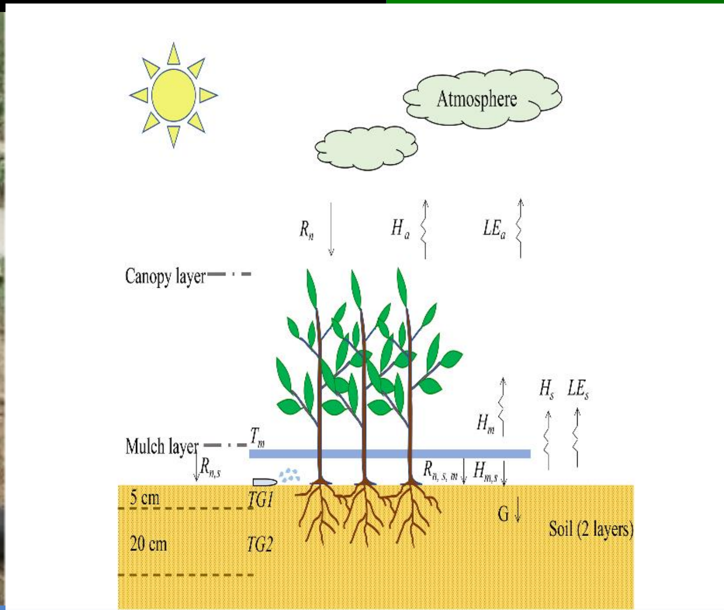


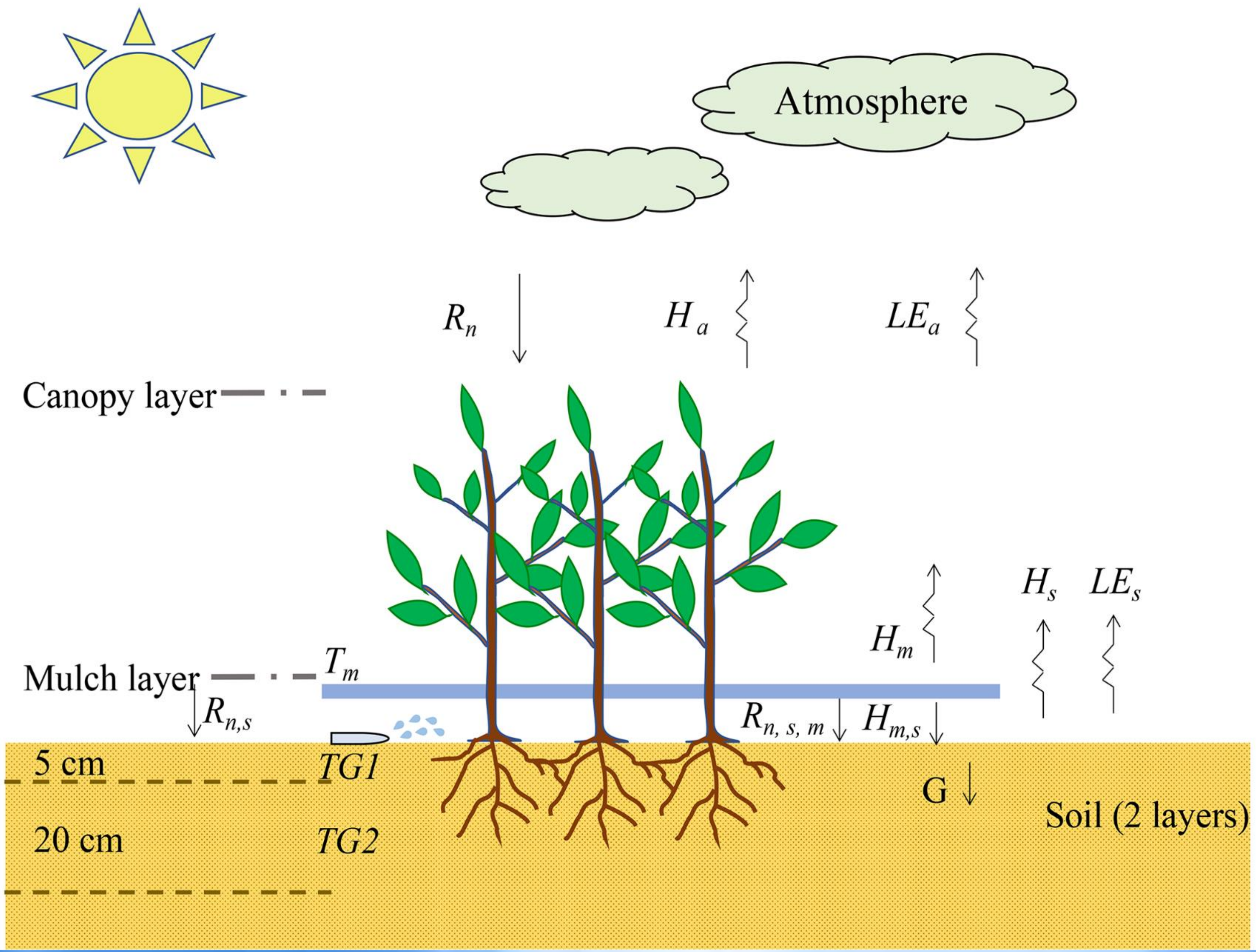
Drip irrigation using Mulch plastic in SURFEX

