Turbulence Impact Mitigation Workshop IV

November 8-10, 2021

Day 2, November 9, 2021

[4:37 PM] Matt Fronzak
Good evening (or day), folks. If you have any questions about MS Teams and/or how to perform certain functions, I'm happy to try to answer them before we get started at 1700E.

[4:42 PM] Matt Fronzak
Also, a reminder to those of you using the chat room to ask questions or make comments: it is very helpful if you start your question or comment with the name of the person it is intended for. If you use the convention @ABCXYZ (where ABCXYZ is the name of the target person), MS Teams will (most of the time) then display a list of folks with the name ABCXYZ, and you can select the one you want from that list.

[4:47 PM] 전혜영
Hi Bob, this is Hye-Yeong. My name is in Korean, somehow I cannot change it in my home desktop computer.

[5:00 PM] Matt Strahan (Guest)
Hi everyone

[5:01 PM] Matt Fronzak
Hello, my brother Matt Strahan

[5:01 PM] Steve Abelman
Hello Matt, so I am in

[5:02 PM] Matt Fronzak
Yes indeed, Steve!

[5:03 PM] Dr. Brian Pettegrew
Hey Jung Hoon

[5:04 PM] Steven Silberberg (Guest)
Hi Jung Hoon. You look terrific.

[5:04 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Hello Brian!

[5:04 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Hello Steve Thank you!

[5:05 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you, Tammy and all, for considering Asian time zone to arrange this wonderful workshop! I really appreciate it!

[5:05 PM] Todd Lane (Guest)
Yes, thank you also from Australia. This is a particularly good time for us, so very much appreciated

[5:17 PM] Walter Rogers (Guest)
What altitude is the ER2 at

[5:19 PM] Steven Silberberg (Guest)
The ER-2 operates at altitudes from 20,000 feet to 70,000 feet,

[5:21 PM] Steven Silberberg (Guest)
The ER-2 operates at altitudes from 6100 m to 21,340 meters,

[5:22 PM] USA - Larry BURCH (Guest)
Walt, the ER-2 is a modified U-2. 50mb is the typical operating altitude.

[5:23 PM] Clark, Ivan O. (LARC-D319)
Those are operational altitudes. It can take off and land from sea level.

[5:23 PM] Steven Silberberg (Guest)
Thanks Larry. Great to see you.

[5:23 PM] Walter Rogers (Guest)
What altitude was ER2 encountering up/down?

[5:23 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you Mattias for wonderful talk. Even though we emphasize weather for UAV developers and operators seems to not consider about the weather in the development stage. How about the atmosphere in US side?

[5:23 PM] Walter Rogers (Guest)
Thx

[5:24 PM] Steven Silberberg (Guest)
Hi Brian. Hope all is well with you.

[5:25 PM] Todd Lane (Guest)
Hi Matthias. Great talk! What do you think is the biggest immediate challenge for forecasting for UAV? Our ability to simulate the appropriate scales for UAVs realistically, or our ability to initialise those models at the appropriate scale?

[5:26 PM] Buchanan, Piers (Guest)
Any suggestion as to how to get (for example) UAV operators to share weather data in a common format and ideally free to access. Seems to be a very emergent area at the moment.

[5:26 PM] Matt Fronzak
Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest) - I wish things were different, but IMO weather continues to be a secondary or tertiary consideration (even though many of us are jumping up and down, trying to get the attention of the developers and operators and providers).

[5:28 PM] Todd Lane (Guest)
Thanks for the comprehensive answer.

[5:28 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you very much!

[5:30 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thanks Matt for sharing the situation over there.

[5:34 PM] Matt Fronzak
Buchanan, Piers (Guest) - I would point you and other participants to the following paper: https://ams.confex.com/ams/2020Annual/mediafile/Manuscript/Paper369277/U-ABO_Final.pdf

[5:53 PM] Todd Lane (Guest)
Excellent talk Jim - thanks.

[5:54 PM] Steven Silberberg (Guest)
Great talk Jim - thank you

[5:54 PM] Domingo Munoz-Esparza (Guest)
Indeed, excellent talk, Jim! Many thanks!

