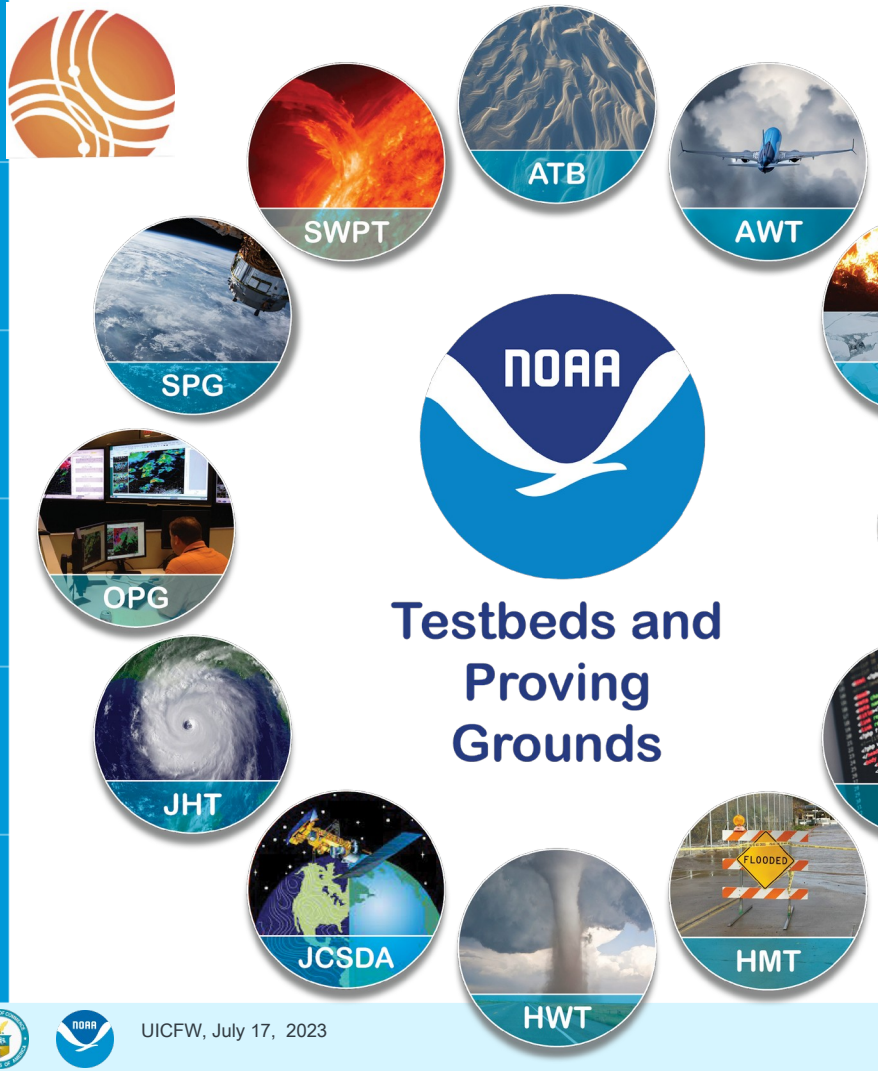


The NOAA Testbeds & Proving Grounds: A Crucible for Transitions between Research & Operations

Andrea Ray, Chair, TBPG Coordinating Committ
(OAR/PSL & HMT)

J.J. Brost, Vice-Chair (NWS/STI/OPG)

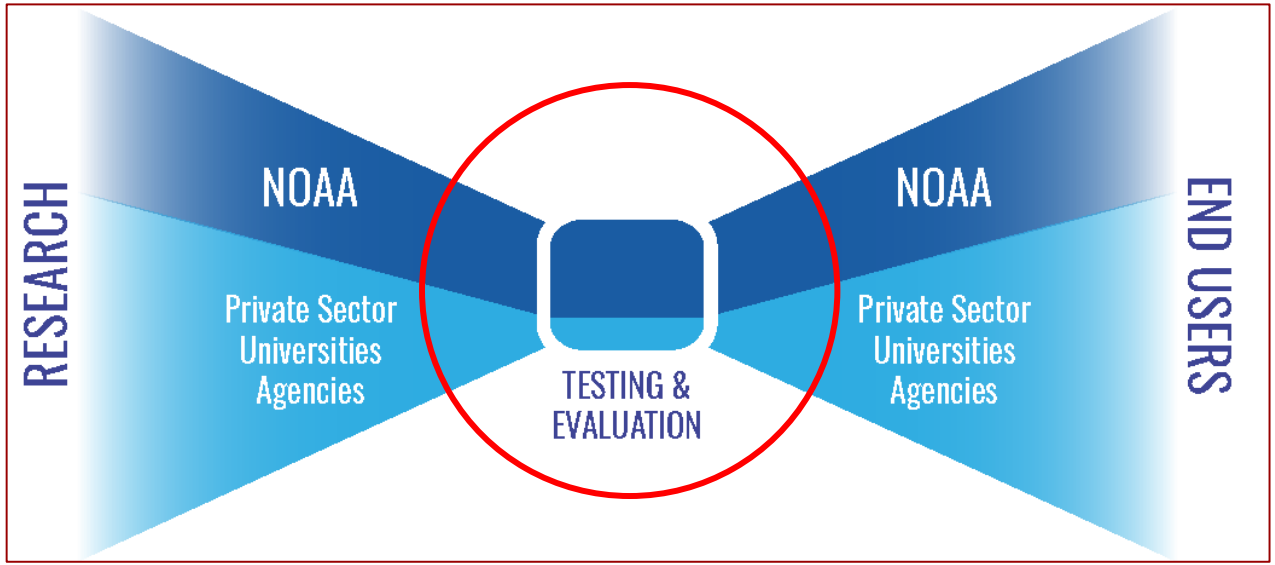
Arctic Testbed, Aviation Weather Testbed

Climate Testbed, Coastal & Ocean Modeling Testbed, Developmental Testbed Center

Hazardous Weather Testbed, Hydrometeorology Testbed, Joint Center for Satellite Data Assimilation, Joint Hurricane Testbed/Hurricane Ocean Testbed, Operations Proving Ground

Satellite Proving Ground, Space Weather Testbed

12 Testbeds & Proving Grounds sit at a critical node in NOAA Research to Operations (R2O) as well as iteration with research (O2R)

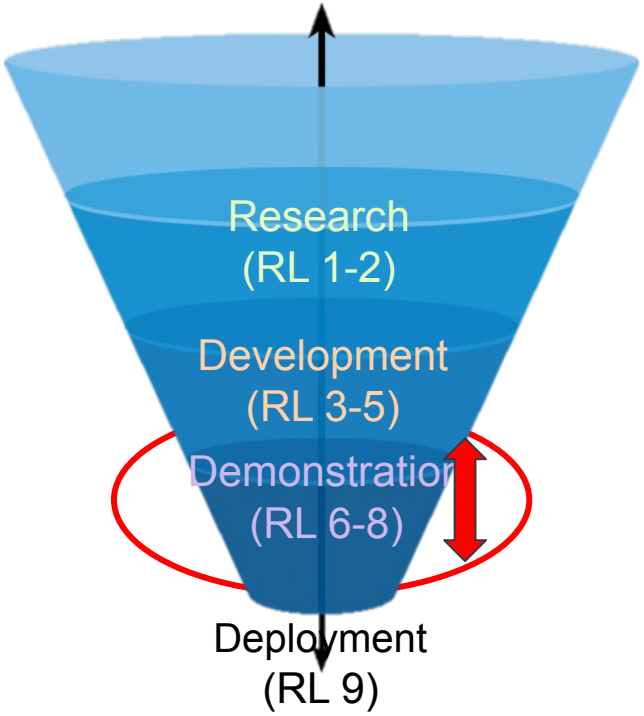


T&E

What are NOAA's Testbeds & Proving Grounds?

