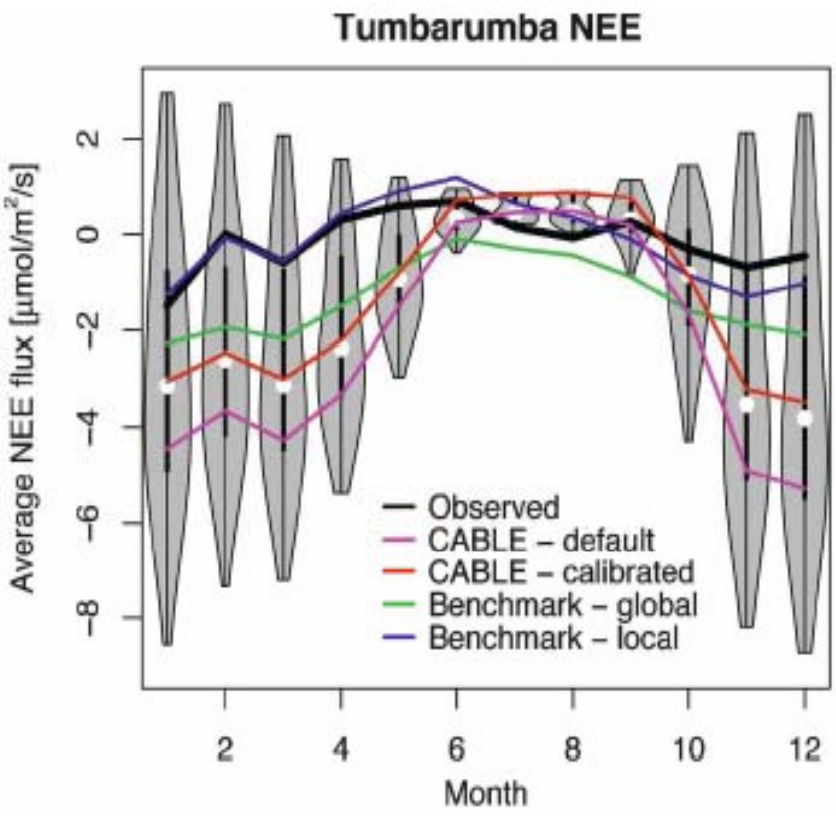
Illustrating: (1) we do not even need to distinguish between vegetation types to achieve the performance of current generation LSMs
(2) the amount of predictive ability local calibration *should* give LSMs
(3) how calibration gives cost-function-specific results



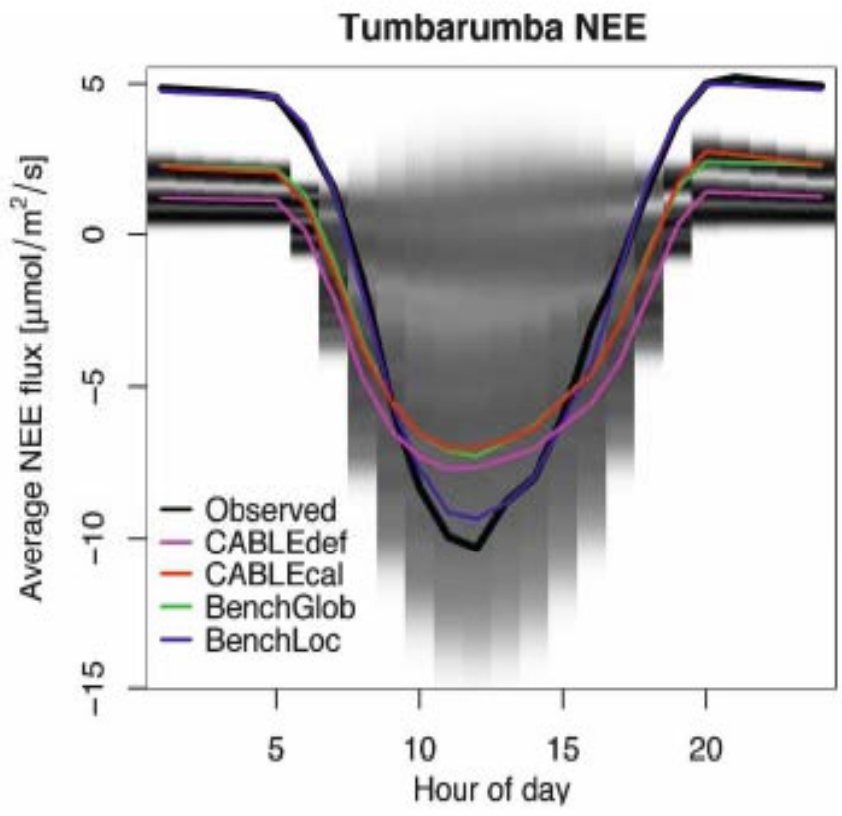


TABLE 1. Values of the eight parameters used to construct the perturbed parameter CABLE ensemble at Tumbarumba.

