Building a Climate Ready Nation: The Importance of Seasonal Predictions for Food and Water Security

Dr. Sarah Kapnick
NOAA Chief Scientist

2023 US CLIVAR Summit
August 1, 2023

NOAA

S2S in Context: Big Picture

- Climate change is fundamental to the US and global economy
- Subseasonal and seasonal extremes (temperature, precip, storms) have consequential & costly impacts
- Increasing skill and predictability is becoming increasingly important for managing risk


★★★★★★

ECONOMIC
REPORT
OF THE
PRESIDENT

TRANSMITTED TO CONGRESS | MARCH 2023

TOGETHER WITH THE ANNUAL REPORT
OF THE COUNCIL OF ECONOMIC ADVISERS

★★★★★★

Chapter 9

Opportunities for Better Managing Weather Risk in the Changing Climate

Global temperatures as high as those in recent years are unprecedented in the time span of human civilization and have likely not been seen in at least the last 125,000 years of Earth's history (Gulev et al. 2021). Many nations, including the United States, are working ambitiously to limit the impact of climate change by reining in greenhouse gas emissions and harnessing the opportunities of the clean energy transition. However, given the time it takes to transform the global energy system and for the climate to respond, the climate will continue changing at least until global greenhouse gas emissions fall to zero. In the coming decades, more intense and frequent weather extremes and the uncertainty of the changing climate will present a range of economic and financial risks to the U.S. economy and will confront the Federal Government with related fiscal challenges. Physical climate risks can be managed by anticipating and planning for coming changes in climate, a process known as adaptation. Adaptation presents opportunities to lower climate change costs over the long-term while also building resilience to natural hazards and weather risks today.

The design of climate adaptation policies must recognize that actors across the United States, including individuals and businesses and all levels of government, already face incentives to adapt to climate change. But they also face informational, financial, and legal constraints that may limit their ability to adapt. Targeting adaptation policies to alleviate these constraints and address related market failures should be most effective in supporting private action.

273

Why Do We Need Advancements in S2S: Impact ($)

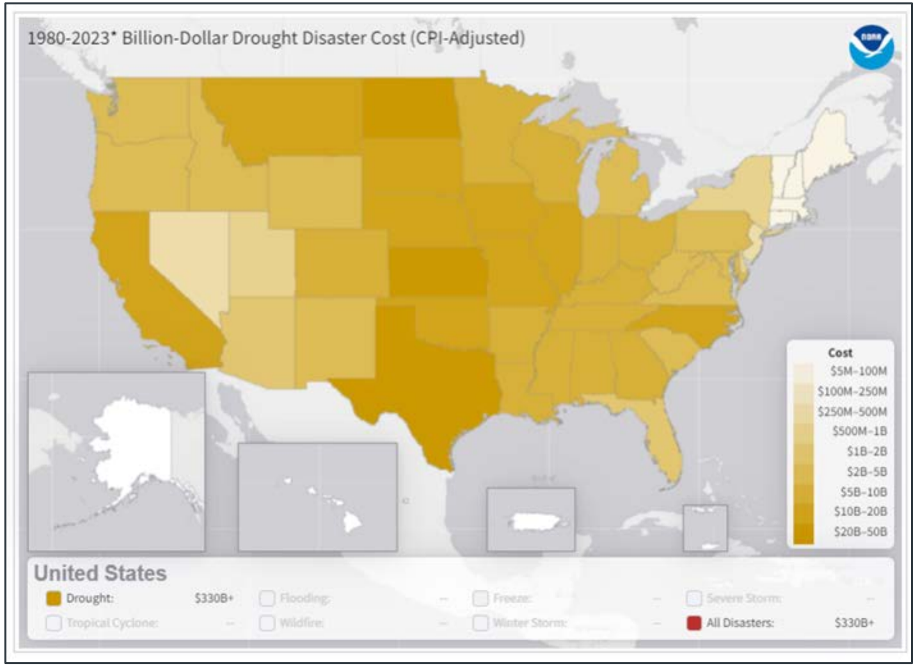
Billion-dollar events to affect the United States from 1980 to 2023 (CPI-Adjusted)*

Disaster Type	Events	Events/ Year	Percent Frequency	Total Costs	Percent of Total Costs	Cost/ Event	Cost/ Year	Deaths	Deaths/ Year
Drought	30	0.7	8.3%	$334.8B CI	13.0%	$11.2B	$7.6B	4,275†	97†
Flooding	41	0.9	11.4%	$190.2B CI	7.4%	$4.6B	$4.3B	723	16
Freeze	9	0.2	2.5%	$36.0B CI	1.4%	$4.0B	$0.8B	162	4
Severe Storm	177	4.0	49.2%	$423.1B CI	16.4%	$2.4B	$9.6B	2,071	47
Tropical Cyclone	60	1.4	16.7%	$1,359.0B CI	52.8%	$22.7B	$30.9B	6,890	157
Wildfire	21	0.5	5.8%	$135.5B CI	5.3%	$6.5B	$3.1B	435	10
Winter Storm	22	0.5	6.1%	$97.1B CI	3.8%	$4.4B	$2.2B	1,402	32
All Disasters	**360**	**8.2**	**100.0%**	**$2,575.7B** CI	**100.0%**	**$7.2B**	**$58.5B**	**15,958**	**363**

