SUSTech Southern University of Science and Technology

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

地球与空间科学系 DEPARTMENT OF EARTH AND SPACE SCIENCES

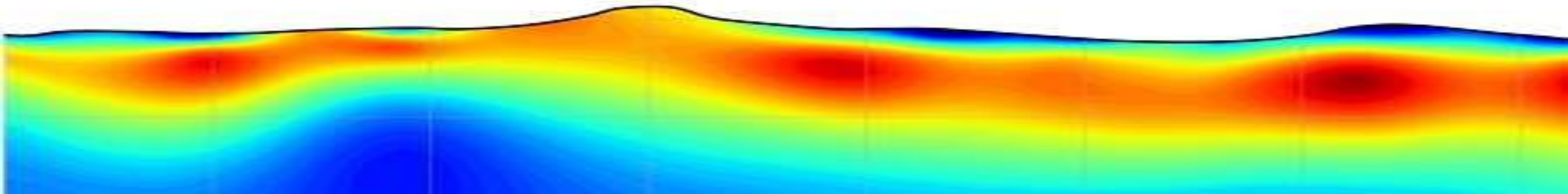
ESS302 Applied Geophysics II

Gravity, Magnetic, Electrical, Electromagnetic and Well Logging

Introduction

Instructor: Dikun Yang

Feb – May, 2020



Course Information

- Instructor: Dikun Yang
  - PhD in geophysics, University of British Columbia, 2014
  - Office: Room 406B, Building 9, Innovation Park
  - Phone: 88018695
  - Email: yangdk@sustech.edu.cn
  - Web: sustech-gem.cn
  - Office hour: By appointment
  - TA: Lichun Yang (11930414@mail.sustech.edu.cn)

Course Information

Week	Tuesday 2 pm	Friday 8 am	Weekend
Wk 1			
Wk 2		Feb 21: Introduction	
Wk 3	Feb 25: Gravity	Feb 28: Gravity	
Wk 4		Mar 6: Gravity	
Wk 5	Mar 10: Gravity	Mar 13: Magnetic	
Wk 6		Mar 20: Magnetic	
Wk 7	Mar 24: Magnetic	Mar 27: Magnetic	
Wk 8		Apr 3: Mid-term exam	
Wk 9	Apr 7: Electric	Apr 10: Electric	
Wk 10		Apr 17: Electric	
Wk 11	Apr 21: Electric	Apr 24: EM	
Wk 12			
Wk 13		May 8: EM	May 9: EM
Wk 14		May 15: EM	
Wk 15	May 19: Well logging	May 22: Well logging	
Wk 16		May 29: Summary	

Task-guided Learning

- Lecture: webcast https://live.bilibili.com/21806110
- Self-study: complete worksheets with the help of notes and internet
- Discussion: webcam conference through **Tencent Meeting**
- Instrument demo: depending on school NCP policies
- Student presentation: TBA

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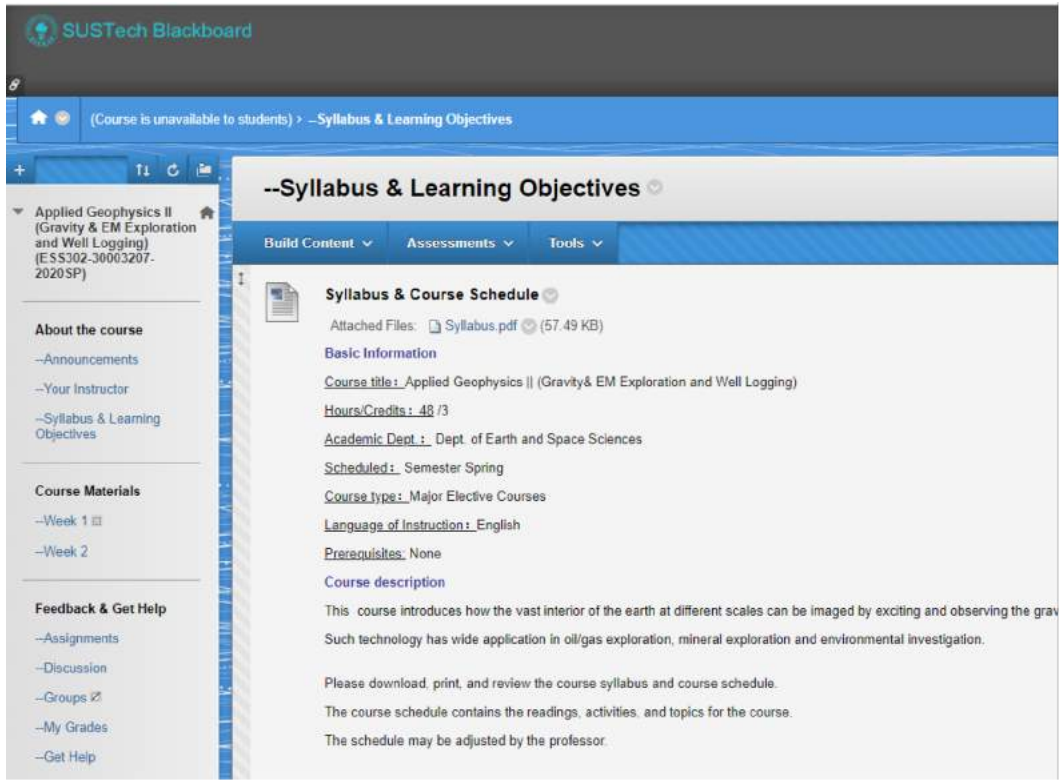
Wk 9	Apr 7: Electric	Apr 10: Electric	
Wk 10		Apr 17: Electric	
Wk 11	Apr 21: Electric	Apr 24: EM	
Wk 12			
Wk 13		May 8: EM	May 9: EM
Wk 14		May 15: EM	
Wk 15	May 19: Well logging	May 22: Well logging	
Wk 16		May 29: Summary	

