Impact of Groundwater Loss Calibration on the National Water Model Streamflow Prediction

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Motivation

- The National Water Model (NWM) overpredicates streamflows in some of the Contiguous United States (CONUS) basins as shown in Figure 1.
- Conducted experiments to test if application of channel losses to groundwater could improve model performance in regions of hypothesized unrepresented losses to groundwater systems.

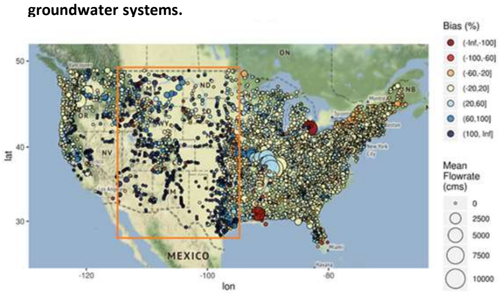

Figure 1. NWM v2.1 streamflow biases at USGS gages. NWM overperdictions with large biases observed at the central of the CONUS domain (redbox).

NWM v2.1 Nonlinear Conceptual Groundwater Model

NWM utilizes a groundwater 'loss' function which removes a fraction of outflow from the total reservoir outflow [1].

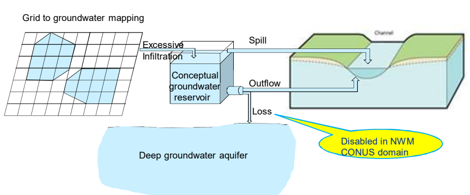

Figure 2. NWM v2.1 nonlinear conceptual groundwater reservoir. Channel losses to deep groundwater are defined as a fraction (between 0 and 1) of the total reservoir outflow.

- Application of channel loss improves the overall streamflow forecasts in terms of the objective function, and other evaluation metrics at high-biased basins.
- Mixture of improved and degraded results for event-based metrics noted in the validation period (peaks and timing).

Table: ObjFunc/Metric Differences (Default - Loss) (Biases are absoluate values)

Better Worse Equal

USGS ID	obj	cor	rmse	bias	nse	nselog	nsewt	nnsesq	kge	msof	hyperResMultiObj	POD	FAR	CSI
08190500	-0.003	0.005	-0.002	3.543	0.037	-0.055	-0.009	0.006	0.003	-0.456	0.016	0.000	0.000	0.000
08201500	-0.080	0.085	-0.197	3.574	0.258	0.234	0.246	0.037	0.080	-41.446	-0.020	-0.194	0.093	-0.127
08202700	0.023	-0.031	0.023	0.676	-0.024	4.337	2.156	-0.002	-0.023	5.610	0.010	0.000	-0.133	0.050
08152900	-0.095	0.098	-0.321	3.877	0.203	0.146	0.175	0.057	0.095	-67.121	-0.025	0.320	0.135	0.016
08150800	0.028	-0.028	0.088	1.260	-0.046	0.479	0.216	-0.082	-0.028	17.086	0.044	0.005	-0.105	0.067
06846500	1.647	0.003	-0.002	246.783	0.039	-45.137	-22.549	0.000	-1.647	-0.477	0.998	0.000	0.000	0.000
06784000	-0.157	0.108	-1.017	-13.639	0.362	1.603	0.983	0.030	0.157	-197.230	-0.096	-0.036	-0.108	0.046
06775500	-0.069	0.006	-1.405	-10.373	13.395	517.584	265.489	0.005	0.069	-287.059	-0.087	-0.004	0.180	-0.005

8 Basins in Northern High Plains and Edwards-Trinity Regions

Table: kge Valid Period ObjFunc/Metric Differences ([w/o loss] - [w loss])

