# *Methodology and Challenges for Measuring and Modeling Nitrous Oxide Emissions from California Cropping Systems.*

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**Research update – November 28th 2012**

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# Outline

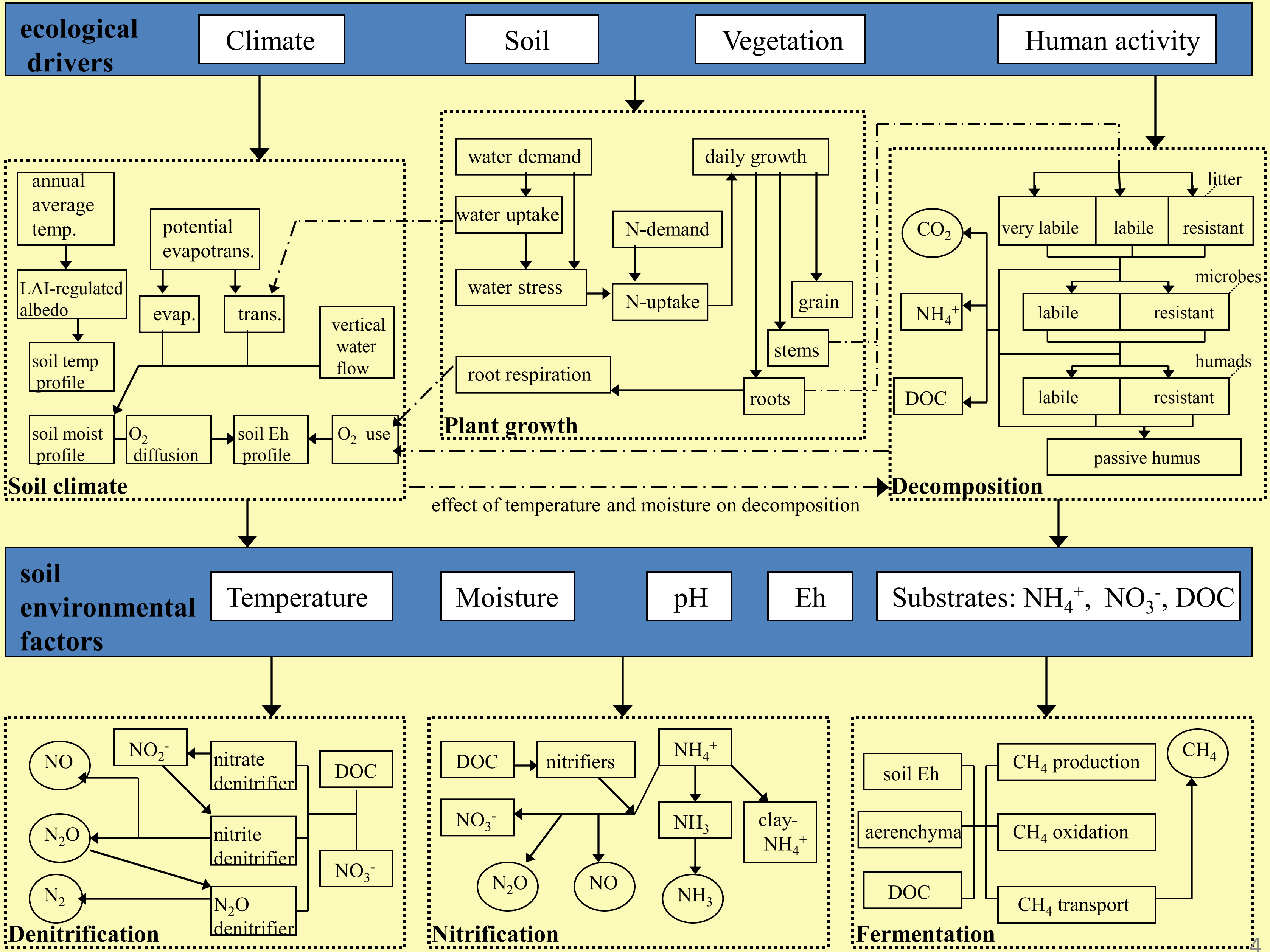
- Recall: Overall Objectives
- Sampling Techniques and Data collected for eventual determination of emission factors
  - Focus on the on campus cotton (Site E)
- Recap of Sites for Cotton & Tomatoes
- Proposed work for remainder of this project
- Additional investigation with INNOVA devices

# Overall Project Objectives

(1) Determine detailed time series of $N_2O$ fluxes and underlying factors at crucial management events such as irrigation, fertilization, and tillage in representative agroecosystems in Central Valley of California; and

(2) Use data on $N_2O$ fluxes to calibrate and validate processed based biogeochemical Denitrification-Decomposition (**DNDC**) model.

