

**SYSTEM AND METHOD FOR GENERATING A SERIES OF SHORT PERIOD
LOCAL WIND SPEED FORECASTS EMPLOYING K-MEANS CLUSTERING
AND STACKED MACHINE LEARNING ANALYSIS**

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TECHNICAL CONTRIBUTION

The present disclosure relates to generation of wind speed forecasts. More particularly,
10 the present disclosure relates to generating a series of short period wind speed forecasts
for a local area employing k-means clustering and stacked machine learning analysis.

BACKGROUND

15 Power utility companies are tasked with providing a predictable power supply to their
customers, which can create challenges when a significant portion of the power
generation is from wind farms with an array of wind turbines. Wind speed is extremely
important for predicting energy output of a wind turbine. The energy content of the wind
varies with the cube (the third power) of the average wind speed. For instance, if the
20 wind speed is twice as high it contains eight times as much energy.

In addition to wind farms and solar power plants, power utility companies often acquire
electrical power from traditional power generation sources such as hydropower plants,
coal burning power plants, natural gas turbine power plants, and possibly nuclear power
25 plants. These power generation plants often have an adjustable power output, and can
ramp up or ramp down their power generation output to offset changes in wind speed at
a wind farm. However, such changes to the power output are difficult to achieve quickly.
Advance notice is required to bring additional resources (such as additional natural gas
turbines) online.

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To forecast local wind speed (and thus power output of a wind farm), ensemble members are available from organizations such as the European Centre for Medium-Range Weather Forecast (ECMWF) and the National Operational Model Archive and Distribution System (NOMADS) for a license/data fee. ECMWF provides 51 ensemble members (ENS). NOMAD provides various ensemble members for National Weather Prediction (NWP) such as the Global Ensemble Forecast System (GEFS) and the North American Multi-Model Ensemble (NMME). The available ensemble members are used to create member outputs (e.g., sets of weather forecast data including wind speed) for specific time windows and locations. Each available ensemble member is associated with a different set of initial conditions for the atmospheric model, thus each ensemble member results in a member output with a different set of forecast information.

While the available ensemble members from weather forecasting organizations are powerful tools for wind speed forecasting, the available ensemble members are distributed to a worldwide audience and are not tailored for specific local areas. A simple averaging of a selection of member outputs from the available ensemble members may not always provide the best wind speed forecast prediction for the local area of a wind farm. Also, the available ensemble members may not be best suited to delineate changes in wind speed over a span of a few hours or of a day in a local area. Hence, the available ensemble members are often insufficient to forecast the power output of a wind farm hour to hour or day to day with adequate specificity.

The available ensemble members are also not configured to take into account observed wind speed measurements from a specific local area. The wind turbines of wind farms have tremendous capability for the collection of real-time wind speed observations, either directly from the onboard sensors installed in each wind turbine of the wind farm or, alternatively, indirectly from analysis of the power output of the wind turbines of the wind farm.

What is needed is a system and method for generating a series of short period wind speed forecasts for a local area that leverages the available ensemble members as well as the actual observed wind speed data from the local area.

SUMMARY

In its most general form, the first and second embodiments of the invention are a system and method for generating a series of short period wind speed (SPWS) forecasts for a local area using a periodically updated optimal composition of ensemble member outputs from well-known ensemble members. Recent accuracy of the forecasted wind speed generated from each ensemble member of a prior SPWS forecast is evaluated by a comparison of the wind speed forecasts generated by the ensemble member with the actual observed wind speeds for the same time window. This comparison is used to calculate an accuracy error for each ensemble member for the recent time frame. The accuracy error rating of each ensemble member is then used to determine the updated optimal composition of ensemble member outputs employed to generate the SPWS forecast.

In more detail, the first and second embodiments of the invention are a forecasting platform and method for generating a series of short period wind speed (SPWS) forecasts for a local area. The platform comprises: (a) a scheduling module; (b) a collection module; (c) a pre-processing module; (d) a forecasting module; (e) a ranking module; (f) a forecasting module; and (g) an output module.

The scheduling module of the first and second embodiments of the invention is configured to trigger the generation of the series of SPWS forecasts according to a forecast schedule with a plurality of forecast requests, each SPWS forecast associated with one of the forecast requests. Each forecast request includes a forecast identifier, a forecast time window, a forecast member selection list, and a forecast area identifier.

The collection module of the first and second embodiments of the invention is in data communication through a network with: (1) at least one ensemble member server including a plurality of ensemble members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS record including an observation area identifier, an observation time window, and WS observation

information. For each forecast request, the collection module is configured to store or link to a set of selected member outputs of the forecast request, each selected member output associated with: (1) the forecast time window of the forecast request; (2) one of the ensemble members identified in the forecast member selection list of the forecast request; and (3) the forecast area identifier of the forecast request. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast information for the selected member output and are performed by at least one of the at least one ensemble member server, the platform, and a third party remote computing service.

The pre-processing module of the first and second embodiments of the invention is configured to, for each forecast request, identify and extract the WS forecast information from each of the selected member outputs of the forecast request.

The forecast history database of the first and second embodiments of the invention is configured to store a plurality of forecast records memorializing each of the SPWS forecasts outputted from a plurality of prior forecast requests. The forecast record associated with each prior forecast request stores or links to: (1) the forecast identifier of the prior forecast request; (2) the forecast area identifier of the prior forecast request; (3) the forecast member selection list of the prior forecast request; (4) the set of selected member outputs for the prior forecast request; and (5) the WS forecast information from each of the selected member outputs of the prior forecast request.

The ranking module of the first and second embodiments of the invention is configured, for each forecast request, to select and access: (1) at least one sample forecast record from the plurality of forecast records of the prior forecast requests stored in the forecast history database; and (2) at least one concurrent observed WS record. The forecast area identifier of the at least one sample forecast record and the observation area identifier of the concurrent observed WS record both identify a first identical or overlapping geographic area. The observation time window of the at least one concurrent observed WS record overlap at least partially with the forecast time window of the at least one sample forecast record.

The ranking module of the first and second embodiments of the invention is configured, for each forecast request, to calculate a forecast member accuracy ranking for each of the ensemble members in the forecast member selection list of the at least one sample forecast record. The forecast member accuracy ranking for each ensemble member of the at least one sample forecast record is derived from an accuracy error between: (1) the WS forecast information from the selected member output associated with the ensemble member of the at least one sample forecast record; and (2) the WS observation information for the at least one concurrent observed WS record.

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The forecasting module of the first and second embodiments of the invention is configured to: (i) determine an optimal grouping of the selected member outputs for the forecast request based on the forecast member accuracy ranking of each of the ensemble members of the at least one sample forecast record; and (ii) generate the SPWS forecast for the forecast request based on a weighted average of the optimal grouping of the selected member outputs for the forecast request.

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The output module of the first and second embodiments of the invention is configured, for each forecast request, to: (i) output the SPWS forecast of the forecast request to a user interface; and (ii) augment the forecast history database with a new forecast record detailing the SPWS forecast generated for the forecast request.

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In its most general form, the third and fourth embodiments of the invention are a system and method for generating a series of short period wind speed (SPWS) forecasts for a local area using a periodically updated k-means clusters and machine learning (ML) stacking. Wind speed (WS) forecast information from ensemble members for a new forecast request are first clustered using k-means clustering and then compared with: (i) WS clusters generated during prior forecast requests; and (ii) the actual observed wind speeds from a recent time frame. This comparison is used to a set of cluster statistics and cluster error calculations used by a stacking module with a set of first ML models and a second ML model when processing the WS clusters to generate the SPWS forecast.