[5:54 PM] Matthias Steiner (Guest)
Yes, I agree, very insightful presentation! Thank you.

[5:55 PM] Bob Sharman (Guest)
Jim: What observations were available from DEEPWAVE in the low-mid stratosphere (20-40 km)?

[5:59 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Yes, it was wonderful talk Dr. Jim Doyle. I'm wondering what was synoptic scale background condition for downslope windstorm and turbulent flow in your case for Alaska. Thank you again for your great talk.

[6:03 PM] Jim Doyle (Guest)
Hi Jung-Hoon. Thanks for the question. The case in Alaska featured a mean state critical level. In the low levels, there was easterly flow and in the upper troposphere, westerlies. The locals in Alaska refer to this type of downslope windstorm as a "Taku". I think these cases of critical levels frequently are associated with mountain wave turbulence.

[6:06 PM] Matt Fronzak
Speakers - to this point, your cursors have not been visible to the audience. So, spatial reference to the figure you are pointing to (e.g., "upper right figure") is helpful, as opposed to saying "this figure here."

[6:06 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thanks Jim for your reply. It sounds really interesting!

[6:07 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
I really enjoyed your LES modeling results for capturing K-H billows in rotors.

[6:09 PM] Jim Doyle (Guest)
Thanks!

[6:11 PM] Bob Sharman (Guest)
Jim: What observations were available from DEEPWAVE in the low-mid stratosphere (20-40 km)? That is above the GV altitudes?

[6:14 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you for interesting talk Paola. I'm wondering what is the horizontal and vertical resolution to calculate Ellrod 1 and 2 indices for capturing MWT case in your slide? Ellrod index is not inferring MWT but seem to have ability to capture them when we use high resolution data.

[6:15 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Yes Thank you!

[6:15 PM] Jim Doyle (Guest)
Hi Bob - Good question regarding the DEEPWAVE obs. On the G-V, there was an uplooking Rayleigh lidar that measured density(z) and temperature (z) between 20 and 60 km. Ground based Rayleigh lidars at Lauder and Kingston were available too.

[6:15 PM] Domingo Munoz-Esparza (Guest)
Very interesting talk, Paola! The limitations of EDR in some cases is something we have been discussing at NCAR for a while. Would you agree that TKE over a proper length scale relevant to the aircraft would be a more appropriate and universal metric to use?

[6:15 PM] Steven Silberberg (Guest)
At the Aviation Weather Center, GTG run on the GFS model shows CAT and MTW turb in the Drake passage, New Zealand, Australia. Antarctica, and S. Africa depending on synoptic/mesoscale flow. Thank you Bob Sharman and collaborators.

[6:17 PM] Todd Lane (Guest)
Very nice talk Paola. I wonder whether we can use the relationship between Lo and the aircraft response scale (typically 100m - 1km I think) to infer something about the turbulence. E.g., if Lo is too small then there shouldn't be a turbulent response from the aircraft.

[6:18 PM] paola imazio (Invitado) (Guest)
Hi Domingo. I think sometimes TKE is a good measure of large scale intermittency not seen in EDR. However, you need to confirm dissipation. The three references I showed at the end show that kurtosis is a good measure of brustiness, but more importantly, they can be linked directly to the spectral index. This might tell whether you are overestimating EDR, for instance

[6:19 PM] Domingo Munoz-Esparza (Guest)
Thank you, Paola. Good points and thanks for the references.

[6:20 PM] paola imazio (Invitado) (Guest)
Hi Todd. Thanks. Yes, very Likely, I think.

[6:23 PM] paola imazio (Invitado) (Guest)
Thank you Steven. We have the world's largest hot spot of GW in the southern Andes, and these GW seem to migrate. We can see them using operational WRF model at fairly low resolution, and we also used GFS for this study, with very similar results to those I showed

[6:23 PM] Nicolás Rivaben (Invitado) (Guest)
Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest) (Invitado), We calculated ETI1 and ETI2 using GFS (operational, 0.25°; WRF-SMN (4km) and ERA5 settings. You are right regarding Ellrod; we calculated also Thermal Front Parameter (TFP), frontogenesis, and made vertical slice looking for trapped waves. MTW CAT is not related in this case, because the synoptic pattern (polar low is not releasing lee waves in the location of HALO flight at that time)

[6:24 PM] larry cornman (Guest)
Paola, Extreme care must be taken when applying theoretical expressions, (e.g., structure functions, Kolmogorov cascade), to real world phenomena or real world signal processing methods, that don't correspond to the assumptions in the theory - e.g., ensemble averaging, isotropy, homogeneity, and fully-developed turbulence (well-separated in both space and time from sources). We're just lucky that the theory allows for us to extract useful information at all!

