GLOBAL SYSTEMS LABORATORY

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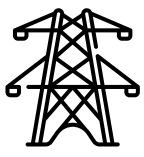
Forecast improvements for clean energy

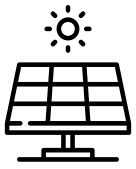
The Need

The U.S. is tackling the climate crisis and is on a path to create an equitable, clean energy future to achieve net-zero emissions economy-wide by 2050. To meet this goal, a large portion of electricity produced from fossil fuels will need to be generated instead from low-carbon sources, such as wind and solar power. As the nation's wind and solar industries grow, NOAA faces increased demands for better products and services, including improved meteorological observations and more accurate wind and cloud forecasts over a range of timescales.

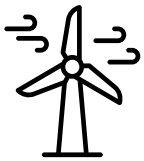
GSL's research supports decision-making in the energy industry, which saves utilities and consumers millions of dollars. Our research investigates:



How can we forecast atmospheric conditions to optimize power lines?



How do weather conditions impact energy efficiency?



How can we forecast wind conditions to make better decisions about wind-power production?

The Solution

With highly accurate observations, forecasts, and an understanding of how wind and solar resources fluctuate across time and space, the electric grid will better accommodate the variable nature of wind and solar energy. In particular, accurate day-ahead to week-two forecasts of hub-height winds and solar radiation at the surface allow energy providers to integrate renewable energy into the electrical grid more efficiently, making the grid more resilient. This will yield greater production of carbon-free renewable energy while also reducing air pollutant emissions. In addition, seasonal-to-decadal predictions from NOAA models are used for planning the development of new generation, transmission, and energy storage infrastructure, extreme event mitigation, and evaluating the impact of climate change on clean energy resources.

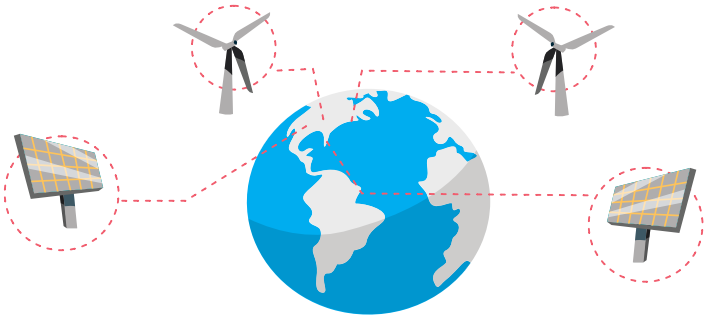
The Science

NOAA's Atmospheric Science for Renewable Energy (ASRE) program works with the Department of Energy (DOE) and the wind and solar energy community to improve existing meteorological observing networks and weather forecast models. NOAA conducted several field campaigns to collect data to study atmospheric processes associated with wind shear, turbulence, low-level jets, clouds, aerosols, and other aspects of the weather. These datasets are analyzed to better understand atmospheric processes that affect winds at the height of wind turbines and the amount of sunshine hitting the solar panels.

RECENT CAMPAIGNS:

- The Wind Forecast Improvement Projects (WFIP) are a collaboration with the DOE's Wind Energy Technologies Office (WETO). Two field campaigns have been conducted: one on initializing forecast models with observations to improve wind forecasts, and one in complex terrain. A third WFIP campaign has launched with WETO to collect a dataset to improve off-shore wind energy predictions.
- The Position of Offshore Wind Energy Resources (POWER) campaign was conducted to enable better predictions of offshore wind resources to inform site selection for offshore wind farms. Lessons from POWER are being used in the design of the WFIP-3 campaign.
- DOE's Solar Energy Technologies Office (SETO) collaborated with ASRE and the National Center for Atmospheric Research and IBM to conduct a field campaign to develop more accurate methods for solar forecasts using their state-of-the-art weather models.

In addition to these field campaigns, long-term observational datasets collected by NOAA (such as the SURFRAD surface radiation network stations) and the DOE's Atmospheric Radiation Measurement (ARM) program are also used heavily by ASRE researchers.

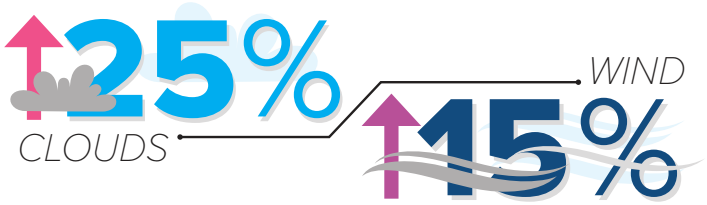


Applications

The private sector uses predictions from NOAA weather prediction models as foundational input to their tailored forecast products. These models can also help the energy industry plan for the variable nature of wind and solar energy and can help target the most beneficial locations for clean energy development.

Transitions

ASRE-supported research results in improvements to NOAA's numerical weather prediction models, which are moved to operations within the National Weather Service approximately every two years.



Metrics

NOAA's High-Resolution Rapid Refresh (HRRR) model has improved its short-term forecasts of clouds by 25%, and winds by 15% over the last decade. In a recent study, researchers found that better 12-hour wind forecasts from the HRRR model between version 2 and 3 would have resulted in a cost savings to the wind energy industry of over $200M per year. This result assumes that the wind industry used only the HRRR forecasts for their day-ahead decisions regarding the mix of wind-produced versus fossil fuel produced energy. The improvement is due to both reduced overprediction and underprediction errors by the improved version 3 of the HRRR, relative to version 2. These savings would have a direct impact on household incomes through reduced energy costs.

Future Work

Future research includes:

- Understand the winds within the atmospheric boundary layer (the lowest approximately 1 km deep layer of the atmosphere that is strongly affected over the course of a day by the land/ocean surface).
- Understand coupling processes between the boundary layer and the Earth's surface.
- Understand cloud properties and aerosols (including wildfire smoke) and their impact on solar energy generation.

This research should span a range of temporal and spatial scales and include the analysis of the impact of large-scale climate modes of variability (e.g., the El Nino Southern Oscillation and the Pacific Decadal Oscillation) on seasonal and longer-term variations of the wind and solar resources.

The ASRE team

ASRE is a collaboration between NOAA laboratories, Cooperative Institutes, and line offices. The team is composed of meteorologists, physicists, chemists, and engineers that are uniquely qualified to improve weather observations and forecasts. This work supports effective planning and efficient observation of a national renewable energy system at least cost to the consumer.