# Global calibration of demographic rates and forest structure in FATES

*Jessica Needham*, Charles Koven, Rosie Fisher, Ryan Knox, Gregory Lemieux, Jennifer Holm*

*Lawrence Berkeley National Lab
*jfneedham@lbl.gov

FATES

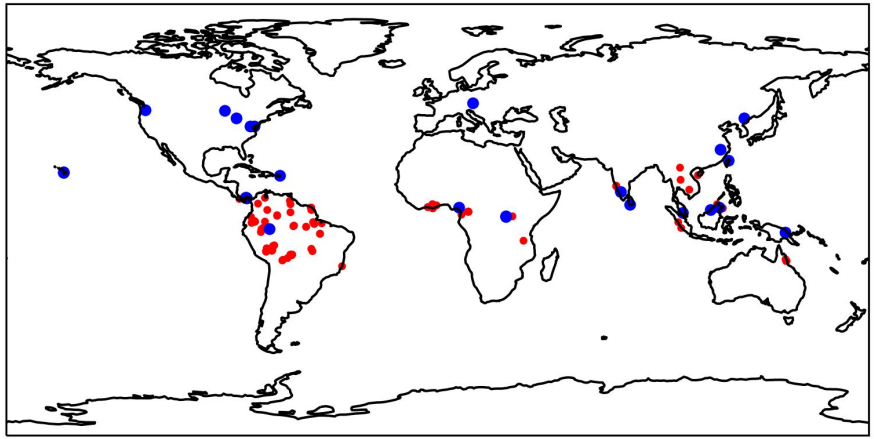
ForestGEO
GLOBAL EARTH OBSERVATORY NETWORK

RUBISCO

U.S. DEPARTMENT OF ENERGY | Office of Science

E3SM Energy Exascale Earth System Model

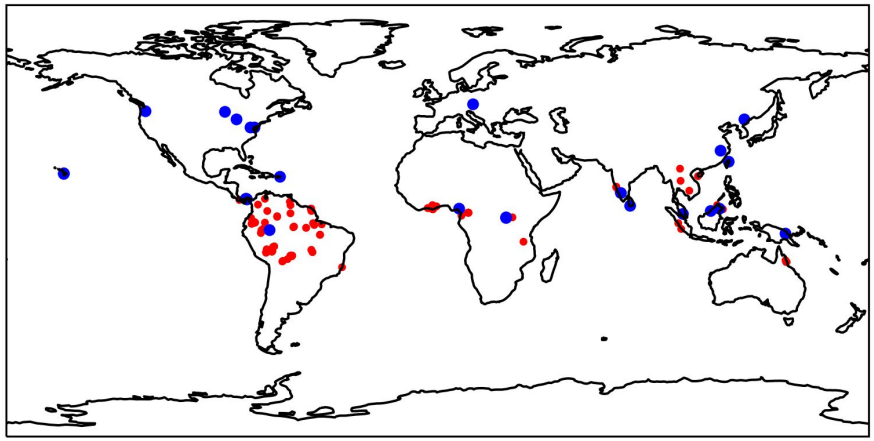
# Networks of forest plots provide useful data for global benchmarking



- Galbraith et al. 2013
  178 smaller (0.2 - 50 ha)
  Total AGB, productivity and carbon residence time.

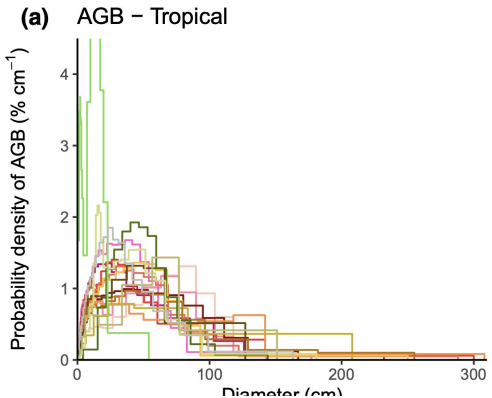
- Pipiniot et al. 2022
  25 large (4 - 50 ha) ForestGEO plots
  Size-dependent and total AGB, productivity and mortality.

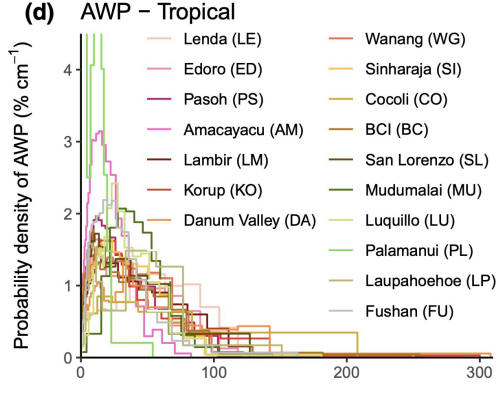
# Networks of forest plots provide useful data for global benchmarking

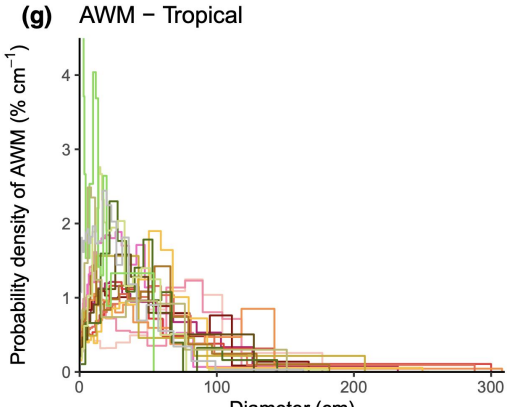


- Galbraith et al. 2013
  178 smaller (0.2 - 50 ha)
  Total AGB, productivity and carbon residence time.

