Root Modeling:

Estimating Storage, Live, and Dead Pool Turnover Times; Storage Inputs to New Root Growth; and Root C Inputs to Soil

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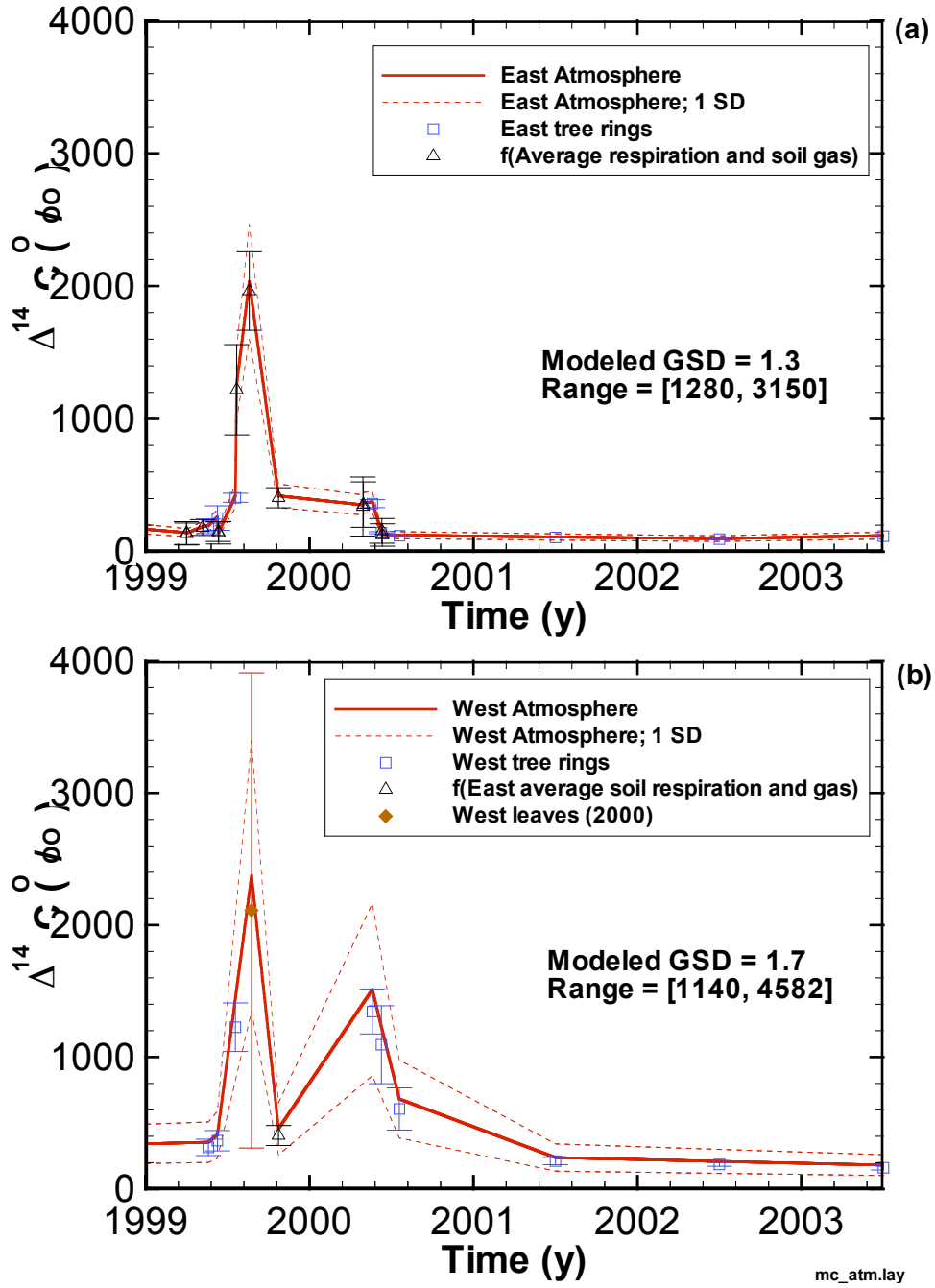
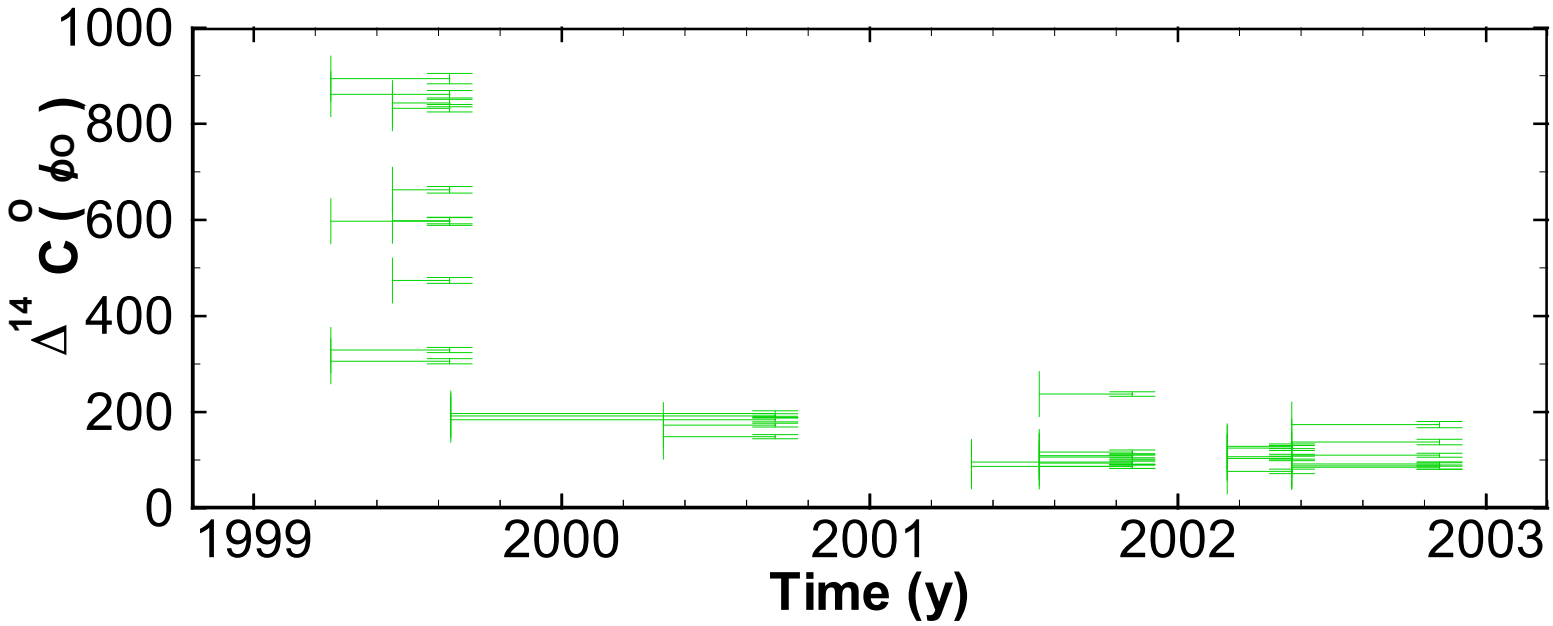
Outline

- Data and goals
- Model description
- Monte Carlo approach to propagate parameter and input uncertainty
- χ^2 approach to choose best-fit parameters
- "Storage" simulations with in-growth cores
- Live and dead pool simulations with cores

