# The NOAA Hydrometeorological Testbed Program: Overview and Progress to Date

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# STIP Integrated Planning Team for Hydrologic Services (**September 2002)**

## *Key Information Gaps*

- **Quantitative Precipitation Information (QPE & QPF)**

  **Unbiased Precipitation Estimates with Reliability Information**

  **Reliable 0-6 Hour Precip. Nowcasts**

  **Longer-term, Unbiased Model QPFs**

- **Hydrologic Forecasting**

  **High-resolution Flash Flood Forecasts & Warnings**

  **Probabilistic River Forecasts Using 0-3 day QPF and Seasonal Precipitation Forecasts**

# STIP IPT for Hydrologic Services

## ***Outstanding R&D Needs***

- *Develop QPE Techniques That Optimally Blend Next-generation Radar, Satellite (e.g, GPM), and Rain Gauge Data*
- *Improve Short-Term Radar-Satellite Precipitation Nowcasting Techniques Blended with NWP Forecasts*
- *Develop High Resolution Hydrologic Forecast Models of Water Excess-Deficit at Ungauged Locations*
- *Develop Ensemble NWP and Hydrologic Model Forecasts with Associated Reliability Information*
- *Improve NWP Model Physics and Increase Assimilation of Existing Observational Datasets*
- *Implement Hydrometeorological Testbeds to Demonstrate & Evaluate Next-Generation Datasets, Forecast Techniques, & Models*

# Developing a Testbed Concept for Hydrometeorology in NOAA

**Jointly organized by NWS** (Rich Fulton of OHD**)** and **OAR** (Marty Ralph of ETL)

**20 November 2002**

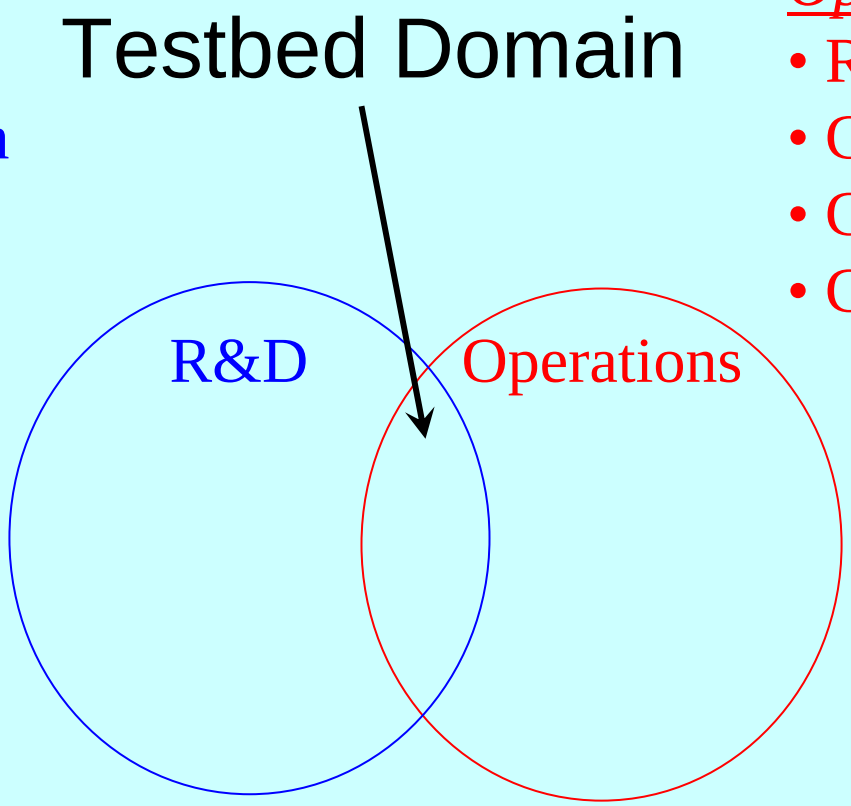
**Background**

The testbed concept is gaining momentum within NOAA as a vehicle for accelerating transitions from research to operations and for fostering technology infusion to the National Weather Service. This is evidenced by the inclusion of testbeds as elements in a number of recent NOAA planning documents and programs, such as the NWS Science Technology Infusion Program (STIP). Most of these elements are associated with precipitation, water cycle and hydrology. Thus, the time for implementing a Hydro-Meteorology Testbed (HMT) may be approaching.

# R&D and Operational Perspectives:
## Observing Systems

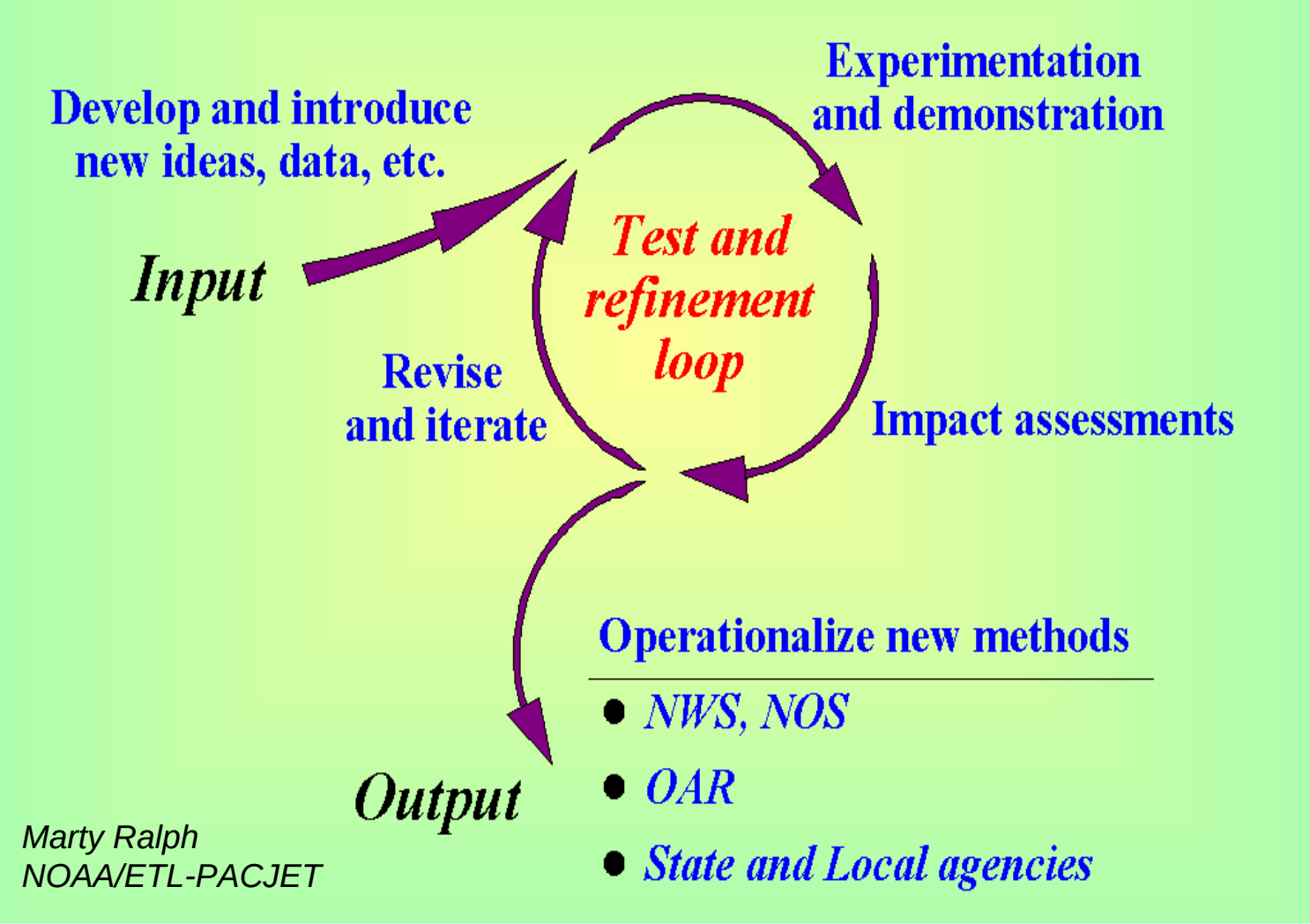
*R&D Priorities*
- Exploratory
- Higher Resolution
- Multi-Sensor
- New Variables
- Publication

