The following supplement accompanies the article

Assessing climate effects on wheat yield and water use in Finland using a super-ensemble-based probabilistic approach

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Supplement.

Table S1. Selected model parameters prior intervals, mean estimates, standard deviation, and intervals (lower limit, upper limit) of the optimal 20 sets of parameters for spring wheat

Parameters	Prior interval	Mean	Standard deviations	Interval of the optimal 20 sets of parameters
r_{maxv1} [per day]	0.015-0.03	0.02	0.01	0.02-0.03
r_{maxv2} [per day]	0.03-0.05	0.04	0.01	0.04-0.05
r_{maxr} [per day]	0.03-0.05	0.03	0.01	0.03-0.04
ω [h^{-1}]	0.1-0.2	0.15	0.03	0.12-0.19
P_c [h]	6.0-9.0	7.38	0.79	6.00-8.71
$L_{AImaxv1}$	1.5-3.0	2.32	0.07	2.20-2.46
Y_{gp}	0.6-0.9	0.83	0.05	0.71 -0.89
H_I	0.38-0.42	0.41	0.01	0.40-0.42
$R_{r:l}$	1.0-1.5	1.41	0.12	1.16-1.50
S_{cr}	0.4-0.6	0.45	0.04	0.41-0.55
S_{le}	0.4-0.6	0.44	0.05	0.41-0.54
A	0.07-0.09	0.08	0.01	0.08-0.09
T_{Tmax}[$mm^{-2}d^{-1}$]	4.0-6.5	5.83	0.23	5.10-5.99
g_m	4.0-6.0	5.85	0.12	5.61-5.99
λ_i	0.7-0.9	0.71	0.01	0.70-0.73
R_{m25} [$gCm^{-2}d^{-1}$]	0.43-0.63	0.52	0.03	0.48-0.57
m_r[gCm^{-2}]	40.0-60.0	49.30	7.81	40.48-59.85
α_g	0.25-0.45	0.29	0.04	0.26-0.37

$r_{maxv1,}$ maximum daily development rate in the emergence-terminal spikelet initiation phase;

$r_{maxv2,}$ maximum daily development rate in the terminal spikelet initiation-anthesis phase;

$r_{maxr,}$ maximum daily development rate in the anthesis-physiological maturity phase;

ω, photoperiod sensitivity coefficient;

P_c, critical photoperiod below which no development occurs, cultivar dependent;

$L_{AImaxv1,}$ maximum leaf area index at the end of terminal spikelet initiation phase;

Y_{gp}, yield gap parameter;

H_I, harvest index;

$R_{r:l}$, relative growth rate of root depth and leaf area index;

S_{cr}, critical threshold value of soil water stress factor to affect growth;

S_{le}, scaling factor for absorbed photosynthetically active radiation at ecosystem versus leaf scale;

A, effective ecosystem-level quantum efficiency;

T_{Tmax}, maximum transpiration rate;

g_m, empirical parameter in calculating atmospheric demand water;

λ_i, parameter balancing intercellular and ambient partial pressure of CO_2;

R_{m25}, maintenance respiration at 25 °C;

m_r, an empirical parameters in calculating maintenance respiration;

α_g, growth respiration parameter.

Table S2. Selected model parameters prior intervals, mean estimates, standard deviation, and intervals (lower limit, upper limit) of the optimal 10 sets of parameters for winter wheat

Parameters	Prior interval	Mean	Standard deviations	Interval of the optimal 10 sets of parameters
r_{maxv1} [per day]	0.015-0.03	0.0248	0.01	0.02-0.026
r_{maxv2} [per day]	0.03-0.05	0.044	0.01	0.040-0.046
r_{maxr} [per day]	0.03-0.05	0.0395	0.01	0.0385-0.0482
ω [h^{-1}]	0.1-0.2	0.149	0.01	0.142-0.16
P_c [h]	6.0-9.0	7.87	0.20	7.30-7.96
$L_{AImaxv1}$	1.5-3.0	2.71	0.12	2.41-2.77
Y_{gp}	0.6-0.9	0.78	0.08	0.71-0.87
H_I	0.38-0.42	0.40	0.01	0.39-0.42
$R_{r:l}$	1.0-1.5	1.43	0.03	1.38-1.48
S_{cr}	0.4-0.6	0.535	0.01	0.50-0.54
S_{le}	0.4-0.6	0.442	0.01	0.44-0.45
A	0.07-0.09	0.075	0.01	0.07-0.08
T_{Tmax}[$mm^{-2}d^{-1}$]	4.0-6.5	6.07	0.24	5.90-6.49
g_m	4.0-6.0	5.65	0.16	5.50-5.85
λ_i	0.7-0.9	0.729	0.01	0.70-0.733
R_{m25} [$gCm^{-2}d^{-1}$]	0.43-0.63	0.53	0.01	0.52-0.54
m_r[gCm^{-2}]	40.0-60.0	50.68	1.65	49.05-55.00
α_g	0.25-0.45	0.3389	0.01	0.33-0.34

