

# 11:670:461 Climate Dynamics

Prerequisites: 11:670:324 DYNAMICS OF THE ATMOSPHERE and 11:670:431 PHYSICAL METEOROLOGY

[Professor Alan Robock](http://www.envsci.rutgers.edu/~robock/) (http://www.envsci.rutgers.edu/~robock/)

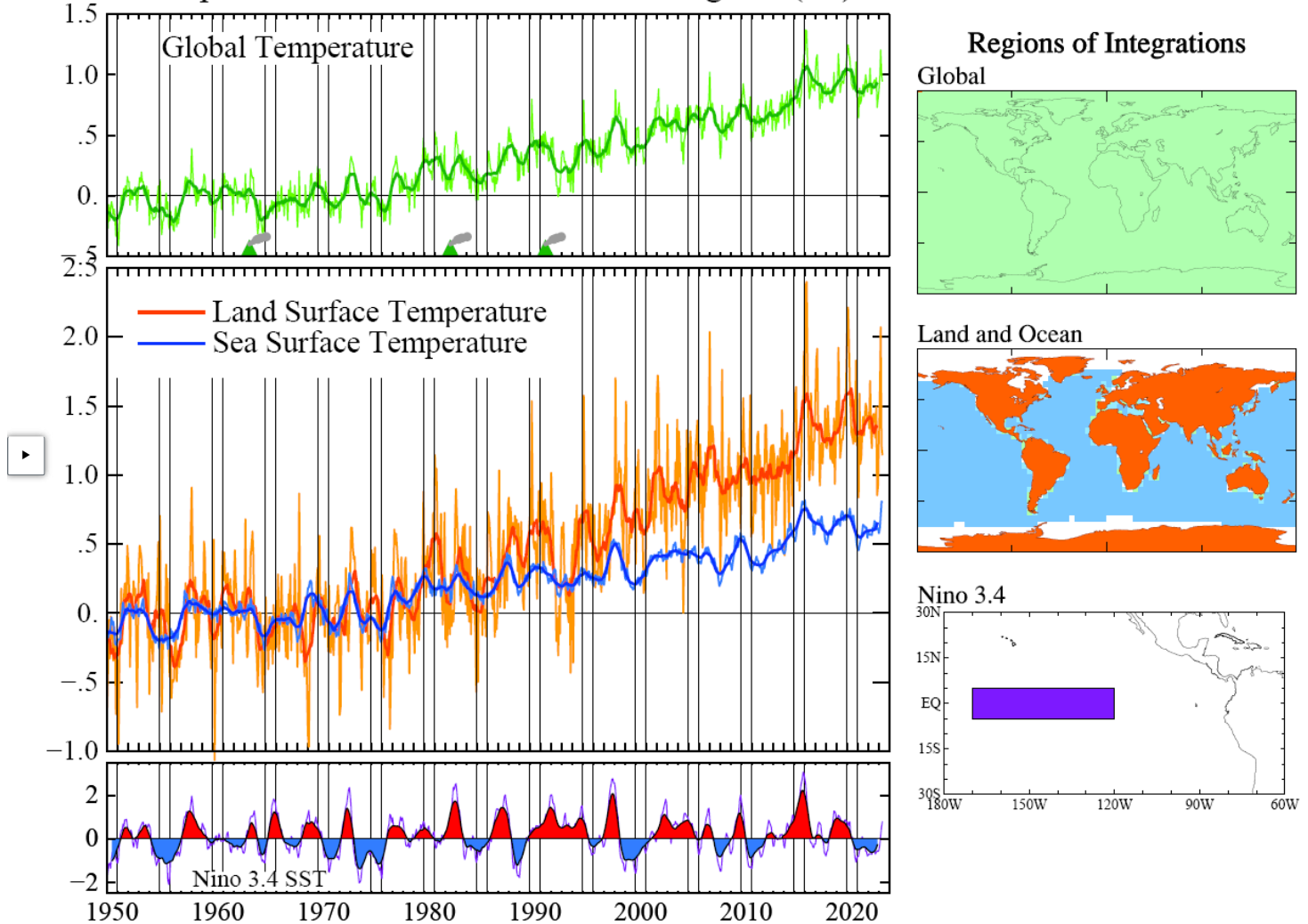
Room 225, Environmental and Natural Resources Building

