



## Physical Sciences Laboratory (PSL) Publication Report

January through March 2026

25 articles, 0 reports, 0 datasets

A list of PSL-affiliated articles, datasets, and reports with abstracts from FY26 Q1. Listed alphabetically by lead author. PSL-affiliated authors at time of publication in **bold**.

### January 2026

#### ARTICLES

**Bytheway, J. L.** and **K. M. Mahoney** (2026). Representation of extreme precipitation in high-resolution, long period-of-record precipitation datasets over the continental US. *J. Hydrometeorol.*, **27**, 85-106, <https://doi.org/10.1175/JHM-D-25-0085.1>.

Extreme precipitation is a highly impactful phenomena, the observation and prediction of which underpin many pressing societal planning and response needs. Rigorous, confident understanding of extreme precipitation and its risks, hazards, and potential impacts (e.g., floods, landslides) requires precipitation data with high resolution and a sufficiently long period of record. Many applications also require low-latency data with global coverage. We examine six precipitation datasets to characterize the representation of extreme precipitation over the continental United States. The Analysis of Record for Calibration (AORC), version 1.1, Stage IV, and CONUS404 provide 4-km hourly precipitation estimates over the CONUS only, while Integrated Multi-satellitE Retrievals for GPM (IMERG) V07 (both early and final) and Multisource Weighted-Ensemble Precipitation, version 2.8 (MSWEP), are 10-km resolution global datasets with 30-min and 3-h time steps, respectively. The global precipitation products struggle to capture extreme precipitation, especially that produced by warm-season convection; IMERG also exhibited spurious events with much higher precipitation than any other dataset, often during West Coast atmospheric rivers. Stage IV and AORC were generally similar to one another, although Stage IV also revealed artifacts in the western United States due to poor radar coverage and missing hourly data. CONUS404 is the only nonobservational dataset included in this study, and while it seems to capture the climatology of extreme precipitation over the CONUS fairly well, it does not reproduce the observed spatial representation of many individual events. This work provides an important foundation from which to further contextualize the representation of extreme precipitation in contemporary, frequently used datasets.

**Fairall, C. W., E. J. Thompson, L. Bariteau, G. A. Wick,** P. J. Minnett, G. Szczodrak, A. T. Jessup and C. Witte (2026). An updated treatment of the oceanic cool skin in the COARE bulk flux algorithm. *Journal of Geophysical Research: Oceans*, **131**, e2025JC023539, <https://doi.org/10.1029/2025JC023539>.

This paper presents physics improvements to the cool skin parameterization in the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm. The principal improvement is adopting a specification of the ocean side mixing profile that combines molecular and turbulent diffusivities via a form that allows turbulent dissipation to suppress turbulence near the interface. The turbulence is also scaled with the viscous friction velocity, since the stress input to waves is not realized continuously as turbulence at the interface but only intermittently at localized regions where the waves are breaking. Additional improvements include adopting a newer specification of the solar absorption profile in the ocean and incorporating the impacts of the rain sensible heat flux. The new parameterization is tuned to published observations of cool skin from a series of cruises and a recent publication of the turbo-molecular mixing term deduced for observations of gas fluxes. Data from three recent ship-based field programs, particularly the Propagation of Intraseasonal Oscillations in the Maritime Continent Region (PISTON) experiment, with radiometric sea surface and floating near-surface temperature sensors as well as high-quality air-sea flux measurements were analyzed to evaluate the model. The improvements led to modest decreases in the nonsolar cool skin (~16%) and in the solar heating contribution, both principally in light winds. The new model better reproduced mean nighttime cool skin amplitudes and was somewhat better than the previous COARE v3.6 model at reproducing the mean diurnal cycle. Overall, cool skin predictions for a large cruise database were reduced by ~0.01°C.

**Hu, I.-K., X. Chen, L. Bengtsson, E. J. Thompson, J. Dias and S. N. Tulich** (2026). Utilizing ATOMIC for assessing marine shallow cumuli in single column models. *Journal of Advances in Modeling Earth Systems*, **18**, e2024MS004814, <https://doi.org/10.1029/2024MS004814>.

