

Introduction to DNDC model

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DNDC

- **DNDC: DeNitrification DeComposition Model**
- **DNDC is a comprehensive biogeochemistry model that simulates crop growth and soil C and dynamics based on input data on soil properties, climate, and farming practices (e.g. Li et al., 1992, 1994).**
- **The model was expanded to simulate the emission of trace gases such as NO, N₂O, NH₄, and CH₄ from agricultural ecosystems and natural wetlands (Zhang et al., 2002; Li et al., 2004).**

De-Nitrification De-Composition model

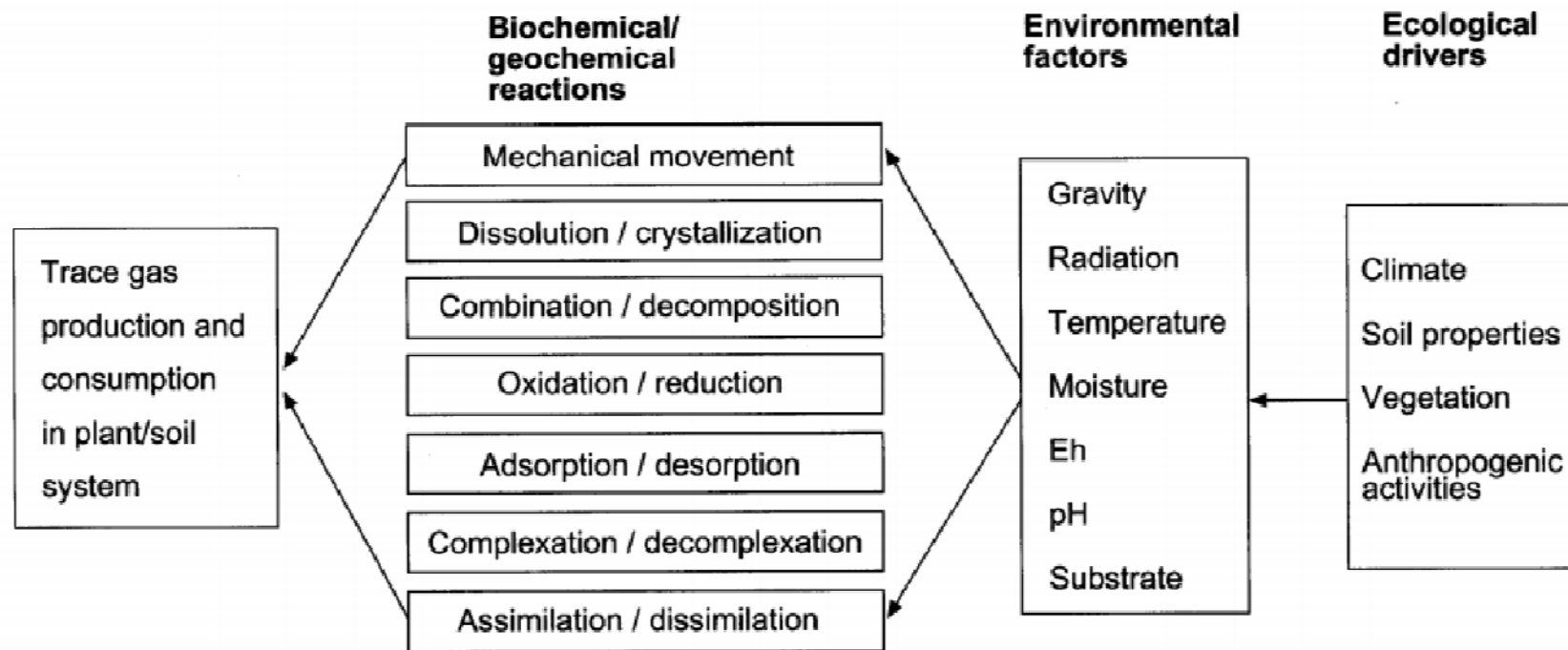


Figure 1. A biogeochemical model is a mathematical expression of biogeochemical field which consists of spatially and temporally differentiated environmental forces driving a series of biogeochemical reactions in ecosystems. Fluxes of NO , N_2O , CH_4 , and NH_3 are regulated by directions and rates of the relevant biogeochemical reactions

DNDC

- **The DNDC model predicts C and N biogeochemistry in agricultural ecosystems at site and regional scales.**
- **The accuracy of prediction depends on the input data on four drivers.**
- **Four major ecological drivers, namely climate, soil physical properties, vegetation, and anthropogenic activities, drive the entire model.**

DNDC

All the impacts in the system can be categorized into 2 groups.

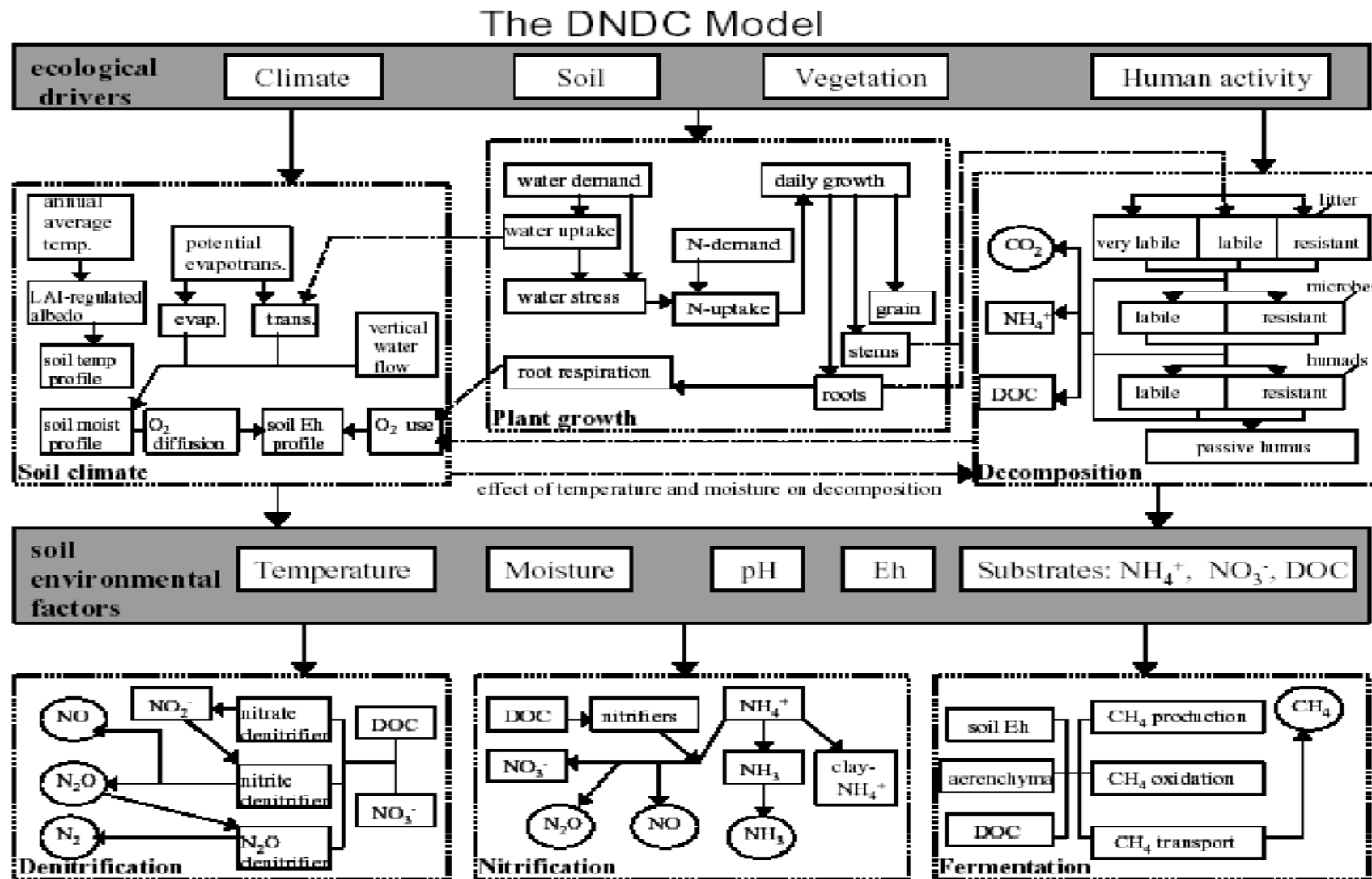
- **The first group includes impacts of ecological drivers on soil environmental variables,**
- **The second groups includes the impacts of the soil environmental variables on trace gas-related geochemical or biochemical reactions.**

