Questions and Answers from the online seminar on Hyperspectral 101, Example Applications, and Recent and Ongoing Hyperspectral Remote Sensing Forestry & Plant Research, featuring Dr. Will Rock, Headwall Senior Application Engineer, and researchers from the University of Florida, including Danilo R. A. de Almeida, Ph.D., Trina Merrick, Ph.D., Dr. Susan Meerdink, and Stephen Lantin, Ph.D. student. The agenda, subject to change without notice is available here: https://www.headwallphotonics.com/hubfs/Headwall-UFlorida-Seminar-Agenda_RevB_24Mar20.pdf

Question Date/Time	Question Asked	Answer Given	Answerer
09:11:13 AM EDT	Do you not work in LWIR?	We don't have current products in the region, but we can talk to you about your needs. We do make our own gratings that can be used in a wide range of wavelengths.	Marketing Headwall
09:15:20 AM EDT	How would we be able to joing the CHRSE? We are broadly experienced in HySpec and have load of research and proven products ready to present and	I can have Christian reach out to you. The center is currently closed to visitors, but we hope to re-open as the coronavirus situation improves.	Marketing Headwall
09:24:14 AM EDT	What do you mean with "objects"?	Can you elaborate? Are you refering to the samples?	Marketing Headwall
09:24:44 AM EDT	Is it possible to distinguish between different genoypes for example in vineyard?	Good question. I will ask Will when Q&A comes up	Marketing Headwall, also an answer was sent by an attendee
09:28:30 AM EDT	can we get this informatuve presentation from Headwall?	Yes. We will try to send everyone links to the recording, hopefully divided into chapters	Marketing Headwall
09:30:55 AM EDT	Is anyone building a large scale library of the spectral signatures of large numbers of individual plant species?	There are two libraries that I know of that have individual plant species spectra - https://speclib.jpl.nasa.gov/ and https://ecosis.org/	Susan Meerdink
09:35:26 AM EDT	In astronomy, they achieve this sort of data cube via longslit spectroscopy - why do remote sensers use hyperspatial imaging instead	I am not familiar with long slit spectroscopy, but in my quick google search it seems very similar to a hyperspectral imager. I would guess that the main differences are size, weight, and power (SWaP) and sensor robustness. The foreoptic is likely quite different for astronomers as well.	Will Rock
09:35:41 AM EDT	It possible to identify petrolium damage in the near under surface?		An answer was sent by an attendee
09:35:44 AM EDT	Yes it is possible. I am working on that with headwall's nano hyperspectral		Answer by an attendee
09:35:54 AM EDT	Will this useful to image different water content in soils?	This is a feasible, but likely difficult application. I have not attempted this, so my answer is speculation. Water absorptions can be quite strong, and absorb all the solar radiation in several bands in the SWIR range. There are other weaker water absorption bands that could be used in the VNIR and NIR spectral ranges to measure moisture content. The challenge will be getting enough light back to the sensor for robust measurements if the soil reflectance (albedo) is very low.	Will Rock
09:35:56 AM EDT	what is the most chalnnging steps in analysis such hyperspectral imagery ?	I think this can be subjective, but in my opinion of the most challenging steps is atmospheric correction for outdoor collections. If not done correctly, it can add noise and artifacts into your data that will impact all future analysis.	Susan Meerdink
09:36:09 AM EDT	Inorder to quantify the ambient impact?		