Rafiq Hamdi

Royal Meteorological Institute of Belgium

Mulch film plastic + Drip irrigation system

ISBA – 2 Layer version + Mulch + Drip



The energy balance for the plastic mulch layer:

$$R_{n,m}^{+} - H_{m}^{+} - H_{m,s}^{+} = 0$$

Surface temperature equation for the first layer Ts having a portion δ_m of ground covered by the mulch and a portion δ_v of irrigated vegetation:

$$\frac{C_s}{\Delta t}(T_s^{+} - T_s^{-}) = R_n^{+} + \delta_m H_{m,s}^{+} - (1 - \delta_m) H_s^{+} - (1 - \delta_m) LE_s^{+} - \delta_v LE_v^{+} - G_1^{+}$$

Net radiation for the mulch as from (Ham and Kluitenberg, 1994):

$$R_{n,m}^{+} = S_{w,m}^{+} + L_{w,m}^{+}$$

$$S_{w,m}^{+} = \alpha_m (1 + \rho^* \tau_m \alpha_s) R_g^{\downarrow}$$

$$\rho^* = (1 - \alpha_s \alpha_m)^{-1} = 1 + \alpha_s \alpha_m + \alpha_s^2 \alpha_m^2 + \cdots$$

$$L_{w,m} = \varepsilon_m \left(1 + \rho_{ir}^* \tau_{m,ir} (1 - \varepsilon_s)\right) R_{atm}^{\downarrow} - 2\sigma \varepsilon_m T_m^4 + \rho_{ir}^* \varepsilon_m \varepsilon_s \sigma T_s^4 + \rho_{ir}^* \varepsilon_m^2 \sigma T_m^4 (1 - \varepsilon_s)$$

Net radiation for the surface layer covered by a fraction δ_m of mulch following (Yuan et al., 2019):

$$R_n^+ = \delta_m R_{n,s,m}^+ + (1 - \delta_m) R_{n,s}^+$$

$$R_{n,s,m}^+ = S_{w,s,m}^+ + L_{w,s,m}^+$$

$$S_{w,s,m}^+ = (1 - \alpha_s)(\rho^* \tau_m) R_g^\downarrow$$

$$L_{w,s,m} = \rho_{ir}^* \varepsilon_s \left(\tau_{m,ir} R_{atm}^\downarrow + \sigma \varepsilon_m T_m^4 + \alpha_{m,ir} \varepsilon_s \sigma T_s^4\right) - \varepsilon_s \sigma T_s^4$$

Surface albedo is modified as in (Yang et al., 2012):

$$\alpha_s = \delta_m 0.324 e^{-0.0031 h_\theta} + (1 - \delta_m)\alpha_s$$

h_θ is the solar zenith angle.

Sensible heat flux between the mulch and the ground layer under the mulch

(Ham and Kluitenberg, 1994):

