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Global testing and sensitivity analyses of VIC hydrologic parameterizations in CLM

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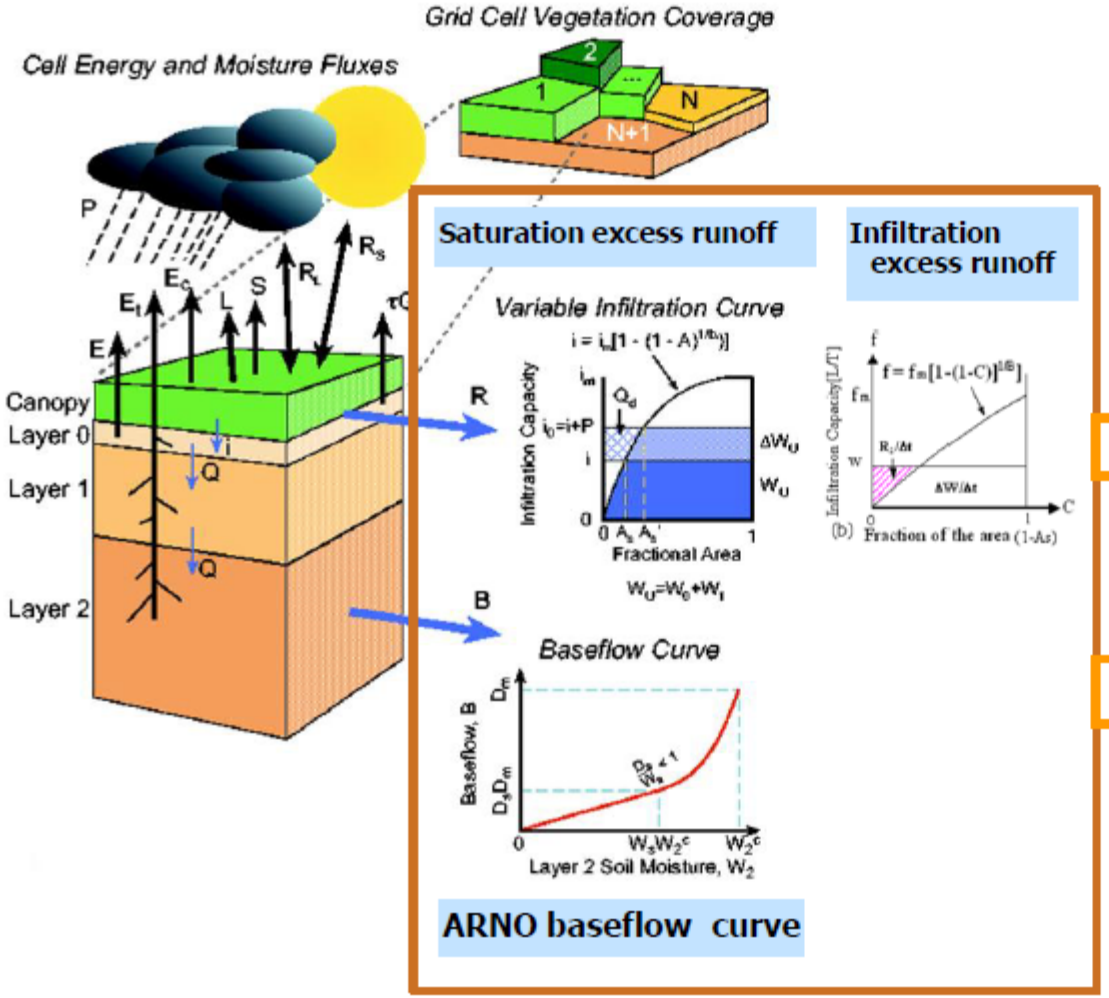
Methodology

- Model
  - CLM4.5 Science Branch Tag: VIC
  - VIC hydrology has been implemented into the Tag

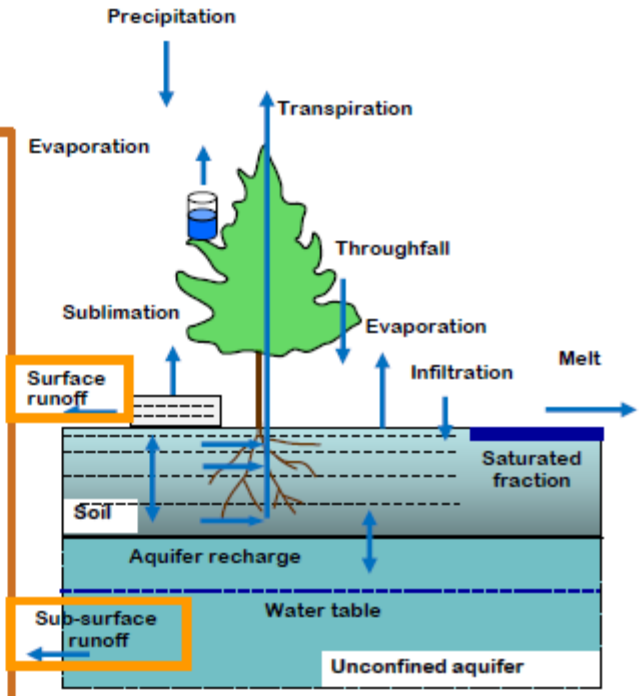
- Methodology
  - Three VIC parameters were selected for sensitivity analyses:
    - b, D_{smax}, W_s
  - The uncertainty quantification framework for CLM developed in Hou et al. (2012) were used for a global sensitivity analysis
  - GRDC annual runoff (climatology) were used as the benchmark dataset
  - CLM was run globally at 0.9x1.25 degree using the I2000 case

