EESI Center Proposal – Spring 2020

1. NAME:
Center for Earth System Modeling, Analysis, and Data (ES-MAD)

2. DIRECTOR:
Prof. Chris E. Forest, Departments of Meteorology and Atmospheric Science & Geosciences

3. PARTICIPANTS:
We have identified the following centers or programs whose activities could collaborate with ESMAD:
- The Network for Sustainable Climate Risk Management (SCRiM, scrimhub.org, Prof. Klaus Keller, Dept. of Geosciences)
- The EESI Center for Climate Risk Management (CLIMA, Prof. Klaus Keller, Dept. of Geosciences)
- The EESI Center for Landscape Dynamics (CLD, Prof. Erica Smithwick, Dept. of Geography).
- Penn State Ice and Climate Exploration (PSICE, Evan Pugh Prof. Richard Alley, Prof. Sridhar Anandakrishnan, Dr. David Pollard)
- Program on Coupled Human and Earth Systems (PCHES, Prof. Karen Fisher-Vanden, Dept. of Agricultural Economics, Sociology, and Education.)
- Institute for Computational and Data Sciences (ICDS) projects (Director: Prof. Jenni Evans, Dept. of Meteorology and Atmospheric Science)
- Institutes for Energy and the Environment Centers (Director: Prof. Tom Richard, Dept. of Agricultural and Biological Engineering)
- Huck Institutes of Life Sciences (Director: Andrew Read, Evan Pugh Professor of Biology and Entomology; Eberly Professor of Biotechnology)
- Ecology Program (Prof. Erica Smithwick, Dept. of Geography)
- Center for Pollinator Research (Prof. Christina Grozinger, Dept. of Entomology)

Potential collaborators who have provided positive feedback on ESMAD:
College of Agriculture Sciences
- Prof. Armen Kemanian, Dept. of Plant Sciences
- Prof. Karen Fisher-Vanden, Dept. of Agricultural Economics, Sociology, and Education
- Prof. Christina Grozinger, Dept. of Entomology
College of Engineering
- Prof. Chaopeng Shen, Dept. of Civil and Environmental Engineering
- Prof. Li Li, Dept. of Civil and Environmental Engineering
- Assoc. Prof. Alfonso Mejia, Dept. of Civil and Environmental Engineering
- Asst. Prof. Xiaofeng Liu , Dept. of Civil and Environmental Engineering
- Assoc. Prof. Gordon Warn, Dept. of Civil and Environmental Engineering
- Asst. Prof. Konstantinos Papakonstantinou, Dept. of Civil and Environmental Engineering
Eberly College of Science
- Prof. Murali Haran, Dept. of Statistics
- Prof. Steinn Sigurdsson, Dept. of Astronomy and Astrophysics
- Prof. Miriam Freedman, Dept. of Chemistry
- Assoc. Prof Maciej Boni, Dept. of Biology, Center for Infectious Disease Dynamics
College of Information Sciences and Technology
- Prof. James Wang

4. RATIONALE:
This center is a critical component for maintaining and enhancing a vibrant collaborative environment across the Penn State research community as planning for climate change remains one of the grand challenges of our generation. Growth in the volume and prominence of Penn State climate research emphasizes the need for this center to share the best available research methods, data, and models to foster collaboration and build strong, long-lasting interdisciplinary collaborations across the university. The center will facilitate the bridging of basic climate and earth system research to the areas focused on finding solutions for both assessing the impacts and implementing mitigation strategies. Penn State research has a long history of strengths in all aspects of Earth system observations and modeling and this center will serve as a gathering place for experts on campus who are motivated to improve our basic understanding of the Earth system and to use the best science to solve societally relevant problems. We look forward to advancing these efforts on campus and developing the capacity to address the full range of future challenges facing our planet.

Vision Statement: The Penn State Center for Earth System Modeling, Analysis, and Data will be the locus for climate research and assessments across the University. The Center will build collaboration between multiple disciplines and foster interaction between the Penn State research community and internal and external decision-makers and stakeholders.

