AGRICULTURAL PRODUCTION SYSTEMS SIMULATOR

APSIM 7.5 Training Manual

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Introduction to Apsim UI

Welcome to the first training module for the Agricultural Production Systems Simulator (APSIM). This first module will introduce you to the Apsim User Interface (Apsim UI) and take you through the process of building, running and graphing a simulation.

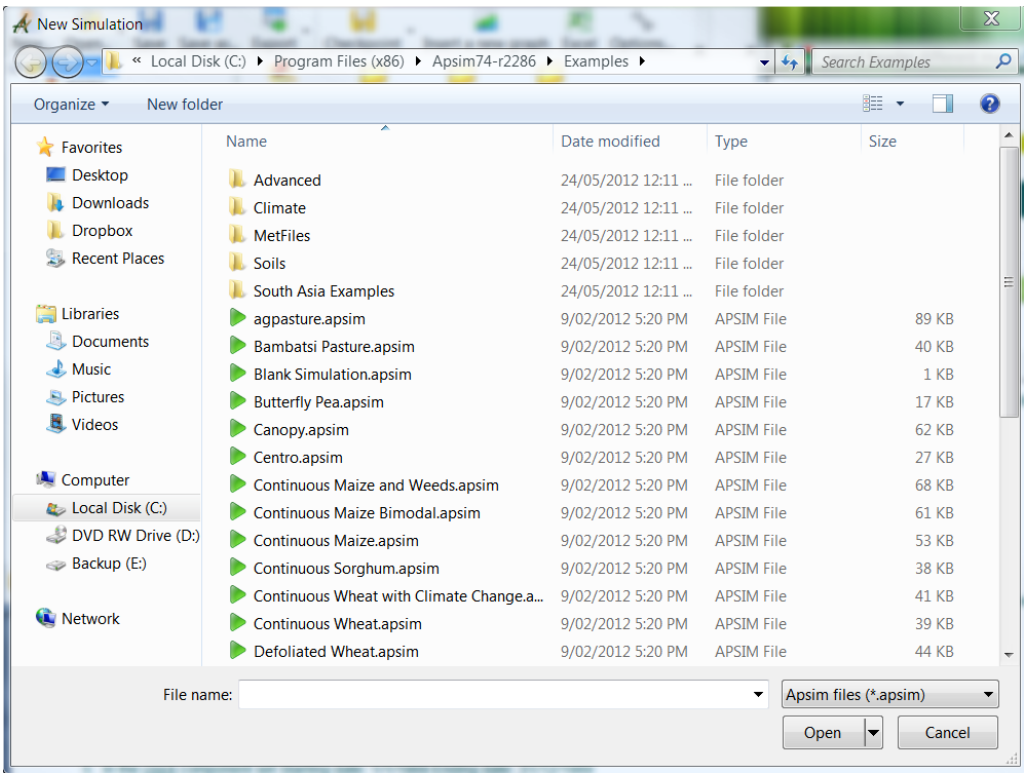
The Main Toolbar

The primary buttons that you will be working with are highlighted above. They generally do what you would expect and will be examined in more detail below. The dimmed ones contain more advanced features that are not looked at in this module. Briefly, Export allows you to export a graph in a number of formats. Checkpoint creates a snapshot of a simulation allowing you to do before and after comparisons or to revert a change. Insert a new graph brings up the add new graph wizard. Excel allows you to export output files as comma delimited text files. Factorials are an advanced topic that will be looked at in a separate module. Run on cluster is for those people with access to the Toowoomba HPC cluster. Help directs you to the local help files; however there are a number of support options that are discussed in a separate module.

Exercise: Fallow Water Balance

We will create a simulation that examines the water balance over time in a fallow field in two locations with different soil types.

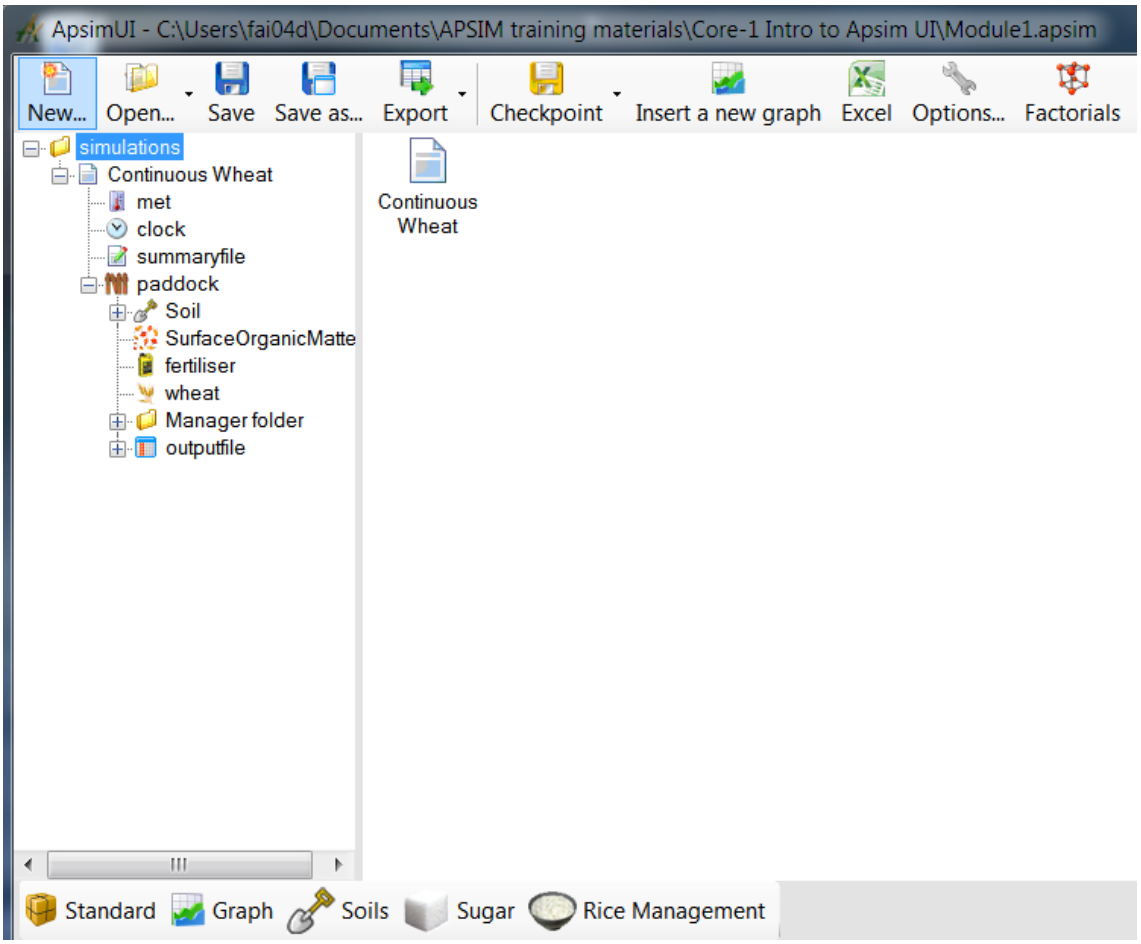
1. Press the new button to create a new simulation. You will be presented with the following screen:



Because all simulations generally share the same base components, we do not recommend starting from scratch. The best method is to choose the simulation closest to the one you want to build then modify it. For the purpose of this exercise we will use the Continuous Wheat simulation. Click “Continuous Wheat.apsim” then click Open.

2. Click Save. Save the file as `Module1.apsim`.

You will now see the new simulation loaded.

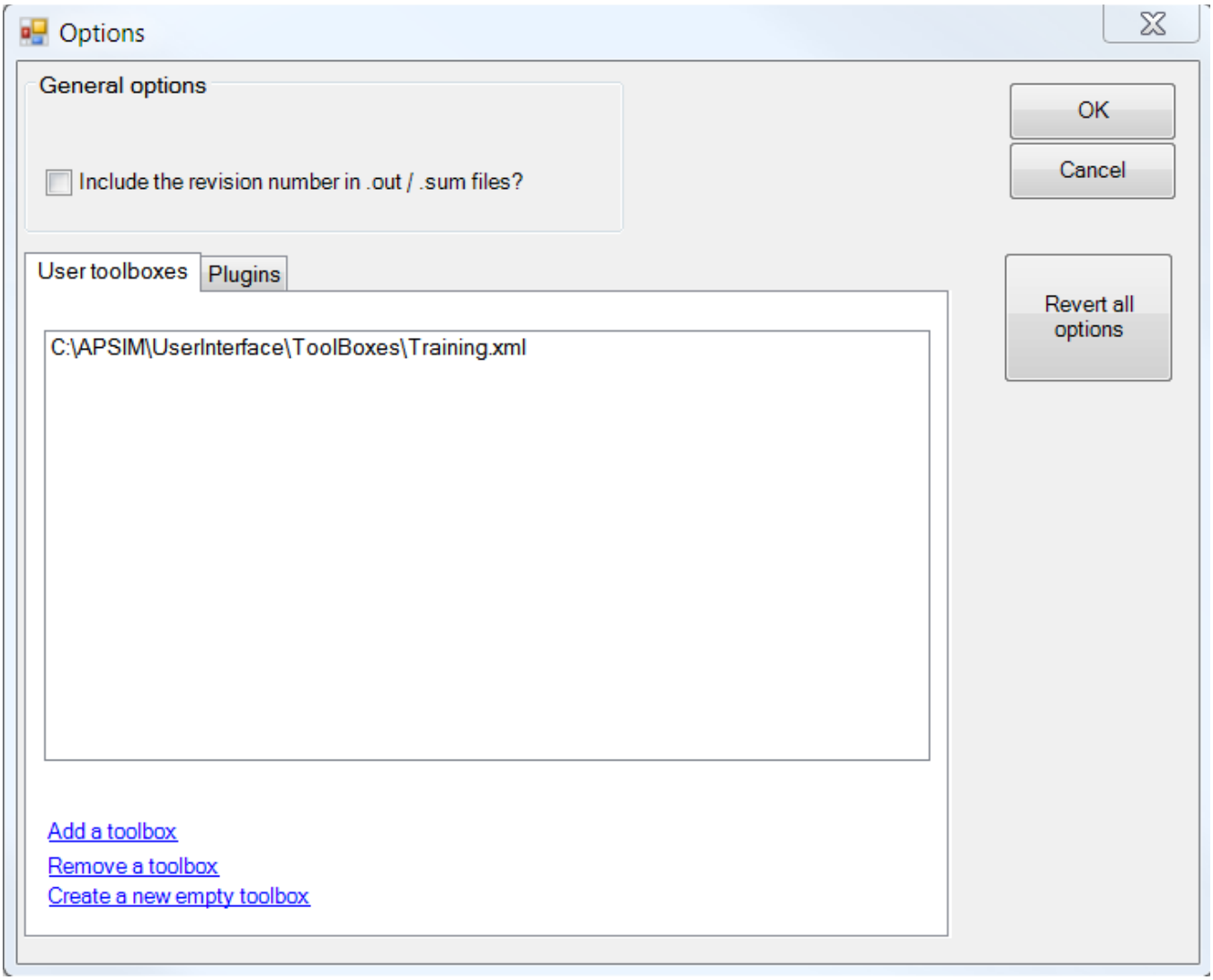


The Apsim UI consists of four panels; the main toolbar at the top, a simulation tree on the left that lists all the components in the loaded file, a module properties pane on the right and a bar at the bottom that lists available toolboxes.

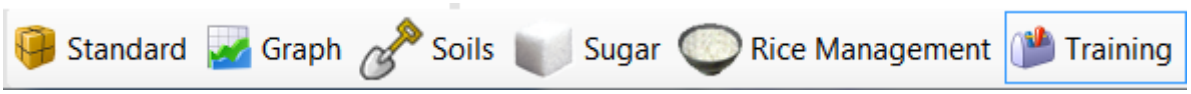
The Toolbox

All available components in Apsim are included in toolboxes. Whenever you need to add a new component to your simulations you will find it in one of the toolboxes along the bottom of the screen. It is possible to add your own toolboxes; for instance, you might have a few components that you use often and want to make them easier to access. Maybe you've written some scripts that you would like to share with a colleague. Or perhaps you have customised some of the standard components and wish to reuse them. We are going to load a pre made toolbox to make it easier to access some soil data.

3. Click the options button. Click on "Add a toolbox". Navigate to your APSIM installation folder (by default it will be in `C:\Program Files (x86)\APSIM 7.5`), then open the UserInterface\Toolboxes folder. Click `Training.xml` and click Open. You should now see the following (your path will be different):



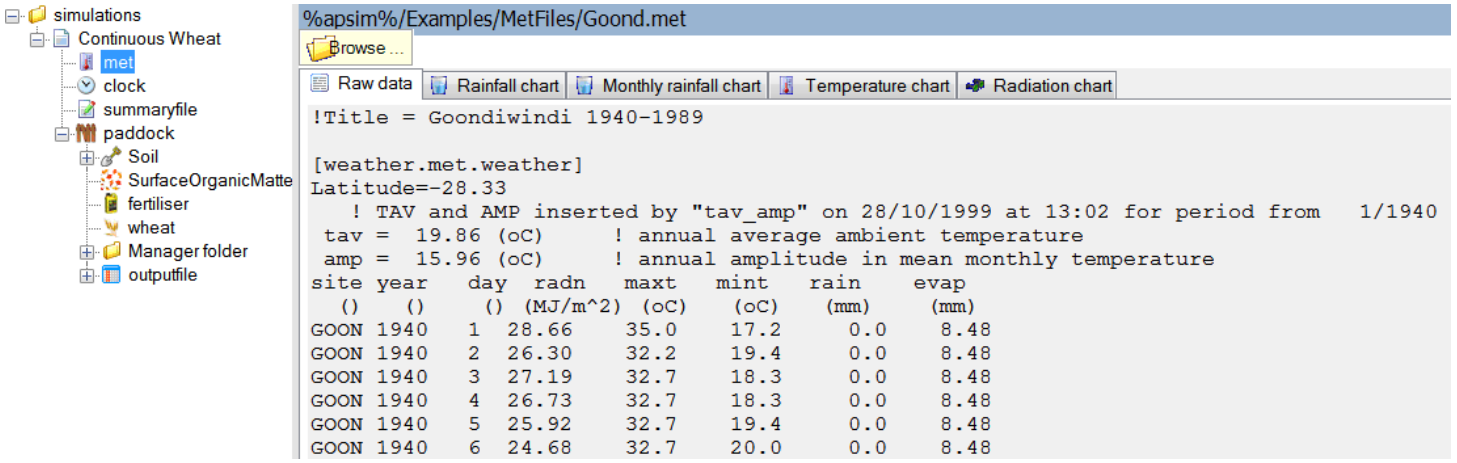
Click OK and you will see the new toolbox in the toolbox bar at the bottom of the APSIM window.



You can add your own components by dragging and dropping from a simulation. You can also copy them directly from another toolbox.

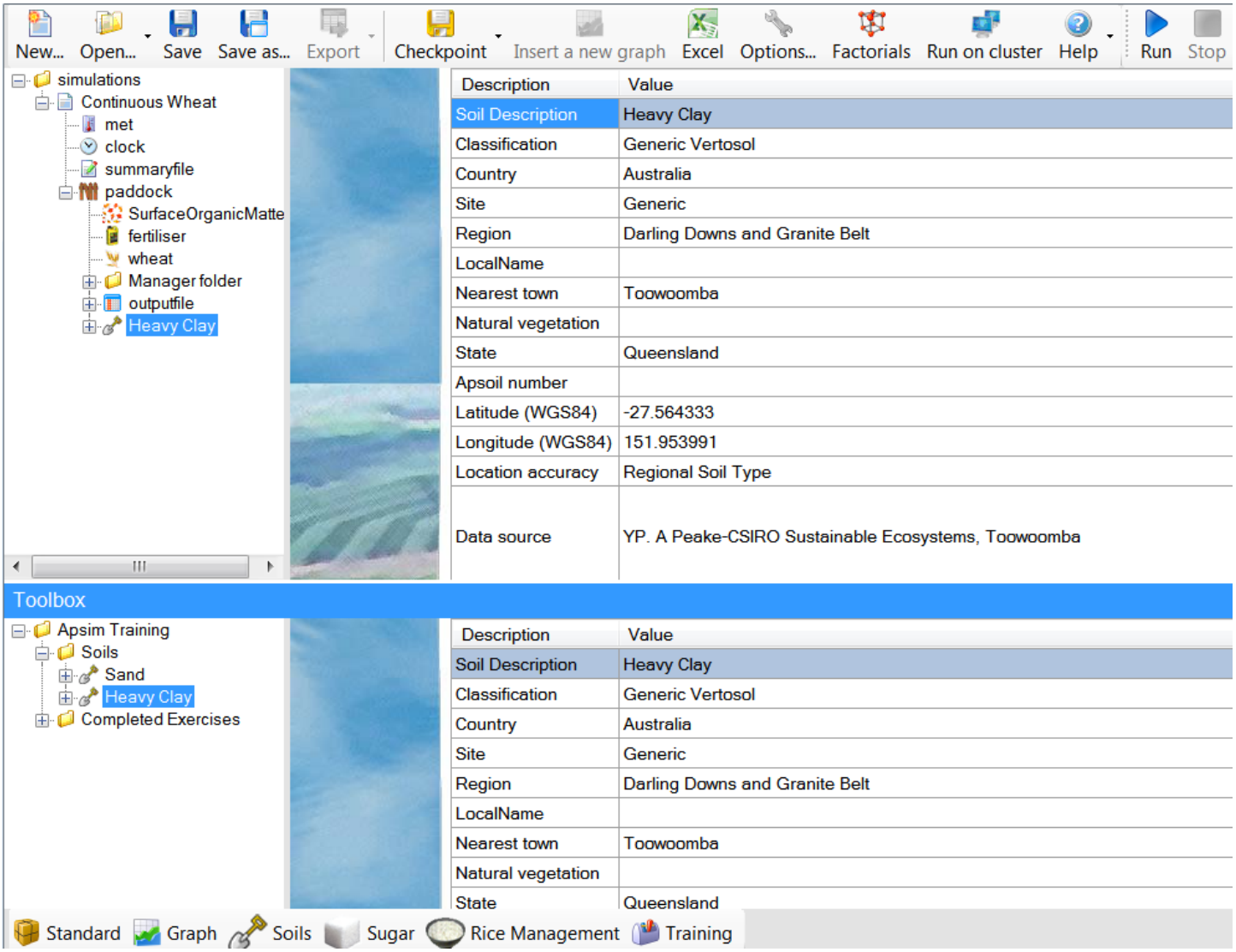
Building a simulation

4. First we will make sure we're using the right weather data. Click the met component in the simulation view. You should be able to see weather data for Goondiwindi loaded.