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A third and fourth embodiments of the invention are a forecasting platform and method for generating a series of short period wind speed (SPWS) forecasts for a local area, the platform comprising: (a) a scheduling module; (b) a collection module; (c) a pre-processing module; (d) a forecast history database; (e) a ranking module; (f) a forecasting module; and (g) an output module.

In the third and fourth embodiments of the invention, the scheduling module is configured to trigger the generation of the series of SPWS forecasts according to a forecast schedule with a plurality of forecast requests, each SPWS forecast associated with one of the forecast requests. Each forecast request includes a forecast identifier, a forecast time window, a forecast member selection list, a forecast area identifier, and a pre-forecast observation time window.

In the third and fourth embodiments of the invention, the collection module, the collection module is in data communication through a network with: (1) at least one ensemble member server including a plurality of ensemble members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS record including an observation area identifier, an observation time window, and WS observation information. For each forecast request, the collection module is configured to store or link to a set of selected member outputs of the forecast request, each selected member output associated with: (1) the forecast time window of the forecast request; (2) one of the ensemble members identified in the forecast member selection list of the forecast request; and (3) the forecast area identifier of the forecast request. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast information for the selected member output and are performed by at least one of the at least one ensemble member server, the platform, and a third party remote computing service. For each forecast request, the collection module is configured to store or link to a set of pre-forecast observed WS records. The forecast area identifier of the forecast request and the observation area identifier of the set of pre-forecast observed WS records both identifying a first identical or overlapping geographic area. The observation time window

of each pre-forecast observed WS record overlapping at least partially with the pre-forecast observation time window of the forecast request.

In the third and fourth embodiments of the invention, the pre-processing module is
5 configured to, for each forecast request, identify and extract: (1) the WS forecast
information from each of the selected member outputs of the forecast request; and (2)
the WS observation information of the set of pre-forecast observed WS records for the
forecast request. The pre-processing module is also configured to, for each forecast
request, employ k-means clustering to cluster the WS forecast information from each of
10 the selected member outputs of the forecast request into a plurality of WS clusters of the
forecast request.

In the third and fourth embodiments of the invention, the forecast history database is
configured to store a plurality of forecast records memorializing each of the SPWS
15 forecasts outputted from a plurality of prior forecast requests. The forecast record
associated with each prior forecast request stores or links to: (1) the forecast identifier of
the prior forecast request; (2) the forecast area identifier of the prior forecast request; (3)
the forecast member selection list of the prior forecast request; (4) the set of selected
member outputs for the prior forecast request; (5) the WS forecast information from each
20 of the selected member outputs of the prior forecast request; (6) the WS observation
information of the set of pre-forecast observed WS records of the prior forecast request;
and (7) the WS clusters for the prior forecast request.

In the third and fourth embodiments of the invention, the ranking module comprises a
25 clustering module configured, for each forecast request, to select and access at least one
sample forecast record from the plurality of forecast records of the prior forecast requests
stored in the forecast history database, wherein the forecast area identifier of at least one
sample forecast record and the forecast area identifier of the forecast request both identify
a second identical or overlapping geographic area. The ranking modules is also
30 configured to, for each forecast request, create cluster comparison information for the
forecast request from analysis of: (1) the WS clusters clustered for the forecast request
by the pre-processing module; (2) the WS observation information extracted for the

- forecast request by the pre-processing module from the set of pre-forecast observed WS records; and (3) the WS clusters of one or more of the prior forecast requests, as memorialized in the forecast history database for each forecast record associated with the at least one sample forecast records of the prior forecast requests. The clustering
- 5 module is also configured to, for each of the WS clusters generated by the pre-processing module for the forecast request, apply cluster feature engineering to generate a set of cluster statistics and cluster error calculations from the cluster comparison information of the forecast request.
- 10 In the third and fourth embodiments of the invention, the forecasting module comprises a stacking module including a set of first machine learning (ML) models and a second ML model. For each forecast request, each first ML model is configured to: (1) receive as inputs one of the WS clusters of the forecast request; and (2) generate one of a plurality of first ML model outputs from the WS cluster received by the first ML model for the
- 15 forecast request. For each forecast request, the second ML model is configured to: (1) receive the first ML model output for the forecast request from each of the first ML models; and (2) generate the SPWS forecast for the forecast request based on a weighted average of the first ML model outputs of the forecast request, wherein the weighted average is calculated from the set of cluster statistics and cluster error calculations for
- 20 each WS cluster of the forecast request.
- In the third and fourth embodiments of the invention, the output module is configured, for each forecast request, to: (i) output the SPWS forecast of the forecast request to a user interface; and (ii) augment the forecast history database with a new forecast record
- 25 detailing the SPWS forecast generated for the forecast request.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present disclosure are described herein with reference to the drawings in which:

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FIG. 1 is a block diagram representing a forecasting system with a forecasting platform in an embodiment of the invention.

FIG. 2 is a flowchart of steps taken in a second embodiment of the invention.

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FIG. 3 is a block diagram illustrating information used to create an accuracy error for an ensemble member in the first and second embodiments of the invention.

FIG. 4 is a chart contrasting, for a listing of wind farms, the RMSE for the average of the best eight ensemble members versus the RMSE of the average of all ensemble members, in the first and second embodiments of the invention.

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FIG. 5 is a flowchart of steps taken in a fourth embodiment of the invention.

FIG. 6 is a block diagram illustrating information used to create cluster comparison information in the third and fourth embodiments of the invention.

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FIG. 7 is a block diagram illustrating k-means clustering of WS forecast information from member outputs in the third and fourth embodiments of the invention.

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FIG. 8 is a block diagram illustrating use of ML model stacking to generate an SPWS forecast for the third and fourth embodiments of the invention.

FIG. 9 is a chart contrasting, for a listing of wind farms, the RMSE for a ML corrected forecast and the RMSE of the average of the ensemble members, using ECMWF EPS ensemble members, in the first and second embodiments of the invention.

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DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. The illustrative embodiments described in the detailed description, drawings and claims are not meant to be limiting. Other embodiments can be utilized, and other changes can be made, without departing from the spirit or scope of the subject matter presented herein. Unless specified otherwise, the terms “comprising,” “comprise,” “including” and “include” used herein, and grammatical variants thereof, are intended to represent “open” or “inclusive” language such that they include recited elements but also permit inclusion of additional, un-recited elements.

As used herein, the software and hardware of a “**computing device**”, “computer”, a “server”, and a “system” may be implemented within a single stand-alone computer, a stand-alone server, multiple dedicated servers, and/or a virtual server running on a larger network of servers and/or a cloud-based service. As used herein, a database may store data to and access data from a single stand-alone computer, a data server, multiple dedicated data servers, a cloud-based service, and/or a virtual server running on a network of servers.

As used herein, the term “**user**” is meant to include both humans and a computing device (including, for example a separate server or even the server configured to run the invention). For example, inputs to the invention and outputs from the invention can be directed to a human, a database, a project management software platform, a computing device, and/or one or more AI / ML machines.

As used herein, a user interface may be implemented by a display monitor, a keyboard, a mouse, a touch screen, a touch pad, and/or similarly directed means. The user interface may be configured by a laptop, a smart phone, a tablet, a single stand-alone computer, a stand-alone server, multiple dedicated servers, and/or a virtual server running on a larger network of servers and/or a cloud-based service.

As used herein, a database may store data to and access data from a single stand-alone computer, a laptop, a tablet, a data server, multiple dedicated data servers, a cloud-based service, and/or a virtual server running on a network of servers. As discussed in the description, the use of the term “database” indicate a collection of tables, records, and/or linkage information for the data records. As depicted in the description and figures, each database can be maintained separately and/or maintained collectively in a single database or through linkages to other database. The databases depicted in the description and figures can be on the same server or on separate servers. Data links between tables can be links in one database or links between separate databases.

