Central Coast Regional Climate Symposium

Monday, December 10, 2018
Welcoming Remarks

Mayor Heidi Harmon
City of San Luis Obispo
Welcoming Remarks

Dominic Roques
Central Coast Water Board
Overview of California’s Fourth Climate Change Assessment

Laurie ten Hope
Deputy Director, Energy Research and Development Division
California Energy Commission
Key Climate Impacts in the Central Coast

Ruth Langridge
Researcher, Politics Department / Lecturer, Legal Studies Program
University of California, Santa Cruz
California's 4th Climate Assessment

CENTRAL COAST REGION REPORT

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<table>
<thead>
<tr>
<th>County</th>
<th>Santa Barbara</th>
<th>Monterey</th>
<th>San Luis Obispo</th>
<th>Santa Cruz</th>
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<td>Population</td>
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<td>415,055</td>
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Maximum temperature will continue to increase through the next century with greater increases inland.

Annual average maximum Temperature (F°)
Blue = RCP 4.5
Red = RCP 8.5

<table>
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<th>County</th>
<th>Historical</th>
<th>RCP4.5</th>
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<td>67.5</td>
<td>71.9</td>
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<tr>
<td>Santa Cruz</td>
<td>67.5</td>
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<td>San Luis Obispo</td>
<td>69.8</td>
<td>74.7</td>
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Average Hottest Day of the Year (°F)
Precipitation

Average precipitation is expected to increase by a small amount, but annual variability increases by end of the century.
Fog

• The future of fog is uncertain because system feedbacks and their response to climate change are not well characterized.

Extreme Storm Events

• Periodic El Niño events dominate
• Projections show a poleward migration of storm tracks and a slight decrease in wave heights compared to historical records

Extreme Drought Events

• Climate projections are for an increase in extreme dry events.
• The adverse effects of the 2011-2016 multi-year drought were not uniformly distributed, highlighting differential susceptibility to climate stresses.
Physical Impacts of Climate Change

Sea Level Rise

Recently observed & projected acceleration of SLR poses a significant threat to coastal communities.

Projected Cliff Retreat Under SLR scenarios

Colored bands around the lines represent projection uncertainty for that SLR scenario

Goleta County Beach and Campus Point

Along the 101 corridor near Gaviota
Floods

- For 2 meters of SLR combined with the 100-year storm event, CoSMoS projects exposure of 11,780 residents & $2.4 billion in property across the most developed portion of Santa Barbara County.
- Most vulnerable regions for future flooding --- Carpinteria, Santa Barbara Harbor/East Beach neighborhood, Goleta Slough/Santa Barbara Airport, Devereux Slough, and Gaviota State Park.

Examples of Future Flood Hazards

Goleta (top), Santa Barbara Harbor/East Beach (middle) and Carpinteria (bottom), showing the 1 m SLR scenario coupled with the 100-year coastal storm from CoSMoS projections.
Wildfires

- Frequent and often large wildfires will continue to be a major disturbance.
- Air temperature in the month of ignition can increase tire size as can low precipitation in preceding 12 months.
- Expansion into the wildland urban interface will continue to increase risks.
- Post-fire recovery time may be lengthened and fire spread following ignitions will be enhanced.
- Winter storms that produce abnormally high sediment export are likely to occur with greater intensity in the future.

Thomas Fire Photos: Mike Eliason, SB County Fire Dept
Natural Resource Systems

Unique topography and climate make the Central Coast a special place to conserve hundreds of species as climate changes.

Carrizo Plain National Monument

Source: B. Wick
Plants

- High biodiversity with numerous endemic, federally-listed & sensitive that could be vulnerable to climate change
- Suitable habitat and overall resilience for chaparral, coastal sage scrub, grasses and forests will depend on the climate in which a species evolved, climatic tolerances, biotic interactions & land use.

Potential Adaptations

- Create diverse seed pools to increase population genetic diversity
- Control grazing to enhance native grasses & forbs at the expense of exotic species
- Monitor & model populations to determine best practices for stewardship (e.g. assisted migration) & to promote desirable outcomes in a future climate
**Wildlife**

**Focus on Herpetofauna**

Extinctions are already underway for

1) Northern alligator lizards (*Elgaria coerulea*),
2) Arboreal salamanders (*Aneides lugubris*),
3) California Giant Salamander (*Dicamptodon ensatus*) - predicted to go totally extinct by 2070.

Species may have robust climate refugia in the Santa Cruz Mountains and Santa Lucia Mountains that protect from the risk of extirpation owing to cooler temperatures, fog and higher levels of precipitation.

**Impacts**

- Invasion by exotic species, prevalence of wildlife disease, loss of native habitats and reduction of geographical range
- Some species have moved towards high latitudes or high altitudes but other species have failed to reestablish their habitat associations.
**Impacts**
- SLR & extreme storms will increase rates of shoreline erosion & degrade & fragment beach habitat.
- Many beaches will narrow & may be completely lost.
- Dune-backed beaches will be most resilient - those backed by bluffs and armoring structures will disappear.

**Beaches**

**Proposed Adaptations**
- Removal of infrastructure - “managed retreat”
- Restore intensively managed but degraded wide beaches
- Allow more sand from streams & watersheds to enter littoral cells & support coastal sediment budgets
Tidal Estuaries and Riparian Areas

• Some marshes may drown or become shallow mudflats leading to a loss of the ecosystem services, including carbon sequestration
• Extremes from drought to floods will threaten the aquatic life of streams & rivers
• Fire & erosion will bury habitat in sediments.

This will impede survival of already endangered migratory Steelhead & Coho salmon, and could further reduce the diversity & abundance of sensitive aquatic insects.
Energy

**Impacts:**
- Higher temperatures will: reduce electricity efficiency leading to deficits especially during peak demand; increase risk of outages; increase cooling requirements affecting electricity from gas-fired plants
- Intense storm events will affect energy infrastructure

**Proposed Adaptations:**
- Energy efficiency,
- Renewable energy,
- Clean fossil-fueled generation,
- Transmission infrastructure improvements,
- Roof materials to reduce the “heat island effect” in new construction
Water

Only modest changes in mean precipitation are projected, but combined with increasing temperatures, managing Central Coast’s already stressed water supplies will be challenging.

