

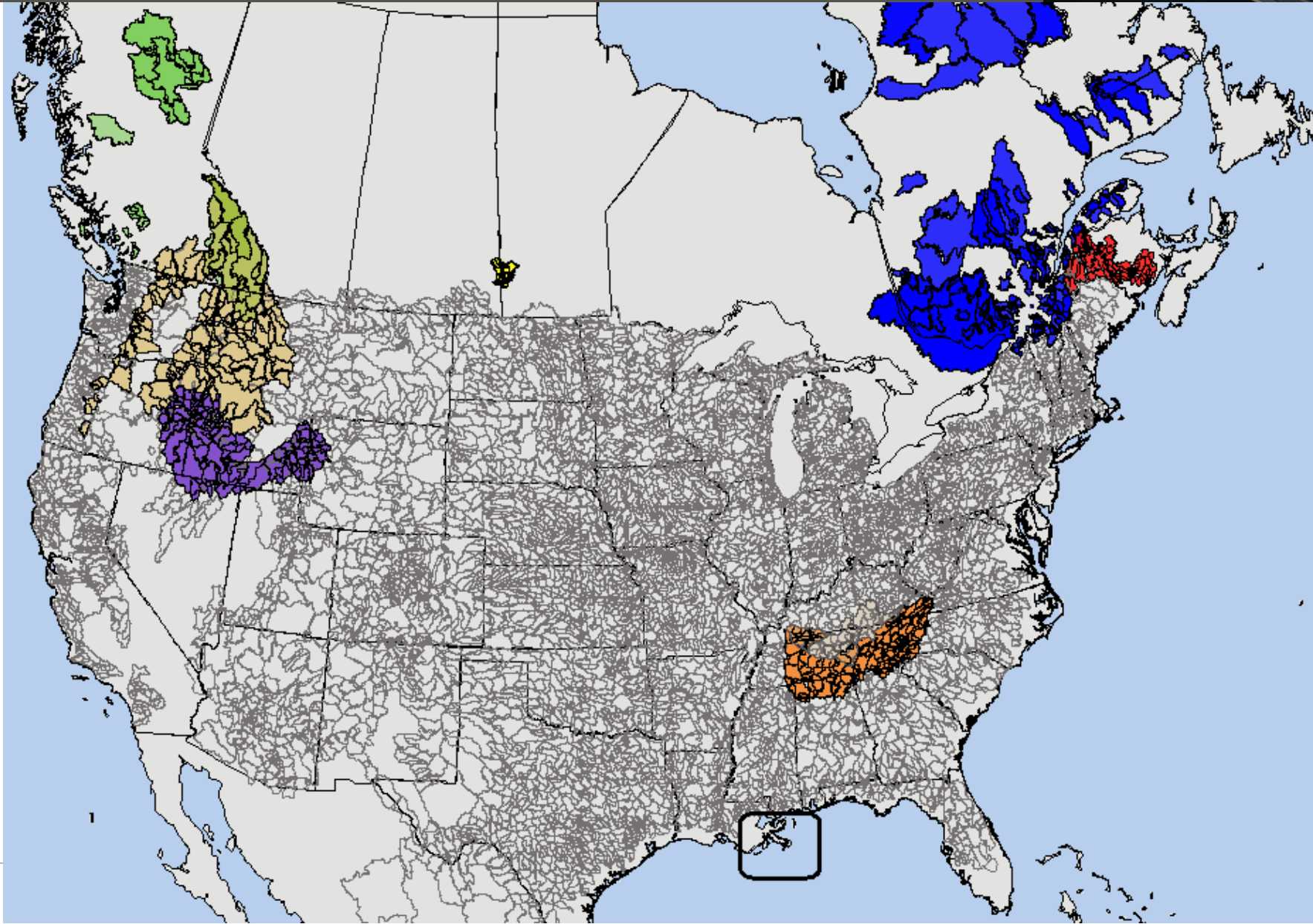


FEWS Applications in North America

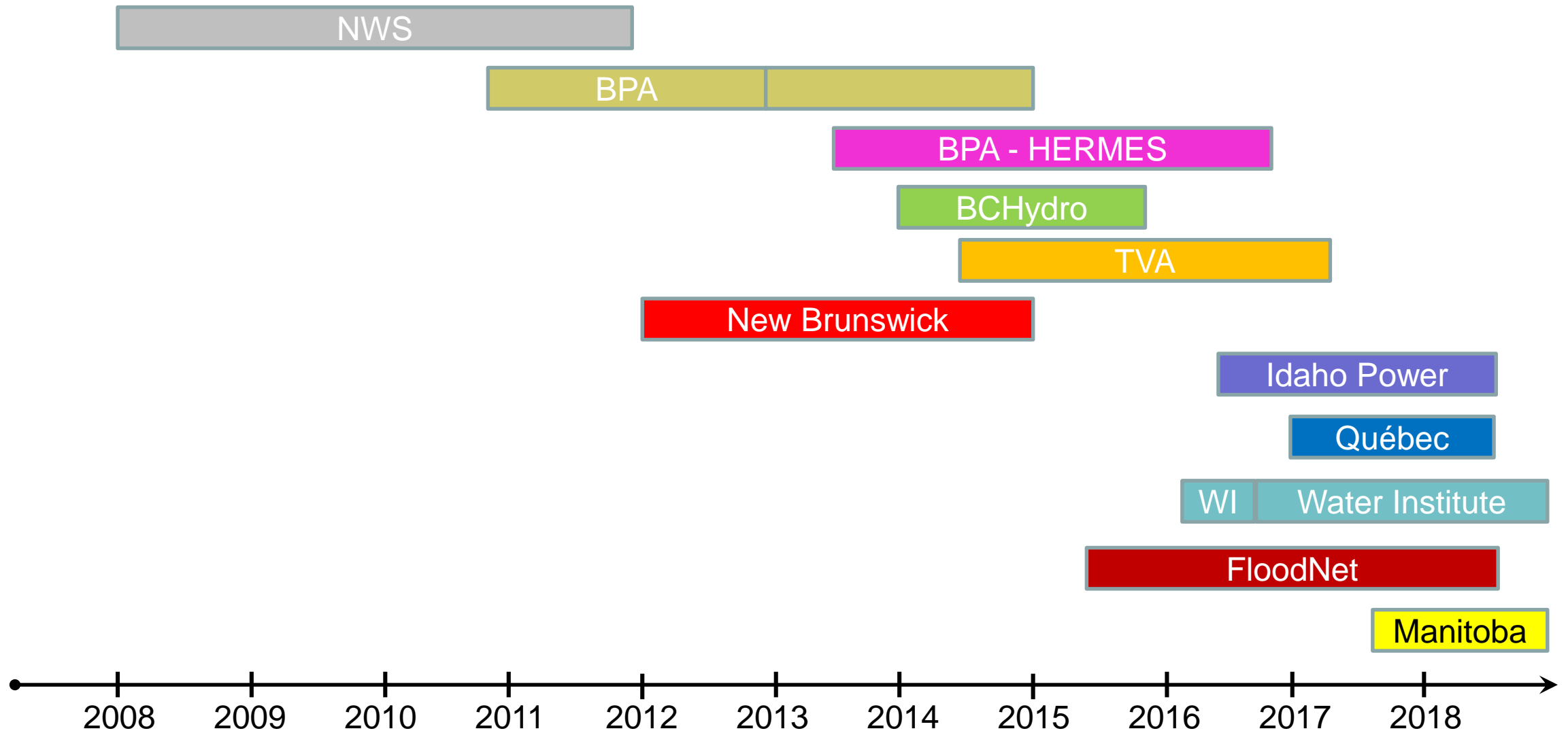
Ben Balk (Deltares USA)

October 26, 2017

North American FEWS Applications – Deltares USA/NL

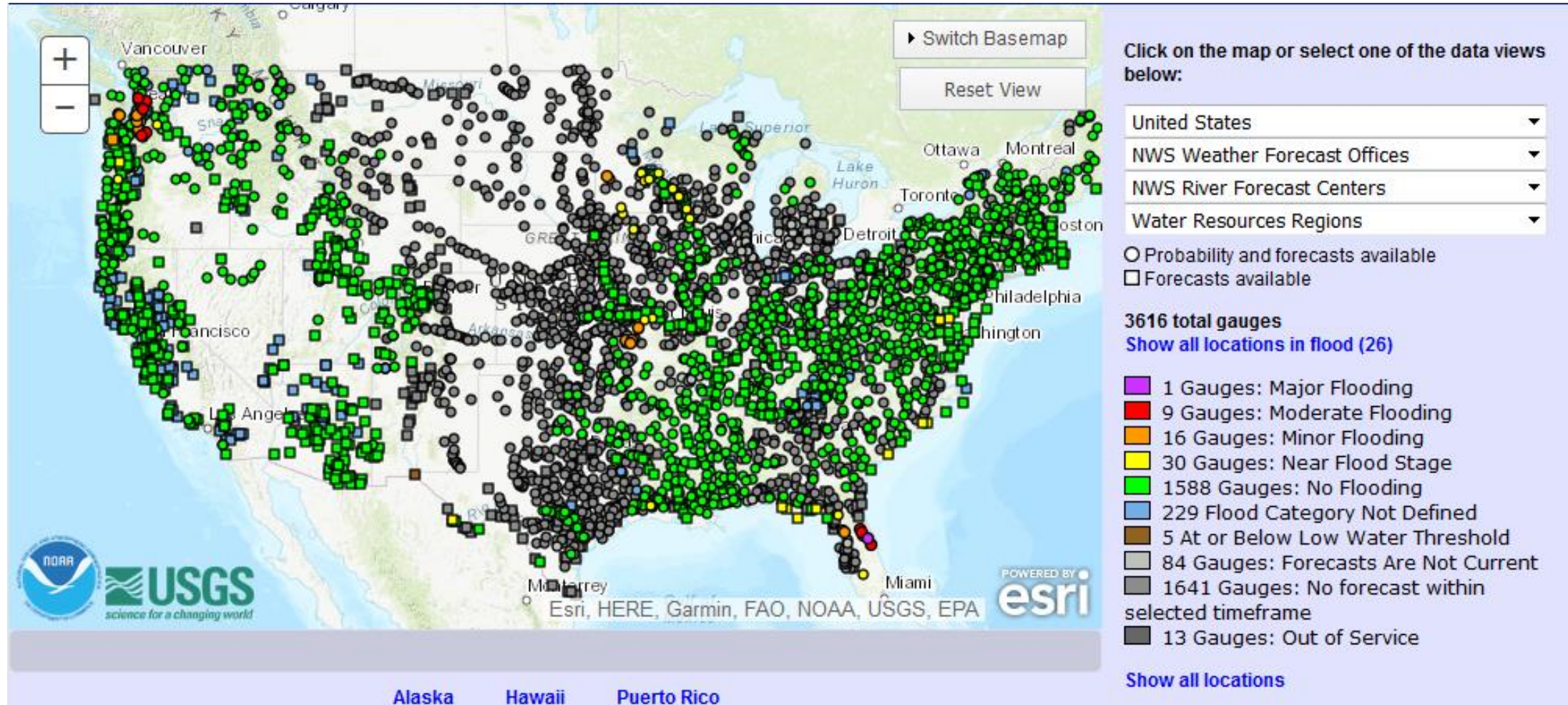


FEWS Implementations Timeline in North America

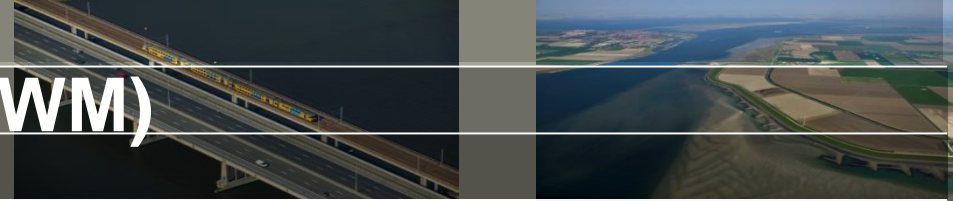


NWS – Community Hydrologic Prediction Service (CHPS)

