Summer 2020

GFDL BULLETIN

Research Highlights from the Geophysical Fluid Dynamics Laboratory Community

Advancing the Modeling, Understanding, and Prediction of Weather and Climate

DETECTED CLIMATE CHANGE IN GLOBAL DISTRIBUTION OF TROPICAL CYCLONES

Proceedings of the National Academy of Sciences

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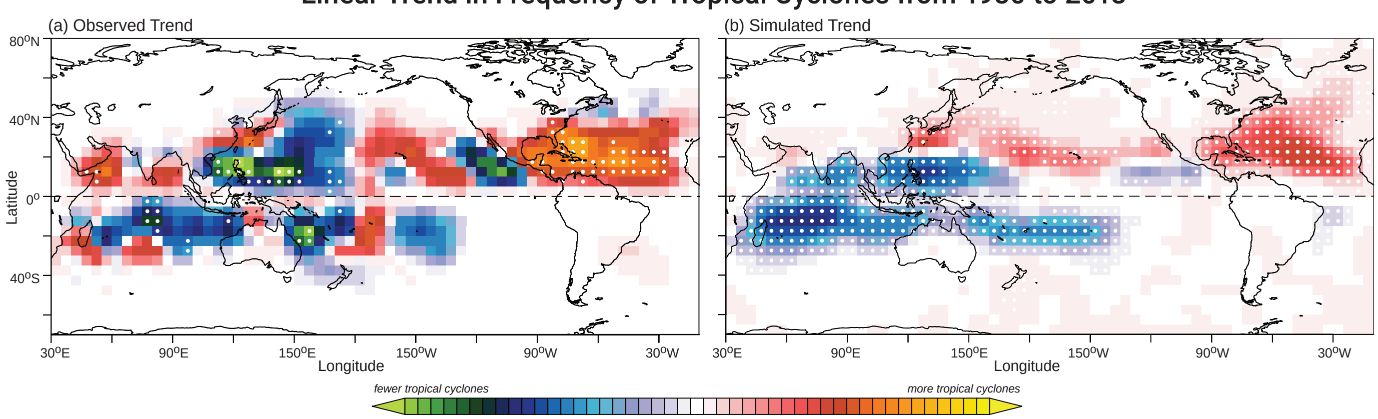
Although global mean temperature has been rising since the mid-twentieth century and can be attributed mainly to increases in emissions of greenhouse gases, the annual number of global tropical cyclones (TCs) has remained steady at around 86 since 1980. This study by GFDL scientists reveals that the effect of climate change on TC activity is more evident in the spatial distribution pattern, rather than the overall number of global TCs. The total effect of anthropogenic greenhouse gases and aerosols, and solar irradiance and volcanic eruptions on global TC distribution is not spatially homogeneous. Increases and decreases in TC occurrence depend on the region.

Increases in the frequency of TC occurrence in the North Atlantic, Central Pacific, and Arabian sea are evident. Conversely, significant decreases in the South Indian Ocean, as well as the Western Pacific, can be seen. Using a suite of high-resolution dynamical model experiments, the authors demonstrate for the first time that the observed spatial pattern in trends cannot be explained only by underlying multi-decadal natural variability, but external forcing such as greenhouse gases, aerosols, and volcanic eruptions likely played an important role.

The authors conducted these simulations with FLOR (currently used for real-time seasonal predictions for the North American Multimodel Ensemble, NMME) and SPEAR, the next generation model developed at GFDL for the NMME. SPEAR shows less systematic biases in the large-scale variables than FLOR, which leads to even better simulation of TCs.

OAR Goals: Drive Innovative Science

Linear Trend in Frequency of Tropical Cyclones from 1980 to 2018



Climate Change has influenced the location of where tropical cyclones have become more frequent, or less frequent

Panel (a) depicts the global pattern of locations where the frequency of tropical cyclones has increased and where it has decreased around the world from 1980 to 2018. Panel (b), as in (a), but for the global pattern simulated by the GFDL SPEAR and FLOR large-ensemble simulations (units: number per year per 5x5 degree grid cell). The white dot indicates the linear trend is statistically significant at the 95% level.

