Historical Evaluation of Hydrologic Components of CLM4: Surface Soil Water Content and Runoff

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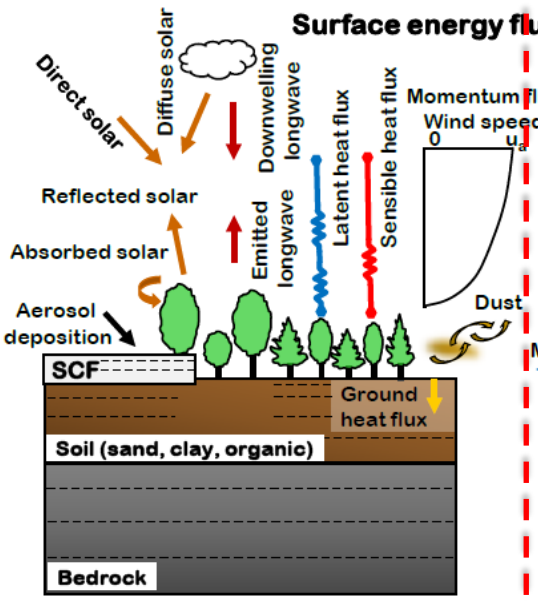
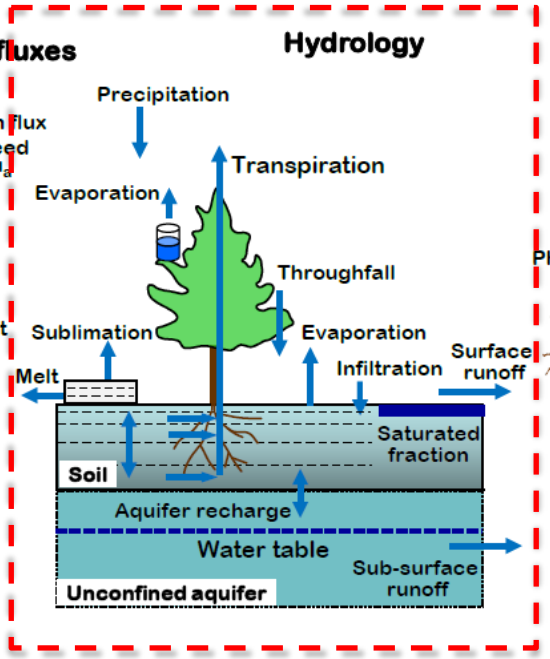
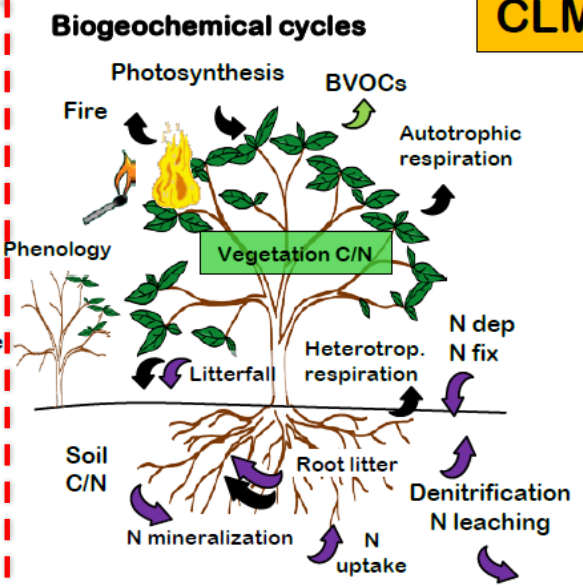
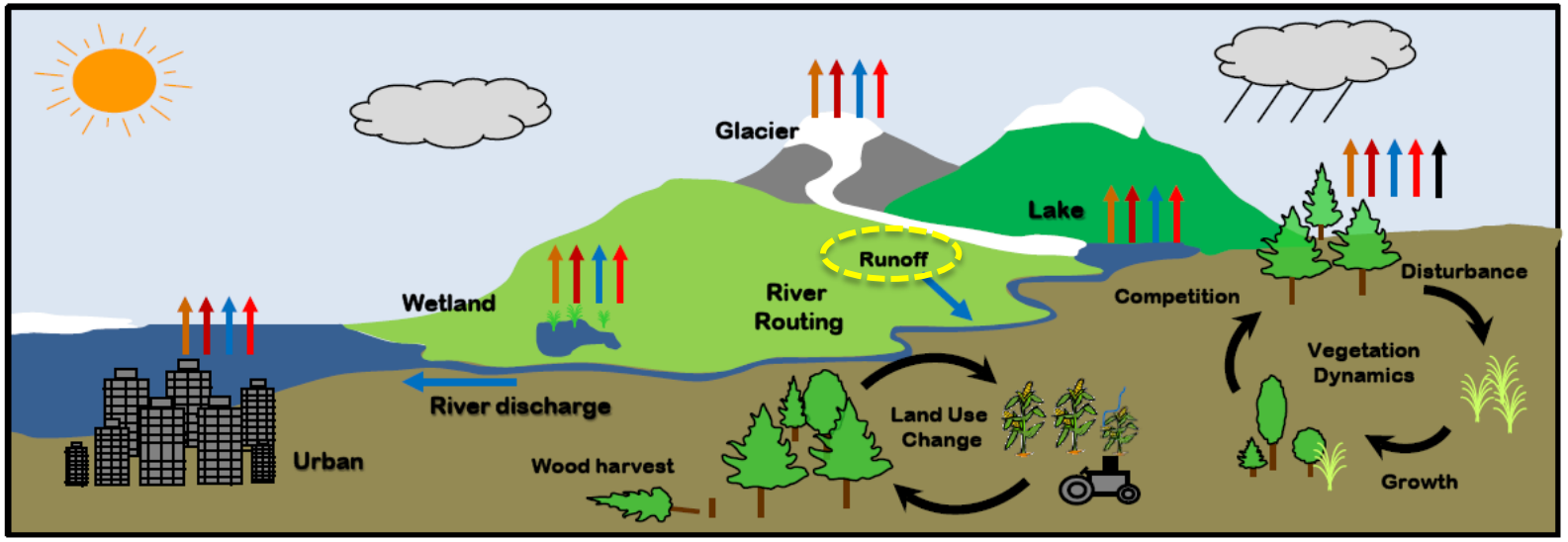
CLM4





