

Research to Operations and Applications

PSL's research to operations and applications activities are summarized under the PSL Annual Operating Plan and are also presented here separately for convenience. They are guided by the NOAA Policy on Research and Development Transitions ([NAO 216-105B](#)) and span a wide variety of partnerships. Examples include working relationships with:

- NOAA national operational forecast offices and centers
- NOAA regional operational forecast offices and centers
- NOAA testbeds
- NOAA laboratories that provide experimental forecasts, predictions, and guidance
- local, regional, national, and international synthesis and assessment efforts
- other non-NOAA local, regional, national, and international agencies

The mechanisms for transitioning research advances into operations and applications are also varied and are motivated by the full spectrum of research-to-operations/applications (R2X) and operations/applications-to-research (X2R) collaborations.

Progress toward meeting PSL's R2X targets was monitored through an annual call for R2X activities distributed every August/September. The Performance Metric Manager of the NOAA Office of Atmospheric and Oceanic Research (OAR) initiated the OAR-wide annual call with updates requested quarterly. R2X advances were tracked in terms of the progression through four stages:

- Research (1,2)
- Development (3,4,5)
- Demonstration (6,7,8)
- Operation/Application (9)

where the parenthesized numbers represent the span of associated NOAA Readiness Levels (RLs):

- RL 1: Basic research, experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications.
- RL 2: Applied research, original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research, or to determine new methods or ways of achieving specific and predetermined objectives.

- RL 3: Proof-of-concept for system, process, product, service, or tool; this can be considered an early phase of experimental development; feasibility studies may be included.
- RL 4: Successful evaluation of system, subsystem, process, product, service, or tool in a laboratory or other experimental environment; this can be considered an intermediate phase of development.
- RL 5: Successful evaluation of system, subsystem process, product, service, or tool in relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.
- RL 6: Demonstration of a prototype system, subsystem, process, product, service, or tool in relevant or test environment (potential demonstrated).
- RL 7: Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).
- RL 8: Finalized system, process, product, service or tool tested, and shown to operate or function as expected within user's environment; user training and documentation completed; operator or user approval given.
- RL 9: System, process, product, service or tool deployed and used routinely.

The tables at the end of this document summarize 2015-2020 R2X targets.

Identifier (Name of Parent Project)	Brief Description	Statement of intended purpose	Lifecycle Phase Moving from			Lifecycle Phase Moving to			Target	Target	Target	Target	Date Completed Fiscal year and quarter the project will transition to operations / applications	OAR Point of Contact	OAR Responsible SES	OAR Contributing Partners	Customer	A clear statement of what condition must be met for the product advancement to have been made. This should be sufficient to allow a	Type of R2A (Choose all applicable)			Cost of R2A Transition amount to move the project into operations/ applications (Only the profile shift and NOT the total funding amount.)
			Research	Development	Demonstration	Operations or Applications	Research	Development	Demonstration	Operations or Applications	15 Q1	15 Q2							15 Q3	15 Q4	Operations	
Reforecasts	Transition of global medium-range reforecast capacity	Dramatically improved weather and weather-climate forecast guidance supported by reforecast data sets											Expect funding for transition in 2015-2017 timeframe	Hamill	Webb		NCEP/EMC		x			
Sea Surface Temperature Diurnal Warming Amplitude Estimates	Modeled global estimates of instantaneous SST diurnal amplitude based on NWP analyses for incorporation in operational Global SST analysis	Improved SST product accuracy enabled by correction for diurnal warming influences on individual satellite retrievals											NESDIS Algorithm Readiness Review scheduled for April 2015; product operationalization to follow	Wick	Webb		NESDIS		x			
Ensemble Kalman Filter Data Assimilation System	An ensemble-based data assimilation technique that incorporates flow-dependent estimates for forecast uncertainty. Became operational at NCEP in 2012.	Improved accuracy of forecast initial conditions, which improves forecast skill											Implemented in NCEP operations May 2012, further improvements in subsequent upgrades.	Whitaker	Webb		NCEP/EMC		x			
Stochastic Parameterizations of Model Uncertainty	Improves the representation of model uncertainty in ensemble forecast, improving forecast reliability and analysis accuracy. Became operational in the EnKF DA system at NCEP in 2014.	Improved reliability of forecast ensembles, improved analysis accuracy.											Implemented in NCEP operations in 2015 for the EnKF analysis cycle, preparing for implementation in the medium range global ensemble system in 2016.	Whitaker	Webb		NCEP/EMC		x			
Hydrometeorology Testbed observations	Research observations collected throughout U.S., but most notably in CA	Provides real-time access to NWS offices, including RFC's with SHEF-encoding											2013-2015	Gottas	Webb		NWS Western Region		x			
Streamflow forecasts	Distributed hydrologic model applied to Russian River basin, CA	Provides streamflow everywhere in the basin - not just forecast points											2014-2015	Johnson	Webb		NWS Western Region, CNRFC, and MTR WFO		x			

