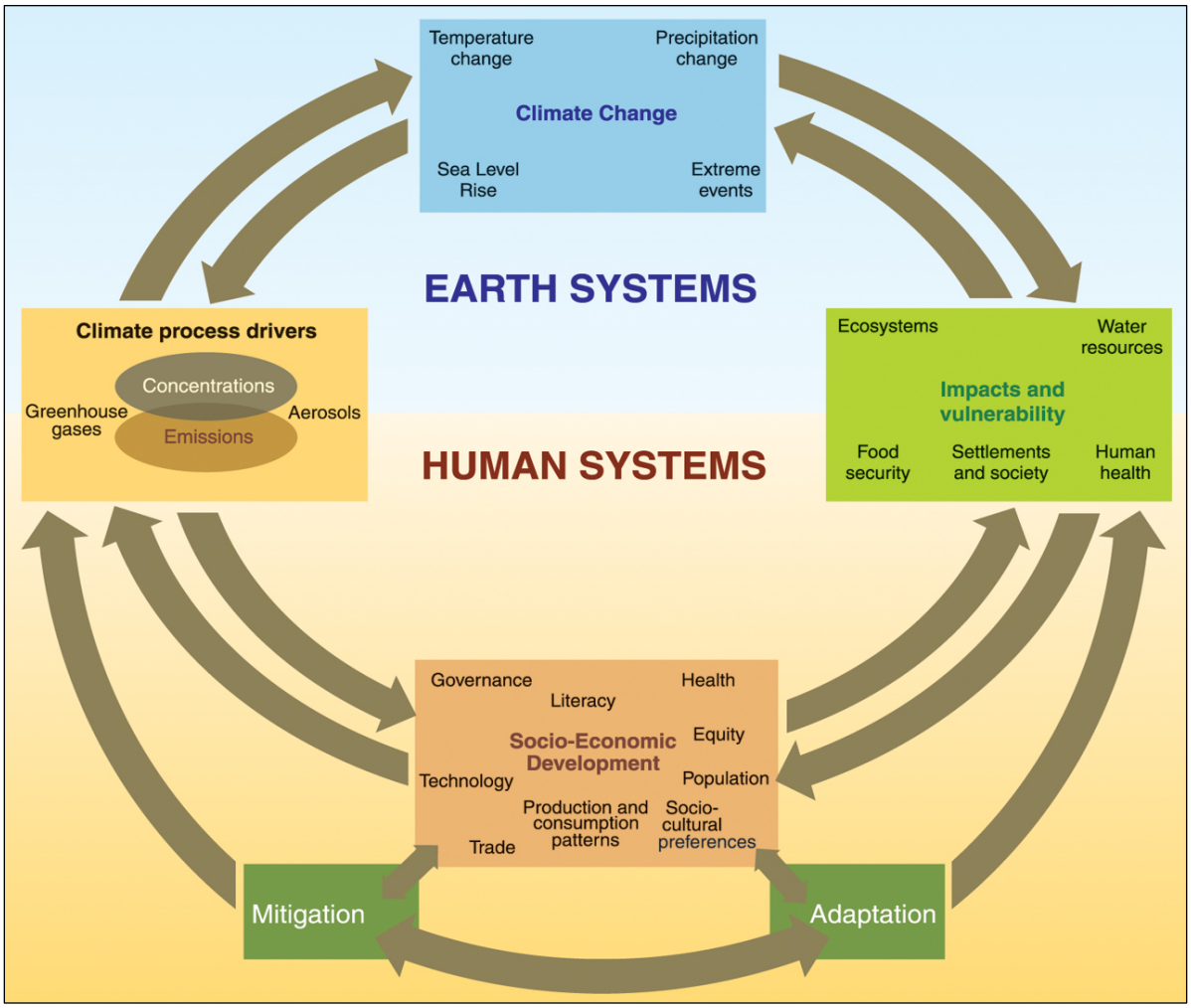
Summary from a symposium on coping with climate change in Sierran systems:
incorporating climate into land and resource management and developing adaptation strategies

The effects of climate change have been documented in numerous montane systems throughout the world, including the Sierra Nevada. Scientists are working to refine predictions about the extent of change and the resulting ecosystem impacts, but they are also working to develop strategies to adapt land and resource planning and management to these changes. The Tahoe Science Consortium organized a symposium in March 2009 to provide information relevant to the Lake Tahoe Basin forest and Lake Tahoe itself, with the specific objectives of

- Summarizing current information about the documented and predicted effects of climate change in the Sierra Nevada.
- Examining ways that scientists and managers are incorporating climate change into resource management.
- Presenting and discussing plausible adaptation strategies to cope with climate change.

