OVERSEER MODEL SCIENCE REVIEW AND THE DEVELOPMENT PROGRAM

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Abstract

In 2018, the Parliamentary Commissioner for the Environment raised concerns about the use of the Overseer software in freshwater regulation. In response, the Ministry for Primary Industries (MPI) and the Ministry for the Environment (MfE) convened a Science Advisory Panel (SAP) to peer review the Overseer model. The SAP released their report [1] in August 2021. One of the Government responses to the SAP review and the advice from the Expert Advisory Group (EAG) was the "development of a next generation Overseer to address the issues raised by the Review Panel and ensure that it is fit for purpose as a tool to use in appropriate regulatory settings".

This paper covers the concerns raised in the SAP report and how they were addressed, as summarised in the technical paper delivered in August of 2023 [2]. We group the concerns into two categories. First, concerns raised that were addressed by clarifying misconceptions. Second, concerns raised that led to a consensus that remediation was necessary. For the latter, a programme of work was initiated in 2021 to address key concerns, namely:

1. Examining the use of daily climate data and annual simulations averaged to provide a 30-year long-term annual average;
2. A multi-layer soil hydrology sub-model that reflects soil hydrological dynamics during drainage;
3. Modelling soil nitrogen (N) mineralisation and immobilisation under arable/cropping as important processes influencing Nitrate leaching, including:
    a. Crop model updates
    b. Incorporating deeper rooted plants
    c. A series of reports examining soil N mineralisation
4. Uncertainty and sensitivity reporting on the model;
5. Model transparency.

This work programme was informed and reviewed by a Technical Advisory Group (TAG), which was convened by MPI and comprised of science experts, regional council representatives, and policy personnel from MPI and MfE.

The paper concludes with comments on how Overseer Ltd. is looking to continue to support and engage key stakeholders going forward, including scientists, rural professionals, farmers, regional councils, government and technologists.

Bruwer, M, 2024. OVERSEER SCIENCE MODEL REVIEW AND THE DEVELOPMENT PROGRAM. In: Opportunities for Improved Farm and Catchment Outcomes. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 36. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 6 pages.

Introduction

In 2018, the Parliamentary Commissioner for the Environment raised concerns about the use of the Overseer software in freshwater regulation. In response, the Ministry for Primary Industries (MPI) and the Ministry for the Environment (MfE) convened a Science Advisory Panel (SAP) to peer review the Overseer model. The SAP released their report [1] in August 2021. One of the Government responses to the SAP review and the advice from the Expert Advisory Group (EAG) was the "development of a next generation Overseer to address the issues raised by the Review Panel and ensure that it is fit for purpose as a tool to use in appropriate regulatory settings".

