Current and Future Research to Advance Subseasonal to Seasonal Prediction

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NOAA ESRL Physical Sciences Division

Conduct research to improve the observation, understanding, modeling and prediction of weather, water and climate extremes and their impacts

- **Deploying existing observing technologies, and develop new technologies, to advance observation-based process understanding**
- **Analyzing data and information to provide diagnostic explanations and to advance predictive understanding of weather, water and climate extremes**
- **Developing and applying models to transform predictive understanding into capabilities to forecast and predict weather, water and climate extremes**
- **Transforming science-based knowledge into actionable science that is readily available to support operations, applications and decision making**

https://www.esrl.noaa.gov/psd/

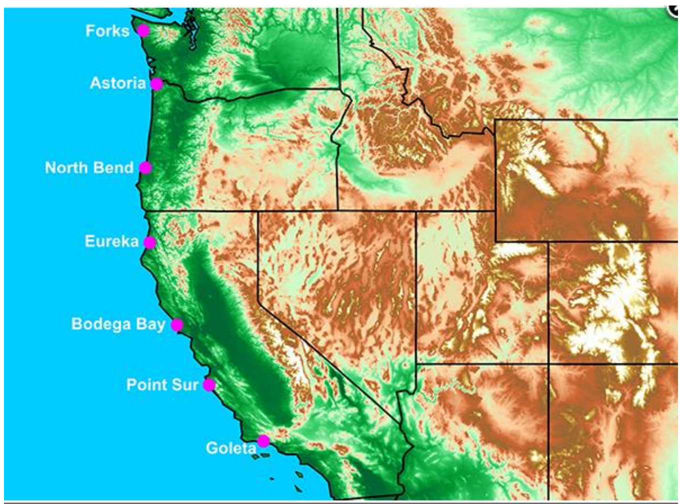
Hydrometeorology Testbed (HMT) Science Contributions to Advancing Sub-seasonal to Seasonal Prediction Capabilities

- **HMT advances in observation-based process understanding are targeted to improve fundamental physics, advance short-term weather prediction and enhance nowcasting of evolving conditions**

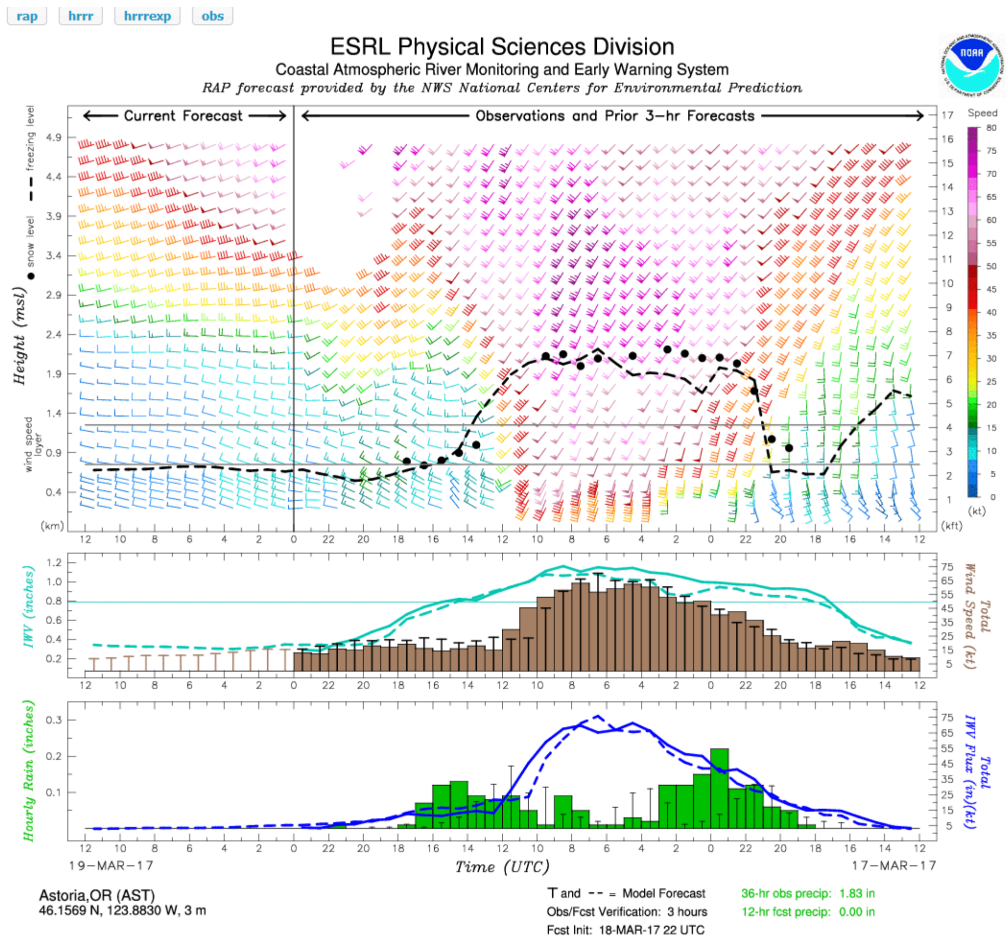
- **These HMT advances in understanding, in improvement in model physics, and in development of alternative parameterizations of key processes can be applied to improve longer-term forecasts and sub-seasonal to seasonal prediction**

