AI-Powered, High-Resolution Weather Intelligence Platform

Rei Goffer and Roy Sahaf
Boston, MA 02205
UNITED STATES

rei@tomorrow.io

ABSTRACT

Weather has a major impact on the operations safety and efficiency of UxVs (uncrewed vehicles). Wind, turbulence, extreme temperatures, humidity, lightning, clouds, icing, and precipitation are just a few of many localized weather phenomena that dictate what can or cannot be done by UxVs in a given area, and our understanding of these microscale phenomena in both real-time and forecast is critical for mission success. The challenge is even greater when considering swarms of UxVs, where each vehicle's situational awareness (SA) is heavily dependent on another's. In today's battlefield, the impacts of weather, and our ability to anticipate and cope with them, can make the difference between mission success or failure.

Founded by military aviators, Tomorrow.io is the fastest growing weather technology company in the world. In just a short time, Tomorrow.io has become a leading weather solution for the military, aviation, and uncrewed aerial system (UAS) industries, with customers including major airlines, armed forces, and leaders in the drone and UAS industry. Tomorrow.io's team comprises over 100 scientists, engineers, and product and business managers. With deep experience in numerical weather prediction, artificial intelligence, and massive parallel computing, as well as aviation, defense, product development, and user experience/user interface (UX/UI), Tomorrow.io is uniquely qualified to deliver a paradigm shift in the weather industry.

Most weather forecasts suffer from the same operational gaps globally. The lack of data sources, especially in remote areas where armed forces operate, and where radars and weather stations are not available, together with the coarse resolution of publicly-available models over these areas, are the main cause for the lack of accuracy and detail of the data and forecasts provided. In addition, the output of raw, non-actionable weather information makes the decision-making process and SA enablement for the end-users, such as UxVs operators, even harder.

Tomorrow.io has developed a holistic approach to solving weather challenges specific to UxVs. The relevant Tomorrow.io capabilities integrate a combination of novel sensing technologies, a comprehensive and nimble data assimilation engine, a bespoke modeling framework, machine learning techniques, and a modern, cloud-native software architecture for flexible delivery of data and insights.

1.0 END-TO-END WEATHER SOLUTION FOR UxVs

Figure 1-1: Tomorrow.io's Weather Intelligence Platform^{TM}.

A highly detailed and rapid-refresh ("short cadence") analysis of UxVs-specific weather conditions is a critical component of swarm flight management, yet comprehensive data for block-level weather conditions remains challenging to acquire. Observations remain sparse and ground-based radars, if available, often sample above relevant airspace. By assimilating millions of data points from traditional and non-traditional sensing technologies, Tomorrow.io's approach offers an unparalleled advantage, particularly for the UxVs airspace. With its robust data assimilation engine, Tomorrow.io is capable of uniquely ingesting into its models any type of data source, such as using the UxVs sensors themselves, as dynamic weather observations. The result is a complete picture of real-time flying conditions at sub-kilometer spatial resolution, with unprecedented vertical resolution and high-frequency temporal updates, even in data-sparse regions where UxVs could create a stand-alone "network" of weather observations.
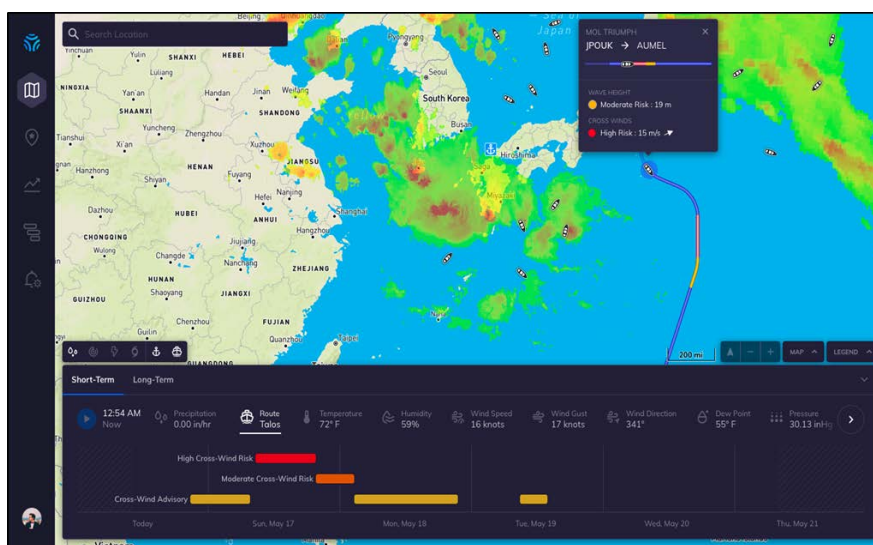

