Testing of OVERSEER nitrogen loss estimates from crop systems

Project Final Report - coversheet

The final report from an assessment of OVERSEER nitrogen-loss estimates by for crop systems is now available to download.

The project was sponsored by Overseer Limited, the Foundation for Arable Research (FAR) and the Vegetable Research and Innovation Board (represented by Horticulture New Zealand). The project was undertaken by the New Zealand Institute for Plant & Food Research Limited (PFR).

The assessment was done by comparing OVERSEER estimates with estimates generated by a modified version of the Agricultural Production Systems sIMulator (SCRUM-APSIM).

The testing process consisted of three-phases:

- Phase I – Benchmark SCRUM-APSIM to a 3-year experimental crop rotation.
- Phase II – Generate long-term average N leaching values for SCRUM-APSIM (using the OVERSEER 30-year climate horizon) and compare with OVERSEER results for the benchmark conditions.
- Phase III – Expand the test outside of the benchmark conditions and compare OVERSEER and SCRUM-APSIM for six different soil and climate and rotation sequences, while looking for systematic differences in the model results.

While some results align, the final report identifies differences in the two data sets, suggesting OVERSEER is not behaving as expected for all crops. The reason for these differences cannot be clearly identified using whole model outputs. Further investigation is needed to pin-point the changes required for OVERSEER.

In consultation with the testers, three recommendations have been prioritised for progress by the project sponsors including:

1. Expanding the current test set to disentangle soil and climate effects.

2. Investigate the causes of differences in the water balance results.

3. Investigate specific areas of the Nitrogen model including:

- Residual decomposition methods.
- Mechanisms for parameterising and modelling soil organic matter mineralisation.

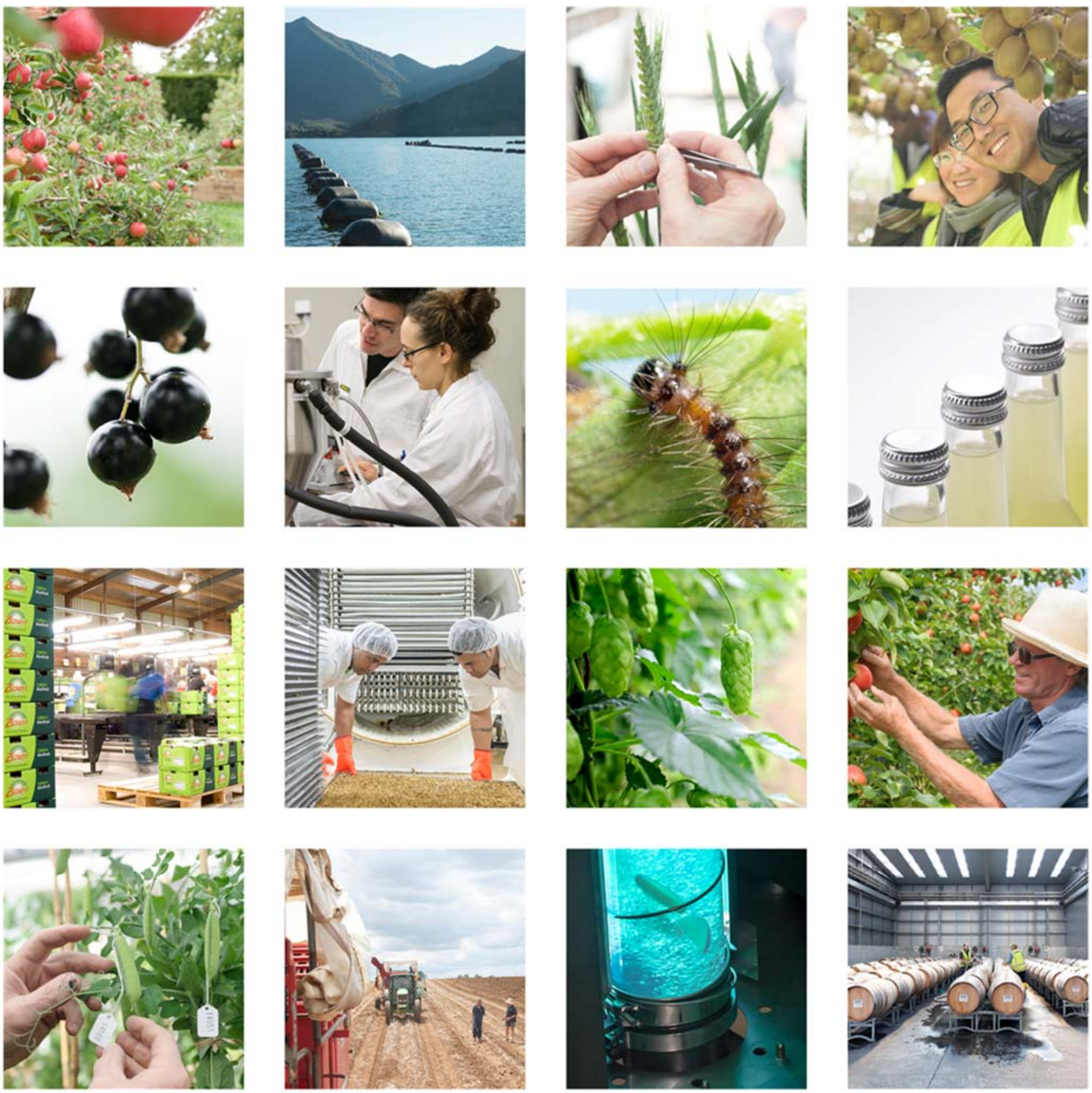
Further investigations are underway based on these results. We hope to have clarity on what changes can be made and when in early 2017.

PFR SPTS No. 14014

OVERSEER crop module testing – end of project report

Khaembah E, Brown H

November 2016



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EXECUTIVE SUMMARY

OVERSEER crop module testing – end of project report

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November 2016

The Foundation for Arable Research (FAR), OVERSEER® Limited and Horticulture New Zealand (HortNZ) contracted the New Zealand Institute for Plant & Food Research Limited (PFR) to test the OVERSEER cropping model for its performance in estimating nitrogen (N) leaching in arable cropping systems. This testing addressed the two recommendations from the FAR commissioned independent peer review of OVERSEER in relation to modelling nutrient flows in arable farming systems (Williams et al. 2013) in a three-step approach outlined below.

- Phase I: a comparison of measured N balance values from 3-year experimental crop rotation treatments with N balance estimates of the same treatments in the **A**gricultural **P**roduction **S**ystems s**IM**ulator (APSIM);
- Phase II: A re-run of Phase I simulations using APSIM with 30 years of climate data to produce long-term average N leaching estimates and compare with long-term estimates of OVERSEER for the same treatments;
- Phase III: Run APSIM with 30 years of climate data and OVERSEER (30-year average climate data) for a broad range of soil and management conditions and compare long-term model averages.

While this testing aimed to identify discrepancies occurring between OVERSEER and APSIM, it did not aim to identify the full extent of the problems or to fix any identified problems.

This report presents the findings and recommendations from the testing undertaken under the three phases.

Phase I focussed on comparing N balance data from 3-year experimental crop rotation treatments with N balance estimates of the same treatments in SCRUM-APSIM (i.e. the **S**imple **C**rop **R**esource **U**ptake **M**odel in APSIM), to establish the accuracy of the model as a benchmark against which to evaluate OVERSEER in Phase II and Phase III. SCRUM was developed using the mechanisms and coefficients of the OVERSEER crop model, and so both models are simple and have similar functionality with regard to plant processes. Within the APSIM environment, SCRUM model computations are integrated at a daily time-scale using soil water and soil N modules. Evaluation of results indicated that SCRUM-APSIM adequately estimated soil water, soil N dynamics and N leaching of the experimental data. On the basis of these results, SCRUM-APSIM was considered a suitable benchmark against which to evaluate OVERSEER in Phases II and III.