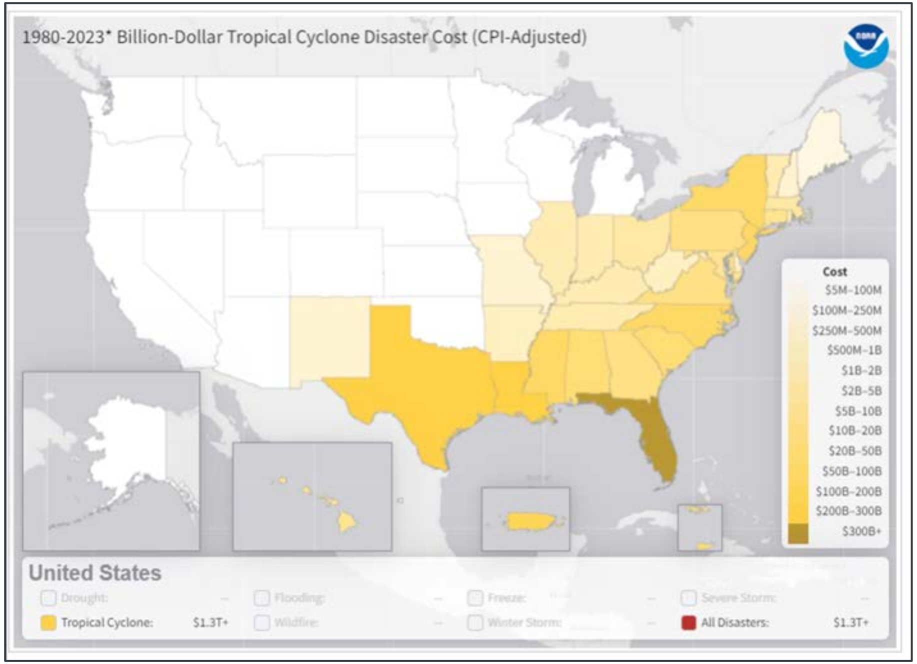
†Deaths associated with drought are the result of heat waves. (Not all droughts are accompanied by extreme heat waves.)
Flooding events (river basin or urban flooding from excessive rainfall) are separate from inland flood damage caused by tropical cyclone events.
The confidence interval (CI) probabilities (75%, 90% and 95%) represent the uncertainty associated with the disaster cost estimates. Monte Carlo simulations were used to produce upper and lower bounds at these confidence levels (Smith and Matthews, 2015).

Why Do We Need Advancements in S2S: Impact ($)

Drought: (Often) Slower Onset



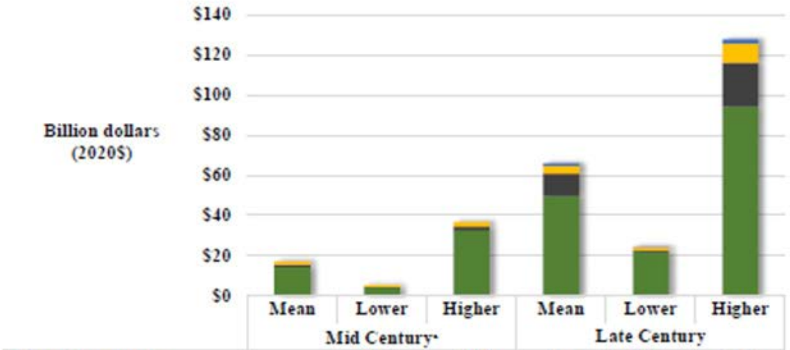
Tropical Cyclone: Acute Onset



Physical + Social Science = Exposure

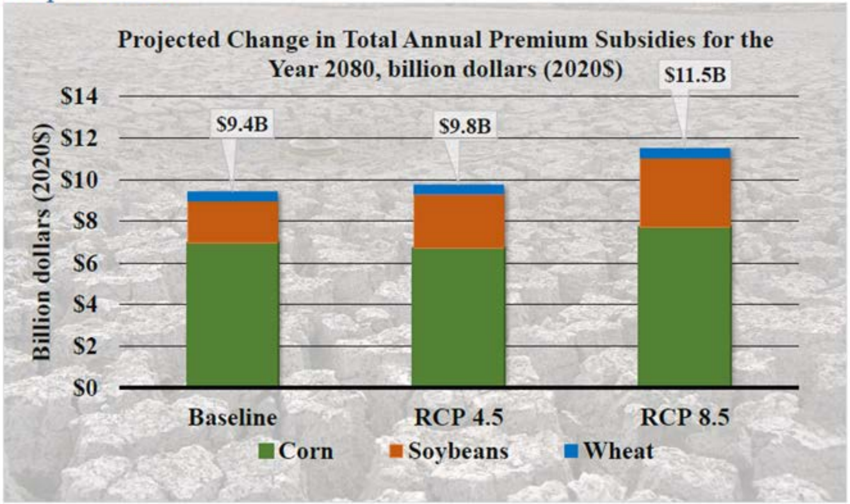
Understanding risk: Where is adaptation critical to reduce impacts?

Table 1. Summary of Spending Increases for Quantified Climate Risk Exposure of Assessed Programs, in billion dollars (2020$)[a]



	Mid Century[c]			Late Century		
	Mean	Lower	Higher	Mean	Lower	Higher
Crop Insurance[b]		NA	NA	$1.2	$0.3	$2.1
Wildland fire Suppression[c]	$1.7	$0.8	$2.3	$3.7	$1.6	$9.6
Health Impacts	$1.0	$0.2	$1.8	$11.3	$0.8	$21.9
Coastal Disasters	$14.6	$4.4	$32.5	$49.6	$21.9	$94.3
Total[d]	$17.3	$5.4	$36.6	$65.8	$24.6	$127.9

Crop Insurance



Source: OMB White Paper *Climate Risk Exposure: An Assessment of the Federal Government's Financial Risks to Climate Change (2022)*

PCAST Report

REPORT TO THE PRESIDENT

Extreme Weather Risk in a Changing Climate: Enhancing prediction and protecting communities

Executive Office of the President

President's Council of Advisors on Science and Technology

April 2023

Drought[62]

- Reduce modeling uncertainties in precipitation projections, including extremes and intermittency.
- Improve understanding of land-vegetation coupling, including soil moisture, evaporation, and plant physiological responses to heat and water stress. This is an urgent need, motivated by the finding that no existing model (CMIP5 or CMIP6) reproduces the magnitude of the observed downward trend in atmospheric humidity (water vapor deficit) over arid regions of the U.S. and elsewhere.

S2S in Context: NOAA's Mandate

SECTION 201 OF THE WEATHER RESEARCH AND FORECASTING INNOVATION ACT OF 2017, PUBLIC LAW 115-25, INCLUDED THE FOLLOWING LANGUAGE

"(c) FUNCTIONS.—The Under Secretary, acting through the Director of the National Weather Service and the heads of such other programs of the National Oceanic and Atmospheric Administration as the Under Secretary considers appropriate, shall—

(1) Collect and utilize information in order to make usable, reliable, and timely foundational forecasts of subseasonal and seasonal temperature and precipitation;

(2) Leverage existing research and models from the weather enterprise to improve the forecasts under paragraph (1);

(3) Determine and provide information on how the forecasted conditions under paragraph (1) may impact—

(A) The number and severity of droughts, fires, tornadoes, hurricanes, floods, heat waves, coastal inundation, winter storms, high impact weather, or other relevant natural disasters;

(B) Snowpack; and

(C) Sea ice conditions; and

(4) develop an Internet clearinghouse to provide the forecasts under paragraph (1) and the information under paragraphs (1) and (3) on both national and regional levels."

