Consortium on Law and Values in Health, Environment & the Life Sciences
2018-19 Proposal Cover Page

Applicant Information

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College: Liberal Arts

Degree program: Geography

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How did you hear about this funding opportunity?
☐ ACCU  ☐ Consortium website  ☐ The Brief  ☑ Dept. email/newsletter  ☐ Around the AHC  ☐ OVPR
Internal Funding Opportunities  ☐ Law Council email  ☐ Other

Funding

Total amount of funding requested: $6950

Executive summary (maximum 200 words)
As the state of Minnesota and utility companies like Xcel Energy craft strategies for shifting towards renewable energy to help mitigate the impacts of accelerating anthropogenic climate change, information on resource variability and long-term energy potential in the Upper Midwest will be key to meeting those goals. Wind will make up a significant portion of the energy mix going forward but faces problems of intermittency that make its widespread adoption more difficult. Further, data on the monthly, seasonal and decadal variability of wind resources is almost nonexistent, rendering efforts at planning, even over the next few years, highly uncertain. This project will utilize information on synoptic scale processes (patterns of high and low pressure that affect the circulation of local and regional winds) to assess the variability of wind speeds at wind turbine height over monthly to decadal time periods in the Upper Midwest. This process will be used to model the impact of this variability on wind energy generation in the region and could be readily applied to other regions nationally or globally. This information will be useful to state and utility efforts to meet their renewable energy targets and will provide a foundation for long-term wind energy planning.

Approvals

Check all appropriate approvals required for your proposal. It is not necessary to have all approvals at the time of proposal submission; however, approvals must be obtained prior to receipt of funding. If you have applied for approval but have not yet received it, indicate that below.

IRB  ☐ Yes  ☐ No  ☑ NA  ☐ Application pending
Other  ☐ Yes  ☐ No  ☑ NA  ☐ Application pending  Specify:

Checklist—for reviewer use

☐ The proposal is 1000 words or less excluding budget, biographies, references and citations.

☐ The proposal includes a work plan with a specific timeline using months or quarters to identify work to be done and completion dates.

☐ The proposal includes a 1-2 paragraph biography of the applicant and all co-investigators.

☐ The budget form is complete including the funds sought for this project, other pending applications for this project, and the amount/source of matching or other funds.

☐ The applicant’s faculty advisor is copied on the application email. Professional students w/o advisors check No Advisor.

☐ All necessary approvals are pending or received.
Assessing Long-term Wind Energy Variability in the Upper Midwest: Fulfilling Our Regional Renewable Energy Goals

Background
The need for carbon-free energy sources has grown exponentially as impacts from human-caused climate change have become increasingly severe. In response, states such as Minnesota have crafted plans to quickly scale up their renewable energy portfolios while utilities like Xcel Energy have made broad promises to shift to total renewable energy generation by 2050. These plans for renewable energy expansion are ambitious and will have to make much greater use of the relatively abundant wind resources in the Upper Midwest than what is currently in production. Yet even as these proposals are drafted and the targets are set, critical information on long-term wind resources and variability is missing. Even while much research has been done to improve the state of wind forecasting over short periods of time (hours to days), assessment of monthly, seasonal and decadal wind variations remains perniciously limited. This is problematic because while short-term variability in wind is currently built into the plans for future energy development, variability over longer time scales is not and could drastically impact our ability to fulfill these goals. For example, while short-term fluctuations in local wind speeds are compensated by energy producers through the practice of spreading their wind farms over wide regions, previous work has shown that strong El Niño events, which affect weather across the globe, drastically slow wind speeds across the entire Upper Midwest for months at a time. Such large scale and long-lasting variability from El Niño and other climatic fluctuations similar to it could drastically undercut regional energy production. The goal of this project is to better quantify the impacts of wind variability over longer time scales, the factors that influence that variability, and to inform and support future wind energy development in Minnesota, the Upper Midwest, and other regions around the world.

Approach
This project is formulated to fulfill the following aims:

1) To quantify wind speed variability in the Upper Midwest on monthly, seasonal and decadal timescales and,
2) To assess the factors which control this variability over these timescales

To facilitate these goals, a process called synoptic classification is used, wherein the spatial pattern of surface pressure variations at the synoptic scale (1000 – 3000 km) are classified according to their similarity. This is facilitated by using an established classification system, the Lamb scheme, in which daily pressure patterns are assigned to one of 26 possible classes. Each day will have a daily averaged wind speed and an associated pressure pattern class for every location analyzed in the region, allowing for the construction of wind speed probability distributions for each of the 26 classified pressure patterns. Since local and regional wind speeds are driven by these synoptic patterns, linking the daily wind speeds at each location to classified pressure patterns has two key benefits;
a) Synoptic pressure patterns have been strongly linked to large-scale factors, such as El Niño cycles, that affect weather over monthly, seasonal and decadal timescales and,
b) This process will not only quantify wind speed variability but will also provide a physical explanation for how this variability occurs.

