

Atmosphere, Clouds, and Climate: Turbulence and Cumulus Clouds

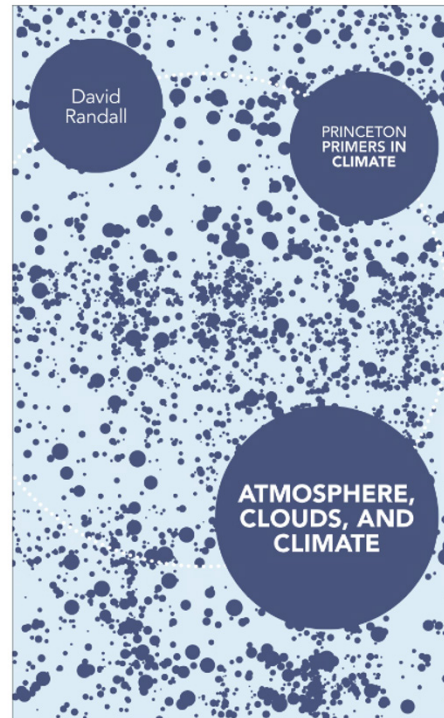
AOSC 680

Ross Salawitch

Class Web Sites:

<http://www2.atmos.umd.edu/~rjs/class/fall2024>

<https://umd.instructure.com/courses/1367293>



Lecture 11

10 October 2024

Student Led Discussions of Princeton Primers In Climate

10/10	Turbulence and Cumulus Clouds	Chapter 3 of <i>Atmospheres, Clouds, and Climate</i> 48 pages	AT 11	Lecture 11: Danny Ross Video		Anderson et al., <i>Nature Comm.</i>, 2016	
10/15	Energy Flows and Climate Feedback	Chapters 4 & 5 of <i>Atmospheres, Clouds, and Climate</i> 56 pages	AT 12 Paper Description	Amanda		Hausfather et al., <i>Nature</i>, 2022 Zelinka et al., <i>JGR</i>, 2022	
10/17	Water Planet and Weather Predictability	Chapters 6 & 7 of <i>Atmospheres, Clouds, and Climate</i> 46 pages	AT 13	Vincent		Wash Post article Ellicott City floods Forbes article Water Cycle UMD Mesonet Chand et al., 2023 Heede and Federov, 2023	
10/22	Basics of Climate and the Oceans	Chapters 1 & 2 of <i>Climate and the Oceans</i>	AT 14	Jasmine		Weblink 1 Weblink 2 Weblink 3 Weblink 4	
10/24	Ocean Dynamics and Circulation	Chapters 2 & 3 of <i>Climate and the Oceans</i> 53 pages (focus on text & concepts rather than equations)	AT 15	Logan		NASA Salinity Map Physics Today Article Jones and Cessi, 2017	
10/29	Oceans Role in Climate & Climate Variability	Chapters 4 & 5 of <i>Climate and the Oceans</i> 51 pages	AT 16	Kenny		Weblink 1 Weblink 2 Youtubelink 1 Youtubelink 2 Youtubelink 3	
10/31	Global Warming and the Ocean	Chapters 7 of <i>Climate and the Oceans</i> 55 pages	AT 17	Emily		Weblink 1 Schlesinger and Ramankutty, <i>Nature</i>, 1994 Canty et al., 2013 AMOC Variability Solomon et al., <i>PNAS</i>, 2009 Mauristen and Pincus, <i>Nature Climate Change</i>, 2017	
11/05	TBD	TBD	AT 18	Student 8			

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CUMULUS FLUXES OF ENERGY AND OTHER THINGS

Recall that the brightness temperature of the Earth as a whole corresponds to a level in the middle troposphere, where the actual temperature is close to 255 K. It follows that, in an average sense, nonradiative processes have to carry energy upward, from the surface to the middle or upper troposphere, where radiation can take over and carry the energy on out to space. Riehl and Malkus (1958) deduced from the observed energy balance and vertical structure of the tropical atmosphere that thunderstorms are the primary mechanism for upward energy transport in the tropics. Their argument is indirect; it is based on eliminating all of the other possibilities.

