Hydrometeorology Testbed (HMT) Charter

Overview: Mission and Vision Statements

The NOAA HMT is a joint OAR-NWS testbed motivated to make "**Communities that are more resilient to the impacts of extreme precipitation on lives, property, water supply and ecosystems**." HMT is co-managed by the OAR Physical Sciences Division (PSD) and the NWS Weather Prediction Center (WPC) in partnership with the NWS Office of Water Prediction (OWP).

The mission of HMT is "**Improving forecasts of extreme precipitation and forcings for hydrologic prediction**." HMT supports both OAR and NWS strategic objectives. For OAR, these include:

- *How can we improve forecasts, warnings, and decision support for high-impact weather events?* (OAR overarching science question)
- *Identify new sources of predictive skill and improve predictions of weather, water, and climate through observations, understanding, and modeling of physical processes and phenomena of the coupled Earth system*. (PSD overarching science goal)

HMT supports a number of goals in the NWS Weather Ready Nation strategic plan:

- *Improve weather decision services for events that threaten lives and livelihoods*
- *Deliver a broad suite of improved water forecasting services to support management of the Nation's water supply*
- *Improve sector-relevant information in support of economic productivity*
- *Enable integrated environmental forecast services supporting healthy communities and ecosystems*

Scope of Activities

HMT accelerates the prototyping, demonstration, use and transition of advanced hydrometeorological observations, models, and products to improve forecasts of extreme precipitation and the atmospheric forcings that can be used in the hydrologic prediction of stream flow and other surface processes in the Day 1 - 10 time period. While individual weather forecast offices and river forecast centers will benefit and incorporate HMT advances in forecasting extreme precipitation and forcings for hydrologic prediction into their operational practices, WPC and OWP will be the primary conduits at the national level for transitioning HMT projects. Collectively, these efforts ultimately lead to improved prediction of extreme weather and water events through WPC and OWP operations.

As shown in Figure 1, HMT covers a large range of the technical readiness levels (TRLs) to reflect the complementary roles of OAR and NWS, as shown in Fig. 1. The HMT effort to improve forecasts of extreme precipitation and forcings for hydrologic prediction will be primarily focused in the TRL 5-8 range (Figure 1). HMT work thus will encompass process studies, model development, parameterization evaluation and improvement, introduction of experimental model or prototypes in an operational environment, demonstration in an operational environment, and the transition to operational implementation. Designed to complement each other, OAR's primary focus is on prototyping and demonstrating at the lower RLs while the NWS concentration is on demonstration and experimental implementation activities at higher RLs. This complementary relationship is illustrated in Fig, 2 with OAR conducting process studies, diagnostic analyses, assessments, and prototyping of model developments and with NWS conducting forecast experiments, evaluations and refinements. Although HMT relies and builds upon experimental development and proof-of-concept demonstration research as foundational activities, these foundational activities will not be commonly supported as part of the testbed.

HMT advances can be applied at the local (WFO), regional, or national level operations; however, the emphasis of HMT work is focused on activities that have the potential to be readily transferable as solutions for other regions or scaled-up to meet national requirements.

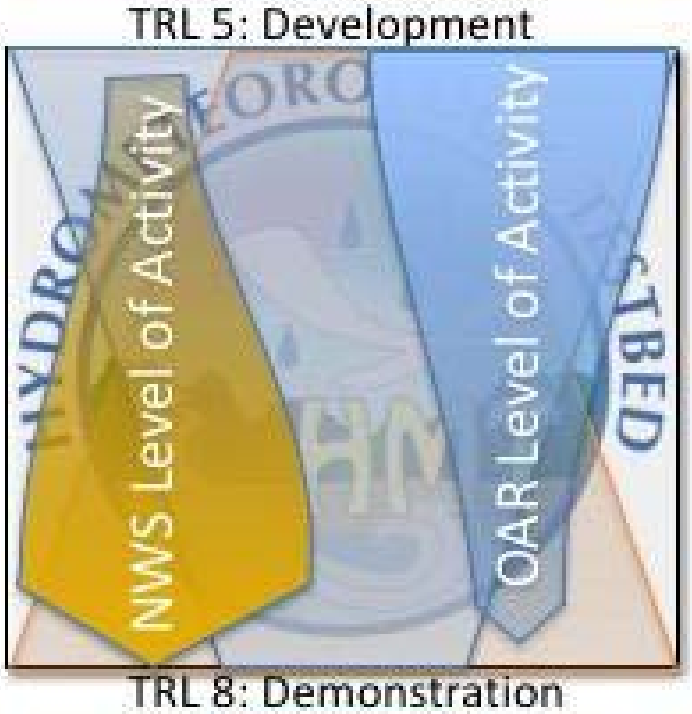

Figure 1. Conceptual diagram showing relative roles of OAR and NWS in HMT within the research to operations (R2O) funnel.