West Coast Network to Observe Extreme Precipitation

"Picket fence" of atmospheric river observatories complete



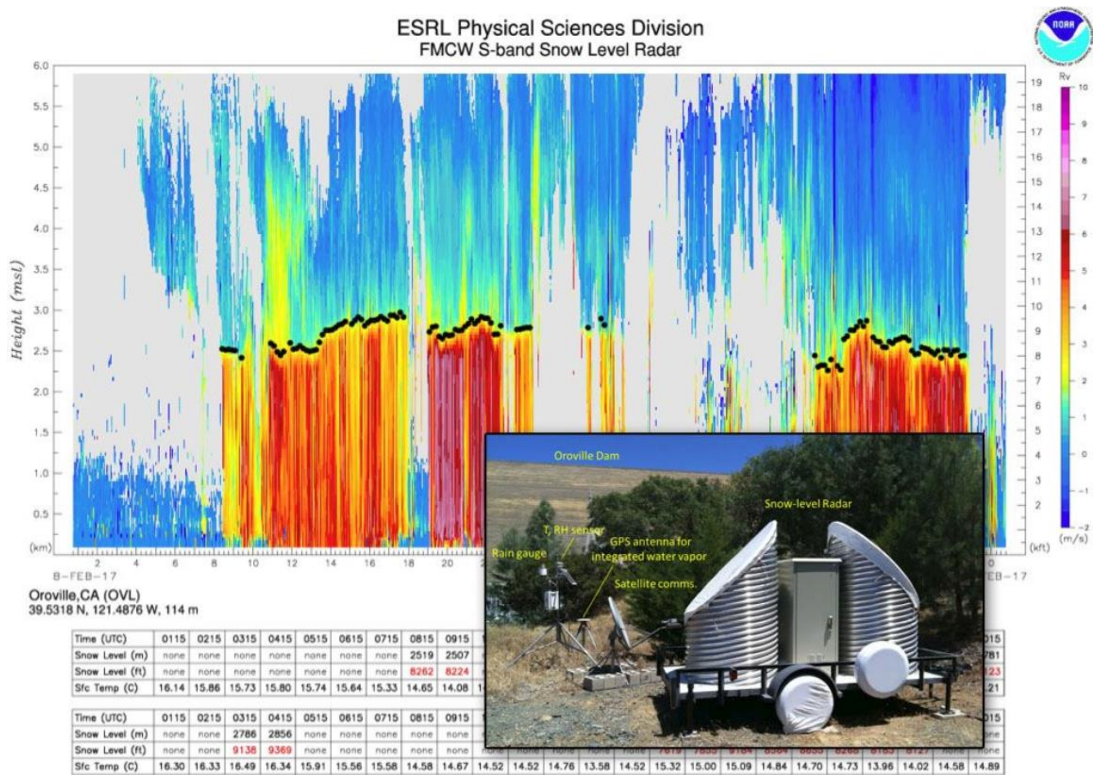
Basemap of the U.S. West Coast showing seven-station 'picket fence' of ¼-scale 449-MHz wind profilers assembled, deployed, operated and maintained by PSD engineers. (Credit: NOAA)



