Third ISMAR Workshop

LERMA, Observatory of Paris
28-30 September 2015

The 3rd International Sub-Millimeter Airborne Radiometer (ISMAR) workshop was organized by LERMA at Observatory of Paris on 28-30 September 2015. The objectives of the workshop were [*1_Prigent_ISMAR_Intro.pdf*]:

- To provide to the European community working on sub-millimeter wave radiometry a status of the instrument itself, on its upcoming technical developments, on future ISMAR-dedicated field campaigns and on possible collaboration with other international measurement campaigns
- To discuss on the ISMAR observations collected during its first research flights,
- To present preliminary results on the analysis of the first ISMAR data,
- To discuss on the way forward for the preparation of Ice Cloud Imager (ICI) using ISMAR.

The workshop consisted in a series of technical and scientific presentations, all related to ISMAR and its potential use in specific field campaigns. Activities related to HALO Microwave Pack (HAMP) were also presented. The list of participants is given in Annex A. The program is available in Annex B. The presentations are available at the following address http://aramis.obspm.fr/~gdr/GDR/Home.html.

Summary of the presentations:

C. Harlow (Met Office) [*1_Harlow_ISMAR_CurrentStatus.pdf*] presented the ISMAR instrument. ISMAR has been designed to passively record simultaneously radiation at 118, 243, 325, 424, 448, 664 and 875 GHz. Currently all channels but 424 GHz and 875 GHz ones are populated. ISMAR is an along track instrument successively pointing downward (+53° to -10° nadir) and upward (+10° to -40° zenith) as well as toward two on-board calibration loads (one is heated, the other running at ambient temperature). A typical ISMAR scan lasts 4 seconds. Hardware activities performed to improve ISMAR instrumental performances have been discussed (e.g., hot target filled with 8-µm polypropylene film, additional ventilation added to the Front-End cover box, additional heaters to the IF enclosure). The ISMAR dual-polarization 874 GHz front-end developed by Omnysis is nearly finished and should be delivered in 2016 without Back-End (Met Office will fund the design and building of the 874GHz Back-End receiver). Omnysis has proposed to build a 424GHz dual polarization Front-End receiver for ISMAR, free of charge. Additional work has been performed to reduce the noise level at 243 GHz observed during the 2014 ISMAR flights.

ISMAR [*1_Harlow_ISMAR_FutureCampaign.pdf*] was operated during two field campaigns: STICCS (Submillimetre Trial In Cirrus and Clear Skies) in November-December 2014 and in COSMICS (Cold-air Outbreak and sub-Millimetre Ice Cloud Study) in March 2015. For the period

2016/2017, FAAM (Facility for Airborne Atmospheric Measurements) should be operated during the Monsoon campaign (India, May/July) and during the CLARIFY campaign (Namibia, September) without ISMAR as it should be undergoing 874 GHz fit and rectification of other ISMAR channels. There should be some flight hours dedicated to ISMAR for flights based from Cranfield (February 2017). For the period 2017/2018, during March 2018, in the frame of the Year of Polar Prediction (YOPP), ISMAR should be operated with opportunity for surface emission work and for mixed phase investigation and maybe some cirrus flights. The possibility for the SALSTICE follow-on, potentially in Spain, was discussed. A cirrus campaign could also be proposed based from Cranfield or through outside funding. For the period 2018/2019, within the Year of Maritime Continent (YMC) program, FAAM should fly to characterize the development of the boundary ahead of convection during the period Jan/Feb 2019 without ISMAR. A cirrus campaign could also be proposed based from Cranfield or through outside funding. For the period 2019/2020, there are no solid plans.
As the FAAM schedule is very busy for the next two years, the interest to operate ISMAR from another platform like HALO or Geophysica was discussed, with obviously needs to evaluate the possibility to install ISMAR on those platforms. The EUFAR program was mentioned as a way to fly ISMAR during dedicated research flights. An airborne campaign dedicated to EarthCARE with HALO and the French Falcon F20 in 2017 was also mentioned, where ISMAR and FAAM could join.

J. Delanoë (LATMOS) [*1_Delanoe_ISMAR_RASTA.pdf*] presented the 95 GHz RASTA (RAdar SysTem Airborne) radar operated on the French Falcon F20. He described the instrument, its typical observations and the list of parameters that can be retrieved, i.e. microphysics (e.g. Ice Water Content, IWC) and wind. He also listed the different campaigns in which RASTA was involved. He presented one coordinated flight with A-Train overpass during the second HAIC (High Altitude Ice Crystals) campaign in Cayenne (French Guyana). He indicated two future campaigns: RALI (December 2015) and NAWDEX (Fall 2016). He also mentioned the technical development of polarimetric capabilities for RASTA.

