**PROJECT TITLE:** **PREDICTION OF INVERSIONS FOR AIR-QUALITY IN COLD WEATHER**

**I. PROJECT STATEMENT**

The objective of the present proposal is to study inversions in the atmosphere using precise measurement data and high-fidelity modeling, to investigate the effects of inversions on the quality of the air in Minnesota, and to develop a mitigation strategy for air pollution. Inversions typically occur in the mornings and cold winters, and are characterized by a layer of cold air near the surface of the Earth that is trapped by a layer of warm air above it. Due to the inability of this trapped air to escape the warm layer, the amount of pollutants in the lowest level of the atmosphere increases as it is unable to enter the higher regions of the atmosphere. This region of high pollution, which is typically in the lowest 20 feet of the atmosphere, directly affects the quality of the air that is inhaled by residents of Minnesota. According to a study performed in 2018, inversions were recorded to occur in over 90% of the days measured in various Minnesota cities. The formation of inversions is governed by a wide variety of environmental variables and for this reason they are often difficult to detect and predict.

While the air quality of Minnesota on average is good when compared to many other areas, there are still regions in Minnesota that are linked to poor air quality. According to the Minnesota Pollution Control Agency 2019 report on air quality, around 2000 deaths per year are linked to the effects of air pollution, with hundreds of additional hospitalizations. Additionally, it was found that 32% of the population was found to live in regions where air pollution is above the risk guidelines. This value gets even worse for communities of color and indigenous communities where 91% of the population is living in regions of air pollution above the risk guidelines. Due to the direct effect of inversions on the quality of the air we breathe, it is important to better understand when and where these inversions occur and be able to provide valuable insights to ensure Minnesotans breathe the cleanest air possible.

The goal of this project is to use measurement data as well as highly accurate models to guide people on where and when strong inversions are likely to occur. Using the extensively developed and tested simulation tools developed at the Saint Anthony Falls Laboratory, it will be possible to accurately recreate the weather conditions, pollutant sources, and geography in which inversions occur. With access to modern supercomputers, it will be possible to rapidly replicate a wide variety of scenarios that occur naturally all throughout Minnesota without having to wait for these conditions to occur. From these simulations, insight into the causes of inversions and their severity, as well as the areas of greatest likelihood for inversions will be gained.

Based on the proposed study, it will be possible to use the information discovered to improve the quality of air in Minnesota. For example, it has been shown that fertilizing crops during inversions increases the amount of fertilizer that is trapped in the air, and drifts into surrounding areas. The detrimental effect is so severe that the Environmental Protection Agency has instructed farmers to refrain from fertilizing their crops during times when inversions are present. However, it is often difficult for the farmers to identify when inversions are present. The proposed research could be used to provide a powerful tool for farmers to use when they are identifying the best times to fertilize their crops.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1 Title:** Collect data from field experiment**Description:**The first phase of the project will be to use previous atmospheric data, together with wind and temperature data in Minnesota, to find out the relationship between air pollution and inversions. Also, air quality monitoring devices will be installed in the city, as well as other locations of interest to get a distribution of air quality in different horizontal layers, and its change over time of a day. By doing so, we will get a general understanding of air quality variance which can be used independently to study inversions, as well as for a tool to validate the simulations that are developed later in the project.**ENRTF BUDGET: $152,492** |  |

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| **Outcome** | **Completion Date** |
| *1. Use previous data to analyze the relationship between air pollution and inversion.* | *June 30, 2021* |
| *2. Install devices to monitor the detailed air quality distribution over different layers.* | *Oct. 31, 2021* |
| *3. Obtain a general description of inversion layer’s effect.* | *March 31, 2022* |
| **Activity 2 Title:** Develop modeling capabilities**Description:**The second phase will involve establishing a model capable of accurate simulation of inversions. The model will first be validated to ensure they are capable of accurately predicting inversions. After the validation, it will be used to conduct a broad study of many different weather scenarios responsible for inversions. We will be able to conduct an extensive study on different weather conditions and pollutant levels. Lastly, these results will be analyzed to identify trends that will allow for development of new and more effective methods of predicting the severity and frequency of inversions.**ENRTF BUDGET: $141,994** |  |

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| **Outcome** | **Completion Date** |
| *1. Development of modeling capabilities* | *March 31, 2021* |
| *2. Validation of the accuracy of the model* | *June 30, 2022* |
| *3. Using model to improve understanding of inversions*  | *Dec. 31, 2022* |
| **Activity 3 Title:** Educating and outreach to the community on findings**Description:**The final phase of the project will be to use the information from the study to provide meaningful insights to a wide range of Minnesotans in a simple and effective manner. From the information gathered, it will be possible to locate regions of Minnesota, as well as times of the year, with a high probability of inversions. This information can then be relayed to the general population by creation of websites and apps that couple weather forecasting and geographic information to provide an easy tool for the average Minnesotan to understand the complicated nature of inversions in a simple, convenient method. These tools can then be used by many different industries and communities. The tools can be used by farmers to better understand safe times to fertilize crops, city planners to best understand regions where air pollution is likely to be of greater concern, and residents who simply want to know when the safest time is to enjoy the outdoors. **ENRTF BUDGET: $10,498** |  |

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| **Outcome** | **Completion Date** |
| *1. Develop an app and website to inform citizens on inversions* | *March 31, 2023* |
| *2. Provide information to farmers on safe fertilization times* | *June 30, 2023* |

**III. PROJECT PARTNERS AND COLLABORATORS:**

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

Air quality is a problem that affects many residents of Minnesota. By learning more about the occurrences of inversions and their effects on pollution, it will be possible to provide insight into many different industries and communities that make up Minnesota. In the future, the continued work of collecting measurement data and performing modeling will provide methods to test potential mitigation methods.

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:**

**A. Proposal Budget Spreadsheet**

**B. Visual Component or Map**

**F. Project Manager Qualifications and Organization Description**