Figure 1-2: Tomorrow.io Weather Intelligence Platform^{TM} enables real-time monitoring and decision-making globally over land and ocean, including traditionally data-sparse regions of the world.

In addition to real-time monitoring, a major gap exists between UxVs weather requirements and the availability of high-quality, three-dimensional forecasts at suitable spatial and temporal resolution. Tomorrow.io's Bespoke Atmospheric Model (CBAM) is a cloud-native numerical weather assimilation and modeling platform that simulates actual microscale and highly variable weather that impacts UxVs and resolves features that other solutions cannot. CBAM is highly configurable over a range of spatial scales and applications, and the results have been validated across a wide range of use cases, including urban and rural areas. With sub-hourly output and resolution as granular as tens of meters, CBAM is perfectly suited to bridge the gap between UxVs requirements and weather intelligence in order to enable SA and autonomy for highly precise planning and decision-making. CBAM is fully customizable and can be deployed quickly anywhere in the world, finely-tuned to a specific mission area or weather nuances of a particular airspace.
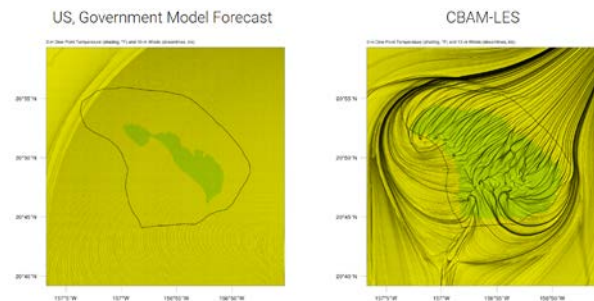

Figure 1-3: Government model output (left) vs. much more granular Tomorrow.io Bespoke Atmospheric Model (CBAM) output (right)

All Tomorrow.io technologies are delivered via the Tomorrow.io Weather Intelligence Platform[TM], which is well-suited for operational swarm management and planning, as well as real-time decision-making. Ultimately, Tomorrow.io delivers intelligence to greatly reduce the weather risk and improve warfare efficiency for UxVs operations globally.

2.0   EXAMPLE OF TOMORROW.IO TECHNOLOGY DEPLOYMENTS

2.1   Rapid-Update UxVs Weather Analysis

Tomorrow.io will deploy a multi-sensor—including existing weather stations, radars, satellites, and non-traditional sensors—and multi-model analysis of weather conditions within any global area of interest. Novel rapid data assimilation techniques will also use the UxVs sensor observations to provide a three-dimensional representation of real-time flying conditions at microscale resolution with high-frequency temporal updates.

2.2   High-Resolution Historical Baseline Analyses and Forecasts for UxVs

In data-sparse areas, weather conditions can change quickly and vary greatly across short distances with no ability to track those changes. To assess the range of possible flying conditions and identify potential "danger zones" to avoid, Tomorrow.io will deploy CBAM, a numerical weather analysis and prediction solution deployable anywhere globally. Tomorrow.io will run CBAM in historical mode to provide a high-precision and comprehensive understanding, down to the scale of tens of meters, of the relevant airspace to define no-fly zones, optimize routes, and avoid surprises.

