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Supplement of

Multiscale assessment of North American terrestrial carbon balance

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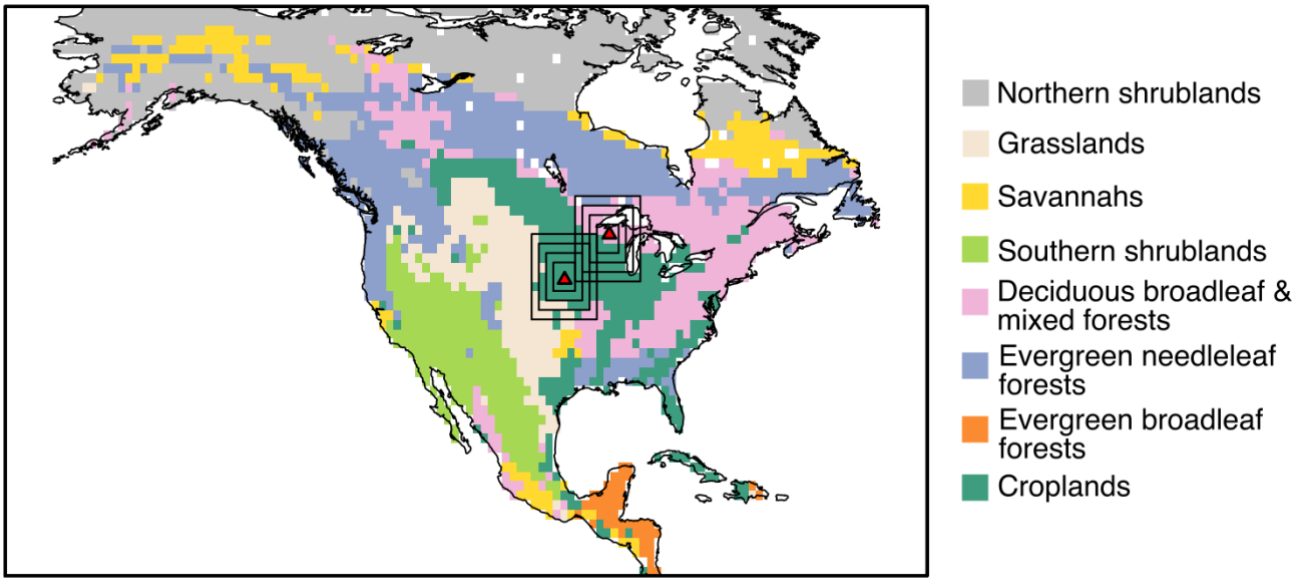

Figure S1: Map of biomes in North America with the locations of two continuous-monitoring towers and outlines visualizing the regions where consistency is evaluated. Red triangles represent locations of towers with high temporal coverage where there are also eddy covariance flux towers nearby. The innermost outlined boxes around each red triangle represents the 3° x 3° box, centered on the 1° x 1° grid cell, where consistency is evaluated by determining whether the TBM or inversion ensemble has the smaller standard deviation across all models within each ensemble. The remaining consecutive outlined boxes represent the 5° x 5°, 7° x 7°, and 9° x 9° scales where consistency is also evaluated.

