Evaluating and Correcting CORe Surface Downward Shortwave and Longwave Fluxes using NASA CERES EBAF-Surface Observations

Jan 4, 2023

Data

- CORe
  - ***Monthly***
    - /cpc/cfsr/reanalyses/corefv3/ens_mean/mon/flx/flx.ctl
    - DSWRFsfc, DLWRFsfc over 2001-2021
- NASA CERES EBAF-Surface Data
  - ***Monthly*** over Mar2000-present, with ~8 months latency
  - Produced based on the computed untuned monthly radiative fluxes from NASA CERES SYN1deg, which are obtained by forcing the Langley Fu-Liou radiative transfer model with MODIS and geostationary satellite cloud properties & atmospheric T and Q profiles from a NASA GMAO reanalysis
  - An objective constrainment algorithm is used to adjust surface, atmospheric, and cloud properties within their uncertainties to ensure that the computed TOA fluxes are consistent with the EBAF-TOA fluxes within their observational error.
    - Such adjustment considerably reduces the bias and root-mean-square error for surface downward longwave flux over both ocean and land, and surface downward shortwave flux over ocean
  - Validated using in-situ observations globally, which shows a good agreement

Analysis

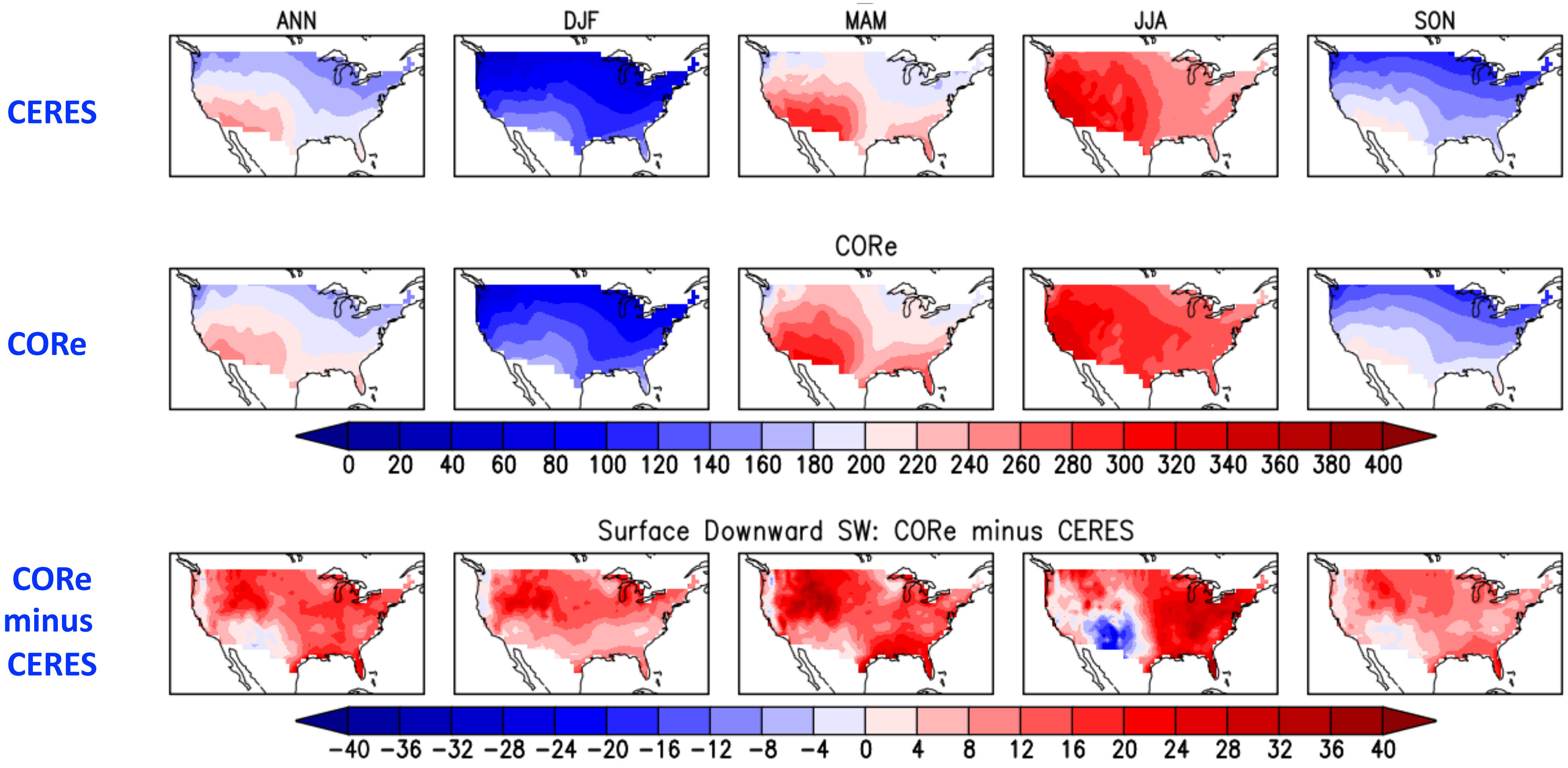
- Evaluated CORe using NASA CERES
  - ***Variables***: surface all-sky SW↓ and LW↓ fluxes
  - ***Period***: monthly over Jan2001-Dec2021
  - ***Metrics***
    - Climatology (Clim)
    - Standard deviation (STD)
    - Root-Mean-Square Error (RMSE)
    - Anomaly correlation coefficient (ACC)

Analysis

- Three methods were tried to correct CORe using NASA CERES
  - Method 1
    - Remove monthly climatological bias
    - CORe_corrected = CORe_monAnom + CERES_monClim
  - Method 2
    - Ratio-based bias correction
      - Berg et al. (2003) use monthly observations (instead of monthly climatology) for correction, which is not doable for our study because of the latency of the NASA CERES data
    - CORe_corrected = CORe_mon * (CERES_monClim/CORe_monClim)
  - Method 3
    - Remove monthly climatological bias, apply STDratio-based correction for monthly anomaly
    - CORe_corrected = CORe_monAnom*(CERES_monSTD/CORe_monSTD) + CERES_monClim

$$S\downarrow_i = \frac{S\downarrow(O)}{\left(\frac{\sum_{i=1}^{n} S\downarrow(R)_i}{n}\right)} S\downarrow(R)_i,$$

