



Delft-FEWS: An operational model integrator

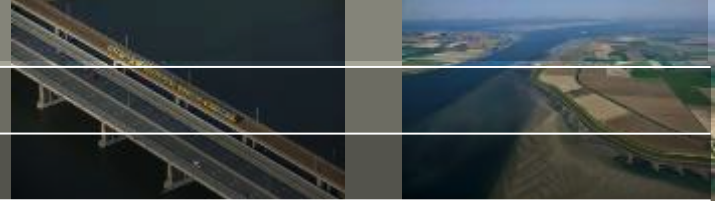
Environmental Modelling Workshop, Alberta

March 13/14, 2013

Matthijs Lemans

Deltares USA

Presentation Overview



- Characteristics of any forecast system
- Description of FEWS, a multi-purpose forecast environment
- FEWS and model control
- FEWS Displays
- Example FEWS applications as model integrator

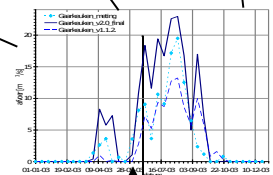
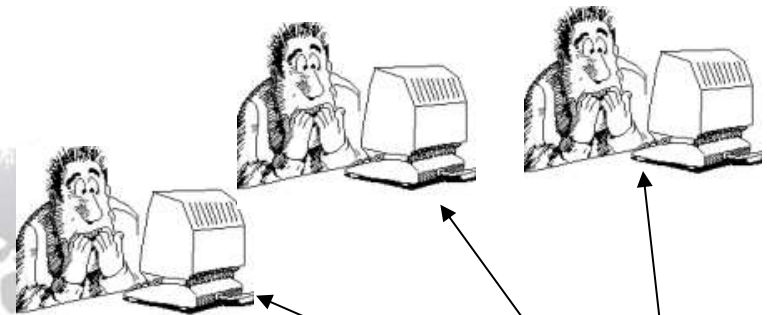
An aerial photograph of a coastal region. A large body of water, likely a river or estuary, flows from the top left towards the bottom left. A long, green dike runs along the right side of the water, separating it from a large area of agricultural fields. The fields are divided into various colored patches of green, brown, and tan, indicating different crops or land uses. In the background, a small town or village is visible on the left side of the water. The sky is clear and blue.

Forecast systems

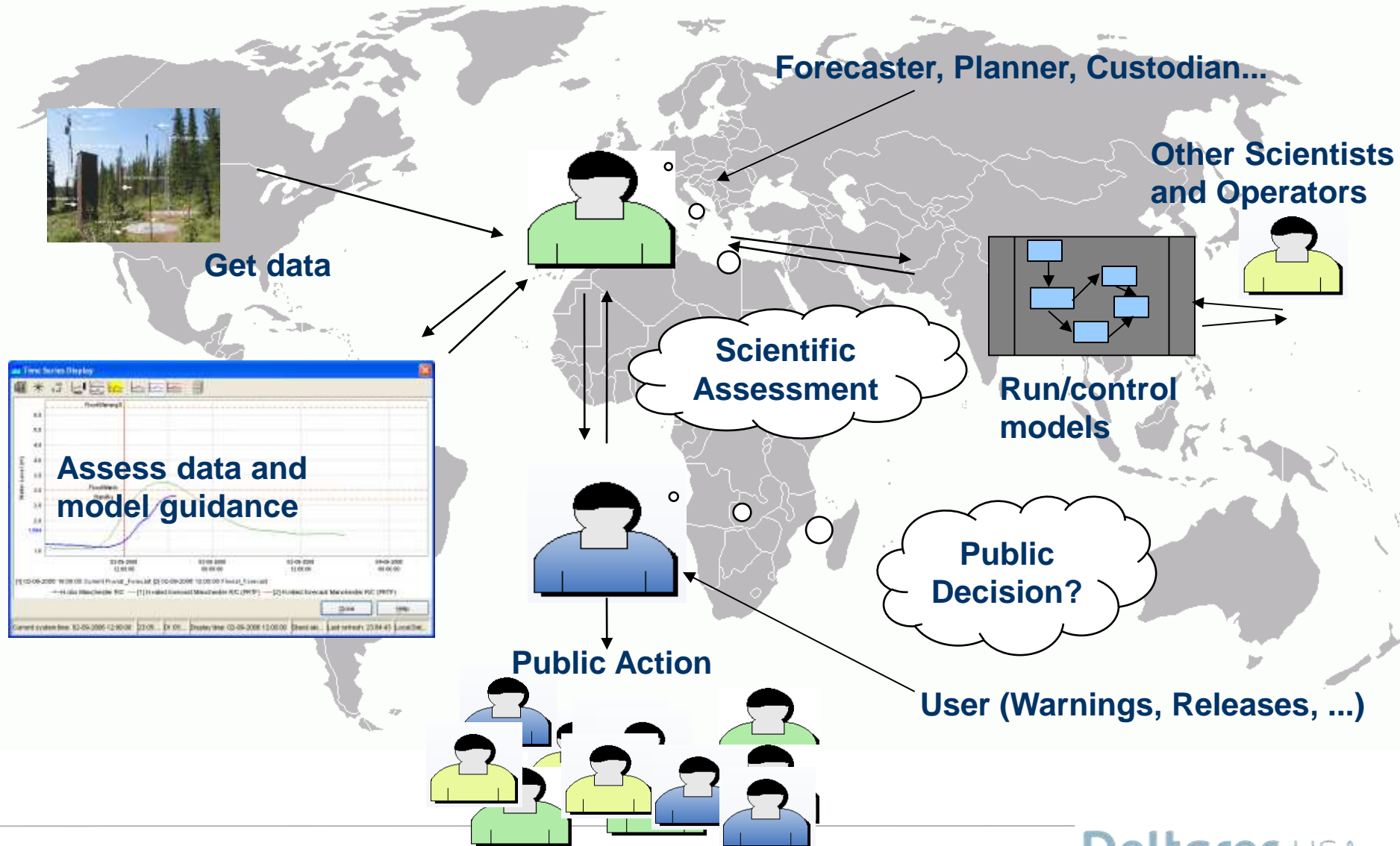
Operational Forecast System Purpose

**Linking Forecasters, Regulators,
Model Developers,
Managers, and the Public**

- By making good science accessible to users
- By making models results understandable
- Presenting current and past observations
- With situational awareness highlighting areas of concern
- Generating Standard Reports



Elements of a Forecast System



An aerial photograph of a coastal region. A large body of water, likely a river or estuary, flows from the top left towards the bottom. A prominent dike or levee runs along the right side of the water, separating it from a vast area of agricultural fields. The fields are divided into various colored patches of green, brown, and tan, indicating different crops or land uses. In the background, a small town or village is visible on the left side of the water. The sky is clear and blue.

