

**Biological and Environmental Research Advisory Committee
(BERAC) Meeting Minutes
October 18-19, 2018
Hilton Washington DC/ Rockville
1750 Rockville Pike, Rockville, MD**

BERAC Members Present

Gary Stacey, Chair
Bruce Hungate, Vice Chair
Sarah Assmann
Julie Biteen
Amy Brunner
James Hack
Andrzej Joachimiak
Cheryl Kuske
L. Ruby Leung
Jerry Melillo
James Randerson
Phil Robertson
Patrick Reed

Matthew Shupe
David Stahl
John Weyant
Huimin Zhao

Guest Speakers

Jake McKinlay
Harvey Bolton
Nigel Mouncey
Greg Lowry
Inder Monga

Designated Federal Officer

Tristram West

Others

T. Reneau Conner, Science Writer

Approximately 90 others were in attendance during the course of the two-day meeting.

**Thursday, October 18, 2018
Morning Session**

All presentations are posted to the BERAC internet site:
<https://science.energy.gov/ber/berac/meetings/berac-minutes/>

BERAC Chair Dr. Gary Stacey called the meeting to order at 8:30 a.m. Eastern Time (ET). At his request, committee members introduced themselves and provided updates on current research activities.

News from the Office of Science – Steve Binkley, Deputy Director, Office of Science (SC)
[Presentation posted]

Discussion

In relation to the increased dependence on cloud services Binkley stated there is movement in that direction across all government agencies. SC and other science agencies are discussing how to implement cloud computing in DOE programs.

Concern was voiced that the focus on Artificial Intelligence (AI) is missing the science, for example, connections in deep learning are not understood. In DOE, Computer Science and Applied Mathematics have the potential to address problems with deep neural networks such as how they operate, how the results are used, and how algorithms arrive at conclusions.

Knowledge is expanding in AI at a dramatically faster rate than scientists are being trained. In addition, commercial companies are investing in AI at DOE levels. Linking into these opportunities and protecting the openness of the scientific endeavor needs to be kept in mind.

Presentation of Award

Binkley and Weatherwax thanked Stacey for his years of service to BERAC and presented him with the Secretary of Energy's Award of Appreciation.

News from BER – Sharlene Weatherwax, Associate Director, Office of Biological & Environmental Research (BER)
[Presentation posted]

Discussion

Weatherwax shared that BER is discussing AI, quantum information science (QIS), synthetic biology, and food and agriculture with other programs as potential new initiatives.

News from Biological Systems Science Division (BSSD) –Todd Anderson, Director
[Presentation posted]

Discussion

Anderson noted representatives from plant and microbial areas will consider commonalities and differences between the plant and microbe kingdoms. More information on the makeup of the workshop will be provided to BERAC.

Anderson indicated the National Microbiome Data Collaborative is currently reaching out to other U.S. agencies, not internationally yet.

Dr. Gary Stacey called for a break at 10:35 a.m. and the meeting reconvened at 10:50 a.m.

News from Climate & Environmental Sciences Division (CESD) – Gary Geernaert, Director
[Presentation posted]

Discussion

Within the past month, Terrestrial-Aquatic Interface (TAI) workshop discussions have taken place between CESD and the National Oceanic and Atmospheric Administration (NOAA) focused on coastal science and biogeochemistry. There is a possibility for a multi-agency workshop late in FY19.

Communication and coordination between NOAA and DOE has always been very good and is expanding. The scientist perspective, from the Climate Modeling Summit, is that a lot of the research supported by DOE is important for weather forecasting. Ocean salinity is an important factor in hurricane intensification yet it has not been considered in the operational forecast models used by the National Hurricane Center. There are collaborations with NOAA scientists to incorporate that factor into their model. Geernaert said there are also discussions about the amplification problem, driven by sea temperature, in hurricanes.

Geernaert stated the concept of coupled-system research is not new. For example, the Southern Great Plains (SGP) in Oklahoma began as an atmospheric-centric facility and over time incorporated land-surface and atmospheric interactions. In Alaska, the Next-Generation Ecosystem Experiments (NGEE) Arctic field site in Barrow, AK is co-located near the Atmospheric Radiation Measurement Climate Research Facility (ARM) facility.

