NOAA Global Systems Laboratory

Community Engagement

Ligia Bernardet
Deputy Division Chief
Earth Prediction Advancement Division

Global Systems Laboratory

GSL Community Engagements

- Earth Prediction Innovation Center (EPIC)
- Developmental Testbed Center (DTC)
- Hazardous Weather, Hydrometeorology, and Aviation Testbeds
- Joint Center for Satellite Data Assimilation (JCSDA)
- UFS Community Governance
- Community Engagement via Social Science
- Leadership of Collaborative Programs (Dave Turner)

NOAA Global Systems Laboratory

EPIC

Global Systems Laboratory

The Earth Prediction Innovation Center (EPIC)

Vision: Enable the most accurate and reliable operational numerical forecast model in the world.

Mission: To be the *catalyst for community research* and modeling system advances that continually inform and accelerate advances in our nation's operational forecast modeling systems.

EPIC
Earth Prediction Innovation Center

What EPIC is….

- A community model development environment
- Management of NOAA cloud- ready code
- Access to NOAA observations, data & tools
- Community support & engagement
- Clear research & model transition to operations priorities
- Expected expansion to other additional model components

Community Engagement

UFS
UNIFIED FORECAST SYSTEM

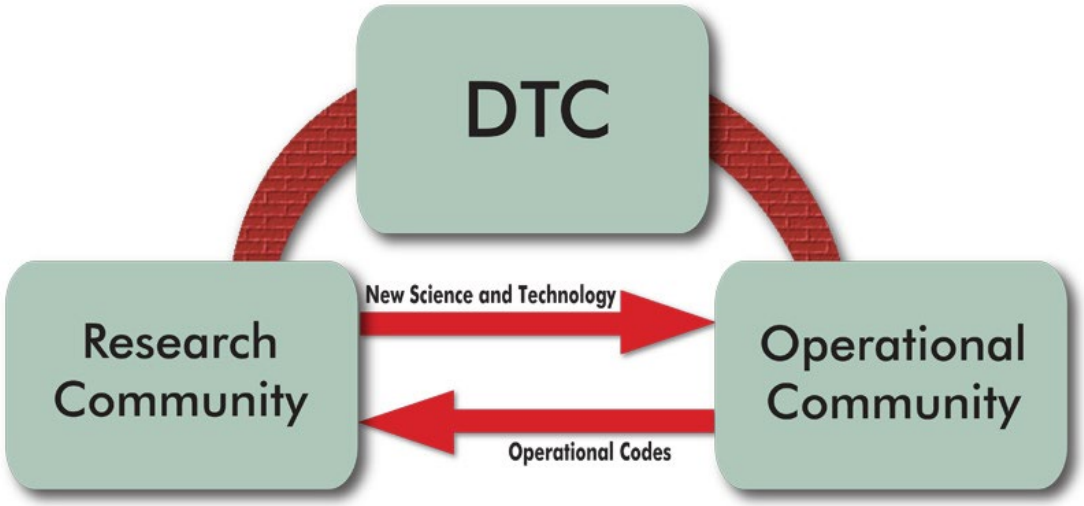
Cloud-based

NOAA Global Systems Laboratory

Developmental Testbed Center

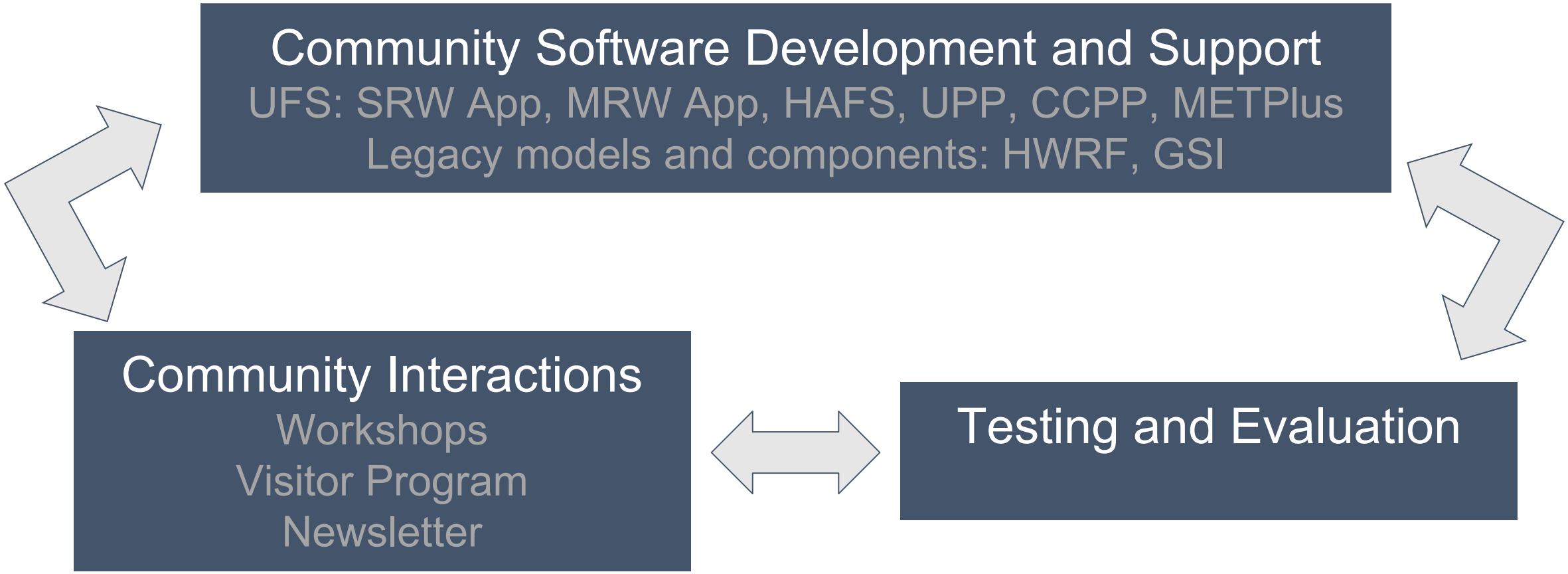
Global Systems Laboratory

The DTC Is...



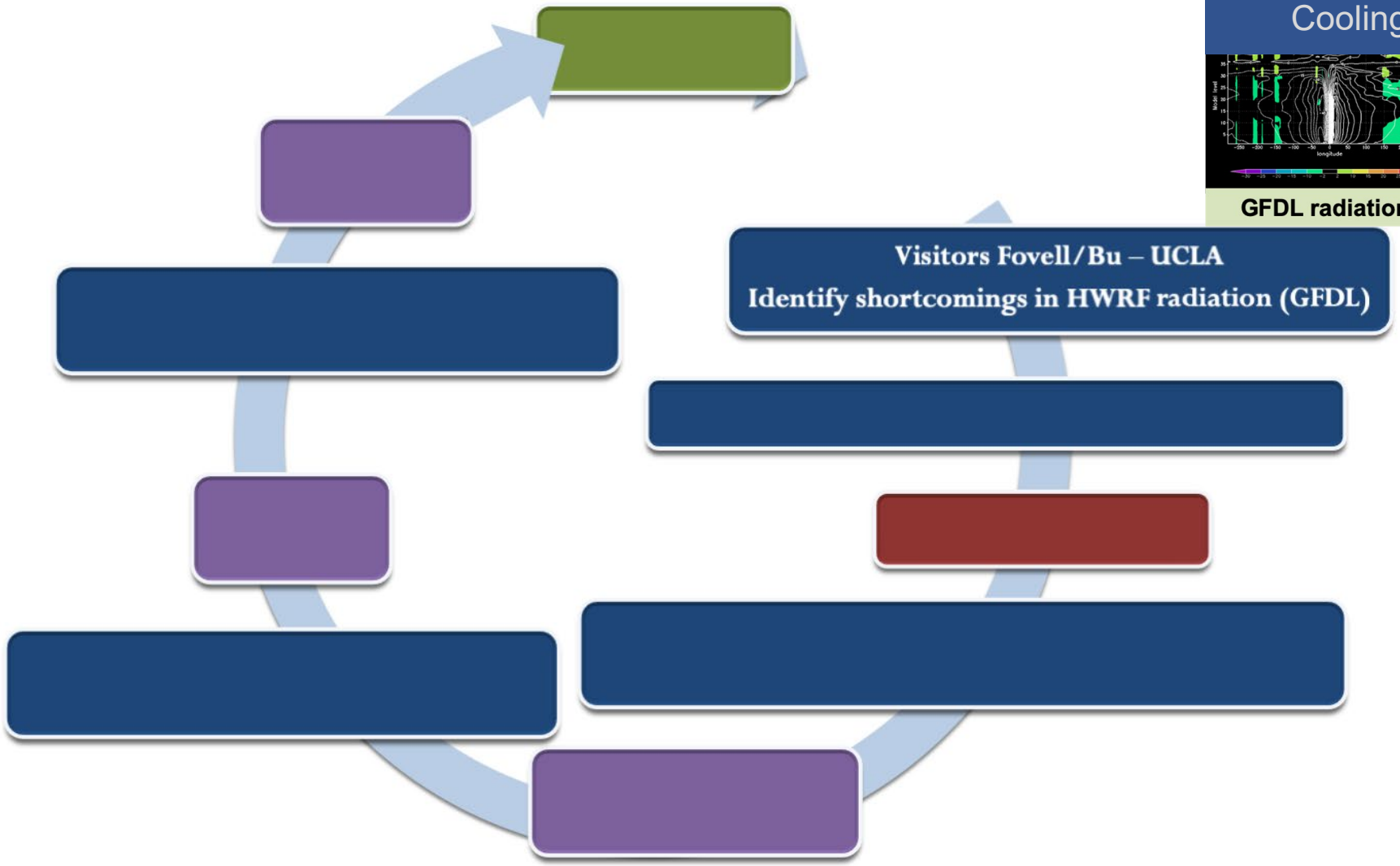
- A NOAA Testbed whose mission is to connect the research and operational communities working on NWP
- Jointly sponsored by NOAA, the Air Force, NSF, and NCAR
- Comprised of staff at GSL and NCAR
- Well aligned with GSL in model improvement and evaluation

Overview of DTC Activities



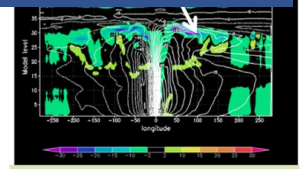
Addresses Review Recommendation C4.1: Identify core competencies within NOAA and the broader community and develop a strategy for how it can best utilize this expertise to improve the research and operational NWP suite.