09:36:13 AM EDT	Answering the question. I think you can use Headwall cameras for phenotyping purposes.		Answer by an attendee
09:36:45 AM EDT	with hyperspectral we can analyse the sugar in the wineyards to select the oportunity window to make the harvest?		An answer was sent by an attendee
09:36:55 AM EDT	It depends on the wavelenght. Not with VNIR sensors		Answer by an attendee
09:37:17 AM EDT	Does headwall nanospec mounted on Matrice 600 Pro work without Lidar?	Yes, you can get a system with or without LiDAR	Marketing Headwall
09:38:09 AM EDT	Are wavelength calibration/validation tools provided with the spectrometer? especially, when we are taking instrument out in the field. how rugged is the spectrometer?	Extremely rugged, but we ask our customers to know more about the environment: e.g. temp, particles, vibration, moisture, etc. Headwall has customers operating in harsh environments, and can often collect high-quality data for years without the need for re-calibration. However, Headwall recommends sending the instrument back to the factory for an annual	Marketing Headwall
09:38:10 AM EDT	Have you any case on HLB diagnostic for citrus?	Yes, see the UF Precision Ag Lab's work on HLB here: https://abe.ufl.edu/precag/research/hlbdetection1.html	Stephen Lantin
09:38:27 AM EDT	what is the depth of detection of water or any material in earth from the space	Headwall's hyperspectral imagers measure surface reflectance, so the penetration depth is usually very small (on the order of microns). This depends strongly on the material and on the wavelength of light - for example, the penetration depth of crystal-clear water (outside the water absorptions) will be much deeper than the penetration depth of a muddy river	Will Rock
09:38:37 AM EDT	Is possible to detect microbiological activity in shalow water?	This is a very active area of research with some initial papers saying yes we can, but nothing has been done on large scales.	Susan Meerdink
09:38:56 AM EDT	Will this seminar discuss about the crop leaf nitrogen and water content estimation from hyperspectral datqa	We did not cover these topics in the seminar, but I would direct you to these papers for more information. Of course you can use spectral indices as correlation, but with hyperspectral why would we limit ourselves to two-three bands? :) Townsend, P. A., Foster, J. R., Chastain, R. A., & Currie, W. S. (2003). Application of Imaging Spectroscopy to Mapping Canopy Nitrogen in the Forests of the Central Appalachian Mountains Using Hyperion and AVIRIS. IEEE, 41(6), 1347–1354. Singh, A., Serbin, S. P., Mcneil, B. E., Kingdon, C. C., Townsend, P. A., Ecology, W., & Singh, A. (2015). Imaging spectroscopy algorithms for mapping canopy foliar chemical and morphological traits and their uncertainties. Ecological Applications, 25(8), 2180–2197. https://doi.org/http://www.esajournals.org/doi/abs/10.1890/14-2098	Susan Meerdink
09:40:42 AM EDT	Do you offer tunable spectrometer where spectral resolution can be changed dynamically?	Headwall's spectrographs use fixed optics that cannot be exchanged. This is necessary to provide an imaging spectrometer that can operate in harsh conditions and provide high-quality data.	Will Rock
09:41:32 AM EDT	I wonder how many 'beginners' you have on this event. Cause it seems there are many specialist, or experienced users, like us. Who already know all about the basics discussed right now. Would prefer to go deeper into the topic.	We probably have 25% new to hyperspectral imaging. Some are RGB or multispectral users or 'snapshot' users. Will will get into more application examples shortly.	Marketing Headwall
09:42:02 AM EDT	Thank you - question answered - it is longslit spectroscopy	Will got ahead of my going through the questions! Yes, we call it 'pushbroom'. Glad we agree! So my interpretation of long slit spectroscopy after my quick Google search was correct!	Marketing Headwall
09:42:55 AM EDT	With the answer to my previous question about CHRSE. Yes please, ask Christian to reach out to me.		
09:49:50 AM EDT	Spectral and Geomatric calibration. How often, how and where?	Headwall recommends annual spectral re-calibration and radiometric calibration. All airborne packages are flight tested and shipped with bore-sighting coefficients. The bore-sighting coefficients may need to be adjusted for each mission for best performance.	
