DNDC Modeling to Quantify Mitigation Potential N2O from CA Agricultural Soils...plus a follow up on OpTIS

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Project Objectives

- Collect field data and evaluate DNDC’s processes for modeling N₂O emissions in California;
- Improve the DNDC model through additional model development to support statewide analyses, calibration, and validation;
- Conduct statistical analysis to assess model structure- and database-induced uncertainty;
- Create geospatial database and run DNDC to estimate N2O emissions and mitigation potential for California croplands
- Perform model analysis of CA N2O emissions (2000-2015) and assess mitigation potential of changes in tillage, cover cropping, nitrification inhibitors and irrigation systems.
Comparison of the DNDC simulated seasonal or annual $N_2O$ emissions against the field measurements for typical cropping systems (alfalfa, wheat, corn, tomato, lettuce, grape vine, cotton, and almond) in California.

Special thanks to UC Davis collaborators.
Input database for modeling N2O emissions from California

County Based Mapping

- Meteorological Data (Daymet)
- Soil properties (SSURGO)
- Crop type (54) and area
- Management (fertilization, irrigation)

DNDC Model

N2O Emission from cropping systems in each county
Model improvements for regional (statewide) modeling $\text{N}_2\text{O}$ under irrigation methods and baseline simulation

- Modified the regional version of DNDC to conduct irrigation-event based simulations – previous version only allowed irrigation index approach which uses crop demand and soil water to set irrigation;
- Built database to parameterize irrigation practices (water input, irrigation frequency, irrigation depth) for different irrigation methods (surface, sprinkler, drip, or subsurface drip);
- Conducted simulations under different irrigation methods and calculated baseline $\text{N}_2\text{O}$ by weighting the $\text{N}_2\text{O}$ simulations under irrigation methods with the corresponding fractions for each crop type.
N2O emissions from California croplands

- N2O emissions from N in fertilizers and crop residues

- ARB EF: 1.00%
- DNDC EF: 1.04% (0.77% to 1.22%)

DNDC simulated and ARB reported N2O emissions:

1. The N2O emissions estimated by these two methodologies are generally comparable;
2. N2O fluctuations across different years and a decreasing trend.
A decreasing trend in N$_2$O emissions has been predicted primarily due to a decreasing in cropland areas and an increasing in low-volume irrigation.
N2O emissions from different crop categories

VMB: Vegetables, Melons, and Berries.
N2O emissions from different counties

- Riverside
- Santa Barbara
- Sacramento
- Sonoma
- Butte
- Solano
- San Luis Obispo
- Sutter
- Glenn
- Stanislaus
- Kings
- Imperial
- Kern
- Kings
- Tulare
- San Joaquin
- Fresno
- Merced
- Monterey
- Yolo
- Imperial
- Kern
- Kings
- Stanislaus
- Colusa
- Glenn
- Sutter
- San Luis Obispo
- Solano
- Butte
- Sonoma
- Sacramento
- Santa Barbara
- Riverside

Percentage of total N2O emissions (%): 0 2 4 6 8 10 12

County: Tulare, San Joaquin, Fresno, Merced, Monterey, Yolo, Imperial, Kern, Kings, Stanislaus, Colusa, Glenn, Sutter, San Luis Obispo, Solano, Butte, Sonoma, Sacramento, Santa Barbara, Riverside

Annual emission (metric ton N):
- 0 - 100
- >100 - 200
- >200 - 300
- >300 - 400
- >400 - 500
- >500 - 600
- >600

Kilometers: 0 60 120 240 360 480
N₂O emissions under scenarios of irrigation management (a) and from different crop categories (b) in California (using 2002 as an example).

- The data in grey and slash bars in the plot (b) were calculated by weighting the simulations under the four irrigation management scenarios with the fractions of corresponding irrigation methods for each type of crops in 2001 and 2010, respectively.

- In this way, we have estimated the changes in statewide N₂O emissions due to shifts in irrigation systems (around 7%) due to changes in irrigation management.

VMB: Vegetables, melons, and berries.
Statewide N2O mitigation: N management, tillage, cover crop, irrigation

- RN: reduced N (85%); NI: nitrification inhibitor (applied in NH4+-based fertilizers); RT: reduced tillage; NT: no tillage; NLCC: non-leguminous cover crop; LCC: leguminous cover crop; SD: surface drip; SubSD: subsurface drip.

- The management practices with relative high mitigation potential: RN*, NI, RN+NI*, NLCC, low-volume irrigation.

- All management impacts of emissions were evaluated using the 2012 database.

*NB: RN scenario – requires more analysis to understand yield implications.
Impacts of input uncertainty on simulated Statewide N$_2$O Emissions:

- **Soils**: performed using the minimum and maximum soil property values as derived from the SSURGO soil database using the approach of the “Most Sensitive Factor” method (Li et al., 2005; Li, 2007).

- **Irrigation water depth**: performed by changing the amount of water applied with +/- 25% of the default value.

- **Scheduling of management practices**: performed by changing the dates of all management events (planting and harvest, irrigation, fertilizer application, and tillage) within a five-week window before and after of the respective default dates.

- All uncertainty analyses were performed using the 2012 activity and management database.
Total N$_2$O emissions (Mg N) for 2012 as affected by uncertainties of input parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average</th>
<th>Minimum (% Average)</th>
<th>Maximum (% Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil properties</td>
<td>6725</td>
<td>4671 (69.5%)</td>
<td>9190 (137%)</td>
</tr>
<tr>
<td>Irrigation water depth</td>
<td>6725</td>
<td>5638 (83.8%)</td>
<td>7720 (115%)</td>
</tr>
<tr>
<td>Management practice scheduling</td>
<td>6887</td>
<td>6744 (97.9%)</td>
<td>7066 (102%)</td>
</tr>
</tbody>
</table>

*Sensitivity Analyses – Single Parameter.
Project Wrap-up

- Update Statewide N$_2$O emissions and mitigation potential, accounting for a full uncertainty budget
- Provide modeling system to ARB
- Timeline: June 2017
...plus a follow up on OpTIS Indiana Pilot from July 2016 C-AGG meeting (time permitting)

Recall: Applied OpTIS remote sensing system to map crop residue dynamics, tillage Systems and cover crop use for Indiana for last decade...
Overview of products:

- Our system provides detailed maps of crop residue cover and cover crops:
  - Tillage in Fall & Spring
  - Winter cover crops
  - Annually
  - Farm-field, county, and watershed level
  - Uncertainty maps
  - Trends
  - Continuous no-till and cover cropping

Close to 90% of explainable variance
Example Products: Continuous no-till & cover crop intensity maps

- 2015 residue cover estimate in:
  - Brown: 0-15%
  - Yellow: 15-50%
  - Green: > 50%
- RED indicates areas with at least five years of continuous no-till;
- PURPLE indicates areas with consistent winter cover cropping over the last 5 years;
OpTIS Next Steps:

- **Goals:**
  - Support USDA Building Blocks
  - Set baseline for conservation no-till/conservation tillage practices and cover cropping for past decade
- **Timeline:**
  - Corn belt and Chesapeake Bay analyses by 2019
  - National by 2021.
Thank you.

Questions?

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