



# Next Generation Interactive Soil Moisture Forecasting System (NG-ISMFS)

## *A Deep Learning Approach*

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Acknowledgments: Thanks to Dr. Jadwiga Richter, and CISL (NCAR) for sharing the CESM2-SubX forecast and computational allocations

This research is supported by USDA DSFAS Grant # 2020-67021-32476 (Lead PI: Kumar)

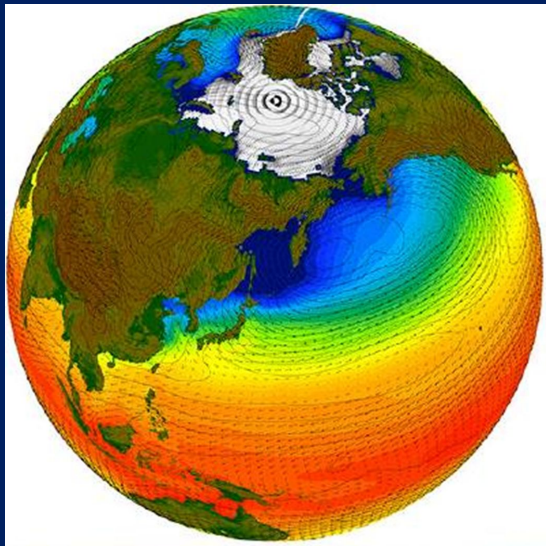
# NG-ISMFS: A web-based interactive platform



# Section 1: Why Next-Generation?

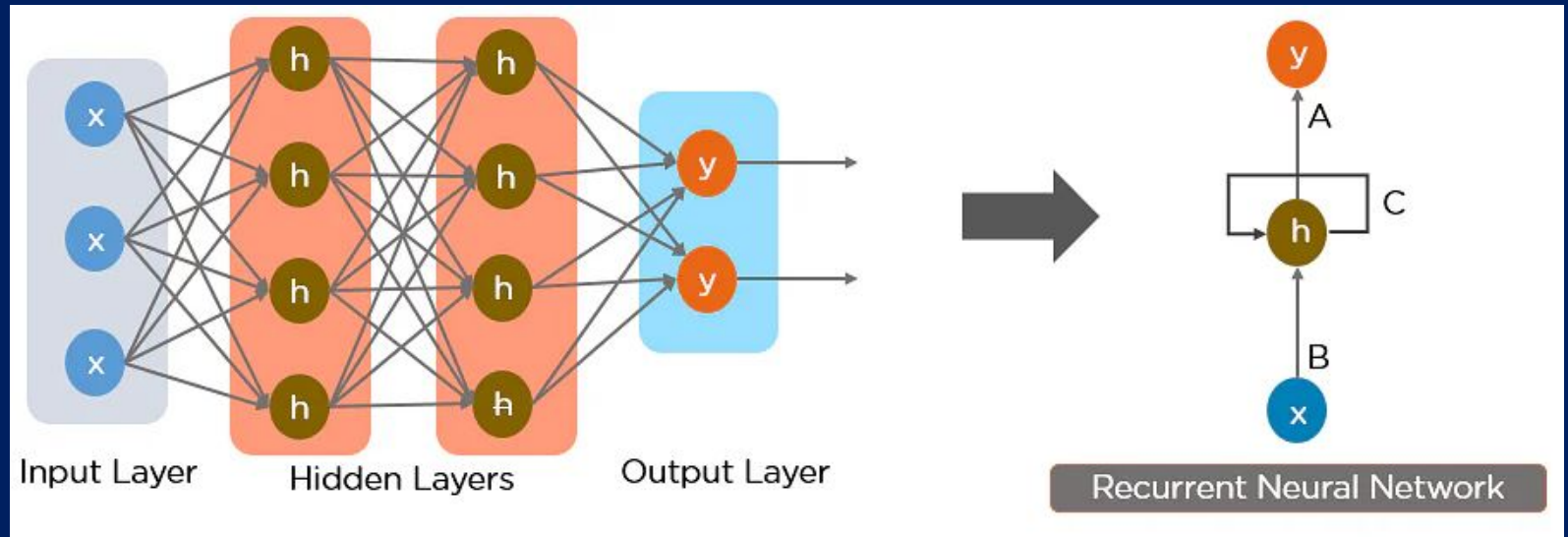
- ✓ What is there in NG-ISMFS?
- ✓ Why is it called Next Generation?
- ✓ What is the potential of NG-ISMSF?

