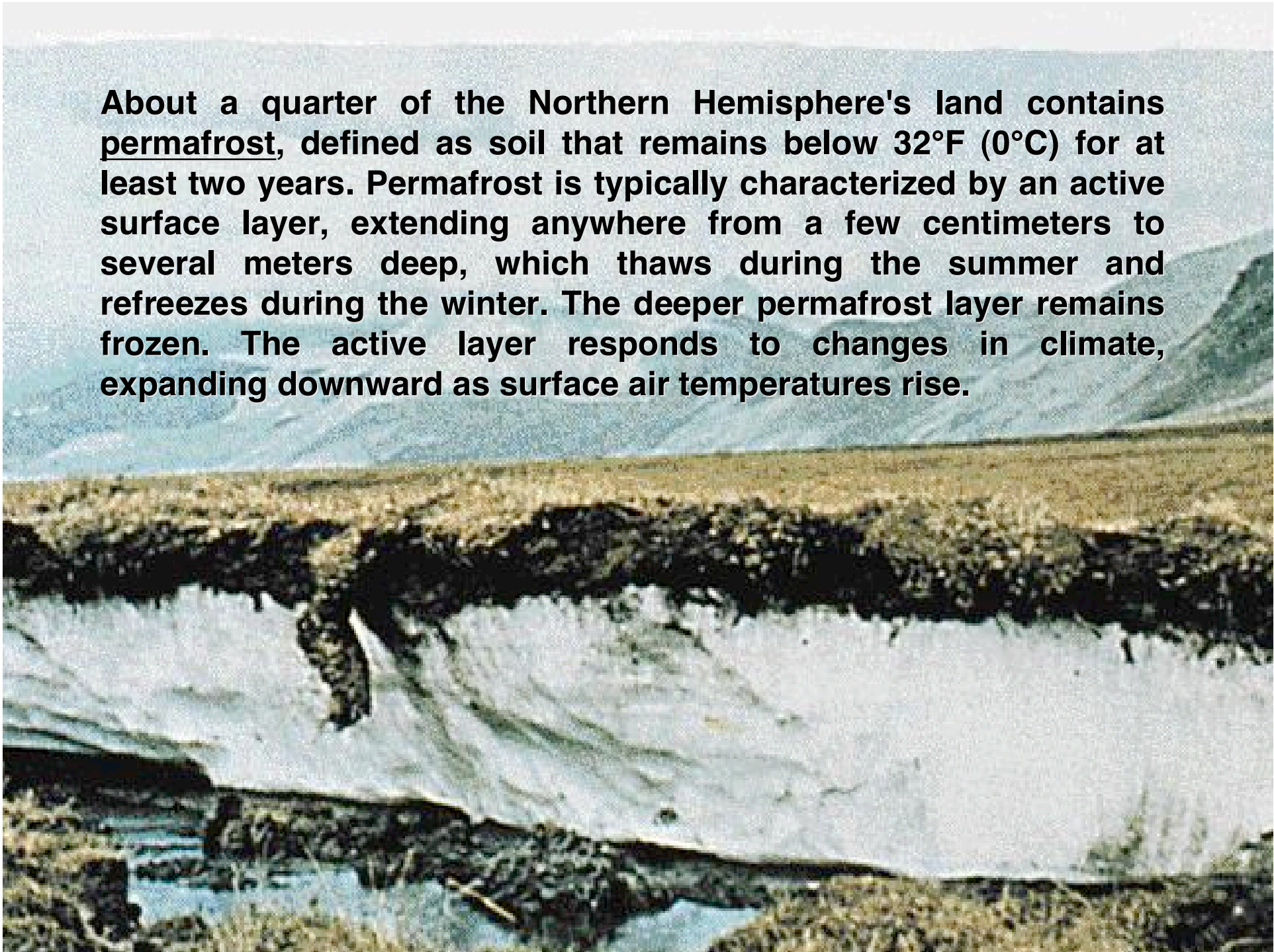



A photograph of a snowy mountain landscape. The foreground is a vast, snow-covered field with some tracks. In the middle ground, there are snow-covered hills and a line of evergreen trees. In the background, a large, dark mountain range is visible under a bright, clear sky with a sun in the upper left corner.

lecture 12

**Regional climate change:
The Arctic and California**

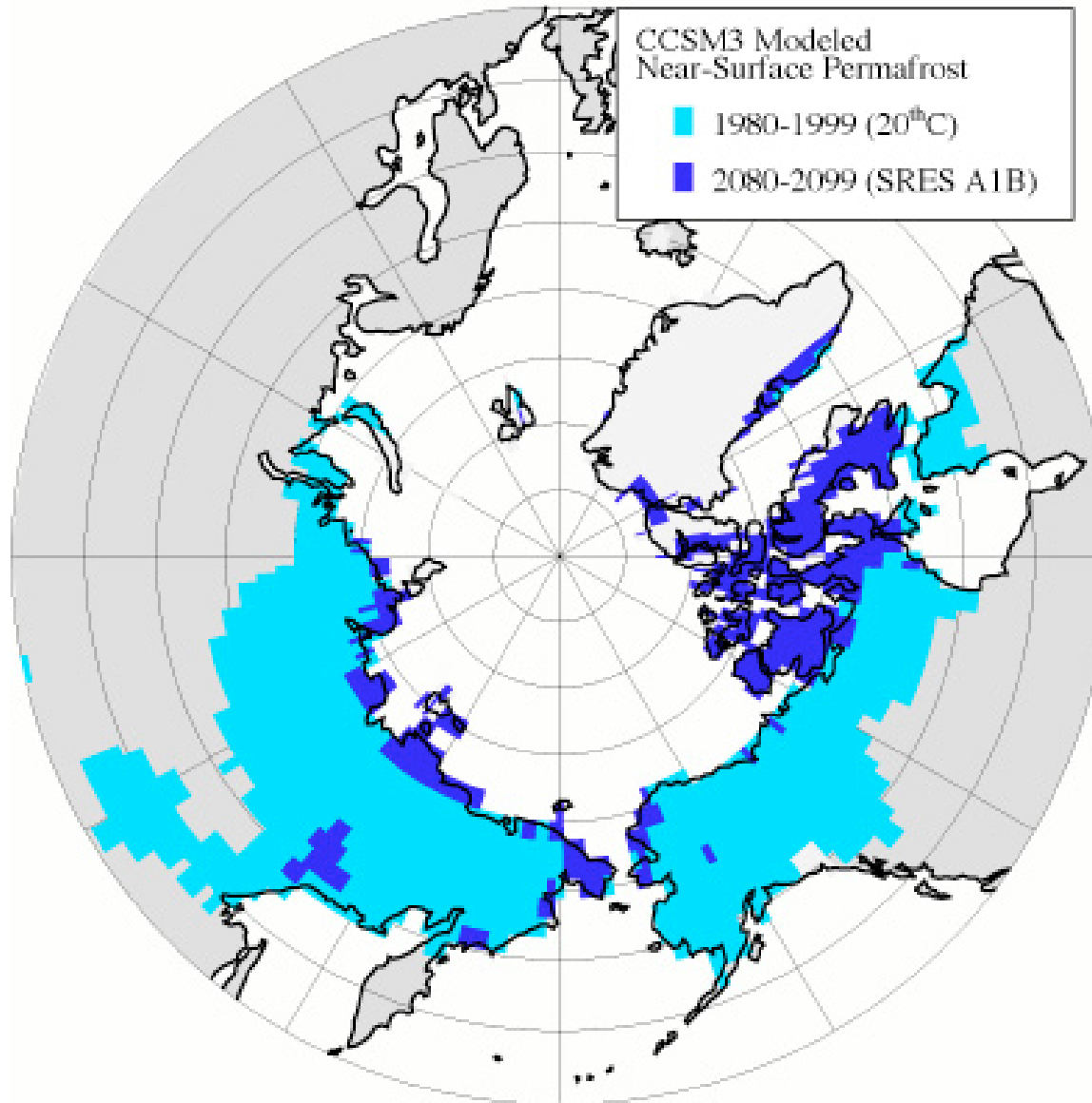
About a quarter of the Northern Hemisphere's land contains permafrost, defined as soil that remains below 32°F (0°C) for at least two years. Permafrost is typically characterized by an active surface layer, extending anywhere from a few centimeters to several meters deep, which thaws during the summer and refreezes during the winter. The deeper permafrost layer remains frozen. The active layer responds to changes in climate, expanding downward as surface air temperatures rise.



