**GSICS Microwave Subgroup Web Meeting**

 **1100-1400 UTC March 18, 2020**

**Attendees:**

CMA: Qifeng Lu, , Wu Shengli, Bin Zhang

NOAA: Mitch Goldberg, Mark Liu, Ralph Ferraro, Ninghai Sun, Manik Bali, Robbie Iacovazzi, Cheng-Zhi Zhou, Shu-Peng Ho, Xingming Liang, Xi Shao

EUMETSAT: Tim Hewison, Christophe Accadia, Viju John, Timo Hanschmann

KMA: Jun Park, Minju Gu, Hyeji Yang

JAXA: Misako Kachi

UK Met Office: Fabien Carminati, Christoforos Tsamalis

ESA: Craig Donlon

ISAC-CNR: Sante Laviola

Colorado State University: Wesley Berg

WMO: Heikki Pohjola

Unknown Affiliation: Hujy and Raffaele

**1. Achievements summary from last year**

**Qifeng Lu**

Microwave Subgroup Achievements in 2019

* Five GSICS MW Subgroup Meetings
* The MWI gap analysis outcome was reported as a plenary talk to CGMS-47
* Fundamental Climate Data Records (FCDR) accomplishments
	+ EUMETSAT FCDR for the microwave humidity sounders provide detailed quality and uncertainty data.
	+ The first version (for evaluation) of CMA FCDR for MWRI/MWHS/MWTS has been released in the end of 2019
	+ Requesting feedback
* Cooperation to establish a GSICS MW XCal Document has been initiated
* Instrumental performance monitoring and uncertainty characterization based on SNO and RTM simulation methods is maturing and more results have been generated.
* SNPP and NOAA 20 reprocessing is complete with algorithm that includes the October 15, 2019 software update.
* CubeSAT TEMPEST-D microwave SDR are now available at (https://tempest.colostate.edu/data) and have been used in studying tropical cyclones.
* Studies have been done to show that AI may enhance the spatial resolution of microwave measurements.
* COSMIC-2 launched on June 25, 2019, and data are operationally used for MW sensor monitoring

**2. Actions of MW Sub-group from last year's annual meeting**

**Qifeng Lu**

Seven out of 10 actions are closed, and three out 10 are open.

Comments About Actions:

*Actions A.GMW.2019.5n.2 and A.GMW.20190507.1*

**Shingli W.** –Applied XCal to MWRI in a similar manner as it has been done for GMI. They have implemented the Simultaneous Nadir Overpass (SNO) method and performed the double difference. They have also applied observed minus radiative transfer model simulated measurements using Era5 and RTTOV, and we get similar results as the XCAL Team.

**Cheng-Zhi Z.** – It look like MWRI has large biases with respect to GMI. Did you compare MWRI with AMSR-E and AMSR-2? These instruments may be good references. It looks like you did not mention that. Why?

For the reference data GMI was used, and we did not use AMSR-2. XCAL used GMI as the reference sensor.

*Action A.GMW.2019.5o.1*

S-NPP and N-20 bias

**Cheng-Zhi** **Z.** – I know S-NPP was reprocessed. For microwave moisture channels, the bias between the first version and second version is large – e.g., even larger than 1K. So, is this new re-calibration used in both N20 and S-NPP?

**Ninghai S.** – In the reprocessed data, we updated NPP antenna pattern correction coefficients and reflector emission correction. This was updated in operations for both S-NPP and NOAA-20 ATMS.

**Ralph F.** – The new reprocessed versions were completed in the October or November time frame. If any change was after that, then they were not implemented.

**Ninghai S.** – Reprocessing has been done with the current algorithm, and we are trying to make it publically available in NCEI or CLASS.

*A.GMW.2019.5n.3*

**Ralph F.** – This was done a while ago. Received all information that was needed. Also, received the feedback and got approval from the GSICS Executive Panel.

**Manik B.** – This was a GSICS deliverable. It was put on GSICS Wiki.

*Action A.GMW.2019.5t.1*

**Manik B.** - ATMS vs AMSU FCDI inter-calibration. Cheng-Zhi’s results reveal a high quality stable reference record that can be used to inter-calibrate other instruments. Put in a document that can be shared.

