Modelling, Uncertainty, and Data for Engineers

MUDE (CEGM1000) Introductory Questionnaire

Use your phone to scan the QR and answer this survey!

OR

Type the URL into your browser:

https://forms.office.com/e/4j3wx6ZdEE

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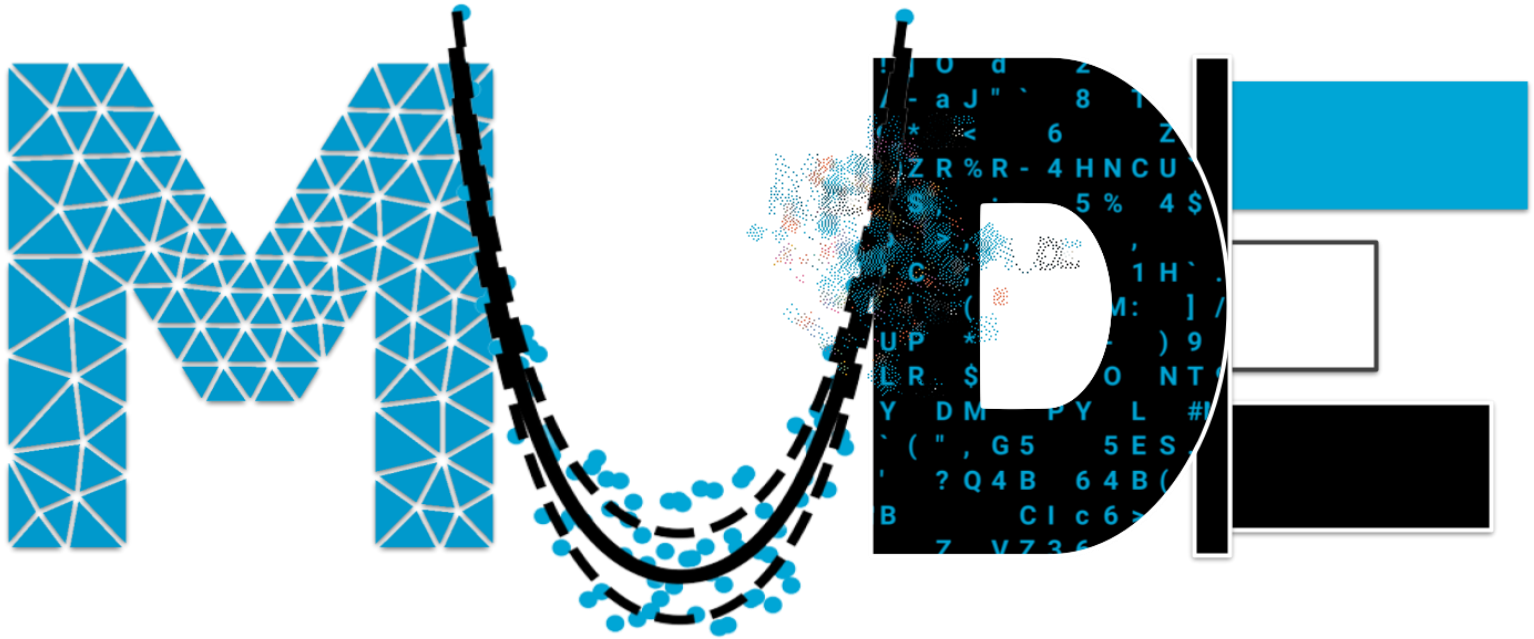
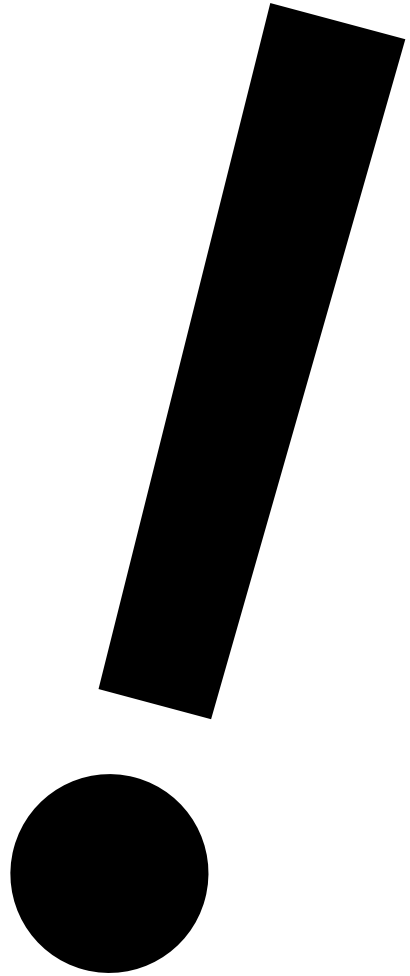
Welcome to...

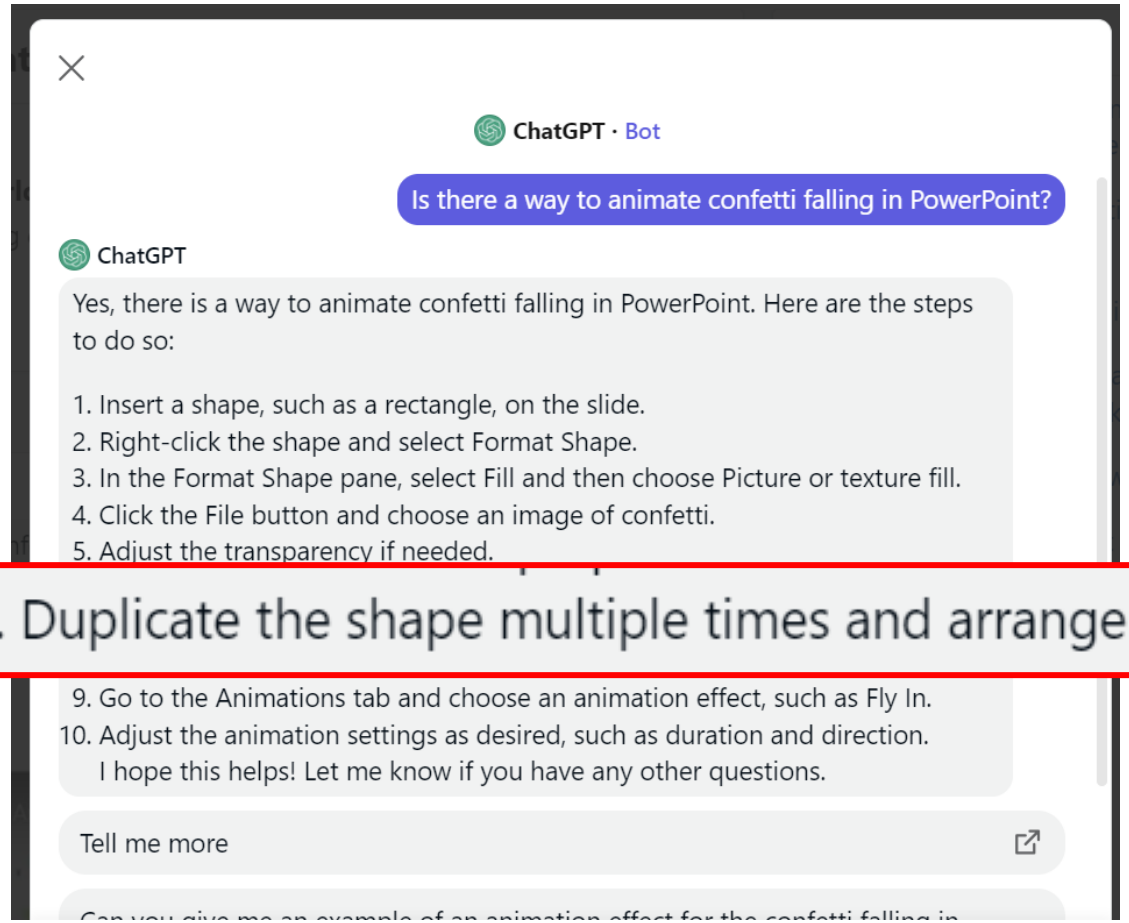


Modelling, Uncertainty, and Data for Engineers



Foreshadowing: using ChatGPT in MUDE?

September, 2023

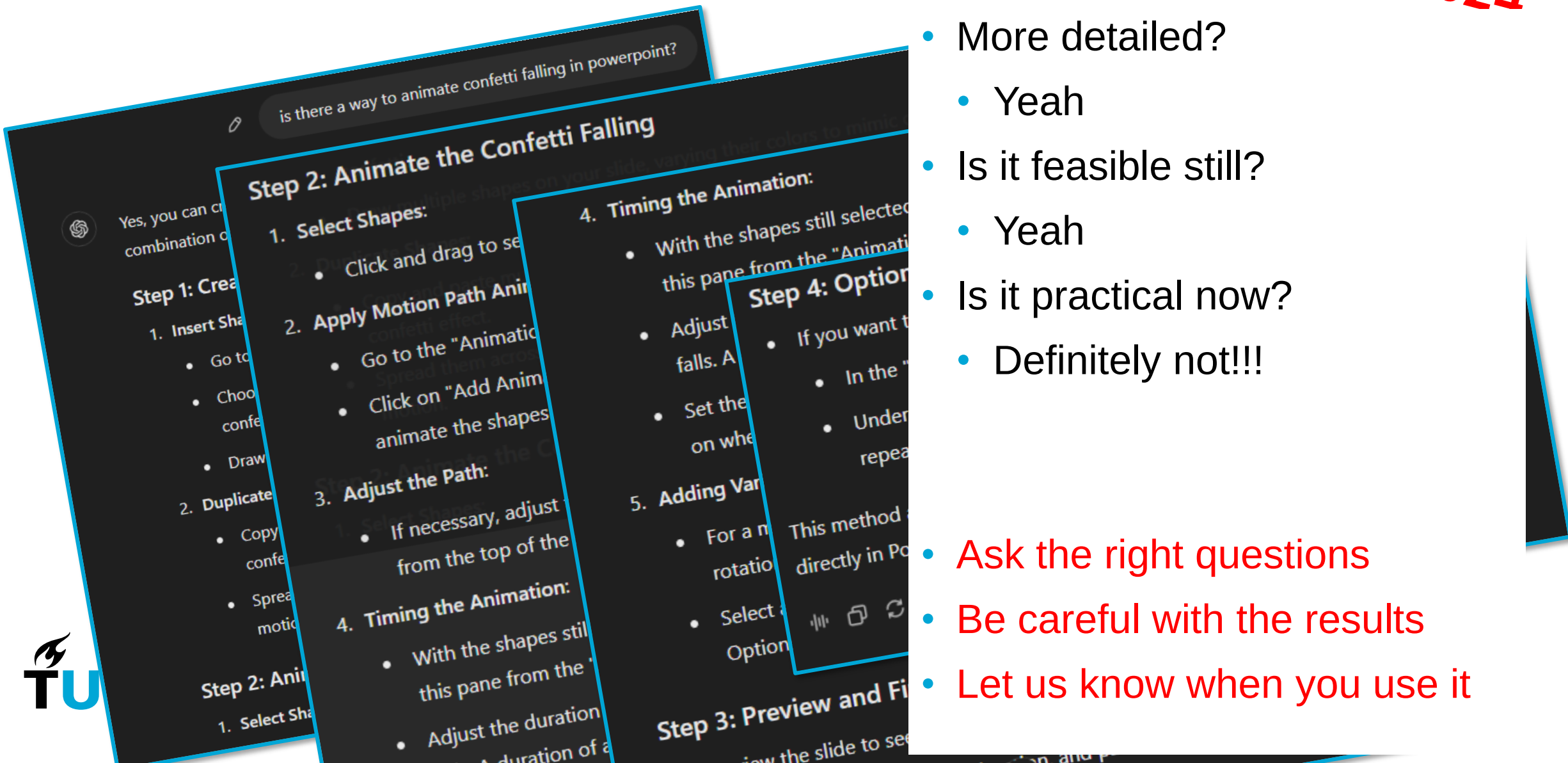


- Is it feasible?
  - Yeah
- Is it practical?
  - No way!
- Can you use ChatGPT?
  - Sure! But...