CORe vs CERES: *SW↓ Climatology (2001-2021)*



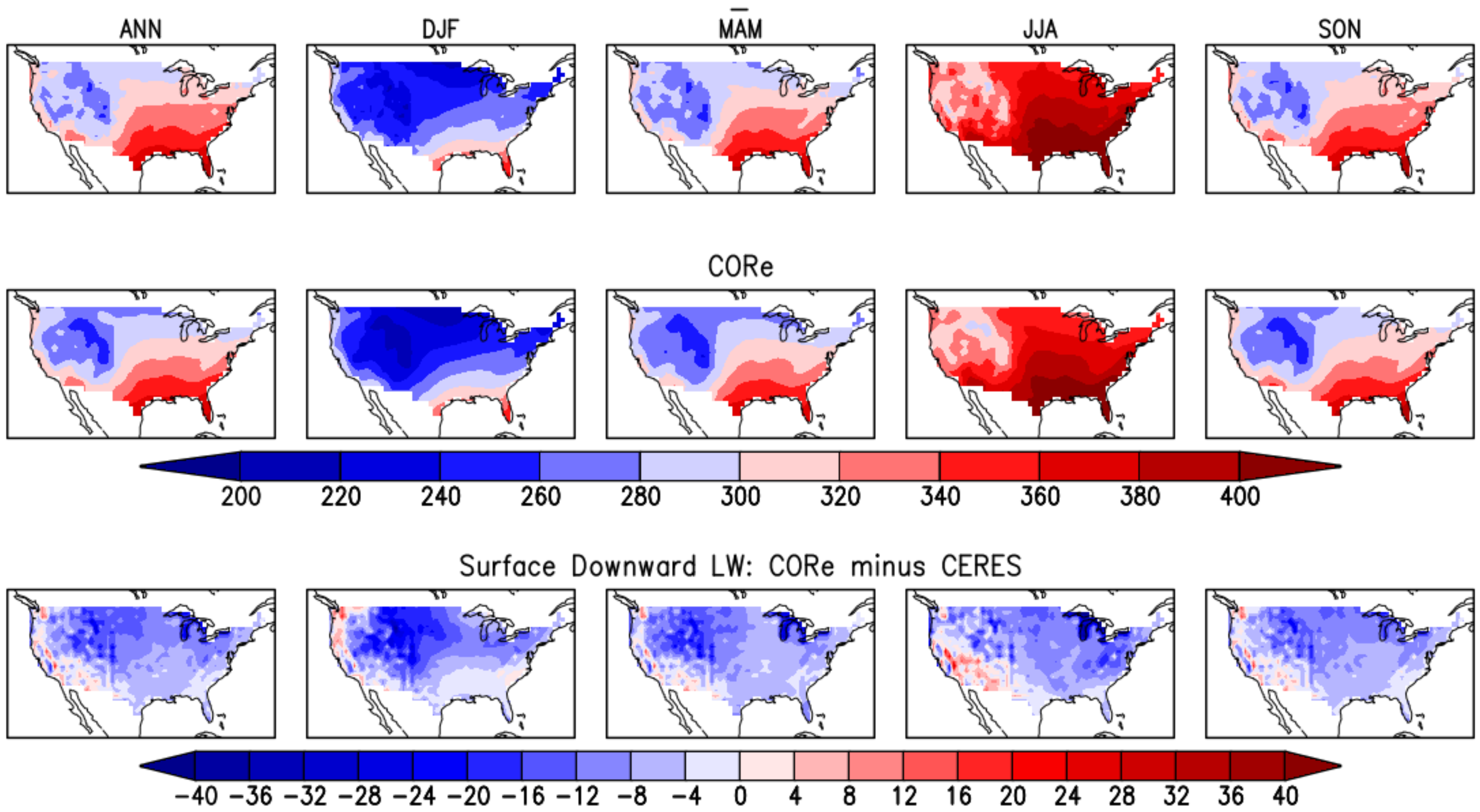
Surface SW↓ Clim: CORe > CERES except over SW US during JJA