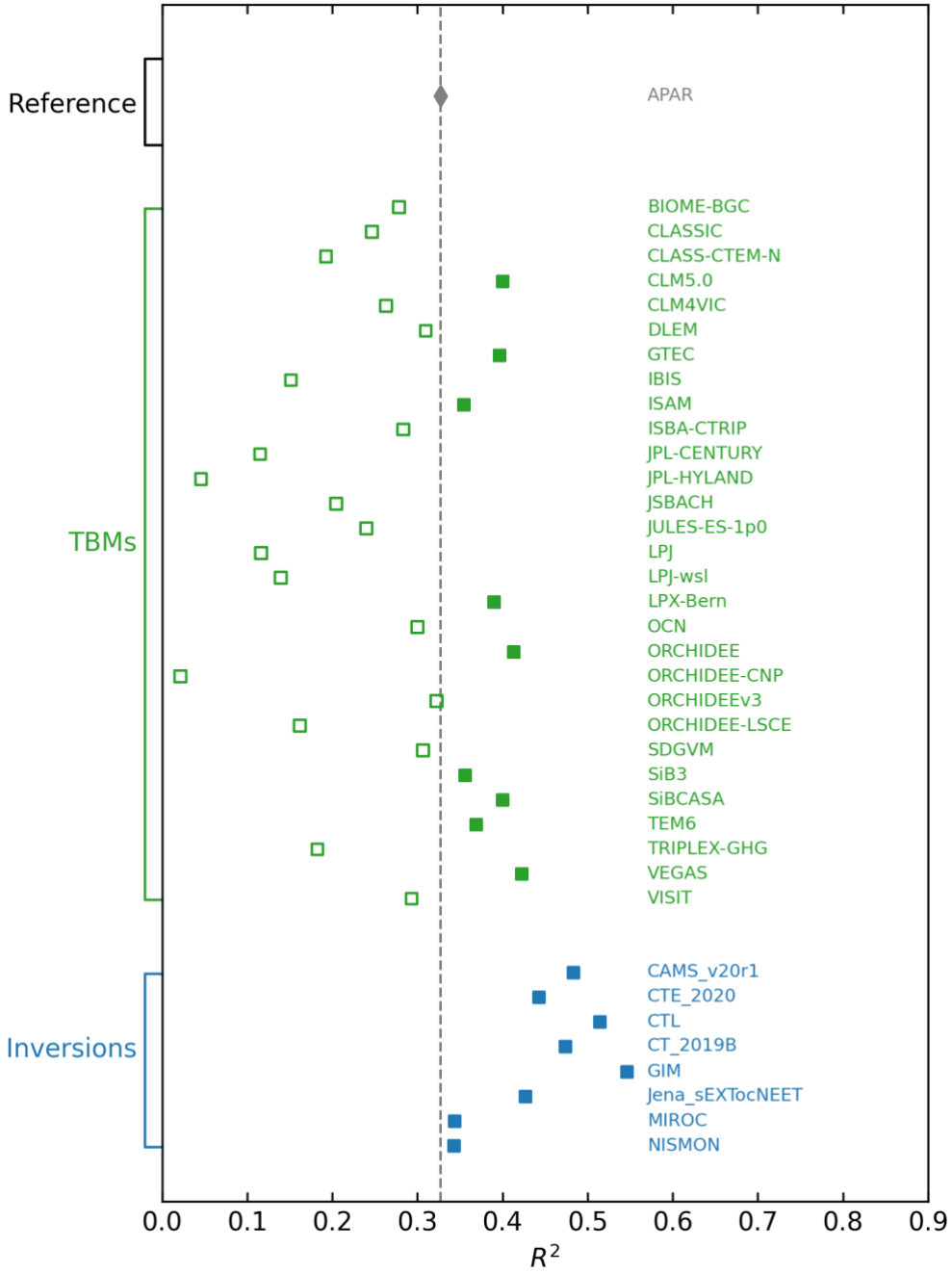

Figure S2: The fraction of variance in atmospheric 3-hourly CO_2 explained by monthly mean fluxes (R^2). Filled squares represent models with an R^2 greater than APAR's R^2.

