

# Using Python to Enhance Computational Simulation for Natural Hazards

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PEER Annual Meeting

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# Outline

- Introduction to Python
- The Python Ecosystem
- Python in Engineering Education
- Research Applications with Python
  - Machine Learning
  - Uncertainty Quantification
- Concluding Remarks

# What is Python?



- Interpreted, high-level programming language
- One of the most popular programming languages today
  - TIOBE Index: <https://www.tiobe.com/tiobe-index/>

Jan 2020	Jan 2019	Change	Programming Language	Ratings	Change
1	1		Java	16.896%	-0.01%
2	2		C	15.773%	+2.44%
3	3		Python	9.704%	+1.41%
4	4		C++	5.574%	-2.58%
5	7	▲	C#	5.349%	+2.07%
6	5	▼	Visual Basic .NET	5.287%	-1.17%
48			TypeScript	0.180%	
49			Tcl	0.180%	
50			Prolog	0.175%	

# Why Is Python Popular?

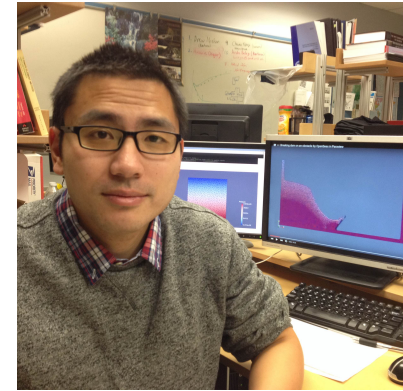


- Free and open source
- Many modules for scientific computing applications



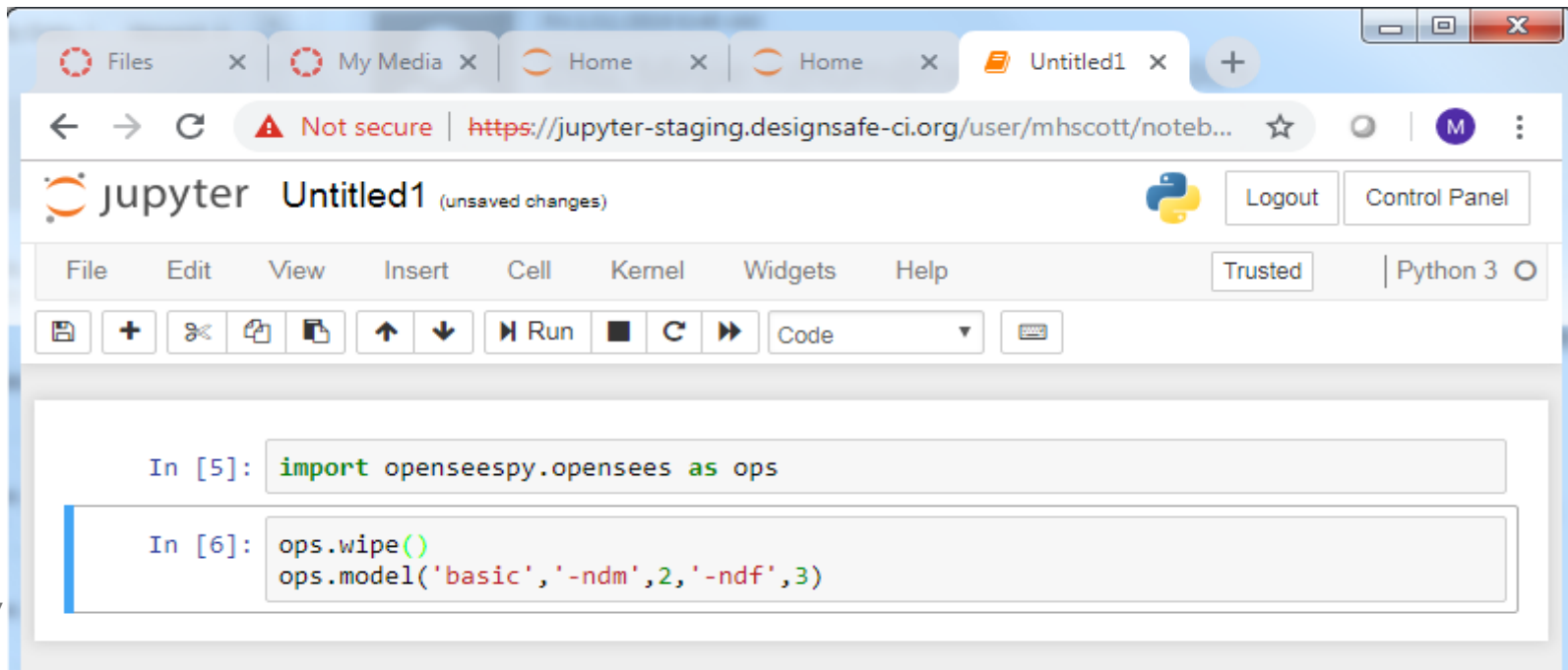