CORe vs CERES: *LW↓ Climatology (2001-2021)*

CERES

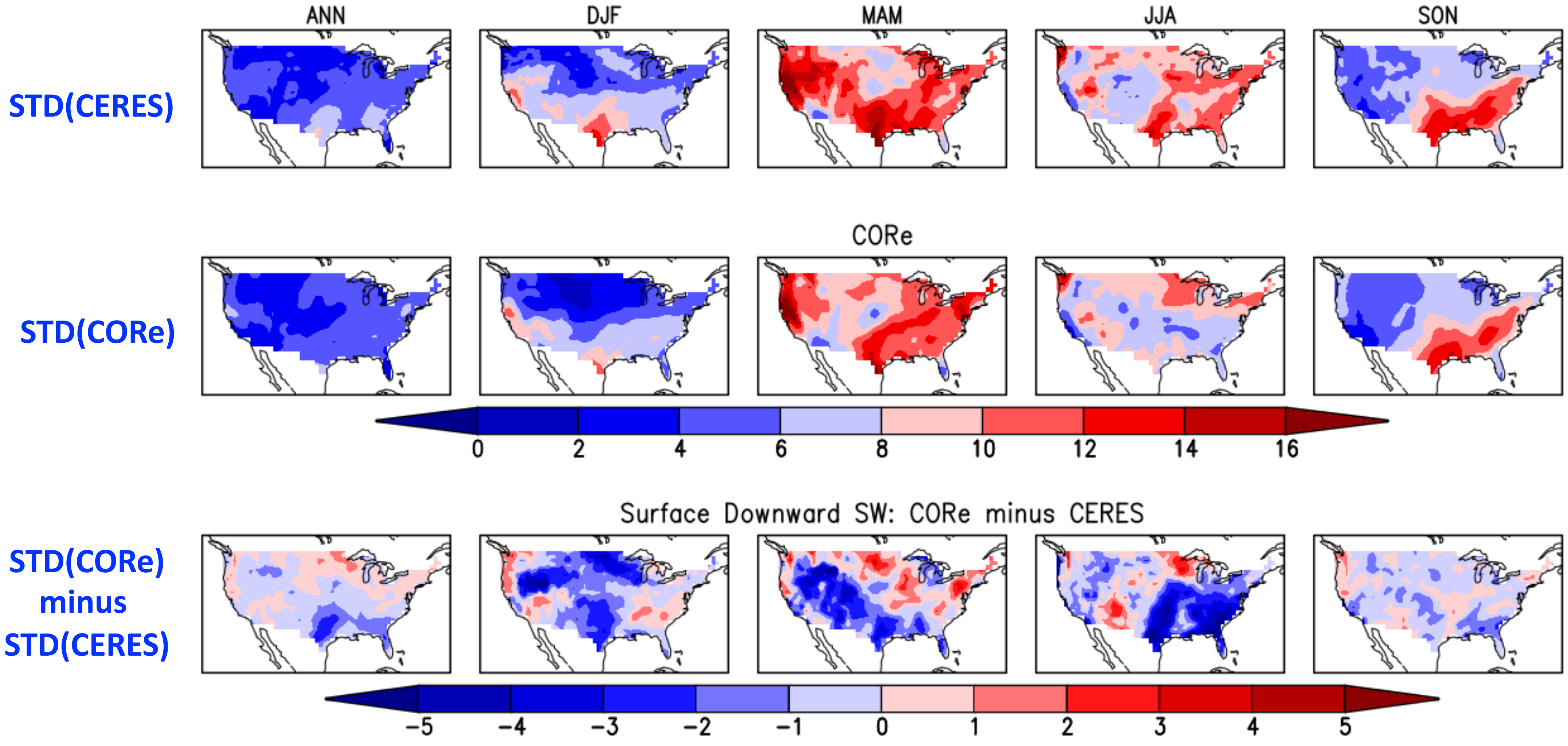
CORe

CORe minus CERES



Surface LW↓ Clim: CORe < CERES except over SW US especially JJA

CORe vs CERES: *SW↓ Standard Deviation (2001-2021)*



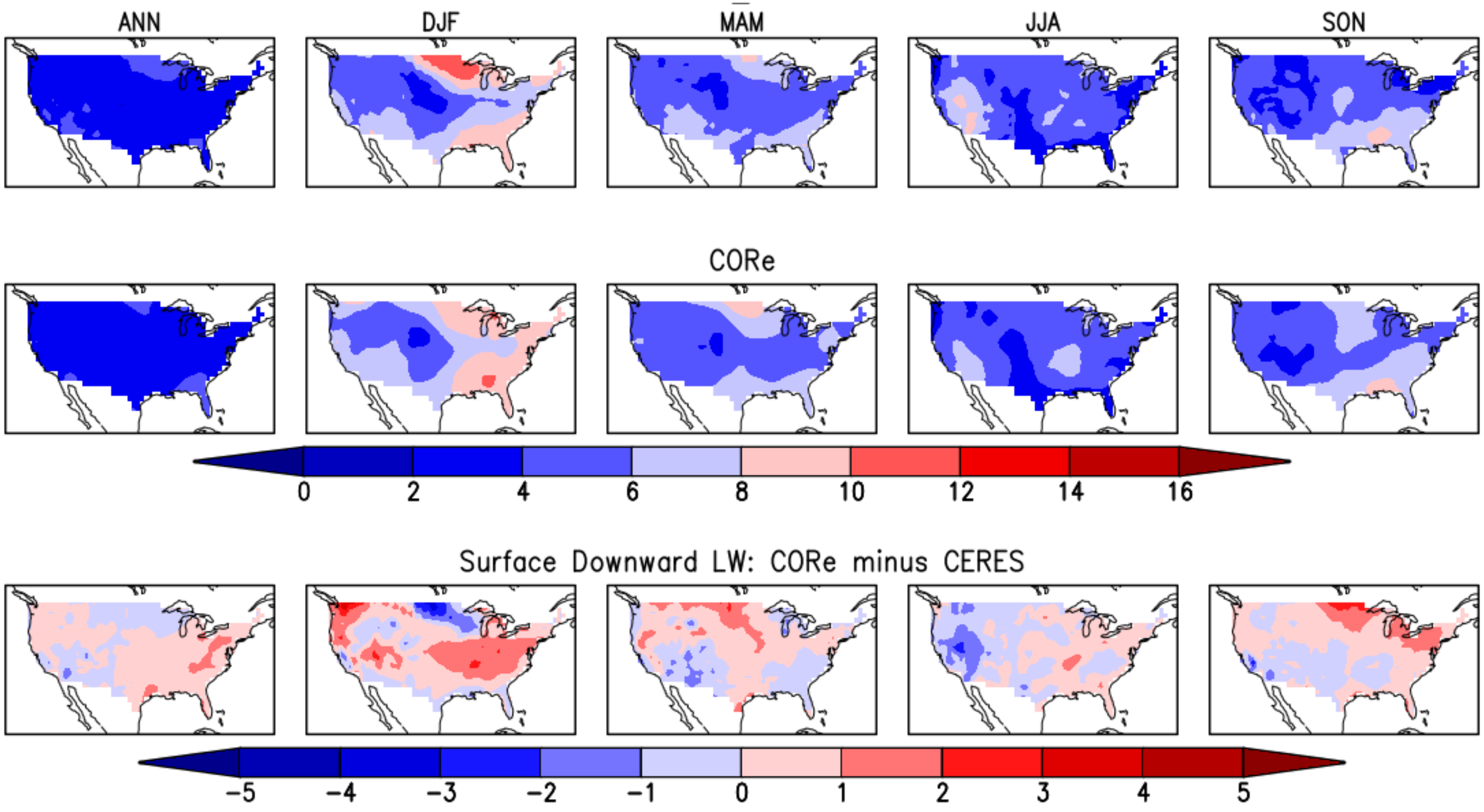
Surface SW↓ STD: CORe < CERES over considerable portions of CONUS

CORe vs CERES: *LW↓ Standard Deviation (2001-2021)*

STD(CERES)

STD(CORe)

STD(CORe) minus STD(CERES)

