic method assumes the form of an optimal estimation problem, in which measured radiances are used sequentially to derive the clear column radiance. Results are illustrated for HIRS channel 6 and the advantages and disadvantages over other methods are summarized.

ATMOSPHERIC TEMPERATURE PROFILE RETRIEVAL IN HUNGARY

M. Putsay
Meteorological Service of Hungary
Hungary

Hungary will have a direct readout station in this year or in the beginning of next year. We are now seeking the appropriate methods to process the AVHRR and TOVS data. The retrieval of atmospheric profiles have already been investigated. Our experts calculated the transmission functions for the U.S. Standard Atmosphere, worked out a temperature correction process for it, and solved the radiative transfer equation using the inverse matrix method. The method has been tested on the Nimbus-5 Selective Chopper Radiometer data: the RMS error is about 3°Centigrade over Hungary including cloudy cases. Unfortunately the investigations were interrupted, but we want to continue them.

HIGH RESOLUTION ANALYSES OF CONVENTIONAL AND SATELLITE DATA

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Bologna, Italy

A program is underway to compare high resolution temperature and humidity profiles obtained from polar orbiting satellites and data gathered during the ALPEX Intensive Observing Period of 4 and 5 March, 1982.

The retrieval technique has been described in Rizzi (1983, 1984). The analysis used is based on a variational method using virtual potential temperature as the vertical coordinate. The horizontal grid has 0.5° spacing in latitude and 0.75° in longitude corresponding to a grid size of about 50 x 50 km. A detailed description of the analysis scheme and our evaluation of its performance can be found in Buzzi et al. (1985).

First results indicate that the agreement between the analyzed fields is quite good between pressure levels 700 to 300 mb. Above 300 mb problems arise because of the lack of vertical resolution in satellite derived temperatures. At this early stage no surface constraint was applied to the first guess statistical resolution. Hence, below 700 mb, retrieved profiles in cold areas are much colder than conventional ones.

The quality of the analysis may evidentiate the phase change in developing troughs due to the time lag between conventional measurements and satellite overpasses.

Buzzi, A., A. Trevisan and E. Tosi, 1985, "Objective analysis of Alpine Cyclogenesis", in press, Contribution to Atmospheric Physics.

Rizzi, R., 1983, "Satellite Soundings Over the Alpex Area", Tech. Proc. of First International TOVS Study Conference, Igls, Austria.

Rizzi, R., 1984, "High resolution satellite soundings over the Alpex area: The 4-5 March case study", 1984, IE Nuovo Cimento.

SATELLITE RETRIEVALS AND THE NEED FOR A BASELINE UPPER-AIR NETWORK

WMO Secretariat
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CH-1211, Geneva 20
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The report of ITSC-I (August, 1983) was reviewed by the Committee for Baseline Systems Working Group on the Global Observing System at its fourth session (December, 1984). The GOS Working Group welcomed the work done by ITSC-I and recognized the value of the recommendations, particularly as regards the more effective utilization of satellite data in the World Weather Watch.

The GOS Working Group gave special attention to the recommendations of ITSC-I concerning the organization of a baseline upper-air network which would, as one function, provide data needed for the retrievals of satellite sounding data. The baseline network concept also had been considered by expert groups in the WMO and was subsequently endorsed by the WMO Executive Council at its thirty-sixth session (May, 1984). Based on a survey conducted in early 1984 and the recommendations of experts, including those of ITSC-I, a concept paper for the baseline network was prepared and reviewed by the CBS Working Group on the Global Observing System. Excerpts from the final report of the fourth session (December, 1984) of the GOS Working Group are contained in the Technical Proceedings of ITSC-II.

The GOS Working Group urged that ITSC-II further refine the recommendations concerning evaluations and the calibration of satellite sounding data and that these be brought to the attention of the President of CBS. In this connection, the ITSC-II is invited to outline a set of specific proposals which in the opinion of the ITSC-II participants would serve to make satellite sounding data have more value to the WWW. Also ITSC-II is urged to comment on the concept of the baseline network, making any recommendations on its organization or operation which would enhance the utility of the data in the retrieval of satellite soundings.

