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WMO WP-22 ADD.1
Prepared by WMO
Agenda item: C.2

UPDATE ON THE STATUS OF THE INITIATIVE FOR AN INTERNATIONAL GEOSTATIONARY LABORATORY (IGeoLab)

Results of the 2nd meeting of the IGeoLab Focus Group on GEO-microwave

(Submitted by WMO)

Summary and purpose of document

This Addendum provides last-minute information on the outcome of the 2nd meeting of the IGeoLab Focus Group on GEO-microwave, held in Rome on 24-25 October 2005.

The meeting was aimed at consolidating as many aspects as possible of the science backing the GEO-microwave concept, and to identify residual issues still controversial or yet to be faced, so as to better address future efforts.

ACTIONS PROPOSED

CGMS to note the report and discuss as appropriate. A list of envisaged future activities is provided in the concluding section. The following is recorded:

"CGMS encourages its Space Agency Members to provide continuity of funding for the scientific studies on GEO-microwave, pending the establishment of a consolidated study programme once a space agency has accepted the role as lead space agency in the implementation of the IGeoLab GEO-microwave project".

Introduction

1. The International Geostationary Laboratory (IGeoLab) activities following the CGMS XXXII deliberation (see Action 32-19) have been reported under WMO WP-22. Results were quoted, i.a., of the 1st meetings of the Focus Group on GIFTS (6 June 2005) and on GOMAS (7 June 2005). In addition, information was provided about further development of the idea to host GIFT on Elektro-L (USA-Russia bilateral contact assisted by the WMO Space Programme).

2. As for the follow-on of the GOMAS project, the 2nd meeting of the Focus Group was held on 24-25 October 2005, only one week before start of CGMS XXXIII. Because of the late delivery, the report of GOMAS FG-2 is provided as an addendum of WMO WP-22.

3. The Focus Group has decided to refer, from now on, to "GEO-microwave" instead of GOMAS, since the term "GOMAS" is traditionally associated to a specific satellite configuration, whereas the current understanding is that the Focus Group, for the moment, is not concerned with technical solutions, pending the identification of a Lead Agency.

Organization of GEO-microwave FG-2

4. GEO-microwave FG-2, sponsored by the WMO Space Programme and the International Precipitation Working Group (IPWG), was hosted by the "Istituto di Scienze dell'Atmosfera e del Clima" (ISAC) of the Italian "Consiglio Nazionale delle Ricerche" (CNR), in Rome. The invitation was limited to the members of the so-called "GOMAS Team", i.e. the 45 participants of the GOMAS Proposal submitted to ESA in August 2005 in response to the Call for Ideas for the next Earth Explorer "core" missions. Specific experts from the Team were charged of reporting about their work addressing outstanding questions of the GEO-microwave scientific aspect. Representatives of ESA and EUMETSAT attended as observers. The Agenda was as follows.

	Welcome from the Host Institute Interest of GEO-microwave for Nowcasting and Civil Protection	**Franco Prodi (ISAC)**
1.	**Introductory items**	
1.1	**Short reminder of the IGeoLab concept**	**Tillmann Mohr (for WMO)**
1.2	**Short report of the 1st IGeoLab GOMAS Focus Group**	**Bizzarro Bizzarri (for GOMAS)**
2.	**Requirements for frequent observation of precipitation**	
2.1	**Sampling rate requirements of different precipitation types**	**Joe Turk (NRL, for IPWG)**
2.2	**Impact of sampling rate in climatic and research applications**	**Vincenzo Levizzani (ISAC)**
2.3	**Impact of sampling rate on detection capability and cumulate precipitation accuracy**	**Massimo Ferri (Italian Meteo)**
2.4	**Simulated precipitation systems and impact of sampling on retrieval accuracy**	**Albin Gasiewski (NOAA/ETL)**
3.	**Basic modelling of the cloud-radiation-precipitation relationships**	
3.1	**Cloud ice and sub-mm radiation**	**Sreerekha Ravi (UniBremen)**
3.2	**Simulation study of precipitating clouds from geostationary orbits with passive MW**	**Mario Mech (UniMunich)**
3.3	**Results of channel optimisation studies**	**Sabatino Di Michele (ECMWF)**
4.	**Retrieval aspects**	
4.1	**Multi-band/multi-parameter retrieval from GOMAS bands**	**Alberto Mugnai (ISAC)**
4.2	**Capability of temperature-humidity profiling by GOMAS bands**	**Sabrina Pinori (ISAC)**
4.3	**Impact of resolution on retrieval: resolution enhancement by image processing**	**Stefano Dietrich (ISAC)**