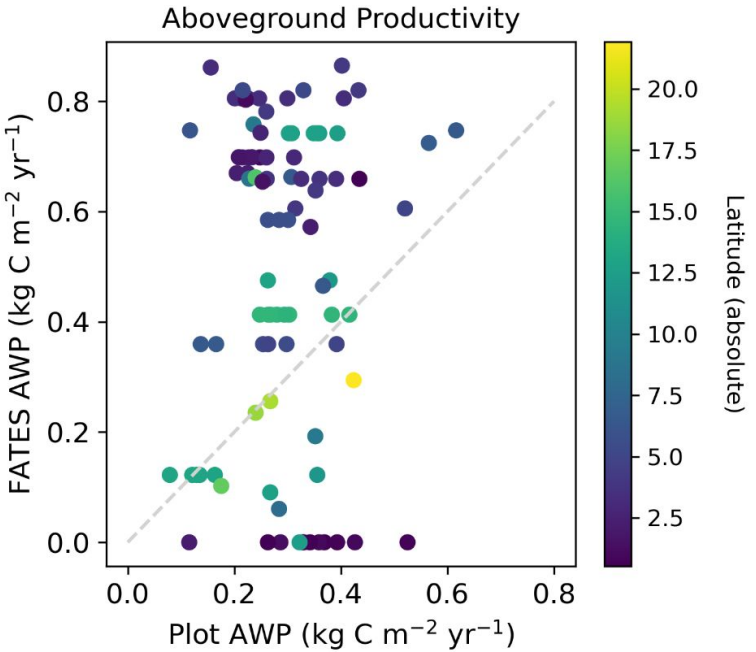
- Pipiniot et al. 2022
  25 large (4 - 50 ha) ForestGEO plots
  Size-dependent and total AGB, productivity and mortality.