# The DNDC Model



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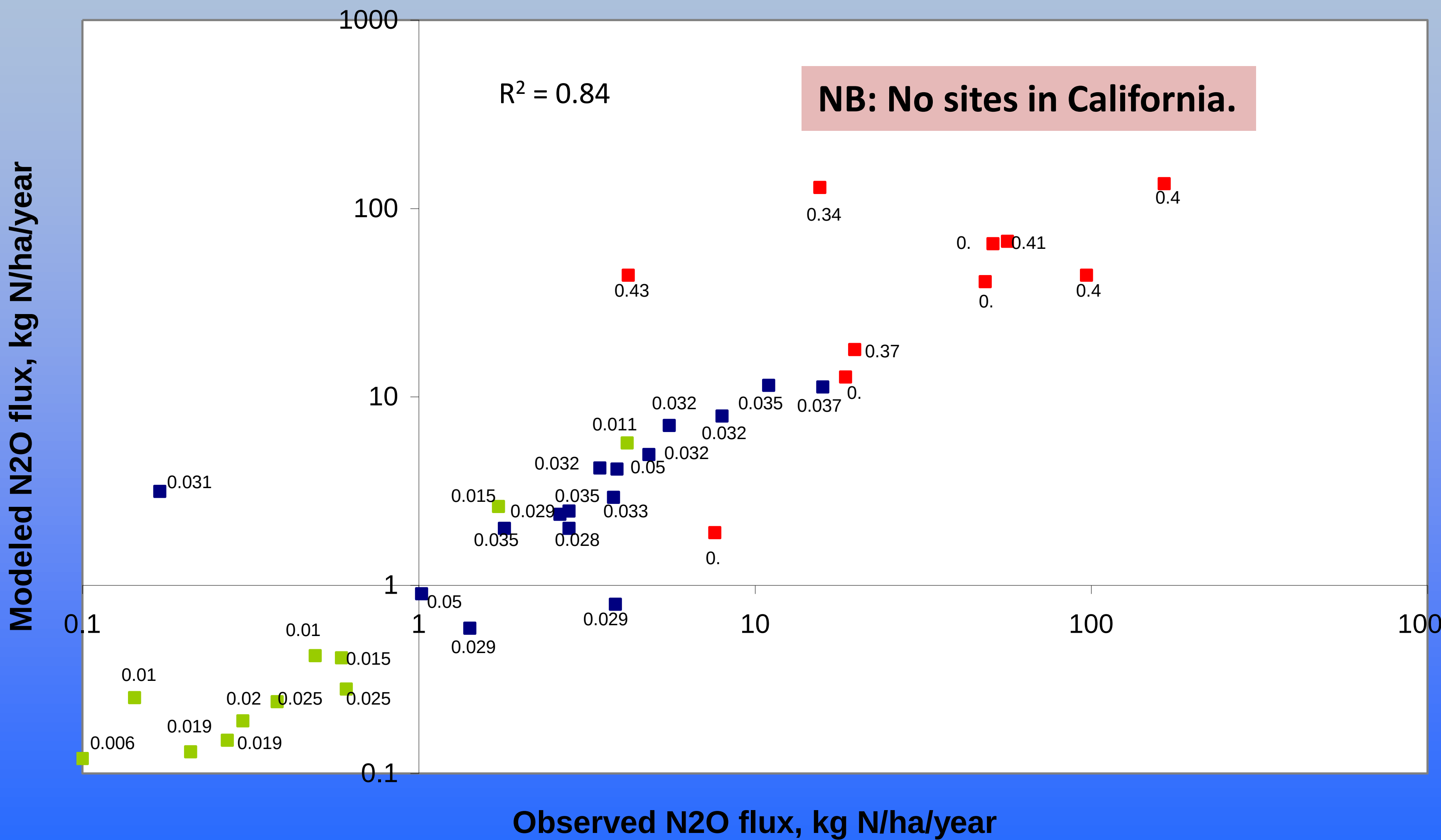
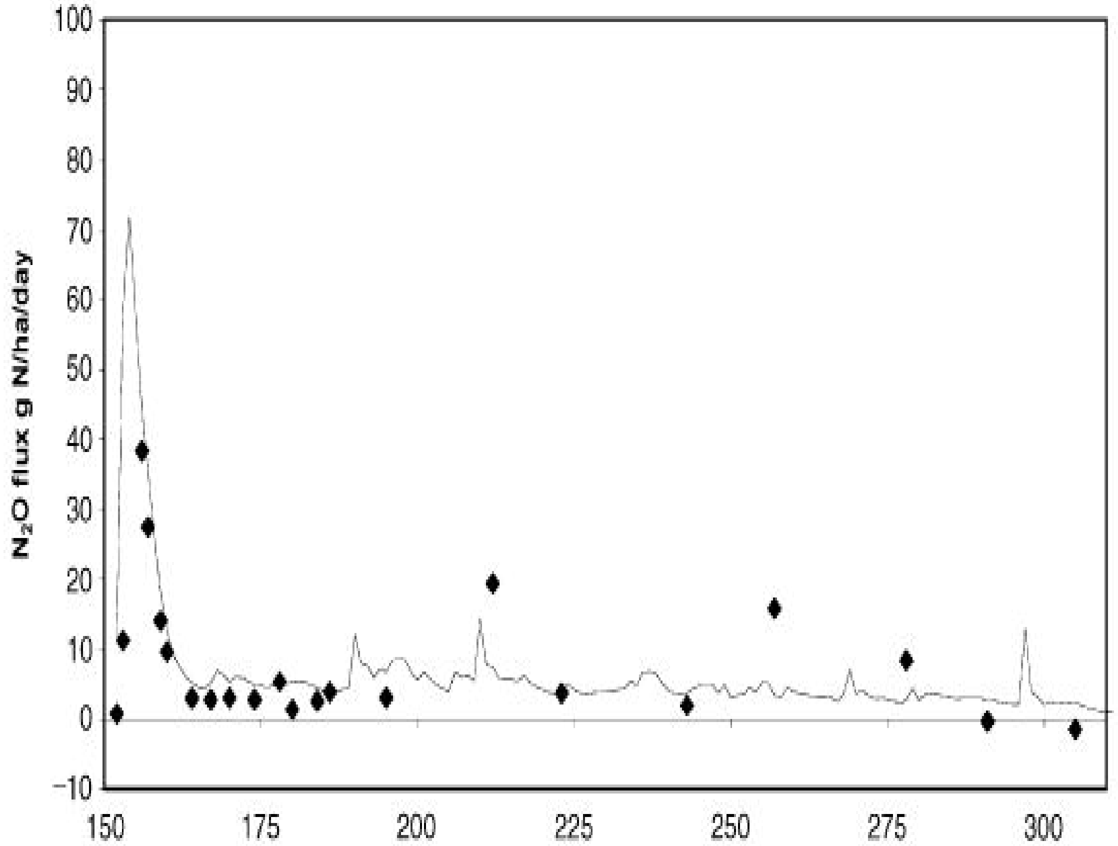
The DNDC model has been utilized for predicting $N_2O$ emissions in the U.S., Canada, EU nations, Australia, New Zealand, Russia, China, Japan and India



