Riverbed Bioclogging and the Effects on Infiltration and Carbon Flux Under Climate Variability

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Introduction

- ***Dynamic permeability***

A change in K <u>over time</u> from sediment, biomass, detritus

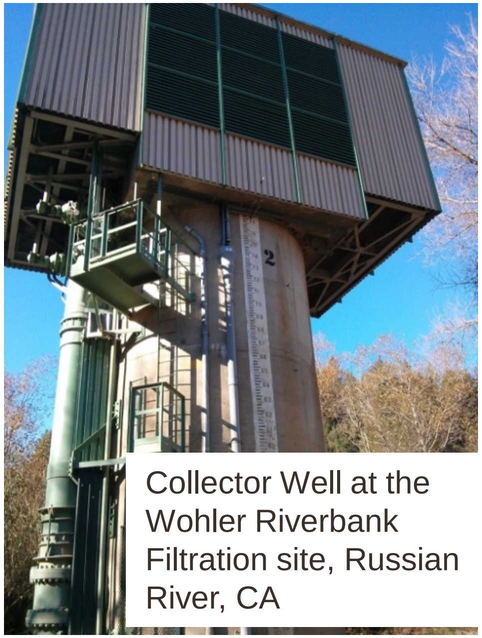
- ***Bioclogging***:

Growth of bacteria and accumulation of cells in the pore-space decrease Φ and K

- ***Climate Variability***:

Changes in Q (discharge) from ENSO can alter the seasonal initial parameter values

Russian River, July 2012



Collector Well at the Wohler Riverbank Filtration site, Russian River, CA

Main Research Questions & Goals

- El Niño Southern Oscillation (ENSO) end-member (dry years (LN) vs. wet years (EN)) effects

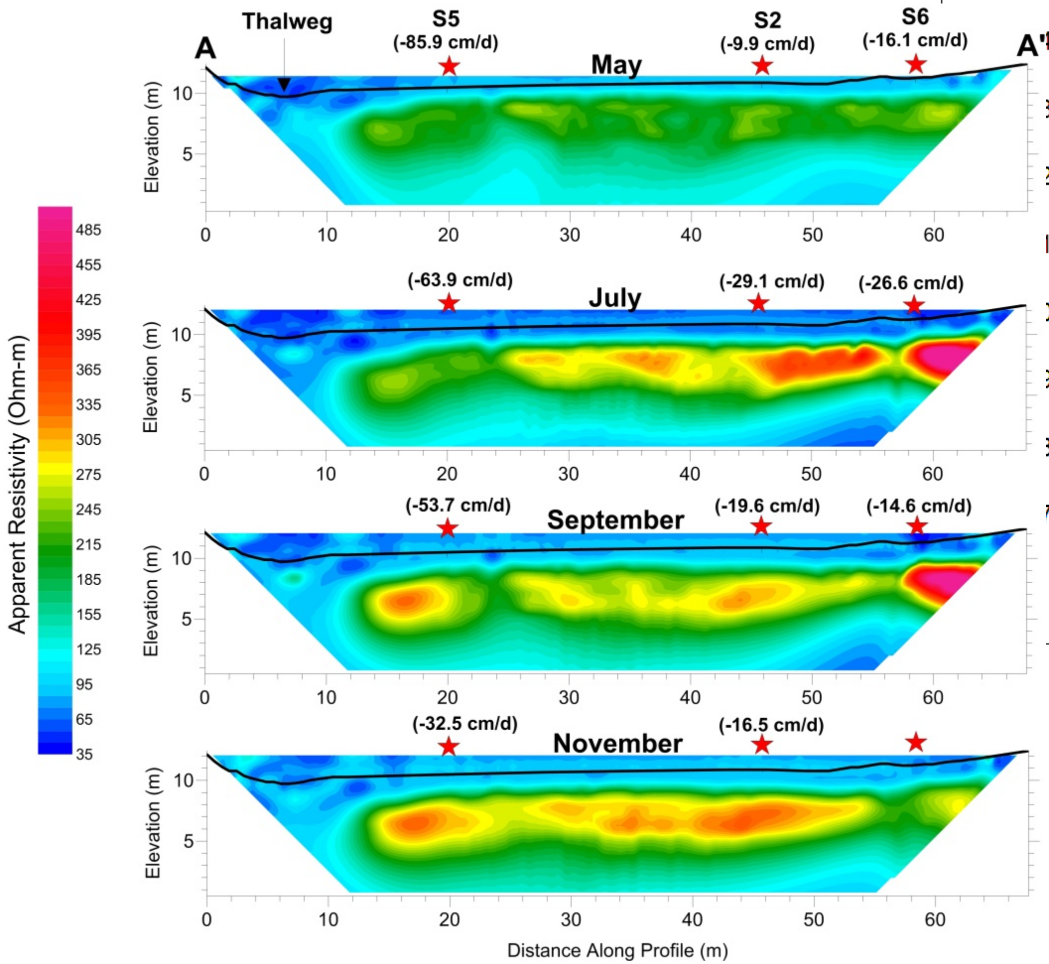
Summer algae growth provides substrate for bioclogging July 2015

