Microjet Sprinklers and Nitrogen Fertilizer Source Diminish Almond Orchards Carbon Footprints

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Interpretive Summary

The increase in concentration of the three major greenhouse gases (GHGs) of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) during the last 250 years is leading to undesirable changes in climate. (Forster, Ramaswamy et al. 2007). In 2006, the California legislature approved AB32, the California Global Warming Solutions Act and in 2009 the US Environmental protection Agency declared an endangerment finding for CO_2, N_2O and CH_4.

Nitrous oxide emissions from nitrogen (N) fertilizer application and soil management practices are estimated to be 47.8% of total agricultural GHG emissions (Carlisle et al. 2010). AB32 requires all California sectors to reduce GHGs to 1990 levels by 2020 including agriculture.

Our objective in this investigation was to test if N fertilizer source, calcium ammonium nitrate (CAN) versus urea ammonium nitrate (UAN) or microirrigation systems, sprinkler versus drip, would lower levels of N_2O emissions from almond orchard soils.

Our results indicated CAN reduced N_2O emissions compared to UAN. In addition, when the same amount of water and fertilizer was applied, nitrogen fertigation using microjet sprinklers resulted in a substantial decrease of N_2O-N loss as compared with drip irrigation.

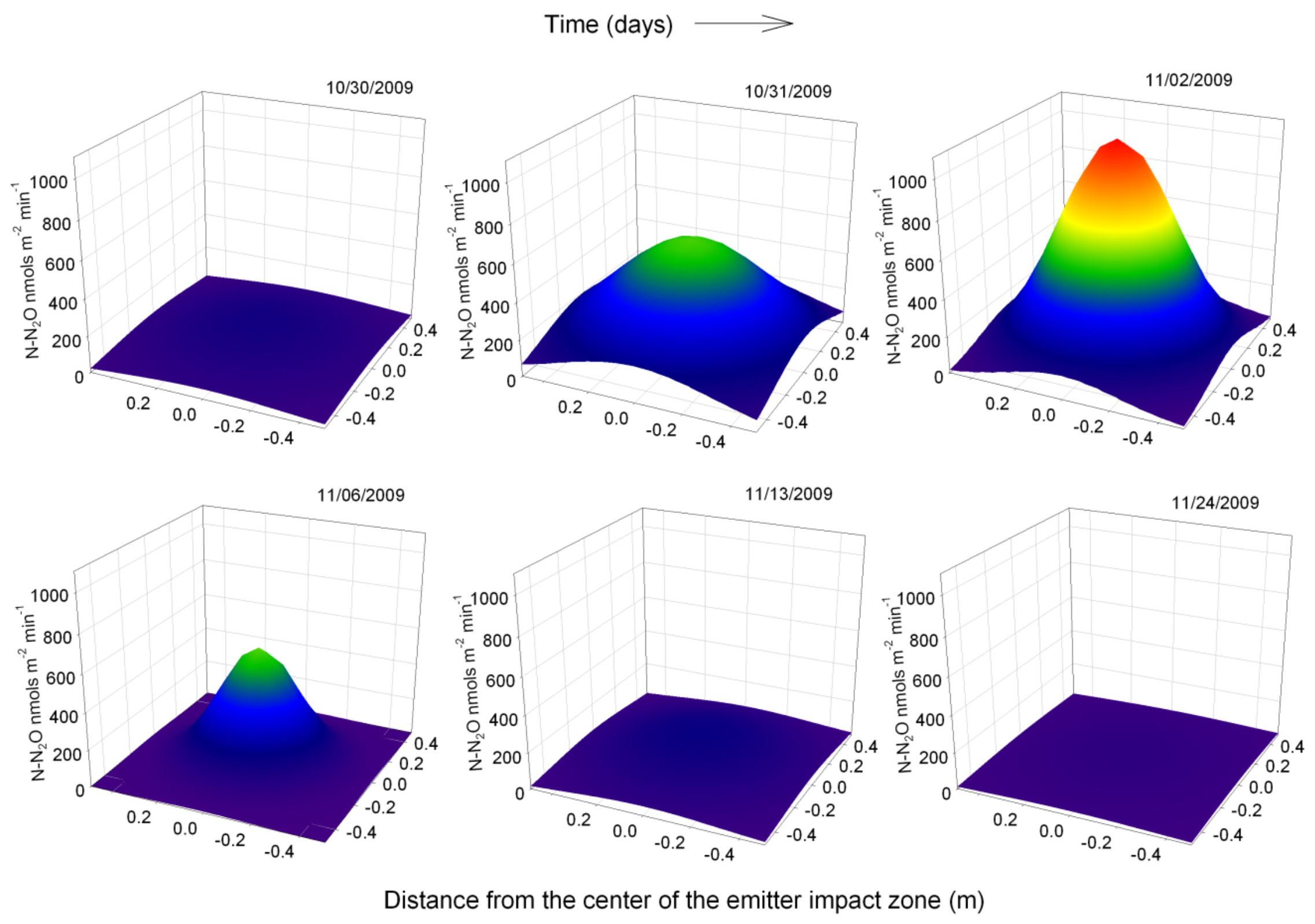

Figure 1. Distribution of N_2O emissions under a drip emitter following a fertigation event of 30 lbs. N per acre in an almond orchard. The distributions of emissions shown were derived from three dimensional fits of the Gaussian distribution. Emissions were well constrained with fits to a Gaussian distribution, achieving R^2 values that exceeded 0.90. These data illustrate the complexity of constraining emissions from localized fertigation events over time (14 days, cf Figure 6).

