Hydrol. Earth Syst. Sci. Discuss., 7, C3567–C3583, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C3567/2010/


Hydrology and Earth System Sciences Discussions

# *Interactive comment on* "Development of streamflow projections under changing climate conditions over Colorado River Basin headwaters" *by* W. P. Miller et al.

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Received and published: 23 November 2010

RESPONSE TO ANONYMOUS REFEREE #1 COMMENTS Streamflow Projections Under Changing Climate Conditions over Colorado River Basin Headwaters

Responses to Anonymous Referee #1 Comments

âĂć Significant Revision Comment 1: This paper uses downscale climate change pro-



jections to estimate changes in streamflow in the Colorado river basin. In recent years there have been a number of papers that have used of downscale GCM data to drive hydrologic model projections has been used to predict hydrologic responses to climate change. The authors in this paper focus specifically on changes in evapotranspiration rates and an agency forecasting model. Other hydrologic models that have been used in the Western US include changes in evapotranspiration rates in their approach (eg. VIC, DHSVM, RHESSys) although none explicitly interpret results in the context of reservoir management using a forecasting model. This is an interesting idea - but it is not developed enough to really explain the value of this paper to the general hydrologic community. The authors should cite (and compare their paper to) examples of previous papers that examine changes in evapotranspiration with warming in the Western US (using both empirical and modeling approaches). The key difference between these other papers and this paper is the methodology - it would be helpful to explain to the readers how this approach compares with other hydrology models that more directly include mechanistic representations (such as Penman Monteith) of ET.

Significant Revision Response 1: The authors appreciate this, and all, of Anonymous Referee #1's comments. While accounting for changing evapotranspiration rates is a significant part of this study, the primary focus of this study is utilizing downscaled GCM climate data to develop projections of future streamflow conditions. By accounting for changing evapotranspiration rates due to changes in temperature, we feel that we are able to develop more a more robust range of projected streamflow conditions. Previous studies have shown that evaporation or evapotranspiration parameters significantly impact streamflow projections from hydrologic models (e.g., Chang and Jung 2010, Christensen and Lettenmaier 2007, Hurkmans et al. 2008, Hurkmans et al. 2009, Lu et al. 2010, Nijssen et al. 1997, Sridhar and Nayak 2010, Wu et al. 2007, Zierl and Bugmann 2005); however, these studies use hydrologic models that evaluate evapotranspiration as a function of temperature primarily. The NWS RFS used in this study does not afford us the opportunity to define evapotranspiration as a function of temperature; as such, we used output from the VIC model to generate a time series which utilizes the Penman Monteith method to account for evapotranspiration. This time series was then used to force the NWS RFS.

We have inserted the following paragraphs to Section 2.2 of the revised manuscript to address previous studies that have examined evapotranspiration impacts:

Impacts of various parameters within the NWS RFS and resultant impacts to streamflow have been studied (Hogue et al. 2000, Hogue et al. 2006, Sorooshian et al. 1993, Vrugt et al. 2006); however, these past studies have focused on the calibration of these parameters to generate more accurate representations of observed streamflow from the NWS RFS. Adjustment of parameters within the NWS RFS with respect to long-term projected changing climate conditions has not yet been fully investigated by the research community. Recent studies indicate that increased warming trends due to climate change will impact future evapotranspiration characteristics and should be considered in future hydrologic assessment (e.g., Ellis et al. 2010, Sridhar and Nayak 2010, Zierl and Bugmann 2005). In particular, Chang and Jung (2010), utilized the Harmon method within the Precipitation Runoff Modeling System to describe potential evapotranspiration over a watershed in Oregon. Additional studies have utilized the Soil Water and Assessment Tool (SWAT) to examine hydrologic impacts to watersheds and have stressed the importance of evapotranspiration to streamflow response (Lu et al. 2010, Sridhar and Nayak 2010) . The Hargreaves method within the SWAT model was specifically used by Sridhar and Nayak (2010) because it is dependent only on temperature to calculate evapotranspiration. Other studies have used models that employ methods that are only reliant on temperature and topography (e.g., Wu et al. 2007).

