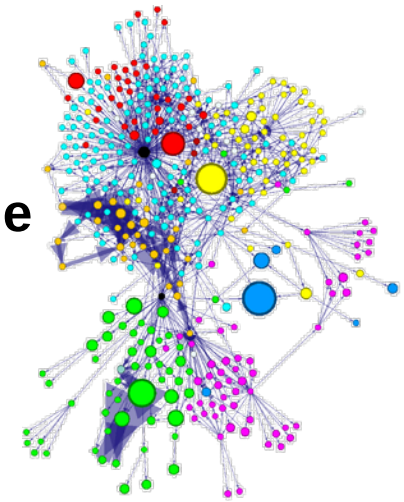
# Physiological Acclimation and Adaptation in CLM4.5

**Anthony King**
**Dan Ricciuto**
**Peter Thornton**
**Dali Wang**
**Jeff Warren**


U.S. DEPARTMENT OF ENERGY
Climate Change Science Institute
AT OAK RIDGE NATIONAL LABORATORY
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

# The framework for functional unit testing allows for evaluation and calibration of CLM processes as modules

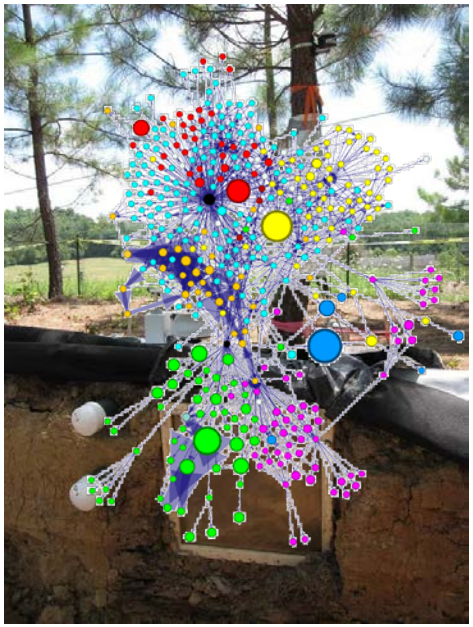
- **Functional Unit Testing**
  - **leaf photosynthesis unit/module**
    - **A subset of CLM4.0's Stomata subroutine**
- **PiTS-1 field experiment**
  - **Partitioning in Trees and Soil - loblolly**
- **MODEX concept**



MOdel ⇌ EXperiment

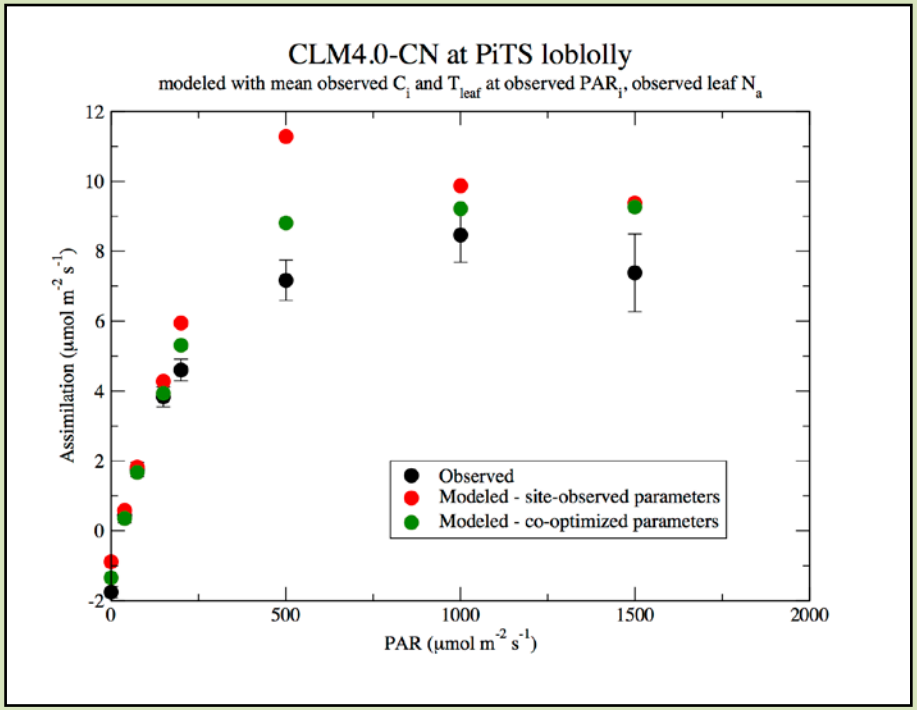
# The framework for functional unit testing allows for evaluation and calibration of CLM processes as modules

