Relationship between Satellite-Derived Snow Cover and Snowmelt-Runoff Timing in the Wind River Range, Wyoming

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MODIS-derived snow cover measured on 30 April in any given year explains ~89% of the variance in stream discharge for maximum monthly streamflow in that year. Observed changes in streamflow appear to be related to increasing maximum air temperatures over the last four decades causing lower spring snow-cover extent.

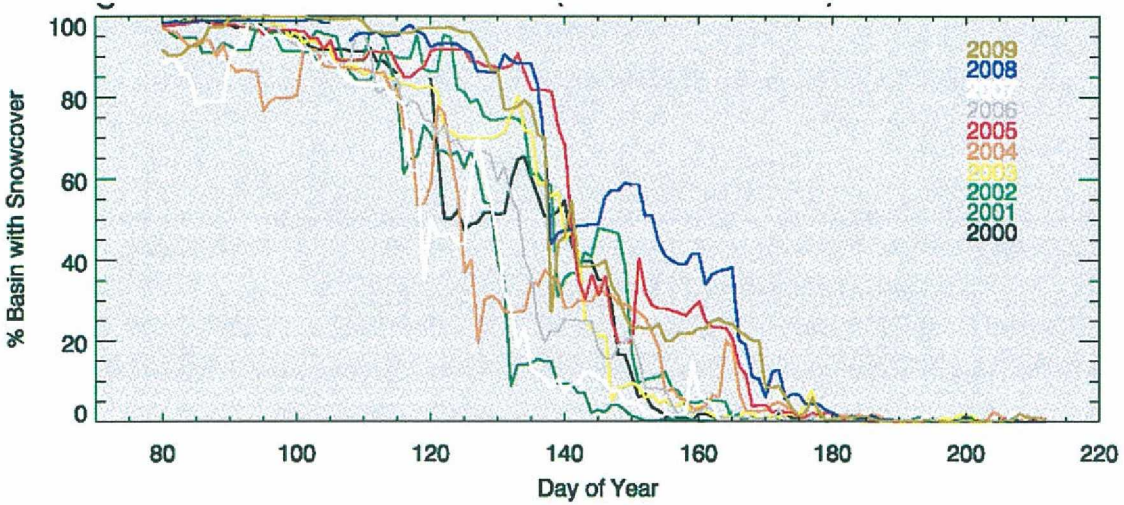

Figure 1: Snow-cover depletion curves from the MODIS cloud-gap-filled (CGF) 500-m resolution product

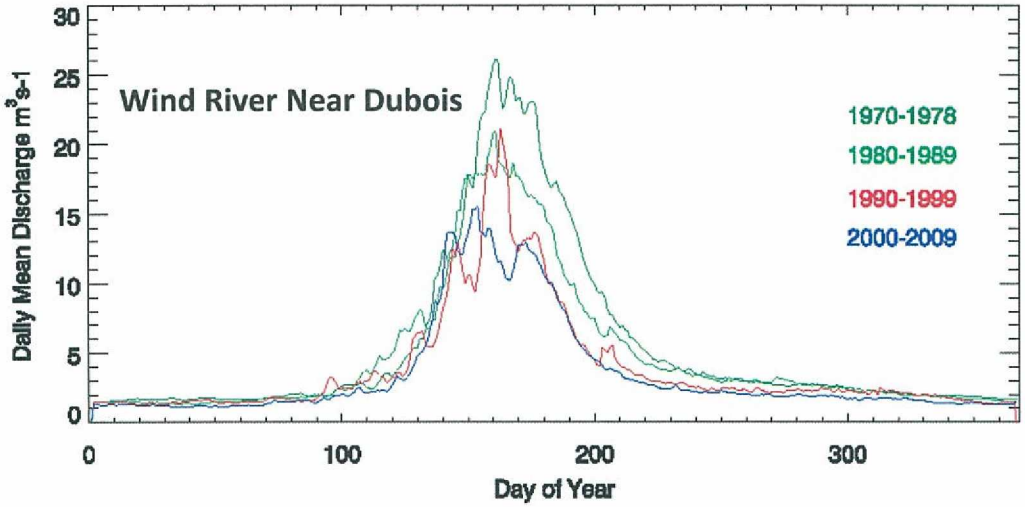

Figure 2: Daily discharge of the Wind River near Dubois in the Wind River Range, Wyoming

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References:

Hall, D.K., J.L. Foster, N.E. DiGirolamo and G.A. Riggs, in press: "Relationship between Satellite-Derived Snow Cover and Snowmelt-Runoff Timing and Stream Power in the Wind River Range, Wyoming," *Geomorphology*.

Hall, D.K., G.A. Riggs, J.L. Foster and S. Kumar, 2010: "Development and validation of a cloud-gap filled MODIS daily snow-cover product," *Remote Sensing of Environment*, 114:496-503, doi:10.1016/j.rse.2009.10.007.

Data Sources: Moderate-Resolution Imaging Spectroradiometer (MODIS) data; meteorological data from NWS co-op observer network; streamflow data from USGS

Technical Description of Image:

Figure 1: Snow-cover depletion curves from the MODIS cloud-gap-filled (CGF) 500-m resolution product (Hall et al., 2010) derived from the fractional snow-cover product, MOD10A1, in the Wind River Range, Wyoming. There are breaks in the plots in some years due to sporadic missing MODIS data. (a) Depletion curves in the elevation range ≥3500 m are shown (Hall et al., in press).

Figure 2: Daily discharge of the Wind River near Dubois in the Wind River Range, Wyoming, shown by decade (Hall et al., in press); note that stream discharge declines each decade from 1970-1979 to 2000-2009. [Data were missing between 1992 and 2001, so the decade of 1990-1999 included only two years, and the decade of 2000-2009 included only nine years (discharge data for the Wind River near Dubois for the decade of the 2000s began on 1 May 2001 so data from the year 2000 is not available).]

Scientific significance: The majority (>70%) of the water supply in the western United States comes from snowmelt, thus analysis of the declining spring snowpack (and resulting declining stream discharge) has important implications for streamflow management in the drought-prone western U.S. Less total stream discharge or a change in the date of maximum streamflow discharge affects the management and planning of the region's scarce water reservoirs. The strong relationship between percent of basin covered and streamflow indicates that MODIS snow maps should be useful for predicting streamflow, leading to improved reservoir management. We have demonstrated that MODIS snow-cover maps can be used for predicting stream discharge on both gauged and ungauged basins once a relationship is established between snow-cover extent and discharge on gauged basins.

Streamflow data from the six streams in the WRR drainage basins studied show lower annual discharge and earlier snowmelt in the decade of the 2000s than in the previous three decades, though no trend of either lower streamflow or earlier snowmelt was observed using MODIS snow-cover maps *within* the decade of the 2000s.

Relevance for future science and relationship to Decadal Survey: This research relates both to Cryosphere research and Water and Energy Cycle research. We show a strong relationship between percent of basin covered by snow as determined from MODIS snow-cover maps and amount of streamflow during the melt season. This indicates that MODIS snow maps are useful for predicting the amount of streamflow. Knowledge of amount of water (from melting snow) just before the snowmelt season is essential for improved reservoir management. This work relates to more than one of the Decadal Survey Big Questions, for example, "What are the consequences of change in the Earth system for human civilization?". A logical extension of this work is to study the MODIS record of snow cover and snowmelt timing on larger basins in the western United States.