# (1) It combines the best of two worlds



Community Earth System  
Climate Model version 2

Global Scale Predictor (H2OSOI)



Deep Learning Model - Recurrent Neural Network Architecture

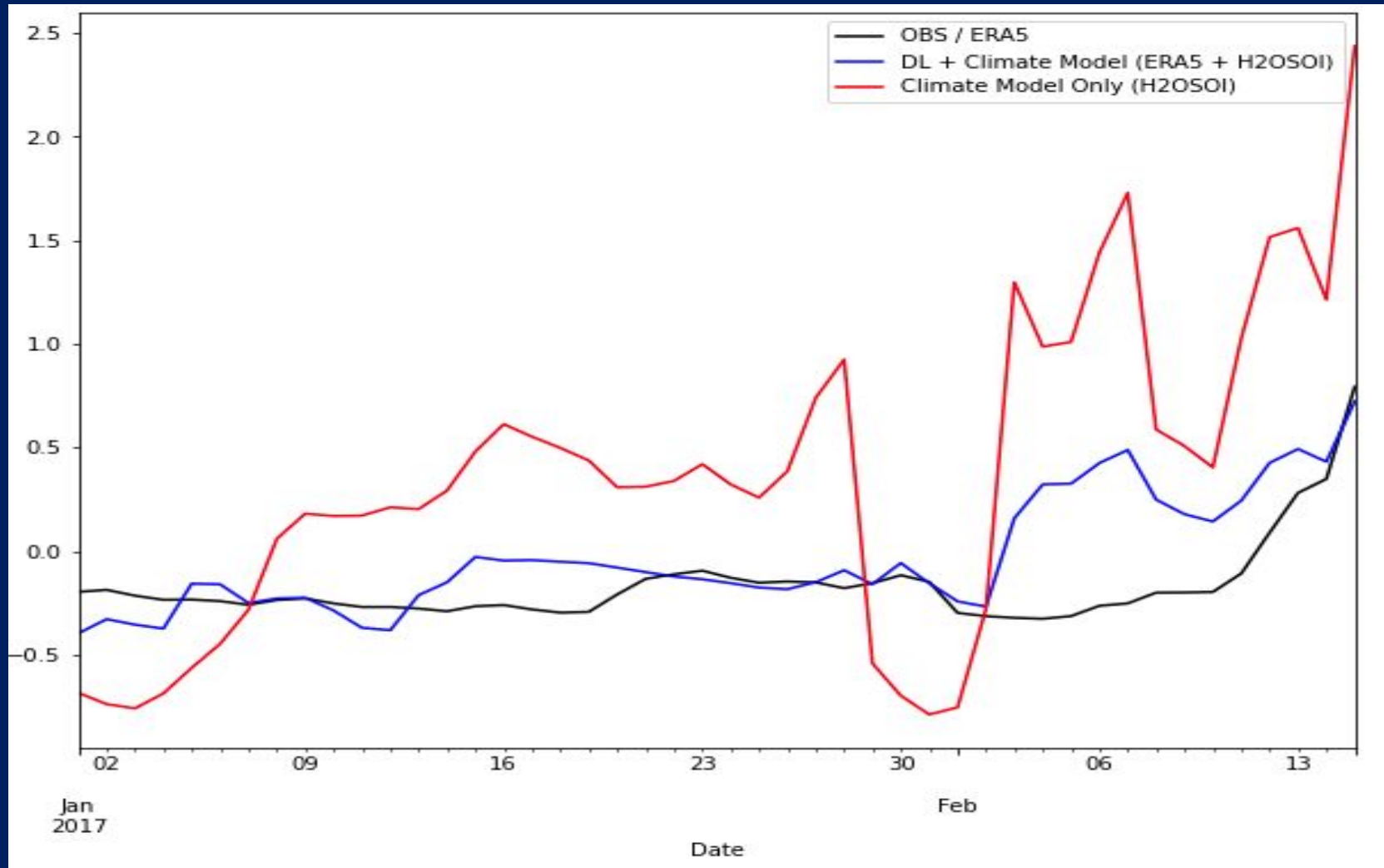
Locally trained DL model that understands the complex pattern of forecast biases in the hindcast data and improves the forecast skill