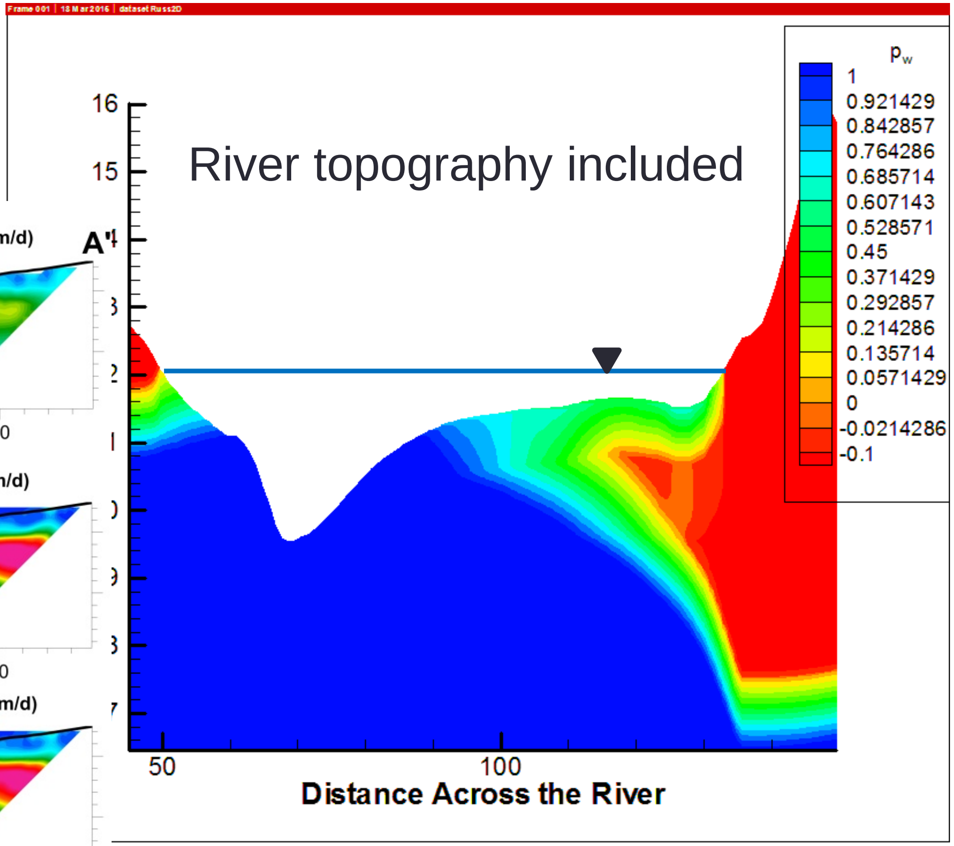
- Do initial riverbed conditions (K and Φ) change with ENSO and enhance or limit CO_2, N_2 production, bioclogging hotspots?
- Novel implementation of topography, bioclogging feedbacks in MIN3P

Methods

A River Undergoing Disconnection

- 1D, 2D models of the river subsurface with **MIN3P**



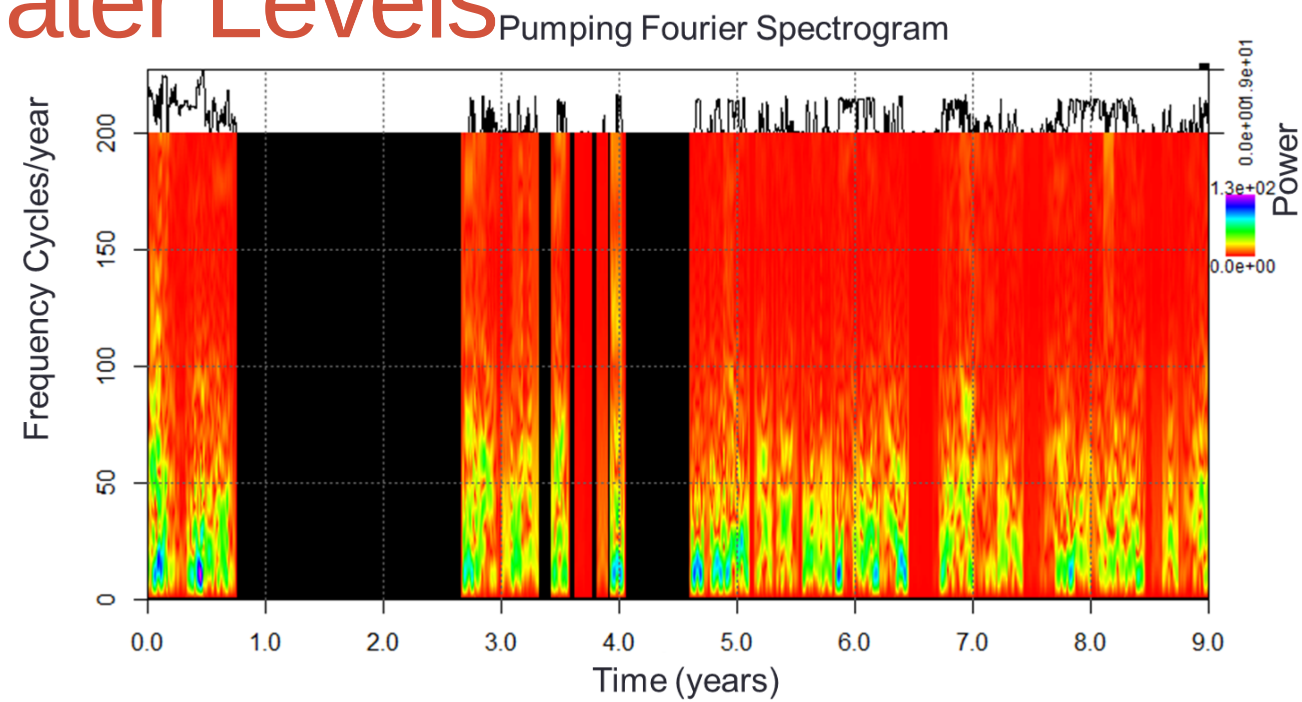


Modeled

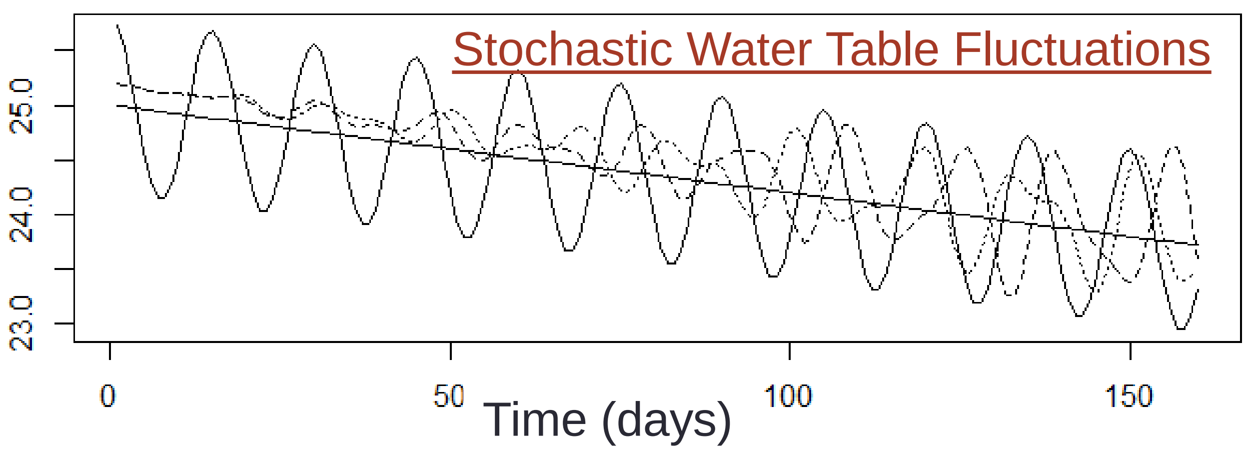
- Disconnection
- Bioclogging
- Pumping
- Topography