A photograph showing two children, one in a blue hooded jacket and the other in a red hooded jacket, standing on a dirt mound. In the foreground, there is a large, dark sinkhole that has formed in the ground. The background shows a road and some trees under a cloudy sky.

Recent warming has degraded large sections of permafrost across central Alaska, with pockets of soil collapsing as the ice within it melts. The results include buckled highways, destabilized houses, and "drunken forests"—trees that lean at wild angles. In Siberia, some industrial facilities have reported significant damage. Further loss of permafrost could threaten migration patterns of animals such as reindeer and caribou.

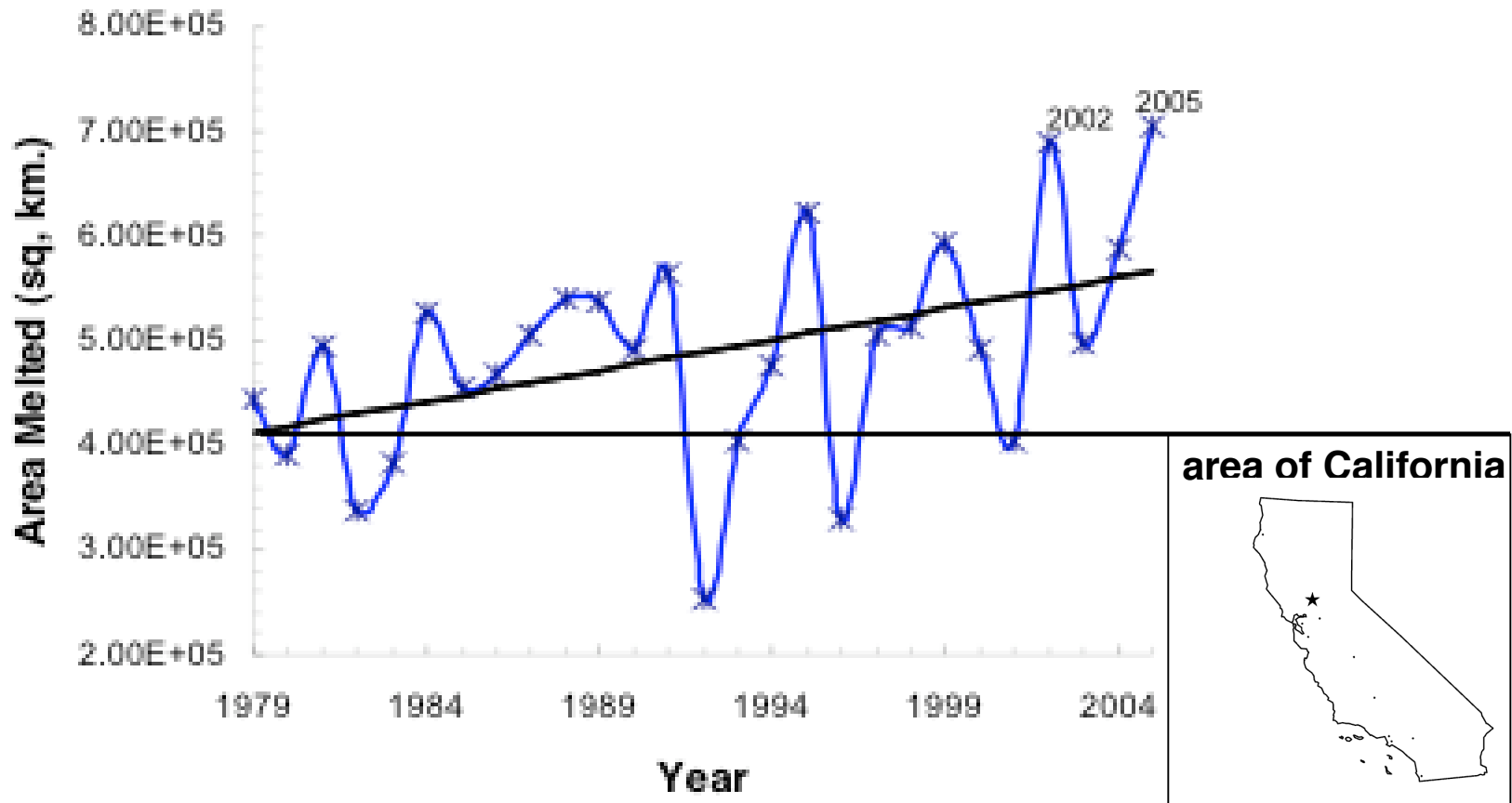
This sinkhole near Fairbanks, Alaska, formed due to the melting of a large ice pocket within permafrost that is gradually thawing as temperatures warm. (Photo courtesy Vladimir Romanovsky, Geophysical Institute, University of Alaska Fairbanks.)