Merging of CLM4 and VIC

VIC



CLM4 Hydrology



CLM4VIC

Comparison between runoff parameterizations

CLM4

- Physically based
- Assumptions from TOPMODEL:
  - High-resolution topographic data are available;
  - Subsurface flow is topographic driven.
  - A quasi-steady state to approximate saturated zone dynamics;
  - Recharge to ground water is spatially uniform;

These assumptions are invalid, e.g., over flat terrain or arid regions

VIC

- Conceptual
- Limited assumptions:
  - land surface, and therefore surface runoff generation, is heterogeneous;
  - Subsurface flow is a nonlinear function of deep-layer water availability
- Calibration of parameters are recommended

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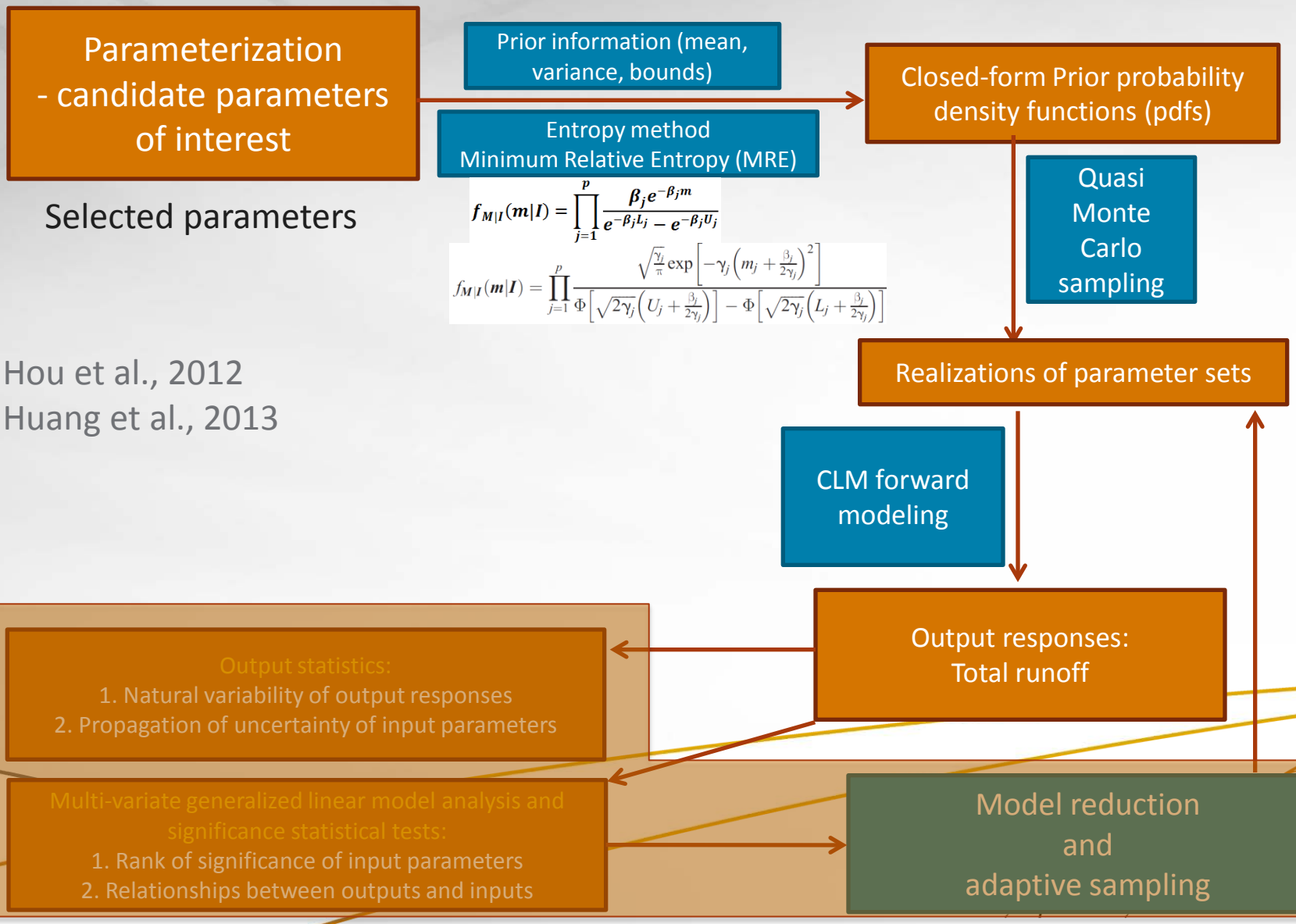
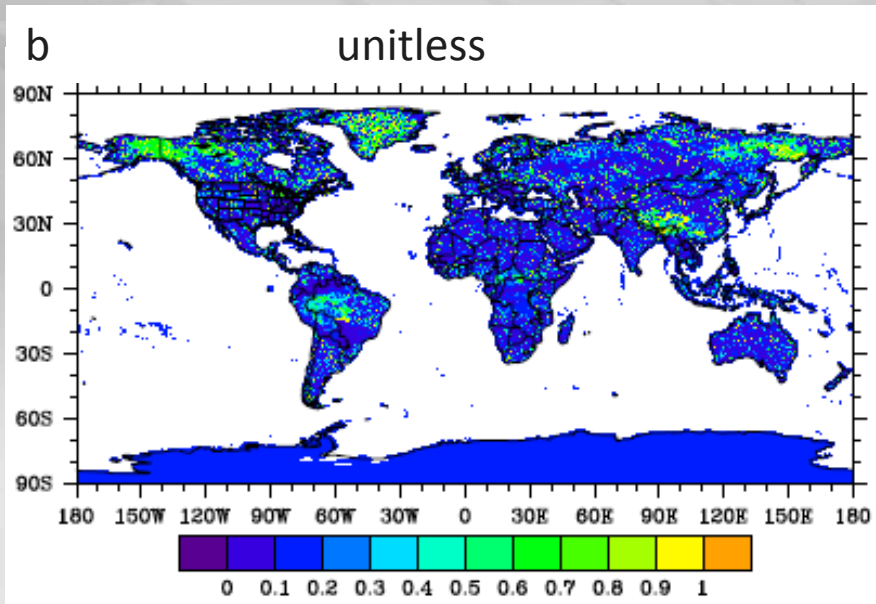
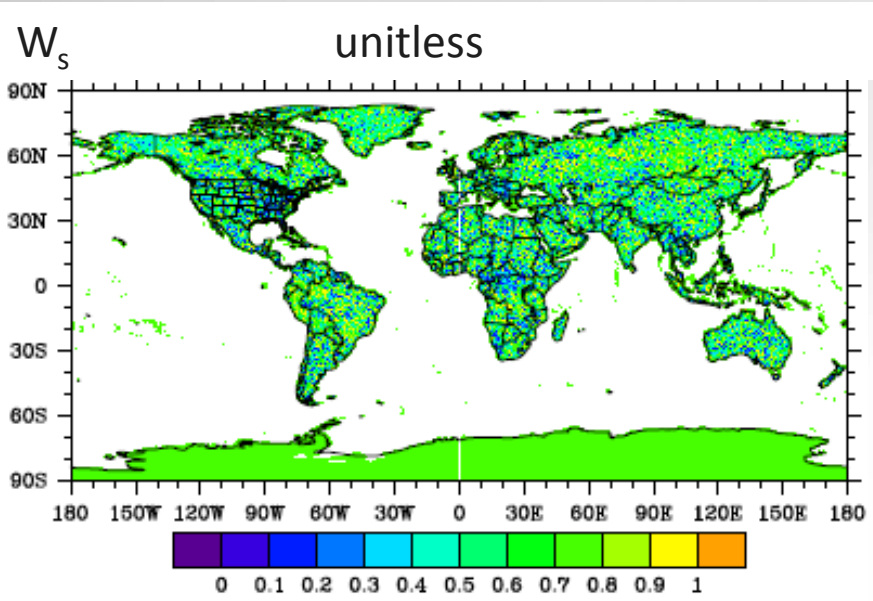
UQ framework designed for CLM

