

# DNDC Application for Inventory and Mitigation of Greenhouse Gases Emitted from Agricultural Lands in California

Changsheng Li<sup>1</sup>, Johan Six<sup>2</sup>, William Horwath<sup>2</sup> and William Salas<sup>3</sup>

<sup>1</sup>University of New Hampshire; <sup>2</sup>University of California, Davis; <sup>3</sup>Applied GeoSolutions LLC

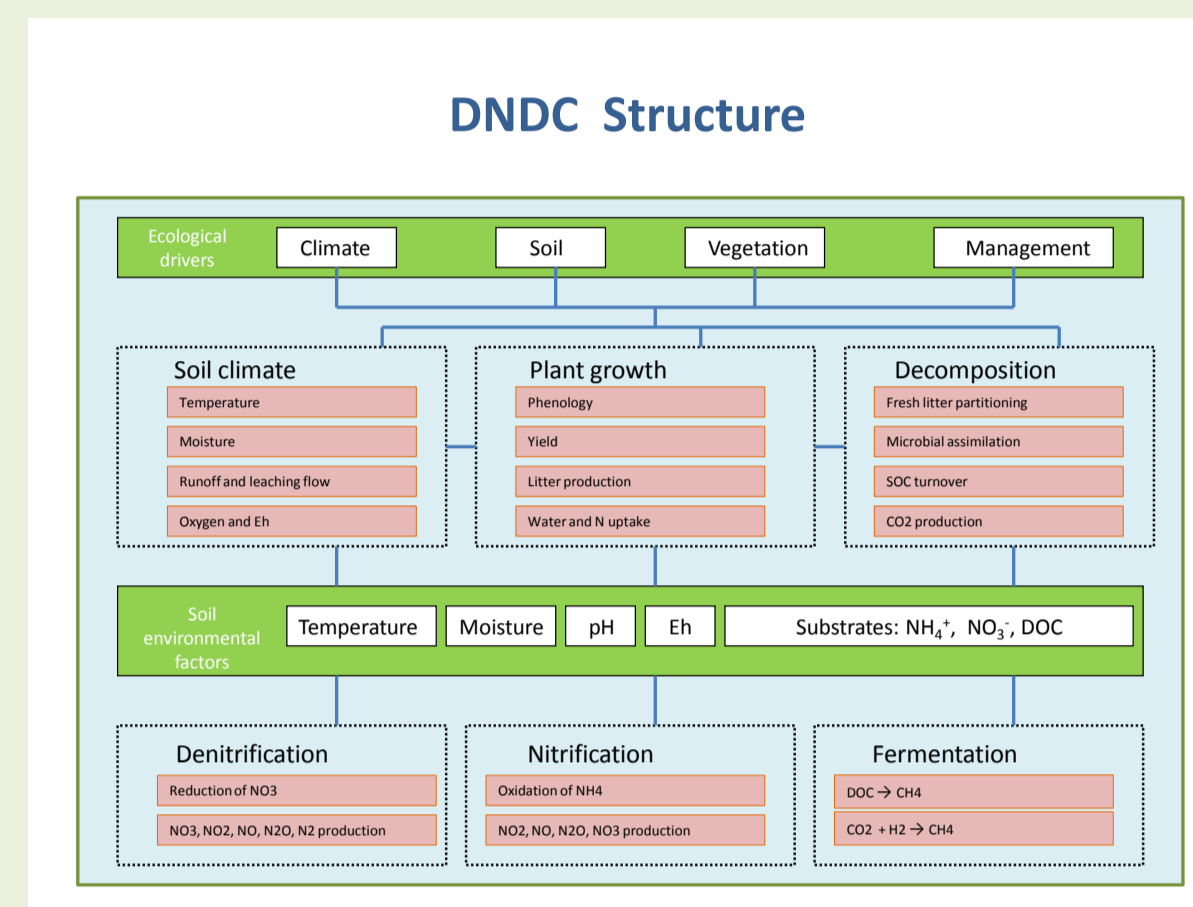
## Background:

The Denitrification-Decomposition or DNDC model is a process-based computer simulation model of carbon (C) and nitrogen (N) biogeochemistry. The model was initially developed for U.S. EPA to quantify greenhouse gas (GHG) emissions from the U.S. agricultural lands in the early 1990s. With the involvement of a large number of domestic and international researchers during the past more than two decades, DNDC has been calibrated and validated against GHG datasets measured worldwide. A number of farming management practices, such as crop rotation, tillage, fertilization, irrigation, grazing etc. have been parameterized in DNDC so that the model is capable of predicting impacts of changes in management on GHG emissions.

