

Using FRED on the Web

Public Health Dynamics Lab
Pitt Public Health
October 2018

- Senior Research Programmer
- BS Mathematics (University of Pittsburgh)
- MS Computer Management & Information Systems (Southern Illinois University at Edwardsville)
- MS Information Science (University of Pittsburgh)
- PhD Student in Computational Modeling and Simulation (University of Pittsburgh)
- Software Developer for the last 21 years

Objectives: Learn how to:

- Register on the FRED web site
- Set up projects
- Define parameter settings for FRED simulations
- Submit jobs to the FRED server
- Visualize and download results

- What is FRED?
 - Software system for developing simulations of population health
 - Uses realistic population models
 - Scales from local to national models
- What does FRED mean?
 - FRamework for Epidemiolgical Dynamics
 - Epidemiology Dynamics = any measurable property of a population that changes over time

- Typical FRED Applications
 - Find expected geo-spatial spread of an epidemic
 - Predict effects of vaccination programs
 - Evaluate interventions such as school closure
 - Evaluate health policies such as paid sick leave
 - Explore interaction of environmental and health dynamics
 - Explore dynamic changes in behavior
 - Stay home (Isolation) decisions
 - Vaccination decisions

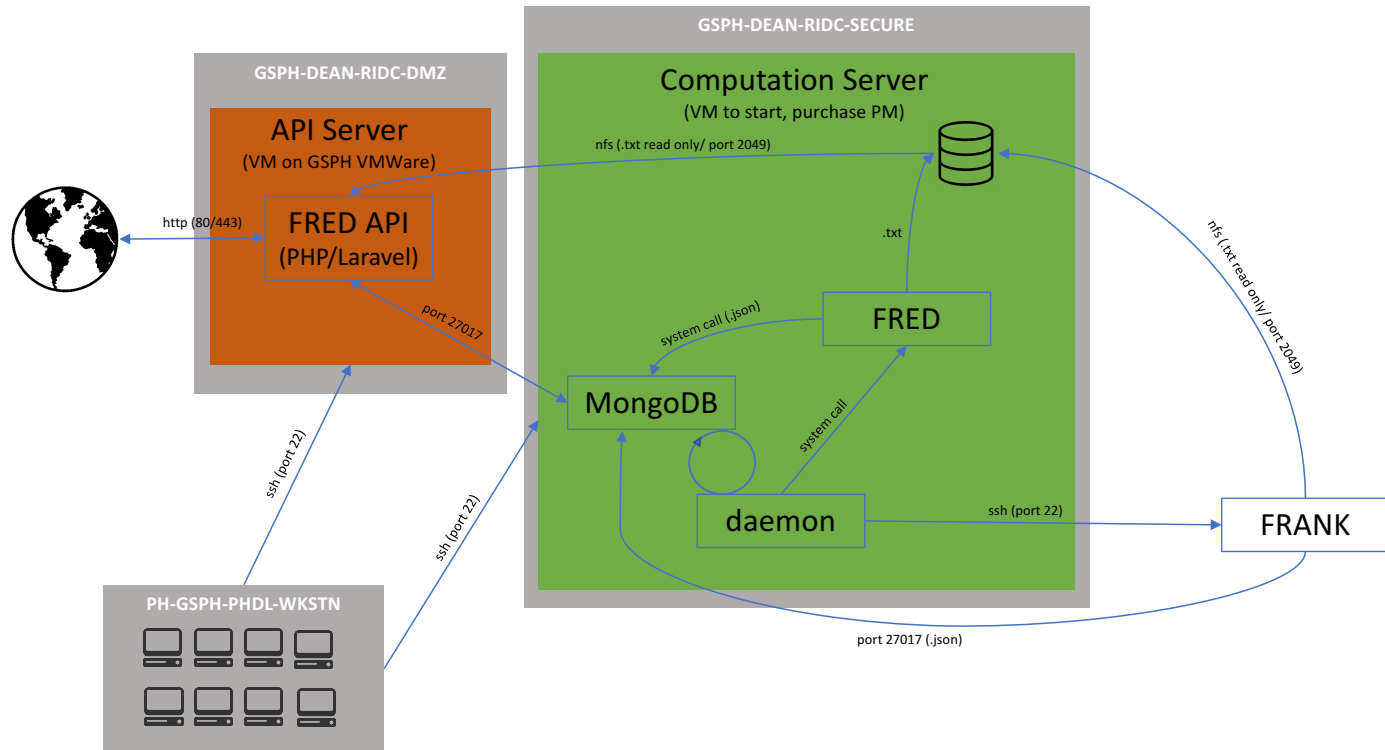
- Why run FRED on the Web?
 - Access to powerful computer resources
 - No software installation on user's computer
 - User can focus on modeling and analysis, not programming

