



Supplement of

Limitations of WRF land surface models for simulating land use and land cover change in Sub-Saharan Africa and development of an improved model (CLM-AF v. 1.0)

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ST1: Addressing Inconsistencies in CLM-AF PFTs

In the savanna category, corn is the fourth most abundant PFT indicating some misclassification with croplands. To eliminate this issue of misclassification, the corn contribution to the savanna category is ignored and the fifth most abundant PFT (broad leaf deciduous tropical trees) is used instead. In the broad leaf evergreen forest category, the third and fourth most abundant PFTs are deciduous tropical and temperate trees. To fix this misclassification, the contributions of each type of deciduous tree are added to their evergreen counterparts (i.e., tropical and temperate) to obtain an appropriate weighted total of tropical to temperate trees. After this, all tropical and temperate trees were assumed to be evergreen to match the MODIS category. In the mosaic cropland category, the fourth most abundant PFT is evenly divided between evergreen and deciduous tropical trees. This is addressed by summing the total deciduous and tropical tree amounts and assuming that all trees within this category were represented by evergreen tropical trees, since most mosaic cropland is in proximity to broadleaf evergreen forests.

ST2: Subdivision of Bio-Climate Regions

The central wet (CW) and northeast semi-dry (NESD) bioclimate regions are split into three sub-bioclimate regions. CW is split into central wet north (CWN) and central wet south (CWS) regions, north and south of the equator respectively. The southern portion of Angola that contains the savanna MODIS-IGBP category is further split from the CWS region (CWSA) to better represent the differences in LAI between tropical and subtropical grasses. The NESD region is also split into NESD north (NESDN) and NESD south (NESDS) regions containing the area within the NESD region north and south of 4°N, respectively. To avoid an arbitrary discontinuity in LAI from occurring at 4°N, the portion of the NESDN region that contains open

shrubland around 4°N is further split off into a separate region (NESDSH) with its own LAI profiles. The central moist (CM) region is also split into two sub-bioclimate regions, central moist north (CMN) and central moist south (CMS) that are divided at the equator.

ST3: Additional Adjustments to LAI Broad Leaf Evergreen Tree Profiles

Some additional adjustments were required for the monthly LAI profiles to ensure the best possible match to the satellite derived climatology. The broad leaf evergreen forest MODIS-IGBP category does not differentiate between tropical and temperate evergreen trees leading to an inconsistency with CLM. As mentioned in the previous section, the broad leaf evergreen forest category is split between tropical and temperate evergreen trees, however, the “one size fits all” approach to PFTs in WRF-CLM does not allow this ratio to change throughout the model domain. This is not reflective of actual PFT distributions as regions like the Congo contain only tropical evergreen trees, while regions like South Africa contain only temperate evergreen trees. To correct for the inconsistency, the broad leaf evergreen temperate trees were given the identical monthly LAI profile as tropical trees in the WW, WWN, and CW regions and the broad leaf evergreen tropical trees were given the identical monthly LAI profiles as the temperate trees in the SSD and SM regions.

ST4: Additional Details Regarding Moisture Variable Evaluation

In most regions cloud fraction (CF) NMB and NME compared to MODIS are under 50% across most LSMs (Fig. 8). The areas experiencing the greatest overpredictions and worst performance are those across the northern part of the simulation domain (i.e., ND, ED, NESD, EW, and WSD). This poor performance could result from multiple causes including domain boundary effects, errors in the cloud fraction parameterization, and poor coupling of cloud

fraction parameterization to the cumulus parameterization. Similar CF performance occurs also occurs against CRU (Fig. S7) estimates.

The overprediction of precipitation (PRE) the EW region is likely the result of poorly resolved complex terrain in the Ethiopian Highlands at 36km grid spacing, as this poor performance is common to all WRF LSM simulations. Strong underpredictions in the LVW region are also consistent across LSMs. This is likely due to inaccurate initialization of Lake Victoria's surface temperatures, which has been shown to substantially reduce simulated precipitation in the region (Argent et al., 2015). In contrast, the magnitude of the underpredictions in PRE within the East Africa regions varies more between LSMs. These regions experience the strongest underpredictions with the Noah LSM, likely as a result of insufficient atmospheric instability from the underpredicted surface temperatures. Some East Africa regions (e.g., SESD and EM) also experience considerable underpredictions in CLM-D, likely as a result of the inaccurate LAI seasonal profile underestimating the LAI during these regions' rainy season (DJF). This indicates that accurate seasonal LAI profiles are an important component to obtaining accurate rainfall predictions in these East African regions. The precipitation performance against TRMM observations discussed above (Fig. 8) are also generally comparable to GPCP and CRU estimates (Fig. S5), but TRMM error statistics are generally larger due to its greater horizontal resolution and spatial variability. ist north (CMN) and central moist south (CMS) north and south of 1°N, respectively.

Table S1: Variables Used from ERA-Interim Reanalysis

Variable	Units
Atmosphere Temperature	K
Geopotential Height	$\text{m}^2 \text{s}^{-2}$
East -West Wind Component (U)	m s^{-1}
North -South Wind Component (V)	m s^{-1}
Relative Humidity	%
Surface Pressure	Pascal
Sea-Level Pressure	Pascal
Surface Skin Temperature	K
Sea Surface Temperature	K
Soil Temperature	K
Soil Moisture	$\text{m}^3 \text{m}^{-3}$
Sea Ice Fraction	Fraction
Snow Density	kg m^{-3}
Snow Height	M

Table S2: Percentage of Plant Functional Types Assigned to MODIS Land Use Categories in the Default CLM

MODIS Land Use Category	1	2	3	4	5	6	7	8	9	10	12	14	16	18	19	20
Bare soil	25	5	50	25	26	20	20	20	-	20	15	15	90	50	60	80
Needle Leaf Evergreen Temperate Tree	75	-	-	-	37	-	-	-	-	-	-	-	-	-	-	-
Needle Leaf Evergreen Boreal Tree	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-
Needle Leaf Deciduous Boreal Tree	-	-	50	-	-	-	-	-	-	-	-	-	-	13	-	-
Broad Leaf Evergreen Tropical Tree	-	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broad Leaf Evergreen Temperate Tree	-	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-
Broad Leaf Deciduous Tropical Tree	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broad Leaf Deciduous Temperate Tree	-	-	-	75	37	-	-	-	-	-	-	-	-	-	-	-
Broad Leaf Deciduous Boreal Tree	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broad Leaf Evergreen Shrub	-	-	-	-	-	80	50	80	-	-	-	-	-	-	-	-
Broad Leaf Deciduous Temperate Shrub	-	-	-	-	-	-	-	-	-	-	-	-	-	24	-	-
Broad Leaf Deciduous Boreal Shrub	-	-	-	-	-	-	-	-	-	-	-	-	10	-	20	10
C3 Artic Grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20
C3 Non-Artic Grass	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-
C4 Grass	-	-	-	-	-	-	30	-	70	60	-	35	-	-	-	-
Corn	-	-	-	-	-	-	-	-	-	-	85	50	-	-	-	-
Wheat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

MODIS Land Use Categories: 1 – Evergreen Needle Leaf Forest; 2 – Evergreen Broad Leaf Forest; 3 – Deciduous Needle Leaf Forest; 4 – Deciduous Broad Leaf Forest; 5 – Mixed Forest; 6 – Closed Shrublands; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated; 18 – Wooded Tundra; 19 – Mixed Tundra; 20 – Barren Tundra

Table S3: Default CLM Monthly Leaf Area Index Profiles

Month	1	2	3	4	5	6	7	8	9	10	11	12
Needle Leaf Evergreen Temperate Tree	4.1	4.2	4.6	4.8	4.9	5.0	4.8	4.7	4.6	4.2	4.0	4.0
Needle Leaf Evergreen Boreal Tree	4.1	4.2	4.6	4.8	4.9	5.0	4.8	4.7	4.6	4.2	4.0	4.0
Needle Leaf Deciduous Boreal Tree	0.0	0.0	0.0	0.6	1.2	2.0	2.6	1.7	1.0	0.5	0.2	0.0
Broad Leaf Evergreen Tropical Tree	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Broad Leaf Evergreen Temperate Tree	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Broad Leaf Deciduous Tropical Tree	0.8	0.7	0.4	0.5	0.5	0.7	1.7	3.0	2.5	1.6	1.0	1.0
Broad Leaf Deciduous Temperate Tree	0.0	0.0	0.3	1.2	3.0	4.7	4.5	3.4	1.2	0.3	0.0	0.0
Broad Leaf Deciduous Boreal Tree	0.0	0.0	0.3	1.2	3.0	4.7	4.5	3.4	1.2	0.3	0.0	0.0
Broad Leaf Evergreen Shrub	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Broad Leaf Deciduous Temperate Shrub	0.9	0.8	0.2	0.2	0.0	0.0	0.0	0.2	0.4	0.5	0.6	0.8
Broad Leaf Deciduous Boreal Shrub	0.0	0.0	0.0	0.0	0.0	0.2	1.4	1.2	0.0	0.0	0.0	0.0
C3 Artic Grass	0.4	0.5	0.6	0.7	1.2	3.0	3.5	1.5	0.7	0.6	0.5	0.4
C3 Non-Artic Grass	0.0	0.0	0.0	0.0	0.0	0.2	1.4	1.2	0.0	0.0	0.0	0.0
C4 Grass	0.4	0.5	0.6	0.7	1.2	3.0	3.5	1.5	0.7	0.6	0.5	0.4
Corn	0.0	0.0	0.0	0.0	1.0	2.0	3.0	3.0	1.5	0.0	0.0	0.0
Wheat	0.0	0.0	0.0	0.0	1.0	2.0	3.0	3.0	1.5	0.0	0.0	0.0

Table S4: MODIS-IGBP Land Cover Category Description (Friedl et al., 2002)

MODIS-IGBP Land Cover Category	Description
Evergreen Broad Leaf Forests	Lands dominated by broad leaf woody vegetation with a percentage cover >60% and height exceeding 2m. Almost all trees and shrubs remain green year round. Canopy is never without foliage.
Closed Shrubland	Lands with woody vegetation less than 2 m tall and with shrub cover >60%. The shrub cover be either evergreen or deciduous.
Open Shrubland	Lands with woody vegetation less than 2 m tall and with shrub canopy cover between 10% and 60%. The shrub foliage can be either evergreen or deciduous.
Woody Savanna	Lands with herbaceous and other understory systems, with forest canopy cover between 30% and 60%. The forest cover height exceeds 2 m.
Savanna	Lands with herbaceous and other understory systems, with forest and canopy cover between 10 and 30%. The forest cover exceeds 2 m.
Grasslands	Land with herbaceous types of cover. Tree and shrub cover is less than 10%.
Cropland	Lands covered with temporary crops followed by harvest and bare soil periods (e.g., single and multiple cropping systems). Note that perennial woody crops will be classified as the appropriate forest or shrub land cover type.
Mosaic Cropland	Lands with a mosaic of croplands, forests, shrubland, and grasslands in which no one component comprises more than 60% of the landscape.

Table S5: Updated CLM-AF Monthly Leaf Area Index Profiles for Broad Leaf Evergreen Tropical Trees

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
EW	4.4	4.5	4.7	5.1	5.4	5.3	5.2	5.2	5.3	5.4	5.2	4.7
WW	4.9	5.2	5.3	5.6	5.6	5.7	5.7	5.8	5.7	5.6	5.4	5.0
CW (N,S,SA)	5.3	5.7	5.8	5.9	5.6	5.1	5.0	5.2	5.7	5.8	5.7	5.4
WWN	3.3	3.5	3.7	4.2	4.3	4.2	4.3	4.5	4.5	4.3	4.3	3.9
CM (S)	5.4	4.9	5.0	5.6	6.0	5.7	5.2	5.2	5.5	5.7	5.9	5.7
LVW	4.8	4.5	4.6	5.1	5.4	5.3	5.0	5.0	5.2	5.2	5.3	5.2
EM ⁶⁰	3.1	3.2	3.3	3.4	3.4	2.9	2.6	2.6	2.6	2.5	2.5	2.8
MAD	5.8	5.8	5.7	5.1	4.6	4.3	4.3	4.7	5.4	5.7	5.7	5.7

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S6: Updated CLM-AF Monthly Leaf Area Index Profiles for Broad Leaf Evergreen Temperate Trees

Region	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
EW	4.4	4.6	4.9	5.3	5.4	5.2	5.2	5.3	5.4	5.4	5.2	4.7
CM (S)	3.3	3.4	3.4	3.4	3.3	3.2	3.0	2.9	2.8	2.8	3.0	3.2
LVW	5.0	4.9	5.0	5.2	5.2	5.0	4.9	5.0	5.0	5.0	5.1	5.0
EM	3.5	3.6	3.5	3.3	3.0	2.5	2.2	2.3	2.5	2.4	2.7	3.1
MAD	5.0	5.1	4.8	4.3	3.9	3.6	3.6	3.7	4.4	4.9	5.0	4.9
SSD	2.3	2.1	2.0	1.6	1.5	1.4	1.4	1.5	1.8	2.1	2.3	2.3
SM ⁶⁰	2.9	2.9	2.6	2.2	1.7	1.5	1.3	1.4	1.5	1.7	2.2	2.7

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S7: Updated CLM-AF Monthly Leaf Area Index Profiles for Broad Leaf Deciduous Tropical Trees

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
WSD	0.6	0.6	0.5	0.6	0.7	1.1	1.6	1.9	1.9	1.6	1.0	0.7
NESD (N)	0.7	0.7	0.7	0.7	0.9	1.2	1.7	1.9	1.9	1.5	1.1	0.8
NESD (S, SH) ⁶⁰	2.1	2.0	1.9	2.2	2.3	2.1	2.0	1.8	1.5	1.4	1.8	2.1
EW	0.3	0.3	0.3	0.3	0.3	0.4	0.8	1.1	1.2	0.9	0.6	0.4
WM	1.3	1.3	1.5	1.8	2.0	2.3	2.6	2.8	2.8	2.6	2.1	1.7
WW	2.3	2.2	2.2	2.3	2.5	3.0	3.4	3.6	3.6	3.6	3.3	2.6
CW (N)	3.1	3.3	3.4	3.6	3.6	3.6	3.6	3.8	3.9	3.7	3.5	3.3
CW(S,SA)	2.9	2.9	3.0	2.7	1.8	1.3	1.0	1.1	1.6	2.1	2.7	2.9
SESD	2.6	2.7	2.7	2.7	2.3	1.9	1.8	1.6	1.5	1.6	1.9	2.4
MAD	1.9	2.1	2.1	1.7	1.2	0.8	0.7	0.7	0.7	0.7	0.8	1.3
SSD ⁶⁰	1.5	1.5	1.4	1.1	0.7	0.4	0.3	0.4	0.4	0.5	0.8	1.2
SM ⁶⁰	3.5	3.7	3.6	3.3	3.1	2.9	2.7	2.7	2.8	3.0	3.2	3.4

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S8: Updated CLM-AF Monthly Leaf Area Index Profiles for Broad Leaf Deciduous Temperate Shrub