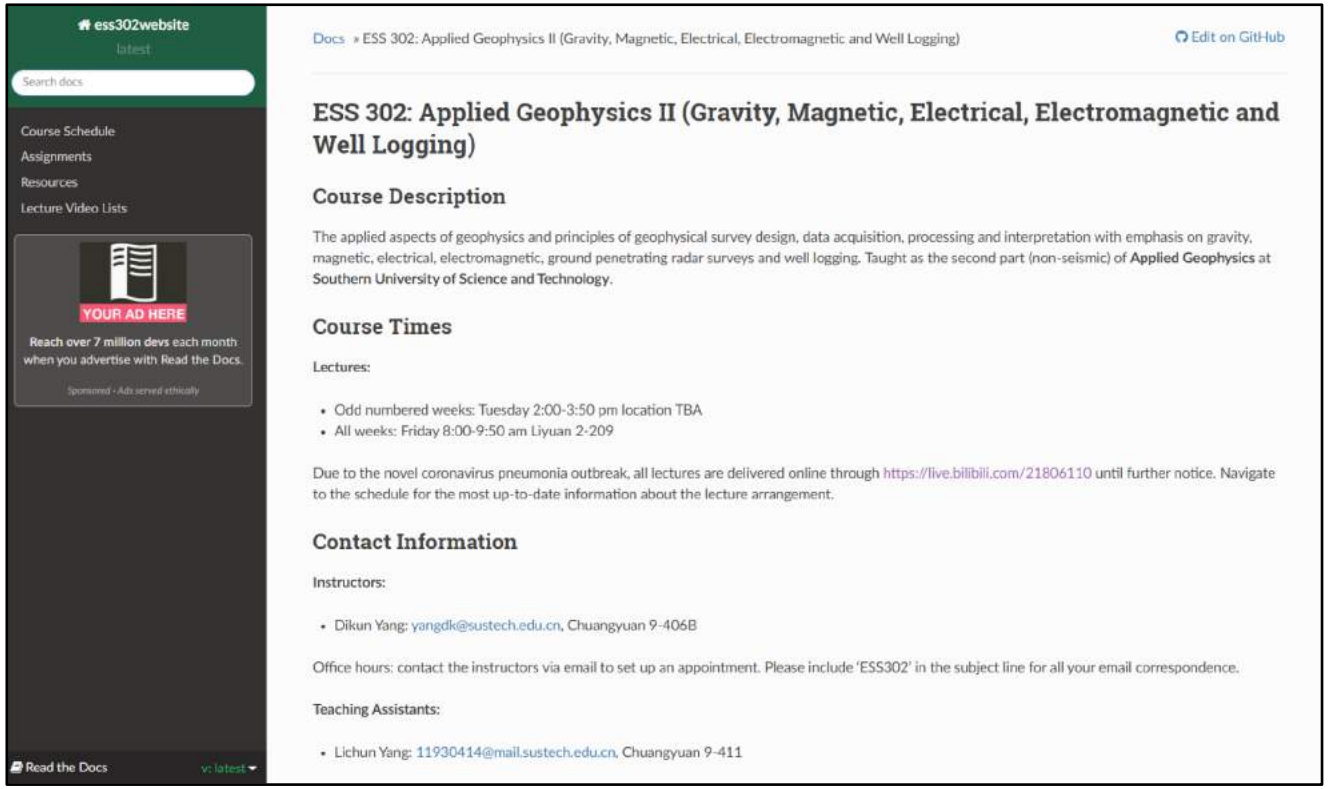
- 10% class attendance, participation and performance
- 20% assignments (gravity, magnetic, electric, EM, GPR worksheet each 4%)
- 20% mid-term exam
- 50% final exam

Course Resources

Blackboard

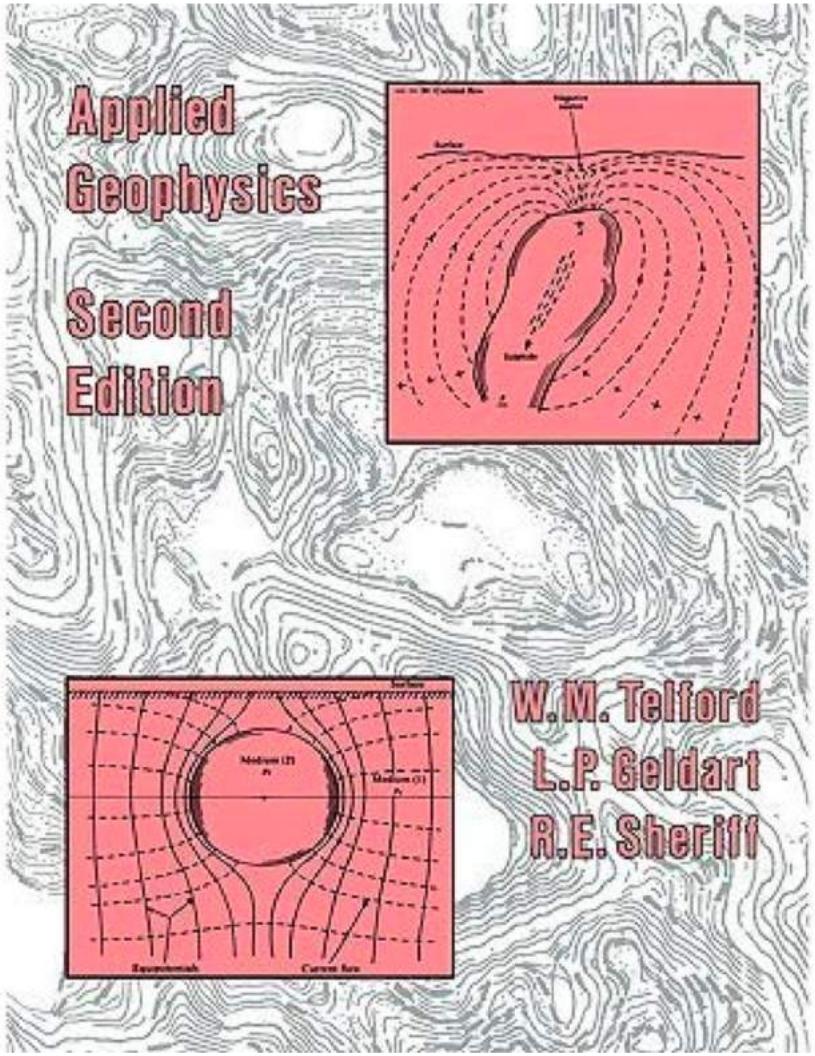


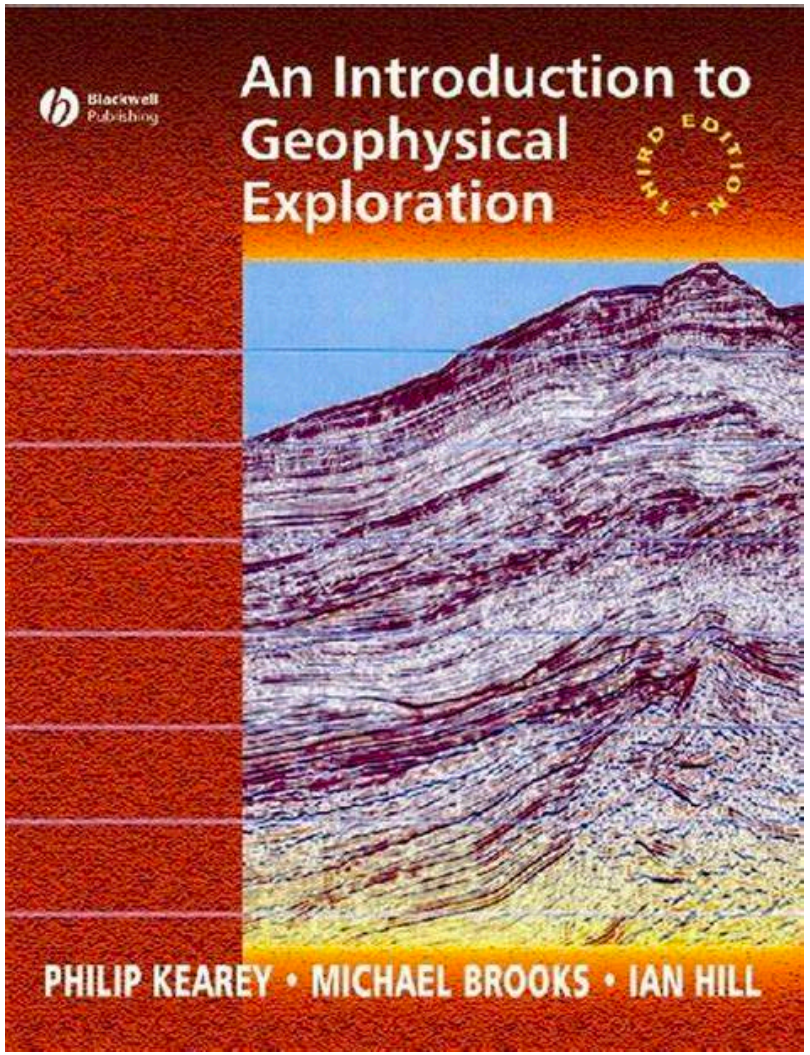
Course Website https://sustech-ess302.readthedocs.io



