EVALUATION OF MODEL ENHANCEMENTS AND PROBABILISTIC FORECASTING TECHNIQUES FOR THE SNOWMELT RUNOFF MODEL

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ABSTRACT

Accurate streamflow forecasts are critical for the responsive management of water resource systems, which are designed and operated for the purposes of irrigation, flood control, and hydroelectric power generation. In the Western United States, water supplies are often derived form runoff due to snowmelt. The objective of this project is to develop an ensemble (probabilistic) prediction system for short to medium range streamflow forecasts (1 to 15 days). The hydrologic model used in this study is the Snowmelt Runoff Model (SRM), which is a conceptually-based model designed to simulate and forecast daily streamflow in mountain basins where snowmelt is a major contributor to runoff (Martinec et al., 1994). To optimize model efficiency and aid in its operational implementation, three enhancements have been made to the model. These enhancements are: 1) the use of an antecedent temperature index method to track snowpack cold-content and account for the delay in melt associated with diurnal refreezing, 2) the use of both maximum and minimum critical temperatures to partition precipitation into rain, snow, or rain/snow mixed, and 3) the stochastic modeling of forecast errors to generate streamflow ensembles, from which exceedence probabilities can be obtained. Results from retrospective model runs, using temperature and precipitation forecasts from NCEP GFS model (2000-2004) will be examined and used to identify the error in the streamflow forecasts. This error is then used to generate probabilistic forecasts for the 2005 snowmelt season (April 1 to July 31). The watershed used in this study is the Big Wood River Basin, Idaho.

PRESENTATION EXTRACTS

Slide 3: Objectives:

- Evaluation of an enhanced version of the Snowmelt Runoff Model (SRM) to generate streamflow forecasts (1 to 15 days) using retrospective (historical) medium-range forecasts of temperature and precipitation.
- Development of an ensemble (probabilistic) prediction system for medium-range streamflow forecasts.

Slide 4: Snowmelt Runoff Model Characteristics:

- SRM is a semi-distributed, temperature index (degree-day) model designed to simulate and forecast streamflow in snowmelt dominated (mountainous) basins.
  - Model inputs: actual and forecasted values of average daily temperature, total daily precipitation, and snow-covered area (from remote sensing).
  - Temporal resolution: daily
  - Model parameters: derived from measurements or estimated by hydrological judgment taking into account the basin characteristics and physical laws.

Slide 5: Model Enhancements:

- The use of both maximum and minimum critical temperatures ($Tcrit_{max}$ and $Tcrit_{min}$) to partition precipitation into rain, snow, and rain/snow mixed.
  - model currently uses a single critical temperature value
- The use of an antecedent temperature index (ATI) method to track snowpack cold-content and account for the delay in melt associated with diurnal refreezing.
  - used to determine when the snowpack is ripe
  - also to determine when the rain falling on the snowpack should contribute to the runoff.

Slide 6: Study Area: Big Wood River Basin. Stream Gauge: Hailey, ID. Contributing Area: 1,625 km^2. Elevation Range: 250-3,630 m

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Slide 7: Model Input Data:

- Forecast data (1 to 15 days): Average daily temperature (NCEP GFS Model), daily total precipitation (NCEP GFS Model) (both downscaled to the locations of the SNOTEL stations within the basin)
- Surface observations: Average daily temperature (SNOTEL, NRCS), daily total precipitation (SNOTEL, NRCS), and stream discharge (USGS) (discharge used to update the model and avoid propagation of errors)
- Remotely sensed data: Snow-covered area (MODIS Operational Snowcover Product), data provided by the National Snow and Ice Data Center (NSIDC)

Slide 8: Modeling Tasks:

- 1. Retrospective model runs using temperature and precipitation forecasts obtained from the NCEP GFS model (2002-2004).
- 2. Stochastic modeling of the errors from the three retrospective model runs.
- 3. Generation of ensemble streamflow forecasts (2005) using the stochastically modeled errors.

Slide 9: Conclusions:

- The streamflow forecasts exhibit sufficient skill out to about 10 days.
- The model tends to adequately capture the timing and magnitude of the peak discharge in 3 of the 4 years tested, however, the 15 day forecasts tend to under-predict the peak.
- The model performed poorly for the 2004 snowmelt season.
- Further analysis is required to assess the skill of the ensemble forecasts.