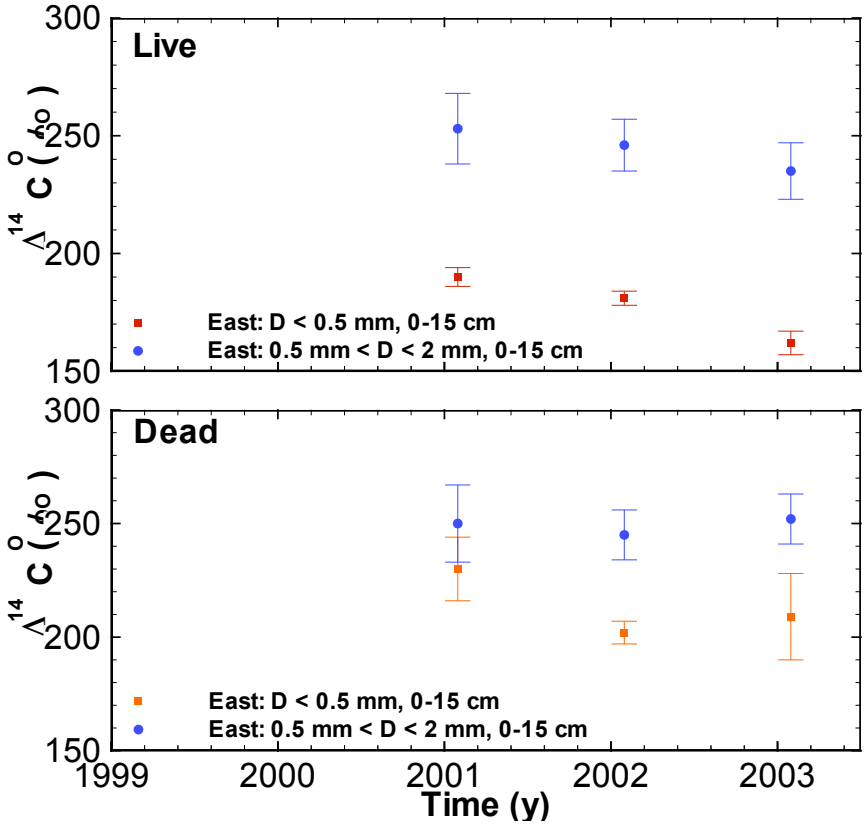
Data: Atmosphere

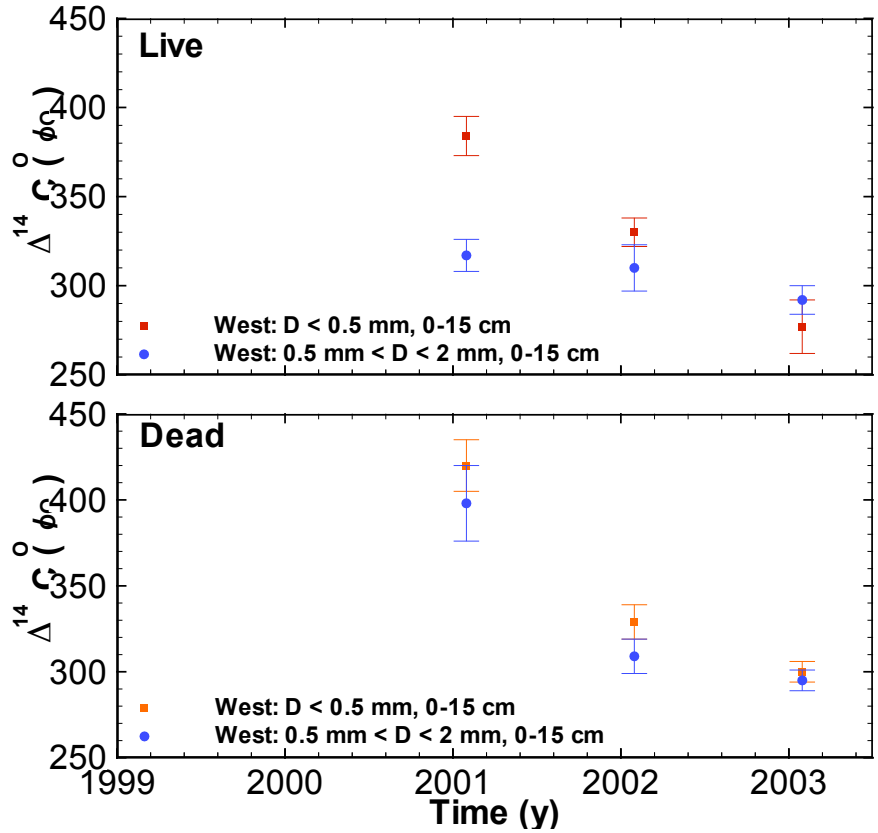


Data: In-growth Cores



Data: Cores


Live
Dead
East: D < 0.5 mm, 0-15 cm
East: 0.5 mm < D < 2 mm, 0-15 cm
Δ14C (‰)
300
250
200
150
1999
2000
2001
2002
2003
Time (y)

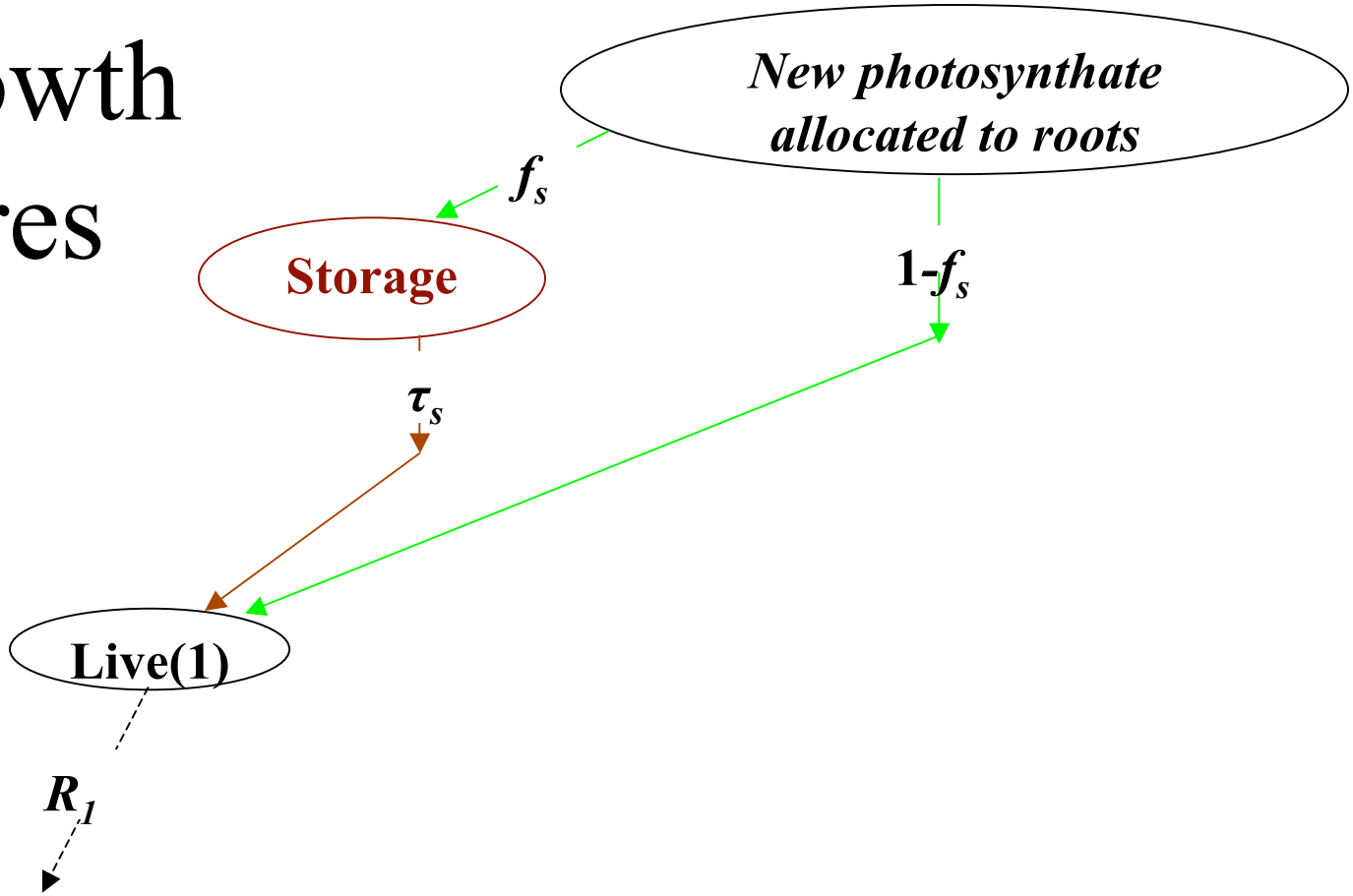

Live
Dead
West: D < 0.5 mm, 0-15 cm
West: 0.5 mm < D < 2 mm, 0-15 cm
Δ14C (‰)
450
400
350
300
250
1999
2000
2001
2002
2003
Time (y)

