WRF-Hydro/Airborne Snow Observatory Assimilated Hydrologic Forecasts: Colorado

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[Updated for all basins each new forecast that becomes available]

Provided by: NCAR WRF-Hydro Modeling Team

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Overview:

This report summarizes WRF-Hydro forecast results for selected major river basin forecast points across the state of Colorado. Included in each report are the following:

- Spatial maps of analyzed ASO-assimilated SWE from WRF-Hydro
- Time-series plots of basin-averaged analyzed and forecasted SWE from the WRF-Hydro OpenLoop model, WRF-Hydro ASO-assimilated model and SNODAS products
- Plots of elevation bin-averaged SWE vs. elevation from WRF-Hydro OpenLoop and ASO-Assimilated analyses and SNODAS
- Tabulations of Apr. 1 – Jul. 31 and/or Apr. 1 – Sep. 30 ensemble seasonal water supply forecasts

WRF-Hydro Forecasts for the Colorado Airborne Snow Measurement (CASM)

The WRF-Hydro modeling system has been employed in various seasonal water supply forecasting activities in the State of Colorado since 2015. Starting first in the Rio Grande/Conejos River basin regions new forecast basins/locations have steadily been added over time as interest in the system has grown. Currently a single model domain has been established over all of the mountain headwater regions of the state to enable snowpack and runoff predictions from key water resource generation areas. While the model integrates over all of these areas, preparation and optimization of *reliable* forecasts at particular locations is limited to areas where funded efforts have been made to engage in data assimilation, model evaluation and model optimization. Prior forecast domains have included the Rio/Conejos system, East/Taylor system, the Dolores basin, Blue River/Dillon Reservoir system and the Upper Colorado/Fraser/Willow Creek/Windy Gap system. The CASM mission has recently (past 2 years) contributed to this data assimilation and model optimization effort by coordinating and support Airborne Snow Observatory, Inc. surveys of snowpack and model forecasting activities. This year new forecast basins include the Roaring Fork/Frying Pan System, the Upper South Platte System and Poudre/ Big Thompson/St. Vrain/Boulder/Clear Creek Front Range systems. Implementation of these new areas along with enhanced optimization of prior domains initiated in April 2023 at the start of the new contract to

fund WRF-Hydro forecasting. As such, forecast development for new basins added this year are still a work in progress and forecast results will be shared as they become available.

This report is organized by river basin which each basin area containing the following information:

- Spatial analyses of ASO-assimilated (where available) snow water equivalent (SWE)
- Basin-averaged analyses and ensemble mean forecast plots of SWE
- Elevation distributions of SWE
- Spatial maps and basin-averaged analyses of modeled soil moisture
- Sub-seasonal (April-July) and seasonal (April-Sept.) values of ensemble accumulated runoff or reservoir inflow

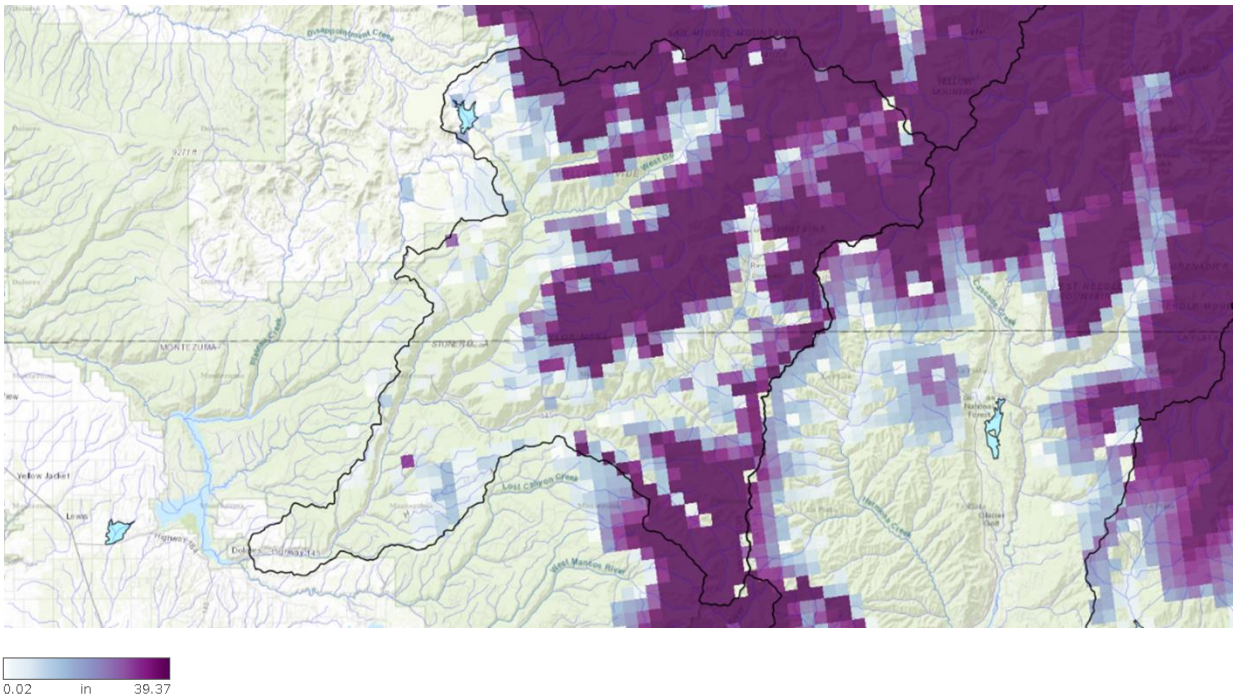
Additional model outputs are being prepared and will be added to future reports as they become available. Additionally, as noted above, several forecast locations are new or are having issues addressed that relate to the availability of timely and quality unregulated flow information for model calibration and forecast preparation. As such, not all locations have forecast information available at this time but will be added as work proceeds.

IMPORTANT: All flow accumulation forecasts from this specific configuration of the WRF-Hydro model are "natural" flow values with no accounting for reservoir storage/release, diversions, transfers or managed return flows. As such, these forecast numbers should be compared against analogous naturalized flow measurements or estimates.

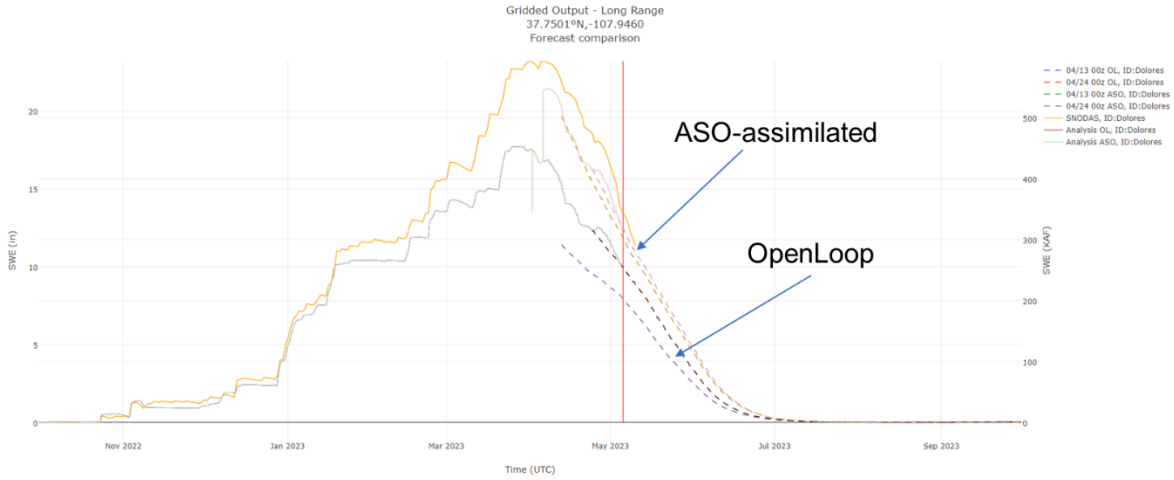
Dolores River Basin:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 315 kac-ft and dropping quickly. Nearly all snowpack resided above 8,500 ft. Basin averaged soil saturation fraction was approximately 75% indicating very wet conditions.

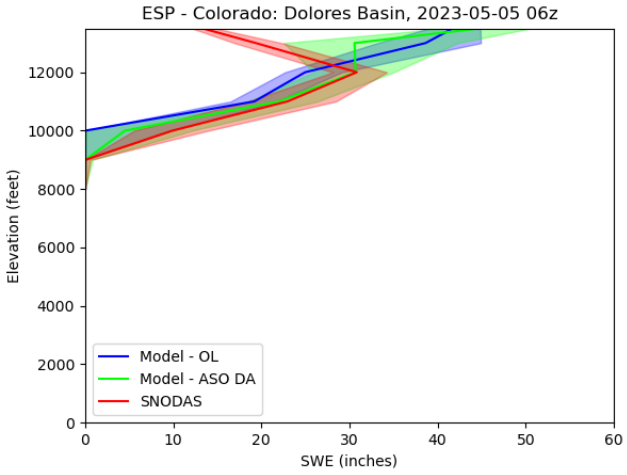
Spatial map of ASO-assimilated SWE:



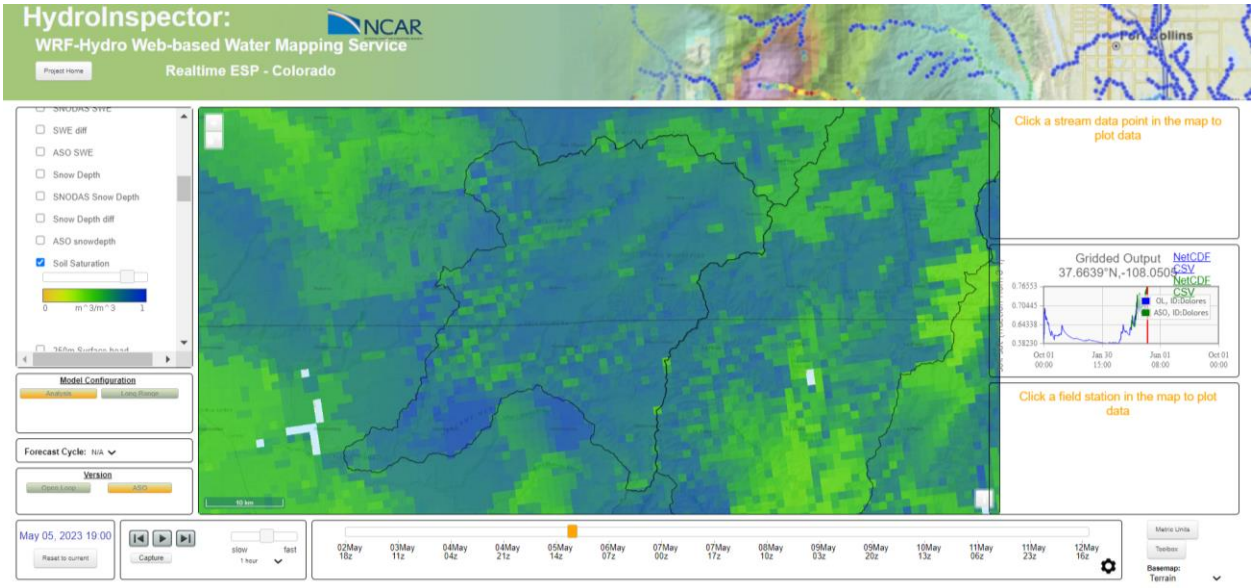
Basin-averaged analyses and forecasts of ASO-assimilated SWE:



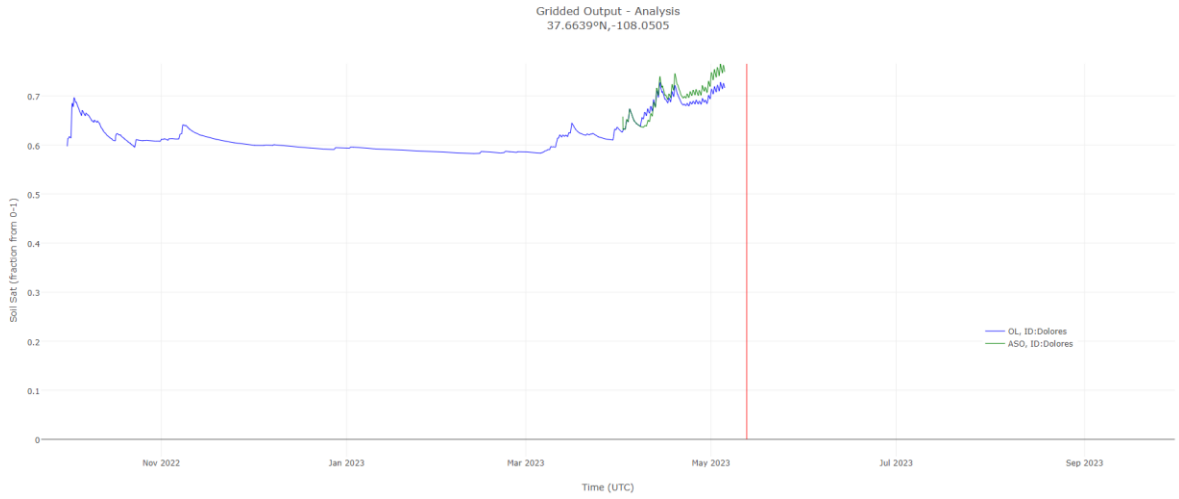
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue)



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values:



Dolores R. at Dolores, CO, median (Q50) runoff forecast (initialized on 5/5/2023):

Apr-Jul: 415.7 kac-ft

Apr-Sep: 442.1 kac-ft

Dolores R. blw Rico, CO:

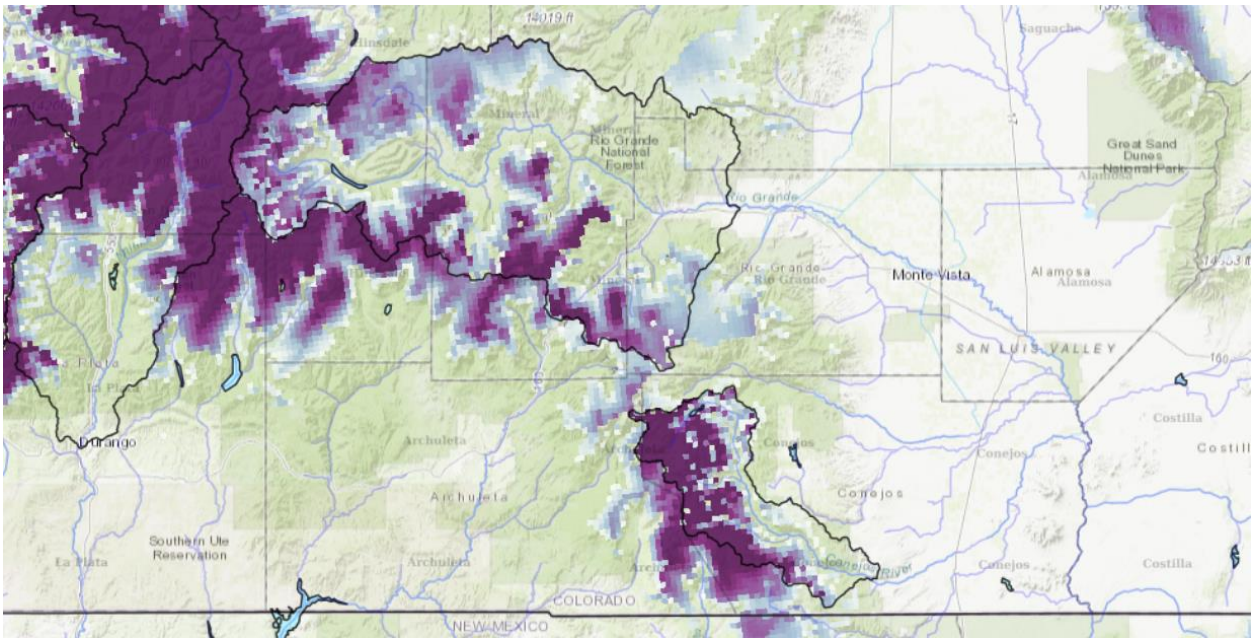
Apr-Jul: 115.5 kac-ft

Apr-Sep: 125.0 kac-ft

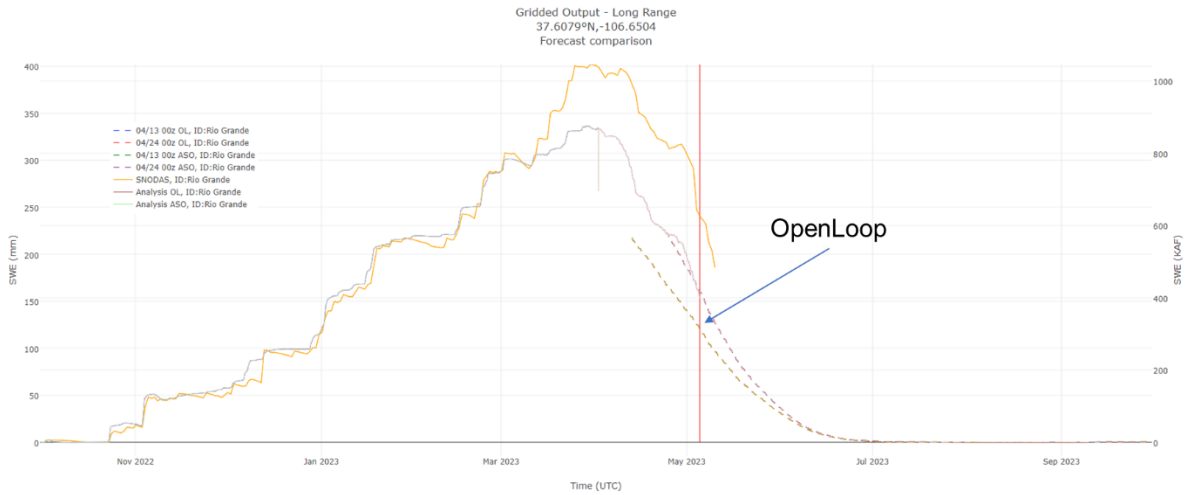
Rio Grande/Conejos System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 397 kac-ft for the Rio Grande above del Norte and 226 kac-ft for the Conejos basin above Mogote. Nearly all snowpack in both basins resided above 8,500 ft. Basin averaged soil saturation fractions for both basins were slightly less than 70%.

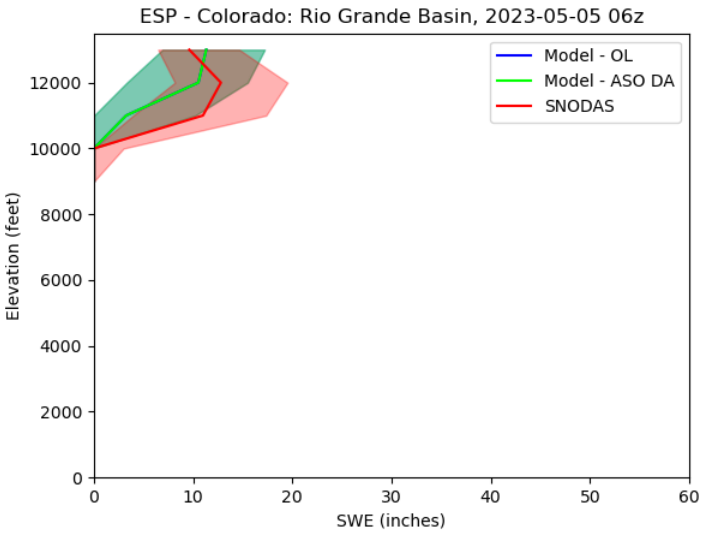
Spatial map of ASO-assimilated SWE:



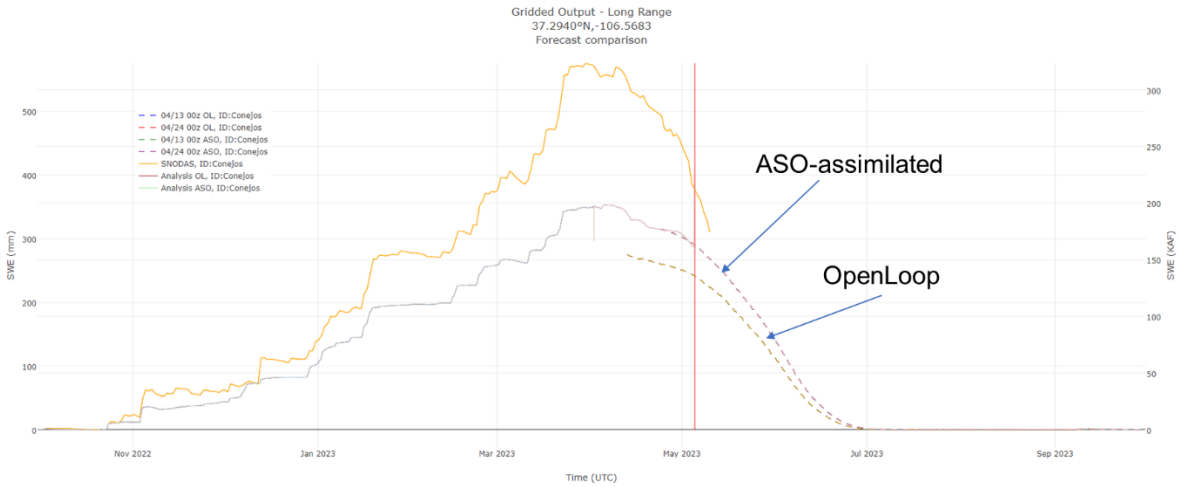
Basin-averaged analyses and forecasts of ASO-assimilated SWE:



Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue)



Basin-averaged analyses and forecasts of ASO-assimilated SWE:



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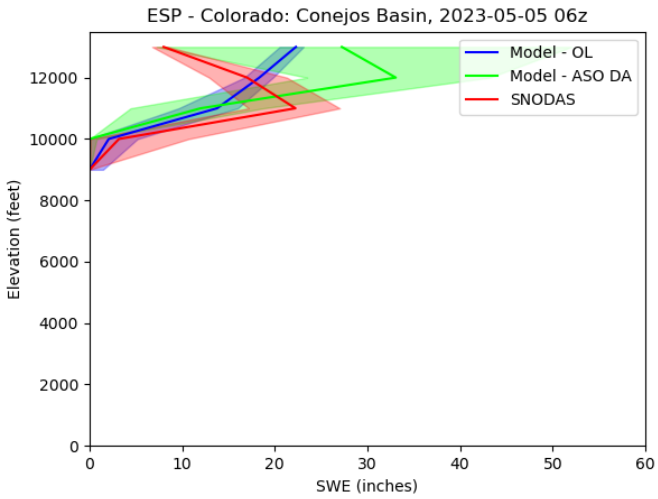
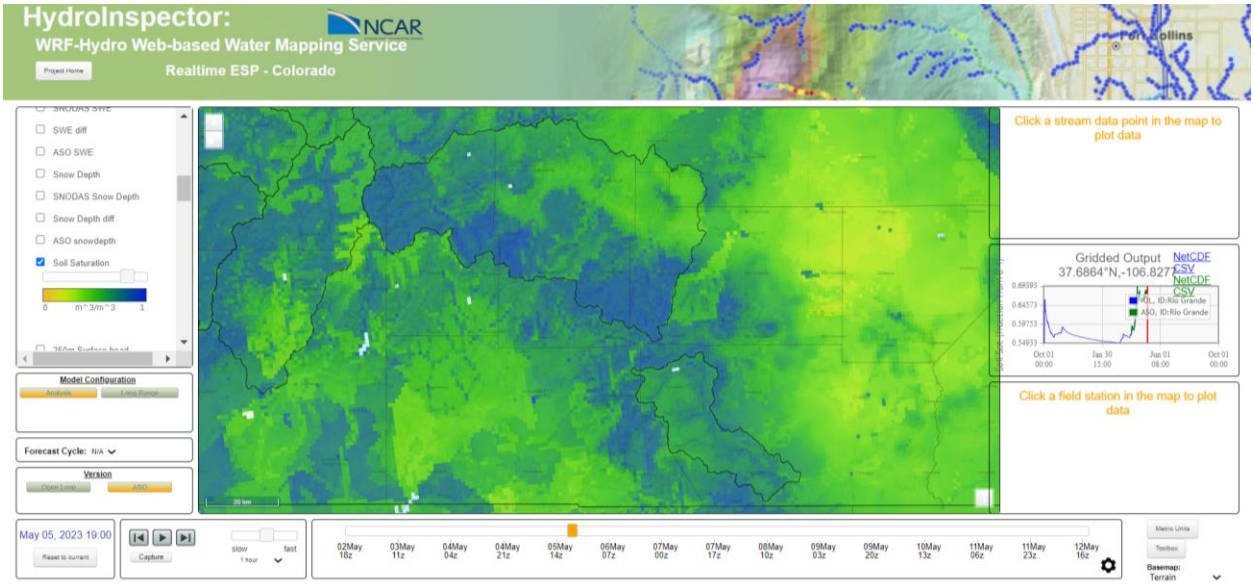
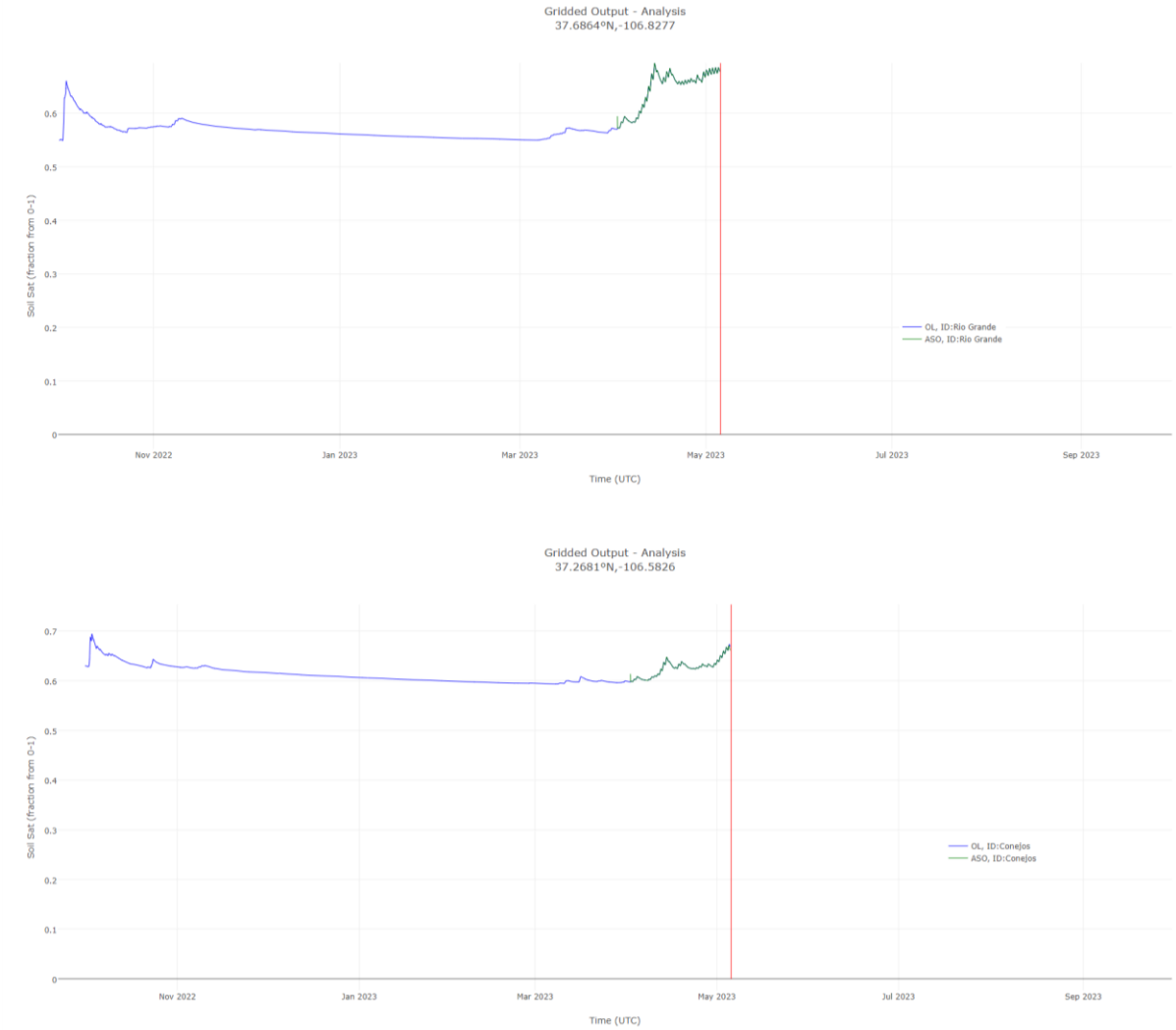


Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values:



Rio Grande and Conejos April-Sep Median (Q50) Accumulated Runoff/Inflow:

Rio at del Norte: WRF-Hydro/OL: 536 kac-ft (Apr-Jul): 574.5 kac-ft (Apr-Sep)

Conejos System: WRF-Hydro/ASO: 302 kac-ft (Apr-Jul): 374.5 kac-ft (Apr-Sep)

Conejos at Mogote: WRF-Hydro/ASO: 219 kac-ft (Apr-Jul): 261.3 kac-ft (Apr-Sep)

