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# Will It Rain On My Parade? Developing Weather Forecasting Website

## Abstract

This research paper explores the development of a personalized weather forecasting website, inspired by the 2025 NASA Space Apps Challenge. The website aims to provide users with tailored predictions regarding adverse weather conditions such as “very hot,” “very cold,” “very windy,” “very wet,” or “very uncomfortable (defined as a combination of high humidity, high temperature, and/or strong winds affecting human comfort)” conditions for specific locations and times. The study delves into the foundational principles of modern weather forecasting, the critical role of Earth observation data, and the methodologies for integrating diverse data sources to enhance predictive accuracy. By leveraging advanced numerical models, satellite imagery, radar data, and in-situ observations, the proposed website seeks to empower individuals with precise, actionable weather intelligence, thereby mitigating risks associated with outdoor activities and improving decision-making. The paper also discusses the challenges and opportunities in developing such a system, emphasizing the need for robust data assimilation techniques and user-friendly interfaces.

# 1. Introduction

Weather phenomena profoundly impact human activities, from daily commutes to large-scale agricultural planning and disaster preparedness. Accurate and timely weather forecasts are indispensable for mitigating risks and optimizing various operations. The advent of advanced Earth observation technologies and sophisticated computational models has revolutionized the field of meteorology, enabling increasingly precise predictions. However, traditional weather forecasts often provide generalized information, which may not cater to the specific needs of individual users or localized events. This gap highlights the necessity for personalized weather intelligence that can offer granular insights relevant to particular user queries.

Inspired by the 2025 NASA Space Apps Challenge, this paper outlines the conceptual framework for a personalized weather forecasting website titled “Will It Rain On My Parade?”. The core objective of this website is to empower users to conduct customized queries about the likelihood of specific adverse weather conditions—such as extreme temperatures, high winds, or heavy precipitation—for a given location and time. Such a tool would be invaluable for individuals planning outdoor events, travel, or any activity sensitive to weather changes.

The development of such an website necessitates a deep understanding of several key areas: the fundamental principles governing weather prediction, the vast array of Earth observation data available, and the computational methodologies required to process and interpret this data effectively. This paper will systematically explore these components, beginning with an overview of modern weather forecasting techniques, followed by a detailed examination of various Earth observation data sources and their utility. Subsequently, it will discuss the proposed methodology for data integration and website development, concluding with a discussion of the potential impact and future directions for personalized weather forecasting solutions. The ultimate goal is to present a robust conceptual design for an website that not only delivers accurate predictions but also enhances user experience through a highly personalized and intuitive interface.

# 2. Literature Review

Modern weather forecasting has evolved significantly from empirical observations to highly sophisticated numerical weather prediction (NWP) models, which form the backbone of contemporary meteorological services . Early forecasting methods relied heavily on synoptic charts and the analog method, comparing current weather patterns to historical ones . While these methods provided foundational insights, their subjective nature limited accuracy and consistency. The introduction of NWP models, which mathematically simulate atmospheric processes, marked a paradigm shift, enabling more objective and reliable predictions .

**2.1. Evolution of Weather Forecasting Models**

The development of NWP models began in the mid-20th century, leveraging increasing computational power to solve complex atmospheric equations. These models ingest vast amounts of observational data, process them through physical laws, and project future atmospheric states. Key advancements include the integration of global and regional models, ensemble forecasting (running multiple models with slightly varied initial conditions to quantify uncertainty), and data assimilation techniques that continuously update models with new observations . Despite their sophistication, NWP models inherently possess limitations, particularly in predicting localized, short-term phenomena due to resolution constraints and the chaotic nature of the atmosphere . This has led to the development of nowcasting techniques, which utilize real-time radar and satellite data to provide very-short-range forecasts (0-6 hours) with high spatial and temporal resolution .

**2.2. Role of Earth Observation Data**

Earth observation (EO) data is indispensable for modern weather forecasting, providing the initial conditions for NWP models and enabling real-time monitoring for nowcasting. EO data encompasses a wide array of measurements collected from various platforms, including satellites, ground-based radar, and in-situ sensors .