# OpenSees Python Module

- Python3 module
- All commands from Tcl have Python equivalents
- **`pip install openseespy`**



Dr. Minjie Zhu

<https://openseespydoc.readthedocs.io>



# Python in Engineering Education

- A common first programming language for engineering students
- Vertical integration through curriculum is necessary
- Graduate courses in structural and geotechnical engineering
- Student-led workshops, bootcamps

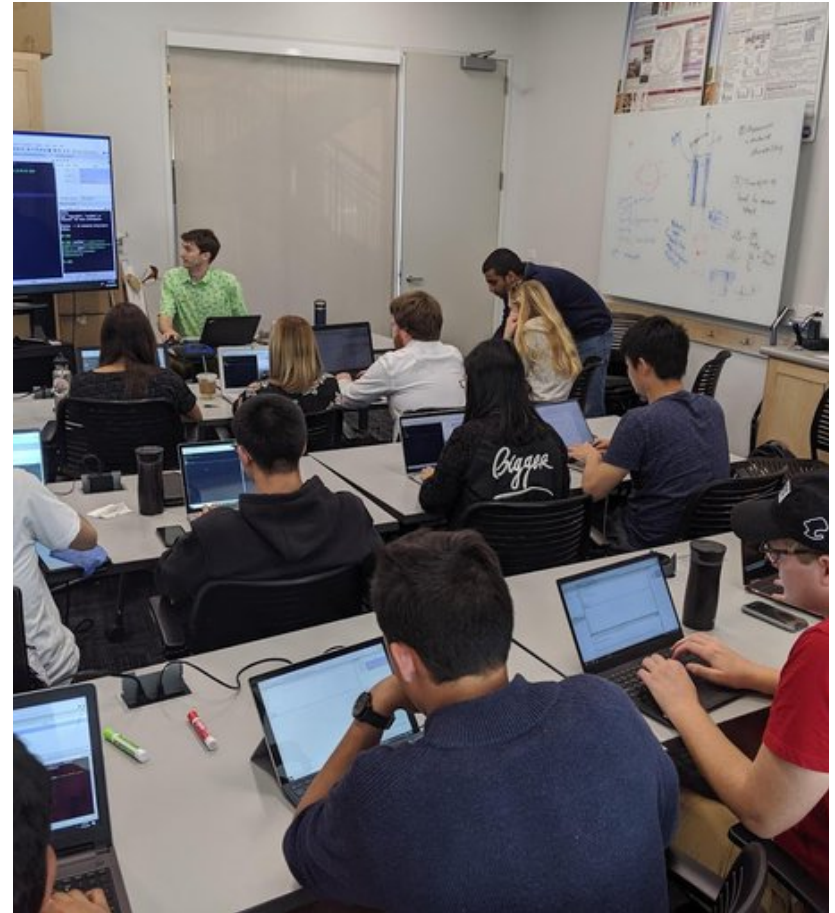
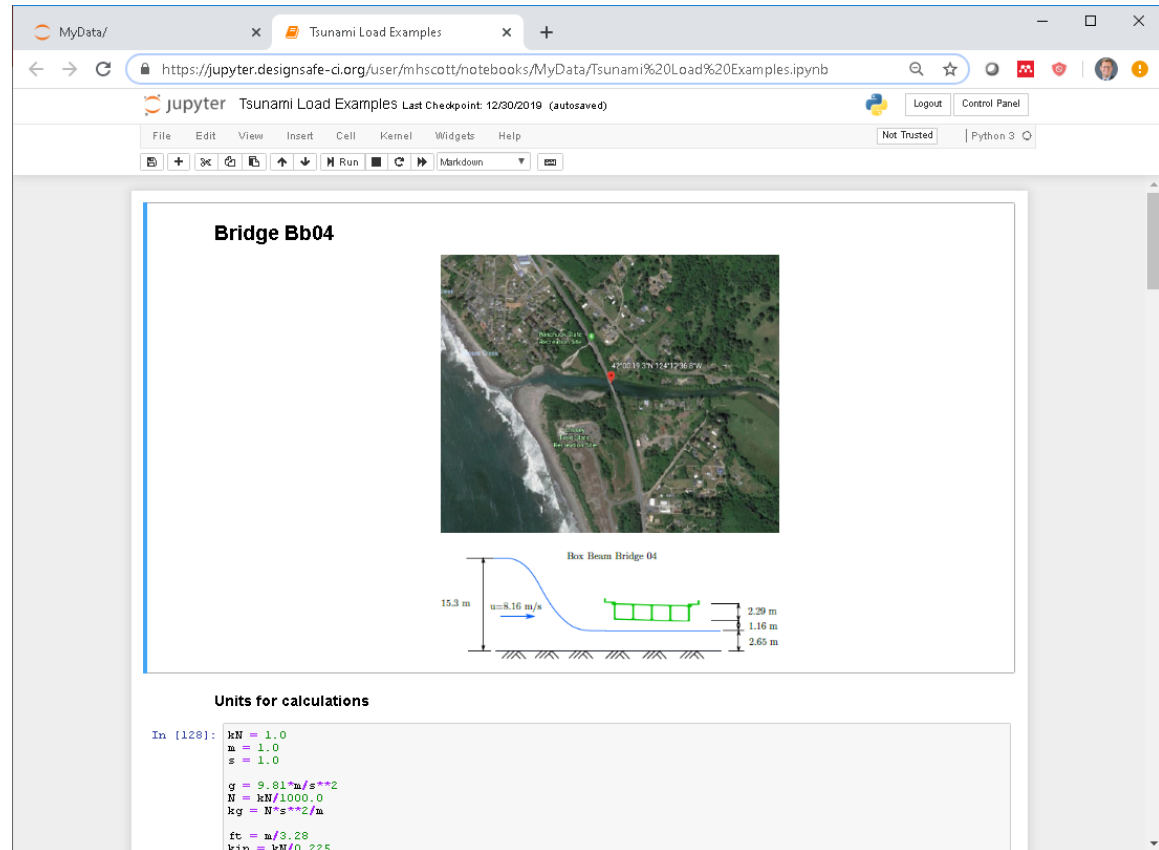