# Brown et al., 2002 – UK Grassland and winter wheat




(c)

Fig. 3. Comparison of modelled (——) and measured (♦) $N_2O$-N emission from (a) a grassland site near Edinburgh with clay loam soil, receiving 360 kg N ha$^{-1}$ as ammonium nitrate (Clayton et al., 1997). (b) A winter wheat site in SE England with a silty-loam soil, receiving 225 kg N ha$^{-1}$ as farmyard manure (Harrison et al., 1995) and (c) a grassland site in SW England with clay loam soil, receiving urine (equivalent to 528 kg N ha$^{-1}$) (Yamulki et al., 1998).

# Hsieh et al., 2005 – Ireland Grassland

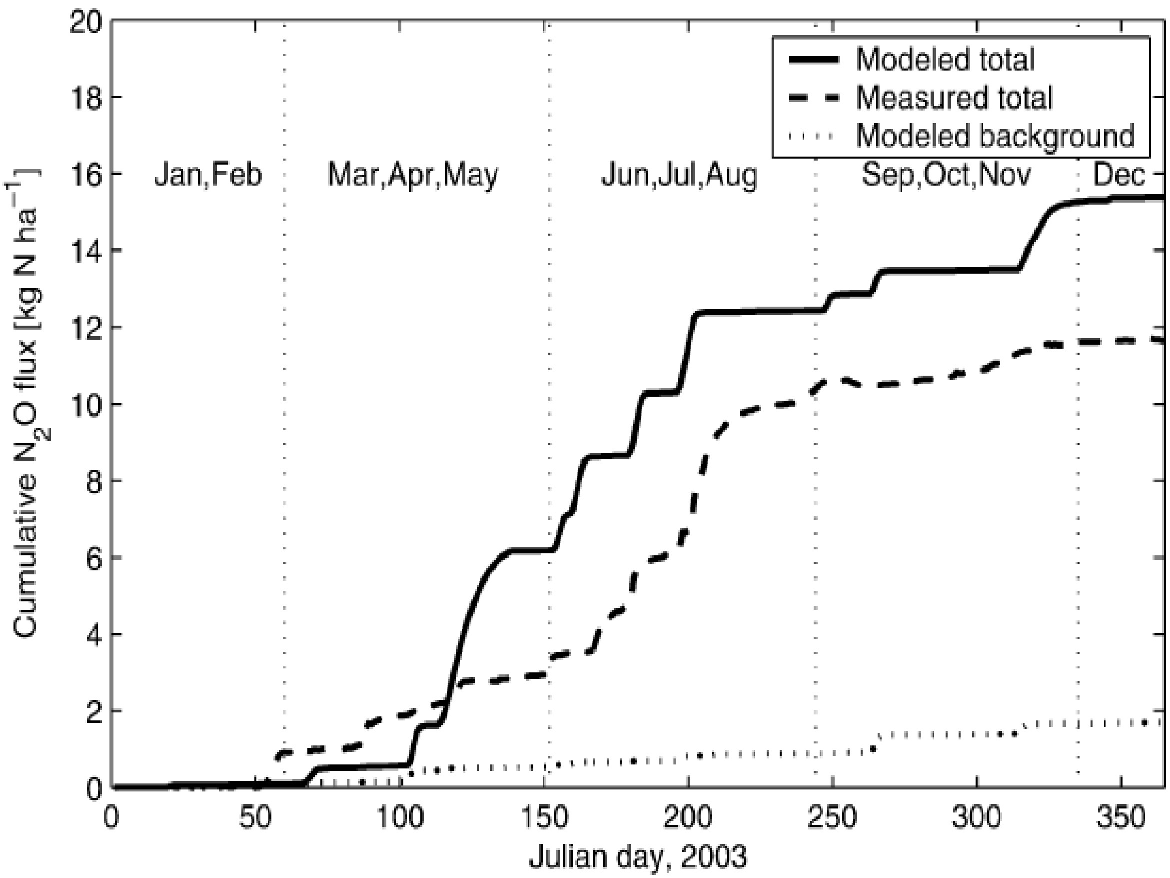



*Figure 2.* Cumulative total modeled, total observed and modeled background $N_2O$ emissions for 2003 in kg $N_2O$–N $ha^{-1}$.

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## People & Places

**Description of Static Non-steady State Flux Chambers Used in Field Studies**

Note: All product names and suppliers mentioned below have been used in our research, but are mentioned only for convenience and imply no endorsement on the part of the USDA.

Our chamber anchors and tops are fabricated using 20-gauge rectangular stainless steel 4-inch "steam pans" equipped with a flange around the edges available from restaurant equipment suppliers (e.g., Hockenbergs or Superior). Anchors are made by cutting out the bottom section of the pan resulting in a frame measuring approximately 0.50 m X 0.29 m X 0.086 m deep. The anchor is inserted into the soil so that the flange is nearly flush with the soil surface (photo). A piece of plywood and a mallet can be used for uniform insertion of the base (photo). Chamber tops are made from an identical steam pan, without the bottom removed. Weather-stripping material (EPDM) to serve as a gasket is attached to the flange on the underside of the chamber top using all purpose cement (e.g. Barge). The outer surfaces of the top are covered with reflective insulation (Reflectix) using aluminum tape. A vent tube (3.5 mm ID X 0.15 m long) is installed horizontally through one side of the chamber top. A brass fitting (Part no. B-200-1-OR, Swagelok) is attached in the center of the top and lined with rubber septum material to serve as a sampling port. The sampling port is connected (glued) on the inside of the chamber top to a manifold (Part no. STCM-13-204, Small

http://www.ars.usda.gov/pandp/docs.htm?docid=19008

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*Sampling:*

Task I: Nitrous oxide sampling

- USDA-ARS GRACEnet protocols
- Rectangular stainless steel chamber bases (50*30*8 cm)
- Stainless steel tops lined with a rubber gasket on bases
- At 0, 20 and 40 min. with syringe in 12 ml vials and stored at room temperature.
- At fertilization, cultivation, irrigation and rainfall events.
- analyzed by Gas chromatograph at UC Davis.