DNDC components

DNDC consisted of 2 components

- The first component consisting of the Soil climate submodel, crop growth, and decomposition submodels, predicts soil temperature, moisture, pH, Eh, and substrates component,**
- The second component consisting of nitrification, denitrification, and fermentation submodels, predicts NH_3 , NO , N_2O , CH_4 fluxes**

De-Nitrification De-Composition model



Source: University of New Hampshire, 2003

Linking ecological drivers to soil environmental variables

- **DNDC needs site-specific input data of climate, soil, vegetation, and farming practices for the simulated agricultural land.**
- **DNDC integrates the ecological drivers in the three submodels to generate their collective effects on soil temperature, moisture, pH, Eh, and substrate concentrations.**

Linking ecological drivers to soil environmental variables

- **The soil climate submodel calculates soil temperature, moisture, pH, Eh profiles by integrating air temperature, precipitation, soil thermal and hydraulic properties, and oxygen status.**
- **By integrating crop characters, climate, soil properties, and farming practices, the plant growth submodel simulates plant growth and its effects on soil temperature, moisture, pH, Eh, dissolved DOC, and available N concentration.**

Linking ecological drivers to soil environmental variables

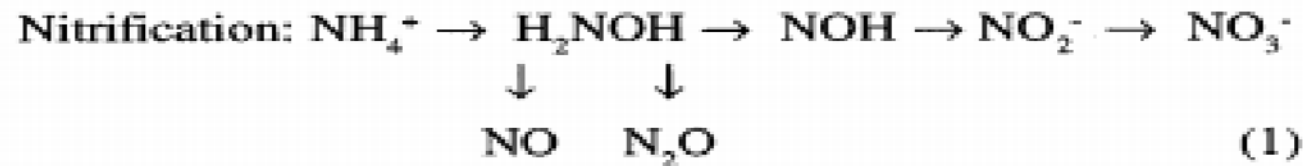
- **The decomposition submodel simulates concentrations of substrates (e.g., DOC, NH_4^+ , and NO_3^-) by integrating climate, soil properties, plant effect, and farming practices.**
- **The three submodels interact with each other to finally determine soil temperature, moisture, pH, Eh, and substrate concentrations in the soil profiles at a daily time step.**

Linking ecological drivers to trace gases

- **The links were set up based on either the basic physical, chemical, or biological laws, or equations obtained from the experiments under controlled conditions so that effect of each soil variable could be distinguished.**

Linking ecological drivers to trace gases

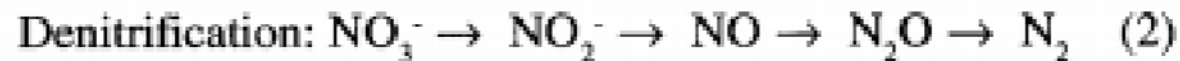
- Biological oxidation/reduction dominates NO and N₂O evolution in soils.
- Nitrification (i.e., microbial oxidation of ammonium) has been observed to be the main source of NO and N₂O under aerobic conditions.



- The factors controlling nitrification have been determined to be soil temperature, moisture, pH, and NH₄⁺ concentration.

Linking ecological drivers to trace gases

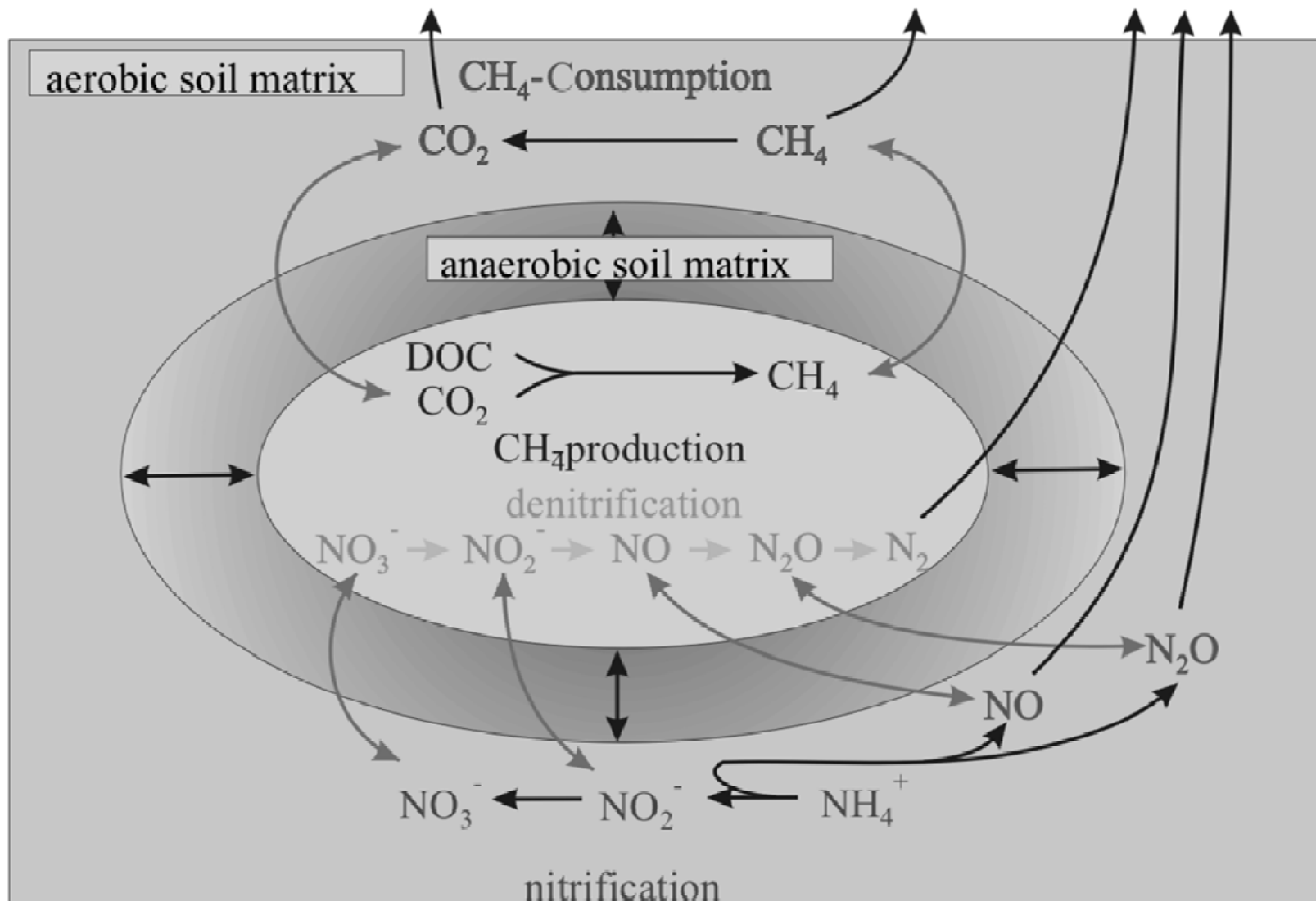
- Denitrification is another main source of N_2O and NO from soil.
- Denitrification includes a sequential reduction of nitrate to dinitrogen (N_2) driven by denitrifying bacteria under anaerobic conditions.



- Denitrification controlled by soil moisture and Eh.

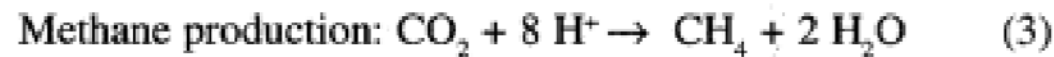
Linking ecological drivers to trace gases

- The DNDC model simulates relative growth rates of nitrate, nitrite, NO, and N₂O denitrifiers based on soil Eh, concentrations of DOC, and nitrogen oxides.
- A simple scheme of anaerobic balloon was developed in the model to divide the soil matrix into aerobic and anaerobic parts.
- DNDC simulated swelling and shrinking of the anaerobic balloon.
- Only the substrates allocated in the anaerobic part are involved in denitrification.



Linking ecological drivers to trace gases

- Methane is an end product of the biological reduction of CO₂ or organic carbon under anaerobic conditions.



or



- Methane fluxes were strongly controlled by soil available carbon (i.e., DOC) content, and soil temperature.
- The reduction of available carbon to methane is mediated by anaerobic microbes (e.g., methanogens) that are only active when the soil Eh is low enough.

Linking ecological drivers to trace gases

- DNDC calculates methane production rate as a function of DOC content and temperature as soon as the predicted soil Eh reaches -150 mV or lower.
- Methane is oxidized by aerobic methanotrophs in the soil. A highly simplified scheme was employed in DNDC to model methane diffusion between soil layers based on methane concentration gradients, temperature, and porosity in the soil.

