

# DNDC Model Updates & Enhancements

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# Outline

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- Background on DNDC
- Motivation for the rewrite
- Rewrite status
- Code availability and licensing
- Next Steps
- Q&A

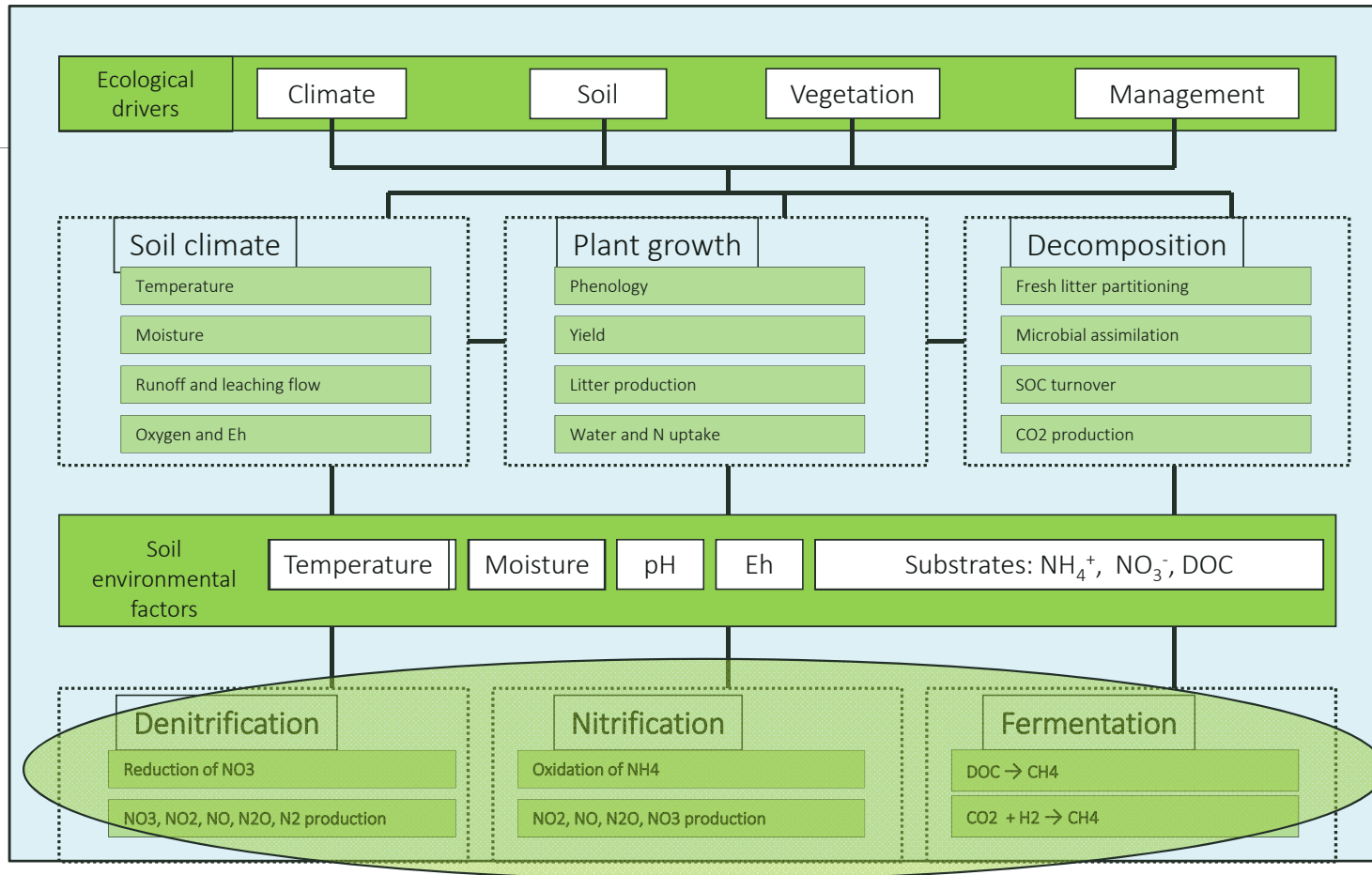
# DNDC Biogeochemical Model Suite: Cropland DNDC

