Global Warming Dynamics

SIO 209 (2 units), winter quarter, 2014

Time: Tuesday 11:00 am – 12:20 pm; **place**: Nierenberg Hall 101
Instructor: Shang-Ping Xie, MESOM 323; Tel: 822-0053; sxie@ucsd.edu;
Class website: http://ted.ucsd.edu

The intergovernmental Panel on Climate Change is to release its fifth assessment report (AR5) in January 2014. What is in the report? How can the world avoid the dangerous 2^{o}C warming? What are the major scientific advances since AR4 (2007)? Specifically what does the report say about the role of ocean beyond the thermal inertia effect? The last question leads us to focus on regional climate change, for which ocean-atmospheric dynamics is important. Regional projections of future changes (e.g., in precipitation) are crucial for adaptation and represent a grand challenge for climate science that raises new questions for physical oceanography and atmospheric dynamics. The class discusses key recent papers that form the basis of AR5.

Class meets once a week. In the first two weeks, lectures will be given to introduce important concepts (radiative forcing, climate feedback, detection and attribution), and to highlight important results in key chapters. In each of the following weeks a core paper for a topic in the list below is presented and discussed, followed by a mini-review of related research/applications by the instructor or a participant. Students should read the core paper before and participate in the discussion during the class. They should present 1-2 core papers during the quarter. Registered students will receive two-unit credit.

Learning objectives: to gain an understanding of IPCC assessment process, key findings of the AR5, multi-model analysis, and latest developments in climate change science, especially regarding ocean's role.

Grading: letter or S/U. Class presentation 40%, participation 40%, and seminar reports 20%. Submit a report (1-2 pages each) on a seminar you are not presenting, and discuss the background, major findings, significance, and implications of the paper(s).

List of topics. Corresponding AR5 sections are denoted in Italic (e.g., 14.3 refers to Chapter 14, section 3). The pdf files for AR5 chapters are available at http://www.climatechange2013.org/report/review-drafts/. Most topics concern ocean effects. Please choose topics you'd like to present and e-mail me your first and second choices. Also feel free to suggest topics not on the list (e.g., *12.4.3.1 Patterns of Surface Warming: Land-Sea Contrast, and Polar Amplification*). If more than one references are listed, the topical presenter needs to narrow down to one core paper and inform the reading group of the choice one week in advance. Only a subset of the topics will be covered because of time constraints.

Energy budget & ocean heat content: *AR5 Box 13.1, TS TFE.4 The Changing Energy Budget of the Global Climate System*

Church, J. A. et al. (2011), Revisiting the Earth's sea-level and energy budgets from 1961 to 2008, *Geophys. Res. Lett*., 38, *L18601, doi:*10.1029/2011GL048794.

Cumulative carbon and climate warming: *12.5.4 Climate Stabilization and Long-Term Climate Targets*

Allen, M., D. Frame, C. Huntingford, C. Jones, J. Lowe, M. Meinshausen, and N. Meinshausen, 2009: Warming caused by cumulative carbon emissions towards the trillionth tonne. *Nature*, 458, 1163–1166.

Matthews, H., N. Gillett, P. Stott, and K. Zickfeld, 2009: The proportionality of global warming to cumulative carbon emissions. *Nature*, 459, 829–832.

Zickfeld, K., M. Eby, H. Matthews, and A. Weaver, 2009: Setting cumulative emissions targets to reduce the risk of dangerous climate change. *Proc. Natl. Acad. Sci. USA*, 106, 16 129–16 134.

Gillett, N. P., V. K. A., D. Matthews, and M. R. Allen, 2013: Constraining the Ratio of Global Warming to Cumulative CO2 Emissions Using CMIP5 Simulations. *J. Climate*, **26**, 6844–6858.

Cloud feedback, *12.4.3.5 Clouds*

Zelinka, M. D., and D. L. Hartmann (2010), Why is longwave cloud feedback positive? *J. Geophys. Res*., 115, D16117, doi:10.1029/2010JD013817.

Zelinka, M., S. Klein, and D. Hartmann, 2012: Computing and partitioning cloud feedbacks using cloud property histograms. Part II: Attribution to changes in cloud amount, altitude, and optical depth. *J. Climate*, **25**, 3736-3754.

Sources of projection uncertainties: *11.3.1.1 Uncertainty in Near-Term Climate Projections*

Hawkins, E., and R. Sutton, 2009: The potential to narrow uncertainty in regional climate predictions. *Bull. Amer. Meteorol. Soc.*, 90, 1095, doi: 10.1175/2009BAMS2607.1.

Interference by natural variability

Wallace, J.M. C. Deser, B.V. Smoliak, and A.S. Phillips, 2013: Attribution of climate change in the presence of internal variability, In *Climate Change: Multidecadal and Beyond* (Eds: C.P. Chang, M. Ghil, M. Latif, and J. M. Wallace). World Scientific Series on Asia-Pacific Weather and Climate, Vol. 6, in press. http://www.cgd.ucar.edu/staff/cdeser/docs/WDSP_BookChapter.pdf

Global warming hiatus: *Box 9.2: Climate Models and the Hiatus in Global-Mean Surface Warming of the Past 15 Years*

Fyfe et al. 2013, Overestimated global warming over the past 20 years. Nature Climate Change 3, 767-769.

Kosaka, Y., and S.-P. Xie, 2013: Recent global-warming hiatus tied to equatorial Pacific surface cooling. *Nature*, 501, 403-407.