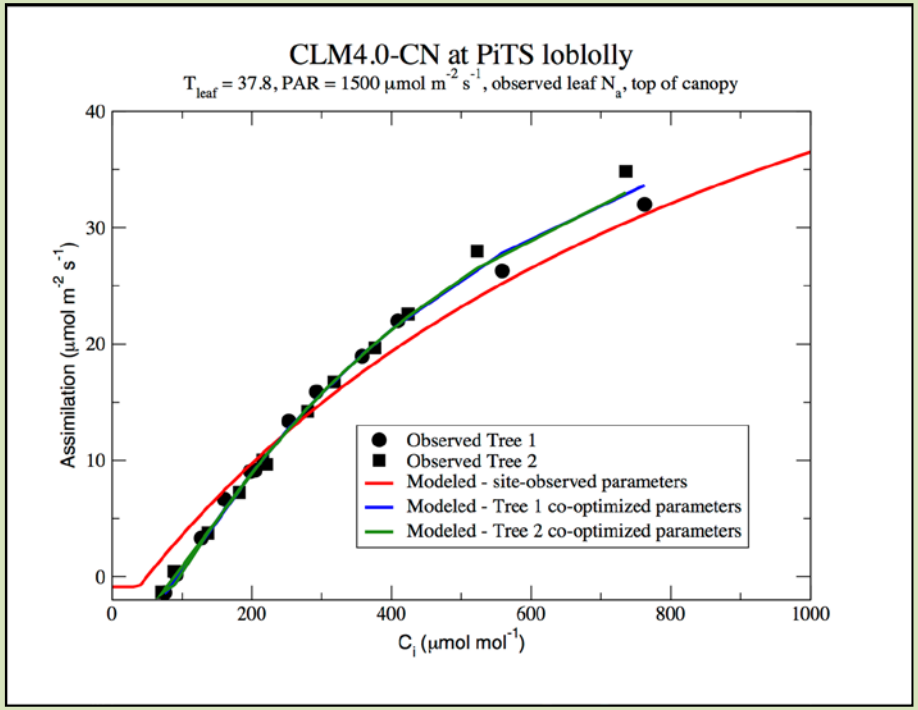
- **Functional Unit Testing**
  - **leaf photosynthesis unit/module**
    - **A subset of CLM4.0's Stomata subroutine**
- **PiTS-1 field experiment**
  - **Partitioning in Trees and Soil - loblolly**
- **MODEX concept**