# (2) NG-ISMF is interactive with the user

- NG-ISMF provides on-demand forecasts for user-selected locations and forecast period

The screenshot displays the NG-ISMF user interface. At the top, there are two dropdown menus: 'Site' set to 'ABBY' and 'Date' set to '2017-01-01 00:00:00'. Below these, the interface shows forecast results for three different time steps. The first result is for a 3ms step, showing MAE: 0.556025554661714 and RMSE: 0.7483874048236637. The second result is for a 7ms step, showing MAE: 0.6192490944604039 and RMSE: 0.7919871142429499. The third result is for an ETA step, showing 'ETA: 0s'. Below the results, there are three empty input fields, each preceded by a '[' character, suggesting a list or table structure. A mouse cursor is visible near the bottom right of the interface.

# (3) NG-ISMFS improves the forecast skill

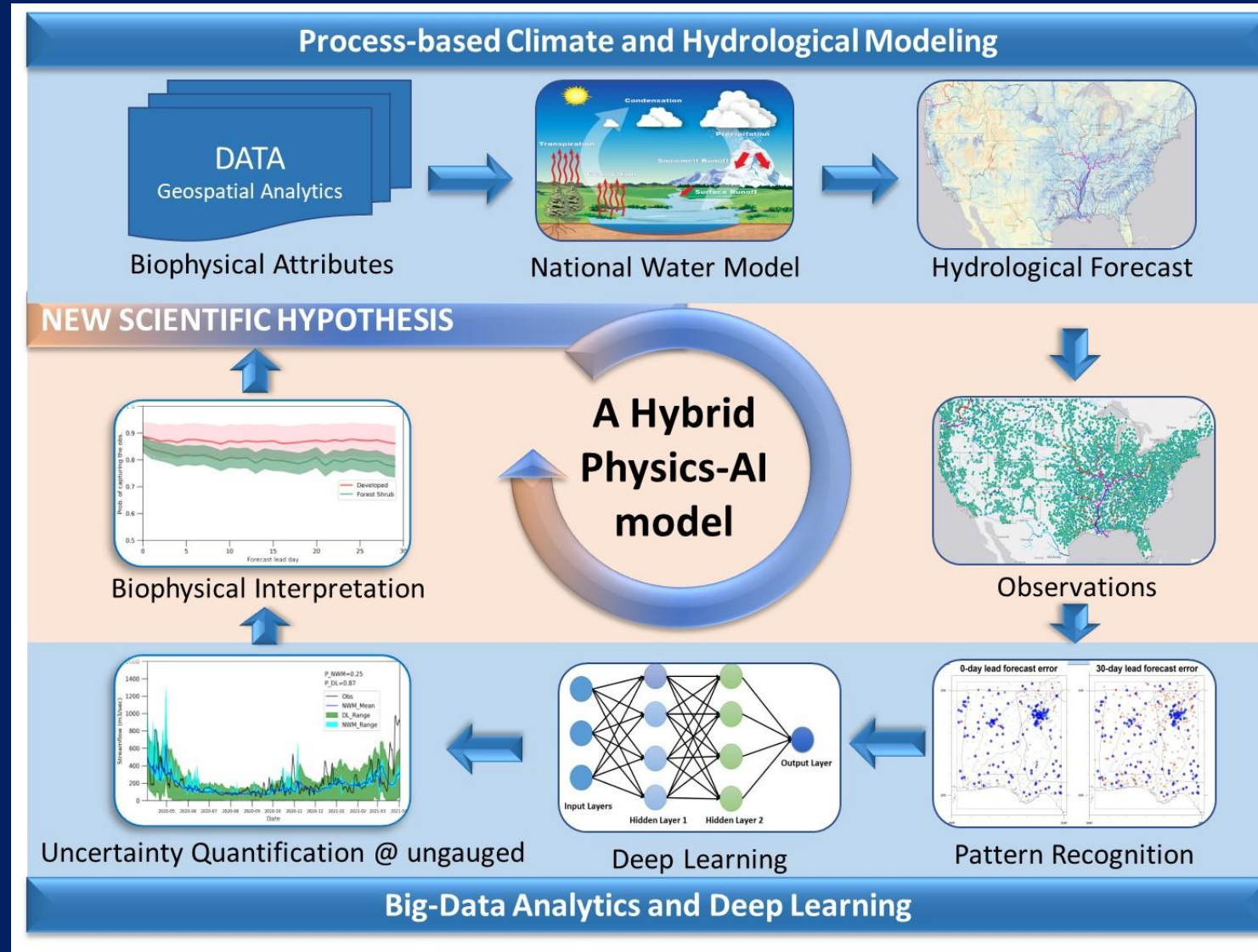




## Section 2: Mechanics of developing NG-ISMFS

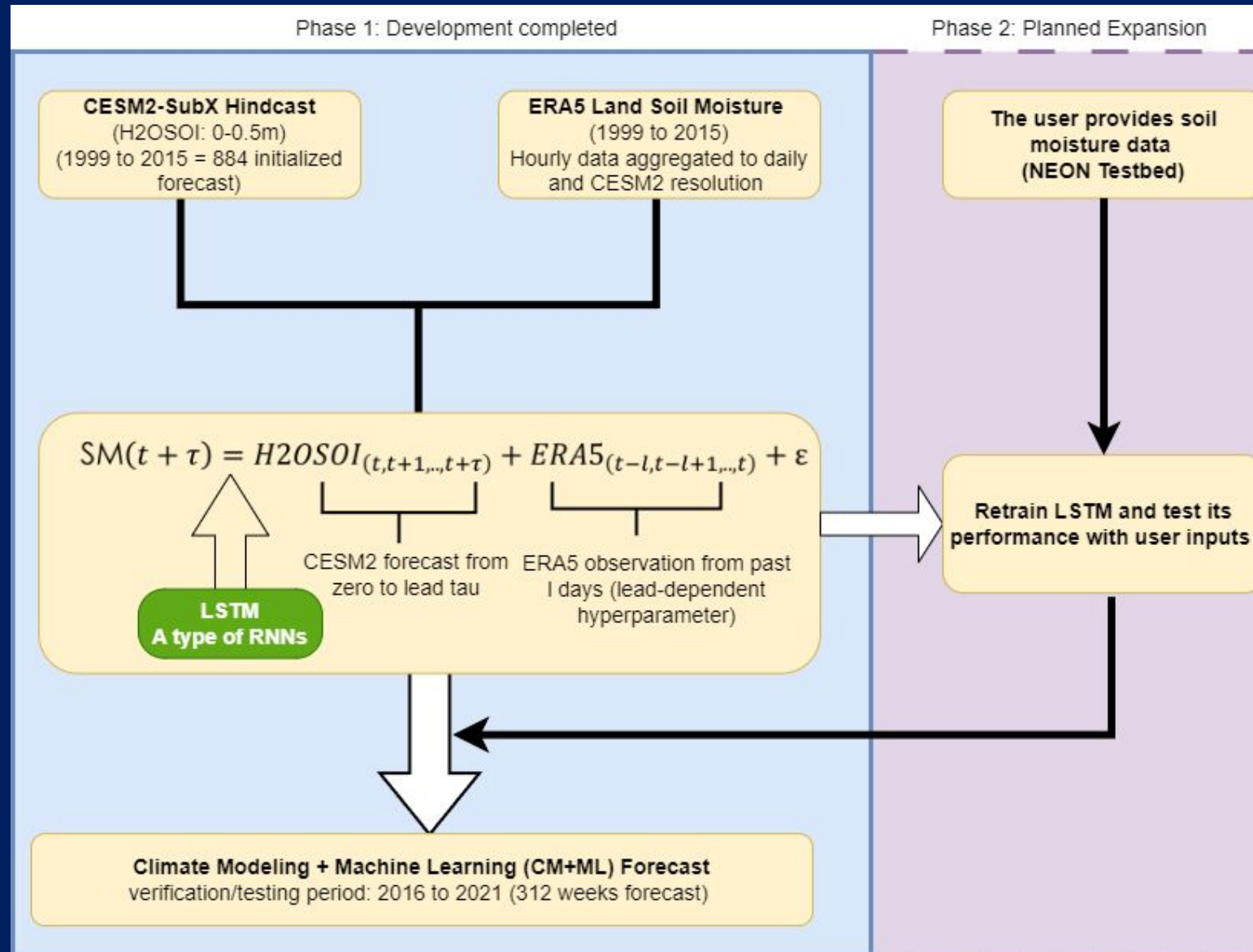
- ✓ What goes into designing NG-ISMFS?
- ✓ What are data ingredients and analytics methods?
  - ✓ Data visualization and accessibility?