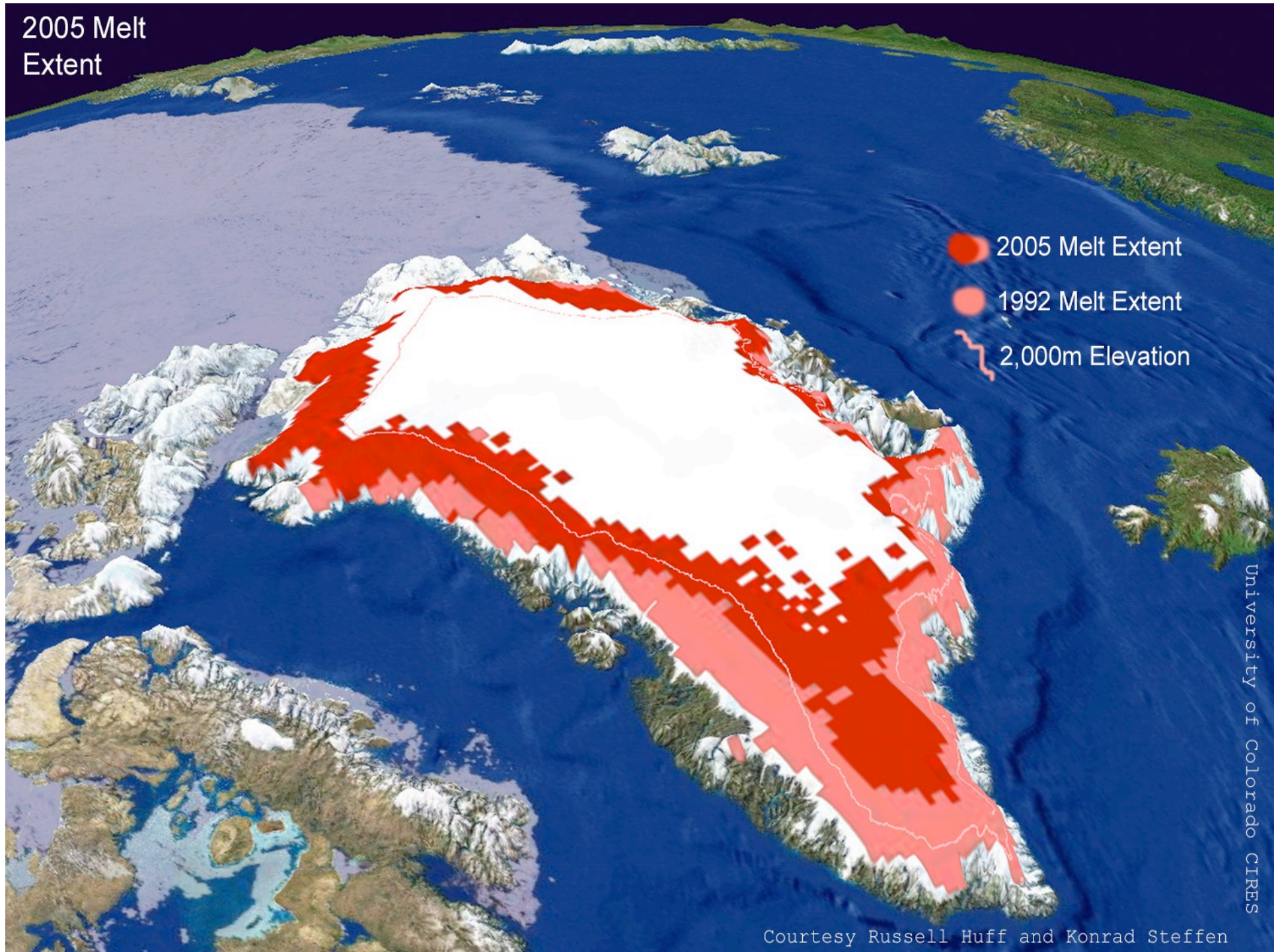
Regions containing permafrost within the top 11 feet of soil could decrease by as much as 90% across the Arctic over the next century, based on simulations by the NCAR Community Climate System Model. Shown are areas with near-surface permafrost in the CCSM simulations for 1980-1999 (light blue) and 2080-2099 (dark blue). The latter projection is based on the UN Intergovernmental Panel on Climate Change's A1B emissions scenario, often called the "business as usual" scenario. (Image courtesy David Lawrence.)

From space, we can monitor the melting areas of the worlds major ice sheets. The melting of Greenland is accelerating...

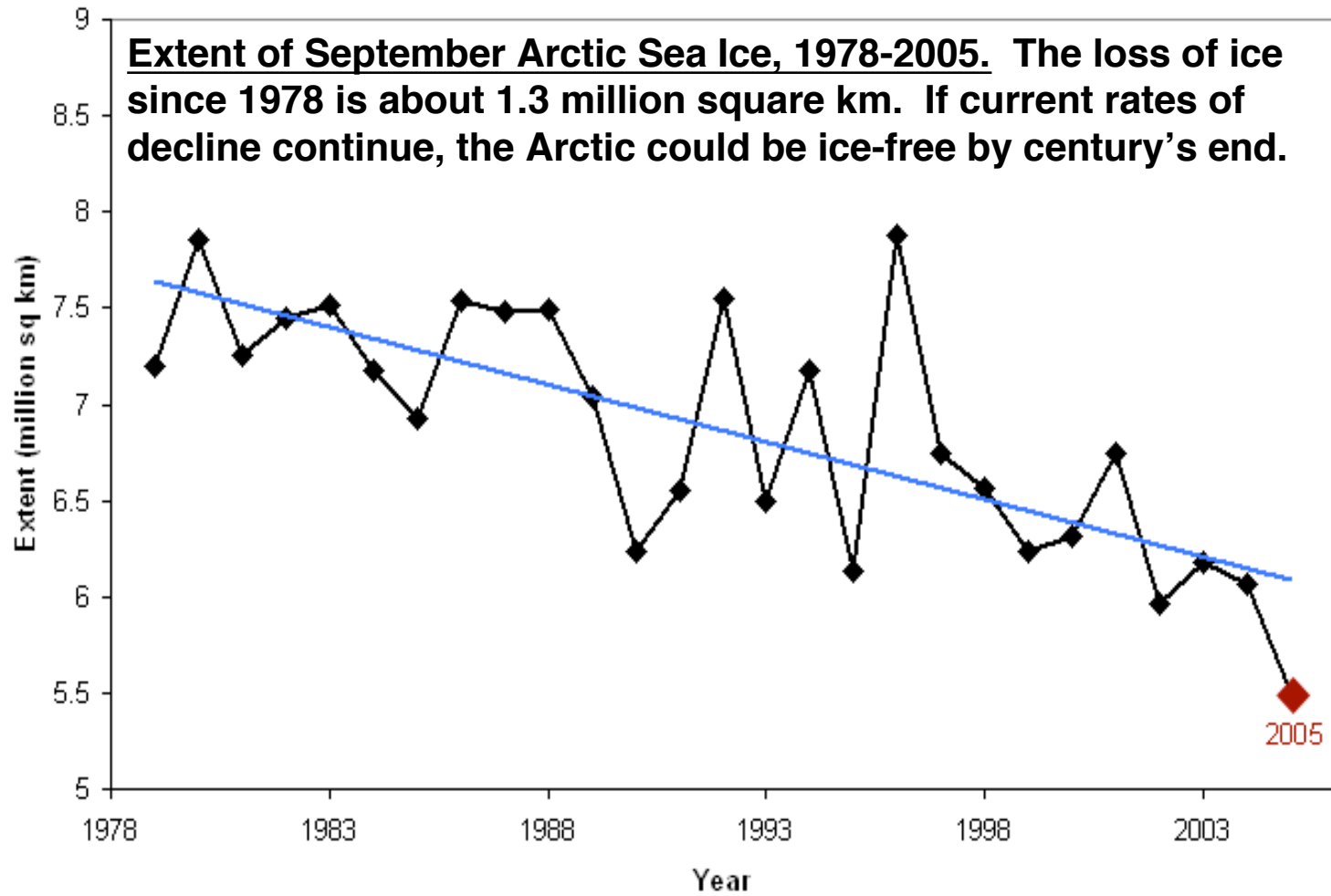
**Extent Experiencing at Least 1 Melt Day
April - September 25**