THE SIMULTANEOUS RETRIEVAL IN THE INTERNATIONAL TOVS PROCESSING PACKAGE - VERSION 3

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USA

A new simultaneous solution for surface temperature and the temperature and water vapor profiles from satellite observed radiances is incorporated into the International TOVS Processing Package Version 3. The solution produces small improvements in the temperature profile accuracy but very large improvements in the water vapor profiling capability of the TOVS data. Since the solution is analytically direct, it is also computationally efficient. It is hoped that the new algorithm will provide the basis for a universally acceptable method of profile retrieval from TOVS observations.

USE OF REGIONAL TOVS RETRIEVALS IN CANADA

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TOVS data received at Toronto are being processed using a statistical scheme similar to the International TOVS Processing Package Version 1. Regression coefficients are updated weekly using synthetic radiances computed from radiosonde observations in eastern North America. Retrieved parameters (level temperatures, dew points, thicknesses, and stability indices) have been sent daily (Monday thru Friday) to several regional forecast offices for periods totalling about five months since the ITSC-I. The operational forecasters were asked to compare the TOVS information subjectively with all other data available to them when time was available. In summer, the objective is to improve short-range forecasts of convective development. In winter, thicknesses between 100-85 KPa and 85-70 KPa are being used to delineate areas of possible freezing rain. The usefulness of the TOVS data has not been quantified but some favorable response has been received from the operational forecasters and we expect to continue to provide the data to the forecast offices on an experimental basis.

TOVS ACTIVITIES IN DENMARK

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Although we have a direct readout station for TOVS data in Denmark, up to now we have not made any use of the data. The interest has mainly been focussed on the use of AVHRR pictures, which are operationally sent to the weather forecasting institute, DMI.

The use of TOVS data is being initiated by a research program on polar lows. The region including the Barent and Norwegian Sea (70°-80°N) shows a tendency for development of a class of polar lows. Because the number of meteorological stations in these areas is very small, the amount of conventional data is small. It is therefore advantageous to make use of the satellite data.

For initial studies, the British Meteorological Office has sent retrieved TOVS temperature profiles. A first analysis shows that the horizontal distribution of cold and warm areas is correct with respect to the ECMWF analysis. Furthermore, this indicates the position of the known polar lows in the area. The position of these are also determined from the AVHRR pictures. The comparison with RAOBs from the period shows a large bias, tending to make the atmosphere stable. This can be due to the extreme synoptic situation under which the development of the study of polar lows takes place.

Our project is to improve the use of TOVS data in the investigation of the nature of polar lows. Furthermore, in the future, we hope to get a retrieval program working in connection with fine mesh models.

A NONLINEAR INVERSION METHOD FOR DERIVATION OF TEMPERATURE PROFILES FROM TOVS DATA

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The International TOVS Processing Package, developed at CIMSS, has been implemented and tested on the computer system at SMHI. A physical, nonlinear inversion method has been constructed and the calculated temperature profiles have been compared to those from the ordinary physical retrieval method in the ITPP. The radiative transfer equation forms the basis for the method, which also utilizes surface observations of pressure, temperature, humidity and estimated tropopause height. Cubic B-splines have been used as basis functions for temperature and water content. Well developed theory, excellent approximation properties and publically available numerical software for B-splines are some of the reasons for this choice. By using multiple knots we are able to approximate functions with discontinuities in the derivatives. This is used in order to improve the temperature retrieval around the tropopause.

Physical constraints on the variables, like limits for the adiabatic lapse rate and for the relative humidity, are incorporated in the method. Temperature and water content are calculated from an initial guess by solving a linear, least-squares problem with linear inequality constraints. These calculated temperature and water content profiles give a new initial guess. The procedure may be repeated once or twice, in order to account for the nonlinear properties of the radiative transfer equation.

TOVS IN NEW ZEALAND

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The operational TOVS processing has remained essentially unchanged since the First International TOVS Study Conference. Increased computer loading has forced the transfer of the retrieval work from the operational processor to the backup/research computer. Research is continuing into the "Typical Shape Function" approach to the retrieval problem.