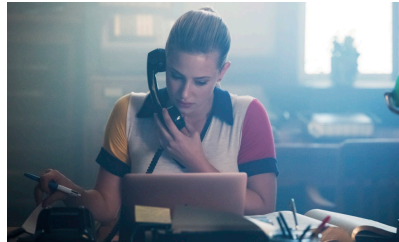
- User login accounts with passwords
- Users can set up and run FRED jobs with no software installation required on the user's computer
- FRED jobs run on the FRED server and results are available through the web
- Users can organize their work flow into Projects
- Users can select specific geographic regions to simulate

- Users can specify the characteristics of the condition to be simulated
 - States
 - Transitions from State to State
 - Modifiers of those Transitions
 - Importation schedule of Condition (seeds)
 - How many
 - Where they should occur
- Users can download results
 - Raw data
 - Plots
 - Movies

- The underlying FRED software has an almost unlimited number of options / parameters
- Many options are not known until the user defines them (i.e. Conditions / States)
- This makes creating a user interface challenging
 - E.g. can't create a drop-down menu of stuff that isn't there yet
 - Limited screen real estate in a web-browser for so many options
 - Needs to be usable across browsers and devices

- One of FRED's best features is its synthetic population
 - Matches the demographic features of a geographic region's population
 - Has one synthetic agent for every real person reported in the census
- Need shared memory (RAM) to be able to create all agents for a given simulation
 - The available RAM on our a machine is a limiting factor in what can be simulated
- The more agents that are created, the longer the simulation takes to run
 - No instant gratification (have to wait for results)





User on our website

Website interface

- What a user sees
- fred.publichealth.pitt.edu



API Site

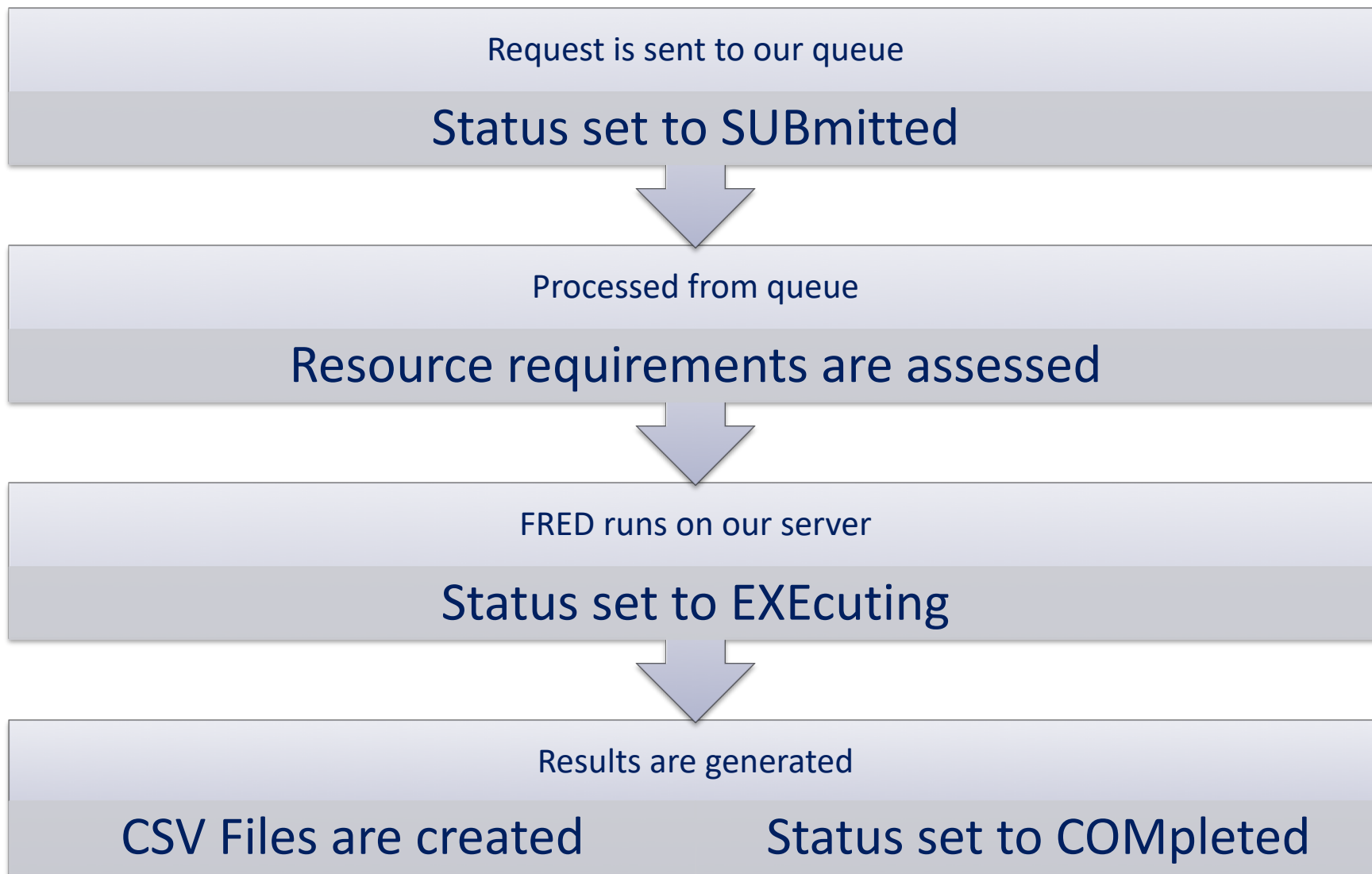
- Agnostic to the front-end
- fredapi.publichealth.pitt.edu