Stochastic Water Levels

- Fourier spectrogram of pumping time series
- Perturb the system with stochastic water table fluctuations

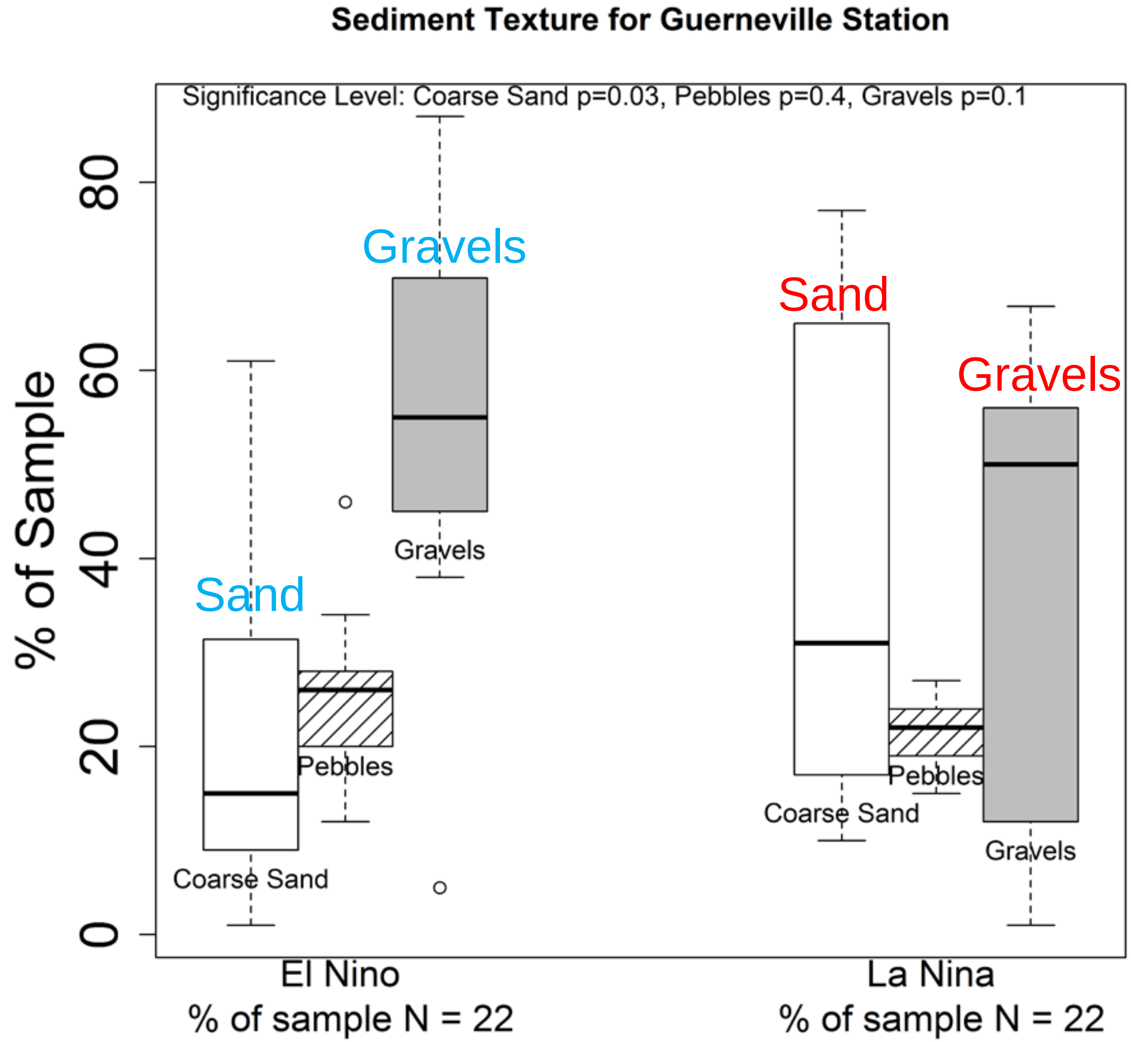


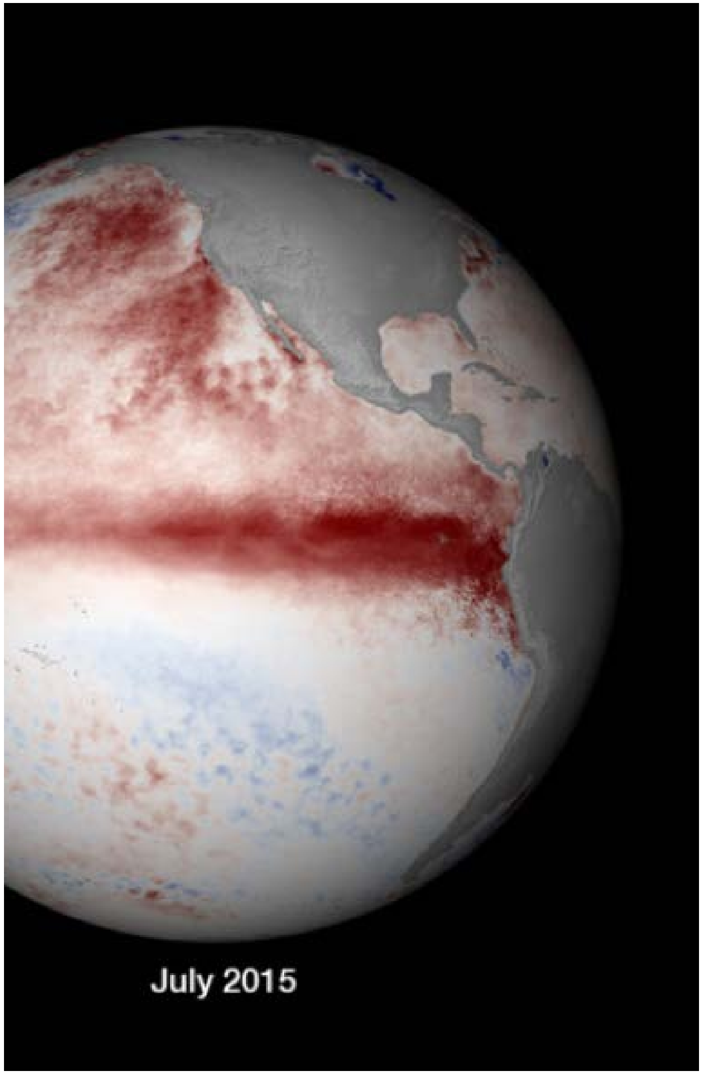
Dominant Cycle ~ 20 cycles/year~ 1.6 cycles/month = 20 day cycle