* **Satellite Data:** Weather satellites are a cornerstone of EO, offering broad spatial coverage and frequent updates. Geostationary satellites (e.g., NOAA’s GOES series) provide continuous views of large areas, crucial for tracking rapidly developing severe weather events like thunderstorms and hurricanes. They carry instruments like the Advanced Baseline Imager (ABI) for cloud properties and atmospheric conditions, and the Geostationary Lightning Mapper (GLM) for lightning activity [3]. Polar-orbiting satellites (e.g., NOAA’s JPSS series) offer higher resolution global observations, circling the Earth multiple times daily. Instruments such as the Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) measure temperature and water vapor profiles, significantly improving 3-to 7-day forecasts . The Visible Infrared Imaging Radiometer Suite (VIIRS) on JPSS satellites provides high-resolution visible and infrared imagery, including a Day/Night band for nighttime observations, useful for assessing power outages after severe weather .
* **Radar Data:** Ground-based radar systems, particularly Doppler radar, are critical for detecting precipitation, wind shear, and the internal structure of storms. They provide high-resolution data on localized weather phenomena, essential for issuing severe weather warnings, including those for tornadoes and flash floods .
* **In-situ Observations:** These include measurements from weather stations, buoys, radiosondes (weather balloons), and aircraft. They provide direct, highly accurate measurements of atmospheric variables like temperature, pressure, humidity, and wind speed at specific points. While their spatial coverage is limited compared to satellites, in-situ data are vital for calibrating remote sensing instruments and validating model outputs.

**2.3. Personalized Weather Websites**

The concept of personalized weather forecasting, as envisioned by the NASA Space Apps Challenge, builds upon these advancements by tailoring weather information to individual user needs. Existing websites often provide location-based forecasts, but the challenge lies in offering truly customized queries for specific conditions (e.g.,

extreme heat, cold, wind, or wetness) and presenting them in an intuitive manner. This requires not only robust forecasting capabilities but also intelligent data interpretation and user interface design. The integration of machine learning and AI techniques, such as NOAA’s ProbSevere and LightningCast, which combine various data sources to predict severe weather probabilities, demonstrates the potential for advanced personalized forecasting . The challenge is to adapt these sophisticated models to a user-centric website that provides actionable insights for individual planning.

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# 3. Data Sources

The development of a personalized weather forecasting website, such as “Will It Rain On My Parade?”, relies heavily on the integration of diverse and high-quality Earth observation data. These data sources provide the necessary atmospheric and surface parameters to drive predictive models and offer real-time insights into current weather conditions. The primary data sources can be categorized into satellite-based, radar-based, and in-situ observations.

**3.1. Satellite Data**

Satellite data forms the backbone of modern weather forecasting due to its extensive spatial coverage and frequent updates. For this website, data from both geostationary and polar-orbiting satellites would be crucial:

* **Geostationary Operational Environmental Satellites (GOES):** Operated by NOAA, GOES satellites (e.g., GOES-R series) provide continuous monitoring of weather phenomena over the Western Hemisphere. Key instruments include the Advanced Baseline Imager (ABI), which offers detailed information on cloud properties, atmospheric moisture, and temperature, essential for detecting the precursors to severe weather. The Geostationary Lightning Mapper (GLM) provides continuous lightning activity monitoring, aiding in the early detection of intensifying storms . These data are vital for short-term, high-frequency updates necessary for personalized nowcasting.
* **Joint Polar Satellite System (JPSS):** Also operated by NOAA, JPSS satellites (e.g., NOAA-20, NOAA-21) provide global coverage twice daily with higher spatial resolution. Instruments like the Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) measure atmospheric temperature and water vapor profiles, which are critical inputs for numerical weather prediction models, improving 3-to 7-day forecasts. The Visible Infrared Imaging Radiometer Suite (VIIRS) provides high-resolution visible and infrared imagery, including a Day/Night band useful for assessing post-event impacts like power outages .

**3.2. Radar Data**

Ground-based radar systems offer high-resolution, localized data, particularly important for severe weather detection and short-range forecasting:

* **Doppler Radar Networks:** Networks like the NEXRAD (Next-Generation Radar) in the United States provide detailed information on precipitation intensity, wind velocity, and storm structure. Doppler radar is instrumental in identifying mesocyclones that can lead to tornadoes, as well as detecting heavy rainfall that can cause flash floods . The high temporal and spatial resolution of radar data makes it indispensable for localized, real-time alerts for conditions such as

heavy rain, strong winds, and hail.

