Climate Change - The Science Behind the Crisis

Course Syllabus: Parts, Units & Chapters

Part 1

Unit 1: Global Warming

Introduction:
We will start the course with an overview of the topic of global warming and climate change. A brief introduction to the story behind the climate crisis and the implications for the future. Following this introduction, we will expand on specific topics every week and dive deeper into the science behind climate change, both natural and man-made.

Chapters:
1.1 What we know?
1.2 The Greenhouse effect and greenhouse gases
1.3 Is what we see unusual?
1.4 So why are GHGs so high?
1.5 What's the forecast for 2050?
1.6 Can we solve the crisis?

Unit 2: Paleoclimate: What can we learn from the past climate changes on Earth

Introduction:
Before we look at the present and future climate scenarios, we need to look back in time to our past climates on Earth. What can we learn from the past about the future? How do we know what the climate was like hundreds of thousands of years ago? How do we explain the ice ages that were not influenced by our activities on this planet.

Chapters:
2.1 Methods for studying past climates
2.2 Ice core data
2.3 Earth's orbit around the sun
2.4 Ice ages explained

Unit 3: How does our Sun influence our climate

Introduction:
The story of our climate starts with our Sun. The Sun determines the Earth's climate, the weather and is also our main source of energy to heat our oceans and atmosphere. However, our Sun has its own variability on many time scales that can impact the Earth's climate. How important is the Sun's variability on the Earth's climate today?

Chapters:
3.1 The history of our Sun

3.2 Solar structure and space weather
3.3 Solar sunspot cycle
3.4 Solar cycle and climate variability
3.5 Cosmic rays and clouds

Unit 4: Energy Balance and the Earth's Temperature

Introduction:
Everybody talks about the rise in the Earth's temperature due to global warming. But how do we know the Earth's temperature? Theoretically we can calculate the Earth's temperature by understanding the energy balance of our planet. Today our planet is in an energy imbalance, and hence the temperatures keep rising.

Chapters:
4.1 Electromagnetic energy
4.2 The Planck function (Stefan Boltzmann and Wien's Law)
4.3 How do we calculate Earth's temperature
4.4 Global energy balance
4.5 Latitudinal energy balance

Unit 5: The Water Cycle

Introduction:
More important that temperatures for life on our planet, is water. And drinking water is related to the formation of clouds and rainfall that impact the Hydrological Cycle, between evaporation from the surface and precipitation to the surface. How will climate change impact this balance in the water cycle?

Chapters:
5.1 The division of water on Earth
5.2 Atmospheric water
5.3 Relative humidity
5.4 How do clouds form
5.5 How do we produce rain
5.6 How will climate change impact the Water Cycle

Unit 6: Clouds and their role in the climate

Introduction:
The temperature of the Earth is strongly dependent on how many clouds we have in the atmosphere. Clouds have a cooling effect on the Earth's temperature, and we are not sure if rising greenhouse gases will increase or decrease cloud type, cover and/or height. All these changes will impact the Earth's temperature.

Chapters:
6.1 Types of clouds
6.2 Cloud forcing
6.3 Cirrus clouds and climate

6.4 Law stratiform clouds and climate
6.5 How does air pollution impact clouds
6.6 How will climate change impact clouds

Unit 7: Winds and motion in the atmosphere

Introduction:
Another important part of the climate system is the motion of air both vertically and horizontally in our atmosphere. The motion of air results in winds, storms and clouds, and defines the locations of our rainforests and deserts. How will the wind patterns change in the future, if at all?

Chapters:
7.1 Coriolis Force
7.2 Intertropical Convergence Zone (ITCZ)
7.3 The Hadley Cell
7.4 The General Circulation of the Atmosphere
7.5 Low and High pressure weather systems
7.6 How will climate change impact the general circulation of the atmosphere

Part 2

Unit 8: The oceans and their role in the Earth's climate

Introduction:
Oceans cover 70% of the area of the Earth, and hence have a huge impact on the climate of the Earth. The ocean currents, temperatures, and absorption of carbon dioxide are all key features that influence the global climate. Furthermore, climate change will impact sea level rise, while also impacting the acidification of the oceans.

Chapters:
8.1 Absorption of solar energy in the oceans
8.2 Salinity of the Oceans
8.3 Dissolved gases in the oceans
8.4 Surface currents and upwelling
8.5 The great ocean conveyor belt
8.6 Climate Change - Sea level rise and ocean acidification

Unit 9: The Cryosphere - glaciers, ice sheets and permafrost

Introduction:
Some parts of the planets are always frozen below 0C. These include glaciers, sea ice, land ice and permafrost regions (frozen ground). The cryosphere is responding dramatically to rising temperatures, with impacts on sea level rise, ocean currents and global temperatures.

Chapters:
9.1 Components of the Cryosphere
9.2 Glaciers and Ice sheets
9.3 Snow-ice feedbacks
9.4 Evidence of global warming
9.5 Disintegration of Ice shelves
9.6 Predictions for the Cryosphere

Unit 10: The Biosphere - the role of vegetation in regulating the climate

Introduction:
Vegetation around the planet also has an important role in modulating the Earth's climate. Both on land and in the oceans plants absorb CO_2 via photosynthesis, while also impacting land temperatures, albedo and moisture balance. In many parts of the globe, we are destroying the vegetation cover, with negative impacts on our climate.

Chapters:
10.1 Vegetation and climate
10.2 Reflectance of plants
10.3 Cooling effect of plants
10.4 Photosynthesis and the carbon sink
10.5 Land use change
10.6 Non-CO2 impact of plants
10.7 Impact of Climate Change

Unit 11: Volcanoes and their impact on the climate

Introduction:
While volcanoes may not seem relevant to the discussion about climate change, we know that large volcanic eruptions in the past have resulted in a significant cooling of global temperatures. Hence, we need to understand the science behind this global cooling. Some researchers even suggest we produce "artificial volcanoes" to offset global warming.

Chapters:
11.1 Types of Volcanoes
11.2 Lifetime of aerosols in the atmosphere
11.3 SO2 and sulfuric acid
11.4 Volcanoes and climate cooling
11.5 Geoengineering

Unit 12: Forecast for 2050? Climate models and simulations

Introduction:
After understanding the different key aspects of the climate system, we can now ask how do we forecast what may happen in 2050? Such forecasts involve developing global climate models to simulate the climate system (past, present, and future) using our best

theoretical knowledge about all parts of the climate system, and how they interact with each other. What will be the climate when your grandchildren reach university age?

Chapters:
12.1 History of climate modelling
12.2 Can we rely on these models
12.3 How do we predict the future climate
12.4 Forecasts for temperature
12.5 Forecast of precipitation changes
12.6 Forecasts of sea level rise
12.7 Examples of expected impacts

Unit 13: How do we solve this problem?

Introduction:
Now that we understand the problem we face, we can also address the solutions. And there are solutions out there. What is the road map to get to net-zero emissions by 2050? Can we do it? What is geo-engineering and should we be considering it as part of the solution? And what can each one of us do to help solve the climate crisis?

Chapters:
13.1 Growing World Population
13.2 Net-zero by 2050
13.3 Renewable clean energy
13.4 Electrifying everything possible
13.5 Synthetic fuels
13.6 Non-energy sector
13.7 Active removal of CO2 from the atmosphere
13.8 Geo-engineering
13.9 What can you do to help