Mission Statement: The Penn State Center for Earth System Modeling, Analysis, and Data will be squarely focused on supporting Penn State's third strategic priority of "Stewarding our Planet's resources" by helping researchers select the best climate data, models, and analytics for their research. This will be accomplished by developing analytic and numerical methods, sharing data, and expanding cross-domain capabilities and expertise in Earth System Modeling. The center will leverage the Penn State climate research efforts occurring across multiple academic areas by assisting in the identification and execution of classes of climate problems with medium to long-term development timeframes and high stakeholder benefit, that also:
1. Support the University's educational goals for graduate students and post-doctoral scholars,
2. Support the University's applied research initiatives, and
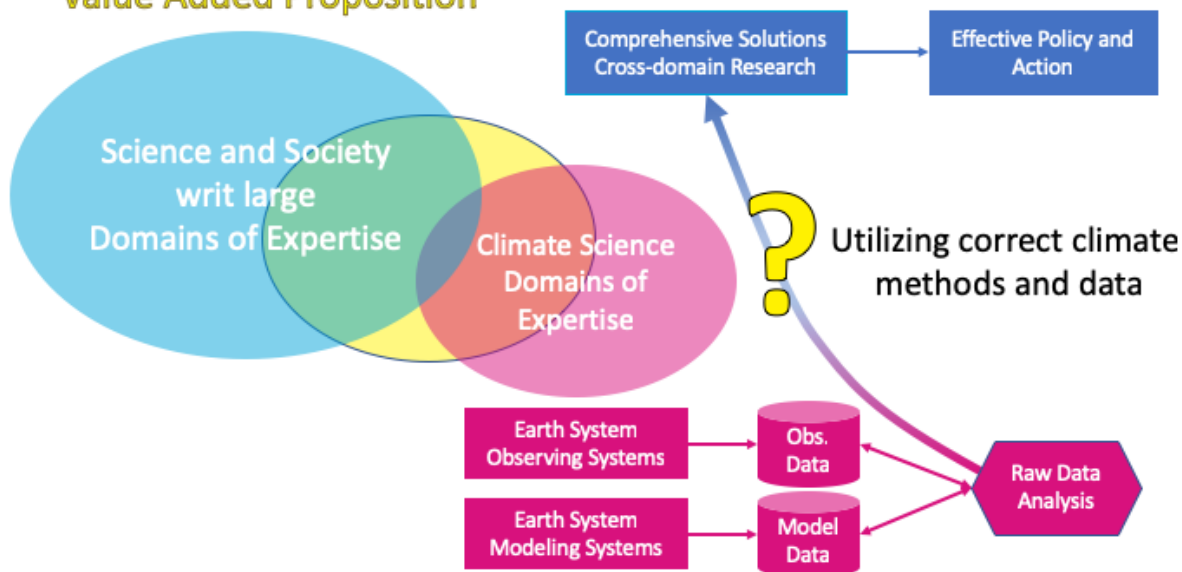3. Enhance the University's service to society.

To accomplish this mission the center will perform four major functions:

1. Catalog existing and develop new analytic tools to support interdisciplinary research,
2. Provide easier access to climate data,
3. Provide access to, develop new, and extend the capabilities of Earth System Models, and
4. Engage in outreach activities with faculty, departments, and colleges to provide up-to-date information on Center capabilities and to actively seek collaborations.

Value added proposition (Value added data for climate research):
As part of Penn State's strategic priority of "Stewarding our Planet's resources," we have the goal of becoming "a leader in creating comprehensive solutions to mitigate the dangers of climate change." To accomplish this, researchers across the University must cross disciplinary domains and use appropriate climate data and analysis techniques developed within the domain of basic climate research. The Center for Earth System Modeling, Analysis, and Data supports more effective inter-disciplinary research to identify and use the vetted approaches from the weather and climate science community, and thus improve cross domain knowledge sharing within the University (see figure).

ESMAD Domain of Expertise and Value Added Proposition

Science and Society writ large Domains of Expertise

Climate Science Domains of Expertise

Comprehensive Solutions Cross-domain Research → Effective Policy and Action

? Utilizing correct climate methods and data

Earth System Observing Systems → Obs. Data

Earth System Modeling Systems → Model Data

Raw Data Analysis

This engagement will add value to research initiatives across the University by:

- Allowing for better faculty, end user/stakeholder engagement,
- Streamlining the level of effort and time required for graduate students to develop needed cross-disciplinary skills,
- Decreasing costs associated with identifying and implementing most appropriate climate research methods and data by allowing for economies of scale and lower learning curves to acquire and utilize climate cross-domain expertise,
- Providing a competitive advantage when competing for research funding,
- Assuring researchers that initiatives across the university are using the best climate research methods and data to support research goals, and thus,
- Improving the overall quality of Penn State climate research results.

5. FUNDING OPPORTUNITIES:

Four proposals have been submitted to date for engaging with the ES-MAD Center. As examples, these demonstrate the collaborative nature and the broad reach of the center. They are listed here:

NSF STC: NATIONAL CENTER FOR POLLINATOR RESEARCH, **PIs:** Christina Grozinger (lead), Chris E Forest, Jose D Fuentes, Claudio Gratton (UW-Madison), Gene E Robinson (UIUC), **Total:** $25,000,000, **Dates:** 6/01/2021-5/30/2026

NSF LEAP-HI: Optimal design and adaptation of civil infrastructure in a changing and uncertain environment for a sustainable future, **PIs:** Gordon Warn (lead), Melissa Bilec, Konstantinos Papakonstantinou, Chris E Forest, **Total:** $2,000,000, **Dates:** 7/01/2020-6/30/2024

NSF CoPe EAGER: Collaborative Research: Developing a Coastal Resilience Decision Making Framework for Rapid Deployment, **PIs:** Chris E Forest, Kyle Mandli (Columbia University), Heather Lazrus (NCAR), Rebecca Morss (NCAR), **Total:** $297,279, **Dates:** 9/1/2019-8/31/221

NOAA: Tower based land-atmosphere coupling metrics for climate model evaluation, **PIs:** Tobias Gerken, Kenneth Davis, Chris E Forest, **Total:** $479,751, **Dates:** 09/01/2020 - 08/31/2023

6. CENTER NEEDS:

No budget is requested from EESI. Currently, we have office space available in Walker Building. As the team grows, eventually, we would like to transition to EES Building but this may be delayed given available space during planned renovations. For current computational resources, we are currently working on the Advanced Computing Infrastructure (ACI) system with support from ICDS. One major need will be additional mass data storage for locally archived data sets as collaborations increase. This additional storage will support local versions of CMIP5 and CMIP6 data sets, which will include high volume data sets given the need for high spatial and temporal resolutions and multiple ensembles.