Phone: 848-932-5751, E-mail: [robock@envsci.rutgers.edu](mailto:robock@envsci.rutgers.edu) (mailto:robock@envsci.rutgers.edu)

**Classes in Room 223, Environmental and Natural Resources Building**

**Monday and Thursday, 12:10 p.m. to 1:30 p.m.**

## Temperature Anomalies in Different Regions (°C)



**Recent climate change.** Monthly (thin lines) and 12-month running mean (thick lines or filled colors in case of Niño 3.4 Index) global land-ocean temperature anomaly, global land and sea surface temperature, and El Niño index. All have a base period 1951-1980. Figure from [http://www.columbia.edu/~mhs119/Temperature/T\\_moreFigs/](http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/) (http://www.columbia.edu/~mhs119/Temperature/T\_moreFigs/). Green triangles denote the 1963 Agung, 1982 El Chichón, and 1991 Pinatubo volcanic eruptions. Niño 3.4 is the tropical Pacific region 5°N-5°S, 170-120°W. Red shading is for periods of El Niño and blue shading is for La Niñas.

### Required Text:

[Goosse, H., P.Y. Barriat, W. Lefebvre, M.F. Loutre, and V. Zunz, 2010: Introduction to climate dynamics and climate modelling. Online textbook available at http://www.climate.be/textbook](http://www.climate.be/textbook) (http://www.climate.be/textbook/)

Download pdf of the text from above link or from First Class Module.

or buy the updated text:

[Goosse, Hugues, 2015: \*Climate System Dynamics and Modelling\*, \(Cambridge University Press, Cambridge, UK\), 378 pp.](https://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/climate-system-dynamics-and-modelling) [↗](https://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/climate-system-dynamics-and-modelling)  
(<http://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/climate-system-dynamics-and-modelling>)

#### Reference Texts:

[IPCC](http://www.ipcc.ch/) [↗](http://www.ipcc.ch/) (<http://www.ipcc.ch/>), particularly the new Working Group I report from the 6th Assessment, <https://www.ipcc.ch/report/ar6/wg1/> [↗](https://www.ipcc.ch/report/ar6/wg1/)  
(<https://www.ipcc.ch/report/ar6/wg1/>).

[State of the Climate in 2022](https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/) [↗](https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/) (<https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/>), Special Supplement to the *Bulletin of the American Meteorological Society*

[A few takeaways from the "State of the Climate in 2022," by Michael Alexander](https://blog.ametsoc.org/2023/09/06/a-few-takeaways-from-the-state-of-the-climate-in-2022/) [↗](https://blog.ametsoc.org/2023/09/06/a-few-takeaways-from-the-state-of-the-climate-in-2022/) (<https://blog.ametsoc.org/2023/09/06/a-few-takeaways-from-the-state-of-the-climate-in-2022/>).

[Archer, David, and Raymond Pierrehumbert \(Editors\), 2011: \*The Warming Papers, The Scientific Foundation for the Climate Change Forecast\*, \(Wiley-Blackwell, Oxford, UK\), 419 pp.](http://www.amazon.com/The-Warming-Papers-Scientific-Foundation/dp/1405196165/) [↗](http://www.amazon.com/The-Warming-Papers-Scientific-Foundation/dp/1405196165/) (<http://www.amazon.com/The-Warming-Papers-Scientific-Foundation/dp/1405196165/>).

For links to other important global warming source material, including the U.S. National Climate Assessment, visit the US Global Change Research Program web page, <http://www.globalchange.gov/> [↗](http://www.globalchange.gov/) (<http://www.globalchange.gov/>).


















#### Learning Goals:

Upon completion of this class, students will be able to:

1. Demonstrate an understanding of anthropogenic impacts on atmospheric chemistry and climate and their potential environmental and societal consequences.
2. Exhibit critical thinking when confronting new information.
3. Communicate clearly orally and in writing, including by electronic means.
4. Apply the mathematical and physical foundations of meteorology and climatology to solve problems using analytical and computational methods.