5.	**Assimilation of precipitation data or brightness temperatures in NWP**	
5.1	**Prospects for NWP assimilation and future airborne campaigns**	**Albin Gasiewski (NOAA/ETL)**
5.2	**Requirements and utilisation philosophy of GEO-microwave data in NWP**	**Amy Doherty (UKMO)**
6.	**Calibration/validation**	
6.1	**IPWG cal/val framework to support GEO-microwave**	**Joe Turk (NRL, for IPWG)**
7.	**General discussion on the state-of-the-art of the scientific aspects of GEO-microwave**	
	- **Statement of consolidated findings.** - **Identification of problem areas to be focused on.** - **Outline report to CGMS.**	**Moderators:** **Tillmann Mohr (for WMO)** **Bizzarro Bizzarri (for GOMAS)**

5. It had been decided at the GOMAS FG-1 that FG-2 should be devoted to review and consolidate the scientific knowledge so far acquired on millimetre-submillimetre wave sounding from GEO. The purpose was to collect and understand experiences, identify and consolidate items on which consensus is collected, and define follow-on work necessary to consolidate further items currently controversial or not yet faced.

6. This document does not constitute the Report of the meeting. It is only a short summary of the main conclusions of the various sessions defined in the Agenda. The full Report will be available later. All presentations have been loaded on the site:

ftp://bizzarri@albert.ifa.rm.cnr.it
username: bizzarri
password: bproject
directory: IGeoLab
sub-directory: GOMAS
folder: FG-2.

Requirements for frequent observation of precipitation

7. FG-2 devoted much effort to demonstrate "beyond any reasonable doubt" that, although the ability of NWP in predicting precipitation is and will continuously increase so as to meet user requirements from several applications, observing precipitation is still a strong requirement for many applications. In addition, frequent observation (i.e., from GEO) is almost always requested. Examples of this requirement were shown not only for nowcasting and hydrology, but also for large-scale features (e.g., tropical cyclone because of spinning) and for regional climatology, and regional climate change, since in several areas climate is dominated by the recurrent occurrence of local-scale fast developing precipitation structures (e.g., orographic enhancement, impact of the diumal cycle …). Other application that would benefit from mm-submm sounding is light rain and snowfall observation over land although, in this case, frequent sampling from GEO might not be necessary.

8. The strong need for frequent observation is demonstrated by the current effort to merge accurate MW-derived measurements from LEO with frequent IR imagery from GEO, a practise that leads to a product of rather variable quality. As a minimum, GEO-microwave would strongly improve and regularize the accuracy of such products by replacing IR with mm-submm.

9. Several experiments were shown, aiming at evaluating the optimal time sampling for precipitation. Animations of simulated images at mm-submm frequencies have shown that the precipitation pattern evolution, both in convective and frontal situations, is well depicted if the sampling interval is < 30 min, whereas several features appear and disappear in the 3-hour interval of GPM. One investigation was shown, on the effect of time sampling on the accuracy of cumulate precipitation computation, resulting in dramatic differences between 3-hourly and 15-min sampling.

10. Although there is full consensus on the necessity of frequent precipitation observation, it was felt necessary to support this requirement with quantitative evidence of the impact of the sampling interval on products quality, function of regional climate and addressed application.

Basic modelling of the cloud-radiation-precipitation relationships

11. Work aimed at demonstrating the correlation between mm-submm observation, mostly ice-sensitive to the upper part of the cloud, and precipitation at ground, have progressed well. Also, much evidence has been added supporting the principle that, in absorption bands, it is feasible to observe all sort of precipitation, including light rain and snowfall, especially over land. One aim of this sort of studies was to "rank" the benefit of the different proposed bands (currently 54, 118, 183, 380 and 425 GHz) and channels in a band (ranging from four or less to 10 or more) and assess the need for window channels.