- Task II:  Soil, Crop and Climatic parameters

*Soil Factors:*

- Soil Moisture: gravimetric soil moisture to 30 cm depth
- C and N: LECO Range by combustion method
- Soil pH, Bulk density, Eh, saturation and field capacity
- Soil temperature

*Crop factors:*

- Type of crop
- Variety
- Crop rotation
- Leaf Area Index
- Maximum height
- Yield
- Biomass
- C:N of root, shoot and fruits at maturity
- Thermal Degree Days to reach maturity

*Climatic factors*

- Daily minimum and maximum air temp.
- Precipitation
- Solar radiation
- CIMIS weather stations

## *Data Analysis, Report writing & Dissemination*

- ppm to flux using USDA ARS GRACEnet
- If rate of change of trace gas conc. in headspace constant- linear regression

  fo= (C1-Co)*60/T1

- Otherwise – curvi-linear

  $fo = (C1 - C0)^2 / [ t1 \times (2 \times C1 - C2 - C0)] \times \ln[(C1 - C0)/(C2 - C1)]$

fo = flux at time 0

C0, C1, and C2 = chamber headspace gas concentrations (ppm(v)) at time 0, 1, and 2, resp.

t1 = interval between gas sampling points (h).

The resulting units of fo are: µL trace gas $Liter^{-1}$ $h^{-1}$.

# Site E- Cotton

- Determine of $N_2O$ fluxes following fertilization, irrigation and tillage events for cotton **fertilized with UAN 32 combined with a nitrification and urease inhibitor**.

**Collaboration with Dr. Bruce Roberts**

- Location: Fresno State campus, CA
- Crop/Variety: Cotton/Acala
- Soil Type: Sandy Loam
- Furrow irrigated

# Site E- Cotton on Fresno state campus

- Flux chamber measurements at various times during the growing season, once at post harvest and once following reside incorporation
- Soil samples also collected
- Samples analyzed (ppm data) on G.C at UC Davis

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# Site E- Cotton Expt. design

- Completely randomized blocks
- Three N rates = 50, 100 and 150 #N/ac
- Treated and non treated with Nutrisphere®
- Include plots with **NO** fertilizer added

