Drought analysis over the USA using long-term climatological SM2RAIN datasets

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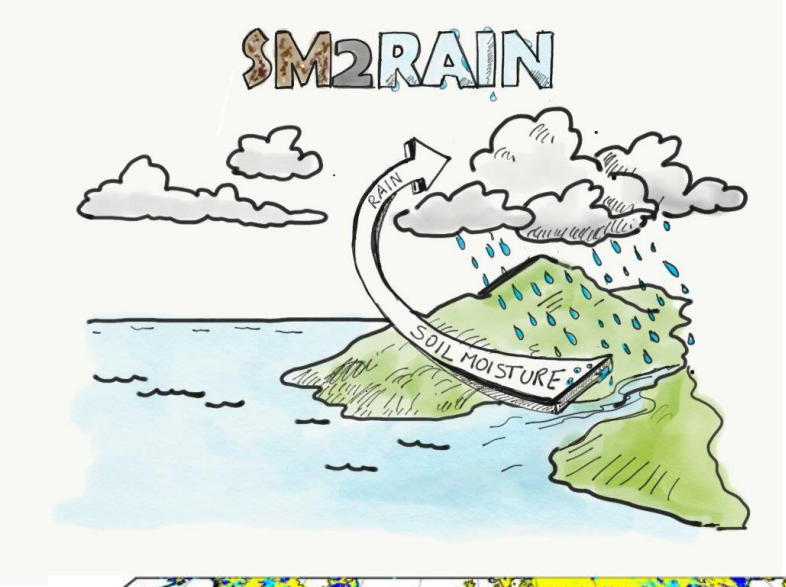
- Drought monitoring

  - Droughts are recognized as an environmental disaster that imposes serious challenges to ecosystems and human societies.

  - Drought monitoring is an essential component of drought risk management.

  - The main requirement of drought monitoring is to have a reliable and accurate long-term rainfall dataset.

- SM2RAIN



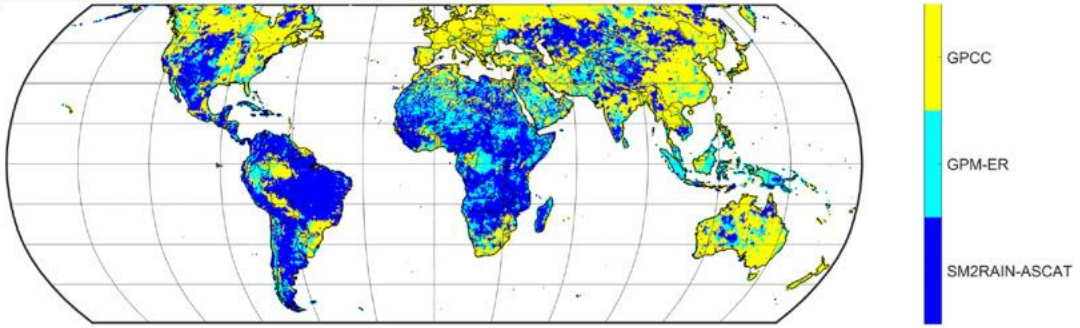
Remote sensing of precipitation ("bottom-up" approach)

The soil water balance equation:

$$n\,Z\,dS(t)/dt = p(t) - g(t) - sr(t) - e(t)$$

$$p(t) = Zn\,dS(t)/dt + KsS(t)^m$$

n (–) is the soil porosity,
Z (mm) is the soil layer depth,
S(t) (–) is the relative saturation of the soil or relative soil moisture,
t (d) is the time,
p(t) (mm d−1) is the rainfall rate,
g(t) (mm d−1) is the drainage (deep percolation plus subsurface runoff) rate,
sr(t) (mm d−1) is the surface runoff rate,
e(t)(mm/d)is the actual evapotranspiration rate.



Relatively best-performing precipitation product based on triple collocation analysis at global scale (figure reprinted from Brocca et al., 2019).

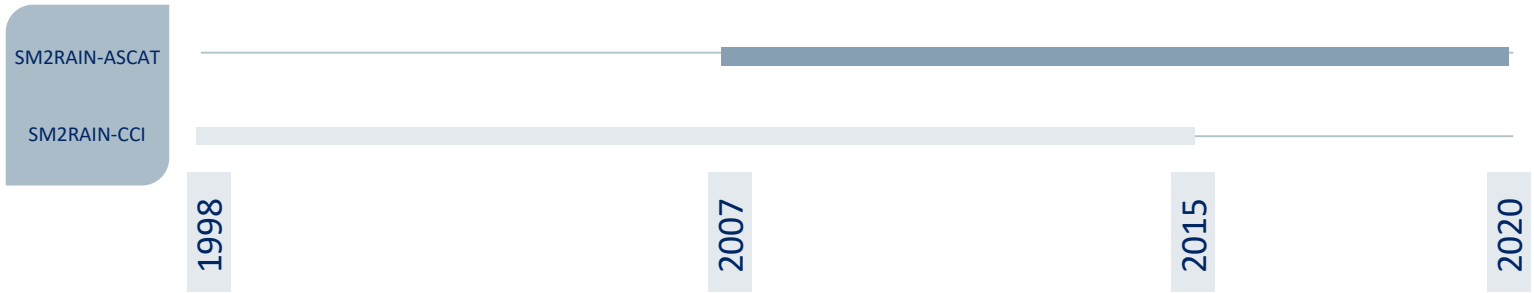
- **SM2RAIN products**

SM2RAIN-CCI

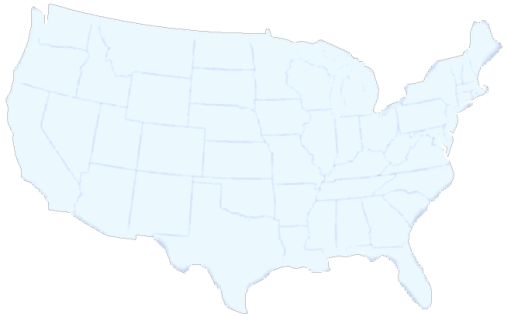
- **Derived from the ESA Climate Change Initiative (CCI) soil moisture data**
- **Time coverage: 1998-2015.**
- **Spatial\temporal resolution: 0.25-degree\1-day.**