Several different time periods of the Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign (ATOMIC) are isolated for examining how the depiction of tradewind marine shallow cumuli in single-column models (SCMs) is affected by choices about model physics. The periods of interest are times when the NOAA Research Vessel Ronald H. Brown and research aircraft WP-3D Orion were collocated, enabling verification of initial conditions and large-scale forcing (advective) tendencies constructed using gridded data from the fifth generation ECMWF atmospheric reanalysis (ERA5). To demonstrate how this new ATOMIC test case can be used to guide model development, three parameterization suites of the NOAA Unified Forecast System are evaluated within the Common Community Physics Package Single Column Model (CCPP SCM). Calculations are also performed using a large-eddy simulation (LES) to further bridge the gap between observations and SCM output, all of which are separated into regimes of either relatively active (“cloudy”) or inactive (“clear”) marine shallow cumuli. In both regimes tested, the parameterization suites tend to: (a) generate an unrealistic skewed or bimodal distribution of cloud fraction, (b) overestimate light to moderate rain rates, (c) produce an erroneously cold and dry boundary layer, and (d) produce higher-than-observed cloud tops. Results show that modifying the treatment of cloud fraction as well as increasing spatial and temporal resolution help bring the SCM more in line with observations. In addition, evidence is found to suggest that some of the remaining model biases may stem from intrinsic differences in the spatio-temporal sampling properties of the observations versus SCM output.

**Malik, D., H. Andersen, J. Cermak, J. V. Vogt and B. Adler** (2026). Cloud base height determines fog occurrence patterns in the Namib Desert. *Atmos. Chem. Phys.*, **26**, 681–701, <https://doi.org/10.5194/acp-26-681-2026>.

In the hyper-arid Namib Desert, fog serves as the only regular source of moisture, vital for sustaining local ecosystems. While fog occurrence in the region is typically associated with the advection of marine stratus clouds and their interaction with topography, its spatial distribution is strongly influenced by cloud base height, which remains poorly understood. To address this gap, this study utilizes ground-based remote sensing and in-situ observations to analyze systematic spatial and temporal patterns of cloud base height. Our results reveal clear seasonality and a diurnal cycle, with cloud base lowering moderately (10–50 m h<sup>-1</sup>) during the evening and early night, and lifting rapidly (30–150 m h<sup>-1</sup>) after sunrise, especially inland. Additionally, the findings indicate that these rates are influenced by horizontal gradients in cloud thickness. Quantile regression highlights the tight relationship between cloud base height and near-surface relative humidity ( $r \approx -0.76$ ) that is expected in well-mixed boundary layer, which can therefore be employed to estimate cloud base height across FogNet sites. In a case study, the potential value of the estimated cloud base height for separating fog from low clouds in satellite-based products is shown. In the future, a full integration of the estimated cloud base height with a satellite-based fog and low-cloud product can enable a spatially continuous mapping of fog in the region for the first time, which would facilitate fog ecological impact studies.

**Marsico, D. H., J. R. Albers, M. Newman, M. Gehne, J. Dias, P. D. Sardeshmukh, G. N. Kiladis, E. LaJoie and Y. Wang** (2026). Modal interference drives Madden-Julian Oscillation evolution and predictability. *Geophysical Research Letters*, **53**, e2025GL118062, <https://doi.org/10.1029/2025GL118062>.

A data-driven dynamical filter is developed to characterize Madden-Julian Oscillation (MJO) variability, by representing tropical variability with nonorthogonal empirical-dynamical modes that allow for constructive and destructive interference. We find that two intraseasonal atmospheric modes, an “MJO-fast” mode (~45 day period) and a newly identified “MJO-slow” mode (~70 day period), alongside El Niño-Southern Oscillation modes that are not entirely removed by temporal filtering, explain nearly all observed Real-time Multivariate MJO (RMM) index-based variability. The fastest growing, and most predictable, MJO events are initiated primarily by the MJO-fast mode over the Indian Ocean, with subsequent progression across the Maritime Continent resulting from destructive and then constructive interference of the MJO-fast and MJO-slow modes. These events, which we demonstrate can be identified at forecast initialization time, are shown to be forecasts of opportunity in the ECMWF operational forecast model, with MJO skill extended by roughly a week compared to all other forecasts.

**Matrosov, S. Y.** (2026). Observationally-based relations among the water cycle parameters during snowfall events in the upper Colorado River basin. *NOAA Technical Memorandum series OAR-PSL*, 319, <https://doi.org/10.25923/e4cf-8f37>.

Remote sensing measurements collected during snowfall events observed in the East River Basin of the headwaters of the Gunnison River are used to investigate statistical interrelations among such parameters of the water cycle as the snowfall accumulation/intensity, vertically integrated amounts of supercooled cloud liquid and ice, expressed as liquid water path (LWP) and ice water path (IWP), correspondingly, and the columnar integrated water vapor (IWV). The analysis of the concurrent water cycle parameter observations shows that there is, on average, little correlation between cloud LWP and snowfall near the ground. The correlation between snowfall and IWP, however, is rather pronounced with correlation coefficients around 0.6 - 0.8. Moderate correlation is observed between snowfall and IWV. There is relatively little sensitivity to the choice of data temporal resolution (e.g., daily averages vs 15-minute averages), though correlations between the daily average values are slightly higher. Mean IWP values during observed snowfall events are a factor of about 20 greater than LWP values, suggesting that, on average, snowflake growth due to riming was not very pronounced. The observational relations among water cycle parameters obtained in this study can be used for evaluating the performance of different weather and climate models in describing atmospheric moisture conversion processes that lead to the development and evolution of winter precipitation.