Geernaert was asked if TAI includes the sea level problem and might offer the dynamic capacity to observe the effects on erosion or amplification from hurricanes. NOAA's concern about erosion and amplification of hurricanes is increasing; they have reached out to agencies to help develop a concerted plan.

Geernaert was asked about the strategy to navigate the different physics versus the social systems and risk information. Acknowledging the complexity, Geernaert said it is a challenge for uncertainty quantification of extreme phenomena.

Early Career Science Presentation: Engineered and Emergent Properties of a Synthetic Microbial Mutualism – Jake McKinlay (Indiana University)

[Presentation posted]

Discussion

McKinlay said the synthetic system highlights the importance of spatial associations; the emergence of the nascent mutualism indicates the rules of competition still apply. Cooperative interactions emerge from parasitic interactions provided the environmental conditions favor the evolution of the mutualism. Reinforcing aspects quickly become involved in these relationships once spatial aspects are added. Clustering and formation of biofilm together allows scenarios of directed reciprocation to emerge.

McKinlay indicated groups are matching genomic information from the Joint Genomic Institute (JGI) with cooperative species, but there will be a rate of false positives in the models. A knowledge gap exists in excretion and transport; it is surprising that organisms appears to be giving up charged molecules.

McKinlay indicated co-evolution might be occurring in nascent mutualism. For example, his team found a higher co-culture growth rate in some of the *R. palustris*, but it is not clear whether the mutations are fostering cooperation or are mechanisms that make *R. palustris* more competitive. McKinlay's team does not have time series data for the naturally evolved mutualism, but they do for the engineered co-culture being used in the Department of Defense (DOD) project.

McKinlay stated the leading theory for prioritization of ethanol production over growth is it is advantageous for *Z. mobilis* to sterilize the environmental competition; *Z. mobilis* sacrifices growth efficiency for production speed but then has exclusive access to those sugars.

Dr. Gary Stacey adjourned the meeting for lunch at 12:00 p.m. ET.

Thursday, October 18, 2018
Afternoon Session

The Chair reconvened the meeting at 1:15 p.m. ET.

Facilities Integrating Collaborations for User Science (FICUS) and other joint facility collaborations – Harvey Bolton (Pacific Northwest National Laboratory)

& Nigel Mouncey (Joint Genome Institute)

[Presentation posted]

Discussion

Integrating international data with FICUS and other joint programs would require an understanding of data availability policies. Environmental Molecular Sciences Laboratory (EMSL) utilizes user agreements to make the data freely available, and JGI's policy is to immediately release sequence data as soon as quality control is passed.

Emphasis was placed on the importance of extending the FICUS model to the broader set of user facilities. Linked websites and cross-references between facilities was suggested. Bolton and Mouncey noted that frequent discussions and a common labeling system are necessary to handle the samples, data, and intellectual property between different facilities.

Mouncey was asked about target selection, and conducting proton studies in the Genome-to-Structure program. In consultation with scientists at JGI, the user selects the targets, and conducts the protein studies in their own lab. Mouncey indicated there have been discussions about making the Genome-to-Structure program more formal. Bolton and Mouncey were encouraged to take a proactive approach to get the community involved.

Workshop report brief: Earth Systems Modeling – Dorothy Koch (BER)
[Presentation posted]

Discussion

Koch was asked about the calibration process and decadal patterns; she suggested the ability to use modes of variability as part of the initialization process is necessary. One BERAC member explained the North American Multi-Model Ensemble (NAMME) makes monthly operational forecasts, which provide practical knowledge to address initialization questions. Koch thought NAMME would be a good way for DOE to participate in the experiment and help improve the model. For Koch the challenge is achieving the decadal predictability.

Koch was asked about theoretical data requirements and about adding in detailed landscape processes. Koch stated there was an assimilation study completed using two different data sets; two very different results were found. Currently, coupled data simulation systems do not include the data on land simulations. An offline land model is used because of problems coupling the atmosphere and ocean. NASA is one group studying land-surface data.

