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Modified regional DNDC and its application in Athabasca River basin

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DNDC

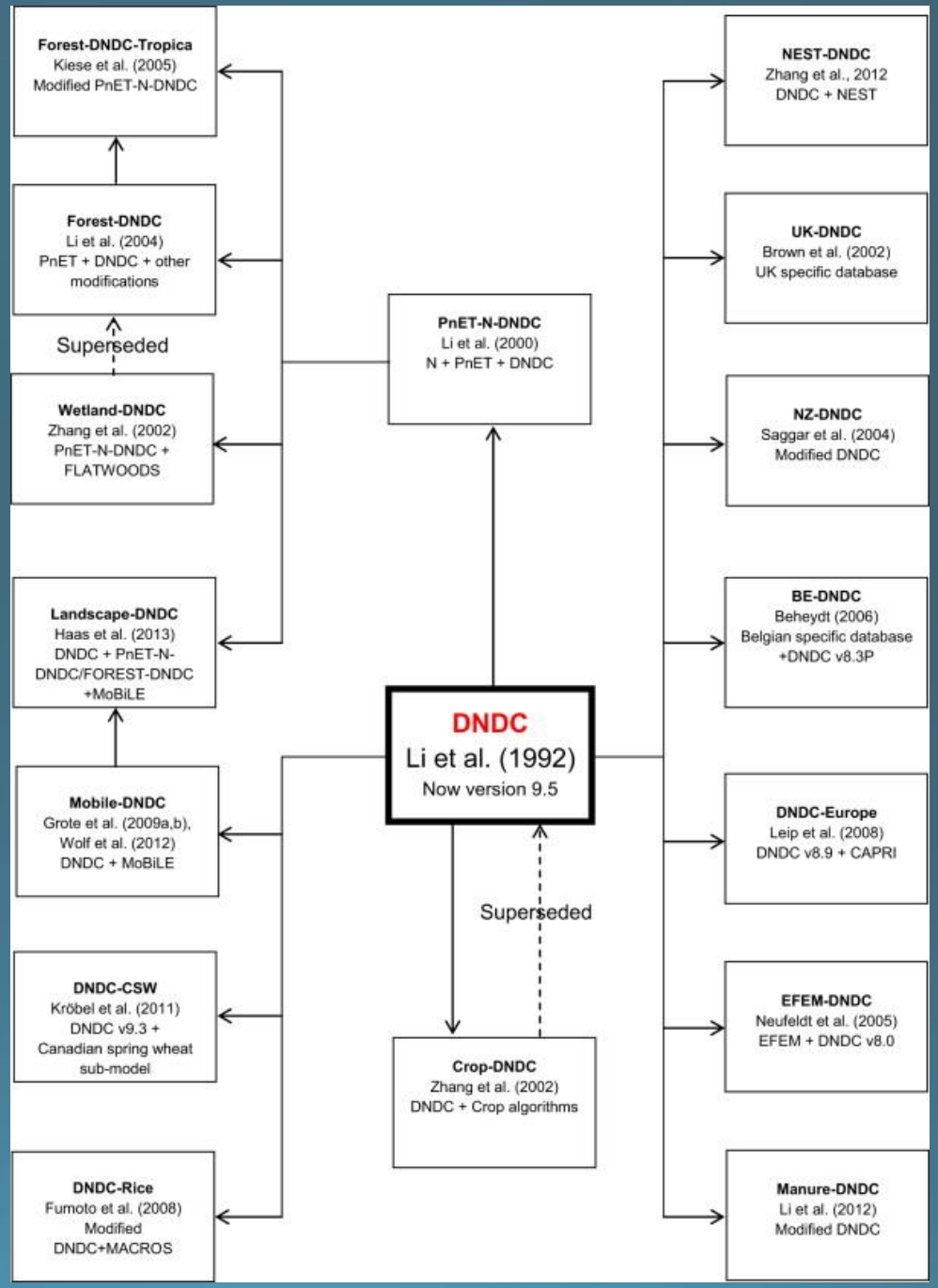
- DNDC: DeNitrification-DeComposition Model
  - Denitrification: dominating N simulation
  - Decomposition: dominating C simulation
- DNDC can simulate soil C and N dynamics.
- DNDC can simulate crop growth.
- DNDC can simulate the emission of trace gas such as NO, N_2O, CH_4, and NH_4 from agricultural ecosystem and wetlands.

DNDC: a process based model

- Biogeochemical processes
  - decomposition
  - Hydrolysis
  - nitrification
  - Denitrification
- Management
  - Irrigation, Weeding, Flooding, Manuring, Cropping, etc.

DNDC model family

- A great success in modeling agricultural ecosystem
- Many variants have been developed.



taken from Gilhespy et al. (2014), Ecological Modelling

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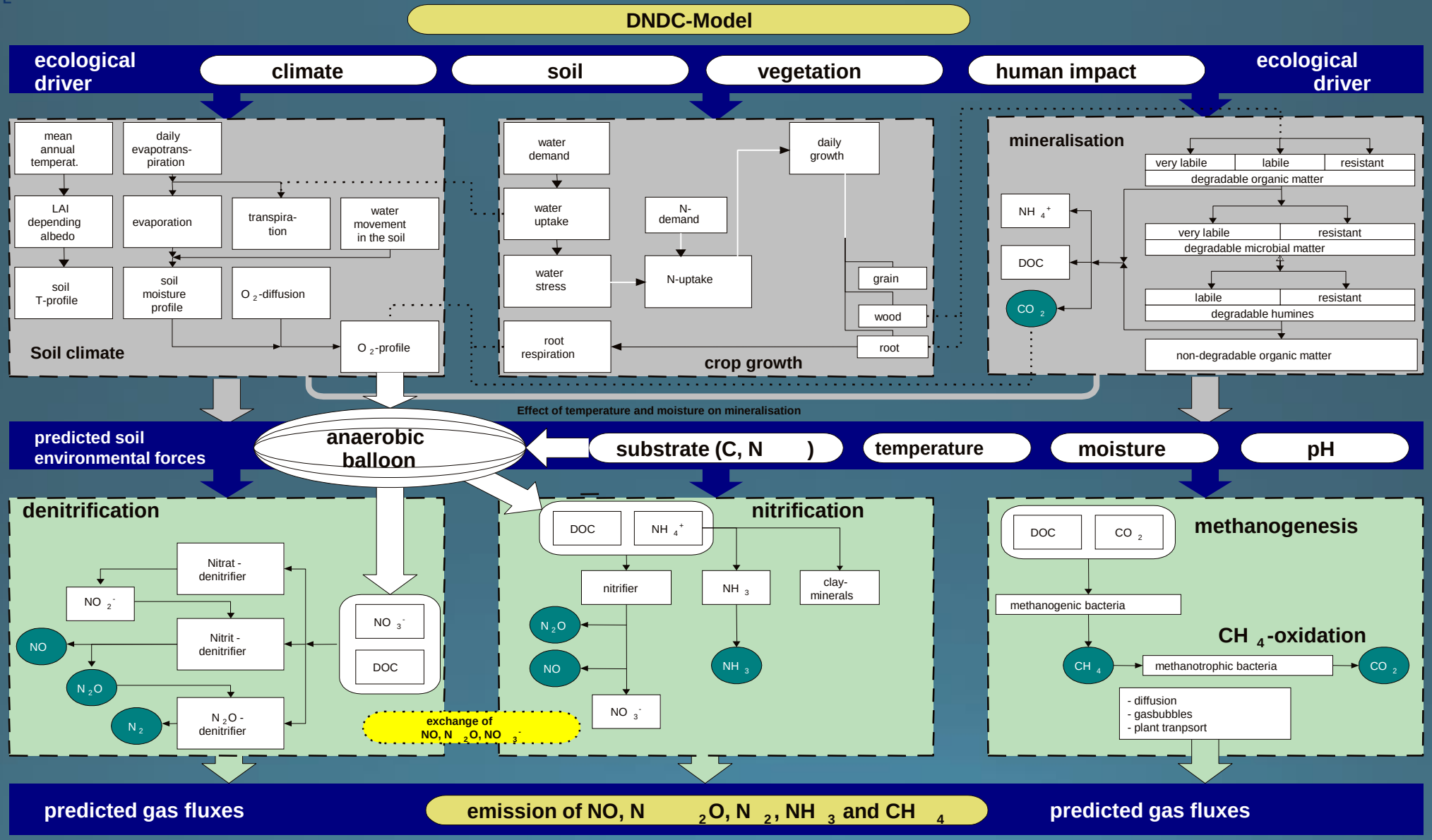
DNDC structure