NWS river forecasts – <http://water.weather.gov/ahps/forecasts.php>



NWS – CHPS + National Water Model (NWM)

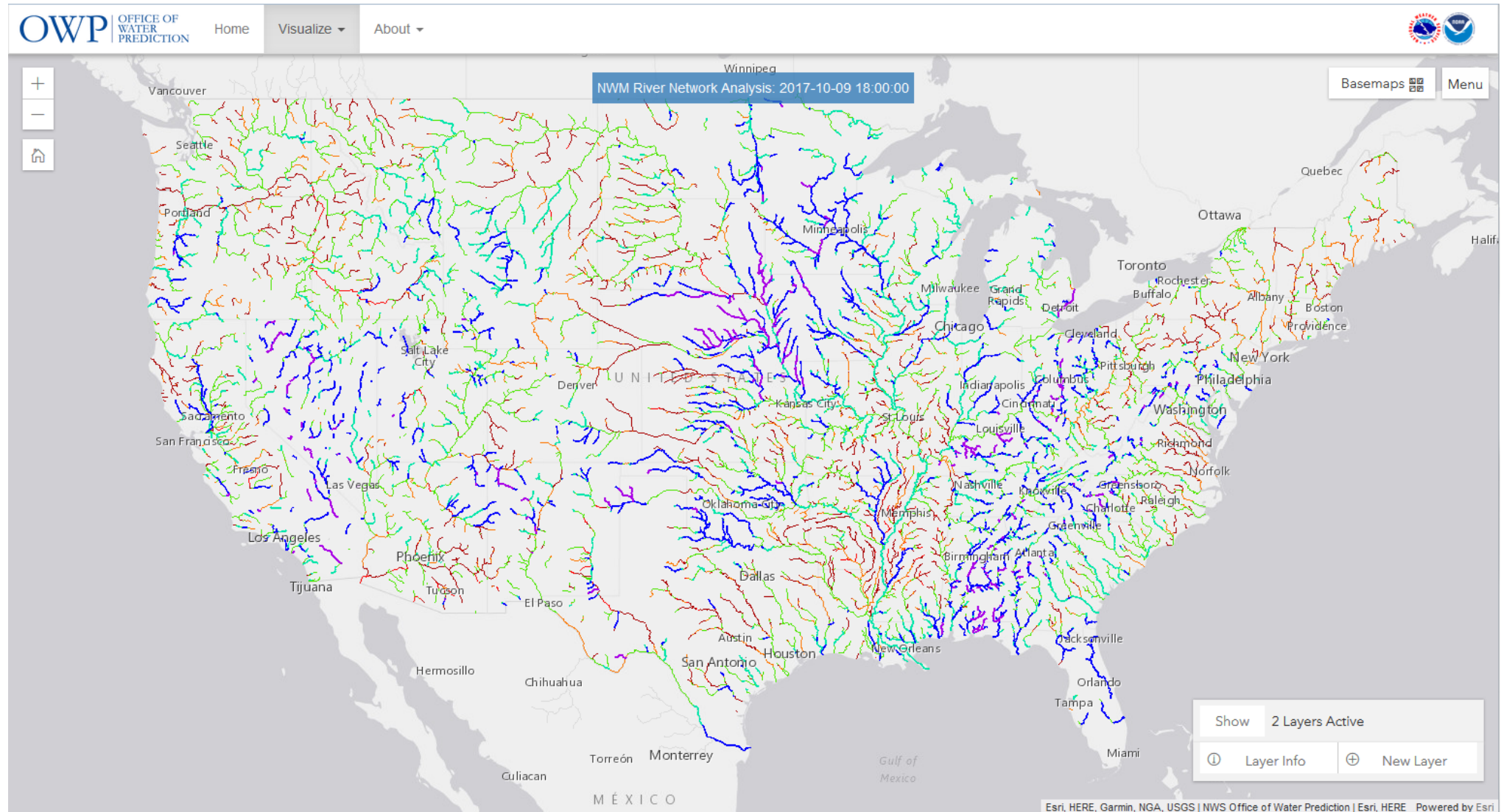


National Water Model – <http://water.noaa.gov/documents/wrn-national-water-model.pdf>

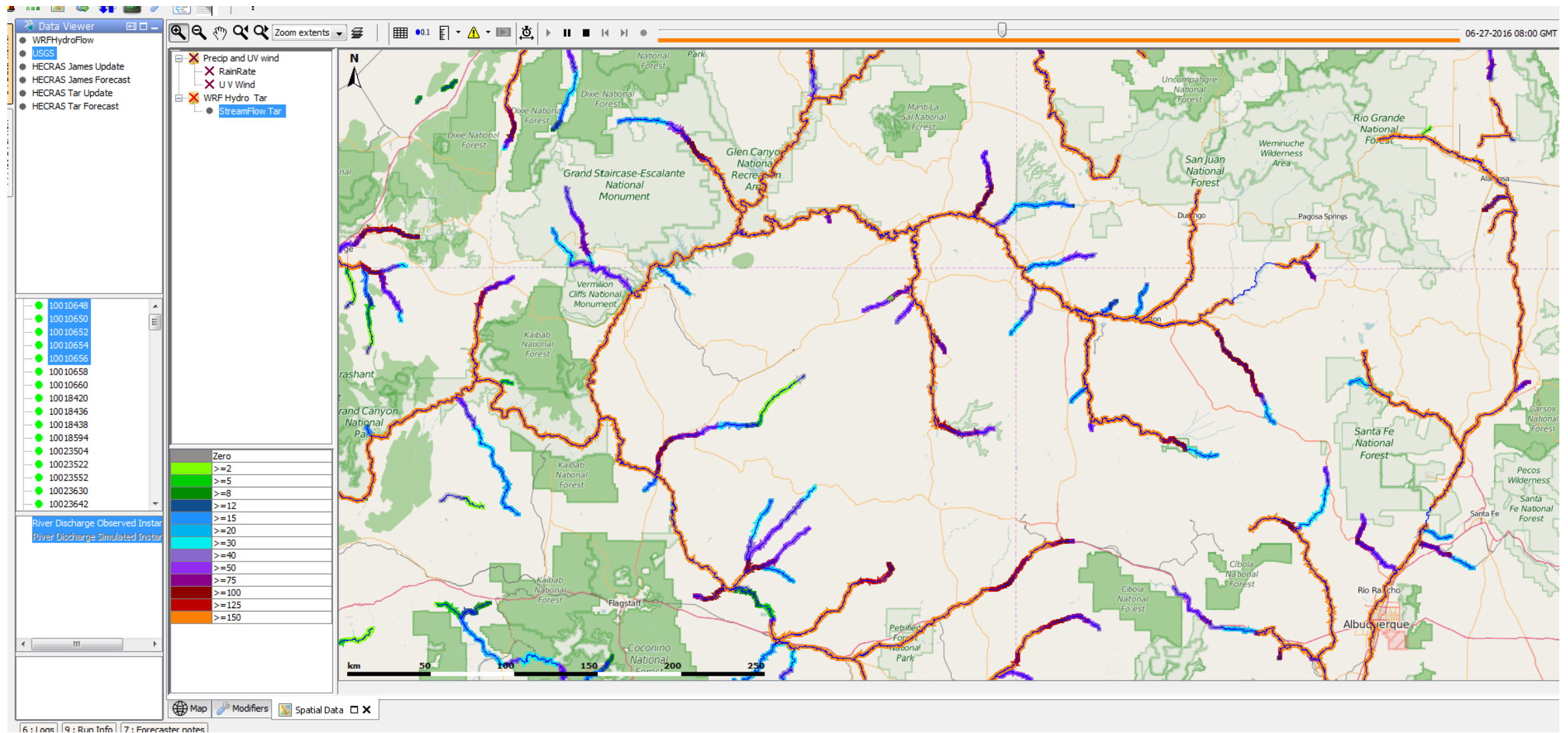


- Current (Yellow) – CHPS
 - ~4000 forecast points
- Future (Blue) – NWM
 - ~2.7 M forecast points

NWS – National Water Model (<http://water.noaa.gov/map>)



NWS – NWM data in FEWS



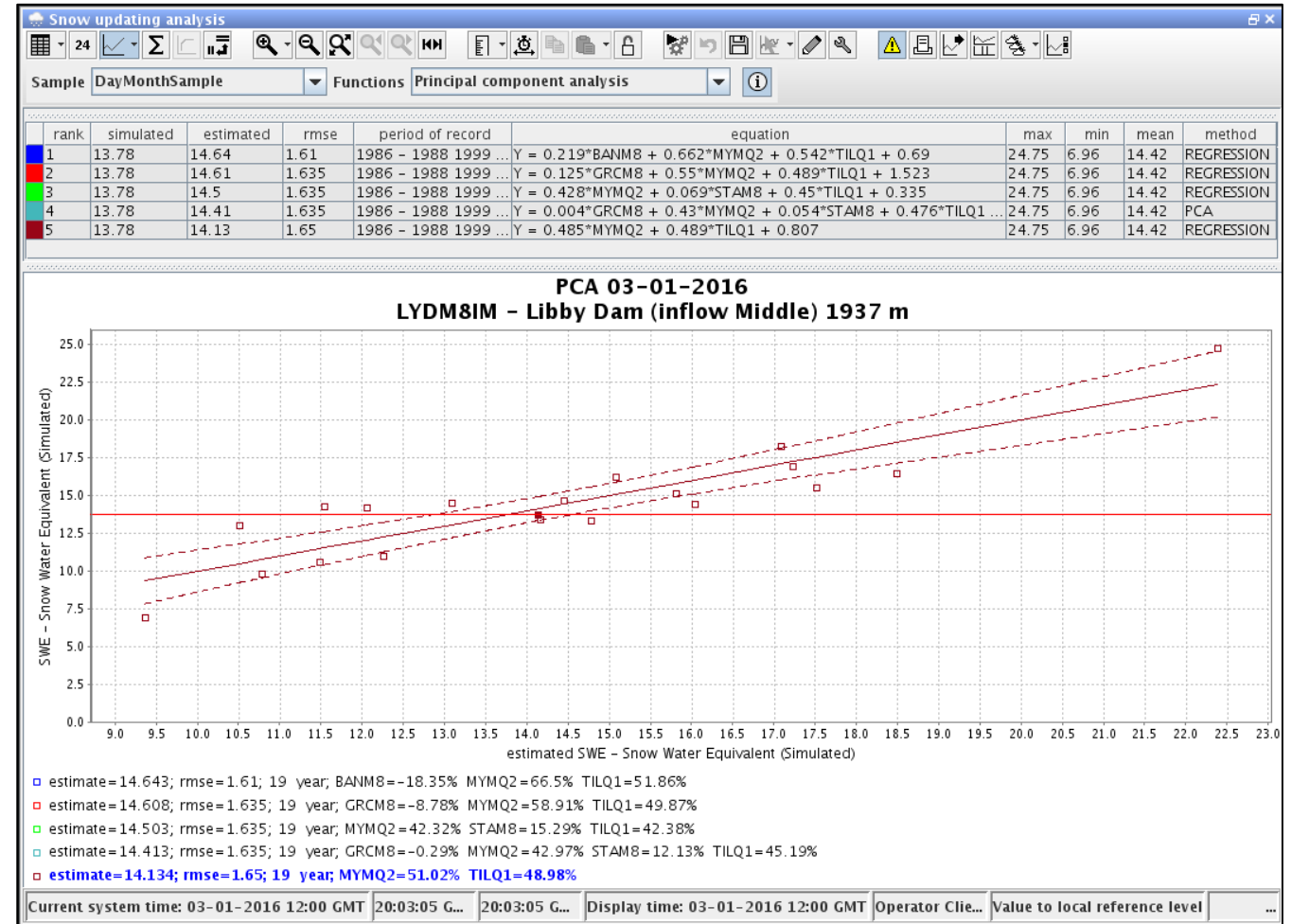
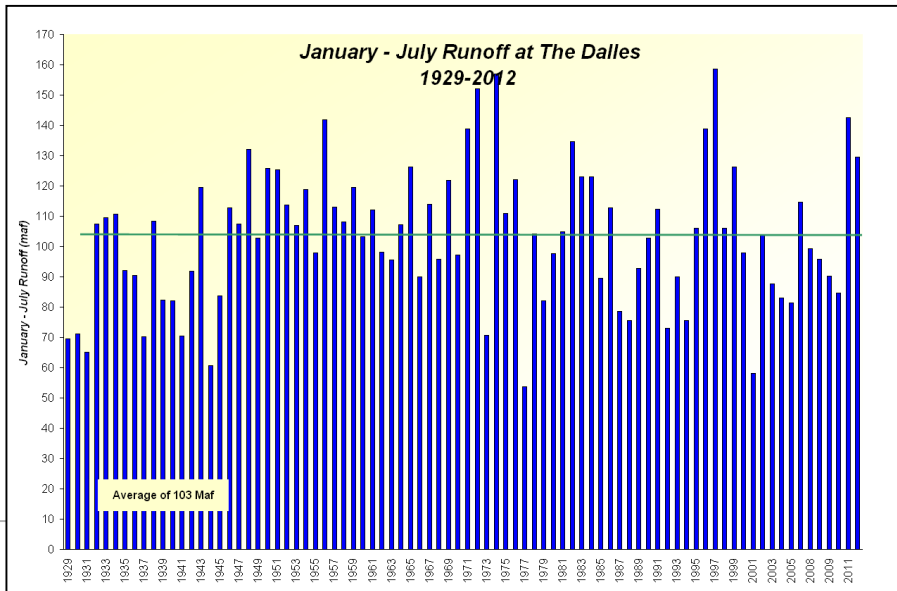
BPA – Bonneville Power Administration (Streamflow)