**Impacts**

- Agricultural water use is likely to increase
- Domestic landscaping water demand will be higher
- Groundwater extraction and rate of saltwater intrusion may increase

Rates of seawater intrusion (1944 to 2015) for the 180-foot (left) & 400-foot (right) aquifer Salinas Valley
Water

More Impacts
- Lower seasonal surface flows will lead to higher pollutant concentrations and affect nitrate inputs, soil processes and agricultural productivity
- Changes in rainfall patterns will affect surface water reservoirs
- Imported water from the SWP will be less reliable and more expensive

Proposed Adaptations:
- Conservation
- Recycled water
- Desalination
- Groundwater Management (SGMA)
- Groundwater drought buffers
Changes in climate influence: crop selection, crop acreage, technology adoption, water demand

Salinas Valley is one of the most vulnerable agricultural regions under climate change.

Proposed Adaptations
- More efficient soil and irrigation management
- Improve soil retention capacity (crop rotations, tillage systems, soil cover)
- Identify potential pests & develop strategies for control
- Improve rainwater harvest, on-farm water capture & storage & groundwater recharge.
Public Health

**Impacts**
- Extreme heat events could increase illnesses for agricultural workers and spark wildfires releasing harmful particulate matter.
- Infectious/Vector-borne diseases may worsen including Valley Fever and Pacific Coast tick fever.
- An increase in harmful algal blooms will expose animals and people to toxins released from the algae.

**Adaptation**
In 2014, San Luis Obispo County Public Health Department initiated the first climate change and health communications campaign, co-developed with the CA Department of Public Health. It is supported by a multiple community partners.

Salinas Valley strawberry pickers.
Image California Magazine
Examples of Community Efforts

- The Central Coast Climate Collaborative involving cities, counties and community groups in climate adaptation activities.
- The Central Coast Action Lab focusing on youth in farmworker communities.
- Many cities counties, NGOs and colleges have completed assessments of local vulnerabilities - including coastal hazard assessments.
- Some natural lands are undergoing vulnerability assessments.
Key Critical Future Issues:
Climate extremes
Land use decisions
Development patterns
AND
Water
Fire
Agriculture
Ecosystems
Public Health
Energy
Thank you

Central Coast Region Report

Questions

www.climateassessment.ca.gov/regions/
Risks and Opportunities for California’s Coast and Ocean

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Research Oceanographer
U.S. Geological Survey

Jennifer Phillips
Senior Scientist
Governor’s Office of Planning and Research
Two Scales of Climate Change Effects on Coastal California

1] Those processes or changes that are oceanic and global in scale, driven by global warming and increased carbon dioxide emissions, and where California’s ability to respond is very limited:

- ocean warming
- ocean acidification
- increasing frequency, duration and intensity of harmful algal blooms
2] Those that are more coastal and that we have the ability to respond and adapt to:

- *sea-level rise with increase in frequency and duration of coastal flooding*
2] Those that are more coastal and that we have the ability to respond and adapt to:

- sea-level rise with increased cliff and bluff erosion
2] Those that are more coastal and that we have the ability to respond and adapt to:

- intensively used beaches with armor or barriers at their back edge will eventually narrow and disappear with continued sea-level rise and passive erosion.
Over at least the next several decades, the extreme events (El Niños, king tides, and large wave at times of high tides) will have greater impacts on the shoreline than sea-level rise alone.

However, sea-level rise is accelerating and will be additive with extreme events presenting greater threats to California’s development and infrastructure along the beaches, dunes, bluffs and cliffs after mid-century.
While the greatest damage to coastal property and infrastructure over the past several decades has occurred during large El Niño events, there are still significant uncertainties involved with future wave climate, and also with the future frequency and intensity of El Niño events.
Ocean warming, ocean chemistry changes, sea-level rise and other greenhouse gas driven changes to California’s ocean and coast – those already occurring and projected – will have significant consequences for California’s coastal economy, communities, ecosystems, culture and heritage.
Climate Impacts along the San Luis Obispo County Coast

Li H. Erikson¹, Patrick L. Barnard¹, Amy C. Foxgrover¹, Juliette Finzi Hart¹, Patrick Limber¹, Andrea C. O’Neill¹, Maarten van Ormondt², Sean Vitousek³, Nathan Wood⁴, Maya Hayden⁵, Doug Moody⁵, Michael Fitzgibbon⁵, Jeanne M. Jones⁶ and Kevin Befus⁷

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Coastal Storm Modeling System (CoSMoS)

- Physics-based numerical modeling system for assessing coastal hazards due to climate change
  - Sea Level Rise Projections
    - 0, 25, 50, 75, 100, 150, 200, 300, 500 cm
  - Storm Projections
    - daily conditions and 1, 20, and 100 year return intervals
  - Shoreline Evolution (v3)
    - Sandy beach position & cliff retreat
- Web-based coastal vulnerability tools (developed in collaboration with federal, state, and city governments to meet their planning and adaptation needs)
CoSMoS Framework

Global Scale
Deep water wave generation and propagation using climate change influenced future winds.

Regional Scale
Swell propagation, wave generation, storm surge, and astronomic tides.

Local Scale
High-resolution hydrodynamics: nearshore waves, wave setup and runup, storm surge, tides, overland flow, fluvial discharge.