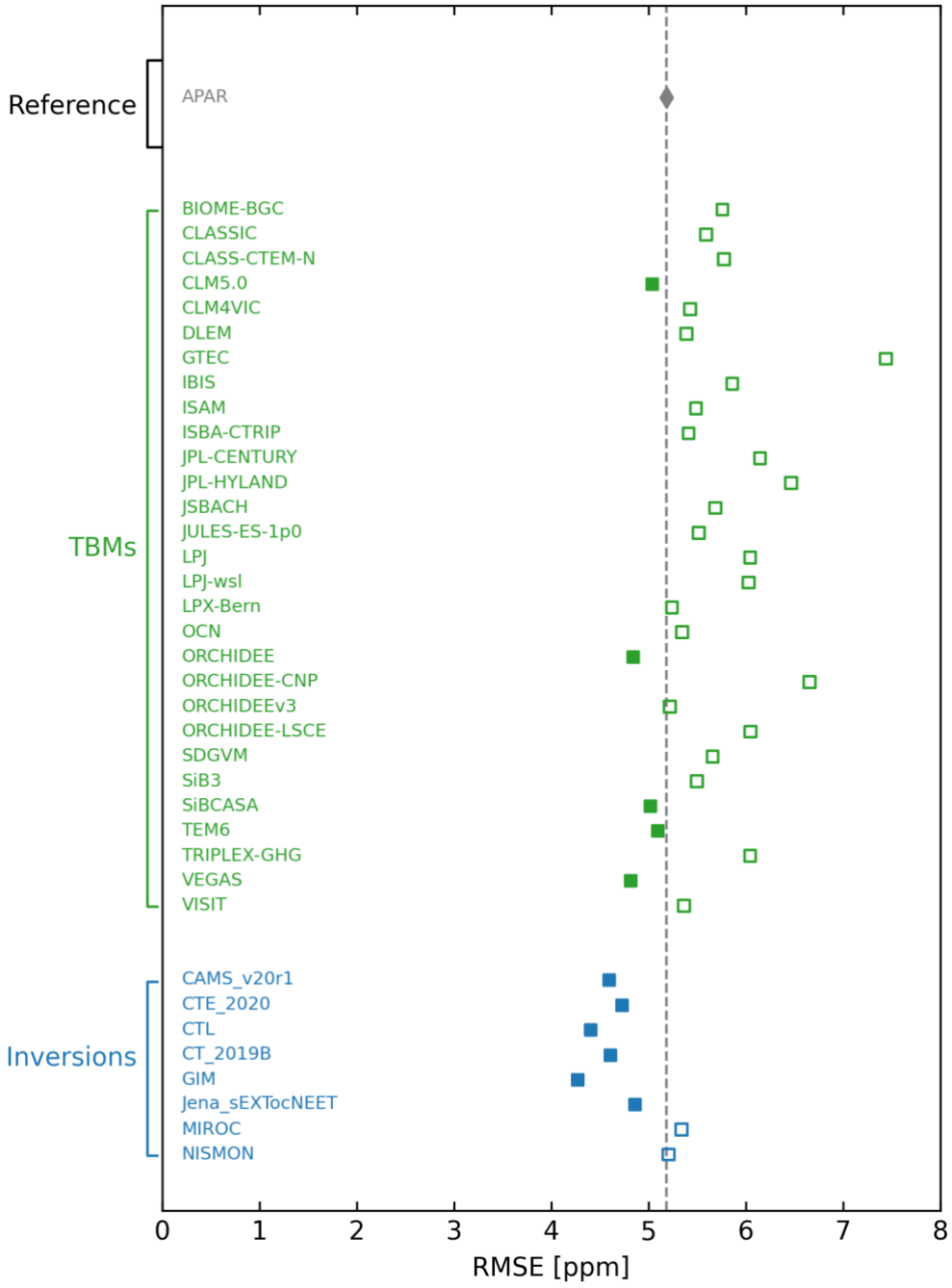

Figure S3: The root mean squared error (RMSE) between measured atmospheric 3-hourly CO_2 and modeled monthly CO_2 signals. Filled squares represent models that have a smaller RMSE than the RMSE of rescaled APAR.

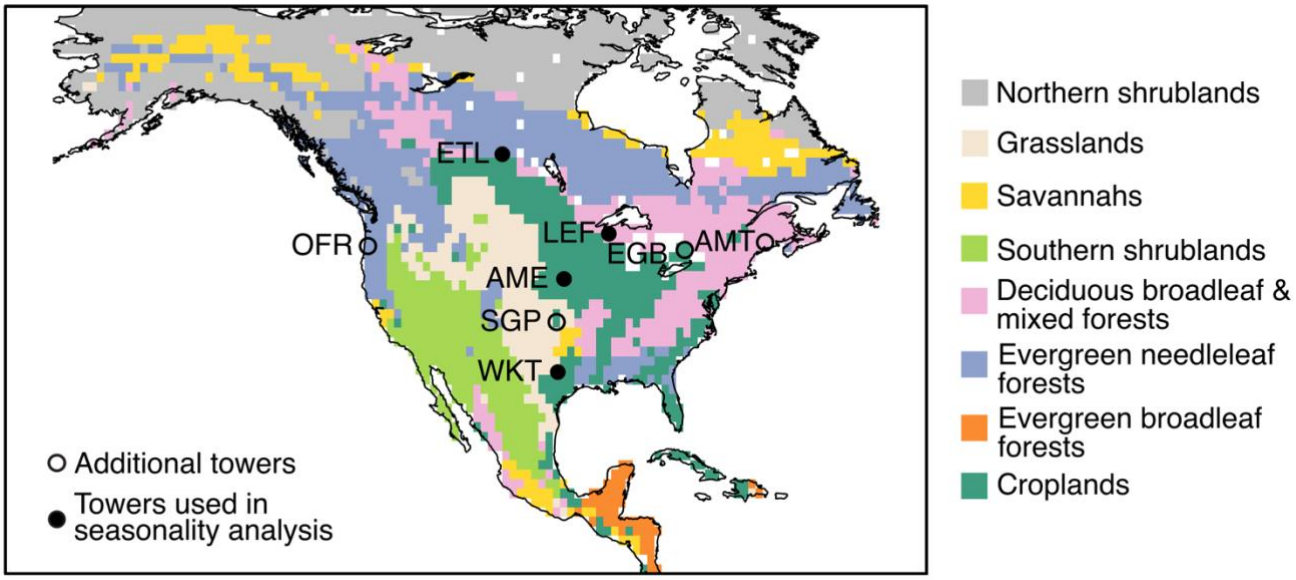

Figure S4: Location of towers used in the seasonality analysis. Towers used in the seasonality analysis are marked with a filled circle. The additional towers that are selected when the tower selection criteria are loosened are marked with empty circles.