Automated Digital Frost Forecast System	Gridded Frost and heat forecasts for Russian River basin, CA	Forecasts allow water agency to plan for reservoir releases to accommodate crop spraying to mitigate frost/heat. Growers can augment storage ponds prior to event to mitigate drawn-downs in tributaries and mainstem Russian on frost days. Goal is to eliminate																	2014-2015	Reynolds	Webb		NWS Western Region, Sonoma County Water Agency, Sonoma-Mendocino County grape growers, Western Wx Group and Fox Weather - Commercial wx forecast vendors for		x	x	x			
C-LIM tropical forecasts	Empirical model yielding forecasts (and a priori forecasts of forecast skill) for pentads (5-day running means) of tropical SSTs, OLR, and 200/850 mb winds, for forecast leads of 5-270 days.	CLIM will provide a nice complement and alternative for the forecast of anomalous tropical convection to that produced from purely physical models (i.e. CFS, etc.). CPC is already using the C-LIM to aid the NWS operational Global Tropics Hazards and Benef																	End of FY15Q4	Newman	Webb		NOAA/NWS/CPC		x					
Air quality PM2.5 post-processing algorithms. Djalalovlrina	A set of codes to improve the skill of the NOAA/NCEP CMAQ air quality model for ozone and particulate matter forecasts through application of analog and Kalman filter post-processing schemes	Post-processing of PM2.5 forecasts greatly improves model forecast skill, and an automated analog post-processing scheme reduces the need for state and local air quality forecasters to apply their own subjective corrections to the model forecasts																	2014-2015	Djalalova	Webb		NWS/National Center for Environmental Prediction, EPA, state and local air management districts		x		x			