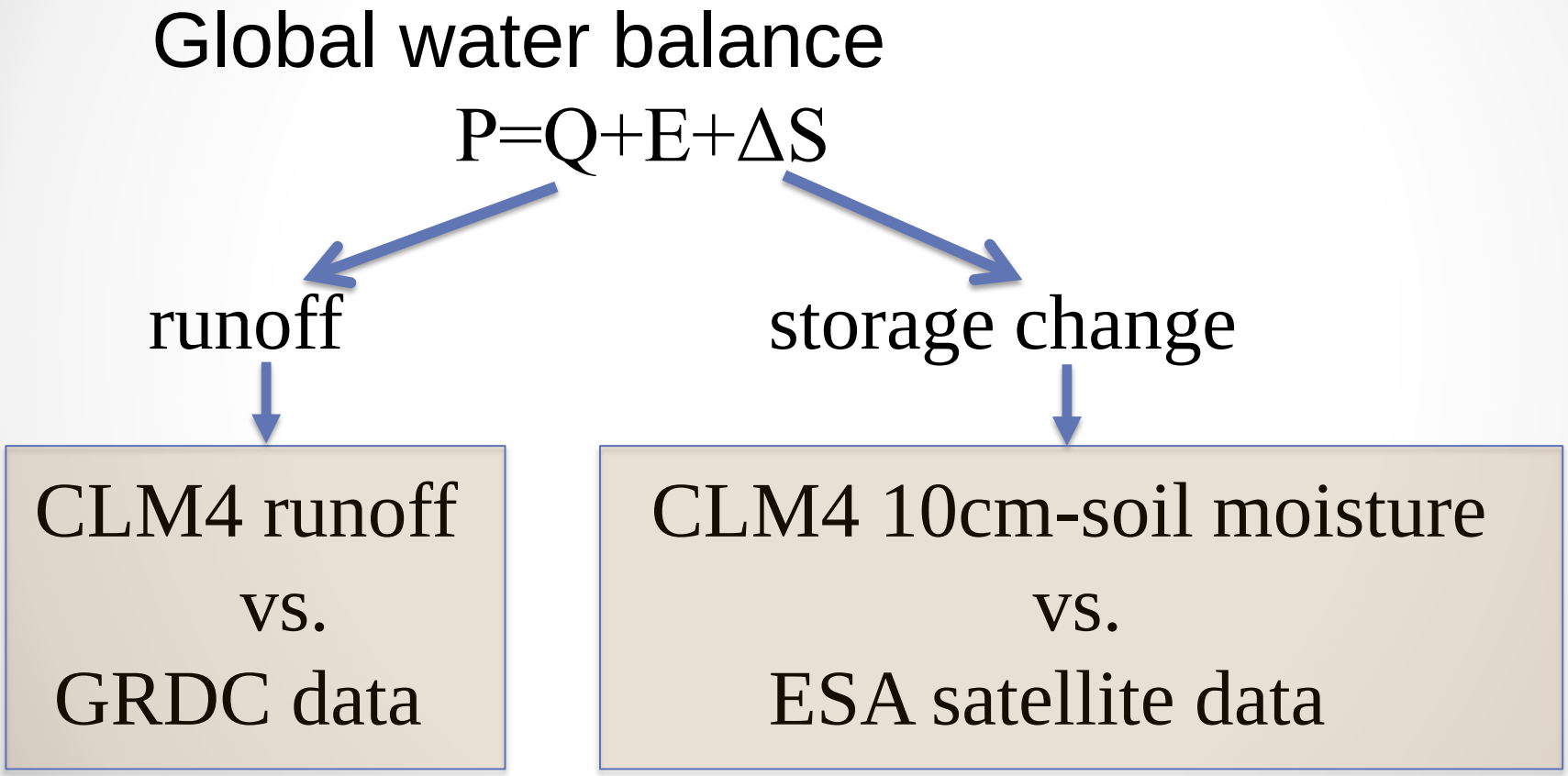




Source: D. Lawrence 2012

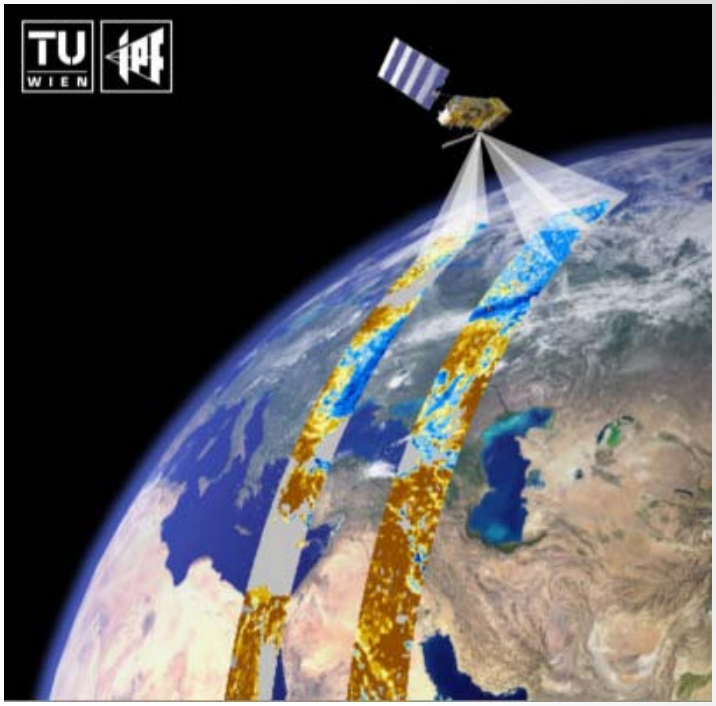
Outline

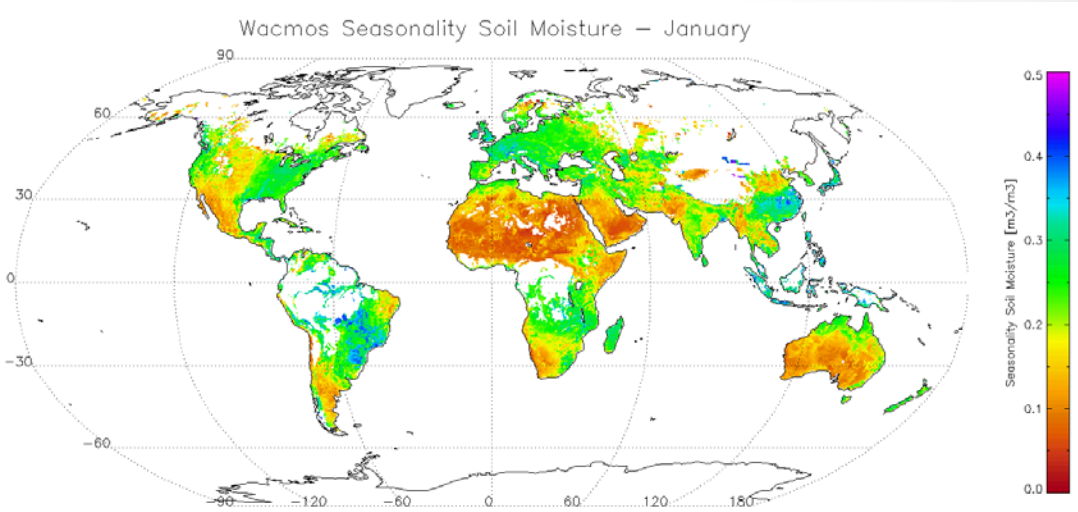
1. Validate key components in hydrologic cycle



European Space Agency (ESA) soil moisture product:

- 30 years of global soil moisture measurements
  - SMMR (1978-1987)
  - SSM/I (since 1987)
  - TRMM (since 1997)
  - AMSR-E (2002-2011)
  - SMOS (since 2009)
  - SCAT (1991-2011)
  - ASCAT (since 2006)
  - AMSR/II (launched 2012)
  - SMAP (2014)
- Measures the surface (<5 cm) soil moisture
- Bare to sparsely vegetated areas only

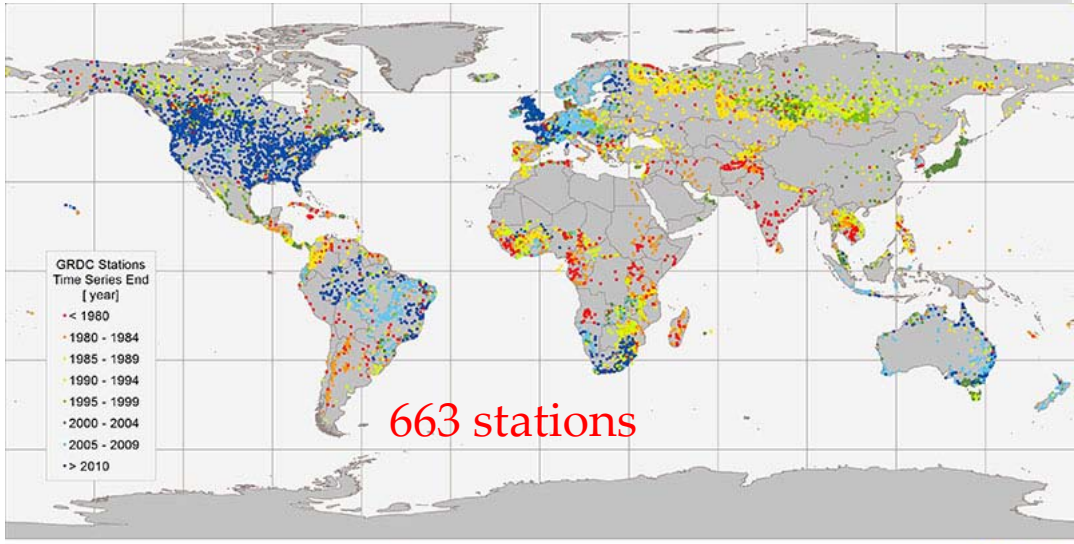




Sources: http://www.esa-soilmoisture-cci.org

Global Runoff Data Center—GRDC

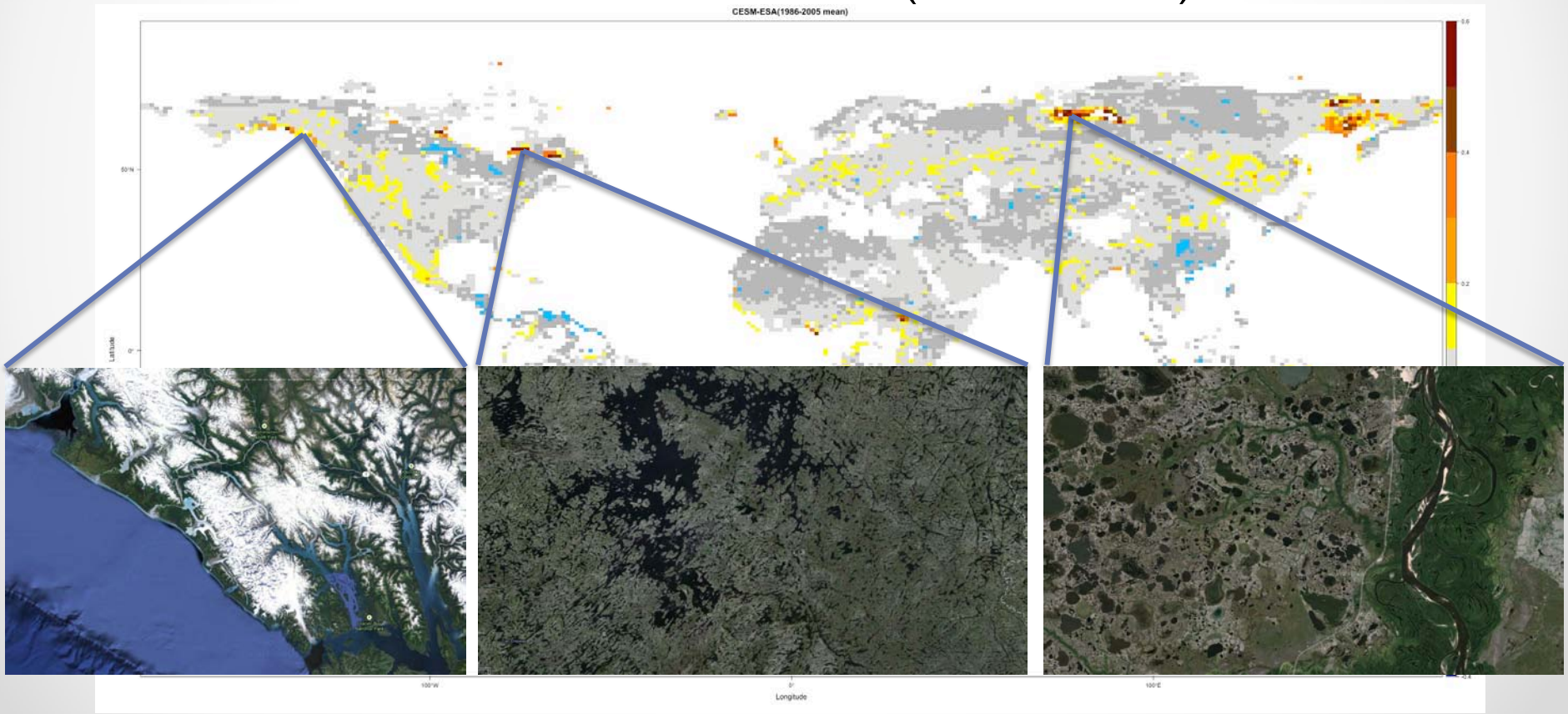
1. Water balance model
2. Discharge gauging station dataset
3. Digital river networks—STN-30p
4. Geographic coregistration



