Physical Sciences Laboratory (PSL) Publication Report

July through September 2025

17 articles, 2 reports, 0 datasets

A list of PSL-affiliated articles, datasets, and reports with abstracts, plain language summaries, or significance statements from FY25 Q4. Listed alphabetically by lead author. PSL-affiliated authors at time of publication in **bold.**

July 2025

ARTICLES

Bao, F., H. G. Chipilski, S. Liang, G. Zhang and **J. S. Whitaker** (2025). Nonlinear ensemble filtering with diffusion models: Application to the surface quasi-geostrophic dynamics. *Mon. Wea. Rev.*, 153, 1155–1169, https://doi.org/10.1175/MWR-D-24-0069.1.

> It is hard to overstate the crucial role that the field of artificial intelligence (AI) has played in the weather and climate enterprise. Considerable progress in the last few years has come from a particular area known as generative AI (GenAI). In this work, we borrow ideas from a popular GenAI technique known as diffusion models to explore a new data assimilation (DA) method which can extract useful information from complex (nonlinear) observation types like satellite data. We implement an efficient (training free) version of the resulting algorithm [ensemble score filter (EnSF)] in a benchmark model of geophysical turbulence. In the case of assimilating nonlinear observations and dealing with unknown model errors, EnSF demonstrates improvements against a popular DA method used in operations [local ensemble transform Kalman filter (LETKF)]. These improvements in EnSF occur without any additional fine-tuning efforts or the application of standard regularization techniques such as localization.

Chen, X, **J. Dias**, **B. Wolding**, P. N. Blossey, C. DeMott, R. Pincus and **E. J. Thompson** (2025). Impacts of Weak Sea Surface Temperature Warm Anomalies on Trade Wind Cloudiness in Large Eddy Simulations. *Journal of Advances in Modeling Earth Systems*, 17, e2024MS004778, https://doi.org/10.1029/2024MS004778.

> We use a high-resolution computer model to study how shallow puffy clouds in the trade wind environment (trade cumulus) respond to a few tenths of a degree increase in sea surface temperature locally, similar to having a tiny "heat island" in the ocean. The computer simulations are set up with the mean atmosphere and ocean conditions experienced during the Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign, which took place near Barbados in early 2020. By comparing simulations with and without a tiny ocean "heat island," we find that trade cumulus cloudiness below 1 km is consistently increased over the ocean "heat island" because of the stronger buoyancy-driven turbulence. As winds carry air across the warmer sea surface, the stronger buoyancy-driven turbulence lifts more surface moisture to the critical height where water vapor condenses, leading to more frequent formation of shallow trade cumulus clouds. Our model results align with recent satellite observations and help to explain how sea surface temperature perturbations can contribute to cloud formation.

Kiladis, G. N., J. R. Albers and J. Dias (2025). Dependence of the Structure of Stratospheric Kelvin and Mixed Rossby–Gravity Waves on the QBO Basic-State Flow. *J. Atmos. Sci.*, 82, 1249-1266, https://doi.org/10.1175/JAS-D-24-0243.1.

> The quasi-biennial oscillation (QBO) is a roughly 28-month cycle of wind reversals along the equator in the stratosphere. The QBO is an important potential source of forecast skill on the weekly and longer time scale. Kelvin and mixed Rossby–gravity waves are types of stratospheric disturbances that are known to force the QBO. Atmospheric forecast and climate models have difficulty in simulating these disturbances and the QBO itself. In this paper, we provide an assessment of the statistical structure of Kelvin and mixed Rossby–gravity waves in observations and describe a previously undocumented form of the mixed Rossby–gravity wave that occurs during extreme easterly QBO phases. These statistical results will provide guidance for improving models' representation of these critically important disturbances.

Kuo, Y.-N., F. Lehner, I. R. Simpson, C. Deser, A. S. Phillips, **M. Newman**, **S.-I. Shin**, S. Wong and J. Arblaster (2025). Recent Southwestern U.S. drought influenced by anthropogenic aerosols and tropical ocean warming. *Nat. Geosci.*, 18, 578-585, https://doi.org/10.1038/s41561-025-01728-x.

