Model meritocracy based on observations does not reconcile global bottom-up and top-down wetland CH_4 emission estimates

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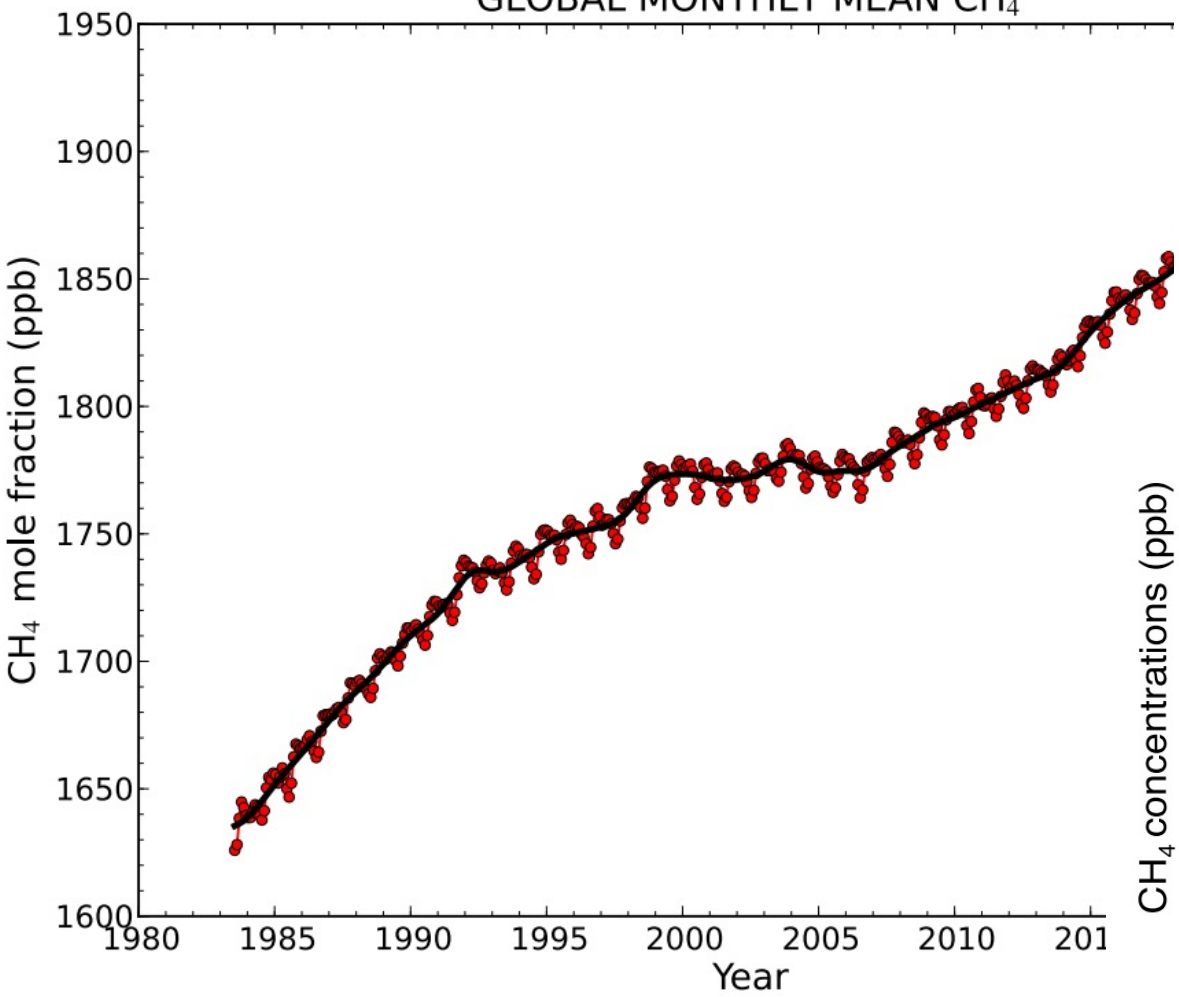
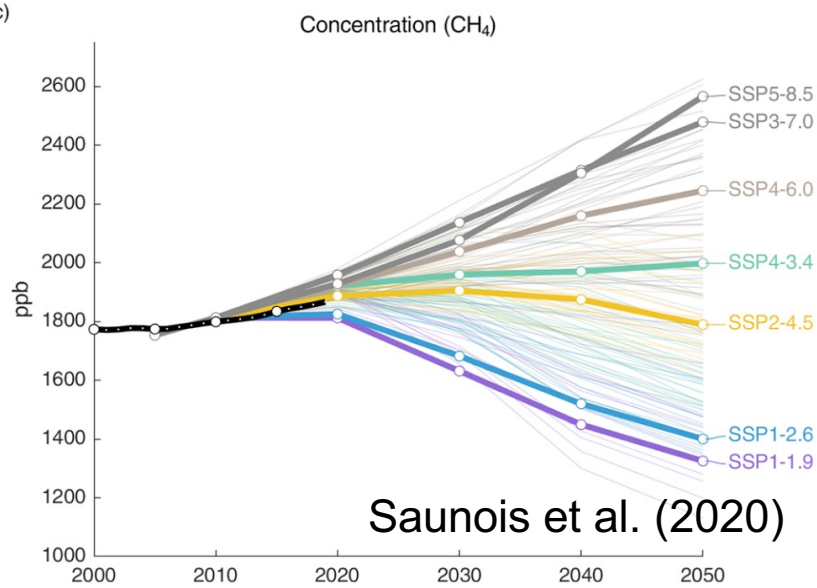
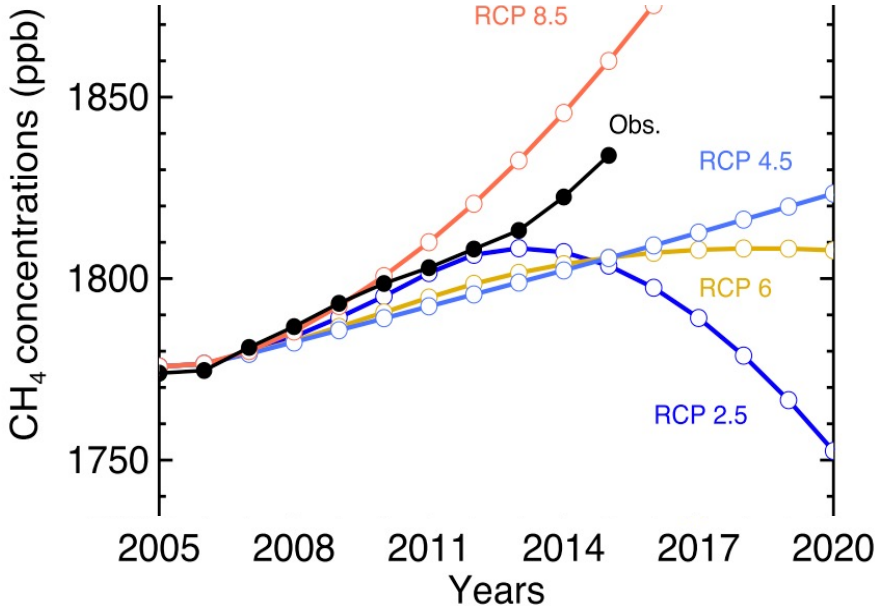
Atmospheric CH_4 concentrations



