Lake Expedition: Response of Anoxia in Lake Mendota to seasonally and diurnally asymmetric air temperature changes

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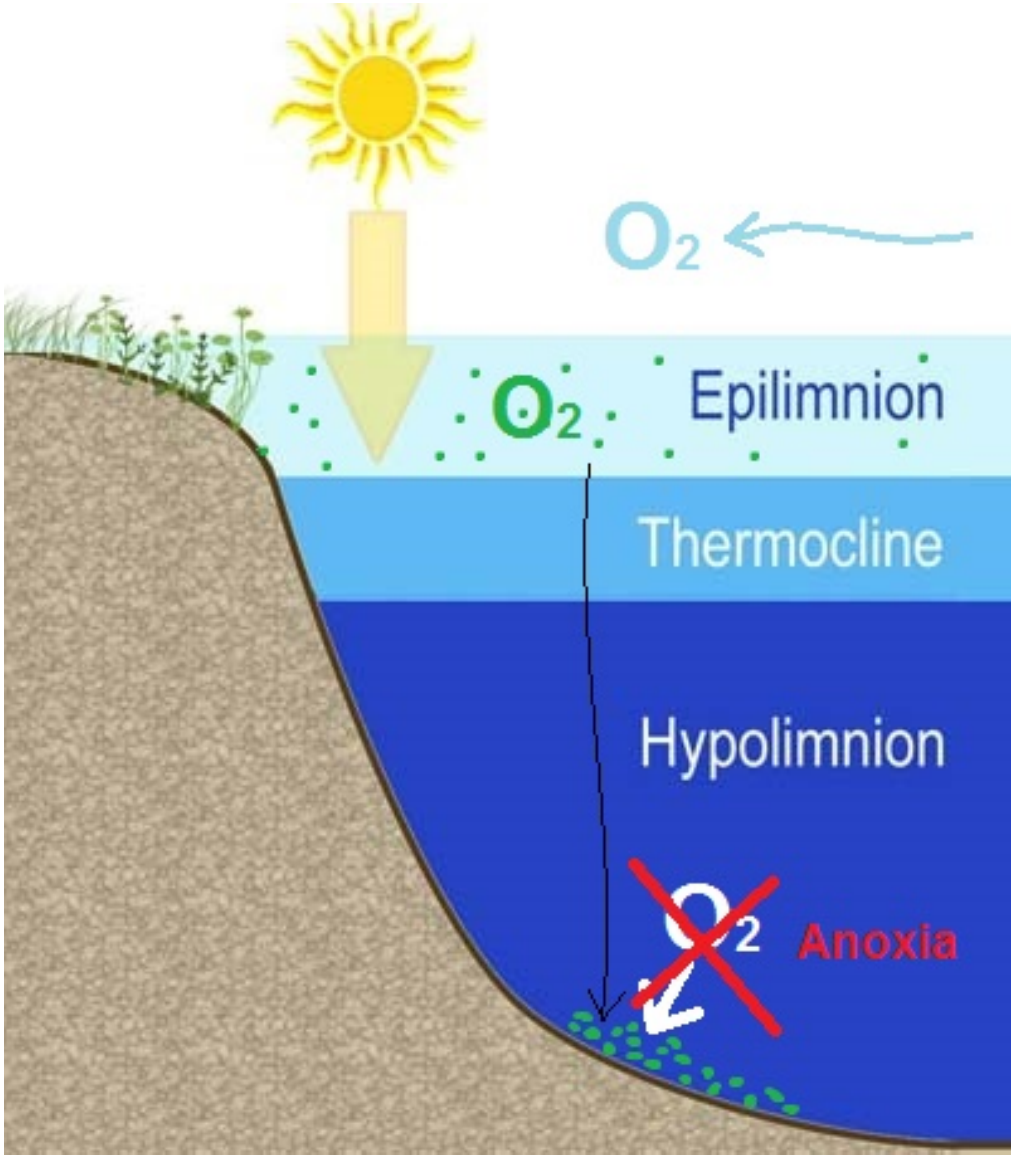
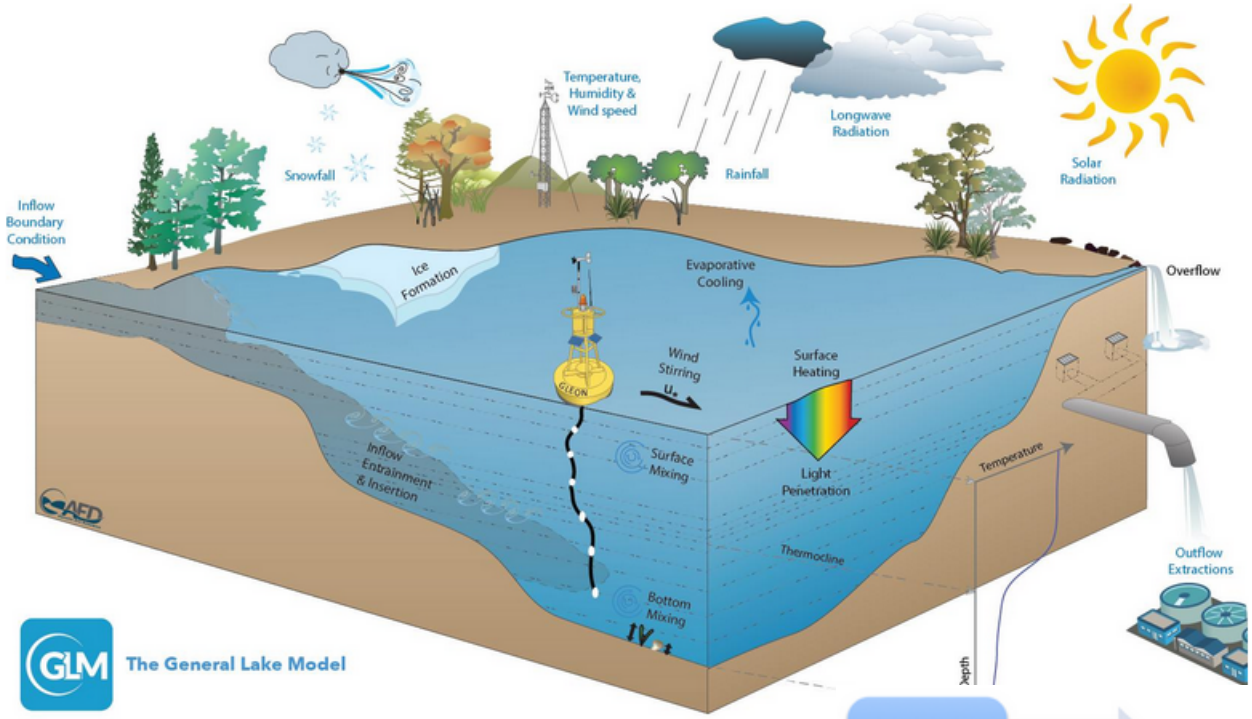
