Optimization of maximum photosynthetic carboxylation rate (*Vc,max*) in CLASSIC for North America's boreal forests using eddy covariance data

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Method

CLASSIC: Canadian Land Surface Scheme including Biogeochemical Cycles

- The land surface component of the Canadian Earth System Model (CanESM)
- https://cccma.gitlab.io/classic_pages/

Hyperopt: bayesian hyperparameter optimization

- Algorithm: tree-structured parzen estimator (TPE) for 500 iterations
- Cost function $f(x)$ to minimize:

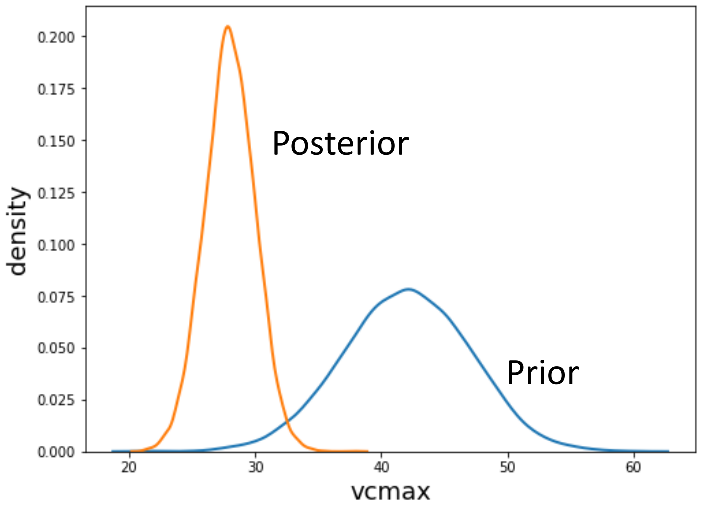
$$f(x) = RMSE(GPP_{obs}, GPP_{sim})$$

Daily criterion:
i. Excluding days when >20% of half-hourly NEE data gap-filled with low confidence;
ii. gpp growing seasons following Gonsamoa et al. (2013)

- *Vc,max* search spaces: normal space centered on default
  - Overstory and understory vegetation PFTs

unit: $\mu molCO_2 m^{-2} s^{-1}$

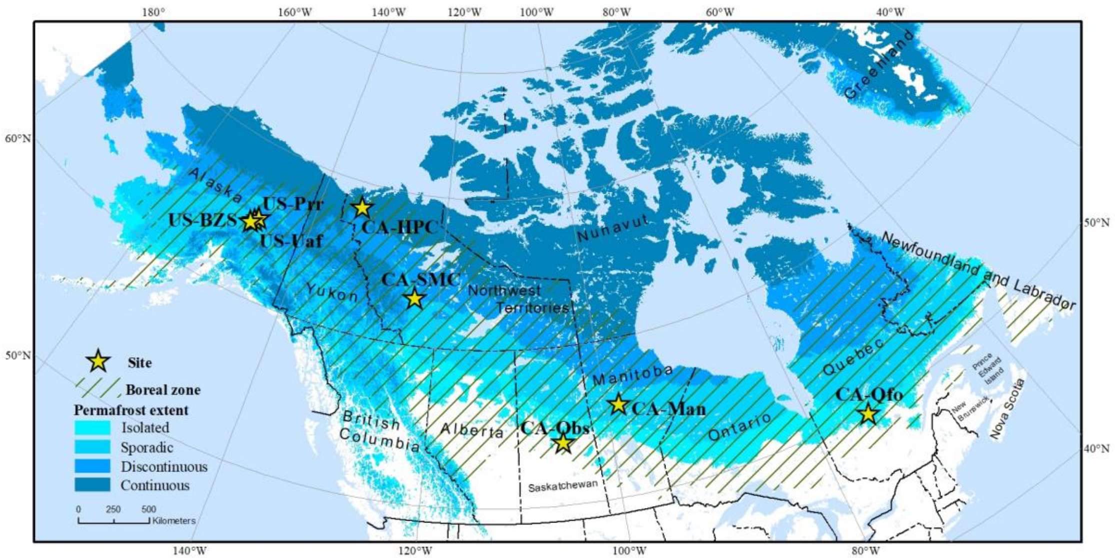
	CLASSIC's PFT	Short name	$V_{c,max}$
Tree	Needleleaf evergreen trees	NdlEvgTr	42
	Needleleaf deciduous trees	NdlDcdTr	47
	Broadleaf evergreen trees	BdlEvgTr	35
	Broadleaf cold deciduous trees	BdlDCoTr	57
	Broadleaf dry deciduous trees	BdlDDrTr	40
Shrub	Broadleaf evergreen shrubs	BdlEvgSh	60
	Broadleaf cold deciduous shrubs	BdlDCoSh	60
Grass	C3 grass	-	55
	C4 grass	-	15
	Sedge	-	40
Crop	C3 crop	-	55
	C4 crop	-	40