09:49:55 AM EDT	Geometric		
09:50:45 AM EDT	How far from the object of interest we can still get good quality data? How height can we fly to monitor crops, rice for example?	Take a look at our FOV calculator on our website. Will can also send you an Excel version. You can select the sensor, height/altitude, speed and get a resolution and estimate of time to cover a certain amount of area. Our UAV packages have very precise GPS to determine altitude.	Marketing Headwall
09:50:48 AM EDT	can you say something about spectral binning to increase the SNR	Spectral binning will decrease the spectral resolution, but increase the SNR by ~√N (where N is the number of binned pixels - or spectral bands)	

Time	Question	Answer	Answered by
09:50:55 AM EDT	Areall reading taken via drones now or are there applications more appropriate to small airplanes?	Yes, we also have customers in manned aircraft (NASA, NOAA, etc) and even satellites.	Marketing Headwall, also an answer was sent by an attendee
09:54:36 AM EDT	Again, it depends on the purpose of your work. GSD shoud be adapt		Answer by an attendee
10:02:25 AM EDT	Are you going to talk about how to do that "best match" calculation?	I think Will will cover that during his narration of operating the scanning kit. If not, i will ask him,Just to be clear, you are refering to the best match of spectra to a known sample, yes?	Marketing Headwall,Marketing Headwall
10:04:30 AM EDT	Can you describe the basic tradeoff between spatial and spectral resolution in terms of performance of Headwall's products?	Most of Headwall's products differ by spectral range; however, Headwall does have 3 VNIR options - Nano, A-series, and E-series. These 3 sensors go from small to large in terms of SWaP and spatial and spectral bands; the E-series is not compatible with a DJI M600pro, but can be used in a manned aircraft. Please refer to our datasheets for more information.	Will Rock
10:10:12 AM EDT	Just curious. For airborne remote sensing, does Headwall have any sensor that can be amounted on the drone to look upward to measure the incoming solar radiance at each spectral band?	Not at this time as a regular item, but some customers have built them. Even NASA is still working on a reliable and good one.	Marketing Headwall
10:13:10 AM EDT	I understand that this is not the focus of this brief, but am interested in gains that may have been made in the use of HSI at night. possibly using artificial light on a drone to detect chemicals on the ground...maybe flying close enough that the artificial light from the drone is sufficient to satisfactorily illuminate the target...coupled with machine learning/AI etc...	I am not aware of any customers collecting hyperspectral images using a drone at night. This would require special permission from the FAA as well. The light would need to be extremely bright, because it needs to propagate a long distance to the ground, and this would likely be a heavy light that requires a lot of power. If I was to design a nighttime hyperspectral imager, it would be on a ground vehicle where SWaP constraints can be relaxed and where the light source can be much closer to the object.	Will Rock
10:14:15 AM EDT	Hello, are you planning to give us some idea about prices of the different equipments? Thanks alot!!	Price depends on where you are located. We sell direct in the US and through authorized resellers around the world. prices can vary due to a lot of factors. Where are you located?	Marketing Headwall
10:16:06 AM EDT	For airborne applications, do you provide spectrometer with vibration suppression mechanism? Or it needs to be procured as a separate unit?	There are special vibration-reduction pads on most (all?) models. Some models also use an active gimbal.	Marketing Headwall
10:16:13 AM EDT	if a pixel is relatively large it will have multiple elements in it. how do you differentiate these	Generally we use a set of methods called unmixing which has a HUGE literature base. I would suggest this article for a starting point: Keshava, N., & Mustard, J. F. (2002). Spectral unmixing. IEEE Signal Processing Magazine, January, 44–57. https://doi.org/10.1080/01431161.2012.661095	Susan Meerdink
10:16:29 AM EDT	Please be more especific about the ortorectification and real applicability of the headwall systems.	Here are some more details about the orthorectification process. If you need more information, please contact Headwall. Headwall's turnkey systems have an integrated GPS/IMU that measures lat, long, alt, roll, pitch, and yaw. Headwall's postprocessing software SpectralView performs orthorectification using these two data streams and a digital elevation model (DEM). SpectralView can use DEMs from public databases or, if LiDAR is included, can use a DEM generated using LiDAR Tools (Headwall's LiDAR software). SpectralView also allows the user to input bore-sighting offset parameters - these are the small differences between the GPS/IMU measurements and the actual pointing of the imager. Headwall test-flies all turnkey packages and provides the user with initial bore-sighting parameters; these parameters will be a good initial guess, and are stored in a config file (that can be updated by the user). Rough handling during transport may make the initial offset parameters sub-optimal and require user correction for best performance. SpectralView can do batch orthorectification if there are many data cubes in a flight. The result can either be IGM files (ENVI data cubes with position information for each spatial pixel) or an orthorectified data cube (a corrected and geo-located hyperspectral image). SpectralView can stitch together multiple data cube (and flight lines) into a single 'multi-ortho' data cube of the entire scene. For large files, SpectralView can generate an orthorectified data cube of user-selected spectral bands rather than the entire spectral range.	