- Ask the right questions
- Be careful with the results
- Let us know when you use it

Did ChatGPT get better since last year?

September, 2024



- More detailed?
  - Yeah
- Is it feasible still?
  - Yeah
- Is it practical now?
  - Definitely not!!!

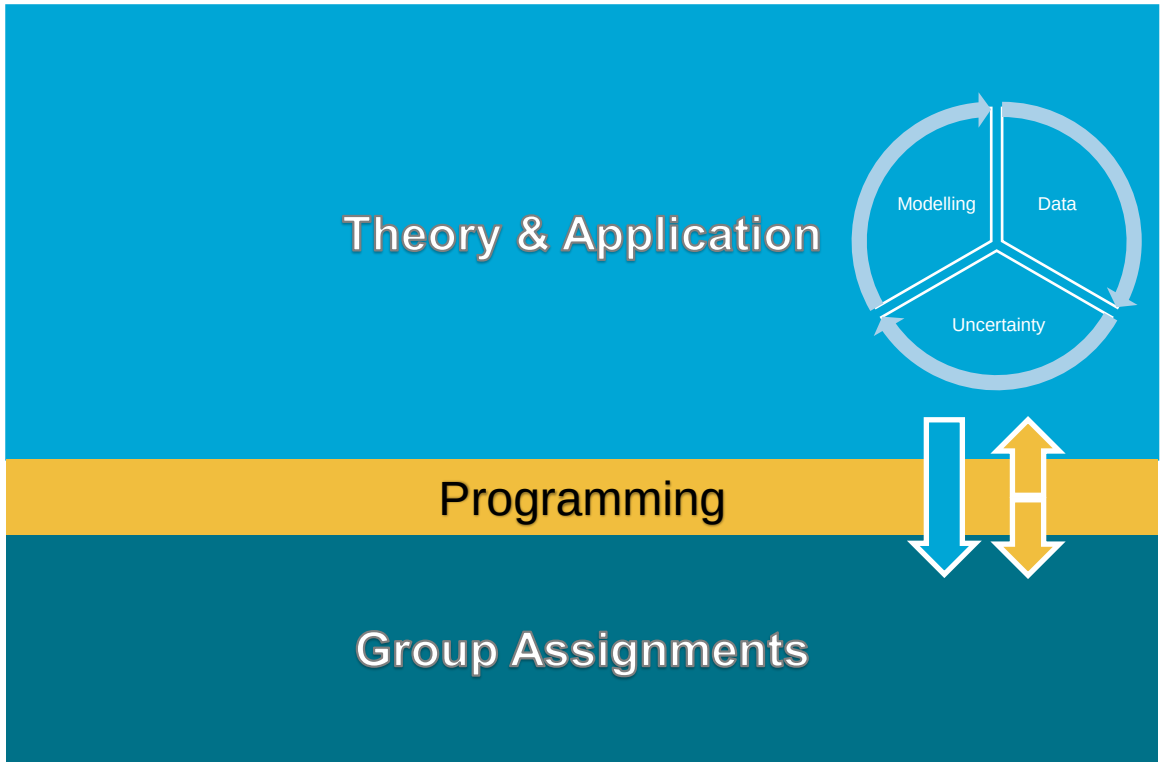
- Ask the right questions
- Be careful with the results
- Let us know when you use it

MUDE: in a nutshell

Theory & Applications (T&A) (~50%)
- Website and online book
- Applications drawn from all programmes

Group Assignments (~30%)
- Apply theory and programming to real problems
- Submit a weekly Report
- Collaborative and multidisciplinary

Programming (~20%)
- Coding and software engineering skills
- Effective documentation and communication
- Weekly Programming Assignments



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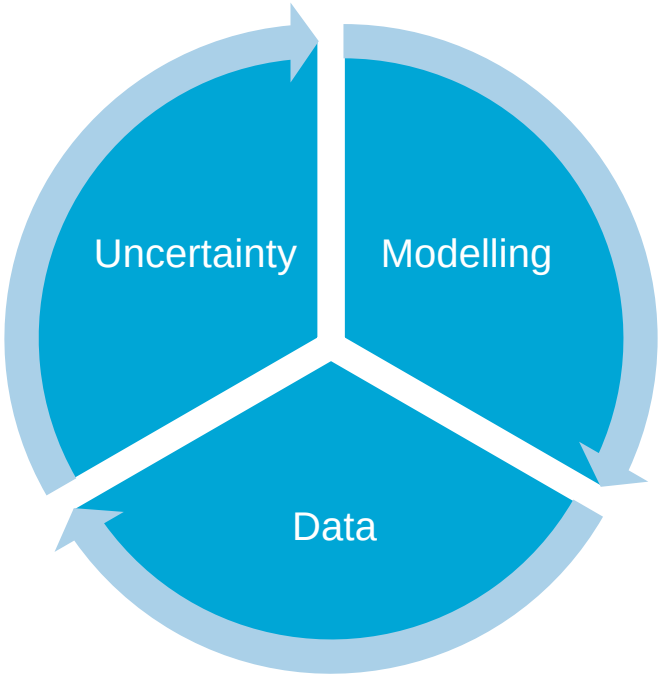
Theory & Application Weekly Content



1.1	Landing zone – Introduction to Modelling
1.2	Data and “U”
1.3	Making a (data) model
1.4	
1.5	Computational Modelling fundamentals
1.6	
1.7	Designing with Probability
1.8	
2.1	Finite Volume Modelling
2.2	Finite Element Modelling
2.3	Signal Processing
2.4	Time-Series Analysis
2.5	Optimization
2.6	Machine Learning
2.7	Extreme Value Analysis
2.8	Risk & Reliability

Who are your MUDE teachers?

- Over 50 people involved!
  - Many familiar faces → you will meet them in class
- Your MUDE Guides
  - The best people to ask about logistics, personal issues, etc
  - At least one of us will ALWAYS be present in every class session

Jialei

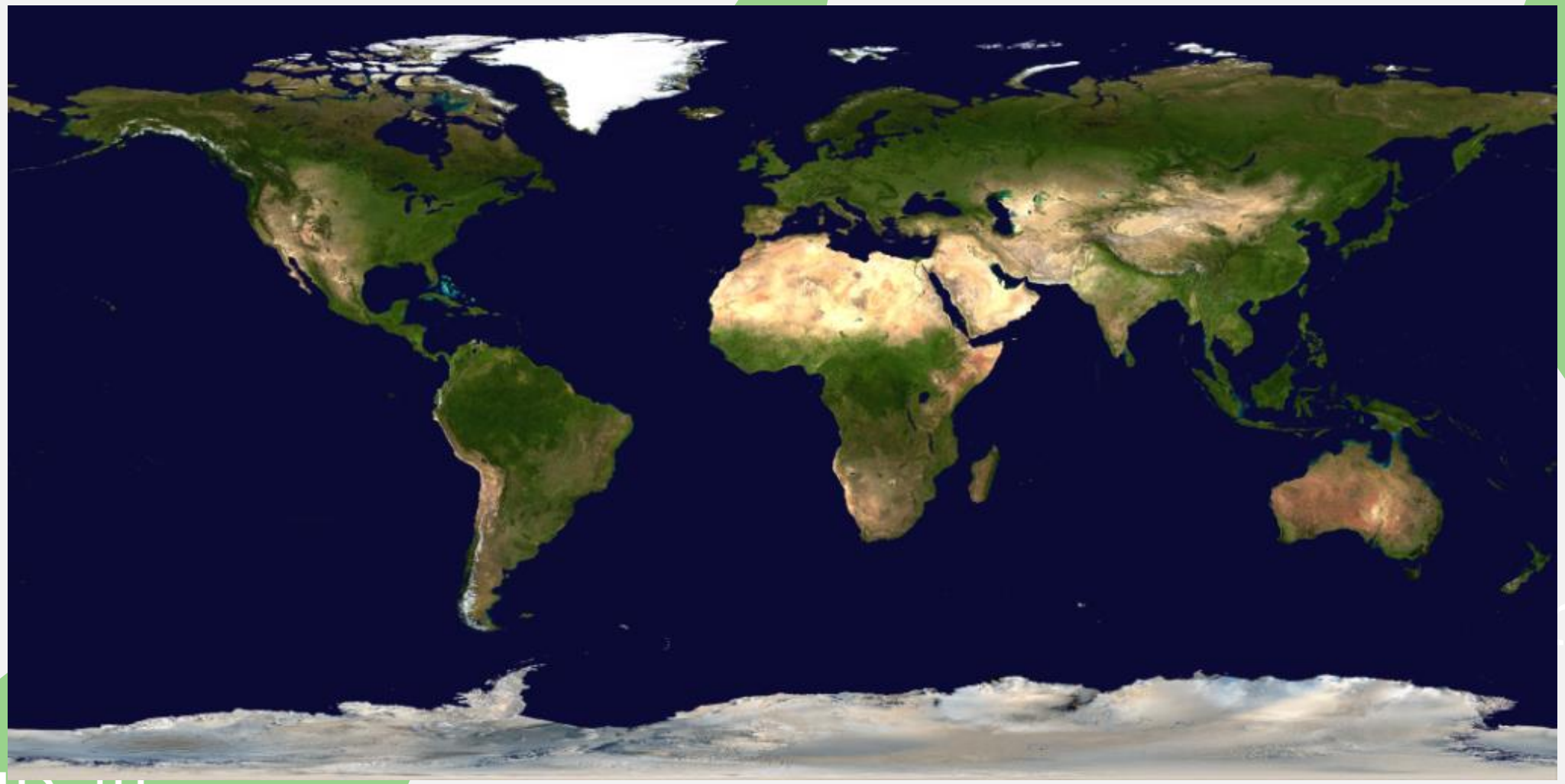
- J-ee-ah (Jug, See, Art)
- Lei (Lay an egg)

Robert

Join at:
vevox.app

ID: **135-108-060**

Question slide



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RESULTS SLIDE

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Question slide

Civil Engineering 0%

Environmental Engineering 0%

Applied Earth Science 0%

What is your masters program?