S. Bony (LMD) [*1_Bony_ISMAR_Clouds.pdf*] discussed on the limited understanding of the interaction between clouds, circulation and climate. She listed out four questions that need to be addressed to provide robust assessments of global and regional climate changes:

i) What role does convection play in cloud feedbacks?
ii) What role does convective aggregation play in climate?
iii) What controls the position, strength and variability of tropical rain belts?
iv) What controls the position, strength and variability of extra-tropical storm tracks?

She presented the plans of the EUREC^{4}A (Elucidating the role of cloud-circulation coupling in climate) campaign (early 2019, Atlantic trades, East of Barbados (13N, 59W)) where HALO (dropsondes launch) and the French ATR42 (lidar) should fly together. The campaign data will be used to test the strength of low-cloud feedbacks in LES and GCM models. It was mentioned the interest of flying ISMAR in that campaign as it can help characterize the atmosphere below and above the aircraft when pointing downward and upward respectively.

S. Crewell (Cologne University) [*1_Crewell_ISMAR_hamp.pdf*] presented the HAMP (HALO Microwave Package; 22, 50, 90, 118, 183 GHz in passive; 35 GHz in active) and the MiRAC (Microwave Radar/radiometer for Arctic Research) instruments that fly on the HALO german aircraft. She discussed results of the analysis of HAMP observations collected during the NARVAL (North Atlantic Rainfall Validation) campaigns, including comparison with modeling outputs, coincident Cloudsat overpass, and flights over instrumented ground-based sites. S. Crewell also presented preliminary results of a closure study for snow scattering (in clouds) using observations and modeling through i) the generation of realistic atmospheric state from dropsonde measurements and of IWC and effective radius (reff) from radar reflectivity, ii) the simulation of brightness temperatures at HAMP frequencies using different particle types listed in Kulie et al. (2010) to identify which particle type works the best. The current results suggest that aggregates work better. She also presented a comparison between coincident HAMP and SSMIS observations (for time difference < 20 min). She reported good agreement between HAMP and SSMIS for IWV (Integrated Water Vapor) over all HAMP flights.
She then mentioned NARVALL II in the Barbados (August 2016) and NAWDEX (Fall 2016). She also mentioned a specific DFG call expected for this fall for research proposals combining airborne measurements and analysis of scientific data. She reported that the schedule of HALO is very busy until 2019. She also introduced the $(AC)^3$ (ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms) project where she submitted a proposal to build and install radiometers on low altitude research aircrafts (Polar 5 and Polar 6) to document the atmosphere and the surface in the Artic.

C.-C. Lin (ESA) [*1_Lin_ISMAR_DopplerRadar.pdf*] presented some activities in development to understand the links between wind, cloud and precipitation, and more specifically on the characterization of the 3D motion of the atmosphere with all-weather capability in complement with the ADM-AEOLUS mission. He discussed on two concepts: one using a conical scan pencil beam, the second one based on stereo radar principle. C.-C. Lin then discussed on some key topics such as the frequency-diversity pulse-pair (FDPP) technique, the vertical resolution for the conical scan concept, ghost echoes, multiple scattering and non-uniform beam filling. C.-C. Lin then introduced the demonstration campaigns using ground-based radar (S-band weather radar at Chilbolton in Nov. 2015 for a period of 6 months; 94 GHz Galileo radar and 35 GHz cloud radar) and airborne radar (NAWX – W & X band radars – on the Canadian NRC Convair aircraft). A technological and proof of concept campaign with NAWX is planed for April 2016 in the Ottawa / Great Lake region.