Function 3.5. CH₄ diffusion rate (kg C/ha/d)

$$Rd = 0.01 * (CH_4[l] - CH_4[l+1]) * T[l] * PORO;$$

AC – Available C concentration, kg C/ha;

T – soil temperature, °C;

l – soil layer number;

AERE – plant aerenchyma;

FloodDay – flooding days;

PORO – soil porosity;

CH₄[l] – CH₄ concentration at layer l, kg C/ha.

Linking ecological drivers to trace gases

- DNDC predicts plant-transported methane flux as a function of methane concentration and plant aerenchyma.

Equation 3.3. CH₄ flux through plant aerenchyma (kg C/ha/d)

$$\text{CH}_{4(\text{aere})} = 0.5 * \text{CH}_4[\text{I}] * \text{AERE};$$

$$\text{AERE} = -0.0009 * \text{PGI}^5 + 0.0047 * \text{PGI}^4 - 0.883 * \text{PGI}^3 + 1.9863 * \text{PGI}^2 - 0.3795 * \text{PGI} + 0.0251;$$

$$\text{PGI} = (\text{days since planting}) / (\text{season days}); (\text{plant growth index})$$

- DNDC assume that ebullition only occurs at the surface layer, and ebullition rate is regulated by soil methane concentration, temperature, porosity, and plant aerenchyma.

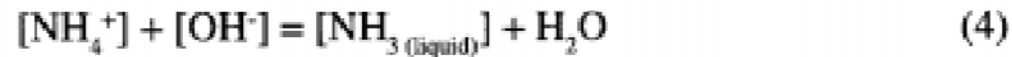
Function 3.4. CH₄ flux through ebullition (kg C/ha/d)

$$\text{CH}_{4(\text{ebullition})} = 0.025 * \text{CH}_4[\text{I}] * \text{PORO} * \text{Ft} * (1 - \text{AERE});$$

$$\text{Ft} = -0.1687 * (0.1 * \text{T}[\text{I}])^3 + 1.167 * (0.1 * \text{T}[\text{I}])^2 - 2.0303 * (0.1 * \text{T}[\text{I}]) + 1.042;$$

Linking ecological drivers to trace gases

- Soil NH_3 concentration is directly regulated by a chemical reaction occurring in the soil liquid phase:



where $[\text{NH}_4^+]$ is ammonium concentration, $[\text{OH}^-]$ is hydroxide ion concentration, and $[\text{NH}_{3(\text{liquid})}]$ is ammonia concentration in soil water.

- DNDC calculate $\text{NH}_{3(\text{liq})}$ concentration base on NH_4^+ and OH^- concentration, and NH_4^+ concentration in the soil profile is calculated by the decomposition submodel.

Linking ecological drivers to trace gases

- The equations describing the effects of soil environmental factors on NO, N₂O, CH₄, and NH₃ were organized into three submodels.
- 1. The fermentation submodel contains all the methane related equation. This submodel calculates production, oxidation, and transport of methane under submerged conditions.
- 2. The denitrification submodel contains all the denitrification equations. This submodel calculates production, consumption, and diffusion of N₂O and NO during rainfall, irrigation, or flooding events.

Linking ecological drivers to trace gases

- **3. Nitrification related equations are included in the nitrification submodel. As a logical extension of the NH_4^+ / $\text{NH}_{3(\text{liq})}$ / $\text{NH}_{3(\text{gas})}$ equilibrium, functions for NH_3 production and volatilization are also included in the nitrification submodel.**
- **The three submodels compose the second component of the DNDC model.**

Input and output

- **Daily temperature**
- **Precipitation**
- **Soil bulk density**
- **Texture**
- **Soil organic carbon content**
- **pH**
- **Farming (e.g., crop type and rotation, flooding, grazing, and weeding)**

Input and output

When the DNC is used for regional estimates of trace gases emissions, the model needs the spatially and temporally differentiated input data stored in geographical information system type database in advance.

Base on the input parameters of the ecological drivers, DNDC first predicts daily soil temperature, moisture, Eh, pH, and substrate concentration, and then uses the environmental parameters to drive nitrification, denitrification, methane production/oxidations.

Daily emissions of trace gases are finally calculated as their daily net fluxes.

Input and output

Most parts of the model run at a daily time step except the soil climate and denitrification submodels which run at an hourly time step.

Output parameters from the model runs are daily soil profiles of temperature, moisture, Eh, pH, and concentrations of total soil organic carbon, nitrate, nitrite, ammonium, urea, ammonia, as well as daily fluxes of trace gases emission.

For the regional version of DNDC, the simulated results are recorded as geographically explicit data in a GIS database.

DNDC Site mode



Figure 2. Main menu of DNDC

DNDC Site mode

III Model Operation

1. Site Mode

1.1. Input Parameters

- Page 1: Site and climate
- Page 2: Soil
- Page 3: Farming management
- Page 4: Crop
- Page 5: Tillage
- Page 6: Fertilization
- Page 7: Manure amendment
- Page 8: Weeding
- Page 9: Flooding
- Page 10: Irrigation
- Page 11: Grazing and cutting

1.2. Save and Open Input File

1.3. Run DNDC at Site Scale

1.4. A Quick View of Modeled Results

1.5. Batch Run

DNDC Site mode



Figure 2. Main menu of DNDC

Climate/Soil/Cropping

The screenshot shows a software window titled "Input Information" with a tabbed interface. The "Climate" tab is selected, showing fields for site name, location, simulation parameters, and climate data source. The "Soil" and "Cropping" tabs are also visible. The "Save" tab is not active. The "Climate" tab contains the following elements:

- Site name:** A text box containing "Arrou9899".
- Latitude:** A text box containing "48.1".
- Longitude:** A text box containing "0".
- Simulated years:** A text box containing "2".
- Record daily results:** A checked checkbox.
- Obtain meteorological data from your database:** A section with buttons "Select Climate Files", "Down", and "Up". Below these is a list box containing two file paths: "C:\DNDC_ValidationCases\N2O\Daniela_Arrou\Climate\Arrou_1998.txt" and "C:\DNDC_ValidationCases\N2O\Daniela_Arrou\Climate\Arrou_1999.txt".
- Use 1 climate file for all years:** An unchecked checkbox.
- Read climate file names from a file:** A button.
- N concentration in rainfall (mg N/l or ppm):** A text box containing "1".
- Atmospheric background NH3 concentration (ug N/m^3) (0.06):** A text box containing "0.06".
- Atmospheric background CO2 concentration (ppm) (350):** A text box containing "350".
- Annual increase rate of atmospheric CO2 concentration (ppm/yr):** A text box containing "0".
- Or read annual CO2 concentrations from a file:** An unchecked checkbox.
- Accept:** A button.
- Select a format matching your climate file(s):** A group box containing five radio buttons:
 - ☐ Jday, MeanT (C), Rainfall (cm)
 - ☒ Jday, MaxT, MinT, Rainfall (cm)
 - ☐ Jday, MaxT, MinT, Rainfall, Radiation (MJ/m2/day)
 - ☐ Jday, MaxT, MinT, Rainfall, wind speed (m/s)
 - ☐ Global met data format
- OK, Cancel, Apply, Help:** Buttons at the bottom right.

Figure 3. Input information for location and climate

Climate/Soil/Cropping

Input Information

Climate | Soil | Cropping | Save

Land-use type = (1) Upland crop field

Soil texture

Soil Texture (4) Silt Loam 0.14 Clay fraction (0-1) 0.137

Bulk density (g/cm³) 1.29 Field capacity (wfps, 0-1) 0.4 Hydro-conductivity (m/hr) 0.02592

Soil pH 6.4 Wilting point (wfps, 0-1) 0.2 Porosity (0-1) 0.485

Soil structure

Macro-pores ☐ Yes ☒ No Bypass flow rate (0-1) 0 Depth of water-retention layer (m) 9.99

Water logging problem ☐ Yes ☒ No Highest groundwater table depth (m) 9.99

Initial soil organic C (SOC) content, partitioning and profile

SOC at surface soil (0-5cm) (kg C/kg) 0.0096

SOC profile

Re-define ☐ Depth of top soil with uniform SOC content (m) 0.2

SOC decrease rate below top soil (0.5 - 5.0) 2

SOC partitioning

Re-define ☐ Bulk C/N 10.9

	V.L. litter	L. litter	R. litter	Humads	Humus	IOC
Fraction	0	0	0.01	0.048	0.942	0
C/N	5	25	100	10	10	500

Modify decomposition rates by multiplying a factor to each of the three SOC pools

Liter ☐ 1 Humads ☐ 1 Humus ☐ 1

Initial NO₃(-) concentration at surface soil (mg N/kg) 0.59875

Initial NH₄(-) concentration at surface soil (mg N/kg) 0.05988

Microbial activity index (0-1) = 1

Slope (%) = 0

Accept

OK Cancel Apply Help

Figure 4. Input information for soil properties

Climate/Soil/Cropping

Input Information

Climate | Soil | Cropping | Save

Design cropping systems for the simulated years

Total years: Number of cropping systems applied during the entire simulated years:

Cropping system #: Duration of this cropping system (yrs):

Duration of a cycle in this cropping system (yrs): Year # in the cycle in this cropping system:

Figure 5. Rotation information: Cropping systems and Cycles

Farming management practices

Farming Management Practices

Crop | Tillage | Fertilization | Manure Amendment | Weeding | Flooding | Irrigation | Grazing or cutting

Number of new crops consecutively planted in this year =

Crop # =

Crop type:

This is a perennial crop ☐

Is it a cover crop? ☐ Yes ☒ No

Planting month: day =

Harvest month: day =

Harvest mode: 1: in this year, 2: in next year

Fraction of leaves and stems left in field after harvest (0-1)

Crop parameters for this case

	Grain	Leaf+stem	Root
Maximum biomass, kg C/ha	2400	2133.33	800
Biomass fraction	0.45	0.4	0.15
Biomass C/N ratio	12	45	52
Total N demand, kg N/ha	262.792		
Thermal degree days	700		
Water demand, g water/g DM	450		
N fixation index	1		
LAI adjustment factor (>0)	4		
Vascularity (0-1)	0		

CropID	CropT...	Planting		Harvest		Mode	Residue	Yield
1st crop	25	1	1	6	1	1	1.000000	2400.0...
2nd crop	2	10	21	7	12	2	0.500000	3500.0...

Figure 6. Input information for crop type, planting/harvest dates, residue management and crop physiological/phenology parameters

Farming management practices

Farming Management Practices

Crop | **Tillage** | Fertilization | Manure Amendment | Weeding | Flooding | Irrigation | Grazing or cutting

Tillage

How many applications in this year =

Tilling # = <- Last Next ->

Month = Day =

Tilling method =

Accept

Till-ID	Month	Day	Method
1st till	6	2	5

OK Cancel Apply Help

Figure 8. Input information for tillage

Farming management practices

Farming Management Practices

Crop | Tillage | **Fertilization** | Manure Amendment | Weeding | Flooding | Irrigation | Grazing or cutting

☒ Manual

How many applications in this year = Fertilization # <- >

Application date Month Day

Application depth ☒ surface ☐ injection Depth (cm)

Applied amount of fertilizers (kg N/ha):

Urea Anhydrous ammonia Ammonium bicarbonate Nitrate

NH₄NO₃ (NH₄)₂SO₄ (NH₄)₂HPO₄

☐ Auto-fertilization

Urea is automatically applied on planting day at rate determined by crop demand and soil residue inorganic N

☐ Fertigation

Select Fertigation File:

Additional alternative method

Controlled release fertilizer ☐ Days for total N release

Use nitrification inhibitor ☐ Efficiency (0-1) Effective duration (days)

Accept

Fer-ID	Month	Day	Method	Nitrate	NH ₄ H...	Urea	NH ₃	NH ₄ N...	(NH ₄) ₂ ...	(NH ₄) ₂ ...	Depth
1st till	1	1	0	0.000	0.000	0.000	0.000	90.000	0.000	0.000	0.200

OK Cancel Apply Help

Figure 9. Input information for fertilization

Farming management practices

Farming Management Practices

Crop | Tillage | Fertilization | **Manure Amendment** | Weeding | Flooding | Irrigation | Grazing or cutting

How many applications in this year?

Manuring parameters

Application # <- Last Next ->

Month = Day =

Manure type =

Amount (kg C/ha) = C/N ratio = N (kg N/ha)

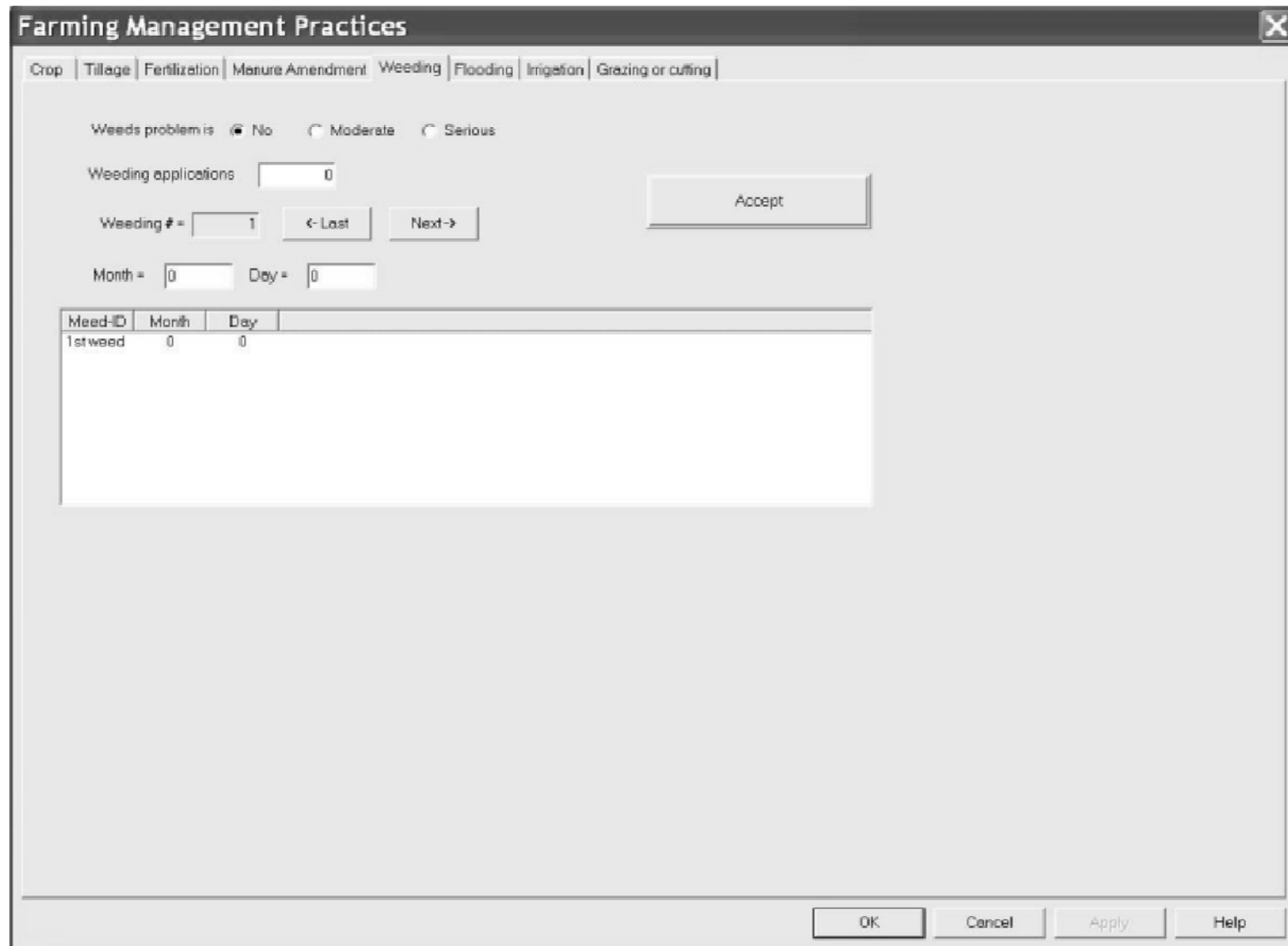
Application method ☒ Surface spreading ☐ Incorporation

Application	Month	Day	Type	Manure-C	C/N	Manure-N
1st	5	10	4	2000.000	3.500	571.429

OK Cancel Apply Help

Figure 10. Input information for manure amendment

Farming management practices



The screenshot shows a software window titled "Farming Management Practices" with a close button (X) in the top right corner. The window contains several tabs: "Crop", "Tillage", "Fertilization", "Manure Amendment", "Weeding" (which is the active tab), "Flooding", "Irrigation", and "Grazing or cutting".

Inside the "Weeding" tab, there are the following controls:

- A group box labeled "Weeds problem is" containing three radio buttons: "No" (selected), "Moderate", and "Serious".
- A text input field for "Weeding applications" with the value "0".
- A text input field for "Weeding #" with the value "1", flanked by "<- Last" and "Next->" buttons.
- Text input fields for "Month =" (value "0") and "Day =" (value "0").
- A table with the following data:

Weed-ID	Month	Day
1st weed	0	0

At the bottom of the window, there are four buttons: "OK", "Cancel", "Apply", and "Help".