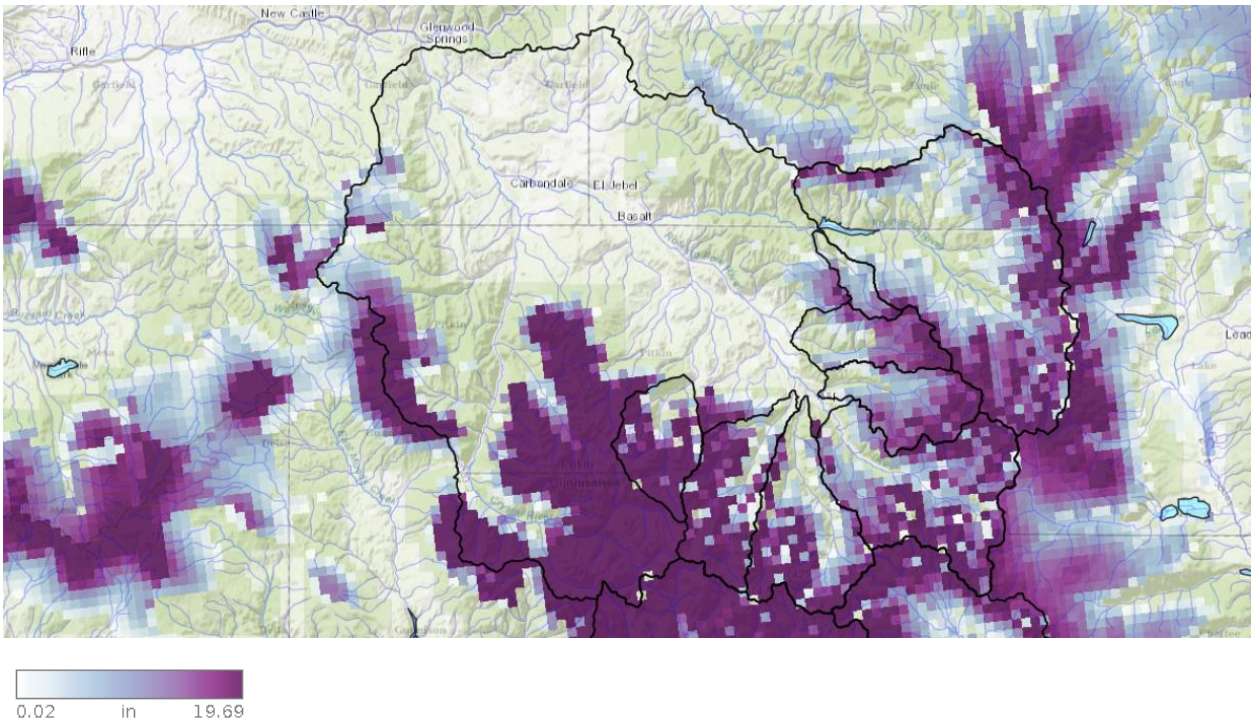
San Antonio @ Ortiz: WRF-Hydro/ASO: 19.9 kac-ft (Apr-Jul): 21.6 kac-ft (Apr-Sep)

Los Pinos @ Ortiz: WRF-Hydro/ASO: 75.6 kac-ft (Apr-Jul) 91.6 kac-ft (Apr-Sep)

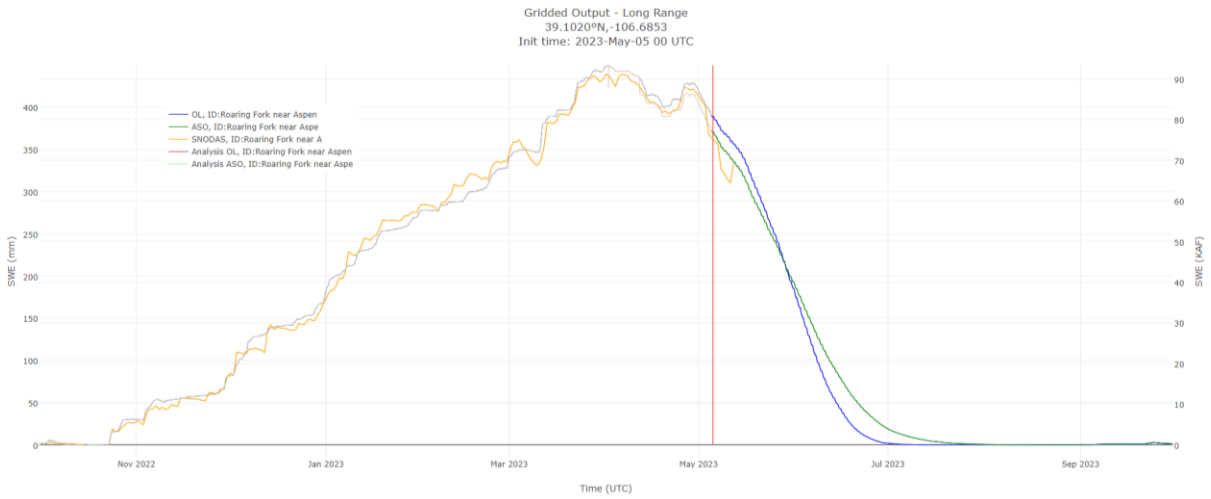
Roaring Fork/Frying Pan System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 109 kac-ft for the Roaring Fork River above Aspen and 76 kac-ft for the Frying Pan River above Ruedi Reservoir. The bulk of the remaining snowpack in the combined Roaring Fork/Frying Pan system resided above 8,500 ft. Basin averaged soil saturation fractions for the combined Roaring Fork/Frying Pan system above Glenwood was around 62%.

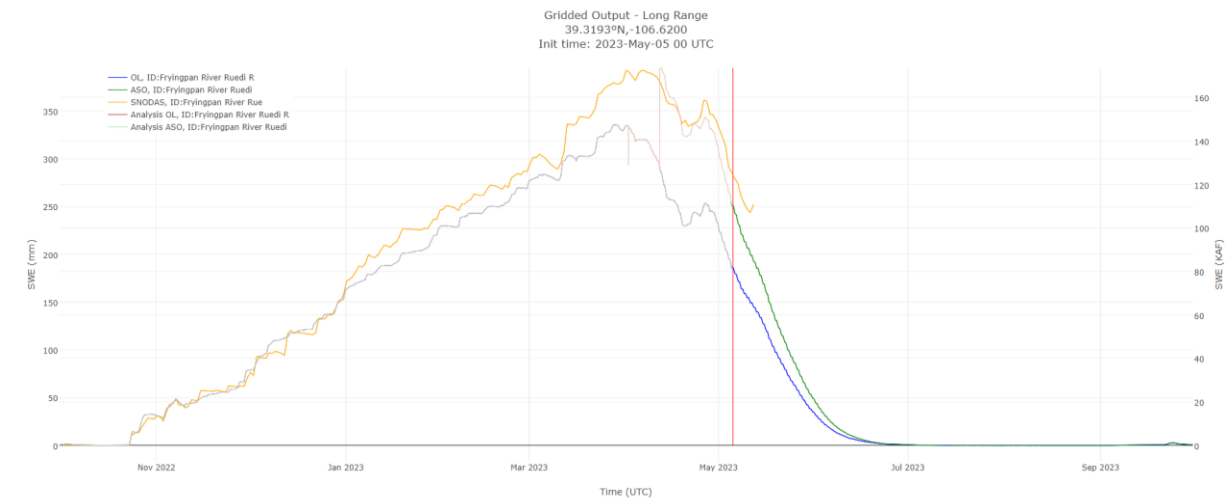
Spatial map of ASO-assimilated SWE:



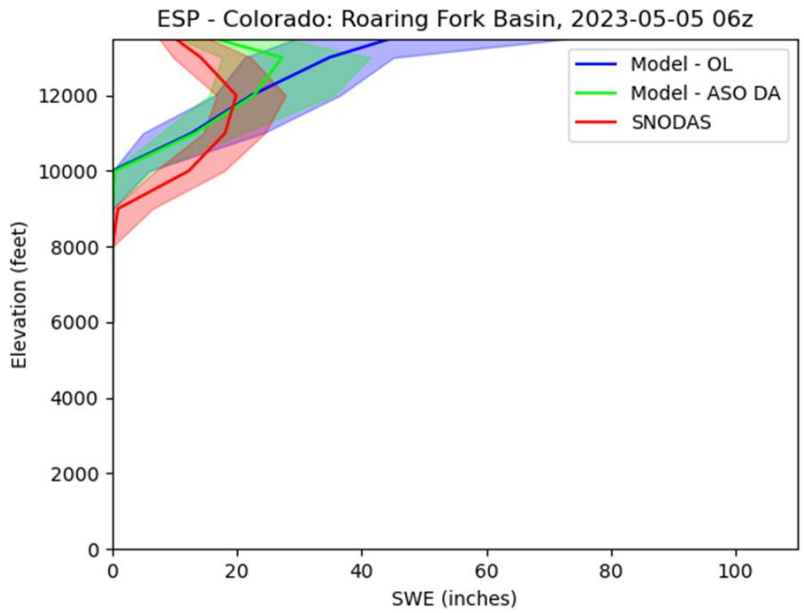
Basin-averaged analyses and forecasts of ASO-assimilated SWE (Roaring Fork River near Aspen):



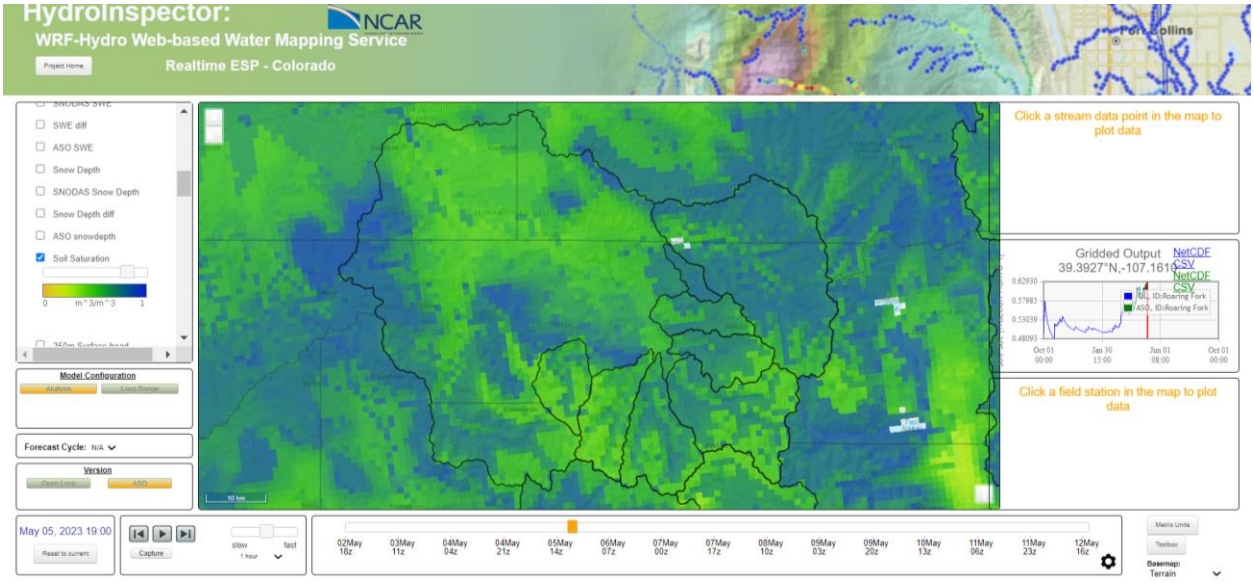
Basin-averaged analyses and forecasts of ASO-assimilated SWE (Frying Pan River above Ruedi Reservoir):



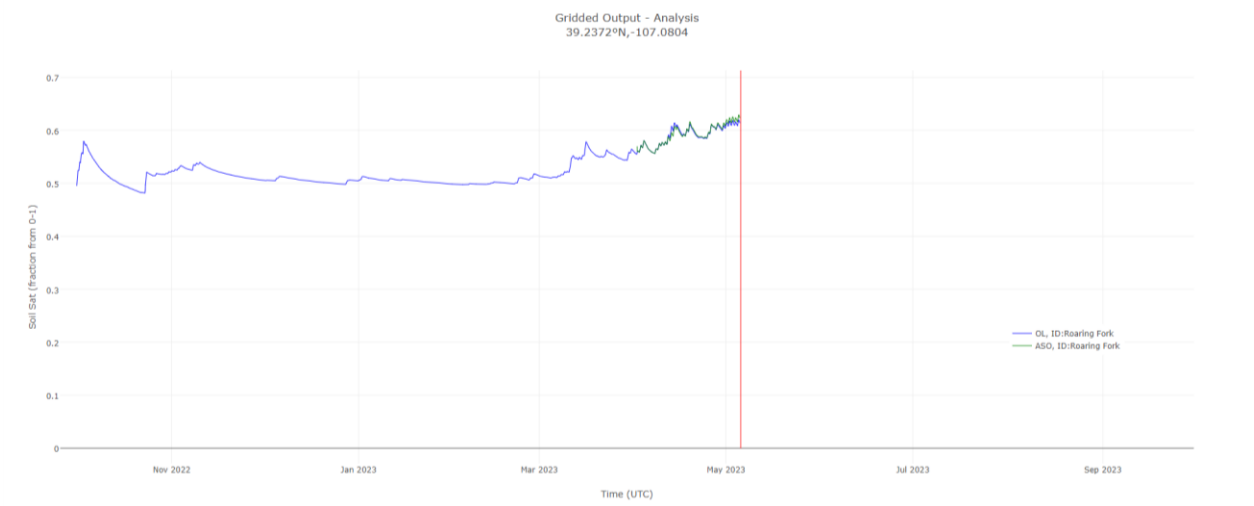
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for the combined Roaring Fork/Frying Pan System above Glenwood Springs, CO:



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values:



Roaring Fork/Frying Pan April-Jul Median (Q50) Accumulated Runoff/Inflow:

