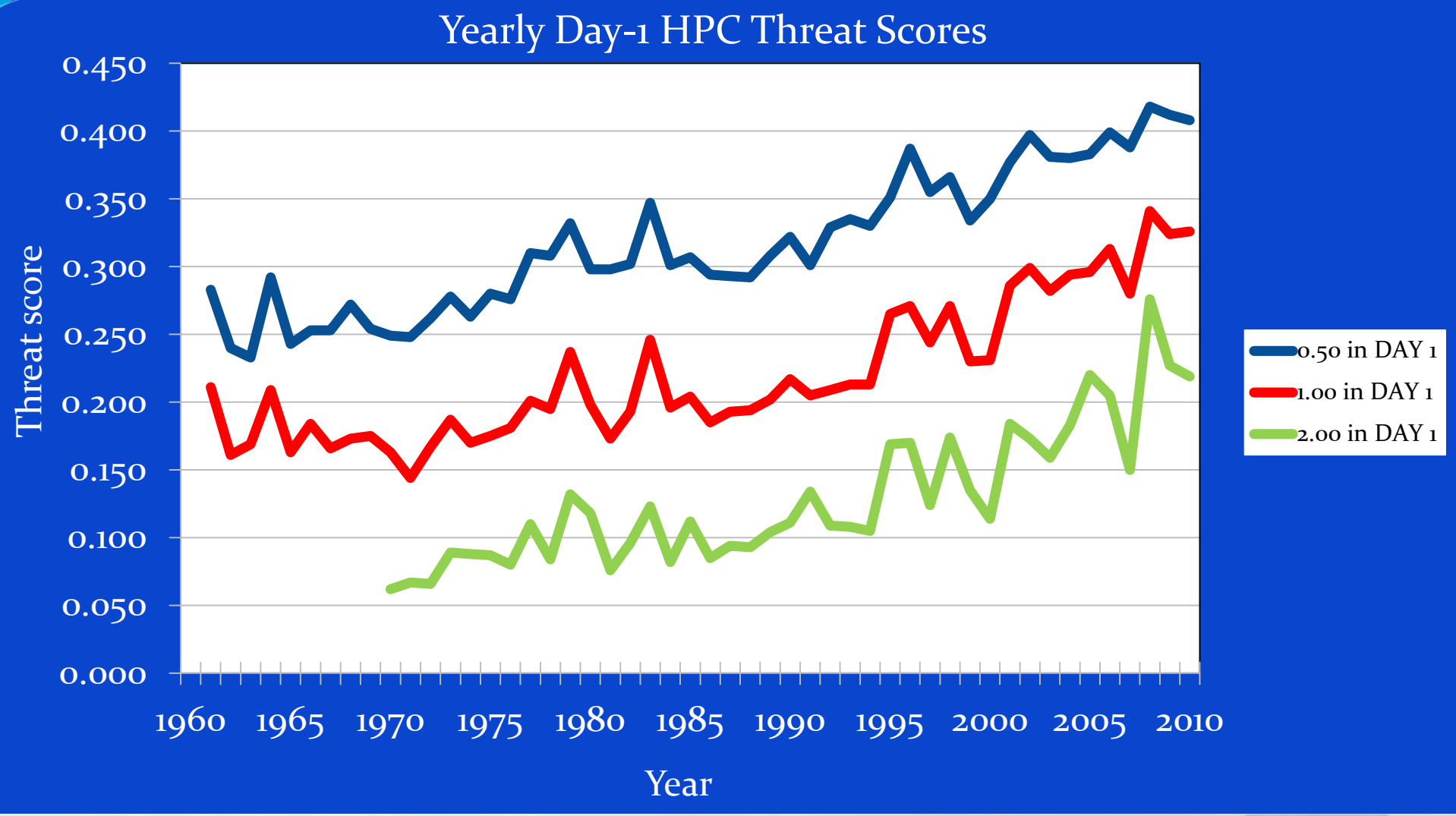
Quantitative Precipitation Forecasting (QPF)

Aerial view of Guerneville, Sonoma County, California.
(Credit: U.S. Army Corps of Engineers)