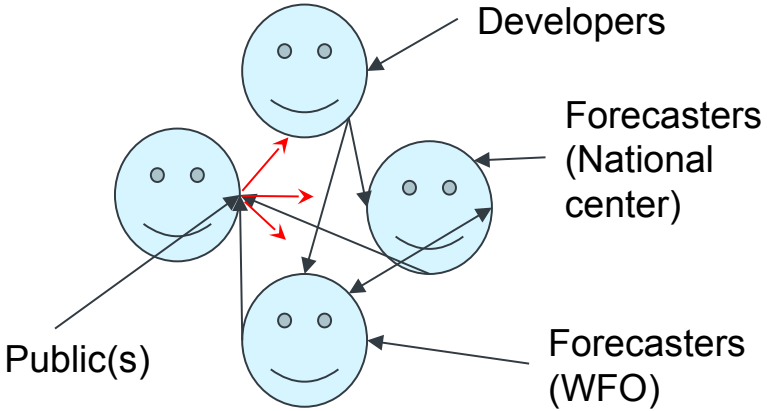
- TB & PG words are used in other contexts, these are:

Multi-project efforts that are ongoing partnerships between research & operations, aimed at improving or creating new operations & operational products in NWS, NOS and NESDIS



- TBPG's facilitate the *orderly transition of research capabilities to operational implementation* through testing and evaluation (T&E)
- They are a *major facilitator of R2O*, moving through "funnel" – and of O2R, operations informing research
- Online Portal: Charters & links to the 12 NOAA TB & PGs www.testbeds.noaa.gov

What else are they?
Interactive- Crucible - Facilitator



and like a road trip together, the or carpool lane, there are often discoveries along the way

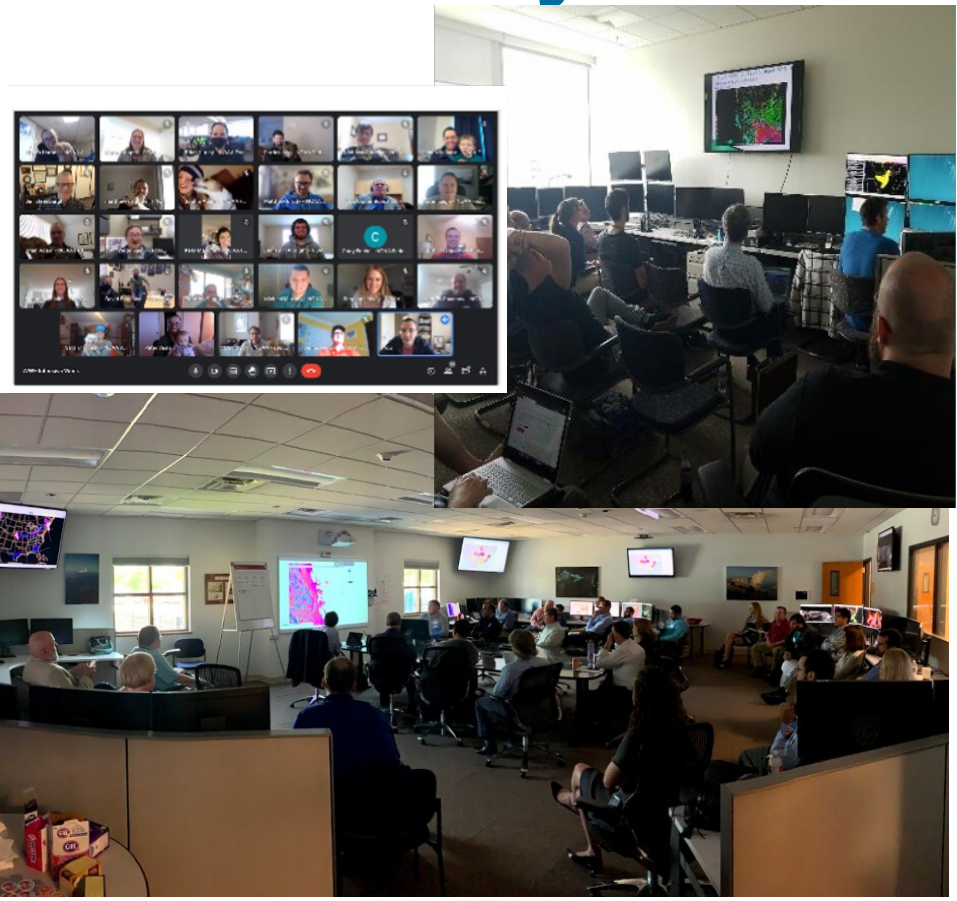
How do they do this?

Most conduct experiments for T&E, e.g.

- HMT Winter Weather and Flash Flood & Intense Rainfall Expts
- HWT Experimental Forecast & Experimental Warning Programs
- Aviation weather experiments with airlines
- Operations PG: conducts readiness evaluations of innovations in a realistic environment mirroring WFOs, before formal deployment
- and/or extended **retrospective** tests focused on robust sample sizes and objective verification metrics

A lot of collaboration between TBPGs in particular OPG and SPG with others

Hands-on, even while virtual: WFO & forecasters often involved; and forecast-users like emergency managers, media



However, no two are alike

- Two are Multi-agency partnerships:
  - JCSDA: NOAA, NASA, Navy and US Air Force
  - DTC: NOAA, NCAR and US Air Force
- COMT is National Ocean Service, SPG and JCSDA NESDIS
- The OAR Weather Program Office runs competitions aimed at four: CTB, HWT, HMT and HOT (formerly JHT); JTTI also funds projects at TBPGs
- NWS/STI funds some NWS personnel and specific projects
- Most are - the weather TBs in particular - operate on ~<$1M & 1-3 FTEs & soft-funded contractors, including some in-kind from OAR lab & NWS/NCEP center base
- Most have SBES (social-behavioral-economic science) aspects, varying ways, e.g.
  - HWT and HMT have embedded social science staff
  - AWT works closely with **FAA's** Aviation Weather Demonstration & Evaluation Services (AWDE) - Social sciences - user aspect.
  - Most are using the findings of social science funded separately
  - Both engaging in and using SBES

T&E goes beyond quantitative

- Often includes forecasters at National and WFO levels
- Increasingly, bringing in external end users, e.g. emergency managers, broadcasters, transportation managers
- Integrating Social, Behavioral and Economic Sciences
  - results of these inform product development
  - and qualitative or subjective evaluation methods