Image: Sumeet Kumar Sinha, UC Davis



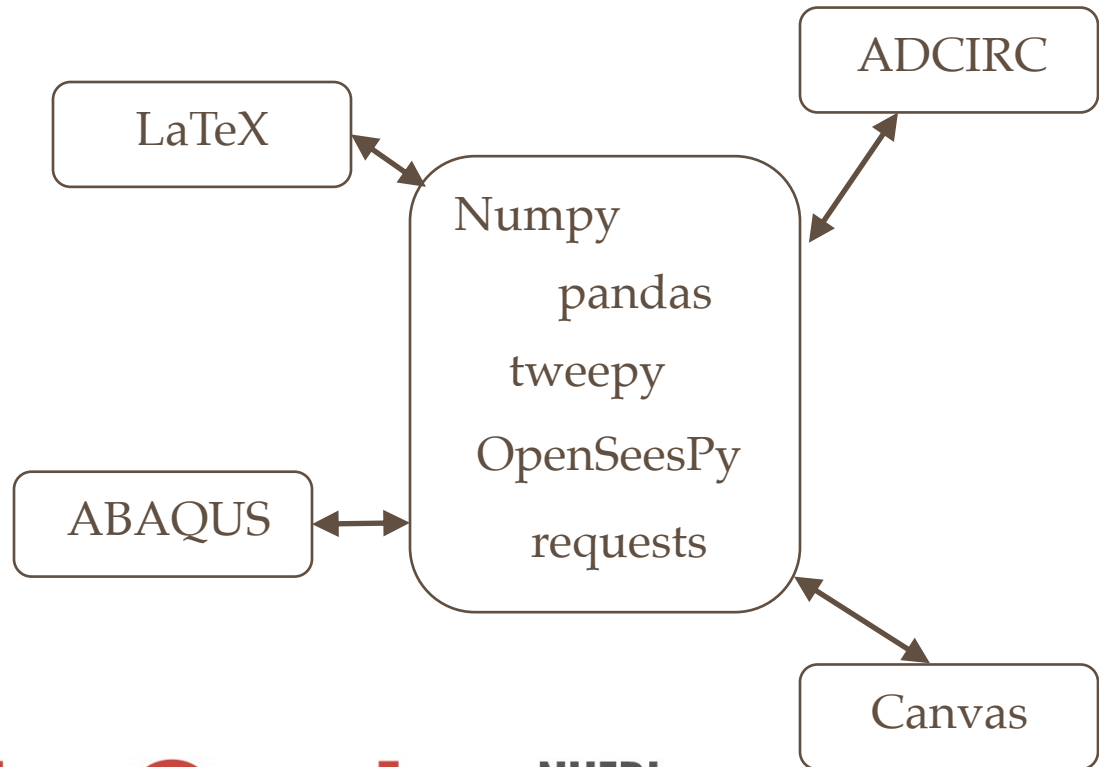
# Jupyter Notebooks

- Interactive environment
  - Python code
  - Visualization
  - Text, Markdown
  - Images
  - Equations
- JupyterHub at DesignSafe
- Run locally with Anaconda
- Suitable for research and teaching



# Python Workflows

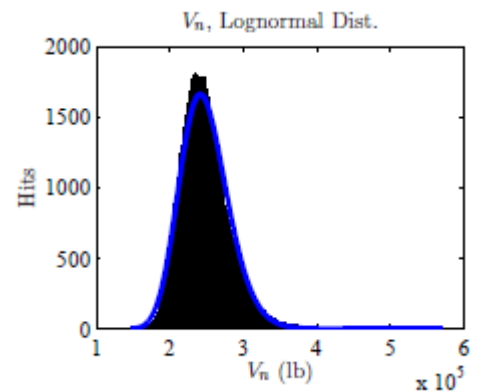
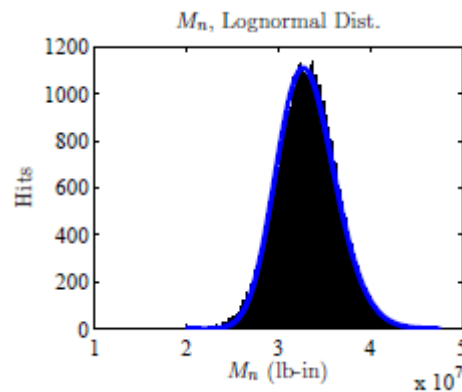
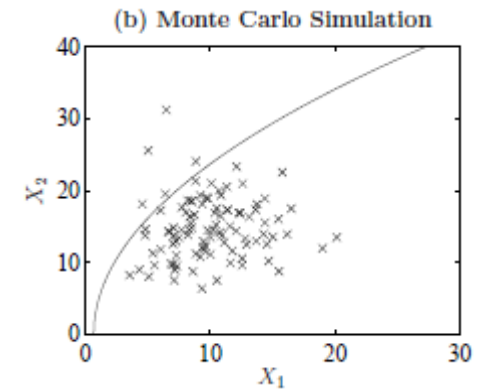
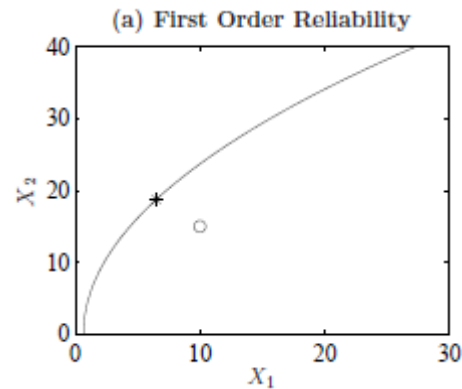
- Glue between Python modules and other software
- Middleware, APIs
- Docker, web-based applications