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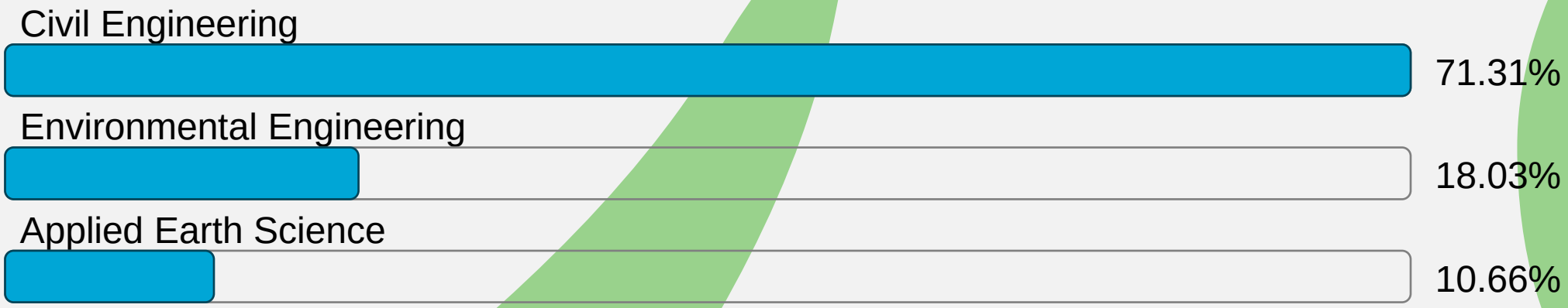

What is your masters program?

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RESULTS SLIDE

Welcome MSc students 2024-2025

Prof.dr.ir. Stefan Aarninkhof
Dean of Faculty of Civil Engineering and Geosciences (CEG)

Sept. 3, 2024

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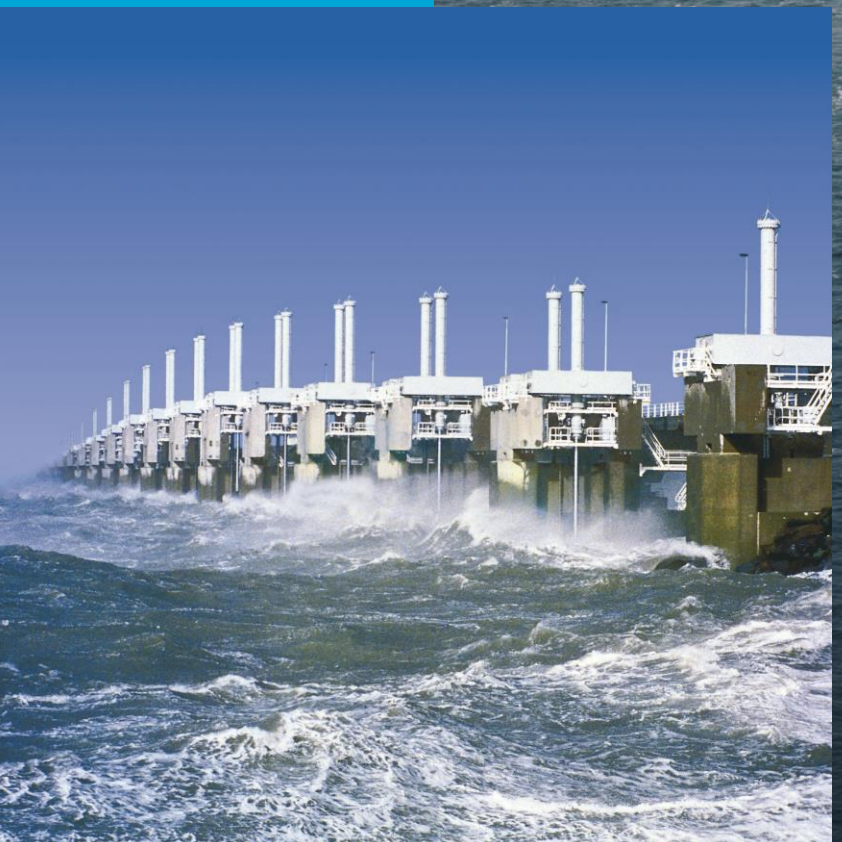
Early inspiration (1985)



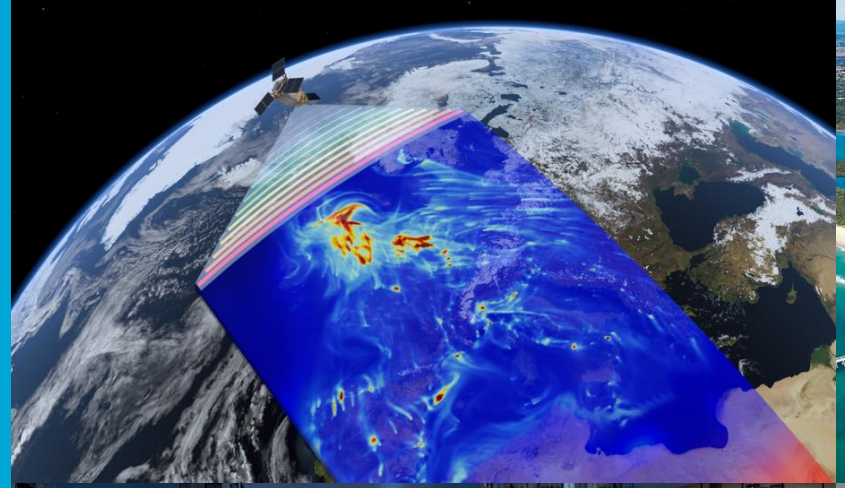
Eastern Scheldt storm surge barrier (NL)

Professional timeline

Year	Affiliation
1990-1996	Civil Engineering, TU Delft
1995	Ecole des Ponts et Chaussées, Paris
1996-2003	PhD @ TU Delft
1996-2006	Delft Hydraulics (nowadays Deltares)
2006-2016	Boskalis
2016-present	Professor of Coastal Engineering, TU Delft
2020-2024	Chair of Hydraulic Engineering Department
2022-2024	Director of EcoShape | Building with Nature
2024-present	Dean, Faculty of Civil Engineering and Geosciences

Drivers for CEG

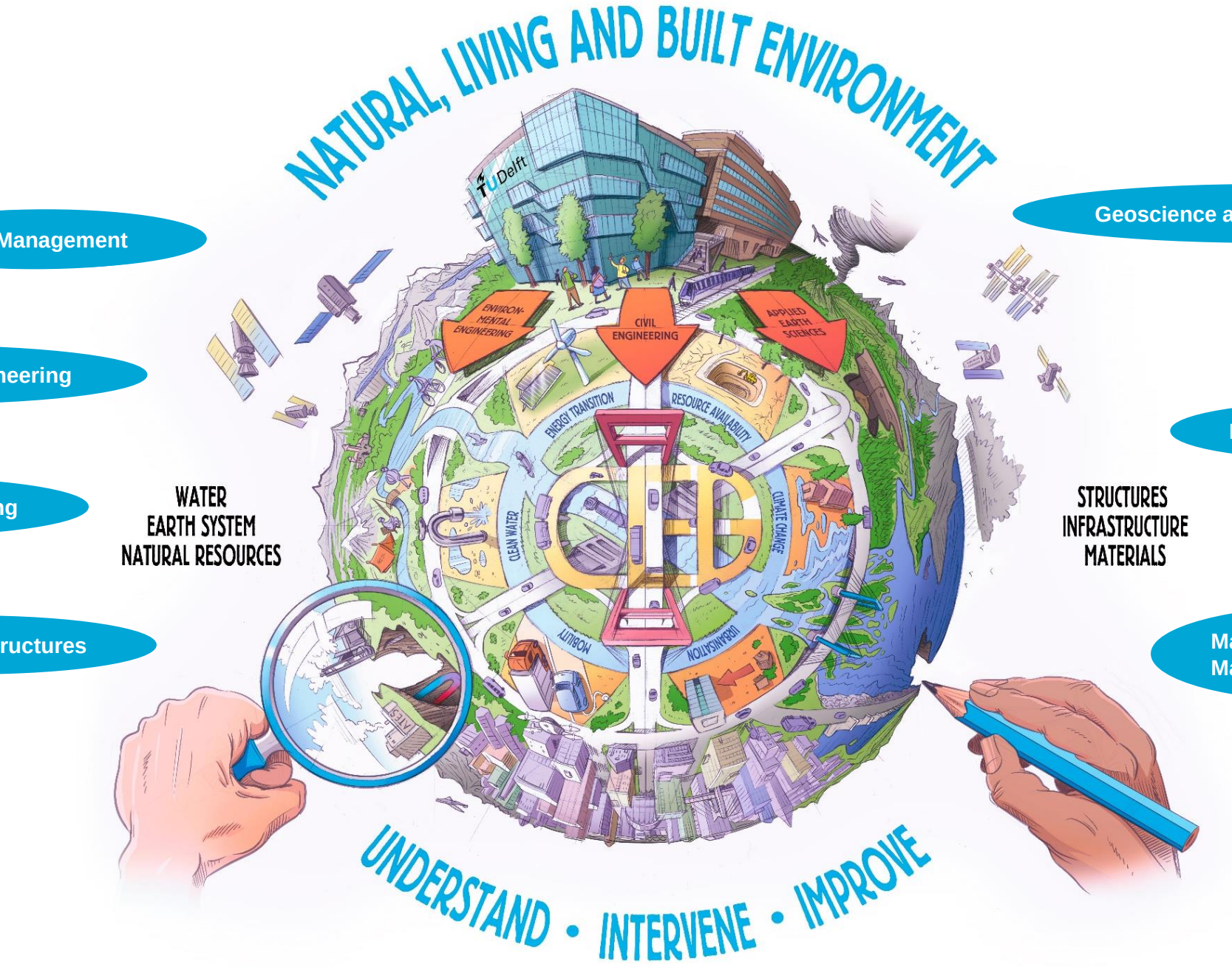
- Climate change
- Energy Transition
- Urbanisation & Mobility
- Clean water
- Resource availability
- Biodiversity
- Infrastructure replacement & restoration







Our scope



Water Management

Geoscience and Engineering

Transport and Planning

Engineering Structures

Geoscience and Remote Sensing

Hydraulic Engineering

Materials, Mechanics, Management & Design

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Importance of fundamental knowledge

Complex, density-driven currents cause difficulties with placement Maasdeltatunnel (Rotterdam)

GEBROKEN KABEL

Herstel mislukte afzinkoperatie Maasdeltatunnel 'gaat maanden duren'

Gepubliceerd op 13-06-2023 om 17:05

De voorbereiding van het afzinken van het eerste tunneldeel in maart. © ANP / Hollandse Hoogte / MediaTV

Het beschadigde deel van de Maasdeltatunnel gaat eind juni naar een reparatiedok in de Botlek in Rotterdam. Dat maakt Rijkswaterstaat in een online update bekend. De beheerder verwacht dat het tunneldeel na aankomst "ongeveer drie maanden" op het dok ligt.

Het tunneldeel botste in april tegen een kade tijdens een mislukte afzinkoperatie op het Scheur tussen Rozenburg en Maassluis. Daar moet de tunnel uiteindelijk onder water komen te liggen.

Maasdeltatunnel, Nieuwe Waterweg (2023)

CEG in a changing world

- Focus on UN Sustainable Development Goals (SDGs)
- Increased stakeholder engagement
- New technologies
- Moral dilemma: balancing different interests
- Engineering vs societal reality
- Inherent uncertainties
- Leave room for the unknown

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Importance of MUDE

- Generic basis in modelling, uncertainty and data analysis
  - Relevant for all three programs: CE, AES and EE
  - Specialization at later moment
- Educate for entire career, not for first job

Take home message

- Be prepared to enter a challenging field
  - High-profile projects, major impact to society
  - Strong knowledge basis, work in multi-disciplinary teams
- Benefit from interaction
- Take time to explore what is driving you

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What is MUDE?