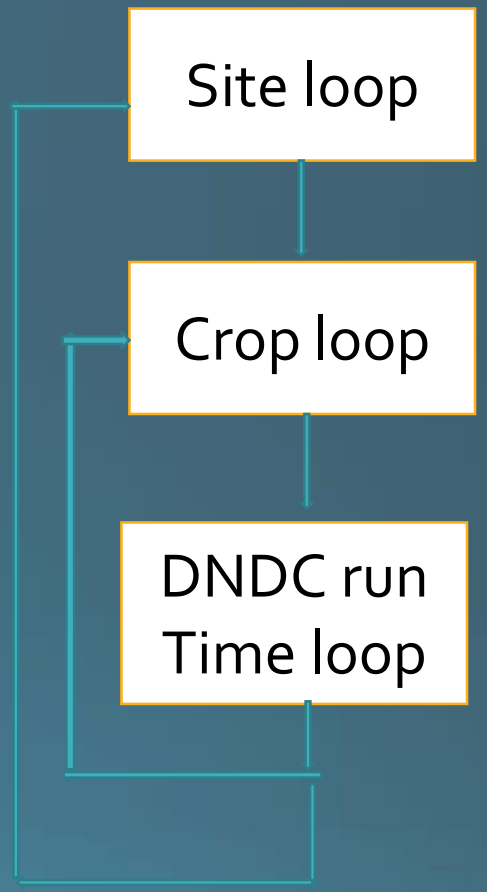
Changsheng Li, 1992, 2000, …

DNDC mode

- Site mode
- Regional mode
  - ✓It is virtually a batch run of site mode.
  - ✓Site leading

- Drawback
  - ➢ It is incompatible with Hydrological model which is time leading .
  - ➢ Different results may be produced for site mode and regional mode (Perlman et al., 2013, Environmental Modelling & Software)

Regional mode



Modified DNDC

- Time leading loop
- Structured module
- Derived data type
- Written in Fortran 2003
- Three dimensional Richards equation

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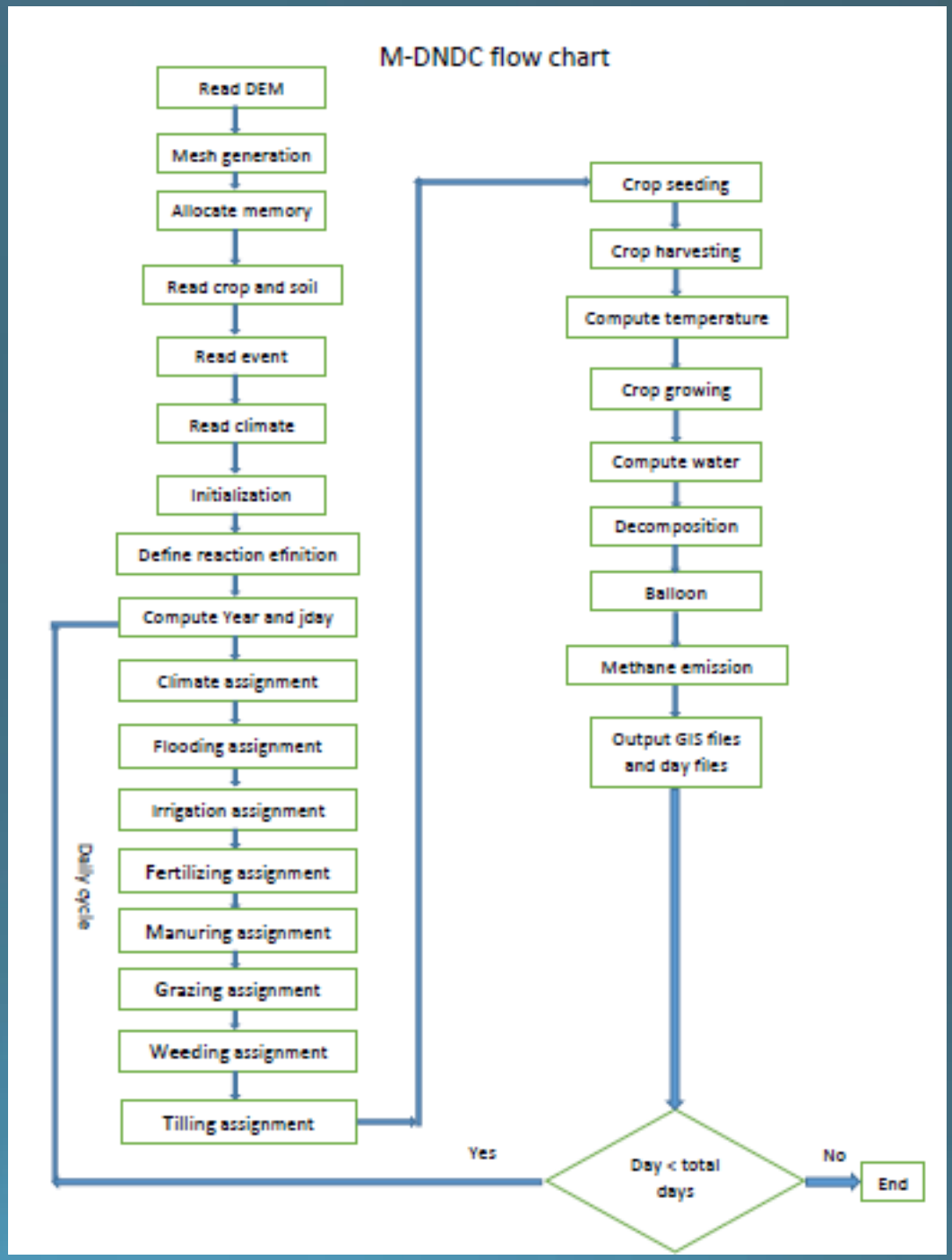
Flow chart

- Time leading loop
- Fully regional mode



Structured module

- Water-temperature module
  - Exchange limited data with DNDC decomposition module and DNDC Denitrification module
  - Three dimensional Richards equation in sigma coordinate system
  - Infiltration boundary condition
- Event module
- DNDC decomposition module
  - Standardized reaction sub-module
- DNDC Denitrification module

Crop data type

- Linked list is created to simulate the seeding and harvesting of crops.
- It is related to the dynamic growth of crop.

