Research Partnerships

Presenter: Kelly Mahoney

Subject Matter Experts: Jian-Wen Bao, Andrew Hoell, George Kiladis, Roger Pulwarty, Gary Wick

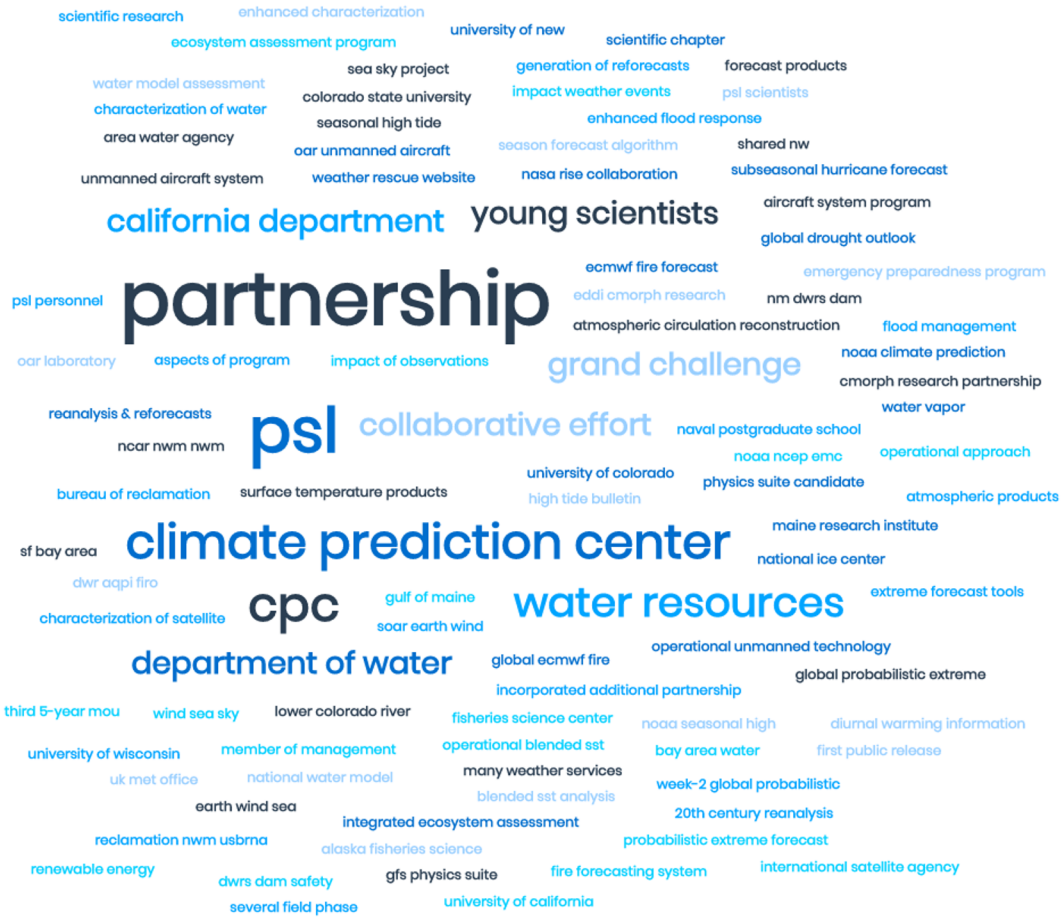
NOAA Physical Sciences Laboratory Review
November 16-20, 2020

Science is a collaborative effort. The combined results of several people working together is often much more effective than could be that of an individual scientist working alone.

— John Bardeen, from his second Nobel Prize Banquet speech (10 Dec 1972)

Research partnerships in NOAA PSL

- NOAA PSL: long-standing culture of partnership, collaboration
- We *choose* this culture: DNA-based(?) draw to public service, use-inspired research
- Reputation for world-class science + openness to engagement = PSL's (not so) secret sauce



Word cloud using responses from
"Please describe some of your research partnerships"

What does it mean to be a partner in research science?

Not all partnerships are easily labeled or categorized…

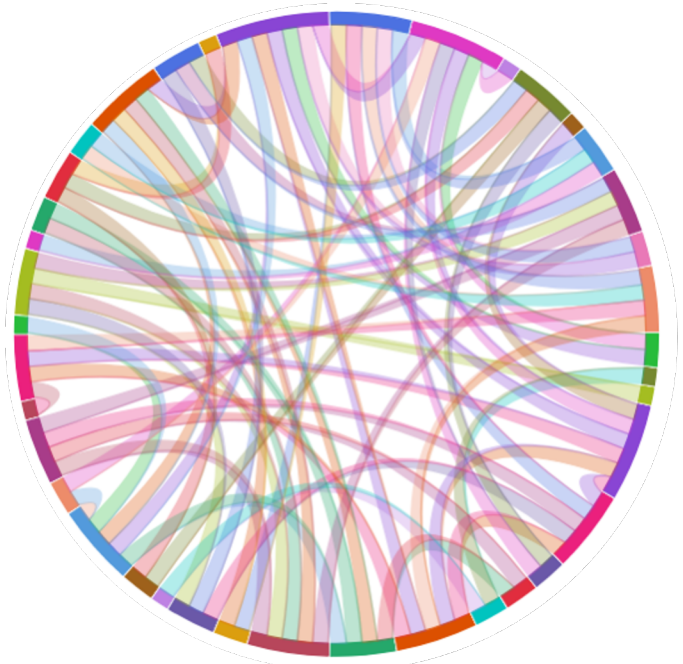
- Sharing
- Leveraging
- Synergizing

- Easier to name "official" (institutionalized, commissioned) partnerships
- Yet informal, unofficial partnerships behind-the-scenes key collaboration building blocks, connector pieces
- PSL partnerships support the NOAA mission *always*; leadership roles, style, number of partners, formality *varies*

Research partnerships in NOAA PSL

Research partnerships allow NOAA PSL to extend and engage across all levels of many important scientific sectors. Our scientists and science teams forge and maintain critical partnerships with...

- ★ OAR's labs and programs
- ★ NOAA's other line offices
- ★ Public/government agencies (outside of NOAA)
- ★ Academia (including cooperative institutes, especially CU/CIRES, CSU/CIRA)
- ★ Private sector



A LOT of partnerships, inter-connections

Many of our projects rely on partnerships in multiple - and sometimes all - of these categories

Research partnerships in NOAA PSL: Some highlights

PSL scientists are critical partners in:

- **NOAA-led community efforts**: EPIC; UFS; National Blend of Models; Regional, National Climate Assessments, Integrated Ecosystem Assessments, Science Grand Challenge planning activities (e.g., Precipitation Prediction Grand Challenge)
- **Multi-agency efforts**: Forecast-informed reservoir operations (FIRO), Developmental Testbed Center (DTC), Interagency Arctic Research Policy Committee (IARPC), Advanced Quantitative Precipitation Information (AQPI), DOE/WFIP projects, Presidential Memo for Managing Water in the West
- **Large field campaigns:** ATOMIC (internal partners: AOML, PMEL, OMAO, CPO)/Eureka (CIMH/David Farrell) + large external partner community; MOSAiC; ENRR, ... (far too many field campaign partners to list!)
- **Service via temporary assignments to other agencies, NOAA offices**: National Weather Service/NCEP, OAR Unmanned Aircraft Systems Program, OAR Headquarters, Weather Program office; Office of Water Prediction; Reclamation, and more

Research partnerships in NOAA PSL: NOAA partner survey

How do our partners' needs inspire and motivate our science?