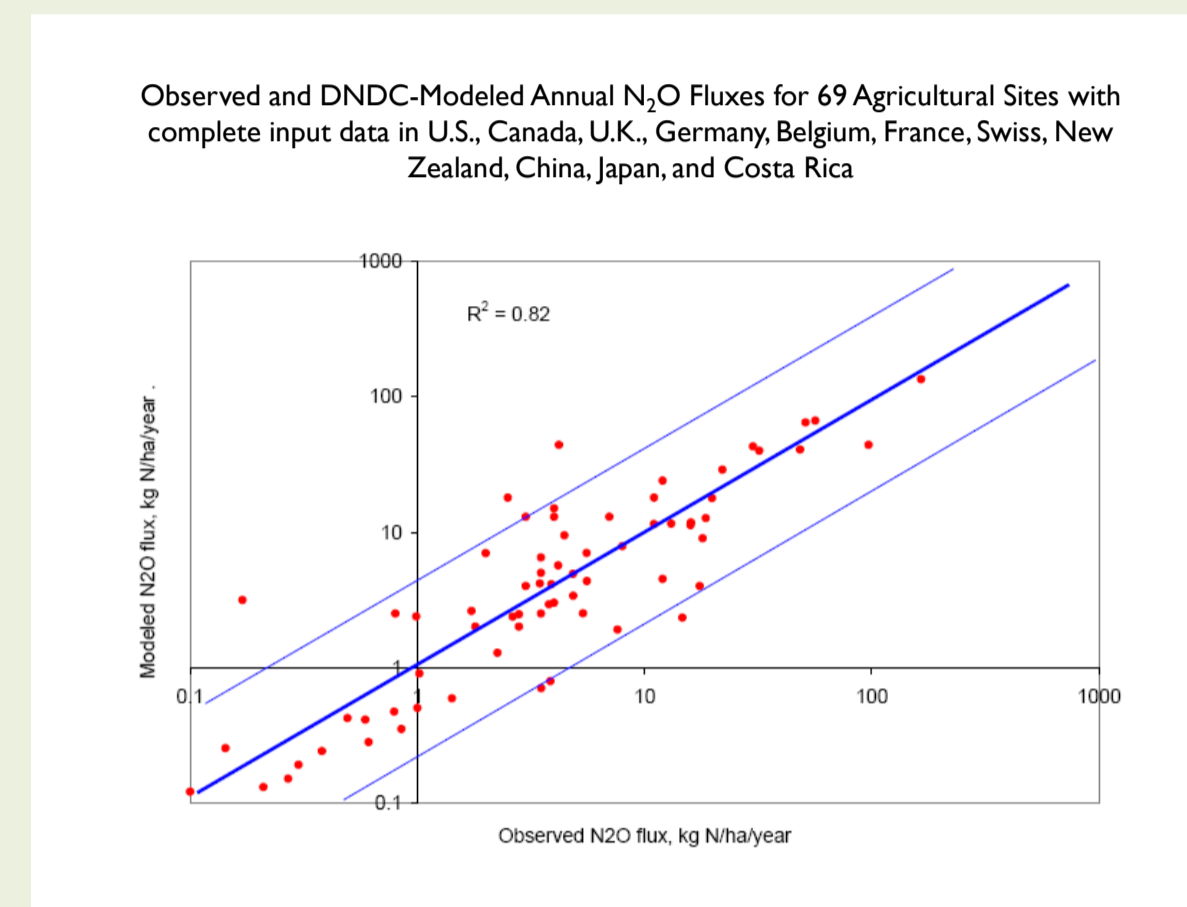
The California Global Warming Solutions Act of 2006 has legislated GHG emission reductions such that 2020 emission levels are at or below 1990 levels. Mandatory GHG emission reductions are now set in law for the first time in the US. In response to this Act, a Climate Action Team (CAT) was created to identify Discrete Early Actions to reduce emissions and meet the 2020 targets. Since 2011, CA ARB (Air Resources Board) sponsored a study on model comparison and then utilizing selected model to improve GHG inventory and mitigation for CA agriculture.



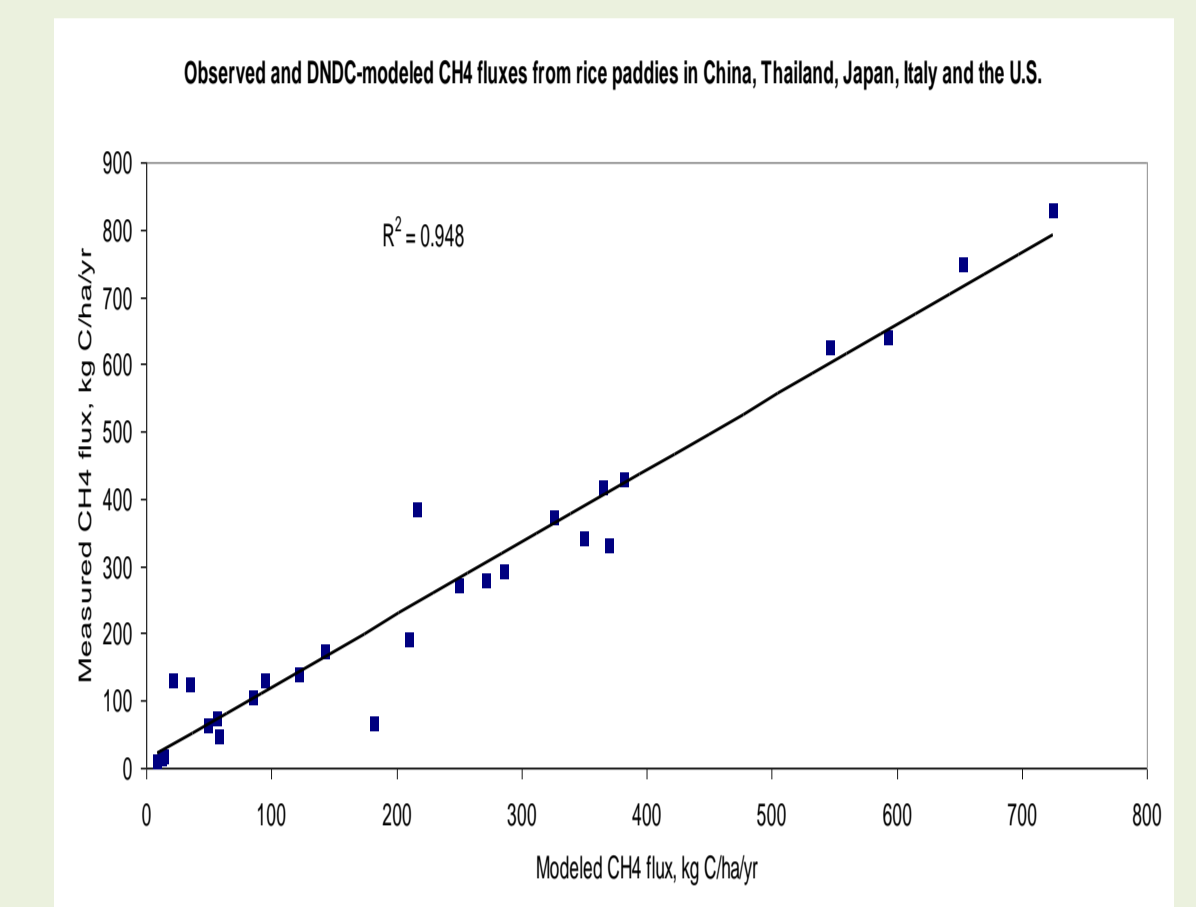
The first working group for DNDC development and implementation, Washington, DC, 1989-1992



