

1
2 **Supplemental Material for**
3

4 **The influence of summer deep soil temperature on early winter snow**
5 **conditions in Eurasia in the NCEP CFSv2 simulation**
6

7 Ravi P. Shukla^{1,*}, Bohua Huang^{1,2}, Paul A Dirmeyer^{1,2} and James L. Kinter^{1,2}

8
9
10 ¹Center for Ocean-Land-Atmosphere Studies
11 George Mason University, Fairfax, Virginia, USA
12

13 ²Department of Atmospheric, Oceanic, and Earth Sciences, George Mason University,
14 Fairfax, Virginia, USA
15
16
17
18

19 **Contents of this file: Figures S1 to S9**
20
21
22
23
24
25

26 *Corresponding author:
27 Dr. Ravi P. Shukla
28 Center for Ocean-Land-Atmosphere Studies (COLA)
29 George Mason University
30 270 Research Hall, Mail Stop 6C5, ,
31 4400 University Drive, Fairfax, VA 22030 USA
32 E-mail: rshukla2@gmu.edu
33
34

35 **Supplementary Figures:**

36 **Figure S1.** Spatial distribution of the climatological observed SCF [%] in (a) Sep, (b) Oct, (c) Nov
37 and (d) Dec. The scale for the magnitude of SCF in “%” is shown below these panels (1st). (e)-(h) as
38 in (a)-(d) but for SWE [kg/m²]. The scale for the magnitude of SWE in “kg/m²” is shown at below
39 these panels (2nd). (i)-(l) as in (a)-(d) but for Surface Albedo (SA). The scale for the magnitude of
40 bias for Surface Albedo in “%” is shown at right of these panels.

41 **Figure S2.** Spatial distribution of the climatological CFSR reanalysis 2-meter Temperature (T2m)
42 [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude for 2-m
43 Temperature in “°K” is shown at left of these panels. Spatial distributions of seasonal mean T2m
44 biases relative to CFSR in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale
45 for the magnitude of bias for surface temperature in “°K” is shown right of these panels.

46
47 **Figure S3.** Spatial distribution of the climatological ERA40 reanalysis land surface temperature
48 (LST) [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude
49 for LST in “°K” is shown at left of these panels. Spatial distributions of seasonal mean LST biases
50 relative to ERA40 in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale for
51 the magnitude of bias for surface temperature in “°K” is shown right of these panels.

52
53 **Figure S4.** Spatial distribution of the monthly climatological ERA40 LST [°K] in (a) Jul, (b) Aug,
54 (c) Sep, (d) Oct and (e) Nov. The scale for the magnitude for LST in “°K” is shown at left of these
55 panels. Spatial distributions of the monthly climatological LST bias relative to ERA40 in model
56 simulation for (f) Jul, (g) Aug, (h) Sep, (i) Oct and (j) Nov. The scale for the magnitude of bias for
57 LST in “°K” is shown at right of these panels. Both red and pink lines in all the panels depict 273.15
58 °K (freezing temperature) for ERA40 (red line) and CFSv2 (black line).

59
60 **Figure S5.** Spatial distribution of the climatological ERA40 reanalysis 2-meter Temperature (T2m)
61 [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude for
62 LST in “°K” is shown at left of these panels. Spatial distributions of seasonal mean T2m biases
63 relative to ERA40 in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale for
64 the magnitude of bias for surface temperature in “°K” is shown right of these panels.

65

66 **Figure S6.** Spatial distributions of the monthly climatological LST biases relative to CFSR in
67 CFSv2 simulation for (a) Apr, (b) May and (c) Jun. Both red and pink lines in all the panels depict
68 273.15 °K (freezing temperature) for CFSR (red line) and CFSv2 simulation (black line). (d)-(e) as
69 in (a)-(c) but for SUBT at 0-10cm. (d)-(e) as in (a)-(c) but for SUBT at 10-40cm. (d)-(e) as in (a)-(c)
70 but for SUBT at 40-100cm. (d)-(e) as in (a)-(c) but for SUBT at 100-200cm.

71 **Figure S7.** Difference between mean of five cold years and warm years of SUBT at 100-200cm over
72 the western Eurasian (outlined by black box in Figure S7; 42°N-64°N, 18°E-58°E) during July to
73 September mean (JAS) in the CFSv2 simulation. (b) as in (a) SUBT at 0-10cm during October. The
74 red line (black line) in Fig. S7(b) denotes 273.15°K in cold year (warm year) in CFSv2. (c) as in (a)
75 but for LST during October. The red line (black line) in Fig. S7(c) denotes 273.15°K in cold year
76 (warm year) in CFSv2. (d) as in (a) but for SCF during October. (e)-(h) as in (a)-(d) but for CFSR
77 reanalysis respectively.

78

79 **Figure S8.** (a-f) Spatial distributions of monthly surface sensible heat flux climatological biases
80 relative to observation in model simulation during May to October. (g-l) as in (a-f) but for net
81 LWR. The net LWR is defined as difference between downward LWR and upward LWR. (m-r) as
82 in (a-f) but for net SWR. The net SWR is defined as difference between downward SWR and
83 upward SWR.

84

85 **Figure S9:** Spatial distributions of monthly mean temperature (1000hPa to 600hPa; hereafter, MT)
86 climatological biases relative to CFSR in model simulation for (a) April (Feb), (b) May (May), (c)
87 June (Jun), (d) July (Jul), (e) September (Sep). and (f) October (Oct). The scale for the magnitude
88 for MT bias in °K is shown below these panels. (g-l) as in (a-f) but for monthly H500 climatological
89 bias relative to reanalysis in model simulation. The scale for the magnitude for H500 bias in meter is
90 shown right of these panels (1st one). (m-r) as in (a-f) but for 500hPa-wind bias relative to reanalysis
91 in model simulation. The scale for the magnitude for 500hPa-wind bias in meter/second is shown
92 right of these panels (2nd one).

