Office of Naval Research

Meteorology Research Supporting Aviation Gaps

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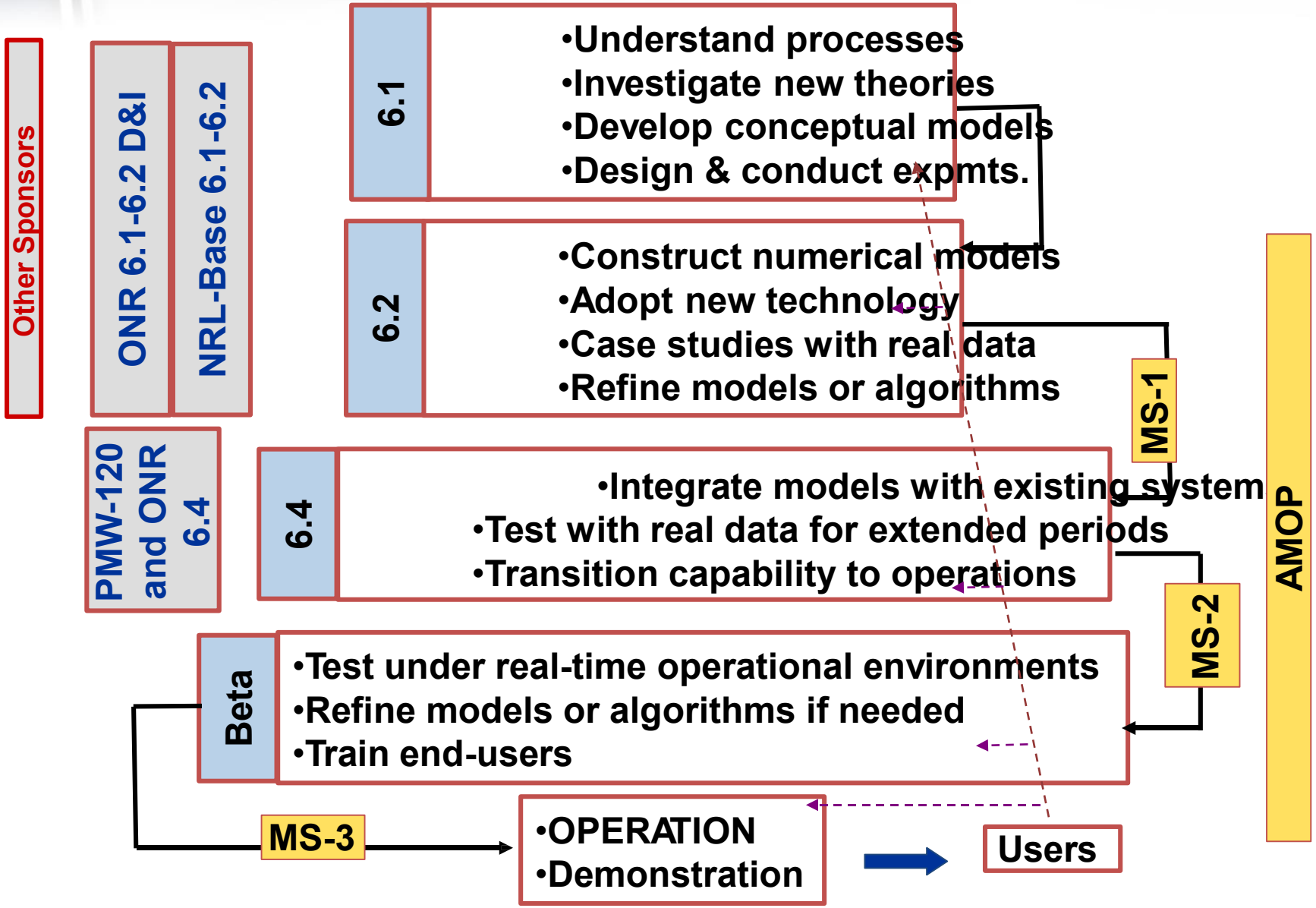
ONR Marine Meteorology and Space Team (Code 322MM)