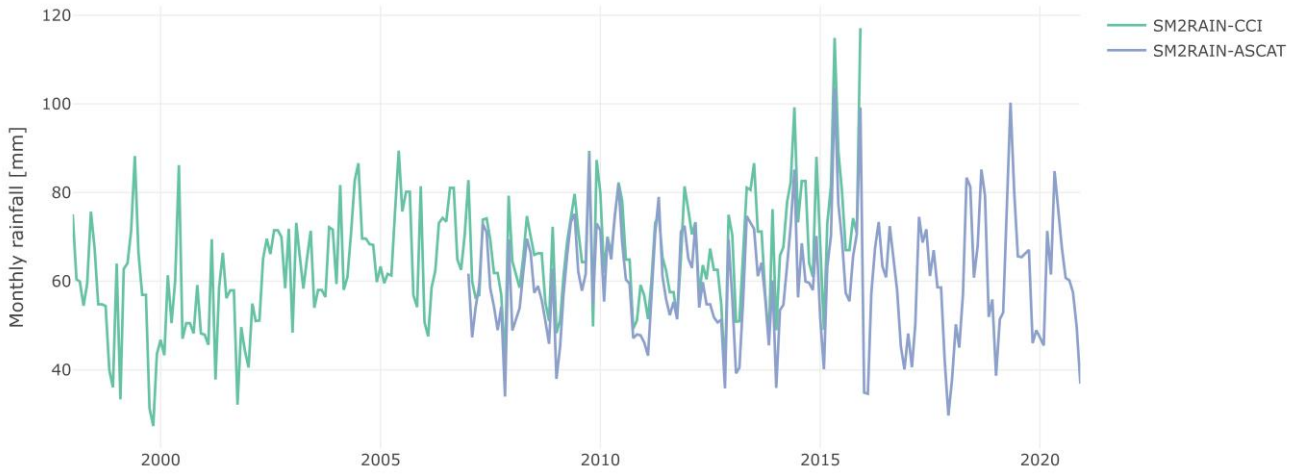
SM2RAIN-ASCAT

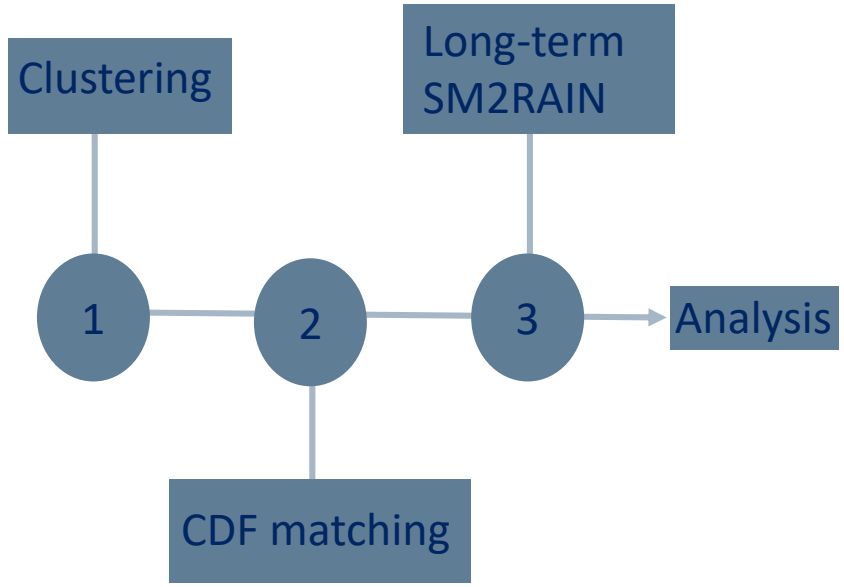
- **Derived from ASCAT soil moisture data record provided by the EUMETSAT H SAF**
- **Time coverage: 2007-2020.**
- **Spatial\temporal resolution: 10 km\1-day.**



- Methods

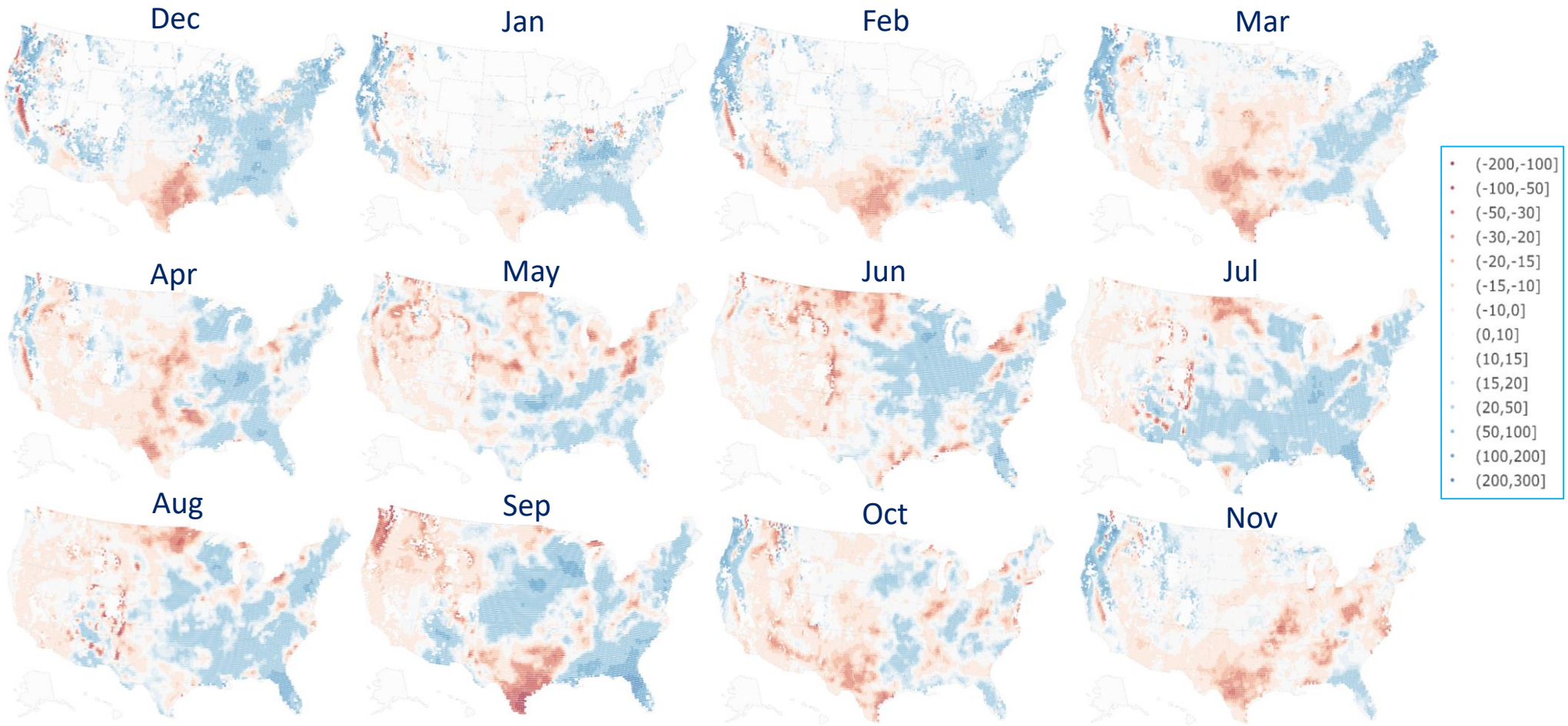



120
100
80
60
40
Monthly rainfall [mm]
2000
2005
2010
2015
2020
SM2RAIN-CCI
SM2RAIN-ASCAT