S. Fox (Met Office) [*2_Fox_ISMAR_Campaign.pdf*] described the two campaigns in which ISMAR was operated. The STICCS campaign (November/December 2014 from Prestwick, Scotland) was mainly a technical campaign to identify any issues with the instrument, to understand in-flight performances, and gather first ISMAR data for initial scientific studies through flights performed in a variety of conditions. S. Fox then showed some maps, pictures and time-height plots to introduce the different STICCS flights (B875 in clear skies; B878 in clear skies and cirrus conditions; B879 over sea; B884 in cirrus conditions). S. Fox listed some of the issues identified during that campaign (e.g., thermal stability of receivers, intermittent excess noise, calibration target temperature biases). The COSMICS campaign (March 2015 from Prestwick, Scottland, with a short detachment to Keflavik, Iceland) was conducted to provide additional ISMAR observations for further case studies and to study the improvements of the ISMAR instrument since the STICCS campaign. S. Fox mentioned that problems with the instrument as well as aircraft power issues led to a number of aborted flights. S. Fox listed the 5 good ISMAR science flights of the COSMICS campaign (B893 in clear skies; B895 in cirrus conditions; B896 over cold surface; B897 in a precipitating frontal system; B898 over cold surface).

S. Fox (Met Office) [*2_Fox_ISMAR_DataQuality.pdf*] then discussed how to assess ISMAR performances through a series of basic sanity checks, laboratory tests and comparison with RT models. He also introduced the factors that could influence ISMAR performances such as thermal stability of the receivers, the behavior of the calibration target, the linearity of the receivers and the random noise. S. Fox first reminded that the gain of any RF amplifiers is strongly dependent on temperature, so temperature should be as stable as possible. He pointed out the need to ensure that the output voltages remain in range of digitizer. He also reminded that temperature drifts could affect the frequency of Local Oscillators. For example, he presented the time-series of the Front-end and IF temperatures during STICCS – B884 and COSMICS – B897 flights. S. Fox reported that the 664-H channel during STICCS campaign was particularly susceptible to voltage saturation due to the lack of temperature control, but he indicated that temperature stability was improved allowing the voltages to mostly remain within the digitizer range. S. Fox detailed the voltage instability of some receivers like the 243-V channel that was initially noisy during STICCS, but repaired during the campaign (cabling issue) or like the 325 GHz receiver that went through issues with instability and noise.
S. Fox then discussed on ISMAR calibration. As gain and offset are retrieved from the calibration target temperatures, any error can significantly impact the brightness temperatures of the observed scene. He reminded the need to have accurate knowledge of the target temperature across the beam and to have a large separation between cold and hot temperatures.
PRT (Platinum Resistance Thermometer) probes are in contact with the two loads for temperature measurement. All updated STICCS and COSMICS data have been processed using interpolation of the PRT records to channel positions and averaging across the beam footprints. During the first flights, the hot target, which is supposed to be as hot as possible with a uniform temperature distribution, struggled to maintain temperature due to the airflow and a polypropylene film was installed during COSMICS that improved hot target stability, but the target was not heated to the optimum temperature. For the cold calibration load, interference from scan motor caused noise and offsets on the cold target PRTs. He discussed on issues with crosstalk, nonlinearity and possibly standing waves from calibration targets in some channels. He mentioned that improvements in thermal stability of receivers and calibration targets between the two campaigns. And he reported consistent observations with modeled zenith brightness temperatures at high altitude. He also reported some excess of noise on some receivers with figures that are higher than the ones computed by D. Wang (LERMA).

S. Fox [*2_Fox_ISMAR_AncillaryData.pdf*] discussed on the ancillary data. All FAAM core data are available BADC (British Atmospheric Data Centre, http://browse.ceda.ac.uk/browse/badc/faam/data, registration required) and the latest revision number of the dataset should be used. Note that variables have associated flag indicating data quality. Data are pressure, altitude, temperature, humidity, winds, cloud bulk water content. Measurements from Heimann infrared thermometer, dropsondes, cloud physics scattering probes, cloud physics imaging probes, ARIES (IR Fourier Transform spectrometer) and LIDAR (Leosphere ALS450 downward pointing, 355nm, depolarisation channel) are also available.