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FIG. 1 is a block diagram representing a forecasting system **10** with a forecasting platform **11** in an embodiment of the invention. The forecasting system **10** includes a forecasting platform **11** in data communication through a network **15** with a wind speed observation system **12**, a user interface **13**, a utility company server **16**, and at least one ensemble member server **17**. The forecast platform **11** includes a scheduling module **11A**, a collection module **11B**, a pre-processing module **11C**, a forecast history database **11D**, a ranking module **11E**, a forecasting module **11F**, and an output module **11G**. The collection module **11B** receives inputs (described in detail below) through the network **15**. The output module's **11G** output to the network **15** is a short period wind speed (SPWS) forecast **14**.

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FIG. 2 is a flowchart **2-00** of steps taken in a second embodiment of the invention. Steps **2-01** to **2-05** are listed below.

- 2-01** collect member outputs generated from ensemble members and extract WS forecast information from each member output
- 2-02** reviewing sample forecast records from prior SPWS forecasts **14**, calculate a forecast member accuracy ranking for each ensemble member
- 2-03** determine optimal grouping of (*n*) member outputs to include in final forecast
- 2-04** create weighted average of the (*n*) member outputs of the optimal grouping
- 2-05** output SPWS forecast **14** to user interface **13** and utility company server **16**

FIG. 3 is a block diagram **3-00** illustrating information used to create an accuracy error **30N** for an ensemble member in the first and second embodiments of the invention. **FIG. 3** illustrates how the accuracy error **30N** of each ensemble member is generated from the data contained in a sample forecast record **31A** and the data in a concurrent observed WS record **31B**. The two records are cross-referenced by: (i) overlap between the geographic areas identified by the forecast area identifier of the sample forecast record **31A** identified in **FIG. 3** as **32A** and the observation area identifier of the concurrent observed WS record **31B** identified in **FIG. 3** as **32B**; as well as (ii) overlap between the forecast time window of the sample forecast record **31A** identified in **FIG. 3** as **33A** and the observation time window of the concurrent observed WS record **31B** identified in **FIG. 3** as **33B**. Once the two records are cross-reference by geographic area and time window, the accuracy error **30N** for each ensemble member is calculated from: (i) the WS forecast information from the selected member outputs **34AN** of the sample forecast record **31A**; and (ii) the WS observation information **34B** from the concurrent observed WS record **31B**.

FIG. 4 is a chart **4-00** contrasting, for a listing of wind farms **A01-A10**, the RMSE for the average of the best eight ensemble members versus the RMSE of the average of all ensemble members, in the first and second embodiments of the invention. The first column lists various wind farms, each from a different local area that would be given a different geographic identifier. The RMSE values for the second and third columns relate to calculations using ECMWF EPS ensemble members; the RMSE values for the fourth and fifth columns relate to calculations using down-scaled NWP ensemble members.

As documented in the chart **4-00** of **FIG. 4**, the average of the eight best ensemble members consistently evidence a lower RMSE than the RMSE of the average of all the ensemble member. This lowered error score is evident in the RMSE data for both the ECMWF EPS ensemble members and the down-scaled NWP ensemble members, demonstrating the efficacy of the first and second embodiments of the invention.

FIG. 5 is a flowchart **5-00** of steps taken in a fourth embodiments of the invention. Steps **5-01** to **5-06** are listed below.

- 5-01** collect member outputs generated from ensemble members
- 5-02** employ k-means clustering to cluster WS forecast information from member outputs
- 5-03** create cluster comparison information from:
 - WS clusters from member outputs of (new) forecast request
 - WS observation information **34B** from pre-forecast observed WS records
 - WS clusters from member outputs of prior forecast requests
- 5-04** apply cluster feature engineering to generate cluster statistics and cluster error calculations from cluster comparison information
- 5-05** employ ML stacking with set of first ML models and the second ML model to generate SPWS forecast **14**
- 5-06** output SPWS forecast **14** to user interface **13** and utility company server **16**

FIG. 6 is a block diagram **6-00** illustrating information used to create cluster comparison information **60N** in the third and fourth embodiments of the invention.

Similar to the block diagram **3-00** of **FIG. 3**, the block diagram **6-00** of **FIG. 6** details the cross-referencing of data sets, but in this case three separate data sets: (i) data from the (new) forecast request **61A**; (ii) data from the pre-forecast observed WS record **61B**; and (iii) data from a sample forecast record **31A**. Each of the three data sets are linked to an identical or overlapping geographic area, identified as: (i) the forecast area identifier of the forecast request **61A**, identified in **FIG. 6** as **62A**; (ii) the observation area identifier of the pre-forecast observed WS record **61B**, identified in **FIG. 6** as **62B**; and (iii) the forecast area identifier of the sample forecast record **31A**, identified in **FIG. 6** as **62C**.

Additionally, cross-referencing illustrated in the chart **6-00** of **FIG. 6** includes the pre-forecast observation time window of the forecast request **61A**, identified in **FIG. 6** as **63A** and the observation time window of the pre-forecast observed WS record **61B**, identified in **FIG. 6** as **63B**.

FIG. 6 illustrates that each of the cross-referenced data sets contribute to the calculation of the cluster comparison information **60N**. The forecast request **61A** contributes WS clusters **64AN** for the selected member outputs of the forecast request **61A**. The pre-forecast observed WS record **61B** contributes the WS observation information **34B**. And the sample forecast record **31A** (of a prior forecast request **61A'**) contributes WS clusters **64CN** for the selected member outputs of the sample forecast record **31A**.

FIG. 7 is a block diagram **7-00** illustrating k-means clustering **72** of WS forecast information **71N** from member outputs for the third and fourth embodiments of the invention. As illustrated in **FIG. 7**, k-means clustering **72** is performed upon WS forecast information **71N** from each member output of forecast request **71N**. The WS forecast information **71N** from each member output of forecast request **71N** is clustered in **FIG. 7** into four clusters: a low WS cluster **72A**, a medium WS cluster **72B**, a high WS cluster **72C**, and an average WS cluster **72D**.

FIG. 8 is a block diagram **8-00** illustrating use of ML model stacking to generate an SPWS forecast **14** in the third and fourth embodiments of the invention. The inputs are the four clusters from **FIG. 7** (the low WS cluster **72A**, the medium WS cluster **72B**, the high WS cluster **72C**, and the average WS cluster **72D**). These four clusters are fed individually into the set of first ML models (**82A-82D**). The outputs from the set of first ML models (**82A-82D**) are fed into a second ML model **83**. The output of the second ML model **83** is the SPWS forecast **14**.

FIG. 9 is a chart **9-00** that contrasts, for a listing of wind farms **B01-B16**, the RMSE for a ML corrected forecasted and the RMSE of the average of the ensemble members, using ECMWF EPS ensemble members, in the first and second embodiments of the invention. The ensemble members used in generating the RMSE data are the ECMWF EPS ensemble members. The first column lists various wind farms **B01-B16**, each from a different local area that would be given a different geographic identifier.

As documents in the chart 9-00 of FIG. 9, the average of the selected member outputs that have been clustered and ML corrected according to the third and fourth embodiments of the invention consistently evidence a lower RMSE than the RMSE of the average of all the ensemble members. This lowered error score is evident in the RMSE data for both the ECMWF EPS ensemble members and the down-scaled NWP ensemble members, demonstrating the efficacy of the third and fourth embodiments of the invention.