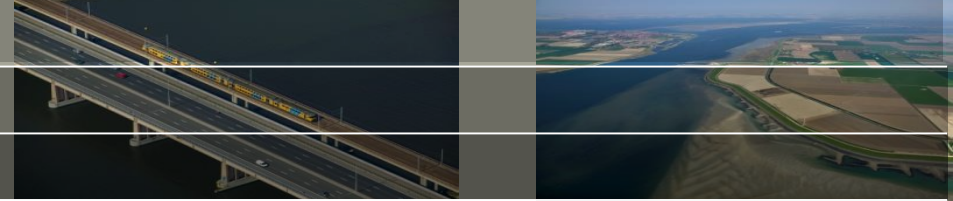


BPA Streamflow (Water Supply Forecasting)

Snowpack-driven water supply forecasting

- Inflow forecasting for 31 reservoirs
- System is storage limited
- ~75-80% of runoff from snowmelt
- Yet seasonal runoff is highly variable
 - El Nino vs La Nina
- PCA snow update analysis
 - Interactive or batch





Ensemble Verification System (EVS) and Open Archive

- Development started at NWS Office of Hydrologic Development...led by James Brown
 - Now at Hydrologic Solutions, Ltd (UK)...continues to develop EVS
- Open source (<https://amazon.nws.noaa.gov/ohd/evs/evs.html>)
- EVS is more than just ensembles...can also verify deterministic forecasts
 - Powerful system utilizing most commonly used verification metrics
- EVS accesses the simulated forecasts stored in the Archive via the FEWS Pi-Service

BPA Streamflow – EVS & Archive

CHPS - Bonneville Power Administration (Stand alone)

File Tools Options Help

search and download datasets create a new event search for events

select data sets to download

area No area selected time series is between 03-13-2016 12:00:00 and 03-23-2016 12:00:00 data set observed source No source

data set	area	source	archive time	time zero	start	end
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-13-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-14-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-15-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-16-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-17-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-18-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-19-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-20-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-21-2016 00...	03-23-2016 00...
Observatons.nc	BPA-Test	--	03-24-2016 23...	--	03-22-2016 00...	03-23-2016 00...

Map Plots Topology Modifiers Forecaster help viewer Archive Catalogue

Logs

04-01-2016 16:35:01 INFO - Finished searching. In total there were 11 data sets found
04-01-2016 16:35:01 INFO - Start searching for datasets of type:observed time series
04-01-2016 16:34:57 INFO - Finished searching. In total there were 2 data sets found
04-01-2016 16:34:57 INFO - Start searching for datasets of type:simulated time series
04-01-2016 16:34:53 INFO - Finished searching. In total there were 2 data sets found
04-01-2016 16:34:53 INFO - Start searching for datasets of type:simulated time series
04-01-2016 16:34:46 INFO - Finished searching. In total there were 2 data sets found
04-01-2016 16:34:45 INFO - Start searching for datasets of type:modifiers

1 : Forecaster notes 8 : Run Info

Ensemble Verification System (EVS) [Project 'HEFS_flow']

File Help

Verification Aggregation Output

1. Choose results to output

1a. Select unit(s) with results

Name	Unit type
FTSC1.Streamflow.RCLIM	VERIFICATION

1b. Choose products for selected unit

Product	Include?
Brier score	<input checked="" type="checkbox"/>
Order skill score	<input checked="" type="checkbox"/>
Correlation coefficient	<input checked="" type="checkbox"/>
Mean absolute error	<input checked="" type="checkbox"/>
Capture rate diagram	<input type="checkbox"/>
Continuous ranked probability score	<input checked="" type="checkbox"/>
Continuous ranked probability skill score	<input type="checkbox"/>
Mean error	<input checked="" type="checkbox"/>
Error of probability diagram	<input type="checkbox"/>

Chart window

Mean Error of the ensemble average by forecast lead time.
FTSC1.Streamflow.RCLIM

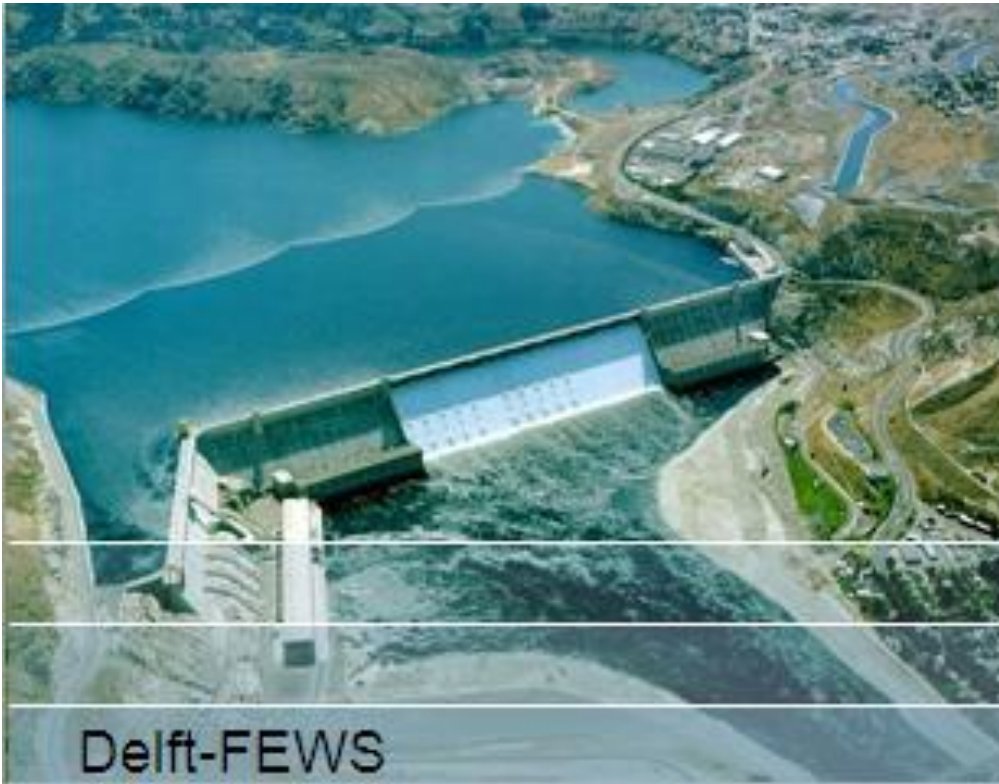
Chart window

Mean Continuous Ranked Probability Score (CRPS) by forecast lead time.
FTSC1.Streamflow.RCLIM

Run

Back First

BPA – Bonneville Power Administration (Reservoir)



Delft-FEWS

B O N N E V I L L E
POWER ADMINISTRATION



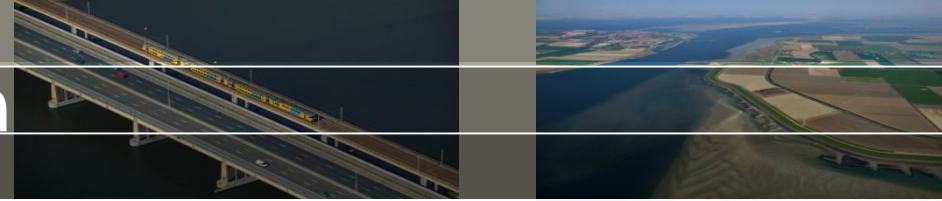
Deltares
Enabling Delta Life



BPA - HERMES

Hydro Regulation Model System

BPA – Role within Columbia River basin



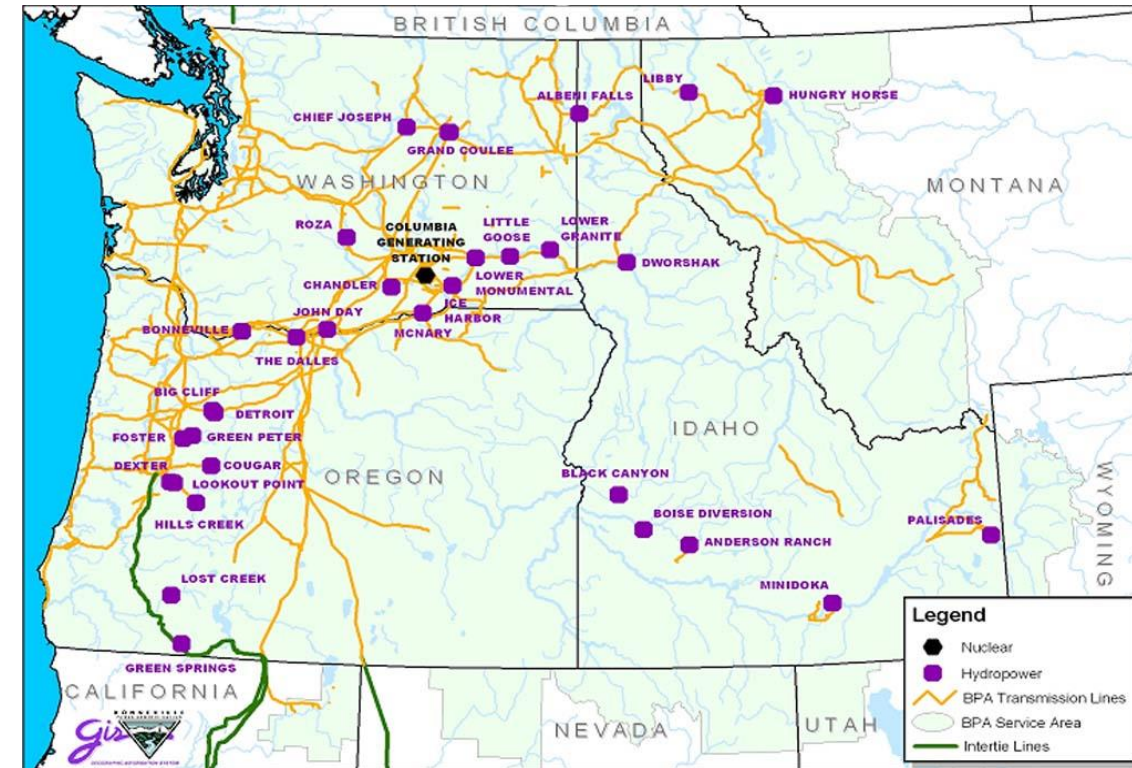
Federal Columbia River Power / Transmission System (FCRPS)

