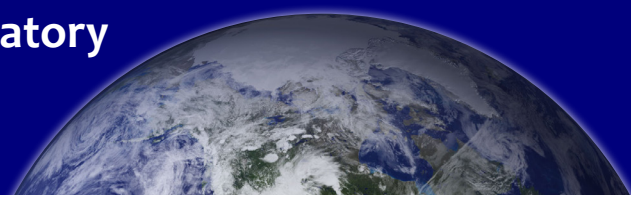
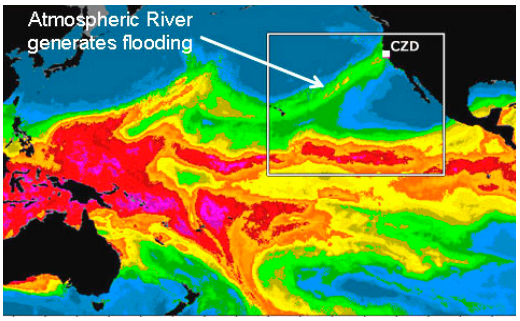
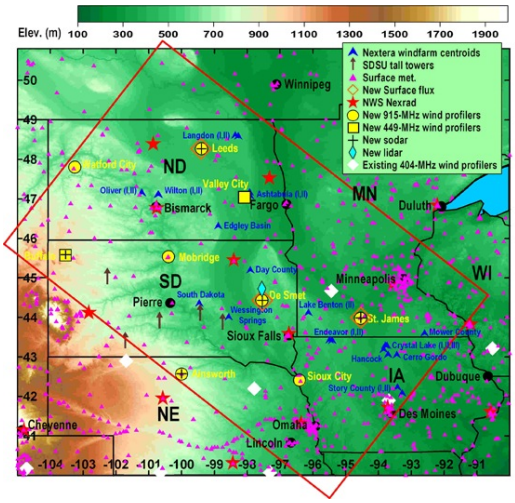
Earth System Research Laboratory
Physical Sciences Division
Diagnosing the weather-climate system



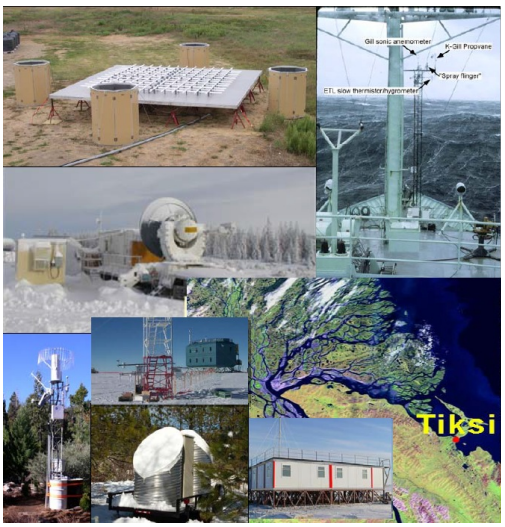
Water: Too much. Working with meteorologists, climatologists and others to improve observation and forecasting of severe land-falling storms that cause flooding in U.S. western coastal areas:



Advancing the goal of a network of networks for regional weather forecasting – applications to wind energy:



Improving our ability to observe the Earth system:



What does the Physical Sciences Division do for the nation?

The **Physical Sciences Division (PSD)** of the Earth System Research Laboratory (ESRL) analyzes and interprets physical processes that influence weather and climate variations from days to decades, and works with partners in other federal and state agencies and universities to provide scientific information necessary for cost-effective decision making. A major effort is to improve predictions on weather-to-climate time scales by identifying early warning indicators in atmosphere and ocean patterns that could cause extreme events (such as floods, droughts, and heat waves). To do this we develop new tools including new observing technology and methods to evaluate the accuracy of computer models of the Earth System.

In-House Partners

PSD hosts the program management for the National Integrated Drought Information System (NIDIS), and the University of Colorado Western Water Assessment, part of NOAA's Regional Integrated Science and Assessment (RISA) program. PSD also leads NOAA's Hydrometeorology Testbed (HMT). These collocated activities motivate and link water research (prediction too much or too little water) to societal needs.

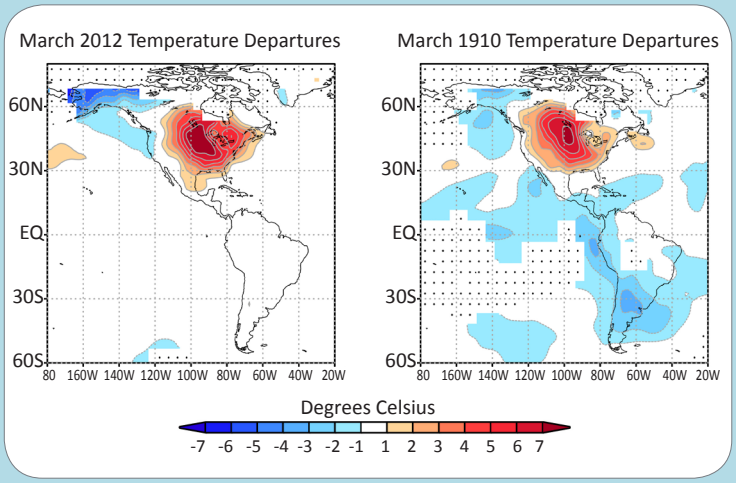
Other Partners

- Bureau of Reclamation
- California Dept. of Water Resources
- Department of Energy/National Renewable Energy Laboratory
- NASA
- National Drought Mitigation Center
- NOAA National Marine Fisheries Service/Fisheries Science Centers
- NOAA National Weather Service/ Climate Prediction Center and Office of Hydrological Development
- Scripps Institution of Oceanography
- Sonoma County Water Agency
- U. S. Army Corps of Engineers
- U. S. Geological Survey
- Western States Water Council