Geo-engineering; CO2 vs. solar forcing: *7.7 Solar Radiation Management and Related Methods*

Schmidt, H. et al. 2012: Solar irradiance reduction to counteract radiative forcing from a quadrupling of CO_2: climate responses simulated by four earth system models, *Earth Syst. Dynam*., 3, 63-78, doi:10.5194/esd-3-63-2012.

Fast and slow climate response to CO2 increase

Held, I. M., M. Winton, K. Takahashi, T. Delworth, F. Zeng, and G. K. Vallis, 2010. Probing the fast and slow components of global warming by returning abruptly to preindustrial forcing. *J. Climate*, **23**: 2418–2427.

Ocean warming pattern: *14.3.0 Tropical phenomena*

Manabe, S., and R.J. Stouffer, 2007. Role of ocean in global warming. *J. Met. Soc. Japan*, **85B**: 385-403.

Xie, S.-P., C. Deser, G.A. Vecchi, J. Ma, H. Teng, and A.T. Wittenberg, 2010: Global warming pattern formation: Sea surface temperature and rainfall. *J. Climate*, 23, 966-986.

Lu, J. and Zhao, B., 2012. The oceanic feedback in the climate response to doubling CO_2. *J. Clim*ate **25**: 7544–7563, doi: 10.1175/JCLI-D-11-00712.1.

Precipitation change: Global perspective. *7.6 Processes Underlying Precipitation Changes, 12.4.5.2 Patterns of Projected Average Precipitation Changes*

Vecchi, G. A., and B. J. Soden, 2007. Global warming and the weakening of the tropical circulation. *J. Climate*, **20**: 4316–4340.

Precipitation change: regional perspective. *14.3.0-1 Tropical phenomena*

Seager, R., Naik, N. & Vecchi, G., 2010: Thermodynamic and dynamic mechanisms for large scale changes in the hydrological cycle in response to global warming. J. Clim. 23, 4651-4668.

Ma, J., and S.-P. Xie, 2013: Regional patterns of sea surface temperature change: A source of uncertainty in future projections of precipitation and atmospheric circulation. *J. Climate*, 26, 2482-2501.

Ocean salinity change: *3.3 Changes in Salinity and Freshwater Content*; *10.4.2 Ocean Salinity and Freshwater Fluxes*

Durack, P., S. Wijffels, and R. Matear, 2012: Ocean salinities reveal strong global water cycle intensification during 1950 to 2000. *Science*, **336**, 455-458.

Hadley cell broadening, *11.3.2.4.3 Tropical circulation*

Lu, J., G. Vecchi, and T. Reichler, 2007: Expansion of the Hadley cell under global warming. *Geophysical Research Letters*, doi:10.1029/2006GL028443, L06805.

Decadal Prediction, *11.2 Near-Term Predictions*

Doblas-Reyes, F. J., et al., 2013: Initialized near-term regional climate change prediction. *Nature Comms*, **4**, 1715-.

Corti, S., A. Weisheimer, T.N. Palmer, F. J. Doblas-Reyes, and L. Magnusson, 2012: Reliability of decadal predictions. *Geoph. Res. Lett.*, doi:10.1029/2012GL053354.

ENSO: *14.4 El Nino-Southern Oscillation*

Stevenson, S. L., 2012. Significant changes to ENSO strength and impacts in the twenty-first century: Results from CMIP5, *Geophys. Res. Lett.*, **39**, L17703, doi:10.1029/2012GL052759.

Seager, R., N. Naik(Henderson) and L. Vogel, 2012: Does global warming cause intensified interannual hydroclimate variability? *J. Climate*, **25**: 3355-3372.

Indian Ocean: *14.3.3 Indian Ocean modes*

Zheng, X.-T., S.-P. Xie, Y. Du, L. Liu, G. Huang, and Q. Liu, 2013: Indian Ocean Dipole response to global warming in the CMIP5 multi-model ensemble. *J. Climate*, 26, 6067-6080, doi:10.1175/JCLI-D-12-00638.1.

Cai, W., X.-T. Zheng, E. Weller, M. Collins, T. Cowan, M. Lengaigne, W. Yu & T. Yamagata, 2013: Projected response of the Indian Ocean Dipole to greenhouse warming. *Nature Geosci*., 6, 999–1007.

Tropical cyclones: *14.6.1 Tropical Cyclones*

Knutson, T.R., J.J. Sirutis, S.T. Garner, G.A. Vecchi and I.M. Held, 2008. Simulated reduction in Atlantic hurricane frequency under twenty-first-century warming conditions. *Nature Geosci.*, **1**: 359-364.

Knutson et al. 2010, Tropical cyclones and climate change, *Nature Geosci.*, 3, 157 – 163.

Extratropical storms: *12.4.4.3 Extratropical Storms: Tracks and Influences on Planetary-Scale Circulation and Transports; 14.6.2 Extra-Tropical Cyclones*

Chang, E. K. M., Y. Guo, and X. Xia (2012a), CMIP5 multimodel ensemble projection of storm track change under global warming, *J. Geophys. Res*., 117, D23118, doi:10.1029/2012JD018578.

Chang, E. K. M., Y. Guo, X. Xia, and M. Zheng, 2012b: Storm track activity in IPCC AR4/CMIP3 model simulations. *J. Climate*, **26**, 246-260.

Regional sea level change: *13.6 Regional Sea Level Changes*

Yin, J. J., S. M. Griffies, and R. J. Stouffer, 2010: Spatial variability of sea level rise in twenty-first century projections. *J. Climate*, **23**, 4585-4607.

Timmermann, A., S. McGregor, and F.-F. Jin, 2010. Wind effects on past and future regional sea level trends in the southern Indo-Pacific. *J. Climate*, **23**: 4429–4437.