Evapotranspiration within the VIC model has been extensively studied (e.g., Christensen and Lettenmaier 2007, Hamlet et al. 2007, Hurkmans et al. 2008, Hurkmans et al. 2009, Lakshmi and Wood 1998, Nijssen et al. 1997). Of particular importance to this study Hamlet et al. (2007), indicated that evapotranspiration trends within VIC were driven by trends in precipitation and temperature; concurrent work indicated that evap-



otranspiration significantly influenced projected streamflow response within the VIC model (Christensen and Lettenmaier 2007). An advantage of the VIC model, and other hydrologic models discussed, over the NWS RFS utilized by the CBRFC is that these models allow for the user to account for evapotranspiration as a function of changing conditions within the model. The NWS RFS utilized by the CBRFC is dependent on user-defined evapotranspiration values.

Also, we have revised a sentence (page 13, lines 16-18) within Section 2.2 of the revised manuscript to read:

Changes to evapotranspiration rates with changing climate have seldom been considered when using hydrologic models and projections of climate data to develop projections of streamflow (Brekke and Prairie 2009).

Significant Revision Comment 2: In general the paper assumes familiarity with US institutions and policies, agency modeling approaches and current agency approaches to climate change assessment in the West - this is problematic for an international journal - The methodology and results from this paper do say something interesting about climate change impacts and modelling climate change impacts from an agency perspective that would be of interest to many - but the authors need to do a better job of providing this contextual information and removing jargon associated with US water management.

Significant Revision Response 2: Thank you for your comment. We feel that the Colorado River Basin is basin that is affected by many important issues that affect the global community, such as climate change, environmental compliance, and changes to population and water use. Many strategies to address water resource issues in the Colorado River Basin can be adapted and applied by the global community. Where possible, we have tried to limit discussion of policy specific to Reclamation and have instead tried to generalize it to encompass the Colorado River Basin. We have also added this line (page 28, lines 8-11) to the discussion section:

Although this research considers a river basin where water resources are administered by a United States federal agency (Reclamation), the methodology here is applicable to any basin or watershed area, as well as any hydrologic model and climate data sets.

Significant Revision Comment 3 (Part 1): I also found the method section difficult to follow and feel that it needs more development. As written, it was not clear to me why a) the authors did not simply use VIC predictions of streamflow - I suspect this has to do with how the RFS model is used but for those not familiar with RFS this is confusing b) if RFS is used, why it was not recalibrated with the VIC-derived ET incorporated for historic periods - why is the ratio method used? Re-calibrating with the "improved model" for historic periods would presumably improve calibrations and make the model more robust in a changing climate. Perhaps I do not understand the RFS calibration process - but that should be clear from the paper. I suspect that the reason why the authors chose their approach has to do with the use of RFS as a forecasting model - OK - but this needs to be presented to the reader - what is different about forecasting models - how is this model calibrated, etc. The paper needs a substantial rewrite to explain the RFS modeling approach, its calibration, why ET needs to be incorporated etc. There are also a lack of presentation of model assessment statistics that would build confidence in the paper results. It is not clear whether relatively small changes in predictions that occur when ET is included are really significant given model uncertainty (that might be estimated by looking at performance during historic periods). Similarly additional justification for some of the choices made is needed e.g how to vary precipitation and temperature in space is needed.

Significant Revision Response 3 (Part 1): We understand and appreciate the need to clarify why the RFS model was used and limitations associated with the calibration of that model. We have changed Section 1.2.1 in the revised manuscript to read:

Reclamation, in cooperation with Lawrence Livermore National Labs (LLNL) and Santa Clara University (SCU), has made available BCSD precipitation and temperature data from the WCRP CMIP3 dataset over the continental United States (available at:



http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections). This climate data has been downscaled to 1/8th degree (approximately 12 kilometers or 7.5 miles) grid cell resolution, making it more useful for regional hydrologic analysis. As previously described, this data have been downscaled using the BCSD technique described in Wood et al. (2004) and is available at a monthly timestep. Statistically downscaled data derived using the Bias Corrected Spatial Downscaling (BCSD) method developed by Wood et al. (2004) is used. The method is documented in numerous peer-reviewed academic studies (Cayan et al. 2007, Christensen et al. 2004, Hayhoe et al. 2004, Hayhoe et al. 2007, Maurer and Duffy 2005, Maurer 2007, Payne et al. 2004, VanRheenen et al. 2004, Wood et al. 2004) and produces downscaled temperature and precipitation data that statistically matches the historical period. Currently, Reclamation is developing streamflow projections over the Upper Colorado River Basin using the Variable Infiltration Capacity (VIC) model and the WCRP CMIP3 dataset described in this study for the Colorado River Basin Water Supply and Demand Study (Basin Study) to examine the impacts of changing water supply and demand conditions over the Colorado River Basin (U.S. Department of the Interior, Bureau of Reclamation, Lower Colorado Region 2009). The VIC model is run at a daily timestep; as such, temporal disaggregation of data from the monthly WCRP CMIP3 dataset over the Colorado River Basin is required. Temporal disaggregation of the monthly data was accomplished by scaling historical daily precipitation or shifting historical daily temperature data to match monthly time series data (Wood et al. 2004). Daily precipitation and temperature time series have been derived for the entire spatial and temporal extent of the monthly Reclamation, LLNL, SCU dataset, and are archived at the Department of Energy (DOE) National Energy Research Scientific Computing (NERSC) Center. To facilitate future research comparing streamflow projections from the Basin Study and streamflow projections developed herein, daily climate data utilized in the Basin Study is also utilized in this effort. and in Section 2.1, page 10, lines 8 through 12 of the revised manuscript:

Reclamation is required to use streamflow forecasts by the CBRFC for input into operational and policy models; as such it is important for Reclamation, or any water manager, to evaluate potential impacts of climate change to streamflow forecasting tools. Streamflow forecasts generated by the CBRFC have the potentially to significantly impact reservoir operations over the Colorado River Basin.

and in Section 2.1, page 10, lines 21-23 of the revised manuscript:

The calibration model utilized by the CBRFC is not available for use by outside agencies due to limitations associated NWS database connections and infrastructure.

âĂć Significant Revision Comment 3 (Part 2): I also found the method section difficult to follow and feel that it needs more development. As written, it was not clear to me why a) the authors did not simply use VIC predictions of streamflow - I suspect this has to do with how the RFS model is used but for those not familiar with RFS this is confusing b) if RFS is used, why it was not recalibrated with the VIC-derived ET incorporated for historic periods - why is the ratio method used? Re-calibrating with the "improved model" for historic periods would presumably improve calibrations and make the model more robust in a changing climate. Perhaps I do not understand the RFS calibration process - but that should be clear from the paper. I suspect that the reason why the authors chose their approach has to do with the use of RFS as a forecasting model - OK - but this needs to be presented to the reader - what is different about forecasting models - how is this model calibrated, etc. The paper needs a substantial rewrite to explain the RFS modeling approach, its calibration, why ET needs to be incorporated etc. There are also a lack of presentation of model assessment statistics that would build confidence in the paper results. It is not clear whether relatively small changes in predictions that occur when ET is included are really significant given model uncertainty (that might be estimated by looking at performance during historic periods). Similarly additional justification for some of the choices made is needed e.g how to vary precipitation and temperature in space is needed.

Significant Revision Response 3 (Part 2): Thank you for your comment. It is a limitation of this paper that there are no model assessment statistics presented in this paper. This



is primarily due to the fact that the calibration model, normally run in conjunction with the NWS RFS, is unavailable to the authors. It is the hope of the authors that Figure 4 conveys that accounting for evapotranspiration is significant and is not just related to uncertainty in the modeling assumptions or climatic input.

As for accounting for changes in precipitation and temperature in space, the authors hope that the following paragraphs explain how the spatial variability of temperature and precipitation was accounted for on page 16, lines 8-19:

Using geographic information system (GIS) software, gridded, 1/8th degree temperature values were overlaid with elevation data from 30 meter resolution digital elevation maps (DEMs) downloaded from the USGS National Map Seamless Server (Available from the USGS, EROS Data Center in Sioux Falls, SD and http://seamless.usgs.gov). The elevation at the center of each 1/8th degree cell was derived from the DEM and assumed to be representative of the elevation over each cell. This elevation was used to classify temperature values over each elevation band within each catchment.

Each catchment is divided into three elevation bands as defined by the CBRFC. For each catchment and elevation band within that catchment, a daily time series of minimum and maximum temperature data was derived by taking the average of daily minimum and maximum temperature values from each 1/8th degree grid cell from the BCSD, temporally downscaled WCRP CMIP3 dataset.

Detailed Comment 1: In the introduction it would be helpful to be more specific about previous studies in the Western US and projected changes - for example - line 15 states that previous research indicates "warming trends" – clarify the magnitude (or ranges in magnitude/direction) of these changes? - similarly the introduction notes "changes in timing of streamflow" - but does not explain how the timing of streamflow has changed.

