H23F-1346: Impact of sub-grid soil textural properties on simulations of hydrological fluxes at the continental scale Mississippi river basin

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1. Introduction

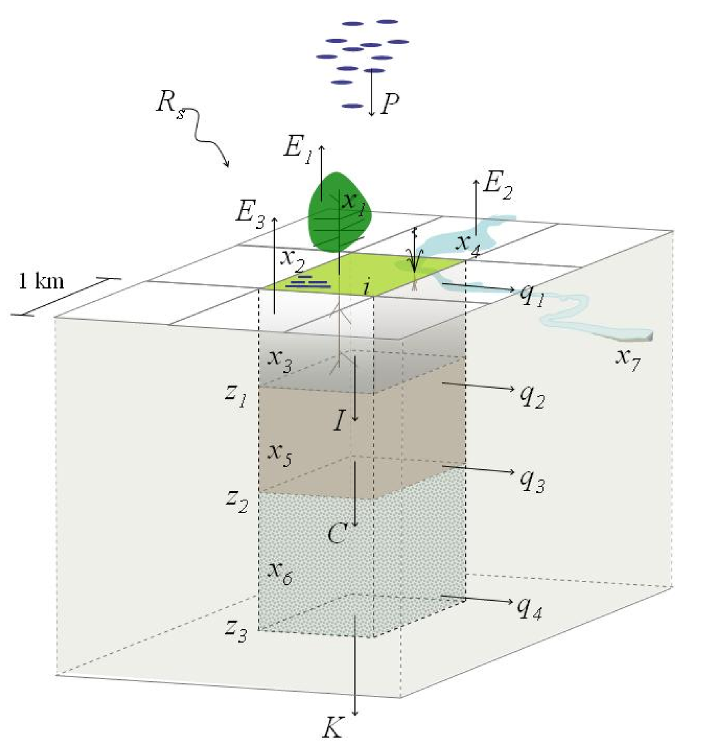
Knowledge of soil hydraulic properties such as porosity and saturated hydraulic conductivity is required to accurately model the dynamics of near-surface hydrological processes (e.g. evapotranspiration and root-zone soil moisture dynamics) and provide reliable estimates of regional water and energy budgets. Soil hydraulic properties are commonly derived from pedo-transfer functions using soil textural information recorded during surveys, such as the fractions of sand and clay, bulk density, and organic matter content. Typically large scale land-surface models are parameterized using a relatively coarse soil map with little or no information on parametric sub-grid variability.

2. Objective

The goal of this study is to assess the impact of sub-grid soil variability on simulated hydrological fluxes over the continental scale Mississippi River Basin ($\approx$ 3,240,000 km^2) . We conducted the analysis using a modeling framework based on the mesoscale hydrologic model (mHM) with two soil datasets available at different scales: (a) the Digital General Soil Map of the United States or STATSGO2 (1:250 000) and (b) the recently collated Harmonized World Soil Database (HWSD) based on the FAO-UNESCO Soil Map of the World (1:5 000 000).

3. Mesoscale Hydrologic Model (mHM)[2, 1]

mHM is a grid based distributed hydrologic model which is parameterized with a multiscale regionalization technique that explicitly accounts for the sub-grid variability of basin physical characteristics, and derives distributed soil hydraulic properties via a set of pedo-transfer functions and regional calibration coefficients.



State variable at cell i, time t

State equations: cell i, time t:

$$\dot{\mathbf{x}}_i(t) = \mathbf{f}(\mathbf{x}_i, \mathbf{u}_i, \boldsymbol{\beta}_i) + \boldsymbol{\eta}_i(t) \quad \forall i \in \Omega$$

Output: runoff:

$$\mathbf{q}_l(t) = \mathbf{g}(\mathbf{x}, \mathbf{u}, \boldsymbol{\beta}) + \boldsymbol{\epsilon}_l(t)$$