Computational Resource

- FRED lives here!
- fredcore.publichealth.pitt.edu



What happens next?



- User doesn't need to install the FRED application
- User only needs to have access to a web browser
- Works on mobile devices
- Jobs are sent to our server
- Website itself asks our server about job status
- Results are stored on our server

- Simple example using a **SHARED** condition
 - Measles
 - Some local counties


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More ▾](#)

David Galloway ▾



FRED Modeling System

A flexible, modular, open source framework for epidemic modeling.

Try the new [FRED Measles](#) page!

FRED (A Framework for Reconstructing Epidemiological Dynamics) is an agent-based modeling system developed by the [Pitt Public Health Dynamics Laboratory](#).

FRED represents every person in a real geographic region as a separate individual each with her/his own unique social, familial, demographic, behavioral, and health characteristics. Individuals interact within realistic household, school, and workplace social networks.

FRED was originally developed to simulate infectious disease epidemics, but has been extended to enable users to model a wide range of health conditions and to study how patterns of those conditions vary over time in a specific region.

FRED is available through this web interface in the hopes of making large-scale agent-based models more useful to the policy-making community, the research community, and as a teaching tool for students in public health.

Citation


If you use FRED in your research, please use the following citation:

Grefenstette JJ, Brown ST, Rosenfeld R, Depasse J, Stone NT, Cooley PC, Wheaton WD, Fyshe A, Galloway DD, Sriram A, Guclu H, Abraham T, Burke DS. FRED (A Framework for Reconstructing Epidemic Dynamics): An open-source software system for modeling infectious diseases and control strategies using census-based populations. *BMC Public Health*. 2013 Oct;13(1): 940. doi: 10.1186/1471-2458-13-940. PubMed PMID: 24103508

Funding

Support for this work is provided by the National Institute of General Medical Sciences under MIDAS grant 1U54GM088491-01, by the Vaccine Modeling Initiative funded by the Bill and Melinda Gates Foundation, and by the Robert Wood Johnson Foundation.

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Projects

Description

This page provides a list of your current Projects. Projects provide a way to organize your work with FRED. A Project is a set of related FRED jobs, such as all the jobs associated with a given research study.

The **My Projects** list shows the status of your current Projects. Click on a Project to see the list of FRED jobs associated with that Project.


My Projects

Name	Created At
Demo	2018-03-06 01:00:57
new	2018-03-06 02:12:31

Create New Project

Submit

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More ▾](#)

David Galloway ▾

Project: *Demo2*

Description

This page provides a list of your FRED Jobs associated with this project and the job's status. When the status of a job changes, this page automatically refresh and display the updates.

Once the status of a Job is "completed", click on a Job Name to see the job details.

Click the "Create Job" button at the top of the list on the right to create a new job.

FRED Jobs


Create Job

None

FRED Plots

None

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Create Job

Description

This page provides the form used to create a new FRED Job.

A job is set of simulations based on the same parameters.

Job Setup

Next

Job Name

TestJob1

FRED Version

4.0.0

Number of Runs

1

2

3

4

5

6

7

8

9

10

Start Date

1/1/2017

End Date

06/30/2017

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

FRED

Projects Conditions Plots Movies More ▾

David Galloway ▾

Create Job

Description

This page provides the form used to create a new FRED Job.

You may select as many locations as you like to run the simulation. Select a country for the simulation and then use the filter box to find locations within that country.

Note: FRED currently only allows simulations to run in one country per job.