[6:25 PM] paola imazio (Invitado) (Guest)
Larry, we are just lucky that we can observe a Kolmogorov cascade between 0.4 and 4 Hz with this resolution. But nature is kind :). Thank you for your comment.

[6:26 PM] larry cornman (Guest)
Yes, consider us lucky! ;)

[6:27 PM] Steven Silberberg (Guest)
Hi Paola. I have yet to work a S. Hemisphere shift where I haven't drawn MTW turb based on satellite and GTG in the southern Andes.

[6:28 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you very much Nicolas for your additional explanations on your calculation.

[6:36 PM] Jim Payne (Guest)
Excellent talk, Walt!

[6:38 PM] Steven Silberberg (Guest)
Excellent suggestion to repackage HRRR output. Thank you.

[6:38 PM] Paula Acethorp (Guest)
Thanks for this presentation Walt - interesting for us in NZ, where severe downdrafts have contributed to aircraft accidents in the past.

[6:39 PM] Todd Lane (Guest)
Do we know whether the HRRRs upper boundary is treating mountain waves properly (i.e., being wave radiative). Has anyone looked carefully at this?

[6:39 PM] Chao, Haiyang
Walt, very interesting talk. I wonder which approach will be better in preventing similar accidents. More understanding on the turbulence or more simulation on aircraft response to turbulence?

[6:39 PM] Ulrich.Schumann (Gast) (Guest)
Thank you for all the interesting talks. It is time for me to quit for this day. I look forward to see the videos. Ulrich

[6:40 PM] Nicolás Rivaben (Invitado) (Guest)
Steven Silberberg (Guest) (Invitado) We are looking for CAT sources over Argentina using GOES-16 and hi-res NWP also. We found out CIT cases related to MCS (polarward flux at high levels) and MTW obviously over Andes combinate with strong cold advections -a combination of synoptic and mesoscale sources. However we have a lack of upper-air data and AMDAR should be the key to solve this.

[6:41 PM] Jim Doyle (Guest)
Thanks for the interesting talk Walt. I'll be happy to make some comments in the discussion session. I generally agree with your comments about the promise of these high res models such as WRF and HRRR and COAMPS in predicting mountain waves. I think ultimately high resolution ensembles are needed to provide reliable probabilistic forecasts, particularly to represent severe cases that are of lower probabilities.

[6:47 PM] Walter Rogers (Guest)
Thanks, Jim. I agree with the use of ensembles to weed out the lower probability severe cases.

[6:50 PM] paola imazio (Invitado) (Guest)
larry cornman (Guest) (Invitado) Again Larry, I understand your comment. Spectra is spectral energy density in our case study, and structure functions are: structure functions, purely, with no filtering. Calculated like this: ensemble averages of are replaced by time averages using Taylor's frozen hypothesis (Frisch, 1995). Velocity increments for each wind component are calculated independently from the in situ measurements. In this sense, calculations follow the approach used in Cho et al. (2003). Increments are defined in terms of time intervals t , as l = Ua·t, where Ua is the mean air

speed over the considered sublegs. The question regarding averaging and ensembles, ok. Turbulence is considered ergodic here. So under this conditions, a "photo" will do, under this hypothesis.

[6:50 PM] Steven Silberberg (Guest)
Nicolas, AWC looks for CAT sources over Argentina using GOES-16, GFS model wind fields, GFS point forecast soundings, and GTG run on the GFS. I have seen cases where CIT is maximized on the poleward side of the CBs over Argentina and over the USA. Add in strong cold advection and there is turb. In situ observations of turb and raobs will have to be assisted by remote sensing at high time and space resolution.