Friends & Partners in Aviation Weather (FPAW) Technical Exchange Meeting
5 October 2021

Outline

- Overview of ONR Marine Meteorology Research Paradigm
- Advanced Prototypes for Operational Transition
  - *Statistical Post Processing of Numerical Model Prediction Biases*
  - *Probability Distributions for Sensible Weather*
  - *Triton Hazardous Weather Avoidance*
- Applied Research
  - *The Geolocation Information Processing System (GeoIPS)*
  - *OVERCAST Technical Candidate Program*.
- Basic Research
  - *MAGPIE Departmental Research Initiative Program*
- Summary

ONR Marine Meteorology: Vertically Integrated R2O



Forecast Improvement Through Statistical Post-Processing

Lead PI: Daniel Hodyss, Daniel.Hodyss@nrl.navy.mil

Objectives

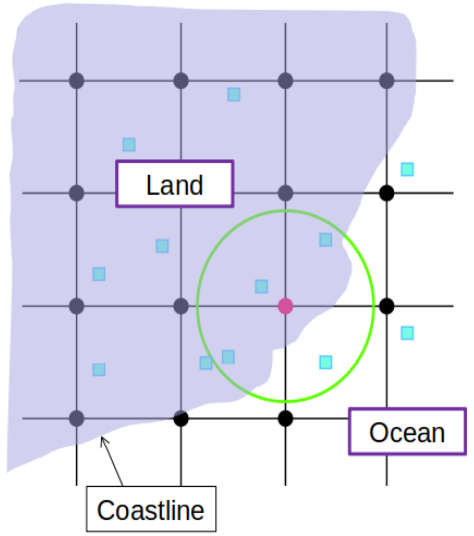
- The prediction of Naval relevant operating parameters is plagued by model biases.
- These model biases strongly vary in space and time, which leads to difficulty building appropriate training sets for learning algorithms.
- We developed software that attacks this regional bias problem

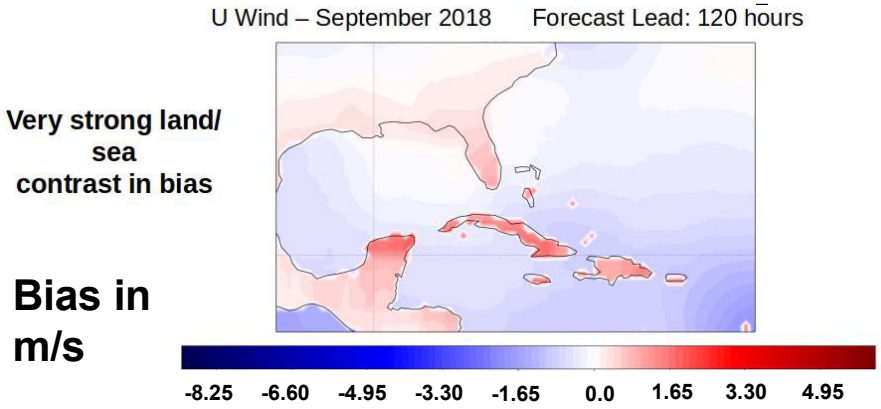
Technical Approach

- Build training sets from observational data rather than analysis datasets, which are highly biased
- Constrain training sets to be highly tuned to the statistics of the particular grid point being processed
- Develop algorithm to minimize the squared error on a point-by-point basis

Accomplishments

- Transitioned surface wind (10-meter) post-processing system in 2019.
- Delivered the algorithm/training suite as well as the performance improvements obtained from the new system to FNMOC.





Developed processing to be land/sea aware.The new algorithm clearly detects the strong land/sea contrasts of the bias in littoral zones and around islands. This strong bias contrast implies model parameterization issues with surface roughness.