12. There is an apparent spread of results from the different scientific groups. Some studies indicate priority for highest frequencies, some for lower ones; some demonstrate that temperature sounding bands carry more information, some that water vapour bands are more effective. As for windows, the need for a 340 GHz channel seems to gain consensus, but 90 GHz and others are also supported.

13. When trying to collect consensus on a prioritised list, it appeared that the problem is ill-posed. In fact, the optimal set of bands/channels depends on the addressed application. Examples were shown such as: large-scale systems over the ocean have preference for low frequencies (more sensitive to liquid water) whereas continental precipitation at high latitude prefers high frequencies (more sensitive to ice); and, in addition to these two extremes, a variety of intermediate cases.

14. It was realized, therefore, that a "vectorial" list of prioritised bands/channels does not make sense, and could never collect consensus, since each group (or, ultimately, delegation in governing boards) have different interests. Rather, a "matrix" should be populated, with various entries corresponding to typical applications identified by climatic regions (i.e., dominant precipitation types) and addressed application (nowcasting, NWP, hydrology, agricultural meteorology, …). The optimal configuration will ultimately be decided by the funding agency and/or relevant region.

15. It was noted that, currently, only few applications have been studied. The Americans have focused on tropical cyclones, Europeans on light rain and snowfall (because of the EGPM project). In the IGeoLab context, more situations need to be analysed (e.g., monsoon). It is necessary that work on the basic relationships between mm-submm observation and precipitation at ground continues and extends to more groups potentially interested to be partners in IGeoLab.

Retrieval aspects

16. So far, highest priority was assigned to the demonstration that the information content would be sufficient. In cascade, however, it is necessary also to demonstrate that the information can be retrieved, i.e. that the inverse problem can be solved. Currently, precipitation retrieval from MW in LEO makes extensive use of external information in the form of forcing the solution towards *a-priori* cloud radiative models resident in a database. With GEO-microwave, more information on the atmospheric structure (temperature and humidity sounding channels) is internal to the system so, in principle, the retrieval is supported by more independent pieces of information. Exercises of multi-band retrieval were shown, synergistically exploiting the differential information of the various bands.

17. The activity on retrieval enables to measure the impact of the different bands on the retrieved product, taking into account practical problems, first of all the coarse resolution of the lower frequencies, that are the most sensitive to the lower troposphere and to liquid precipitation (thus the most attractive, in principle).

18. Experiments aimed at evaluating the effectiveness of image processing to enhance resolution, function of the available oversampling and Signal to Noise Ratio (SNR) at the various frequencies, were presented. Very promising results were shown, particularly for the lower frequency bands where heavy oversampling is available.

19. It was considered very important that this activity continues up to full characterization of the achievable performances and the applicable conditions. Also, it was noted that past work can be recovered and actualised to the GEO-microwave concept. The outcome could be very relevant for the selection of the 54 GHz band.

20. Focus was also placed on the matter of full temperature and humidity profiling, currently not a priority, but supported by several experts. Initial work was presented, showing that the

performance could, in principle, be better than with AMSU (in fact, there are two more temperature-sensitive bands, and one more water-vapour band, that provide contribution in the mid- high-troposphere); and, of course, the product would be much more frequent. The experiment also started assessing the impact on non-precipitating clouds over the retrieval, aiming at determining to which extent mm-submm sounding can be considered "cloud-free".

21. It was considered important to continue working on this subject aiming at characterizing the possible product accuracy and how close to the precipitating "cores" useful soundings can be retrieved. In fact, there are experts who argue that the availability of frequent temperature/humidity profiles in clear-air, through non-precipitating clouds and in the proximity of precipitating cores would impact on Quantitative Precipitation Forecasting more than the observed precipitation itself.

Assimilation of precipitation data or brightness temperatures in NWP

22. The assistance of NWP models in precipitation retrieval from GEO-microwave will be essential. In fact, although a great amount of information (on temperature, humidity, water phase, drop size) is internally provided by the observing system (several absorption bands at several frequencies), it will always be an "incomplete" dataset, since most information on the cloud interior, particularly on the lower layers, is simply not observable. Currently, this information is input through an *a-priori* cloud radiative model database, pre-built by using a Cloud Resolving Model (CRM) to generate the microphysical parameters inside the cloud. In future, it will be possible to use the CRM on-line in predictive mode. "Locking" the retrieval to a NWP/CRM model will also facilitate keeping self-consistency of the observed precipitation pattern. Spectacular examples of this concept were presented at FG-2.

