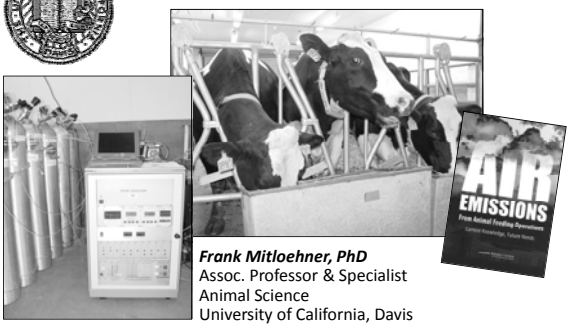
Advances and uncertainties in regard to criteria pollutants



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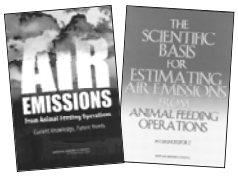

Process-based Experiments and Models for Estimating Air Emissions from Dairies

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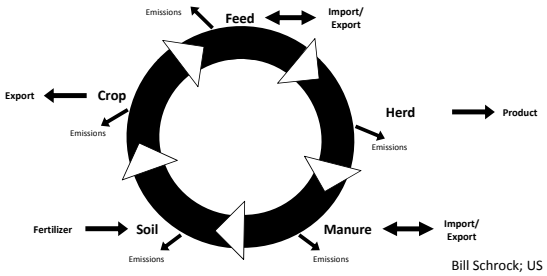
Qualifications of the Team

Team experience with:

- Measuring gaseous emissions from animal production systems (Mitloehner, Zhang, Rotz)
- Process-based modeling of ammonia and other emissions from farms (Zhang, Rotz)
- Modeling the biogeochemical processes in soil and similar media such as manure (Li, Salas)
- Process-based modeling and simulation of whole-farm systems (Rotz)

Process-Based Simulation Models Should Replace Emission Factors

- Accounts for site-specific design and management practices as variables and reflects interactions between emission sources
- Reflects mass balance constraints
- Scale specific (e.g., individual AFOs or regional/national scale)

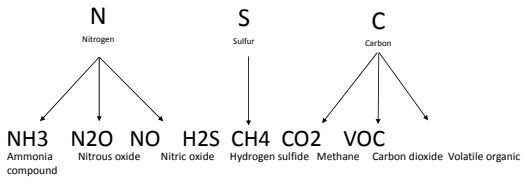


Bill Schrock; US

What are Process-based Models?

- **"Process-based modeling"** refers to biochemical and geochemical reactions or processes
  - Process modeling, in this case, does **not** refer to dairy practices or components (e.g., drylots or lagoons), but
- **Biogeochemical processes**… like decomposition, fermentation, hydrolysis, nitrification, denitrification, etc…

Nutrient elements and related emissions



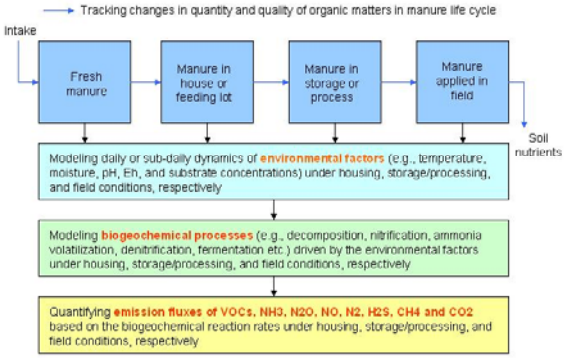
Gaseous Emissions from Dairy Farms

Ammonia (NH3)
Hydrogen sulfide (H2S)
Volatile organic compounds (VOCs)
Methane (CH4)
Nitrous oxide (N2O)
Carbon dioxide (CO2)

Project Objective

To construct a model-based software tool that quantifies emissions of NH3, CH4, N2O, H2S, VOCs and CO2 from the entire life cycle of feeds and manure on dairy farms

Modeling Gas Emissions from Life Cycle of Manure

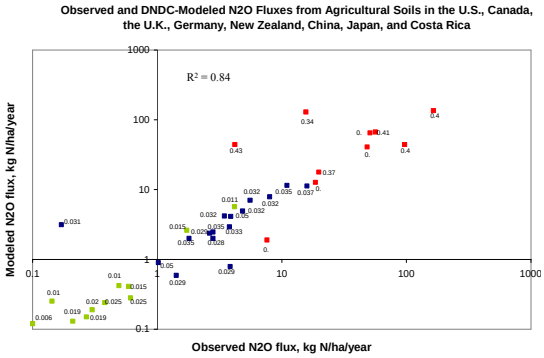


Six Submodels

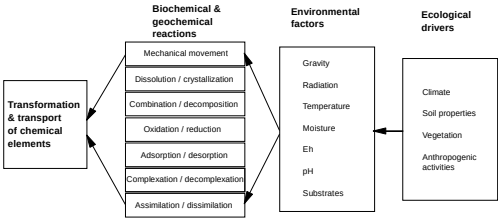
1. NH3, CH4, N2O and VOC production and emission from animal **housing facilities** driven by house climate, production of fresh animal manure, and house management
2. NH3, CH4, N2O and VOC production, consumption and emission under **aerobic storage** (e.g., vented manure stacks, and compost) conditions, driven by quantity and quality of the composted manure mass as well as environmental factors
3. NH3, CH4, N2O, H2S and VOC production, consumption and emission under **anaerobic storage** (e.g. silage stacks, slurry tank and lagoon), driven by quantity and quality of stored manure and environmental factors

Six Submodels

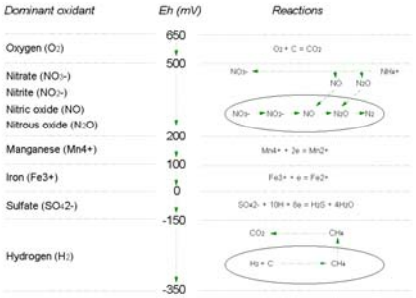
4. NH3, CH4, N2O and VOC production, consumption and emissions following **field application** of manure, driven by quantity and quality of the manure applied, other farming practices, and environmental factors;
5. **Enteric** CH4, N2O and VOC production, driven by quality and quantity of feeding materials as well as animal characteristics;
6. CH4 and VOC production and consumption during anaerobic digestion under **digester** conditions, driven by quantity and quality of the digested manure as well as environmental factors.