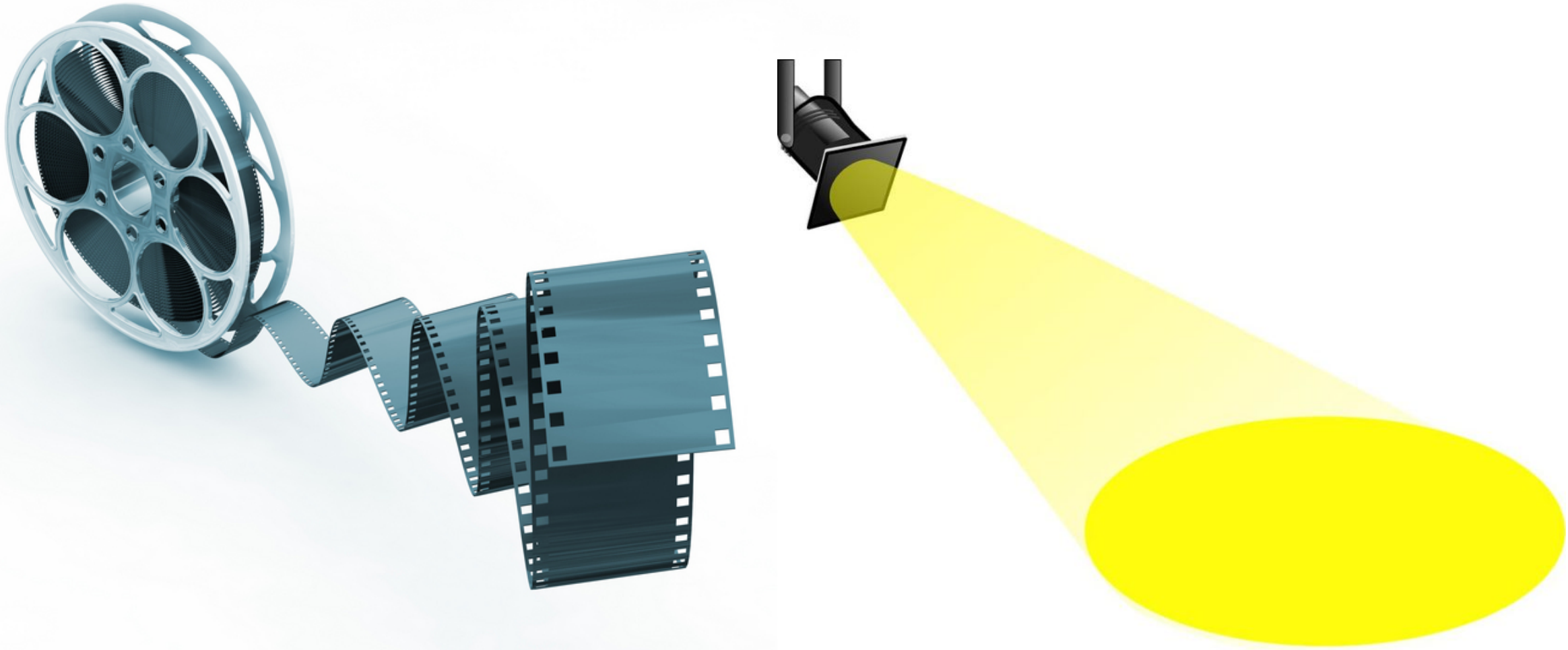
- Sent out three survey questions as part of March 2019 PSL Water Science Theme Workshop
- We received a lot of thoughtful responses
  - Confirmed: partner push-pull relationships generally balanced; strong mutual appreciation for exchange of expertise, assets, inspiration, needs, capabilities
  - Facilitated dialogue, bolstered confidence in future research partnerships (partner interest, synergistic potential)
  - Reinforced communication, strength of connections, momentum around use-inspired, innovative research

Survey

1. What are your current, pressing water science needs?
2. How do you see PSD connecting to and/or serving your office's needs for water information?
3. What might be a potential future water topic, goal, or project on which PSD and your line office could partner?

- PSL has many non-NOAA partners and stakeholders as well; let's highlight a few exemplary projects now...

Highlight reel



Physical Science Research Themes

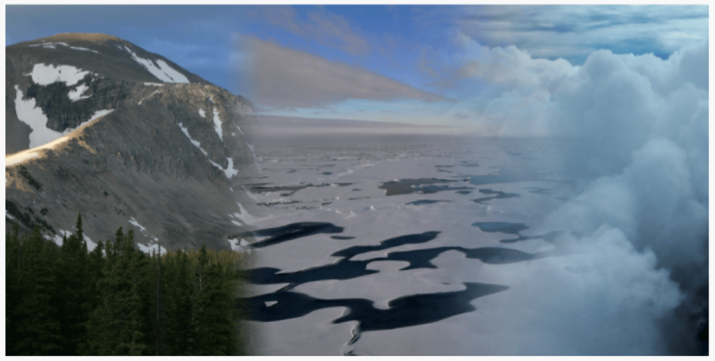
Water Resource Management

- California Department of Water Resources 21st Century Observing Systems, AQPI
- Regional Extreme Precipitation Study for Dam Safety
- Office of Water Prediction
- NWS/Weather Prediction Center
- US Bureau of Reclamation

Marine Resource Management

- NOAA Fisheries (NMFS) and National Ocean Service (NOS) Integrated Ecosystem Assessments
- NOAA NOS Predicting Sea Level

Predicting Extremes



- Uncrewed Aircraft Systems (UAS)
- Drought Task Force
- FEWSNET
- NWS/National Blend of Models
- USACE Missouri River Basin Flooding
- UFS, Model Diagnostic Toolkit
- NOAA CESSRST

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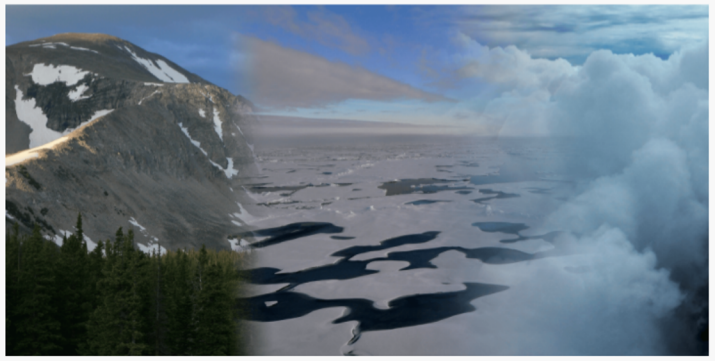

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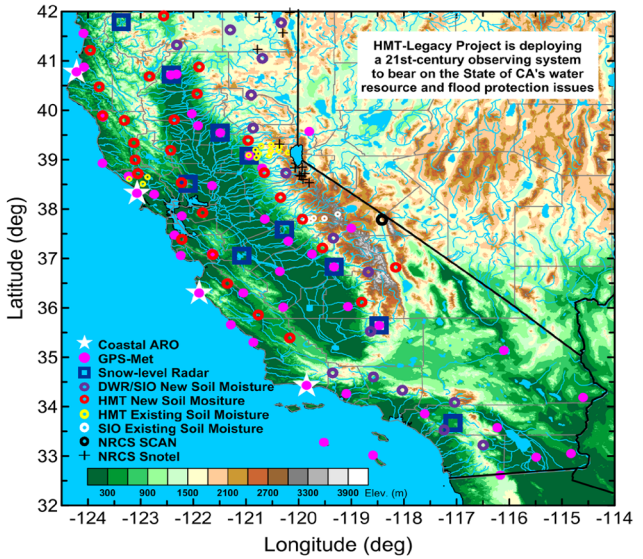
PSL + California Department of Water Resources partnership: State-of-the art observations, modeling for critical precipitation information

- Mutual interest, exchange of resources and expertise benefits both PSL, CA-DWR
  - Deployment, operation, and maintenance of a 21st century observing system for water supply and flood prediction
  - Advanced Quantitative Precipitation Information (AQPI) System
  - PSL gathers unique, real-time data, deploys experimental products, services to NOAA WFOs, RFCs, other CA water agencies
  - Data publicly available, widely used in research publications
- Establishes partnership framework for other regional implementations
- S2S prediction studies with CA-DWR span multiple PSL teams



Avoiding deadly floods through innovative partnerships:
Estimating extreme precipitation to enhance dam safety and community resilience

Partnerships Enable Cutting Edge Science, Service

Colorado Div. Water Resources & New Mexico Office of State Engineer: Partner with Federal, State, Local government, private, academic partners to modernize extreme precipitation estimation for dam safety.

PSL recruited to identify, prioritize best available scientific methods, understanding.