- What do current students need?
  - Programming literacy
  - Modelling concepts
  - Data structures and analysis
  - Uncertainty/risk comprehension
- Multidisciplinary group work helps to facilitate this

What is MUDE?

- NOT going to directly address applications from ALL tracks ALL of the time
- NOT crash course in Python
- NOT going to make you a "pro" coder

What is MUDE?

- A fundamentals course (methods, data analysis, etc)
- Applications lean towards on universal topics
- Interdisciplinary
- Communicating with a common language and interests from different backgrounds

	Monday	Tuesday	Wednesday	Thursday	Friday
8:45	Lecture				In-Class Group Assignments *multiple rooms* *attendance required*
10:30					
10:45	Collaboration Space *no teachers present*		In-Class Workshops *multiple rooms*		
12:30					

Programming Assignment: any time during the week, but... **Finish before Friday!**

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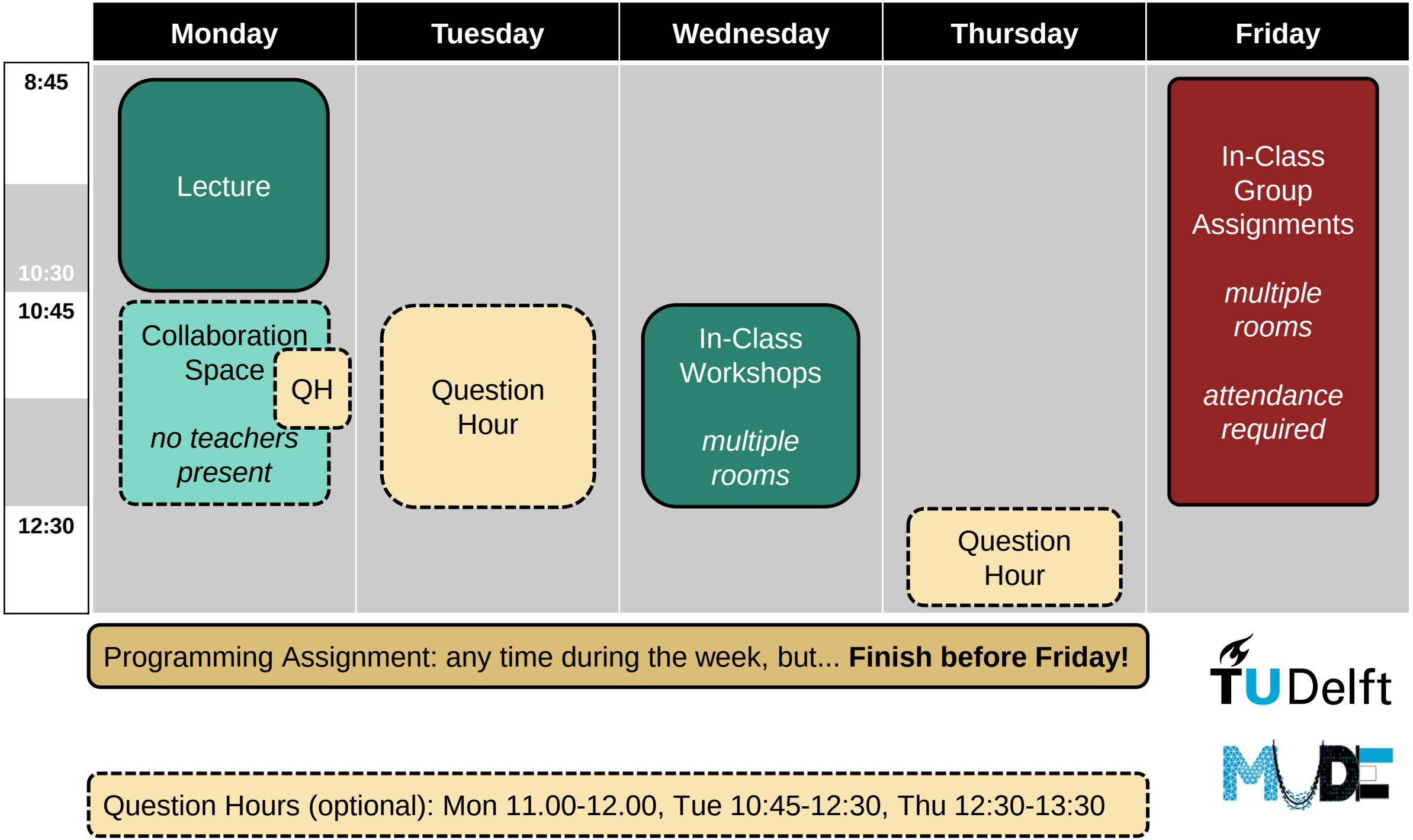
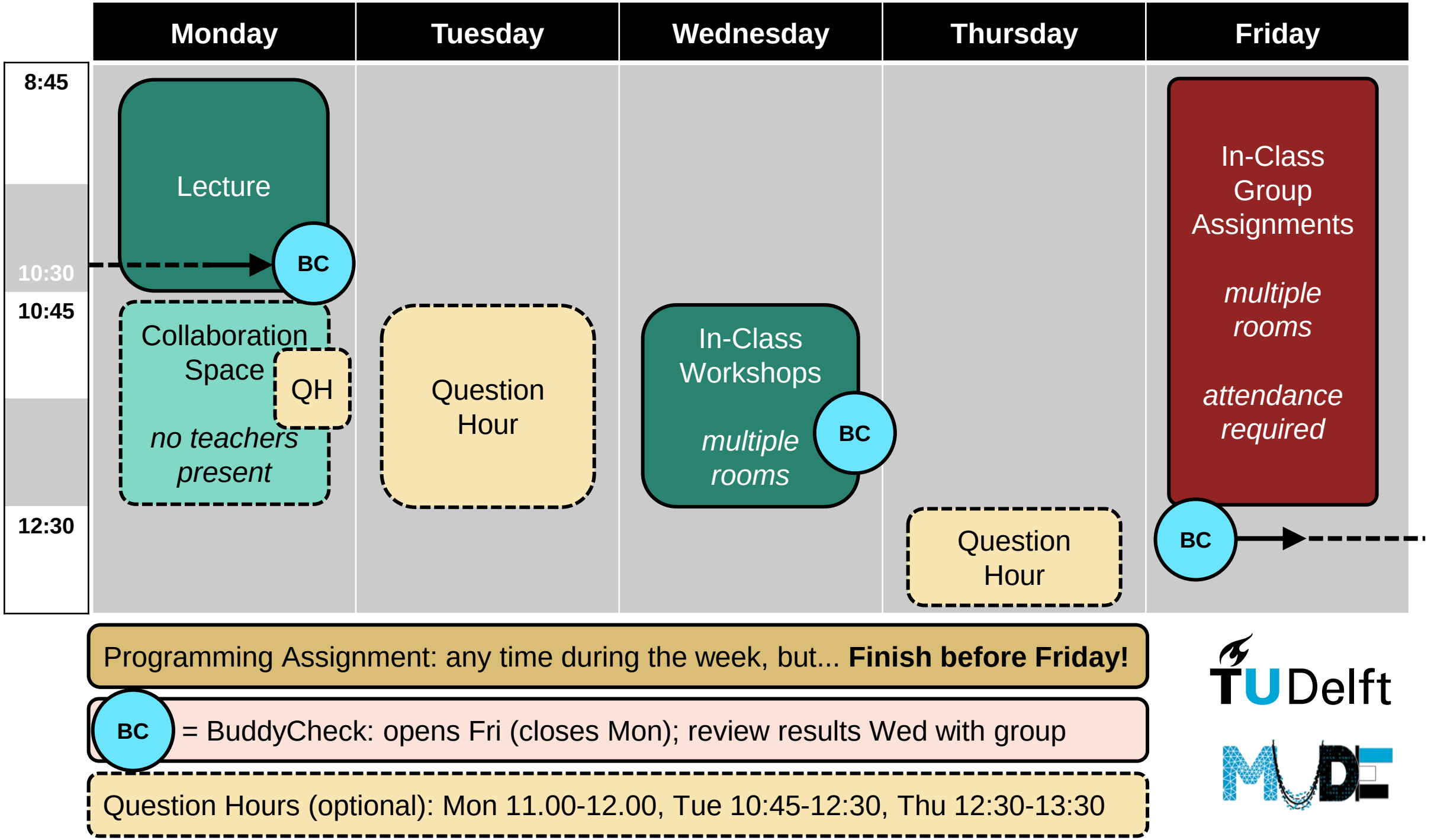

Monday
Tuesday
Wednesday
Thursday
Friday
8:45
10:30
10:45
12:30
Lecture
Collaboration Space
QH
no teachers present
Question Hour
In-Class Workshops
multiple rooms
Question Hour
In-Class Group Assignments
multiple rooms
attendance required
Programming Assignment: any time during the week, but... Finish before Friday!
Question Hours (optional): Mon 11.00-12.00, Tue 10:45-12:30, Thu 12:30-13:30


Monday
Tuesday
Wednesday
Thursday
Friday
8:45
10:30
10:45
12:30
Lecture
BC
Collaboration Space
QH
no teachers present
Question Hour
In-Class Workshops
multiple rooms
BC
Question Hour
In-Class Group Assignments
multiple rooms
attendance required
BC
Programming Assignment: any time during the week, but... Finish before Friday!
BC = BuddyCheck: opens Fri (closes Mon); review results Wed with group
Question Hours (optional): Mon 11.00-12.00, Tue 10:45-12:30, Thu 12:30-13:30
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MUDE

Practicalities: Personal Computer

- You should have one! (Mac, Windows, Linux are all OK)
- Bring it with you
- Keep it closed during Monday lectures
- Wednesday workshops may include Jupyter exercises
- Friday will definitely require computer

- Is this an issue? Contact MUDE-CEG@tudelft.nl immediately.

- This week: install Miniconda and VS Code; be able to run a Jupyter Notebook

Programming Learning Line

- Provides essential programming skills, based in Python
- Content based on inputs from industry (e.g., Deltares, HKV, RHDHV, RWS, …)

Some examples of what you will learn:

- Coding standards and good practices
- Effective documentation, communication, visualization
- Debugging, Version control
- Objected Oriented programming

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ID: **135-108-060**

Question slide

No experience 0%

Beginner 0%

Functional 0%

Expert! 0%

What is your experience with using Python programming language?

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Showing

What is your experience with using Python programming language?

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Question slide

Yes 0%

No 0%

Have you ever used a Jupyter Notebook?