THE DETERMINATION OF HIRS SCENE TEMPERATURES FROM AVHRR DATA

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USA

An experiment is described whereby the AVHRR data is used to obtain scene temperatures within the HIRS FOV for the US case study of 7 June 1984. Aoki's method for geometric alignment is used to colocate the data based on time of observation. The cloud detection techniques of Coakley and Bretherton, together

with simple histogram methods, are used to provide one, two, or all of a uniform warm scene, a uniform colder scene, and the average scene for four minutes of data over the midwestern US. Examples are shown where the combinations of scenes are achieved and failed.

STATUS OF TOVS PROCESSING AT CENTRAL WEATHER BUREAU, R.O.C.

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Meteorological Satellite Ground Station
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The research of TOVS data processing is just beginning in the Central Weather Bureau of Republic of China. We had established the HRPT readout system in 1981. The major routine work is to provide the nephanalysis of the AVHRR image to the forecasting center. In 1982, we received the International TOVS Processing Package from Wisconsin. After an effort of two years, we made the sounding retrieval software work for one case; however, the results exhibit a somewhat large error which may be due to outdated coefficients. The results can be displayed on the interactive image processing system which was installed last summer for GMS and NOAA data. We hope to improve the TOVS processing and establish routine operations for sounding retrieval in the next few years.

APPENDIX A. AGENDA FOR THE SECOND INTERNATIONAL TOVS STUDY CONFERENCE
Igls, Austria
February 18-22, 1985

Monday, February 18

8:30 - 8:50	Welcome (*Smith, Rizzi, Bolle*)		
8:50 - 9:00	Agenda Approval (*Menzel*)		
9:00 - 10:00	ITSC-I Intercomparison Results (presented by *LeMarshall*)		
10:00 - 10:15	Coffee Break		
10:15 - 11:45	Discussion of Intercomparison Results (chaired by *Rizzi*)		
11:45 - 12:15	Draft Conclusions of Intercomparison		
12:15 - 1:30	Lunch		
1:30 - 3:50	Presentations of Participants (chaired by *Smith*)		
	1:30	AUSTRALIA	*Kelly*
	1:50		*LeMarshall*
	2:10		*Lynch*
	2:30		*Prata*
	2:50	AUSTRIA	*Bolle*
	3:10	CANADA	*Steenbergen*
	3:30	CHINA	*Yen*
3:50 - 4:10	Coffee Break		
4:10 - 6:10	Presentations of Participants (chaired by *Hayden*)		
	4:10	DENMARK	*Steffensen*
	4:30	FRANCE	*Chedin*
	4:50		*Phulpin*
	5:10		*Rochard*
	5:30		*Scott*
	5:50		*Vachat*

Tuesday, February 19

8:25 - 8:30	Submission of Day-1 Abstracts		
8:30 - 10:30	Presentations of Participants (chaired by *Menzel*)		
	8:30	FRG	*Billing*
	8:50	HUNGARY	*Putsay*
	9:10	ITALY	*Cannizzaro*
	9:30		*Tosi*
	9:50	JAPAN	*Aoki*
	10:10	NEW ZEALAND	*Taylor*
10:30 - 10:50	Coffee Break		

10:50 - 12:30	Presentation of Participants (chaired by *Chedin*)		
	10:50	NORWAY	*Pedersen*
	11:10	POLAND	*Baranski*
	11:30	SWEDEN	*Svensson*
	11:50	UK	*Eyre*
	12:10		*Lloyd*
12:30 - 2:00	Lunch		
2:00 - 3:00	Presentations of Participants (chaired by *Chedin*)		
	2:00	US	*Smith*
	2:20		*Hayden/Taylor*
	2:50		*Menzel*
3:00 - 4:00	Presentation of Supporting Organizations (chaired by *Bolle*)		
	3:00	WMO Activities	*Sarukhanian*
	3:20	NOAA TOVS Support	*Popham*
	3:40	NOAA Plans for Polar Satellites	*Fischer*
4:00 - 4:20	Coffee Break		
4:20 - 5:00	Presentation of Supporting Organizations (chaired by *Bolle*)		
	4:20	ECMWF Activities	*Kelly*
	4:40	IAMAP Activities	*Bolle*