COLORADO Division of Water Resources, Department of Natural Resources
U.S. Department of the Interior, Bureau of Reclamation
US Army Corps of Engineers
FEMA
USGS science for a changing world
U.S.NRC
NOAA
CIRES
University of Colorado Boulder

GOVERNOR'S AWARDS FOR HIGH-IMPACT RESEARCH

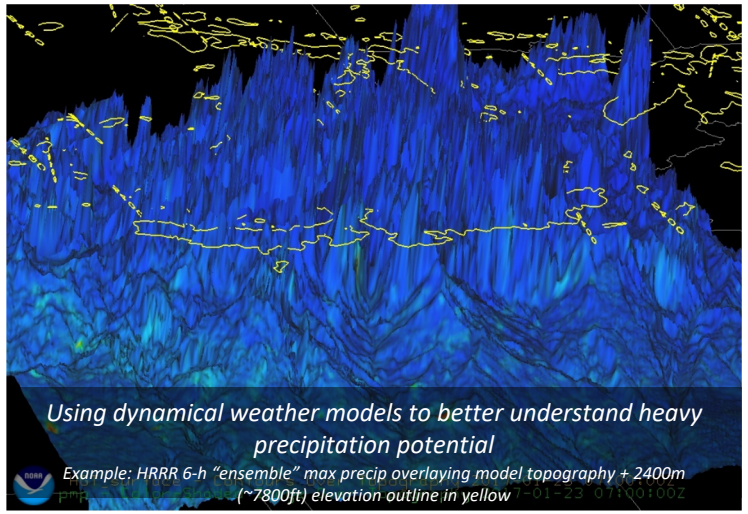
"Pathfinding Partnerships: For those projects whose results leveraged creative, even unique collaborations among disparate and/or multiple partnering organizations"

Are our high-hazard dam spillways currently safe?

- Methods to estimate potential extreme rainfall amounts (probable maximum precipitation; "PMP") for dam safety are outdated; can new approaches improve estimates?
- Impact of climate change on PMP not currently represented in standard practice; (how) should it be?

PSL, NOAA role: Modernize methods with state-of-the-art models, state-of-the-science contributions, including:

1) "Mega ensemble" of High-Resolution Rapid Refresh (HRRR) model forecasts
2) Storm seasonality, precipitation-elevation relationships, rain-vs.-snow
3) Numerical simulation of specific historic flood events
4) Recommendations based on improved physical process understanding, climate change expertise



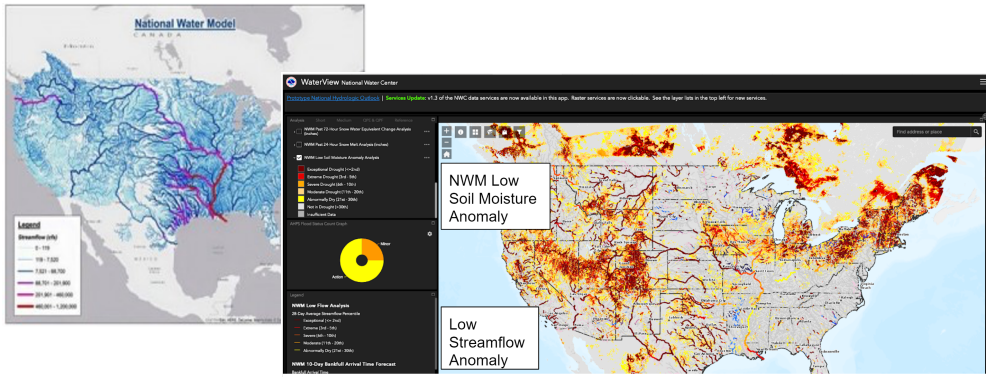
Using dynamical weather models to better understand heavy precipitation potential

Example: HRRR 6-h "ensemble" max precip overlaying model topography + 2400m (~7800ft) elevation outline in yellow

PSL + NWS Office of Water Prediction/National Water Center: Explaining too much, too little water for improved prediction

PSL-OWP collaborate on many projects and research foci. National Water Center/Model strengthened, expanded stakeholder partnership connections in recent years.

- Evaluation of NWM forecast forcings/Ellicott City, MD 2018 Flood NWM Case Study
- Application of the National Water Model for Drought Monitoring
- Rob Cifelli service on detail to National Water Center
- NOAA Water Initiative Teams, Team Leads
- Co-coordination of Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West (with NOAA Fisheries, Reclamation, USACE, USGS)
- Providing GEFS reforecasts for hydro calibration and validation
- Probable Maximum Precipitation (PMP): modernization potential



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RESEARCH ARTICLE | 23 MARCH 2020

A Multiscale, Hydrometeorological Forecast Evaluation of National Water Model Forecasts of the May 2018 Ellicott City, Maryland, Flood

Francesca Viterbo ✉; Kelly Mahoney; Laura Read; Fernando Salas; Bradford Bates; Jason Elliott; Brian Cosgrove; Aubrey Dugger; David Gochis; Robert Cifelli

J. Hydrometeor. (2020) **21** (3): 475–499.

https://doi.org/10.1175/JHM-D-19-0125.1

Share

Federal action plan focused on improving water prediction for Western U.S.

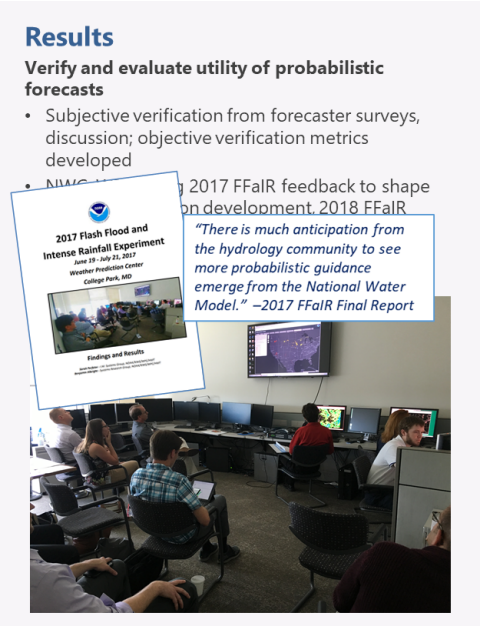
Weather | water

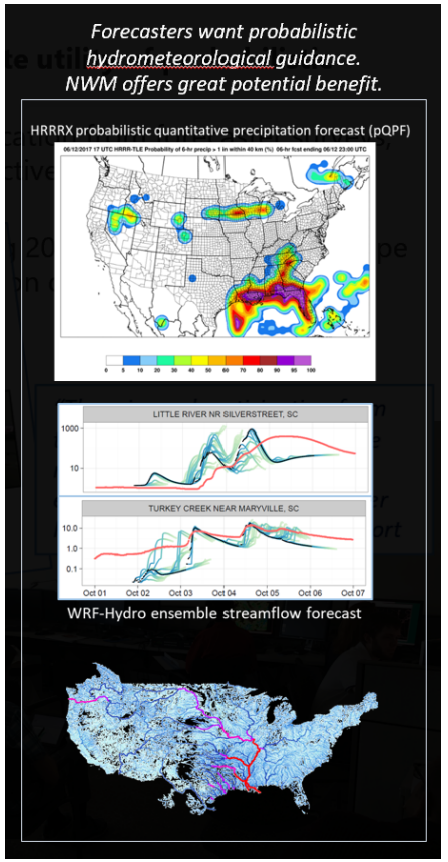
SHARE

October 18, 2019 —

PSL + NWS Weather Prediction Center (WPC) partnership: Cutting edge extreme precipitation, flood prediction science

- NOAA Hydrometeorological Testbed: Long-established partnership between PSL and WPC
- HMT-West Legacy Observing System
- 2019 NOAA Extreme Precipitation Workshop (PSL-WPC co-led)
- Flash Flood and Intense Rainfall Forecast Experiment
  - Highlight: "Demonstration of Advanced Ensemble Prediction Services for NWS Hydrometeorological Forecast Operations"
  - Demonstrate hydrologic time-lagged ensemble techniques; guide design of NWM med-range ensemble; create & demonstrate probabilistic verification, visualization techniques
- Partnership on Disentangling Forecast Forcings (NOAA Water Initiative research topic)
- Planned: HMT PSL-WPC regular extreme precip science discussions