Abstracts and information presented at the symposium are available at http://tahoescience.org/tsc_products/Products.aspx.

Figure from IPCC, AR4 Synthesis Report



Highlights from the symposium

Effects of climate change on Sierra Nevada meteorology and hydrology

- Although natural variability is great, scientists have evidence that regional meteorology and hydrology are changing in ways consistent with a warming climate.
- Regional weather patterns will continue to become more variable, with extreme events (e.g., droughts and floods) becoming more common.
- Generally, the precipitation belts are moving pole-ward and drier zones are expanding in the mid-latitudes.
- Regional hydrologic modeling suggests a continued decoupling of the hydrologic cycle from the normal growing cycle.

More information is available at http://www.globalchange.gov/ and http://www.wrcc.dri.edu/

Forest ecosystem management: conservation strategies for adapting to climate change

- There is a high correlation between increasing air temperatures (associated with global climate change) and the number of forest fires.
- Reducing the risk of severe wildfires may be the best practical strategy to deal with climate change.
- A highly variable forest structure is the best hedge to restoring/retaining a healthy forest that supports species of special concern.

Scientists have been working to develop and evaluate several potential adaptation strategies for managing forests in the face of climate change. These strategies include:

- Homeland security approach: defend high-value resources against the effects of climate change.
- Promote resilience: improve the capacity of the ecosystem to return to prior conditions.
- Enabling change: assist ecosystems to follow climate change (e.g., assisted migrations).
- Realigning system conditions: realign ecosystems to reflect conditions arising through natural variability and dynamics. (This applies to systems that are far outside the range expected from natural variability.)
- Reduce global climate change impacts: increase the natural capacity of forest ecosystems to sequester carbon.

More information is available at http://www.fs.fed.us/ccrc/ and http://www.fs.fed.us/psw/cirmount/.

Climate change and adaptation strategies for Lake Tahoe and its watershed

- A distinctive feature of Lake Tahoe is that vertical mixing can occur throughout the water column, which keeps the lake oxygenated down to its bottom.
- Lake Tahoe has been warming at a rate of 0.15ºC/decade, which increases thermal stratification of the lake (i.e., warm water on top and cold water on the bottom). Such stratification makes vertical mixing less likely to occur.
- Lake Tahoe has only mixed to the bottom in 10 out of the last 40 years. If the rate of lake warming continues, thermal stratification will strengthen and the lake may not mix to the bottom for decades at a time, leading to depleted oxygen levels at the bottom.
- Increased thermal stratification will also suppress nutrient exchange through the water column; a condition that would favor certain (low nutrient) species of phytoplankton. In particular, diatoms are expected to be replaced as lake mixing is reduced. Changes to the phytoplankton community would affect Lake Tahoe's ecology by altering the base of the food web and the light environment.
- Nearshore areas in Lake Tahoe are expected to warm by 1.5 – 2 ºC over the next 60 years. Such temperature increases would make the nearshore areas more suitable for colonization by aquatic invasive species and would increase the active growing and reproductive periods of those species.
- Climate change has affected the hydrologic characteristics of the Tahoe Basin watershed. The timing of the spring snowmelt peak is occurring earlier and continues to change at a rate of +0.42 days/yr.
- Meteorological and snow melt data suggest the Tahoe Basin is warming faster than the surrounding areas. Two hypotheses might explain this phenomenon: (1) local heat enhancement from the warming of the lake. (2) Reduction of the snow albedo (the extent to which snow can reflect sunlight) due to increased deposition of soot and other fine particles.
- California air basins are among the worst in the nation in terms of air pollution. Roughly half of the problem is due to weather, while the other half is due to emissions.

Science/information needs

- Making changes in policies, regulations, or management strategies can be difficult for agencies when uncertainty is high. Additionally, agencies have a hard time planning for changes in processes (e.g., planning to support processes leading to a highly variable forest structure, or changes in Lake mixing dynamics). The development of science-based decision support systems could help agencies to design "low-regrets" adaptation strategies that achieve objectives despite uncertainty.

- More research is needed to support the future design of hydrologic control structures. More variability in storm intensity or shifting from a snow-dominated to rain-dominated system may require different designs.
- Increasing our ability to predict the consequences of changes in weather and air pollution dynamics in the Tahoe Basin will require development of a basin-specific model. The model should be based on a 2-km grid system. Model simulations should be run on a 7-14 year time-step the capture the 7-year ENSO cycle.
- Agency and stakeholder representatives are challenged to keep up with the abundance of new information on the effects of climate change and adaptation strategies that are particularly relevant to the Lake Tahoe Basin. Scientists are encouraged to devote some effort to literature syntheses and summaries.