Seidel, S., N. Arnold and **B. Wolding** (2026). How Convective Mass Flux Responds to Environmental Humidity. *Journal of Advances in Modeling Earth Systems*, **18**, e2025MS005289, <https://doi.org/10.1029/2025MS005289>.

Our goal in this study is to characterize the relationship between lower tropospheric environmental humidity and convective mass flux in the tropics. To do so, we have created gridded convective mass flux data sets from five global storm-resolving models (GSRMs). We have three principal findings. First, in humid environments, mass flux increases with height from the surface through the depth of the lower free troposphere, forming a “deep-inflow.” In dry environments, mass flux does not increase with height in the lower free troposphere. Second, mid-tropospheric mass flux increases nonlinearly with increasing lower tropospheric humidity, resembling a widely reported pickup in tropical precipitation. Third, increased lower tropospheric humidity is associated with reduced updraft buoyancy. To interpret these findings, we employ a simple three-equation parcel model with stochastic entrainment. The parcel model suggests that the response of convective mass flux to lower tropospheric humidity is governed by two effects: (a) survival, in which a greater share of entraining parcels ascend rather than detrain with greater humidity; and (b) dilution, in which the average entrainment rate among surviving parcels increases with environmental humidity. Together, survival and dilution account for the three mass flux responses to humidity.

Wedum, A., C. Pettersen, H. Guy, **M. R. Gallagher**, **M. D. Shupe** and K. S. Mattingly (2026). Impacts of atmospheric rivers in central Greenland: Snowfall, clouds, and atmospheric state. *Journal of Geophysical Research: Atmospheres*, **131**, e2025JD044309, <https://doi.org/10.1029/2025JD044309>.

Atmospheric rivers (ARs) are long bands of strong horizontal water vapor transport responsible for over 90% of total integrated vapor transport (IVT) in extratropical and polar regions. Using a 12-year record (2010–2022) of ground-based remote sensing, radiosonde, snow stake, and reanalysis data from Summit Station, Greenland, we quantify the impacts of 41 AR events on snowfall, clouds, and the atmospheric state. Although ARs occur 0.97% of all times and 2.68% of snowing times, they contribute 5.8% to total snowfall, enhance snowfall rates by 80%, and double daily snowfall accumulation relative to general snowing conditions. AR events increase near-surface and atmospheric profile temperatures by over 7°C up to 350 hPa and increase specific humidity by 66%, deepen clouds and increase radar reflectivity. While ARs contribute only a modest fraction to total accumulation in central Greenland, they consistently produce clouds and snowfall and create an environment that enables enhanced snow particle growth processes typically not observed in an area characterized by cold, dry conditions.

Wu, S., E. Di Lorenzo, Y. Zhao, **M. Newman**, Z. Liu, **A. Capotondi**, D. Sun, S. Stevenson and Y. Liu (2026). Decomposition of Pacific Decadal Oscillation using linear inverse models sheds light on its dominant modes and future response. *npj Climate and Atmospheric Science*, **9**, 43, <https://doi.org/10.1038/s41612-025-01315-2>.

The Pacific Decadal Oscillation (PDO) is the leading mode of North Pacific climate variability, yet its response to climate change remains uncertain. Here, we use Linear Inverse Model (LIM) diagnostics to decompose PDO into three dynamical constituents: the Kuroshio-Oyashio Extension (KOE) mode, the North Pacific–Central Tropical Pacific (NP-CP) mode, and the El Niño–Southern Oscillation (ENSO) mode. Applying an observationally derived LIM large ensemble, we show that the relative importance of these modes varies substantially over 85-year periods due to internal climate variability—requiring at least 300 years for stationary estimates. LIMs trained on climate model ensembles reveal that, despite comparable variability, models exhibit systematic biases in representing the spatial structures of the KOE and NP-CP modes. Under global warming, models project a more dominant ENSO contribution and a diminished KOE influence, leading to a shortened PDO timescale. This LIM-based dynamical decomposition enables more direct comparisons of PDO mechanisms between models and observations.

## February 2026

### ARTICLES

Achtert, P., J. Seelig, G. Wallentin, L. Ickes, **M. D. Shupe**, C. Hoose and M. Tesche (2026). Occurrence of multi-layer clouds and ice-crystal seeding in the Arctic: MOSAiC and beyond. *Atmos. Chem. Phys.*, **26**, 3049–3068, <https://doi.org/10.5194/acp-26-3049-2026>.