Some findings of HWT on benefits of bringing end users in (from Kodi Berry, HWT)

- Realism in testing helps identify, address, & mitigate factors that create the "valley of death" in transitioning R2O (Karstens et al. 2018)
- Interaction between NWS forecasters and end users enables the generation of useful, usable, and understandable information (Karstens et al. 2018)
- End-user engagement to the level of co-production results in a parallel increase in the use of products developed in those projects (Nygren et al. 2018)

Subjective & qualitative evaluation of RRFS: comments from Hydromet TB 2022 experiment participants

- "The RRFSs generally performed similar to the NAM. They both had pros and cons. One thing that stuck out for me was that while the NAM has high rain rates, the RRFSs have even higher rain rates."
- "One bias I generally noticed from the RRFSp1 and p2 was the tendency to over forecast coverage and rainfall maxima pockets for the pulse thunderstorm convection over the Texas/Louisiana/Arkansas Gulf Coast area. Otherwise it handled the northeast CONUS convection and southwest convection fairly well."
- "RRFS seemed to really overdo precip accums, especially in moist air masses like with the tropical system or the southeast."
- "Overall, I thought it was too popcorny and wasn't showing enough more organized thunderstorm clusters."
- "Toward the end of the week, I gained some confidence in relying more on them (RRFSp#s) for guidance in my forecasting."
- "Most of the time the smaller clusters of convection were drier/smaller in area than the MRMS verification, but the overall max on the grid seemed high/wetter."
- "The RRFS models tended to show heavy precipitation totals over a larger areal extent than was observed."
- "I am a bit sketchy on my memory, but I seem to recall being impressed by all of the RRFS runs."

Another role & benefit: Introduce innovations to forecasters at national & WFO levels

Recent examples of R2O related to UFS

Hurricane and Ocean TB (HOT)

Coastal and Ocean Modeling TB (COMT)

Developmental Testbed Center (DTC)

Satellite Proving Ground (SPG)

Hydrometeorological TB (HMT)

Climate TB (CTB)

…and their NOAA and external collaborators

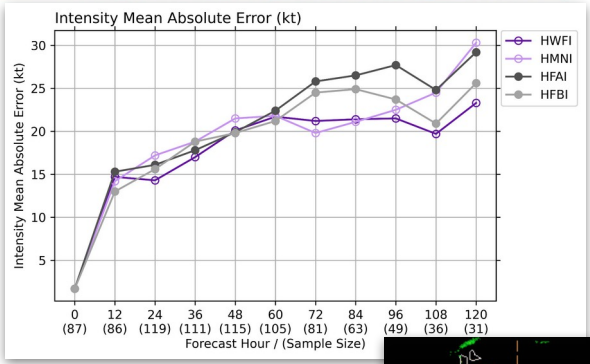
Hurricane & Ocean Testbed (HOT): Role in the Operational HAFS Evaluat

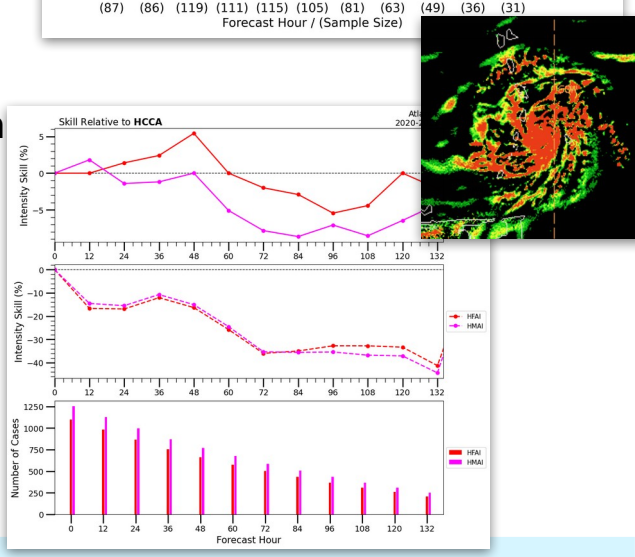
Hurricane and Ocean Testbed

In advance of the operational HAFS implementation, the HOT team worked with Natl Hurricane Ctr staff and the NOAA Environmental Modeling Center (EMC) to:

- Acquire a 3-year sample of retrospective forecasts
- Gather critical metrics from operational forecasters
  - Track, intensity, structure, rapid intensification, etc.
- Perform thorough verification and assess the impact of HAFS on downstream multi-model statistical guidance
- Implement upgrades to the NHC model suite on WCOSS
- Test the ingest and configuration of HAFS data in Cloud AWIPS system to prepare for operational transition

**Jon Martinez' talk Tuesday of UIFCW23 described this process!





COMT: Improving DA algorithms for U.S. West & East coastal ocean forecast systems

Multi-resolution and mixed precision ROMS 4D-Var

- **faster … more resolution** - down to 4km

Time- and space-averaged observation operators- maxim information content

- represent time-average data (e.g., low-passed HF-radar) and conventional altimetry with geophysical corrections (d tide and DAC) to *emphasize ocean mesoscalef*

Ecosystem/BGC modeling with WCOFS

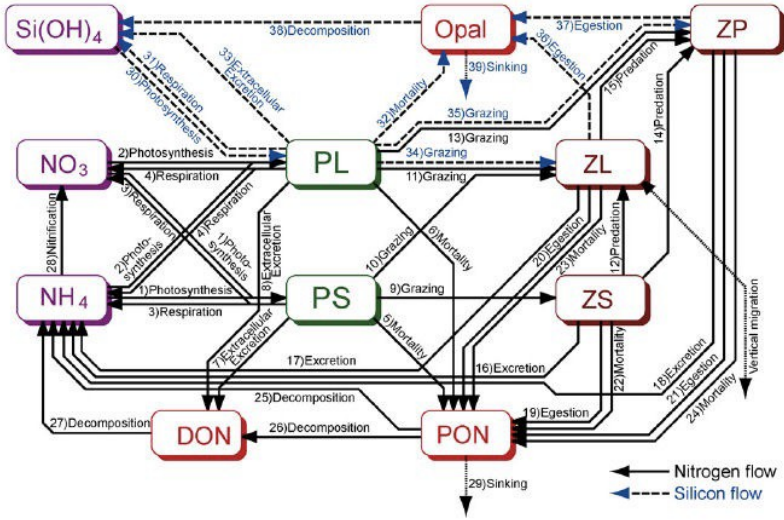
- **better physics … better bio:** UCSantaCruz version of ROMS-NEMURO coupled BioGeoChem model

ROMS 4D-Var sandbox

- community crowd sourced development

Transition activities (make it relevant)

- e.g. Stakeholder workshop – prioritize opportunities for follow-on products & capacity building and training on use of ROMS 4D-Var using Cloud Sandbox



Biogeochemical model run in WCOFS domain w/ initial/boundary conditions from operational WCOFS

Developmental Testbed Center: Supporting R2O in UFS

Software framework

- Developed community workflow for SRW App
  - Transitioned to EPIC
  - Continuing to contribute verification aspects
- Develop/support Common Community Physics Package (CCPP)
  - Adopted by UFS
  - Flexibility supported operational implementation of 2 HAFS configurations in 2023
- Develop/support advanced Model Evaluation Tools (METplus)
  - Selected as verification system for UFS

Testing and Evaluation

- RRFS
  - Critical feedback to the development team through an agile testing framework
  - Tests informing ensemble design
- HAFS
  - Integral part of testing team focused on v1 implementation
- Physics
  - Support UFS R2O physics team by applying aspects of Hierarchical System Development approach
    - Feedback to developers on issues with schemes
    - Support decisions to include innovations in GFS proto-types

Satellite Proving Ground & NWS transition major innovation: HRRR-Smoke

Societal impacts of smoke include:
Human health – both near fire and distant; Aircraft operations; Fire Operations; Transportation – Amtrak & highways; Recreational & school sports; Visual

"Users overwhelmingly need higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion." (2011 OFCM, 4.1.a.)