> The southwestern United States is currently in a multi-decade drought that has developed since a precipitation maximum in the 1980s. While anthropogenic warming has made the drought more severe, it is the decline in winter–spring precipitation that has had a more profound effect on water resources and ecosystems. This precipitation decline is not well understood beyond its attribution to the post-1980 La Niña-like cooling trend in tropical sea surface temperatures, which caused a North Pacific anti-cyclonic atmospheric circulation trend conducive to declining precipitation in the southwestern United States. Using a hierarchy of model simulations, we show that, even under El Niño-like sea surface temperature trends, there is a tendency towards a North Pacific anti-cyclonic circulation trend and declining precipitation in the southwestern United States, counter to the canonical El Niño teleconnection. This unintuitive yet robust circulation change arises from non-additive responses to tropical mean sea surface temperature warming and radiative effects from anthropogenic aerosols. The post-1980 period exhibits the fastest southwestern US soil moisture drying among past and future periods of similar length due to the combination of this forced precipitation decline and anthropogenic warming. While the precipitation trend might reverse due to future projected El Niño-like warming and aerosol emissions reduction, it is unlikely to substantially alleviate the currently projected future drought risk.

Moore, B. J., **K. M. Mahoney** and **M. Abel** (2025). Extreme wet spells in the Upper Colorado River Basin during the cool season. *J. Hydrometeor.*, 26, 951–973, https://doi.org/10.1175/JHM-D-24-0125.1.

> This study investigates extreme wet spells—periods of precipitation that result in exceptional accumulations—over the upper Colorado River basin during the cool season. These spells contribute substantially to cool-season precipitation totals and snowfall accumulations in the basin, especially at high-altitude locations, and, thus, exert a strong influence on the regional hydroclimate. Extreme wet spells typically last for >5 days and tend to occur in persistent weather patterns that feature the successive passage of multiple storm systems, often accompanied by inland moisture transport from the Pacific, over the western United States. The findings of this study may have utility for prediction and could provide context for future research on precipitation processes and predictability in the upper Colorado River basin.

Perovich, D., . . ., **D. Clemens-Sewall**, . . ., **C. J. Cox**, . . ., **M. D. Shupe**, et al. (2025). Theoretical estimates of light transmittance at the MOSAiC Central Observatory. *Elementa: Science of the Anthropocene*, 13 (1), 00076, https://doi.org/10.1525/elementa.2024.00076

> Light transmission through a sea ice cover has strong implications for the heat content of the upper ocean, the magnitude of bottom and lateral ice melt, and primary productivity in the ocean. Light transmittance in the vicinity of the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) Central Observatory was estimated by driving a two-stream radiative transfer model with physical property observations. Data include point and transect observations of snow depth, surface scattering layer thickness, ice thickness, and pond depth. The temporal evolution of light transmittance at specific sites and the spatial variability along transect lines were computed. Ponds transmitted 4–6 times as much solar energy per unit area as bare ice. On July 25, ponds covered about 18% of the area and contributed roughly 50% of the sunlight transmitted through the ice cover. Approximating the transmittance along a transect line using average values for the physical properties will always result in lower light transmittance than finding the average light transmittance using the full distribution of points. Transmitted solar energy calculated using the standard five ice thickness categories and three surface types used in the Los Alamos sea ice model CICE, the sea ice component of many weather and climate models, was only about 1 W m^{-2} less than using all the points along the transect. This minor difference suggests that the important processes and resulting feedbacks relating to solar transmittance can be represented in models that use five or more categories of ice thickness distributions.