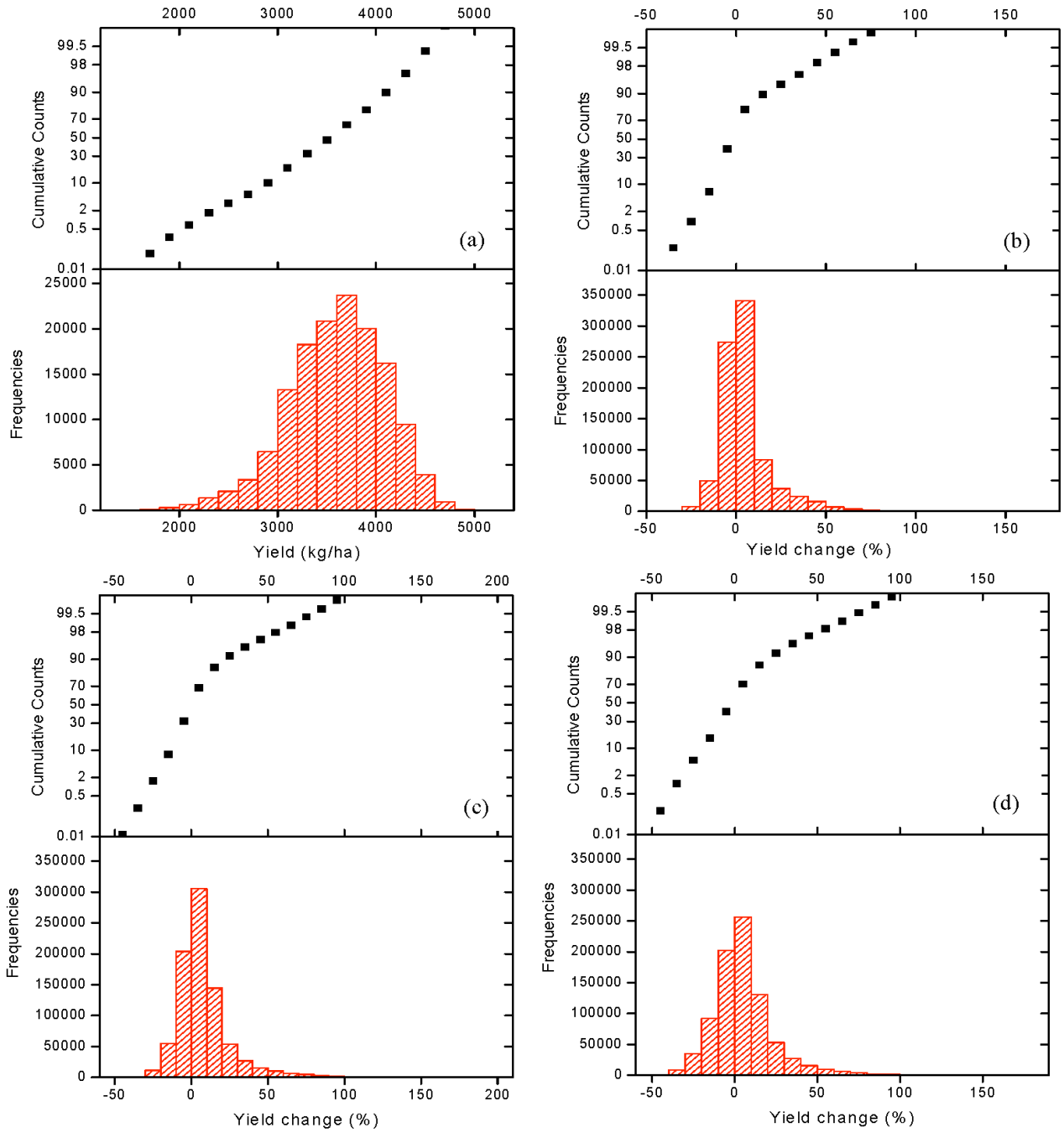