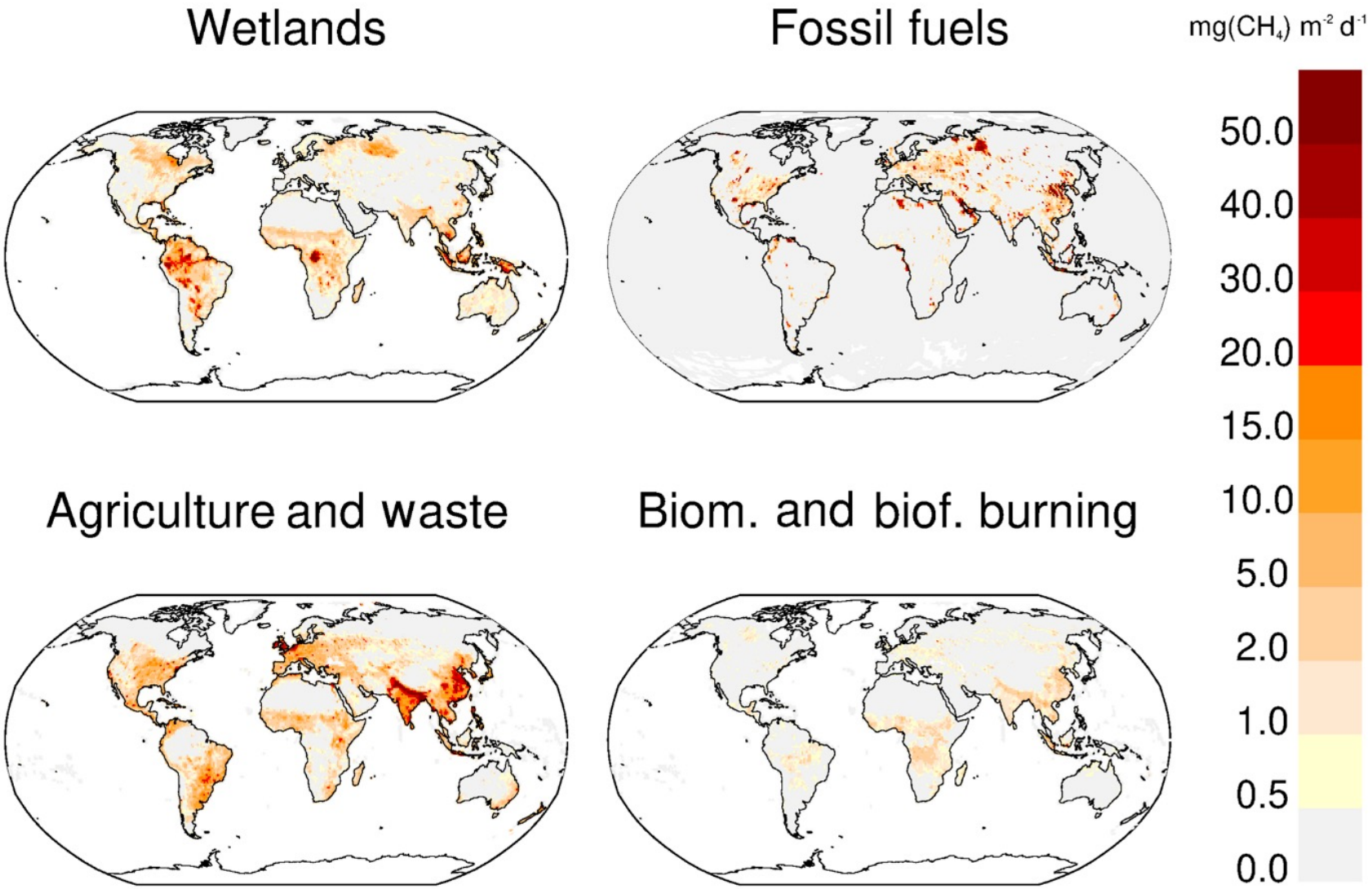


Saunois et al. (2020)



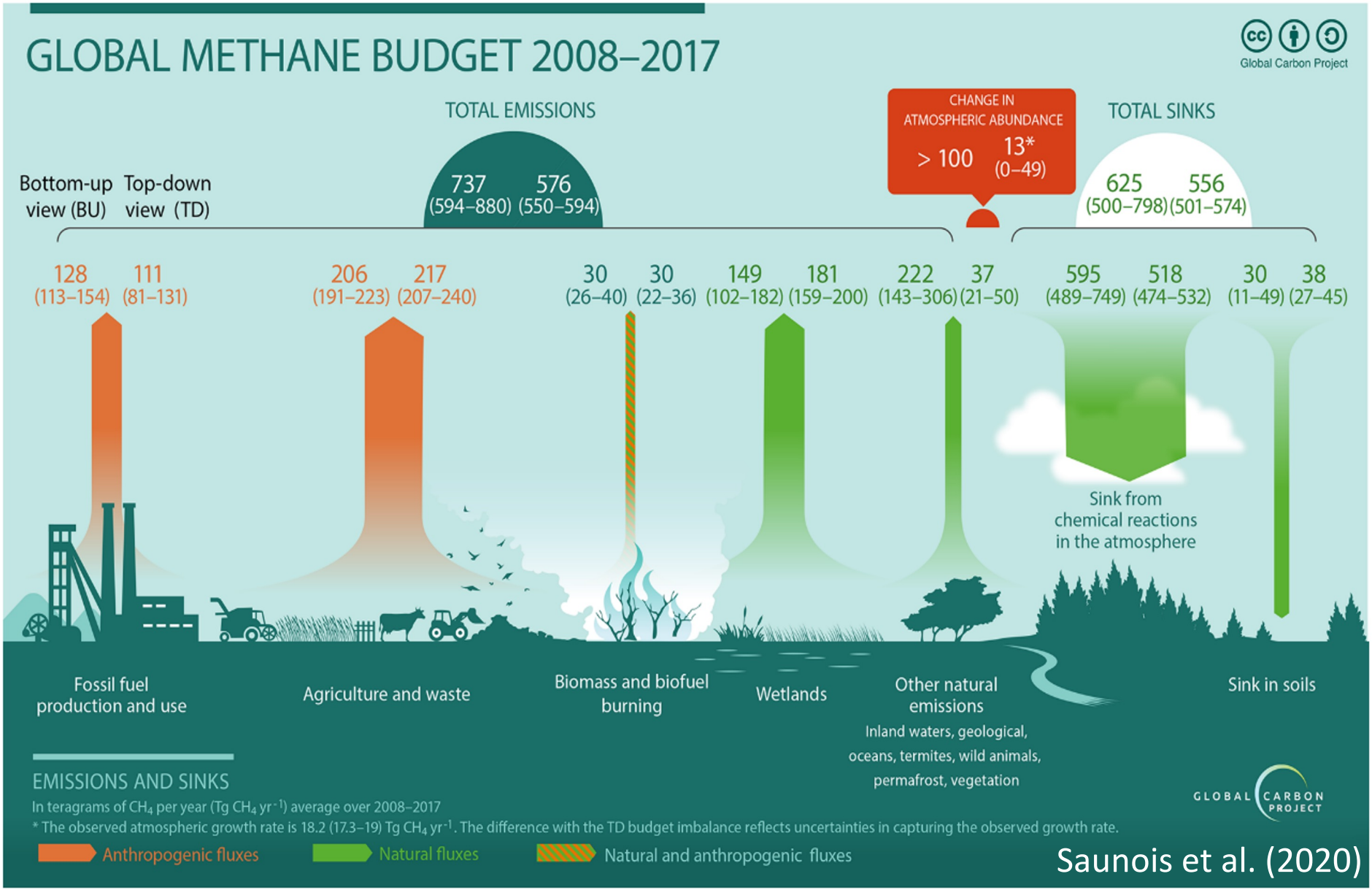
Saunois et al. (2016)

Sources of CH_4 emissions, 2008-2017



Saunois et al. (2020)

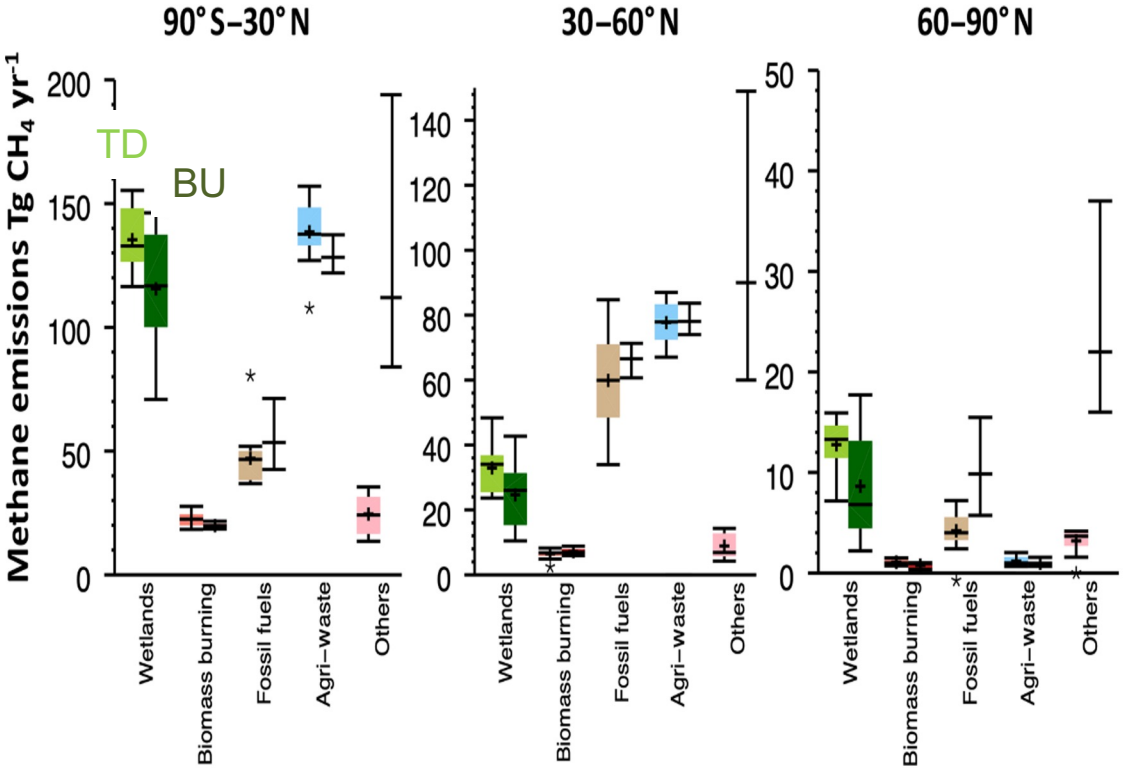
Wetlands are the largest and most uncertain natural CH_4 source