MOdel ⇌ EXperiment

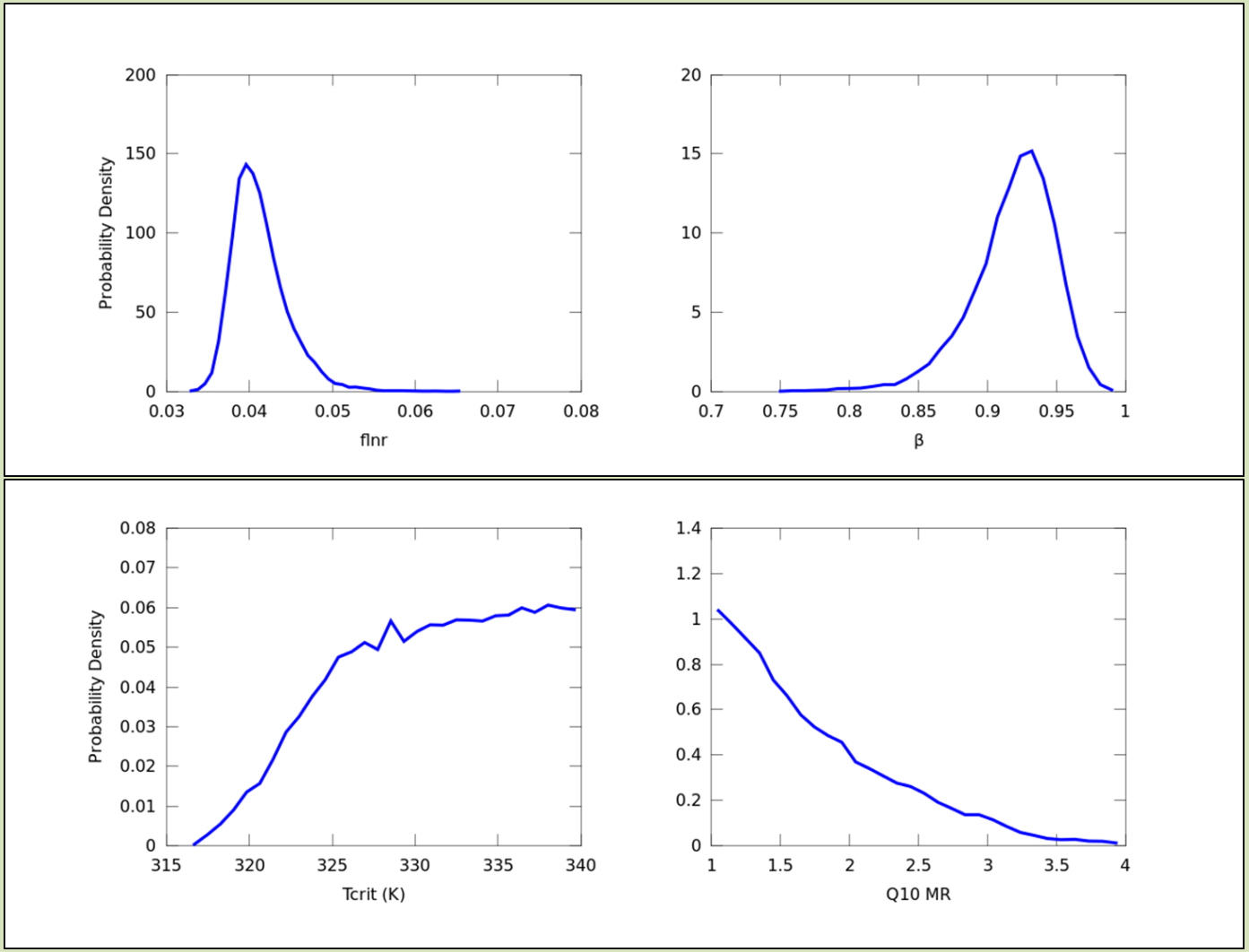
# With multi-scale co-optimization…




Modeled light-response and A-$C_i$ curves after combining stand-level optimized parameters with  parameters co-optimized using Markov Chain Monte Carlo (MCMC) and leaf-level observations of net photosynthetic assimilation response to both light and internal $CO_2$ concentration from the PiTS-1 field experiment.

# Posterior distributions for select parameters from the co-optimization



# Optimized Tcrit and leaf-level Pn acclimation

- **The MCMC optimized $T_{crit}$ shifted photosynthetic optimum to warmer temperatures**
- **Suggested possibility of photosynthetic acclimation to warmer temperatures in loblolly pine**
- **Along came CLM4.5 with temperature acclimation in photosynthetic functions**