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ED ⁶⁰	0.3	0.2	0.2	0.4	0.5	0.4	0.2	0.2	0.2	0.4	0.5	0.5
WSD ⁶⁰	0.4	0.4	0.4	0.4	0.4	0.7	1.3	1.7	1.7	1.3	0.7	0.5
NESD (N)	0.3	0.2	0.3	0.3	0.6	1.2	1.7	1.9	2.0	2.0	1.5	0.7
NESD (S)	0.4	0.4	0.4	0.9	1.2	0.7	0.5	0.4	0.4	0.9	1.1	0.8
NESD (SH) ⁶⁰	0.3	0.3	0.3	0.4	0.6	0.4	0.3	0.3	0.3	0.4	0.5	0.4
CW (S) ⁶⁰	0.5	0.6	0.7	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.4
CW (SA) ⁶⁰	0.8	1.0	1.1	1.1	0.9	0.7	0.5	0.5	0.5	0.5	0.6	0.8
SESD ⁶⁰	0.7	0.7	0.6	0.6	0.4	0.3	0.2	0.2	0.2	0.3	0.4	0.6
MAD ⁶⁰	1.0	1.1	1.1	1.0	0.8	0.6	0.5	0.4	0.4	0.4	0.5	0.7
SD ⁶⁰	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.3	0.3
SSD ⁶⁰	0.5	0.6	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.5
SM ⁶⁰	0.9	0.9	0.8	0.6	0.4	0.3	0.3	0.3	0.3	0.4	0.6	0.8

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S9: Updated CLM-AF Monthly Leaf Area Index Profiles for C3 Non-Artic Grass

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
WSD ⁶⁰	0.6	0.5	0.5	0.5	0.8	1.2	1.6	1.8	1.9	1.6	0.9	0.7
NESD (N)	0.4	0.4	0.4	0.6	0.8	0.9	1.3	1.6	1.6	1.2	0.8	0.5
NESD (S)	1.4	1.6	1.6	1.6	1.2	0.8	0.6	0.6	0.5	0.5	0.6	0.9
NESD (SH) ⁶⁰	1.0	0.9	0.8	1.2	1.3	1.0	0.8	0.9	0.9	0.9	1.2	1.2
EW	0.5	0.4	0.4	0.5	0.6	0.8	1.3	1.8	1.9	1.5	1.0	0.6
WW ⁶⁰	1.0	1.0	1.1	1.4	1.6	2.1	2.4	2.5	2.6	2.4	1.8	1.2
CW (N) ⁶⁰	1.4	1.3	1.5	2.1	2.6	2.7	2.7	2.7	2.6	2.6	2.3	1.8
CW (S)	1.8	1.8	1.8	1.8	1.7	1.3	1.1	1.2	1.5	1.8	1.9	1.9
CW (SA)	1.4	1.5	1.6	1.5	1.2	0.8	0.6	0.6	0.6	0.8	1.1	1.3
WWN ⁶⁰	0.5	0.5	0.7	1.3	2.0	2.3	2.3	2.3	2.3	2.2	1.5	0.8
CM (N) ⁶⁰	1.0	0.9	0.9	1.3	1.6	1.7	1.7	1.7	1.6	1.4	1.4	1.2
CM (S)	1.6	1.6	1.7	1.8	1.6	1.1	0.8	0.8	0.8	0.7	0.9	1.3
LVW	1.4	1.2	1.3	1.5	1.8	1.7	1.6	1.5	1.5	1.4	1.5	1.5
EM	1.5	1.6	1.6	1.5	1.2	1.0	0.8	0.7	0.7	0.7	0.9	1.2
SESD	1.6	1.6	1.6	1.3	1.0	0.7	0.6	0.5	0.6	0.6	0.8	1.3
MAD	1.3	1.6	1.6	1.5	1.1	0.9	0.7	0.6	0.6	0.6	0.8	1.0
SD ⁶⁰	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SSD	1.0	1.2	1.1	0.9	0.6	0.4	0.4	0.3	0.3	0.4	0.6	0.8
SM	1.8	1.9	1.6	1.2	0.7	0.5	0.4	0.4	0.5	0.8	1.2	1.6

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S10: Updated CLM-AF Monthly Leaf Area Index Profiles for C4 Grass

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ND ⁶⁰	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.3	0.2	0.2
WSD	0.4	0.4	0.4	0.4	0.5	0.9	1.3	1.7	1.7	1.3	0.8	0.5
NESD (N)	0.4	0.3	0.3	0.4	0.6	1.0	1.5	1.9	1.9	1.5	0.9	0.6
NESD (S)	1.2	1.0	1.0	1.3	1.4	1.2	1.1	0.9	0.8	0.9	1.2	1.3
NESD (SH) ⁶⁰	0.3	0.3	0.2	0.4	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4
EW	0.6	0.4	0.5	0.8	1.4	2.0	2.3	2.6	2.5	2.2	1.6	1.0
WM	0.5	0.6	0.6	0.9	1.2	1.5	1.8	2.0	2.0	1.9	1.2	0.7
WW	0.7	0.7	0.9	1.1	1.4	1.8	2.1	2.2	2.3	2.1	1.4	0.9
CW (N)	0.5	0.5	0.6	0.8	1.1	1.7	2.2	2.3	2.4	2.0	1.2	0.6
CW (S)	2.1	2.1	2.2	2.3	2.0	1.4	1.1	1.2	1.4	1.6	1.9	2.1
CW (SA)	1.5	1.7	1.8	1.7	1.3	0.9	0.7	0.7	0.7	0.8	1.1	1.5
WWN	0.5	0.6	0.7	1.0	1.5	1.8	2.0	2.1	2.1	2.1	1.4	0.8
CM (N)	0.6	0.6	0.6	0.9	1.4	2.0	2.3	2.5	2.2	1.7	1.1	0.7
CM (S)	1.7	1.7	1.7	1.7	1.6	1.2	1.1	0.9	0.8	0.8	1.1	1.5
LVW ⁶⁰	0.8	0.7	0.8	1.1	1.3	1.3	1.3	1.3	1.2	1.2	1.2	0.9
EM	1.9	2.1	2.2	2.2	1.8	1.3	1.0	0.8	0.7	0.7	0.8	1.2
SESD	1.8	1.9	1.9	1.6	1.1	0.8	0.7	0.6	0.6	0.6	0.8	1.4
MAD	1.5	1.6	1.6	1.3	1.0	0.7	0.6	0.6	0.6	0.6	0.7	1.1
SSD	1.1	1.2	1.1	1.0	0.7	0.5	0.4	0.4	0.4	0.4	0.6	0.9

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S11: Updated CLM-AF Monthly Leaf Area Index Profiles for Corn

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ND	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.1
WSD	0.2	0.2	0.1	0.2	0.2	0.3	0.4	0.6	0.6	0.5	0.3	0.2
NESD (N)	0.2	0.2	0.3	0.5	0.6	0.5	0.5	0.6	0.6	0.5	0.5	0.3
NESD (S, SH)	0.4	0.4	0.4	0.7	1.0	1.0	0.9	1.0	0.9	0.7	0.6	0.5
EW ⁶⁰	0.4	0.5	0.5	0.6	0.6	0.6	0.8	1.2	1.3	1.1	0.7	0.5
WM	0.6	0.6	0.7	0.9	1.1	1.4	1.7	1.8	1.9	1.7	1.3	0.9
WW	0.6	0.8	1.1	1.6	1.9	2.0	2.2	2.2	2.2	2.3	1.5	0.8
CW (N) ⁶⁰	0.9	1.0	1.2	1.7	2.3	2.6	2.7	2.6	2.6	2.5	1.8	1.1
WWN	0.7	0.8	1.0	1.3	1.7	1.9	2.0	2.1	2.1	2.0	1.6	1.0
CM (N)	0.6	0.5	0.7	1.4	2.2	2.5	2.5	2.6	2.6	2.2	1.7	1.0
CM (S)	1.6	1.4	1.4	1.7	1.9	1.4	1.0	0.9	1.1	1.5	1.8	1.8
LVW	1.1	1.0	1.1	1.5	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.2
SESD ⁶⁰	1.8	1.9	1.9	1.7	1.3	0.9	0.8	0.6	0.6	0.6	0.8	1.3
SSD	0.6	0.6	0.6	0.5	0.4	0.5	0.7	0.8	0.7	0.5	0.4	0.5
SM ⁶⁰	2.1	2.2	2.0	1.7	1.3	0.9	0.8	0.8	0.8	1.2	1.7	2.0

⁶⁰: Profile generated using 60% of grid cell threshold.

Table S12. Dinamica EGO Explanatory Variables

Type	Group	Variable	Resolution	Product Acronym	Source	
Static	Biophysical conditions	Elevation (DEM)	~ 1 km	GTOPO30	USGS	Global 30 Arc-Second Elevation (GTOPO30) Digital Object Identifier (DOI) number: /10.5066/F7DF6PQS
		Slope	~ 1 km		Derived from DEM	
		Aspect	~ 1 km		Derived from DEM	
		Bulk density	~ 1 km	BLDFIE_M_sl1	ISRIC - World Soil Information	
		Clay content	~ 1 km	CLYPPT_M_sl1	ISRIC - World Soil Information	
		Sand content	~ 1 km	SNDPPT_M_sl1	ISRIC - World Soil Information	
		Silt content	~ 1 km	SLTPPT_M_sl1	ISRIC - World Soil Information	
		Soil organic carbon content	~ 1 km	ORCDRC_M_sl1	ISRIC - World Soil Information	
	Land status	Protected areas		WDPA	UCN and UNEP	https://www.protectedplanet.net/
	Demography	Population density	~ 1 km	GPWv4	SEDAC	https://sedac.ciesin.columbia.edu/data/collection/gpw-v4
	Infrastructure	Roads		GPWv4	SEDAC	https://sedac.ciesin.columbia.edu/data/collection/gpw-v4
		Settlements			SEDAC	https://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1
Dynamic	Distance to LULC categories	Evergreen Broadleaf forest				
		Open shrublands				
		Woody savannas				
		Savannas				
		Grasslands				
		Croplands				
		Cropland/natural vegetation mosaic				
		Barren or sparsely vegetated				
		Waterbodies				

Table S13. Comparison of Noah and Satellite Derived Albedo values for MODIS-IGBP categories

MODIS-IGBP Category	Noah	Houldcroft et al. (2009)
1	12	9.2
2	12	13.9
3	14–15	10.3
4	16–17	13.3
5	17–25	11.2
6	25–30	13.4
7	22–30	16.1
8	25–30	13.1
9	20	15.5
10	19–23	16.8
11	14	10.2
12	17–23	16.5
13	15	14.9
14	18–23	15.8

Table S14. Noah-MP LAI Seasonal Profiles for each MODIS-IGBP Category

[illegible]

Table S15. Noah LAI Maximum and Minimum Values for each MODIS-IGBP Category

MODIS-IGBP Category	Min.	Max.
Evergreen Needle Leaf Forest	5.00	6.49
Evergreen Broad Leaf Forest	3.08	6.48
Deciduous Needle Leaf Forest	1.00	5.16
Deciduous Broad Leaf Forest	1.85	3.31
Mixed Forest	2.80	5.50
Closed Shrubland	0.50	3.66
Open Shrubland	0.60	2.60
Woody Savanna	0.50	3.66
Savannas	0.50	3.66
Grasslands	0.52	2.90
Permanent Wetlands	1.75	5.72
Cropland	1.56	5.68
Urban and Built	1.00	1.00
Cropland/Natural Vegetation	2.29	4.29
Mosaic		
Ice	0.01	0.01
Barren/Sparsely Vegetated	0.10	0.75
Water	0.01	0.01
Wooded Tundra	0.41	3.35
Mixed Tundra	0.41	3.35
Barren Tundra	0.41	3.35

Table S16: Annual Average Surface Radiative Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-AF

	USRS		SWDOWN		ULRS		GLW	
Transition	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion *	1.6	-	0.4	-	4.0	1.0	0.0	0.2
10 to 12	2.1	-	-0.3	-	3.3	0.0	0.0	0.0
2 to 14	11.9	-	2.3	-	19.4	10.9	0.4	1.0
8 to 14	3.1	-	0.9	-	3.5	1.2	-0.1	0.3
10 to 14	-4.4	-	-2.3	-	3.4	-1.5	0.4	-0.1
Deforestation/Degradation *	7.2	-	2.4	-	1.3	2.7	-0.4	0.1
8 to 9	4.3	-	1.2	-	3.5	1.3	-0.3	0.0
9 to 7	5.9	-	2.3	-	-0.8	1.5	-0.4	0.1
9 to 10	20.0	-	7.2	-	-7.9	8.8	-1.2	0.4
Greening *	-11.1	-	-2.2	-	4.8	-6.8	-0.2	-0.6
9 to 8	-3.4	-	0.7	-	-2.6	-1.0	-0.2	-0.4
10 to 9	-0.4	-	-4.6	-	0.3	-3.4	0.8	-0.7
16 to 7	-14.7	-	-6.0	-	20.4	-8.8	-0.1	-0.7
16 to 10	-37.9	-	-7.1	-	26.5	-23.0	-0.6	-1.5

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S17: Annual Average Surface Radiative Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah-MP

Transition	USRS		SWDOWN		ULRS		GLW	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion *	22.8	-	8.0	-	4.7	1.1	-0.9	0.0
10 to 12	-0.5	-	0.2	-	2.4	0.7	-0.1	0.1
2 to 14	25.2	-	10.6	-	13.5	6.0	-0.4	0.4
8 to 14	33.3	-	12.4	-	4.9	0.8	-1.5	-0.1
10 to 14	-0.7	-	0.4	-	0.8	0.4	-0.1	0.0
Deforestation/Degradation *	9.1	-	1.9	-	1.6	-0.1	-0.3	-0.1
8 to 9	9.7	-	2.3	-	-0.1	-0.1	-0.3	-0.1
9 to 7	-3.1	-	-2.1	-	5.6	-0.9	-0.1	-0.3
9 to 10	20.7	-	4.4	-	2.3	-0.3	-0.6	-0.1
Greening *	-6.3	-	-1.1	-	-3.7	-0.9	0.0	-0.1
9 to 8	-8.9	-	-1.9	-	-0.1	-0.1	0.1	-0.2
10 to 9	-25.2	-	-7.5	-	-3.4	-0.5	0.7	-0.4
16 to 7	-5.5	-	-1.2	-	-4.0	-0.6	0.1	0.2
16 to 10	1.6	-	0.6	-	-5.1	-1.9	-0.2	0.1

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S18: Annual Average Surface Radiative Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-D