In Phase II, SCRUM-APSIM was used to simulate crop rotation treatments tested in Phase I with 30 years (1980–2010) of climate data to obtain long-term estimates of N leaching, soil N, drainage and irrigation from multiple years. The same simulations were set up in OVERSEER and model results were compared. The monthly average rainfall data based on the 30 years (1980–2010) used in SCRUM-APSIM were used in OVERSEER. Results indicated similar N

leaching response patterns to management by OVERSEER and SCRUM-APSIM. However, OVERSEER estimated less N leaching than SCRUM-APSIM across treatments, with values progressively decreasing with year in rotation. Low N leaching estimates by OVERSEER was associated with markedly low estimates of soil N as a consequence of re-initialising rotations. The conclusion was that re-initialisation of rotations in OVERSEER broke the continuity of the rotation and created a new soil N status that had a significant effect on N leaching. This highlighted the need for caution when using OVERSEER to predict absolute values of the N balance of crop rotations. Phase II also identified that OVERSEER estimated greater drainage and less irrigation than SCRUM-APSIM and recommended a review of the water balance model in OVERSEER.

In Phase III, six different crop rotations, six different locations (with differing soils and climates) and 30 years (1980–2010) were simulated in SCRUM-APSIM and OVERSEER. Simulations were set up using three different initial soil N conditions. The aim was to compare long-term N leaching model estimates obtained from a broad range of soils, climates and crop management conditions. Two-year rotations were used in Phase III in order to eliminate the impact of re-initialisation on N leaching identified in Phase II. Model estimates of N leaching, soil N at the end of the season (residual N), irrigation, drainage, soil organic matter mineralisation, denitrification and crop N uptake were compared. All model estimates were based on the final year (year 2) of rotation except crop N uptake which was based on both years (year 1 and year 2). With regard to N leaching, results indicated that both models were sensitive to initial soil N conditions, but differed in the magnitude of response. There was a good agreement of N leaching model estimates for two of the six sites. Within these sites, the agreement was better for some sequences than others. Across treatments, OVERSEER estimated less N leaching than SCRUM-APSIM. However, it was notable that sites for which N leaching estimates were greater for OVERSEER tended to be those with soils having high plant available water. Analysis of N balance components i.e. N leaching residual N, denitrification, soil organic N mineralisation and crop N uptake indicated that low N leaching estimates by OVERSEER were partly due to greater N uptake and denitrification losses estimated by the model.

Phase III concluded that the model agreement for N leaching differed with location and sequence, highlighting the need to evaluate the consistency of the model across locations. Refinement of the water and N balance in OVERSEER and broader testing is required to improve confidence in the model's ability to predict N leaching in cropping systems.

Specific recommendations for further expanded testing to determine the exact cause of the discrepancies between the two models are suggested in section 4 of this report.

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1 INTRODUCTION

Present intensive agriculture is associated with high inputs of inorganic nitrogen (N) fertiliser, which can be in excess of the crop's N requirements. Unused N is subject to loss, mostly as nitrate-N which can easily leach out of the soil profile and into groundwater. Nitrate leaching is a major environmental issue, and many governments have formulated environmental policies to protect water systems from nitrate contamination. In August 2014, the New Zealand government released the National Policy Statement for Freshwater Management (NPS-FM 2014; Anonymous 2014) which authorises regional councils to control discharge of contaminants into water systems. To enforce this, regional councils require a common and robust tool that can reliably estimate the flow of nitrate through farm systems and the risk of its loss via leaching. The OVERSEER® model (Wheeler et al. 2006) already has an established role of nutrient management throughout New Zealand and is therefore a tool of choice to fill this role under the NPS-FM 2014.

OVERSEER was originally designed as an on-farm support tool for farm consultants to guide nutrient management advice in pastoral systems, but with the addition of cropping model, OVERSEER is now being used to implement regional policy and regulations in relation to nutrient losses from all types of agriculture (Dunbier et al. 2012). In 2011, a panel of experts commissioned by the board of The Foundation for Arable Research (FAR) to independently review the OVERSEER cropping model recommended that more testing was needed before it could be regarded as a suitable tool to regulate or manage nutrient losses in cropping systems (Dunbier et al. 2012; Williams et al. 2013). The basis for this was that OVERSEER uses long-term average climate data to predict long-term N leaching, which means the cropping model is incapable of simulating the impacts of crop management interventions occurring on short time scales (days, weeks and months). The panel recommended a three-phase approach to testing the OVERSEER cropping model outlined below & schematically presented in Figure 1.

Phase I: The aim of Phase I was to compare measured N balance data with estimates of the **A**gricultural **P**roduction **S**ystems s**IM**ulator (APSIM) to establish the accuracy of the model as a standard against which to evaluate OVERSEER. APSIM is an established detailed research model widely used to assess environmental impacts of agricultural activities (Stewart et al. 2006; Stone & Heinemann 2012; Biggs et al. 2013; Vogeler et al. 2013). A key feature of APSIM is its daily time-step modules which allow continuous simulation of changes in the N and water status of the soil in response to weather, management and crop uptake. This is critical for quantifying N leaching in crop rotations in which temporal soil N and soil water dynamics are influenced by the status of the crop and climatic variations.

Phase II: Phase II was a scale-up in which experimental treatments used in Phase I were simulated over multiple climates (30 years) in APSIM and OVERSEER and long-term average model estimates of N leaching compared and analysed for any differences.

Phase III: In this phase, OVERSEER was tested over a broad range of conditions to identify any systematic failings. This involved a range of crop sequences (i.e. different crop managements) over a range of sites (i.e. different soils and weather patterns) simulated in APSIM and OVERSEER and analysis of long-term N balance to identify any differences.

2 SIMULATION TOOLS

2.1 Simple Crop Resource Uptake Model operating in APSIM (SCRUM-APSIM)

The APSIM model used in this study is SCRUM-APSIM (abbreviation of the **S**imple **C**rop **R**esource **U**ptake **M**odel operating in APSIM). The crop model SCRUM, was developed using the mechanisms and coefficients of the OVERSEER crop model (Cichota et al. 2010), and so the two models have similar functionality with regard to crop processes. However, unlike OVERSEER, SCRUM includes dynamic water and N functions to allow production to decrease when water or N shortage occurs. Documentation of the SCRUM model can be viewed at http://www.apsim.info/SCRUM. Within APSIM, the nutrient and soil water modules function on a daily time-scale, allowing continuous simulation of changes in the N and water status in response to weather, management and crop uptake (Probert et al. 1998; Holzworth et al. 2014).

2.2 OVERSEER

OVERSEER 6.2.2 (available from http://overseer.org.nz/) was evaluated in this study. This version contains a new feature that allows long-term rainfall data to be entered on an annual or monthly basis. Monthly long-term average rainfall data were used in this study.