2005 Melt Extent



Extent of September Arctic Sea Ice, 1978-2005. The loss of ice since 1978 is about 1.3 million square km. If current rates of decline continue, the Arctic could be ice-free by century's end.



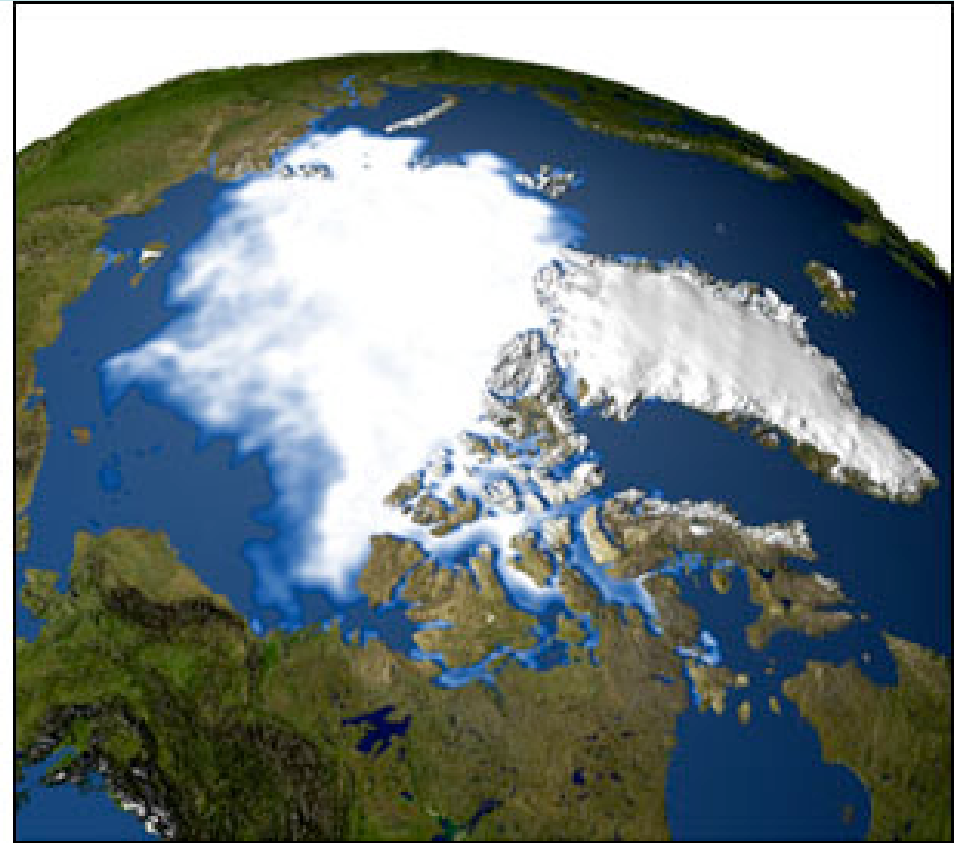
1.3 million square km =



Arctic researchers see early warming signals



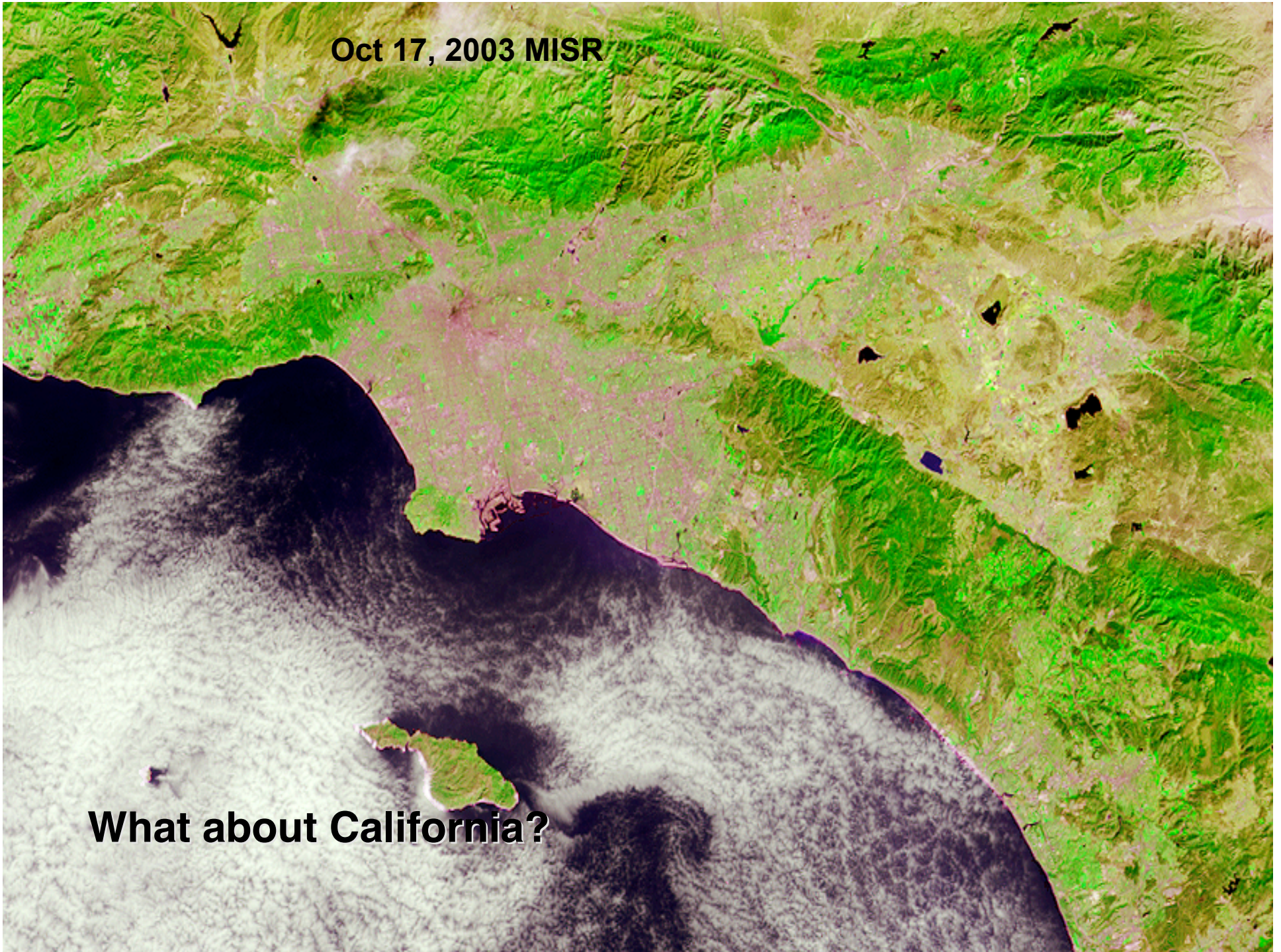
1979



2000

Based on satellite data, these images show summertime Arctic sea ice. The ice cover shrunk by about 20 percent over that time.

Oct 17, 2003 MISR



What about California?

The Union of Concerned Scientists recently published an assessment of climate change in California.

They based their assessment on the results from two global climate models, one with a relatively low sensitivity to CO₂ doubling (PCM), and the other with a relatively high sensitivity (HADCM3).