Transition	USRS		SWDOWN		ULRS		GLW	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion *	17.4	-	6.2	-	-10.5	3.8	-0.6	0.3
10 to 12	3.3	-	1.4	-	-11.6	8.2	0.1	0.4
2 to 14	12.9	-	5.0	-	11.4	11.4	0.0	1.0
8 to 14	29.8	-	9.4	-	-15.8	1.3	-0.9	0.2
10 to 14	1.4	-	0.8	-	-6.0	4.1	-0.2	0.1
Deforestation/Degradation *	11.1	-	1.4	-	-2.6	-0.3	-0.1	-0.1
8 to 9	18.9	-	2.1	-	-6.4	-2.6	0.0	-0.3
9 to 7	-7.3	-	-3.1	-	2.2	3.0	-0.1	0.3
9 to 10	8.6	-	2.8	-	-2.0	2.1	-0.4	0.2
Greening *	-19.2	-	-3.3	-	7.9	-6.3	0.2	-0.4
9 to 8	-18.7	-	-2.6	-	4.9	1.4	-0.1	0.1
10 to 9	-2.8	-	-6.8	-	0.9	-4.3	1.0	-0.7
16 to 7	-37.5	-	-7.3	-	26.9	-11.6	1.0	-0.8
16 to 10	-21.2	-	-3.8	-	19.4	-20.8	0.1	-1.4

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S19: Annual Average Surface Radiative Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah

Transition	USRS		SWDOWN		ULRS		GLW	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion *	-10.3	-	-2.2	-	0.5	-1.2	0.3	0.1
10 to 12	-3.5	-	-1.1	-	1.4	-0.2	0.1	0.1
2 to 14	37.3	-	11.9	-	-1.6	-2.0	-0.5	-0.1
8 to 14	-32.2	-	-7.6	-	-1.1	-1.9	0.7	0.3
10 to 14	-2.1	-	-1.1	-	0.8	-0.4	0.2	0.1
Deforestation/Degradation *	-12.4	-	-2.3	-	-0.4	-0.5	0.3	0.1
8 to 9	-35.0	-	-6.7	-	-1.6	-0.9	0.8	0.1
9 to 7	29.0	-	5.2	-	2.5	1.1	-0.7	0.1
9 to 10	4.0	-	0.2	-	1.1	-0.2	0.0	0.1
Greening *	-18.0	-	-2.6	-	3.7	0.4	0.3	-0.1
9 to 8	34.8	-	5.6	-	2.5	0.9	-0.4	0.2
10 to 9	-5.4	-	-1.7	-	-1.2	0.2	0.3	0.2
16 to 7	-59.2	-	-8.0	-	7.6	-0.2	0.9	-0.5
16 to 10	-82.8	-	-12.7	-	5.7	-0.7	1.4	-0.7

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S20: Annual Average Surface Heat Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-AF

Transition	HFX		LH		GRDFLX	
	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	0.6	1.2	-9.0	1.1	4.0	-3.8
10 to 12	0.9	0.4	-6.0	0.4	2.1	-2.1
2 to 14	0.4	9.7	-61.0	8.7	31.1	-30.1
8 to 14	-1.4	1.6	-8.7	0.9	3.8	-3.7
10 to 14	10.0	-1.0	-4.3	-0.4	-1.3	1.1
Deforestation/Degradation*	-6.7	2.2	-8.3	0.7	5.3	-5.1
8 to 9	-4.7	1.6	-6.4	0.4	3.7	-3.6
9 to 7	-14.7	2.6	-10.1	0.8	7.5	-7.1
9 to 10	-9.3	2.4	-4.2	0.4	4.6	-4.3
Greening*	8.4	-3.8	13.3	-1.4	-9.0	8.7
9 to 8	3.0	-1.8	7.4	-0.6	-3.4	3.2
10 to 9	13.8	-4.3	-0.1	-1.3	-9.8	8.8
16 to 7	10.0	-2.8	4.7	-0.3	-6.1	5.8
16 to 10	27.3	-3.9	10.3	-0.5	-11.9	11.8

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S21: Annual Average Surface Heat Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah-MP

Transition	HFX		LH		GRDFLX	
	Day	Night	Day	Night	Day	Night
Agricultural Expansion *	-20.1	1.9	-3.3	0.0	3.0	-2.9
10 to 12	-3.6	0.6	1.0	-0.4	0.9	-0.8
2 to 14	-4.2	6.6	-38.6	1.9	14.0	-13.8
8 to 14	-30.8	2.2	0.6	-0.1	3.0	-3.0
10 to 14	-2.1	0.2	1.8	-0.2	0.4	-0.4
Deforestation/Degradation *	-7.6	0.9	-2.3	-0.1	0.8	-0.8
8 to 9	-7.6	0.3	-0.2	0.0	0.3	-0.3
9 to 7	-2.2	1.9	-3.6	-0.1	1.1	-1.1
9 to 10	-19.1	-1.0	-0.2	1.0	1.1	-1.1
Greening *	1.5	-1.3	9.4	0.0	-2.0	2.0
9 to 8	6.5	-0.4	0.7	0.1	-0.2	0.2
10 to 9	24.6	-1.8	-0.7	0.0	-2.2	1.9
16 to 7	2.2	-0.7	7.8	0.1	-1.4	1.4
16 to 10	-2.9	-1.3	10.2	0.3	-3.1	2.9

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S22: Annual Average Surface Heat Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-D

Transition	HFX		LH		GRDFLX	
	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	-8.8	1.9	-8.1	0.2	3.9	-3.8
10 to 12	0.0	0.4	-3.1	-1.2	0.3	-0.3
2 to 14	-3.2	12.3	-63.0	6.2	31.9	-30.7
8 to 14	-12.1	0.2	-2.8	-0.5	-0.5	0.5
10 to 14	0.8	0.1	-0.5	-0.8	-0.3	0.3
Deforestation/Degradation*	-4.5	0.3	-2.9	0.0	0.3	-0.4
8 to 9	-1.9	-2.0	-0.1	-0.6	-4.7	4.4
9 to 7	-6.0	1.9	0.5	0.2	3.3	-3.3
9 to 10	-14.0	3.2	-2.3	0.2	6.0	-5.7
Greening*	7.8	-3.2	16.6	-0.7	-7.6	7.4
9 to 8	-0.7	1.6	5.1	0.8	3.8	-3.5
10 to 9	16.8	-5.0	-1.1	-1.0	-11.5	10.4
16 to 7	24.7	-4.9	13.6	0.1	-10.1	9.8
16 to 10	13.3	-4.0	17.5	-0.8	-13.7	13.5

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S23: Annual Average Surface Heat Flux Change (W m^{-2}) in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah

Transition	HFX		LH		GRDFLX	
	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	5.4	-0.7	5.5	-1.0	3.1	-3.0
10 to 12	-0.8	0.4	2.3	-0.2	0.2	-0.2
2 to 14	-0.4	1.2	-21.2	-2.0	2.8	-2.7
8 to 14	11.9	-2.0	20.1	-1.4	5.8	-5.7
10 to 14	-2.3	0.5	3.0	-0.2	0.3	-0.3
Deforestation/Degradation*	9.3	-1.1	3.7	-0.5	2.2	-2.2
8 to 9	23.9	-2.9	11.4	-0.8	4.7	-4.6
9 to 7	-23.2	2.8	-7.8	0.2	-4.0	3.9
9 to 10	-3.8	-0.1	-0.2	-0.4	0.8	-0.8
Greening*	12.2	-1.0	0.0	0.2	0.2	-0.3
9 to 8	-16.6	2.8	-19.7	0.7	-4.3	4.2
10 to 9	6.2	0.1	-1.7	0.4	-0.7	0.6
16 to 7	42.5	-3.4	5.9	-0.6	3.8	-3.9
16 to 10	57.6	-7.8	16.6	-0.4	8.2	-8.3

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S24: Annual Average Near Surface Temperature Profile Change in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-AF

Transition	TSK (°C)		T2 (°C)		TATM (10^{-1} °C)		TGSATM (10^{-2} °C m ⁻¹)	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	0.7	0.1	0.0	0.3	0.1	0.7	2.2	0.0
10 to 12	0.7	0.0	0.1	0.2	0.2	0.2	2.1	-0.3
2 to 14	3.1	1.8	0.4	2.3	1.8	6.3	9.6	2.0
8 to 14	0.5	0.2	0.0	0.3	-0.1	0.5	1.8	0.3
10 to 14	0.8	-0.3	0.1	0.0	0.7	-0.2	2.5	-0.9
Deforestation/Degradation*	0.0	0.5	0.0	0.4	-0.2	1.4	0.2	0.8
8 to 9	0.5	0.2	0.0	0.3	-0.2	0.8	1.9	0.1
9 to 7	-1.9	1.9	-0.1	0.8	-0.2	4.0	-6.4	4.0
9 to 10	-0.4	0.3	-0.1	0.3	-0.7	0.7	-1.1	0.5
Greening*	1.1	-1.4	-0.1	-0.7	-1.3	-2.5	4.6	-3.1
9 to 8	-0.4	-0.2	0.0	-0.2	0.2	-0.4	-1.5	-0.2
10 to 9	0.5	-0.6	0.1	-0.6	0.7	-2.5	1.4	-0.3
16 to 7	4.0	-2.0	-0.3	-0.5	-3.7	-2.9	16.2	-5.0
16 to 10	4.8	-4.8	-0.1	-1.4	-2.8	-6.1	17.8	-12.4

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S25: Annual Average Near Surface Temperature Profile Change in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah-MP

Transition	TSK (°C)		T2 (°C)		TATM (10 ⁻¹ °C)		TGSATM (10 ⁻² °C m ⁻¹)	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	0.7	0.2	0.0	0.2	-1.3	0.9	3.3	0.1
10 to 12	0.4	0.1	0.2	0.1	0.0	0.7	1.4	0.1
2 to 14	2.2	1.0	0.3	0.9	0.5	4.1	7.4	0.8
8 to 14	0.8	0.1	-0.2	0.2	-2.2	0.5	3.9	0.1
10 to 14	0.1	0.1	0.1	0.1	-0.1	0.2	0.5	0.1
Deforestation/Degradation*	0.3	0.0	-0.1	0.0	-0.6	-0.1	1.3	0.0
8 to 9	0.0	0.0	-0.1	0.0	-0.6	-0.1	0.3	0.0
9 to 7	0.9	-0.1	-0.2	0.1	-0.5	-0.5	3.3	-0.2
9 to 10	0.3	-0.1	-0.1	0.0	-1.2	-0.1	1.9	-0.1
Greening*	-0.6	-0.2	-0.1	-0.2	-0.1	-0.1	-2.0	-0.5
9 to 8	0.0	0.0	0.0	0.0	0.3	-0.1	-0.2	0.1
10 to 9	-0.5	-0.1	0.2	-0.2	0.1	-0.1	-2.6	0.2
16 to 7	-0.6	-0.1	-0.1	-0.1	-0.1	0.9	-2.2	-1.1
16 to 10	-0.8	-0.3	-0.1	-0.3	-0.4	0.8	-2.5	-1.7

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S26: Annual Average Near Surface Temperature Profile Change in WRF Grid Cells that experience LULCCs between 2001 and 2015 with CLM-D

Transition	TSK (°C)		T2 (°C)		TATM (10^{-1} °C)		TGSATM (10^{-2} °C m ⁻¹)	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	-2.0	0.8	-0.1	0.3	-0.5	1.5	-6.6	1.7
10 to 12	-2.4	1.8	0.1	0.2	1.6	2.4	-9.3	4.7
2 to 14	1.3	1.9	0.4	2.3	1.2	6.4	3.9	2.3
8 to 14	-2.7	0.3	-0.2	-0.1	-1.3	0.3	-8.3	0.8
10 to 14	-1.3	0.9	0.0	0.1	-0.1	0.8	-4.3	2.7
Deforestation/Degradation*	-0.4	-0.1	0.0	0.0	-0.3	-0.2	-1.0	-0.1
8 to 9	-0.7	-0.5	0.0	-0.4	-0.2	-1.3	-2.3	-0.7
9 to 7	0.0	0.6	-0.1	0.4	-1.3	0.9	0.8	1.5
9 to 10	-0.6	0.3	-0.1	0.3	-1.1	0.9	-1.5	0.6
Greening*	1.6	-1.3	0.0	-0.6	-0.2	-2.6	5.4	-2.7
9 to 8	0.5	0.3	0.0	0.2	-0.5	0.1	2.1	0.7
10 to 9	0.7	-0.7	0.1	-0.7	0.9	-2.9	1.7	-0.5
16 to 7	5.3	-2.5	0.2	-0.9	0.8	-0.4	17.4	-6.1
16 to 10	3.6	-4.2	0.0	-1.6	-0.4	-5.6	12.3	-10.8

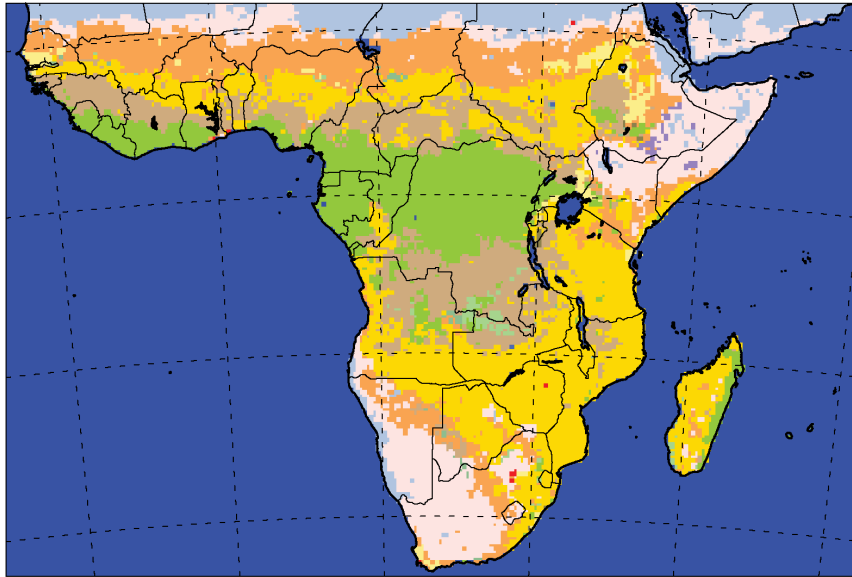
*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

Table S27: Annual Average Near Surface Temperature Profile Change in WRF Grid Cells that experience LULCCs between 2001 and 2015 with Noah