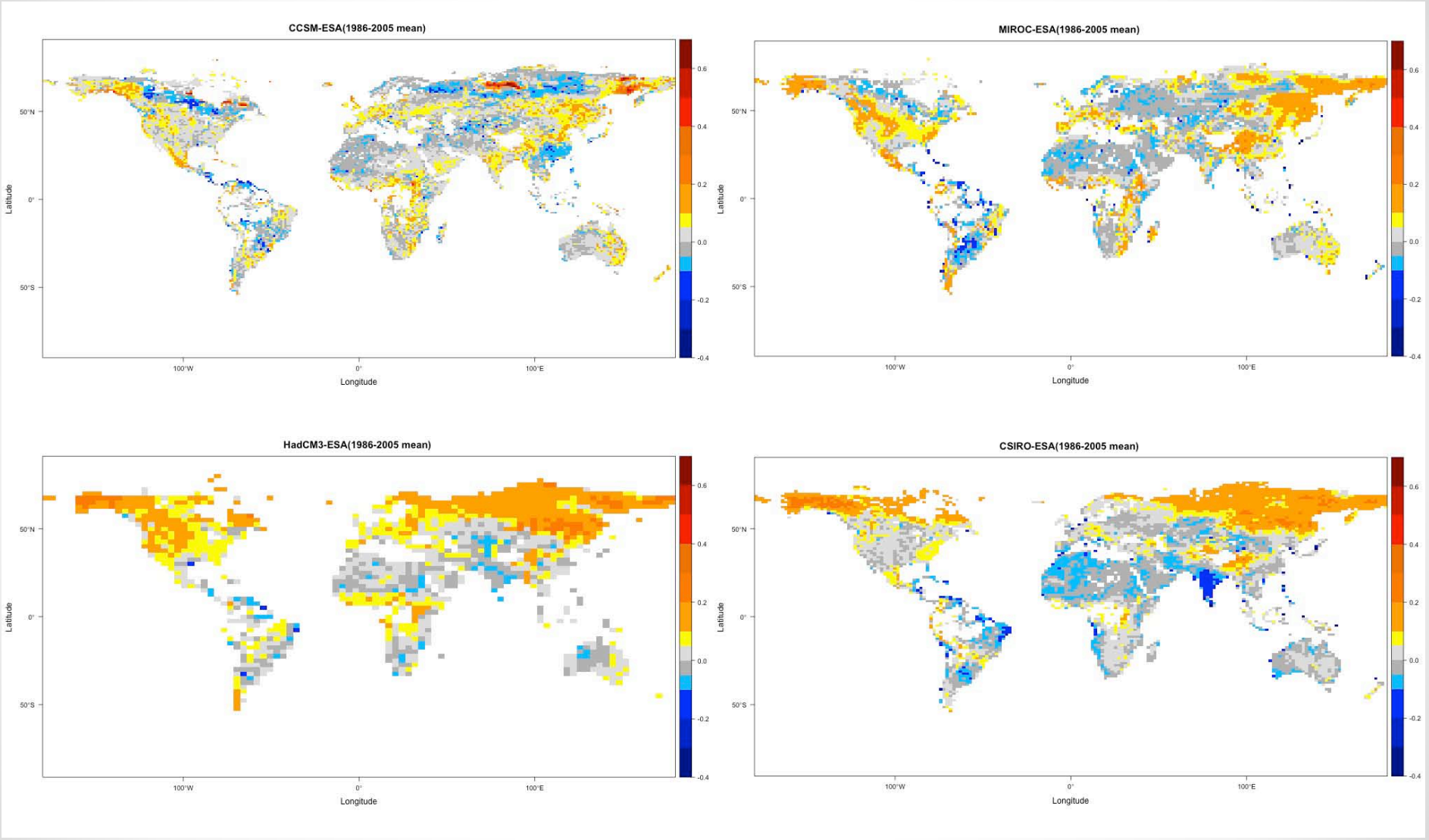
6152 river basins

Results: surface soil moisture

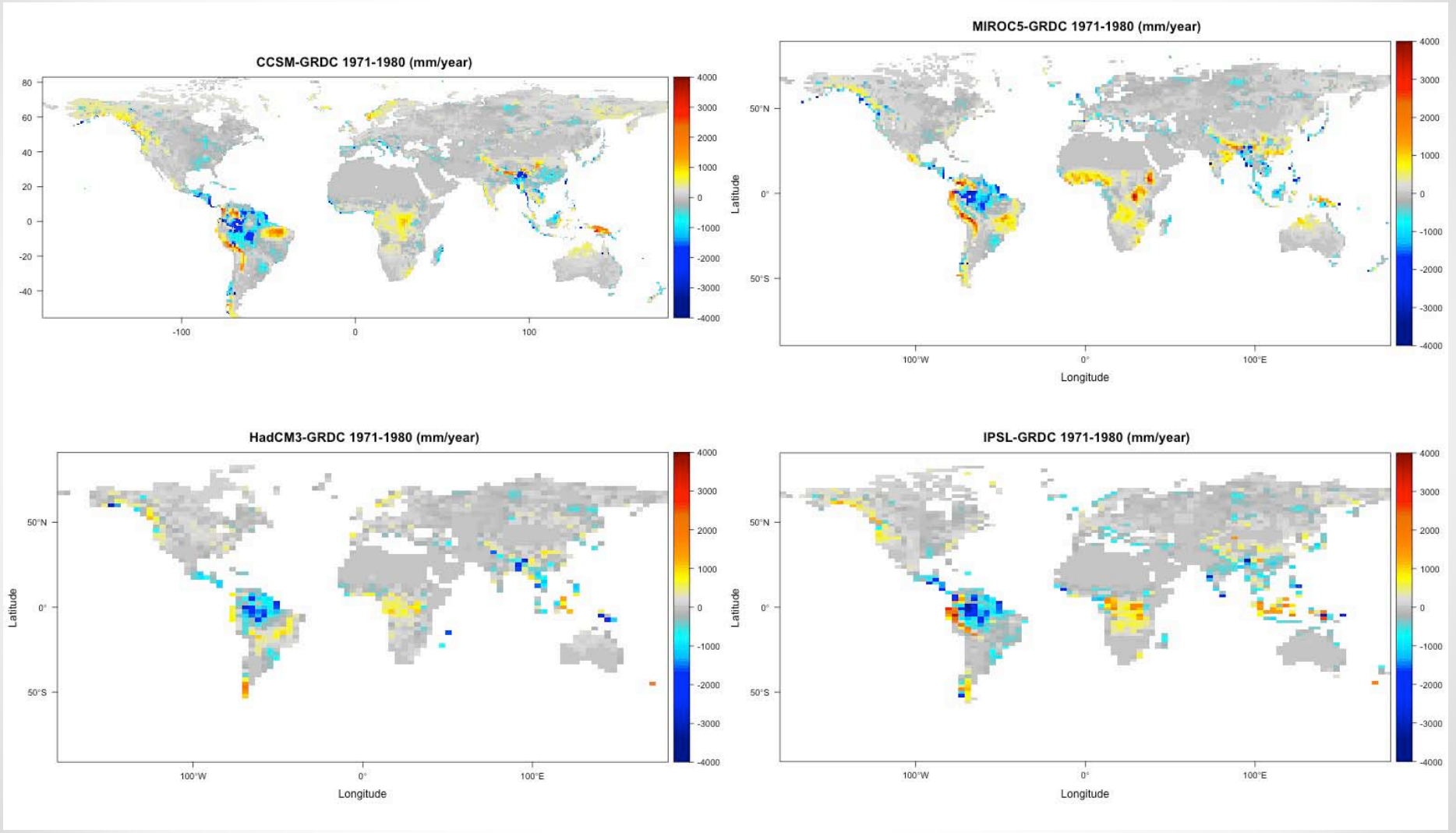
1. Overall CLM4 tends to overestimate soil moisture (partly due to thickness and state mismatch)
2. Especially in high latitude zones
3. Most differences are within 10% (volumetric)