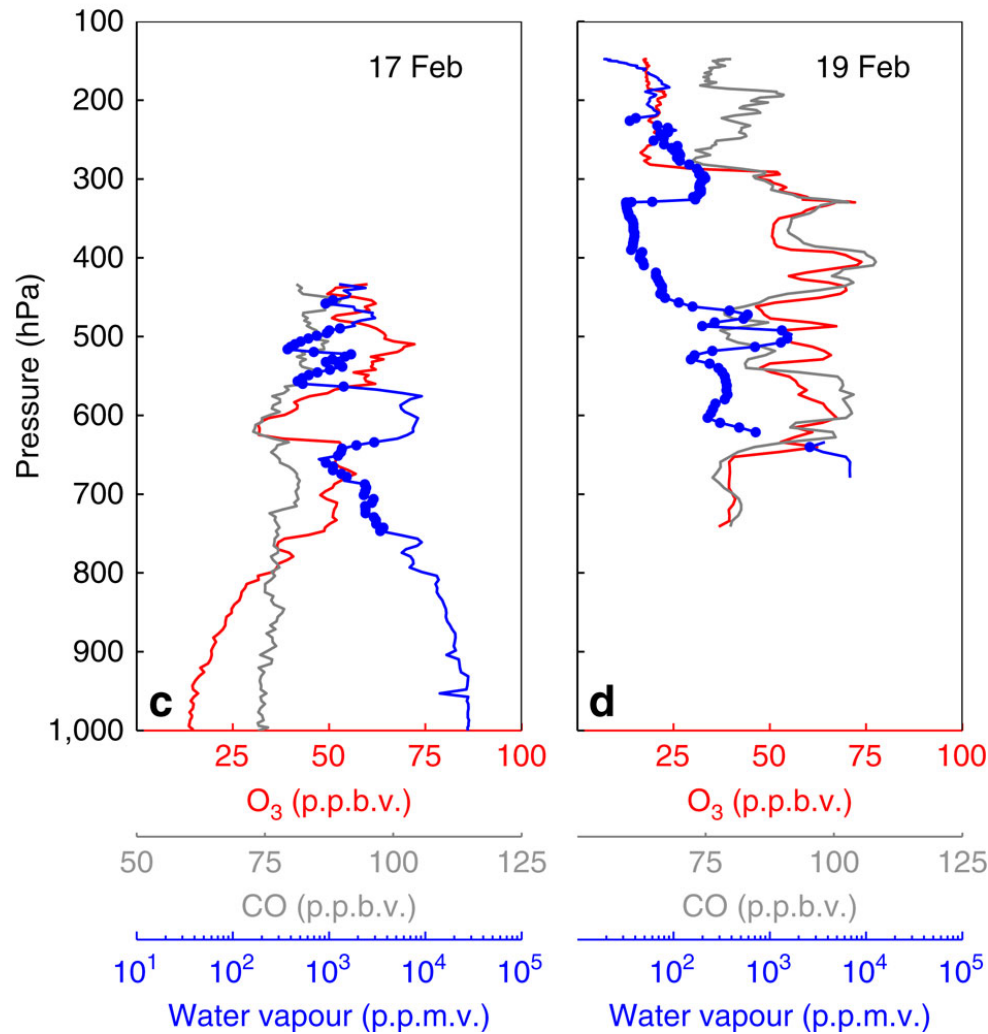
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Figure 3.6. Sketch illustrating a strong updraft, represented by the large arrow, and surrounding weak downdrafts, represented by the small arrows.

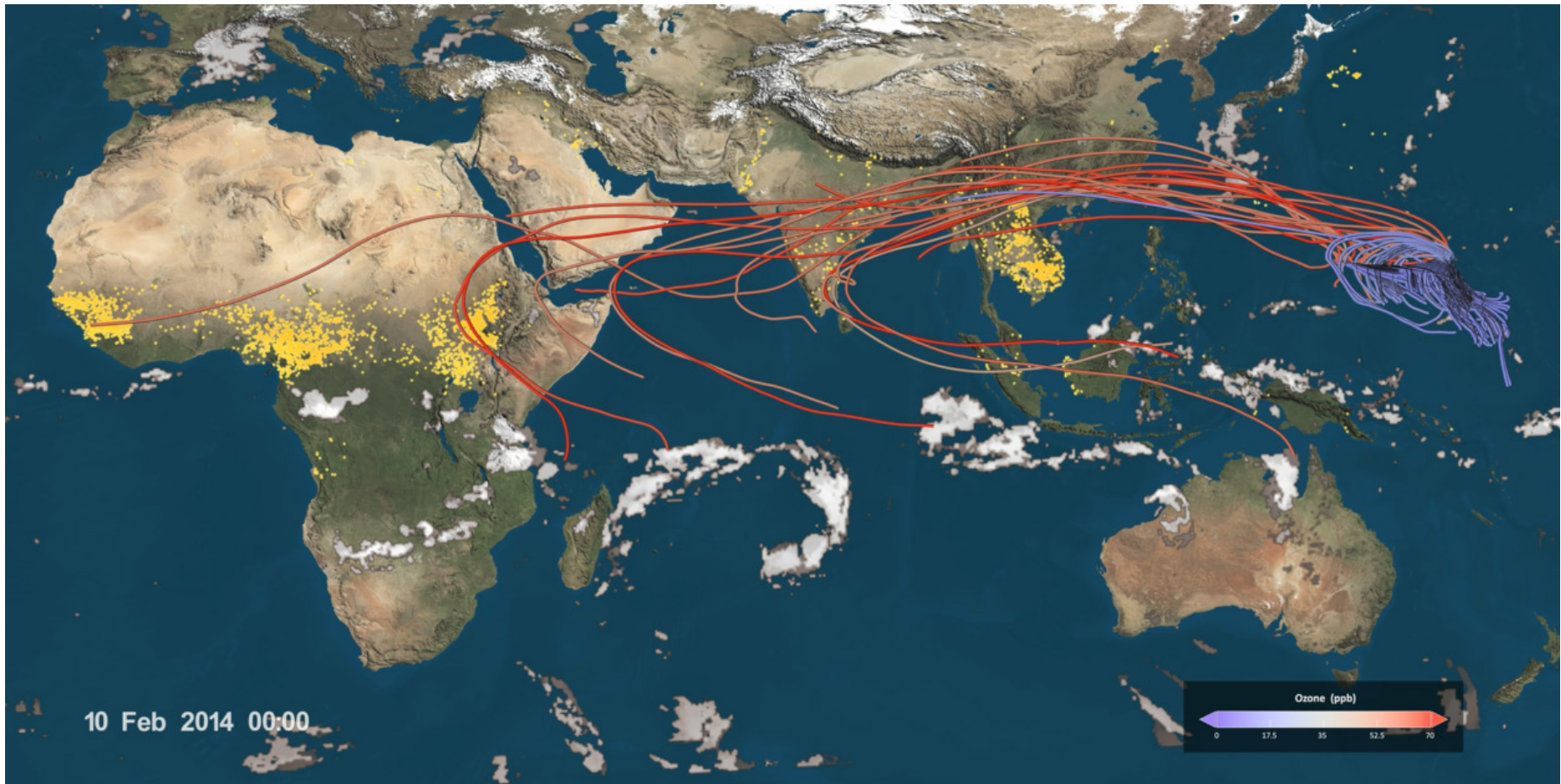
The upward and downward mass flows can cancel.