REPORT TO CONGRESS

SUBSEASONAL AND SEASONAL FORECASTING INNOVATION: PLANS FOR THE TWENTY-FIRST CENTURY

Developed pursuant to:
Section 201 of the Weather Research and Forecasting Innovation Act of 2017, (Public Law 115-25)

S2S in Context: NOAA's Strategic Goals

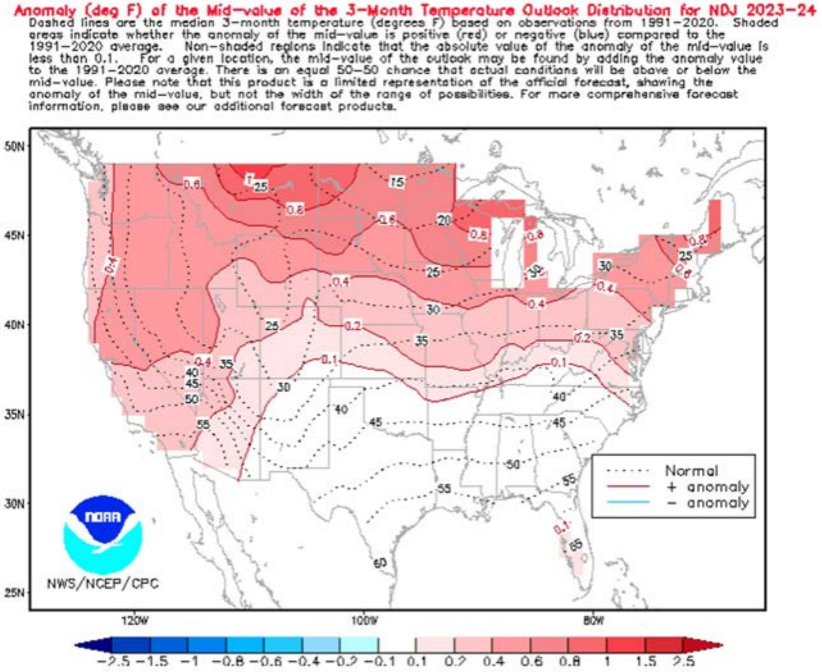
NOAA Contributes to Understanding Our Earth System Through Weather, Climate, and Ocean Enterprises

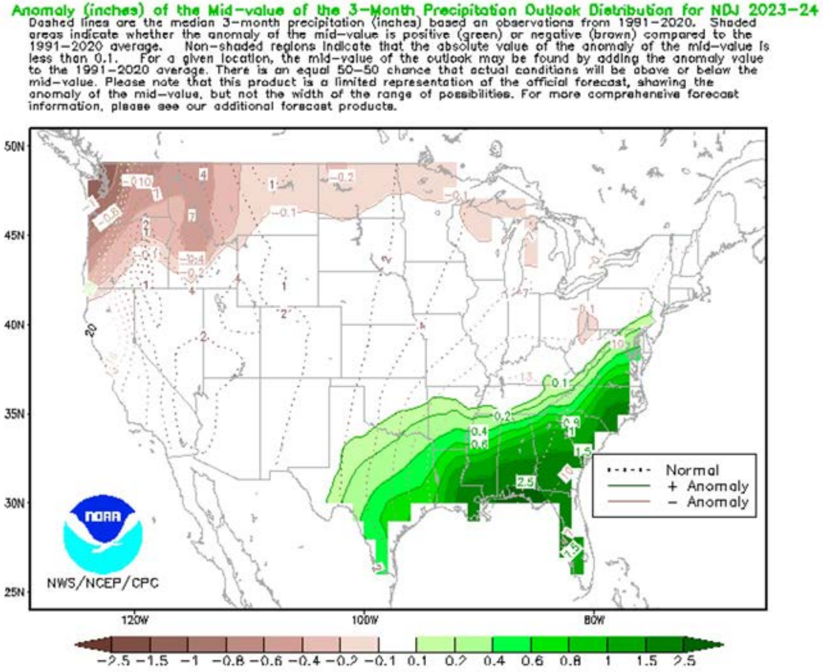
Accelerate Growth and Transformation of the Blue Economy