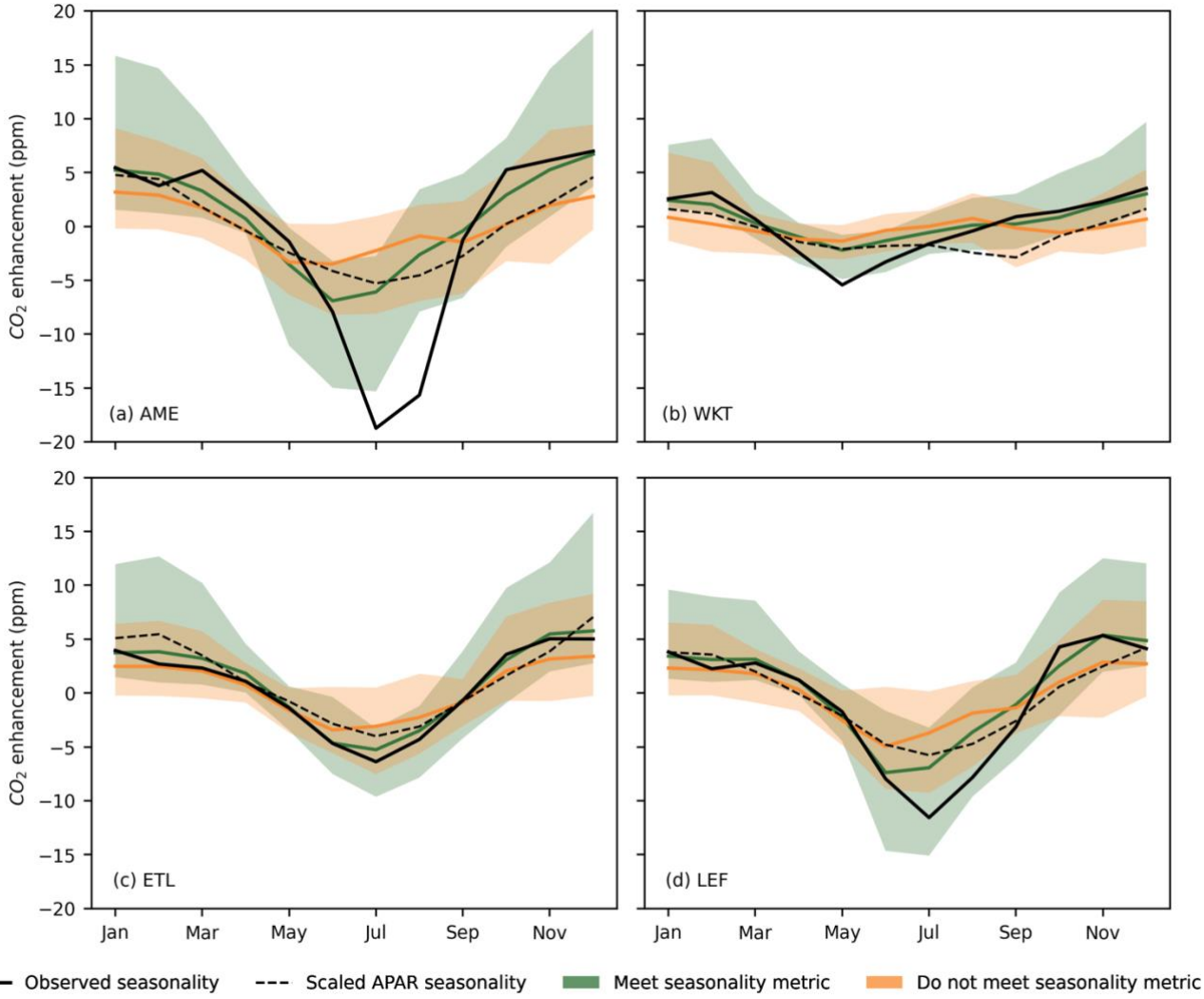

Figure S5: Monthly averaged seasonal cycles of observed CO_2 enhancements and CO_2 enhancements resulting from modeled carbon fluxes from TBMs. The black line represents the seasonality observed at each tower site and the dotted line is the seasonality of rescaled APAR (see Sect. 2.3). The green line is the mean of models that meet the seasonality metric (i.e., at least two of the seasonality sub-metrics) at all four sites and the green shading represents the full range of these estimates. The orange line is the mean of models that do not meet the seasonality metrics at all four sites and the orange shading represents the full range of these estimates.