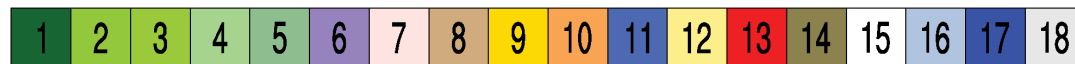
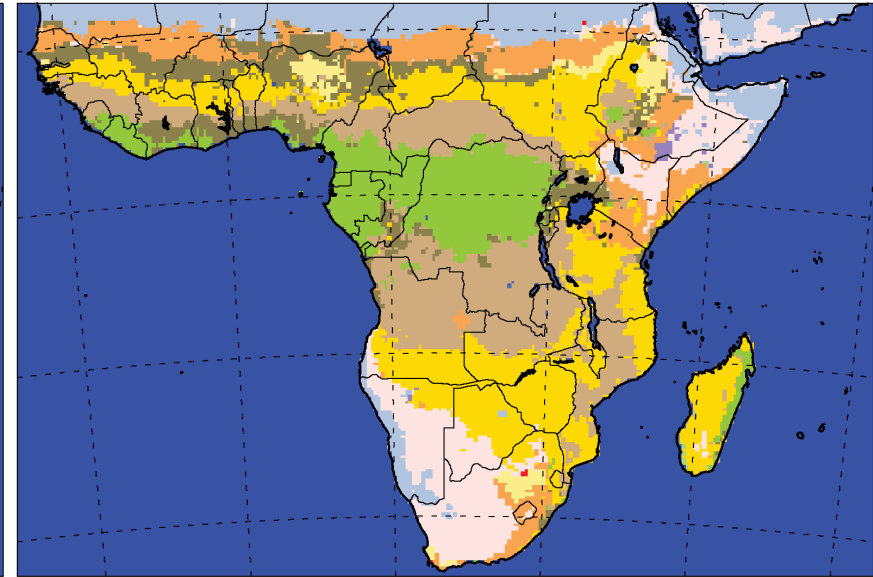
Transition	TSK (°C)		T2 (°C)		TATM (10^{-1} °C)		TGSATM (10^{-2} °C m ⁻¹)	
	Day	Night	Day	Night	Day	Night	Day	Night
Agricultural Expansion*	-0.2	-0.4	0.1	-0.3	0.1	-1.1	-0.7	-0.5
10 to 12	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.3	-0.4
2 to 14	-0.3	-0.4	-0.3	-0.3	-0.2	-0.7	-0.7	-0.8
8 to 14	-0.5	-0.5	0.3	-0.5	0.3	-2.0	-1.9	-0.4
10 to 14	0.0	-0.2	-0.1	-0.1	-0.2	-0.1	0.1	-0.5
Deforestation/Degradation*	-0.1	-0.1	0.2	-0.1	0.5	-0.3	-0.6	-0.1
8 to 9	-0.1	-0.1	0.5	-0.1	1.2	-0.8	-1.2	0.3
9 to 7	0.1	0.0	-0.5	0.1	-0.8	1.2	0.9	-0.7
9 to 10	-0.1	-0.2	-0.1	-0.1	-0.3	-0.3	-0.2	-0.4
Greening*	0.3	-0.1	0.2	-0.1	0.9	-0.5	0.4	-0.1
9 to 8	0.3	0.1	-0.3	0.1	-0.6	0.6	1.4	-0.2
10 to 9	0.2	0.3	0.1	0.2	0.4	0.9	0.4	0.3
16 to 7	0.5	-0.5	0.5	-0.5	2.6	-1.7	0.0	-0.7
16 to 10	0.2	-0.5	0.8	-0.6	3.1	-3.1	-1.3	0.2

*: Shows average difference for a broad class of LULCC followed by the average difference in the major MODIS LULC transitions that comprise that class. MODIS Land Use Categories: 2 – Evergreen Broad Leaf Forest; 7 – Open Shrublands; 8 – Woody Savanna; 9 – Savannas; 10 – Grasslands; 12 – Croplands; 14 – Cropland/Natural Mosaic; 16 – Barren/ Sparsely Vegetated.

WRF Default MODIS Land Use



LU01 MODIS Land Use



- | | | | | | |
|------------------------|-----------------------|-------------------|-----------------------|-----------------------|------------------------|
| 1 Evergreen Needleleaf | 4 Deciduous Broadleaf | 7 Open Shrublands | 10 Grasslands | 13 Urban and Built-up | 16 Bare Soil and Rocks |
| 2 Evergreen Broadleaf | 5 Mixed Forest | 8 Woody Savannas | 11 Permanent Wetlands | 14 Cropland Moasi | 17 Water Bodies |
| 3 Deciduous Needleleaf | 6 Closed Shrublands | 9 Savannas | 12 Croplands | 15 Snow and Ice | 18 Tundra |

Fig S1. Comparison of the default WRF LULC dataset used in the meteorological evaluation simulations and the 2001 MODIS LULC dataset used in the LU01 simulations



Fig S2. Regions used to model LULCC in Africa

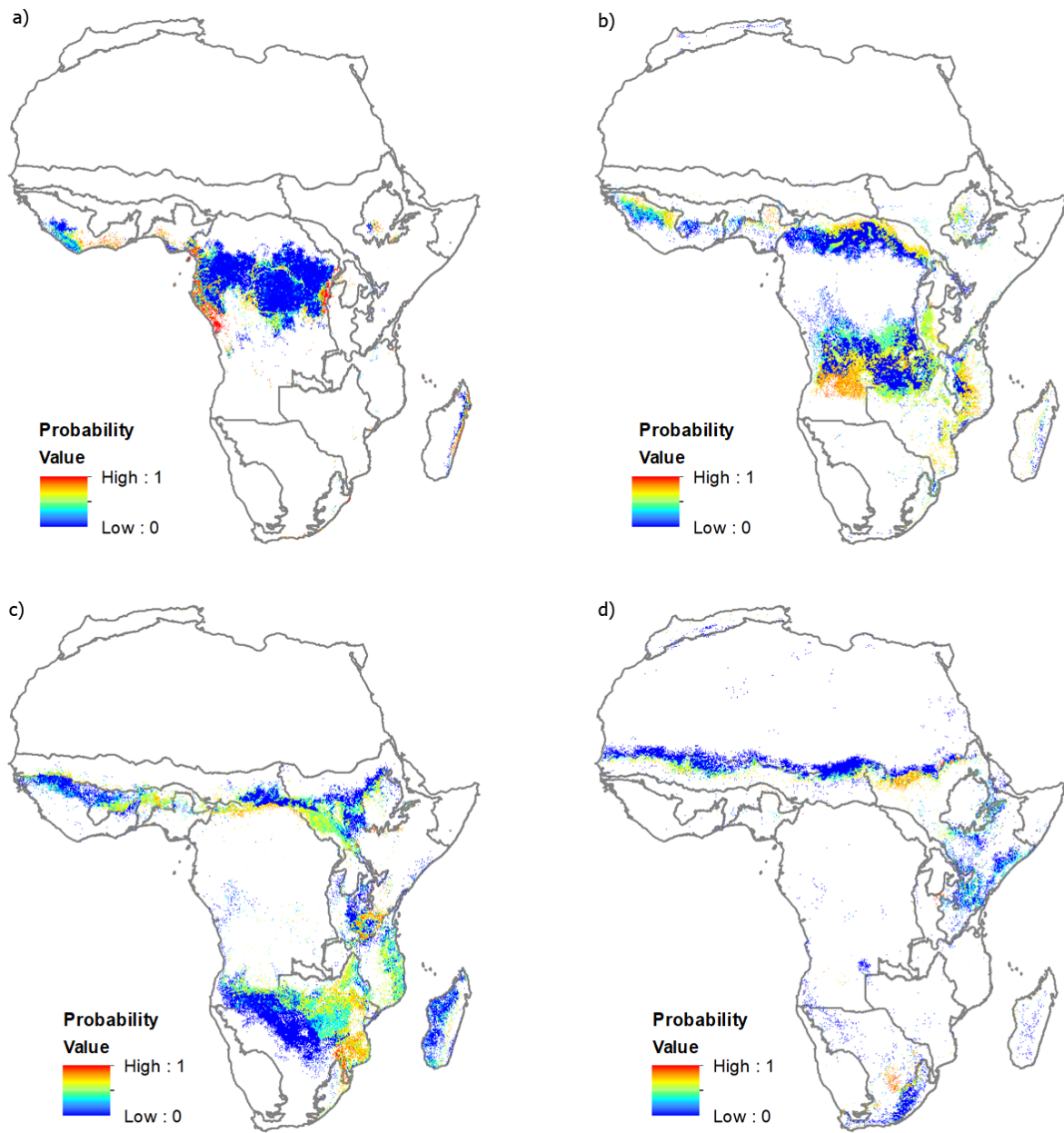


Fig S3. Probability maps for transitions a) Evergreen broadleaf forest to Cropland/Natural vegetation mosaic, b) Woody savannas to savannas, c) Savannas to woody savannas, and d) Grasslands to croplands.

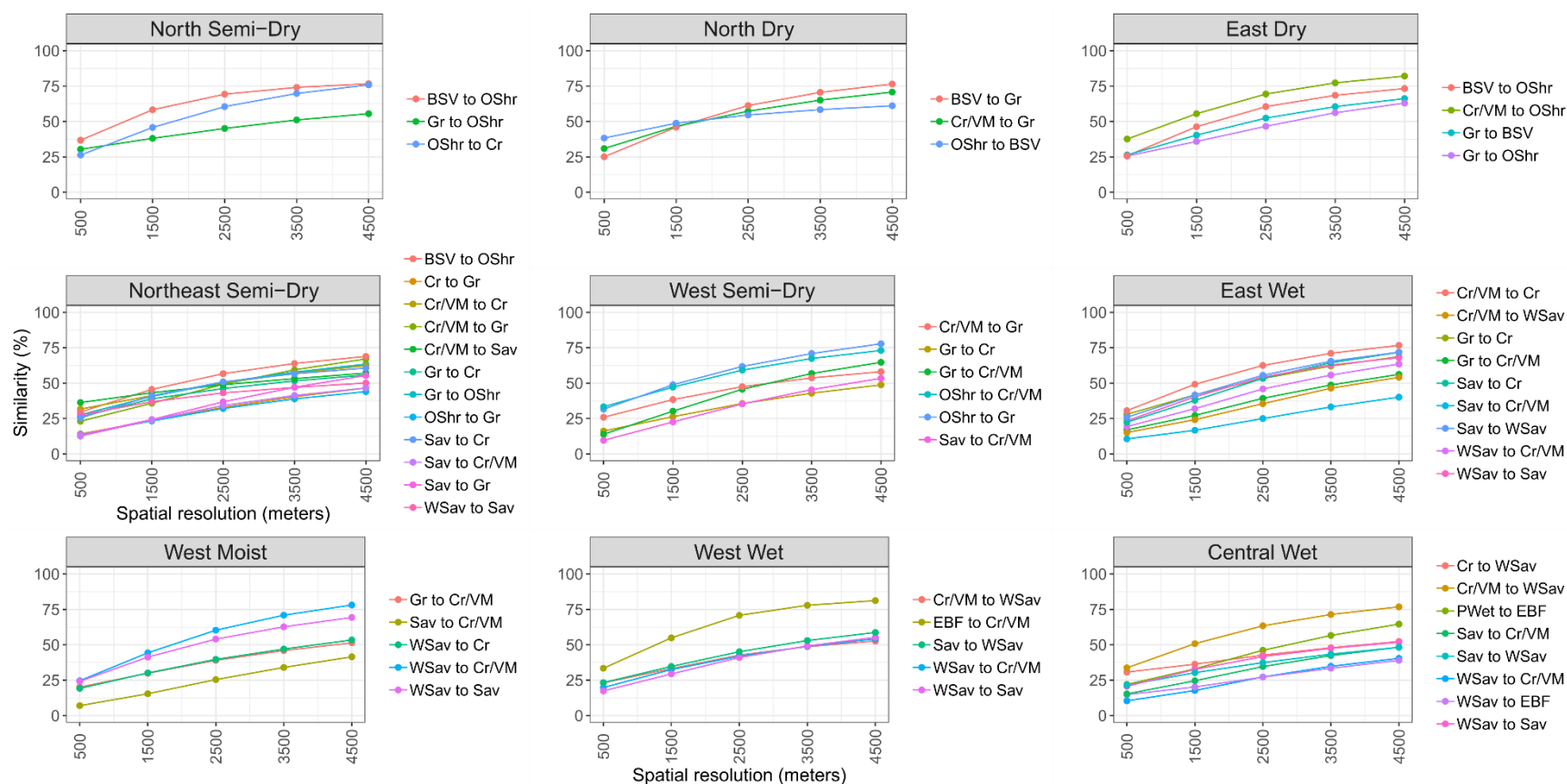


Fig S4 Part 1. Fuzzy similarity index between real and simulated changes for each transition by region.

Acronyms: EBF = Evergreen Broadleaf forest, MF = Mixed forest, CShr = Closed shrublands, OShr = Open shrublands, WSav = Woody savannas, Sav = Savannas, Gr = Grasslands, PWet = Permanent wetlands, Cr = Croplands, Cr/VM = Cropland/Natural vegetation mosaic, BSV = Barren or sparsely vegetated.

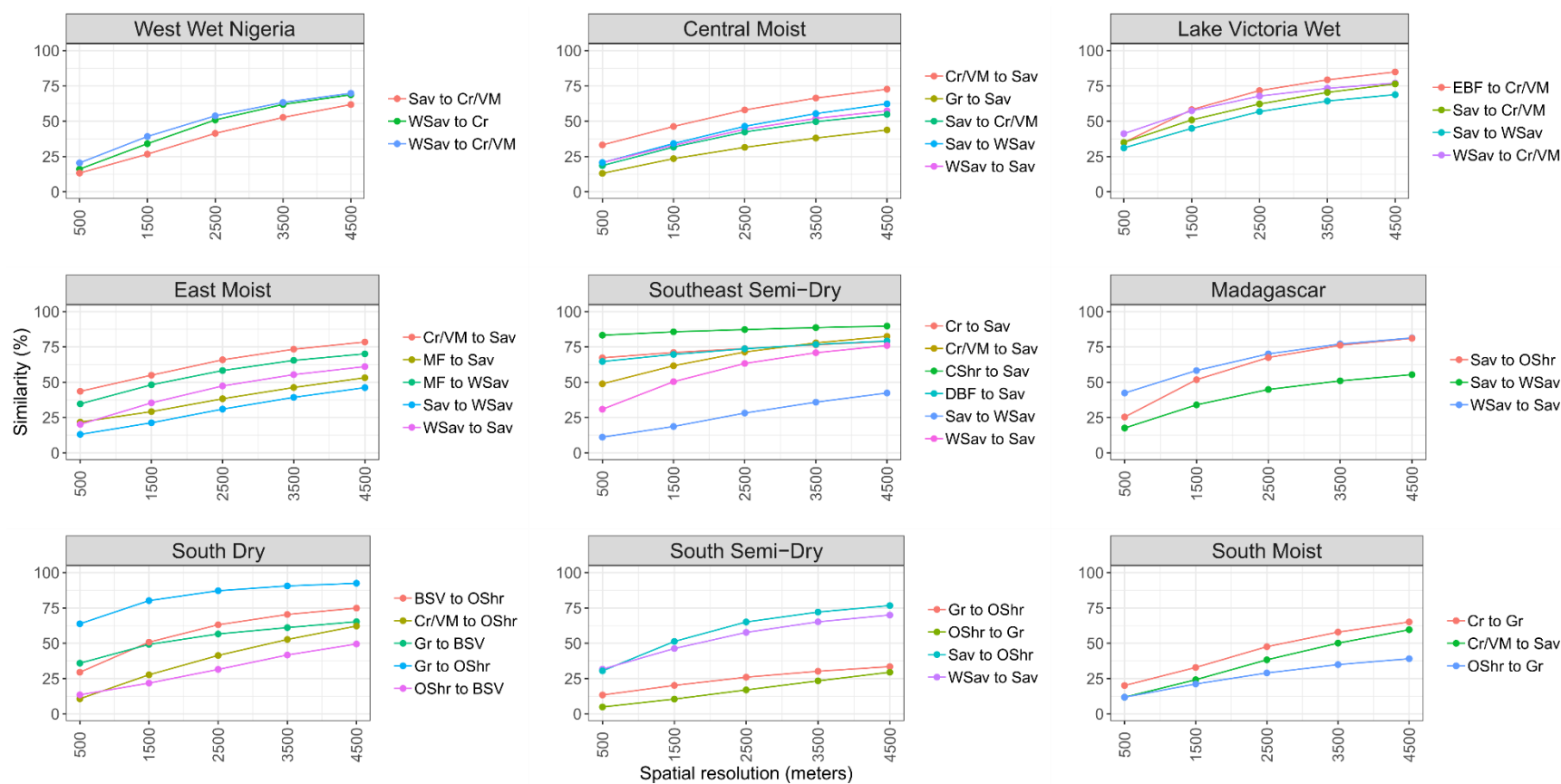


Fig S4 Part 2. Fuzzy similarity index between real and simulated changes for each transition by region.