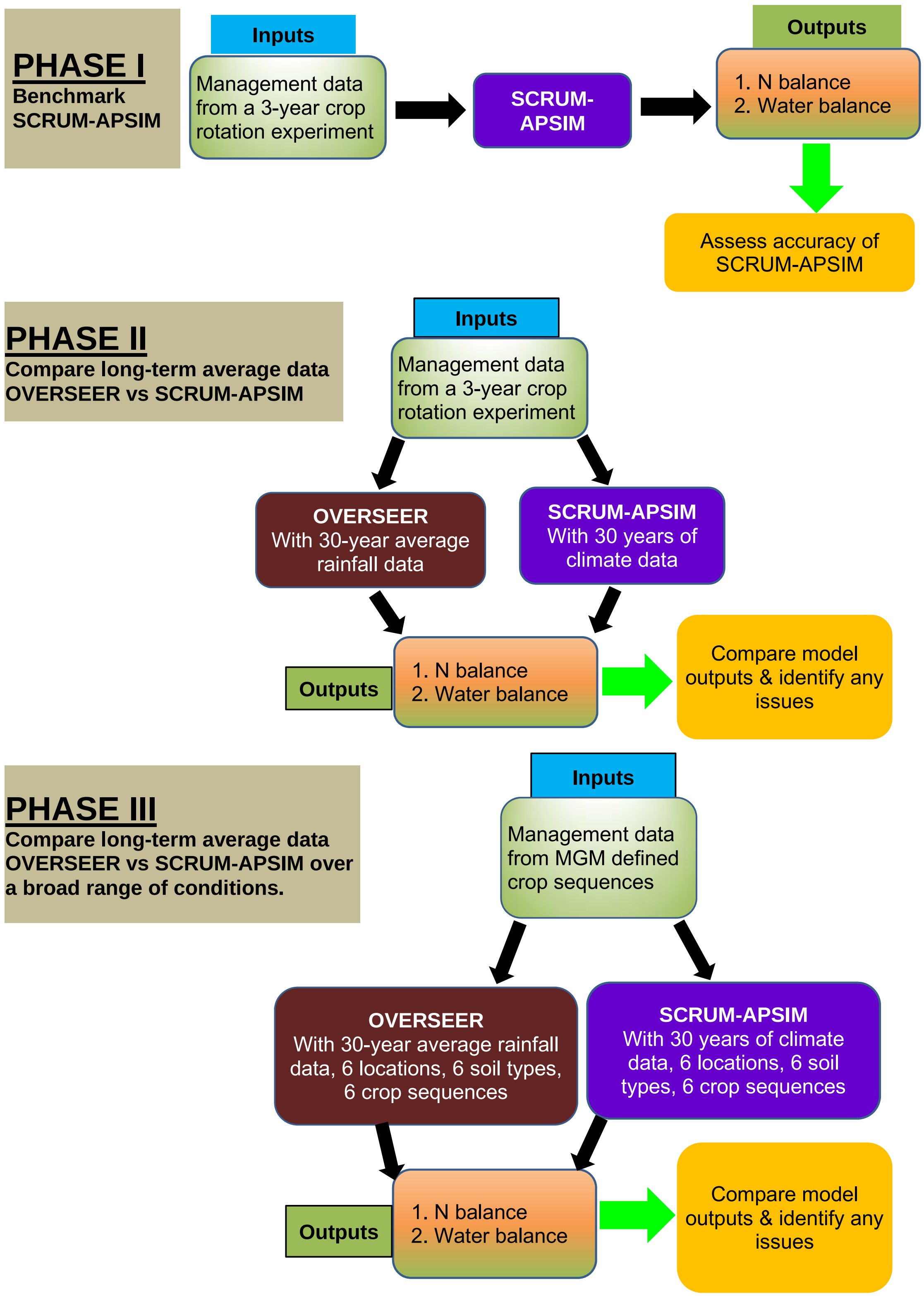

Figure 1. Schematic figure depicting the three-step evaluation of the OVERSEER® crop module. N = nitrogen; SCRUM-APSIM = Simple Crop Resource Uptake Model operating in the Agricultural Production Systems sIMulator APSIM

3 PROCESS, FINDINGS AND RECOMMENDATIONS

3.1 Phase I: Estimation of soil nitrogen (N) and soil water dynamics in crop rotations using SCRUM-APSIM

The objective of Phase I was to evaluate SCRUM-APSIM for its dynamic estimation of soil water, soil mineral N and N leaching in crop rotations. Data from a 3-year (Francis et al. 2006; 2007) crop rotation field trial involving two crop sequences shown below were used for evaluation.

- Sequence 1: potatoes → fallow (6 months) → peas → fallow (7 months) → potatoes
- Sequence 2: potatoes → fallow (1½ months) → wheat → fallow (7 months) → potatoes

The trial was conducted at the New Zealand Institute for Plant and Food Research Limited (PFR) (43.83°S, 171.72 °E, 12 m above sea level), Canterbury, New Zealand and included two irrigation and three fertiliser N treatments. The soil at the site described as deep well-drained Templeton silt loam with high water-holding capacity (~190 mm/m of depth) (Jamieson et al. 1995) was used in simulations. Climate data were obtained from 'Broadfields' weather station (National Institute of Water and Atmospheric Research) (NIWA 2016)) located at the site. Simulations were set up in SCRUM-APSIM using crop management data from the trial. SCRUM-APSIM-predictions of soil water, soil mineral N and N leaching at periods corresponding to sampling times in the trial were compared with measured data. Detailed results are documented in Khaembah et al. (2015a, b).

Phase I key findings:

- Statistical analysis indicated SCRUM-APSIM satisfactorily predicted soil water dynamics (Table 1), an important prerequisite for accurate simulation of drainage and N leaching;
- There was a good agreement between measured and SCRUM-APSIM-predicted data for soil N with predicted values accounting for ~57% of variation in the measured data (Table 1);
- SCRUM-APSIM-predicted N leaching data correlated well with measured N leaching data (R^2 = 0.88; Figure 2) and the fit was good as indicated by the high modelling efficiency (EF = 0.84; Table 1).

Table 1. Validation results of simulated soil water content, mineral nitrogen (N) content and N leaching. RMSE% = Relative root mean square error; EF = model efficiency.

	Soil water content (mm) 0–150 cm depth	Mineral N (kg ha^{-1}) 0–150 cm depth	*N leaching (kg ha^{-1})
Number of observations	166	66	36
Observed mean	403.9	189.7	78.7
RMSE% *(optimum = 0)*	8.9	43.2	32.9
BIAS *(optimum = 0)*	-1.3	-34.6	7.2
BIAS% *(optimum = 0)*	-0.3	-18.3	9.1
EF *(optimum = 1)*	0.45	0.39	0.84

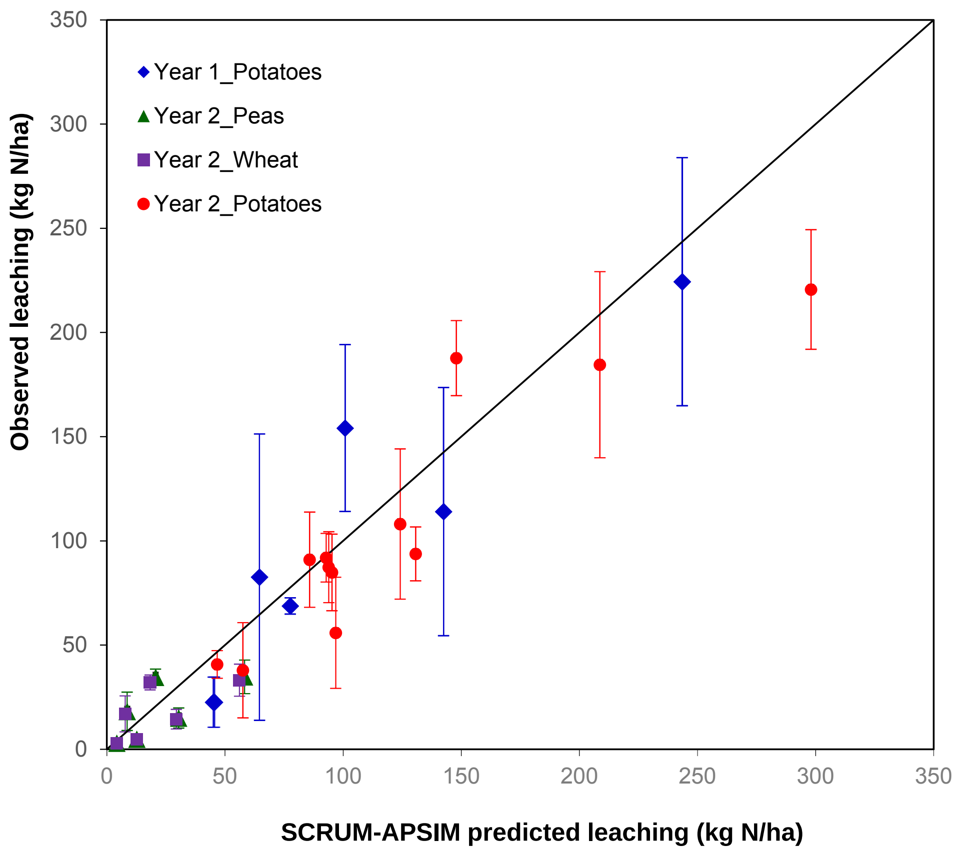

Figure 2. Observed (mean ± SD) versus predicted values of cumulative nitrate leached under different crops in two crop rotation sequences, relative to the 1:1 line.

Phase I conclusion:

- Comparisons between predicted and measured values, as well as the statistical analysis indicated that SCRUM-APSIM adequately accounted for the temporal changes in soil water content, soil N concentration and N leaching. These results provided confidence in the ability of SCRUM-APSIM to simulate N leaching in crops grown in rotation in New Zealand.