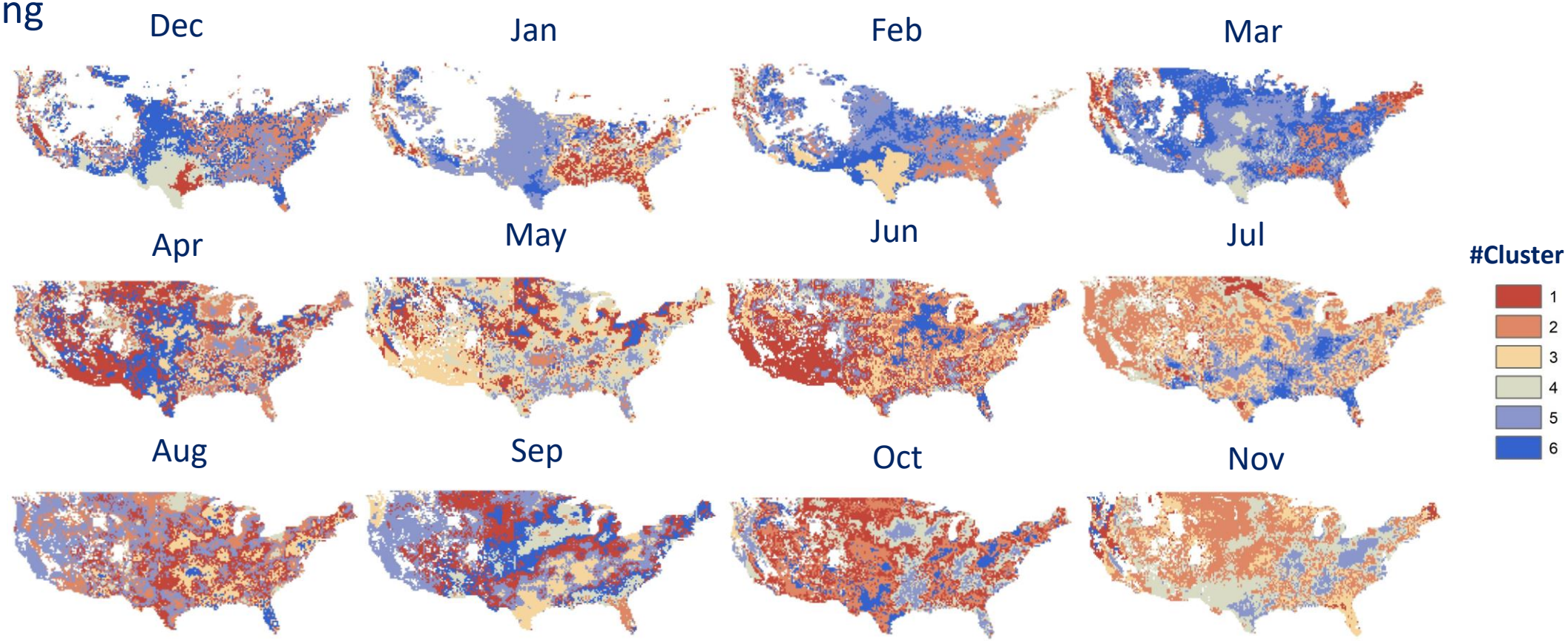

Clustering
Long-term SM2RAIN
1
2
3
Analysis
CDF matching

- Methods
  - Clustering

Difference of SM2RAIN-CCI vs SM2RAIN-ASCAT based on 2007-2015 (mm/month)



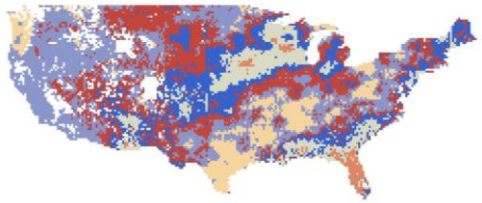
- Methods
  - Clustering



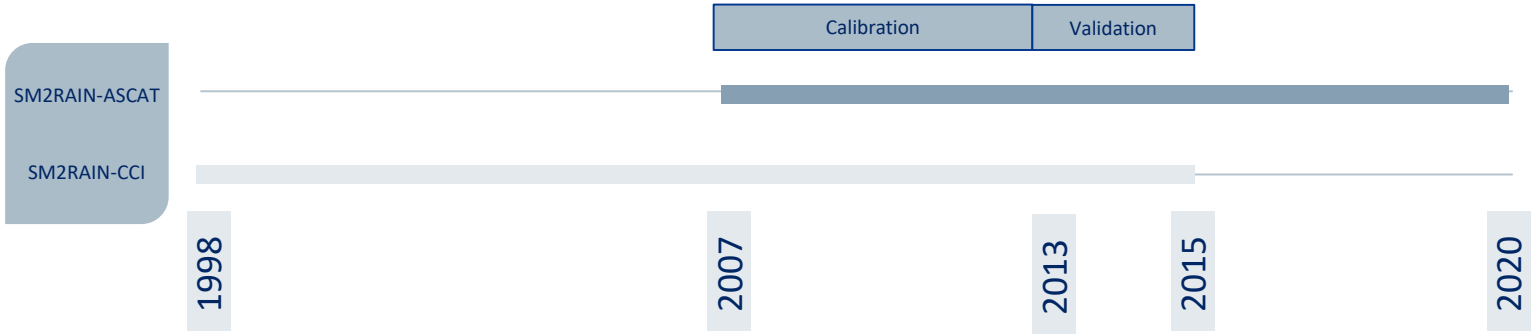
- Methods
  - Bias Correction

$$P_i(\mathrm{t}) = CDF^{-1}_{ASCAT-\mathrm{M}-C} \cdot \left(CDF_{CCI-M-C}(p_i(\mathrm{t}))\right)$$