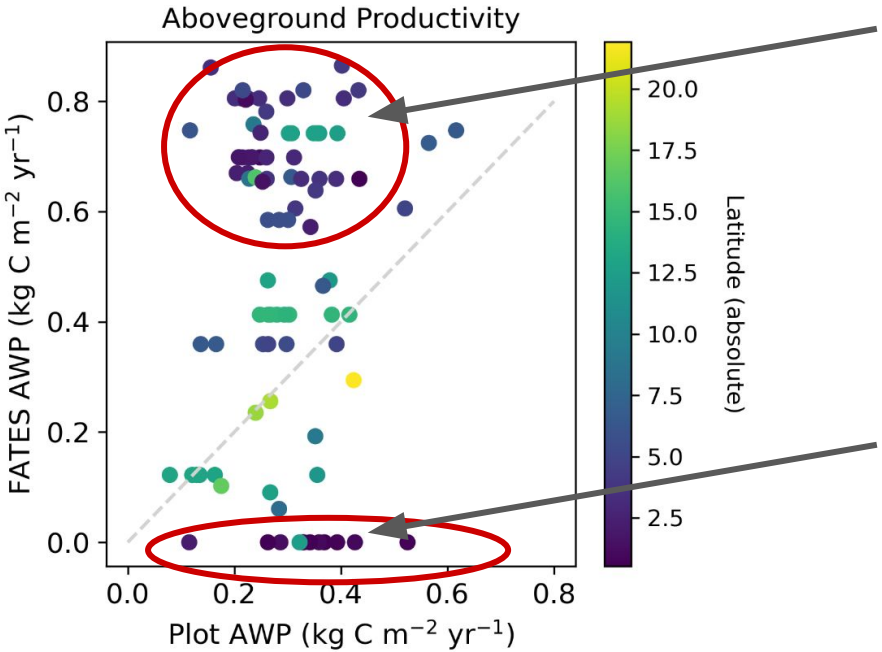



# FATES has a high productivity bias



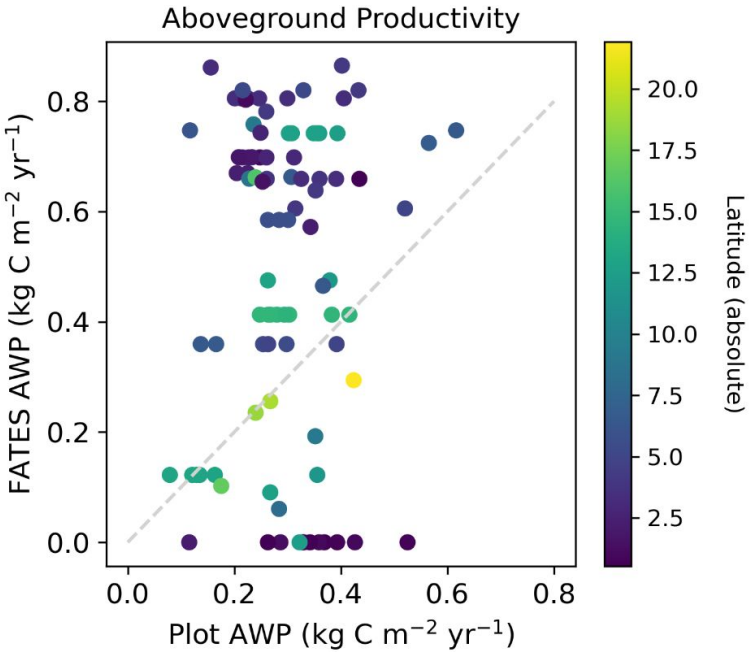
# FATES has a high productivity bias



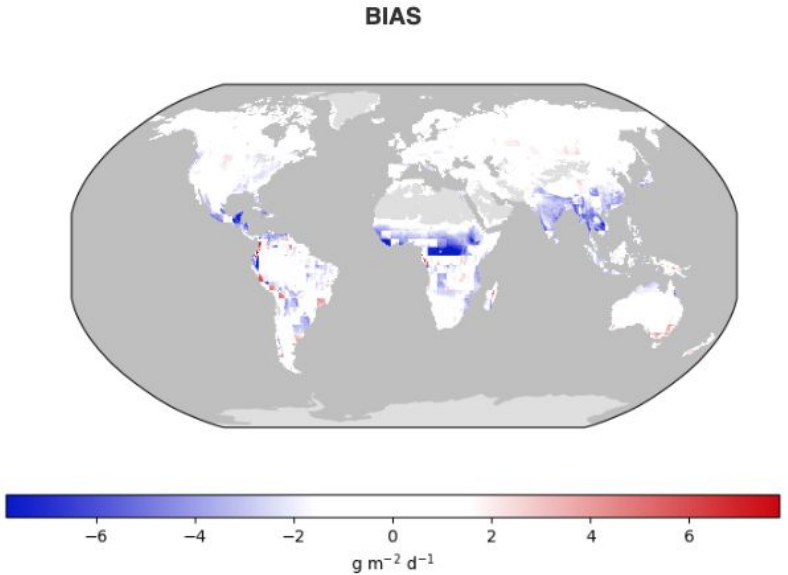

Productivity too high in FATES

Some sites fail to establish

# FATES has a high productivity bias




…despite low GPP




ILAMB comparison of FATES and FLUXCOM data https://www.ilamb.org/

# Is respiration too low?

# Respiration in FATES

- Maintenance Respiration

Whole plant MR = Leaf layer dark respiration  + Sapwood + fineroot MR  **‘fates_base_mr_20’**

# Respiration in FATES

- Maintenance Respiration

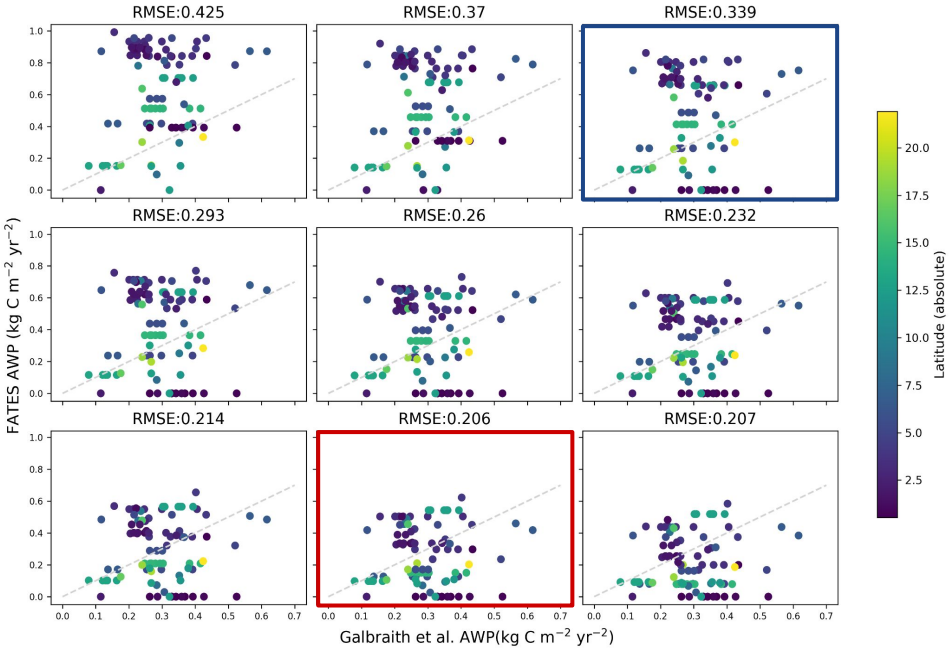
Whole plant MR = Leaf layer dark respiration  + Sapwood + fineroot MR  **‘fates_base_mr_20’**

- Growth Respiration

GR is (GPP - MR) multiplied by the growth respiration factor parameter **‘fates_grperc’**

# Maintenance respiration sensitivity

Increasing MR (**fates_base_mr_20**) leads to lower AWP (but lack of establishment in some sites)