$$H_{m,s}^{+} = \frac{T_m^{+} - T_s^{+}}{r_c}$$

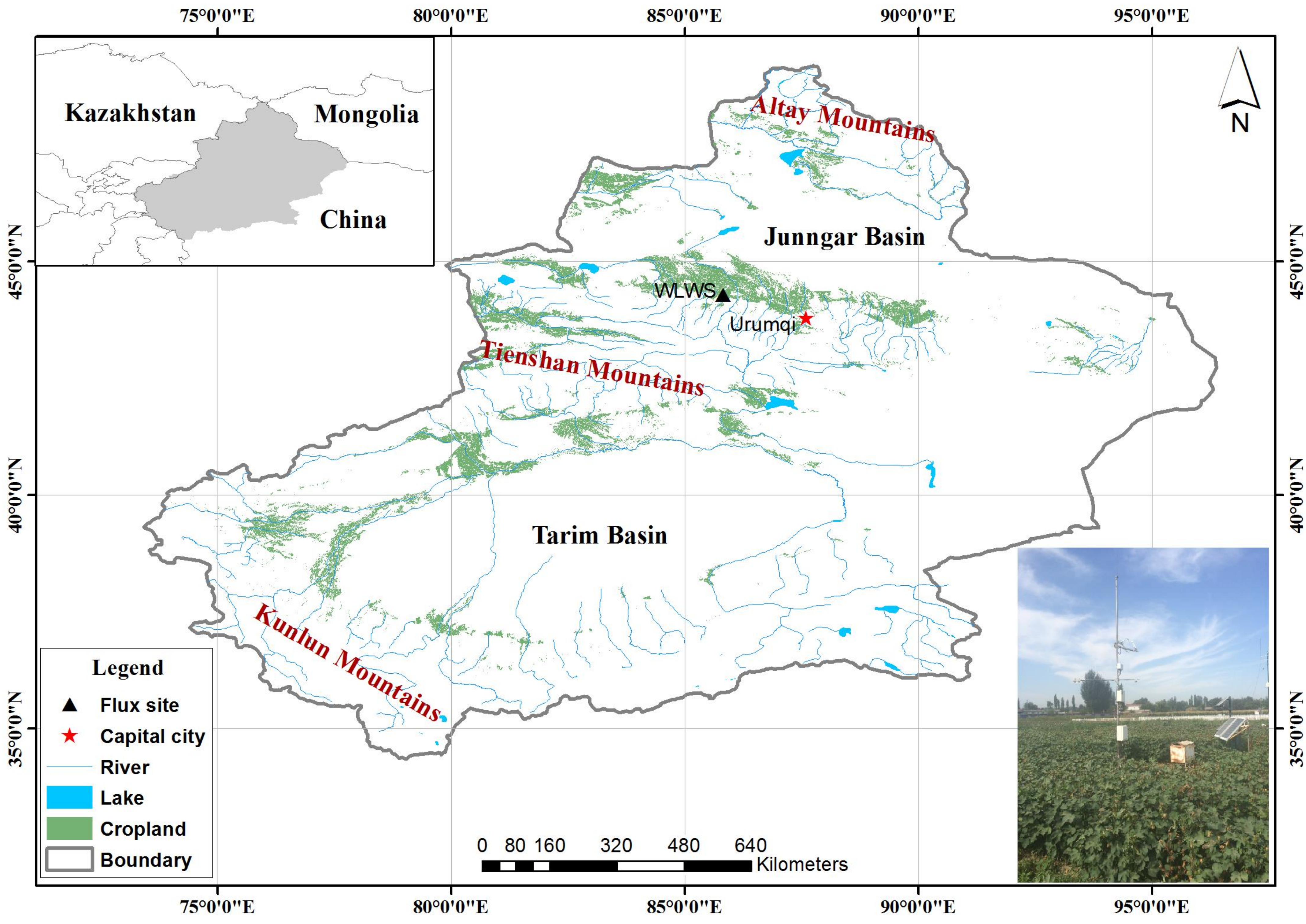
$$E_1 + E_2 T_m^+ + E_3 T_s^+ = 0$$

$$E_4 + E_5 T_m^+ + E_6 T_s^+ = 0$$

$$\frac{SW}{SW_{FC}} < Threshold$$

$$SW = SW_{FC} * \beta$$

Compared to the flood irrigation, less irrigation, by the high water-saving drip irrigation technology will be applied to the soil layer to sustain crop growth without water stress than traditional flood irrigation practices that leading soil to saturation. Therefore, we designed the water demand factor β which ranges from 0 to 1, meaning no water was irrigated or the soil reached saturation moisture content after irrigation.



75°0'0"E
80°0'0"E
85°0'0"E
90°0'0"E
95°0'0"E
45°0'0"N
40°0'0"N
35°0'0"N
Kazakhstan
Mongolia
China
N
Altay Mountains
Junngar Basin
WLWS
Urumqi
Tienshan Mountains
Tarim Basin
Kunlun Mountains
Legend
Flux site
Capital city
River
Lake
Cropland
Boundary
0 80 160 320 480 640
Kilometers