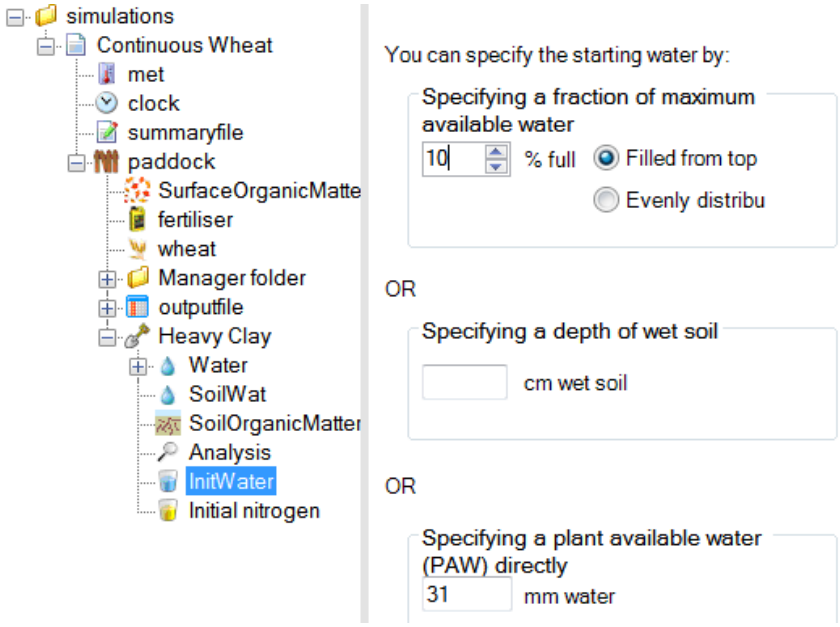
5. Next we'll set the start and end dates for the simulation. In the clock component, set the start date to 1/1/1989 and the end date to 31/12/1989.

6. Now we're going to change the soil. Click the Soils toolbox that you loaded earlier. Drag the Heavy Clay soil node from the toolbox and drop it on the paddock node in your simulation.



7. Delete the old soil by clicking it and pressing delete. You can reorder components by right clicking and choosing Move Up/Down.

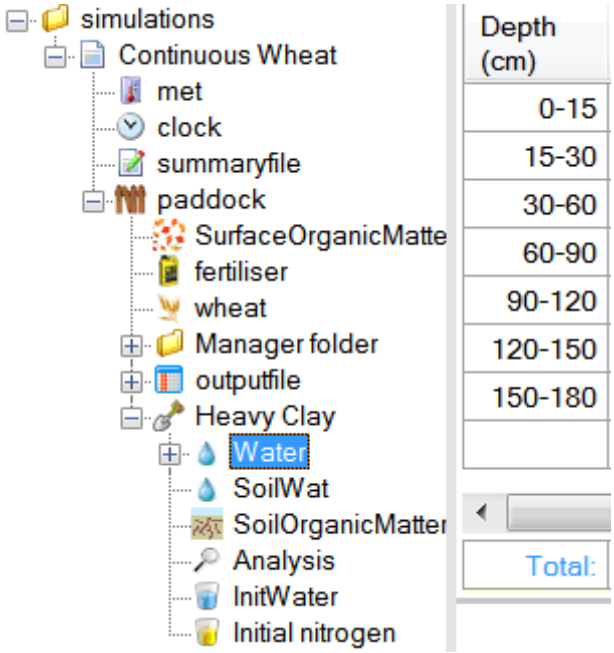
8. Expand the new soil node and click Init Water. Make sure "Filled from top" is selected and set the fraction available to 10%.



9. Click the Initial Nitrogen component and set the starting NO_3 to 50.34 kg/ha and starting NH_4 to 3.23 kg/ha. We'll spread it evenly through the entire soil profile. First, we need to tell Apsim that we want to work in units of kg/ha, not ppm. You can change units by right clicking the column header. Change NO_3 and NH_4 to kg/ha.

Depth (cm)	NO3 (kg/ha)	NH4 (kg/ha)	SW (mm/mm)
0-10	50.340	3.230	0.000

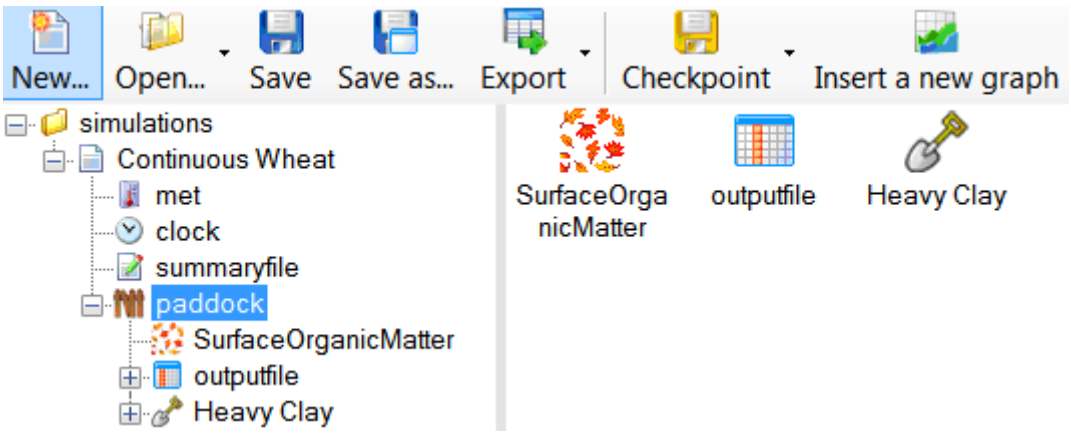
10. We wanted the nitrogen spread evenly through the entire soil profile. To find out how deep the profile is, click the Water node under Soil.



We can see the soil profile is 180cm deep and is split into seven layers. Go back to the Initial nitrogen node and change Depth to read 0-180.

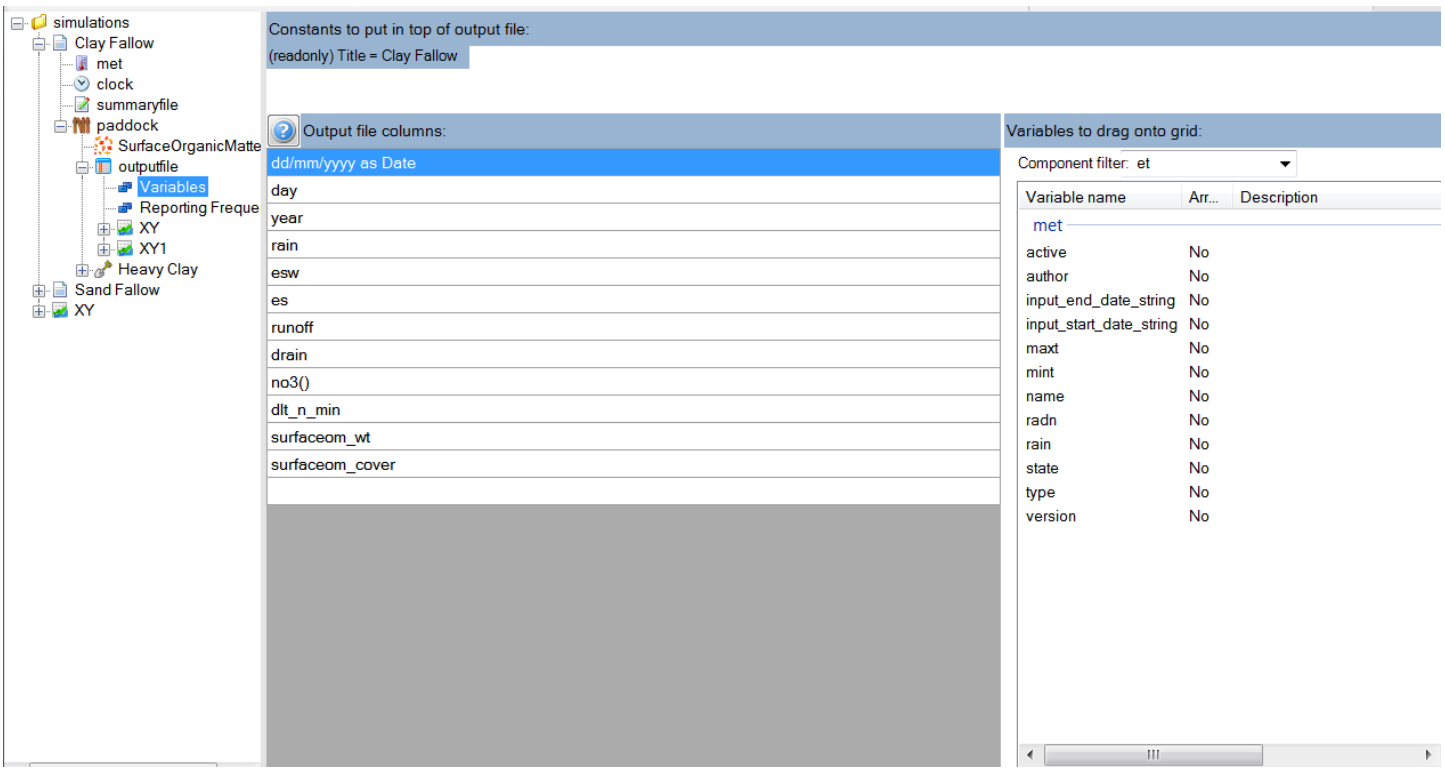
11. In the SurfaceOrganicMatter node, check that the "Organic Matter type" is wheat and the "Initial surface residue" is 1000 kg/ha. This means we start the simulation with 1000kg/ha of wheat stubble on the surface. This will decay over time putting nutrients back in the soil. It will also reduce surface evaporation.

12. Delete the Fertiliser, Wheat and Manager components as we do not need them for a fallow simulation. It should now look like this:



13. Rename the simulation. To do this, right click Continuous Wheat and choose "rename". Type in "Clay Fallow".

14. Results for the simulation are found in the "outputfile" node. This is also where you set what variables you want reported and how often. Click the "outputfile" node and delete all the default variables except the first one.



There are two ways to enter new variables. You can type them directly into the "Output file columns" list or select them (double click or drag) from the pane on the right. This pane shows all the available variables for the chosen component. You can change their order in the list by right clicking and choosing move up/down.

Enter the following variables to report:

Component	Variable name	Description
Clock	day	
	year	
Met	rain	
Soil (Heavy Clay)	esw	Extractable soil water (mm)
	es	Evaporation
	runoff	
	drain	Drainage
	no3()	Summed over the profile. To sum over the soil profile put an opening and closing bracket () next to the name of the variable in the variables list. (click "?" button next to variable list for more info)
	dlt_n_min()	summed over the profile - N mineralised
Surface organic matter	surfaceom_wt	Weight of all surface organic materials.
	surfaceom_cover	Fraction of ground covered by all surface organic materials.

15. Click “Reporting Frequency” to specify how often you want the variables written to the output file. You can choose a regular interval such as every day or once a month/year, etc, or you specify an event. For instance you might want to output on sowing, harvesting or fertilising. You can have multiple events in an output file but this will result in duplicated writes if a day meets both criteria.

For this simulation we want to output daily so delete “harvesting” (there’s no crop to harvest so it would never write) and type in “end_day”.

16. We’ve finished building the simulation. Click the “Run” button on the main toolbar.

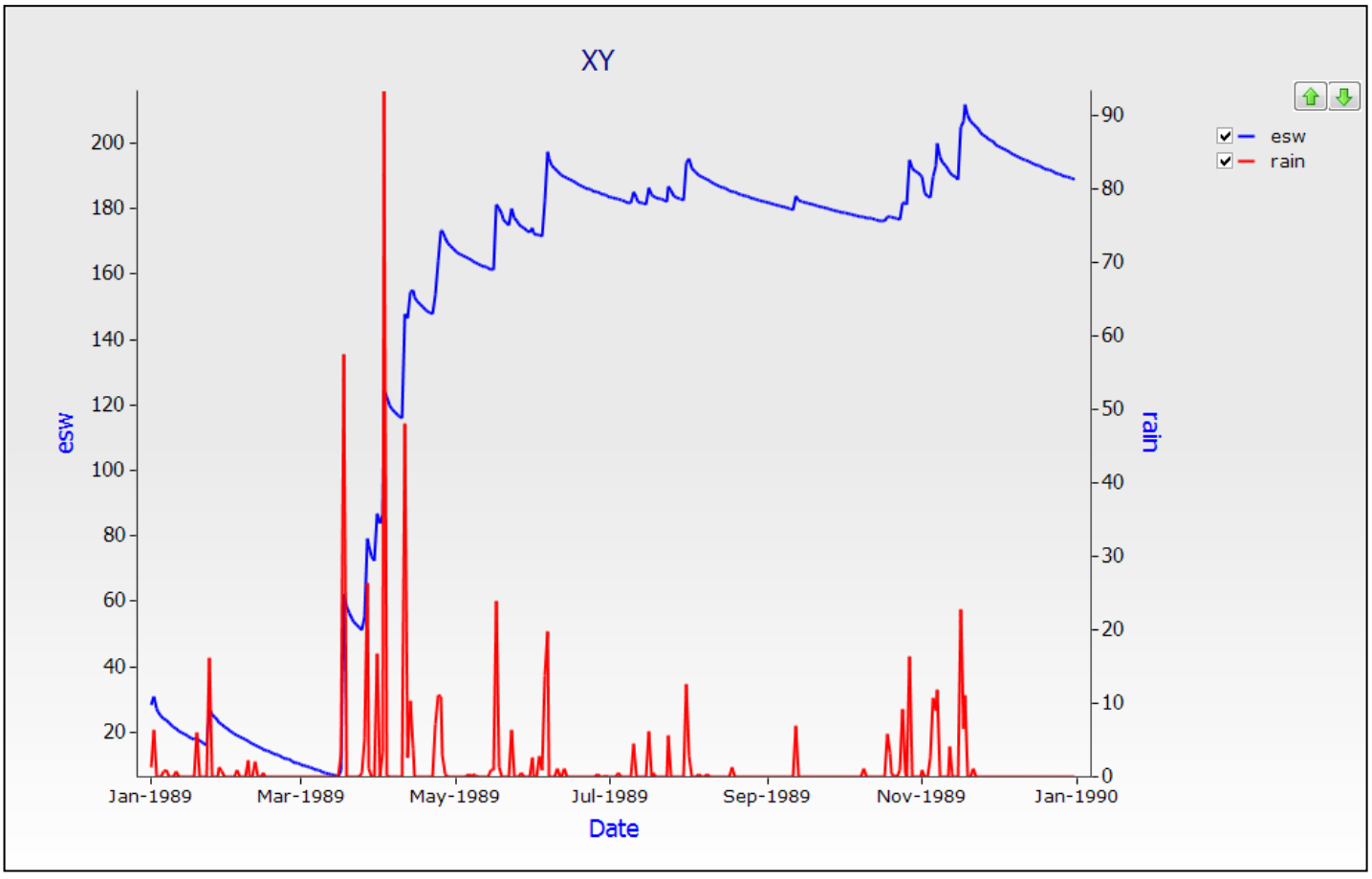
17. Once the run is complete, click the “outputfile” component to view the results. This is just a text file so you can easily import it into other programs for analysis. It will be saved in the same directory your simulation is in with the file name being <simulation_name>.out. If there is no file available it means the run failed. Check the “summaryfile” for errors.

Creating a Graph

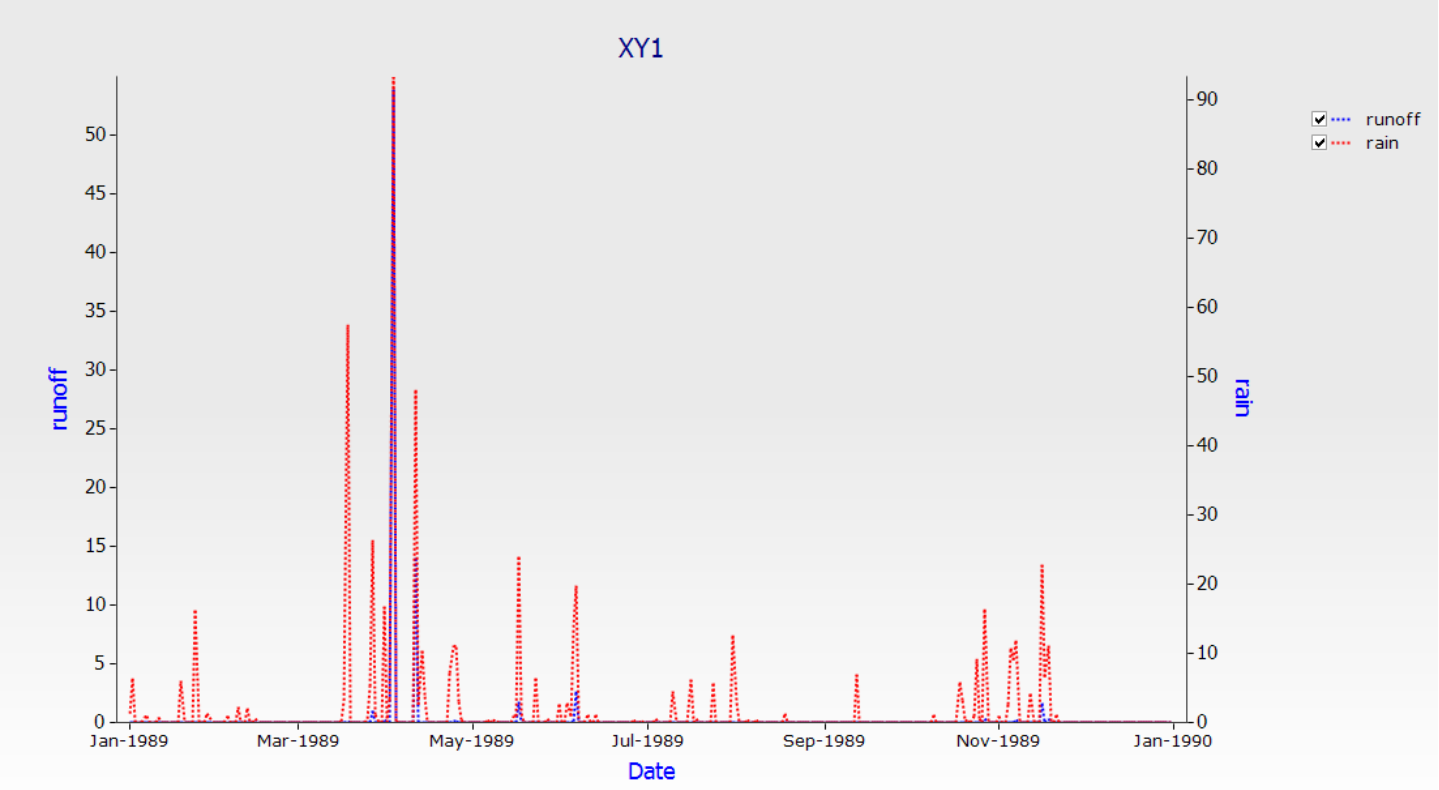
Apsim has the ability to do basic visualisation and analysis right in the user interface. Let's use the inbuilt APSIM graphs to display the output file in a graph.

We will create a graph of Date vs ESW and Rain(Right Hand Axis).

