Introduction to Remote Sensing for Harmful Algal Blooms

Please type your questions in the Question Box. We will try and get to all your questions, but if we don't, feel free to email Sherry Palacios your question at sherry.l.palacios@nasa.gov

Session 3 Q&A Transcripts

Question 1: How does the C-HARM model include pH in the predictions?

Answer 1: We do not have ph in that model - it's not one of the parameters we measured when we built the model. It doesn't mean ph and acidity are not important, there's a lot of work that suggests an interaction between ocean acidification and HABs, but it's not something that's been a predictor.

Question 2: Why let the C-HARM model predict negative values?

Answer 2: These are logistic models that predict on a scale from 0 to 1. The output is always a value between 0 and 1.

Question 3: Is the C-HARM model only for California?

Answer 3: You can apply this to another region, but all the parameterizations and numbers/coefficients are tuned to the kinds of data and relationships we see in California. In particular, only a couple of regions like Santa Barbara and Monterey Bay. Another option is to collect own datasets and do your own.

Question 4: HABs form due to multiple reasons, however particular HAB species identification and forecasting of species would be difficult. Would considering multiple factors, like physico-chemical forcing, help in HAB prediction?

Answer 4: Resounding yes! We always want to consider complexity and multiple factors that contribute to blooms when we designed the model for *Pseudo-nitzschia* and domoic acid, in the end, when it came down to creating a real time product, we were restricted to using variables that came in real-time, and that restricted us to some degree. If you want to create a predictive

model, you might find you're restricted to certain datasets, and you have to create your best model.

Question 5: Any quorum chemical sensing? Might new aerosol sensors pick them up?

Answer 5: There's some new sensors out there for doing this but it - multiple, small sensors out at once creating a certain machine learning that goes into the algorithms for what that signal looks like. For aerosol sensors, that might be something interesting, but I don't think we've done it for ocean enough. We're developing some very small domoic acid sensors that would go on robotics, gliders, AMPs, and that would give us a good spatial sense of where domoic acid is on the subsurface.

Question 6: How do I get chlorophyll data for the coasts and lakes of Guatemala to process them in GIS? What optical images can I use to detect domoic acid in the Pacific and Atlantic waters of Guatemala? With what method do they complement remote sensing to check the flowering of domoic acid in situ?

Answer 6: Certainly, we've been trying to apply this to other regions. I can't say yet how successful a model tuned for CA is for other regions. Optical images you can use to detect domoic acid - if that's just the reflectance yields, there's no reason you can't apply them to your region. It'll just require training and understanding to understand how it applies to *in situ* levels.

Could the code work for elsewhere? Yes - it'll be 6 months-a year before we're ready to put those out as we transfer the tool to NOAA. Some things on semi-public website, but it'll be helpful for us to annotate our scripts/routines, but the end-goal is that people are able to tweak on their own.

Question 7: Are there known linkages between HABs and air pollution? Any particular sources of concern?

Answer 7: Is the HAB of the source of the air pollution? Or is air pollution having impact on HABs? Talked some about *Karenia brevis* and how it can cause a shore respiratory problem, but what is more information on both as a source and on how pollution can have an impact?

Karenia brevis is an exception where we know there's a clear impact on air quality. The research in the other direction is much more scant. There's a lot of research going into nitrogen deposition into waterways (like in Chesapeake Bay) and they've thought about nitrogen deposition and you have some that might respond to deposition and don't know direct correlation to Harmful species.

Not only karenia brevis, but there's a lot more work on microcystis and an explosion of research in Great Lakes region and that's often an overlooked factor.

Question 8: Which physical oceanography model is being used in C-HARM? SARMAP/OILMAP?

Answer 8: The Regional Ocean Modeling System (ROMS). For more information on this model, visit https://www.myroms.org/

Question 9: New Jersey DEP conducts daily flights over its coastal waters during the summer season to collect chl-a data. Can such data be correlated with satellite data to create a model with increased accuracy?

Answer 9: If it is possible to have in situ measurements of chlorophyll that correspond to the daily flights, which also coincide with the satellite overpasses, that may be one way to better refine the chlorophyll algorithms for your region. From these measurements, you would need to determine uncertainty estimates and apply those to future chlorophyll-a estimates. What this refined chlorophyll-a algorithm would do is improve your chlorophyll estimates from future flights and satellite overpasses when you do not have coincident in situ samples.

Question 10: Is there any model for other toxins?