#### CLASS SCHEDULE

Date	Subject	Reading*
Sept. 7	Introduction	<a href="https://www.ipcc.ch/report/ar6/wg1/download">IPCC WG I Summary for Policymakers,</a> <a href="https://www.ipcc.ch/report/ar6/wg1/download">↗</a> ( <a href="https://www.ipcc.ch/report/ar6/wg1/download">https://www.ipcc.ch/report/ar6/wg1/download</a> )
Sept. 11	Climate System - Atmosphere	G1
Sept. 14	Climate System - Ocean	G1
Sept. 18	Climate System - Ice and Land	G1
Sept. 21	Climate Variability, El Niño, ENSO, QBO, AO	G5, <a href="http://climate.envsci.rutgers.edu/pdf/HansenRevGeophys2010/">Hansen et al. (2010)</a> <a href="http://climate.envsci.rutgers.edu/pdf/HansenRevGeophys2010/">↗</a> ( <a href="http://climate.envsci.rutgers.edu/pdf/HansenRevGeophys2010/">http://climate.envsci.rutgers.edu/pdf/HansenRevGeophys2010/</a> ), <a href="https://rutgers.instructure.com/courses/244061/files/33761885?wrap=1">McPhaden (2015)</a> ( <a href="https://rutgers.instructure.com/courses/244061/files/33761885?wrap=1">https://rutgers.instructure.com/courses/244061/files/33761885?wrap=1</a> ), <a href="https://climate.envsci.rutgers.edu/pdf/059695b18b9a%2FMcPhadenENSONclimate2775.pdf%3Ftoken%3DeyJ0eXAiOiJKV1QiLCJhbGw%3D">059695b18b9a%2FMcPhadenENSONclimate2775.pdf%3Ftoken%3DeyJ0eXAiOiJKV1QiLCJhbGw%3D</a> )
Sept. 25	IPCC, Reconstructing Past Climates	G5, <a href="https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-2/">IPCC AR6 WGI Chapter 2</a> <a href="https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-2/">↗</a> ( <a href="https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-2/">https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-2/</a> ), <a href="https://climate.envsci.rutgers.edu/pdf/8909&amp;lang=en_us&amp;url=http%3A%2Fclimate.envsci.rutgers.edu%2Fpdf%2FVinnikov2">Vinnikov (2015)</a> ( <a href="https://climate.envsci.rutgers.edu/pdf/8909&amp;lang=en_us&amp;url=http%3A%2Fclimate.envsci.rutgers.edu%2Fpdf%2FVinnikov2">https://climate.envsci.rutgers.edu/pdf/8909&amp;lang=en_us&amp;url=http%3A%2Fclimate.envsci.rutgers.edu%2Fpdf%2FVinnikov2</a> )
Sept. 28	IPCC, Reconstructing Past Climates	G5, <a href="http://climate.envsci.rutgers.edu/pdf/NASreport.pdf">NAS report</a> <a href="http://climate.envsci.rutgers.edu/pdf/NASreport.pdf">↗</a> ( <a href="http://climate.envsci.rutgers.edu/pdf/NASreport.pdf">http://climate.envsci.rutgers.edu/pdf/NASreport.pdf</a> ), <a href="https://docear.com/">Docear</a> <a href="https://docear.com/">↗</a> ( <a href="https://docear.com/">https://docear.com/</a> )
Oct. 2	Energy Balance <b>Term Paper Topic Due</b>	G2
Oct. 5	Energy Balance	G2