D. Wang (LERMA) [*2_Wang_ISMAR_Emissivity.pdf*] discussed on three topics: evaluation of ISMAR observations relative to radiative transfer calculations in clear sky, evaluation of the noise instrument, calculation of surface emissivity. First she described the RT setup: she used ARTS, used as input ERA-Interim profiles, used Rosenkranz absorption models (water vapor, oxyden, nitrogen). She indicated that ozone absorption, liquid water absorption and particle scattering are not considered in her RT simulations. Actual ISMAR observing angles are considered in her computations. She presented times series of simulated and measured brightness temperatures for the flight B893. She indicated that differences between simulated and observed brightness temperatures might be explained by an excess of water vapor from ERA-Interim in some layers according to comparison between simulated and measured water vapor profiles. She described the methodology she applied to estimate the noise level from observations at high altitude. Noise levels are close to the specifications; 664V channel presents a larger noise compared to 664H as it can be seen in the time series plots. She concluded that similar results are obtained for the other ISMAR flights. She presented results on the surface emissivity derived from ISMAR records. She gave a brief background on published works on emissivity and described how to retrieve the emissivity from observations. She presented the data collected during the flight B893 and the results for ice-free ocean emissivity in terms of angular dependence – she reported noisier emissivity at large incidence angles especially for the water vapor sounding channels - and frequency dependence – she showed good agreement for window channels at frequency below 243 GHz, question remained on the quality of the retrieved emissivity at 325 GHz. She discussed the flight B896 and more specifically the sea-ice emissivity. She concluded that at higher frequencies (>325 GHz), the large atmospheric opacity limited the surface contribution, and that the surface emissivity could not be estimated even when flying at low altitude. C. Prigent (LERMA) briefly described the activities at LERMA to prepare ICI. It includes the preparation of realistic radiative transfer simulations up to 700 GHz to form a training database for statistical retrieval, the evaluation of simulations up to 200 GHz with existing satellite instruments and above 200 GHz with ISMAR, and the development of statistical retrievals. It was stressed that i) the simulations are very sensitive to the frozen particles, ii) the cloud models do not provide all required information for the calculation of the optical properties, and iii) several hypothesis are required that need some consistency between the cloud model and RT assumptions.

M. Brath (Hamburg University) [*2_Brath_ISMAR_NN.pdf*] presented the development of a neural network (NN)-based retrieval experiment, to derive liquid water, ice water, rain and snow from the aircraft observations with DEIMOS, MARSS, and ISMR. First the training database was described: the ARTS radiative transfer code is run on a large range of selected ECMWF atmospheric profiles (25 000), for all the channels available on board the FAAM. The hydrometeor characteristics follow the work by Geer and Baordo (2014). Preliminary results concern nadir views over black body surfaces. The theoretical accuracy of the retrieval of ice and snow is reasonable, but liquid water and rain retrieval have problems. The retrieval is briefly tested on an ISMAR flight.

V. Grützun (Hamburg University) [*2_Gruetzun_ISMAR_ICA.pdf*] performed an information content analysis of the ISMAR frequencies up to 325 GHz, based on a case study over Germany (ICON). Cloud resolving model simulations (using a two-moment cloud microphysics) are coupled to ARTS to produce the radiances and the Jacobians. It is shown that the Jacobians are very sensitive to the hydrometeor hypothesis, raising problems for the accuracy of the estimation. The dependence of the results on the a priori and measurement noise assumption is raised.

C. Harlow (Met Office) [*2_Harlow_ISMAR_IR.pdf*] analyzed the observations from the COSMIC campaign to derive the skin surface temperature as well as the surface emissivity (infrared and microwave) over the boreal region. There are different ways to estimate the Ts (Heimann instrument, ARIES IR interferometer, and MARSS) that are compared. Some results are presented on the surface emissivity at 89 GHz, and are compared with satellite-derive emissivity atlas, with different assumptions on the surface reflexion (lambertian and specular).

P. Eriksson [*2_Eriksson_ISMAR_Inversion.pdf*] synthesized a study that used Cloudsat data to generate databases to develop ISMAR retrieval algorithms. He discussed different approaches that could be used to generate retrieval databases: purely empirical approach, approach using outputs from atmospheric models, and approach using observations. He then focused on an observational-based approach using the Cloudsat IWC/LWP profiles combined with ERA-Interim atmospheric products over ocean. He pointed out the current limitations of FASTEM and he discussed on the single scattering data as well as particle size distribution. He described the ARTS configuration applied to perform the radiative transfer calculations. He presented simulated brightness temperatures as a function of IWP, LWP for different microphysics scenarios and ISMAR frequencies and discussed on the sensibility to the different parameters.

