Supplementary Information (SI):

Estimation of hourly near surface air temperature across Israel using an ensemble-based model

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This Supplementary Information (SI) contains

1) Geospatial variables incorporated into the model (Table S1).
2) Statistics of the hyper-parameters tuned in the Stage 1 (Table S2- S3), Stage 2 (Table S4), and Stage 3 (Table S5) models.
3) Overall (Figure S1), spatial (Figure S2), and temporal (Figure S3) Root Mean Square Error (RMSE) disaggregated by month and for RF and XGBoost, and their difference (RF-XGBoost) in Stage 1.
4) Spatial pattern of multi-annual overall MAE (Figure S4) and R^2 (Figure S5) of RF, XGBoost, and their difference (RF-XGBoost) in Stage 1.
5) Feature importance in the Stage 2 models and the relative ranking changes of each feature between RF and XGBoost (Figure S6)
6) Overall, spatial and temporal RMSE of Ta estimated using GAM based on 5-fold cross-validation for each station (Figure S7)

Table S1 Geospatial variables incorporated into the model

Data	Source	Resolution	Pre-processing
Normalized Difference Vegetation Index (NDVI)	MODIS* Aqua-MYD13A3, Terra-MOD13A3 (v06)	monthly 2004-2017, at 1 x 1 km^2	The monthly mean NDVI values averaged over Terra and Aqua are aggregated to the SEVIRI grid (~4km resolution) and assigned to all hours in that month.
Road density	Survey of Israel, (2013)	Polylines, in 2012	The road density is computed as the total length of road segments within each SEVIRI grid cell.
Population density	Israeli Central Bureau of Statistics, (2014)	3067 census units (polygons), in 2012.	The population estimates are homogeneously disaggregated into a grid of 10 x 10 m^2 raster cells and then re-allocated to the SEVIRI grid.
Distance to sea water	Natural Earth Portal coastline, version 4.1.0	1:10,000,000	The distance is computed from the centroid of each SEVIRI grid cell to the nearest coastline.
Elevation	ASTER** global digital elevation model (GDEM), version 2	30 m	The elevation is aggregated to the SEVIRI grid.
Slope aspect			The slope aspect is computed for each elevation cell using aspect function in ArcGIS 10.6 (Esri, 2018), and later aggregated to the SEVIRI grid.
Urban built-up fraction	Israeli Central Bureau of Statistics, (2015).	100 m, in 2014	The urban/vegetation fraction for each SEVIRI grid is computed as the ratio of the number of urban/vegetation cells to the total number of land cells in that cell.
Vegetation fraction			

* Moderate Resolution Imaging Spectroradiometer **Advanced Spaceborne Thermal Emissions and Reflection Radiometer

Table S2 Statistics of the hyper-parameters tuned in the Stage 1 RF model. The number of trees (num.trees) is set at 300.

Variable	code	min	Q1	median	Q3	max
No. of variables available for splitting at each tree node	mtry	6	10	12	13	17
min No. of observations in a terminal node	min.node.size	2	2	3	4	10
fraction of observations available for splitting at each tree node	sample.fraction	0.483	0.731	0.774	0.816	0.888

Table S3 Statistics of the hyper-parameters tuned in the Stage 1 XGBoost model. The maximum number of rounds for boosting (nrounds) is set at 200.

Variable	code	min	Q1	median	Q3	max
Learning rate	eta	0.040	0.060	0.076	0.089	0.156
L1 regularization term on weights	alpha	0.100	0.158	0.206	0.250	0.300
min split loss	gamma	0.000	0.320	0.702	1.179	2.000
max tree depth	max_depth	15	17	18	19	20

Table S4 Hyper-parameters tuned in the Stage 2 RF and XGBoost models. The setting of *num.trees* in RF and *nrounds* in XGBoost are consistent with those in the Stage 1 model.

	RF			XGBoost			
year	**mtry**	**min.node.size**	**sample.fraction**	**eta**	**alpha**	**gamma**	**max_depth**
2004	10	4	0.817	0.197	0.174	0.626	12
2005	8	4	0.879	0.127	0.161	0.163	14
2006	10	2	0.715	0.150	0.300	1.344	13
2007	8	3	0.801	0.136	0.279	0.398	13
2008	10	4	0.763	0.148	0.192	0.010	14
2009	9	3	0.624	0.173	0.139	0.989	13
2010	8	3	0.673	0.167	0.231	0.117	15
2011	7	4	0.667	0.152	0.248	0.428	13
2012	10	2	0.769	0.100	0.260	0.060	14

2013	10	5	0.859	0.137	0.223	0.469	15
2014	10	2	0.814	0.116	0.244	0.229	15
2015	9	6	0.889	0.148	0.300	0.165	14
2016	8	6	0.779	0.164	0.299	0.782	14
2017	8	2	0.814	0.163	0.300	0.227	14

Table S5 Hyper-parameters tuned in the Stage 3 RF and XGBoost models. The setting of *num.trees* in RF and *nrounds* in XGBoost are consistent with those in the Stage 1 model.

