Climate Models from the Global to Regional Scale

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Earth and Planetary Sciences
Scales - temporal and spatial

- Weather models: high spatial resolution, and short temporal scale (days to weeks)
- Global climate models: low spatial resolution, long temporal scale (years to decades)
- Regional climate models: high spatial resolution, long temporal scale (years to decades)
Global Climate Models

- 3D representation of the climate system
- Various component models: land surface, dynamic ocean, sea-ice, atmospheric chemistry, carbon cycle
- Horizontal resolution typically > 1 degree
IPCC SRES Scenarios

Global GHG emissions (GtCO₂-eq/yr)

Year

2000 2100

post-SRES (max)

Global surface warming (°C)

Year

1900 2000 2100

post-SRES range (80%)

B1

A1T

B2

A1B

A2

A1FI

Year 2000 constant concentrations

20th century

B1  A1T  B2  A1B  A2  A1FI
Representative Concentration Pathways (RCPs) - The future of scenarios
Global Temperature Change (IPCC, 2007)
DJF Precipitation (A1B)
Regional Climate Models (RCMs)

- Also 3D, hydrostatic and non-hydrostatic
- Generally less component models than GCMs
- Cover limited areas of the Earth at higher than GCM resolution
Unique California

• Steep topographic gradients, a variety of microclimates
• Maritime influence confined to a relatively narrow band
• Balance of snow and rain critical to water resources
• High marine and terrestrial biodiversity
• Interaction of human and natural systems
DEM

250 km (GCM)  10 km (RCM)
Developing an Experiment

- Choice of domain location, extent, and spatial resolution
- Land cover from high resolution global datasets
- Choice of atmospheric forcing data, also called boundary conditions
Input to the RCM

• Atmospheric forcing data from GCMs or RCMs
  • 3D temperature, relative humidity, winds, geopotential height
  • 2D surface pressure, sea surface temperatures
• GHG concentrations from scenarios or observations (incl. carbon dioxide, methane, nitrous oxide)
Experiment Types

• Sensitivity experiment - change only one variable

• Transient experiment - many variables varying through time
CA Climate Change

- CEC Scenarios Project
- Probabilistic future climate scenarios using multiple models and downscaling methods
- Statistical and dynamical downscaling of global climate model (GCM) scenarios
Temperature change (1985-1994 to 2060-2069)
July Maximum Temperature - Cumulative Distribution Functions
January Minimum Temperature - Cumulative Distribution Functions
Precipitation change (1985-1994 to 2060-2069)
Maximum 3-day mean precipitation in a calendar year - Cumulative Distribution Functions
California Current upwelling response to future pCO2 increases & climate change

- Observations suggest that wind-driven upwelling along the coast of California has been increasing over the past 30 years
- The hypothesized cause for the increase is greenhouse gas forcing, leading to increased land-sea thermal contrast and intensified wind strength
- We test this hypothesis using surface winds from our regional model results
Coastal Wind-Driven Upwelling
Wind-Driven Upwelling Response to doubled CO$_2$

**RESULT:**
INTENSIFIED UPWELLING LATE IN THE SEASON, WEAKER UPWELLING EARLY IN THE SEASON

*Snyder et al., 2003*
Upwelling and Sea Surface Temperature: The Future?

Colder esp. late in the season (Stronger Upwelling)

Warmer all season (Weaker Upwelling)
Land Use Change - Irrigation and Urbanization

Kueppers, Snyder, and Sloan, GRL, 2007
Irrigation Cooling Effect - August
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