93

94

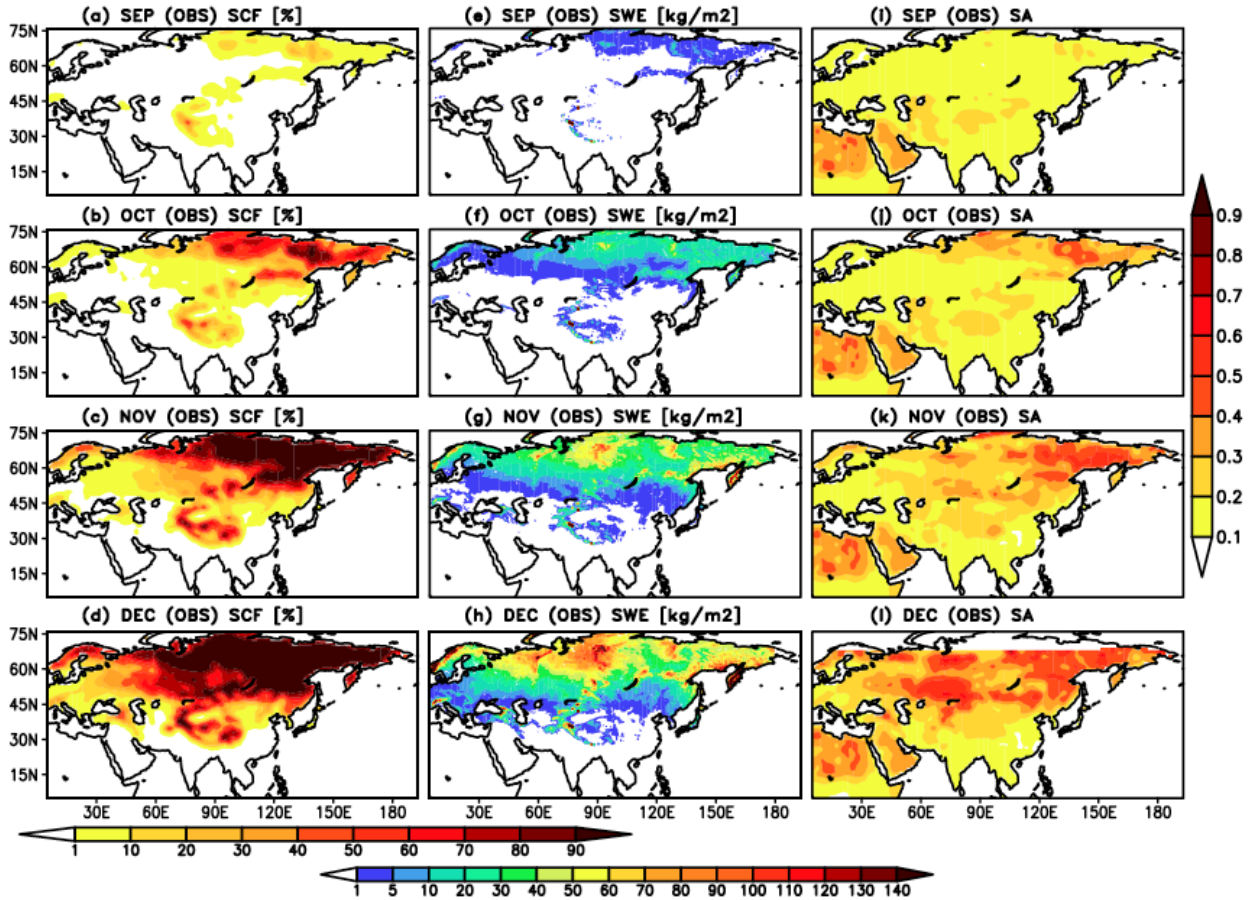
95

96

97

98

99
100
101
102
103



104

105 **Figure S1.** Spatial distribution of the climatological observed SCF [%] in (a) Sep, (b) Oct, (c) Nov
106 and (d) Dec. The scale for the magnitude of SCF in “%” is shown below these panels (1st). (e)-(h)
107 as in (a)-(d) but for SWE [kg/m²]. The scale for the magnitude of SWE in “kg/m²” is shown at below
108 these panels (2nd). (i)-(l) as in (a)-(d) but for Surface Albedo (SA). The scale for the magnitude of
109 bias for Surface Albedo in “%” is shown at right of these panels.