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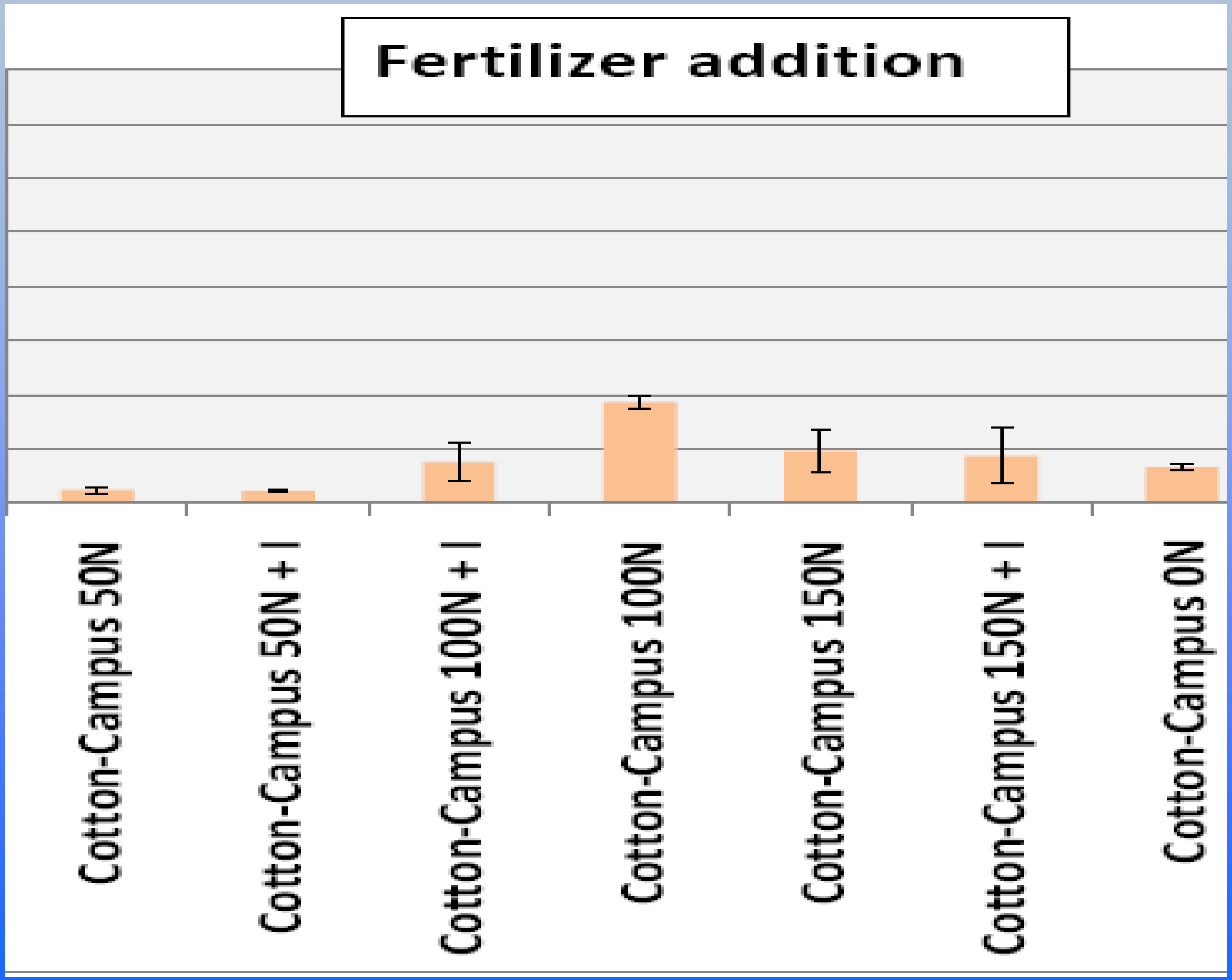
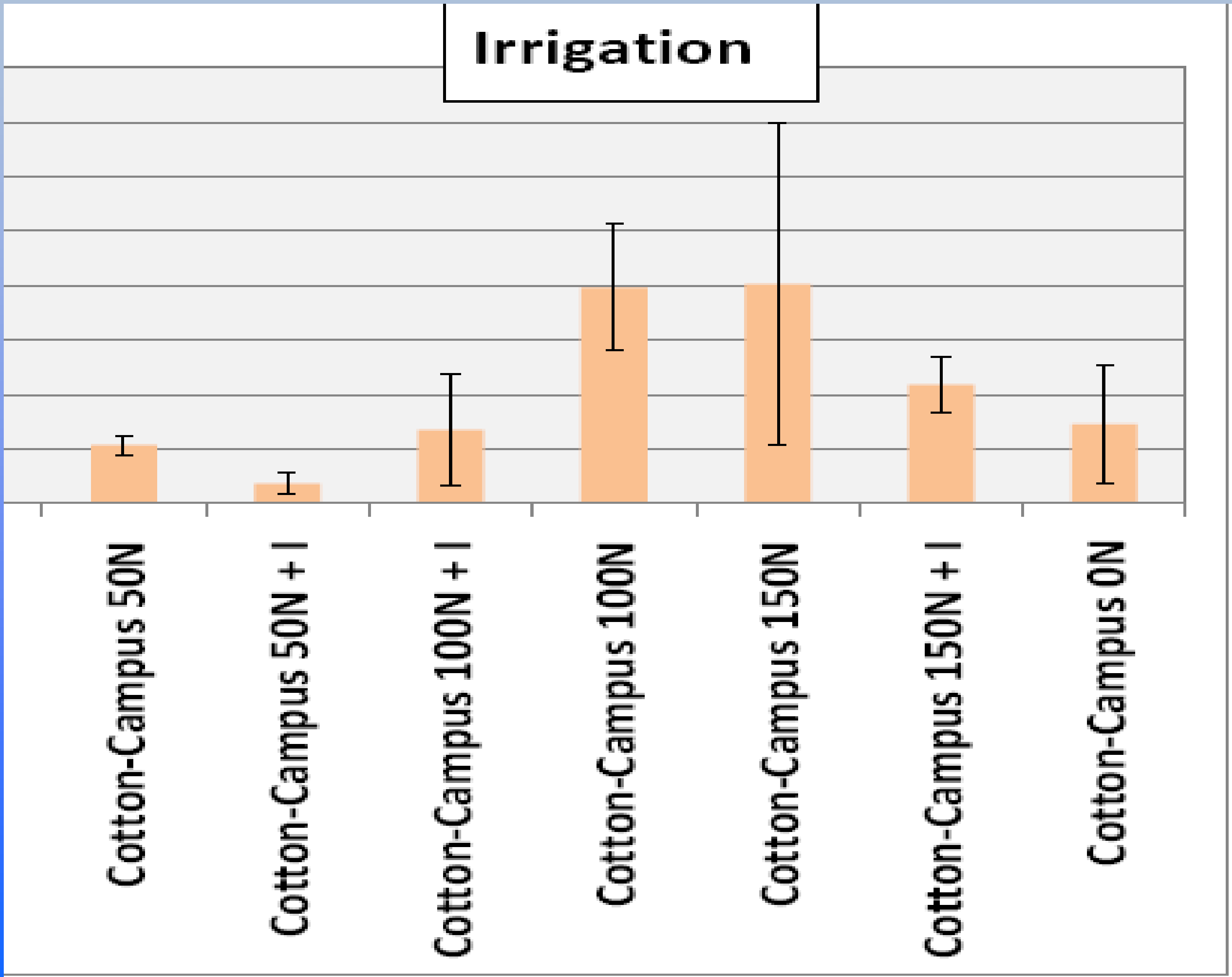
Example of trends in $N_2O$ fluxes
Note: Units not included!



Example of trends in $N_2O$ fluxes
Note: Units not included!



## 2012 Sampling Schedule for N2O emissions for Cotton at Fresno

| Sampling Date | Label | Field | Location | Crop | Practice | No. |
|---|---|---|---|---|---|---|
| 4/3/2012 | 855-964 | E | Fresno | Cotton | pre-sowing | 111 |
| 4/20/2012 | 965-1053 | E | Fresno | Cotton | after rain | 89 |
| 5/31/2012 | 1237-1325 | E | Fresno | Cotton | after cultivation & before fert. | 89 |
| 6/5/2012 | 1326-1414 | E | Fresno | Cotton | after fert. | 90 |
| 6/6/2012 | 1415-1498 | E | Fresno | Cotton | after fert. | 85 |
| 6/11/2012 | 1499-1588 | E | Fresno | Cotton | after irrigation | 91 |
| 6/12/2012 | 1589-1678 | E | Fresno | Cotton | after irrigation | 91 |
| 6/21/2012 | 2206-2295 | E | Fresno | Cotton | before irrigation | 91 |
| 7/11/2012 | 2746-2835 | E | Fresno | Cotton | after irrigation | 91 |
| 7/12/2012 | 2836-2925 | E | Fresno | Cotton | after irrigation | 91 |
| 8/27/2012 | 3777-3866 | E | Fresno | Cotton | before irrigation | 91 |
| 9/8/2012 | 3981-4064 | E | Fresno | Cotton | after irrigation | 85 |
| 9/9/2012 | 4065-4148 | E | Fresno | Cotton | after irrigation | 85 |
| 10/1/2012 | 4209-4298 | E | Fresno | Cotton | before defoliation | 91 |
| 10/27/2012 | 4329-4418 | E | Fresno | Cotton | after defoliation and rain | 91 |
| 11/11/2012 | 4443-4532 | E | Fresno | Cotton | after harvest, discing and 2nd rain | 91 |