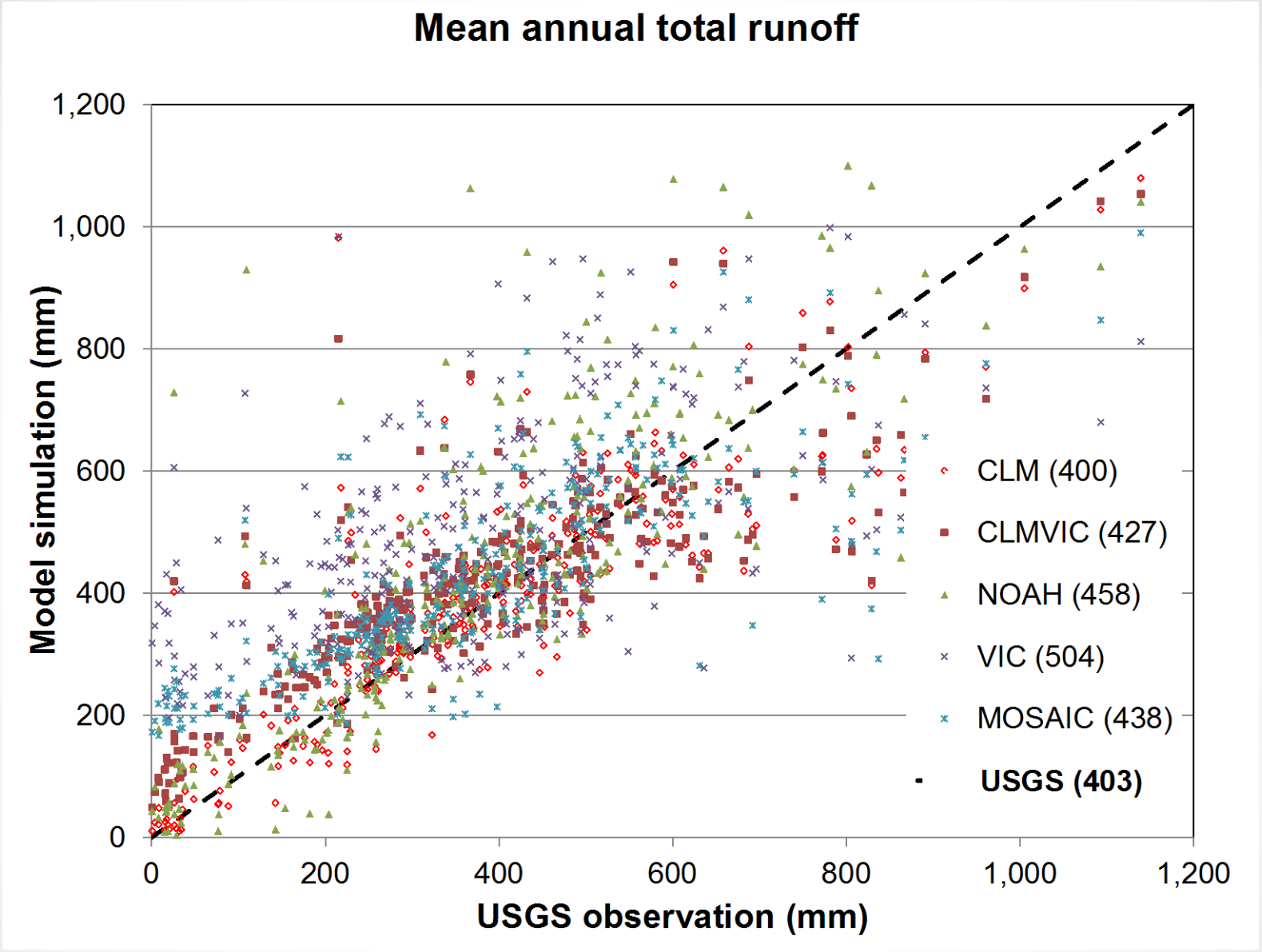


Results: surface soil moisture



Results: runoff




Mean annual total runoff
Model simulation (mm)
USGS observation (mm)
0
200
400
600
800
1,000
1,200
CLM (400)
CLMVIC (427)
NOAH (458)
VIC (504)
MOSAIC (438)
USGS (403)

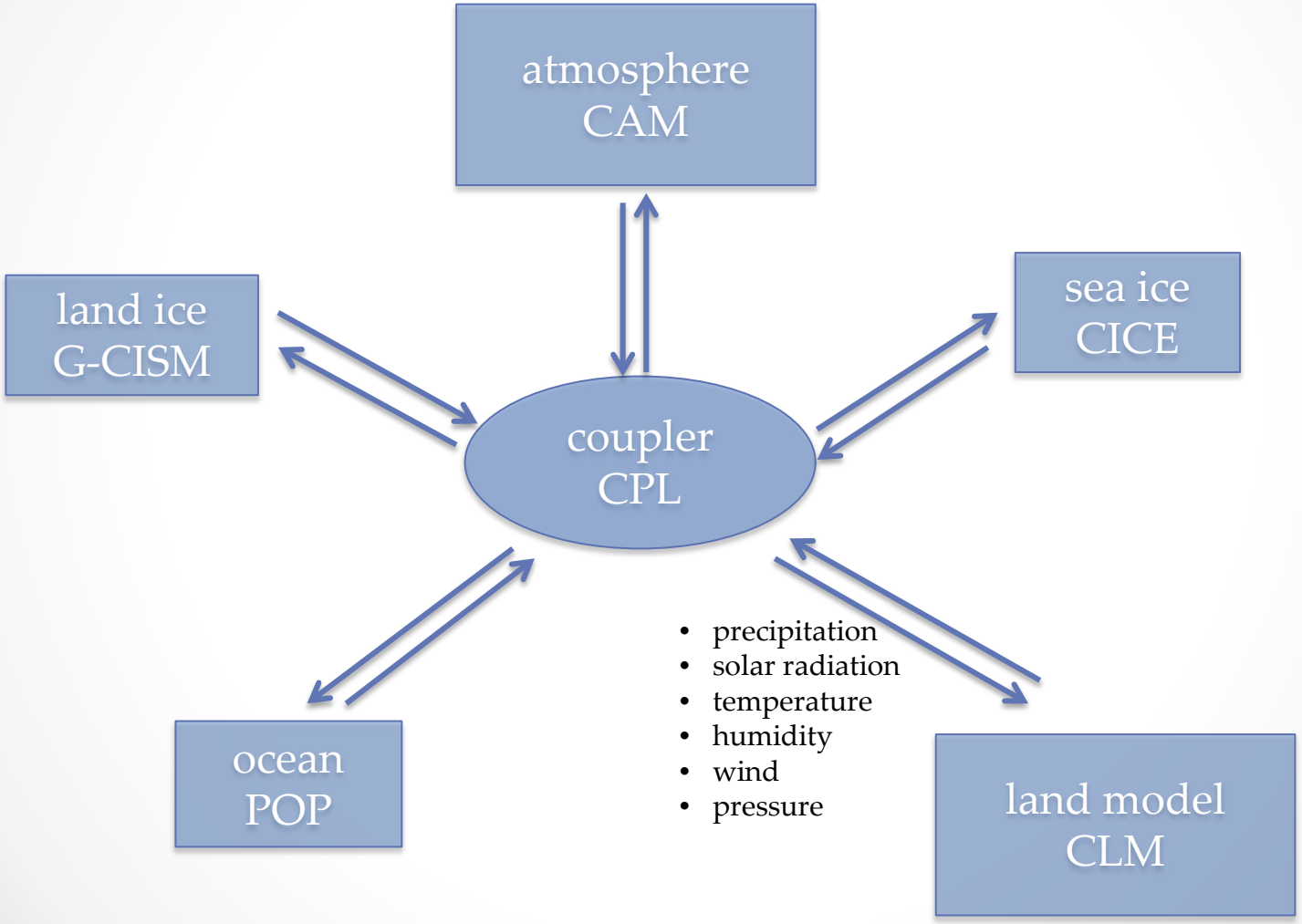
(Leung, PNNL)

Discussions

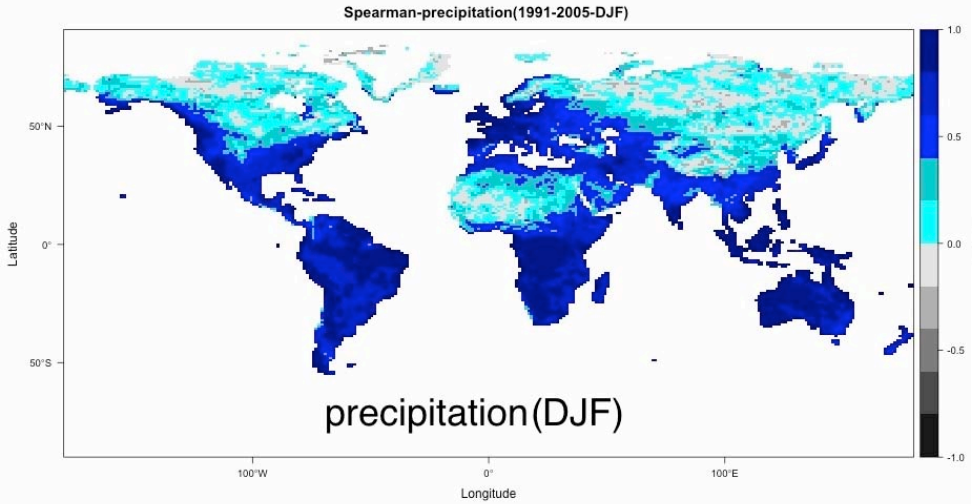
Potential sources of discrepancy between CLM4 and observations