Syllabus

- Resources
  - Textbooks

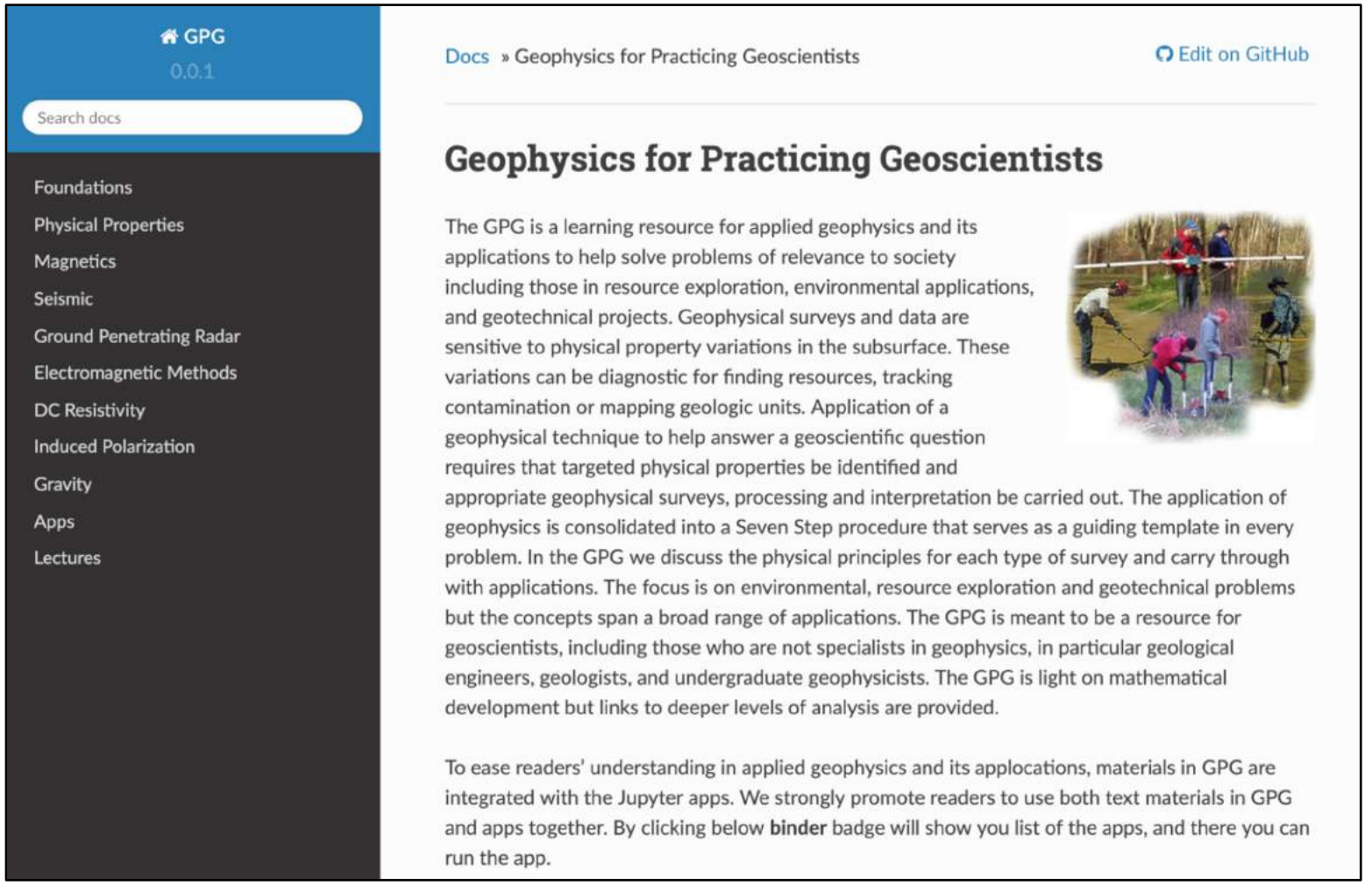




(Available in my office)

Syllabus

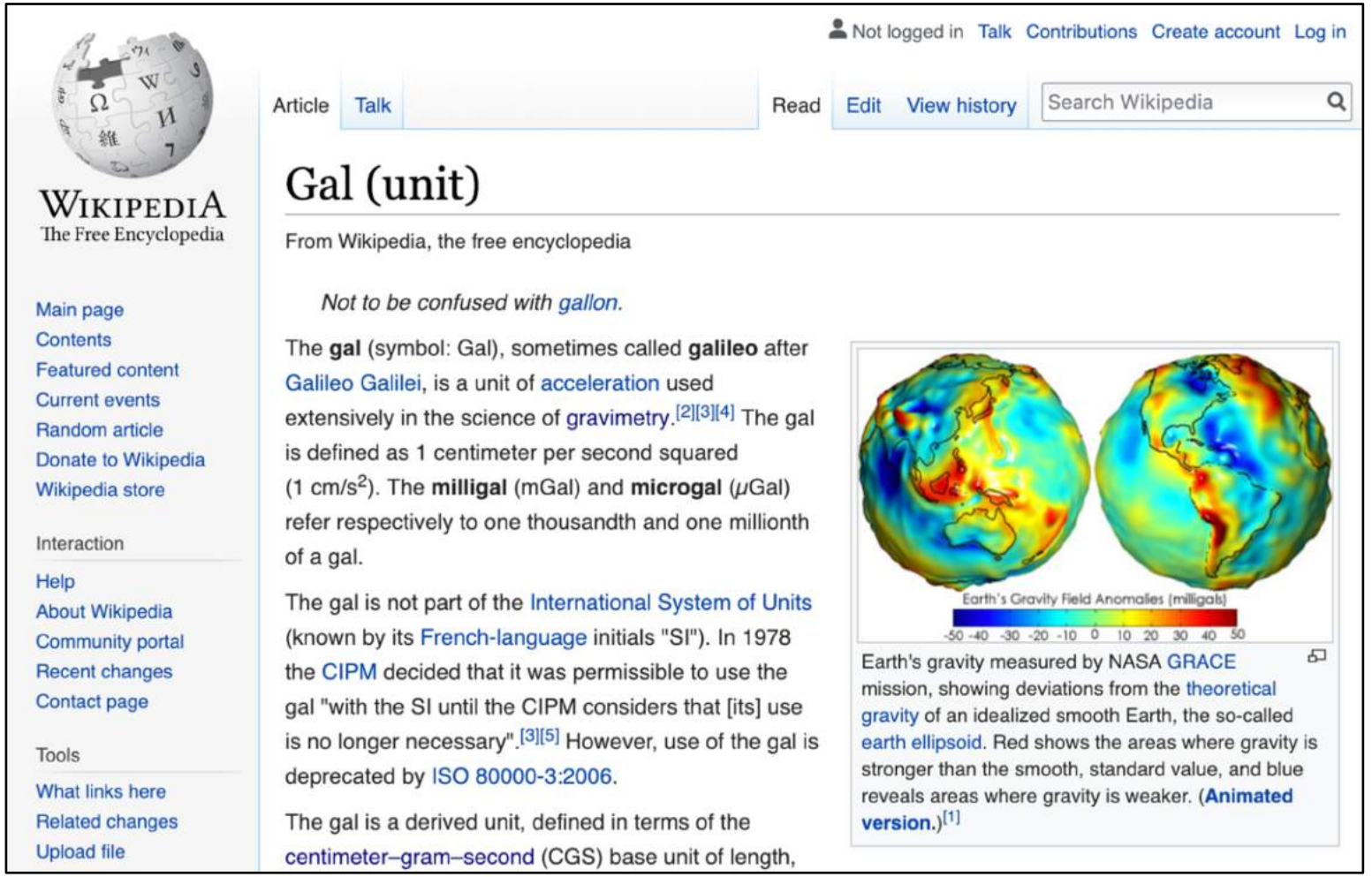
- Resources
  - Textbooks
  - eBooks, websites



https://gpg.geosci.xyz
https://em.geosci.xyz

Syllabus

- Resources
  - Textbooks
  - eBooks, websites
  - Wikipedia



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Gal (unit)

From Wikipedia, the free encyclopedia

Not to be confused with gallon.

