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ATS 681 (soon to be 608)
Introduction to Climate Variability - Fall 2017

Instructor:

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TA:

None.

Office Hours:

Anytime.

Class Schedule:

Tuesday/Thursday 11:00-11:50 ATSW 121

Student Learning Goals and Objectives:

The successful student will gain a detailed graduate level process-oriented understanding of key aspects of climate variability in Earth's climate system.

Text:

Books that everyone in climate science should have on their shelves. None are required for the course.

1) Global Physical Climatology, by D.L. Hartmann, Academic Press, 2016, 2nd edition.

2) Atmospheric Science: An Introductory Survey, by J. M. Wallace and P. V. Hobbs, Second Edition, Academic Press, 483pp.

3) Vallis, G. K., 2017. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation, 2nd edn. Cambridge University Press. 946 pp. http://empslocal.ex.ac.uk/people/staff/gv219/aofd

Format:

The format of the class is lecture/discussion. The course will focus on the fundamentals of climate dynamics, with an emphasis on current themes and problems in climate research.

Evaluation:

Reading research papers/participation in class discussion: 50%
Term project: 50%

Course Outline:

- Atmospheric-ocean interaction in the tropics and extratropics
- Current topics in climate change

To be determined:

Patterns of variability in the large-scale tropical circulation, including the MJO
Patterns of variability in the large-scale extratropical circulation
Stratospheric variability, including the QBO and sudden warmings

Atmosphere-ocean interaction in the tropics and extratropics.

1. ENSO
2. Pacific decadal variability
3. Tropical Atlantic decadal variability/meridional modes
4. Extratropical atmosphere/ocean interaction

ENSO

Overview (recent review)

* Wang, C., C. Deser, J. -Y. Yu, P. DiNezio, and A. Clement, 2016: El Nino and Southern Oscillation (ENSO): A Review. *Coral Reefs of the Eastern Pacific*, P. Glymn, D. Manzello and I. Enochs, Eds., Springer Science Publisher, **4**, 85-106.
(available in print via Clara Deser's website)

Observations of ENSO (synopsis of classic work in the 80s and 90s)

Wallace, J. M., E. M. Rasmusson, T. P. Mitchell, V. E. Kousky, E. S. Sarachik, and H. v. Storch, 1998: On the structure and evolution of ENSO-related climate variability in the tropical Pacific: Lessons from TOGA. *J. Geophys. Res.*, 103, 14241-59.

Chen, X., and J.M. Wallace, 2015: ENSO-like variability: 1900-2013. J. Atmos. Sci., 28(24), 9623-9641, doi:10.1175/JCLI-D-15-0322.1.

Tropical atmospheric response to heating

***** Gill, A.E., 1980: Some simple solutions for heat-induced tropical circulation. *Quart. J. R. Met. Soc.*, **106**, 447-462.

Lindzen, R.S., Nigam, S., 1987. On the role of sea surface temperature gradients in forcing low level winds and convergence in the tropics. J. Atmos. Sci. 44, 2418–2436.

***** Chiang, J. C. H., S. E. Zebiak, and M. A. Cane, 2000: On the relative roles of elevated heating and surface temperature gradients in driving anomalous surface winds over tropical oceans. *J. Atmos. Sci.*

ENSO theory

Battisti, D.S., 1988: The dynamics and thermodynamics of a warm event in a coupled atmosphere/ocean model. *J. Atmos. Sci.*, **45**, 2889-2919.

***** Jin, F.-F., 1997: An equatorial ocean recharge paradigm for ENSO. Part I: Conceptual model. J. Atmos. Sci., 54, 811–829.

Link to extratropics

Alexander et al., 2002: The atmospheric bridge: The influence ENSO teleconnections on air-sea interaction over the global oceans. J. Climate, 15, 2205-2231.

* Deser, C., I. R. Simpson, K. A. McKinnon and A. S. Phillips, 2017: The Northern Hemisphere extra-tropical atmospheric circulation response to ENSO: How well do we know it and how do we evaluate models accordingly? *J. Climate*, **30**, 5059-5082, doi: 10.1175/JCLI-D-16-0844.1

Pacific decadal variability

***** Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. Francis, 1997: A Pacific interdecadal climate oscillation with impacts on salmon production. Bull. Amer. Meteor. Soc., 78, 1069–1079.

Zhang, Y., J.M. Wallace and D.S. Battisti, 1997: ENSO-like Interdecadal Variability: 1900-93. J. Climate, 10, 1004-20.

***** Vimont, Daniel J., David S. Battisti, and Anthony C. Hirst, 2001: Footprinting: A seasonal connection between the tropics and mid−latitudes. Geophysical research letters 28, 3923-3926.

Schneider, N., A. J. Miller, and D. W. Pierce, 2002: Anatomy of North Pacific decadal variability. J. Climate, 15, 586-605

Newman, M.,, G. P. Compo, and M. Alexander, 2003: ENSO-forced variability of the Pacific decadal oscillation. J. Climate, 16, 3853–3857.

Schneider, N., and B. D. Cornuelle, 2005: The forcing of the Pacific Decadal Oscillation. J. Climate, 18, 4355-4373.