Detailed Comment Response 1: Thank you for the comment, we have modified the introduction to read on page 3, lines 4-10 of the revised manuscript:

Previous research indicates warming temperature trends over the Colorado River Basin region of up to 3oC over the next 50 to 100 years (e.g., Christensen et al. 2004, Hoerling and Eischeid 2007, McCabe and Wolock 2008) and corresponding changes in the timing of streamflow within the basin, resulting in earlier peak runoff events (e.g., Christensen and Lettenmaier 2007, Hamlet et al. 2005, Hamlet and Lettenmaier 2007, Hidalgo et al. 2009, Kalra et al. 2008, Miller and Piechota 2008, Regonda et al. 2005, Timilsena and Piechota 2008).

Detailed Comment 2: "Research on the impacts of teleconnection events on drought and streamflow conditions in the Green River Basin have provided some insight as to the role of climate variability 5 over the Colorado River Basin (Tootle and Piechota, 2003)" - This sentence is vague - it would be helpful to say more of what this insight is

Detailed Comment Response 2: Thank you for the opportunity to clarify, we have modified the introduction to read on page 7, lines 3-6 of the revised manuscript:

Research on the impacts of teleconnection events on drought and streamflow conditions in the Green River Basin have provided some insight as to the role of teleconnections to climate variability over the Colorado River Basin (Tootle and Piechota 2003).

Detailed Comment 3: "Pursuant to the National Environmental Protection Act (NEPA) of 1969, an Environmental Impact Statement (EIS) and Record of Decision (ROD) were published in 2006 defining the operations of the Navajo Reservoir within the San Juan River Basin to aid in the conservation of endangered fish species, habitat, and continue to meet Reclamation's obligations to 10 water delivery requirements and Native American water rights (US Department of the Interior, Bureau of Reclamation, Upper Colorado Region, 2006)." - While this may be true it is not clear how this statement contributes to a paper for a general hydrology audience

Detailed Comment Response 3: Thank you for the opportunity to present our work in a broader context, we have modified the introduction to include the additions on page 7, lines 6-8:



The San Juan River Basin is an example of a water management agency actively working with stakeholders to adaptively manage a reservoir system in response to changing environmental and anthropogenic needs.

Detailed Comment 4: In the "study area" section, some general information on the hydro-climatology of the basin should be provided, particularly given that this is an international journal. Provide information on mean annual precipitation, streamflow, seasonality, elevation ranges, snow versus rain etc.

Detailed Comment Response 4: We appreciate the opportunity to define the characteristics of the Colorado River Basin to those who may not be familiar with it, we have modified the study area section to include the additions on page 6, lines 4-16:

The Colorado River Basin spans much of the American West, providing water to seven basin states and Mexico. The Colorado River provides water to over 27 million people and irrigates over 14,000 km2 of farmland while generating over 8 billion kilowatt hours of hydroelectric power annually. The Colorado River Basin is divided between the supply-driven Upper Colorado River Basin and the demand-driven Lower Colorado River Basin; that is, water allocation in the Upper Colorado River Basin is dependent on available resources, whereas water is allocated based on demand in the Lower Colorado River Basin. Of the approximately 18,500 million cubic-meters (MCM) of inflow into the Colorado River Basin, approximately 17,900 MCM is currently allocated annually. The Colorado River Basin is unique from other water management systems in that it has the capability to store approximately four times (74,000 MCM) the average annual inflow; most of the storage is concentrated within the Lake Powell and Lake Mead reservoirs. Historically, inflow into the Colorado River Basin is highly variable and typically driven by snowpack in the Upper Colorado River Basin.

Detailed Comment 5: Again in the study area section (pg 5582 line 1-5), statements are often vague and it would be helpful to provide more information on what previous studies have shown regarding climate change in the study basin eg. what did the studies of using “downscaled climate projections” show?

Detailed Comment Response 5: The authors hope that additional information provided in Detailed Comment Responses 1 through 4 address this need for more specificity. As for previous studies using downscaled climate projections, this is a relatively new dataset, and to the best of our knowledge, has not been used in previous work to force a hydrologic model. However, monthly BCSD data has been used over the Gunnison River Basin. We have added the following to read on page 8, lines 5-10:

Brekke and Prairie (2009) previously applied monthly BCSD climate data over the Gunnison River Basin to generate projections of streamflow through 2099. Brekke and Prairie (2009) note that mean annual runoff is consistent throughout the 21st century, but note that these flows may be an overestimate, as changes to potential evapotranspiration in response to future warming were not accounted for.

Detailed Comment 6: Pg 5580 - how specifically does the Colorado River exhibit non-stationarity, line 14

Detailed Comment Response 6: Streamflow projections in the Gunnison and San Juan River Basin exhibit evidence of non-stationarity as results of the KS-Test indicate that future probability distributions are significantly different that the observed period. We have added the following to clarify on page 25, lines 1-2 of the revised manuscript:

Significantly different probability distributions are indicative of non-stationary behavior.