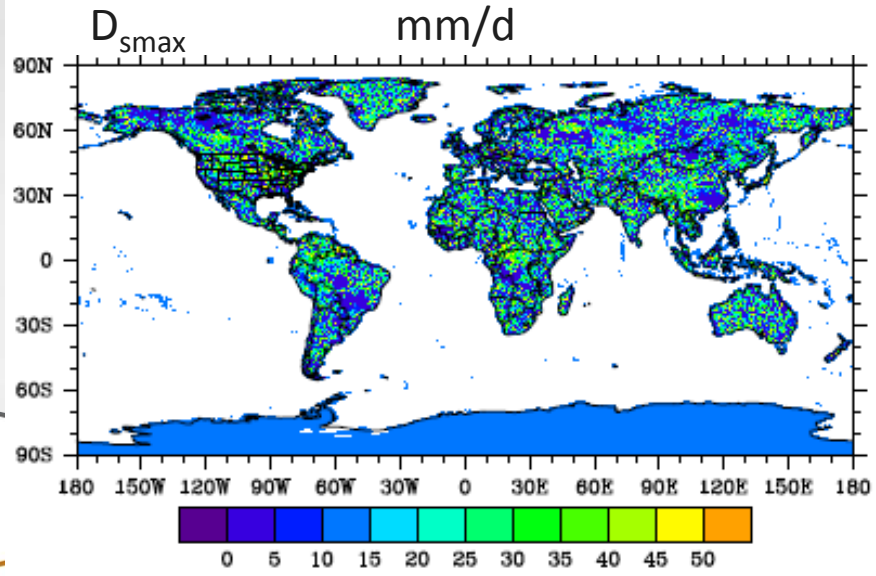


Hou et al., 2012
Huang et al., 2013

VIC parameter values from GLDAS



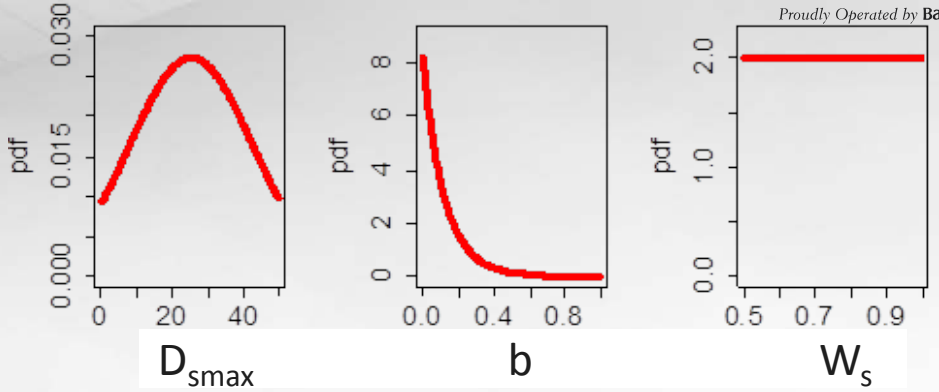




	D_{smax}	b	W_s
Mean:	25.14	0.13	0.75
Max:	49.94	0.99	1.00
Min:	0.11	0.00	0.50
STD:	12.44	0.13	-----