P. Eriksson (Chalmers) [*3_Ericksson_ISMAT_ARTS.pdf*] provided an overview of ARTS (http://www.radiativetransfer.org/) with an application on ISMAR. He started with a general description of the ARTS model (e.g. full polarization, 1 to 3D atmosphere, different geometries; flexibility, modularity, documented and maintained, open source). He then described the different steps to perform radiative transfer calculations with ARTS (parameter setup; calculation of the absorption; radiative properties of the surface; characteristics of the sensor to simulate). He introduced the “Met MM system” designed to handle non-conical scan observations like AMSU or ISMAR. P. Eriksson presented an example of observed and simulated 325 GHz brightness temperatures at close to nadir showing consistency between the observations and the simulations for the atmospheric (purely absorbing) and radiative parameters applied. P. Eriksson then discussed on how ARTS handled the scattering processes (single scattering properties, particle number densities). He also discussed the available methods to solve the polarized RT calculations (Discrete Ordinate Iterative method, DOIT ; Monte Carlo, MC). P. Eriksson recommended using DOIT-1D to perform ISMAR simulations. The need of 3D radiative transfer simulation was discussed but without any specific conclusion.

M. Mech (Cologne University) [*3_Mech_ISMAR_PAMTRA.pdf*] introduced the new PAMTRA (Passive and Active Microwave TRAnsfer model) model. PAMTRA is a passive and active forward simulator developed in support to the airborne HAMP and MiRAC instruments. PAMTRA takes into account the gas absorption (H_2O, O_2, O_3). It offers the possibility to use different particle size distributions but can also handle new particle size distribution. He discussed on the single scattering properties and models (Mie, T-matrix, DDA databases; Rayleigh-Gans Approximation for radar only). PAMTRA uses the RT4 module (plan parallel, 1D, single-scattering, polarized, oriented particles, doubling and adding method). In addition M. Mech discussed the interest of using higher moments of the Doppler spectrum for better radar simulations. M. Mech presented some examples of simulations at AMSU-B and HAMP frequencies,

J. Pardo (CSIC-INTA) [*3_Pardo_ISMAR_ATM.pdf*] presented an overview of the RT ATM (Atmospheric Transmission at Microwaves) model originally designed to solve the general radiative transfer equation in the Earth's Atmosphere from 0 to 1.6 THz mainly for astronomy applications. He discussed on the processes that induce the atmospheric absorption, including the "continuum-like" absorption. He also discussed on the Zeeman effect. Then he discussed on the contribution of the hydrometeors in cloudy conditions. In ATM, the calculations of the phase matrix use the work from M. I. Mishchenko (prolate and oblate spheroids, azimuthally random distribution; T-matrix). It also uses the refraction indexes from literature. Note that only single scattering is assumed within each layer, while surface can be Lambertian, Fresnel and other types. He then presented some results on the analysis of the polarization signal at 85 GHz using observations (TRMM TMI) and ATM simulations (non-spherical ice hydrometeors predominantly oriented). He discussed on the need to get accurate phase delay (or path length variation) measurements for ground-based astronomic observations and presented example of corrections using 183 GHz water vapor radiometers. He introduced the CASPER (Concordia Atmospheric SPectroscopy of Emitted Radiation) experiment at Concordia Station, Antarctica (2015). He concluded his presentation by showing RT simulations performed with ATM up to 900 GHz to demonstrate the capability of ATM to compute brightness temperatures in cloud conditions.

C. Harlow (Met Office) [*3_Harlow_ISMAR_rttov.pdf*] presented the version of RTTOV for airborne sensors. RTTOV is a fast RT model for simulation of space-borne passive visible, IR and MW sensors, developed through the EUMETSAT NWP SAF (Satellite Applications Facility for Numerical Weather Prediction). RTTOV uses an optical depth prediction scheme based on methods developed by McMillin and Fleming in the 1970s. C. Harlow indicated that an experimental version was recently developed to enable clear-sky simulations of airborne sensors (in particular ISMAR). C. Harlow reminded that RTTOV for airborne sensors has yet to be tested against real data. C. Harlow stressed the requirement that the airborne RTTOV must be compiled with quadruple precision in order to represent all transmittances. In preparation for ICI, preliminary clear-sky RTTOV coefficients are available. Work is planned to validate and if necessary improve the spectroscopic database above 200GHz. It is planned to update the scattering model RTTOV-SCATT.