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			Moving from	Moving to	18 Q1	18 Q1																18 Q2	18 Q2	18 Q3				18 Q3	18 Q4	18 Q4	19	20	21	22	23	Operations	Commercial	Other
			Research	Development	Demonstration	Operations or Applications																Research	Development	Demonstration				Operations or Applications										
	Finalize a CRADA with Radiometrics, Inc. to commercialize PSD's snow-level radar technology	Transfer of federally developed technology into commercial sector		x		x										FY18, Q4	White	Webb	CIRES	Radiometrics	Signed CRADA				x						There is currently some concern about getting the CRADA signed by the end of the fiscal year due to a lack of available labor force to execute manufacture process at commercial partner (80 % probability of completion)							
	Develop experimental HRRR data to use to inform Probable Maximum Precipitation estimation in CO-NM Dam Safety Study	Develop model-based precipitation products to inform dam safety risk minimization and prototype future improvements to Probable Maximum Precipitation generation methods		x		x					x					FY18, Q3	Mahoney	Webb	ESRL GSD	Colorado, New Mexico Divisions of Dam Safety	High-resolution Rapid Refresh (HRRR) and other dynamical model produced grids of maximum precipitation, precipitation type, and historical extreme events disseminated to project sponsors and incorporated into user software utilities				x	x					The "Lifecycle Phase Moving to" is likely somewhere between "Development" and "Demonstration." Products do exist and have already been demonstrated. They are a prototype though, and in that sense are an "experimental tool"							
	Transition to NCEP an updated Kalman-Filter Analog (KFAN) bias correction method for ozone and PM 2.5 forecasts from the operational CMAQ air quality model.	Improve NWS air quality forecasts		x		x										FY18, Q4	Wilczak	Webb		NWS, State and local forecasters, public	Bias-corrected gridded ozone fields created for each forecast cycle tested and evaluated by NCEP and incorporated into operational NCEP air quality forecasts				x						Forecast grids have already been transitioned to and tested and evaluated by NCEP but still are waiting on higher level sign-off to operationalize.							
	Transition the Evaporative Demand Drought Index (EDDI) to an operational status at the National Water Center.	Provide a service for drought early warning, and ongoing drought monitoring to stakeholders affected by agricultural, hydrologic, and ecological drought, and at wildfire risk				x										FY19, Q3	Hobbins	Webb	Desert Research Institute & NOAA-National Water Center	NOAA-National Water Center	EDDI running at National Water Center and providing user-queryable drought monitoring and ancillary information to stakeholders					x					Target date for complete transition to NWC is May 2019.							
	Develop and transition to operations improved methods for postprocessing of precipitation related variables using multi-model ensembles under the National Blend of Models project.	Develop statistically postprocessed, high-resolution multimodel ensemble guidance to provide National Weather Service forecasters with a calibrated, downscaled starting point for producing digital forecasts.		x		x										FY18, Q2	Hamill	Webb		NWS/NCEP	Algorithms tested and delivered for implementation in initial version of NBM QPF product					x												
	The first-generation stochastic physics package from the NOAA Environmental Modeling System/Global Spectral Model (NEMS/GSM) will be ported to new NEMS dynamical core (FV3) to better represent model uncertainty in ensemble forecasts.	Improved representation of model uncertainty in the NOAA Global Ensemble Forecast System (GEFS)				x										FY18, Q2	Whitaker	Webb		NWS/NCEP	Stochastic physics parameterizations implemented in time for use in beta implementation of FV3GFS data assimilation system and FV3GFS reforecasts					x												
	ESRL/PSD is a co-developer of the NOAA operational ensemble-variational data assimilation system. This project supports ongoing development and maintenance of the code, and testing of new algorithms, in collaboration with NCEP/EMC	Improved analyses and forecasts in the operational NCEP Global Forecast System (GFS)		x		x										FY18, Q2	Whitaker	Webb		NWS/NCEP	Code developed, tested and integrated into the master repository for the NCEP Global Statistical Interpolation System. Experiments performed and analyzed to quantify the impact of the code changes.						x											
	Demonstrate and provide forecast guidance during Freeze up period - Q1, Q4 of sea ice, atmosphere, ocean conditions for the Arctic Basin on 0-10 day scales.	Improve forecasts of sea ice and Arctic conditions during Arctic fall freeze-up period				x	x	x								FY19, Q3	Intrieri	Webb	NWS Arctic Testbed	NWS	Adoption by NWS of current experimental sea ice forecasting capability.						x											
	Develop, produce, and release a new modern-era high-resolution atmospheric global reanalysis and reforecast to facilitate the generation of high-quality operational post-processed model guidance by the National Weather Service	Improve NWS operational forecasts		x		x										FY19, Q3	Hamill	Webb	NCEP OAR/CPO	NCEP CPC and EMC, as well as NWS forecast offices	Provide datasets needed to post-process operational global ensemble forecasts to provide calibrated probabilities to the public.					x												