Detailed Comment 7: Pg 5580, line 18 - again be a little more clear about how runoff event impact the operation of reservoirs - a key issue is what level of error in prediction is likely to alter decisions - providing more specific information on types of decision made would help reader to interpret the relevances of changes in prediction shown here.

Detailed Comment Response 7: The authors intend for the introduction to be somewhat broad and generally applicable to water management in general. Runoff and



anticipated runoff has the potential to change the operation of reservoirs, specifically with regards to release rates and schedules. The sentence has been edited to read on page 4, lines 14-18:

The timing and magnitude of runoff events is of particular importance, as actual and forecasted runoff events can impact the operation of reservoirs (e.g., release schedules and magnitudes); however, climate change and anthropogenic alterations to basin characteristics increase the difficulty in accurately projecting streamflow conditions within hydrologic systems (e.g., Villarini et al. 2009).

Detailed Comment 8: Pg 5580 - provide some additional information on the RFS – in particular information on the type of hydrologic model (so it is clear to the reader why information on evapotranspiration is needed) - Providing performance statistics for prior uses of this model in the study basin would also be helpful if available.

Detailed Comment Response 8: The authors appreciate the need to provide additional information regarding the RFS, but feel that information is not appropriate introductory material. The RFS model used in this study is described in Section 2, and references to past studies regarding the use of the RFS model are provided throughout the manuscript. In particular, language has been added to Section 2, on page 11, line 10 through page 13, line 14 to further describe the model and need to account for information on evapotranspiration.

Detailed Comment 9: Pg 5584 line 13 - again I disagree that changes to evapotranspiration rates have not been considered in hydrologic models - there are published examples from the western us that should be cited and compared with results here

Detailed Comment Response 9: The authors hope that our response to Significant Revision 1 addresses this concern satisfactorily.

Detailed Comment 10: Pg 5584 - line 18 - again here it is not clear to the reader why VIC is not used directly to predict streamflow (since it already incorporates ET)-

additional information on how different models are used by the agencies involved is needed.

Detailed Comment Response 10: The authors hope that our response to Significant Revision 3 addresses this concern satisfactorily.

Detailed Comment 11: Pg 5585 - line 8 - explain how potential ET is reduced when area is not saturated – this is critical since in many cases warming will reduce area saturated, increase drought stress and reduce actual ET - so it is important to clarify how AET/PET is determined

Detailed Comment Response 11: This is an important and interesting point. In this study, changes to PET were not considered. Since the RFS is a lumped model, and at no time is there more evaporation than water availability over any particular catchment, we did not need to adjust for changes in PET. Using VIC model output, we could examine impacts to AET and PET; however, since we did not need that particular parameter for the RFS model, we did not account for it.

Detailed Comment 12: Pg 5585 - line 20 - this section needs a clearer description of how ET from VIC is used in RFS - as presented here it sounds like evapotranspiration rates are assumed to be those predicted by VIC given a 1C warming - but then why not use VIC-ET estimates from downscaled climate data.

Detailed Comment Response 12: Section 2.5 of the revised manuscript describes how ET from VIC is used in the RFS in more detail. The following statement has been added to Section 2.2, page 15, lines 4 through 6 of the revised manuscript to read:

Section 2.5 describes in further detail how evapotranspiration rates are utilized for input into the NWS RFS.

Furthermore, we hope that our response to Significant Revision 1 addresses the need to use the model that is required for reservoir operations in this study.

Detailed Comment 13: Pg 5585 - line 22 - why is this study not able to recalibrate - it



seems to me that recalibrating for historic period where ET is incorporated would be appropriate! Pg 5586 - line 1-10 - some of this information would be helpful earlier so that the reader can better understand how ET predictions discussed in the previous section will be used

“The NWS RFS model used here was provided by the CBRFC and is run in calibration mode; that is, the model is run without the calibration model that is typically run in parallel with the model at the CBRFC. This calibration model is run to calibrate streamflow output from the RFS to observed streamflow from gage records.” This sentence is very hard to understand if you are not familiar with their calibration approach - what does it mean to run a calibration model in parallel?

Detailed Comment Response 13: The authors hope that our response to Significant Revision 3 (Part 1) addresses this concern satisfactorily.

Detailed Comment 14: Pg 5586 - line 15-20 - mean area temperature (at what time scales?) - these are derived from gages? how?

