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NEWS IN THIS QUARTER

Treatment of Microwave (MW) Emission Depth for Skin SST Assimilation

The aim of this study is to investigate the feasibility of assimilating low frequency microwave observations from different satellite microwave radiometers, such as the Advanced Microwave Sounding Unit-A (AMSU-A), Global Precipitation Measurement (GPM), Microwave Imager (GMI), and Advanced Microwave Scanning Radiometer 2 (AMSR2). These observations are relevant to the description of air temperature, humidity, and surface parameters, such as ocean surface temperature. Their assimilation into the Goddard Earth Observing System (GEOS) modeling and assimilation system helps better constrain models in regions where very few observations are assimilated. In recent years, surface sensitive channels have not been assimilated in GEOS because of their large sensitivities to uncertain surface parameters, such as emissivity and skin temperature. Skin Sea Surface Temperature (SST) is essential for an atmospheric data assimilation system because it is used to specify the lower boundary condition over the oceans. The analysis needs it for direct assimilation of satellite radiance observations, and the atmospheric general circulation model uses it to calculate important variables, such as air temperature and air-sea fluxes. Akella et al, 2017, studies the assimilation of near sea surface sensitive satellite infrared observations. This work modifies the GEOS Atmospheric Data Assimilation System (ADAS) for assimilation of microwave (MW) observations.

Problem Statement

Penetration depth is a measure of how deep electromagnetic radiation can penetrate into a material, and it is defined as the depth at which the intensity of the radiation inside the material falls to 1/e of its original value. It depends on electromagnetic radiation wavelength and the material's properties. In current Gridpoint Statistical Interpolation (GSI) based atmospheric analysis, GMAO set the penetration depth over the ocean water for all the MW sensors to 1.25 mm. This study modifies the penetration depth for different MW wavelengths and investigates its effect on measured brightness temperature.

In order to simulate brightness temperature, the atmospheric profiles, such as wind, temperature, moisture, etc., and surface fields, such as the surface type, surface temperature, etc., are needed. The focus of this article is on the surface temperature over open water. In reality, the near-surface water temperature is a nonlinear function of many variables (current and wind speed, solar insolation, evaporation, precipitation, subsurface temperature and salinity, etc.); but, for the purpose of this study, it is assumed that it is a function of depth (positive downward).

Figure 1 shows a schematic of the near-surface temperature variation. The air-sea interface is modeled as a layer of thickness (d) set to a constant value of 2 m. The foundation temperature (denoted by T_d and T_δ) is the temperature at the top of diurnal warm layer that has warmed by ΔT_w from T_d. The skin SST, Ts is cooler than T_δ by ΔT_c. Within the cool-skin layer (depth: δ), the temperature is assumed to vary linearly. Whereas in the warm layer, it varies non-linearly. For infrared sensors, the emission depth is very near the surface and is within the cool skin layer, but for MW sensors the emission depth is deeper and can be within the warm layer.

The emission depth is a function of scan angle (θ) in addition to the frequency (f). ***Figure 2*** represents a schematic of the variation of z_{ob} as a function of scan angle (θ). Dependence on θ is trivial to derive $z_{ob} = z_{ob}(\theta = 0)/\cos\theta$, where $z_{ob}^0 = z_{ob}(\theta = 0)$ is the emission depth at nadir.

Considering the emission depth variation based on frequency and scan angle, an expression was derived for the near-surface temperature variation with respect to depth and for corresponding changes in brightness temperature (Ebrahimi et al, 2018).

Finally, all that remains to be specified is the variation of zob as a function of frequency. This can be obtained from Segelstein, D.J., 1981. ***Figure 3*** presents penetration depth for each frequency band from 6.8 to 89 GHz. As can be seen, the penetration changes from 2.7 mm to 0.2 mm.

Figure 4 presents penetration depth variation based on scan angle variation. As can be seen, there is a significant variation on lower frequencies (up to 2 mm changes for 6.8 GHz) for edge of scan compared to the nadir. This dependency decreases as frequency increases.

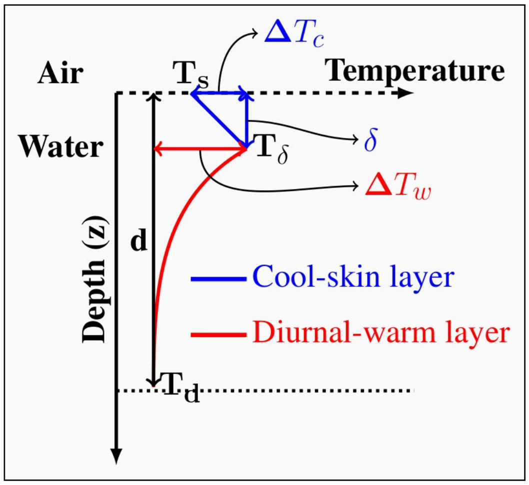

Figure 1. *A schematic of the near-surface temperature variation. The air-sea interface is modeled as a layer of thickness. Within the cool-skin layer (depth: δ), the temperature is assumed to vary linearly. Whereas in the warm layer, it varies non-linearly.*

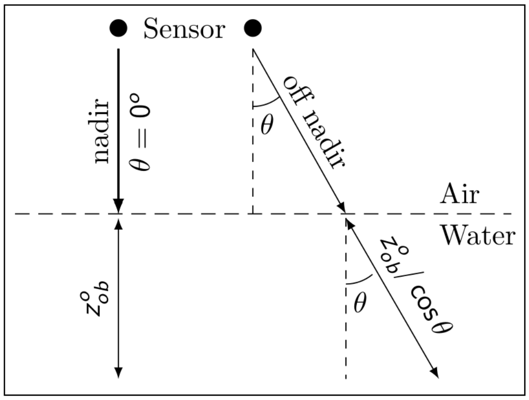

Figure 2. *A schematic of the variation of Zob as a function of scan angle (θ). At nadir ($\theta = 0^0$) and $Zob = Zob^0$ whereas off nadir, it increases to $Zob^0 / \cos\theta$.*