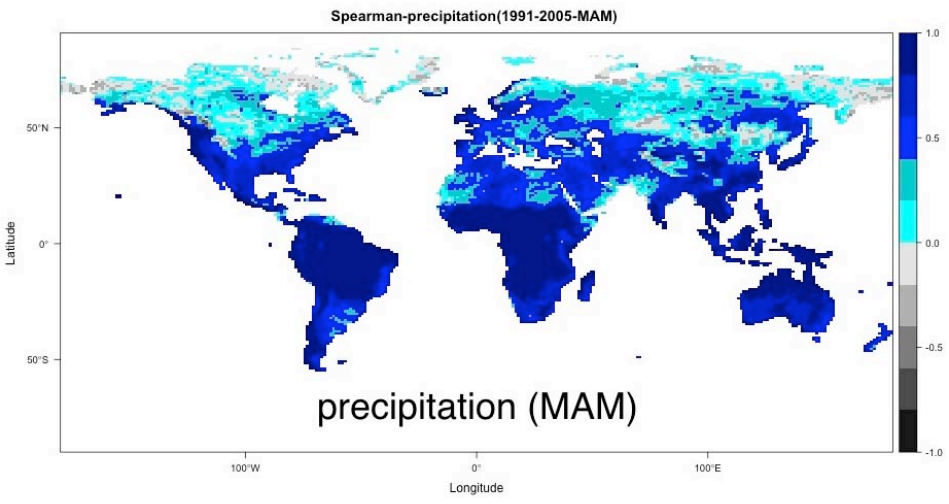
1. Errors from "observations"
2. Dimension mismatches
3. Structural deficiencies of CLM
4. Forcing errors from atmosphere model (i.e. CAM)

