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Interactive comment on "Dynamics of water fluxes and storages in an Alpine karst catchment under current and potential future climate conditions" *by* Zhao Chen et al.

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The subject paper discusses an advance in the ability to model an integrated model of an Alpine watershed that was developed to assess potential impacts to the dynamics of the watershed due to climate change. The study area is an Alpine watershed and, as such, exhibits particular features and dynamics endemic to watersheds greatly affected by orographic dynamics and a complex recharge system subject to a snowpack and snowmelt dynamic. Being an Alpine climate, water is seasonally held in storage as snow.

Of concern is how climate change will alter the durations of when water is held in storage as snow or in the subsurface in the liquid phase. Future climate changes will have two impacts on recharge: (i) the sheer quantity of precipitation and (ii) change of precipitation from snow to rain due to increases in temperature. Increased temperatures will also result in increased evapotranspiration. Model simulations indicate that total recharge (and discharge) decreases under all evaluated future climate conditions.

The study area is only 35 km2, but varies in elevation from 1,000 m to 2,230 m. Mean precipitation at 1,240 m is 1,836 mm/yr. The study domain has two sub-areas, one is a karst area with a subsurface drainage system. The other is a non-karst area with a surface drainage system. The conceptual and numerical model has a number of sub-basins. The karst sub-basins incorporate a conduit/diffuse flow regime. Discharge is measured hourly at four springs, at varying elevations: 1,035 m, 1,080 m, 1,120 m, and 1,122 m, but only for 11/2013-10/2014 at the two lower springs and 7-10/2014 for the two higher springs. The duration for which data are available is not long. This may be the source for the excessively high estimation of recharge percentage of precipitation.

Air temperature, precipitation, and relative humidity were measured at nine stations across the study domain. The authors cite Wending and Muller (1984) as the source for the Turc-Ivanov approach to calculate evapotranspiration. This may be an original source for this approach, however it is not readily available (and not in English). The authors might consider adding Conradt et al. (2013) (HESS) as an additional more accessible citation on this. Precipitation, temperature, and relative humidity are measured at nine weather stations. Each data type is input at a 100 m x 100 m grid using combined inverse distance weighting and linear regression gridding. I suspect this is key to the ability of the authors to match discharge at the four gauging stations as illustrated in Figure 4.

Simulations considered incremental decreases in precipitation in conjunction with incremental increases in evapotranspiration. These changes in input resulted in decreases to recharge. Frie (2004) provides projections for temperature increases by 2030, 2050, and 2070. Gobiet et al. (2014) is cited as a possible source for climate projections.

The authors acknowledge that their calculation that recharge is 95.5% of precipitation may be overestimated. They noted that Malard et al. (2016) estimate average infiltration rates for mountainous karst catchments across Switzerland vary between 60% and 90%. The source of the over-estimation may be inherent in the pipe network model used to replicate groundwater flow coupled with the optimization routine used to estimate recharge values. The pipe network software package does not allow for matrix-pipe hydraulic communication. Adding the pipe network to the analysis is an advancement to Alpine water-resource assessment, but not including matrix-pipe communication is a limitation. This could be addressed in future work.

Given the high density of precipitation measurement stations (nine) in such a small area, I would think that that precipitation is fairly well constrained. Likewise, all discharge from the basin is measured at the four springs. Unless the basin water budget is not consistent with this conceptualization, it should be possible to provide an independent estimate of recharge using this simplified water budget analysis.

Authors should define FDC. I believe it is Flow Duration Curve, but not positive.

Are tables 1a and 1b from Frei (2004)? If so, please provide citation. Details on the distributed karst catchment model used in this study are in Chen and Goldscheider (2014). The model was derived from a distributed hydrologic-hydraulic water quality simulation model - Storm Water Management Model (SWMM versions 5.0). The GW system was modeled as a pipe network with no hydraulic communication between the matrix and the conduits. Recharge was input as focused point sources. This modeling approach is possible, in part, due to the relatively small size of the study domain (35 km2) and by virtue of the fact that the pipe network (i.e., conduits) has been well defined using tracer tests (Gremaud and Goldscheider, 2010). This limits the ability of the model to be used for predictive simulations. It would be interesting, that given the fact that the conceptual model of the system is fairly well known, if an alternative

mechanistic GW flow model could be developed to test the predictive ability of a model.

The authors used 5000 Latin hypercube runs to determine best fit input parameters. Flow predictions at the four gauges were quite good. There is the risk the authors over-parameterized the model domain. Given the modest duration of data, there was no opportunity to validate the model for time series data not used in the calibration.

Two recommendations for future work on this watershed. (i) Validate the model using future data series. (ii) Develop a mechanistic model to replicate GW flow. This should allow for independent confirmation of the conceptual model and state variable properties currently estimated.

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