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MULTIPLE HYDROMETEORS ALL-SKY MICROWAVE RADIANCE ASSIMILATION IN FV3GFS

Monthly Weather Review

Mingjing Tong[1,2], Yanqiu Zhu[3], Linjiong Zhou[1,4], Emily Liu[5], Ming Chen[6], Quanhua Liu[7], Shian-Jiann Lin[1]

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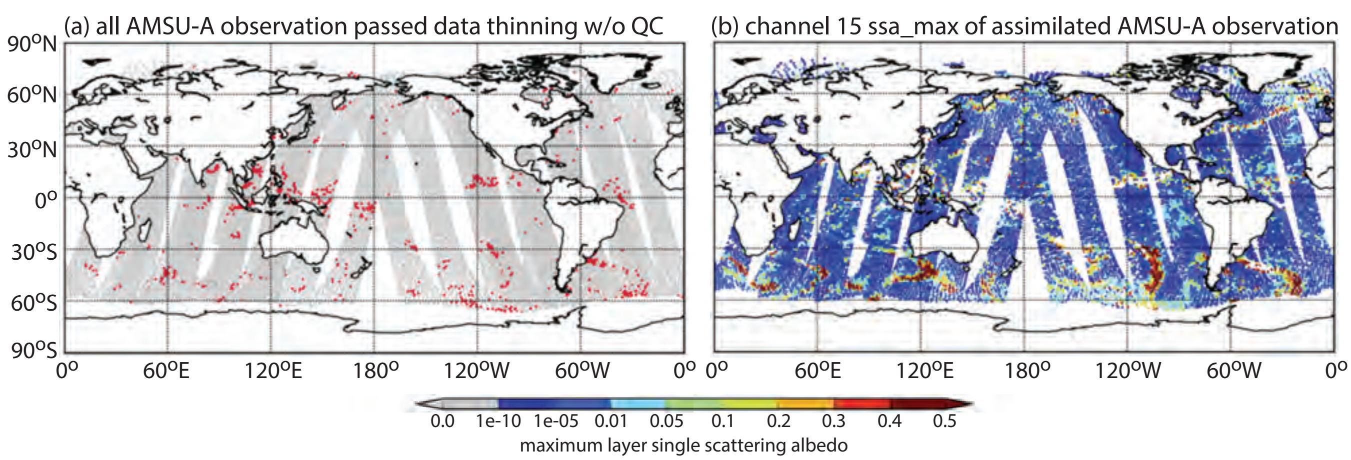
GFDL scientists have collaborated with colleagues from NOAA's National Center for Environmental Prediction and National Environmental Satellite, Data and Information Service to improve model forecast skill in the operational Global Forecast System (GFS), by enhancing data assimilation to make full use of satellite radiance observations under all-sky conditions. Current operational GFS is constrained in assimilating precipitation-affected radiances because of the limitations of the all-sky framework.

This new work represents a major upgrade to the microwave radiance assimilation and is capable of implementation in future versions of the operational GFS. Cloud liquid water, cloud ice, rain, snow and graupel are the new analysis variables that can be updated through direct assimilation of radiances from satellite observations. The implementation of the more advanced GFDL six-category cloud microphysics in GFS, and improved radiative transfer modeling, make it possible to assimilate radiances without empirically distinguishing between observed cloudy and precipitation conditions, an important physics-based advancement.

The upgraded all-sky radiance assimilation framework produces neutral to positive impact on overall forecast skill. Significant improvement was found in the large-scale forecast skill and lower-tropospheric temperature out to five days. This research reveals biases in the current forecast model and radiative transfer operator, indicating that additional research on sub-grid clouds and improved radiative transfer modeling of hydrometeor properties can further improve forecasts.

OAR Goals: Make Forecasts Better, Drive Innovative Science

Data Usage in the Original and New All-Sky Framework and Precipitation Conditions in the Model Forecast



(a) Locations of all AMSU-A satellite observations (including NOAA-15, NOAA-18, NOAA-19, and MetOp-A) that passed data thinning without quality control being applied at 0000 UTC 15 Jul 2017. Observations detected as precipitation conditions are shown in red. These observations are rejected in the original all-sky framework but are kept for potential assimilation in the new all-sky framework.

(b) AMSU-A channel 15 maximum layer single-scattering albedo of assimilated observations in the new all-sky framework. The warmer the color indicates larger precipitating particles (rain, snow and graupel). It is likely that the detection criteria in the old framework misinterprets some precipitation conditions. If the precipitation is misinterpreted, the resulting cloud, temperature, and humidity fields in the analysis can be incorrect. In the upgraded framework, there is no need to distinguish precipitation and non-precipitation conditions. More observations can be assimilated and the model is then more appropriately matched with the radiance observations.