**3.3. In-situ Observations**

In-situ observations provide direct measurements of atmospheric conditions and are crucial for ground-truthing remote sensing data and improving model accuracy:

* **Surface Weather Stations:** Networks of automated and manual weather stations collect data on temperature, humidity, pressure, wind speed and direction, and precipitation. These stations provide continuous, high-accuracy point measurements that are essential for local forecasts and for validating broader-scale model outputs .
* **Radiosondes (Weather Balloons):** Launched twice daily from numerous locations worldwide, radiosondes provide vertical profiles of temperature, humidity, pressure, and wind speed through the atmosphere. This upper-air data is critical for initializing NWP models and understanding atmospheric stability, which is key for forecasting severe weather .
* **Aircraft and Buoy Data:** Commercial aircraft contribute valuable upper-air wind and temperature data, particularly over data-sparse regions. Ocean buoys provide surface weather and oceanographic data, crucial for marine forecasts and understanding air-sea interactions that influence weather patterns .

By integrating these diverse data sources, the personalized weather forecasting website can achieve a comprehensive and accurate understanding of atmospheric conditions, enabling precise predictions for specific user queries.

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# 4. Methodology

The development of the “Will It Rain On My Parade?” website involves a multi-faceted methodology encompassing data acquisition, processing, modeling, and user interface design. The overarching goal is to create a robust system that can ingest various Earth observation data, process them to generate personalized forecasts, and present these forecasts in an intuitive and actionable manner.

**4.1. Data Acquisition and Pre-processing**

The first step involves establishing reliable pipelines for acquiring data from the identified sources. This will include:

* **Satellite Data Feeds:** Accessing real-time and archival data from NOAA’s GOES and JPSS satellites. This typically involves utilizing APIs or data portals provided by NASA Earthdata and NOAA NESDIS . Raw satellite imagery and derived products (e.g., cloud top temperatures, atmospheric moisture profiles) will be acquired.
* **Radar Data Integration:** Connecting to national radar networks (e.g., NEXRAD in the US) to obtain high-resolution precipitation and wind data. This may involve processing raw radar reflectivity and velocity data to derive meaningful weather parameters.
* **In-situ Data Collection:** Aggregating data from surface weather stations, radiosondes, and other in-situ sensors. Publicly available datasets from national meteorological services (e.g., NOAA’s Climate Data Online) and global observation networks will be utilized .

Once acquired, the raw data will undergo a rigorous pre-processing phase. This includes quality control, where erroneous or missing data points are identified and corrected or interpolated. Data from different sources, often in varying formats and resolutions, will be harmonized and re-gridded to a common spatial and temporal resolution suitable for integration into predictive models. This step is crucial for ensuring data consistency and compatibility across the system.

**4.2. Predictive Modeling and Data Assimilation**

To generate personalized forecasts, the website will employ a combination of numerical weather prediction (NWP) outputs and advanced statistical/machine learning models:

* **NWP Model Integration:** Instead of running a full NWP model, the website will leverage outputs from established operational NWP models (e.g., GFS, ECMWF). These models provide foundational forecasts for atmospheric variables over various lead times. The website will focus on downscaling and refining these outputs for specific user queries.
* **Statistical Downscaling and Bias Correction:** NWP model outputs often have biases and may not fully resolve local-scale phenomena. Statistical downscaling techniques will be applied to translate large-scale model predictions to finer spatial resolutions relevant to user locations. Bias correction methods, potentially using historical in-situ observations, will be employed to improve the accuracy of model outputs.
* **Machine Learning for Personalized Conditions:** To predict specific

user-defined conditions like “very hot,” “very windy,” or “very uncomfortable (defined as a combination of high humidity, high temperature, and/or strong winds affecting human comfort),” machine learning models will be developed. These models will be trained on historical weather data, including satellite, radar, and in-situ observations, to learn the relationships between atmospheric parameters and these specific conditions. For example, a model for “very uncomfortable (defined as a combination of high humidity, high temperature, and/or strong winds affecting human comfort)” could be trained using a combination of temperature, humidity, and wind speed data, potentially incorporating a heat index or wind chill factor. Techniques like logistic regression, support vector machines, or neural networks could be employed for this classification task.

* **Data Assimilation:** A key component of the methodology is data assimilation, which involves continuously updating the predictive models with the latest observations. This ensures that the forecasts remain accurate and responsive to changing weather conditions. For nowcasting, real-time satellite and radar data will be assimilated to provide high-frequency updates on developing storms and other short-term phenomena.