Figure 11. Input information for weeding

Farming management practices

Farming Management Practices

Crop | Tillage | Fertilization | Manure Amendment | Weeding | **Flooding** | Irrigation | Grazing or cutting

Water table (WT) control method:

Irrigation ☒

How many times the field is flooded in this year? Flooding # < ->

Start on month day End on month day

Conventional flooding (10 cm) ☒ Marginal flooding (-5 - 5 cm) ☐

N received with flood water (kg N/ha) Water leaking rate (mm/day)

Rainfed ☐

Water gathering index

Observed water-table data ☐

Select an observed water-table data file

None0.00000

Empirical parameters ☐

Initial WT depth, cm* Surface inflow fraction of precipitation

Lowest WT depth ceasing surface outflow, cm* Intensity factor for surface outflow

Lowest WT ceasing ground outflow, cm* Intensity factor for ground outflow

* Positive WT is above ground

Flood ID	Flood-M	Flood-D	Drain-M	Drain-D

Accept

OK Cancel Apply Help

Figure 12. Input information for flooding

Farming management practices

Farming Management Practices

Crop | Tillage | Fertilization | Manure Amendment | Weeding | Flooding | Irrigation | Grazing or cutting

Irrigation input mode

☒ Based on irrigation events Number of irrigation events =

☐ Based on an irrigation index Irrigation index (0-1) =

Input irrigation date and amount for each irrigation event

Irrigation # <=> Month = Day =

Amount of water applied (cm) =

Irrigation method ☒ Flood ☐ Sprinkler ☐ Drip

Accept

Irr.ID	Month	Day	Water...	Method
1st Irr.	4	17	2.50	0
2nd Irr.	5	9	20.70	0
3rd Irr.	5	11	20.70	0
4th Irr.	5	29	23.30	0
5th Irr.	6	16	21.60	0
6th Irr.	6	26	8.70	0
7th Irr.	7	11	17.00	0
8th Irr.	7	18	21.60	0
9th Irr.	7	26	20.40	0
10th Irr.	8	13	23.00	0

Figure 13. Input information for irrigation

Farming management practices

The screenshot shows a software window titled "Farming Management Practices" with a close button (X) in the top right corner. The window has a tabbed interface with the following tabs: Crop, Tillage, Fertilization, Manure Amendment, Weeding, Flooding, Irrigation, and "Grazing or cutting" (which is currently selected).

The "Grazing or cutting" tab is divided into two main sections: "Grazing" and "Grass cutting".

Grazing section:

- Number of grazing time periods =
- Grazing # = with "<- Last" and "Next ->" buttons.
- Start month = day =
- End month = day =
- Grazing hours per day =
- Grazing intensity (heads/ha):
 - Cattle:
 - Horse:
 - Sheep:

Grass cutting section:

- Number of grass cutting =
- Cutting # = with "<- Last" and "Next ->" buttons.
- Month = day =
- Cut fraction of above-ground biomass (0-1) =

Below these sections is an "Accept" button.

At the bottom of the window, there are two empty tables for data entry:

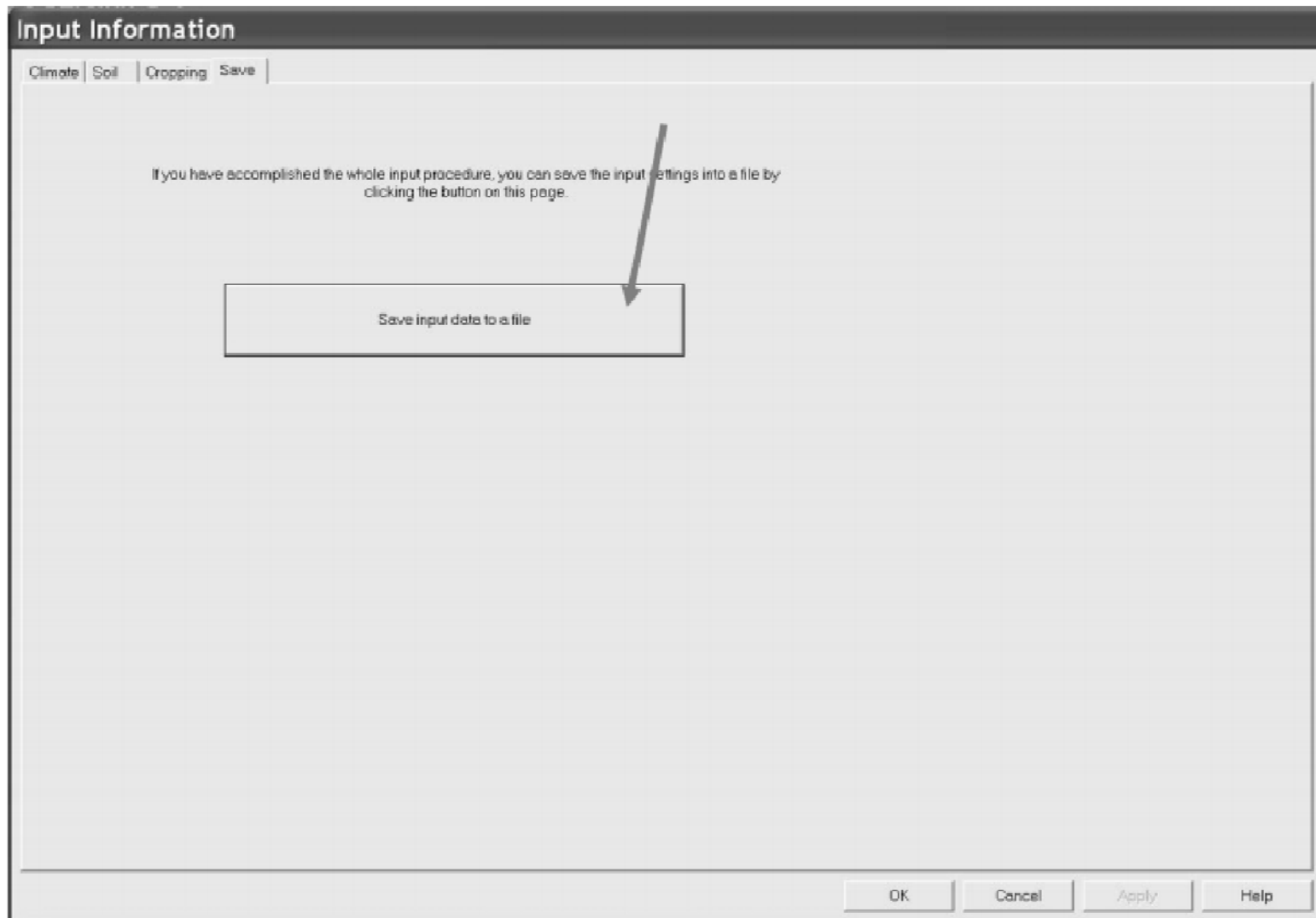
Graz.ID	Start M	Start D	End M	End Day	Cattle	Horse	Sheep	Hours

Cut.ID	Month	Day	Fraction

At the very bottom of the window are four buttons: "OK", "Cancel", "Apply", and "Help".

Figure 14. Input information for grazing and grass cutting

Save and open an input file



Input file

Input_Parameters:

```
-----  
Site_data:                Arrou9899  
Simulated_Year:           2  
Latitude:                 48.100  
Daily_Record:             1  
-----
```

Climate_data:

```
Climate_Data_Type:        1  
NO3NH4_in_Rainfall       1.0000  
NO3_of_Atmosphere        0.0600  
BaseCO2_of_Atmosphere    350.0000  
Climate_file_count=      2  
    1   C:\DNDC\N2O\Arrou\Climate\Arrou_1998.txt  
    2   C:\DNDC\N2O\Arrou\Climate\Arrou_1999.txt  
Climate_file_mode         0
```

```

CO2_increase_rate          0.000000
-----
Soil_data:
  Soil_Texture              4
  Landuse_Type              1
  Density                   1.29000
  Soil_pH                   6.40000
  SOC_at_Surface            0.00960
  Clay_fraction             0.13700
  BypassFlow                0.00000
  Litter_SOC                0.01000
  Humads_SOC                0.04800
  Humus_SOC                 0.94200
  Soil_NO3(-) (mgN/kg)     0.59875
  Soil_NH4(+) (mgN/kg)     0.05988
  Moisture                  0.30000
  Temperature               7.45000
  Field_capacity             0.400000
  Wilting_point             0.200000
  Hydro_conductivity        0.025920
  Soil_porosity             0.485000
  SOC_profile_A             0.200000
  SOC_profile_B             2.000000
  DC_litter_factor          1.000000
  DC_humads_factor          1.000000
  DC_humus_factor           1.000000
  Humad_CN                  10.000000
  Humus_CN                  10.000000
  Soil_PassiveC              0.000000
  Soil_microbial_index      1.000000
  Highest_WT_depth          9.990000
  Depth_WRL_m               9.990000
  Slope                     0.000000
  Use_ION_file              0
-----