- Merit
  - Arbitrary number of crops in the single site can be simulated.
  - It totally mimics the actual crop seeding and harvesting.
  - Memory can be saved.

type crop1_type

Crop area

Variables for common characteristics of crop, such as period of growth, etc.

Variables related to time, such as crop seed, etc.

Pointer for RICE

Pointer NEXT

end type

type rice1_type

Variables related to methane

Variables related to growth stage of rice

end type

DNDC main entrance and event data type

- patch data type
  - The main entrance
  - It contains a linked list for crop.
  - It contains climate information.
- Event data type
  - It describes the management event.
  - Totally eight data types

Material parameter data type

- Reference soil data type
  - All variables related to soil are categorized together, such as water content at field capacity, water content at wilting point, density, specific heat, pH, porosity and hydrologic conductivity, etc.
- Reference crop data type
  - All variables related to crop are categorized together, such as the period of growth, etc.

Input files

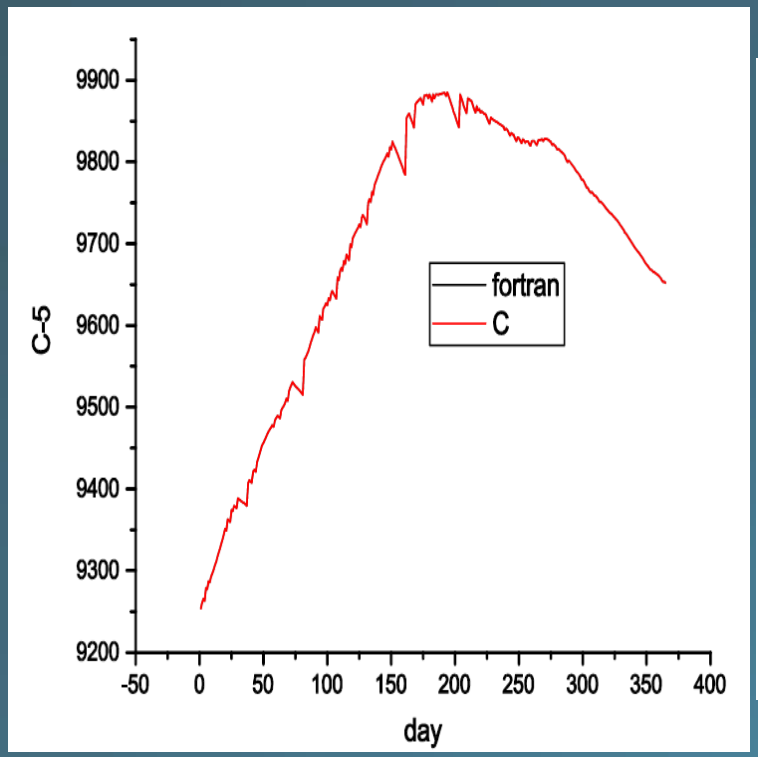
- Control file => running parameters
- Crop information files => Reference crop data type
- Soil information files => Reference soil data type
- Climate files name => file names
- Climate files => rainfall, temperature everyday
- Event information file => events in each year
- DEM files
  - Longitude, latitude, base concentrations
  - Management evets
  - Soil parameters if obtained

