Python for Environmental Analysis and Visualization
Short Title: Big Data with Python
Syllabus
BC EESC 3050
Milbank 222
Monday, Tuesday, Wednesday, and Thursday: 10:10-11:25

Brian Mailloux
Office hours Sunday, Monday, Tuesday, Wednesday 9:00-10:00 PM (Might change)
Class Link
Office Hour Link
bmaillou@barnard.edu
212 854 7956

COURSE OBJECTIVES

Short Description for Catalog
Big Data is changing how we interact with and understand the environment. Yet analyzing Big Data requires new tools and methods. Students will learn to use the Jupyter Notebook programming environment to analyze and visualize large environmental data sets. This will include both time series and spatial analyses.

Course description:
Big Data is changing how we interact with and understand the environment. Yet analyzing Big Data requires new tools and methods. Microsoft Excel is not sufficient to analyze big data and quickly becomes frustrating. We are going to analyze environmental data using Python in order to better understand the earth’s system. The class will be a hands-on flipped classroom with programming occurring interactively during class and assignments designed to strengthen the methods and results of class.

The class will begin by analyzing climate data from Central Park and comparing it to different cities around the world. This analysis will enable us to better learn about climate and comparative statistics while at the same time learning the programming language Python.

The class will then utilize Python to analyze bacterial transport distances. We will learn how computer programs can quickly compute and store hundreds to millions of simulations to find optimal fitting parameters.

The class will analyze 50,000 arsenic measurements from Bangladesh. We will spatially analyze the data and learn how to sub-select large data sets and perform statistics while mapping the results.

The class will then visualize and analyze global scale data sets. We will download global scale data sets from the internet and use the data in our own analyses.

The class will then be introduced to time series data and learn how to organize a time series and then analyze a time series for trends.
Finally, the students will individually analyze a data set and present the results of the analysis. Students will learn how to clean and organize data and independently perform an analysis on the data set with the goal of testing a hypothesis or answering a specific question.

Student Learning Goals and Outcomes:

- To be able to organize and analyze large datasets.
- To able to perform statistical analyses on large data sets
- To be able to write code in Python.
- To be able to download and analyze datasets from the internet
- To be able to plot and map large data sets.
- To develop a hypothesis and then be able to take any data set no matter how large or complicated and analyze and visualize it in order to test that hypothesis.

Lecture topics:

<table>
<thead>
<tr>
<th>Week #</th>
<th>Date</th>
<th>Lecture #</th>
<th>Topic</th>
<th>Due</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>9/8</td>
<td>1</td>
<td>Class Introduction Central Park Example</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9/9</td>
<td>2</td>
<td>Print, Markdown, directories, lists</td>
<td>Code.org 1 hour Frozen Install Anaconda</td>
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<tr>
<td></td>
<td>9/10</td>
<td>3</td>
<td>Make a list and plot it</td>
<td>Notebook 1</td>
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<tr>
<td>2</td>
<td>9/14</td>
<td>4</td>
<td>More lists, Start Strings</td>
<td>Notebook 2</td>
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<tr>
<td></td>
<td>9/15</td>
<td>5</td>
<td>For loops</td>
<td>Notebook 3</td>
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<tr>
<td></td>
<td>9/16</td>
<td>6</td>
<td>If/elif/else Plot LGA data</td>
<td>All code.org due Notebook 4</td>
</tr>
<tr>
<td></td>
<td>9/17</td>
<td>7</td>
<td>Fit a line. Fit to LGA and JFK data</td>
<td>Notebook 5</td>
</tr>
<tr>
<td>3</td>
<td>9/21</td>
<td>8</td>
<td>Numpy, fit a line. GDP data</td>
<td>Notebook 6</td>
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<tr>
<td></td>
<td>9/22</td>
<td>9</td>
<td>Arrays and Colormaps</td>
<td>Notebook 7</td>
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<tr>
<td></td>
<td>9/23</td>
<td>10</td>
<td>Pandas (the Python library) and Arsenic data</td>
<td>Notebook 8. Read arsenic paper. Listen to Podcast</td>
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<tr>
<td></td>
<td>9/24</td>
<td>11</td>
<td>More Pandas, Multiple plots</td>
<td>Notebook 9. All Sololearn Due</td>
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<tr>
<td>4</td>
<td>9/28</td>
<td>12</td>
<td>Correlations in Pandas</td>
<td>Notebook 10</td>
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<td>9/29</td>
<td>13</td>
<td>Senior thesis data? p-hacking</td>
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<td></td>
<td>9/30</td>
<td>14</td>
<td>Sediment Core Data on your own. Test a hypothesis</td>
<td>Read Chillrud Paper. Listen to Podcast</td>
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<tr>
<td></td>
<td>10/1</td>
<td>15</td>
<td>Sediment Core Data on your own</td>
<td>Notebook 11</td>
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<tr>
<td>5</td>
<td>10/5</td>
<td>16</td>
<td>CO₂ Time Series</td>
<td>Turn in Final Topic Meet with Fellow I</td>
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<tr>
<td></td>
<td>10/6</td>
<td>17</td>
<td>CO₂ Time Series Part 2</td>
<td>Notebook 12</td>
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<tr>
<td>Week #</td>
<td>Date</td>
<td>Lecture #</td>
<td>Topic</td>
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<tr>
<td>10/7</td>
<td>18</td>
<td>Mapping part 1</td>
<td>Turn in final topic Data</td>
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<tr>
<td>10/8</td>
<td>19</td>
<td>Work on Data Set part 1</td>
<td>Notebook 13d</td>
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<tr>
<td>10/12</td>
<td>20</td>
<td>Mapping part 2</td>
<td></td>
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<tr>
<td>10/13</td>
<td>21</td>
<td>Netcdf, SST, Animated GIF part 1</td>
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<tr>
<td>10/14</td>
<td>22</td>
<td>Work on Data Set part 2</td>
<td>Noteook 14d</td>
<td>Meet with Fellow II</td>
</tr>
<tr>
<td>10/15</td>
<td>23</td>
<td>Finish Netcdf, SST, Animated GIF part 2</td>
<td></td>
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</tr>
<tr>
<td>10/19</td>
<td>24</td>
<td>Work on Data Set part 3</td>
<td>Notebook 15d</td>
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<tr>
<td>TBD</td>
<td>25</td>
<td>Final Presentations</td>
<td>Final Projects Due TBD</td>
<td></td>
</tr>
</tbody>
</table>

**Website**

We will be using both courseworks and edblogs [http://edblogs.columbia.edu/eescx3050-001-2015-3/](http://edblogs.columbia.edu/eescx3050-001-2015-3/). Be prepared to use both. Generally we do
- Courseworks is for handing in homework.
- Edblogs is for all course information.

**Brave New World-How it will work this semester**

Usually I teach this course by handing each student a packet as they enter the classroom. Once students are settled in and started I will give an introduction. Students work through the packet and I walk around helping students as issues arise. When needed I stop the class and we all talk through an issue. Luckily, I think this is one of the better teaching methods that can go to zoom. Each class you will download the packet. If you have a printer you can print them. Else you can look at them online. This is where a second device or screen comes in handy. You can look at the handout on one screen and work on the other. This could even be a phone. Each day I will give an introduction about the day and we will get started. and we can get started. This is how I am envisioning the course.

- We work as a large class for ~10 minutes and go over the big picture issues as everyone gets started.
- After 10 minutes I will assign everyone to breakout rooms of about 5 people. The breakout room will be consistent for the week.
- In the breakout room it will be easier for you to talk and help each other.
- I will go around joining each breakout room. I will ask if there are questions. We can work through them. Then each person will share their screen and we can check on any progress and issues.
- I will keep working around the class throughout the period.
- With a few minutes left we will join the large class in case there are issues or questions.

