Using POAMA for reducing $\text{N}_2\text{O}$ emissions in subtropical dairy systems
Lessons from a modelling approach using DayCent

Martin Labadz, Clemens Scheer, David Rowlings

This project is funded by Dairy Australia and the Australian Government Department of Agriculture as part of its Filling the Research Gap Program
Mid-range climate forecasts

• POAMA: Predictive Ocean Atmosphere Model for Australia.
• Bureau of Meteorology's dynamical (as opposed to statistical) climate model used for multi-week to seasonal through to inter-annual climate outlooks
• outlooks 1-9 months ahead.
• twice weekly forecasts consisting of 33 scenarios. The variability of the results among the 33 runs gives an indication of the uncertainty in the future evolution of the climate system.
• Hindcasts available
Using POAMA for reducing N\textsubscript{2}O emissions in subtropical dairy systems

Select suitable simulation model

Collect input data

Long-term climate
Land management history
Site specific parameters

Model Calibration and validation

POAMA

Extract weather forecast for selected months

Simulate mineralization, N uptake and yield using POAMA

Calculate system N deficiency

Providing decision support for N application

Numerical simulation approach
Case study site

- 11 km east of Gympie and 180 km north of Brisbane
- Rye Grass/ Kikuyu
- Farmer owned/operated property
  - 240 milking cows
- Red dermosol
  - 0-25 cm: Clay loam
  - 25 cm+: Clay
- 4.7% Carbon (0-10cm)
- pH 6.0 (0-10cm)
- site rainfall 1000 - 1250 mm
  - 1<sup>st</sup> Jan 2012; 1200 mm
Two years of field measurements: May 2012-April 2014 (NANORP)

- **Treatments**
  - 0 kg N ha
  - 23 kg N ha (1 kg N ha day)
  - 23 kg N ha applied as ENTEC
  - 45 kg N ha (typical N rate applied in the region; 2 kg N ha day)
  - 45 kg N ha applied as ENTEC

- **Greenhouse gases (N\textsubscript{2}O, CH\textsubscript{4}, CO\textsubscript{2})**

- **N\textsuperscript{15} subplots (10\% enrichment)**
  - Added every fertilisation
  - Analysed for recovery in pasture (each grazing)
  - roots and soil (end of fertilisation)

- **Pasture biomass production**
Selecting numerical simulation model

**DairyMod**
- Multi-paddock, biophysical simulation model

**DayCent**
- Daily version of CENTURY
- Biogeochemical simulation model
- Simulates fluxes of C and N between the atmosphere, vegetation and soil
Simulated average annual N losses from denitrification and expected total denitrification losses from Gympie for the period 2003 to 2012. Expected losses from Rowlings et al. 2016.
Simulated and observed N$_2$O emissions for Gympie during model calibration (2012-2013) and validation (2013-2014).

Total denitrification losses (44-90kg/ha/year)
Model calibration and validation: Yield

Simulated and observed biomass production for Gympie during model calibration (2012-2013) and validation (2013-2014).
POAMA ensembles for Gympie

POAMA anomalies for rainfall, and minimum and maximum temperature for the 33 ensembles for August 2013.
POAMA ensembles for Gympie

- Selecting ensemble means for model POAMA model A, B, and C
- Using year 2013 as forecast year
- Calculating rainfall, and min and max temperature for August 2013 from POAMA anomalies and long-term mean climate data
- Running DayCent from 1905 to 2012 as model spin-up
- Estimating yield potential and N mineralization for August 2013
**Simulation Results**

<table>
<thead>
<tr>
<th></th>
<th>Observed weather</th>
<th>POAMA ensembles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield (kg N/ha)</strong></td>
<td>10.2</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Mineralisation for August 2013 (kg N/ha)</strong></td>
<td>6.3</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.7</td>
</tr>
<tr>
<td><strong>N deficiency (kg N/ha)</strong></td>
<td>3.9</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.8</td>
</tr>
</tbody>
</table>

**DayCent predicts a fertiliser requirement of 0.5-1.0 kg day**
Conclusions

• N turnover in dairy pastures is difficult to simulate.
• Calibration is essential (better N turnover data needed).
• Promising approach if N mineralisation and yield potential can be simulated adequately.
• Value of forecasts needs to be tested.
• N$_2$O reduction from reduced fertiliser rates possible.
• Not suitable for ERF methodology (yet?).
• Calculate fertiliser requirement for all (fertilised/winter) months.
• Validate results by running DayCent with different fertiliser rates.
• Assess impact on N₂O emissions.
• Assess value of forecasts on mineralisation estimates.
• Integrate with irrigation.
• Field validation?
Enhanced resolution

August Mean Rainfall

Higher resolution greatly improves the depiction of mean rainfall

POAMA-2

Obs

ACCESS-S

250 km

60 km

0.1 0.2 0.3 0.4 0.5 0.6 0.8 1 2 3 4 5 6 8

mm/day
Acknowledgements

This project is funded by Dairy Australia and the Australian Government Department of Agriculture as part of its Filling the Research Gap Program.

Special thanks to the farmers Rob and Ruve Thefs
Bill Parton from Colorado State