NOAA Global Systems Laboratory

Advanced Technologies

Speakers

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Global Systems Laboratory

Review - Technologies and Developments

Technology

- Data Systems
- GPU Computing
- Exascale Computing
- Machine Learning
- Cloud Computing
- Visualization

Development

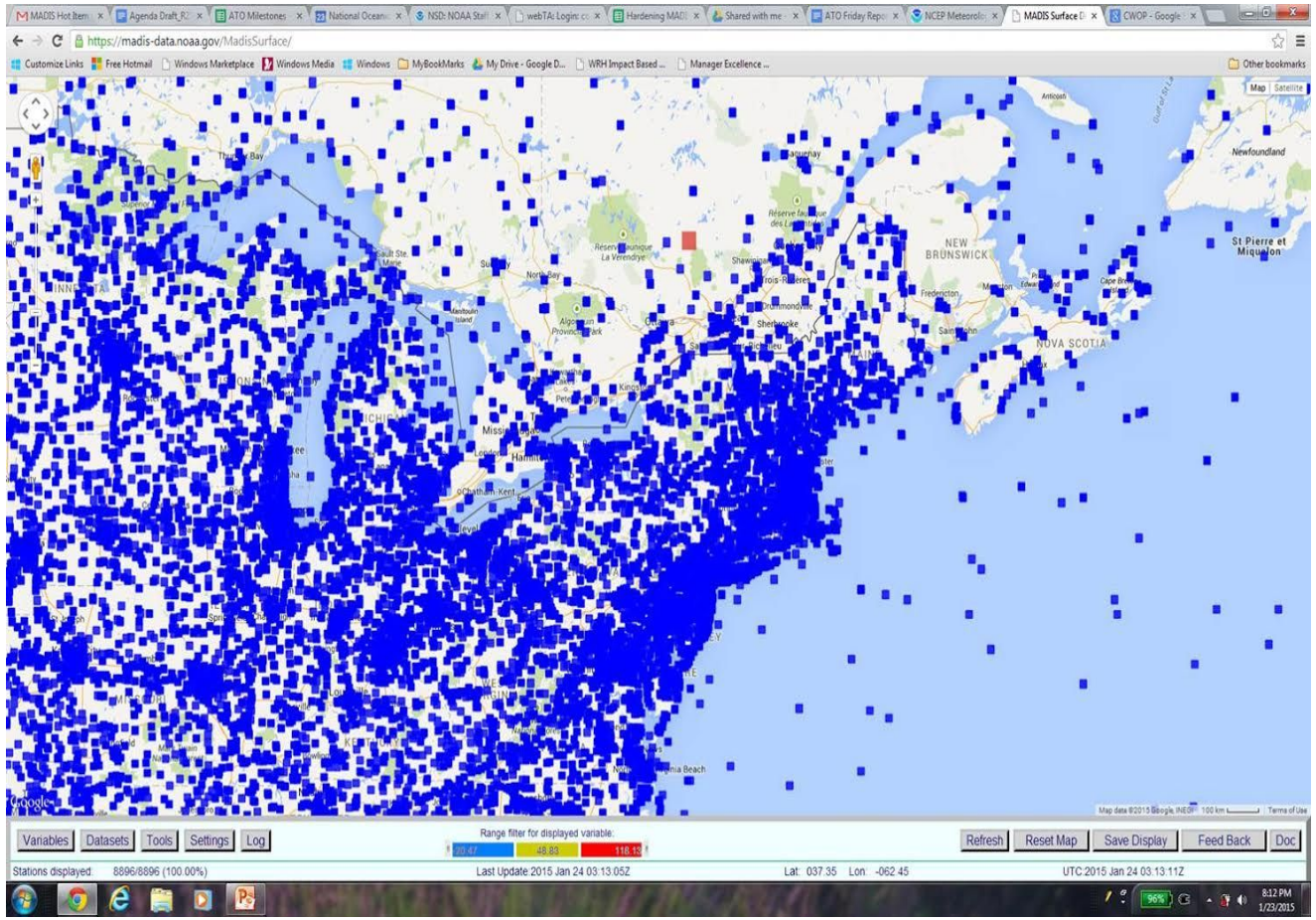
- MADIS
- AQPI
- NUM

Investment and Impact

• Explore and track potential technologies • Investigate promising technologies to understand potential • Develop prototypes to understand, measure value, capability	GSL Funds
• Sustain investment to improve capabilities ○ performance, ease-of-use, data handling, flexibility, understanding • Transition capability to an operational entity	GSL, JTTI WPO, NWS Funds

Data Systems – MADIS (2001 – 2020)