A Cycle of R2O2R2O2R2O



Cooling due to radiation

GFDL radiation



RRTMG radiation

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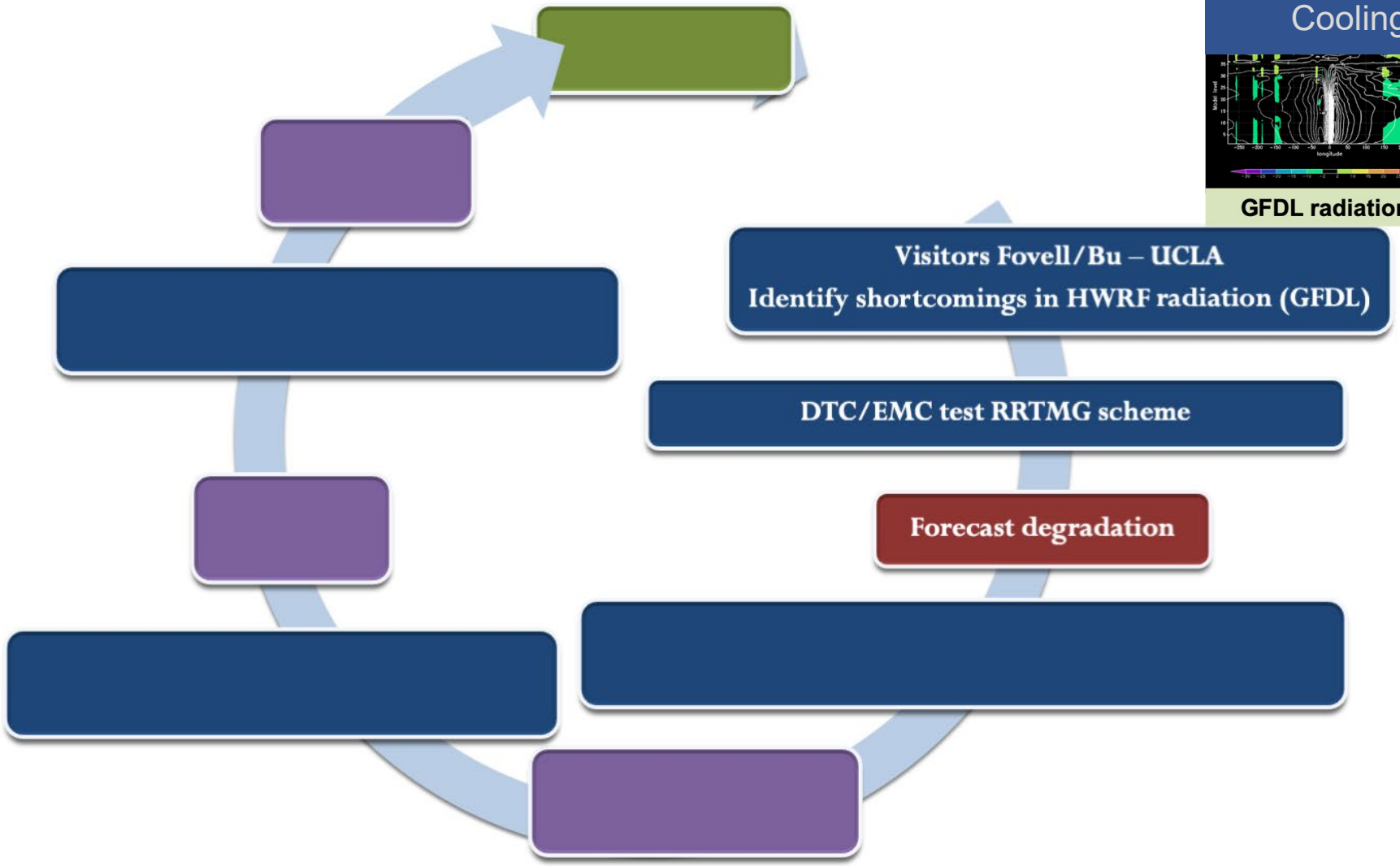

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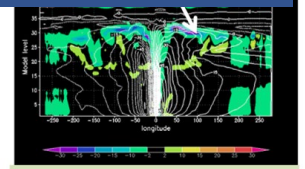

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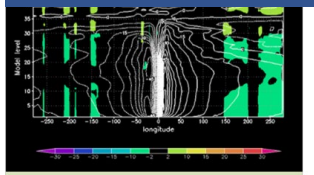

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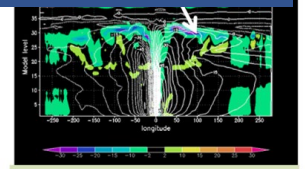


RRTMG radiation

Visitors Fovell/Bu – UCLA
Identify shortcomings in HWRF radiation (GFDL)

DTC/EMC test RRTMG scheme

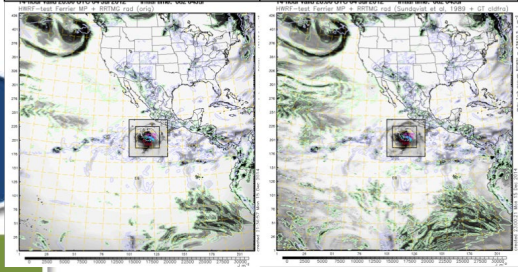
Forecast degradation

DTC develops and T&E partial cloudiness scheme

Environmental Modeling Center Evaluation

2015 HWRF implementation

RRTMG old	RRTMG+partial cld



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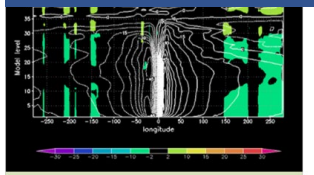

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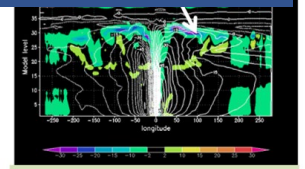

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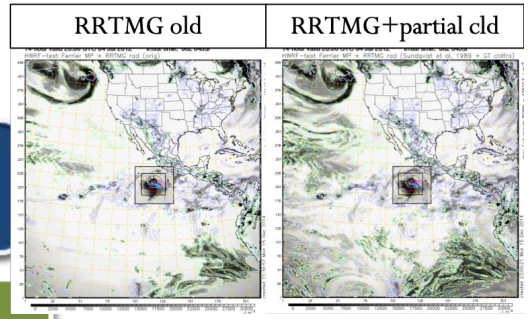


2015 HWRF implementation

Environmental Modeling Center Evaluation

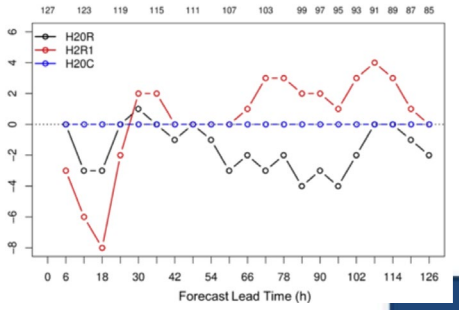
Visitors Iacono/Henderson - AER
Improve cloud overlap method

DTC Evaluation

2018 HWRF implementation

A Cycle of R2O2R2O2R2O

Track Skill Improvement



2020 HWRF implementation

DTC evaluation

Visitors Iacono/ Henderson – AER
Further develop cloud overlap method

2018 HWRF implementation

DTC Evaluation

Visitors Iacono/Henderson - AER
Improve cloud overlap method

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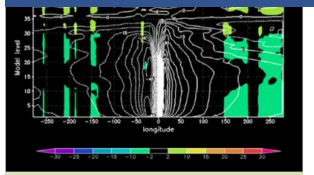
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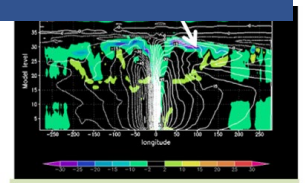
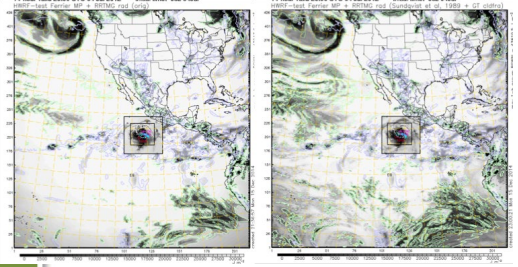

RRTMG radiation

↓ Shortwave at sfc

RRTMG old	RRTMG+partial cld

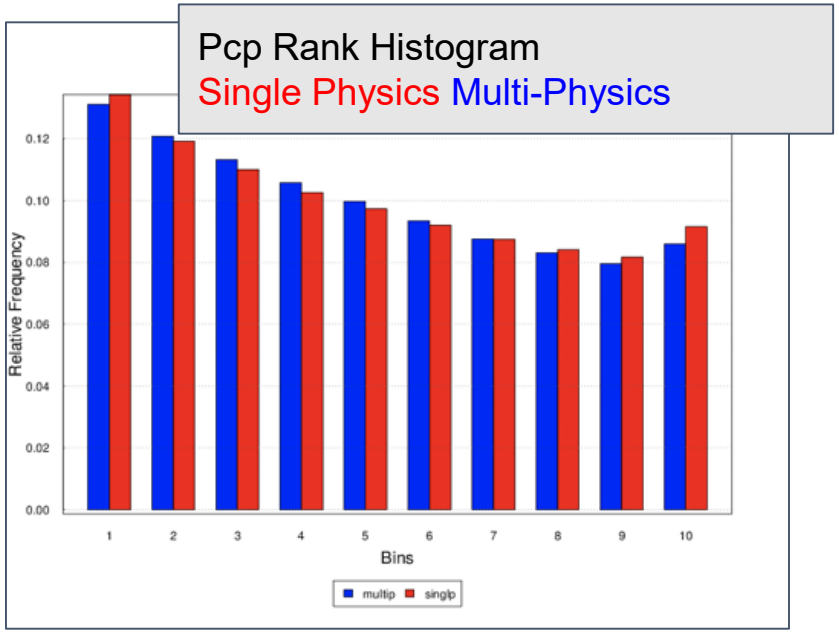


Collaboration with Hazardous Weather Testbed

DTC evaluations leveraged datasets from the Spring Experiment and helped inform future ensemble design

2016 - Multi- and single-physics ensemble precipitation forecast performance within the Community-Leveraged Unified Ensemble (CLUE)

- Single-physics has advantages but performance lagged from multi-physics



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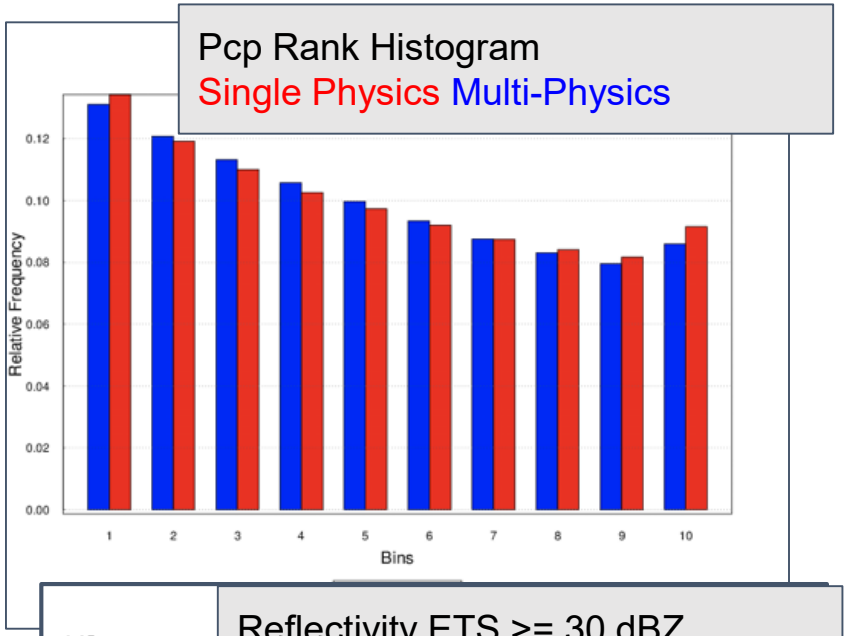
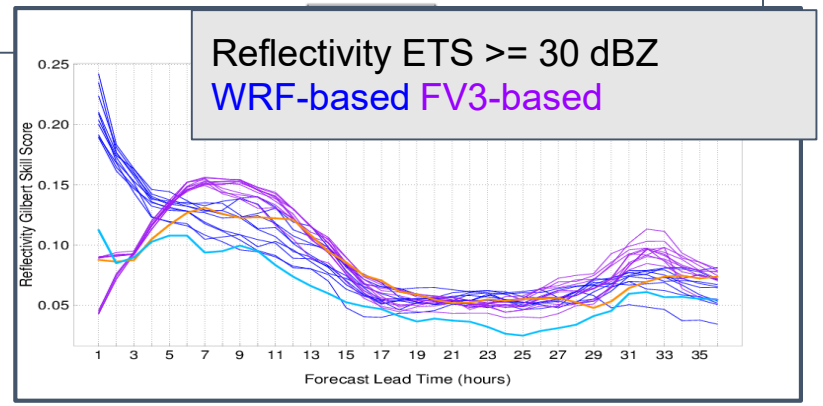
2018 - UFS ensemble compared against ensemble based on the WRF model