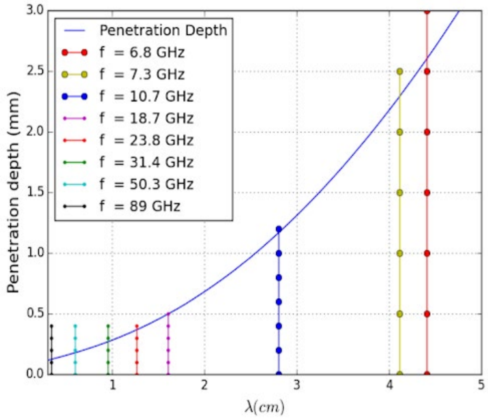

Figure 3. *Penetration depth for frequency bands from 6.8 GHz to 89 Ghz. The solid blue line is the penetration depth from Segelstein, D.J., 1981.*

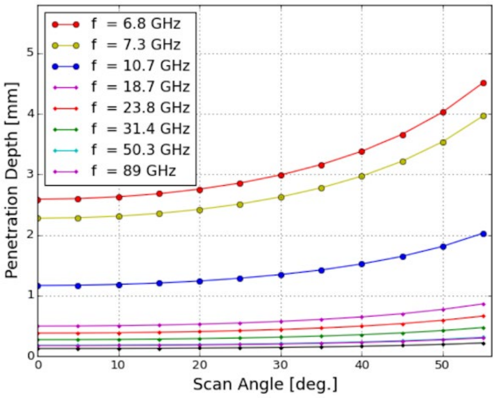

Figure 4. *Penetration depth variation based on scan angle variation.*

Experiment

To apply this correction algorithm on measured brightness temperatures, an experiment was done assimilating MW observations from 6.8 to 89 GHz. This experiment was performed for AMSU-A surface sensitive channels between 23.8 to 89 GHz, GMI channels from 10 to 89 GHz, and AMSR2 channels 6.9 to 89 GHz. The experiments were configured on a cube sphere (C360) grid, and all experiments were started with the same initial conditions. ***Figure 5*** represents the dTB/dTs jacobians from CRTM output for channels from 7 GHz to 89 GHz. As can be seen, vertically-polarized channels are more sensitive to surface temperature than horizontally-polarized channels. 7 V and 10 V GHz channels have the most sensitivity to the surface temperature; 37 H and 89 H have the least sensitivity.

The TB corrections for the GMI surface sensitive channels (10 GHz to 89 GHz) are presented in ***Figure 6***. For 10 V GHz channel, we can have up to 0.1 K correction. The observation (minus forecast for the corresponding channels) are presented in ***Figure 7***. Except for 37 H and 89 H, the observation minus forecast values seem reasonable. After investigating those channels in detail, the discrepancies were due to issues within the CRTM version 2.2.3. Those issues have been fixed in CRTM 2.3.

To see the effect of penetration depths variation in lower frequencies, an experiment was performed to assimilate the AMSR2 6.9 to 10.65 GHz channels. The TB correction are presented in ***Figure 8***. As it was expected, the correction values are much higher in lower frequencies, reaching up to 0.7 K at some points in the 6.9 V GHz channel. However, as it can be seen in ***Figure 9***, the observation minus forecast values are significant in those channels.

Conclusion

Initial attempt to assimilate surface sensitive channels have been performed in the GEOS system. Penetration depth changes versus frequency and scan angle changes and its effect on measured Tbs has been investigated, which for channels higher than 10 GHz is negligible. However, for 10 V GHz, the correction can be in order of 0.1K. For channels 6.9 and 7.3 GHz in AMSR2, we see up to 0.7 K correction at some regions. Also, it has been noticed there is a significant difference between observation and forecast. A further investigation is needed to resolve this matter.

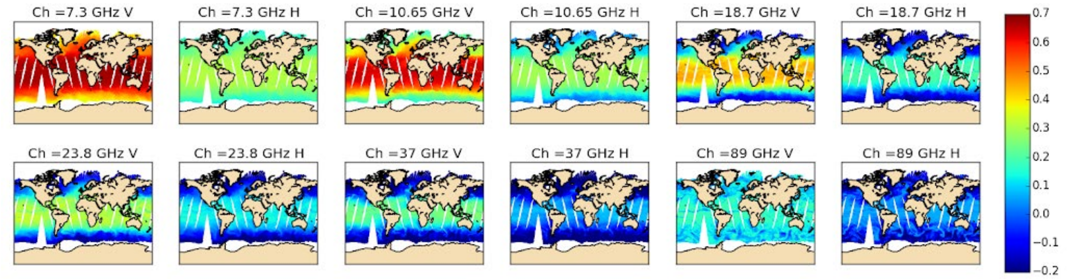

Figure 5. *The dTB/dTs jacobians from CRTM output for channels from 7 GHz to 89 GHz.*