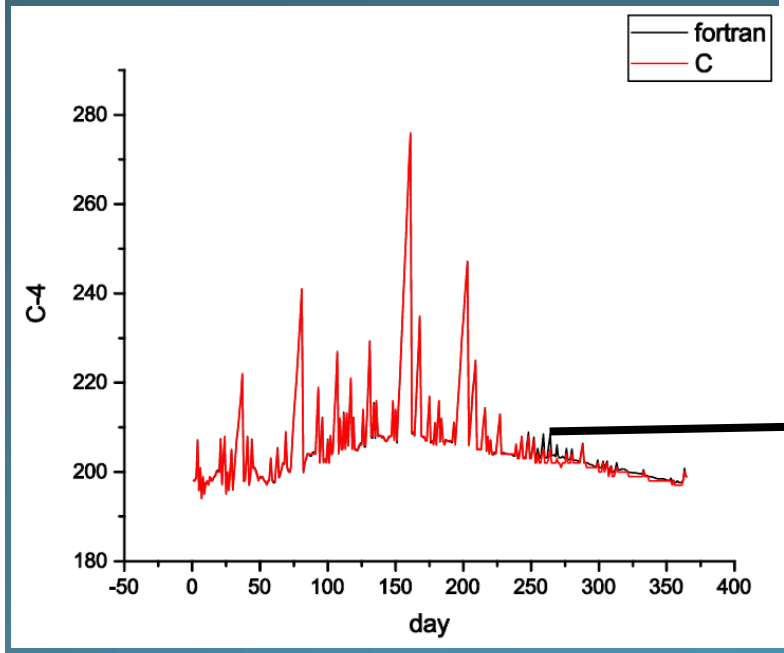
Output files

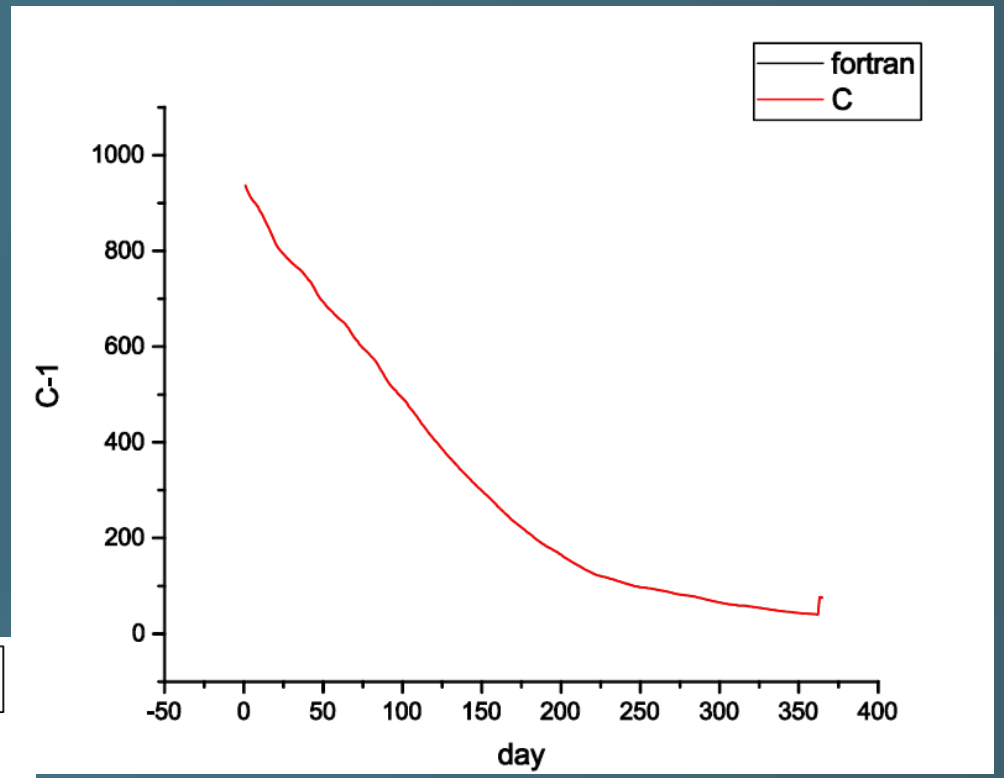
- Tecplot format
- DEM format, same as the input files.
  - Any variable can be output, such as CO_2, N_2O, etc.