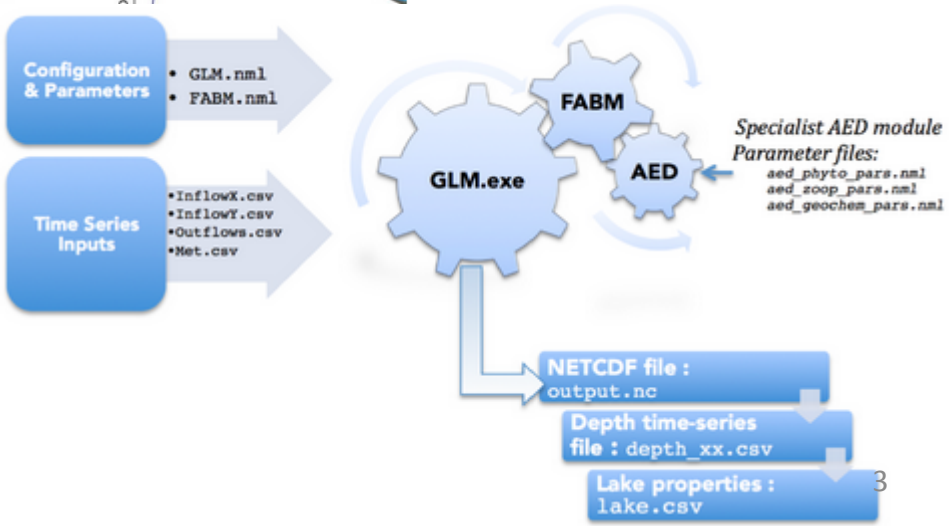
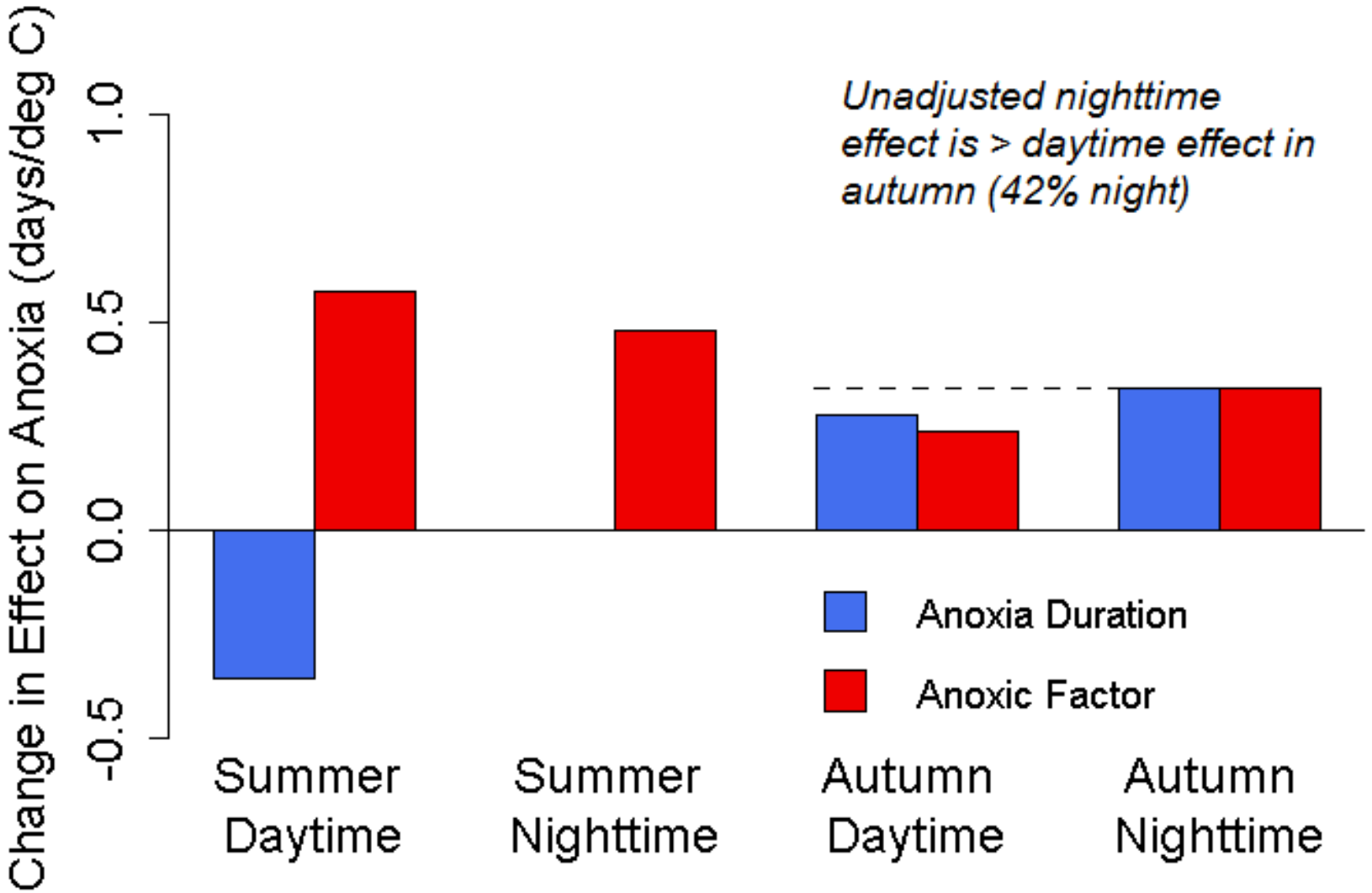
Lake Stratification and Anoxia