Location Selection

Back Next

Country

United States

State

Pennsylvania

Locations

Showing all 62

Filter

PA-Adams
PA-Armstrong
PA-Bedford
PA-Berks
PA-Blair

Showing all 5

Filter

PA-Allegheny
PA-Beaver
PA-Butler
PA-Washington
PA-Westmoreland

[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Create Job

Description

This page provides the form used to create a new FRED Job.

Select as many conditions as you need for your simulation. You can use the filter box to search for conditions.

Condition Selection

BackNext

Your Conditions

Empty list

Filter

>>

Shared Conditions

Showing all 6

Filter

>>

Baseline Influenza (INF)
 Baseline Maternity (MATERNITY)
 Baseline Mortality (MORTALITY)
 Workshop Example: Perceived Risk of Influenza (RSKw)
 Workshop Example: Influenza Vaccine (Perceived Risk) (VA)

Showing 1

Filter

<<

Baseline Measles (MEASLES)

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

FRED

Projects Conditions Plots Movies More ▾

David Galloway ▾

Create Job

Description

This page provides the form used to create a new FRED Job.

Visualization allows you to show changes in states for agents on a map of the simulation area. Please select all of the states you may want to show on the map.

Visualize

Back Next

States to Visualize

Showing all 6

Filter

MEASLES.Start
MEASLES.Susceptible
MEASLES.Exposed
MEASLES.Latent
MEASLES.Recovery

Showing all 2

Filter

MEASLES.Fever
MEASLES.Rash

Create Job

Description

This page provides the form used to create a new FRED Job.

Imports allow you to seed condition cases into the population. All seeded cases are placed in the exposed state of the condition.

Imports

Back Next

Condition to Import

MEASLES

Start Day

0

End Day

5

Type of import?

☒ Max ☐ Fraction

Max

2

Restrict location?

☐ Yes ☒ No

Restrict by age?

☒ Yes ☐ No

Min Age

0.0

Max Age

12.0

Add Import

Imports

Condition to Import	Start Day	End Day	Max	Fraction	Latitude	Longitude	Radius	Min Age	Max Age
---------------------	-----------	---------	-----	----------	----------	-----------	--------	---------	---------

MEASLES	0	5	2	n/a	n/a	n/a	n/a	0.0	12.0
---------	---	---	---	-----	-----	-----	-----	-----	------

Delete

FRED

Projects Conditions Plots Movies More

David Galloway

Create Job

Description

This page provides the form used to create a new FRED job.

FRED Job level parameter code can be added into the text area below. Please note that for condition level parameters the condition needs to be edited.

Additional Parameters

Back Next

Parameter Text

FRED Web v2.2.0, © 2018 Public Health Dynamics Laboratory, University of Pittsburgh

Create Job

Description

This page provides the form used to create a new FRED Job.

Please review all of your settings for this simulation. Use the "Back" button to make any changes.

Review and Submit

[Back](#) [Submit Job](#)

Variable Name Selection

[Job Name](#) TestJob1

[FRED Version](#) 4.0.0

[Number of Runs](#) 5

[Start Date](#) 1/1/2017

[End Date](#) 06/30/2017

[Country](#) United States


[Locations](#) PA-Allegheny, PA-Beaver, PA-Butler, PA-Washington, PA-Westmoreland

[Conditions](#) Baseline Measles (MEASLES)

[States to Visualize](#) MEASLES.Fever, MEASLES.Rash

Imports

Condition to Import	Start Day	End Day	Max	Fraction	Latitude	Longitude	Radius	Min Age	Max Age
MEASLES	0	5	2	n/a	n/a	n/a	n/a	0.0	12.0



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway ▾

A new job was created named: TestJob1
Additionally, the status column below will be automatically refreshed.

Project: *Demo2*

Description

This page provides a list of your FRED Jobs associated with this project and the job's status. When the status of a job changes, this page automatically refresh and display the updates.

Once the status of a Job is "completed", click on a Job Name to see the job details.

Click the "Create Job" button at the top of the list on the right to create a new job.


FRED Jobs Create Job

Name	Status	Build
TestJob1	submitted	4.0.0

FRED Plots Create Plot

None

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway ▾

A new job was created named: TestJob1
Additionally, the status column below will be automatically refreshed.

Project: *Demo2*

Description

This page provides a list of your FRED Jobs associated with this project and the job's status. When the status of a job changes, this page automatically refresh and display the updates.

Once the status of a Job is "completed", click on a Job Name to see the job details.

Click the "Create Job" button at the top of the list on the right to create a new job.


FRED Jobs Create Job

Name	Status	Build
TestJob1	executing	4.0.0

FRED Plots Create Plot

None

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway ▾

A new job was created named: TestJob1
Additionally, the status column below will be automatically refreshed.

