3. TECHNICAL SUB-GROUP REPORTS

3.1 ATOVS AND AVHRR PROCESSING PACKAGE (AAPP)

For a detailed report on AAPP status, see presentation 5.1 (N. Atkinson).

AAPP version 5 was released in July 2005, shortly after ITSC-XIV and the launch of NOAA-18. Since then there have been a number of minor updates, mainly bug fixes.

Most of the development effort has concentrated on version 6, supporting MetOp. Version 6.1 was released on 12th October 2006. To mitigate the MetOp-A launch delays, AAPP v6 was released before the launch of MetOp-A, and therefore before it had been tested on live MetOp data. Thanks are due to the various beta testers who provided feedback. The NWP SAF will issue updates as required during MetOp-A commissioning.

For MetOp direct readout processing, the interface to AAPP v6 is at EPS Level 0 (as defined by EUMETSAT). Users are advised to ensure that their HRPT stations are upgraded to deliver this format. AAPP v6 can also ingest the BUFR format data that EUMETSAT will be distributing.

Several AAPP users had requested that the NWP SAF consider updating the AAPP build system that is used in versions 1 to 5. Given that new modules are in any case required for the MetOp processing, a new build system was therefore introduced in v6. It is hoped that this system is more flexible and easier to use than the old.

The IASI Level 1 processor is called OPS-LRS (Operation Software – Local Reception Station). It is a self-contained module and is delivered as an optional component of AAPP v6.

During the next phase of development, work will start on the ingest and pre-processing modules for data from ATMS, CrIS and VIIRS instruments on NPP. AAPP will not process the direct-readout data stream directly, but will be able to ingest level 1 radiances from the International Polar Orbiter Processing Package (IPOPP), being developed jointly by IPO, NASA and the University of Wisconsin-Madison. There is an urgent need for IPO to release details of the instrument data formats as soon as possible.

3.2 INTERNATIONAL ATOVS PROCESSING PACKAGE (IAPP)

There are at present two versions of IAPP running routinely at CIMSS:

Version 2.1 is the current public release, and is available for download from the SSEC anonymous ftp server. It is capable of processing data from NOAA-15 through NOAA-18. Note that NOAA-17 can be handled only prior to the failure of AMSU-A1 in October 2003. This package is used for daily operational processing of NOAA-16.

Version 3.0 is undergoing development. It will have the capability to process data from NOAA-18 and subsequent spacecraft carrying "second-generation" ATOVS, consisting of HIRS-4, AMSU-A, and MHS, such as MetOp. This package is used for daily operational processing of NOAA-18.

When Version 2.1, which for the first time provided Linux support for IAPP, was first released, there was a lot of interest. Unfortunately, many users experienced problems – and frustration – in compiling and linking, especially in regard to the required netCDF software. To address these issues, an "open binary" subdirectory was set up on the ftp server – to accompany the "Open Source" – containing the libraries and executables that produced a working system on the CIMSS Linux system. A number of users have reported success in utilizing those files.

Because two of the three ATOVS instruments changed with NOAA-18, and the new suite will be flown on several future spacecraft, this was considered an appropriate occasion to make some evolutionary changes to IAPP, resulting in Version 3.0:

- To accommodate the variance in spacecraft names, rather than just numbers, the portion of the program interface relating to spacecraft identification was modified. The internal "bookkeeping" engendered by this change is invisible to the user.
- The regression first guess procedure originally involved eight files and eight subroutines, to handle for different instrument combinations and the presence or absence of supporting surface observations. Through a fairly simple coding change in the off-line coefficient generation software, it was possible to reduce the number of subroutines to four (there are still eight files).
- The new version (3.0) will be released after testing with live MetOp data.

Feedback from both established and potential/beginning users is always welcome! Requests for assistance with installation and/or running problems are addressed as rapidly as resources permit (see Web site at http://cimss.ssec.wisc.edu/opsats/polar/iapp/IAPP.html).

3.3 INTERNATIONAL MODIS/AIRS PROCESSING PACKAGE (IMAPP)

The International Moderate Resolution Imaging Spectroradiometer/Atmospheric Infrared Sounder (MODIS/AIRS) Processing Package (IMAPP) has been providing EOS Terra and Aqua direct broadcast users with the capability to calibrate and navigate locally received satellite data since 2000. This NASA funded software package has expanded to include a number of environmental data products of significant regional interest and is freely distributed to end users by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison. IMAPP can be downloaded via anonymous ftp at http://cimss.ssec.wisc.edu/~gumley/IMAPP/.