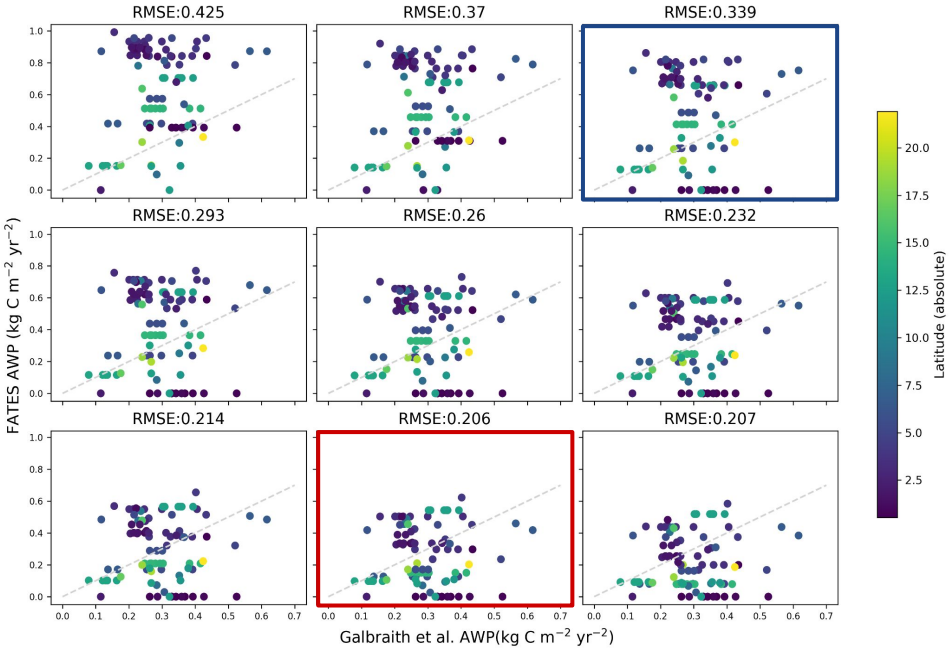



Default **fates_base_mr_20**

Lowest RMSE

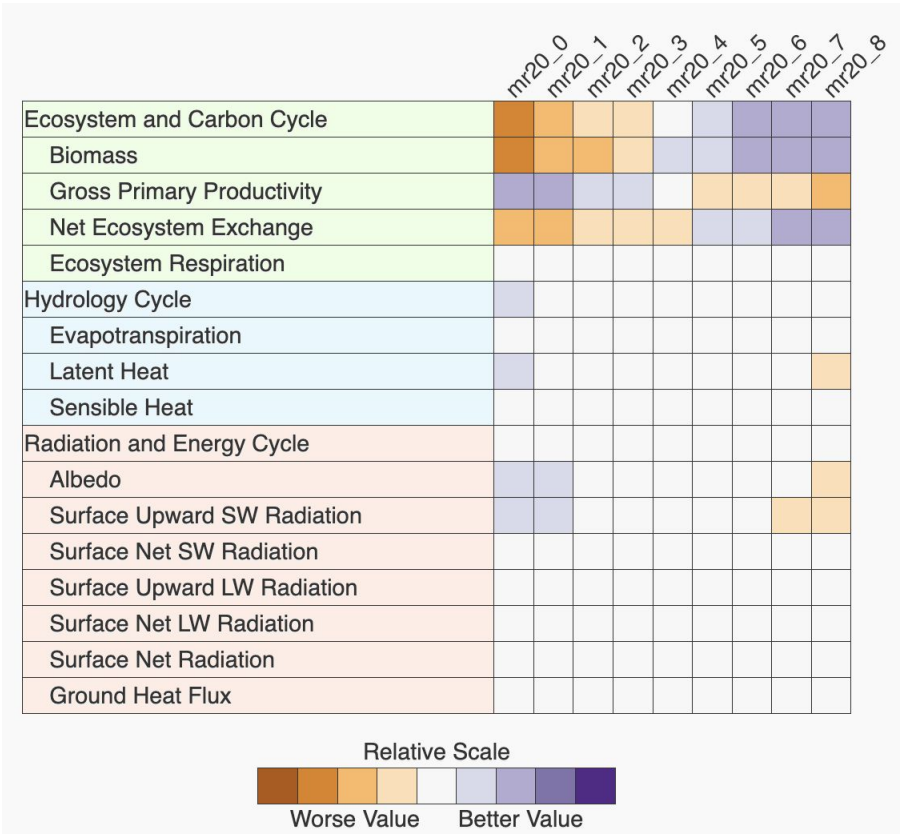
# Maintenance respiration sensitivity

Increasing MR (**fates_base_mr_20**) leads to lower AWP (but lack of establishment in some sites)