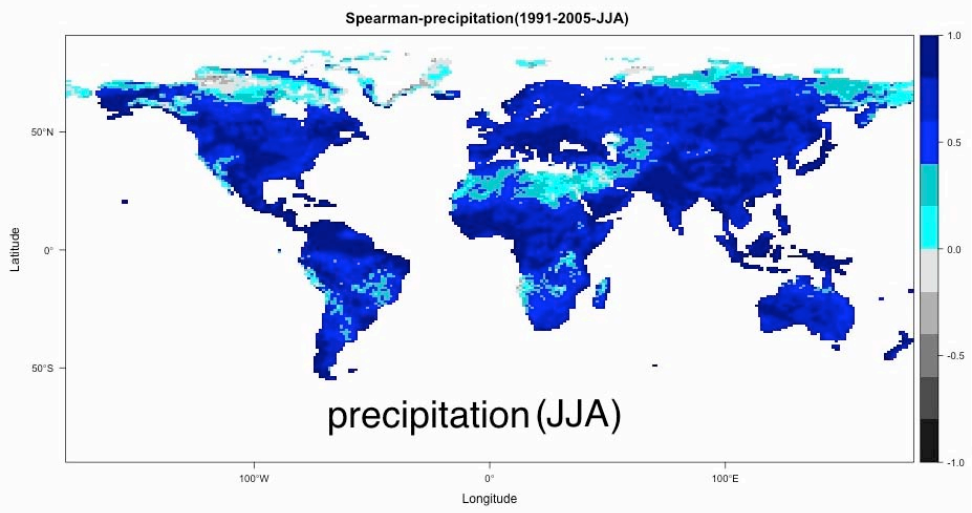
2. Trace to the sources of bias

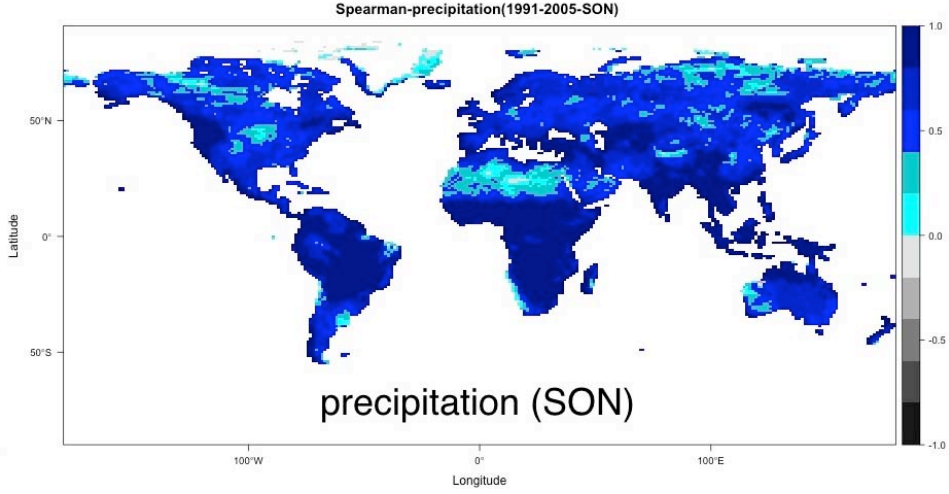


Discussion: surface soil moisture vs precipitation

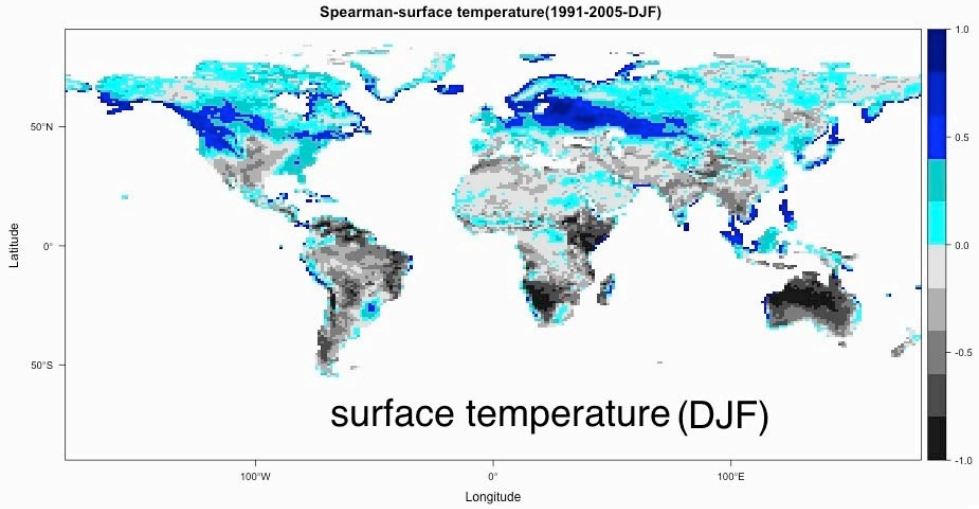


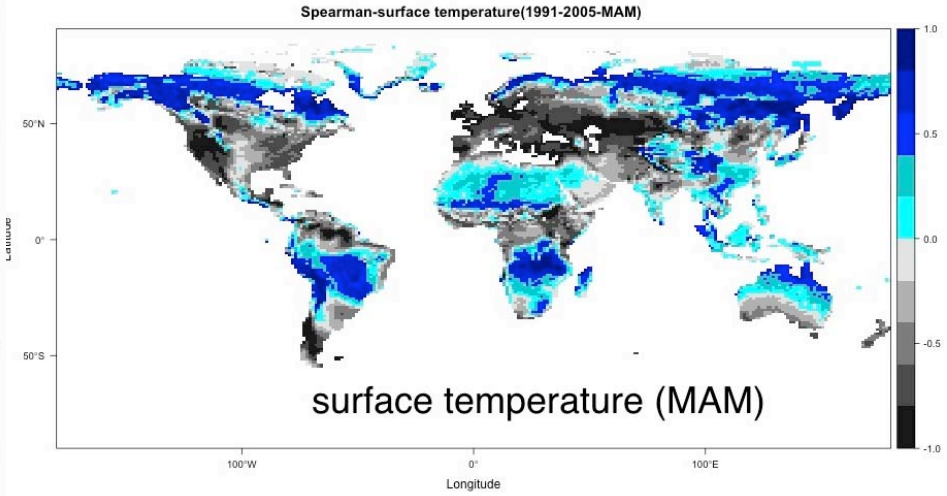


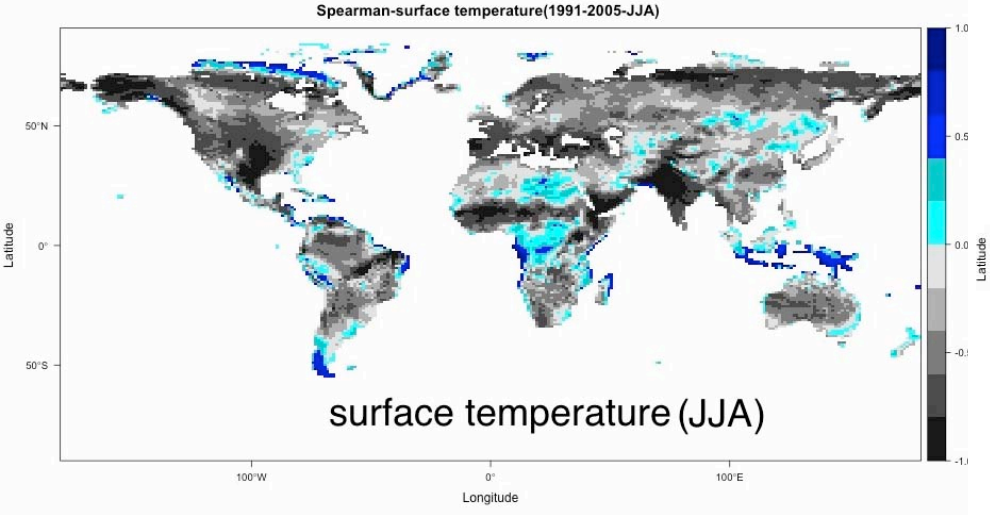


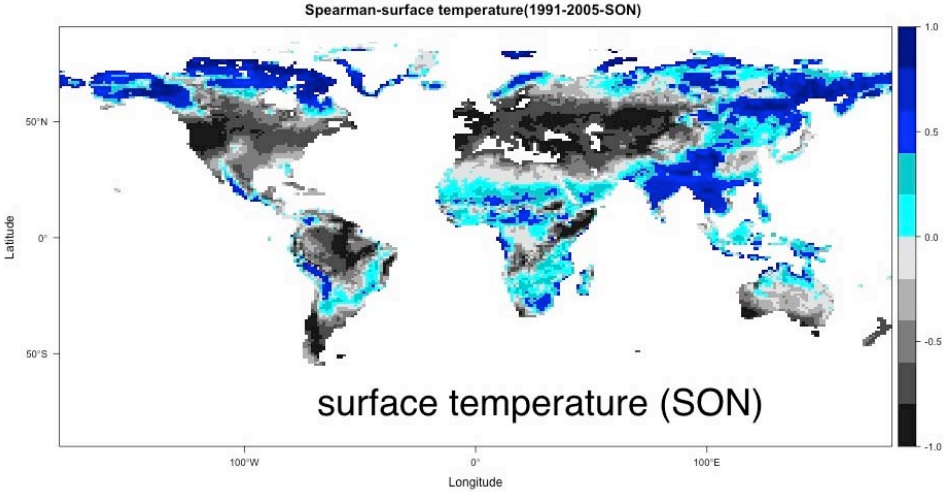


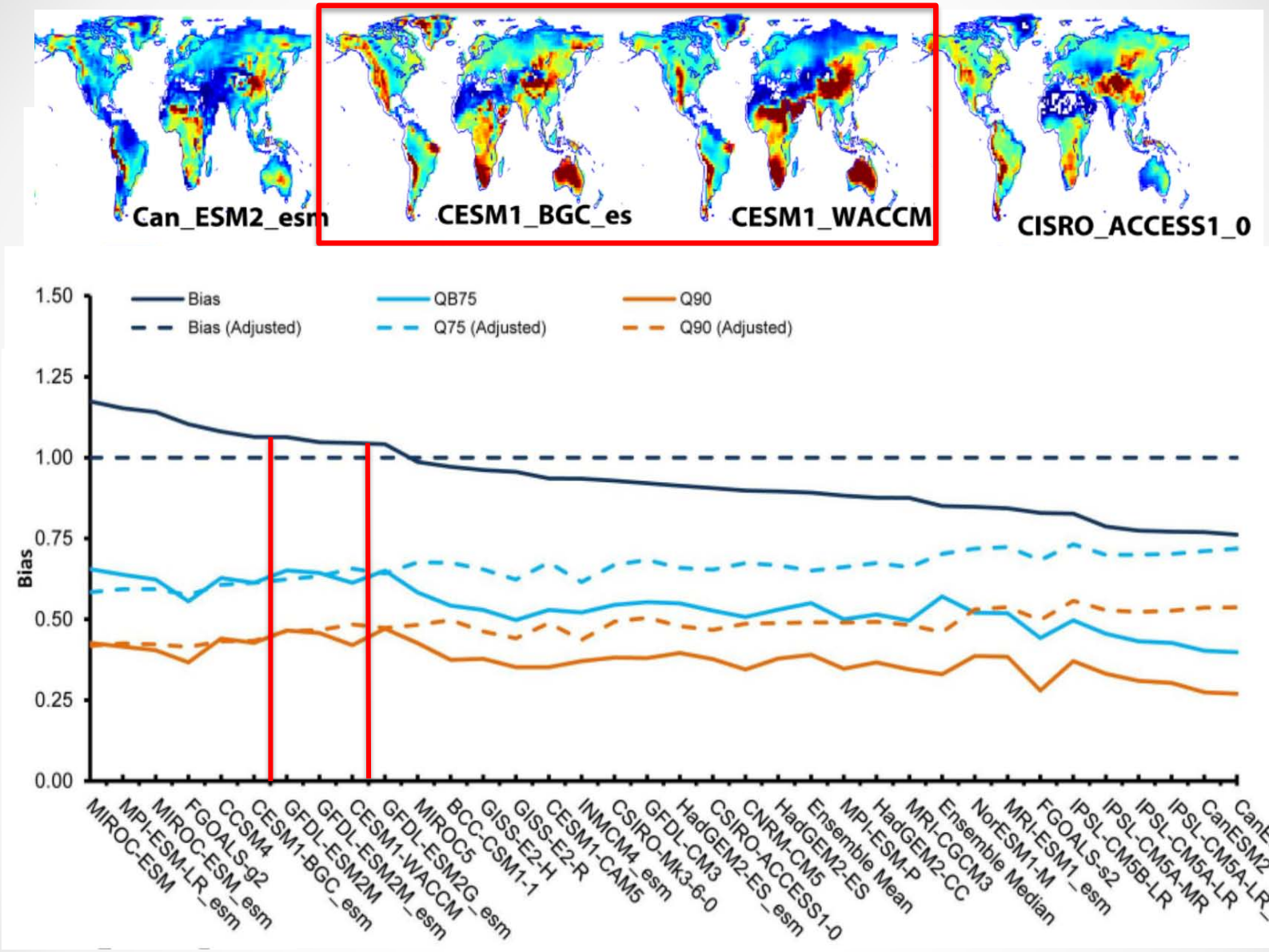
Discussion: soil moisture vs surface temperature