The model structure of DNDC



DNDC has been validated against N<sub>2</sub>O fluxes measured worldwide



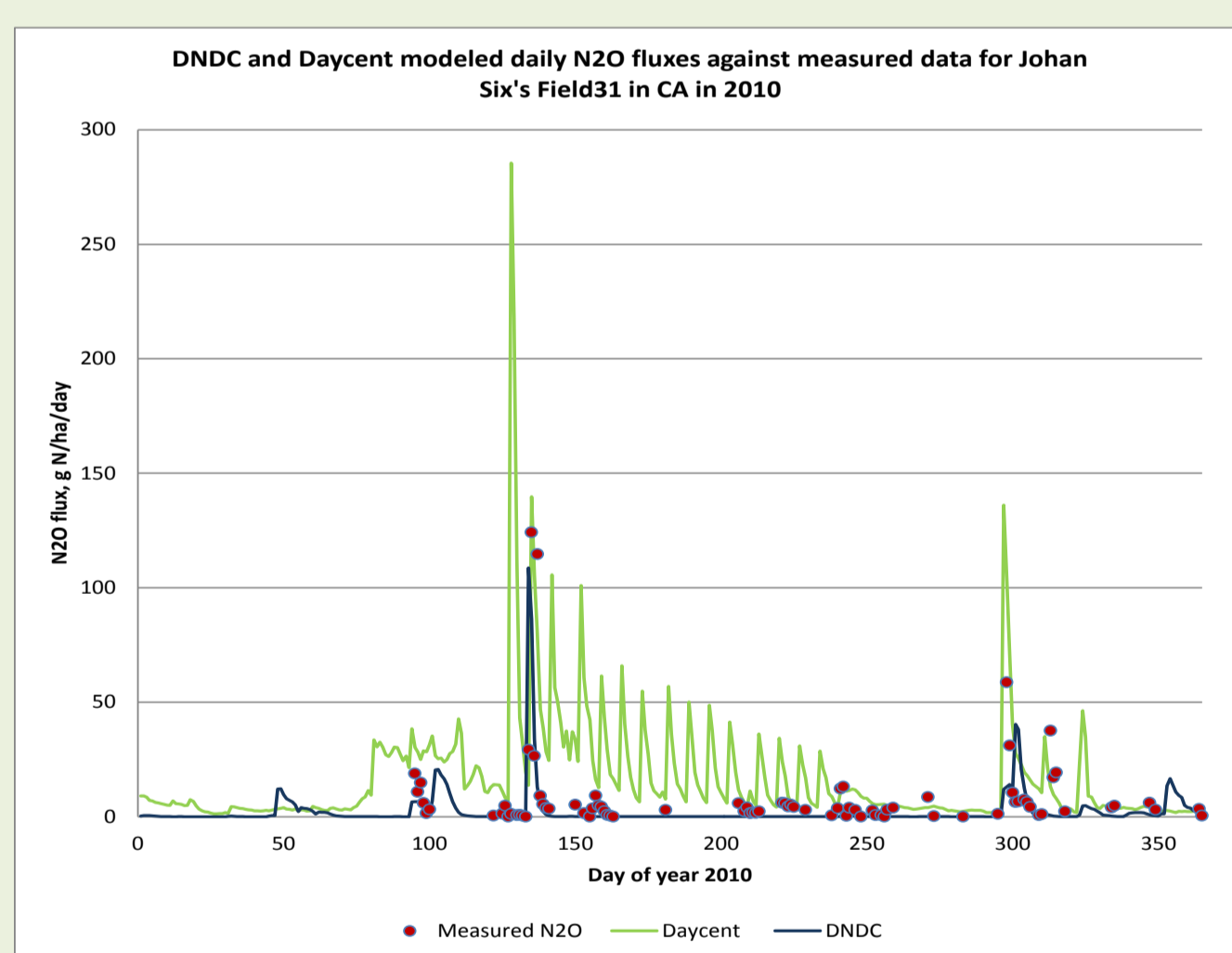
DNDC has been validated against CH<sub>4</sub> fluxes measured worldwide