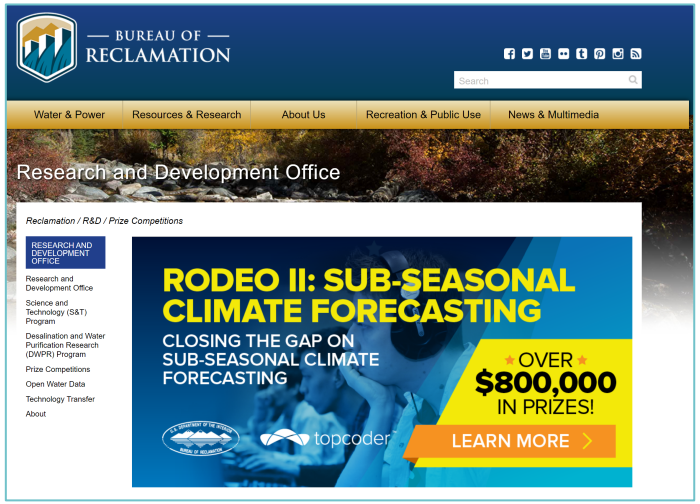


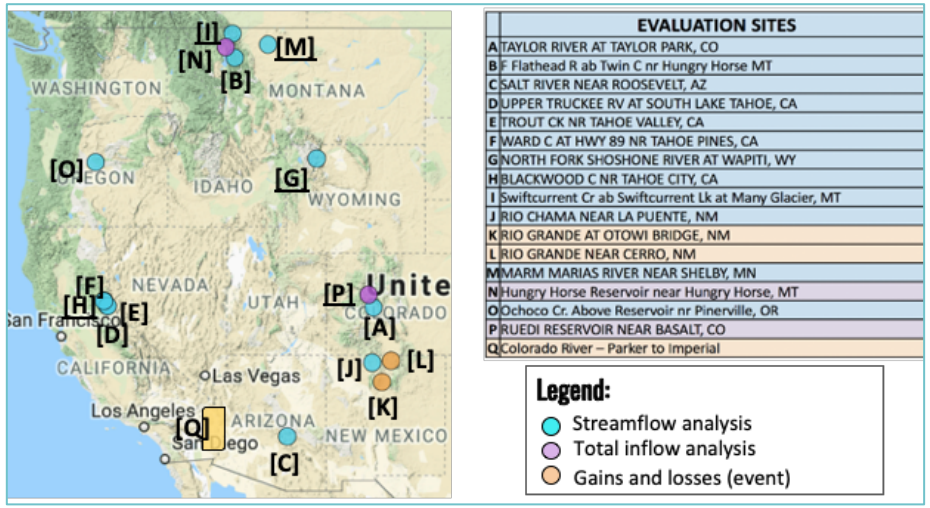


PSL + Reclamation partnerships span mutual weather, water, and climate science priorities

Recent examples of PSL-Reclamation's strong, long-standing partnership efforts include:

- Forecast rodeo: Combined USBR's Inaugural Forecast Rodeo Competition with focus on NOAA priorities to improve subseasonal forecasts of temperature and precipitation.
  - Cost-free opportunity for NOAA to tap into external alternative approaches for developing forecast information.
- Evaluation of Western US regional climate projections for water resource planning
- National Water Model Assessment for Reclamation's Water Management Needs
- Channel loss/gain forecasts for the lower Colorado River





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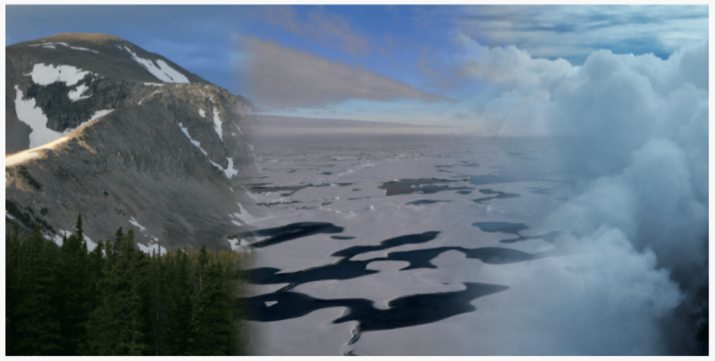

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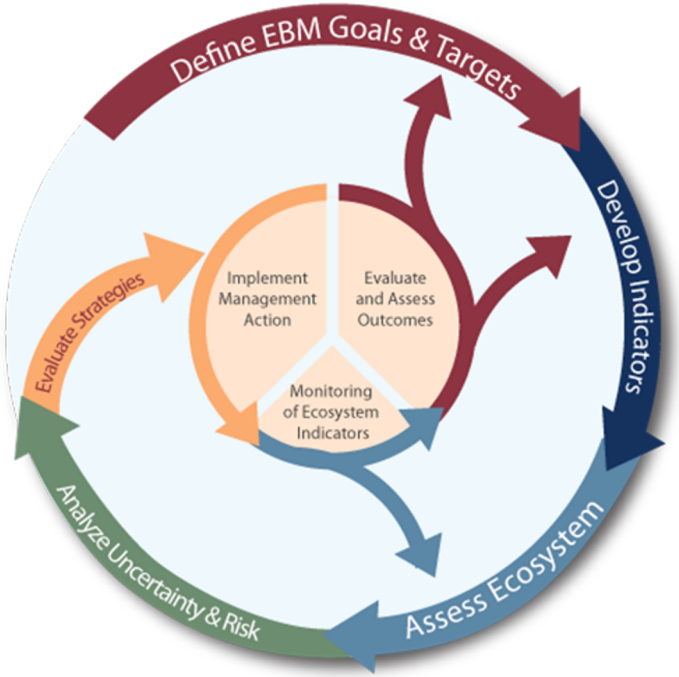
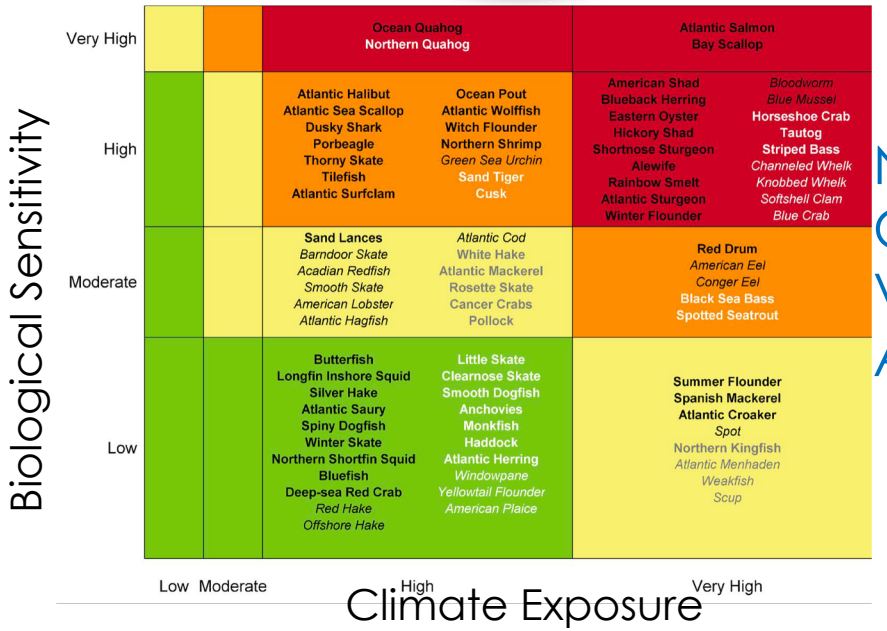
PSL + NOAA Fisheries (NMFS) and National Ocean Service (NOS) partnerships innovate marine ecosystem science

- **Integrated Ecosystem Assessment (IEA) Program**
  - Climate Change Web portal developed in conjunction with IEA program
  - Service on Scientific Steering Committee
  - PSL hosted national meetings
- Ecosystem Tipping Points in the North Pacific: Identifying Thresholds in Response to Climate Change and Potential Management Strategies (Werner and **Webb** 2016)
- Fish/invertebrate and habitat vulnerability Assessments
  - Hare, … **Alexander, Scott**, et al. 2016
- Explaining Extreme Ocean Conditions Impacting Living Marine Resources (**Webb** and Werner 2019)
- Participated in developing NMFS Climate Science Strategy
- Planning NOAA's Climate-Fishery Initiative
- Scenario planning for endangered species