RF			XGBoost			
mtry	**min.node.size**	**sample.fraction**	**eta**	**alpha**	**gamma**	**max_depth**
12	6	0.710	0.066	0.224	1.698	16

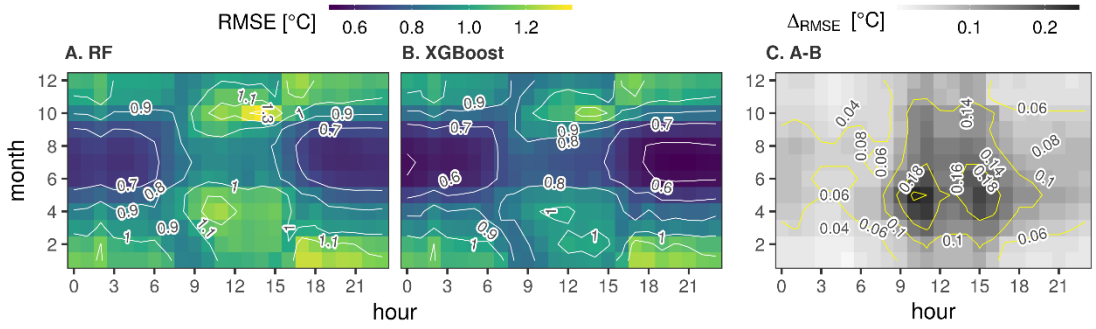

Figure S1 Overall Root Mean Square Error (RMSE) disaggregated by month and hour for RF (a) and XGBoost (b), and their difference (c, RF-XGBoost) in Stage 1.

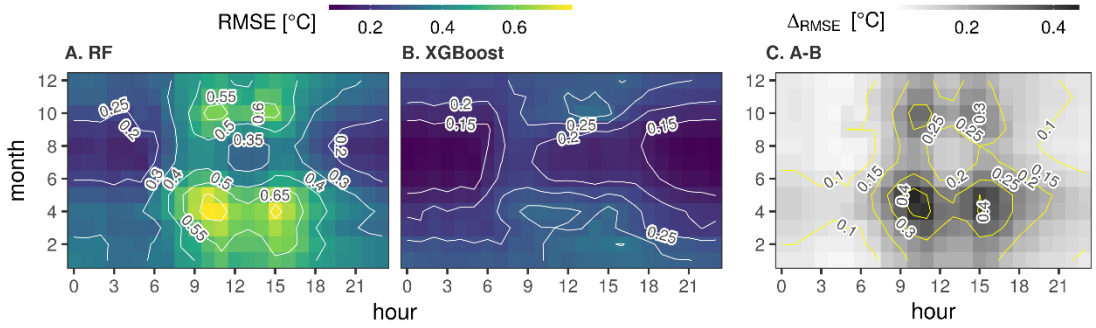

Figure S2 Spatial RMSE disaggregated by month and hour for RF (a) and XGBoost (b), and their difference (c, RF-XGBoost) in Stage 1.

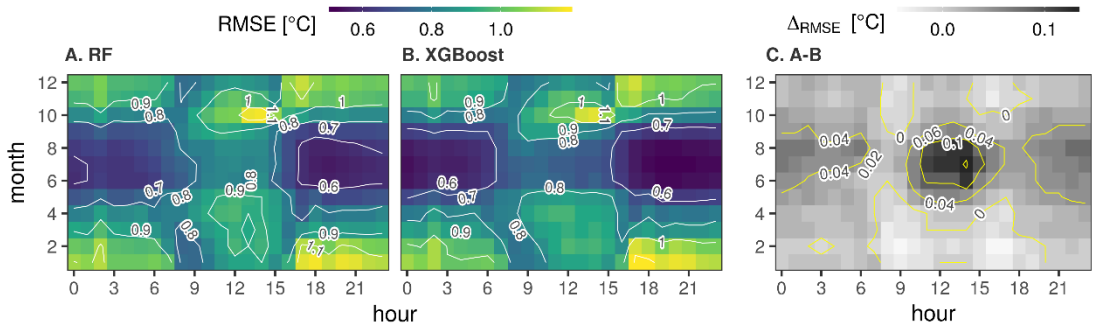

Figure S3 Temporal RMSE disaggregated by month and hour for RF (a) and XGBoost (b), and their difference (c, RF-XGBoost) in Stage 1.