- UFS ensemble performance was comparable or better than WRF ensemble

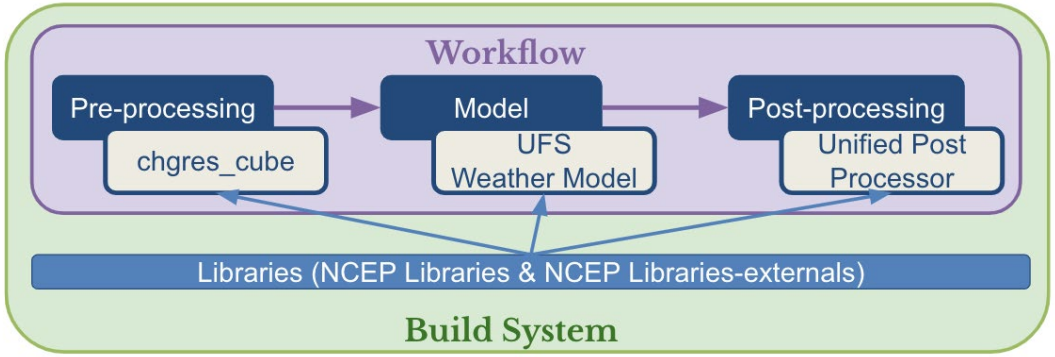




UFS Application Releases

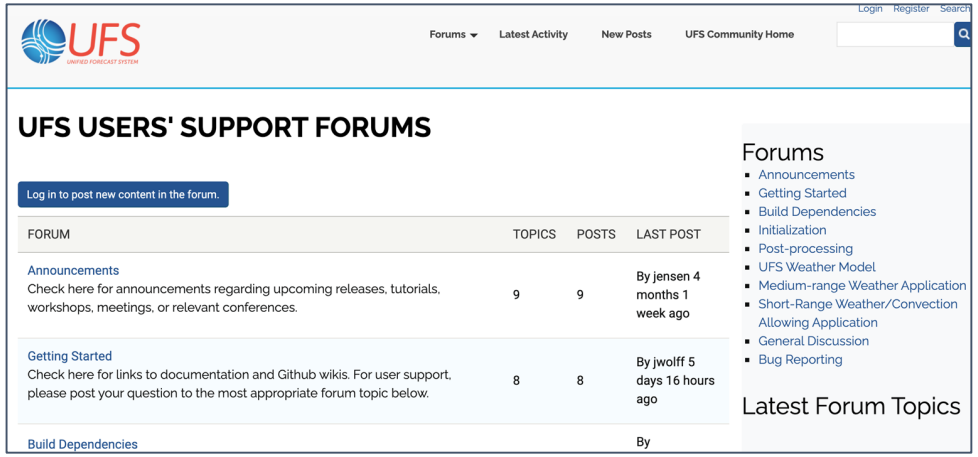
UFS MRW App - v1.0 (March 2020) and v1.1 (October 2020)

UFS SRW App - v1.0 (March 2021)



DTC responsibilities for releases

- Co-lead the preparations
- Develop workflow (SRW only)
- Create test cases
- Port and test the code on various platforms
- Prepare documentation
- Provide user support via the UFS Forum



For more information, visit https://ufscommunity.org/science/code/ and dtcenter.org

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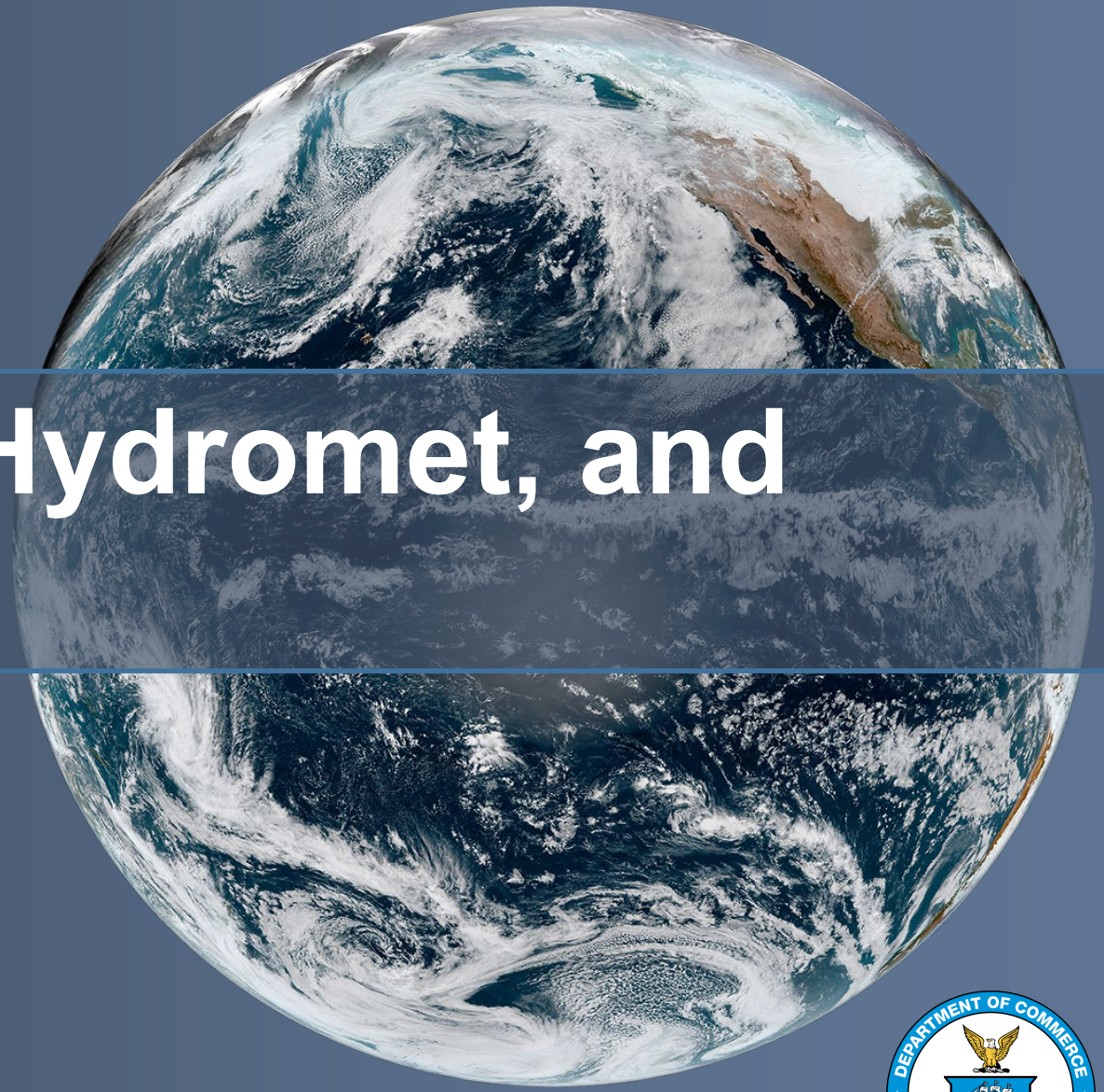
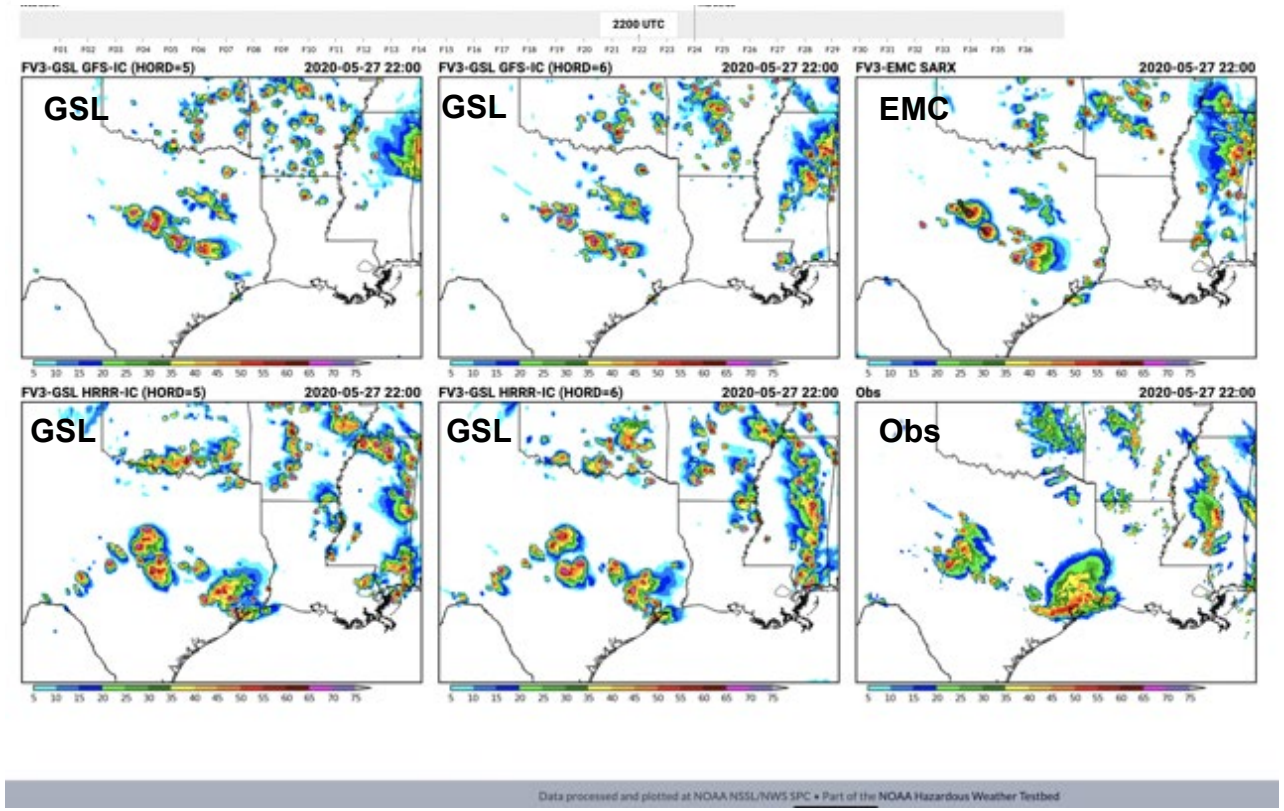


Hazardous Weather, Hydromet, and Aviation Testbeds

Global Systems Laboratory

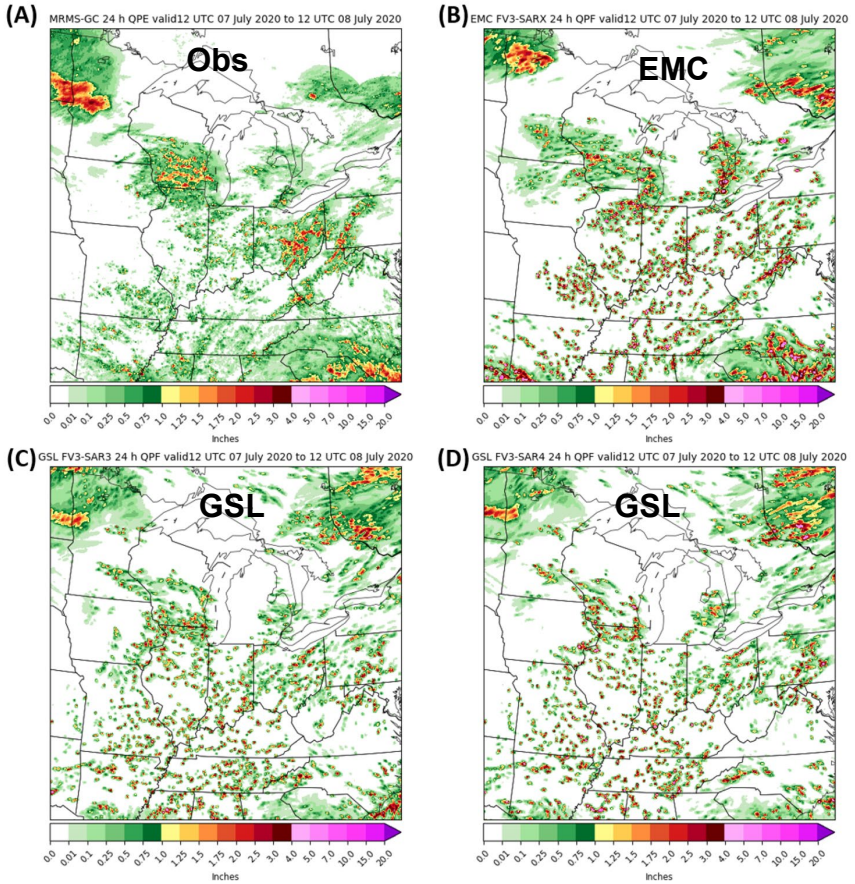
Hazardous Wx and Hydrometeorology Testbeds

