2.4 ADVANCED SOUNDERS

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

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2.4.1 Introduction

This working group 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 Potential Observation Gaps in Geostationary IR Sounding

The WMO vision of the GOS in 2025 asks for a complete coverage of hyperspectral infrared sounders in geostationary orbit; current implementation plans of space agencies only partially consider an implementation. The group recognises a growing concern of potential observation gaps, particularly over America, the Pacific Ocean, and the Indian Ocean.

Recommendation AS-1 to CGMS

To work with operational meteorological agencies to devise a plan to fill gaps in geostationary coverage of hyperspectral infrared sounding data.

Action AS-1

ITWG Co-Chairs to present the concern of this group to CGMS.

2.4.3 Geostationary Satellite MW Sounding

Temperature and water vapour soundings in the microwave region in geostationary orbit have been limited through noisy receivers and antenna size. Acknowledging recent advancements in microwave receiver technology to enable sounding frequency measurements in the microwave spectral regions between 50, 118, and 183 GHz with low noise, it now appears feasible to implement a geostationary MW sounding capability (noting antenna size issues for lower frequencies).

Recommendation AS-2 to space agencies

Pursue the development of advanced microwave sounders for geostationary satellites and pursue a demonstration of this new technology from aircraft and/or satellite.

Action AS-2

ITWG Co-Chairs to present the recommendation of this group to relevant Space Agencies (e.g., NASA, ESA, JAXA).

2.4.4 Improved Sounding from Polar Orbit

Considerations for advancing polar orbiting sounding capability improvements include higher spatial resolution and denser spatial sampling to increase the likelihood of clear soundings, commensurate with finer grid size of future NWP models, as well as improvements in spectral resolution and detector signal to noise performance. With new technological developments, the employment of infrared detector arrays, which allow for higher spatial resolution at reasonable noise increase, seems feasible. It has been realized that the limitation of the use of hyperspectral radiances for sounding retrieval and model assimilation is cloud and forward model noise rather than the instrument detector noise level (i.e., the atmospheric and spectroscopy errors produce higher uncertainties in the difference between measured and calculated radiance spectra than does the instrument detector noise). Thus, the working group urges designers of next generation polar sounding systems consider these limitations in performing trade-offs between detector noise, Field-of-View size, and spectral resolution. Simulation experiments could be conducted using high spatial resolution NWP model nature runs provided by NWP centres.

Recommendation AS-3 to space agencies

Conduct studies to trade off benefits of spectral, radiometric, and spatial resolutions of infrared sounders considering the noise floor due to atmospheric noise and current errors in spectroscopy.

Recommendation AS-4 to NWP Centres

Provide the results of a global nature run which has the highest possible (ideally at least 1-km) spatial resolution which can be used in simulation studies to determine the optimal trade-offs between instrument FOV size, spectral resolution, and spectral resolution for advance sounding from Polar orbit.

Action AS-3

ITWG Co-Chairs to present the concerns of this group to space agencies and operational satellite user agencies to form expert teams to conduct studies leading to the improved designs of next generation polar satellite atmospheric sounding instruments.

Recommendation AS-5 to NASA and NOAA

Form an interagency science working group to develop an optimal design for the next generation infrared sounder (evolution of CrIS) for the JPSS-2 and follow-on satellites.

Recommendation AS-6 to EUMETSAT and CNES

Re-evaluate the current design priorities for the IASI-NG considering the noise floor limiting the utility of these data posed by FOV size related cloud contamination and atmospheric and forward model noise.

Action AS-4

ITWG Co-Chairs to present the recommendation of this group to NASA/NOAA and EUMETSAT/CNES.

Action AS-5

Groups interested in high-resolution nature runs to request existing nature runs from ECMWF and NASA GMAO, and to work with these and other NWP centers to create a global high (ideally towards 1-km) resolution nature run that can be used to develop the specifications for next generation satellite sounding instruments.

2.4.5 Apodisation of CrIS Data

CrIS was designed with a spectral resolution that is closely adapted to the CO2 line spacing. The CrIS 399 BUFR channel set is Hamming apodised. This set preserves most of the spectral information content of the full CrIS spectra but cannot be reversed to unapodised radiances. Hamming apodization does 3 things: i) localizes the SRF (i.e., removes the large side-lobes of the unapodised SRF and increases the FWHM of the central lobe by ~50%), ii) reduces the random noise in the radiances by ~40%, and iii) correlates the noise in adjacent channels by 63% and channels separated by 2 samples by 13% (NOTE: channels separated by more than 2 samples remain uncorrelated). Applications that cannot handle correlated (i.e., off-diagonal) instrument noise will not realize the full spectral potential of unapodised radiances. Most NWP users today make use of a sub-set of spectral samples and therefore will suffer from lost performance if they use adjacent apodised radiances with a diagonal instrument error covariance. Also, by using a reduced set of spectral radiances, the statistical random spectral noise reduction benefit of using the entire spectrum of radiance is lost unless Principal Component (PC) reconstructed radiances are used in place of the original radiance measurements and forward model calculations.

Recommendation AS-7 to users

Provide, in addition to the CrIS 399 channel subset of apodized radiances, either a set of reconstructed apodized radiances or a set of PC scores for a given set of leading PCs used to reconstruct the radiances. Also consider the provision of either a set of unapodised radiances or a (smaller?) set of reconstructed unapodized radiances along with the corresponding leading PCs used to compute them.

Action AS-6

Advanced Sounders Working Group Co-Chairs to present the concern of this group to ITWG users of CrIS data.

2.4.6 MW Sounder FOV size

It is desirable to use MW sounding data with hyperspectral infrared radiances for obtaining soundings in the presence of clouds. Also, global numerical models that utilize satellite data will soon have a spatial resolution which far surpasses the horizontal resolution of current MW sounding instruments.

Recommendation AS-8 to space agencies

Investigate the use of new MW technology to enable future MW sounding instruments to possess a field of view size which is closer to that provided by hyperspectral infrared sounders and the spatial resolution expected for future global NWP models, without compromising the noise performance.

Action AS-7

ITWG Co-Chairs to convey the need for higher spatial resolution MW measurements for utilization with future polar satellite hyperspectral radiances in

the presence of clouds and to better approximate the resolution of future global NWP models.

2.4.7 SI Traceable Reference Instruments for improved climate observatories

The AS working group believes that the advent of advanced climate observatories to benchmark the Earth's climate (using spectrally resolved IR and reflected solar radiances plus GPS radio-occultations like the NASA Tier 1 CLARREO Mission) could be used to cross-calibrate operational sounding instruments to SI-traceable standards which would increase their value for quantifying the climate state and decadal trends.

Recommendation AS-9 to space agencies

Develop, test, and implement an SI Traceable radiometric standard in space as soon as feasible. Particularly, the ASWG encourages early pathfinder demonstrations of new technologies for referencing these measurements to International Standards on-orbit. As a specific example, an International Space Station flight of the new technologies developed for CLARREO with NASA Earth Science Technology Office (ESTO) support would be especially valuable for furthering a full-up mission.

Action AS-8

ITWG Co-Chairs to convey this recommendation to space agencies via CGMS.