Motivated by new parameters available from JPSS VIIRS, SPG organized a Fire and Smoke Initiative to address this need, including NWS scientists and forecasters, OAR Global Systems Lab, NESDIS and key stakeholders

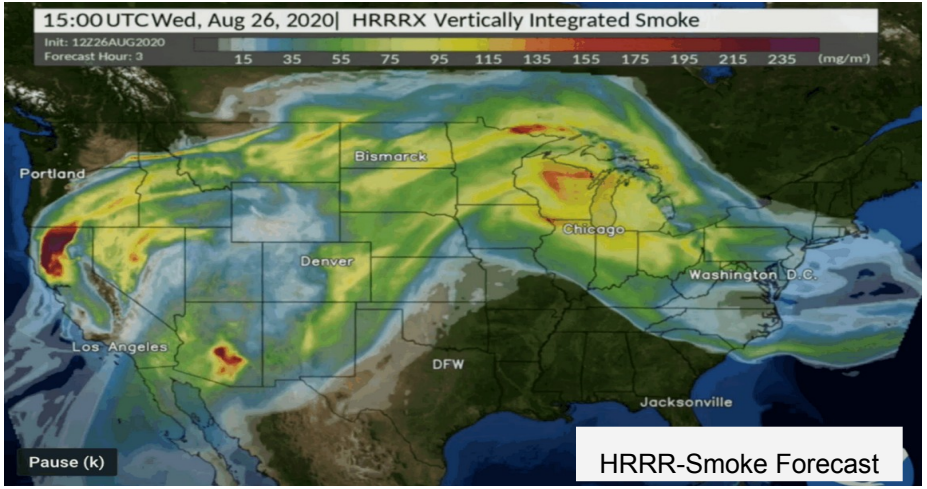
"Orange sky" smoke event, San Francisco Bay area, September 9, 2020

NOAA HRRR-Smoke Nowcasting/Forecasting

SPG worked with NOAA/NWS and NOAA Research Global Systems Lab to develop and test a HRRR-Smoke Model in which smoke and weather are fully interactive

- **HRRR Smoke is a combo of HRRR model upgraded with aerosols and improved Fire Radiative Power (FRP) capability from JPSS VIIRS**
- Uses high resolution satellite obs of fires (location & intensity)
- **WFO and Public acceptance very high** - animations are a huge selling point!

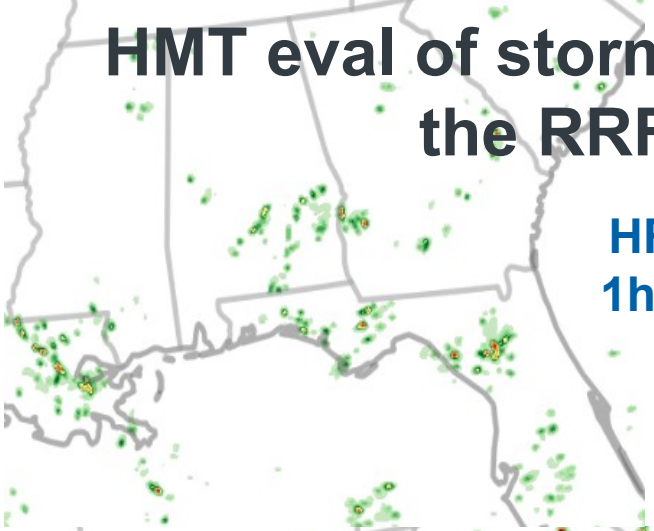
36 hour 3km animations



https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke

HMT eval of storms in the RRFSp#

MRMS
1h QPE



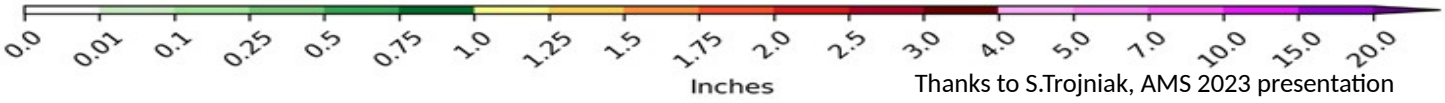
HRRR
1h QPF

Popcorn observed, but not >5”/hr

LAM
1h QPF

RRFS1
1h QPF

21z 15 July 2021



Thanks to S.Trojniak, AMS 2023 presentation

Changes in UFS inspired by HMT Flash Flood & Intense Rainfall Expt

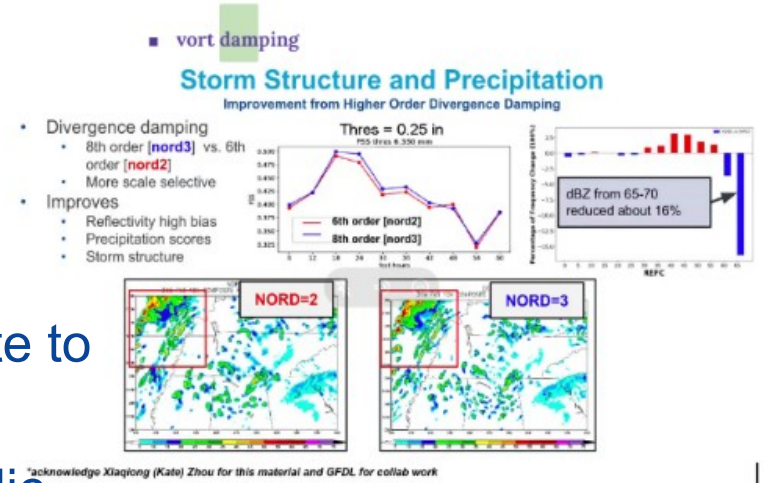
Recommended UFS modifications to alleviate the precip rates:

- Microphysics adjustments
- Divergence damping nord2 -> nord3 (ramifications on MCSs?)
- Energy conservation

We requested to add hourly max precip rate to understand this further

Situation has improved (Still seeing sporadic HM rates up to 130”/hr)

Hourly maximum has proven to be a decent diagnostic for detection of subhourly issues.