ACTION: Looking for feedback on the ATMS vs AMSU FCDR inter-calibration whitepaper.

*Action A.GMW.2019.5x.1*

MWSG Chair to coordinate the development of a summary of the current status of MW sensor calibration methods (by sensor and frequency type), needs by product type, and provide a 3-year roadmap for developing GSICS MW calibration products.

**Ralph F.** – What sort of methods should we do in the future? Want to gather information from group in terms of the methods and activities that are going on. There is a wiki page for this activity, but not much has been done since then. My goal is to finish it, and hand it off to someone that could work towards the roadmap. Maybe in a month or two can get it done? Once it is done, we can bring it up in another meeting. Maybe before CGMS, or last GSICS meeting? This is a broad ambitious task. Ralph wants to start, and have someone else take over.

Action will be kept open.

ACTION Update: Need to update Ralph Ferraro’s Wiki page that began to create an overarching architecture for this activity. Need to find someone to spearhead working towards a more complete roadmap, and present it at another GSICS Meeting this year.

Other Progress and 2020 Focus shown in package (MW-Subgroup-Summary\_2019\_v2.1). Aavailable on the GSICS Wiki (http://gsics.atmos.umd.edu/bin/view/Development/20200318mw)

**3. Plan for MW Group activities**

**Qifeng Lu**

We need to understand Users’ requirement for inter-calibration, long-term time series products, or near-real time products for MW instruments.

**Manik B.** – Need to understand user requirements. How are we going to collect these user requirements?

For example, there are Users in NWP and communities that perform retrievals using MW data. We could invite them to contribute.

**Ralph F.** – We have tried this several time in the past. We felt that we needed a champion for each agency to survey their users. For example, we need NOAA to poll different parts of NOAA to find out what Users need. Each agency would have to do the same thing. Need something more formal where you could document what people want. Need to make it formal to get a full range of Users.

**Manik B.** – Could have a designated person at each agency.

**Cheng-Zhi Z.** – As a user and developer, the fundamental need is a measurement that is radiometrically stable, and based on a stable orbit. If you have those, inter-calibration is much easier and the trend is more reliable.

Identify existing product that could meet those requirements

We need standards – calibration algorithm standards, radiance or brightness temperature correction algorithm standards, and a process for creating standards and calibration products that adheres to GSICS principles

We could focus on tools/algorithms like SNO, Double Difference, RTM, etc.

Make SNO method as a reference standard method for imager and sounder. Input data of RTM and the RTM model should be open to GSICS user and easy to access.

We need to define data standards (Jointly with GDWG)

Continue coordination with other groups would also be required to generate standards and best practices

**Manik B.** – Best practices have been adopted from IR team.

**4. Other urgent topics that need to be addressed as soon as possible**

**Qifeng Lu**

Found in the presentation MW-Subgroup-Summary\_2019\_v2.1, which is available on the GSICS Wiki (http://gsics.atmos.umd.edu/bin/view/Development/20200318mw)

X-Cal algorithm and document cooperation

**Wes B.** – Talked to Tim Hewison. Delayed plan to visit EUMETSAT next month to write a report detailing the X-Cal process, and how it is used to inter-calibrate MW imagers. That will be written up. The document will try to detail the X-Cal Teams process and how they do that for GSICS. A quick overview of the plan was presented several months ago at the GSICS Microwave Subgroup meeting. If there is a EUMETSAT conference, that may create an opportunity for face-to-face collaboration on this task.

**Manik B.** - Will circulate a white paper on MW imager inter-calibration to all agencies

ACTION: MWSG Co-Chairs to coordinate the development of the documentation of the X-Cal algorithms.

**Future Plans**

**Qifeng Lu**

* Early morning orbit to provide global data every 4 hours (also with Wind Radar )
* The first ATMS Active Geolocation
* Preparing AMSR-3 and EPS-SG MWS, MWI; JPSS-2 ATMS; and ICI
* Precipitation Radar (PR) for Chinese FY-3G satellite is being developed, the prototype phase will be completed soon in 2020, and to be launched at 2022

Closer collaboration with NWP community for improved understanding in user requirements and feedback.