Saunois et al. (2020)

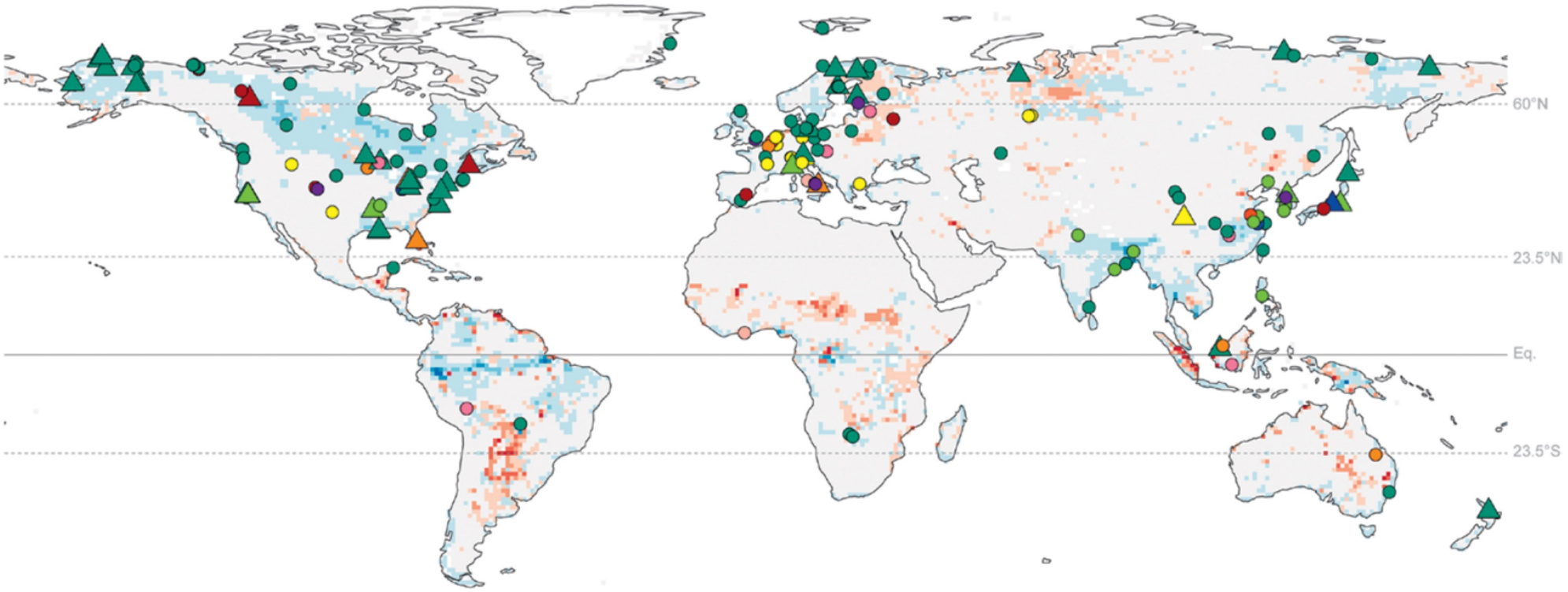
Table 3. Global methane emissions by source type ($Tg\,CH_4\,yr^{-1}$) from Saunois et al. (2016) (left column pair) and for this work using bottom-up and top-down approaches. Because top-down models cannot fully separate individual processes, only five categories of emissions are provided (see text). Uncertainties are reported as the [min–max] range of reported studies. Differences of $1\,Tg\,CH_4\,yr^{-1}$ in the totals can occur due to rounding errors.

	Saunois et al. (2016)		This work					
Period of time	2000–2009		2000–2009		2008–2017		2017	
Approaches	Bottom-up	Top-down	Bottom-up	Top-down	Bottom-up	Top-down	Bottom-up	Top-down
Natural sources	BU – TD = 17				BU – TD = -32			
Wetlands	183 [151–222]	166 [125–204]	147 [102–179]	180 [153–196]	149 [102–182]	181 [159–200]	145 [100–183]	194 [155–217]



Saunois et al. (2020)

FLUXNET-CH_4 Community Product



IGBP Site Types

- Cropland – Other
- Cropland – Rice
- Deciduous Broadleaf Forest
- Evergreen Broadleaf Forest
- Evergreen Needleleaf Forest
- Grassland
- Mixed Forest
- Urban & Built-Up
- Waterbodies
- Permanent Wetlands

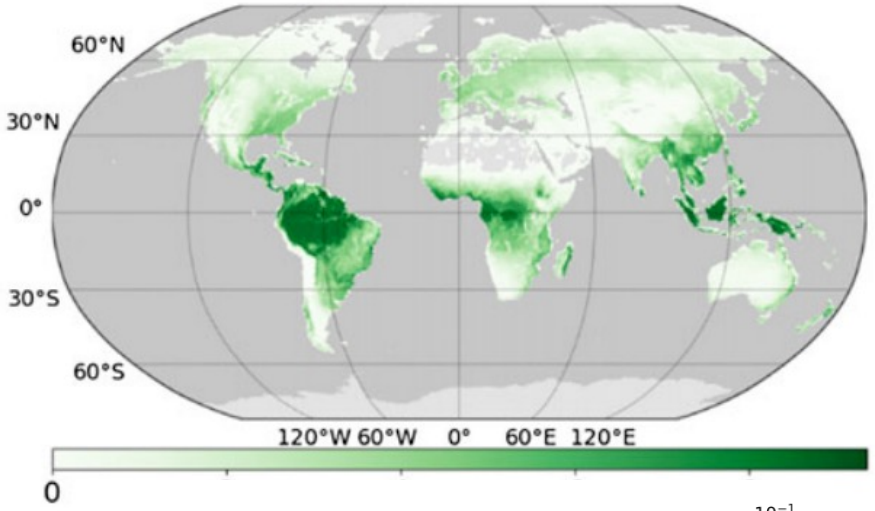
Annual Flux Difference (g CH_4 m^{-2} yr^{-1})