*Operational Priorities*
- Reliability
- Cost Effectiveness
- COTS (plug n' play)
- Continuity




Basic R&D → Improved User Decisions

# Test bed concept




*Marty Ralph*
*NOAA/ETL-PACJET*

Hydrometeorology Testbed

# Primary Goals

- Systematically evaluate promising new methods that can influence both NWP and nowcasting using the man-machine mix forecasting paradigm.
- Assess their value in terms of improved regional performance on Flood/Flash Flood Warning and QPF GPRA measures.
- Use these results as an objective basis for decisions on transitions to operations both in the test region and nationally.

Hydrometeorology Testbed

# A Broad Approach Is Required*

***i.e., There is no "Silver Bullet"**

- Better numerical model guidance (i.e., QPF)
- Better observations for forecaster use and model assimilation and verification (i.e., QPE)
- Better physical understanding for parameterizations and conceptual models
- Better knowledge of capabilities and limitation of key tools

# Hydrometeorological

# Testbed Definition

"A testbed is a working relationship in a quasi-operational framework among measurement specialists, forecasters, researchers, the private sector, and government agencies aimed at solving operational and practical regional hydrometeorological problems with a strong connection to the end users. Outcomes from a testbed are more effective observing systems, better use of data in forecasts, improved services, products, and economic/public safety benefits. Testbeds accelerate the translation of R&D findings into better operations, services, and decision-making. A successful testbed requires physical assets as well as long-term commitments and partnerships."

*USWRP Mesoscale Observing Workshop, December 2003*

# *CALJET / PACJET*

**GOAL: Improve 0-24 h prediction of land-falling Pacific winter storms**

**METHODS**

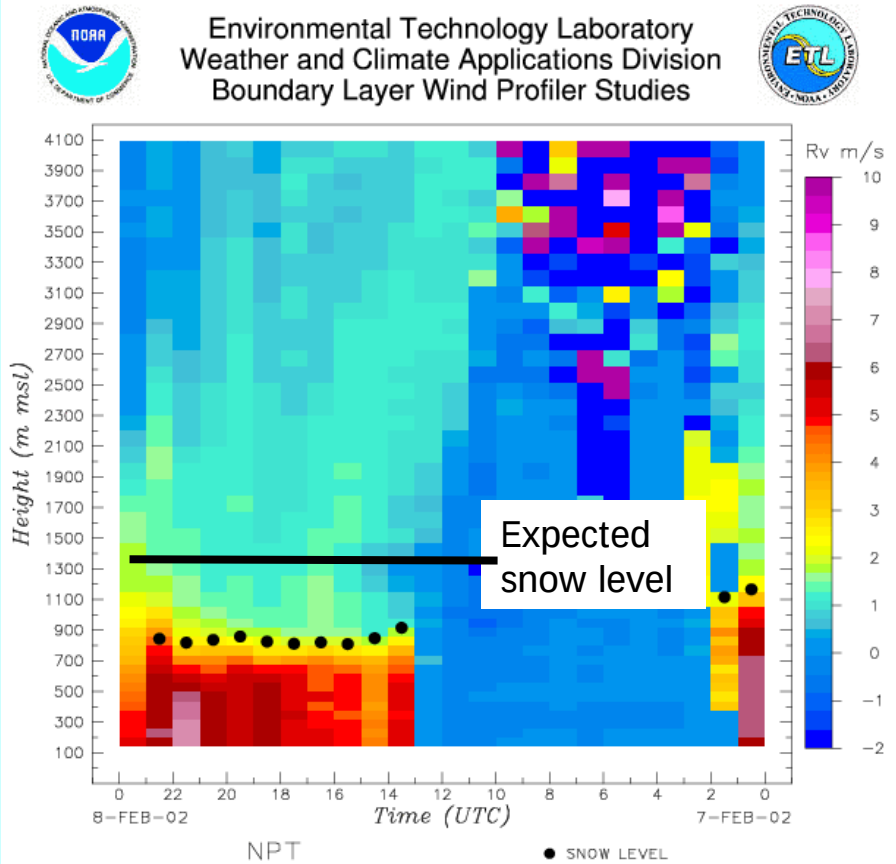
- **Physical Process Studies**
- **Observing System Tests**
- **Forecasting Applications**

# Winter Storm Warning Issued Based on PACJET-2002 Melting-Level Data

- Newport, OR profiler detected a lower snow level than had been expected (2700 ft vs 4000 ft).

- This caused Portland NWS to change from a Snow Advisory to a Winter Storm Warning.

