

**Quantifying the long-term changes of land water availability and their driving factors** 

2020 ESMD-E3SM PI meeting

**Xiaoying Shi1\*, Yaoping Wang2, Jiafu Mao1, Ricciuto M. Daniel1, Forrest M. Hoffman3, and Peter E. Thornton1**

*1Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

*2Institute for a Secure and Sustainable Environment, University of Tennessee, Knoxville, TN, USA*

3*Computational Sciences and Engineering Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

ORNL is managed by UT-Battelle, LLC for the US Department of Energy 

**Motivation** 

✔ **Fresh water is one of the key natural resources for human development and its availability affects water supplies,**

**agricultural yields, energy production, and infrastructure safety and operation.** ✔ **However, the investigation of long-term changes of water availability (WA) and quantification of their natural and**

**anthropogenic drivers remain**

**challenging.**

**Methods**

✔ **The GRACE reconstructions for both *R* and** Δ***TWS* (Ghiggi et al., 2019; Humphrey and Gudmundsson, 2019), and the land WA is defined as**

***P – ET = R* +** Δ***TWS***

✔ **36 half-degree global offline factorial (S1 to S6) simulations of ELMv1.0 with CN or CNP configurations driven by 3 different climatic drivers (right table).**

2 

**Simulations Climate forcing CNP and CN GSWP3 CRUNCEP PRINCETON**

**S1** Control, 1901-1920 climate cycling and 1850 conditions

**S2** Transient climate only (CN and CNP)

**S3** Transient climate and LULCC

**S4** Transient climate, LULCC and CO2

**S5** Transient climate, LULCC, CO2 and Ndep **S6** Transient climate, LULCC, CO2, Ndep and aerosol **S2-S1** Climate only

**S3-S2** LULCC only

**S4-S3** CO2 only

**S5-S4** Ndep only

**S6-S5** Aerosol only

**ELM Experimental design**

****

**Observed and ELM simulated (S6) annual anomalies (mm) of land WA during 1941-2012**

3 

**Spatial distributions of observed and ELM simulated (S6) WA trends and their differences (1941-2012)**

4

**All factors Climate effects**

**CNP-met CN-met**

**CNP-met CN-met**

**ELM** 

**CRUNCEP ELM**

**ELM** 

**PRINCETON **

**ELM** 

**CRUNCEP ELM**

**ELM** 

**PRINCETON **

**GSWP3 AVG**

**GSWP3 AVG**

****

**Spatial distributions of ELM simulated all-factor (left) or climate (right)**

S6-S1 WA trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg)

**induced WA changes** 

5 S6-S1 WA trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg) S2-S1 Clim olny trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg)

**CO2 effects Ndep effects**

**CNP-met CN-met**

**CNP-met CN-met**

**ELM** 

**CRUNCEP ELM**

**ELM** 

**PRINCETON **

**ELM** 

**CRUNCEP ELM**

**ELM** 

**PRINCETON **

**GSWP3 AVG**

**GSWP3 AVG**

**Spatial distributions of ELM simulated CO2 (left) or Ndep (right) induced** 

S6-S1 WA trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg)

**WA changes**

S4-S3 CO2 trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg) S5-S4 Ndep trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg) 6

**LULCC effects Aerosol effects**

****

**Spatial distributions of ELM simulated LULCC (left) or Aerosol (right)**

S6-S1 WA trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg)

**induced WA changes** 

7 S6-S5 Aerosol trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg) S3-S2 LULCC trend (CNP-met, CN-met, elm-CRUNCEP, elm-PRINCETON, elm-GSWP3 and Avg)

**Summaries of component (left) and factorial (right) contributions to WA** 

**By component By forcing**

8 

**Spatial distributions of dominant component (left) or factor (right) driving the WA changes**

9

**Summary** 

✔ **Both observation-based and ELM simulated global-averaged annual WA showed significant increasing trends for the 1941-2012 period;**

✔ **ELM basically captured the changing sign and magnitudes of the spatial patterns of the WA trends, albeit with differences for ecoregions including the cropland, wetlands and deserts;**

✔ **For each component of WA, the precipitation controlled the WA changes across most global areas; but ET demonstrated primary local effects, especially over the temperate grassland and shrubland, deserts and wetlands;**

✔ **Although the climate change was identified to determine the long-term trends of WA, anthropogenic CO2 concentration, nitrogen deposition, land use/land cover changes, and aerosol induced significant WA changes at regional scales. For example, CO2 demonstrated evident effects over the boreal forests, and LULCC mattered over west Europe and African tropical forests;**

✔ **The impacts of different factors on the changes of WA are sensitive to the model configurations and climatic forcings.**

10 