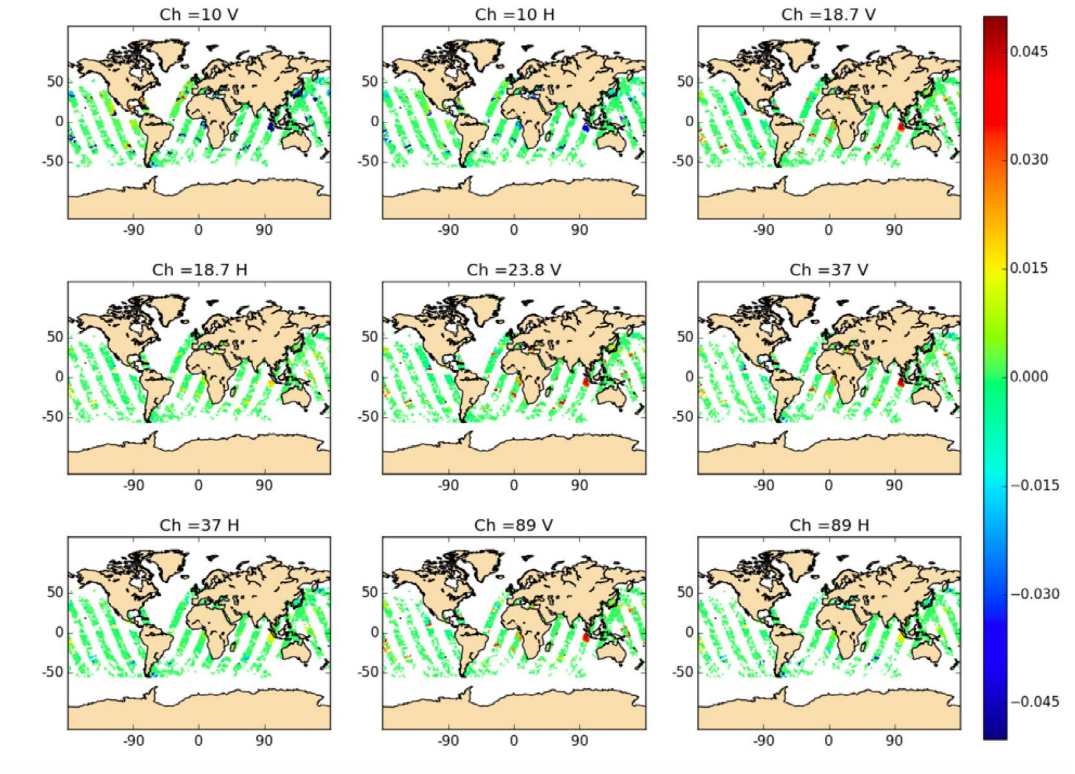

Figure 6. *TB corrections for the GMI surface sensitive channels 10 GHz to 89 GHz.*

Authors

Hamideh Ebrahimi (JCSDA), Santha Akella (NASA/GMAO), and Will McCarty (NASA/GMAO)

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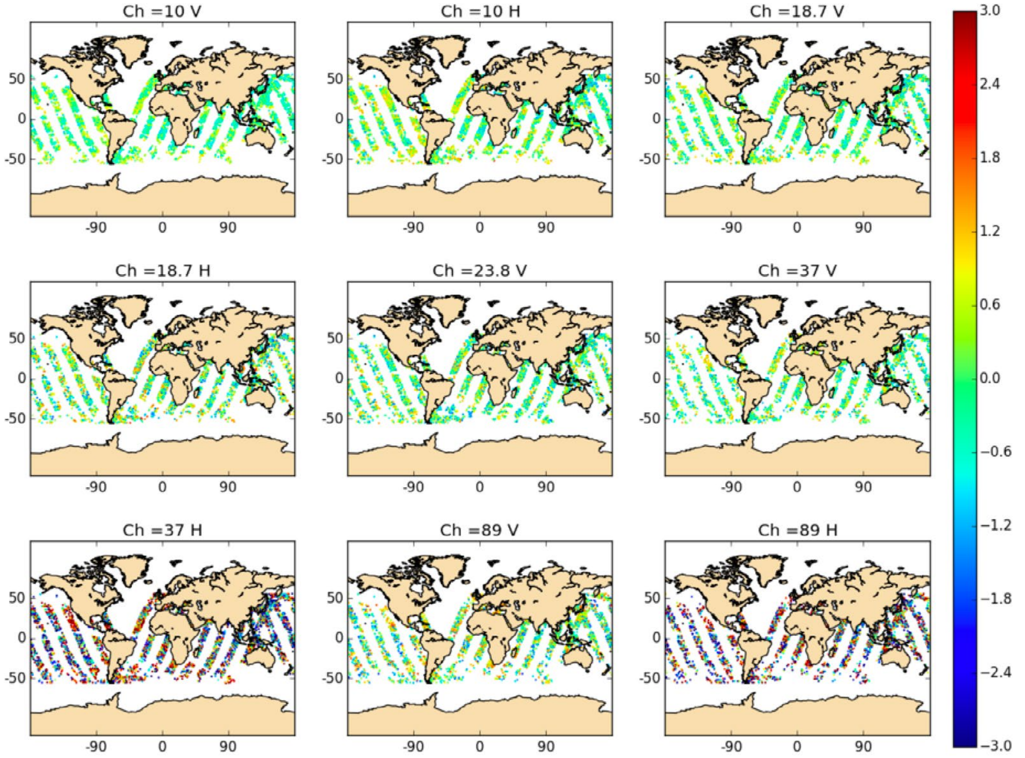


Figure 7. *Observation minus forecast for the GMI surface sensitive channels 10 GHz to 89 GHz.*