The current package now contains collection 5 software which will create MODIS products including:

- calibrated/navigated radiances,
- cloud mask, cloud top properties,
- cloud phase,
- retrievals of atmospheric profiles,
- total precipitable water vapor,
- aerosol optical depth,
- sea surface temperature, and a
- near-infrared technique to determine atmospheric water vapor.

In addition, the package also includes AIRS sounder suite calibration and navigation software for the AIRS and AMSU instruments. Two complementary techniques for generating temperature and moisture profiles from the AIRS Sounder suite have now been added, one using a physical based algorithm and the other a clear sky only statistical algorithm at single AIRS pixel resolution. Finally, AMSR-E calibration and navigation software is available along with science production software for generating rain rate and soil moisture.

Future enhancements to IMAPP will include a new way to execute the software, automatically retrieving all required dynamic ancillary data, as well as an updated distribution Web page. Other future additions include:

- AMSR-E sea surface temperatures and snow/water equivalent software,
- AMSU liquid water path software,
- AIRS/MODIS collocation software and combined products,

and the transition to the next generation of direct broadcast software, the International Polar Orbiter Processing Package (IPOPP), will begin and encompass a broad array of instruments and platforms from NPP/NPOESS VIIRS and CrIS to MetOp IASI.

Beyond the EOS direct broadcast software development, distribution, and user support, the IMAPP team at CIMSS/UW also has conducted training workshops to educate software users in general remote sensing principles, sensor characteristics, data processing techniques, processing algorithms, product applications, and real time utilities. IMAPP workshops conducted so far were at:

- 2004 – Nanjing, China
- 2004 – Perth, Australia
- 2005 – Taipei, Taiwan
- 2005 – Bejing, China
- 2006 – Andenes, Norway
- 2006 – Pretoria, South Africa

The CIMSS/UW IMAPP and IPOPP team will continue its effort in supporting ITWG and global direct broadcast users in the form of:

- Developing and distributing production software (Level 1 and level 2 data and products),
- Providing processing scripts and cluster processing expertise,
- Developing and providing visualization tools, and
- Conducting tutorials and workshops for many more years to come.

3.4 FAST RADIATIVE TRANSFER MODEL (RTTOV)

The development of the RTTOV fast radiative transfer model — part of the EUMETSAT-sponsored NWP-SAF activities — is continuing since the release of RTTOV-8 in November 2004. Around 180 users worldwide have received the new version. For your free copy, visit the URL below and click on 'software requests' in the right panel. A few bugs have been detected in the code and the fixes to these are available together with all the documentation from the RTTOV Web site at: http://www.metoffice.gov.uk/research/interproj/nwpsaf/rtm/.

Since ITSC-XIV the RTTOV_SCATT code has been rewritten and released as part of the updated model RTTOV-87. Work is ongoing to make the code more efficient on vector machines. Both RTTOV-7 and RTTOV-8 participated in the AIRS radiative transfer comparison exercise which is reported as a paper in this conference proceedings.

New coefficient files are now available both for RTTOV-7 and RTTOV-8 from the Web site which currently are:

- MetOp (n.b. satellite id=2)
    - IASI
    - HIRS
    - AMSU-A
    - MHS
    - AVHRR
- MSG-2 SEVIRI
- GOES-12 sounder
- MeghaTropiques
    - Saphir
    - Madras

Work is now proceeding on the development of RTTOV-9 due for release in the Spring of 2007. The major enhancements are:

- Inclusion of multiple scattering for cloudy and aerosol radiance calculations
- Linear in tau mean path values
- Zenith angle dependence of path
- Include reflected solar for SWIR
- More active trace gases CO, CH_4, N_2O,
- Further optimisation of predictors
- Minor improvements to RTTOV_SCATT (new Mie tables)
- Change interface to allow profile input on user levels
- Change interface to avoid need to specify polarisation index

Most of these changes are described in more detail in the talk by M. Matricardi given at this conference. It is planned to make the science changes optional so that RTTOV-9 is backward compatible and be able to reproduce the results of RTTOV-8 if required.

If you would like to be informed about RTTOV developments, bugs in the code, and new coefficient files you can join an RTTOV email list by sending an email to: nwpsaf@metoffice.gov.uk and requesting to be added to the list.