110

111

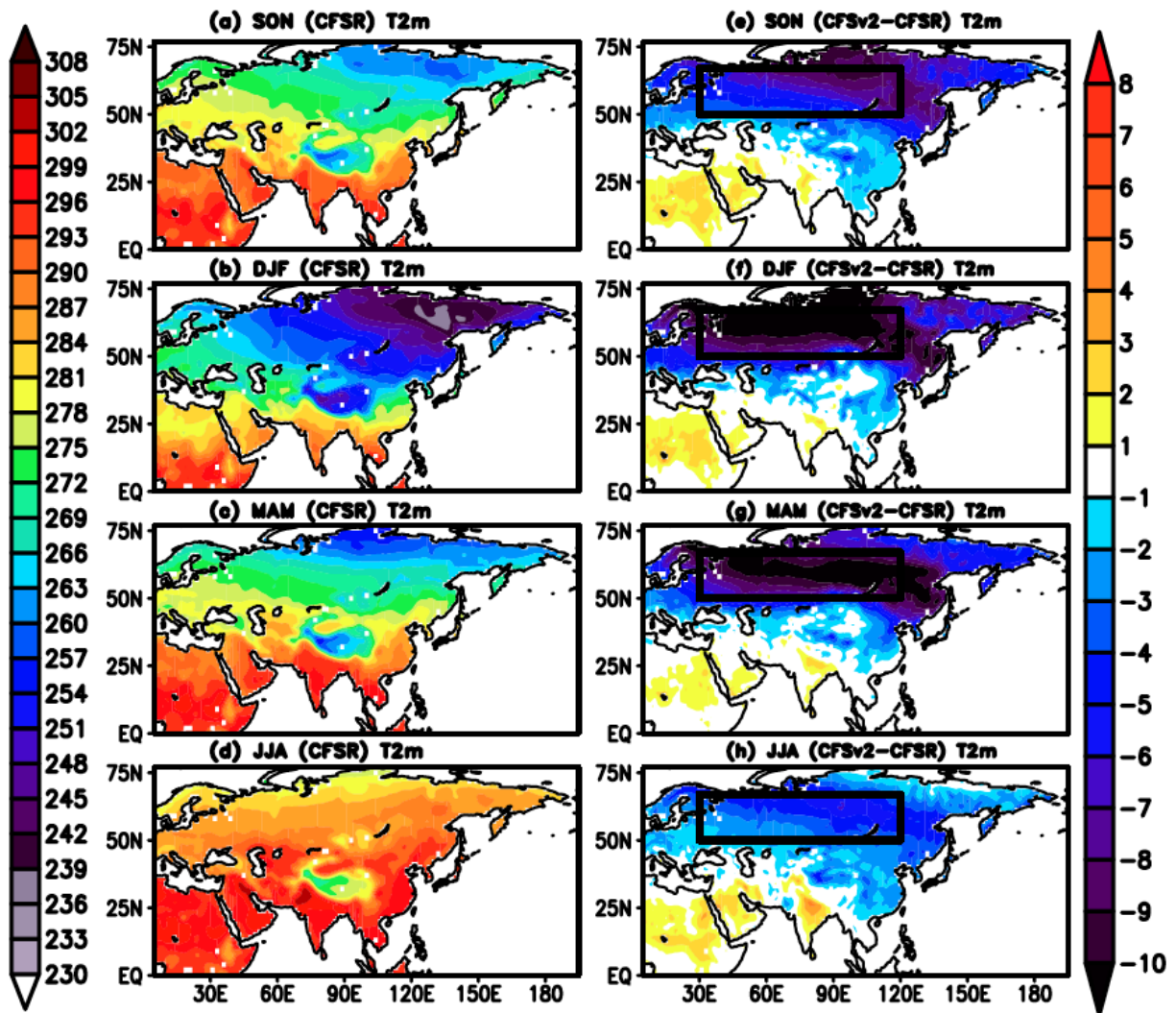
112

113

114

115

116



117

118 **Figure S2.** Spatial distribution of the climatological CFSR reanalysis 2-meter Temperature (T2m)
119 [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude for 2-m
120 Temperature in “°K” is shown at left of these panels. Spatial distributions of seasonal mean T2m
121 biases relative to CFSR in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale
122 for the magnitude of bias for surface temperature in “°K” is shown right of these panels.