# A Generalized Hybrid Physics-AI Modeling Framework



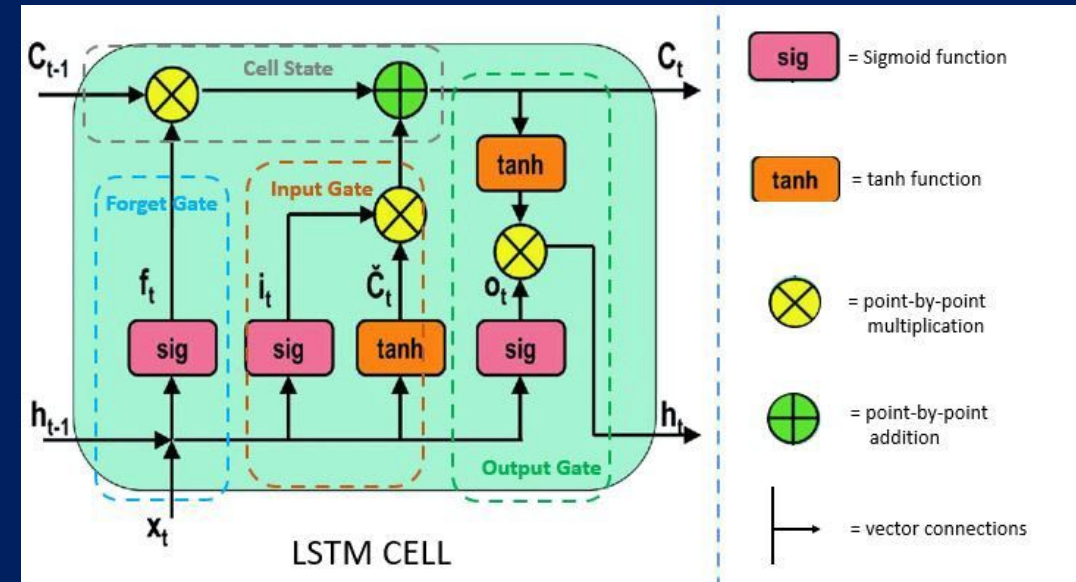


# NG-ISMFS Design



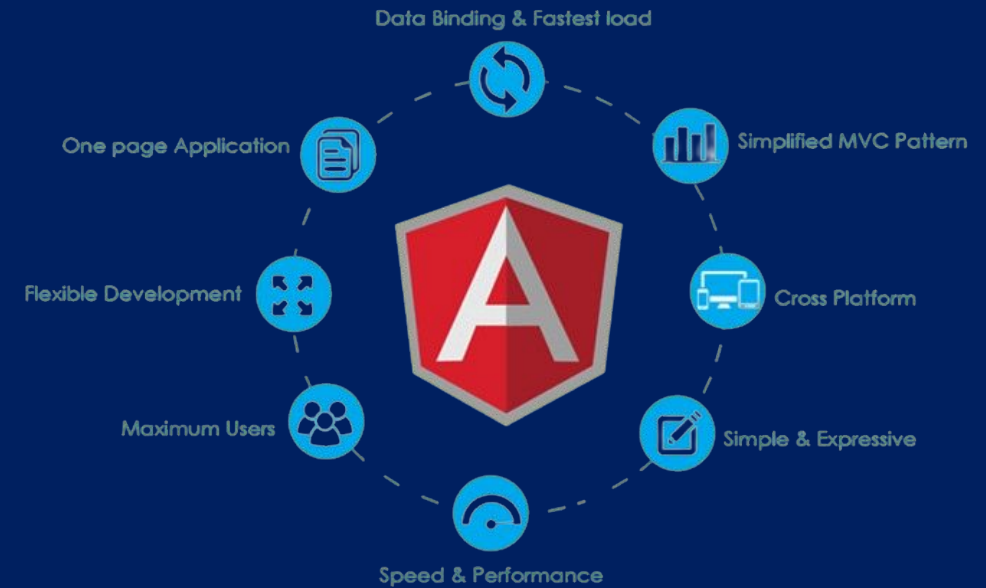
# Long Short-Term Memory (LSTM)