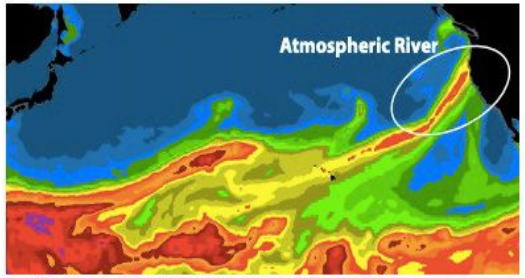
NOAA surface stations with MADIS



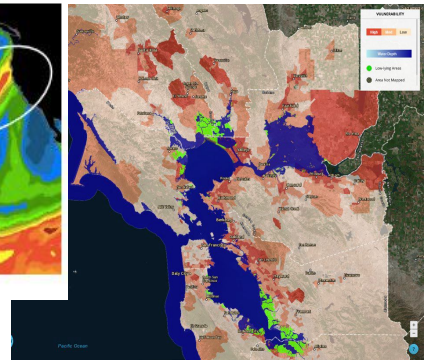
- Revolutionized data systems development
  - Thousands of providers
  - Millions of observations
  - Standardized data access
  - High-quality QC procedures
  - Operational capability
  - Transitioned to NWS
- Established a high quality standard for handling observations

AQPI – observations, models, forecasters

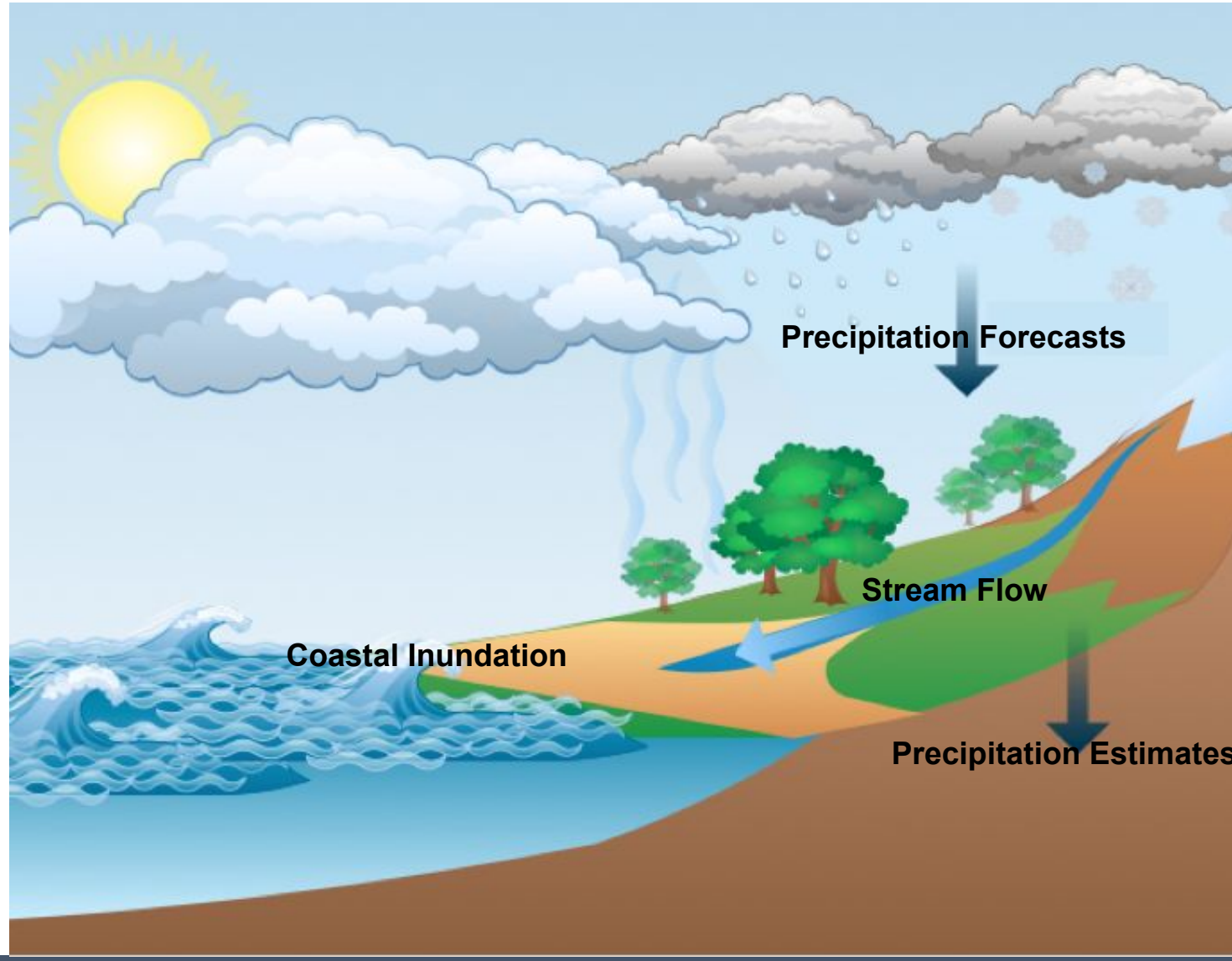
- Prediction
  - Flooding, waste water, coastal impacts, streams flow