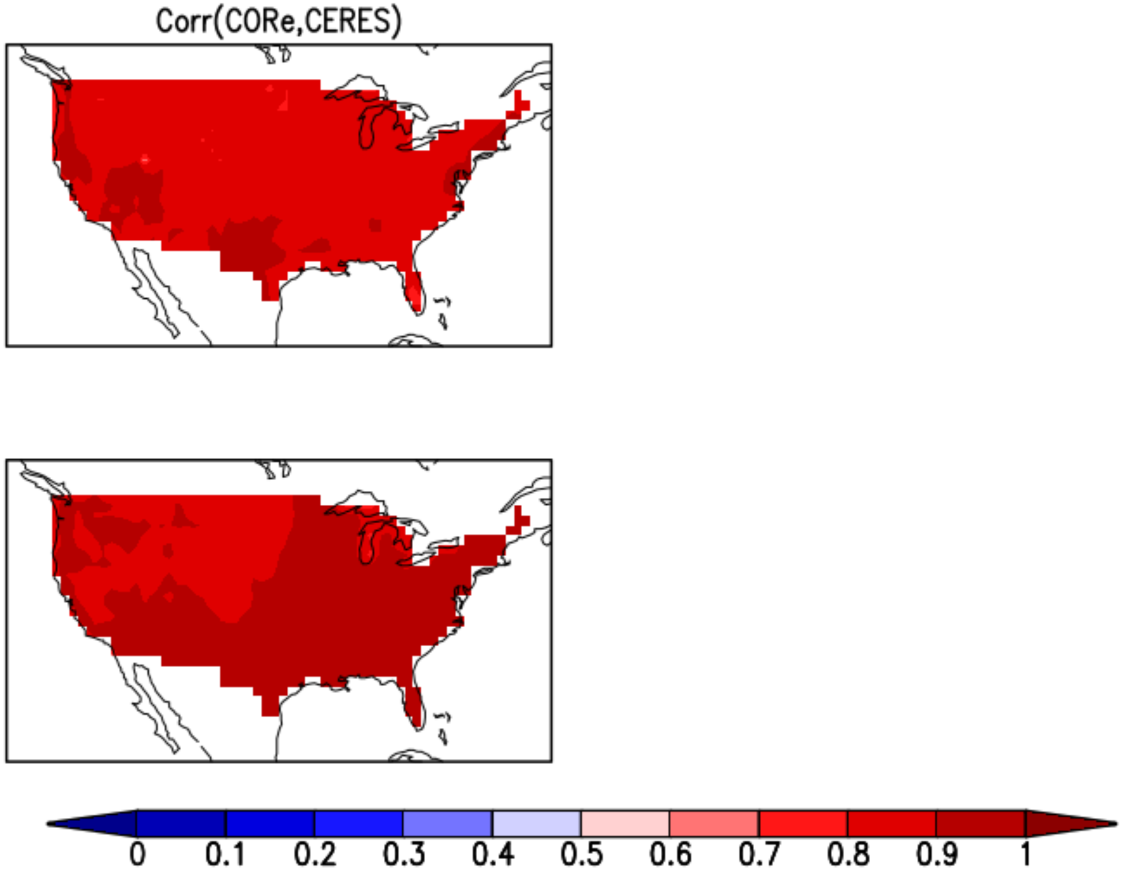


Surface LW↓ STD: CORe > CERES over considerable portions of CONUS

ACC(CORe, CERES): *2001-2021*

SW↓

LW↓

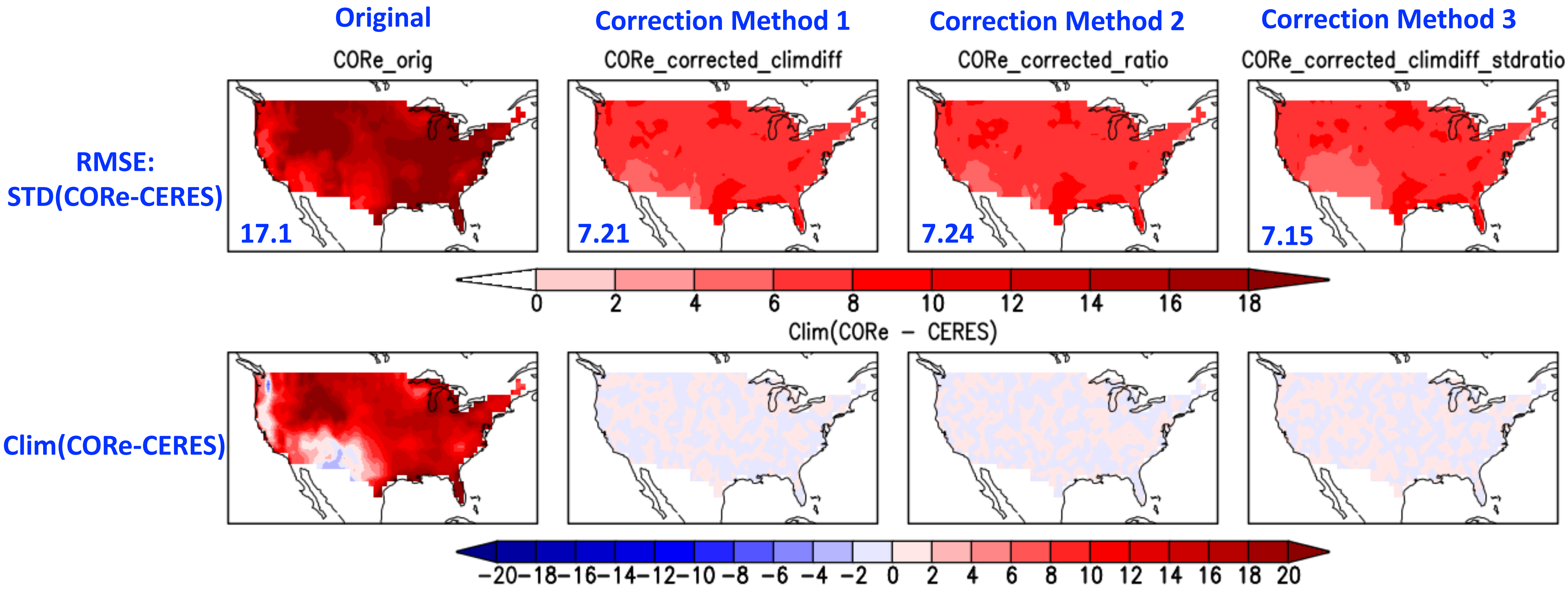


Good temporal agreement (ACC>0.7), especially for LW↓

Next apply the three correction methods, and check their performance in improving

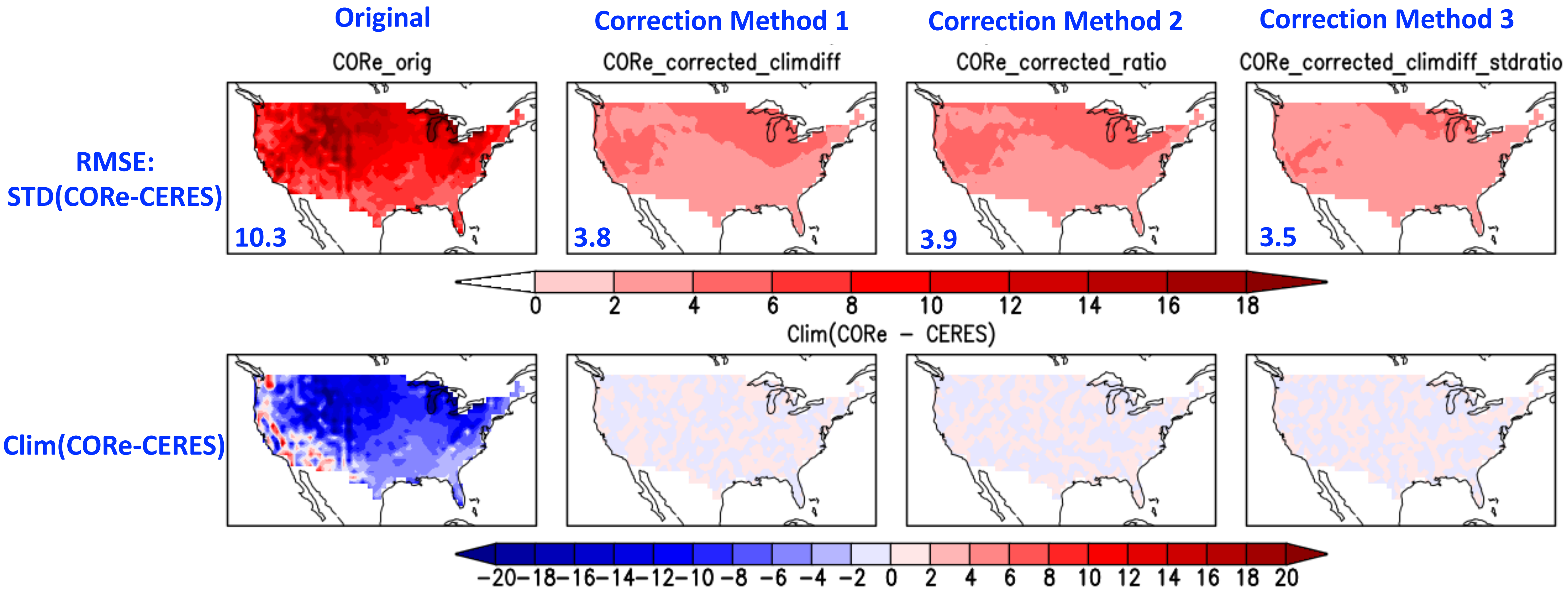
- Climatology (Clim)
- Standard deviation (STD)
- RMSE
- ACC