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			Moving from	Moving to	18 Q1	18 Q1																18 Q2	18 Q2	18 Q3				18 Q3	18 Q4	18 Q4	19	20	21	22	23	Operations	Commercial	Other
			Research	Development	Demonstration	Operations or Applications																Research	Development	Demonstration				Operations or Applications										
	Develop, produce, and release a new version of the 20th Century reanalysis (version 3) to better represent extreme events and characterize their uncertainty back to 1850.	See column B		x												FY19, Q3	Compo	Webb	CIRES, NCEI, PMEL	climate researchers, federal, private sector and academic	A dataset is made available to climate researchers that includes 3-hourly gridded fields back from 1850-present.				x													
	Provide quarterly services to better inform regional decision makers on evolving climate conditions and extreme events (NIDIS)	See column B	x					x	x	x	x	x	x	x		Ongoing	Hoell	Webb	NIDIS	NIDIS Federal Partners	Understand characteristics and predictability of Northern Plains Drought and apply to seasonal forecasts used by NIDIS partners				x			This is an FY18-19 project in which we use the case of the 2017 Northern Plains drought to motivate examination of the causes and predictability of all droughts over the region (FY19, Q1 end date)										
	Provide quarterly services to better inform regional decision makers on evolving climate conditions and extreme events (FEWSNET)	See column B	x					x	x	x	x	x	x	x		Ongoing	Hoell	Webb	USGS NASA USAID	USAID Famine Early Warning System Network	Understand predictability of African and Asian drought and apply to seasonal forecasts used by food security analysts				x			This is an ongoing collaboration in which we examine predictability of drought and use that information to advise food security analysts famine outlooks that are then used by the U.S. government to mobilize aid										
	Develop a new version of the Climate Change Web Portal	Provide accessible climate variability and change information to fisheries and water resource managers								x	x					FY18, Q2	Alexander	Webb		NMFS, fishery and water managers			x	x	x													
	Improve stratospheric ozone in GFS	Upgraded Naval Research Laboratory's CHEM2D-OPP stratospheric ozone parameterization in NCEP GFS system	x													FY19, Q2	Compo	Webb	EMC, NRL, CPC, SUNY-Albany	NCEP/NOAA	The parameterization is currently in parallel testing in the new FV3GFS and will be included in the operational implementation FV3 GFS	x																
	Improve stratospheric water vapor in GFS	Included Naval Research Laboratory's CHEM2D-OPP stratospheric water vapor parameterization in NCEP GFS system	x													FY19, Q2	Compo	Webb	EMC, NRL, CPC, SUNY-Albany	NCEP/NOAA	The parameterization is currently in parallel testing in the new FV3GFS and will be included in the operational implementation FV3 GFS																	
	Testing channel loss parameterization in the National Water Model	This is NOAA Joint Technology Transfer grant funded research that seeks to improve National Water Model performance in arid climate regimes by simulating water losses in river channels.	x													FY 20 Q2	Zamora	Webb	University of Arizona, OWP	OWP	The parameterization will be included in the 2021 National Water Model Operational NCEP Update after parallel testing in 2020.																	