Satellite image of an atmospheric river in February 2017.

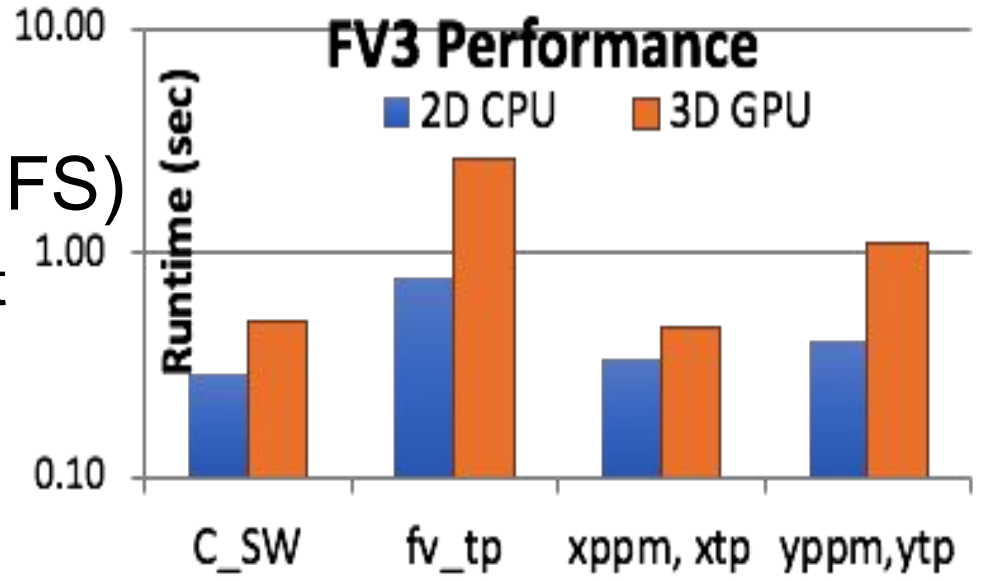


- Users
  - Cal Dept of Water Resources
  - 9 San Francisco counties
  - USGS
  - CIRA
  - NOAA GSL, PSL