123

124

125

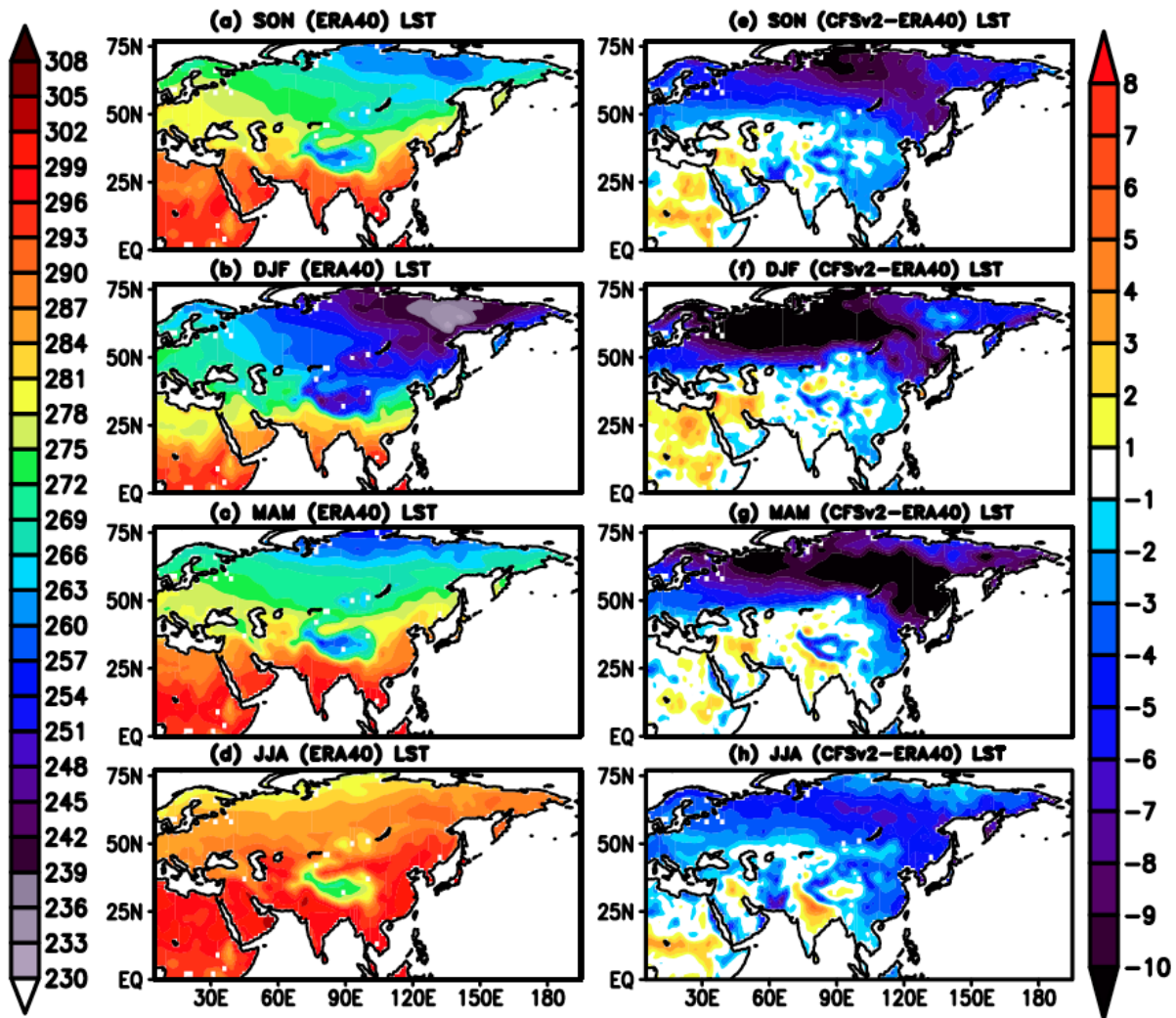
126

127

128

129

130



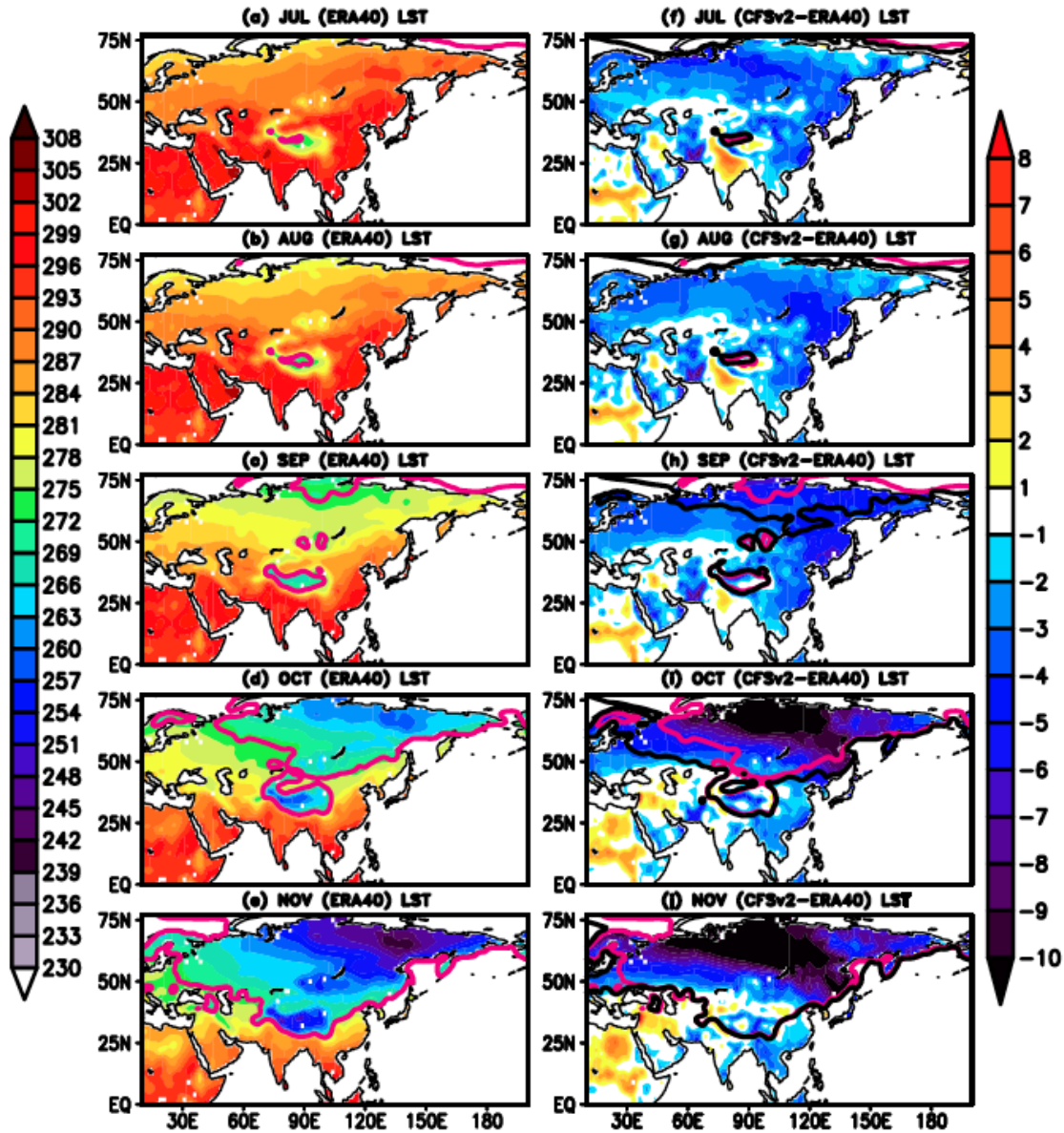
131

132 **Figure S3.** Spatial distribution of the climatological ERA40 reanalysis land surface temperature
133 (LST) [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude
134 for LST in “°K” is shown at left of these panels. Spatial distributions of seasonal mean LST biases
135 relative to ERA40 in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale for
136 the magnitude of bias for surface temperature in “°K” is shown right of these panels.
137