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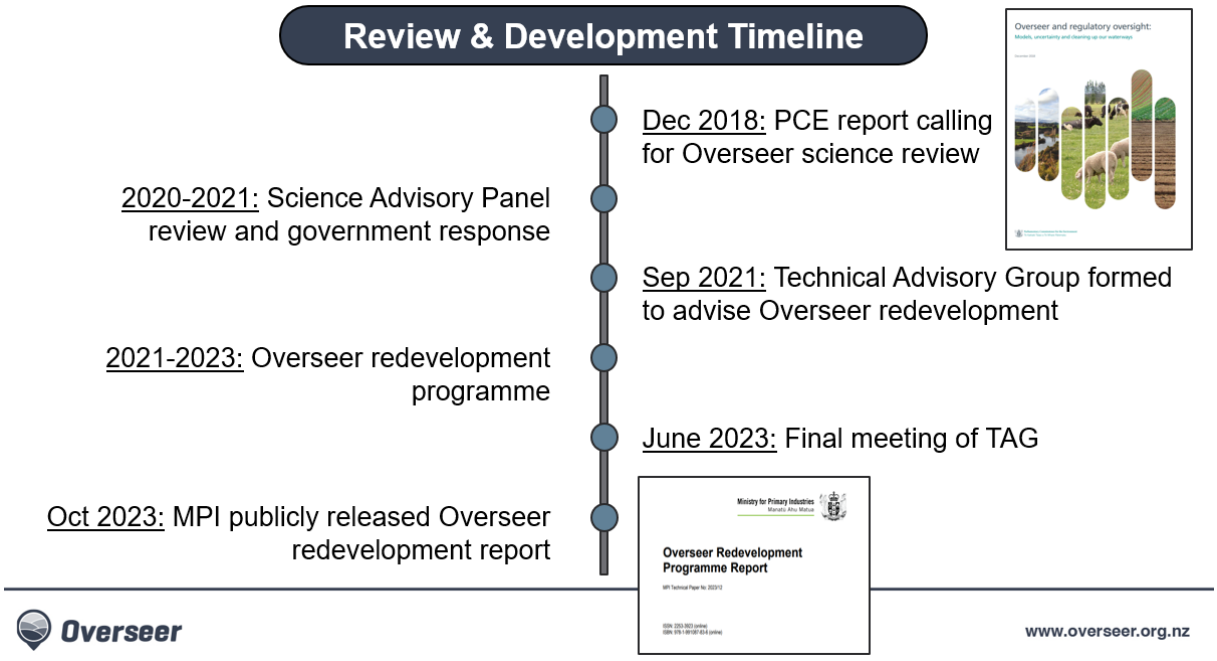

Figure 1: Timeline of Overseer science review and development program

Concerns, response and outcomes

In this section we explore the concerns raised in the science review, the response taken in each case, and details of the workstreams and outcomes that have been delivered, including ongoing work.

Climate temporal resolution

The concern was raised that the Overseer model approach of using a 30-year average temperature, potential evapotranspiration (PET) and rainfall for each month of the year provides insufficient temporal resolution.

In response, the Overseer science team collaborated with NIWA and Plant & Food Research to consider modifications. Two alternative temporal approaches were tested, namely daily average and monthly average, both as a sequential time-series that cover a 30-years time period.

No statistically significant differences in model results were found among these three temporal approaches. This finding confirmed that the existing approach of using a 30-year average temperature, PET and rainfall for each month of the year is a reasonable approach for generating reliable long-term estimates.

In addition, as part of this work, the 30-year averages for temperature, PET and rainfall were revised for the 30-year period ending in 2020 (previously were for the 30-year period ending in 2010). The geographic spatial resolution remained unchanged at 500 metres.

Soil spatial resolution

The concern was raised that the Overseer model has insufficient vertical spatial resolution, with only one soil layer down to a depth of 600mm.

In response, the Overseer science team collaborated with Manaaki Whenua Landcare Research to investigate a more detailed spatial model. A multi-layer soil model (100mm layers) was investigated for water transport (with embedded nutrients). A representative range of soil types and rainfall conditions were considered.

It was found that poorly drained soils show the greatest difference in model results between the single layer (existing) and multi-layer soil model. It was found that the k_{sat} water transport coefficients need to be updated, as well as the way impeded soil layers are modelled. Despite these opportunities for model improvement, it was found that both the existing and alternative model approaches produce results that are similar when compared to the available field data.

Deep rooted plants (DRP)

The concern was raised that the existing Overseer soil model, down to 600mm, did not adequately account for the additional nitrogen uptake plants that had roots beyond this depth.

In response, the Overseer science team collaborated with Plant & Food Research to investigate adding an additional soil layer down to 1500mm. This augmented model was compared with

simulated results from the APSIM (Agricultural Production Systems SIMulation) model, for wheat, maize, onions, and pasture. APSIM was chosen as a benchmark given its reputation as a leading crop simulation tool, in the absence of suitable field data.

This study demonstrated that deep rooted plants (i.e. > 600mm) can indeed absorb significantly more nitrogen, given the greater depth (down to 1500mm). In response, an extra soil layer from 600 to 1500mm was added to the Overseer model and published in Overseer version 6.5.0, released on 21 December 2022.