Study sites

North America's boreal forest EC sites

- Span the permafrost and climate gradients;
- Vary in vegetation composition of overstory and understory.



Dominant overstory and understory vegetation species

Site	Overstory species	Understory species	CLASSIC settings
CA-Obs	*Picea mariana, Larix laricina*	-	90% NdlEvgTr, 10% NdlDcdTr
CA-Qfo	*Picea mariana*	*Alnus rugosa, Kalmia angustifolia, Ledum groenlandicum, etc.*	90% NdlEvgTr, 5% BdlEvgSh, 5% BdlDCoSh
CA-Man	*Picea mariana*	*Ledum groenlandicum, Betula glandulosa, Rosa spp., Vaccinium spp., etc.*	90% NdlEvgTr, 5% BdlEvgSh, 5% BdlDCoSh
US-Uaf	*Picea mariana*	*Ledum groenlandicum, Vaccinium vitis-idaea, Vaccinium uliginosum, Salix spp. Betula glandulosa, etc.*	20% NdlEvgTr, 37% BdlEvgSh, 13% BdlDCoSh, 30% Sedge
US-Prr	*Picea mariana*	*Ledum groenlandicum, Vaccinium uliginosum, Rubus chamaemorus, Betula glandulosa, Eriophorum vaginatum, etc.*	20% NdlEvgTr, 14% BdlEvgSh, 13% BdlDCoSh, 24% Sedge
US-BZS	*Picea mariana*	*Rhododendron groenlandicum, Vaccinium vitis-idaea, Oxycoccus microcarpus, etc.*	20% NdlEvgTr, 37% BdlEvgSh, 13% BdlDCoSh, 30% Sedge
CA-SMC	*Picea mariana*	*Carex sp., Empetrum nigrum, Andromeda polifolia, Vaccinium vitis-idaea, Betula glandulosa, etc.*	21% NdlEvgTr, 42% BdlEvgSh, 16% BdlDCoSh, 21% Sedge
CA-HPC	*Picea mariana*	*Vaccinium vitis-idaea, Rhododendron tomentosum, Empetrum nigrum, Poaceae sp., Rhododendron groenlandicum, etc.*	15% NdlEvgTr, 69% BdlEvgSh, 6% BdlDCoSh, 5% Sedge, 5% C3 Grass