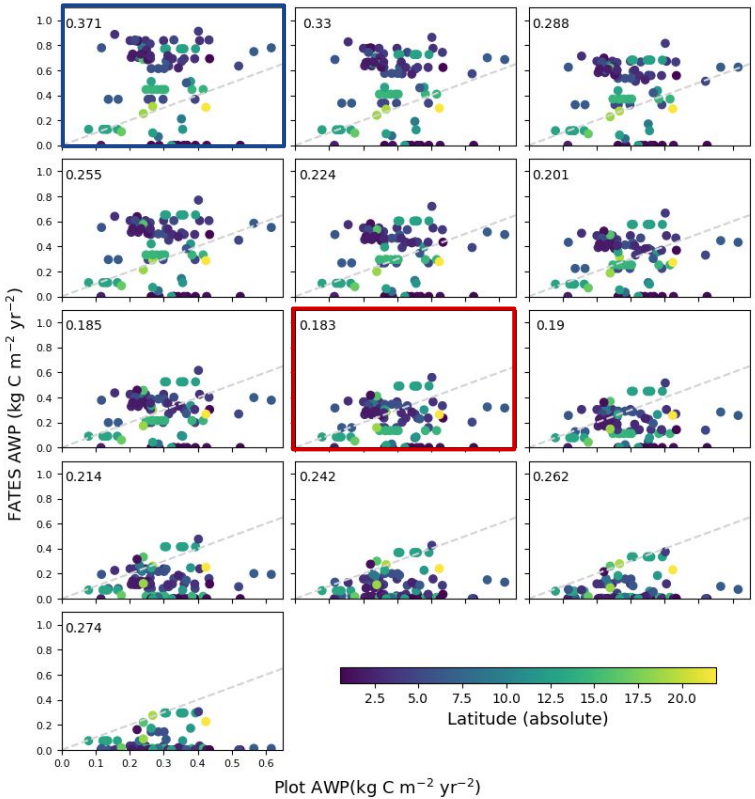


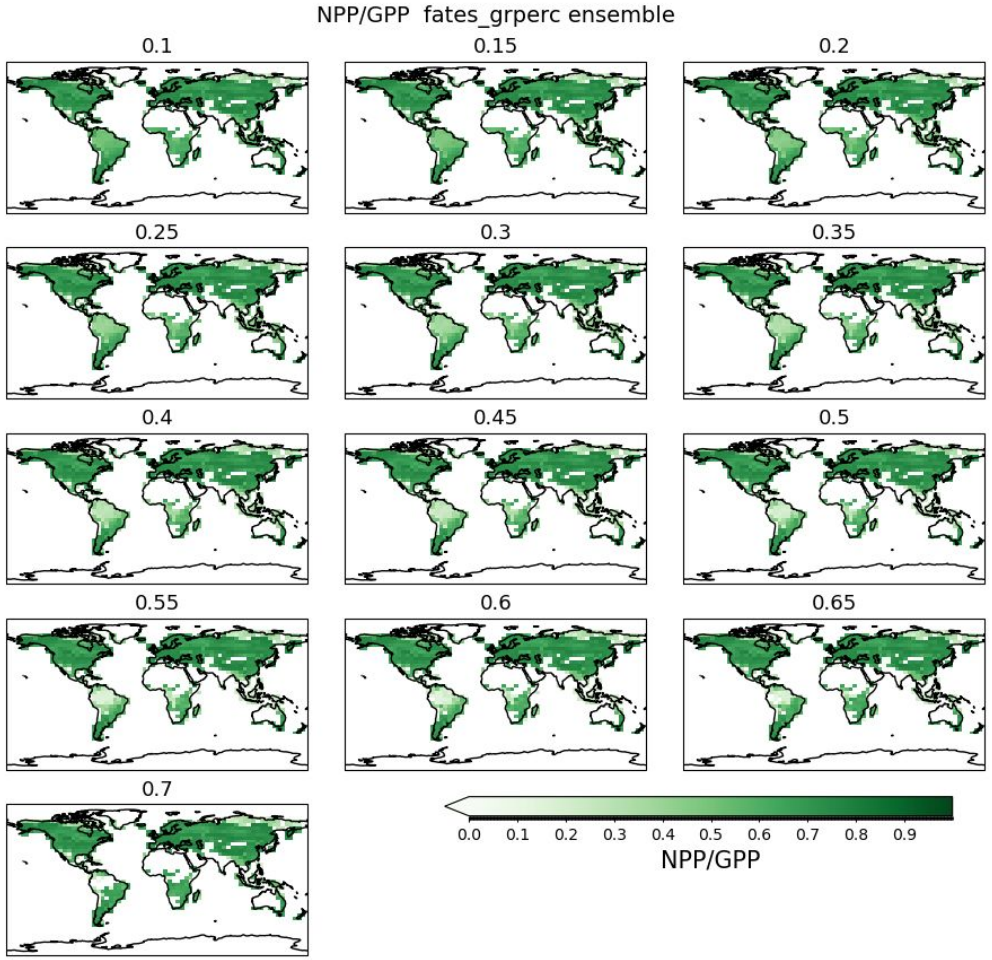

Default **fates_base_mr_20**

Lowest RMSE



# Growth respiration sensitivity




Lowest RMSE  Default **fates_grperc**

# Leaf layer dark respiration - two alternate schemes:

**Ryan 1991**

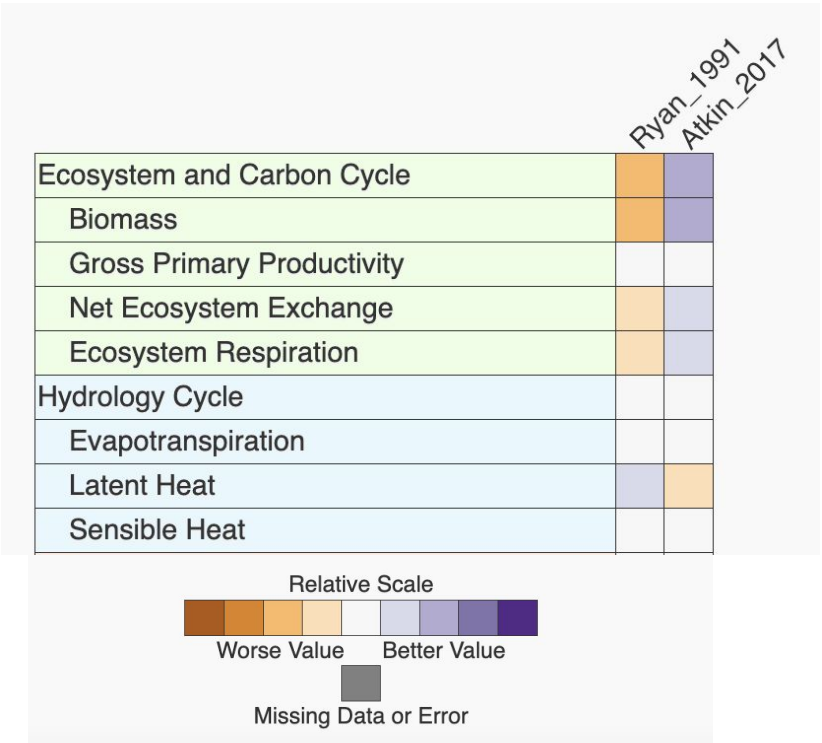