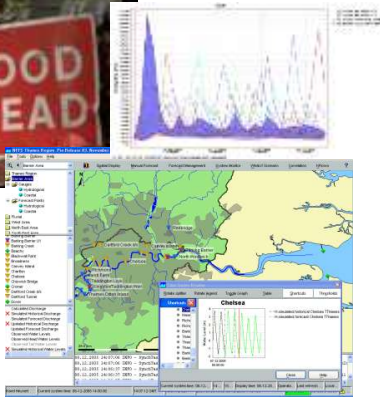
FEWS: Introduction and Architecture

Delft – Flood Early Warning System

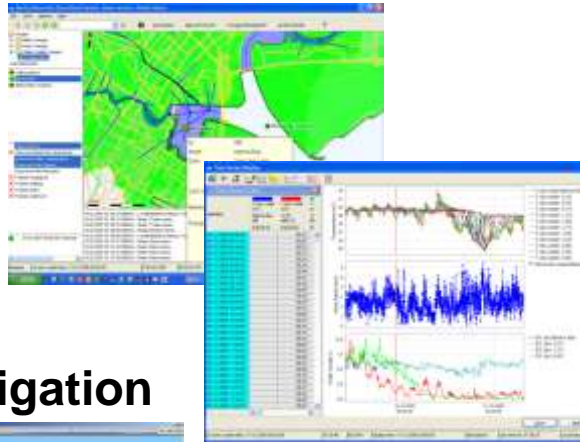
Delft-FEWS Systems Have Many Flavors



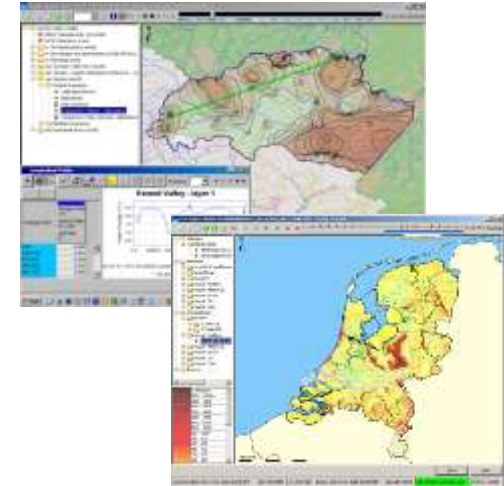
floods



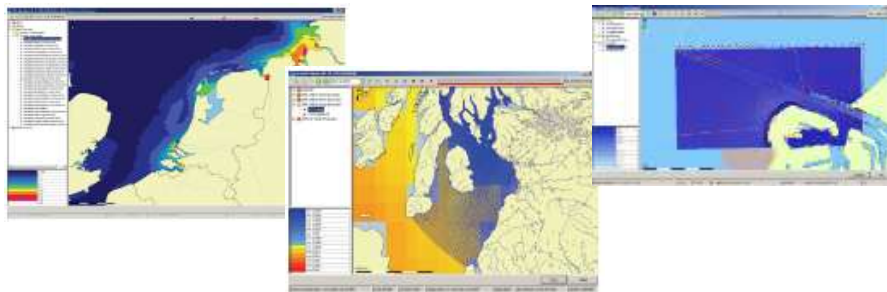
water quality



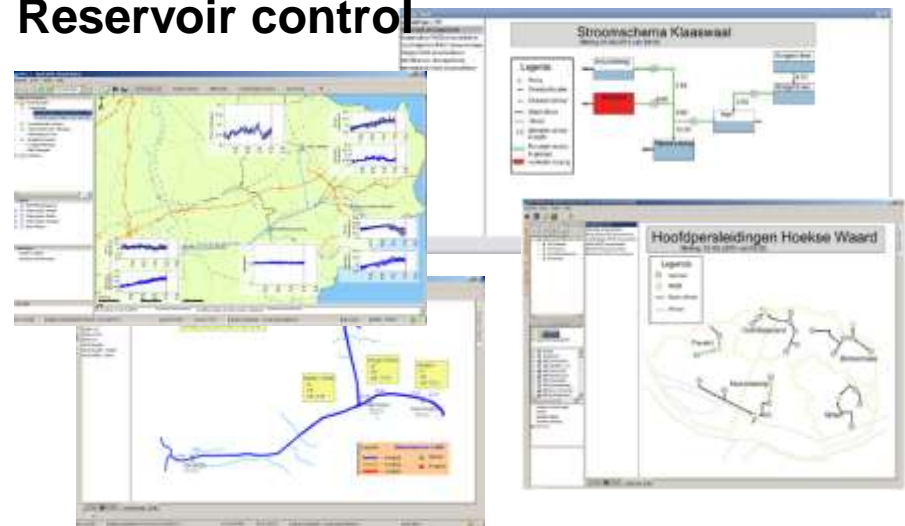
groundwater



coastal wq, storm surge, navigation



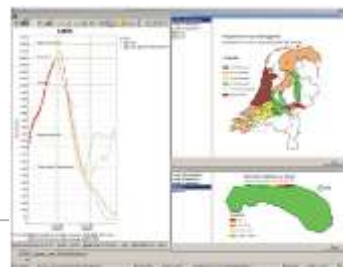
Reservoir control



lakes



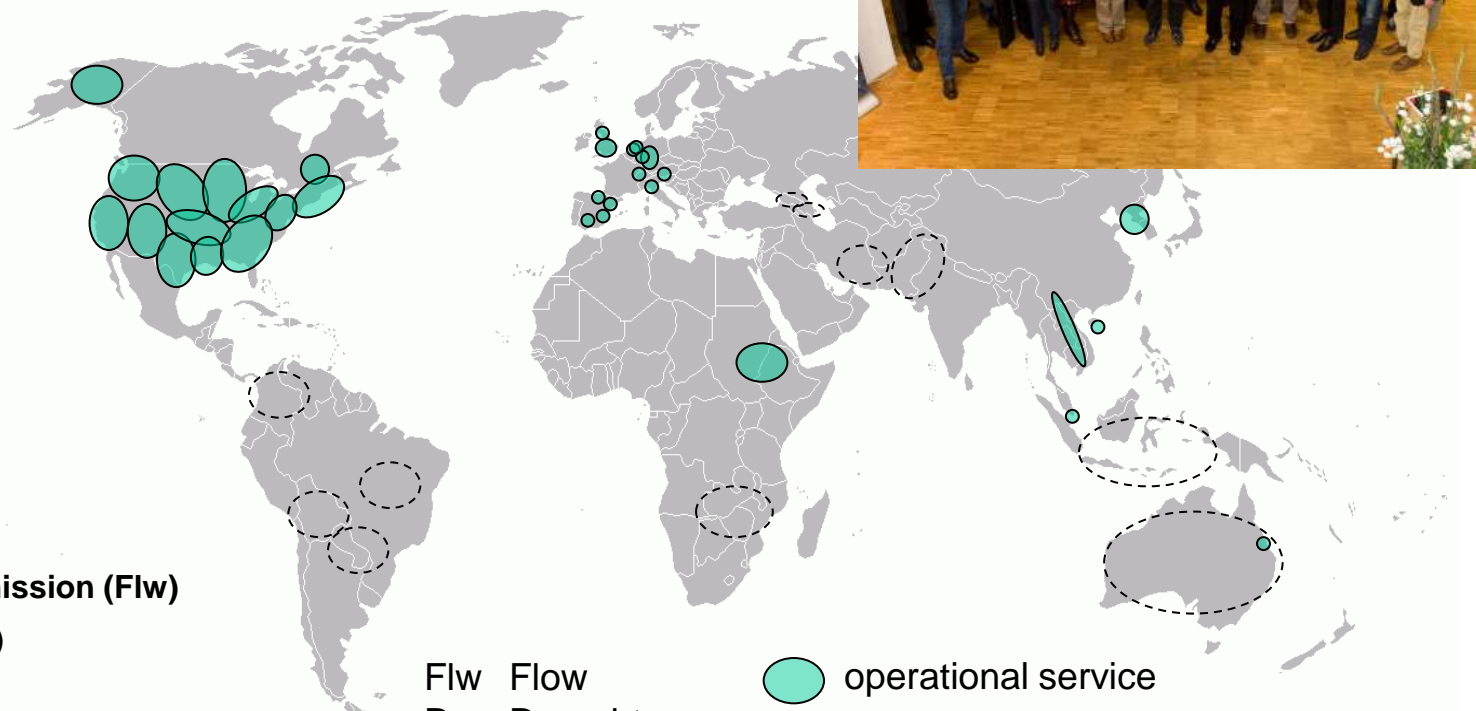
dike strength



Delft-FEWS User Community

- USA, NWS (Flw)
- USA, BPA (Flw, Res)
- Canada (Flw)
- UK (Flw, Gw)
- Netherlands (Dr, Flw, Wq, Ds)
- Germany (Flw)
- Suisse (Flw)
- Italy (Flw)
- Austria (Flw, Res)
- Spain (Flw)
- Singapore (WQ, Flw)
- Taiwan (Flw)
- South-Korea (WQ)
- Australia (Flw)
- Sudan
- Georgia
- Mekong River Commission (Flw)
- Indonesia (Peat, Flw)
- Azerbaijan (Flw)
- Zambezi (Dr, Flw)
- Colombia (Flw)
- Bolivia (Flw)
- Uruguay (Flw)
- Brazil (Flw, Res)

www.delft-fews.com

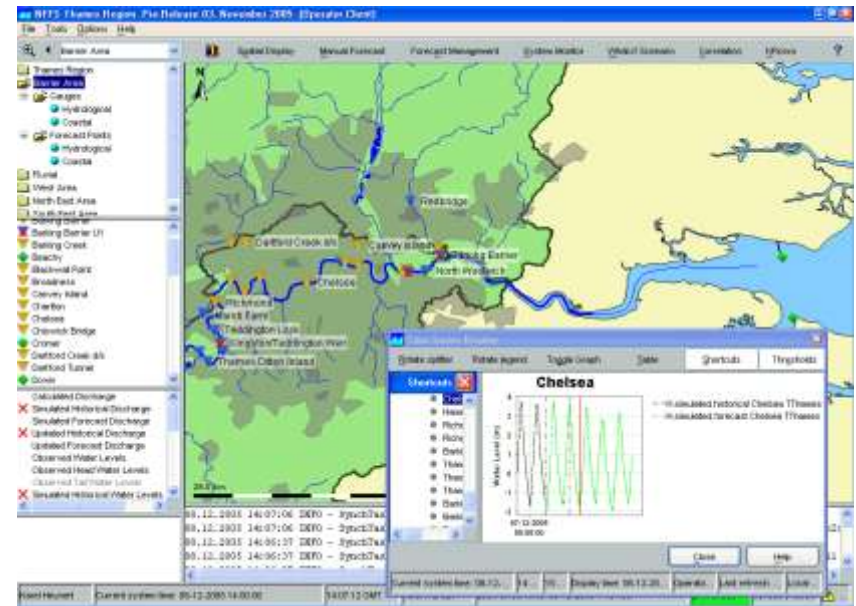


Flw	Flow		operational service
Dr	Drought		in development
Wq	Water Quality		
Res	Reservoir operation		
Ds	Dike strength		
Gw	Ground Water		

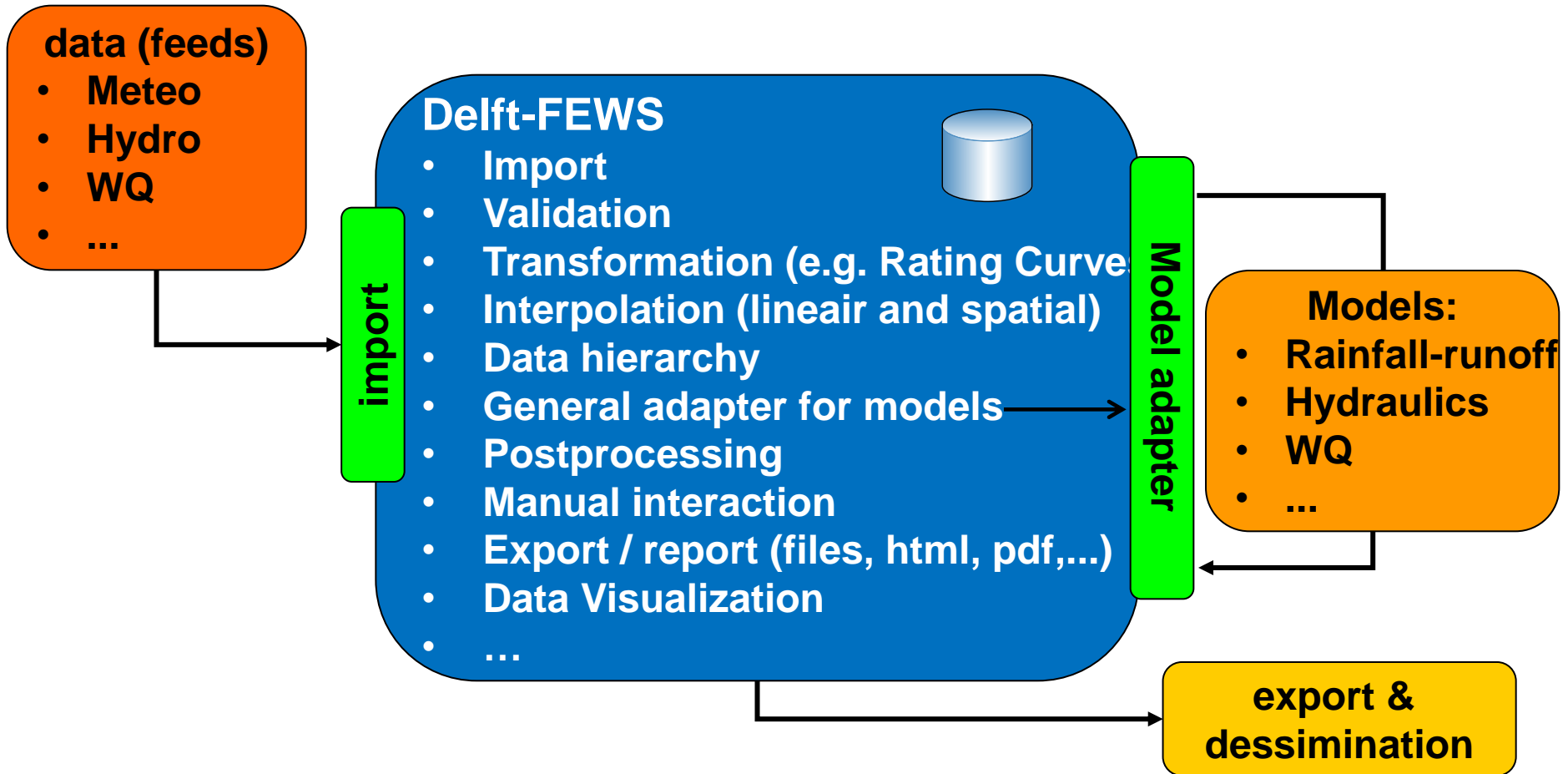
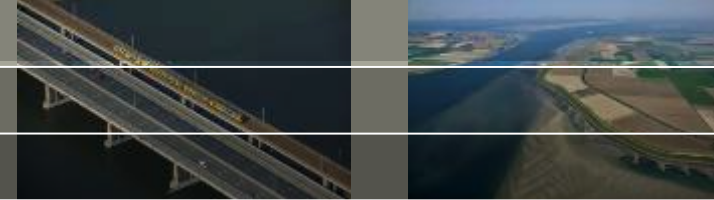


