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Supplement of

Building a machine learning surrogate model for wildfire activities within a global Earth system model

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Supplementary Material

Table S1. Burned area datasets used in this study

Dataset name	Temporal range	Spatial resolution	Burned area, mean (std)	Citations
GFEDv4s	1997-2015	0.25 degree	455(39)	(Van Der Werf, Randerson et al. 2017)
Fire_CCI51	2001-2019	0.25 degree	476(26)	(Lizundia-Loiola, Otón et al. 2020)
Fire_CCILT11	1982-2018	0.25 degree	484(20)	(Lizundia-Loiola, Pettinari et al. 2018)
MCD64	2001-2019	0.25 degree	424(35)	(Giglio, Boschetti et al. 2018)
Fire_Atlas	2003-2016	0.25x0.25 degree	459(43)	(Andela, Morton et al. 2019)

Note: the long-term average global burned area was calculated using data with the same overlapping temporal range (2003-2015), unit Mha yr^{-1}

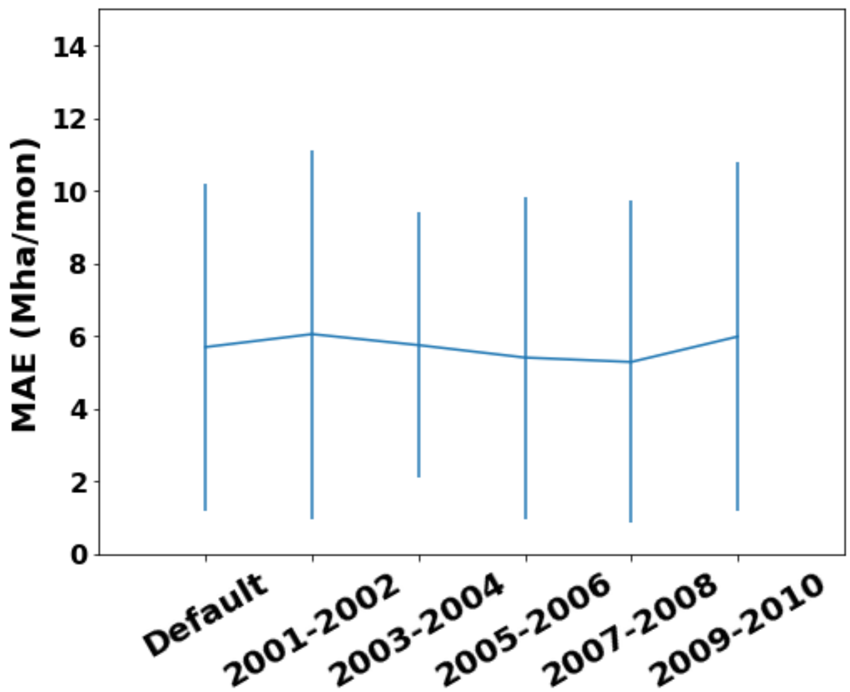

Figure S1. Model performance evaluated with testing datasets of default (20% randomly selected samples), or fixed to 2001-2002 period, 2003-2004 period, 2005-2006 period, 2007-2008 period, and 2009-2010 periods (the rest of the dataset was used as a training dataset.).

