OVERSEER® NUTRIENT BUDGETS: SELECTING APPROPRIATE TIMESCALES FOR INPUTTING FARM MANAGEMENT AND CLIMATE INFORMATION

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Introduction

There has been considerable discussion on selecting the most appropriate timescales for data input to the OVERSEER® Nutrient Budgets (*Overseer*) model. Initial views on this issue have been included in the *Overseer* Best Practice Data Input Standards (Overseer Management Services, 2013). However, there is still uncertainty on the timescale of key input data. Much of this uncertainty has centred on the meaning of the term 'long-term annual average'.

The term 'long-term annual average' can be traced back to the original development objectives for *Overseer*. These included: being New Zealand wide; being farm specific; using data that farmers had, or suitable defaults were available; and being fair and equitable. However, the timescale of the input data has never been categorically stated. This leads to questions such as: 'Should I use annual management data or the average of three years', or 'How many years should I average data over', etc. This question is surprisingly hard to answer as there are a limited amount of short to medium duration experimental data on which to base a robust assessment.

This paper provides tentative recommendations for the use of different timescales for the input data. The factors that were considered when making the recommendations are described first. This paper focuses primarily on the nitrogen (N) outputs, and in particular N leaching.

Timescale in *Overseer*

When considering the implications of the operational timescale of the model, the following factors were identified as important: climate data, climate patterns, farm management practices, the N leaching model and the calibration process.

Climate data inputs and patterns

As the model has evolved, the use and importance of climate data within the model has changed. This is because *Overseer* now uses a monthly time step in the N model, and a daily time step in the hydrology model. To accommodate this, two categories of climate data therefore need to be considered: annual input data and climate distribution patterns.

Annual climate data inputs include rainfall (mm/year), potential evapotranspiration (PET, mm/year) and average temperature (°C). Rainfall is a compulsory input as it is an important driver of drainage and N cycling, and it is generally known. Total annual PET (mm/year) and average annual temperature have default values based on long-term data for the region or nearest town, as these are less well known. However, there are also menu options to enter/modify these.

Critically, annual data are expanded to a monthly or daily distribution using modifiers derived from the underlying climate patterns within the *Overseer* database. The methodology is described in detail in the Technical Manual Chapter on Climate (Wheeler, 2013). For rainfall and temperature, the annual value is distributed to monthly values based on monthly 30-year (1971-2000) data for the region or nearest town. Daily rainfall pattern and monthly PET are based on climate modifiers, which are categorical selections for range and seasonality that have default values based on the region. However, the seasonality can be further modified on the climate input page. The default distributions are all based on 'long-term' annual averages.

In summary, the user must enter annual rainfall but can optionally enter temperature and PET to replace default values. Monthly patterns for rainfall, temperature and PET data are based on regional long-term average values and their use needs to be considered carefully when deciding on the timescale for use of *Overseer*.

<u>Farm management</u>

Overseer assumes that inputs are in quasi-equilibrium with production (Wheeler and Shepherd, 2013). A consequence of this is that the transition periods cannot currently be modelled, for example changes in the farm system in a dairy conversion, or moving from conventional to organic farming. Thus, the model produces an annual nutrient budget assuming that management is constant over time.

In practice, farm management changes with seasons, and systems also evolve over time. Research trials tend to attempt to have more constant management systems than most commercial farms. In addition, they tend to focus on a narrower period; for example, treatments in a research trial may be grazed six times per year only, whereas *Overseer* models a block that has animals grazing every day. This and the paucity of medium- to long-term research trials where nitrogen leaching was measured (Watkins and Shepherd, 2014) means that we do not have research data to evaluate the effects of different input timescales for management data on model outputs.

<u>N leaching model and the calibration process</u>

Management and climate input data both influence the estimation of N leaching. The largest source of N leaching in pastoral systems is the urine patch. The amount of urine N deposited on a block is largely dependent on farm management, for example, the number of animals, animal production, feeding regime, and the use of wintering, feed, or standoff pads. The proportion of the N deposited that is leached is estimated using a transfer function (Cichota *et al*. 2012) driven by drainage, in combination with estimates of other N removal processes (e.g., ammonia volatilisation, pasture N uptake), which are all influenced by climate. Thus, it is important to have a reasonable representation of climate, both in terms of annual amounts (e.g., rainfall, and PET) and distribution through the year, since the N model is structured using a monthly time step calculation process.

