The Climate and Water Consortium

The Climate and Water Consortium is working on understanding **the US southwest desert ecosystem**. How does it look and behave now and what will the future bring to it? How will life in the SW adjust to changes that the climate will bring? How can we prepare for changes?

Providing climate change assessments and solutions for the future is important for our ecosystem in many different ways. Water in the SW is a major and very important part of its ecosystem. For example, agriculture, into which most of our surface and groundwater goes, is a major part of our economy that heavily depends on the supply of water. Floods and droughts bring significant hardship on everyone working or living in the SW. Stronger extreme events bring change to our ecosystem that will lead to new diseases.

> *Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability. (The Intergovernmental Panel on Climate Change, IPCC)*

It is estimated that if we do not act and adapt to climate change, we will lose 6.3 billion dollars by the year 2040, just in New Mexico. This is $5,410 per household per year. Therefore, knowing the climate change of SW and its impact on water resources, economy, health, etc, is extremely important for our future.

Providing more accurate weather forecast, specialized weather forecasts of extreme events (monsoon timing and strength, droughts) and improved climate change assessments have a direct impact on:

- Economy
- Agriculture
- Biodiversity
- Ranching
- Ecosystem capital, biodiversity, forestry and wildfires
- Renewable energy (solar and wind industry location, alternate cheaper energy sources)
- Airports and traffic control
- Snow forecasts
- Frost forecasts
- Lightning as an extreme event
- Health

To be able to provide better weather forecasts and assessments of the climate change and its influence on our ecosystem, we need to have better models and more **measurements and data.**

The weather forecasts and climate assessments heavily depend on surface and upper air measurements, obtained from surface weather stations (Figure 1) and upper air weather stations (Figure 2) that are **sparse** in SW of USA.

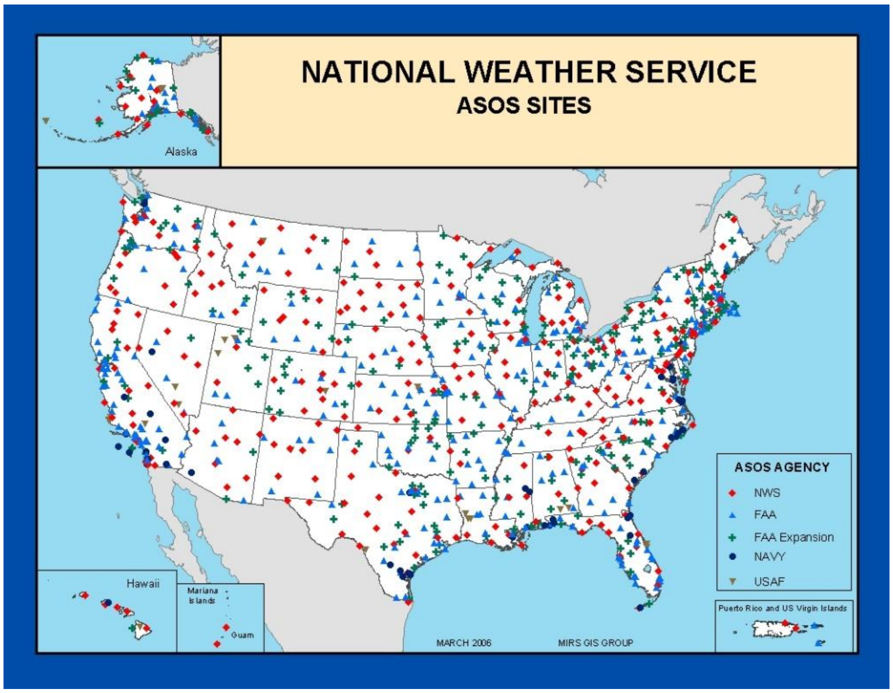

Figure 1: Map showing all US Automatic Surface Observation System (ASOS) sites. Image credit: NOAA. Note the sparse distribution of stations in the southwest compared to the east coast
http://www.hurricanescience.org/science/observation/landbased/automatedsurfaceobssystems/

