Operationalizing a Weather Forecasting Systems at Tomorrow.io

Session:

UFS as a Decision Tool: A Private Industry Perspective

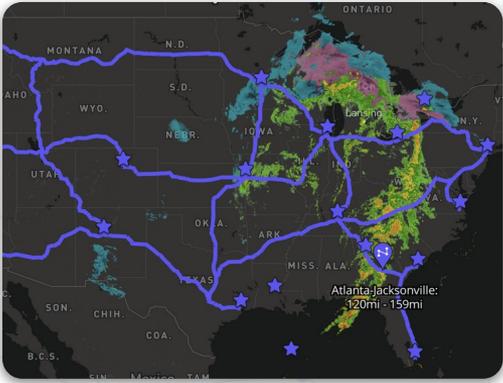UCAR Center Green Campus
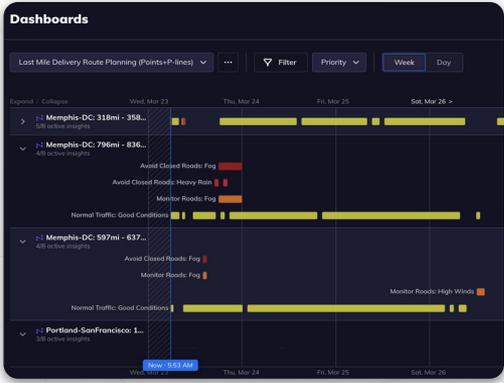
Thursday July 27, 2023

3:30pm Mountain

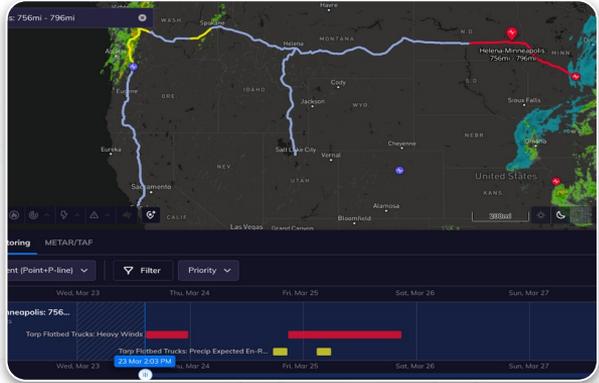UIFCW 2023
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Tomorrow.io's dashboard can be tailored to your specific needs

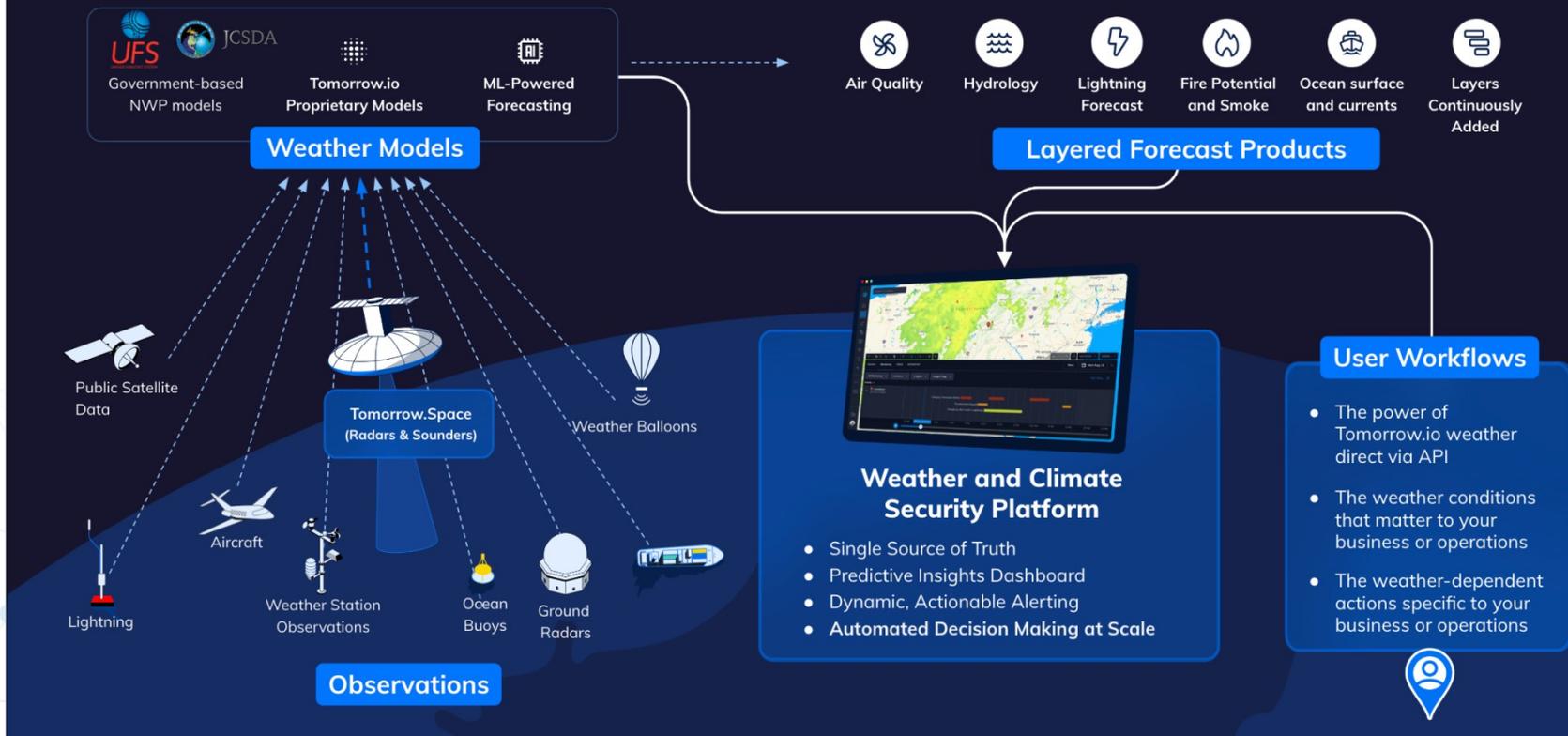Upload fixed routes point location or use the routing endpoint for dynamic routes

