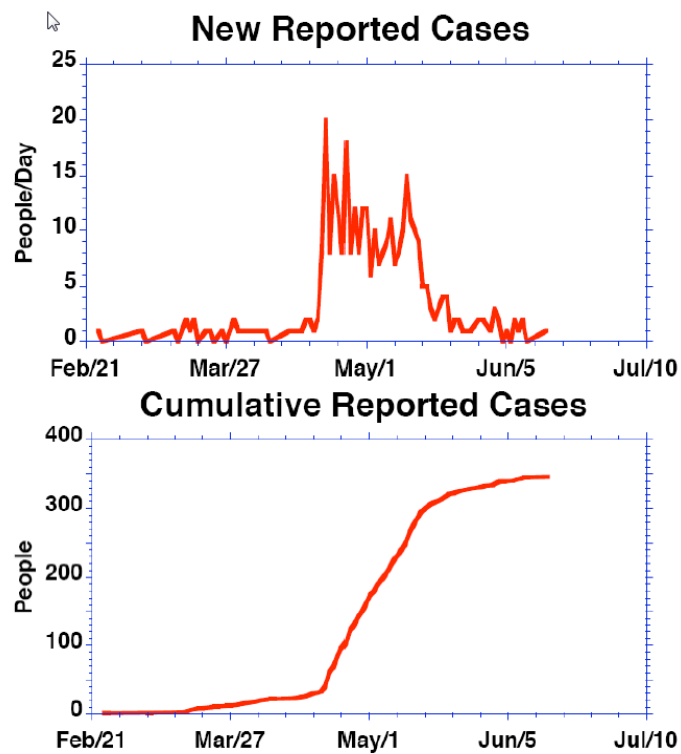


15.871 System Dynamics Recitation#1

Understanding Epidemics Using **VensimPLE**

For use with VensimPLE, version 6.0

A simple model that captures the dynamics of an infectious disease- SARS

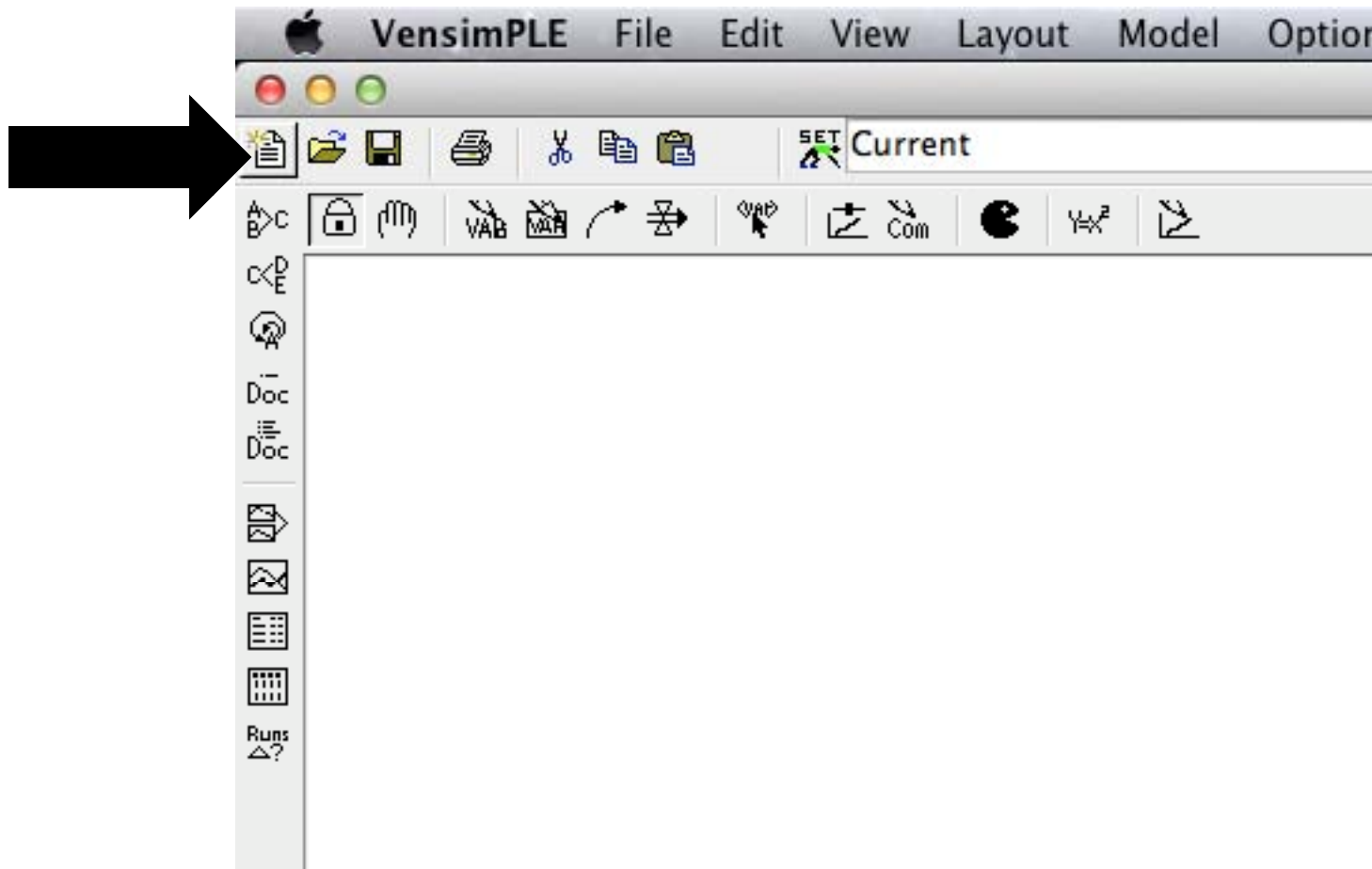


Historical data: SARSDATA.vdf

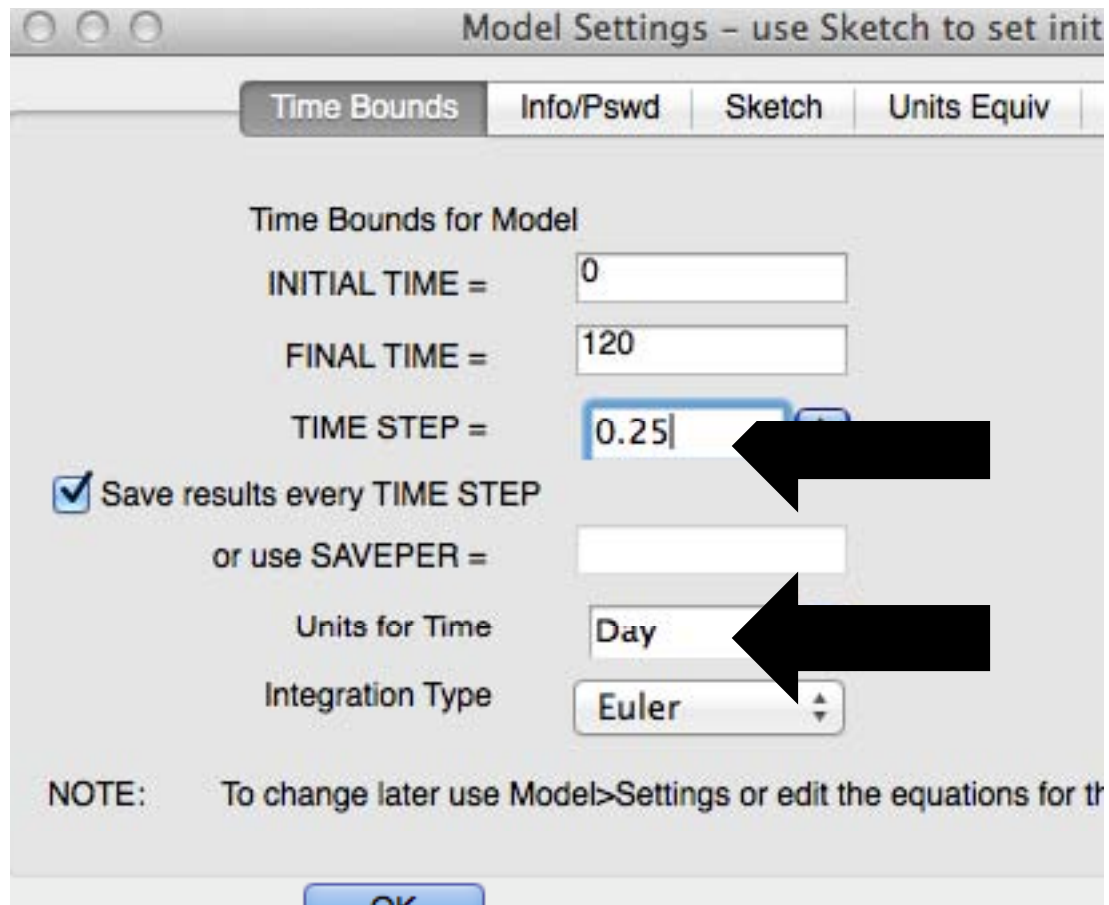
- **the incidence** (rate at which new cases were reported, measured in **people/day**)

- **cumulative prevalence** (cumulative number of cases reported, measured in **people**) for SARS in Taiwan

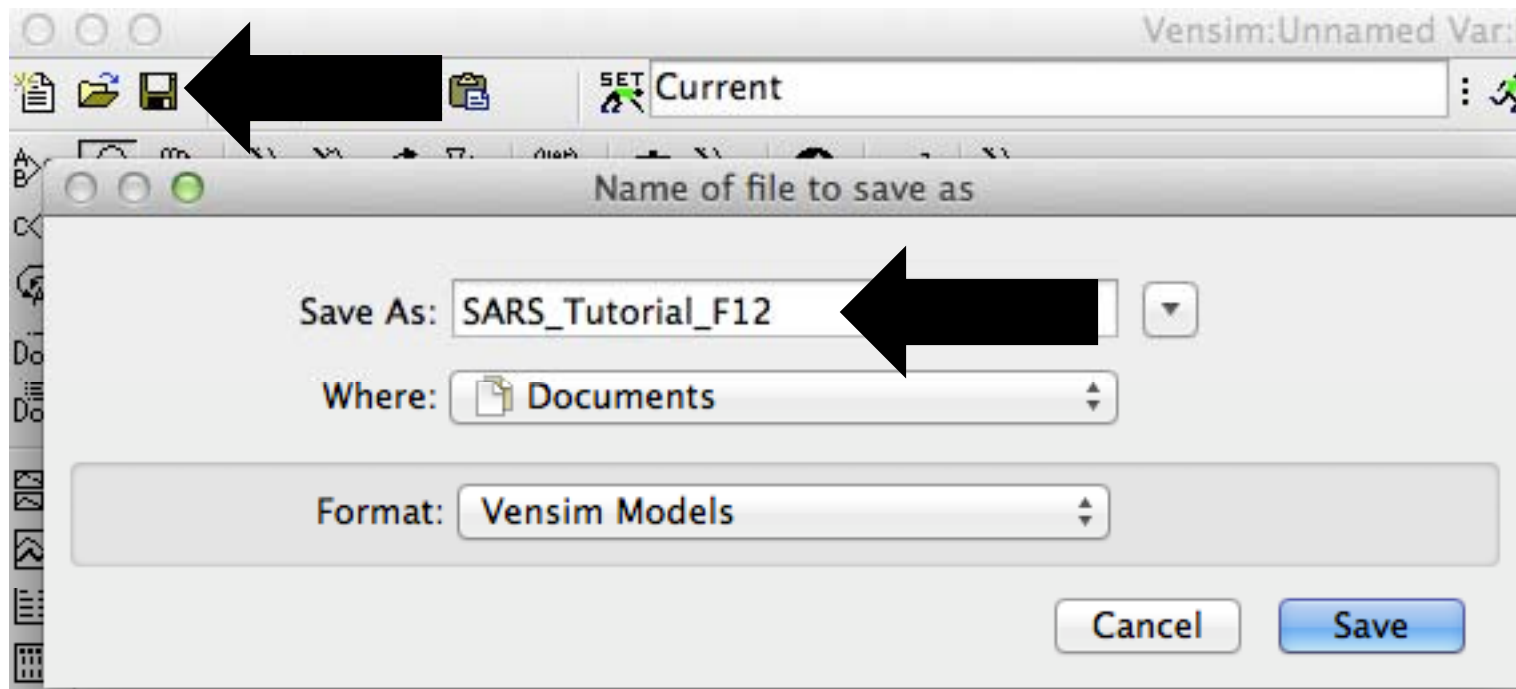
Step 1: Open A New Model



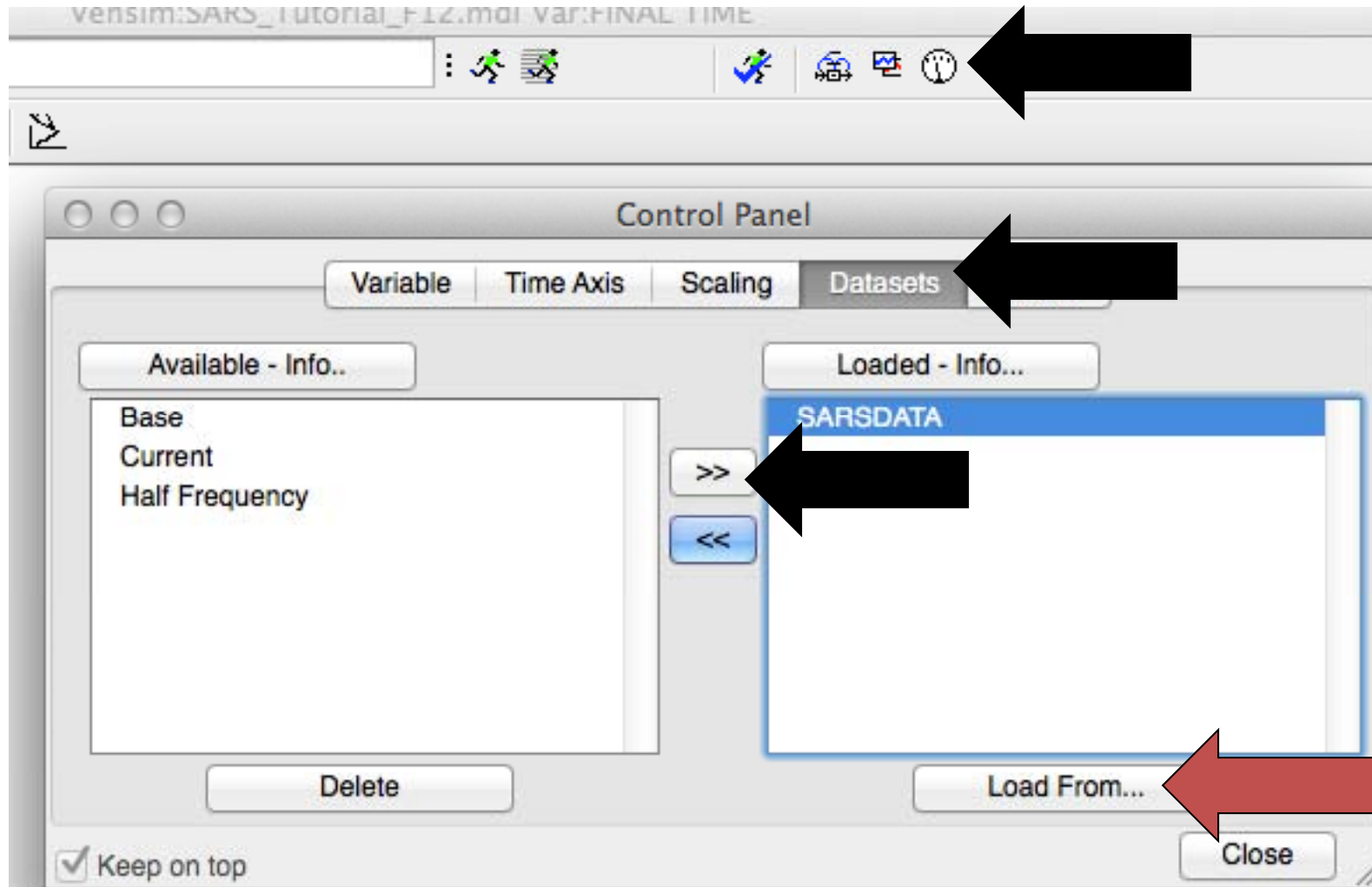
Step 2: Initial Settings



Step 3: Save As “SARS_Tutorial_F12”