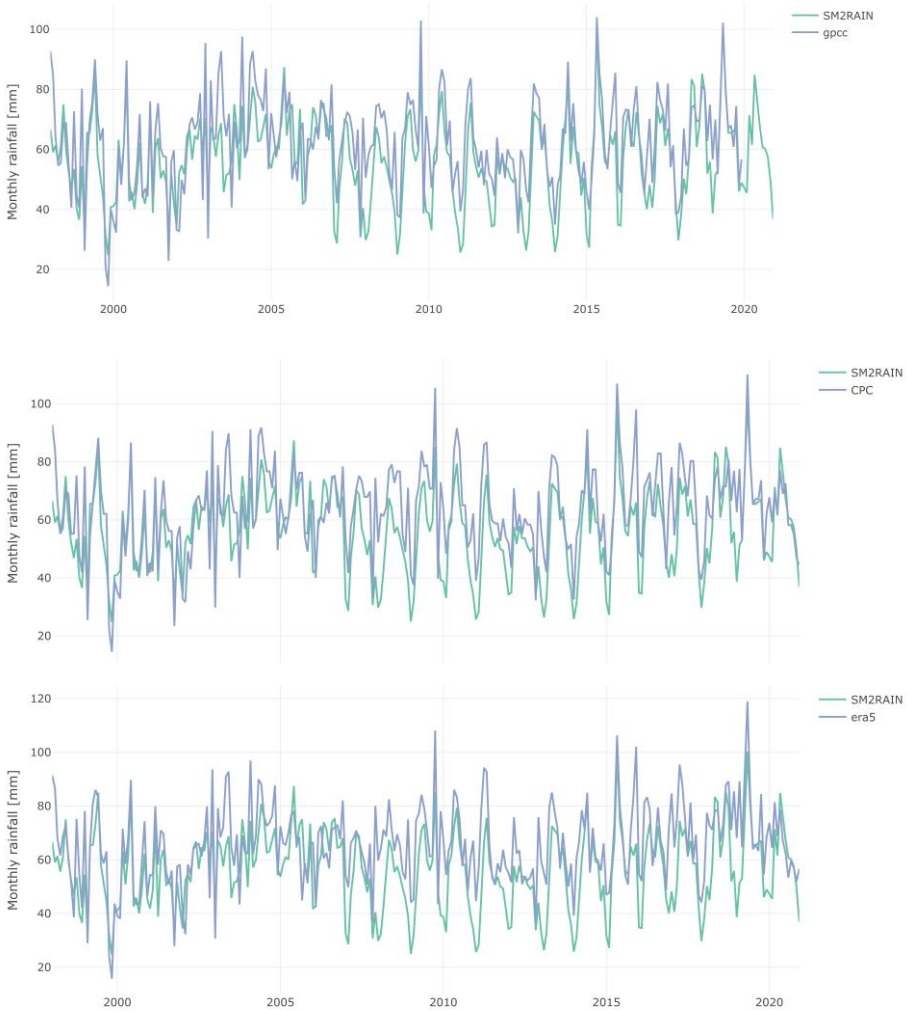
$P_i(\mathrm{t})$ and $p_i(\mathrm{t})$ are the SM2RAIN-CCI before and after bias correction time t and pixel I
$CDF^{-1}_{ASCAT-M-C}$ and $CDF_{CCI-S-C}$ are the inverse CDF of ASCAT and CDF of CCI, respectively in each month (M) and cluster (C).



Sep-cluster

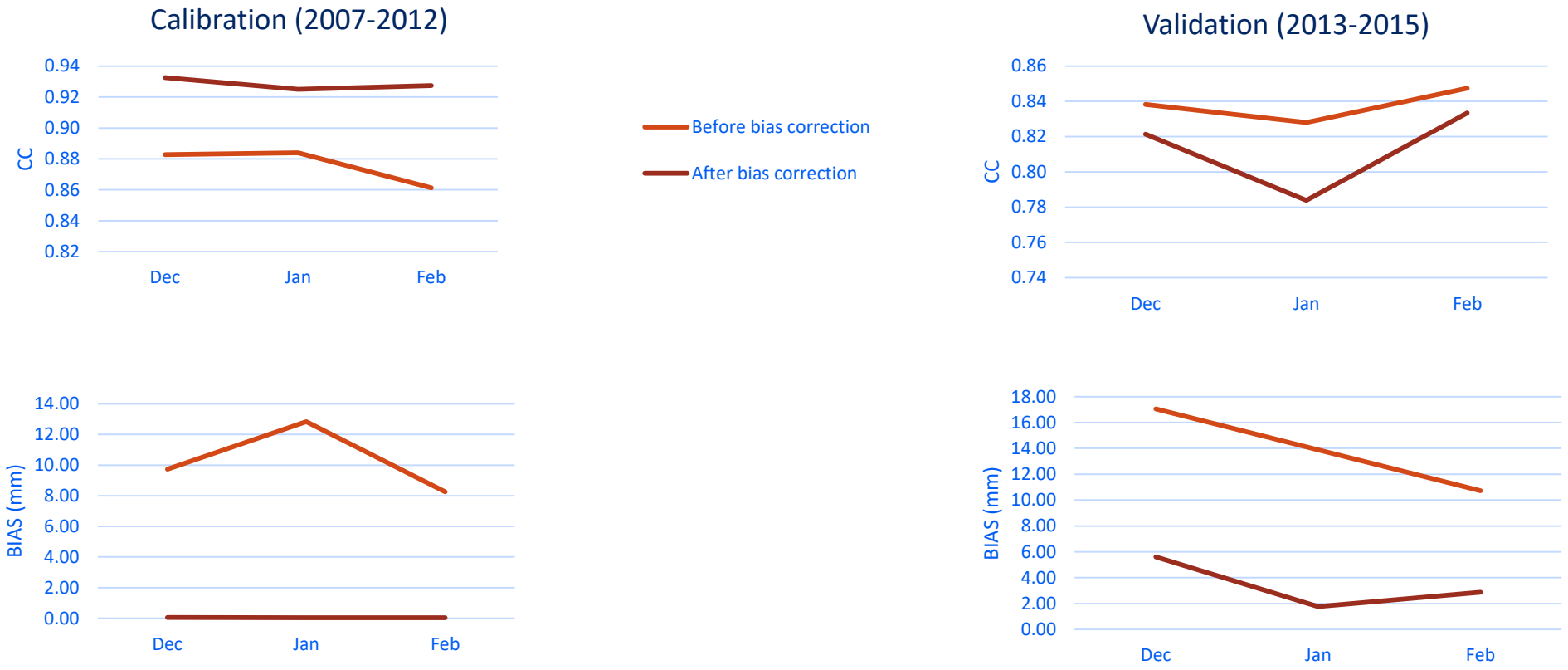


- Result


SM2RAIN
gpcc
Monthly rainfall [mm]
100
80
60
40
20
2000
2005
2010
2015
2020
SM2RAIN
CPC
Monthly rainfall [mm]
100
80
60
40
20
SM2RAIN
era5
Monthly rainfall [mm]
120
100
80
60
40
20
2000
2005
2010
2015
2020