Phase I recommendation:

- SCRUM-APSIM was considered a fit-for-purpose model against which to test OVERSEER estimates of N and water balance in Phase II and Phase III.

3.2 Phase II: A comparison of OVERSEER and SCRUM-APSIM N balance from crop rotations

Evaluation of SCRUM-APSIM using experimental data provided confidence in the ability of SCRUM-APSIM to predict N leaching in crops grown in rotations in New Zealand (Khaembah et al. 2015a, b). On the basis of this, the 3-year crop rotations used in Phase I were simulated over multiple years (i.e. weather conditions from different years at the same site) for further analysis. In Phase II, the 3-year crop rotation treatments used in Phase I were simulated in SCRUM-APSIM using 30 years (1980–2010 i.e. 10 sets of 3-year rotations) of climate data. The same simulations were set up in OVERSEER in which monthly average rainfall data based on averages of 30 years (1980–2010), and default potential evapo-transpiration and air temperature were used. Long-term (1980–2010) climate data were obtained from 'Broadfields' weather station (NIWA 2016), located at the experimental site. The soil (deep Templeton silt loam) used in both models was obtained from S-map (https://smap.landcareresearch.co.nz/). Automatic irrigation scheduled by soil water deficit in the top 0–60 cm of the profile was used in both models. Long-term average of N leaching (Figure 3), soil mineral N at the end of the season (residual N), drainage and irrigation predicted by SCRUM-APSIM and OVERSEER were compared (Khaembah et al. 2016).

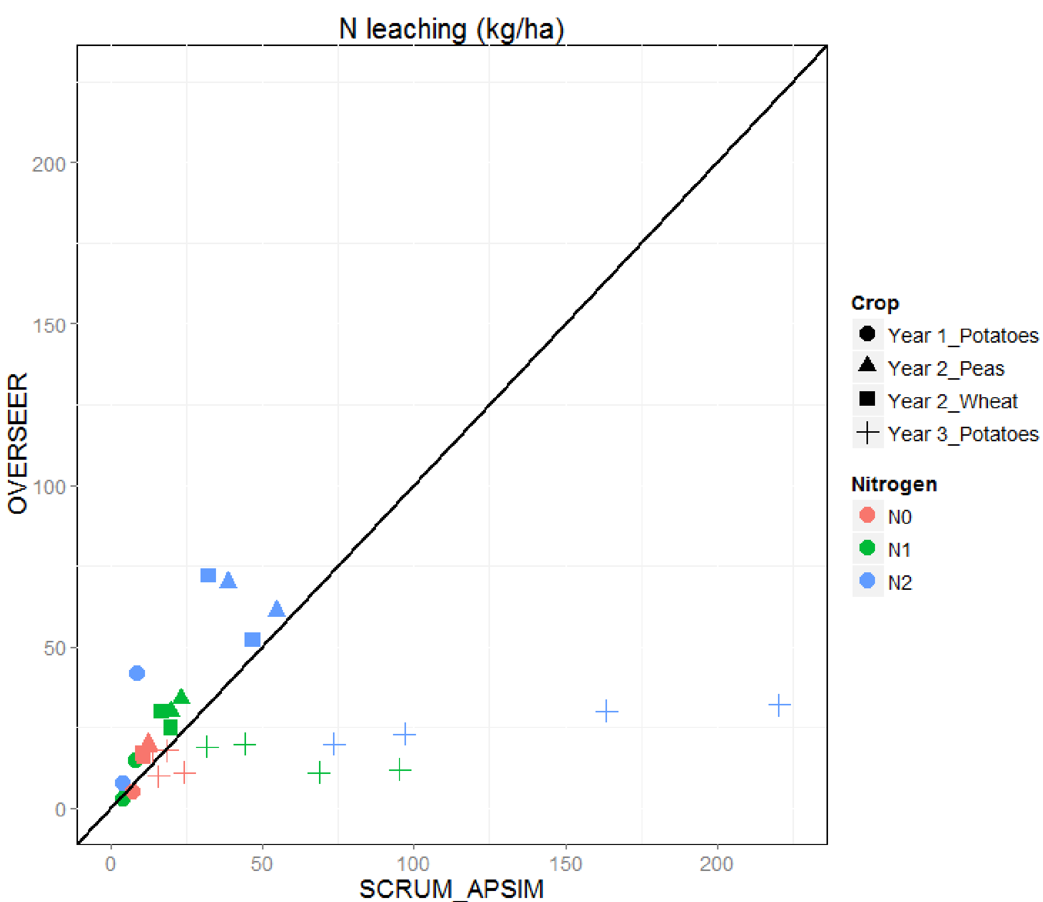

Figure 3. Long-term average N leaching predicted by SCRUM-APSIM versus OVERSEER relative to the 1:1 reference line. Estimates are based on two crop sequences (potatoes-peas-potatoes and potatoes-wheat-potatoes), two irrigation rates (optimum and excess) and three fertiliser N rates (N0 = no added fertiliser, N1 = optimum (recommended rate) and N2 = excess (twice the amount applied in N1).

Phase II key findings:

- When treatments were considered collectively, there was lack-of-fit and no correlation between model estimates of N leaching (relative RMSE = 204%, R^2 = 0.1)
- Grouping data by year of rotation resulted in modest–well correlations (R^2 values of 0.5, 0.7, 0.6, for year 1, year 2 and year 3, respectively) of model estimates, suggesting similar relative response of N leaching to irrigation and fertiliser in both models
- Lower estimates of N leaching by OVERSEER were associated with low soil residual soil N as a consequence of re-initialising rotations
- OVERSEER estimated less irrigation and greater drainage than SCRUM-APSIM, pointing to inconsistency in the way irrigation and drainage are associated with N leaching in OVERSEER

Phase II recommendations:

- Re-initialisation of rotations in OVERSEER created new soil N conditions which affected N leaching and further consideration is needed regarding OVERSEER treatment of initial soil N conditions and the implication for interpreting OVERSEER N balance results
- In OVERSEER drainage and irrigation influenced N leaching differently, highlighting the need for a detailed investigation of the water balance model

3.3 Phase III: A comparison of OVERSEER and SCRUM-APSIM N balance from crop rotations over a broad range of environmental conditions.

Phase III simulations were set up using data from six sites consisting of different soil and climate combinations (Table 2) and six crop sequences (Table 3). Soil data were obtained from S-map (https://smap.landcareresearch.co.nz/) and ranged in plant available water (0–150 cm) from 123 to 306 mm (Table 2). Climate data were extracted from the Virtual Climate Station network. Monthly average rainfall data based on long-term averages of 30 years (1980–2010) for each site and default values of potential evapotranspiration (PET) and temperature were used in OVERSEER. Simulations in SCRUM-APSIM used the daily rainfall data from the different sites. The 30-year period average annual rainfall ranged from 598 mm to 1145 mm among sites (Table 2).

Table 2. Soils for SCRUM-APSIM and OVERSEER simulations of OVERSEER Crop Module Testing in Phase III. PAW represents plant available water. Rainfall is the long-term (1980–2010) total average.

Site name	Climate		Soils	
	Climate name	Rainfall (mm/yr)	Soil name	PAW (mm to 150 cm)
CL04	Climate 04	855	Claremont	228
CL06	Climate 06	630	Templeton	210
CL09	Climate 09	750	Barrhill	306
CL12	Climate 12	1145	Wakanui	225
CL14	Climate 14	588	Chertsey	123
CL25	Climate 25	925	Waikiwi	273

Rotation treatments (Table 3) included five crop sequences (sequence 1– 5) selected from the Matrix of Good Management (MGM) (Hume et al. 2015) and one sequence (sequence 6) used in Phase I and Phase II. Rotations were in turn simulated through the OVERSEER portal to determine crop N requirements. Adjustments to the amounts and timing of fertiliser N were made where necessary while ensuring crops did not experience N limitation at any time during growth in OVERSEER. Resulting fertiliser N rates were used in SCRUM-APSIM. In all simulations, the season started on 1 April and ended on 31 March. Three initial soil N treatments were imposed for each treatment; N1 [5–32 kg N/ha depending the climate], N2 [50 kg N/ha], and N3 [100 kg N/ha]) to test the effect of initial soil N conditions at the beginning of the year 1 on N leaching. To eliminate the effect of rotation re-initialised on soil N and N leaching identified in Phase II, two-year rotations were used in Phase III.

