Developmental Testbed Center

DEVELOPMENTAL TESTBED CENTER ENSEMBLE TESTBED (DET)

Tara Jensen

For DET Team

Team Members:

Zoltan Toth, Isidora Jankov, Paula McCaslin, Ed Tollerud, Linda Wharton, Jeff Smith, Barabara Brown, and Brian Etherton

ICAP Workshop - May 11, 2011 Boulder Colorado

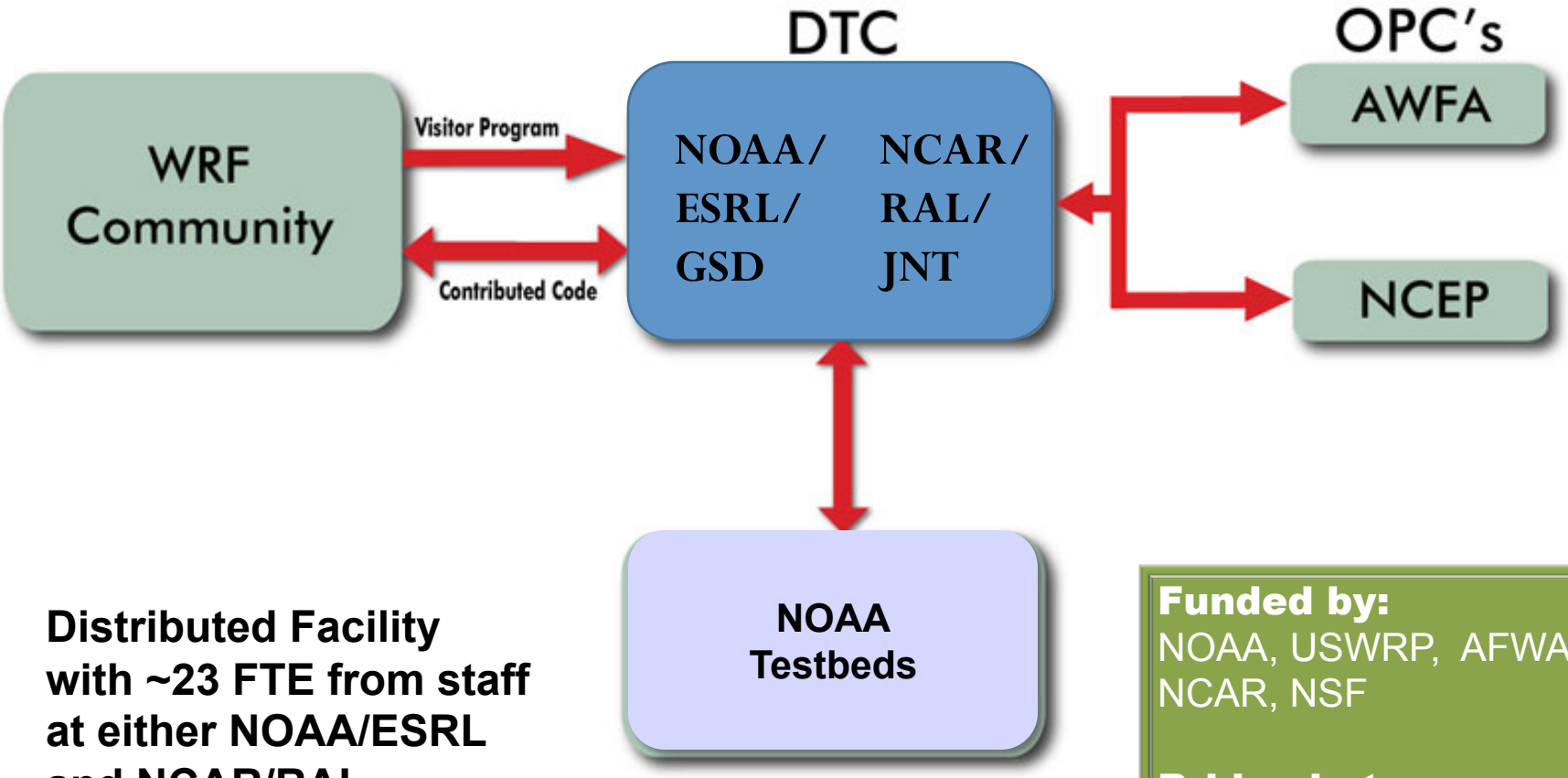
What is DTC?

- A National Facility where the NWP community can test and evaluate new models and techniques for use in research and operations
- Established in 2003 as a multi-agency effort (NOAA and NCAR)

- Objective: Bridge between Research and Operations
- Focus: Mesoscale and Convective Scale NWP

- Benefits
  - Research community gets a functionally equivalent operational environment to test and evaluate new NWP methods in retrospective extended period tests using advanced tools
  - Operational community benefits from DTC testing and evaluation of strengths and weaknesses of new NWP advances prior to consideration for operational implementation

Who are our partners?



Distributed Facility with ~23 FTE from staff at either NOAA/ESRL and NCAR/RAL and 2 staff at NOAA/NCEP

Funded by:
NOAA, USWRP, AFWA, NCAR, NSF

Bridge between Research And Operations
Community Code Support
Testing and Evaluation
Verification Research

What do we do?

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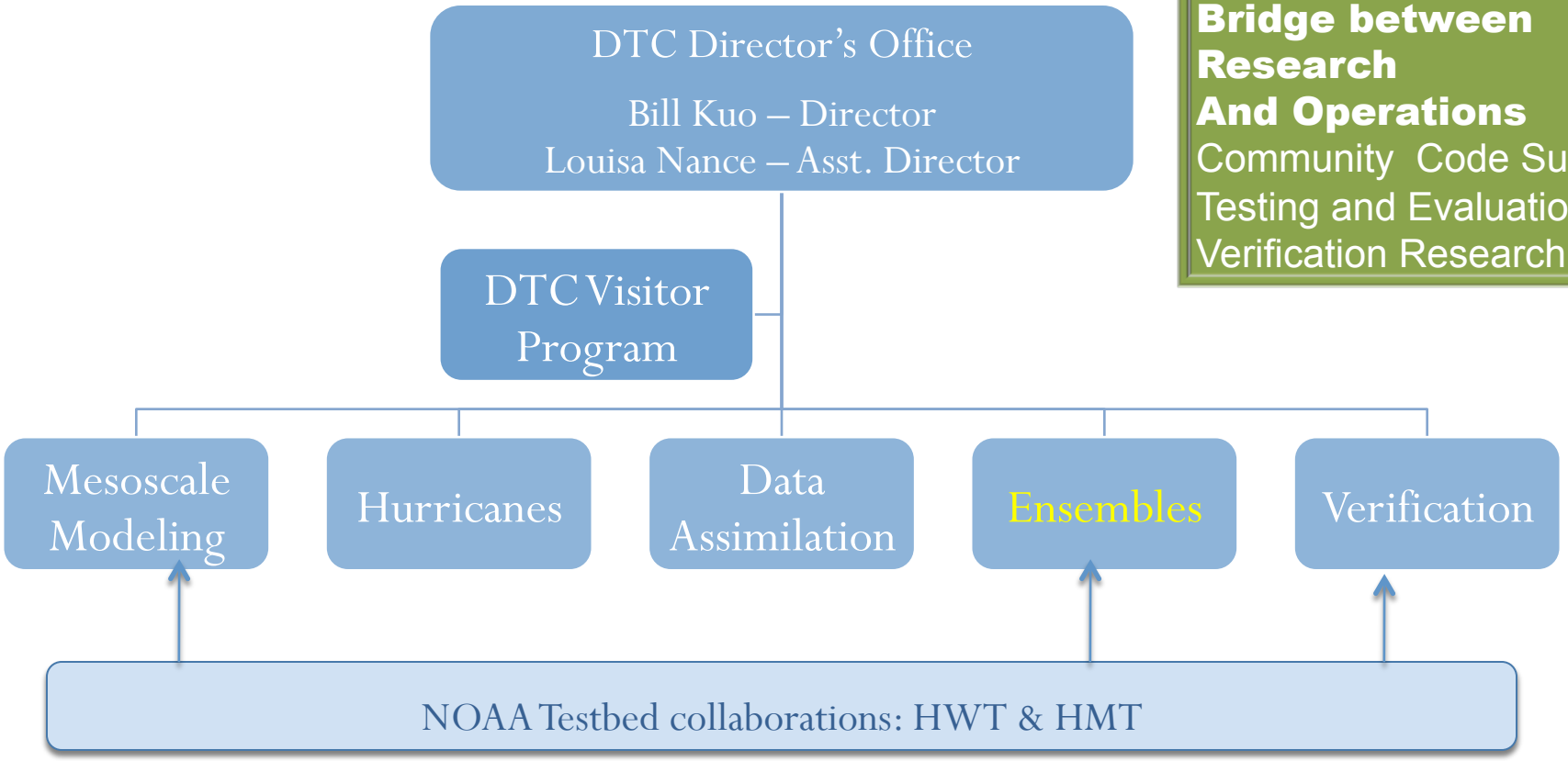
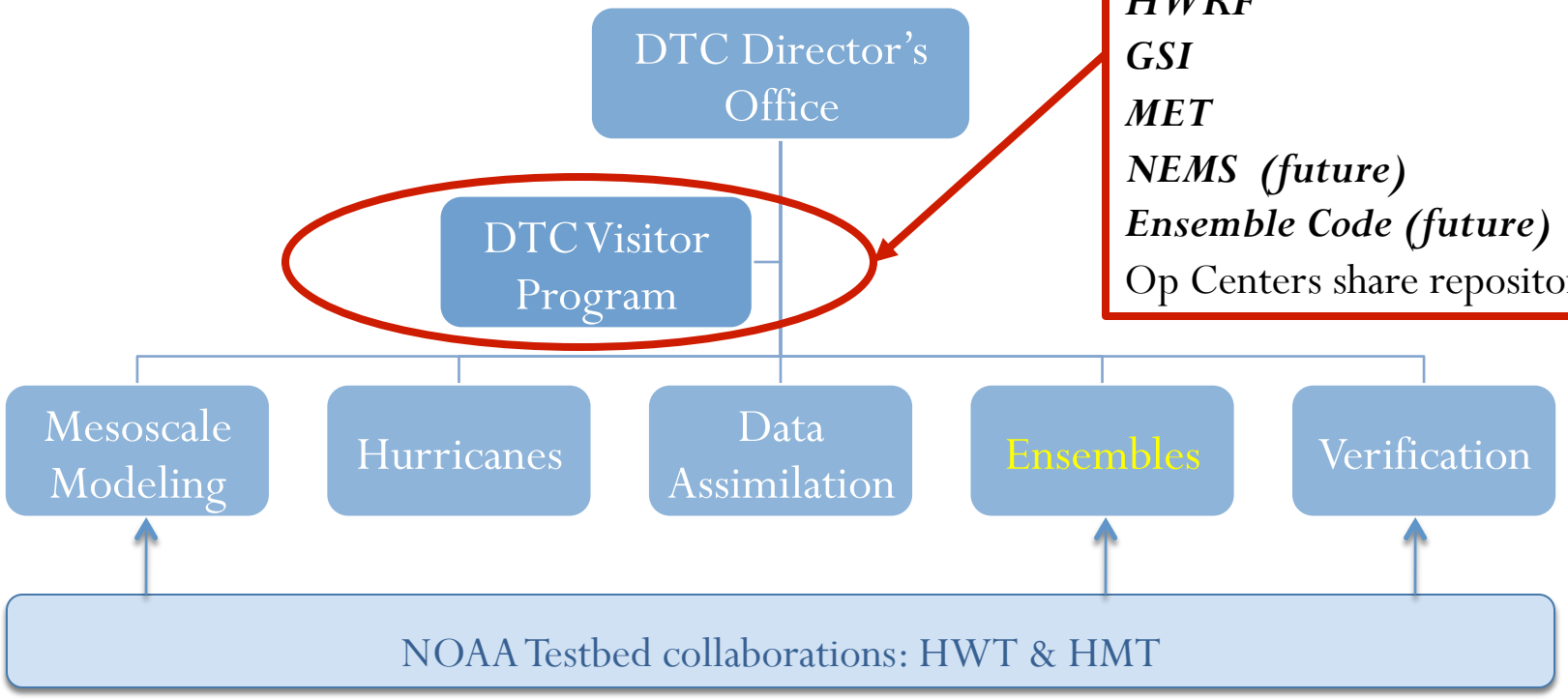