Other Data & Goals

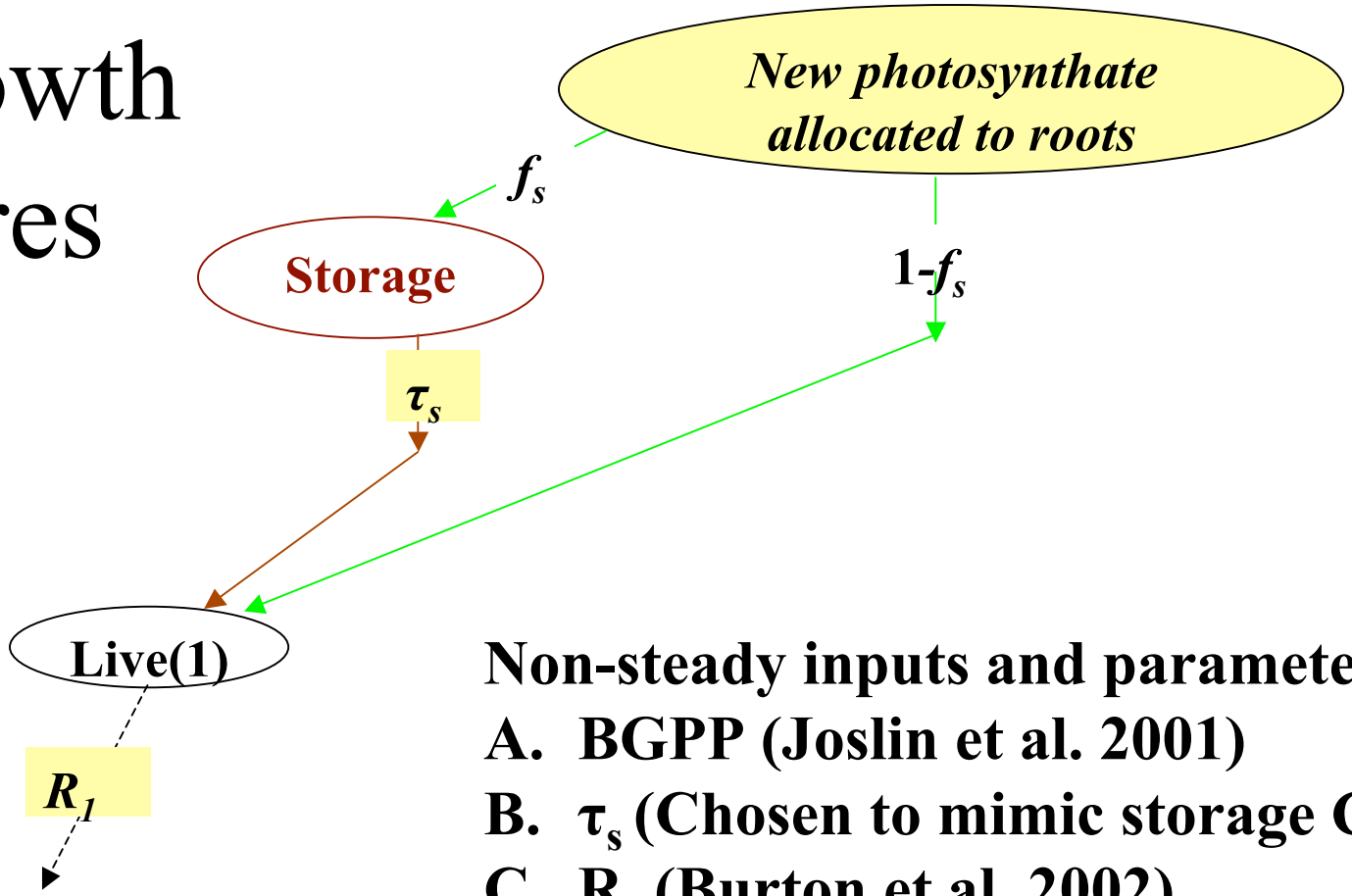
- Data
  - BGPP magnitude and timing
  - Respiration magnitude and timing
  - Fine root biomass
  - Etc.
- Estimate
  - Storage turnover
  - Live fine root mortality turnover
  - Dead fine root mortality turnover
  - C inputs to soil

Model Description

Ingrowth Cores



Ingrowth Cores



Non-steady inputs and parameters:

A. BGPP (Joslin et al. 2001)

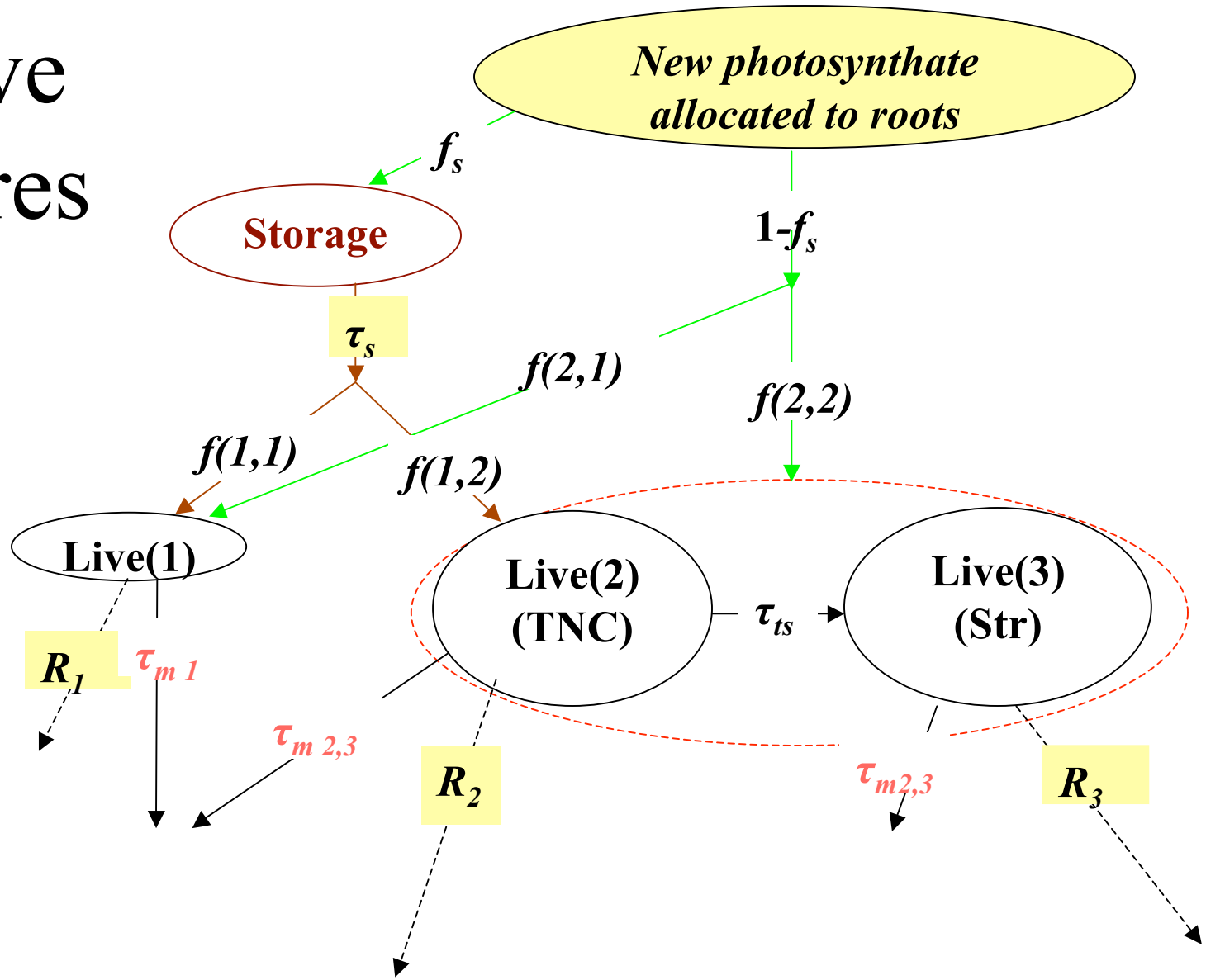
B. τ_s (Chosen to mimic storage C use)