Automatic irrigation management was used in all simulations and followed the recommendations outlined by the MGM (Hume et al. 2015). Briefly, irrigation was triggered when plant available water (PAW) in the top 60 cm of the soil profile dropped to 50%. Upon trigger, 25 mm of water was applied. The time (months) to irrigate were indicated by OVERSEER after running simulations through the OVERSEER portal using the six climate-soil combinations (Table 2).

Table 3. Six crop sequences used in SCRUM-APSIM and OVERSEER simulations of Phase III. Shaded areas represent the fallow periods. Seq represents sequence.

Seq	Year 1												Year 2 (reporting year)											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1	Forage oats						Maize silage							Wheat										
2	Forage oats						Carrots											Barley						
3	Broccoli						Carrots												Maize					
4	Ryecorn						Maize silage						Forage oats						Squash					
5		Wheat										Green beans							Potatoes					
6		Wheat																	Potatoes					

An important point to note here is that in SCRUM-APSIM, drainage and N leaching are represented by water drained and N leached out of the bottom-most layer of the soil profile at 150 cm depth. By contrast, OVERSEER uses drainage at 60 cm depth to calculate N leaching, but the depth at which N leaching is calculated is variable.

Phase III key findings

- In general, model comparison across treatments (Figure 4) indicated a poor agreement for N leaching (R^2 = 0.21 and relative RMSE = 114% of SCRUM-APSIM mean)
- There was a good agreement between N leaching estimates for some specific sites/sequences such as site CL04 and CL25 for all crop sequences except sequence 3 (Figure 5)
- There was indication of greater N leaching estimates in OVERSEER for high PAW of soils (Figure 5)
- Generally, estimates of drainage were greater and irrigation lower in OVERSEER than in SCRUM-APSIM (Figure 6 & 7), similar to the findings of Phase II
- Residual soil N (i.e. soil mineral N remaining in the soil at the end of the season) was greater in SCRUM-APSIM than OVERSEER (Figure 8)
- Further analysis performed to quantify N balance components indicated greater estimates of denitrification losses by OVERSEER than SCRUM-APSIM (Figure 9)
- Crop N uptake was greater in OVERSEER than SCRUM-APSIM (Figure 10), reflecting constrained yield and N uptake as a result of limited supply of soil N in SCRUM-APSIM. By contrast, OVERSEER assumes user-defined yield is always achieved and that is why the defined crop N uptake was always achieved for the three soil N treatments (Figure 10)
- Greater estimates of denitrification losses and crop N uptake in OVERSEER than SCRUM-APSIM partly explains the discrepancy between estimates of N leaching and residual soil N since soil organic N mineralisation was similar in the two models (Figure 11)

Phase III recommendations

- The models were inconsistent in the estimation of N leaching showing different responses depending on sites and crop sequences. Review of the OVERSEER water and N balance mechanisms and a broad set of benchmarking tests are required to improve confidence in the model’s ability to predict N leaching in crop rotations

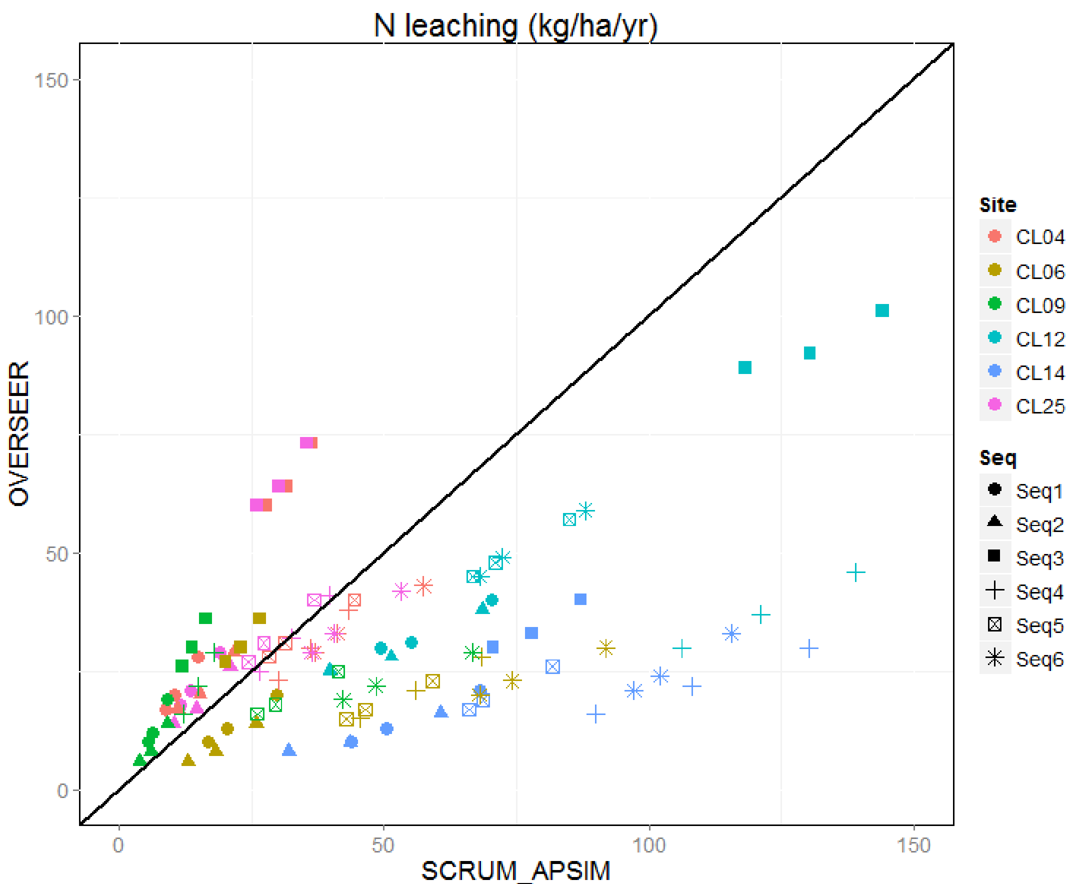

Figure 4. Comparison of long-term estimates of N leaching by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line.

Overall there was poor agreement between the two models (Figure 4). In some situations where the agreement was good there was an over-prediction of up to 30 kg N/ha and under-prediction by up to 100 kg N/ha by OVERSEER. Separating this out into a site by site analysis (Figure 5) resulted in some clear patterns. Sequence 3 was an outlier and generally gave higher N leaching predictions in OVERSEER than SCRUM-APSIM. This rotation contained broccoli, which returns a large amount of high N residue to the system and this result suggests discrepancies in the way the two models handle the breakdown of crop residues. The majority of the variation in N leaching predictions could be attributed to site by site variation, with good agreement at some sites but poor agreement at others. At individual sites both models predicted an increase in N leaching in response to different starting N conditions.

