Ministry for Primary Industries
Manatū Ahu Matua

Stocktaking Report

Overseer whole-model peer review

Prepared for Science Advisory Panel
By the Secretariat

February 2020

Contents

Page

1 Executive summary

This report is intended to provide context to the members of the Science Advisory Panel for the Overseer whole-model peer review. It presents a summary of Overseer's sub-models and the peer review work done to date. 10 sub-models have been reviewed out of 41. The summary of sub-models (Table 1) includes a list of sub-models and identifies their descriptions and reviews, if available. The peer review work to date is then summarized.

The recommendations from the peer review work cover a broad range of topics. They include:

- Technical advice, such as changing specific model parameters (e.g. emissions factors), adding new terms, and reviewing specific algorithms;
- Increasing transparency, such as including the rationale for the modelling approach or equation choice in the technical manuals;
- Methods to ensure model quality, such as periodically reviewing relevant literature, undertaking sensitivity and uncertainty analysis, testing sub-models against measured values and other established models, and calibrating the model for other farming systems (e.g. cropping);
- Addressing questions of governance; and
- Improving the user interface for greater clarity.

Many of these were also recommended by the Parliamentary Commissioner for the Environment (PCE) (PCE, 2018) and are already being addressed.[1]

2 Stocktaking of sub-models and peer reviews

The sub-models that have been peer-reviewed are:[2]

- Animal metabolisable energy requirements (Pacheco et al., 2016)
- Characteristics of soils (Pollaco et al., 2014)
- Crop-based nitrogen (Dunbier et al., 2013)
- Phosphorus (Gray et al 2016)
- Calculation of methane emissions (Kelliher et al., 2015)
- Calculation of carbon dioxide emissions (Kelliher et al., 2015)
- Greenhouse gas reporting (de Klein et al., 2017)

The sub-models that have not been peer reviewed are below.[3]

The animal model
Characteristics of animals
Animal intakes
Climate
Characteristics of fertilisers
Characteristics of pasture
Characteristics of crops
Supplements
DCD
Wetland
Riparian strip
Dairy goats
Outdoor pigs
Supplement allocation
Crop growth
Crop feeding
Between-source and enterprise allocation
Distribution of farm data to block scale
Effluent and pad management
Farm distribution
Pastoral
Fodder crop
Cut and carry
House blocks
Tree blocks
Urine patch sub-model
Sulphur and potassium
Cations (sulphur, magnesium, sodium)
Acidity
Constructing a nutrient budget
Constructing reports and indices
Carbon dioxide, embodied and other gaseous emissions

[1] See Project Overview document for more information. https://www.mpi.govt.nz/dmsdocument/39938-overseer-whole-model-peer-review-by-independent-experts-project-overview-including-panel-terms-of-reference
[2] The hydrology and climate sub-models have also been peer-reviewed but they have recently been updated, so this review is no longer helpful.
[3] This list is based on Table 3.2 in the PCE's report (PCE, 2018, p. 41).