- ✓ Designed to learn and recall long-term dependencies by maintaining information over extended periods
- ✓ Each LSTM network consists of three crucial components, often called "gates."
  - 1) **FORGET GATE:** Determine the information that should be preserved and carried forward through the network. Filter out unnecessary information, ensuring that only relevant data is passed along.
  - 2) **INPUT GATE:** Performs the task of integrating new, pertinent information into the existing data pool by updating the network's cell states; Allows the LSTM to continuously adapt and learn from the influx of fresh data
  - 3) **OUTPUT GATE:** Involves the creation of the next set of hidden states; Ensures that the updated cell states are carried over to the subsequent time step
- ✓ In this way, the LSTM can generate an output while simultaneously preparing for the next sequence of data



# Accessibility, Scalability, and Adaptability in NG-ISMFS

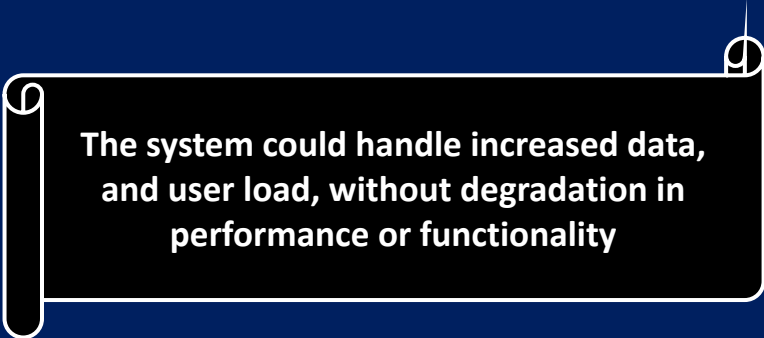
- **ACCESSIBILITY:** Constructed using the robust **Angular** Framework for the front-end and the versatile **Django** Framework for the back-end, NG-ISMFS ensures a seamless user experience
- **SCALABILITY:** NG-ISMFS is scalable and adaptable, allowing for future enhancements and integration of additional data sources or features
- **ADAPTABILITY:** Underlying Technology and Framework allow for potential expansion to include global locations in the future. This adaptability is a hallmark of "Next Generation" systems



**Django** is a high-level Python web framework that encourages rapid development and clean, pragmatic design. It's open-source and available for free.

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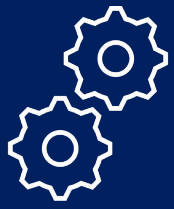


The system could handle increased data, and user load, without degradation in performance or functionality