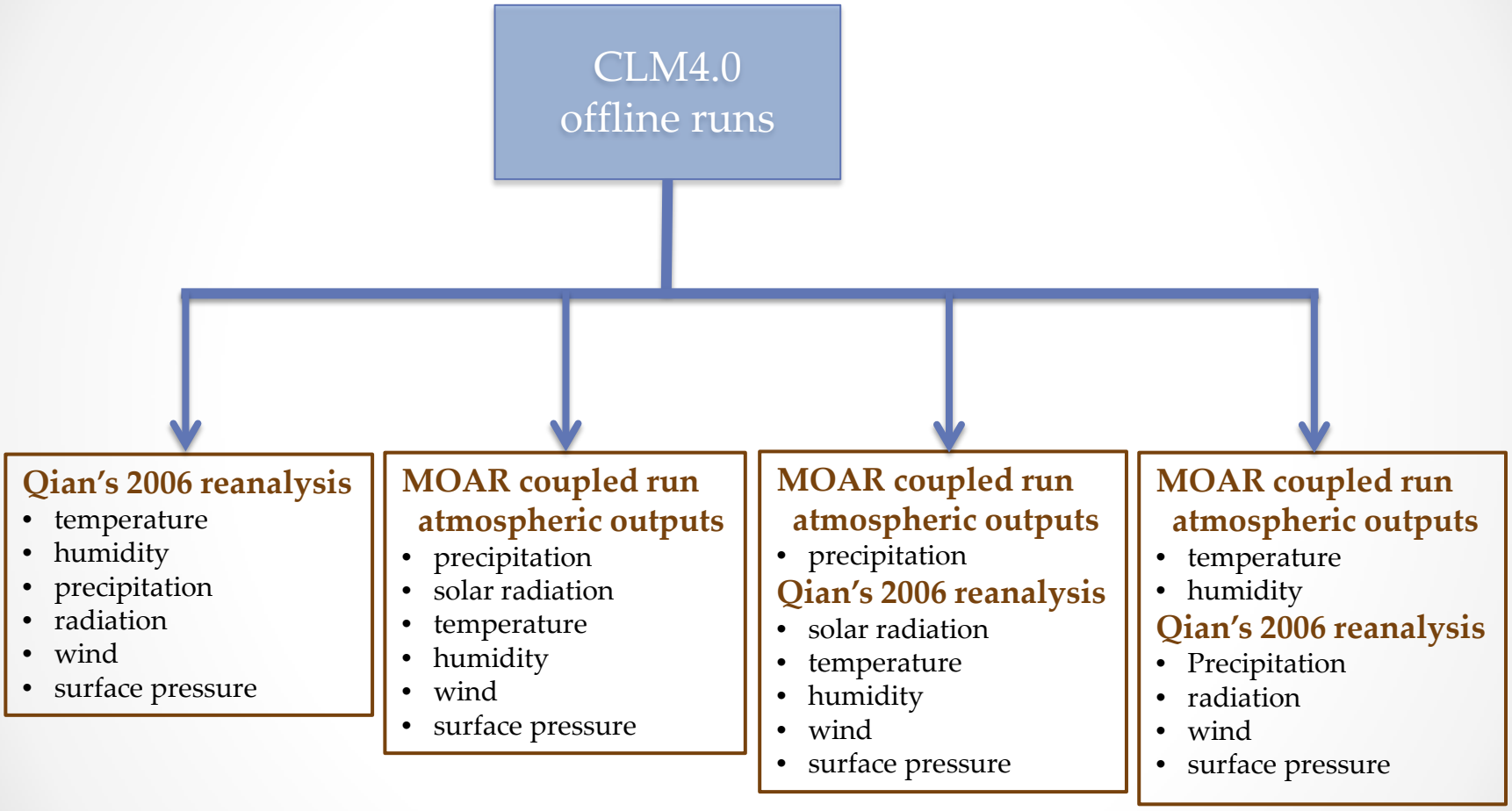




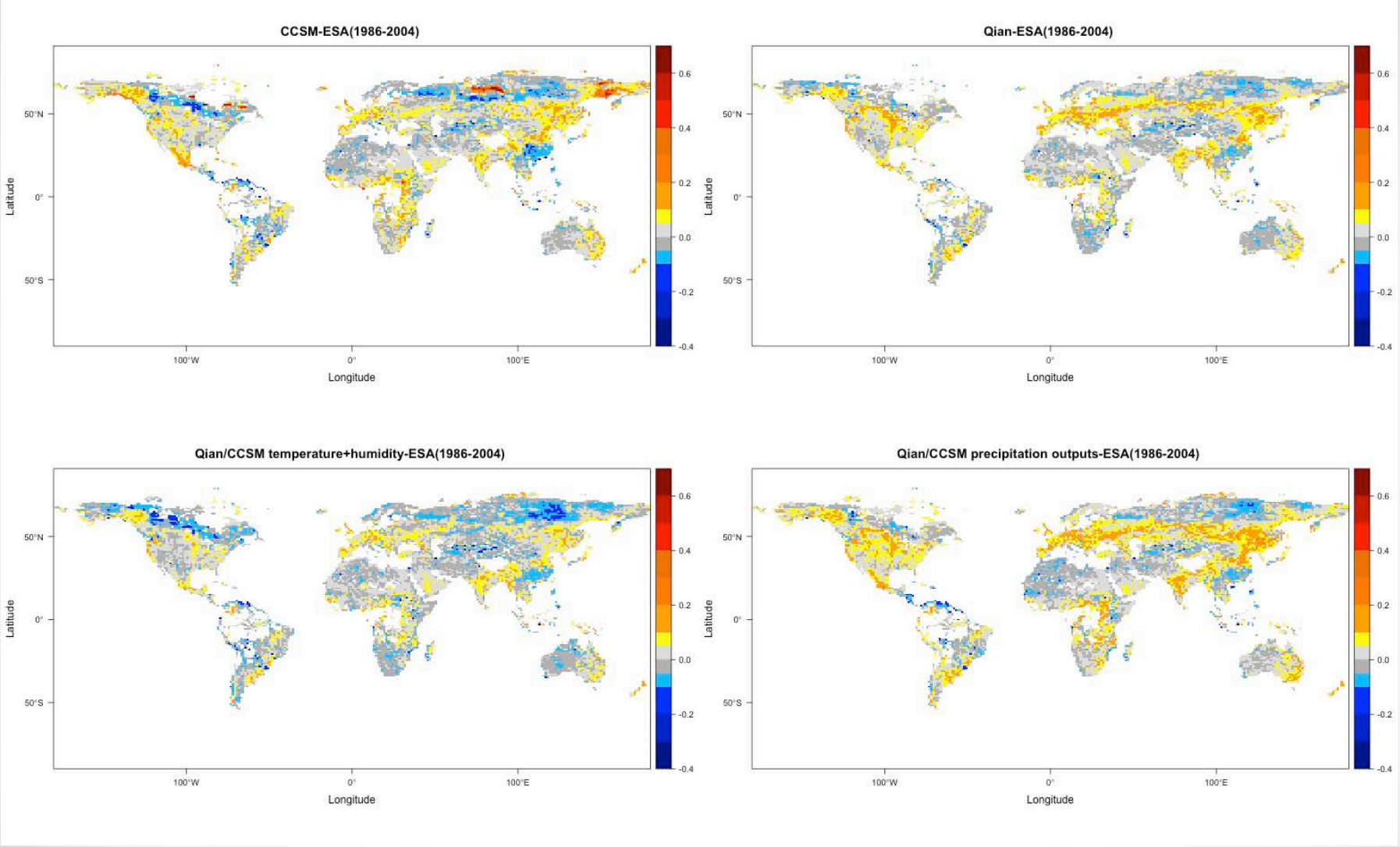

Can_ESM2_esm
CESM1_BGC_es
CESM1_WACCM
CISRO_ACCESS1_0
Bias
Bias (Adjusted)
QB75
Q75 (Adjusted)
Q90
Q90 (Adjusted)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Bias
MIROC-ESM
MPI-ESM-LR_esm
MIROC-ESM_esm
FGOALS-92
CCSM4
CESM1-BGC_esm
GFDL-ESM2M
GFDL-ESM2M_esm
CESM1-WACCM
GFDL-ESM2G_esm
MIROC5
BCC-CSM1-1
GISS-E2-H
GISS-E2-R
CESM1-CAM5
INMCM4_esm
CSIRO-Mk3-6-0
GFDL-CM3
HadGEM2-ES_esm
CSIRO-ACCESS1-0
CNRM-CM5
HadGEM2-ES
Ensemble Mean
MPI-ESM-P
HadGEM2-CC
MRI-CGCM3
Ensemble Median
NorESM1-M
MRI-ESM1_esm
FGOALS-s2
IPSL-CM5B-LR
IPSL-CM5A-MR
IPSL-CM5A-LR
IPSL-CM5A-LR_esm
CanESM2
CanESM2_esm

Mehran (2014)

CLM4.0 forced by various combinations

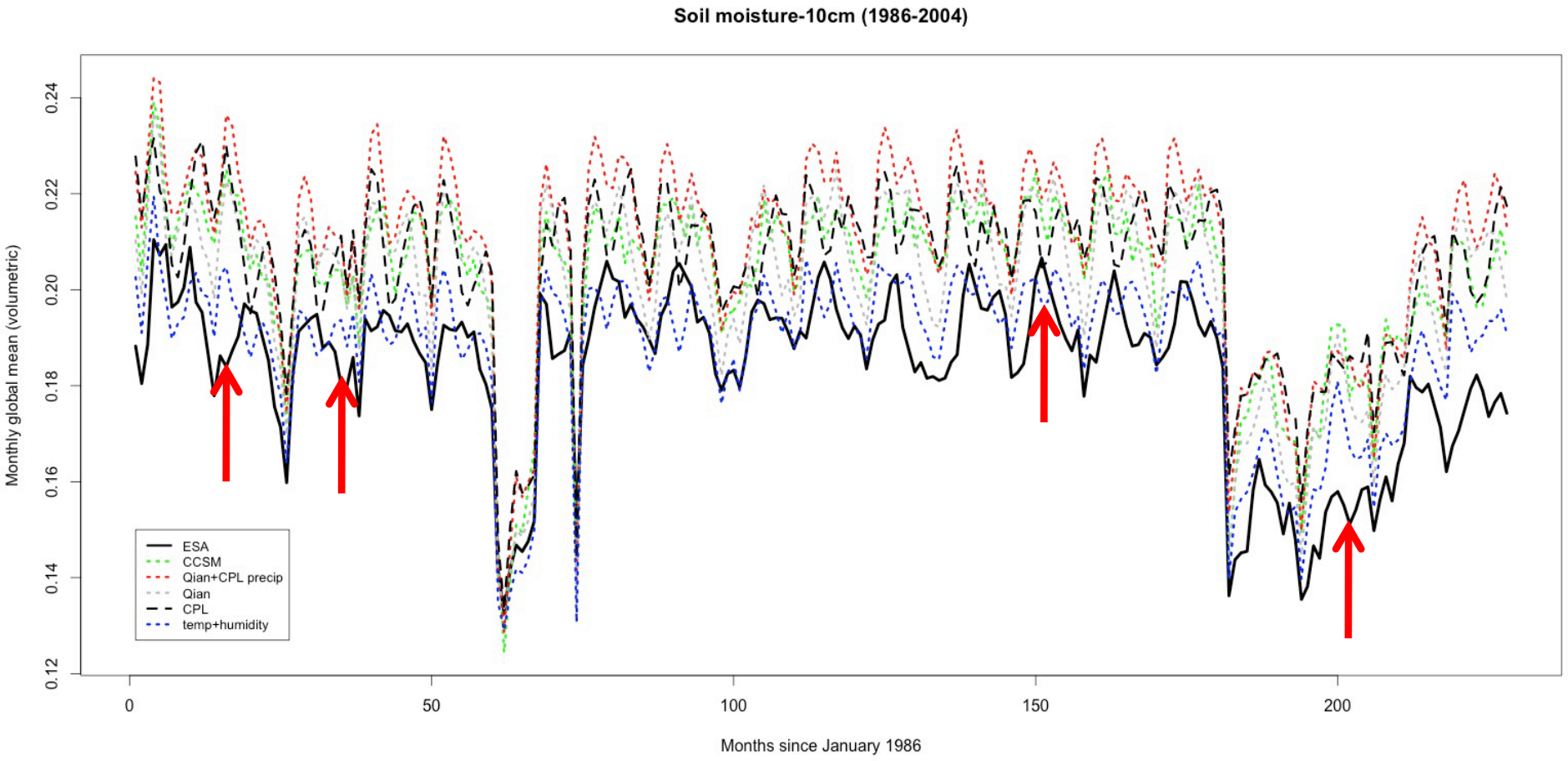


Discussion: soil moisture



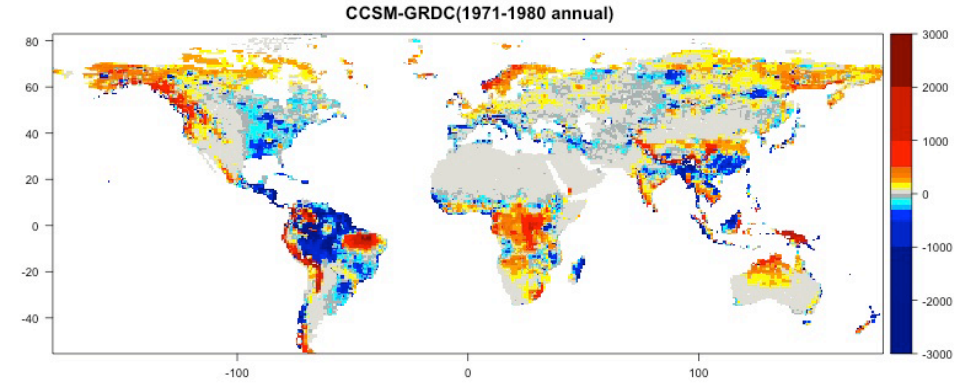
- Offline run by CCSM atm outputs eliminates the high latitude over-saturation
- Offline run by CCSM precipitation wets up the surface soils
- Offline run by CCSM temperature and humidity dries up the surface soils