Total samples 1453

# Site E-Cotton - Proposed Work

- Flux chamber measurements after harvest
- Additional samplings scheduled for 2013
- Soil samples to be analyzed for C and N contents
- $N_2O$ ppm data to be converted to flux values
- Incorporation of data into DNDC model
- Comparison of measured values with those predicted from DNDC simulations

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# Site C- Cotton

- Determine of $N_2O$ fluxes following fertilization and irrigation events for silage corn **fertilized with Urea Ammonium Nitrate (UAN 32)**.

- Comparison of emissions from **furrows and beds**
- Location: Hanford, CA
- Crop/Variety: Cotton/ Acala
- Soil Type: Fancher's Sandy Loam
- Furrow irrigated

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2012 Sampling Schedule for N2 O emissions for Cotton in Hanford

| Sampling Date | Label | Field | Location | Crop | Practice | No. |
|---|---|---|---|---|---|---|
| 5/10/2012 | 1054-1077 | C | Hanford | Cotton | after planting | 25 |
| 5/21/2012 | 1078-1102 | C | Hanford | Cotton | before fertilization | 25 |
| 5/21/2012 | 1103-1130 | C | Hanford | Cotton | after fert. | 28 |
| 5/22/2012 | 1131-1178 | C | Hanford | Cotton | after fert. | 49 |
| 5/23/2012 | 1179-1207 | C | Hanford | Cotton | after fert. | 29 |
| 5/24/2012 | 1208-1236 | C | Hanford | Cotton | after fert. | 30 |
| 6/13/2012 | 1679-1702 | C | Hanford | Cotton | before irrigation | 25 |
| 6/18/2012 | 2158-2181 | C | Hanford | Cotton | after irrigation | 24 |
| 6/19/2012 | 2182-2205 | C | Hanford | Cotton | after irrigation | 25 |
| 6/26/2012 | 2296-2319 | C | Hanford | Cotton | before and after cultivation | 25 |
| 6/27/2012 | 2320-2349 | C | Hanford | Cotton | after cultivation | 31 |
| 6/28/2012 | 2350-2379 | C | Hanford | Cotton | after cultivation | 31 |
| 8/7/2012 | 3551-3580 | C | Hanford | Cotton | before irrigation | 31 |
| 8/10/2012 | 3715-3738 | C | Hanford | Cotton | after irrigation | 25 |
| 9/21/2012 | 4179-4208 | C | Hanford | Cotton | before defoliation | 31 |
| 10/12/2012 | 4299-4328 | C | Hanford | Cotton | after defoliation | 31 |
| 10/31/2012 | 4419-4442 | C | Hanford | Cotton | after harvest and discing | 25 |

Total samples 490

# Site F- Fresh Market Tomatoes

- Determine soil $N_2O$ fluxes for sub surface drip irrigated tomatoes treated with **varying UAN 32 fertilizer rates (60, 120 and 180 lbs N/ac).**

- Location: Fresno State campus, CA
- Crop/Variety: Tomatoes/Quali-T 21 and 47
- Soil Type: Sandy Loam
- Sub surface drip irrigated

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2012 Sampling Schedule for N2O emissions for Tomatoes- Fert/SDI at Fresno

| Sampling Date | Label | Field | Location | Crop | Practice | No. |
|---|---|---|---|---|---|---|
| 7/16/2012 | 2926-2949 | F | Fresno | Tomato | before fertilization | 25 |
| 7/16/2012 | 2950-2973 | F | Fresno | Tomato | after fert. | 25 |
| 7/17/2012 | 2974-2997 | F | Fresno | Tomato | after fert. | 25 |
| 7/18/2012 | 2998-3021 | F | Fresno | Tomato | after fert. | 25 |
| 7/24/2012 | 3022-3045 | F | Fresno | Tomato | before fertilization | 25 |
| 7/24/2012 | 3046-3069 | F | Fresno | Tomato | after fert. | 25 |
| 7/25/2012 | 3070-3093 | F | Fresno | Tomato | after fert. | 25 |
| 7/26/2012 | 3094-3117 | F | Fresno | Tomato | after fert. | 25 |
| 8/1/2012 | 3455-3478 | F | Fresno | Tomato | before fertilization | 25 |
| 8/1/2012 | 3479-3502 | F | Fresno | Tomato | after fert. | 25 |
| 8/2/2012 | 3503-3526 | F | Fresno | Tomato | after fert. | 25 |
| 8/3/2012 | 3527-3550 | F | Fresno | Tomato | after fert. | 25 |
| 8/8/2012 | 3581-3604 | F | Fresno | Tomato | before fertilization | 25 |
| 8/8/2012 | 3605-3628 | F | Fresno | Tomato | after fert. | 25 |
| 8/9/2012 | 3629-3652 | F | Fresno | Tomato | after fert. | 25 |
| 8/10/2012 | 3653-3682 | F | Fresno | Tomato | after fert. | 31 |
| 9/14/2012 | 4149-4178 | F | Fresno | Tomato | after harvest | 31 |