1. DTC activities focused on five key areas: Mesoscale Modeling, Hurricanes, Data Assimilation, Ensembles and Verification.
2. Testbed collaborations are cross-DTC special projects that contribute to identified focus areas.

What do we do?

Direct Infusion of Research into Community Codes:

WRF (NMM)
HWRF
GSI
MET
NEMS (future)
Ensemble Code (future)
Op Centers share repositories



1. DTC activities focused on five key areas: Mesoscale Modeling, Hurricanes, Data Assimilation, Ensembles and Verification.
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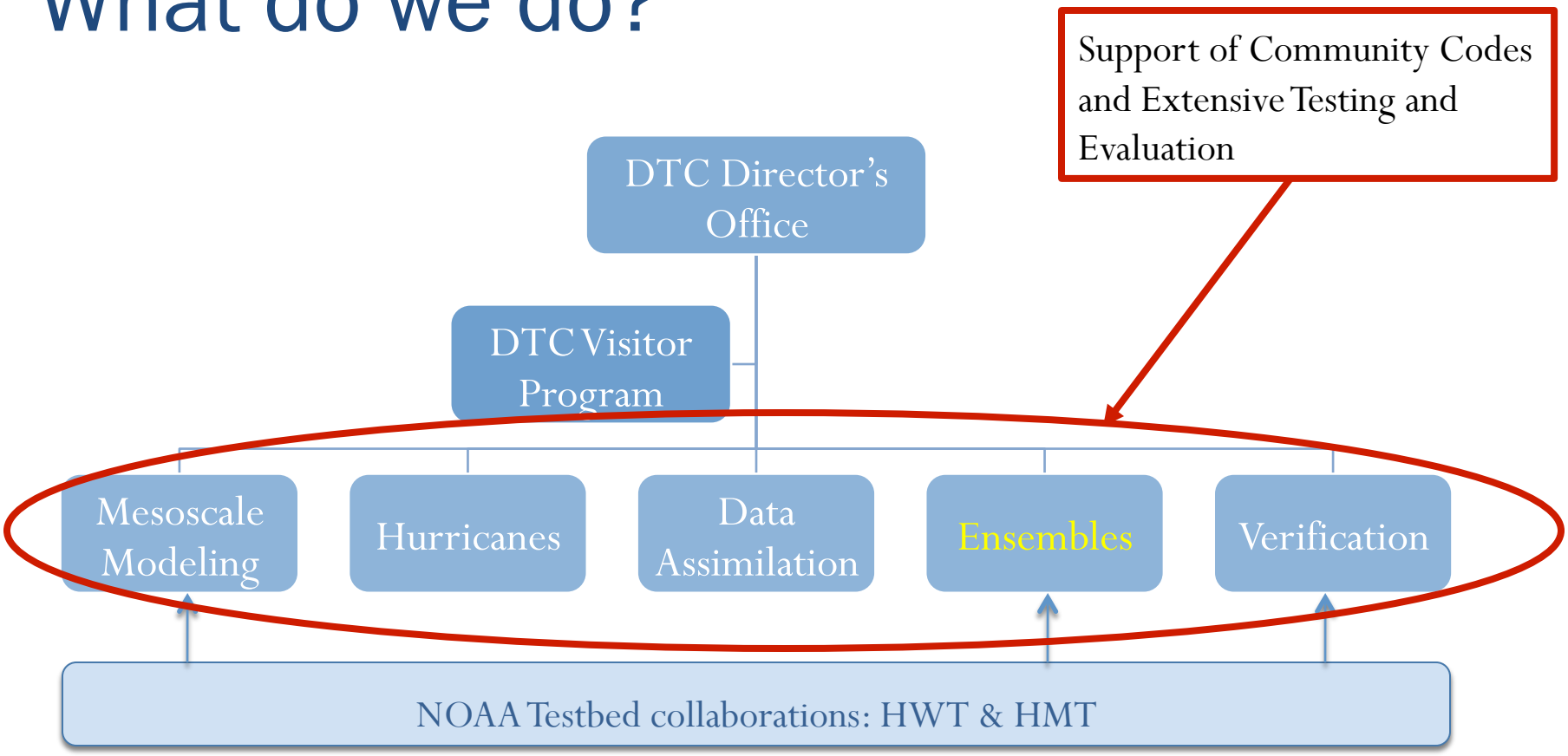
What do we do?



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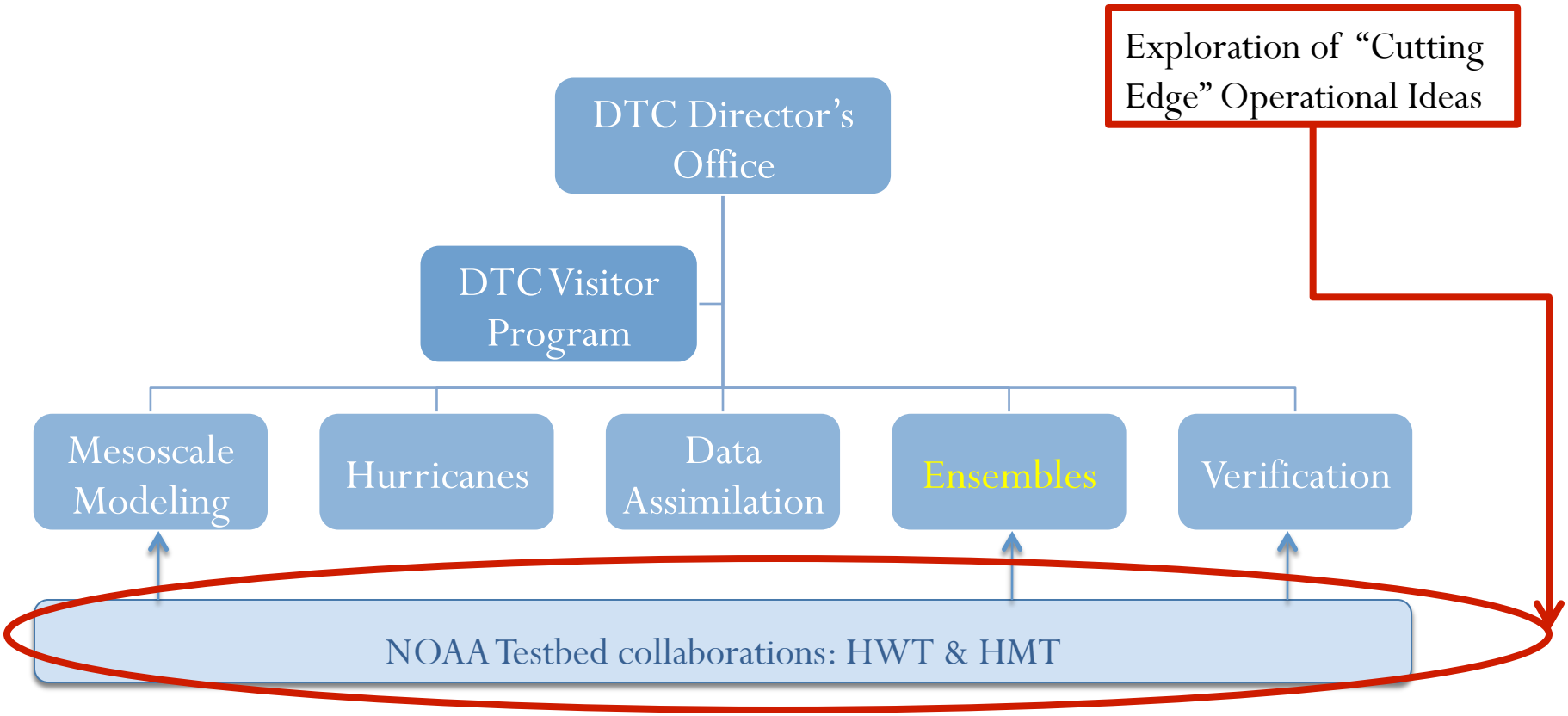

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Formation of DET in 2009

Confluence of necessary ingredients

- **Need**
  - Strong interest from both community & agencies
- **Knowledge base**
  - Roadmap from Sept 2009 Workshop
    - National Workshop on Mesoscale Probabilistic Prediction at NCAR
- **Opportunity**
  - Increase in funding for DTC from NOAA
- **Initiative**
  - DTC Director's Office set planning process in motion (Oct 09)