Foundational Capabilities / Collaborative Roles

OAR and NWS have complementary roles in HMT (Figure 2). WPC is focused on **atmospheric forecasting, including quantitative precipitation forecast (QPF), winter weather, and medium range forecasting**. An important focus is improving QPF performance over time scales ranging from a few hours to day 10. WPC's challenge is that the improvement of operational model QPF (e.g., HRRR, GFS/GEFS, and SREF) has been very slow. Efforts to address fundamental deficiencies in numerical weather prediction (NWP) systems in terms of physical parameterizations, data assimilation techniques, and ensemble forecasts are needed. Further, new techniques and decision support tools (DSTs) can be used to draw forecasters attention to key signals, summarize uncertainty, and correct for model QPF biases. WPC also focuses on winter weather challenges, including critical forecasts of precipitation type and intensity. Finally, as NWP improves WPC is challenged to extend forecasts beyond a week, including appropriate formats of the information. Assessing and communicating uncertainty is an ever-present challenge and focus of the testbed effort for these three topic areas - QPF, winter weather, and medium range.

The OWP is focused on **hydrologic** analyses and forecasting. The OWP collaboratively researches, develops and delivers state-of-the-science national hydrologic analyses, forecast information, data, decision-support services and guidance to support and inform essential emergency services and water management decisions**. Within HMT, the OWP focuses on the application of experimental atmospheric forcings to hydrologic and hydraulic modeling and forecasting environments**. The OWP will leverage and integrate HMT based advancements in atmospheric forcings with parallel OWP efforts to account for water regulation processes (e.g., reservoir releases, diversions, inter basin transfers) and related uncertainty in water forecasts. Similar to WPC, the OWP strives to enhance the quantification and communication of uncertainty across all forecast horizons with a near-term emphasis on the short range (0 to 18-hour) and Medium Range (0 to 10-day) hydrologic model simulation cycles.

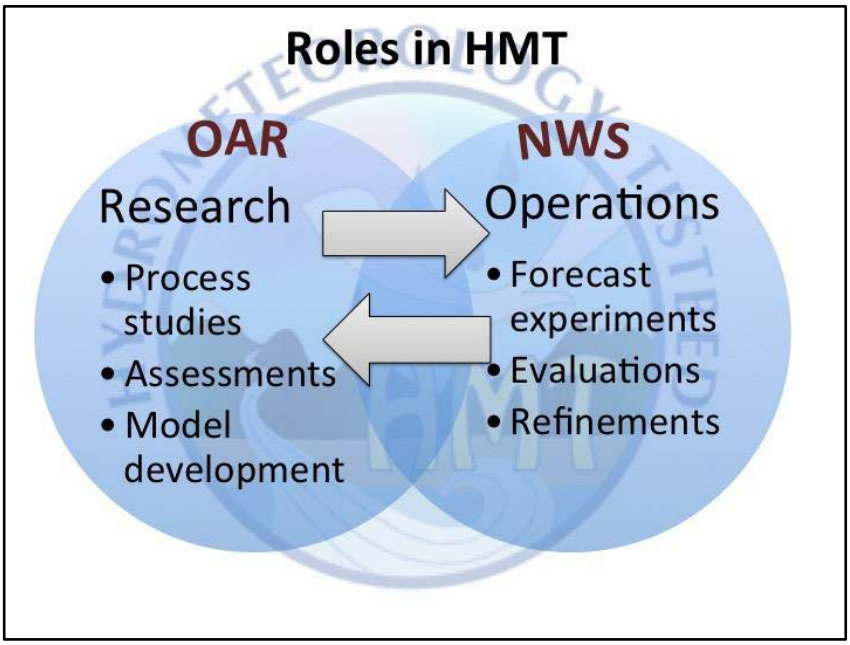

Figure 2. Conceptual diagram showing complementary roles of OAR and the NWS.