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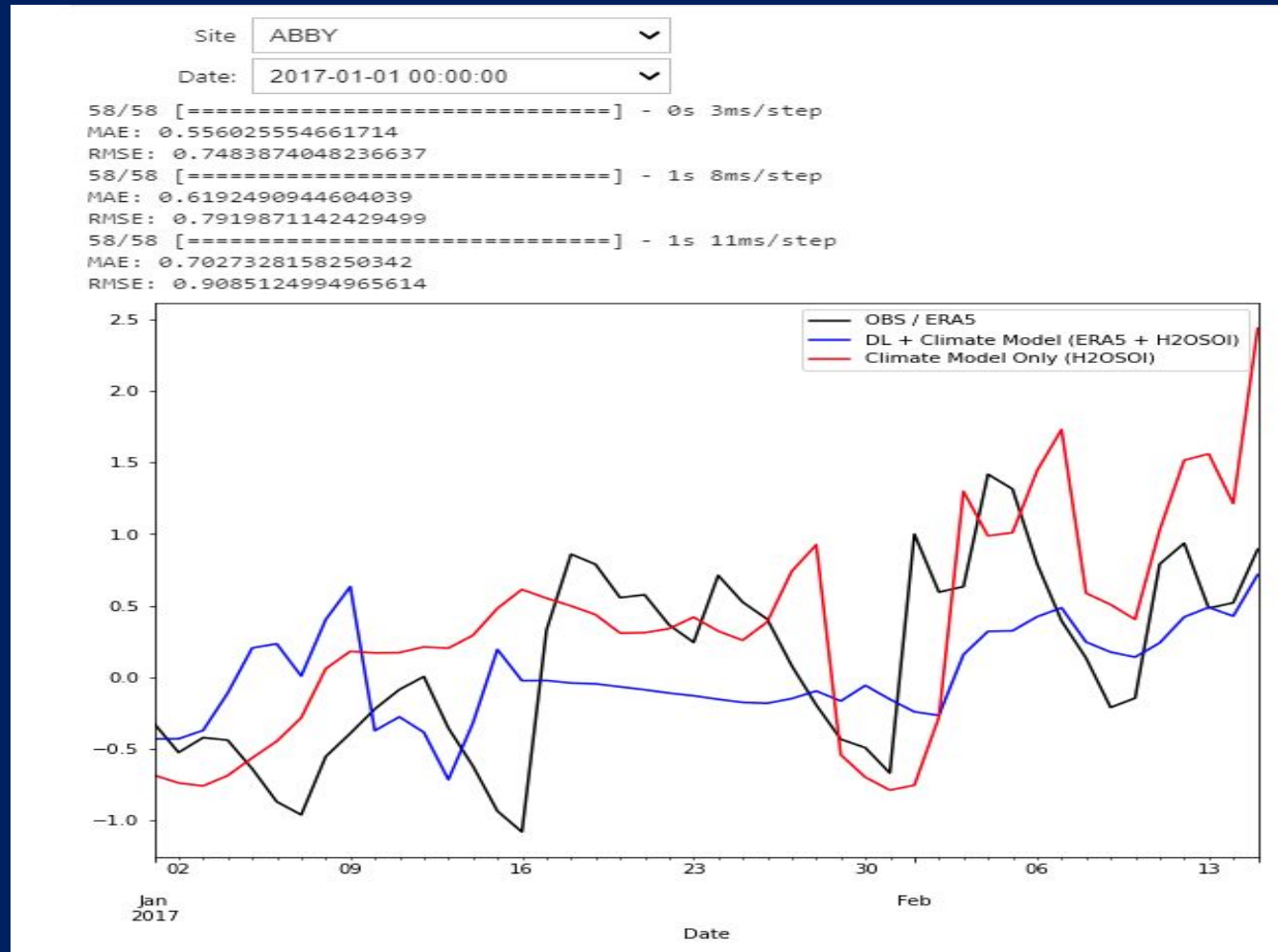
The system's flexible technology and framework could adapt to include global expansions in future