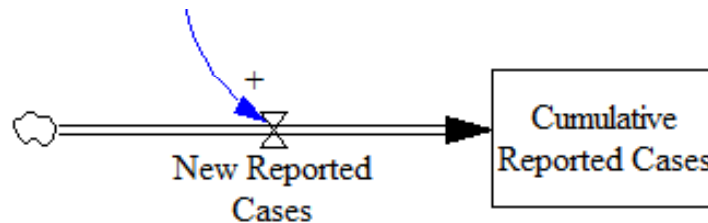


Step 4: Load SARSDATA.vdf

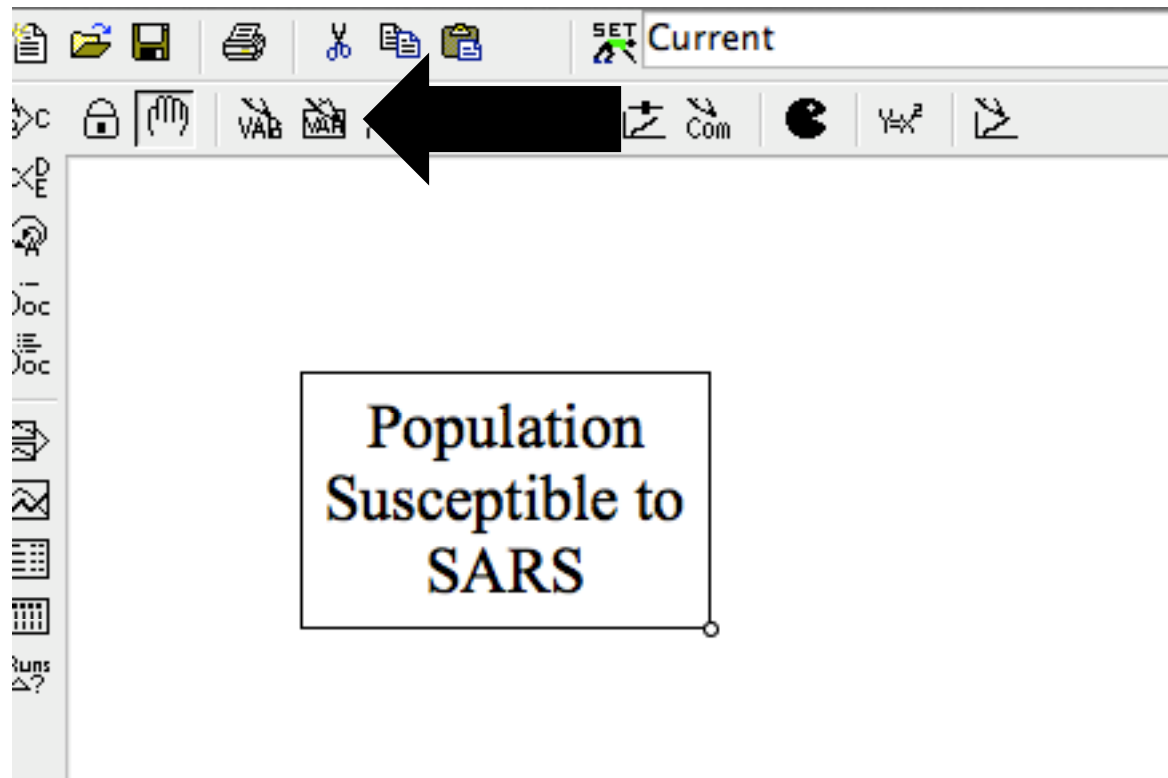


-----Warning-----

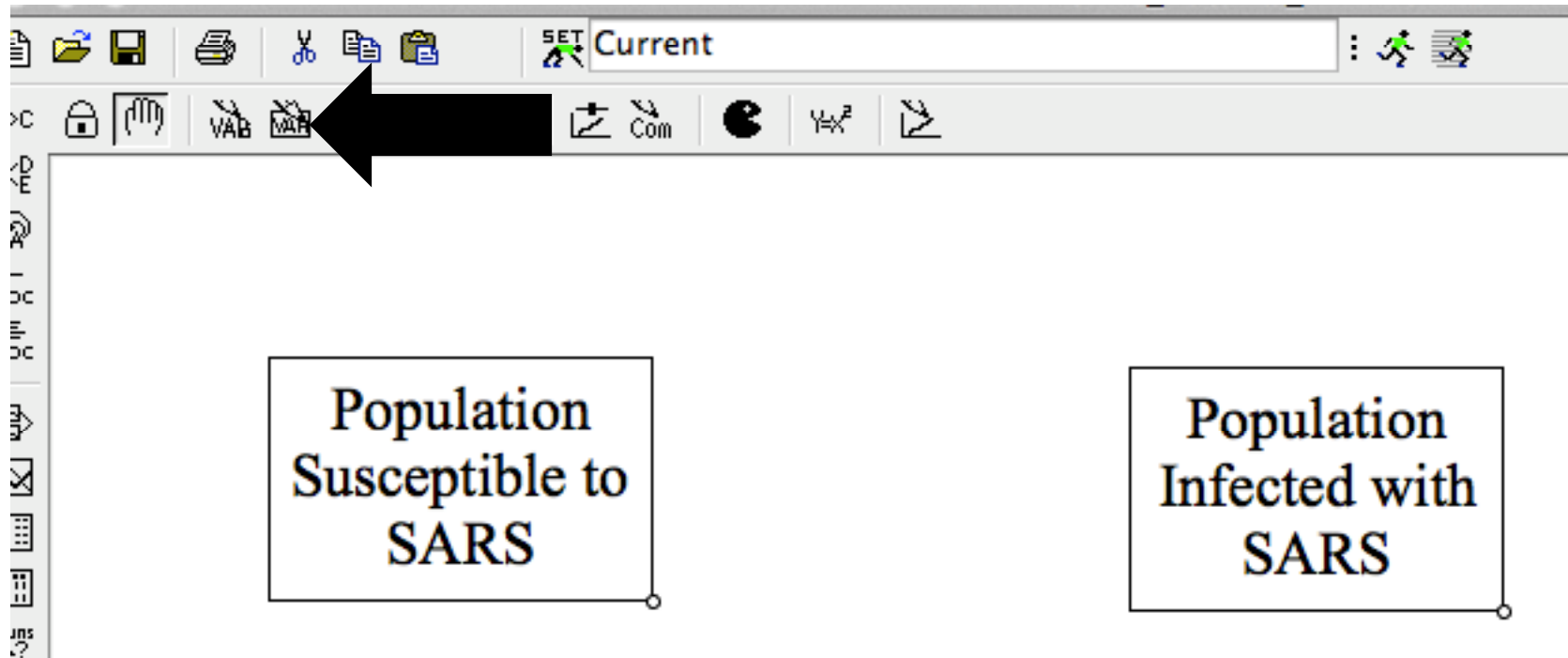
- We will compare our simulation data to the actual/historical data in this file, so variable names need to match EXACTLY
- SARSDATA has 2 variables, those names have to match:
 - New Reported Cases
 - Cumulative Reported Cases



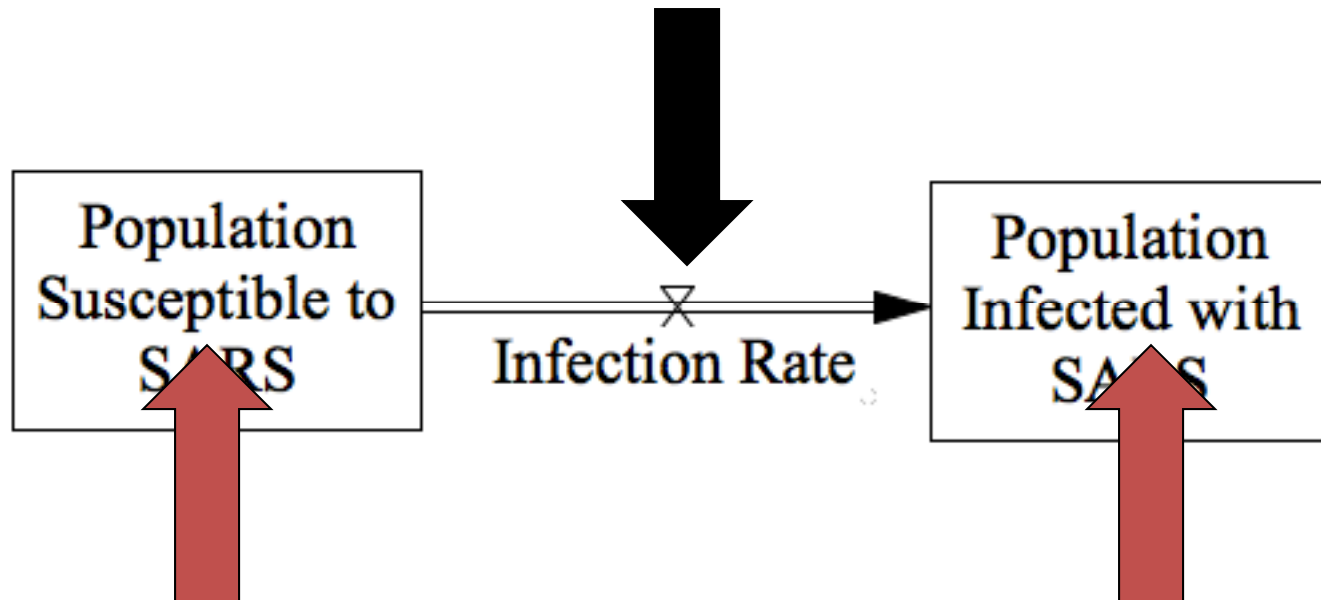
Step 5: Population Susceptible to SARS (stock)



Step 6: Population Infected with SARS (stock/level)



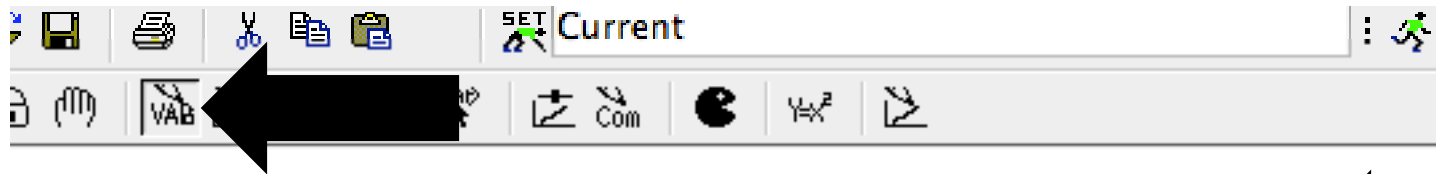
Step 7: Infection Rate (flow/rate)