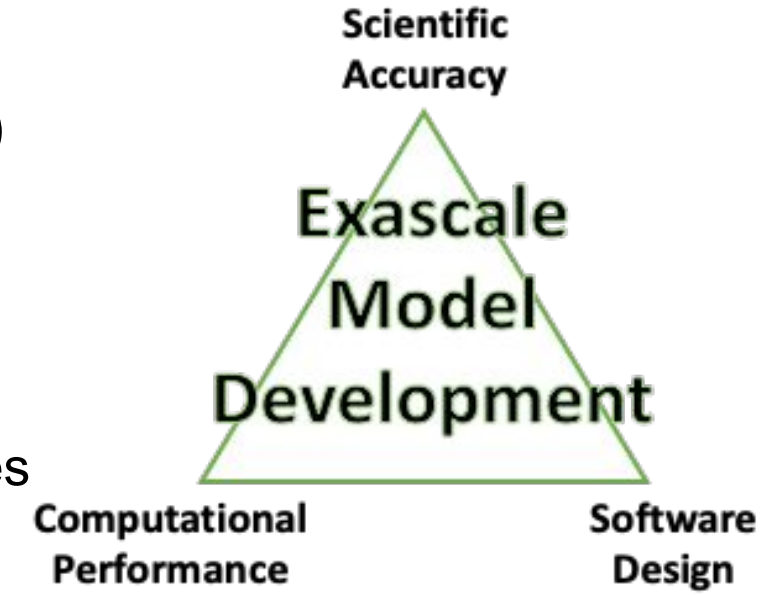
GPU Computing

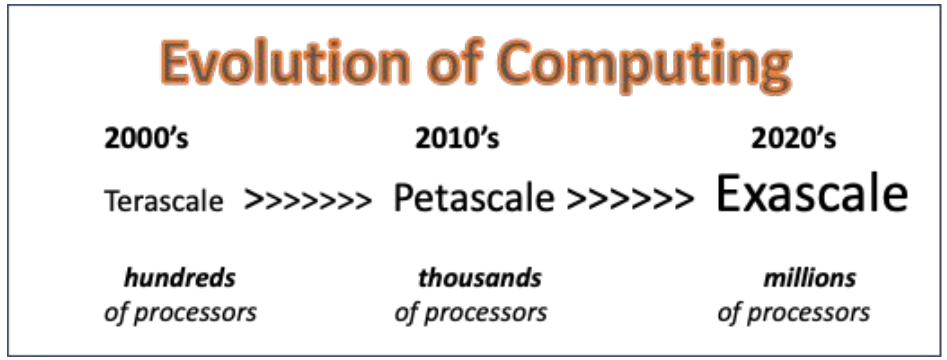
- 2010: GSL built directive-based GPU compiler
  - Worked with the industry to develop, improve standard for GPU programming
- 2015: GSL demonstrated performance and portability with a single Fortran code on CPU, GPU and MIC processors with Nonhydrostatic Icosahedral Model (NIM)
  - Approach adopted by MPAS model
- 2017-18: Parallelization of FV3 dycore (UFS)
  - Poor performance and portability showed that a major rewrite would be required
  - GFDL modeling team support



GeoFLuid Object Workbench (GeoFLOW)

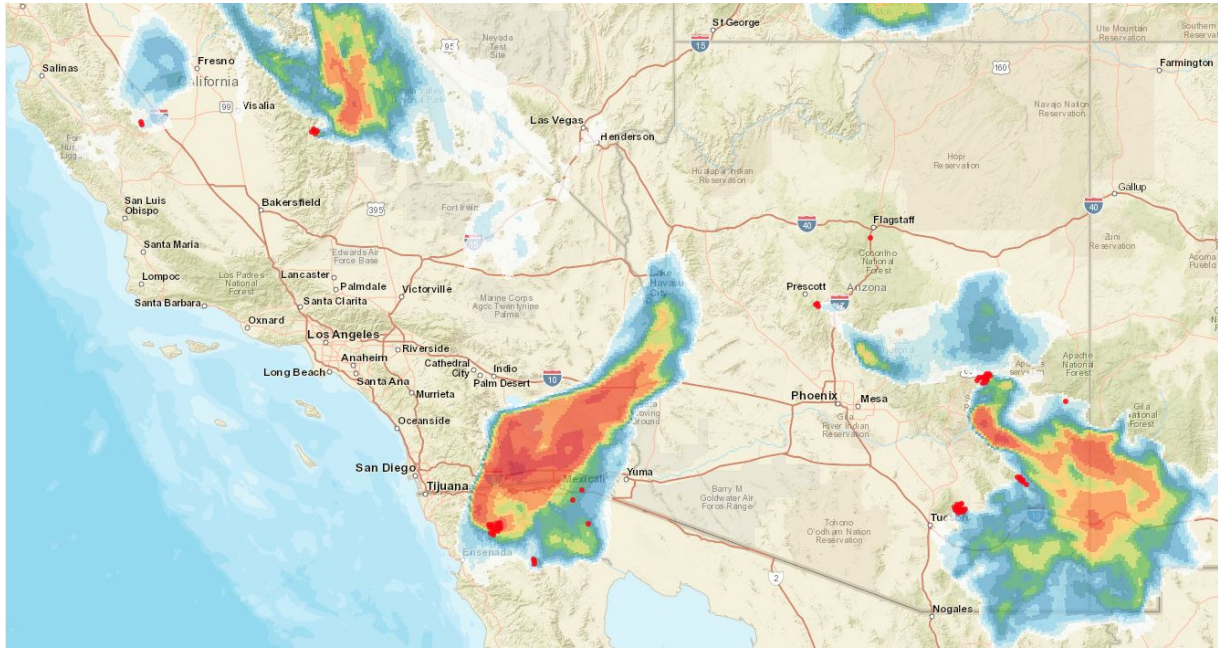
- Explore how to develop kilometer-scale, global earth system models for Exascale Computing Era (2025 -)
  - Performance: target operational capability
  - Portability: CPU, GPU, hybrid
  - Productivity: for scientists, developers, engineers, users
  - Software: manage complexity, explore alternative languages
  - Visualization: handle high volume data effectively
- Evaluate algorithms for scientific accuracy and computational performance
  - Spectral element and finite volume approaches
  - Cartesian, icosahedral, cube-sphere grids
- Push the boundaries in science
  - Enable sub-kilometer processes