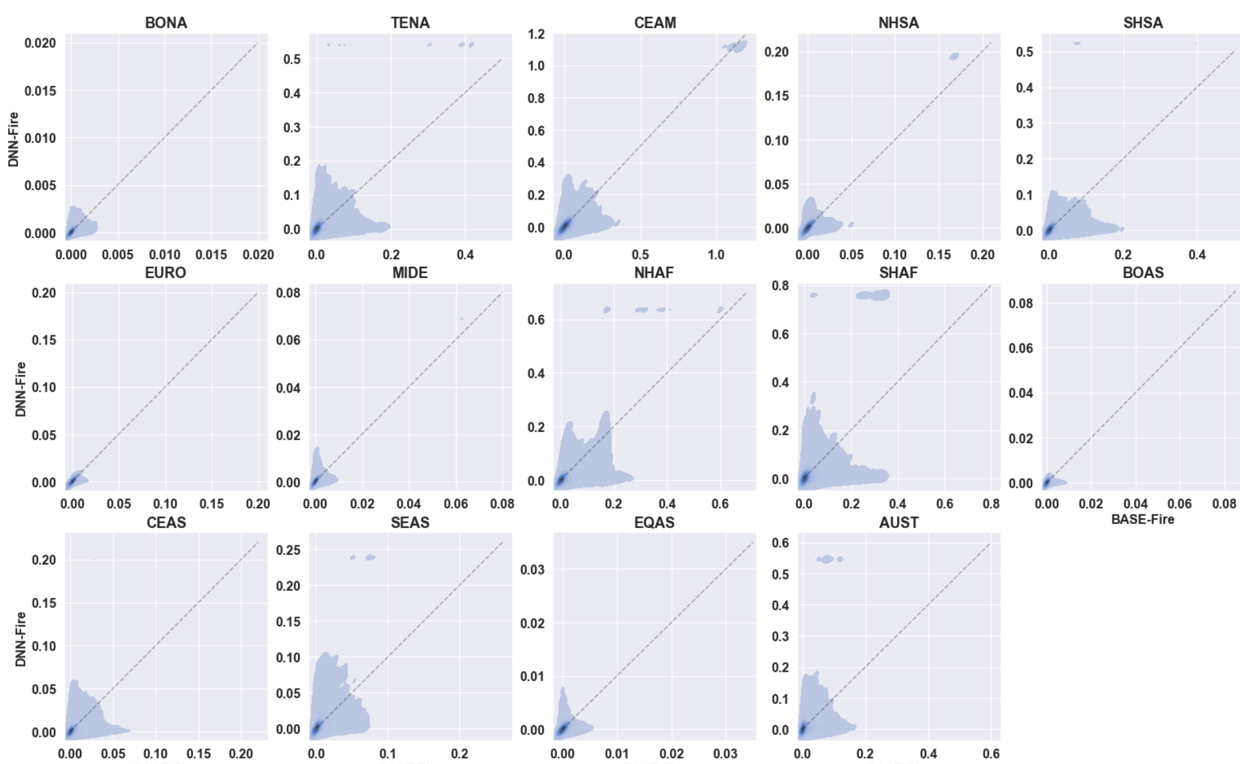

Figure S2. Performance of surrogate model (DNN-Fire) compared with ELMv1 process-based model (BASE-Fire).

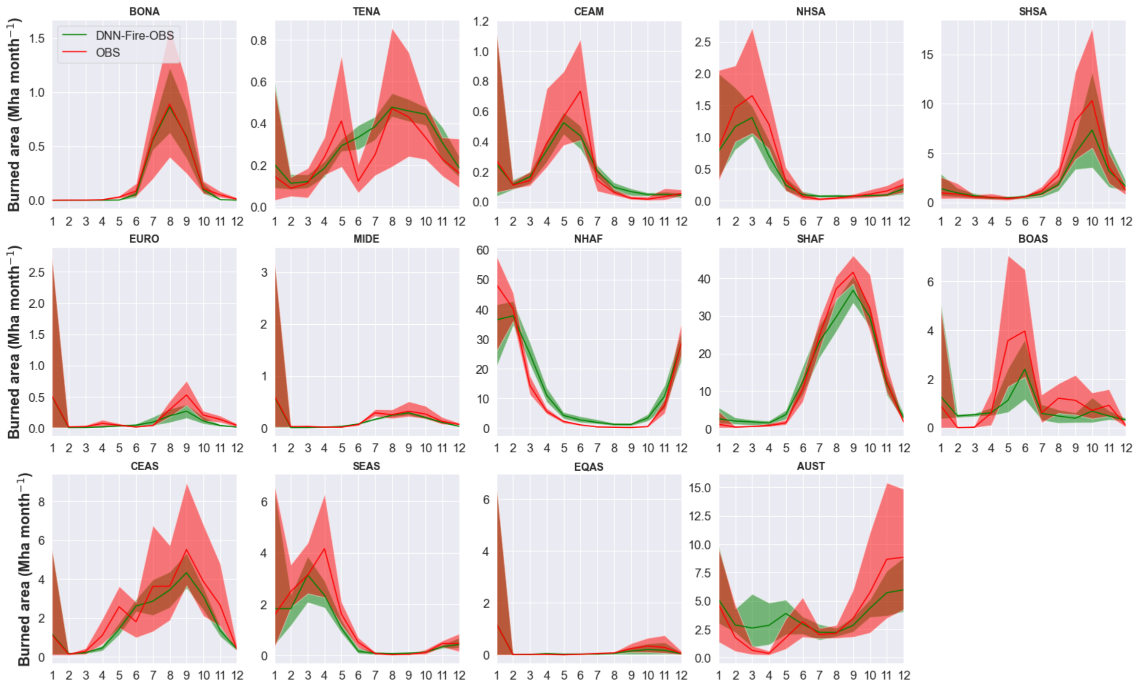

Figure S3. Seasonal cycles of fine-tuned Deep Neural Network wildfire model (DNN-Fire-OBS) and observations over 14 GFED fire regions.