10:16:39 AM EDT	If you always measure one strip and the other direction is given by the movement of the probe or the meter then this movement shall be synchrone to the scans. Is the speed of the drone synchronized to the hyperspectral meter?	Yes. We can set the speed in the flight-planning software. The actual flight is done automatically.	Marketing Headwall
10:18:19 AM EDT	Hello! Could this camera be tested for know pigment type of rock art?	Yes.	Marketing Headwall
10:35:44 AM EDT	Is there a property requirement for the sampling cup? Is there any difference in reflectance between a white plastic cup and black non-reflective cup?	There is no property requirement for the sample cup, however it is often desirable to have background materials with low reflectance to avoid contributions of the background to the sample spectra. Different materials will absolutely have different reflectance spectra.	Will Rock
10:35:53 AM EDT	Is it possible to recognize the components of a pigment in rock art?		
10:37:53 AM EDT	do you have spectral library? for different minerals? and how can we automate the process?	This spectral library has spectra of different materials measured in laboratory settings: https://speclib.jpl.nasa.gov/	Susan Meerdink
10:39:25 AM EDT	Do you have an rgb camera attached to any of your imagers (to overlay) or is it only false color images (because some of your detectors don't contain the typical r,g, and b values)	RGB imagers are not included in any of the standard products, but Headwall has integrated them for select customers.	Will Rock
10:39:58 AM EDT	Could be used to detect pathologies? i.e. comparing between healthy and other pathological tissues	Preliminary data shows promise in detecting stressed plants vs. healthy plants. We will be doing experiments shortly in the Ecosystem Dynamics Laboratory to see if we can detect pathogens.	Stephen Lantin
10:43:44 AM EDT	which of your model has VNIR+SWIR?	The co-aligned system has a VNIR and a SWIR sensor co-aligned in a single flight-ready package	Will Rock
10:44:43 AM EDT	I'm intersted on aerial hyperespectral systems, but we have not experience with Hyperespectral data. How hard do you think it's the lesarning curve?. We have experience with LiDAR systems on manned aircraft	Hyperspectral experiments are difficult. It comines imaging, spectroscopy, and GIS into a single rich data set. Headwall prides itself on its customer support and training to ensure that its customers collect high-quality hyperspectral data, and can help you start to collect high-quality data fairly quickly. Fully exploiting hyperspectral data can consume an entire career.	Will Rock

Time	Question	Answer	Name
10:44:58 AM EDT	How is the synchronization between camera recording and sample motion realized? In particular: UAV typically do not fly at constant speed but may change angular view and speed	Headwall strongly recommends that all data collection is done using flight paths pre-programmed with flight-control software (and not user-controlled 'free' flights). Data should only be collected when the drone is flying in a straight line; turns should be made outside of the capture polygon. Programmed flights on a DJI M600pro maintain speed fairly well. Wind will cause deviations in the flight path, and these deviations are measured with the GPS/IMU and corrected in the orthorectification process.	Will Rock
10:50:19 AM EDT	Does the optimum exposure time give you the same spatial resolution in both dimensions?	In practice, the optimal exposure time is set by measuring reflectance on a white target; this sets the frame period. Then the flight speed is set so the drone travels 1 spatial pixel per frame period (flight speed = [spatial pixel size]/[frame period].) This will result in the capture of square pixels (the spatial sampling will be identical both across-track and along-track). The along-track spatial resolution (not the sampling) will be slightly larger in the along-track direction because the entrance slit is larger than the pixel size on the focal plane.	Will Rock
10:52:12 AM EDT	Do you provide software that will answer the following question on a pixel by pixel basis? The question is: does this pixel's spectral signature contain the spectra contained in a reference spectral signature? And adjust that answer based on what % of the light captured is in the reference spectral signature?	Headwall's classification software utilizes spectral angle mapping (SAM). This comapares the spectral shape of a set of reference spectra to the spectral shape of each of the spatial pixels. Each reference spetrum is color-coded, and the spatial pixels in the image are assigned the color of the best spectral match. This treats every spatial pixel as a single spectral signature. SAM is not a spectral un-mixing algorithm.	Will Rock
10:54:05 AM EDT	Sounds like there is a great need and huge market opportunity for a camera that really communicates with the drone to make all this planning and calculation much easier!!		