**Ralph F.** – Co-chairs have got a lot accomplished in the last year. Want to encourage people to keep working closely together. Quarantine may be an opportunity to work on some things. Applauds the hard work.

**5. Inter-comparison SNPP and NOAA-20 ATMS Data**

**Robbie Iacovazzi presenting on behalf of the ATMS SDR Team**

(GSICS2020\_N20-SNPP-ATMS-Comparison\_Iacovazzi\_Oral\_18MAR2020\_Final.pptx)

Ben H. – Be aware that there are COSMIC post-processing differences, and this may affect your result. Not only that, different data suppliers have different sounding retrievals. Will talk off-line about this.

Cheng-Zhi Z. - How was 32-day mean calculated? Not clear why there should be such a large diurnal cycle.

Robbie I. – I am not sure, as it is not my product.

**6. Real CubeSat Microwave Sensor Measurements and Assessment**

**Wesley Berg**

(Berg\_Tempest-D\_18Mar2020.pptx)

TEMPEST-D

* Deployed on Intl Space Station.
* One download station on Wallops Island, so only able to download a day to two days of data per week.
* 6-U Cubesat. It is about the size of a large box of cereal.

**Cheng-Zhi Z**. – Why is the requirement for bias and noise so large compared to other operational instruments.

**Wesley B.** – It has to do with the intended application. Original proposal was to monitor changes in clouds and precipitation. It was supposed to be several instruments flying in formation, with 3-5 minute separation. The idea was to detect changes in developing precipitation systems. These instruments were not intended for detailed temperature and water vapor retrievals. New technology does not have infrastructure that ATMS/AMSU had. On the other hand, it exceeded requirements by a lot.

There is a temperature dependent bias that is quite large for the 164 GHz channel. Is that close to the oxygen line? No. Quite a ways off. Temp dependence bias. Why?

**Christophe A.** – Maybe it has to do with the difference in orbit – i.e., the difference between operational polar orbiting instruments and the international space station. The center frequency and channel is different. Could be radiative transfer issue.

**Wesley B.** - Fast Microwave Emissivity Model (FASTEM) 6 emissivity model for CRTM was used. Just ocean surface emissivity. Mono RTM atmosphere. The CRTM implementation of the spectral response function was not used. Could be useful to use another model to see how that works. Especially a model that has done a better job with surface emissivity at higher channels above 89 GHz.

XCal Team has worked on imager data to 89 GHZ, but have not done a lot of radiative transfer model work for higher frequencies. It may be worthwhile comparing different models. All have issues.

**Tim H.** – For the 164 GHz channel, the magnitude of water vapor absorption can change from one side of band to the other. The bulk difference should be taken out by the RTM though. If not captured well in the model though, this could cause issues.

**Wesley B.** - Used an RTM (GEOS-5) for GMI. It is a 1-D var approach. Run on GMI Tb. Get more consistent for matchups to GMI. Sensitive to error in water vapor distribution.

**Mark L**. – Was this a comparison for land/ocean or just ocean.

**Wesley B.** - Just ocean

**Tim H**. - How well characterized is the polarization?

This could be a factor. Looking to get out a journal article on the instrument. It does not have the level of testing as for ATMS.

**Tim H.** – Could try to tweak the polarization angle, and see if the line flattens out.

**Wesley B.** - What if there is an error in the view angle? Could have a geolocation issue. TEMPEST does not have to acquire data from the same scan angle every single scan line. May be a mismatch in calculated view angle and there would be an ensuing polarization shift. Resources are limited in the team.

**Xingming L.** – Have you compared versus another sensor?

**Wesley B.** - No, just Observed minus RTM Simulated. Simulation (GEOS-5) error could be a factor.

**Xingming L.** – How did you to pick points for comparison?

**Wesley B.** - Ocean-only and there is a screen for precipitation and land effects. There can be influences there as well. Want places that are homogenous. Could research tropics versus mid-latitude.