Oct. 9	Water and Carbon Cycles	G2, <a href="http://climate.envsci.rutgers.edu/pdf/OkiKanaeGlobalHydrolo">Oki and Kanae (2006)</a>  ( <a href="http://climate.envsci.rutgers.edu/pdf/OkiKanaeGlobalHydrolo">http://climate.envsci.rutgers.edu/pdf/OkiKanaeGlobalHydrolo</a> )
Oct. 12	Water and Carbon Cycles	G2,  ( <a href="http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/">http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/</a> ) <a href="http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/">Robock et al. (2011)</a>  ( <a href="http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/">http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/</a> ) <a href="http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/">Robock et al. (2011)</a>  ( <a href="http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/">http://www.realclimate.org/index.php/archives/2011/07/reanalyses-r-us/</a> )
Oct. 16	Reanalysis	 ( <a href="http://climate.envsci.rutgers.edu/pdf/Robock2002JD003245.pdf">http://climate.envsci.rutgers.edu/pdf/Robock2002JD003245.pdf</a> )  ( <a href="https://docreader.reanalysis">https://docreader.reanalysis</a> )
Oct. 19	Climate Modeling	G3
Oct. 23	<b>Exam 1</b>	
Oct. 26	Radiative Forcing, Climate Feedbacks	G4, <a href="#">IPCC AR6 WGI, Chapter 7, "The Earth's energy budget, climate feedbacks, and c</a>
Oct. 30	Long-range Weather Forecasting	see handouts in Long-range Forecasting Module
Nov. 2	Future Climate Scenarios, Global Warming	G6, <a href="#">AR6 WG I Technical Summary,</a>  ( <a href="https://www.ipcc.ch/report/ar6/wg1/downloads/rep">https://www.ipcc.ch/report/ar6/wg1/downloads/rep</a> )
Nov. 6	Global Warming <b>Term Paper Outline Due</b>	G6
Nov. 9	Global Warming	G6
Nov. 13	Climate Intervention (also called Climate Engineering or Geoengineering)	<a href="#">Stratospheric Aerosol Geoengineering</a>  ( <a href="http://climate.envsci.rutgers.edu/pdf/RobockS">http://climate.envsci.rutgers.edu/pdf/RobockS</a> )
Nov. 16	Volcanic Eruptions and Climate	<a href="#">Robock (2000)</a>  ( <a href="http://climate.envsci.rutgers.edu/pdf/ROG2000.pdf">http://climate.envsci.rutgers.edu/pdf/ROG2000.pdf</a> )  ( <a href="https://docreader.re">https://docreader.re</a> )
Nov. 20	Volcanic Eruptions and Climate	
Nov. 21 <b>TUESDAY</b>	Policy Debate	<a href="#">AR6 WGII</a>  ( <a href="https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/">https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/</a> ), <a href="#">Polan</a>  ( <a href="https://www.cis.upenn.edu/~bcperce%2Fpapers%2F">https://www.cis.upenn.edu/~bcperce%2Fpapers%2F</a> )
Nov. 23	THANKSGIVING	
Nov. 27	Nuclear Winter <b>Term Paper Due</b>	<a href="http://climate.envsci.rutgers.edu/nuclear/">http://climate.envsci.rutgers.edu/nuclear/</a>  ( <a href="http://climate.envsci.rutgers.edu/nuclear/">http://climate.envsci.rutgers.edu/nuclear/</a> )
Nov. 30	<a href="#">Ozone Hole</a>  ( <a href="https://ozonewatch.gsfc.nasa.gov/facts/hole_SH.html">https://ozonewatch.gsfc.nasa.gov/facts/hole_SH.html</a> )	<a href="#">Montreal Protocol</a>  ( <a href="https://www.unep.org/ozonaction/who-we-are/about-montreal-protoc">https://www.unep.org/ozonaction/who-we-are/about-montreal-protoc</a> ) <a href="#">YouTube</a>  ( <a href="https://www.youtube.com/watch?v=AU0eNa4GrgU">https://www.youtube.com/watch?v=AU0eNa4GrgU</a> )  <a href="https://www.youtube.com/watch?v=AU0eNa4GrgU">https://www.youtube.com/watch?v=AU0eNa4GrgU</a>
Dec. 4	Oral Term Paper Presentations	
Dec. 7	Oral Term Paper Presentations	
Dec. 21 noon - 3 pm	<b>Final Exam, Room 223</b>	

\*G = Chapter in Goosse

**Course grade will be determined by:**

Homework		35%
Term paper	25% (paper 15%, oral 10%)	
Exam		15%
Final exam		<u>25%</u>
		100%

Prepared by [Alan Robock](http://www.envsci.rutgers.edu/~robock) (<http://www.envsci.rutgers.edu/~robock>), ([robock@envsci.rutgers.edu](mailto:robock@envsci.rutgers.edu)) - Last updated on August 31, 2023