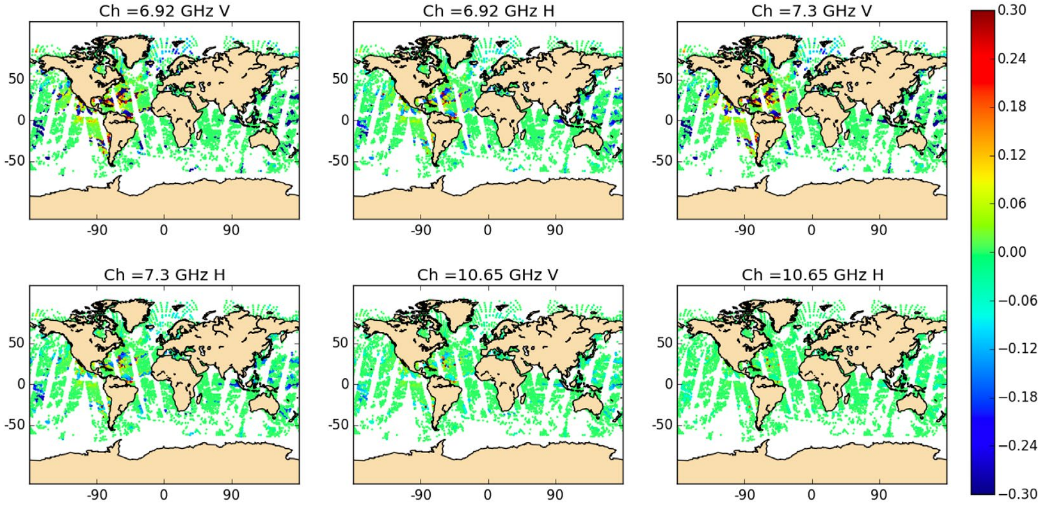


Figure 8. *TB corrections for AMSR2 channels 6.9 to 10.65 GHz.*

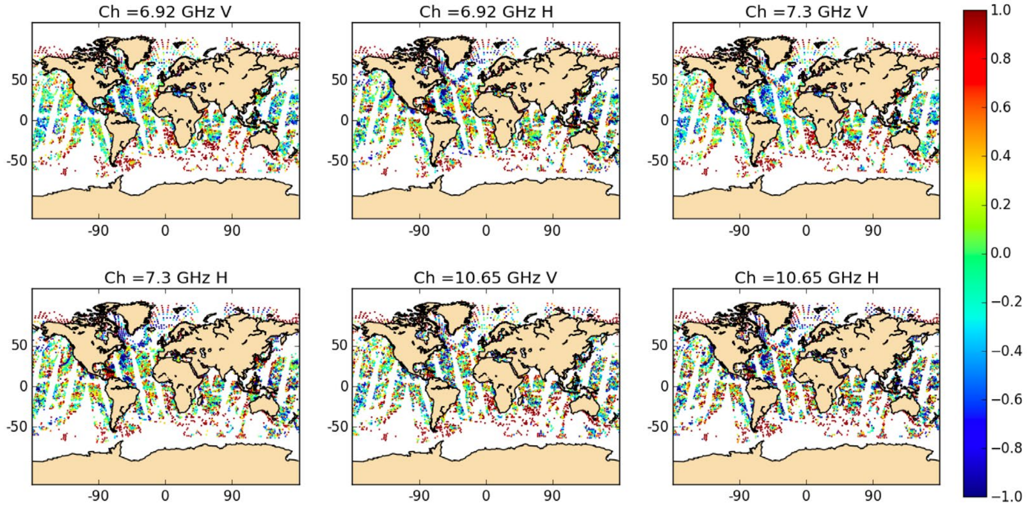


Figure 9. *Observation minus forecast for AMSR2 channels 6.9 to 10.65 GHz.*

Assimilating Microwave Cloudy Observations into NASA GEOS Model Using a Novel Bayesian Monte Carlo Technique

Despite the importance of clouds and their influence on atmospheric water and energy balance, Numerical Weather Prediction (NWP) centers systematically exclude cloud information from the assimilation process and only assimilate clear-sky radiances (Janiskov´a et al., 2012). In order to ensure that only clear sky radiances are assimilated, strict cloud detection thresholds are applied before radiances are fed into data assimilation (DA) systems. This process not only excludes a large portion of satellite radiances, but it causes loss of information in the regions that are of high interest to meteorologists and are most challenging for weather forecasts (Errico et al., 2007; Haddad et al., 2015). Although in recent years there has been great advances in the operational weather forecasting, the prediction of tropical cyclones (TC), especially the intensity of TCs, remains challenging. According to Aksoy et al. (2013), in addition to the model deficiencies, another important factor that contributes to this challenge includes lack of observations in the peripheral environment (rain-bands) of TCs mainly because of the selective assimilation of existing observations. Satellite observations provide more than 90% of the input data for the initialization of NWP models, but more than 75% of satellite observations are discarded due to the cloud contamination, as well as land, snow, and ice emissivity issues (Bauer et al., 2010).

Satellite observations assimilated into NWP models are largely measured by microwave (MW) and infrared instruments. Although MW observations are less sensitive to clouds than IR observations, a large portion of microwave observations, especially in the presence of deep convective clouds (e.g., in the presence of tropical cyclones), are still affected by clouds. Assimilation of microwave cloudy radiances is fundamentally different from assimilating clear-sky satellite radiances. The efforts so far have focused on the assimilation of cloudy radiances using variational techniques (i.e., minimizing the difference between the real observations and observations simulated using a radiative transfer model (RTM) from the atmospheric state variables provided by the forecast model). The accuracy of simulated observations in cloudy conditions is adversely impacted by several factors related to the first guess provided by the NWP model, as well as the RTM specific inputs, such as phase functions and particles size and shape.

We have examined using a novel Bayesian Monte Carlo Integration (BMCI) technique to retrieve the profiles of temperature, water vapor, and cloud liquid/ice water content, as well as sea surface temperature, wind speed, and rain rate from microwave cloudy measurements in the presence of TCs. The BMCI technique includes three steps: (i) generating a stochastic database using ECMWF Era Interim, CloudSat CPR, GPM DPR, as well as cloud information from several campaigns; (ii) generating absorption and scattering coefficients for selected instruments then simulating satellite observations and including them in the retrieval database; and (iii) retrieving atmospheric and surface information, such as temperature, water vapor, cloud liquid and ice water content profiles, as well as sea surface temperature, rain rate, and wind speed using BMCI and real observations. One advantage of the BMCI over other techniques is that, in addition to retrieving such parameters, the uncertainty related to each retrieval is also estimated. These retrievals then can either be directly used by meteorologists to analyze the structure of TCs or be assimilated into models to provide better initial conditions for the forecasts.

The BMCI technique, as well as practical aspects of assimilating such retrievals into NASA GEOS model, were examined for Hurricane Irma using the data from the Advanced Technology Microwave Sounder (ATMS) onboard Suomi National Polar-orbiting Partnership (NPP) and Global Precipitation Measurement (GPM) Microwave Imager (GMI). Two main limitations of the current work include the resolution of the model (around 25 km), which was too coarse to show the potential impact of such retrievals in improving the representation of TC in model forecast and also the data assimilation system not being able to consider the correlated observation errors.