Answer 10: C-HARM model is really interesting - what has been done with other models and systems for toxins? In Lake Erie the detection algorithms are more on the optical side of things, typically for the organism itself and changes in chlorophyll biomass. Not aware of toxin models per say and where they're being used. There have been a number of academic references, implementing them has been very different. Don't know of any being implemented. Most of the time, they're looking at the organism and when the biomass will increase. The pacific northwest bulletin does try to give a predictive sense of shellfish toxicity but it isn't done in quite the same way as C-Harm model.

Question 11: What are the limitations of C-HARM?

Answer 11: One comes down to spatial resolution of the model - it's 3 km and it's hard to resolve near shore and inner shelf, which is an important area. When it comes to shellfish growers - we fall short in that a bit because we can't tell them from one shellfish growing sight to another, it's hard to resolve what's happening at a granular scale. When it comes to off-shore we do better because we're capturing offshore flow, and that pertains to larger ecosystem effects. If we want to know on km by km scale, we fall short. That will change as models change and sensors with higher resolutions will improve our abilities with respect to all HAB models.

Question 12: What kinds of atmospheric algorithms will be used to predict HABs and will the algorithms be the same for a sensor with similar wavelengths?

Answer 12: The algorithms used for HABs are typically ocean color algorithms that focus on chlorophyll concentration, pigment-specific discriminators, or taxon-specific discriminators. These algorithms are applied to water leaving radiance or remote sensing reflectance measurements of light emitted from the water's surface. Algorithms that are developed for the particular wavelengths (and bandwidths) for a particular sensor, must be adapted to the specifications of another sensor.

If the questioner is asking if there are atmospheric algorithms that can be used to identify phytoplankton groups (not specifically HAB organisms), we direct the questioner to look into the phytoplankton functional type algorithm named PhytoDOAS developed by Astrid Bracher. We suggest the questioner view the citation below, and more recent work citing this work.

Bracher, A., Vountas, M., Dinter, T., Burrows, J. P., Rottgers, R., ¨ and Peeken, I.: Quantitative observation of cyanobacteria and diatoms from space using PhytoDOAS on SCIAMACHY data, Biogeosciences, 6, 751–764, doi:10.5194/bg-6-751-2009, 2009.

Question 13: Hello are there forecasting models for HABs for Nigeria? Saudi Arabia (e.g., *Noctiluca scintillans*)?

Answer 13: Are there other HAB forecasting models outside the U.S. we can point folks to? There's work going on globally, but not any good knowledge about Nigeria specifically. Say that the UK has been working to develop a number of systems throughout the whole EU - there are a number of harmful algae systems going into operations. Again, they're going to be a similar situation. Applying something for the waters off France is different than Nigeria or Saudi. You can take platforms and apply to your region, but you'll have to rely on a certain amount of regional sampling to get ground truth and understand the species/toxins you're working with.

Question 14: In the C-HARM model, it uses variables such as winds or upwelling rate. Are these variables important to generate a model?

Answer 14: Those variables were important to developing the model for this region. This region is the California Current System which is an eastern boundary current. Wind driven upwelling is important for the supply of nitrate and silicate to the surface in this system. So to have real-time data and to be able to incorporate it to help with constraining estimates of nutrients to the surface was important. In other systems where winds are less important to the physics and biology, having those variables included may be less important. This is where it would be necessary to take the conceptual model of this type of model and modify (and test) it for your region of interest.

Question 15: Was the over-estimation near SF because the conditions would signify a HAB, but it was not observed? This may be a potential region to watch either way.

Answer 15: Dr. Anderson is not available for the evening Q&A. She answered questions during the morning session and when that Q&A document is put onto the course website (in the next day or so) we encourage you to read them there. If you have detailed questions about Dr. Anderson's presentation, we encourage you to contact her at the email she listed at the end of the presentation (clrander "at" ucsd.edu).

If you would like to know more about the details of C-HARM, we encourage you to read Dr. Anderson's publication on it:

Anderson, CR, RM Kudela, M Kahru, Y Chao, LK Rosenfeld, FL Bahr, DM Anderson, TA Norris. (2016) Initial skill assessment of the California Harmful Algae Risk Mapping (C-HARM) system. Harmful Algae 59: 1–18.

Question 16: Could the models/sensors help in monitoring inland lake algal blooms, just like oceanic blooms?

Answer 16: A resounding yes! We will be talking more about this next week when we talk about cyanoHAB monitoring