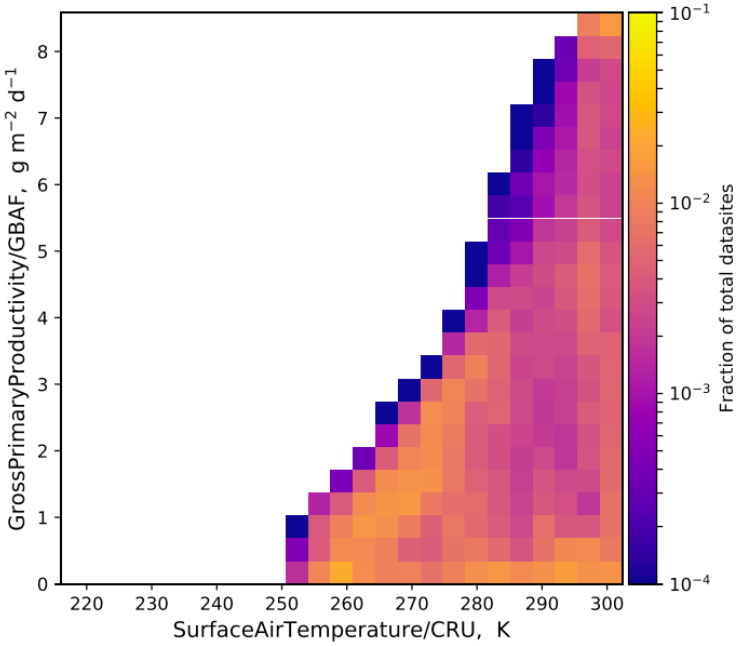
More Top-down — More Bottom-up

-120 -50 -25 -10 -1 1 10 25 50 120

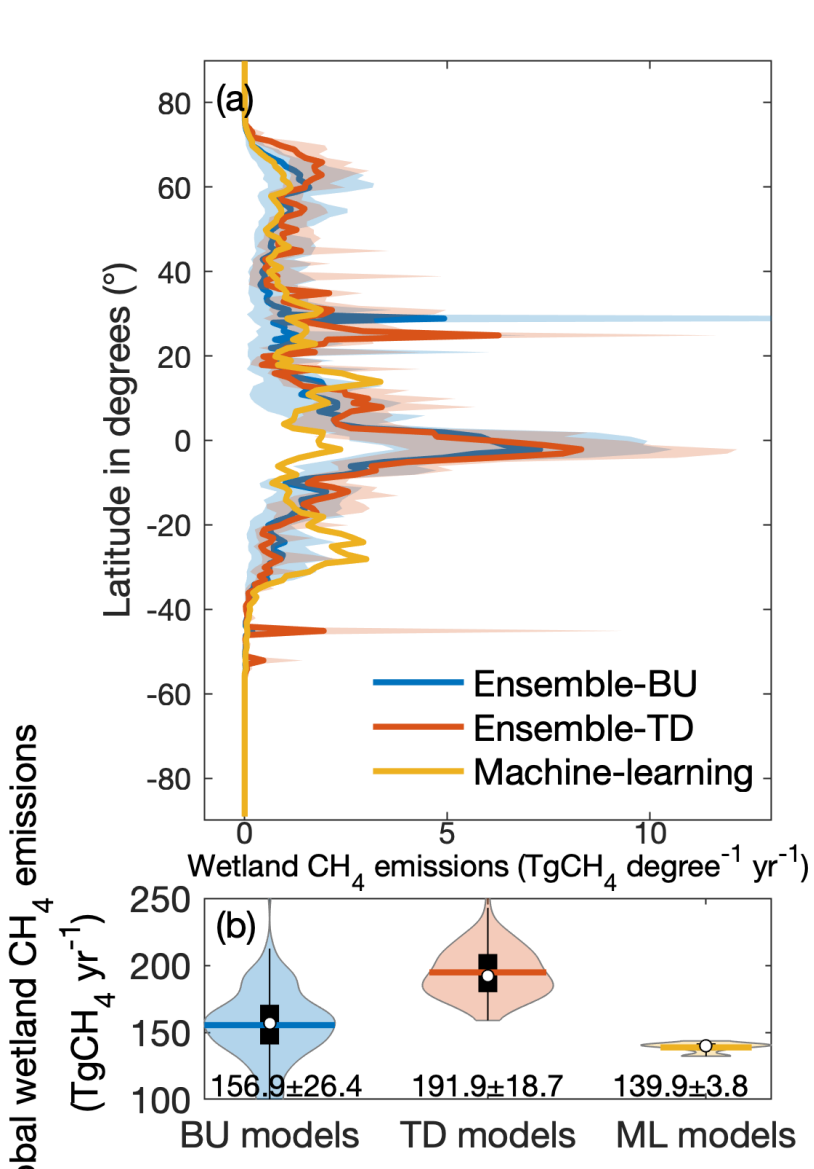
Knox et al. (2020)

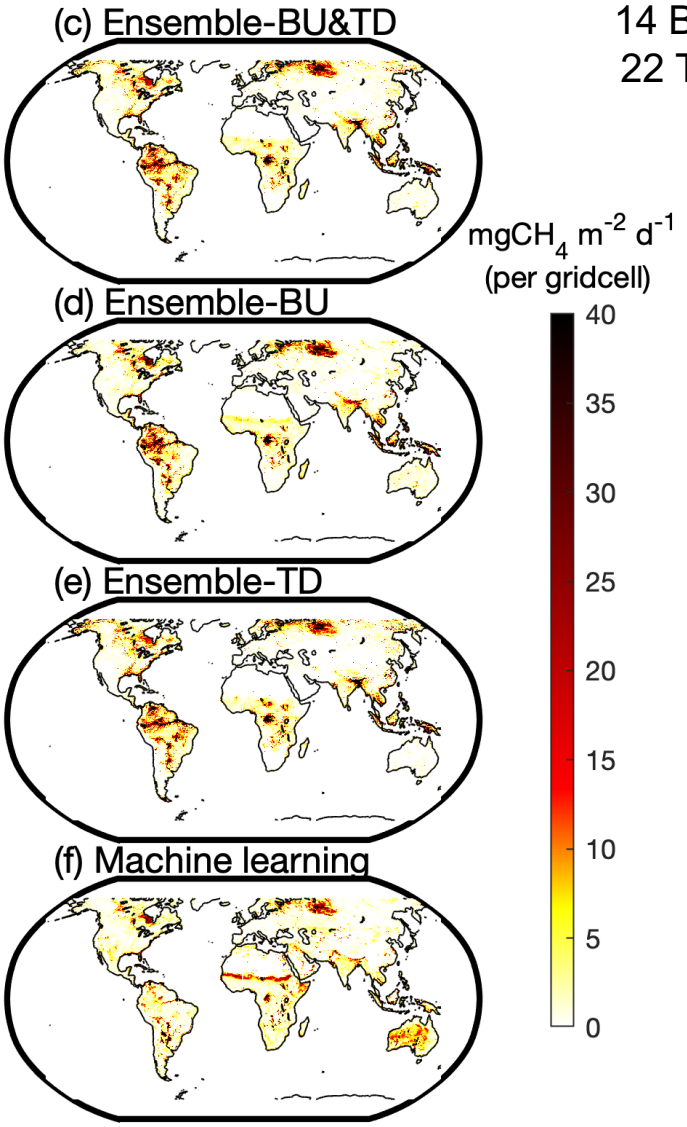
The International Land Model Benchmarking (ILAMB) System