138

139

140



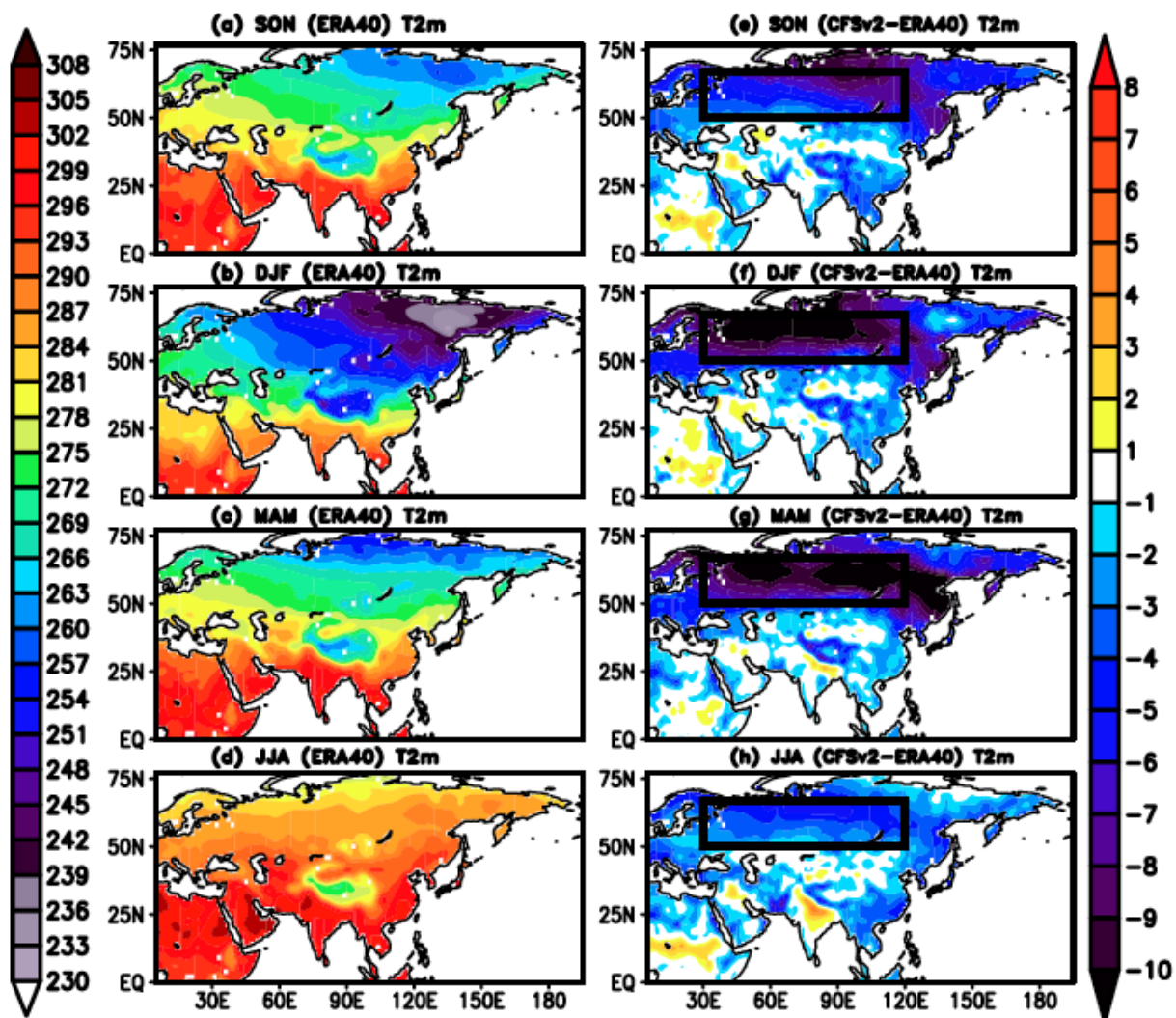
141

142 **Figure S4.** Spatial distribution of the monthly climatological ERA40 LST [$^{\circ}\text{K}$] in (a) Jul, (b) Aug,
 143 (c) Sep, (d) Oct and (e) Nov. The scale for the magnitude for LST in “K” is shown at left of these
 144 panels. Spatial distributions of the monthly climatological LST bias relative to ERA40 in model
 145 simulation for (f) Jul, (g) Aug, (h) Sep, (i) Oct and (j) Nov. The scale for the magnitude of bias for
 146 LST in “K” is shown at right of these panels. Both red and pink lines in all the panels depict 273.15
 147 $^{\circ}\text{K}$ (freezing temperature) for ERA40 (red line) and CFSv2 (black line).
 148

149

150

151



153

154 **Figure S5.** Spatial distribution of the climatological ERA40 reanalysis 2-meter Temperature (T2m)
 155 [degree Kelvin; °K] in (a) SON, (b) DJF, (c) MAM and (d) JJA. The scale for the magnitude for
 156 LST in “°K” is shown at left of these panels. Spatial distributions of seasonal mean T2m biases
 157 relative to ERA40 in model simulation for (e) JJA, (f) SON, (g) DJF and (h) MAM. The scale for
 158 the magnitude of bias for surface temperature in “°K” is shown right of these panels.
 159