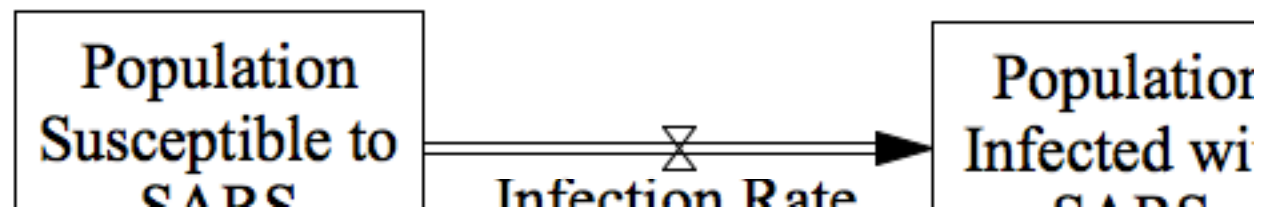
First click in center of this stock

Then click in center of this stock

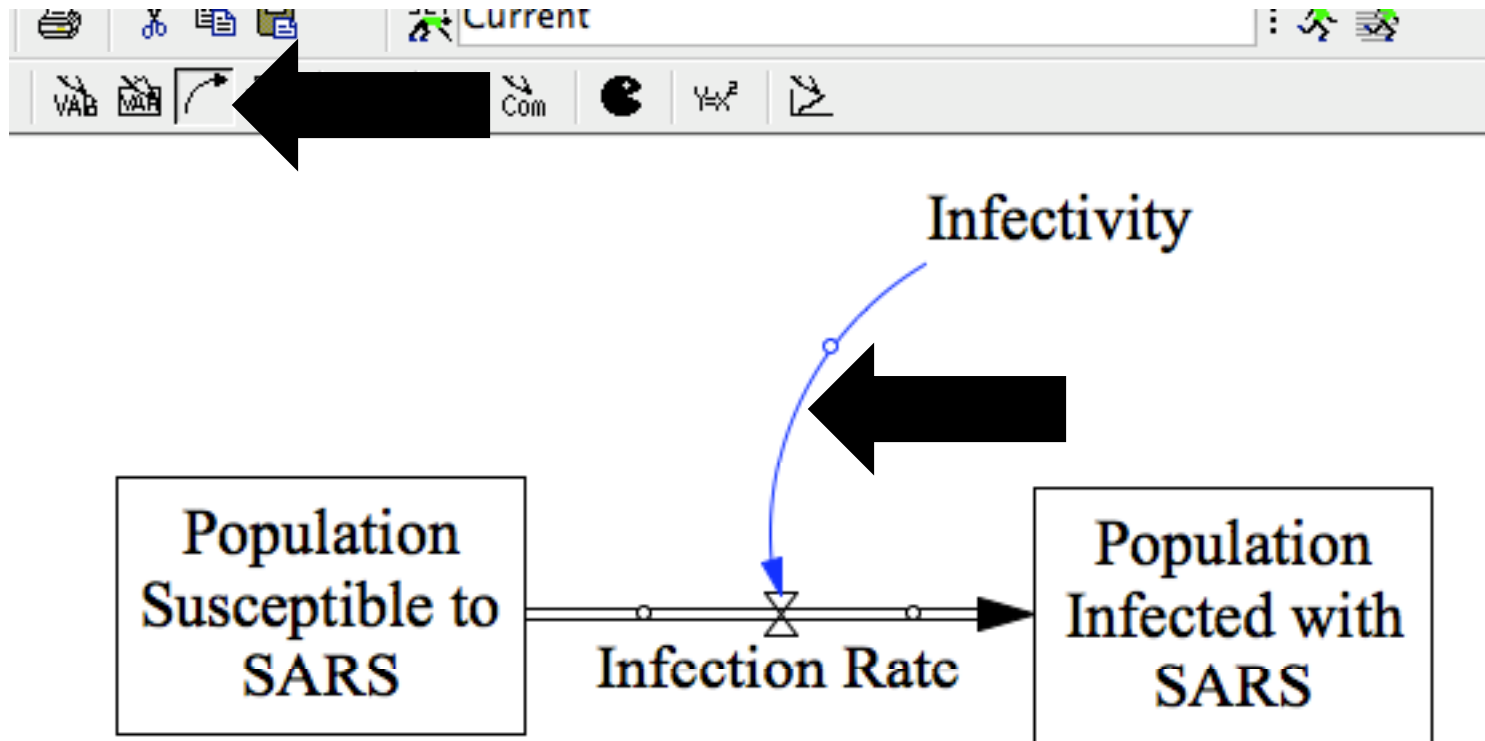
Step 8: Infectivity (auxiliary)



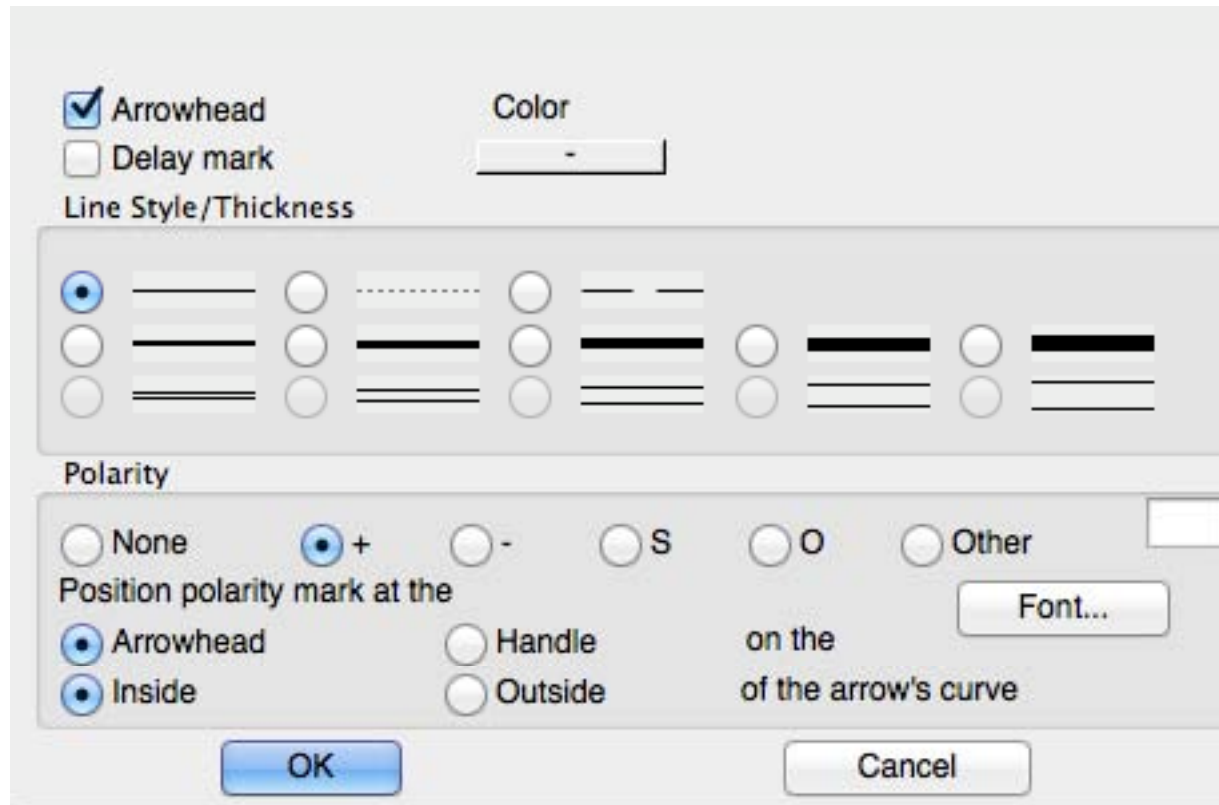
Infectivity



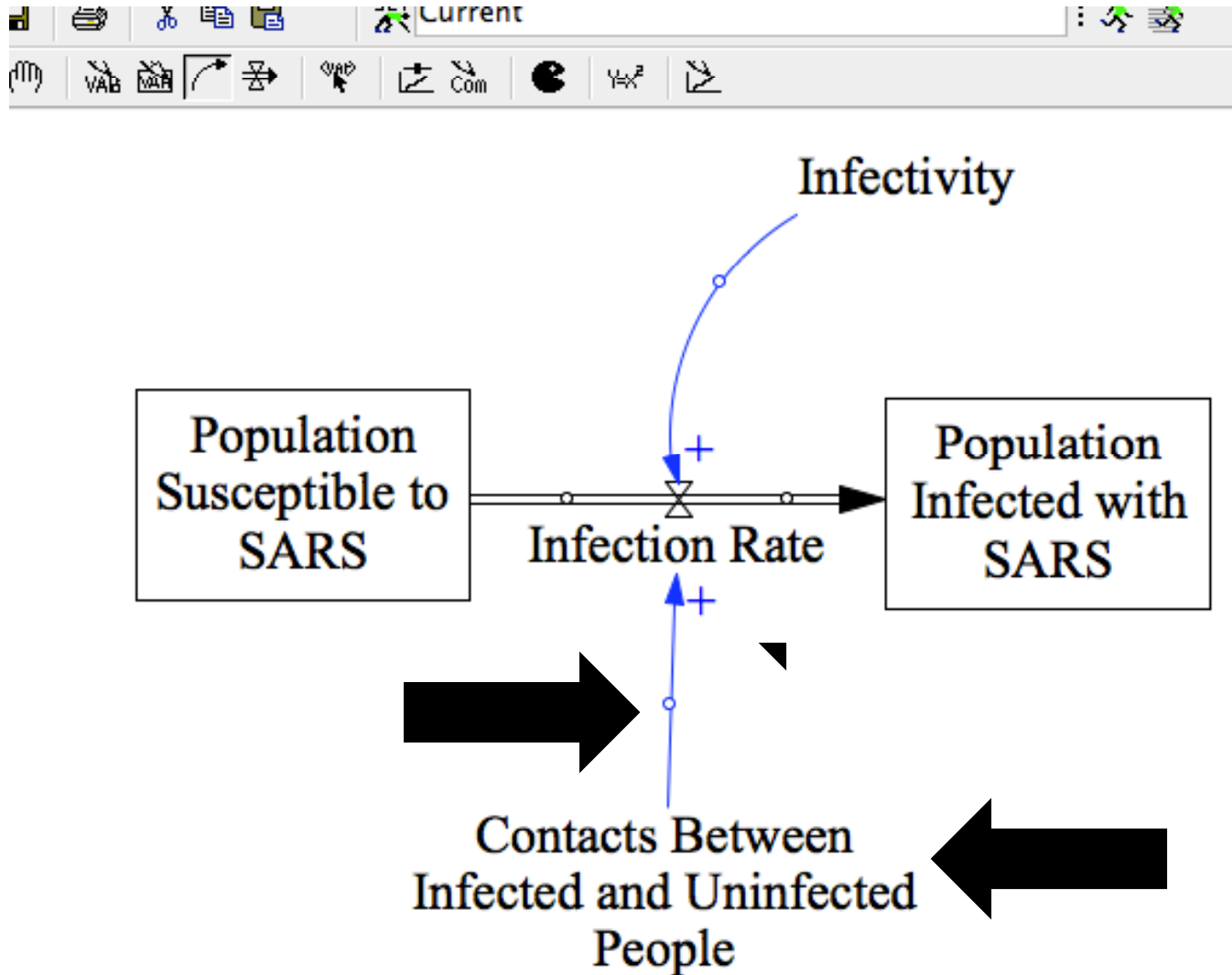
Step 9: Add Causal Arrow



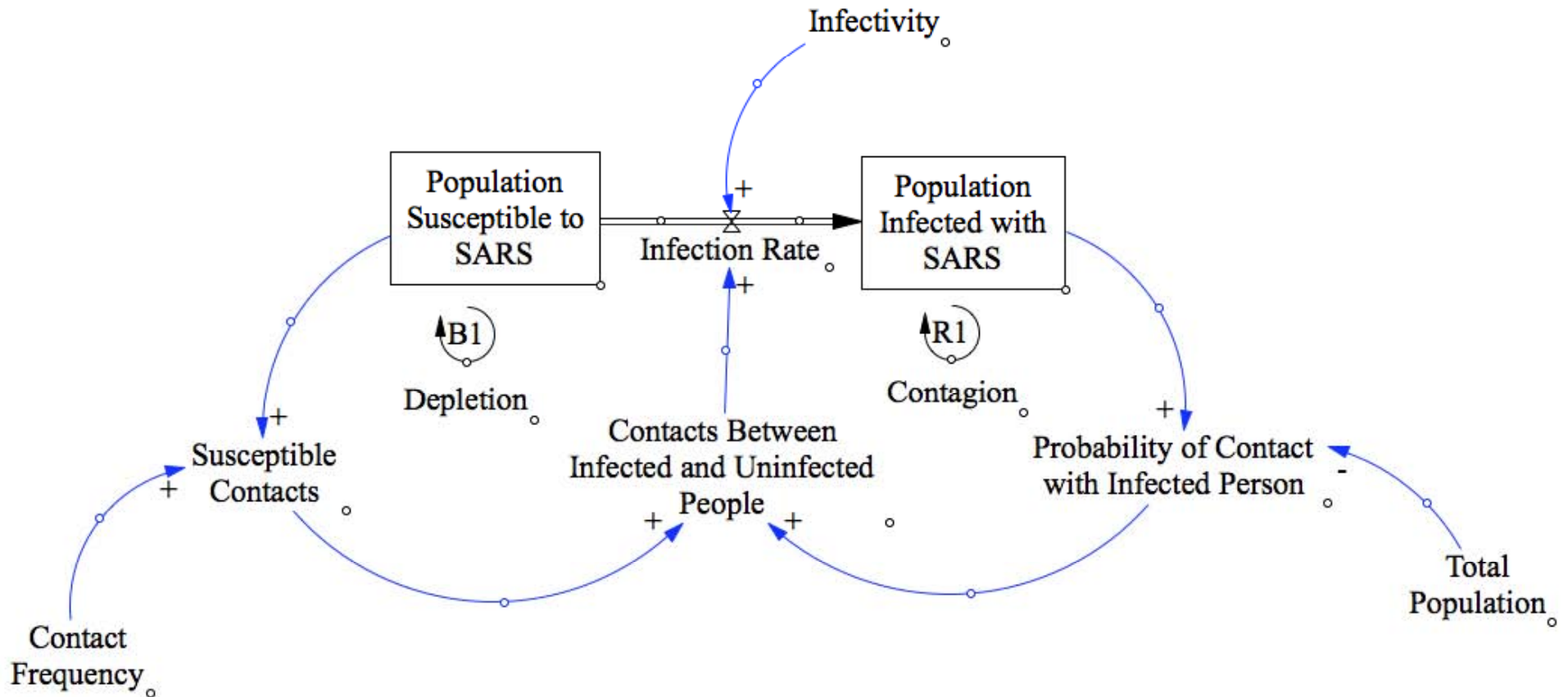
Step 10: Right-click on Arrow “handle” to Add Polarity