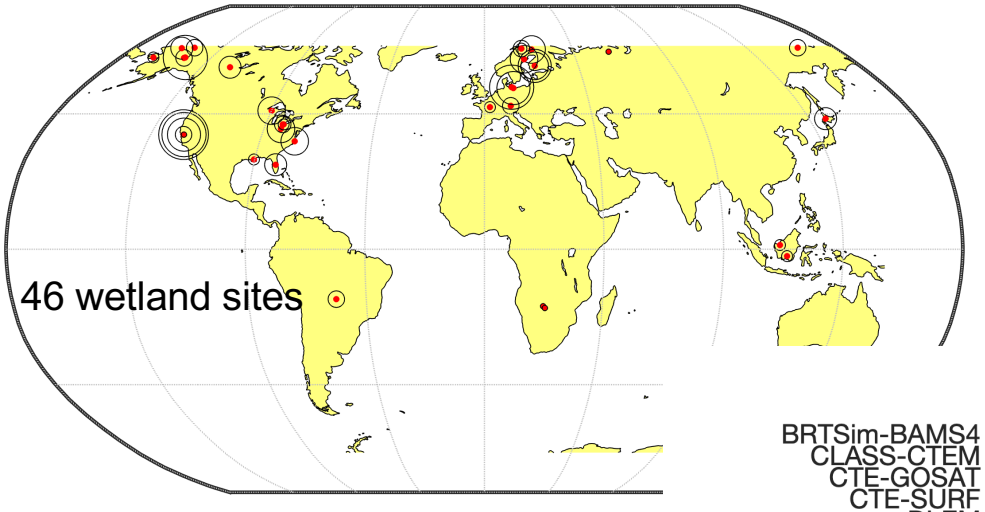
Wetland CH_4 emission estimates



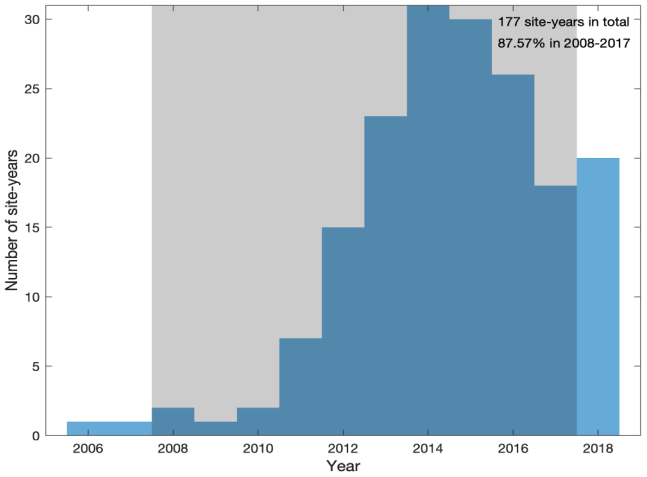


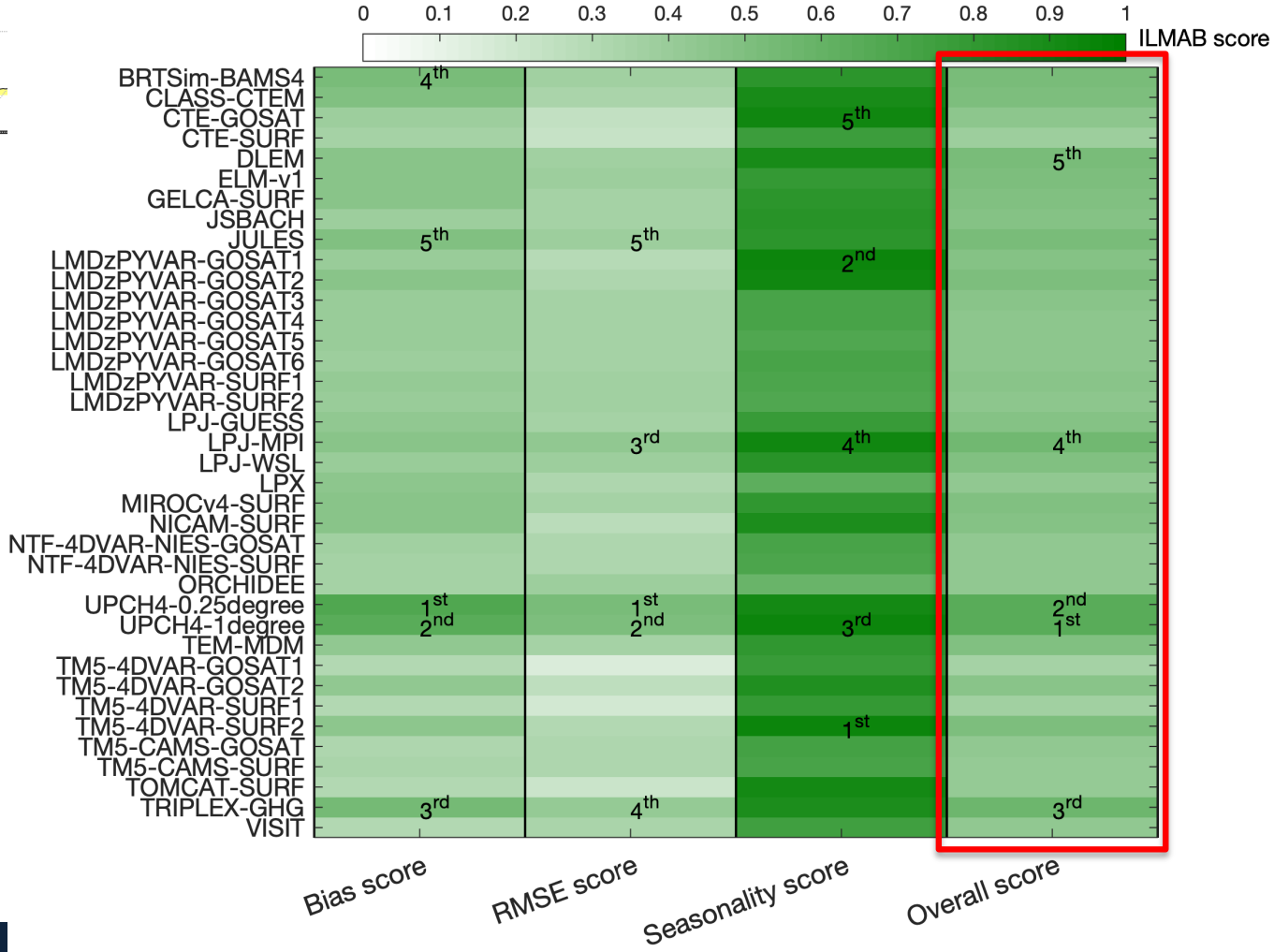
14 Bottom-Up models
22 Top-Down models
One ML model

Wetland CH_4 emission benchmarking

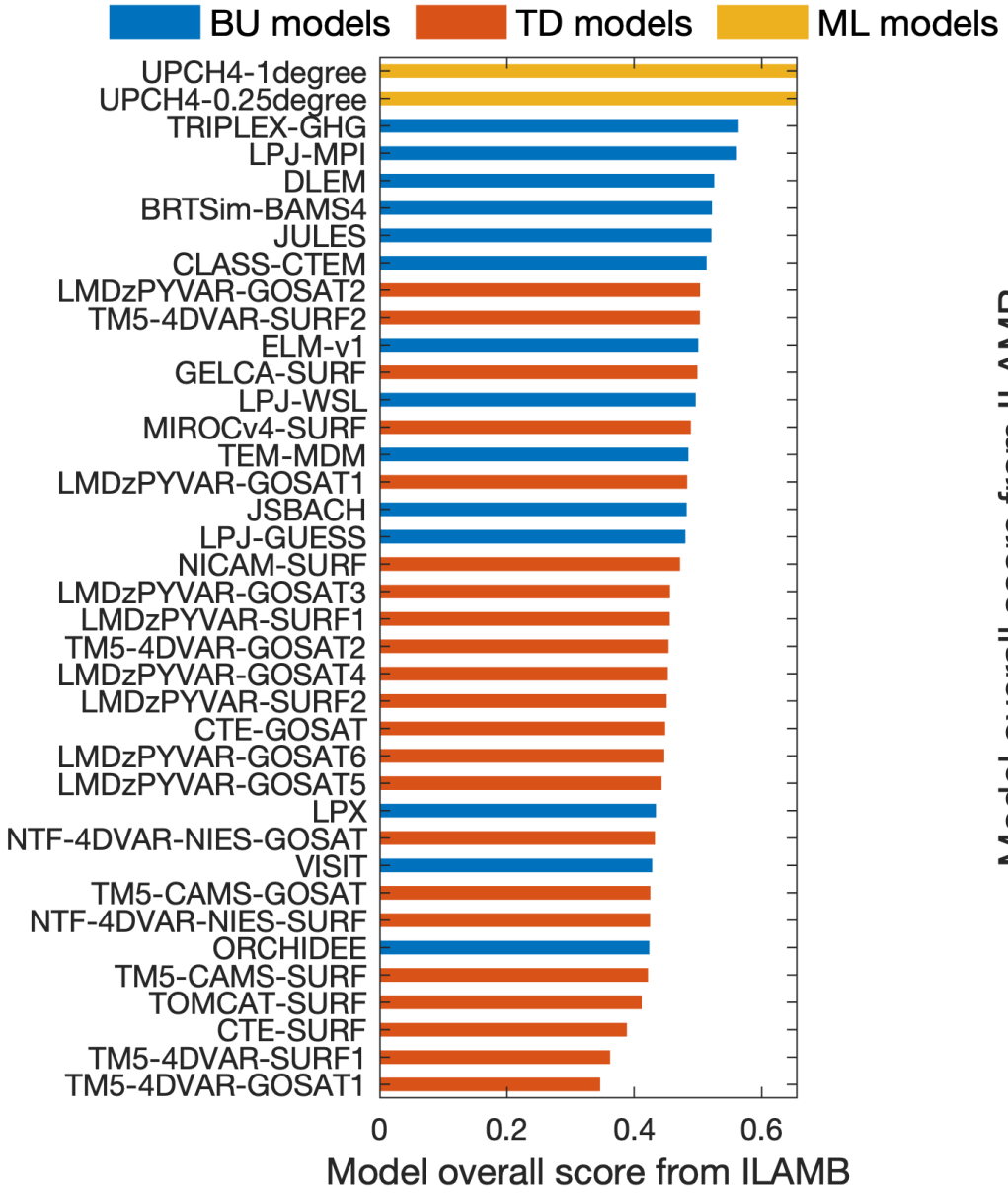


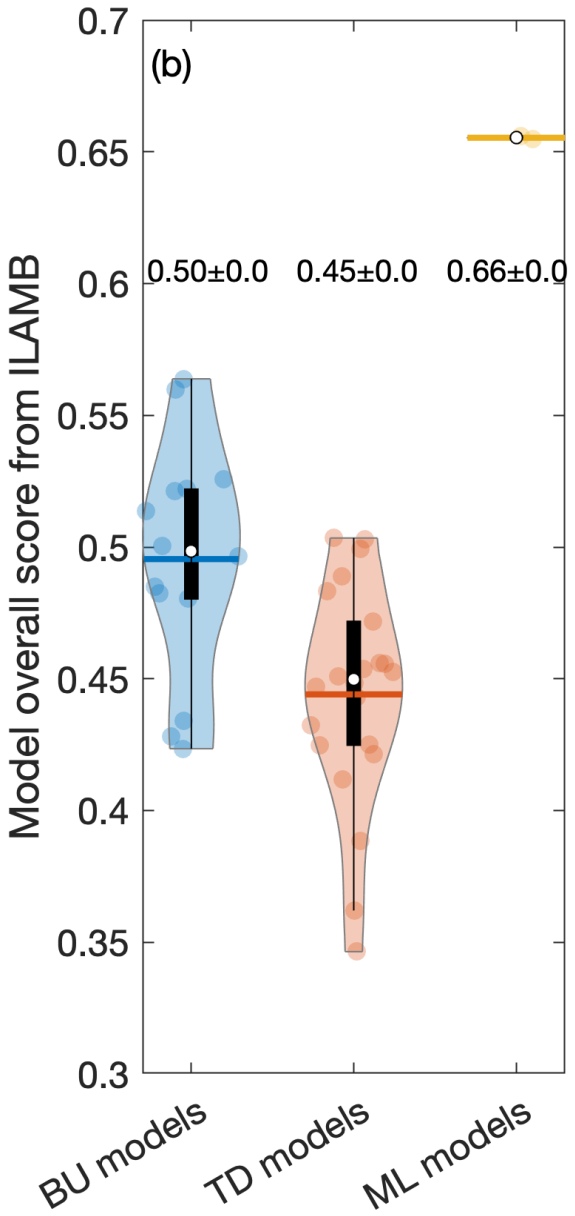
14 Bottom-Up models
22 Top-Down models
One ML model