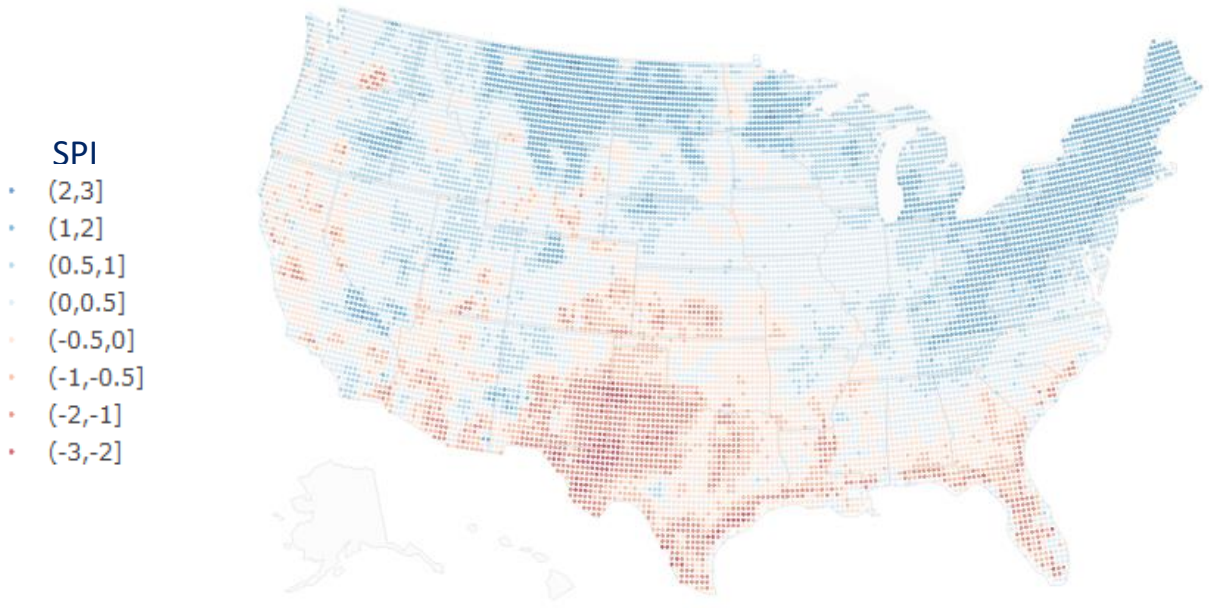
- Results

  - Bias correction evaluation

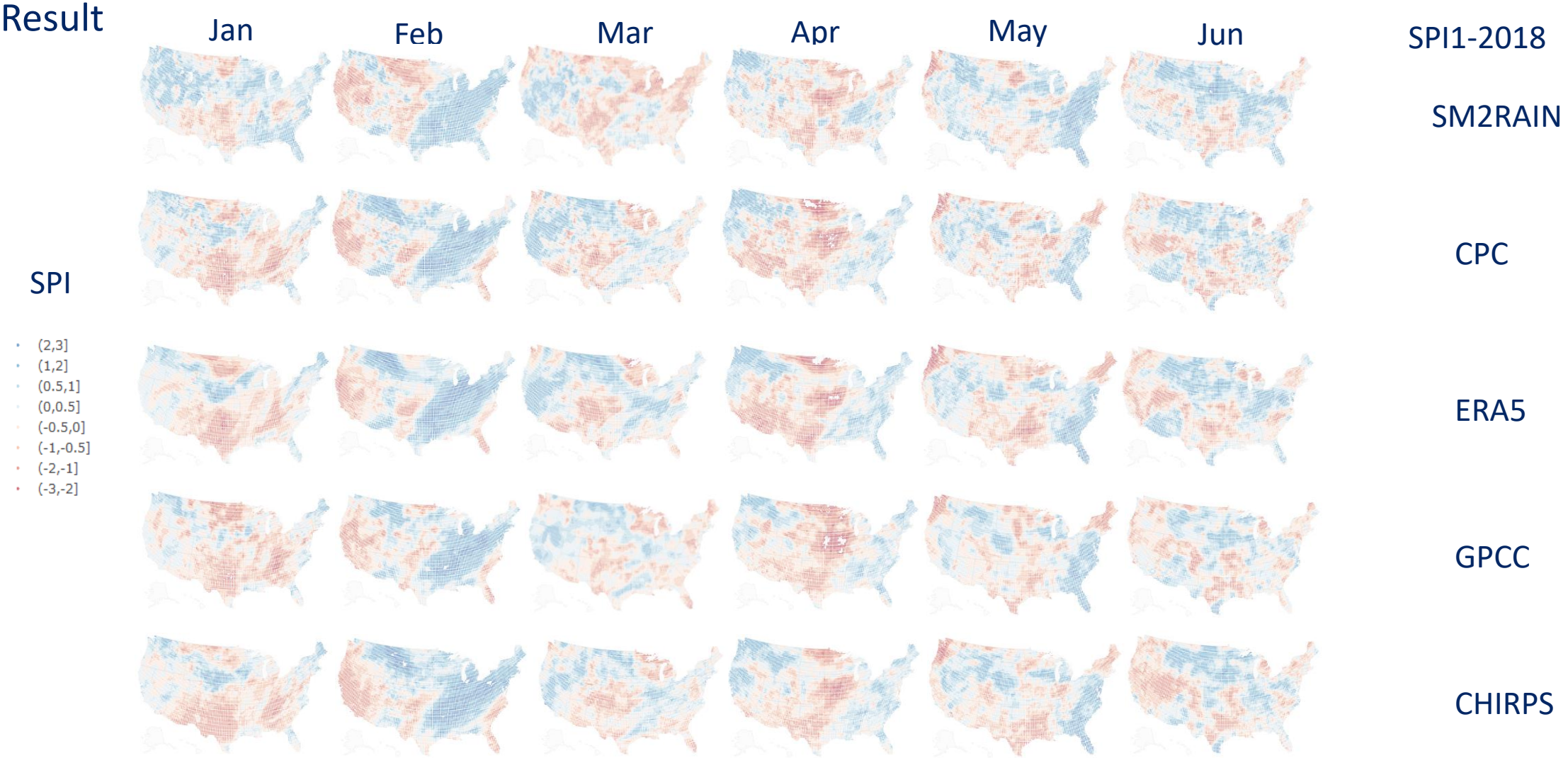


- Results
  - SPI

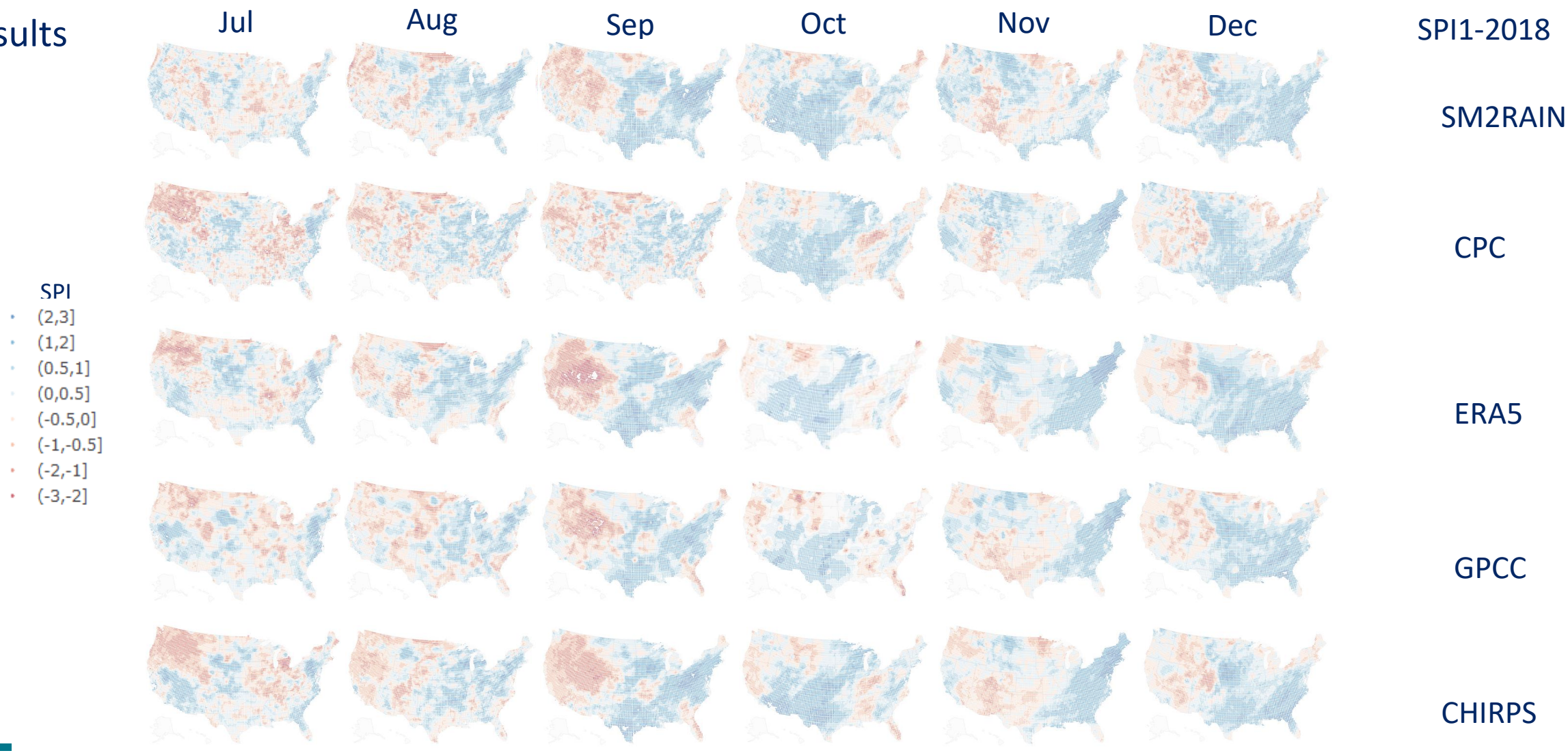