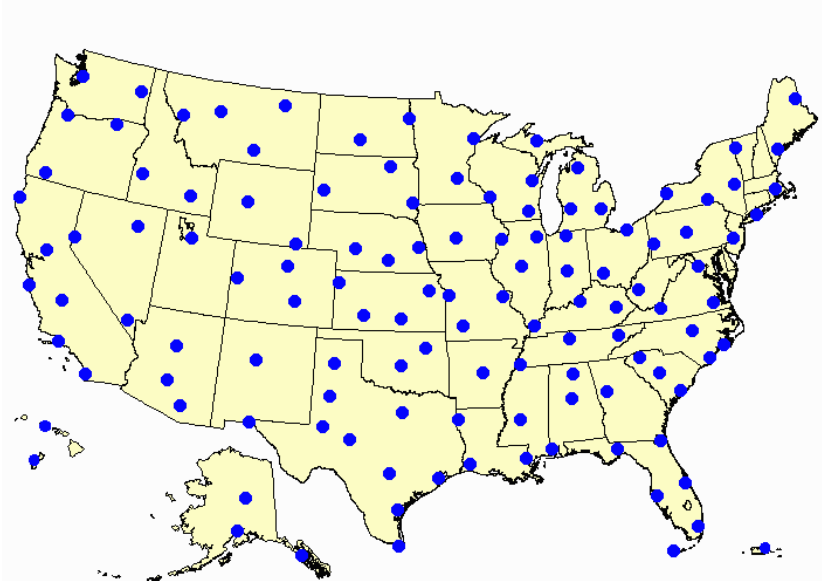

Figure 2: Upper air sounding stations in the US. Note the sparse distribution of sounding stations in the south west compared to the east coast. (Figure source: NOAA)

The Climate and Water Consortium focuses on:

- Research in weather and climate
- Improving forecast and climate models with better treatment of convection
- Research on climate effects on local ecosystem
- Research in climate and weather effects on agriculture, economy, extreme events (droughts and floods)
- Research in hydrological processes and modeling (groundwater, irrigation)
- Renewable energy (solar and wind)
- Research projects using solar induced fluorescence data and remote-sensing data on land/vegetation cover
- Research in evaluating native plant restoration and the biogeochemistry/climate effects that serve as controls.
- Research on different scenarios and their impact on the economy and society
- Proposed solutions, advising policy makers (policy research on how to improve climate- and water-related decisions)

Instruments that the **Climate and Water Consortium** proposes for improving the weather forecasts, climate assessments and their impact on our ecosystem, economy and health:

- Meteorological instruments: standardized surface weather stations linked to the forecasting network, sounding (upper air vertical profiles), GPS precipitable water, LIDAR.
- Standardized meteorological stations around the NM and SW will lead to improved weather forecasts and better climate assessments as well as specialized forecasts for agriculture. Placing the GPS precipitable water at the different sites and connecting their data to SuomiNet will provide a denser network to understand better the timing and location of precipitation events. Radiosonde sounding from OTREC (a field project that NMT is leading) will give us the vertical profiles of all meteorological fields. LIDAR: meteorology and hydrology need the wind profiles for their models. Possible wind turbine sites can be explored using LIDAR.
- Hydrological instruments: scintillometers (sensible heat fluxes), soil moisture sensors, groundwater level monitoring, LIDAR, GPS precipitable water. Data from scintillometers that measure sensible heat fluxes are used to study the atmospheric boundary layer (turbulence) as well as a crucial constraint parameter for hydrological models to tell the farmers how to optimize irrigation. Groundwater real-time level monitoring to relate possible surface water, land management changes, or precipitation events to groundwater locally.

THE COST OF CLIMATE CHANGE FOR NEW MEXICO

Potential Cost	2020	2040	2080
Costs of Climate Change			
Increased Energy-Related Costs	$248 million	$647 million	$2.6 billion
Reduced Trout Populations	$38 million	$46 million	$61 million
Increased Flood and Storm Damage	$88 million	$181 million	$435 million
Reduced Food and Agricultural Production	$73 million	$129 million	$382 million
Increased Wildland Fire Costs	$488 million	$1.0 billion	$2.2 billion
Increased Health-Related Costs	$421 million	$759 million	$1.6 billion
Lost Recreation Opportunities	$286 million	$563 million	$812 million
Reduced Streamflows	$8 million	$11 million	$21 million
Subtotal for Costs of Climate Change	*$1.7 billion*	*$3.4 billion*	*$8.2 billion*
Additional Costs from Business-as-Usual (BAU) Activities that Contribute to Climate Change			
Inefficient Consumption of Energy	$1.3 billion	$2.4 billion	$8.3 billion
Increased Health Costs from Coal-Fired Emissions	$275 million	$527 million	$1.9 billion
Subtotal for Costs from BAU Activities	*$1.5 billion*	*$2.9 billion*	*$10.2 billion*
TOTAL	**$3.2 billion**	**$6.3 billion**	**$18.4 billion**
Average Cost per Household per Year	$3,430	$5,410	$12,000

Source: ECONorthwest.

Notes: These numbers illustrate different types of annual costs New Mexicans potentially would incur if society were to continue with a business-as-usual approach to climate change. There may be overlap between the values for some of the different types of costs. Nonetheless, adding the different types of costs probably seriously understates the total potential cost of climate change because the table excludes many additional types of climate-related costs that New Mexicans would incur under a business-as-usual approach. The numbers do not indicate the net effect of climate change, as they do not represent a forecast of how the economy will respond to the different effects of climate change, or account for potential economic benefits that might materialize from moderate warming and other changes in climate.