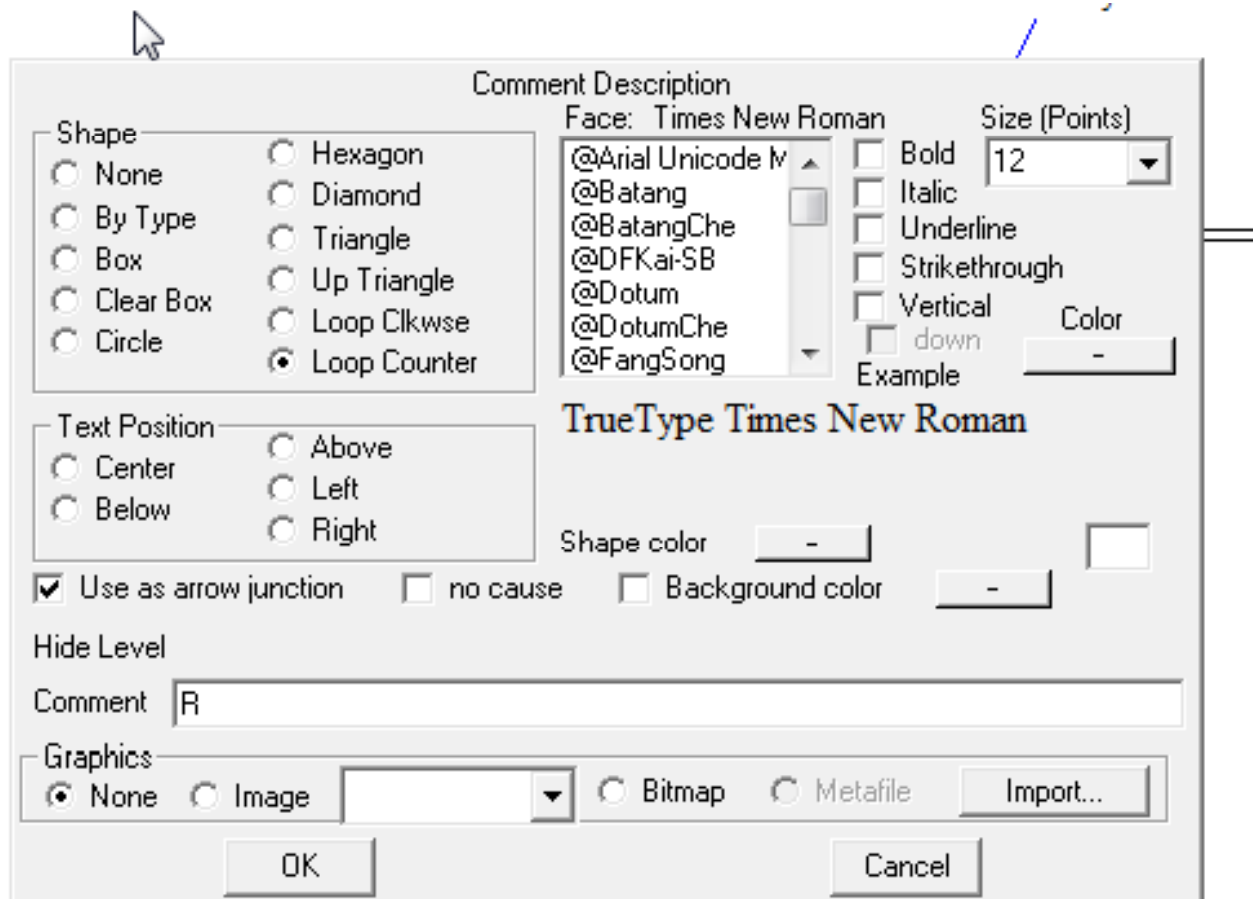
Step 11: Contacts Between Infected and Uninfected People



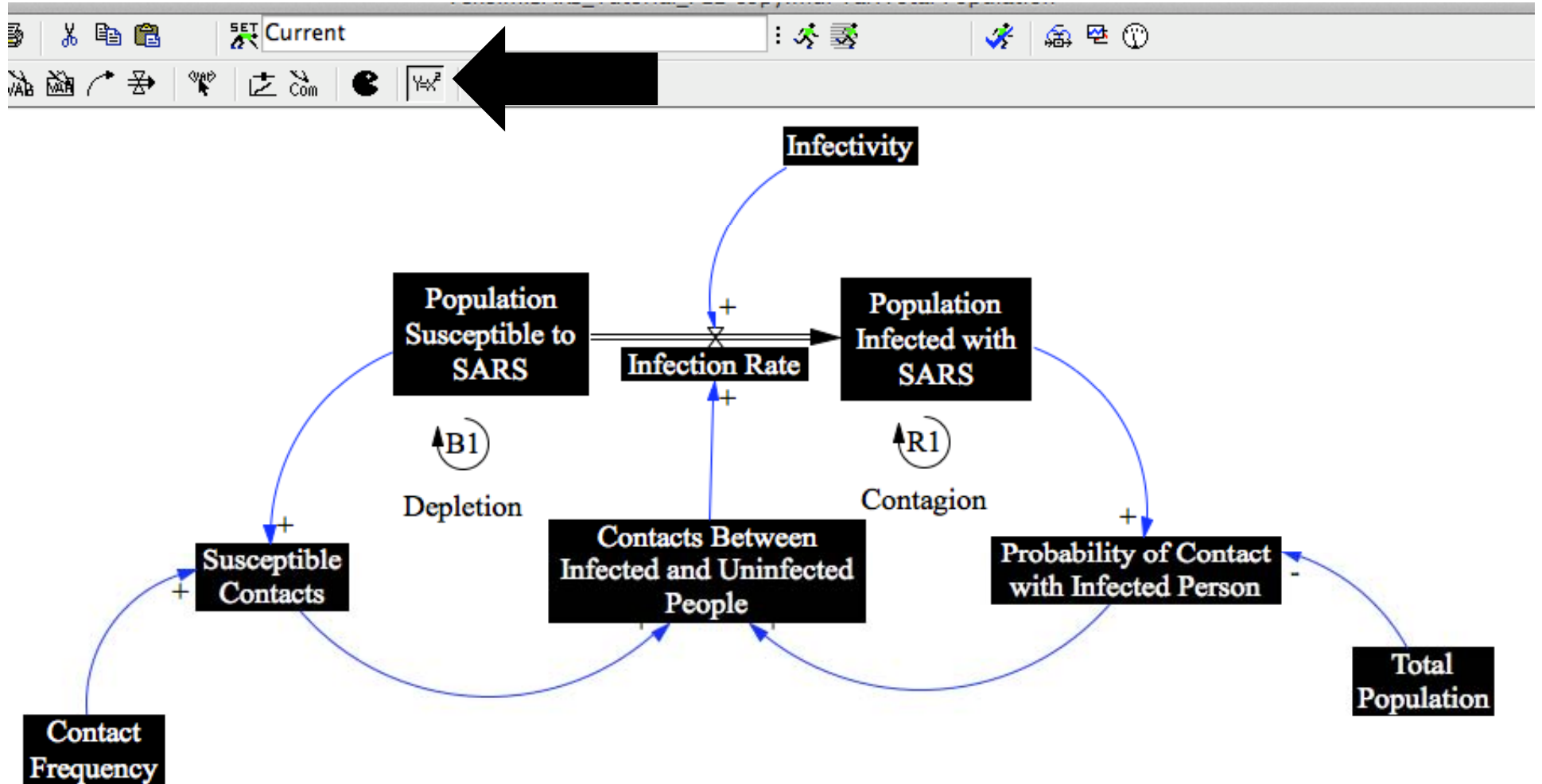
Step 12: Complete the Rest of the Model + Label the Loops



Use comment tool to add labels



Step 13: Specify Equations



Exogeneous and Endogeneous Variables

- Variables in SD models are classified as either exogenous or endogenous:
 - Exogenous variables are defined independent of other variables of the model.
 - They are functions of time (i.e., Exogenous Variable = $f(t)$).
 - *Of course the exogenous variables may be constants, in which case they are called parameters.*
 - Endogenous variables are influenced by other variables in the system
 - Endogenous Variable = $f(x, y, z)$, where x, y, z are other variables in the model

Step 14: Define Infection Rate

The screenshot shows a window titled "Editing equation for - Infection Rate". The main text area contains the equation: $\text{Contacts Between Infected and Uninfected People} * \text{Infectivity}$. A black arrow points to this equation. Below the equation is a control panel with several sections:

- Type:** Includes dropdowns for "Auxiliary" and "Normal", and a checkbox for "Supplementary".
- Units:** A dropdown menu is set to "People/Day". A black arrow points to this dropdown.
- Comment:** A text area containing the text: "The infection rate is determined by the total number of contacts between infected and uninfected people each day and the probability that each such contract results in transmission from the infected to uninfected (denoted infectivity)." A black arrow points to this comment.
- Variables:** A panel with tabs for "Variables", "Functions", and "More". It contains a list of variables: "Contacts Between Infected and Uninfected People" and "Infectivity". A red arrow points to this list.
- Buttons:** Includes "Undo", "Help", "Check Syntax", "Check Model", "Delete Variable", and "Cancel". A black arrow points to the "Check Model" button.
- Errors:** A dropdown menu showing "Equation Modified".

Step 15: Define Population Susceptible to SARS

Editing equation for - Population Susceptible to SARS

Population Susceptible to SARS

= INTEG (-Infection Rate)

Initial Total Population

Type Level

Undo 7 8 9 +

[()] 4 5 6 -

1 2 3 *

0 E . /

() , ^

Variables Functions More

Choose Initial Variable...

Population Susceptible to SARS

Infection Rate

Units: People

Comment: The Population Susceptible to SARS is equal to the population susceptible prior to the onset of the disease less all of those that have contracted it. It is initialized to the Total Population, which assumes taht all individuals are initially susceptible (no prior natural or vaccine-conferred immunity).

Minimum Value Maximum Value Increment

Errors: Equation Modified

OK Check Syntax Check Model Delete Variable Cancel

Step 16: Define Susceptible Contacts

The screenshot shows a software window titled "Editing equation for - Susceptible Contacts". The main text area contains the equation: $\text{Population Susceptible to SARS} * \text{Contact Frequency}$. A black arrow points to this equation. Below the equation, there is a "Type" section with a dropdown menu set to "Auxiliary", a "Normal" dropdown, and a "Supplementary" checkbox. A "Units:" field is set to "People/Day", with a black arrow pointing to it. To the right, a "Variables" panel is open, showing a list of variables: "Contact Frequency" and "Population Susceptible to SARS". A red arrow points to "Contact Frequency". At the bottom, there are fields for "Minimum Value", "Maximum Value", and "Increment", all currently empty. An "Errors:" field shows "Equation". At the bottom of the window are buttons for "OK", "Check Syntax", "Check Model", "Delete Variable", and "Cancel".

Step 17: Define Contacts Between Infected and Uninfected People

Editing equation for - Contacts Between Infected and Uninfected People

Contacts Between Infected and Uninfected People

Susceptible Contacts*Probability of Contact with Infected Person

Type: Auxiliary, Normal, Supplementary

Units: People/Day

Comment: Insert your comment here...

Minimum Value: Maximum Value: Increment:

Errors: Equation defined

Buttons: OK, Check Syntax, Check Model, Delete Variable, Cancel

Variables: Probability of Contact with Infected Person, Susceptible Contacts

Step 18: Define Probability of Contact with Infected Person

Editing equation for - Probability of Contact with Infected Person

Probability of Contact with Infected Person

Population Infected with SARS/Total Population

Type: Auxiliary, Normal, Supplementary

Units: Dimensionless

Comment: Insert your comment here...

Minimum Value, Maximum Value, Increment

Errors: Equation defined

Buttons: OK, Check Syntax, Check Model, Delete Variable, Cancel

Variables: Choose Initial Variable...
Population Infected with SARS
Total Population

Step 19: Define Total Population

The screenshot shows a window titled "Editing equation for - Total Population". The main input field contains "350", with a large black arrow pointing to it from the left. Below the input field is a control panel with several sections:

- Type:** A dropdown menu set to "Constant", another dropdown set to "Normal", and an unchecked checkbox for "Supplementary".
- Buttons:** "Undo", "Help", and a numeric keypad with symbols for +, -, *, /, and ^.
- Variables Panel:** Tabs for "Variables", "Functions", and "More". A button labeled "Choose Initial Variable..." is present above a large empty text area.
- Units:** A text field containing "People" with a small up/down arrow button to its right.
- Comment:** A text field containing "Insert your comment here..." with a large black arrow pointing to it from below.
- Parameters:** Fields for "Minimum Value", "Maximum Value", and "Increment", each with an empty input box.
- Errors:** A dropdown menu showing "Equation not defined".
- Buttons:** "OK", "Check Syntax", "Check Model", "Delete Variable", and "Cancel".

Step 20: Define Contact Frequency

Editing equation for - Contact Frequency

Contact Frequency

10

Type: Constant

Normal

Supplementary

Help

Units: People/Day

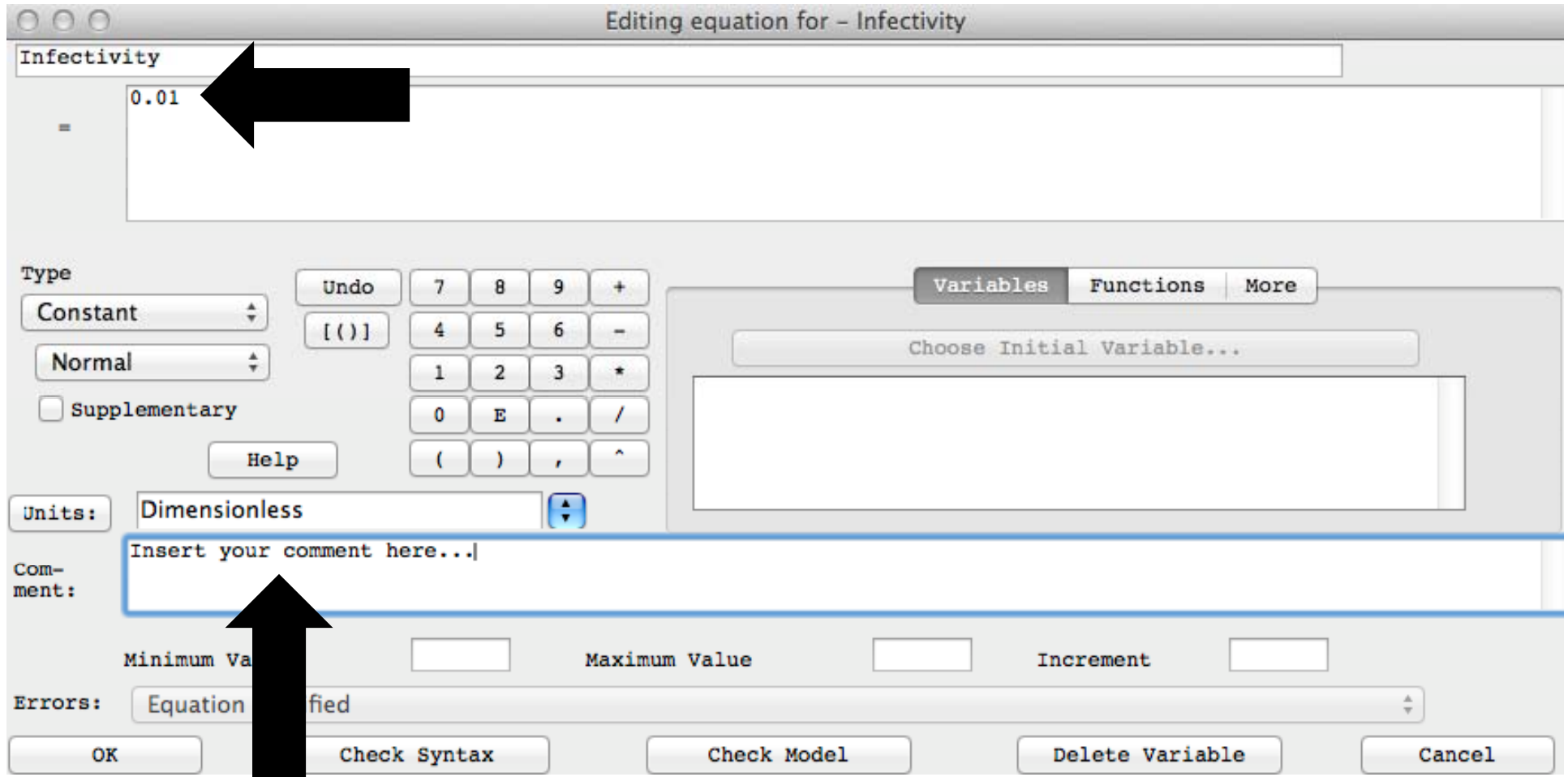
Comment: Insert your comment here...