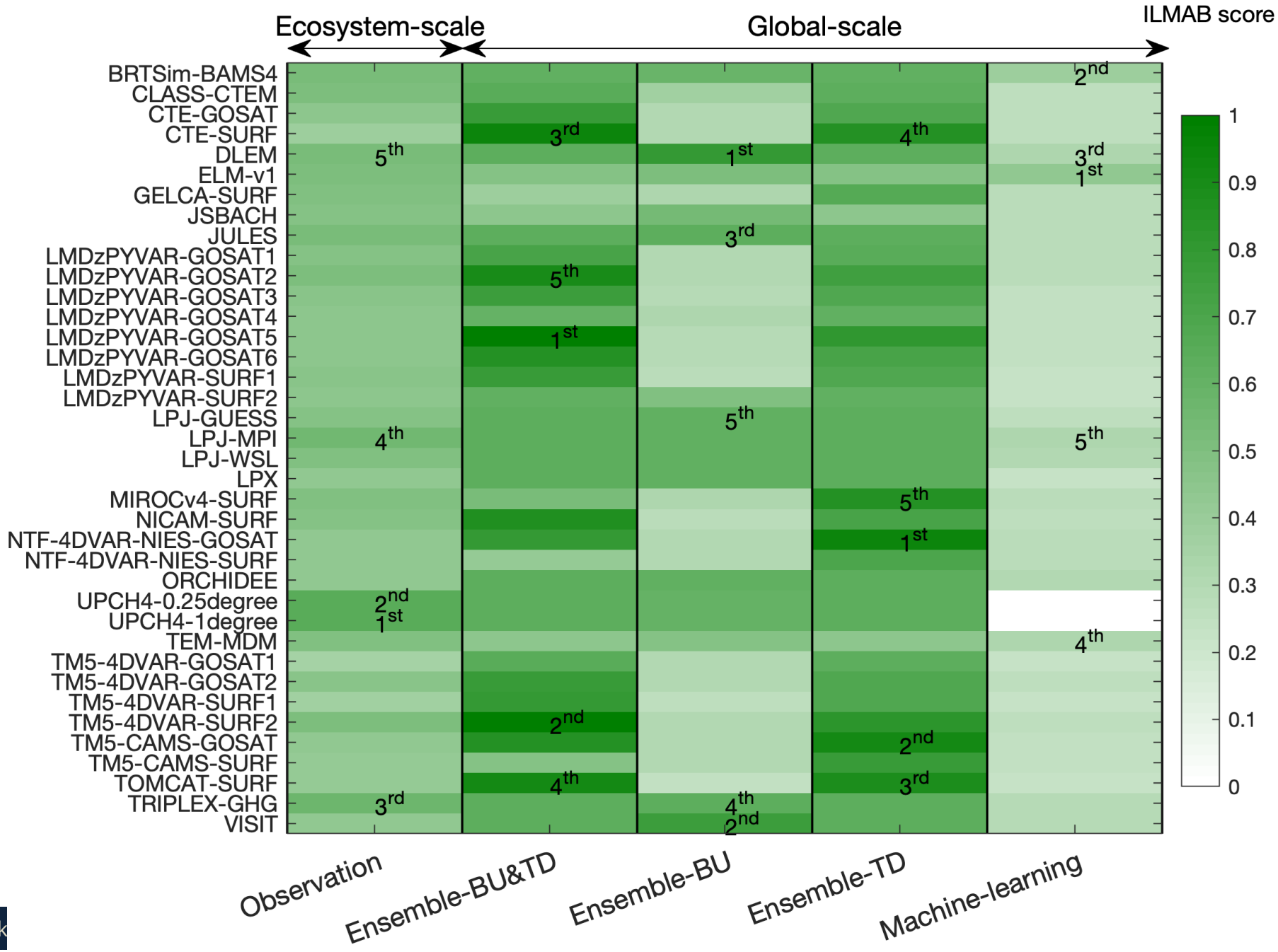


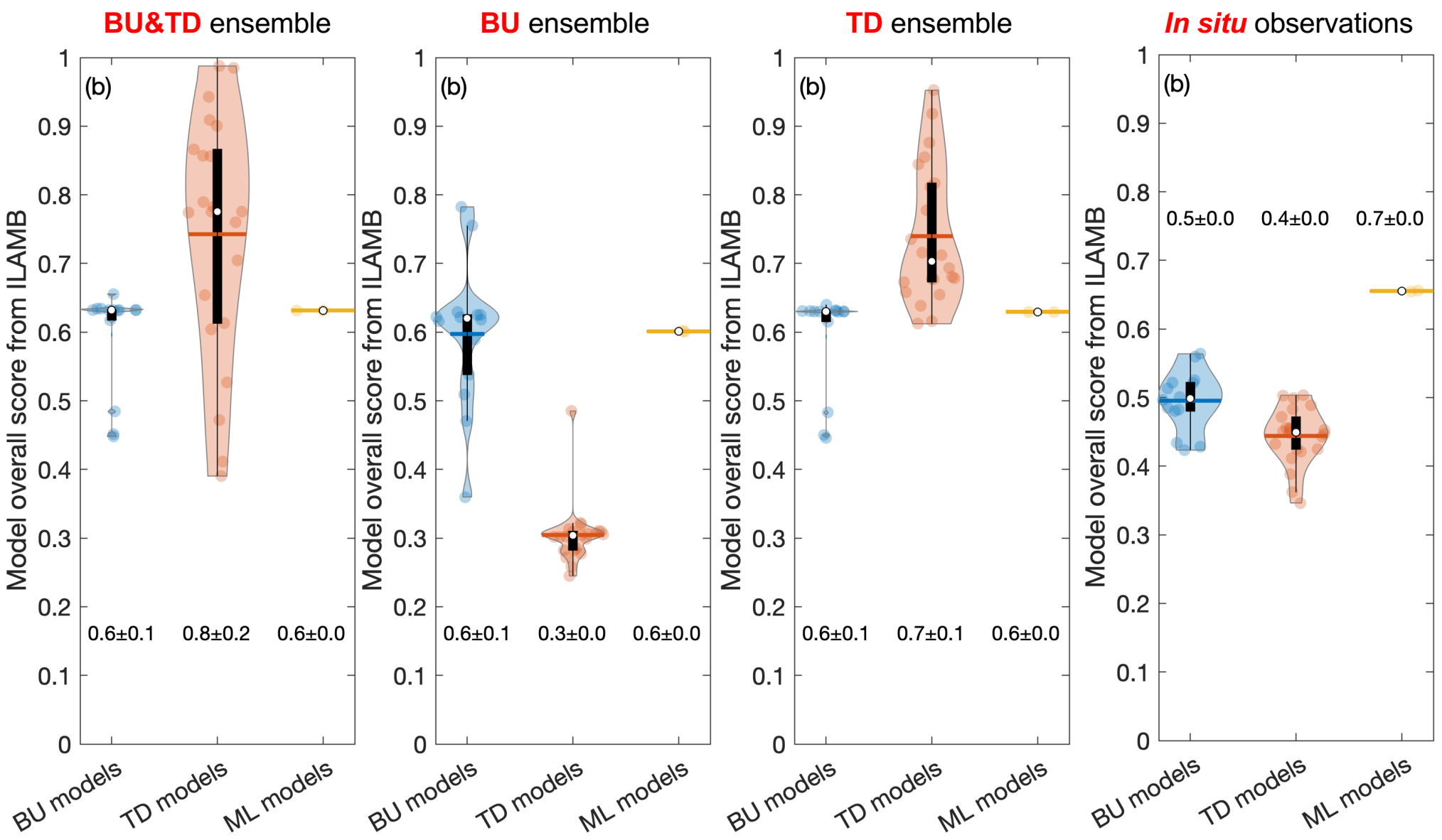
Apparent accuracy of wetland CH_4 modeling