Hazardous Weather Testbed (HWT)
2020 Spring Forecast Experiment



GSL demonstrating FV3 LAM convective forecast sensitivity to differences in initial/boundary conditions (GFS top and HRRR bottom) and use of different horizontal advection options (less diffusive left, more diffusive middle) at 22 UTC 27 May 2020

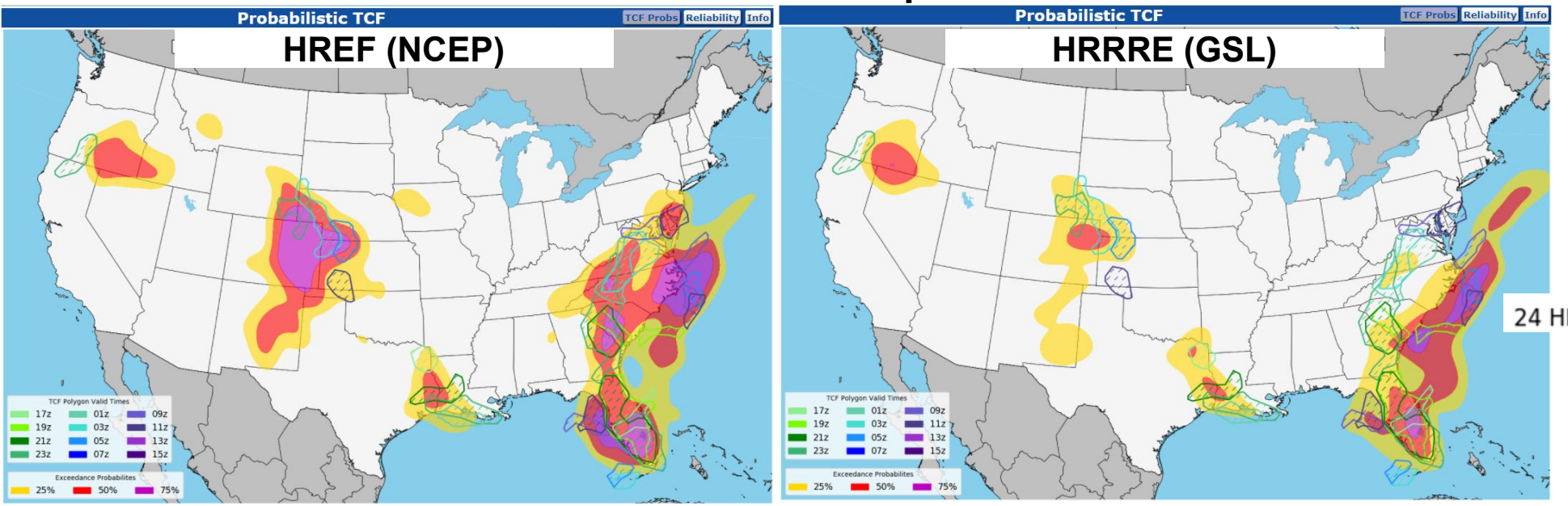
Hydrometeorology Testbed (HMT)
2020 Flash Flood and Intense Rainfall Experiment



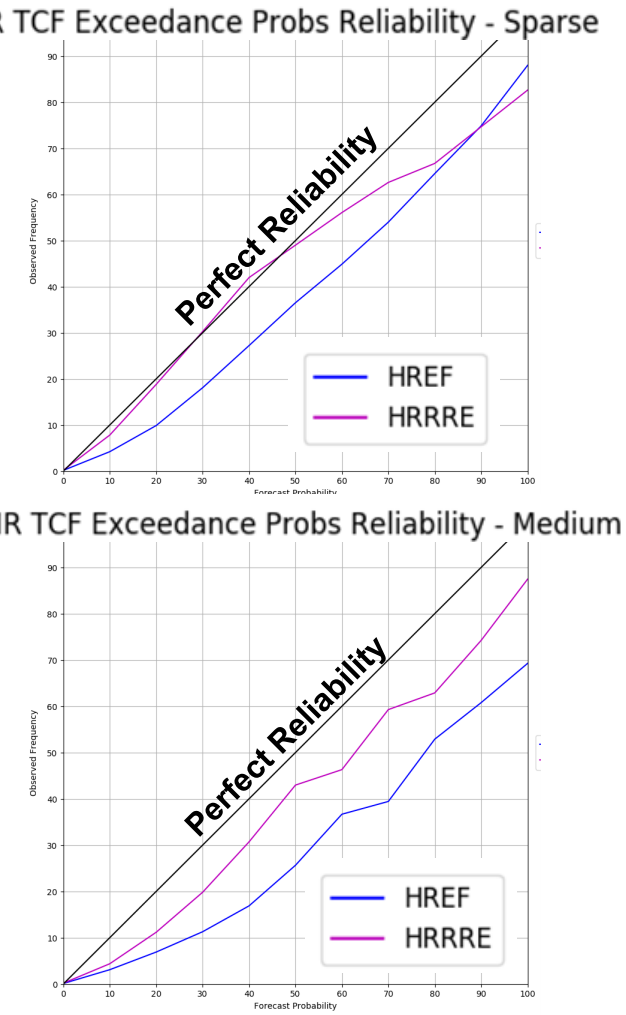
GSL demonstrating FV3 LAM 24-hr precipitation forecast sensitivity to differences to use of different horizontal advection options on 7-8 July 2020

Aviation Weather Testbed

Aviation Weather Testbed (AWT)
2020 Probabilistic Convection Experiment



GSL demonstrating HRRRE forecast probabilities (color fill) for sparser coverage of convection (tops ≥ 25 kft and 40 dBZ) on 8 Aug 2020 compared with MRMS radar observations (polygons)



Statistical comparison of HREF (blue) and HRRRE (pink) forecasted probabilities of sparse (top) and medium (bottom) convective coverage

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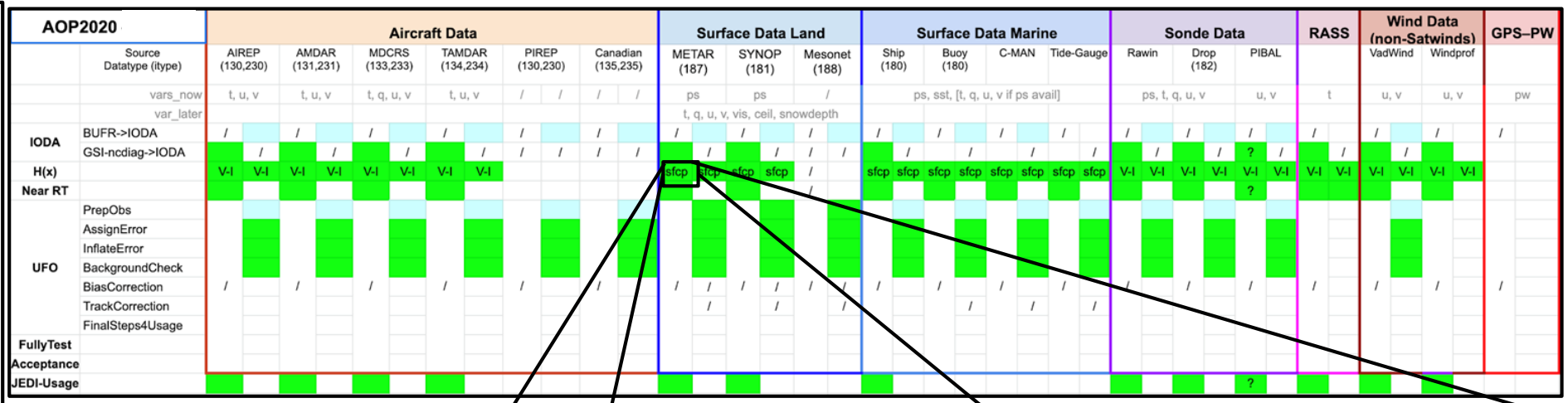
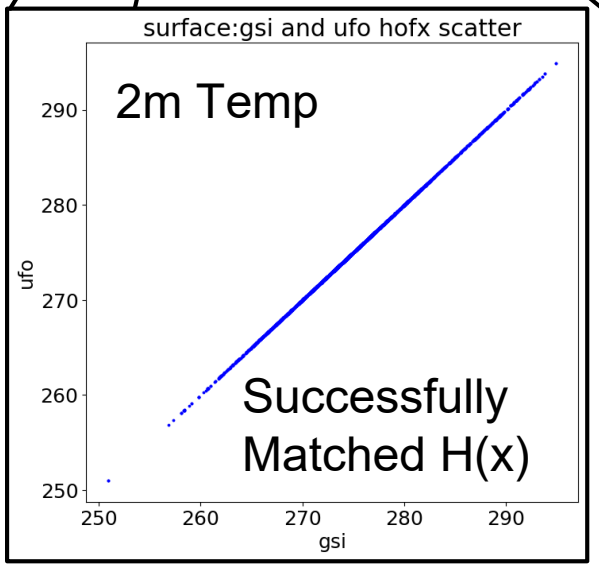
Joint Center for Satellite Data Assimilation (JCSDA)

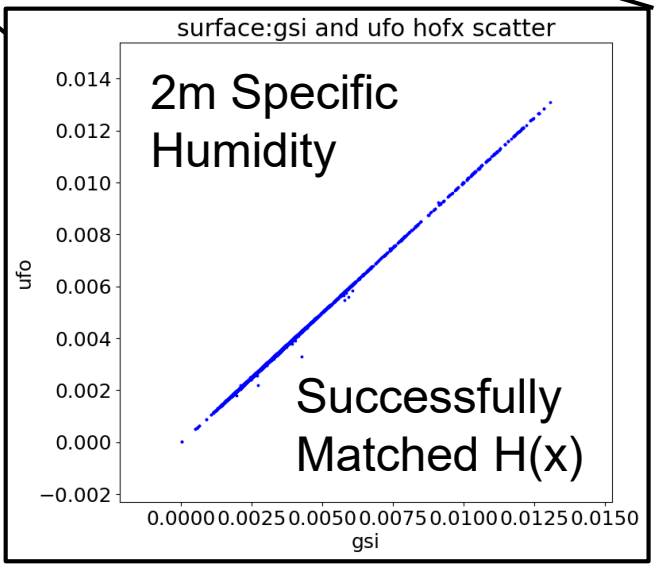
Global Systems Laboratory

JEDI Development Contributions

Joint Center for Satellite Data Assimilation
Operating Plan 2020







New JEDI UFO

Legacy GSI Observer

- GSL 1-2 FTE in-kind contributions
- Assimilation of regional conventional observation
- Development of Unified Forward Operators (UFOs) i.e. H(x)

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UFS Community Governance

Earth System Prediction: Community Engagement

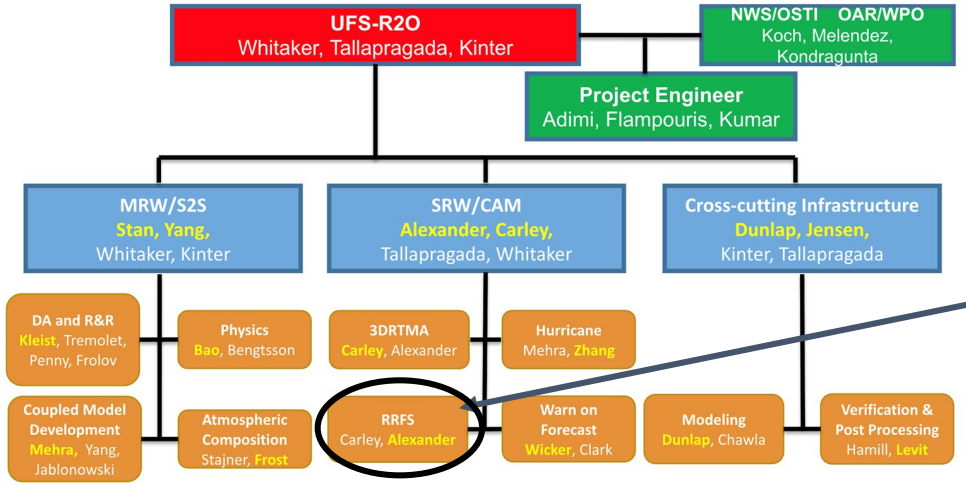
Global Systems Laboratory

UFS Is a Community Effort

GSL role in the UFS governance

- **Steering Committee**: Ligia Bernardet (member)
- **SRW/CAM App Team:** Curtis Alexander (co-lead)
- **Physics WG:** Georg Grell, co-lead
- **System Architecture:** Dom Heinzeller (co-lead)
- **Atmospheric composition, physics, verification WGs**: GSL staff (members)

GSL role in the UFS-R2O Project governance



RRFS: Curtis Alexander, lead

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Community Engagement via Social Science

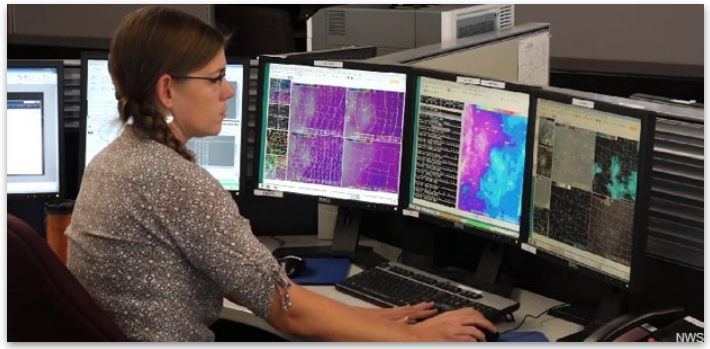
Global Systems Laboratory

From Model Output to Improved Decision Making

A Role for Social Science in Weather Research!