Total samples 437

# Site G- Fresh Market Tomatoes

- Determine soil $N_2O$ fluxes for tomatoes subjected to **<u>elevated Carbon Dioxide levels</u>** and **<u>two subsurface drip irrigation rates ( 100% & 80% ET)</u>**

- **<u>Collaboration with Dr. Florence Cassel Sharma</u>**

- Location: Fresno State campus, CA
- Crop/Variety: Tomatoes/Quality 21
- Soil Type: Sandy Loam
- Sub surface drip irrigated

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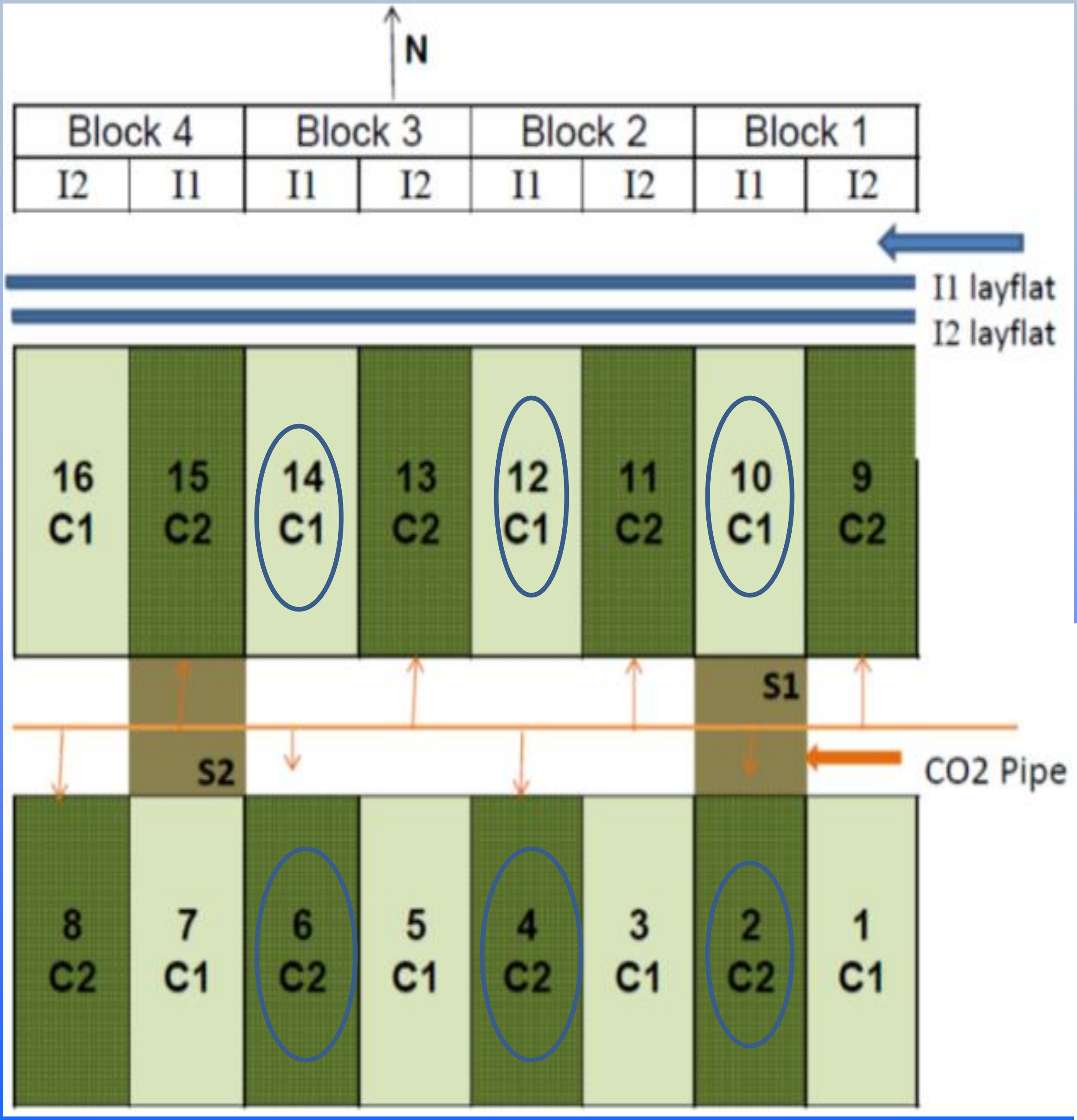
Split- Plot Design




| Treatments | Water | $CO_2$ |
|---|---|---|
| I1 - C1 | 100% ET | Ambient |
| I1 - C2 | 100% ET | Elevated |
| I2 - C1 | 80% ET | Ambient |
| I2 - C2 | 80% ET | Elevated |

## 2012 Sampling Schedule for $N_2O$ emissions for Tomatoes-$CO_2$ Fresno

| Sampling Date | Label | Field | Location | Crop | Practice | No. |
|---|---|---|---|---|---|---|
| 6/18/2012 | 1703-1816 | G | Fresno | Tomato | before fertilization | 115 |
| 6/19/2012 | 1817-2043 | G | Fresno | Tomato | after fert. | 228 |
| 6/20/2012 | 2044-2157 | G | Fresno | Tomato | after fert. | 115 |
| 7/3/2012 | 2404-2517 | G | Fresno | Tomato | before fertilization | 115 |
| 7/5/2012 | 2518-2631 | G | Fresno | Tomato | after fert. | 115 |
| 7/6/2012 | 2632-2745 | G | Fresno | Tomato | after fert. | 115 |
| 7/25/2012 | 3118-3231 | G | Fresno | Tomato | before fertilization | 115 |
| 7/26/2012 | 3233-3344 | G | Fresno | Tomato | after fert. | 114 |
| 7/27/2012 | 3345-3454 | G | Fresno | Tomato | after fert. | 110 |
| 8/30/2012 | 3867-3980 | G | Fresno | Tomato | after harvest | 115 |
| 8/30/2012 | 3867-3980 | G | Fresno | Tomato | after harvest | 115 |
| | | | | | Total samples | 1372 |