Complementing WPC and OWP's role, PSD is focused on the analysis and interpretation of physical processes that influence weather from hours to days to provide the scientific advances necessary to improve the prediction of weather and water extremes. **PSD works to enhance the prediction of precipitation extremes and hydrologic forcings through improved observations, understanding, modeling and predictions of weather and water extreme events and their related impacts**. Observations are used to augment existing operational data, provide new insight into critical processes, and in combination with other observing datasets, develop the process understanding needed to improve prediction. Advances in understanding of atmospheric processes combined with application of state-of-the-art the observing systems provide the basis to assess operational and experimental models representations of key hydrometeorological processes and identify opportunities for model improvement. This scientific knowledge is also used to guide observing network design, modeling assimilation and analysis, and predictions of weather and water extremes that can be applied in NWS operations as well as to inform planners, and decision makers at local, regional, and national levels,

As a collaborative partnership, OAR's primary role is to determine if a scientific innovation resulting from an experimental development or proof-of-concept research has a path toward operations and then, guided by NWS requirements, move that innovation up the readiness levels through demonstration and prototyping to a maturity level where NWS can evaluate the capability in a forecast experiment or other experimental implementation. NWS's primary role in this partnership is to articulate requirements and evaluate and validate the performance of innovations in an operational setting, and then to assess the feasibility of innovations as an operational product or service. In an iterative mode, OAR would then work with NWS to refine or improve the innovation. For example, forecast experiments are conducted annually for WPC

for heavy rain (Flash Flood and Intense Rainfall - FFaIR), winter weather (Winter Weather Experiment), and extended range forecasts (Medium Range Forecast Experiment) with funded projects designed to eventually be tested in one or more of these experiments and/or undergo ongoing evaluation. The infusion and subsequent testing of scientific innovations such as advances in observing capabilities, the processing of observational data, prediction of extreme precipitation, or modeling of critical hydrometeorological processes in an operational setting is thus the ultimate goal of HMT's collaborative partnership between OAR and NWS.

The link between OWP and HMT is through advancements in the atmospheric forcings that are used in hydrologic prediction. These advancements are particularly important as atmospheric forcings are typically the greatest source of uncertainty in hydrologic predictions. Thus within HMT, OWP focuses on the application of experimental atmospheric forcings to hydrologic and hydraulic modeling and forecasting environments. In a synergistic relationship with HMT, OWP will ensure that the experimental forecasts of precipitation and hydrometeorological fluxes (e.g., evapotranspiration) are indeed aligned with operational hydrologic needs.

Management Structure

HMT contains both a research (OAR) and operational (NWS) NOAA Line Office. Collectively OAR and NWS partner to infuse scientific advances into operational capabilities. As such, the HMT management structure is set up to maximize coordination between these two NOAA line **offices. PSD coordinates among the OAR laboratories and is the primary interface to NWS.** WPC and OWP are the primary interfaces to OAR as landing pads for transitioning HMT projects and therefore represent the NWS "face" of HMT, coordinating closely with PSD. HMT innovations can also be transitioned to local and regional NWS offices (Weather Forecast Offices, River Forecast Centers, and Regional Headquarters) as appropriate.

HMT has a two level management structure with the Testbed Leads providing tactical, day-to-day management and the Executive Oversight Council providing strategic oversight. The Executive Oversight Council is comprised of the Directors of PSD, OWP, and WPC or their designees. As the HMT strategic body, the Council will meet regularly to establish testbed priorities, address strategic issues, and discuss funding opportunities. The Testbed Leads are guided strategically by the HMT Executive Oversight Council in the goals and objectives of the program, and are responsible for ensuring the R2O process occurs. The Testbed Leads are the day-to-day managers in the implementation of the testbed, which includes coordinating both formally funded and internally funded projects. In addition, the Testbed Leads jointly represent HMT on the NOAA Testbeds and Proving Grounds Committee, report out highlights at the annual NOAA testbed and proving grounds workshop and issue a brief summary report of annual accomplishments