1. To do this Click on the Graph toolbox to open it.
2. Expand the Graph folder then the Graphs folder. (Click on the "+" symbol next to the Graphs folder to expand the node.)
3. Then drag in an XY component onto the output file in your simulation.
4. Expand the XY component.
5. Click on the Plot sub component.
6. Now in the Plot window click on the "X variables" square to make sure the background of the square is pink.
7. Now click on the "Date" column heading. It should appear in the list in the square.
8. Now click on the "Y variables" square to make its background pink.
9. Then click on the esw column heading, then the rain column heading. They should be added to the list in the square.
10. Now to make "rain" appear on the right hand axis, click rain in the square to highlight it, and then right click on it.
11. In the popup menu click on "Right Hand Axis".
12. Now we want a nice clean line to be plotted with no points so now under "Point type" choose "None".
13. Now just click on the top level XY component to view the graph. The graph should show the ESW (in mm) increasing with day of year. The sudden increases are due to rainfall events and the declines to evaporation and drainage loss. Daily rainfall will show this more clearly.



Try to create a graph of Date vs Runoff and Rain (right hand axis). Change the graph type to "dot line" and set the point type to "none. Tip: you can copy a graph by dragging it to the node where you want it to appear. Try copying your graph to the outputfile node and then edit the new one. To delete a variable, click it and press delete. It should look like this:



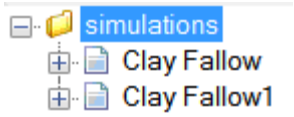
Where is the excess water going?

You can zoom in on a specific area by dragging a box down and to the right. To zoom back out simply drag in the opposite direction.

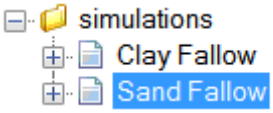
Comparing Simulations

Quite often you will want to examine differences between multiple simulations. Let's examine the effect of runoff on the water balance of two different soil types. To do this, we'll copy our simulation to create a new one exactly the same.

1. Drag the Clay Fallow node up to the top simulations node.

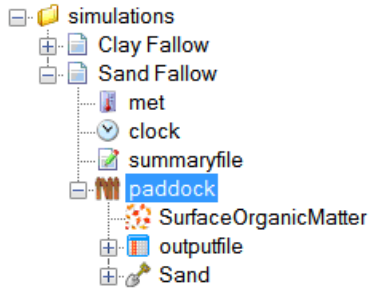


2. Rename this new simulation "Sandy Fallow"

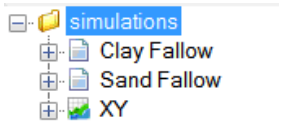


3. Drag the Sand soil from the Training toolbox onto the paddock under the new Sand Fallow simulation.

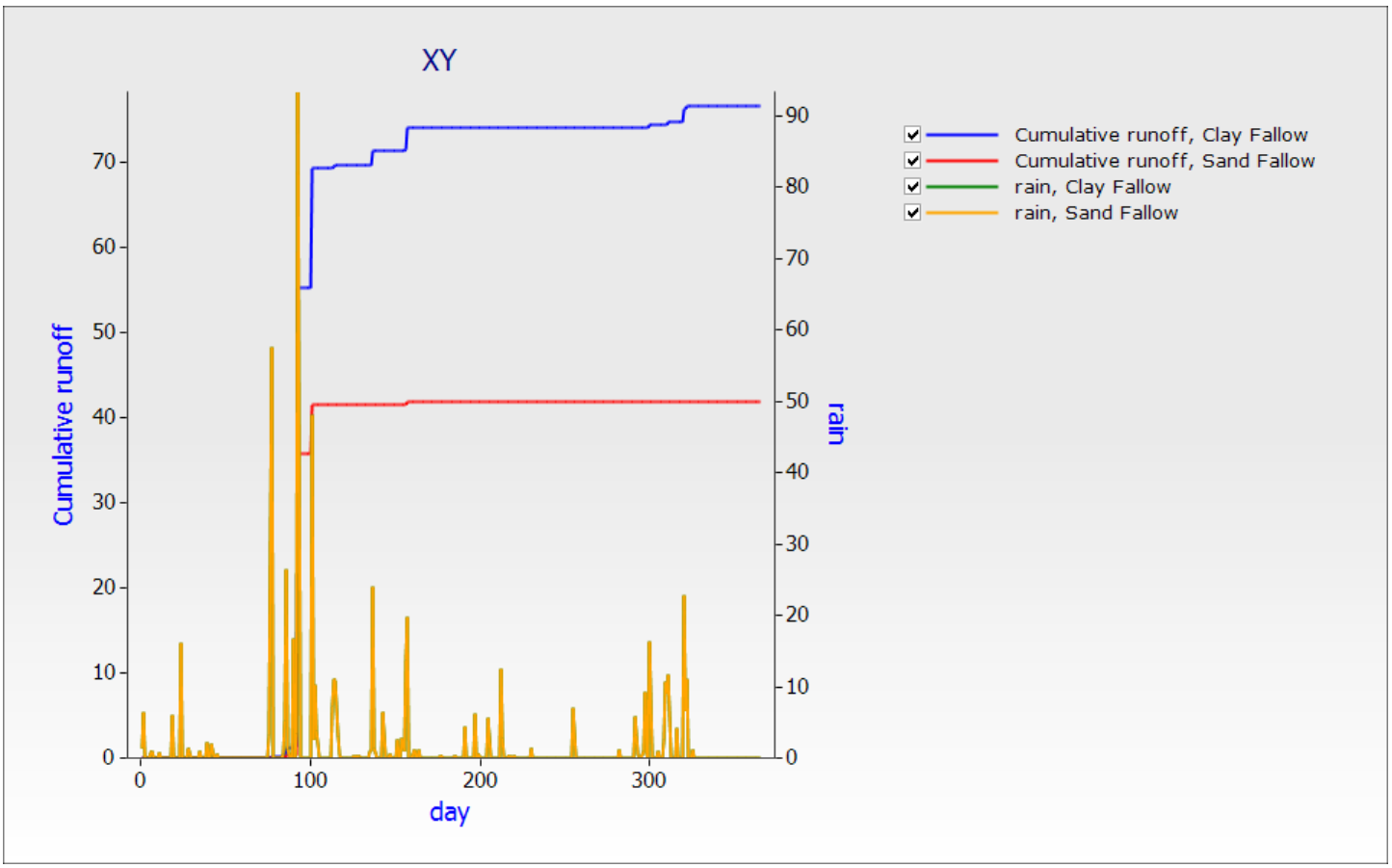
4. Delete the Heavy Clay soil. We do it in this order as other components that reference the soil would lose their link if there is no soil component. If this happens you'll need to set them again.



5. Since we have a new soil we need to set initial Water and Nitrogen again. Water 10% filled from top. NO_3 to 50.34 kg/ha and NH_4 to 3.23 kg/ha.
6. Run Apsim.
7. Graph both simulations together by dragging an XY graph onto the top "simulations" node in the tree.



8. Create a graph of day vs. runoff(cumulative) and rain (right hand axis). To make runoff cumulative, use the same procedure as for right hand axis, only select "cumulative" from the pop-up menu. Set point type to "none".



What factors influence runoff?

Surface Organic Matter

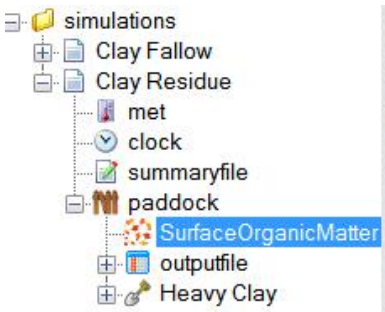
Exercise 2: The Effect of Residue Cover on Soil Water Storage During Fallow

Tracking the Decline of Cover as Residues Decompose.
APSIM simulates the influence of crop residues on the efficiency with which water is captured and retained during fallows. Residue cover declines as residues decompose.

Residue decomposition is simulated in APSIM in response to weather, as well as the chemical composition of the residues. By doing this simulation you will reinforce skills learned in previous exercises and learn to do some basic editing of default values to "customise" your simulations.

This module assumes you have read and walked through the previous module: Introduction to APSIM UI. It will introduce you to the Surface Organic Matter module and demonstrate how surface residue decomposes over time.

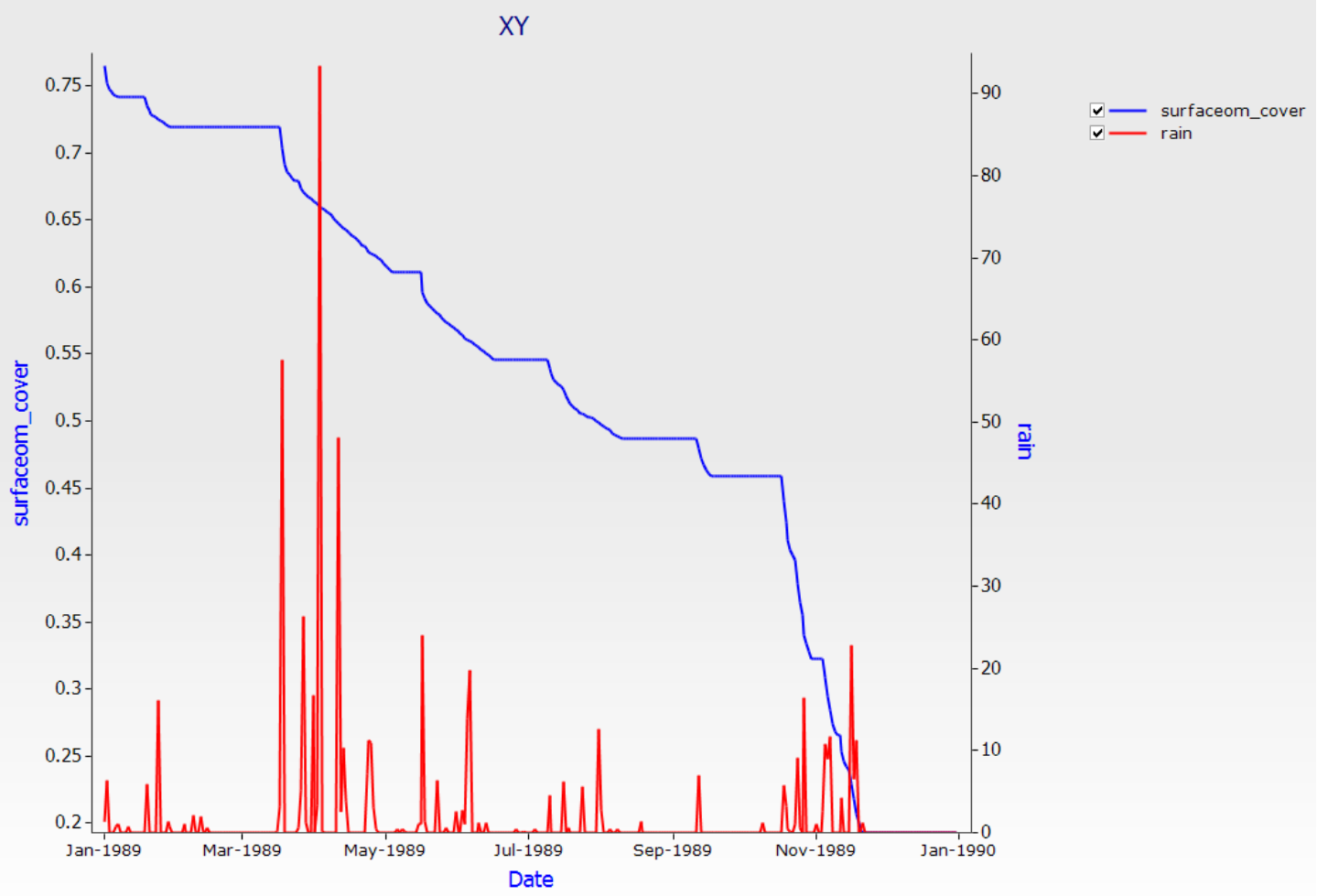
1. For this module we will use the simulation we created in module 1 as a base. There is also a completed example in the training toolbox if you would prefer to use that. Open the file `Module1.apsim`.
2. Save the file as `Module2.apsim` in the Core 2 –Surface Organic Matter folder. Remember to use “Save As” not “Save” or you will overwrite the old file.
3. Remove the “Sand Fallow” simulation. We’ll use “Clay Fallow” as the starting point. Remove the graph.
4. Make a copy of “Clay Fallow” by dragging it to the simulations node in the tree
5. Rename this new simulation to “Clay Residue”.
6. Expand the new simulation then expand the paddock node. Click the SurfaceOrganicMatter module and change the initial surface residue to 3000 kg/ha.



Description	Value
Organic Matter pool name	wheat
Organic Matter type	wheat
Initial surface residue (kg/ha)	3000
C:N ratio of initial residue	80
Fraction of residue standing	0

7. Run the simulations.

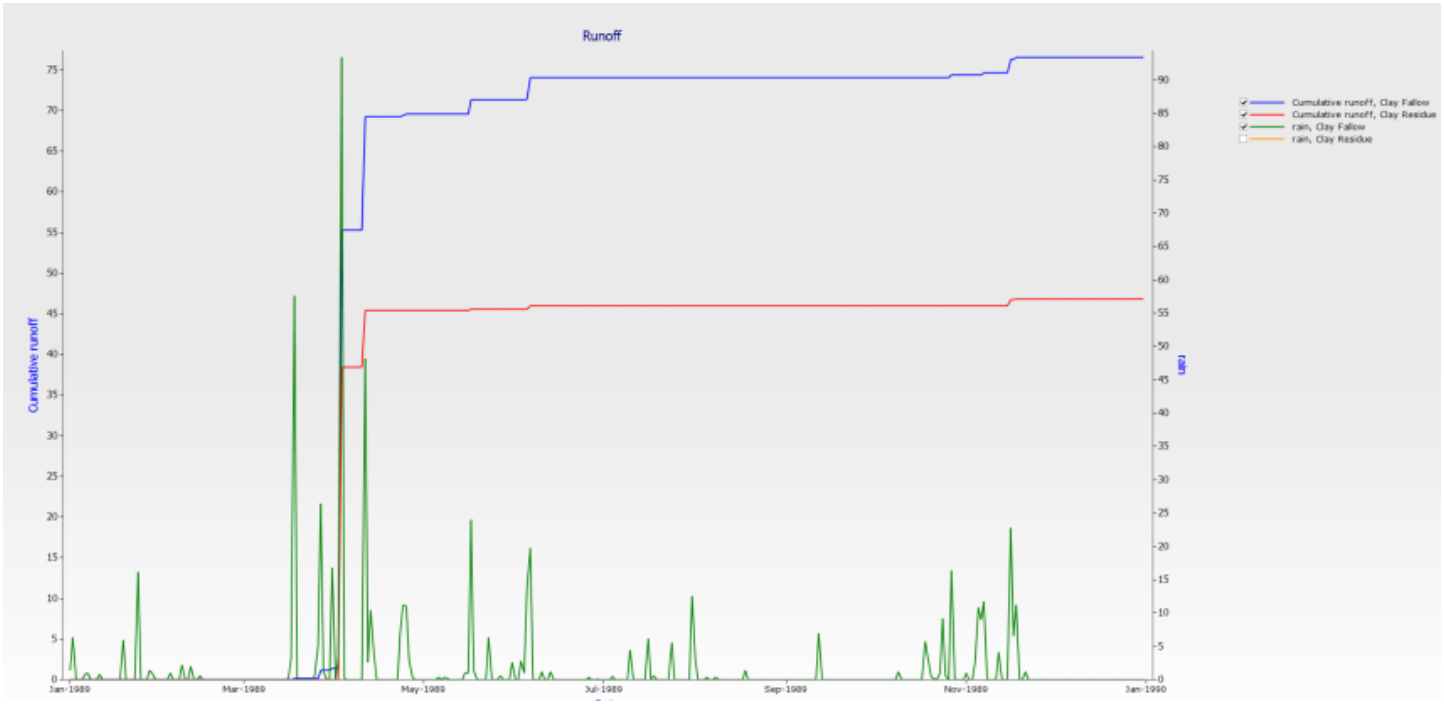
8. Create a graph of Date vs surface organic matter cover (surfaceom_cover) and rain (right hand axis) for the "Clay Residue" simulation. To do this, open the "outputfile" node and delete the two previous graphs then drag a new one in from the graphs toolbox.



What effect does rain have on decomposition?

The Effect of Cover Decline on Runoff and Evaporation

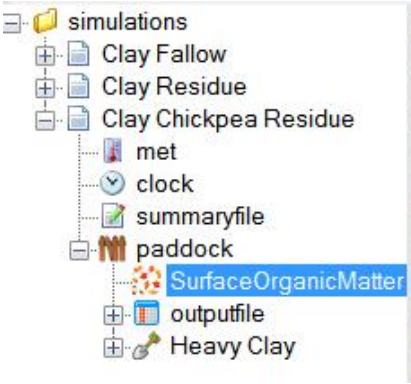
We will compare the effect that ground cover has on runoff. Graph both output files with Date vs runoff (cumulative) and rain (right axis). Rename the graph to Runoff. If you only get one graph it means that one simulation has not been run yet. Click the simulations node then click Run to run them both.



The Effect of Residue Type on Speed of Decomposition

The APSIM residue model will decompose residues at differing rates according to the C:N ratio of the material. To demonstrate this we will reproduce the previous simulation but apply legume residues in the place of the wheat residues.

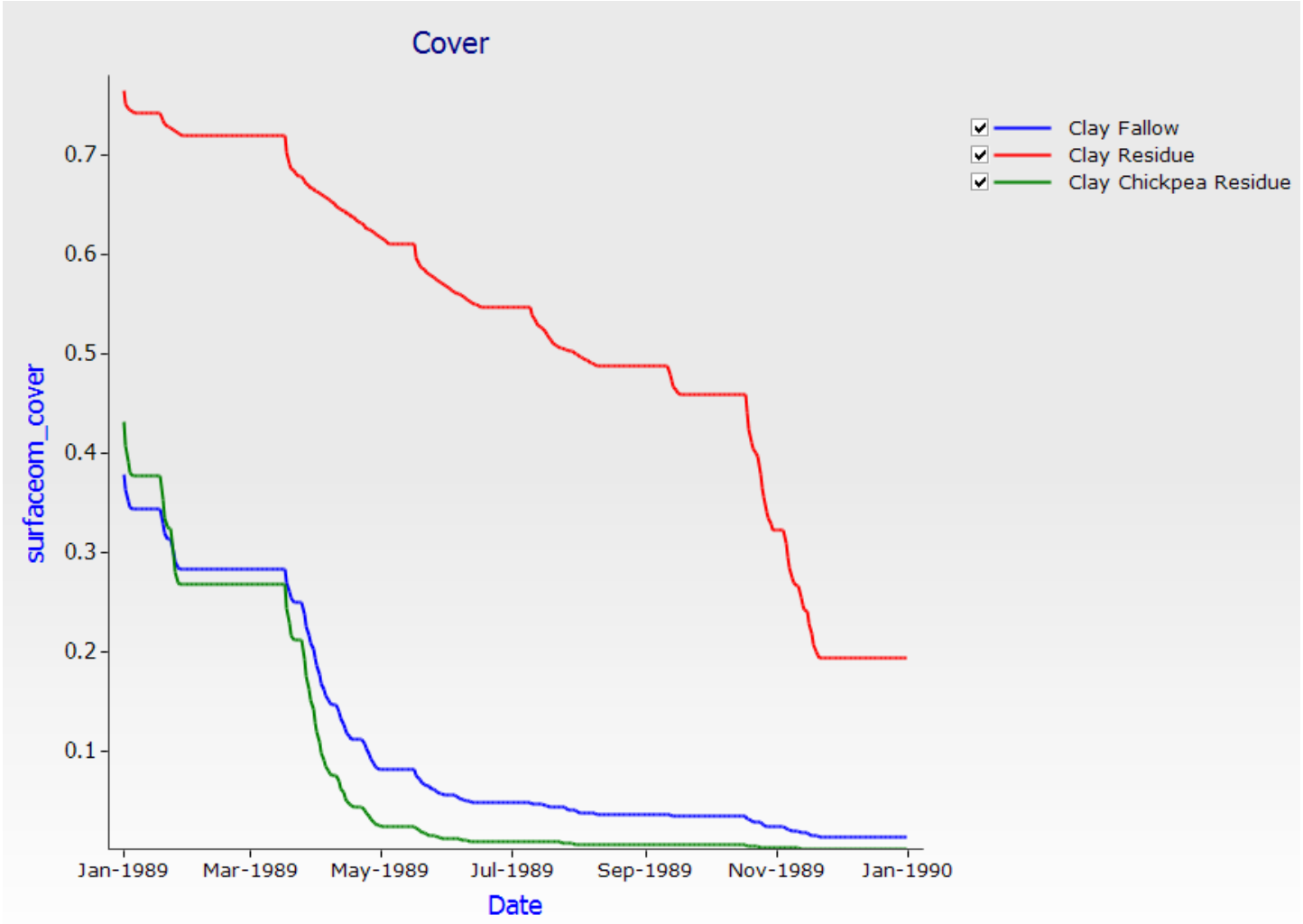
1. Create another copy of the “Clay Residue” simulation. Rename it to “Clay Chickpea Residue”. Remove the graph component.
2. Change the residue parameters to 3000 kg/ha of Chickpea residue. Also change the organic matter pool name to “Chickpea”.
3. Change the C:N ratio to 25.