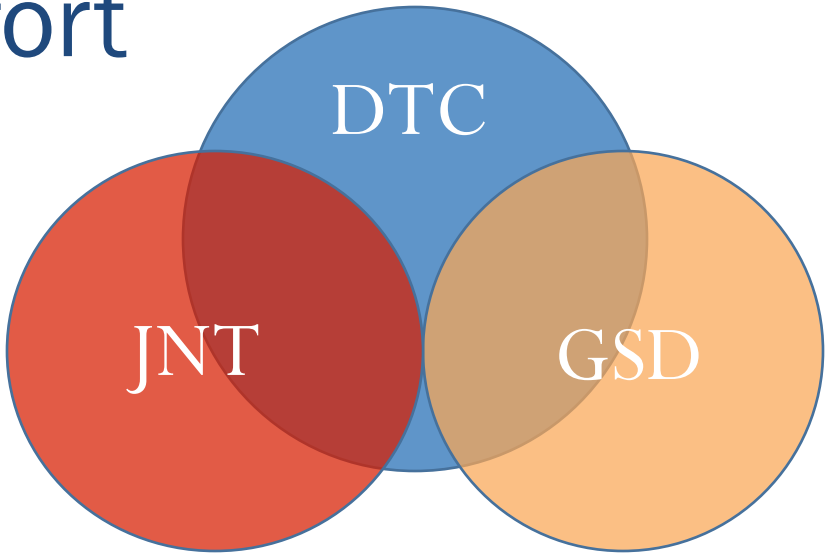
DTC Ensemble Testbed Leadership

Brian Etherton

Zoltan Toth

DET Staff – A Joint Effort

- Infrastructure Development
- Methods Integration
- Robust Testing and Evaluation
- Community Code Packaging



Funding for ~3 FTE

	NOAA/GSD	NCAR/JNT
Scientists	Brian Etherton Isidora Jankov Ed Tollerud Zoltan Toth	Barbara Brown Michelle Harold Tressa Fowler Tara Jensen
Software Engineers	Paula McCaslin Linda Wharton Jeff Smith	John Halley Gotway Eugene Mirvis Paul Oldenburg Bonny Strong
Students		Lisa Coco

INFRASTRUCTURE

- **Objective**
  - Assemble software and procedures to carry out main function of testing and evaluation of community methods
- **Structure**
  - Six modules identified
    - Ensemble configuration
    - Initial perturbations
    - Model-related uncertainty

    } Ensemble generation – meso-specific

    - Statistical post-processing
    - Products / Services
    - Verification

    } Use of info – general, applies to all ensembles
- **Requirements**
  - *Modularity* to facilitate transition to operations
  - *Portability* for ease of execution where computational resources are available
  - *Flexibility* to allow testing of new ideas

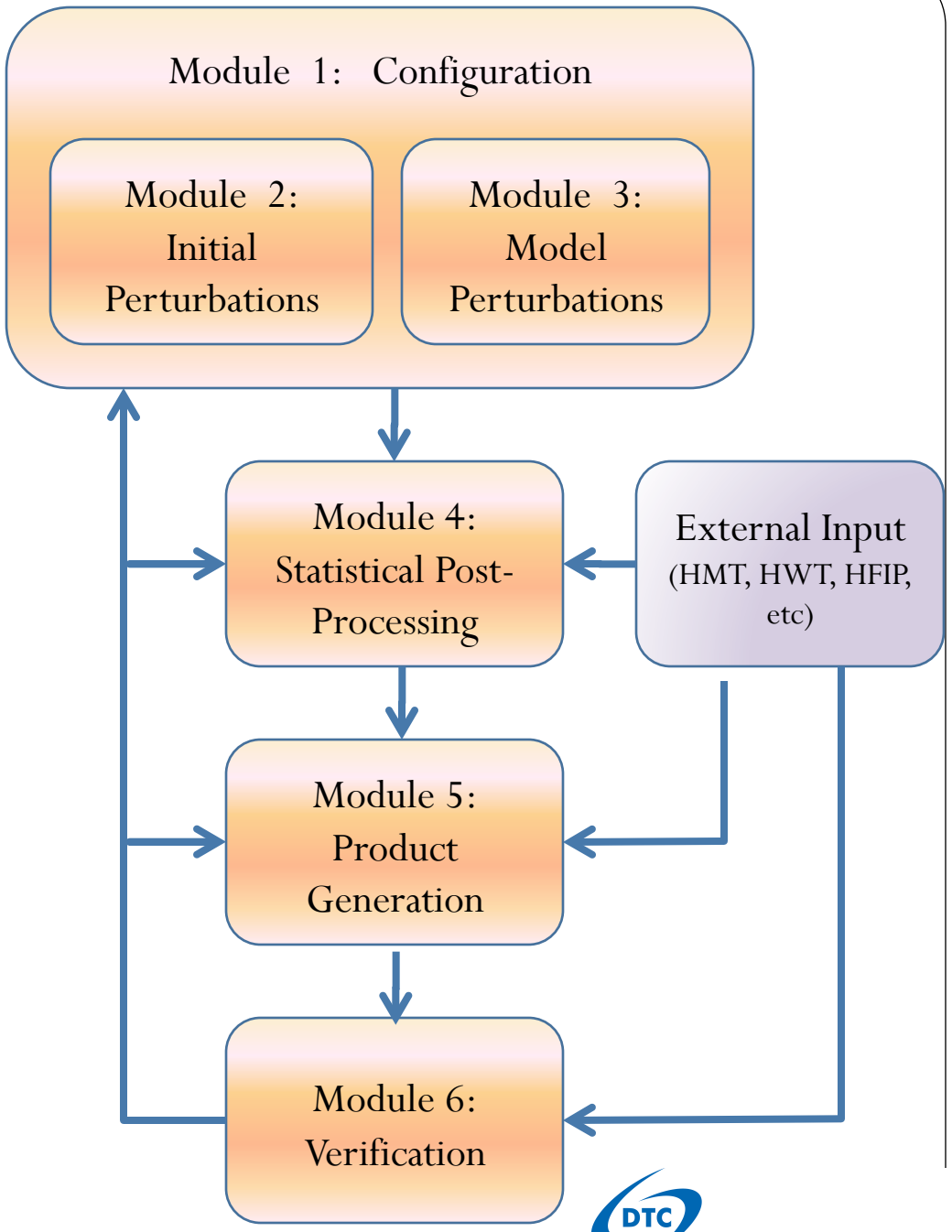
DET Modules – What They Explore

- ***Ensemble configuration*:** Membership; Resolution; Multi-Model/Same Model; Number of Members
- ***Initial perturbations*:** Ability to represent uncertainty in initial conditions based on a variety of techniques.
- ***Model perturbations*:** Model-related uncertainty based on a variety of techniques
- ***Statistical post-processing*:** Fusing information from ensemble using Bias Correction or Calibration of forecast distribution or Statistically downscaling information to user relevant variables.
- ***Products / Services*:** Deriving information from the ensemble, generating probabilistic products, providing decision support services, etc.
- ***Verification*:** Evaluation of ensemble and derived probabilistic forecasts.

DET MODULES

COMPONENT:	Based on
Configuration UI:	WRF Portal
Model Architecture:	WRF and NEMS
Initial Conditions:	OPC Needs
Model Perturbations:	OPC Needs
Statistical Post-Proc:	OPC Needs
Product Generation:	OPC Needs
Verification:	Model Evaluation Tools (MET)

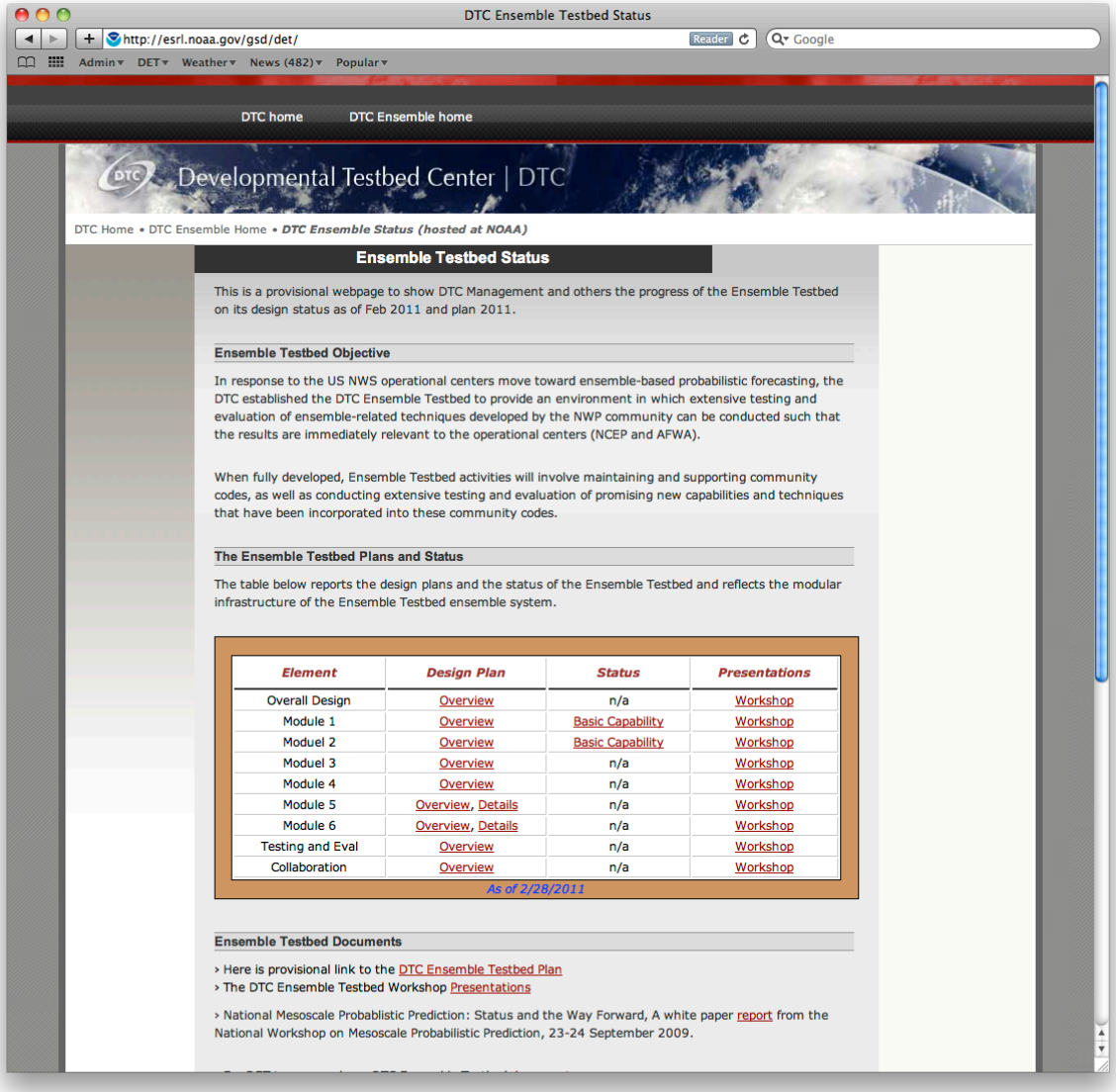
OPC = Operational Centers



DTC Ensemble Testbed: Major Accomplishments - Past Year (Mar 2010-2011)