Ensemble model development to generate probabilistic output / information

- PDFs
- methods
- post processing



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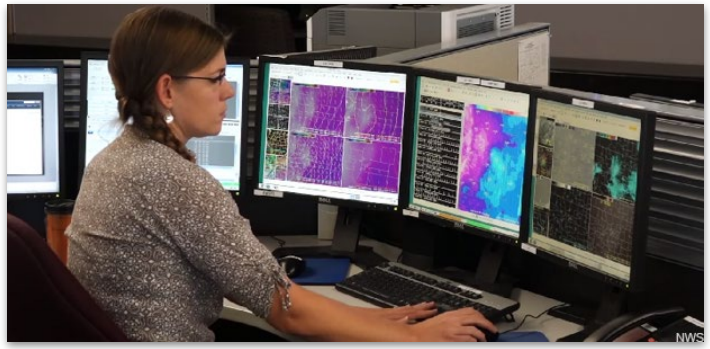
Forecasters receive this probabilistic information and provide Decision Support Services (DSS)

- Do they understand?
- Can they properly communicate probabilistic info?
- Confidence informed by verification



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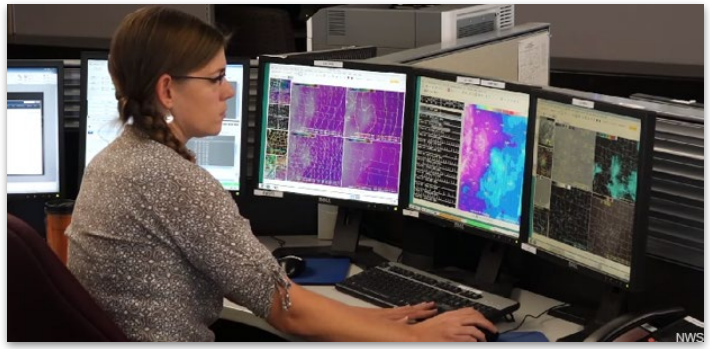

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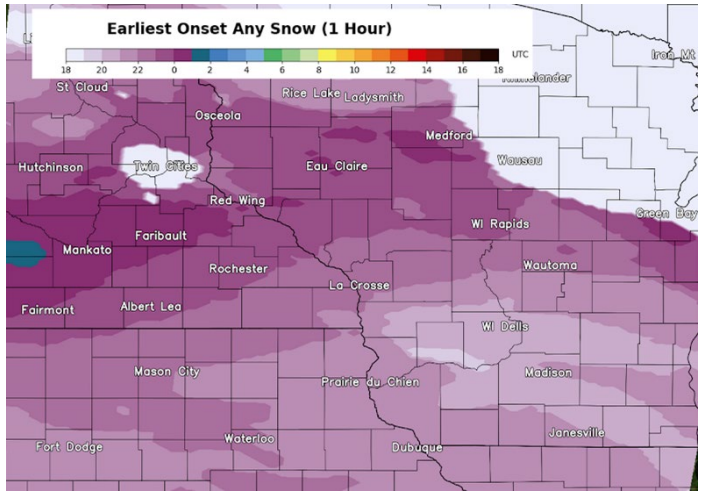
Core Partners receive this information from the forecasters

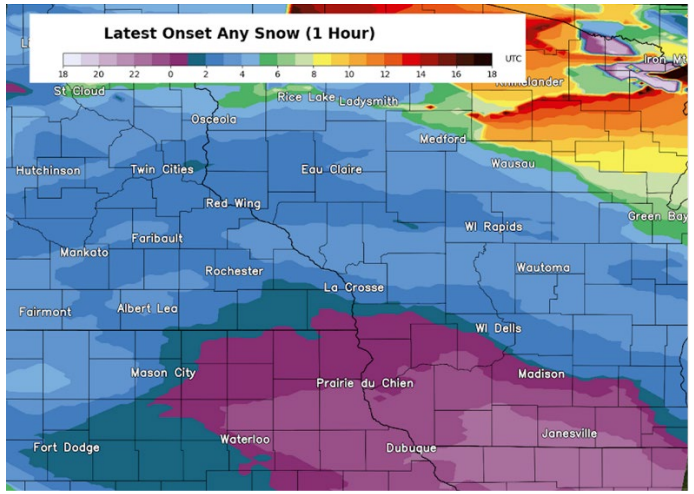
- Do they understand?
- Does it help them make more informed and better decisions?

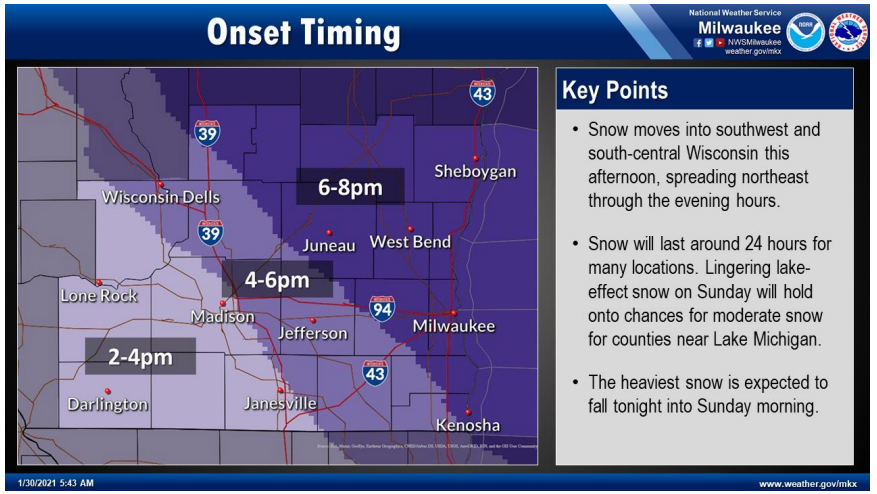
Deriving Timing Uncertainty from Ensembles

Goal of 2 Projects: Help better assess and communicate hazardous weather risks for Impact-based Decision Support Services (IDSS) through 3 integrated, iterative R&D threads:

- Social science research (interviews & surveys) with NWS forecasters and core partners (EMs, Fire Officials, etc.) ***to identify their key informational needs***
- Derivation of ensemble ***timing guidance*** for winter and fire weather parameters
- Development of forecaster-oriented verification of ensembles to quantify confidence





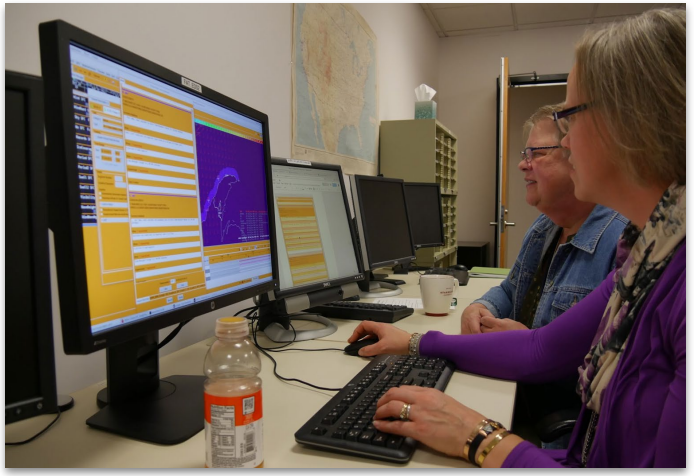


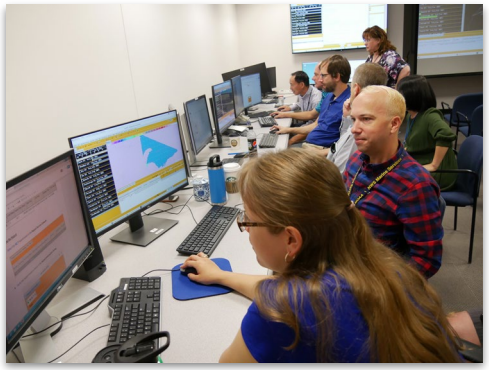
Recommendation D4.2

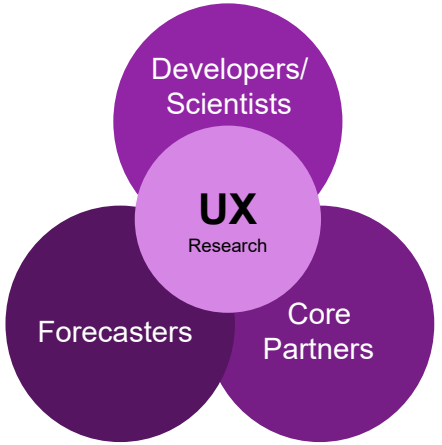
User Feedback and Involvement at GSL

Hazard Services Development

- Forecaster involvement over the past 12 years:
  - Dozens of in-person, week-long, Forecaster Assessment Tests
  - Weekly calls/demos with Forecasters / focal points
  - Hazardous Weather Testbed experiments







NOAA Global Systems Laboratory

Leading Collaborative Programs

Dave Turner
Manager, ASRE Program

Global Systems Laboratory

Leading Multi-Lab Collaborative Projects

- Atmospheric Science for Renewable Energy (ASRE) Program
  - Initiated in late 2010
  - $2.8 M annual budget
  - Includes participants from Physical Sciences Lab (PSL), Global Monitoring Lab (GML), Chemical Sciences Lab (CSL), and Global Systems Lab (GSL)