Simplify crop characterisation and expand list of supported crops

The concern was raised that the Overseer model was too complex in terms of the way crops were characterised.

In response, the Overseer science team collaborated with Plant & Food Research to review the existing crop descriptions and identify opportunities to simplify. The approach taken was to implement standard crop biomass, cover and root depth curves from planting to harvest.

This simplified crop characterization enabled a rationalization of the crop list as well as lowering the barrier to adding additional important crop types.

Overseer version 6.5.1, released 30 April 2023, delivered the simplified crop descriptions. Ongoing work at the present time includes i) the addition of new crops, and ii) improvements in the way catch crops are modelled.

Nitrogen mineralisation

The concern was raised that a more comprehensive approach is needed for modelling the mechanisms of soil nitrogen mineralisation.

In response, the Overseer science team collaborated with Plant & Food Research to commission reports on model improvements for:

- Soil organic matter
- Plant residue mineralisation
- Land use change (pasture-to-cultivation)
- Crop root biomass

These reports have been created for Overseer Ltd by science experts in these topics. Current work is to seek peer review of these reports by a complementary set of science experts. Following peer review, the Overseer science team will prioritize updates to the Overseer model to address the recommendations of these reports.

Model evaluation

The concern was raised that there was no public information on sensitivity, uncertainty and goodness-of-fit (to field data) for the Overseer model.

In response, the Overseer science team collaborated with AgResearch and Callaghan to address these items.

A model sensitivity analysis was undertaken for a wide range of Overseer model parameters. Soil type and rainfall were, not surprisingly, found to be the two farm characteristics with the greatest impact on nitrogen leaching. Overseer Ltd. published a report on this work in August 2022 [3].

Additionally, a model goodness-of-fit analysis was undertaken against pastoral and arable field data using three performance indicators recommended by Moriasi et al. [4]. These methods are (i) Nash-Sutcliffe efficiency, (ii) percentage bias, and (iii) ratio of root-mean-square-error to standard deviation of measured data. These measures found the goodness-of-fit to the field data to be 'very good' for pastoral and 'satisfactory' to 'good' for crops in Overseer version 6.5.2, as outlined in a report released in August 2023 [5]. The goodness-of-fit for pastoral systems was further improved by the model update included in Overseer version v6.5.4, released in December 2023.

Model evaluation and improvement is an ongoing initiative by the Overseer science team. We welcome collaboration with researchers that are doing relevant field trials. Contact us via science@overseer.org.nz.

Model transparency

The concern was raised that technical descriptions of parts of the Overseer model were not publicly available.

In response, the Overseer science team collaborated with AgResearch to publish a comprehensive set of Technical Manual Chapters (TMCs) that detail all components of the Overseer model. These are now publicly available on the Overseer website [6]. There is also an ongoing initiative to update these TMCs as new science is added to the Overseer model.

In parallel, a project is currently underway to produce a conceptual-level technical model description to aid understanding for all interested stakeholders. A key aspect of this document is to help users and scientists across different disciplines understand the complex interactions between the sub-model components (hydrology, soil, crops, animals, etc.).

A simplified model architecture diagram is also available on the Overseer website [7].

Looking to the future

Overseer Ltd is committed to improving accessibility of the Overseer model to aid engagement and mutual benefit between Overseer and the science community. In support of this we have priced the work to rewrite the model code as a modern, modular architecture that is easier to understand, maintain and extend. This code modernisation exercise is a common need in multiple industries where a model code has been developed organically over a few decades.

The Overseer science team continue to build strong collaboration with key agricultural scientists across New Zealand and overseas, helping to boost the quality and speed with which the Overseer science model continues to develop.

In conclusion, the Overseer science model review and development program has set the stage for a strong future of the Overseer model contributing to the advancement of farming practices in New Zealand such that agriculture and the environment can thrive together. As a for-purpose, not-profit organization, the team at Overseer Ltd are passionate about our role in this future.

References

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[7] Overseer Model