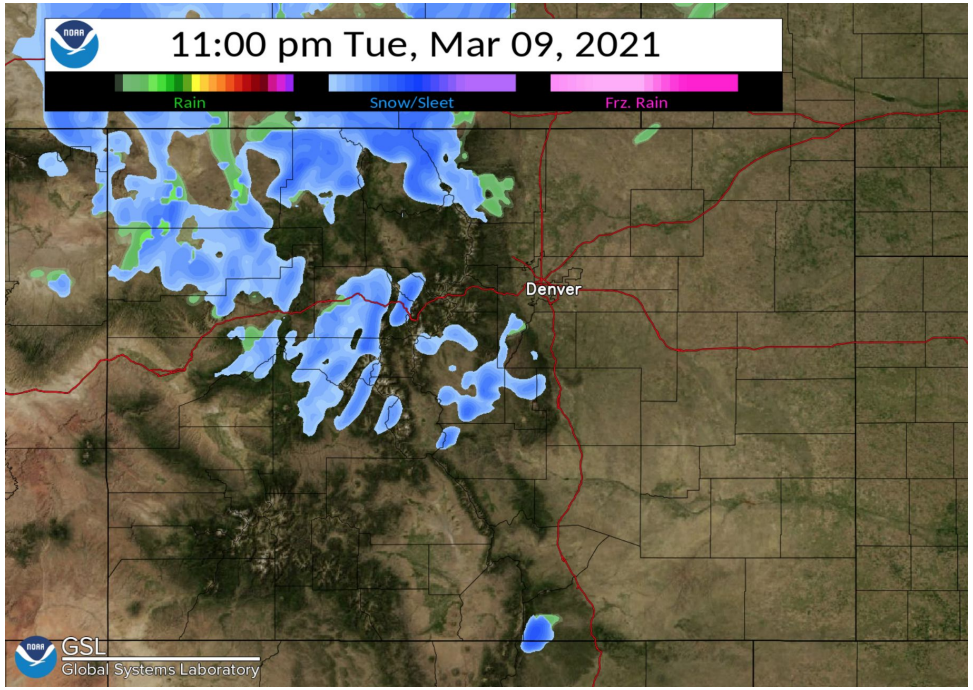


Visualizations Reaching Forecasters

Widely used visualization capabilities



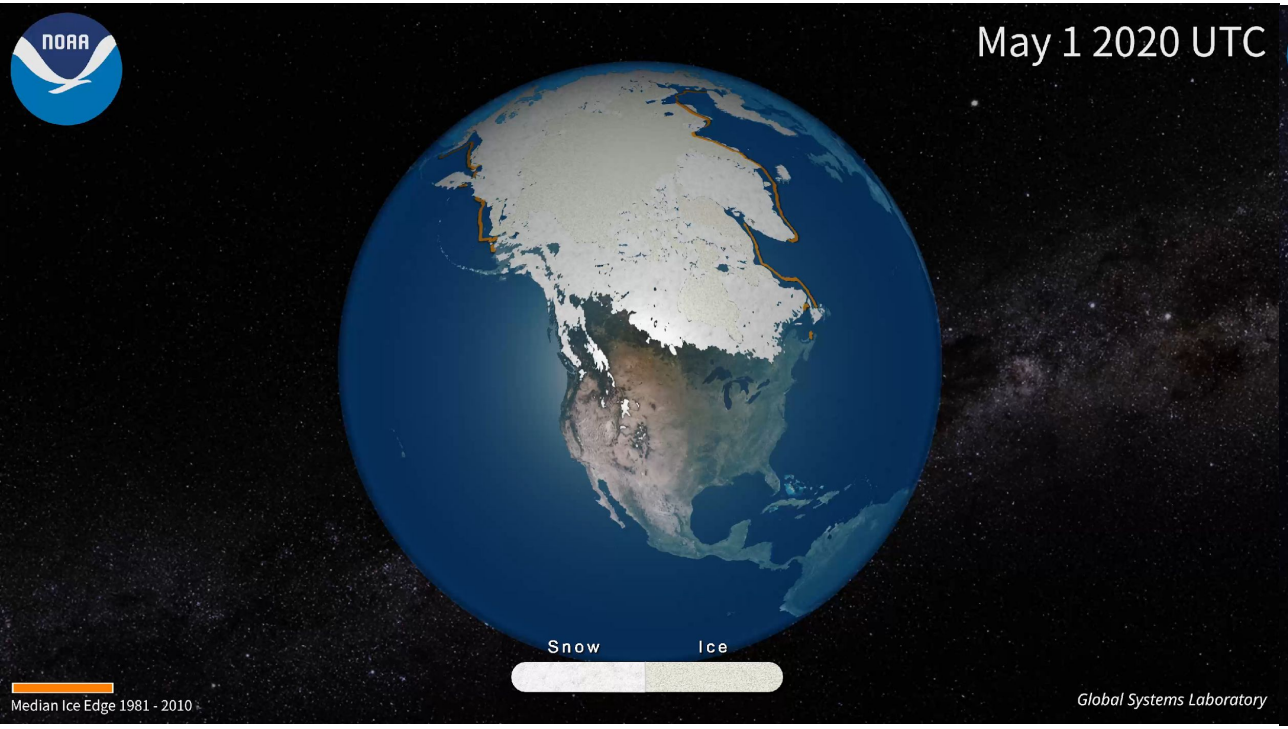
Interactive smoke visualization
(Peak ~ 1 million request per hour)