- Plans developed for http://www.dtcenter.org/det/
  - Overall architecture of DET infrastructure
  - Each of 6 modules
  - Test and Evaluation
- Established and tested basic capabilities for 2 modules
  - Configuration (Module 1)
  - Initial perturbations (Module 2)
- Collaboration with other DTC tasks / projects
  - NOAA Testbeds – Joint plans for testing DET & testbed ensemble generation
  - HFIP – Fostered connections for future joint efforts
- Outreach
  - Organized DET Workshop and engaged with WRF Ensemble WG
  - Activities coordinated with NCEP/EMC via regular meetings

DTC Ensemble Testbed:
Major Accomplishments - Past Year (Mar 2010-2011)



- Status of project, planning documents, and presentations for Ensemble Testbed located at www.dtcenter.org/det

Developmental Testbed Center

DTC Ensemble Testbed: Planned Activites - Next Year (Mar 2011-2012)

- Establish benchmark for initial perturbation module
  - Testing & evaluation to contribute to next NCEP SREF implementation
- Establish basic capability for model perturbation module
  - Capability of using different versions of NMM under NEMS
- Interface with other testbeds & projects
  - Evaluation of HMT ensemble with focus on hydrometeorological variables
  - Contributions to Product & Verification Modules with HWT ensemble products & evaluation
  - Joint planning for HFIP ensemble development & testing
- Continued engagement with community
  - Co-organize 5th Ensemble User Workshop with NCEP
  - Participate in NUOPC Workshop

Foundation of DET

WRF Portal

WRF – ARW and NMM

NEMS – NMM and ARW

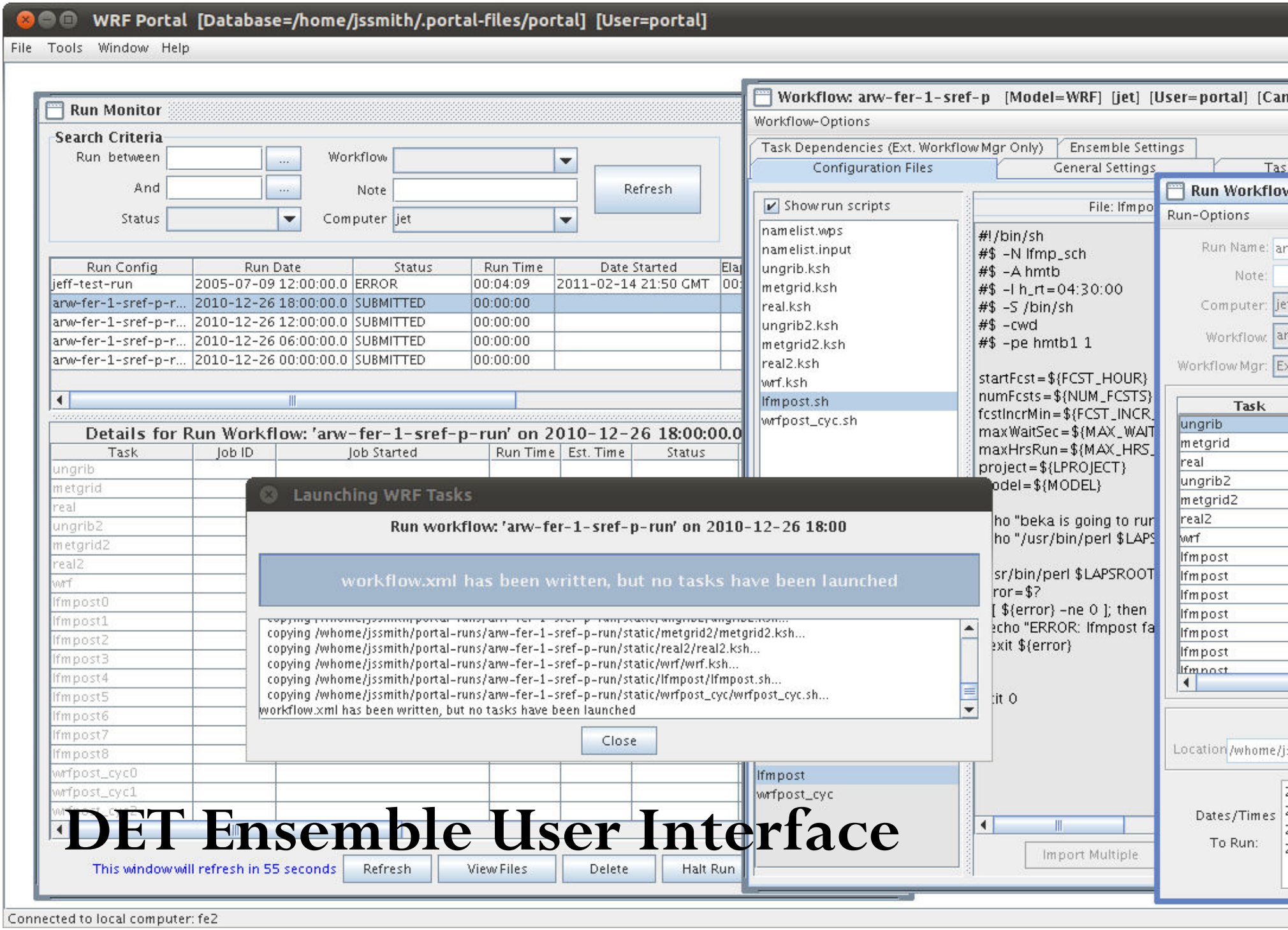
MET

COMPUTE RESOURCES:

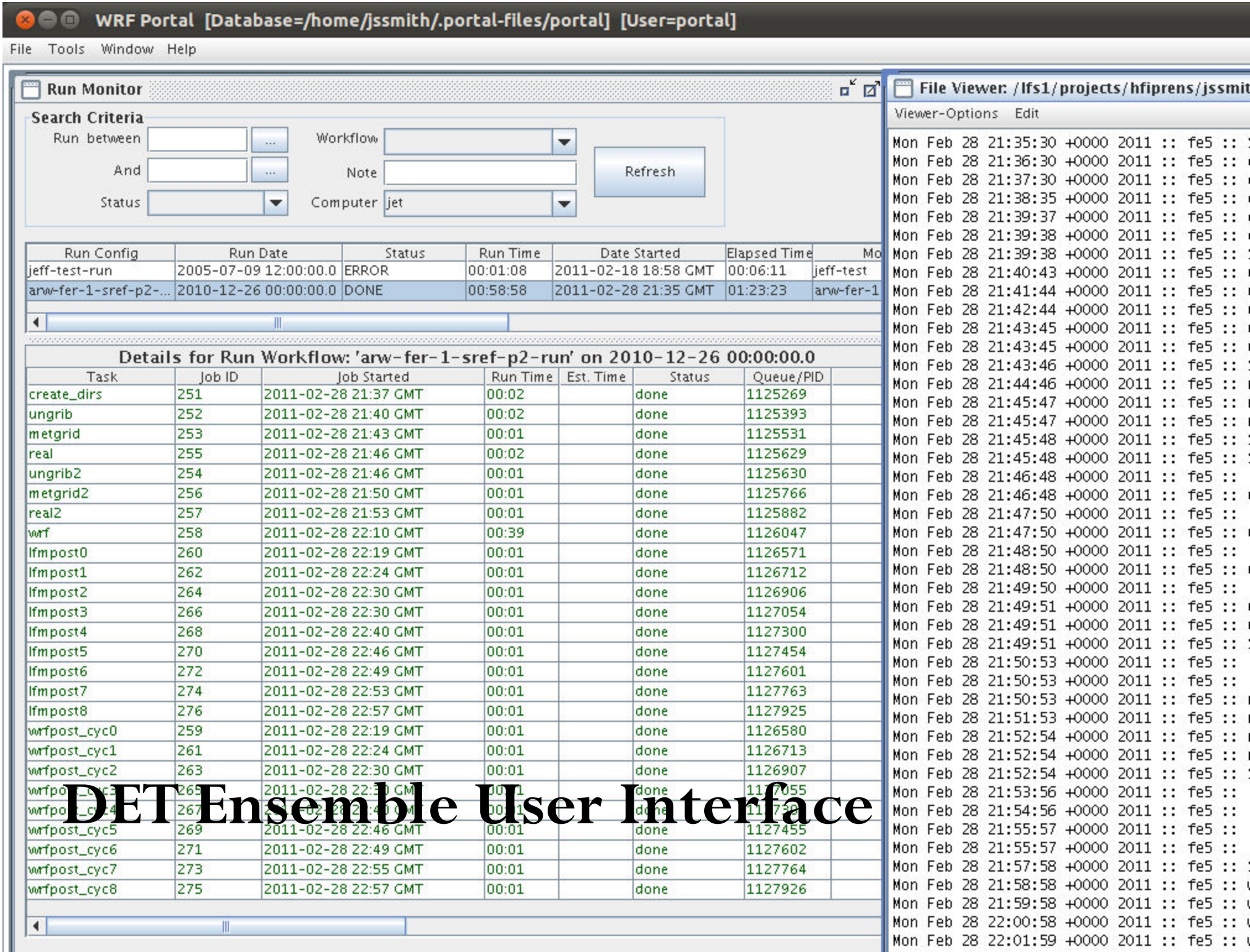
NOAA Jet

TeraGrid

Others TBD



DET Ensemble User Interface



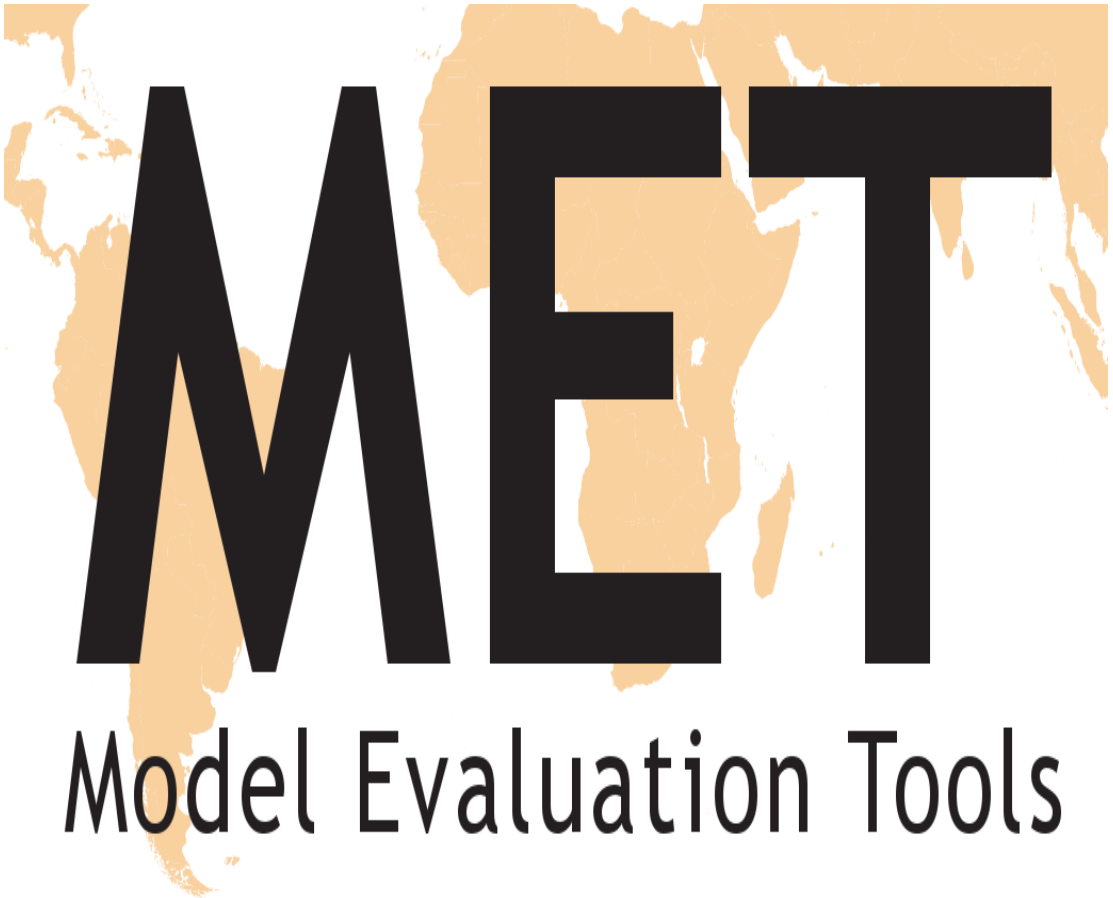
DET Ensemble User Interface

WRF and NEMS

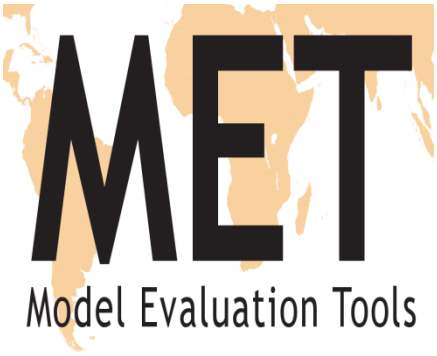
- Weather Research and Forecast (WRF)
  - ARW
  - NMM
  - WRF-Chem is definitely possible
- NOAA Environment Modeling System (NEMS)
  - NMM-B
  - ARW (being ported now)

MET is a set of tools for evaluating NWP forecasts and beyond…

- Preprocessing
- Statistics
- Analysis



MET Tools



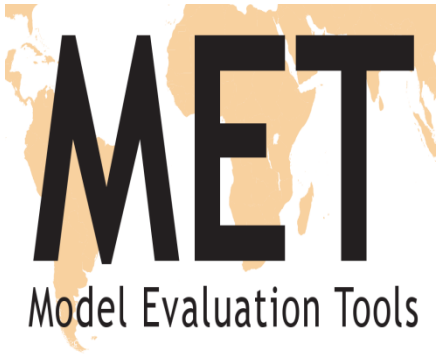
- **Data preprocessing**
  - Accumulate gridded precipitation/other cumulative variables over time
  - Convert Ascii and PREPBUFR to netCDF
  - Read in CloudSat data (other satellite data planned)
- **Individual forecast and observation dataset evaluation**
  - Evaluate forecast with point observations
  - Evaluate forecast with gridded observations
    - Traditional scores
    - Neighborhood methods
  - Evaluate forecast objects with observed objects
  - Determine the scale forecast is skillful through wavelet-based spatial decomposition methods

Not limited to Forecast/Obs comparison - Comparing two observation datasets or two models also possible

MET Tools continued

- **Probabilistic/Ensemble verification**
  - Probability Contingency Table Scores
    - Brier Score, Reliability, Resolution, Uncertainty, Area Under ROC
  - Joint/Continuous Statistics of Probabilistic Variables
    - Calibration, Refinement, Likelihood, Base Rate
  - Rank Histogram and Ranked Probability Scores
  - Simple ensemble products
    - Mean, Spread, Min, Max, Probability

MET Tools continued



- **Cumulative analysis**
  - Stat-Analysis
    - Reads Point-Stat, Grid-Stat, and Wavelet-Stat ascii output – aggregates and filters – writes ascii output
  - MODE-Analysis – same as Stat-Analysis but for MODE output
  - METViewer database and display system
    - loads all ascii output into database
    - user Interface allows analyst to select options for aggregation
    - uses R statistics package for plotting
    - calculates bootstrapped confidence intervals if requested

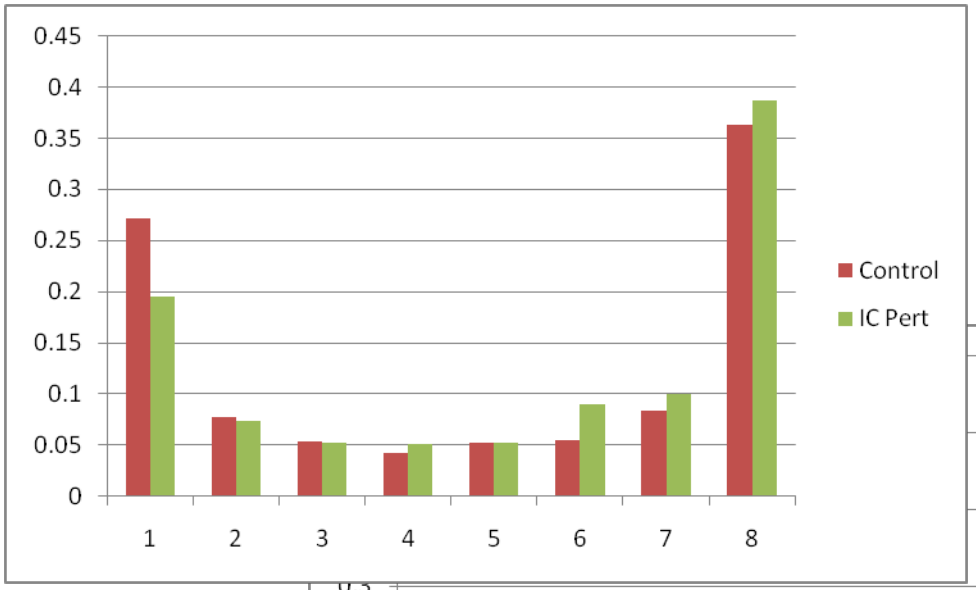
DTC Testing and Evaluation Principles

- **Execution of test is independent of the developer**
  - Developer may have a role in helping to create the test plan
- **A formal test plan is developed**, defining all of the important aspects of the testing and evaluation
- **Focus of test depends on the questions that are of interest**
  - Module being used
  - Variables of interest
- **Many cases evaluated for statistical significance**
  - Not just a few case studies
  - Multiple seasons
- **Meaningful stratifications**
  - Location/region
  - Season
  - Other user-based criteria

Considerations for T&E

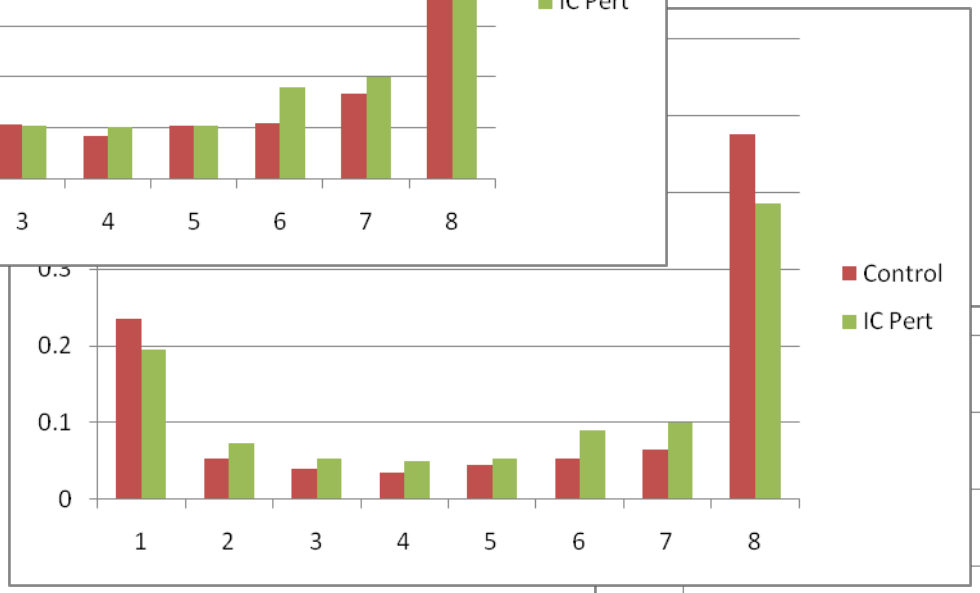
- **Number of cases will likely need to be increased**
  - Large enough to assess statistical significance
  - Focused enough for representativeness
- **Verification approaches and metrics are somewhat unique**
- **Computer resources may be a limitation**
- **Real-time vs. post-analysis**
  - DTC intensive tests generally done in post-analysis
  - Real-time demonstrations also have many benefits (e.g., NOAA Testbeds and Projects)
- **How much rigorous end-to-end testing required vs. evaluation of individual components**