Studies of Arctic clouds often focus on low-level single-layer clouds (SLCs). Here, we use combined observations of soundings and cloud radar during the MOSAiC, ACSE, and AO2018 research cruises as well as from long-term observations at Ny-Ålesund, Svalbard and Utqiagvik, Alaska to investigate the occurrence of SLCs and multi-layer clouds (MLCs) in the Arctic and to assess the rate of ice-crystal seeding in cold MLCs. MOSAiC observations show cloudy conditions in between 70 % and 90 % of sounding-radar cases. SLCs show occurrence rates of 30 % to 40 % with the highest value of 45 % during October. Cold MLCs are most abundant from November to June (40 % to 55 % of cases). Seeding occurs in about half to two thirds of the identified cold MLCs during MOSAiC for which the sub-saturated layer extends between 100 and 1000 m. The seeding rate increases by as much as 20 percentage points as the assumed size of the falling ice crystals is increased from 100 to 400  $\mu\text{m}$ . The observations reveal a stable rate of cloud-free conditions of around 20 % over the covered latitude range. Cloud occurrence during MOSAiC and at Ny-Ålesund in July, when the geographical distance between observations was minimal, shows reasonable agreement. Comparisons of MOSAiC and other research cruises to the central Arctic also indicate consistent occurrence rates of different cloud types despite the likely effect of year-to-year variability. The comparison of data from ship campaigns and land sites suggests that the latter are not necessarily a good indicator of cloud occurrence in the high Arctic.

**Freeman, N. M., G. Hervieux**, M. A. Alexander, **M. G. Jacox**, **D. J. Amaya**, **J. D. Scott** and **A. Capotondi** (2026). Characterizing compound physical and biogeochemical extremes in the California Current Large Marine Ecosystem. *PLOS Climate*, **5** (2), e0000638, <https://doi.org/10.1371/journal.pclm.0000638>.

Discrete environmental stressors, such as prolonged periods of extreme temperature or low oxygen, threaten the functioning of marine ecosystems. While considerable attention has been given to studying extremes occurring in isolation, our understanding of such events co-occurring in the water column—referred to as multi-stressor events or compound extremes—is still limited, despite their potentially synergistic effects on individual species. We use a historical ocean model simulation with biogeochemistry to characterize the frequency, intensity, and duration of multi-stressor events (temperature, chlorophyll, and oxygen) in the California Current Large Marine Ecosystem (CCLME) from 1996–2019. We highlight key spatiotemporal patterns of compound physical and biogeochemical extremes in the context of large-scale climate variability, particularly ENSO. Marine heatwaves and low chlorophyll extremes are generally associated with strong El Niño events, while shallow hypoxia extremes are generally associated with La Niña events. Marine heatwave-low chlorophyll extremes are the most common compound extreme in nearshore waters, while triple extremes are relatively rare, as conditions favoring warm and low productivity anomalies tend to also favor high oxygen anomalies. Results from this study advance our understanding of where and when multi-stressor events tend to occur in the CCLME, highlighting spatiotemporal characteristics that suggest potential sources of predictability, which could be leveraged in the ecosystem-based management of living marine resources.

**Jesberg, D. R. , K. M. Mahoney, D. Novak, J. Nelson and B. Albright (2026).** An Evaluation of Extreme Precipitation Forecasts at the Weather Prediction Center between 2012 and 2024. *Wea. Forecasting*, **41**, 357-380, <https://doi.org/10.1175/WAF-D-25-0139.1>.

When extreme hydrometeorological events threaten the United States, quantitative precipitation forecasts (QPFs) from the National Centers for Environmental Prediction's Weather Prediction Center (WPC) provide critical decision support to help mitigate risks to life and property. This study builds on previous work by providing an updated benchmark of WPC QPF skill for extreme precipitation events from 2012 to 2024, through evaluating the 6- and 24-h accumulations for the day 1–3 lead times. Extreme precipitation is defined using three thresholds: the 99th and 99.9th percentile precipitation values of all wet-site days from 2012 to 2024 for each National Oceanic and Atmospheric Administration (NOAA) River Forecast Center (RFC) region and the 2-yr average recurrence interval from the NOAA Atlas 14. WPC forecasts are verified against Stage IV quantitative precipitation estimates. Forecast skill is assessed seasonally, regionally, and temporally for the 1200 UTC forecast cycle. Results show that WPC forecasts of extreme precipitation have improved over time. The highest skill is observed along the West Coast, where events are dominated by atmospheric rivers from late fall through early spring. Forecasts in these regions often retain skill through day 3. The East Coast shows the second-highest skill, particularly in fall and winter, when extreme precipitation occurs from tropical and synoptic systems. Skill is lowest in inland areas, especially in the summer months when precipitation systems are weakly forced, smaller in scale, and often underforecasted by WPC. These events rarely show skill after a day 1 lead time.