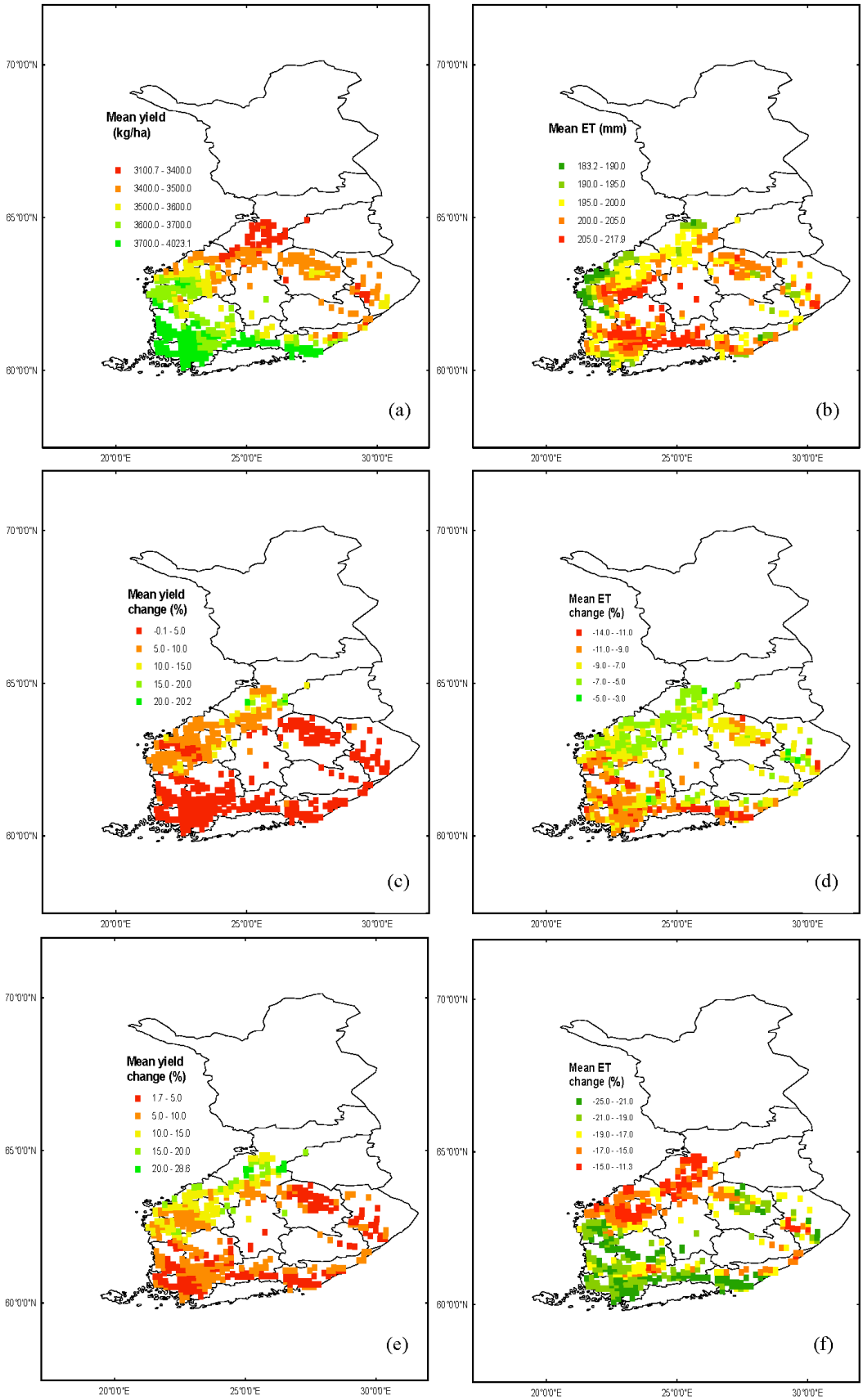