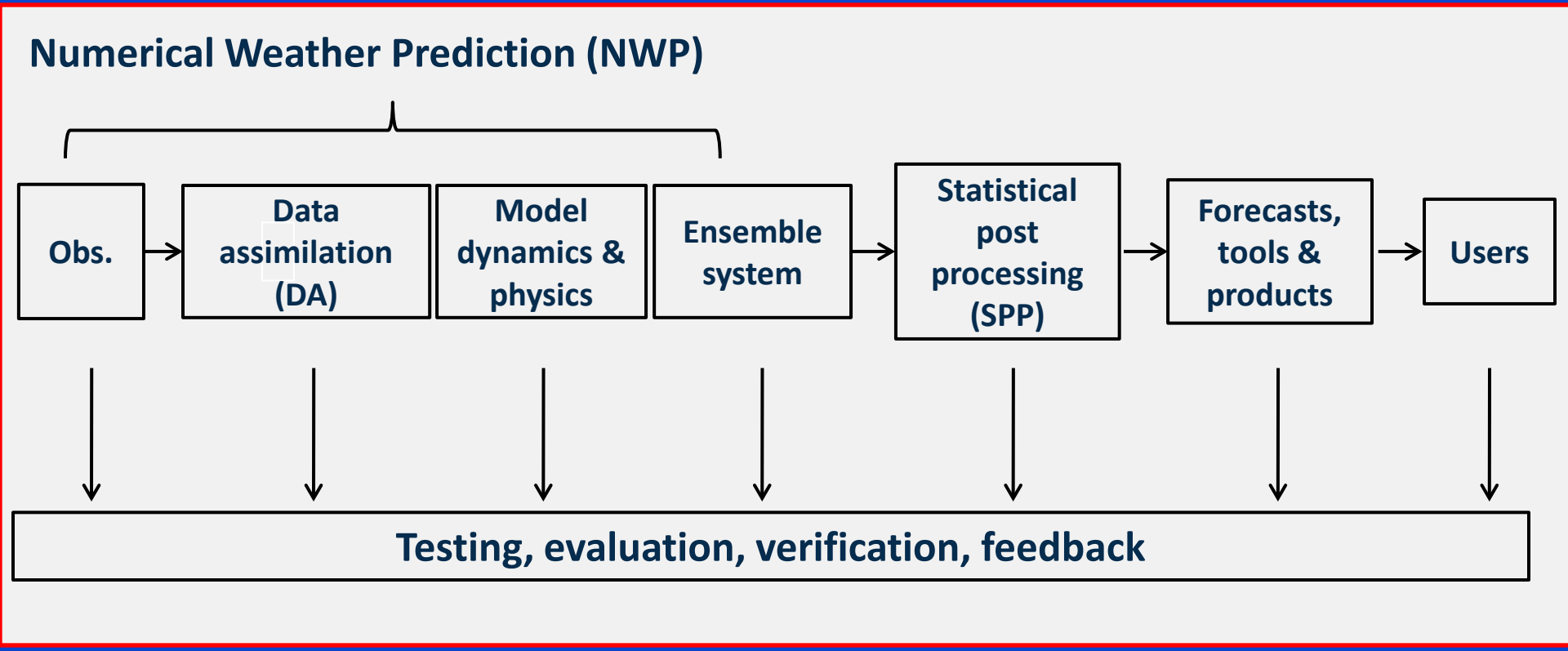
Past flooding in California
(Credit: Dave Gatley/FEMA)

Southern CA: Jan. 2010 (Credit: Kevork Djansezian/Getty Images)

Motivation


Yearly Day-1 HPC Threat Scores
Threat score
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year
0.50 in DAY 1
1.00 in DAY 1
2.00 in DAY 1

Precipitation Forecast Process



QPF Challenges

- Current QPF skill is often insufficient to provide high-quality precipitation and hydrologic forecasts.

Basic problems contributing to degraded QPF skill include:

- Deficiencies in the physical parameterizations of the forecasting models
- Insufficient model resolution and sub-optimal initial conditions from observations
- Insufficiently advanced data assimilation techniques to optimally link observations with forecast models
- Insufficient understanding of the dynamical and physical processes associated with heavy precipitation events for the purpose of model evaluation and improvement
- Chaotic dynamics, which amplify even the smallest of initial errors.

HMT Major Activity Area: QPF

Mission:

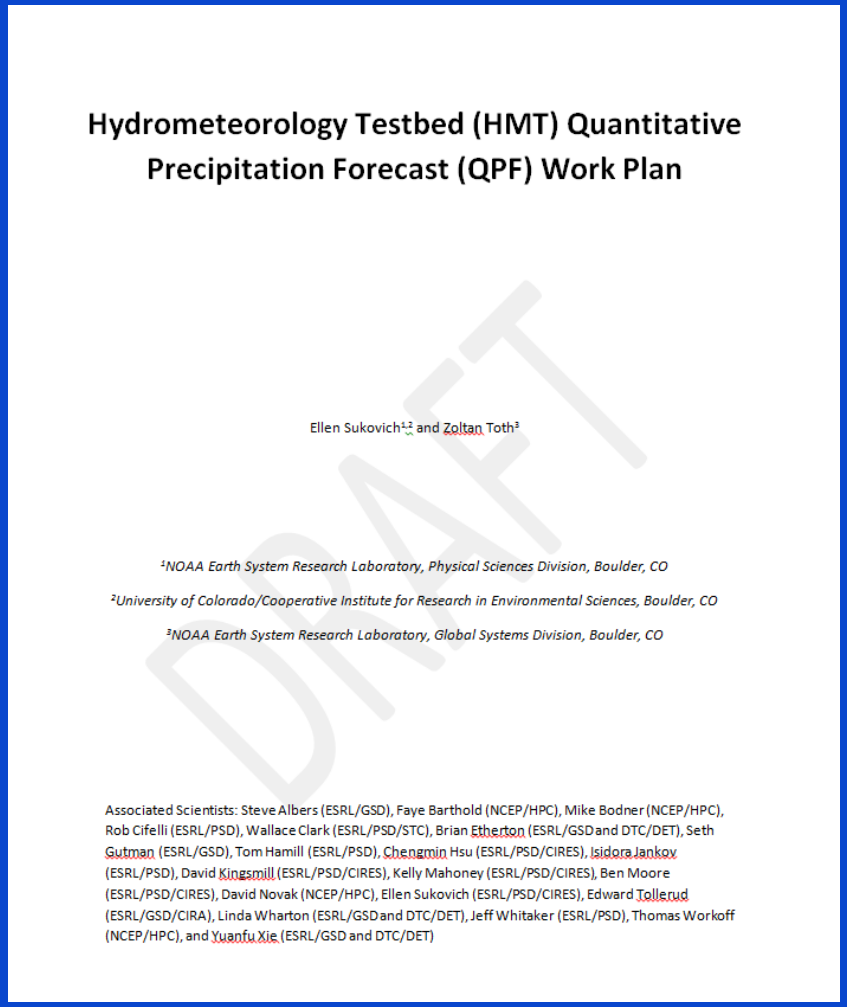
- To improve QPF/PQPFs and establish a framework to translate these advancements into improved NWS precipitation and hydrologic forecasts.