Description	Value
Organic Matter pool name	chickpea
Organic Matter type	chickpea
Initial surface residue (kg/ha)	3000
C:N ratio of initial residue	25
Fraction of residue standing	0

4. Run the new simulation.

5. Graph all three residue simulations with residue cover as a function of time. Call the graph “Cover”.



What can the graphs tell us about the effect of residue on runoff?

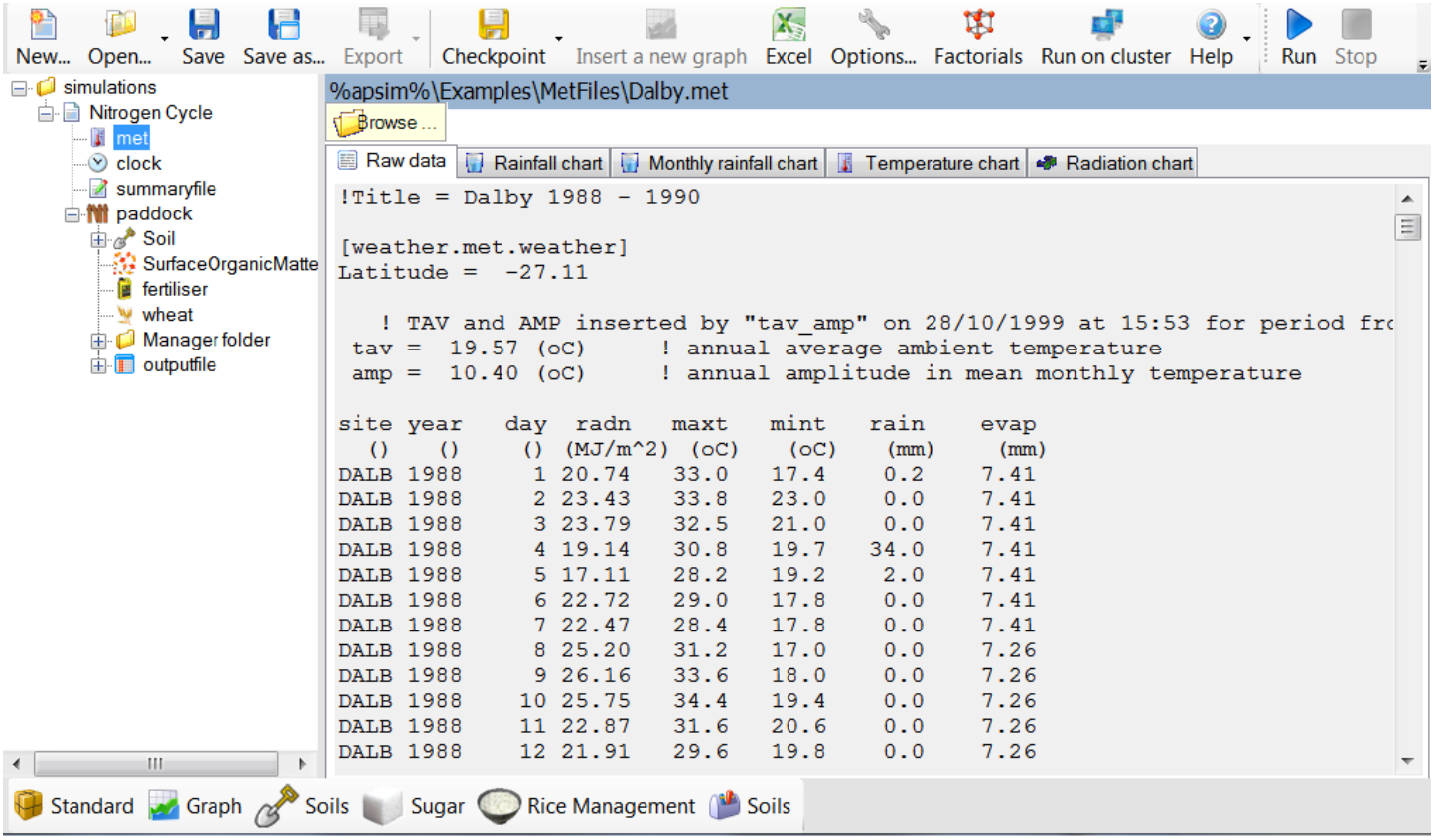
What causes the effects seen in the surfaceom_cover graph?

The Nitrogen Cycle

Exercise 3: Nitrogen Cycling

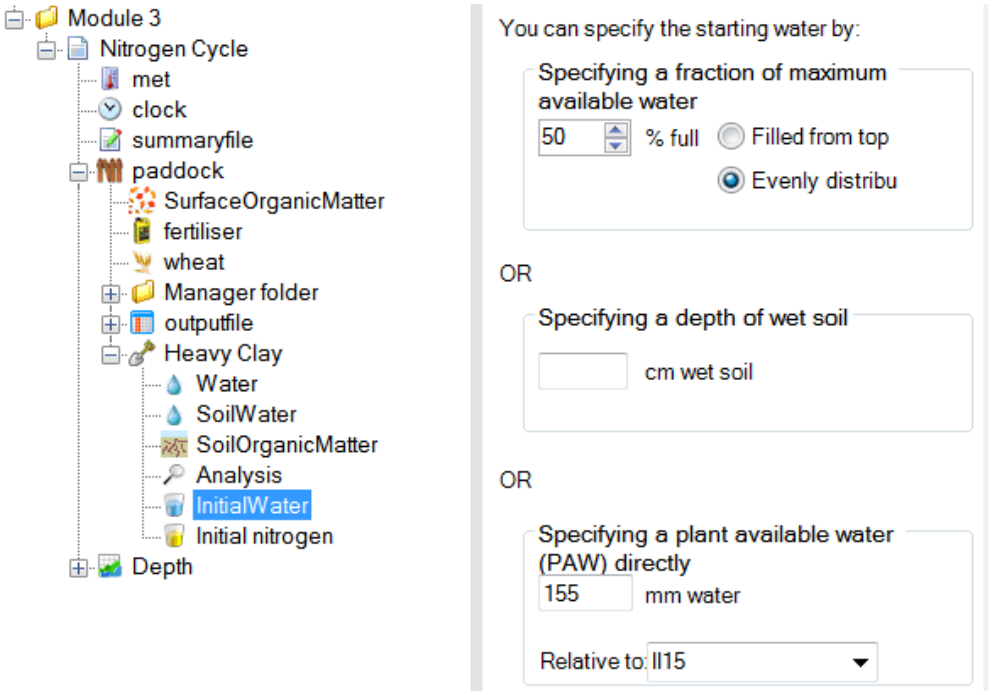
In this exercise you will observe the cycle of fertiliser nitrogen in a fallow situation; urea to ammonium, ammonium to nitrate and the loss of soil nitrate via denitrification. This simulation will introduce editing a simple Manager rule and to more advanced features of graphing simulation results.

1. Start a new simulation based on `Continuous Wheat.apsim`.
2. Rename the simulation to "Nitrogen Cycle".
3. Save this file as `Module3.apsim` in the Core-3 Nitrogen Cycle folder.
4. Click the met module and select Dalby weather (C:\Program Files\Apsim75\Examples\MetFiles\ by default).



5. Change the starting date to 1/1/1989 and the end date to 31/12/1989
6. Add the heavy clay soil from the Training Soils toolbox (it will be to the right of the Rice Management toolbox if you've completed Module 1. If not, see that module to add it).

7. Set starting water to 50% full, evenly distributed.



8. Set starting nitrogen to 19kg/ha NO_3 and 0 NH_4, evenly distributed. Don't forget to change units to kg/ha (right click the column header). Make the depth equal to the entire soil profile (check Water node for the profile depth).

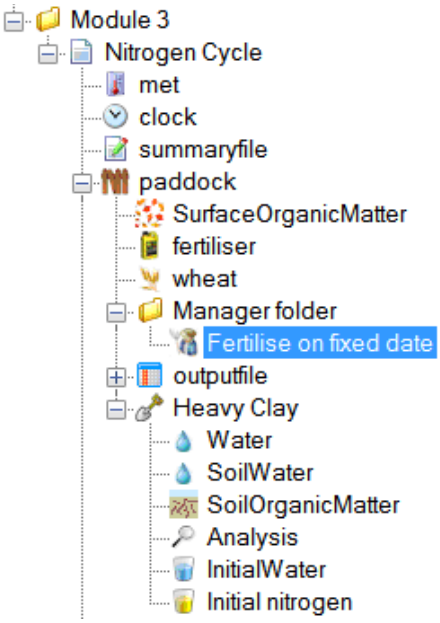
These values are used to initialise the simulation. Sample date is not used by APSIM.

Name:	Initial nitrogen
Date:	

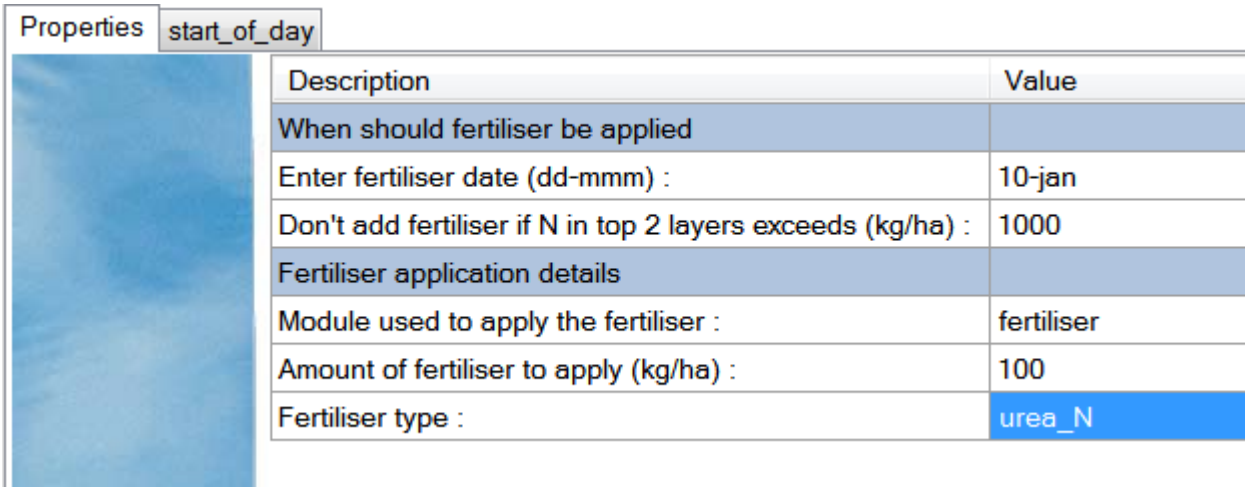
Depth (cm)	NO3 (kg/ha)	NH4 (kg/ha)	SW (mm/mm)	OC (Total %)	EC (1:5 dS/m)	CL (mg/kg)	ESP (%)
0-180	19.000	0.000	0.000				

9. Make sure SurfaceOrganicMatter is set to 1000 kg/ha wheat.
10. Remove all manager scripts under the Manager folder, but leave the folder itself.

11. Drag a “Fertilise on fixed date” script to the Manager folder. You will find it in the standard toolbox under Management > Manager (Common Tasks).



12. Change the fertiliser management parameters to apply 100 kg/ha of urea_N on 10-Jan. Leave the "Don't add fertiliser if N in top 2 layers exceeds (kg/ha)" property, and use the drop down box to set "Module used to apply the fertiliser" to "fertiliser".

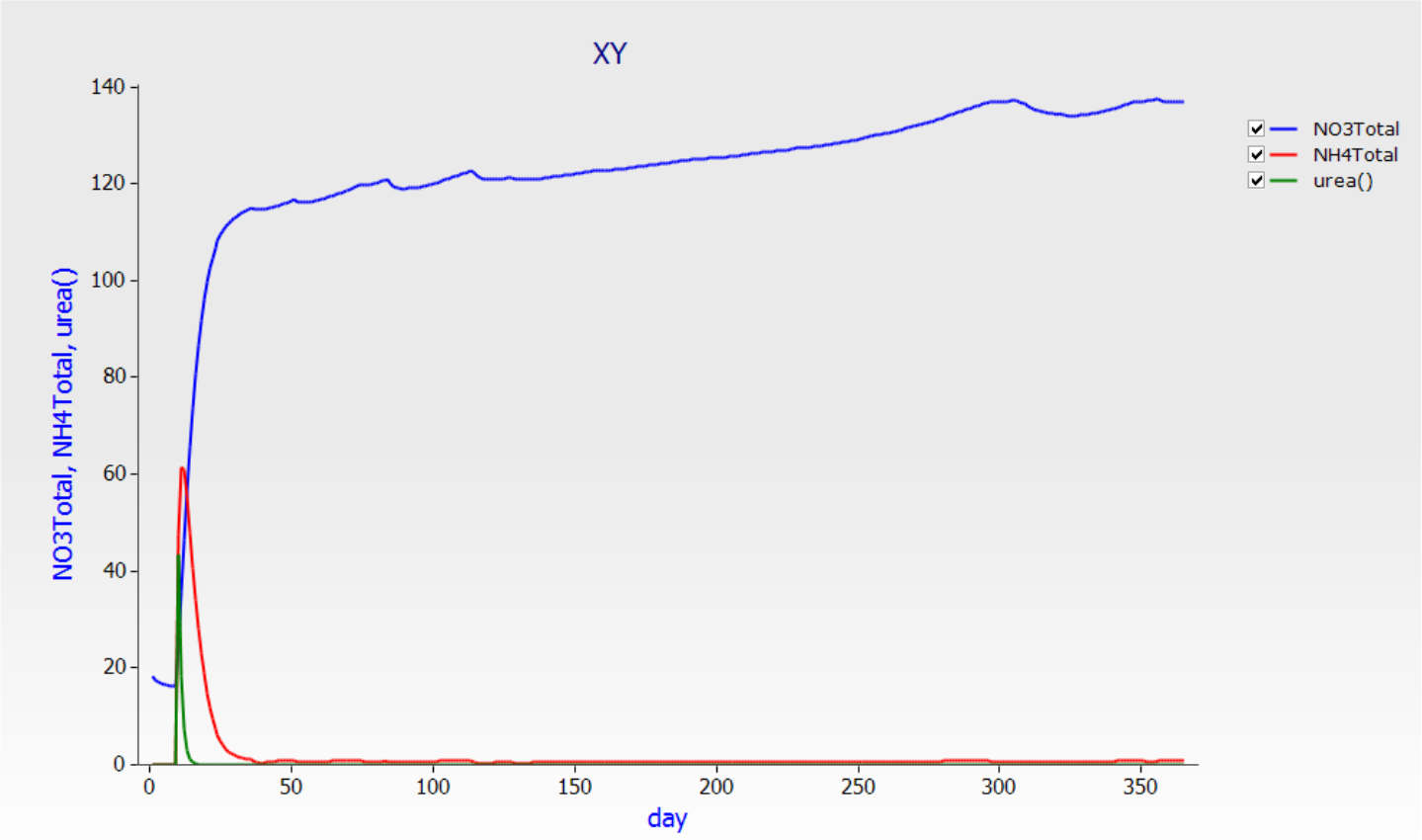


13. Make sure you have a fertiliser component in your simulation. Even though it doesn’t have any changeable properties it’s needed to tell APSIM that you want to use fertiliser.