Generating samples of VIC parameters

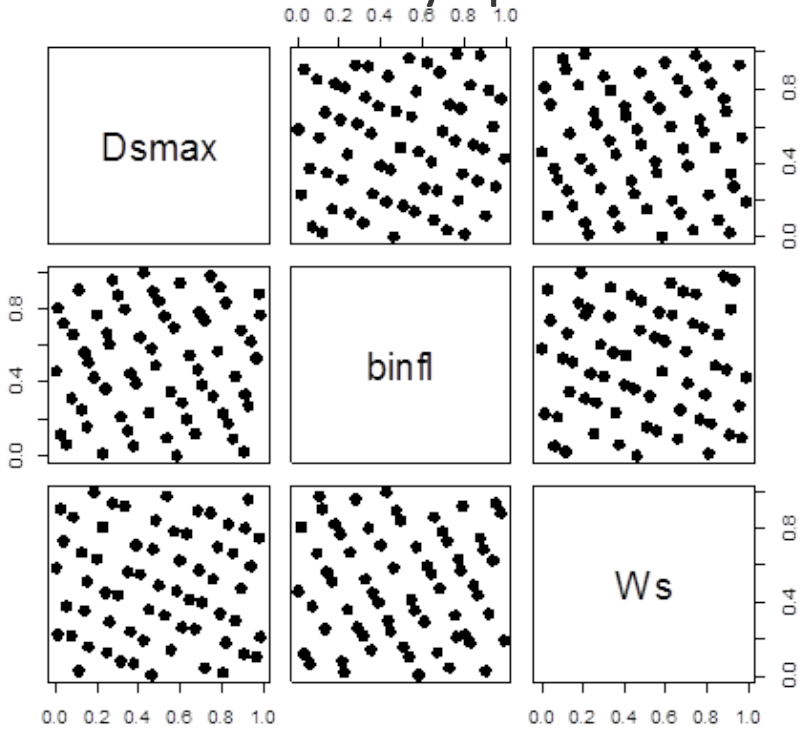
- Probability density functions of the three selected parameters