C. R_1 (Burton et al. 2002)

1. Based on individual pool size

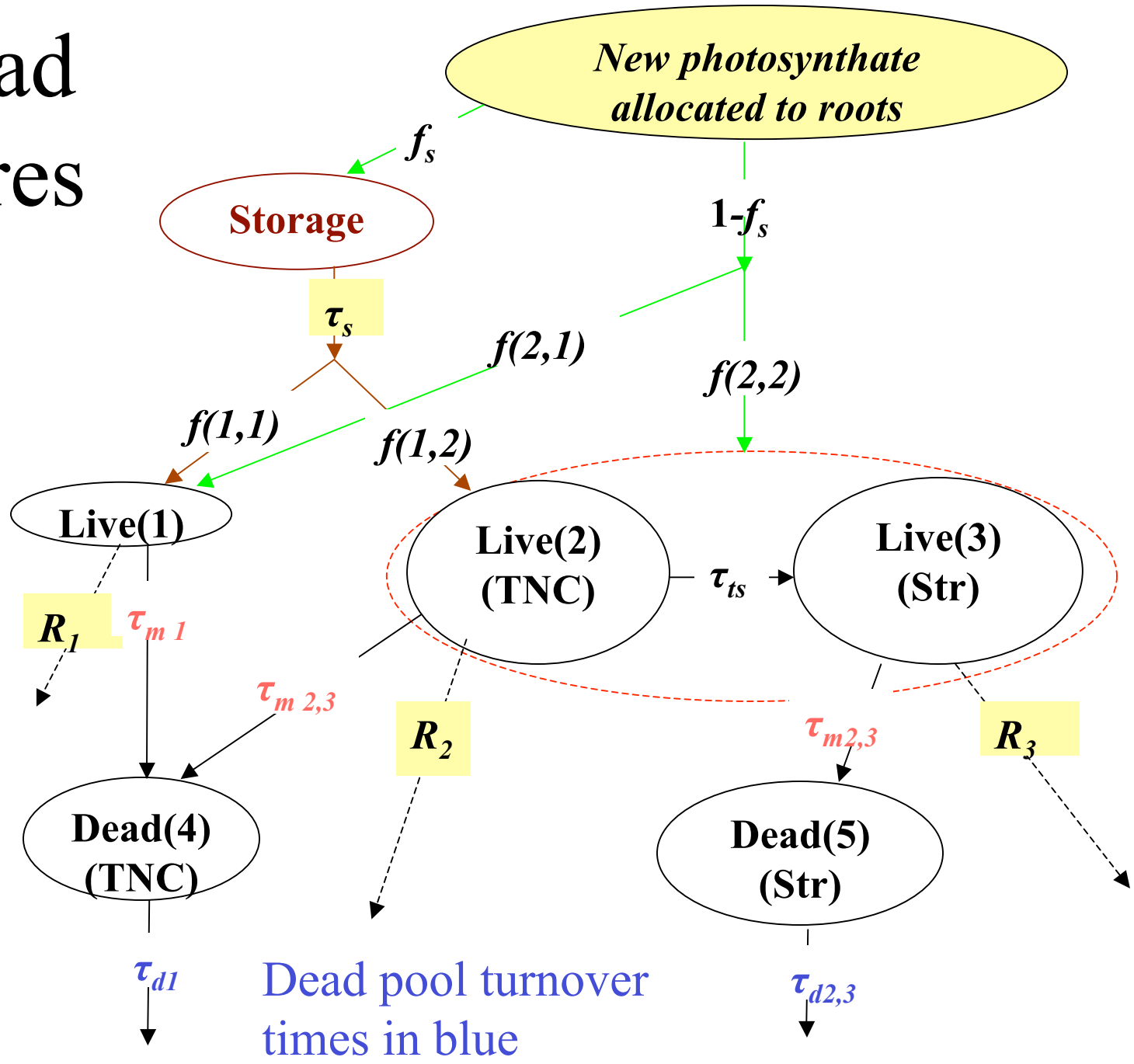
Attempt to identify τ_s and f_s using ingrowth core data