Acronyms: EBF = Evergreen Broadleaf forest, MF = Mixed forest, CShr = Closed shrublands, OShr = Open shrublands, WSav = Woody savannas, Sav = Savannas, Gr = Grasslands, PWet = Permanent wetlands, Cr = Croplands, Cr/VM = Cropland/Natural vegetation mosaic, BSV = Barren or sparsely vegetated.

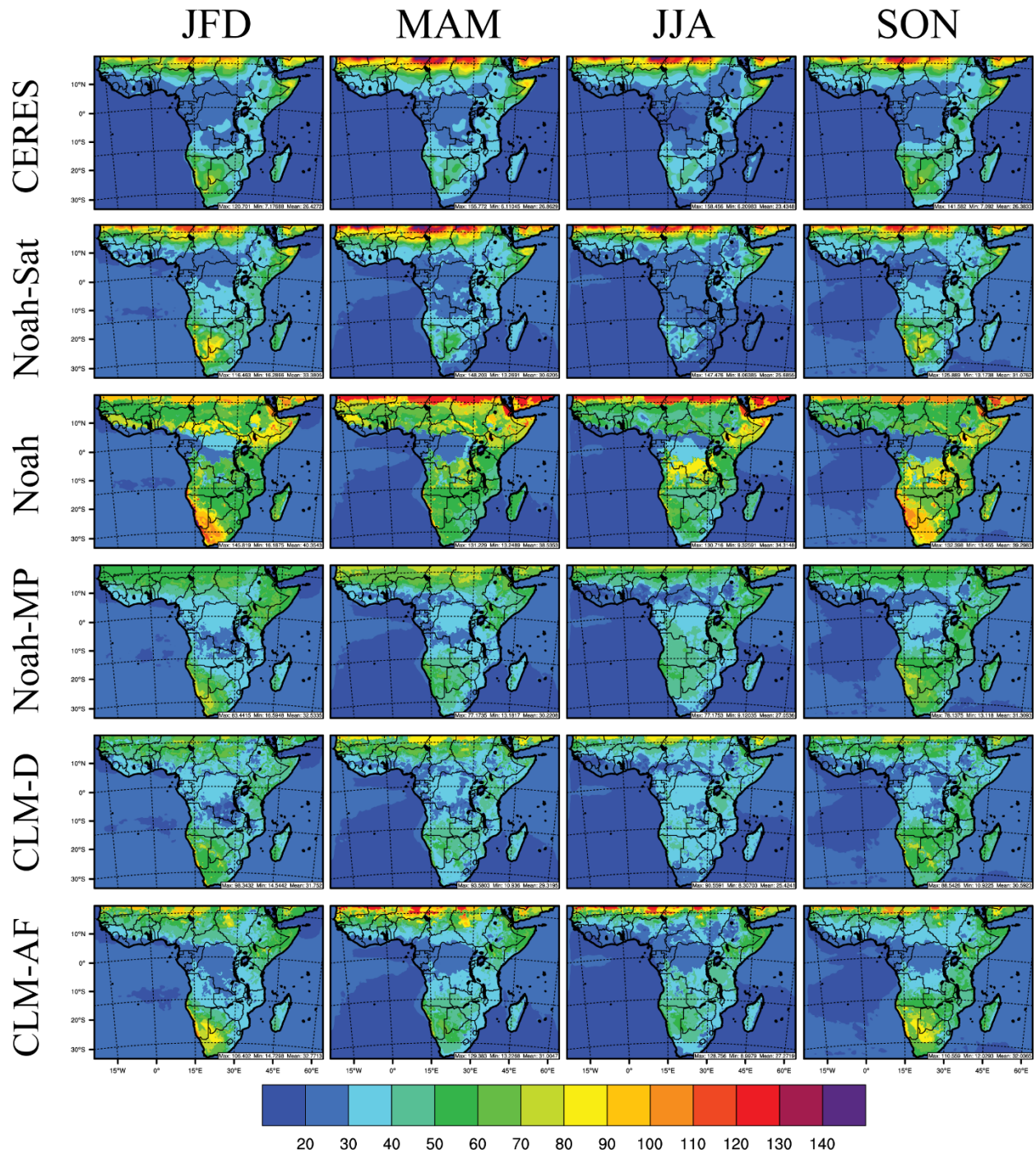


Fig S5: 2013 seasonal average upwelling shortwave radiation at the Earth's surface (W m^{-2}) for CERES-EBAF estimates and WRF

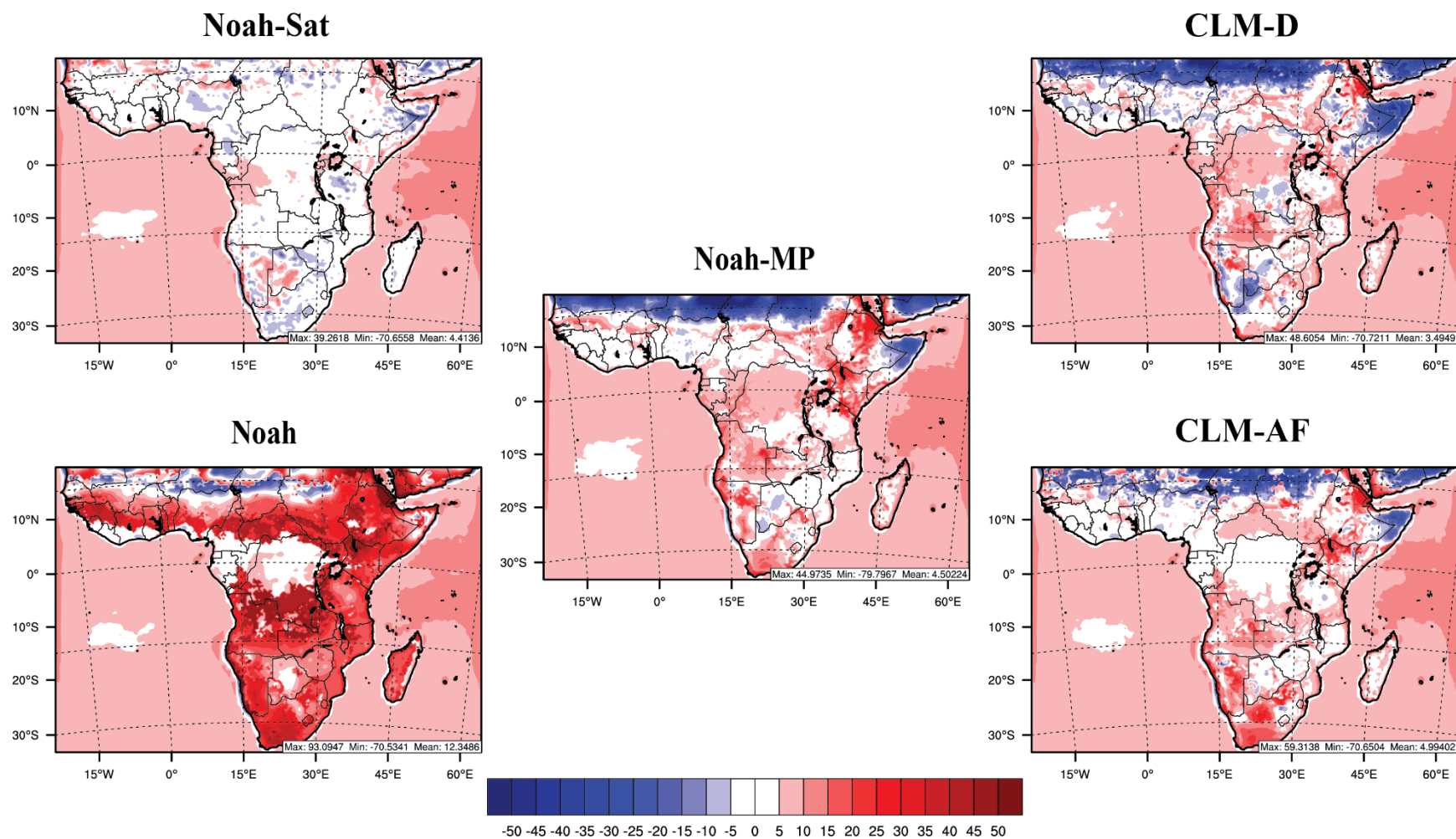


Fig S6: 2013 annual average differences in upwelling shortwave radiation at the Earth's surface (W m^{-2}) between the WRF simulations and CERES-EBAF estimates (WRF - CERES-EBAF)

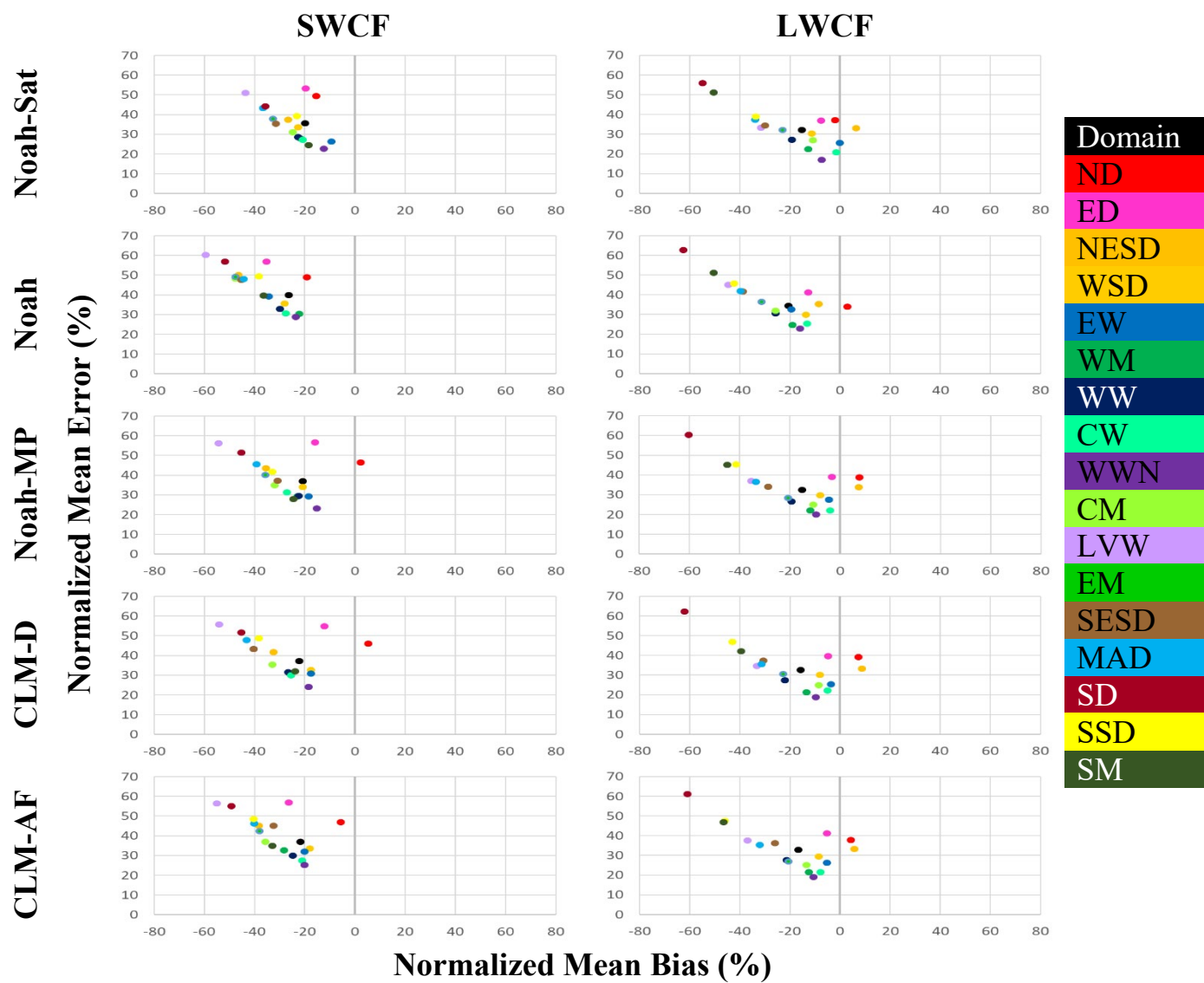


Fig S7 Soccer plot of domain and regional WRF SWCF and LWCF model performance statistics versus CERES-EBAF estimates