Snow Level Radar

- Cost-effective, snow-level radar developed by NOAA ESRL measures where falling snow changes to rain above the dam. This distinction is critical. Rain falling on snow or bare ground increases immediate flood threats, while snow falling in the watershed stays in place until it melts.

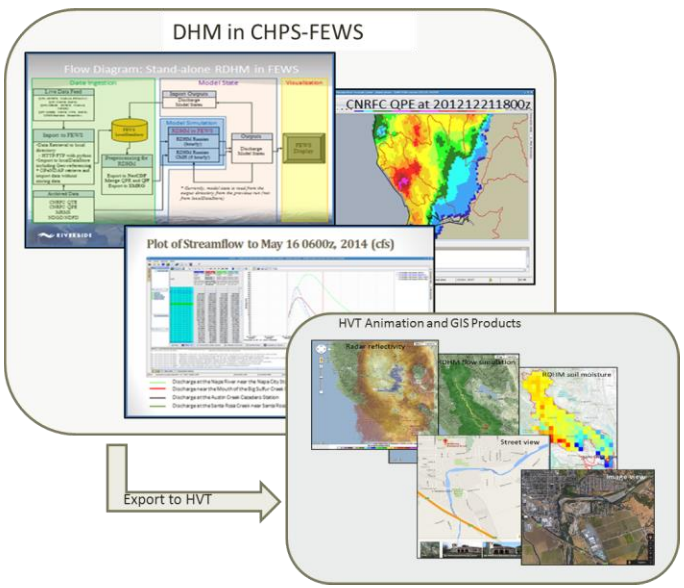
- Ten year-plus time series of snow level observations at select locations provide long enough records to evaluated to evaluate forecast system model performance and to guide model development



S-band Snow level radar at Oroville Dam

Distributed Hydrological Modeling for NWS Flash Flood Operations

Goal: Assess whether and how a DHM approach can provide enhanced hydrologic services.



Highlights:

Prototype

- DHM/CHPS/FEWS maintained by Riverside
- Inconsistencies found in precipitation data sets – currently being evaluated
- Currently operationalizing QPF/QPE workflows and export of additional data for the HVT