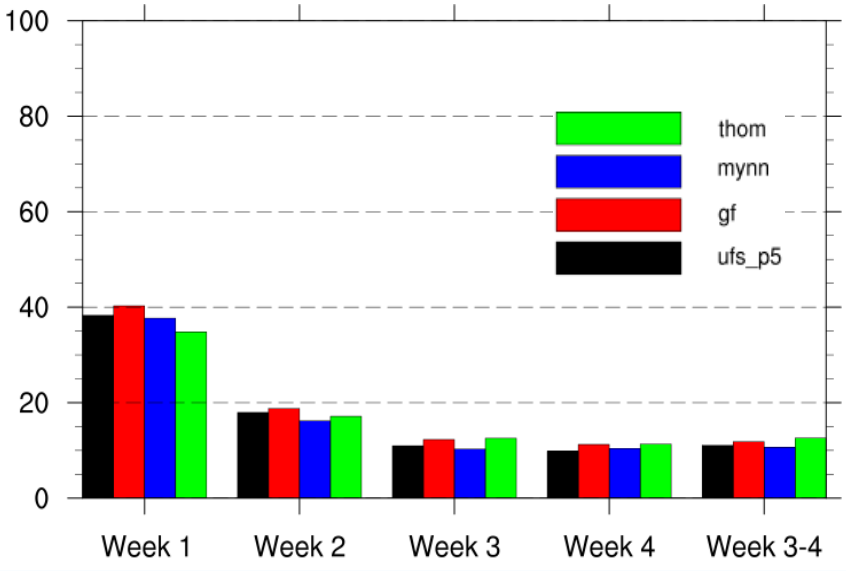


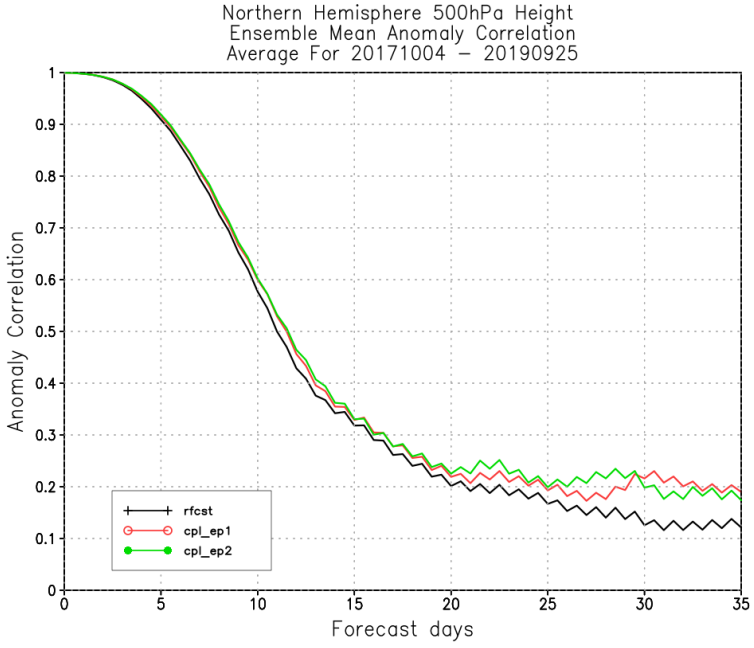
Thanks to J. Correia, HMT EPIC presentation

Climate TB Supporting UFS Development

OAR/WPO funded projects with development directly targeting UFS improvements

- Swapping out physics schemes in UFS prototypes. Thompson was tested, evaluated well, and is being implemented in NCEPs GEFSv13/GFSv17 (left)
- Making the prototypes into Ensembles (EP1, EP2, EP3). Ensembling strategy worked out by CTB is being used for GEFSv13 (right)





Thanks to M. Rosencranz, CTB

NOAA TBPG Coordinating Committee

- A venue for coordination, collaboration, synergies & learning among individual TB/PGs
- Identify opportunities for collaboration
- Network for addressing common issues and opportunities
- Annual & monthly meetings
- Subcommittee of the NOAA Line Office Transition Manager Committee (LOTMC)

Online Portal includes Charters & links to the TB & PGs
https://www.testbeds.noaa.gov/

Funding opportunities for engaging in R2O2R

NOAA Weather Program Office

- JTTI (POC: Chandra Kondragunta - chandra.kondragunta@noaa.gov): Next NOAA Internal competition in FY25 and Notice of Funding Opportunity (external) in FY26.
- Testbeds (POC: Jordan Dale - jordan.dale@noaa.gov):
  - NOFO expected in August for Climate Testbed and Fire Weather
  - FY25 competition anticipated, will include priorities for FWT, HMT, HOT, HWT
- EPIC (POC: Maoyi Huang - maoyi.huang@noaa.gov)

NWS OSTI

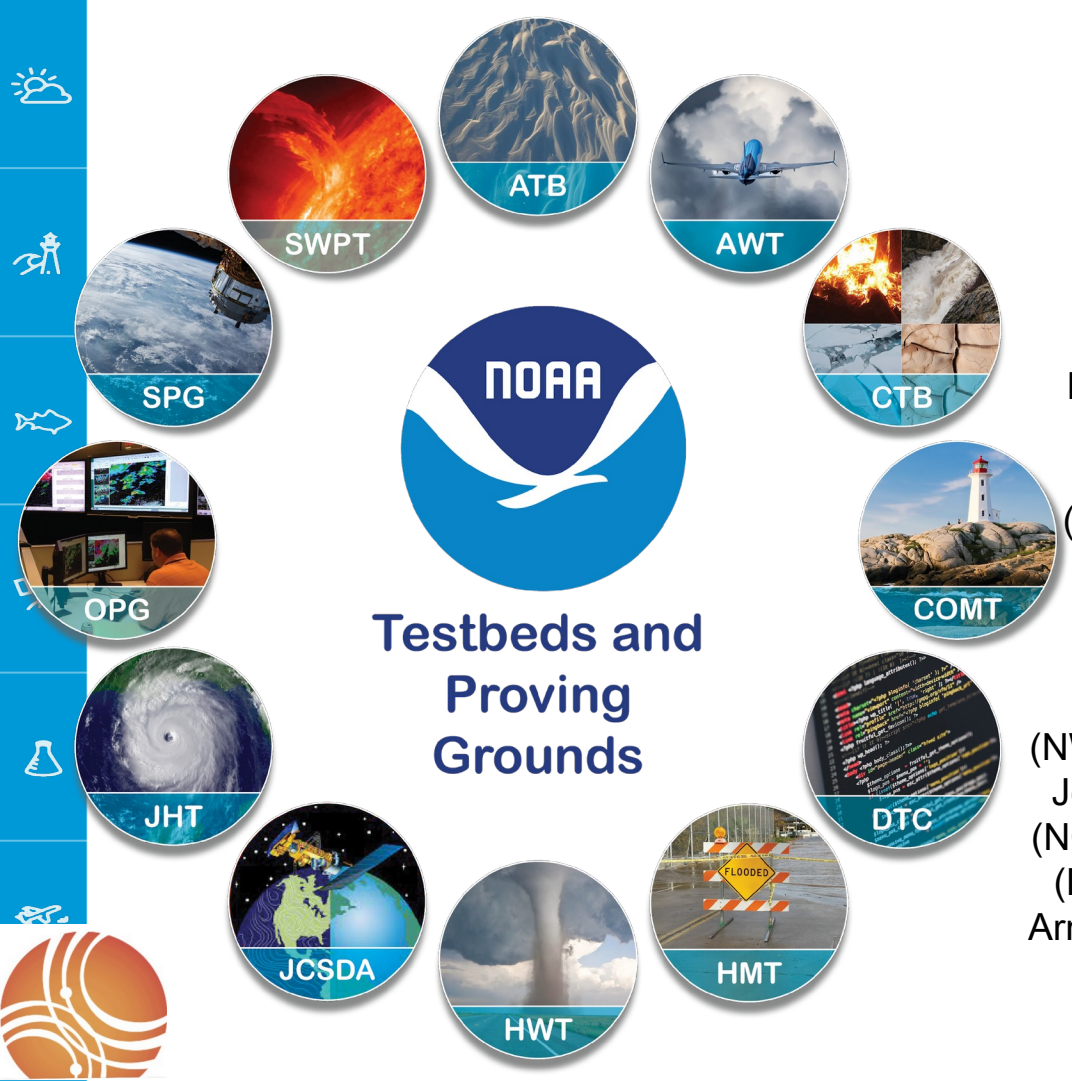
- CSTAR (POC: Christopher Hedge - christopher.hedge@noaa.gov)
- HFIP/NGGPS (POC: Kevin Garrett - kevin.garrett@noaa.gov): Expecting Notice of Funding Opportunity (external) in FY24. Information to be posted on the OSTI-Modeling site.
- COMET Partners (POC: Peter Roohr - peter.roohr@noaa.gov