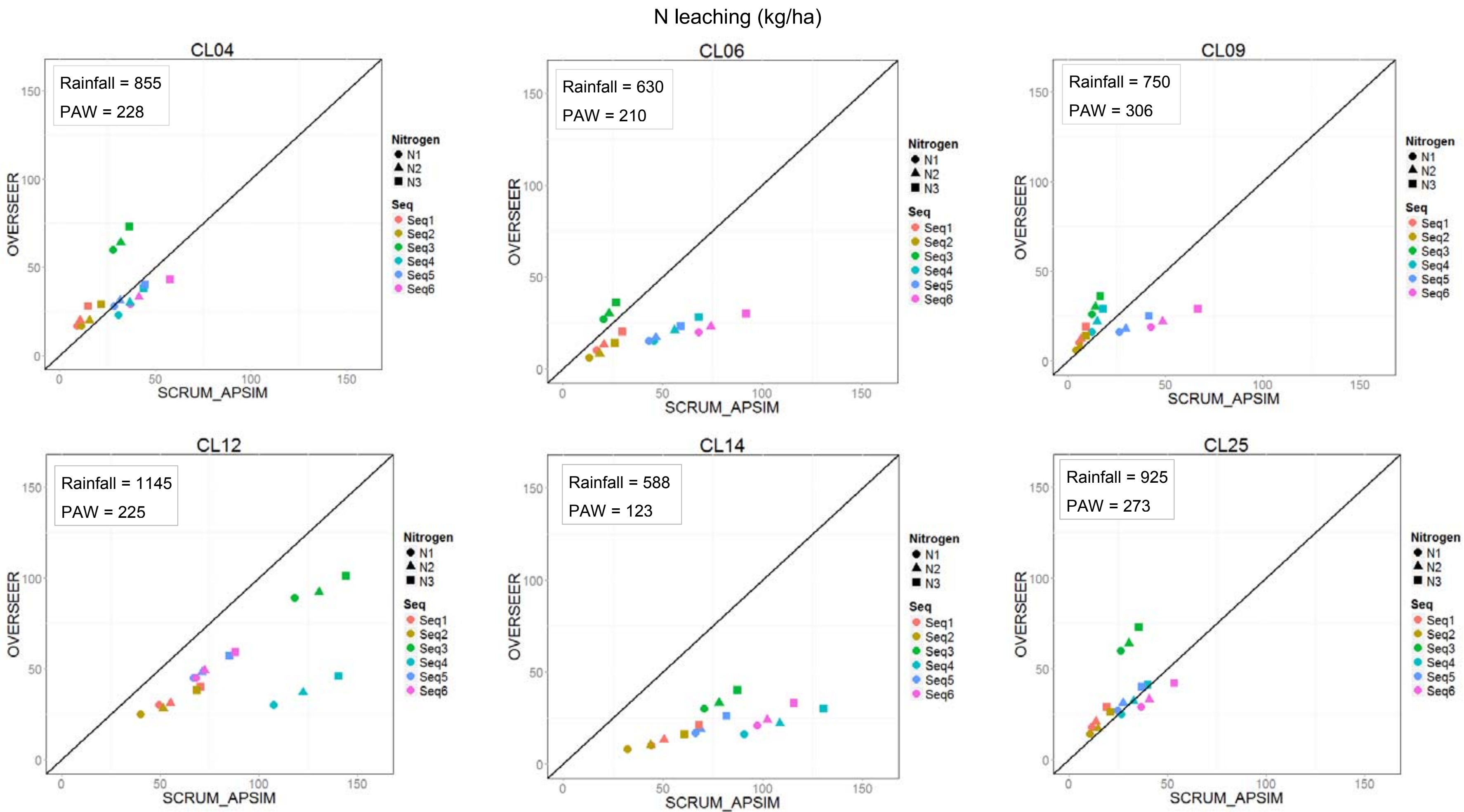

Figure 5. SCRUM-APSIM versus OVERSEER estimates of N leaching under six crop sequences (Seq1, Seq2, Seq3, Seq4, Seq5, Seq6) established at six different sites (CL04, CL06, CL09, CL12, CL14, CL25) relative to the 1:1 reference line. PAW is the soil plant available water (mm) to 150 cm and Rainfall is the long-term (1980–2010) total average (mm/yr).

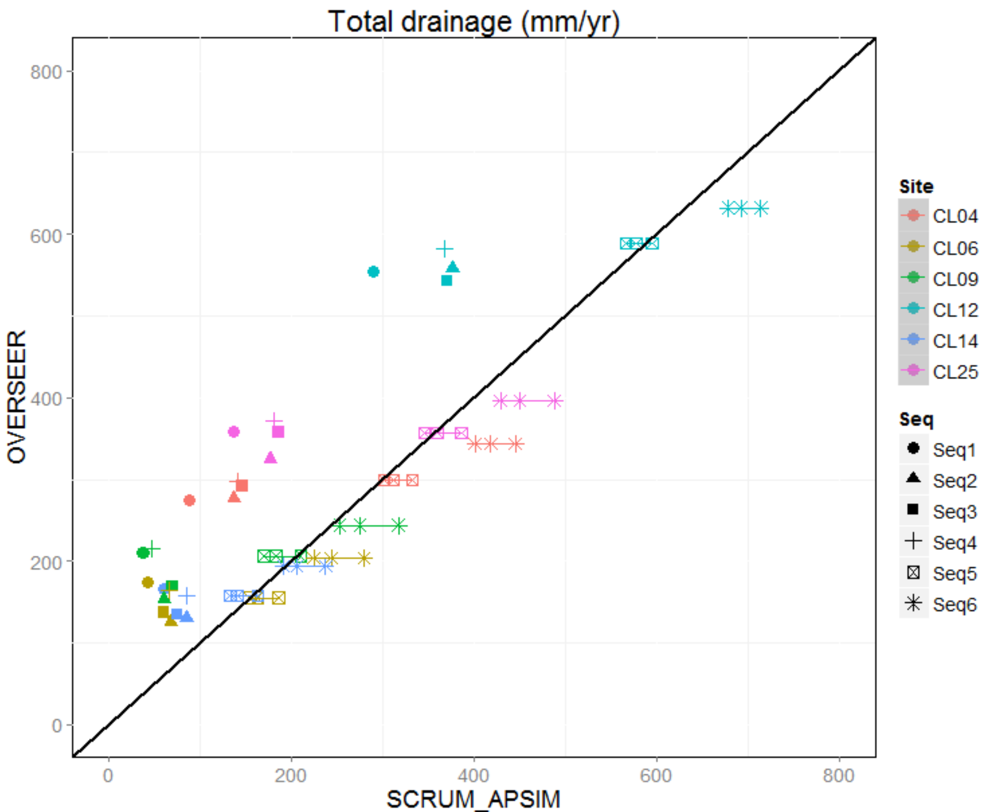

Figure 6. Comparison of long-term estimates of drainage by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line.

A general under prediction in N leaching by OVERSEER could be explained by an under-prediction in drainage, the process that carries mineral N out of the soil profile. However, comparison of drainage predictions between the two models (Figure 6) showed good agreement in drainage predictions for sequence 5 and 6 and an over-prediction of drainage for the other sequences. This result does not explain why the two models gave different N leaching predictions. Indeed, if there was good agreement in drainage, OVERSEER N leaching predictions would be even lower. The discrepancies in drainage were related to sequence rather than site. This shows the models are consistent in their prediction of the effects of climate and soil on the water balance but differ in the way they deal with crop effects on evapotranspiration.

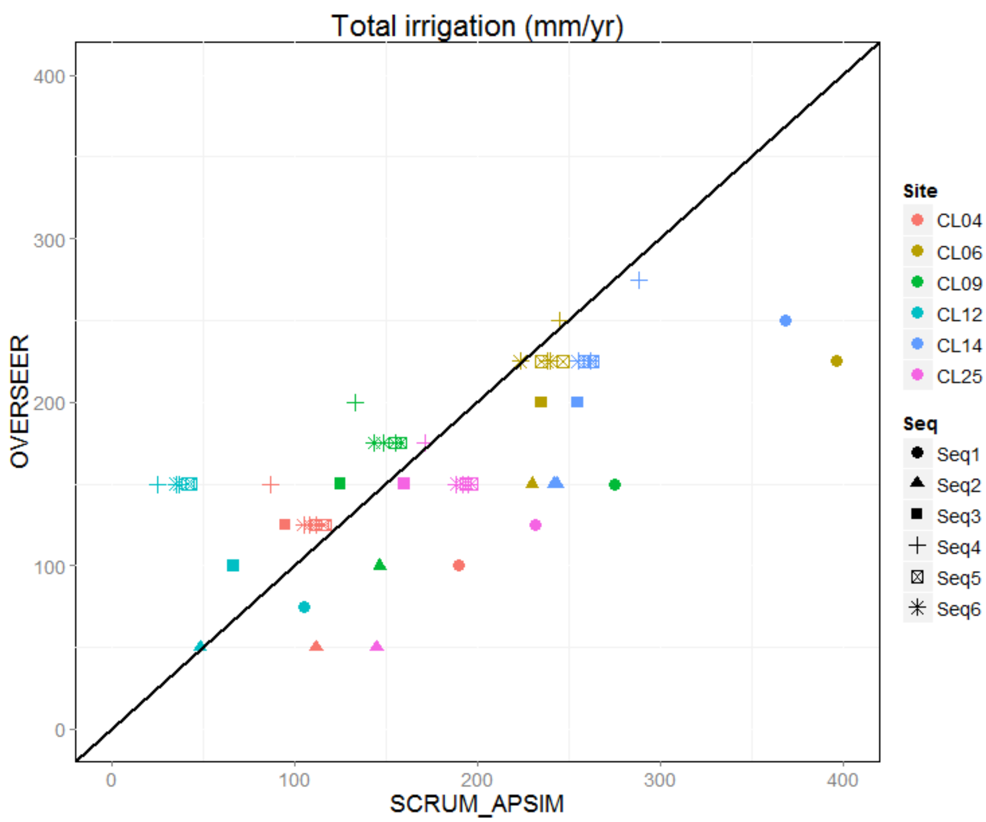

Figure 7. Comparison of long-term estimates of irrigation by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line.