Beam-filling Modification

There is considerably a mismatch between the GEOS grid size of 25 km and the ATMS/GMI footprint sizes. This size mismatch is important due to the large spatial variability of precipitation in ATMS and GMI footprints and the nonlinear relationship between precipitation and microwave brightness temperatures, which results in the beam-filling problem (see, Kummerow 1998).

The beam-filling correction procedure is designed to statistically account for the radiative transfer effects of realistic rain and ice horizontal variability over large passive microwave footprints. Since we are not using high-resolution observations to actually learn about the sub-footprint variability, the information available about the variability is inherently a priori and statistical. Specifically, the goal is to determine the uncertainty (standard deviation or sigma) and the bias of the brightness temperatures due to sub-footprint variability. The beam-filling bias and uncertainty would be expected to depend on the intensity of rain and precipitating ice, so ideally they should depend on the rain and ice water path in the footprints. The observed brightness temperatures can then be corrected by subtracting the bias and the beam-filling sigma can be added to other types of uncertainty to use in the Bayesian retrieval. ***Figure 1*** shows an example of the impact of beam-filling on ATMS brightness temperatures. The channels operating at 89 GHz and below are sensitive to liquid particles, and the channels operating at 90 GHz and above are sensitive to ice particles.

Correlated Observation Error

One of the advantages of the BMCI technique is that the observation error can be estimated during retrieving process. These errors are used during assimilation process as observation error. ***Figure 2*** shows an example of the observation error covariance matrix for clear sky and cloudy cases. We assimilated these observations similar to the way the GSI assimilates radiosonde profiles. GSI currently considers observations from different levels as single independent observations, therefore only the diagonal elements of the covariance matrix are used. This means that correlated observations errors cannot be taken into account when assimilating these profiles into GSI. As shown in ***Figure 2***, in clear sky cases, the retrieved atmospheric temperature profiles are much more vertically correlated in lower troposphere than in middle and upper troposphere. The off-diagonal elements of covariance matrix, which show the correlation between observation error at different levels, do not change significantly from clear to cloudy cases. However, in the case of RH, in clear-sky conditions, there is a larger correlated observation error in

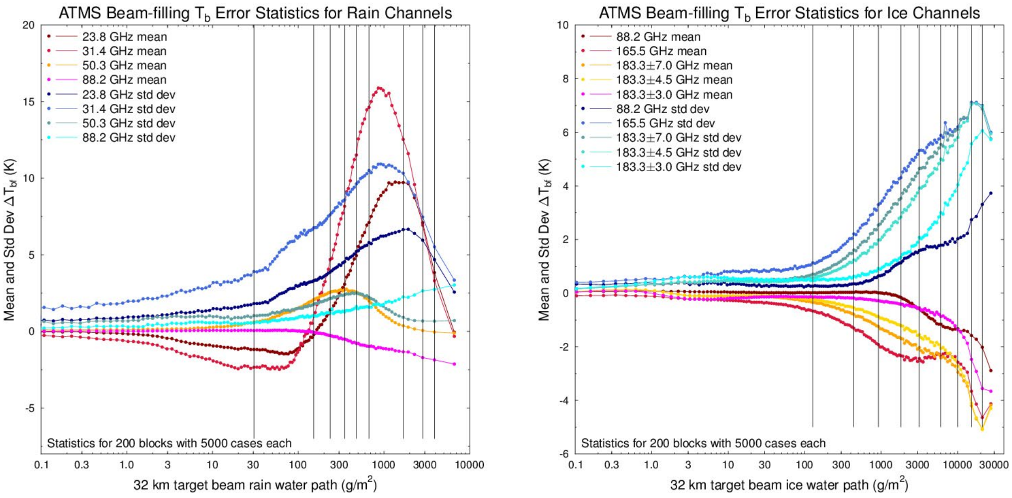


Figure 1. *The beam-filling impact on ATMS lower (left) and higher (right) frequency channels.*