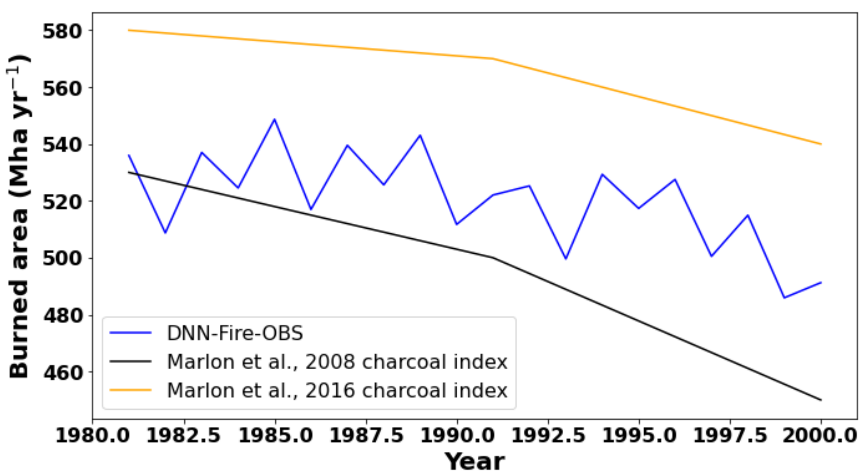

Figure S4. Comparison of DNN-Fire-OBS model simulated global burned area during 1981-1999 with two charcoal index inferred burned area.