- Reconstruct water levels with imposed dominant frequencies

Accounting for Natural Climate Variability





Larger Porosities

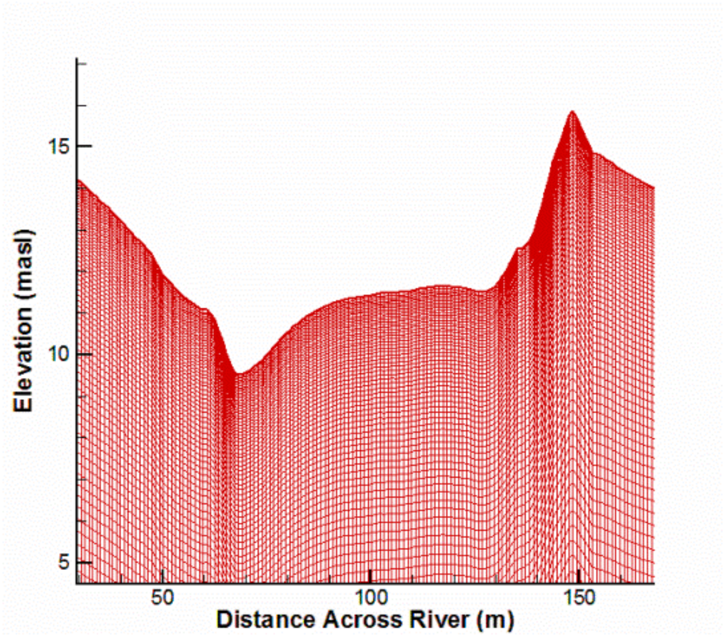
Smaller Porosities

Simulating Feedbacks

- MIN3P allows sequential biomass growth + K, Φ reduction

→ A novel approach in numerical models

- Implement ENSO effects through initial values of K and Φ for the riverbed



- Assumptions:

  Wet year end-member:

  ↑Q, ↑K, ↑Φ

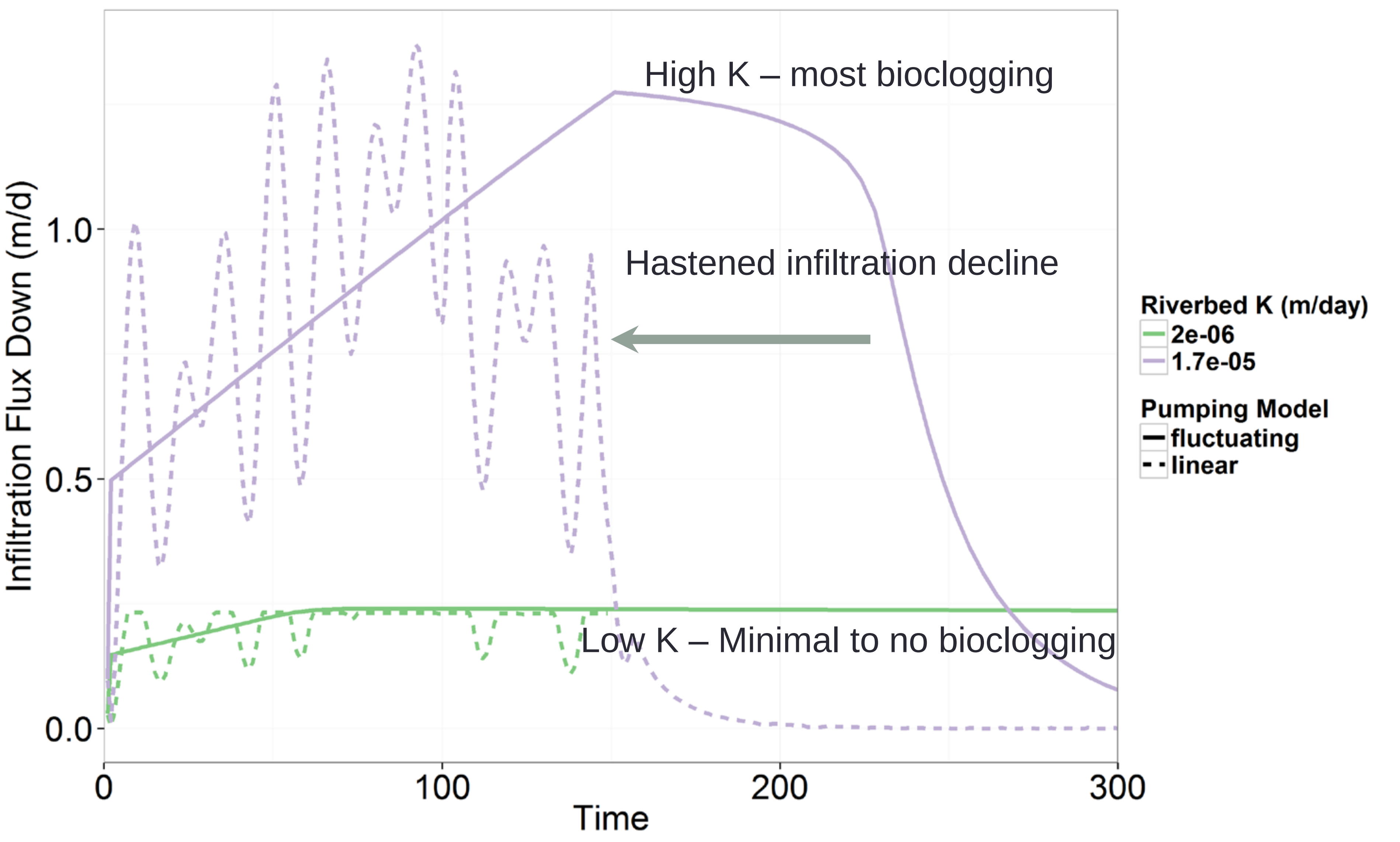
  Dry year end-member:

  ↓Q, ↓K, ↓Φ

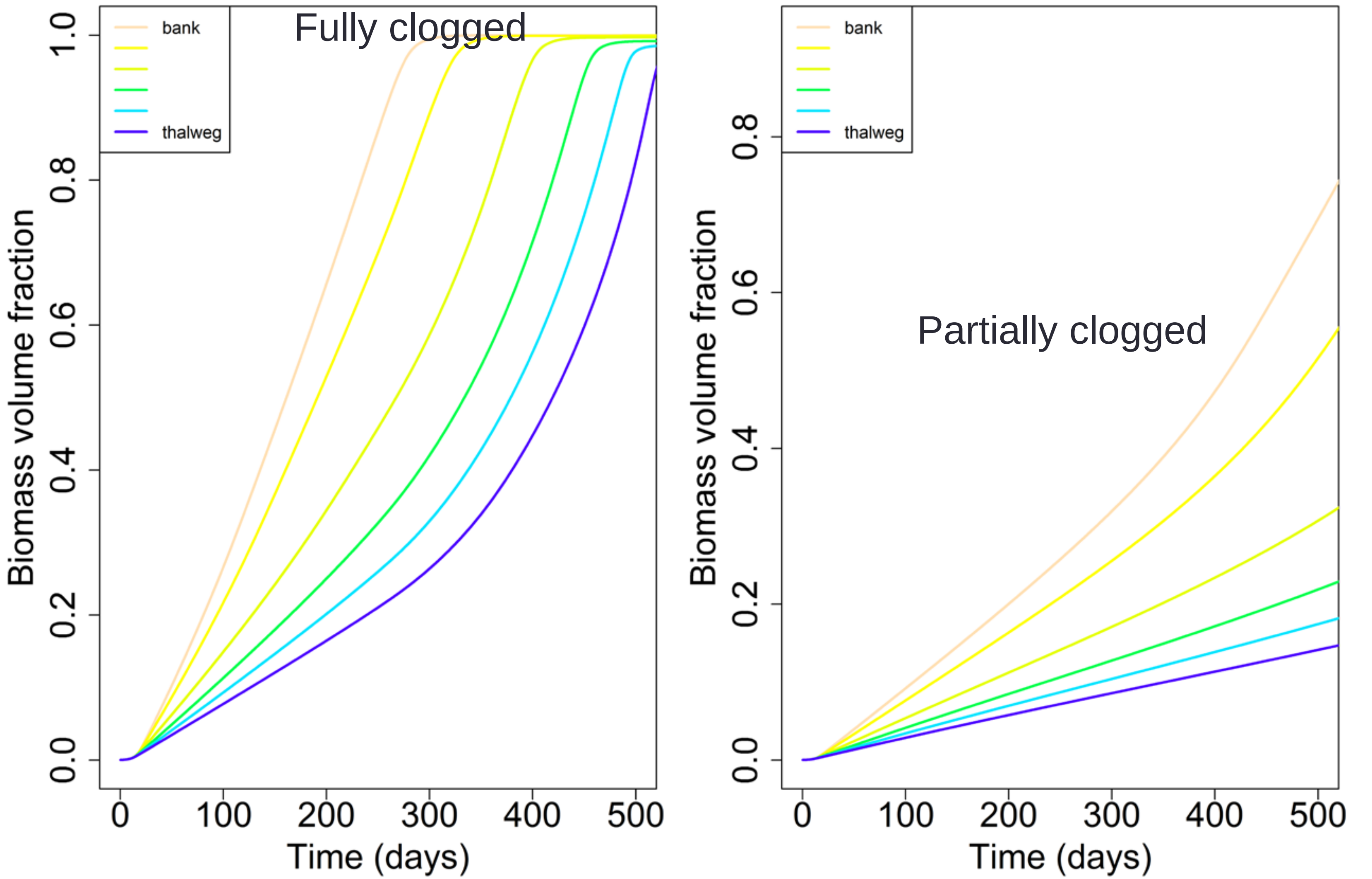
- Measure C consumption, biomass growth, CO_2 and N_2 production