Data for this project will come from atmospheric retrospective analyses, or reanalyses – climate models that are used to recreate observed atmospheric conditions by correcting the model using observational data. Since wind observations are extremely limited in space and time, especially at the height of wind turbines, reanalyses provide a continuous, high-resolution alternative. Gridded 80-meter wind speed and sea level pressure data from three reanalyses have already been extracted for the Upper Midwest (40–52N, 87–105W) over the period 1979–2016.

The results of this work will be submitted for publication in a scholarly journal and presented at applicable local, regional and national scientific conferences.

Significance
The work proposed here has important practical implications for the renewable energy targets set by Minnesota, Xcel Energy, and other regional entities. Quantifying wind speed variability over monthly to decadal timescales directly alleviates some of the risk and uncertainty inherent in long-term energy planning. The results of this work will help better prepare stakeholders for the potential challenges posed by various scales of wind variability that may affect the region. By extension, to the degree that factors which affect the synoptic patterns in the Upper Midwest – El Niño or the polar vortex – can be predicted, this project would yield information for projecting wind patterns and power potential months or even a year or more ahead of time. On a broader level, the process proposed here is unique and has not been applied to the problem of regional wind variability. If successfully demonstrated in the Upper Midwest, synoptic classification could be useful to wind variability assessment for other regions. Further research could also investigate the usefulness of synoptic classification to solar energy assessment, which would bolster our understanding we need to meet our renewable energy goals.

Timeline [June 2019 – January 2020]
1. Assess the accuracy of wind data from reanalyses and demonstrate successful extrapolation of reanalyzed wind data to 80-meters for use in the rest of the project.
2. Classify daily pressure patterns according to the Lamb scheme by using daily surface pressure data from the reanalyses and,
3. Aggregate daily 80-meter wind data from the reanalyses by the classified circulation types and generate wind speed and power curves for each type and,
4. Use the synoptic types and their associated wind probability distributions to assess the variability of the wind over timescales of months, seasons and decades and,

5. Assess the influence of largescale climate factors such as the El Nino cycles and other similar phenomena on the synoptic pattern-induced wind speed and power variability. [June – August 2019]

6. Draft a publication-ready manuscript for submission to a scholarly journal, as well as the final narrative and financial report for the Consortium. [August – December 2019]

7. Present the results at applicable scientific conferences, including the annual American Meteorological Society meeting in Boston, MA. [January 2020]

Biography

Jacob Coburn is a third-year PhD student in the department of Geography, Environment and Society (GES) with a goal of graduating in Spring 2020. He works under the oversight of Dr. Katherine Klink, with a focus on wind climatology and wind energy in the Upper Midwest. Previous work has been recognized by GES in the form of summer research funding awards as well as by the annual American Meteorological Society meeting where he won the Best Student Poster Presentation award two years in a row for his work on the effects of surface roughness on terrestrial wind stilling (January 2018) and for the assessment of several methods of vertical wind speed extrapolation to hub-height (January 2019). Other work in the department includes participating in the GES Graduate Student Union, for which he maintains the departmental Wiki page (http://umngeoggrad.wikidot.com/) and attends faculty meetings in order to help take notes and present graduate student concerns and feedback on departmental matters. Recognizing the need for renewable energy and education, Jacob has volunteered for the Windustry booth at the Minnesota State Fair, where he helped guide visitors through the wind energy exhibits and conducted some of the games and activities.

Jacob received his Master of Science in Earth System Science and Policy from the University of North Dakota in 2015. There, his work focused on downscaling climate model output to better suit the needs of local stakeholders. He obtained his undergraduate degree in Physical Geography from the University of Montana in 2012. His future endeavors are to work in academia or industry, using the skills and understanding he has gained from his time in school to advance our understanding of climatology and aid in crafting the best societal responses to climate change.
References

Consortium on Law and Values in Health, Environment the Life Sciences
Budget for Student Proposals

Project Title: Assessing Long-term Wind Energy Variability in the Upper Midwest: Fulfilling Our Regional Renewable Energy Goals

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*Stipend Justification: stipend is used in this project for research time, programming R code, analyzing output and writing (publication manuscript, materials for the Consortium), primarily through summer and into autumn

**Supplies and Services Justification: based on experience with a previous, similar length publication in the Journal of Applied Meteorology and Climatology (~ 20 typeset pages and 5 color figures - see reference 23), $2300 publication fee, as invoiced