**4.3. User Interface and Query System**

The user interface (UI) will be designed to be intuitive and user-friendly, allowing users to easily specify their location, time of interest, and the specific weather conditions they are concerned about. The query system will translate these user inputs into specific parameters for the predictive models. For example, a query for “very windy” conditions will trigger the corresponding machine learning model to generate a probability forecast for that condition at the specified location and time.

The website will present the forecast in a clear and understandable format, potentially using a combination of text, graphics, and maps. For instance, a probability score (e.g., 75% chance of “very wet” conditions) could be provided, along with visualizations of the expected weather patterns. The UI will also allow users to set up alerts for specific conditions, providing proactive notifications of potential weather hazards.

By integrating these methodological components, the “Will It Rain On My Parade?” website aims to provide a powerful and personalized weather forecasting tool that goes beyond traditional forecasts, offering actionable intelligence tailored to individual user needs.

# 5. Expected Results

The successful implementation of the “Will It Rain On My Parade?” website is expected to yield a range of valuable outcomes, primarily centered on the delivery of highly personalized and actionable weather forecasts. The key expected results include:

* Personalized Condition-Based Forecasts: The website will provide users with tailored predictions for specific, user-defined weather conditions such as “very hot,” “very cold,” “very windy,” “very wet,” and “very uncomfortable (defined as a combination of high humidity, high temperature, and/or strong winds affecting human comfort).” These forecasts will be presented as probabilities, offering a clear indication of the likelihood of these conditions occurring at a specified location and time. This represents a significant advancement over traditional forecasts that provide general weather parameters without direct interpretation of their impact on user comfort or plans.
* **High-Resolution Localized Predictions:** By integrating high-resolution satellite and radar data and employing statistical downscaling techniques, the website is expected to deliver forecasts with a high degree of spatial and temporal accuracy. This will enable users to obtain predictions for their immediate vicinity, rather than relying on regional forecasts that may not capture local variations in weather patterns.
* **Enhanced User Decision-Making:** The primary benefit of the website will be its ability to empower users to make more informed decisions regarding their outdoor activities. For example, a user planning a hike could query the likelihood of “very wet” or “very windy” conditions along their intended trail, allowing them to adjust their plans accordingly to ensure safety and comfort. Similarly, event organizers could use the website to assess the risk of adverse weather and implement contingency plans.
* **Intuitive and Actionable User Interface:** The website will feature a user-friendly interface that simplifies the process of querying complex weather data. Forecasts will be presented in an easily understandable format, potentially using a combination of textual summaries, graphical icons, and interactive maps. This will make sophisticated weather intelligence accessible to a broad audience, regardless of their technical expertise.
* **Proactive Alerting System:** The website will include a proactive alerting feature, allowing users to set up notifications for specific weather conditions. This will provide timely warnings of impending weather hazards, enabling users to take necessary precautions. For instance, a user could receive an alert for a high probability of a severe thunderstorm, giving them ample time to seek shelter.

Overall, the “Will It Rain On My Parade?” website is expected to demonstrate the significant potential of integrating advanced Earth observation data and machine learning techniques to create highly personalized and impactful weather forecasting solutions. The successful delivery of these results will not only enhance individual user experiences but also contribute to the broader field of applied meteorology by showcasing a novel approach to user-centric weather intelligence.

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# 6. Discussion

The development of a personalized weather forecasting website like “Will It Rain On My Parade?” presents both significant opportunities and inherent challenges. The core opportunity lies in bridging the gap between generalized meteorological data and individual user needs, thereby enhancing the utility and impact of weather information.

**6.1. Implications and Benefits**

The primary implication of such an website is the broader accessibility of advanced weather intelligence. By translating complex scientific data into easily digestible, personalized forecasts, individuals can make more proactive and informed decisions. This extends beyond simple planning for outdoor events to potentially influencing sectors such as localized agriculture, energy consumption management (e.g., anticipating extreme heat for HVAC adjustments), and even public health advisories (e.g., warning vulnerable populations about uncomfortable conditions). The ability to query specific conditions, rather than interpreting raw meteorological parameters, significantly lowers the barrier to entry for utilizing sophisticated weather data.

Furthermore, the website fosters a **more resilient and adaptive society**. By providing early warnings for localized adverse conditions, it can contribute to reducing weather-related risks, minimizing economic losses, and improving public safety. The proactive alerting system, in particular, shifts the paradigm from reactive responses to anticipatory actions, which is crucial in an era of increasing climate variability and extreme weather events.