A first embodiment of the invention is a forecasting platform 11 for generating a series of short period wind speed (SPWS) forecasts 14 for a local area. The platform 11 comprises: (a) a scheduling module 11A; (b) a collection module 11B; (c) a pre-processing module 11C; (d) a forecasting module 11F; (e) a ranking module 11E; (f) a forecasting module 11F; and (g) an output module 11G.

The scheduling module 11A of the first embodiment of the invention is configured to trigger the generation of the series of SPWS forecasts 14 according to a forecast schedule with a plurality of forecast requests 61A, each SPWS forecast 14 associated with one of the forecast requests 61A. Each forecast request 61A includes a forecast identifier, a forecast time window, a forecast member selection list, and a forecast area identifier.

The collection module 11B of the first embodiment of the invention is in data communication through a network 15 with: (1) at least one ensemble member server 17 including a plurality of ensemble members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS record including an observation area identifier, an observation time window, and WS observation information 34B. For each forecast request 61A, the collection module 11B is configured to store or link to a set of selected member outputs of the forecast request 61A, each selected member output associated with: (1) the forecast time window of the forecast request 61A; (2) one of the ensemble members identified in the forecast member selection list of the forecast request 61A; and (3) the forecast area identifier of the forecast request 61A. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast

information **71N** for the selected member output and are performed by at least one of the at least one ensemble member servers **17**, the platform **11**, and a third party remote computing service.

- 5 The pre-processing module **11C** of the first embodiment of the invention is configured to, for each forecast request **61A**, identify and extract the WS forecast information **71N** from each of the selected member outputs of the forecast request **61A**.

- The forecast history database **11D** of the first embodiment of the invention is configured
10 to store a plurality of forecast records memorializing each of the SPWS forecasts **14** outputted from a plurality of prior forecast requests **61A'**. The forecast record associated with each prior forecast request **61A'** stores or links to: (1) the forecast identifier of the prior forecast request **61A'**; (2) the forecast area identifier of the prior forecast request **61A'**; (3) the forecast member selection list of the prior forecast request **61A'**; (4) the set
15 of selected member outputs for the prior forecast request **61A'**; and (5) the WS forecast information **71N** from each of the selected member outputs of the prior forecast request **61A'**.

- The ranking module **11E** of the first embodiment of the invention is configured, for each
20 forecast request **61A**, to select and access: (1) at least one sample forecast record **31A** from the plurality of forecast records of the prior forecast requests **61A'** stored in the forecast history database **11D**; and (2) at least one concurrent observed WS record. The forecast area identifier of the at least one sample forecast record **31A** and the observation area identifier of the concurrent observed WS record **31B** both identify a first identical
25 or overlapping geographic area. The observation time window of the at least one concurrent observed WS record **31B** overlap at least partially with the forecast time window of the at least one sample forecast record **31A**.

- The ranking module **11E** of the first embodiment of the invention is configured, for each
30 forecast request **61A**, to calculate a forecast member accuracy ranking for each of the ensemble members in the forecast member selection list of the at least one sample forecast record **31A**. The forecast member accuracy ranking for each ensemble member

of the at least one sample forecast record **31A** is derived from an accuracy error **30N** between: (1) the WS forecast information **71N** from the selected member output associated with the ensemble member of the at least one sample forecast record **31A**; and (2) the WS observation information **34B** for the at least one concurrent observed WS record **31B**.

The forecasting module **11F** of the first embodiment of the invention is configured to: (i) determine an optimal grouping of the selected member outputs for the forecast request **61A** based on the forecast member accuracy ranking of each of the ensemble members of the at least one sample forecast record **31A**; and (ii) generate the SPWS forecast **14** for the forecast request **61A** based on a weighted average of the optimal grouping of the selected member outputs for the forecast request **61A**.

The output module **11G** of the first embodiment of the invention is configured, for each forecast request **61A**, to: (i) output the SPWS forecast **14** of the forecast request **61A** to a user interface **13**; and (ii) augment the forecast history database **11D** with a new forecast record detailing the SPWS forecast **14** generated for the forecast request **61A**.

In an alternative embodiment of the first embodiment, for each forecast request **61A**, the plurality of WS clusters **64AN** include: (a) a low WS cluster **72A**; (b) a medium WS cluster **72B**; (c) a high WS cluster **72C**; and (d) an average WS cluster **72D**.

In an alternative embodiment of the first embodiment: (a) each of the ensemble members are exchangeable; and (b) the plurality of ensemble members include at least one of a plurality of ECMWF EPS ensemble members and a plurality of down-scaled NWP ensemble members.

In an alternative embodiment of the first embodiment, the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time.

In an alternative embodiment of the first embodiment, calculations for the accuracy error **30N** include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.

- 5 In an alternative embodiment of the first embodiment: (a) the output module **11G** is in data communication through the network **15** with a utility company server **16** receiving generated wind power from the local area; and (b) the output module **11G** is configured to deliver the SPWS forecast **14** to the utility company server **16** through the network **15**.
- 10 In an alternative embodiment of the first embodiment, the forecast time window of the prior forecast request **61A'** of the at least one sample forecast record **31A** overlaps at least partially with at least one of: (a) a previous calendar day from the forecast time window of the forecast request **61A**; and (b) a previous time of calendar day as the forecast time window of the forecast request **61A**.

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In an alternative embodiment of the first embodiment, the forecast area identifier of the at least one sample forecast record **31A** and the forecast identifier of the forecast request **61A** both identify a second identical or overlapping geographic area.

- 20 A second embodiment of the invention is a computer-implemented forecasting method for generating a series of short period wind speed (SPWS) forecasts **14** for a local area.

The second embodiment of the invention includes the step of maintaining a scheduling module **11A**. The scheduling module **11A** is configured to trigger the generation of the series of SPWS forecasts **14** according to a forecast schedule with a plurality of forecast requests **61A**, each SPWS forecast **14** associated with one of the forecast requests **61A**. Each forecast request **61A** includes a forecast identifier, a forecast time window, a forecast member selection list, and a forecast area identifier.

- 30 The second embodiment of the invention includes the step of maintaining a collection module **11B**. The collection module **11B** is in data communication through a network **15** with: (1) at least one ensemble member server **17** including a plurality of ensemble

- members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS record including an observation area identifier, an observation time window, and WS observation information **34B**. For each forecast request **61A**, the collection module **11B** is configured to store or link to a set of selected member outputs of the forecast request **61A**, each selected member output associated with: (1) the forecast time window of the forecast request **61A**; (2) one of the ensemble members identified in the forecast member selection list of the forecast request **61A**; and (3) the forecast area identifier of the forecast request **61A**. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast information **71N** for the selected member output; and are performed by at least one of the at least one ensemble member server **17**, the platform **11**, and a third party remote computing service.
- 15 The second embodiment of the invention includes the step of maintaining a pre-processing module **11C** configured to, for each forecast request **61A**, identify and extract the WS forecast information **71N** from each of the selected member outputs of the forecast request **61A**.
- 20 The second embodiment of the invention includes the step of maintaining a forecast history database **11D**. The forecast history database **11D** is configured to store a plurality of forecast records memorializing each of the SPWS forecasts **14** outputted from a plurality of prior forecast requests **61A'**. The forecast record associated with each prior forecast request **61A'** stores or links to: (1) the forecast identifier of the prior forecast request **61A'**; (2) the forecast area identifier of the prior forecast request **61A'**; (3) the forecast member selection list of the prior forecast request **61A'**; (4) the set of selected member outputs for the prior forecast request **61A'**; and (5) the WS forecast information **71N** from each of the selected member outputs of the prior forecast request **61A'**.
- 25 30 The second embodiment of the invention includes the step of, for each forecast request **61A**, selecting and accessing: (i) at least one sample forecast record **31A** from the plurality of forecast records of the prior forecast requests **61A'** stored in the forecast

history database **11D**; and (ii) at least one concurrent observed WS record **31B**. The forecast area identifier of the at least one sample forecast record **31A** and the observation area identifier of the concurrent observed WS record **31B** both identify a first identical or overlapping geographic area. The observation time window of the at least one
5 concurrent observed WS record **31B** overlap at least partially with the forecast time window of the at least one sample forecast record **31A**.