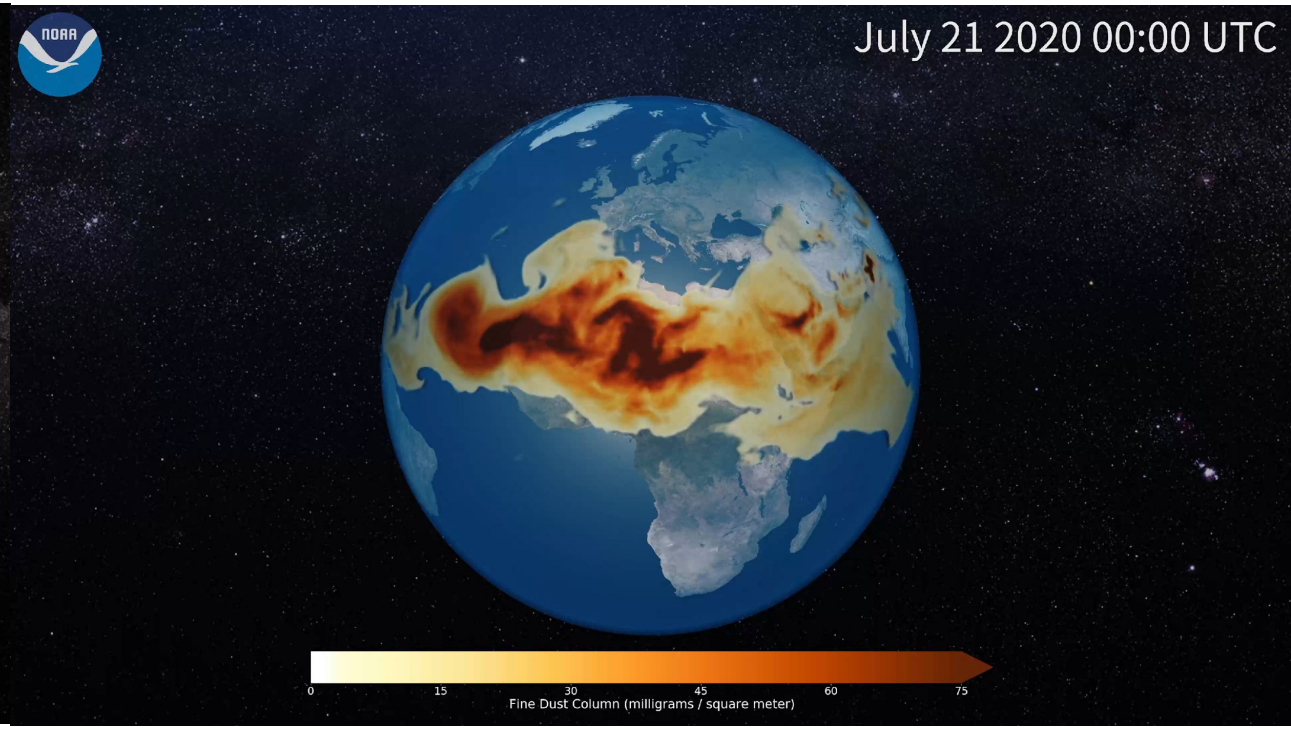
Weather Archive and Visualization Environment (WAVE)