**6.2. Challenges and Limitations**

Despite the promising benefits, several challenges must be addressed during the development and deployment of this website:

* **Data Volume and Velocity:** Integrating and processing vast amounts of real-time data from diverse sources (satellites, radar, in-situ sensors) requires robust infrastructure and efficient data pipelines. The sheer volume and continuous flow of data necessitate advanced computational resources and sophisticated data management strategies.
* **Model Accuracy and Uncertainty:** While NWP models have improved significantly, they still contain inherent uncertainties, especially for long-range forecasts and highly localized phenomena. The machine learning models developed for personalized conditions must be carefully trained and validated to ensure their accuracy and reliability. Communicating forecast uncertainty to users in an understandable manner is also critical to manage expectations and build trust.
* **Computational Complexity:** Running and continually updating machine learning models for a multitude of personalized queries, coupled with data assimilation processes, demands substantial computational power. Optimizing algorithms and potentially leveraging cloud-based computing resources will be essential.
* User Interface Design and Interpretation: Designing an intuitive interface that effectively communicates complex weather probabilities and conditions without overwhelming the user is a delicate balance. The language used for conditions like “very uncomfortable (defined as a combination of high humidity, high temperature, and/or strong winds affecting human comfort)” needs to be clearly defined and consistently applied to avoid ambiguity. User feedback and iterative design will be crucial.
* **Data Access and Licensing:** Accessing high-resolution, real-time data from various meteorological agencies and satellite operators may involve navigating complex data access policies and licensing agreements. Ensuring sustainable and legal access to necessary data streams is a foundational requirement.

**6.3. Opportunities for Future Development**

Looking ahead, the “Will It Rain On My Parade?” concept opens several avenues for future development. Integrating **climate change projections** could allow users to query future probabilities of extreme events, aiding long-term planning. Incorporating **Internet of Things (IoT) sensors** for hyper-local data collection could further refine predictions for specific microclimates. Moreover, the website could evolve to include **impact-based forecasting**, where predictions are linked directly to potential consequences (e.g., “high probability of travel delays due to heavy snow”) rather than just meteorological parameters. The continuous advancement in AI and machine learning techniques, coupled with increasing availability of Earth observation data, will undoubtedly provide further opportunities to enhance the sophistication and utility of such personalized weather forecasting tools.

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# 7. Conclusion

The “Will It Rain On My Parade?” website, conceptualized within the framework of the 2025 NASA Space Apps Challenge, represents a forward-thinking approach to personalized weather forecasting. By meticulously integrating diverse Earth observation data—ranging from high-resolution satellite imagery and radar data to precise in-situ measurements—and leveraging advanced predictive modeling techniques, this website aims to transcend the limitations of generalized weather reports. The core objective is to deliver highly specific, actionable insights into adverse weather conditions, tailored to individual user queries for particular locations and times.

This research paper has outlined the foundational principles underpinning modern weather prediction, highlighted the indispensable role of various Earth observation data sources, and detailed a comprehensive methodology for developing such a personalized forecasting system. The expected outcomes underscore the potential for significantly enhanced user decision-making, improved safety during outdoor activities, and a more proactive stance against weather-related disruptions. While challenges related to data management, model accuracy, and computational demands are acknowledged, the continuous advancements in meteorological science and artificial intelligence offer promising pathways for overcoming these hurdles.

Ultimately, the successful realization of “Will It Rain On My Parade?” would not only fulfill the ambitious goals of the NASA Space Apps Challenge but also contribute meaningfully to the broader societal objective of fostering greater resilience in the face of dynamic environmental conditions. By placing sophisticated weather intelligence directly into the hands of users, this website embodies the future of personalized environmental information services, empowering individuals to navigate their world with greater confidence and preparedness.

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Summary: Smart Web System for Real-Time Weather Prediction

This project proposes a smart web-based weather prediction system that integrates datasets from NASA, NOAA, and OpenWeatherMap to deliver precise, real-time forecasts. The system processes collected data through cleaning, integration, and normalization before applying machine learning models such as linear regression, neural networks, and ARIMA for predictive analysis. Results are presented as a Weather Comfort Index, allowing users to interpret conditions via visual cues (colors, icons, charts) and personalize comfort thresholds. Beyond accurate forecasting, the system emphasizes continuous learning, mobile integration, and social impact, particularly in agriculture and risk reduction. By merging AI with open-source data and interactive interfaces, the system aspires to provide a globally scalable, user-centric tool for safer and more efficient activity planning.

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