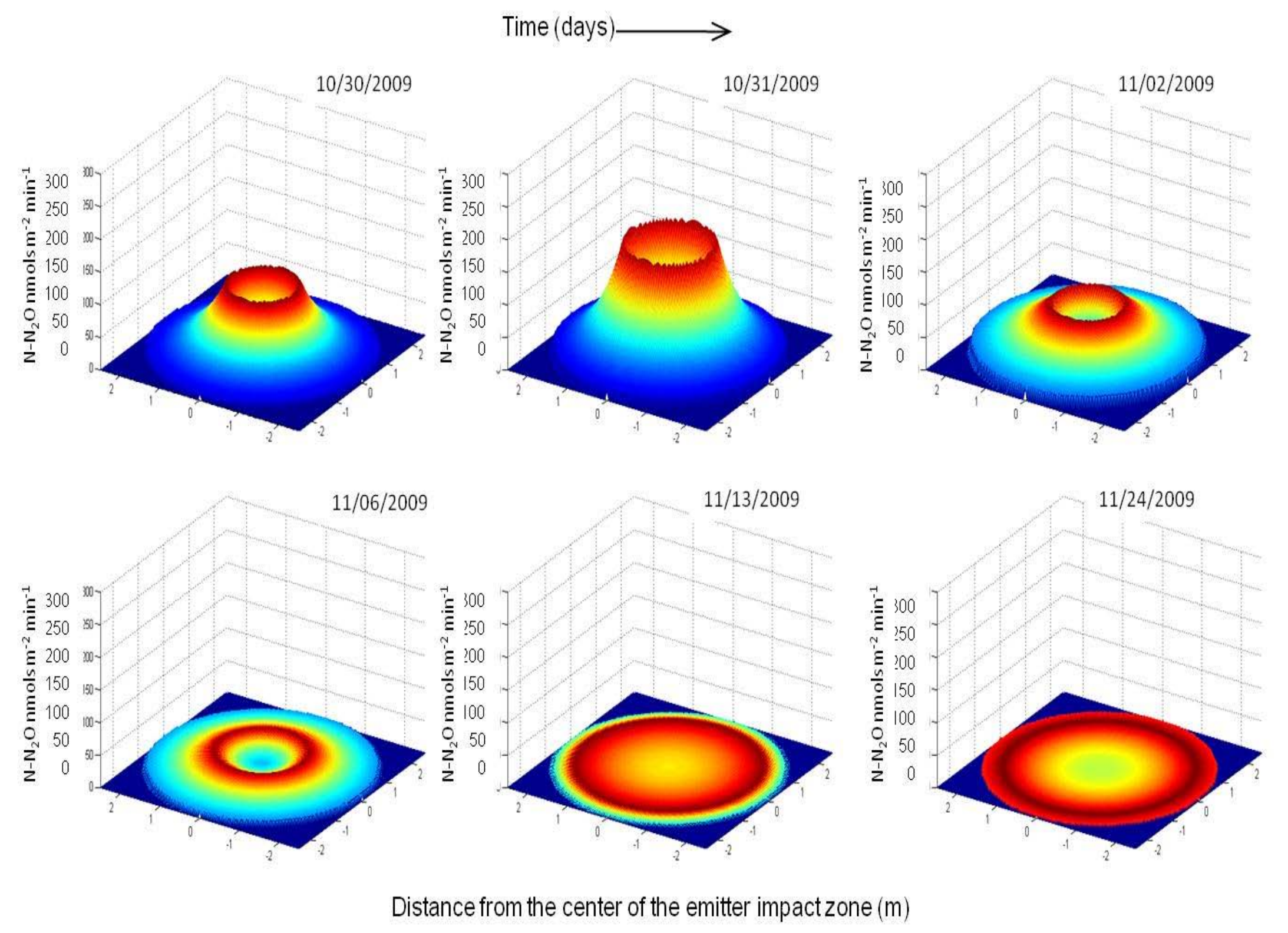

Figure 2. Examples of N_2O distributions from microjet sprinkler delivered fertigation. The models were derived from three dimensional fits of 2-dimensional functions defined by two parts: a second degree polynomial and an exponential decay. They illustrate the complexity of constraining emissions from localized irrigation/fetigation events.

Objectives

The overarching objective is to develop commodity specific (almond) emissions factors for GHG production and consumption (sequestration) in cooperation with growers, State agencies and other commodity organizations.

In order to achieve the overall objective, we are working to:

1) Assemble a GHG inventory by quantifying extent of annual CO_2, N_2O and CH_4 fluxes from almond orchards.
2) Model N_2O emission plumes around surface drip and microjet sprinklers, for CAN and UAN to quantitatively understand emissions and identify management opportunities to lessen emissions.

Conclusions

The emissions of nitrous oxide (N_2O), a greenhouse gas that is 300 times more potent than CO_2, and targeted for regulation by the State of California and US Environmental Protection Agency, was lessened by using CAN17 and microjet sprinkler irrigation systems for their application. This provides growers with tools for lowering almond orchard carbon footprints.