[6:51 PM] Walter Rogers (Guest)
Chao, the severe downdraft GA type accidents are usually not turbulence related (unless they encounter the low level SEV turb or EXTREME turb of rotors). The strong downdrafts simply force the pilots into climb mode in which they are unable to escape. Clearly identifying the strength and location of the downdraft reliably is more important that the turb forecast.

[6:55 PM] Steven Silberberg (Guest)
I agree Walt about severe downdraft GA accidents. GA planes may not have the power to climb. I flew a Cessna 150 under a modest Cu cloud and flew into a 1500 ft/min updraft. We flew out of the updraft just before we reached cloud base.

[6:55 PM] Walter Rogers (Guest)
Todd, reference HRRR upper boundary treatment of MW's. Good question. I don't think this has been looked at carefully.

[6:56 PM] Nicolás Rivaben (Invitado) (Guest)
Yes, Steve, I know what you said, I read also Bob's works about that and it is amazing what GTG can do. It will be wonderful if we could access that data to validate some incidents.

[6:59 PM] paola imazio (Invitado) (Guest)
And to finish larry cornman (Guest) (Invitado), you are right. I always remember what Kraichnan and Montgomery wrote in 1980: "But it does seem proper to stress that great caution must be used when interpreting phenomena of the real world in terms of asymptotic solutions of approximate statistical treatments of idealised theory. In some cases the idealised theory may be more valid in providing a language for discussion rather than a true explanation." And in spite of this warning, and of the limitations of the theory, we must also acknowledge that the theory of turbulence has provided a very useful language to understand the phenomena we observe in the atmosphere. :)

[7:00 PM] Walter Rogers (Guest)
Steven... that's nothing. Try soaring a P-38 fighter in 1950 in the Bishop area with 4000fpm up/down drafts!

[7:00 PM] Steven Silberberg (Guest)
HI Nicolas. GTG is excellent and AWC is waiting for GTG-N. Accessing GTG is above my pay grade and will take more international cooperation. The data is just an scp away if permission is granted.

[7:03 PM] Matt Fronzak
Let me commend the audience for being SO good regarding muting microphones except when speaking or being asked to speak. You've made one of my jobs (below) VERY easy.

[7:04 PM] Walter Rogers (Guest)
Domingo, what about using the LES 5-10m resolution models to virtually fly ultra low speed aircraft UAVs (like the Aerovironment HAPS) to determine aircraft response? Is is practical to get the voluminous data sets todo such simulations?

[7:05 PM] larry cornman (Guest)
Paola, yes - I use the theory, as we all do. It's just one needs to be careful about trying to extract too much from the data. (for example, 3rd-order sf's with inhomogeneous data. Just because sf's look smooth, the random errors are still there!)

[7:07 PM] Todd Lane (Guest)
Great talk Domingo.. For ensembles at this scale, what is the best approach (e.g., using ensembles from the driving model, or perturbing at the scale of the LES model)?

[7:08 PM] Jim Doyle (Guest)
Domingo - Really great talk. Does FastEddy represent boundary layer clouds and microphysics? If not, are there plans to include it?

[7:08 PM] Walter Rogers (Guest)
Domingo, I mean to do this purely for research... not operational.

[7:08 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Great talk Domingo, for multi-scale modeling how the Fast eddy model sensitive to the accuracy of IC/BC from mesoscale model output?

[7:10 PM] Todd Lane (Guest)
Thanks Domingo..

[7:10 PM] Walter Rogers (Guest)
Excellent talk, Domingo

[7:10 PM] Jim Doyle (Guest)
Thanks Domingo

[7:11 PM] Steven Silberberg (Guest)
Thank you Domingo

[7:11 PM] Nicolás Rivaben (Invitado) (Guest)
Thanks Steve...Let me check it with my authorities about that.

[7:12 PM] Matt Strahan (Guest)
The drone noise issue caught my eye (ear). Those things are pretty loud. Can you imagine a bunch of them delivering amazon in a busy city?

