

From:



Focus on Climate Change

Western Ground Water and Climate Change—Pivotal to Supply Sustainability or Vulnerable in Its Own Right?

by Michael Dettinger, U.S. Geological Survey, La Jolla, California;
and Sam Earman, Desert Research Institute

The NGWA policy statement on ground water and global climate change (www.ngwa.org/ngwainwashington/climatechange.cfm) outlines several current and potential impacts of climate change on water supplies and concludes that ground water will be pivotal to sustainable water supplies because of its capacity to balance large swings in precipitation and demand. The impacts discussed include reductions in snowpacks, changes in precipitation, sea level rise, warming surface waters, and changes in water demand. However, in the western United States, other important challenges also face ground water science and management communities because climate change may impact ground water supplies directly and indirectly, in ways that have, to date, been largely unexplored.

Current climate change projections are unanimous in predicting warming across the United States, with most ranging from about +3° to +6°C. Projected precipitation changes are more complicated, with some consensus developing toward modestly wetter conditions in the northern tier of states and modestly drier conditions in the southwesternmost states, but with relatively small changes of uncertain sign in the regions between these projections (conclusions by the authors from analyses of projections used in IPCC 2007). Based on these projections, the impacts of warming—the more confident of the projections—on water supplies, including ground water, are urgently in need of assessment. Warming will likely reduce runoff generation, whether precipitation increases or decreases, because of attendant increases in the potential for evapotranspiration.

Due to the parallels between such runoff declines and historical droughts, it has been natural to envision ground water as a safeguard against climate change. However,

the same tendency for ground water to respond more to slow climate fluctuations than to fast ones (Changnon 1987, Dickinson et al. 2004) makes ground water an attractive option during droughts. This could also mean that ground water will respond more strongly to the comparatively slow trends associated with climate change than to isolated droughts. The linkages between climate and ground water are inherently complex. In anticipation of unprecedented times ahead, some of those intuitions need to be reassessed.

There are likely many different ways that warming may influence ground water supplies. One particular concern in the western United States is warming's effects on snowpacks. In the West, because mountains are generally wetter and cooler than adjacent basins, most ground water is derived from mountain precipitation. Some recharge occurs in place in mountain recharge areas, sustaining important surface water base flows and cooler water temperatures. Recharge also occurs by infiltration where runoff crosses from mountain blocks onto abutting fans and alluvium or onto basin floors.

A growing tide of studies is showing that snowmelt provides more mountain recharge than rain does in western settings (Earman et al. 2006). This is probably because large and intense infiltration is required to break through the region's thick unsaturated zones. Additionally, snowpacks store and then release precipitation from several storms at once. Studies in the Great Basin indicate that 50% to 90% of the recharge there originates from snowmelt (Winograd et al. 1998).

Recharge-temperature analyses based on dissolved gases show that recharge in the central part of the Chiricahua Mountains, Arizona, is derived only from altitudes above seasonal snowlines and not

from lower altitudes (Earman and Phillips 2003). Geochemical hydrograph separations in the highest basins of the Rockies demonstrate that, even during the peak snowmelt, 60% or more of the streamflow is supplied by ground water (Liu et al. 2004). On the other hand, recharge from streamflow infiltration through fans and basin floors depends on large, rapid, but generally infrequent, outflows of runoff from the mountains onto surrounding fans and basins. The mix of mountain vs. fan and basin recharge presumably varies from basin to basin and from year to year, but these variations are poorly understood in most of the West.

As the region has warmed in recent decades (Cayan et al. 2001), precipitation has occurred more frequently as rain rather than snow (Knowles et al. 2006) and snowpacks have thinned (Mote 2003). If warming continues, snowline elevations are expected to rise. If this happens, mountain recharge may also be expected to decline, because recharge areas will shrink and the amount of snowmelt available to infiltrate at any one time will dwindle. Using the University of Washington's VIC model (Maurer et al. 2002), recent simulations by the authors of near-surface water budgets in the western mountains, with and without warming, suggest that the partitioning of net precipitation between surficial runoff and subsurface runoff may respond to warming with declines in subsurface runoff of as much as 50%. We conjecture that the declines would, most likely, be reflected also in ground water recharge declines.