10:54:33 AM EDT	what is suitable working temperature?	Generally 0 to 50 deg C for the sensors. This varies by drone or if you have other instruments in a payload.	Marketing Headwall
10:54:46 AM EDT	What sort of temperature issues might occur with a Headwall sensor mounted on an external belly pod on a manned aircraft ? Will it be too cold at, for example, 5000 ft AGL	I do not know how cold it would be under those conditions. The operational temperature of most Headwall sensors is ~0-50 C. This is wider for certain sensors - please contact Headwall for data sheets if you are interested in a specific sensor. The storage temperature is usually a bit wider. Headwall does not guarantee operation outside the operational temperature range.	Will Rock
10:57:51 AM EDT	Thanks, this has been great! I need to teach my online class shortly but will try to return later. Will Rock had some great slides explaining the basics. Will the slides or a recording of the webinar be available afterwards?	Yes, we hope to have a recording or recordings broken up into chapters in the next few days. Good luck with your online class!	Marketing Headwall
11:29:48 AM EDT	Simple question: what ink are you using for labels and focusing grid so that you can "see" it in swir?	I believe a regular Sharpie lab marker and in some cases a marker with India ink. will check with Will Rock to confirm	Marketing Headwall
11:37:39 AM EDT	Using SPOT, do you take pictures only from top (nadir) view?	For now, yes.	Marketing Headwall
11:45:05 AM EDT	What is the reflectance panel made of or what is its source?	Spectralon	Marketing Headwall
11:48:57 AM EDT	What kind of LED do you need to use SPOT?	We use standard LED grow lights (mainly in red and blue wavelengths), paired with outlet timers to simulate a 16/8 day/night cycle. Your exact wattage and optimal combination of RGB lights will depend on your plant.	Stephen Lantin
11:49:33 AM EDT	Is it a spectralon?	Yes.	Marketing Headwall
11:49:37 AM EDT	Hi, how do you integrate lidar data to hyperspectral image?	We will be using orthorectification. Headwall's SpectralView program provides options for doing so; however, we have not integrated it yet.	Stephen Lantin
11:49:47 AM EDT	have you tried to estimate water status throughout thermal imagery?	We do have a FLIR Vue Pro R Thermal Camera, but we have not performed any thermal imagery yet. One thing you will have to be aware of when doing therma imagery in a lab setting is that the heat from the illumination lamps for hyperspectral imaging may change the ambient temperature over the course of data collection.	Stephen Lantin
11:51:26 AM EDT	What is the % of relative humidity of the environment studied ? What are the technical specifications of the several cameras you used for this parameter ?	Probably about 20%. We will get some specs for the cameras themselves.	Marketing Headwall
11:51:35 AM EDT	do you have any bio-chemical measurements?	We have SPAD measurements taken on the last day of the experiment. We are currently doing data analysis to see if SPAD measurements correlate with hyperspectral data.	Stephen Lantin
11:51:51 AM EDT	say water content, chlorophyll content?	We have SPAD measurements taken on the last day of the experiment. We are currently doing data analysis to see if SPAD measurements correlate with hyperspectral data.	Stephen Lantin