Integrated Ecosystem Assessment



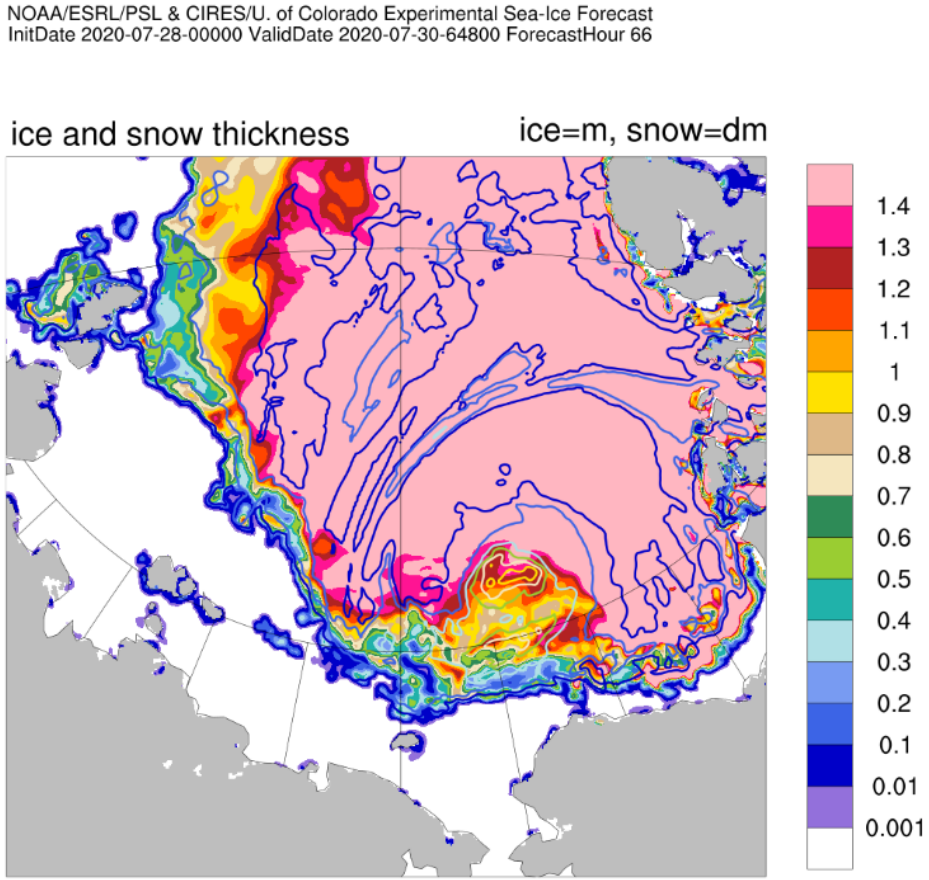
NE U.S. Climate Vulnerability Assessment

PSL + NWS Alaska Region Sea Ice Program forecasters and National Ice Center (a tri-agency service: NOAA, Navy, Coast Guard)

NOAA Workshop Report on NWS Alaska Forecast Needs identified a need to provide forecasters with sea ice guidance on the 0 – 10 day time scale.

PSL worked in consultation with forecasters to develop, configure, implement, optimize and validate the experimental Coupled Arctic Forecast System (CAFS) model as a high-resolution, regional, fully-coupled, ocean-ice-atmosphere forecast modeling system to produce daily experimental sea ice guidance

PSL partnered with NWS Alaska Region staff to tailor products based on the CAFS, in order to improve the delivery of science-based forecast information to support marine and transportation safety decision making.



Experimental sea-ice forecast product of Arctic ice and snow thickness up to 10 days in advance.

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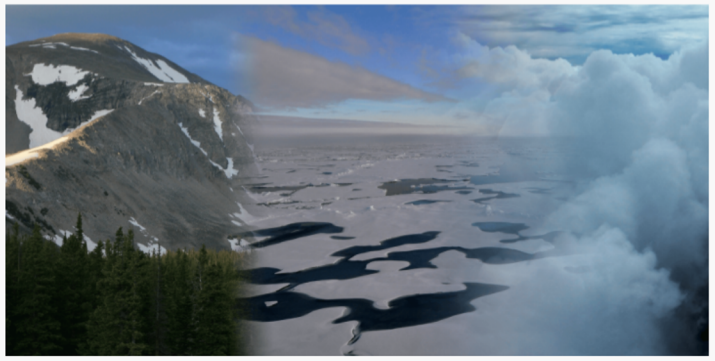

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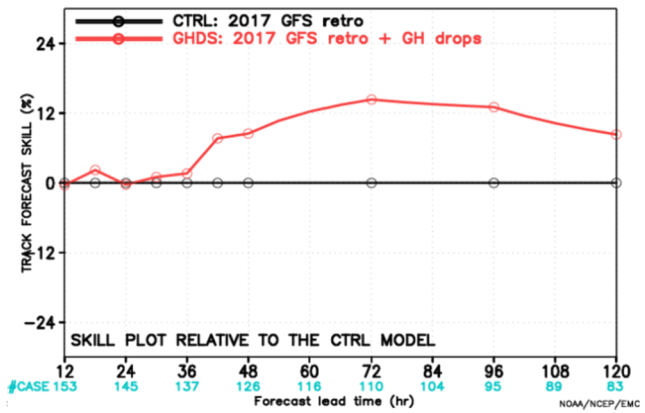
PSL + OAR Partnerships in Uncrewed Aircraft Systems (UAS) Enable Cutting Edge Observations, Improve Forecasts

- UAS partnerships with OAR HQ, other LOs, NWS, other government agencies bring PSL expertise in observations and forecasting to other NOAA priorities such as hurricane forecast improvement.
- PSL subject matter experts helped guide research direction of UAS program (Gary Wick currently on detail, acting director of Uncrewed Systems Research Transition Office)
- UAS partnerships enhance field projects, bring additional capabilities
  - Sensing Hazards with Operational Unmanned Technology (SHOUT)
  - El Nino Rapid Response experiment
  - ATOMIC
- UAS partnerships, UAS physical platform lead to miniflux technology to observe lower atmosphere processes
- Sensor development, validation, and application
- Mentorship of students from U. Oklahoma and University of Puerto Rico, Mayaguez and CESSRST



Graphic from J. Sippel, AOML, as appearing in Wick et al. BAMS

PSL North American Drought Partnerships: Advancing Understand of Drought Causes, Predictability, and Impacts

Partnerships with NIDIS, federal and academic partners, including leadership of community efforts like the NOAA Drought Task Force

PSL leads collaborative drought assessments that improve our understanding of physical mechanisms, predictability and drought impacts

PSL leads collaborative efforts summarizing current understanding and organizes meetings charting future directions on research and applications

NIDIS

NOAA

NASA

FOREST SERVICE US DEPARTMENT AGRICULTURE

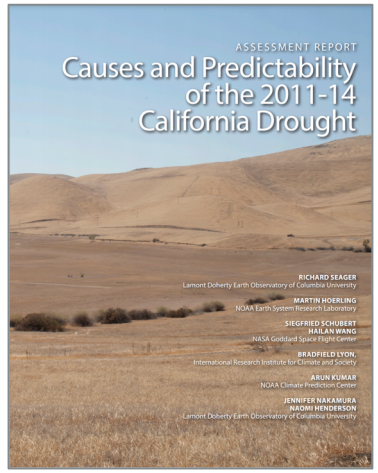
NCAR

DARTMOUTH

GEORGE MASON UNIVERSITY

DROUGHT TASK FORCE

Advancing drought monitoring and prediction over North America



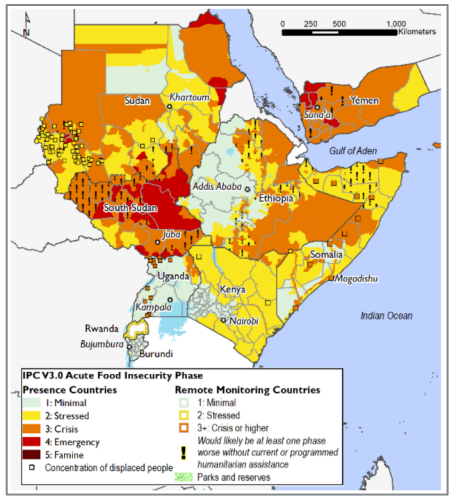
PSL International Partnership: Famine Early Warning Systems Network
Early Warning of Acute Food Insecurity for Over 30 Countries Worldwide