Name	Units	Default	Ensemble values	Description
LAIadd	—	0.0	−1.0, 0.0, 1.0	Additive adjustment to LAI
HcAdd	m	0.0	−5.0, 0.0, 5.0	Additive adjustment to vegetation height
Bch	—	7.1	6.5, 7.1, 7.9, 8.7	Parameter b in Campbell equation
Hyds	$m\ s^{-1} \times 10^{-6}$	4	2, 4, 6, 10	Hydraulic conductivity at saturation
Sfc	$m^3\ m^{-3}$	0.301	0.26, 0.301, 0.35	Volume H_2O at soil field capacity
Sucs	m	−0.59	−0.35, −0.45, −0.59, −0.62	Suction at saturation
Vcmax	$mol\ m^{-2}\ s^{-1} \times 10^{-5}$	8.5	1, 5, 8.5, 12	Maximum RuBP carboxylation rate top leaf
Rp20	—	1.1342	0.1, 1.1342, 3.0	Plant respiration scaling factor

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An illustration of how Fluxnet data can point to parts of LSMs that require improvement

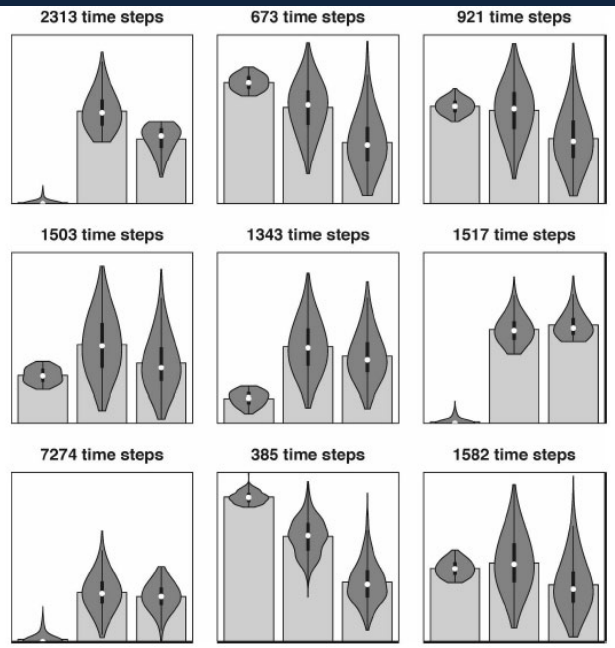

FIG. 7. Partitioning of the LSM input space using a nine-node SOM. The three columns in each node represent downward shortwave radiation, air temperature, and humidity, respectively. Light gray bars represent mean values, white dots the median, black line the 25th–75th quartile, and the dark gray–shaded regions are rotated probability density functions spanning the range each variable. Values have been scaled to fit all variables on a single axis. Data are for Tumbarumba only.