CORe vs CORe_corrected: *SW*↓



- The three correction methods remove climatological biases and substantially reduce monthly biases by >60%
- The 3rd correction method (CLIMdiff_STDratio) works the best

CORe vs CORe_corrected: *LW*↓



- ➢ The three correction methods remove climatological biases and substantially reduce monthly biases by >60%
- ➢ The 3rd correction method (CLIMdiff_STDratio) works the best

STD(CORe) vs. STD(CERES): *SW*↓

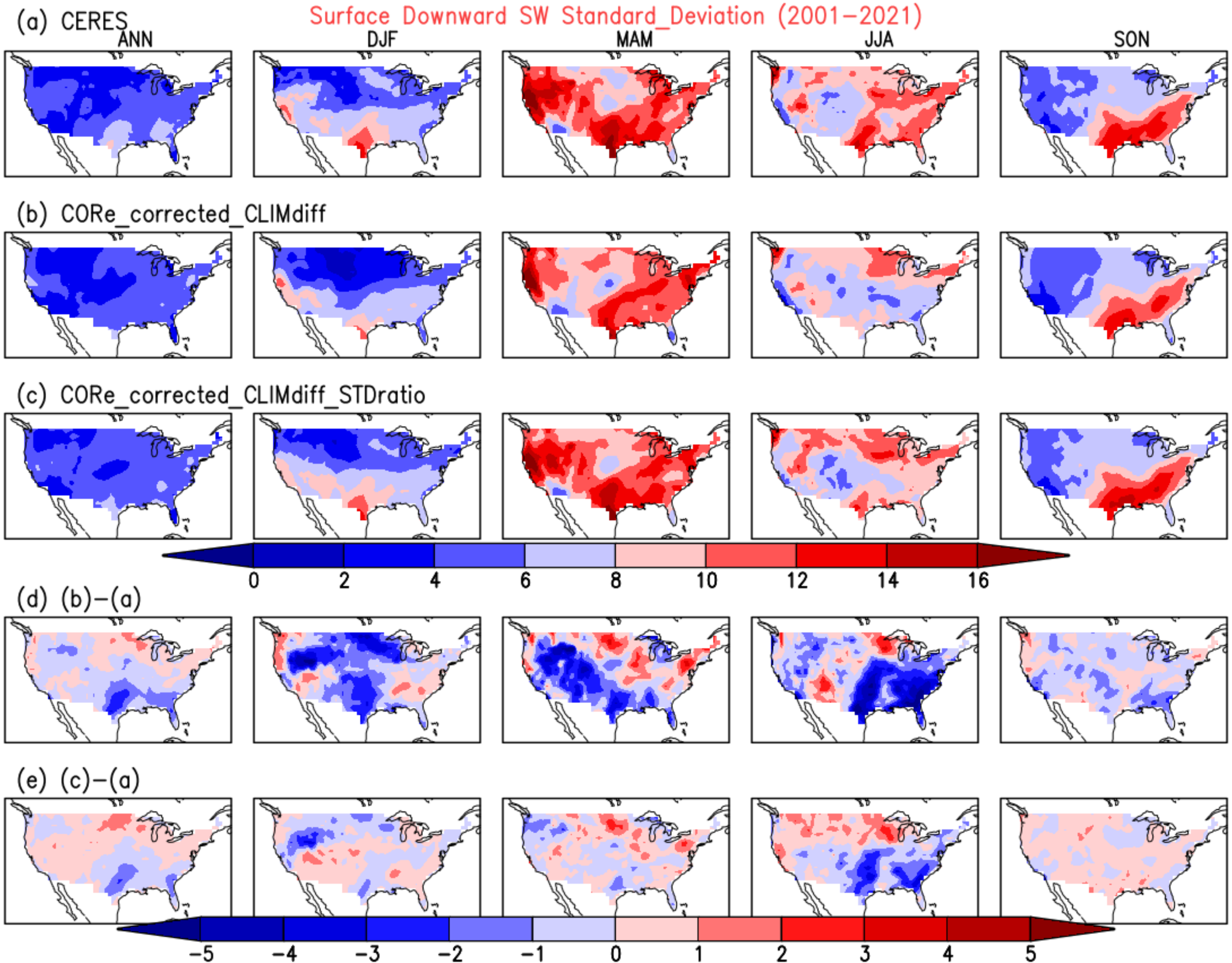
(a) STD(CERES)

(b) STD (CORe_corrected1)

(c) STD (CORe_corrected3)

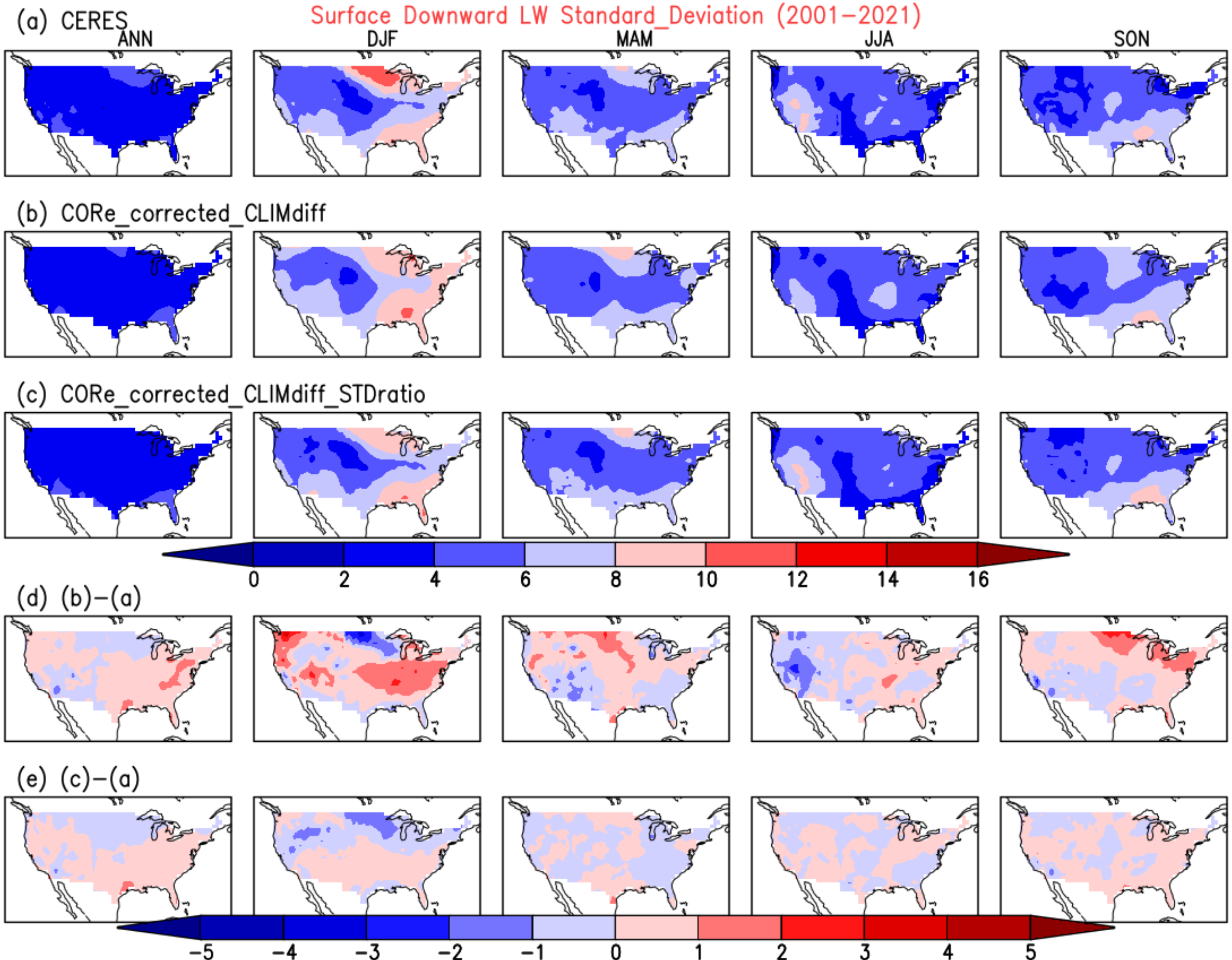
(b)-(a)