White et al. (2002), *J. Atmos. Ocean. Tech.*

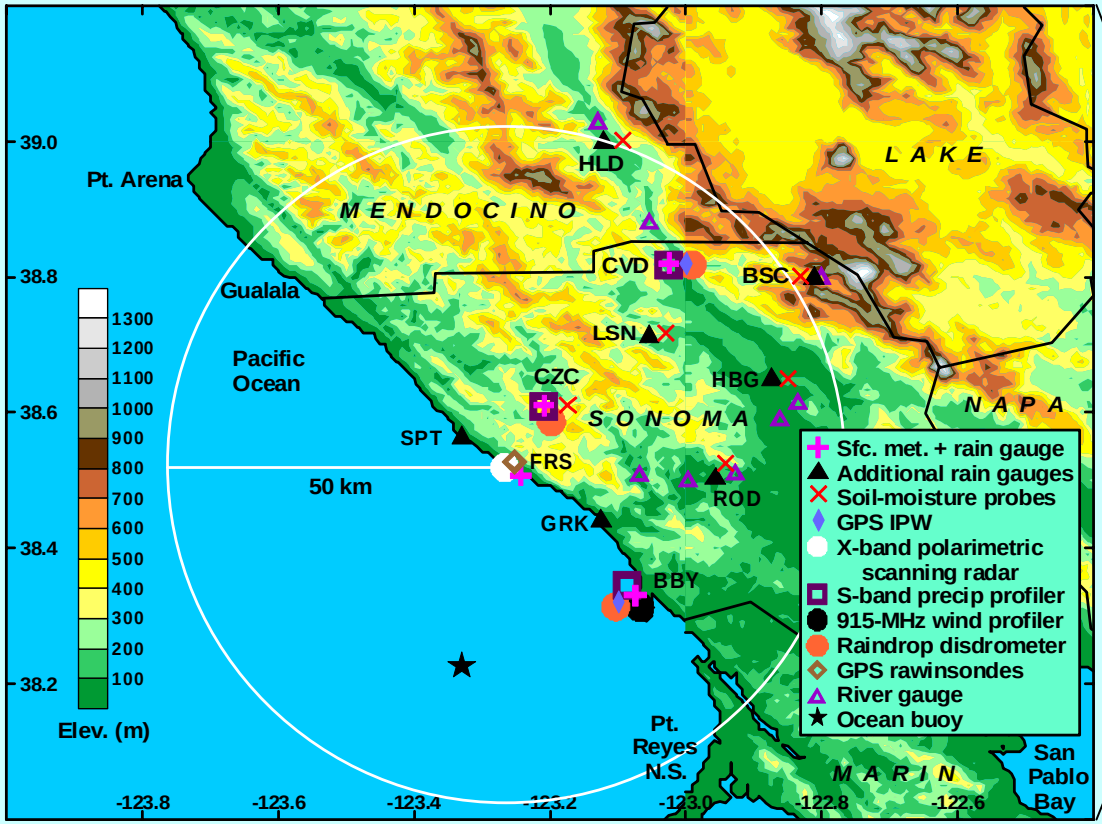


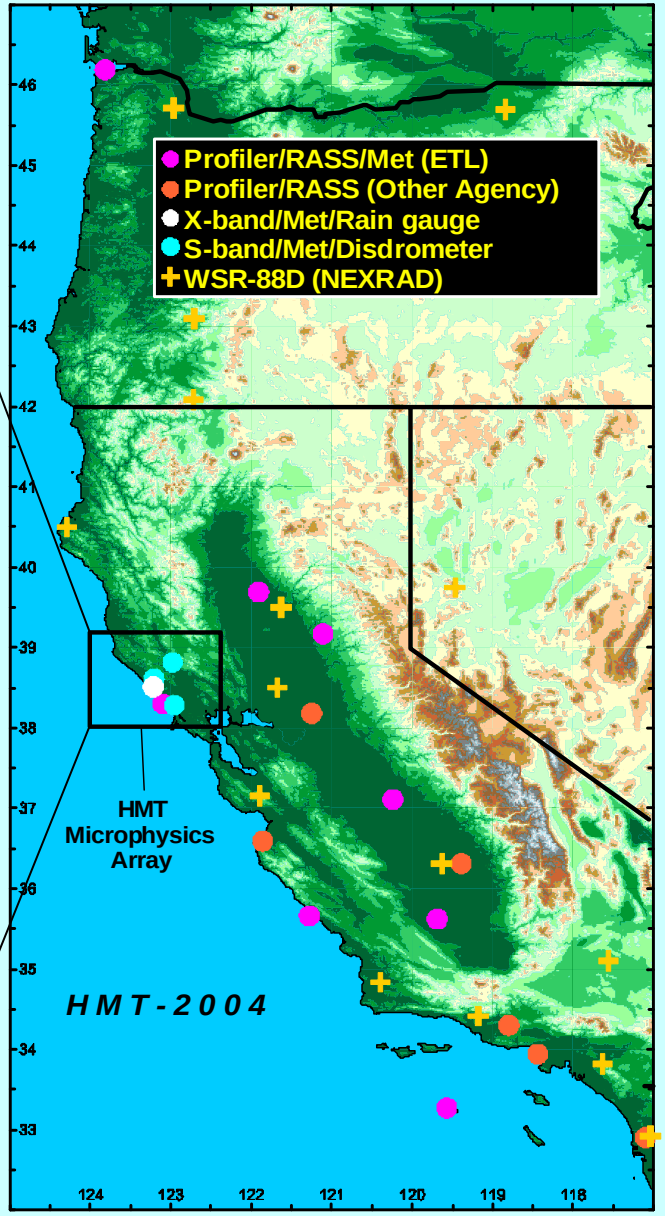

| Time (UTC) | 2330 | 2230 | 2130 | 2030 | 1930 | 1830 | 1730 | 1630 | 1530 | 1430 | 1330 | 1230 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Snow Level (m) | none | 843 | 818 | 836 | 858 | 825 | 811 | 820 | 809 | 847 | 915 | none |
| Snow Level (ft) | none | 2765 | 2683 | 2742 | 2814 | 2705 | 2660 | 2689 | 2653 | 2778 | 3001 | none |
| Sfc Temp (C) | 4.00 | 4.74 | 5.42 | 6.02 | 6.21 | 6.46 | 6.52 | 6.95 | 7.25 | 7.30 | 7.93 | 8.70 |