Delft-FEWS Philosophy

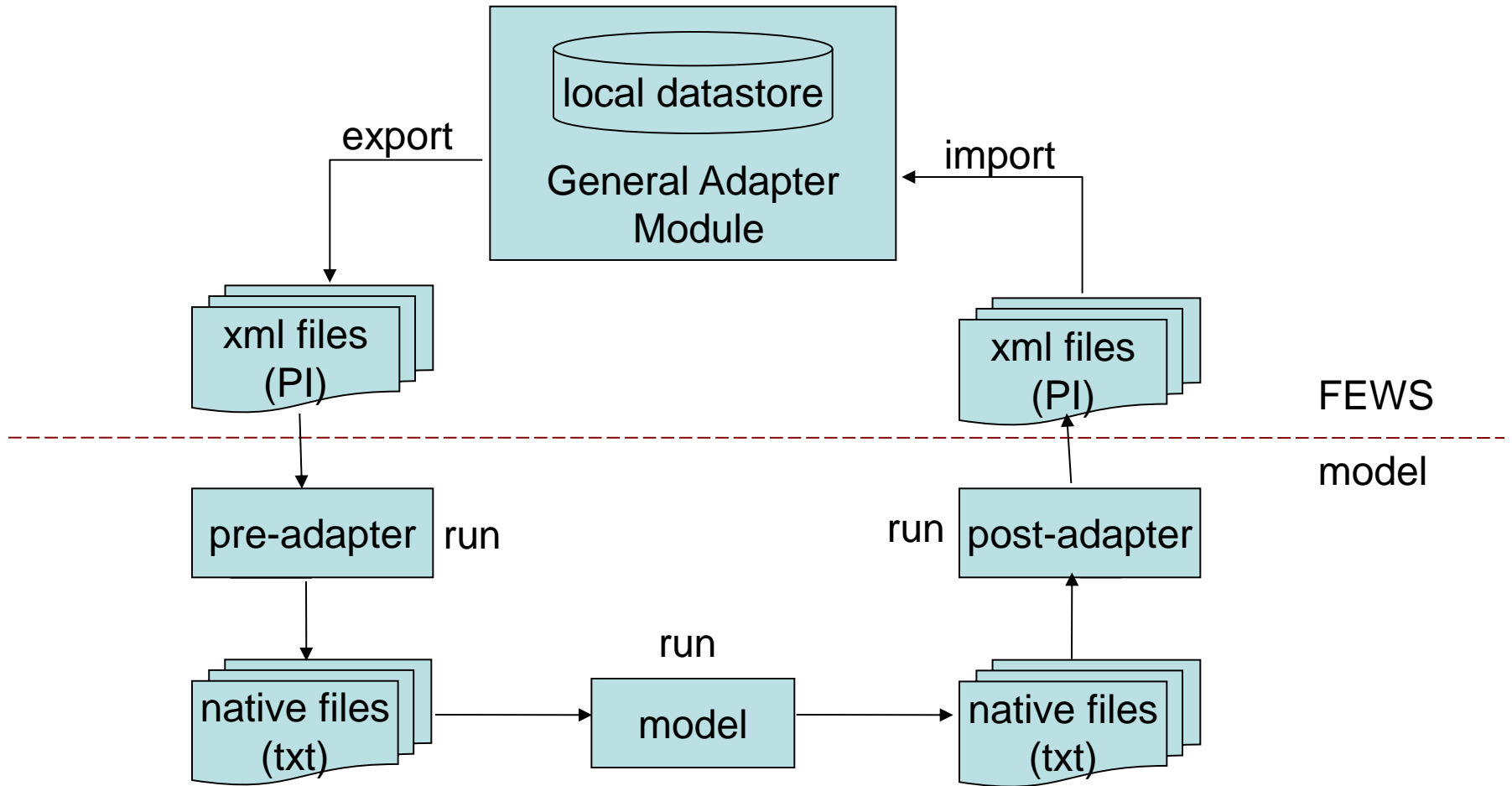
- FEWS is a data management system!
- Toolbox for development of forecasting systems
- Binding dataflows + models
- Fully 'configurable' by user
- Real-Time
- Rapid implementation, scalable & flexible
- High resilient & automatic / manual & stand alone



DELFT-FEWS Concept



Running models – how does it work



Delft-FEWS External Models – Model Adapters

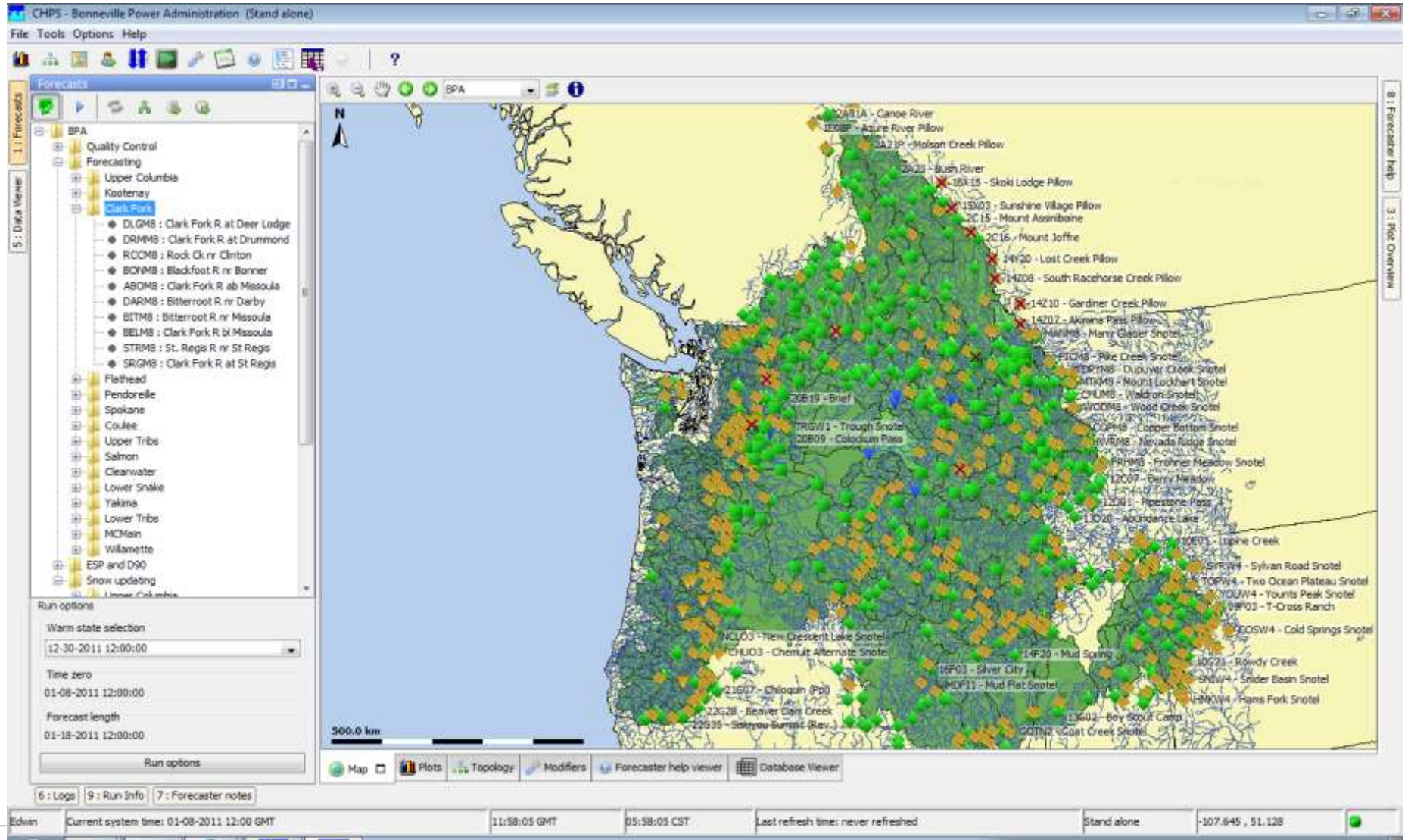
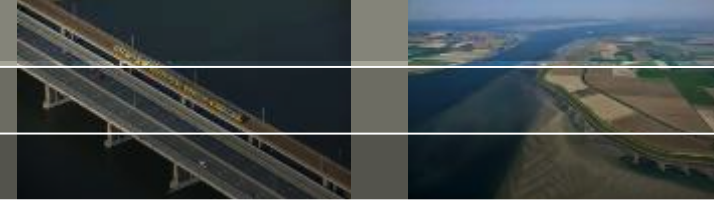
- CEH Adapters (SNOWP, SNOW, PDM, KW, ARMA, TCM, HEC, GRID2GRID)
- HR (ISIS)
- PlanB Adapters (TRITON & PRTF)
- DHI Adapters (Mike11, NAM)
- Midlands Region (DODO, MCRM)
- Southern Region (STF)
- Northwest Region (NW TF – Common Adapter)
- Wales (SW Overtopping module - Common Adapter)
- SouthWest (Bruton/Holbeam Dam module – Common Adapter)
- **Deltares** (RTC Tools, Delft3D, SOBEK, RIBASIM, HYMOS, Sacramento, SSARR)
- SMHI (HBV)
- University of Karlsruhe (PRMS)
- JRC (Lisflood - PCRaster)
- NWS (SNOW17, SAC-SMA, UNIT-HG, LAG/K, SARRROUTE, SSARRESV, RESSNGL, BASEFLOW, CHANLOSS, APICONT, CONSUSE, GLACIER, LAYCOEF, MUSKROUT, RSNELEV, SACSMA-HT, TATUM)
- USACE (HEC-RAS, HEC-ResSim)
- University of Valencia (TETIS)
- EPA (EFDC, HSPF)