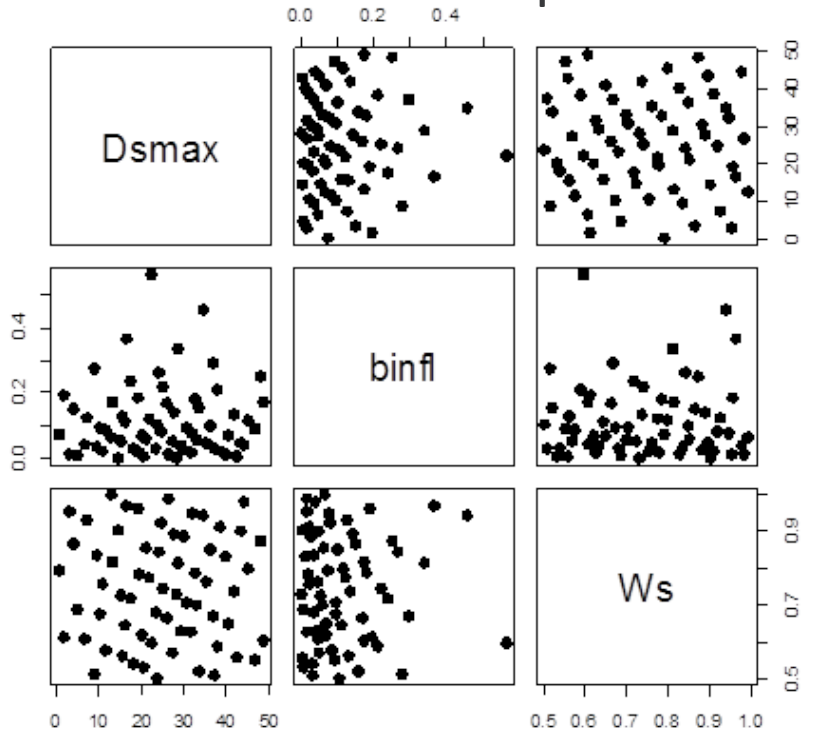
D_{smax} b W_s

- 64 samples for CLM global simulations

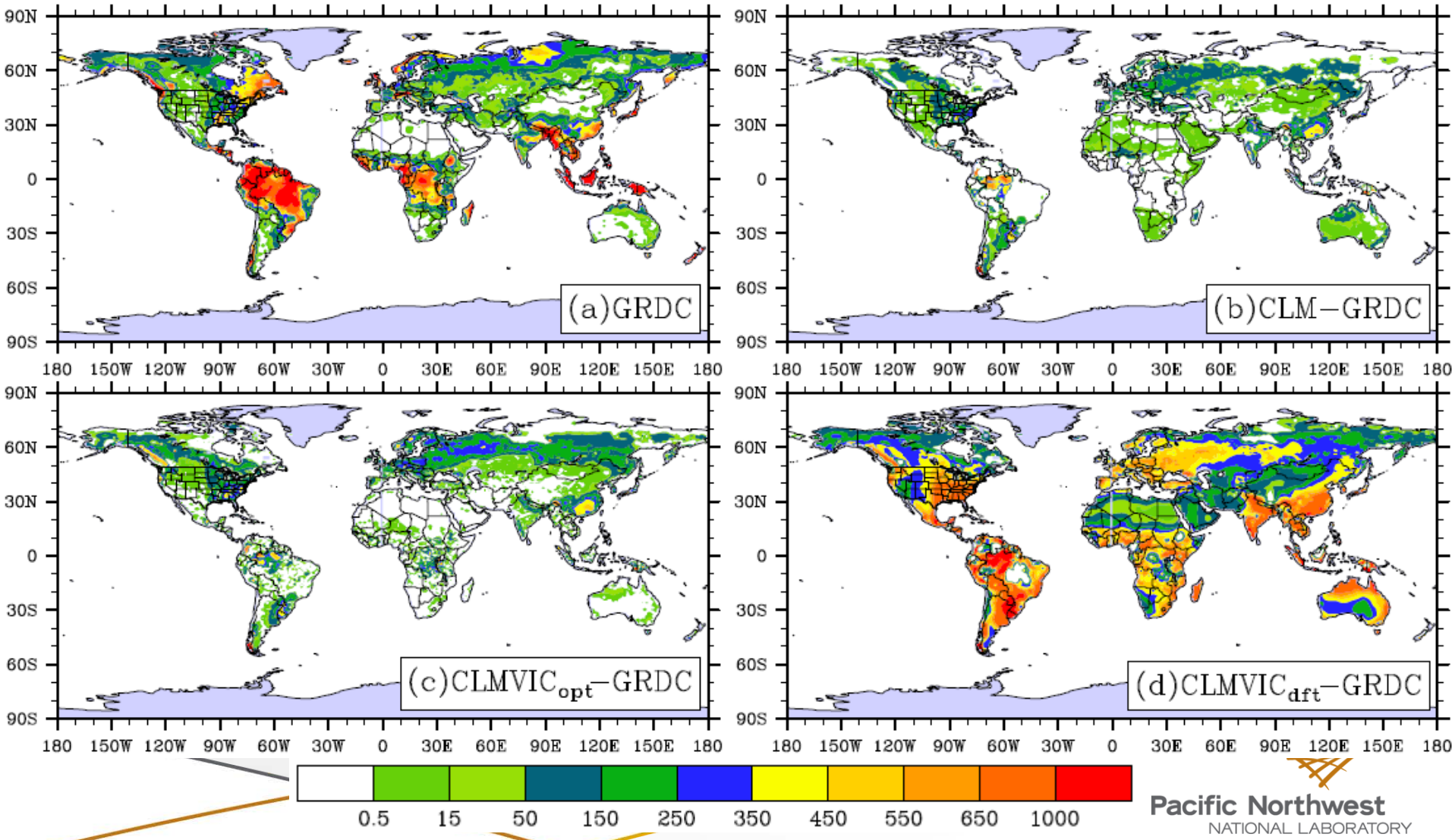
Probability space



Parameter space



Calibration against the GRDC total runoff field (climatology)



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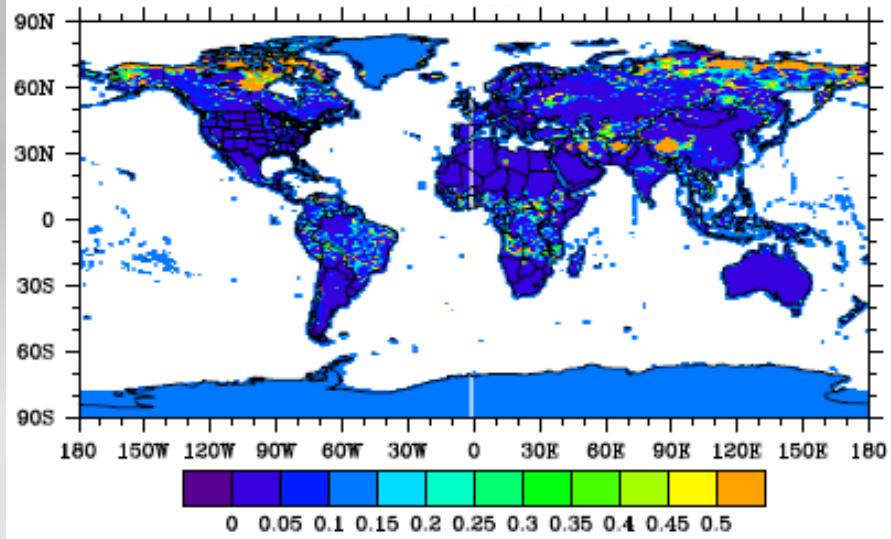
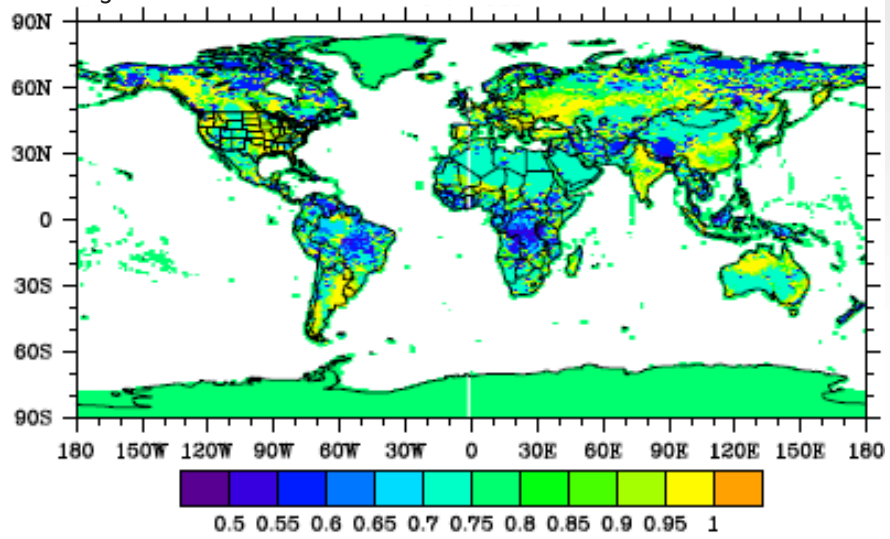
Calibrated VIC parameter values