Example – Preliminary IC Perturbation Testing

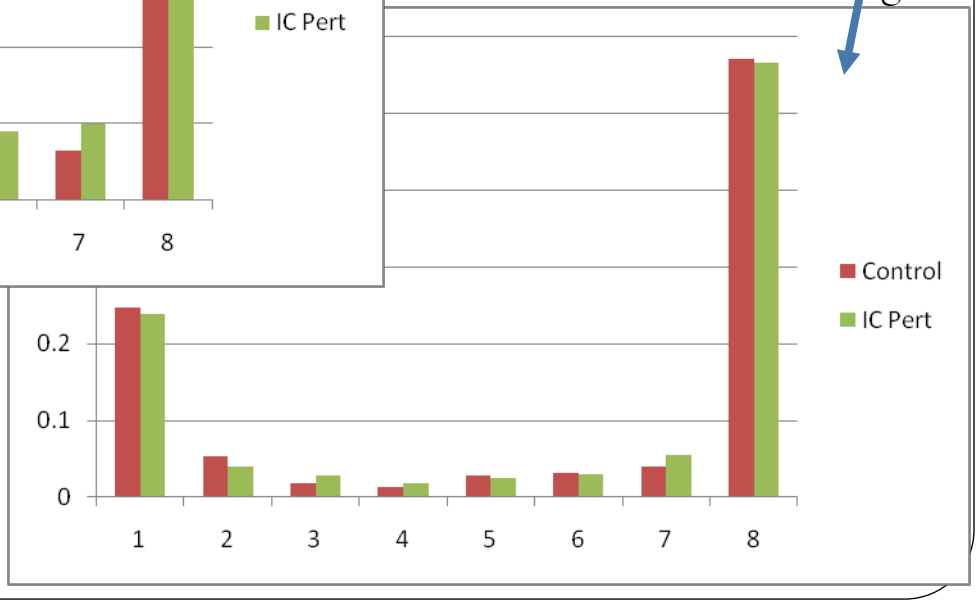


500 hPA TMP Rank Histogram

700 hPA TMP Rank Histogram

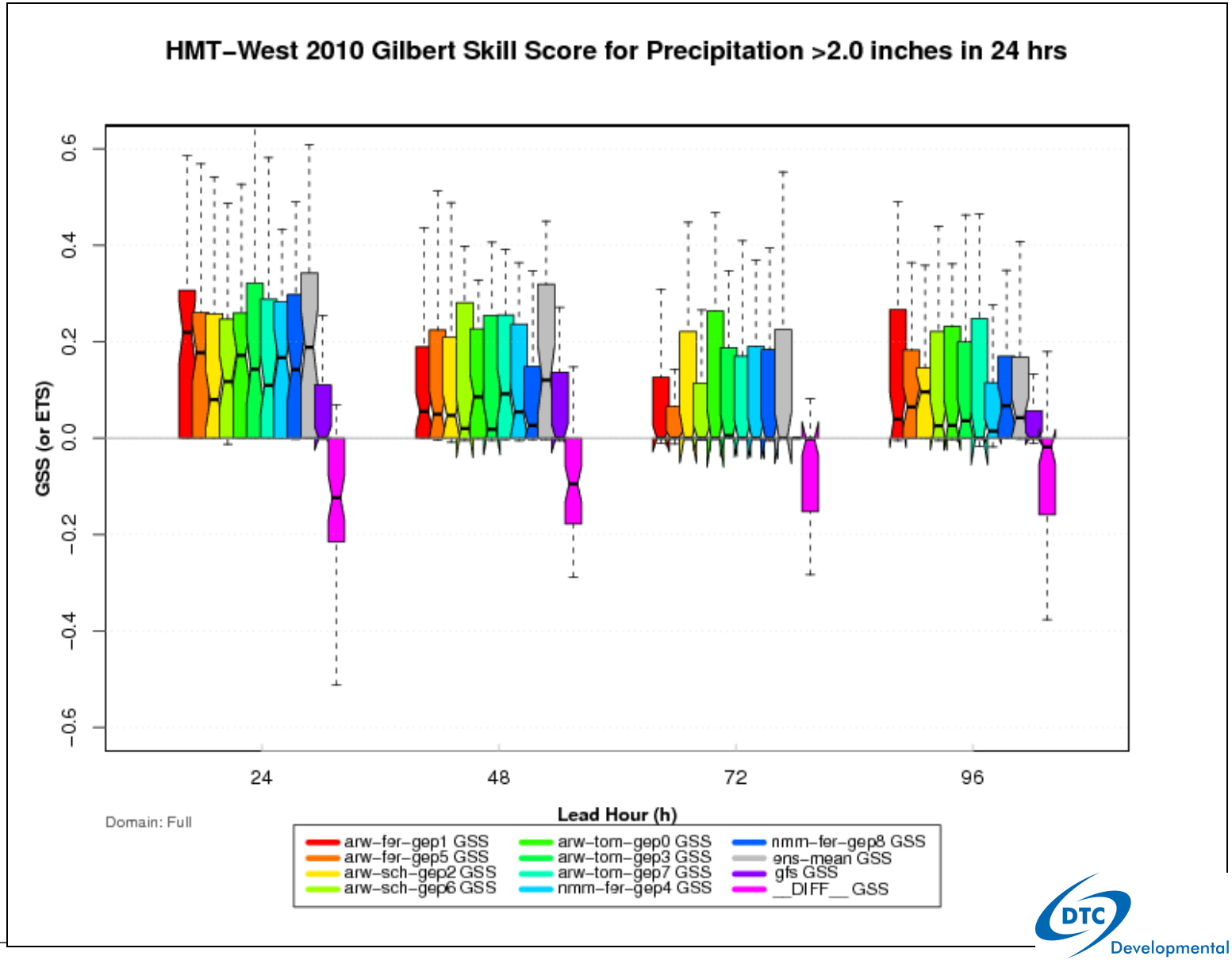


1000 hPA TMP Rank Histogram



Slight improvement in dispersion near surface
And more at 700 mb
But shift in underdispersion to a high bias at 500 mb

NOAA HydroMet Testbed – Precip Forecasts



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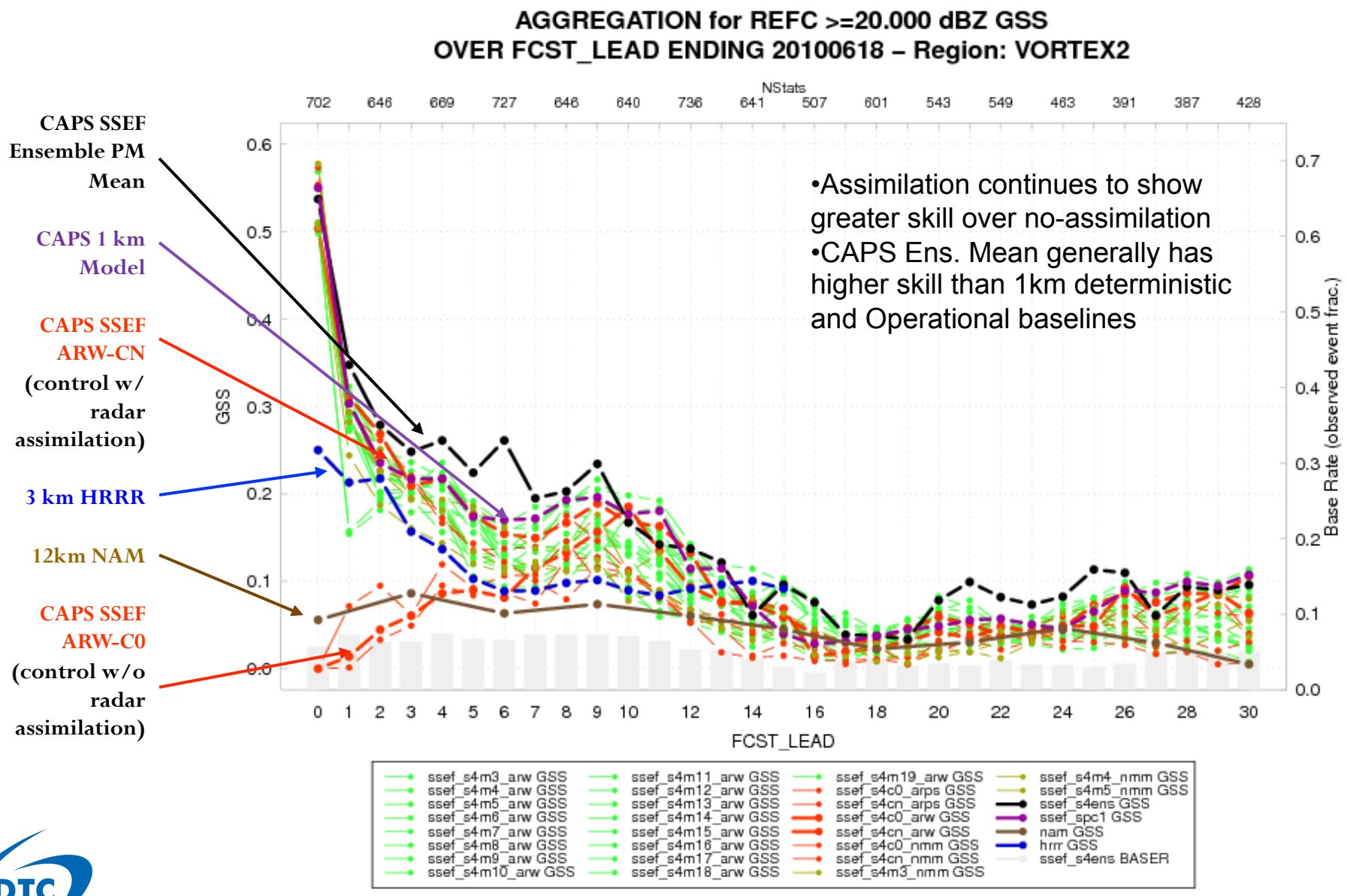
NOAA Haz. Wx. Testbed – Simulated Radar