(c)-(a)



The application of STD_ratio_scaling reduces error in STD

STD(CORe) vs. STD(CERES): *LW↓*



(a) STD(CERES)

(b) STD (CORe_corrected1)

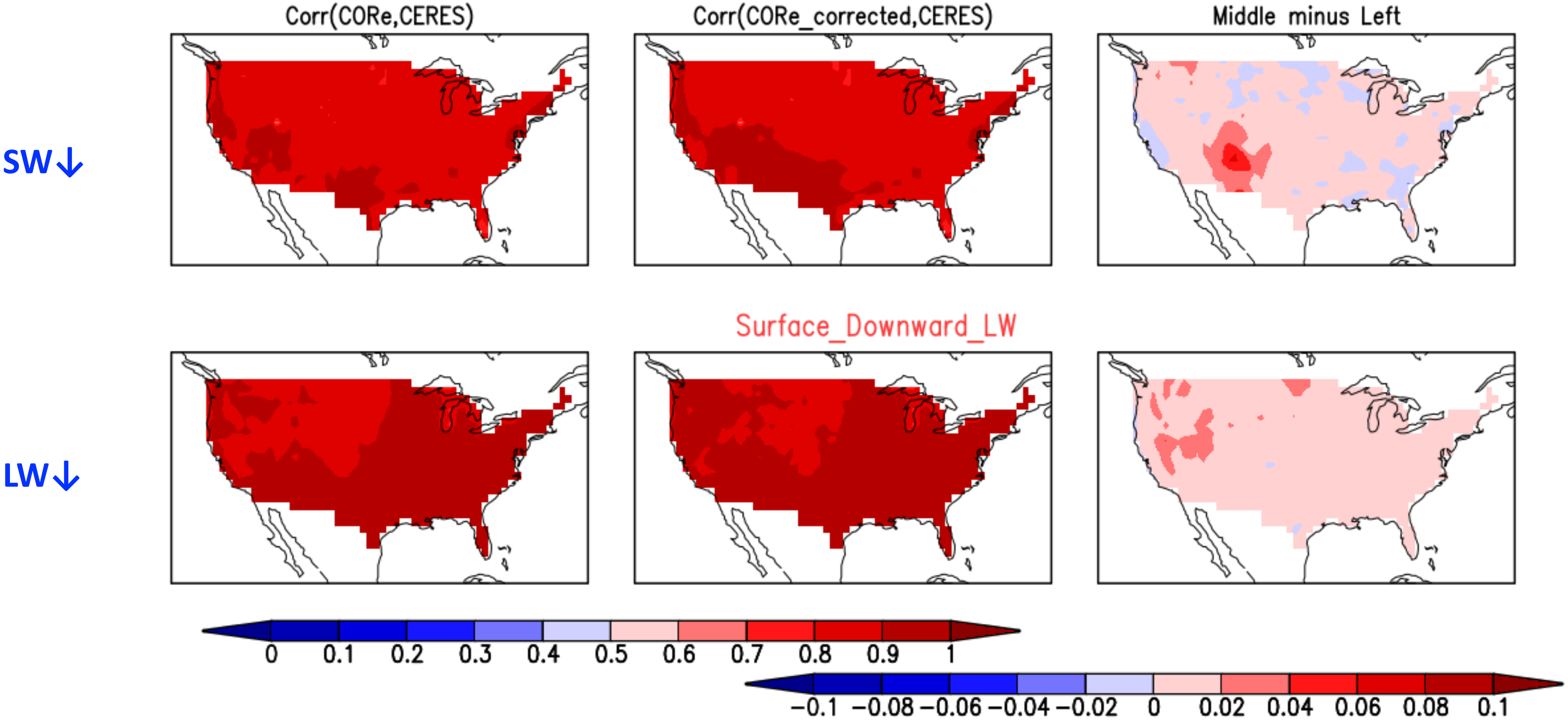
(c) STD (CORe_corrected3)

(b)-(a)

(c)-(a)