Build a Climate Ready Nation

Make Equity Central

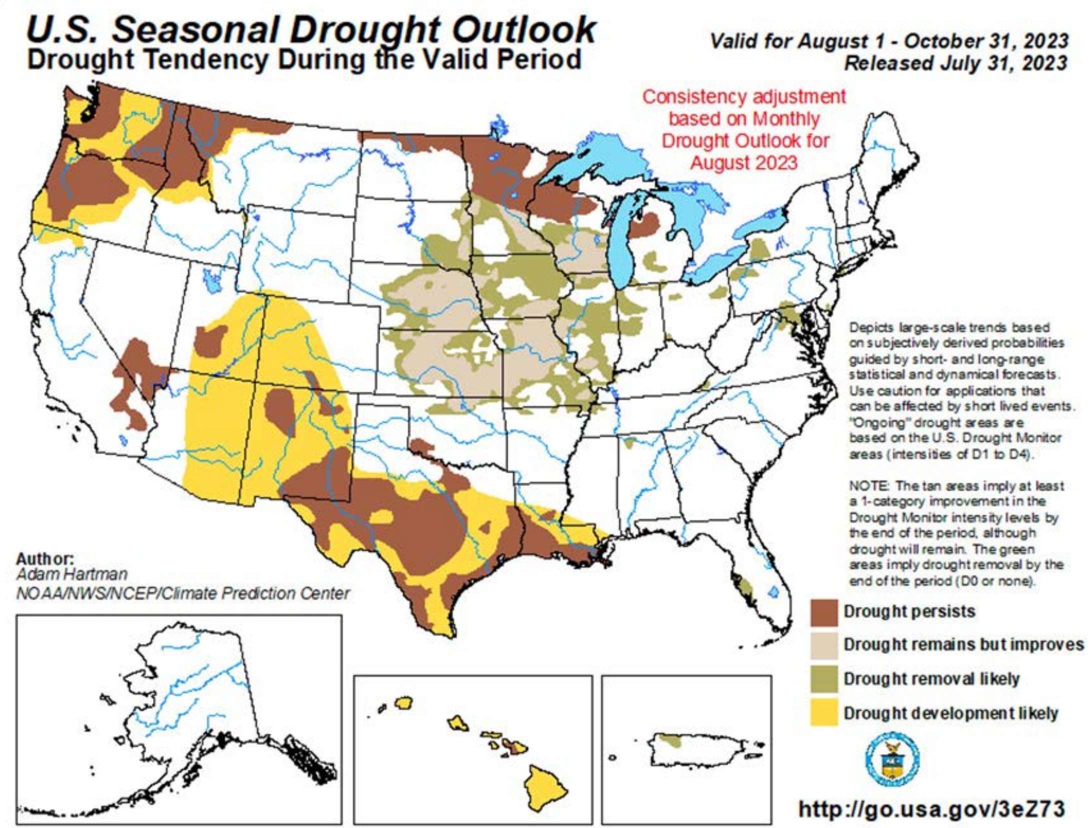
NOAA Products: Temperature & Precipitation Outlooks



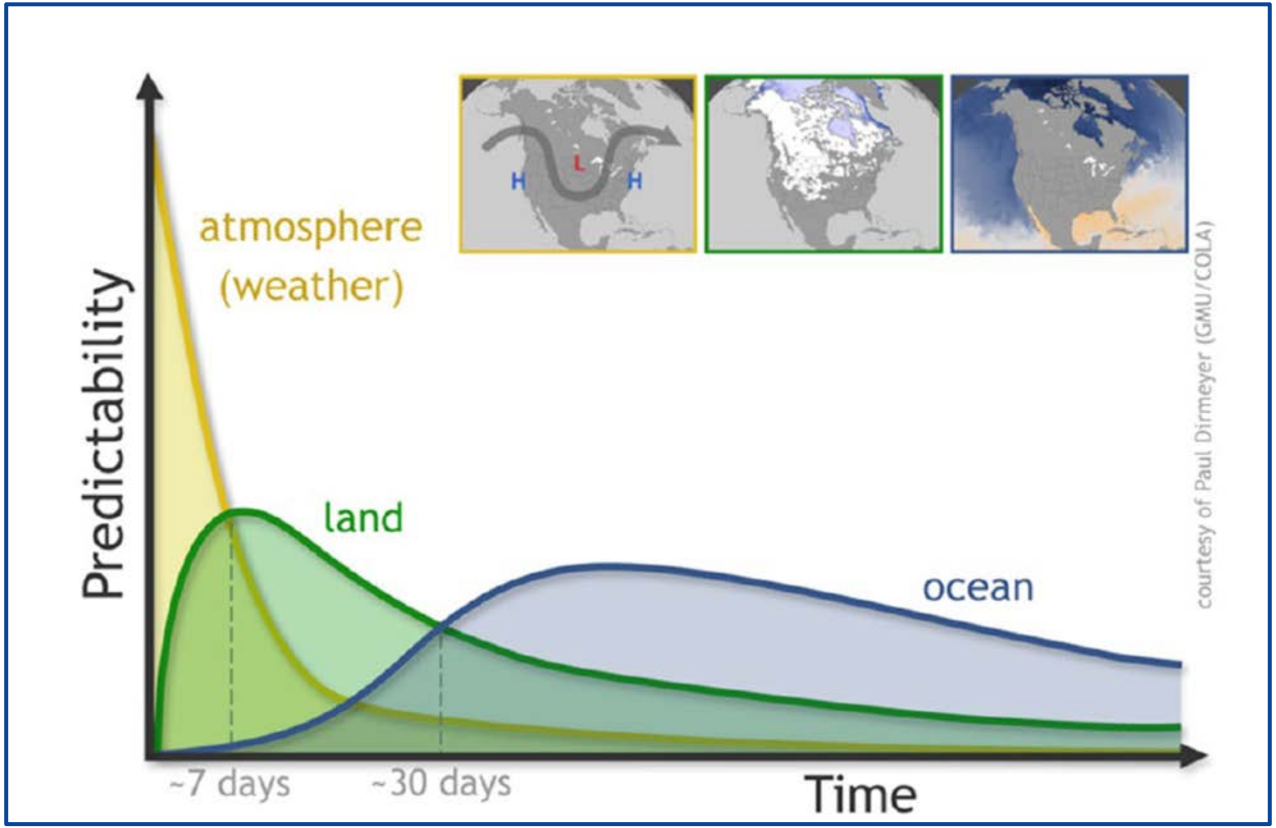


NOAA Products: Drought Outlook

- Critical outlook used by water managers and agriculture
- Insurance contracts are written from drought outlook and monitor



S2S Advancements Require Earth System Approaches



S2S Advances Through Partnerships

Kirtman et. al. 2014

THE NORTH AMERICAN MULTIMODEL ENSEMBLE

Phase-1 Seasonal-to-Interannual Prediction; Phase-2 toward Developing Intraseasonal Prediction

BY BEN P. KIRTMAN, DUGHONG MIN, JOHNNA M. INFANTI, JAMES L. KINTER III, DANIEL A. PAOLINO, QIN ZHANG, HUUG VAN DEN DOOL, SURANJANA SAHA, MALAQUIAS PENA MENDEZ, EMILY BECKER, PEITAO PENG, PATRICK TRIPP, JIN HUANG, DAVID G. DEWITT, MICHAEL K. TIPPETT, ANTHONY G. BARNSTON, SHUHUA LI, ANTHONY ROSATI, SIEGFRIED D. SCHUBERT, MICHELE RIENECKER, MAX SUAREZ, ZHAO E. LI, JELENA MARSHAK, YOUNG-KWON LIM, JOSEPH TRIBBIA, KATHLEEN PEGION, WILLIAM J. MERRYFIELD, BERTRAND DENIS, AND ERIC F. WOOD