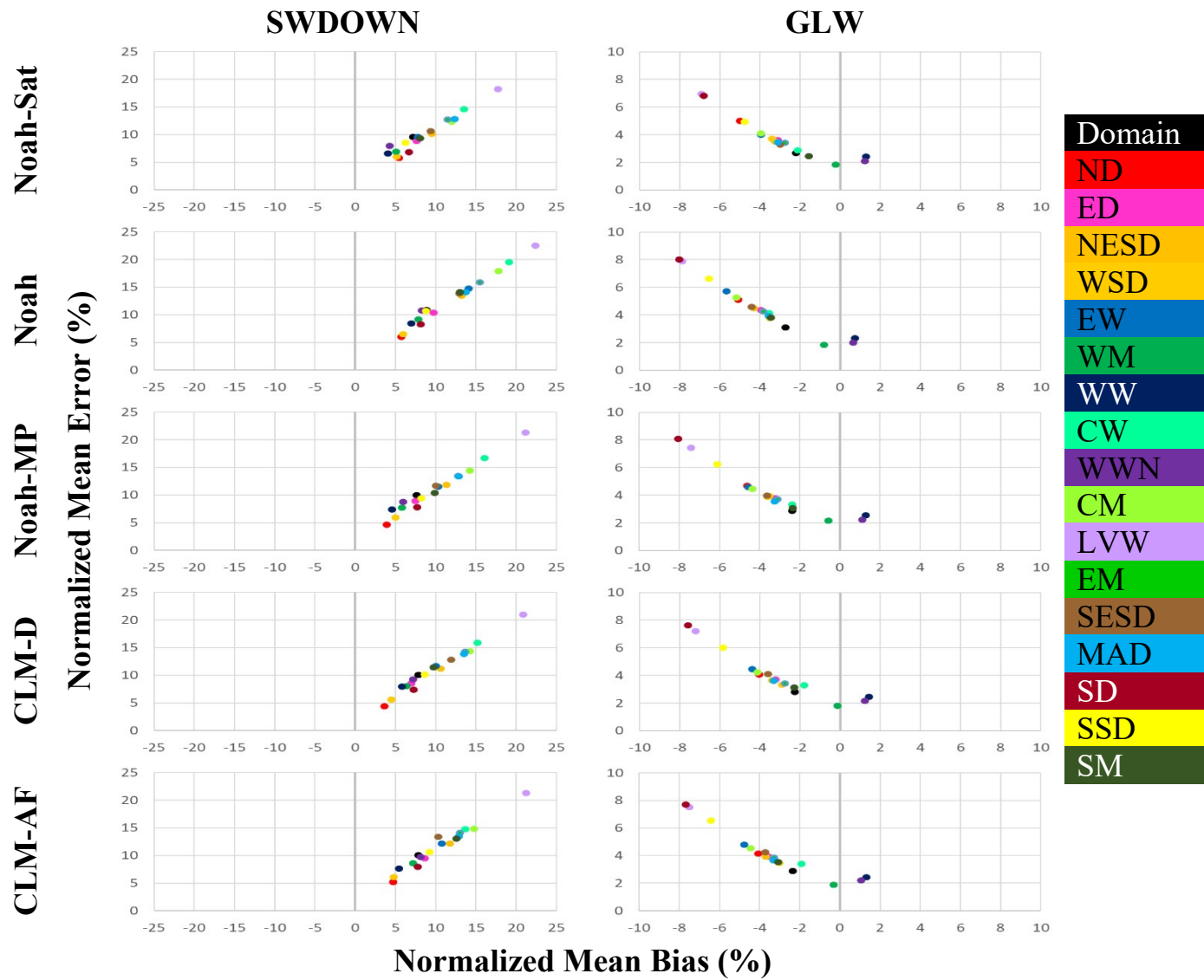


Fig S8: Soccer plot of domain and regional WRF SWDOWN and GLW model performance statistics versus CERES-EBAF estimates

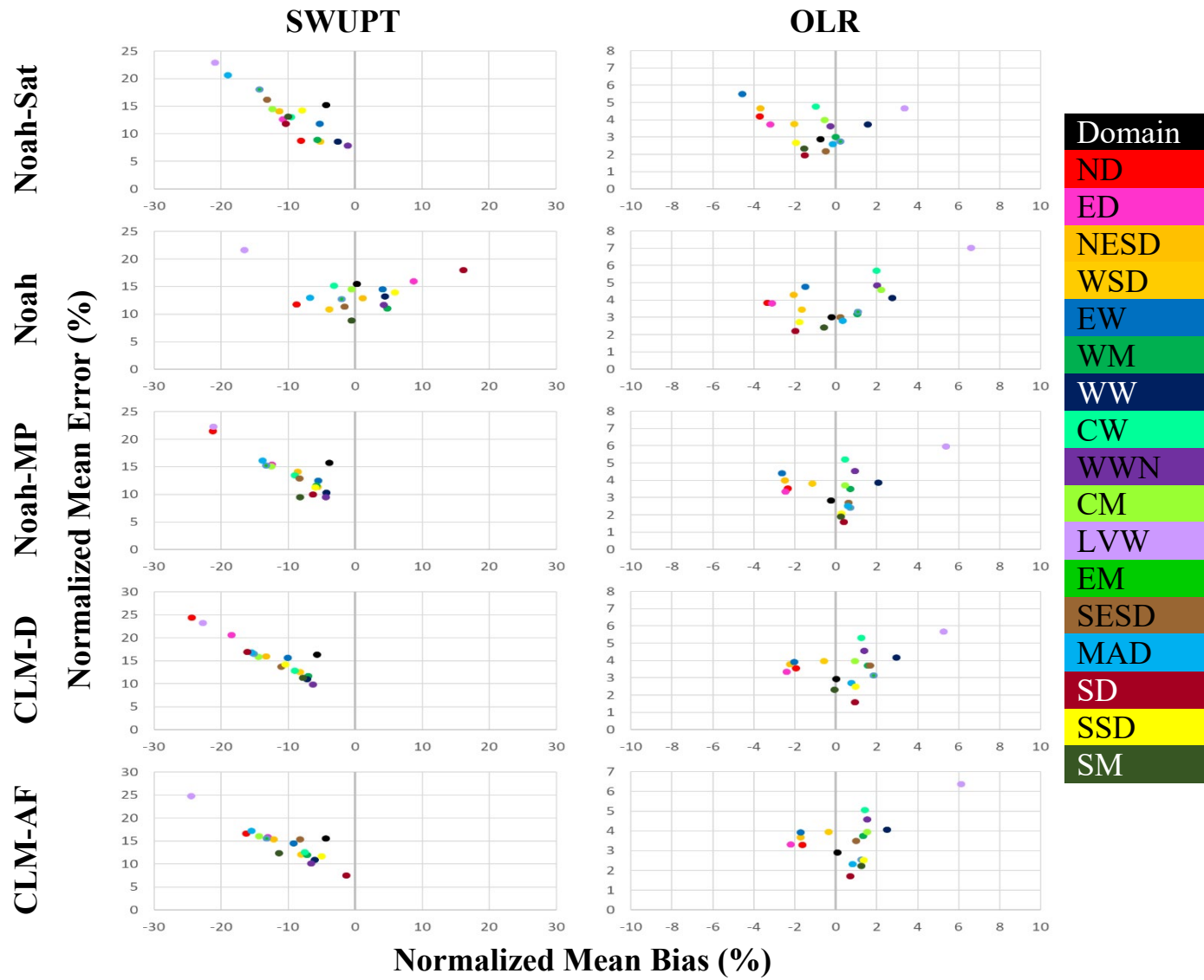


Fig S9: Soccer plot of domain and regional WRF SWUPT and OLR model performance statistics versus CERES-EBAF estimate

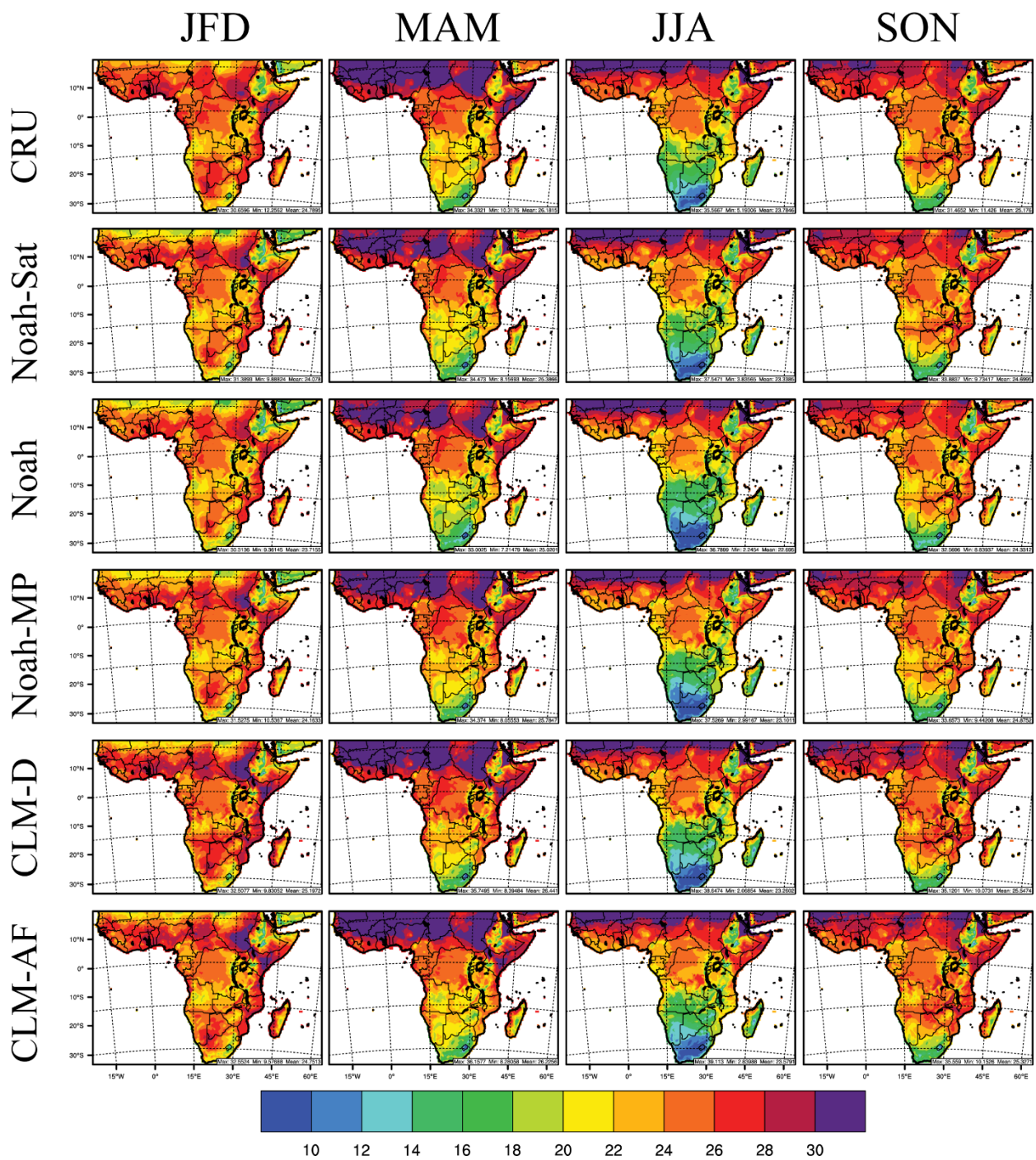


Fig S10: 2013 seasonal average 2-m temperature (°C) for CRU estimates and WRF

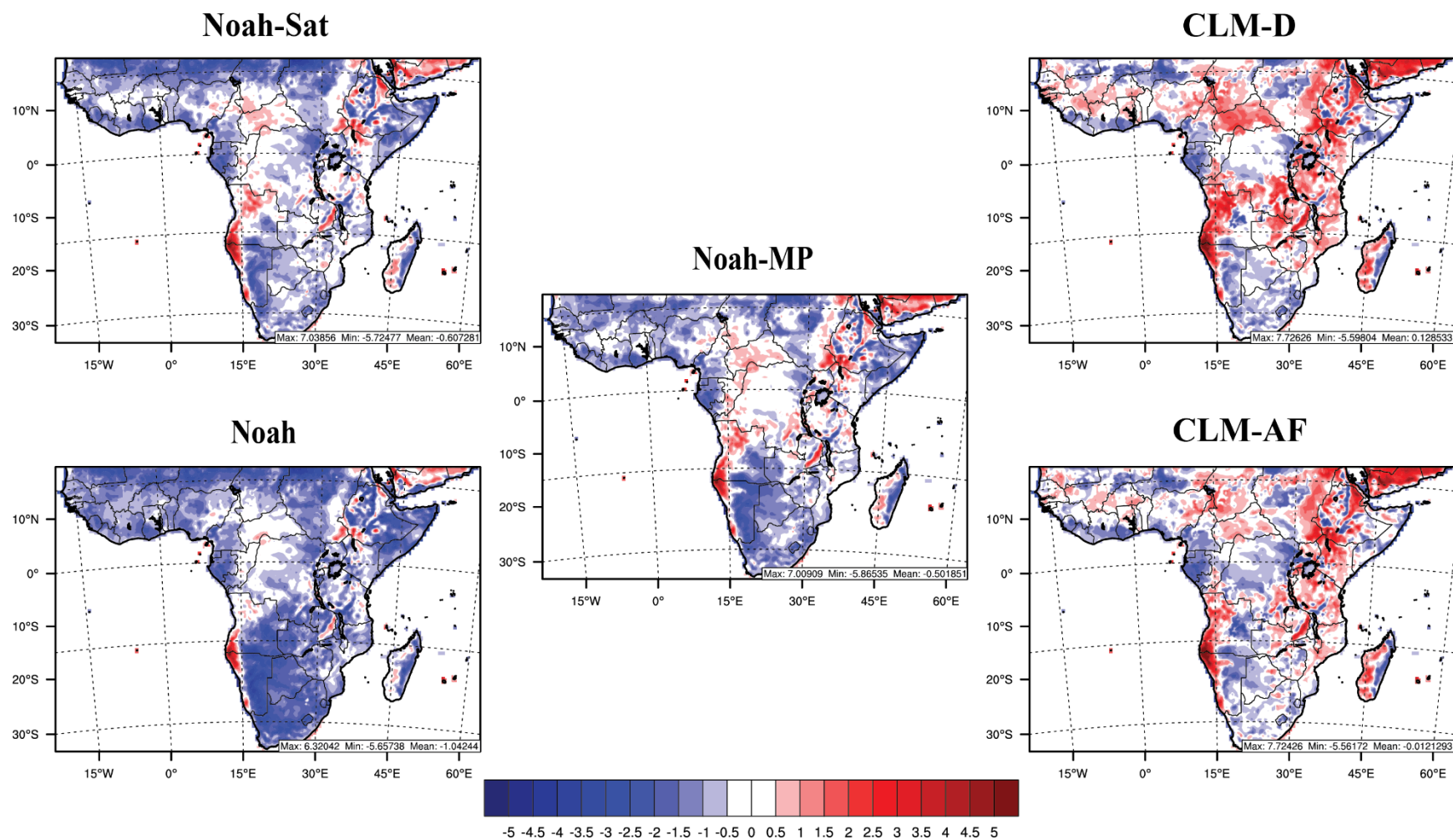


Fig S11: 2013 annual average differences in 2-m temperature (°C) between the WRF simulations and CRU estimates (WRF - CRU)

