**Title**

Prediction of streamflow in ungauged, *irrigated* basins

**Prediction of irrigation practice in sparsely observed catchments**

Understanding irrigation’s effect on streamflow

Can we predict irrigation practice from streamflow?

**Introduction**

The international “predictions in ungauged basins” or “PUB” effort has improved the tools available to support water resources management in sparsely observed regions. However, these tools have focused on regions with limited diversion of surface water or groundwater resources.

Incorporating anthropogenic activity into PUB methods is essential given the high level of development of many basins.

Irrigation is one of the anthropogenic greatest disruptors of streamflow. We extended a soil moisture balance and transport model to explore the effects of irrigation on streamflow dynamics for different catchment types (Botter et al., 2007).

The results of our analysis will allow us to predict irrigation practice, which is often poorly documented or unmeasured, by analyzing streamflow.

[insert picture of irrigation and river?]

**Research Questions and Methods**

1. How does a given irrigation strategy affect on streamflow for a variety of catchment types?

2. Can we predict irrigation practice in a basin by analyzing streamflow?

**Method**

We dictated a deficit irrigation strategy in which farmers begin irrigation when soil moisture reaches 50% of field capacity and continue to irrigate until soil moisture reaches full field capacity. A wide range [what is the range] of catchment types, comprising a variety of soil types and climate regimes

We considered, individually, four sources of irrigation:

(source 1) water imports,

(source 2) direct in-channel diversions,

(source 3) shallow groundwater with direct connectivity to stream channels, and

(source 4) deep groundwater that is indirectly connected to surface flow via a shallow aquifer.

The Botter model is an established and verified model for predicting streamflow using a “bucket model” approach (Botter et al., 2007). We have modified this model to account for our four irrigation sources.

[insert bucket model figure]

γp α λQ *ET n sw s1 Zr*

**Timeseries**

This timeseries of streamflow and irrigation was produced for x climate, y soil with deficit irrigation sourced from z source. The streamflow timeseries for the same catchment with no irrigation (“natural”) is shown for comparison.

[insert Q, SA, GW, P, I, soil moisture timeseries, both natural and irrigation]

-point out interesting highlights in timeseries, illustrate alpha, gamma and dailyQavg on the timeseries

A distance metric describes the magnitude of change in streamflow daily average (avgQ), average magnitude of the peaks (alpha), and average frequency of peak occurrence (gamma) compared to natural streamflow.

**Results**

Four contour plots – one for each case (only do soil moisture and full sync; all four cases)

Or do an environmental impact plot

Highlight most important parts

Say that some climates have no irrigation; show plot for this

Plot of environmental impact factor on the river?

Aaγ aλ aα

**Conclusion**

The distance metric indicates a catchment’s susceptibility to a given irrigation regime. (say how well we can predict irrigation given a type of catchment)

Our results provide a first insight into PUB methodologies that could be employed in heavily managed basins. Application of this work could shed light on worldwide irrigation practices that are unavailable through remote sensing data and serve as a step towards improved water resources planning in basins affected by human activity.

**Next Steps**

To expand on our first research question, we will vary the irrigation regime. We will include fixed scheduling of irrigation and an ET balance irrigation method.

To address our second research question, we will use statistical techniques to compute the likelihood of each irrigation practice in a set of potential irrigation scenarios using streamflow data alone.

Our predictions in irrigation will be validated through comparison with basins for which irrigation and streamflow details are already known.

References

Botter, G; Porporato, A; Rodriguez-Iturbe, I; Rinaldo, A. “Basin-scale soil moisture dynamics and the probabilistic characterization of carrier hydrologic flows: Slow, leaching-prone components of the hydrologic response”. *Water Resources Research,* 43, 2007.