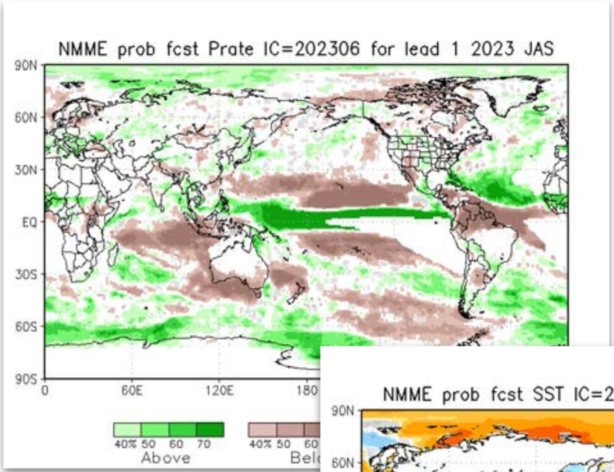
The North American Multimodel Ensemble prediction experiment is described, and forecast quality and methods for accessing digital and graphical data from the model are discussed.

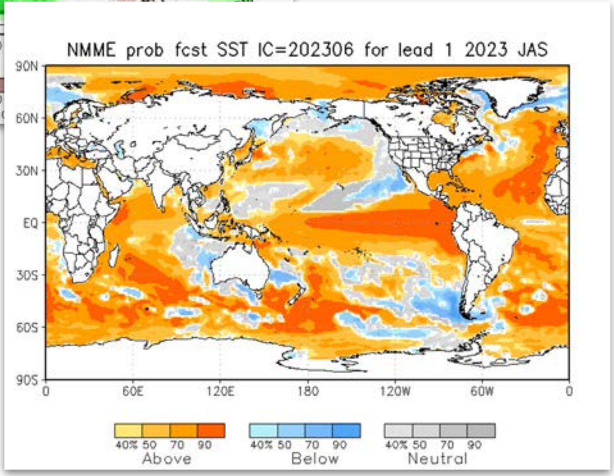
After more than three decades of research into the origins of seasonal climate predictability and the development of dynamical model-based seasonal prediction systems, the continuing relatively deliberate pace of progress has inspired two notable changes in prediction strategy, largely based on multi-institutional international collaborations. One change in strategy is the inclusion of quantitative information regarding uncertainty (i.e., probabilistic prediction) in forecasts and probabilistic measures of forecast quality in the verifications (e.g., Palmer et al. 2000; Goddard et al. 2001; Kirtman 2003; Palmer et al. 2004; DeWitt 2005; Hagedorn et al. 2005; Doblas-Reyes et al. 2005; Saha et al. 2006; among many others). The other change is the recognition that a multimodel ensemble strategy is a viable approach for adequately resolving forecast uncertainty (Palmer et al. 2004; Hagedorn et al. 2005; Doblas-Reyes et al. 2005; Palmer et al. 2008), although other techniques such as perturbed physics ensembles (currently in use at the Met Office for their operational system) or stochastic physics (e.g., Berner et al. 2008) have been developed and appear to be quite promising. The first change in prediction strategy naturally follows from the fact that climate variability includes a chaotic or irregular component, and, because of this, forecasts must include a quantitative assessment of this uncertainty. More importantly, the climate prediction community now understands that the potential utility of climate forecasts is based on end-user decision support (Palmer et al. 2000; Morse et al. 2005; Challinor et al. 2005), which requires probabilistic forecasts that include quantitative information regarding forecast uncertainty. The second change in prediction strategy follows from the first, because, given our current modeling capabilities, a multimodel strategy is a practical and relatively simple approach for quantifying forecast uncertainty due to uncertainty in model formulation, although it is likely that the uncertainty is not fully resolved.

More recently, there has been a growing interest in forecast information on time scales beyond 10 days but less than a season. For example, the National Centers for Environmental Prediction Climate Prediction Center (NCEP/CPC) in the United

AMERICAN METEOROLOGICAL SOCIETY APRIL 2014 BAMS | 585

NMME: Research Multi-Model Effort



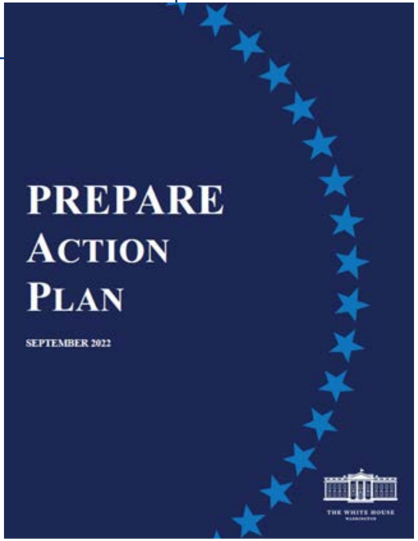


- Produces **global** climate information every month
- Monthly variables
  - 200 hPa Geopotential Height
  - Total Precipitation
  - Sea Surface Temperature
  - Maximum Temperature
  - Minimum Temperature
  - Reference Temperature

Not Just a Domestic Issue… S2S Matters For All

Early Warnings for All

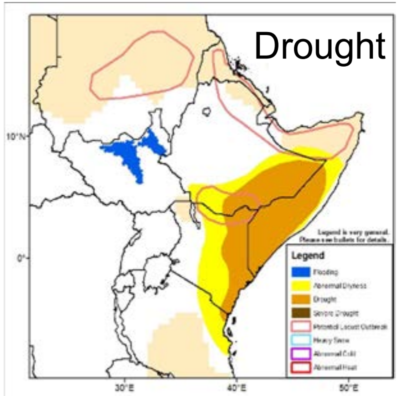
Source: WMO

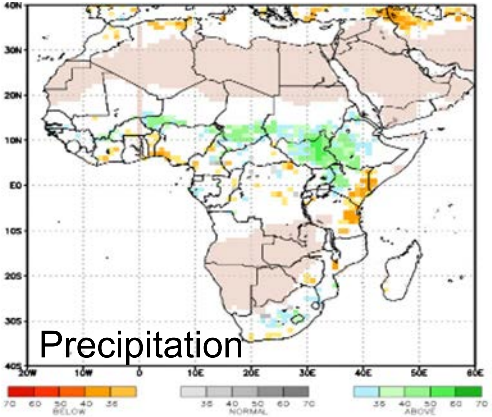


- President’s Emergency Plan for Adaptation and Resilience (PREPARE) → improve the ability of more than half a billion people in developing countries to adapt to and manage the impacts of climate change by 2030
- COP27: USAID and NOAA provide $33M to provide at risk communities with early warning systems