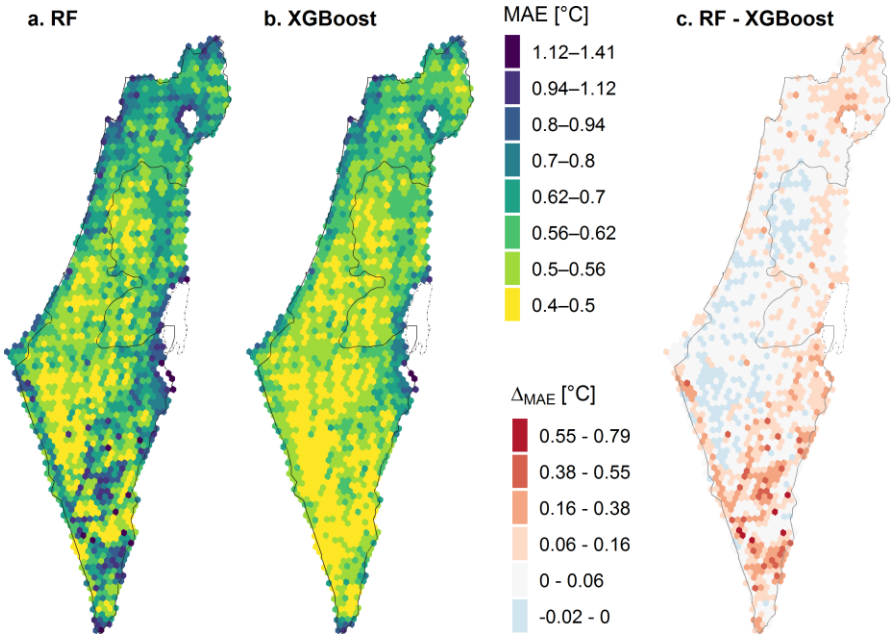

Figure S4 Spatial pattern of multi-annual overall MAE in Stage 1. (a) RF; (b) XGBoost; (c) their difference (RF-XGBoost).

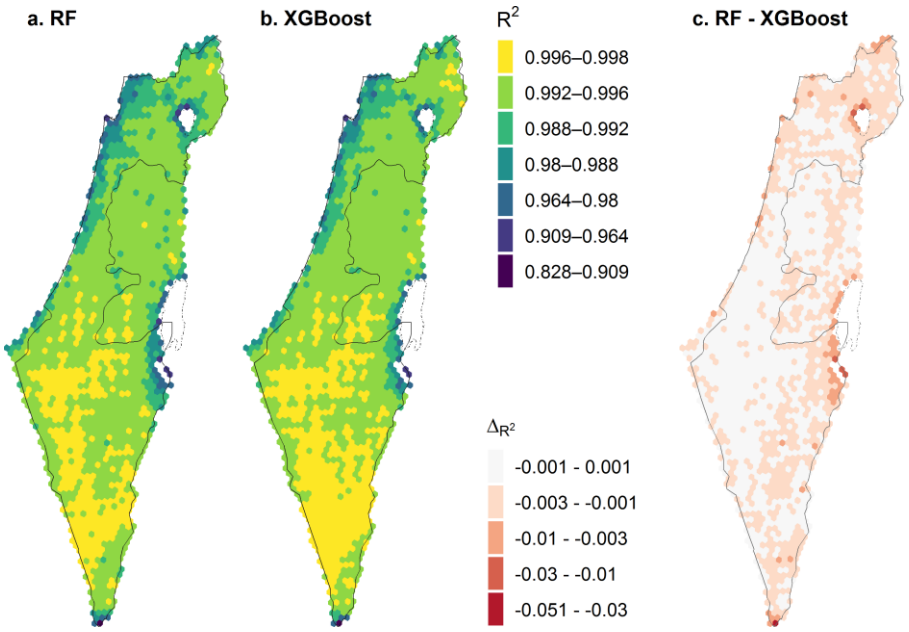

Figure S5 Spatial pattern of multi-annual overall R^2 in Stage 1. (a) RF; (b) XGBoost; (c) their difference (RF-XGBoost)..