# HMT-2004

## A Hydrometeorological Testbed (HMT) for the Russian River Watershed

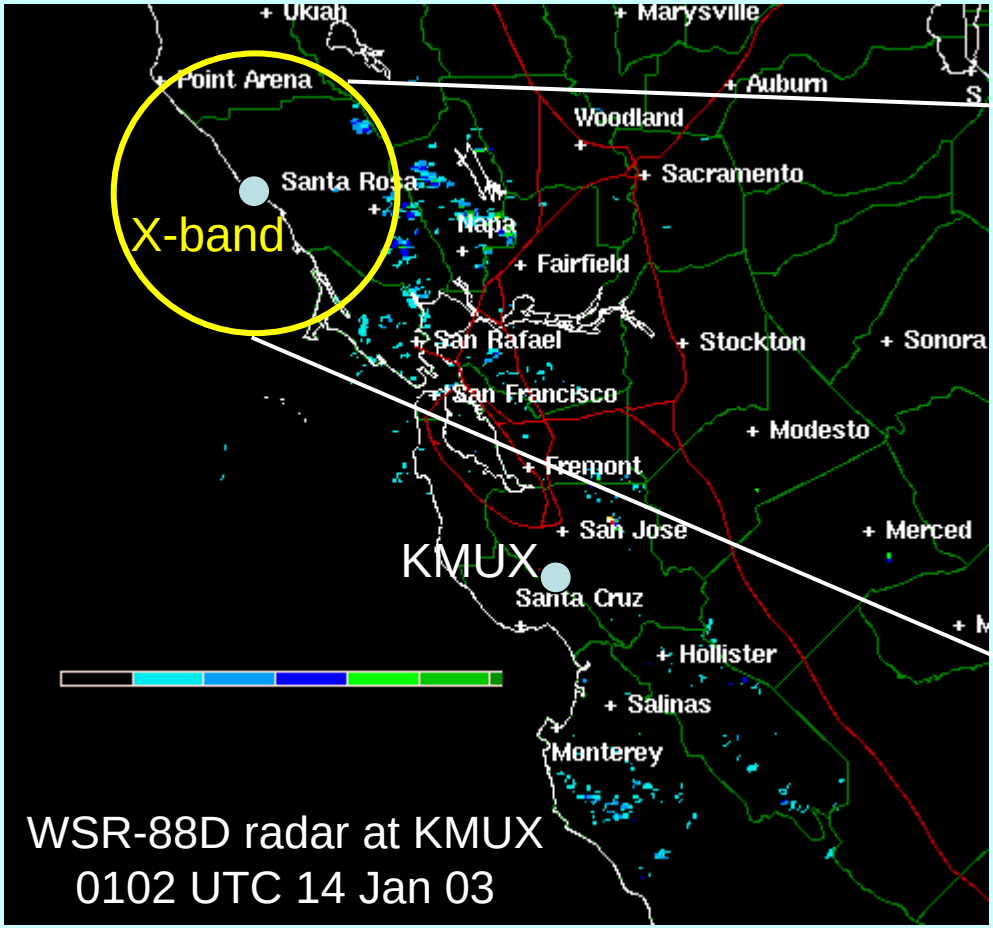
### HMT-2004 Microphysics Array

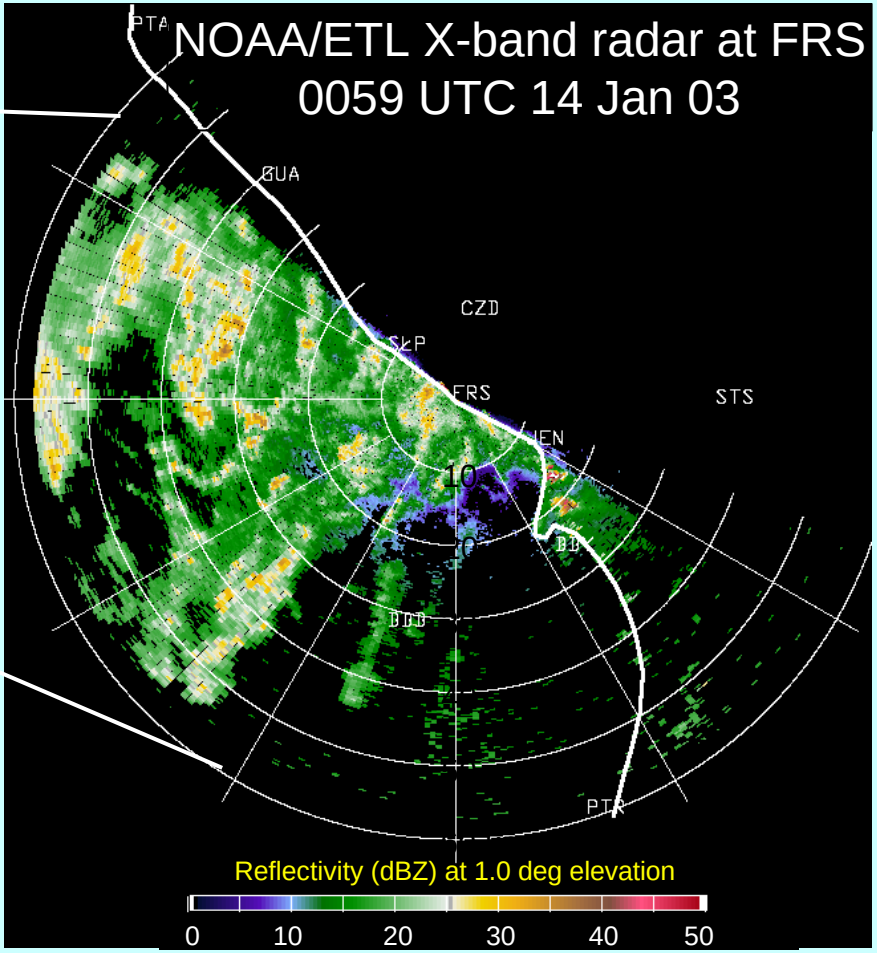


BBY = Bodega Bay
BSC = Big Sulfur Creek
CVD = Cloverdale
CZC = Cazadero
FRS = Fort Ross
GRK = Goat Rock
HBG = Healdsburg
HLD = Hopland
LSN = Lake Sonoma
ROD = Rio Dell
SPT = Salt Point

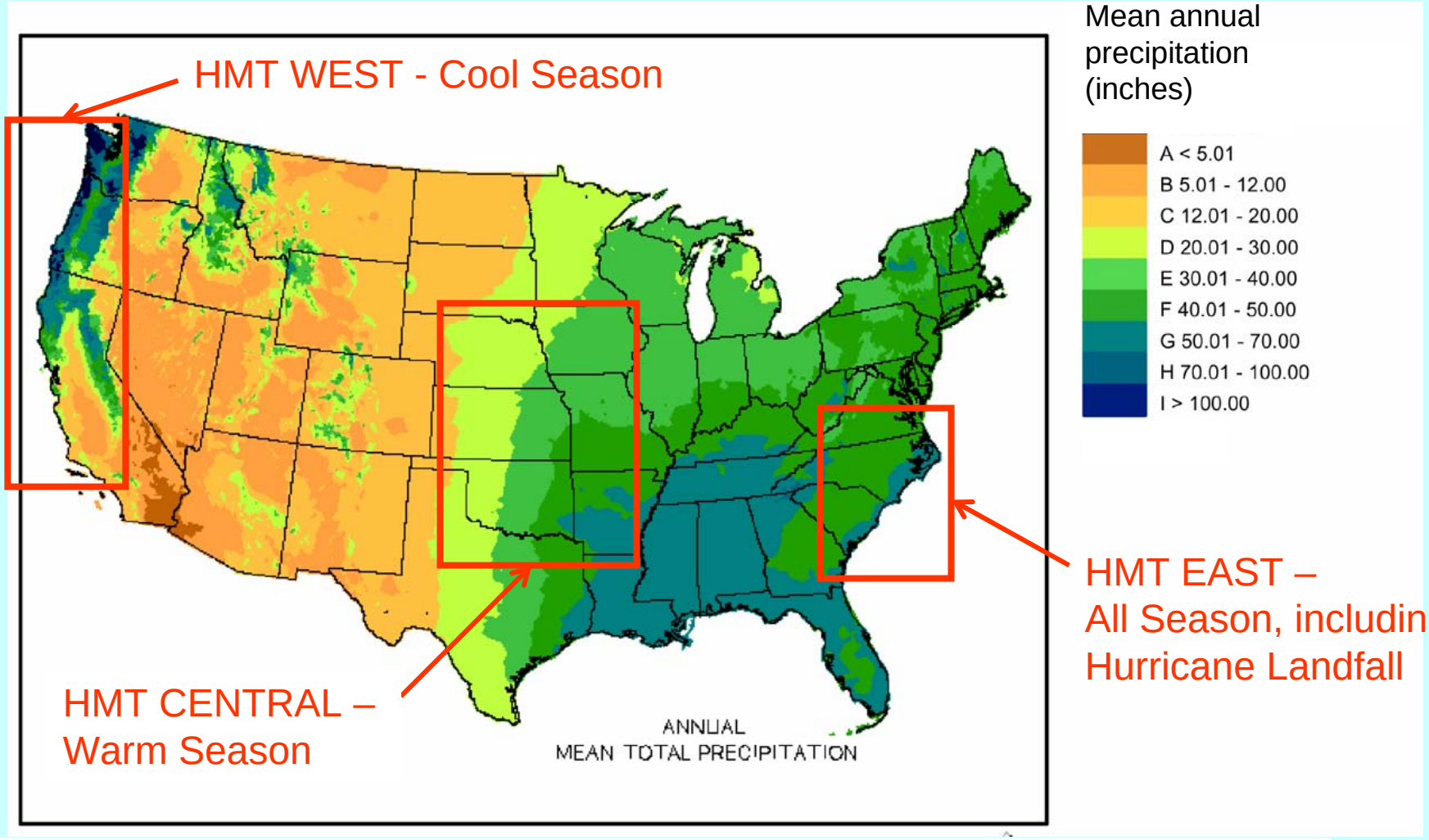
# Coastal Gap-Filling X-band Radar vs. WSR-88D