Workshop report brief: Genome Engineering for Materials Synthesis (GEMS)
– Seema Singh (BER)
[Presentation posted]

Discussion

Singh was asked if there are clear drivers or indications of materials to manufacture. Singh said the workshop, in terms of drivers of materials to manufacture, would focus on short-term goals relevant to the DOE mission. The first immediate goal should be in energy area in sensors and imaging.

When asked if there was discussion of codon replacements, Zhao said there was talk about incorporating amino acids to make hybrid, not just organic, material.

Dr. Gary Stacey called for a break at 2:55 p.m. and the meeting reconvened at 3:10 p.m.

BERAC Science Talk: Biofuel Sustainability Ten Years On – G. Philip Robertson (Michigan State University)
[Presentation posted]

Discussion

Robertson stated calculations with phosphorus had not been made, and that while a carbon market is a huge incentive opportunity the problem is generating the value for the carbon credits.

Robertson indicated the low productivity area on farmer's land is primarily related to texture and organic matter; these areas tend to be on droughty soils, particularly on slopes. Unstable areas tend to be in low spots in the landscape and appear to be weather driven. There is also a potential compaction issue because many low productivity areas occur around field edges. A recent study demonstrated that an ancestral strain of maize was capable of supporting fixation through oxidation of polysaccharides in the roots above the surface. A study completed 7-8 years ago, across worldwide corn and wheat nitrogen experiments for the past 20-30 years, stated a mass balance for nitrogen, although only 3-7kg, in corn could be distinguished.

Robertson explained management considerations are not directly transferable to other parts of the world. While the same considerations apply, climate interactions will accelerate microbial processes.

Report from Subcommittee on Facility Evaluation and Alignment – Bruce Hungate (Northern Arizona University)

Hungate summarized the subcommittee activities and findings. User facilities were sent a detailed questionnaire asking for a self-assessment of the degree to which the facility aligned with the Grand Challenges and an example or justification of where the alignment was strong. The survey results identified

opportunities for collaboration. At the April working meeting there were five working groups in Biological Systems Science, Earth & Environmental System Science, Microbe to Earth System Pathways, Energy Sustainability & Resilience, and Data Analysis & Computing. Eighty-one recommendations were drafted and Hungate shared one from each of the five groups.

Discussion

Hungate indicated training approaches are found in Chapters 4 and 6. The different articulations of each idea are expressed in the chapters and the priority recommendations will be condensed in the executive summary.

BERAC members suggested that a qualitative description of the content in Table 1 would avoid misrepresentation and misinterpretation.

Upon request, Weatherwax and Stacey explained the subcommittee report is a companion to the Grand Challenges report. The report is for internal use by BER and SC, but as a BERAC report, it will be publicly available.

Hungate agreed to revise the executive summary and delete Table 1. A printed copy of the revised executive summary would be made available to BERAC on Friday morning with a vote to be held by the end of the BERAC meeting.

Public Comment

The Innovator in Residence with the U.S. Department of Health and Human Services (HHS) and Vice-Chair of the Tick-Borne Disease Working Group expressed to BERAC that there might be some synergies with DOE and the national labs. The U.S. is experiencing a pandemic of Lyme disease, with over 300,000 Americans affected every year, more than HIV-AIDS and breast cancer combined. The Centers for Disease Control and Prevention recognize 18 different pathogens and there are 13 unique human tick-borne illnesses. New diseases are being introduced and discovered, as well as new species such as the Asian Longhorned Tick. Two recommendations from the Tick-Borne Disease Working Group pertain to capabilities in the national labs. The two recommendations are to fund studies and activities on tick biology and tick-borne disease ecology including systemic tick surveillance efforts particularly in regions beyond the northeast and upper mid-west; and fund systematic studies and activities to identify and characterize novel tick-borne disease agents in the U.S. The problem is a limited understanding of the ecology in the tick microbiome. The national labs are already beginning to elucidate fundamental organizing principles in microbiome architectures in vertebrates and arthropods, which could be applied to ticks. The existing national lab infrastructure and methodologies, and the tools and approaches to study the microbiome, could increase the resolution of ecological studies. The foundations seem to be set for studies that seek to deploy

metagenomic sequencing along with metabolomics to map architecture of the tick microbiome. The national labs have the capabilities necessary to yield transformative advances in these areas in a complimentary way that HHS cannot do alone.