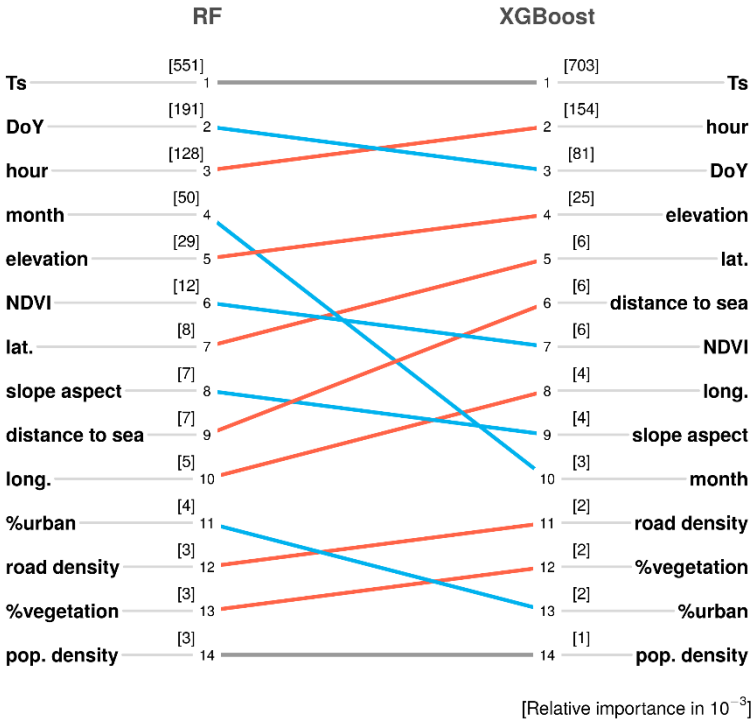

Figure S6 Importance of features incorporated in the Stage 2 models and the relative ranking changes of each feature between the random forest (RF) and extreme gradient boosting (XGBoost). The value in brackets denotes the relative feature importance for each model with a scaling factor of 10^{-3}.

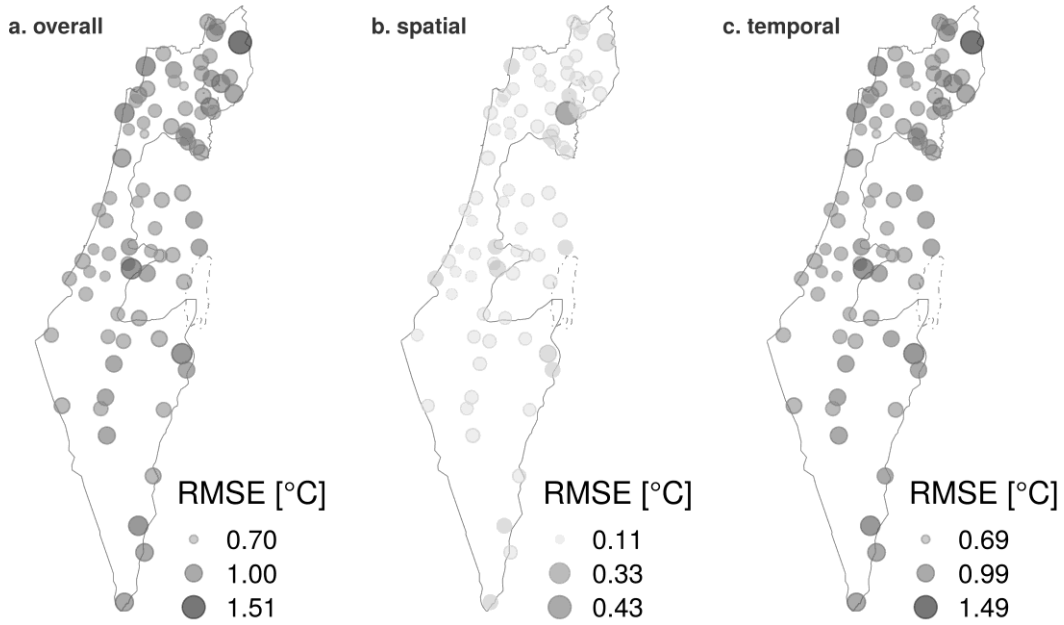

Figure S7 Overall, spatial and temporal RMSE of *Ta* estimated using GAM based on 5-fold cross-validation for each station.

References

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