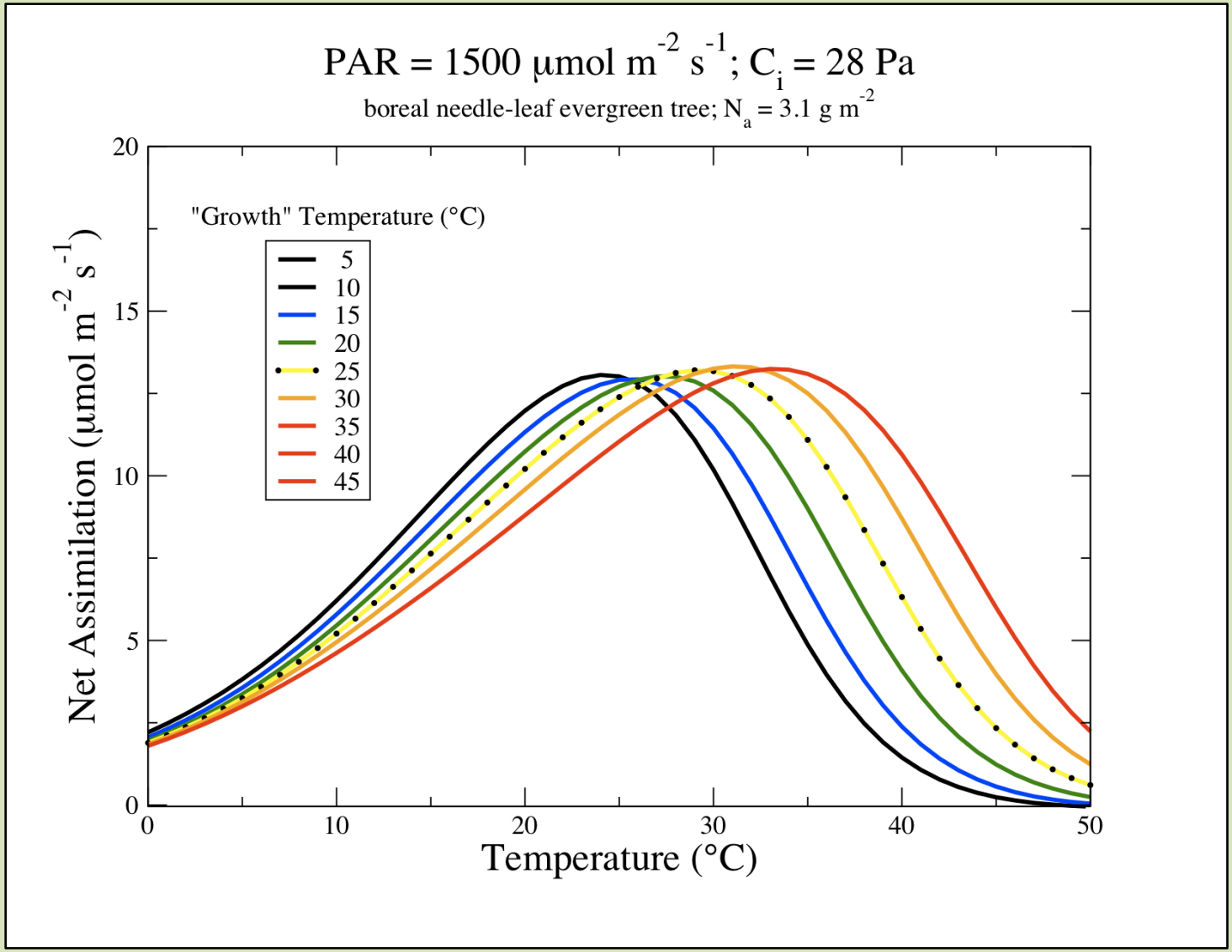
  **Temperature response functions influenced by 10-day running average of 2m temperature (t10)**