SPI12-Apr-2012



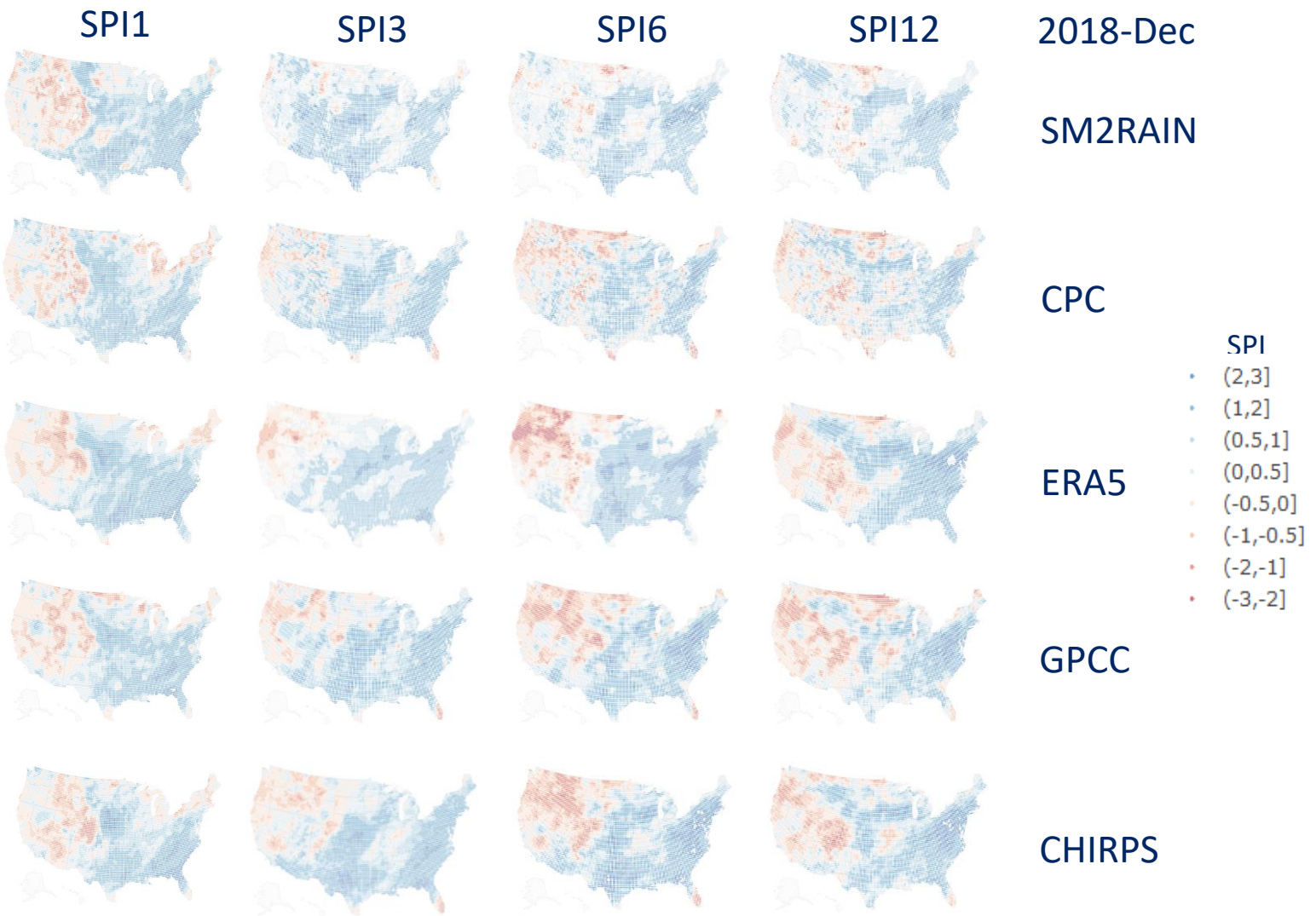
- Result


Jan
Feb
Mar
Apr
May
Jun
SPI1-2018
SM2RAIN
CPC
ERA5
GPCC
CHIRPS
SPI
(2,3]
(1,2]
(0.5,1]
(0,0.5]
(-0.5,0]
(-1,-0.5]
(-2,-1]
(-3,-2]