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- Boundary Layer Program
  - Initiated in 2018
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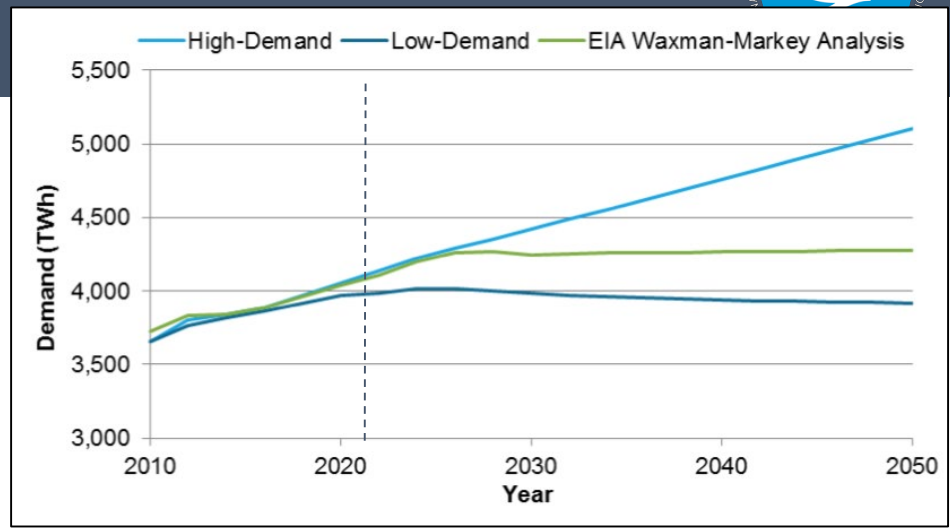
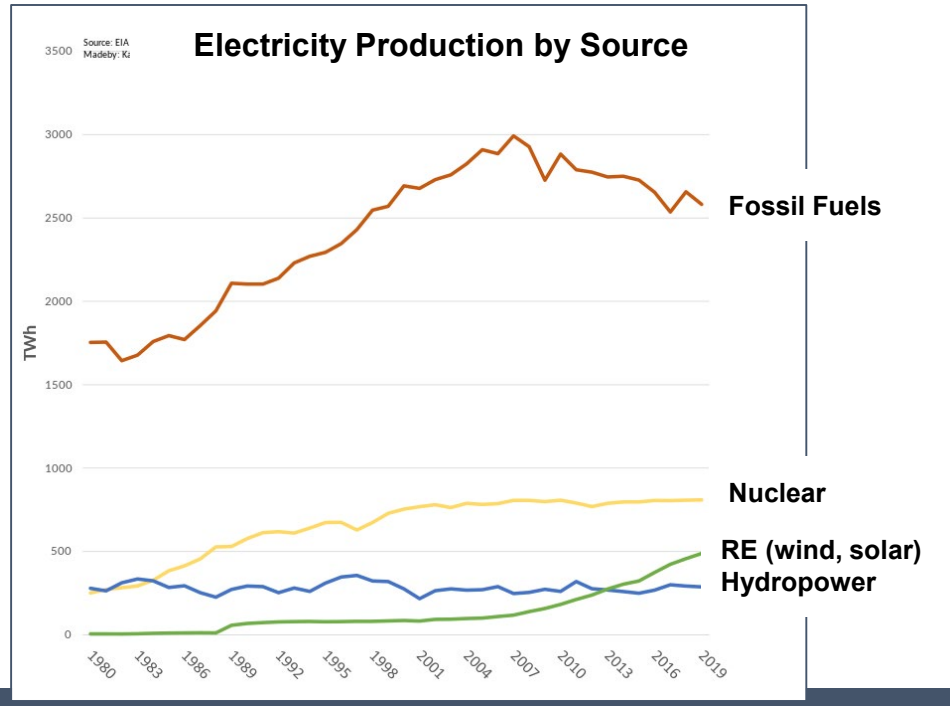
  - Includes PSL, GML, GSL, Air Resources Lab (ARL), and National Severe Storms Lab (NSSL)
- Fire Weather Program
  - New program being developed in last 8 months
  - Potentially a $25M annual budget
  - Involve most OAR labs, as well as NESDIS and NWS

Renewable Energy - Motivation

- US electricity demand continues to increase
- Strong desire to move towards more renewables
  - Priority of the Biden administration
  - One way to mitigate climate change
- Economic benefits
  - Renewable energy is cost competitive

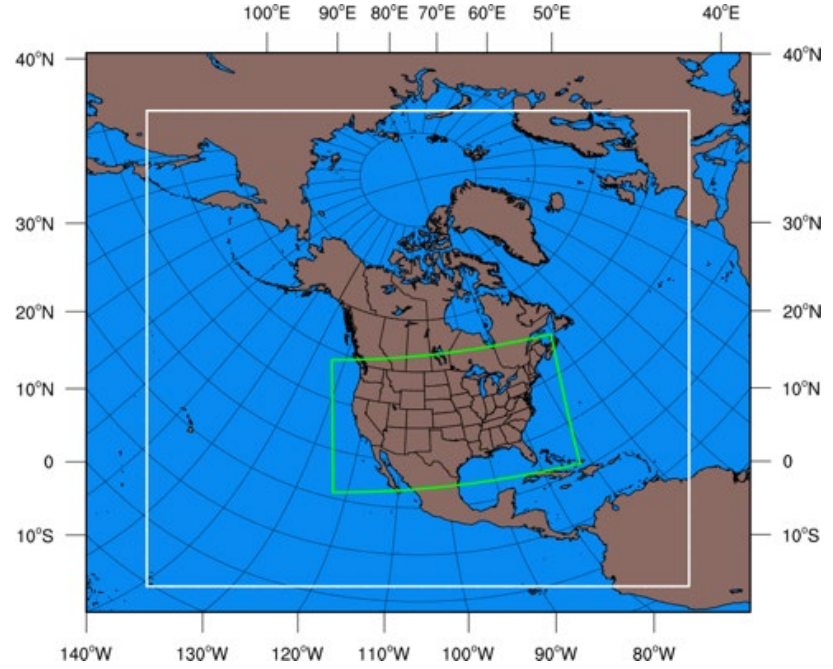
Simple cycle gas turbine:	$160/MWh
Nuclear:	$112/MWh
Coal:	$60/MWh
Combined cycle gas turbine:	$41/MWh
Utility scale solar:	$36/MWh
Wind energy:	$29/MWh





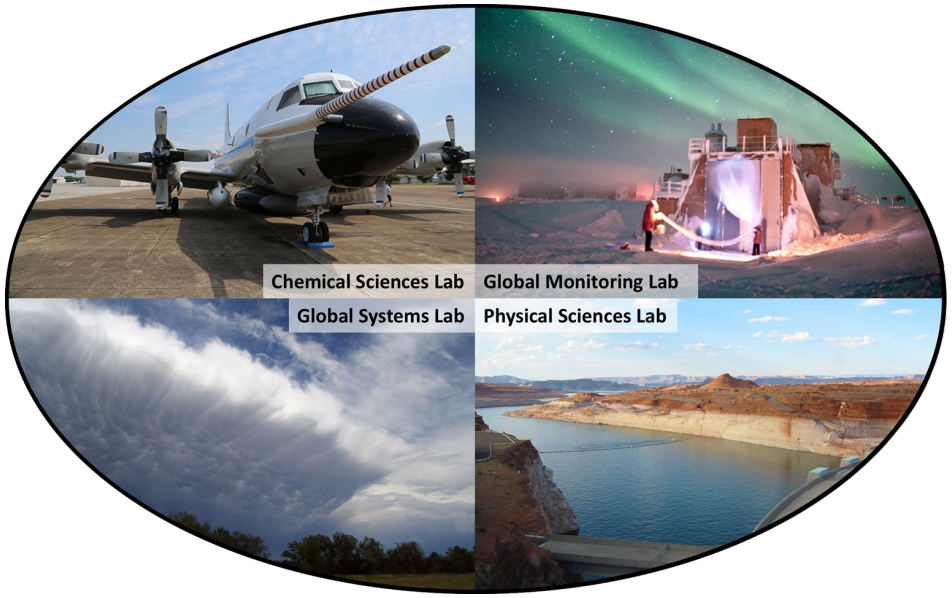
Renewable Energy - Motivation

- Renewable energy (RE) from wind and solar is highly variable; depends on the weather
- Accurate day-ahead forecasts are needed to optimally integrated RE into the electric grid
- High spatial resolution weather forecasts needed for forecasts in complex terrain and in off-shore areas; HRRR is ideal



Atmospheric Science for Renewable Energy

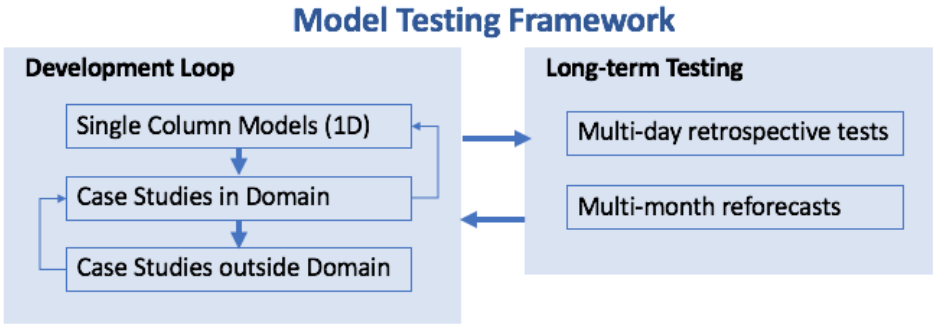
- An integrated, multi-lab, applied research program; was initiated in 2010
- Improve downwelling solar and surface-to-300m wind forecasts, especially in the 1 to 48 h forecasts from the HRRR
- Strong emphasis on boundary layer turbulence and subgrid-scale clouds



- Constraint is “do no harm” to the convective forecasts
- Over 35 published papers with multi-lab authorships since 2016
- ASRE efforts span the technical readiness range and facilitates R2O

Collaboration with Department of Energy

- DOE Office of Energy Efficiency and Renewable Energy (EERE) Wind Energy Technology Office (WETO) is major partner
- WETO supported Wind Energy Forecast Improvement Projects (WFIP)
  - WFIP-1: in 2011-12, focus on data assimilation
  - WFIP-2: in 2016-17, focus on complex terrain
  - WFIP-3: in 2022-23, focus on off-shore issues



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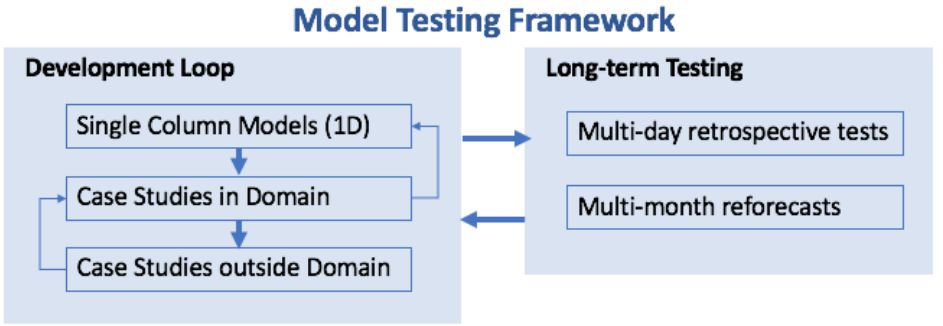
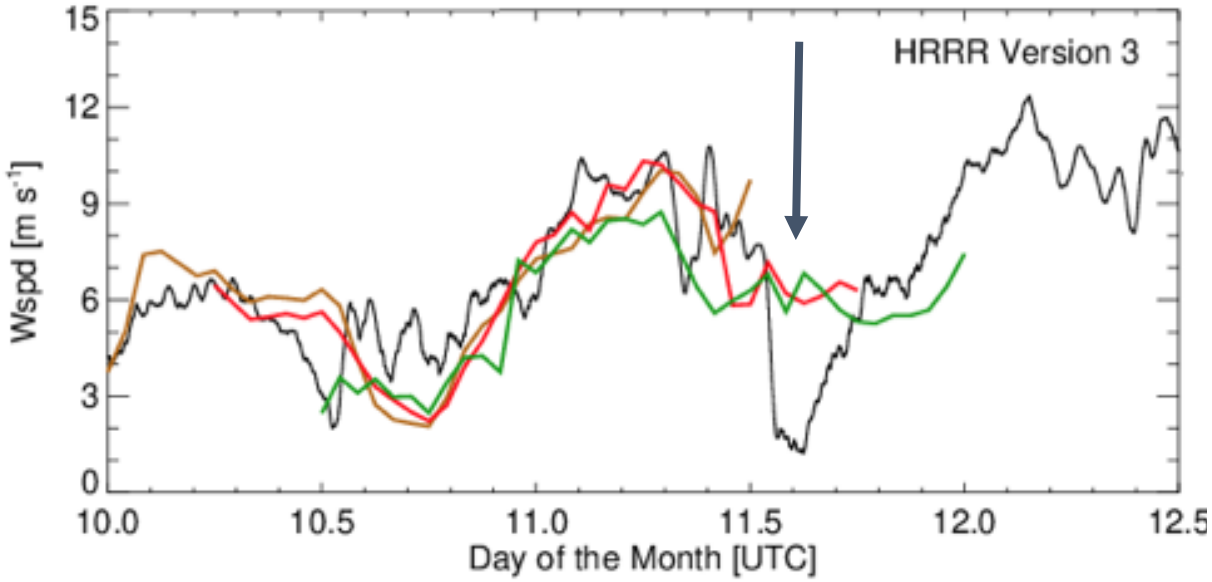
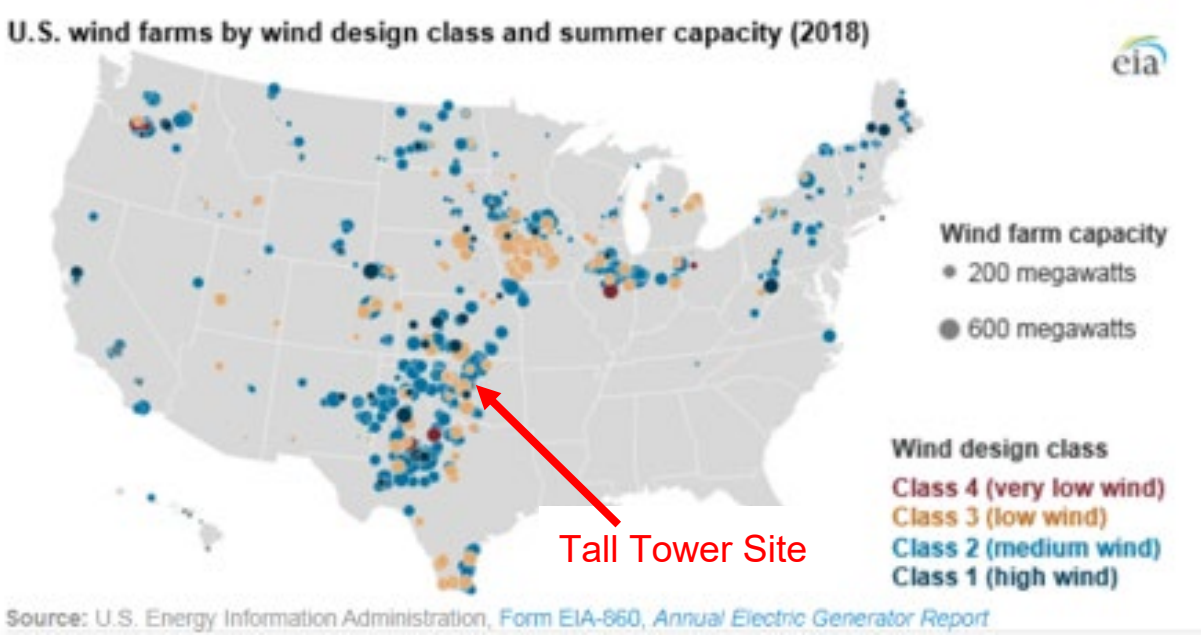