The **gal** (symbol: Gal), sometimes called **galileo** after Galileo Galilei, is a unit of acceleration used extensively in the science of gravimetry.[2][3][4] The gal is defined as 1 centimeter per second squared (1 cm/s^2). The **milligal** (mGal) and **microgal** (μGal) refer respectively to one thousandth and one millionth of a gal.

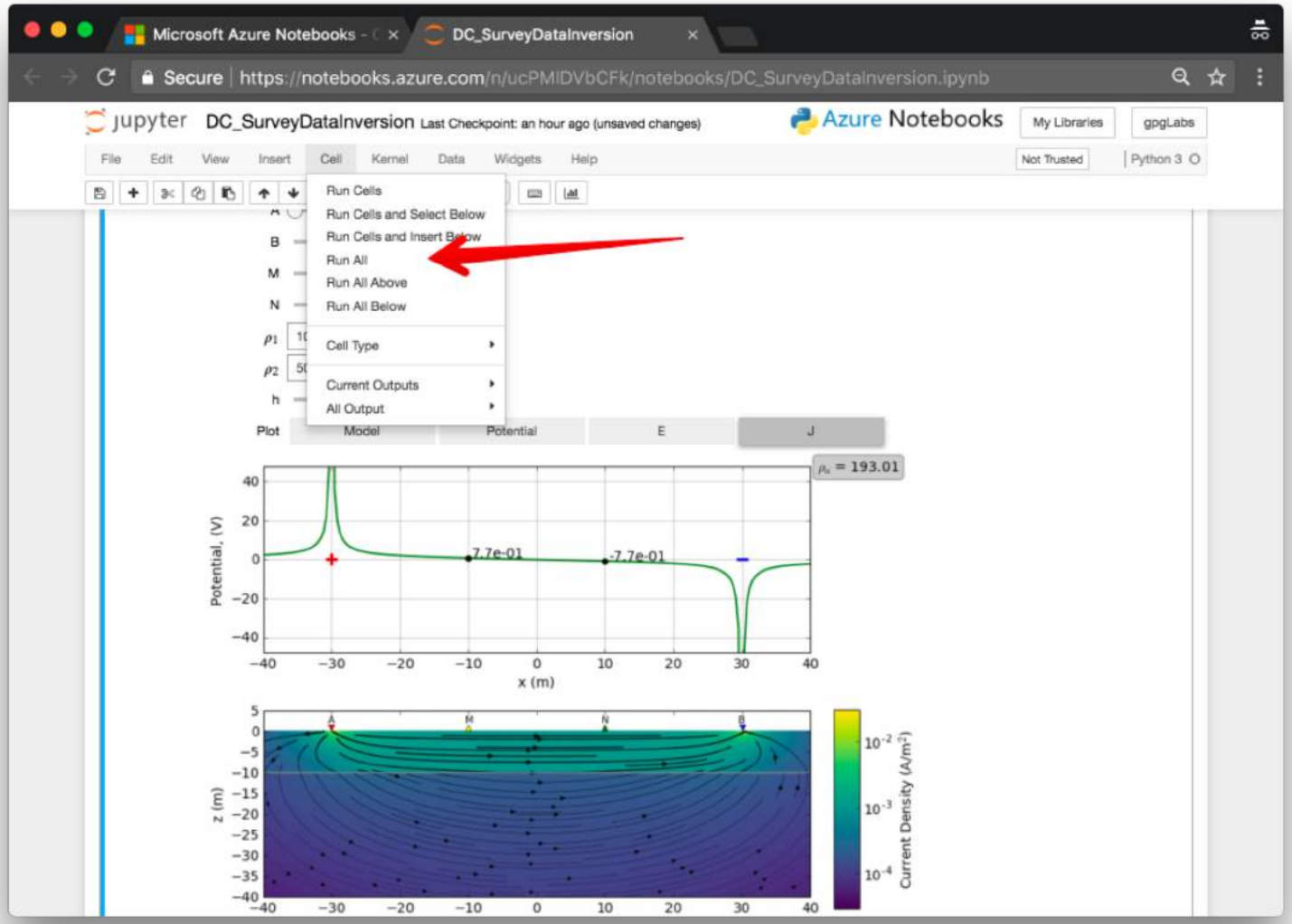
The gal is not part of the International System of Units (known by its French-language initials "SI"). In 1978 the CIPM decided that it was permissible to use the gal "with the SI until the CIPM considers that [its] use is no longer necessary".[3][5] However, use of the gal is deprecated by ISO 80000-3:2006.

The gal is a derived unit, defined in terms of the centimeter–gram–second (CGS) base unit of length,

Earth's gravity measured by NASA GRACE mission, showing deviations from the theoretical gravity of an idealized smooth Earth, the so-called earth ellipsoid. Red shows the areas where gravity is stronger than the smooth, standard value, and blue reveals areas where gravity is weaker. (**Animated version.**)[1]

Syllabus

- Resources
  - Textbooks
  - eBooks, websites
  - Wikipedia
  - Interactive apps



(Python Jupyter notebooks)