They looked at outcomes in California for two scenarios. One is “business as usual” scenario, that envisages fossil fuel emissions increasing at approximately the same rate as present for the remainder of the 21st century. The other is a lower emissions scenario, where emissions continue to increase but at a lower rate, stabilizing around 2050, then declining to levels below the present level by 2100.

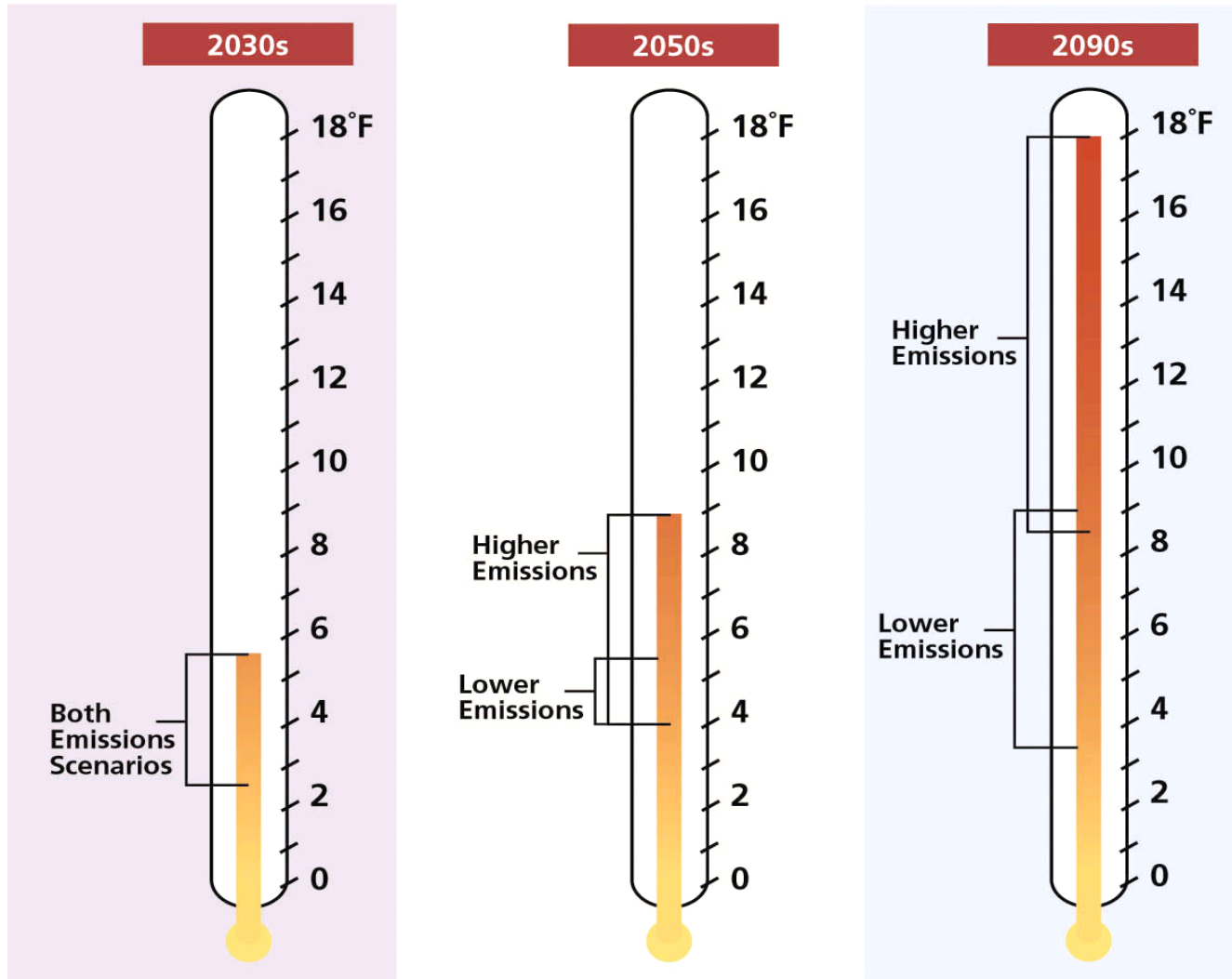
There are therefore two scenarios for each model, giving a range of possible outcomes for California.

The global models’ resolutions are on the order of 200 km. Regional details have been supplied by a regional climate model.