23. The reciprocal aspect is: what is the most valuable information from GEO-microwave to NWP ? Current thinking is that the main interest is for "fresh" information in respect of that one that the NWP already carries forward. This is the precipitation itself or, better, the brightness temperatures that are mostly correlated with precipitation, to be directly assimilated. Of course, as noted in sections 13 and 14, the most valuable channels change with the scale, the geographical position and the purpose of the NWP model.

24. Work in this area should continue, in both directions: NWP support precipitation retrieval efforts and input of value-added information on precipitation to NWP.

Calibration and validation

25. In principle, cal/val of GEO-microwave products will be facilitated because of the abundance of ground truth (radar and raingauge) over the (continental) field of view, and the space-time co-registration assured by the geostationary orbit. In practise, there is the problem of the measurement being very much indirect, therefore it will not be easy to clarify and characterise the error structures. The cal/val worldwide international structure being set up by IPWG is regarded as the baseline framework.

26. The need for experimental data from airborne campaigns has been re-emphasised. This will support radiative transfer modelling and retrieval algorithm development, and also will provide essential information for instrument design. The case for flying a (nearly-available) radiometer equipped with the mm-submm channels and the "conventional" SSM/I channels as reference was already put forward at the two IPWG workshops (Madrid 2002 and Monterey 2004), and subject of Action CGMS 32-16 (recommendation to R&D space agencies to support as much as possible the IPWG request for procuring experimental data). However, in spite of strong progress for planning the campaign and preparing the radiometer, moving to implementation was not possible, due to relatively high cost. FG-2 considered that it is not realistic to implement the campaign before a Leading Agency to support the implementation of GEO-microwave within the IGeoLab context shows up. However, it was considered that implementation of an airborne campaign should be the first item on the agenda of the Leading Agency.

Follow-on activity

27. In summary, the state-of-the art on the scientific aspect of GOMAS is considered rather satisfactory. Progress has being recorder in all sectors, no blocking difficulty has emerged so far, nor is expected to emerge in future, and no missing area has been identified so far. The status achieved so far would justify the start of the implementation of an IGeoLab GEO microwave mission ny a Lead Space Agency.

28. The following points may be highlighted:

There is a need:

- From section 10 – to provide quantitative evidence on the impact of time sampling on products quality, function of regional climatology and addressed application;
- From section 15 –to continue work on the basic relationships between mm-submm observation and precipitation at ground – Plot bands/channels priorities spread by regional climatology and addressed application – Extend cooperation to more groups potentially interested to be partners in IGeoLab so as to consider their requirements in the context of stating bands/channels priorities;
- From section 19 – to focus on image processing activities aimed at enhancing resolution;
- From section 21 – to focus on the characterisation of temperature and humidity profiles as a deliverable, specifically in cloudy areas as close as possible to precipitating cores;
- From section 24 – to continue investigating how Cloud Resolving Models used in predictive mode may help precipitation retrieval – To continue to analyse which data from GEO-microwave provide more valuable information for NWP;
- From section 26 – to implement an airborne campaign as soon as a Lead Agency for the IGeoLab GEO-microwave undertaking shows up.

29. It was noted that the continuation of the current studies and the need to better focus certain aspects is at serious risk due to the recent or incoming termination of all studies awarded on the subject by ESA and EUMETSAT. ***It is recommended that CGMS encourages its Space Agency Members to provide continuity of funding for the scientific studies, pending the establishment of a consolidated study programme once a space agency has accepted the role of the lead space agency in the implementation of the IGeoLab GEO microwave project.***

30. The next meeting of the IGeoLab GEO-microwave Focus Group, FG-3, will be organised in April 2006 and will attempt to involve other interested people in IGeoLab, beyond the restricted GOMAS-Team that was invited at FG-2. The Agenda will depend on the success of the idea of involving newcomers.