Table 1: Summary of sub-models and peer reviews

Sub-model	Description	Peer review
Animal sub-model		
Animal model	Technical manual (not publicly available)	
Characteristics of animals	*OVERSEER® Technical Manual: Characteristics of animals* (Wheeler, 2018e)	
Animal metabolisable energy requirements	*OVERSEER® Technical Manual: Animal metabolisable energy requirements* (Wheeler, 2018e)	(Pacheco et al., 2016)
Intakes	Technical manual (not publicly available)	
Subject-related sub-models		
Hydrology	*OVERSEER® Technical Manual: Hydrology* (Wheeler, 2018i) (Wheeler & Bright, 2015)	
Climate	*OVERSEER® Technical Manual: Climate* (Wheeler, 2018h)	
Characteristics of soil	*OVERSEER® Technical Manual: Characteristics of soils* (Wheeler, 2018g)	(Pollaco et al., 2014)
Characteristics of fertilisers	*OVERSEER® Technical Manual: Characteristics of fertilisers* (Wheeler & Watkins, 2018a)	
Characteristics of pasture	*OVERSEER® Technical Manual: Characteristics of pasture* (Wheeler, 2018f)	
Characteristics of crops	Technical manual (not publicly available) (Chakwizira et al., 2011)	
Supplements	*OVERSEER® Technical Manual: Supplements* (Wheeler & Watkins, 2018b)	
Crop growth	(Cichota et al., 2010)	
DCD	(Shepherd et al., 2012)	
Wetland	(Rutherford & Wheeler, 2011)	
Riparian strip		
Specific enterprises		
Dairy goats	(Carlson et al., 2011)	
Outdoor pigs	(Barugh et al., 2016) (Wheeler et al., 2016)	
Allocation procedures		
Supplement allocation	*OVERSEER® Technical Manual: Supplements* (Wheeler & Watkins, 2018b)	
Crop feeding		
Between-source and enterprise allocation		
Distribution of farm data to block scale	Technical manual (not publicly available)	
Effluent and pad management	Technical manual (not publicly available)	
Farm distribution		
Pastoral		
Fodder crop		
Cut and carry	(Wheeler et al., 2010b)	
House blocks	(Wheeler et al., 2010a)	
Tree blocks		
Nutrient models		

Crop-based nitrogen sub-model	Technical manual (not publicly available) (Cichota ete al., 2010) (Wheeler et al., 2011a)	(Dunbier et al., 2013) (Khaembah & Brown, 2016)
Urine patch sub-model	Technical manual (not publicly available) (Cichota et al., 2012)	
Phosphorus	(McDowell et al., 2005) (McDowell et al., 2008)	(Gray et al., 2016)
Sulphur and potassium		
Cations (sulphur, magnesium, sodium)	(Carey & Metherell, 2002)	
Acidity	(de Klein et al., 1997)	
Reporting		
Constructing a nutrient budget	(Selbie et al., 2013)	
Constructing reports and indices	(Wheeler et al., 2011b)	
Greenhouse gases		
Carbon dioxide embodied and other gaseous emissions	*OVERSEER® Technical Manual: Carbon dioxide, embodied and other gaseous emissions* (Wheeler, 2018d)	
Calculation of methane emissions	*OVERSEER® Technical Manual: Calculation of methane emissions*	(Kelliher et al., 2015)
Calculation of nitrous oxide emissions	*OVERSEER® Technical Manual: Calculation of nitrous oxide emissions* (Wheeler, 2018c)	(Kelliher et al., 2015)
Greenhouse gas reporting	(Wheeler et al., 2011c) (Wheeler et al., 2008) (Wheeler et al., 2013)	(de Klein et al., 2017)

3 Summary of peer reviewing findings to date

3.1 ANIMAL METABOLISABLE ENERGY REQUIREMENTS

3.1.1 Pacheco, D., Cottle, D., Vibart, R., Vetharania, K. and Zobel, G. 2016. Assessment of the OVERSEER Metabolisable Energy Requirements Model. Final report December 2016. AgResearch.

Lead author: David Pacheco, AgResearch (Contact: david.pacheco@agresearch.co.nz)

Objectives

The objectives of this review were to assess the model used in Overseer to calculate the metabolisable energy (ME) requirements of New Zealand ruminants. This included assessing relevant animal characteristics, examining specific model parameters (existing parameter values and adding new parameters), and determining what future research was needed.

Methods

A literature search was conducted to identify recent studies and determine whether the current model for ME in Oversee is best. The animal characteristics used as inputs to the ME model were then assessed. Overseer manuals were also reviewed.