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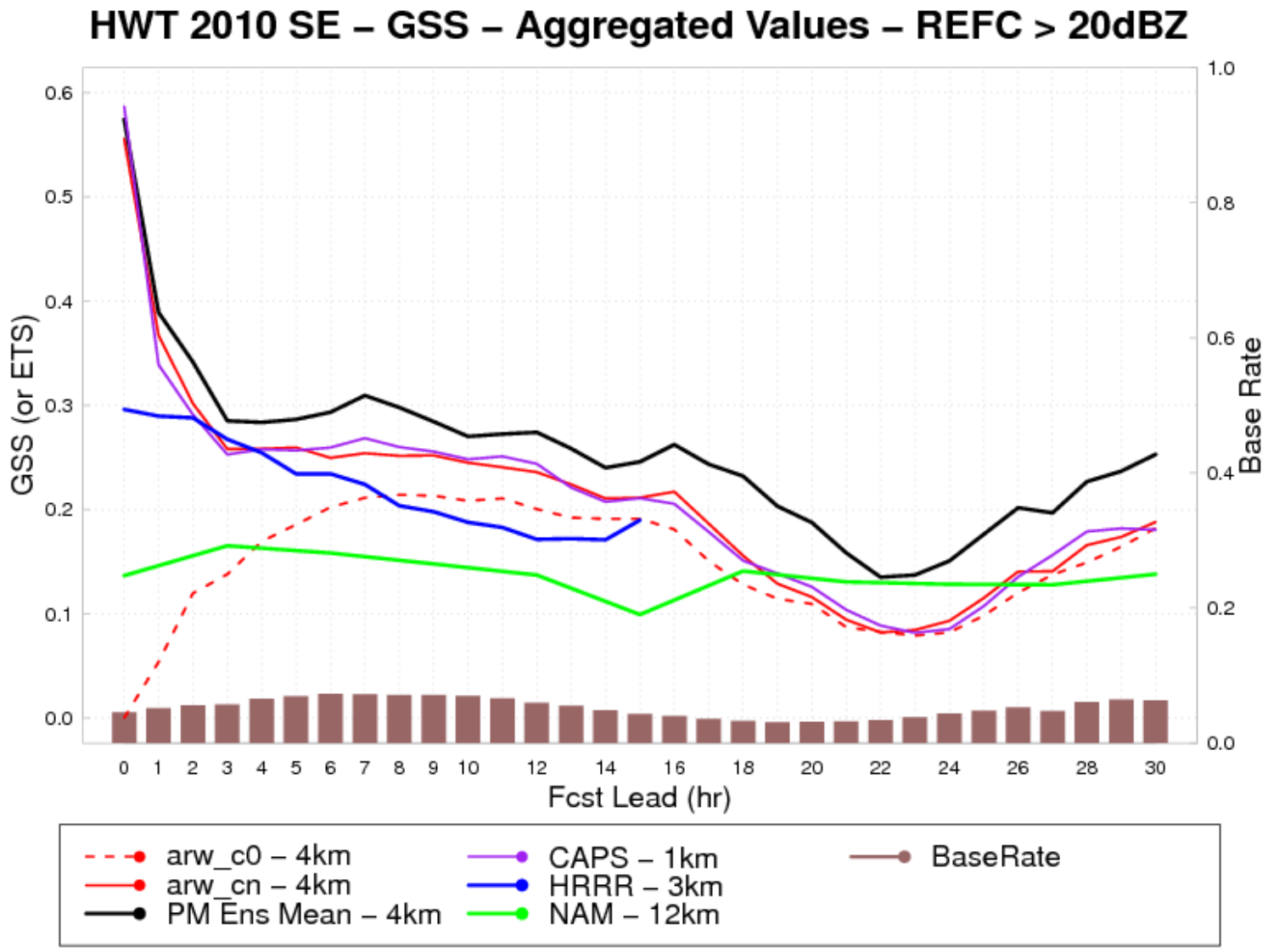


DET and Aerosol Community

- Areas in which DET could provide help for the aerosol community:
  - Provide baseline information on how the NWP community currently assembles and evaluates ensembles, including recent efforts in multi-model ensembles.
  - Determine computational and infrastructure needs for generating and disseminating the multi-model ensemble of aerosol forecasts.
  - Suggest metrics for evaluating the value and skill of the multi-model ensemble.
  - Plan for advancing research on ensemble aerosol forecasting and ensemble-based data assimilation issues.
  - Provide early findings from other multi-model ensembles.
  - Interact with regards to issues of statistical post processing.
  - Help with code, variables, verification standardization.

What if DET is not for you??

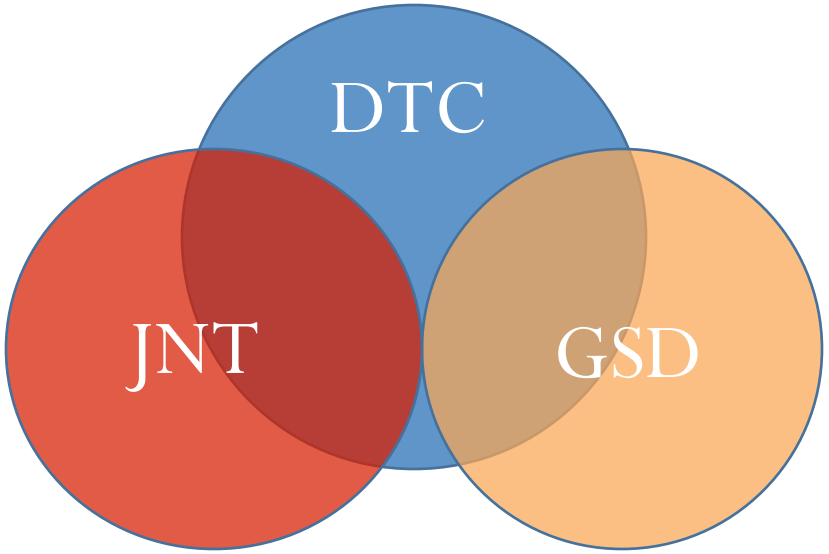
Both Contributing Organizations have a Research Component:

NOAA/ESRL/GSD and NCAR/RAL/JNT

Relationship of JNT to DTC and GSD

DTC is a national organization with a mission of facilitating R2O and O2R activities for numerical weather prediction

DTC Activities are distributed and undertaken in collaboration by JNT and NOAA/GSD staff



- Many Joint Numerical Testbed staff are also DTC staff
- JNT hosts the office of the DTC National Director
- JNT performs other T&E / Verification activities

Mission and Goals of the JNT

Mission:

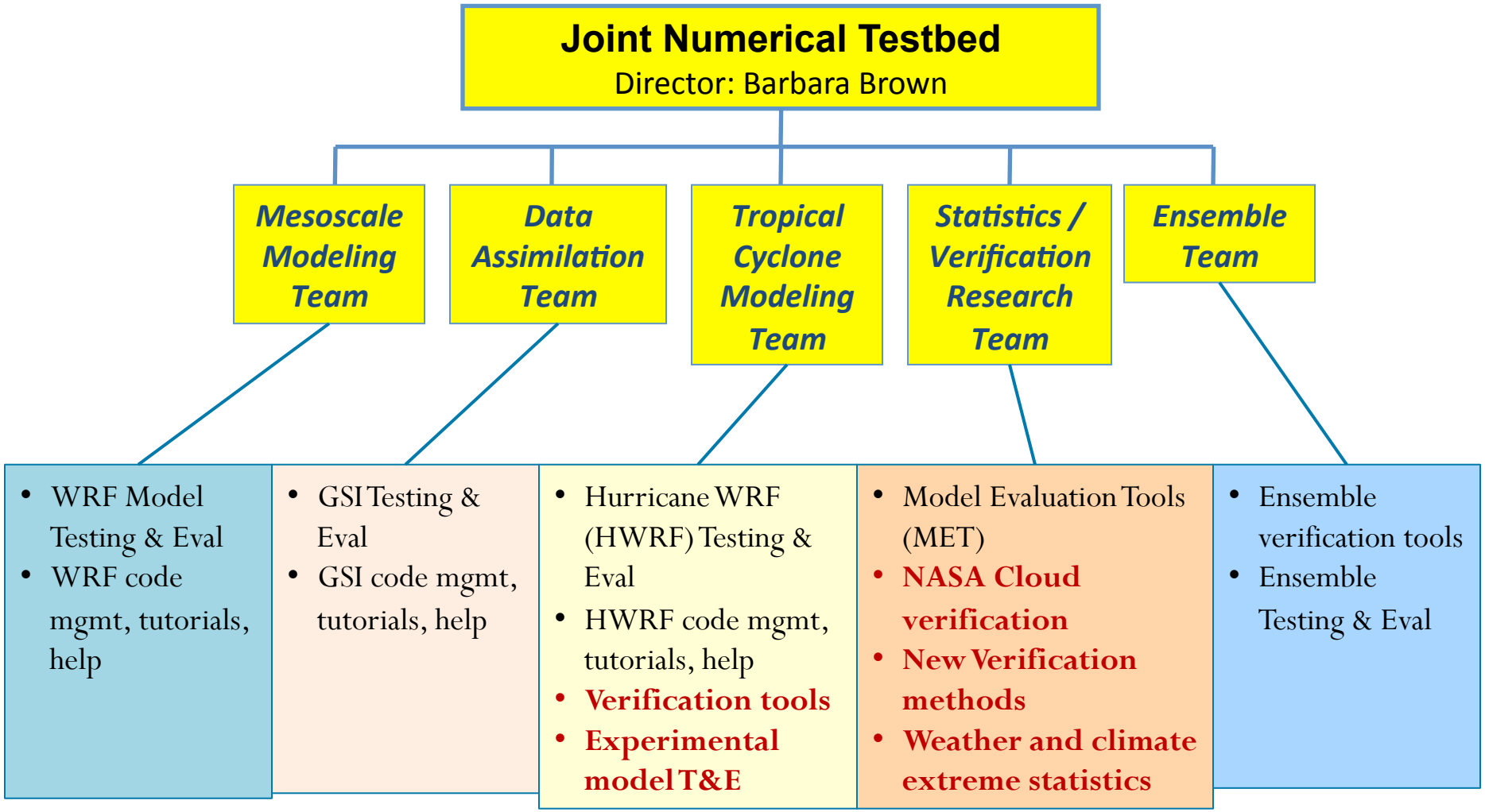
To support the sharing, testing, and evaluation of research and operational numerical weather prediction systems, and to

JNT acts as an "independent broker" for the testing and evaluation of forecasting systems.