Respiration at the canopy top at 25 °C scaled by temperature and leaf N through the canopy.

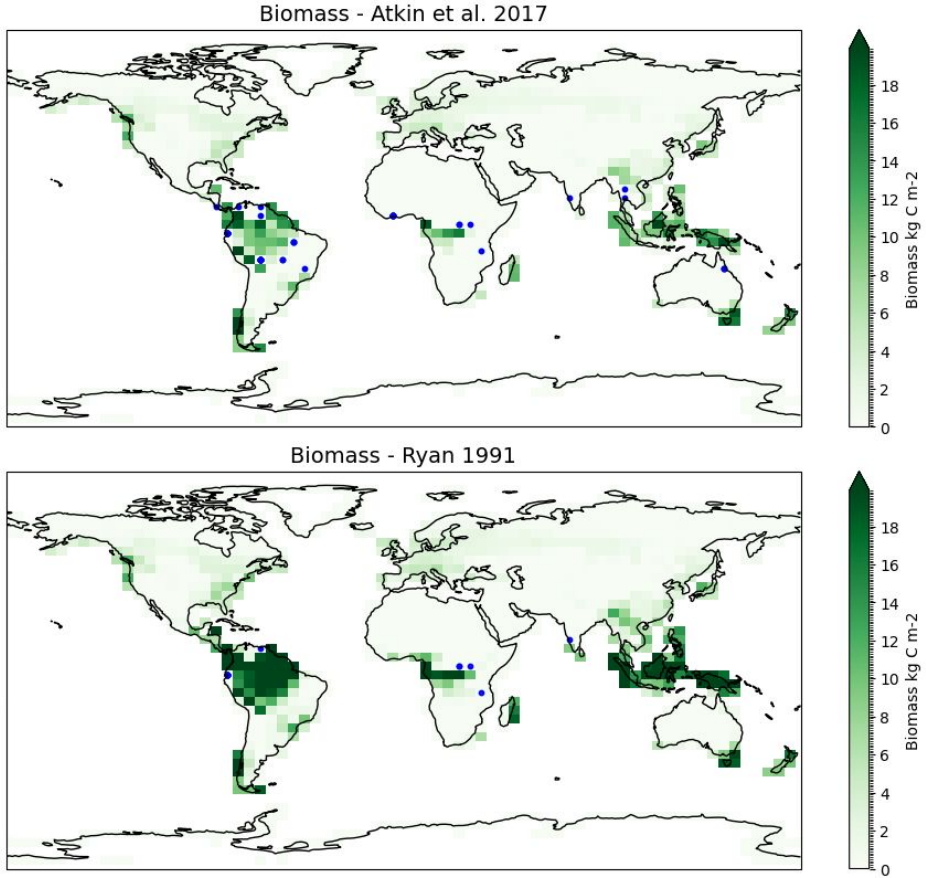
**Atkin et al. 2017**

Base respiration rate scaled by leaf N through the canopy and a **moving window of temperature**.