Debugging and programming are hard and take practice. People move at their own pace. We are going to make this work and we are going to learn python and data analysis skills. We are going to be flexible. I plan on teaching each day via zoom and recording the class. Then also, the night before each class I will have office hours 9:00-10:00pm. Also, the class is very busy at
the beginning. You really need to be ready to begin on day 1. But I am hoping the class is over before your full semester classes get really busy. Below is how we are hoping things will work but we are going to be flexible and will change as needed to help your learning.

Videos
Required
Before many classes I will post a video on the blog and youtube. You are responsible for watching the videos before coming to class. In the videos I will say something that you will then need to answer on a coursework quiz to prove you watched it.

Podcasts
Required
I have started making podcasts where I talk to authors about their work. There are two you need to listen to over the course of the semester.

Readings
Required
Each day you will download a packet on the day’s work. These packets should be put into a binder and brought to every class. Or save them electronically in an organized fashion. They will become your book. You should add notes to them and use them. I use them all the time as I program. Many times I write in a hint or say you will need this point later. You will!!!!

Supplemental
Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython Paperback – October 29, 2012 - by Wes McKinney (Author)

Computational Science Fellows
We are going to have computational science fellows helping with the course. You will be required to meet with them twice during the semester to get help on your final project.

Grading:
Online Tutorials 15%
Python Notebooks for each Section 60%
Final Presentation 15%
Class Attendance and Quizes. 10%

CLASS PREMISE: This is a flipped classroom. You will learn some programming from code.org and sololearn. During class time we will work on in class projects that are designed to teach about different components of Environmental Science while at the same time teaching you how to analyze and visualize large data sets and how to program. At the end of each class or section you will have an iPython/Jupyter Notebook that teaches you multiple concepts. Then at the end of each class you will use this knowledge for your nightly homework. Many times it is quicker to review the day’s notes before you begin the homework. This is worth repeating.
Going through the class notes a second time before starting the homework usually saves you time! All homeworks try to build on concepts from that day. The Notebooks and scripts will contain all your notes, figures, results, etc. By running and examining the Notebooks and results we will be able to quickly determine how much of the in class material you completed. You cannot rush through the class work because taking your time and learning it you learn the concepts needed for the homework and the next class. I am repeating this also. Do not rush through the class notebooks. Take your time and lean them. It all builds on itself.

CLASS PROJECTS:

WEB BASED TUTORIALS: In order to help you learn programming you will do web based tutorials during the first half of class. These tutorials don’t always match class but will help you learn how to program. Code.org is designed for younger kids but really teaches for loops and if statements so it is really helpful. Students are always thankful at the end of the semester that I made them do all the tutorials. For the web based tutorials you will join the class group at each website and your progress will be tracked online by the professor. You have three due dates for the web based tutorials. Your grade will be the percent you complete by the due date. If you complete 100% of the tutorials you get 100%. So make sure you give yourself enough time and complete the tutorials. In the past some people have done the wrong tutorial. Make sure you are doing to correct tutorial and sign up for the correct class. YOU WILL NOT GET CREDIT FOR DOING THE WRONG ONE. Your three tutorials are

1. Code.org 1 hour with Frozen
2. Code.org 20 hour “Accelerated Course”. (You do not need to do the offline parts).

NIGHTLY PYTHON NOTEBOOKS: There will be a nightly homework based on each class. The homeworks will be posted on edblogs. If you diligently worked through the work in class you should be able to do the nightly homework. This makes coming to class a necessity as if you fall behind it will be difficult to accomplish all of the steps independently. The notebooks will consist of code, annotation, and results. The figures are presented inline in the notebooks. You need to add comments and markdown to your notebooks describing what you did. You are expected to have a figure caption and a description of the figure. Homework is due at the beginning of class time. I will use the time stamp on courseworks dropbox to determine if the homework is on time. I will post grading rubrics on courseworks/edblogs. You can see exactly what I am looking for. For the notebooks, if the notebook takes two classes it will be worth twice as much in the grading. If you do not add Markdown and notes you will lose points and the amount of points will get larger with each homework. For many homeworks I will make the final 10% of the grade harder to achieve and take more time. For example you can choose to not work on the last question and get a 90. This will be clearly stated on each homework.