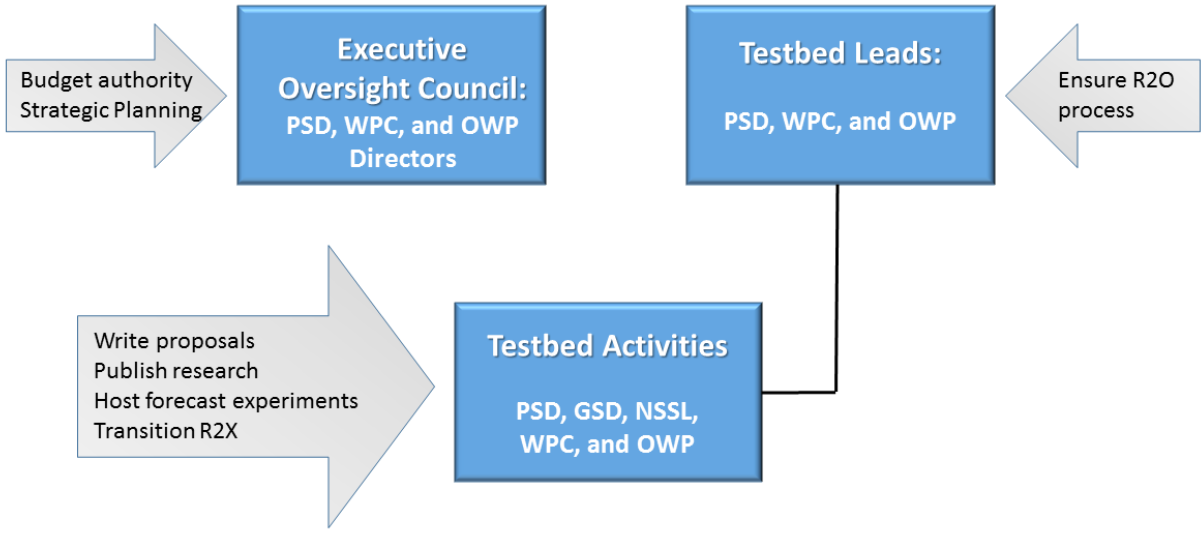

Figure 3. Flow chart showing HMT management structure

The HMT management structure is shown in Fig. 3 and includes:

- Executive Oversight Council (PSD, OWP, WPC Directors or their designees))
    - Role: Strategic Planning
        - Identify research priorities
        - Identify infrastructure needs
        - Identify funding opportunities
    - Council Engagement
        - Periodic phone tag-ups
        - Face-to-face meeting at annual Testbed Workshop
- Testbed Leads (WPC; PSD, OWP) supported by administrative coordinator to ensure HMT integration
    - Role: Tactical Implementation
        - USWRP competition (interface to OWAQ)
        - Planning and executing contracts
        - Reports
        - Proposals (outside USWRP)
        - NOAA Testbeds and Proving Ground Coordinating Committee participation (meetings, coordination activities, reporting)
        - Planning, coordination and evaluation of annual or semiannual pseudo-operational experiments.
        - Coordination OAR and NWS to ensure execution of projects
        - Preparation of documentation, training, and performance evaluations of successfully transferred products to facilitate use and support in operations
    - Leads Engagement
        - Periodic phone tag-ups

- Periodic face-to-face visits
- Face-to-face meeting at annual Testbed Workshop

Stakeholder Engagement

HMT has internal NWS stakeholders, (e.g., OWP, WFOs, and RFCs), internal NOAA stakeholders within other line offices with management responsibilities (e.g., NMFS and NOS), and external stakeholders in both the academic and federal, state and local agencies as well as the private sector. HMT will engage stakeholders directly through the individual funded projects and as opportunities arise at professional meetings and conferences.

Business Model

HMT identifies and fosters the adoption of new techniques, models, observing systems, and other advances with potential for improving forecast guidance and hydrologic forcings. The HMT business model design has drawn upon well-established practices from the Joint Hurricane Testbed to expedite the transfer of research advances into an operational setting[1]. Guided by operational needs, including official NWS requirements identified through the CaRDS process, the Testbed Leads from WPC, PSD and the OWP apply their technical expertise to identify high priority hydrometeorology challenges in the forecast of extreme precipitation and forcings for hydrologic prediction as candidate issues targeted for demonstration and testing in HMT. The HMT Executing Oversight Council will then work with the Testbed Leads to select a limited number of candidate issues that address pressing operational requirements. A federal funding opportunity call will be used to support internal and external projects to advance scientific capabilities that will address the resulting short-list of high priority hydrometeorological challenges. Key factors to evaluate projects include relevance and connection to operational priorities, technical merit, research maturity, qualification of applicant, and project cost. As part of the coordination responsibilities, a shared WPC-PSD infrastructure is maintained to facilitate the modification and transfer of research advances into the operational environment when these products and services are mature enough to be tested in annual or semi-annual HMT pseudo-operational experiments with end-user interactions. Decisions are made after the demonstration portion of the projects to determine what activities will be moved forward to the end-user agency representative to consider for operational deployment or which ones require more follow-on development or testing, using each project's transition plan as a roadmap. A successful transition occurs when the end-user agency formally accepts and implements the projects into operations and performance measures are documented, and the executive sponsors are notified. This process is then repeated for a new round of projects.

