Satellite Data Application to Cover Lack of In-situ Observations for Mapping Precipitation and Direct Runoff in Semi-arid Basin

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INTRODUCTION

Mapping hydrological parameters such as runoff and precipitation requires a variety of approaches and the most widely used tools are data-driven. However, in most catchments around the world runoff is not gauged and, especially in developing countries, rain gauge networks have poor spatial and temporal resolution. A good example is Lake Urmia in north-west Iran, where water overuse has led to lake desiccation and where a marked lack of in-situ data for the basin is affecting lake restoration policy. In Lake Urmia basin, there are two main limitations in runoff estimation: (i) the lake is surrounded by an ungauged buffer zone; and (ii) there is a lack of sufficient data on water withdrawal by intensive irrigation in central sub-basins. There are also problems in estimating precipitation owing to lack of inadequate rain gauges, especially at high elevations. To overcome the lack of runoff data in the ungauged buffer zone around Lake Urmia and precipitation records in high elevations, we present a novel data assimilation and modeling approach. First, precipitation is estimated by coupling TRMM, NDVI, and Digitized Elevation Model (DEM), as satellite-based data sets, with station data. Next, direct runoff is estimated using the Kennessey Soil Conservation Service Curve Number (SCS-CN) models.

METHOD

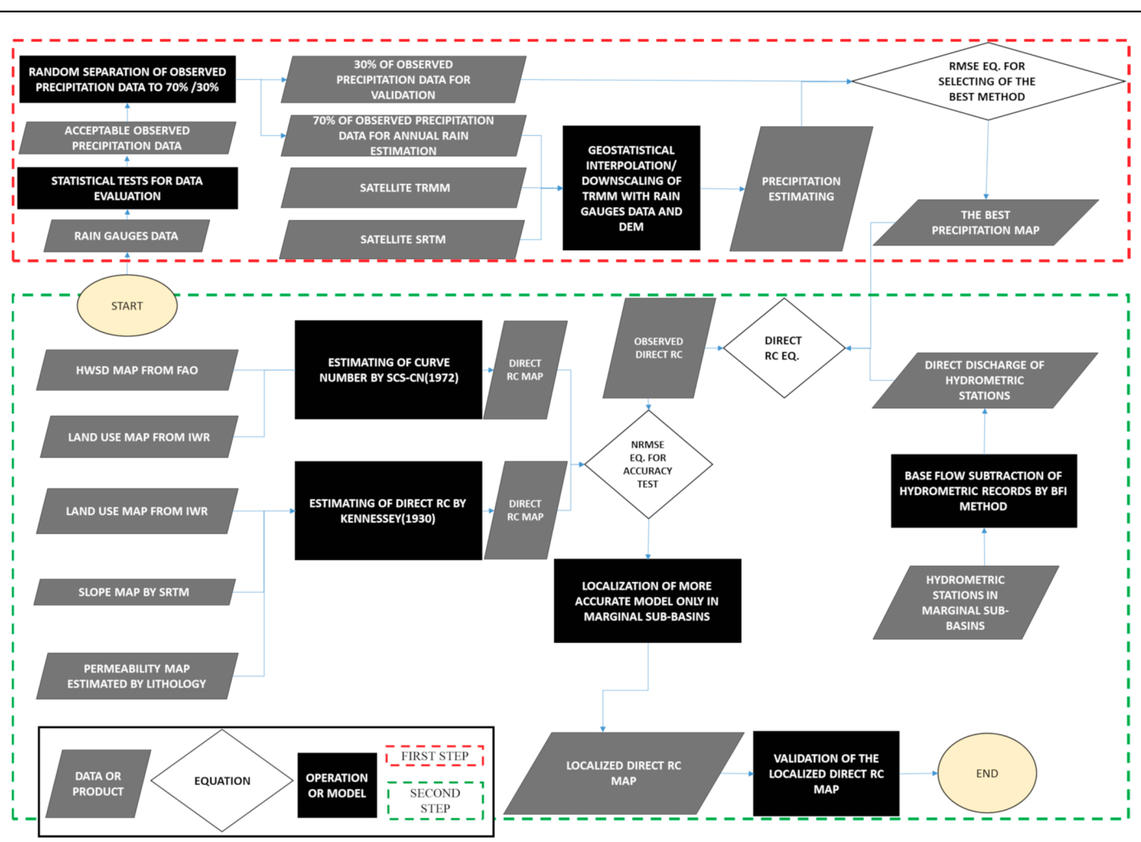

Figure 1. Flowchart showing steps followed in estimation and mapping of annual precipitation and direct runoff coefficient