Web-based tools for data visualization and analysis

***USGS CoSMoS for Central Coast to be completed in 2019***
Coastal Storm Modeling System

http://walrus.wr.usgs.gov/coastal_processes/cosmos

Hazard Exposure Reporting and Analytics (HERA)

Socio-economic web tool
www.usgs.gov/apps/hera

Web tool for data visualization, synthesis, download
http://outcoastourfuture.org
Flood hazard web tool

Our Coast, Our Future tool: www.ourcoastourfuture.org
Available outputs

- Long term (LT) cliff recession and sandy beach shoreline change
- Flood depths, extents, and low-lying vulnerable areas (including integration of LT morphodynamic change)
- Maximum water levels
- Flood duration
- Maximum wave heights
- Maximum velocities
- Maximum wave runup
- Flood extent uncertainties (model + DEM uncertainties, & vertical land motion)

4 coastal management scenarios + SLR

40 scenarios of SLR + storms
Coastal Storm Modeling System

http://walrus.wr.usgs.gov/coastal_processes/cosmos

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USGS Hazard Exposure Reporting & Analytics

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Coastal Climate Impacts

- 600,000+ residents
- $150 billion in property
- 4,700 km of roads
- 350 critical facilities (e.g., schools, police stations, hospitals)

California's Fourth Climate Change Assessment

Hazes Reporting and Analytics (HERA)

USGS

www.usgs.gov/apps/hera
CoSMoS: Major Advancements

- Identification and selection of multiple storm scenarios for detailed deterministic modeling of local extreme events
- Long-term cliff retreat
- Long-term shoreline change
- Long-term coastal profile and DEM evolution
- Integration of climate change-driven morphodynamic change and coastal flood projections
- Development and integration of projected fluvial discharge rates
- Temporal downscaling of daily winds
Morro Bay
Digital Elevation Model (2 m)
CoSMoS-COAST: Coastal One-line Assimilated Simulation Tool

- A (hybrid) numerical model to simulate long-term shoreline evolution
- Modeled processes include:
  - Longshore transport
  - Cross-shore transport
  - Effects of sea-level rise
  - Sediment supply by natural & anthropogenic sources

Shoreline Change Projections

- 4 coastal management scenarios
  - No erosion beyond urban infrastructure ('hold the line'), or not
  - Incorporate historical rates of change in future projections (e.g., nourishment), or not
Projected Cliff Retreat

- Rain
- Cliff Toe
- Wave Energy
- Coastal Slope
- Rock Strength
Cliff Retreat

Limber et al. (2018)
Central Coast CoSMoS

- Coastal change projections completed
- Flooding projections to be completed in 2019, with Our Coast, Our Future and HERA web tools
- Groundwater modeling completed, to be released in early 2019

USGS CoSMoS website:


Our Coast, Our Future tool: www.ourcoastourfuture.org

HERA Tool: www.usgs.gov/apps/hera

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References (cont.)


Q&A
California’s 4th Climate Assessment: The Coast and Ocean

Jenn Phillips
Governor’s Office of Planning & Research
California’s 4th Climate Change Assessment

- Periodic scientific assessments to understand the potential impacts of climate change in California
- Elements of the 4th Assessment (new addition of ocean and coast topical report):
  - Regional and Topical Synthesis Reports
  - Statewide Summary Report
  - Technical Reports (45+)
  - 9 Regions
  - 3 Topical
  - Energy
  - Non-energy
  - External

Climate Change Research Plan for California
Increased atmospheric greenhouse gas concentrations (incl. CO₂)

- Increased run-off
- Coastal erosion
- Changes to winds/storms/waves
- Sea level rise
- Changes to rainfall
- Land thaw and ice melt

Increased CO₂ level

- Acidification
- Reduced uptake of CO₂
- pH
- CO₂

- Foodweb effects
- Stratification
- Changes in ocean currents
- Changes to ocean salinity
- Nutrient enrichment
- Nutrients

Increased sea temperature

- Thermal expansion

Increased air temperature
Why the coast matters for Californians...

California ports handle 60 percent of the nation’s imports from the Far East and more than 70 percent of California’s agricultural export trade; they are at risk from storm impacts and sea level rise.

Agriculture depends on coastal fog; reduced coastal fog and saltwater intrusion threatens some of the most valuable farming areas in the state.

Coast redwoods depend on marine fog; they may become drought-stressed if summer fog declines.

There are a number of locations along the California coast where beaches and other popular shoreline features will be permanently lost to a rising ocean.

Climate change is altering connections between the ocean and the atmosphere, potentially leading to even more severe droughts in our future.
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Builds on and points to ocean-climate research and policy

• **Sea Level Rise**
  - Rising Seas Report and State Policy Guidance

• **Ocean Acidification and Hypoxia**
  - State of California Ocean Acidification Action Plan

• **Multi-sector engagement**
  - 4th California Climate Change Assessment
  - Safeguarding California
Major findings

• The ocean has limited terrestrial climate change impacts, but ocean’s capacity to buffer rising GHGs will diminish.

• Coastal impacts will have implications for inland communities and economies.

• Sea-level rise is already affecting the coast; the greatest impacts at present are from extreme events, such as king tides and large storms.

• Climate extremes and ocean acidification are impacting species, ecosystems, industries and people who depend on them, such as aquaculture growers.

• Some of California’s iconic coastal areas and species may be displaced or lost, and some new, historically uncommon species may become common.

• Vulnerable communities in coastal areas face increased risks from climate change impacts due to pre-existing socioeconomic inequities.

• Though science can continue to advance our knowledge of impacts and adaptation options, we know enough to respond now.

• Uncertainties will persist; natural and social science research can illuminate adaptation options and evaluate future actions.
Research needs

• Integrating projected future socio-economic conditions with forecasts of climate change can provide predictions and scenarios that can be used to prioritize among adaptation options.

• Improving scientific understanding of conditions or triggers for harmful algal blooms, including interactions with ocean temperature and chemistry, can protect human health.

• Understand and quantify the role that restoration or conservation of habitats play in reducing the impact of rising carbon dioxide levels on coastal marine environments.

• Maintaining and expanding monitoring of ocean acidification and dissolved oxygen can aid in developing adaptive responses and in assessing impacts of policy changes.

• Continuing to monitor short- and long-term coastal change through existing and developing tools and technologies will allow for more accurate predictions.
Adaptation measures

• State efforts to continue to evaluate, assess, and educate all Californians about how climate change is affecting the coastal zone and ocean waters can result in a more informed public and improved decision-making.