Testbed programs

- DTC Visitor Program (POC: Eric Gilleland - ericg@ucar.edu)
  - Offer opportunities for both PIs and graduate students
  - See https://dtcenter.org/visitor-program for more information
- Coastal & Ocean Modeling TB (COMT) - NOFO tracey.fanara@noaa.gov

In closing

- Most TBPGs **already have activities supporting UFS** development or UFS-based products & are willing partners
  - Only a few examples here
- Have capabilities that can directly support/benefit UFS
  - Robust T&E processes already being used for UFS
  - Access to forecasters and other users who can provide meaningful feedback to UFS development at different stages for different hazard scenarios
  - Engaged with SBES - both implementing findings and generating SBES science
  - Probabilistic products are a major focus
- Work with us - start talking to us early so we know your schedule for innovations needing T&E, so we can get activities on calendars, and talk with our funders about your priorities



Thank you

https://testbeds.noaa.gov

Andrea Ray (Chair, OAR/PSL & HMT)

J.J. Brost (Vice-Chair, NWS/STI/OPG)

For the TBPG community: Kodi Berry (OAR/NSSL & HWT), Michele Cash (NWS/SWPC & SWTB), Jordan Dale (OAR/WPO), Tracy Fanara (NOS/IOOS & COMT), Mitch Goldberg (NESDIS & SPG), Satya Kalluri (NESDIS), Patrick Marsh (NWS/SPC & HMT), Gene Petrescu & Rebecca Mazur (NWS/Alaska Region & ATB), Louisa Nance (NCAR/RAL & DTC), Jim Nelson (NWS/WPC), Matt Rosencrans, (NWS/CPC & CTB), Joshua Scheck (NWS/AWC & AWT), Peter Stone (NOS), Jim Yoe (NCEP & JCSDA), Wallace Hogsett (NWS/NHC, JHT/HOP), & our support staff: Abby Arnold (Exec. Sec, FedWriters, Inc. & Katie Geddes, Groundswell, both supporting OAR/ORTA)

Presentation at the UICFW, July 17, 2023

EXTRAS and other examples

Website: testbeds.noaa.gov

Testbeds and Proving Grounds
National Oceanic and Atmospheric Administration

Home What's New Events Committee

NOAA Testbeds and Proving Grounds Portal

NOAA's Testbeds and Proving Grounds facilitate the orderly transition of research capabilities to operational implementation through dev
readiness/suitability evaluati

In 2011, a coordinating comm
consistency among the appr
Testbeds and Proving Groun
Transition Manager Committ

Arctic Testbed

ATB facilitates testing and

Aviat
Testb

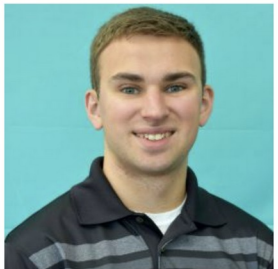
News stories

Testbeds and Proving Grounds
National Oceanic and Atmospheric Administration

Home What's New Events Committee

Satellite Liaisons between SPG & other TBPG

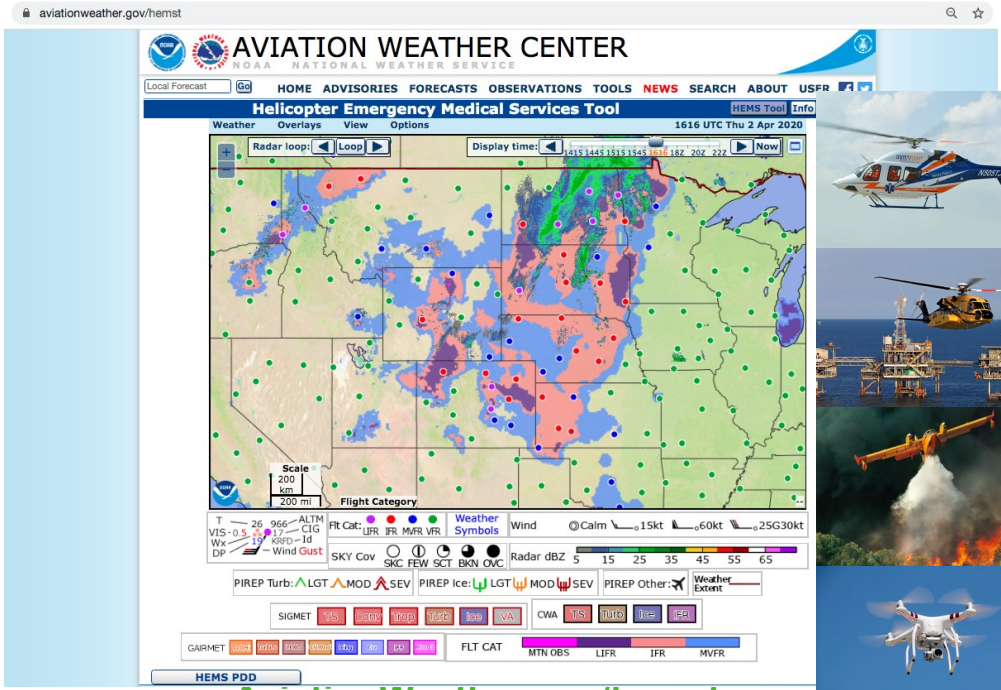
NOAA's Satellite Proving Ground (SPG) tests and evaluates satellite products before they're transitioned to operations. SPG employs cooperative institute employees known as satellite liaisons for the Hazardous Weather Testbed (HWT), Storm Prediction Center (SPC), the NWS Operations Proving Ground (OPG), and Ocean and Weather Prediction Centers (OPC, WPC). This role within NOAA began in 2010 and is helping realize the benefits of satellite systems and explore the possibilities available from advanced satellites into operation across several testbeds. The Satellite Liaisons are advancing collaboration between testbeds within NOAA and play a key role in moving transition projects forward.