Field trials used in the calibration of the N model have been typically conducted for 2 to 5 years duration (Watkins and Shepherd 2014). This provides challenges because these data cannot be considered long-term and the run of years is unlikely to adhere to the long-term climate distribution patterns within *Overseer*. The following procedure has therefore been used when evaluating field trials against the model. *Overseer* was set up so that the estimated annual drainage was the same as values reported in the experiments. Default (long-term) climate patterns were used because these are embedded in *Overseer*. Management data were inputted for the experimental period, with care taken to align field trial managements with the farm system inputs *Overseer* requires. Field trial management is usually constant over the experimental period, so average and within-year (annual) managements are therefore similar. Measurements of annual N leaching are aggregated into an experiment mean for comparison with *Overseer* estimates. By averaging annual inputs and outputs, the evaluation process is as similar as possible, to using average management data with average climate data for the site.

Tentative recommendations

The user needs to consider the interaction of three data sources when determining the most appropriate timescale for input data. These are: timescale for management data input, timescale for climate data input and the timescale used to determine the distribution of the climate data (climate pattern). Tentative recommendations for the use of 'annual' and 'average' data are shown in Table 1. There is a limited amount of evidence to support definitive conclusions at this stage. However, the tentative recommendations are based on the following principles:

- Inputs must be consistent with a realistic farm system and specifically that farm management inputs reflect climate data and climate patterns.
- Climate data and climate patterns should be consistent.

Table 1. Tentative recommended combinations for data input timescales. Tick = recommended; cross = not recommended.

Management	**Climate data**	**Climate pattern**	
		Average	**Annual**
Average	Average	✓✓	✗
Average	Annual	✗	?
Annual	Average	✓	✗
Annual	Annual	?	?

<u>Average management, average climate data and average climate pattern inputs</u>

This option is appropriate when *Overseer* is used in a 'predictive' mode, for example to answer questions such as: 'What would the future long-term annual N loss be with this management and level of productivity'. The input data would be predicted annual average data over a user-defined period. The calibration of the N leaching model fits reasonably closely with this option. Maintenance fertiliser nutrient recommendations also fit reasonably closely with this option.

This option can also be used in a long-term 'monitoring' mode, where assessment of farm discharges over many years is required. This would use previous years' management data. It is unclear what the required period is to average input data, for example, should management data be averaged over 3, 5 or 10 years? There is also uncertainty about how to 'average' management data, particularly inputs such as stock numbers or supplement feeding. The time period is dependent on the year-to-year variability that occurs in farm and biological systems, and as noted earlier, there is insufficient experimental data to make a robust recommendation on what the most appropriate time period should be. At this stage, we suggest averaging over a minimum of five years for the predictive mode, and 3-5 years for the monitoring mode. Further work is needed to better define options and implications for averaging.

Annual management, average climate data and average climate pattern inputs
This option is typically used as a means of collating annual management data to estimate average outputs when the results are aggregated over a number of years. This option uses a previous year's management data. However, great care is required, particularly to avoid inconsistencies between annual management data and average climate data or patterns. An example of this is if monthly irrigation application rates are entered. The use of rates applied in either wet or dry years with average climate data can lead to over- or underestimation of outputs. Procedures aimed to minimise this risk are given in the *Overseer* Best Practice Data Input Standards (Overseer Management Services, 2013).

For this option, it is clear that a single year's management data should be used with great caution. At this stage, we suggest using a minimum of 5 years of model estimates to calculate an average output, for example, an average or a 5-year rolling mean.

Annual management, annual climate data and average or annual climate pattern inputs

This option could potentially be used in an annual monitoring role. This approach would typically use the previous year's management and climate data. Annual rainfall, PET, and temperature can be entered, for example. However, it is not currently possible to apply the actual annual climate patterns; if the analysis year is significantly different from the long-term climate pattern, model estimates of N leaching will differ from actual leaching losses.

Other options
Average management and annual climate data should not normally be used because the two sets of data would generally be inconsistent.

Conclusions

This paper identifies key principles that *Overseer* farm management inputs must be consistent with both a realistic farm system and with the climate data and climate pattern. As a consequence, the option of 'average management, average climate data, and long-term climate pattern' is considered appropriate when *Overseer* is used in a 'predictive' mode. The option of 'annual management, average climate data, and average (long-term) climate pattern' is also considered to be a viable option for use in a 'monitoring' mode. However, great care is required to avoid inconsistencies between the annual management data and average climate data or patterns.

The choice of management and climate input options has to be fit for the purpose for which model output is being used, and it is important that data timescales are not mixed, e.g. using average numbers and annual production. More work is required to further refine these recommendations, and particularly to identify an appropriate period over which input data should be averaged.

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