Enhanced Probability Distributions

Lead PI: Justin McLay, Justin.McLay@nrlmry.navy.mil

Objectives

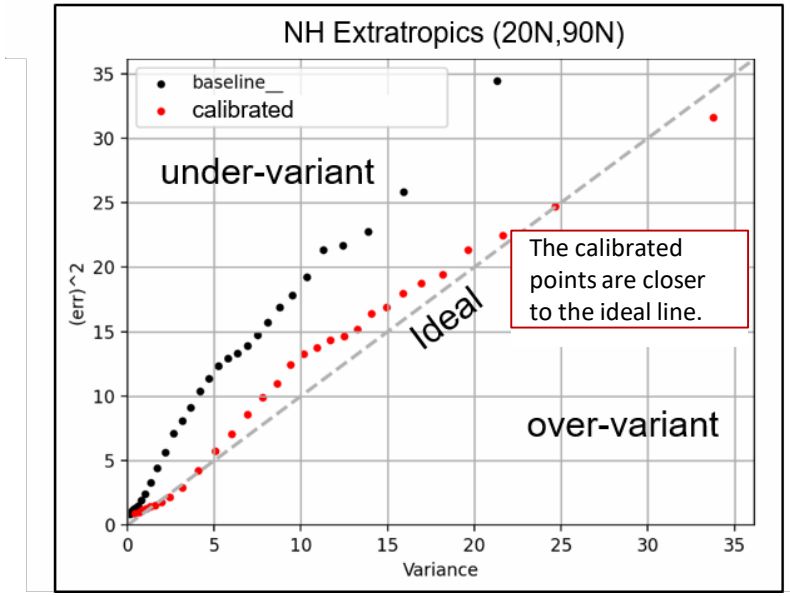
- To provide superior forecast probability distributions for selected operationally-critical weather variables.
- The difficulty is that often the variables that are most operationally critical (e.g. icing, clouds, turbulence) are not well predicted by global numerical forecasts.

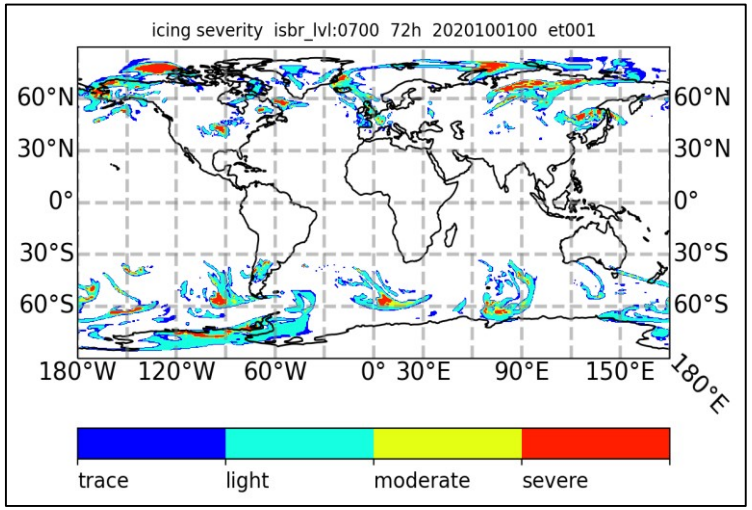
Technical Approach

- Add value to the raw numerical forecast using statistical methods to correct the variance of the raw forecast distribution, a process called “calibration”.
- This will provide the first ever aviation calibration capability for the Navy global ensemble forecasts.
- There is potential for strong gains in skill at relatively modest computational cost.

Accomplishments

- A fully functional prototype calibration system was developed for flight-level air temperature and winds.
- A multi-season (winter/summer) validation was completed. It confirmed that the calibration greatly improves the forecast’s spread-skill relationship.
- Sensitivity testing was used to identify optimal calibration parameter settings.