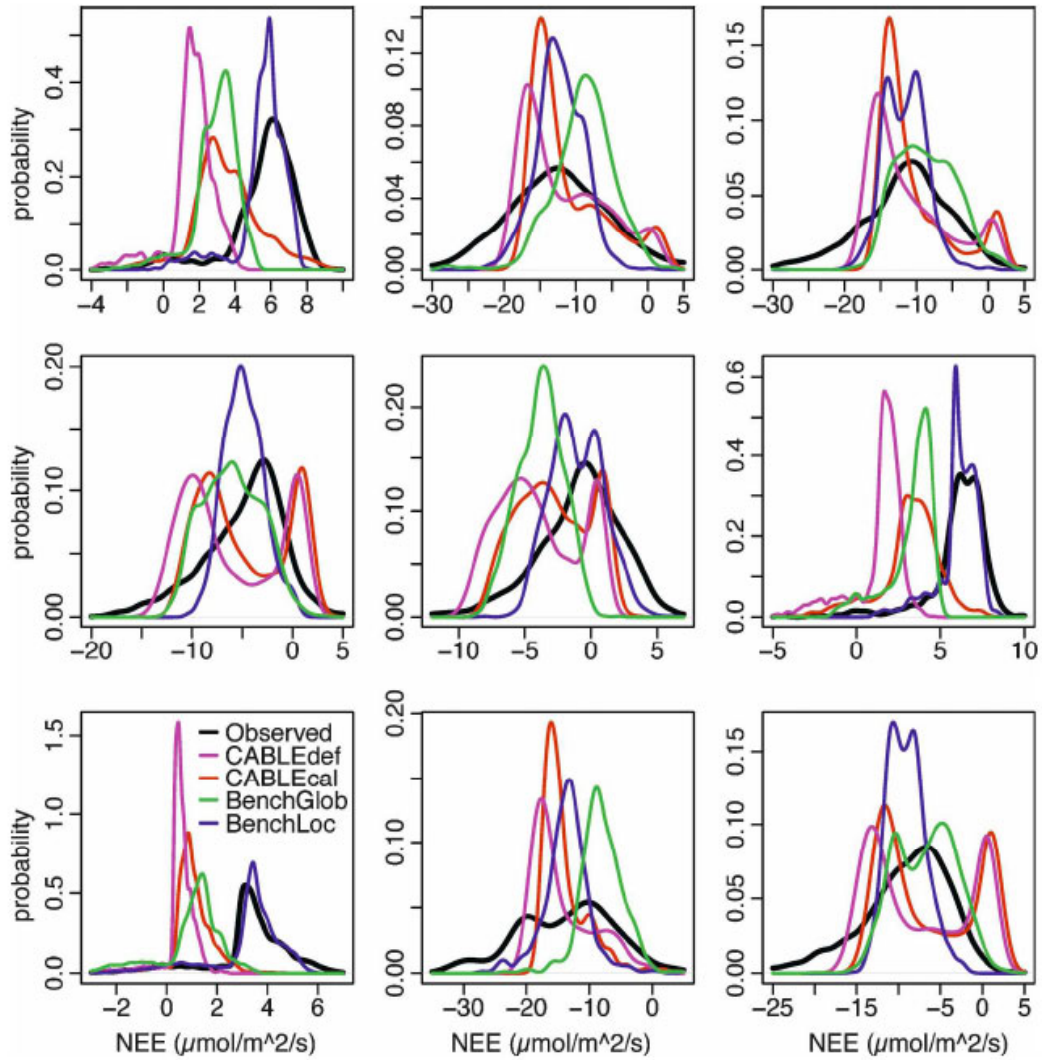

FIG. 6. Probability density function for each SOM node for NEE at Tumbarumba: Results are shown for observed data, two CABLE simulations, and two ANN benchmark simulations. The set of meteorological conditions for each corresponding SOM node is shown in Fig. 7. Note that abscissa is at different scales to show separation of the models.