Aviation Weather Testbed: Evolving the Helicopter Emergency Medical Services Tool

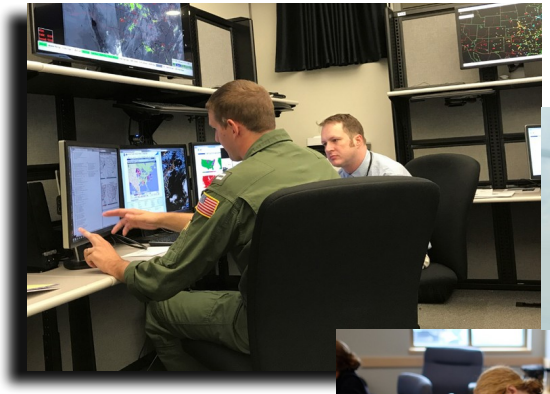
HEMS is a web interface that shows weather conditions for short-distance & low-altitude flights that are common for the Helicopter Emergency Medical Services (HEMS) community. Also supports other low level fliers: airtankers for firefighting, cropdusters, balloons, drones

- ➔ Cloud ceiling and surface visibility (C&V) and other parameters presented for non-weather experts quickly and effectively
- ➔ Existing one-off product was going out of service, needed new 24-7 product in WCOSS framework, reduced O&M costs
- ➔ Federal Aviation Administration requirement



AWT & Helicopter Emergency Service (HEMS) Tool Improvements

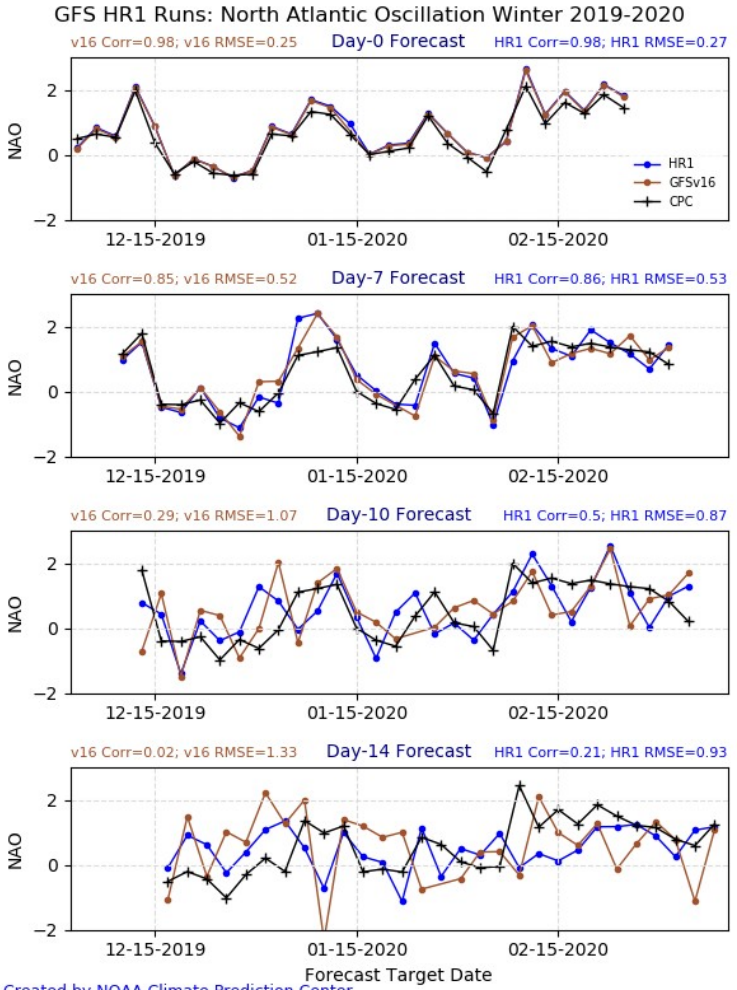
- NOAA's Environmental Modeling Center (EMC) & Model Development Laboratory (MDL) developed experimental analyses for evaluation as replacement
- AWT worked with OAR/Global Systems Lab (GSL) to do quantitative assessment of Ceiling & Visibility analysis
- **FAA's** Aviation Weather Research Program (AWRP) funded assessment & some development work
- **FAA's** Aviation Weather Demonstration and Evaluation Services (AWDE) - Social sciences - user aspect.
    - Improved user interface features include a Time slider & Configurations menu
- New product had to pass FAA's Safety Risk Management Panel - it did! Risk of misinterpretation of the tool was actually downgraded from previous version



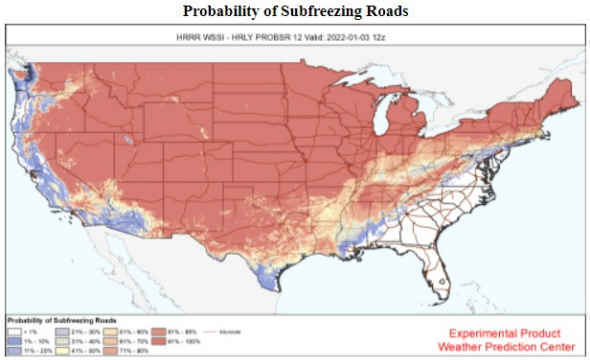
AWDE held interviews with pilots and key users of the HEMS tool to gain feedback both in the testbed and in their research lab

CPC Supporting UFS Development (draft slide

- CPC is involved in the development of UFS-MRW/S2S
- Evaluation of prototypes
- Evaluation of retrospectives
- Structure of reforecast/real-time delivery
- Evaluation of reforecasts for final science review/approval at NCEP.