Detailed Comment Response 14: The derivation of mean area temperature files is described in detail in Section 2.3 of the revised manuscript. As for how the CBRFC derives this information from gages, the CBRFC develops a weighting process for gages within a particular catchment to derive areal temperatures. This is unique to each catchment and to each River Forecasting Center. While this is an interesting topic, it is not a focus of this paper, and the authors would defer to the CBRFC to explain this process in more detail.

Detailed Comment 14: “The NWS RFS model provided by the CBRFC relied on values of evapotranspiration demand unique to each month; that is, evapotranspiration demand in any given month is identical throughout the length of the model run.” This is a KEY statement - and the reader need to know this much earlier in the paper -

Detailed Comment Response 14: We have added the following statement earlier in the paper to read on page 13, line12-14 of the revised manuscript:

The NWS RFS utilized by the CBRFC is dependent on user-defined evapotranspiration demand that is unique to each month; that is, evapotranspiration demand in any given month is identical throughout the length of the model run.

Detailed Comment 15: Pg 5588 - Recent studies (eg.Linquist et al., 2009) have shown that accounting for spatially variable temperature lapse rates can be critical in predicting snow accumulation and melt / streamflow - how are lapse rates with elevation determined here to downscale from 1/8th degree cell to elevation bands within catchment? are 3 elevation bands sufficient?) -(Note if statistics on prior model performance were given this would help convince the reader that their approach is reasonable). Similarly a key challenge for hydrologic modellers in mountain environments is interpolating precipitaiton data over space - it is not clear how the authors have addressed this issue.

Detailed Comment Response 15: This is an interesting point, and the authors feel that this could be subject to future research. However, this study relies on lapse rate parameters set by the CBRFC within the NWS RFS (specifically in the SNOW-17 model). Lapse rates were not addressed in this study. We have added the following to read on page 10 line 20 through page 11, line 2:

The NWS RFS model used here was provided by the CBRFC and is run in calibration mode; that is, the model is run without the calibration model that is typically run concurrently with the NWS RFS at the CBRFC. This calibration model is run to calibrate streamflow output from the RFS to observed streamflow from gage records. The calibration model utilized by the CBRFC is not available for use by outside agencies due to limitations associated NWS database connections and infrastructure. Aside from input files associated with temperature, precipitation, and evapotranspiration, the NWS RFS provided by the CBRFC is unchanged in this study.

Additionally, we have added the following to read on page 11, lines 11 – 15 of the revised manuscript:



Each catchment may then be divided into up to three elevation bands. These elevation bands are unique to each catchment and are derived by the CBRFC; it is important to note that the SAC-SMA model within the NWS RFS is limited to three elevation bands per catchment, though some catchments rely on only one or two elevation bands.

Further information regarding the SAC-SMA and SNOW-17 models may be found in the references provided within the manuscript.

Detailed Comment 16: Pg 5588 -give ranges of elevation bands - why 3? is that sufficient?

Detailed Comment Response 16: The ranges of elevation bands are unique to each catchment; this study investigated 165 unique and separate catchment and elevation band pairs. The topic of elevation bands is interesting and warrants additional research, but is not a focus of this particular study.

Detailed Comment 17: Pg 5598 - line 15-20 - I agree with the authors the ET is a sensitive and important parameter - but I think there are other sources of uncertainty in ET predictions that should at least be mentioned that are not accounted for by their approach. Consider for example the potential impact of increased water use efficiency with elevated $CO_2$, or changes in land use/land cover (see paper by Cuo et al., 2009) as an example.

Detailed Comment Response 16: We appreciate the referee's concern, and hope that in no way does this paper insinuate that we believe that ET is the only sensitive and important parameter to account for in light of changing climate. By incorporating projected climate change from multiple emissions scenarios, we hope that we have implicitly captured some of that potential change in this study. We have added the following to read on page 28, lines 11-19 of the revised manuscript:

While this research investigated changes to streamflow in response to projected changes in climate, specifically with respect to temperature, precipitation, and evapotranspiration, it is important to note that these are not the sole parameters that may be investigated when using a hydrologic model to project future water supply. Recent research has investigated the role of land cover and climatic change to basin hydrology (Cuo et al. 2009). By accounting for multiple emissions scenarios from multiple climate models, this study implicitly accounts for additional impacts to hydroclimatic variables due to climate change. Future research is necessary to assess the impacts of specific hydroclimatic variables to regional and global hydrology.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 5577, 2010.