RESULTS

Table 1. RMSE of different methods for precipitation estimation in Lake Urmia basin in 2007

Method	Mean (mm)	RMSE (mm)
TRMM raw images	361	100
Kriging interpolation of 70% of station records	297	85
Downscaling TRMM with DEM	372	86
Cokriging interpolation of station records with DEM and TRMM	290	81
Cokriging interpolation of station data with Aspect and TRMM	290	86

The precipitation layers for 2006–2011 obtained by cokriging interpolation of rain gauge values with DEM and TRMM 3B43 V7 as the best method generated.

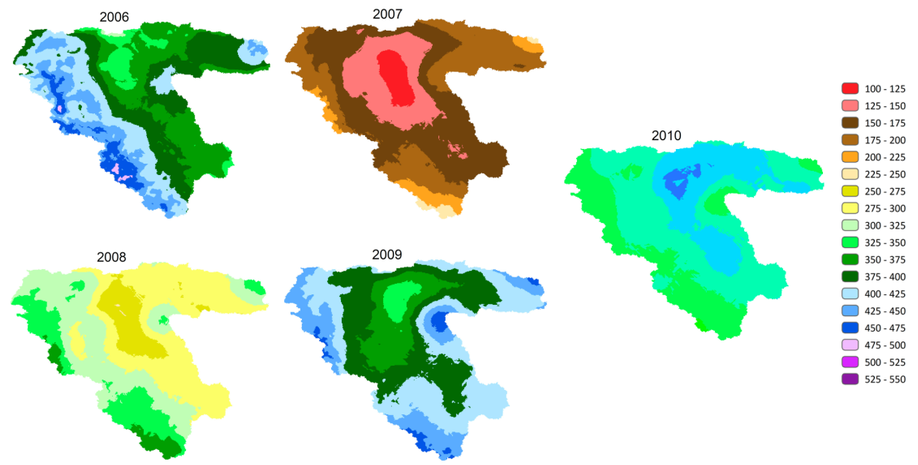

Fig 2. Precipitation (mm) in Lake Urmia basin in five investigated water years (September–August) from 2006–2011

In runoff modeling, Kennessey gave higher accuracy. Calibrating Kennessey reduced the Normalized RMSE (NRMSE) from 1 in the standard model to 0.44. Direct runoff coefficient map by 1 km spatial resolution was generated by calibrated Kennessey.

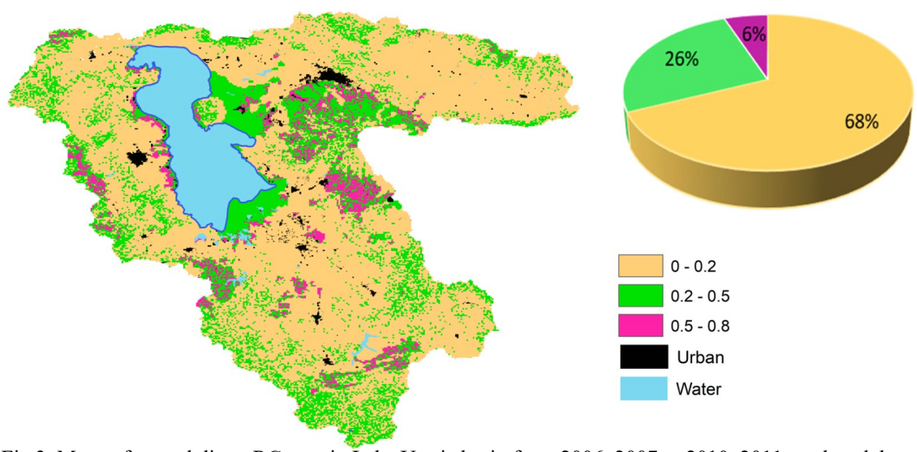

Fig 3. Mean of annual direct RC map in Lake Urmia basin from 2006–2007 to 2010–2011 produced by calibrated Kennessey