• Social inclusion will be critical to advancing coastal adaptation strategies that incorporate all sources of relevant information, are fair and just to all community members, and ultimately have a better chance of adoption and implementation.

• California can develop more transparent and information-based adaptation approaches. Better coordination of public agencies can promote opportunities for and barriers to working together.

• Opportunity exists to test and evaluate adaptation strategies in different environments as they are implemented, to assess how well they meet different needs, and to export and scale.
Formula for success

- Strengthen governance structures
- Leverage partnerships
- Cultivate ocean and climate stewards
- Couple mitigation and adaptation
- Science-informed decision making now with flexibility
Thank you
Connecting the Dots between Water, Agriculture, and Ecosystems

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Jennifer Phillips
Governor’s Office of Planning and Research

moderated by Kif Scheuer | Climate Change Program Director, LGC
Networking Lunch
Climate Change and the Energy System

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California’s Fourth Climate Change Assessment

Overview of key findings about the energy sector

Guido Franco
Team Lead for Climate Change and Environmental Research
California Energy Commission

Central Coast Region
Fourth Climate Change Assessment
Santa Cruz
December 10, 2018
Outline

• What is the energy sector?
• How are GHG emissions from the energy sector changing in California?
• Overall climate impacts
• How should the energy sector evolve in the next 30 years?
• Is the energy system adapting?
What is the energy sector?

• The standard definition includes all activities providing energy services, such as mobility, illumination, and space heating and cooling

“….. the energy system includes energy extraction, transport, conversion (such as combusting natural gas in power plants to generate electricity or producing gasoline and diesel from crude oil in refineries), and consumption for services (such as electricity for lighting, natural gas use in homes and buildings for space and water heating, and gasoline and diesel to fuel cars and trucks), as well as electricity from out-of-state plants serving California.”

How are GHG emissions from the energy sector changing in California?

GHG Emissions in California: 1990 - 2016

Electricity generation has reduced emissions by about 37% since 1990.

The energy sector accounts for more than 80% of statewide GHG emissions.

Data Source: 2018 ARB GHG Inventory
Overall climate impacts and opportunities and adaptation options
Statewide annual electricity and natural gas demands

Substantial changes in annual residential demand

- Use of billions of monthly bills from households. Results aggregated at the zip code level.
- This study inquires about the expected changes to the existing energy system assuming the climate of the future.
- Increased residential electricity consumption approximately offset by decreased demand for natural gas (end-use basis).

Projected end-of-century percent change in annual residential electricity consumption relative to 2000-2015 baseline.

Impact in the Central Coast: annual electricity demand

Projected percent change in annual residential electricity consumption relative to 2000-2015 baseline.

Potential Changes in Wildfires in California

At the statewide level, increases in wildfire regimes would decrease the reliability of the electricity system

Source: Leroy Westerling 2018
Wildfire Scenarios for California

Extreme wildfire events projected to become larger and more frequent.

**Adaptation action:** Fuel treatments in Sierra Nevada could reduce projected increase in area burned (Westerling, 2018).

**Critical research need:** Understanding potential for megafires fueled by massive tree mortality.

Potential impacts to the petroleum system

- Transportation system, including airports and seaports, must contend with flood-related risks as sea level rises. The transportation system is also used to deliver fuels to consumers.
- Some oil terminals and refineries would be flooded, affecting the supply of gasoline and other petroleum products to California.
- A refinery in Wilmington could experience flooding of 40% to 50% of its area by 2040.

Figure*: Near-term (left) and end-century (right) flooding projections for Andeavor Long Beach Terminal 1, where 80% of Southern California’s crude oil is offloaded from marine tankers.

Other Statewide Impacts

• Reduction of hydropower in the hottest months of the year.
• Continuous record breaking high temperatures, which would result in unexpected increases in peak electricity demand.
• Lower performance of thermal power plants (e.g., natural gas combined cycle units) with high temperatures.
• Increased risk of exceeding design temperature limits for transmission and distribution lines, transformers, etc.
How should the energy sector evolve in the next 30 years?

- The mandate to reduce GHG emissions by 40% by 2030 and the goal of 80% reduction by 2050 requires a **drastic and rapid transformation of the energy sector**.
- SB 100 mandates 100 net zero GHG emissions from the electricity generating sector by 2045.
- The **electricity sector must decarbonize** as required by legislation and all the energy services (e.g., space heating, transport) that can be electrified must do so.
- **Natural gas should also be decarbonized.**
- The reduction of fossil fuel combustion will substantially improve air quality with estimated **public health benefits exceeding the potential postulated costs** of reducing GHG emissions.*

Is the energy system adapting?

• YES!

• The Energy Commission has been supporting climate research for the last decade to inform the evolution of a clean and more resilient energy system.

• The CPUC and CEC have formed an adaptation working group headed by CPUC Commissioner Randolph and CEC Chairman Weisenmiller to coordinate climate adaptation policies.

• The CPUC recently released an Order Instituting Rulemaking to discuss how energy utilities could identify and implement adaptation options.
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Thank you!
Climate Change:
The future is now for Utilities

Geoffrey Danker, Policy & Environmental Strategy
Southern California Gas Company and San Diego Gas & Electric

December 10, 2018 – Central Coast Symposium
WHO WE ARE...

SoCalGas & SDG&E Territory

Both Utilities in service for over 135 years

SoCalGas

- Largest natural gas distribution utility in the US
- Serve 12 counties (over 500 communities) and more than 21 million people
- Over 5.8 million gas meters

SDG&E

- Provides electricity and natural gas to 3.4 million people from Orange County to the Mexican border.
We are aligned in our climate goals

- **Governing Law – SB100**: By 2030, obtain **60%** of electricity from renewable sources
- **Governing Law – SB1383**: By 2030, reduce methane emissions **40%** below 2013 levels
- **Executive Order B-55-18**: By 2045, economy-wide, become **Carbon Neutral**
“...ability to **prepare** for and **adapt** to changing conditions and **withstand** and **recover rapidly** from ...deliberate attacks, accidents, or **naturally occurring threats** or incidents...”