160

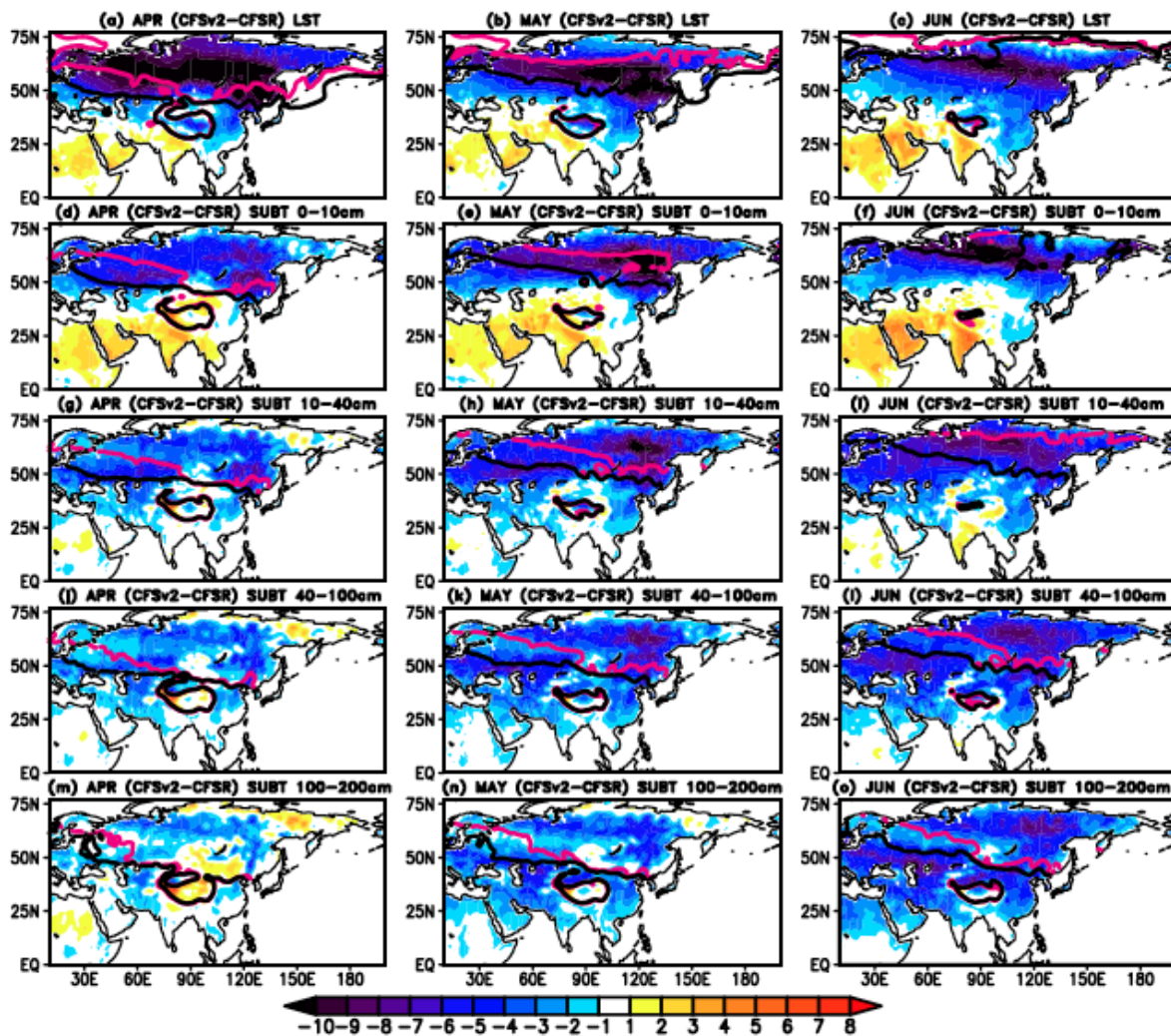
161

162

163

164

165



166

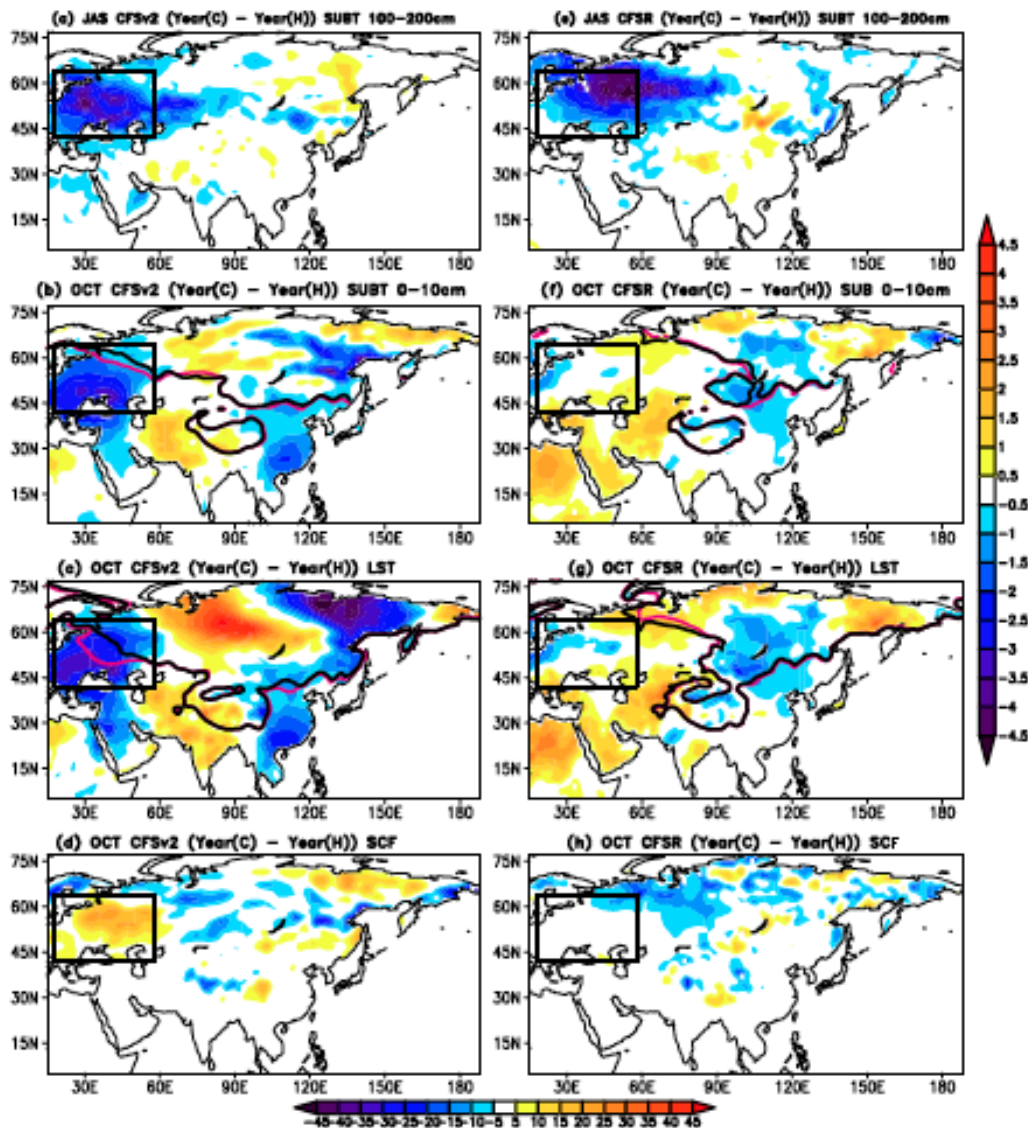
167 **Figure S6.** Spatial distributions of the monthly climatological LST biases relative to CFSR in
168 CFSv2 simulation for (a) Apr, (b) May and (c) Jun. Both red and pink lines in all the panels depict
169 273.15 °K (freezing temperature) for CFSR (red line) and CFSv2 simulation (black line). (d)-(e) as
170 in (a)-(c) but for SUBT at 0-10cm. (d)-(e) as in (a)-(c) but for SUBT at 10-40cm. (d)-(e) as in (a)-(c)
171 but for SUBT at 40-100cm. (d)-(e) as in (a)-(c) but for SUBT at 100-200cm.