Visualizations Reaching the Public

Engaging Visualization, Driving Readers to Stories



Arctic sea ice minimum

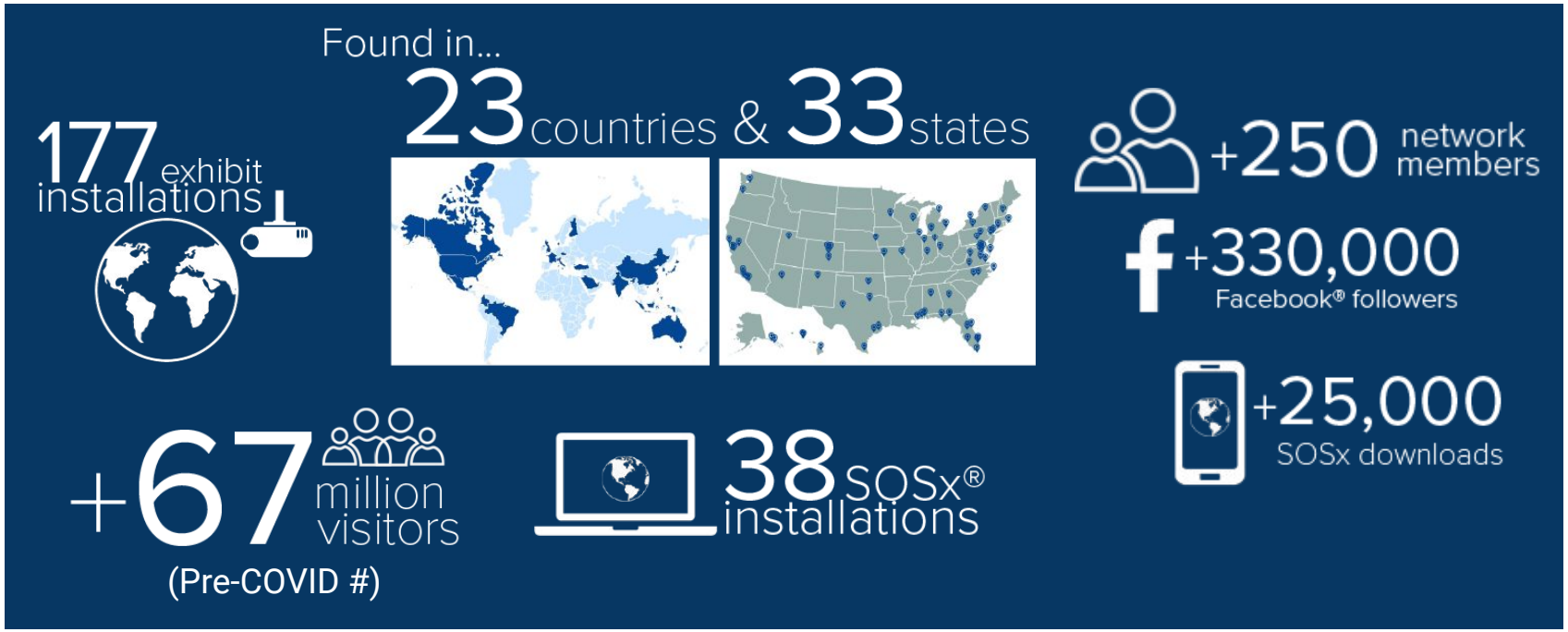


African dust across the Atlantic

Visualizations Reaching the World

Science on a Sphere
NOAA's Premier Education Tool

SOSx Mobile 25K+ Downloads



Cloud Development for NOAA

Modeling and Computing

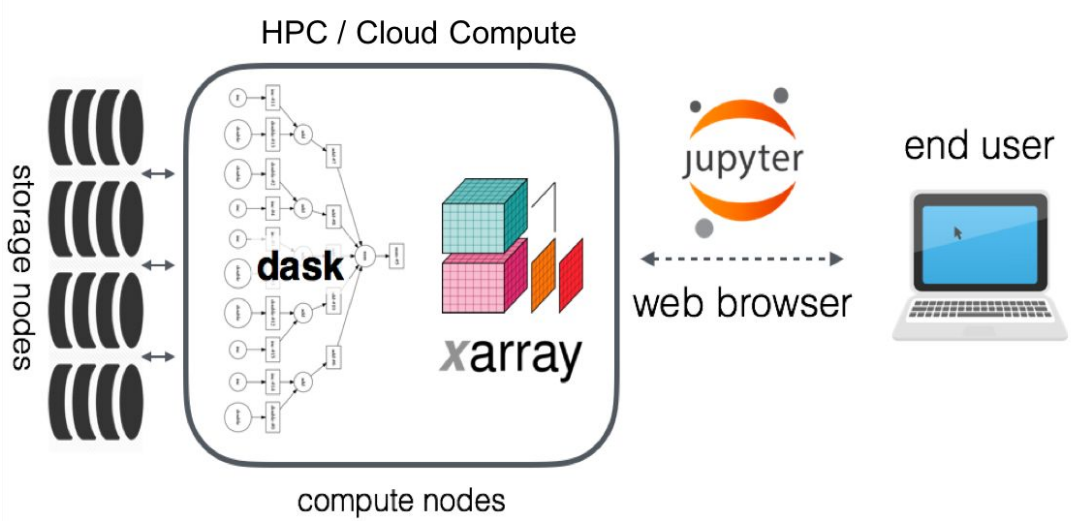
- Development of UFS and Global Workflow
  - Ability to run end-to-end workflow using cloud services
- Rapid Refresh Forecast System (RRFS) in the cloud (Partnership with EMC)

