

AT 753
Fall 2019
Prof. Christian Kummerow

Required text: None

Useful texts for own library: Piexoto and Oort, 1992
Liou, 1992

Course Outline

Week 1

Aug. 26 & 28 – No class due to NOAA NESDIS meeting in DC. Skim *IPCC AR5 Synthesis Report*. Focus on Water and Energy budget issues. Be prepared to share findings.

Aug. 30 – Lecture 1: Introduction to Water and Energy budgets.

Week 2

Sept. 2 – CSU closed (Labor Day)

Sept. 4 – Lecture 2: Review of radiation and radiative fluxes (AT622 in a day)

Sept. 6 – Lecture 3: A historical perspective of the water and energy budgets. Read *Dines, 1917*.

Week 3

Sept. 9 – Student led review of: *The Earth's Annual Global Mean Energy Budget*. Kiehl and Trenberth, 1997 & Updates: *Earth's Global Energy Budget*. Trenberth, Fassulo and Kiehl, 2009.

Sept. 11 – Lecture 4: Water vapor as a greenhouse gas

Sept. 13 – Lecture 5: Water vapor measurements + makeup class: Student led review of: *Weather and Climate Analyses using Improved Global Water Vapor Observations*. Vonder Haar et al., 2012

Week 4

Sept. 16 – Lecture 6: Evaporation. Read: The Story behind the Bowen Ratio. Lewis, 1995.

Sept. 18 – Lecture 7: Evaporation over ocean.

Sept. 20 – Student led review of: *Why is there an Evaporation Minimum at the Equator?* R. Seager et al., 2003 + makeup class – Lecture 8: Evaporation over land

Week 5

Sept. 23 – Lecture 9: Land Surface temperature and soil moisture

Sept. 25 – Student led review of: *Is the Hydrologic Cycle Accelerating?* A. Ohmura & M. Wild. *Science*, '02 + makeup class – Lecture 10: Water vapor transport

Sept. 27 – Lecture 11: Review of water vapor, evaporation and transport

Week 6

Sept. 30 – Oct. 4 No class due to the AMS Satellite Conference in Boston

Week 7

Oct. 7 – Lecture 12: Clear sky radiation. *Read: Examination of Relationships between Clear-Sky Longwave Radiation and Aspects of the Atmospheric Hydrological Cycle in Climate Models, Reanalyses, and Observations. R. Allan, 2008.*

Oct. 9 – Lecture 13: Cloud Physical Properties

Oct. 11 – Student review of: *Intensification of Precipitation Extremes with Warming in a Cloud-Resolving Model. Muller & O’Gorman, 2011* + makeup class – Lecture 14: Impact of clouds on climate

Week 8

Oct. 14 – Lecture 15: Cloud/Climate feedbacks. Read *Thermodynamic regulation of ocean warming by cirrus. Ramanathan and Collins, 1991*

Oct. 16 – The GEWEX Integrated Product

Oct. 18 – Student led discussions – *Does the Earth have an Adaptive Infrared Iris? R. Lindzen et al., Bull. Amer. Met. Soc. ’01* + makeup class – Lecture 16: The many rebuttals to the Iris Hypothesis

Week 9

Oct. 21 – Lecture 17: From Clouds to Precipitation

Oct. 23 – Lecture 18: Remote Sensing of Precipitation

Oct. 25 – Lecture 19: Precipitation and the water cycle

Week 10

Oct. 28 – Student led discussion – *How much more rain will Global Warming bring? Wentz, Nature 2007.*

Oct. 30 – Lecture 20: Clouds, Aerosols and Precipitation

Nov. 1 – Student projects – Presentation of ideas and discussion

Week 11

Nov 4 – Nov 8: No class due to the GPM Science Team meeting in Indianapolis

Week 12

Nov. 11 – Student led discussion: *Aerosol-induced intensification of rain from the tropics to the mid-latitudes, Koren et al., Nature geoscience, 2012.*

Nov. 13 – Lecture 21: Radiative/Convective equilibrium

Nov. 15 – Lecture 22: MJO and self similar tropical precipitation regimes

Week 13

Nov. 18 – Student led discussion: *Observational Evidence for the Mutual Regulation of the Tropical Hydrologic Cycle and Tropical Sea Surface Temperature*. Stephens et al., *J. Climate*, 2004.

Nov. 20 – Student led discussion: *Constraints on future changes in climate and the hydrologic cycle of self-selected paper*. Allen and Ingram, *nature*, 2002.

Nov. 22 – Student projects – Presentation of revised/final ideas

Fall recess

Week 14

Dec. 2 – Lecture 23: Water/Energy storage and Ocean circulation

Dec. 4 – Lecture 24: Linking Radiation, the hydrologic cycle and climate change

Dec. 6 – Lecture 25: Water and energy storage over the Colorado River Basin

Week 15

Dec. 4 – Lecture 26: Current Topics

Dec. 6 – Student project presentations

Dec. 8 – Student project presentations

Finals Week

Dec. 11 – Student project presentations (if necessary)

Books:

Peixoto, José P. and Abraham H. Oort, 1992: *Physics of Climate*, Springer Verlag, New York, NY, 520 p.