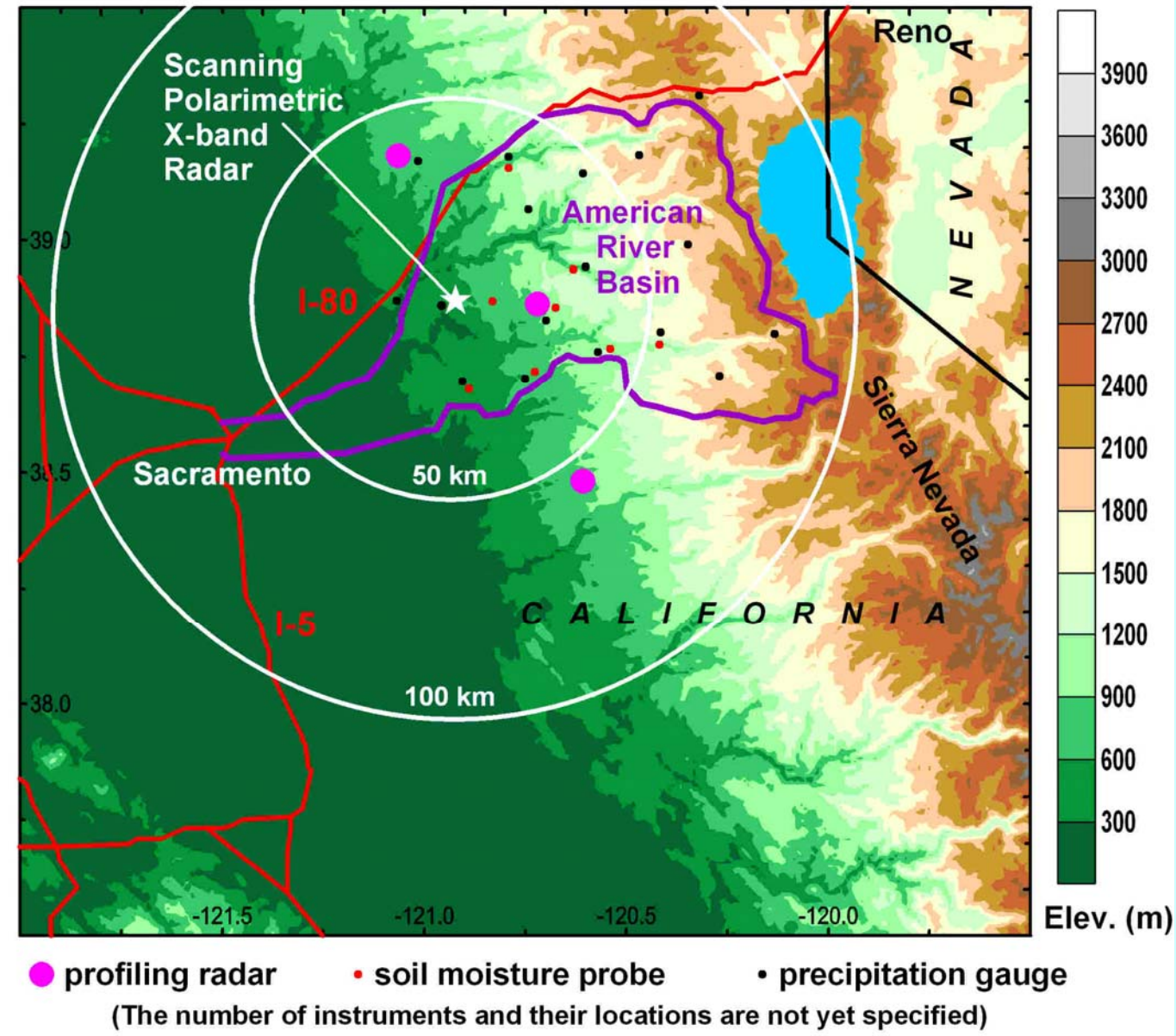

- **Nearest NEXRAD radar sees no significant echoes approaching flood-prone watershed**
- **NOAA/ETL's Coastal X-band radar fills NEXRAD gap**