- Building relationship with EERE Solar Energy Technology Office
- Long-term relationship with DOE Office of Science via Atmospheric System Research and Atmospheric Radiation Measurement programs
- ASRE helps facilitate DOE supported work into NWS operations

Improvements to Wind Ramp Forecasts

- Wind ramps (sudden increases or decreases in wind speed) have significant impacts on integrating RE into the electrical grid
- Improvement in HRRR v4 physics (e.g., turbulent mixing, subgrid-scale drag) allows wind ramps to be captured much more accurately





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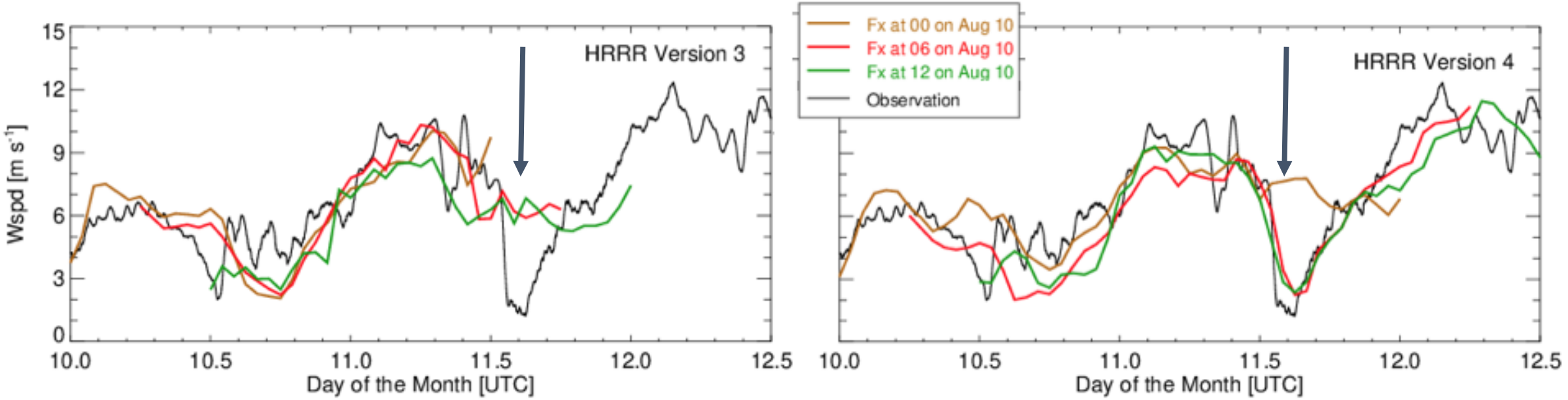
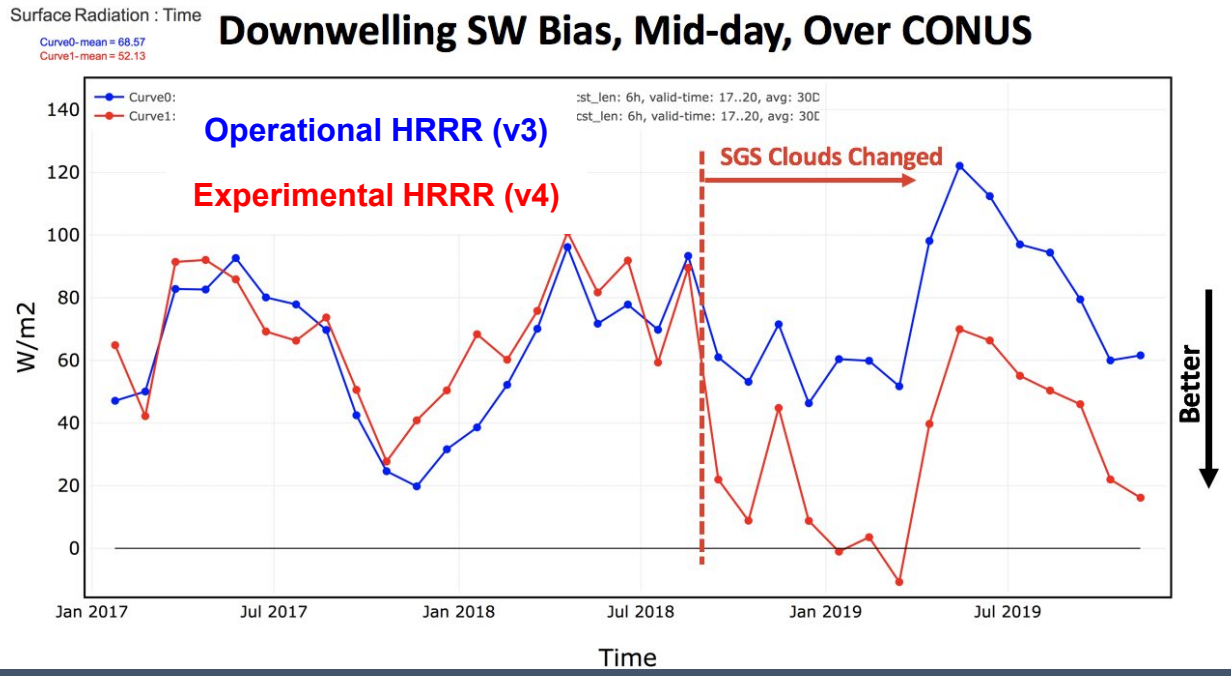
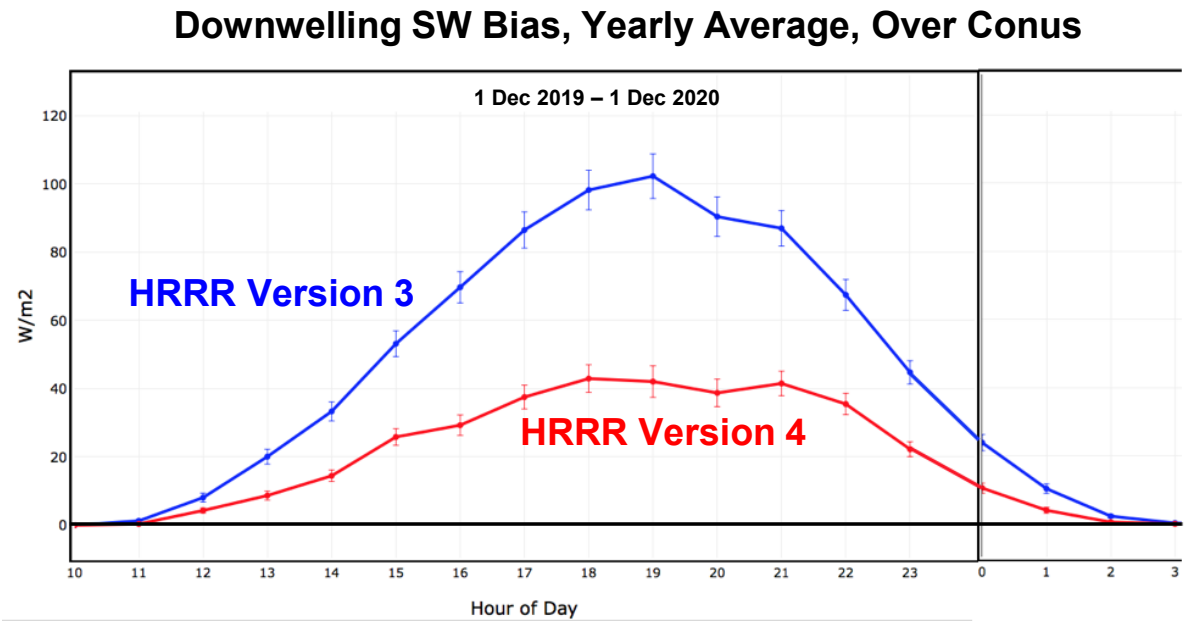


Improvements in Subgrid-scale (SGS) Clouds

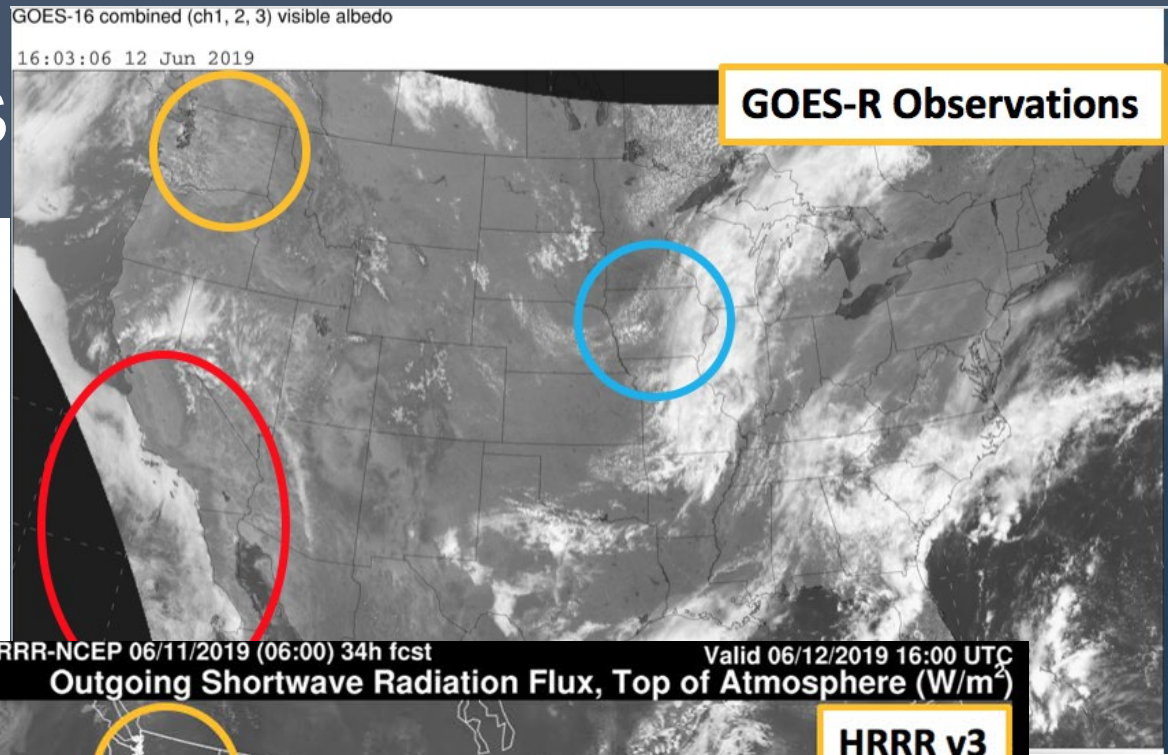
- All weather (and climate) models struggle to represent SGS clouds
- HRRR used to have a significant bias in downwelling solar flux
- Improvements made to both the stratiform and convective SGS