Triton Hazardous Weather Avoidance

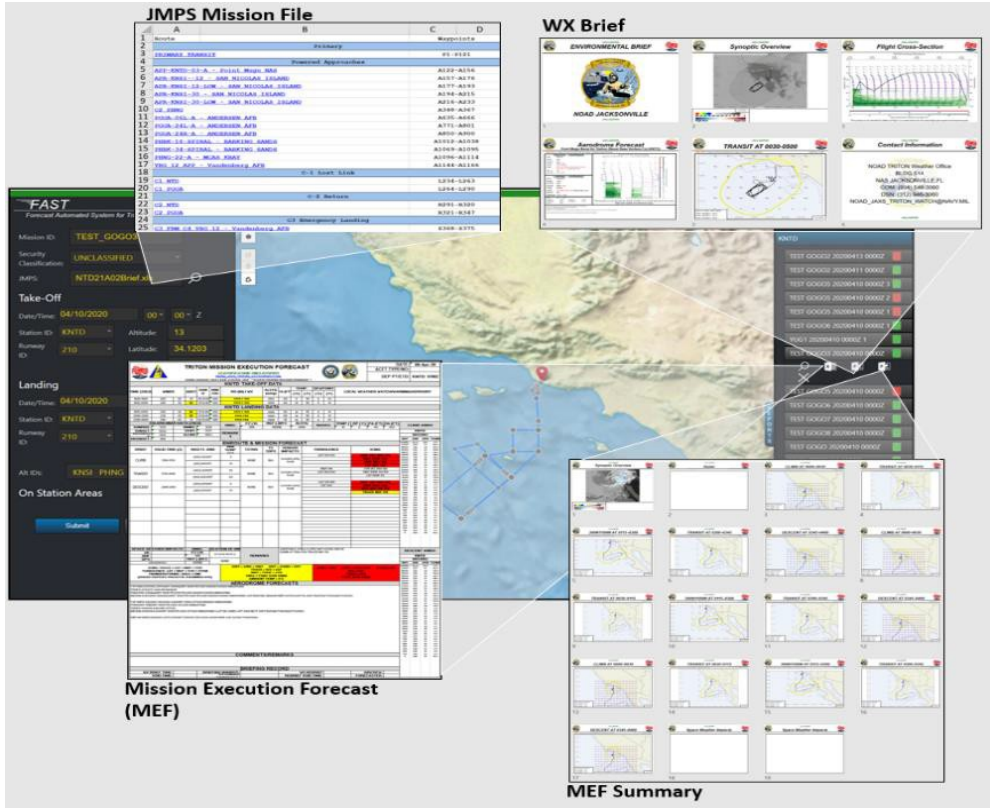
Lead PI: Brent Houghton, Brent.Houghton@nrlmry.navy.mil

Objectives

- Problem: Flight weather briefing preparation takes 2-4hrs of manual data compilation and briefing material prep time – time should be used for data analysis and forecast.
- Objective: Automate flight weather briefing preparation process, saving Aerographer's Mate (AG) 1.5-2.0 hrs per flight that can be used for analysis and/or additional support tasks

Technical Approach

- Parse Joint Mission Planning System's (JMPS) mission file, and eliminate any manual input errors
- Provide flexibility to adjust flight duration due to last minute considerations
- Automate the creation of flight briefing products to less than 15 minutes, and return to AG for analysis and updates
- Briefing products in Microsoft formats for easy AG edits