Tomorrow.io will also deploy CBAM to produce rapidly updating near-real-time analyses and forecasts of weather conditions, accounting for local topography, land-sea complexities, and other effects. Derived products include ascent/descent profiles, flight-level winds at high vertical resolution, and hazard-specific analytics such as turbulence and thunderstorms.

2.3   UxVs Tracking and Ingestion of In-Situ Data

For situational awareness of the airspace, Tomorrow.io will deploy a system to ingest a real-time feed of data available from the aircraft, including location, altitude, and weather observations (if available). Tomorrow.io will visualize the asset movements against a three-dimensional landscape in its Weather Intelligence Platform, which will allow human operators to track and monitor missions in the context of ongoing weather, including a mapping overlay of no-fly zones, and enable real-time decision-making.

2.4   Insights and Alerts

Certain weather conditions pose challenges for UxVs, and operators must make decisions quickly to minimize risks. The vast volume of high-resolution data created by the solutions above will enable novel insights—virtually impossible to obtain with traditional weather data and models—to make automated decisions within the airspace. For example, Toorrow.io will develop a new turbulence or ceiling/visibility risk index to send alerts to operators who commonly inhabit a certain portion of the airspace or trigger the automated closure of airspace.
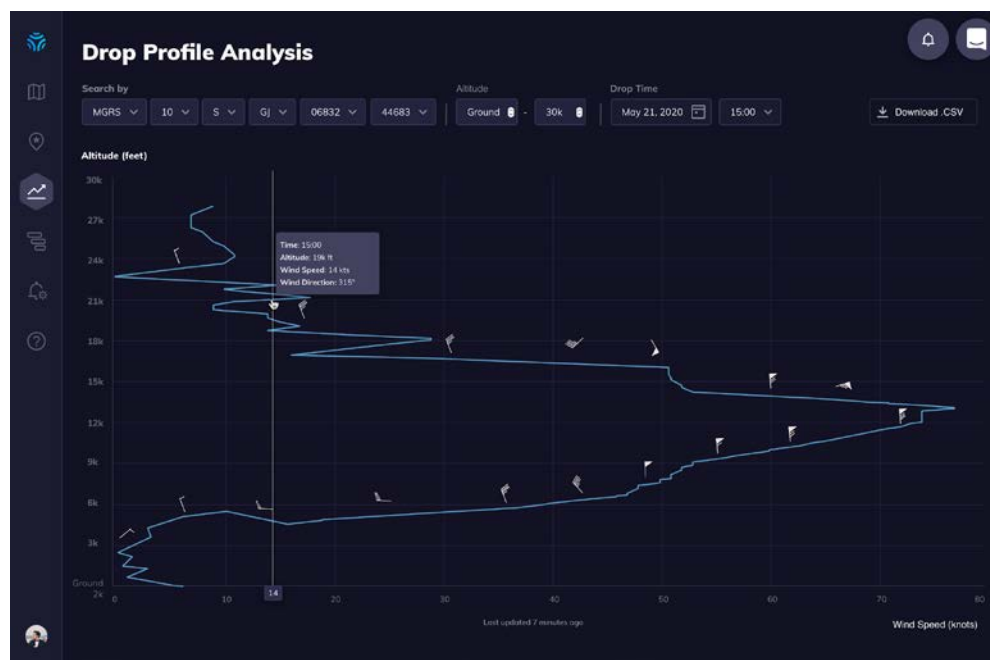