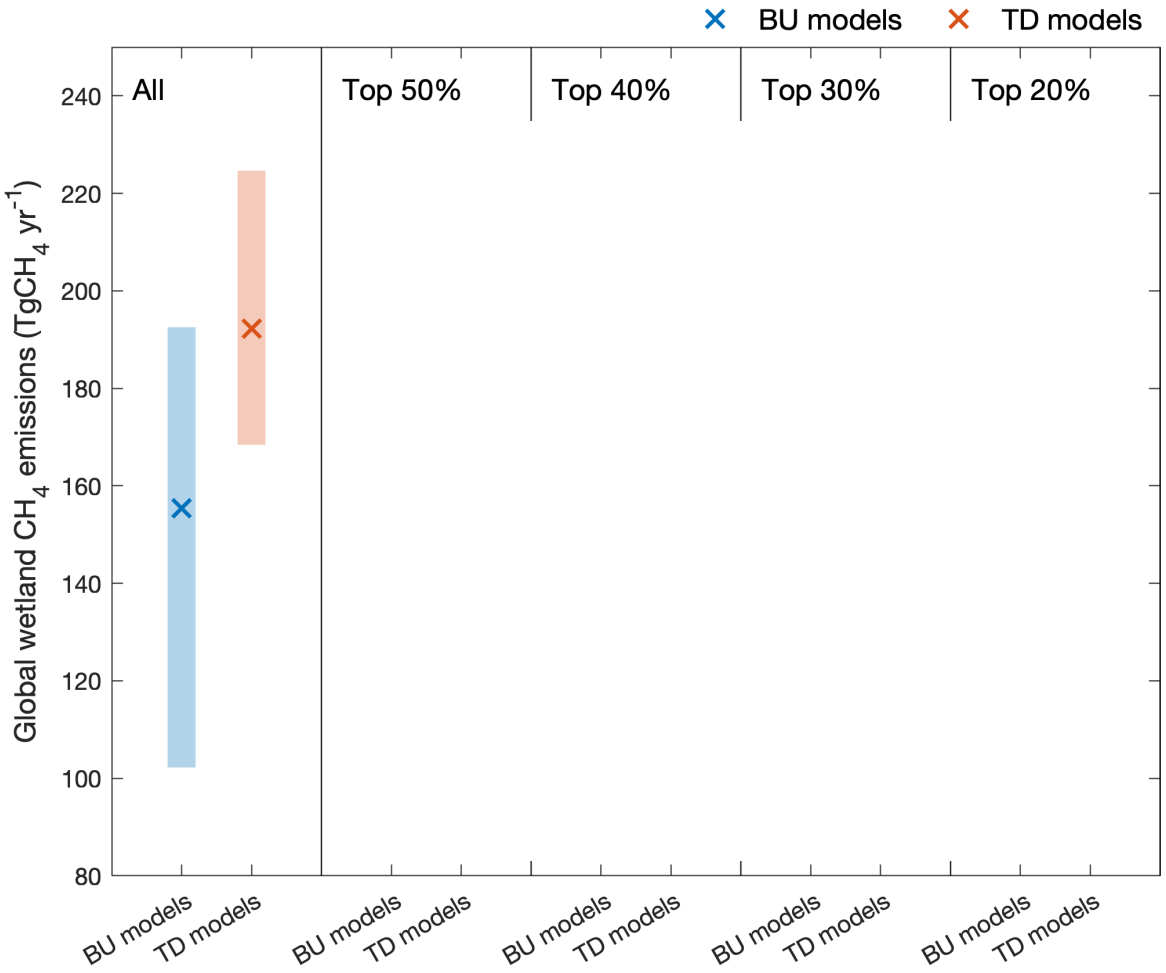


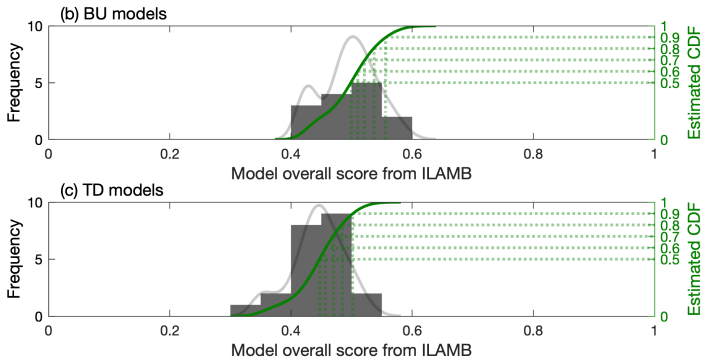
Sensitivity to reference dataset



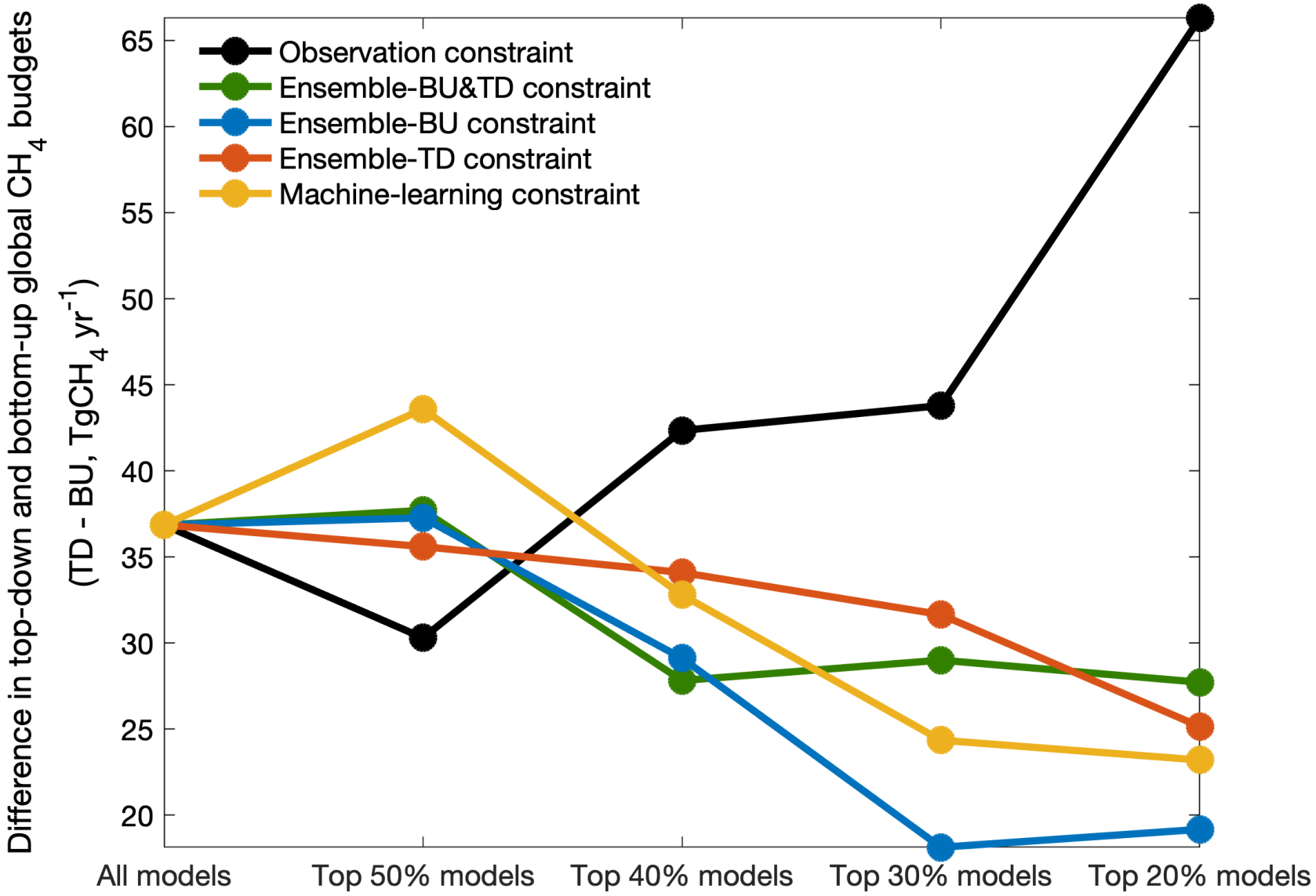

BU&TD ensemble
BU ensemble
TD ensemble
In situ observations
(b)
Model overall score from ILAMB
0.6±0.1
0.8±0.2
0.6±0.0
0.6±0.1
0.3±0.0
0.6±0.0
0.6±0.1
0.7±0.1
0.6±0.0
0.5±0.0
0.4±0.0
0.7±0.0
BU models
TD models
ML models

Better models imply reduced BU and TD discrepancies?