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SUSCEPTIBLE SUPPLY LIMITS THE ROLE OF CLIMATE IN THE EARLY SARS-CoV-2/COVID-19 PANDEMIC

Science

Rachel E. Baker[1,2], Wenchang Yang[3], Gabriel A. Vecchi[1,3], C. Jessica E. Metcalf[2,4], Bryan T. Grenfell[2,4,5]*

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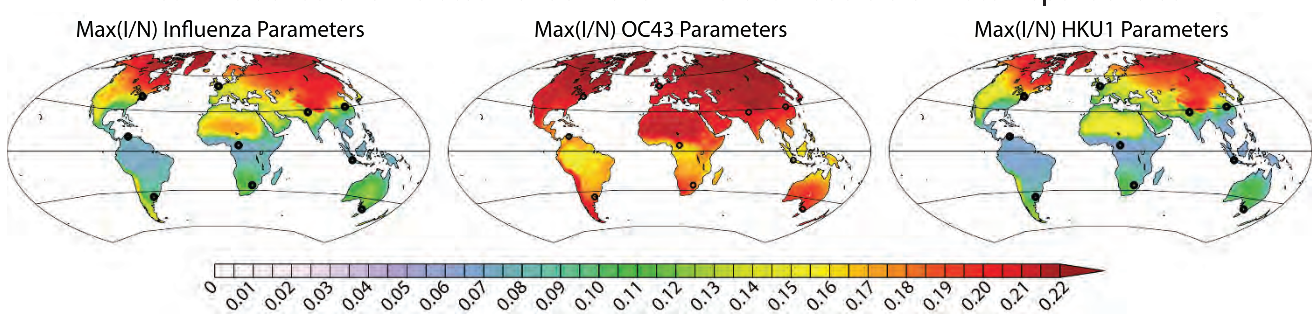
Recently published research shows that local climate is not likely to have much influence on the spread of COVID-19. Researchers found that warmer or more humid climates will not slow the virus at the early stages of the pandemic. The vast number of people vulnerable to an emerging pathogen, and the speed at which it can spread are the core drivers. Climate conditions are likely to have only a minor influence on the size and timing of the pandemic.

An interdisciplinary team of scientists from Princeton University and the National Institutes of Health used a climate-dependent epidemic model to simulate the pandemic, probing different scenarios based on what is known about the role seasonal variations have on the occurrence of similar viruses. In these simulations, climate became a mitigating factor only when large portions of the human population were immune or resistant to the virus. For all climate regimes in the planet we see the development of an epidemic independent of the climate-dependence of the pathogen. Experience with other viruses suggests that, without a vaccine or other control measures, COVID-19 will likely only become responsive to seasonal changes after the supply of unexposed hosts is reduced. A simulation that accounted for the impact of control measures such as social distancing suggested that the longer these measures are in place and slow the transmission of COVID-19, the more sensitive the virus becomes to warmer weather. The study has broader implications for refining the integration of meteorological information into understanding disease outbreaks.

**Funded in part out of Task III of the NOAA/GFDL – Princeton Cooperative Agreement.*

OAR Goals: Drive Innovative Science

Peak Incidence of Simulated Pandemic for Different Plausible Climate Dependencies



Model results showing the proportion infected (I = infected/N = population) at the peak of the simulated epidemic for all global locations. The three maps show different scenarios of climate-dependence based on influenza and two Beta Coronaviruses: OC43 and HKU1. The fraction of the population that is infected at any particular point in time is one measure of intensity of infection, and will, in an approximate sense, represent a strain on society among other factors. Since the climate dependence of SARS-CoV2 is not known directly, and because the epidemic has a number of factors that make detecting such an effect problematic, this study used two other Beta Coronaviruses that are endemic in the US (HKU1 and OC43) and influenza, for which we can estimate the range of plausible climate dependence. (The black circles represent cities that are explored in more detail in the paper).