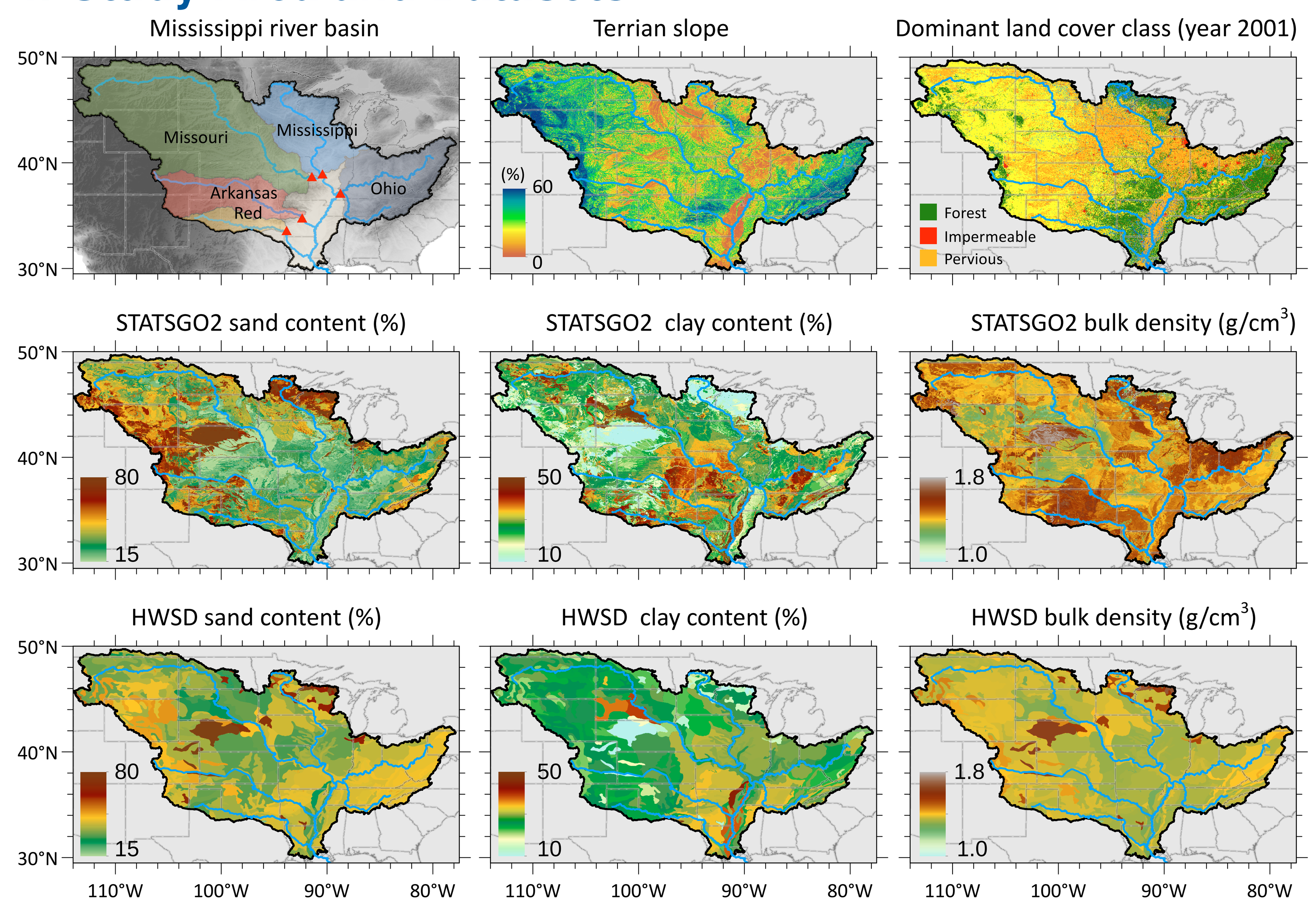
Multiscale parametrization[2]:

$$\beta_{ki}(t) = \mathrm{O}_k \Big\langle \beta_{kj}(t) \quad \forall j \in i \Big\rangle_i$$