Rising Temperatures

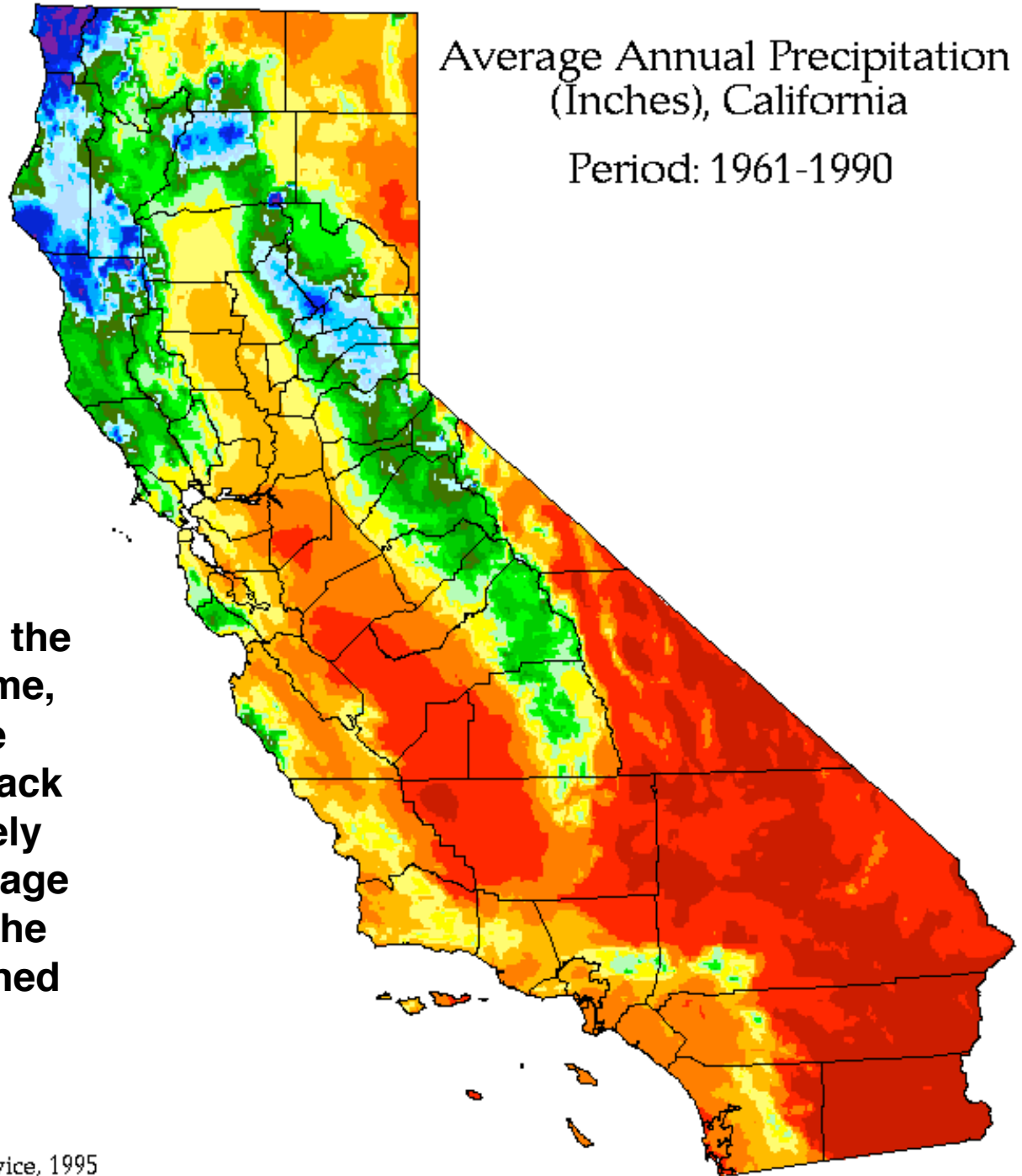
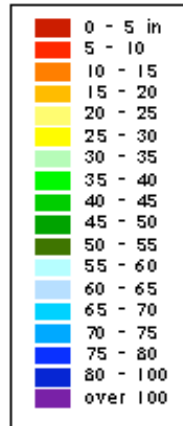
California statewide

Projected average summer temperature changes



Source: A Luers/Union of Concerned Scientists

Average Annual Precipitation
(Inches), California
Period: 1961-1990



Most precipitation over the Sierras falls in wintertime, where it is stored in the snow pack. The snowpack comprises approximately half the total water storage capacity of California, the other half being contained mainly in human-made reservoirs.