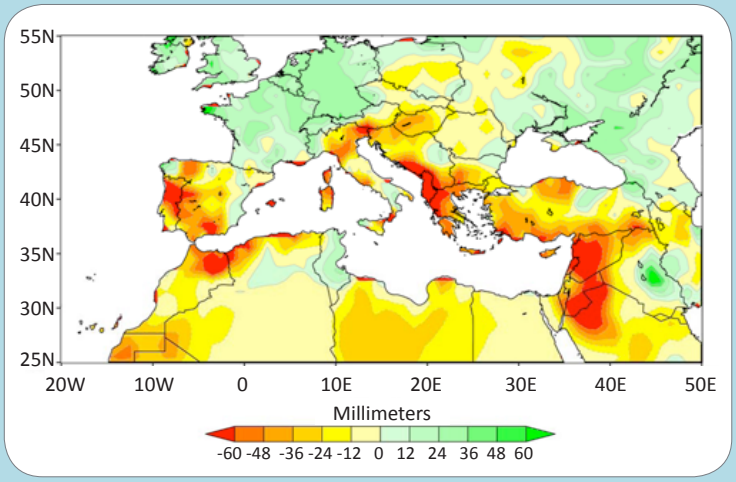
What does PSD do?

- Leads national and international field programs to observe and measure the behavior of the atmosphere over land, oceans, ice, and snow.
- Studies Earth system processes in NOAA's challenge areas of water, climate variability, and extreme events.
- Identifies early warning indicators in the Earth system that can help improve predictions at weather and climate time scales.
- Pioneers research to explain weather and climate extreme events based on rigorous evaluation of observed conditions and state-of-the-art computer simulations.
- Leads an innovative effort to reconstruct the Earth's atmospheric weather and climate patterns using only surface pressure data back to 1870 that puts today's weather and climate extremes in the context of the past.
- Develops observing technologies, data analyses, and applications that support decision making for water resource management and wind energy production.
- Advances numerical representations of physical processes in computer models and evaluates the performance of these models across weather and climate time scales.
- Helps NOAA formulate its scientific vision and contributes to national and international assessments (led four NOAA Science Challenge Workshops).

A Tale of Two Extremes: Understanding the Reasons for Extreme Events and Climate Trends to Guide Decision Making



Daily temperature anomalies at many locations in the central and eastern U.S. exceeded 20°C through much of March 2012. This extreme warmth was due primarily to natural climate and weather variability. Over this region there has been approximately 1°C warming in March temperatures since 1901. This 1°C regional warming is an order-of-magnitude smaller than the observed 20°C temperature anomalies during March 2012. The March 2012 temperature anomalies closely resemble a similar regional extreme warming event in March 1910. Climate modeling studies reveal that forcing from anomalous sea surface temperatures (SSTs) increased the probability of extremely warm temperatures in March 2012, above that anticipated from the long-term warming trend. A strong Madden-Julian Oscillation further increased the probability for extreme regional warmth and provided important additional predictive information on the timing and regional extent of temperature anomalies. The combination of a strong natural variation similar to March 1910 with the observed long-term warming can explain the record warmth in March 2012, and indicates much of this warming event was predictable a month in advance.



Wintertime droughts are increasingly common in the Mediterranean region. In the last 20 years, 10 of the driest 12 winters have taken place in the lands surrounding the Mediterranean Sea. The amount and frequency of the drying that has occurred is too great to be explained solely by natural variations, and natural variability alone is unlikely to return the region's climate to normal. Greenhouse-induced climate change has caused somewhat greater warming of the tropical oceans compared to other ocean regions – a pattern that drives drought-conducive weather patterns around the Mediterranean. Climate models predict an increased risk of drought, indicating the need to begin implementing adaptation to reduced water resources from climate change.

What's next for PSD?

During the next five to ten years, PSD will continue to support NOAA by:

- Explaining the underlying causes of recent weather and climate extremes and assessing their predictability;
- Advancing the use of hydrometeorology testbeds in large water sheds across the United States to deliver improved scientific information for managing water resources, for protecting lives and property, and informing preparedness;
- Improving understanding of the physical processes underlying short-term climate variations and long-term trends to improve the skill and reliability of climate predictions and projections;
- Improving observation and understanding of physical processes in polar regions, especially as related to impact on the mid-latitude weather and extreme weather and climate;
- Improving physical understanding of the causes of regional climate variations and impacts, such as those associated with droughts and floods, and evaluating model forecast performance;
- Developing regionally-specific weather and climate information and forecast products.

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