Minimum Value: Maximum Value: Increment:

Errors: Equation not defined

OK Check Syntax Check Model Delete Variable Cancel

Step 21: Define Infectivity



Step 22: Define Population Infected with SARS

Editing equation for - Population Infected with SARS

Population Infected with SARS

= INTEG (Infection Rate

Initial 1

Type Level

Supplementary

Units: People

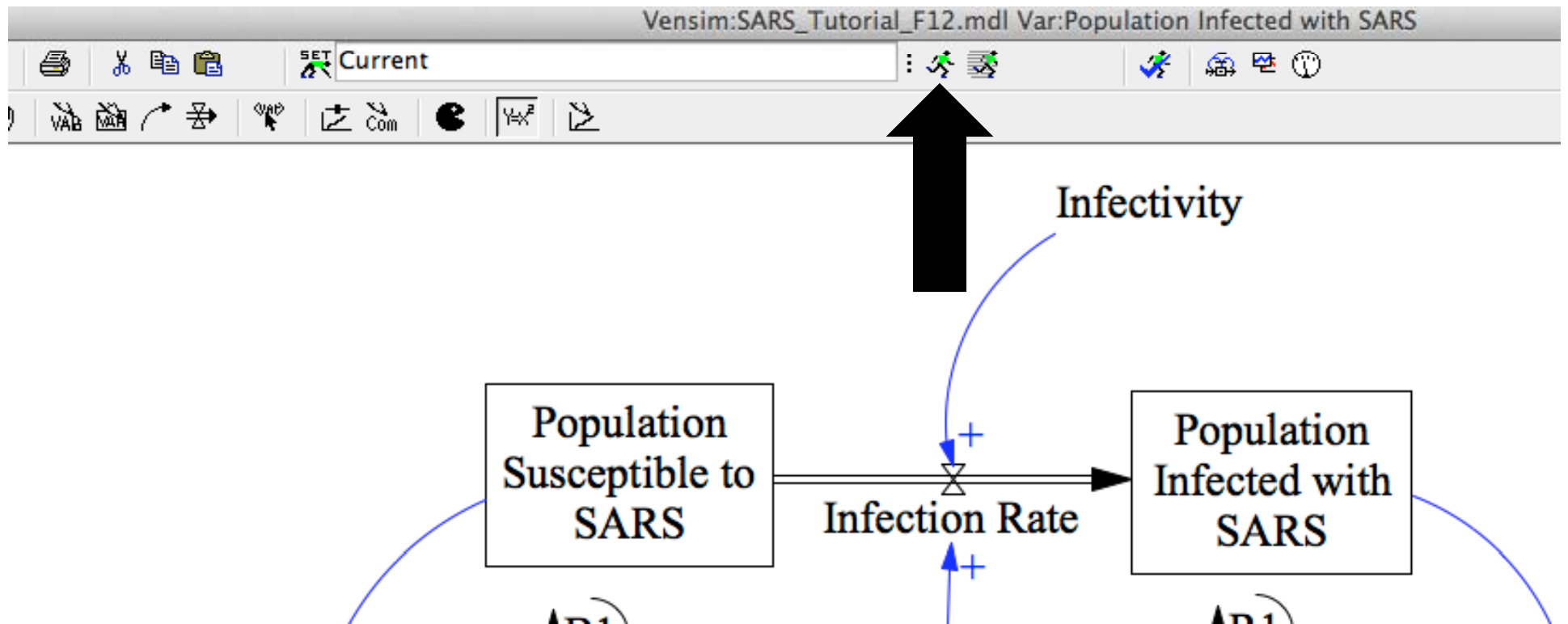
Comment: Insert your comment here...]

Minimum Value Maximum Value Increment

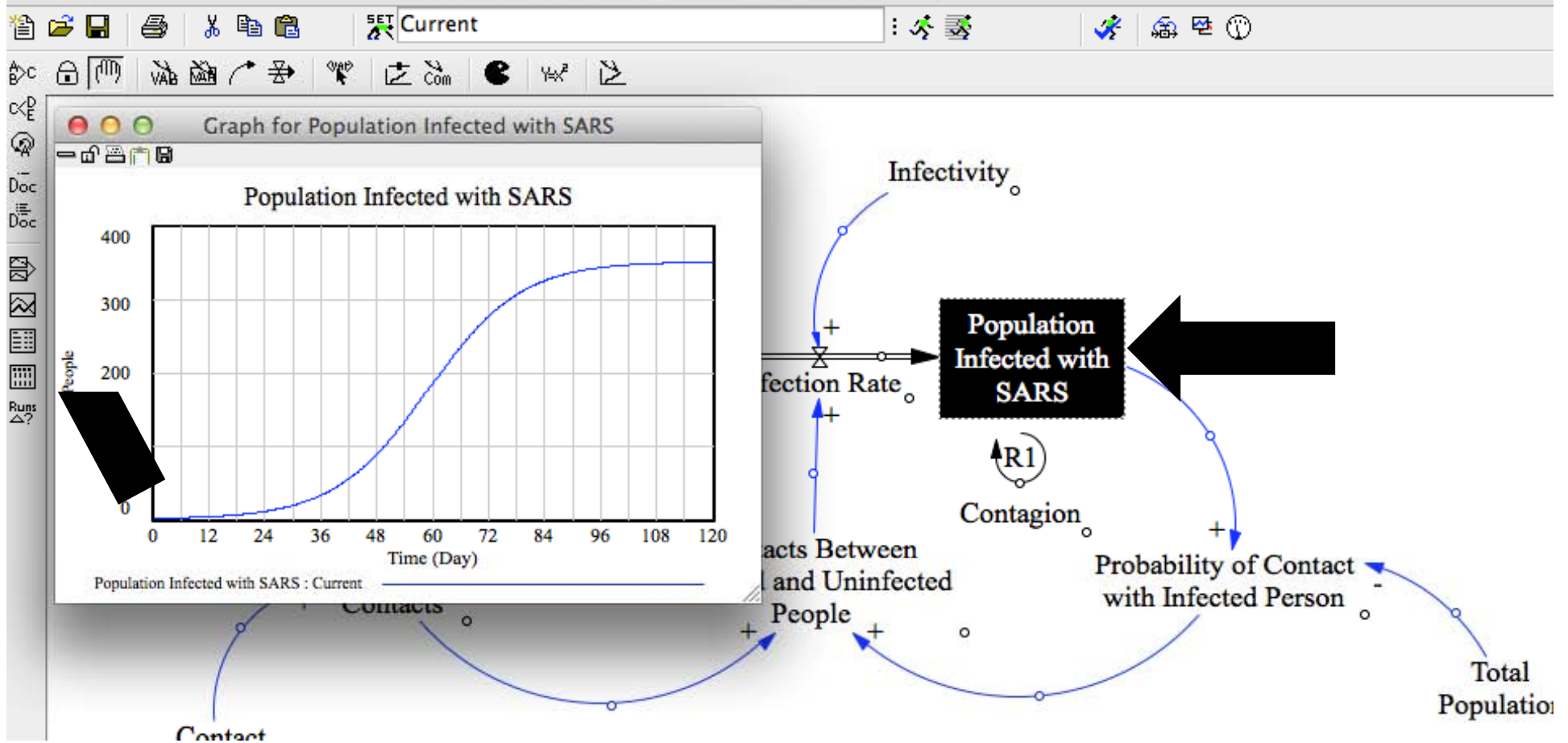
Errors: Equation defined

OK Check Syntax Check Model Delete Variable Cancel

Time Out and Run



Plotting Results



Optional: Permanent Graph

Use: I/O Object or Custom Graph

The screenshot displays a software toolbar with the following icons: I/O Object, Comment, Delete, Equations, and Reference Mode. A settings dialog titled "Input Output Object settings" is open, showing the following configuration:

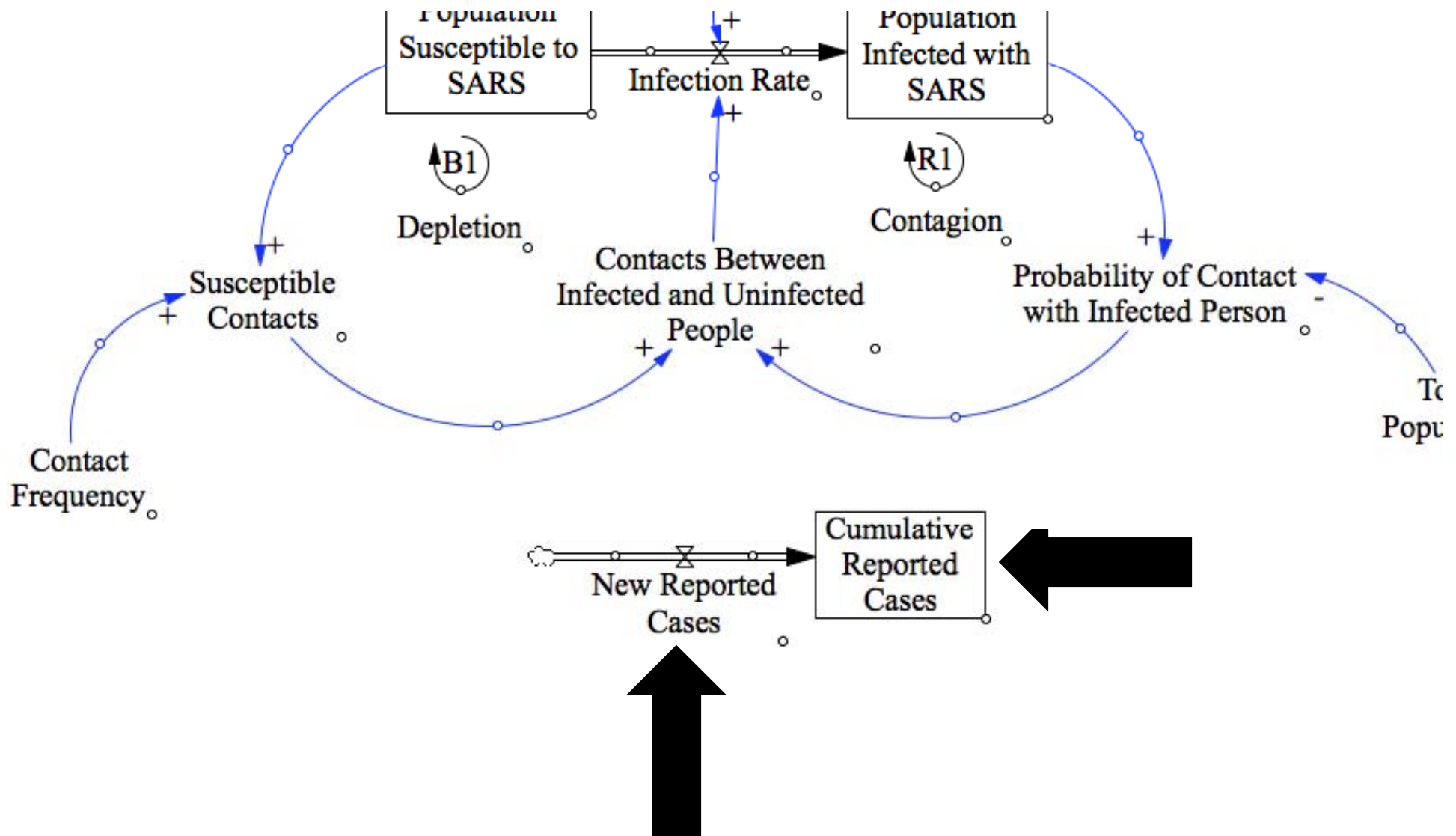
- Object Type:** Input Slider, Output Workbench Tool, Output Custom Graph
- Variable name:** Choose: Level..., Auxiliary..., Data...
- Cumulative Reported Cases:** [Empty text field]
- Slider Settings:** Ranging from 0 to 1 with increment 0.01
- Units:** People
- Label with varname:**
- Custom Graph or Analysis Tool for Output:** [Dropdown menu]

Below the dialog, two graphs are shown:

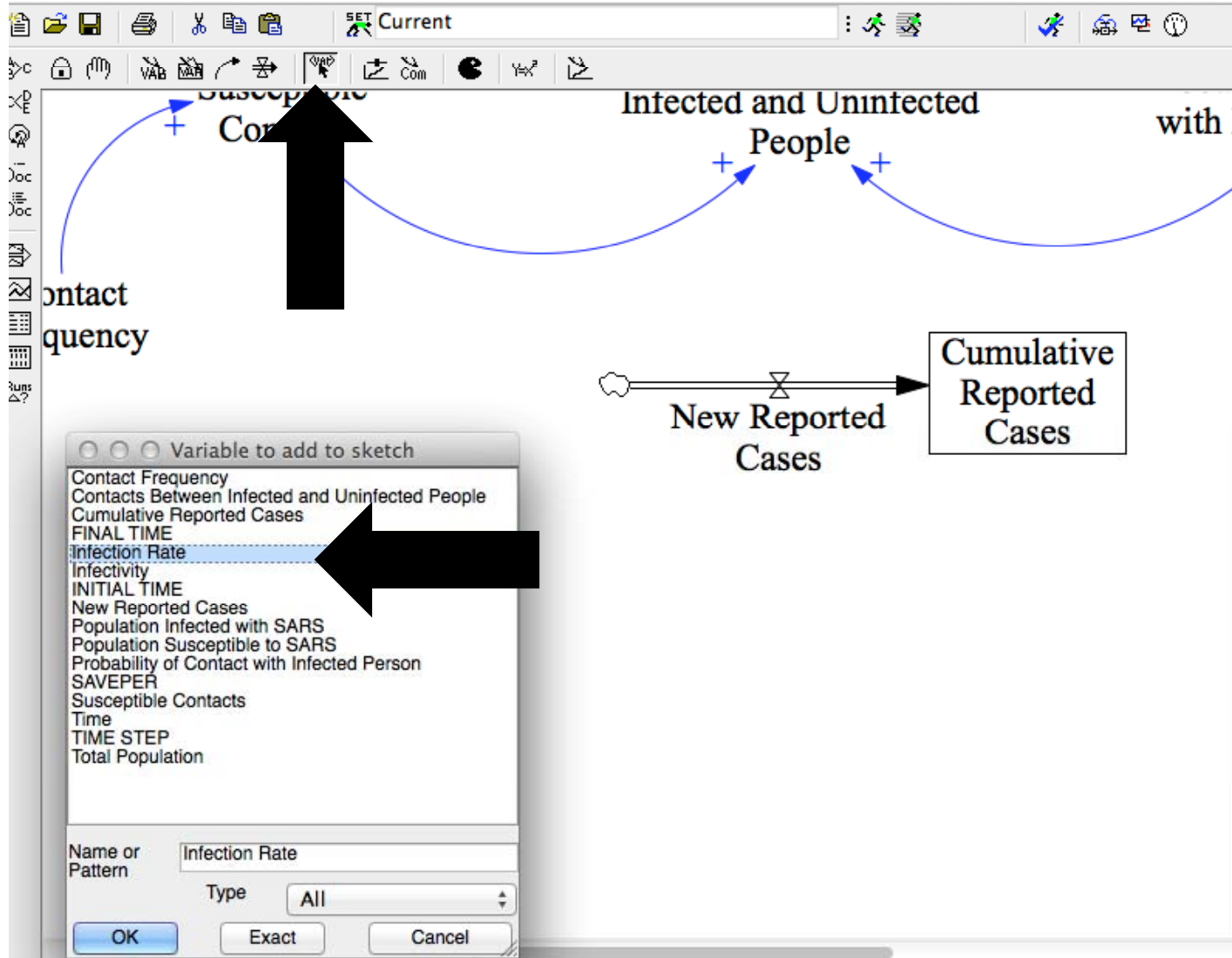
- Population:** A line graph showing the number of people over 120 days. The y-axis is labeled "People" (0 to 400) and the x-axis is "Time (Day)" (0 to 120). Two curves are shown: a blue curve for "Base" and a red curve for "SARSDATA". Both curves show an S-shaped growth, with SARSDATA reaching a higher plateau than Base.
- New Reported Cases:** A line graph showing the number of new reported cases per day over 120 days. The y-axis is labeled "People/Day" (0 to 20) and the x-axis is "Time (Day)" (0 to 120). Two curves are shown: a blue curve for "Base" and a red curve for "SARSDATA". Both curves show a bell-shaped distribution, with SARSDATA having a higher peak than Base.

At the top left, a diagram shows a feedback loop. A blue arrow labeled "Infectivity" points to a summing junction with a "+" sign. Below it, a blue arrow labeled "Infection Rate" points to another summing junction with a "+" sign. A feedback arrow points from the "Infection Rate" back to the "Infectivity" input.

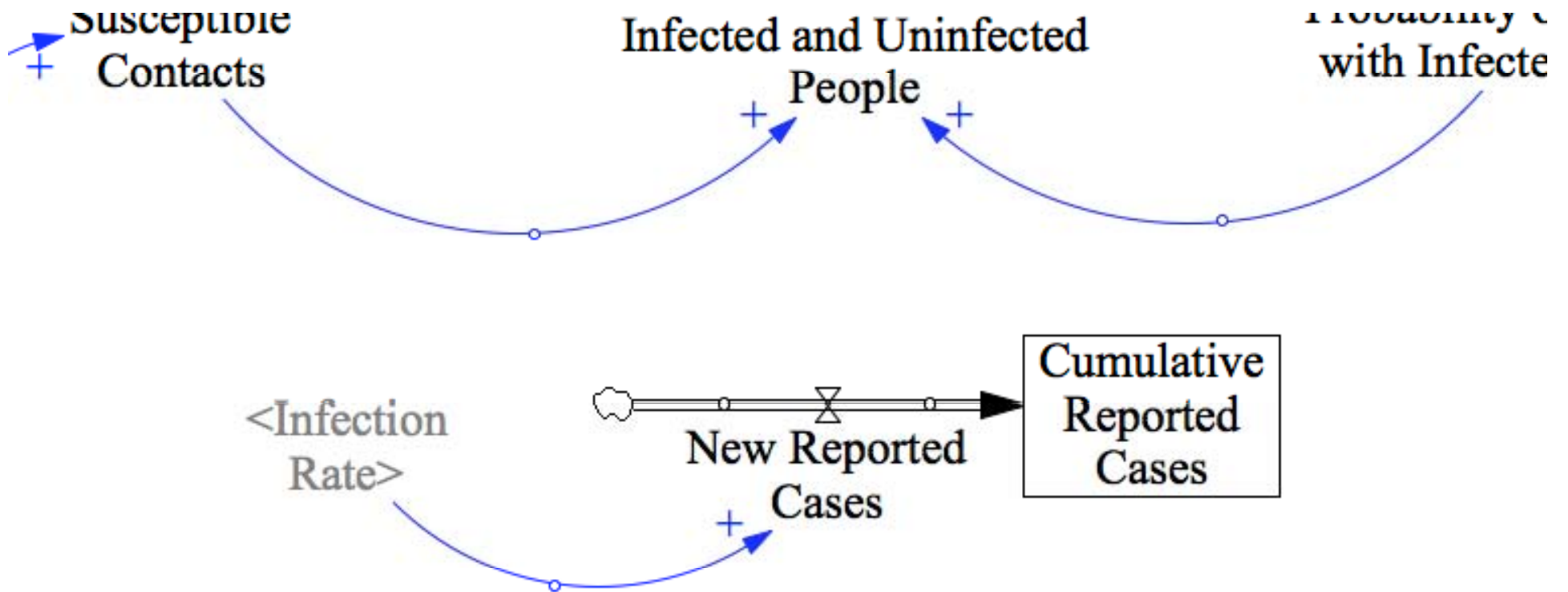
Step 23: Add Variables in the Dataset



Step 24: Add Infection Rate (as a shadow variable)



Step 25: Add Causal Link and Polarity



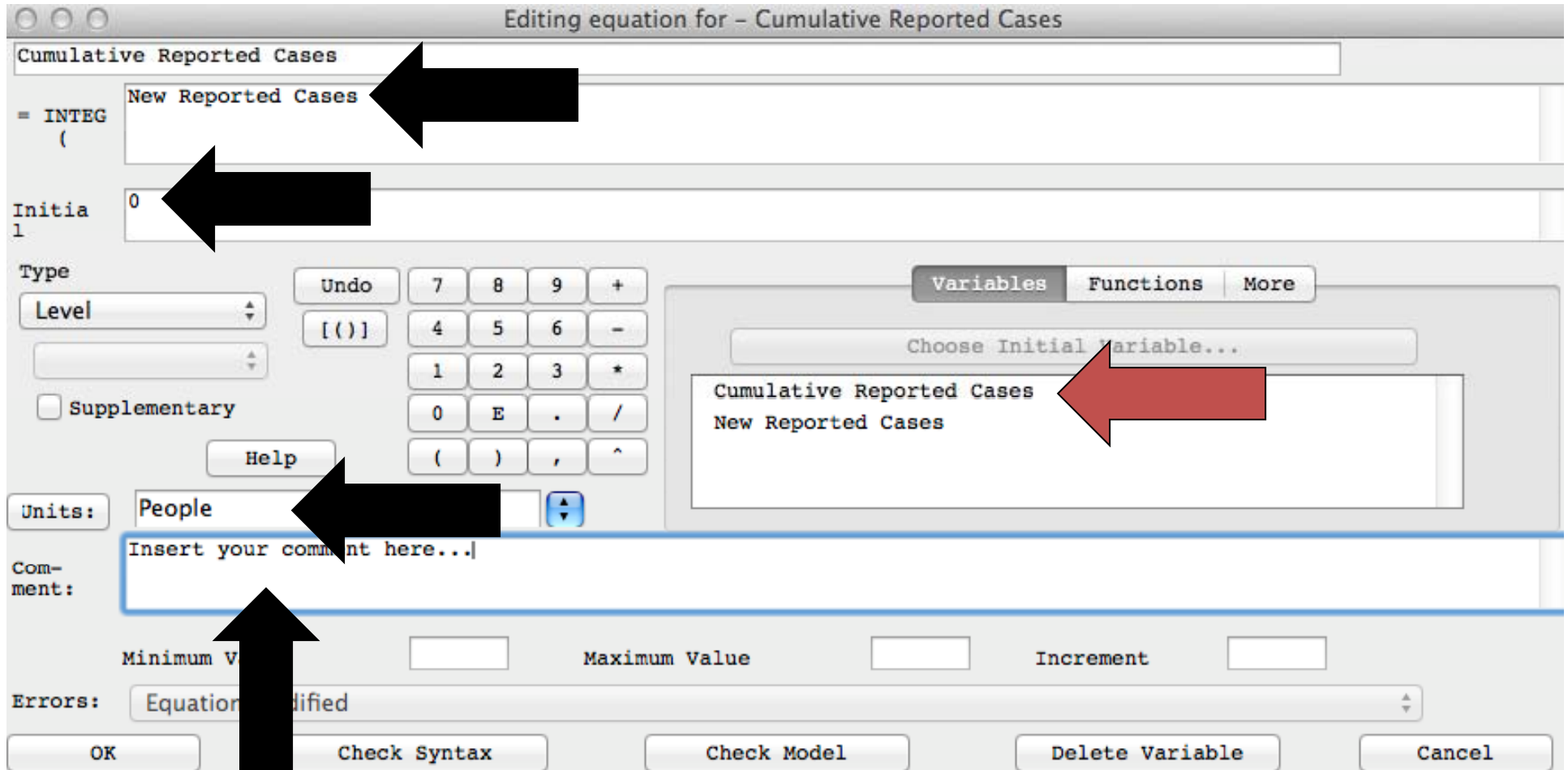
Step 26: Define New Reported Cases

The screenshot shows a software interface for defining a new reported case. The window title is "Editing equation for - New Reported Cases". The main text field contains "Infection Rate". Below this, there are several sections:

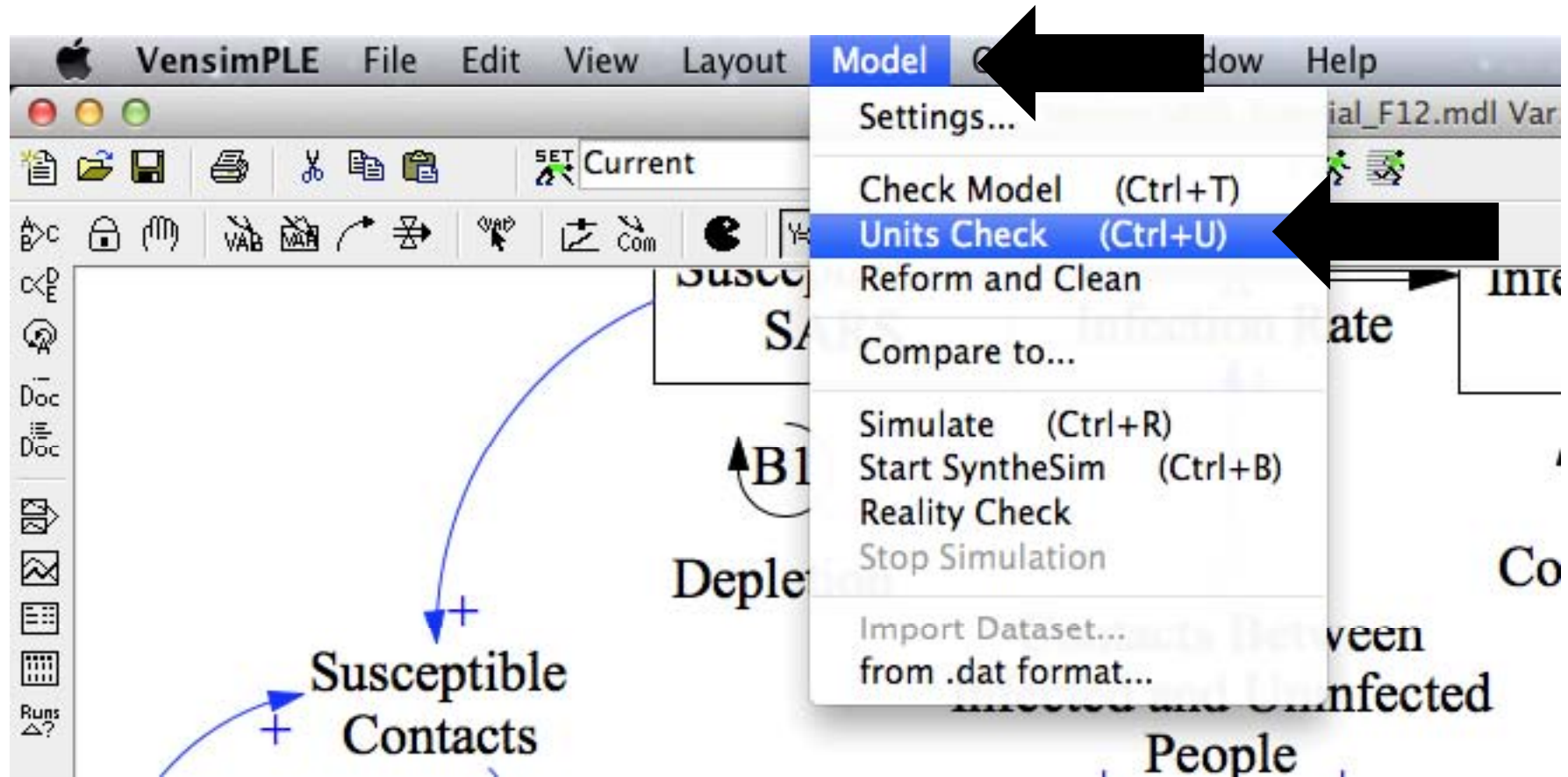
- Type:** Includes a dropdown menu with "Auxiliary" and "Normal" options, and a checkbox for "Supplementary".
- Units:** A dropdown menu showing "People/Day".
- Comment:** A text area with the placeholder "Insert your comment here...".
- Variables:** A panel with tabs for "Variables", "Functions", and "More". It contains a list of variables, with "Infection Rate" selected. A red arrow points to this selection.
- Buttons:** Includes "OK", "Check Syntax", "Check Model", "Delete Variable", and "Cancel". A black arrow points to the "OK" button.