```

Input file

Input file

```
Crop_data:
Rotation_Number=      1
  Rotation_ID=        1
  Totalyear=          2
  Years_Of_A_Cycle=    2
    YearID_of_a_cycle= 1
    Crop_total_Number= 2
      Crop_ID=         1
        Crop_Type=     25
        Plant_time=    1 1
        Harvest_time=  6 1
        Year_of_harvest= 1
      Ground_Residue=  1.000000
      Yield=          2400.000000
      Rate_reproductive= 0.020000
      Rate_vegetative=  0.040000
      Psn_efficiency=   0.480000
      Psn_maximum=      35.000000
      Initial_biomass=  12.500000
      Cover_crop=       0
      Perennial_crop=   0
      Grain_fraction=   0.450000
      Shoot_fraction=   0.400000
      Root_fraction=    0.150000
      Grain_CN=         12.000000
      Shoot_CN=         45.000000
      Root_CN=          52.000000
      TDD=              700.000000
      Water_requirement= 450.000000
      Max_LAI=          4.000000
      N_fixation=       1.000000
      Vascularity=      0.000000
    Crop_ID=           2
      Crop_Type=       2
      Plant_time=      10 21
      Harvest_time=    7 12
      Year_of_harvest=  2
```

```
Tillage_number=      1
  Tillage_ID=        1
    Month/Day/method= 6 2 5
Fertil_number=      1
  fertilization_ID=  1
    Month/Day/method= 1 1 0
    Depth=           0.200000
    Nitrate=          0.000000
    AmmBic=           0.000000
    Urea=             0.000000
    Anh=              0.000000
    NH4NO3=           90.000000
    NH42SO4=          0.000000
    NH4HPO4=          0.000000
    Release_rate=     1.000000
    Inhibitor_efficiency= 0.000000
    Inhibitor_duration= 0.000000
    FertilizationOption= 0
Manure_number=      0
Weed_number=        0
Weed_Problem=       0
Flood_number=       0
Leak_type=          1
Water_control=      0
Leak_rate=          0.000000
```

Input file

```

Water_gather= 1.000000
WT_file= None0.000000
Empirical_parameters= 0.0 0.0 0.0 0.0 0.0 0.0
Irrigation_number= 0
Irrigation_type= 0
Irrigation_Index= 0.000000
Grazing_number= 0
Cut_number= 0
YearID_of_a_cycle= 2
Crop_total_Number= 0
Tillage_number= 1
Tillage_ID= 1
Month/Day/method= 7 13 5
Fertil_number= 3
fertilization_ID= 1
Month/Day/method= 2 6 0
Depth= 0.200000
Nitrate= 0.000000
AmuBic= 0.000000
Urea= 0.000000
Anh= 0.000000
NH4NO3= 58.000000
NH42SO4= 0.000000
NH4HPO4= 0.000000
Release_rate= 1.000000
Inhibitor_efficiency= 0.000000
Inhibitor_duration= 0.000000
fertilization_ID= 2
Month/Day/method= 3 12 0
Depth= 0.200000
Nitrate= 0.000000
AmuBic= 0.000000
Urea= 42.000000
Anh= 0.000000
NH4NO3= 41.000000
NH42SO4= 0.000000
NH4HPO4= 0.000000
Release_rate= 1.000000
Inhibitor_efficiency= 0.000000
Inhibitor_duration= 0.000000
fertilization_ID= 3
Month/Day/method= 3 27 0
Depth= 0.200000

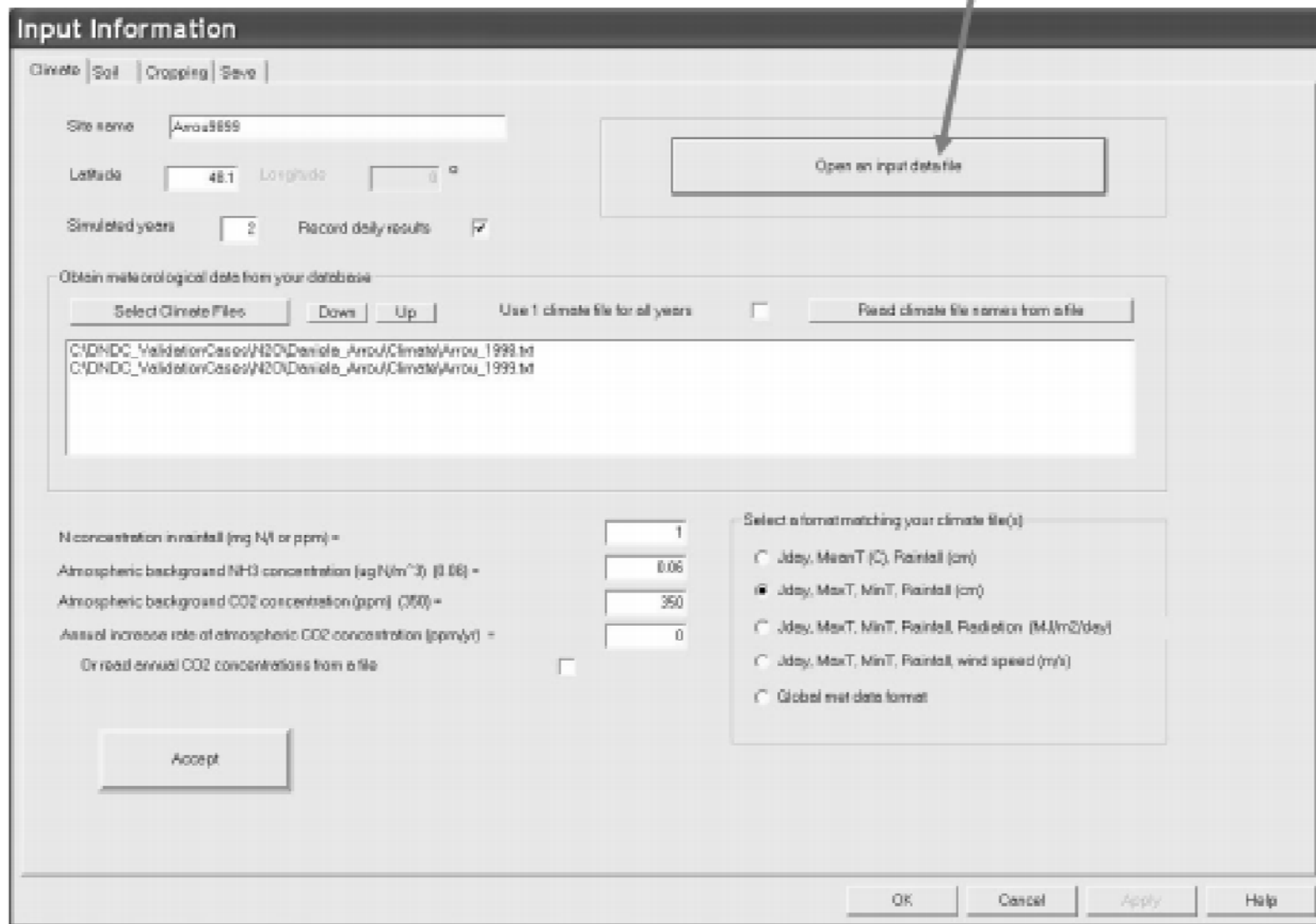
```

Input file

Input file

```
fertilization_ID=      3
  Month/Day/method=  3 27 0
  Depth=               0.200000
  Nitrate=             0.000000
  AmmBic=              0.000000
  Urea=                20.000000
  Anh=                0.000000
  NH4NO3=             20.000000
  NH42SO4=            0.000000
  NH4HPO4=            0.000000
  Release_rate=        1.000000
  Inhibitor_efficiency= 0.000000
  Inhibitor_duration=  0.000000
  FertilizationOption= 0
  Manure_number=       0
  Weed_number=         0
  Weed_Problem=        0
  Flood_number=        0
  Leak_type=           1
  Water_control=        0
  Leak_rate=           0.000000
    Water_gather=       1.000000
    WT_file=            None0.000000
    Empirical_parameters= 0.0 0.0 0.0 0.0 0.0 0.0 0.0
  Irrigation_number=   0
  Irrigation_type=     0
  Irrigation_Index=    0.000000
  Grazing_number=      0
  Cut_number=          0
Crop_model_approach    0
```

Open an input data file



The screenshot shows a software window titled "Input Information" with a tabbed interface. The "Climate" tab is selected. The window contains several input fields and buttons. A grey arrow points from the top of the window to a button labeled "Open an input data file".