GLM-FABM-AED


Temperature, Humidity & Wind speed
Longwave Radiation
Solar Radiation
Snowfall
Rainfall
Inflow Boundary Condition
Ice Formation
Evaporative Cooling
Overflow
Wind Stirring
Surface Heating
Surface Mixing
Light Penetration
Inflow Entrainment & Insertion
Temperature
Thermocline
Outflow Extractions
Bottom Mixing
GLM
The General Lake Model


Configuration & Parameters
• GLM.nml
• FABM.nml
Time Series Inputs
•InflowX.csv
•InflowY.csv
•Outflows.csv
•Met.csv
GLM.exe
FABM
AED
Specialist AED module Parameter files:
aed_phyto_pars.nml
aed_zoop_pars.nml
aed_geochem_pars.nml
NETCDF file : output.nc
Depth time-series file : depth_xx.csv
Lake properties : lake.csv

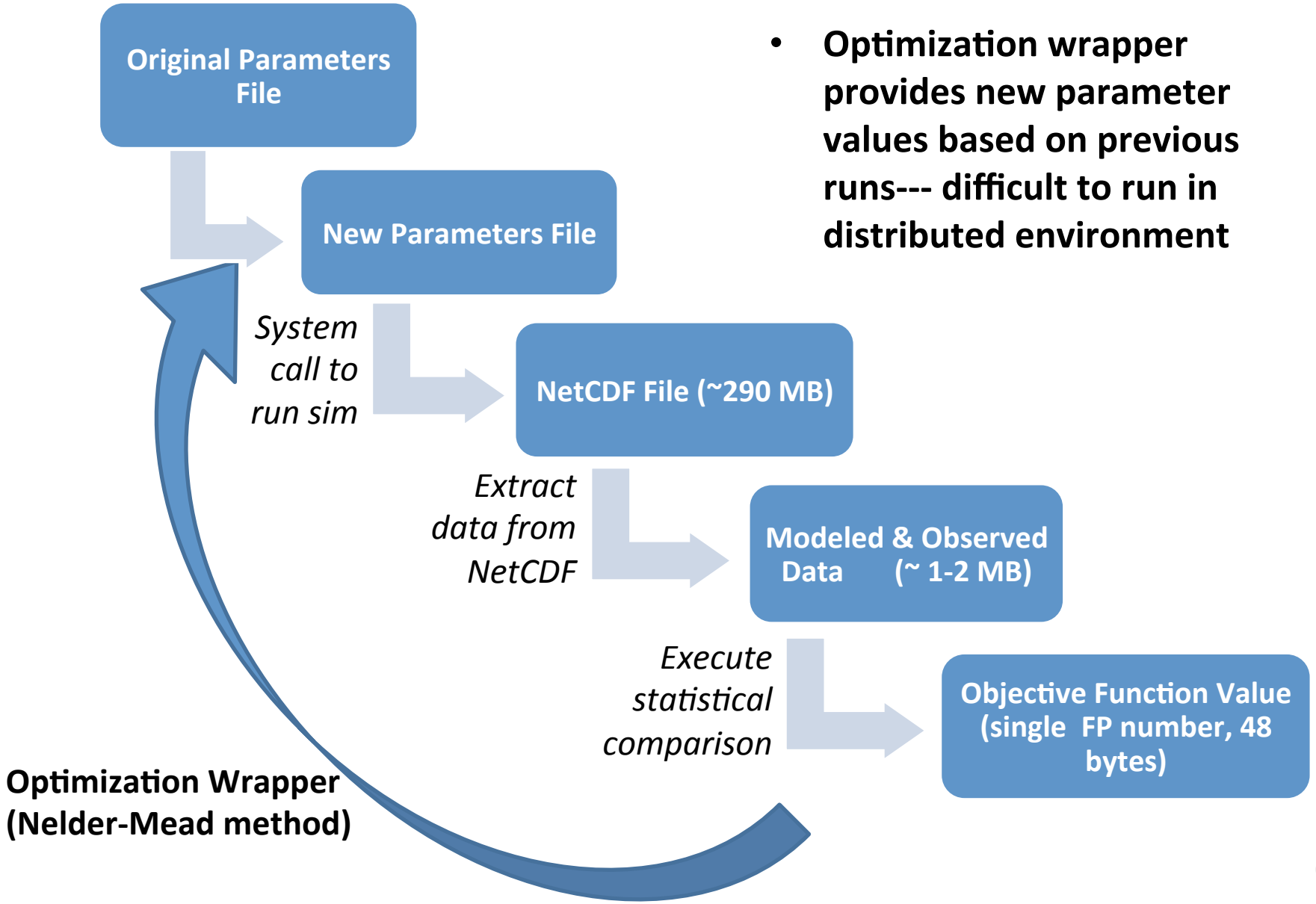


****Nighttime effects (days/deg C) are about 2x daytime effects when accounting for time of exposure**

Versatility of R

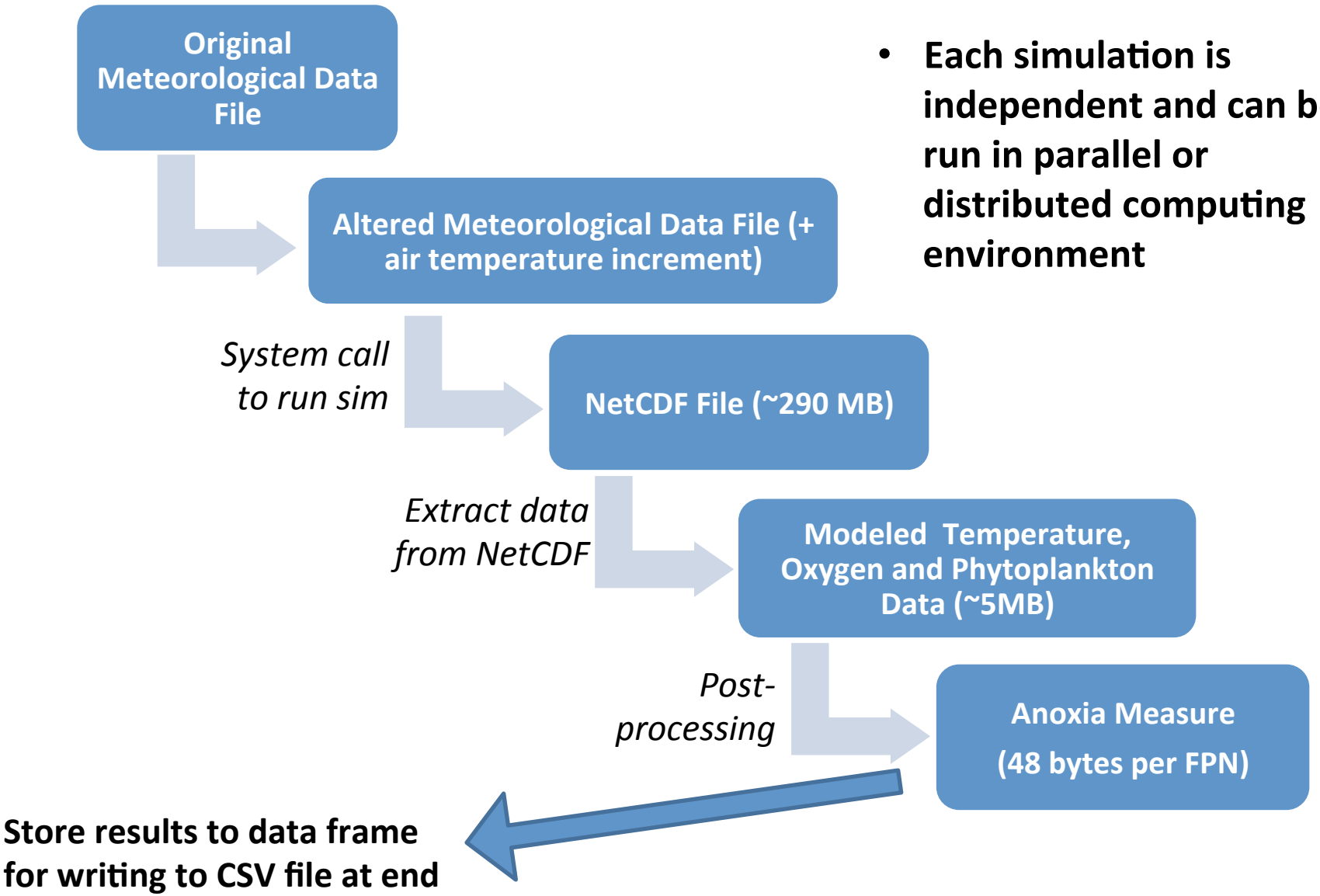
- **Pre-processing:**
  - changing parameters in configuration files