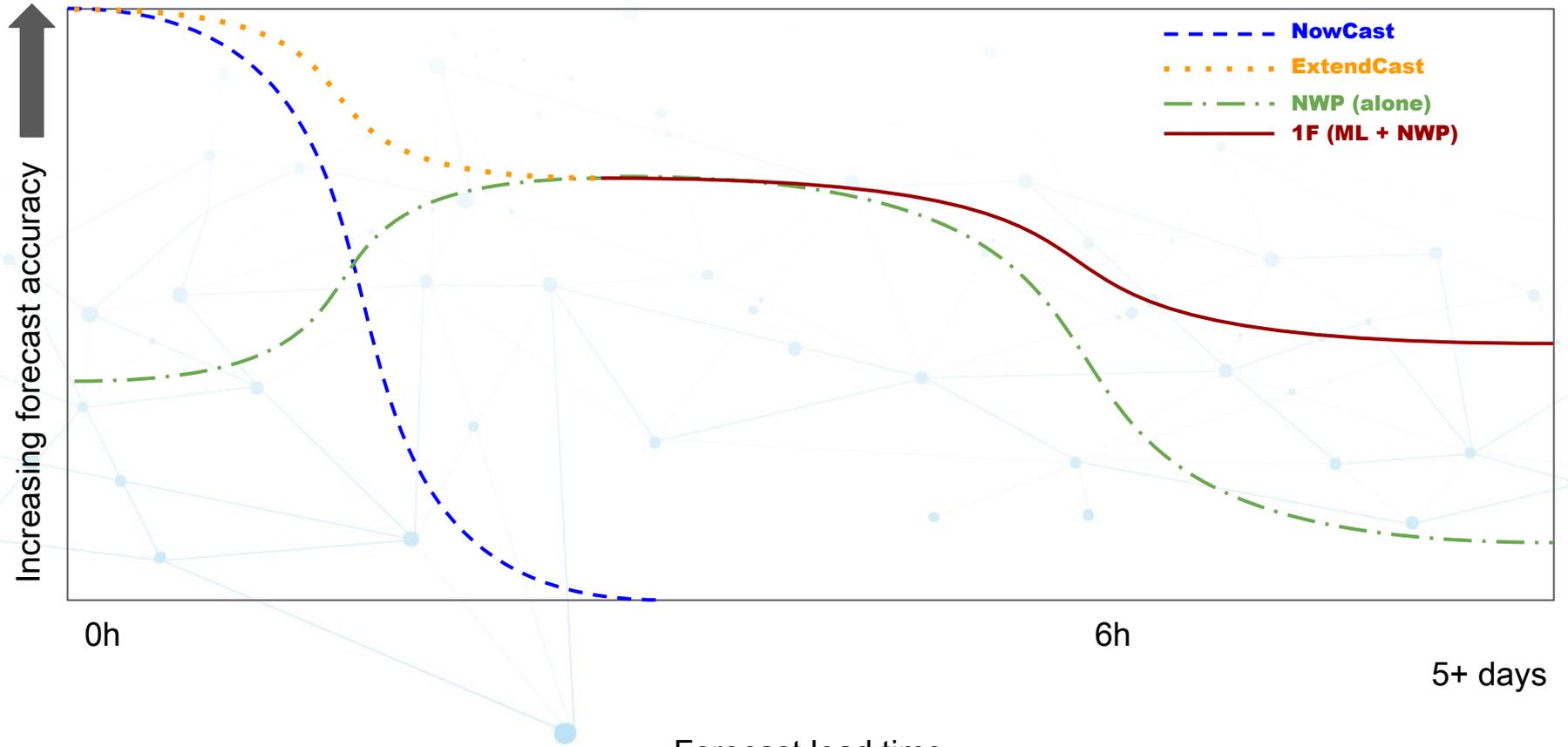Create insights and alerts based on specific weather parameters