Stone, Z., . . ., **G. N. Kiladis**, . . ., **V. Maithel**, et al. (2025). The Organization of Tropical East Pacific Convection (OTREC) Field Campaign—Five Years Later. *Bull. Amer. Meteor. Soc.*, 106, E1264–E1275, https://doi.org/10.1175/BAMS-D-24-0134.1

> Studying convection, which is one of the least understood physical mechanisms in the tropical atmosphere, is very important for weather and climate predictions of extreme events such as storms, hurricanes, monsoons, floods, and hail. Collecting more observations to do so is critical. It is also a challenge. The Organization of Tropical East Pacific Convection (OTREC) field project took place in the summer of 2019. More than thirty scientists and twenty students from the United States, Costa Rica, Colombia, México, and the United Kingdom were involved in collecting observations over the ocean (east Pacific and Caribbean) and land (Costa Rica, Colombia). We used the NSF NCAR Gulfstream V airplane to fly at 13-km altitude sampling the tropical atmosphere under diverse weather conditions. The plane was flown in a "lawnmower" pattern and every 10 min deployed dropsondes that measured temperature, wind, humidity, and pressure from the flight level to the ocean. Similarly, over the land, we launched radiosondes, leveraged existing radars, and surface meteorological networks across the region, some with collocated global positioning system (GPS) receivers and rain sensors, and installed a new surface GPS meteorological network across Costa Rica, culminating in an impressive systematic dataset that when assimilated into weather models immediately gave better forecasts. We are now closer than ever in understanding the environmental conditions necessary for convection as well as how convection influences extreme events. The OTREC dataset continues to be studied by researchers all over the globe. This article aims to describe the lengthy process that precedes science breakthroughs.

REPORTS

Nakamura, H., . . ., **L. C. Slivinski,** et al. (2025).Toward future reanalyses that meet evolving needs in science, public services, policy making and socio-economic activity. *Bull. Amer. Meteor. Soc.,* 106, E1445–E1453, https://doi.org/10.1175/BAMS-D-25-0126.1

> The Sixth World Climate Research Program (WCRP) International Conference on Reanalysis (ICR6) took place in Tokyo from 28 October to 1 November 2024 and brought together reanalysis producers, observation data providers, numerical modelers, and members of the user community to discuss progress, applications, challenges, and future priorities in the field. The ultimate aim was to guide the development and use of reanalysis data in science, public services, policymaking, and socioeconomic activity.

Xue, Y., . . ., **P. Pegion**, . . ., **J. S. Whitaker**, et. al. (2025). Advancing NOAA's Subseasonal and Seasonal Applications and Enhancing Collaboration among Stakeholders, Modelers, and Researchers. *Bull. Amer. Meteor. Soc.*, 106, https://doi.org/10.1175/BAMS-D-25-0060.1

> Hosted by the Office of Science and Technology Integration (OSTI) Modeling Program in the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA), the first annual NOAA's Subseasonal and Seasonal (S2S) Applications Workshop provided a forum for about 330 participants (in-person and virtual) to discuss recent advances in NOAA's global S2S applications, compile stakeholder requirements and needs and use cases of those applications in developing forecast products/outlooks and downstream applications, and share experience and insights from S2S modeling systems such as those in the North American Multimodel Ensemble (NMME) and at the European Centre for Medium-Range Weather Forecasts (ECMWF) and Environment and Climate Change Canada (ECCC). The workshop discussed in depth the challenges and progress that NOAA has made in the past 5 years in developing the next-generation subseasonal Global Ensemble Forecast System (GEFSv13) and Seasonal Forecast System (SFSv1) under the Unified Forecast System (UFS) framework. The workshop aimed to identify essential points of engagement and collaboration across the S2S community and promote the formation of best practices and strategies in the development and implementation of operational S2S forecast systems through collaborative research and development endeavors.

August 2025

ARTICLES

Agarwal, N., D. E. Amrhein and I. Grooms (2025). Cross-attractor transforms: Improving forecasts by learning optimal maps between dynamical systems and imperfect models. *Geophys. Res. Lett.,* 52, e2024GL110472, https://doi.org/10.1029/2024GL110472.

> Modeling and forecasting natural systems, such as Earth's oceans and atmosphere, is difficult due to their inherent unpredictability, our incomplete understanding of their dynamics, and their vastness and complexity. One way to improve forecasts is by improving physical representations within numerical models. However, models will always have shortcomings. The alternative approach explored here is to maximize the utility of available imperfect or incomplete models by revising how the model is used and how its forecast is interpreted. Here, we employ machine learning to learn pre- and post-processing operators, called cross-attractor transforms (CATs), which reduce the overall forecast errors from imperfect models. We demonstrate the framework's efficacy by using a simplified dynamical model as an imperfect representation of a higher-dimensional chaotic dynamical system, analogous to using a simple pendulum to forecast the behavior of a double pendulum. In addition to improving forecasts, CATs offer insights into how the two systems evolve in time. The approach is generalizable across dynamical systems and disciplines.