Objectives:

- Establish new observation systems and techniques
- Improve physics parameterizations and initialization of numerical weather prediction models
- Develop ensemble-based PQPF techniques
- Improve the understanding of dynamical and physical processes responsible for rare but heavy and frequent but moderate precipitation events
- Develop new downscaling and post processing techniques
- Develop new long-range forecasting techniques
- Explore traditional (e.g., skill scores) and non-traditional (e.g., object-oriented) verification methods and techniques
- Develop ways to infuse new technologies into NOAA operations.

FY12 Activities: HMT QPF Work Plan

- A HMT QPF work plan was developed in December 2011 that outlined HMT's strategy and implementation plan to improve QPF skill in order to meet the needs and demands of the HMT QPF and PQPF user communities.



Hydrometeorology Testbed (HMT) Quantitative Precipitation Forecast (QPF) Work Plan

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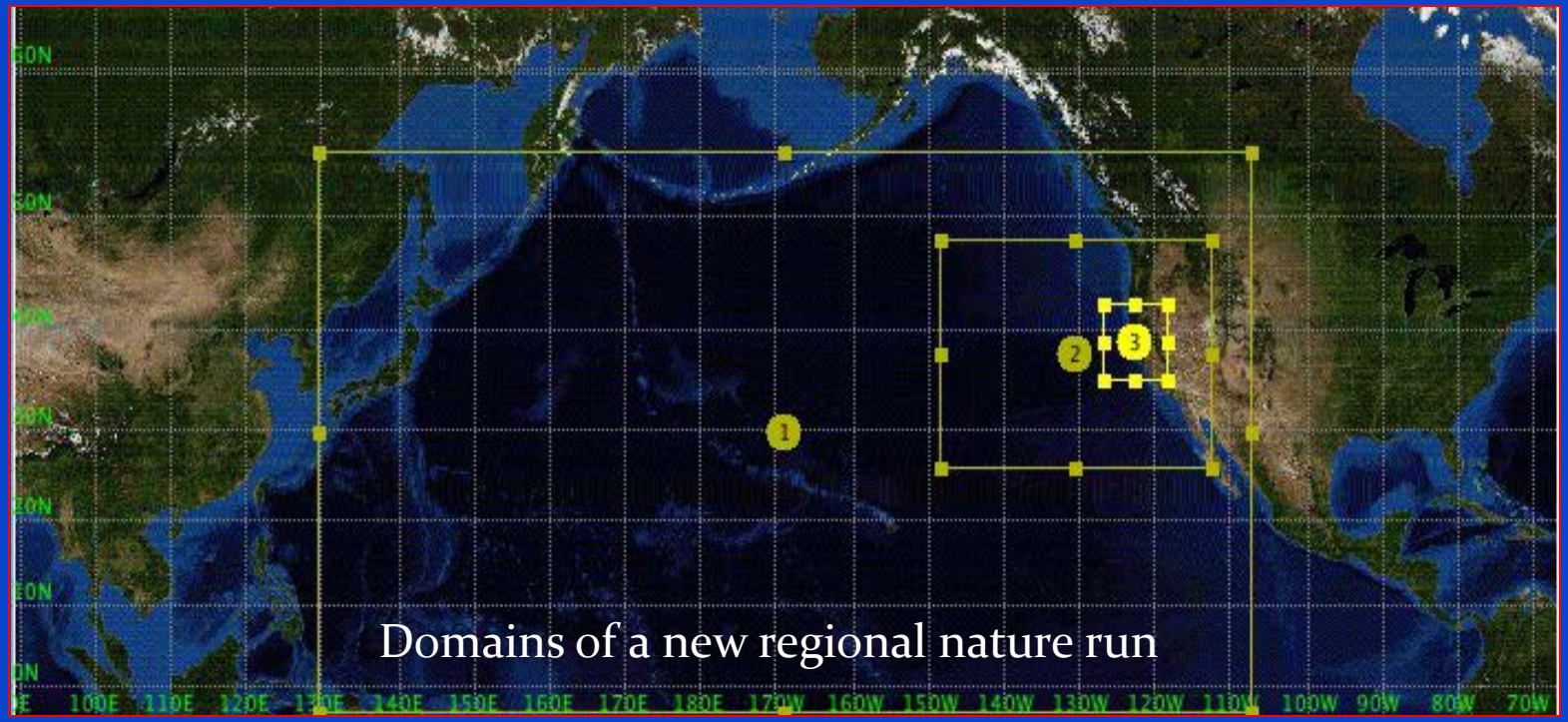
Observation System Simulation Experiment (OSSE)