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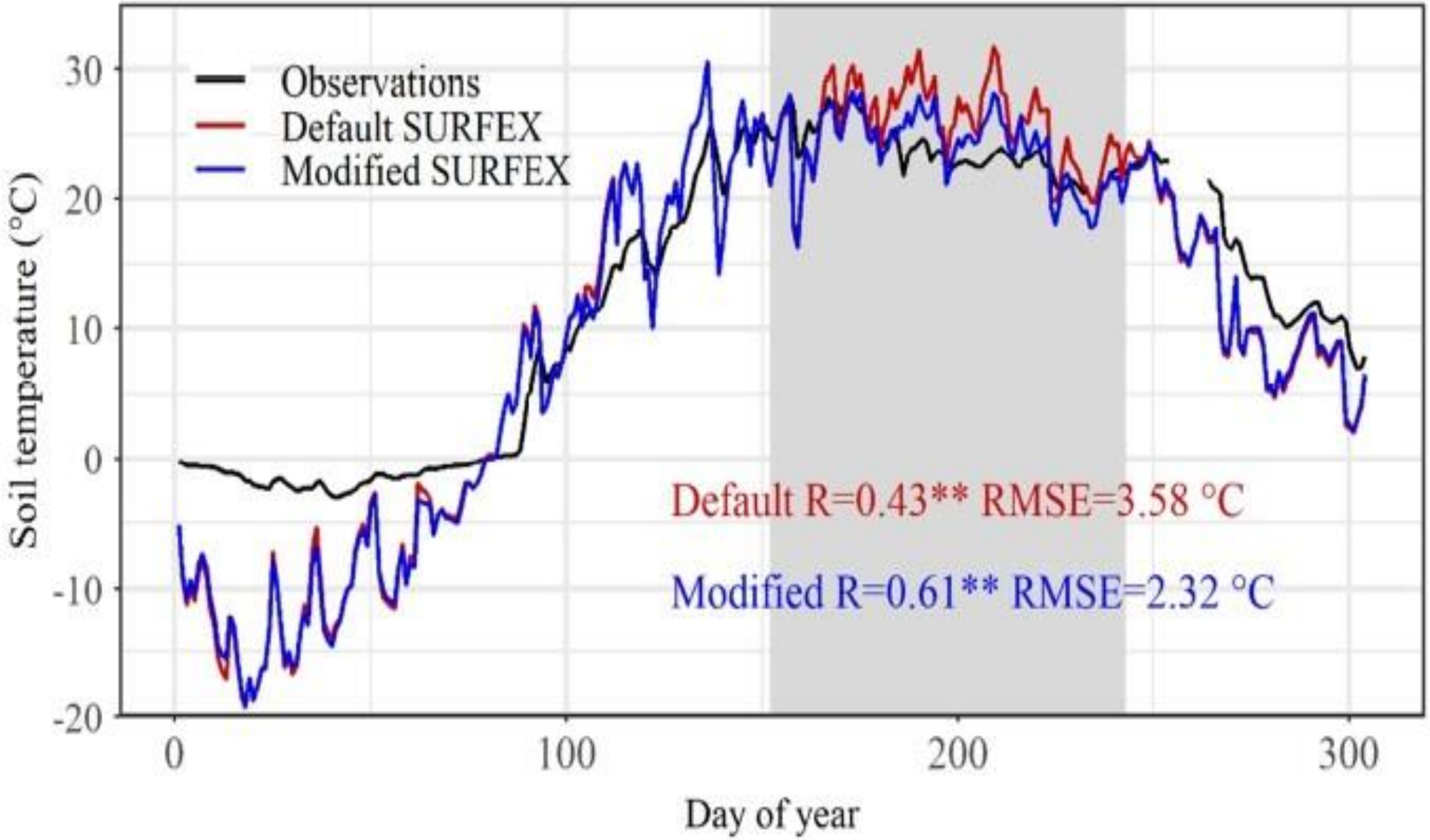
