**The Modified Snowmelt Runoff Model for Forecasting Water Availability in Chile**

**Software Description & NASA Software Engineering Classification**

**Introduction**

Chile’s central northern regions depend largely on seasonal Andean snowmelt and a system of dams to provide enough water to support their growing population and industry. Water allocation strategy for each agricultural growing season is influenced by reservoir levels at the time the decisions are made. This information alone however is no longer sufficient in water management planning as the region suffers from decreasing precipitation and increasingly severe drought conditions every year.   
  
Though adequately robust methods for forecasting highly variable precipitation in the upper Andes do not yet exist, a snowmelt runoff modeling approach based on the Snowmelt Runoff Model created by the United States Department of Agriculture (USDA) and MODIS snowcover data may be employed to grant short range estimates of water availability from snowmelt during the most critical growing season. An exceptionally dry climate with slightly more complex physics, a sub-optimal number of monitoring stations and limited in-situ data required a customized approach to implementing the a snowmelt runoff model in this region of the world.

**Applications and Scope**

This implementation of the Snowmelt Runoff Model, originally developed by the United States Department of Agriculture, was created specifically for studying snowmelt in Chile. Minor modifications were made to allow precipitation inputs from multiple sources including NASA earth observation data, which accommodate the unique elevation characteristics and capabilities of the in situ data collection network in Chile. Additional modifications were included which use individual time lag parameters for water from rainfall, and water from snowmelt to better suit the observed hydrological characteristics of the region. Each of these considerations culminates into a customized set of data manipulation tools and accompanying graphical user interface in both Spanish and English versions to assist in making 3 month water availability forecasts.

**Capabilities**

This software models daily stream flow as a function of temperature, elevation, snow covered area, precipitation rate, and experimentally determined coefficients. The tools provided allow users to properly synthesize daily fractional snow cover products from MODIS, and daily precipitation measurements from TRMM into tabular formats for use in a forward time stepping equation to study the hydrological characteristics of basins within central northern Chile. The tools provided also allow daily stream flow estimates to be made three months forward at the start of the growing season. This software includes a GUI to aid the analysis process while retaining a high level of user awareness and control. The tools are ready for substitution of GPM precipitation measurements in lieu of TRMM, which are expected to provide much higher accuracy in this part of the world.

**Interfaces**

This software is implemented in both python and Matlab script programming languages. Components which synthesize data from NASA Earth Observing Systems are written in python and require the use of modules available only with ArcMap 10.1 or 10.2. The model for simulating stream flow is controlled through a graphical user interface and is written in Matlab. This graphical user interface is provided in both English and Spanish versions with supporting documentation.

**Assumptions, Limitations, & Errors**

- The software assumes snow cover, consequent melting rate and precipitation remain constant for each 24 hour time interval.

- The software will be delivered with three basins characterized and validated. Users who wish to study other basins must go through the characterization process themselves.

- The software demonstrates high degree of error in instances where precipitation occurs completely outside the range of ground monitoring networks.

- On the fly calibration for each forecast must be performed by the user.

- The software is intended for research purposes to give low certainty estimates of future water availability and to identify key physical phenomenon with high impacts.

**Additional Information**

**Software Classification & Justification**

This software is considered to be Class E software per NPR 7150.2.

This software is used to:

* + Perform minor desktop analysis of science or experimental data.

The software is not used to:

* + make decisions for an operational Class A, B, or C system or to-be built Class A, B, or C system
  + support engineering development
  + test other Class D software systems
  + support mission planning or formulation
  + operate a research, development, test, or evaluation laboratory
  + provide decision support for non-mission critical situations
  + in a Major Engineering/Research Facility
  + perform research associated with airborne vehicles or systems

The software will not:

* + operate, directly support, or be flight qualified to support an operational system
  + be used in technical decision concerning an operational system
  + directly affect primary or secondary mission objectives
  + adversely affect the integrity of engineering/scientific artifacts
  + have an impact on operational vehicles

Additionally, if the software had anomalous behavior, that behavior would not cause or contribute to a failure of a system function:

* + resulting in a minor failure condition for the airborne vehicle
  + with an effect on airborne vehicle operational capability or pilot workload

When these criteria are no longer valid, categorization/classification will be reevaluated and the project will start following the procedures for the higher class.

**Not Safety Critical**: The software does not:

* Reside in a safety-critical system with at least one of the following being applicable to the software:
  + Causes or contributes to a hazard
  + Provide control or mitigation for hazards
  + Controls safety-critical functions
  + Processes safety-critical commands or data
  + Detects and reports, or takes corrective action, if the system reaches a specific hazardous state
  + Mitigates damage if a hazard occurs
  + Resides on the same system (processor) as safety-critical software
  + Process data or analyze trends that lead directly to safety decisions (e.g. determining when to turn power off to a wind tunnel to prevent system destruction)
  + Provide full or partial verification or validation of safety-critical systems, including hardware or software systems