The Key to Prediction in Ungauged Basins

Can we predict runoff without ground stations?

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What is required ?

1. A model structure reflecting dominant processes in the landscape
2. Independent estimation of key parameters (root zone storage capacity)
3. Climatic drivers observed from space (E and P)
4. Information to constrain remaining parameters

What is available ?

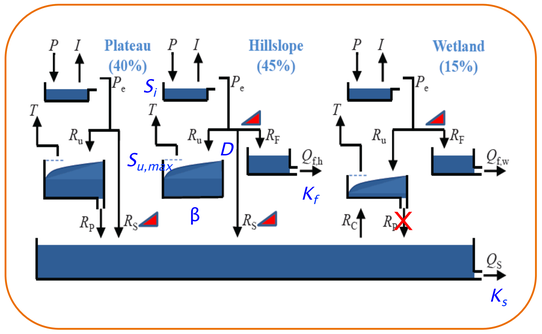
1. DEM at 30 m resolution
2. P (CHIRPS 0.05°, CRU 0.5°) and E (SSEBop 0.01°, MOD16 0.05°), ERA-I (0.5°)
3. W: Total Water Equivalent from GRACE at 1-2° resolution

CIRPS: Climate Hazards Group InfraRed Precipitation with Stations (USGS)
CRU: Climate Research Unit Time Series;
SSEBop: operational Simplified Surface Energy Balance;
MOD16: MODIS_ET
ERA_I: ERA-Interim

Model Structure

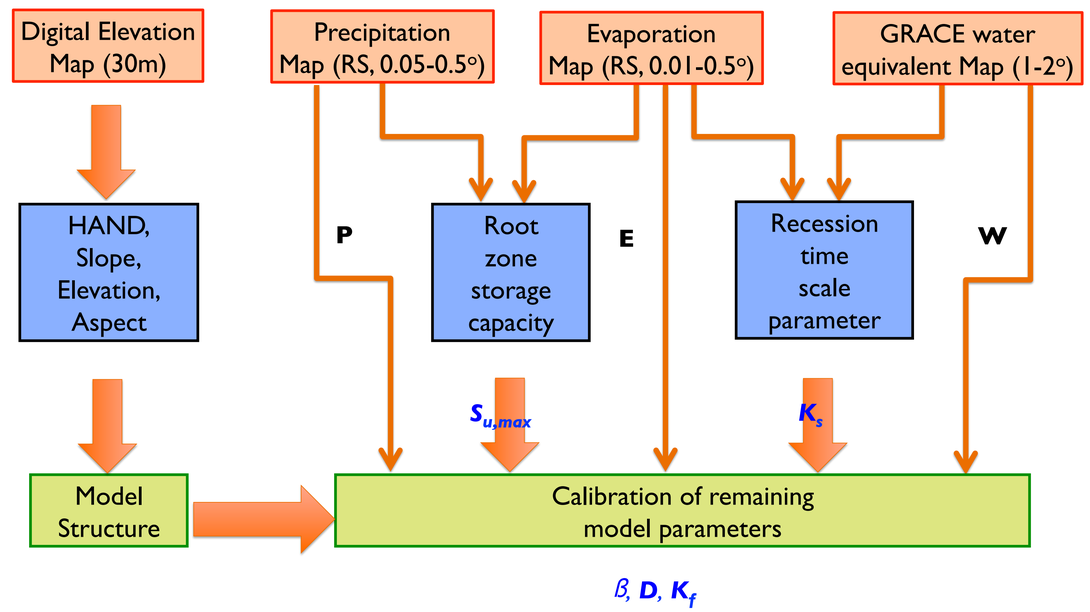
From DEM
1. HAND (height above the nearest drain)
2. Slope
3. Elevation (for tree line and snow limit)
4. Aspect (different ecosystem)
5. Low HAND: Wetland
6. High slope: Hillslope
7. High HAND, low slope: Terrace and Plateau