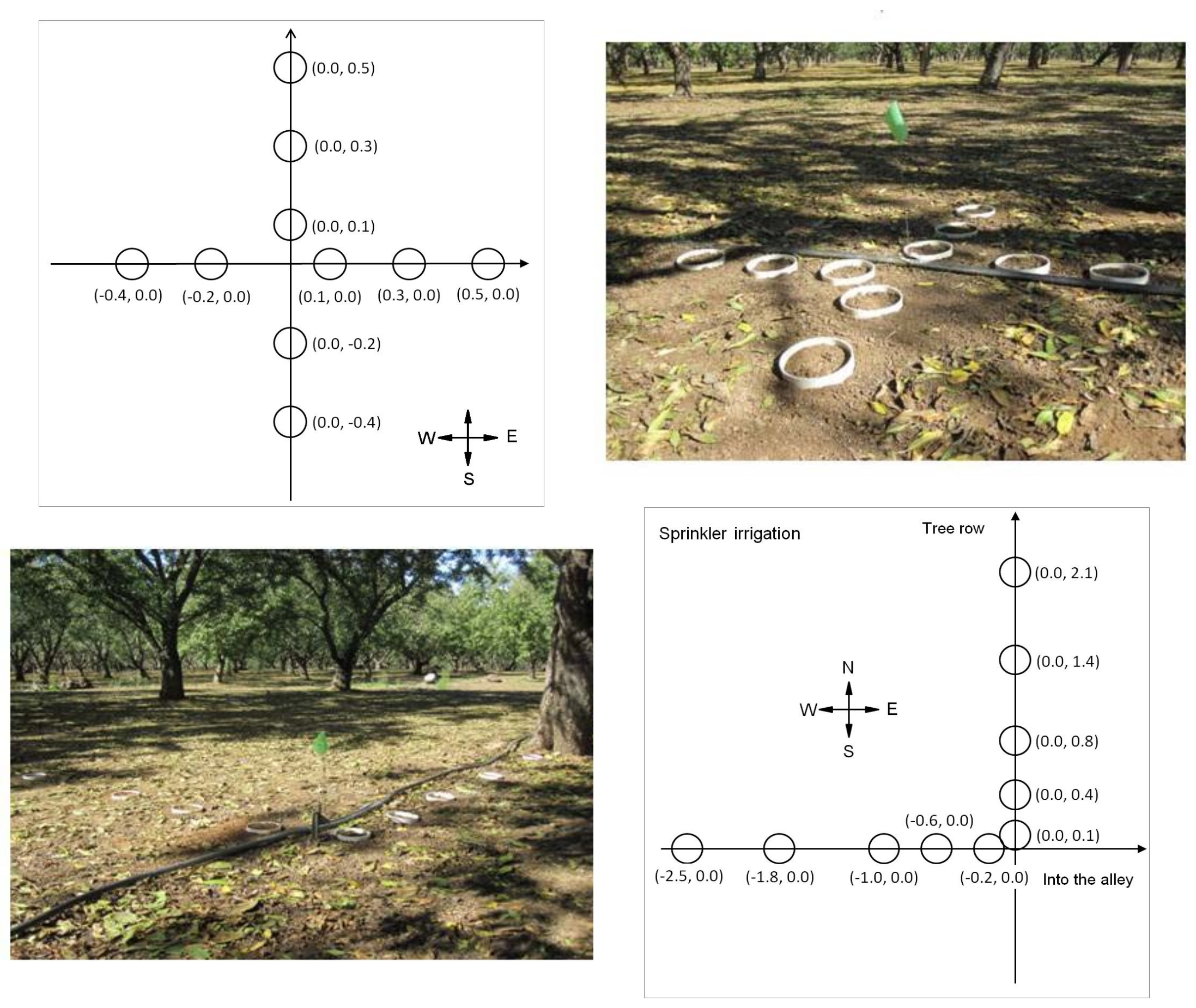

Figure 3. The distribution of the spatial samplings around a dripper (top panels) and a sprinkler (bottom panels). Collars where chambers were placed to sample N_2O were situated on two orthogonal axis centered on the water emitter. The observations in each of the collars were rotated to populate the whole wet area and obtain the 3D representations of the spatial emissions (Figures 1 and 2).

Materials and methods

In simultaneous experiments, we measured N_2O fluxes, soil inorganic N, soil water content and soil temperature during seasonal fertigation events in two different almond orchards. Nitrous oxide fluxes were measured using a static chamber technique (Livington and Hutchinson 1995).

- The first experiment compared N_2O emissions fro CAN and UAN fertigated by microjet sprinklers during split-applications in Belridge, CA. Measurements taken from the berm, edge and alley provide a 2-dimensional model over time (Figures 4-5).

- The second experiment took place at the Nickels soil laboratory in Arbuckle, CA. In this case, the N_2O was to be quantified depending on the microirrigation system, drip irrigation or sprinkler irrigation. The fertilizer used in this site was CAN at the same doses for both treatments, and irrigation was regulated to deliver the same amount of water to all the experimental trees. Because of the different water distributions created around the water emitter depending on the nature of it (drip or sprinkler), the emissions were spatially modeled in the wet area. The obtained models were used to calculate the N_2O-N lost at orchard level.

Results

Nitrous oxide emissions after fertigation events responded to temperature with peak emissions from Feb after 60 hours, Apr after 25 hours, Jul after 10 hours and November returning to 60 hours. Across seasonal variability, CAN consistently diminished N_2O emissions compared to UAN. Maximum concentrations of inorganic N (NH_4^+ + NO_3^-) differed during peak fluxes and may offer an explanation of treatment differences.

The Fall fertigation results in Arbuckle showed a peak of N_2O emissions one day after fertigation in the microjet sprinkler treatment and then a gradual decline until it reached base-line values about 2 weeks later. This observed rapid peak is consistent with the dynamics observed in Belridge. Under drip treatment, the dynamic was slower with peak emissions on day 3 and emissions still slightly elevated 2 weeks later.

In Spring, nitrous oxide emissions did not show a discernible peak in either the drip or the microjet fertigated systems. Rather, emissions were highly erratic and driven by 7 individual precipitation events that occurred during a three week period following fertigation (Figure 5).