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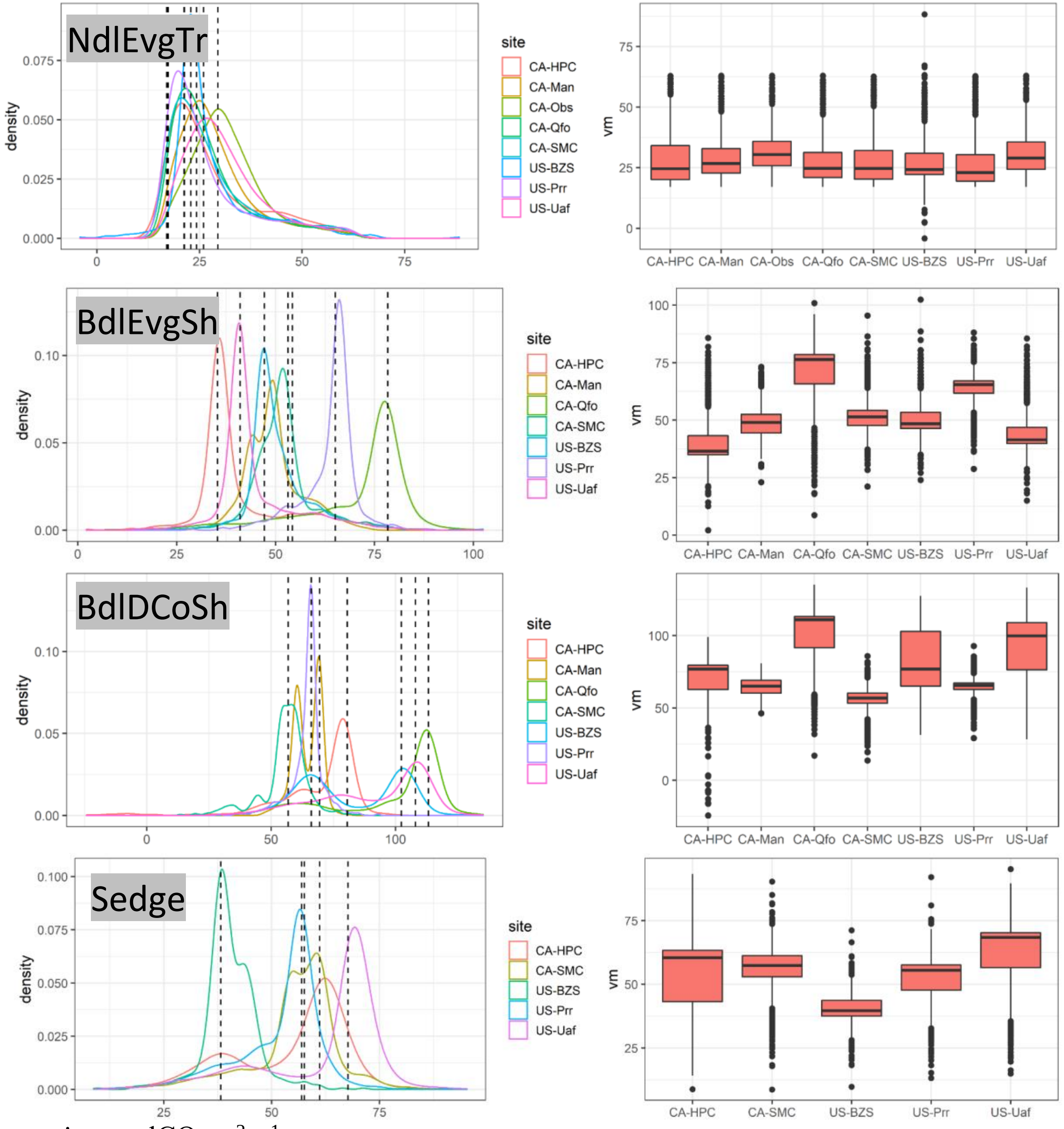
Photos courtesy of sites' PIs

Results

Posterior distributions of *Vc,max*



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Vc,max optimization

- NdlEvgTr
  - good consistent among sites, suggesting a convergence across North America's boreal forests.
- BdlEvgSh and BdlDCoSh
  - tend to be higher than NdlEvgTr;
  - vary greatly among sites, possibly corresponding to varied species diversity.
- Sedge
  - converges at around 55-65 over most sites (US-BZS around 38)

From results

- Site-level parameter optimizations will help constrain terrestrial ecosystem models but parameter variations would limit models' skills.
- Modelling understory vegetation, in particular shrubs, is critical for improving modeling vegetation properties, e.g. CO_2 fluxes, across a broad range of North America's boreal forests.

Thanks! Qs?