Input Information

Climate | Soil | Cropping | Save

Site name:

Latitude: Longitude:

Simulated years: Record daily results: ☒

Obtain meteorological data from your database:

Select Climate Files: Use 1 climate file for all years: ☐ Read climate file names from a file:

N concentration in rainfall (mg N/l or ppm) =

Atmospheric background NH₃ concentration (kg N/m³) (0.06) =

Atmospheric background CO₂ concentration (ppm) (350) =

Annual increase rate of atmospheric CO₂ concentration (ppm/y) =

Or read annual CO₂ concentrations from a file: ☐

Select a format matching your climate file(s):

- ☐ Jday, MeanT (C), Rainfall (cm)
- ☒ Jday, MaxT, MinT, Rainfall (cm)
- ☐ Jday, MaxT, MinT, Rainfall, Radiation (MJ/m2/day)
- ☐ Jday, MaxT, MinT, Rainfall, wind speed (m/s)
- ☐ Global met data format

OK Cancel Apply Help

Run model at site mode

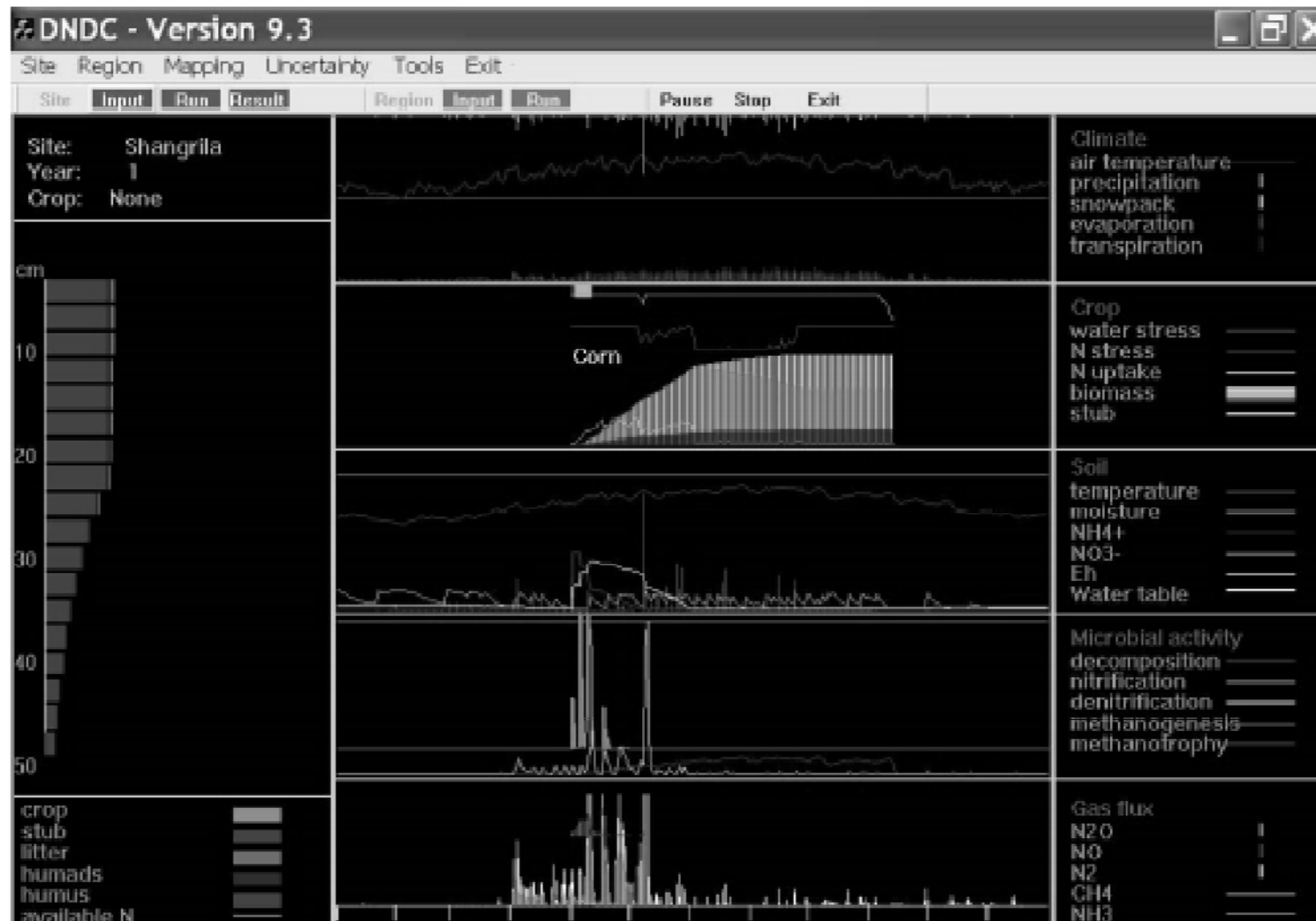


Figure 15. The seven windows allow users to monitor daily dynamics of several major simulated factors during the model run.