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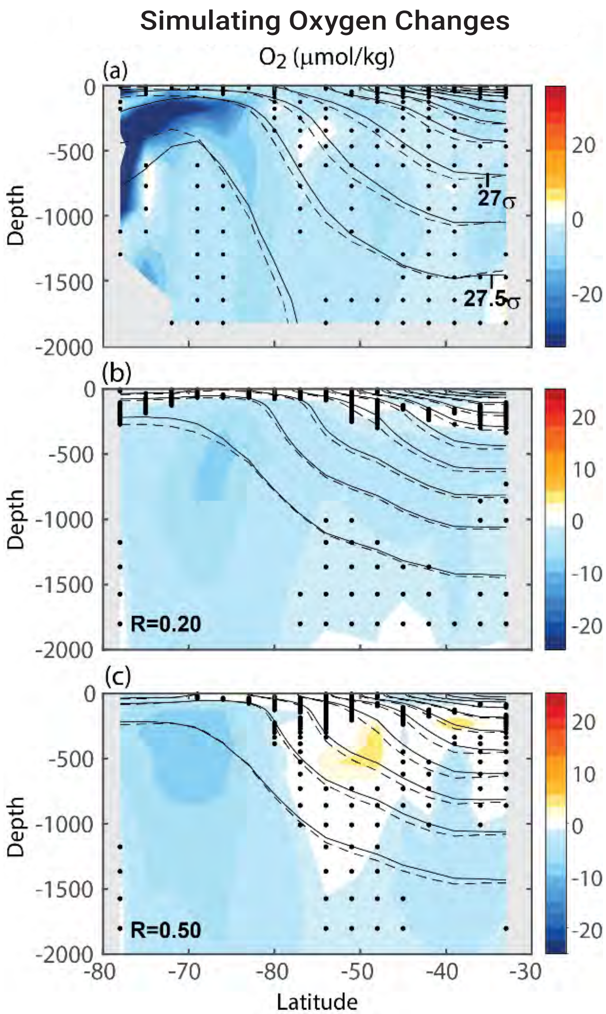
GFDL SCIENTISTS IN THE SPOTLIGHT

Rong Zhang

has been selected by the American Meteorological Society to deliver the **Bernhard Haurwitz Lecture**, for advancing scientific understanding of the causes and impacts of Atlantic multidecadal variability and Arctic sea ice variations through insightful analysis of models and observations.

IMPORTANCE OF WIND AND MELTWATER FOR OBSERVED CHEMICAL AND PHYSICAL CHANGES IN THE SOUTHERN OCEAN



Nature Geosciences

Bronselaer, B.[1,2,3], Russell, J.L.[1], Winton, M.[2], Williams, N.L.[4], Key, R.M.[3], Dunne, J.P.[2], Feely, R.A.[5], Johnson, K.S.[6], Sarmiento, J.L.[3]

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The Southern Ocean (south of 30° S) represents only one-third of the total ocean area, yet absorbs half of the total ocean anthropogenic carbon and over two-thirds of anthropogenic heat going into the oceans. The Southern Ocean has also been one of the most sparsely measured regions of the global ocean. Pre-2005 ocean shipboard measurements were used alongside new (2014-2019) observations from autonomous floats with biogeochemical sensors (courtesy of the joint NOAA-NSF Southern Ocean Carbon and Climate Observations and Modeling project) to calculate changes in Southern Ocean temperature, salinity, pH, nitrate, dissolved inorganic carbon and oxygen over recent decades. Over this period, warming and salinification were found near the Antarctic coast and isopycnals (lines of constant density) were found to deepen between 65° and 40° S. Deoxygenation and increased nitrate was found along the Antarctic coast but reduced deoxygenation and nitrate concentrations where isopycnals deepened farther north. Simulations with GFDL Earth System Model version 2M (ESM2M) demonstrate the importance of recent changes in Southern Ocean wind and meltwater forcings to the observed physical and biogeochemical trends.

OAR Goals: Detect Changes in the Ocean and Atmosphere

Fig.(left): Zonal mean differences in oxygen concentration as a function of depth *(a) between 2014-to-2019 SOCCOM float data and pre-2005 shipboard data, (b) simulated by historical ensemble of GFDL ESM2M (correlation coefficient 0.2), and (c) simulated with augmentation of forcing to represent Antarctic freshwater input and Southern Ocean wind stress trends (correlation coefficient 0.5). Contours are lines of constant density in the earlier (solid) and recent (dashed) period. Stippling indicates where differences are not significant at the 90% level.*

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The bibliography contains professional papers by GFDL scientists and collaborators from 1965 to present day. You can search by text found in the document title or abstract, or browse by author, publication, or year. Princeton University's Atmospheric and Oceanic Sciences Program Ph.D. dissertations are also listed.

Erratum: *Andrew Wittenberg was inadvertently omitted and Paul Ginoux inadvertently included in the list of the GFDL scientists who form six of the 12 NOAA scientists with the highest citations in Geosciences, as determined by Clarivate Analytics.*