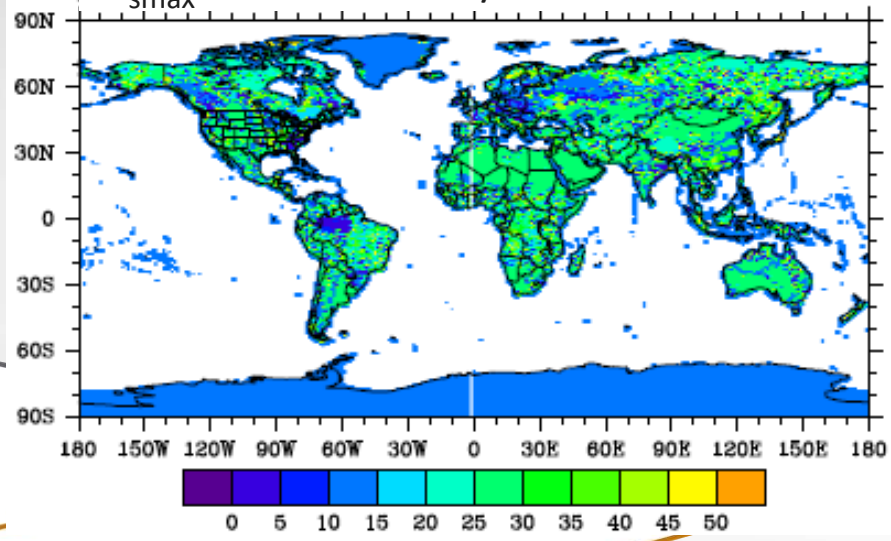
b unitless



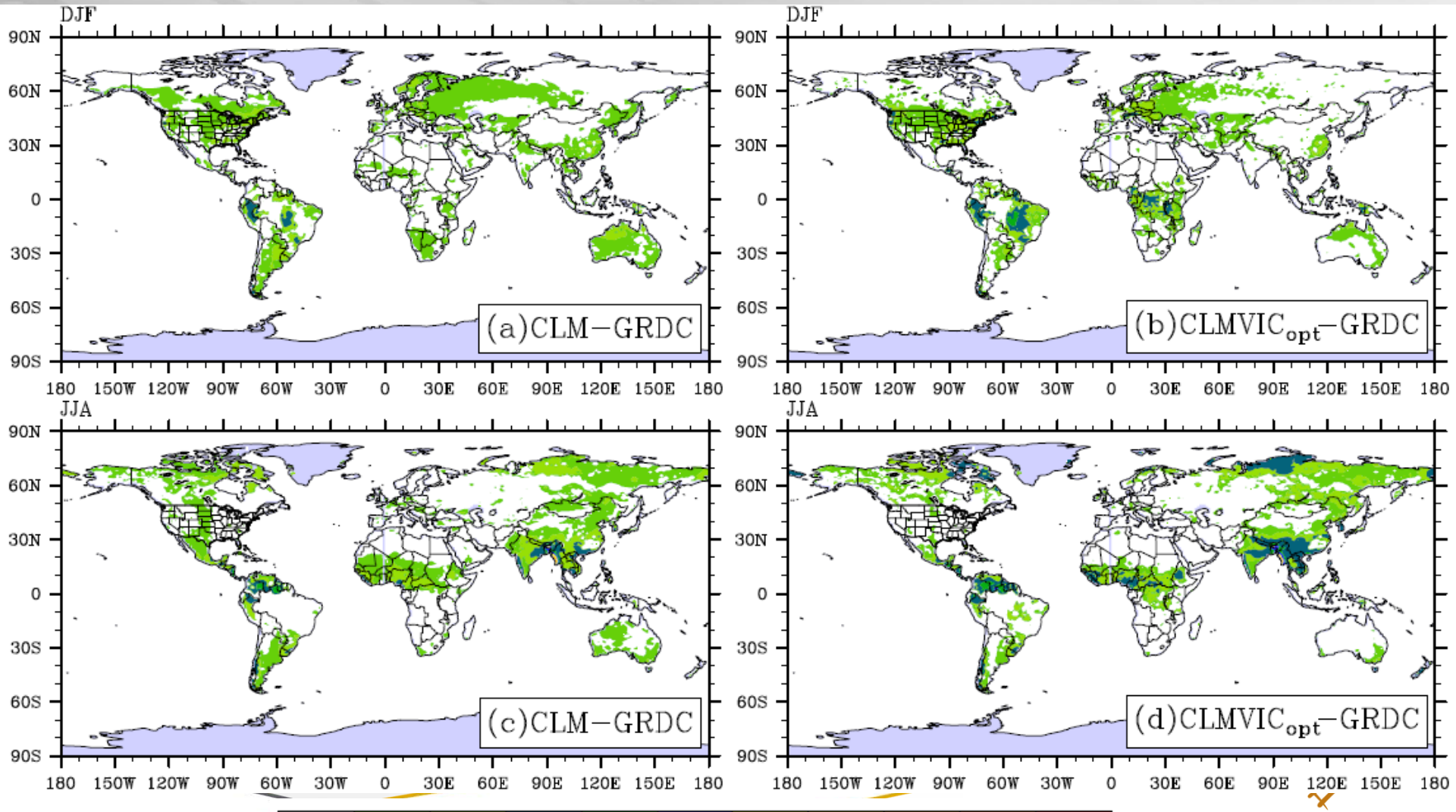
W_s unitless



D_{smax} mm/d



Seasonal differences in runoff



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