Roaring Fork near Aspen: 47.6 kac-ft

Snowmass Creek: 40.1 kac-ft

Frying Pan River @ Meridith: 112.4 kac-ft

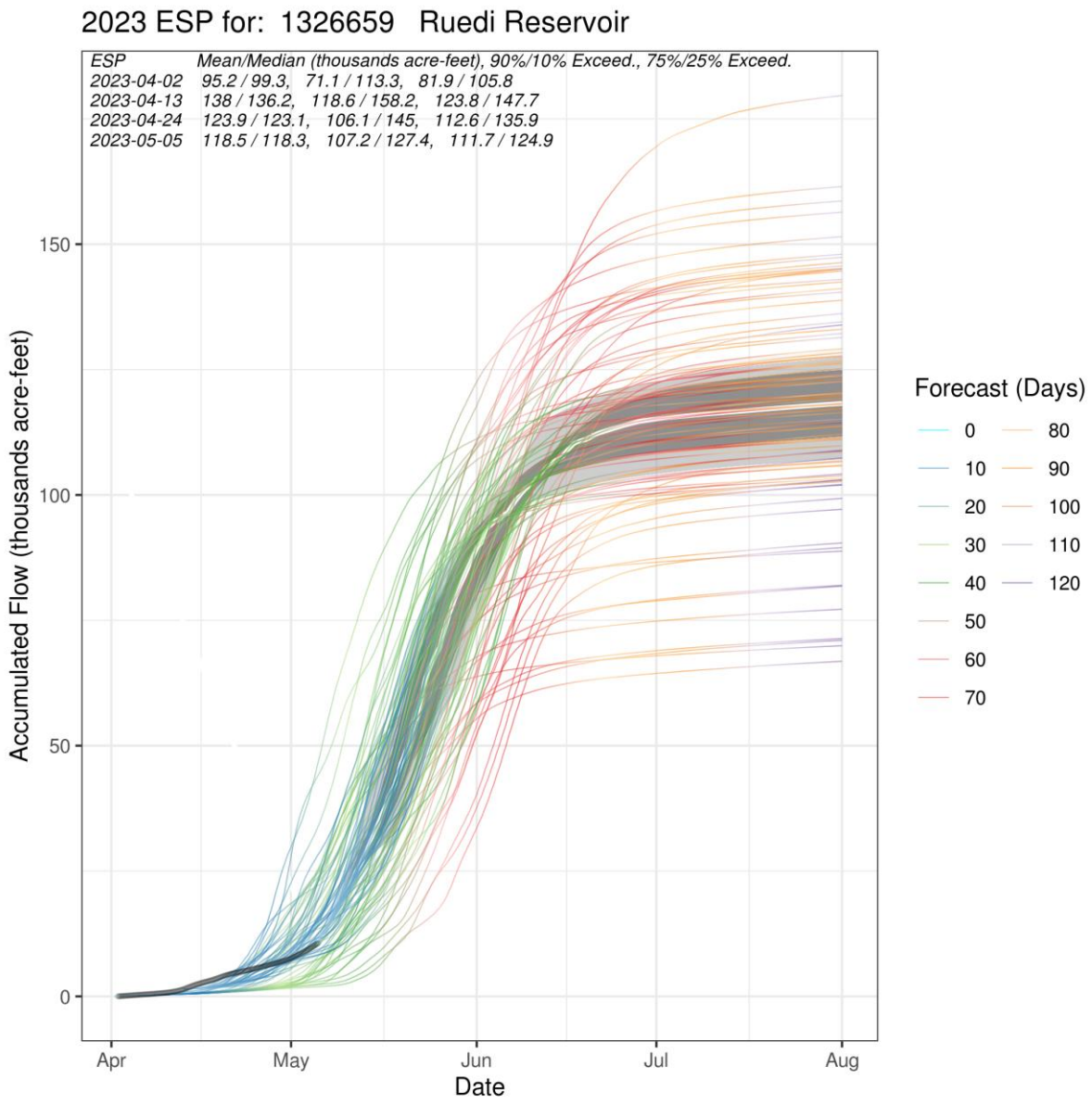
Ruedi Reservoir Inflow: 118.3 kac-ft

Hunter Cr: New station in progress…

Maroon Cr: New station in progress…

Castle Cr: New station in progress…

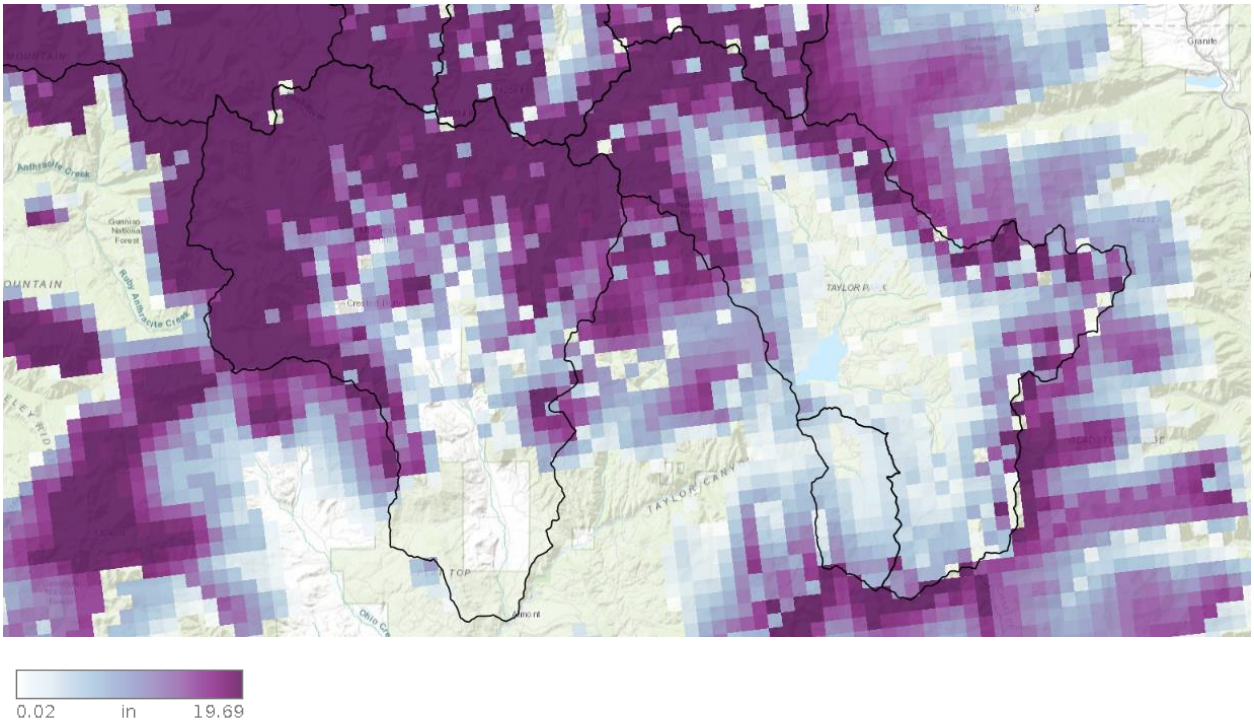
Example ensemble flow accumulation plot for Apr-Jul inflow to Ruedi Reservoir:



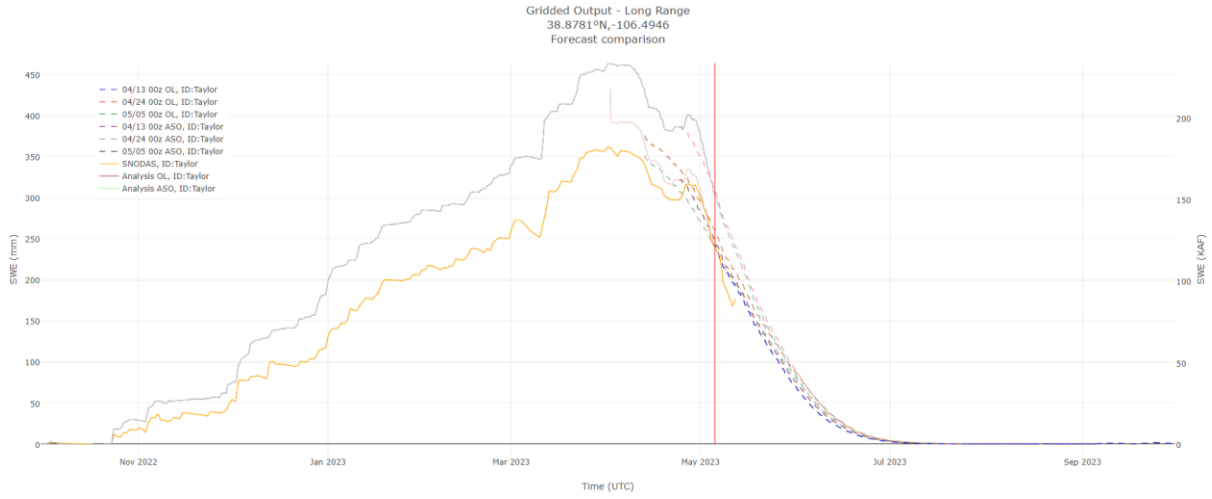
Taylor River/East River System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 122 kac-ft for the Taylor basin above Taylor Reservoir and 276 kac-ft for the East River above Almont. The bulk of the remaining snowpack in the throughout the region resided above 9,000 ft. Basin averaged soil saturation fractions for both systems was over 72%, indicating very wet conditions.

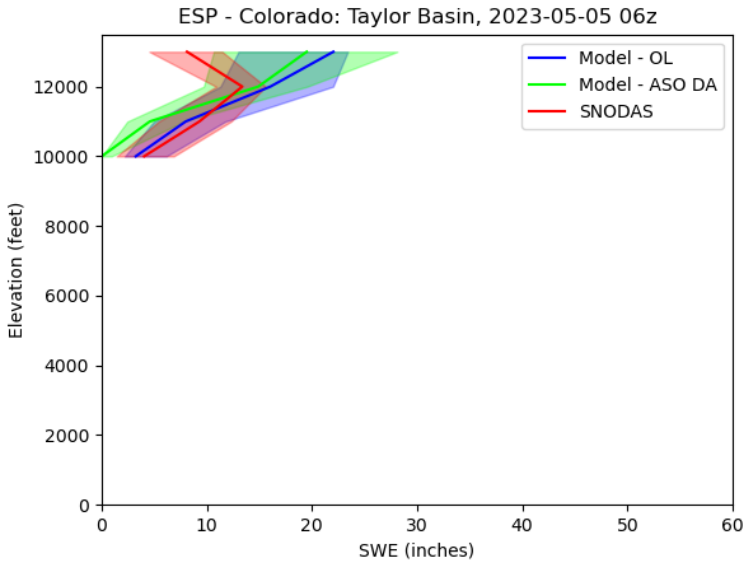
East and Taylor River Water Equivalent (SWE) Analysis and Forecasts



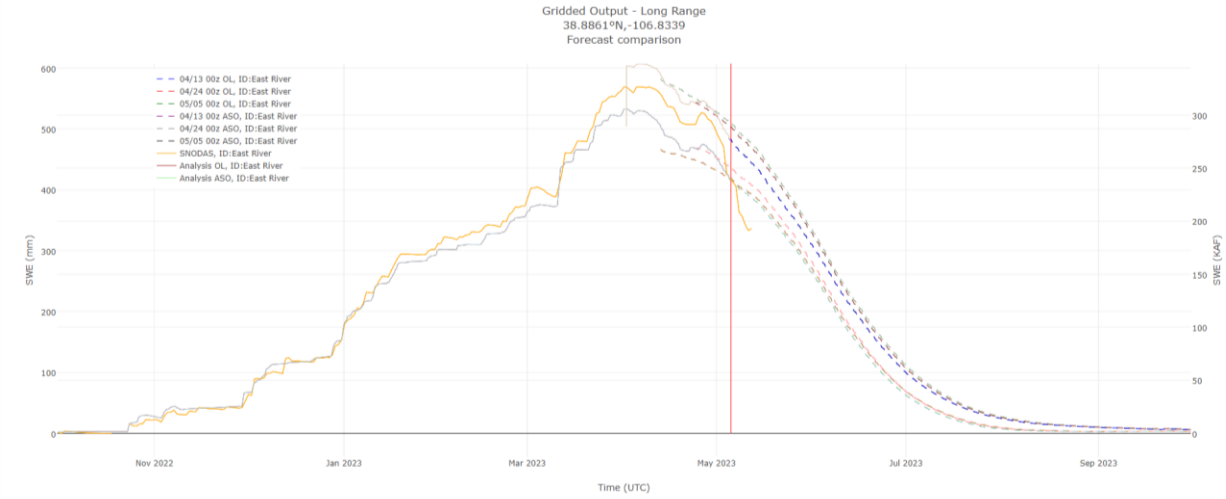
Taylor Basin Basin-averaged Snow Water Equivalent (SWE) Analysis and Forecasts



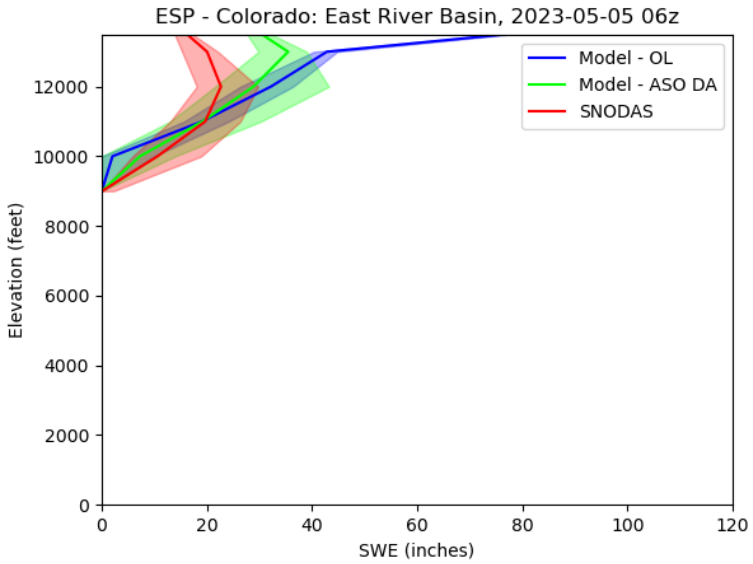
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for the Taylor basin above Taylor Park Reservoir:



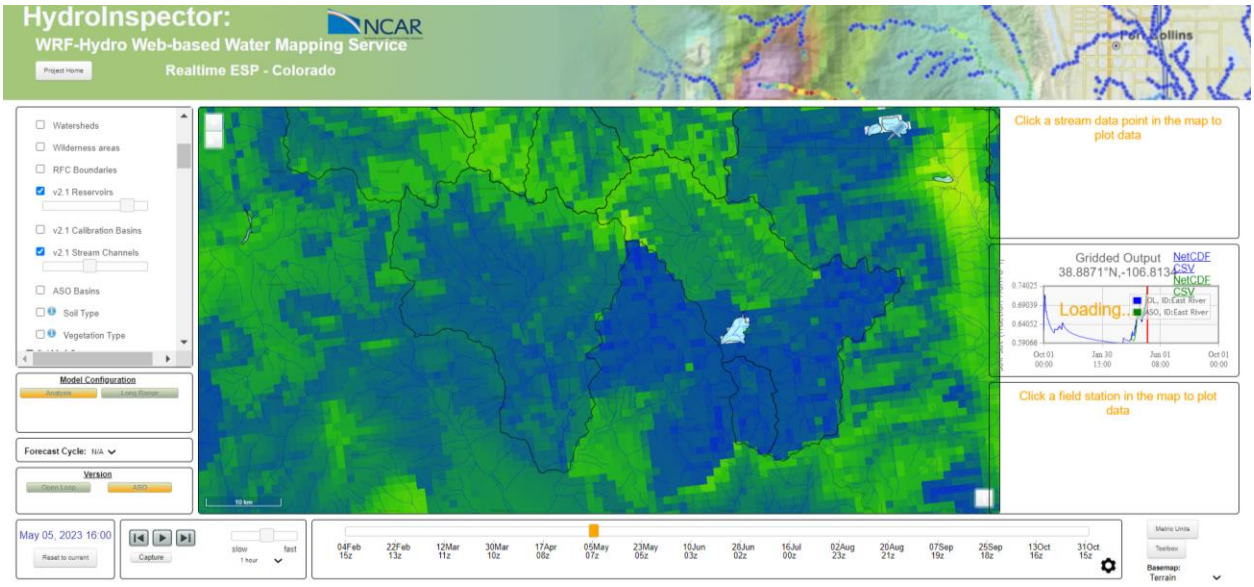
East River Basin-averaged Snow Water Equivalent (SWE) Analysis and Forecasts:



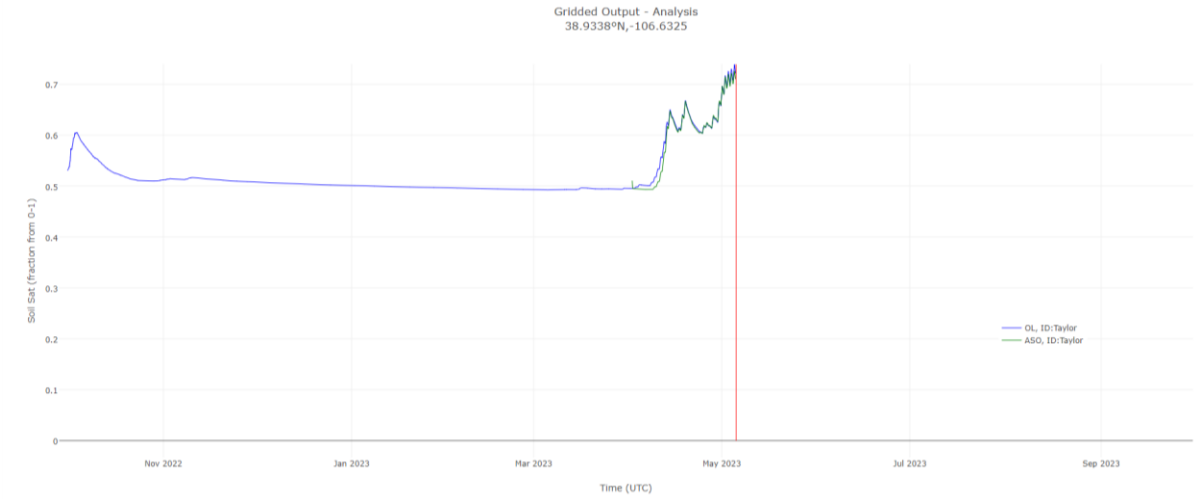
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for the East River basin above Almont, CO:



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values for the Taylor River basin above Taylor Reservoir:



Taylor and East Rivers April-Jul Median (Q50) Accumulated Runoff/Inflow:

Taylor Reservoir Inflow: 108.6 kac-ft

Taylor R. abv Taylor Res: 76.3

Texas Cr. abv Taylor Res: 18 kac-ft

Willow Crk abv Taylor Res: 10.5 kac-ft

East River at Almont: 302.8 kac-ft

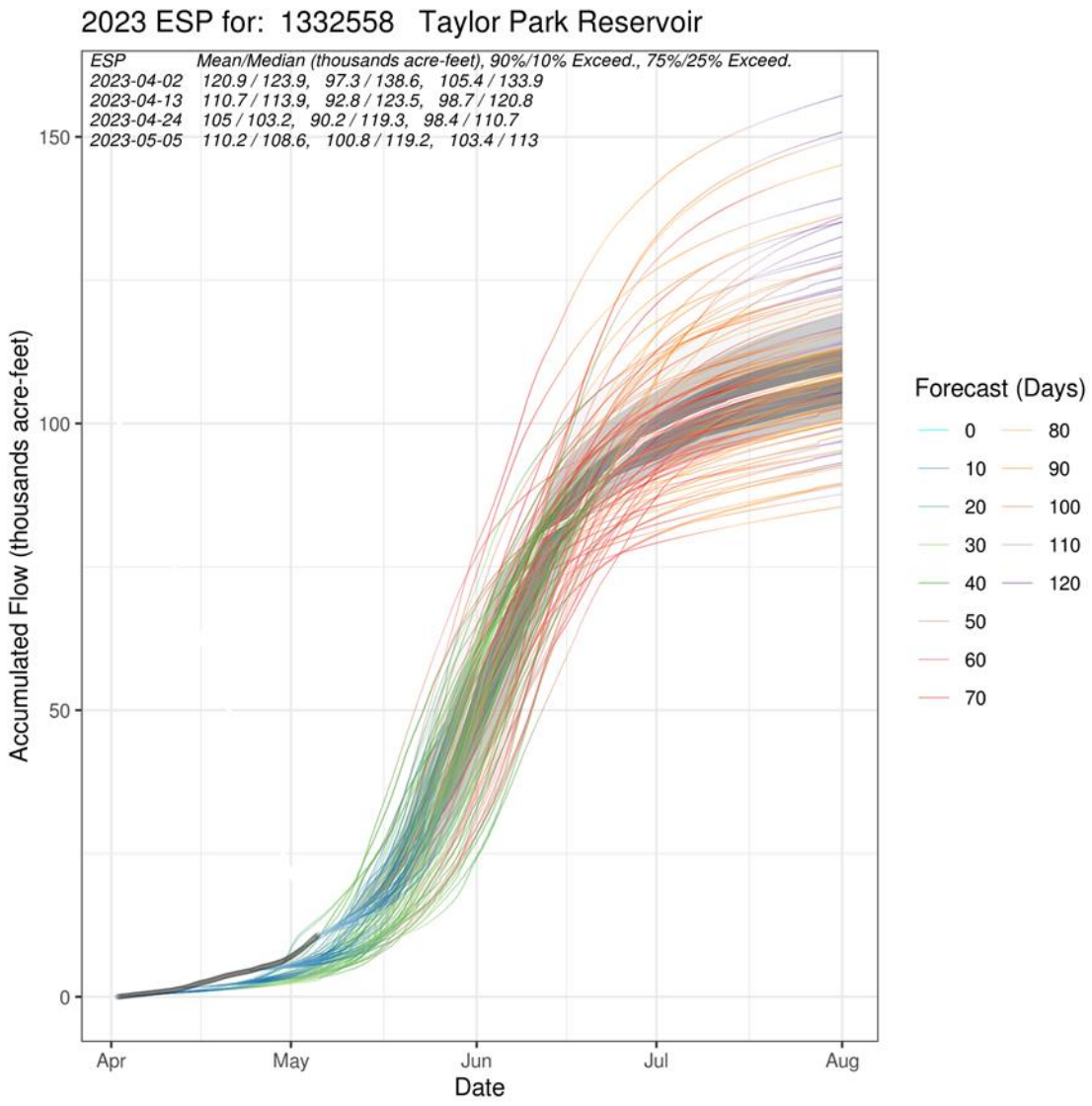
Ohio @ Baldwin: 80.1 kac-ft

Slate River nr Crested Butte: 120.6 kac-ft

Coal Cr nr Crested Butte: 28.2 kac-ft

Blue Mesa inflow: 900.6 kac-ft

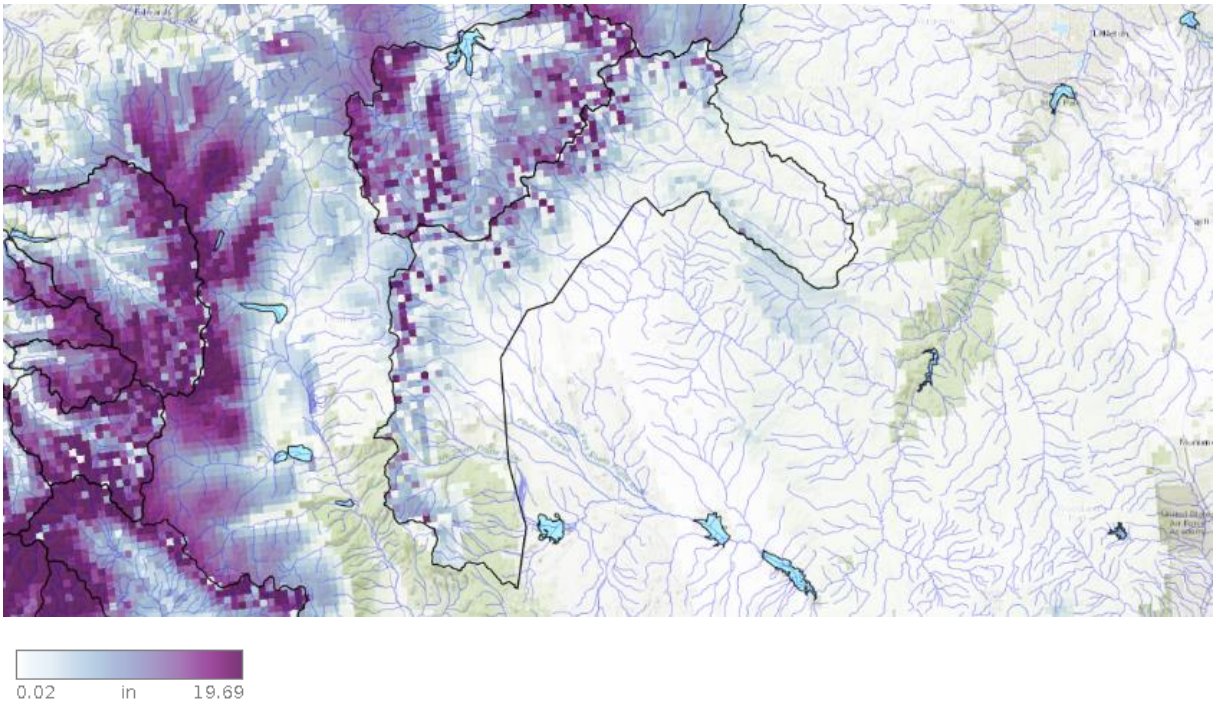
Example ensemble flow accumulation plot for Apr-Jul inflow to Taylor Park Reservoir:



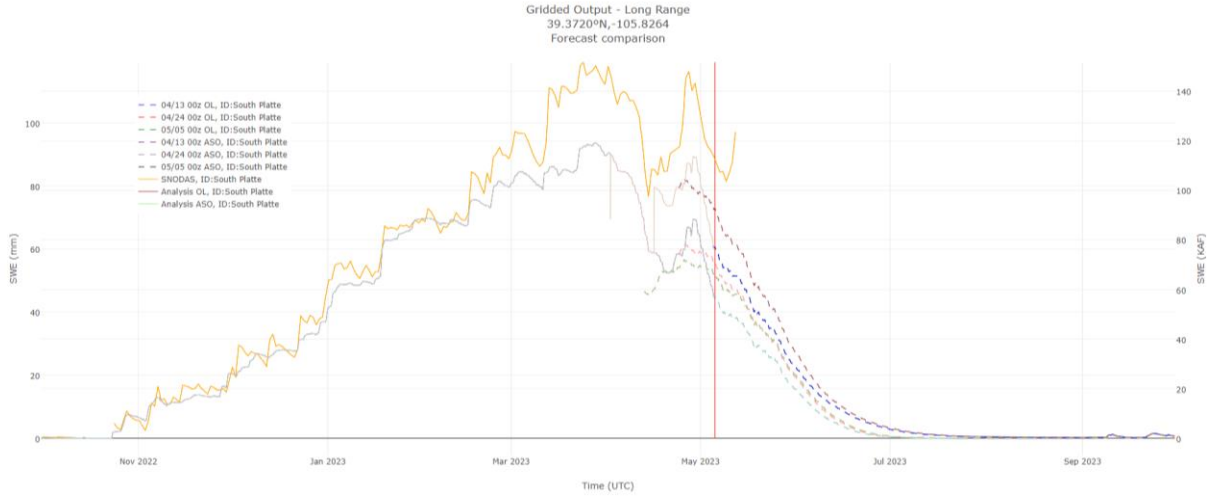
Upper South Platte River System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 76 kac-ft for the Upper South Platte River basin. The bulk of the remaining snowpack in the throughout the region resided above 10,000 ft. Basin averaged soil saturation fractions for basin was over 72%, indicating generally wet conditions.

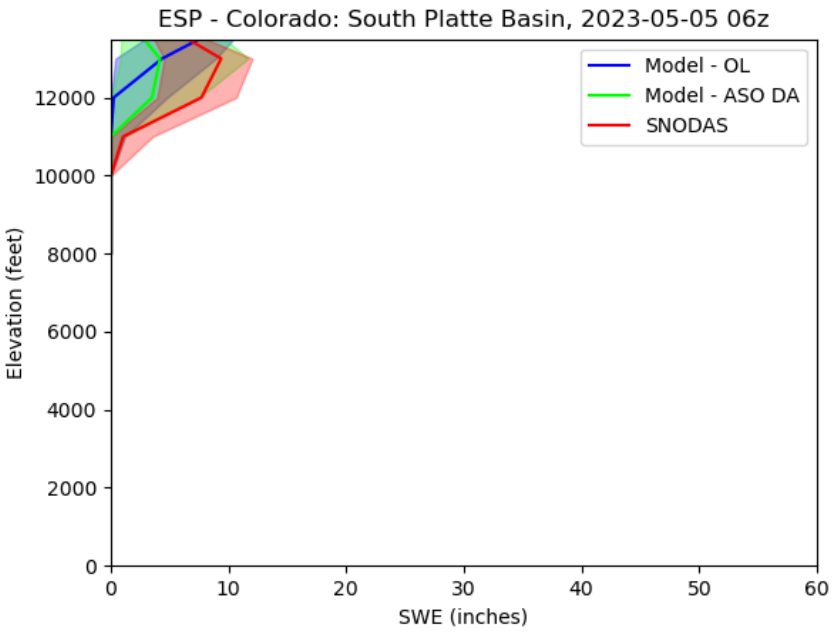
Upper South Platte River Snow Water Equivalent (SWE) Analysis and Forecasts



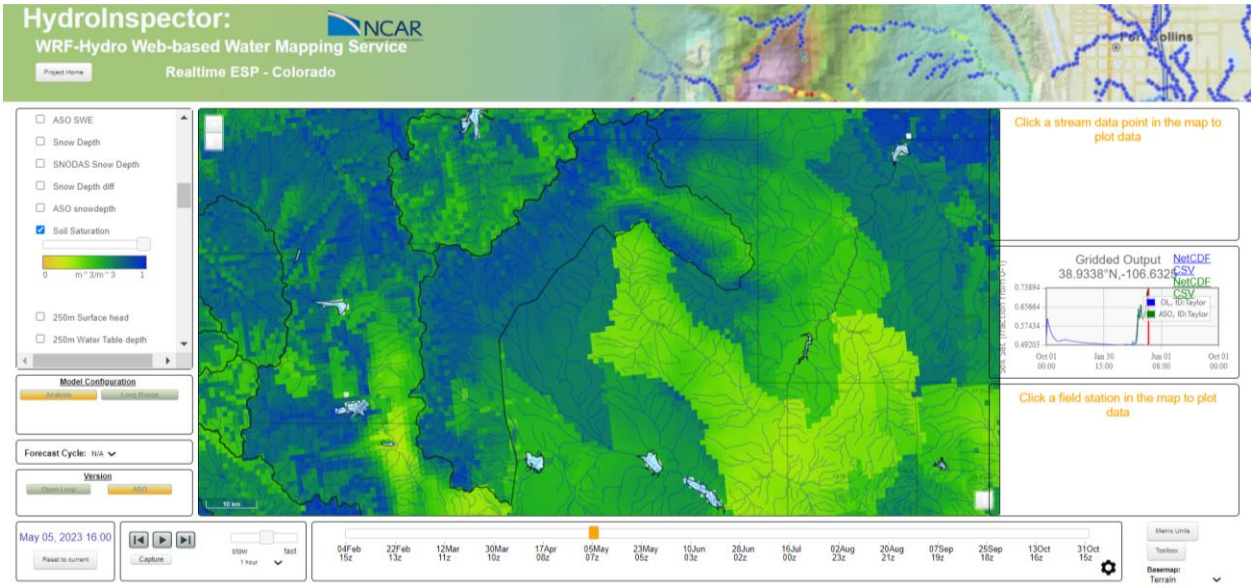
Upper South Platte River Basin-averaged Snow Water Equivalent (SWE) Analysis and Forecasts:



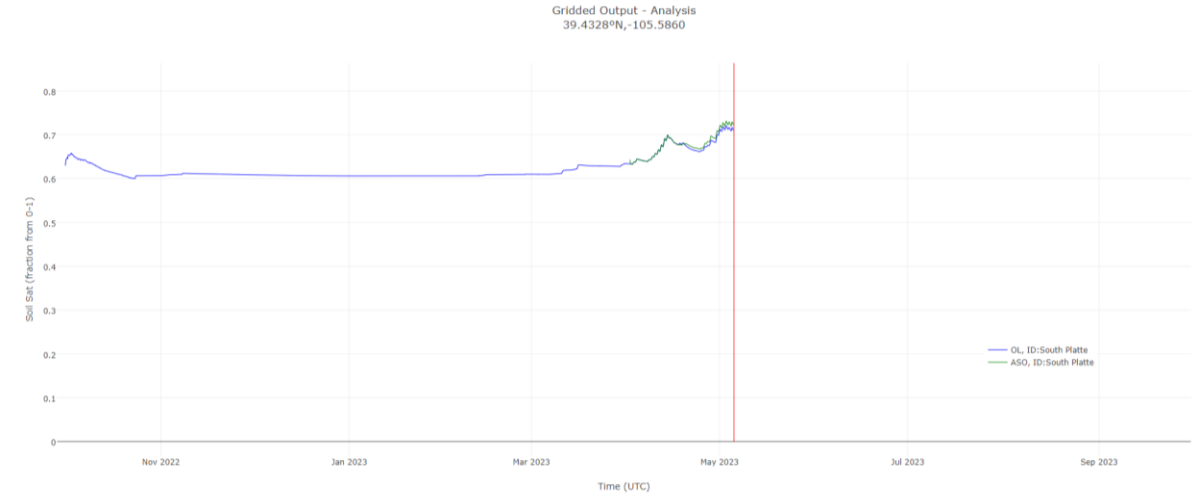
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for Upper South Platte River basin:



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values for the Upper South Platte River basin:



Upper South Platte April-Jul Median (Q50) Accumulated Runoff/Inflow: [PROPOSED SITES]

N. Fork, S. Platte at Bailey (CDWR PLABAICO)… New forecast site, in progress…

Jefferson Cr. near Jefferson (CDWR JEFJEFCO)… New forecast site, in progress…

Michigan Cr. near Jefferson (CDWR MCHJEFCO)… New forecast site, in progress…

Tarryall Cr at Upper Station (CDWR TARRUPCO)… New forecast site, in progress…

Middle Frk S. Platte abv Montgomery Res (CDWR MFKABMCO)… New forecast site, in progress…

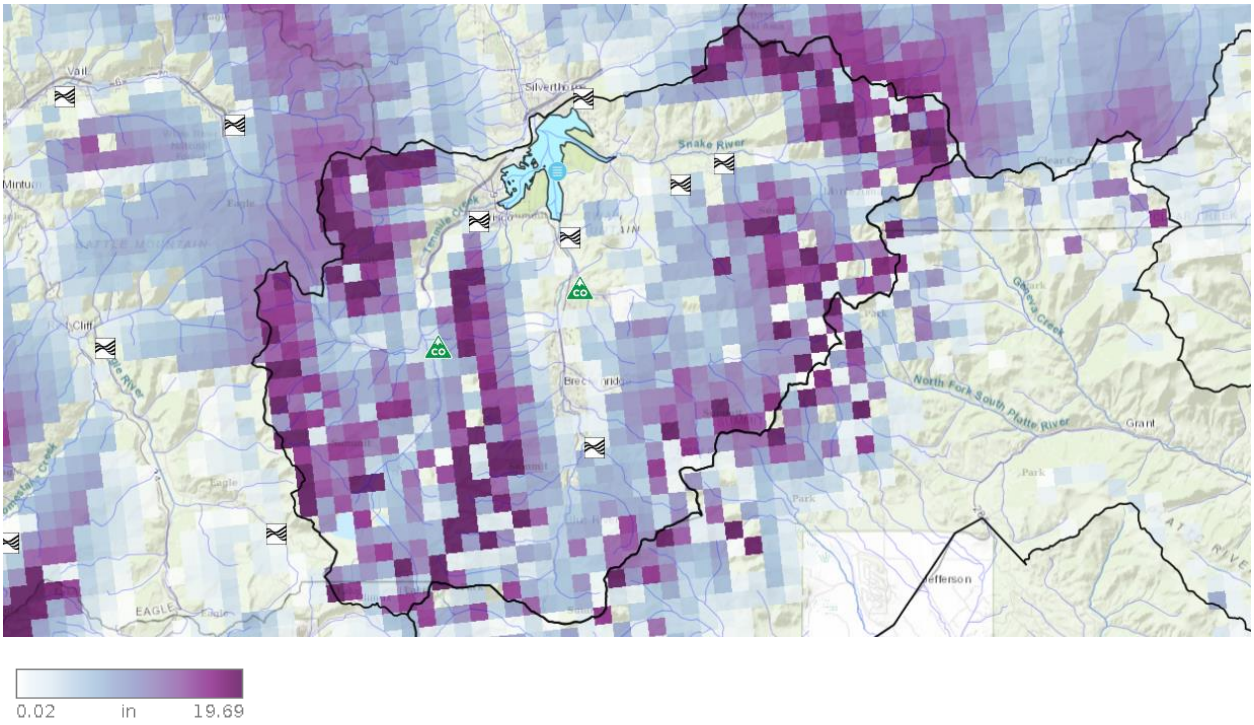
S. Fork of S. Platte abv Antero Res (CDWR SFKANTCO)… New forecast site, in progress…

Antero Res. Inflow…. New forecast site, in progress…

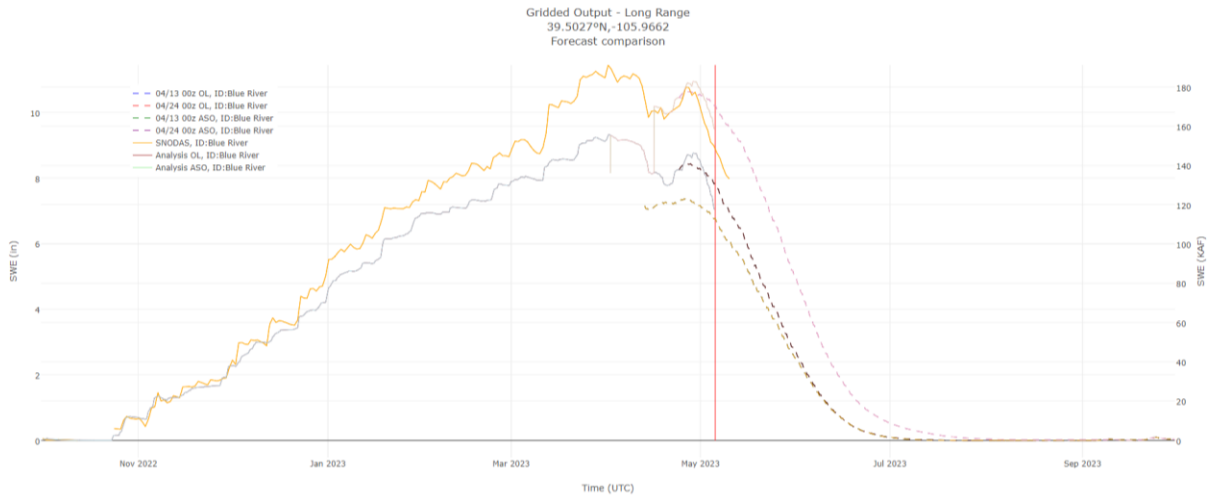
Blue River/Dillon Reservoir System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 159 kac-ft for the Blue River/Dillon Reservoir basin. The bulk of the remaining snowpack in the throughout the region resided above 9,500-10,000 ft. Basin averaged soil saturation fractions for the basin was over 72%, indicating generally wet conditions.

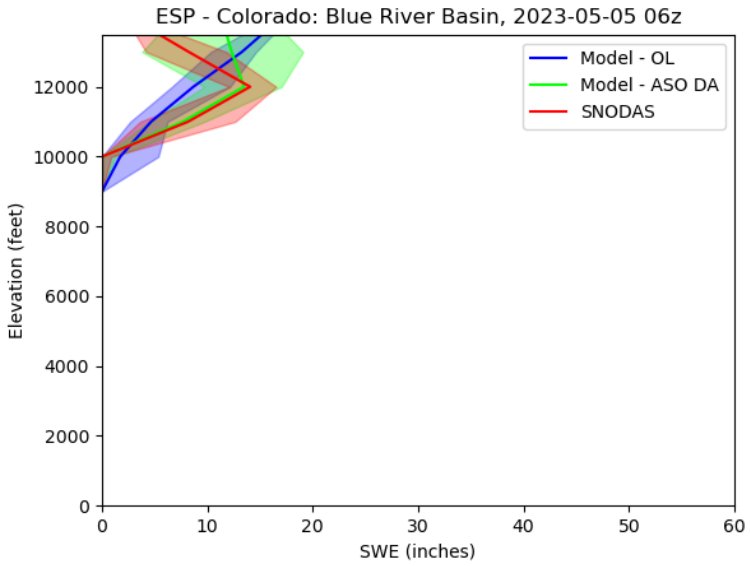
Blue River/Dillon Reservoir Snow Water Equivalent (SWE) Analysis and Forecasts



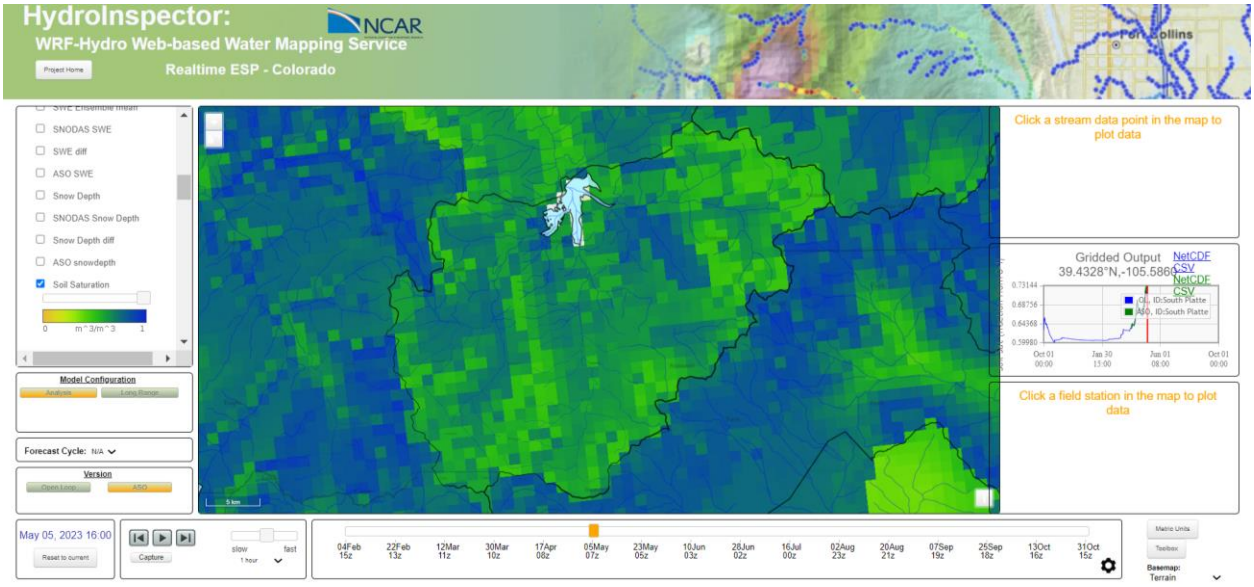
Blue River/Dillon Reservoir basin-averaged Snow Water Equivalent (SWE) Analysis and Forecasts:



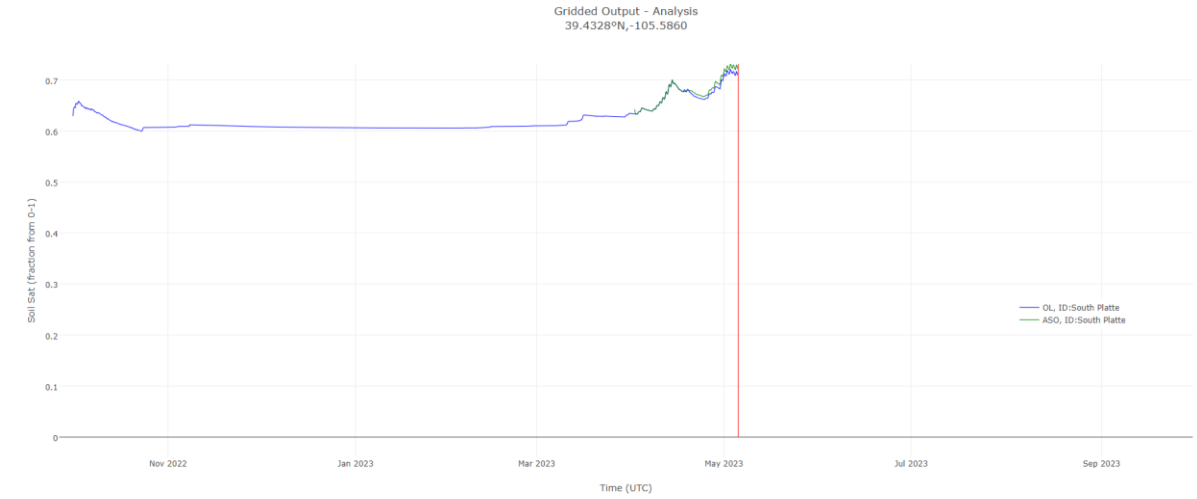
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for the Blue River/Dillon Reservoir basin:



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values for the Upper South Platte River basin:



Blue River/Dillon Reservoir April-Jul Median (Q50) Accumulated Runoff/Inflow:

Dillon Reservoir: 116.8 kac-ft

Blue River abv Dillon: 37.5 kac-ft

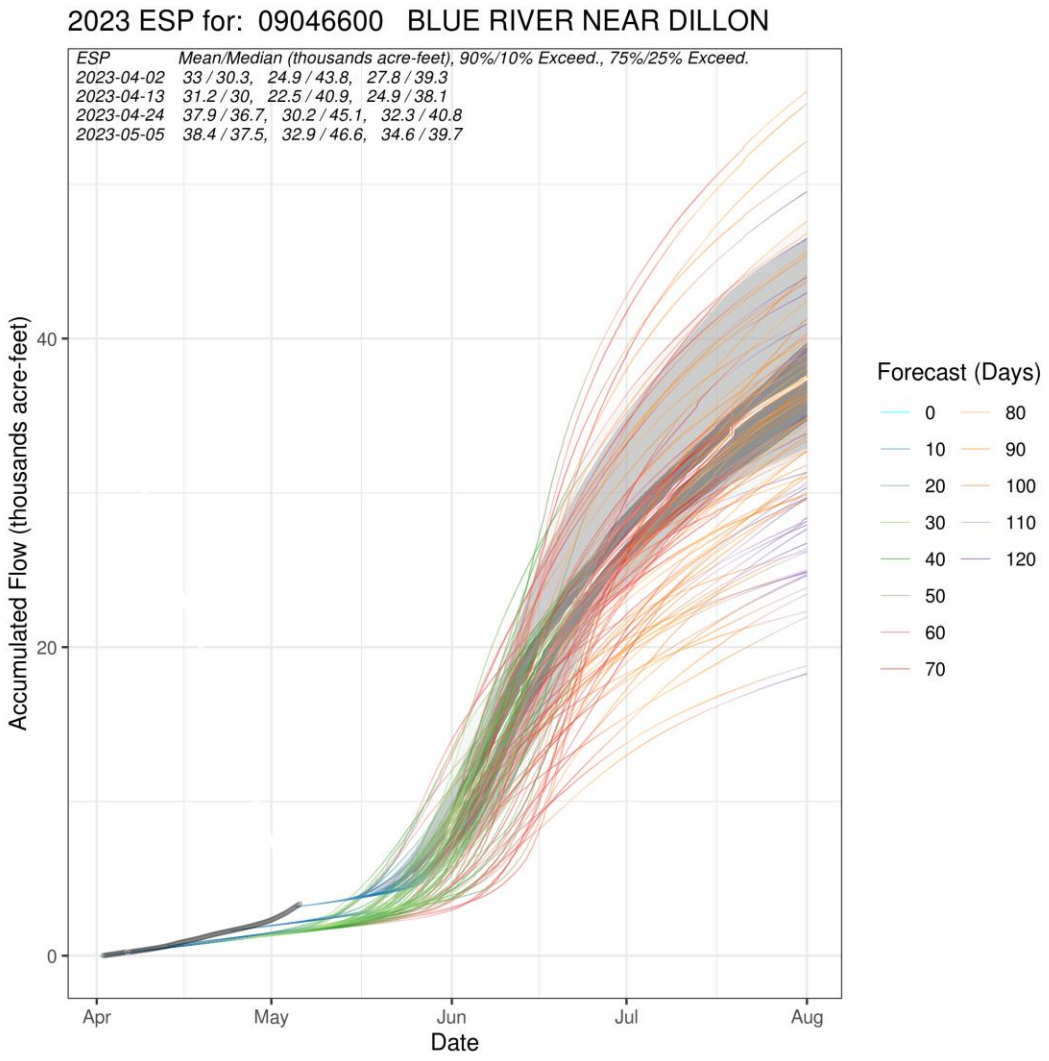
Snake River nr Montezuma: 21.2 kac-ft

Tenmile Creek nr Frisco: 45.7 kac-ft

Keystone Gulch nr Keystone: 2.8 kac-ft

Straight Cr. Nr Dillon: 2.9 kac-ft

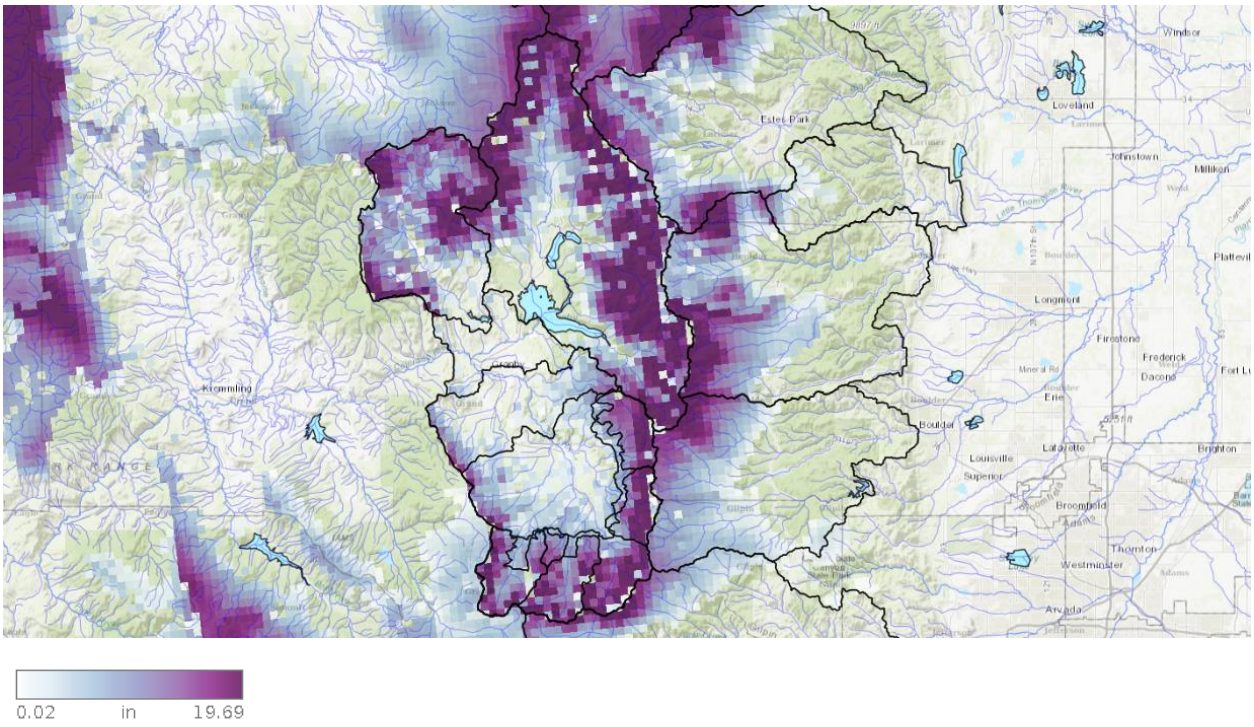
Example ensemble flow accumulation plot for Apr-Jul the Blue River at Dillon Reservoir:



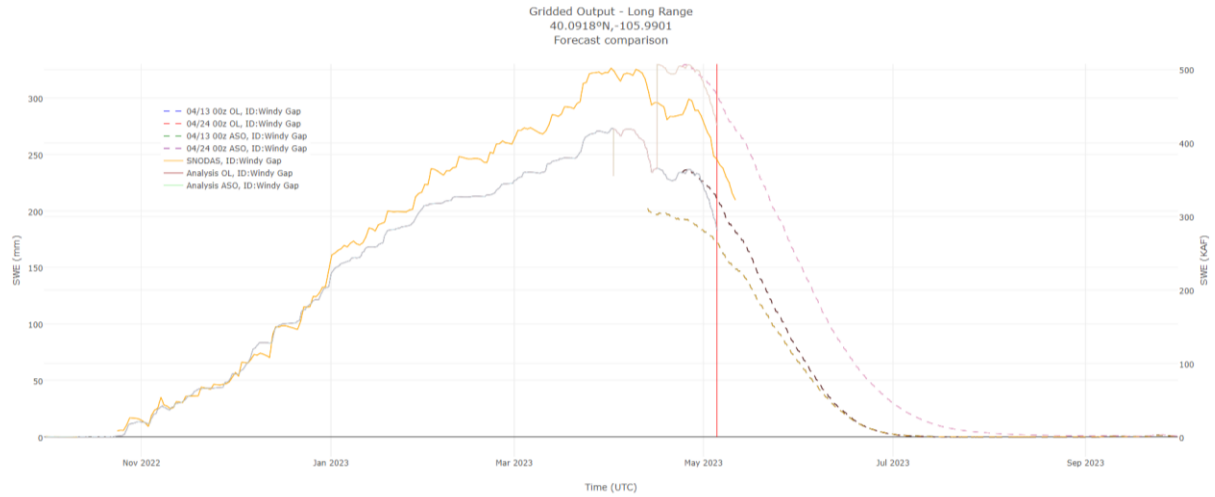
Upper Colorado River/Windy Gap System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model was approximately 423 kac-ft for the Upper Colorado Windy Gap basin. The bulk of the remaining snowpack in the throughout the region resided above 8,500 ft. Basin averaged soil saturation fractions for the basin was around 62%.

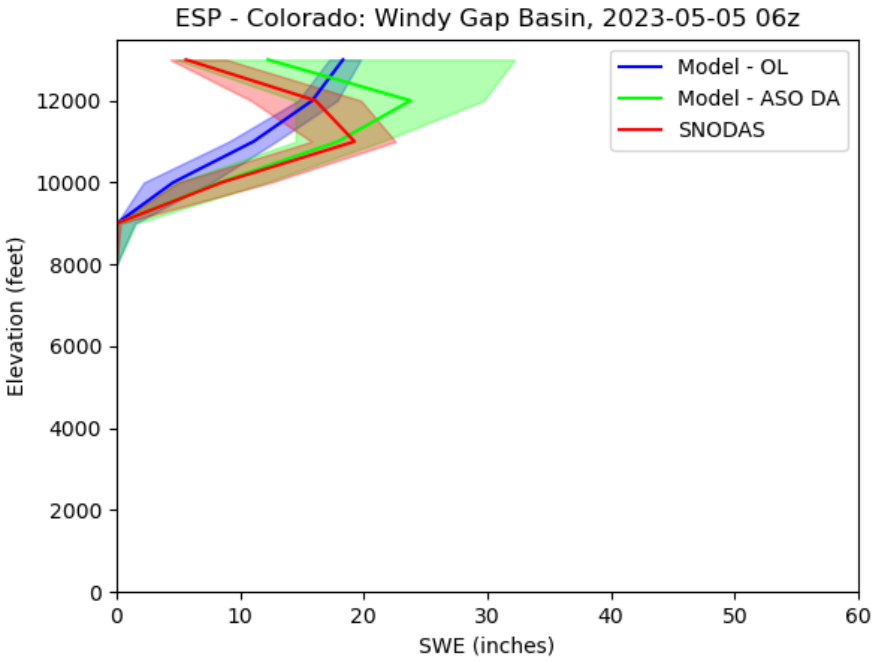
Upper Colorado/Windy Gap Snow Water Equivalent (SWE) Analysis and Forecasts



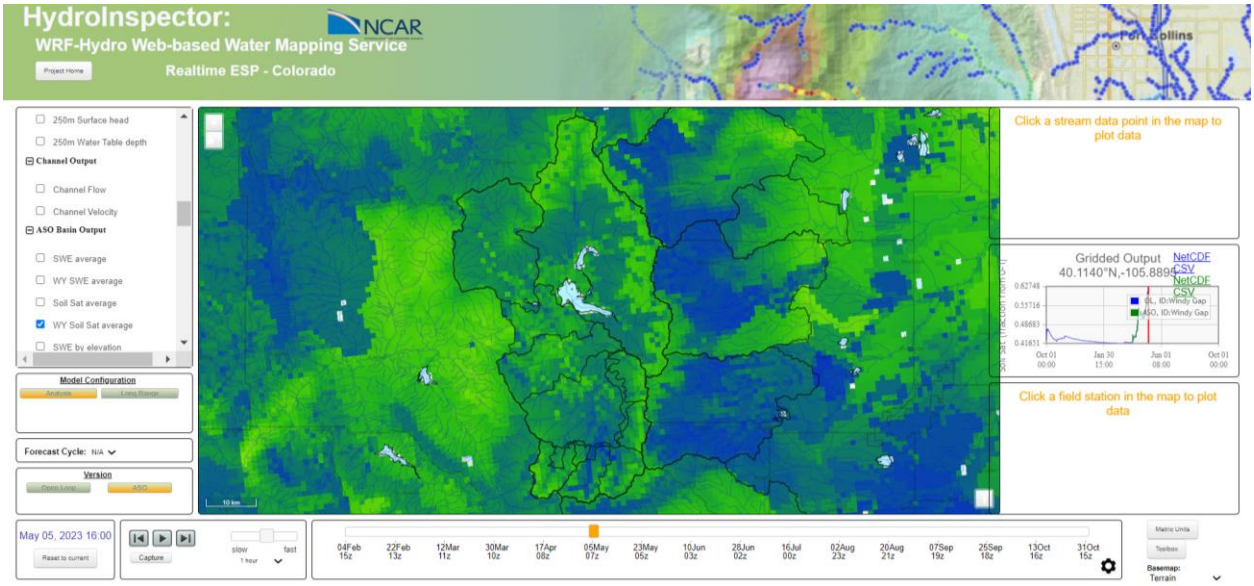
Upper Colorado/Windy Gap basin-averaged Snow Water Equivalent (SWE) Analysis and Forecasts:



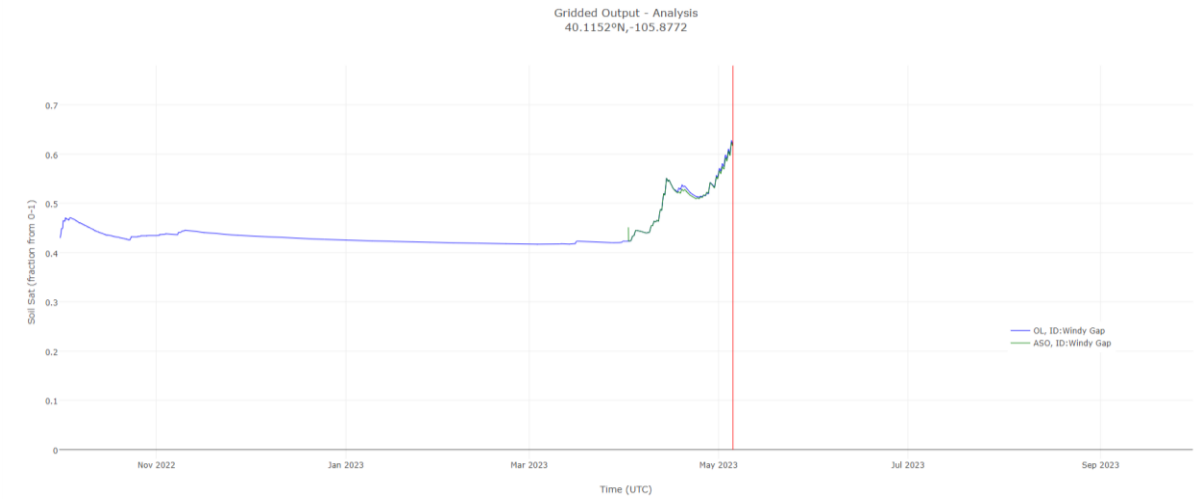
Elevation profile of SWE for SNODAS (red), ASO-assimilated snowpack (green) and WRF-Hydro OpenLoop (blue) for the Upper Colorado/Windy Gap basin:



Spatial map of WRF-Hydro modelled soil saturation:



Basin-averaged soil saturation values for the Upper Colorado/Windy Gap basin:



Upper Colorado/Fraser to Windy Gap April-Jul Median (Q50) Accumulated Runoff/Inflow:

Col. R. blw Baker Gulch: 41.9 kac-ft

East Inlet Cr.: 22.1* kac-ft

Fraser R @ Upper Sta: 5.9* kac-ft

Fraser R @ Winter Park: 12.7 kac-ft

Vazquez Cr. nr Winter Park: re-calibration in progress…

Ranch Cr. nr Fraser: re-calibration in progress…

Cabin Cr nr Fraser: re-calibration in progress…

Elk Cr. nr Fraser: re-calibration in progress…

St. Louis Cr. nr Fraser: re-calibration in progress…

Fraser R @ Tabernash: needs naturalized flow time series, re-calibration in progress…

Fraser R blw Crooked @ Tabernash: needs naturalized flow time series, re-calibration in progress…

Fraser R @ Granby: needs naturalized flow time series, re-calibration in progress…

Willow Cr. abv Willow Creek Reservoir: re-calibration in progress…

Willow Cr. Reservoir inflow: re-calibration in progress…

Grand Lake inflow: = 115 kac-ft

Lake Granby inflow: 175.4 kac-ft*

Col. R. nr Granby: 182.47 kac-ft

Williams Frk nr Leal: 29.4 kac-ft

S. Frk Williams Crk nr Leal: 11.1 kac-ft

Bobtail Cr. Nr Jones Pass: 3 kac-ft

Williams Frk Res. Inflow: 36.8 kac-ft*

** denotes incomplete flow record for Apr.*

*** denotes incomplete flow record and no current accounting for upstream diversions/withdrawals for Apr.*

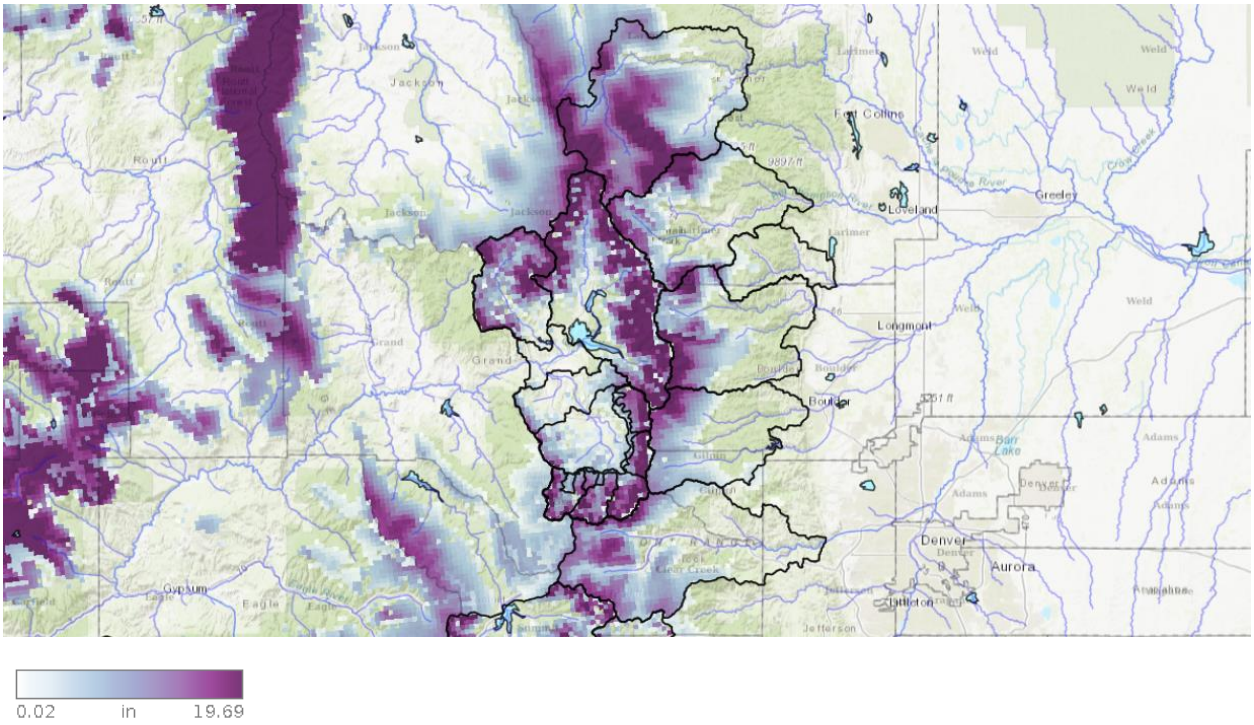
Front Range System:

As of May 5 the ASO-assimilated snowpack from the WRF-Hydro model for the 5 Front Range basins was: [OpenLoop model data only available…i.e. no ASO data yet assimilated]

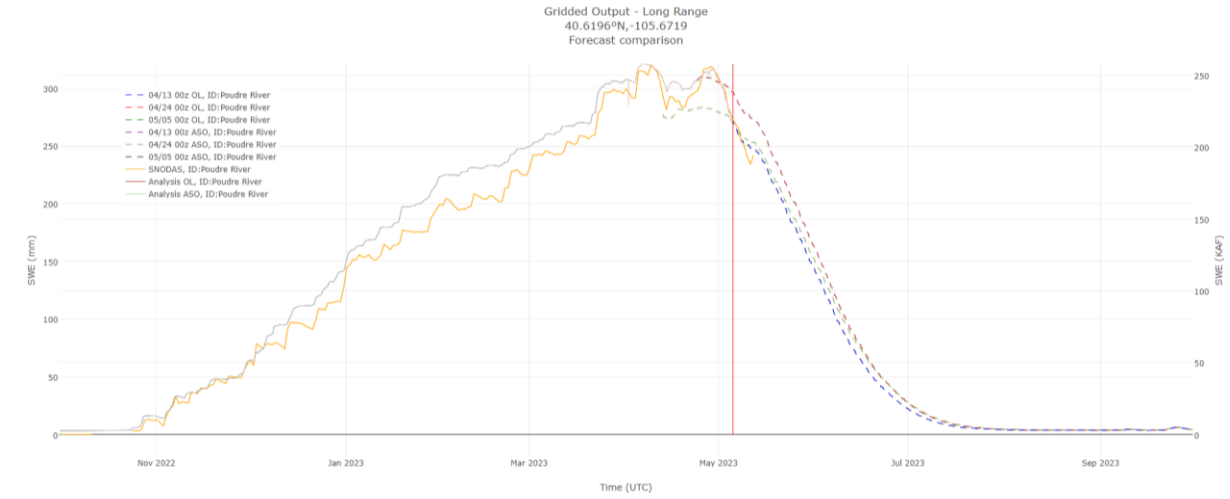
Poudre River Basin:	217 kac-ft
Big Thompson River Basin:	69 kac-ft
St. Vrain River Basin:	in progress…
Boulder Creek Basin:	50 kac-ft
Clear Creek Basin:	102 kac-ft

The bulk of the remaining snowpack in the throughout the region resided above 9,500 ft.

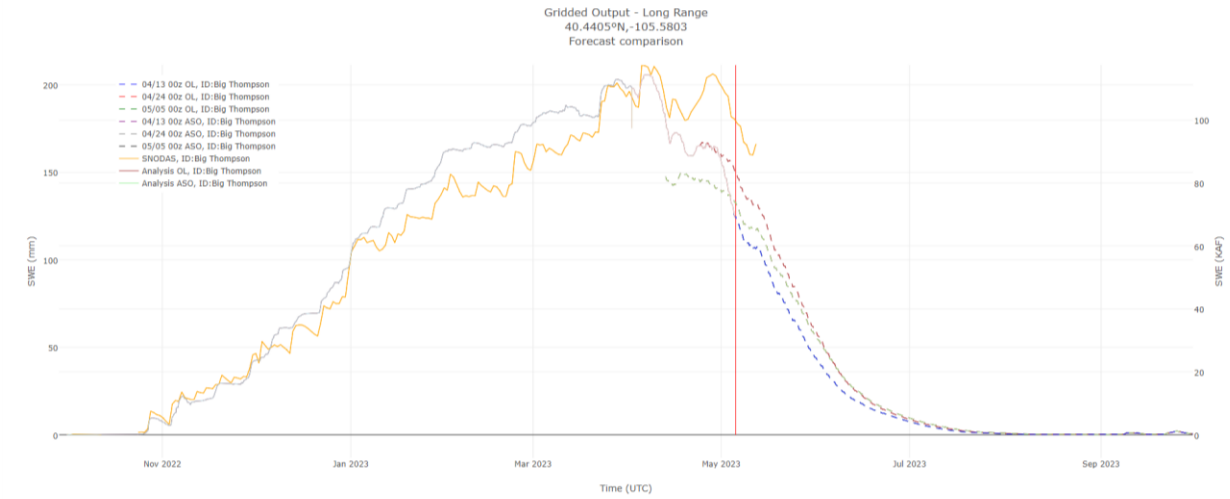
Front Range System Snow Water Equivalent (SWE) Analysis and Forecasts (OpenLoop configuration):



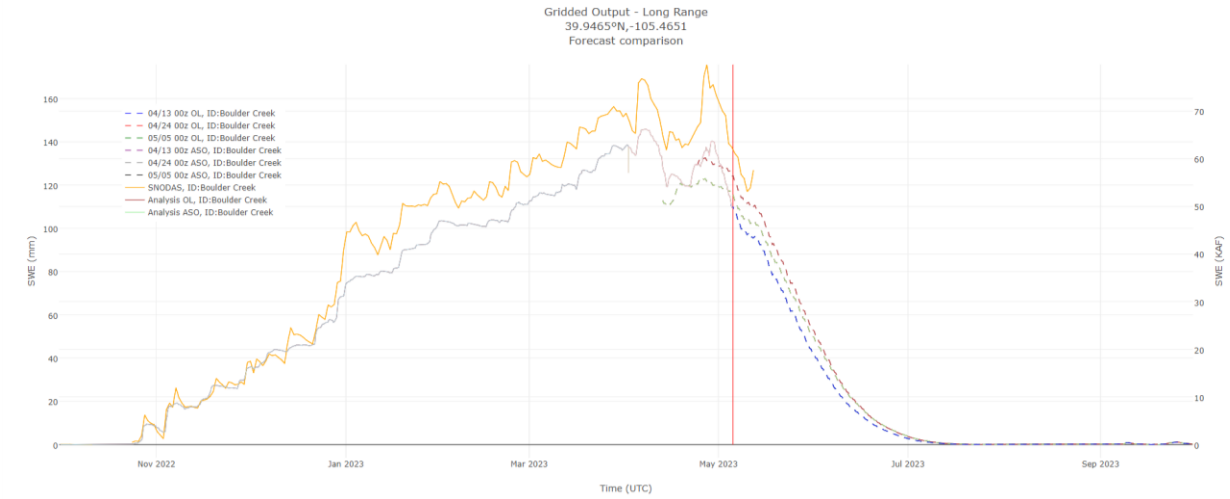
Poudre River basin averaged SWE:



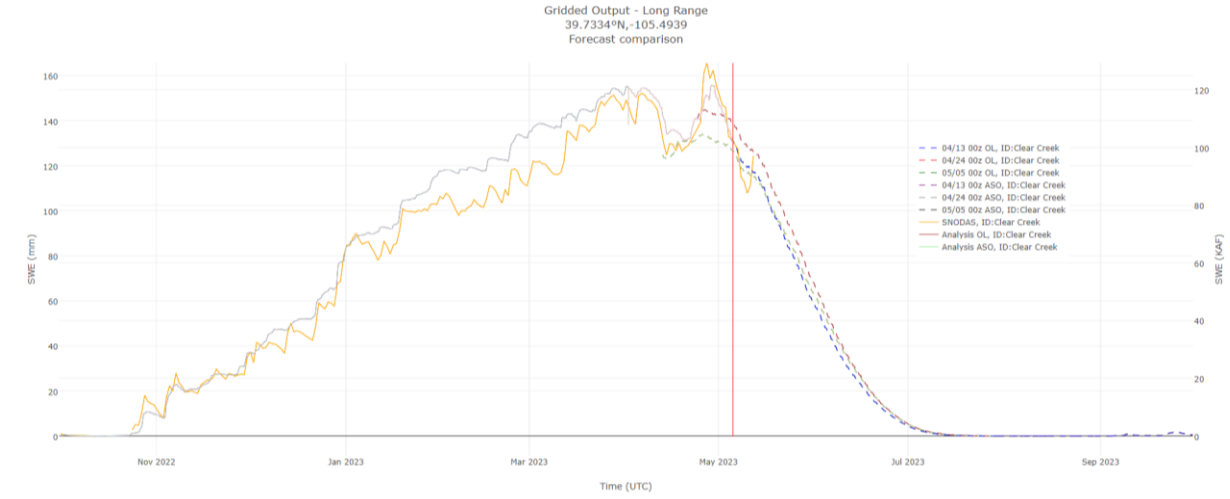
Big Thompson basin averaged SWE:



Boulder Creek basin-averaged SWE:



Clear Creek basin-averaged SWE:



Poudre River Sub-basin: [PROPOSED]

No headwater/unregulated sites have yet been identified.

Big Thompson River Sub-basin: [PROPOSED]

Big Thompson at Moraine Park (CDWR BTBMORCO)… in progress…

Big Thompson abv Lake Estes…(CDWR BTABESCO)… in progress…

N. Fork Big Thompson at Drake (CDWR BTNDFRCO)… in progress…

St. Vrain River Sub-basin: [PROPOSED]

Button Rock Reservoir Inflow…. ?is inflow data available?...in progress…

South St Vrain near Ward, CO…(CDWR SSVWARCO)…in progress…

North St. Vrain abv Button Rock Reservoir…(CDWR NSVABRCO?)…does this station exist?…

Middle Fork St. Vrain at Peaceful Valley… (CDWR MIDSTECO)… in progress…

St. Vrain at Lyons…(CDWR SVCLYCO)…in progress…

Boulder Creek Sub-basin: [PROPOSED]

Middle Boulder Cr at Nederland…(CDWR BOCMIDCO)…in progress…

Boulder Cr. at Orodell…(CDWR BOCOROCO)…in progress…

Clear Creek Sub-basin: [PROPOSED]

Clear Creek abv Georgetown…(CDWR CLEGLKCO)… in progress…

Clear Creek at Lawson…(CDWR CLELAWCO)… in progress…

N. Clear Creek abv mouth at Black Hawk…(CDWR NCCBLACO)… in progress…

Clear Creek at Golden…(CDWR CLEGOLCO)… in progress…