Albers, J. R., **M. Newman, M**. A. Balmaseda, W. Sweet, **Y. Wang** and **T. Xu** (2025). Assessing Subseasonal Forecast Skill for Use in Predicting US Coastal Inundation Risk. *Ocean Sci.*, 21, 1761–1785, https://doi.org/10.5194/os-21-1761-2025.

> Developing predictions of coastal flooding risk on subseasonal timescales (2–6 weeks in advance) is an emerging priority for the National Oceanic and Atmospheric Administration (NOAA). In this study, we assess the ability of two current operational forecast systems, the European Centre for Medium-Range Weather Forecasts Integrated Forecasting System (IFS) and the Centre National de Recherches Météorologiques climate model (CNRM), to make subseasonal ensemble predictions of the non-tidal residual component of coastal water levels at U.S. coastal gauge stations for the period 2000–2019. These models were chosen because they assimilate satellite altimetry at forecast initialization and attempt to predict the mean sea level, including a global mean component whose absence in other forecast systems complicates assessment of tide gauge reforecast skill. Both forecast systems have skill that exceeds damped persistence for forecast leads through 2–3 weeks, with IFS skill exceeding damped persistence for leads up to 6 weeks. Post-processing forecasts to include the inverse barometer effect, derived from mean sea level pressure forecasts, improves skill for relatively short forecast leads (1–3 weeks). Accounting for vertical land motion of each gauge primarily improves skill for longer leads (3–6 weeks), especially for the Alaskan and Gulf coasts; sea-level trends contribute to reforecast skill for both model and persistence forecasts, primarily for the East and Gulf coasts. Overall, we find that current forecast systems have sufficiently high levels of deterministic and probabilistic skill to be used in support of operational coastal flood guidance on subseasonal timescales.

Robinson, J., L. Jaegle, S. P. Palm, **M. D. Shupe**, G. E. Liston and M. M. Frey (2025). ICESat-2 observations of blowing snow over Arctic sea ice during the 2019-2020 MOSAiC expedition. *J. Geophys. Res. Atmos.*, 130, e2025JD043919, https://doi.org/10.1029/2025JD043919.

> Blowing snow occurs when strong winds lift surface snow into the air. In polar regions, this process impacts the energy budget and results in snow loss through sublimation, thereby adding water vapor to the atmosphere. However, direct surface observations of blowing snow over Arctic sea ice are limited. Active satellite sensors, such as the one on NASA's ICESat-2 satellite, help fill this gap by sending pulses of light toward the surface and measuring the signal returned. These high-resolution observations of blowing snow need to be validated against ground-based measurements. In this work, we combine ICESat-2 observations with surface measurements from an Arctic field campaign between November 2019 and April 2020. We first refine the methods used to detect blowing snow and estimate its properties using ICESat-2 and find these refinements align with the surface observations of blowing snow occurrence, particle number, and particle mass. Additionally, ICESat-2 estimates of blowing snow sublimation match the surface observations and predictions from a high-resolution computer simulation. Over the six-month period studied, the amount of snow lost to blowing snow sublimation accounts for 16%–21% of total central Arctic snowfall, highlighting the significant role of blowing snow in the Arctic climate.

Storto, A., **S. Frolov**, **L. C. Slivinski** and C. Yang (2025). Correction of Air-Sea Heat Fluxes in the NEMO Ocean General Circulation Model Using Neural Networks. *Geosci. Model Dev.*, 18, 4789-4804, https://doi.org/10.5194/gmd-18-4789-2025.