Live Cores



Mortality time constants are in red

Dead Cores

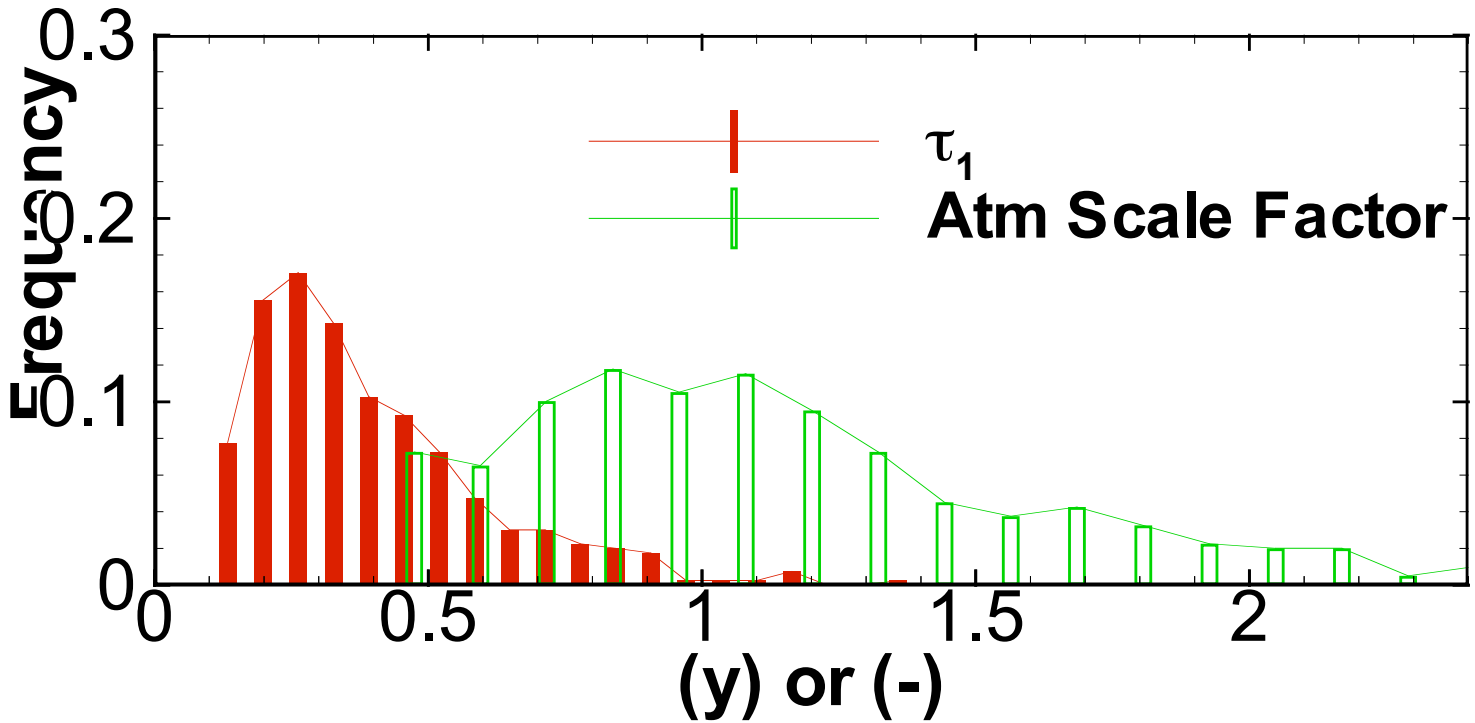


Dead pool turnover times in blue

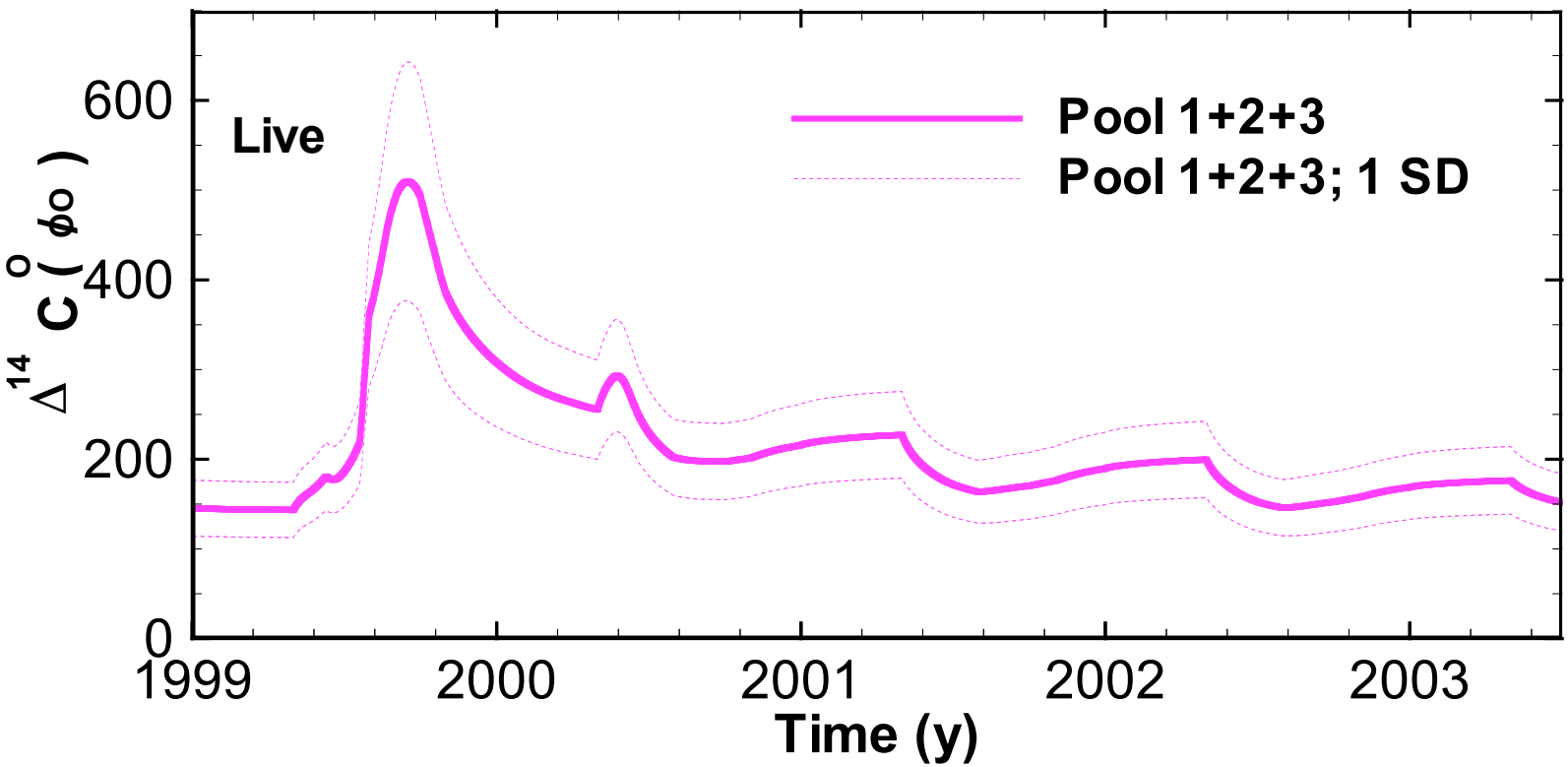
Monte Carlo Uncertainty Propagation

- Estimate uncertainty in parameters using a normal or lognormal pdf (i.e., mean and SD; geometric mean and GSD)
- Run many simulations with parameters chosen from these pdf's
- Report results as mean and SD from the ensemble simulations
- Eleven parameters varied in results shown here

Example Monte Carlo Parameter Space



Example Monte Carlo Mean and Uncertainty



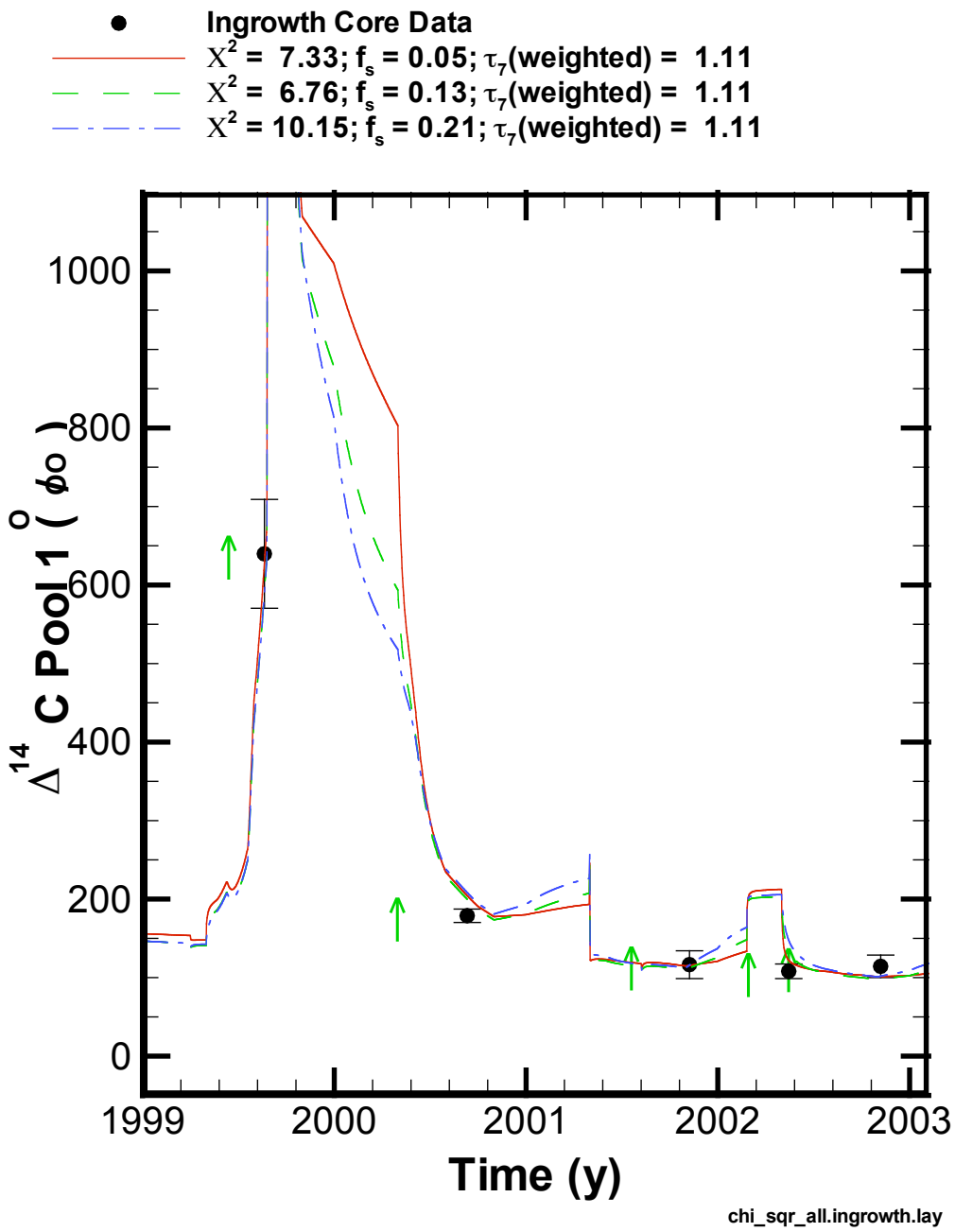
χ^2 Parameter Fitting

- Method to choose parameter set that results in best fit of simulations to data:

$$\chi^2 = \sum_{i=1}^{N} \left(\frac{y_i - y(t_i; p_1 \ldots p_m)}{\sigma_i} \right)^2$$