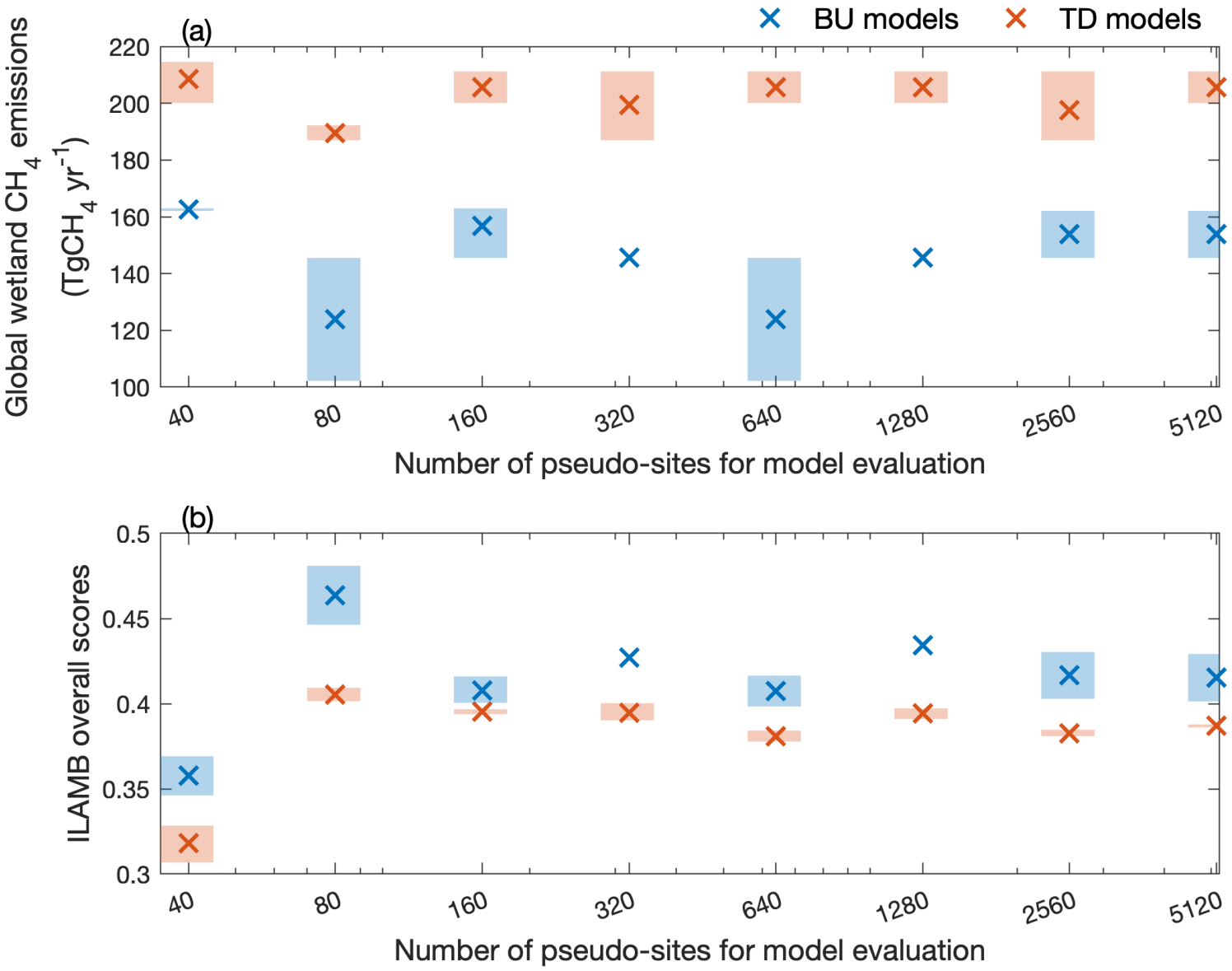




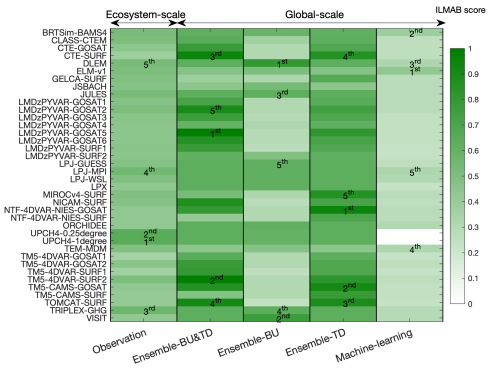
Can we use ML products as a benchmark?



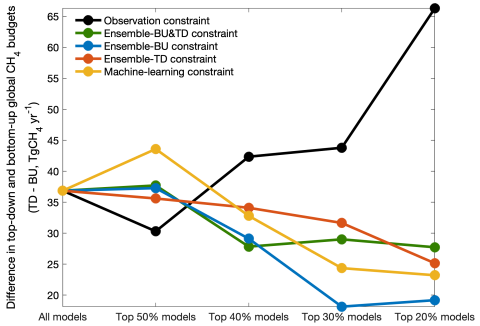
How many sites do we need to reduce uncertainties in CH_4 models



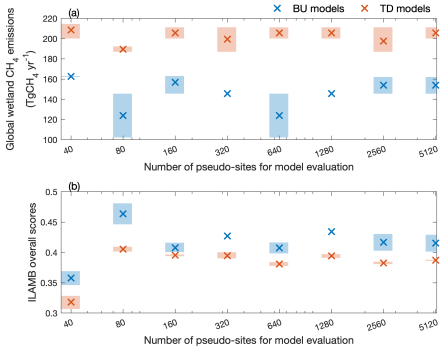
Conclusions



Using multi-model ensemble as a reference favors models implementing the same approach and underlying assumptions.



ML models provide an independent reference that reduces the discrepancy of global wetland CH_4 emissions inferred from BU and TD approaches.



Future CH_4 model benchmarking should focus on understanding and representing the observed functional relationships.

EARTH & ENVIRONMENTAL SCIENCES

Thank you!

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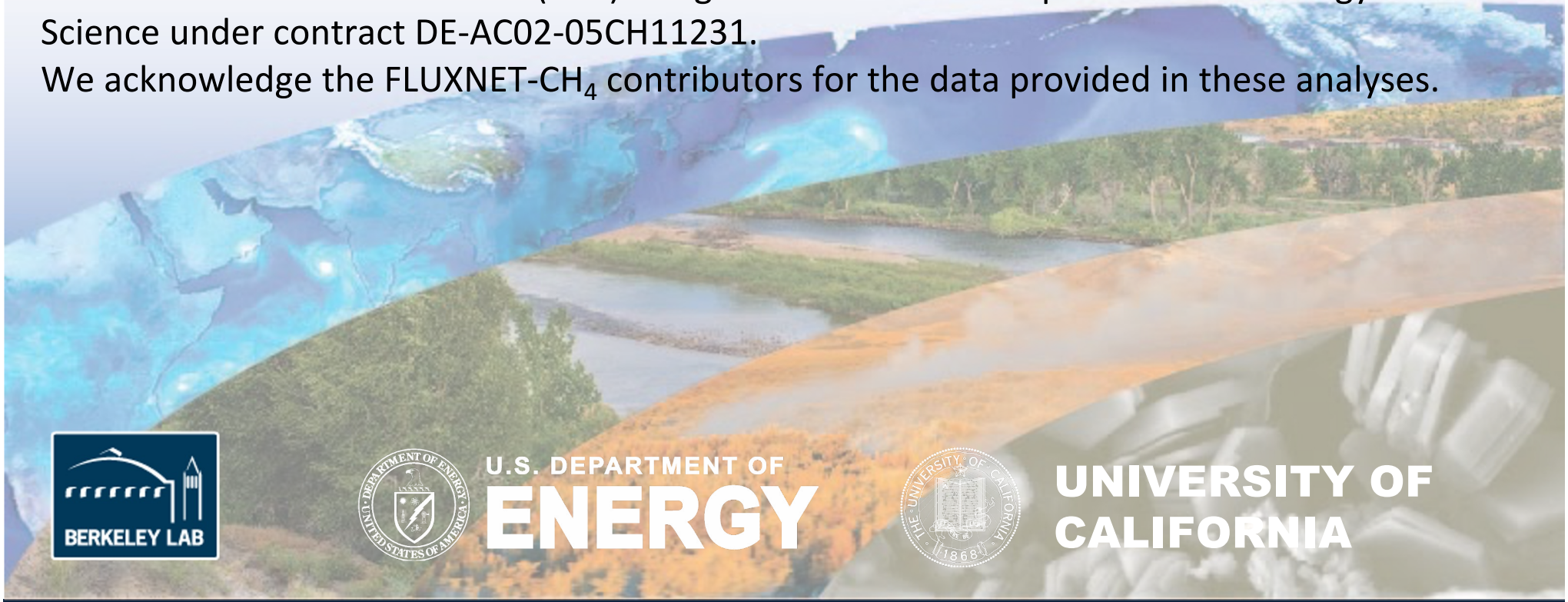
We acknowledge the FLUXNET-CH_4 contributors for the data provided in these analyses.



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