11:53:45 AM EDT	Hello, could you send some examples of usues of hyperespectral combined with LiDAR?	Here is a ShareFile link that contains the following data cubes: https://headwallphotonics.sharefile.com/d-se85a7c045ce44b4b • Bolton_VNIRcube_rd • Bolton_VNIRcube_rd.hdr – orthorectified VNIR (400-1000 nm) hyperspectral data cube – radiance • Bolton_VNIRcube_rd_rf • Bolton_VNIRcube_rd_rf.hdr – orthorectified VNIR (400-1000 nm) hyperspectral data cube – reflectance (converted using the reference tarp in the scene) • Bolton_VNIRcube.png – RGB image of the data cube • Lidar_PointCloud.las – LiDAR point cloud • BoltonDEM_MinMaxMeanStdev_5cm.tif – GeoTiff DEM created using the LiDAR point cloud; the GSD of the DEM was set to 5 cm (all of the points in the point cloud in each 5cmx5cm area are used to calculate the value for the DEM pixel); there are 4 layers for different ways to calculate the DEM from the point cloud (minimum, maximum, mean, standard deviation) • Bolton_VNIRcube_LiDAR_Fusion • Bolton_VNIRcube_LiDAR_Fusion.hdr – reflectance data cube with the 4 layers	Will Rock
11:54:00 AM EDT	Question about LiDAR in SPOT: would you use laser scanner indoors for 3D model of plants? or is it for airborne only (say drone?) ?	Currently Headwall only supports airborne LiDAR, but LiDAR can be used to create 3D models indoors as well	Will Rock
12:04:20 PM EDT	why the spectra around 940nm and 1130 nm were removed?	In this imagery, the atmospheric correction algorithm was being actively improved. 940 and 1130 nm are near minor water absorption bands which were getting high errors in the atmospheric correction algorithm. I removed them from the analysis because of the high variability and low confidence. That is the great thing about hyperspectral - we can remove 20 bands and with hundreds of bands still have plenty of data!	Susan Meerdink
12:21:44 PM EDT	Does the bag size (the window size)? vary in your algorithm?	Yes, bag size can be whatever the user defines it as. In the PFT example, those bags had a very large range in sizes depending on the plants from 5 pixels to 100s of pixels.	Susan Meerdink

Time	Question	Answer	Respondent
12:22:25 PM EDT	and can you run your algorithm on GPU?	Yes, this algorithm can be run on a GPU. We have not found the need to do this because the calculations are straight forward matrix multiplications.	Susan Meerdink
12:23:59 PM EDT	have you compared drone vs satellite data for your algorithm?	We have not used this on satellite data yet, but only because we don't have a dataset ready to go. This algorithm can easily apply to satellite data or many other types of data.	Susan Meerdink
12:25:24 PM EDT	have you compared with different height	Yes, with increased height you increase the amount of mixtures in your pixels. One of our examples used 18 m spatial resolution which has a lot of mixtures of materials. The algorithm performs quite well when your target of interest is smaller than the spatial resolution of your imagery.	Susan Meerdink
12:26:15 PM EDT	Can you tell me how to create whitened reflectance?	To create the whitened reflectance, see equation #4 in this paper. You would mean adjust the data and then scale it based on the inverse background covariance. Zare, A., Jiao, C., & Glenn, T. (2018). Discriminative Multiple Instance Hyperspectral Target Characterization. IEEE Transactions on Pattern Analysis and Machine Intelligence, 40(10), 2342–2354. https://doi.org/10.1109/TPAMI.2017.2756632	Susan Meerdink
12:26:27 PM EDT	have you compared gpu vs cpu? different height for flying	We have not compared times between GPU and CPU. I've found that CPU has been processing the data quickly enough that there has been no need for us to test the GPU yet.	Susan Meerdink
12:46:04 PM EDT	On this slide. Some beatiful graphs and aesthetics. What tool do you use for them?	Yes, I'll make sure to ask. The ones with the capsule-shaped error bars and overlaid areas under curves, yes?	Marketing Headwall
12:50:43 PM EDT	How are you controlling sun ilumination artifcts?	We have several issues to deal with in this arena, not the least of which are scattered clouds. While we will not necessarily be able to control all the effects, we do plan to address these uncertainties and make us of the redundancy of our instruments. We are working to understand the illumination geometry and the effects on the quantitties calculated (insrument noise->porpagated through calculations.We have conducted cross calibration (trying to take into consideration flying height, sun angle, cloud/shadow) and performed robust radiometric calibration, which will be a part of the published studies. Going forward, the GatorEye also has a UAV-mounted spectrometer (cosine receptor), which will make these processes even more robust.	Trina Merrick