Comparison with DNDC

- The same water and temperature
- The same events

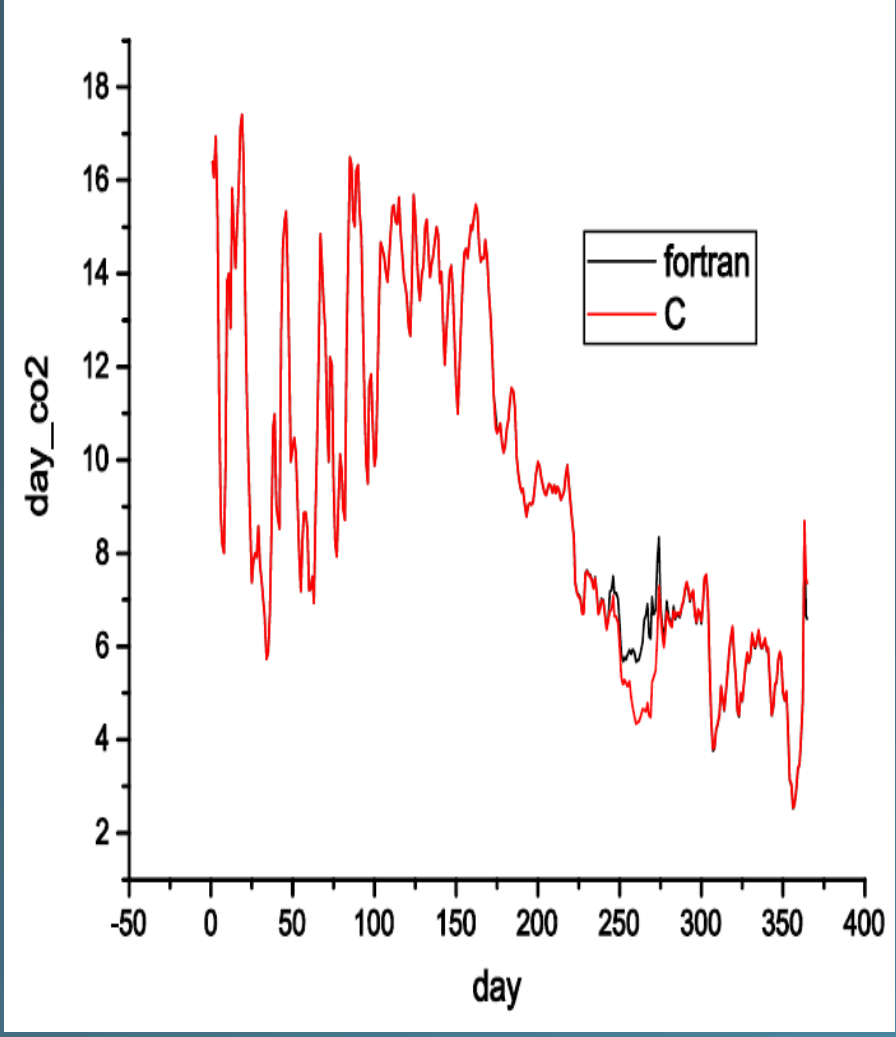


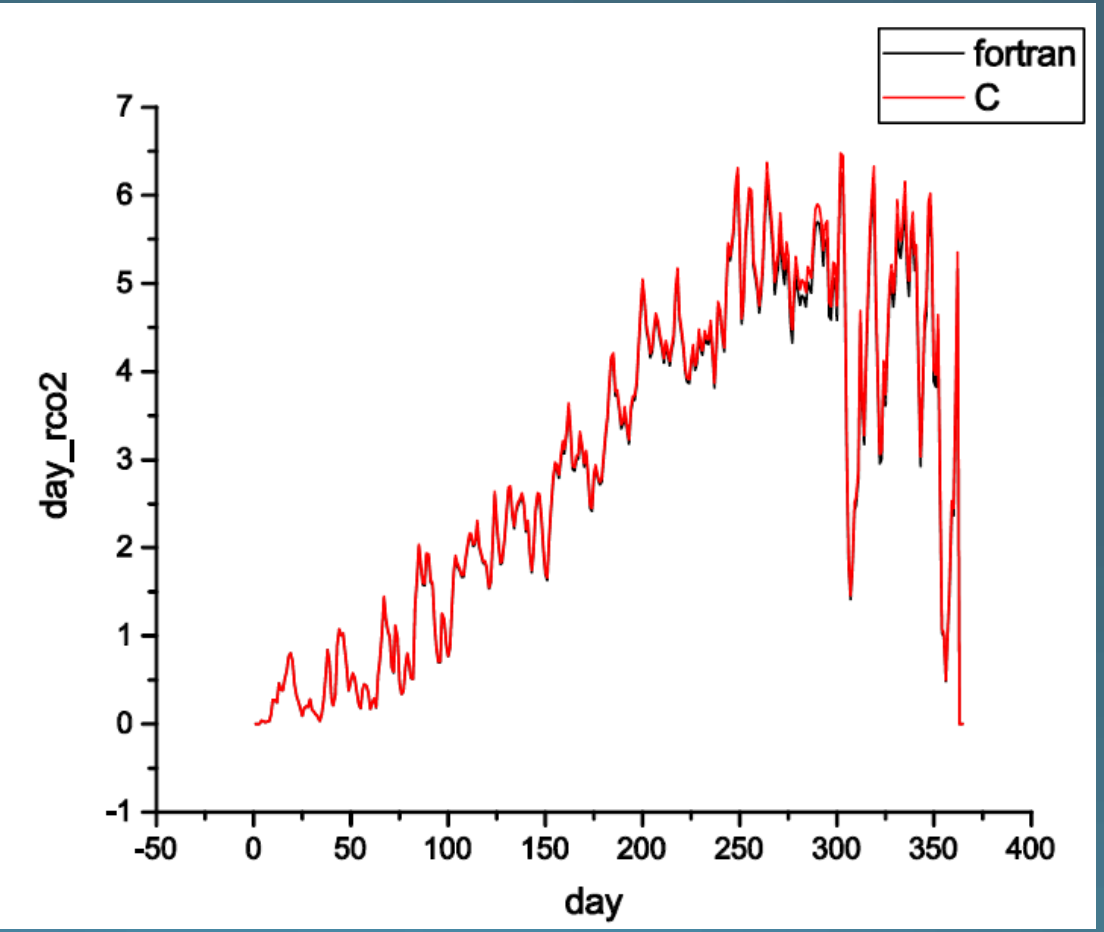




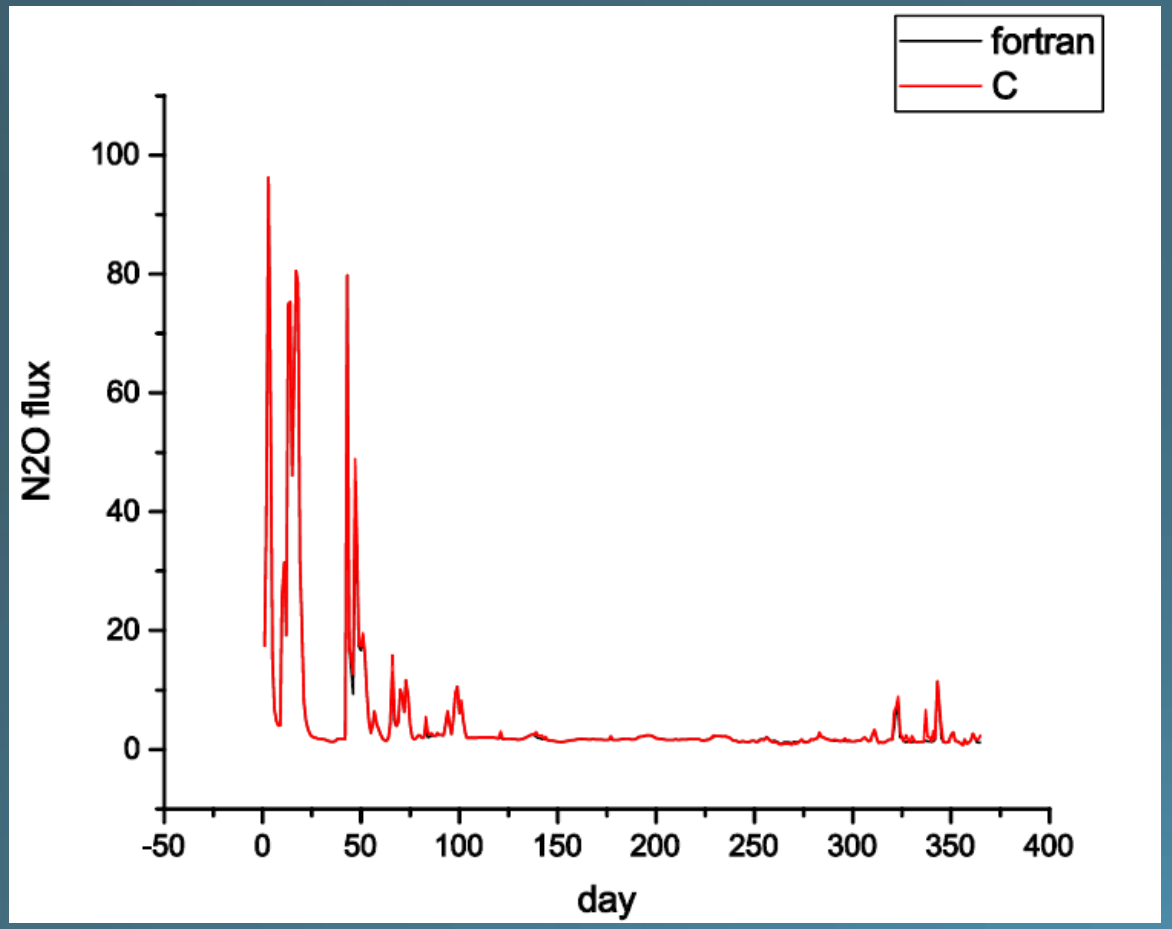
Subtal difference

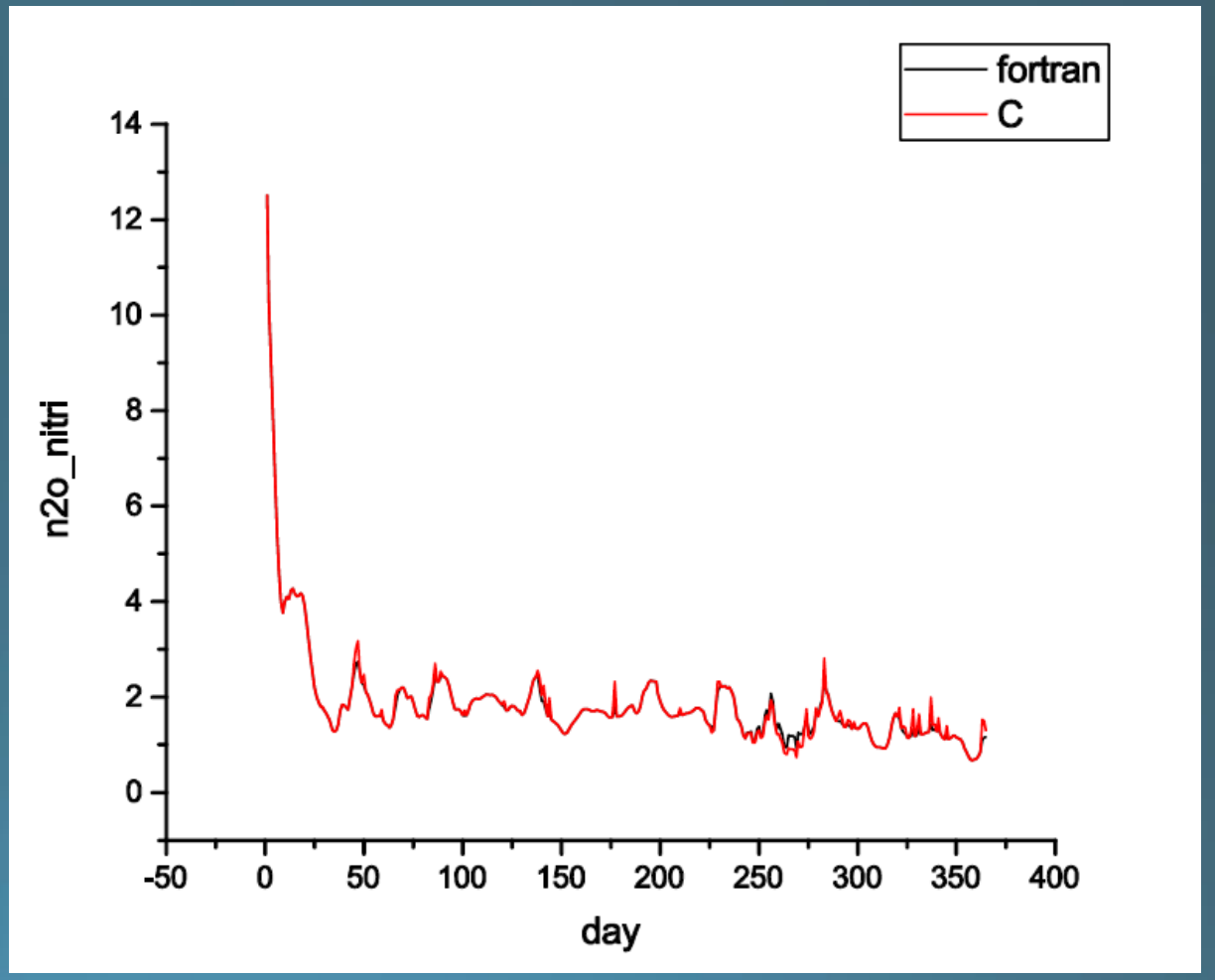
Comparison with DNDC