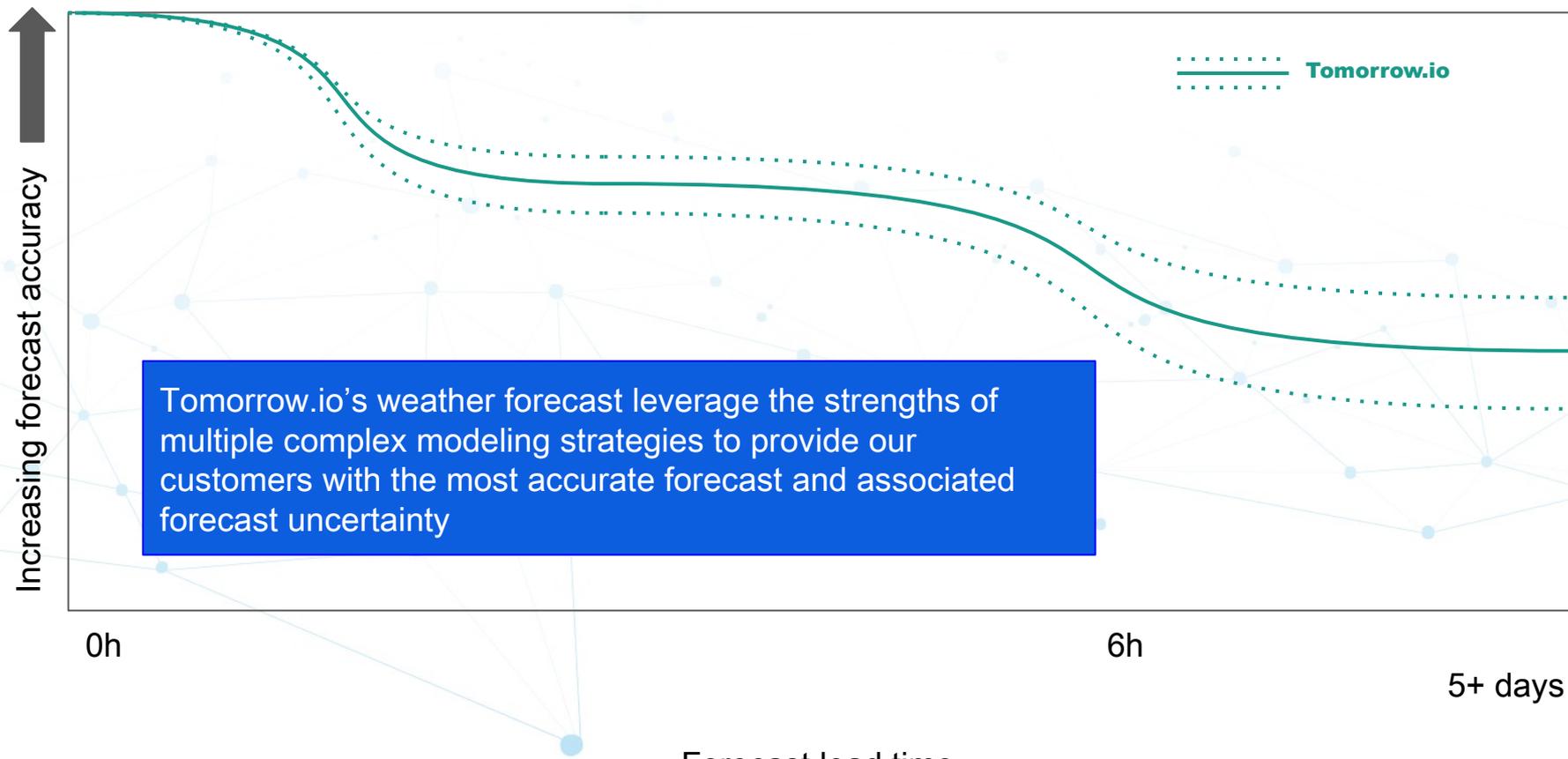Visualize and manage alerts along routes in real time