# Future work on CDFA funded Project

- **California State University - Agricultural Research Institute project funds will be used for expanding field measurements and model validation efforts.**

- **No cost extension requested to December 2013 to ensure that field samplings conducted in summer 2012 and 2013.**

***Task Timeline and Milestones:***

| Tasks | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|
| | Jun-Sep | Oct to Nov | | Dec | Jan to Mar | Apr to Jul | Aug to Oct | Nov & Dec |
| Task 1: Continue $N_2O$ flux measurements and calculations | X | X | X | | | X | X | |
| Task 2: Model calibration & validation | | X | X | X | X | X | X | |
| Task 5: Reporting and dissemination | | | X | X | | X | | X |

# Additional Investigation with INNOVA

- Comparison of soil $N_2O$ concentrations measured in silage corn with flux chambers and the INNOVA 1412 device.

- Location: Fresno State campus, CA
- Crop/Variety: Corn/ To be confirmed
- Soil Type: Sandy Loam
- Furrow irrigated

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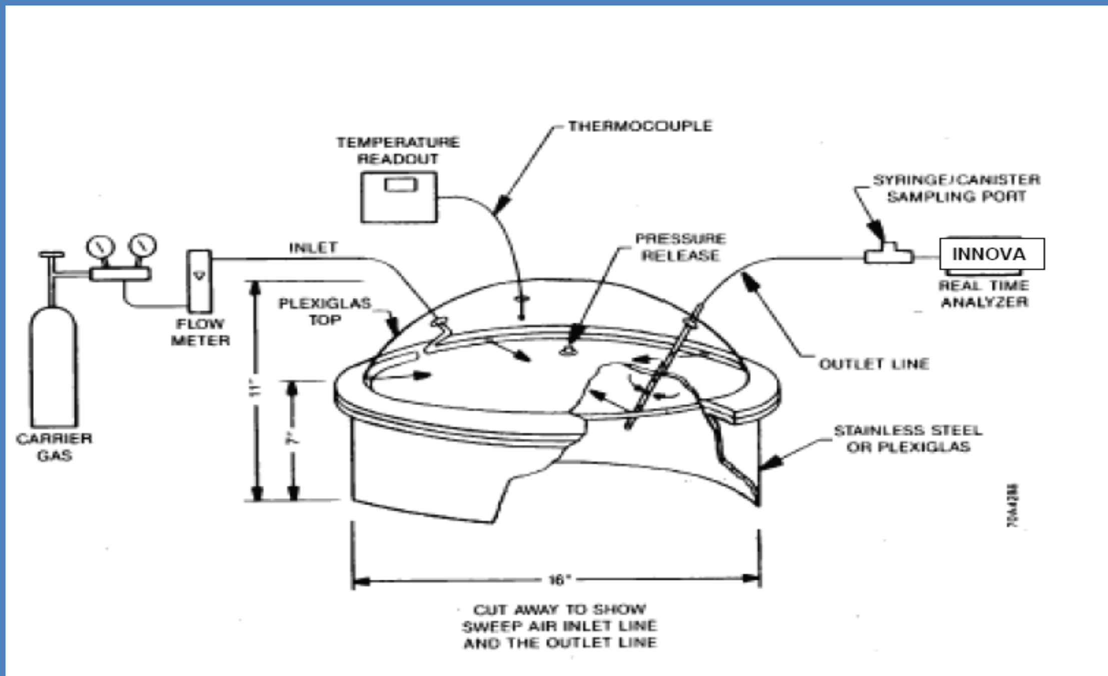



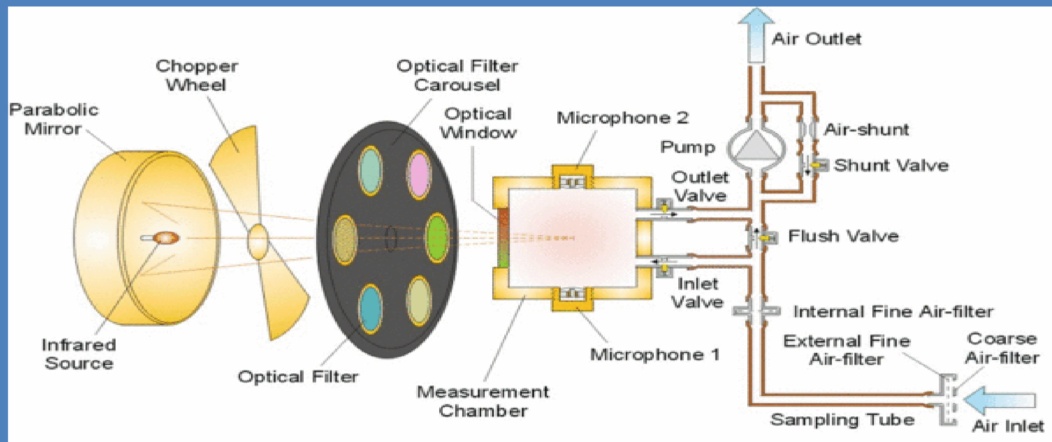


1. An air sample is drawn into the measurement chamber and the chamber is sealed by the valves.

2. Radiation from the IR-source passes through a chopper and optical filter into the chamber, where it is absorbed, generating heat and pressure variations.

3. The pressure variations correspond to the chopper frequency, creating a pressure wave which can be detected by the microphones.

4. The microphone signal, proportional to the gas concentration, is post processed and the measurement result is calculated.

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- Sampling events to be conducted during summer 2013
- Comparison of data from both methods to evaluate the compatibility of using data from two methods to determine flux values.

# THANK YOU !

☺

# Any Questions?

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