Project: *Demo2*

Description

This page provides a list of your FRED Jobs associated with this project and the job's status. When the status of a job changes, this page automatically refresh and display the updates.

Once the status of a Job is "completed", click on a Job Name to see the job details.

Click the "Create Job" button at the top of the list on the right to create a new job.


FRED Jobs Create Job

Name	Status	Build
TestJob1	completed	4.0.0

FRED Plots Create Plot

None

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Description

This page provides details about an individual FRED Job.

The results will be available via a CSV download.

Additionally, basic plots and movies are provided.

Click the "New Job" tab at the top of the page to create a new job.

Job Details

Name	Project	Status	Build
TestJob1	Demo2	completed	4.0.0


Results

Download CSV

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

30

- Now we can create a plot
- Let's look at the following states
 - Susceptible
 - Exposed
 - Fever
 - Rash
 - Recovery


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Project: *Demo2*

Description

This page provides a list of your FRED Jobs associated with this project and the job's status. When the status of a job changes, this page automatically refresh and display the updates.

Once the status of a Job is "completed", click on a Job Name to see the job details.

Click the "Create Job" button at the top of the list on the right to create a new job.

FRED Jobs

Create Job


Name	Status	Build
TestJob1	completed	4.0.0

FRED Plots

Create Plot

None

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More ▾](#)
David Galloway ▾

Create Plot for Project: *Demo2*

Description

This page provides the form used to create a new FRED Plot.

You can plot the results from any of your "Completed" jobs from this specific project ("Demo2"). Please select the appropriate job(s) and any additional plotting parameters.

Once you have completed the forms within each tab, click "Finish".

Step 1

Jobs

TestJob1

Find Variables to Plot

Step 2

Plot Name ?

Measles

Title

Measles Pittsburgh Area

Bar Chart ?

☐

Error Bars

☐

Normalize ?

☐

By Week

☐

Show Year

☐

Show All Runs

☐

Line Width ?

X-tics Frequency ?

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

FRED

[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

<input type="checkbox"/>	TestJob1	Popsiz	Popsiz	Blue
<input checked="" type="checkbox"/>	TestJob1	MEASLES.Exposed	MEASLES.Exposed	Green-Yellow
<input checked="" type="checkbox"/>	TestJob1	MEASLES.Fever	MEASLES.Fever	Orange
<input type="checkbox"/>	TestJob1	MEASLES.Immune	MEASLES.Immune	Blue
<input type="checkbox"/>	TestJob1	MEASLES.Latent	MEASLES.Latent	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newExposed	MEASLES.newExposed	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newFever	MEASLES.newFever	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newImmune	MEASLES.newImmune	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newLatent	MEASLES.newLatent	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newRash	MEASLES.newRash	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newRecovery	MEASLES.newRecovery	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newStart	MEASLES.newStart	Blue
<input type="checkbox"/>	TestJob1	MEASLES.newSusceptible	MEASLES.newSusceptible	Blue
<input checked="" type="checkbox"/>	TestJob1	MEASLES.Rash	MEASLES.Rash	Red
<input checked="" type="checkbox"/>	TestJob1	MEASLES.Recovery	MEASLES.Recovery	Black
<input type="checkbox"/>	TestJob1	MEASLES.RR	MEASLES.RR	Blue
<input type="checkbox"/>	TestJob1	MEASLES.Start	MEASLES.Start	Blue
<input checked="" type="checkbox"/>	TestJob1	MEASLES.Susceptible	MEASLES.Susceptible	Blue