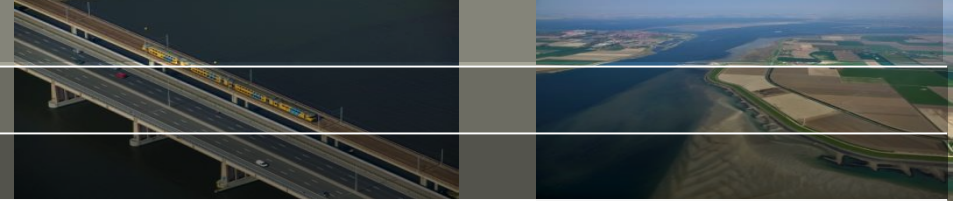
- The US Army Corps of Engineers and the Bureau of Reclamation operate the federal dams for multiple public purposes:

- Flood Control
- Navigation
- Fish protection operations
 - Endangered Species Act, Clean Water Act
- Irrigation
- Recreation
- Power production

- BPA's Role

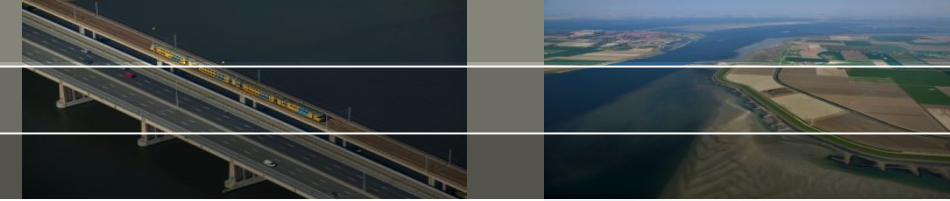
- Markets the power produced from the federal dams within the constraints and requirements for other river purposes
- Primary high-voltage transmission provider in the Columbia River Basin





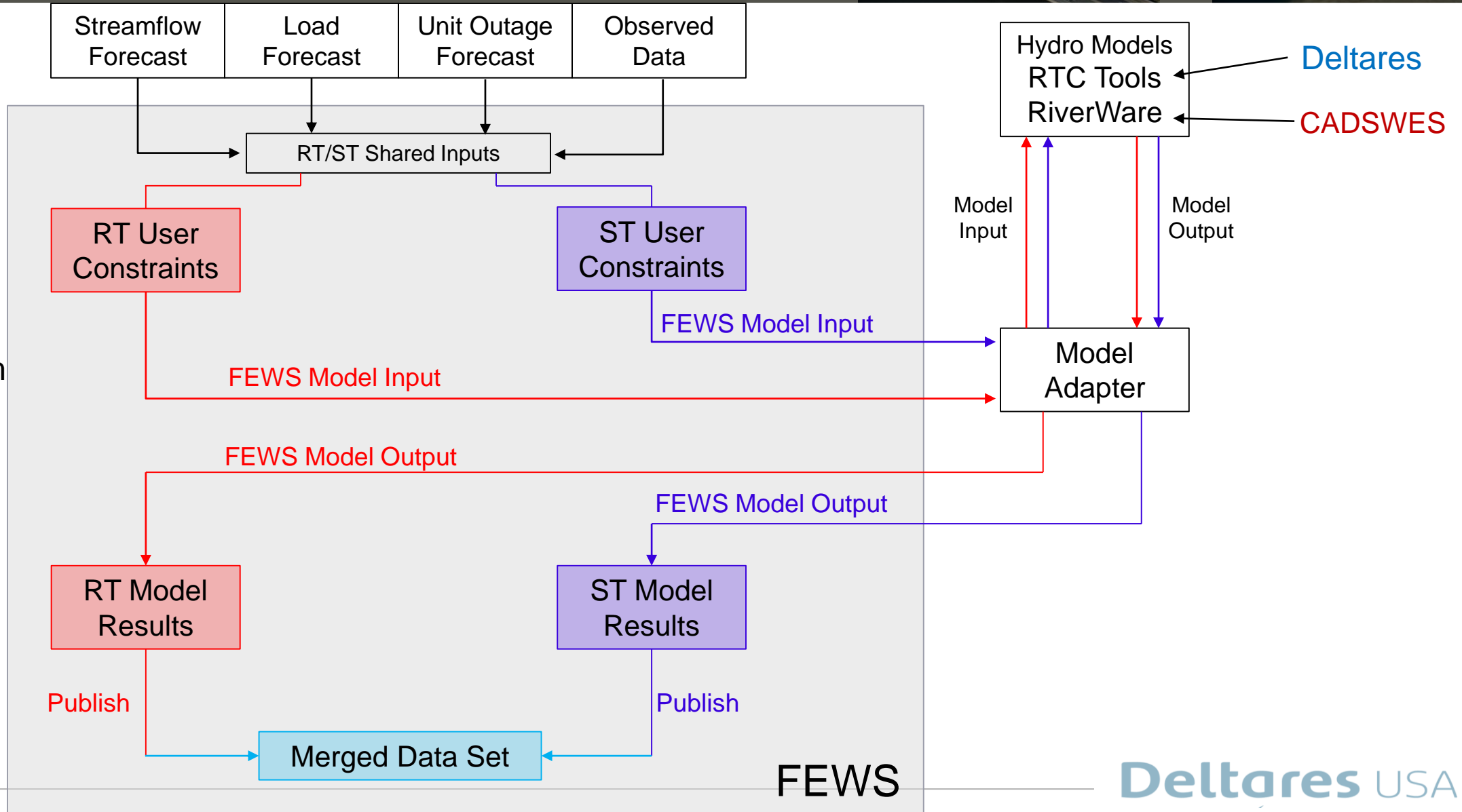
- Operational objectives/constraints on the FCRPS significantly reduce flexibility of the hydro system
 - Flood control, fish obligations, outages, etc.
- Flexibility further affected by uncertainties
 - Streamflow, Load, Wind, etc.
- Optimize value of generation within remaining flexibility
 - Need models with various objectives to solve a wide scope of operational problems
 - Models for both “Real Time” and “Short Term” planning horizons

BPA – HERMES design in FEWS

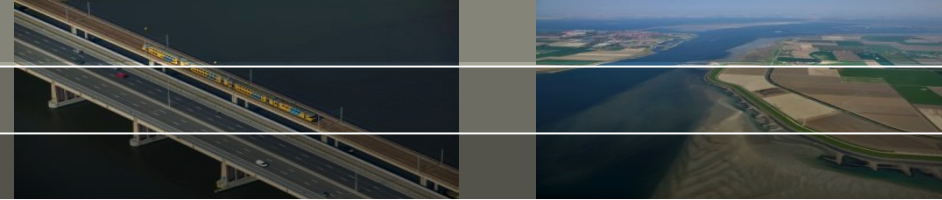


RT- Real-Time
(current day)

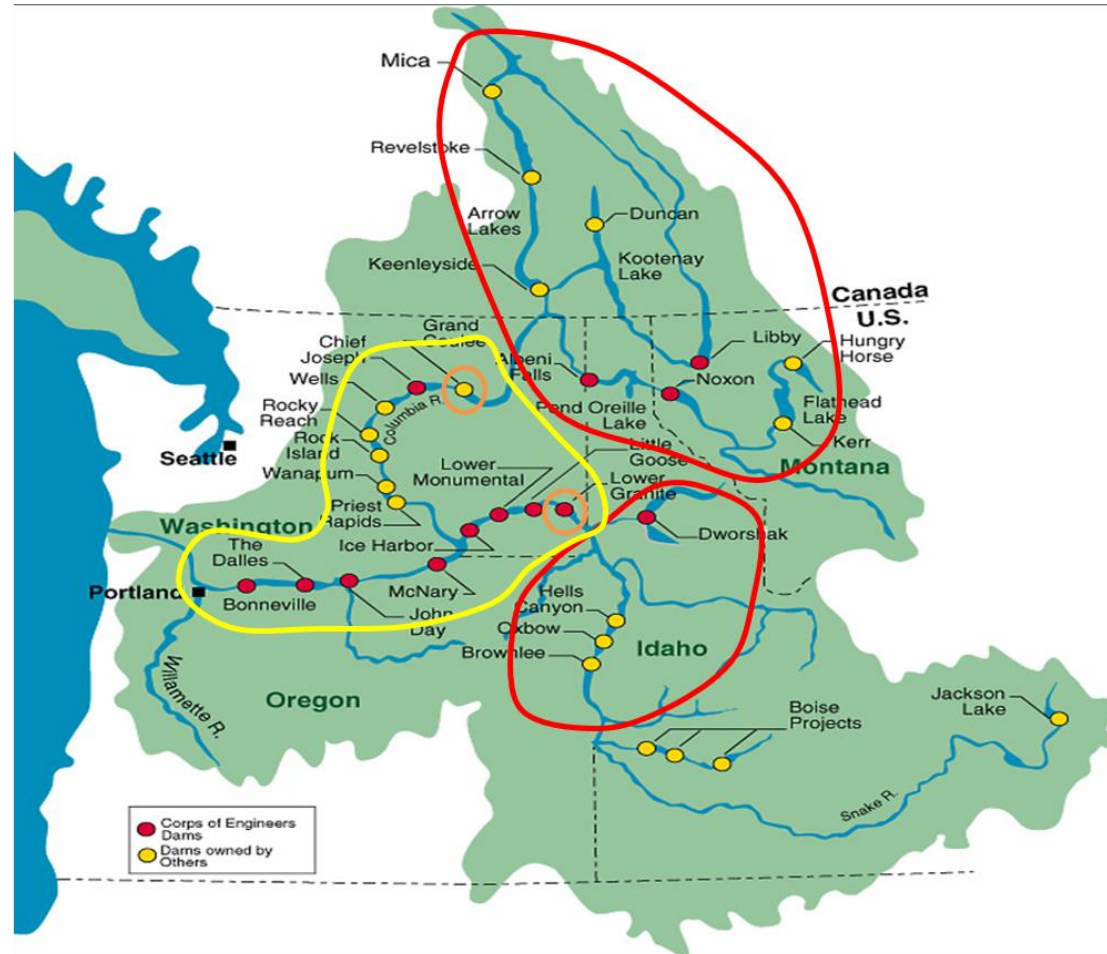
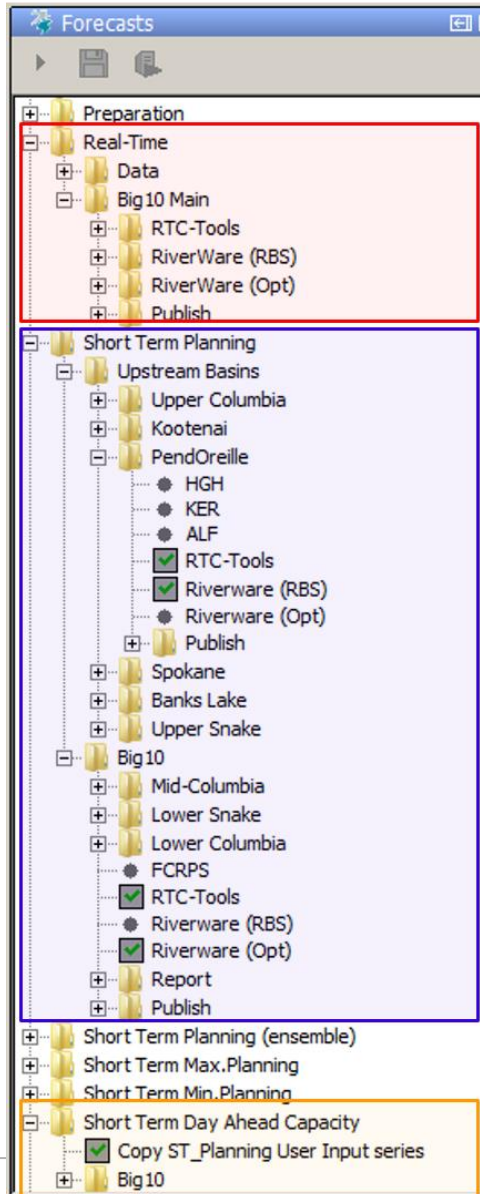
ST- Short-Term
(out 3 weeks)