Different types of adaptation

**Physical Protection**
- Building a flood barrier to protect an asset from inundation
- Making adjustments to building design or materials selection to reduce sensitivity

**Operational Adjustments**
- Developing a plan to continue to provide service to most customers even if there is a disruption somewhere in the system

**Recovery Efforts**
- Ensuring adequate materials are on hand to make necessary repairs quickly
- Developing a plan for restoring service after a disruption occurs
Flexible Adaptation Pathways Approach

- **What is it?**
  - The implementation of iterative adaptation actions over time to allow for the adjustment of strategies and planning incorporating new information or circumstances

- **What is the benefit?**
  - Helps manage future uncertainty by allowing decision-making to adjust based on new information or conditions, (e.g., new technologies, customer needs, climate change projections, and the economic and policy landscapes)

- **SoCalGas and San Diego Gas & Electric**
  - Both utilities are constantly assessing vulnerabilities of their own systems while analyzing best management practices from throughout the country to safeguard our assets and continue to provide reliable energy service
Potential Impacts

- Threat of impacts to energy infrastructure is driving state and regional agencies to develop plans and policies to reduce system vulnerability.

- Ensure resiliency from impacts due to:
  - Sea level rise
  - Increasing Temperatures
  - Wildfires
  - Floods/Storms (including “wind” storms)
  - Changing Precipitation (e.g. Droughts)

Climate Adaptation-Droughts
Impacts to Pipelines

- Vertical Subsidence
  - not the primary concern with pipeline structural integrity
- Horizontal subsidence
  - at edge of subsidence zone creates compression and can cause buckling
- Local subsidence can create sinkholes, which cause bending stress
- Cathodic Protection effectiveness diminished
El Niño rain intense events can create debris flows, flash flooding or landslides, which can cause:

- **Wash outs** of access roads
- **Pipeline exposures** that can lead to corrosion
- **Increase dewatering** activities (e.g. regulator vaults)
- **Delays** in routine maintenance, repairs and construction projects
- **Workforce diversion** and potentially limited mutual assistance availability.
Lessons From the Past Hurricane Sandy

• Electricity Supply—severe impact
  – Biggest fragilities were Transmission & Distribution Components
    • Winds downed power lines, flooding affected dozens of substations
  – Power outages created a domino effect across other sectors
  – Every system dependent on electricity alone was vulnerable
    • Fueling, Information and Communication, Transportation

• Gas System—no major impact
  – Flooding/power outages concern at compressor stations along some interstate pipelines, but natural gas flows were not interrupted
  – One company vented gas from distribution lines causing water intrusion in flooded areas
Hurricanes Irma and Harvey

- Hurricane Harvey (August 2017)
- Natural gas-powered combined heat and power (CHP) systems kept hospitals running despite historic flooding.

- Hurricane Irma (September 2017)
- Natural gas generators ensured AC and refrigeration units stayed on saving both lives and livelihoods.
California Wildfires

Northern California Wildfires (October 2017)
Emergency deliveries of compressed and liquefied natural gas kept the power on at local hospitals facing electricity outages.

Southern California Wildfires and Mudslides (December 2017 – January 2018)
SoCalGas’ satellite monitoring and Advanced Meter network supported life-saving actions of first responders by pinpointing damages to customers and potential impacted areas.
Internal Initiatives

- CEC-Funded 4th Climate Assessment Projects in the SDG&E Service Area
  - Develop an understanding of climate change vulnerability and adaptation options to coastal (wave flooding, tidal inundation, coastal erosion) and inland hazards (flooding, wildfire, extreme heat, landslide)

- Risk Assessment Mitigation Phase (RAMP)
  - Adaptation assessment to provide information on potential mitigation efforts for threats posted by global climate change

- Utilizing Innovative Technologies
  - Drones
  - Satellite Monitoring
  - Advanced Meters
Climate Adaptation – Increasing Resiliency

• Link between climate change and key enterprise risks.
  ▪ Drought increases wildfire risk; sea level rise increases infrastructure integrity risk; extreme temperatures increase electricity supply risk.
  ▪ Relying on electricity alone increases energy system vulnerability.

• Increasing Resiliency:
  ▪ Just like buying stock, diversifying energy assets helps protect the overall system.
  ▪ Need variety of energy options to increase energy system resiliency.
  ▪ An all electric system places great risk to critical infrastructure in the event of climate change impacts
    ▪ E.g. Need a way to power hospitals and fire stations during power outages.
Protecting Customers from Outages: Distributed Generation

- Distributed generation technologies can isolate consumers from the electricity grid → protection from power outages.

- “Islandable”, black start energy sources that provide power separate from the vulnerabilities of the grid.

- Broader, diverse mix of energy sources increases energy system security and resiliency
Realizing California’s Renewable Energy Future

Power-to-Gas makes renewable feasible
Energy has to be available when people need it

Solar power generation dwindles right at the moment when electricity demand peaks.

Reliability means keeping our everyday lives predictable, every hour and every day.
We’re already producing a lot of wasted energy

Building more solar and wind farms leads to more over-production

Rather than cut back and curtail solar and wind, P2G gives us a way to store it
California needs renewable energy storage

...but batteries alone simply won’t cut it
Power-to-Gas gives California a practical way to store renewable energy
Power-to-gas
converts excess renewable electricity into renewable natural gas

excess renewable energy → goes through Electrolysis, which splits the molecule → hydrogen & carbon combine through methanization → methane can be stored in the pipeline for future use

carbon captured from factories and plants
P2G provides seasonal storage
But today

we’re behind Europe

- 70 Projects Now Launched In Europe
- 40 Projects Launched in Germany, with more in development
- 30 MW of installed capacity
To expand renewable energy we need renewable energy storage.