Differences in drainage could not be attributed to differences in irrigation. Agreement was modest between the two models (Figure 7) but this variation could not be attributed to site or sequence in the same way that drainage was so it does not explain differences in drainage.

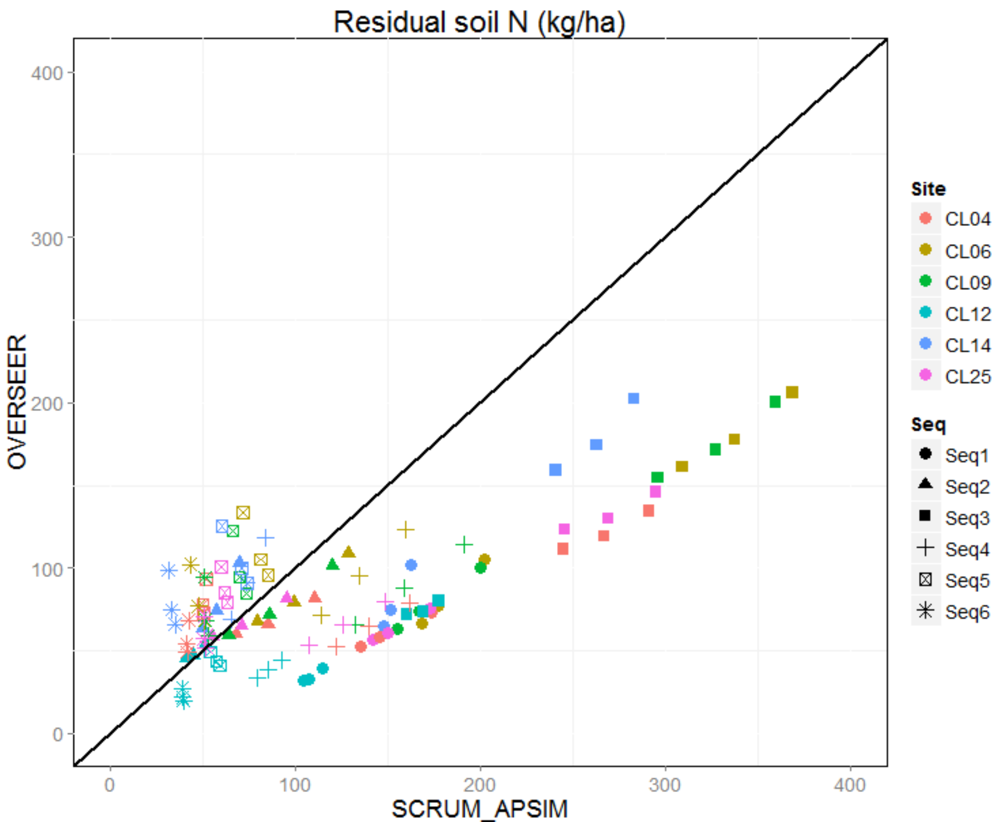

Figure 8. Comparison of long-term estimates of residual N (i.e. mineral N remaining in the soil at the end of the second year) by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line.

If the discrepancies in N leaching were due to differences in the methods for predicting mobility of N in drainage water, we would expect a general under-prediction of N leaching in OVERSEER to result in a general over-prediction of mineral N remaining in the soil at the end of the modelled sequence. This was true for sequence 5 and 6 but the reverse was true for other sequences. So this alone cannot explain differences.

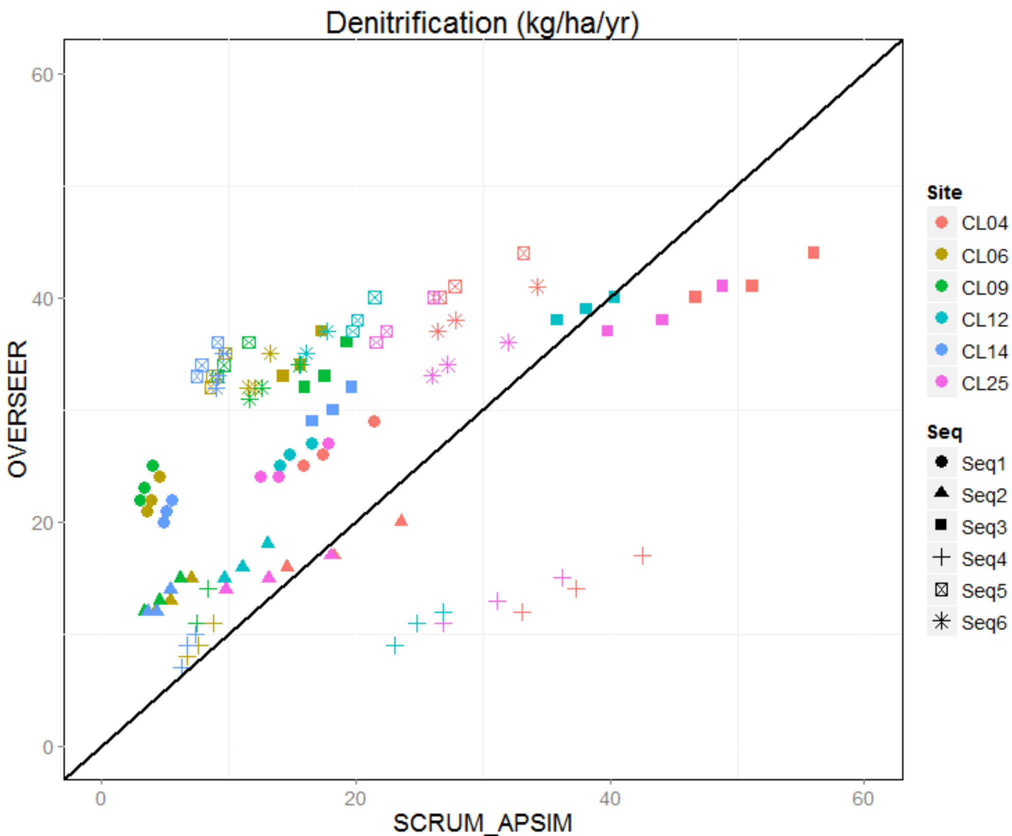

Figure 9. Comparison of long-term estimates of denitrification losses by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line.

OVERSEER generally predicted greater estimates of denitrification, by up to 30 kg N/ha in some cases. This can explain in part the differences in N leaching, as N lost to the system via denitrification cannot be lost by leaching.