Results

Fluctuations Lead to Enhanced Bioclogging and Hastened Infiltration Decline

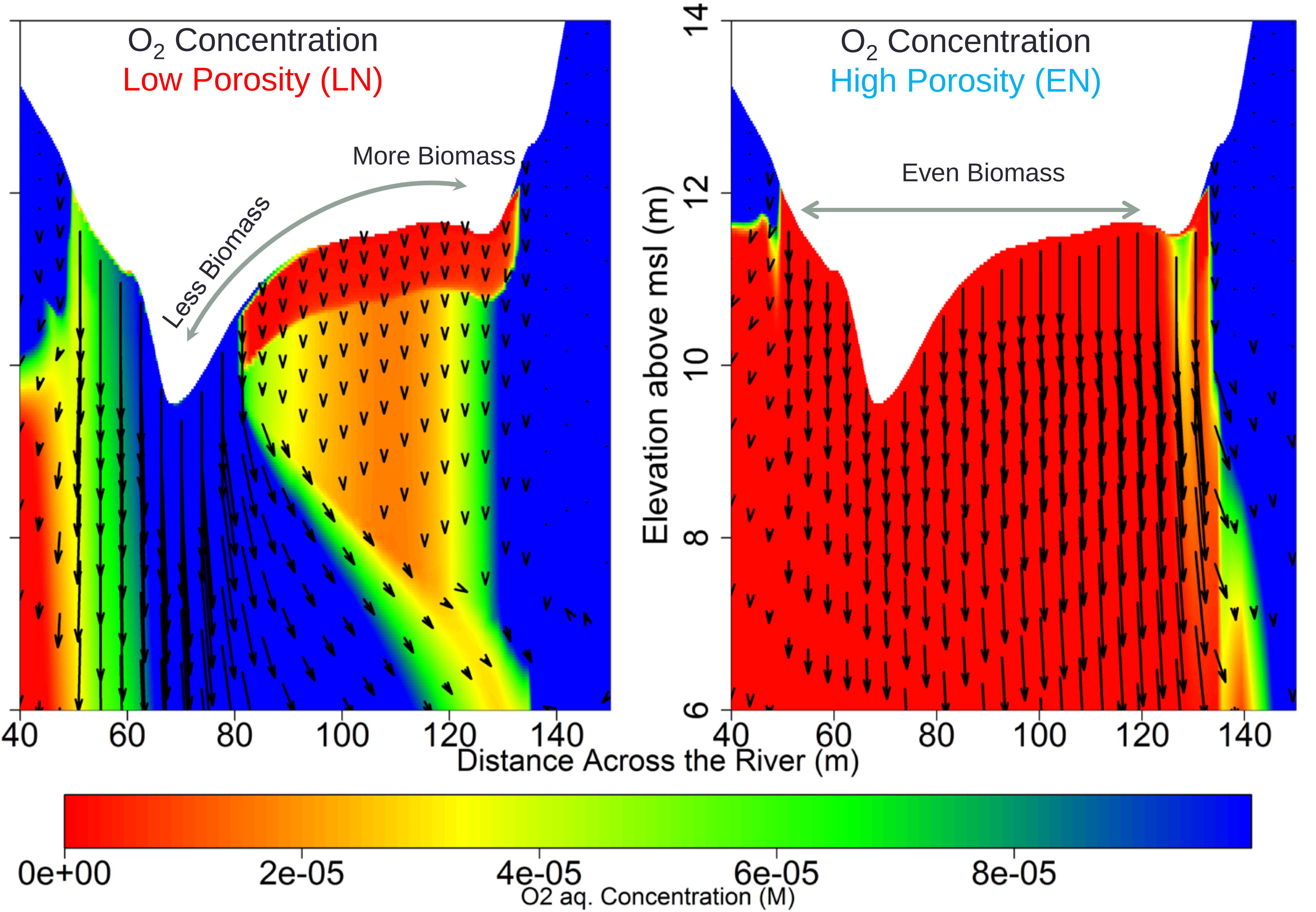


High Porosity Sediments Remain Partially Clogged

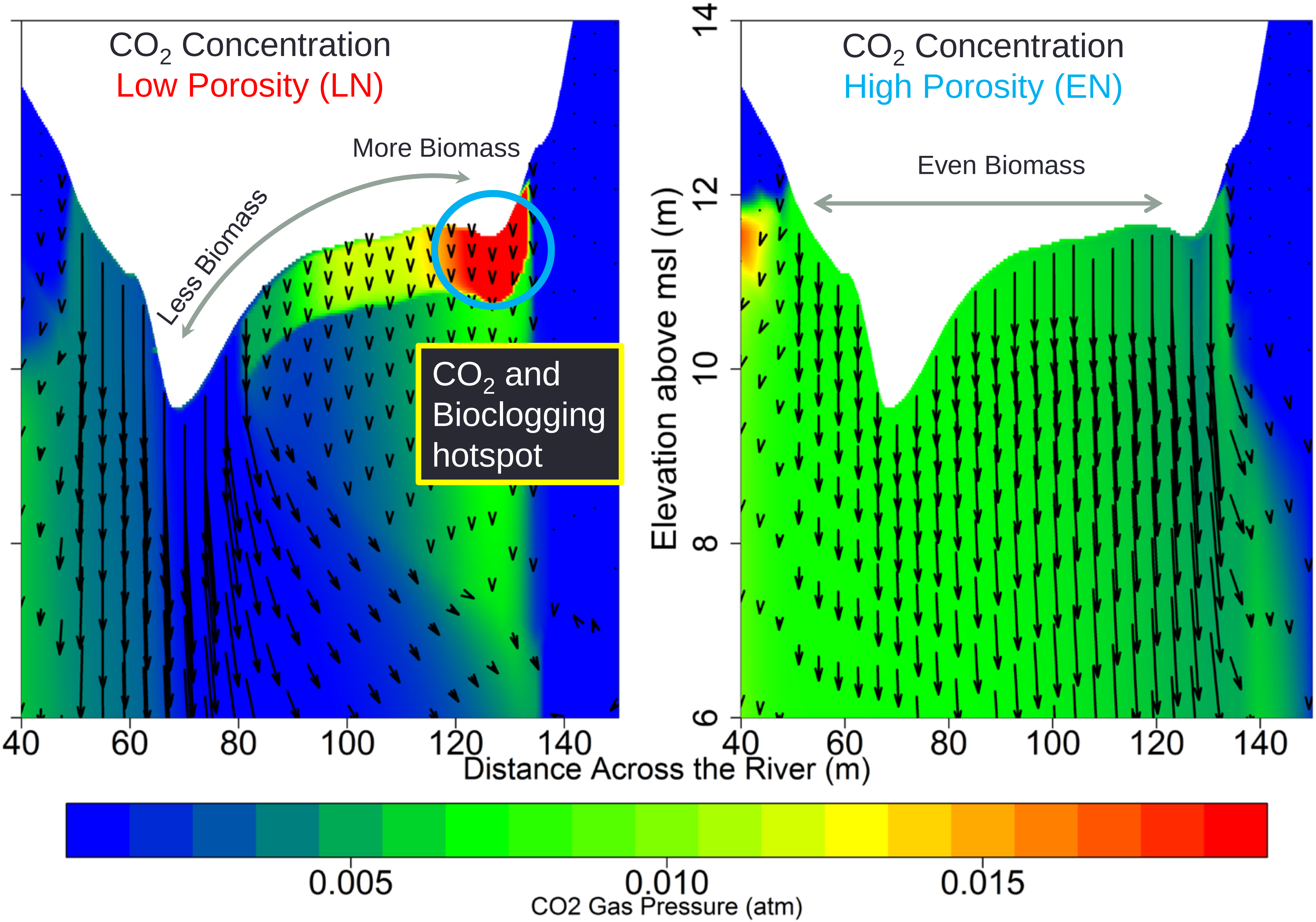


Low Porosity Sediment (La Nina)

High Porosity Sediment (El Nino)