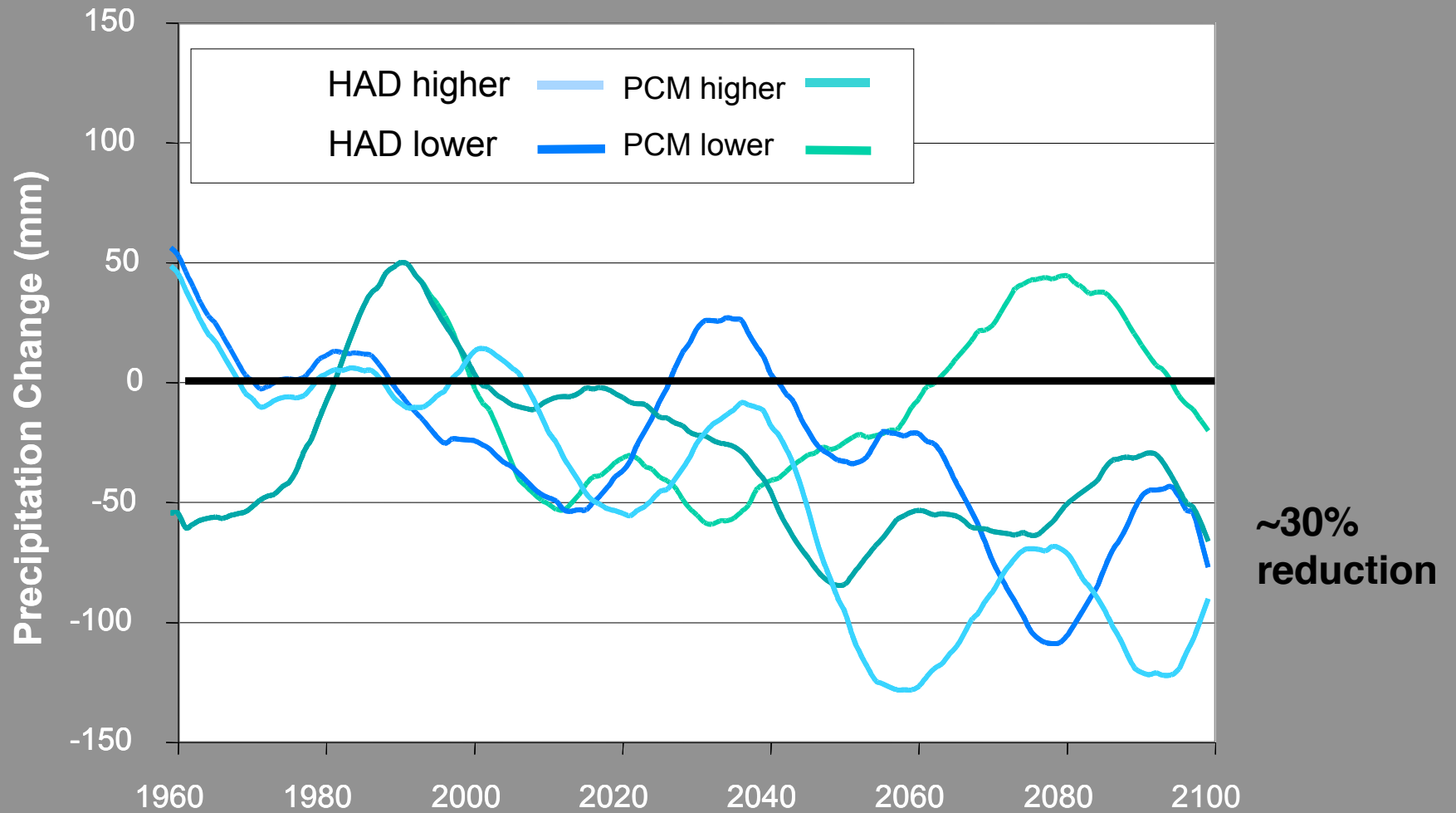


As the snow melts, water flows to reservoirs, where it makes its way through aqueducts to agricultural and urban areas.

This shows aqueducts for water resource re-distribution in California

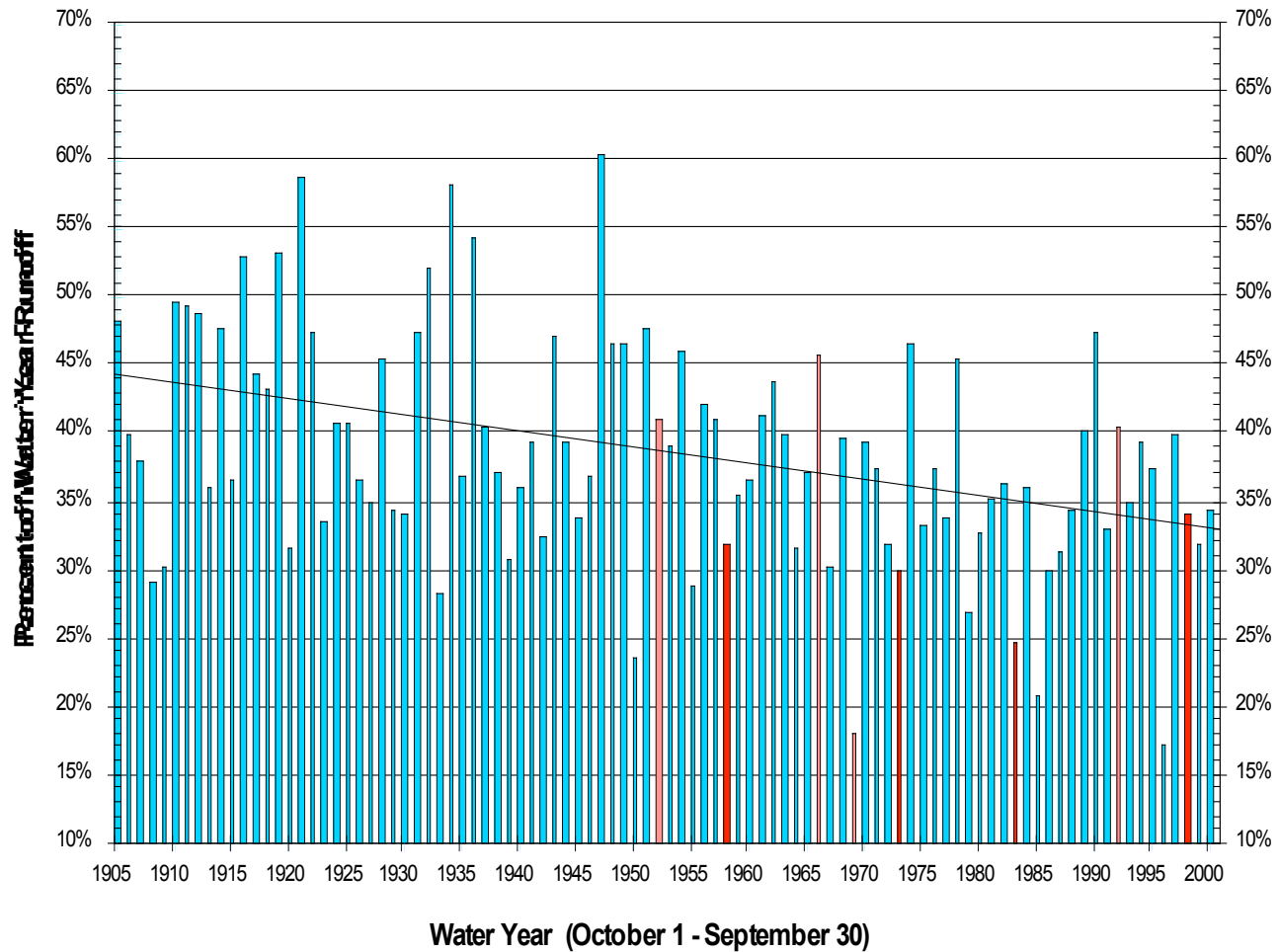
Precipitation Projections

Statewide, Winter



Source: A Luers/Union of Concerned Scientists

The Sierra snow pack has been steadily shrinking over the past century...