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

FRED

Projects Conditions Plots Movies More ▾

David Galloway ▾

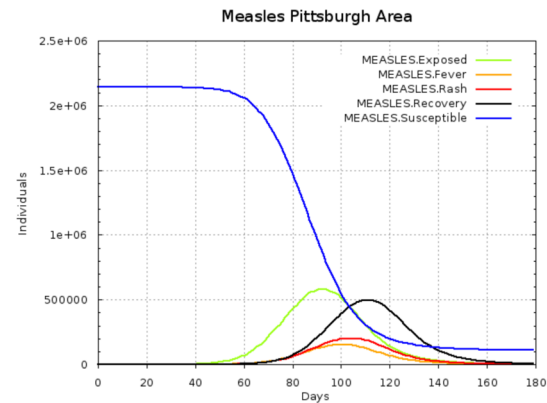
FRED Plot for Project: *Demo2*

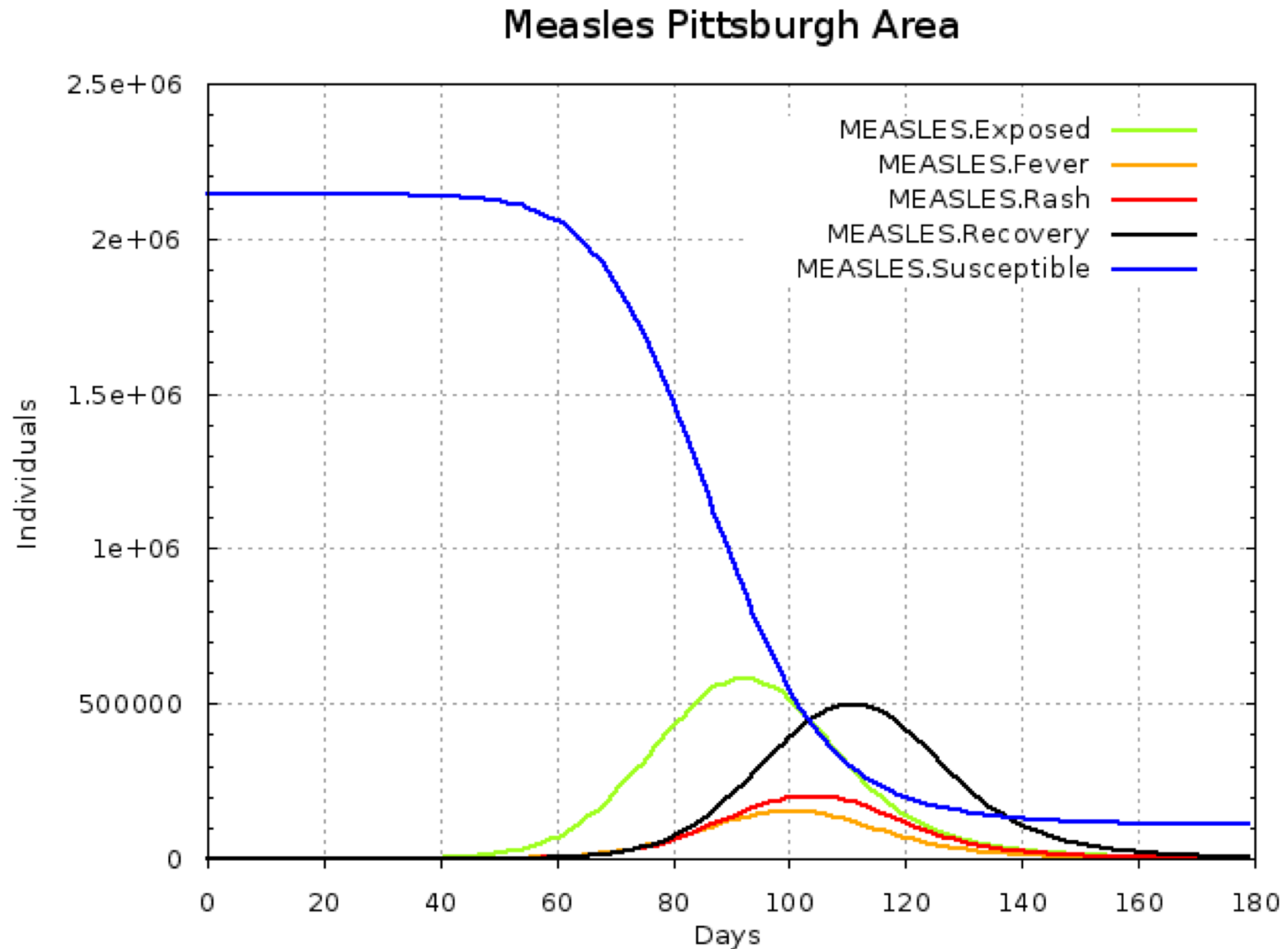
Description

This page provides the plot of the results of your previously selected FRED Jobs.


Measles

[Back to Project](#)





- We can also make a movie
- I'm just going to show the new agents who are in the following states on a given day
 - Fever
 - Rash


[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Create Movie

Description

This page provides the form used to create a new FRED Movie from single FRED Job.

You can create movies from any of your "Completed" jobs.

Please select the appropriate job and any additional movie parameters.

Once you have completed the forms within each tab, click "Finish".


Step 1

Job

TestJob1

Find Variables to Display

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Create Movie

Description

This page provides the form used to create a new FRED Movie from single FRED Job.

You can create movies from any of your "Completed" jobs.

Please select the appropriate job and any additional movie parameters.

Once you have completed the forms within each tab, click "Finish".