A long-standing partnership with USAID's FEWS NET that includes U.S. federal science agencies, universities, and private businesses

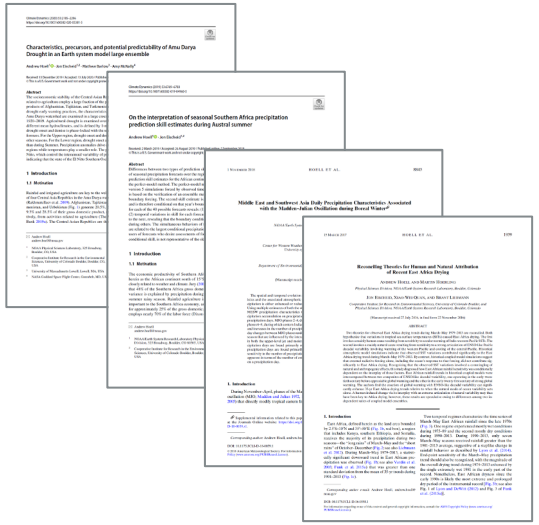
FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

USAID
FROM THE AMERICAN PEOPLE
USGS science for a changing world
USDA
NASA
NOAA
Climate Hazards Center
UC SANTA BARBARA
Kimetrica
Chemonics

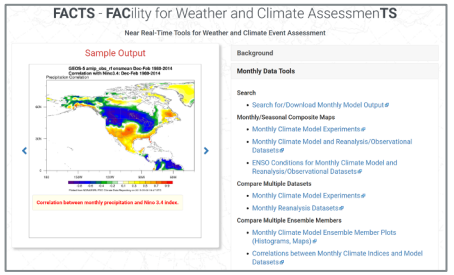
PSL leads collaborative prediction activities. Forecasts relevant to agricultural yield are used to develop food security scenarios

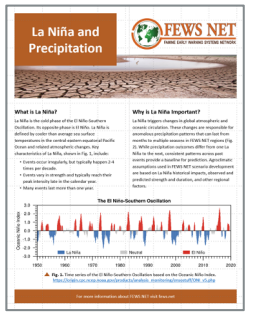


PSL pioneers collaborative research that guides a predictive understanding of weather and climate in FEWS NET regions



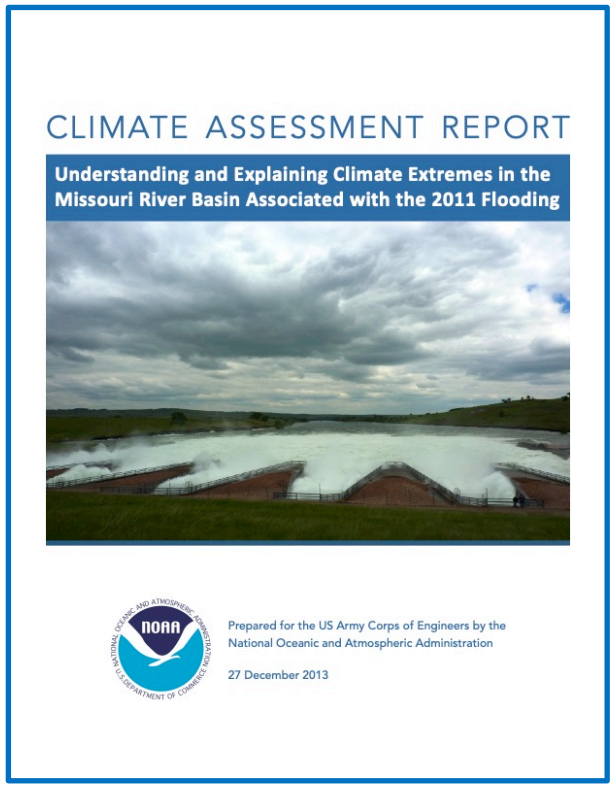
PSL develops tools that enable our partners research and trains core partners on weather/climate

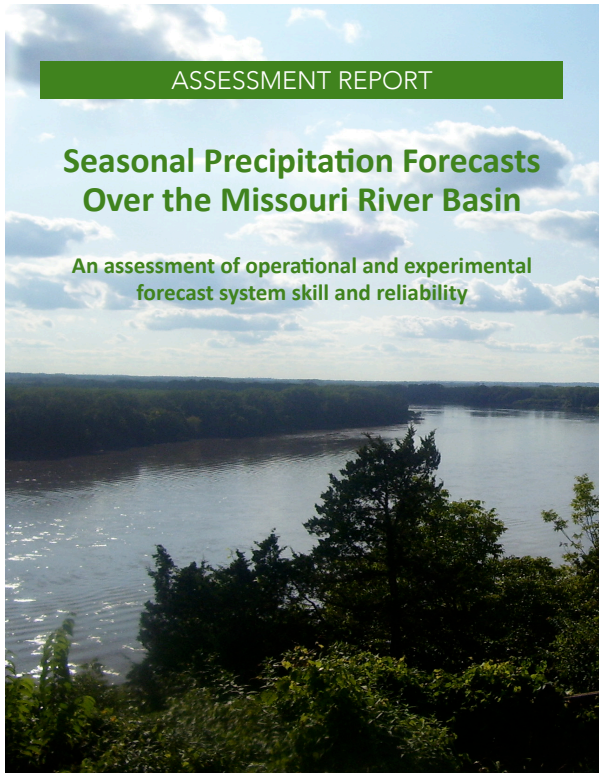


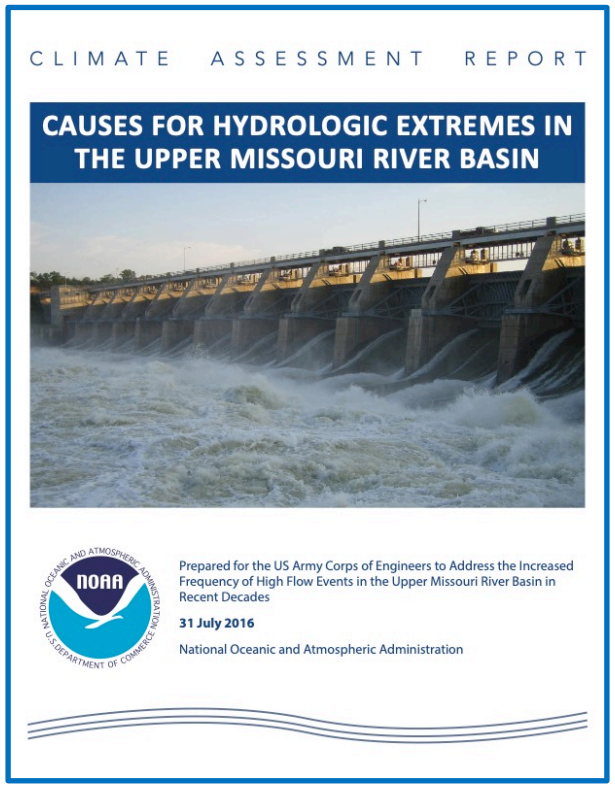


PSL + US Army Corps of Engineers (USACE) partnership explains extreme events at the weather-climate interface

- A collaborative partnership with USACE to produce attribution and prediction knowledge assessments to inform flood and drought risk policy and planning in the Missouri River Basin
- Expert witnesses on behalf of the USACE for the Department of Justice in the Ideker Farms, Inc. et al. vs. United States of America case at the U.S. Federal Court of Claims in Washington, DC