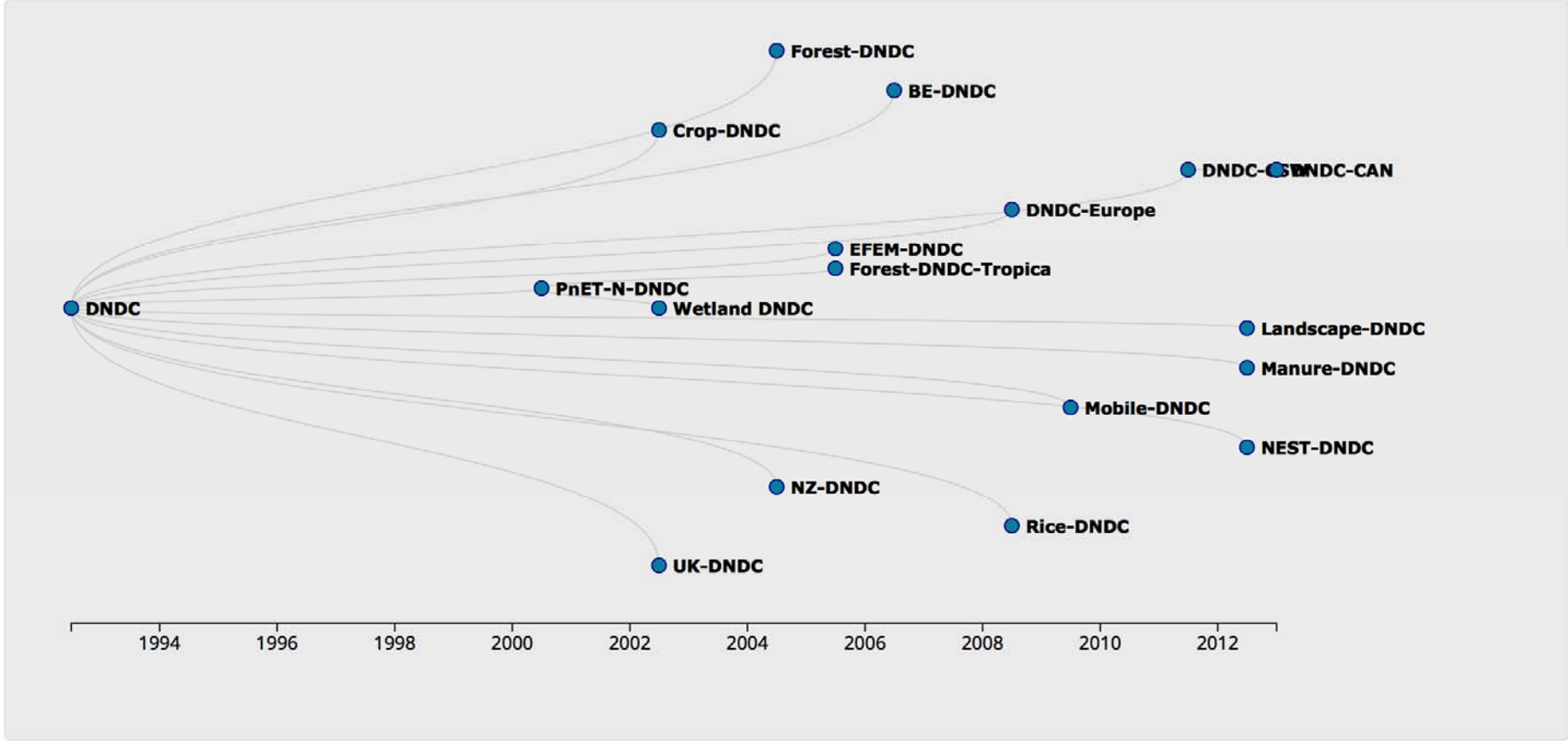
## DNDC

- Model development started in 1990
- Initial focus on  $N_2O$
- Focus on crop lands (>20 types of crops)
- Models  $CO_2$ ,  $CH_4$ ,  $N_2O$ , and crop growth/yields



# Structure of the DNDC Model





# Use in offset protocols

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- Climate Action Reserve (CAR) Rice Cultivation Project Protocol (CH<sub>4</sub>)
- American Carbon Registry (ACR) Methodology for N<sub>2</sub>O Emission Reductions through Changes in Fertilizer Management
- Air Resource Board (ARB) Rice Cultivation Carbon Offset Protocol