<u>Wednesday, February 20</u>

8:25 - 8:30	Submission Day-2 Abstracts		
8:30 - 10:40	Status Reports (chaired by *Rizzi*)		
	8:30	Calibration	*Rochard*
	8:40	Angle Correction	*Phulpin*
	8:50	Earth Location	*Taylor*
	9:00	Transmission Function Standard	*Chedin*
	9:10	Trace Gases	
	9:20	Empirical Adjustments	
	9:30	AVHRR	*Aoki/Smith*
	9:40	SST	*Lynch*
	9:50	Ozone	
	10:00	Quality Flags	*Eyre*
	10:10	Simultaneous Retrieval	*Smith*
	10:20	Description of Latest Export Package	*Woolf*
10:40 - 11:00	Coffee Break		
11:00 - 11:30	Formation of New Working Groups (organized by *Smith*)		
11:30 - 6:30	Recess		
6:30 - 10:00	Working Group Deliberations (during Dinner)		

Thursday, February 21

8:30 - 11:30	Working Group Deliberations • Data Intercomparisons • Incorporation of AVHRR • Improving Operational Utility of TOVS Sounding • Impact on Forecast Models • Assistance for Future TOVS Users and PC-Based TOVS Ground System • Possibilities for Global Dissemination of Regional TOVS Products • Baseline Upper Air Network
11:30 - 1:00	Lunch
1:00 - 3:00	Reports of the Working Groups (chaired by *Smith*) • Submission of Written Reports
3:00 - 3:20	. Coffee Break
3:20 - 5:20	Drafting of Executive Summary and Recommendations

Friday, February 22

8:30 - 10:30	Discussion of Executive Summary and Recommendations (chaired by *Rizzi*)
10:30 - 11:30	Future Activities (*Eyre*)
11:30 - 12:00	Plans for ITSC-III (*Menzel*)
12:00 - 12:30	Closing (*Bolle*)

APPENDIX B. LIST OF ACRONYMS

ALPEX	-	Alpine Experiment
AMSU	-	Advanced Microwave Sounding Unit
ASSA	-	Austrian Solar Energy and Space Agency
AVHRR	-	Advanced Very High Resolution Radiometer
B/UA	-	Baseline Upper Air
CBS	-	Committee for Baseline Systems
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
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
ECMWF	-	European Centre for Medium range Weather Forecasting Bracknell, Berkshire, UK
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
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
ITSC	-	International TOVS Study Conference
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
PC	-	Personal Computer
RAOB	-	Radiosonde Observation
RMS	-	Root Mean Square
RTE	-	Radiative Transfer Equation
SCAMS	-	Scanning Microwave Spectrometer
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. LIST OF DIRECT SOUNDER BROADCAST STATIONS

1. Summary

Since 1972, U.S.-launched polar orbiting satellites have had operational instruments on board to collect, store, and simultaneously transmit signals which could be used to produce atmospheric temperature profiles. The first such instrument, the Vertical Temperature Profile Radiometer, was carried aboard NOAA-2, launched in October 1972. In 1978, it was replaced by the TIROS Operational Vertical Sounder (TOVS) instrument.

Provisions for direct readout of data from both instruments by any properly equipped ground station have been incorporated in all of the polar orbitors launched since 1972, through a service known as the Direct Sounder Broadcast service. However, because of the complex mathematics and physics involved in reducing atmospheric sounder data to a useful form, only the United States received and processed the data until 1978. In that year, the Australian Meteorological Service began receiving and processing the data on an experimental basis. Today, although no standard or universal technique exists for reducing the data to a common interchangeable format, 20 stations in 16 countries (including the United States) currently receive and use atmospheric sounder data in their national forecast programs. Three of these countries plan additional stations; three more plan to have this capability in the near future, and at least three other countries are actively exploring the feasibility of receiving and utilizing the Direct Sounder Broadcast services.