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			Moving from		Moving to		FY20 Q1	FY20 Q2	FY20 Q3	FY 20 Q4					21	22	23	24	25								Operations	Commercial	Other					
			Research	Development	Demonstration	Operations or Applications																									Research	Development	Demonstration	Operations or Applications
EDDI	Complete transition the Evaporative Demand Drought Index (EDDI) to an operational status at the National Water Center.	Provide a service for drought early warning, and ongoing drought monitoring to stakeholders affected by agricultural, hydrologic, and ecological drought, and at wildfire risk		X							X																				X			Reference ET and EDDI are now being estimated at NWC using PSD-originated software, with their data to be shared with PSD (either pushed or pulled) in a raw format not usable by stakeholders; PSD will add any value for stakeholders and host the EDDI products exactly as we do currently; the NWC and PSD IT groups are finalizing the data transfer details, leaving PSD's remaining tasks to check their EDDI against ours and set up the data transfer at our end, which we anticipate being completed in Q1 of FY20. Target date for complete transition to NWC is December 2019.
NGGPS/UFS Improvements (GEFS)	ESRL/PSD has developed parameterizations of model uncertainty in the NCEP operational global ensemble forecast system. These parameterizations are crucial for producing accurate representations of forecast uncertainty for both the data assimilation cycle and the ensemble prediction system. This project supports ongoing development aimed at improving these parameterizations, in collaboration with NCEP/EMC.	Improved representation of model uncertainty in the NOAA Global Ensemble Forecast System (GEFS)		X																											X			Stochastic physics parameterizations implemented in time for use in beta implementation of FV3GFS data assimilation system and FV3GEFS reforecasts
NGGPS/UFS Improvements (GSI/EnKF)	ESRL/PSD has developed the Gridpoint Statistical Interpolation (GSI) Ensemble Kalman Filter (EnKF) component for the operational global data assimilation system. The EnKF is used to update an ensemble of forecasts in the data assimilation cycle, and that ensemble is used to estimate background-error covariances needed by the data assimilation update. This project supports ongoing development aimed at improving the use of ensemble information in the data assimilation system, in collaboration with NCEP/EMC.	Improved representation of background errors in the operational data assimilation system, leading to improved use of observations, improved analyses and forecasts.		X																											X			Improvements to the operational data assimilation system tested and merged in time for the code freeze ahead of the next operational FV3GFS upgrade.
Arctic Sea Ice Forecasting	Produce daily experimental forecast guidance products of sea ice, atmosphere, ocean conditions for the Arctic Basin on 0-10 day scales.	Improve 0-10 day forecasts of sea ice and Arctic conditions		X																											X			Daily forecasts are posted online for use by NOAA NWS, outside partners (https://www.esrl.noaa.gov/psd/forecasts/seaice/)
NGGPS/UFS Improvements (Arctic)	Deliver Arctic-focused diagnostics toolkit for assessing UFS performance wrt high quality observations and provide SME analysis	Assess and improve UFS Arctic region forecast skill		X																											X			Transition toolkit and analysis information to EMC UFS Development Team (POC: Avichal Mehra)

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			Moving from		Moving to		Target	Target	Target	Target	Future Targets					Operations								Commercial	Other				
			Research	Development	Demonstration	Operations or Applications	Research	Development	Demonstration	Operations or Applications	FY20 Q1	FY20 Q2	FY20 Q3	FY 20 Q4	21	22								23	24	25			
CMAQ Improvements	Over the past several years PSD has been working to improve NCEP codes for air quality forecasts via the Community Multiscale Air Quality (CMAQ) Modeling System.	Develop post processing code for PM2.5 and ozone for a new coupled FV3-CMAQ air quality forecast system.	X									X														X			Delayed because FV3-CMAQ model simulations have not yet been provided by NCEP due to problems in implementing the GFS FV3 model. Instead, promising new post-processing algorithms have been developed using the older NAM-CMAQ model, and these will be applied to the FV3-CMAQ simulations when they become available.
Temperature and Precipitation Forecast Improvements	Deployment of experimental cool-season temperature and precipitation forecasts based on a combined, lagged sea-surface temperature regression model	Provide cool-season probabilistic forecasts of temperature and precipitation based on method developed internally at PSD..		X																							X		Experimental web graphics page completed and following submitted for publication: Switanek, M. B., J. J. Barsugli, M. Scheuerer, and T. M. Hamill, 2020: Present and Past Sea Surface Temperatures: A Recipe for Better Seasonal Climate Forecasts. <i>Weather Forecasting</i> , 35, 1221–1234, https://doi.org/10.1175/WAF-D-19-0241.1 .
Sensor Improvements	Develop and demonstrate miniflux and microbuoy observing technologies	Advance air-sea-ice observational capability, in particular, as related to the measurement of ocean and atmosphere boundary layer fluxes to help improve our predictive understanding of these processes and their representation in climate models.	X																								X		Flight testing of miniFlux onboard the L3 Harris vehicle (in AZ) and from a moving ship platform (The Becker ship in FL).
Attribution Assessments	Produce two or more attribution assessments of climate extreme events, anomalies and trends	Investigate and communicate our understanding of the causes of climate extreme events, anomalies and trends.	X																								X		Possible contributions may include: (1) BAMS paper submitted on FACTS web site maintained by PSD. (2) BAMS Explaining Extremes Events publication (coordination and editing by Hoell, Hoerling) ("Dec 2019) (3) Reattribution / reforecasting of Colorado rain of 2013. Hoerling will present at AGU in special session extreme events. Possible written assessment depending on interest and feedback. (4) Andy Hoell will present at the CDPW on understanding record winter/spring 2019 precipitation in the US Great Plains. Possible AMS Annual presentation as well. A journal article is likely too, perhaps in 2020. (5) An internal document on PSD attribution / predictability data set evolution, including counter-factual best practices and a plan for FACTS 2.0. (6) Peer-reviewed manuscript submitted on "Confirmation for and Predictability of Distinct Impacts of El Niño Flavors" (Tao Zhang, Hoell, Hoerling, Perlwitz)