HIRING NEEDS:

The center will initially need to fill two research positions with expertise in two core areas: Earth System Modeling and Climate Data Analysis. Given the nature of the work, each researcher would overlap to some degree and they would work together on projects.

Earth System Modeler

We plan to hire a full-time researcher who will focus on Earth System modeling and be part of the core ESMAD team. This person will have expertise implementing and using several types of Earth System Models at varying levels of complexity and size, and leading the use of these models in research initiatives. The Earth System Modeler will establish and sustain core Penn State capability to run many combinations of Earth System Models on the Penn State HPC environment at ICDS-ACI and, in some cases, on outside systems (such as the CESM models). She/he will develop and maintain a wiki-style repository of climate model knowledge relevant to Penn State Climate research. She/he will become especially familiar with Penn state developed models. She/he will work with the Penn State climate science community to identify gaps in the existing model output archives where the models are missing physics, forcings, chemistry, resolution or other factors that limit their applicability. She/he will be an active participant in research intended to fill these gaps. She/he will assist in identifying opportunities and writing technical aspects of related scientific proposals.

Climate Data Analyst
We plan to hire a full-time researcher who will focus on Climate Data analysis and be part of the core ESMAD team. This person will have expertise developing and implementing data analysis tools in support of both Earth System Modeling and maintaining climate data archives. The Climate Data Analyst will establish and sustain core Penn State capability to work with multiple tools on the Penn State HPC environment at ICDS-ACI and, in some cases, on outside systems (such as the CESM models). She/he will develop and maintain a wiki-style repository of climate data analysis tools relevant to Penn State Climate research. She/he will work with the Penn State climate science community to identify gaps in the climate model analyses, advanced statistical methods, machine learning, data visualization, and other relevant areas. She/he will be an active participant in research intended to develop the analysis tools and work with the collaborators to assess suitability for purpose. She/he will assist in identifying opportunities and writing technical aspects of related scientific proposals.

7. MANAGEMENT STRUCTURE:
The new center will be setup as a university level center within the Institutes of Energy and the Environment, although center personnel will reside within the Department of Meteorology and Atmospheric Science and the Earth and Environmental Systems Institute. ESMAD is co-sponsored by the College of EMS, the Department of Meteorology and Atmospheric Science, and the Institute for Computational and Data Sciences (ICDS). The governance will include a Director and Assistant Director with an advisory committee. The advisory committee will include 3-5 members with representation from the communities interacting with ESMAD and, at a minimum, meet once each semester to assess the Center's progress. In the first year, the Director and Assistant Director will work with the advisory committee to generate a set of bylaws for the center based primarily on this proposal to establish the basic governance and activities of the center. The bylaws will establish the administrative oversight with representation from IEE, ICDS, and EMS and identify the role of the advisory committee.

8. PRIOR EXPENDITURES AND PAST WORK:
The ES-MAD Center was recently approved in late April 2020.

9. SUPPORT LETTERS:
This center has been approved by the Senior Vice President for Research, Dr. Lora Weiss.

Additionally, as part of the approval process, Professor Chris Forest has met with Heads of Departments and Institute Directors:

College of Agricultural Sciences:
Departments of:
      Agricultural and Biological Engineering: Paul Heineman
      Agricultural Economics, Sociology, and Education: László Kulcsár
      Entomology: Gary Felton
      Plant Pathology: Carolee Bull
      Plant Sciences: Erin Connolly

Eberly College of Sciences:
Departments of:
      Astronomy and Astrophysics: Don Schneider
      Chemistry: Philip Bevilacqua
      Math: Mark Levi
      Physics: Samarth Nitin
      Statistics: Murali Haran

College of Engineering:
Departments of:
      Civil and Environmental Engineering: Patrick Fox
      Architectural Engineering: Sez Atamturktur

College of IST:
      Associate Dean for Research: Prasenjit Mitra

College of Earth and Mineral Sciences
Departments of:
      Geography: Cindy Brewer
      Materials Science and Engineering: Susan Sinnott
      Energy and Mineral Engineering: Sanjay Srinivasan

Huck Institute for Life Sciences:
Director: Andrew Read
Center for Infectious Disease Dynamics: Director, Beth McGraw

Penn State Institutes for Energy and the Environment
Director: Tom Richard

Institute for Computational and Data Sciences
Director: Jenni Evans