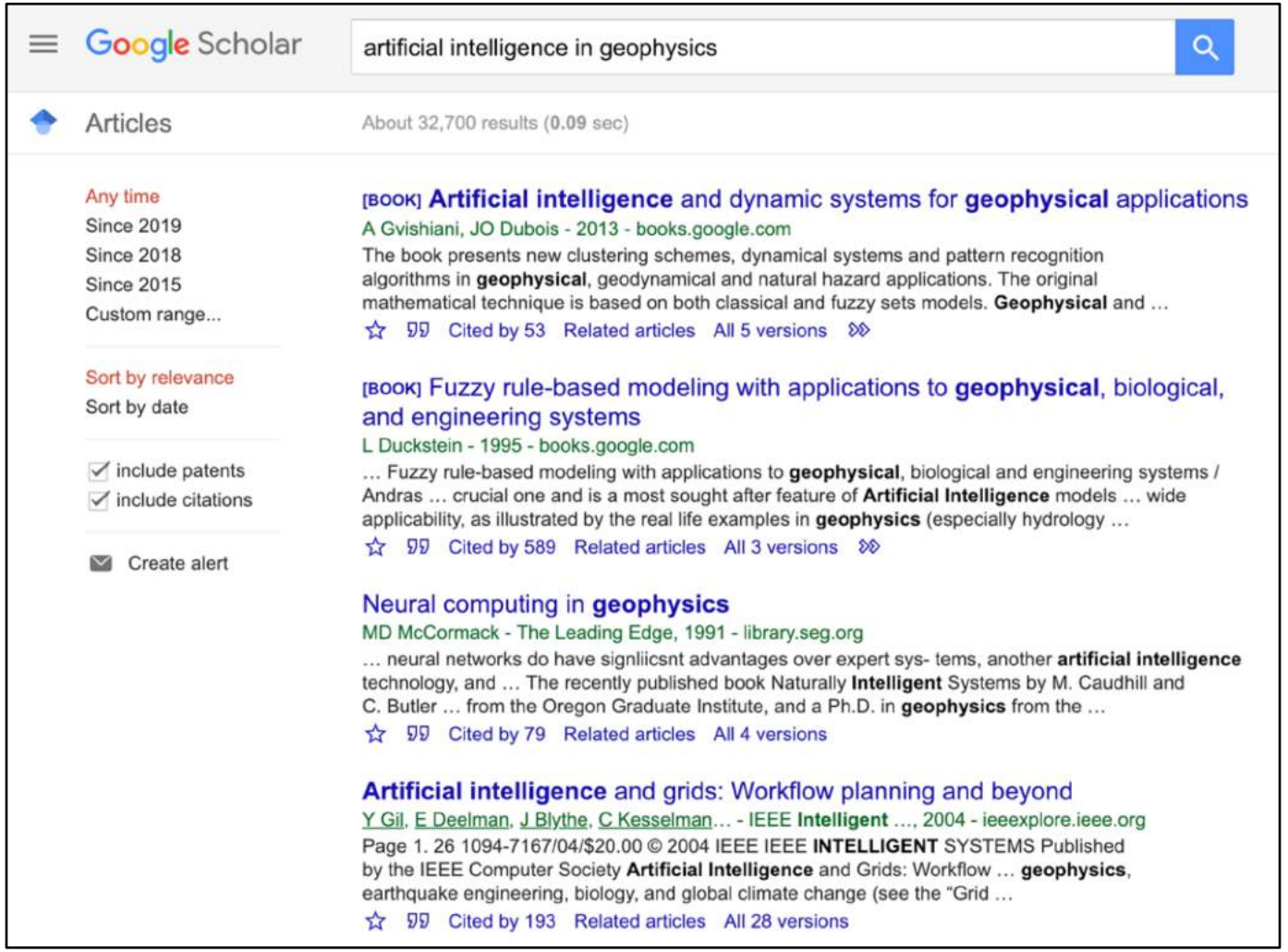
Syllabus

- Resources
  - Textbooks
  - eBooks, websites
  - Wikipedia
  - Technical publications

(Available online or in my office)

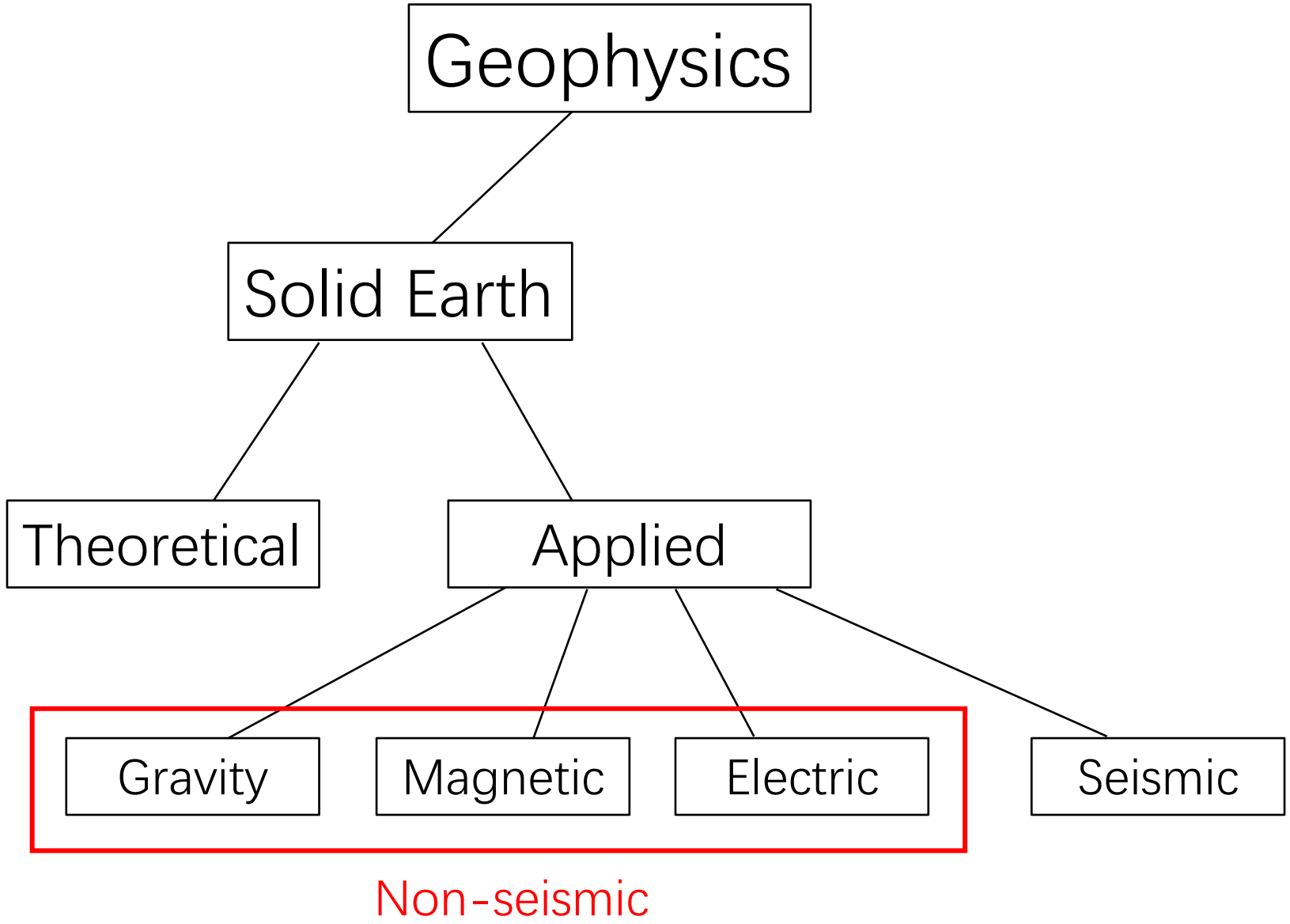
Syllabus

- Resources
  - Textbooks
  - eBooks, websites
  - Wikipedia
  - Technical publications
  - Google scholar