14. Enter the following variables into the outputfile Variable list and remove all but the first:

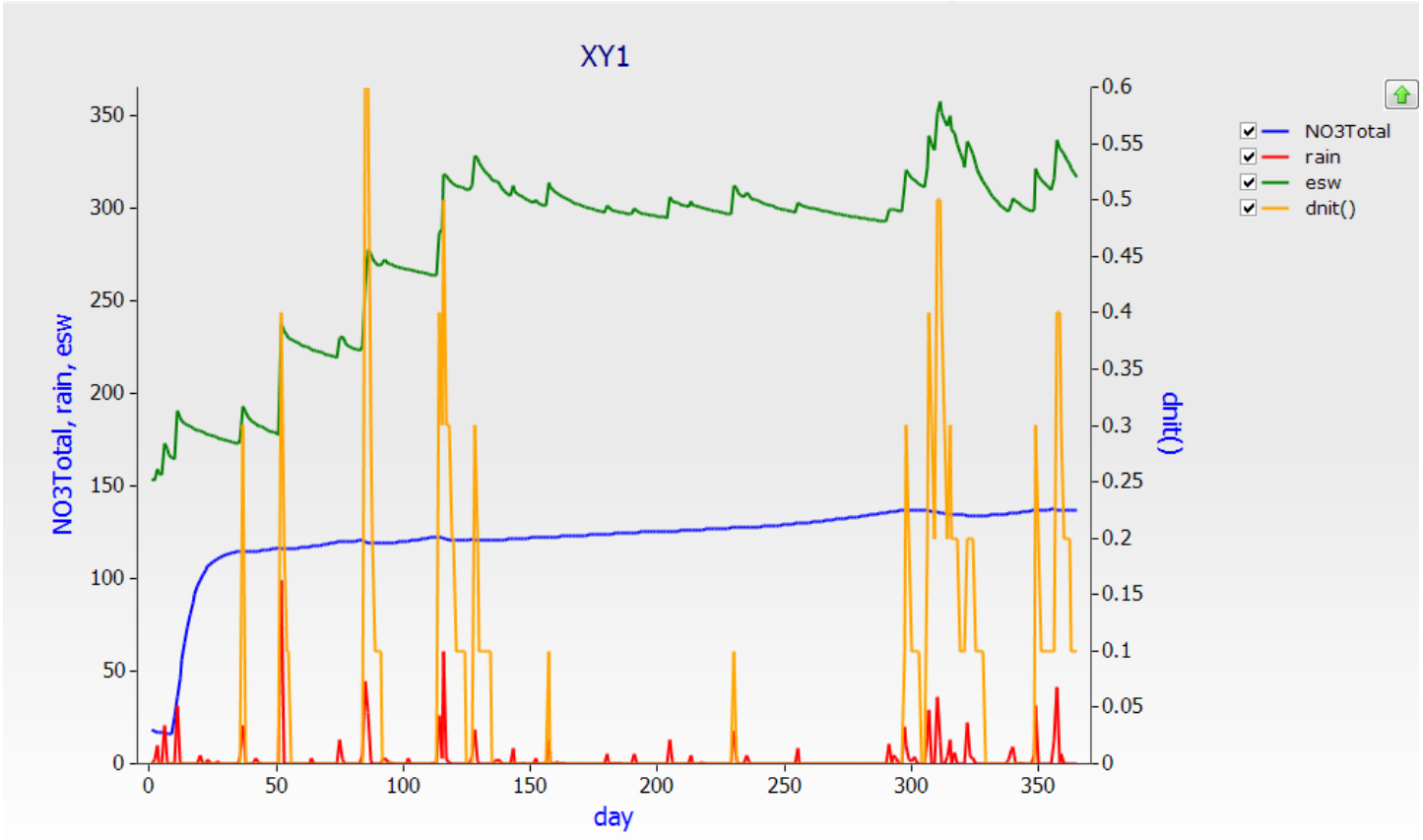
Component	Variable Name	Comment
Already included	dd/mm/yyyy as Date	
Clock	day year	
Met	rain	
Soil (Heavy Clay)	dlayer drain esw no3() as NO3Total nh4() as NH4Total no3 nh4 dnit() urea()	Depth of each layer Drainage Extractable soil water Some variables will output as an array. Here we are summing the values over the profile to return one value then using an alias to rename to variable. We are also outputting the individual layers. Denitrification summed over profile Urea summed over profile

15. Change reporting frequency to end_day.
16. Run the simulation.
17. Create a graph of day vs urea, total ammonium and total nitrate. Set "Point type" to "None".



What is different between the two types of fertiliser? Is this what you would expect to see?

18. Create a new graph of day vs rain, dnit(right axis), esw and NO3Total.

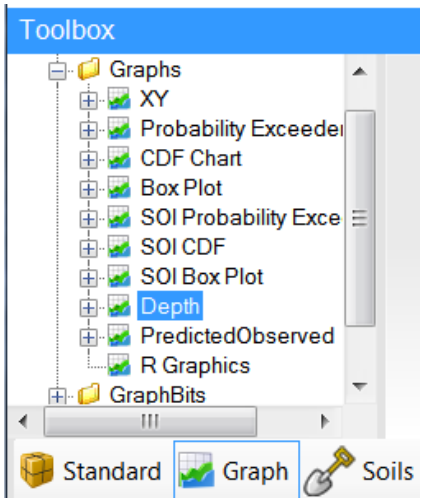


From this chart you can see that significant nitrogen is lost via denitrification when large amounts of nitrate are available in saturated soil conditions.

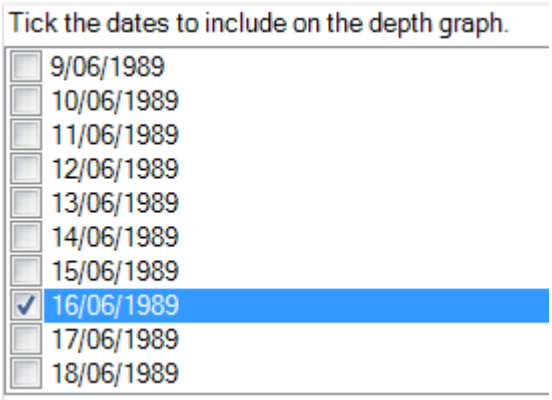
Exploring Vertical Movement of Nitrate through the Soil Profile

Let's look at the distribution of nitrate through the soil profile at 21 days after fertilisation, and again at 5 months. We will create a depth plot to help visualise this. Depth plots require two values, the "dlayer" variable which holds the depth of each layer and at least one other layer variable. Layered variables are always held in arrays. This is why we included no3 and nh4 as layered variables and not just as totals.

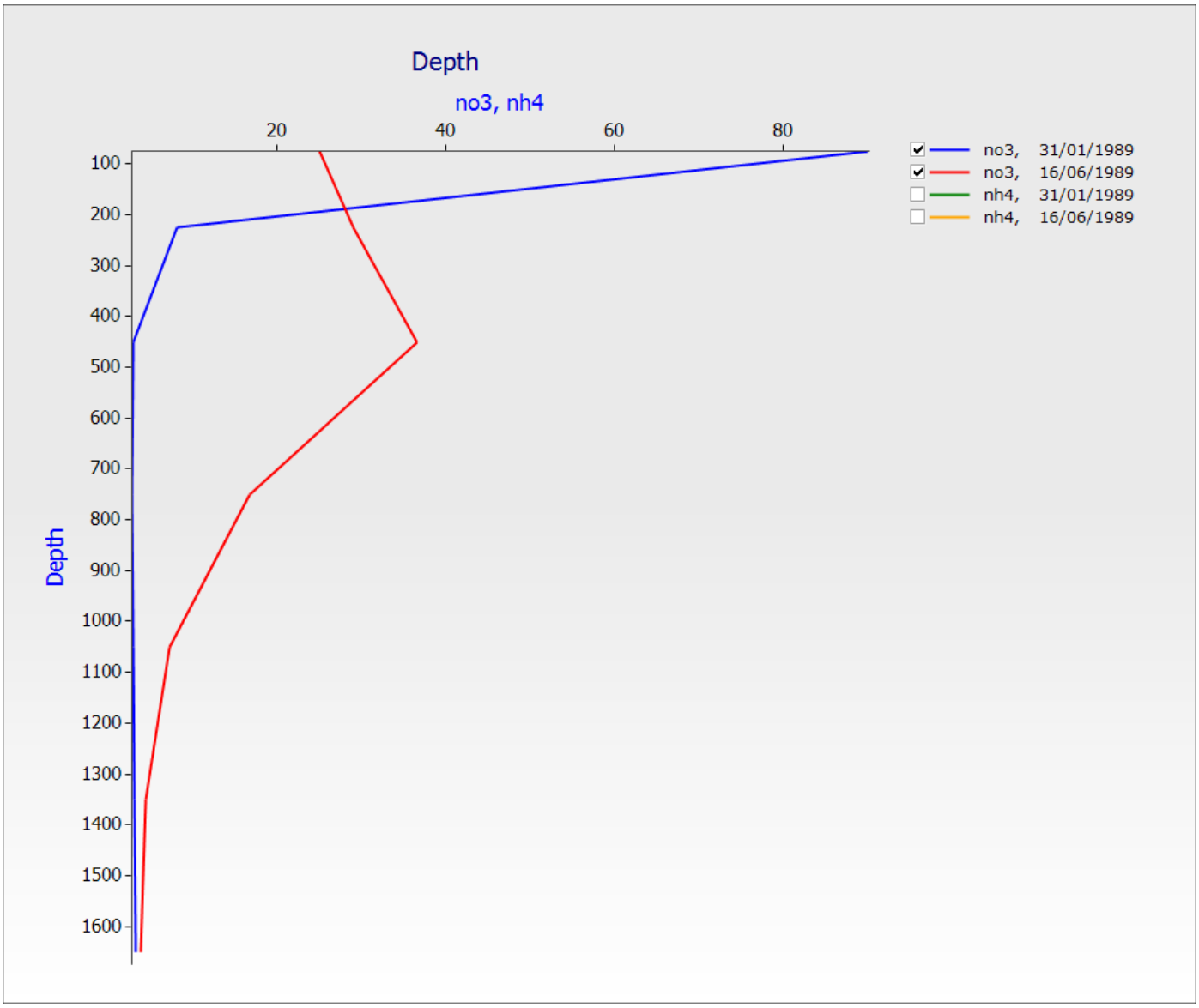
1. Drag a depth graph from the Graph toolbox onto the simulation.



2. Expand the Plot node and click the Depth node.
3. We want to examine the profile on 31/01/1989 and 16/06/1989. Tick those two dates.



4. In the Plot node, add no3 and nh4 as the X variable. Leave the Y variable as Depth.
5. Click on the graph and untick the two nh4 lines so we can see nitrate only.



You can see the distribution of nitrate in the soil profile 21 days after the addition of fertiliser and at 5 months.

Sowing A Crop

Exercise 4: A Sorghum Crop Simulation

In this exercise you will observe the growth a crop over a single season. You will learn a bit more about how to use APSIM to do a "what-if" experiment with fertiliser rates. These skills can not only be used to experiment with fertiliser rates but also variables such as:

- time of planting,
- rate of sowing,
- crop comparisons and different starting soil moisture conditions.

1. Start a new simulation using "Continuous Sorghum.apsim"
2. Rename the simulation as Sorghum Nil Fertiliser. Save the file as "Module4.apsim"
3. Choose the Dalby met file and set the start and end dates of the simulation to 1/1/1988 - 30/6/1988.
4. Select the Clay soil from the right most Soils toolbox. If you do not see a Soils toolbox on the right (not the one with a shovel icon) see Module 1 to add it.
5. Set the Starting water to 25% full - filled from top.
6. Set the Starting nitrogen to 12 kg/ha of NO3 and 3 kg/ha of NH4, evenly distributed.
7. Change the sowing rule to reflect the following:

Description	Value
Sowing criteria	
Enter sowing window START date (dd-mmm) :	1-jan
Enter sowing window END date (dd-mmm) :	1-jan
Must sow? :	yes
Amount of rainfall :	30
Number of days of rainfall :	3
Enter minimum allowable available soil water (mm) :	200
Sowing parameters	
Enter name of crop to sow :	sorghum
Enter sowing density (plants/m2) :	8
Enter sowing depth (mm) :	30
Enter cultivar :	early
Enter row spacing (mm) :	1000
Skip row :	solid

   By setting the sowing window start and end to the same data and changing 'must sow' to yes, we force the crop to be sown on that particular day.

8. Check that the harvest rule indicates that Sorghum should be harvested.

9. Add a “Fertilise at sowing rule”. Set the starting fertiliser to 0 and change wheat to sorghum. We are including this rule here as it will be used later when linked simulations are introduced.

10. Report the following variables:

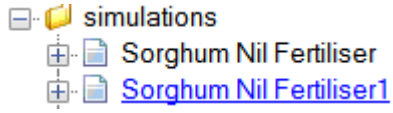
Component	Variable name	Notes
Clock	dd/mm/yyyy as Date	
	day	
	year	
Soil	dlayer	Depth - layered (mm)
	sw	Soil water – layered (mm)
Sorghum	DaysAfterSowing	
	lai	
	biomass	
	yield	

11. Change the reporting frequency to end_day.

Linking Simulations

Often you will find yourself making a large number of simulations that have only very minor differences between them. For example, in this exercise we will make three simulations and the only difference between them will be the amount of fertiliser used. We can easily do this by cloning the simulation then changing the fertiliser amount. But what if we later find out that we've used the wrong cultivar or would like to try a different starting nitrogen value or report different variables? If we've cloned the simulations then we would need to go through each one and change the value. This may not be such a problem if we're only looking at three simulations like this exercise, but if we have tens or even hundreds this becomes a prohibitive task. The solution is to link simulations together so that changes made to one simulation affect all linked simulations.

12. To create a linked simulation, hold down the ALT key and drag Sorghum Nil Fertiliser to the Simulations component at the top of the simulation tree. You should see the new simulation appear as a blue link:



    This means that the two are linked. You can make changes to either simulation and it will affect the other one. There is no limit to the number of simulations that can be linked and it is possible to link from a linked simulation.

    IMPORTANT: Deleting many linked simulations can be very slow as all components need to be unlinked. Do not delete more than one or two at a time or your computer will become unresponsive.

13. Rename this copy to "Sorghum 30 kg N Fertiliser".

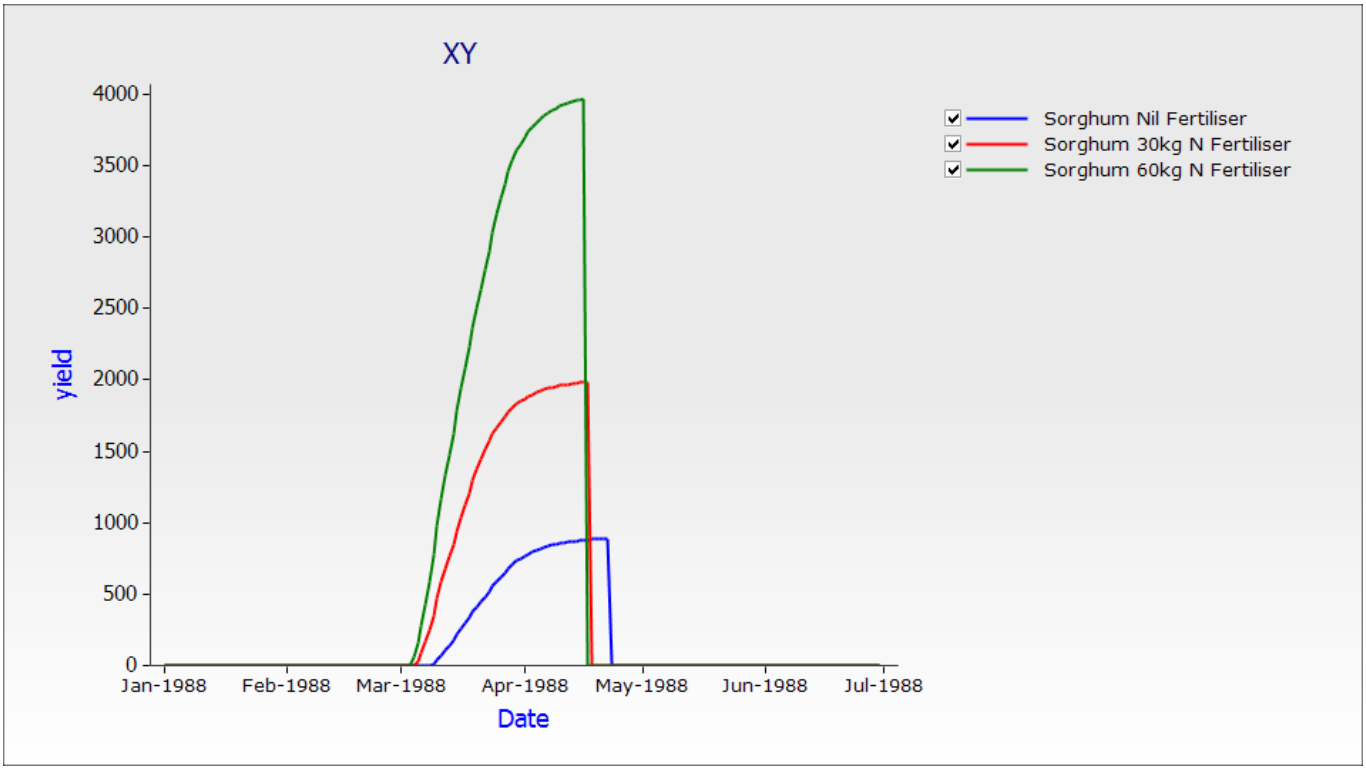
14. Right click the linked fertiliser sowing rule and select “unlink this node”. You can now edit the rule without changing any of the other linked simulations.

15. Apply 30 kg urea_n fertiliser.

16. Make another linked copy of the simulation, this time adding 60 kg/ha of fertiliser (don't forget to unlink the node). Call the simulation "Sorghum 60Kg N Fertiliser"

17. Run all 3 simulations. You can run all 3 simulations by clicking on the top Simulations component then clicking the Run button. If you just click on one of the simulation sub components (e.g. Sorghum Nil Fertiliser or any sub component under it) then click the Run button, it will only run that simulation.

18. Graph all 3 output files creating a Date vs Yield graph using a graph component. Click on the Graph toolbox. Drag an XY graph component onto the top component Simulations.



Examination of the Rate of Water Extraction From Soil Profile

Create a new depth graph of dlayer vs. sw with dates 15 Mar (crop is growing) and 31st May (after the harvest).

1. Drag a Depth component onto the top Simulations node.
2. Expand the Plot sub component to get the Depth sub component.
3. Tick the dates mentioned above.

4. In the Plot sub component, add "sw" as the X variable and leave the Y variable as "Depth"

Long Term Simulations

Exercise 5: Chickpea Sowing Rates – 10 Year Runs

In this exercise you will use sowing rules to plant Chickpea crops and observe yield probabilities for a 10 year period given a half full soil moisture profile at sowing. We will compare two sowing rate strategies for these conditions with the goal of maximising yield. The weather will be different each year but the soil starting conditions will be the same.

By default, in long term simulations (i.e. longer than one year), the end of one years' simulation becomes the starting point of the next year. This is useful if you are interested in seeing the degradation or improvement of the soil over a long time period. What if you wanted to work out what the best strategy would be for the current year using weather scenarios from the past 10 years? To do this we could create 10 different simulations all with the same starting conditions but a different weather file (which would be a lot of work), or we could run the same simulation over 10 years and just reset the starting conditions each year (much simpler).

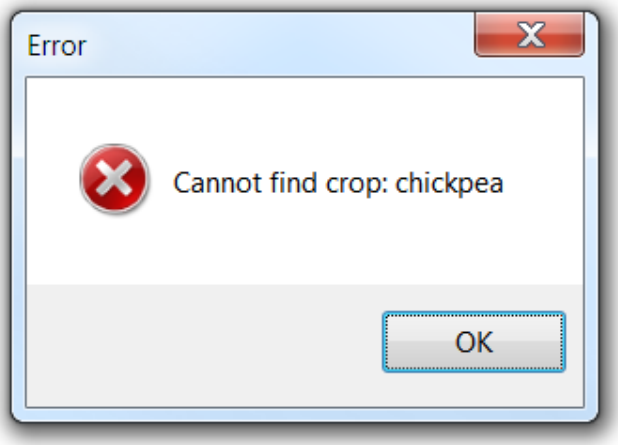
We can then try different management strategies to see which one would have worked best under the past 10 years weather scenarios.

