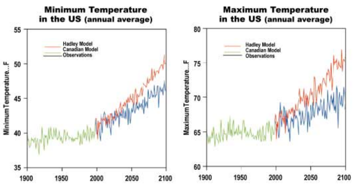
Past and Future US Temperature Change

Observations from 1200 weather stations across the US show that temperatures have increased over the past century, on average by almost 1°F (0.6°C). The coastal Northeast, the upper Midwest, the Southwest, and parts of Alaska have experienced increases in the annual average temperature approaching 4°F (2°C) over the past 100 years. The rest of the nation has experienced less warming. The Southeast and southern Great Plains have actually experienced a slight cooling over the 20th century, but since the 1970s have had increasing temperatures as well. The largest observed warming across the nation has occurred in winter.

Average warming in the US is projected to be somewhat greater than for the world as a whole over the 21st century. In the Canadian model scenario, increases in annual average temperature of 10°F (5.5°C) by the year 2100 occur across the central US with changes about half this large along the east and west coasts. Seasonal patterns indicate that projected changes will be particularly large in winter, especially at night. Large increases in temperature are projected over much of the South in summer, dramatically raising the heat index (a measure of discomfort based on temperature and humidity).

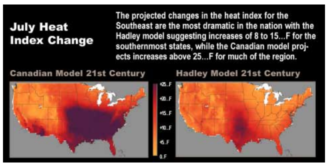
In the Hadley model scenario, the eastern US has temperature increases of 3-5°F (2-3°C) by 2100 while the rest of the nation warms more, up to 7°F (4°C), depending on the region.

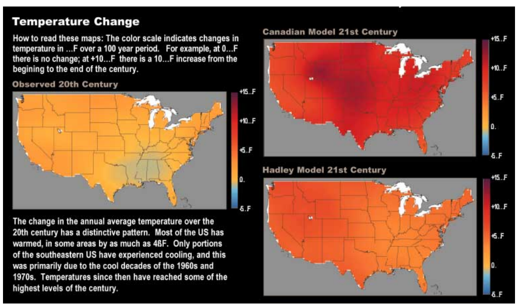
In both models, Alaska is projected to experience more intense warming than the lower 48, and in fact, this warming is already well underway. In contrast, Hawaii and the Caribbean islands are likely to experience less warming than the continental US, because they are at lower latitudes and are surrounded by ocean, which warms more slowly than land.



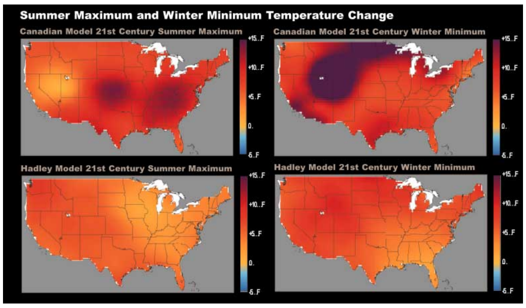
The annual average of minimum and maximum temperatures are compiled from the daily lows and highs. These graphs show the lows and highs, averaged over the year and over the lower 48 states. The green line shows observed temperatures while the red and blue lines are model projections for the future.

The minimum and maximum temperatures are important because, far more than the average, they influence such things as human comfort, heat and cold stress in plants and animals, maintenance of snowpack, and pest populations (many pests are killed by low temperatures; a rise in the minimum often allows more pests to survive).





Both the Canadian and Hadley model scenarios project substantial warming during the 21st century. The warming is considerably greater in the Canadian model, with most of the continental US experiencing increases from 5 to 15°F. In this model, the least warming occurs in the West and along the Atlantic and Gulf Coasts. In the Hadley model, annual temperatures are projected to increase from 3 to 7°F, with the largest warming occurring in the western half of the country.