## Section 3: Results

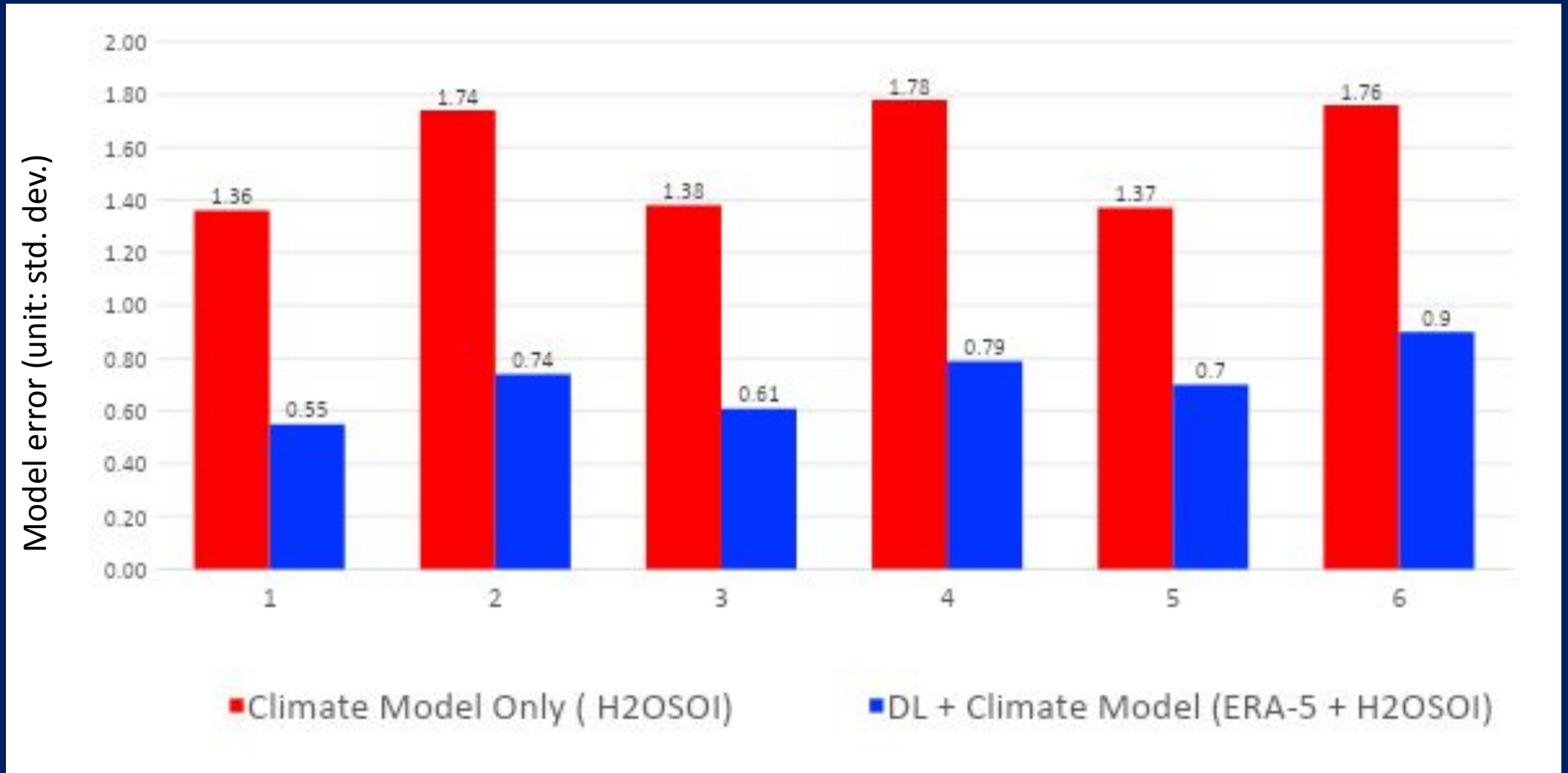
- ✓ What is the validation performance of NG-ISMFS?
- ✓ How can users interact with the NG-ISMFS website?
- ✓ What is a near-term plan to complete NG-ISMFS development?

# NG-ISMFS forecast with climate model only forecast at NEON site



ABBY SITE

# Comparing MAE and RMSE Values of ABBY Neon Sites



MAE – Mean Absolute Error (MAE), RMSE – Root Mean Square Error



# Near-term plan for NG-ISMFS

- ✓ Local host to public domain transition of NG-ISMFS
- ✓ Automated routines: Real-time processing and downloading of CESM2-SubX weekly forecast and ERA5 Land data; and their integration into NG-ISMFS (a hybrid computational framework)
- ✓ NEON Testbed demonstration



# Conclusions

- NG-ISMFS is an innovative technology that uses advanced analytics and deep learning to provide accurate and location-specific soil moisture forecasts
- The system integrates multiple data sources, including climate models, satellite data, and ground observations, to generate its forecasts
- NG-ISMFS features an interactive interface that allows users to customize their forecasts and explore different scenarios based on their needs and interests
- Overall, NG-ISMFS represents a significant step forward in the field of soil moisture forecasting and has the potential to improve decision-making and resource management in various sectors