J. Mendrok (LTU) [*3_Mendrok_ISMAR_ARTS.pdf*] first discussed on the Jacobians in cloud-sky and informed that it is now handled through a WSM (Workspace Method) which generate outputs from relevant inputs. She discussed on in-ARTS calculation of particle number density (PND) fields. In ARTS scattering objects are fully characterized by single scattering data (scat_data) and associated particle number density fields (pnd_field). She reminded that since ARTS v2.2, ARTS can handle GCM-type hydrometeor fields (mass content, mass flux, number density, and/or mean mass), particle size distribution (PSD) specified per hydrometeor species, and that multiple PSDs are included (e.g. MH97). She then focused on a frequency setup optimization for ISMAR simulations, as scattering calculations are very costly. The idea is then to find a small set of monochromatic frequencies that represents the signal of the radiometers. She suggested picking up optimal frequency from a larger set or explore the potential of equally spaced frequency bins. She introduced the setup of her computations. She presented the differences of down-looking brightness temperatures simulated at both monochromatic frequency and studied channel (center-of-each-passband), with min. RMSE (min maximum absolute error MaxErr) lower than 0.5 K (1 K) in most cases. For up-looking simulations, the current results show higher errors and J. Mendrok indicated that further investigations are required.

R. Ekelund (Chalmers) [*3_Ekelund_ISMAR_DDA.pdf]* discussed DDA calculations of single scattering properties of snowflakes. He first gave an overview of DDA technique and discussed on the current microphysics representations and geophysical parameters applied in Hong et al. (2009) and Liu (2008) parameterizations. He then described the setup of ARTS simulations he performed. He also discussed on the mass-size relationship used in his computations. He then showed the different parameters (extinction, forward scattering, backward scattering) as a function of the D_{max} parameter. He also discussed on the angular dependence of the scattering and presented the integrated extinction as a function of ice water content.

S. Fox (Met Office) [*4_Fox_COSMICSAnalysis.pdf*] presented some results on the analysis of the B893 (clear sky) and B895 (Cirrus). He introduced the ARTS configuration applied to the B893 flight at zenith and nadir views. He used two atmospheric profiles derived from FAAM measurements during ascent and descent while the simulated brightness temperatures were interpolated to the aircraft altitude. FASTEM was used to characterize the state of the surface. He then discussed on the times series of simulated and observed brightness temperatures for that specific flight. He discussed the polarization and reported the need to have a large difference between Tb_{down} and Tb_{surf} to get good a sensitivity to surface reflection, so he used MARSS and lower-frequency ISMAR channels. He presented rather consistent polarized signal between measurements and simulations (at 1000ft) suggesting that ISMAR and MARSS polarizations are correct, and correctly modeled. He presented the detection of a signal induced by a cloud through the difference between clear-sky simulations and measured values. He discussed the large biases between clear sky measurements and simulations using measurements of the dropped sondes as inputs. He demonstrated the need for better atmospheric profile below aircraft at time of radiometric measurements. He proposed to use MARSS 183 GHz observations to constrain the H_2O profile. That produces moister profile and provides better match to simulations in most ISMAR channels (< 1 K). He applied the same method to the “cirrus” B895 flight where cirrus clouds were sampled from above first and through (for in-situ microphysics characterization) as shown with the curtain of lidar observations simultaneously collected. Based on MARSS retrieval of water vapor, differences of several K were found relatively to clear sky conditions with larger differences at higher frequencies, suggesting that ISMAR potentially recorded the scattering signal induced by the cirrus microphysics. S. Fox reported that in-situ measurements suggest IWP between 8 and $20g/m^2$ in the sampled cirrus clouds.

P. Ericksson (Chalmers) [*4_Ericksson_ISMAR_COSMICS.pdf*] presented results on the analysis of COSMICS dataset (B897, B894, B895 flights), focusing on the retrieval activities. For the different flights, he first presented the time-series of measured brightness temperatures and simulated brightness temperatures (using ERA-Interim) but without any scattering calculations. A retrieval training dataset has been derived from CloudSat profiles. The validity of the database is evaluated, by comparing the relationship between frequencies, in the real world (ISMAR) and in the simulated database. A series of plots are presented where the ISMAR brightness temperatures are overlaid over simulated Cloudsat-based brightness temperatures by pairs of frequencies (e.g. TB325+/-9 GHz vs TB243 GHz, TB325+/-1.5 GHz vs TB664 GHz), for different ice water paths and for different microphysics representations (e.g. MH97). The relationships between frequencies are rather different depending on the assumptions in the simulated database, with direct consequences on the derived retrievals.

Discussions:

There is no specific ISMAR dedicated campaigns planed in the near future. It was suggested to use any opportunity to fly ISMAR when possible, and when ISMAR is flying, to optimize its operation.