3.5 COMMUNITY RADIATIVE TRANSFER MODEL (CRTM)

Gas Absorption

Currently CompactOPTRAN, a polychromatic algorithm, is used for all sensors. Work is underway to allow the integration of different gas absorption algorithms (e.g. OPTRANv7, SARTA, RTTOV) simultaneously. The methodology to allow this is still being tested and will require a minor change in the CRTM User Interface.

Initial work on the integration of the RTTOV gas absorption algorithm into the CRTM was undertaken by Roger Saunders (Met Office) during a visit to the JCSDA in April-May 2006. Completion of the initial integration of RTTOV in the CRTM extended from the forward model to the tangent-linear (TL), adjoint (AD), and K-matrix (KM) models during a visit by Paul van Delst (CIMSS/EMC/JCSDA) to the Met Office in Aug-Sep 2006. Details of the results of this work are available as NWP-SAF Visiting Scientist Reports.

OSS (Optimal Spectral Sampling), a monochromatic algorithm, has been integrated into an earlier version of the CRTM. This code is still being tested.

Cloud Scattering

The initial cloud scattering module of the CRTM produces optical parameters for six different cloud types: water, ice, rain, snow, graupel, and hail. The optical parameters are interpolated from a lookup table (LUT) based on effective radius and water amount. This module is currently being tested for continuity across the LUT hinge points, and consistency between the forward, tangent-linear (TL), and adjoint (AD) models. that are used in the scattering radiative transfer.

Aerosol Scattering

The code to provide the optical parameters for aerosol scattering is still under review and has not been integrated into the CRTM. This code performs similarly to the cloud scatter module in that it uses a LUT to provide the optical parameters. Seven aerosol types are included in the table: dust, sea salt, dry organic carbon (OC), wet OC, dry black carbon (BC), wet black carbon, and sulphates.

Surface Optics

The surface optics portion of the CRTM has infrared (IR) and microwave (MW) models for the four basic surface types: land, water, snow, and ice. Each basic surface type has within it categories of allowable subtypes. The non-water IR surface models are rudimentary and are placeholders for further development. The integration of the CIMSS/SSEC IR land surface emissivity database into the CRTM SfcOptics module is underway. The inclusion of IR land surface emissivity models is being investigated.

Radiative Transfer

The current radiative transfer solver in the CRTM is the NESDIS advanced doubling-adding module. The UW-SOI is also available and is still being tested in the CRTM.

3.6 FREQUENCY MANAGEMENT

This technical Working Group met during ITSC-XV. Jean Pla (CNES) has taken over the leadership of the group from Guy Rochard. A comprehensive presentation was given on the latest status regarding microwave frequency protection for passive sounders during the ITSC-XV conference and a paper containing detailed information is available in the conference proceedings. During the Conference, the following issues have been discussed.

- Several examples of radio frequency interference on passive sounder data have been presented at 6 and 10.6 GHz.
- Review of two agenda items for the next World Radio Conference to be held in October 2007.
- Study the impact on meteorological forecast and climate modeling of having corrupted measurements within the field of view of a passive radiometer.

Examples of RFI

One example especially deals with the sharing situation within the band 10.60-10.68 GHz: it was shown that large degradation due to interference is experienced over **Japan**, **UK** and **Italy**. It is to be noted that only one form of interference (horizontal polarization emissions) is shown, and fails to demonstrate how extensive undetectable interference is. However it is reasonable to assume that in regions of extensive detectable RFI there are likely to be larger areas of undetectable interference. Therefore, detectable interference at high levels is a symptom of a problem, but absence of detectable RFI does not imply that there is not a problem. This situation illustrates that the problem is real and growing given that such signatures were not detectable a few years ago.

Another dramatic example is the interference situation experienced by space borne passive sensors in 6-7 GHz. This band is very useful for monitoring soil moisture, sea surface temperature and sea surface wind speed. According to observations made by JAXA at 6.9 GHz (350 MHz bandwidth), the AMSR (Advanced Microwave Scanning Radiometer) mounted on the ADEOS-II, and the AMSR-E mounted on the AQUA, it was noticed that this band is highly polluted in most of the countries and corresponding observations are becoming more and more difficult due to the very high level of interference. Moreover, it appears that this interference seems to increase year by year.

The next World Radio Conference (WRC)

The next World Radio Conference which will be held in October-November 2007 (WRC-07) contains two agenda items (1.2 and 1.20) dealing with passive services. Agenda item 1.2 deals with in band sharing for the shared frequency bands 10.6-10.68 and 36-37 GHz with Fixed and Mobile Service. Agenda item 1.20 deals with out of band emissions since the frequency bands under consideration are exclusive (1400-1427 MHz, 23.6-24 GHz, 31.3-31.5 GHz, 50.2-50.4 GHz and 52.6-52.8 GHz). A solution which is preferred by the space and meteorological agencies is the inclusion of limits in terms of power or radiated power of active services within the frequency bands of passive services in the regulations.