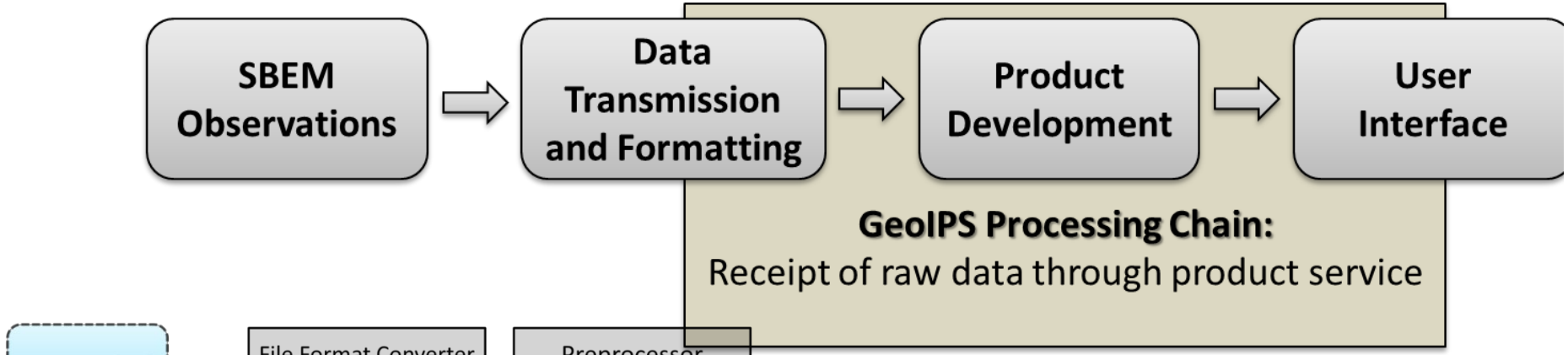
Accomplishments

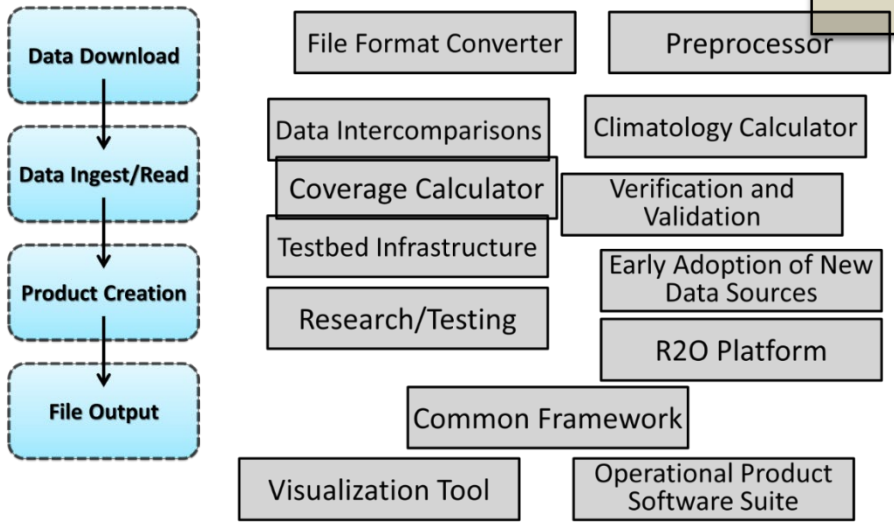
- Eliminated manual inputs by loading/parsing JMPS file from squadron
- Automation of Support Brief Generation
- Implemented ability to change JMPS flight duration prior to flight. Occurs >50% of time.
- Transitioned to FNMOC 18 Sep 2020

Geo-located Information Processing System (GeoIPS®)

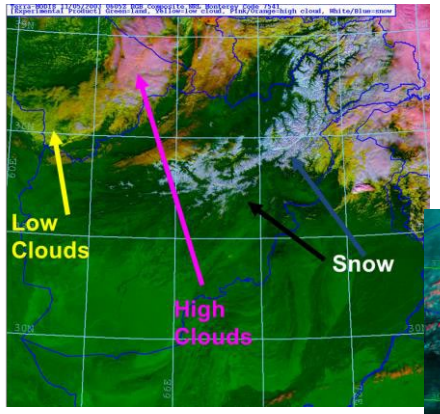
Lead PI: Mindy Surratt, Melinda.Surratt@nrlmry.navy.mil