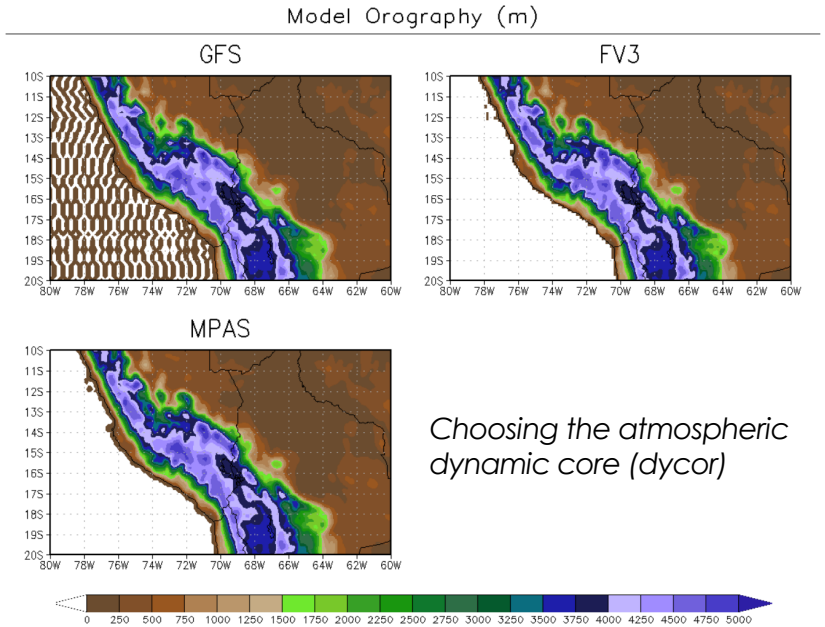


PSL + Unified Forecast System (UFS) Community-wide Partnerships:
Accelerating scientific research and engineering to meet NOAA's operational needs

PSL is playing integral role in leading and executing the R2O part of the UFS development.

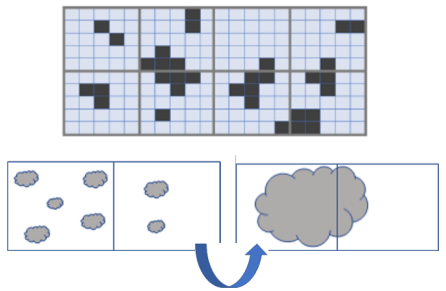
Specific UFS partner activities at PSL include:

- PSL staff led team that selected GFDL's FV3 for the UFS atmospheric dycore
- Now co-leads UFS-R2O project (NOAA's program to advance the operational capabilities of the UFS through collaborative research)
- Atmospheric physics development for the coupled UFS based on scientific understanding/evaluation using field campaign overservations
- Stochastic physics development for coupled data assimilation and probabilistic forecast applications of the UFS
- PSL maintains the stochastic physics repository for the UFS
- PSL developed and maintains ensemble initialization component of the operational UFS data assimilation system
- Process-based diagnostic tools (MET+) for improving tropical convection simulation and S2S forecast of the UFS



Choosing the atmospheric dynamic core (dycor)

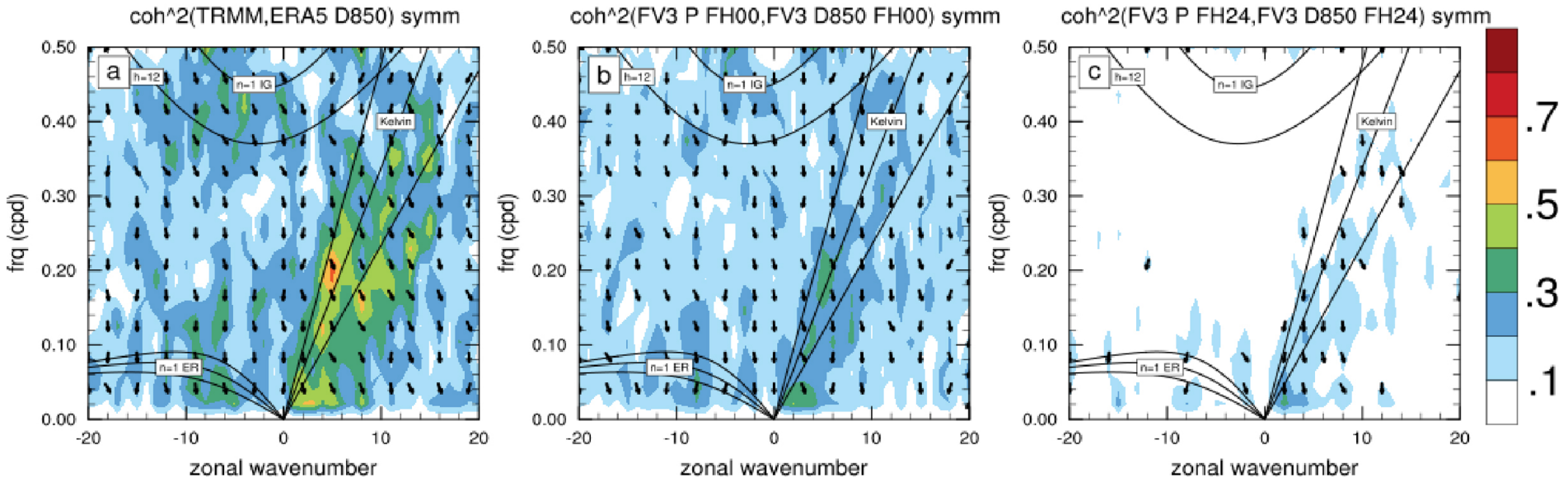
Figure 3.1: Model terrain over the Andes for GFS, FV3 and MPAS. Units are meters.



Cellular automata to simulate subgrid stochastic convective organization (courtesy of Lisa Bengtsson)

PSL partners with NCAR, UCLA to develop diagnostic toolkit for model forecast errors

PSL is taking a lead role in developing process-oriented metrics for the evaluation of model performance in both the tropics and extratropics- These are being made available in MetPlus (NCAR) package and also MDTF (UCLA)



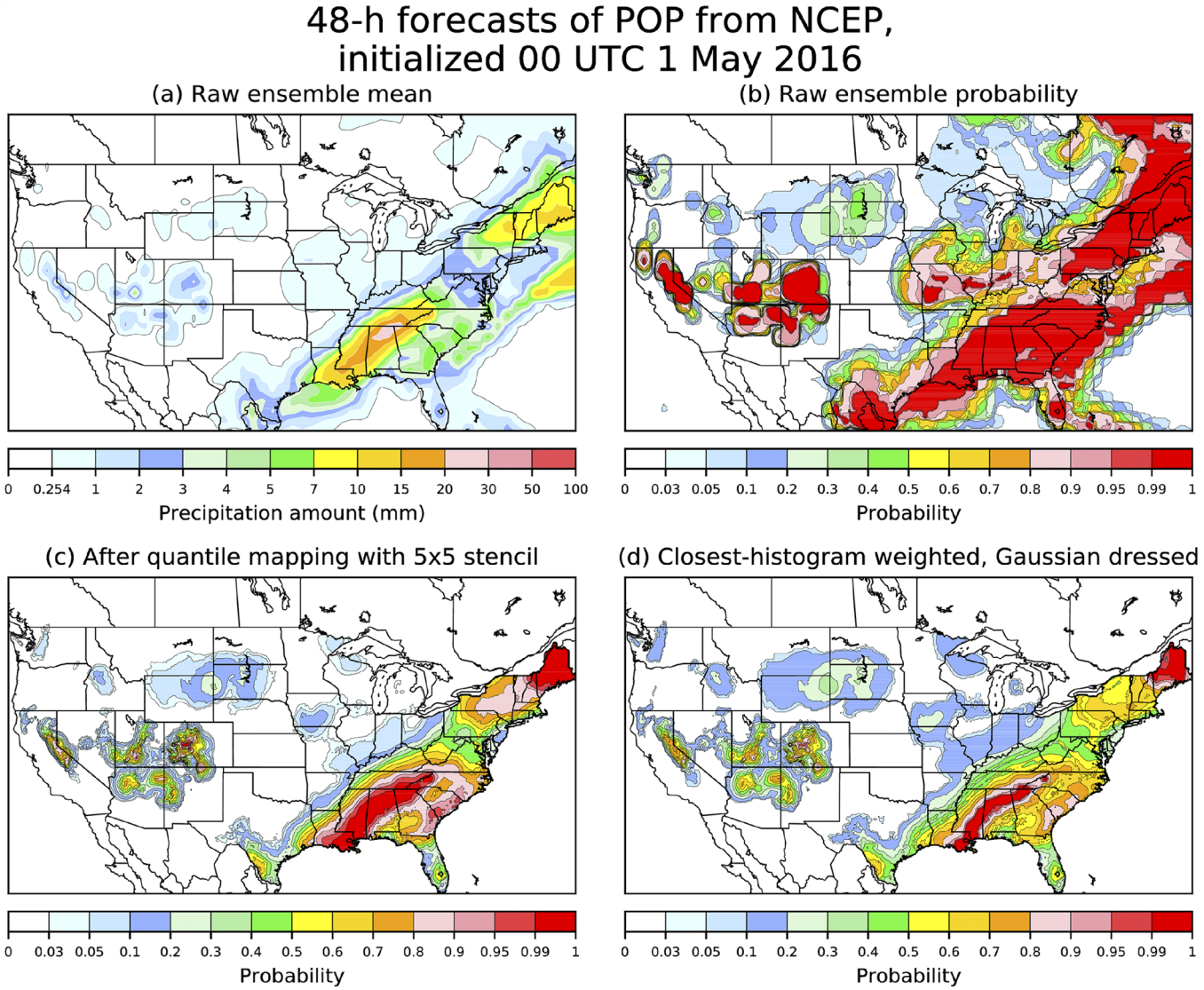
Space-time Coherence Plots of the relationship between TRMM precip and ERA5 850 hPa Divergence (left) and a recent version of the NCEP FV3 for initial analysis (middle) and the 24 hour forecast (right). Coherence shown as shading, arrows represent temporal phase (downward means precipitation is in phase with convergence)