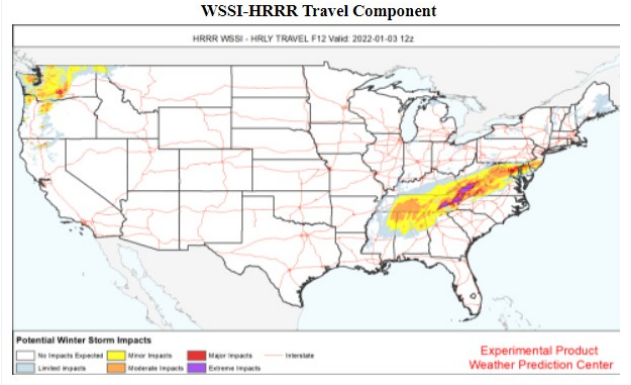
Focus Groups with forecasters: an HMT WWE Activity



Development of a DSS tool that provides a 0 - 100% probability that roads are subfreezing. (ProbSR; Reeves et al. JTTI)

Development of a Travel Component to WSSI

- Based on 1h HRRR data
- 3 WSSI components
  - **Snow amount** (since initialization)
  - **Snow rate** (hourly)
  - **Ice accumulation** (since initialization)



Feedback on ensemble visualization & tools (Radford & Lackman; Paper in preparation)

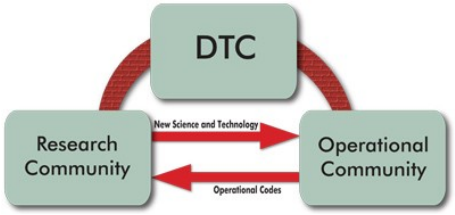
Funding

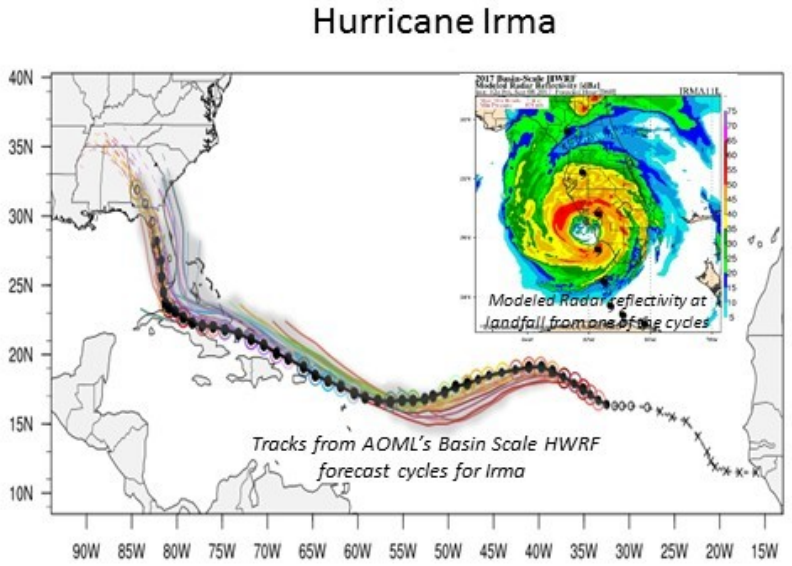
From a number of sources varies among TBPG

- NWS Science and Technology Integration Office (STI) and NOAA/OAR Weather Program Office (WPO)
  - Competitive grants/Coop agreements support PIs on projects to be evaluated in TBs
- STI – funds some NWS personnel and TB Milestones for ATPG, AWT, JHT, OPG, HWT, HMT, FWTB
- WPO funds infrastructure for their
- NESDIS GOES-R and POES satellite programs
  - also funds satellite liaison positions at HWT, JHT/HOT, WPC
- COMT, Space Wx TB and some others run their own competitions.

The Hurricane Weather Research & Forecast system (HWRF) is NOAA's operational hurricane forecasting model. It continues to be refined and improved in collaboration with agency and university researchers.

The Developmental Testbed Center has facilitated the transition of innovations into the HWRF through sustained focus over a number of years.



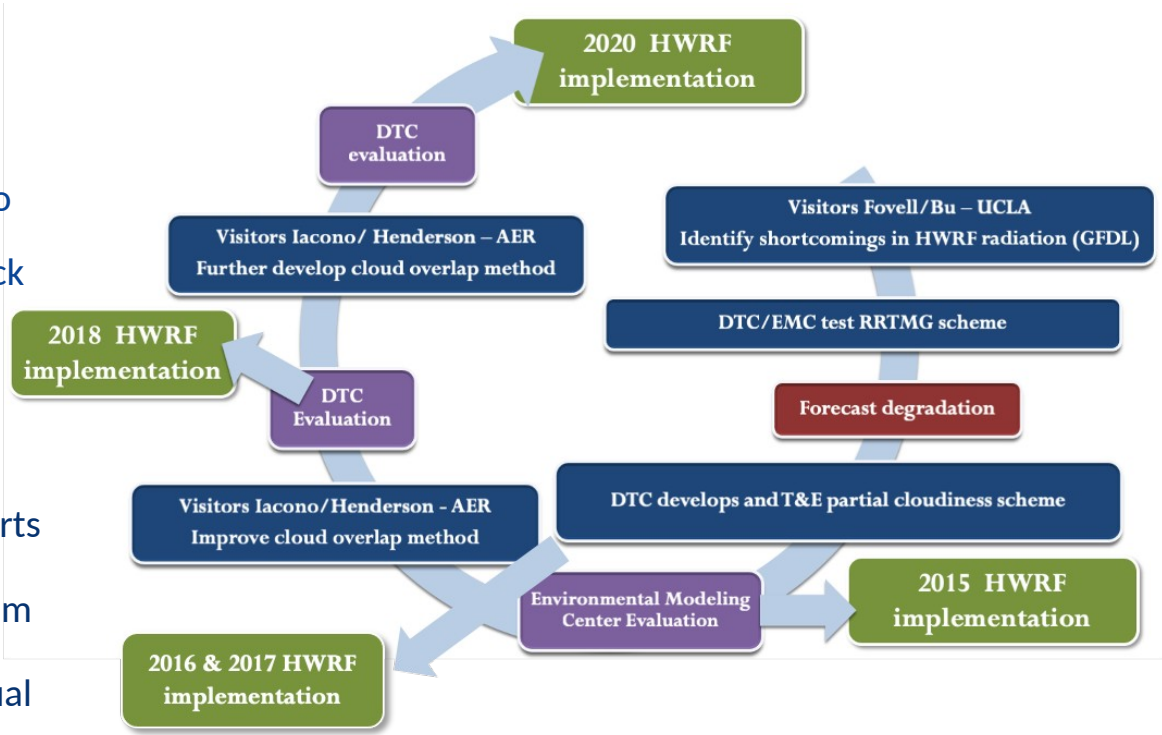


HWRF forecast plume 3-km resolution regional model

Iterative testing & evaluation of innovations by DTC staff in collaboration with researchers external innovations on one side, and by NOAA EMC which implements HWRF – example of **bundling innovations on next slide**

DTC's iterative testing & evaluation led to solving radiation code issue in HWRF

- Problem identified at DTC with radiation in the operational HWRF,
- Case studies using RRTMG showed that it would fix the deficiency
- However - **replacing with RRTMG led to degradations in track and intensity skill**
- DTC engaged a model developer at NCAR to implement a bundle of RRTMG and partial cloudiness that led to improvements in track and intensity
- **DTC efforts have contributed to steady improvement of hurricane forecasting. Success strategies:**
  - Dedicated funding to support R2O & sustained focus through multi-year efforts of iterative diagnostics and evaluation
  - Engagement with model developers from universities, NOAA & the private sector
  - Communicating timelines to meet annual implementation cycle at EMC



from JJ Brost

We exist - and we have capabilities that can directly support/benefit UFS 2. We have access to a lot of forecasters (users) who can provide meaningful feedback to the UFS group at different stages of development for different hazard scenarios (often times leveraging cloud technology to increase sample size) 3. You really should be using us more formally. Start talking to us early so we can get projects set on calendars.