On the other hand, another simulated result of warming in the western mountains is relatively more surficial runoff. Declines in mountain recharge triggered by loss of snowpack would have immediate impacts on mountain water resources, including low flows and stream temperatures, and may also have serious impacts on long-term ground water supplies in surrounding basins through reductions in mountain recharge. Although recharge that supplies mountain ground water may decline, much of this uncharged water may run off onto the region's fans and basins and potentially increase recharge on fans and basin floors. However, if the uncharged water is instead mostly evapotranspired from the mountain soils, the overall recharge (mountain plus basin) may decline.

At present, whether the overall recharge will increase, decrease, or stay the same is unknown at any scale in the West. Similarly, the impacts to ground water supplies due to changed conditions of the location and timing of recharge are also insufficiently understood.

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Given ground water's crucial role, the potential impacts of warming on recharge deserve more attention than it has received to date. It is possible that ground water supplies will fare well, overall, in a warming world, but they may also fare poorly. The projected climate changes are unprecedented in the modern era, and we lack the tools and data (e.g., long-term continuous monitoring of recharge processes) to confidently detect or predict ground water responses to climate.

In a world with a changing climate, our intuition and ground water science's traditional focus on long-term average conditions may fail to recognize, predict, and alert us to significant changes in ground water supplies. Monitoring commitments like the USGS's national-scale Ground-Water Climate-Response Network are a start (<http://groundwaterwatch.usgs.gov/>), but that network's focus on ground water level variations from days to years needs to be extended beyond ground water level fluctuations to the full range of ground water issues and processes on multi-decadal time scales. Otherwise, changes may come from unexpected directions to ground water managers and users.

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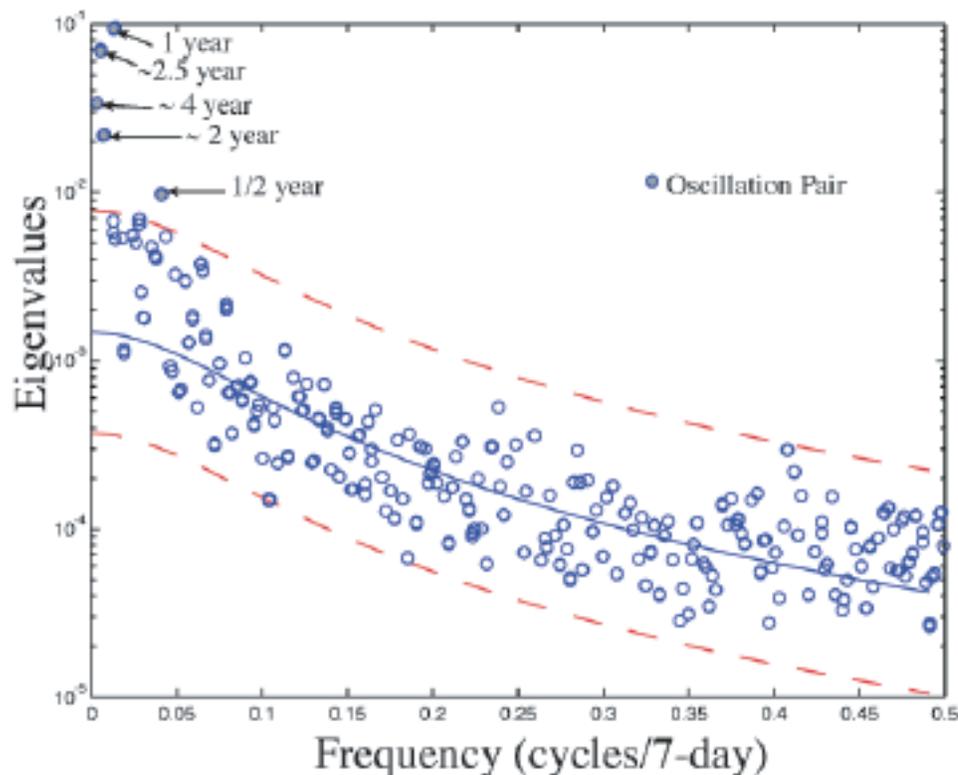


Figure 2b. The eigenspectrum for one observation well plotted versus frequency in cycles/7 days.

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so that it includes the role of ground water resources.

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