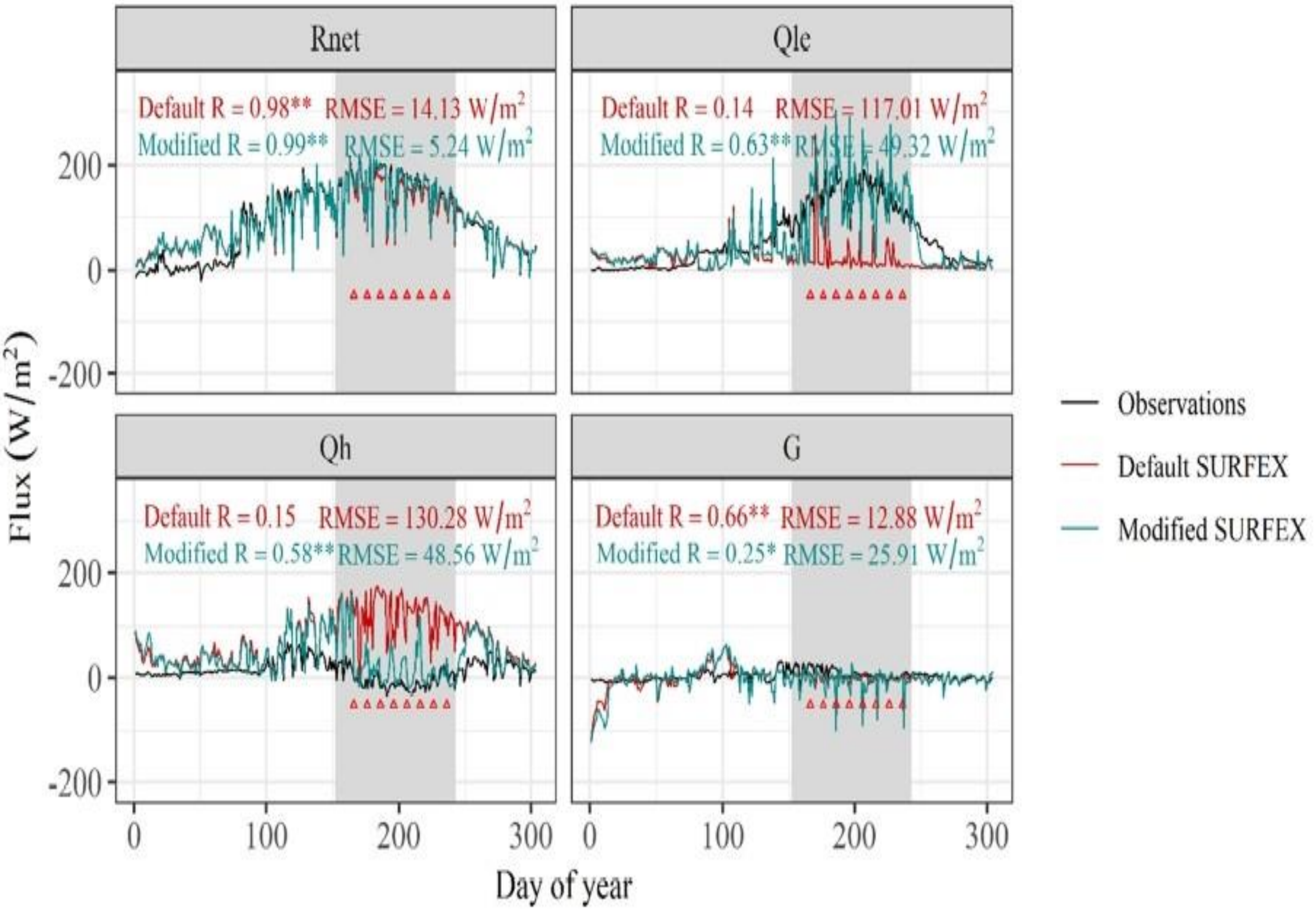
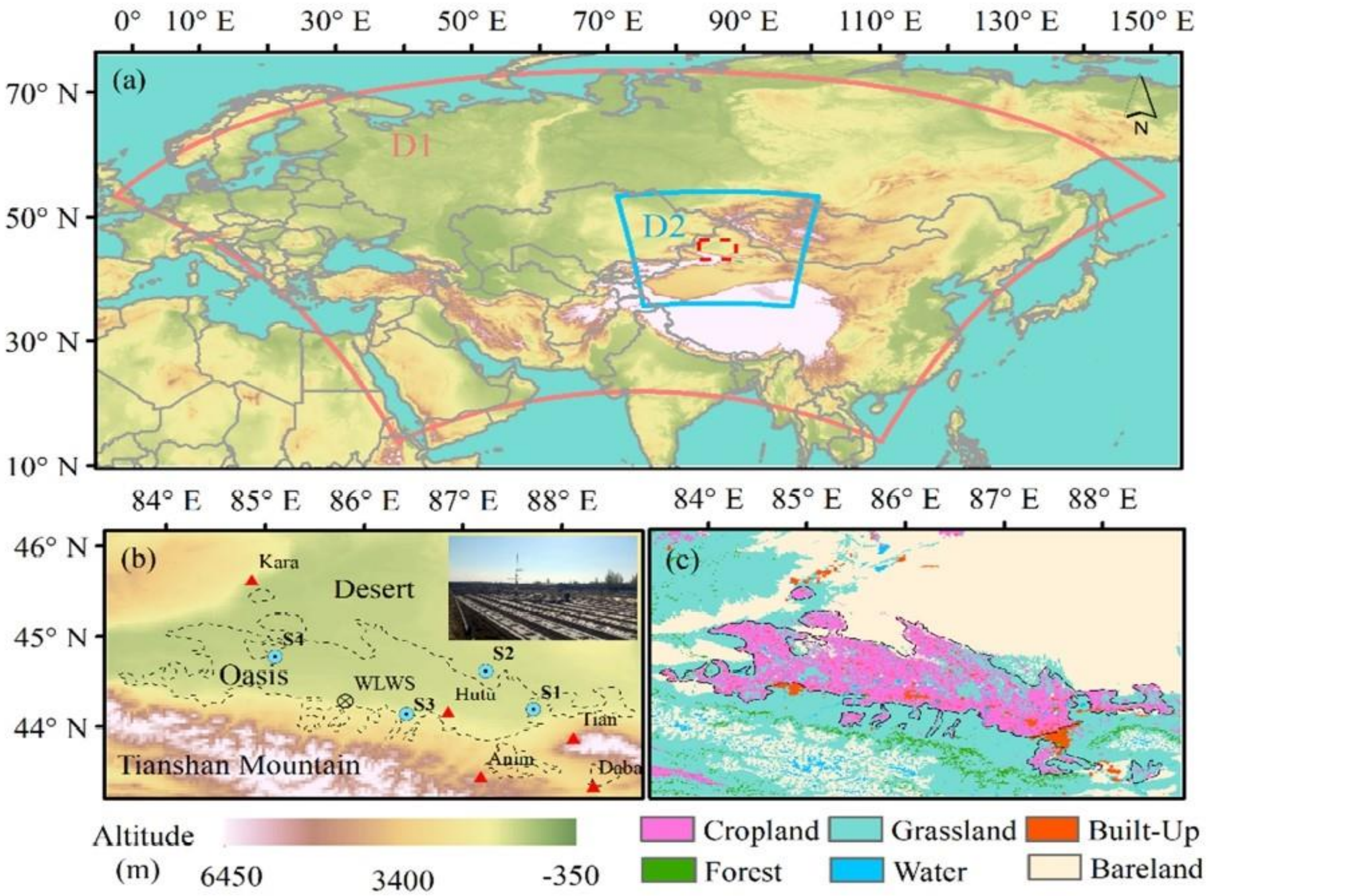