## Field Measurement and Model Comparison:

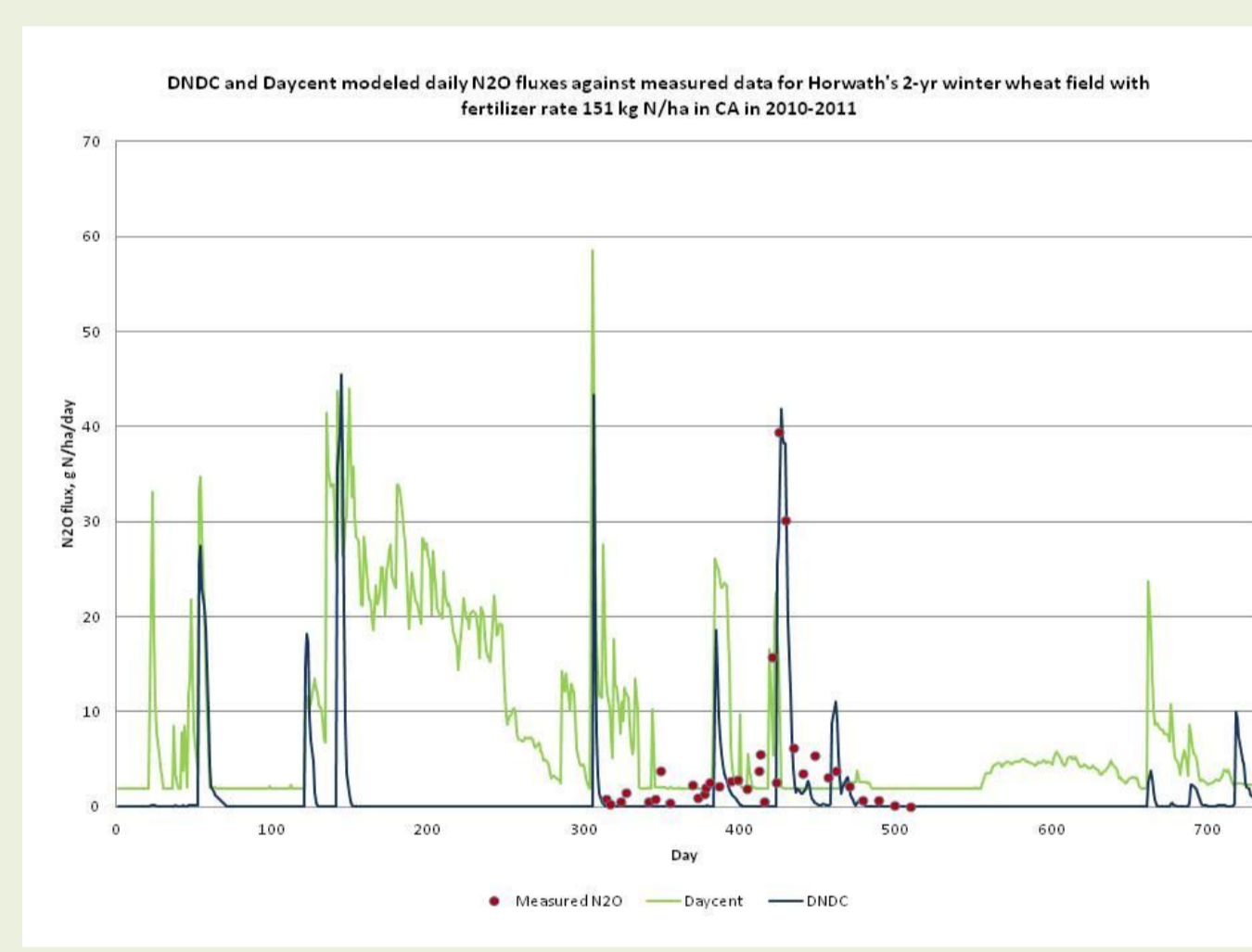
Field measurements were conducted for quantifying N<sub>2</sub>O fluxes from 10 agricultural sites in CA by groups led by Dave Smart, Johan Six, Cynthia Kallenbach and William Horwath. The crops planted at the sites included grapes, almond, tomato, alfalfa, winter wheat and other row crops, which well represented the major crop types across the agricultural regions in CA. At each of the sites, alternative farming practices were applied, which included different crop rotation sequences, standard tillage vs. reduced till, furrow irrigation vs. drip irrigation, different rates of fertilizer application, with vs. without winter cover crop etc. N<sub>2</sub>O fluxes were measured at the sites with static chambers during the time period from 2003-2011. The 40 datasets resulting from the field campaigns were utilized for model comparison.

Three well documented and widely applied models, DNDC, DAYCENT and IPCC Method, were selected to test their applicability for CA GHG emissions. The modeled results were compared against the same datasets of measured N<sub>2</sub>O data at daily or annual basis. The comparison tests showed that DNDC-simulated results were closer to observations.