BPA – HERMES FEWS platform



HERMES Design in FEWS



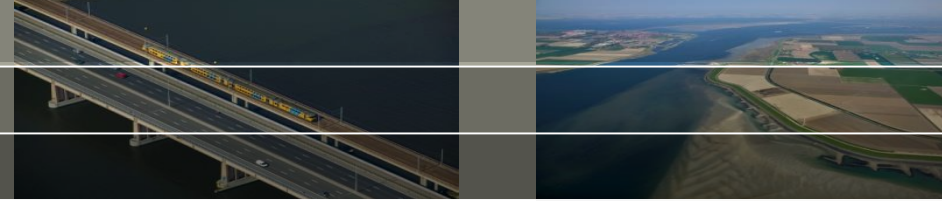
Flexibility for multiple groups, multiple models, and control of data management within one platform

BCHydro – British Columbia (Canada) Hydro



Deltares USA

BCHydro – Water Supply Forecasting

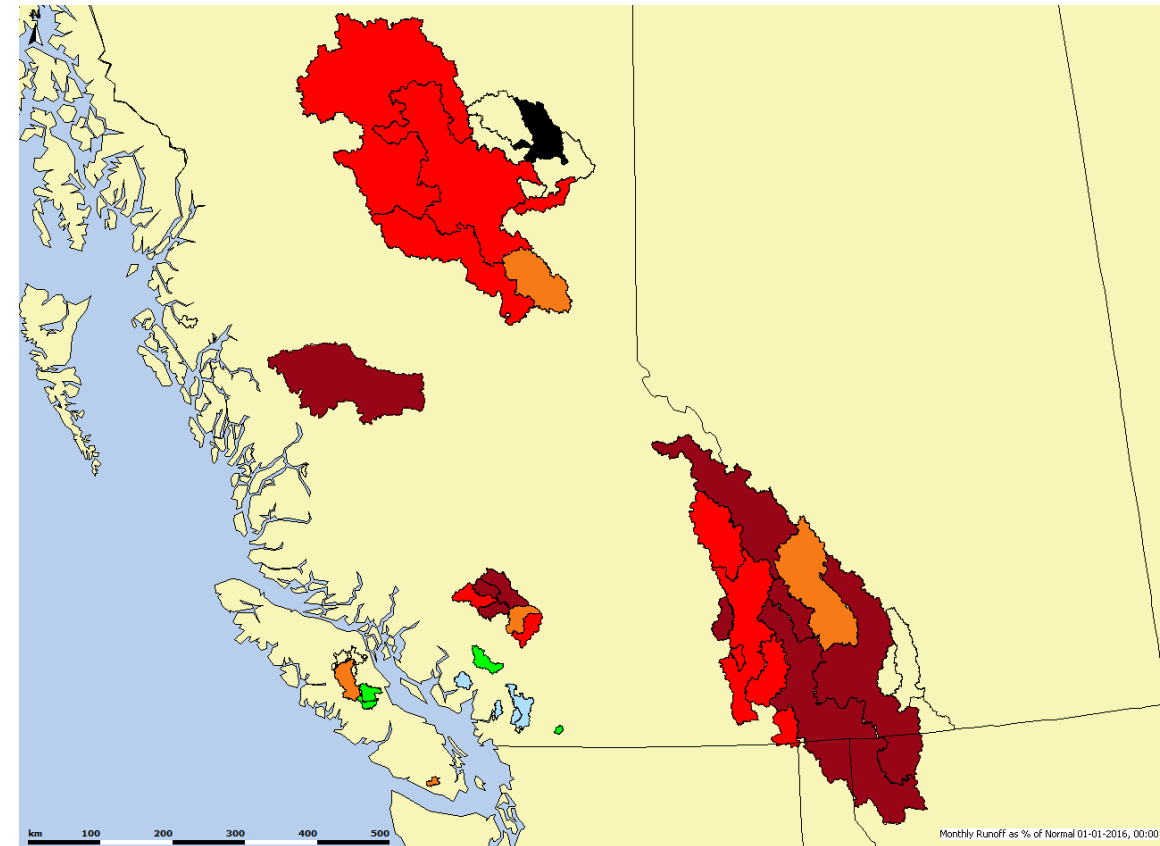


Quick Facts

- Serves 95% of BC (1.8 million customers)
- 11,300 MW capacity (3rd largest in Canada)
- 99% hydroelectric and 1% thermal

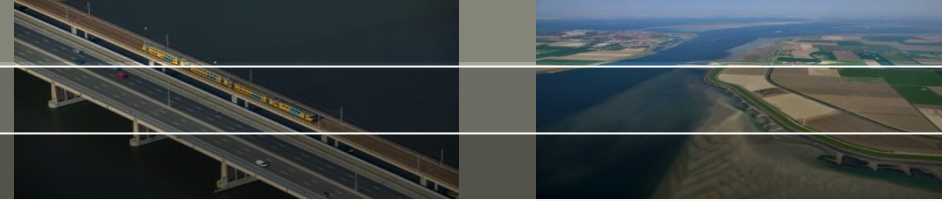
Modeling

- RAVEN
 - Flexible, modular (UBC Watershed Model)
 - Lumped to semi-distributed
 - <http://www.civil.uwaterloo.ca/jrcraig/Raven/Main.html>
- Ensembles
 - Multi-parameter (GLUE) – 20 parameter sets / basin
 - ESP of ESP
 - Restart and state update at monthly time steps
 - Uncertainty in snow accumulation and ablation



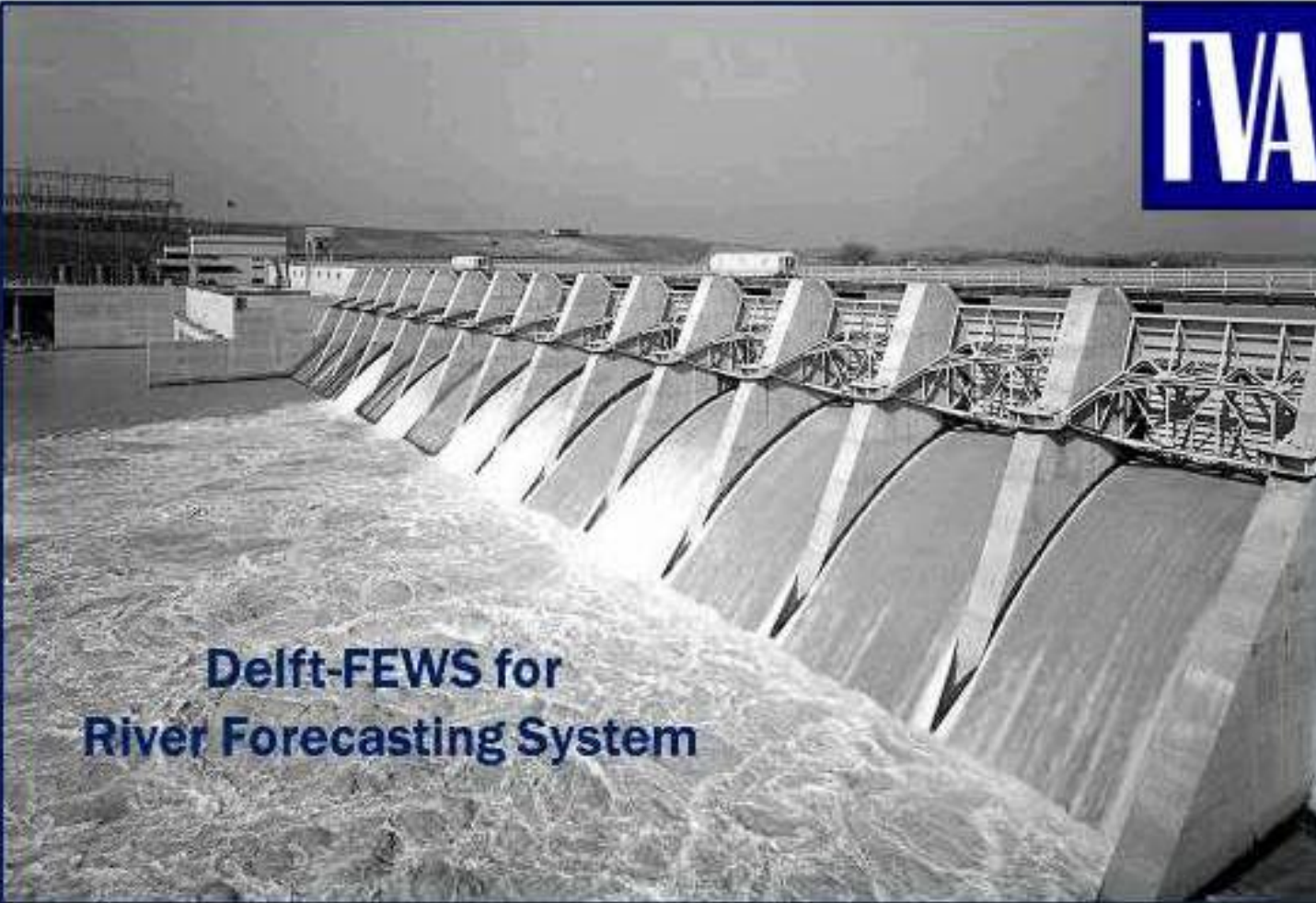
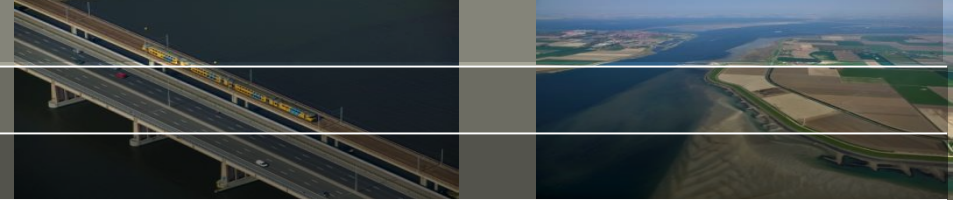


New Brunswick (Canada)




- U.S. – Canada border
 - St. John's River
- Strong relations with NERFC
- Standalone system
- Models
 - SSARR
 - Raven (UBC Watershed)
 - HEC-RAS