<http://publicwiki.deltares.nl/display/FEWSDOC/Models+linked+to+Delft-Fews>

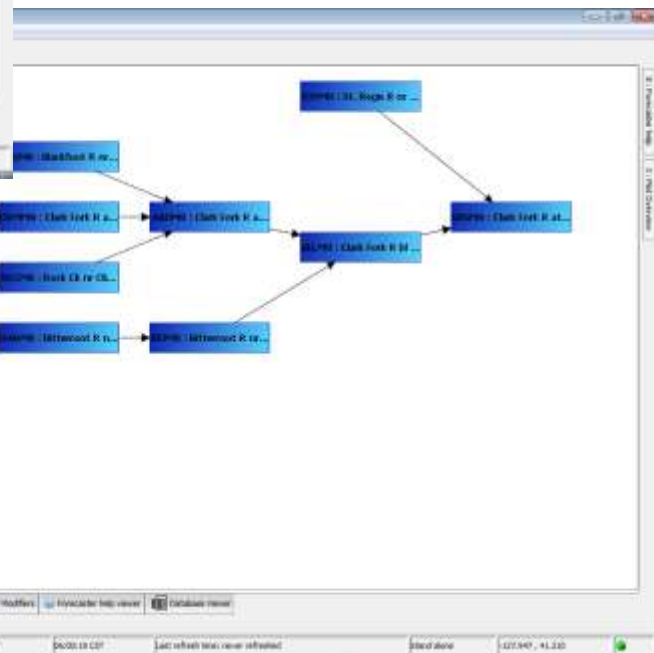
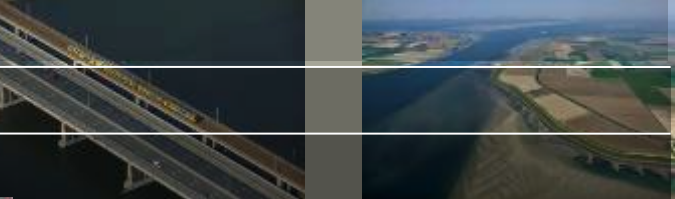
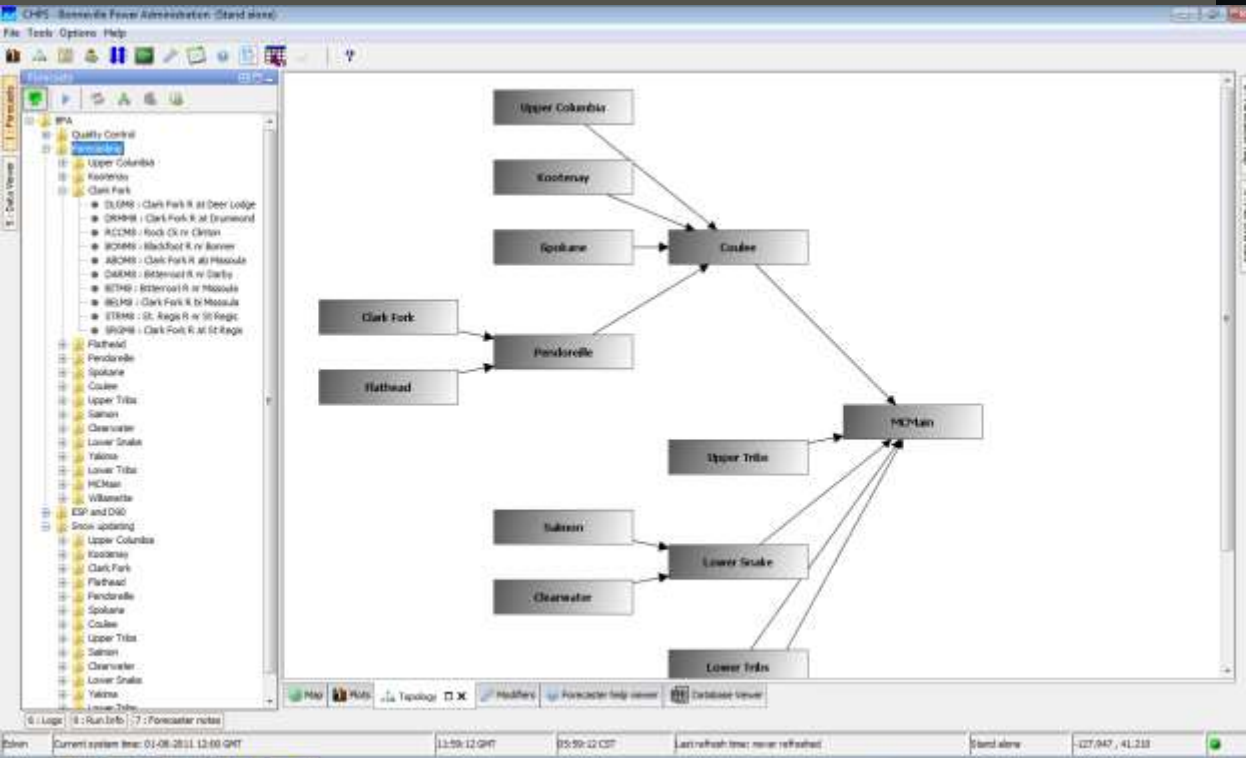
An aerial photograph of a coastal region. A large body of water, likely a river or estuary, flows from the top left towards the bottom. A prominent dike or levee runs along the right side of the water, separating it from a vast area of agricultural land. The land is divided into numerous rectangular plots of varying colors, including green, brown, and tan, indicating different crops or land uses. In the distance, a small town or village is visible on the left side of the water. The sky is clear and blue.

FEWS: Model Control

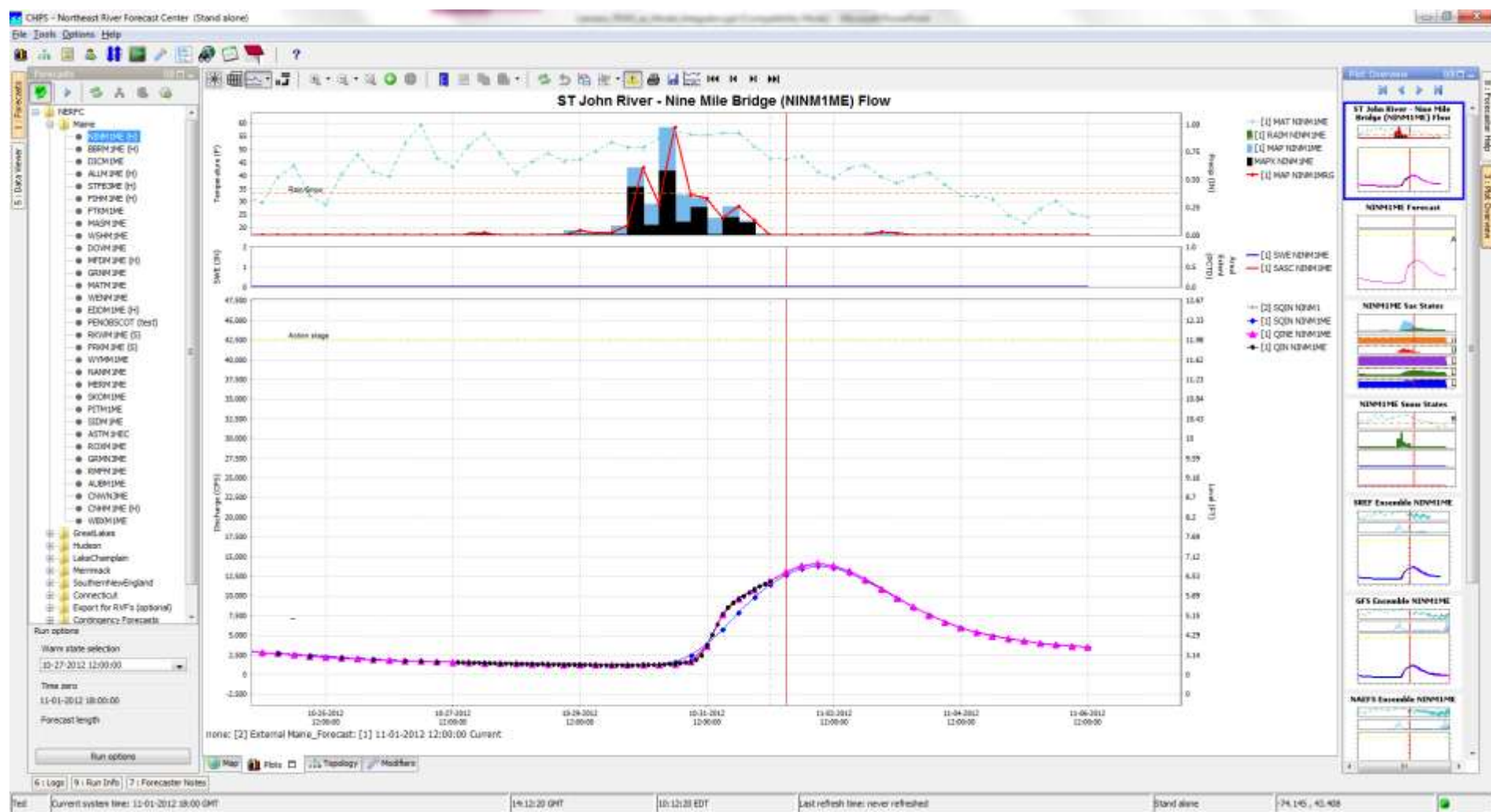
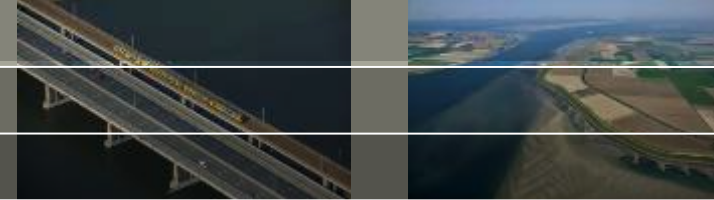
Situational Awareness