Kwon, Y.-O. and C. Deser, 2007: North Pacific decadal variability in the Community Climate System model version 2. J. Climate, 20, 2416-2433.

* Newman, M., and Coauthors, 2016: The Pacific Decadal Oscillation, Revisited. J. Climate, 29, 4399–4427, doi:10.1175/JCLI-D-15-0508.1.

* Deser, C. and A. Phillips, 2017: An overview of decadal-scale sea surface temperature variability in the observational record. Joint Issue of CLIVAR Exchanges and PAGES Magazine, doi: 10.22498/pages. 25.1.2.

Tropical Atlantic/meridional modes

Hastenrath, S., and L. Heller, 1977: Dynamics of climatic hazards in northeast Brazil, Q. J. R. Meteorol. Soc., 103, 77–92.

Zebiak, S. E., 1993: Air-sea interaction in the equatorial Atlantic region, J. Clim., 6, 1567–1586.

* Chang, P., L. Ji, and H. Li, 1997: A decadal climate variation in the tropical Atlantic Ocean from thermodynamic air-sea interactions, Nature, 385, 516–518.

Xie, Shang-Ping, 1999: A dynamic ocean–atmosphere model of the tropical Atlantic decadal variability." Journal of Climate 12, 64-70.

* Chiang, J.C.H., and A.H. Sobel, 2002: Tropical tropospheric temperature variations caused by ENSO and their influence on the remote tropical climate. Journal of Climate, 15, 2616-2631.

Xie, Shang−Ping, and James A. Carton, 2004: Tropical Atlantic variability: Patterns, mechanisms, and impacts. Earth's Climate, 121-142.

* Chiang, J. C. H., and D.J. Vimont, 2004: Analogous Pacific and Atlantic meridional modes of tropical atmosphere-ocean variability. Journal of Climate, 17, 4143-4158 .

Kwon, Y.-O., and C. Frankignoul, 2014: Mechanisms of Multidecadal Atlantic Meridional Overturning Circulation Variability Diagnosed in Depth versus Density Space. J. Climate, 27, 9359-9376. doi: http://dx.doi.org/10.1175/JCLI-D-14-00228.1.

* Clement, A., K. Bellomo, L. N. Murphy, and M. A. Cane, 2015: The Atlantic Multidecadal Oscillation without a role for ocean circulation. Science, doi:10.1126/science.aab3980.

* O'Reilly, C. H., M. Huber, T. Woollings, and L. Zanna, 2016: The signature of low-frequency oceanic forcing in the Atlantic Multidecadal Oscillation. Geophys. Res. Lett, 43, 2810–2818, doi: 10.1002/2016GL067925.

Zhang, Honghai, Amy Clement, and Pedro Di Nezio, 2014: . The South Pacific meridional mode: A mechanism for ENSO-like variability." Journal of Climate27, 769-783.

* Zhang, R., R. Sutton, G. Danabasoglu, T. L. Delworth, W. M. Kim, J. Robson, and S. G. Yeager, 2016: Comment on "The Atlantic Multidecadal Oscillation without a role for ocean circulation." Science, 352, 1527–1527, doi:10.1126/science.aaf1660.

Zhang, R., 2017: On the persistence and coherence of subpolar sea surface temperature and salinity anomalies associated with the Atlantic multidecadal variability. Geophys. Res. Lett, 41, 2133–11, doi:10.1002/2017GL074342.

Extratropical atmosphere/ocean interaction

* Bretherton, C. S., D. S. Battisti, 2000: An interpretation of the results from atmospheric general circulation models forced by the time history of the observed sea surface temperature distribution. Geophys. Res. Lett., 27, 767-770.

* Marshall, J., H. Johnson, and J. Goodman, 2001: A study of the interaction of the North Atlantic Oscillation with ocean circulation. J. Climate, 14, 1399-1421.

Kushnir, Y., W. A. Robinson, I. Bladé, N. M. J. Hall, S. Peng, and R. Sutton, 2002: Atmospheric GCM response to extratropical SST anomalies: Synthesis and evaluation. J. Climate, 15, 2233–2256

* Nakamura, H., T. Sampe, A. Goto, W. Ohfuchi, and S. P. Xie, 2008: On the importance of midlatitude oceanic frontal zones for the mean state and dominant variability in the tropospheric circulation. Geophysical Research Letters, 35, L15709, doi:10.1029/2008GL034010.

Chelton, D. B., and S. P. Xie, 2010: Coupled Ocean-Atmosphere Interaction at Ocean Mesoscales. Oceanography, 23, 52-69.

* Minobe, S., A. Kuwano-Yoshida, N. Komori, S.-P. Xie, and R. J. Small, 2008: Influence of the Gulf Stream on the troposphere. Nature, 452, 206–209.

* Brayshaw, D. J., B. Hoskins, and M. Blackburn, 2008: The storm- track response to idealized SST perturbations in an aqua- planet GCM. J. Atmos. Sci., 65, 2842–2860.

Kwon, Y.-O., M.A. Alexander, N.A. Bond, C. Frankignoul, H. Nakamura, B. Qiu, L. Thompson, 2010: Role of Gulf Stream and Kuroshio-Oyashio Systems in Large-Scale Atmosphere-Ocean Interaction: A Review. J. Climate, 23, 3249–3281.