An individual from Lawrence Berkeley National Lab (LBNL) shared that the Biosciences area had achieved 74% of their 5-year milestones laid out in their strategic plan for research goals.

A scientist with Argonne National Lab (ANL) mentioned that the computer science division at ANL conducts regular training sessions in genomic analysis and adaptation.

The Chair adjourned the meeting at 5:04 p.m.

Friday, October 19, 2018

Dr. Gary Stacey called the meeting back into session at 9:00 a.m. ET.

News from the Office of the Under Secretary of Energy for Science – Under Secretary Paul Dabbar

Dabbar stated that advisory boards are an integral part of DOE as they provide guidance, community coherence, and input. He gave an overview of DOE and the energy side of research, discussed SC's budget, SC's future areas of interest and near-term topics, and talked about BER research, regulatory reform, and crosscutting research.

DOE and the National Lab complex have significant support and a large community across all the areas of science, applied offices, and defense areas. Significant advancement in the last decade and substantial improvements of energy at cost and of emissions were driven by innovation and investment from DOE. For example, the cost of solar has dramatically dropped, batteries have increased in efficiency and improved across performance metrics, wind capacity factors have doubled, and oil and gas production costs have plummeted because of innovation.

Higher budgets across the science, innovation, and the research arms for the DOE complex demonstrate the country's interest in innovation. Six major global occurrences have captured SC's interest: QIS, AI, mobility, advanced and sustainable energy, space exploration (including high-energy physics and nuclear physics), and genomics.

QIS includes computing, networking, sensing, and biological implications and Congress demonstrated interest by passing a \$1.25B National Quantum Initiative. DOE recently announced \$218M in funding opportunities for quantum. A

quantum network is being developed to send entangled data between machines. DOE is focusing on the data implications and applications for biological topics. In microelectronics, DOE is considering questions about chip size and reaching the limits of Dennard scaling, Amdahl's Law, and Moore's Law. DOE is looking at next generation accelerator technologies, high field magnets, and superconducting radio frequency cavities in physical science crosscutting core technologies.

NOAA is using a derivative of the E3SM model to help with computing and algorithm challenges related to weather services. LBNL is working on biotech drug manufacturing modeling and computing. X-Lab Innovation Summits, which take an industry-, market-, or technology-centric approach, share what is possible across the national labs with private industry to increase commercial opportunities. There were over 300 attendees from labs, universities, venture capitalists, manufacturing, and end use customers at the first Summit on Batteries and Storage. The next two Summits will cover Grid Management and Biotech Drug Manufacturing.

Working with the national labs is challenging. The labs will soon have the authority to conduct facilitated reviews for smaller Strategic Partnership Projects (SPP) and Cooperative Research and Development Agreement (CRADA) below \$1M. This involves ~50% of all CRADAs and SPPs.

To standardize a process for communications between offices working on crosscutting technologies Dabbar will stand up a regular review group for research, applied science, ARPA-E, and defense program areas and create sub-committees to push down through the organization to have regular dialogue.

Dabbar closed by thanking BERAC for their hard work. He stated the reason everything works is that the community spends time and effort communicating and deciding what is important, and provides input to DOE concerning where the dollars should be invested.

Discussion

One BERAC member asked how the innovation process might change over time, for example getting the labs integrated with the commercial sector, and if In-Q-Tel, the DOD venture fund, was a model worth exploring. Dabbar explained DOD and Intel established In-Q-Tel because they noticed a lack of capital going into technologies with potential defense applications. Breakthrough Energy Ventures (BEV) is the only large entity set up to solve the problems seen in the last investment cycle in the energy sector. BEV is bigger and has longer hold periods; however, one large venture capital firm is not a community.

Dabbar was asked about facilitating collaborations across agencies in DOE for computing, AI, and E3SM. Dabbar stated that DOE's strength is building capabilities that others can come and use and noted environmental data collection,

and access and sequencing. He welcomed input from the community on how to build more bridges and on capabilities and facilities.