HAND map

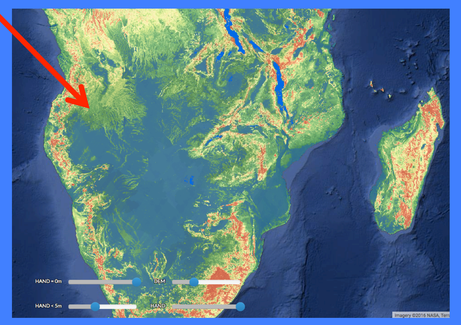


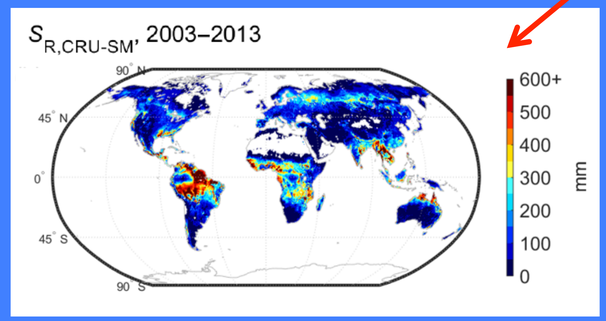
Key parameters:
$S_{u,max}$: root zone storage capacity
β: shape of the VIC-type threshold
D: splitter for recharge
K_s: recession of groundwater flow
K_f: recession of fast flow
S_i: interception capacity

Flow diagram for PUB



$$\frac{dW}{dt} = \frac{dS_g}{dt} + \frac{dS_u}{dt} + \frac{dS_s}{dt} = P - E - Q$$





Recession Coefficient

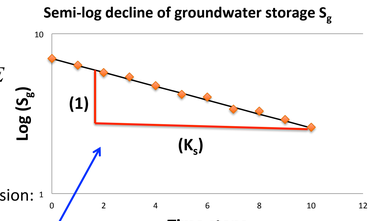
Dry Season disconnect:

$$\frac{dS_u}{dt} + \frac{dS_s}{dt} = P - E$$

$$\frac{dS_g}{dt} = -Q$$

With exponential recession:

$$Q = S_g / K_s$$



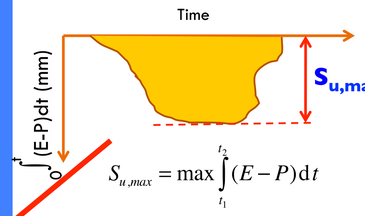
ΔS_g from GRACE and $(E - P)$

$$S_g(t+\Delta t) = S_g(t) + \Delta W + (E-P)\Delta t$$

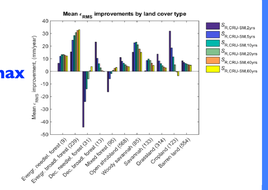
$$\frac{dS_g}{dt} = \frac{dW}{dt} + (E-P) = -\frac{S_g}{K_s}$$

Note: in this way we can derive crucial aquifer characterisitcs from RS

Root zone storage capacity



$$S_{u,max} = \max \int_{t_1}^{t_2} (E-P)\,dt$$



Note: in this way we obtain the primary control on runoff generation from RS

Calibrating remaining parameters

Using time series of P, E and W, the remaining parameters can be further constrained. Key parameters to be constrained are:
1. the β parameter of the root zone (VIC-like)
2. the splitter D between preferential recharge and fast runoff
3. the fast recession parameter K_f

(e.g. Winsemius et al., 2009)
Use comparative constraints between landscapes, e.g. $S_{u,max}$ and S_i of wetlands are less than of hillslopes, etc. (Gharari et al., 2014)

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Conclusions

1. The method is, in principle, scale independent up to the Representative Elementary Area
2. It is possible to predict runoff in ungauged areas for the entire globe, provided we interpret the landscape for its dominant mechanisms
3. Timing and attenuation may not be accurate, but water balance and main characteristics are obtainable
4. As more detailed information becomes available the method will become more accurate