COMMENTS: One of your homeworks will be to leave feedback on three different class days. You will get this homework later in the semester. I take the feedback very seriously and try to incorporate what you suggest. So please provide lots of comments!

STACKOVERFLOW: Part of learning to program is learning to find answers on your own. This might be through trial and error, asking a friend or looking online. When learning something
new I will watch a youtube video or read a tutorial. But for programming questions stackoverflow is a commonly used website. People post questions and answers. It can be really helpful for figuring out bugs and issues and doing something new. Unfortunately people can also be mean. You will need to use it over the course of the semester. I can’t answer all your questions and you need to learn how to learn on your own. Make a login and start liking your favorite answers!

**FINAL POSTER SESSION:** Each student is going to create a poster presentation from a data set. Each student will analyze their own data set. The student will develop questions or hypotheses about the data set and will use what we learned throughout the semester to tackle their problem. We will have 3-4 days of classes near the end of the semester devoted to the final project. Students will present there results during the finals time in a virtual poster session. You can analyze a dataset that you are interested in and find or I can supply you with a dataset. You cannot just repeat an analysis you did for another class. Many people have used this section to analyze their senior thesis data more in depth. Final Posters will be due before the final class. There will be a separate page describing the process and the due dates. These due dates are **very strict** as everyone needs to present during the finals session. The three due dates on the syllabus are:

1. Your poster topic.
2. Your poster data
3. Your final poster.

**HANDING IN HOMEWORK:** I will use the timestamp on dropbox in coursework to check when it was posted. All homework is due at the beginning of class. Each day late you will lose 10% with a maximum loss of 50%. In order to do well in class you need to hand in each homework and get them in on time. When handing in homework you will post your notebook on dropbox in coursework. You will name it by assignment number and name as shown on coursework.

**Class Attendance and Participation:**

- Normally I make students sign into class. I realize that is hard/impossible this year. But this is a hands-on class where we learn by coding as a group during class. If you miss a class you will fall behind and it will be difficult to catch up. In addition since we are doing an accelerated class it will happen even quicker. So in summary you need to keep up with daily classes and it will be hard to do if you miss classes. I will check the zoom log to make sure people are attending. If time zone differences or other issues will make this difficult let me know asap so we can make alternative plans.
- Usually I say no headphones in class. Make sure you are listening to the class and questions. It will help you in the long run as people ask questions. You might even know the answer!
- You may be tempted to come late or leave early. Do the notebooks. Students who take their time and do the notebooks do really well.
- You need to be in class coding in order to learn.
- You are expected to have a computer, webcam, high speed internet and a quiet space to attend class. If you do not have these let me know asap.
• Zoom video and backgrounds: It is tempting to mute zoom and to not show the video. We are going to have lots of group work. When working in a group it is much nicer seeing a welcoming face. I ask that we all try to keep our video on. I will try to show my background.

• Technical glitches: Something is going to go wrong. My internet can get slow and go out. My computer might crash. If we get disconnected you are responsible for staying on during class time and I will re-login as soon as possible. If you get disconnected I trust you will do everything in your power to re-join the class. Don’t forget you can always call in and listen if your internet goes out.

OFFICE HOURS: 9-10:00PM the night before each class.

Collaboration:
When working on coding and projects it is easy to run into roadblocks and stumble. This is when talking to a classmate is very helpful. You can ask how you tackled a problem. How did you iterate over the data? What type of if statements did you use? I strongly urge you to work with and talk to your classmates. The “classroom” should have people speaking. **However, you cannot copy a classmate’s code.** Since everyone comments and codes are slightly differently it is easy to observe when someone has copied and pasted and this is not allowed and will be considered plagiarism and reported. If you have an identical homework answer to a classmate you will both receive a zero. If it happens twice I will report it to the appropriate Dean.

Email:
I try to answer emails as fast as possible. But do not expect rapid replies late at night or on weekends. Also, if a person emails me a good question, I usually do not reply directly but send an email to the whole class through Coursework with the question and answer.