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<https://www.nature.com/articles/ncomms10267>

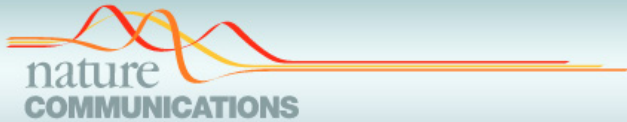
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<https://www.youtube.com/watch?v=zj-dETgdcdM>

<https://www.nasa.gov/feature/goddard/2016/tropical-fires-fuel-elevated-ozone-levels-over-western-pacific-ocean>

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ARTICLE

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A pervasive role for biomass burning in tropical high ozone/low water structures

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Air parcels with mixing ratios of high O₃ and low H₂O (HOLW) are common features in the tropical western Pacific (TWP) mid-troposphere (300–700 hPa). Here, using data collected during aircraft sampling of the TWP in winter 2014, we find strong, positive correlations of O₃ with multiple biomass burning tracers in these HOLW structures. Ozone levels in these structures are about a factor of three larger than background. Models, satellite data and aircraft observations are used to show fires in tropical Africa and Southeast Asia are the dominant source of high O₃ and that low H₂O results from large-scale descent within the tropical troposphere. Previous explanations that attribute HOLW structures to transport from the stratosphere or mid-latitude troposphere are inconsistent with our observations. This study suggest a larger role for biomass burning in the radiative forcing of climate in the remote TWP than is commonly appreciated.

<https://www.nature.com/articles/ncomms10267>

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Air mass transport to the tropical western Pacific troposphere inferred from ozone and relative humidity balloon observations above Palau

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Abstract. The transport history of tropospheric air masses above the tropical western Pacific (TWP) is reflected by the local ozone and relative humidity (RH) characteristics. In boreal winter, the TWP is the main global entry point for air masses into the stratosphere and therefore a key region of atmospheric chemistry and dynamics. Our study aims to identify air masses with different pathways to the TWP using ozone and radio soundings from Palau from 2016–2019. Supported by backward trajectory calculations, we found five different types of air masses. We further defined locally controlled ozone and RH background profiles based on monthly statistics and analyzed corresponding anomalies in the 5–10 km altitude range. Our results show a bimodality in RH anomalies. Humid and ozone-poor background air masses are of local or Pacific convective origin and occur year-round, but they dominate from August until October. Anomalously dry and ozone-rich air masses indicate a non-local origin in tropical Asia and are transported to the TWP via an anticyclonic route, mostly from February to April. The geographic location of origin suggests anthropogenic pollution or biomass burning as a cause for ozone production. We propose large-scale descent within the tropical troposphere and radiative cooling in connection with the Hadley circulation as being responsible for the dehydration during transport. The trajectory analysis revealed no indication of a stratospheric influence. Our study thus presents a valuable contribution to the discussion about anomalous layers of dry ozone-rich air observed in ozone-poor background profiles in the TWP.

<https://acp.copernicus.org/articles/24/4693/2024/acp-24-4693-2024.pdf>

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Under conditions that will be explained later in this chapter, some of the thermals that grow near the surface can break away from the boundary layer and grow into thunderstorms, like the ones shown in the upper portion of Figure 3.1. A typical thunderstorm is 5 to 10 km across. In the atmosphere as a whole, many thousands of thunderstorms are occurring at any given moment. The storms grow rapidly upward because they contain strong, organized updrafts, with speeds of 20 m s^{-1} or more, much faster than any elevator you have ever ridden on. The updrafts lift energy through the depth of the troposphere, and sometimes even stab into the lower stratosphere. They also lift moisture, momentum, and various chemical species.