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ID: **135-108-060**

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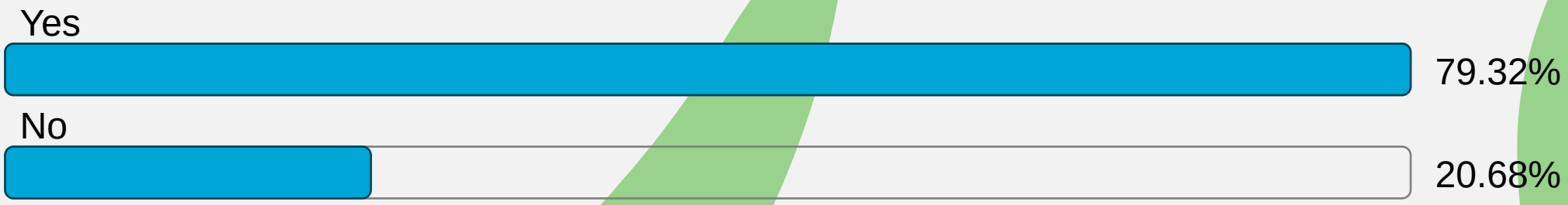

ever used a Jupyter Notebook?

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RESULTS SLIDE

Programming Learning Line

- Your peers and supervisors will have diverse backgrounds, experiences and expertise
- In MUDE we will guide you in how to communicate and relay your findings in an effective manner
- Beyond MUDE, you will apply these skills in professional situations that require them, and efficiently in a team!

What was the experience of your first employer?

10 min break...

If you haven't already,
use your phone to scan the QR
and answer this survey!

OR

Type the URL into your browser.

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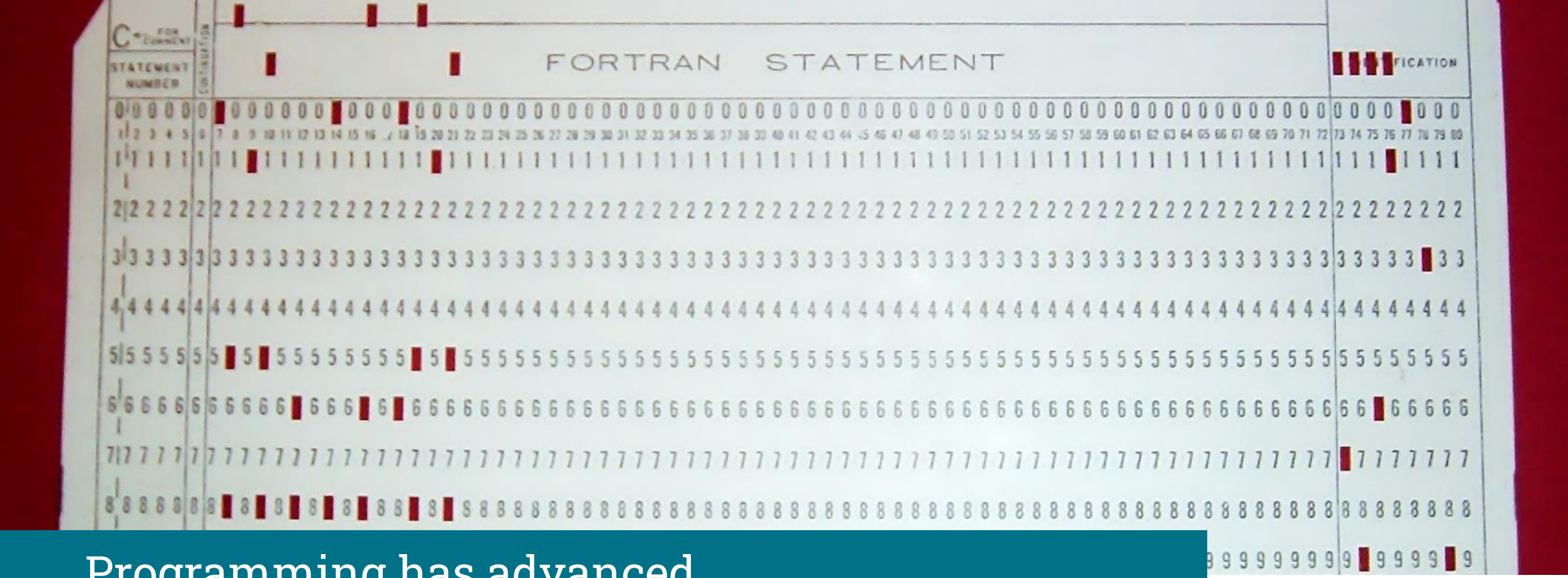
MUDE (CEGM1000) Introductory Questionnaire

https://forms.office.com/e/4j3wx6ZdEE



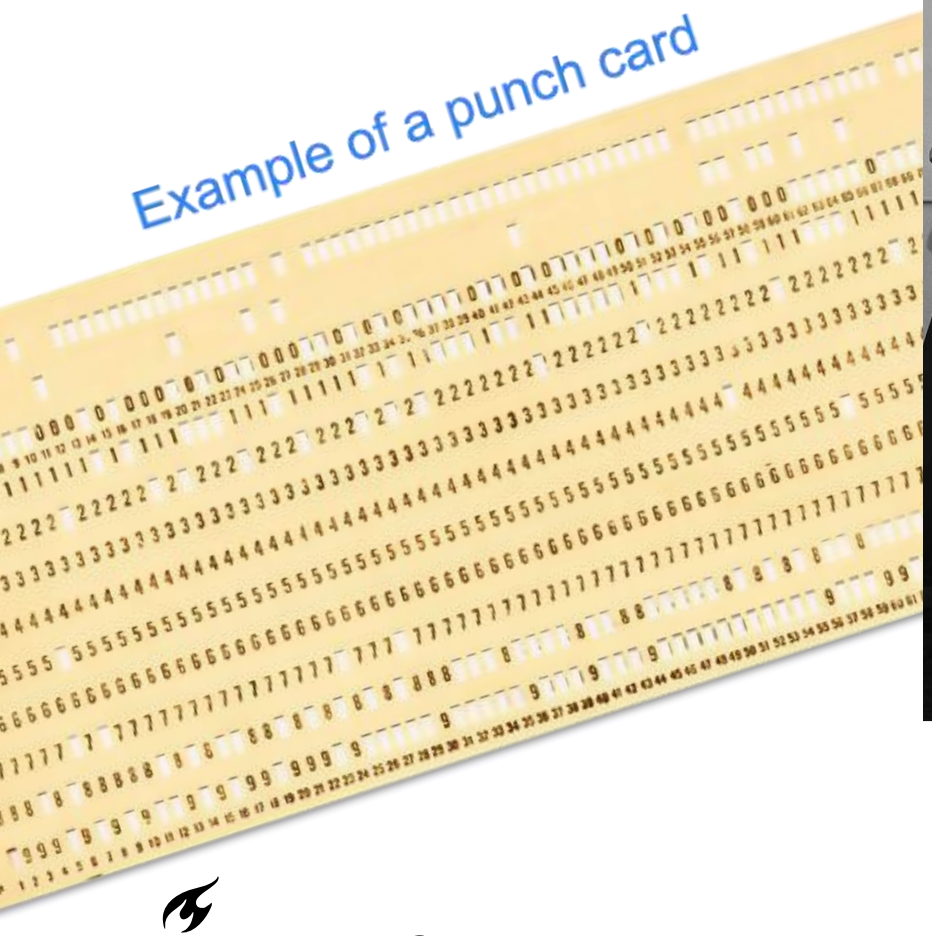
Programming has advanced…

- https://en.wikipedia.org/wiki/Computer_programming_in_the_punched_card_era#/media/File:FortranCardPROJ039.agr.jpg
- Retrieved on 05-09-2023

Programming has advanced...

Retrieved from: https://www.youtube.com/watch?v=kKJxzay85Vk

Programming has advanced…



https://www.computerhope.com/jargon/p/punccard.htm

Practicalities

All material will be available via the website:

mude.citg.tudelft.nl

This website has several components that are important for your learning and interacting with the material. Announcement in the coming days!

Brightspace: Important announcements and updates. Join the MUDE module!

Online textbook: mude.citg.tudelft.nl/book

Answers: answers.citg.tudelft.nl

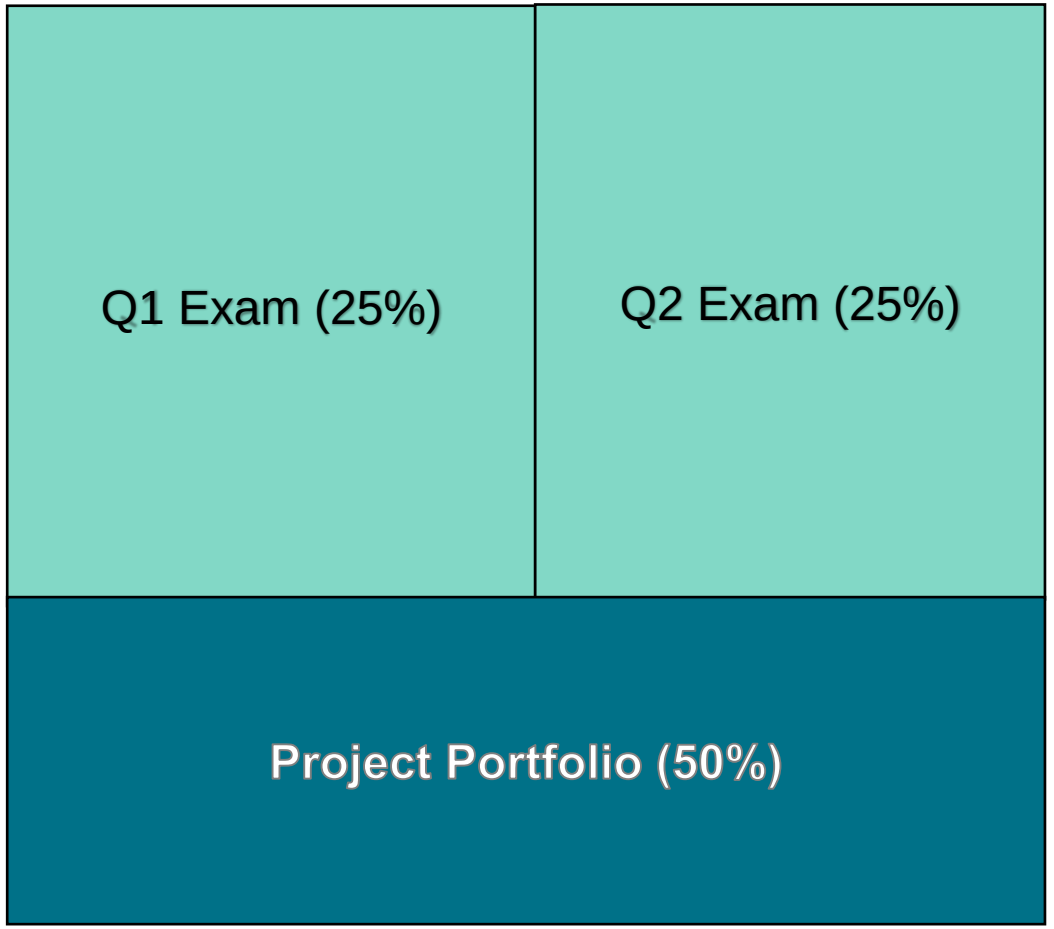
GitLab: You'll see this soon! gitlab.tudelft.nl

MUDE email: MUDE-CEG@tudelft.nl (personal issues only)

Practicalities: Assessment

- 50%: 2 written exams (Q1 + Q2)
- 50%: Project Portfolio
  - 80%: Project Reports (bi-weekly)
  - 20%: Programming Assignments (weekly)
- Deadlines: end of each quarter (see website)

•See MyTimetable for up-to-date exam info



Special Request

- Does anyone want to work in a group in a separate room?