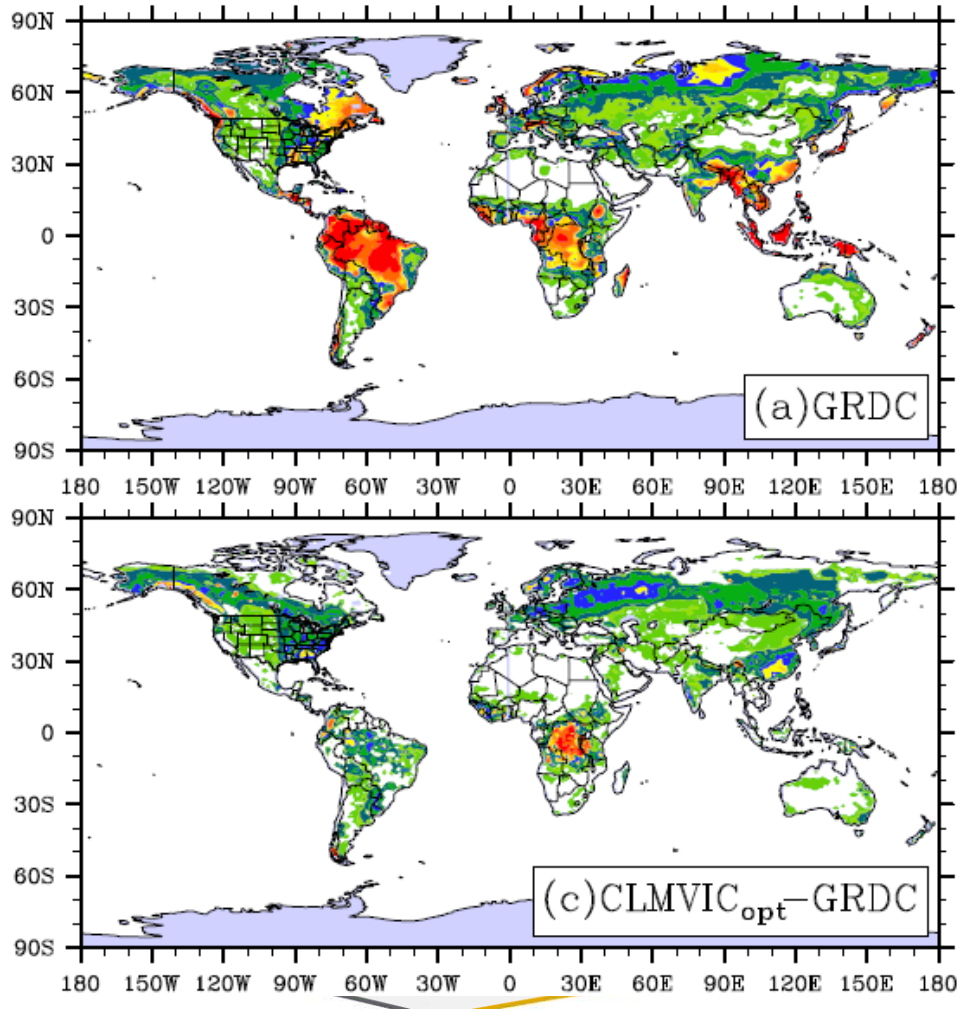
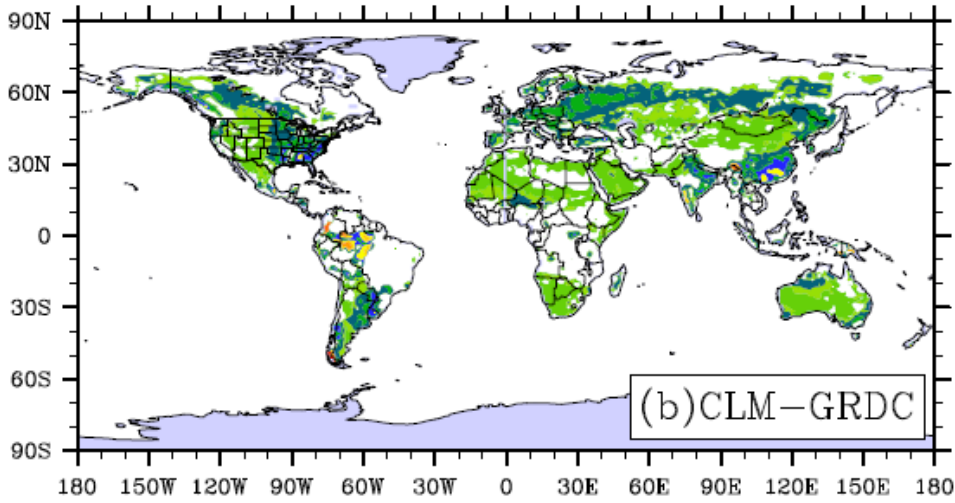
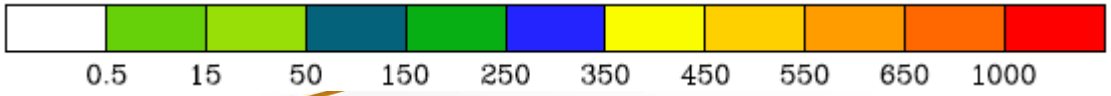
Simulations outside of the calibration period