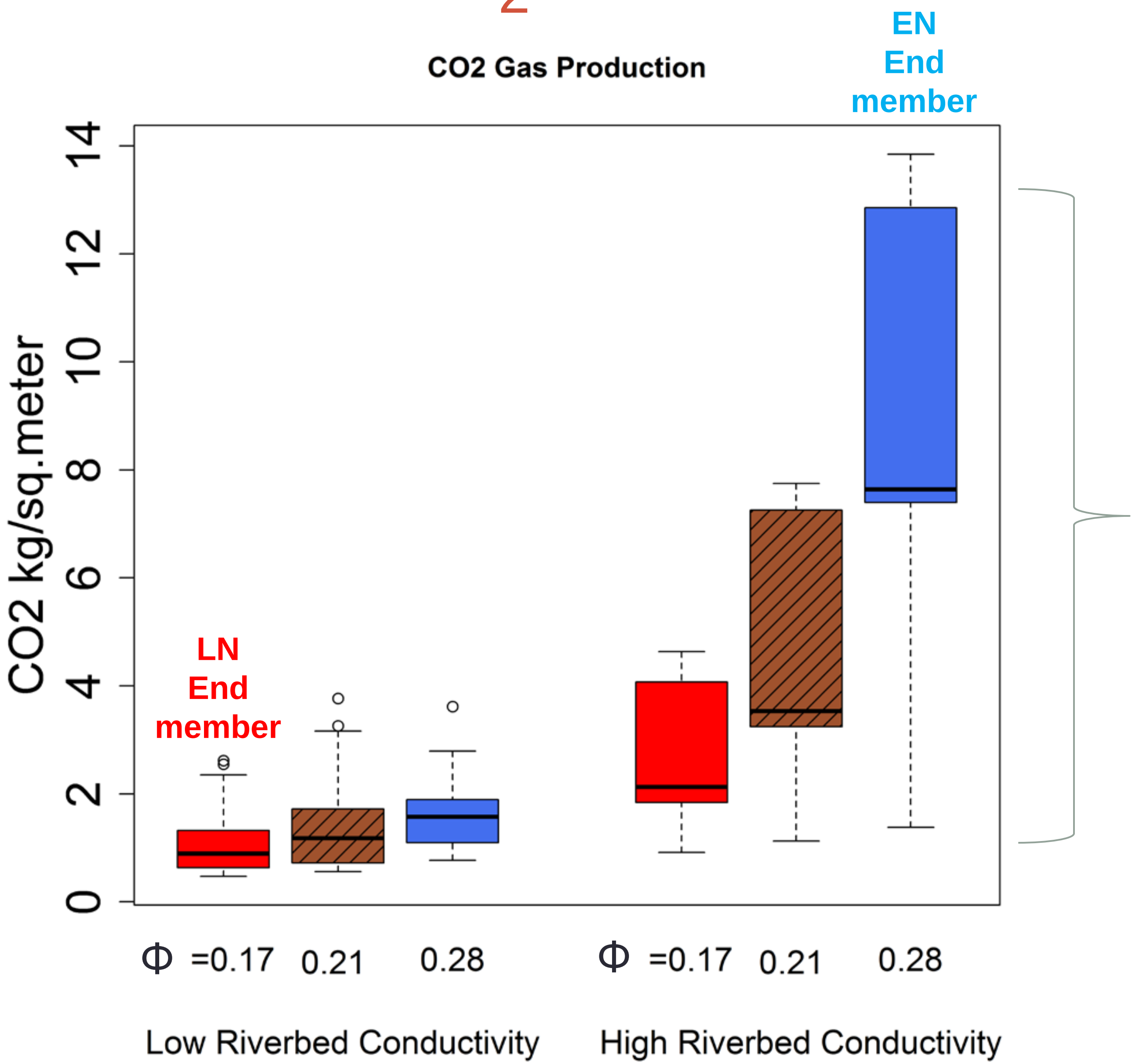


O2 Concentration
Low Porosity (LN)
More Biomass
Less Biomass
O2 Concentration
High Porosity (EN)
Even Biomass
Elevation above msl (m)
14
12
10
8
6
40
60
80
100
120
140
Distance Across the River (m)
0e+00
2e-05
4e-05
6e-05
8e-05
O2 aq. Concentration (M)