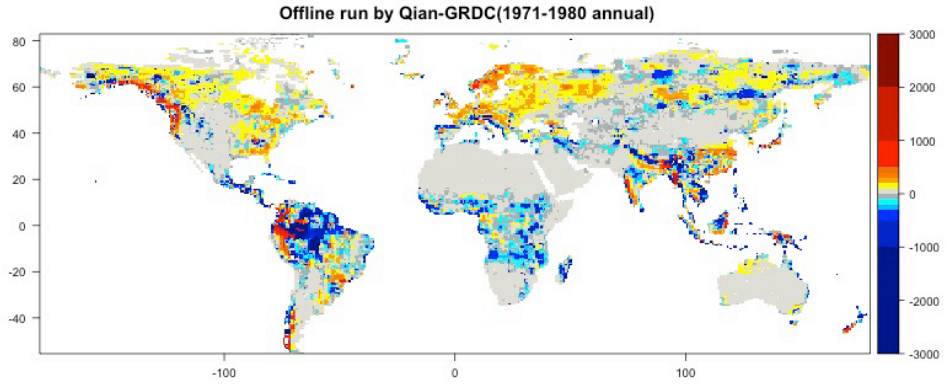
Discussion: soil moisture-monthly global mean

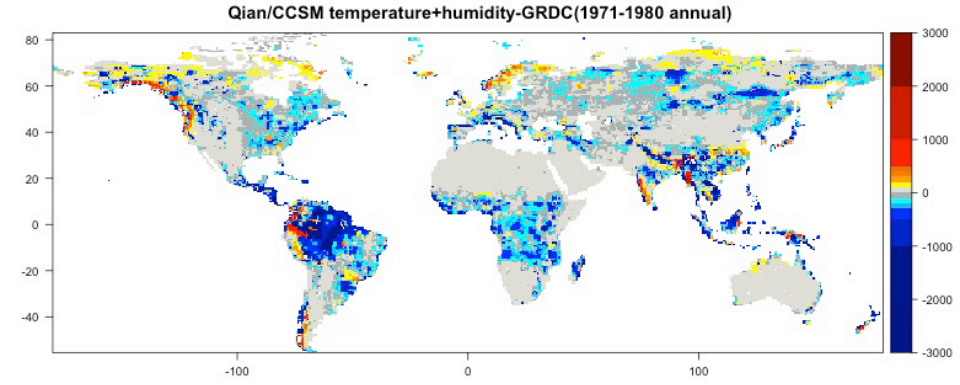


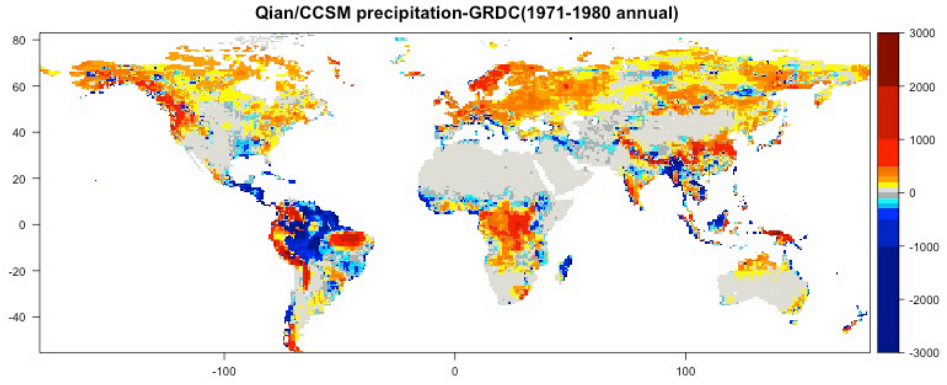
- Wettings are exaggerated
- Phase shift of dry-wet cycles

Discussion: runoff differences



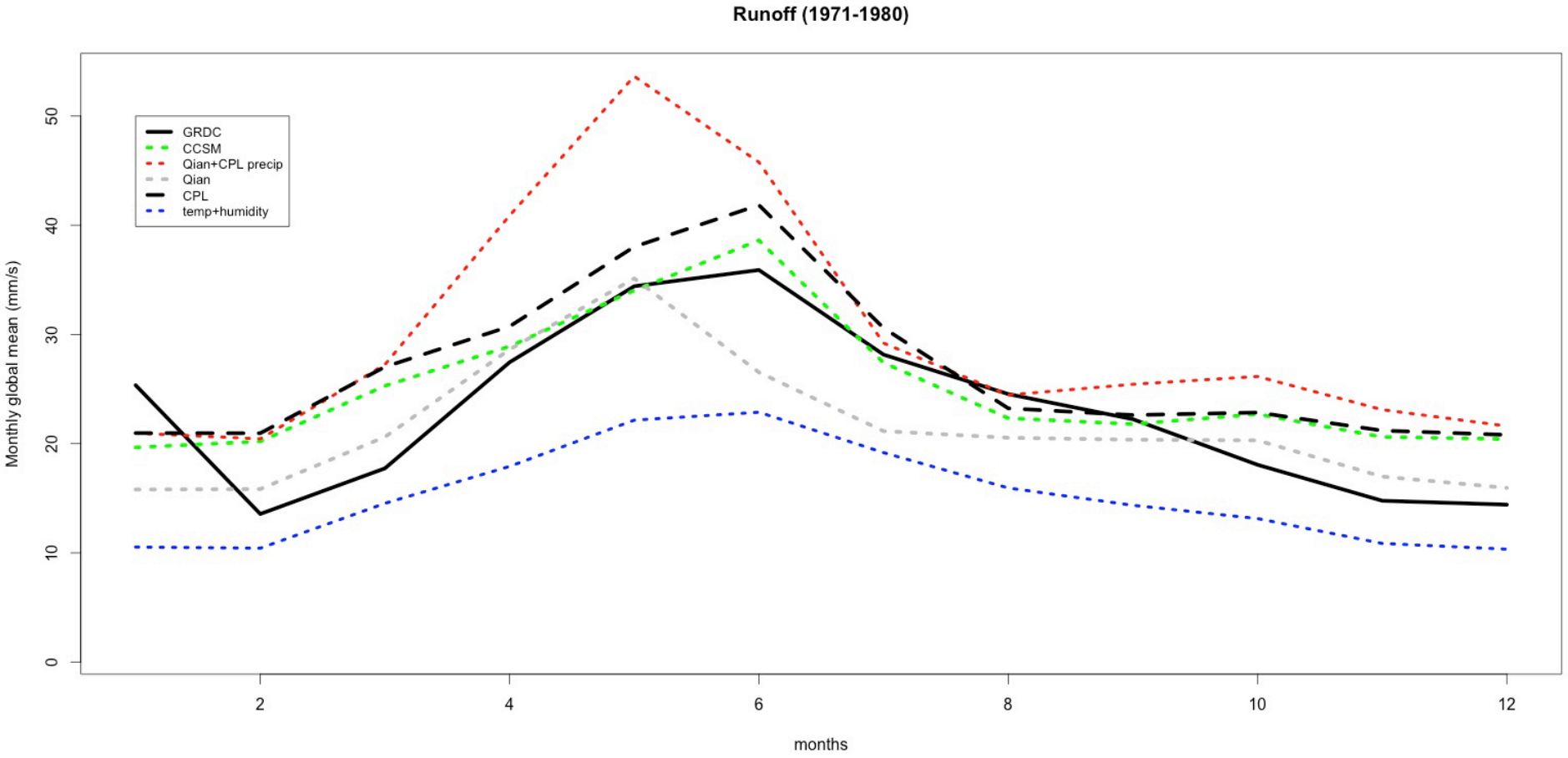






- Offline run by CCSM atm outputs makes similar runoff simulation as the coupled run
- Offline run by Qian's forcings makes better predictions: north America, north Eurasia
- Offline run by CCSM precipitation generates excessive runoff

Discussion: monthly runoff-global mean



- CCSM coupled run overestimates runoff year-round (except August and January)
- Offline run by Qian's matches the GRDC the best except JJA
- Precipitation and temperature+humidity runs offset each other's runoff simulations

Conclusions

1. Precipitation overestimation has led to surface soil moisture and runoff biases
2. Temperature and humidity offset the precipitation effects on runoff and soil moisture
3. CLM can be improved in tropical and high latitude areas
4. Offline run can provide some useful information on hydrology, although feedbacks between land and atmosphere models make differences