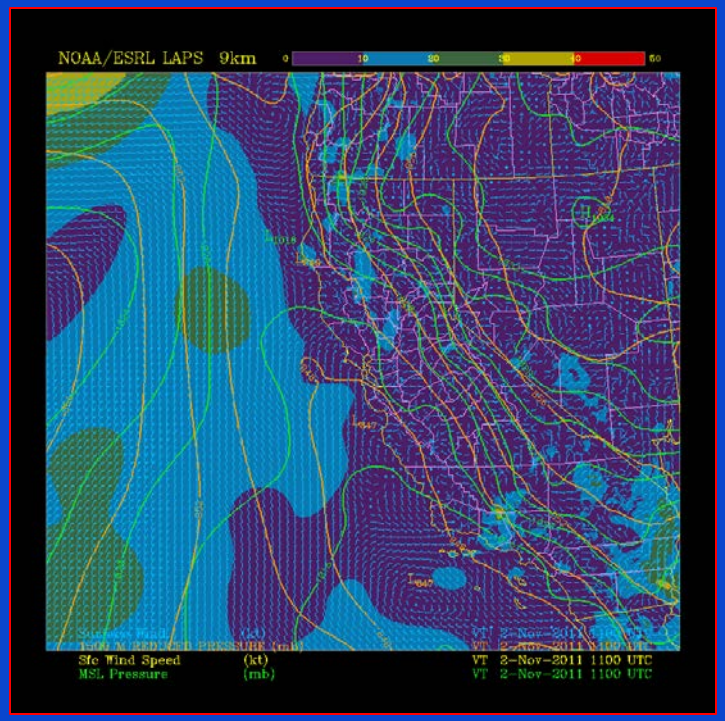
- A new regional nature run was developed that will be used as true atmosphere in the OSSE. The new nature run was nudged towards a GFS 0.5-degree analysis such that existing observations and ensemble forecasts can be used in future HMT OSSE experiments.

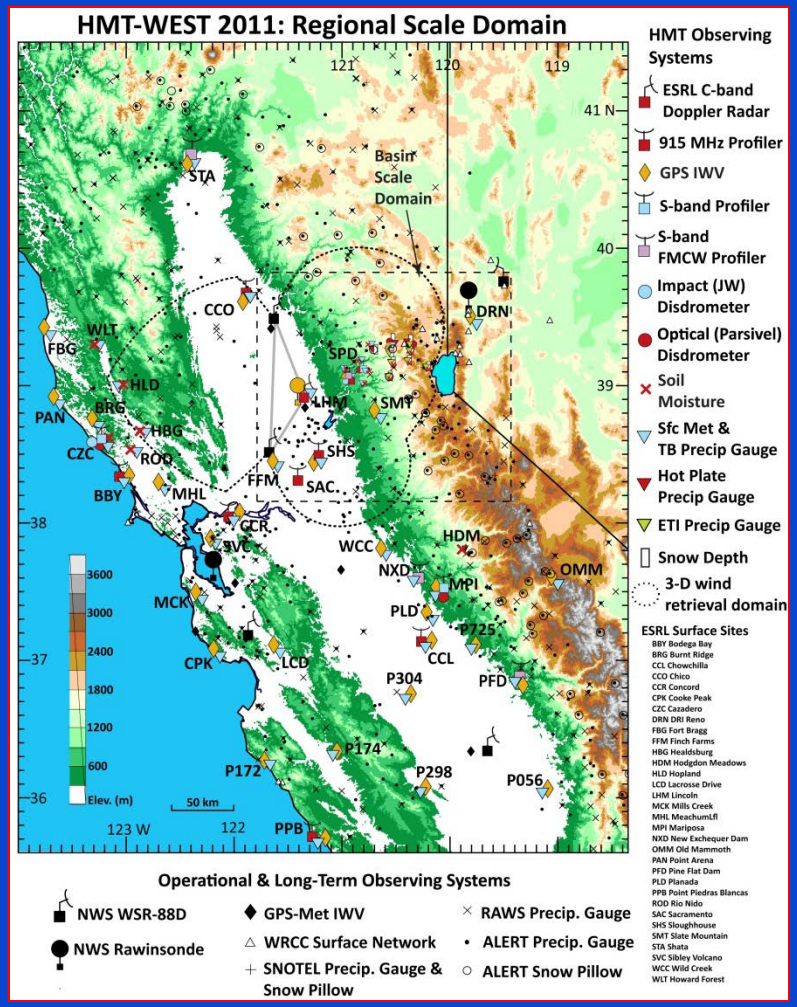


Domains of a new regional nature run

Microphysics Validation

- Model simulations were run for a physical validation of WRF NWP output with observations collected from HMT-West during 16 major precipitation events from the 2005-2006 through 2011-2012 cool seasons.