Liou, K. N. 1992: *Radiation and Cloud Processes in the Atmosphere: Theory, Observation, and Modeling*, Oxford University Press, New York, NY, 487 pp.

Papers (in order of appearance)

IPCC AR5 Climate Change 2014. Synthesis Report

Dines, W. H., 1917: The heat balance of the Atmosphere. *Quart. J. of the Royal Meteor. Soc.*, 43, 151-158.

Kiehl, J. T. and K. Trenberth, 1997: The Earth's Annual Global Mean Energy Budget. *Bull. Amer. Met. Soc.*, **78**, 197-208

Trenberth, Kevin E., J. T. Fasullo, J. Kiehl, 2009: Earth's Global Energy Balance. *Bull. Amer. Met. Soc.*, **90**, 311-323

- Vonder Haar, T. H., J. Bytheway and J. M. Forsythe, 2012: Weather and Climate Analysis using Improved Global Water Vapor Observations. *Geophys. Res. Letters*, **39**, L15802
- Lewis, J. M., 1995: The Story Behind the Bowen Ratio. *Bull. Amer. Met. Soc.*, **76**, 2433-2442
- Seager, R., R. Murtugudde, A. Clement, and C. Herweijer, 2003: Why is there an evaporation minimum at the Equator? *J. Climate*, **16**, 3793–3802.
- Ohmura, A., and M. Wild, 2002: Is the Hydrologic Cycle Accelerating? *Science*, **298**, 1345-1346.
- Allan, R., 2009: Examination of Relationships between Clear-Sky Longwave Radiation and Aspects of the Atmospheric Hydrological Cycle in Climate Models, Reanalyses, and Observations. *J. Climate*, **22**, 3127 – 3145
- Muller, C. J., P. . O’Gorman, 2011: An energetic perspective on the regional response of precipitation to climate change. *Nature Climate Change*, **1**, 266-271.
- Ramanathan, V. and W. Collins, 1991: Thermodynamic regulation of Ocean Warming by Cirrus Clouds Deduced from Observations of the 1987 El Niño. *Nature*, **351**, 27-32.
- Lindzen, R. S. M.-D. Chou, and A. Y. Hou, 2001: Does the Earth have an adaptive infrared iris? *Bull. Amer. Met. Soc.*, **82**, 417-432.
- Wentz, F. J., L. Ricciardelli, K. Hilburn and C. Mears, 2007: How much more rain will global warming bring? *Science*, **317**, 233–235.
- Koren, I., O. Altaratz, L. A. Remer, G. Feingold, J. Vanderlei Martins, and R. H., Heiblum, 2012: Aerosol-induced intensification of rain from the tropics to the mid-latitudes, *Nature Geoscience*, **5**, 118 - 122.
- Stephens, Graeme L., Peter J. Webster, Richard H. Johnson, Richard Engelen, and Tristan L’Ecuyer, 2004: Observational evidence for the mutual regulation of the tropical hydrological cycle and tropical sea surface temperatures, *J. Climate*, **17**, 2213–2224.
- Allen, M. R., and W. J. Ingram, 2002: Constraints on future changes in climate and the hydrologic cycle of self-selected paper. *Nature*, **419**, 224-232.

Some of the Adaptive Iris rebuttals:

Dennis L. Hartmann and Marc L. Michelsen, 2002: No Evidence for Iris. *Bulletin of the American Meteorological Society*, Volume 83, Issue 2 (February 2002) pp. 249–254

Halstead Harrison, 2002: Supplement to Comments on “Does the Earth Have an Adaptive Infrared Iris?” *Bulletin of the American Meteorological Society*, Volume 83, Issue 4 (April 2002) pp. 598–598

Richard S. Lindzen, Ming-Dah Chou, and Arthur Y. Hou, 2002: Comment on "No Evidence for Iris". *Bulletin of the American Meteorological Society*, Volume 83, Issue 9 (September 2002) pp. 1345–1349

Bing Lin, Bruce A. Wielicki, Lin H. Chambers, Yongxiang Hu, and Kuan-Man Xu, 2002: The Iris Hypothesis: A Negative or Positive Cloud Feedback? *Journal of Climate*, Volume 15, Issue 1 (January 2002) pp. 3–7

Ming-Dah Chou, Richard S. Lindzen, and Arthur Y. Hou, 2002: Comments on “The Iris Hypothesis: A Negative or Positive Cloud Feedback?” *Journal of Climate*, Volume 15, Issue 18 (September 2002) pp. 2713–2715