Figure 3: Potential Economic Costs in New Mexico Under a Business-as-Usual Approach to Climate Change, 2020, 2040, and 2080 (dollars per year). Neimi. E. et al. (2009). *"An Overview of Potential Economic Costs to New Mexico of a Business-As-Usual Approach to Climate Change".* University of Oregon.

Investing in instruments that would collect sufficient measurements to provide better weather forecasts (especially when it comes to precipitation on short and long time scales), more accurate climate assessments and better solutions on usage of surface and groundwater (Aquifer Mapping Program) can save us lots of money, see figure 3. More meteorological and hydrological data leads to more accurate models as well as a better understanding and improving of modeled physics. In long term that leads to more accurate climate assessments as those are based on forecasting weather models (after all physics remains the same).

Estimated cost for instruments and 3 years of research by CWC: 1.5 million dollars

Example: climate and agriculture and ranching

> *"As temperatures increase, crop production areas may shift to follow the temperature range for optimal growth and yield, though production in any given location will be more influenced by available soil water during the growing season. Weed control costs total more than $11 billion a year in the U.S.; those costs are expected to rise with increasing temperatures and carbon dioxide concentrations.*
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> *Changing climate will also influence livestock production. Heat stress for any specific type of livestock can damage performance, production, and fertility, limiting the production of meat, milk, or eggs. Changes in forage type and nutrient content will likely influence grazing management needs. Insect and disease prevalence are expected to increase under warmer and more humid conditions, diminishing animal health and productivity. " (The USDA Office of the Chief Economist)*
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> *"Estimated costs to U.S. agriculture are: from 1.59 billion (1982$) to 114.97 billion (1990$) for producers. $2.5 to +$13 billion (2000$) for consumers." Walthall et al. (2012).*
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> *"Climate change will affect New Mexico in significant ways beyond dewatering rivers and streams. Increased drying of soils and significant reductions in soil moisture are likely to occur as potential evapo-transpiration rises with increasing temperatures (Wang, 2005). These effects will compound the adverse effects of changes in the hydrology of runoff and water availability throughout New Mexico. Such changes will affect the quality and condition of New Mexico's forests and rangelands, which is likely to accelerate the severity and extent of forest fires and diminish forage production on rangelands, adversely impacting livestock and wildlife across the region (Hurd et al., 2007). Such changes in range productivity and livestock production due to climate change will likely add to the estimated agricultural sector impacts in New Mexico by damaging its most important agricultural activity, beef cattle, accounting for about 40% of agricultural income, or $2 billion in cash receipts (NMDA, 2005)." Hurd and Coonrod (2008, page 22).*
> Most recent data suggests that the dairy industry alone counts for 37% of the total cash receipts; Dairy + livestock industry (mainly beef) count for 65% of the total cash receipts, almost 2/3 of the NM Agricultural sector. *2016 New Mexico Agricultural Statistics Bulletin.*

If we decide not to act, the price that we will pay will be astronomical, 18.4 billion dollars by 2080, figure 3. If we act now, make an effort to understand the problem better by collecting more data and doing more research, we will be able to find solutions and save money and lives.

Maximizing the Intelligence of Climate Solutions

Albert Einstein is often quoted as saying, “We can’t solve problems by using the same kind of thinking we used when we created them.” So is the case with attempts to utilize technology and political policy to avert, mitigate, or adapt to anticipated global climatic changes. Creating more climate conscientious and resilient technological societies will require a paradigm shift, consciously making more room for active learning and responsive action into the processes of technological development and commercialization as well as into governmental action. Potentially beneficial technologies like carbon capture, devices to filter and treat contaminated and brackish waters at large scales, and “green” energy as well as carbon taxes or credits and other policy proposals are all characterized by some degree of uncertainty regarding their climate benefits as well as their possible risks. Intelligently coping with these uncertainties requires research providing insight into how to:

1) Create the conditions wherein technical professionals working within private industry are properly incentivized to innovate more responsibly

2) Design policies that foster quicker and more reliable feedback on technological developments with regard to potentials for success, failure, and unintended consequences

3) Develop communication strategies and institutions that enable and encourage citizens and policy makers to thoughtfully deliberate over solutions to climate change rather than sink into unproductive divisiveness

About CWC:

The Climate and Water Consortium features natural and social scientists working on cutting-edge research and applying it to the real world. We are looking at the fundamental science across interdisciplinary fields, considering water and energy balance, connections between climate and groundwater, water and geology, climate and ecology, etc.

The goal of the Consortium is to improve the New Mexico and south-western economies and industry through interdisciplinary research. The Consortium is an innovative problem-solving center for interdisciplinary research and outreach; bridging physics, atmospheric physics, engineering, hydrology, geophysics, biology, applied math, economics, computer science, public policy, and education; a way to use science to solve overarching problems of our society, in particular applied to weather prediction, climate change, water management, and high technology.

cwc.nmt.edu

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