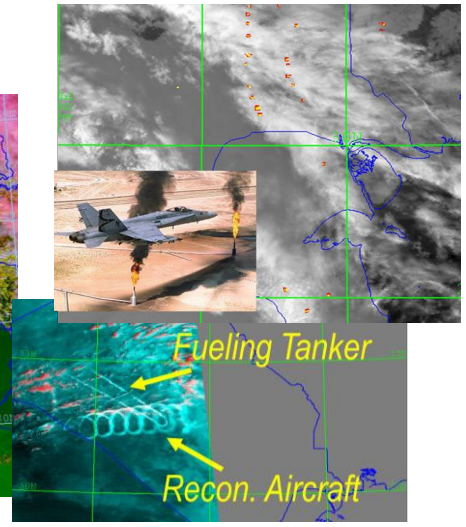
- An open source, government IP software suite for METOC data processing/fusion capabilities.
- Have researchers share same software suite as operational production, streamlining R2O.





File Format Converter
Preprocessor
Data Intercomparisons
Climatology Calculator
Coverage Calculator
Verification and Validation
Testbed Infrastructure
Early Adoption of New Data Sources
Research/Testing
R2O Platform
Common Framework
Visualization Tool
Operational Product Software Suite





Optical Variability Evaluation of Regional Cloud Asymmetries in Space and Time (OVERCA
Candidate
FY22-FY24

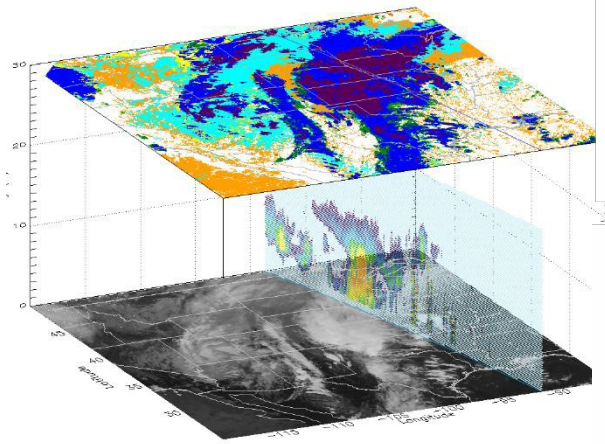
Goal: Integrate new atmospheric research with weather satellites and models to prototype an advanced 4-dimentional atmospheric cloud/aerosol/water visibility tool.

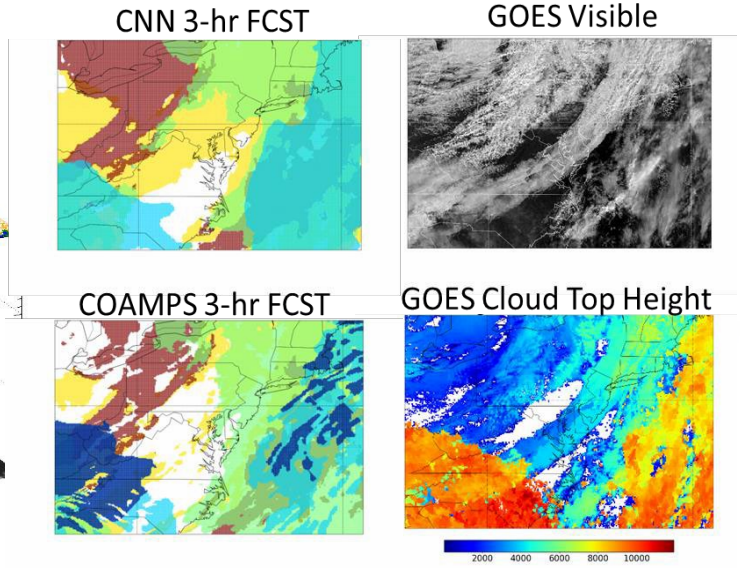
- **Leverage GeoIPS to facilitate data fusion and algorithmic development.**