# Regional Implementation Strategy

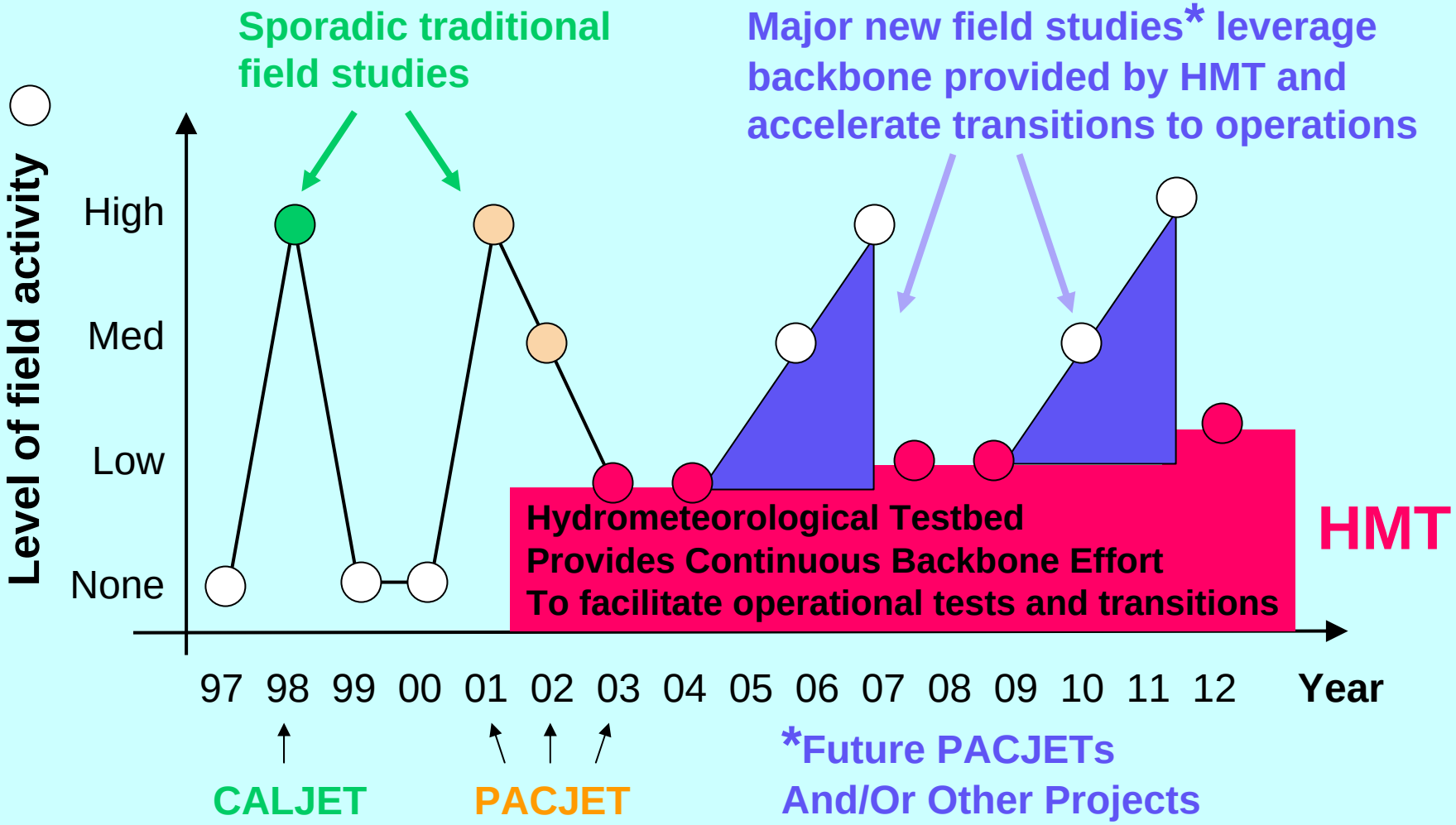



**The national Hydrometeorological Testbed program will be implemented incrementally in different regions of the U.S.**

# HMT-WEST: American River Basin 2005-2008

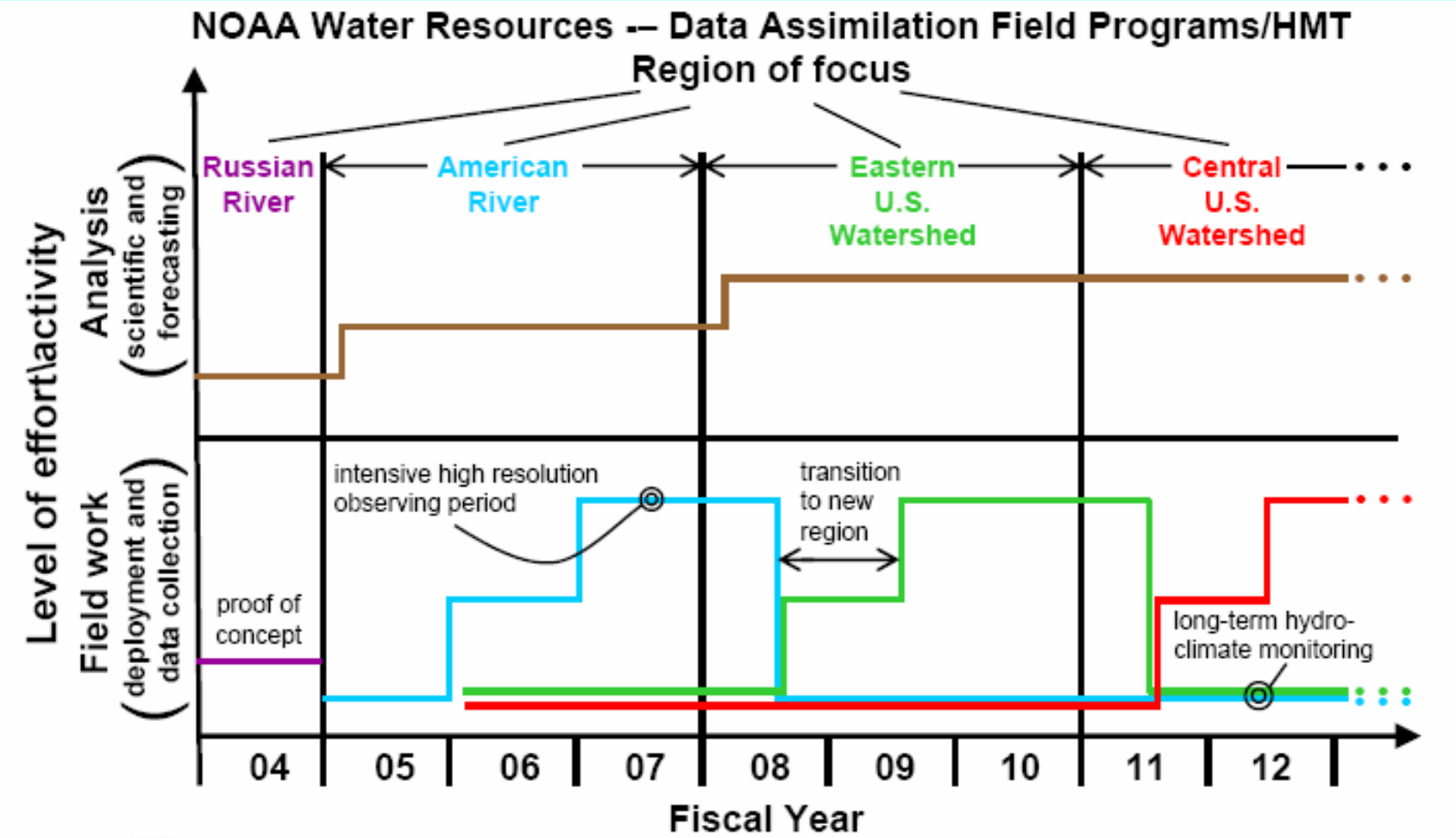


# CALJET to PACJET to HMT



# Proposed Hydrometeorology Testbed Timeline

NOAA Partners Include: OAR(ETL,NSSL,FSL,CDC,AOML), NWS(OHD,HPC,NOHRSC,WR,ER,EMC), NESDIS(ORA)




*Science, Technology and Infusion*
*Hydrology*
*Local Forecasts and Warnings*

- Russian River (California)
- American River (California)
- a key Eastern U.S. Watershed
- a key Central U.S. Watershed

Hydrometeorology Testbed

# Better Physical Understanding

- Basis for improved parameterizations in numerical models
- Allows forecasters to create an internal conceptual model of what is controlling precipitation in a given event
- Alerts forecasters to focus on certain variables or features in the observations or models that will influence a given precipitation event

# Hydrometeorology Testbed
# **Primary Goals**

- Systematically evaluate promising new methods that can influence both NWP and nowcasting using the man-machine mix forecasting paradigm.
- Assess their value in terms of improved regional performance on the QPF GPRA measure.
- *Use these results as an objective basis for decisions on transitions to operations both in the test region and nationally.*

# Operational / Research Interaction: Cultural Differences

- Operational
  - Get the forecasts out, and make them as accurate as possible
    - Forecasts must be issued in a timely way
    - Episodic availability of new methods is problematic
- Research
  - Advance understanding, develop new tools, publish
    - Publication process is time consuming but crucial
    - Typically, field studies occur every few years