# Uncertainty Quantification

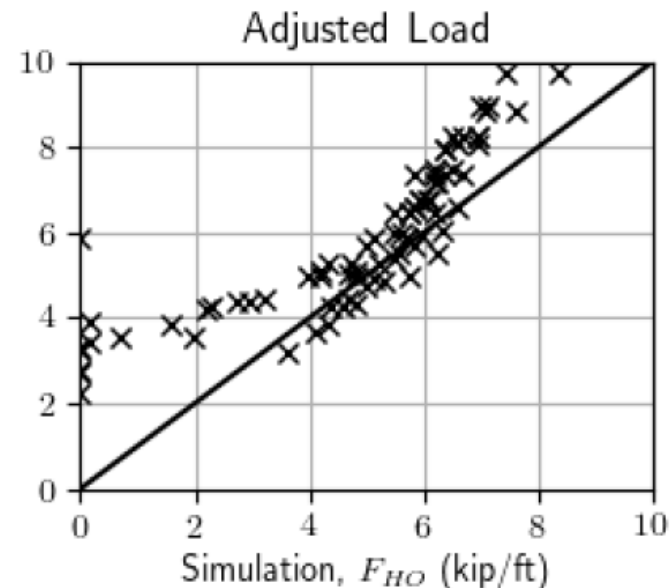
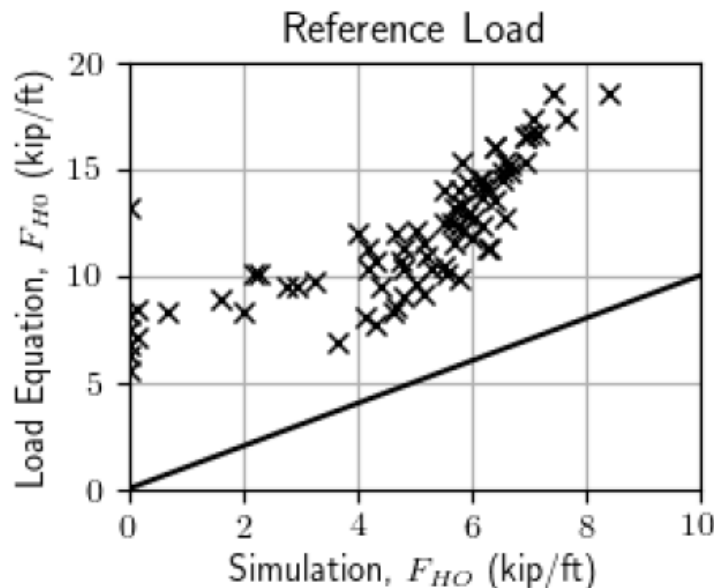
- Assess uncertainty in natural hazard simulation
- UQpy - general purpose
- uqFEM - SimCenter
- PyRe - Python implementation of FERUM
- OpenSeesPy



# Machine Learning - Tsunami Loads

- Adjust load equations to match validated simulations
- Minimize cost function on difference between equation and simulation

$$F_{H0} = C_1(0.5\rho g(2h_0 - d_b)d_b) + C_2(0.5\rho d_b u^2)$$



# Machine Learning

- Image Recognition
- Deep Learning Classification
- PEER Hub ImageNet Challenge

8. **Damage type:** 4 classes (no/flexural/shear/combined damage)