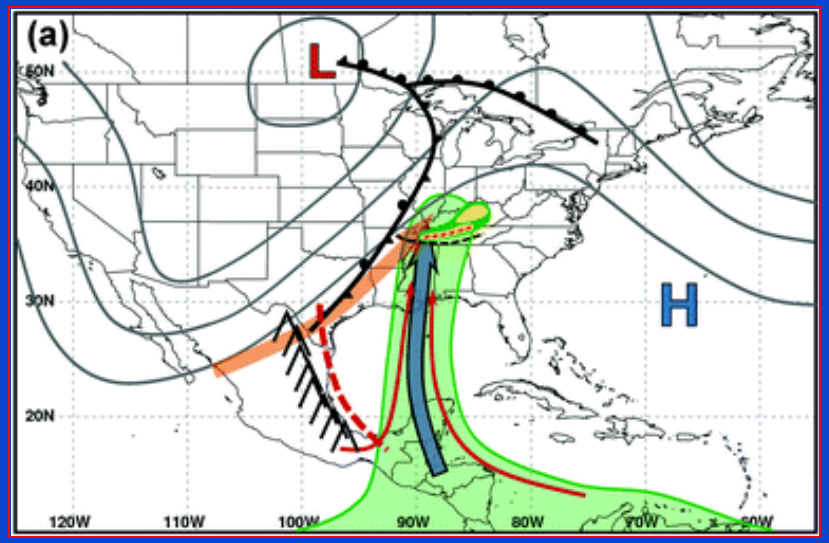


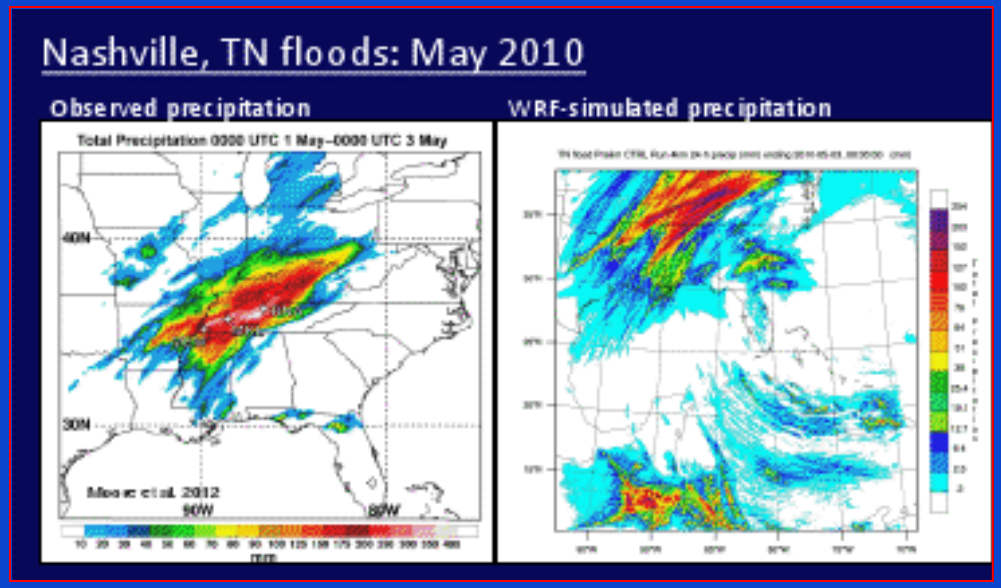


Precipitation Process Studies

- A paper on key features and processes of the Tennessee 2010 Flood was published.

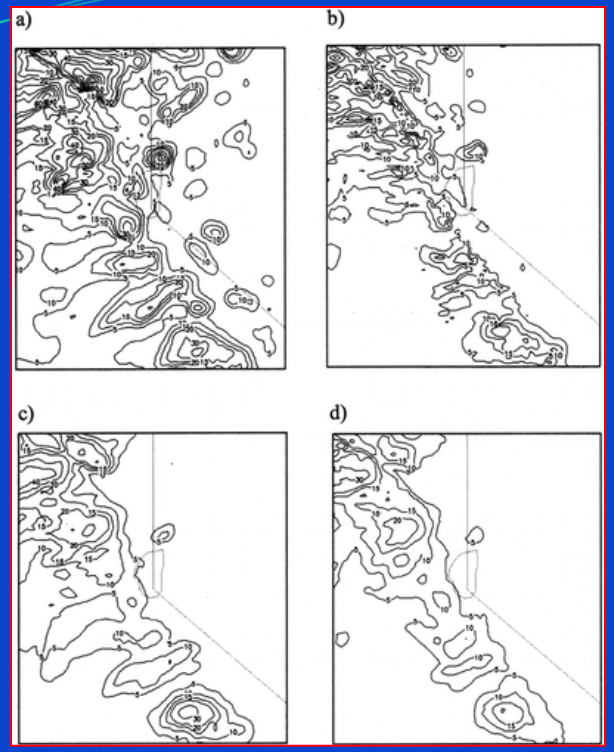
Moore, B., P. Neiman, F. M. Ralph, F. Barthold, 2012: Physical processes associated with heavy flooding rainfall in Nashville, Tennessee, and vicinity during 1–2 may 2010: The role of an atmospheric river and mesoscale convective systems. *Mon. Wea. Rev.*, **140**, 358–378.