[1] Rappaport, Edward N.; Jiing, Jiann-Gwo; Landsea, Christopher W.; Murillo, Shirley T.; Franklin, James L. (2012). The Joint Hurricane Test Bed: Its First Decade of Tropical Cyclone Research-To-Operations Activities Reviewed. Bulletin of the American Meteorological Society Vol. 93 Issue 3, p371-380.

Formal funding opportunities are used to develop projects that address HMT's forecast improvement mission. Proposal projects are intended to take advantage of knowledge and expertise across NOAA. For example, OAR laboratories contributing to an HMT project could include ESRL Physical Sciences Division, and ESRL Global Systems Division, or National Severe Storms Laboratories. The HMT Executive Oversight Council and Testbed Leads meet to develop proposal requirements. As part of the funded infrastructure support, Testbed Leaders have responsibility to coordinate participation in proposal calls, lead peer review and evaluate submitted proposals, track projects, and complete reporting requirements for externally funded projects.

As part of the HMT infrastructure activities, annual forecast experiments are conducted at WPC focused on QPF, Winter Weather, and Medium Range challenges. The HMT Executive Oversight Council develops the requirements for these forecast experiments. These experiments are designed to simulate the WPC, OWP, WFO and RFC operational environments such that realistic tests of formally funded project tools as well as internally developed HMT innovations can be conducted. Generally both objective and subjective verification and evaluation is conducted. The experiments foster diverse participation from NOAA forecasters, researchers, model developers, and the external research community. Formally funded projects are often designed with the intention that they can be candidates for evaluation in the annual forecast experiments; however, not all projects are relevant for the intensive experiments. As such, tools and techniques may also be tested outside formal experiment periods on an ongoing basis in an appropriate research to applications, operations or services (R2X) environment.

Based on objective results of the annual experiments and other demonstrations, projects may be declared ready for transition, need to be refined, or abandoned. Projects declared ready for transition are presented to the respective operational Center Director to ascertain the resources required to transition the project into operations, and assign these resources, if available. If transition of a ready project has the potential to improve or advance broader NWS science and service areas, or requires resources beyond those available to support transition activities, then the NWS Governance Process will be used to assess the need and associated operational resource demand.

Testbed Infrastructure

Infrastructure is a critical component of HMT to provide support for projects to be evaluated in forecast experiments, and on an ongoing basis, in the tracking of projects, and in the transition of scientific advances into applications, operations or services (R2X) environment. Infrastructure in HMT has to be compatible with operational environments at WPC, OWP, WFOs and RFCs. WPC facilitates annual testbed experiments and ongoing demonstrations, as well as engages with the academic and research community for testbed-relevant tools and techniques. WPC also supports a room and 3 NAWIPS workstations to mimic the operational environment of the national center and 1 AWIPS workstation to mimic the operational environment of WFOs. The

OWP has a proving ground facility that can be leveraged for hands-on demonstration of guidance datasets, and products. The OWP also maintains a testing instance of the AWIPS environment housed at the National Water Center in Tuscaloosa, with connectivity to operational datasets. PSD advances AWIPS 2 and IT support capabilities. Workstations with access to NWS operational model data (e.g., HRRR, GFS, MRMS) are maintained. WPC, PSD and OWP provide scientific expertise and intellectual leadership at both strategic and technical implementation levels in the management of HMT.

Summary

The HMT **improves forecasts of extreme precipitation and forcings for hydrologic prediction** through the prototyping, and use of advanced hydrometeorological observations, models, and products. The testbed focuses on improving forecasts of extreme precipitation, and atmospheric forcings that can be used in the hydrologic prediction of streamflow and other surface processes in the Day 1 - 10 time period. WPC and OWP are the primary landing pads for transitioning HMT projects, with application at WFOs and RFCs. These efforts ultimately lead to improved prediction of extreme weather and water events through NWS operations.