1. Start a new simulation using "Continuous Wheat.apsim"
2. Save the file as "Module5.apsim"
3. Change the simulation start and end dates to 1/01/1979 - 30/04/1989 (10 years)
4. Select the Heavy Clay soil from the Training Soils toolbox. If you can't see it, see Module 1 to add it. Delete the old soil.
5. Set the Starting water to 50% full - filled from top.
6. Set the Starting nitrogen to 20 kg/ha NO_3 and 0 kg/ha NH_4, evenly distributed.
7. Change the surface residue type to sorghum (don't forget to rename the pool name to "sorghum" as well), initial surface residue: 550 kg/ha, C:N ration of 76, leave the Fraction of residue standing as is.
8. Replace the wheat crop with chickpea. (Standard toolbox -> Crops)
9. Replace the Sowing rule with the Sow using a variable rule from the toolbox and enter the values below:

Description	Value
Sowing criteria	
Enter sowing window START date (dd-mmm) :	1-may
Enter sowing window END date (dd-mmm) :	1-aug
Must sow? :	no
Amount of rainfall :	15
Number of days of rainfall :	3
Enter minimum allowable available soil water (mm) :	200
Sowing parameters	
Enter name of crop to sow :	chickpea
Enter sowing density (plants/m2) :	10
Enter sowing depth (mm) :	30
Enter cultivar :	amethyst
Enter crop growth class :	plant
Enter row spacing (mm) :	350

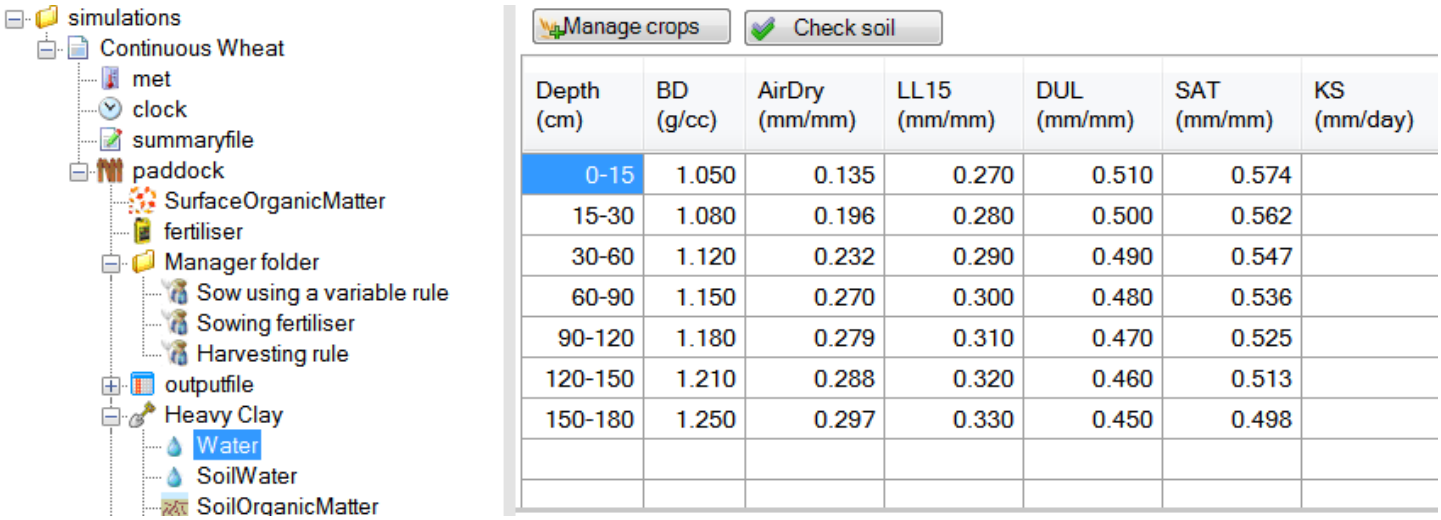
The last three criteria mean that for a crop to sow within the given window at least 15mm of rain must have fallen in the last three days and there must be a minimum of 200mm soil water available.

10. Run the simulation. You should see the following error:



This means Apsim is unable to find certain crop properties in the soil. This is because we're using a crop that has not been parameterised for this particular soil.

11. Click ok to dismiss the error. Click on the Water node under Heavy Clay soil.



Depth (cm)	BD (g/cc)	AirDry (mm/mm)	LL15 (mm/mm)	DUL (mm/mm)	SAT (mm/mm)	KS (mm/day)
0-15	1.050	0.135	0.270	0.510	0.574	
15-30	1.080	0.196	0.280	0.500	0.562	
30-60	1.120	0.232	0.290	0.490	0.547	
60-90	1.150	0.270	0.300	0.480	0.536	
90-120	1.180	0.279	0.310	0.470	0.525	
120-150	1.210	0.288	0.320	0.460	0.513	
150-180	1.250	0.297	0.330	0.450	0.498	

Every crop used in a simulation must have an entry in the Water node that specifies crop specific limits. To add extra crops, click "Manage crops". Click 'wheat' and rename it to 'chickpea'. Copy the values from sorghum. The real values entered must be determined experimentally, but they really only affect the output in severe water stress so it won't matter here. Also note the PAWC column will update automatically when you click another node.

12. Now we've fixed the error we can continue. Remove the sowing fertiliser rule.

13. Make sure the harvesting rule will harvest chickpea, not wheat.

14. Add the rule: **Reset water, nitrogen and surfaceOM on fixed date**. Use 1-may for the reset. Make sure the name of the soil module and the name of the surface organic matter module is correct. We want to reset water, nitrogen and surface organic matter to remove the year to year effects. Move it up to make sure it's the first rule under the Manager component. The order is important in the Manager folder. It is the order the rules are run in (right click on the rule and select "Move up". You can also use the shortcut Ctrl + Up).

15. Report the following variables:

Component	Variable
Clock	year
Chickpea	yield

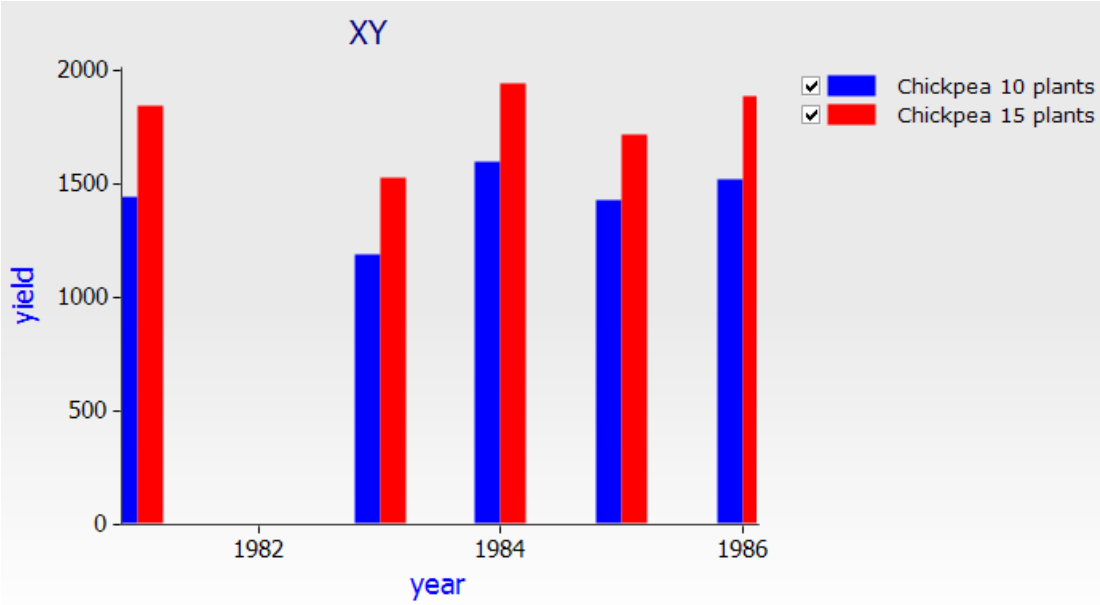
16. Rename simulation to "Chickpea 10 plants"

17. Make a copy of the simulation and create a new one with 15 plants/m2

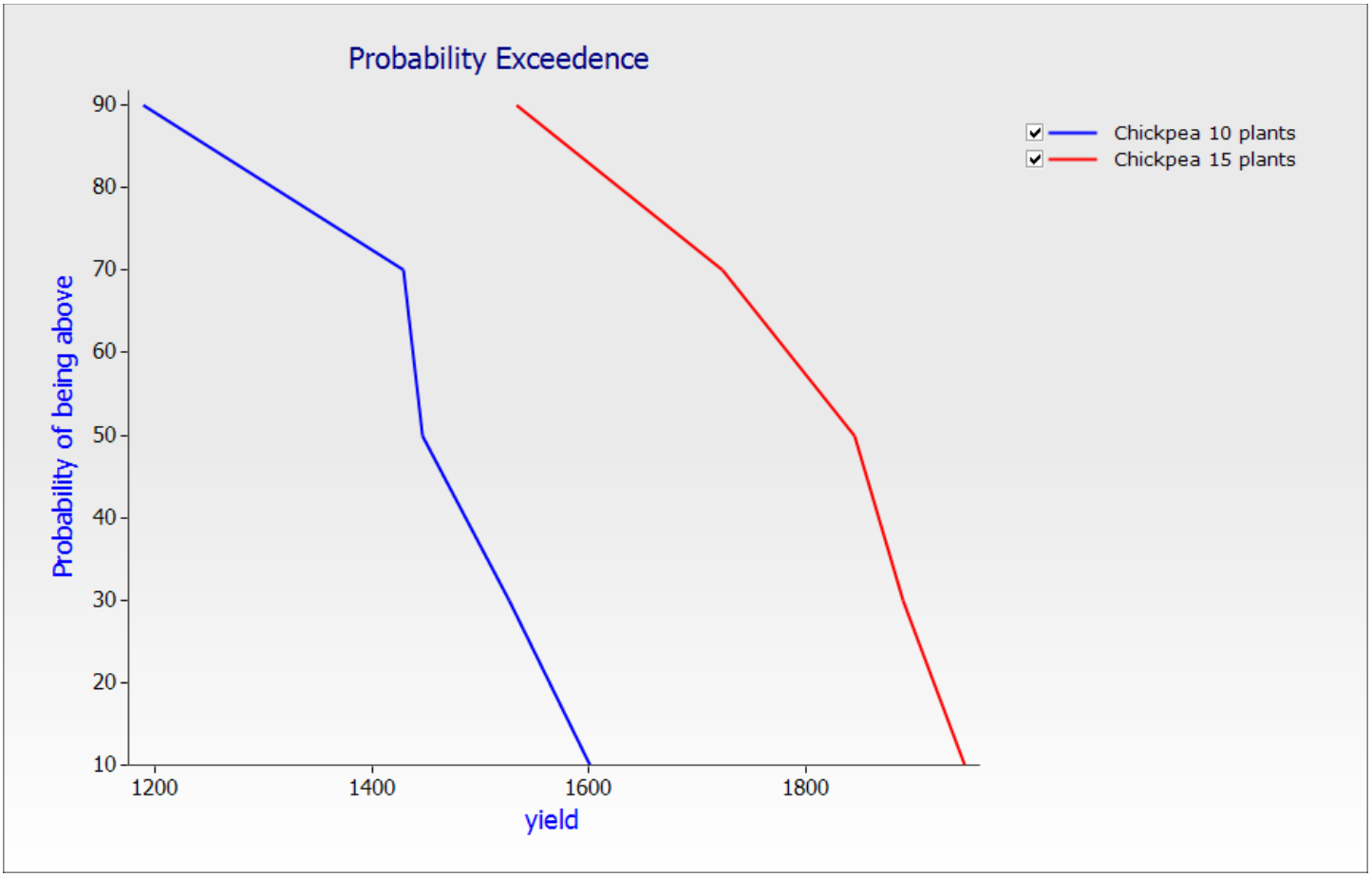
18. Rename this copy to "Chickpea 15 plants".

19. Run the simulations.

20. Graph both output files creating a Year vs Yield by using a Graph component. Drag an XY graph onto the Simulations component from the Graph toolbox. To get a bar graph, in the Plot component select "Bar" in the "Type" drop down list.



21. Create a Probability Exceedence plot of Yield by using a Graph component. Drag a Probability Exceedence component onto the Simulations component from the Graph toolbox. Select the Yield as the X variable and leave Probability as the Y variable.



Apsim Help and Support

The Apsim Website

APSIM INITIATIVE

Documentation

- Training Manual (Australia)
  - Package containing workshop training materials.
  - “How-To” list. A group of documents that explain how to accomplish common tasks in the Apsim User Interface.
- Documentation for Crop, Soil, Stock and Other Modules
  - Information on modules contained in Apsim. Written by module authors, usually contains an explanation of the science simulated, references and module inputs and outputs.
- Technical and Developer Documentation
  - Information for people interested in building Apsim from source or modifying or building new modules.

The Apsim Website

APSIM INITIATIVE

Products

- Downloads
  - Apsim registration and download.
- Utilities
  - Tools built by Apsim developers and the community.
- Apsoil and the Apsoil Database
  - An interface built on top of Apsim that allows a user to build their own soil modules using gathered data.
  - The Apsoil Database is a collection of soils sampled from around Australia. It is updated every few weeks.

Bugs and Tasks

APSIM INITIATIVE

- A list of items the Apsim development team is currently working on.
- If you find an error in the Apsim program or a module is returning bad data, you can file a bug report and a developer will look at it.
- Please include as much information as possible as well as steps required to recreate the issue.
- You can also request new features by submitting a report.

APSIM.info tasks search go to ID search text advanced

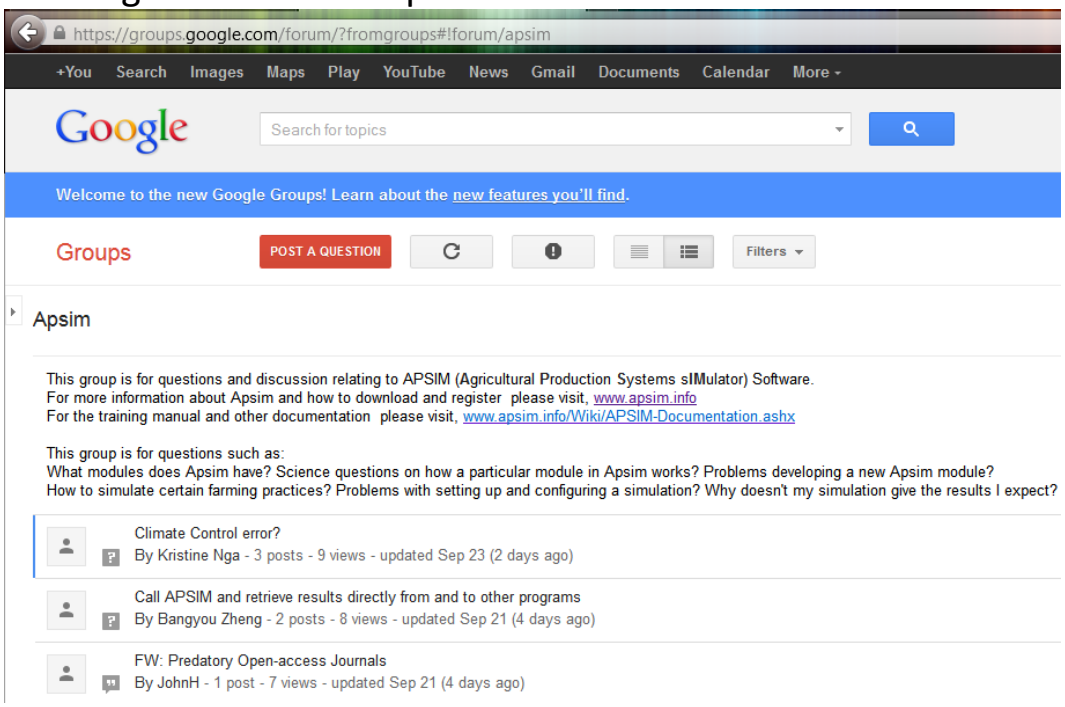
add new task open tasks print list print detail export to excel

id	priority	status	desc	project	category
1592		Submitted	User Interface: Add ability to load multiple .apsim files into a single .apsim file	User Interface	Minor
1591		Submitted	Add tav and amp on ApsimX	Module Code	Bug
1590		Submitted	Send to Excel not working	User Interface	Bug
1589		Submitted	Sorghum Code cleanup	Module Code	Bug
1588		Submitted	Add ability to do Plant2 development of components, with nested functions, using Manager2 script.	Module Code	Minor

Apsim Support Group

APSIM INITIATIVE

- A forum to request help from Apsim developers and users.
- A Google account is required to use the forum.



Advanced Exercises

Congratulations on completing the Core exercises! You should now have a solid grasp of how to use Apsim to build and run moderately complex simulations. The following exercises do not introduce new Apsim features; instead, they build upon the knowledge you have already gained to demonstrate how to accomplish common modelling scenarios.

Climate Change

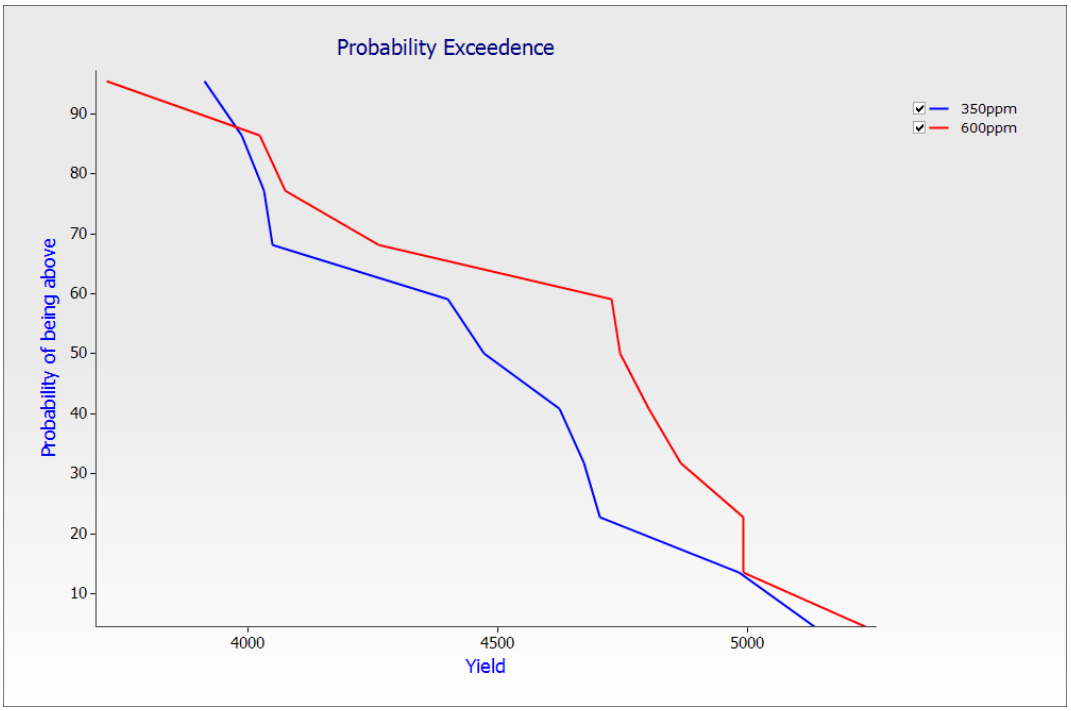
Climate Change projections in APSIM

This exercise aims to explore the effects of climate change on wheat cropping systems. Some background is in this PDF. Firstly, the response of wheat to elevated CO_2 is examined. Please be aware that as of version 7.4 only wheat, oats and barley are responsive to CO_2 changes. All other crops will generate an error.