The atmospheric forcing and the heat exchanges between the ocean and the atmosphere represent one of the major sources of uncertainty for numerical ocean reconstructions and predictions, together with inaccuracies in vertical mixing and solar radiation penetration. Air–sea heat fluxes may suffer from inaccuracies in meteorological fields, sea surface variables, and bulk formulations, which have a strongly nonlinear dependence on the ocean state. Here, state-dependent errors in heat fluxes are learned by artificial neural networks (ANNs) from a dataset of heat flux correction terms, derived in turn from previous sea surface temperature nudging experiments. The pre-trained model predictors include stationary fields, atmospheric forcing data, ocean state, and stratification indices. Variable importance scores emphasize the dependence of air–sea heat flux errors on wind forcing. The pre-trained heat flux correction model is then used to adaptively correct fluxes online, in a series of global ocean experiments performed with the NEMO version 4 (Nucleus for European Modelling of the Ocean) ocean general circulation model, augmented with ANN inference capabilities in Fortran90. Results indicate the positive impact of the correction procedure, beyond the training period, e.g. in independent observation–poor and –rich periods, leading to the same dynamic and subsurface signature as in nudging experiments. Prediction experiments also indicate the method's potential for use in operational forecast applications. The method may also be adopted in coupled long-term reanalyses, long-range predictions, and projections.

Sun, S., Y. Liu, J. Zhu, W. Wang, **P. Pegion** and N. Barton (2025). Importance of Ocean Initialization in ENSO Predictions: Accuracy Versus Consistency. *Geophys. Res. Lett.*, 52, e2025GL116972, https://doi.org/10.1029/2025GL116972.

The El Niño–Southern Oscillation (ENSO) is a naturally occurring climate phenomenon that influences global weather and rainfall patterns. Accurate ENSO predictions in seasonal forecast models rely on multiple factors, including the representation of atmospheric and oceanic processes, air-sea interactions, and the quality of the ocean initial conditions. This study investigates the impact of ocean initialization, focusing on both its accuracy and consistency with the forecast model (FM), using three different ocean reanalysis products: ORAS5 (independent of the FM); Replay (the FM nudged toward ORAS5); and GLORe (based on the same ocean model as the FM, ensuring greater consistency). Results show that ENSO forecast skill is highest when the FM is initialized with GLORe, even though ORAS5 and Replay provide more accurate ocean initial states. This improved performance with GLORe highlights the importance of minimizing initialization shock by maintaining consistency between the OI generator and the FM.

September 2025

ARTICLES

Hovenga, P. A. , M. Newman, J. R. Albers, W. Sweet, G. Dusek, **T. Xu**, J. Callahan and **S.-I. Shin** (2025). Using Stochastically Generated Skewed Distributions to Represent Hourly Nontidal Residual Water Levels at United States Tide Gauges. *Frontiers in Marine Science*, 12 - 2025, https://doi.org/10.3389/fmars.2025.1618367.

> The daily likelihood of High Tide Flooding (HTF) predicted by NOAA for leads up to one year is expressed as the sum of a long-term trend, tides, and nontidal residuals (NTRs) whose probability density functions (PDFs) are assumed to be Gaussian (i.e., normally distributed). We analyzed observed detrended hourly NTR distributions at 148 NOAA tide gauges along the U.S. coastline and show that 98.7% of them are better characterized by 'Stochastically Generated Skewed' (SGS) distributions, a class of non-Gaussian (skewed, heavy-tailed) PDFs. In contrast to other methods that generate PDFs by fitting observed raw histograms, SGS distributions are determined through time series analysis. Observations are fit to a simple linear (autoregressive) time series model, driven by stochastic noise with a linear dependence upon the NTR anomaly. The PDF is then determined from the fitted model parameters. The SGS distributions improve upon the Gaussian PDF high-water probabilities at varying thresholds throughout the year along all U.S. coasts, with significantly better estimates along the U.S. East and Gulf coasts during summer (apart from large hurricane events) and along the U.S. West Coast during winter (even though variability there is often dominated by monthly time scales and many locations have nearly Gaussian PDFs). For evaluating extreme high-water event probabilities, the SGS distribution is no more sensitive to limited observations than kernel density estimation or Generalized Extreme Value methods. Tail probabilities for all three methods are generally similar. Our results may contribute to more robust and accurate HTF forecasts and, more broadly, provide additional insight in developing adaptation and mitigation strategies for future sea level conditions.