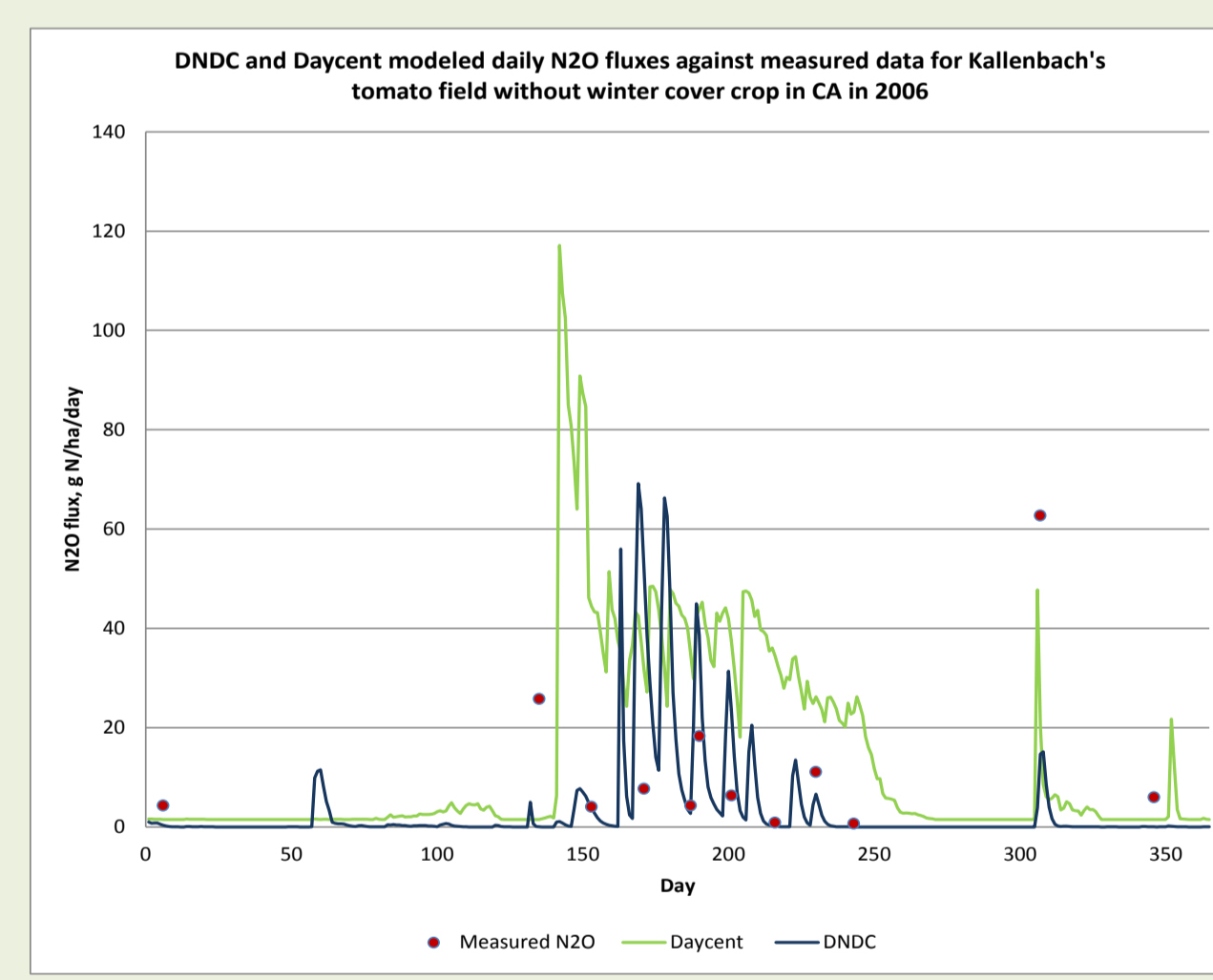
### Daily Comparison Examples:



Comparison of DNDC- and DAYCENT -modeled daily N<sub>2</sub>O fluxes with measured N<sub>2</sub>O fluxes for a tomato field in California in 2010 (Field data from Johan Six)