- (Quiet place required)

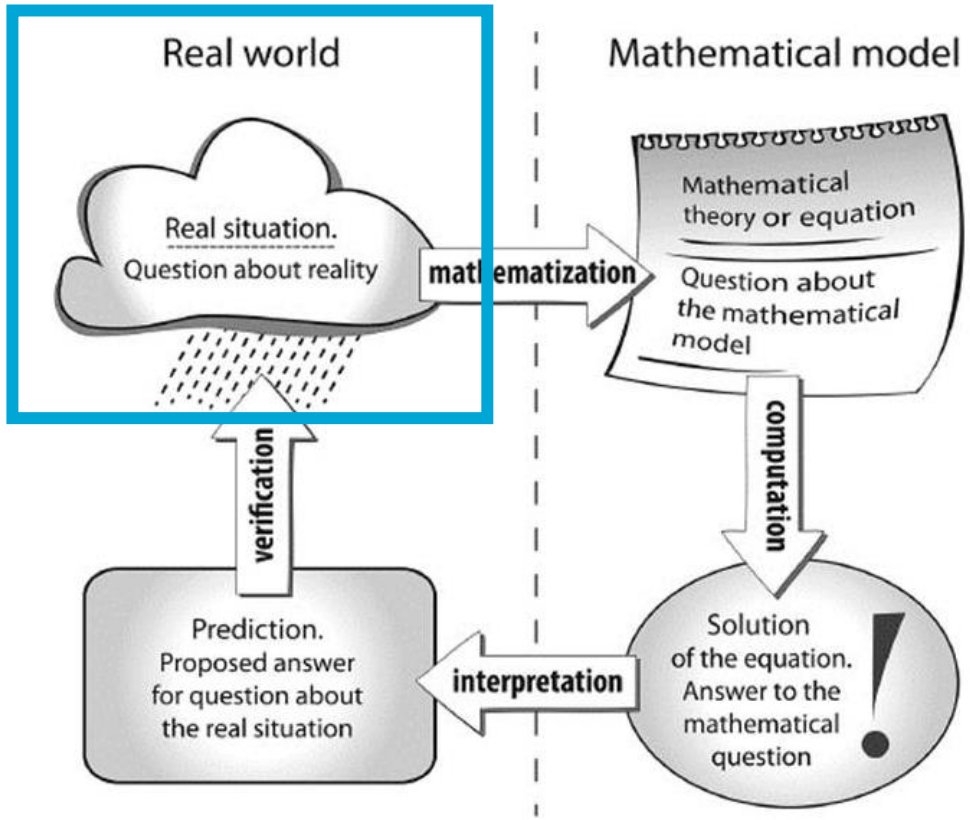
- Email MUDE-CEG@tudelft.nl

Introduction to modelling

- **What's a model?**
- In short: a model is a purpose-built abstraction of physical reality
- **Let's see it in more detail.**

What is a model?

A model is a purpose-built abstraction of physical reality



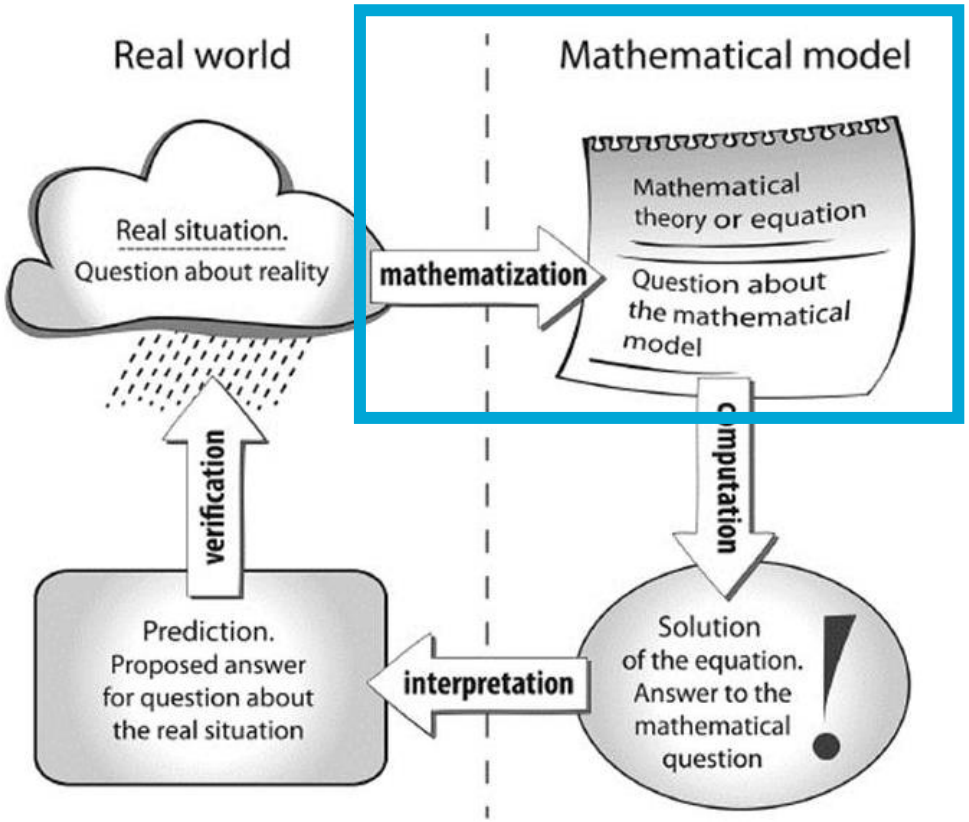
Retrieved from: https://schoolbag.info/mathematics/numbers/103.html

- We interact with complex systems in reality

"Anglo American's Drayton mine - mine water discharge" by lockthegate is licensed under CC BY 2.0.

What is a model?

A model is a purpose-built abstraction of physical reality

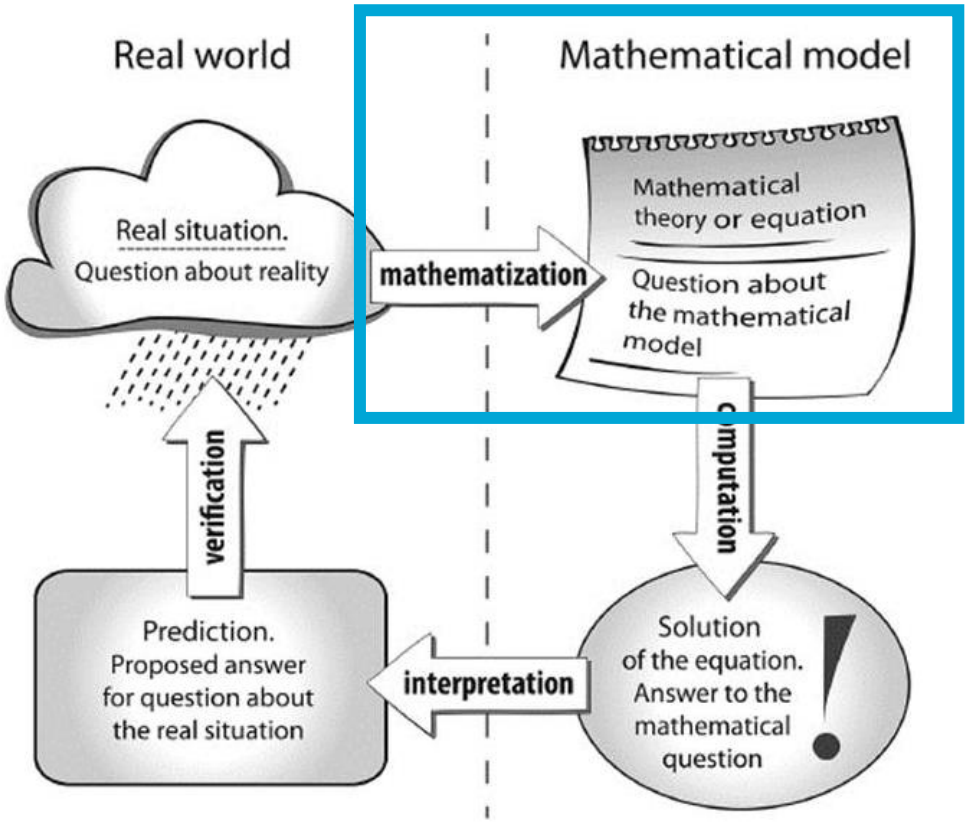


- We interact with complex systems in reality
- We build an abstraction of the system which can **mimic those aspects we are interested in**
- How will the river respond to the discharge?
  - Temperature? → Heat transfer
  - Erosion in the margin? → Hydrodynamics and sediment transport
  - Contaminants? → Water quality

Retrieved from: https://schoolbag.info/mathematics/numbers/103.html

What is a model?

A model is a purpose-built abstraction of physical reality



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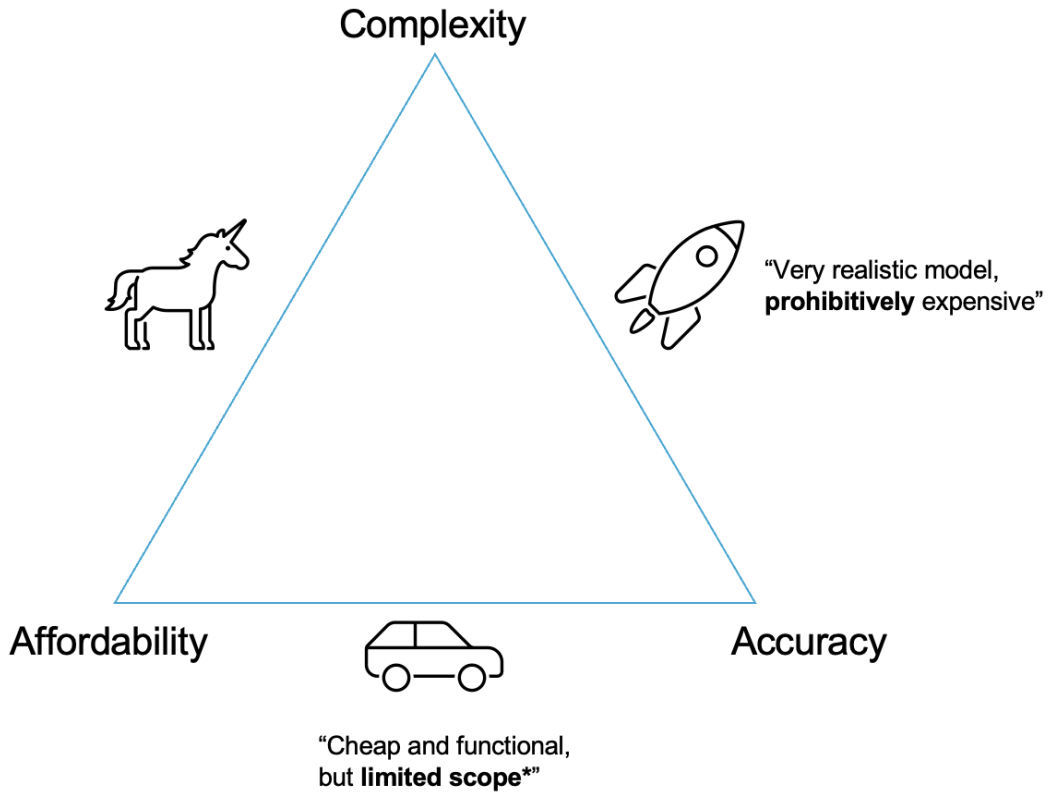
- How detailed/complex do I need it to be?