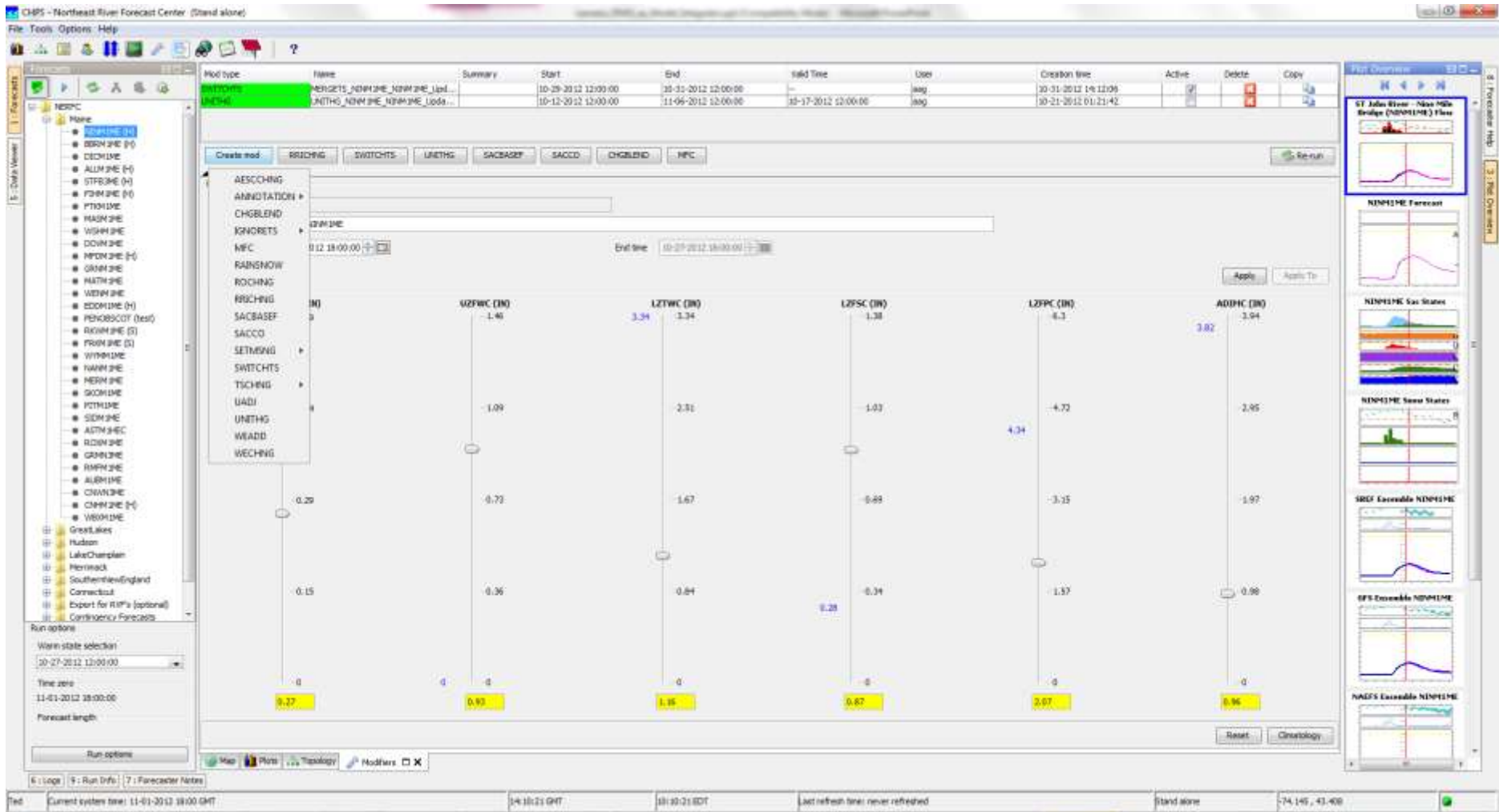
Model Connectivity

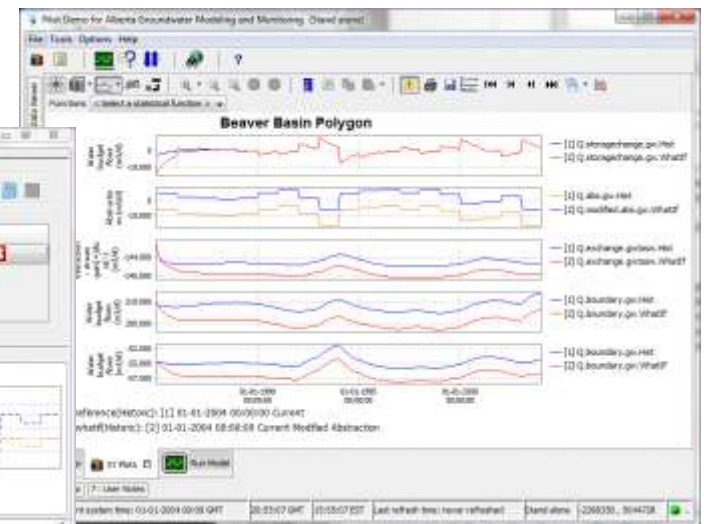
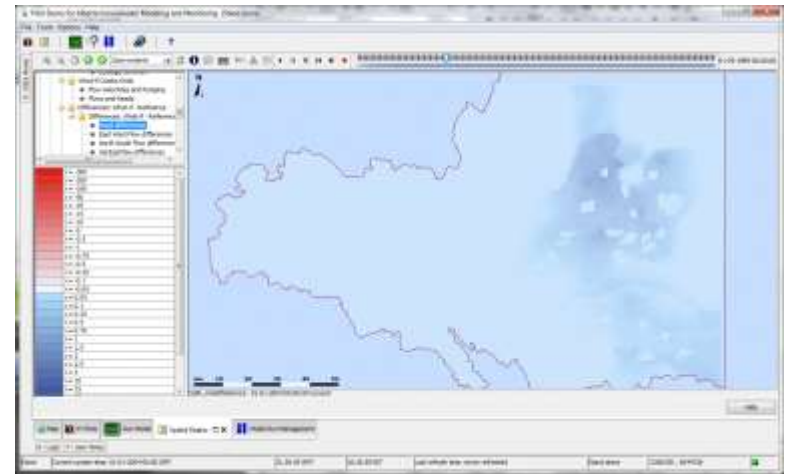