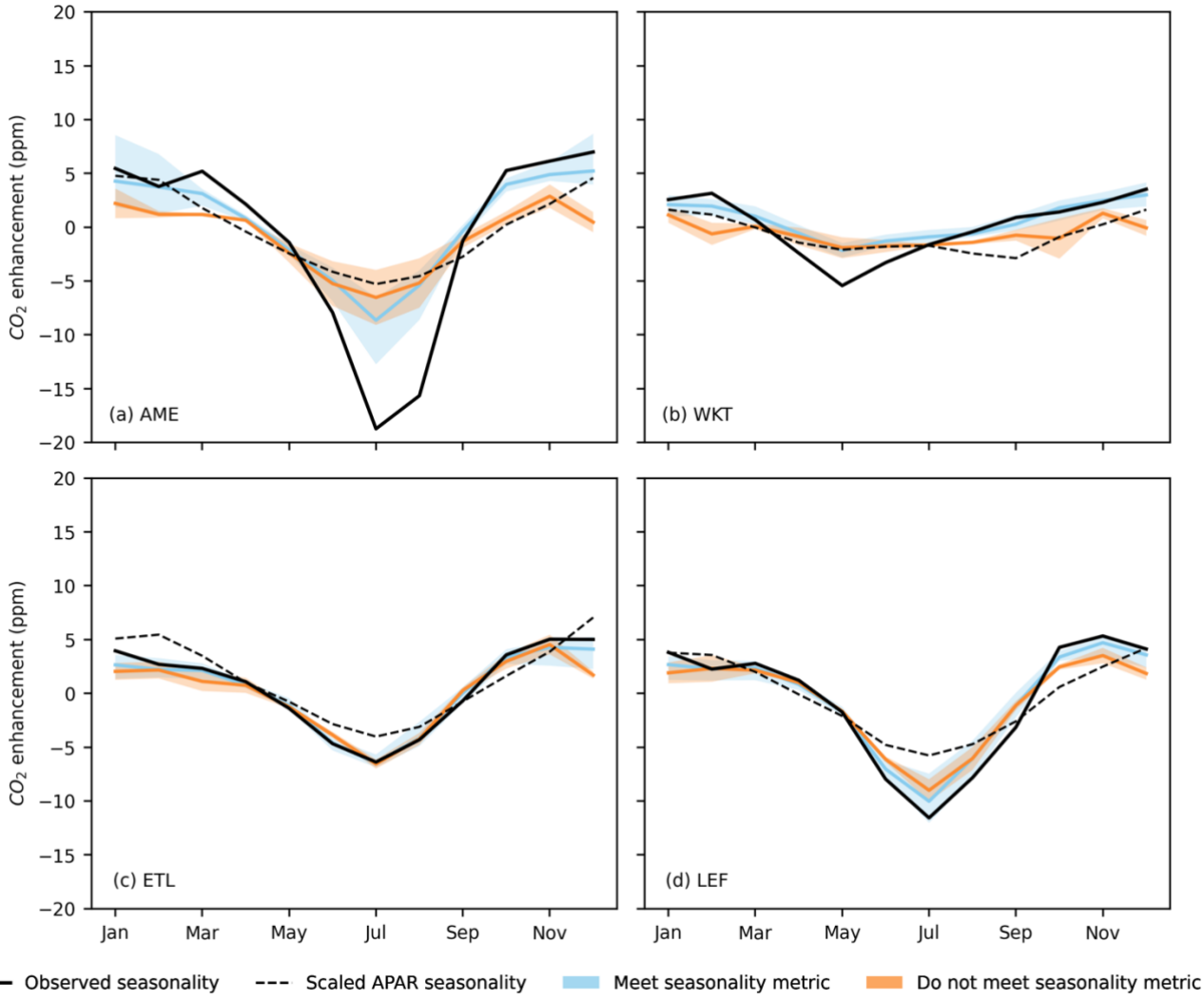

Figure S6: Monthly averaged seasonal cycles of observed CO_2 enhancements and CO_2 enhancements resulting from modeled carbon fluxes from inversions. The black line represents the seasonality observed at each tower site and the dotted line is the seasonality of rescaled APAR (see Sect. 2.3). The blue line is the mean of models that meet the seasonality criteria (i.e., at least two of the seasonality sub-metrics) at all four sites and the blue shading represents the full range of these estimates. The orange line is the mean of models that do not meet the seasonality metrics at all four sites and the orange shading represents the full range of these estimates.