Comparison with DNDC





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Regional Case:

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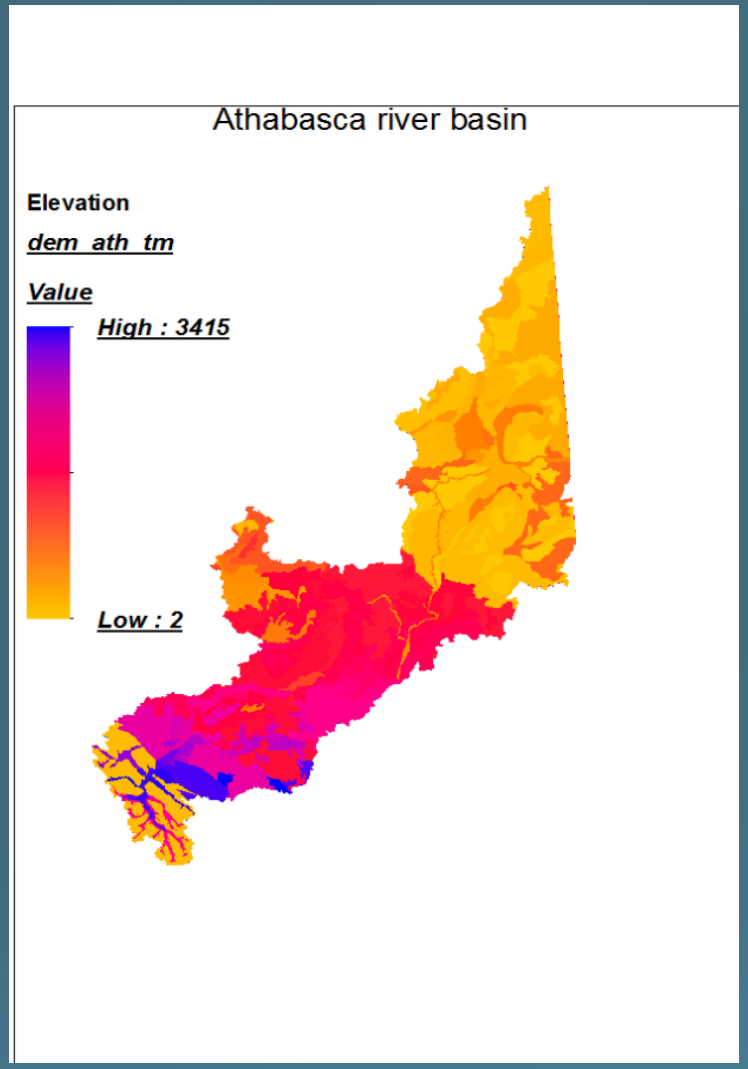
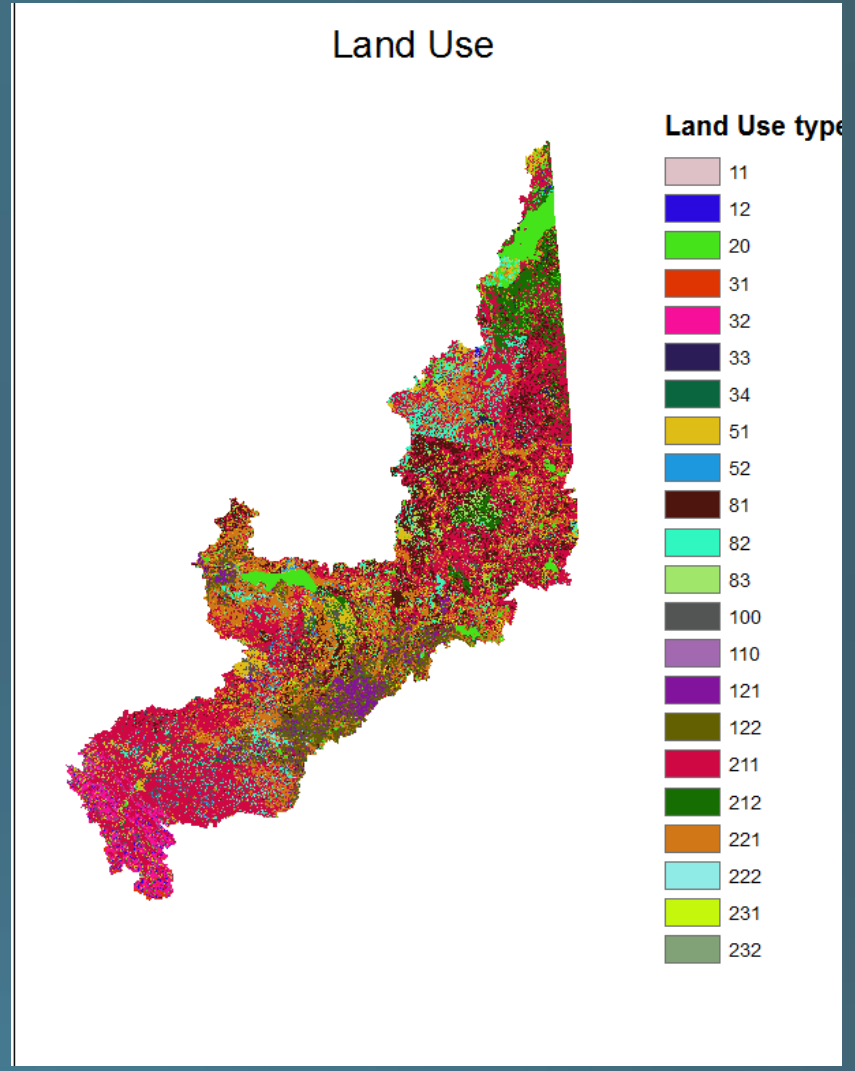
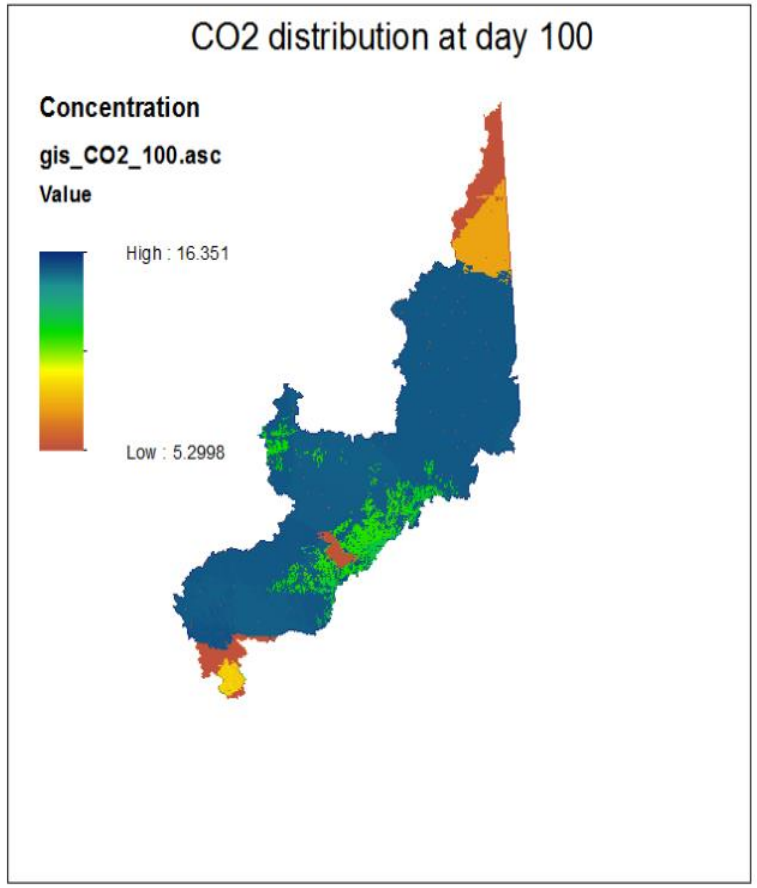