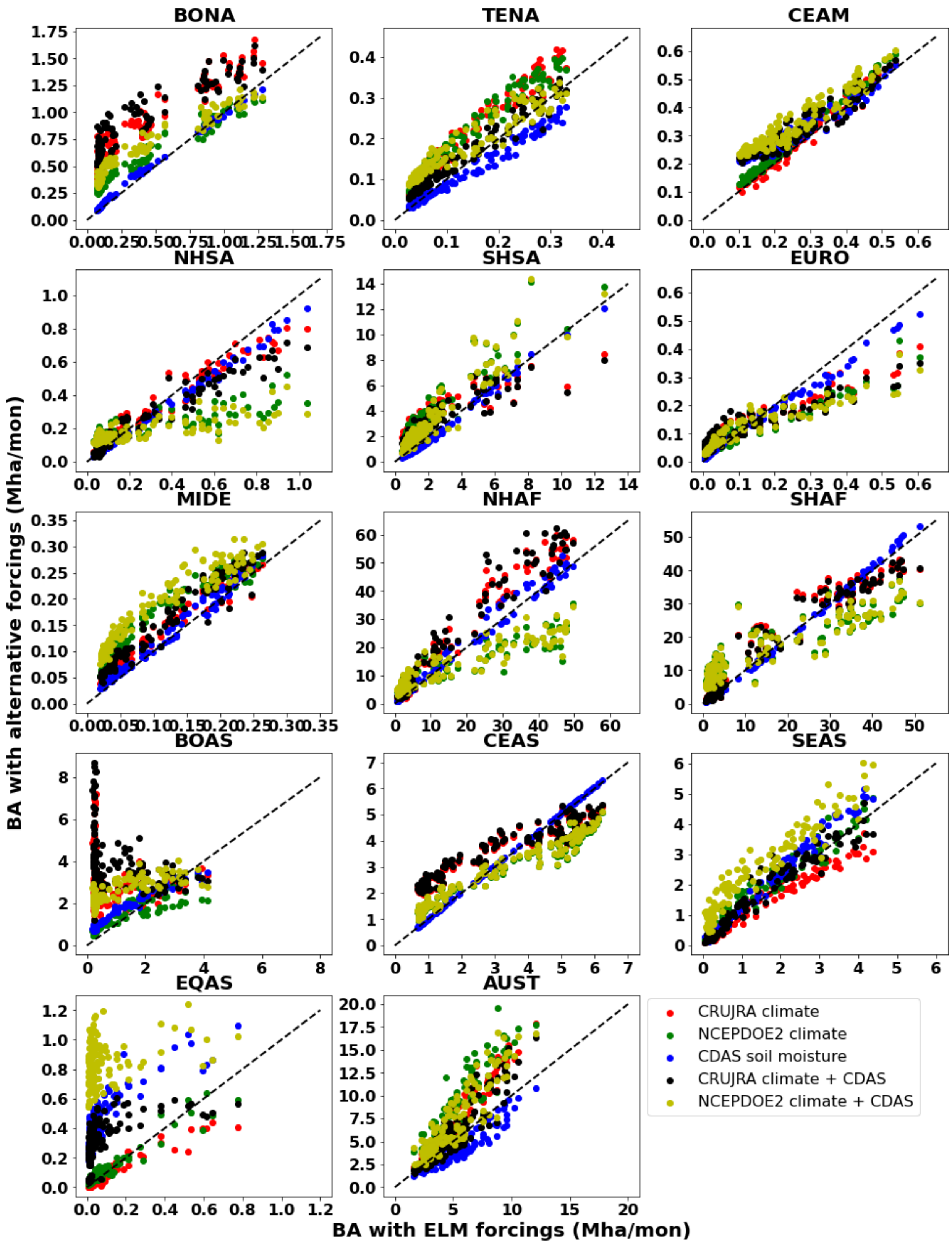

Figure S5. Sensitivity of modeled burned area (2001-2010 long-term averaged) to climate forcings (including temperature, precipitation, wind speed, relative humidity) and soil moisture.

X-axis was burned area simulated by the default model using GSWP3 climate forcing and ELMv1 simulated soil moisture. Y-axis were models with alternative climate forcing (CRUJRA, NCEPDOE2) and soil moisture product (NCEP CDAS soil moisture).

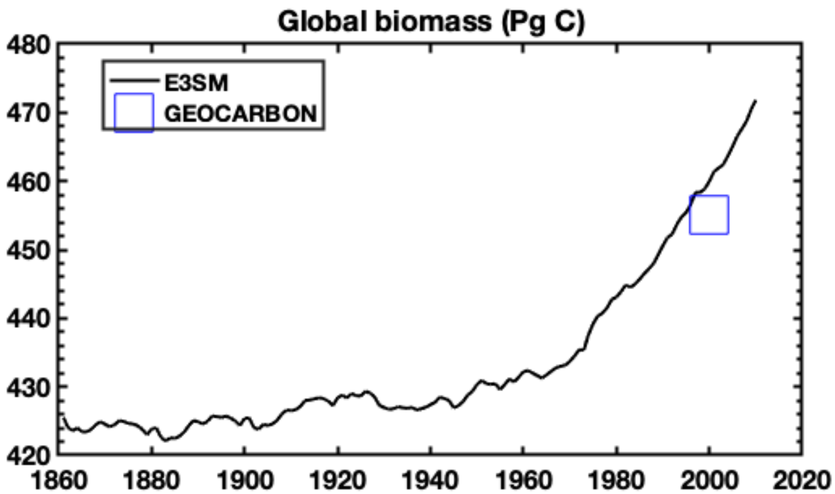

Figure S6. 3SM simulated global vegetation biomass [425-472 PgC] and observational based estimate of present-day living biomass (455 PgC GEOCARBON).

