ES507/ES7013 – Climate and Climate Change last updated on 19 January 2022

Lecturer:
Assoc. Prof. WANG Xianfeng (xianfeng.wang@ntu.edu.sg)

Pre-requisites:
Background in mathematics, physics, chemistry or combined science at O or H1 level, or equivalent, would be helpful but not required.

Course Structure:
PART ONE - Climate Fundamentals, Present and Future
PART TWO - Past Climate Change

Time and Venue
Lecture: Tuesday 09:30 – 12:30, at LT26, Week 3 onwards

Grading Policy
For ES5007 students only:
Ten quizzes (total 40%) – each week except weeks 1, 4, and 13
Final exam (60%) – 28 April 2022

* This is a letter-graded course.
* All the quizzes and final are in the form of multiple-choice questions (MCQ) and closed book.
* All the quizzes will be conducted online. Final will be conducted in an exam hall.

For ES7013 students only:
Ten quizzes (total 30%) – each week except weeks 1, 4, and 13
First written assignments (10%)
Final exam including 2nd written assignment (total 60%)

* This is a letter-graded course.
* MCQ questions in ES7013 may be different from those in ES5007.
* Details on written assignments will be available later.
* All the quizzes are in the form of multiple-choice questions (MCQ), closed book and conducted online.
* Final (MCQ portion only) will be conducted in an exam hall.

Consultation Policy
Teaching assistants (TAs) are generally available by email.
Lecturer is available for consultation by appointment only.
Students are encouraged to seek clarification from TAs first before approaching the lecturer for the simple reason of low staff-to-student ratio.

Teaching Assistants:
Ms. Zhang Yilin (YILIN003@e.ntu.edu.sg)
Ms. Hu Wan-Lin (WANLIN001@e.ntu.edu.sg)
References
* All the books listed are available in the library.
* Students are recommended to read the references, but it is not compulsory to buy these books.

Basic reading

<table>
<thead>
<tr>
<th>Book Title</th>
<th>Edition</th>
<th>Author</th>
<th>Publisher</th>
<th>ISBN</th>
<th>Year of Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth's Climate: Past and Future</td>
<td>3rd</td>
<td>William F. Ruddiman</td>
<td>Freeman, W. H. &amp; Company</td>
<td>9781429255257</td>
<td>2014</td>
</tr>
<tr>
<td>The Earth System</td>
<td>3rd</td>
<td>Lee R. Kump, James F. Kasting, Robert G. Crane</td>
<td>Prentice Hall</td>
<td>9780321597793</td>
<td>2010</td>
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A bit advanced reading

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<tr>
<th>Book Title</th>
<th>Edition</th>
<th>Author</th>
<th>Publisher</th>
<th>ISBN</th>
<th>Year of Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Warming: Understanding the Forecast</td>
<td>2nd</td>
<td>David Archer</td>
<td>Wiley</td>
<td>9780470943410</td>
<td>2011</td>
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<tr>
<td>Special Report on Global Warming of 1.5°C</td>
<td></td>
<td></td>
<td></td>
<td><a href="https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/">link</a></td>
<td>2018</td>
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<tr>
<td>Special Report on Climate Change and Land</td>
<td></td>
<td></td>
<td></td>
<td><a href="https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/">link</a></td>
<td>2019</td>
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<tr>
<td>Special Report on Ocean and Cryosphere in a Changing Climate</td>
<td></td>
<td></td>
<td></td>
<td><a href="https://www.ipcc.ch/srocc/chapter/summary-for-policymakers/">link</a></td>
<td>2019</td>
</tr>
<tr>
<td>Singapore’s 2nd National Climate Change Study – Climate Projections to 2100 Science Report</td>
<td></td>
<td></td>
<td></td>
<td><a href="http://ccrs.weather.gov.sg/wp-content/uploads/2015/07/V2_Ch1_Executive_Summary.pdf">link</a></td>
<td>2015</td>
</tr>
</tbody>
</table>
Lecture Course Content

* This outline is subject to changes as the course proceeds, while details are incrementally specified appropriate to the level of progress of the class.
* The lectures are demarcated by dashed lines below.
* All the lectures, quizzes and midterms are conducted online.
* There are no tutorials for this course.
* Consultations with teaching assistants by emails or appointments are strongly encouraged.

References to course texts are meant as supplementary reading to the lectures. They are listed to the right of the course content. The letters/numbers following the symbol “x§” refer to the chapters in the course texts below. It is OPTIONAL to buy these books.

b§ = Atmosphere, Weather and Climate, by Roger G. Barry and Richard J. Chorley
r§ = Earth’s Climate: Past and Future, by William F. Ruddiman
k§ = The Earth System, by Lee R. Kump, James F. Kasting, and Robert G. Crane
d§ = Global Warming: Understanding the Forecast, by David Archer
s§ = Summary for Policymakers, in Climate Change 2013: The Physical Science Basis
Or if you are interested, the full report of IPCC Assessment Report 5, the Physical Science Basis, can be downloaded from http://www.climatechange2013.org/report/full-report/)
g§ = Special Report on Global Warming of 1.5°C
(e-copy available from https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/ and the full report can be downloaded from https://www.ipcc.ch/sr15/.)
1. Introduction
   a. Course Briefing

   b. Earth’s Climate
      The Climate System
      Atmospheric Structure & Composition b§2.A.1-A.6, 2.C
      Climate Variability & Change b§2.A.7, b§13.A;

Week 2, Online Quiz-1

2. Radiation
   a. Blackbody Radiation, Solar & Terrestrial b§3.A, 3.B.1-B.3,
      Radiation, Atmosphere-Radiation Interaction b§3.C;

   b. Earth's Radiation Budget, Albedo, Radiative Heating b§3.D

   c. Horizontal Energy and Water Vapour Transport b§3.E

Week 3, Online Quiz-2

3. Dynamics
   a. Pressure, Ideal Gas Law, Hydrostatic Balance b§2.B.1
      Atmospheric Mass Distribution


Week 4, Chinese New Year on 1 February (No Class)

Week 5, Online Quiz-3

4. Thermodynamics
   a. Tropical Weather
      Ocean Circulations, Eddies and Waves b§7.D

   b. Vapour Pressure and Humidity b§2.B, 4.B.1

Week 6, Online Quiz-4

5. Numerical Modelling
   b. GCMs, Basic Scientific Principles b§8.A-8.B
   c. Climate Feedbacks b§13.B.2-B.3; d§7

Week 7, Online Quiz-5

6. Global Warming & Consequences
   a. IPCC and Recent Climate Change b§13.D; s§A-D
   c. Climate Means, Variability and Extremes lecture notes

RECESS WEEK

Week 8, Online Quiz-6

7. Earth’s climate in the deep time and carbon cycle
   a. Evolution of Earth’s atmosphere r§4, k§10
   b. Plate tectonics and Carbon cycle r§6, k§8

Week 9, Online Quiz-7

8. Earth’s climate in the deep time and carbon cycle
   a. The faint young Sun paradox, Snowball Earth k§11, k§12
   b. Greenhouse to icehouse r§7, k§12

Week 10, Online Quiz-8

9. Ice ages
   a. Pleistocene glaciations r§8, r§10
   b. Abrupt climate change r§14, r§15
Week 11, Online Quiz-9

10. Climate and human evolution
   a. Dawn of civilization
      r§16
   b. Historical climate change
      r§17

Week 12, Online Quiz-10

11. Anthropocene
   a. Anthropogenic climate impact
      r§19
   b. Geo-engineering
      r§20

12. Discussions on some emergent climate topics

Final exam, 28 April!