The World Administrative Radio Conference in 1979 allocated both bands 10.68-10.7 and 36-37 GHz to the EESS (passive) on a co-equal basis with the FS and MS services. The objective of agenda item 1.2 is to review the sharing situation between passive and active services at 10.6 and 36 GHz and to propose if necessary adequate limits for MS and FS. The most appropriate method in order to better protect the shared passive band at 10.6 and 36 GHz is to introduce within the Radio Regulations a single entry emission limit taking into account the results of the compatibility analysis. Those limits would be non-retroactive for the terrestrial active systems notified or brought into use before WRC-07 (the exact date corresponding to this concept will have to be decided by WRC-07).

Allocations for EESS (passive) were established by WARC-79 at specific frequencies where passive sensing of important parameters are uniquely possible. These allocations were necessarily adjacent to allocations for active services, many of which have been implemented for active transmission systems that, like EESS (passive) measurements, are also vital to national economies, and safety-of-life applications in some cases. Active systems in adjacent or nearby bands emit unwanted emissions that fall within the EESS (passive) allocations (Radio Regulation (RR) numbers **1.144-1.146** and Appendix 3), thus presenting a risk that unwanted emissions could cause unacceptable interference to EESS (passive) measurements.

Prior to WRC-03, ITU-R conducted studies between the EESS (passive) and active services in certain adjacent or nearby bands. WRC-03 did not reach any agreement and decided to further the studies for specified pairs of frequency allocations EESS (passive) and active services. Preliminary calculations have shown that low levels of interference received at the input of the passive sensors may degrade passive sensor operations according to the thresholds contained in Recommendation ITU-R S.1029-2.

Concerning the band pairs under investigation for agenda item 1.20, it is to be noted that only **5.340** bands are considered for this agenda item, since these bands are in principle protected from in-band emissions (except for the automotive short range radars which have been unfortunately authorized in some countries). It is assumed that due to their status provided by **5.340** (« All emissions are prohibited »), those bands are able to receive RFI from services in operation in adjacent bands only: those kinds of RFI are also known under the name of unwanted emissions (composed of spurious emissions and of out of band emissions).

For each band pair as mentioned in ITU-R Resolution 438, the Conference may decide a method to satisfy the Agenda Item. The main objective is to ensure equitable burden sharing for achieving compatibility between active and passive services. It is to be noted that the Conference may decide that, for a given band pair, no regulatory measures are required. The method which is preferable is to propose for each band pair a mandatory power limit for unwanted emissions from a single transmitter of a specified service in an adjacent or nearby band.

Impact of corrupted measurements (non natural or derived from man made emissions)

Generally the impact of RFI or wrong measurements derived from non-natural or man-made transmissions within satellite passive bands is not precisely known, especially within ITU-R

One issue that needs to be clarified is: if the proposed limits, which are based on internationally agreed recommendations for the protection of microwave passive sensors are exceeded, what are the actual consequences in terms of reliability of the weather forecasting, climatology and monitoring of the environment? What are the consequences on the weather forecast if, for example, some sounder fields of view are corrupted with bad data due to non-natural emissions at 24 or 50 GHz? It is now becoming urgent to get a good *quantitative* explanation of the various levels of degradation. It is still possible to keep arguing that it is not easy to derive this kind of information since complex algorithms are needed to model the atmosphere which is known to be unpredictable in nature. However, Space and Meteorological Agencies have to bring evidence to the regulation authorities that interference exceeding the levels quoted in the ITU recommendation, RS.1029-2, will corrupt the atmospheric measurements for weather forecasting and climate monitoring purposes.

It is recognized that the impact of potential interdependencies of interference in various passive bands is a complex issue that has not been studied thoroughly in the ITU–R including if the extent of interference in one band has any impact on measurements in another band.

Another issue is the impact of missing data, due to high level of interference. As the data are known to be bad over the same area of the globe, they are systematically deleted from the dataset to be used. What are the consequences if data are lost? It is recommended that studies should continue in order to properly assess the impact of corrupt data (exceeding the corresponding radiometric resolution of the passive sensor) showing the level of degradation of the NWP or climate modeling.