1. Create a new simulation using "Continuous Wheat with Climate Change" as a base. Save it as "Climate.apsim".
2. Change the start date to 1/1/1970. This will give us a 20 year run.
3. Add a "Reset water, nitrogen and surfaceOM on fixed date" rule and set the date to 1-jan. Don't forget to set the soil and surfaceOM modules as well.
4. Rename the simulation as 350ppm and click on the ClimateControl module.

Description	Value
Climate Control Window	
Enter window START date (dd-mmm) :	1-jan
Enter window END date (dd-mmm) :	31-dec
Climate Change Parameters	
Change in maximum temperature (oC):	0
Change in minimum temperature (oC):	0
Relative change in daily rainfall (%):	0
Relative change in daily radiation (%):	0
Atmospheric CO2 Concentration (ppm)	350

   Here you will find the settings that control how the climate can be varied. We'll look at changes to CO_2 and rainfall.
5. Create a linked simulation (see module 4), rename it to 600ppm then unlink the ClimateControl module and change the CO_2 concentration to 600 ppm. Change both temperature deltas to 2 and change in rainfall to -10.
6. Run and graph the simulations using a Probability Exceedence chart. You can see that the elevated levels of CO_2 along with the increase in temperature offset the drop in rainfall and end up increasing the grain yield.

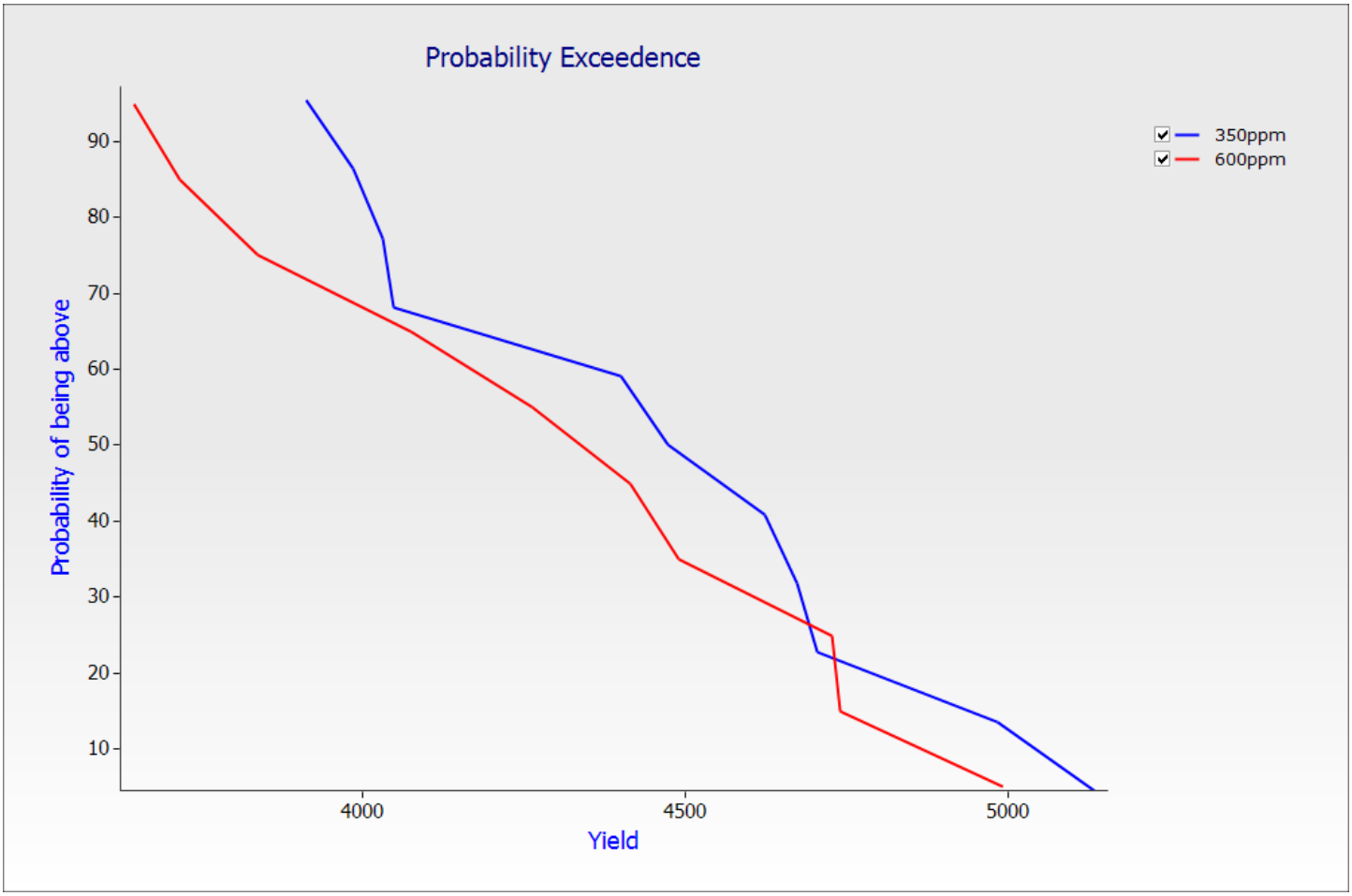


The Big Picture

When modelling, you need to remember that the data you get out of your model is only as good as the data you put into it. The above graph shows that yields will increase as the climate gets hotter, but it doesn't reflect water usage properly. Remember that we're using a full water profile on a soil that has a high water holding capacity and we're resetting that each year. Even though we've reduced rainfall by 10% to reflect drier conditions we still end up with high yields. This is because the crop is using all the stored water so the smaller amount of rainfall has no effect on yields.

If we're reducing rainfall and we expect more drought conditions because of it, it is unlikely that we're going to end up with a full profile at sowing. Let's see what happens if we assume that the profile is only 30% full due to drought.

1. In the 600ppm simulation, unlink the 'Initial water' node and change the profile to 30% full.
2. Run and graph using a Probability Exceedence chart.



We now have a lower yield since the crop is water limited. When doing simulations always ensure that everything makes logical sense. So in this case, since we were reducing rainfall and expecting more droughts, it makes sense that our initial soil water would be lower.

Crop Rotations

Creating A Wheat Long Fallow Rotation

In this exercise you will create a wheat long fallow rotation where wheat is potentially sown every second year using the following schedule:

	Year1												Year2											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Summer Fallow			15					23							15					23				
Winter Fallow			15					23							15					23				
Wheat Sowing Window					15		10																	

1. Create a new simulation based on "Rotation Sample.apsim".
2. Change the name of the simulation to "LongFallowV" and save to the same filename.
3. Check met file is Goondiwindi 1940-1989 and make the simulation run for entire length of met file (1/01/1940 to 31/12/1989).
4. Change the soil to Heavy Clay from the Training Soils toolbox (see Module 1 if you don't have it).
5. Set starting water to 100% filled from the top.
6. Set starting nitrogen to 0.1 ppm in every layer (copy the layer structure from the Water node) for both NO_3 and NH_4.
7. Delete the cotton and chickpea crops from the simulation. Delete all the sowing rules and harvesting rules for every crop other than Wheat.
8. Change minimum allowable soil water criteria of the Wheat sowing rule to 0 so that it doesn't play a part in the sowing criteria. You'll notice the correct sowing window is already present.
9. Set the crop order in the Rotations rule to the following:

1st crop	wheat
2nd crop	sf
3rd crop	wf
4th - 6th crop	nil

You have to type in sw, wf and nil in manually. sf, wf and nil are standard abbreviations. sf for summer fallow, wf for winter fallow and nil for the point where the rotation will return to the beginning and repeat. APSIM will not recognise anything else. When you're finished it should like the following:

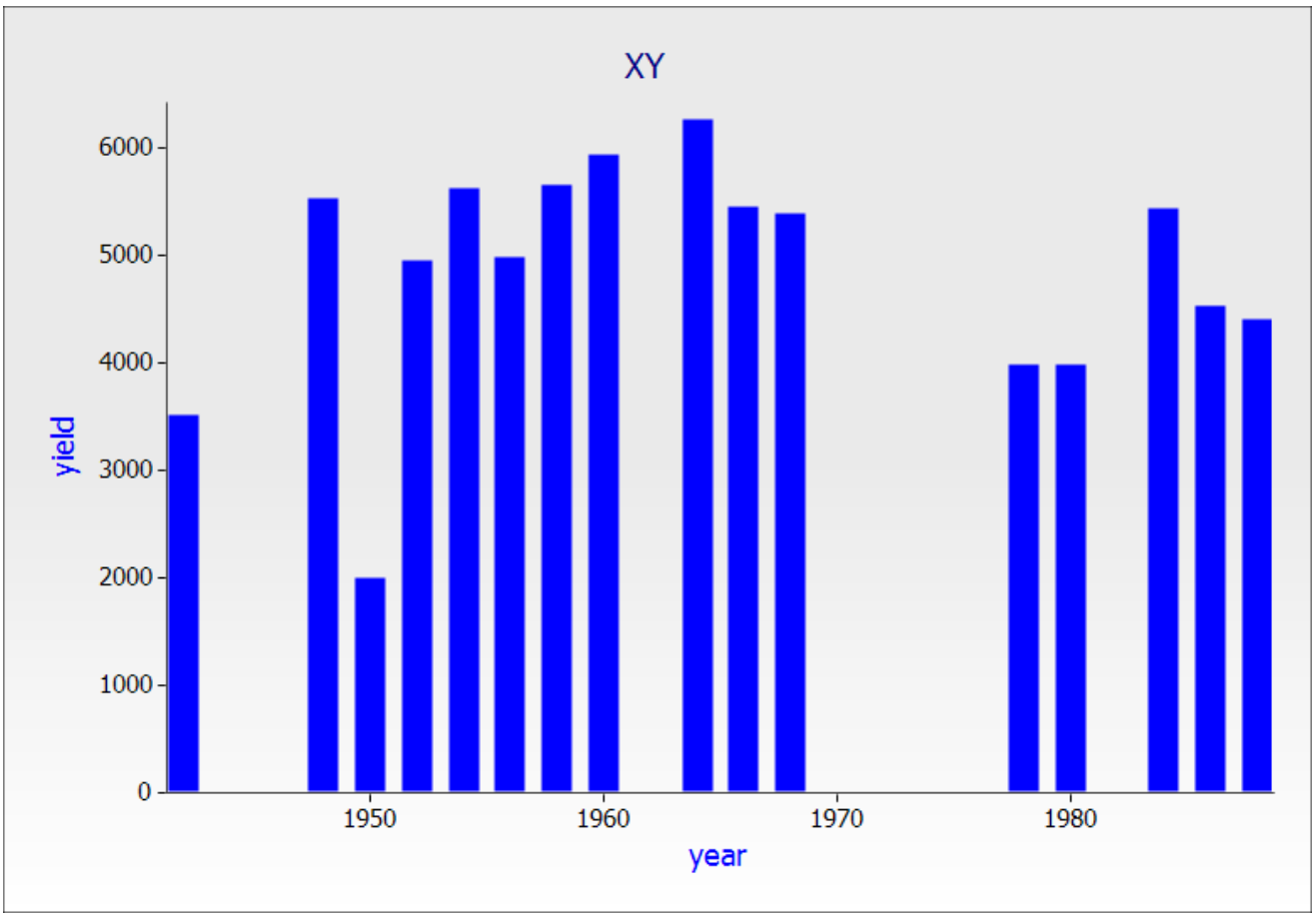
Description	Value
Fallow options	
Enter summer fallow name :	sf
Enter summer fallow END date (dd-mmm) :	15-mar
Enter winter fallow name :	wf
Enter winter fallow END date (dd-mmm) :	23-aug
Crop rotation sequence	
Enter 1st crop :	wheat
Enter 2nd crop :	sf
Enter 3rd crop :	wf
Enter 4th crop :	nil
Enter 5th crop :	nil
Enter 6th crop :	nil

10. Report the following variables:

Component	Variable
Clock	dd/mm/yyyy as Date
	year
Wheat	Yield

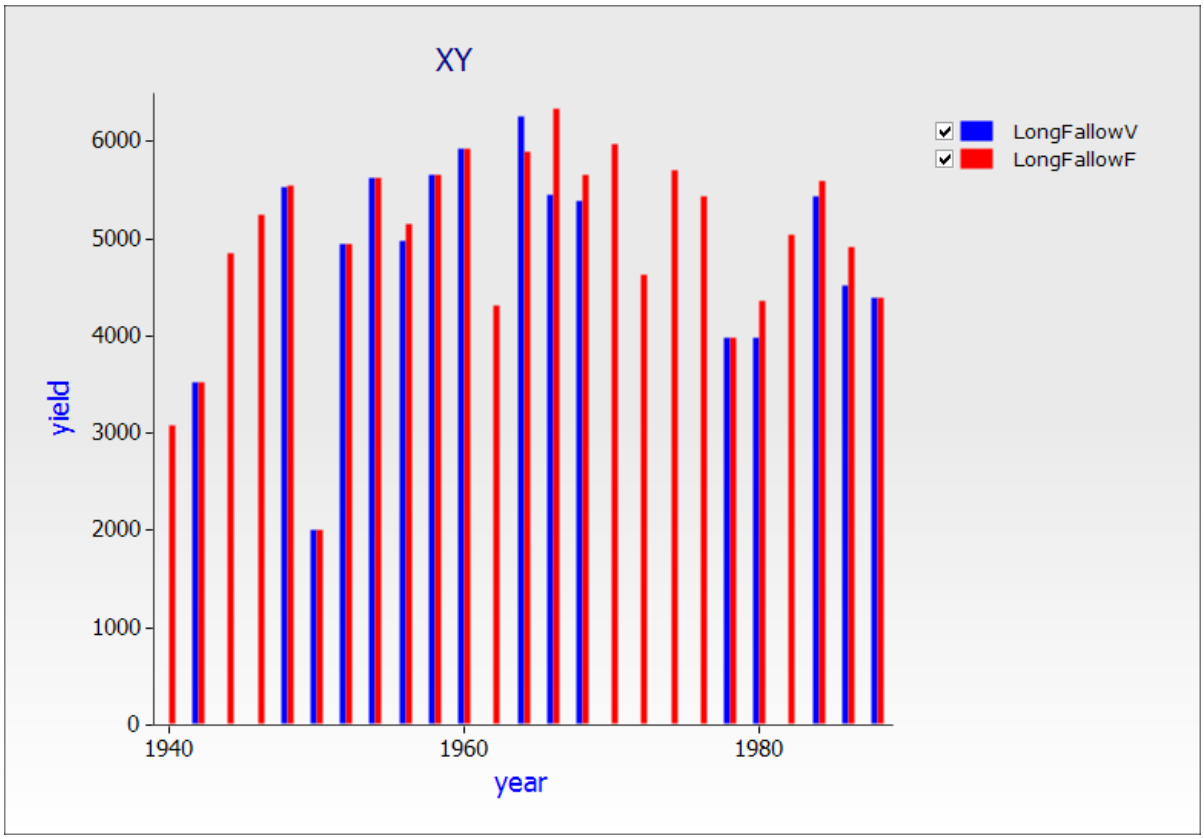
11. Change the output frequency to harvesting.

12. Run APSIM and plot year vs yield as a bar chart using a graph component.



Fixed Vs. Variable Rotation

1. Duplicate the previous simulation and name it LongFallowF.
2. Change the wheat sowing rules in the LongFallowF simulation from "must sow = No" to "must sow = Yes".
3. Run this second simulation and plot year vs. yield for both simulations on the same graph using a graph component.



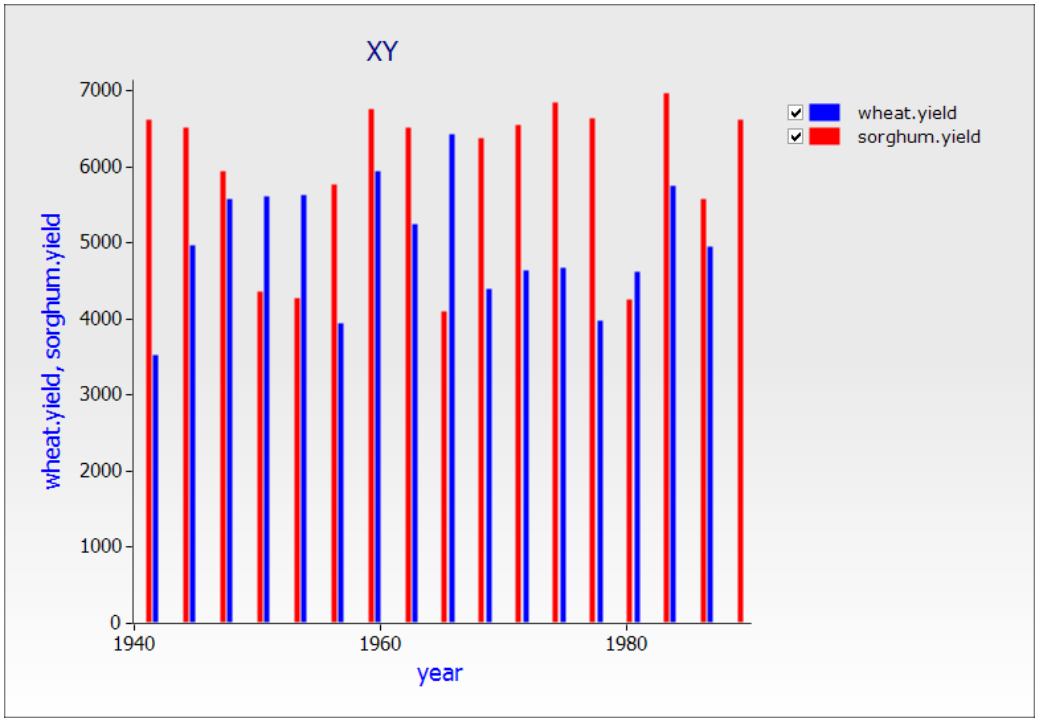
What are the differences between fixed and variable sowings?

Sorghum – Wheat Rotation

We will now look at a three year rotation with a fallow followed by a sorghum crop then a wheat crop in the third year.

	Year1												Year2												Year3											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Summer Fallow			15					23							15					23							15					23				
Winter Fallow			15					23							15					23							15					23				
Wheat Sowing Window																													15		10					
Sorghum Sowing Window										15			15																							

1. Save your current project to a new file called SorghumWheat.apsim. Remember to use the “Save As” button NOT “Save”. Rename the LongfallowF simulation to “SorghumWheat Rotation” and remove the other simulation.
2. Add Sorghum crop from the toolbox.
3. Add Sorghum sowing rule from the toolbox and set the cultivar to “early”.
4. Rename Fertilise at sowing rule to WheatFertilise. Copy it, and rename the copy SorghumFertilise (make sure to change the "On which module should the event come from" property to sorghum).
5. Add a Harvest Rule from the toolbox, rename to SorghumHarvesting and change crop from wheat to sorghum.
6. Make sure the sowing windows for sorghum and wheat sowing rules match those in the table above.
7. Set Rotation sequence to sf, wf, sorghum, wf, sf, wheat, nil.
8. Run and graph your simulation.