**Song, S.-Y., S. Stevenson, E. Di Lorenzo, M. Newman, A. Capotondi and N. Schneider (2026).** North Pacific Model Biases Influence Kuroshio Extension Atmospheric Circulation Patterns. *Geophysical Research Letters*, **53**, e2025GL118765, <https://doi.org/10.1029/2025GL118765>.

The Kuroshio Extension (KE) system significantly impacts decadal North Pacific climate variability by modulating downstream atmospheric circulation patterns. Using satellite-derived and reanalysis products, and simulations from the High Resolution Model Intercomparison Project within the Coupled Model Intercomparison Project Phase 6, we evaluate how well coupled models reproduce KE atmospheric circulation patterns and their mechanisms. Observational KE regression patterns show that warm sea surface temperature (SST) anomalies over the Kuroshio-Oyashio Extension (KOE) enhance local surface evaporation and lower-tropospheric diabatic heating, accompanied by downstream cyclonic circulation anomalies over the North Pacific. In coupled models, a stronger latent heat flux response is linked to better simulation of these mechanisms and circulation patterns, whereas models with cold SST biases over the KOE region systematically underperform. Increasing resolution does not consistently alleviate these biases, reflecting structural issues across models that may obscure the potential benefits of higher resolution.

**Toride, K. , G. J. Hakim and A. Hoell (2026).** Roles of MJO and Tropical–Extratropical Interactions in Subseasonal Conditions Related to Landfalling Atmospheric Rivers. *J. Climate*, **39**, 885–901, <https://doi.org/10.1175/JCLI-D-25-0211.1>.

This study investigates the role of the Madden–Julian oscillation (MJO) and other tropical–extratropical interactions in generating atmospheric rivers (ARs) using a linear inverse model (LIM) framework. We examine subseasonal conditions that preferentially lead to landfalling ARs over Alaska, the Pacific Northwest, and California during boreal winters. We identify LIM dynamical modes that strongly project onto tropical sea surface temperature, such as El Niño–Southern Oscillation (ENSO); modes coupled with tropical heating, such as the MJO; and modes that are weakly coupled between the tropics and extratropics. The composite analysis of prolonged AR active conditions (14-day window) reveals that they are driven primarily by weakly coupled modes, with small contributions from tropically driven modes. The only significant signal from tropical heating modes is the subtropical vapor transport associated with MJO phases 6–7 for Alaska ARs. We also examine the role of the MJO in the optimal growth of initial conditions into the AR patterns. For all regions, the evolving optimals show nearly stationary phase patterns but propagating wave activity that shifts the location of maximum amplitude in time. The contributions from three mode groups are consistent across the regions, with the MJO partially contributing to the linear predictable growth, while weakly coupled modes remain the main drivers. The MJO and weakly coupled modes constructively interfere in subtropical vapor transport and destructively interfere in tropical convective activity. These findings underscore the importance of accurately resolving weakly coupled tropical–extratropical interactions to improve subseasonal AR predictions.

## March 2026

### ARTICLES

**Amaya, D. J., M. G. Jacox and M. A. Alexander** (2026). Skillful high-resolution seasonal forecasts of the California Current System using model-analogs. *Process in Oceanography*, **244**, 103723, <https://doi.org/10.1016/j.pocean.2026.103723>.

Despite recent advances in the development of seasonal forecasting systems, high-resolution climate modeling in support of operational prediction efforts remains a computational challenge. Here, we use the model-analog technique to overcome computational bottlenecks associated with model resolution and data availability, generating a suite of high-resolution (0.1°) ocean reforecasts at 1–12 months lead from an existing high-resolution global climate simulation—CESM-HR. In our model-analog framework, we compare past observed climate states to the CESM-HR data library (i.e., model sea surface temperature output), with the best matches retained as “analogs”. The subsequent model evolution of each analog is then treated as a forecast. We show that high-resolution model-analog (HR-MA) ocean forecasts in the California Current System (CCS) are comparable to the skill of similar high-resolution initialized forecasts derived from a regional model. Forecasts of sea surface temperature, sea surface height, and bottom temperature are particularly skillful, with significant skill above persistence at ~6–10 month leads when forecasting boreal winter. By selecting analogs based on different regions, we further show that seasonal predictability in the CCS is primarily driven by ENSO and month-to-month persistence. Finally, we show that, in an absolute sense, HR-MA forecasts are generally more skillful than low-resolution (1°) model-analog forecasts at predicting coastal conditions throughout the CCS. However, both high- and low-resolution analog forecasts similarly capture the observed timing of nearshore CCS variability, suggesting that even relatively coarse resolution models could provide useful management support tools. Our research highlights model-analogs as a cost-effective method for generating skillful, high-resolution seasonal climate forecasts in support of operational management strategies.