  - changing driver data (scenario)
  - creating directories and copying simulation files
- **Simulation Execution:**
  - system call to run simulation
  - parallel computing interface
  - non-linear, multi-dimensional optimization functions
- **Post-processing:**
  - reading data from NetCDF file
  - statistical comparison to field data
  - summarizing results or calculating metrics
  - visualization of modeled data

Parameter Optimization Workflow



- **Optimization wrapper provides new parameter values based on previous runs--- difficult to run in distributed environment**

Climate Change Scenario Workflow



- **Each simulation is independent and can be run in parallel or distributed computing environment**

Compute Times

- Serial: 36.1 seconds/run (100.3 hours)
- Parallel (6 cores): 8.0 seconds/run (22.2 hours)
- Distributed (100 cores): ???

  - Amdahl's Law: B= 0.07 (serial fraction, solved from above values)
  - Speedup for 100 cores: $S(n) = 1/B + 1/n\,(1-B) = 1/0.07 + 1/100\,(1-0.07) = 12.6$x
  - 2.9 seconds/run ➔ 7.3 hours for simulations in this project

- Even further improvements possible by reducing the serial fraction and overhead (shared config or application files, etc.)

References

- Lake Stratification w/ sun: http://pelicanlakemn.org/Education/Lake_Learning/spring_turnover_in_our_lakes.htm
- Louisiana Fishkill (+ NG logo): http://news.nationalgeographic.com/news/2010/09/100916-fish-kill-louisiana-gulf-oil-spill-dead-zone-science-environment/
- Toledo Water: http://www.nytimes.com/2014/08/04/us/toledo-faces-second-day-of-water-ban.html
- Qingdao Algae Bloom (+ NY Times logo): http://www.nytimes.com/2008/07/01/world/asia/01algae.html?_r=0
- GLM Model diagrams (2):
- http://aed.see.uwa.edu.au/research/models/GLM/
- R logo: http://www.r-project.org/
- Amdahl's Law: http://en.wikipedia.org/wiki/Amdahl%27s_law