Courseworks
Courseworks will be utilized to post all files and readings from class.

Course Requirements
If you miss the test you need a note from your class Dean in order to reschedule the exam.

**Definition of Grades:** All grades will be based on a scale of 100 with

<table>
<thead>
<tr>
<th>Grade</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>93.00-100</td>
<td>Rare performance. Reserved for exceptional achievement</td>
</tr>
<tr>
<td>A</td>
<td>90.00-92.99</td>
<td>Excellent work. Outstanding achievement.</td>
</tr>
<tr>
<td>A-</td>
<td>87.00-89.99</td>
<td>Excellent work that exceeds course expectations.</td>
</tr>
<tr>
<td>B+</td>
<td>83.00-86.99</td>
<td>Very good work. Solid achievement (expected of Barnard/Columbia undergraduates) that meets all course expectations.</td>
</tr>
<tr>
<td>B</td>
<td>80.00-82.99</td>
<td>Good work. Acceptable achievement that meets almost all course expectations.</td>
</tr>
<tr>
<td>B-</td>
<td>77.00-79.99</td>
<td>Satisfactory work. Acceptable achievement that meets major course expectations.</td>
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</table>
| C+    | 74.00-76.99 | Fair achievement just above that which is minimally
<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>C</td>
<td>73.00-76.99</td>
<td>Fair achievement but only minimally acceptable.</td>
</tr>
<tr>
<td>C-</td>
<td>70.00-72.99</td>
<td>Barely acceptable achievement.</td>
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<tr>
<td>D</td>
<td>60.00-69.99</td>
<td>Very low performance. Unsatisfactory work. Lowest achievement to still allow for a passing grade. This grade may not be counted toward the major or minor option</td>
</tr>
<tr>
<td>F</td>
<td>59.99 or less</td>
<td>Failure.</td>
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Consult the Barnard or Columbia College Catalogs or the Registrar's Office for other information about grading, including: the definitions of other letter grades, pass/D/fail option, incompletes, and calculation of GPA.

**The Honor Code and Academic Integrity**

The Barnard Honor Code (established in 1912) reads:

*We, the students of Barnard College, do hereby resolve to uphold the honor of the College by refraining from every form of dishonesty in our academic life. We consider it dishonest to ask for, give, or receive help in examinations, quizzes, or to use in them any papers or books in any manner not authorized by the instructor, or to present oral or written work that is not entirely our own, except in such way as may be approved by the instructor. We pledge to do all that is in our power to create a spirit of honesty and honor for its own sake.*

The Honor Code governs all aspects of academic work. If a violation should arise, it will be reported to the Dean of Studies for appropriate action. Honor Board Guidelines on the procedures for implementing the Honor System and acting on charges of dishonesty can be found in the Student Handbook. Remember that Barnard students reaffirm their acceptance of the Honor Code by signing their registration form. Columbia students commit themselves to the Honor Code upon registering for a Barnard course. Because the Honor Code is not entirely specific and contains qualifications and exceptions, such as "authorized by the instructor" or "approved by the instructor", please read the attached summary of "What behaviors constitute academic dishonesty?"

**Students with disabilities**

Students who may need disability-related classroom accommodations are encouraged to make an appointment to see me as soon as possible. Disabled students who need test or classroom accommodations must be registered in advance with the Office of Disability Services (ODS) in 105 Hewitt. Thank you.
ZOOM CLASS

Brian Mailloux is inviting you to a scheduled Zoom meeting.