12:52:20 PM EDT	How do you calculate SIF from the hyperspectral data?	We are using the 3-band Fraunhofer Line Depth Method (Maier et al 2003; Meroni et al 2007; Zarco-Tejada et al 2013).	Trina Merrick
12:54:49 PM EDT	Could you describe the experimental setup of the drone? Height flown? Pixel sizes? etc.	We flew at 120mAGL (forest approx 40m at Nadir), pixel size is apprx 12.3 cm. This is quite variable and we expect noise due to geometry. We plan to examine these geometric factors (and illumination angles) as carefully as possible and propagate the uncertainty independently for quantities used (i.e. Merrick et al 2020 IJRS). We expect to aggregate to species level in the next steps as well.	Trina Merrick
12:56:43 PM EDT	What was the use of thermal camera and how was it combined into the dataset? Was it a LW or MW broadband cam?	The thermal camera is a FLIR-A325 (more details can be found in Pau et al 2018 in Ecosphere). The thermal camera is continuously recording images of a portion of the EC tower footprint. These data (not highlighted in the presentation today) are being fused with the Hyperspectral-deived quantities, EC, and meteo data to examine species-specific performance over time.	Trina Merrick
12:57:44 PM EDT	Was PAR being measured on the ground as well, via upward facing PAR sensors?	At BCI, we are actually running a PAR sensor on the tower, plus 4-way radiometer, on the ground we have a spectrometer (1nm sampling, ~3nm FWHM) and nother PAR sensor.	Trina Merrick
12:59:21 PM EDT	what is the take-home message of comparing GPP estimation between leaf, canopy, and satellite scale, in terms of accuracy and sensitivity?	The takeaway message when comparing across these scales in terms of accuracy and sensitivity is that, filling in gaps in what we know about GPP (the largest component of the carbon budget) in the tropics is critical. Researchers at the different scales have detailed productivity (GPP, etc), but quantitative RS is a potential bridge between them. In this relatively early stage, interpreting results (even understanding noise and sensitivity) are challenging, but progress is being made. We are trying to use the data collected to improve interpretation, i.e. "is SIF tracking GPP or APAR or both and at what scale may it be a relatively good proxy?"	Trina Merrick
01:00:58 PM EDT	Thank you for the most informative and very good presentations. Unfortunately it is getting pretty late here and I have to step out. If there is a kind of material shown repository or wrap up, I would be glad to receive knowledge of.	Yes, we will send a link to the recording in the next few days.	Marketing Headwall
01:08:28 PM EDT	Maybe a stupid question: but why Drone and Satellite? We do HS from airborne, why most research and projects skip this level ??? It's often best trade-off and ideal for large areas but not all countries.	Do you mean HS from manned aircraft vs drone and satellite? I think this was answered by someone else but I (Trina) will chime in as well. The cost and availability of UAV systems makes it appealing. An aerial platform is very expensive and few researchers have access. However, platform like NEON make their AOP data available and you can apply to have their platform fly. There are also differences in the data processing techniques, but the cost and access are likely larger barriers for most researchers. By comparison, UAVs are potentially *easier* to transport, but have some challenges when travelling or in difficult terrain. One must also be midful of rules for UAVs wherever you work.	Marketing Headwall and Trina Merrick