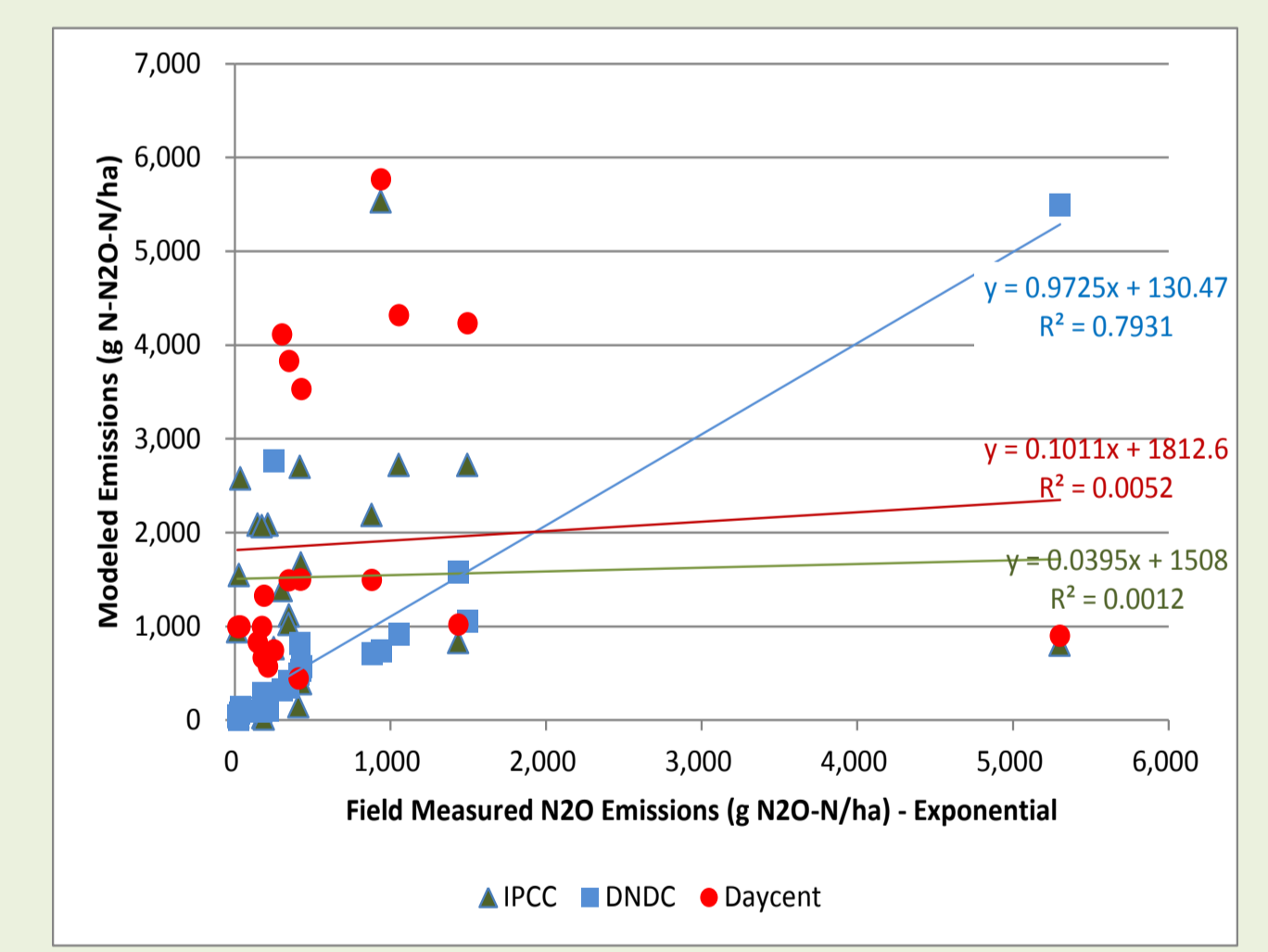


Comparison of DNDC- and DAYCENT -modeled daily N<sub>2</sub>O fluxes with measured N<sub>2</sub>O fluxes for a winter wheat field with fertilizer application rate of 0 kg N/ha in California in 2010-2011 (Field data from William Horwath)



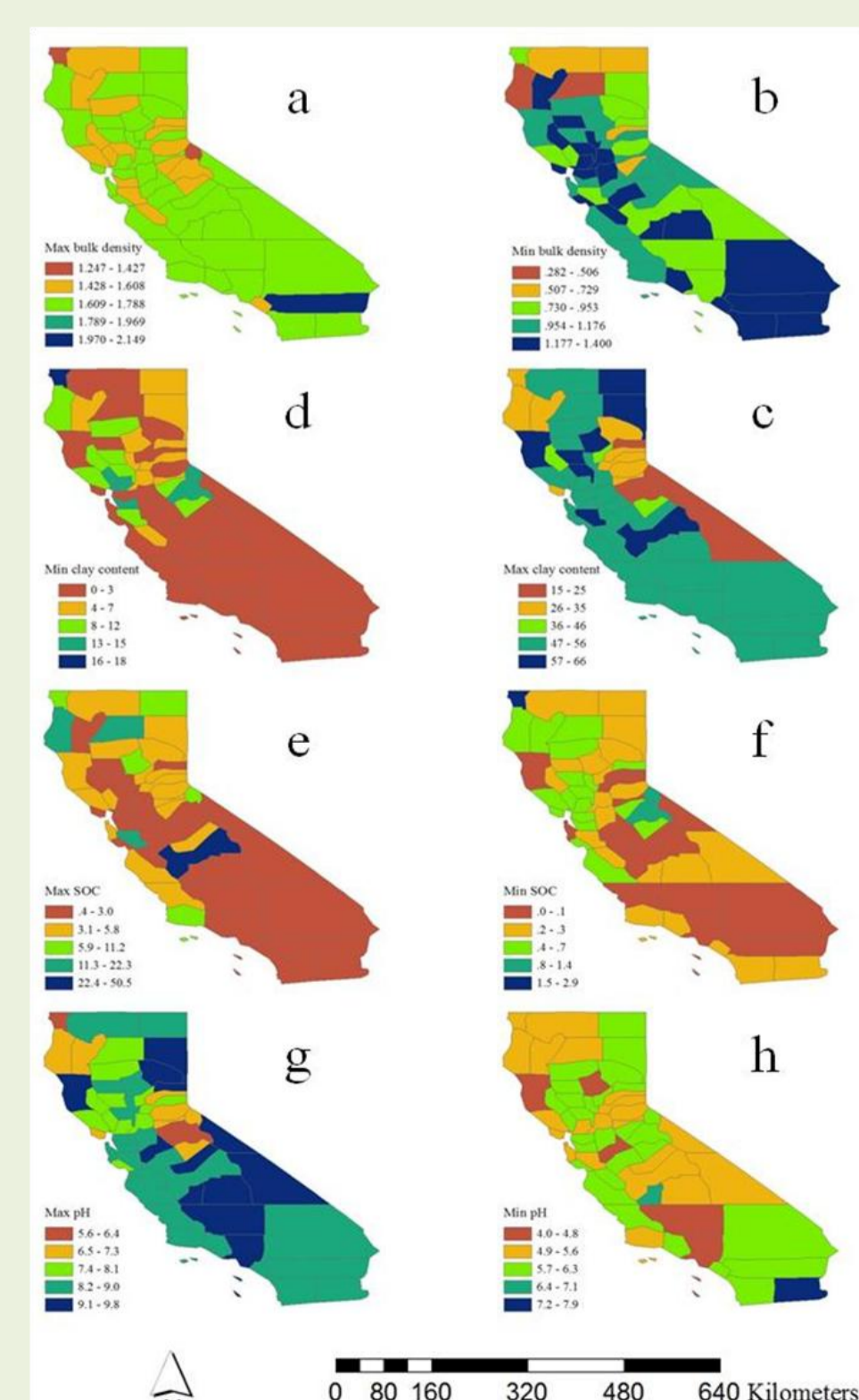
Comparison of DNDC- and DAYCENT -modeled daily N<sub>2</sub>O fluxes with measured N<sub>2</sub>O fluxes for a tomato field without cover crop in California in 2006 (Field data from Cynthia Kallenbach)