Opportunity Cropping

Wheat / Mungbean Opportunity Cropping

In a previous exercise we reset the starting conditions each year. We are not going to do this resetting in this exercise. Instead we are going to look at how to change what is sown based on these differing starting conditions; specifically, starting soil moisture.

In this exercise you will use sowing rules to opportunistically plant mungbean and wheat crops over a 10 year period without resetting water or nitrogen etc. You will observe the effect of this rotation on soil biomass nitrogen and the response of the rotation to the different sowing rules.

1. Start a new simulation using "Continuous Wheat.apsim"
2. Rename simulation to "MungbeanWheat". Save the file as “Opportunity Cropping.apsim”.
3. Choose the Goondiwindi weather. Set start and end dates to 1/4/1974 - 30/4/1984 (10 years)
4. Select the “Heavy Clay” soil from the training toolbox. This soil doesn't have crop lower limits for mungbean, so you will need to add these new crop properties to the soil. Open the water component and rename the sorghum component to mungbean. See “Core 5-Long Term Simulations” for more information on adding new crops. Set LL, PAWC, KL and XF values to the following:

Depth (cm)	mungbean ll (mm/mm)	mungbean PAWC (mm)	mungbean kl (/day)	mungbean xf (0-1)
0-15	0.220	43.5	0.060	1.000
15-30	0.240	39.0	0.060	1.000
30-60	0.260	69.0	0.060	1.000
60-90	0.260	66.0	0.060	1.000
90-120	0.260	63.0	0.060	1.000
120-150	0.260	60.0	0.060	1.000
150-180	0.260	57.0	0.060	1.000

   Make sure you call the component "mungbean". It must have the same name as the crop component under the Paddock component.
5. Set the initial water to 50% full - filled from top.
6. Set the initial nitrogen to 140 kg/ha NO3 and 0 kg/ha NH4, evenly distributed.
7. Add a mungbean crop component to the Paddock , leaving the wheat component alone.

8. Replace the Sowing rule with the Sow using a variable rule from the toolbox and rename to "Wheat sowing - Janz". Change the properties to match the image below:

Description	Value
Sowing criteria	
Enter sowing window START date (dd-mmm) :	1-jun
Enter sowing window END date (dd-mmm) :	14-jun
Must sow? :	no
Amount of rainfall :	30
Number of days of rainfall :	3
Enter minimum allowable available soil water (mm) :	200
Sowing parameters	
Enter name of crop to sow :	wheat
Enter sowing density (plants/m2) :	100
Enter sowing depth (mm) :	30
Enter cultivar :	janz
Enter crop growth class :	plant
Enter row spacing (mm) :	250

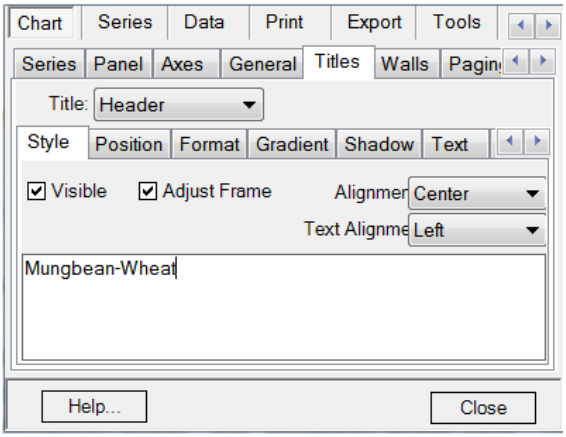
9. We want to sow an earlier maturing cultivar (if the sowing conditions for Janz is not met by 14-jun) so make a copy of this rule but change the window to 15-jun to 1-aug and the cultivar to Hartog. Rename this new rule to "Wheat sowing - Hartog"
10. Rename the harvesting rule to "Wheat harvesting" - make sure it points to wheat.
11. Rename the Sowing fertiliser rule to "Wheat sowing fertiliser". Make sure it points to wheat and set the amount to 70kg/ha of urea_n.
12. Duplicate one of the wheat sowing rules and rename it to "Mungbean sowing". Set the parameters to:

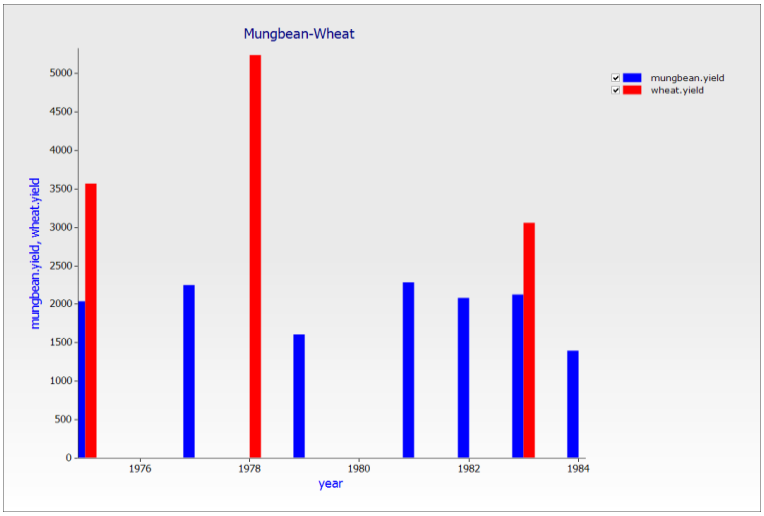
Description	Value
Sowing criteria	
Enter sowing window START date (dd-mmm) :	1-dec
Enter sowing window END date (dd-mmm) :	15-jan
Must sow? :	no
Amount of rainfall :	20
Number of days of rainfall :	3
Enter minimum allowable available soil water (mm) :	200
Sowing parameters	
Enter name of crop to sow :	mungbean
Enter sowing density (plants/m2) :	36
Enter sowing depth (mm) :	50
Enter cultivar :	berken
Enter crop growth class :	plant
Enter row spacing (mm) :	500

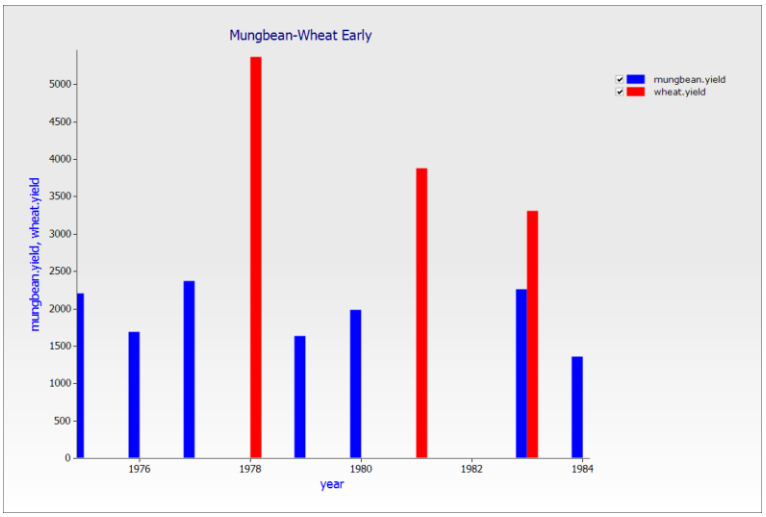
13. Duplicate the wheat harvesting rules and rename to “Mungbean Harvesting”. Change the crop to harvest to mungbean.
14. Report the following variables:

Component	Variable	Description
Clock	year	
Heavy Clay	biom_n()	Summed over profile.
Crop	yield	Both crops will report their yield. You don’t need to report each separately.

15. Make sure reporting frequency is set to “harvesting”.
16. Create a linked copy of this simulation and rename it to “MungbeanWheatEarly”. See “Core – 4 Sowing A Crop” for more information on linking simulations.
17. Unlink the mungbean sowing rule and change the sowing window to 1-nov to 1-jan.
18. Run all simulations.
19. Create **separate** bar graphs of Year vs Mungbean Yield **for each simulation**. The easiest way to do this is to create the graph for one simulation then drop it onto the other simulation.
20. Change the Titles of each graph identifying them as "Mungbean-Wheat" and "Mungbean-Wheat Early". To do this, right click the graph and select “Format graph”. Click the “Titles” tab and enter the text in the box. Click “Close” when finished.






Mungbean-Wheat Early
mungbean.yield
wheat.yield
mungbean.yield, wheat.yield
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1976
1978
1980
1982
1984
year

SOI phase and Economic Analysis

In this exercise, you will examine the effect of SOI (Southern Oscillation Index) phase on yield probability, and gross margin outcomes. Exercises will also be conducted using manual generation of a probability distribution and the application of economic principles.

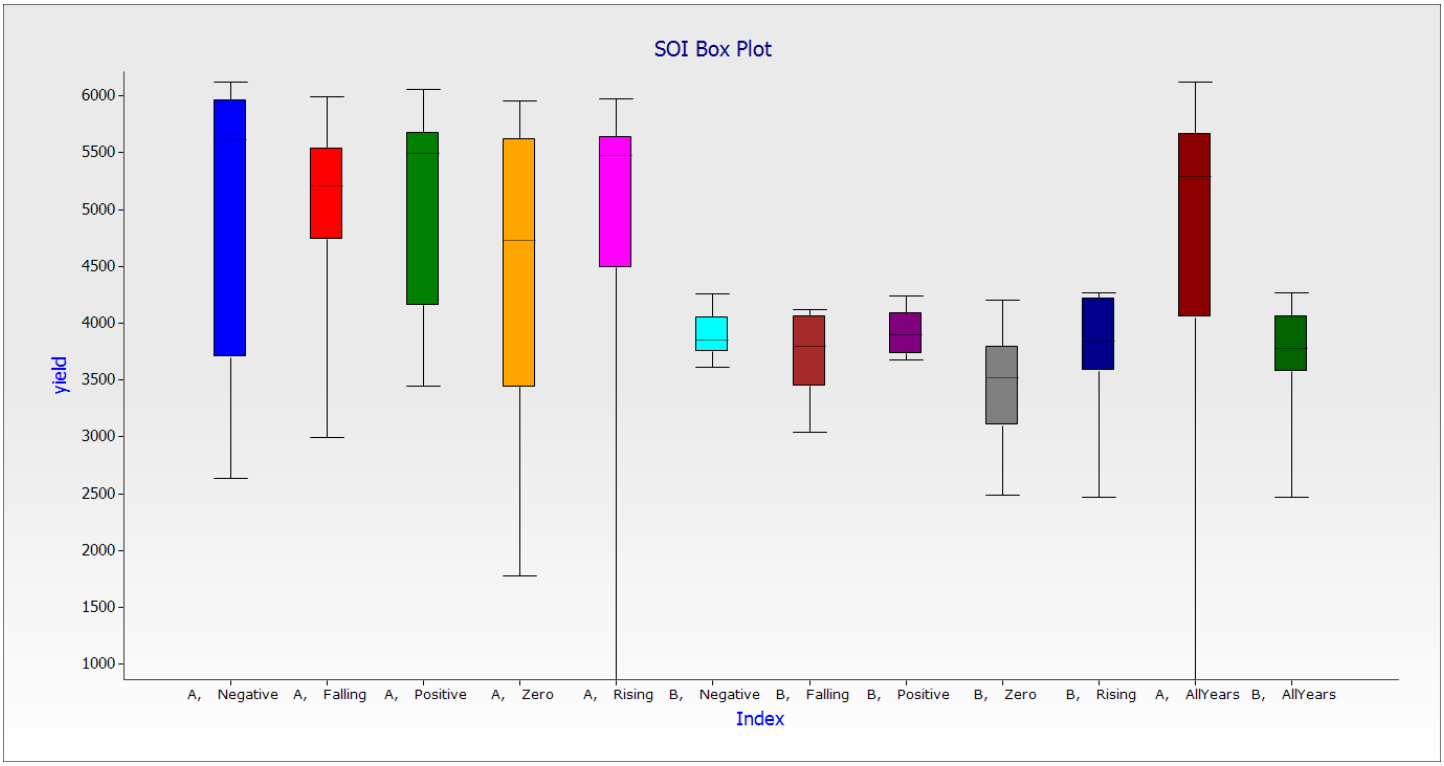
1. Create a new simulation using "Continuous Sorghum.apsim". Save it as "`SOI.apsim`".
2. Rename simulation to "A" (we are choosing this short name to save space on the graph later on).
3. Ensure the Goondiwindi met file is being used.
4. Set the starting date to 01/01/1940 and the ending date to 31/12/1989. When looking at probabilities the longer the simulation the better.
5. Choose "Heavy Clay" from the training soils toolbox (see Module 1 for more information).
6. Set the starting soil water to 33% full – filled from the top
7. Use the following initial soil nitrogen:

Depth (cm)	NO3 (kg/ha)	NH4 (kg/ha)
0-15	0.282	0.249
15-30	0.282	0.282
30-60	1.200	1.200
60-90	1.221	1.221
90-120	1.317	1.317
120-150	1.427	1.427
150-180	1.519	1.519

8. Set initial surface organic matter to 1500 kg/ha of sorghum (rename the pool name, but leave everything else).
9. Modify the sowing rule as follows:

Description	Value
Sowing criteria	
Enter sowing window START date (dd-mmm) :	10-dec
Enter sowing window END date (dd-mmm) :	10-dec
Must sow? :	yes
Amount of rainfall :	30
Number of days of rainfall :	3
Enter minimum allowable available soil water (mm) :	200
Sowing parameters	
Enter name of crop to sow :	sorghum
Enter sowing density (plants/m2) :	5
Enter sowing depth (mm) :	30
Enter cultivar :	early
Enter row spacing (mm) :	1000
Skip row :	solid

10. Set fertiliser at sowing to 100 kg/ha of urea_no3 (you'll need to add it).
11. From the Standard toolbox drag in a "Yield moisture correction" and a "Simple gross margin" rule. The moisture correction rule must come before the gross margin rule and both must be before the harvest rule.
12. Report year, yield and Bank in the output file (type "Bank" in manually into the variable list).
13. Report at harvesting.
14. Delete the XY component under the outputfile component.
15. Create a linked copy of this simulation via drag and drop and rename this new one to "B" (see Core-4 Sowing a Crop for more information).
16. Unlink the sowing rule and change the "Skip row" property to "double".
17. Graph Yield of both simulations using an SOI Box Plot from the Graph toolbox. Fully expand the graph component. For the SOI component, given we used a sowing date of December, use the SOI from November to split the years.

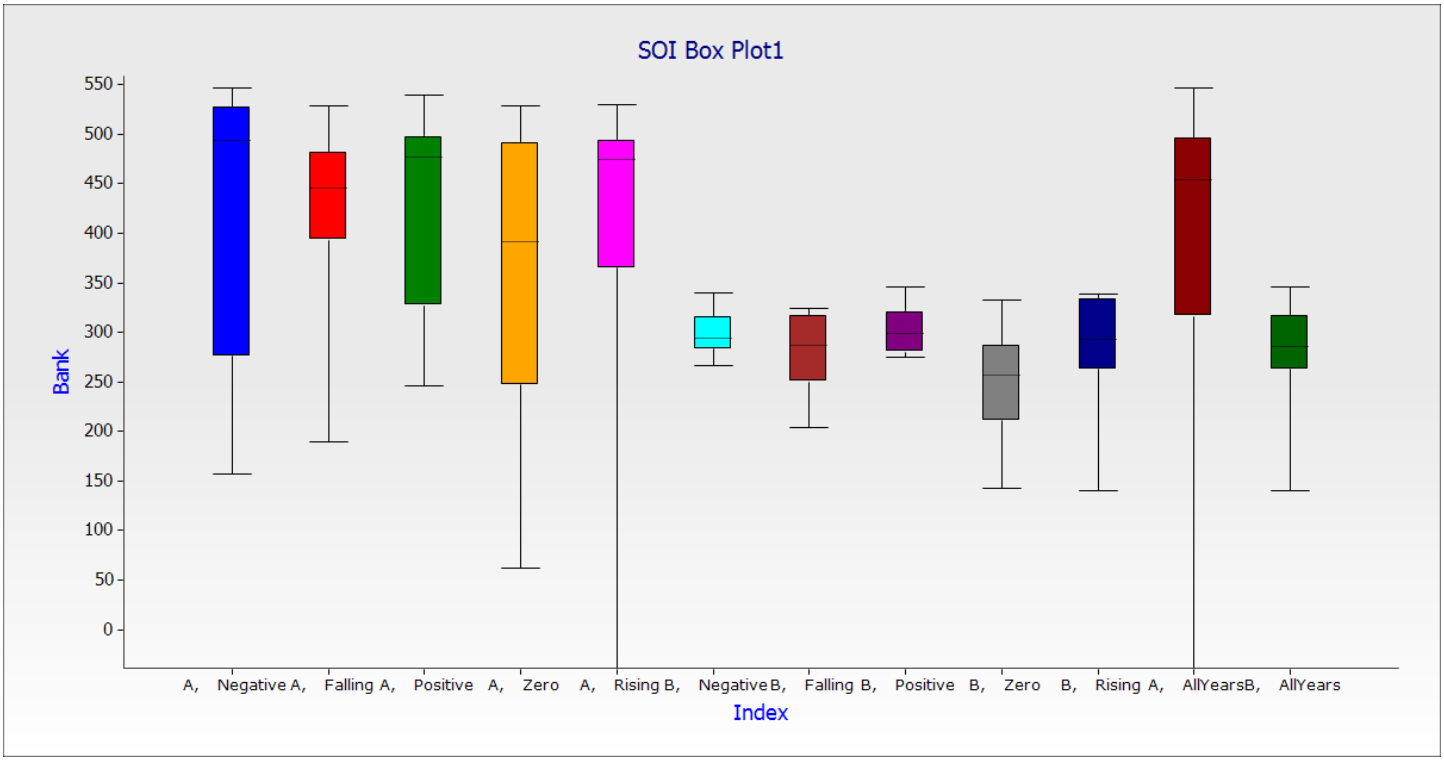


The output demonstrates the differing probability distributions of solid vs. double skip configuration in negative and positive SOI phases. You will notice that the distribution is far greater with the Solid row spacing (A) as opposed to the Double (or Skip) row spacing (B). This is because the skip row spacing allows greater spacing between individual plants and therefore for less competition for water. This makes the plants more drought tolerant. However it comes at the cost of the average yields that it can achieve in better rainfall years.

Economic Analysis

This simulation has two rules from the Standard toolbox that we dragged in. A Yield moisture correction and a Simple gross margin rule. You also remember how you manually typed in Bank into the output variable list.
You can create your own economic calculations by using these kinds of manager rules. Keep in mind though when using these rules, that yield in APSIM is calculated as dry yield. So this assumes no water content. Much economic analysis requires a wet yield which is what a farmer will actually harvest from his paddock. This is why in our simulations we used a Yield moisture correction to do a simple calculation to work out this wet yield (see its "start_of_day" tab).

1. Graph gross margin using the SOI graph you have already created by copying it, deleting “yield” and adding “Bank”.



Further Analysis in Excel

1. Select the top component Simulations then click the Excel button on the top toolbar. Choose the simulations you want to output and click Ok. You will notice that the output files have been exported to 2 separate Excel windows as .CSV files.