01:11:07 PM EDT	Will the presentations and Q&A be shared?	Yes, we are recording and hope to send out links to each section in the next few days	Marketing Headwall
01:12:38 PM EDT	Yes.	I'll ask the whole set of speakers at the end when we have a general Q&A for anything and everything. Will will also have some input, as we did an experiment with Battelle NEON by flying simultaneous flights by manned aircraft and drone over the same area.	Marketing Headwall
01:17:30 PM EDT	You know some use that into a green urban areas?	Do you mean in green areas in cities like parks or urban agriculture? Trina: This is an interesting question. Ther could be some interesting things to look at for green spaces, maybe. I do know of studes using field (and potentially UAV) data to look at pollution effects even at leaf level (nice study looking at vertical changes in leaves, too) (I think Van Wittenberghe et al 2013; Meroni et al 2008 & 2009; and probably more recent ones). SM: There are many projects that have worked in an urban setting with hyperspectral. Here are some papers that might interest you: Alonzo, M., McFadden, J. P., Nowak, D. J., & Roberts, D. A. (2016). Mapping urban forest structure and function using hyperspectral imagery and lidar data. Urban Forestry and Urban Greening, 17, 135–147. https://doi.org/10.1016/j.ufug.2016.04.003 Wetherley, E. B., Roberts, D. A., & McFadden, J. (2017). Mapping spectrally similar urban materials at sub-pixel scales. Remote Sensing of Environment, 195, 170–183. https://doi.org/10.1016/j.rse.2017.04.013	Marketing Headwall and Trina Merrick, Susan Meerdink,also an answer by an attendee

01:20:35 PM EDT	like parks and tree streets	I'll ask that durng the open Q&A before the wrap-up. Good question.	Marketing Headwall
01:23:21 PM EDT	To all speakers, any experience/comments on using fixed-wing drones instead of multirotor/VTOL?	Headwall has some customers that use fixed wing platforms. These customers are responsible for their own integration. Some of these platforms belly-land or crash land, and this would not be good for a hyperspectral imager. A larger spotting crew is generally required for large-area unmanned flights. If the drone is outside of Part-107 sUAS flight operations it also requires more training and FAA certifications than the M600pro.	Will Rock
01:27:36 PM EDT	can you explain how the upward hyperspectral sensor work? If the idea is taking up and downware sensors at the same time to derive reflectance, then no need to set up ground calibration target?	Trina: On the GatorEye, the Flame sensor is using the cosine receptor mounted on the top and integrated intot he system (with the Nano and LiDAR and Thermal). It is still a good idea (where possible) to use the ground tarp for cross-calibration/comparison and for redundancy. It is nice, however, to have such fine resolution solar irradiance data.	Trina Merrick
01:30:53 PM EDT	My company has a great example of this (Urban Green). Please target them to me.		Answer by an attendee
01:30:56 PM EDT	From UFPR Brasil		
01:32:17 PM EDT	Some information here: https://www.linkedin.com/posts/mggp-aero_remotesensing-hyperspectral-hybridplatform-activity-6638048105512095745-t3Ga		Answer by an attendee
01:33:22 PM EDT	how do you adjust sensor vibration?		
01:33:41 PM EDT	sensor vibration on the drone?	Sensor vibrations are not corrected, and do not greatly harm the imagry (any of the images shown during the presentation did not have any vibration correction). Headwall's imaging spectrometers have no moving parts and a very robust design, so drone vibrations will not knock them out of alignment.	Will Rock
01:37:07 PM EDT	can you share the paper of drone-aircraft with NEON?	Yes, I will send that out later	Marketing Headwall