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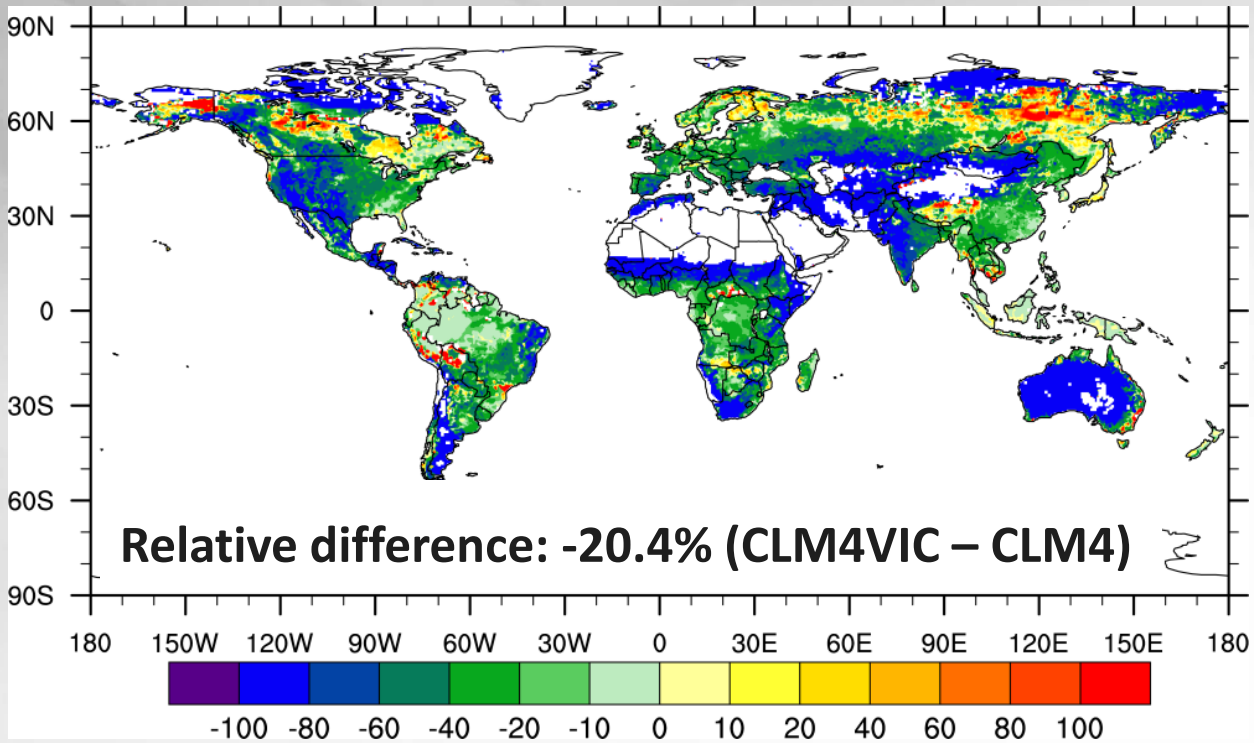
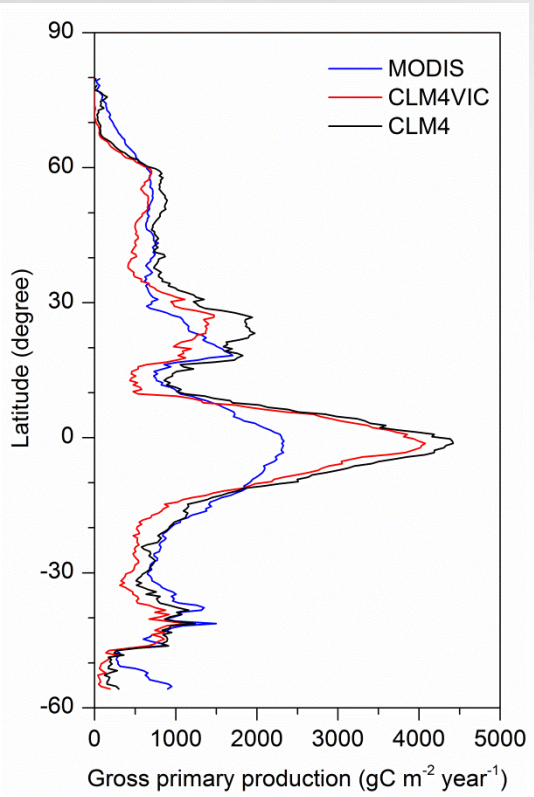
Beyond water:
GPP simulations from NASA-MsTMIP





MODIS: 112 Pg C/year

CLMVIC: 114 Pg C/year

CLM4.0: 143 Pg C/year

Poster:
Impacts of hydrologic parameterizations on global terrestrial carbon cycle dynamics in the Community Land Model

Summary and future work

- VIC runoff parameterizations have been implemented into the CLM4.5 science branch; Selected VIC parameters were calibrated under a UQ framework against GRDC total runoff field;
- In general, calibration could reduce biases in annual runoff simulations for both the calibration and simulation periods.
- However, the calibration strategy presented here is oversimplified. We will investigated parameter uncertainties, transferability, and UQ strategy separately in the near future;
- Both structural and parameter uncertainties in the runoff generation schemes can lead to large uncertainty in carbon modeling, highlighting the significant interactions among the water, energy, and carbon cycles and the need for improving hydrologic parameterizations in land surface models.

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Acknowledgement

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