The next opportunity to fly ISMAR can be expected in January, February, and March 2016. The flights should be oriented toward science and not toward technical tests. Clear sky flights with characterization of the surface should be performed. In cloudy conditions, it is proposed to sample simple cirrus clouds and if possible cloud systems with precipitating snow. Characterization of the ice particles with in situ microphysics probes should be conducted, especially for cirrus cases. Flying ISMAR over instrumented sites like the Chibolton radar should be encouraged but it is reminded that the weather is not always cooperative. It is also suggested to coordinate FAAM flights relative to A-Train, in particular under CloudSat.

It was recognized that it is better to fly as high as possible (to mimic the satellite conditions) but flying in the clouds and below is also interesting to investigate the scattering and emission properties of clouds. It might actually be easier to characterize the cloud interaction from below, against a cold and stable background. An airborne campaign with ISMAR on FAAM (below the clouds) and COSSIR on ER2/WB-57 (above the clouds) is suggested. Contact is to be taken with the COSSIR team.

Joining cal/val activities related to upcoming European missions like EarthCare and ADM-AEOLUS is suggested. Potential campaigns are planed in Feb 2020 for EarthCARE. These communities should be contacted to present the ISMAR instrument and the benefits of sub-millimeter wave radiometry.

The need for remote sensing observations (mainly radar) is mentioned to help characterize the clouds. Flying two aircrafts simultaneously is a possibility, despite co-location issues. The rather limited sampling area of the in situ probes has also been indicated, along with the issue of cloud motion.

The instrument noise has been evaluated by two groups with rather large differences. The UK MO and LERMA will work to reconcile their estimates.

A decision has to be taken rapidly about the building of a dual polarization receiver around 424 GHz channel by Omnisys, free of charge. Some simulations should be done to optimize the frequencies.

Installing ISMAR on another platform, like the ER2 or the Geophysica was again mentioned. Questions about the availability of the Geophysica were raised.

A large range of ancillary observations is available from the campaigns. All the data cannot be delivered to the community as it requires significant processing efforts and it can be difficult to handle. Specific needs should be identified and discussed with the potential providers. It is suggested to have a representative from this community at the next ISMAR workshop. Unfortunately, none was available for this workshop.

Questions were raised about the accuracy of the radiative transfer calculations under cloudy conditions, but also under clear sky situations. There are large uncertainties on the continuum at high frequencies, and some work should be done on this issue. The different RT activities performed around the ISMAR data should be better coordinated.

The importance of the development of realistic and representative databases is stressed, for the training of the statistic retrievals. The retrieval methodology is also an issue, but in the case of the estimation of cloud properties, the production of a good training dataset is the key problem.

Support from ESA, EUMETSAT could be obtained for the different activities (for the aircraft campaign or for the retrieval preparation). Suggestions have to go through ICI SAG. The directions have to be clearly identified in the ICI science plan.

It is proposed to organize the next workshop ISMAR/HAMP workshop May or early June 2016, in Hamburg.

ANNEX A: List of participants

Name	First name	Affiliation	email
AIRES	FILIPE	ESTELLUS	filipe.aires@estellus.fr
BARAN	ANTHONY	MET OFFICE	Anthony.baran@metoffice.gov.uk
BONY	SANDRINE	LMD	Sandrine.Bony@lmd.jussieu.fr
BRATH	MANFRED	ZMAW	manfred.brath@zmaw.de
BUEHLER	STEFAN	Hamburg Univ.	stefan.buehler@uni-hamburg.de
CREWELL	SUSANNE	Koeln Univ.	crewell@meteo.uni-koeln.de
DEFER	ERIC	LERMA	eric.defer@obspm.fr
DELANOE	JULIEN	LATMOS	julien.delanoe@latmos.ipsl.fr
EKELUND	ROBIN	CHALMERS	robin.ekelund@chalmers.se
ELIASON	SOLOMON	SMHI	salomon.eliasson@smhi.se
ERIKSSON	PATRICK	CHALMERS	patrick.eriksson@chalmers.se
FOX	STUART	MET OFFICE	stuart.fox@metoffice.gov.uk
GRUTZUN	VERENA	Hamburg Univ.	verena.gruetzun@uni-hamburg.de
GOLDSTEIN	CHRISTOPHE	CNES	christophe.goldstein@cnes.fr
HARLOW	CHAWN	MET OFFICE	chawn.harlow@metoffice.gov.uk
LEE	CLARE	MET OFFICE	clare.lee@metoffice.gov.uk
LIN	CHUNG-CHI	ESA	Chung-Chi.Lin@esa.int
MENDROK	JANA	LTU	mendrok@www.sat.ltu.se
MECH	MARIO	Koeln Univ.	mech@meteo.uni-koeln.de
ORLHAC	JEAN-CLAUDE	Airbus Defence and Space	jean-claude.orlhac@airbus.com
PARDO	JUAN	CSIC-INTA	jrpardo.fuentealbilla@gmail.com
PRIGENT	CATHERINE	LERMA	catherine.prigent@obspm.fr
WANG	DIE	LERMA	die.wang@obspm.fr
WANG	XIAONI	LERMA	xiaoni.wang@obspm.fr