Exascale Visualization and Analysis

- Multi-threaded data processing
- Data storage, access, tools

Leadership

- GSL co-lead of OAR Cloud Tiger Team



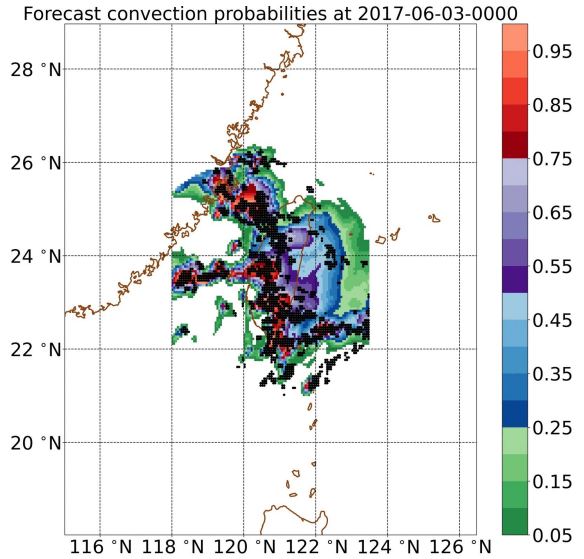
Computing and Data Handling Pipeline

Machine Learning – Computing and Data

Feature detection, tracking and prediction

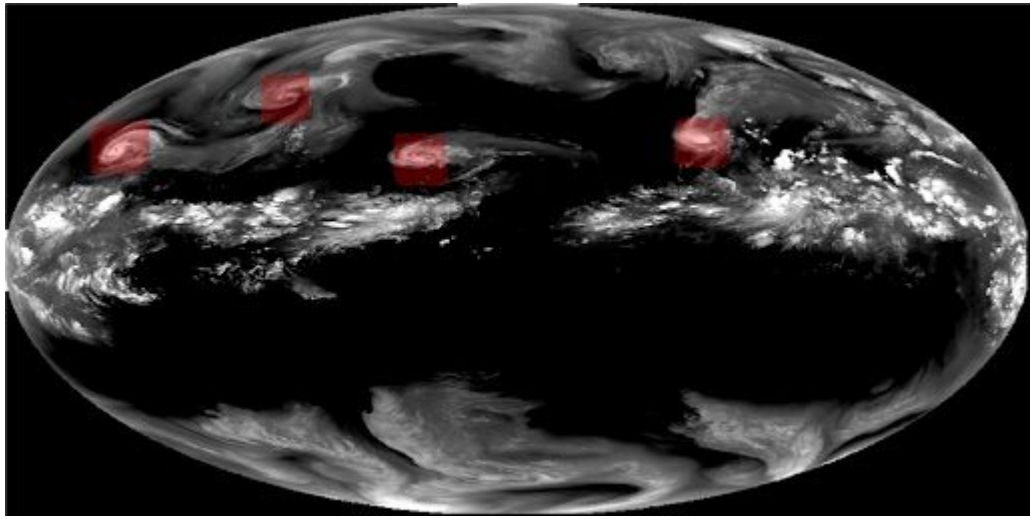
Tracking

- Generate probabilistic forecasts of areas of likely convection initiation



Feature Detection

- Detect and target areas for data extraction



Physics Parameterizations

- Radiative Transfer Model
- Physics guided neural network with physical constraints for higher accuracy

Summary

- Relevance
  - Computational challenges running cloud resolving models on exascale computers
  - Develop cloud, ML, visualization to handle enormous amounts of data
- Quality
  - Cloud and Machine Learning demonstrate new capabilities in data, computing
  - Demonstrate world-class research in GPU, exascale
  - Impactful visualizations support forecasters, communicate science to world
- Performance
  - GPU research has been impactful
  - NIM demonstrated performance and portability on CPU, GPU is achievable
  - MADIS transition to NWS operations
  - SOS installations around the world viewed by millions of people