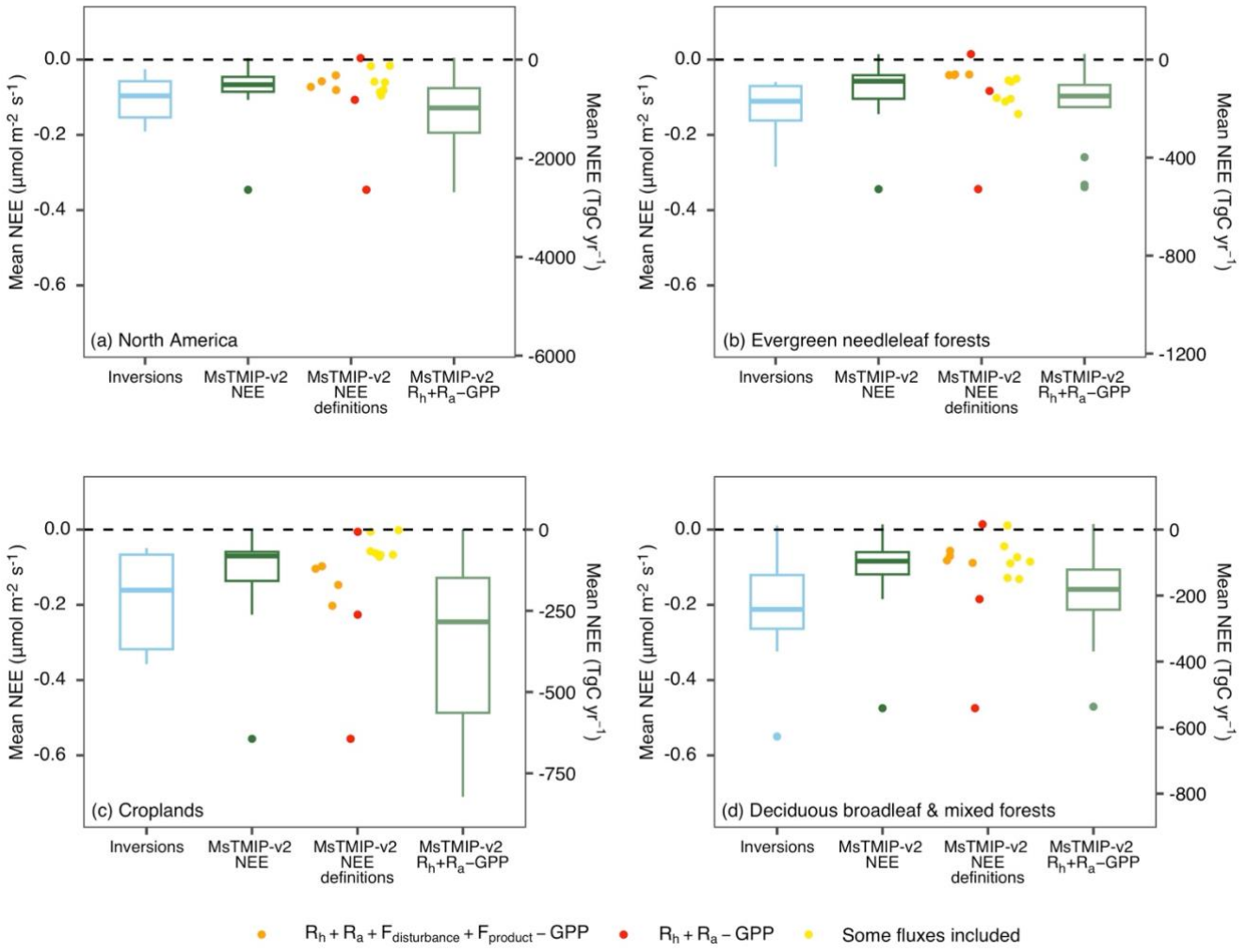

Figure S7: The impact of using consistent definitions of NEE for MsTMIP-v2 models on ensemble spread and agreement with inversions. The MsTMIP-v2 models are a subset of the full set of TBMs used to evaluate consistency. Only MsTMIP-v2 models are included here because the data needed to do this analysis is provided with the MsTMIP-v2 data. The colored points represent differences in how models define NEE with orange points representing NEE = $R_h + R_a + F_{disturbance} + F_{product} – GPP$, red points representing NEE = $R_h + R_a – GPP$, and yellow points representing models that include some fluxes from the full definition beyond R_h, R_a, and GPP (see Sect. 2.1.1), but not all. JPL-CENTURY, JPL-HYLAND, and CLASS-CTEM-N+ were excluded due to missing data or not passing our quality control. CLM, ISAM, and VISIT were included even though they are not included in the TBM superensemble for a more robust analysis.

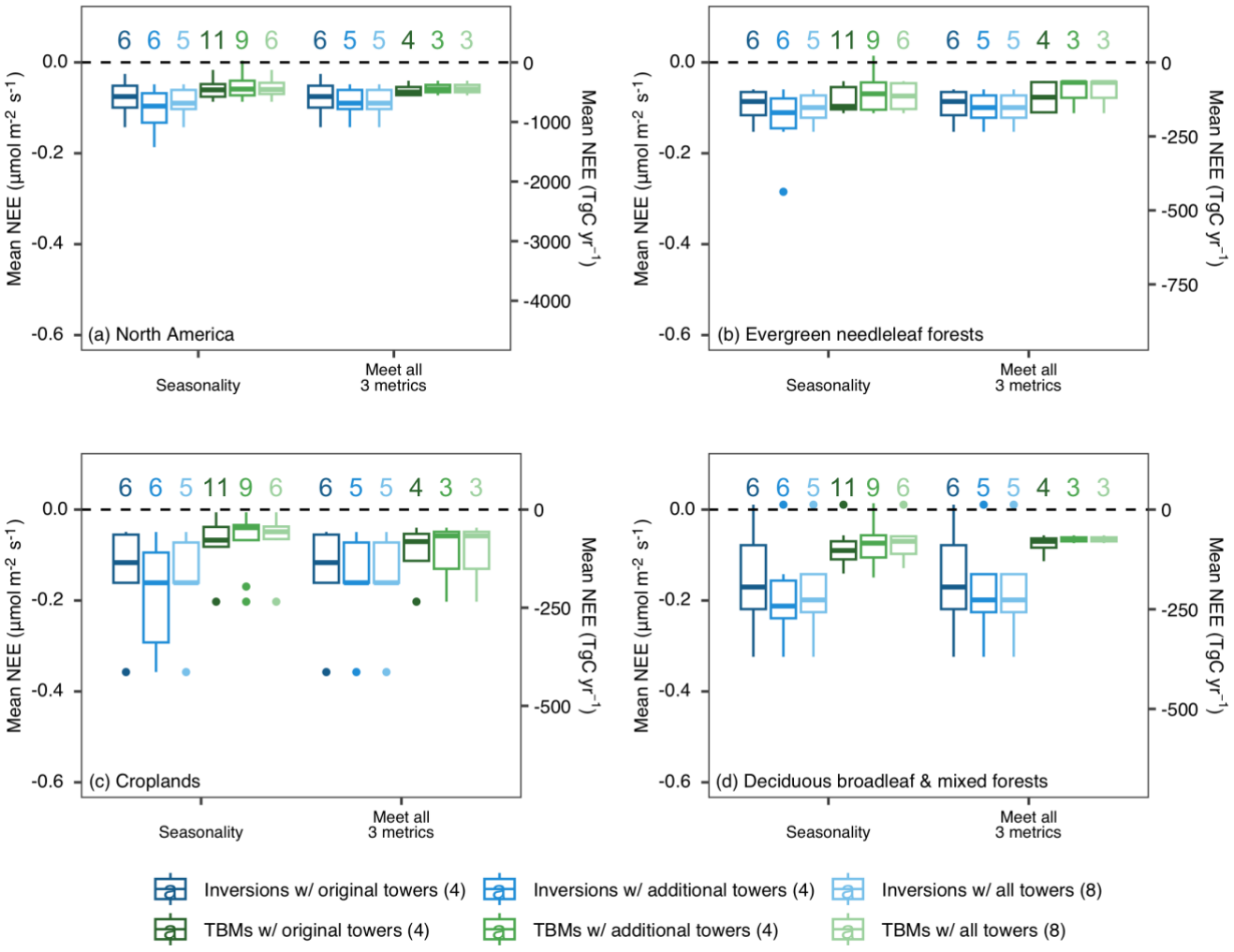

Figure S8: Boxplots showing the impact on consistency and agreement when different towers are used to calculate the seasonality metrics for North America and the three biomes with largest data availability. Boxplots for inversions are in shades of blue and boxplots for TBMs are in shades of green. From left to right, the boxplots are ordered as inversions that meet the seasonality metric when the original four towers are included (AME, WKT, ETL, and LEF), when only the four additional towers are included (SGP, OFR, AMT, and EGB), and when all eight towers are included (AME, WKT, ETL, LEF, SGP, OFR, AMT, and EGB). The same ordering applies for TBMs. Numbers above each boxplot indicate the number of models used to create each boxplot.