Fig. S1. Cumulative probability functions and histograms of winter wheat yield during 1971–2000 (a) and its changes during 2020s (b), 2050s (c), and 2080s (d), across the wheat cultivation grids in Finland


Mean yield (kg/ha)
3100.7 - 3400.0
3400.0 - 3500.0
3500.0 - 3600.0
3600.0 - 3700.0
3700.0 - 4023.1
(a)
Mean ET (mm)
183.2 - 190.0
190.0 - 195.0
195.0 - 200.0
200.0 - 205.0
205.0 - 217.9
(b)
Mean yield change (%)
-0.1 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 20.2
(c)
Mean ET change (%)
-14.0 - -11.0
-11.0 - -9.0
-9.0 - -7.0
-7.0 - -5.0
-5.0 - -3.0
(d)
Mean yield change (%)
1.7 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 28.6
(e)
Mean ET change (%)
-25.0 - -21.0
-21.0 - -19.0
-19.0 - -17.0
-17.0 - -15.0
-15.0 - -11.3
(f)
70°0'0"N
65°0'0"N
60°0'0"N
20°0'0"E
25°0'0"E
30°0'0"E

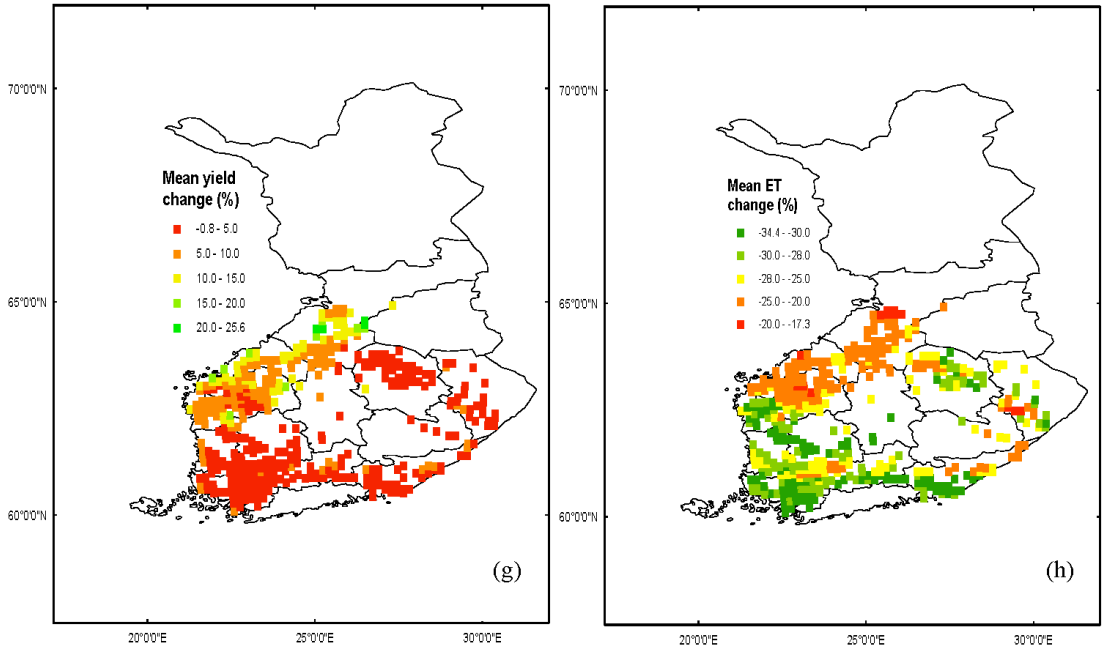


Fig. S2. Spatial patterns of winter wheat mean yield (a) and evapotranspiration (ET) over wheat growing period (b) during 1971–2000, and the projected changes in mean yield (c, e, g) and ET (d, f, h) during 2020s (c,d), 2050s (e,f), and 2080s (g, h), respectively