No damage



Flexural  
damage



Shear damage

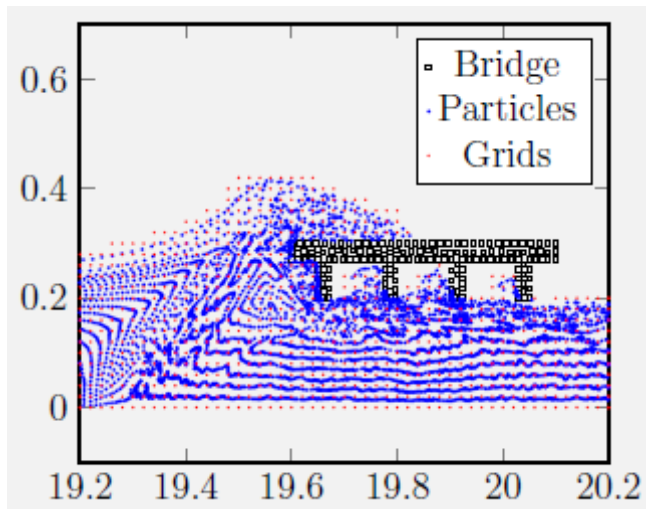


Combined  
damage

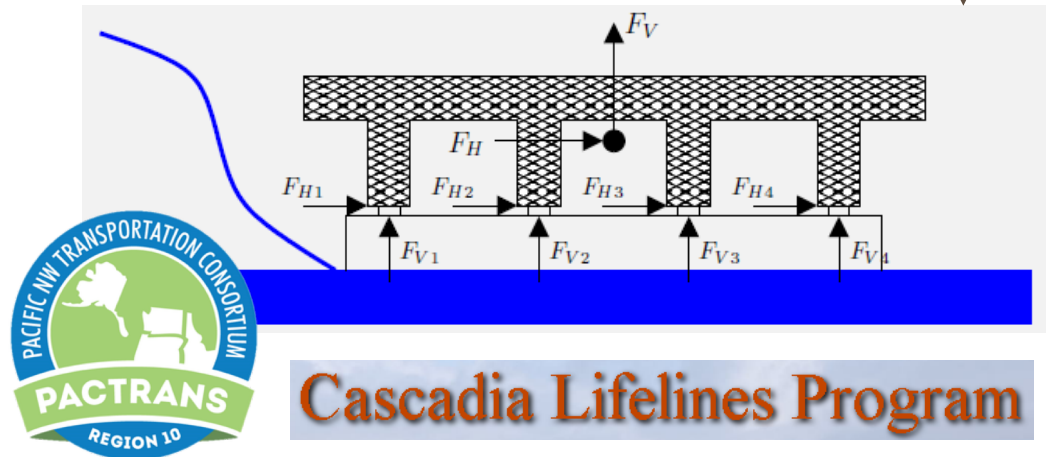
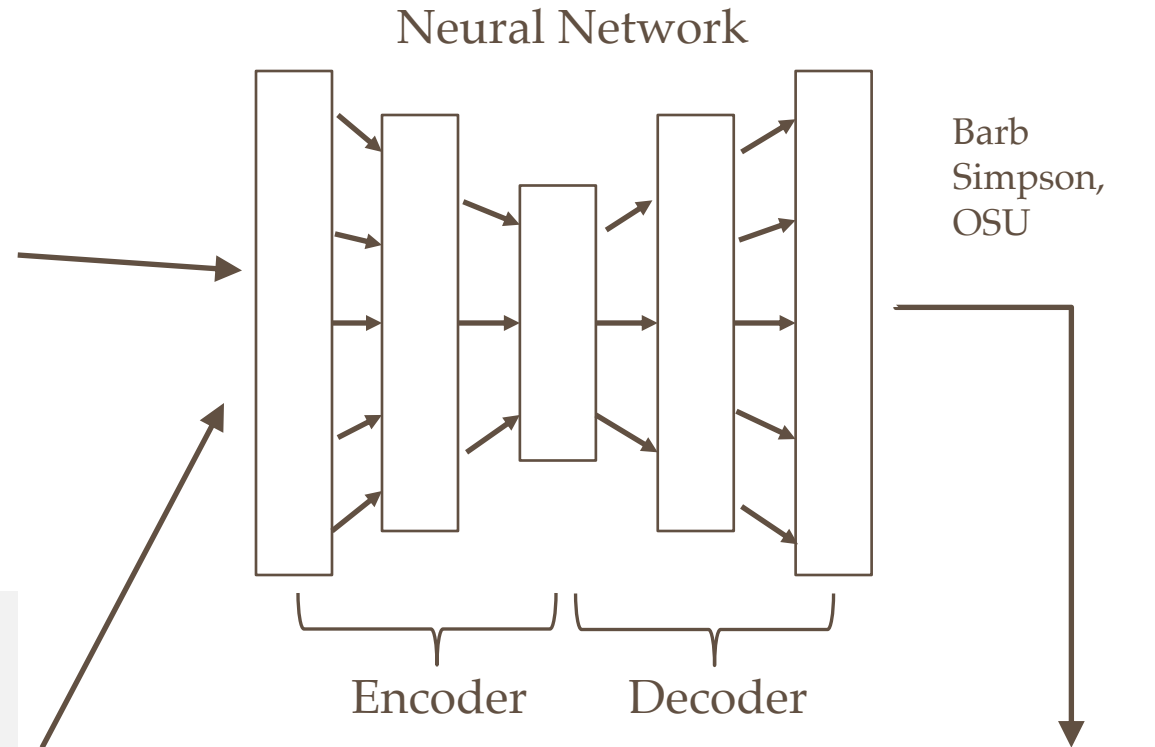
# Deep Learning



Image: PWRI



January 22, 2020



**Cascadia Lifelines Program**

## Concluding Remarks

- Vast potential for developing applications with Python
  - MyShake
  - Text Analytics
  - Data Science
- Several resources online
  - DesignSafe-CI Media YouTube channel
  - Python cheat sheets
  - Stack Exchange, Stack Overflow
- Leverage students' knowledge of Python