TVA – Tennessee Valley Authority




TVA

**Delft-FEWS for
River Forecasting System**

Deltares USA 

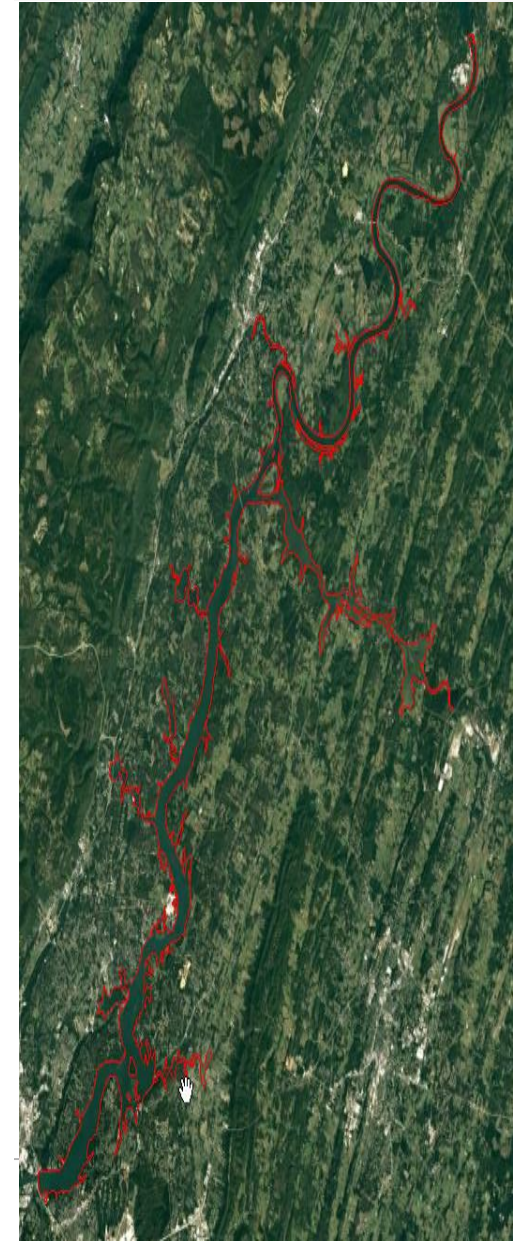
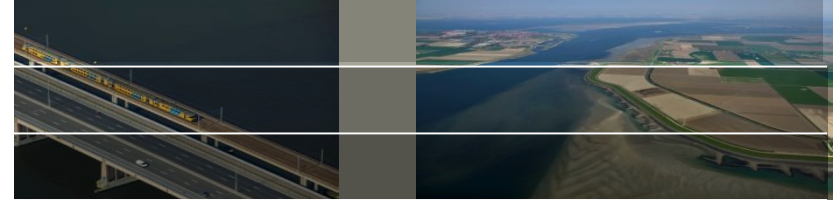
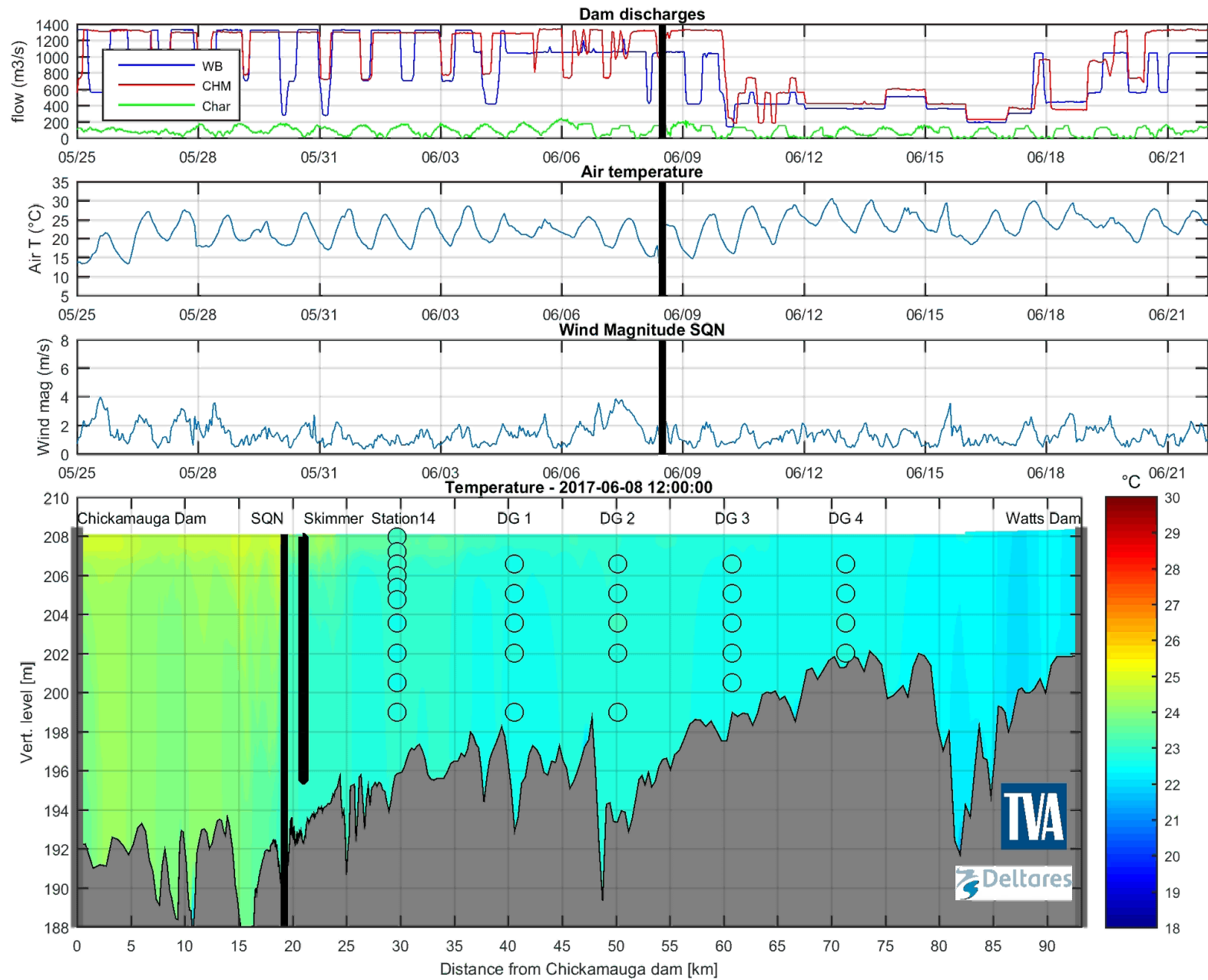
 **RIVERSIDE**

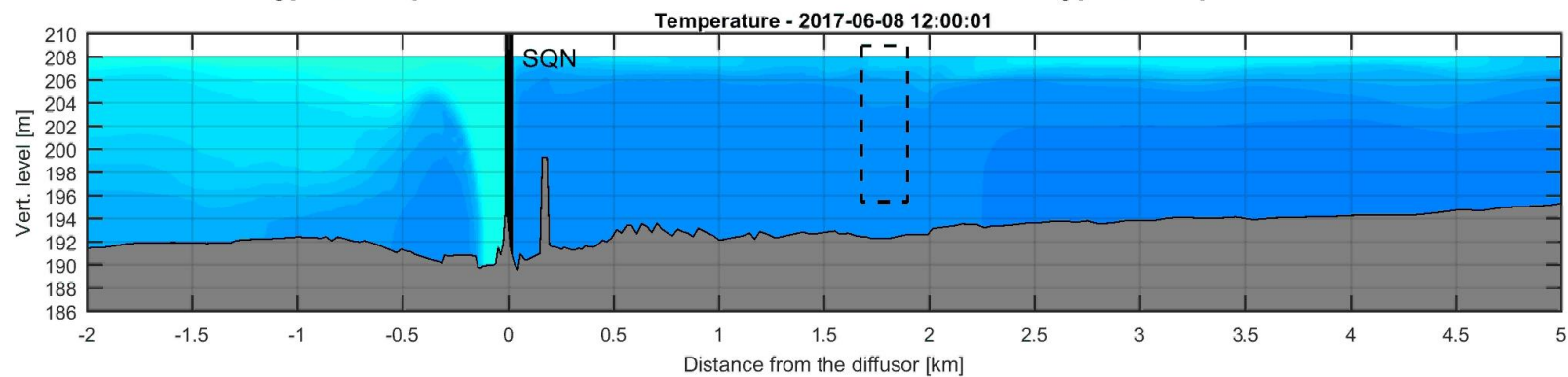
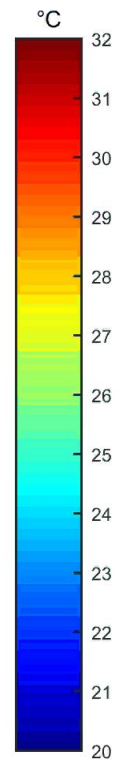
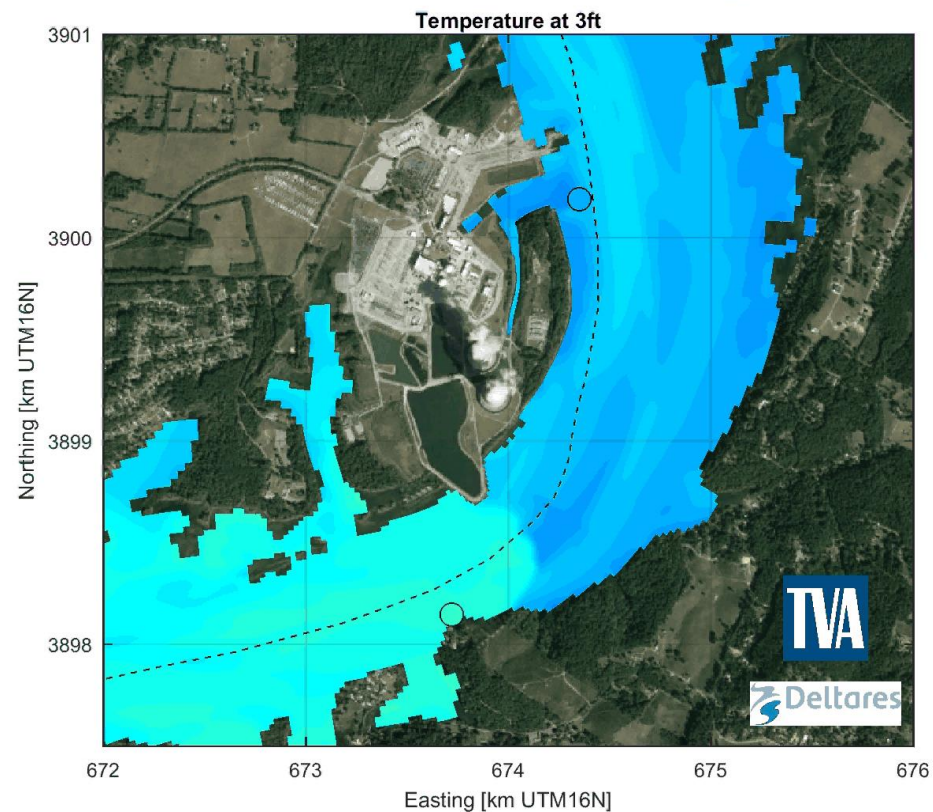
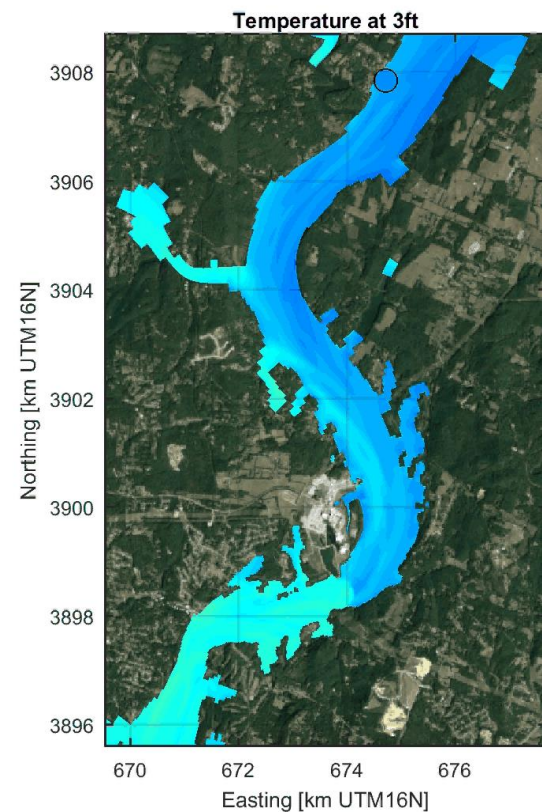
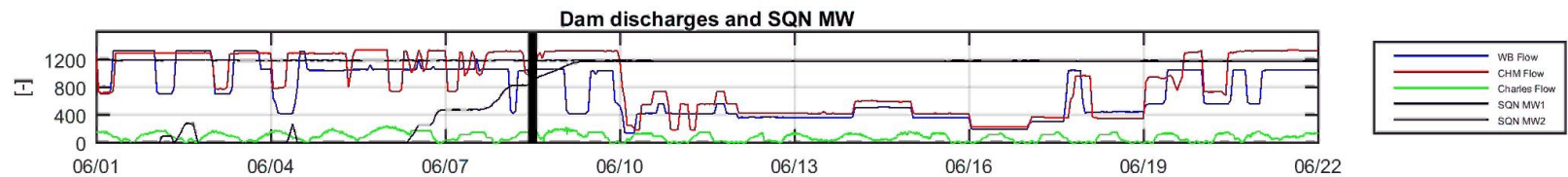
amec 