Acknowledgement: the conceptual diagram is from Marco Rinaldi

Some examples of models… too simple?

- What would a user choose to travel from Delft to Paris?
- My model: the user will choose the shortest time.
- Is it good enough?
- No! People choices are way more complicated!
  - Travel cost
  - Comfort
  - Sustainability

Acknowledgement: the Delft-Paris example is from Marco Rinaldi

Some examples of models… too complex?

- Estimating wave forces on a crown wall

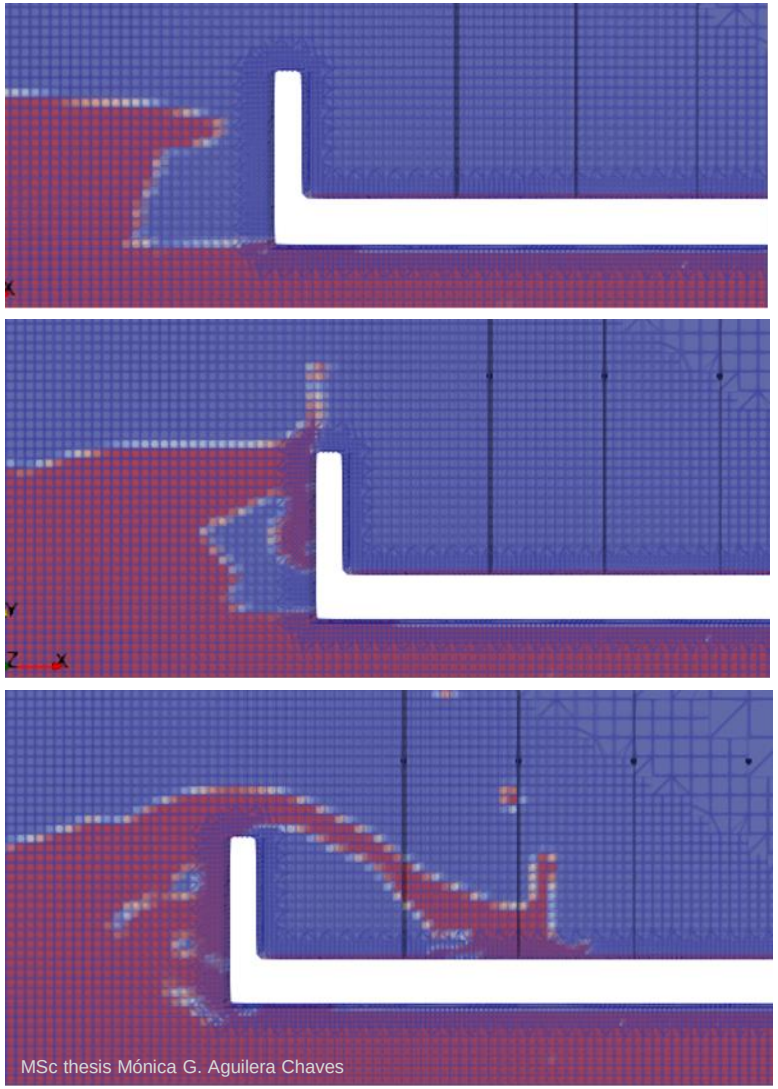
- **Option 1**: complex CFD model
  - Simulations > 1 week in HPC

- **Option 2**: simpler empirical equations

$$\frac{Fh_{0.1\%}}{(0.5\rho g C_h^2)} = \left(-1.29 + 1.80\frac{\gamma_f R_{u0.1\%}}{R_c} + 0.93\frac{(R_c - A_c)}{C_h} + 0.16\sqrt{\frac{L_m}{G_c}}\right)^2$$

$$\frac{PbFh_{0.1\%}}{(0.5\rho g C_h)} = \frac{1}{0.5}\left(-0.86 + 0.75\frac{\gamma_f R_{u0.1\%}}{R_c} + 0.41\frac{(R_c - A_c)}{C_h} + 0.17\sqrt{\frac{L_m}{G_c}} - 0.9\frac{F_c}{C_h}\right)^2$$

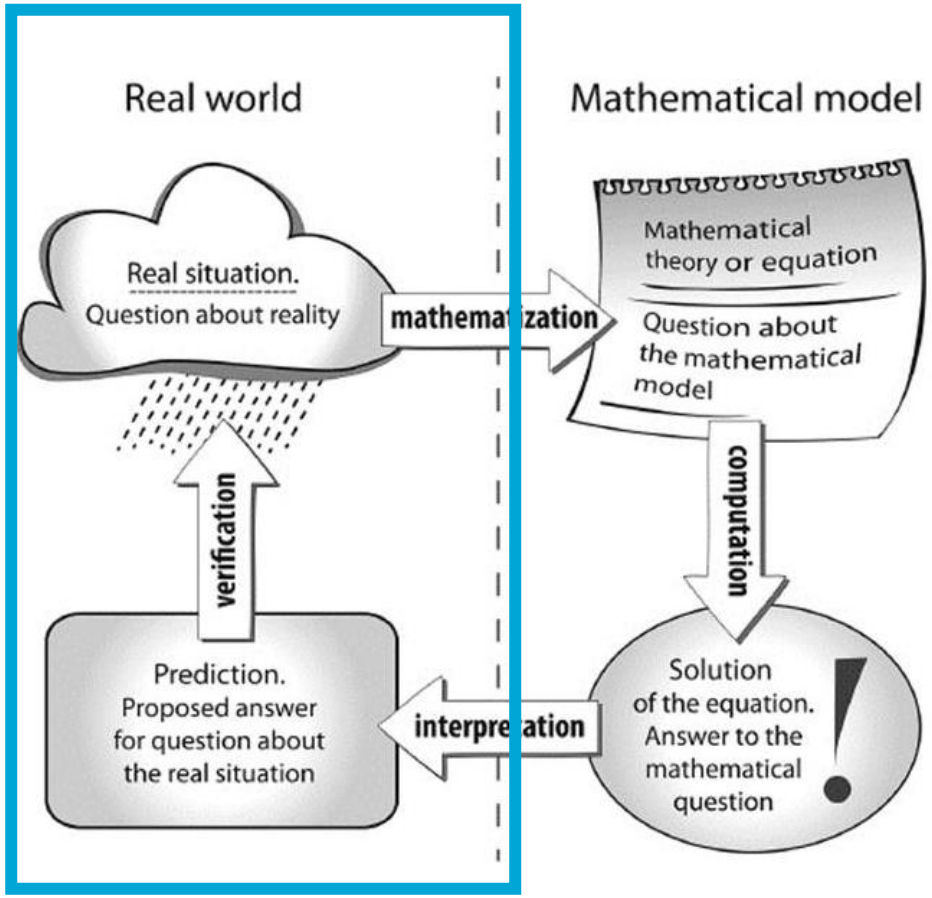
Formulations from Molines (2016)



MSc thesis Mónica G. Aguilera Chaves

What is a model?

A model is a purpose-built abstraction of physical reality



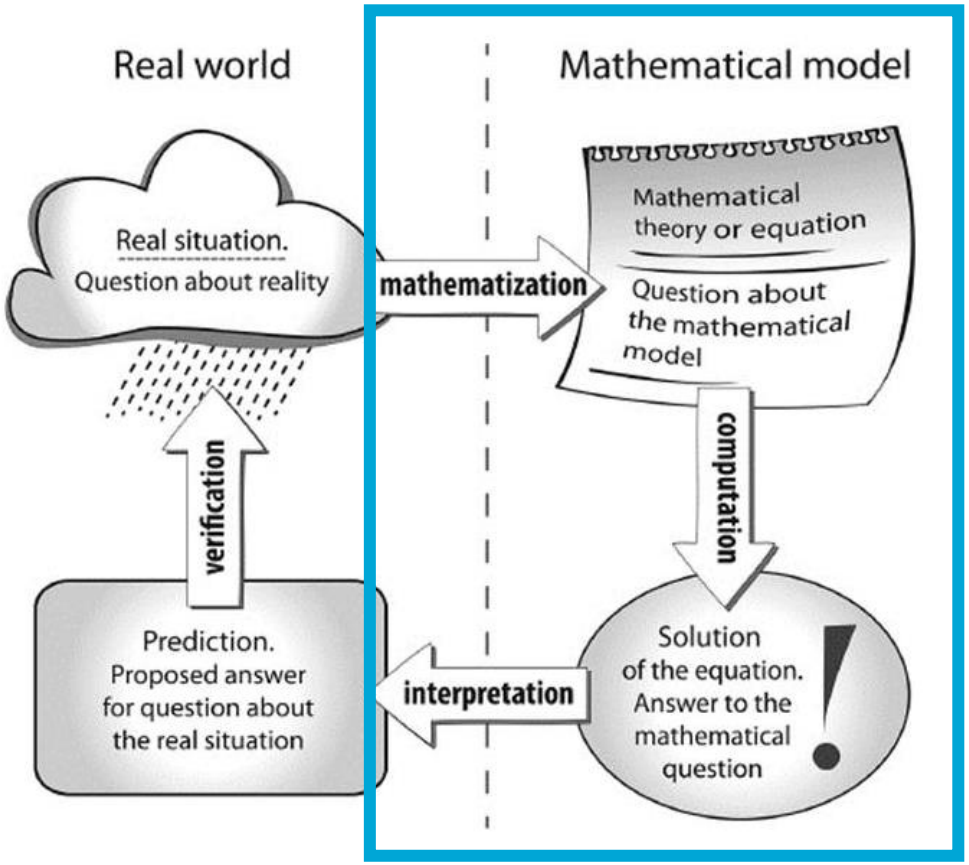
- Once we have the model:
  - Computations: use it!
  - Interpret the results to get the answer to your question

Track-related!!

Retrieved from: https://schoolbag.info/mathematics/numbers/103.html

What is a model?