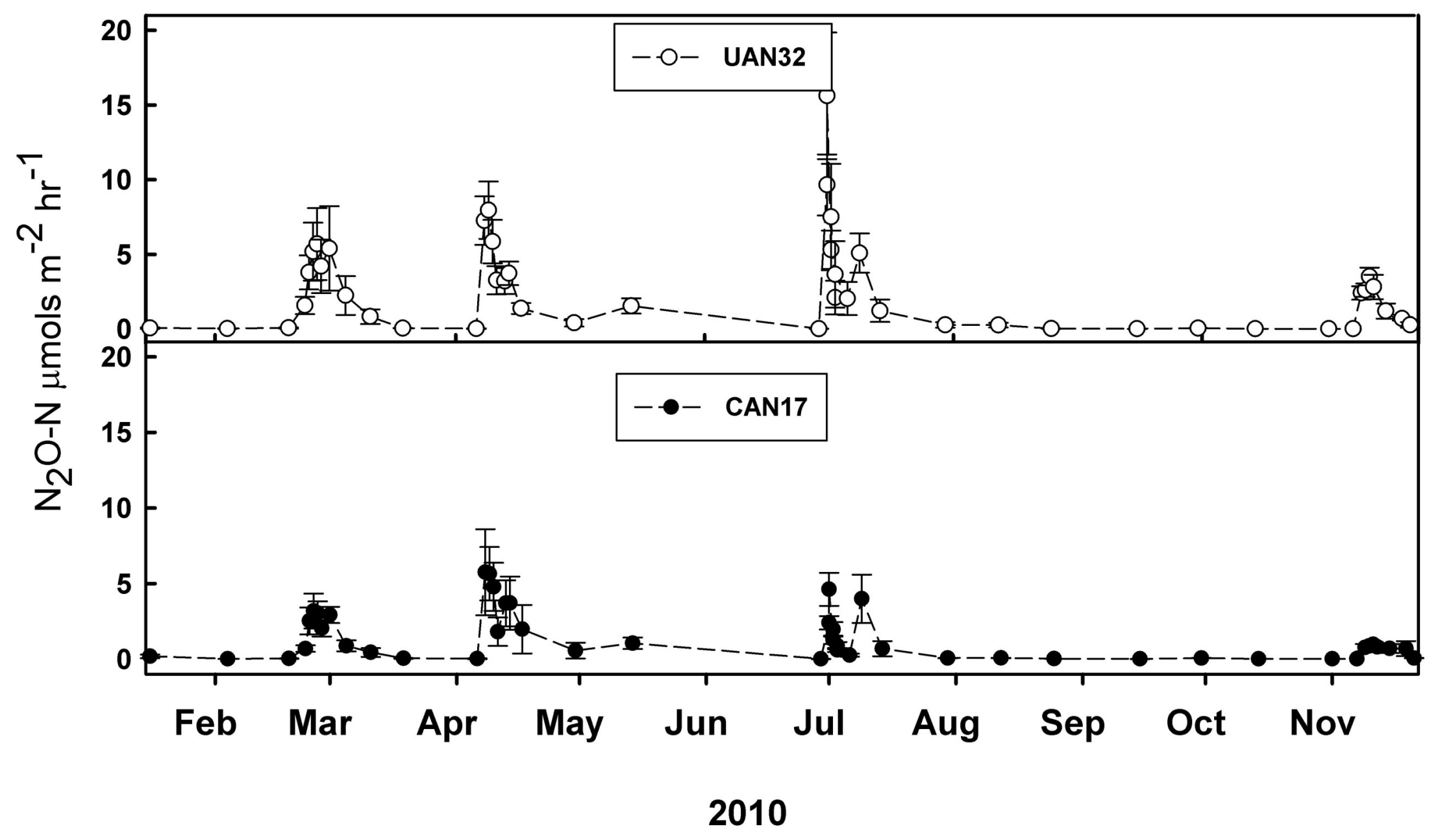

Figure 4. Seasonal emissions of N_2O from an almond orchard at Belridge, CA. Seasonal applications of N fertilizer were split in Feb, Apr, Jul and Nov events. Mean values from 5 repetitions are presented with standard errors.