Findings

Key findings of the review were:

- Technical Manuals should include a summary of the methodology and logic framework used to choose between equations;
- Lactation curves and milk composition values should be revised;
- The lactation description for goats should be revised to allow lactation length greater than 365 days;
- The yearly average in milk protein and fat should be replaced to allow seasonal variation in milk composition;

- Some parameter values should be modified;
- Relevant studies should be periodically reviewed to keep parameter values accurate and incorporate new information;
- The feasibility of accounting for gains in genetic merit over time should be assessed; and
- New terms should be added to account for more effects on ME and allow for more variation in production methods.

3.2 CHARACTERISTICS OF SOILS

3.2.1 Pollaco, J. A. P., Lilburne, L. R., Webb, T. M. and Wheeler, D. M. 2014. Preliminary assessment and review of soil parameters in OVERSEER® 6.1. Reported prepared for AgResearch. Lincoln: Landcare Research.

Lead author: Joseph Pollaco, Manaaki Whenua – Landcare Research (Contact: https://www.landcareresearch.co.nz/about/contact-us/contact?id=cG9sbGFjY29q&name=Sm9zZXBoIFBvbGxhY2Nv)

Objectives

This report reviewed soil data inputs and processes in Overseer. Soil data can be inputted as a qualitative description of the soil profile characteristics (Level 1) and a quantitative description of the soil moisture characteristics (Level 2). The review involved a comparison of available water estimates computed by Overseer with S-Map estimates, running Overseer on a range of soils to identify unexpected estimates of nitrate leaching and denitrification, and recommending improvements in algorithms within the nutrient and hydrological modules.

Methods

Available water estimates computed by Overseer were compared with S-Map estimates. Overseer soil inputs were then tested using 31 soils covering a range of soil types under various profile drainage class, slope, and climate scenarios. Soil inputs and soil-related algorithms as documented in technical manuals were assessed and compared with expert knowledge, information that is currently available, and information that could be developed using S-Map.

Findings

There are significant differences between Overseer and S-Map estimates of available water when using Level 1 inputs. This can be improved by revising the default water content values for different soils, adding additional non-standard layers, extending the ability to use the subsoil texture group for other orders, reviewing the characteristics of organic soils, and creating a reference for topsoil texture group options so users know what the available classes mean.

When using Level 2 inputs, modelling results followed expected trends. Level 2 soil water characteristics should be used over Level 1, once these have been fully retested and Overseer has been revised and recalibrated.

There are a number of modelling issues:

- The runoff algorithm needs to represent runoff related to slow permeability of subsurface conditions more accurately;
- Overseer needs to be adjusted to take into account the effect of runoff and slope on evapotranspiration; and
- The denitrification algorithm needs to be reviewed.

Addressing these issues will require a recalibration of the Overseer model.

Other recommendations include:

- Overseer models should undergo a sensibility test using the full range of information available in S-Map;
- A formal uncertainty analysis should be undertaken; and
- Data entry forms for soil data should be redesigned for greater clarity.

3.3 MODELLING NUTRIENT FLOWS IN ARABLE CROPS

3.3.1 Dunbier, M., Brown, H., Edmeades, D., Hill, R., Metherell, A., Rahn, C., Thorburn, P. and Williams, R. 2013. A peer review of OVERSEER® in relation to modelling nutrient flows in arable crops. Report prepared for The Foundation for Arable Research.

Chair: Michael Dunbier, The Foundation for Arable Research
(Contact: https://www.far.org.nz/contact)

Objectives

Overseer was developed for nutrient management in pastoral farming. It was later enhanced to model nutrient flows in arable crops. This review investigates ways to improve its fitness for purpose in the arable sector.

Methods

The working group received technical briefings from Mark Shepherd and David Wheeler of AgResearch discussing Overseer's modelling of nutrient flows in arable crops.

Findings

The review's overall conclusion was that, while Overseer is currently the best tool for modelling nutrient losses in New Zealand, further work is required on the cropping model.

The group made a number of recommendations, including:

- Increased testing of Overseer with measured values of nitrogen leaching and estimates from other established models, and continuing to improve Overseer based on findings;
- Increased transparency in the development of Overseer by establishing a peer review process and facilitating greater stakeholder engagement in development;
- Addressing usability issues, such as improving the user interface of the crop model;
- Providing greater communication and training to users and stakeholders; and
- Reviewing the governance of Overseer.