Quick view of modeled results

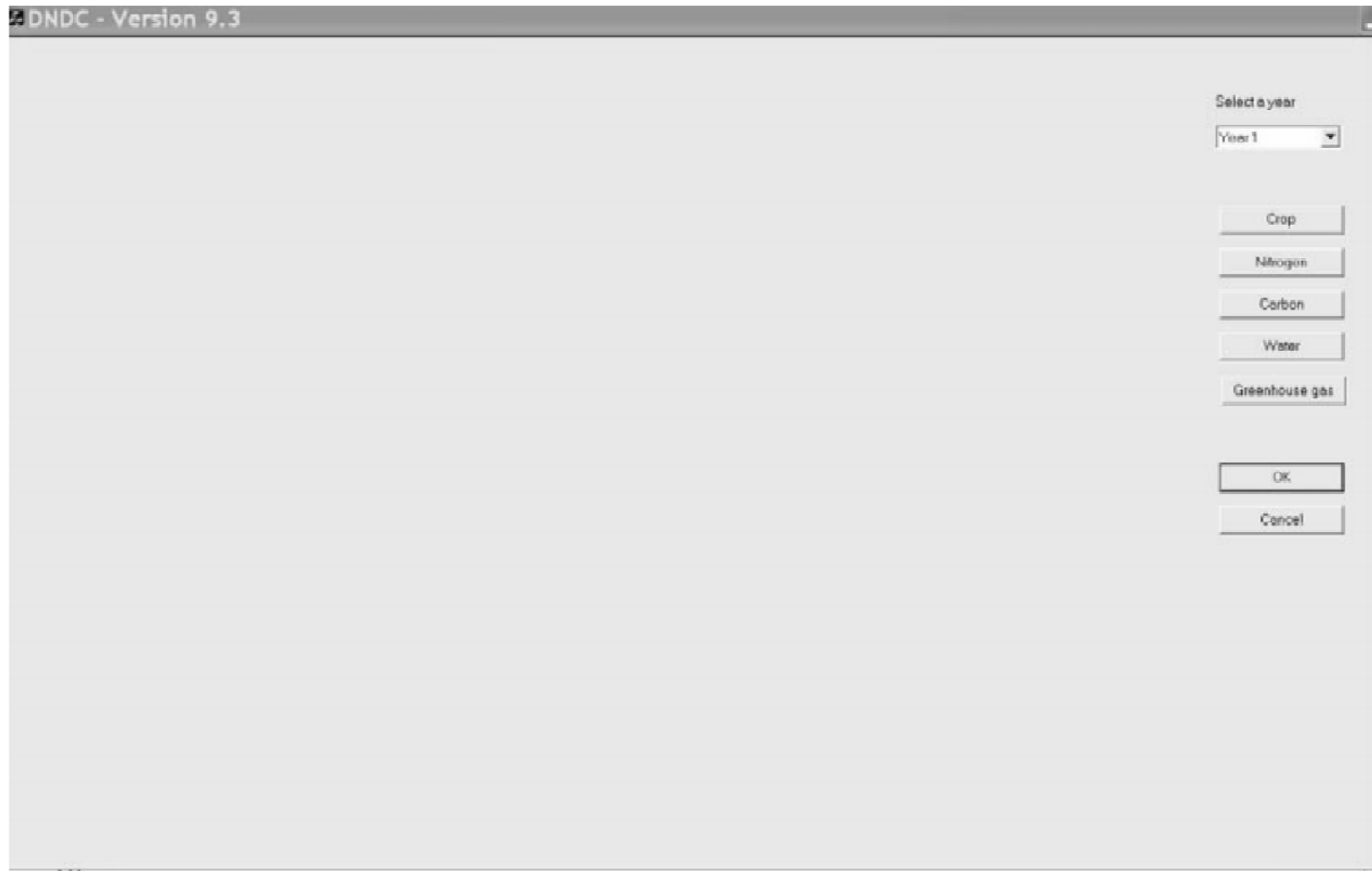


Figure 16. Main menu for quick view of modeled results

Modeled results

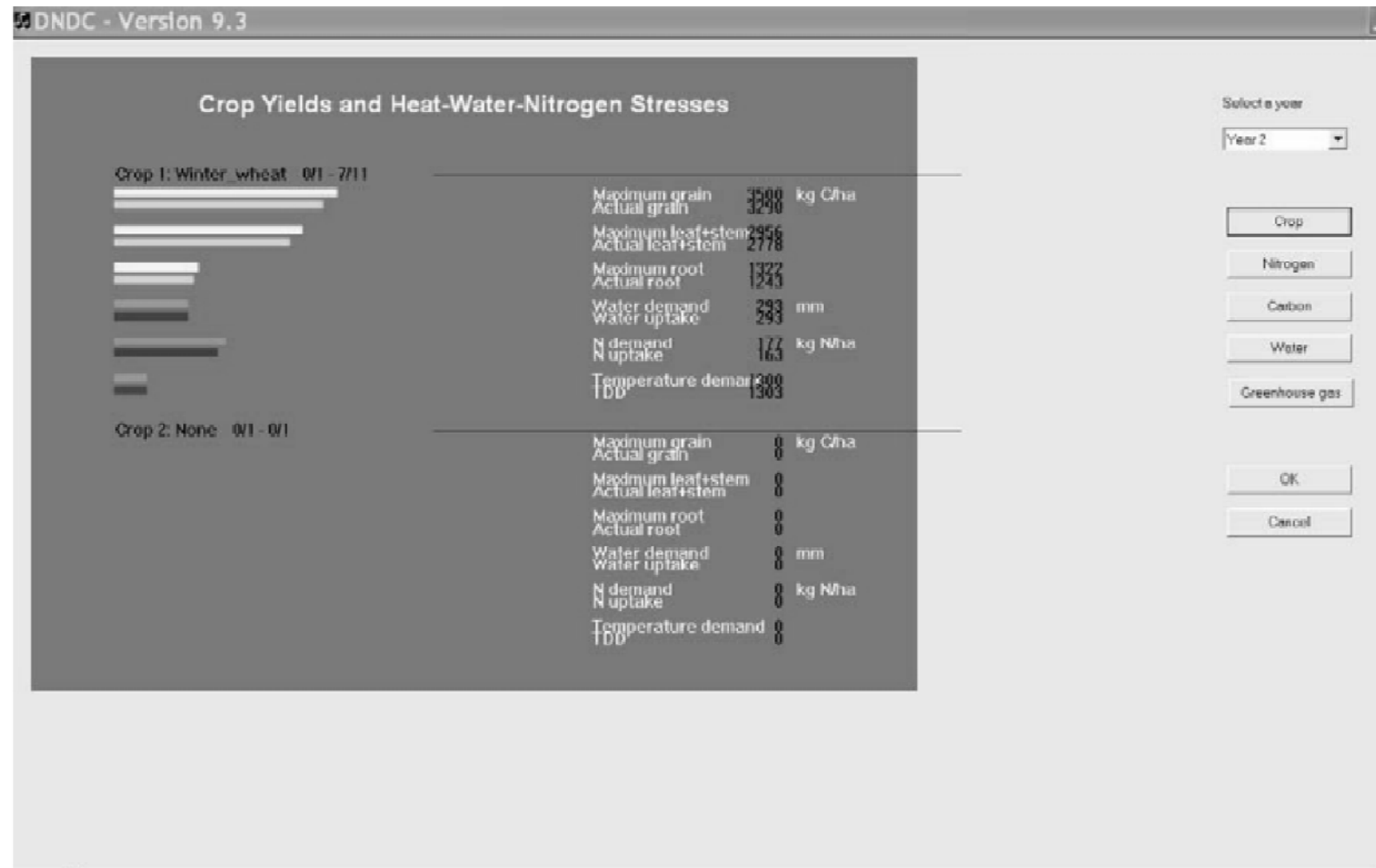


Figure 17. Modeled result 1: Crop biomass production and stresses of temperature, water or nitrogen. (TDD – accumulative thermal degree days of crop growth season)

Modeled results

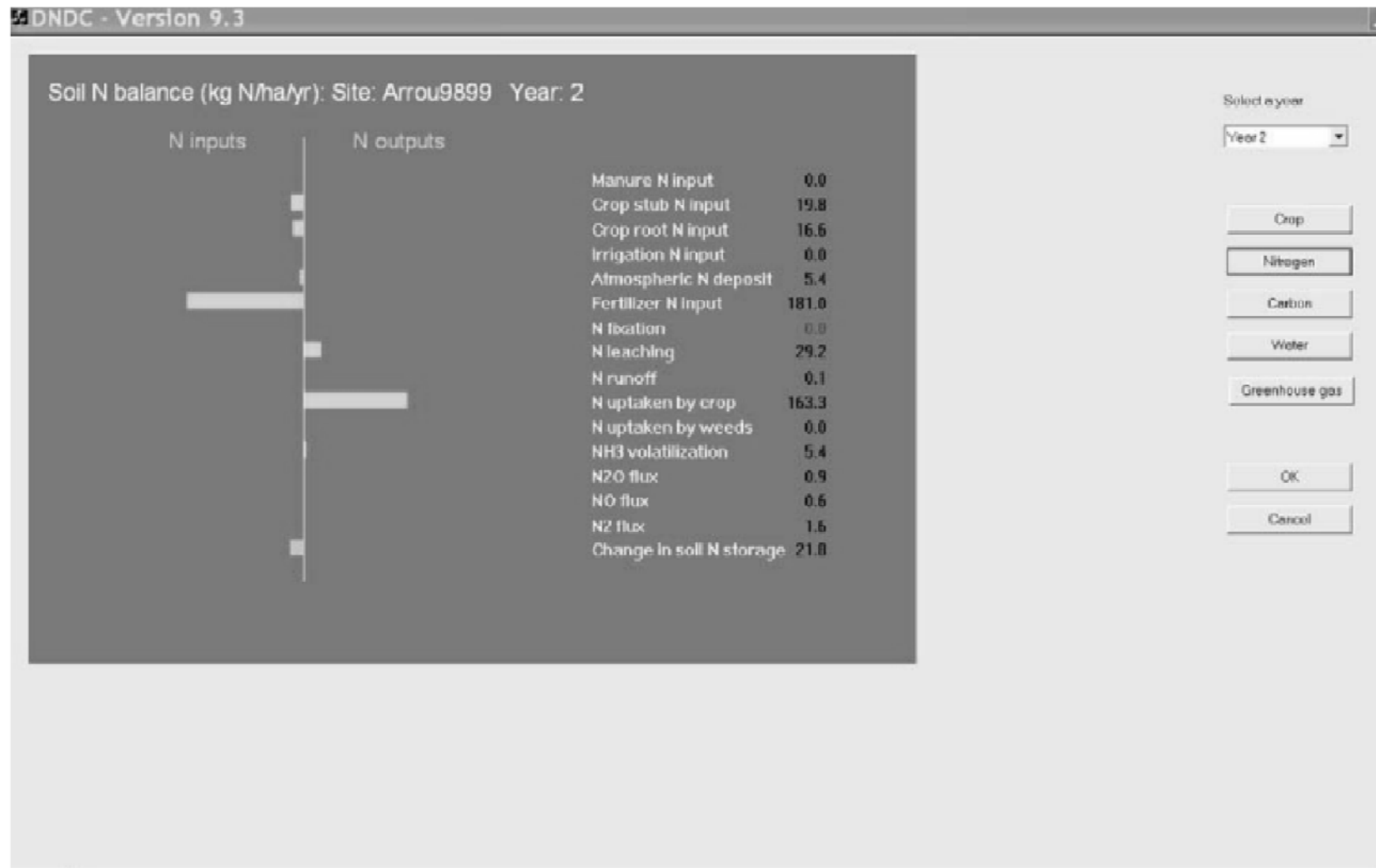


Figure 18. Modeled result 2: Soil N budget.

Modeled results



Figure 19. Modeled result 3: Soil C budget.

Modeled results



Figure 20. Modeled result 4: Water budget

Modeled results



Figure 21. Modeled result 5: Net greenhouse gas emission

A black and white photograph of a dragonfly perched on a stalk of rice or grain. The dragonfly is positioned in the center-right of the frame, facing left. Its body is segmented and has a mottled pattern. The wings are folded against its body. The stalk it is perched on is filled with numerous small, elongated grains. The background is a soft-focus field of similar stalks, creating a sense of depth. The text "Thank you" is written in a large, elegant, black script font, positioned in the lower-left quadrant of the image.

Thank you