With few exceptions, all of the DSB stations in operation today are operated by government meteorological services. The exceptions are in Australia, where one of two DSB stations there is a university; the Federal Republic of Germany, where one station is operated by a space agency (DFVLR) and Norway, where DSB data are received and processed by the Tromsoe Telemet Station. In the future, Italy's Telespacio, a commercial organization, plans to acquire the data.

Although any country or organization capable of receiving the S-band High Resolution Picture Transmission (HRPT) signals (or even VHF beacon channel transmissions, at present) can acquire atmospheric sounder data, the complex nature of the data reduction, alluded to above, has limited its use thus far. The fact that data acquisition and processing at even 20 locations is possible today is almost entirely due to research activities at, and support by, the University of Wisconsin's Space Science and Engineering Center and the Cooperative Institute for Meteorological Satellite Studies. These groups work with the sounder data on a scale comparable to the data available to a typical direct readout station. By contrast, NOAA's central processing of TOVS sounder data is done on a global scale, and by necessity utilizes lower resolution data. A technological transfer of NOAA's ability to process these soundings is therefore neither feasible nor applicable to direct readout stations.

2. List

a. DSB Active Countries

Country	Location	Started
Australia	Melbourne	1978
Australia	Perth	1980
Canada	Toronto	1979
Denmark	Copenhagen	1982
France	Lannion	1978
FRG	Munich	1980
FRG	Berlin	1981
Iran	Karadi	1983
Israel		UNK
Japan	Tokyo	1978
New Zealand	Wellington	1979
Norway	Tromso	1975
PRC	Beijing	UNK
Poland	Krakow	1984
Sweden	Norrkoping	UNK
Taiwan	Taipei	1981
UK	Lasham	1979
USA	Suitland, MD	1972
USSR	Moscow	UNK

b. Countries Planning for DSB Capability

Bangladesh
Chile
Hungary
Italy
Mexico
Spain

APPENDIX D. RECIPIENTS OF INTERNATIONAL TOVS PROCESSING PACKAGE VERSION 3

Name	System*	New User
T. Aoki	I,V	
L. Baranski	V	
H. Billing	V	
T. Böhm	V	yes
G. Cannizzaro	V	yes
J. Eyre	V	
S. Haga	V	yes
T. Kleespies	V	yes
J. LeMarshall	I	
F. Löchner	I	
M. Lynch	V	
J. Pedersen	V	yes
M. Putsay	V	yes
J. Quere	I,V	
R. Rizzi	V	
E. Sarukhanian	V	yes
D. Steenbergen	V	
M. Steffensen	V	yes
J. Svensson	V	
B. Taylor	V	
T. Yen	V	yes

* I indicates IBM, V indicates VAX

APPENDIX E. Mailing List for Second International TOVS Study Conference (18-22 February, 1985)

	Attending	Sent Tapes	Submitting Paper
Dr. Tadao Aoki Meteorological Research Institute Nagamine, Yatabe Ibaraki 305 JAPAN	yes	no	yes
Mr. Jan Askne Dept. of Electron Physics and Onsala Space Observatory Chalmers University of Technology S-412 96 Goteborg SWEDEN	no	no	no
Dr. Les A. Baranski Satellite Data Receiving Centre, Institute of Meteorology and Water Management Piotra Borowego Str. 14 PL-30-215 Krakow POLAND	yes	no	yes
Dr. Lennart Bengtsson Director European Centre for Medium Range Weather Forecasts Shinfield Park Reading, Berkshire RG2 9AX, UNITED KINGDOM	no	no	no
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Dr. M. T. Chahine Jet Propulsion Laboratory California Inst. of Technology 4800 Oak Drive Pasadena, CA 91109 USA	no	no	no
Dr. A. Chedin Laboratoire de Meteorologie Dynamique Ecole Polytechnique Route Departementale 36 F-91128 Palaiseau Cedex FRANCE	yes	yes	yes
Mr. Eduardo Diaz NASA Station Director U.S. Embassy APO, Miami, FL 34033 USA CHILE	no	no	no
Dr. Yves Durand Centre de Recherche en 3-235, Meteorologie Dynamique 63, rue de Sevres F-92100 Boulogne FRANCE	no	no	no
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