

**AT 753**  
**Fall 2017**  
**Prof. Christian Kummerow**

Required text: None

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

**Course Outline**

Week 1

Aug. 21 – Eclipse

Aug. 23 – Lecture 1: Introduction to Water and Energy budgets. Read Michael Crichton, 2003: Aliens cause Global Warming.

Aug. 25 – Lecture 2: Review of Radiative Fluxes

Week 2

Aug 28 – Lecture 3: An historical perspective of the water and energy budgets. Read Dines, 1917.

Aug. 30 – Lecture: Water vapor as a greenhouse gas

Sept. 1 – Student led review of: The Earth's Annual Global Mean Energy Budget. Kiehl and Trenberth, 1997

Week 3

Sept. 4 – CSU Holiday (Labor Day)

Sept. 6 – Lecture: Water vapor measurements.

Sept. 8 – Student led discussion of: Weather and climate analyses using improved global water vapor observations. Vonder Haar et al., 2012

Week 4

Sept. 11 – Lecture: Evaporation. Read: The Story behind the Bowen Ratio. Lewis, 1995.

Sept. 13 – Lecture: Evaporation over ocean.

Sept. 15 – Student led review of: Why is there an Evaporation Minimum at the Equator? R. Seager et al., 2003.

Week 5

Sept. 18 – Lecture: Evaporation over land

Sept. 20 – Lecture: Land Surface temperature and soil moisture

Sept. 22 – Student led review of: Is the Hydrologic Cycle Accelerating? A. Ohmura & M. Wild. Science, '02

Week 6

Sept. 25 – Lecture: Water vapor transport. Read: Uncertainties in Estimating Moisture Fluxes over the Intra-Americas Seas. A. Mestas-Nuñez et al., J. of Hydromet. '05

Sept. 27 – No Class

Sept. 29 – Lecture: Review of how well do we know water vapor, evapotranspiration and the transport of heat and water vapor?

#### Week 7

Oct. 2 – Lecture: Clear sky radiation. Read: An examination of the Clear Sky Solar Absorption over the Central Equatorial Pacific. Observations versus Models. Conant et al., '97

Oct. 4 – Lecture: Cloud Physical Properties

Oct. 6 – Lecture: Impact of clouds on climate

#### Week 8

Oct. 09 – Lecture: Cloud/Climate feedbacks. Read Thermodynamic regulation of ocean warming by Cirrus. Ramanathan and Collins

Oct. 10 - Students invited to sit in on annual GEWEX meeting (Boulder) to discuss latest in closure of water and energy budgets

Oct. 11 – No class

Oct. 13 – Student led discussions – Does the Earth have an Adaptive Infrared Iris? R. Lindzen et al., Bull. Amer. Met. Soc. '01.

Week 9 – No class

#### Week 10

Oct. 23 – Lecture: Comments on “Does the Earth have an adaptive Iris?”

Oct. 25 – Guest Lecture: ERA-5 Getting it and using it.

Oct. 27 – No Class

#### Week 11

Oct. 30 – Lecture: From Clouds to Precipitation

Nov. 1 – Lecture: Precipitation & the water budgets over Tropical Oceans

Nov. 3 – Student led discussion – How much more rain will Global Warming bring? Wentz, Nature 2007.

#### Week 12

Nov. 6 – Lecture: Clouds/Aerosols and Precipitation

Nov. 8 – Student project proposals and discussion

Nov. 10 – Student project proposals and discussion

#### Week 13

Nov. 13 – Lecture: Radiative/Conv. Equilibrium

Nov. 15 – Student led discussion: Observational Evidence for the Mutual Regulation of the Tropical Hydrologic Cycle and Tropical Sea Surface Temperature. Stephens et al., J. Clim. 2004

Nov. 17 – Lecture: MJO and Self similar cloud regimes

Fall Recess/Thanksgiving Holiday

Week 14

Nov. 27 – Lecture: Water/Energy storage and Ocean circulation Lecture 26:

Nov. 29 – Lecture: Water and energy storage over the Colorado River Basin

Nov. 29 – Student led discussion: The sensitivity of the tropical hydrologic cycle to ENSO. Soden, 2000.

Week 15

Dec. 4 – Lecture: Current Topics. Read Trenberth et al., 2009 & Stephens et al., 2012.

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)**

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

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.
- Mestas-Nuñez, A., C. Zhang, and D. Enfield, 2005: Uncertainties in Estimating Moisture Fluxes over the Intra-Americas Seas. *J. Hydromet.*, **6**, 696 - 709
- Conant, William C., V. Ramanathan, and Francisco P. J. Valero, 1997: An Examination of the Clear-Sky Solar absorption over the Central Equatorial Pacific: Observations vs Models., *J. Climate*, **10**, 1874-1884.
- 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.
- Wentz, F. J., L. Ricciardelli, K. Hilburn and C. Mears, 2007: How much more rain will global warming bring? *Science*, **317**, 233–235.
- 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.
- Soden, B., 2000: The sensitivity of the tropical hydrologic cycle to ENSO, *J. Clim.*, **13**, 538-549.
- 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.
- Kevin E. Trenberth, K., J. T. Fasullo, J. Kiehl, 2009: Earth's Global Energy Balance. *Bull. Amer. Met. Soc.*, **90**, 311-323
- Stephens, G. I., J. Li, M. Wild, C. A. Clayson, N. Loeb, S. Kato, T. L'Ecuyer, P. Stackhouse, M. Lebsock and T. Andrews, 2012: An update on Earth's energy balance in light of the latest global observations. *Nature Geoscience*, **5**, 691–696

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