[7:12 PM] Domingo Munoz-Esparza (Guest)
Jung-Hoon: That is a really good point. Uncertainties/errors do propagate from the mesoscale to the LES, so definitely part of the ensemble would be designed to tackle that aspect.

[7:14 PM] Domingo Munoz-Esparza (Guest)
Matt Strahan: Yes, that is an excellent point. That's exactly the reason why we want to do research on that problem, since it may likely be of high value to operators and policy makers :-)

[7:15 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thanks Domingo, yes I totally agree that we need more computational resources and/or your GPU based fast running LES modeling for ensemble LES forecast.

[7:16 PM] Domingo Munoz-Esparza (Guest)
Indeed, Jung-Hoon. Accelerated modeling is the only way to get to operational weather guidance at street-scale levels!

[7:17 PM] Walter Rogers (Guest)
Turbulence forecasts for aviation are always framed in either a safety perspective or optimization in order to minimize costs for avoidance. But, what about using turbulence/convection/GW's to extract energy to enhance aircraft performance? Glider pilots use this latter approach. We (I'm a glider pilot) look for turbulence to provide our energy of flight. Can future UAS's use this approach with practicality in the future?

[7:18 PM] Matthew Wandishin (Guest)
John, when we discuss potential value of forecasts in the cost/loss sense, it is important to note the range of C/L ratios where that increased value is realized and how that maps to estimates of actual user C/L ratios.

[7:21 PM] Walter Rogers (Guest)
John, this C/L analysis would be essential in using atmospheric effect to increase aircraft energy. Airbus and others are investigating use of aircraft vortices to enhance cruise performance for trailing aircraft.

[7:24 PM] Matthew Wandishin (Guest)
John (and Domingo), regarding ML approaches, is there a reason to prefer using turbulence diagnostics as inputs to the ML algorithm rather than raw model output, or perhaps gradients of raw model output?

[7:27 PM] Clark, Ivan O. (LARC-D319) (Guest)
Walter: Would the type of turbulence generated by building walls in urban canyons be useful to a glider pilot?

[7:27 PM] Domingo Munoz-Esparza (Guest)
Hi Matt. I would say using the diagnostics is a better way since we help the AI/ML algorithms by providing physically relevant turbulence diagnostics as inputs. Otherwise the AI/ML algorithm will have to be much more complex to the point of learning things like Richardson number and so on...

[7:28 PM] Domingo Munoz-Esparza (Guest)
Clark: I do not think that would be the case. There some much small scale variability in the instantaneous flow that you will very easily hit a wall...

[7:29 PM] Matthew Wandishin (Guest)
More of a comment.

[7:29 PM] Clark, Ivan O. (LARC-D319) (Guest)
Domingo: thanks

[7:29 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Great talk John, For calculation of cost/loss, we need to take care of another domain of uncertainties from ATC side (efforts to change flight routes in a busy traffic airspace and others).

[7:30 PM] Jim Doyle (Guest)
Hi John - I enjoyed your talk. I was wondering about the ability of our ensembles to represent rare (but important) turbulence events that might be in the tails of the ensemble. Are there methods being used to represent these relative rare and maybe extreme type of events.

[7:30 PM] Matthew Wandishin (Guest)
Thanks, John and Domingo.

[7:31 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
And, the impact from different sources of turbulence to ATC is different. For example, we need to avoid laterally CIT, while we can only change flight altitude for CAT.

[7:33 PM] Steven Silberberg (Guest)
Excellent point Jung-Hoon. Lateral avoidance stresses the USA airspace system.

[7:34 PM] John Williams (Guest)
Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest), very good points. I focused more on the airline decisions, but modeling the impact on the NAS with a focus on ATC workload is certainly also important.

[7:35 PM] Steven Silberberg (Guest)
There is a limit to the number of aircraft allowed in an air traffic control sector. Deviate too many aircraft and there is no safe space for them to fly.

[7:36 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Yes, I totally agree. Thank you John and Steve.