NOAA CPC International Desk: Building Capacity and Products Since 1995

- Use state of the art monitoring, modeling and forecasting capabilities at NCEP to train a cadre of meteorologists from around the world
- 300 trainees from 46 countries
- Global and regional multi-model ensemble sub-seasonal to seasonal prediction tools
- Host of WMO-Regional Climate Center (RA-IV): Tailored multi-model ensemble sub-seasonal to seasonal prediction tools
- Specific to USAID:
  - Famine early warning system (FEWS)
  - Disaster risk reduction (DRR)
  - Excessive heat forecasts

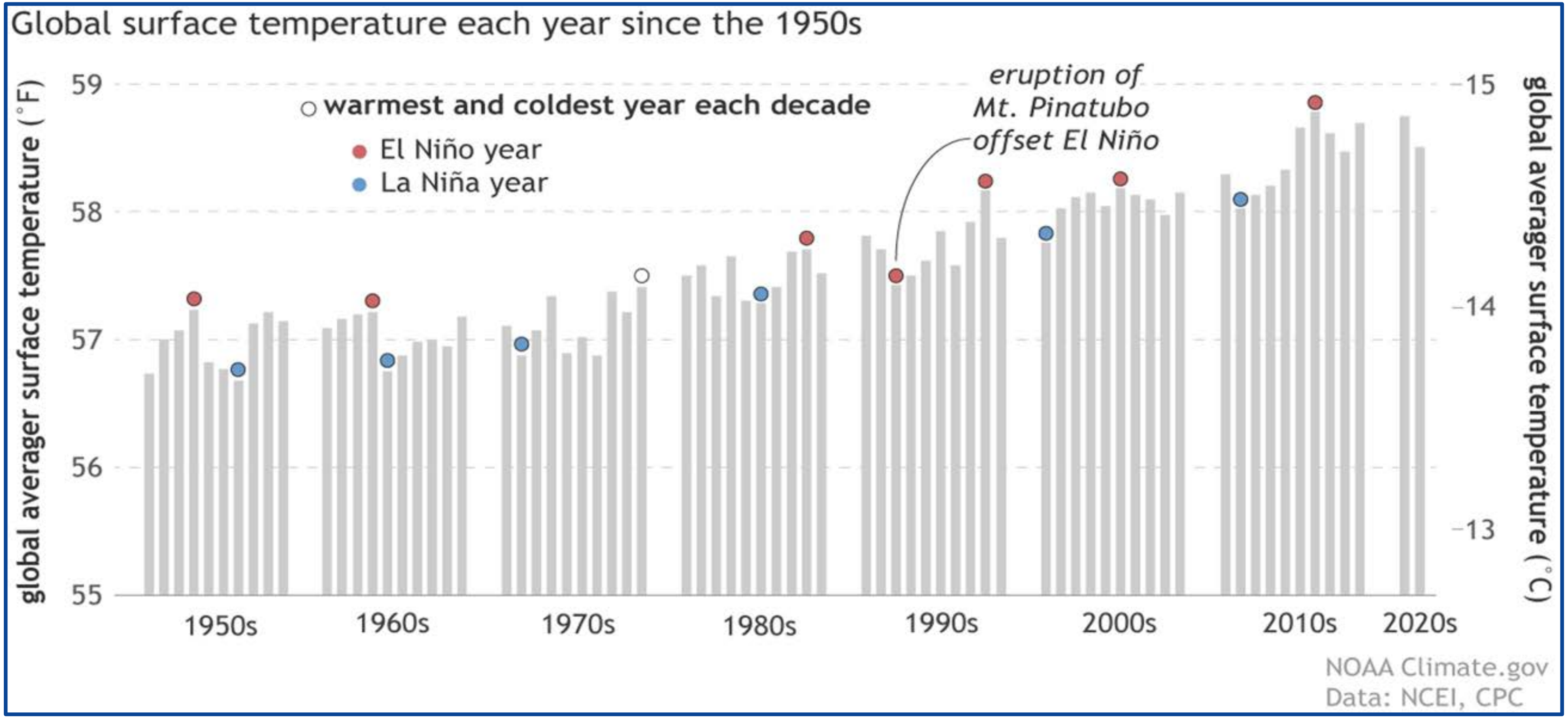