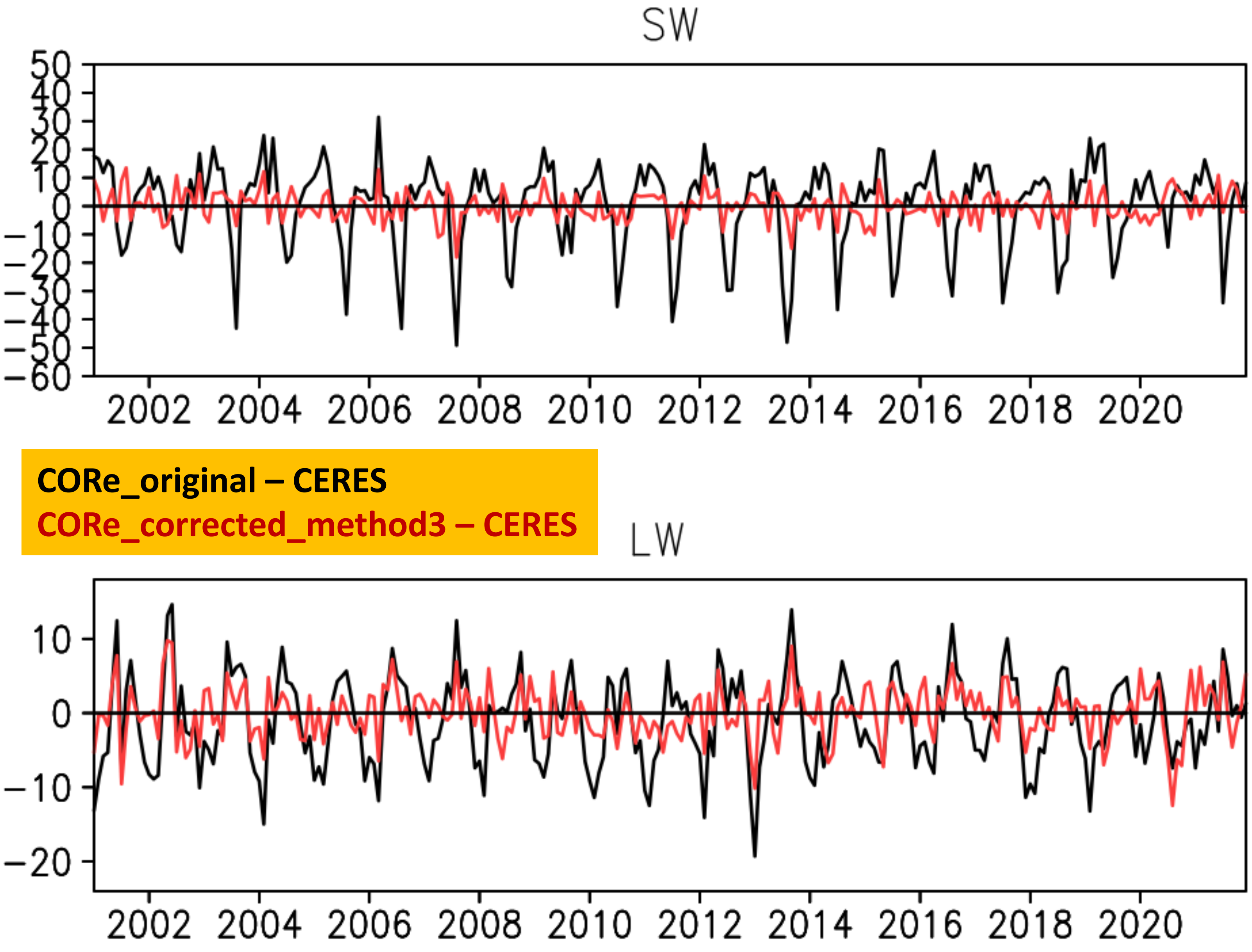
The application of STD_ratio_scaling reduces error in STD

ACC(CORe, CERES): *2001-2021*



The 3rd correction method also slightly improves ACC.

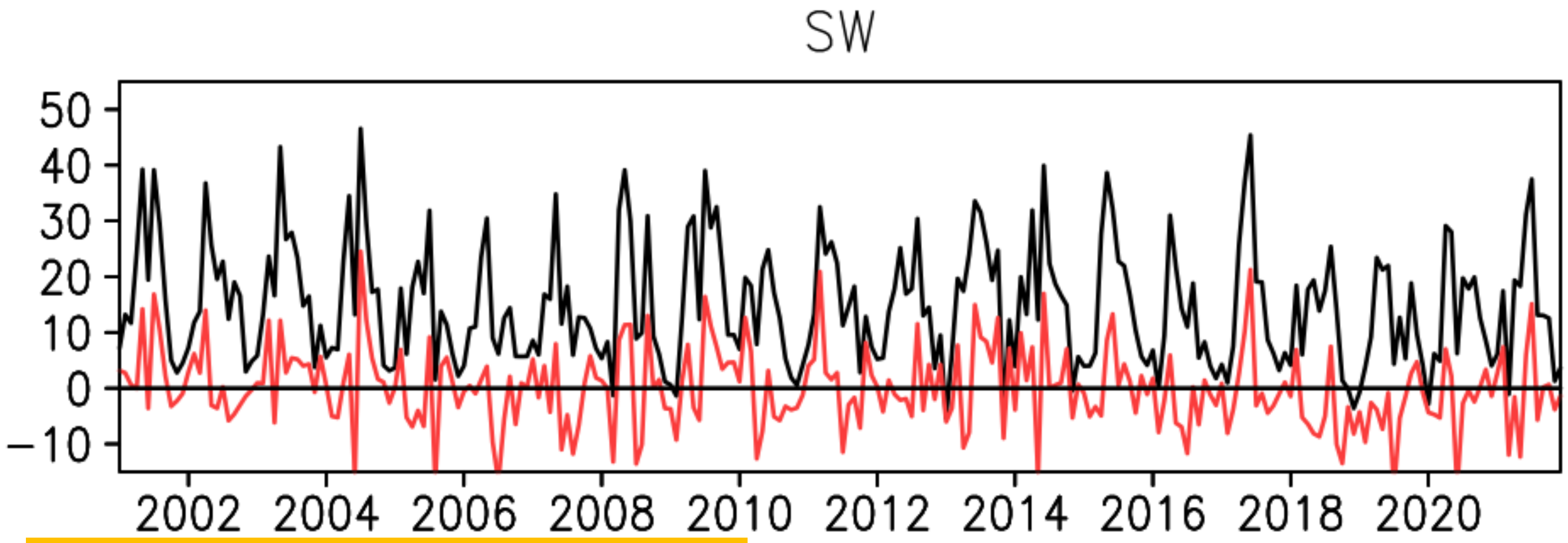
CORe-CERES: *Original vs Corrected_method3, 250E35N (SW US)*



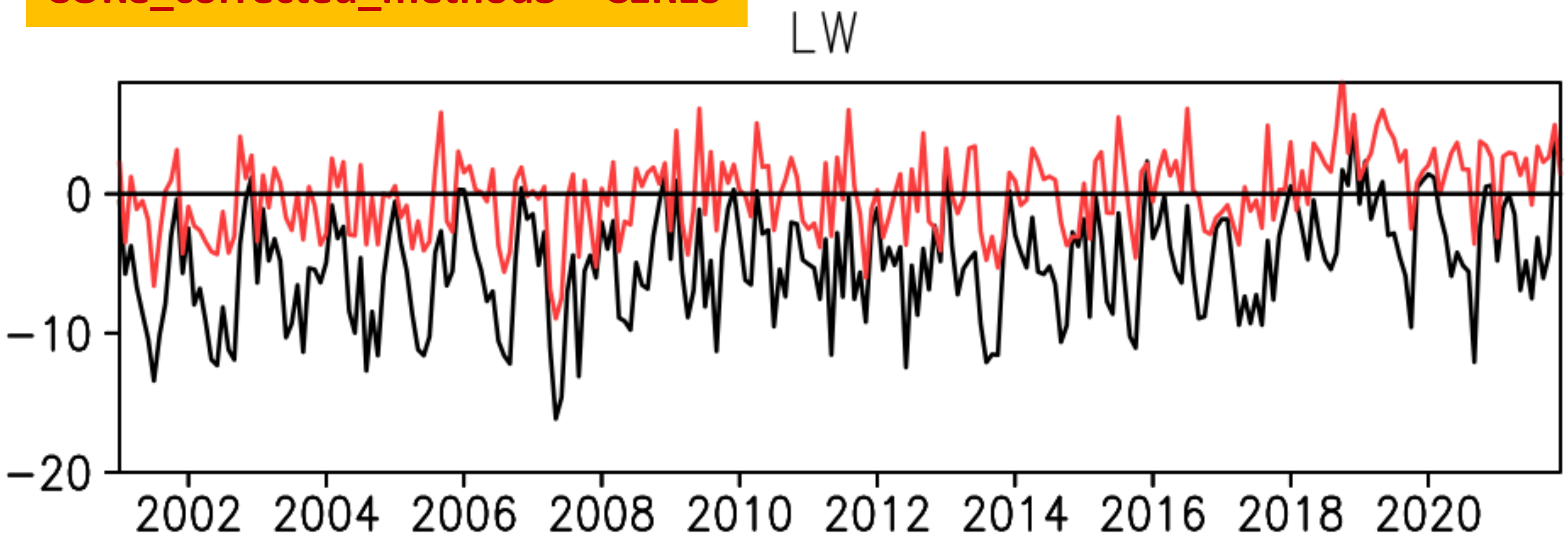
CORe_original – CERES
CORe_corrected_method3 – CERES

- The (3rd) correction method considerably reduces CORe's biases.