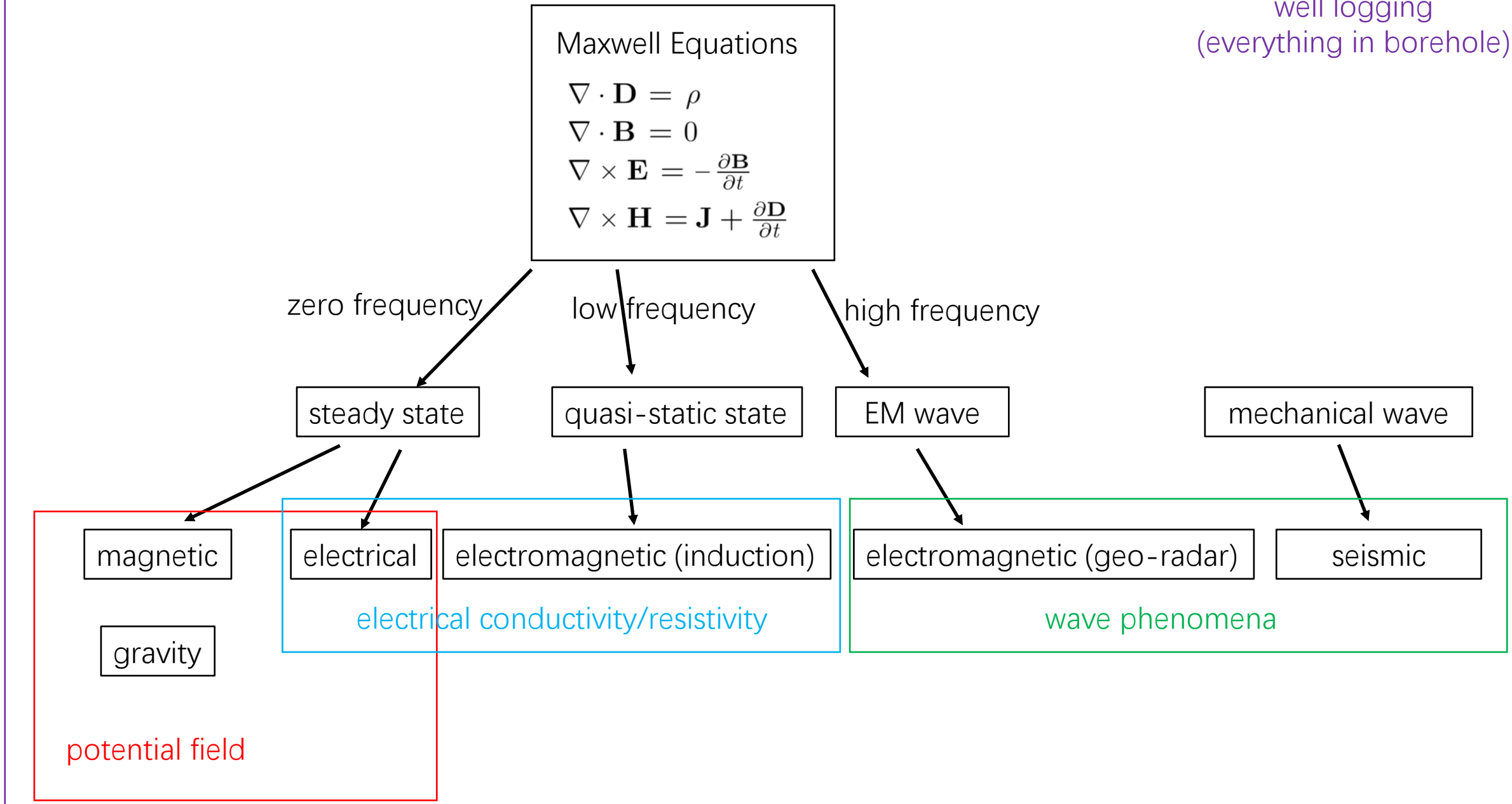
Syllabus

- Course Policies
  - Instructional language: English
  - Turn in your completed worksheets before the end of last class of each module
  - The top-ranked student before the final goes to ICEEG2020 in Changchun


Geophysics
Solid Earth
Theoretical
Applied
Gravity
Magnetic
Electric
Seismic
Non-seismic

Method	Theoretical	Applied
Gravity	The acceleration of gravity is not constantly 9.8 m/s^2!	Can I make money with it? Yes. Build houses on stable ground with no strong gravity variation. Then you are rich!
Magnetic	There are magnetic stripes on the seafloor!	Can I make money with it? Yes. Dig at where the magnetic field is strong for gold, silver… Then you are rich!
Electric	Magnetic storms from the sun induces strong electric currents in the earth!	Can I make money with it? Yes. Drill at where the electric field is strong for groundwater. Then you are rich!
Seismic	The wave from earthquakes travel more slowly in sedimentary basins!	Can I make money with it? Yes. Compare the wave travel times and find the rocks that trap the oil. Then you are rich!

well logging
(everything in borehole)



Why You Never Heard About Applied Geophysics?

- You drink **water** off a bottle, but do not care where the water comes from.
- You play games on your **smartphone**, but do not ask where the lithium in the battery comes from.
- You give a thumbs up for the magnificent **Hongkong-Zhuhai-Macau Bridge**, but did not see how the route was planned.
- You throw away a bag of **trash**, but do not know how it can be kept safe in a landfill.
- You struggle to buy a **medical mask**, but do not realize it is made of the sticky oil from a remote desert.




How Exactly Does Geophysics Work in Reality?

1. **Setup**: What is the question to be answered?
2. **Properties**: What are the diagnostic physical properties?
3. **Survey**: Choose survey and design data acquisition
4. **Data**: Go to the field and collect data
5. **Processing**: Processing of field data
6. **Interpretation**: Associate the processed results to the original question
7. **Synthesis**: Has the question been answered? Need to iterate?

Surface Subsidence in Urban Area

City of Guangzhou, Guangdong Province, December 1, 2019

City of Xining, Qinghai Province, January 14, 2020

Surface Subsidence in Urban Area

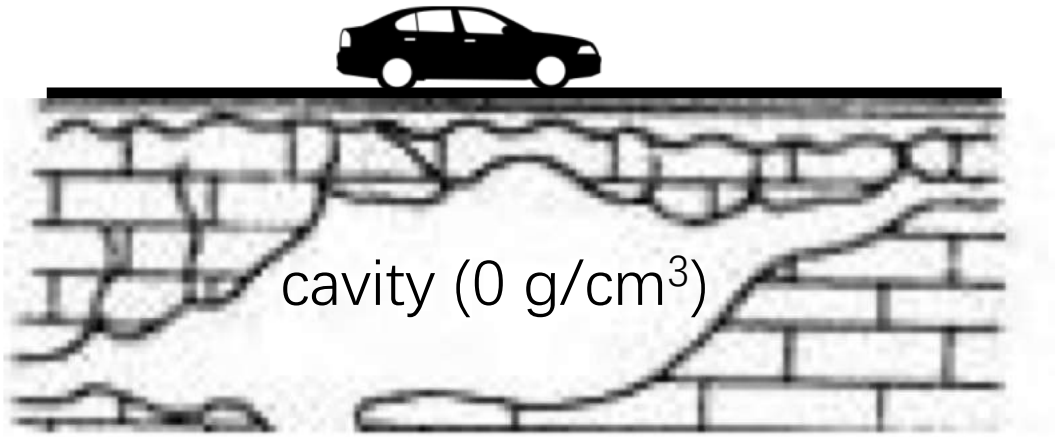
1. **Setup**: What is the question to be answered?

   Detect and forecast the next deadly subsidence

Surface Subsidence in Urban Area

2. **Properties**: What are the diagnostic physical properties?

What *physically* distinguish an air-filled cavity from regular soil?