Kanaya, Y., . . ., **M. D. Shupe**, et al. (2025). Observational ozone data over the global oceans and polar regions: The TOAR-II Oceans data set version 2024. *Earth Sys. Sci. Data*, 17, 4901–4932, https://doi.org/10.5194/essd-17-4901-2025.

> Studying tropospheric ozone over the remote areas of the planet, such as the open oceans and the polar regions, is crucial to understand the role of ozone as a global climate forcer and regulator of atmospheric oxidative capacity. A focus on the pristine oceanic and polar regions complements the available land-based datasets and provides insights into key photochemical and depositional loss processes that control the concentrations and spatiotemporal variability in ozone as well as the physicochemical mechanisms driving these patterns. However, an assessment of the role of ozone over the oceanic and polar regions has been hampered by a lack of comprehensive observational datasets. Here, we present the first comprehensive collection of ozone data over the oceans and the polar regions. The overall dataset consists of 77 ship cruises/buoy-based observations and 48 aircraft-based campaigns. The dataset, consisting of more than 630 000 independent ozone measurement data points covering the period from 1977 to 2022 and an altitude range from the surface to 5000 m (with a focus on the lowest 2000 m), allows systematic analyses of the spatiotemporal distribution and long-term trends over the 11 defined ocean/polar regions. The datasets from ships, buoys, and aircraft are complemented by ozonesonde data from 29 launch sites or field campaigns and by 21 non-polar and 17 polar ground-based station datasets. The datasets contain information on how long the observed air masses were isolated from land, as estimated by backward trajectories from the individual observation points. To extract observations representative of oceanic conditions, we recommend using a subset of the data with an isolation time of 72 h or longer, from the analysis with coincident radon observations. These filtered oceanic and polar data showed typically flat diurnal cycles at high latitudes, whereas daytime decreases in ozone (11 %–16 %) were observed at lower latitudes. The ship/buoy- and aircraft-based datasets presented here will supplement the land-based ones in the TOAR-II (Tropospheric Ozone Assessment Report Phase II) database to provide a fully global assessment of tropospheric ozone. The described dataset is available at https://doi.org/10.17596/0004044 (Kanaya et al., 2025).

Luna, L. V., J. B. Woodard, **J. L. Bytheway**, G. M. Belair and B. B. Mirus (2025). Constraining landslide frequency across the United States to inform county-level risk reduction. *Natural Hazards and Earth System Science*, 25, 3279–3307, https://doi.org/10.5194/nhess-25-3279-2025.

> Informative landslide hazard estimates are needed to support landslide mitigation strategies to reduce landslide risk across the US. Whereas existing national-scale landslide susceptibility products assess where landslides are likely to occur, they do not address how often, which is a critical element of landslide hazard and risk assessments. In particular, the U.S. FEMA's National Risk Index (NRI) requires landslide frequency estimates to inform expected annual loss estimates. We present county-level landslide frequency (landslides per area per year) estimates for the 50 US states. We applied Bayesian negative binomial regression to estimate both the expected (average) reported landslide frequency and full distribution of annual landslide counts for each county. We compared a suite of models that used combinations of landslide-susceptible area, probability of potentially triggering earthquakes, frequency of potentially triggering precipitation, and ecological region as predictors. We trained our models with landslide inventory data from counties with the most comprehensive records available nationwide and used zero-inflated negative binomial distributions as an incompleteness model to correct for temporal reporting gaps. We selected a preferred frequency model to inform the NRI based on information criteria and physically plausible parameter estimates. The model showed that average annual reported landslide frequencies vary by 5 orders of magnitude across US counties, ranging from 0.002 (0.00015–0.05) landslides 1000 km^{-2} yr^{-1} in Kusilvak Census Area, AK, to 29 (19–46) landslides 1000 km^{-2} yr^{-1} in Lake County, CA, reflecting the country's strong variations in landslide susceptibility, earthquake probability, and other factors for which ecological region serves as a proxy. Counties with estimated frequencies in the top 20 % of all counties are predominately along the West Coast of the continental US, in mountainous regions of the Pacific Northwest and Intermountain West, in locally steep or earthquake-prone regions of the Midwest and Southeast, along the Appalachians, in southern and southeastern Alaska, and on some Hawaiian islands. By examining the number of landslides predicted in 99th percentile years for each county, we identified that 26 % of US counties likely have potential for widespread landsliding with more than 10 landslides 1000 km^{-2} yr^{-1}, even when such large events have not been reported in the training data for that county. Overall, our results better represent the range of possible landslide frequencies and spatial variations than previous national-scale estimates reported in the NRI, and our approach can inform other risk-reduction and loss-mitigation efforts across the US and globally.