172

173

174

175



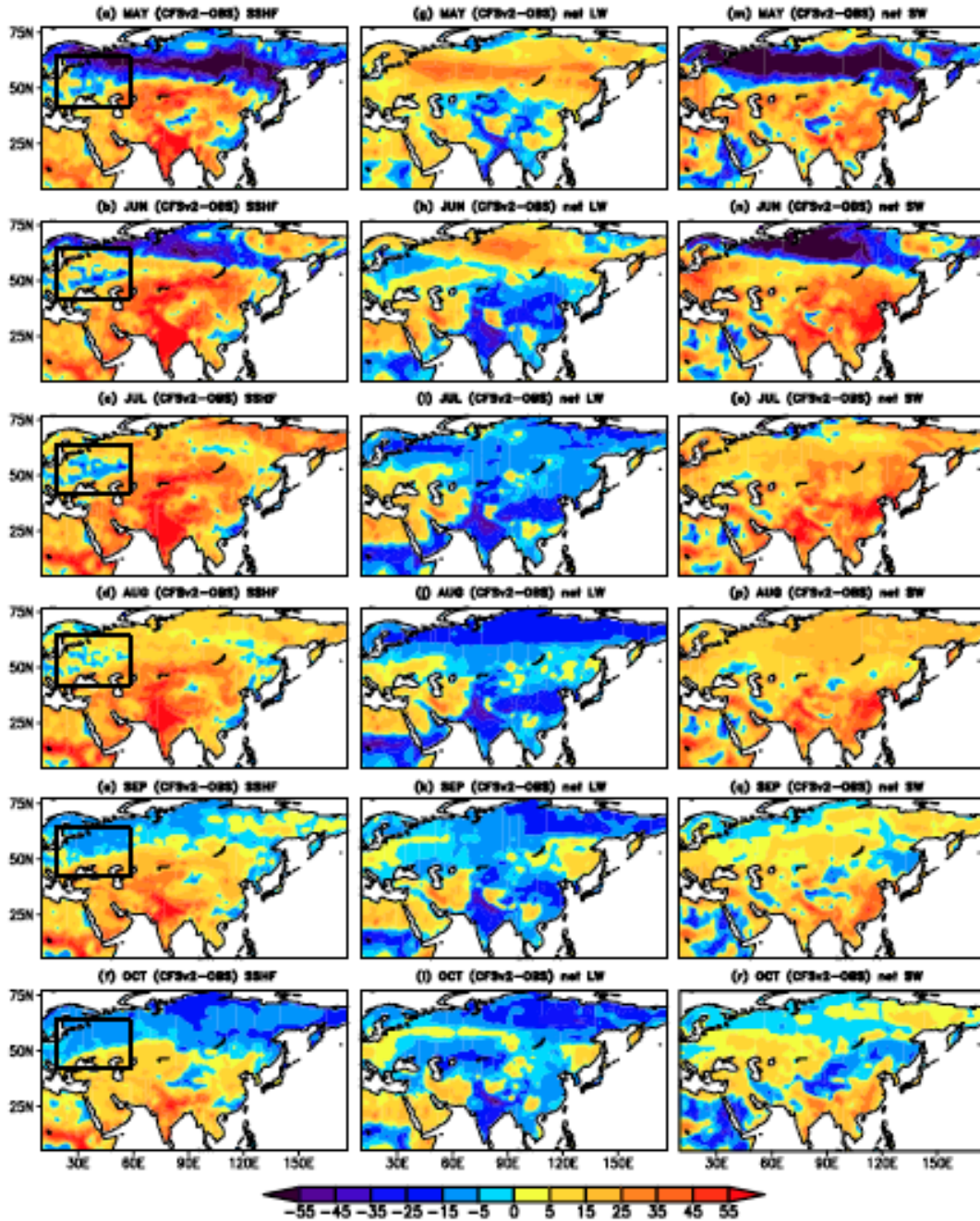
177

178 **Figure S7.** Difference between mean of five cold years and warm years of SUBT at 100-200cm over
 179 the western Eurasian (outlined by black box in Figure S7; 42°N-64°N, 18°E-58°E) during July to
 180 September mean (JAS) in the CFSv2 simulation. (b) as in (a) SUBT at 0-10cm during October. The
 181 red line (black line) in Fig. S7(b) denotes 273.15°K in cold year (warm year) in CFSv2. (c) as in (a)
 182 but for LST during October. The red line (black line) in Fig. S7(c) denotes 273.15°K in cold year
 183 (warm year) in CFSv2. (d) as in (a) but for SCF during October. (e)-(h) as in (a)-(d) but for CFSR
 184 reanalysis respectively.