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			Moving from		Moving to		Target	Target	Target	Target	21	22	23	24	25								Operations	Commercial	Other	
			Research	Development	Demonstration	Operations or Applications	Research	Development	Demonstration	Operations or Applications	FY20 Q1	FY20 Q2	FY20 Q3	FY 20 Q4												
Predictability Assessments	Produce two or more predictability assessments for subseasonal to decadal time scales in order to quantify the prospects and gaps for skillful predictions, including droughts.	Investigate and communicate our understanding of the limits of predictability of subseasonal to decadal weather-climate phenomenon.	X																	Weather/climate community Decision/policy makers	Possible contributions may include: 1. Submit a proposal for an AGU Chapman Conference on "Colorado River Flow and its Climate Drivers", for the 15 March 2020 AGU call for proposals. 2. Complete analysis and prepare a manuscript on the topic "The Millennium Drought on the Colorado River." 3. Preliminary results of the diagnoses of GFS reforecasts for stratospheric and precipitation. 4. Some or all of GLACE protocol data for FV3 GFS system created. Possible associated journal articles.			X		
Marine Heat Waves	Examine marine heat waves, including the processes that cause them and their predictability	Survey of the processes that cause marine heat waves to improve the predictive understanding of these events. Examine the heat wave developing off the US west coast in 2019.									X									Weather/climate community	Draft and submit for publication a journal paper describing the result of this study.			X		
Water Vapor Flux Tool	Add the GFS (FV3 core) to PSD's water vapor flux tool	PSD's water vapor flux tool is available at sites where PSD operates Doppler wind profilers, and more specifically, the picket fence of semi-permanent atmospheric river observatories deployed along the U.S. West Coast. The tool combines observations and numerical weather prediction output in a unique display that allows forecasters to evaluate model predictions of the the incoming flux of water vapor, the snow level, and the precipitation that result from landfalling atmospheric rivers. This effort will allow NWS forecasters to evaluate how well the GFS is predicting atmospheric river conditions several days in advance. This complements the current tool, which does the same for the HRRR and RAP models on shorter time scales.										X								Weather/climate community NWS Western Region	Implementation of of advanced capability on current website		X		Update to the tool to include the GFS was completed early in Q2. Forecasters can now choose from the HRRR, HRRRX, RAP, and GFS to compare with observations. An example can be viewed at https://www.esrl.noaa.gov/psd/data/obs/datadisplay/ViewDataType.php?DataTypeID=67&SiteID=bb&DataSourceID=1 by choosing one of the model buttons in the upper left of the display.	
ATOMIC Field Program	Lead the ATOMIC field program to study shallow cumulus and air-sea interaction in the North Atlantic	ATOMIC is a the U.S. contribution to an international field program being conducted in Jan-Feb 2020 off Barbados. NOAA is providing a research vessel and a P-3 aircraft. https://www.esrl.noaa.gov/psd/atomic/ . The purpose of the field program is to improve our predictive understanding of the phenomena and their representation in climate models.											X							Weather/climate community	Successful completion of field study			X	The project was successfully completed in Jan 5-Feb 15, 2020. In processes of creating data archive.	