Anderson, W., M. C. Arcodia, **D. J. Amaya**, E. Becker, J. A. Callahan, J. C. Furtado, B. Kirtman, S. Kumar, M. L. L'Heureux, D. Li, S. M. Larson, M. J. Molina, **M. Newman**, K. Pegion, A. Robertson, **E. Towler** and B. Xiang (2026). The Critical Need for Hindcast Infrastructure in Climate Science and Sectoral Applications. *Bull. Amer. Meteor. Soc.*, **107**, E615–E627, <https://doi.org/10.1175/BAMS-D-24-0311.1>.

Forecasting the impacts of climate extremes is challenging but critical to a range of sectors, including agriculture, water management, public health and safety, infrastructure, energy, national defense, and ecology. Foundational to these forecasts are hindcast model archives, which are routinely used for applications produced for the private sector and agencies, including the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of State, and the U.S. Department of Defense. Forecast and hindcast archives underpin scientific inquiry funded by these agencies, particularly in relation to forecasting weather and climate extremes, as well as by the U.S. National Science Foundation (NSF). In this article, we catalog the sector-specific decision support systems that depend upon hindcast archives and survey the current state of hindcast archive infrastructure. We find that despite the tremendous amount of investment and the dependent decision support systems, the U.S. hindcast archive is relatively fragile and underfunded, especially when compared with the Copernicus system in Europe. We conclude with recommendations for improving hindcast archive infrastructure to support routine sector-specific applications and improve resilience to climate extremes.

**Cox, C. J. and C. Penland** (2026). Medium-Range Predictability of the Wintertime Bering Sea Ice Edge using Linear Inverse Modeling. *Journal of Geophysical Research - Oceans*, **131**, e2025JC023413, <https://doi.org/10.1029/2025JC023413>.

Beginning in autumn, sea ice expands into the southern Bering Sea, where it remains until spring. In winter, some commercial stocks, particularly crabs, thrive in ice-infested areas, necessitating short-lead forecasts of the ice edge for fishers. At time scales of days to weeks, wintertime expansions and retractions of the ice edge are forced by winds through a combination of dynamic ice transport and thermodynamic coupling with the ocean. Previous research has shown that the mean atmospheric flow across the ice in winter and spring is modulated by the planetary wave structure, which can impart persistence in the tendency of winds through the Bering Strait beyond synoptic time scales. Here, we evaluate the predictability of the wind-forced ice edge in winter using a data-adaptive stochastic dynamical methodology, Linear Inverse Modeling. The analysis is based on the observed ice edge, taken from the National Snow and Ice Data Center Sea Ice Index on 18 meridional transects from 181 to 198°E, which the LIM treats as a linear, multivariate system. Skillful forecasts of the wintertime Bering Sea ice edge relative to its seasonal cycle are found for 5–6 days lead times, increasing to 6–9 days for conditional “forecasts of opportunity” when off-ice northeasterlies prevail. Interruptions to the mean flow associated with southerly advection through the Bering Strait produce retreat in the sea ice that is less predictable. Generally, predictability is higher in the eastern Bering Sea than in the west. The large amplitude of the seasonal cycle contributes to predictability, even at weather scales.

**Hoell, A., R. Robinson, M. T. Hobbins, M. L. Breeden, R. P. Worsnop** and E. Guerrero (2026). The Relationship between the El Niño-Southern Oscillation and Wildfire Area Burned in Contiguous United States Geographic Area Coordination Centers. *Journal of Geophysical Research: Atmospheres*, **131**, e2025JD045436, <https://doi.org/10.1029/2025JD045436>.

We examine the relationship between the El Niño-Southern Oscillation (ENSO) and extensive wildfire area burned from 1984 to 2022 in nine contiguous United States Geographic Area Coordination Centers (GACCs). The La Niña and El Niño phases of ENSO significantly alter the chances of extensive area burned in several GACCs up to 12 months in advance, potentially rendering predictable future such occurrences of area burned. Autumn La Niña increases the chances of extensive area burned in the Southwest, Southern, and Rocky Mountain GACCs during the following winter and spring. This increased likelihood extends to the Great Basin and Northern California GACCs during the following summer. These increases are linked to a heightened chance of low precipitation during winter and spring wet seasons and high evaporative demand during the following spring and summer seasons associated with anomalous higher pressure over the southern United States. Conversely, autumn El Niño increases the likelihood of extensive area burned in the Eastern and Northern Rockies GACCs during the following spring. This is associated with an increased likelihood of low precipitation and high evaporative demand linked to anomalous high pressure over the northern United States. Additionally, autumn El Niño decreases the chances of extensive area burned in the Great Basin, Rocky Mountain, and Southern GACCs during the following spring and summer. This reduction is associated with a decreased likelihood of low precipitation and high evaporative demand during the intervening months associated with anomalous low pressure over the southern United States.