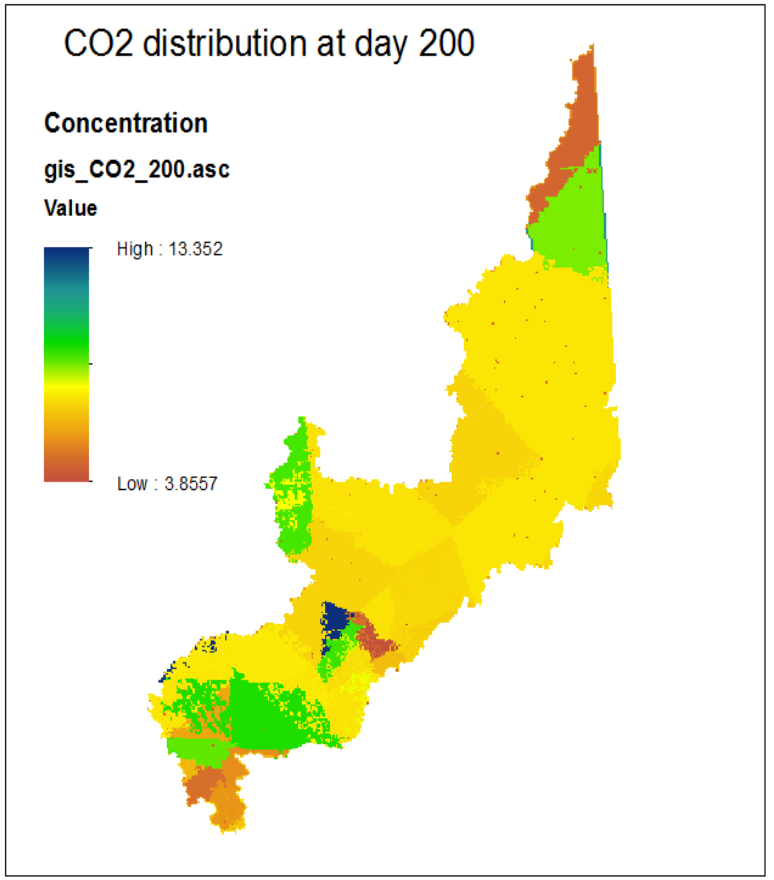


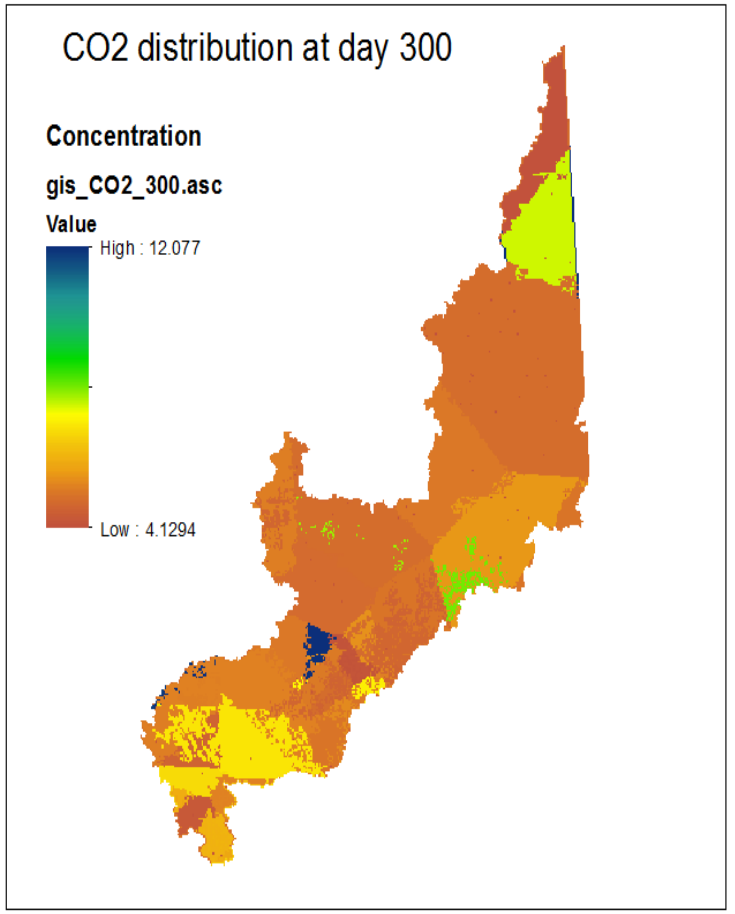
Simulation parameters

- 1 year simulation
- climate files from 33 stations
- Plants distribution
  - Wheat in agricultural area
  - Grass in other area
- Events
  - Irrigation, tillage, fertilization, crop seeding for agricultural area