CORe-CERES: *Original vs Corrected_method3, 270E33N (SE US)*

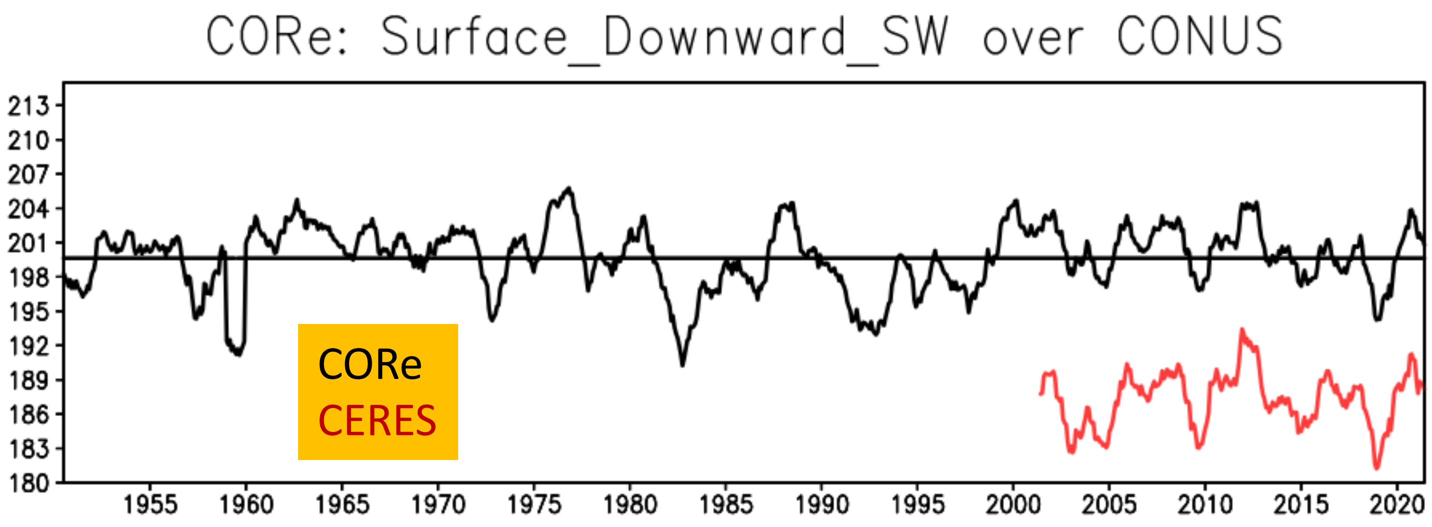


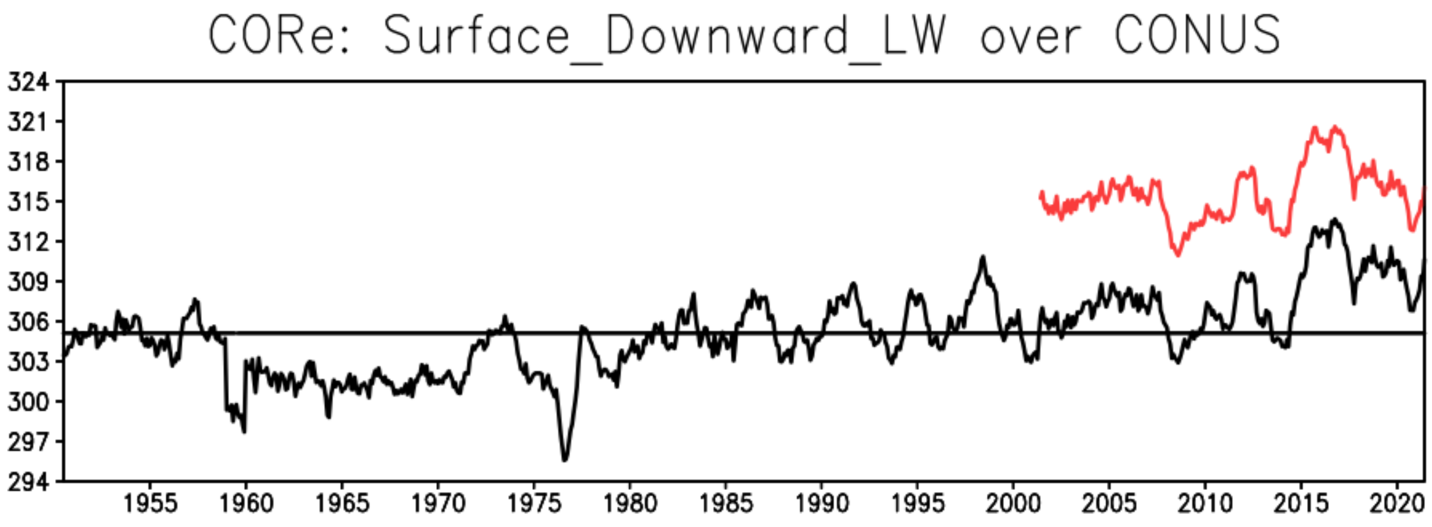
CORe_original – CERES
CORe_corrected_method3 – CERES



- The (3rd) correction method considerably reduces CORe's biases.

CORe: *2001-present vs. 1950-present*





- The correction is performed using data over the recent two decades (2001-2021)
  - Applicable to earlier decades?
  - Should work for correcting first-order biases
- CORe LW does show a notable warming trend over 1950-2021.

Summary

- Using CERES EBAF-Surface as the observational reference, CORe:
  - overestimates SW↓ and underestimates LW↓ climatologically
    - Except over SW US during JJA where CORe has weaker SW↓
  - underestimates (overestimates) year-to-year variations for SW↓ (LW↓) over considerable portions of the CONUS
  - ACC >0.7, higher for LW↓
- Three simple correction methods were tested. The method that corrects both climatology and standard deviation works the best.
- The correction was performed using observations over the recent two decades. It should presumably work to remove first-order biases for earlier decades
  - This is also the best we can do as CERES observations are only available for 2000 onwards