185

186

187



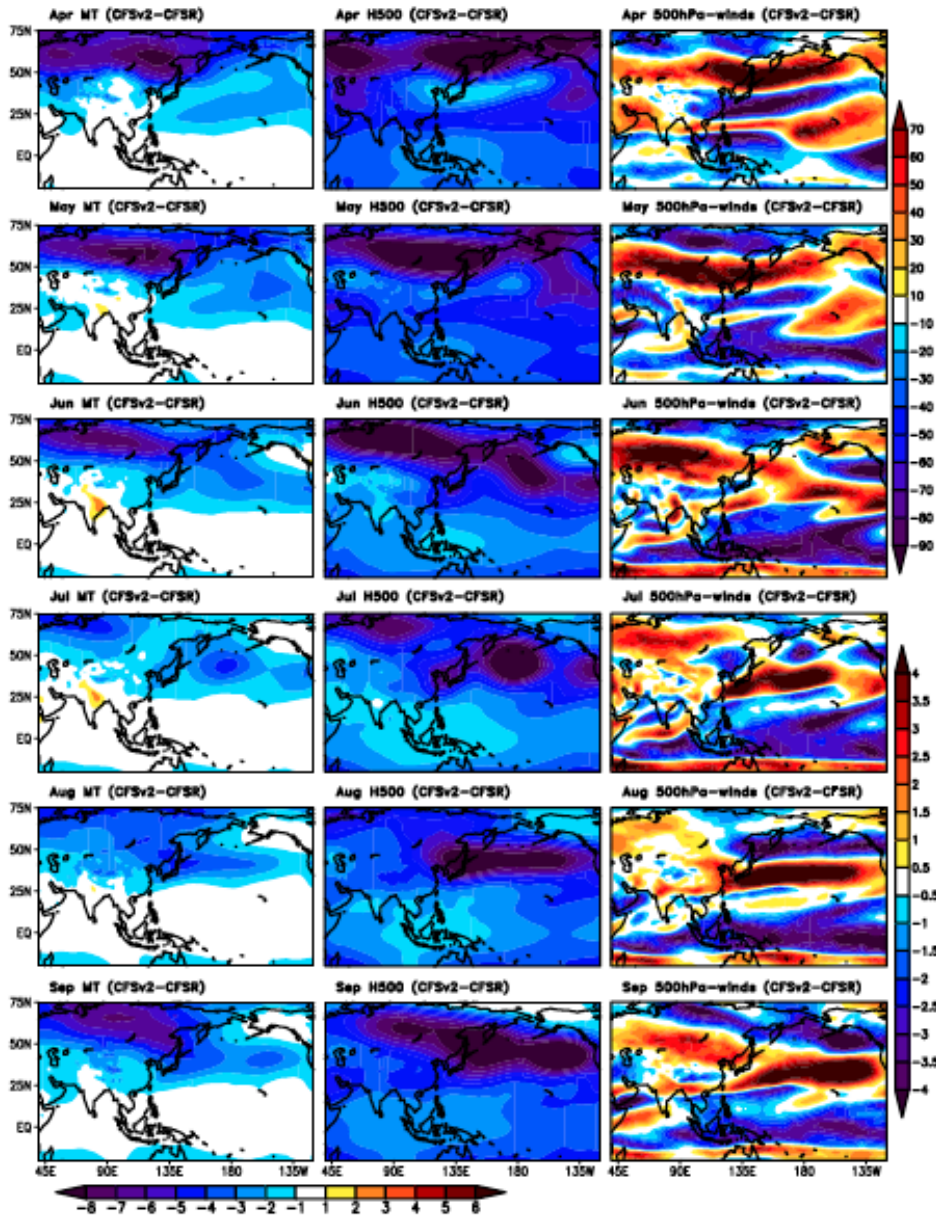
188

189 **Figure S8.** (a-f) Spatial distributions of monthly surface sensible heat flux climatological biases
 190 relative to observation in model simulation during May to October. (g-l) as in (a-f) but for net
 191 LWR. The net LWR is defined as difference between downward LWR and upward LWR. (m-r)
 192 as in (a-f) but for net SWR. The net SWR is defined as difference between downward SWR and
 193 upward SWR.

194

195

196



197

198 **Figure S9:** Spatial distributions of monthly mean temperature (1000hPa to 600hPa; hereafter, MT)
 199 climatological biases relative to CFSR in model simulation for (a) April (Feb), (b) May (May), (c)
 200 June (Jun), (d) July (Jul), (e) September (Sep). and (f) October (Oct). The scale for the magnitude
 201 for MT bias in °K is shown below these panels. (g-l) as in (a-f) but for monthly H500 climatological
 202 bias relative to reanalysis in model simulation. The scale for the magnitude for H500 bias in meter
 203 is shown right of these panels (1st one). (m-r) as in (a-f) but for 500hPa-wind bias relative to reanalysis
 204 in model simulation. The scale for the magnitude for 500hPa-wind bias in meter/second is shown
 205 right of these panels (2nd one).
 206