CO_2 distribution







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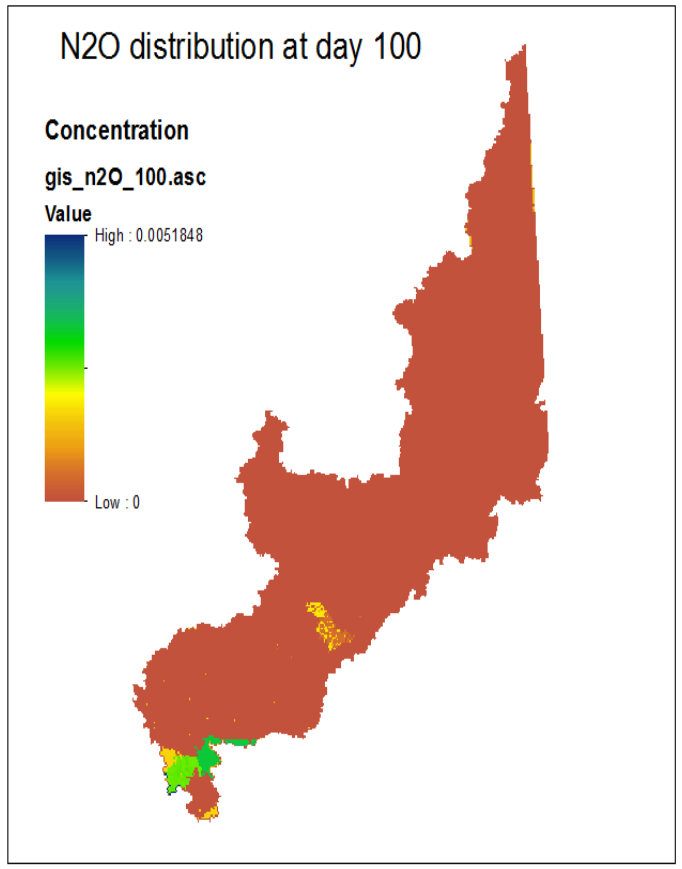
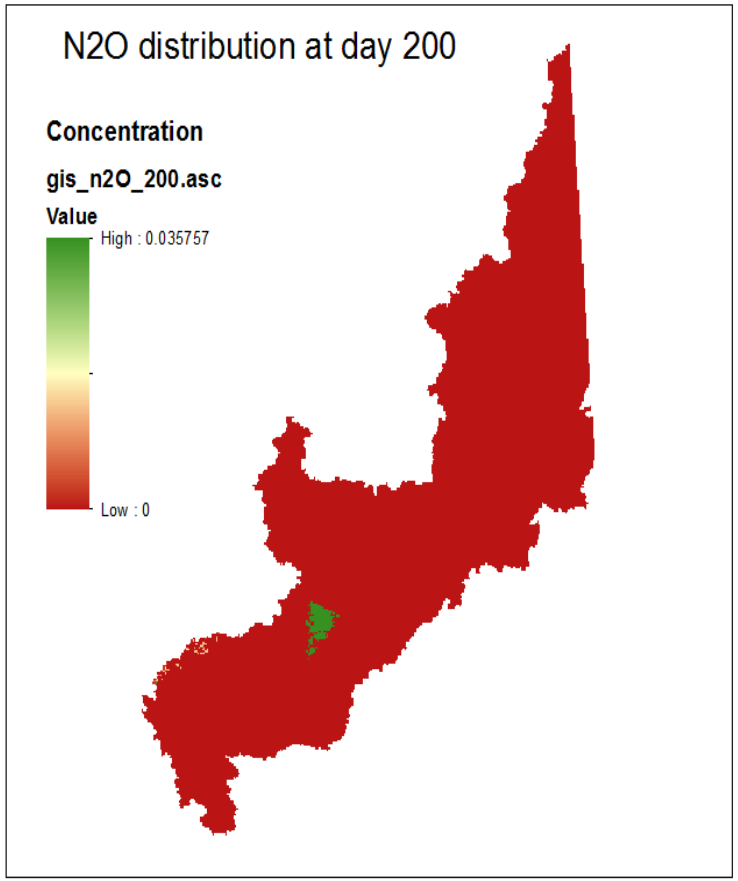
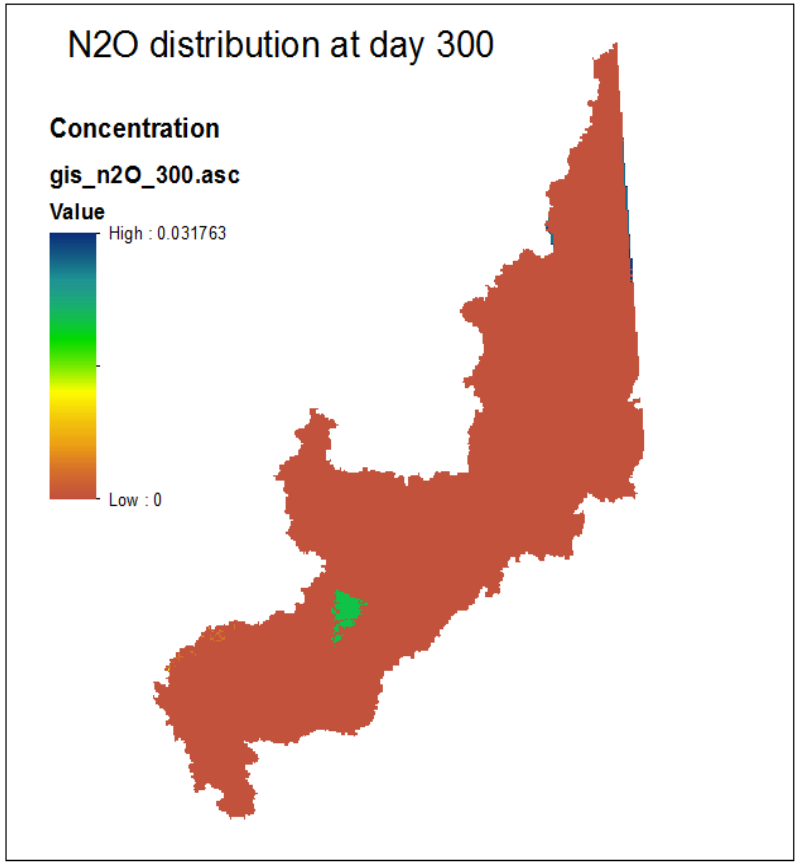
N_2O distribution







Conclusion

- A fully regional DNDC has been developed coupled with hydrologic model.
- The forest module will be combined into the modified DNDC.
- The wetland module requires to be standardized in future.

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