Step 1

Job

TestJob1

Find Variables to Display

Step 2

Movie Name

Measles Outbreak

Title

Measles Outbreak

Subtitle

Pittsburgh Area

Left Caption

Left Caption Color

Center Caption

Center Caption Color

Right Caption

Right Caption Color

Show Census Tracts

☐

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Right Caption Color

Show Census Tracts
☐

Add Grid
☐

Run Number

Line Width

Min X

Max X

Min Y

Max Y

Start Day

End Day


Interval

Step 3

Display?	Movie Variable	Point Size (0 - 0.100)	Period	Color
<input type="checkbox"/>	MEASLES.Fever	<input type="text" value="0.002"/>	<input type="text"/>	<input type="text" value="Red"/>
<input checked="" type="checkbox"/>	MEASLES.newFever	<input type="text" value="0.002"/>	<input type="text"/>	<input type="text" value="Orange"/>
<input type="checkbox"/>	MEASLES.Rash	<input type="text" value="0.002"/>	<input type="text"/>	<input type="text" value="Red"/>
<input checked="" type="checkbox"/>	MEASLES.newRash	<input type="text" value="0.002"/>	<input type="text"/>	<input type="text" value="Red"/>

Create the Movie

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Movies

Description

This page provides a list of your current Movies.

If the status is "Complete", click on a movie name to view the movie.

My Movies

Create Movie

Name	Status	Created At	Delete?
test movie	completed	2018-10-14 18:52:03	<input type="checkbox"/>
Measles Outbreak	completed	2018-10-25 10:43:47	<input type="checkbox"/>