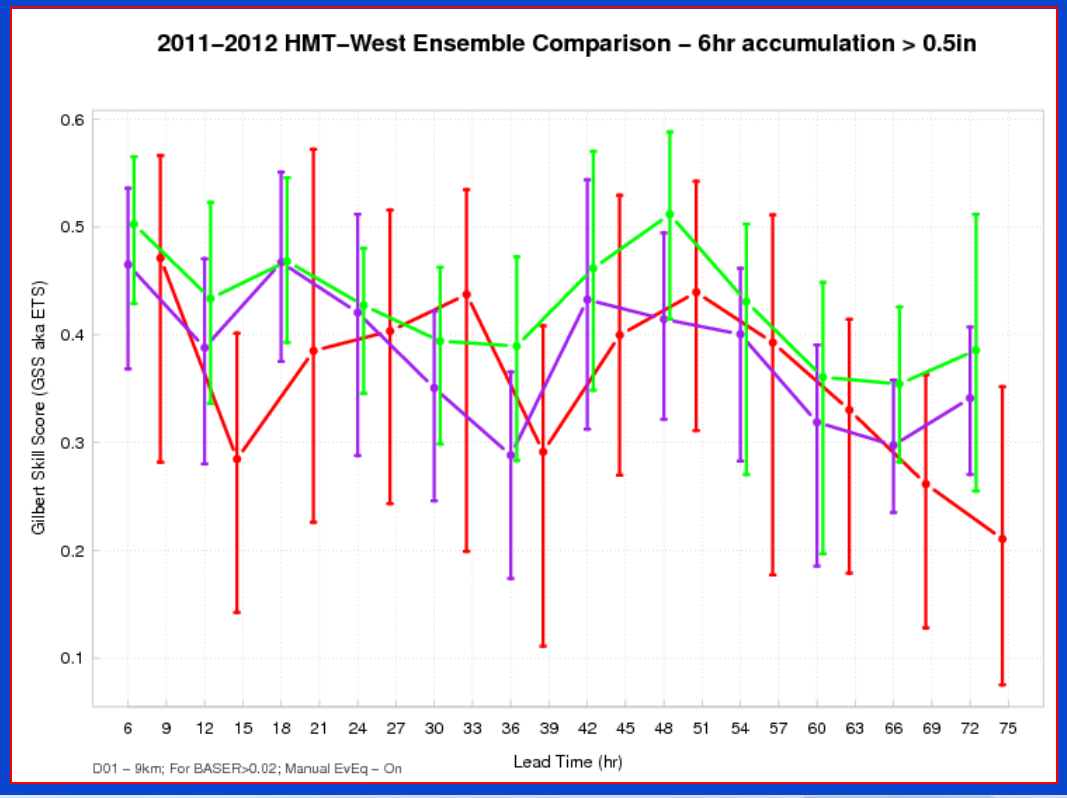


- Initial model simulations to investigate moisture sources and transport in the HMT-SE region were developed.

HMT-Ensemble



- The HMT-ensemble system was run for the 2011-2012 cool season over HMT-West and HMT-PN.

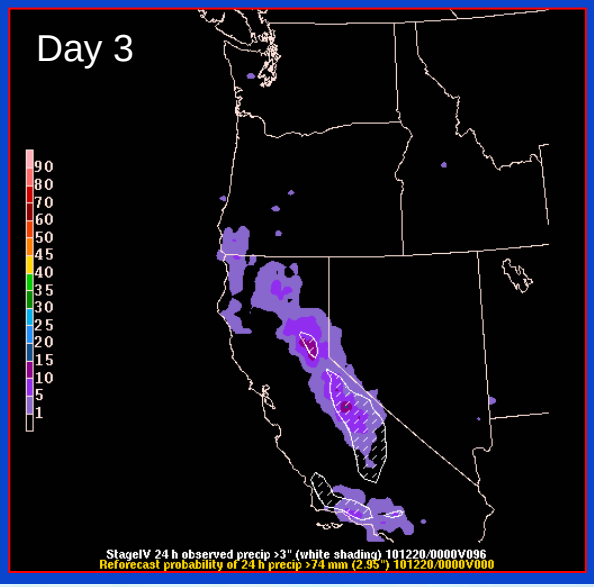


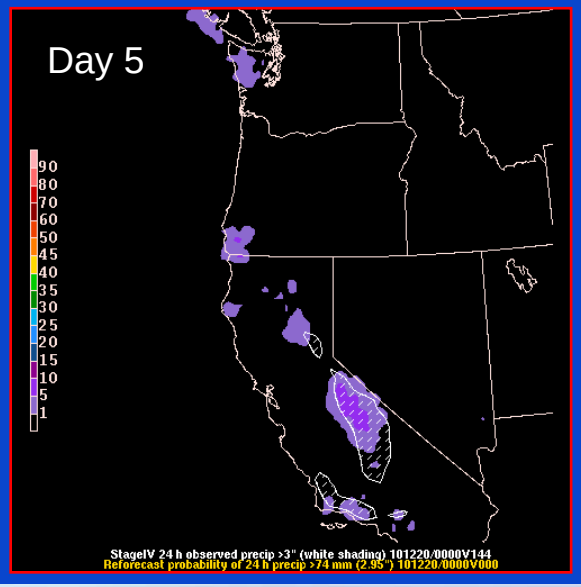
- The HMT-Ensemble was verified against other ensembles for the past season.

Reforecasting Dataset

- A new reforecast database was developed using the GEFS. Data are now available: http://esrl.noaa.gov/psd/forecasts/reforecast2/. Additionally, this work was documented in a paper submitted to BAMS: http://www.esrl.noaa.gov/psd/people/tom.hamill/reforecastv2_bams.pdf

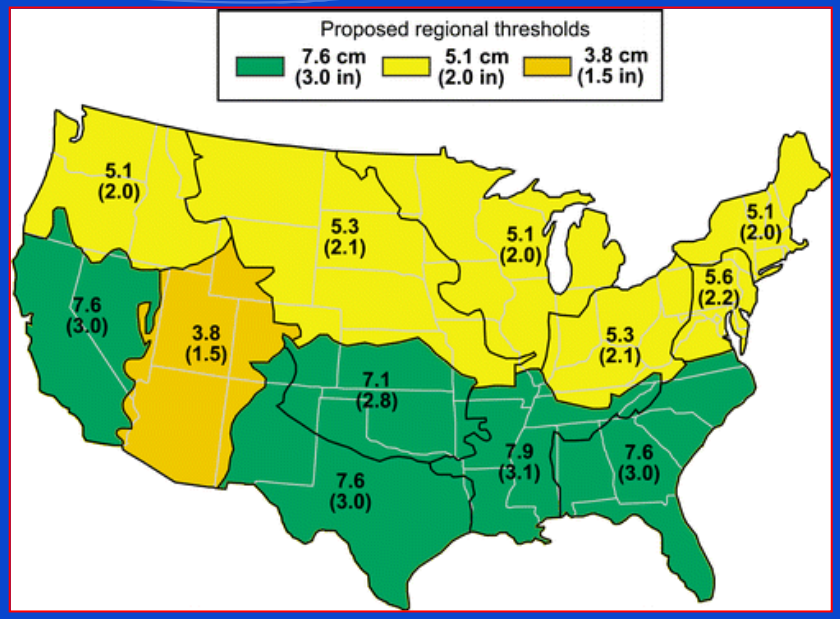
- The new reforecast database was utilized to determine the value added to extreme PQPFs of 8 AR events in the HMT-West domain. These results were used during the ARRFEX experiment.