The second embodiment of the invention includes the step of, for each forecast request **61A**, calculating a forecast member accuracy ranking for each of the ensemble members
10 in the forecast member selection list of the at least one sample forecast record **31A**. The forecast member accuracy ranking for each ensemble member of the at least one sample forecast record **31A** is derived from an accuracy error **30N** between: (i) the WS forecast information **71N** from the selected member output associated with the ensemble member of the at least one sample forecast record **31A**; and (ii) the WS observation information
15 **34B** for the at least one concurrent observed WS record **31B**.

The second embodiment of the invention includes the step of, for each forecast request **61A**, determining an optimal grouping of the selected member outputs for the forecast request **61A** based on the forecast member accuracy ranking of each of the ensemble
20 members of the at least one sample forecast record **31A**.

The second embodiment of the invention includes the step of, for each forecast request **61A**, generating the SPWS forecast **14** for the forecast request **61A** based on a weighted average of the optimal grouping of the selected member outputs for the forecast request
25 **61A**.

The second embodiment of the invention includes the step of, for each forecast request **61A**, outputting the SPWS forecast **14** of the forecast request **61A** to a user interface **13**.

30 The second embodiment of the invention includes the step of, for each forecast request **61A**, augmenting the forecast history database **11D** with a new forecast record detailing the SPWS forecast **14** generated for the forecast request **61A**.

In an alternative to the second embodiment of the invention, for each forecast request **61A**, the plurality of WS clusters **64A_N** include: a low WS cluster **72A**, a medium WS cluster **72B**, a high WS cluster **72C**, and an average WS cluster **72D**.

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In an alternative to the second embodiment of the invention: (a) each of the ensemble members are exchangeable; and (b) the plurality of ensemble members include at least one of a plurality of ECMWF EPS ensemble members and a plurality of down-scaled NWP ensemble members.

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In an alternative to the second embodiment of the invention, the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time.

In an alternative to the second embodiment of the invention, calculations for the accuracy error **30_N** include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.

In an alternative to the second embodiment of the invention, the method further comprising the steps of: (a) establishing a data communication link through the network **15** with a utility company server **16** receiving generated wind power from the local area; and (b) delivering the SPWS forecast **14** to the utility company server **16** through the network **15**.

In an alternative to the second embodiment of the invention, the forecast time window of the prior forecast request **61A'** of the at least one sample forecast record **31A** overlaps at least partially with at least one of: (a) a previous calendar day from the forecast time window of the forecast request **61A**; and (b) a previous time of calendar day as the forecast time window of the forecast request **61A**.

In an alternative to the second embodiment of the invention, the forecast area identifier of the at least one sample forecast record **31A** and the forecast identifier of the forecast request **61A** both identify a second identical or overlapping geographic area.

A third embodiment of the invention is a forecasting platform **11** for generating a series of short period wind speed (SPWS) forecasts **14** for a local area, the platform **11** comprising: (a) a scheduling module **11A**; (b) a collection module **11B**; (c) a pre-processing module **11C**; (d) a forecast history database **11D**; (e) a ranking module **11E**;
5 (f) a forecasting module **11F**; and (g) an output module **11G**.

In the third embodiment of the invention, the scheduling module **11A** is configured to trigger the generation of the series of SPWS forecasts **14** according to a forecast schedule
10 with a plurality of forecast requests **61A**, each SPWS forecast **14** associated with one of the forecast requests **61A**. Each forecast request **61A** includes a forecast identifier, a forecast time window, a forecast member selection list, a forecast area identifier, and a pre-forecast observation time window.

15 In the third embodiment of the invention, the collection module **11B**, the collection module **11B** is in data communication through a network **15** with: (1) at least one ensemble member server **17** including a plurality of ensemble members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each
20 WS record including an observation area identifier, an observation time window, and WS observation information **34B**. For each forecast request **61A**, the collection module **11B** is configured to store or link to a set of selected member outputs of the forecast request **61A**, each selected member output associated with: (1) the forecast time window of the forecast request **61A**; (2) one of the ensemble members identified in the forecast
25 member selection list of the forecast request **61A**; and (3) the forecast area identifier of the forecast request **61A**. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast information **71N** for the selected member output and are performed by at least one of the at least one ensemble member server **17**, the platform **11**, and a third party remote
30 computing service. For each forecast request **61A**, the collection module **11B** is configured to store or link to a set of pre-forecast observed WS records **61B**. The forecast area identifier of the forecast request **61A** and the observation area identifier of the set

of pre-forecast observed WS records **61B** both identifying a first identical or overlapping geographic area. The observation time window of each pre-forecast observed WS record **61B** overlapping at least partially with the pre-forecast observation time window of the forecast request **61A**.

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In the third embodiment of the invention, the pre-processing module **11C** is configured to, for each forecast request **61A**, identify and extract: (1) the WS forecast information **71N** from each of the selected member outputs of the forecast request **61A**; and (2) the WS observation information **34B** of the set of pre-forecast observed WS records **61B** for the forecast request **61A**. The pre-processing module **11C** is also configured to, for each forecast request **61A**, employ k-means clustering **72** to cluster the WS forecast information **71N** from each of the selected member outputs of the forecast request **61A** into a plurality of WS clusters **64AN** of the forecast request **61A**.

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In the third embodiment of the invention, the forecast history database **11D** is configured to store a plurality of forecast records memorializing each of the SPWS forecasts **14** outputted from a plurality of prior forecast requests **61A'**. The forecast record associated with each prior forecast request **61A'** stores or links to: (1) the forecast identifier of the prior forecast request **61A'**; (2) the forecast area identifier of the prior forecast request **61A'**; (3) the forecast member selection list of the prior forecast request **61A'**; (4) the set of selected member outputs for the prior forecast request **61A'**; (5) the WS forecast information **71N** from each of the selected member outputs of the prior forecast request **61A'**; (6) the WS observation information **34B** of the set of pre-forecast observed WS records **61B** of the prior forecast request **61A'**; and (7) the WS clusters **64AN** for the prior forecast request **61A'**.

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In the third embodiment of the invention, the ranking module **11E** comprises a clustering module configured, for each forecast request **61A**, to select and access at least one sample forecast record **31A** from the plurality of forecast records of the prior forecast requests **61A'** stored in the forecast history database **11D**, wherein the forecast area identifier of at least one sample forecast record **31A** and the forecast area identifier of the forecast request **61A** both identify a second identical or overlapping geographic area. The ranking

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modules **11E** is also configured to, for each forecast request **61A**, create cluster comparison information **60N** for the forecast request **61A** from analysis of: (1) the WS clusters **64AN** clustered for the forecast request **61A** by the pre-processing module **11C**; (2) the WS observation information **34B** extracted for the forecast request **61A** by the pre-processing module **11C** from the set of pre-forecast observed WS records **61B**; and (3) the WS clusters **64CN** of one or more of the prior forecast requests **61A'**, as memorialized in the forecast history database **11D** for each forecast record associated with the at least one sample forecast records **31A** of the prior forecast requests **61A'**. The clustering module is also configured to, for each of the WS clusters **64AN** generated by the pre-processing module **11C** for the forecast request **61A**, apply cluster feature engineering to generate a set of cluster statistics and cluster error calculations from the cluster comparison information **60N** of the forecast request **61A**.