- Results
  - SPI

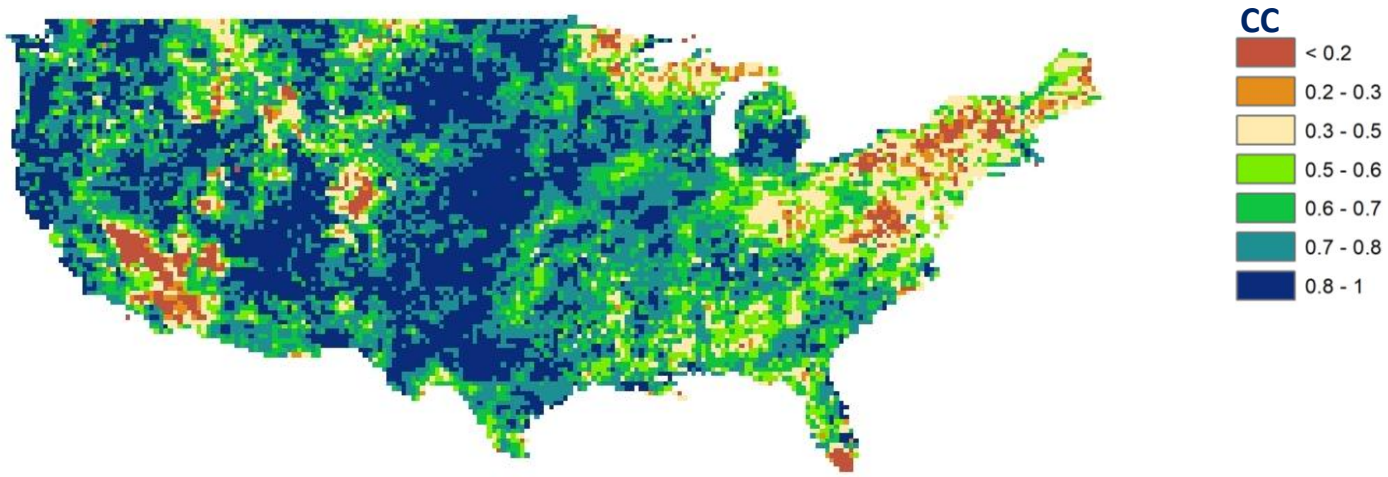

Jul
Aug
Sep
Oct
Nov
Dec
SPI1-2018
SM2RAIN
CPC
ERA5
GPCC
CHIRPS
SPI
(2,3]
(1,2]
(0.5,1]
(0,0.5]
(-0.5,0]
(-1,-0.5]
(-2,-1]
(-3,-2]

- Results
  - SPI


SPI1
SPI3
SPI6
SPI12
2018-Dec
SM2RAIN
CPC
ERA5
GPCC
CHIRPS
SPI
(2,3]
(1,2]
(0.5,1]
(0,0.5]
(-0.5,0]
(-1,-0.5]
(-2,-1]
(-3,-2]