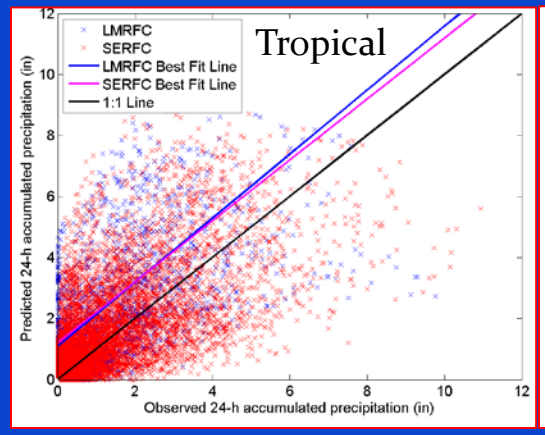


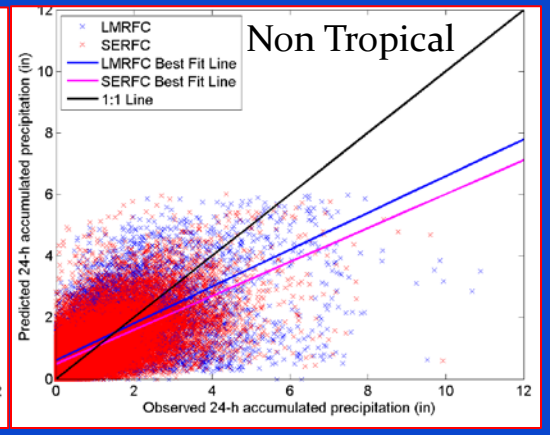


Extreme Precipitation Verification

- Analysis of regional extreme precipitation event thresholds to better monitor extreme precipitation event performance was completed and a draft manuscript was written.



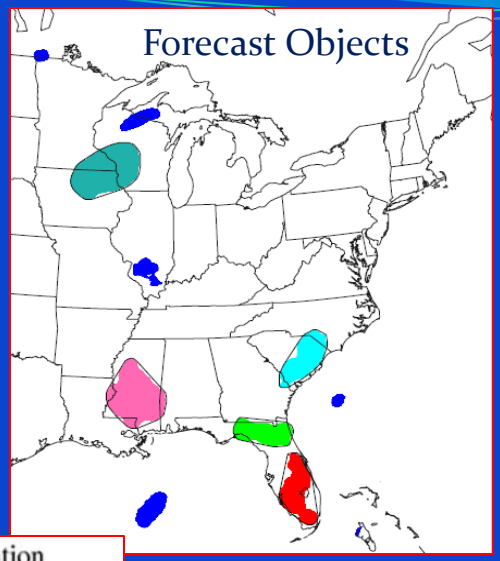


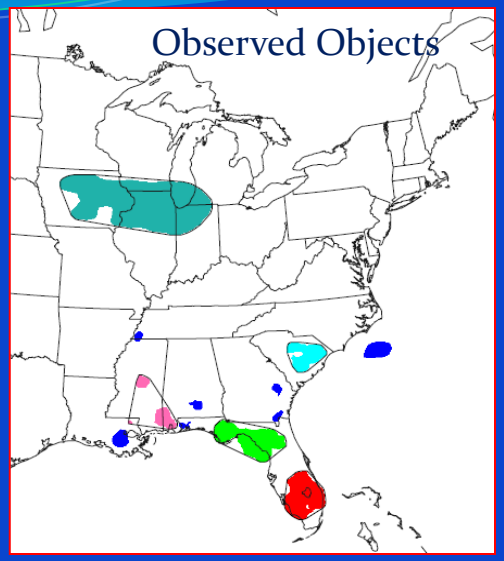


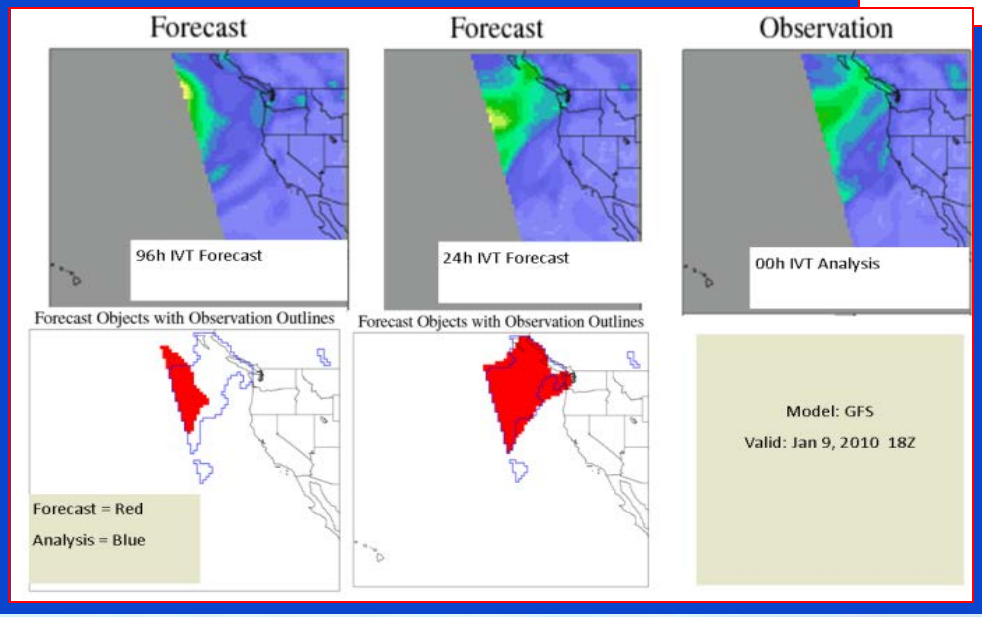
- An extreme precipitation climatology was developed for the HMT-SE region and verification of these extreme events was initiated.