[7:39 PM] Walter Rogers (Guest)
Clark, urban canyon/building wall turb prediction is not useful for glider pilots (unless there is a multi $$$million lawsuit that requires case analysis ;)). LES 5meter simulations in a small domain would be useful to test optimization strategies for entering thermals (for climb) and optimizing decision for location lift

[7:42 PM] Clark, Ivan O. (LARC-D319) (Guest)
Walter: Thanks. That was my assumption, but I don't trust my assumptions without validation. wink

[7:43 PM] Chao, Haiyang
Walter & Clark, urban canyon/building updraft prediction may be useful for Amazon delivery drones for endurance boost

[7:45 PM] John Williams (Guest)
Jim Doyle (Guest) One can use extreme value theory to try to model the distribution tails, but the effectiveness on that approach probably depends on the models having sufficient skill. Extremes are certainly a challenge!

[7:47 PM] Clark, Ivan O. (LARC-D319) (Guest)
Chao: agreed. Updraft, downdraft, and large steady-state eddies on a vertiport (caused by a backward facing step of the adjoining building) can be very important to know about for urban operations.

[7:47 PM] Jim Doyle (Guest)
Thanks John

[7:48 PM] John Williams (Guest)
Steven Silberberg (Guest) Yes, I agree that congestion needs to be taken into account. That could be part of the decision optimization cost function.

[7:48 PM] Steven Silberberg (Guest)
I agree John!

[7:50 PM] Smith, Brandon (FAA) (Guest)
It would be interesting to know what some potential probability thresholds are for certain aircraft - i.e., what probability of certain EDR do you reroute vice attempting to fly through.

[7:51 PM] Steven Silberberg (Guest)
Working with the FAA John, you can run optimized cost functions on the FAA playbooks for convection, icing, and turb and perhaps improve the playbooks

[7:53 PM] Matthew Wandishin (Guest)
Brandon, yes, and when we bring in the combination of probability thresholds and intensity thresholds, it can get ugly quite quickly.

[8:06 PM] John Williams (Guest)
Smith, Brandon (FAA) I think it will depend on the situation, including the width of the predicted EDR PDFs and the magnitude of the deviation required. But it would certainly be interesting to look at some standardized cases for a mid-sized flight at cruise, To be more general, one can translate the EDR PDF into a cost PDF and make the decisions based on that.

[8:08 PM] John Williams (Guest)
Steven Silberberg (Guest) interesting idea. Yes, you could potentially fine-tune the playbooks for a particular day's forecast.

[8:10 PM] Polderman, Nathan
John Williams (Guest) - great presentation! Curious how the PDFs would vary for different synoptic and mesoscale forcing mechanisms and how that would impair or enable decision-making. Would the distribution be "less Gaussian" for smaller scale CIT / near-cloud turb scenarios given the run-to-run or model-to-model variability in resolving these features?

[8:15 PM] John Williams (Guest)
Polderman, Nathan - yes, I think PDF shapes would be related to predictability and scale. So small and hard-to-forecast turbulence regions would likely result in multi-modal ensemble PDF forecasts.

[8:16 PM] Smith, Brandon (FAA) (Guest)
Evening session and angry toddlers don't mix so will have to sign off. Great information this session!! Thank you.

[8:17 PM] Steven Silberberg (Guest)
Nice presentation Jung-Hoon.

[8:18 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thanks Steve!

[8:25 PM] Matthias Steiner (Guest)
There is also a question about proper calibration of probabilities with data that are biased in their sample (i.e., trying to avoid MOG turbulence).

[8:25 PM] Polderman, Nathan
And not only the shape of the PDF, but also how that PDF shape is trending over time say for example in an hourly or sub-hourly model update cycle. Information overload!

[8:28 PM] Walter Rogers (Guest)
tech issue

[8:28 PM] Walter Rogers (Guest)
disregard

[8:29 PM] Matthias Steiner (Guest)
Thank you for another stimulating workshop day! :-)

[8:29 PM] John Williams (Guest)
Matthias Steiner (Guest) yes, very good point!

[8:30 PM] Jung-Hoon Kim (Seoul National Univ., South Korea) (Guest)
Thank you very much!

[8:30 PM] Jim Doyle (Guest)
Thanks everyone!

[8:30 PM] Walter Rogers (Guest)
Good night!

[8:30 PM] Soo-Hyun Kim (게스트) (Guest)
Thank you!