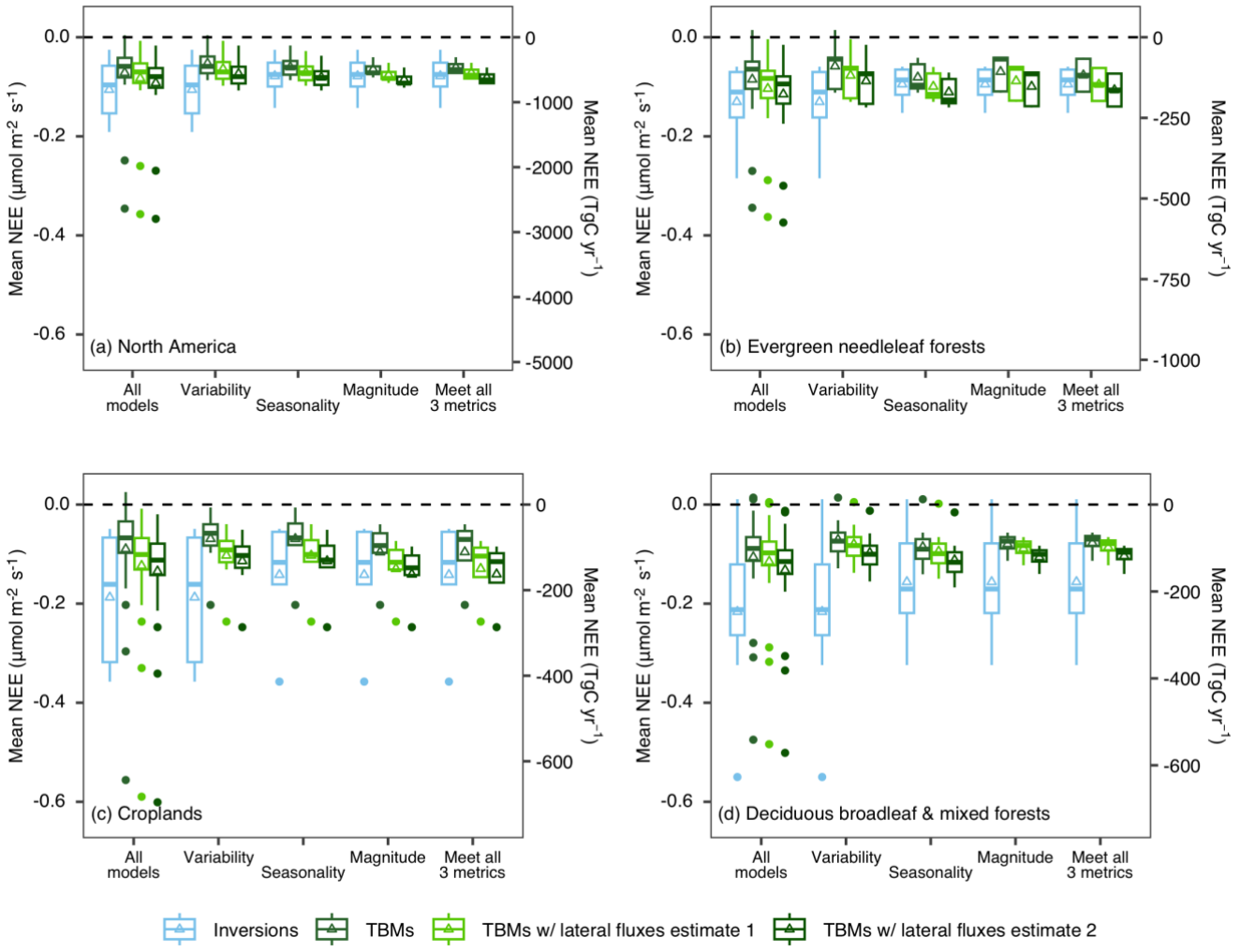

Figure S9: Boxplots showing the agreement between bottom-up and top-down models when lateral fluxes are included. The boxplots of inverse models are shown in blue and boxplots for TBMs are shown in shades of green. Green boxplots represent TBMs without the addition of lateral fluxes. Light green boxplots represent TBMs with the addition of gridded lateral fluxes from Byrne et al., (2022). Dark green boxplots represent TBMs with a second estimate of lateral fluxes added, which was obtained by scaling the gridded fluxes to the North American regional total in Byrne et al., (2023). The order of the boxplots from left to right are inversions, TBMs without lateral fluxes added, TBMs with gridded lateral fluxes added, and TBMs with gridded lateral fluxes scaled to the North American regional total added.