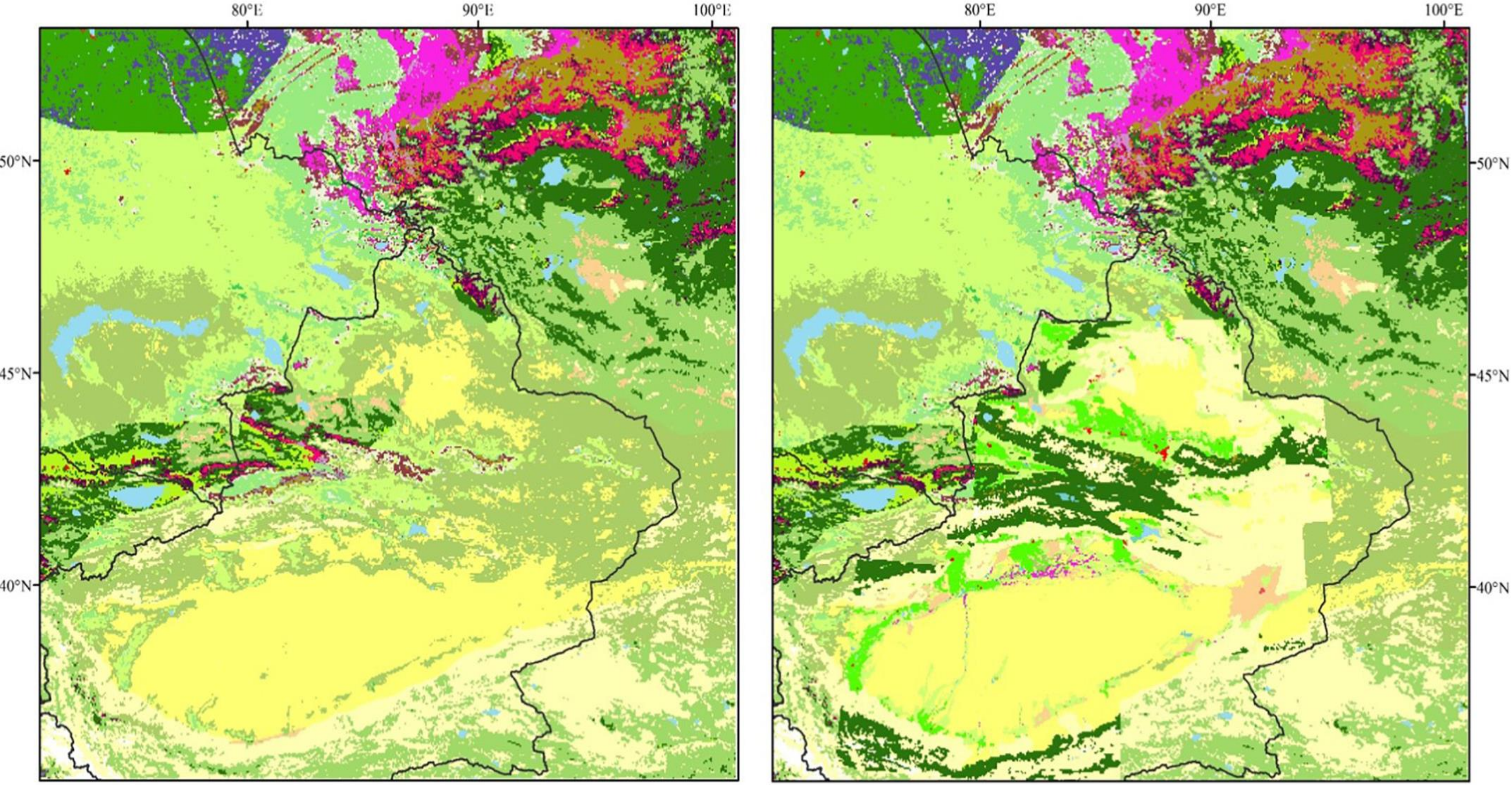


Rnet
Default R = 0.98** RMSE = 14.13 W/m2
Modified R = 0.99** RMSE = 5.24 W/m2
Qle
Default R = 0.14 RMSE = 117.01 W/m2
Modified R = 0.63** RMSE = 49.32 W/m2
Qh
Default R = 0.15 RMSE = 130.28 W/m2
Modified R = 0.58** RMSE = 48.56 W/m2
G
Default R = 0.66** RMSE = 12.88 W/m2
Modified R = 0.25* RMSE = 25.91 W/m2
Flux (W/m2)
Day of year
Observations
Default SURFEX
Modified SURFEX