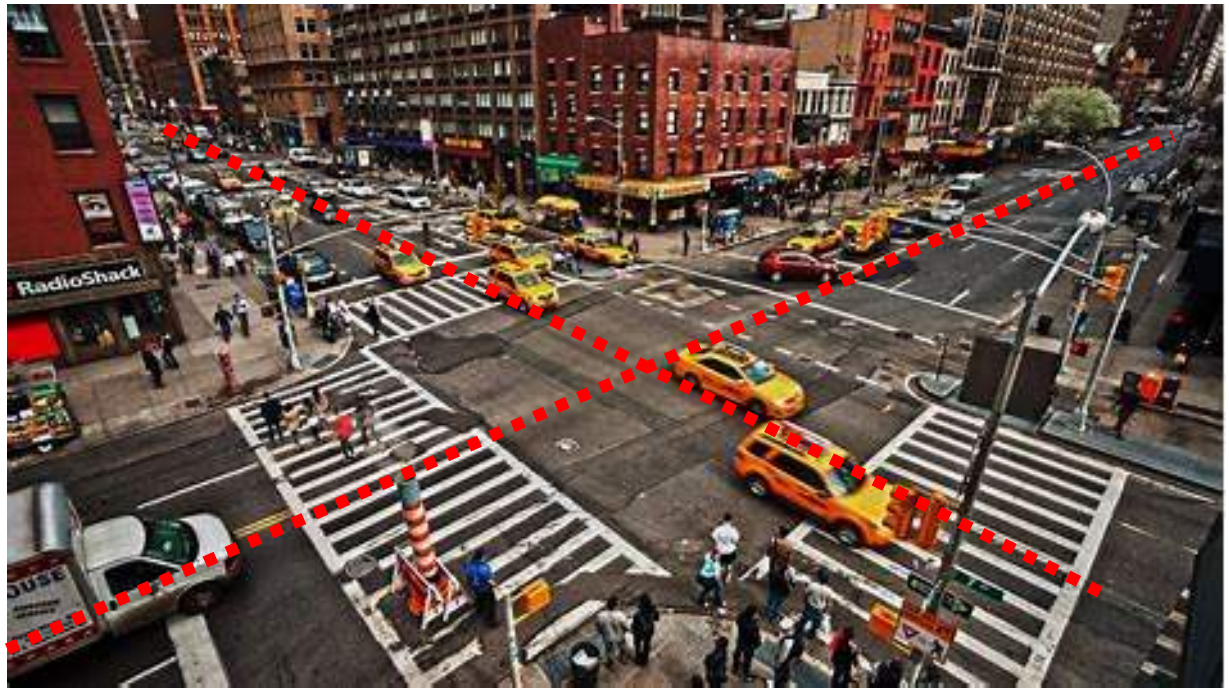


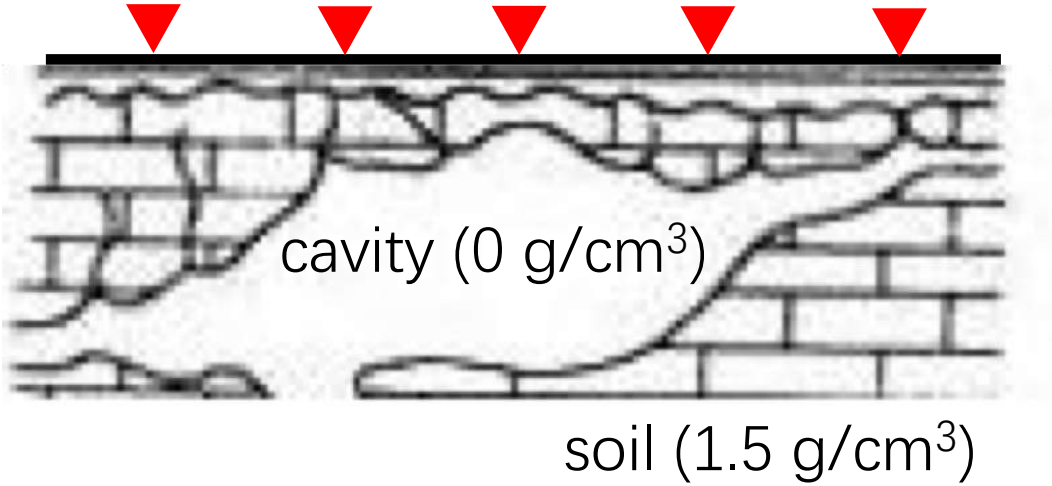
Density contrast:
Smaller gravitational pull above the cavity compared to above regular soil

Surface Subsidence in Urban Area

3. **Survey**: Choose survey and design data acquisition

   Placement of gravity stations: survey lines, spacings, etc.