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Innovating Across the Entire Weather Value Chain

Weather Models

UFS — Government-based NWP models

JCSDA

Tomorrow.io Proprietary Models

ML-Powered Forecasting

Layered Forecast Products

- Air Quality
- Hydrology
- Lightning Forecast
- Fire Potential and Smoke
- Ocean surface and currents
- Layers Continuously Added

Observations

- Public Satellite Data
- Lightning
- Aircraft
- Weather Station Observations
- Tomorrow.Space (Radars & Sounders)
- Ocean Buoys
- Ground Radars
- Weather Balloons

Weather and Climate Security Platform

- Single Source of Truth
- Predictive Insights Dashboard
- Dynamic, Actionable Alerting
- **Automated Decision Making at Scale**

User Workflows

- The power of Tomorrow.io weather direct via API
- The weather conditions that matter to your business or operations
- The weather-dependent actions specific to your business or operations

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Leveraging multiple models to optimize accuracy across time scales

Increasing forecast accuracy

NowCast
ExtendCast
NWP (alone)
1F (ML + NWP)

0h   6h   5+ days

Forecast lead time

Integrated Modeling View From the Eyes of Our Customers

Tomorrow.io's weather forecast leverage the strengths of multiple complex modeling strategies to provide our customers with the most accurate forecast and associated forecast uncertainty
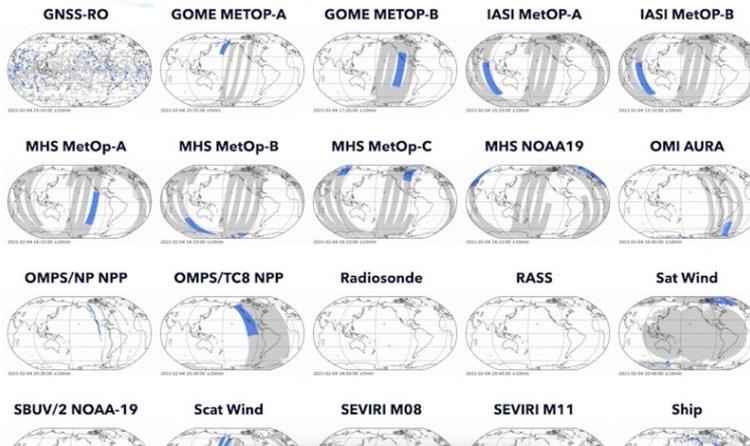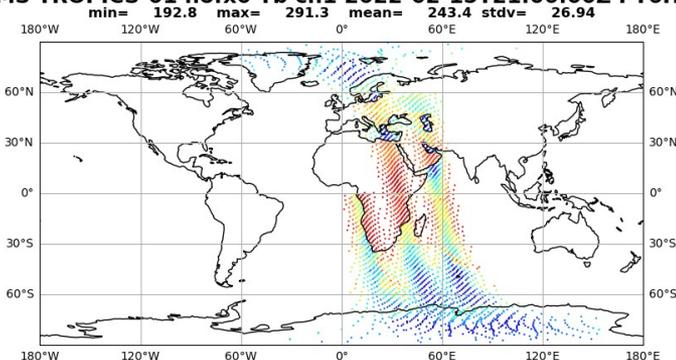
Partnerships and Plans