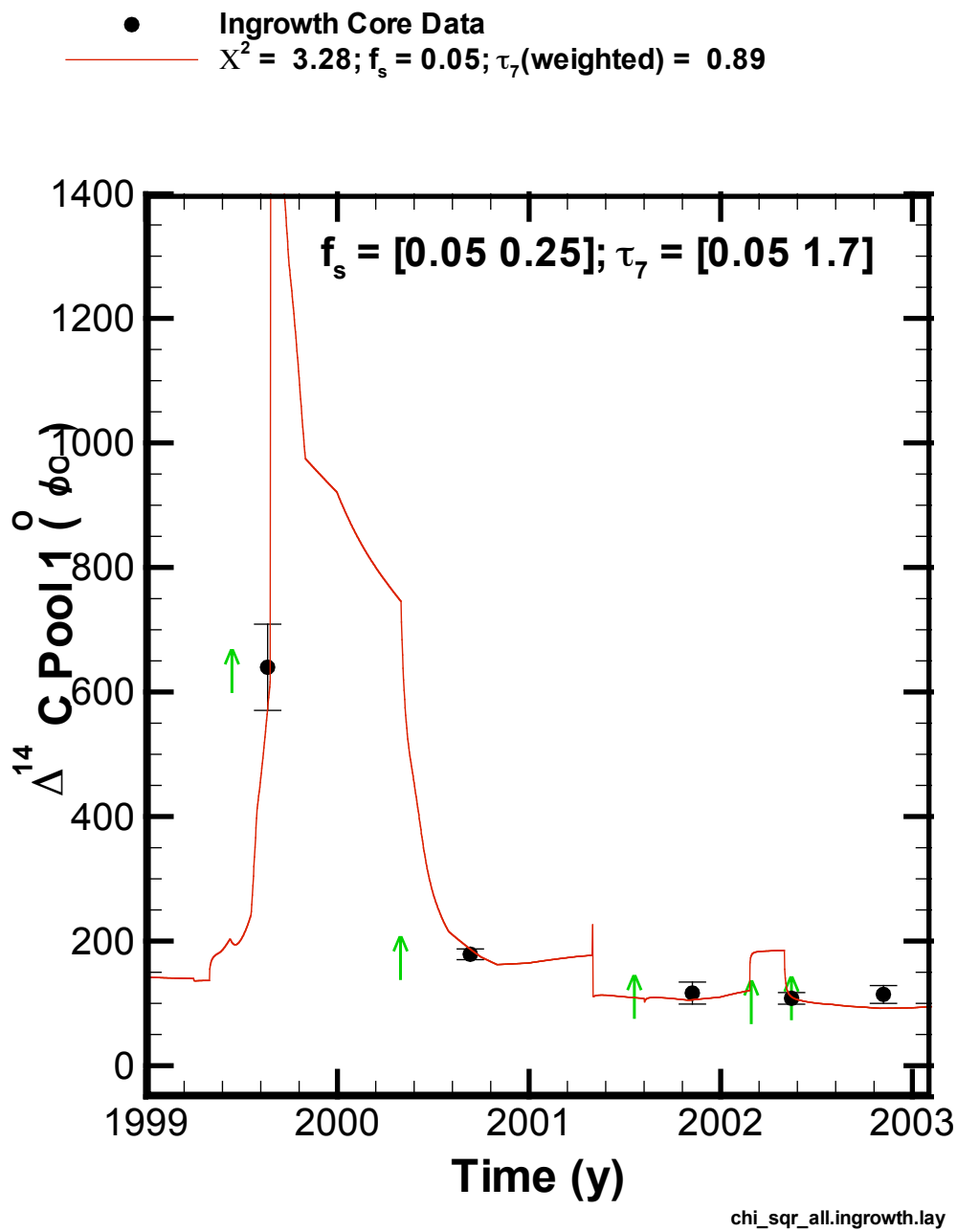
- Where:
  - N = number of observations; y_i = observations; y = model prediction; p_i = parameters; σ_i = SE of observations
- Include Monte Carlo uncertainty