3.3.2 Khaembah, E. and Brown, H. 2016. OVERSEER crop module testing – end of project report. Report prepared for The Foundation for Arable Research.

Lead author: Edith Khaembah
(Contact: 03 977 7340 / 03 325 969 / Edith.Khaembah@plantandfood.co.nz)

This report addressed some of the recommendations of Dunbier et al. (2013) (above) by:

- Comparing measured nitrogen balance values from three-year experimental crop rotation treatments with nitrogen balance estimates of the same treatments in APSIM;
- Re-running simulations using APSIM with 30 years of climate data to produce long-term average nitrogen leaching estimates for comparison with long-term estimates of Overseer for the same treatments; and
- Running APSIM with 30 years of climate data and Overseer (which uses 30-year average climate data) for a broad range of sol and management conditions, and comparing long-term model averages.

The comparison of measured nitrogen balance values with APSIM nitrogen balance estimates aimed to establish the accuracy of APSIM as a benchmark against which to evaluate Overseer. Results indicated that APSIM adequately estimated soil water, soil nitrogen dynamics and nitrogen leaching. It was therefore considered a suitable benchmark.

APSIM was used to simulate crop rotation treatments with 30 years of climate data to estimate long-term nitrogen leaching, soil nitrogen, drainage, and irrigation from multiple years. The same simulations were performed in Overseer. Results showed similar nitrogen leaching response patterns. However, Overseer estimated less nitrogen leaching across treatments. Values progressively decreased with years in rotation. This was associated with low estimates of soil nitrogen due to re-initialising rotations. This suggested that Overseer broke the continuity of crop rotations, thereby creating a new soil nitrogen status which reduced estimated nitrogen leaching. Overseer also estimated greater drainage and less irrigation than APSIM.

Six different crop rotations and six different locations (with different soils and climates) from 1980-2010 were simulated in APSIM and Overseer. Simulations were set up with three different initial soil nitrogen conditions. Both models were sensitive to the initial nitrogen conditions, but differed in the magnitude of the response. Across treatments, Overseer estimated less nitrogen leaching. Model agreement differed by location.

The report recommended:

- A review of Overseer's water and nitrogen balance models; and
- Broadening testing to improve prediction of nitrogen leaching for cropping systems.

3.4 PHOSPHORUS SUB-MODEL

3.4.1 Gray, C. W., Wheeler, D. M. and McDowell, R. W. 2016. Review of the phosphorus loss submodel in OVERSEER®: Report prepared for OVERSEER® owners under AgResearch core funding contract A21231(A). AgResearch report RE500/2015/050.

Lead author: C. W. Gray, AgResearch. (Contact: https://www.agresearch.co.nz/contact/)

Objectives

This review aimed to describe how phosphorus loss is currently modelled in Overseer, and identify potential gaps and opportunities which may need to be addressed to improve phosphorus loss modelling.

Methods

The review did not explicitly describe the methods.

Findings

The review found that some agricultural systems are not adequately modelled. Some components of farm systems could be considered for inclusion, or updated to improve phosphorus loss estimates.

The review recommended:

- Standardise the estimation of phosphorus loss via runoff;
- Separate reporting of phosphorus loss via different pathways;
- Consider how new features in Overseer should be evaluated (e.g. different irrigation timing, estimation of phosphorus removal in wetlands);
- Increase spatial and temporal capability;
- Increase phosphorus loss data for some agricultural systems (arable cropping, cut and carry, fodder crop) to calibrate the phosphorus loss sub-model and validate the modelling approach for these systems;
- Re-calibration with measured loss to establish how well phosphorus loss is currently being modelled (after any agreed changes have been completed); and
- Conduct sensitivity and uncertainty analysis once the sub-model has been updated.