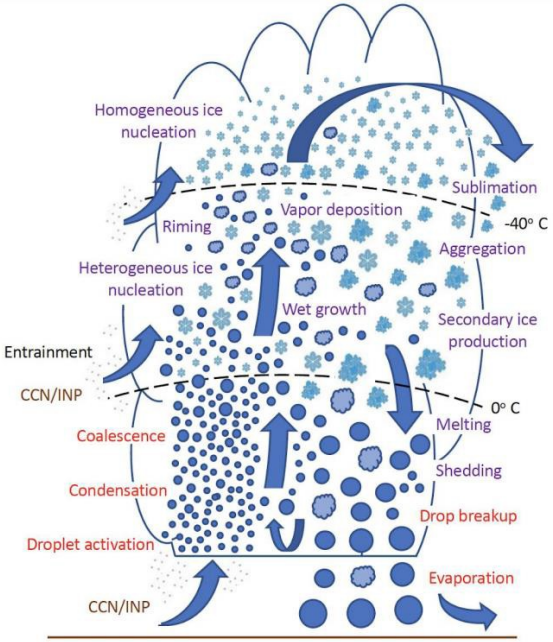
Augment NOAA and NASA enterprise algorithms to support slant path visibility, cloud bases, and 3D structures

Use machine learning techniques to marry satellite and observation data with numerical modeling

Improvements in physics parametrization and representation in forecast models



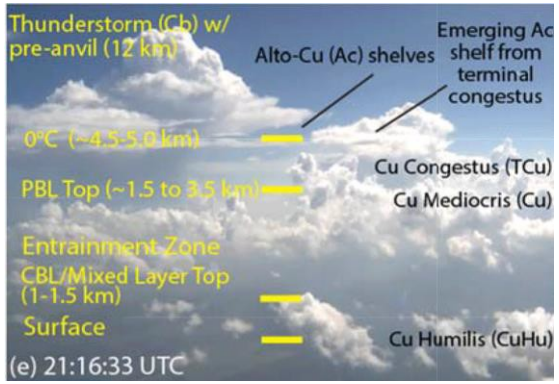


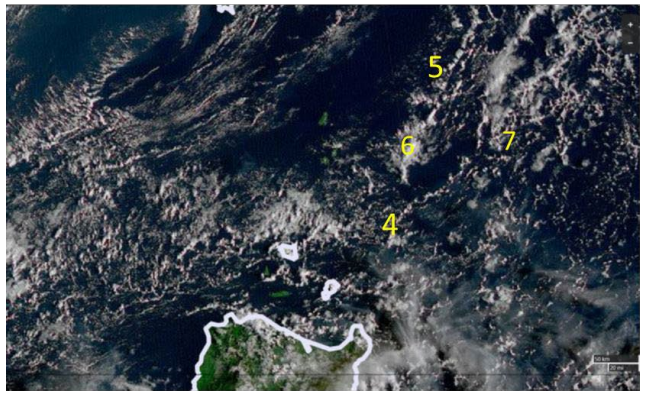


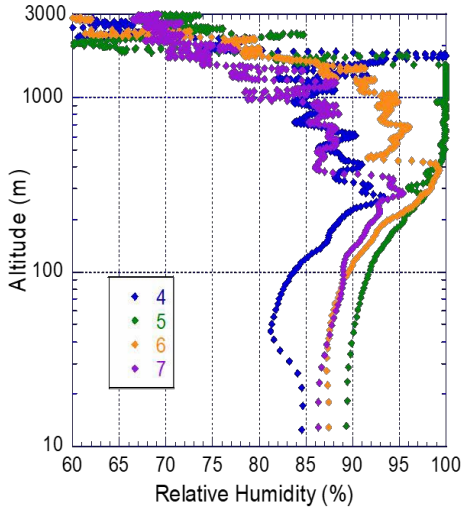
MAGPIE Departmental Research Initiative (DRI) FY22-FY26