See FATES github PR #931 and issue #729

# Atkin et al. respiration scheme improves overall biomass but with lack of establishment in some grid cells



# Exploring conditions for successful establishment

**Hypotheses:**

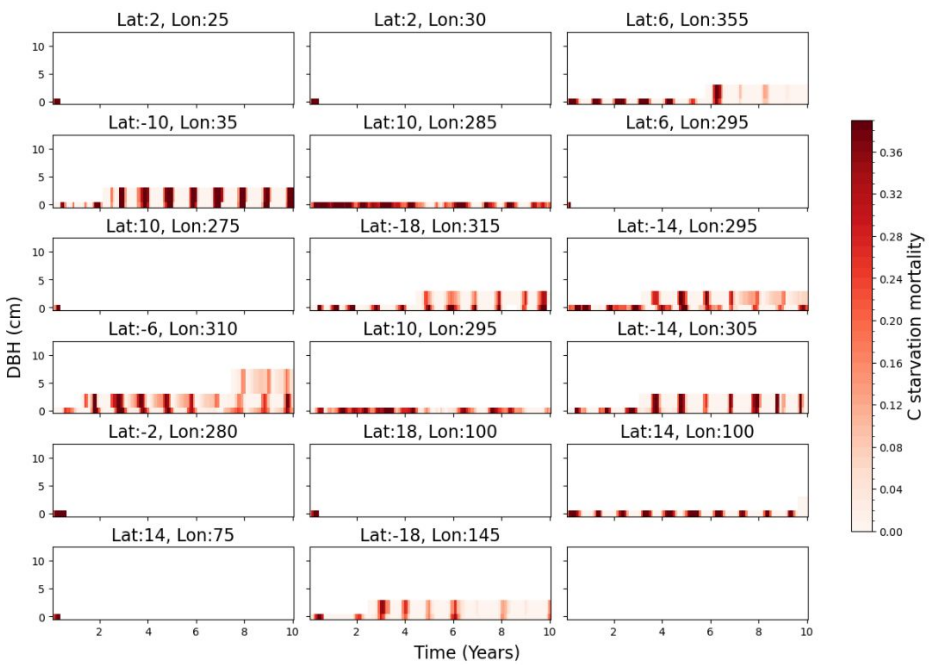
- Growth is too slow to allow trees to reach reproductive size before the population declines
- High initial carbon starvation/hydraulic failure kills all recruits in first few year

No improvement from:

- high initial recruit density
- high storage carbon
- starting runs in the wet season

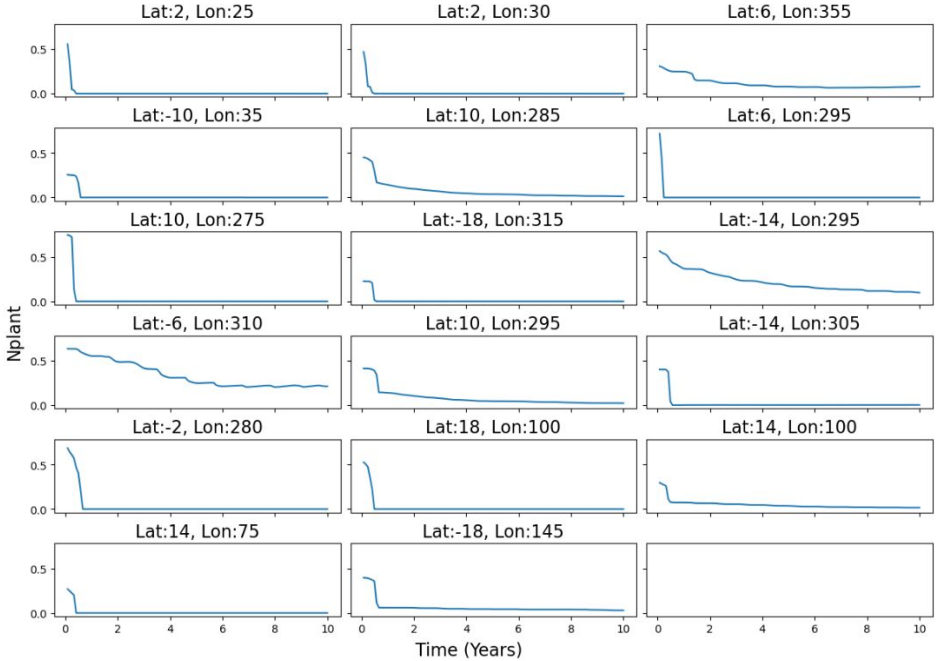
Some improvement from supplemental seed rain

