## 2.4 ADVANCED SOUNDERS

*Web site:* http://cimss.ssec.wisc.edu/itwg/aswg/

*Working Group members: Dieter Klaes (Co-Chair, EUMETSAT), William L. Smith* (*Co-Chair, SSEC/UW-Madison and Hampton Univ.*), *Nigel Atkinson (Met Office, UK), Chris Burrows (ECMWF), James Cameron (Met Office, UK), Keyi Chen (CU2T), Yong Chen (NOAA/STAR UMD), Chu-Yong Chung (NMSC/KMA), Olivier Coopmann (Météo-France), Dorothée Coppens (EUMETSAT), Mohamed Dahoui (ECMWF), Reima Eresmaa (ECMWF), Imane Farouk (Météo-France), Vincent Guidard (Méteo-France), Liam Gumley (CIMSS/SSEC), Stephan Havemann (Met Office, UK), Junhyung Heo (NMSC/KMA), Tim Hultberg (EUMETSAT), James Jung (CIMSS), Norio Kamekawa (JMA), Hyeyoung Kim (NMC/KMA), Allen Larar (NASA LaRC), Zhenglong Li (CIMSS/SSEC), Agnes Lim (CIMSS/SSEC), Qifeng Lu (CMA/NSMC), Will McCarty (NASA GSFC), Kim Meeja (NMC/KMA), Stefano Migliorini (Met Office, UK), A.K. Mitra (I.M.D., MDES, Delhi), Kozo Okamoto (JMA/MRI), Ed Pavelin (Met Office, UK), Alexander Polyakov (SPBSCU), Hank Revercomb (CIMSS/SSEC), Kirsti Salonen (ECMWF), A.K. Sharma (NOAA/NESDIS), Joe Taylor (SSEC), Bertrand Theodore (EUUMETSAT), Robert Tubbs (Met Office, UK), Alexander Uspensky (SRC "Planeta"), Francesca Vittorioso (Météo-France), Likun Wang (Univ. of Maryland), Qiang Zhao (NESDIS/STAR)*

### 2.4.1 Introduction

The Advanced Sounder Working Group (ASWG) focuses on scientific issues affecting the optimal performance of advanced satellite sounder systems. The working group reviews the status of the development of advanced sounder systems and recommends changes pertaining to instrument specification, performance, data processing, and utilisation. For the purpose of this group, "Advanced Sounders" are defined as instruments that present significant new scientific and technological challenges and which require new methods for data processing and utilization. Thus, Advanced Sounders currently include high spectral/spatial resolution passive infrared and microwave sounders and active sensors.

### 2.4.2 Advanced Sounding from Polar and Geostationary Orbit

Improved sounding from polar orbit has been one of the highly recommended action items from ITWG. The consideration for advancing polar orbiting sounding improvements includes high spatial resolution and denser spatial sampling to increase the density of high quality clear air radiance measurements commensurate with finer grid size of current and future NWP models as well as improvements in absolute accuracy, traceable to radiometric standards, and spectral coverage for the purpose of cross-calibration of instruments of lesser accuracy in geostationary and polar orbits. The ASWG noted with satisfaction the progress towards achieving the availability of hyperspectral infrared soundings in the Polar Orbit: Meteor-M (IKFS-2), FY-3D (HIRAS), JPSS-1, FY-3E in the early morning orbit. The ASWG noted also with satisfaction the arrival of the first geostationary hyper-spectral sounding mission in geostationary orbit on FY-4A (GIIRS). The ASWG expressed the following related concerns and recommendations:

1) In order to make timely and optimal use of the data it is considered important that the availability of the new data and the provision of scientific support to the new Chinese hyperspectral sounders (GIIRS and HIRAS) be ensured. They will provide an important contribution to the global observing system.
2) The Russian Meteor-M satellite is flying a hyper-spectral sounding instrument (IKFS-2) the data of which provide an important contribution to the global observation system. It was noted that no Direct Broadcast capability is available so far, which

reduces the timeliness of the data for international users. It was noted that the orbit for the next Meteor-M satellite is still being discussed.

3) The ASWG noted progress establishing a geostationary ring of hyperspectral sounders to provide global coverage. With the arrival of FY-4A and the planned arrival of MTG-S, important building blocks of such systems will be available. ASWG likes to re-enforce its recommendation for a geo-hyperspectral sounding coverage over the Americas, where a crucial gap in future geo-hyperspectral sounding coverage exists.

**Recommendation AS-1 to space agencies (CMA)**

**Consider making available as soon as possible the data of the GIIRS hyperspectral data on FY-4A and of HIRAS on FY-3D to the international user community.**

4) ASWG strongly supports the activities of Roshydromet & Roscosmos of the further development of hyperspectral sounders (of IKFS-2 type) for Meteor-M series satellites as well as encourages providing in Near Real Time (NRT) the data from IKFS-2 to the international community. Along with this the ASWG notes the importance of the work on the development of a new generation of IKFS-sounders with improved spatial and spectral resolution. ASWG noted that the orbit for the Meteor-M satellite to be launched next year (2018) was not specified yet.