Figure 2-1: Tomorrow.io's Weather Intelligence Platform – 3-D wind and turbulence output for route planning.
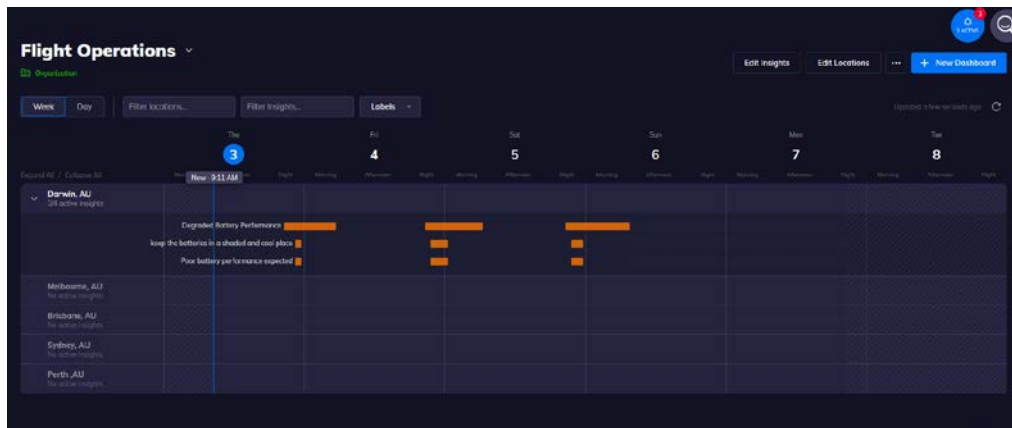
Figure 2-2: Tomorrow.io's Weather Intelligence Platform – a streamlined "Go/No-Go" decision-support tool.

3.0   SUMMARY

Tomorrow.io is proposing its Weather Intelligence Platform to be used by UxVs human operators to monitor weather impacts on swarm activity in real-time, at microscale resolution with high-frequency temporal updates. In order to address existing data gaps and the coarse resolution of publicly-available models, Tomorrow.io's approach combines millions of data points from traditional and non-traditional sensors, including from the UxVs themselves, with a customizable microscale model deployable anywhere across the globe, to provide high-precision and comprehensive understanding down to the scale of tens of meters.

Using unique modeling and data assimilation capabilities, Tomorrow.io will provide UxVs with enhanced SA and autonomous decision-making capabilities, based on highly localized weather information, to improve warfare efficiency and safe operations of UxVs globally.

4.0   ABOUT TOMORROW.IO

To date, Tomorrow.io has received more than $185 million (USD) in funding from the following major investors: Canaan Partners (USA), Clear Visions Ventures (USA), Evergy Ventures (USA), Fontinalis Partners (USA), Ford Mobility (USA), Pitango Venture Capital (Israel), JetBlue Technology Ventures (USA), National Grid Partners (UK), SquarePeg Capital (Australia), Softbank Energy (Japan), Stonecourt Capital (USA), Highline Capital (USA), Tata Trusts (India).

Tomorrow.io has customers and technical/design partners across a broad swath of the aviation industry. These include:

- **DOD/U.S. Air Force** – Tomorrow.io is participating in multiple U.S. Air Force (USAF) Small Business Innovation Research (SBIR) initiatives, including one ongoing Phase II project, to research and develop products that further the USAF mission. Current projects are focused primarily on providing high-quality weather and aviation data to the USAF to assist with mission planning and operations.

- **Major Airlines** – JetBlue is an investor (via JetBlue Technology Ventures), customer, and lead product design partner. Tomorrow.io has worked closely with JetBlue to understand the needs around aviation

weather (as well as the gaps in existing products), and has built a product that is widely and increasingly used throughout the company operations. Delta and United Airlines are both customers and design partners, helping Tomorrow.io to develop tools and capabilities that meet the needs of airline and aviation operations at airports, as well as test various product designs targeting the aviation sector.

- **UAS Industry Leaders** – Leaders in the UAS industry, including Boeing, trust Tomorrow.io to deliver solutions specifically tailored to address emerging needs and challenges that weather poses to the next generation of advanced air mobility.

Tomorrow.io's solutions are all cloud-based and delivered using a software-as-a-service (SaaS) model. Absolutely no hardware is required to be installed on-site or anywhere within the premises or operating environment of the customer. The Weather Intelligence Platform can be accessed using any modern web browser (Chrome, Safari, Firefox, etc.) on a late-model (generally last five years) computer. The Weather Intelligence mobile app is available for iOS and Android smartphone devices, and is compatible with both smartphones and tablets. The API is accessed programmatically and thus carries no explicit technical requirements as long as appropriate security credentials are provided and correct protocols (REST) are used.