Delete Selected

FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh

FRED

Projects Conditions Plots Movies More ▾

David Galloway ▾

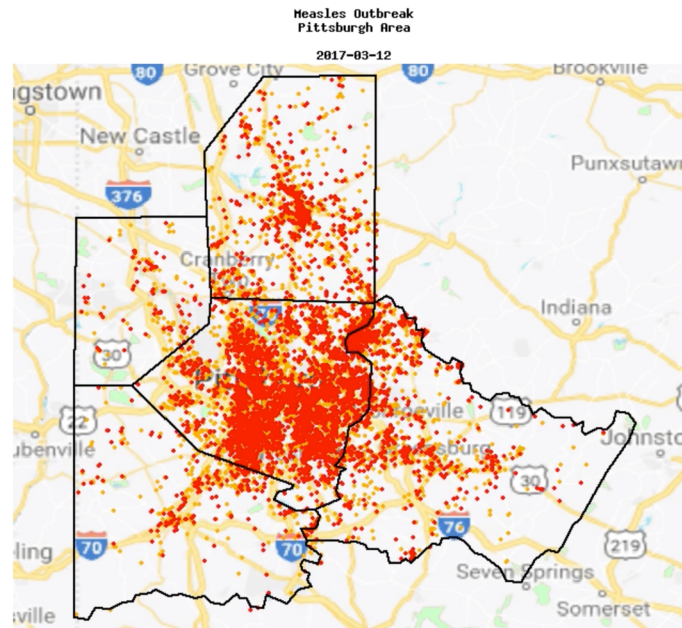
FRED Movie

Description

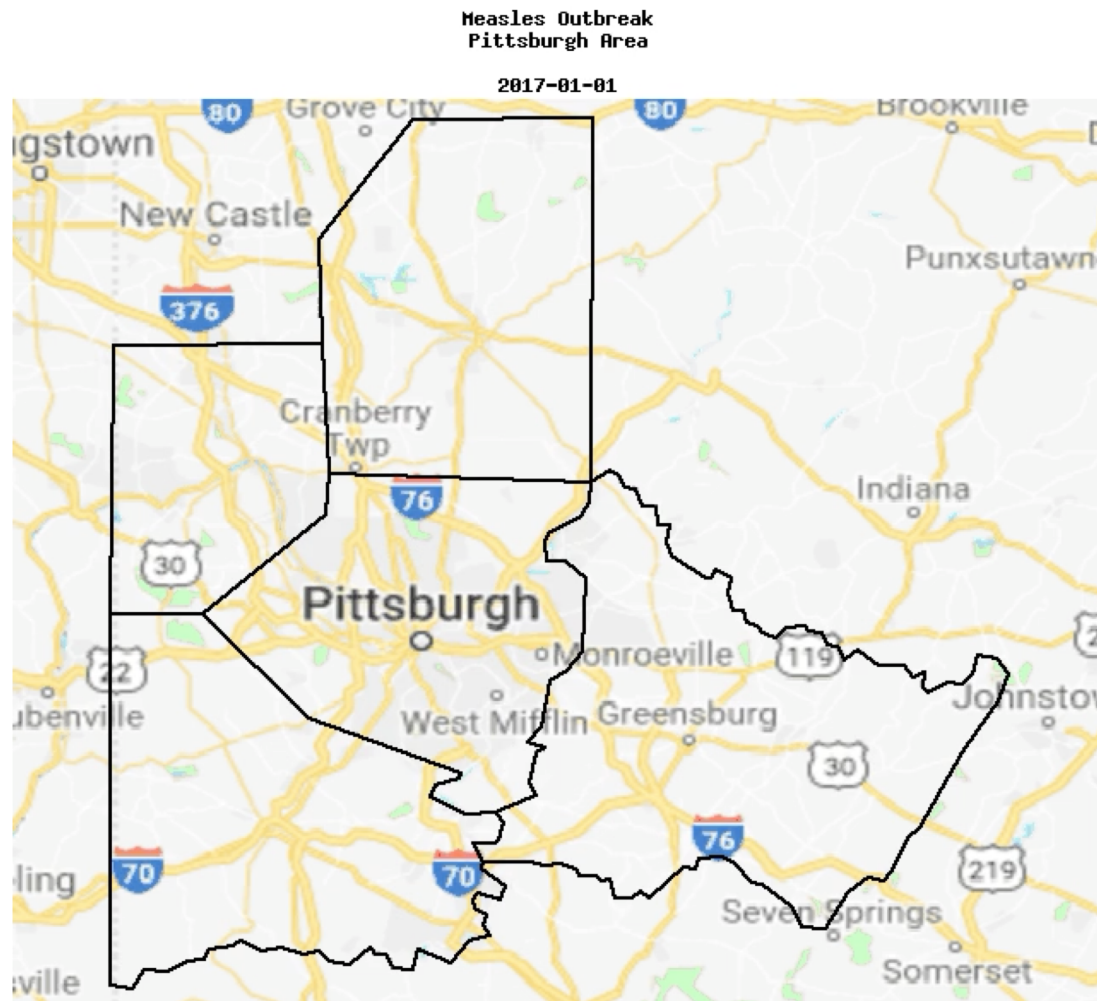
This page provides the movie of the results of your previously selected FRED Job.

Once the status of a Movie is "completed", click on a Movie Name to see the movie.

Measles Outbreak



FRED Web v2.2.0, © 2018 [Public Health Dynamics Laboratory](#), University of Pittsburgh



- We will be doing this in the workshop
- I wanted to briefly discuss the Parameter Text box
- On the Condition page allows user to enter:
 - Transitions (in addition to what is on the GUI)
 - Transition Factors that alter the transition probabilities
 - Side effects

FRED

[Projects](#)
[Conditions](#)
[Plots](#)
[Movies](#)
[More](#)

David Galloway

Edit Condition

Description

This page provides the form used to edit your condition and add or remove states.

Enter the required information and click "Update".

Condition Properties

Name

MyTestCond

Transmission Mode

respiratory

Transmissibility

1.4

Short Description

First condition

Long Description

A simple condition

Parameter Text

MyTestCond.states = A B C
MyTestCond.transmission_mode = respiratory
MyTestCond.transmissibility = 1.4
MyTestCond.exposed_state = B
MyTestCond.A.duration_median = -1

Save

FRED Web v2.2.0, © 2018 Public Health Dynamics Laboratory, University of Pittsburgh

- As I mentioned in the Challenges
 - Many parameters /options are not known when the condition is created (they are user-defined)
 - The Parameter Text box is a work-around for the short-term
 - The parameters will still be validated
 - But, allows flexibility for user to submit additional parameters
 - Will be using this more during the Hands-on portion

- Any thoughts?
- Questions?
- Concerns?

Pitt Public Health

- John Grefenstette
- Don Burke
- Mark Roberts
- Saumyadipta Pyne
- Mary Krauland
- David Galloway
- Mike Lann
- Bob Frankeny
- David Sinclair

RTI

- Phil Cooley
- Bill Wheaton

Pittsburgh Supercomputing Center

- Shawn Brown
- Nathan Stone
- Jay DePasse

Carnegie Mellon University

- Roni Rosenfeld
- Alona Fyshe
- Anuroop Sriram
- Jack Paparian

FRED Resources

- FRED Web:

<http://fred.publichealth.pitt.edu>

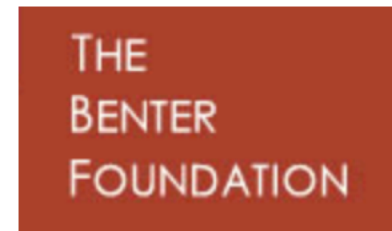
- FRED Github:

<https://github.com/PublicHealthDynamicsLab/FRED>

Acknowledgments

Support

- Robert Wood Johnson Foundation
- NIH / NIGMS (MIDAS Program)
- Bill and Melinda Gates Foundation
- Benter Foundation



Thanks!