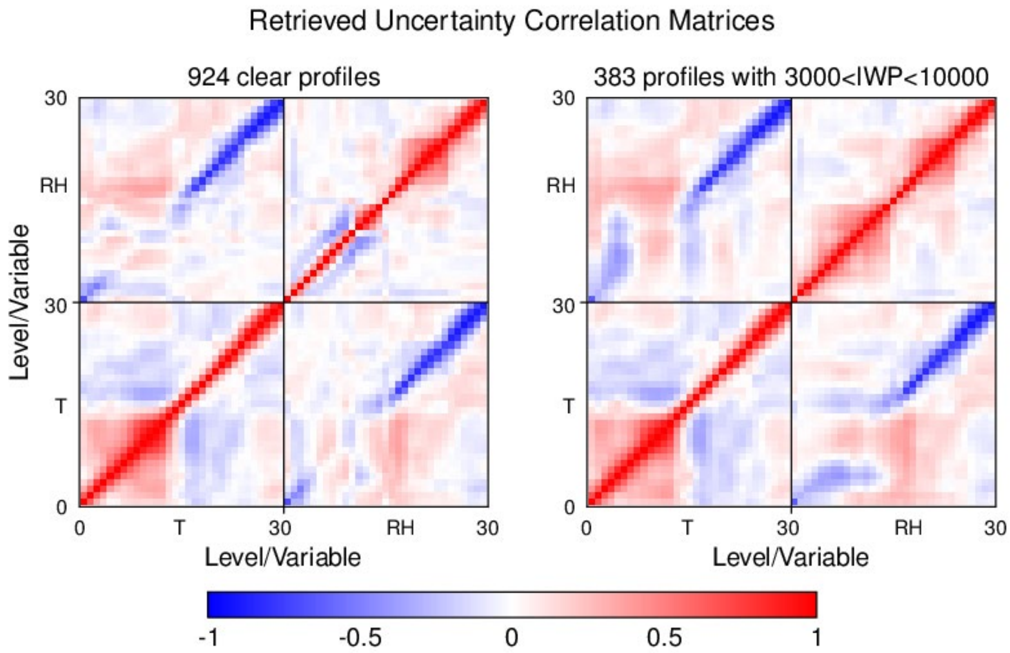


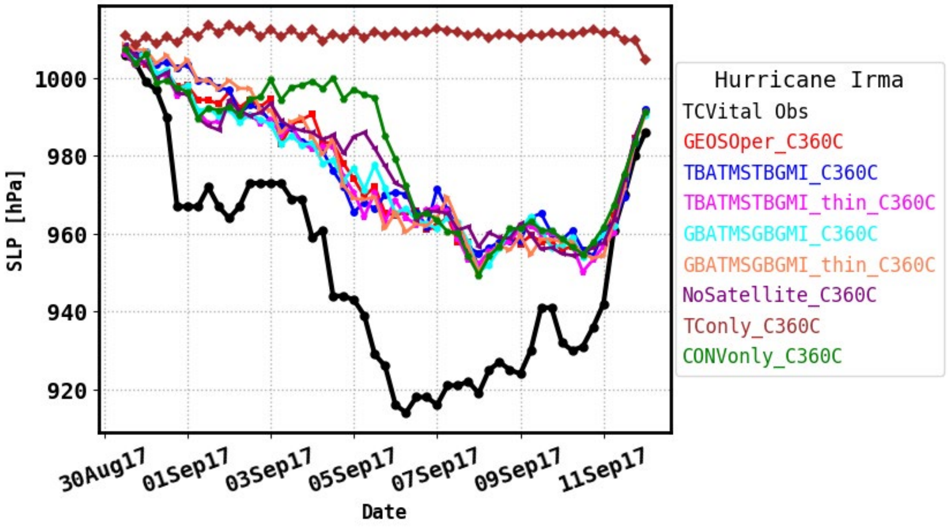
Figure 2. *Observation error covariance matrix for clear and cloudy conditions.*

upper troposphere than in middle and lower troposphere, but the correlation significantly changes from clear to cloudy conditions. Consequently, in cloudy conditions, the errors for RH profiles become correlated in both lower and upper troposphere. Since the current DA system (i.e., GSI) does not allow to account for correlated observation error, the only other option to avoid the negative impact from the correlated observation error was to thin the data vertically. Therefore, we thinned the temperature profiles at 50hPa and RH profiles at 100hPa to avoid correlated observation error. The DA system only allows uniform thinning for the entire atmosphere, otherwise the thinning can be performed differently for lower and upper troposphere.

Impact on Hurricane Irma's Track and Intensity

Two important features of tropical cyclones that are normally not well presented in the NWP forecast are minimum sea level pressure and maximum wind speed. These two are some of the limitations of the global models. ***Figure 3*** shows the analysis minimum sea level pressure for Hurricane Irma for the period of August 30, 2017, to September 11, 2017. The minimum pressure was calculated by first extracting the location of TC based on information from TCVital data. Since the location of TC in analysis do not necessarily match that in TCVital, a box expanding 2 degree in North-South and East-West directions was placed around the TC, and the minimum SLP inside the box was taken as the minimum SLP for the TC. Generally, the experiments where only TCVital data are assimilated fails to even initiate the tropical cyclone. This is mainly because TCVital data are assimilated as a single observation in the GEOS system. However, the difference between the experiment where only conventional data are assimilated with the experiments when satellite data are assimilated was not as large as it was expected. Possible reasons for this include:, first, satellite data are mostly assimilated outside the TC core so do not contribute to constraining minimum SLP of TC; second, the initiation of TC is affected by mesoscale atmospheric features that are well

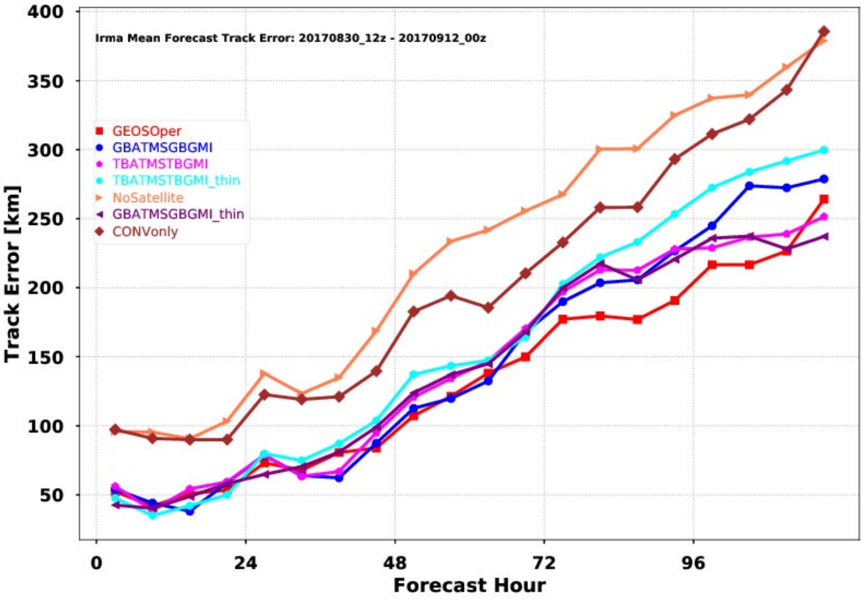
Figure 3. *Analysis intensity error for Hurricane Irma.*



represented by conventional data. That being said, there are some periods where assimilating satellite observations improves the minim SLP quite significantly. The experiments where BMCI profiles are assimilated do not differ significantly from GEOS operational runs where only clear-sky radiances are assimilated.