0°
10° E
30° E
50° E
70° E
90° E
110° E
130° E
150° E
70° N
50° N
30° N
10° N
(a)
D1
D2
N
84° E
85° E
86° E
87° E
88° E
46° N
45° N
44° N
(b)
Kara
Desert
S4
S2
Oasis
WLWS
S3
Hutu
S1
Tian
Tianshan Mountain
Anim
Daba
(c)
Altitude
(m)
6450
3400
-350
Cropland
Grassland
Built-Up
Forest
Water
Bareland

ECOCLIMAP

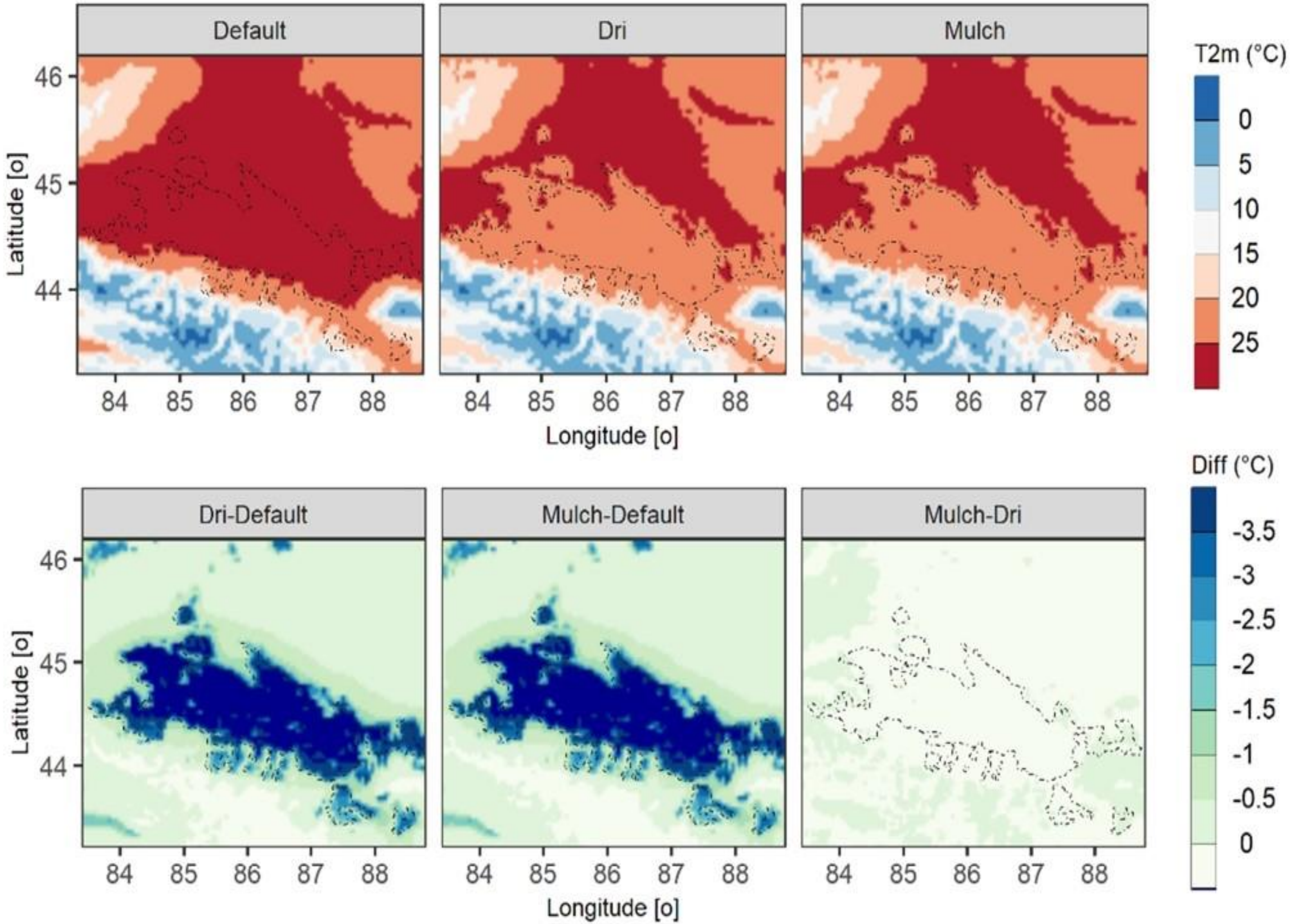
Updated ECOCLIMAP



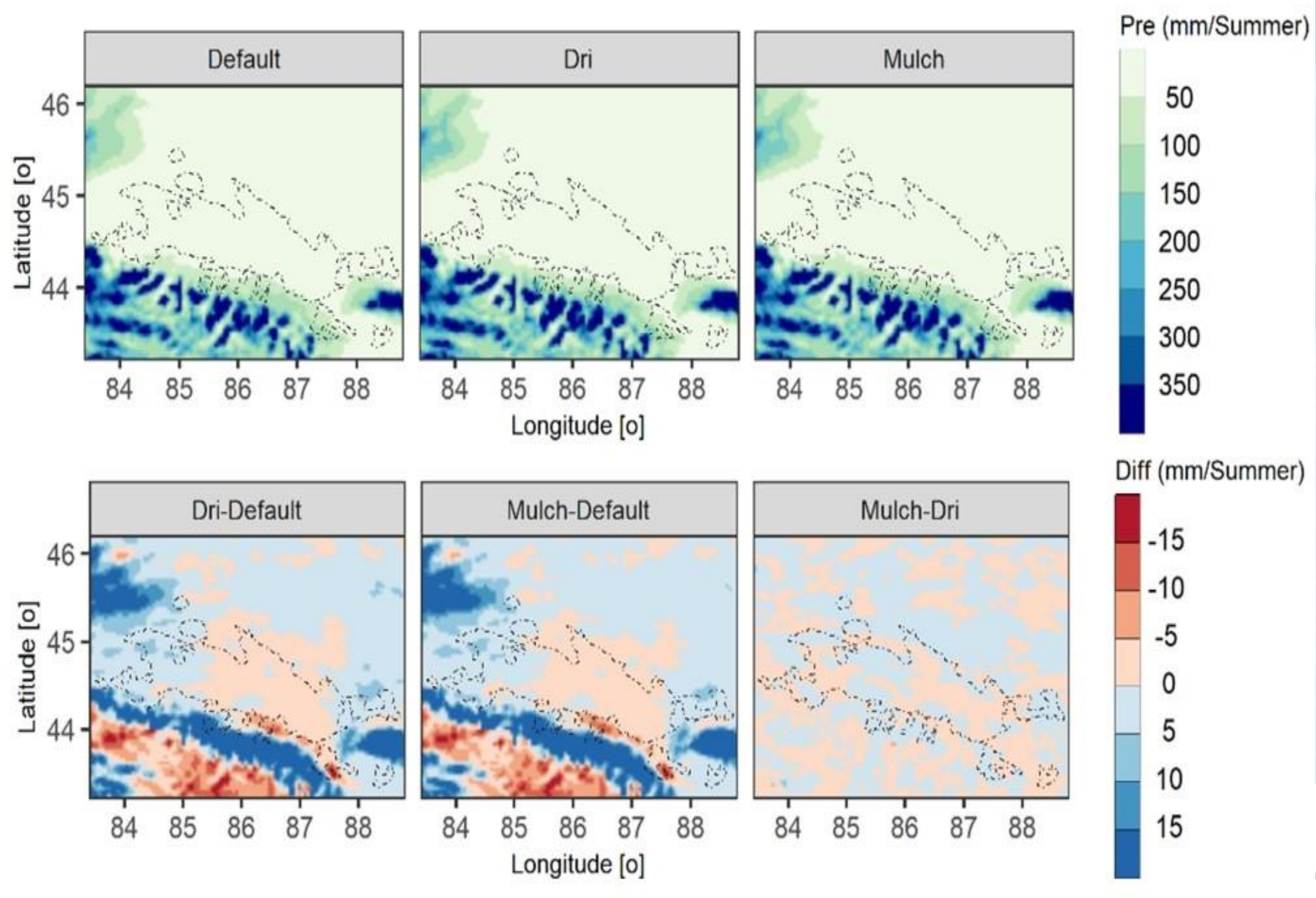
Cai et al. 2019

Land Use/Land Cover Codes

2, 4, 5, 6, 7, 11, 24, 31, 32, 33, 41, 42, 59, 60, 74, 75, 80, 84, 85, 86, 99, 100, 101, 102, 113, 114, 116, 123, 125, 159, 175



Default
Dri
Mulch
T2m (°C)
0
5
10
15
20
25
Latitude [o]
46
45
44
84
85
86
87
88
Longitude [o]
Dri-Default
Mulch-Default
Mulch-Dri
Diff (°C)
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0



Default
Dri
Mulch
Pre (mm/Summer)
50
100
150
200
250
300
350
Latitude [o]
46
45
44
84
85
86
87
88
Longitude [o]
Dri-Default
Mulch-Default
Mulch-Dri
Diff (mm/Summer)
-15
-10
-5
0
5
10
15


Thanks for your time and attention !!

References

Xiuliang Yuan, **Rafiq Hamdi**, Geping Luo, Jie Bai, Friday Uchenna Ochege, Alishir Kurban, Philippe De Maeyer, Xi Chen, Jin Wang, Piet Termonia, The positive climate impacts of drip irrigation underneath plastic mulch on a typical Mountain-Oasis-Desert System in northwest China, Agricultural Water Management, Volume 273, 2022, 107919, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2022.107919