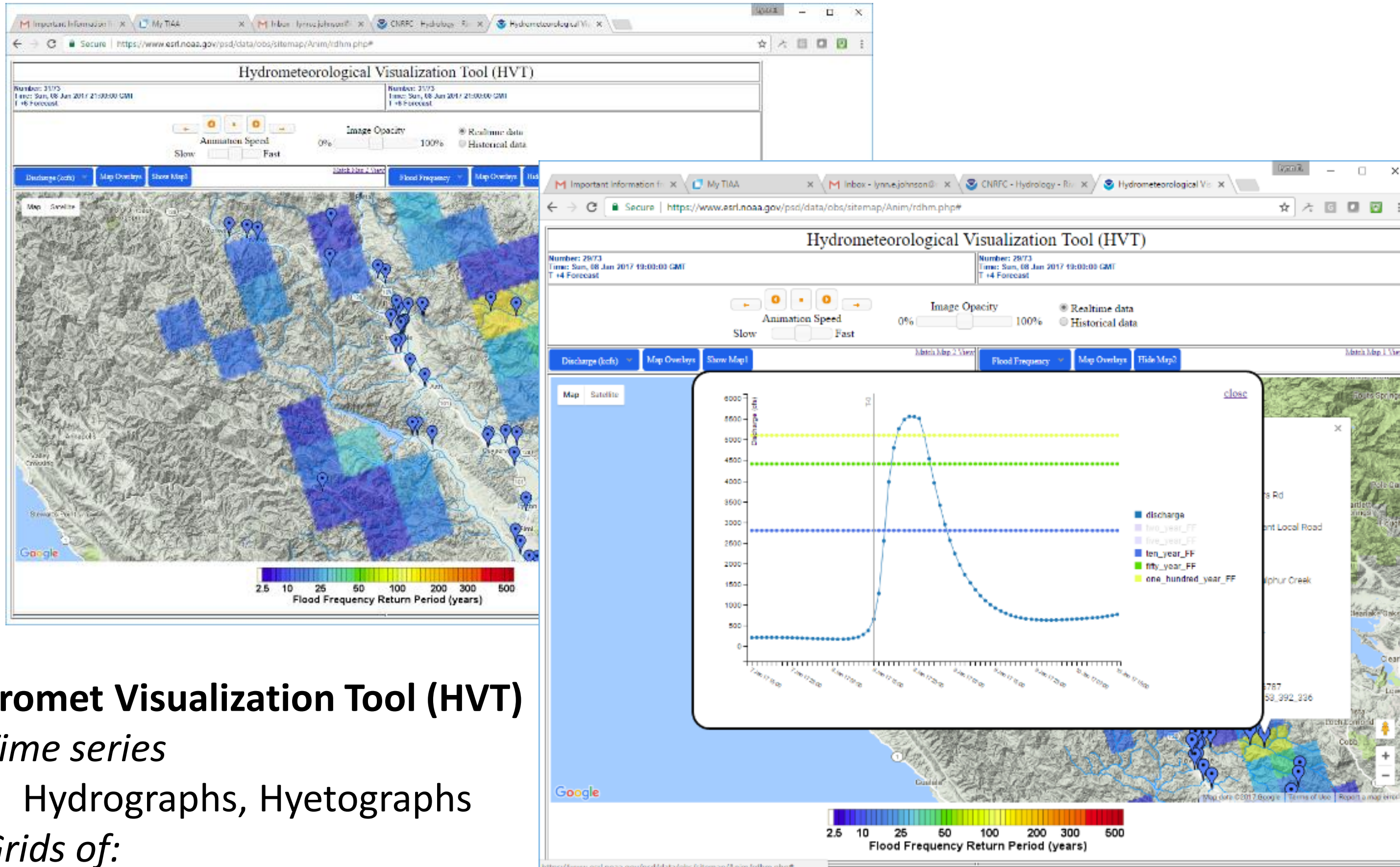
Interface

- Hydromet Visualization Tool (HVT) developed using Google Maps interface
- HVT remained stable and operational during the 2016-2017 winter storm season
- Archived storm event data will be made available for retrospective assessments