Workshop Report Brief: Atmospheric River Tracking Method Intercomparison Project – Ruby Leung (PNNL)

Discussion

In a recent study Leung's team used earth system models to help address predictability of hurricanes. The atmospheric river (AR) definition is most applicable to North America because the impacts are based on the analysis for North America. North Atlantic hurricanes are defined as category 1-5; for other ocean basins there are different considerations.

Reanalysis data sets have quite a bit of uncertainty. Satellite data is one way to look at reanalysis data using a benchmark. ARs are defined by the vertically integrated water vapor amount as far as the vertically integrated water vapor transport. Satellite information can be used as a constraint but even satellite data retrieval has some uncertainty. Uncertainty bounds for the observation data used as a benchmark are essential to evaluate the reanalysis products, but in-situ observation still has a very important role.

Leung noted the AR definition and algorithms are based on modern knowledge, the threshold values are based on satellite data and do not consider paleo climate information. However, there is greater recognition of the role ARs have played in the past and analysis of paleo climate information is important and useful.

BERAC Discussion on Subcommittee on Facility Evaluation and Alignment

Hungate explained revisions to the executive summary. No questions were asked. BERAC voted unanimously to accept the report.

The Chair called a break at 10:20 a.m. and the meeting reconvened at 10:35 a.m.

NAS Report Briefing: Science Breakthroughs to Advance Food and Agricultural Research by 2030 – Greg Lowry (Carnegie Mellon University) [Presentation posted]

Discussion

Lowry indicated that both block chain and stakeholder engagement were extensively discussed by the committee and are in the report. Lowry emphasized it is important to impress on people that food security is not a given in the U.S. and to generate large-scale centers to get teams of people together to converge on certain problems.

Work on the program is motivated by the flattening yield curves. Now is the time for the next green revolution, which may come from genetics, data analytics, and better systems models. Land use and marketability are not in the report as they are outside the scope.

Lowry referred to the Supporters of Agricultural Research (SoAR) Foundation and the Foundation for Food and Agriculture Research (FFAR) as entities created to enhance awareness, to secure funding, and to create a cohesive agriculture research voice. Lowry also said the report stresses translating breakthroughs into practice through the university extension services.

Energy Sciences Network (ESNet) Update – Inder Monga (Lawrence Berkeley National Laboratory)

Discussion

Monga noted that traffic engineering, the network and architecture design, overcame the leaky pipe challenge. Users should not resign themselves to bad performance, they need to be more educated and aware and push to get better performance. Users need to adopt the technology to push data over the network and take advantage of the engineering work put into ESNet.

Monga said the slowest link in chain would define one's experience with the network; capacity is an end-to-end challenge. Having the compute and the data together is an ideal solution, but there are issues to accomplishing that. Monga stated if compute is not next to your data ESNet can help. A change in thinking is occurring; next generation instruments are being designed with data in mind.

Exascale means that a singular computational experiment can generate unprecedented scales of data and lead to a question about using compression and similar technologies. Using the tools of compression and triggers is a good thing, but there is data growth regardless. ESNet is trying to build cost-effective growth into the network. The next network fiber has the capacity of 25TB; if the fiber is fully used, there is enough capacity. Monga suggested looking at the network as a partner.

BERAC Open Business (new charge) and Discussion

Stacey mentioned the new charge to create a Committee of Visitors for the CESD division. James Hack will be the chair and BERAC members were encouraged to contact Hack if they wanted to volunteer. Weatherwax clarified that the conflict of interest statement in the charge referred to specific activities within CESD, not CESD as a whole.

Public comment

The Energy and Environmental Science Directorate at ORNL was encouraged to increase their output in the number and impact of publications. Over the past three years, there has been a 40% overall increase in publications, from 488 in 2016, 604 in 2017, and 681 in 2018. One-third of the publications appear in Impact Factor journals 5+, there have been 14 major papers and 2 science papers in the science division (4% of publications). About 2/3 of the overall publications are in Biological Sciences and Environmental Sciences; 85% are BER relevant. Mitchel Doktycz was elected as a AAAS Fellow.

Dr. Gary Stacey thanked BERAC for their support over the years and turned the Chair position over to Bruce Hungate.

The Chair adjourned the meeting at 11:50 a.m.

Respectfully submitted,
T. Reneau Conner, PhD, PMP, AHIP
October 29, 2018