- Undertake and report on independent tests and evaluations of prediction systems
- Research, develop and implement state-of-the-art tools for forecast evaluation

JNT Project Areas

DTC related activity
Non-DTC activities



NCAR/RAL/JNT Other Interests

- Interested in exploring use of MET on more Satellite Products
- Ties to AFWA dust forecasting
- Strong ties to WMO Verification Community

Relationship of GSD to DTC and JNT

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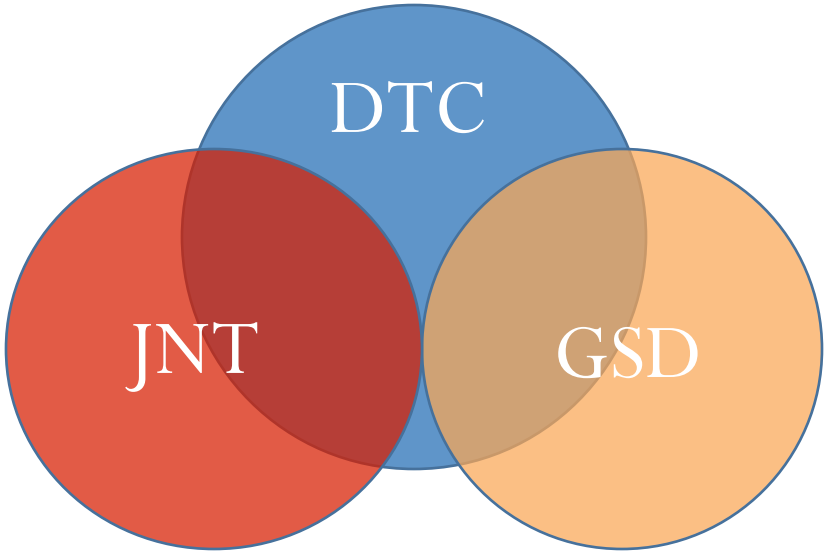
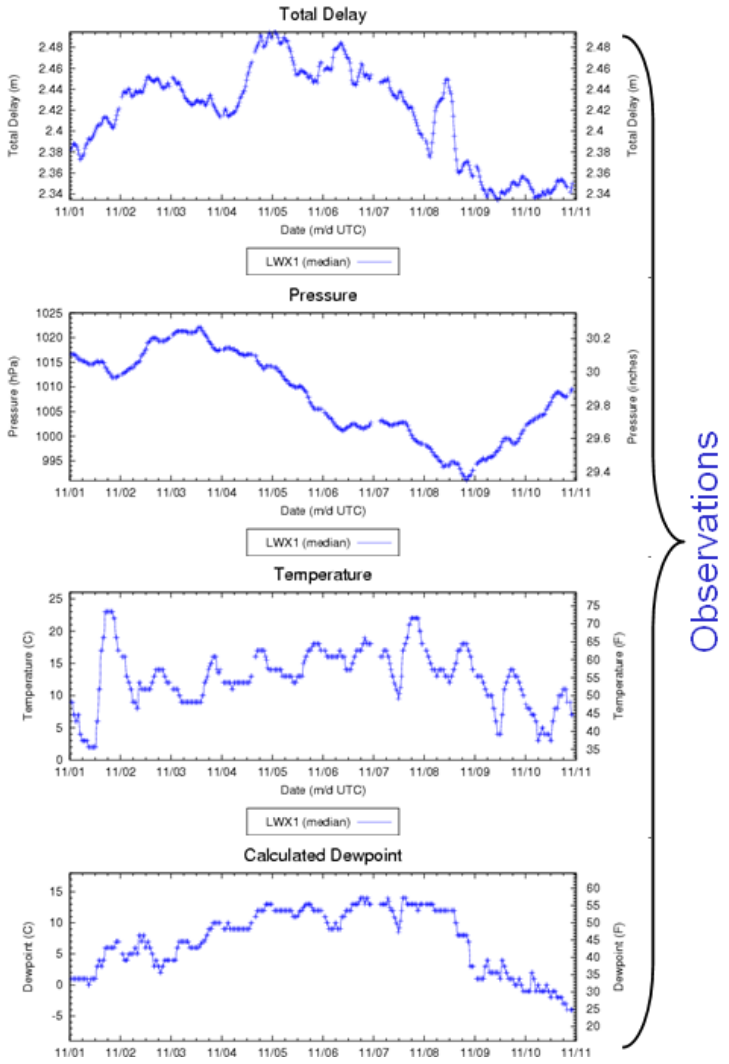


- Many GSD Forecast Applications Branch (FAB) staff are also DTC staff
- GSD also performs Observing Systems, NWP, and Ensemble development research

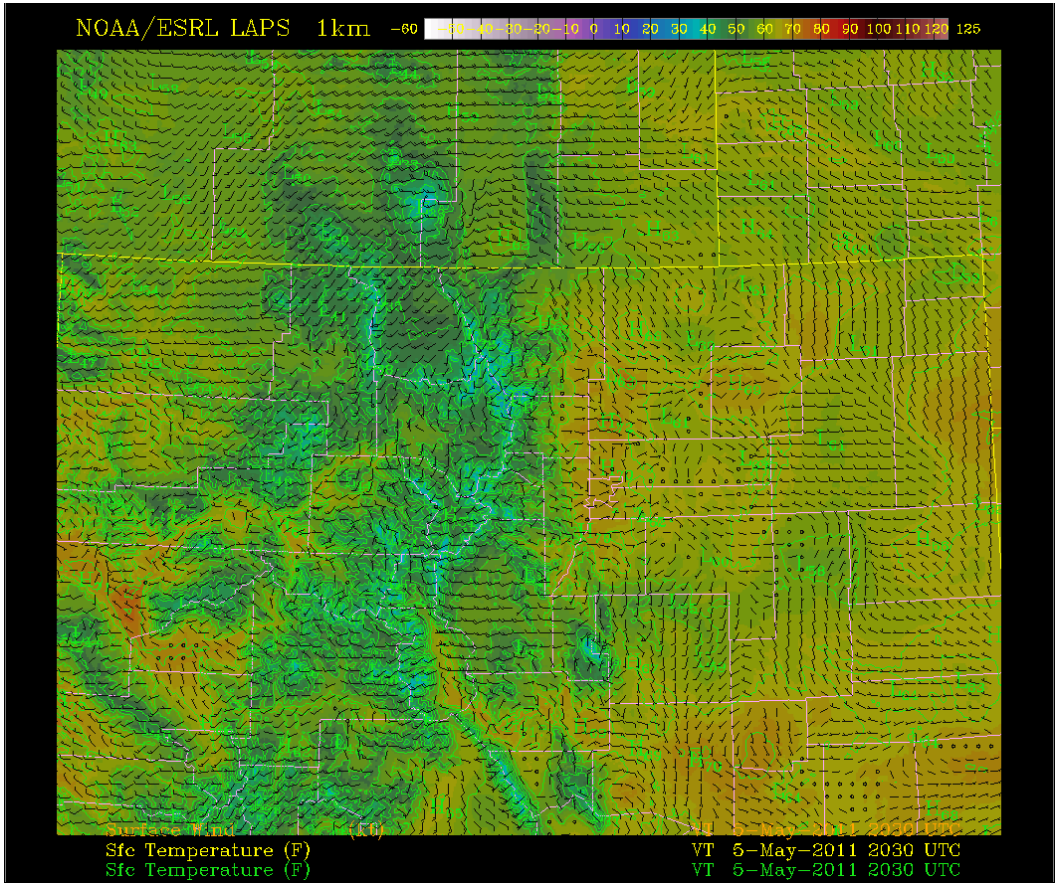
Observing Systems – GPSMet

- Ground-Based GPS-IPW project
- GPSMet was developed by ESRL/ GSD in response to:
  - need for low cost, all weather moisture observations for the full thermodynamic (winds, temp, moisture) profiler project
- GPSMet data could be used for improved NWP (precipitable water bounds T, P, Td in the atmospheric column)



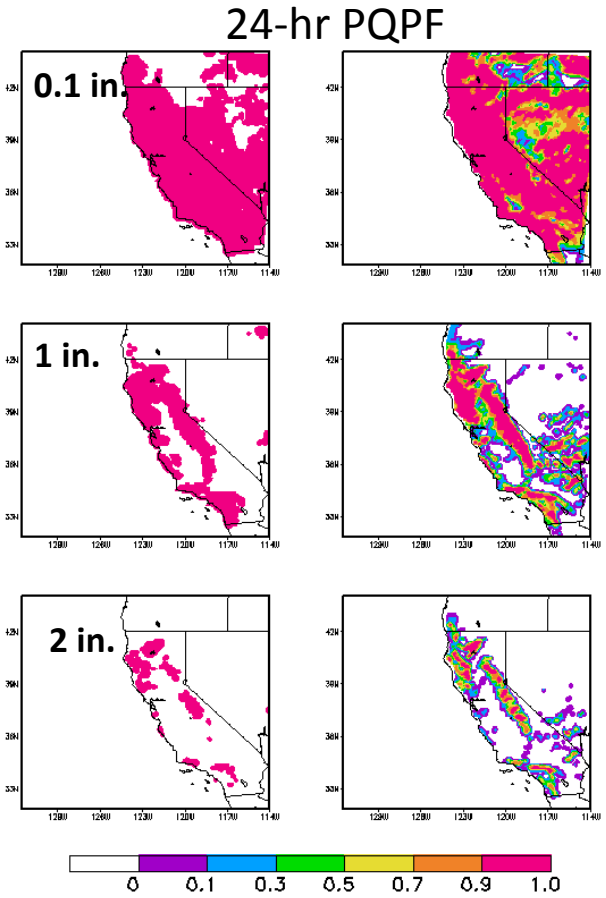
Data Assimilation – LAPS and STMAS

- Generation of high resolution analyses has been a strength of the NOAA/GSD/FAB for years
  - Local Analysis and Prediction System (LAPS)
  - Space Time Multi-scale Analysis System (STMAS)

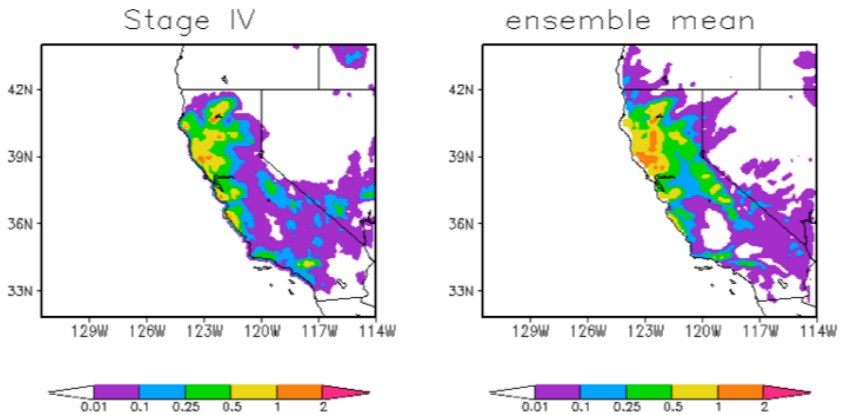


1km LAPS analysis of surface temperature/wind

Ensemble Forecasting



- GSD personnel developed HMT (Hydro-Meteorology Testbed domain) ensemble precipitation forecasting
  - mixed model
  - mixed physics
  - mixed IC/LBCs
- 9 members nested domain LAPS analysis



48-hr forecast starting at 12 UTC, 18 January 2010

Summary

- DTC is geared toward facilitating the R20 and O2R for mesoscale and convective scale models
- DET addresses the Ensemble focus area of DTC
- One avenue to transitioning research on aerosol NWP to operations may be through DTC and DET
- The Statistical Post Processing, Products and Services, and Verification Modules should be useful regardless of scale (i.e. should be able to help address regional climate and potentially global simulations)
- DTC is interested in staying involved in this community!!

Thank Yous and Further Information

DTC would like to thank you for your interest and the assistance of all of our collaborators…

DTC: http://www.dtcenter.org

DET: http://www.dtcenter.org/det

MET: http://www.dtcenter.org/met

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