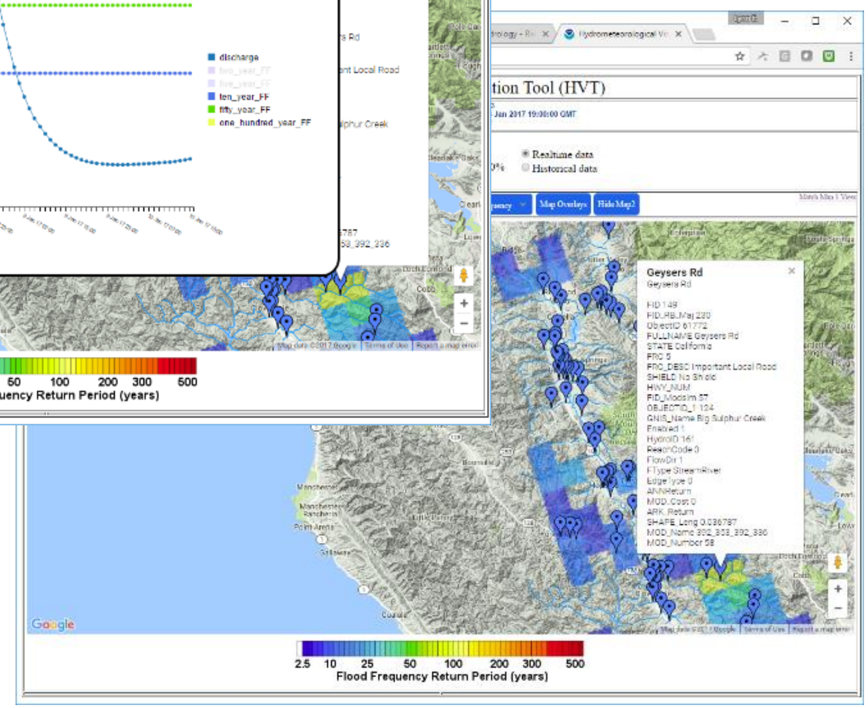
Assessment and Evaluation

- Five user groups identified
- Assessment plan will be finalized
- Will conduct retrospective reviews of significant fllod events with the AP

Distributed Hydrological Modeling for NWS Flash Flood Operations



RUSSIAN RIVER BASIN
EVENT JANUARY 4-9, 2017
Big Sulfur Creek – Geysers Road



Hydromet Visualization Tool (HVT)

Time series

Hydrographs, Hyetographs

Grids of:

Precipitation, Surface runoff

Soil moisture, Threshold frequency

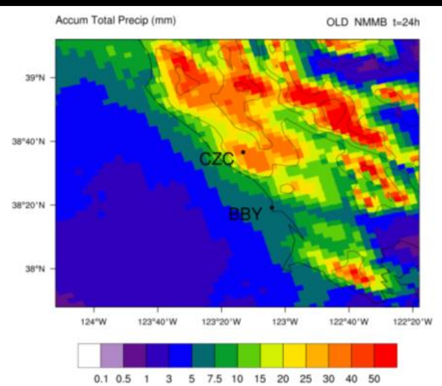
Impact features

Road crossings, Critical facilities

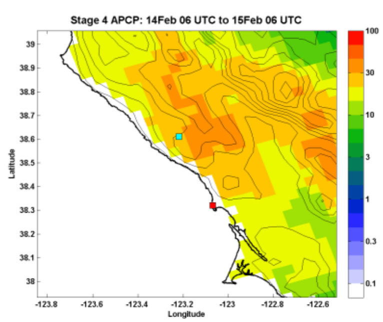
Evaluation and Improvement of Microphysical Parameterizations for Better Orographic Precip Forecasts

- Retrospective simulations of a western U.S. storm using the NMMB with various operational microphysics schemes evaluated using high-quality HMT observations.
- Use results to change Ferrier-Aligo scheme to improve orographic precipitation
- GRAPHICS: NMMB simulation of a landfalling storm impacting the HMT-West coastal domain 14-16 Feb 2011.
- The original Ferrier-Aligo (F-A) microphysics scheme was employed in this simulation.

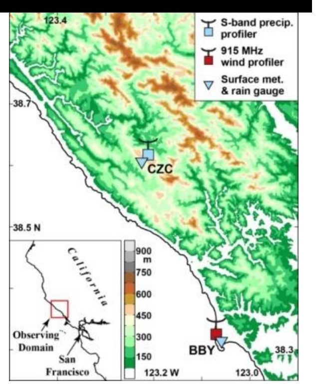
NMMB 24h QPF Ending at 06 UTC 15 Feb 2011



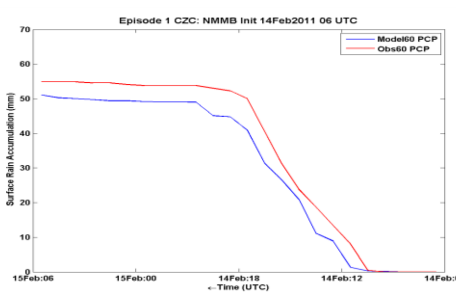
Stage 4 24h QPE Ending at 06 UTC 15 Feb 2011