Spatial Verification

- Object-oriented spatial verification techniques are being tested at HMT-HPC and an internal HPC spatial verification website was created.







- Atmospheric river characteristics were analyzed and verified using spatial verification techniques. A draft manuscript of this work is in progress.

Forecasting Experiments

- 2nd Annual Winter Weather Experiment at NCEP/HPC was held at NCEP/HPC (January/February 2012)

- Atmospheric River Retrospective Forecasting Experiment (ARRFEX) was conducted at NCEP/HPC. (September 2012)

2013 Select HMT QPF Activities

- Run an initial OSSE with future radiosonde dataset.
- Develop and test an experimental real-time North American Ensemble (~9 km).
  - Develop and apply movable nest to North American Ensemble (~3 km).
  - Determine optimal configuration for North American Ensemble .
  - Set up and run HMT-Ensemble for 2012-2013 west coast cool season.
- Apply developed data assimilation system (LAPS/STMAS) prototype to a case study.
- Process data (e.g., HMT obs data: Sband , wind profiles; vertical profile extraction from model output) for EMC and WRF microphysics validation. (Begin analysis if time.)
- Determine moisture sources & methods of transport in SE U.S. (modeling study.)
- Write and submit manuscript describing extreme precipitation climatology in SE U.S. (obs & verification study.)
- Analyze and write manuscript for reforecast QPF performance for west coast precipitation events.
- Develop spatial verification techniques for
  - HPC 32-km gridded QPF (CONUS)
  - Atmospheric rivers (West Coast)
- Forecasting experiments (HPC-HMT)
  - Conduct the 2013 Winter Weather Experiment
  - Analyze ARRFEX data (e.g., reforecast data, HMT-Ensemble)

HMT QPF Issues

- Truth: What will be established as "truth" for any QPF verification? (Stage IV? Q2? Another QPE product?)
- Skill: How does HMT define skill? What constitutes good/bad QPF skill? What QPF skill level provides skillful decision-making?
- Short term QPF: What is HMT QPF doing to address and improve short term QPF? Should this be a focus?
- Priorities: What is the goal of HMT QPF? How should HMT prioritize QPF tasks? Too many tasks?
- Communication: Communication is still an issue (i.e., task leads are not aware of other projects, more feedback needed.)

Extra Slides

Precipitation Forecast Process

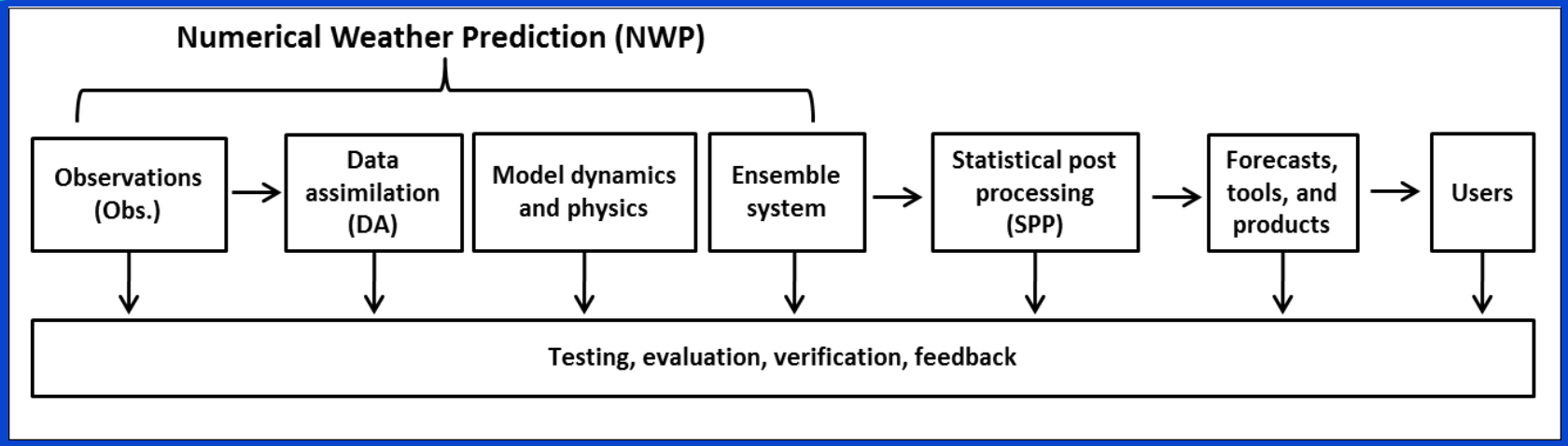


Figure 1: Forecasting process diagram.

Tool	Observations (Obs.)	Data assimilation (DA)	Model dynamics and physics	Ensemble system	Statistical post processing (SPP)	Forecasts, tools, and products
Product (Output)	Observational data	Initial conditions for numerical model	Set of future scenarios	Set of future scenarios	Calibrated ensemble	User specific information and guidance
Testing, evaluation, verification, feedback	Assess observational errors	Analysis error variance	Information content (Reliability)	Information content (Reliability)	Reliability (Information content)	User feedback

Table 1: Forecast process components