- Results
  - Maps of correlation between SM2RAIN SPI and CPC SPI

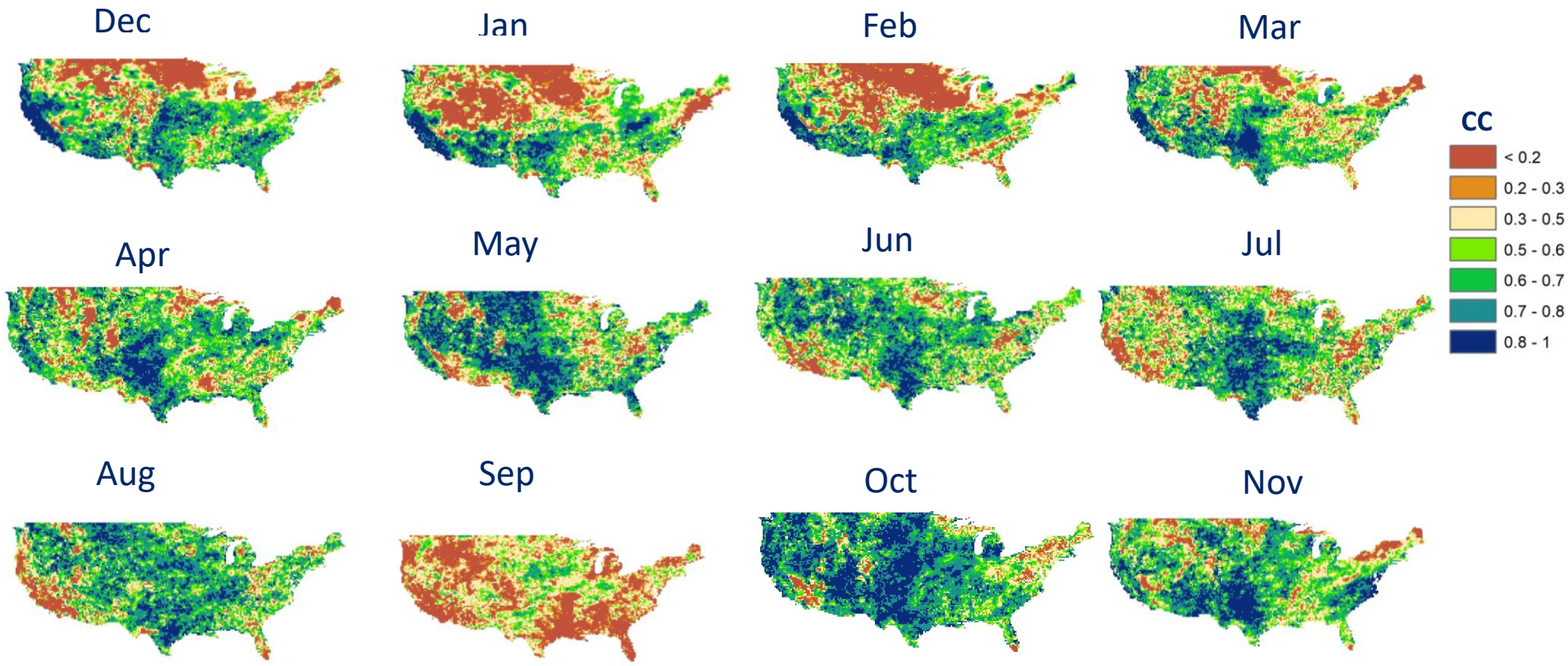
Oct



- Result

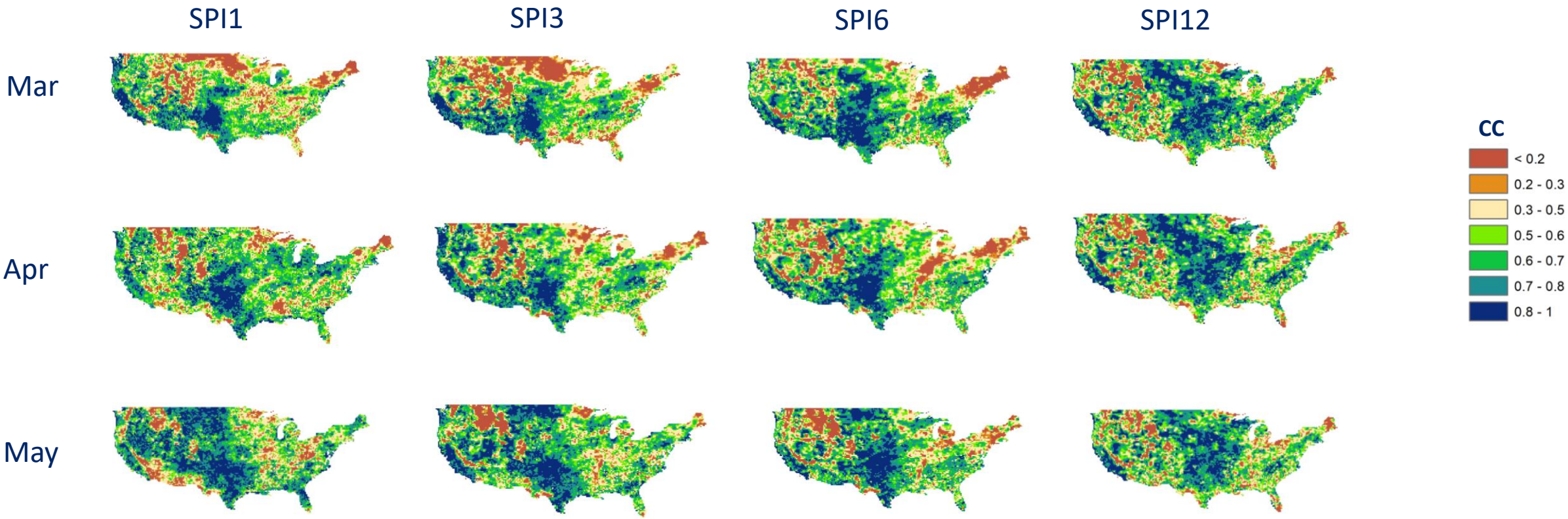
SM2RAIN vs CPC

Spi-1

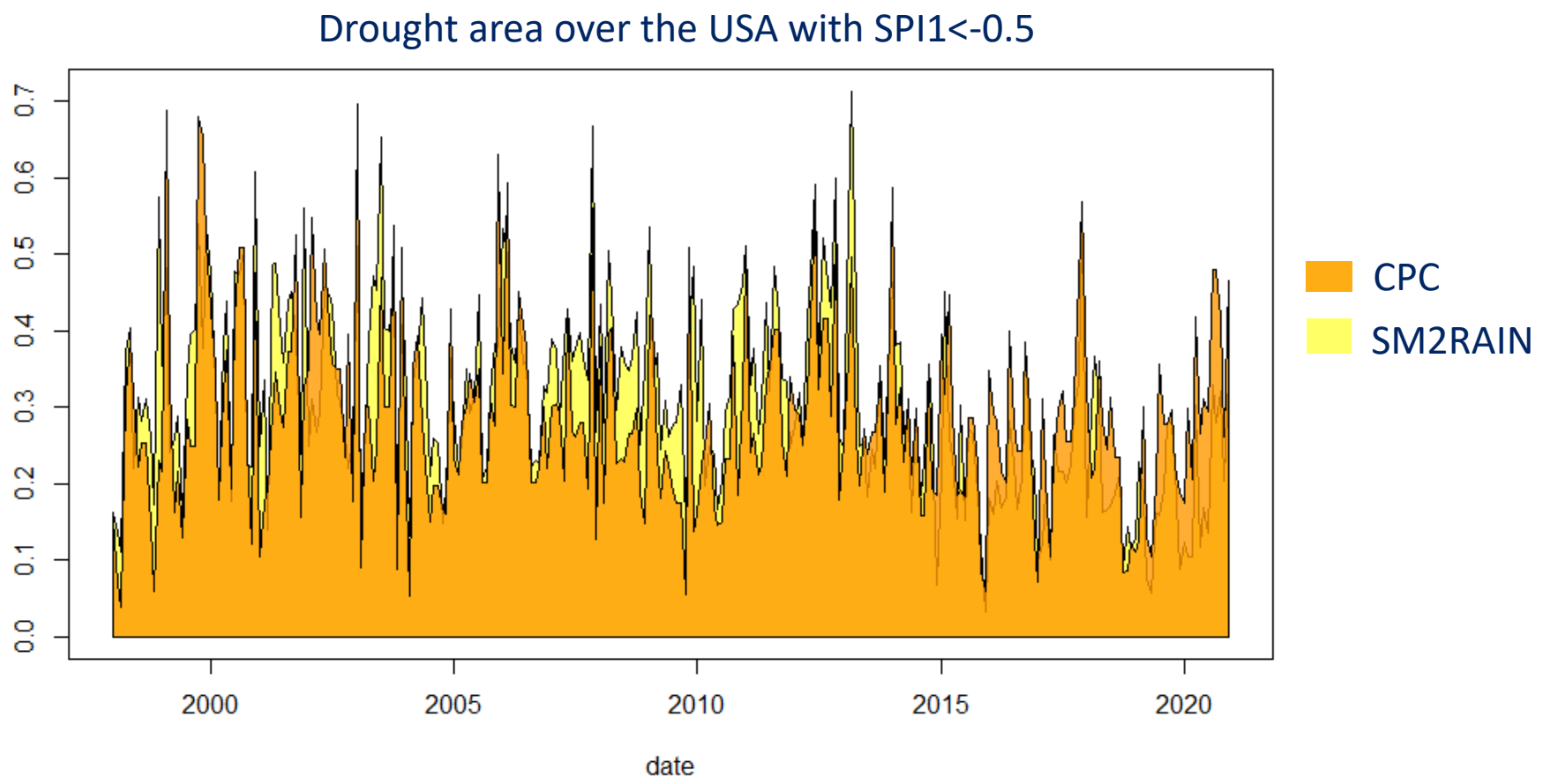


- Result

SM2RAIN vs CPC



- Result


Drought area over the USA with SPI1<-0.5
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2000
2005
2010
2015
2020
date
CPC
SM2RAIN

Thank you for your attention