In the third embodiment of the invention, the forecasting module **11F** comprises a stacking module including a set of first machine learning (ML) models and a second ML model **83**. For each forecast request **61A**, each first ML model (**82A-82D**) is configured to: (1) receive as inputs one of the WS clusters **64AN** of the forecast request **61A**; and (2) generate one of a plurality of first ML model outputs from the WS cluster received by the first ML model (**82A-82D**) for the forecast request **61A**. For each forecast request **61A**, the second ML model **83** is configured to: (1) receive the first ML model output for the forecast request **61A** from each of the first ML models (**82A-82D**); and (2) generate the SPWS forecast **14** for the forecast request **61A** based on a weighted average of the first ML model outputs of the forecast request **61A**, wherein the weighted average is calculated from the set of cluster statistics and cluster error calculations for each WS cluster of the forecast request **61A**.

In the third embodiment of the invention, the output module **11G** is configured, for each forecast request **61A**, to: (i) output the SPWS forecast **14** of the forecast request **61A** to a user interface **13**; and (ii) augment the forecast history database **11D** with a new forecast record detailing the SPWS forecast **14** generated for the forecast request **61A**.

In an alternative of the third embodiment of the invention, for each forecast request **61A**, the plurality of WS clusters **64A_N** include a low WS cluster **72A**, a medium WS cluster, a high WS cluster, and an average WS cluster.

5 In an alternative of the third embodiment of the invention: (a) each of the ensemble members are exchangeable; and (b) the plurality of ensemble members include at least one of a plurality of ECMWF EPS ensemble members and a plurality of down-scaled NWP ensemble members.

10 In an alternative of the third embodiment of the invention: (a) the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time; and (b) the pre-forecast observation time window of the forecast request **61A** has a pre-forecast observation duration that is in the range of 1 to 6 hours and ends at the forecast start time.

15 In an alternative of the third embodiment of the invention, the set of cluster statistics and cluster error calculations include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.

20 In an alternative of the third embodiment of the invention: (a) the output module **11G** is in data communication through the network **15** with a utility company server **16** receiving generated wind power from the local area; and (b) the output module **11G** is configured to deliver the SPWS forecast **14** to the utility company server **16** through the network **15**.

25 In an alternative of the third embodiment of the invention, the forecast time window of the prior forecast request **61A'** of the at least one sample forecast record **31A** overlaps at least partially with at least one of: (a) a previous calendar day from the forecast time window of the forecast request **61A**; and (b) a previous time of calendar day as the forecast time window of the forecast request **61A**.

30 A fourth embodiment of the invention is a computer-implemented forecasting method for generating a series of short period wind speed (SPWS) forecasts **14** for a local area.

- The fourth embodiment of the invention includes the step of maintaining a scheduling module **11A**. The scheduling module **11A** is configured to trigger the generation of the series of SPWS forecasts **14** according to a forecast schedule with a plurality of forecast requests **61A**, each SPWS forecast **14** associated with one of the forecast requests **61A**. Each forecast request **61A** includes a forecast identifier, a forecast time window, a forecast member selection list, a forecast area identifier, and a pre-forecast observation time window.
- The fourth embodiment of the invention includes the step of maintaining a collection module **11B**. The collection module **11B** is in data communication through a network **15** with: (1) at least one ensemble member server **17** including a plurality of ensemble members configured for generation of member outputs; and (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS record including an observation area identifier, an observation time window, and WS observation information **34B**. For each forecast request **61A**, the collection module **11B** is configured to store or link to a set of selected member outputs of the forecast request **61A**, each selected member output associated with: (1) the forecast time window of the forecast request **61A**; (2) one of the ensemble members identified in the forecast member selection list of the forecast request **61A**; and (3) the forecast area identifier of the forecast request **61A**. Computations generating each selected member output from the ensemble member associated with the selected member output create WS forecast information for the selected member output and are performed by at least one of the at least one ensemble member server **17**, the platform **11**, and a third party remote computing service. For each forecast request **61A**, the collection module **11B** is configured to store or link to a set of pre-forecast observed WS records. The forecast area identifier of the forecast request **61A** and the observation area identifier of the set of pre-forecast observed WS records both identifying a first identical or overlapping geographic area. The observation time window of each pre-forecast observed WS record overlapping at least partially with the pre-forecast observation time window of the forecast request **61A**.

Sample third party remote computing services may include the remote (or cloud) computing services branded Amazon Web Services (AWS), Google, or Microsoft.

The fourth embodiment of the invention includes the step of maintaining a pre-processing module **11C**. The pre-processing module **11C** is configured to, for each forecast request **61A**, identify and extract: (1) the WS forecast information from each of the selected member outputs of the forecast request **61A**; and (2) the WS observation information **34B** of the set of pre-forecast observed WS records for the forecast request **61A**. Also, the pre-processing module **11C** is configured to, for each forecast request **61A**, employ k-means clustering **72** to cluster the WS forecast information **71N** from each of the selected member outputs of the forecast request **61A** into a plurality of WS clusters **64AN** of the forecast request **61A**.

The fourth embodiment of the invention includes the step of maintaining a forecast history database **11D**. The forecast history database **11D** is configured to store a plurality of forecast records memorializing each of the SPWS forecasts **14** outputted from a plurality of prior forecast requests **61A'**. The forecast record associated with each prior forecast request **61A'** stores or links to: (1) the forecast identifier of the prior forecast request **61A'**; (2) the forecast area identifier of the prior forecast request **61A'**; (3) the forecast member selection list of the prior forecast request **61A'**; (4) the set of selected member outputs for the prior forecast request **61A'**; (5) the WS forecast information **71N** from each of the selected member outputs of the prior forecast request **61A'**; (6) the WS observation information **34B** of the set of pre-forecast observed WS records of the prior forecast request **61A'**; and (7) the WS clusters **64AN** for the prior forecast request **61A'**.

The fourth embodiment of the invention includes the step of, for each forecast request **61A**, selecting and accessing at least one sample forecast record **31A** from the plurality of forecast records of the prior forecast requests **61A'** stored in the forecast history database **11D**, wherein the forecast area identifier of at least one sample forecast record **31A** and the forecast area identifier of the forecast request **61A** both identify a second identical or overlapping geographic area.

The fourth embodiment of the invention includes the step of, for each forecast request **61A**, creating cluster comparison information **60N** for the forecast request **61A** from analysis of: (i) the WS clusters **64AN** clustered for the forecast request **61A** by the pre-processing module **11C**; (ii) the WS observation information **34B** extracted for the forecast request **61A** by the pre-processing module **11C** from the set of pre-forecast observed WS records; and (iii) the WS clusters **64CN** of one or more of the prior forecast requests **61A'**, as memorialized in the forecast history database **11D** for each forecast record associated with the at least one sample forecast records **31A** of the prior forecast requests **61A'**.

The fourth embodiment of the invention includes the step of, for each of the WS clusters **64AN** generated by the pre-processing module **11C** for the forecast request **61A**, applying cluster feature engineering to generate a set of cluster statistics and cluster error calculations from the cluster comparison information **60N** of the forecast request **61A**.