Example: In-growth Core Sensitivity to f_s

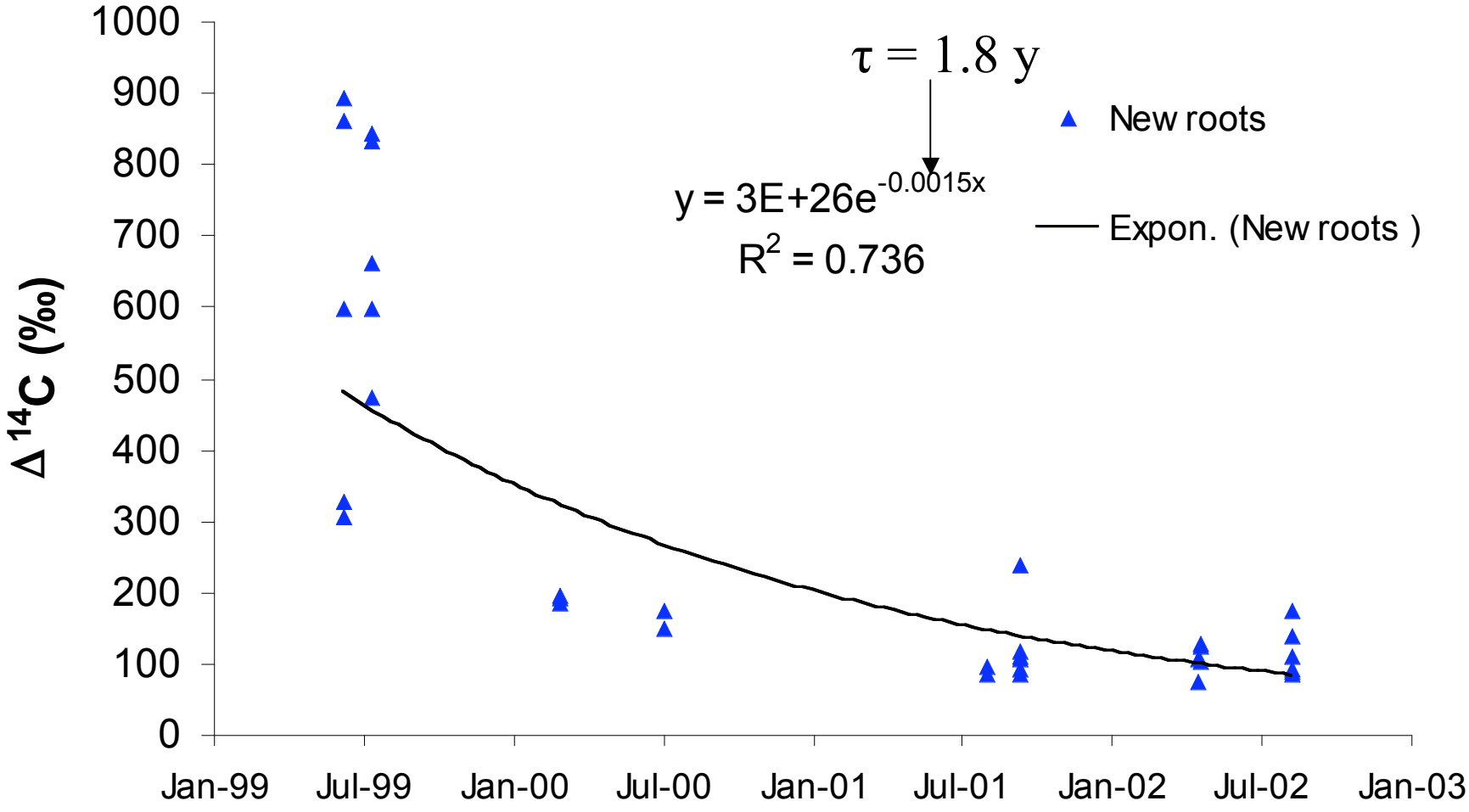


Green arrows indicate in-growth core start date

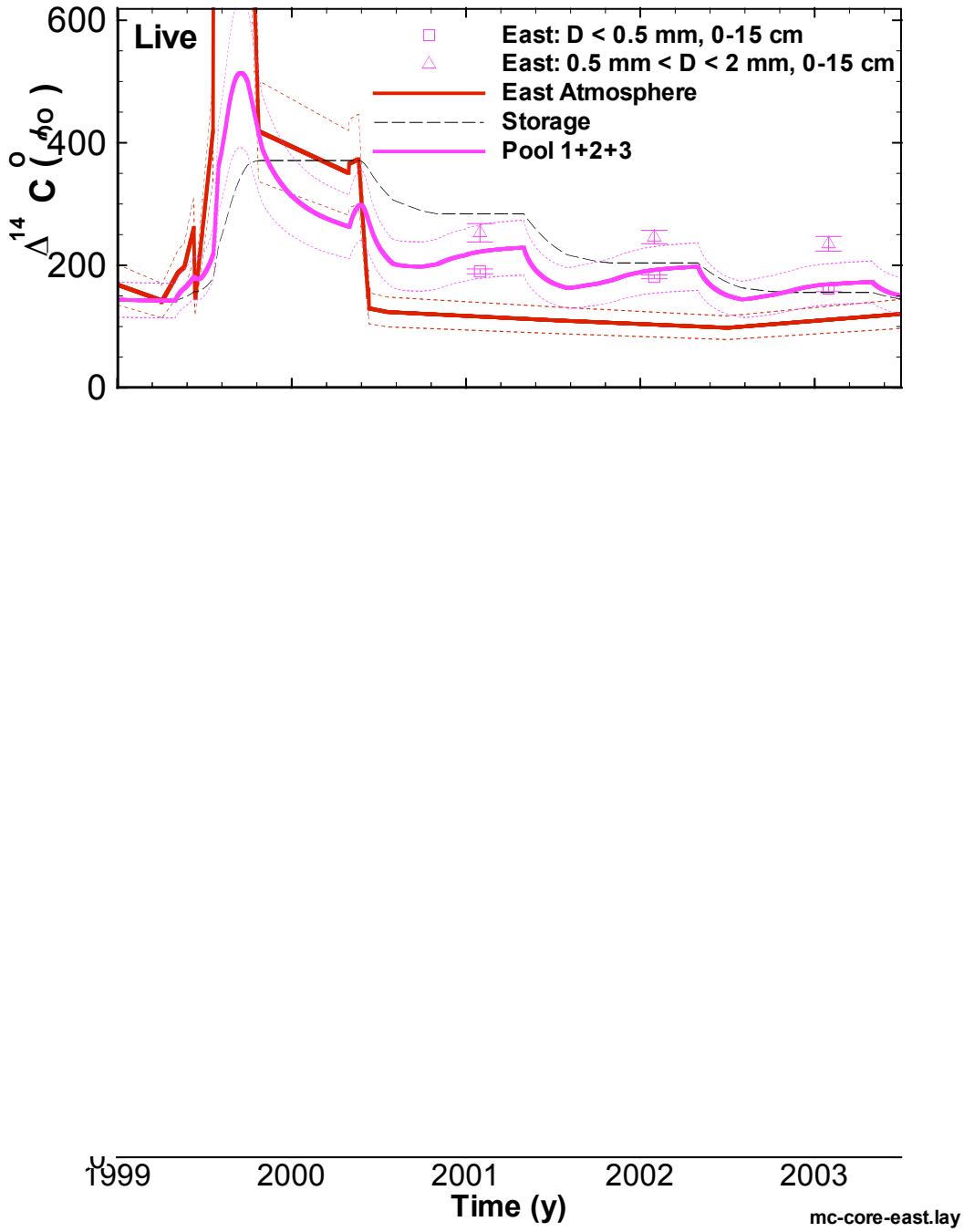
χ^2 Results Example: In-growth Cores



Comparison with Simple Exponential Fit Approach



East Cores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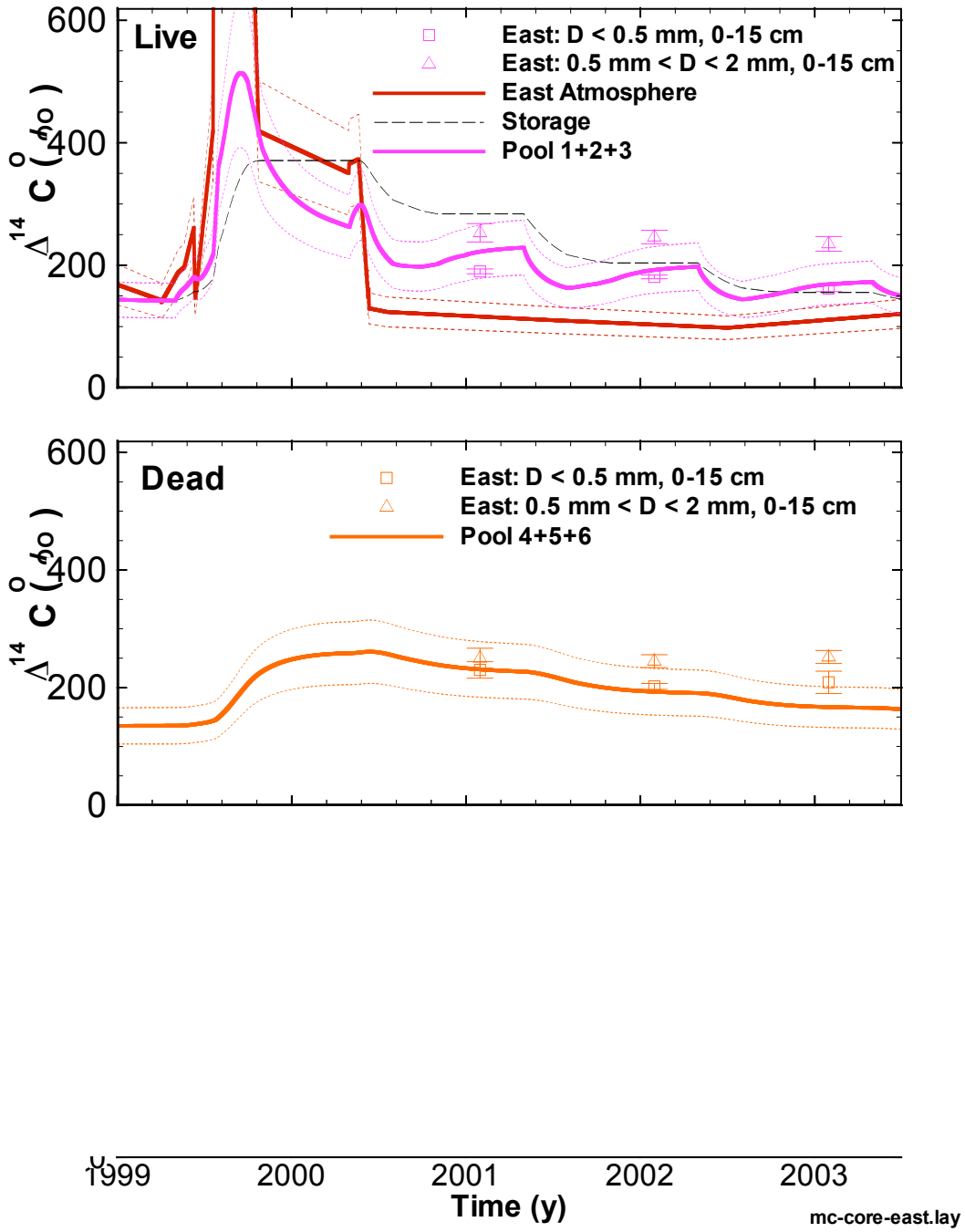
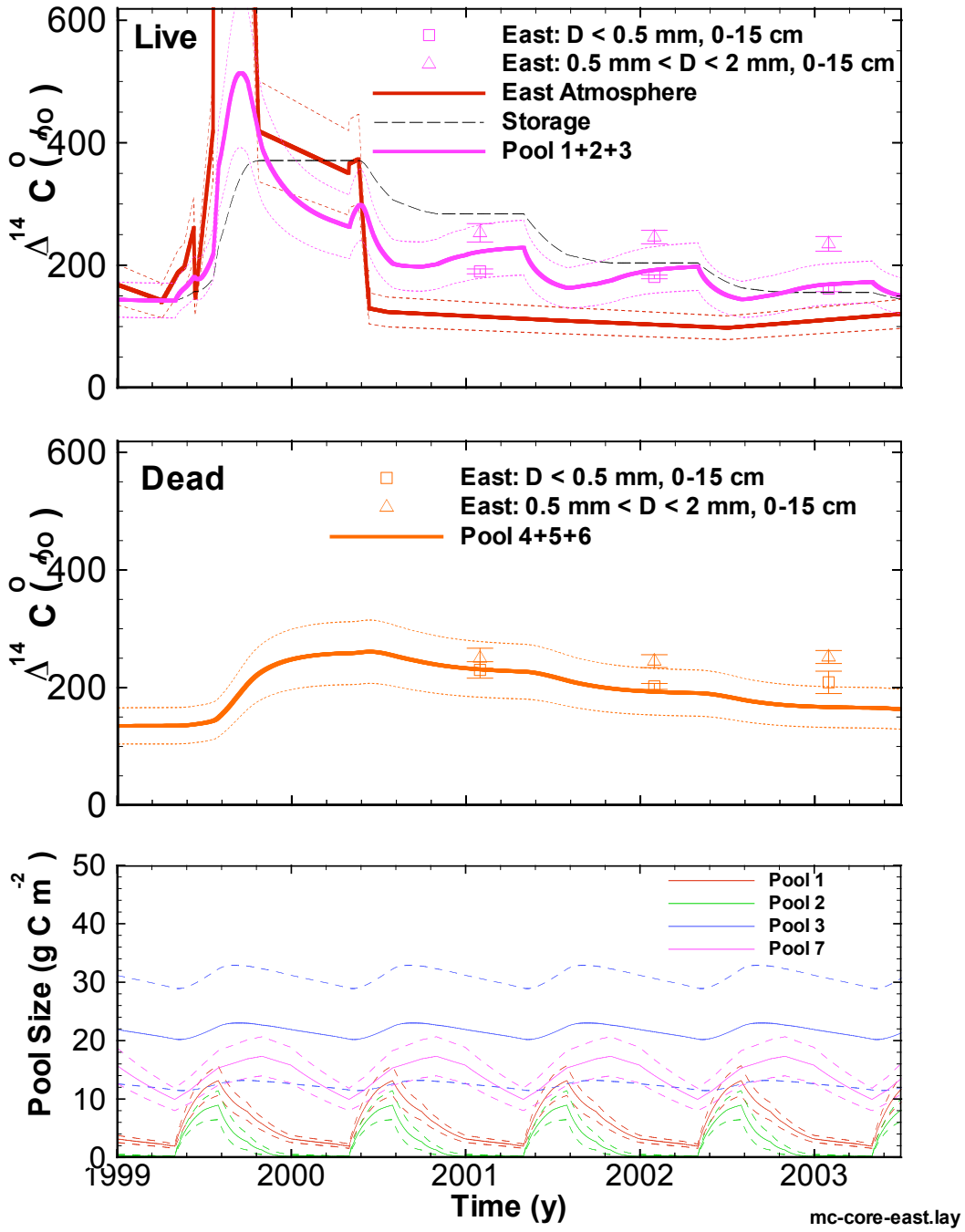
East Atmosphere
Storage
Pool 1+2+3
$\Delta^{14}C$ (‰)
600
400
200
0
1999
2000
2001
2002
2003
Time (y)
mc-core-east.lay