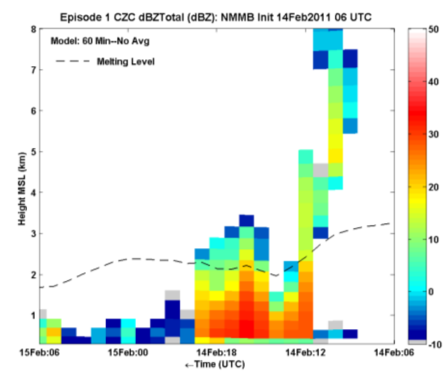
HMT-West Coastal Domain



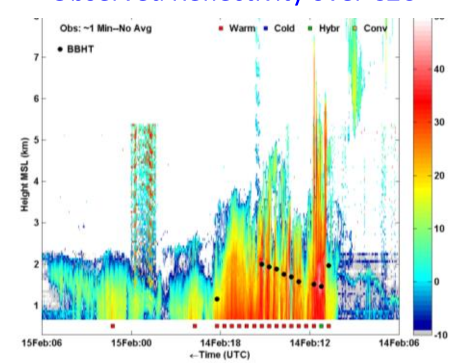
Observed and Simulated Precipitation at Cazadero (CZC)



Simulated Reflectivity over CZC



Observed Reflectivity over CZC



Research and Development Opportunities Identified by PSD to Improve the Skill and Reliability of Sub-seasonal to Seasonal (S2S) Predictions of Precipitation and Associated Prediction Products

WWRP World Weather Research Programme

WCRP World Climate Research Programme

THORPEX An element of the WWRP

SUBSEASONAL TO SEASONAL PREDICTION

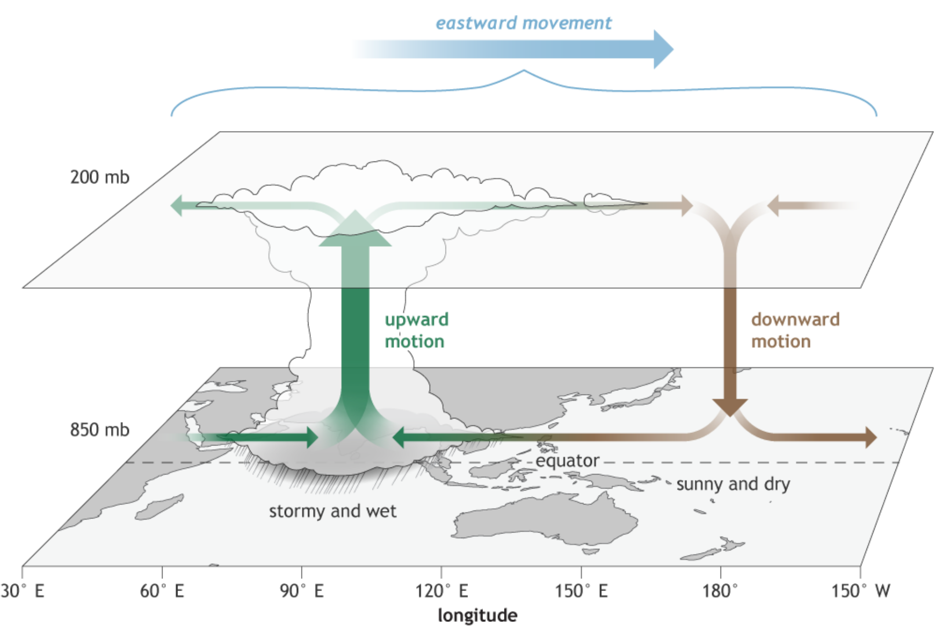
RESEARCH IMPLEMENTATION PLAN

22 June 2012

www.wmo.int/pages/prog/arep/wwrp/new/documents/Implementation_plan_V6.4_nolinenos.pdf