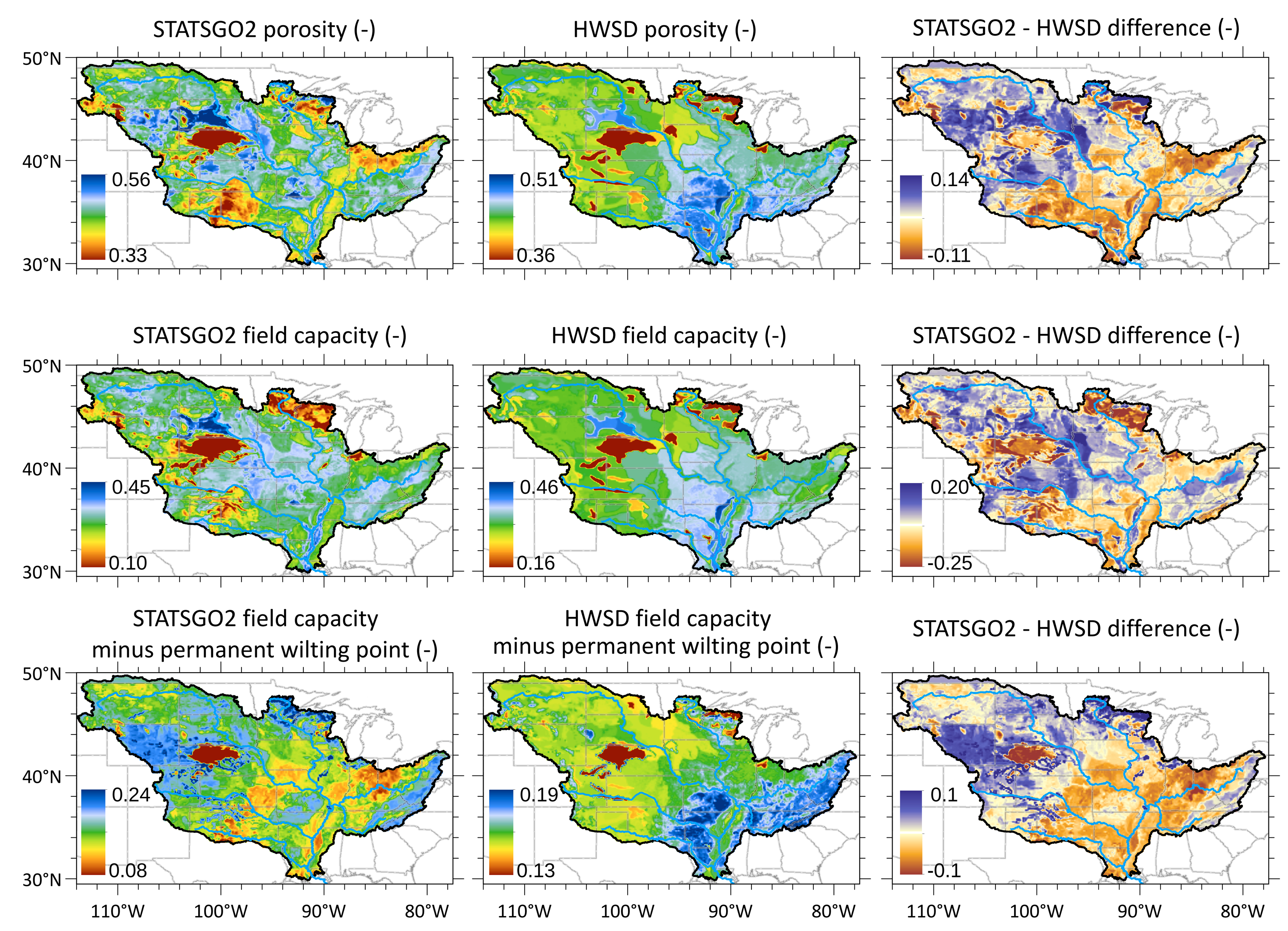
$$\beta_{kj}(t) = \mathbf{w}_k \Big(\boldsymbol{u}_j(t), \boldsymbol{\gamma} \Big)$$

$\mathbf{f}, \mathbf{g}$	system and output functional relationships
$\mathbf{x}$	state variables
$\mathbf{q}$	l-dimensional output vector
$\mathbf{u}$	fields of physiographical and meteorological variables
$\boldsymbol{\eta}$	unmeasurable stochastic inputs
$\boldsymbol{\epsilon}$	system's uncertainty due to measurements defects
Ω	control volume (e.g. river basin)
$\boldsymbol{\beta}$	distributed model parameter field
$\boldsymbol{\gamma}$	global (or calibration) parameters
w	transfer or regionalization function
O	upscaling operators
i, j	cell location indexes at model grid and sub-grid levels
k, t	parameter and time indexes