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		NEE of CO_2 (μmol/m²/s)					Latent heat flux (W/m²)					Sensible heat flux (W/m²)				
		mean (obs)	rmse	grad	int	rsq	mean (obs)	rmse	grad	int	rsq	mean (obs)	rmse	grad	int	rsq
Tumbarumba	CAB	-2.3 (-0.1)	5.48	0.55	-2.2	0.52	49 (52)	55.9	0.71	12.0	0.61	38 (54)	58.3	0.79	-5.0	0.82
	ORC	-0.5 (-0.1)	5.16	0.47	-0.4	0.50	46 (52)	58.1	0.73	8.1	0.59	14 (54)	118.	0.16	6.0	0.78
	CLM	-1.2 (-0.1)	6.13	0.24	-1.6	0.35	26 (52)	72.9	0.38	6.5	0.40	56 (54)	84.5	0.83	10.9	0.64
	MLR	-1.5 (-0.1)	4.40	0.55	-1.4	0.70	45 (52)	47.6	0.59	14.5	0.74	43 (54)	54.9	0.69	5.2	0.87
	ANN	-1.3 (-0.1)	4.65	0.52	-1.2	0.64	42 (52)	49.9	0.54	14.1	0.74	41 (54)	51.4	0.81	-3.0	0.86
Bondvil	CAB	-1.7 (-0.9)	6.13	0.61	-1.2	0.49	43 (47)	64.5	0.89	1.8	0.55	-0.1 (26)	71.8	0.62	-16.1	0.32
	ORC	-0.4 (-0.9)	9.07	0.68	0.2	0.29	30 (47)	48.0	0.84	-9.4	0.70	3.2 (26)	52.2	0.69	-14.5	0.56
	CLM	-1.2 (-0.9)	7.92	0.12	-1.1	0.08	33 (47)	50.5	0.63	3.0	0.62	30 (26)	57.9	1.01	4.3	0.59
	MLR	-0.7 (-0.9)	7.38	0.21	-0.5	0.20	38 (47)	45.8	0.53	13.6	0.73	26 (26)	47.7	1.08	-2.0	0.71
	ANN	0.0 (-0.9)	7.69	0.20	0.2	0.15	39 (47)	45.7	0.53	14.4	0.72	27 (26)	49.0	1.14	-2.2	0.73
Tharand	CAB	-1.2 (-1.7)	4.18	0.50	-0.3	0.77	46 (38)	47.4	0.98	8.0	0.61	-34 (26)	84.3	0.62	-50.4	0.56
	ORC	-0.5 (-1.7)	4.08	0.65	0.6	0.72	32 (38)	41.8	0.68	5.7	0.55	-28 (26)	76.8	0.64	-45.0	0.62
	CLM	-1.2 (-1.7)	5.28	0.31	-0.7	0.70	28 (38)	41.1	0.68	2.1	0.58	14 (26)	56.3	0.92	-9.9	0.69
	MLR	0.7 (-1.7)	5.81	0.32	1.3	0.62	28 (38)	37.3	0.58	5.4	0.65	16 (26)	43.3	0.69	-2.1	0.79
	ANN	0.1 (-1.7)	5.28	0.36	0.7	0.70	31 (38)	36.6	0.57	9.5	0.65	10 (26)	44.5	0.75	-9.6	0.78
Washita	CAB	-0.7 (0.6)	4.15	0.34	-0.9	0.15	46 (39)	64.7	0.95	9.6	0.46	31 (38)	77.9	0.67	5.4	0.41
	ORC	-0.1 (0.6)	4.13	0.52	-0.4	0.23	33 (39)	37.7	0.86	-0.2	0.69	30 (38)	56.0	0.78	0.5	0.64
	CLM	-0.9 (0.6)	4.00	0.29	-1.1	0.16	42 (39)	48.6	0.87	8.5	0.57	53 (38)	56.8	0.98	15.3	0.72
	MLR	-2.5 (0.6)	6.29	0.60	-2.8	0.16	61 (39)	43.7	0.96	24	0.72	31 (38)	40.4	1.00	-7.0	0.83
	ANN	-2.5 (0.6)	8.51	1.31	-3.3	0.29	65 (39)	58.4	1.33	14.0	0.75	29 (38)	46.9	0.73	0.9	0.73
Weiden	CAB	-1.0 (0.2)	2.90	0.66	-1.1	0.67	26 (24)	40.0	1.21	-2.9	0.7	-23 (-5)	62.7	0.51	-20.1	0.67
	ORC	-0.5 (0.2)	2.70	0.89	-0.7	0.73	11 (24)	38.0	0.89	-10	0.61	-19 (-5)	62.4	0.51	-16.2	0.65
	CLM	-1.1 (0.2)	3.37	0.42	-1.2	0.62	18 (24)	35.5	0.79	-0.2	0.59	15 (-5)	57.4	0.73	18.6	0.70
	MLR	-0.5 (0.2)	3.01	0.53	-0.6	0.62	29 (24)	28.3	0.70	12.1	0.69	20 (-5)	62.3	0.54	22.8	0.70
	ANN	-0.4 (0.2)	2.45	0.81	-0.6	0.75	30 (24)	27.0	0.73	12.5	0.72	19 (-5)	60.0	0.59	21.7	0.71
Metolius	CAB	-0.8 (-0.7)	3.02	0.50	-0.4	0.50	29 (40)	56.7	0.51	8.8	0.26	22 (34)	61.8	0.97	-11.2	0.71
	ORC	-1.0 (-0.7)	3.27	0.93	-0.3	0.60	34 (40)	53.6	0.71	5.0	0.38	9 (34)	63.9	0.68	-14.1	0.64
	CLM	-0.7 (-0.7)	3.54	0.26	-0.5	0.32	21 (40)	51.5	0.45	2.9	0.32	40 (34)	57.5	0.83	11.7	0.69
	MLR	-1.5 (-0.7)	3.36	0.71	-1.0	0.50	37 (40)	48.7	0.72	7.9	0.43	42 (34)	53.7	0.82	13.6	0.72
	ANN	-0.8 (-0.7)	2.88	0.81	-0.2	0.61	36 (40)	47.7	0.69	8.6	0.43	46 (34)	55.3	0.88	15.7	0.73

Which model wins?

- CABLE : 12
- CLM : 14
- ORCHIDEE : 17
- neural network : 21
- linear regression : 25
- neural net and linear regression are NOT trained at the sites at which they're tested and have no mechanism to distinguish between vegetation types – SWdown, Tair and humidity ONLY
- Deciding on a LSM benchmark is easy – any performance measure

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