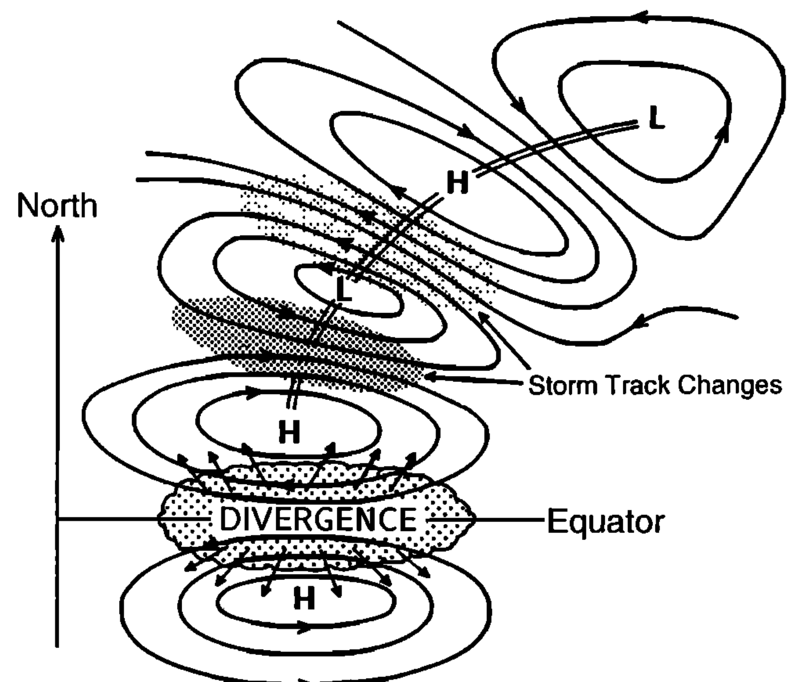
Advance S2S forecasting by improving forecast model representation of large scale global circulation and initial responses of the atmosphere

Madden-Julian Oscillation



Cartoon from www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

Enhanced convection, tropical divergent/outflow, subtropical convergence, shifts in storm tracks



Cartoon from Trenberth et al. (1998)

Understanding and Predicting Sub-seasonal to Seasonal (S2S) variability

Challenge
Characterize the atmospheric state, its variability, its predictability, and its change.

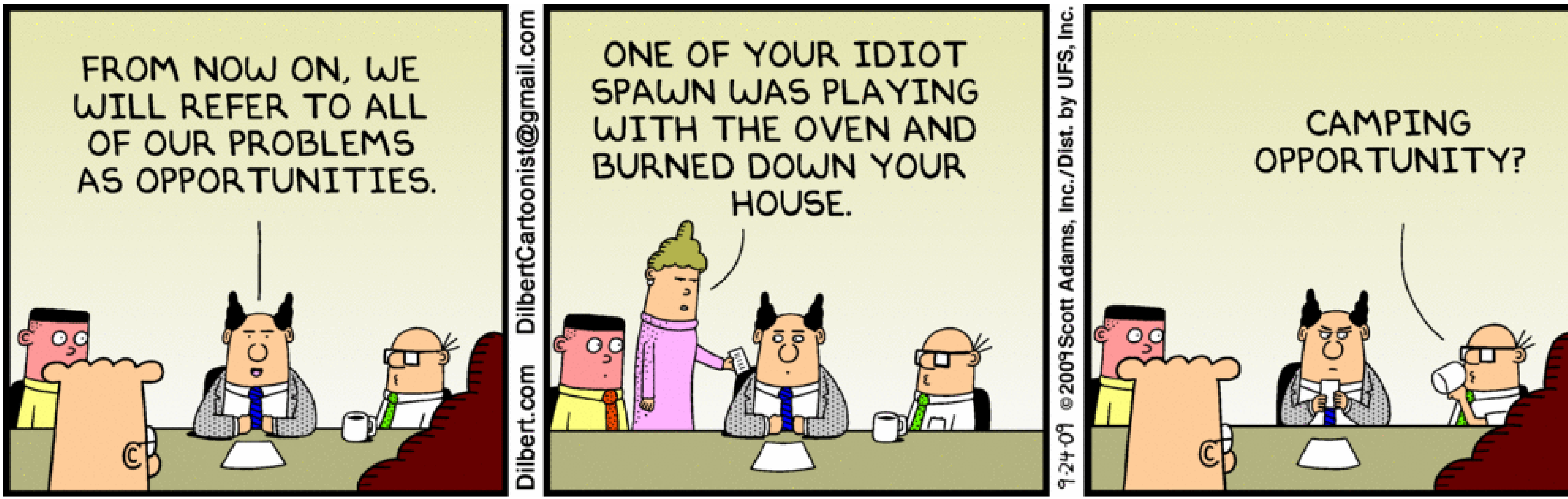
Assess the ability of Numerical Systems to Forecast Sub-seasonal to Seasonal (S2S) variability

Challenge
Characterize the errors in operational weather-climate forecast systems to inform and guide forecast system improvements.