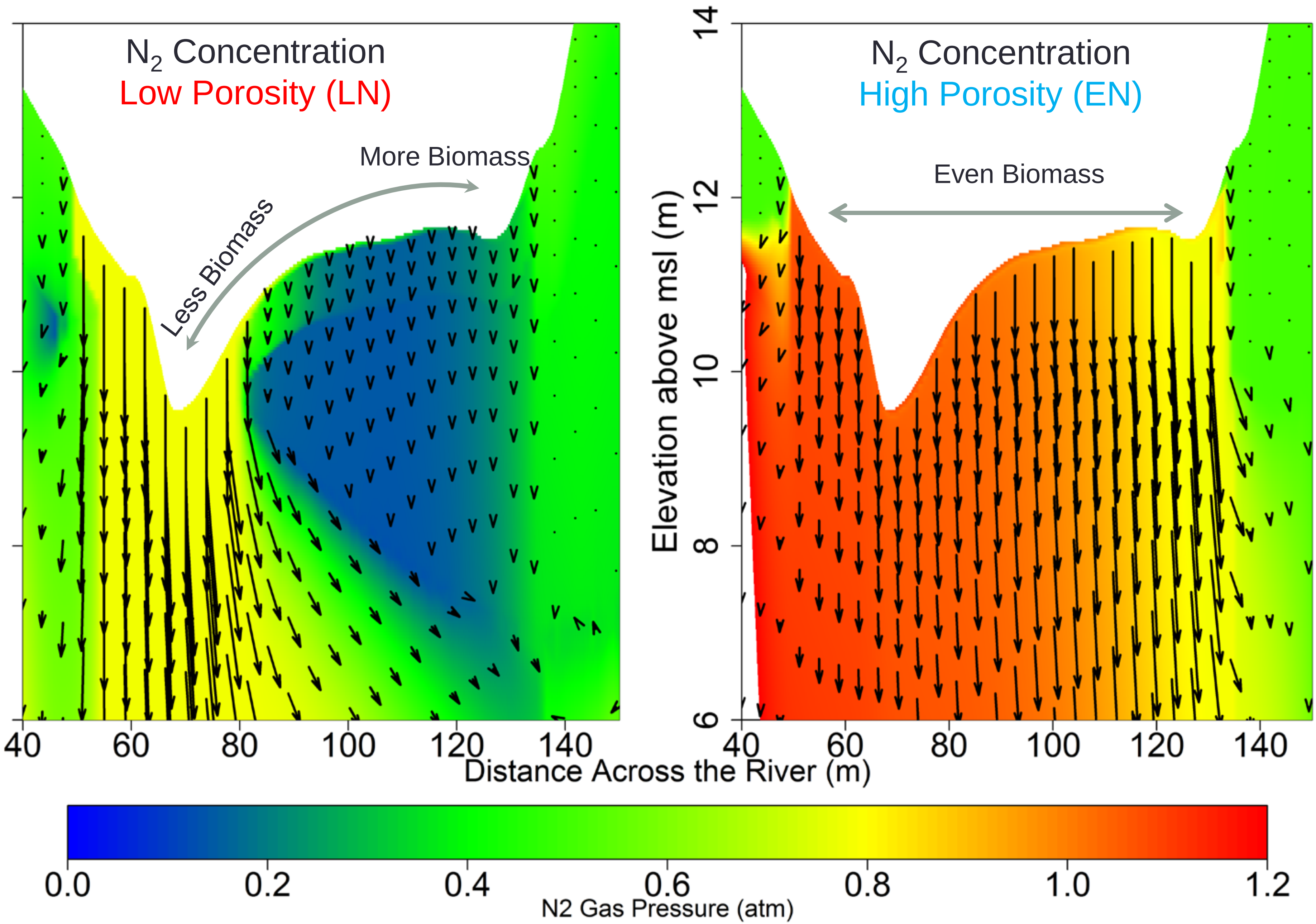


CO2 Concentration
Low Porosity (LN)
More Biomass
Less Biomass
CO2 and Bioclogging hotspot
CO2 Concentration
High Porosity (EN)
Even Biomass
Elevation above msl (m)
14
12
10
8
6
40
60
80
100
120
140
Distance Across the River (m)
0.005
0.010
0.015
CO2 Gas Pressure (atm)

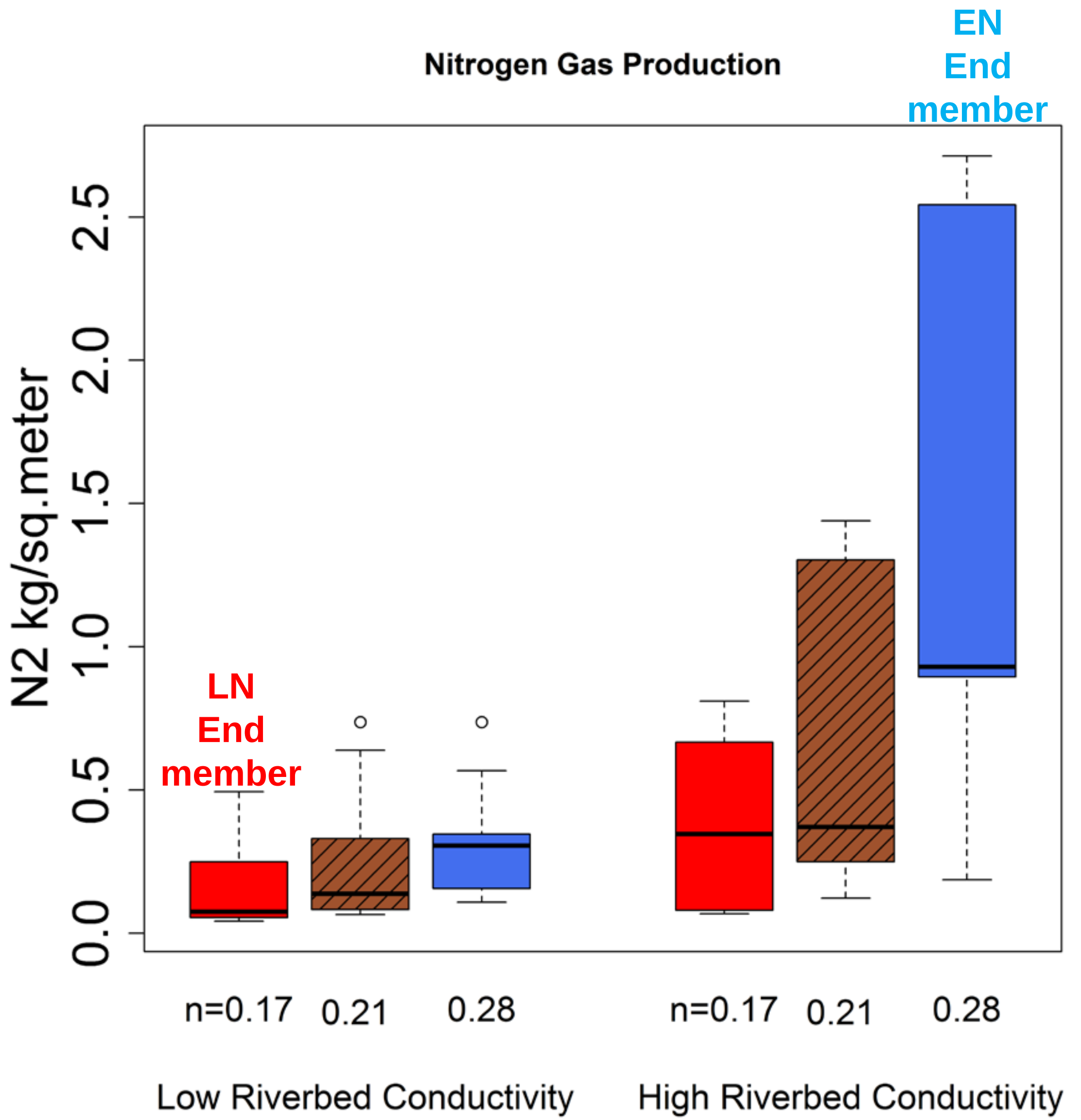
ENSO Effects on CO_2 Gas Production



Range represents differences from water table fluctuations


N$_2$ Concentration
Low Porosity (LN)
More Biomass
Less Biomass
N$_2$ Concentration
High Porosity (EN)
Even Biomass
Elevation above msl (m)
6
8
10
12
14
40
60
80
100
120
140
Distance Across the River (m)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
N2 Gas Pressure (atm)

ENSO Effects on N_2 Gas Production



High range represents variation frequency of pumping variations

Conclusions

- Novel implementation of bioclogging feedbacks in rivers using MIN3P
- ENSO end-member effects on clogging and gas production

Near Healdsburg (Dec. 2014 Flood) during LN year

Oct. 2015

- Hot spot of CO_2 in LN end-member
- EN end-member contributes to 10x CO_2 and N_2 gas production compared with LN

Thank You!