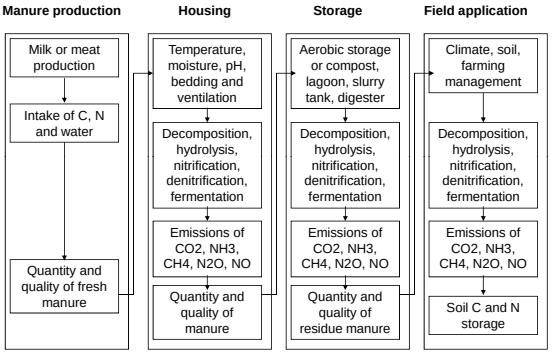
Biogeochemical processes controlling C and N transformation in soil organic matter



DNDC quantifies trace gas emissions by tracking microbial activity in response to environmental drivers (e.g., pH)



PBM utilizes the existing biogeochemical processes to track manure turnover in the farm components



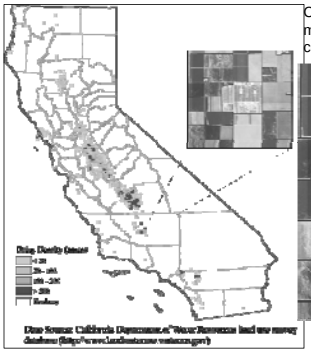
Input parameters

- Daily climate data
- Animal type and population; milk/meat production; Intake protein and feed quality
- Housing: ventilation; floor surface and bedding; cleaning method
- Compost size, density, storage time, litter addition
- Lagoon/tank/digester capacity, surface area, coverage, draining frequency

Output parameters

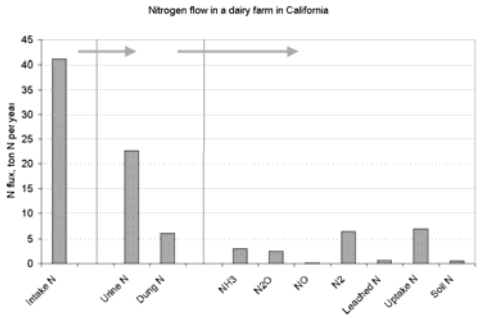
- Production of urine and feces
- Enteric CH4, N2O and CO2
- Emissions of CH4, N2O, NH3, NO, N2 and CO2 from feeding lot, compost, lagoon, slurry tank and field
- N leaching and uptake in field
- Crop growth and yield
- Soil C sequestration

GIS databases support regional simulations for CA dairies

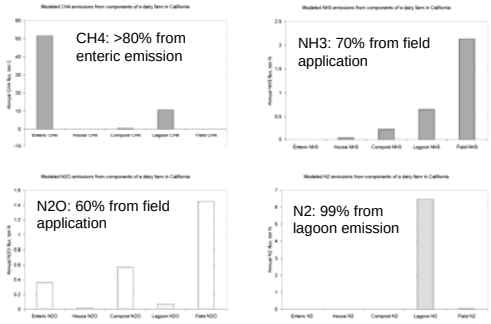


Climate, soil, livestock and management information have been collected.

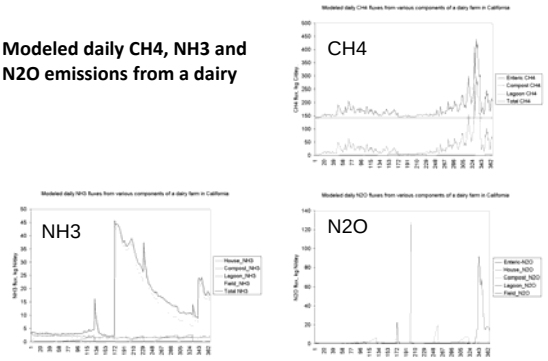
PBM tracks N transport and transformation at farm scale



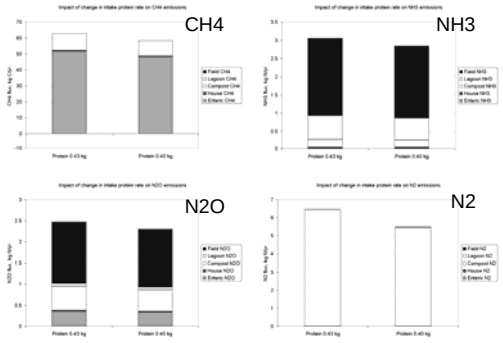
Emissions of CH4, NH3, N2O and N2 are dominated by different farm components



Modeled daily CH4, NH3 and N2O emissions from a dairy



Impact of diet change on gaseous emissions



Model Integration

- **Sub-models will be integrated into a single modeling tool that has a user friendly interface and is menu driven**
- **Software will be MS Windows based**

Expected Project Outcomes

- Biogeochemical process modeling tool for estimating air emissions (CH4, VOC, H2S, NH3, N2O, NO) and N leaching;
- GIS databases of dairies (location, types, herd sizes, manure management, local soils, climate, etc);
- Regional estimates of NH3 and GHG emissions from dairies;
- Emission inventory tool for emission inventories ranging from project or facility level up to air-district and state level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