ANNEX B: Program

3rd ISMAR workshop
LERMA, Observatory of Paris
Salle du conseil
28-30 September 2015

28/09 Monday afternoon
(Moderator: C. Lee)
13:30 Coffee
14:00 Goal of the workshop (C. Prigent & E. Defer, LERMA)
14:15 Current status of ISMAR (C. Harlow, UK Met Office)
14:45 Up-coming campaigns with ISMAR (C. Harlow, UK Met Office)
15:15 Guest presentations (30 mn each, including discussion)
-RASTA, an airborne tool for cloud studies, J. Delanoe, LATMOS
-(Ice-)clouds, circulation and climate sensitivity, S. Bony, LMD
-HALO status and planed campaigns, S. Crewell, Univ. Koeln
-94 GHz Doppler wind radar campaigns, C.-C. Lin, ESA

A tour of Paris Observatory should be organized, as well as a little cocktail in the Observatory.

29/09 Tuesday morning
(Moderator: S. Crewell)
09:30 Overview of the STICCS and COSMICS campaigns (S. Fox, UK Met Office)
10:00 Quality of the ISMAR data collected during the STICCS & COSMICS campaigns (S. Fox, UK Met Office)
10:30 Auxiliary data (S. Fox, UK Met Office)
11:00 Coffee
11:20 Description of the analysis activities performed in each group on ISMAR data
(20 mn each maximum, including discussion)
- Clear-sky verification and single scattering calculations (P. Eriksson, Chalmers)
- Clear-sky verification, noise evaluation, emissivity calculations (D. Wang, LERMA)
- Microwave and infra-red surface properties from the Greenland flights
(C. Harlow, UK Met Office)
- Training database and NN retrieval (M. Brath, Hamburg)
- Jacobians and preliminary OEM information content (V. Gruetzun, Hamburg)
13:00 Lunch

29/09 Tuesday afternoon
(Moderator: S. Buehler)
14:00 Radiative transfert simulations relevant for ISMAR
(20 mn each, including discussion)
- ARTS and ISMAR (P. Eriksson, Chalmers)
- RTTOV (C. Harlow, UK Met Office)

- ATM (J. Pardo, CSIC)
- DDA calculations (R. Ekelund, Chalmers)

15:20 Coffee
15:50 Discussion on the ISMAR flights (all)
B893 flight
B895 flight
B896 & B898 flights
Other interesting ISMAR flights

Dinner at Bal Bullier (http://www.cafebullier.com/) around 19:00

30/09 Wednesday morning

(Moderator: P. Eriksson)

09:00 ISMAR activities in preparation to ICI
(instrumentation, analysis / radiative transfer tools) (all)
10:00 Discussions and way forward (all)
11:00 Coffee
11:30 Review of actions (all)

ANNEX C: Glossary

BADC	British Atmospheric Data Centre
COSMICS	Cold-air Outbreak and sub-Millimetre Ice Cloud Study
FAAM	Facility for Airborne Atmospheric Measurements
HALO	High Altitude and LOng Range
HAMP	HALO Microwave Pack
ICI	Ice Cloud Imager
ISMAR	International Sub-Millimeter Airborne Radiometer
IWC	Ice Water Content
IWV	Integrated Water Vapor
MiRAC	Microwave Radar/radiometer for Arctic Research
PAMTRA	Passive and Active Microwave TRAnsfer model
PRT	Platinum Resistance Thermometer
RASTA	RAdar SysTem Airborne
STICCS	Submillimetre Trial In Cirrus and Clear Skies
YMC	Year of Maritime Continent
YOPP	Year of Polar Prediction