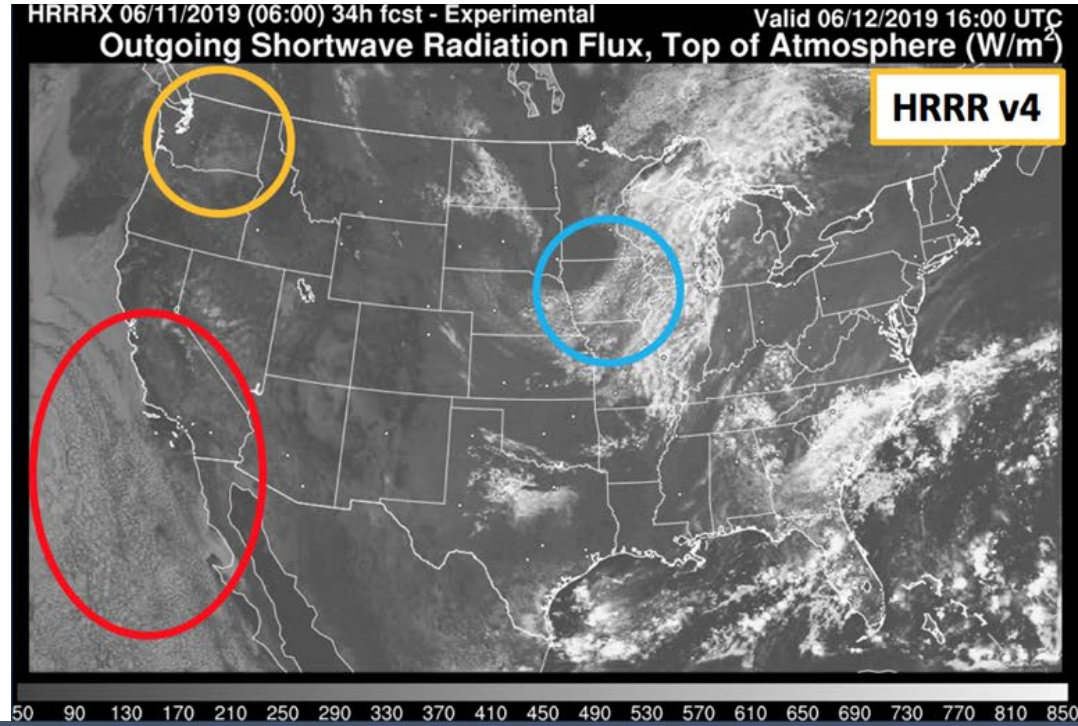


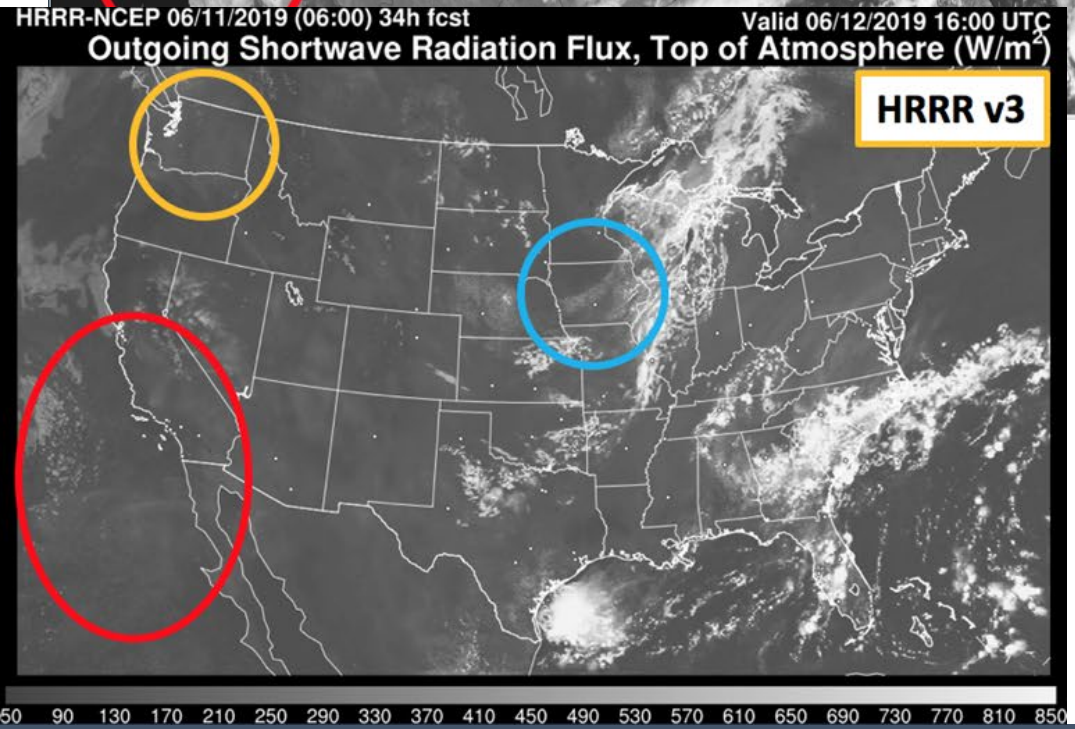


Improvements in SGS Clouds

Improvements are qualitative as well as quantitative

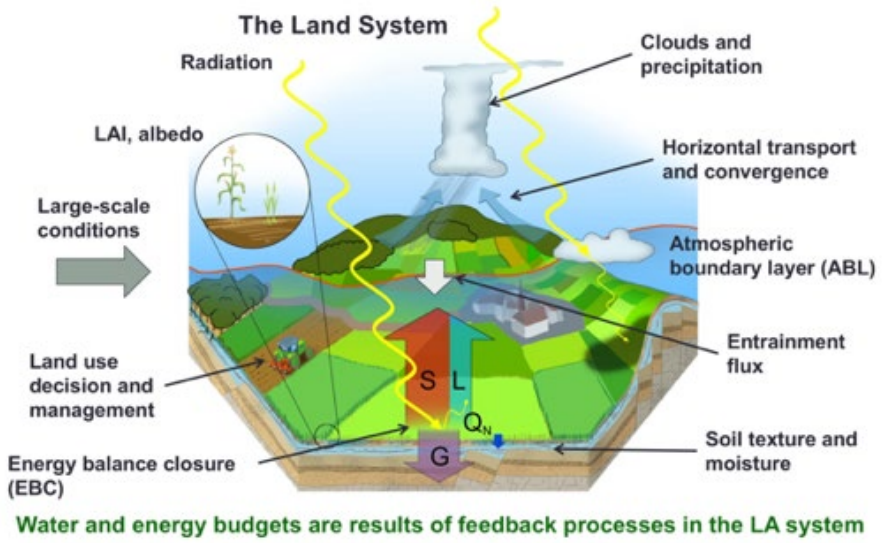




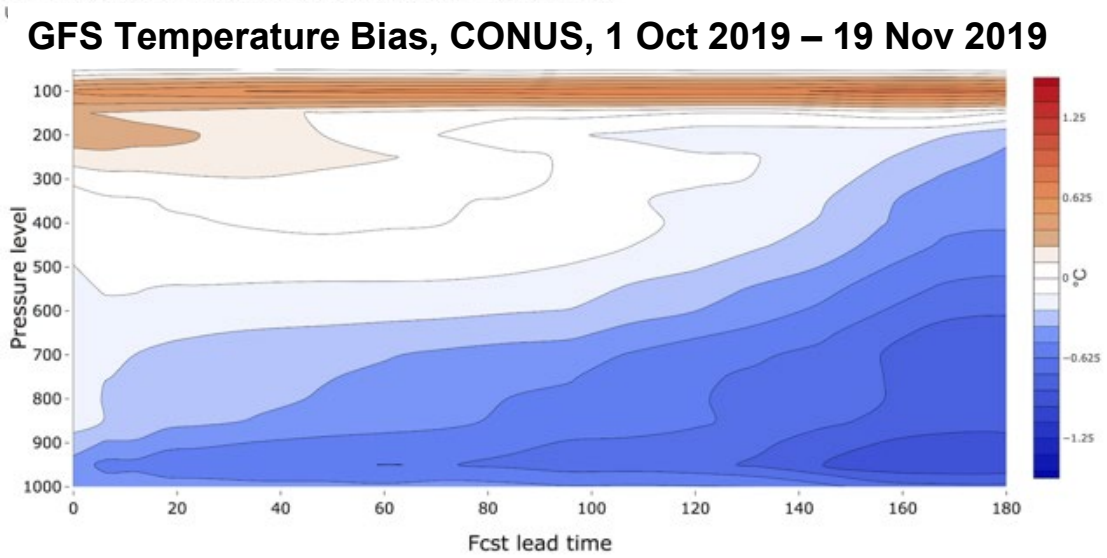


Boundary Layer (BL) Program

- All OAR laboratories have research interests in the BL
- Significant errors in Global Forecast System (GFS) weather forecasts due to errors in BL physics
- Research tools (instruments/models) distributed across the OAR lab system
- Joined other agency efforts
  - NSF-funded effort in 2018-20
  - Plan on joining DOE-funded effort in 2020-22

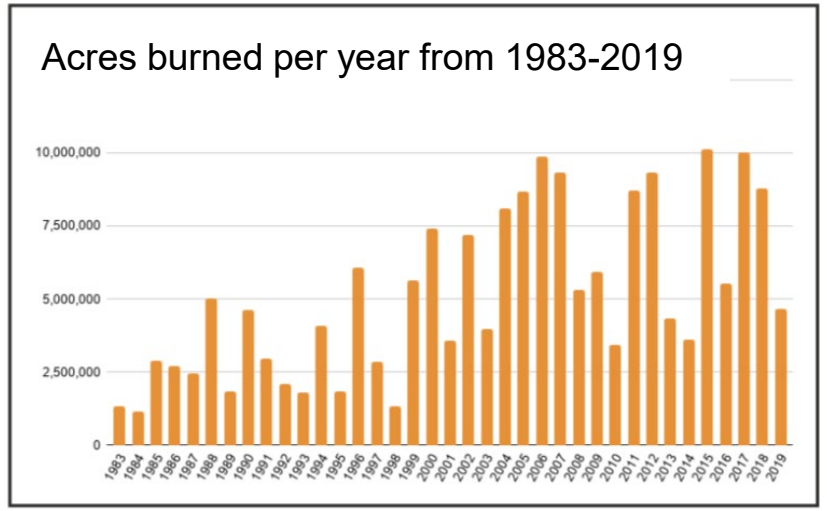


Water and energy budgets are results of feedback processes in the LA system



Fire Weather Program

- Strong desire to better understand/predict wildfire - weather interactions
  - GSL is leading NOAA-wide effort to support Congressional request
  - Integrating efforts across OAR, NESDIS, and NWS
  - Developing Fire Weather Testbed to facilitate R2O



- Developed briefings for Congressional staff, other agencies
- Developed short-term (1-2 yr) spend plan and program change summary for next 5-10 yr
- Research includes: coupled fire-weather modeling, fire emissions and air quality impacts, subseasonal-to-decadal prediction, products and tool development for operations, ...

Summary of Community Activities

Performance

- Leadership of multi-lab projects
- DTC management
- Tutorials and community workshops
- Testing and evaluation
- Testbed participation

Quality

- Dozens of multi-lab authored papers
- Improved models to NWS operations
- Release of medium- and short-range UFS models
- Improving ensemble design and uncertainty estimates

Relevance

- Multi-lab, cross-line office, cross-agency to improve NOAA R2O
- Community engagement
- Responding to national needs

Overall Summary

- Modeling
- Data assimilation
- Improving prediction across scales
- Community engagement

GSL Grand Scientific Challenge:

Provide actionable environmental information through the delivery of global storm-scale predictions and innovative decision support capabilities to serve society

Thank you!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