Title
CON 2: A Multiscale Embedded Networked Sensing Water Quality Observatory Pilot Study at the Merced and San Joaquin Rivers Confluence

Permalink
https://escholarship.org/uc/item/11555917

Authors
Thomas Harmon
William Kaiser
Alexander et al.

Publication Date
2006
A Multiscale Embedded Networking Sensing Water Quality Observatory Pilot Study at the Merced and San Joaquin Rivers’ Confluence

Thomas Harmon1, William Kaiser2, Alexander, Rat’ko1, Jason Fisher1, Chris Butler1, Michael Stealey1, Sandra Rocio Villamizar Amaya1
1School of Engineering, University of California, Merced; 2Electrical Engineering Department, UCLA

Introduction: Unprecedented observations of coupled flow and mass transport in rivers and streams

Multiscale Embedded Networked Sensing

- Conventional (sparse) observations at regional scale
  Existing gauging data can direct us to potential trouble spots
- Human-actuated sensing then further resolves “WHERE”
  In this case, kayaks are equipped with bathymetry and water quality sensors for reconnaissance in key river reaches
- Higher granularity stationary ENS resolve “WHEN”
  Stationary arrays in the river and river sediments provide continuous data in the key river reach, identifying optimal times for NIMS RD deployments
- NIMS RD is then used to provide super-resolution, process oriented data to answer science and engineering questions

Pilot Study

- Confluence of the San Joaquin and Merced Rivers
  Study site is located in the San Joaquin River Basin, California, USA
- Rapidly Deployable Networked Infomechanical System (NIMS RD)
  Technology for observing spatiotemporal hydraulic and chemical properties across stream channels.
- Javelin Sensor Arrays
  Enable in-river (inputs from tributaries, canals) and sub-river (hyporheic zone) observations.

Problem Description: Developing strategies for improving water quality

On a regional or basin scale, using traditional (sparse) gauging station data to calibrate one-dimensional flow and mixing models is a useful approach for estimating downstream flows and water quality based on upstream releases, withdrawals and returns. For example, this simplistic approach is currently used to manage one of the largest water conveyance systems in the world in Central California. On sub-basin or smaller scales, spatiotemporal variability of velocity and water quality properties result from pollutant inputs, hydrodynamic mixing regimes, and the biogeochemical cycling processes that are themselves distributed in time and space. Higher resolution observations are needed if we are to understand processes well enough to predict conditions and manage water quality at these scales.

Proposed Solution: NIMS RD and Javelin Sensor Array deployments

Methods

- Identify trouble spots along the river
  Agency gauging station data are used to identify the reservoir operations-related flow conditions throughout the region, allowing rough identification of potential trouble spots along the rivers in terms of the flow, temperature and salinity observations.
- In-field analysis
  Human-actuated nodes in river kayaks characterize the river geometry, bathymetry and water quality at the potential trouble spots. The exploratory data would also be used to design a stationary embedded sensor network for longer term autonomous observations in the critical zones. In the present example, javelin sensor arrays are enabling in-river (inputs from tributaries, canals) and sub-river (hyporheic zone) observations.
- Super-resolution scanning
  The onset of particular events (e.g. reservoir operational changes) can be used to trigger super-resolution scanning of the river flow and water quality using a NIMS RD at the optimal time and place.

Results

- Velocity distributions
  High resolution velocity distributions from NIMS RD were successfully reproduced in separate deployments, and quantitatively matched stage-based volumetric flow rates at the site.
- Total salt load estimates
  The product of the velocity and associated specific conductivity distributions yielded total salt load estimates similar to reported values, but no basis for direct comparison was available.
- Nitrate distributions
  The nitrate distribution reflected a clear gradient from relatively low to relatively high moving from the Merced to the San Joaquin portions of the channel. Assuming both rivers were receiving nitrate in runoff and/or groundwater discharges, this suggests anaerobic reduction of the nitrate on the San Joaquin side of the river under the late autumn, low flow conditions.

“Javelin” sensor array

A conceptual drawing depicting Javelin Sensor construction and deployment. The Javelin Sensor Array measures nitrate, temperature and water pressure over time.

* A digital orthophotoquadr (DOQ) image of the San Joaquin - Merced confluence located in the San Joaquin River Basin, CA, USA. The image was taken on July 7th, 2002 and has 1-meter ground resolution. The area within the red polygon gives the approximate location of a bathymetric survey conducted on February 25th, 2006.

* A level contour map describing the bathymetry within the San Joaquin - Merced confluence. The bathymetric survey was conducted on February 25th, 2006 using an integral GPS receiver and digital echo sounding technology. The location of the NIMS RD transect for the October 8th, 2005 deployment is shown as a solid red line. Potential locations for future NIMS RD transects (dashed black lines) and Javelin sensor arrays (solid brown squares) are also given.

* A three-dimensional rendering of the bathymetric surface within the San Joaquin - Merced confluence (02/25/06). The vertical exaggeration is 3X.

* The NIMS RD system is shown in schematic view. The cableway system provides support for the sensor node payload (1). The cableway supports a horizontal actuator (2) controlled by an embedded computing system (3). The cableway is supported by aluminum support towers (4), and anchor systems (5) and (6), while a counterweight (7) provides tension.

* Data collected during the San Joaquin River NIMS RD deployment (11/06/2005). Water velocity, specific conductivity, nitrate, pH, and temperature distributions are shown within a single cross-section of the San Joaquin river, approximately 125 m downstream of the San Joaquin - Merced confluence (note: plot aspect ratio is 10:1).

* “Javelin” sensor array