DNDC Model Updates & Enhancements

Justin Fisk* and William A. Salas

Applied GeoSolutions, LLC

* Contact info: jfisk@appliedgeosolutions.com

Presented to Coalition on Agricultural Greenhouse Gases, February 13, 2017

Outline

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

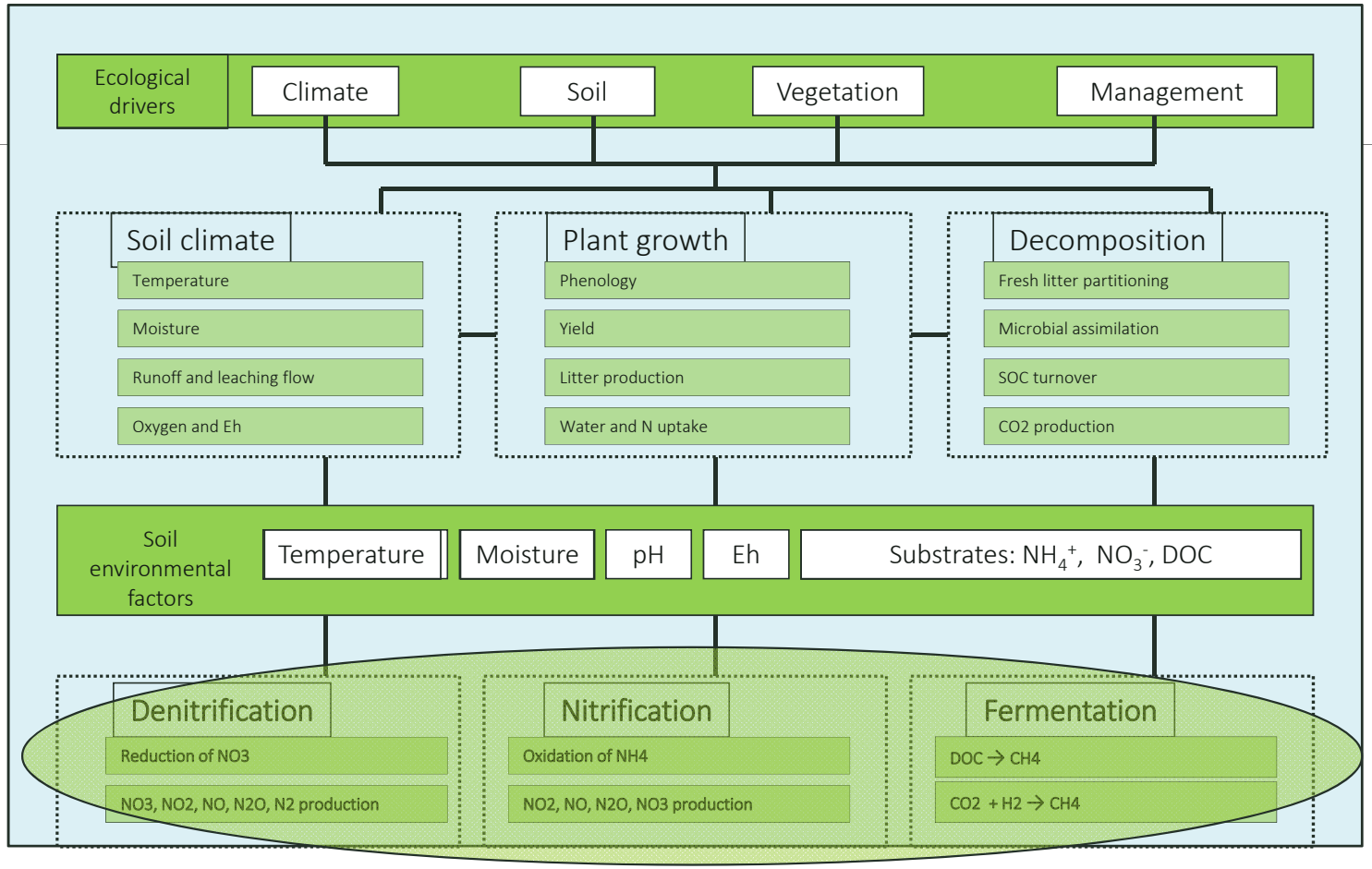
Applied · Geosolutions

DNDC Biogeochemical Model Suite: Cropland DNDC

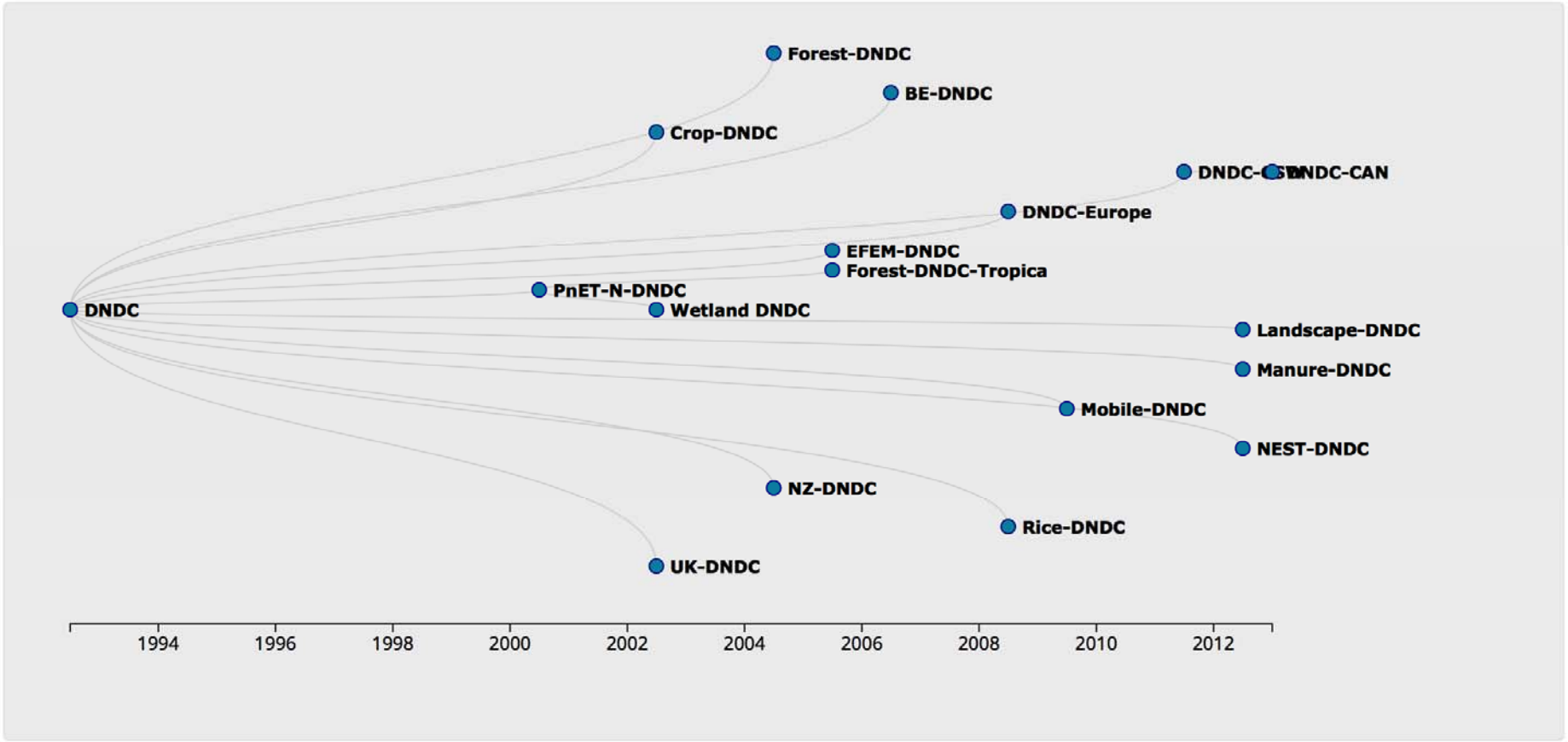
DNDC

- 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



Applied · Geosolutions



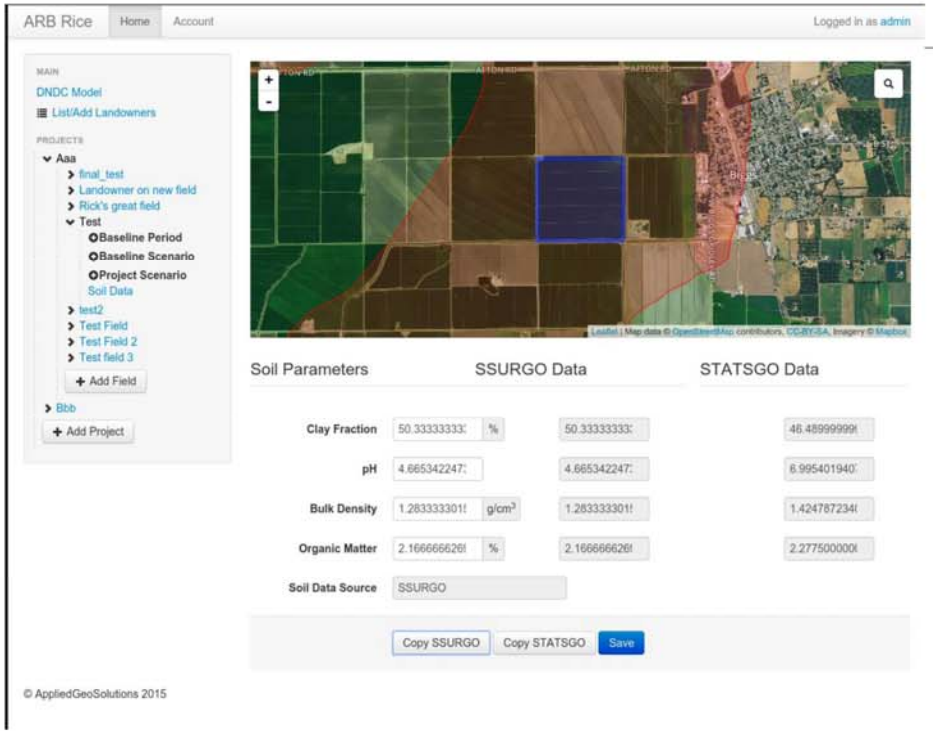
Applied · Geosolutions

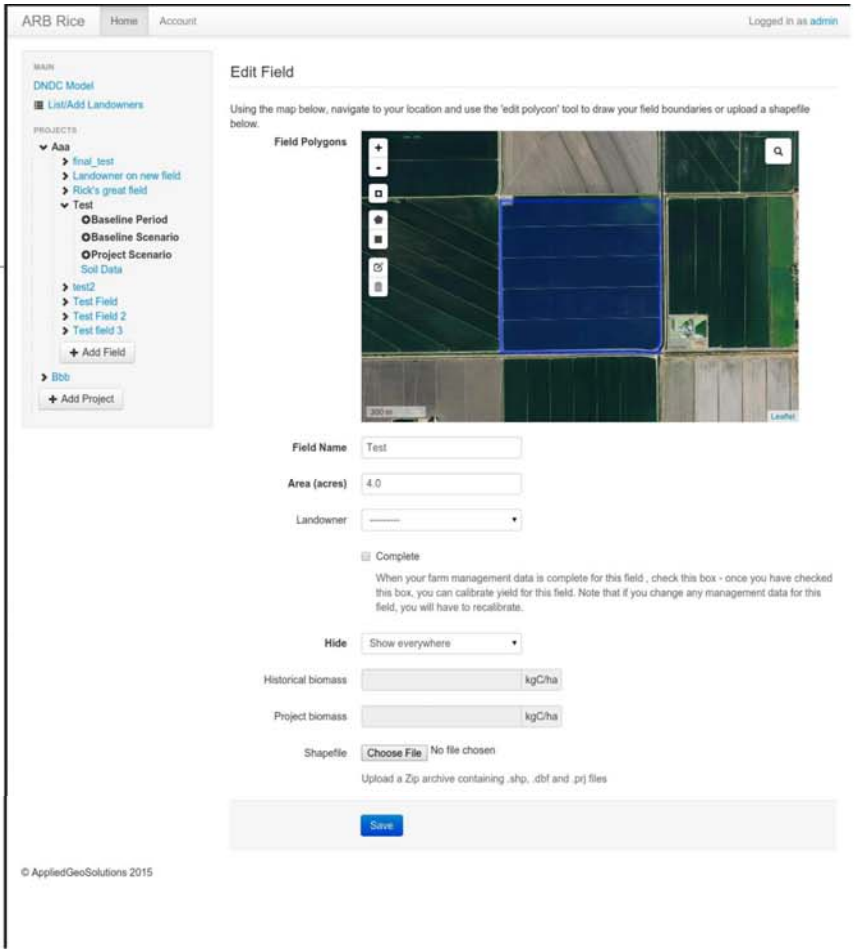
Use in offset protocols

- Climate Action Reserve (CAR) Rice Cultivation Project Protocol (CH_4)
- American Carbon Registry (ACR) Methodology for N_20 Emission Reductions through Changes in Fertilizer Management
- Air Resource Board (ARB) Rice Cultivation Carbon Offset Protocol

Applied · Geosolutions

ARB Rice Web Tool





Applied · Geosolutions

Rewrite motivation

- Model is 27 years old

Applied · Geosolutions

Rewrite motivation

- 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

Applied · Geosolutions

Rewrite

- 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

Applied · Geosolutions

Rewrite

- 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

Applied · Geosolutions

Rewrite

- 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

Applied · Geosolutions

Rewrite

- 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

Applied · Geosolutions

Rewrite

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

Applied · Geosolutions

In progress

- 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

Applied · Geosolutions

License and availability

- 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

Applied · Geosolutions

Next Steps

- 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

Applied · Geosolutions

Next Steps

- 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.

Applied · Geosolutions

Questions?

Applied · Geosolutions