# SPRUCE field site

## Marcell Experimental Forest, north of Grand Rapids, MN

Warming and elevated $CO_2$ experiment with large open top chambers

# CLM4.5 process simulations

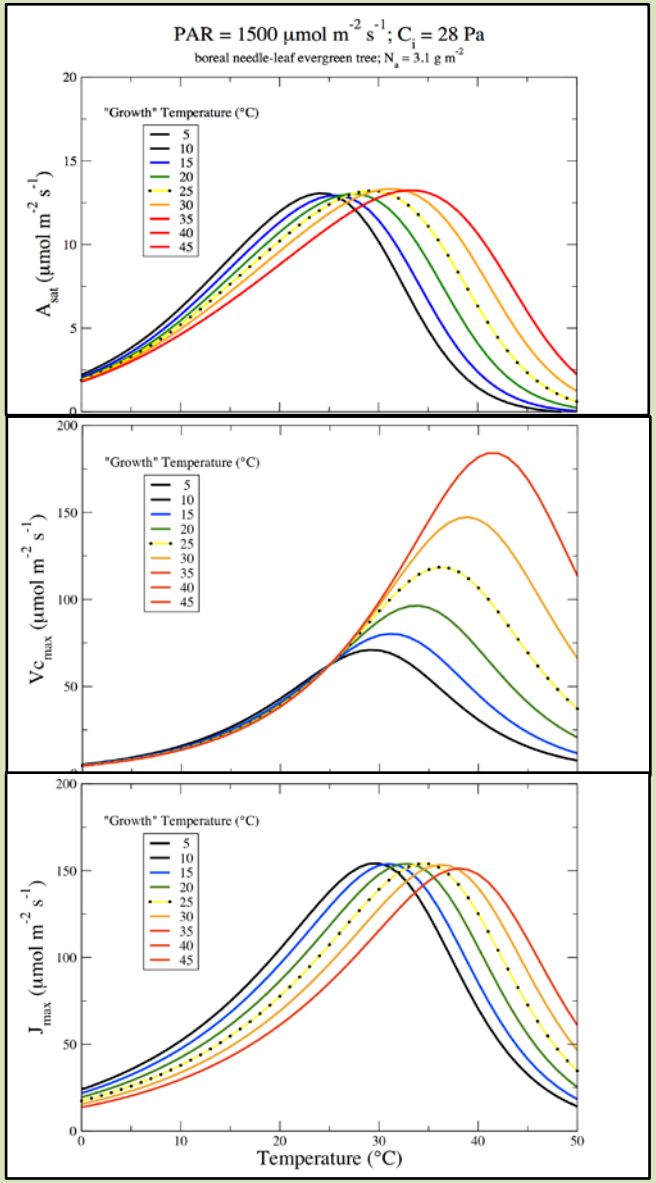


# CLM4.5 process simulations – boreal needle-leaf evergreen

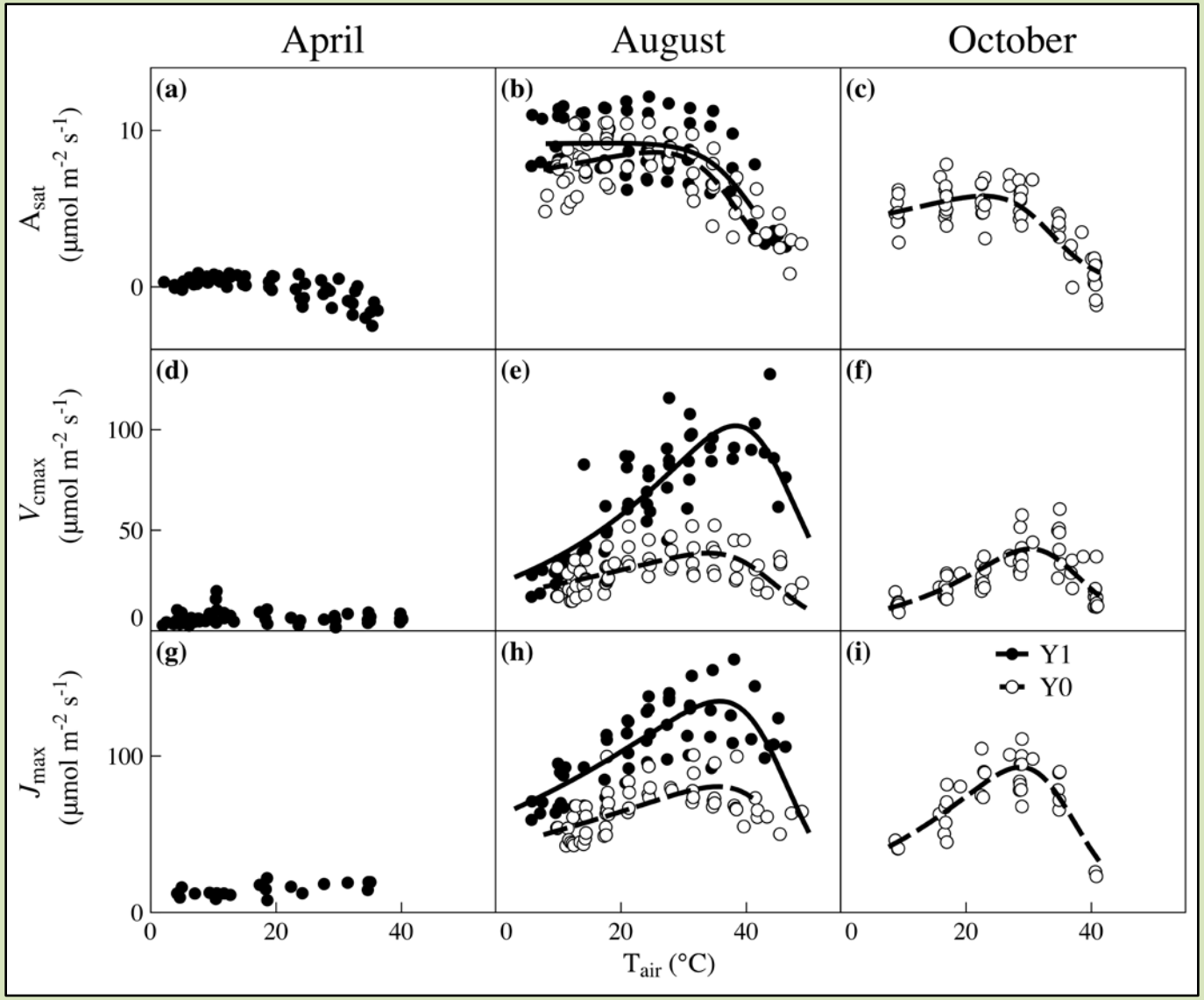
PAR = 1500 µmol $m^{-2}$ $s^{-1}$

$C_i$ = 28 Pa

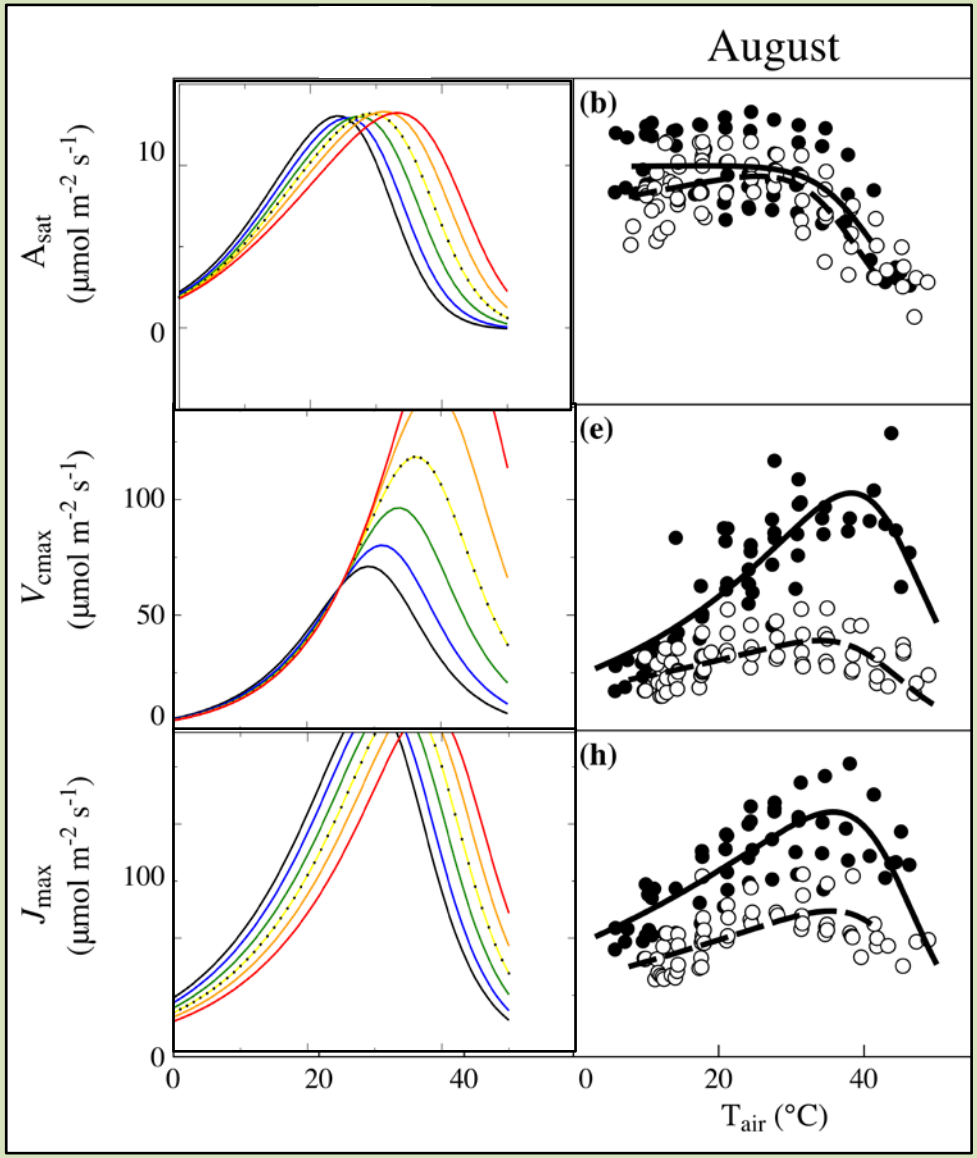
$N_a$ = 3.1 g $m^{-2}$



# SPRUCE field measurements on black spruce

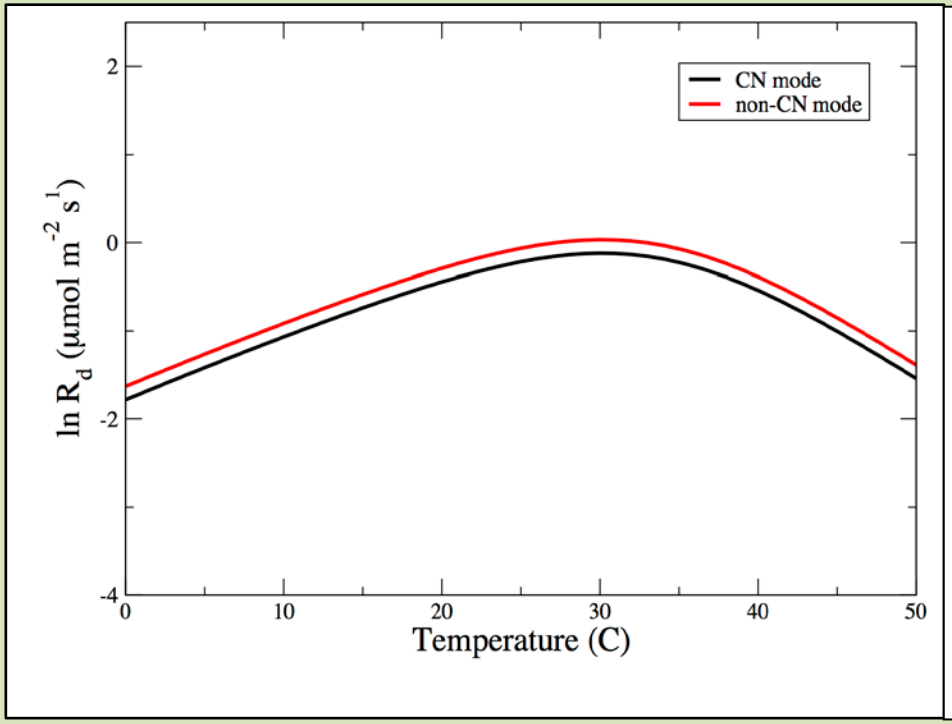