Lac, J., H. Chepfer, **M. D. Shupe** and H. Griesche (March 2026): Understanding the spring cloud onset over the Arctic sea ice. *Atmos. Chem. Phys.*, **26**, 4189–4213, <https://doi.org/10.5194/acp-26-4189-2026>.

Using 13 years of space-based lidar cloud observations over the Arctic sea-ice, we show that the low cloud cover increases from 34% to 71% between 7 April and 7 May, mainly due to the increase of liquid-containing clouds below 1 km altitude. This study assesses the relative roles of moisture transport from the mid-latitudes and the spring warming driven by the seasonal increase of solar radiation in setting this transition called “spring cloud onset”. We highlight that daily moisture mass advected over the sea-ice in March represents 14% of the moisture mass already present, exceeding the increase of atmospheric moisture carrying capacity due to the rising temperatures. Consistently, MOSAiC campaign data suggest that moisture is not limiting the spring cloud onset as most of the radiosoundings in spring contained layers saturated with respect to ice (96%). Instead, we identify a temperature dependency in the ratio of ice to liquid-containing layer occurrence, confirmed by ground-based MOSAiC lidar. While the proportion of ice layers over all atmospheric layers is poorly dependent on temperature below 0 °C, the occurrence of liquid-containing layers increase steeply between –20 and –10 °C. As a result, March lower troposphere temperatures (–20 °C) favor more ice clouds, while May (–13 °C) favors more liquid-containing clouds. Overall, our results suggest that moisture availability is not the limiting factor and that spring warming induced by solar radiation sets the transition toward more liquid-containing low clouds.

Landsberg, J. B., **M. Newman** and E. A. Barnes (2026). AI-informed model-analogs for understanding subseasonal-to-seasonal jet stream and North American temperature predictability. *Mach. Learn.: Earth*, **2**, 015007, <https://doi.org/10.1088/3049-4753/ae4805>.

Subseasonal-to-seasonal (S2S) forecasting is crucial for public health, disaster preparedness, and agriculture, yet both forecasting and diagnosing sources of potential forecast skill on this timescale remains particularly challenging. We adapt an interpretable AI-informed analog forecasting approach, previously used for longer timescales, to improve S2S model-analog prediction and understanding of its climate drivers. Using an artificial neural network, we learn a mask of weights to optimize analog selection and showcase its versatility across two prediction tasks: (1) regional continuous prediction of Month 1 Midwestern U.S. summer temperatures and (2) classification of Month 1–2 North Atlantic wintertime upper atmospheric winds. The AI-informed analogs outperform traditional model-analog forecasting approaches, as well as climatology and persistence baselines, for deterministic and probabilistic skill metrics on both climate model and reanalysis data; moreover, this skill gap grows for extreme predictions. Moreover, our interpretable-AI framework allows analysis of learned masks of weights, yielding improved understanding of the role of underlying physical processes upon predictability. We find skin temperature and the Northern Hemisphere to be more important predictors of North Atlantic wintertime upper atmospheric winds than upper atmospheric winds 1–2 months prior and the Southern Hemisphere, respectively.

**Maithel, V., B. Wolding, S. N. Tulich, M. Gehne, J. Dias, X.-W. Quan and L. Bengtsson** (2026). Plume Model Assessment of Tropical Convection Biases in Weather Forecast Systems: Application to the NOAA Unified Forecast System. *Wea. Forecasting*, **41**, 489-503, <https://doi.org/10.1175/WAF-D-25-0152.1>.

We develop a diagnostic framework for assessing systematic biases in tropical precipitation to support the improvement of weather forecast systems. The approach is demonstrated through its application to a suite of global models associated with various stages of National Oceanic and Atmospheric Administration's (NOAA's) Unified Forecast System (UFS) development. The diagnostics are based on observed relationships between precipitation and lower-tropospheric buoyancy, estimated offline using a plume model. This buoyancy metric serves as a proxy for convective instability, incorporating the effects of dry air entrainment, a key factor in tropical convection. Among the models examined, tropical convection biases primarily arise during two convective regimes: the transition from shallow to deep convection, involving cumulus congestus clouds, and periods of widespread deep convection, dominated by mesoscale convective systems (MCSs). When large-scale conditions favor enhanced cumulus congestus activity in observations, the NOAA models analyzed here tend to overproduce precipitation and develop a dry bias in the lower troposphere. This leads to rapid stabilization of the convective environment compared to observations, suppressing the frequency of highly convectively unstable conditions that typically support active MCS development. During periods when large-scale conditions favor MCS activity in observations, the models often underpredict precipitation, partly due to this artificially stabilized model environment. Systematic coupled biases in precipitation, humidity, and lower-tropospheric buoyancy emerge rapidly, within less than a day, and persist over longer time scales. Building on previous applications to other models, these results underscore the value of plume model diagnostics as a powerful tool for evaluating how convection scheme modifications influence tropical precipitation biases, providing actionable insights that can directly inform operational model development.

