Efficiency Space

- References:
  - Koster, R. D., and S. P. P. Mahanama, 2012: Land surface controls on hydroclimatic means and variability. *J. Hydrometeor.*, **13**, 1604-1620, doi: 10.1175/JHM-D-12-050.1.
  - Koster, R., 2015: "Efficiency Space": A Framework for Evaluating Joint Evaporation and Runoff Behavior. *Bull. Amer. Meteor. Soc.*, 96, 393–396, doi: 10.1175/BAMS-D-14-00056.1.
- Principle:
  - Building on a large body of research going back to Budyko (1974) centered on determining the dependency of ET (usually represented as evaporative fraction) and runoff (normalized by precipitation) on soil moisture, Koster and Mahanama (2012) demonstrate evidence for a limited range of likely functional dependencies among these variables that determine observed "hydroclimatic sensitivities;" the means and variability of these terms. Using a simple water balance model tuned to maximize skill of reproducing observed river discharge provide complimentary estimates of evaporation and soil moisture properties within catchments.
  - Koster (2015) directly relate the efficiencies Q/P and EF that depend on soil moisture in a metric that is a 2-dimensional phase-space. For any catchment, running of the simple water balance model with a variety pairings of efficiency functions, produce curves in efficiency space. Those that produce the same curve in efficiency space generate essentially the same hydrological fluxes. These can be validated as in Koster and Mahanama (2012) to find the best relationship.
- Data needs:
  - The simple water balance model is driven by daily precipitation and net radiation.
  - Validation requires observed runoff (streamflow) on daily to monthly intervals.
  - Well suited to application to climate model output.
- Observational data sources:
  - Readily available from in situ and/or remote sensing sources.
- Caveats:
  - Provides a potentially useful tool for developing and validating the joint ET–runoff behavior of LSMs. Best-fit observationally-validated relationships can be used to tune LSMs.
  - Results depend somewhat on the choice of the size of the active soil reservoir, which is an unconstrained parameter in this formulation.
  - Multiple pairs of Q/P and EF functions of soil moisture can produce the same curve in efficiency space. Additional data (evaporation or soil moisture time series) can be used to better constrain those functions.

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