### Annual Comparison:

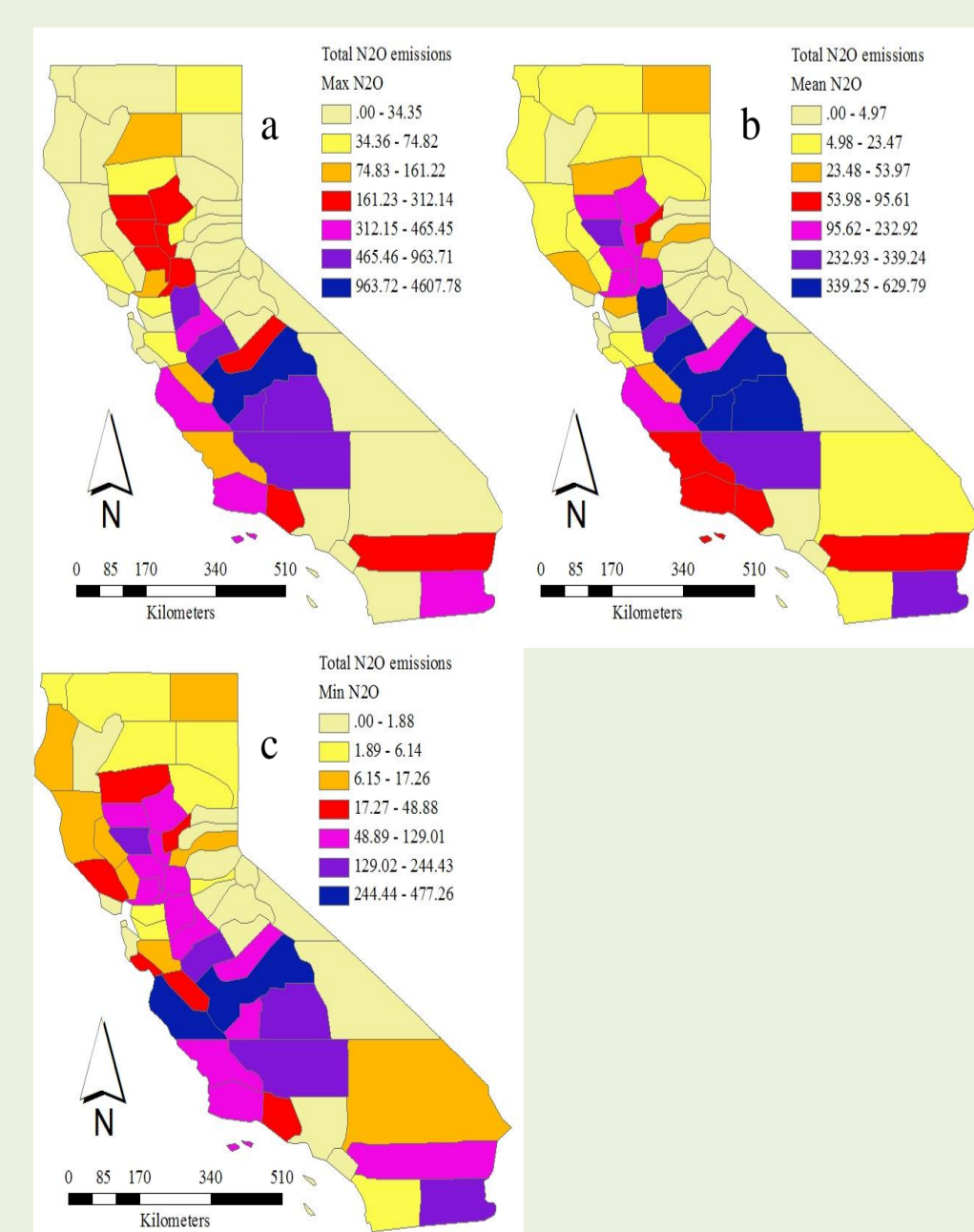


## Regional Database and Simulations:

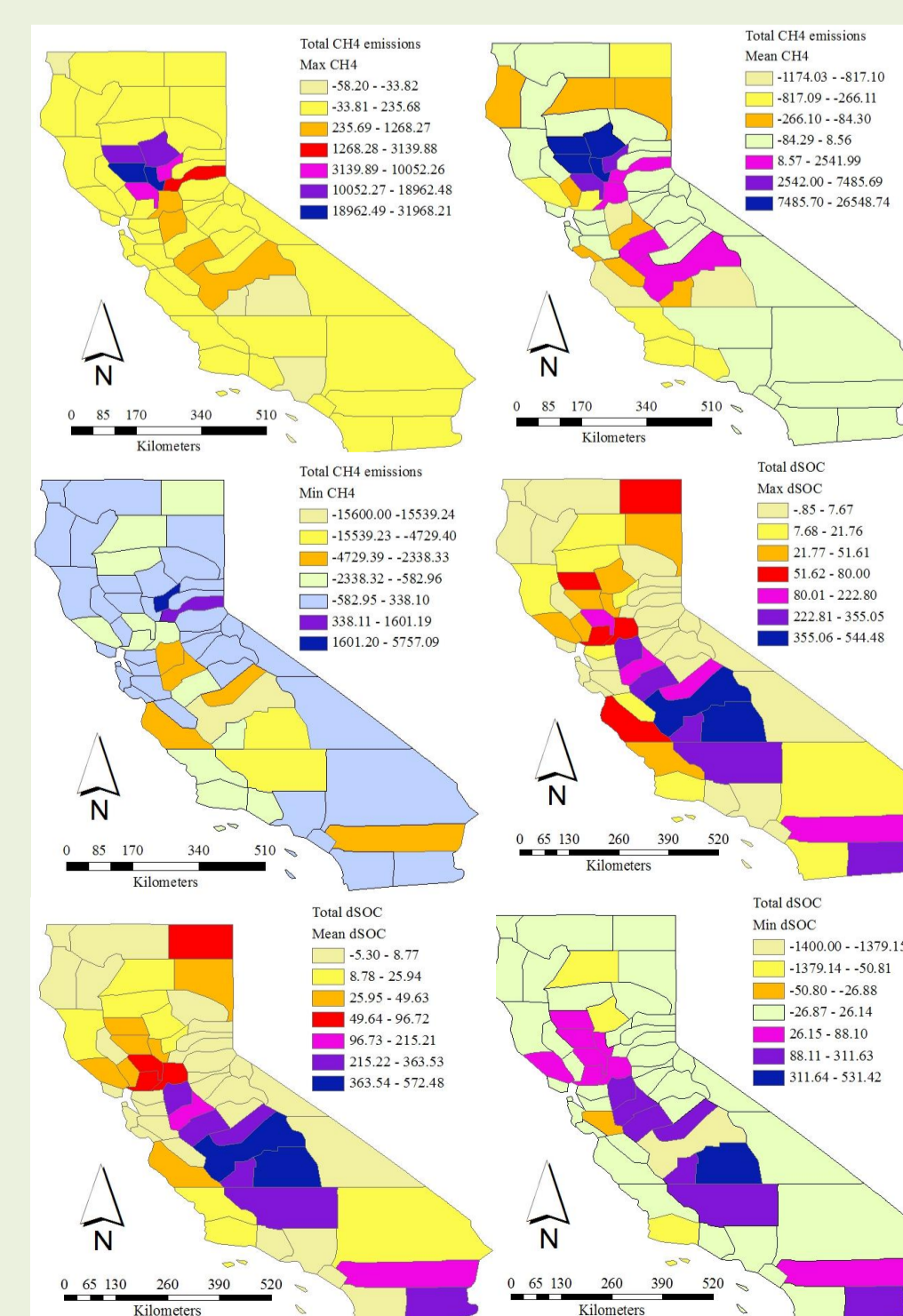
County-based database was established to hold spatially differentiated information of climate, soil, crop types and farming management practices. DNDC was run for all the 58 counties with 54 cropping systems in CA for 2011.



Maps of maximum and minimum (a and b) bulk density (g cm<sup>-3</sup>), (c and d) clay content (%), (e and f) soil organic carbon content (%), and (g and h) pH in California.



DNDC-simulated county-scale maximum (a), area-weighted mean (b), and minimum (c) N<sub>2</sub>O emissions (metric tons N yr<sup>-1</sup>) from agricultural lands in California.



DNDC simulated county-scale (a) maximum CH<sub>4</sub> emissions, (b) area-weighted mean CH<sub>4</sub> emissions, and (c) minimum CH<sub>4</sub> emissions (metric tons C yr<sup>-1</sup>), (d) maximum SOC change, (e) area-weighted mean SOC change, and (f) minimum SOC change (10<sup>3</sup>g C yr<sup>-1</sup>) from agricultural lands in California.

## Updated CA Agricultural GHG Inventory:

Greenhouse gas	N <sub>2</sub> O	CH <sub>4</sub>	CO <sub>2</sub> *	Sum
Total emission	Direct: 0.0085±0.0048Tg N Indirect: 0.0040±0.0002 Tg N	0.037±0.085Tg C	-2.72±1.41Tg C	
GWP** (TgCO <sub>2</sub> equivalent yr <sup>-1</sup> )	Direct: 4.14 ± 2.33 Indirect: 1.94±0.12	1.23± 2.83	-9.97±5.17	-4.60±10.33 (-2.66±10.21***)
Major contributors	Major emitter: corn (11%), lettuce (11%), cotton(8%), rice (6%)	Major emitter: rice 100%	Major emitters: tomato (27%), cotton (37%), alfalfa (35%), grape (17%)	

## Next Project:

**From Inventory to Mitigation:** "Improving DNDC Modeling Capability to Quantify Mitigation Potential of N<sub>2</sub>O from California Agricultural Soils", 2014-2017, PI: Changsheng Li (UNH), sponsored by CA Air Resources Board.

## Acknowledgements:

We thanks CA ARB for its support for the former and current projects.