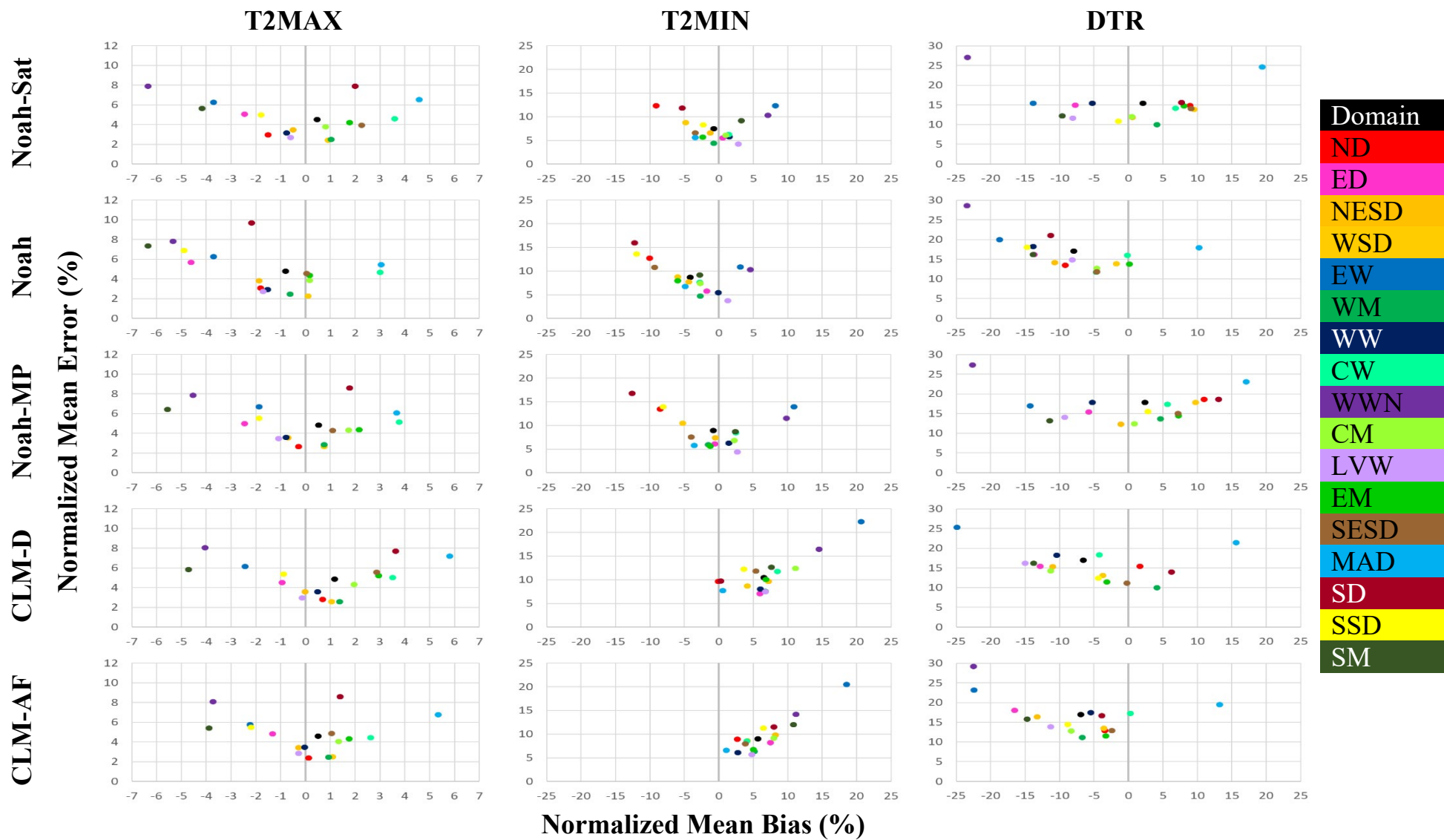


Fig S12. Soccer plots of domain and regional WRF annual average daily maximum 2-m temperature, daily minimum 2-m temperature, and diurnal temperature range compared to CRU estimates from the five WRF LSM configuration

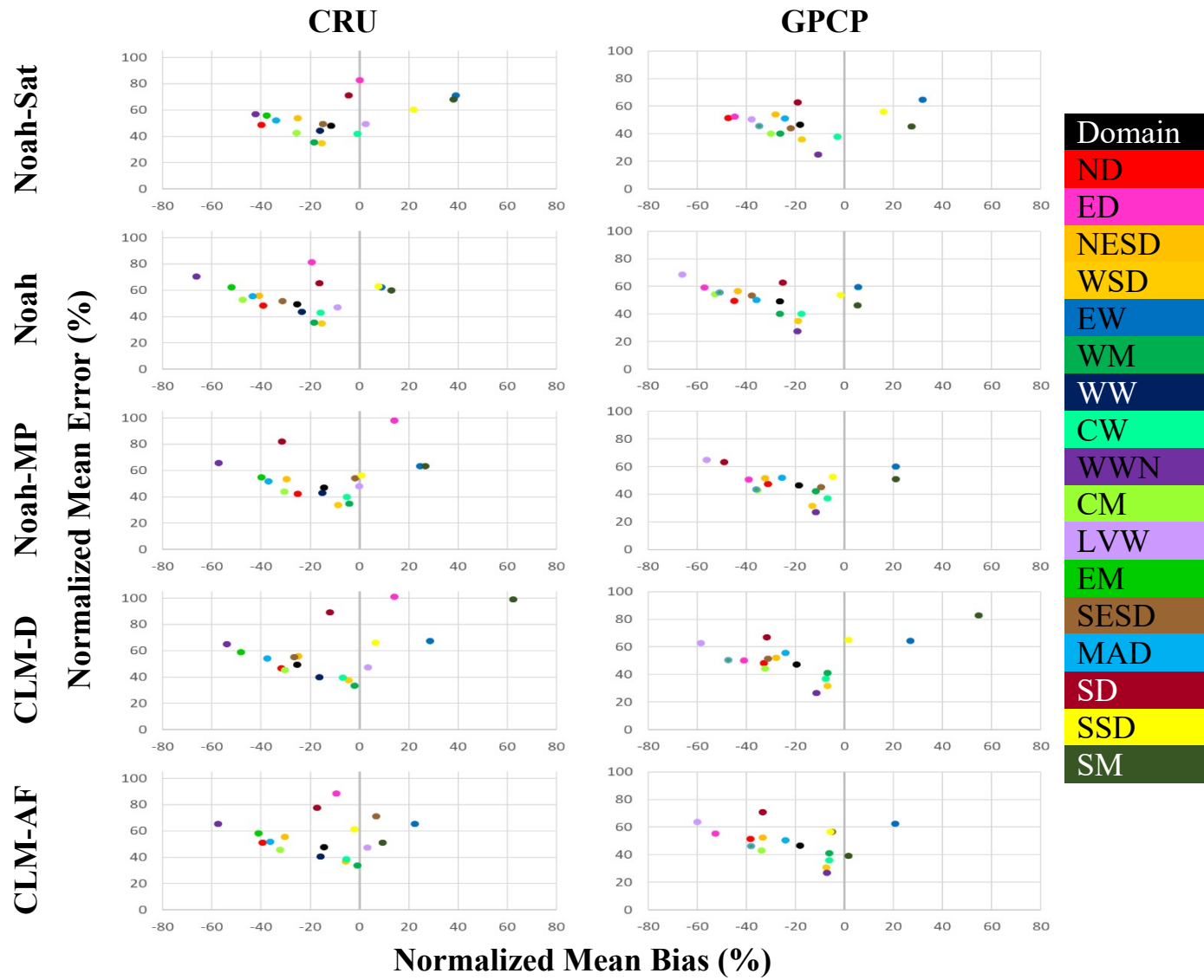


Fig S13: Soccer plot of domain and regional WRF precipitation model performance statistics versus CRU and GPCP estimates

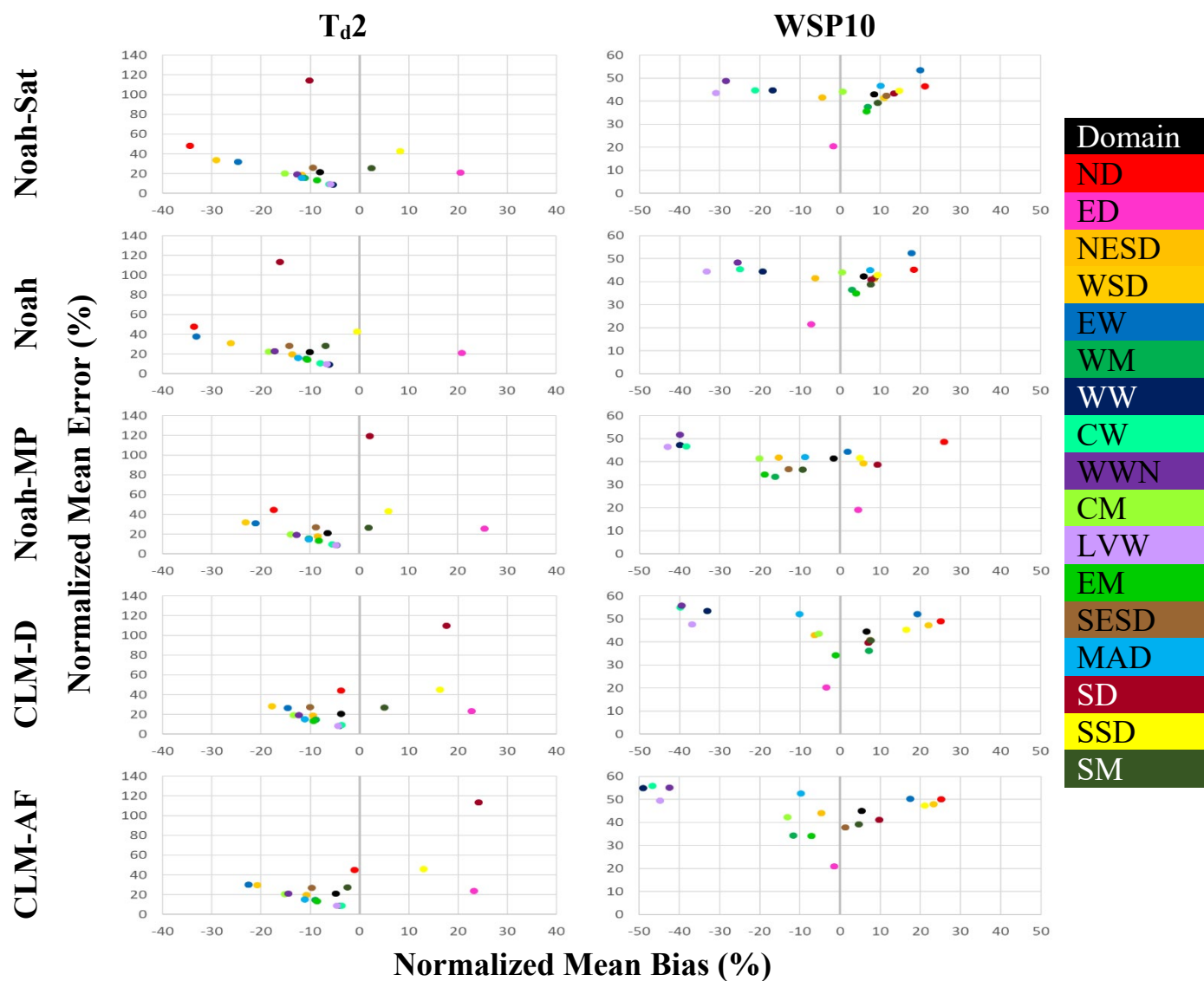


Fig S14: Soccer plot of domain and regional model performance statistics of WRF 2-m dew point temperature and 10-m wind speed versus NCEI-ISD observations

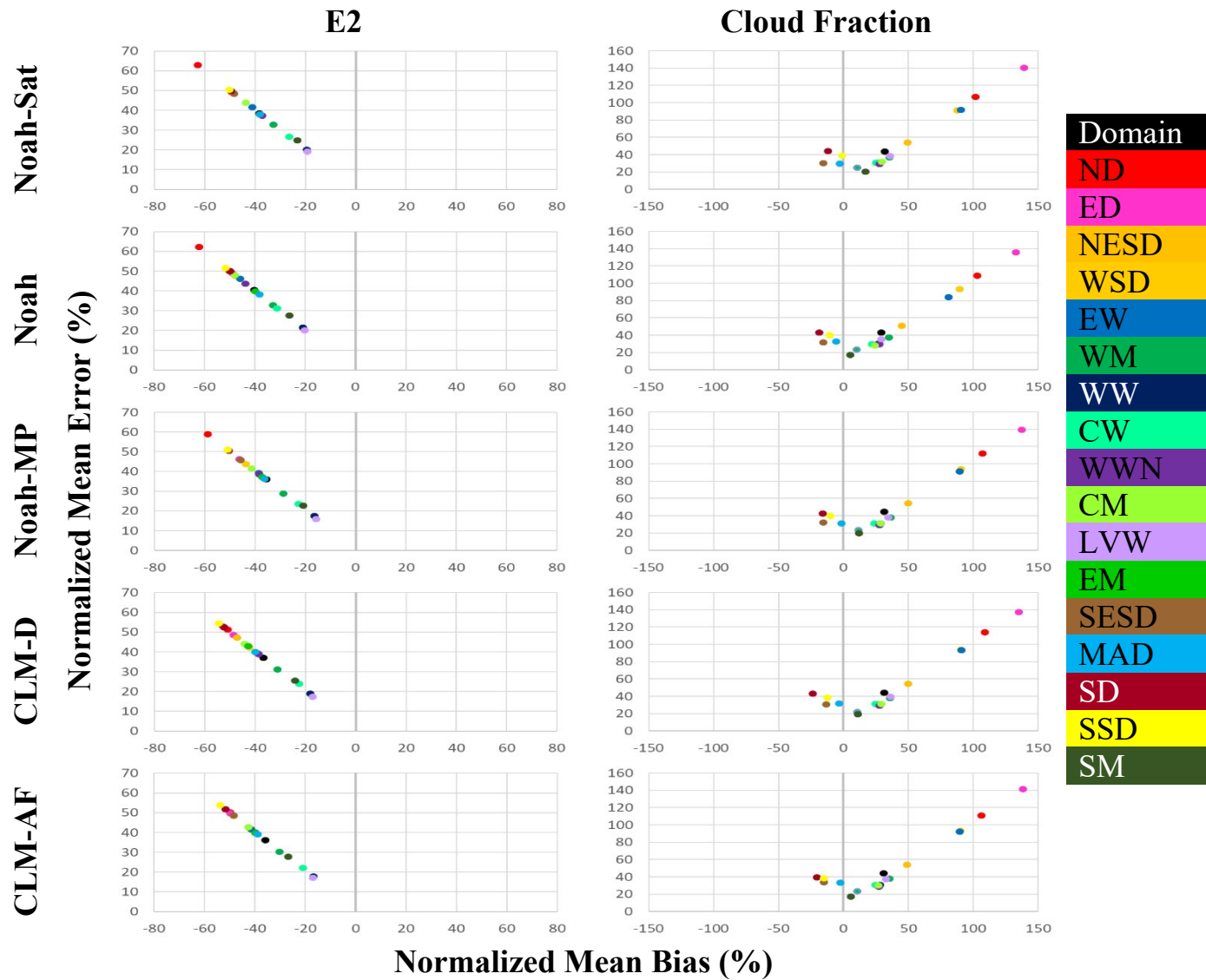


Fig S15: Soccer plot of domain and regional model performance statistics of WRF 2-m vapor pressure and cloud fraction speed versus CRU estimates