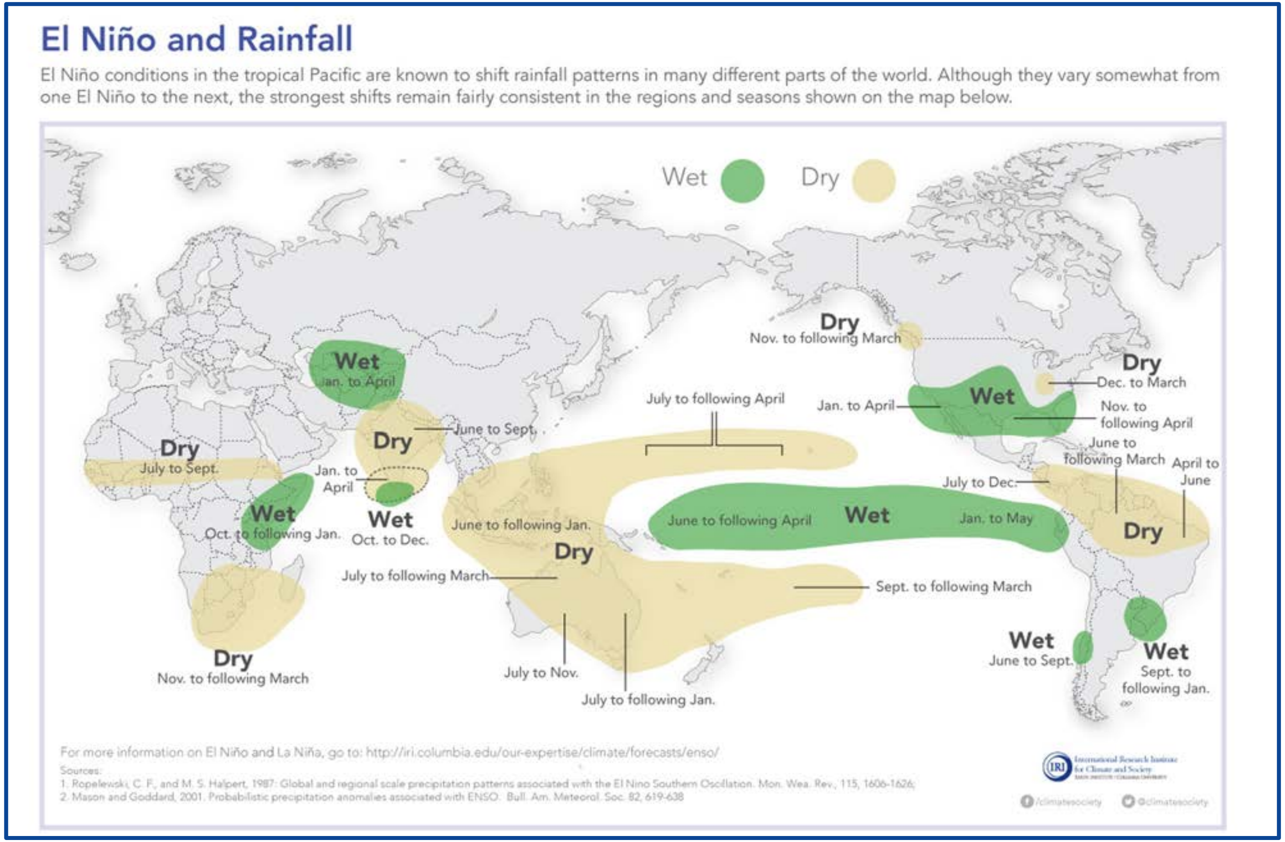
A note on the developing El Niño

NOAA

Some of the most extreme years: El Niño



Past El Niños: Precipitation Patterns



Past El Niños: Crop Yield Teleconnections

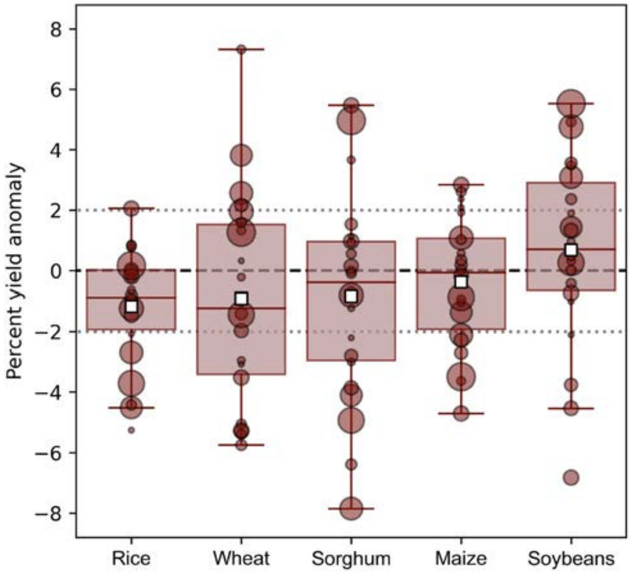


Figure 1: Global-scale yield anomalies relative to expected yields during past El Niño events. Boxplots show the interquartile range and median of the yield anomalies, with the mean denoted by a white square. The size of each point corresponds to the strength of the El Niño in Oct-Dec during that year

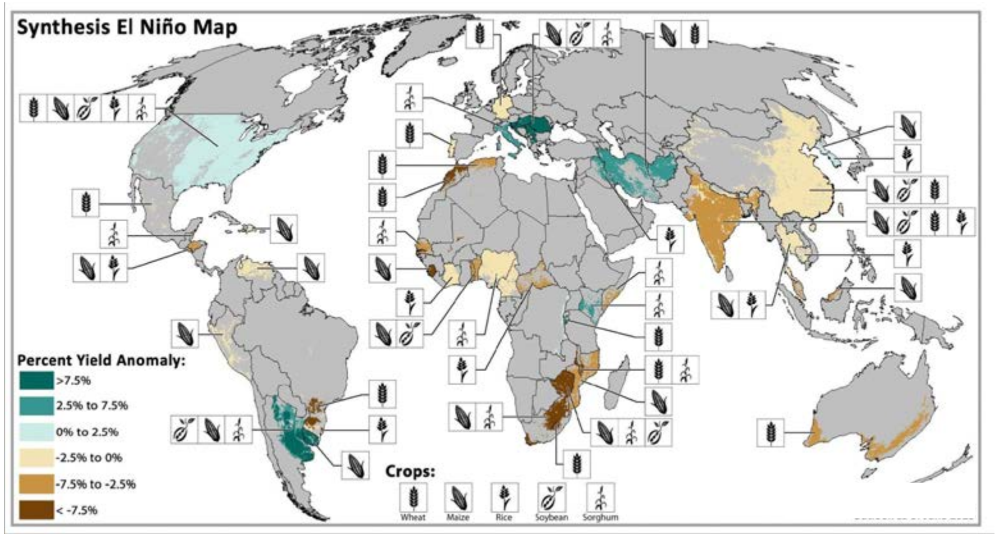
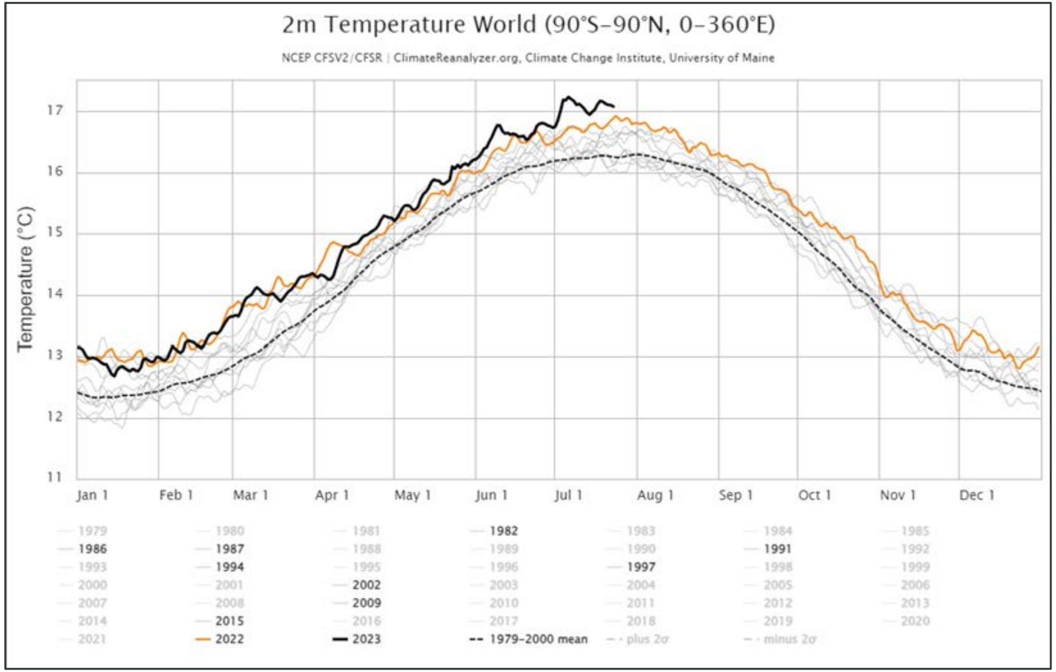