A model is a purpose-built abstraction of physical reality



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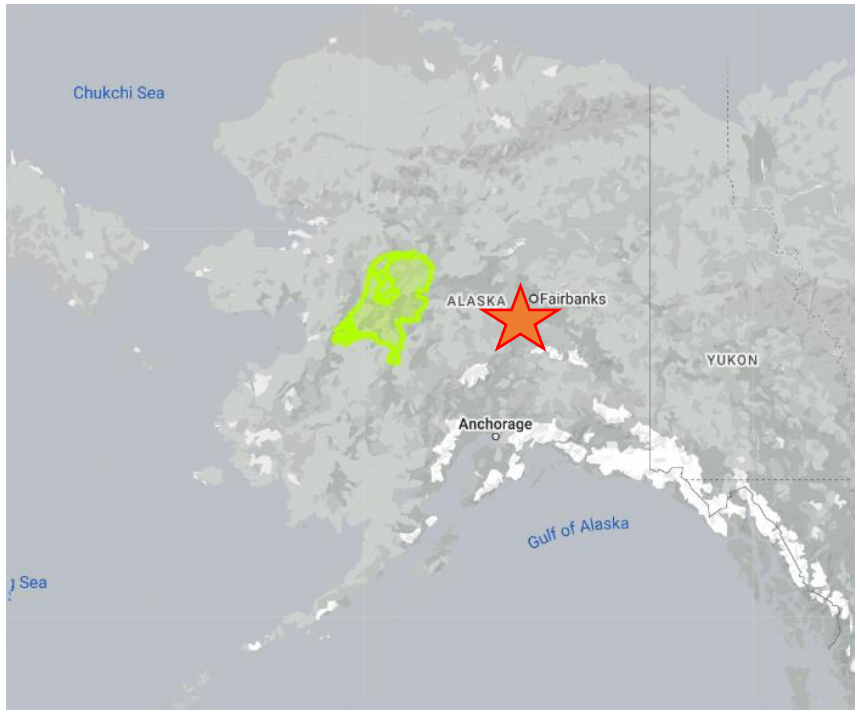
Modelling, Uncertainty, and Data for Engineers

Common interest?

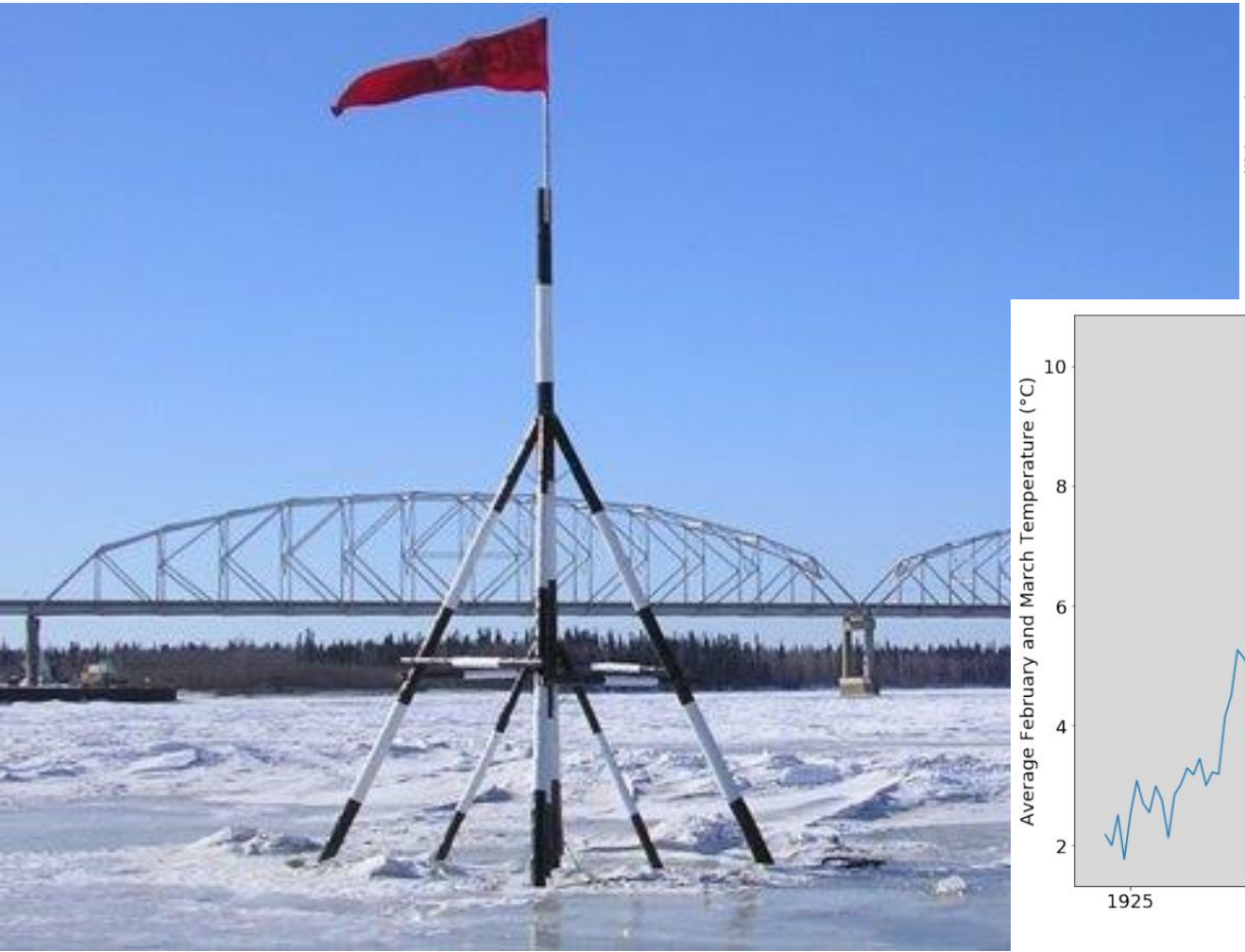
Nenana Alaska Ice Classic

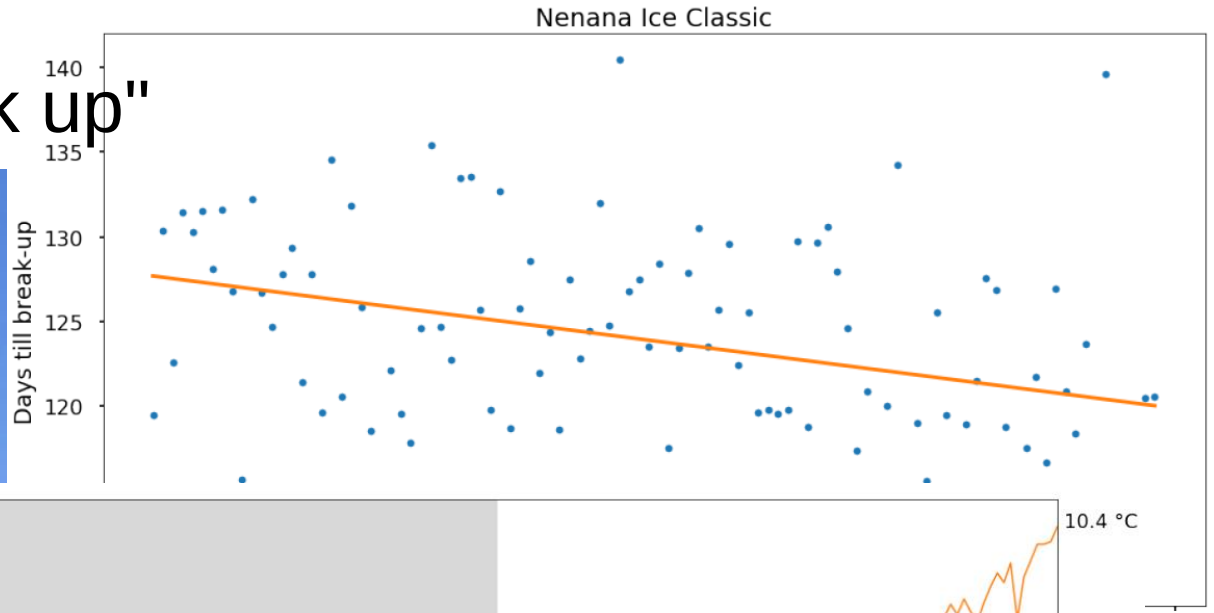


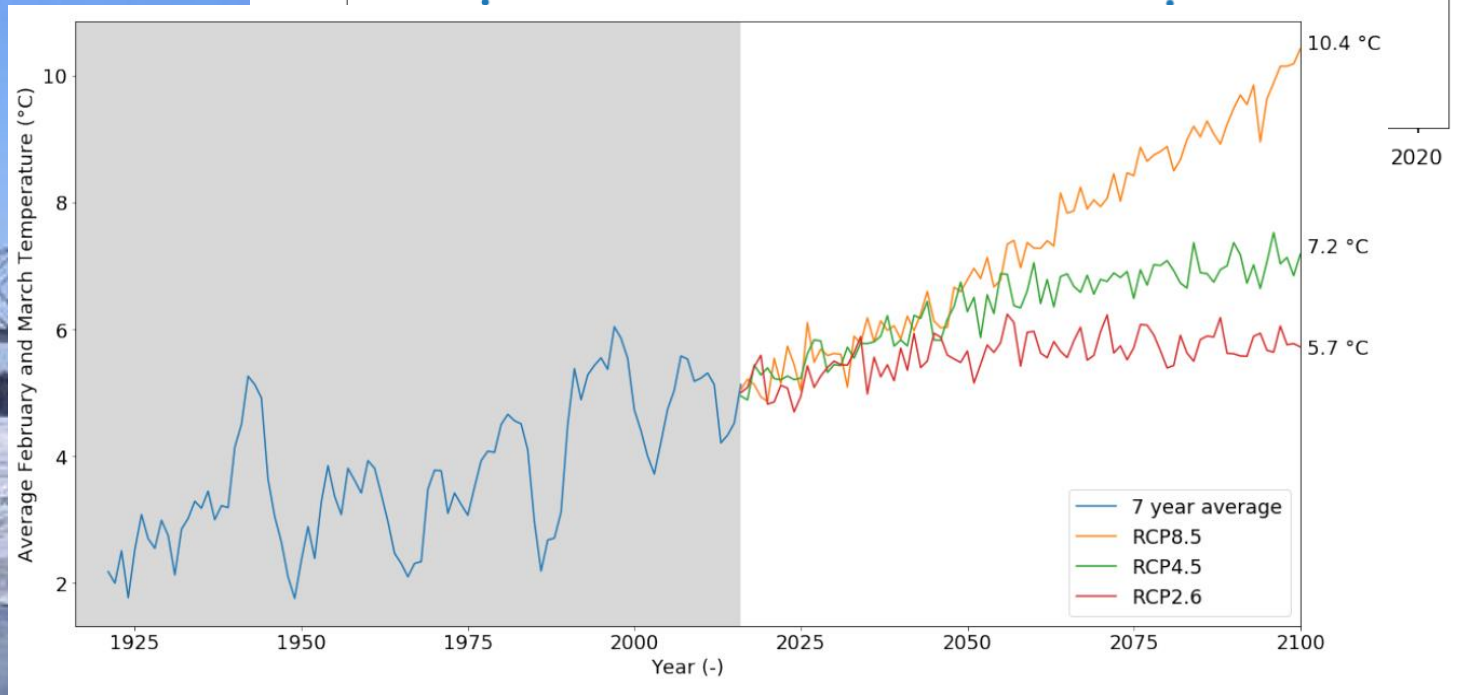
Last year's winnings: $210,155

What does the Nenana Ice Classic have to do with MUDE?

- Predict the day and time of "break up"







What does the Nenana Ice Classic have to do with MUDE?

- Analyze the data (time series, signal processing)
- Formulate physics-based and data-driven models to predict break-up date and time
- Maximize probability of success
- Optimize the betting strategy

These are all MUDE topics!

What now?

- Fill out the Questionnaire
- Visit the MUDE Website and read it
- Read the Book!
- Install Miniconda and VS Code
- Run the Jupyter Notebook on the Python Warmup page (in the book)

- See you in class tomorrow at 10:45!

  → Keep an eye on Brightspace

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https://forms.office.com/e/4j3wx6ZdEE