# CLM 4.5 “out-of-the-box” and SPRUCE field measurements



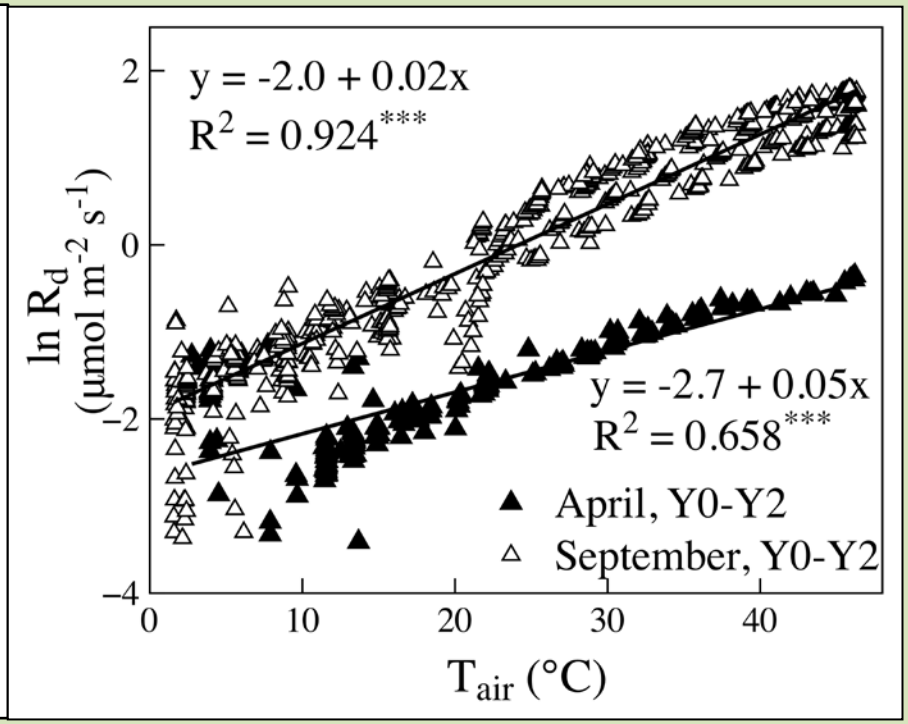
# Leaf dark respiration $R_d$

CLM4.5




…decline in $R_d$ at high $T_{air}$

SPRUCE




…no decline in $R_d$ at high $T_{air}$

# Next steps...

- Check yet again the the functional units are correct against CLM4.5
- Explore alternative $R_d$ temperature response functions
- Add temperature acclimation to $R_d$ (and $R_a$ generally)
- Add needle cohorts to CLM4.5 canopy?
- Parameterize CLM4.5 functions for SPRUCE black spruce
- Calibrate to SPRUCE measurements using MCMC methods
- Repeat SPRUCE measurements at different growth temperatures (i.e. t10)
- Compare temperature responses of CLM4.5 with SPRUCE experimental effects

# Next steps...

- Check yet again the the functional units are correct against CLM4.5
- Explore alternative $R_d$ temperature response functions
- Add temperature acclimation to $R_d$ (and $R_a$ generally)
- **Add needle cohorts to CLM4.5 canopy?**
- Parameterize CLM4.5 functions for SPRUCE black spruce
- Calibrate to SPRUCE measurements using MCMC methods
- Repeat SPRUCE measurements at different growth temperatures (i.e. t10)
- Compare temperature responses of CLM4.5 with SPRUCE experimental effects

# Next steps...

- Check yet again the the functional units are correct against CLM4.5
- Explore alternative $R_d$ temperature response functions
- Add temperature acclimation to $R_d$ (and $R_a$ generally)
- Add needle cohorts to CLM4.5 canopy?
- Parameterize CLM4.5 functions for SPRUCE black spruce
- Calibrate to SPRUCE measurements using MCMC methods
- Repeat SPRUCE measurements at different growth temperatures (i.e. t10)
- Compare temperature responses of CLM4.5 with SPRUCE experimental effects
- **Adaptation…**