3.5 GREENHOUSE GASES

3.5.1 Kelliher, F., Rollo, M. and Vibart, R. 2015. Desk-top review of GHG components of OVERSEER®. Draft report prepared for the New Zealand Agricultural Greenhouse Gas Research Centre. AgResearch report RE500/2015/081.

Lead author: Francis Kelliher, AgResearch (Contact: https://www.agresearch.co.nz/contact/)

Objectives

More information is needed about how well Overseer is aligned to national greenhouse gas inventory methods. This review compared Overseer's greenhouse gas emission methodology with New Zealand's Agricultural Greenhouse Gas Inventory model (NZAgInv), investigated the incorporation of greenhouse gas emission mitigation technologies into Overseer, and compared greenhouse gas emissions calculated by Overseer and the inventory methodology.

Methods

The methodology comparison involved listing the greenhouse gas emissions factors used by Overseer, calculating animal feed intake using Overseer and comparing that to results from NZAgInv, and, if necessary, making recommendations to modify Overseer's emission factors, activity data, and animal feed intake estimates.

Greenhouse gas emission mitigation technologies were listed. A desktop assessment was conducted to determine whether each could be implemented using Overseer. If not, the changes needed were investigated.

Greenhouse gas emissions were calculated using Overseer and NZAgInv and the results were compared.

Findings

Some emission factors in Overseer need to be updated. Overseer calculated a 14% greater annual feed intake for dairy cows than NZAgInv. There was not enough detail in Overseer's technical manuals for the authors to be sure of the reason; they therefore recommended greater transparency.

Eight of the ten available emission mitigation technologies could be implemented using Overseer. The exceptions were applying nitrogen fertiliser with a urease inhibitor, and applying effluent when nitrogen losses are lowest. Changes to Overseer could be made to enable implementation.

There were differences in estimated emissions between Overseer and NZAgInv. The mean methane emissions by dairy cows were 14% greater for Overseer than for NZAgInv, and the mean nitrous oxide emissions were 12% greater. The reasons for the difference were unclear; the authors again recommended greater transparency about Overseer's methodology.

3.5.2 de Klein, C., van der Weerden, T., Kelliher, F., Wheeler, D. and Rollo, M. 2017. Initial review of the suitability of OVERSEER Nutrient Budgets Model for farm scale greenhouse gas reporting. Final report for the Ministry for Primary Industries and the Biological Emissions Reference Group. AgResearch report RE450/2017/022.

Lead author: Cecile de Klein, New Zealand Agricultural Greenhouse Gas Research Centre (Contact: https://www.agresearch.co.nz/contact/)

Objectives

This review built on Kelliher et al (2015). It investigated the suitability of Overseer for greenhouse gas reporting and assessed how well it is aligned with NZAgInv.

Methods

This review assessed a number of Overseer model components using different case studies. ME requirements were assessed using the Kelliher et al (2015) case study, nitrous oxide emissions were assessed using a number of case study pastoral farms on well drained soils, and on an irrigated dairy farm with contrasting soils.

Results

The review found that Overseer had improved since the Kelliher et al (2015) review. The ME requirements estimated by Overseer and NZAgInv were similar. However, there were still some large differences in emissions factors between Overseer and NZAgInv when using Overseer's default emissions factor setting (farm-specific emission factors). If users choose annual average emission factors (same as NZAgInv) or seasonally-adjusted annual average emission factors, there is better agreement. The authors therefore recommended that Overseer change the default setting to annual average emission factors, and that emissions factors are changed to align better with NZAgInv. The other two options should be disabled and reviewed.

Future evaluation and updates of methane and nitrous oxide emissions factors should be aligned with updates to NZAgInv. They recommended that a process is created to ensure reviews of relevant research are conducted regularly, and that a calibration dataset is developed for validating Overseer algorithms. Ongoing alignment should be implemented within Oversee sub-models as well as between Overseer and NZAgInv.

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