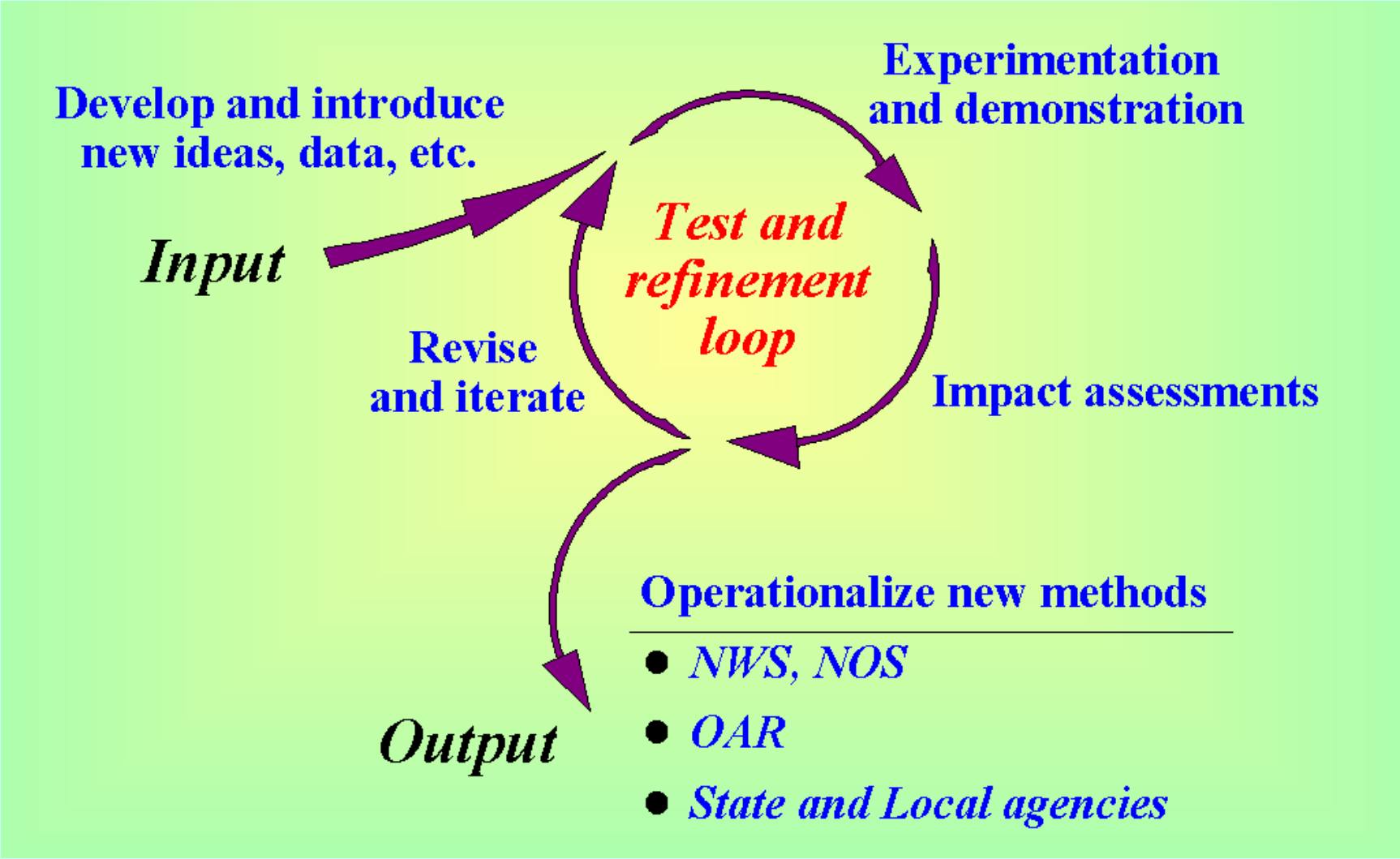
# Operational / Research Interaction: Cultural Differences

- Exploratory Research
  - Curiosity driven, plausible impacts but highly uncertain
    - Papers published in peer-reviewed journals
    - Better conceptual models
- Applied Research
  - Focused advances in understanding aimed at practical outcomes
    - New tools and methods used for specific operational goals
    - Demonstrable impacts on policy or operations

# Timeline *CALJET to PACJET*

- 1997-98:  CALJET field phase during strong El Nino (Dec ‘97-Mar ’98, Monterey, CA)
- 1999: Workshop addressed science, forecasting & user needs and expanded CALJET to Pacific Northwest (Renamed PACJET)
- 2001: PACJET-01 field phase (Jan-Mar, Monterey, CA)
- 2001: Planning Workshop defines and recommends “Testbed” approach
- 2002: PACJET-02 field phase (Jan-Mar, Portland, OR)
- 2003: PACJET-03 field phase (Dec-Mar, N. CA)

# A New Approach: Hydrometeorological Testbed



# Hydrometeorology Testbed

## Outline of concept adopted by Hydro IPT in Sept '02

**STIP Question:**

**What major science and technology improvements are needed in order for the NWS to achieve its QPF SKILL performance goals in 2007 and 2012?**

**The Integrated Planning Team for Hydrology answered:**

**A key step is to Establish a Hydrometeorology Testbed**

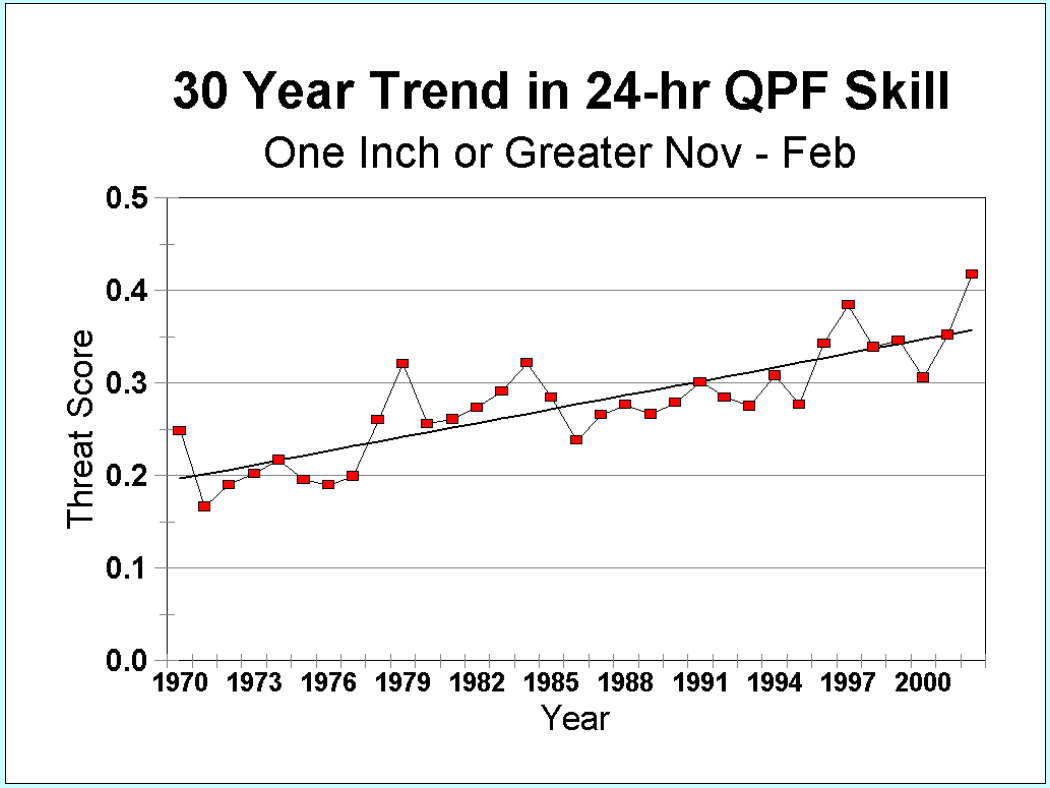
Hydrometeorology Testbed

# The Man-Machine Mix Paradigm

- Watches and warnings are issued by forecasters.
- QPFs from HPC are created by forecasters and are then adjusted by other forecasters based on local experience.
- Observations and numerical models are used as key guidance.
- Experience and conceptual models are also essential.
- Forecasters add value as their tools (i.e., models, observations, concepts) improve.
- The greatest hydrological forecast improvements will come by improving both the tools and the ability of forecasters to use them.