**Xingming L**. – Trying to understand the large scan dependent bias. Was the end-to-end spectral response used, and if so was the analysis performed with the theoretical filter function?

**Wesley B.** – Both were used, and there were small or negligible difference, until you get to wards 183 GHz water vapor absorption line. The 181 GHs channels does show some sensitivity. Depends on amount of water vapor. Could get several tenths of a Kelvin impact depending on spectral response. SRF has almost no impact at 87 GHz.

Did on-orbit pitch. Tried to get rid of some scan-dependent bias artifacts this way.

**Recommendations** – Brightness temperature dependent biases for 164 GHz. Did you check non-linearity effects from instrument?

**Wesley B.** – There is one channel that has a different spectral response than the other. Nonlinearity is small. Personal feeling ... done simulations … similar issues in that band. There may be RTM models issue in that band. There may be RTM model errors for 164 GHz . There are water vapor effects between MHS and TEMPEST-D. Also difference in polarization.

**Tim H**. – Comments

How to tune the inter-calibration algorithm? Could there be a metric to determine the performance inter-calibration algorithm quality? Need to know performance of algorithm for cold scenes. Did not pay that much attention to this for IR.

Could have error bars for different temperature bins. This covers the dynamic range, and statistics could be built up from there. Error bases are mean in each bin. Could look at weighted mean. For example, they could be weighted by variance of collocation radiances within an area around each colocation. Scene variability could be propagated. Could do standard error of the mean, and then standard error of the weighted mean. Use standard error instead of standard deviation. You could use scene variability to weight your samples.

n.b. This was also discussed at the IR Sub-Group session: <http://gsics.atmos.umd.edu/bin/view/Development/20200319>

**Wesley B. –** This does not account forerrors with respect to models. Want to run RTM errors for each physical process or parameter. Channels are not the same (167 GHz versus 164 GHz) and has RTM models residuals.

**7. An introduction to the Copernicus Imaging Microwave Radiometer (CIMR)**

**Craig Donlon, ESA**

(DonlonCIMR-GSICS-v1.0.pptx)

* Calibration - Active cold loads as noise sources.
* Awaiting bids, so cannot talk about technology. Final solution not chosen.
* Antenna is 6-8 meters!

**Tim H.** – Total standard uncertainty. How is it defined?

Want to separate what would be measured and controlled. Don’t know an absolute reference. If we go to a standards institute, such as NIST/NPL, they want to use uncertainty instead of accuracy and precision. We need to compute the root sum square of uncertainty contributions – e.g., using FIDUCIO. Bring down to uncertainty of components. For example, we can build up an uncertainty from pre-launch hardware testing, as well as estimates on on-orbit systematic and random effects that cannot be tested before launch. There is a section on uncertainty in the mission requirements. Christophe developed the requirements.

**Tim H.** – Important to include structured components of uncertainty – e.g., scan line to scan line uncertainties.

**Craig D. -** There will be unknowns in the uncertainty budget. We want to have estimates of potential uncertainty impacts – e.g., on polarization. Correlation of uncertainty must have a budget.

Preflight estimated errors do not always manifest itself in flight. Once we are confident with our preflight estimate of uncertainty, we will know what to look for on flight. We are getting at this early, so we can get an idea of uncertainty early in the mission.

**Manik B.** – Can you estimate radiometric accuracy with respect to AMSR or similar.

**Craig D.** - Original idea was to go from 1.4 GHz to MWI. This instrument will not have high frequency channels.

Think that we can do a lot with GSICS. Already pushing industry 36.5 GHz with deployable mesh antenna. There are restrictions at high frequencies.

**Cheng-Zhi Z.** – Time series of sea ice concentration SSMI based? Are you going to try to merge Copernicus with historical time series?

**Craig D.** - Want to continue the time series, and have a way to merge them together. Will be using different channels. We plan to use an algorithm that has a high resolution 6.9 GHz band. We found an algorithm that utilizes C, Ka, Ku and C band is best bet. Don’t want to have bias with respect to long term record. Knowledge is not absolute. Want stability within 0.1K. Difficult for industry.