Black arrows also point to the "Infection Rate" text in the main field and the "People/Day" units.

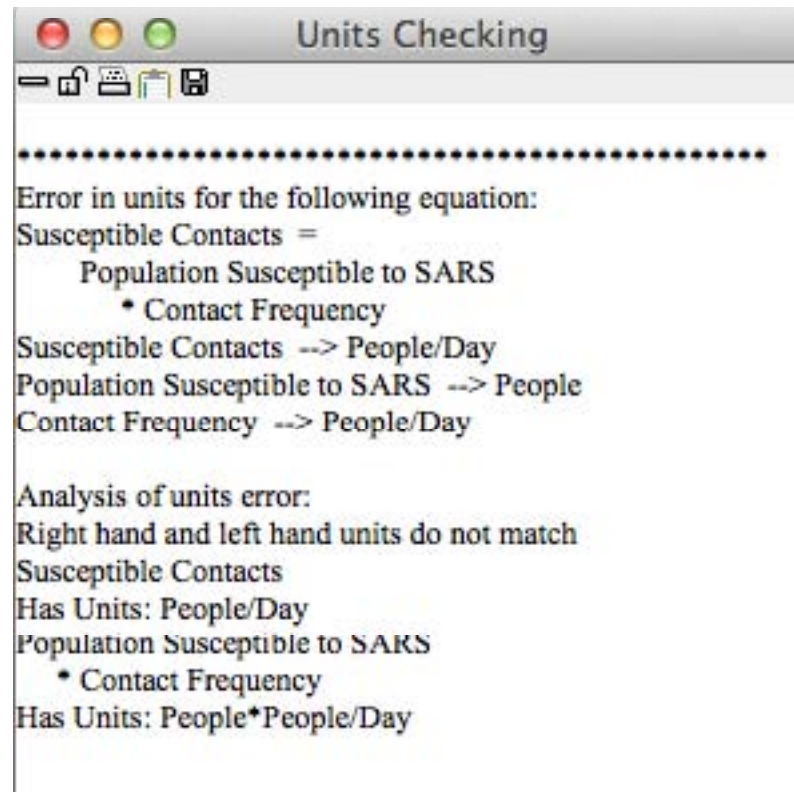
Step 27: Define Cumulative Reported Cases



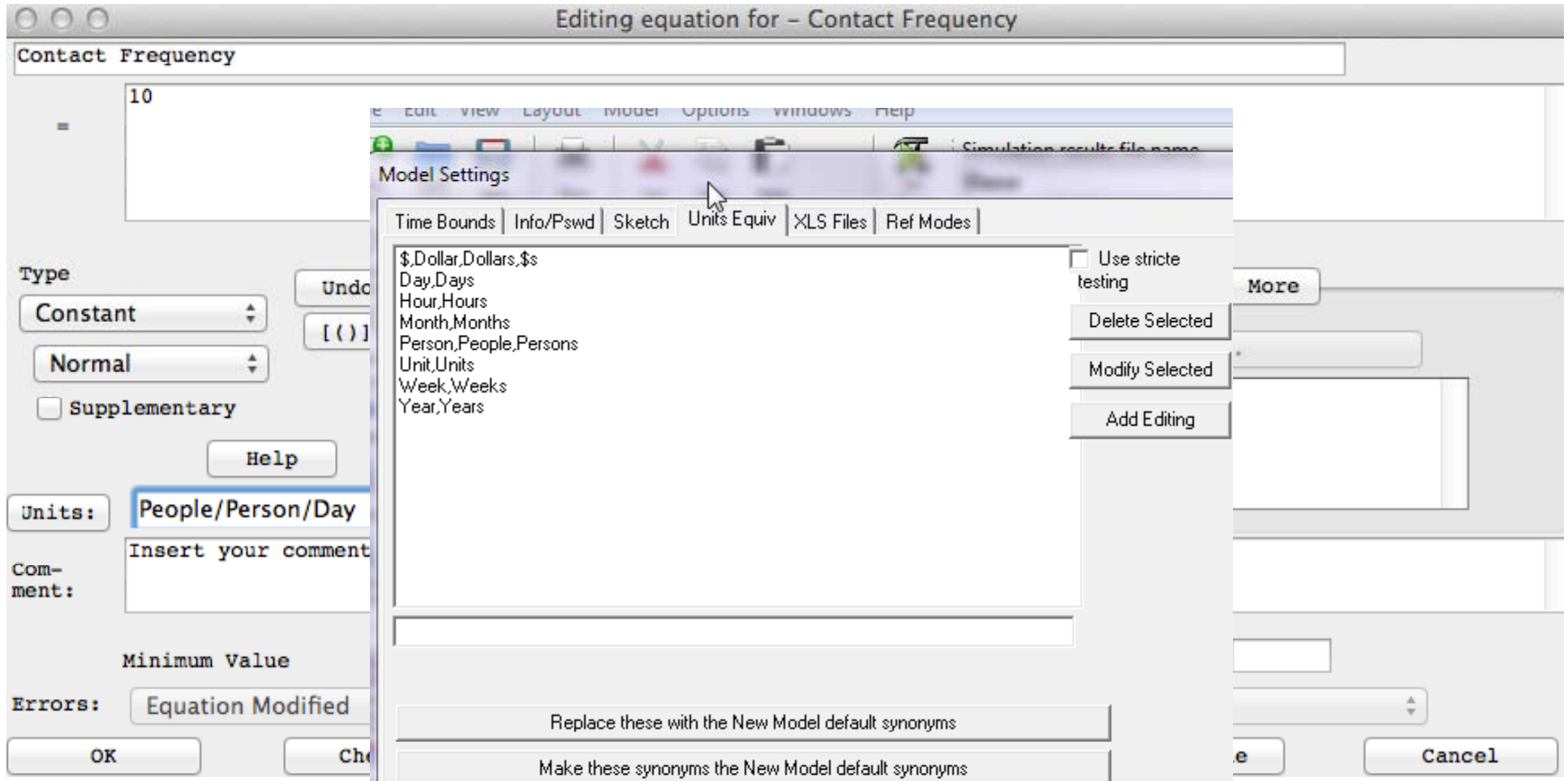
Step 28: Units Check



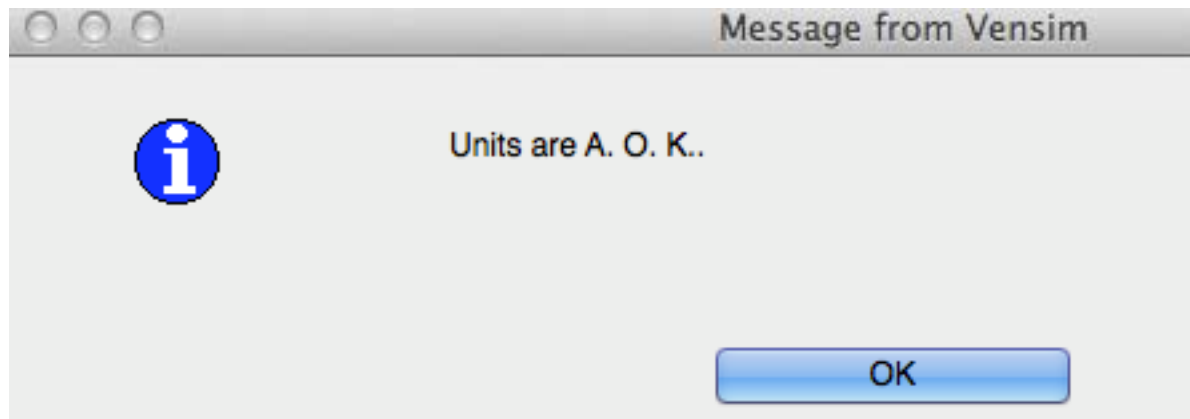
Step 29: Error!!!



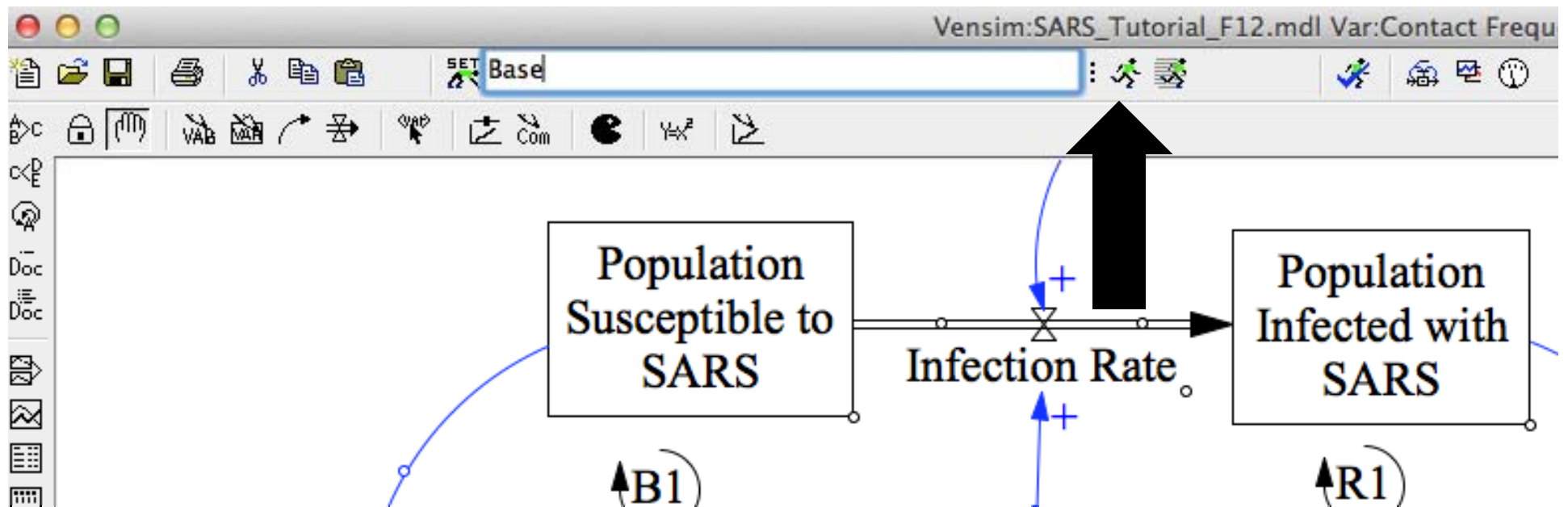
Step 30: Redefine Contact Frequency



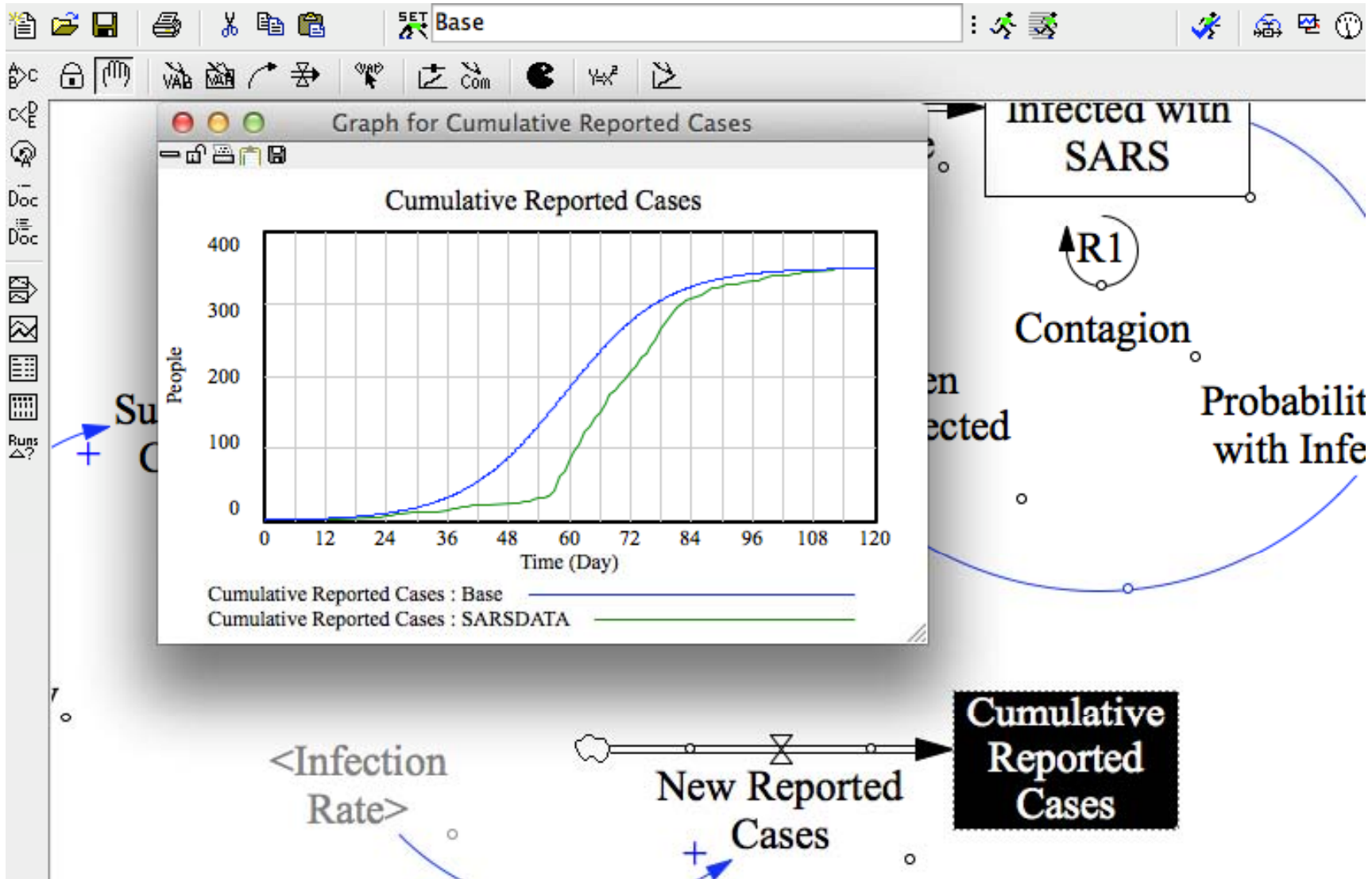
Step 31: Units Check – A. O. K.