**Recommendation AS-2 to space agencies (Roshydromet and Roscosmos)**

**ASWG recommends to consider the Direct Broadcast capability for the hyperspectral sounder IKFS-2 data on the Meteor-M satellite.**

**Recommendation AS-3 to Space agencies (Roshydromet and Roscosmos)**

**ASWG further welcomes the planned development of an improved IKFS sounder and recommends pursuing availability as soon as possible.**

**Action AS-1 to ITWG Co-Chairs**

**Bring these recommendations to the attention of Space Agencies at CGMS.**

### 2.4.3 Future Hyperspectral Sounders

The ASWG noted with interest and satisfaction that further work has been performed to demonstrate the advantage of increased spatial resolution in order to improve the probability of a uniform scene with the instrument FOV (all clear or all cloudy). Studies were presented to the ASWG that provided a trade-off for smaller FOVs.

**Recommendation AS-4 to space agencies**

**Implement high spatial resolution and contiguous sampling detector arrays in future hyperspectral infrared sounding instruments.**

**Action AS-2 to ITWG Co-Chairs**

**Bring this recommendation to the attention of space agencies at CGMS.**

The cost and complexity of hyperspectral instruments are some of the obstacles for their fast and widespread development. If proven and flying technologies (e.g., proven imagers) are used as the basis for a new development, it could be possible to achieve a faster implementation and a wider distribution of this measurement technology.

ASWG noted with interest a presentation discussing these aspects. In particular, because of the use of advanced imagers on US, as well as Japanese and Korean geostationary satellites, the ability to achieve geo-hyperspectral sounding, as well as the current imagery, with an upgrade of the imaging instruments appears to represent a potential for enhancing/upgrading the desired global geostationary sounding system.

**Recommendation AS-5 to space agencies (NOAA)**

**Consider implementing a combined imager/sounder instrument approach on future geostationary meteorological satellites.**

**Action AS-3 to ITWG Co-Chairs**

**Bring this recommendation to the attention of space agencies via CGMS.**

### 2.4.4 Use of and Investment in Airborne Systems

ASWG noted the availability of a number of airborne systems, able to carry advanced sounding instrumentation, which can serve as vehicles to foster the development and implementation of advanced space borne instruments and enhanced data processing and application approaches.

**Recommendation AS-6 to space agencies (NOAA & NASA)**

**a) Make greater use and interpretation of available airborne systems.**

**This will serve as pathfinders for new systems, and will be a cost effective way to validate the utility of new higher resolution instruments and the applications of their data.**

**(Primarily to NOAA) Recommend greater field campaign use/exploitation of existing aircraft validation sensors for enhanced measurement system (sensors, algorithms, data products) validation AND data processing/algorithm improvements for handling complex scenes of most meteorological significance (i.e., cold scene retrievals, surface emissivity over snow and ice, aerosols and clouds, etc.).**

**b) Invest in hardware for next generation sounder specification.**

**(NOAA and NASA). Recommend investment for developing advanced aircraft sensor system hardware to enable new and improved airborne validation sensors to serve as pathfinders for the development and risk mitigation for the next generation atmospheric satellite sounding system sensors. The aircraft sensor specifications (spatial, spectral, radiometric, and temporal) should far exceed current day state of the art to fulfil the desired pathfinder role.**

**Action AS-4 to ITWG Co-Chairs**

**Bring these recommendations to the attention of Space Agencies at CGMS.**

### 2.4.5 Data Use

ASWG discussed the pros and cons to distribute apodised or non-apodised data.

**Recommendation AS-7 to space agencies**

**Consider providing non-apodised data to users and having users perform the application related apodisation.**

Alternatively users could use reconstructed radiances using Principal Components of the entire radiance spectrum.

**Action AS-5 to ITWG Co-Chairs**

**Bring this recommendation to the attention of space agencies.**

### 2.4.6 Use of Alternative Satellite Technologies and Related Studies

ASWG encourages concept studies and missions utilizing hyperspectral IR instruments with reduced spectral range and higher spatial resolution on constellations of small satellites (including cube-satellites), to evaluate the benefit of high temporal measurements, and retrievals of temperature and humidity. These could provide a baseline for upcoming geostationary missions in terms of: ideal spatial-temporal sampling and spectral tradeoffs for new applications in clear sky and above cloud such as 3D winds (AMVs derived from humidity fields on vertically stacked pressure surfaces in the troposphere) and time rate of change in atmospheric stability (precursors of severe weather). These types of missions have the endorsement of the National Research Council, NASA, and the NWP community as a potential source of global 3D wind information.

There is a general need to study the utility of sounder measurements from small satellites as supplements to the global observing system. This first includes the characterization of the instruments, which are fundamentally expected to be different from the existing global observing system due to their low-cost, small-sized nature. Second, studies should be conducted to determine how these instrument effects translate onto the exploitation of these observations, be it as retrieved products or within NWP data assimilation.

**Recommendation AS-8 to space agencies**

**Consider conducting studies on the utility of sounder measurements from small satellites.**

**Action AS-6 to ITWG Co-Chairs**

**Bring this recommendation to the attention of space agencies.**

### 2.4.7 Available Expertise to ASWG

The lack of expertise in the room on microwaves, active sounding etc. was noted. However the WG encouraged the development of higher spatial resolution microwave sounder systems to enable these data to be used with hyperspectral infrared measurements for obtaining convective-scale atmospheric sounding measurements.

### 2.4.8 Related Software Issues

Questions regarding the development of the MTG-IRS processing software package were discussed in the Working Group. These related to the process of generating reconstructed radiances, conversion from one PC basis set to another, sub-sampling options, apodisation, and output formats. WG members were encouraged to provide feedback to Nigel Atkinson.