Hydrometeorology Testbed

# The Challenge




Improvements in many areas (observations, models, understanding etc) has resulted in gradual improvement in QPF.

Hydrometeorology Testbed

# Better Model Guidance

- Improving the performance of individual models through better data assimilation
- Evaluating biases in model physics, and improving their parameterization
- Increase the number and representativeness of ensemble members
- Tuning the models for heavier precipitation amounts

Hydrometeorology Testbed

# Better Observations

- Improving model initialization
- Improving detection of key triggers and precipitation features and their trends
- Develop real-time model forecast evaluation tools to help forecasters identify relatively high or low quality model forecasts, including filtering out unrealistic ensemble members
- Higher quality forecaster verification leading to improved future performance

Hydrometeorology Testbed

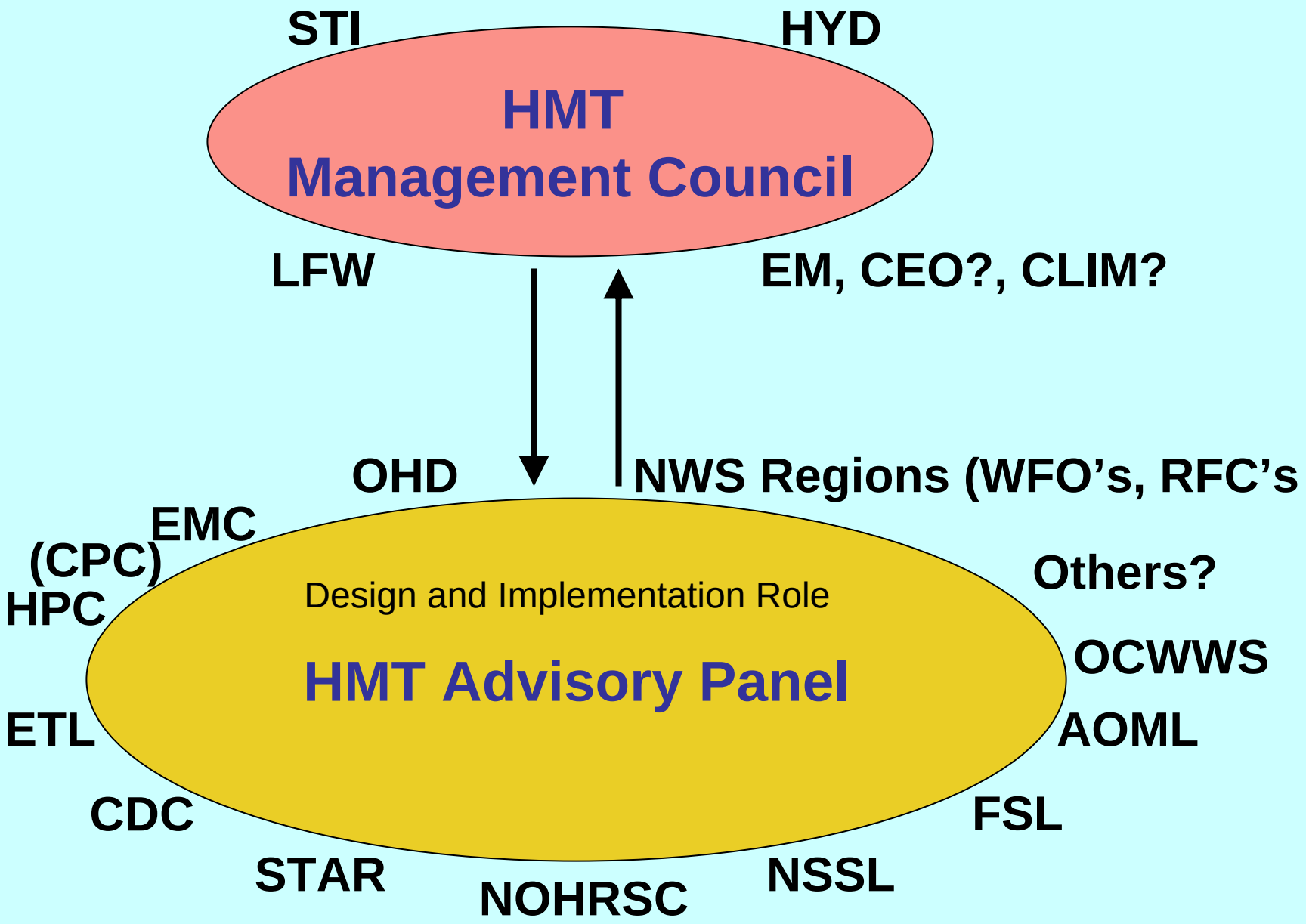
# Knowledge of Capabilities and Limitation of Key Tools

- Improves the ability of models to assimilate observations
- Enables forecasters to better take advantage of capabilities
- Enables forecasters to adjust for limitations in their tools

# Proposed Hydrometeorology Testbed Timeline

NOAA Partners Include: OAR(ETL,NSSL,FSL,CDC,AOML), NWS(OHD,HPC,NOHRSC,WR,ER,EMC), NESDIS(ORA)

Level of Activity: Low | Moderate | High | Beyond FY11: Transition to HMT-CENTRAL

| Task | | FY06 | FY07 | FY08 | FY09 | FY10 | FY11 |
|---|---|---|---|---|---|---|---|
| Observing System Acquisitions | | New Equipment | Refurbish | Replacements, Spare Parts | | | |
| Field Deployments | LFW Oriented | HMT-WEST | Intensive Campaign(s) | | Legacy Instruments Remain | | |
| | | | | HMT-EAST | | Intensive Campaign(s) | |
| | Hydroclimate Oriented | HMT-WEST | | | | | |
| | | | HMT-EAST | | | | |
| Observing System Tests | | | Airborne Soil Moisture, Snowpack | | | Airborne Soil Moisture | |
| | | Gap-Filling Radar, Polarimetric Hydrometeor ID | | | | Polarimetric Hydrometeor ID | |
| Physical Process Studies | | Atmospheric Rivers, Orographic Effects, Airmass Transformation, | | | | Hurricane Decay/Precipitation | |
| | | Soil Moisture Variability, | | Streamflow Response to Precipitation | | | |
| Model verification and data assimilation | | Water Vapor Transport, Microphysical Processes | | | | | |
| | | HMT-WEST | WRF Evaluations | | Water Vapor Transport, Microphysical Processes | | |
| | | | | | HMT-EAST | HWRF Evaluations | |
| Forecast Decision Tool Development | | Rhea Model for Orographic Precipitation | | | | | |
| | | Multi-Sensor Precipitation Utilization in Forecasting | | | | | |
| | | | | GPM: Algorithm Development, Ground Validation, | | | GPM Launch |
| Research / Operations Integration | | SOO's (current or former) Working at ETL and HPC with WFO's and RFC's | | | | | |
| Testbed Impact Assessment | | | HMT-WEST | | HMT-EAST | | |
| | | | Recommendations for Permanent and/or National Operational Upgrades | | | | |
| Operational Implementation | | | | Rhea Model | | | |
| | | | | | Multi-Sensor Precip. | | |
| | | | | | | | GPM |

# Possible HMT Management Structure