Model Execution and Display



Control of Model Input, States, Options

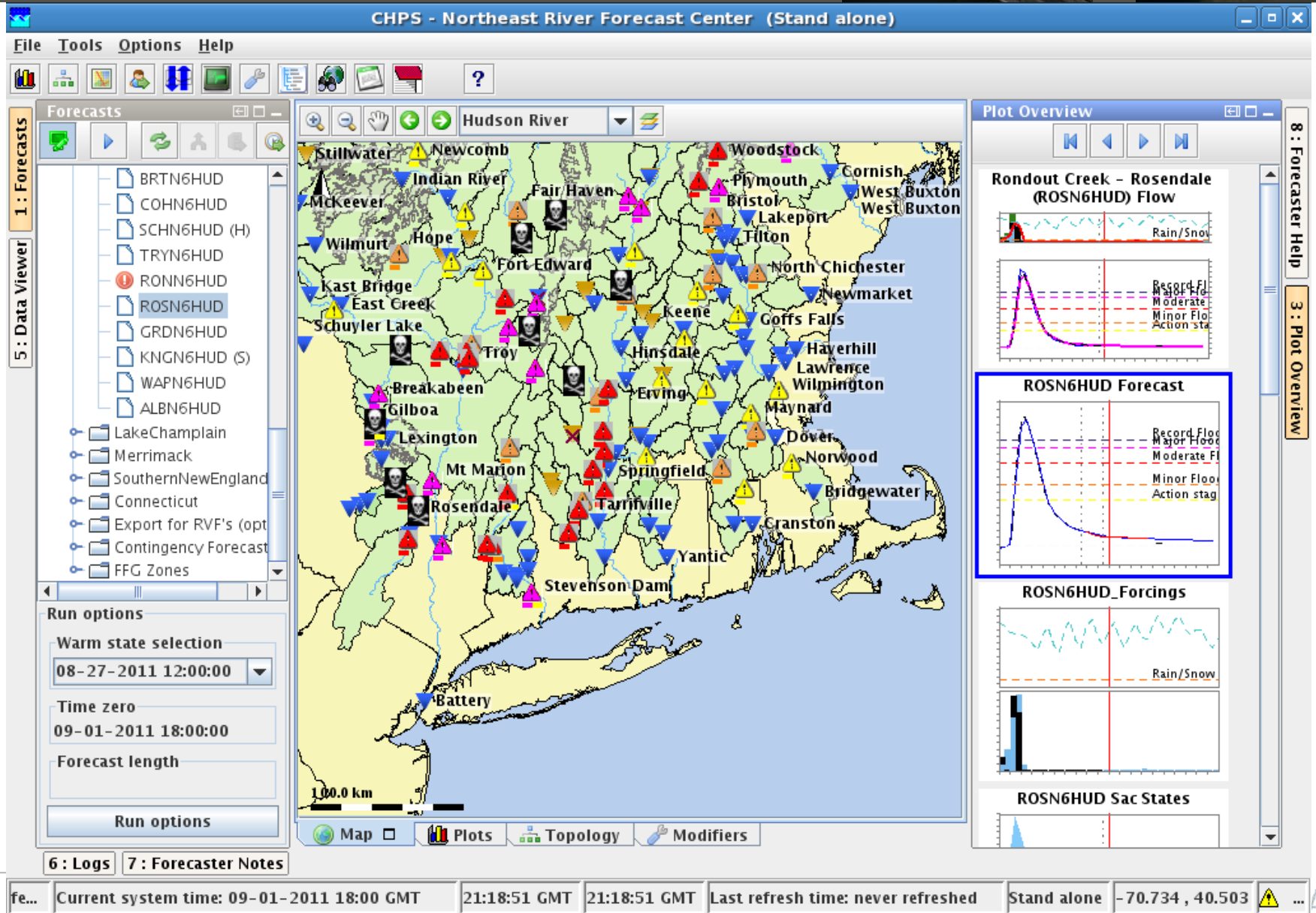




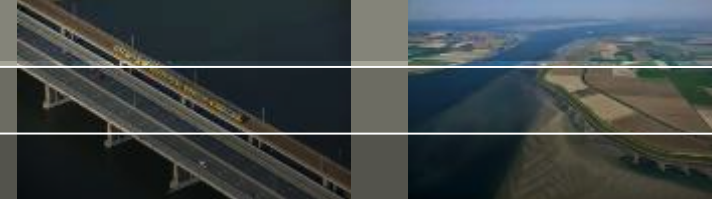
An aerial photograph of a coastal region. On the left, a large body of water (likely a bay or estuary) meets a sandy beach. A town with red-roofed buildings is situated on a peninsula in the upper left. A long, green dike runs along the coast, separating the land from the water. Several white wind turbines are visible along the dike. The land behind the dike is divided into large, rectangular agricultural fields in various shades of brown and green. The sky is clear and blue.

FEWS: Displays

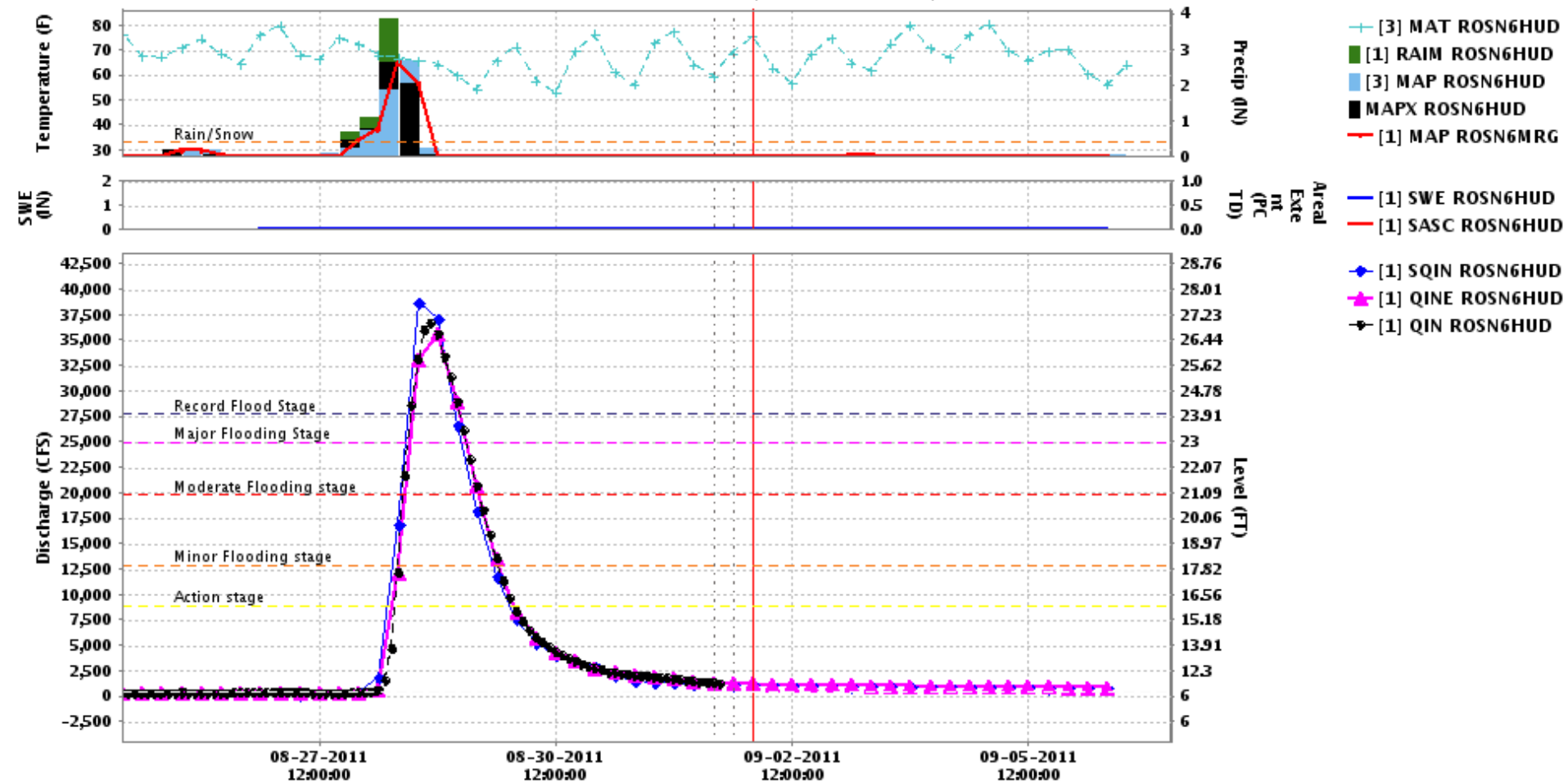
Customized Icons for the New England flood



Threshold crossings

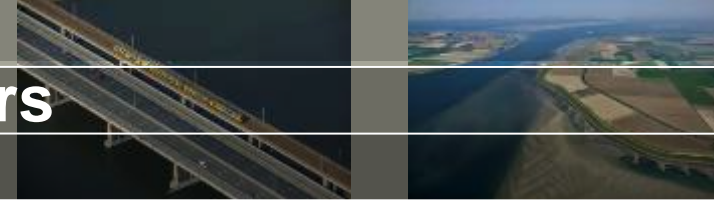


Rondout Creek - Rosendale (ROSN6HUD) Flow

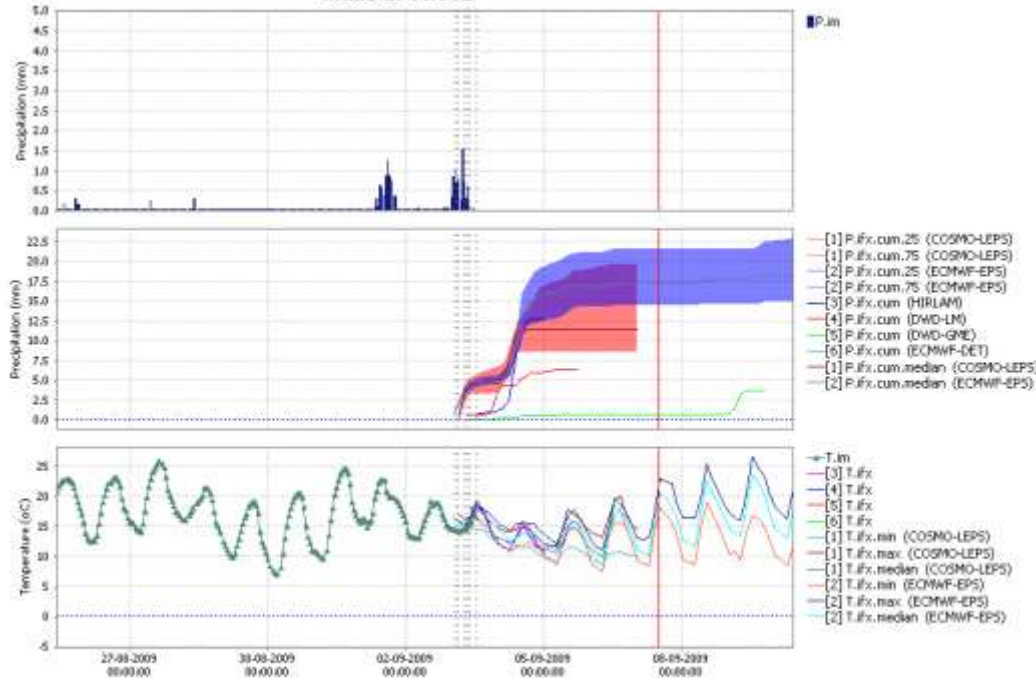


[1] 09-01-2011 12:00:00 Current FFG_FFH [2] 09-01-2011 18:00:00 Current MTRN6HUD_Forecast