- Use Power-to-Gas technology for long-term renewable energy storage.
- Encourage the development of a Hydrogen and Renewable Natural Gas market.
- Support policies that will get Power-to-Gas projects up and running in California.
State Tools & Resources

Guido Franco
Team Lead for Climate Change and Environmental Research
California Energy Commission

Nuin-Tara Key
Resilience Program Manager
Governor’s Office of Planning and Research
Data Sets for Long-term Planning in California: Climate Change

Regional Workshop: Central Coast

Guido Franco
Team Lead for Climate Change and Environmental Research
California Energy Commission

December 10, 2018
Santa Cruz
• Background information and brief historical perspective
• Scenarios created for the Fourth Assessment: Cal-Adapt
• Sources of data
The California Energy Commission (CEC) has been developing climate scenarios for California for both research and long-term planning since 2003 (Franco et al., 2003). Every five or more years research centers around the world produce global climate scenarios for the IPCC Assessments, but they are not adequate for California because their geographical resolutions are too coarse and because, as expected, they have large biases for small topographically complex regions such as California.

Source: Pierce et al., 2018
Development of climate scenarios for California

- With the availability of each generation of new IPCC global climate scenarios, the CEC has supported the development of “downscaled” climate scenarios for California, adequate for both research (e.g., scientific papers for the 2006, 2009, 2012, 2018 California Assessments, Climatic Change) and for long-term planning (e.g., State Forestry Plan, State Water Plan, Integrated Energy Policy Report).

Source: Pierce et al., 2018
• Historical data in the RCPs end in 2005. It is possible, therefore, to compare projections that started in 2006 with actual emissions after 2005.
• Historical emissions after 2005 are following the RCP8.5 scenario.
Desire to make research results available at local scales

- In 2007 Dr. Amy Luers (then at Google) and I envisioned the creation of a system to make data sets created from CEC sponsored research available to the general public and managers at local scales.
- CEC and Google contributed $150K each to create CalAdapt. SEI developed a prototype using Google Earth to visualize climate data.
- The CA prototype was a resounding success and it was embraced by then Governor Schwarzenegger. He issued an Executive Order mandating the development of a full version of CalAdapt. GIF (UC Berkeley) was selected to make CalAdapt operational.
- Because the name CalAdapt was already in use, we changed the name to Cal-Adapt.
- Secretary Laird and CEC Chair Weisenmiler held a press event to announce the availability of Cal-Adapt (version 1).
- At that time Cal-Adapt may have been the only website in the USA that allowed easy access to climate projections at the local scales.
- The level of geographical resolution was about 7 miles.
• In between IPCC Assessments, when research centers around the world are improving their GCMs and/or producing new global climate projections for the IPCC, the CEC has supported enhancements of downscaling techniques (regional climate models).

• To address deficiencies of prior downscaling techniques used for the 2012 California Assessment, the CEC commissioned the development of LOCA.

• LOCA uses historical weather conditions that correlate with large atmospheric situations (analogs), relatively well simulated by GCMs to estimate temperature, precipitation, and other parameters at the local scale (grids/squares with sides ~ 3.7 miles). The use of analogs allows LOCA to be approximately physically realistic. LOCA includes a new advanced bias correction technique.

• LOCA provides information to a hydrological model known as the Variable Infiltration Capacity (VIC) model to estimate other parameters such as soil moisture, runoff, and snowpack levels.

• See the next slide for typical results for temperature and precipitation
CMIP5/LOCA predicted changes at Sacramento, CA

Historical 2030 2050 2090

Ann Precip (in)        RCP 4.5  7.4  18.4  32.3  7.6  18.7  34.5  7.1  18.4  36.3  6.5  18.8  38.3
                      RCP 8.5  7.4  18.4  32.3  7.4  19.2  34.4  7.3  18.7  35.4  5.8  19.5  37.6
Hottest Day (°F)      RCP 4.5  102  108  115  105  110  117  106  112  119  107  113  121
                      RCP 8.5  102  108  115  105  111  119  107  113  120  110  117  127

The three numbers are: typical lowest, mean, and typical highest yearly value

Source: From an early 2017 presentation by David Pierce
• The CEC is using these scenarios to estimate the official state electricity and natural gas demand forecasts that will be reported in the 2018 IEPR and future IEPRs.

• Executive Order B-30-15 directed state agencies to integrate climate change into all planning and investment, including accounting for current and future climate conditions in infrastructure investment.

• Executive Order B-30-15 also directed OPR to convene a Technical Advisory Group to develop guidance to support implementation of the Executive Order. The guidance indicates that State agencies should “work with regionally downscaled data from at least two of the four global climate models (GCMs) that have been prioritized for California’s Fourth Climate Change Assessment” and explicitly refers to the LOCA scenarios.

• The OPR guidance and the Fourth Assessment recommend using the RCP8.5 for impact and adaptation studies before ~ 2050.

• The 2016 IEPR also indicated the following:
  – Energy planning efforts should use the climate scenarios adopted for California’s Fourth Climate Change Assessment and follow the OPR guidance.
  – For sea level rise, energy planning should be conducted using guidance documents approved by the Ocean Protection Council (OPC).
Scenarios Developed for the Fourth Assessment
Results are available for 32 GCMs, but a technical advisory committee convened by the Department of Water Resources selected 10 of them as more suitable for California.

For the Fourth Assessment research groups were asked to prioritize four of the ten models because they more or less cover the range of the 10 models, and because most groups were not able to use more than a handful of models.

Temporal resolution: daily from 1950 to 2100 (1950 to 2005 historical simulations)

Two future global GHG emission scenarios (RCP4.5 and RCP8.5) from 2006 to 2100

Geographical resolution: ~ 3.7 miles

Main Parameters:
- Maximum and minimum daily temperatures
- Precipitation
- Relative humidity
- Solar radiation
- Wind speed
- Runoff
- Soil moisture
- Snow water equivalent
- Other variable
“Probabilistic” Sea Level Rise Scenarios

- Combination of expert opinion and numerical simulations to obtain the frequency of potential outcomes. They are not real probabilities in the statistical sense.
- The simulations consider potential high contributions from Antarctic to sea level rise.
- Potential sea level rise for 9 regions in California
- OPC issued a guidance document on what sea level rise scenarios to use for planning in California. Please consult this guidance document for planning work.