Miller, A. J., **M. A. Alexander, D. J. Amaya**, N. Cordero-Quirós, C. A. Edwards, **M. G. Jacox**, J. Li, and M. R. Stukel (2026). Physical oceanographic mechanisms associated with recent ecological responses in the California Current Ecosystem. *BioScience*, biag020, <https://doi.org/10.1093/biosci/biag020>.

The California Current System (CCS) is an upwelling eastern boundary ocean current that supports a productive ecosystem through a multitude of physical processes. The fundamental aspects of the ocean circulation are highlighted here and connected to their roles in driving and modulating various components of the California Current Ecosystem (CCE) in the context of pulse and press disturbances. Recent short-term climate events (pulses), such as marine heat waves, that generated highly anomalous responses in the ecology are identified and explained in terms of physical process drivers. The long-term vulnerability of the ecosystem to long-term climate changes (presses) is also discussed. The need for ecologists to collaborate with physical scientists to unravel the press versus pulse impacts on the CCE through sustained physical-ecological observations and high-resolution modeling is emphasized.

Turner, D. D., **B. Adler, L. Bianco, J. M. Wilczak**, V. Michaud-Belleau and L. Rochette (2026). Intercomparison of seven collocated ground-based infrared spectrometer radiance observations and retrieved thermodynamic profiles. *Atmos. Meas. Tech.*, **19**, 1573–1586, <https://doi.org/10.5194/amt-19-1573-2026>.

Thermodynamic profiles, especially in the atmospheric boundary layer (ABL), are essential for many research and operational applications. Ground-based infrared spectrometers (IRS) are commercially available, and thermodynamic profiles in the ABL can be retrieved from these observations at 5 min resolution or better. This study deployed seven IRS systems within 5 m of each other in Boulder, Colorado, USA, in September–October 2023, providing an opportunity to evaluate the relative accuracy of the measured radiances from these systems as well as the retrieved thermodynamic profiles. The analysis demonstrates that the observed radiances from the seven instruments agree within 1 % of the ambient radiance in both opaque and more transparent channels. The differences in the spectral calibration between the instruments were smaller than 0.11 cm<sup>-1</sup>, relative to the nominal effective wavenumber of the metrology laser of 15 799 cm<sup>-1</sup> (i.e., better than 7.1 ppm). Further, the retrieved temperature and humidity profiles agree with each other well within the uncertainty of the retrieved profiles, and quantities derived from these thermodynamic profiles such as precipitable water vapor and height of the convective boundary layer also agree within their uncertainties. These results demonstrate a high degree of repeatability and precision, and that if these instruments were deployed as part of a network, any differences larger than the retrieval uncertainty would be associated with real environmental differences and not an artifact of the instrument calibration or retrieval.

Wang, L., J. Lu, **M. L. Breeden**, et al. (2026). Gaps and ways forward in atmospheric blocking and extreme weather research. *Nat Commun*, **17**, 2873, <https://doi.org/10.1038/s41467-026-70487-z>.

Atmospheric blocking often results in significant weather extremes and associated impacts such as heatwaves, droughts, wildfires, cold spells, and floods in mid-latitude regions. However, the physical processes behind blocking and associated extreme weather events are not well understood, hampering prediction and decision-making for mitigation and adaptation. Further, numerical models often struggle to simulate the frequency, duration, and geographic distribution of atmospheric blocking events. Here, we provide an overview of blocking-related weather extremes and impacts, as well as of our current understanding of the key physical processes. We identify knowledge gaps and current challenges and provide our perspective on potential ways forward.

Wu, J., P. Perezhogin, D. J. Gangne, B. Reichl, A. C. Subramanian, **E. J. Thompson** and L. Zanna (2026). Data-Driven Probabilistic Air-Sea Flux Parameterization. *Geophys. Res. Lett.*, **53**, e2025GL120472, <https://doi.org/10.1029/2025GL120472>.

Accurately quantifying air-sea fluxes is important for understanding air-sea interactions and improving coupled weather and climate models. This study introduces a probabilistic framework to represent the highly variable nature of air-sea fluxes, which is missing in deterministic bulk algorithms. Assuming Gaussian distributions conditioned on the input variables, we use artificial neural networks and eddy-covariance measurement data to estimate the mean and variance by minimizing negative log-likelihood loss. The trained neural networks provide alternative mean flux estimates to existing bulk algorithms, and quantify the uncertainty around the mean estimates. A stochastic parameterization of air-sea turbulent fluxes can be constructed by sampling from the predicted distributions. Tests in a single-column forced upper-ocean model suggest that changes in flux algorithms influence sea surface temperature and mixed layer depth seasonally. The ensemble spread in stochastic runs is most pronounced during spring restratification.

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