Uncertainty: Performance Indicators

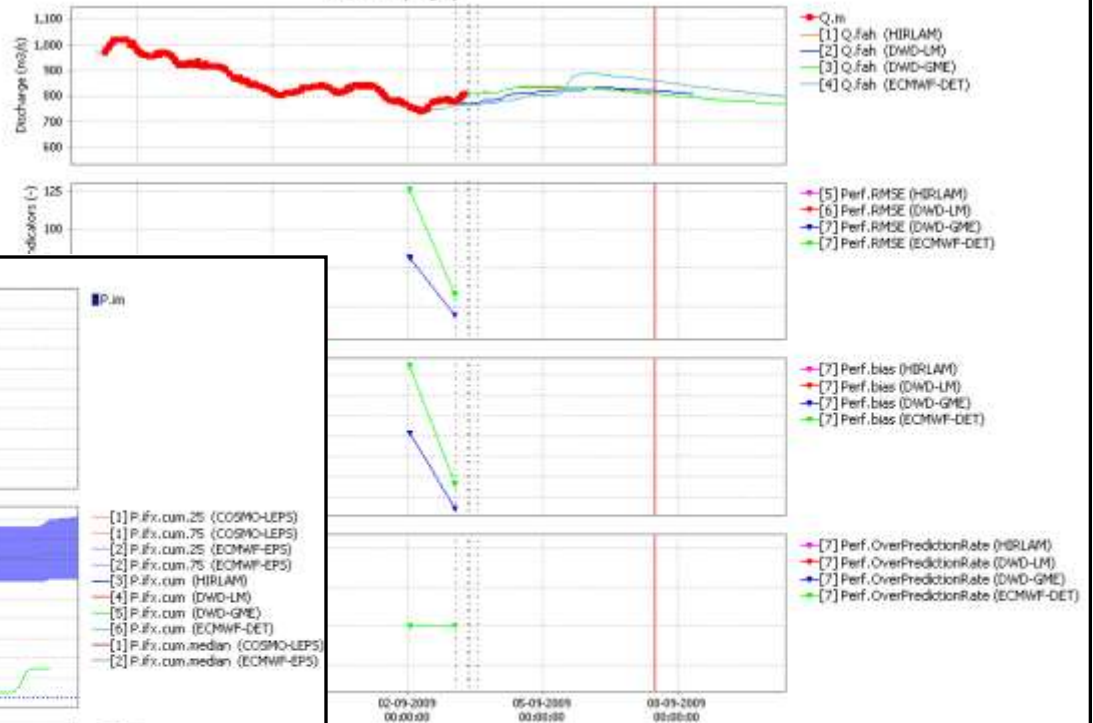


Maas at Chooz



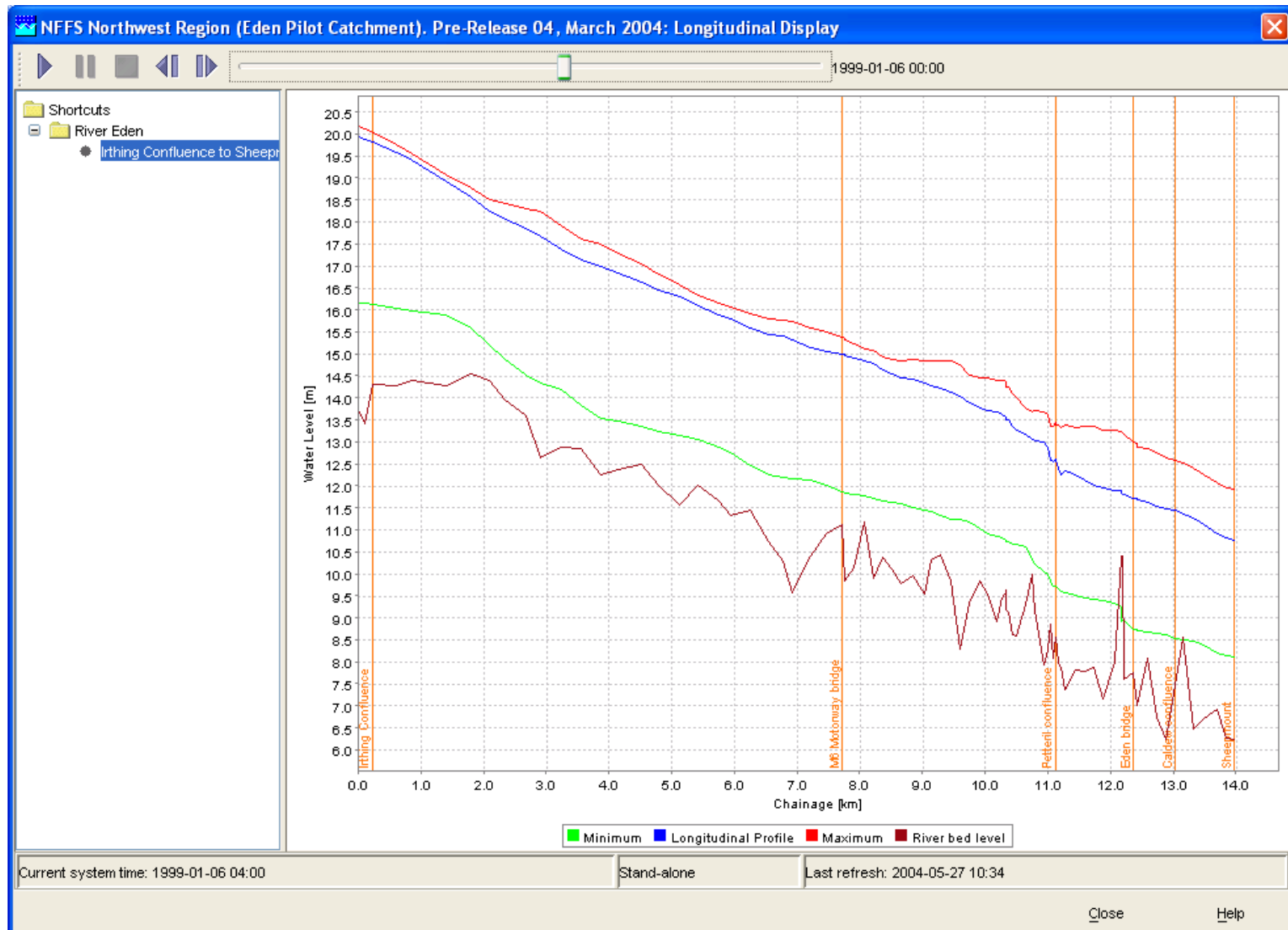
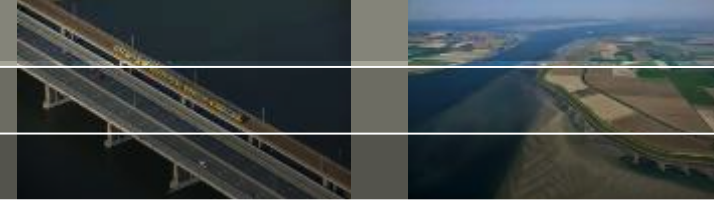
[1] 03-09-2009 06:30:00 Current Maas_Forecast_COSMO-LEPS [2] 03-09-2009 03:00:00 Current Maas_Forecast_ECMWF-EPS [3] 03-09-2009 13:00:00 Current Maas_Forecast_HIRLAM [4] 03-09-2009 08:00:00 Current Maas_Forecast_DWD-LM [5] 03-09-2009 09:00:00 Current Maas_Forecast_DWD-GME [6] 03-09-2009 02:00:00 Current Maas_Forecast_ECMWF-DET

Maxau (Rijn)

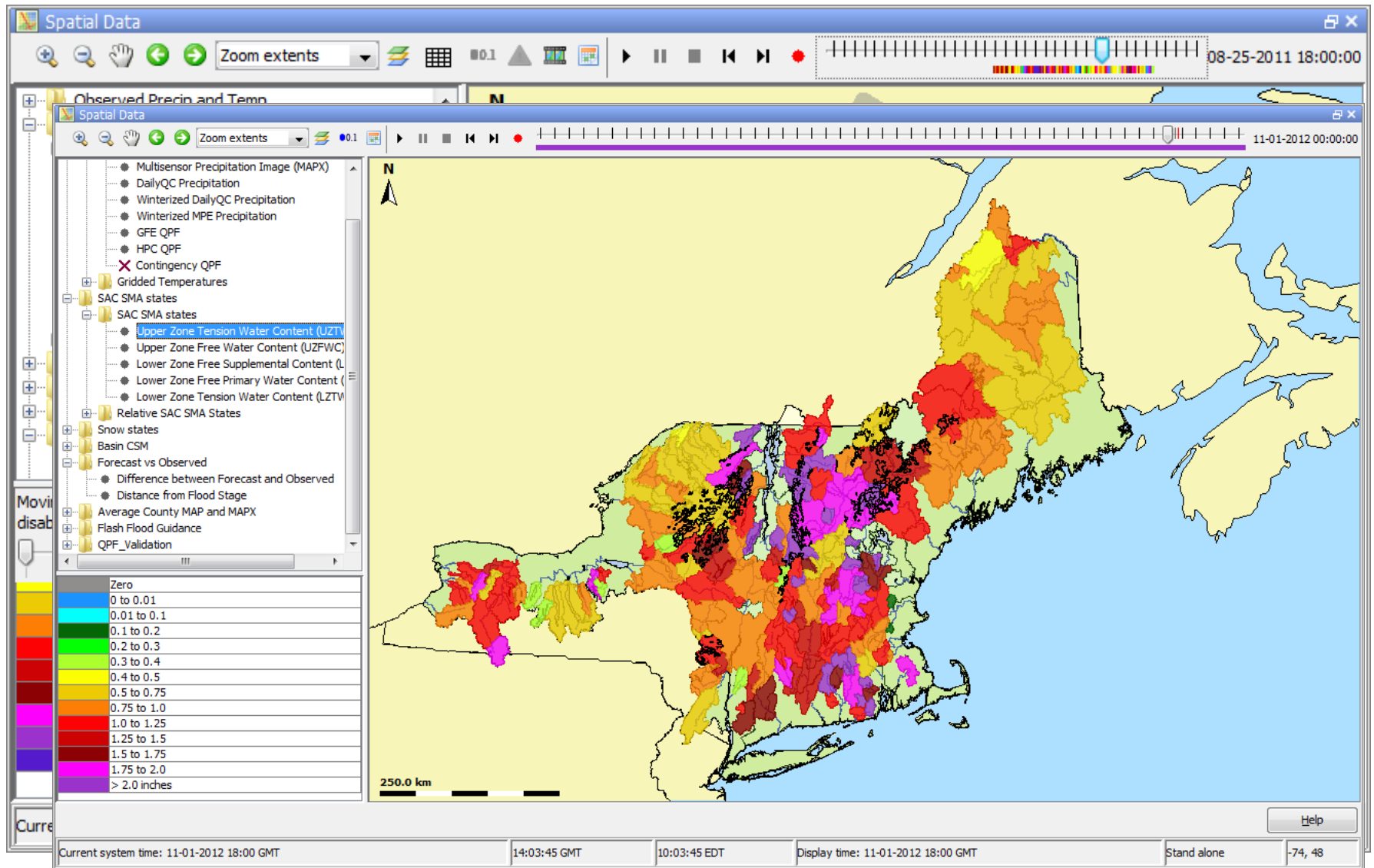


HIRLAM [2] 03-09-2009 08:00:00 Current Rijn_Forecast_DWD-LM
DWD-GME [4] 03-09-2009 02:00:00 Current Rijn_Forecast_ECMWF-DET
01:00:00 External [7] 01-09-2009 01:00:00 External