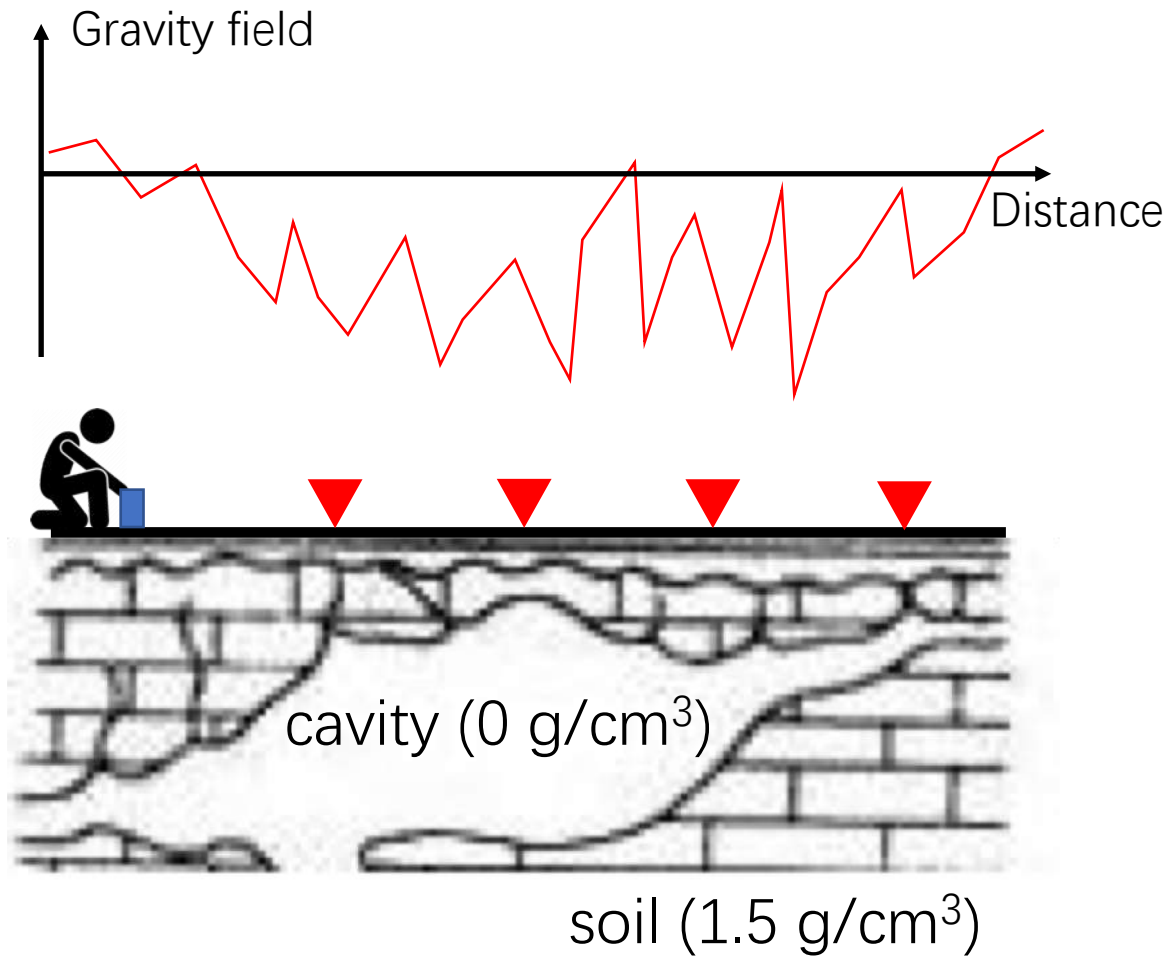


Surface Subsidence in Urban Area

4. **Data**: Go to the field and collect data

   Deploy instrument and obtain data

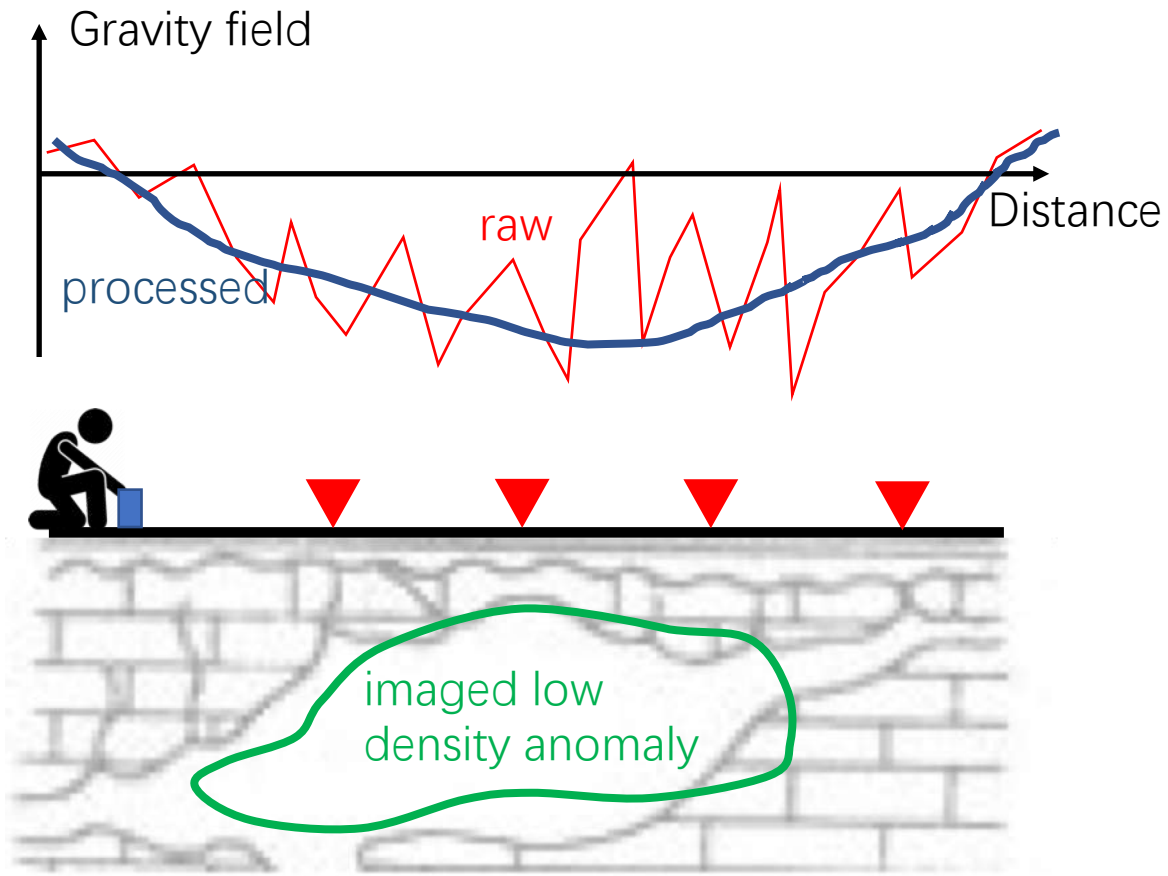
Gravitometer



Surface Subsidence in Urban Area

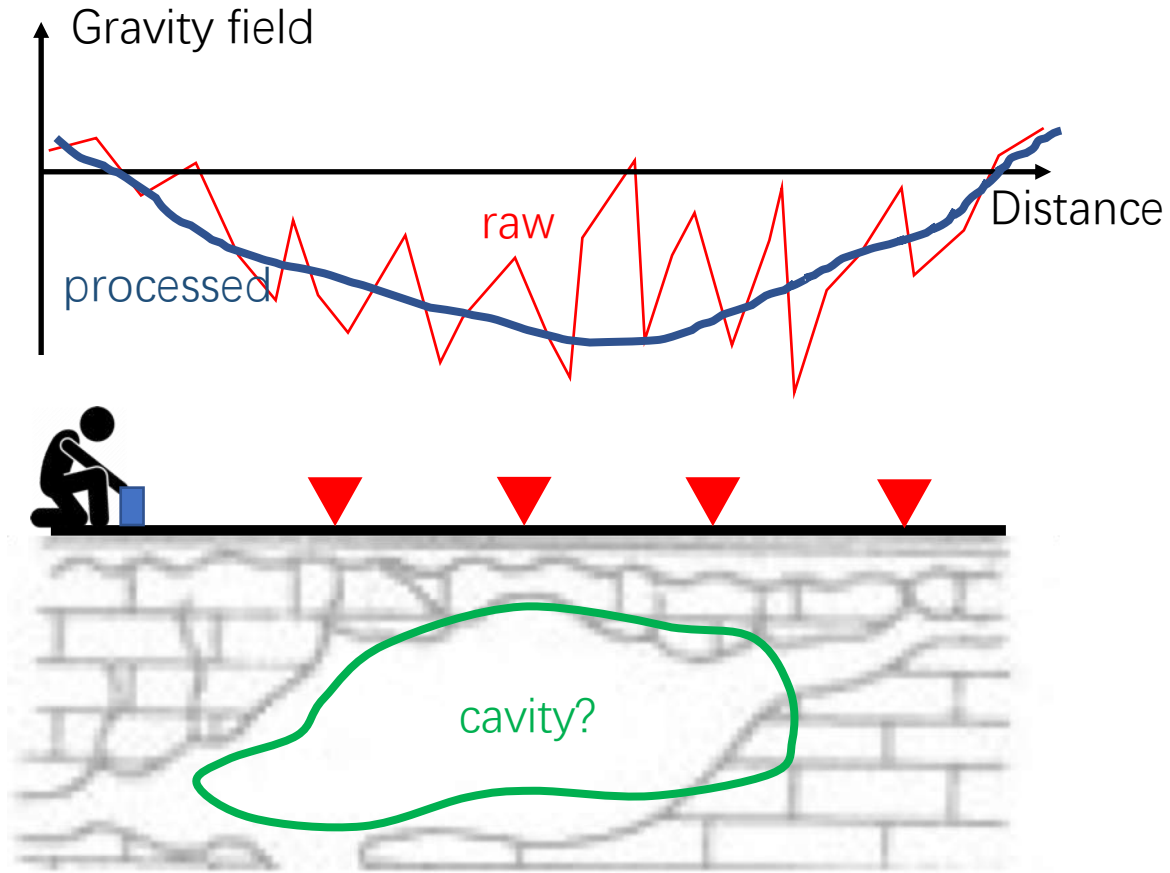
5. **Processing**: Processing of field data

   Example:
   - Filtering and correction to suppress undesired signals
   - Numerical modeling or inversion to reconstruct the subsurface image of density distribution
   - Geological modeling based on geophysical evidences
   - Assess *uncertainties*



Surface Subsidence in Urban Area

6. **Interpretation**: Associate the processed results to the original question



Surface Subsidence in Urban Area

7. **Synthesis**: Has the question been answered? Need to iterate?

The city is really scared because of the big cavity imaged by the gravity method, but they are hesitant about locking down the street.

- Is the imaged result reliable?
- Is the survey large enough to cover the entire affected area?
- Are there any other methods to confirm the size and extent of the cavity?
- If confirmed, where to drill?

Self-Testing Questions

- Name the four major methods in applied geophysics
- Which step in the seven-step procedures concerns electric resistivity?
- True or false: The interpretation is guaranteed to be exact and correct if the data are properly processed.
- Identify an application of applied geophysics that is not mentioned in this lecture
- An introductory video from SEG https://youtu.be/De5Yl4aSbOM

Feedback

- English ok?
- Pace ok?
- Need more explanation of terms?
- Webcasting lectures ok?