East Cores

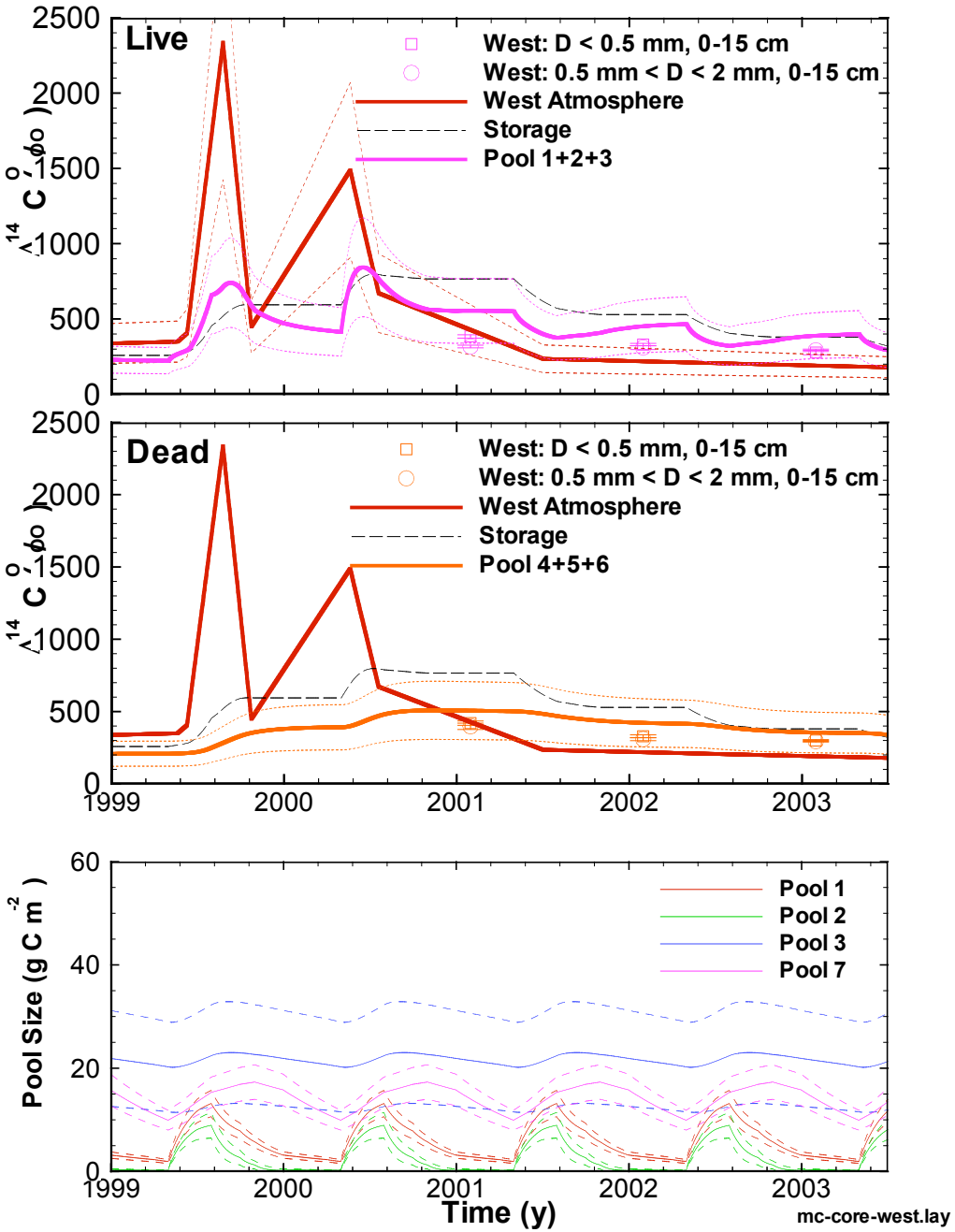

Live
East: D < 0.5 mm, 0-15 cm
East: 0.5 mm < D < 2 mm, 0-15 cm
East Atmosphere
Storage
Pool 1+2+3
Dead
East: D < 0.5 mm, 0-15 cm
East: 0.5 mm < D < 2 mm, 0-15 cm
Pool 4+5+6
Δ14C (‰)
600
400
200
0
1999
2000
2001
2002
2003
Time (y)
mc-core-east.lay

East Cores



Further constrain with measurements of biomass in pools 1+2+3 and ratio of biomass in pool 1 to pools 2+3

West Cores



Further constrain with measurements of biomass in pools 1+2+3 and ratio of biomass in pool 1 to pools 2+3

Observations

- Atmospheric $\Delta^{14}C$ record is uncertain and important
- Inferred mortality turnover times depend strongly on whether respiration is included in analysis
- Uncertainty in estimates may be large