Rugg, A., R. McCrary, A. Rhoades, D. Yates, **M. Abel** and N. Devineni (2025): Climate models show Colorado drying sooner and with greater certainty east of the Continental Divide. *Environmental Research Communications*, 7 (9), https://doi.org/10.1088/2515-7620/ae05f6.

> Many studies have examined the aridity of the Colorado River Basin and the possible impacts of climate change which could further strain already over-allocated water resources in the region. Fewer studies have examined the multiple Colorado Rocky Mountain headwater regions specifically. This is especially true of areas East of the Continental Divide, despite water originating there being critical to cities and agriculture in Eastern Colorado and further downstream. This paper explores and compares drying trends in the Eastern and Western Colorado Rocky Mountains using single-model initial-condition large ensembles from ten global climate models. The use of multiple models allows us to identify signals that are consistent across different physics parameterizations, model grids, and other model intricacies. The large ensembles also allow us to quantify the time of emergence of these climate change signals--that is, when did (or when will) the long term change due to anthropogenic greenhouse gasses exceed the internal variability of the climate system. Consistent with previous studies, we find evidence of drying on both sides of the Continental Divide. That drying is more pronounced, occurs sooner, and is more consistent across global climate models in the East, however, highlighting the region's importance despite generally receiving less attention than the West.

Wolding, B., **J. Dias**, **M. Gehne**, **G. Kiladis**, F. Ahmed, K. Schiro, A. F. Adames Corraliza and **X.-W. Quan**: Plume Model Assessment of the Convective Coupling of Equatorial Waves. *J. Atmos. Sci.*, 82, 1799-1814, https://doi.org/10.1175/JAS-D-24-0280.1

A plume model applied to radiosonde observations and the fifth generation ECMWF atmospheric reanalysis (ERA5) is used to assess the relative importance of lower-tropospheric moisture and temperature variability in the convective coupling of equatorial waves. Regression and wavenumber–frequency coherence analyses of satellite precipitation, outgoing longwave radiation (OLR), and plume model estimates of lower-tropospheric vertically integrated buoyancy (⟨B⟩) are used to identify the spatial and temporal scales where these variables are highly correlated. Precipitation and OLR show little coherence with ⟨B⟩ when zero entrainment is prescribed in the plume model. In contrast, precipitation and OLR vary coherently with ⟨B⟩ when "deep inflow" entrainment is prescribed, highlighting that entrainment occurring over a deep layer of the lower troposphere plays an important role in modifying the thermodynamic properties of convective plumes in the tropics. Consistent with previous studies, moisture variability is found to play a more dominant role than temperature variability in the convective coupling of the Madden–Julian oscillation (MJO) and equatorial Rossby (ER) waves, while temperature variability is found to play an important role in the convective coupling of Kelvin (KW) and inertio-gravity (IG) waves. Convective coupling is most strongly impacted by moisture variations in the 925–850- and 825–600-hPa layers for the MJO and ERs, and by 825–600-hPa temperature variations in KWs and IGs, with 1000–950-hPa moist static energy variations playing a relatively small role in convective coupling. Simulations of the Energy Exascale Earth System Model (E3SM), version 2, and a preoperational prototype of NOAA Global Forecast System (GFS) V17 are examined, the former showing unrealistically high coherence between precipitation and 1000-hPa moist static energy, the latter a more realistic relationship.

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