Figure 2: Historical crop yield conditions during El Niño events for wheat, maize, sorghum, rice, and soybeans. In countries with more than one crop affected the color reflects the strongest effect.

Material courtesy Andy Hoell, NOAA PSL

What We Don't Know!

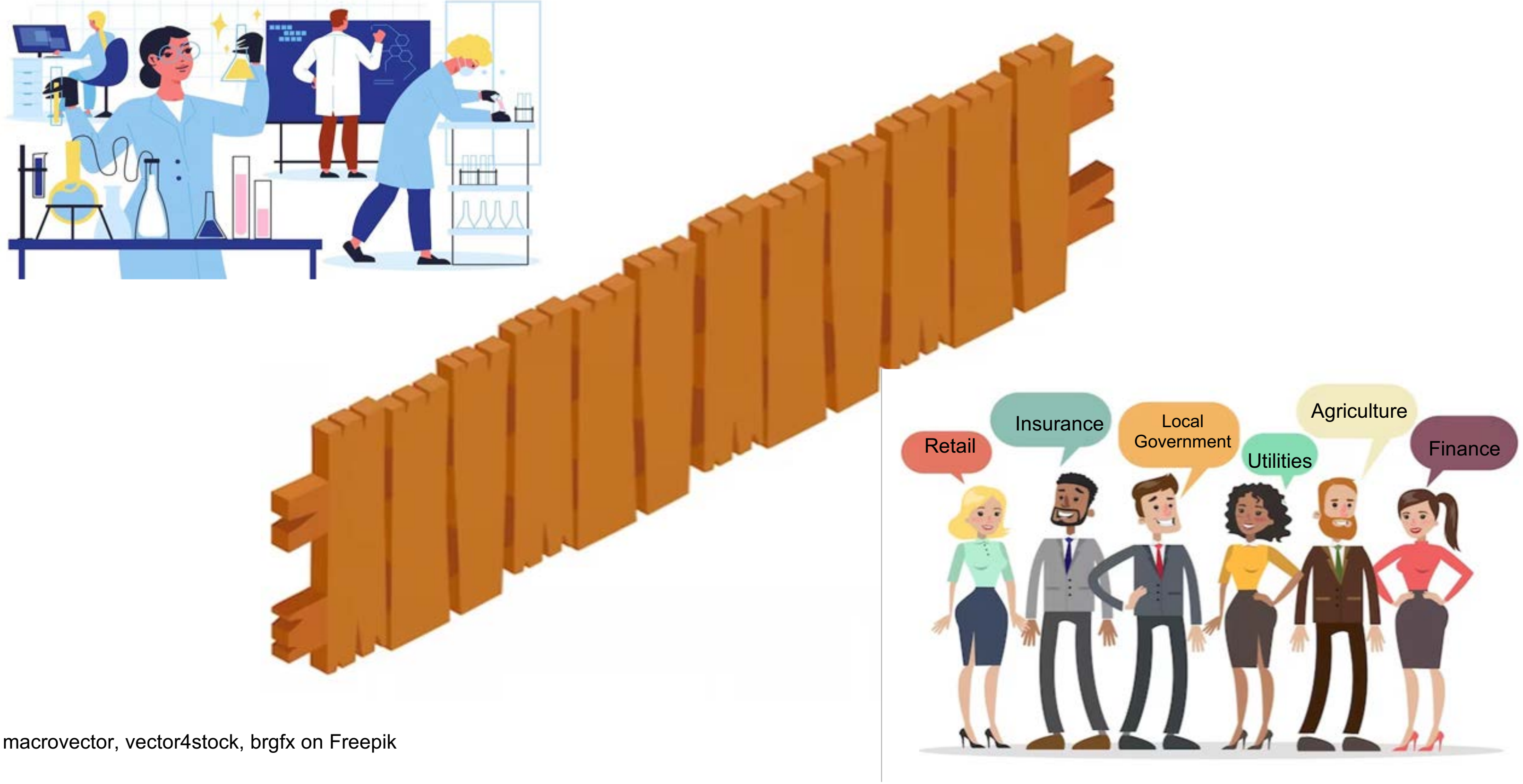
- No previous strong El Niño has developed under such warm conditions
- With hotter than average conditions expected globally, will precipitation offset temperature stress to protect food production?



Record high global 2m air temperatures during Summer 2023, and temperatures compared to 2022 and analog moderate-strong El Niño years. From ClimateReanalyzer.org and NCEP CFS data.

Material courtesy Andy Hoell, NOAA PSL

Understanding Stakeholder Needs



Images by macrovector, vector4stock, brgfx on Freepik