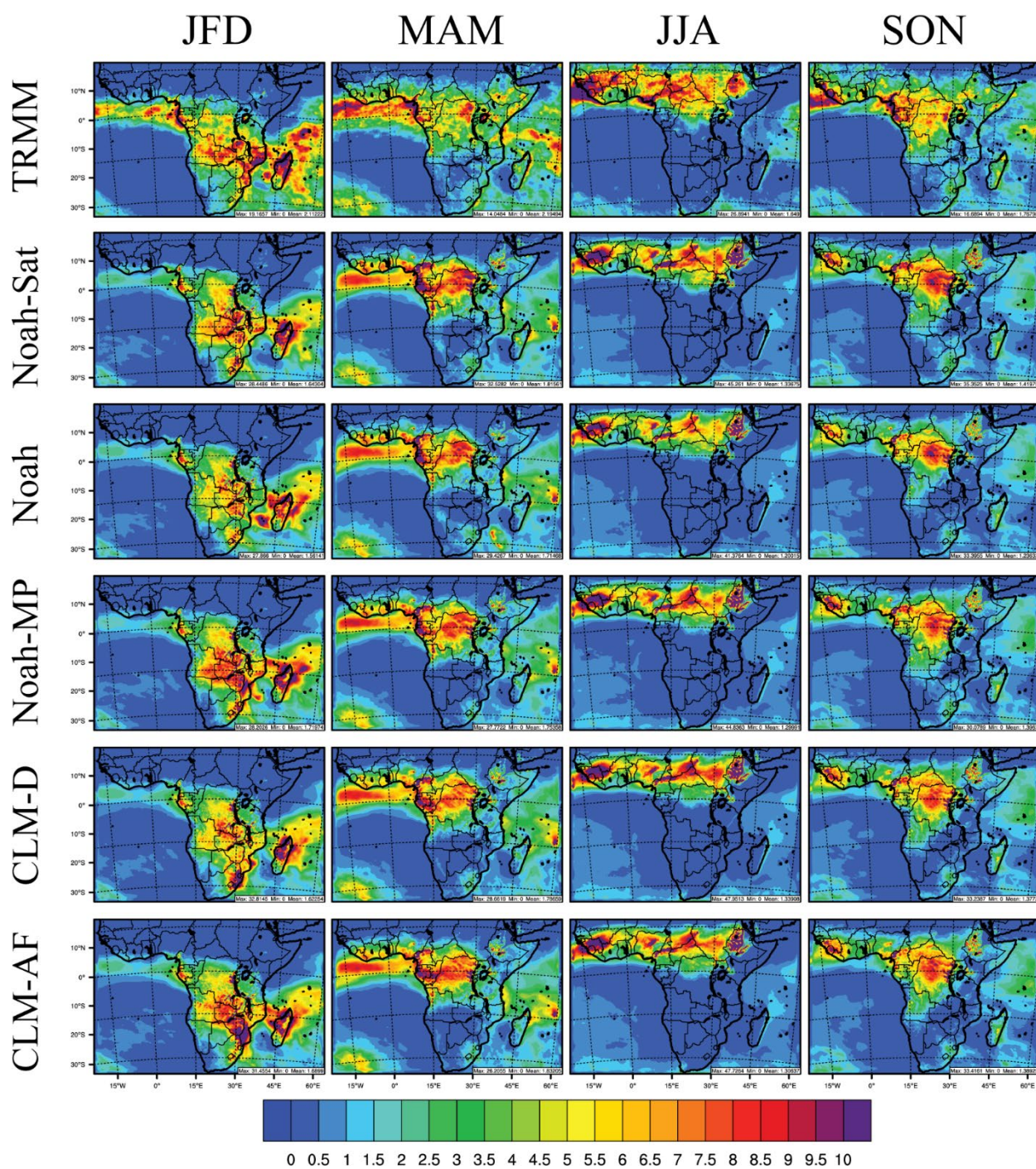


Fig S16: 2013 seasonal average precipitation (mm day⁻¹) for TRMM estimates and WRF

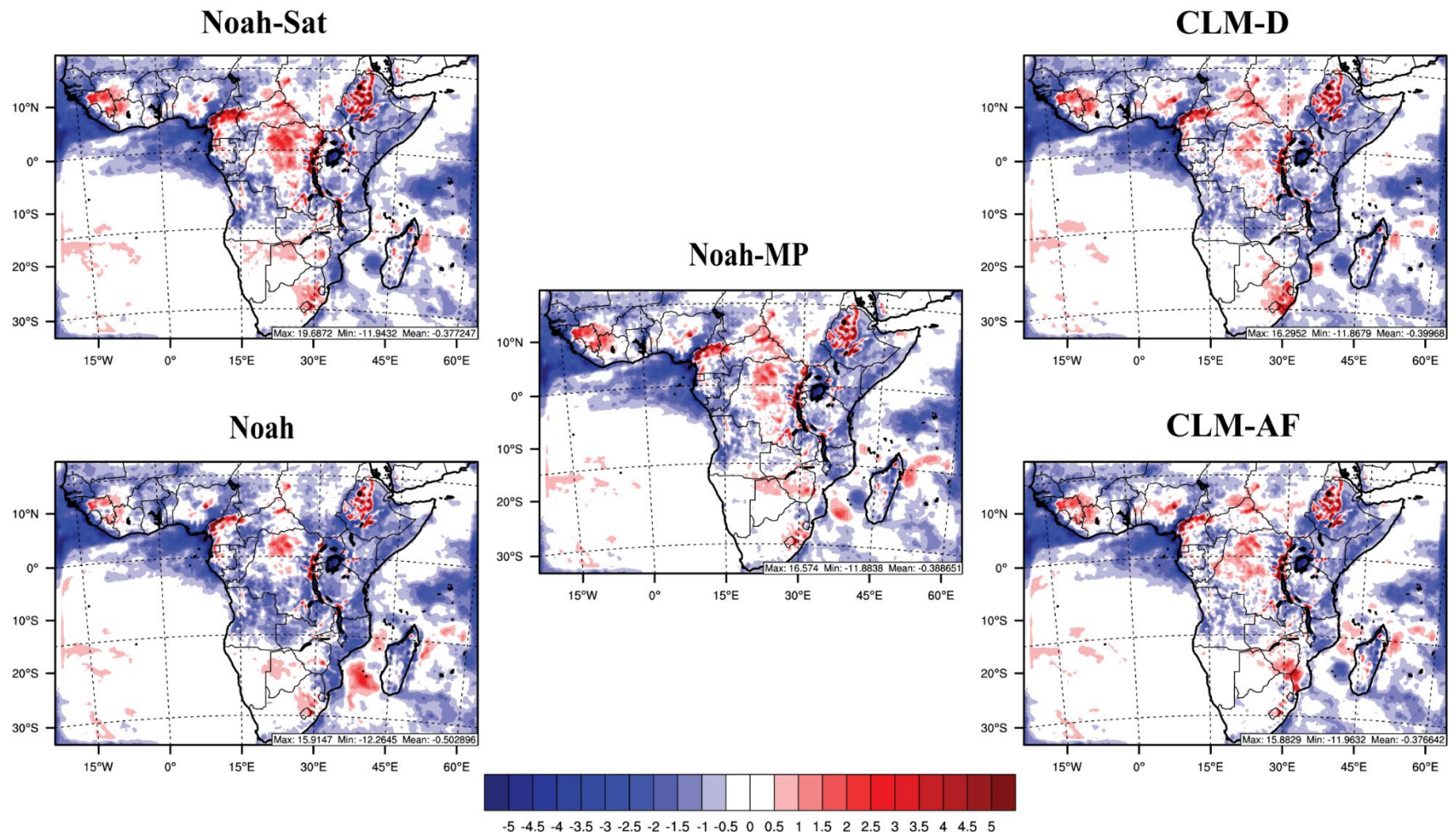


Fig S17: 2013 annual average differences in precipitation (mm day⁻¹) between the WRF simulations and TRMM estimates (WRF - TRMM)

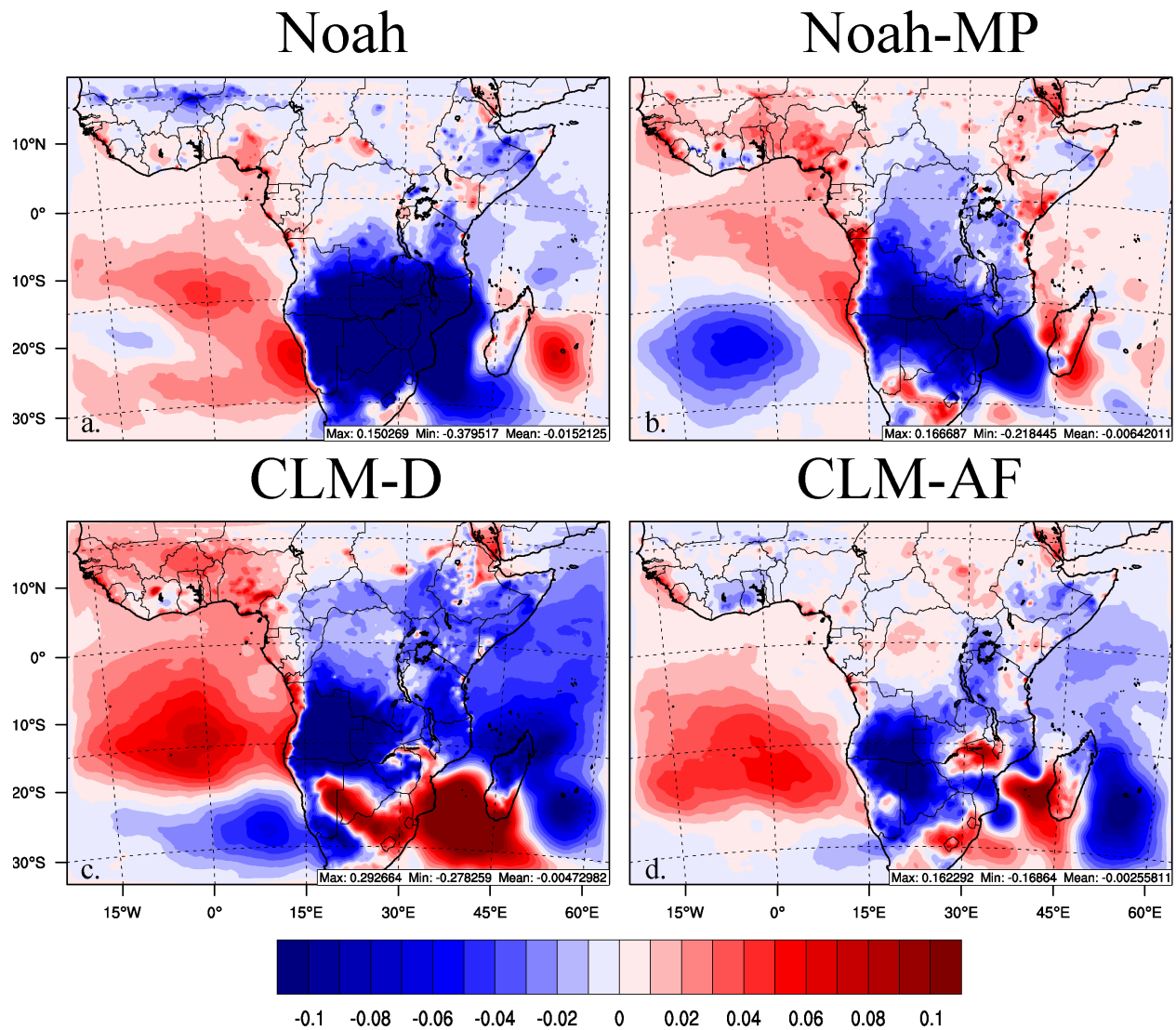


Fig S18. Differences in average DJF sea level pressure (hPa) between the dynamic and 2001 LULC simulations using (a) Noah, (b) Noah-MP, (c) CLM-D, and (d) CLM-AF

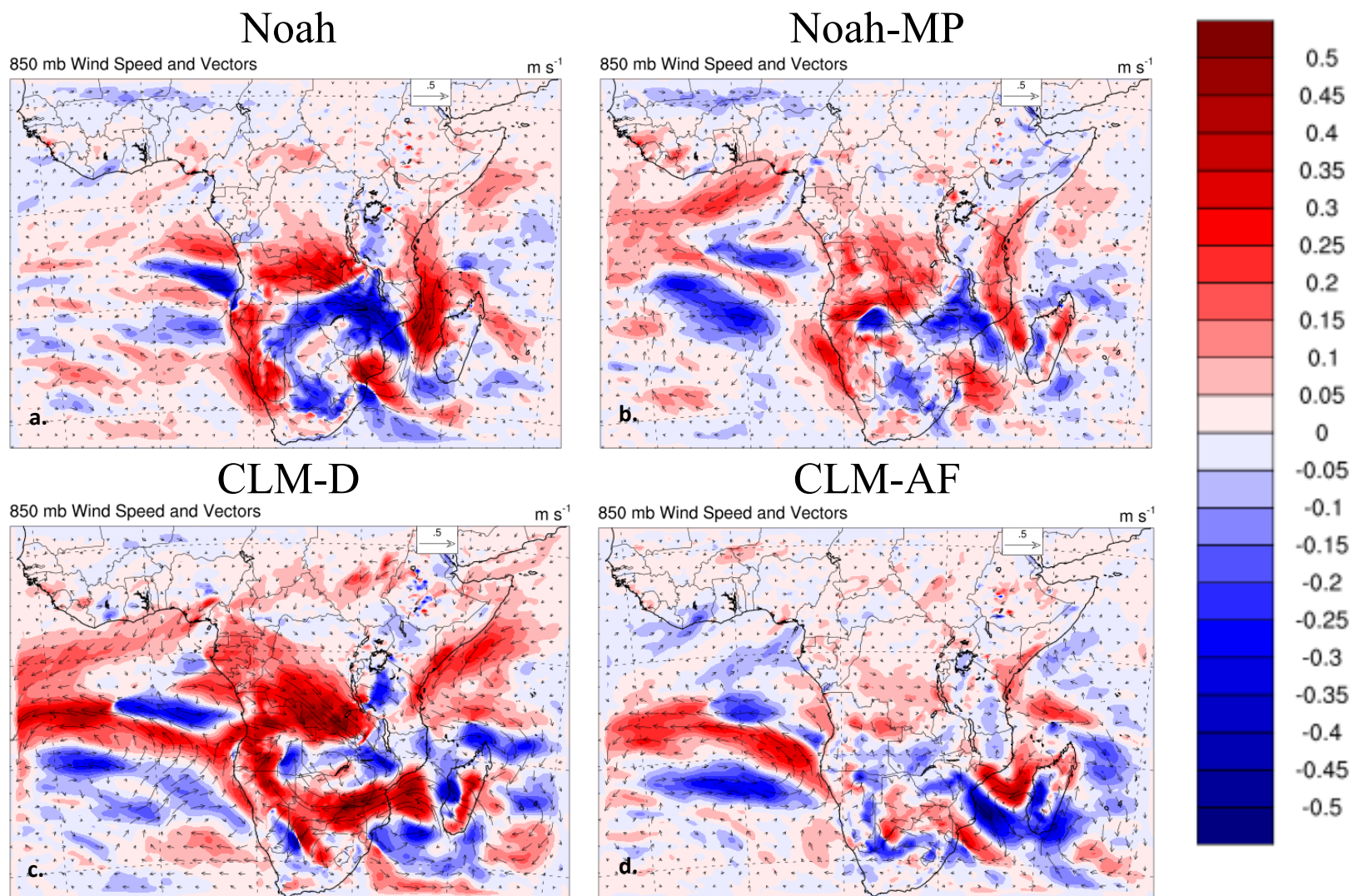


Fig S19. Differences in average DJF 850 mb wind vectors and wind speed (m s^{-1}) between the dynamic and 2001 LULC simulations using (a) Noah, (b) Noah-MP, (c) CLM-D, and (d) CLM-AF