Table S1: Tower sites for atmospheric CO_2 observations from ObsPack CO_2 GLOBALVIEWplus v3.2.

Site Name	Site Location	Latitude	Longitude	Height (m)	Principal Investigators
AAC	Austin Cary Memorial Forest, Gainesville, FL, USA	29.7381	-82.2188	32	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
ACR	Chestnut Ridge, TX, USA	35.9311	-84.3324	61	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
ACV	Canaan Valley, WV, USA	39.119	-79.4523	7	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
AME	Mead, NE, USA	41.1649	-96.4701	4.5	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
AMT	Argyle, ME, USA	45.0346	-68.6821	107	Arlyn Andrews (NOAA)
AOZ	Ozark, MO, USA	38.7441	-92.2	30	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
BAO	Boulder Atmospheric Observatory, CO, USA	40.05	-105.004	300	Arlyn Andrews (NOAA)
BCK	Behchoko, NT, Canada	62.7979	-115.918	60	Doug Worthy (EC)
BRA	Bratt's Lake, SK, Canada	50.2016	-104.711	35	Doug Worthy (EC)
BRW	Barrow Atmospheric Baseline Observatory, AK, USA	71.323	-156.6114	16.46	Kirk Thoning and Pieter Tans (NOAA)
CDL	Candle Lake, SK, Canada	53.9871	-105.1179	30	Doug Worthy (EC)
CHM	Chibougamau, QC, Canada	49.6925	-74.3423	30	Doug Worthy (EC)
EGB	Egbert, ON, Canada	44.231	-79.7838	3	Doug Worthy (EC)
ESP	Estevan Point, BC, Canada	49.3829	-126.544	40	Doug Worthy (EC)
EST	Esther, AB, Canada	51.67	-110.206	3	Doug Worthy (EC)
ETL	East Trout Lake, SK, Canada	54.3537	-104.987	105	Doug Worthy (EC)
FPK	Fort Peck, MT, USA	48.3079	-105.1017	3	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
FSD	Fraserdale, ON, Canada	49.8752	-81.5698	40	Doug Worthy (EC)

HDP	Hidden Peak, UT, USA	40.56	-111.65	17.7	Britton Stephens (NCAR)
HFM	Harvard Forest, MA, USA	42.5378	-72.1714	29	Steve Wofsy and Bill Munger (Harvard)
KCMP	Rosemount Research and Outreach Center, MN, USA	44.6886	-93.0728	200	Tim Griffis (UMN)
LEF	Park Falls, WI, USA	45.9453	-90.2744	396	Arlyn Andrews (NOAA)
LLB	Lac La Biche, AB, Canada	54.9538	-112.467	10	Doug Worthy (EC)
MVY	Martha's Vineyard, MA, USA	41.325	-70.5667	10	Colm Sweeney (NOAA)
NWR	Niwot Ridge, CO, USA	40.0531	-105.5864	5.1	Britton Stephens (NCAR)
OFR	Fir, OR, USA	44.6465	-123.5514	38	Beverly Law (Oregon State) and Andres Schmidt (RWTH Aachen)
OMP	Mary's Peak, OR, USA	44.5043	-123.553	10	Beverly Law (Oregon State) and Andres Schmidt (RWTH Aachen)
OMT	Meolius, OR, USA	44.4524	-121.5572	33	Beverly Law (Oregon State) and Andres Schmidt (RWTH Aachen)
ONG	Burns, OR, USA	43.4704	-119.691	6	Beverly Law (Oregon State) and Andres Schmidt (RWTH Aachen)
OYQ	Yaquina Head, OR, USA	44.675	-124.067	12	Beverly Law (Oregon State) and Andres Schmidt (RWTH Aachen)
RBA	Roof Butte, AZ	36.4614	-109.0956	21.9	Britton Stephens (NCAR)
RCE	Centerville, IA, USA	40.7919	-92.8775	110	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
RGV	Galesville, WI, USA	44.091	-91.3382	140	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
RKW	Kewanee, IL, USA	41.2762	-89.9724	140	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
RMM	Mead, NE, USA	41.1386	-96.4559	120	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
RRL	Round Lake, MN, USA	43.5263	-95.4137	110	Natasha Miles, Scott Richardson, and Ken Davis (PSU)
SCT	Beech Island, SC, USA	33.4057	-81.8334	305	Arlyn Andrews (NOAA) and Matt

					Parker (SRNL)
SGP	Southern Great Plains, OK, USA	36.607	-97.489	60	Sebastien Biraud and Margaret Torn (LBNL)
SNP	Shenandoah National Park, VA, USA	38.617	-78.35	17	Arlyn Andrews (NOAA) and Stephan De Wekker (UVA)
SPL	Storm Peak Laboratory, CO, USA	40.45	-106.73	9.1	Britton Stephens (NCAR)
WBI	West Branch, IA, USA	41.7248	-91.3529	379	Arlyn Andrews (NOAA)
WGC	Walnut Grove, CA, USA	38.265	-121.4911	483	Arlyn Andrews (NOAA) and Marc Fischer (LBNL)
WKT	Moody, TX, USA	31.3149	-97.3269	457	Arlyn Andrews (NOAA)
WSA	Sable Island, NS, Canada	43.9323	-60.0126	25	Doug Worthy (EC)