Better Worse Equal

USGS ID	obj	cor	rmse	bias	nse	nselog	nsewt	nnsesq	kge	msof	hyperResMultiObj	event_volume_bias	peak_bias	peak_tm_err_hr	POD	FAR	CSI
07001985	1.087	0.011	0.065	116.321	0.104	1.738	0.921	-0.026	1.087	3.905	0.475	nan	nan	nan	-0.081	0.396	0.321
02303420	0.462	-0.041	1.005	45.122	0.518	0.296	0.407	0.054	0.462	166.363	0.387	nan	nan	nan	0.075	nan	0.075
04163400	0.796	0.027	0.233	142.134	1.314	2.102	1.708	0.000	0.796	37.885	0.593	203.080	-12.295	7.520	-0.084	0.346	-0.002
02336152	2.719	0.007	0.898	277.324	1.487	3.980	2.733	0.389	2.719	118.408	1.522	167.021	24.891	1.075	-0.242	0.734	0.551
02336526	0.258	0.076	0.232	-5.167	0.118	0.152	0.135	0.023	0.258	38.434	0.021	0.753	-9.083	0.855	-0.084	0.175	0.020
02095000	0.921	0.015	0.396	104.027	0.130	1.684	0.907	-0.017	0.921	68.746	0.426	84.775	-3.854	-0.601	-0.126	0.350	0.104
02303350	0.067	0.077	0.190	1.439	0.116	0.127	0.122	0.075	0.067	30.811	0.076	9.228	5.980	-14.483	0.019	-0.018	0.013
02336968	0.505	0.120	0.888	54.744	0.362	1.017	0.890	0.204	0.505	141.714	0.362	20.632	2.706	0.262	-0.029	0.300	0.174
02378170	-0.057	0.067	-0.364	26.830	-0.181	-3.726	-1.953	-0.045	-0.057	-59.529	-0.078	152.399	48.793	-0.353	-0.246	0.416	0.241
02392975	0.535	-0.018	0.336	65.668	0.126	1.195	0.661	0.053	0.535	55.083	0.302	12.806	-17.082	1.950	-0.193	0.362	-0.033
08068325	1.435	0.252	8.942	85.715	2.986	1.038	2.012	0.427	1.435	1408.722	1.026	82.757	149.960	-0.687	-0.114	0.334	0.136
06102500	1.035	-0.000	3.087	74.352	1.960	0.480	1.220	0.578	1.035	421.046	0.744	-4.807	96.141	-78.150	-0.324	0.381	0.255
10205030	0.365	0.320	0.022	-11.893	0.169	-0.419	-0.125	0.392	0.365	3.134	0.902	10.599	187.034	-242.500	0.000	0.000	0.000
12381400	0.669	0.160	1.381	63.239	1.106	0.334	0.720	0.447	0.669	200.607	0.552	97.282	152.659	29.875	0.490	0.455	0.372
06710150	0.340	0.006	0.069	27.873	0.321	-4.088	-1.884	0.013	0.340	11.700	0.160	-101.760	52.979	-0.739	-0.033	-0.223	-0.175
08158860	-0.182	-0.017	-1.485	10.114	-0.264	5.220	2.478	-0.044	-0.182	-251.681	-0.069	13620.649	3916.890	-73.647	-0.343	0.610	0.089
08177300	0.299	0.138	0.209	46.760	0.209	-0.491	-0.141	0.042	0.299	33.774	0.182	970.894	1772.725	9.055	0.031	0.159	0.151
08181480	6.928	0.086	14.649	668.653	14.777	1.519	8.148	0.282	6.928	2440.219	2.998	1836.122	1501.744	2.306	-0.329	0.624	0.432
08210400	3.296	0.003	1.024	309.410	7.284	5.975	6.629	0.318	3.296	167.541	1.820	-1753431.766	-454233.349	2.500	-0.205	-0.018	-0.023
08212400	-4.981	-0.101	-4.073	-139.249	-113.152	3.597	-54.777	-0.005	-4.981	-469.162	-3.680	-7109.379	-8514.160	115.473	0.000	0.000	0.000
10258500	-2.694	0.145	0.001	-340.803	0.413	-2.852	-1.220	0.325	-2.694	0.171	-1.520	-147.048	131.726	-656.750	nan	nan	nan
11046360	0.836	0.022	0.014	86.739	1.605	-4.352	-1.378	0.293	0.836	2.261	0.363	1582.348	591.937	-466.908	nan	nan	nan

[1] Absolute values are used: absolute(default) - absolute(kge)

22 high wet-biased basins in CONUS domain

Figure 3. Results from the 8 basin and 22 basin experiments with mixed results.

Discussion and future work

- Challenge exists in connecting the conceptual model parameters with groundwater physics.
- Various sources of uncertainty such as forcing and anthropogenic impacts are difficult to disentangle.
- Given mixed results, groundwater loss will not be implemented in NWM v3.0, but may be further explored in future versions.

Testing Basins

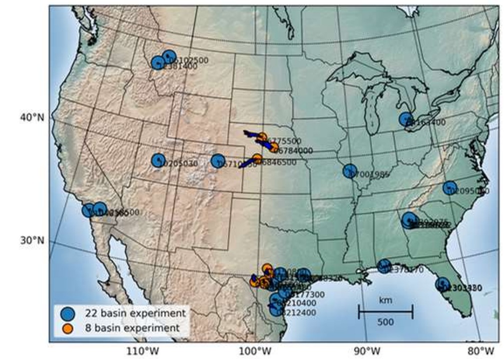

Figure 4. Basin locations in the 8 basin and 22 basin experiments. The basins were selected by criteria including, 1) Overlapping with NWM v2.1 calibration basins, 2) Hypothesized areas of groundwater losses such as central US and coastal areas, and 3) Basins with high-biased streamflow values.

Methods

Baseline Case: **NWM v2.1 Calibration parameters**

GW Loss Case: **NWM v2.1 Calibration parameters + GW loss**

NWM Calibration [2][3]:
- Objective Function: KGE
- Spin-up: 2007-2016
- Calibration: 2008-2013
- Validation: 2013-2016
- Iterations: 400

Compare results of the two cases in calibration/Validation periods:
- Objective Functions
- Evaluation Metrics
- Hydrographs

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