# ARB Rice Web Tool

ARB Rice Home Account Logged in as admin

MAIN  
DNDC Model  
List/Add Landowners

PROJECTS  
Aaa  
final\_test  
Landowner on new field  
Rick's great field  
Test  
Baseline Period  
Baseline Scenario  
Project Scenario  
Soil Data  
test2  
Test Field  
Test Field 2  
Test field 3  
Add Field  
Bbb  
Add Project



Soil Parameters

	SSURGO Data	STATSGO Data
Clay Fraction	50.33333333% 50.33333333	46.48999999
pH	4.665342247 4.665342247	6.995401940
Bulk Density	1.283333301 g/cm <sup>3</sup> 1.283333301	1.424787234
Organic Matter	2.166666261% 2.166666261	2.277500000
Soil Data Source	SSURGO	

Copy SSURGO Copy STATSGO Save

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Soil Data  
test2  
Test Field  
Test Field 2  
Test field 3  
Add Field  
Bbb  
Add Project

## Edit Field

Using the map below, navigate to your location and use the 'edit polycor' tool to draw your field boundaries or upload a shapefile below.

Field Polygons



Field Name: Test

Area (acres): 4.0

Landowner: \_\_\_\_\_

Complete  
When your farm management data is complete for this field, check this box - once you have checked this box, you can calibrate yield for this field. Note that if you change any management data for this field, you will have to recalibrate.

Hide: Show everywhere

Historical biomass: \_\_\_\_\_ kgC/ha

Project biomass: \_\_\_\_\_ kgC/ha

Shapefile:  No file chosen  
Upload a Zip archive containing .shp, .dbf and .prj files

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# Rewrite motivation

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- Model is 27 years old





# Rewrite motivation

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- Code is “research grade”, i.e. buggy, fragile, and difficult to understand
- Single monolithic structure -- impossible to unit test
- Polluted with unused legacy code
- Tightly coupled to the GUI
- Relies on dozens of intermediary files for each year of simulation with hard-coded paths, preventing parallel execution
- Challenges with model execution order / timing
- Cumbersome input and output formats
- Many software engineering issues – memory leaks, memory corruption, redundant calculations, duplicated code



# Rewrite

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- Difficult task
  - ~125,000 lines of code
  - Little developer-level documentation
  - Active development on multiple versions
  
- Initial focus on science code – GUIs will come later
  
- Started by creating an automated test harness and comprehensive test cases to compare new version to reference version

# Rewrite

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- Modern software practices
  - Emphasis on code modularity, reducing code coupling, and unit testing
  - Cleaner, more understandable code
  - Reduced size of science code by ~30%
  - Redesigned data structures to be more flexible
    - Eliminated hard-coded limits on management events, crops, soil layers
  - Eliminated memory leaks and corruption
  - Cross platform

# Rewrite

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- Science code is fully decoupled from the GUI
- Well defined model API, both external and between sub-models
  - Ease development of additional User Interfaces
    - Stand-alone applications
    - Web Services
  - Easier incorporation of new sub-models, management practices

# Rewrite

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- Complete rewrite of model inputs and configuration processing
  - JSON inputs -- standard set of tools to integrate with other software, databases, etc.
  - Access to more driver data sources
  - Increased the number of parameters exposed to the user

# Rewrite

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- Dramatic performance increase – execution time reduced by ~90%

# In progress

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- Multi-processor and distributed computing support
  - Support for larger, more complex simulations
  - Automated cluster processing
  
- Configurable output formats
  - Easier visualization
  - Easier access to output data from other applications
  
- Documentation
  
- Additional unit tests

# License and availability

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- DNDC rewrite will be available under a free license for non-commercial research use
- Want to encourage a vibrant research community
  - Researches will register to access the code repository
  - Developing plan to facilitate incorporation of model improvements from the community



# Next Steps

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- Still a great deal of work to be done to modernize entire code-base
- User interfaces
- Integrate Manure components into new version
- New tools to select and process inputs, outputs
- Reduce the human overhead of model calibration and validation
- Looking to raise addition \$150k to continue work

# Next Steps

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- Decoupling from the GUI provides avenues to integrate DNDC science into other DSTs – Comet-FARM, farm management tools, etc.
- Can create much easier tools for stakeholders to participate in carbon and water quality markets.

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Questions?