Changes in Precipitation

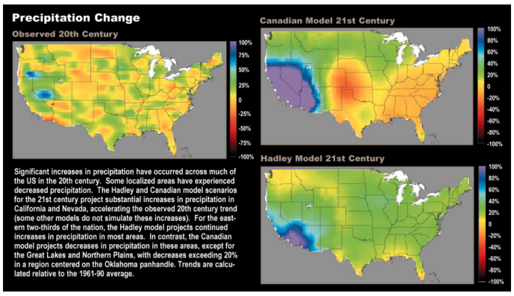
Average US precipitation has increased by 5-10% over the last century with much of that due to an increase in the frequency and intensity of heavy rainfall. Precipitation increases have been especially noteworthy in the Midwest, southern Great Plains, and parts of the West and Pacific Northwest. Decreases have been observed in the northern Great Plains.

For the 21st century, the Canadian model projects that percentage increases in precipitation will be largest in the Southwest and California, while east of the Rocky Mountains, the southern half of the nation is projected to experience a decrease in precipitation. The percentage decreases are projected to be particularly large in eastern Colorado and western Kansas, and across an arc running from Louisiana to Virginia. Projected decreases in precipitation are most evident in the Great Plains during summer and in the East during both winter and summer. The increases in precipitation projected to occur in the West, and the smaller increases in the Northwest, are projected to occur mainly in winter.

In the Hadley model, the largest percentage increases in precipitation are projected to be in the Southwest and Southern California, but the increases are smaller than those projected by the Canadian model. In the Hadley model, the entire US is projected to have increases in precipitation, with the exception of small areas along the Gulf Coast and in the Pacific Northwest. Precipitation is projected to increase in the eastern half of the nation and in southern California and parts of Nevada and Arizona in summer, and in every region during the winter, except the Gulf States and northern Washington and Idaho.

In both the Hadley and Canadian models, most regions are projected to experience an increase in the frequency of heavy precipitation events. This is especially notable in the Hadley model, but the Canadian model shows the same characteristic.

While the actual amounts are modest, the large percentage increases in rainfall projected for the Southwest are related to increases in atmospheric moisture and storm paths. A warmer Pacific would pump moisture into the region and there would also be a southward shift in Pacific Coast storm activity. In the Sierra Nevada and Rocky Mountains, much of the increased precipitation is likely to fall as rain rather than snow, causing a reduction in mountain snow packs. This would tend to increase wintertime river flows and decrease summertime flows in the West. Across the Northwest, and the central and eastern US, the two model projections of precipitation change are in less agreement. These differences will be resolved only by improvements in climate modeling.



Changes in Soil Moisture

Soil moisture is critical for both agriculture and natural ecosystems. Soil moisture levels are determined by an intricate interplay among precipitation, evaporation, run-off, and soil drainage. By itself, an increase in precipitation would increase soil moisture. However, higher air temperatures will increase the rate of evaporation and, in some areas, remove moisture from the soil faster than it can be added by precipitation. Under these conditions, some regions are likely to become drier even though their rainfall increases.

In fact, soil moisture has already decreased in portions of the Great Plains and Eastern Seaboard, where precipitation has increased but air temperature has risen.

Since soil moisture projections reflect both changes in precipitation and in evaporation associated with warming, the differences between the two models are accentuated in the soil moisture projections. For example, in the Canadian model, soil moisture decreases of more than 50% are common in the Central Plains due to the combination of precipitation reductions exceeding 20% and temperature increases exceeding 10°F. In the Hadley model, this same region experiences more modest warming of about 5°F and precipitation increases of around 20%, generally resulting in soil moisture increases.

Increased drought becomes a national problem in the Canadian model. Intense drought tendencies occur in the region east of the Rocky Mountains and throughout the Mid-Atlantic-Southeastern states corridor. Increased tendencies toward drought are also projected in the Hadley model for regions immediately east of the Rockies. California and Arizona, plus a region from eastern Nebraska to Virginia's coastal plain, experience decreases in drought tendency. The differences in soil moisture and drought tendencies will be significant for water supply, agriculture, forests, and lake levels.