4. Study Area and Datasets

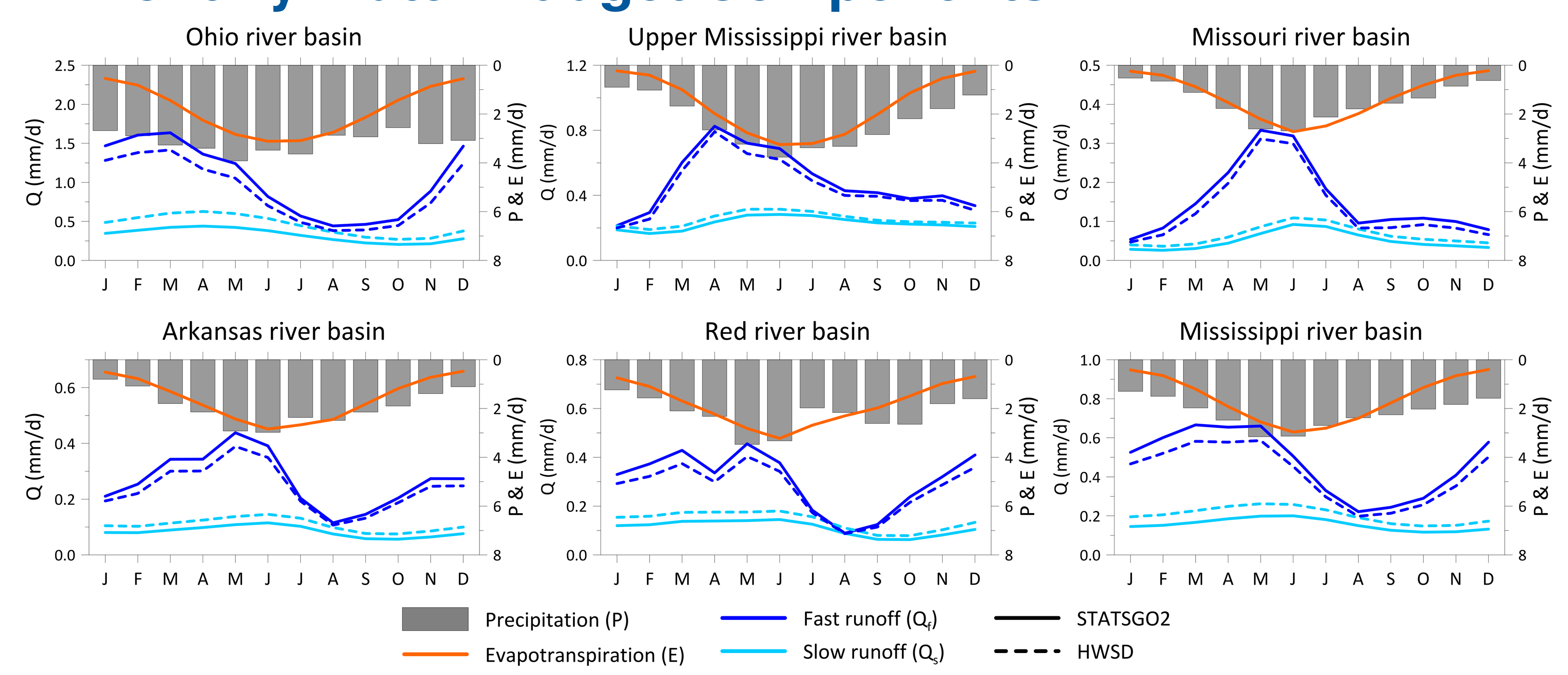


5. Soil Hydraulic Parameter Fields



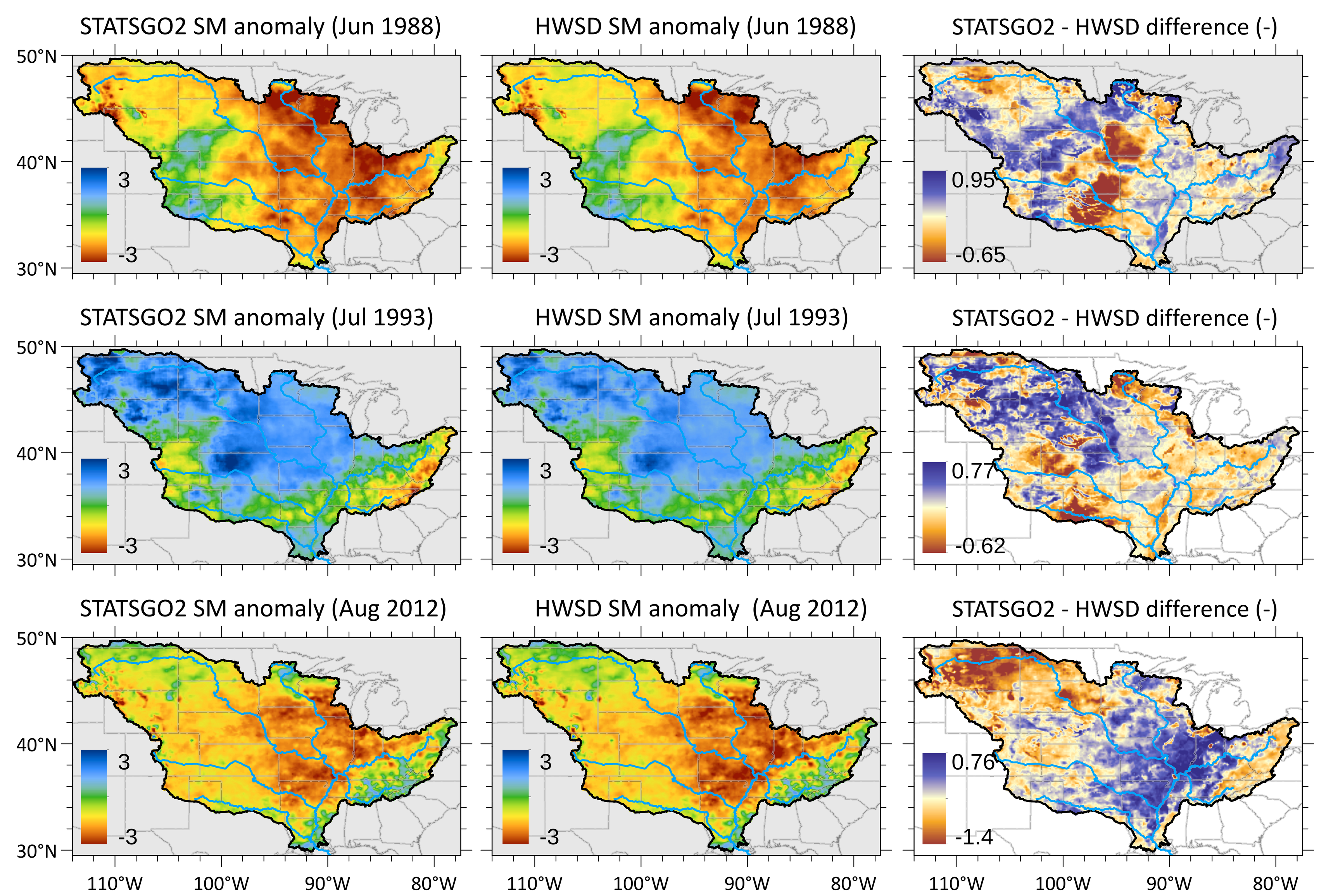
Parameter fields were estimated using a set of pedo-transfer functions developed by Zacharias and Wessolek (2007)

7. Monthly Water Budget Components



Modeled fluxes using North American Land Data Assimilation System-2 (NLDAS-2) datasets for the period 1980 to 2012

8. Soil Moisture Anomaly During Extreme Events



Root zone soil moisture anomaly standardized using climatological mean and stnd. dev. for the period 1980 to 2012

9. Conclusions

- The two soil datasets although having substantial differences produced nearly similar annual patterns of modeled runoff and evapotranspiration.
- The partitioning of total runoff into fast and slow flow components, however, varied substantially depending on the soil dataset used.
- The differences in the SM anomaly during extremes ($\approx$ 20-50%) highlight an additional source of uncertainty arising from input soil datasets.

[1] R. Kumar, L. Samaniego, and S. Attinger, “Implications of distributed hydrologic model parameterization on water fluxes at multiple scales and locations,” *Water Resour. Res.*, vol. 49, 2013.

[2] L. Samaniego, R. Kumar, and S. Attinger, “Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale,” *Water Resour. Res.*, vol. 46, 2010.

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