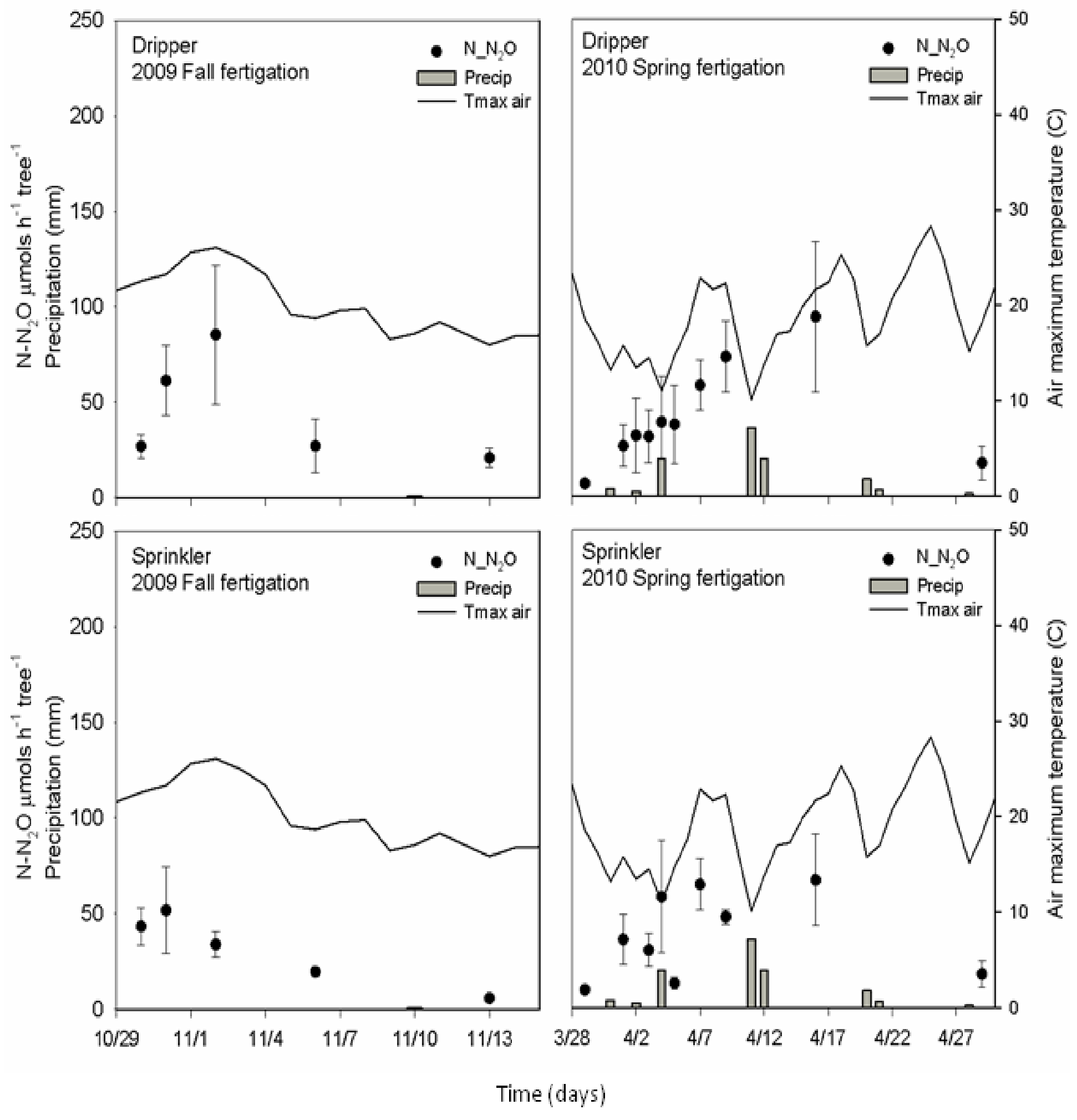

Figure 5. Shown are the integrated N_2O emissions on a per tree basis for a Fall (left panel) and Spring (right panel) fertigation event of 30 lbs per acre using either drip or microjet spray delivery systems. Each data point represents the integrated total instantaneous emissions derived from the 3-dimensional models shown in Figures 1 and 2.

Livington G.P. and G.L. Hutchingson. 1995. Eds. P.A. Matson and R.C. Harriss. Blackwell Science: 14-51.
Forster, P., V. Ramaswamy, et al. (2007). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.".

Almond Board of California