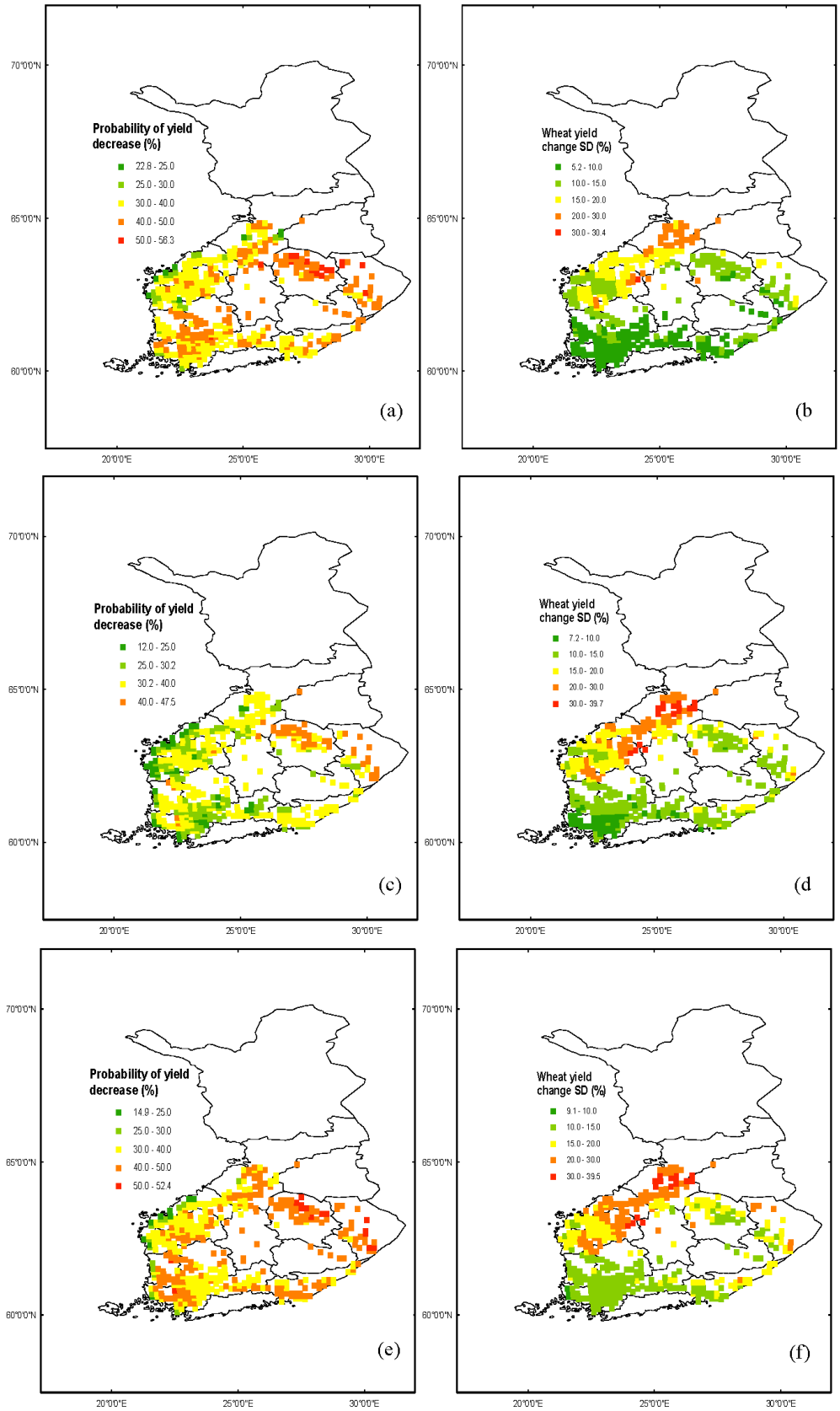


Fig. S3. Spatial patterns of yield decrease probability (a, c, e) and yield change standard deviation (b, d, f) for winter wheat during 2020s (a, b), 2050s (c, d), and 2080s (e, f), across the wheat cultivation grids in Finland