Topic: EESCB3050_001_2020_3 - BIG DATA WITH PYTHON
Time: Sep 8, 2020 10:10 AM Eastern Time (US and Canada)
   Every week on Mon, Tue, Wed, Thu, until Oct 19, 2020, 24 occurrence(s)
   Sep 8, 2020 10:10 AM
   Sep 9, 2020 10:10 AM
   Sep 10, 2020 10:10 AM
   Sep 14, 2020 10:10 AM
   Sep 15, 2020 10:10 AM
   Sep 16, 2020 10:10 AM
   Sep 17, 2020 10:10 AM
   Sep 21, 2020 10:10 AM
   Sep 22, 2020 10:10 AM
   Sep 23, 2020 10:10 AM
   Sep 24, 2020 10:10 AM
   Sep 28, 2020 10:10 AM
   Sep 29, 2020 10:10 AM
   Sep 30, 2020 10:10 AM
   Oct 1, 2020 10:10 AM
   Oct 5, 2020 10:10 AM
   Oct 6, 2020 10:10 AM
   Oct 7, 2020 10:10 AM
   Oct 8, 2020 10:10 AM
   Oct 12, 2020 10:10 AM
   Oct 13, 2020 10:10 AM
   Oct 14, 2020 10:10 AM
   Oct 15, 2020 10:10 AM
   Oct 19, 2020 10:10 AM

Please download and import the following iCalendar (.ics) files to your calendar system.
Weekly:
https://columbiauniversity.zoom.us/meeting/tJYlcuGurDouGdbbW7NiTlFVXqRxUW7Oont6/ics?icsToken=98tyKuCqpj4iHNaUtBqFRowQGo_4We7zpn5bjadfmiyiLSlnbiXADvNwKodIR_ff

Join Zoom Meeting
https://columbiauniversity.zoom.us/j/92858621432?pwd=YVViM1RiQm1HZ0pDSIv2VFF6R1Zodz09

Meeting ID: 928 5862 1432
Passcode: 7o476p
One tap mobile
+13126266799,,92858621432#,,,,0#,470851# US (Chicago)
+16468769923,,92858621432#,,,,0#,470851# US (New York)
Dial by your location
+1 312 626 6799 US (Chicago)
+1 646 876 9923 US (New York)
+1 301 715 8592 US (Germantown)
+1 346 248 7799 US (Houston)
+1 669 900 6833 US (San Jose)
+1 253 215 8782 US (Tacoma)
Meeting ID: 928 5862 1432
Passcode: 470851
Find your local number: https://columbiauniversity.zoom.us/u/ai10CYfZB

Join by SIP
92858621432@zoomcrc.com

Join by H.323
162.255.37.11 (US West)
162.255.36.11 (US East)
221.122.88.195 (China)
115.114.131.7 (India Mumbai)
115.114.115.7 (India Hyderabad)
213.19.144.110 (EMEA)
103.122.166.55 (Australia)
209.9.211.110 (Hong Kong SAR)
64.211.144.160 (Brazil)
69.174.57.160 (Canada)
207.226.132.110 (Japan)
Meeting ID: 928 5862 1432
Passcode: 470851
ZOOM OFFICE HOURS
Brian Mailloux is inviting you to a scheduled Zoom meeting.

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    Sep 28, 2020 09:00 PM
    Sep 29, 2020 09:00 PM
    Sep 30, 2020 09:00 PM
    Oct 4, 2020 09:00 PM
    Oct 5, 2020 09:00 PM
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Join Zoom Meeting
https://columbiauniversity.zoom.us/j/92249700931?pwd=V0pmckt2RlpoRml0RDA4eXpCamk5Zz09

Meeting ID: 922 4970 0931
Passcode: 6v283f
One tap mobile
+16468769923,,92249700931#,,,,0#,,574431# US (New York)
+13017158592,,92249700931#,,,,0#,,574431# US (Germantown)

Dial by your location
Meeting ID: 922 4970 0931
Passcode: 574431
Find your local number: https://columbiauniversity.zoom.us/u/ad8YUGulri

Join by SIP
92249700931@zoomcrc.com

Join by H.323
162.255.37.11 (US West)
162.255.36.11 (US East)
221.122.88.195 (China)
115.114.131.7 (India Mumbai)
115.114.115.7 (India Hyderabad)
213.19.144.110 (EMEA)
103.122.166.55 (Australia)
209.9.211.110 (Hong Kong SAR)
64.211.144.160 (Brazil)
69.174.57.160 (Canada)
207.226.132.110 (Japan)
Meeting ID: 922 4970 0931
Passcode: 574431