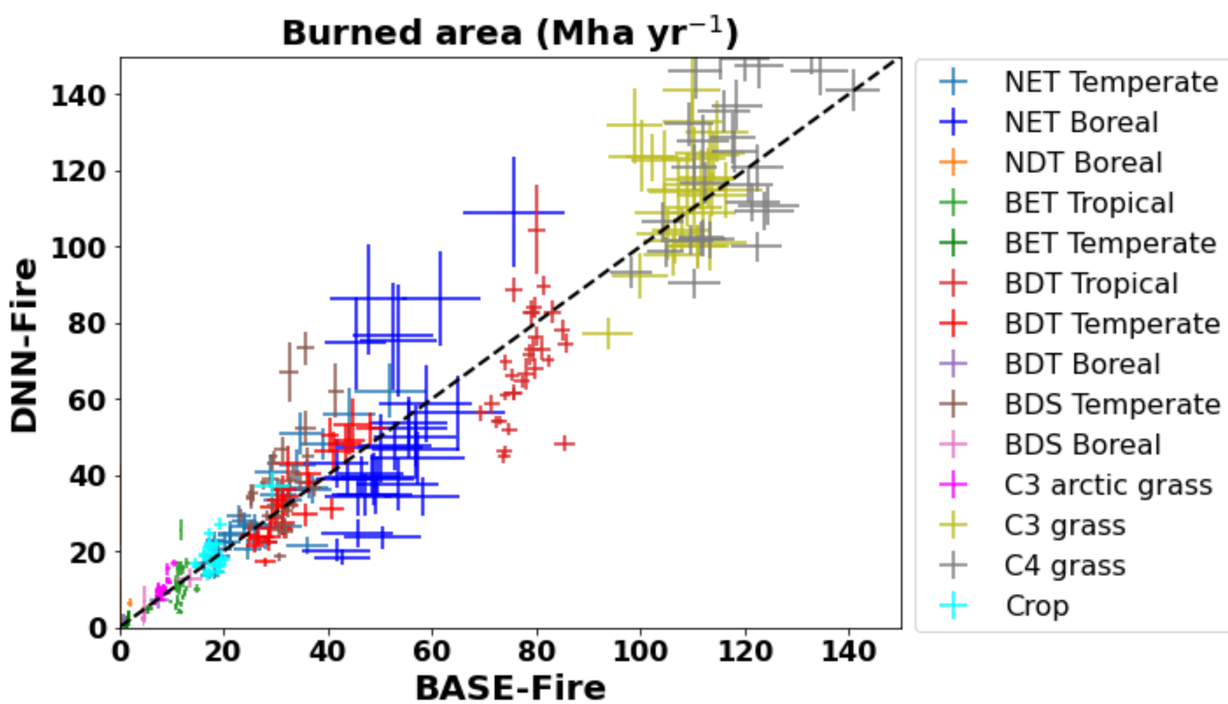

Figure S7. The performance of the Deep Neural Network wildfire model (DNN-Fire), compared with the original ELMv1 process-based wildfire model (BASE-Fire) aggregated over 14 plant functional types between years 2001 and 2010.

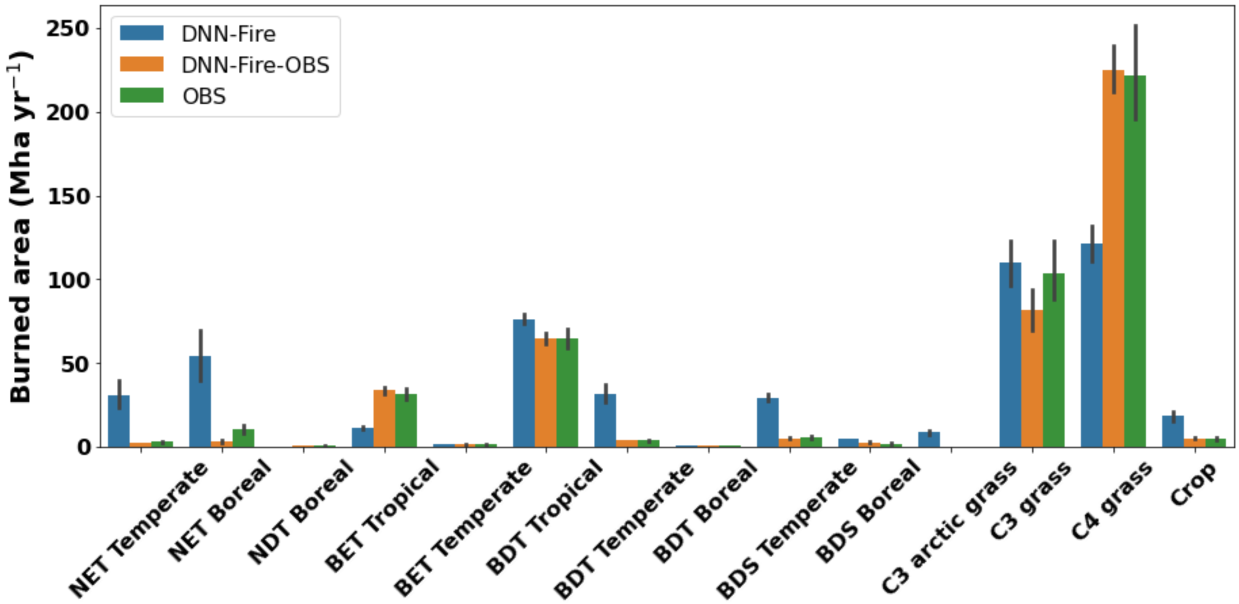

Figure S8. A comparison of wildfire burned area among Deep Neural Network wildfire model (DNN-Fire), Deep Neural Network wildfire model fine-tuned with observed burned area (DNN-Fire-OBS), and observations for 14 plant functional types.