External Science/Development Support

- NOAA CRADA
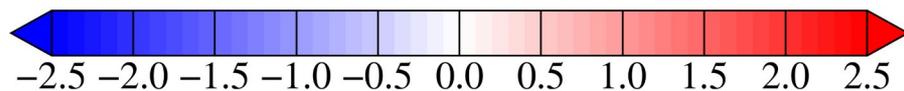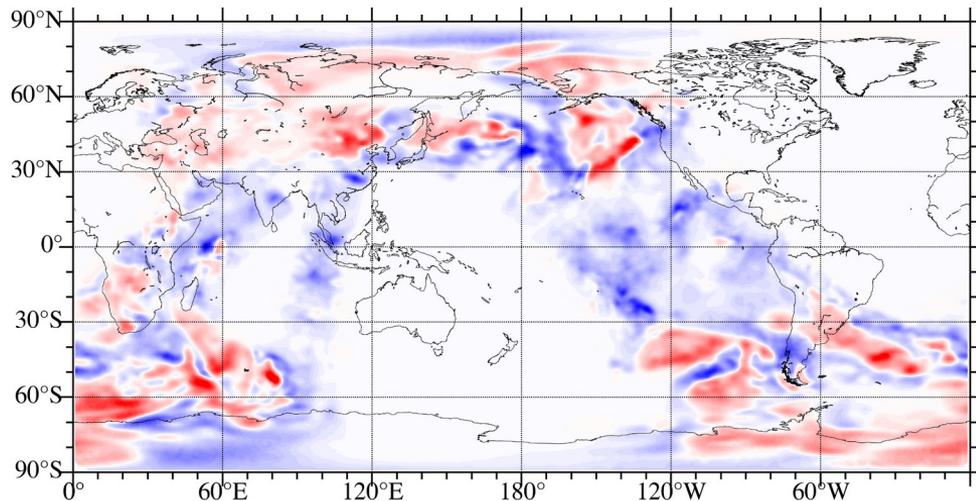- JCSDA

Internal Weather Team Development

- Operational UFS/JEDI Cycling
- Continue using nature runs to simulate observations
- Work on building up our testbed system to assimilate the simulated observations
- Radar operators
  + 3DVAR / 4DVAR / EnKF
  + Many observations
  = OSSE

TMS TROPICS-01 hofx0 Tb ch1 2022-02-15T21:00:00Z PT6H
min= 192.8   max= 291.3   mean= 243.4   stdv= 26.94