Source: Pierce et al., 2018
Common Wildfire Projections for Assessment

- **Wildfire Simulations for the Fourth California Climate Assessment.** Leroy Westerling, UC Merced
  - Statistical model trained with historical data up to 2013
  - Uses land use/land cover and climate projections developed for the Assessment
  - Projects substantial increases in area burned

### Mean Area Burned (hectares)

<table>
<thead>
<tr>
<th></th>
<th>1961-1990</th>
<th>2035-2064</th>
<th>2070-2099</th>
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<tbody>
<tr>
<td>Source: Westerling, 2018</td>
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</table>
The wildfire simulation used for the assessment suggests that extreme wildfires (e.g., 97.5th percentile) should be occurring under present conditions, in agreement with observations, and they could rise to unprecedented levels.
Costal Impact Scenarios

- The California Natural Resources Agency (CNRA) supported substantial refinements of the CoSMoS (Coastal Storm Modeling System) model by USGS for Southern California. USGS and their partners are extending the simulations with the new enhanced version of CoSMoS (version 3) to central and northern California.

- CoSMoS 3 is a sophisticated sea level rise, coastal storm and shoreline evolution model that considers wave action, movement of sand, cliff erosion, and other factors.

- The CEC supported UC Berkeley (Prof. Radke) to study the vulnerability of the natural gas and the petroleum systems. For this work Radke’s group used a three dimensional hydrodynamic model with high level or geographical resolution calibrated to observed tide gauge data.

http://data.pointblue.org/apps/ocoif/cms/
Accessed on 7/30/2018

CoSMoS 3
Prof. Alex Hall (UCLA) and his group are using a dynamic regional climate model known as the Weather Research and Forecasting (WRF) model.

UCLA is applying new downscaled climate projections, under funding by the CEC, to estimate the vulnerability of the natural gas system in an on-going project that is not part of the Fourth Assessment.

The CEC is providing funding to make some WRF modeling results available via Cal-Adapt.
Data scenarios availability
LOCA/VIC data Sets
(available in the public domain)

• Cal-Adapt aligns with a number of state guidance documents and presents only peer-reviewed data/information. The first version of Cal-Adapt was released in June 2011 and has been influential in educating the public and decision-makers about potential changes in our climate.

• Cal-Adapt provides access to the data throughout California, and provides value-added abilities to visualize and analyze the data.

• Cal-Adapt 2.0 was unveiled in 2018 and now includes the scenarios created for the Fourth Assessment.

• Further enhancements are taking place to be as useful as possible to the energy sector.

• The Strategic Growth Council (SGC) is partially supporting the addition of non-energy data sets and tools.
Cal-Adapt: one example

Projected annual number of extreme heat days in a Disadvantaged Community in Stockton

CENSUS TRACT ID 6077001900 (CES SCORE 64)
Emissions continue to rise strongly through 2050 and plateau around 2100 (RCP 8.5)

Four “priority” models suggest an order of magnitude end-of-century increase in number of very hot days (BAU).
Power users have other options to access data not only for California but also for outside California (e.g., WECC region).

- Lawrence Livermore National Laboratory: Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections (https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html). This is the best and easiest to use site from this list.
- NASA OpenNEX. The LOCA downscaling was done on NASA supercomputers, and the data is available from the NASA Earth Exchange (https://nex.nasa.gov/nex/static/htdocs/site/extra/opennex/).
- US Geological Survey Geo Data Portal provides THREDDS access to the data (https://owi.usgs.gov/blog/LOCAdownscaling/).
- Desert Research Institute (DRI) SCENIC (Southwest Climate and Environmental Information Collaborative https://wrcc.dri.edu/csc/scenic/). This site may be still under development.

The raw data set for California in NetCDF format is about 14 Terabytes which currently can be easily stored in relatively inexpensive storage units (<$1,000) but requires expertise in handling NetCDF files. Fast access requires more expensive storage units.
• Cal-Adapt provides access to coastal and wildfire data in California, and provides value-added abilities to visualize and analyze the data. Further enhancements are taking place to be as useful as possible to the energy sector. For sea level rise impacts a tool is being created to compare across different models (including CoSMoS).

• Cal-Adapt will include some basic access to the CoSMoS scenarios but more detailed information is available via the *Our Coast Our Future* (OCOF) website [http://data.pointblue.org/apps/ocof/cms/](http://data.pointblue.org/apps/ocof/cms/)

• USGS has created an outstanding analysis product known as HERA (Hazard Exposure Reporting and Analytics - [https://www.usgs.gov/apps/hera/](https://www.usgs.gov/apps/hera/)) that combines CoSMoS results with socio-economic and infrastructure data to show impacts in Google Earth and in tabular form.

• Additional visualizations and raw data from the coastal inundation projections created by Prof. Radke (UC Berkeley) are available from [http://keystone.gisc.berkeley.edu](http://keystone.gisc.berkeley.edu)
Questions

Guido Franco

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References


• Climate Action Team Research Working Group. 2017. Projected climate scenarios selected to represent a range of possible futures in California. Docketed 16-IEPR=04


• Pierce, D. W. and D. R. Cayan, 2015: Downscaling humidity with Localized Constructed Analogs (LOCA) over the conterminous United States. Climate Dynamics, DOI 10.1007/s00382-015-2845-1


• Westerling, Anthony Leroy. (University of California, Merced). 2018. Wildfire Simulations for the Fourth California Climate Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate. California ’s Fourth Climate Change Assessment, California Energy Commission (Forthcoming)
Nuin-Tara Key
Resilience Program Manager
Governor’s Office of Planning and Research