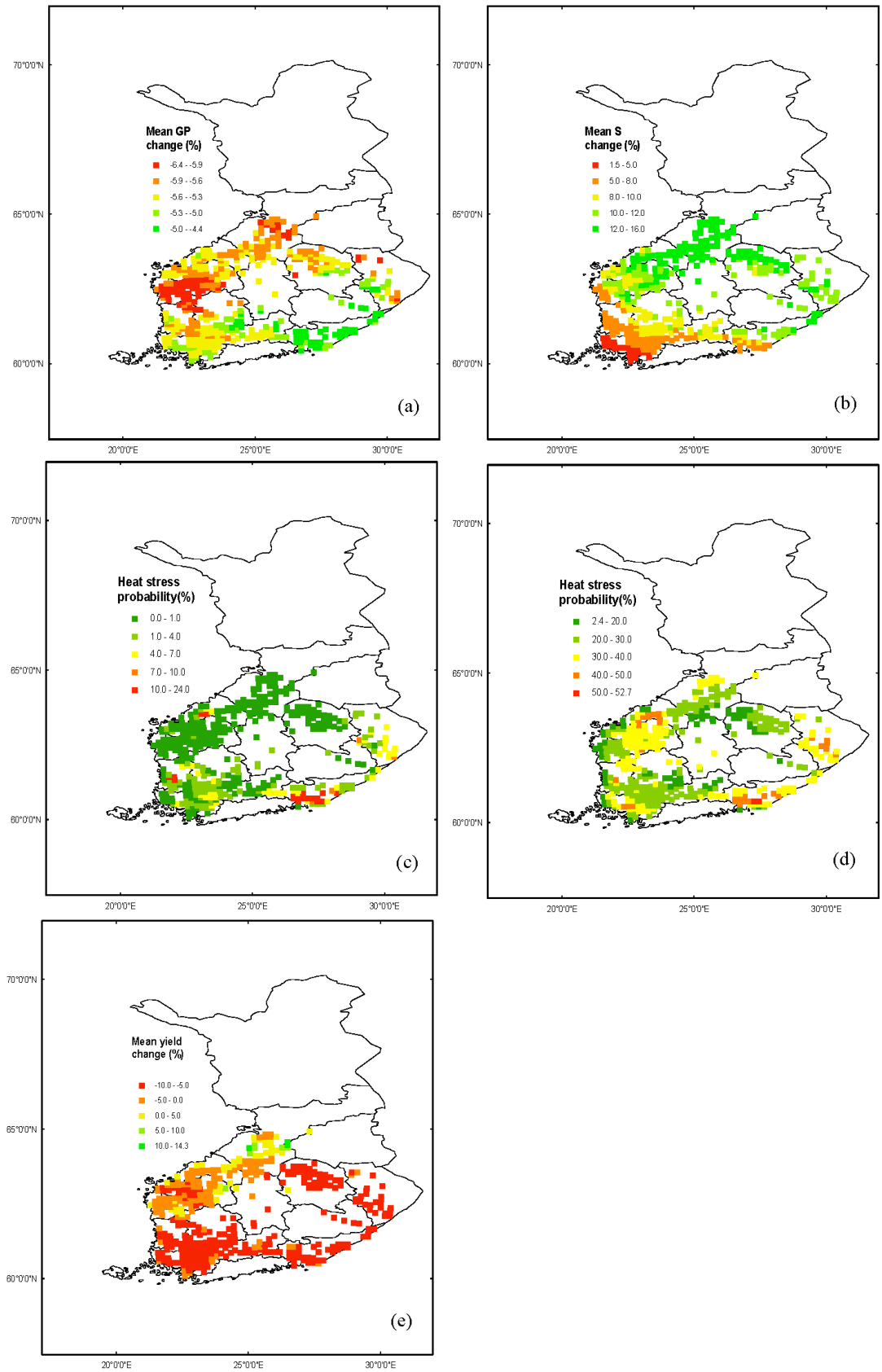


Fig. S4. Spatial patterns of changes in simulated duration of winter wheat growing-period (a), and mean daily ratio of transpiration and potential transpiration over growing period (b) during 2050s, relative to 1971 – 2000 level; the simulated heat stress occurrence probability during 1971–2000 (c) and 2050s (d); and the spatial patterns of changes in simulated mean yield (e) without CO_2 fertilization effects