# High carbon starvation mortality and low plant density in sites that fail to establish

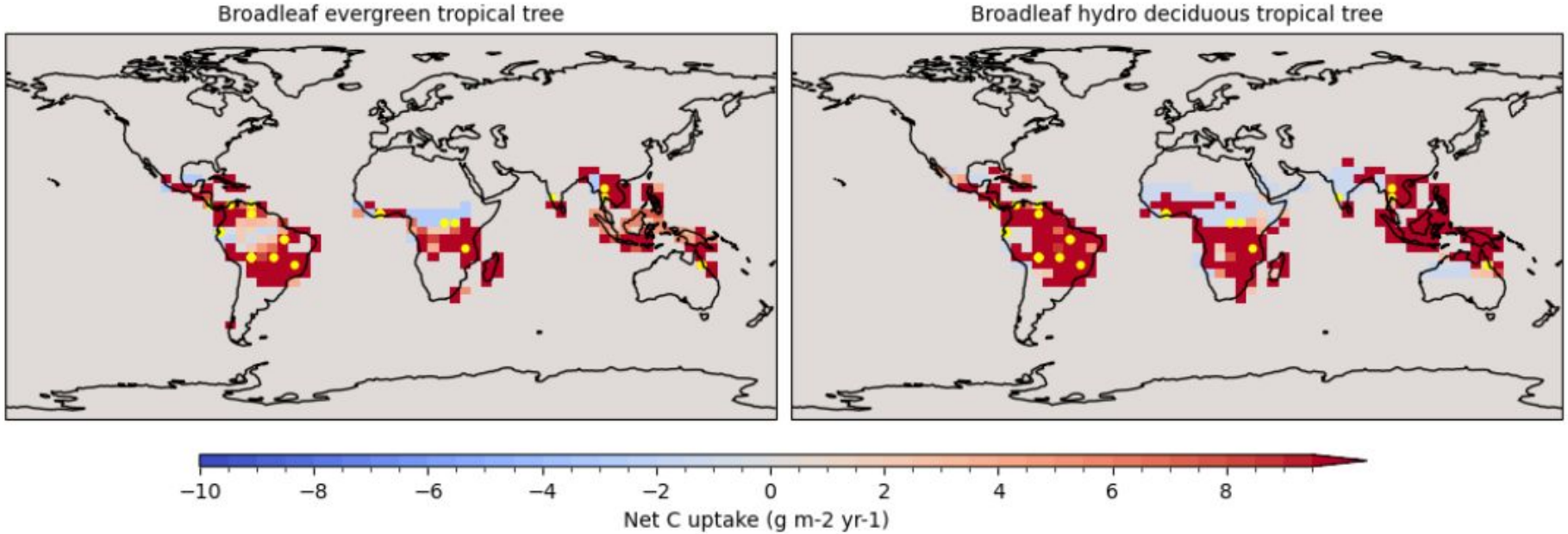




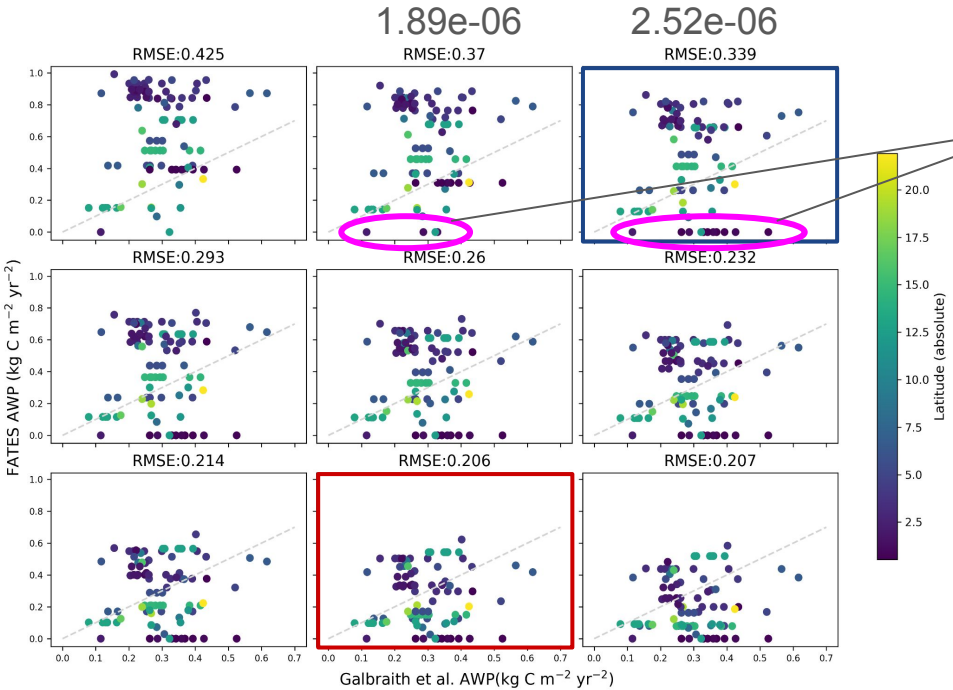




# Not all sites that fail to establish have negative net C uptake



# Can we identify thresholds that cause a lack of establishment?




Increase in fates_base_mr_20 from 1.89e-06 to 2.52e-06 causes a big increase in the number of sites that fail to establish

Default **fates_base_mr_20**

Lowest RMSE

# Conclusions

- Networks of forest plots provide valuable demographic benchmarks
- Comparisons with plot data reveals a high aboveground woody productivity (AWP) bias
- AWP is reduced by increasing respiration costs
- But higher respiration causes lack of establishment in some grid cells - still being explored

# Conclusions

- Networks of forest plots provide valuable demographic benchmarks
- Comparisons with plot data reveals a high aboveground woody productivity (AWP) bias
- AWP is reduced by increasing respiration costs
- But higher respiration causes lack of establishment in some grid cells - still being explored

# Next steps

- Find thresholds that allows for successful establishment
- Acclimation of Vcmax
- Explore the CUE of different vertical scalings of respiration, N and vcmax