December 10, 2018
## Climate adaptation in California

### State policy landscape

**EO B-30-15**  
climate considerations in all state investment and planning decisions, entities under Executive Branch

**SB 379**  
Incorporate climate considerations in Safety element of General Plans

**SB 246**  
Integrated Climate Adaptation and Resiliency Program (ICARP), OPR & Adaptation Planning Guide, CalOES

**AB 1482**  
Safeguarding update every three years, CNRA

**AB 2800**  
Climate-Safe Infrastructure Working Group, CNRA

*Additional bills recently signed (SB 901, SB 1035, multiple insurance, etc.)*
EO B-30-15: State Agency Guidance

- Roughly 50 members
- Met from March 2016-January 2017
- Workgroups:
  - Scenarios
  - Community Development and Equity
  - Infrastructure
  - Metrics
- Product: Guidebook for State Agencies
  - What to plan for
  - How to plan differently
- Available online: [http://opr.ca.gov/docs/20171117-Building_a_Resilient_CA.pdf](http://opr.ca.gov/docs/20171117-Building_a_Resilient_CA.pdf)
SB 379: Local Planning Requirements

- Every City and County in CA required to have a General Plan
- Long-term vision for future growth and development
- 2017 Update, first inclusion of climate adaptation
- Suite of tools
  - Data Mapping Tool
  - Cal-Adapt
  - Adaptation Planning Guide
- Available online: http://opr.ca.gov/planning/general-plan/guidelines.html
Purpose
Coordinate state, tribal, local, and regional activities with a focus on local implementation

Cross-cutting objectives
Advance equity and environmental justice
Support an integrated approach to climate change (adaptation and mitigation)

Programmatic elements
Adaptation Clearinghouse
Technical Advisory Council
All Californians thrive in the face of a changing climate...

- **All people and communities** respond to changing average conditions, shocks, and stresses in a manner that minimizes risks to public health, safety, and economic disruption and maximizes equity and protection of the most vulnerable.
- **Natural systems** adjust and maintain functioning ecosystems in the face of change.
- **Infrastructure and built systems** withstand changing conditions and shocks, including changes in climate, while continuing to provide essential services.

ICARP Technical Advisory Council Vision Framework

http://opr.ca.gov/planning/icarp/tac/
RESOURCES: Vulnerability Assessments

Resource Guide for Defining Vulnerable Communities

http://www.opr.ca.gov/planning/icarp/vulnerable-communities.html
RESOURCES: Adaptation Clearinghouse

ICARP

Adaptation Clearinghouse

Explore the clearinghouse database to find resources on climate adaptation and resiliency efforts in California

Search for Resources
Implementation is taking place, but lags behind planning efforts...

Survey question on where jurisdiction is in adaptation process*

- Not begun = 10%
- Building understanding = 46%
- Planning = 29%
- Implementation = 15%

*Respondents, n = 230, self selected

Agencies face multiple “financing” challenges...

Survey question on perceived barriers to adaptation efforts – top four

- Lack of funding to implement
- Insufficient staff resources to analyze relevant information
- Current pressing issues are all consuming
- Lack of funding to prepare a plan


[https://resilientca.org/topics/investing-in-adaptation/](https://resilientca.org/topics/investing-in-adaptation/)

*OPR Adaptation Clearinghouse - Investing in Adaptation Topic Page*
• Need revenue stream if going to rely on financing mechanisms other than grants

• **Chapter 1**: Need to mainstream definitions – what are we working towards?
  ✓ Risk mitigation
  ✓ Resilience
  ✓ Adaptation
Chapter 2: Need to incorporate climate projections and uncertainty into standard accounting and disclosure processes, especially in asset management.

Figure 3: Balancing Adaptation Costs and Benefits/Avoided Losses

Adapted from IPCC (2014).
Funding sources covered

• Loans, Insurance & Incentives
• Taxes, Assessments, Charges & Fees
• Public Sector Grants, Loans, Insurance and Incentives

Chapter 3: survey of funding sources

• Local
• Public and private utilities
• State government
• Federal government
• Civic and private sectors
• Alternative funding models
Chapter 4: Standard assessment approaches to determining the right funding options
Example: City and County of San Francisco, Strategies for Funding the Seawall Resilience Project (2017)

Chapter 5: Ensuring investments in equitable outcomes
Example: Strong Prosperous and Resilient Communities Challenge (SPARCC), Capital Project Screen (2018)
Adaptation Planning Guide (APG)
Purpose

• Equip local and regional governments with the latest adaptation resources and planning methodologies
• Incorporate findings from the 2018 Safeguarding California Plan
• Integrate with the Adaptation Clearinghouse
  – including potential alignment with federal 5-step process on US Climate Resilience Toolkit
  – Develop a web-based tool
• Streamline with California’s Fourth Climate Change Assessment and other State climate documents
• Integrate with LHMP and other planning processes, which will ultimately lead to funding opportunities for implementation
Process/Timeline

Late 2018
- Collect public input
- Analyze feedback & compile list of needs
- Map out content-develop plan

Early 2019

Mid 2019
- Develop initial drafts
- Release 45-day public review draft
- Implement necessary changes

Late 2019
- Publish & promote finalized draft
- Development of a web application tool
- Build-out of online interface on Adaptation Clearinghouse
Stakeholder Input

- Seeking input from the government and community-based leaders in local and regional climate preparedness through:
  - Public workshops and webinars
  - APG update needs assessment survey on the Cal OES website

- Currently determining additional engagement channels to ensure end-users are included throughout the process
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• Sarah Risher
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THANK YOU!

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916.322.6079
Participant Discussions

1. What opportunities and resources can be leveraged to accelerate adaptation efforts in the Central Coast region?

2. What actions have you taken, or need to take, to increase staff capacity and improve coordination?
Networking Break

Next panel will begin promptly at 3:00 PM.
Accelerating Adaptation along the Central Coast

Monique Myers  
California Sea Grant

Anna Olsen  
Cachuma Resource Conservation District

Chris Read  
City of San Luis Obispo

moderated by Nuin-Tara Key | Resilience Program Manager, OPR
Thank You!

Central Coast Regional Climate Symposium