Figure 4 shows the 120-hour forecasts for the TC intensity and track. Since the location of TC in forecasts can be significantly different from the actual TC location, the location and minimum sea level pressure are calculated based on a box expanding 5 degrees in each direction. Unlike intensity, assimilating satellite observations significantly improves the TC track in the forecast. The difference between GEOS operational and ConvOnly and TCOnly experiments is about 50 km in terms of TC track forecast. Most of the experiments using BMCI slightly improve the track forecast compared to GEOS operational run in the first 48-hour but then afterwards the operational run mostly performs better than the experiments with

Figure 4. *Forecast track error for Hurricane Irma.*



BMCI profiles assimilated. Again, the reason can be that only a small portion of the satellite observations can be collocated with the TC center. Besides, we ran a very coarse resolution model (almost 25 km) that would significantly impact the results.

Authors

Isaac Moradi (NASA/GMAO/ESSIC), Frank Evan (University of Colorado), Will McCarty (NASA/GMAO), and Marangelly Cordero-Fuentes (NASA/GMAO)

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MEETING REPORT

The 2019 International Workshop on Radiative Transfer Models for Satellite Data Assimilation

Figure 1. *Conference participants enjoying traditional Chinese dishes.*

Many satellite instruments measure the radiation emitted by or reflected from the Earth at different spectral wavelengths. These observations – generally referred to as radiances – contain information about the Earth's surface and atmosphere. Satellite radiances are not components of the atmospheric state vectors predicted by numerical weather prediction (NWP) models. In order for these radiances to be assimilated by NWP models, a relationship between the model state vectors and the observed radiances is required.

This relationship is derived from the forward radiative transfer model simulations (simply forward models) with the state vectors as input. In addition, the Jacobian vectors (or the derivative of radiance relative to the state vectors) are also needed in satellite data assimilation systems. For each satellite mission, a fast and accurate radiative transfer model is deemed necessary for the overall mission success. In the past two decades, the United States, Europe, and many other countries have already invested in the development of fast radiative transfer models through their space programs.

These models have resulted in huge successes in uses of satellite data in operational data assimilation frameworks. Advancements in these radiative transfer (RT) models, in turn, have created an increased capability to assimilate a broader range of observations from various sensors and under all-weather and all-surface conditions.

From April 29 – May 2, 2019, the Chinese Meteorological Administration (CMA), the European Centre for Medium-Range Weather Forecasts (ECMWF), and the Joint Center for Satellite Data Assimilation (JCSDA) jointly held an international workshop in Beijing, China, on radiative transfer models in support of satellite data assimilation.

The JCSDA Community Radiative Transfer Model (CRTM), the ECMWF Radiative Transfer for TOVS (RTTOV), and the CMA Advanced Radiative Transfer Modeling System (ARMS) are the three key fast radiative transfer models that are used operationally, and they featured heavily in this workshop.

The specific goals of this workshop were to:

1. Review the current capabilities of fast radiative transfer models (e.g., CRTM, RTTOV, ARMS).
2. Identify new requirements on radiative transfer models for satellite data assimilation.
3. Prioritize new developments of super-fast computational methods for atmospheric and surface radiative transfer processes.

Over 28 talks were presented, with multiple opportunities for in-depth discussion among the panel members. Participants from several nations attended and enjoyed the highly technical but also fruitful discussions.

A key action that arose out of the workshop is to develop an international reference radiative transfer model (IRRTM), which will be initiated by Dr. Benjamin T. Johnson (JCSDA). This will be an internationally coordinated effort between multiple operational NWP center agencies. This effort will also be supplemented by a recently selected proposal to the International Space Science Institute (ISSI) entitled: A Reference Quality Model for Ocean Surface Emissivity and Backscatter from the Microwave to the Infrared, led by Dr. Stephen English (ECMWF). Additionally, a special issue for the conference-related publications will be published in Journal of Quantitative Spectroscopy & Radiative Transfer (JQSRT).

Website for the 2019 International Workshop

Workshop summary provided by Benjamin Johnson (JCSDA).

PEOPLE

Welcome Clémentine Gas

After an internship at JCSDA from September to March, Clémentine joined the Joint Effort for Data Assimilation Integration (JEDI) core team at the beginning of May 2019. She is working on block methods (Lanczos, Krylov and Full Orthogonalization Method) to solve ensemble of data assimilations. She was working with simple models during her internship and is now moving to real ones! The ultimate goal for this project is to apply these block methods to coupled Earth systems.

Clémentine just got a double Master's degree in Environmental and Energy Engineering from the Royal Institute of Technology in Sweden and Mechanical engineering from the French engineering school ENPC in Paris. For her Bachelor of Science in Mechanical Engineering, she was also studying at ENPC focusing particularly on fluid dynamics. Interested in a lot of domains, the main focus of her studies was to be able to provide technical solutions to environmental problems.

Coming from a city that is not too far from the Alps in France, she is really happy to live so close to the mountains where she will enjoy hiking and skiing as much as possible. She also plays music – oboe and piano – and recently discovered that cooking is indeed a hobby. She will happily share recipes and samples!

Introducing Dr. Benjamin Menetrier

Dr. Benjamin Menetrier joined the Institut de Recherche en Informatique de Toulouse (IRIT, Computer Science Research Institute of Toulouse) in Toulouse, France, contracting for the Joint Center for Satellite Data Assimilation (JCSDA). Since October, he has been working on the implementation of generic background error covariance operators within the Joint Effort for Data-assimilation Integration (JEDI) project.

Dr. Menetrier earned a PhD in Meteorogology from the Institut National Polytechnique de Toulouse (INPT, National Polytechnic Institut of Toulouse), working at the Centre National de Recherches Météorologiques (CNRM, National Center for Meterological Research) in Toulouse, France. He received the Léopold Escande award for this work in 2014. He has been involved in the development of the variational data assimilation system for the high-resolution model AROME, run operationally at Météo-France.

After graduation, Benjamin joined the Mesoscale and Microscale Meteorology (MMM) laboratory at the National Center for Atmospheric Research (NCAR), as a project scientist, working on advanced variational methods, such as hybrid covariance modelling and variational ensemble updates. In 2015, he joined the Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS, European Center for Research and

Advanced Training in Numerical Simulation) in Toulouse, France, working on ocean data assimilation. In 2016, he obtained a scientist position at the CNRM, working on ensemble-variational data assimilation methods for the French global model ARPEGE.