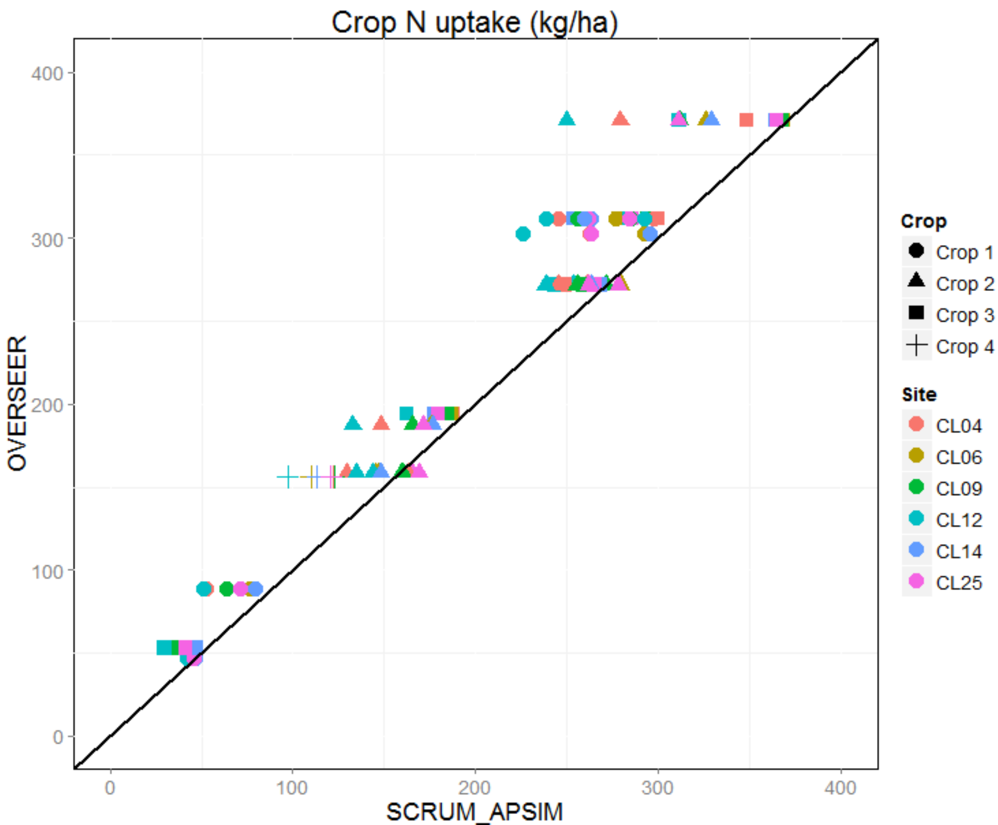

Figure 10. Comparison of long-term estimates of crop N uptake by SCRUM-APSIM and OVERSEER across sites and crop sequences in relation to the 1:1 reference line. Crop 1, Crop 2, Crop 3 and Crop 4 represent the first, second, third and fourth crop in rotations, respectively.

OVERSEER generally gave higher crop N removal predictions than SCRUM-APSIM, the differences ranging from 0–100 kg N /ha. This variation is because of fundamental differences in the approach to modelling the N balance; OVERSEER creates N to meet specified crop N demand whereas SCRUM-APSIM reduces crop N uptake if soil N is insufficient. The difference in these approaches and the subsequent differences in N uptake could explain a large amount of the differences in N leaching.

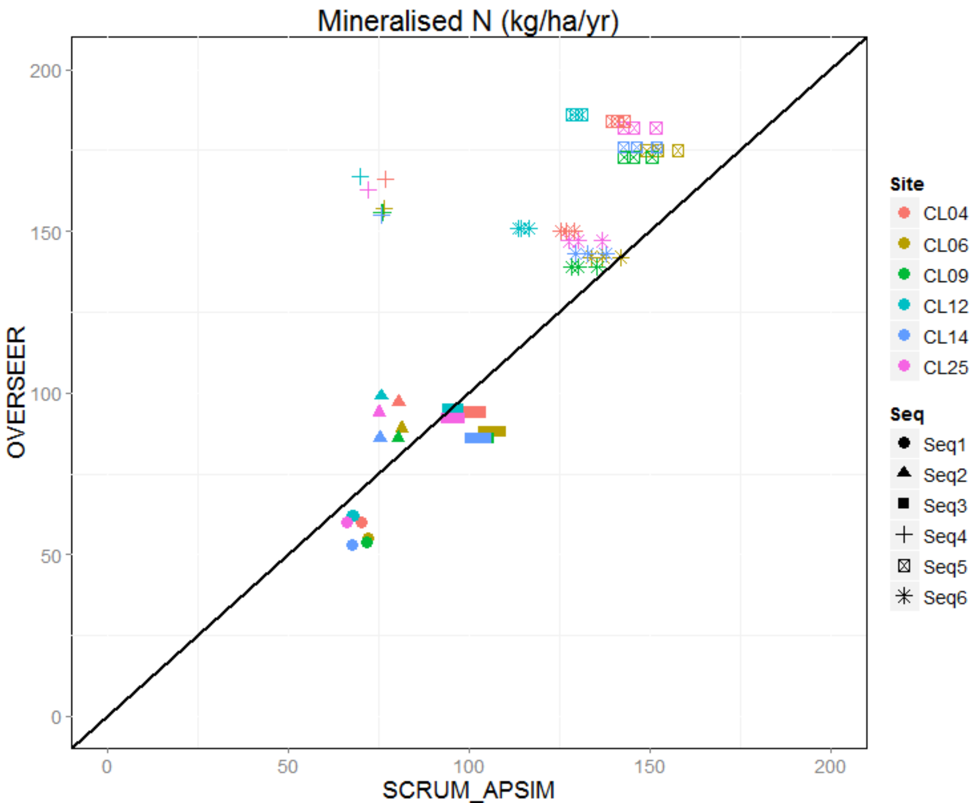

Figure 11. Comparison of long-term estimates of soil organic N mineralisation by SCRUM-APSIM and OVERSEER® across sites and crop sequences in relation to the 1:1 reference line.

There was reasonable agreement between the two models for the prediction of mineralisation and this is one of the areas of greatest uncertainty for both models.

4 CONCLUSION AND RECOMMENDATIONS FROM WORKSHOP

A workshop was conducted on 14 November 2016 involving OVERSEER developers (David Wheeler, AgResearch) and testers (Hamish Brown and Edith Khaembah, PFR) to establish reasons for the differences between OVERSEER and SCRUM-APSIM model outputs identified in Phase III testing.

The analysis of whole model outputs indicates that there are key places in the calculation sequences where differences may be occurring, but the reason for these differences cannot be clearly identified using whole model outputs.

A key recommendation of the workshop is that the testing conducted in Phase III needs expanding and closer integration with OVERSEER developers and testers to determine the exact cause of the discrepancies between OVERSEER and SCRUM-APSIM.

Specific recommendations for forward activity include:

1. Expand the current test set to a full factorial with each of the 6 soil types being simulated at each of the 6 climate sites to enable disentangling of soil and climate effects. This would enable better isolation of the parts of the model that are giving differences. It would also ensure that changes in the last release are fully captured in the comparison.

2. Create outputs of all the components of the water and nitrogen balances in OVERSEER and SCRUM-APSIM and key predictor variables to enable full comparison of the models.

3. Hydrology model. There are some situations where OVERSEER is over predicting leaching and these relate to sequence type. This indicates that it may not be the hydrology model per se causing the difference, rather the difference may be due to crop specific inputs that drive parts of the hydrology model. Further activity should investigate what is causing these differences in the water balance and possible methods of improvement.

4. Nitrogen model. A detailed comparison of the components of the N balance is needed to determine where improvement is required.

    a. Crop N-uptake. A large amount of the discrepancy between models appeared to relate to differences in crop N uptake. Although the APSIM model was engineered to have the same potential N uptake as OVERSEER, it will restrict N uptake if soil/root factors are limiting. Conversely OVERSEER assumes that the entered crop yield is attained, and hence the crop takes up all the N, and generates a surplus to meet any deficit. It is possible this approach leaves low amounts of N in the soil, resulting in lower leaching. More detailed investigation is required of the consequence of the two different approaches.

    b. Residual decomposition methods. It appeared differences between sequences were due to differences in decomposition of residues from different crops. In some sequences, N release from residues appears to be underestimated whereas in others it is over-estimated. Residue breakdown sub-models require careful comparison to determine potential improvements.

   c. Some soil types showed large differences in denitrification suggesting a review of this sub-model is necessary.

   d. Soil organic matter mineralisation was different in some simulations showing the mechanisms for parameterising and modelling mineralisation need review.

5. Develop a proposal for using OVERSEER & SCRUM-APSIM results (described in point 1 above) for continuous testing as improvements are implemented.

6. Consider approaches to vary initial soil N conditions using soil test or capturing soil N status from previous year's farm files.

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