In Observations (left), the MJO and Kelvin waves stand out clearly as regions of high coherence.

In the initialized GFS fields (middle) the waves are visible but weaker than observations, indicating poor initialization.

The relationship between precipitation and divergence breaks down quickly in the 24 hour forecast, indicating erroneous coupling between the equatorial waves and diabatic heating

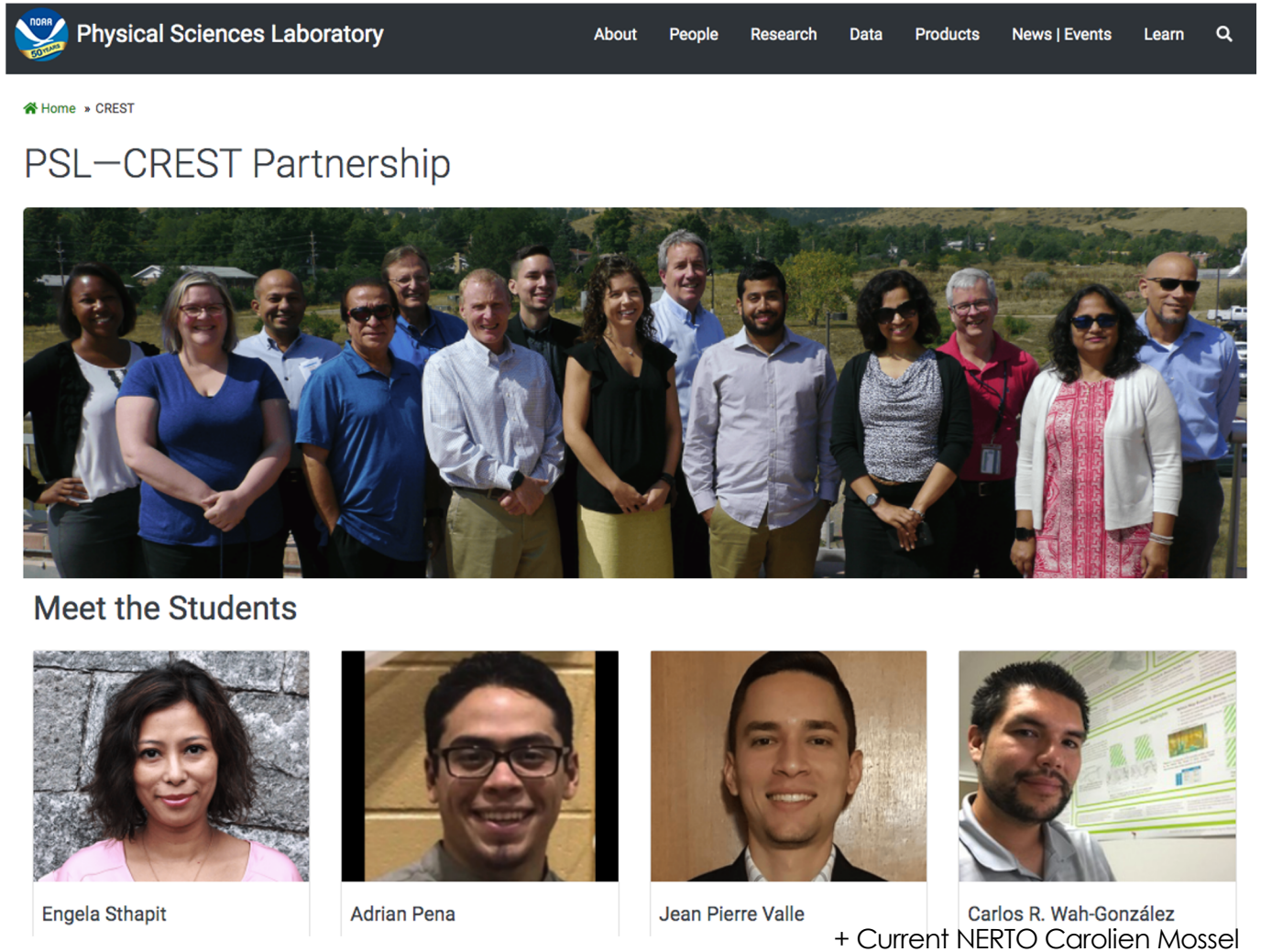
PSL + NWS partnership improves National Blend of Models



PSL contributions to NWS National Blend of Models precipitation post-processing:

- PSL developed novel, improved methods for multi-model ensemble postprocessing of precipitation that markedly improved skill and reliability.
- These are now used operationally by the NWS.
- See here for more.
- PSL part of a 2020 National Weather Association Award for this work.

PSL + NOAA CESSRST partnership infuses PSL science, develops diverse, young workforce



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PSL—CREST Partnership

Meet the Students

Engela Sthapit

Adrian Pena

Jean Pierre Valle

Carlos R. Wah-González

+ Current NERTO Carolien Mossel

The NOAA Experiential Research and Training Opportunities (NERTO)

NERTO (NOAA Experiential Research & Training Opportunities) helps the Center's Masters and PhD students learn about NOAA's mission and workforce opportunities by interning for at least 12 consecutive weeks in a NOAA lab or office. The goal is to augment students' academic research with NOAA mission science and place-based experiential hands-on opportunities.

- PSL partners with NOAA's NOAA Center for Earth System Sciences and Remote Sensing Technologies (CESSRST).
- Affiliated with the City University of New York, CESSRST conducts research and educates and trains a diverse group of students, early career scientists, and engineers in NOAA-related science missions.
- Partnership contributing to a larger NOAA effort to create a diverse STEM workforce for NOAA and its contractors, academia, industries and the private sector.

Summary & Future Opportunities

- PSL has a long-standing culture of partnership, collaboration
  - Reputation for world-class science + openness to engagement
  - How and why do we develop so much breadth and depth in our partnerships?
    - PSL scientists are driven to engage, connect to advance mission science, achieve use-inspired research success
    - Our partners trust us, *want* to work with us, seek us out: PSL has deep roots, long histories + opportunities for cutting edge beginnings
- Research partnerships -- enduring, nascent, and future -- enhance scientific productivity and reach, allowing PSL research to most effectively achieve NOAA mission goals of science, service, and stewardship.
- Future: PSL's reputation for strong partnerships beget leadership roles in upcoming large community efforts such as EPIC, UFS development
- In an increasingly virtual world, strength and leadership in research partnerships ensure PSL research will grow in enduring and unrestricted ways