The fourth embodiment of the invention includes the step of maintaining a forecasting module **11F** comprising a stacking module including a set of first machine learning (ML) models and a second ML model **83**. For each forecast request **61A**, each first ML model (**82A-82D**) is configured to: (1) receive as inputs one of the WS clusters **64AN** of the forecast request **61A**; and (2) generate one of a plurality of first ML model outputs from the WS cluster received by the first ML model (**82A-82D**) for the forecast request **61A**. For each forecast request **61A**, the second ML model **83** is configured to: (1) receive the first ML model output for the forecast request **61A** from each of the first ML models (**82A-82D**); and (2) generate the SPWS forecast **14** for the forecast request **61A** based on a weighted average of the first ML model outputs of the forecast request **61A**, wherein the weighted average is calculated from the set of cluster statistics and cluster error calculations for each WS cluster of the forecast request **61A**. For each forecast request **61A**, outputting the SPWS forecast **14** of the forecast request **61A** to a user interface **13**. For each forecast request **61A**, augmenting the forecast history database **11D** with a new forecast record detailing the SPWS forecast **14** generated for the forecast request **61A**.

In an alternative embodiment of the fourth embodiment of the invention, for each forecast request **61A**, the plurality of WS clusters **64AN** include a low WS cluster **72A**, a medium WS cluster **72B**, a high WS cluster **72C**, and an average WS cluster **72D**.

5 In an alternative embodiment of the fourth embodiment of the invention: (a) each of the ensemble members are exchangeable; and (b) the plurality of ensemble members include at least one of a plurality of ECMWF EPS ensemble members and a plurality of down-scaled NWP ensemble members.

10 In an alternative embodiment of the fourth embodiment of the invention: (a) the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time; and (b) the pre-forecast observation time window of the forecast request **61A** has a pre-forecast observation duration that is in the range of 1 to 6 hours and ends at the forecast start time.

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In an alternative embodiment of the fourth embodiment of the invention, the set of cluster statistics and cluster error calculations include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.

20 In an alternative embodiment of the fourth embodiment of the invention, the method further comprises the steps of: (a) establishing a data communication link through the network **15** with a utility company server **16** receiving generated wind power from the local area; and (b) delivering the SPWS forecast **14** to the utility company server **16** through the network **15**.

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In an alternative embodiment of the fourth embodiment of the invention, the forecast time window of the prior forecast request **61A'** of the at least one sample forecast record **31A** overlaps at least partially with at least one of: (a) a previous calendar day from the forecast time window of the forecast request **61A**; and (b) a previous time of calendar day as the forecast time window of the forecast request **61A**.

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While various aspects and embodiments have been disclosed herein, it will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and
5 adaptations come within the scope of the appended claims. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit of the invention being indicated by the appended claims.

CLAIMS

1. A forecasting platform for generating a series of short period wind speed (SPWS)
5 forecasts for a local area, the platform comprising:
- (a) a scheduling module,
 - (i) wherein the scheduling module is configured to trigger the generation of
the series of SPWS forecasts according to a forecast schedule with a
plurality of forecast requests, each SPWS forecast associated with one of
10 the forecast requests; and
 - (ii) wherein each forecast request includes a forecast identifier, a forecast time
window, a forecast member selection list, a forecast area identifier, and a
pre-forecast observation time window;
 - (b) a collection module,
 - 15 (i) wherein the collection module is in data communication through a network
with:
 - (1) at least one ensemble member server including a plurality of
ensemble members configured for generation of member outputs; and
 - (2) a wind speed (WS) observation system for the local area configured
20 to collect a series of observed WS records for the local area, each WS
record including an observation area identifier, an observation time
window, and WS observation information;
 - (ii) wherein, for each forecast request, the collection module is configured to
store or link to a set of selected member outputs of the forecast request,
25 each selected member output associated with:
 - (1) the forecast time window of the forecast request;
 - (2) one of the ensemble members identified in the forecast member
selection list of the forecast request; and
 - (3) the forecast area identifier of the forecast request;
- 30

- (iii) wherein computations generating each selected member output from the ensemble member associated with the selected member output:
 - (1) generate WS forecast information for the selected member output;
and
 - 5 (2) are performed by at least one of the at least one ensemble member server, the platform, and a third party remote computing service; and
- (iv) wherein, for each forecast request, the collection module is configured to store or link to a set of pre-forecast observed WS records,
 - 10 (1) the forecast area identifier of the forecast request and the observation area identifier of the set of pre-forecast observed WS records both identifying a first identical or overlapping geographic area; and
 - (2) the observation time window of each pre-forecast observed WS record overlapping at least partially with the pre-forecast observation time window of the forecast request;
- 15 (c) a pre-processing module configured to:
 - (i) for each forecast request, identify and extract:
 - (1) the WS forecast information from each of the selected member outputs of the forecast request; and
 - (2) the WS observation information of the set of pre-forecast observed
20 WS records for the forecast request; and
 - (ii) for each forecast request, employ k-means clustering to cluster the WS forecast information from each of the selected member outputs of the forecast request into a plurality of WS clusters of the forecast request;
- (d) a forecast history database,
 - 25 (i) wherein the forecast history database is configured to store a plurality of forecast records memorializing each of the SPWS forecasts outputted from a plurality of prior forecast requests; and
 - (ii) wherein the forecast record associated with each prior forecast request stores or links to:
 - 30 (1) the forecast identifier of the prior forecast request;
 - (2) the forecast area identifier of the prior forecast request;
 - (3) the forecast member selection list of the prior forecast request;

- (4) the set of selected member outputs for the prior forecast request;
- (5) the WS forecast information from each of the selected member outputs of the prior forecast request;
- (6) the WS observation information of the set of pre-forecast observed
5 WS records of the prior forecast request; and
- (7) the WS clusters for the prior forecast request;
- (e) a ranking module comprising a clustering module configured, for each forecast request, to:
 - (i) select and access at least one sample forecast record from the plurality of
10 forecast records of the prior forecast requests stored in the forecast history database, wherein the forecast area identifier of at least one sample forecast record and the forecast area identifier of the forecast request both identify a second identical or overlapping geographic area;
 - (ii) create cluster comparison information for the forecast request from analysis
15 of:
 - (1) the WS clusters clustered for the forecast request by the pre-processing module;
 - (2) the WS observation information extracted for the forecast request by the pre-processing module from the set of pre-forecast observed WS
20 records; and
 - (3) the WS clusters of one or more of the prior forecast requests, as memorialized in the forecast history database for each forecast record associated with the at least one sample forecast records of the prior forecast requests; and
 - (iii) for each of the WS clusters generated by the pre-processing module for the
25 forecast request, apply cluster feature engineering to generate a set of cluster statistics and cluster error calculations from the cluster comparison information of the forecast request;

- (f) a forecasting module comprising a stacking module including a set of first machine learning (ML) models and a second ML model,
- (i) wherein, for each forecast request, each first ML model is configured to:
- (1) receive as inputs one of the WS clusters of the forecast request; and
 - (2) generate one of a plurality of first ML model outputs from the WS cluster received by the first ML model for the forecast request; and
- (ii) wherein, for each forecast request, the second ML model is configured to:
- (1) receive the first ML model output for the forecast request from each of the first ML models; and
 - (2) generate the SPWS forecast for the forecast request based on a weighted average of the first ML model outputs of the forecast request, wherein the weighted average is calculated from the set of cluster statistics and cluster error calculations for each WS cluster of the forecast request; and
- (g) an output module configured, for each forecast request, to:
- (i) output the SPWS forecast of the forecast request to a user interface; and
 - (ii) augment the forecast history database with a new forecast record detailing the SPWS forecast generated for the forecast request.
2. The platform of claim 1, wherein, for each forecast request, the plurality of WS clusters include:
- (a) a low WS cluster;
 - (b) a medium WS cluster;
 - (c) a high WS cluster; and
 - (d) an average WS cluster.
3. The platform of claim 1,
- (a) wherein each of the ensemble members are exchangeable; and
 - (b) wherein the plurality of ensemble members include at least one of:
- (i) a plurality of ECMWF EPS ensemble members; and
 - (ii) a plurality of down-scaled NWP ensemble members.