In his leisure time, Benjamin enjoys outdoor activities, such as hiking and biking, and playing the nyckelharpa, a mysterious but beautiful Swedish instrument. He is an active member of a self-managed cultural place in Najac, the medieval village where he lives.

Say Hello to Dr. Travis Sluka

Travis Sluka joined JCSDA in Boulder, CO, in February 2019, with the Sea-ice, Ocean, and Coupled Assimilation (SOCA) project, where he is responsible for helping implement ocean data assimilation and ensemble Kalman filters within the Joint Effort for Data Assimilation Integration (JEDI).

Travis came to atmospheric and oceanic science with a lifelong interest in computer programing, 3D graphics, and game design, which motivated him to obtain a B.S. in computer science and electrical engineering from the University of Virginia. Following his undergraduate studies, he spent 5 years as a civil servant for the US Navy at the Patuxent River Naval Air Station in southeast Maryland. There, Travis developed high fidelity simulators for various military helicopters, missiles, and jet aircraft such as the F-18 Hornet and the new F-35 Lightning II, often leading to many fun hours of "testing" his code.

In 2012, he quit his job to become a full-time student again, obtaining his Ph.D. in atmospheric science from the University of Maryland under Dr. Eugenia Kalnay. His thesis focused on developing strategies for strongly coupled ocean-atmosphere ensemble data assimilation (i.e., using magic to let atmospheric observations improve ocean analyses and vice versa). His computer science background also led him to design and teach a graduate level course on high-performance computing while still a graduate student. Starting in late 2016, Travis began working at the NOAA Climate Prediction Center where he developed the Hybrid Global Ocean Data Assimilation System (Hybrid-GODAS). This system is slated to replace the aging ocean monitoring system currently used at CPC for tasks such as ENSO and tropical hazard outlook monitoring.

Outside of work, Travis enjoys cultivating an odd assortment of ever-changing hobbies. In the past, this has included chainmaille making for renaissance festivals, lepidoptera collecting, and medieval siege weapon construction. Now he spends his time on more "normal" activities, such as hand-tool based fine woodworking, bird photography, beer brewing, and German-style board games (anyone interested in a game night?).

EDITOR'S NOTE

Colleagues,

Summer is upon us, and I hope that each of you has been able to set aside time to enjoy it in the company of family and friends. If it's a little harder to reach people during vacation season, that inconvenience is offset by the contagious vigor, energy, and creativity everyone seems to have as they return.

The summer began, of course, with the annual JCSDA Science and Technical Workshop held at the end of May at NASA Headquarters in Washington, DC. The quality of the 35+ oral presentations and 22 posters was uniformly high, and the record audience - over 130 registered participants - was strongly engaged throughout. Many of the presentations and posters may be viewed at:

The 17th JCSDA Technical Review Meeting Presentation

The 17th JCSDA Technical Review Meeting Poster Gallery

In this edition of the Quarterly, we present a pair of science articles, of which I hope to write just enough to incite the curiosity of readers without stealing the authors' thunder.

Isaac Moradi and co-authors have provided an article that returns to a long-term science challenge for the JCSDA community, that of assimilating cloud-impacted satellite microwave observations. They report on their attempts to assimilate retrieved profiles and surface properties in NASA's GEOS model using a new Bayesian Monte Carlo retrieval technique and discuss some limitations and possible next steps.

Hamideh Ebrahimi and her co-authors address the topic of microwave radiance assimilation, likewise in the GEOS framework, for surface-sensitive channels. They examine the feasibility of a more realistic, wavelength-dependent penetration depth that is used currently to refine simulated brightness temperatures and sea surface temperatures and present preliminary results.

We frequently say that the success of the Joint Center depends on the shared mission and the cooperation of its partners, and that's certainly true; but our success is a consequence of the effort and commitment of individual persons, too, and it's gratifying to be joined by talented new staff. In this month's issue you have an opportunity to meet three of them via short biographies: Clémentine Gas, Travis Sluka, and Benjamin Ménétrier.

Jim Yoe

SCIENCE CALENDAR

UPCOMING EVENTS

MEETINGS OF INTEREST

DATE	LOCATIONS	WEBSITE	TITLE
September 16-20, 2019	Honolulu, HI	http://www.oceanobs19.net/	OceanObs'19
September 28–October 4, 2019	Boston, MA	https://www.ametsoc.org/index.cfm/ams/meetings-events/ams-meetings/2019-joint-satellite-conference/2019-joint-satellite-conference-call-for-papers/?utm_source=Subscribers&utm_medium=Email&utm_campaign=Newsletter&_zs=5EW4e1&_zl=cf3a5	Joint AMS/EUMETSAT/NOAA conference
October 31–November 6	Saint-Saveur, Québec, Canada	https://cimss.ssec.wisc.edu/itwg/index.html	TOVS ITSC THE 22nd INTERNATIONAL TOVS STUDY CONFERENCE (ITSC-22)
November 4–8, 2019	Herzliya, Israel	http://www.cospar2019.org/	4th COPSAR Symposium Small satellites for sustainable Science and Development
December 9–13, 2019	San Francisco, CA	https://sites.agu.org/	AGU
January 12–16, 2020	Boston, MA	https://www.ametsoc.org/index.cfm/ams/	AMS Annual Meeting
June 8–12, 2020	Fort Collins, CO	https://www.cira.colostate.edu/conferences/8th-international-symposium-on-data-assimilation/	8th International Symposium on Data Assimilation (ISDA)

MEETINGS AND EVENTS SPONSORED BY JCSDA

DATE	LOCATIONS	WEBSITE	TITLE
TBA 2020	Monterey, CA (proposed)		JEDI Academy 4
TBA 2020	Monterey, CA (proposed)		CRTM Workshop

CAREER OPPORTUNITIES

Opportunities in support of JCSDA may be found at https://www.jcsda.org/opportunities as they become available.