Deltares USA

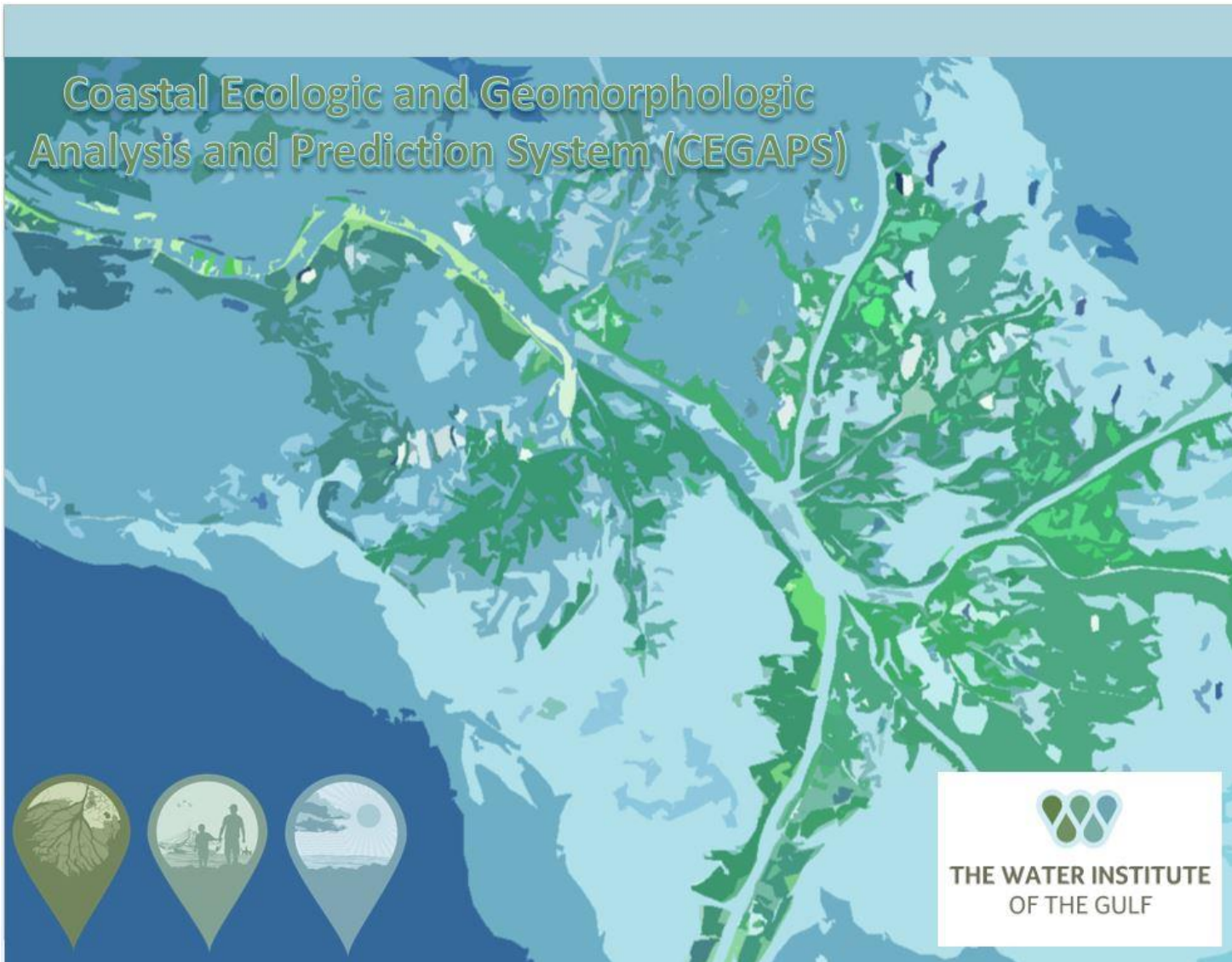
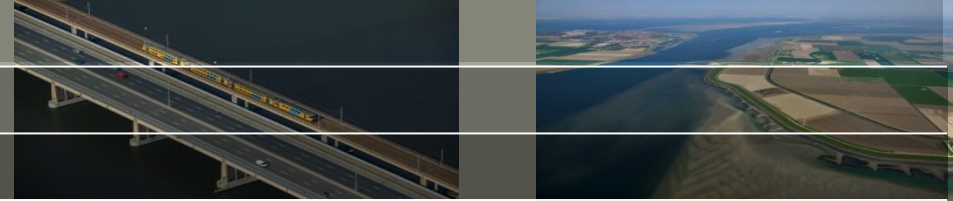
TVA – Hydrothermal Data Validation and Modeling

- Data validation and archival of water temperatures
 - Previous: 3-5 days of staffing per month (paper reports)
 - Current: ~4 hours per month
- Hydrothermal modeling
 - Assist the power plants in maintaining environmental compliance for thermal river discharges
 - Generate river temperature forecasts
 - Coordinate use of cooling towers
 - Coordinate river operations and hydro production
- Delft3D-FLOW reservoir models
 - Dynamic two-way coupling to near-field TVA slot-jet models
 - COSUMO (Deltares software) handles coupling
 - Intensive field campaigns to collect data under various scenarios (low flows, sloshing)
 - Calibrate model to field campaign data
 - Implement in FEWS

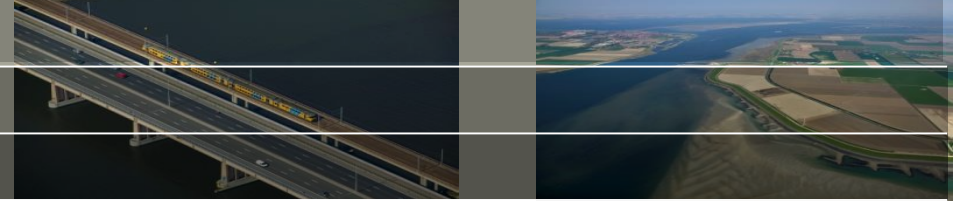




The Water Institute of the Gulf



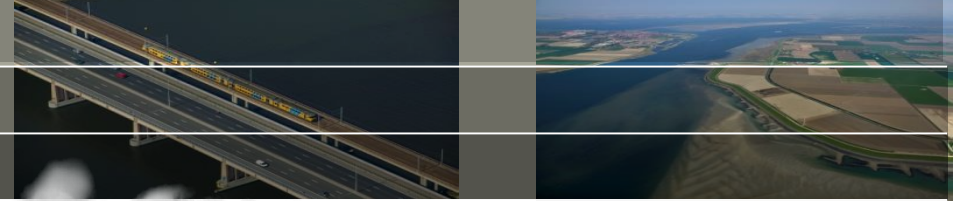
Deltares USA



Coastal Ecomorphological Real-Time Forecasting (CERF) System

- Forecast system for coastal Louisiana
 - Water level
 - Salinity
 - Water temperature
 - Sediment
- Support the management of existing Mississippi Delta restoration projects
 - Management of diversions
- Support the design of large scale monitoring programs
- Delft-FEWS platform with Delft3D as primary model

The Water Institute of the Gulf – CERF



- River
 - Hindcast – USGS/USACE
 - Forecast – NWS
- Temperature
 - USGS with extrapolation

Open Water –
Hindcast/Forecast

- Tide
 - ESTOFS
- Salinity
 - HYCOM
- Temperature
 - HYCOM

River Forecast Model



Atmospheric
Forecast Model

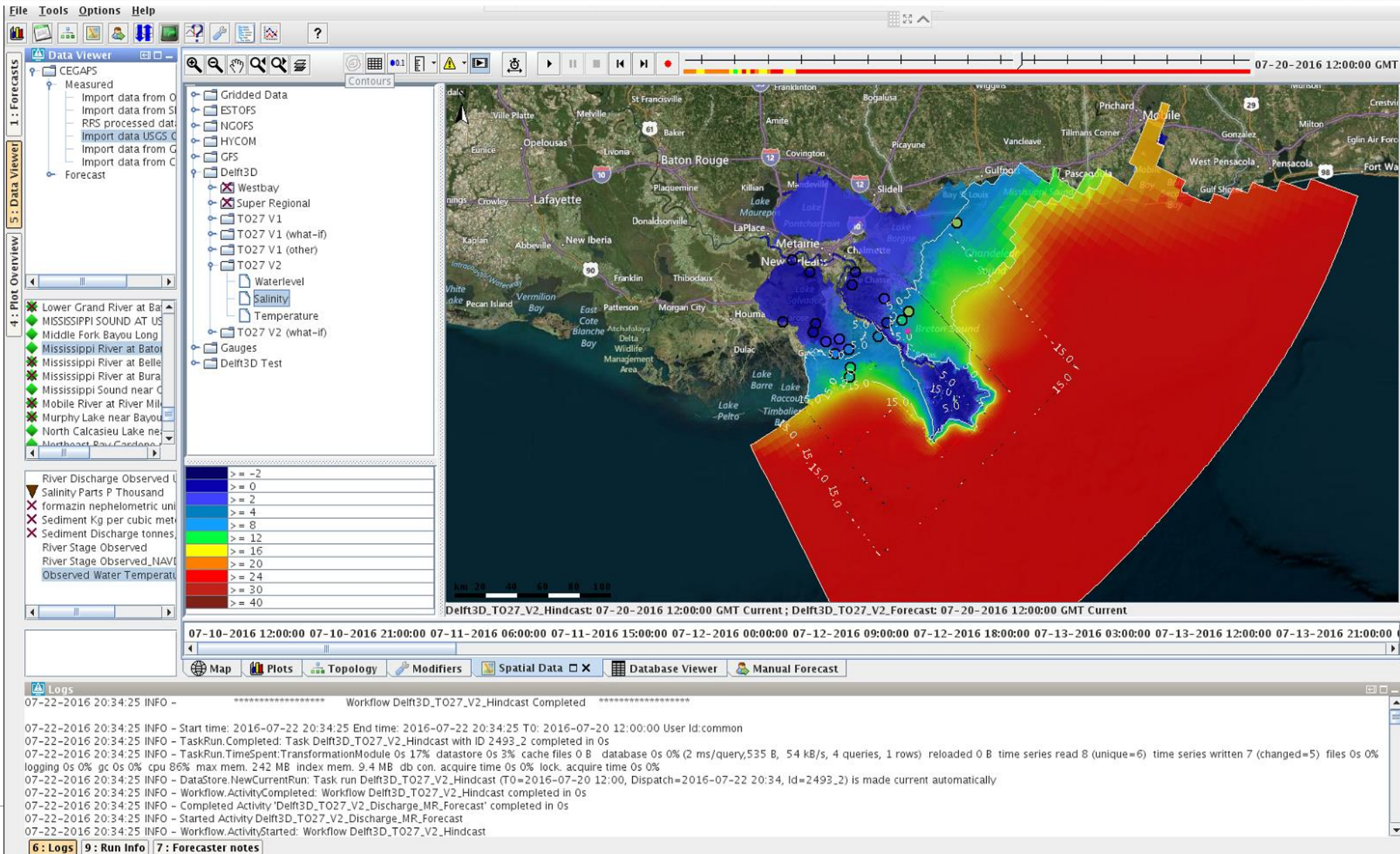


- Hindcast & Forecast (GFS)
 - Wind
 - P & ET
 - Temperature (heat flux, cloud cover, RH)

Gulf Forecast Model



The Water Institute of the Gulf – CERF



Idaho Power (IPC) – River, Reservoir, Meteo, Water Quality

DELFT-FEWS:

**RIVER FORECASTING
SYSTEM**



Deltares USA


 **IDAHO
POWER**
An IDACORP Company

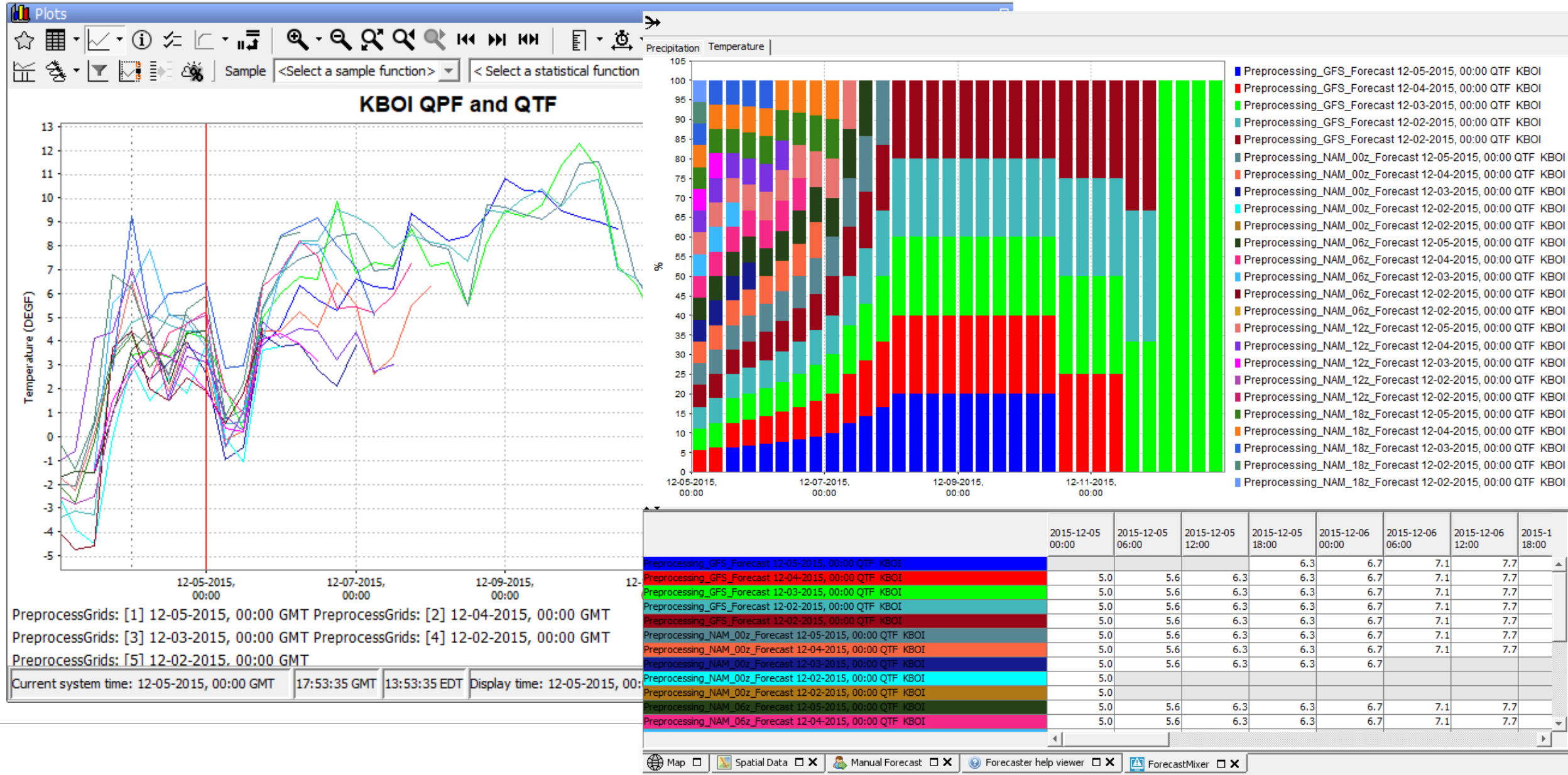
Deltares USA

Idaho Power (IPC) – River, Reservoir, Meteo, Water Quality

Idaho Power (in progress)

- 3 separate groups – eventually merge configuration into one joint system
 - Operational Hydrology (OH), Meteo Analysis, River Engineering (Water Quality)
- OH – RFS
 - NWSRFS models for inflow forecasting
 - Switching to RiverWare (CADSWES) for reservoir forecasting
- Meteo
 - Grid analysis
 - Provide OH the meteo forcings
 - Forecast Mixer
- River Engineering
 - HEC-RAS and CE-QUAL-W2 models for river studies
 - Focus on water temperature

IPC Meteo – Forecast Mixer






Systeme Prévision Hydrologique

*Développement durable,
Environnement et Lutte
contre les changements
climatiques*

Deltares

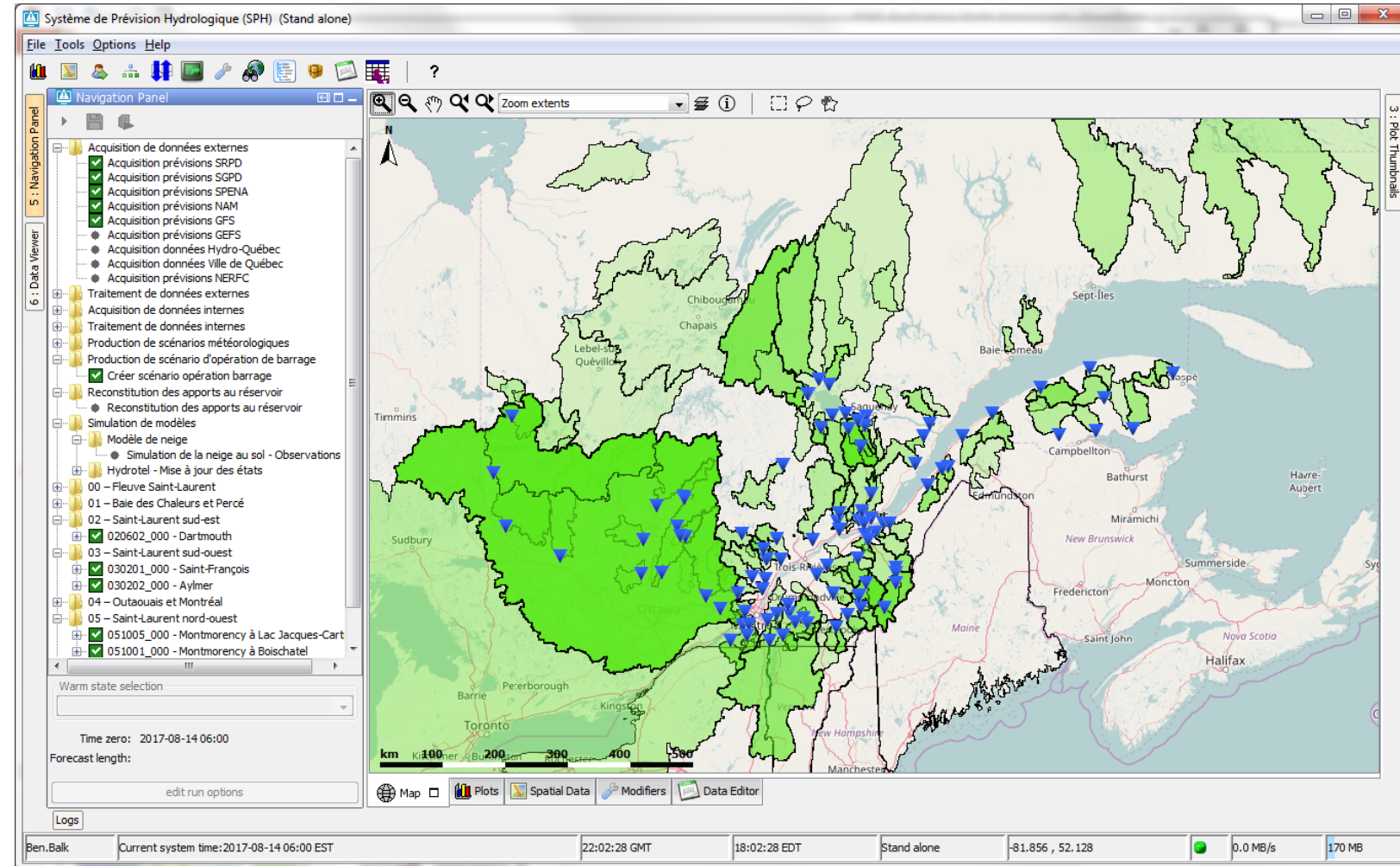
Québec 

Deltares USA

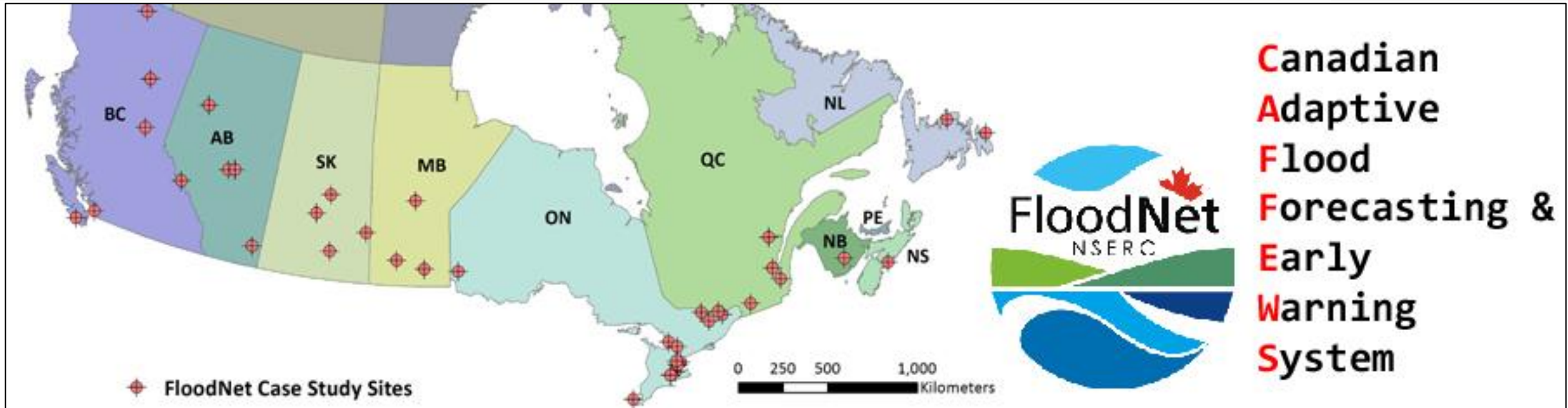
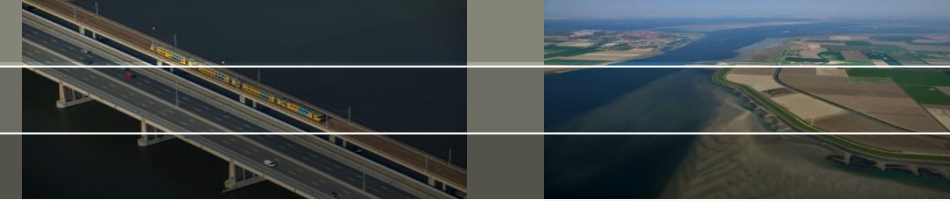
Québec – Système Prédiction Hydrologique

Québec SPH (in progress)

- Provincial Government
 - River and reservoir forecasting
- Models
 - Hydrotel (local university)
 - Reservoir, uncertainty (in-house)
 - Québec coded the adapters
 - Users and programmers
- U.S. and Canadian met models
 - quick learners of FEWS
- Climate change studies
 - WaSiM



FloodNet (Canada)



FloodNet – NSERC CAFFEWS (in progress)

- Goal: common flood forecasting platform
 - Currently no overarching national program
 - Each province largely independent from neighbors
 - Delft-FEWS is one of several software being considered
- WATFLOOD adapter



Questions?