Step 32: Rename Case – “Base” and Run



Step 33: Plot Cumulative Reported Cases



Step 34: Try Lowering Contact Frequency

Editing equation for - Contact Frequency

Contact Frequency

= 5

Type: Constant

Normal

Supplementary

Help

Units: People/Person/Day

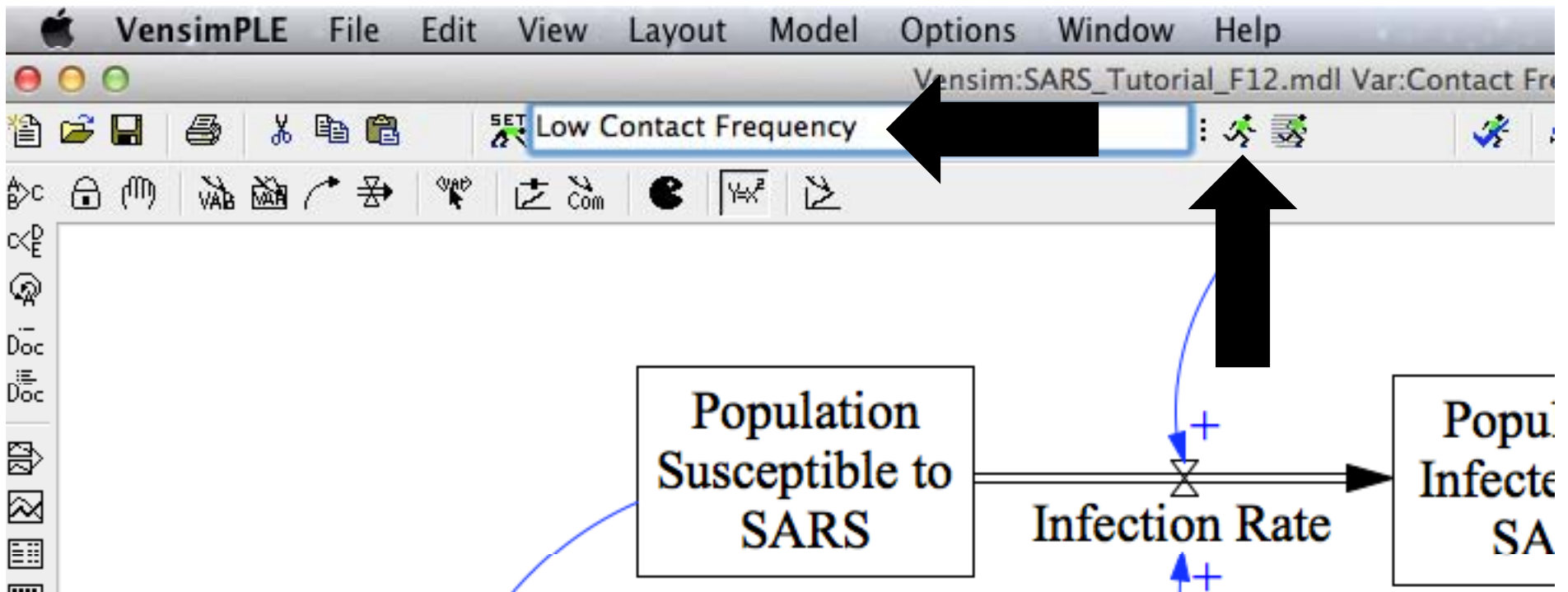
Comment: Insert your comment here...

Minimum Value: Maximum Value: Increment:

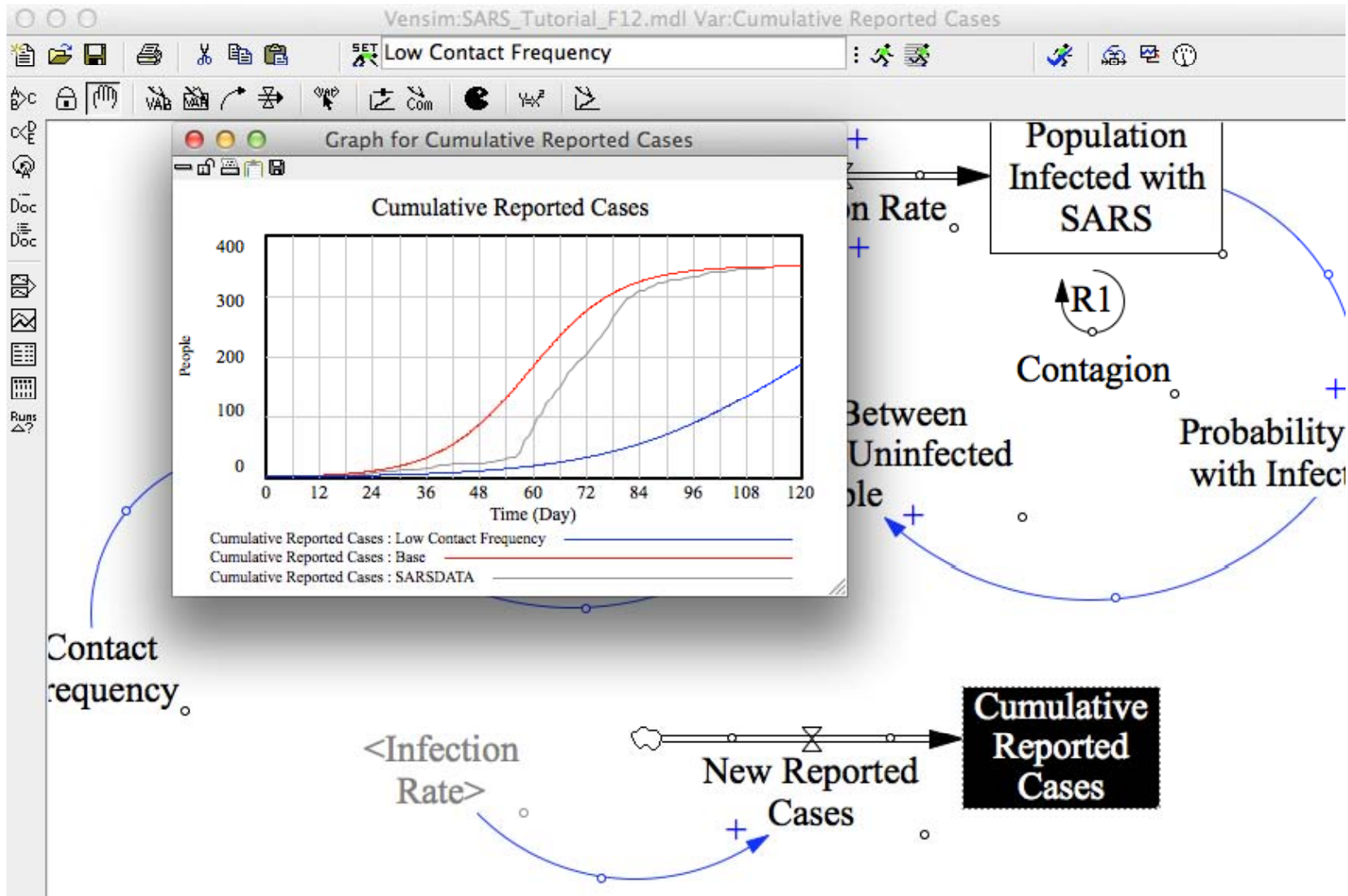
Errors: Equation Modified

OK Check Syntax Check Model Delete Variable Cancel

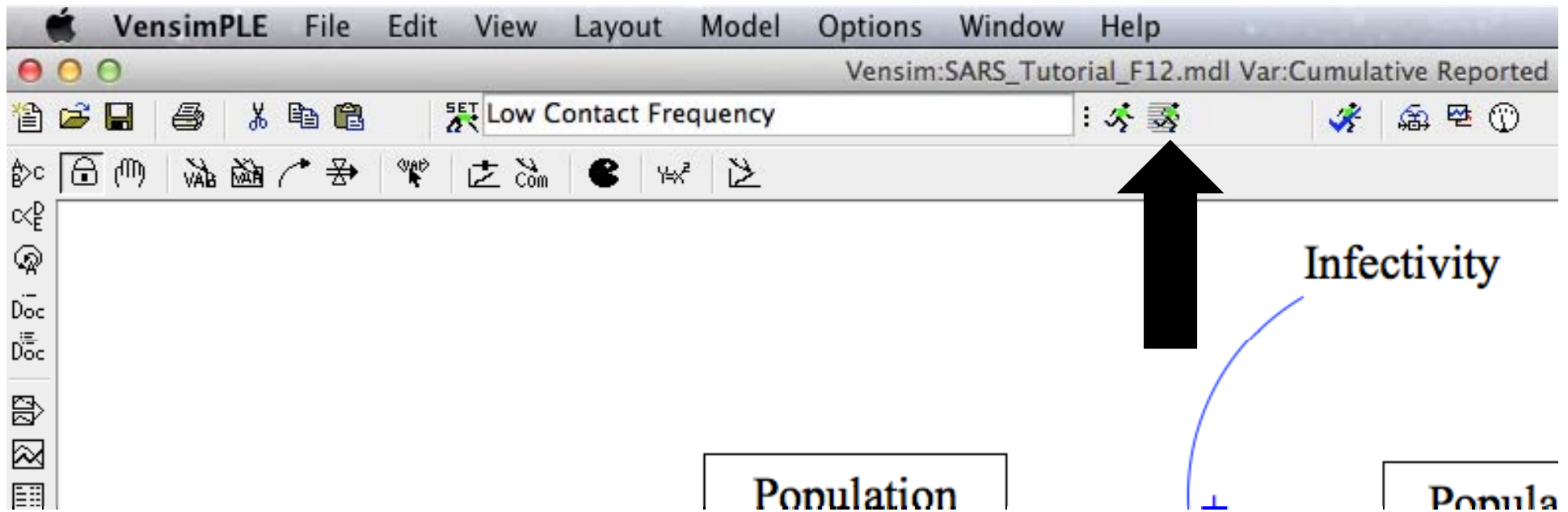
Step 35: Change Run Name



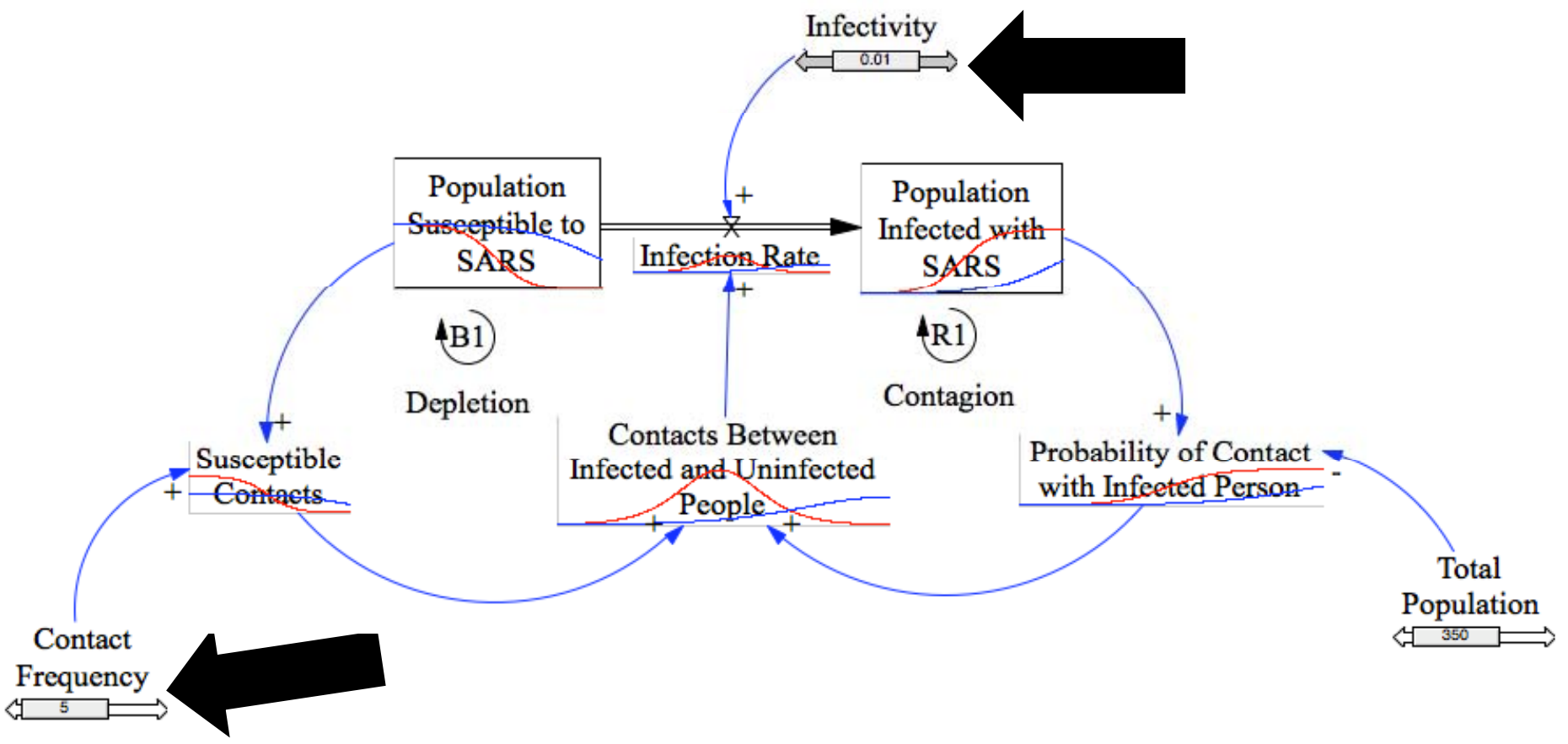
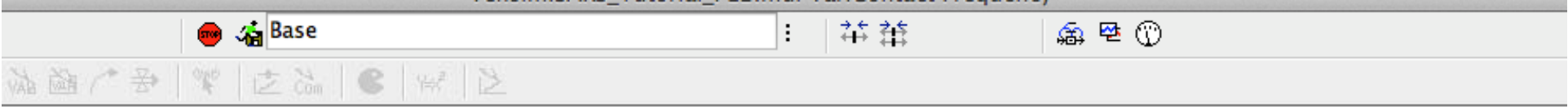
Step 36: Displaying Multiple Runs



Step 37: Synthesim



Amazing!!!



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15.871 Introduction to System Dynamics

Fall 2013

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