***Sacramento River Runoff (1906-2001)
April to July as a Percent of Total Runoff***

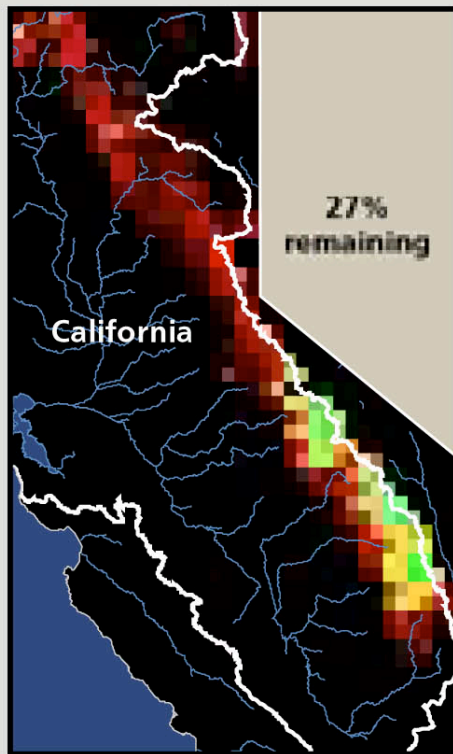
Source: California Protection Agency, Environmental Protection Indicators for California, 2001

Diminishing Sierra Snowpack

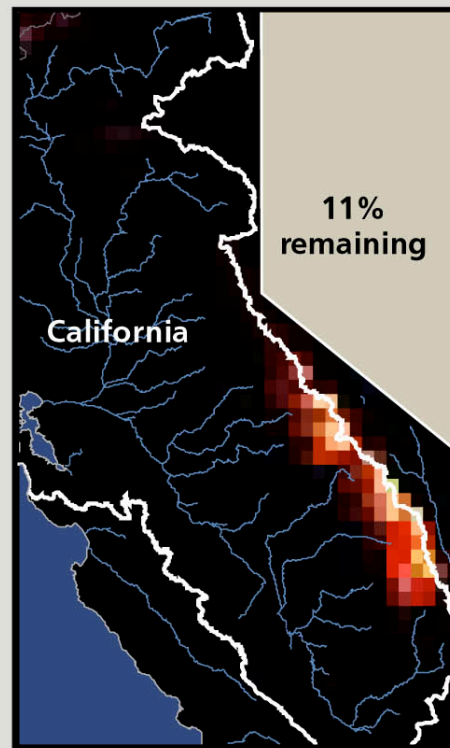
% Remaining, Relative to 1961-1990

2070-2099

Lower Emissions



Higher Emissions



This shows how the more sensitive global model projects snowpack to change in the Sierras.

The change in snowpack is significant because it comprises approximately half the total water storage capacity of California, the other half being contained mainly in human-made reservoirs.

Remaining Snowpack (%)



Source: A Luers/Union of Concerned Scientists

Decreasing Wine Grape Quality

Temperature Impacts

	1961-1990	2070-2099			
	Current Conditions	LOWER (B1)		HIGHER (A1fi)	
		PCM	HadCM3	PCM	HadCM3
Wine Country	Optimal (mid)	Impaired	Marginal	Impaired	Impaired
Cool Coastal	Optimal (low)	Optimal (mid-high)	Optimal (mid-high)	Optimal (high)	Impaired
Northern Central Valley	Marginal	Impaired	Impaired	Impaired	Impaired

Wine Country (Sonoma, Napa Counties)

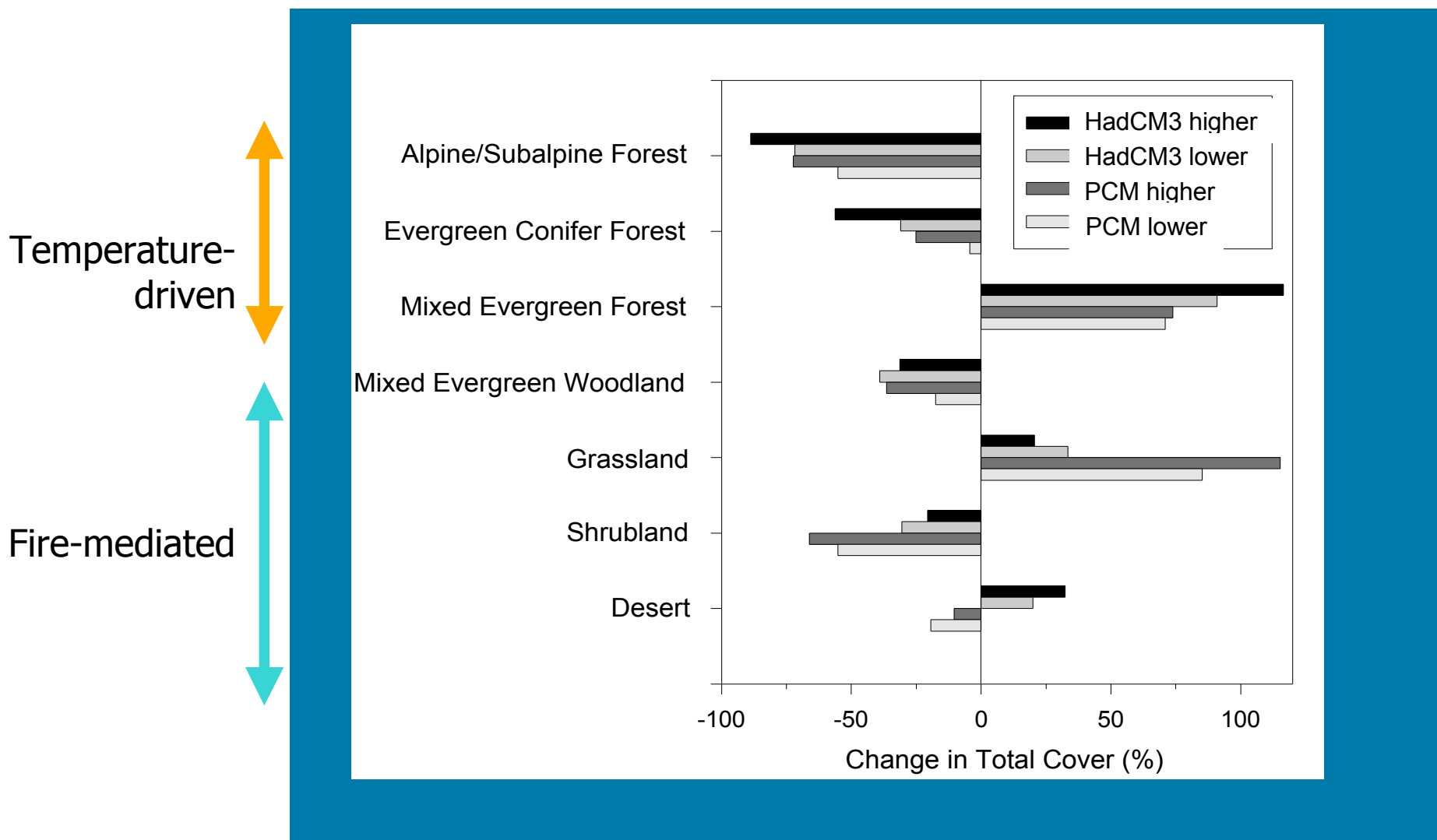
Cool Coastal (Mendocino, Monterey Counties)

Northern Central Valley (San Joaquin, Sacramento Counties)

Source: A Luers/Union of Concerned Scientists

Changes in Vegetation Distribution

2070-2099, relative to 1961-1990



Source: A Luers/Union of Concerned Scientists