Total: 2739.0

GNSS-RO   GOME METOP-A   GOME METOP-B   IASI MetOP-A   IASI MetOP-B

MHS MetOp-A   MHS MetOp-B   MHS MetOp-C   MHS NOAA19   OMI AURA

OMPS/NP NPP   OMPS/TC8 NPP   Radiosonde   RASS   Sat Wind

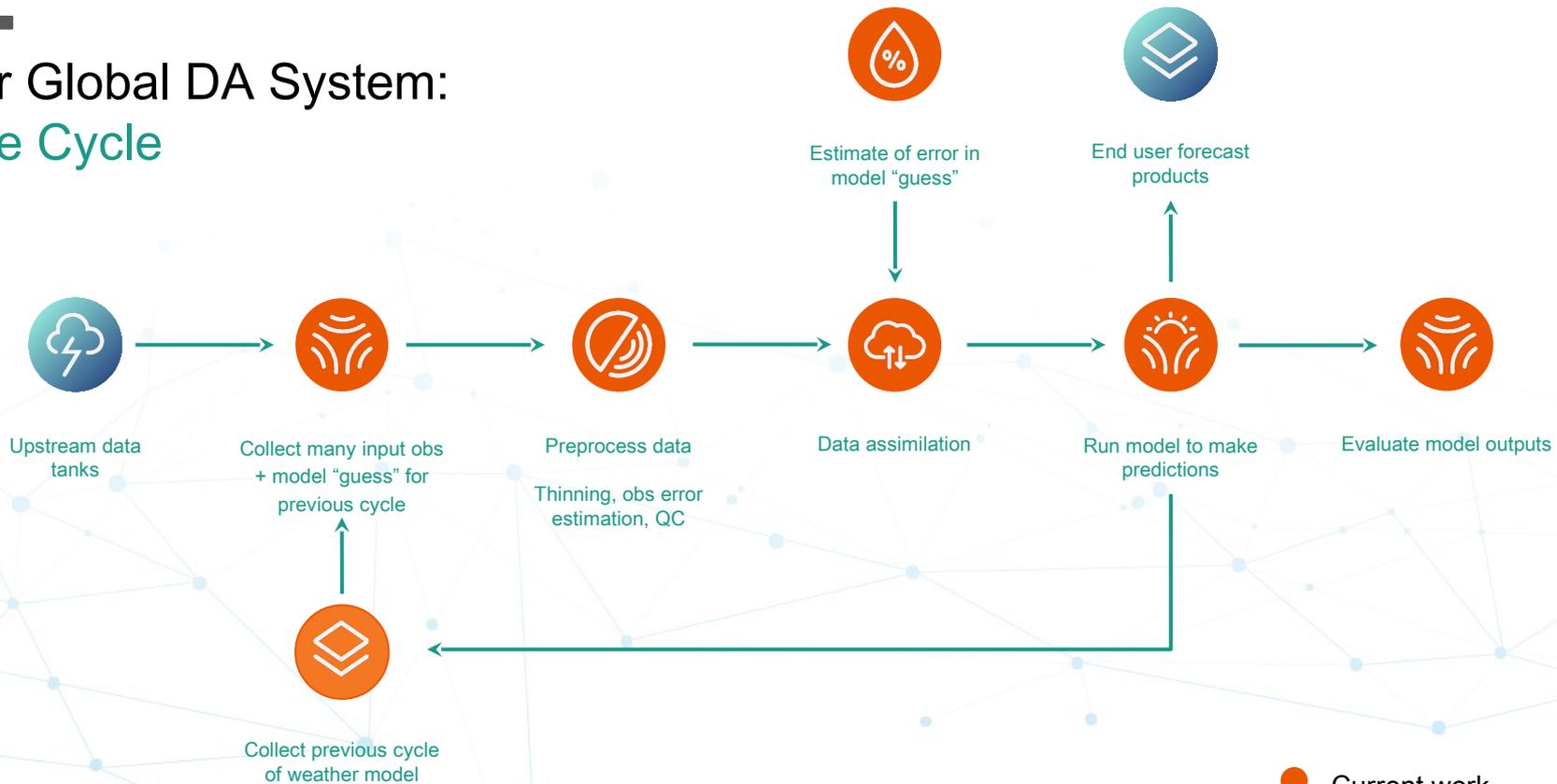SBUV/2 NOAA-19   Scat Wind   SEVIRI M08   SEVIRI M11   Ship

Building Our Global DA System

- UFS/JEDI 3DVAR is working! Our simulated data has an impact on our model.

- Figure shows model **increment** for temperature at 540 hPa, based on multiple TMS orbits ingested over a six hour window.

- Next work: Adding more instruments.

Collect input obs + model results from previous cycle

Preprocess data

Thinning, obs error estimation, QC

Data assimilation

Update model to reflect the new observations

Run a new forecast and repeat the cycle

Our Global DA System:
One Cycle

Estimate of error in model "guess"

End user forecast products

Upstream data tanks → Collect many input obs + model "guess" for previous cycle → Preprocess data (Thinning, obs error estimation, QC) → Data assimilation → Run model to make predictions → Evaluate model outputs

Collect previous cycle of weather model

● Current work
● Cross-org connections

Helpful Government Support

- Tutorials, academies, and workshops are a great way to introduce new users to the system
- NOAA's transition to GitHub has made it much easier to understand their systems.
- Shared computing resources (like the Orion supercomputer) make collaboration easier

HPC Considerations

- The JCSDA/NOAA/NASA effort to unify the software stack needed to perform DA and run models is fantastically implemented
  - Users can be confident that codes are portable and decently tested
  - Containerization and cloud migration efforts also help users to use NOAA models
- Many missed opportunities for optimizing code to reduce runtime and overall cost.
  - GMAO has novel work on automatic differentiation and GPU offload of models
  - Overall system needs considerable performance profiling.

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Barriers to Development

- Too much code is still hardcoded to NOAA systems
  - This is being addressed, but there is a ton of remaining technical debt
- At present, there is no good method to work closely with JCSDA, even on a NOAA CRADA project
  - This blocks shared research and development
  - There is also no policy for community contributions to JCSDA
  - Contributions are somewhat discouraged, and this goes against the UFS/EPIC vision
  - Documentation practices need work
    - JCSDA example: rationale for changes and change logs are kept internal
    - This breaks downstream applications, and it makes it hard for EPIC to prepare for JEDI

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How we would want to contribute:

- We would like to work with CRTM, JEDI, and the wider community to develop the core science needed to use satellite radar in a global DA system
  - It would help if CRTM development were more open
  - We need a radar operator, and we need an open source CRTM coefficient generation package
- We want to make instruments with the best possible impact
  - Shared experiments
  - We need a framework for open collaboration.

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Thank you!