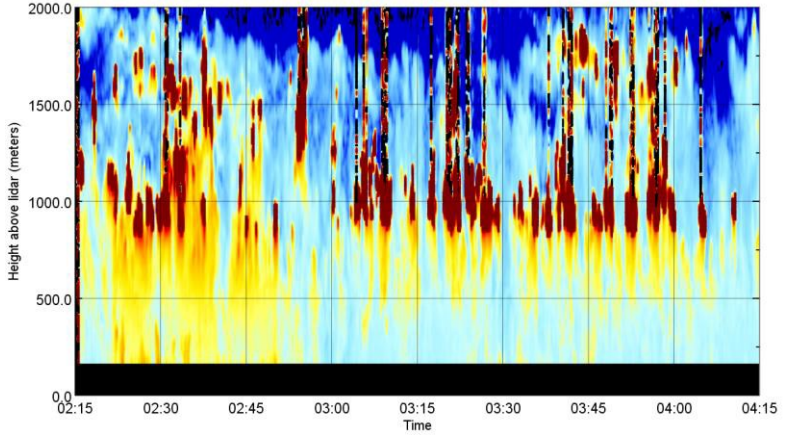
Basic Research on Moisture and Aerosol Gradients/Physics of Inversion Evolution

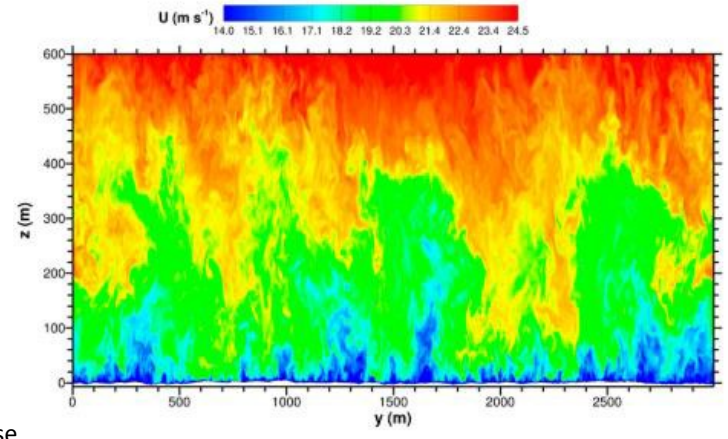
*Understand the **physical mechanisms that control the evolution of the marine atmospheric boundary layer (MABL) inversion top** and, in turn, provide a conceptual theory of how **inversions, clouds, ocean fluxes, and differential gradients of thermodynamics and particles interact as a holistic system** to modulate the atmospheric and ocean surface and boundary layers.*











Summary of ONR Meteorology Aviation

- **What is the goal of your research related effort (which stakeholder gaps will you fill)? (How will it support safer AAM operations?)**
  - ***Support research (from basic science through advanced prototyping) in all aspects of meteorology needed for Naval mission support***
- **Who are your partners?**
  - ***Navy partners – Fleet Numerical Meteorological and Oceanography Center, Fleet Weather Centers, Naval Aviation Forecast Center, Naval Air Systems Command***
  - ***Research partners – Universities, Industry, NOAA, NASA, FAA, AF/SF***
- **What is your timeline?**
  - ***Operational transition projects turn over every 2-3 years***
  - ***Basic and applied research programs mature every 3-5 years***
- **What will you deliver against your stakeholders gaps?**
  - ***Improvements in data collection, algorithmic development, and product fusion***
  - ***Numerical model improvements toward evolving aviation mission requirements***
  - ***Software upgrades or demonstrations for streamlined operational usage***
- **What other research gaps/future needs are you aware of?**
  - ***Need for better 4-dimensional/slant path visibility (including cloud and aerosol layer bases, thickness)***
  - ***Understand and characterize variability of atmospheric boundary layer – quantify types and patterns of turbulent variability in meteorological parameters***