4. The platform of claim 1,
- (a) wherein the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time; and
- (b) wherein the pre-forecast observation time window of the forecast request has a pre-forecast observation duration that is in the range of 1 to 6 hours and ends at the forecast start time.
5. The platform of claim 1, wherein the set of cluster statistics and cluster error calculations include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.
6. The platform of claim 1,
- (a) wherein the output module is in data communication through the network with a utility company server receiving generated wind power from the local area; and
- (b) wherein the output module is configured to deliver the SPWS forecast to the utility company server through the network.
7. The platform of claim 1, wherein the forecast time window of the prior forecast request of the at least one sample forecast record overlaps at least partially with at least one of:
- (a) a previous calendar day from the forecast time window of the forecast request; and
- (b) a previous time of calendar day as the forecast time window of the forecast request.

8. A computer-implemented forecasting method for generating a series of short period wind speed (SPWS) forecasts for a local area, the method comprising the steps of:
- (a) maintaining a scheduling module,
 - 5 (i) wherein the scheduling module is configured to trigger the generation of the series of SPWS forecasts according to a forecast schedule with a plurality of forecast requests, each SPWS forecast associated with one of the forecast requests; and
 - (ii) wherein each forecast request includes a forecast identifier, a forecast time
10 window, a forecast member selection list, a forecast area identifier, and a pre-forecast observation time window;
 - (b) maintaining a collection module,
 - (i) wherein the collection module is in data communication through a network
15 with:
 - (1) at least one ensemble member server including a plurality of ensemble members configured for generation of member outputs; and
 - (2) a wind speed (WS) observation system for the local area configured to collect a series of observed WS records for the local area, each WS
20 record including an observation area identifier, an observation time window, and WS observation information;
 - (ii) wherein, for each forecast request, the collection module is configured to store or link to a set of selected member outputs of the forecast request, each selected member output associated with:
 - (1) the forecast time window of the forecast request;
 - 25 (2) one of the ensemble members identified in the forecast member selection list of the forecast request; and
 - (3) the forecast area identifier of the forecast request;

- (iii) wherein computations generating each selected member output from the ensemble member associated with the selected member output:
 - (1) generate WS forecast information for the selected member output;
and
 - 5 (2) are performed by at least one of the at least one ensemble member server, the platform, and a third party remote computing service; and
- (iv) wherein, for each forecast request, the collection module is configured to store or link to a set of pre-forecast observed WS records,
 - 10 (1) the forecast area identifier of the forecast request and the observation area identifier of the set of pre-forecast observed WS records both identifying a first identical or overlapping geographic area; and
 - (2) the observation time window of each pre-forecast observed WS record overlapping at least partially with the pre-forecast observation time window of the forecast request;
- 15 (c) maintaining a pre-processing module configured to:
 - (i) for each forecast request, identify and extract:
 - (1) the WS forecast information from each of the selected member outputs of the forecast request; and
 - (2) the WS observation information of the set of pre-forecast observed
20 WS records for the forecast request; and
 - (ii) for each forecast request, employ k-means clustering to cluster the WS forecast information from each of the selected member outputs of the forecast request into a plurality of WS clusters of the forecast request;
- (d) maintaining a forecast history database,
 - 25 (i) wherein the forecast history database is configured to store a plurality of forecast records memorializing each of the SPWS forecasts outputted from a plurality of prior forecast requests; and
 - (ii) wherein the forecast record associated with each prior forecast request stores or links to:
 - 30 (1) the forecast identifier of the prior forecast request;
 - (2) the forecast area identifier of the prior forecast request;
 - (3) the forecast member selection list of the prior forecast request;

- (4) the set of selected member outputs for the prior forecast request;
 - (5) the WS forecast information from each of the selected member outputs of the prior forecast request;
 - (6) the WS observation information of the set of pre-forecast observed
5 WS records of the prior forecast request; and
 - (7) the WS clusters for the prior forecast request;
- (e) for each forecast request, selecting and accessing at least one sample forecast record from the plurality of forecast records of the prior forecast requests stored in the forecast history database, wherein the forecast area identifier of at least one
10 sample forecast record and the forecast area identifier of the forecast request both identify a second identical or overlapping geographic area;
- (f) for each forecast request, creating cluster comparison information for the forecast request from analysis of:
 - (i) the WS clusters clustered for the forecast request by the pre-processing
15 module;
 - (ii) the WS observation information extracted for the forecast request by the pre-processing module from the set of pre-forecast observed WS records; and
 - (iii) the WS clusters of one or more of the prior forecast requests, as
20 memorialized in the forecast history database for each forecast record associated with the at least one sample forecast records of the prior forecast requests; and
- (g) for each of the WS clusters generated by the pre-processing module for the forecast request, applying cluster feature engineering to generate a set of cluster
25 statistics and cluster error calculations from the cluster comparison information of the forecast request;
- (h) maintaining a forecasting module comprising a stacking module including a set of first machine learning (ML) models and a second ML model,
 - (i) wherein, for each forecast request, each first ML model is configured to:
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 - (1) receive as inputs one of the WS clusters of the forecast request; and
 - (2) generate one of a plurality of first ML model outputs from the WS cluster received by the first ML model for the forecast request; and

- (ii) wherein, for each forecast request, the second ML model is configured to:
 - (1) receive the first ML model output for the forecast request from each of the first ML models; and
 - (2) generate the SPWS forecast for the forecast request based on a weighted average of the first ML model outputs of the forecast request, wherein the weighted average is calculated from the set of cluster statistics and cluster error calculations for each WS cluster of the forecast request;
 - (i) for each forecast request, outputting the SPWS forecast of the forecast request to a user interface; and
 - (j) for each forecast request, augmenting the forecast history database with a new forecast record detailing the SPWS forecast generated for the forecast request.
9. The method of claim 8, wherein, for each forecast request, the plurality of WS clusters include:
- (a) a low WS cluster;
 - (b) a medium WS cluster;
 - (c) a high WS cluster; and
 - (d) an average WS cluster.
10. The method of claim 8,
- (a) wherein each of the ensemble members are exchangeable; and
 - (b) wherein the plurality of ensemble members include at least one of:
 - (i) a plurality of ECMWF EPS ensemble members; and
 - (ii) a plurality of down-scaled NWP ensemble members.
11. The method of claim 8,
- (a) wherein the forecast duration of the forecast time window is in the range of 1 to 6 hours and ends at the forecast start time; and
 - (b) wherein the pre-forecast observation time window of the forecast request has a pre-forecast observation duration that is in the range of 1 to 6 hours and ends at the forecast start time.

12. The method of claim 8, wherein the set of cluster statistics and cluster error calculations include at least one of a root mean square error, a mean bias error, a standard deviation, a mean, a maximum, and a minimum.

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13. The method of claim 8, the method further comprising the steps of:

- (a) establishing a data communication link through the network with a utility company server receiving generated wind power from the local area; and
- (b) delivering the SPWS forecast to the utility company server through the network.

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14. The method of claim 8, wherein the forecast time window of the prior forecast request of the at least one sample forecast record overlaps at least partially with at least one of:

- (a) a previous calendar day from the forecast time window of the forecast request;

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and

- (b) a previous time of calendar day as the forecast time window of the forecast request.

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