Improve weather-climate prediction systems

Challenge
Improve the assimilation system's ability to correctly initialize the full environmental state (atmosphere, ocean, land, cryosphere, etc.)
Improving the operational prediction system.
Develop post-processing methodologies appropriate to climate time scales

Rethinking the Sub-seasonal to Seasonal Forecasting Challenge as a Research Opportunity



Research Capabilities to improve Sub-seasonal to Seasonal (S2S) forecasting

- **Atmosphere-Oceanic Processes**: Understand and characterize the roles of ocean processes, air-sea interaction, and tropical-extratropical exchanges driving the earth's weather and climate variability.
- **Attribution and Predictability Assessments:** Understand and predict variations and trends in weather, water, and climate, with an emphasis on extremes using theoretical, observational, and modeling approaches.
- **Hydrometeorology Modeling and Applications:** Advance hydro-meteorological prediction methods, models and applications to address weather and climate extremes.
- **Hydrometeorology Observations and Processes: I**mprove predictions of precipitation and streamflow through improved observations and knowledge of processes critical moisture and energy fluxes between the land surface and the atmosphere.
- **Forecast and Model Development:** Performs R&D to improve NOAA operational forecast products by improving the models that underpin forecasts, the data assimilation systems, and statistical post-processing

Understanding and Predicting Sub-seasonal to Seasonal (S2S) variability

Challenge	Proposed PSD activities and collaborations
Characterize the atmospheric state, its variability, its predictability, and its change.	(1) Develop and apply reanalyses to focus on S2S forecast challenges (2) Refinement of Linear-Inverse Models to diagnose predictability and provide a baseline for measuring forecast improvement. (3) Improve understanding of the interactions between tropical convective clouds and large-scale atmospheric circulation to guide model forecast system development and the parameterization of tropical clouds and rainfall (4) Advance NOAA seasonal-to-intraseasonal prediction capabilities by determining climate state dependencies of daily weather extremes

Assess the ability of Numerical Systems to Forecast Sub-seasonal to Seasonal (S2S) variability

Challenge	Proposed PSD activities and collaborations
Characterize the errors in operational weather-climate forecast systems to inform and guide forecast system improvements.	(1) Conduct targeted field campaigns to advance observation-based process understanding and apply the resulting knowledge to guide model forecast system development (2) Generate reforecasts for diagnosing the ability of the prediction system to respond to various boundary forcings and use them to characterize forecast errors. (3) Develop and gather other supporting data sets, e.g., large-eddy simulations that may be needed for parameterization development. (4) Generate new diagnostic tools that indicate what aspect of the prediction system may be responsible for sub-optimal forecast performance.

Improve weather-climate prediction systems

Challenge	Proposed PSD activities and collaborations
Improve the assimilation system's ability to correctly initialize the full climate system state (atmosphere, ocean, land, cryosphere, etc.)	(1) Basic R&D into the proper design of "strongly coupled" data assimilation methodologies. (2) Transfer of new methodologies into operational use in future reanalysis and operational analysis systems.
Improving the operational prediction system.	(1) Improve the parameterization suite, with emphasis on development of physically based and scale-aware stochastic parameterizations for improved ensemble prediction system performance. (2) Develop methods for improving simulations of the coupled model state, especially methods for simulating the interactions of uncertainties between state components.
Develop post-processing methodologies appropriate to climate time scales	(1) Develop, archive, and support the production of related data sets. (2) Develop new statistical post-processing methodologies appropriate to climate timescales. (3) Develop statistical tools for synthesizing information from a variety of forecast sources and tools.