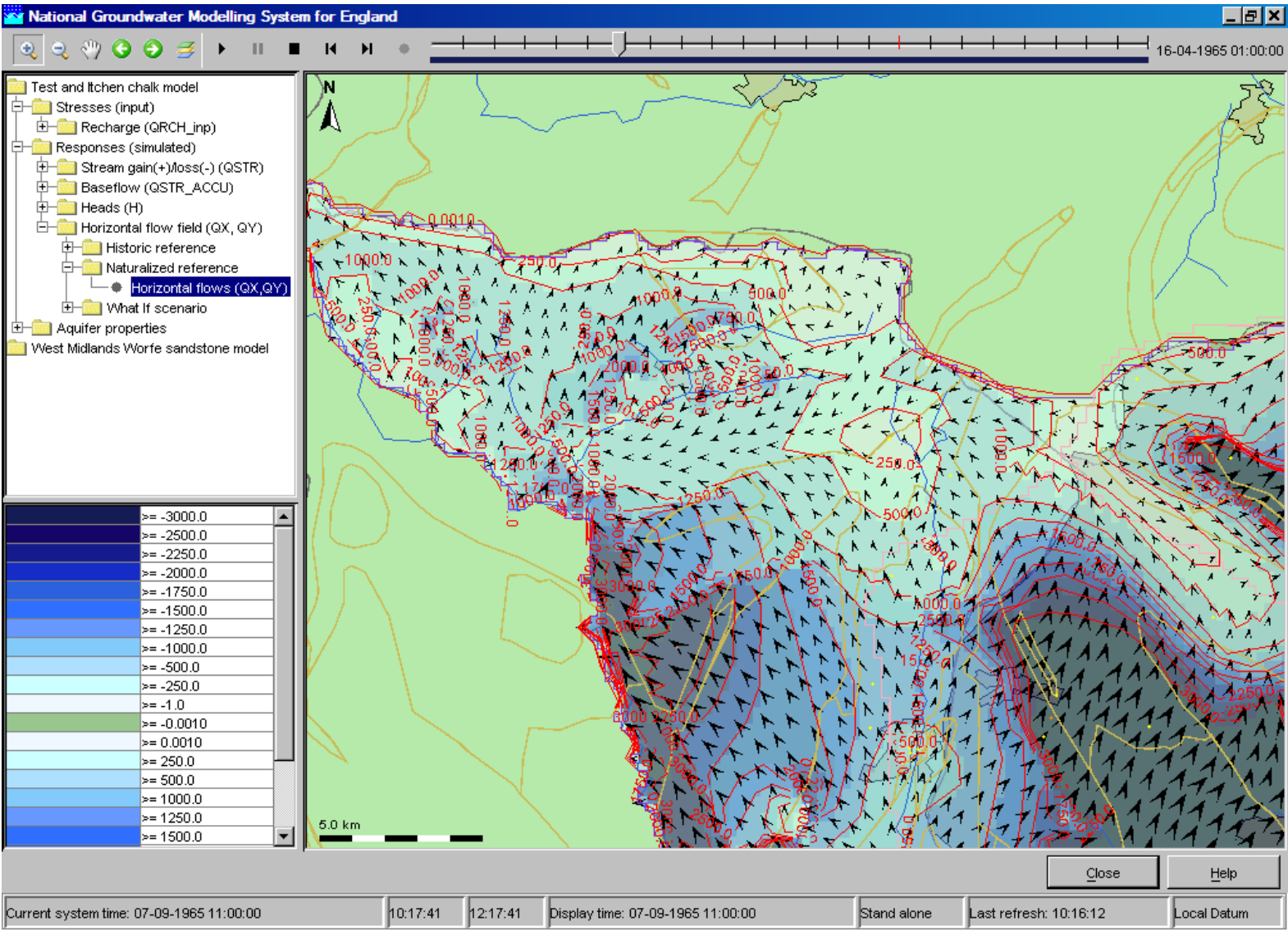
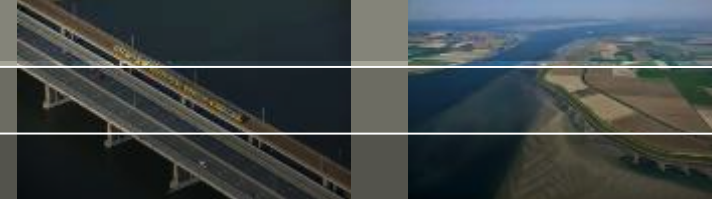
FEWS: Longitudinal Display



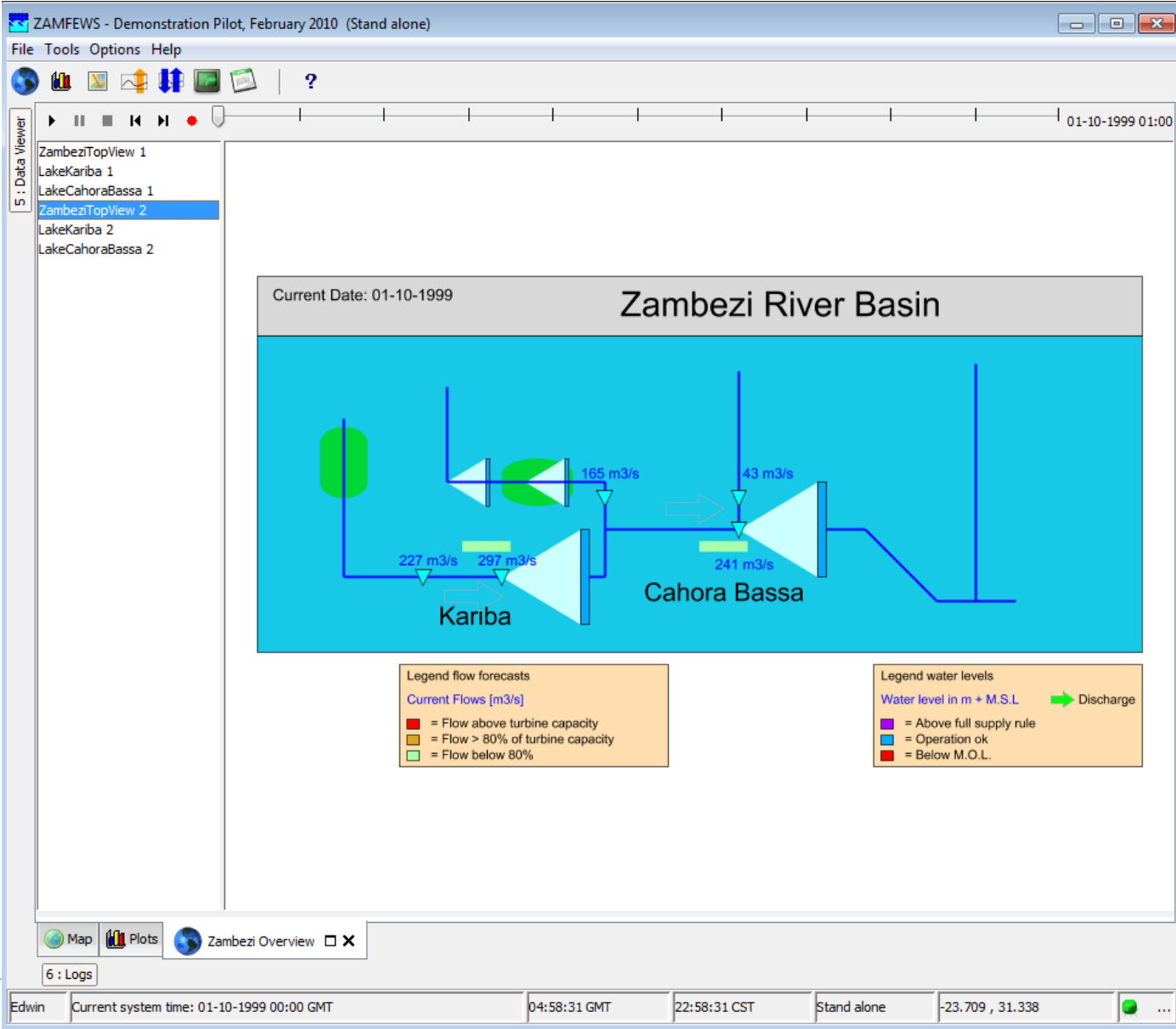
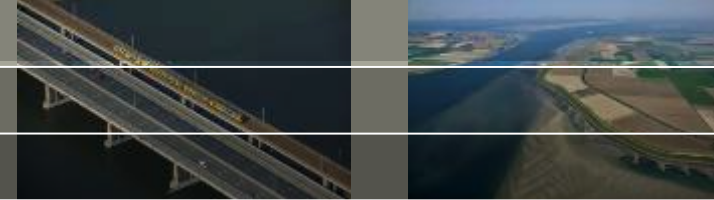
Spatial data



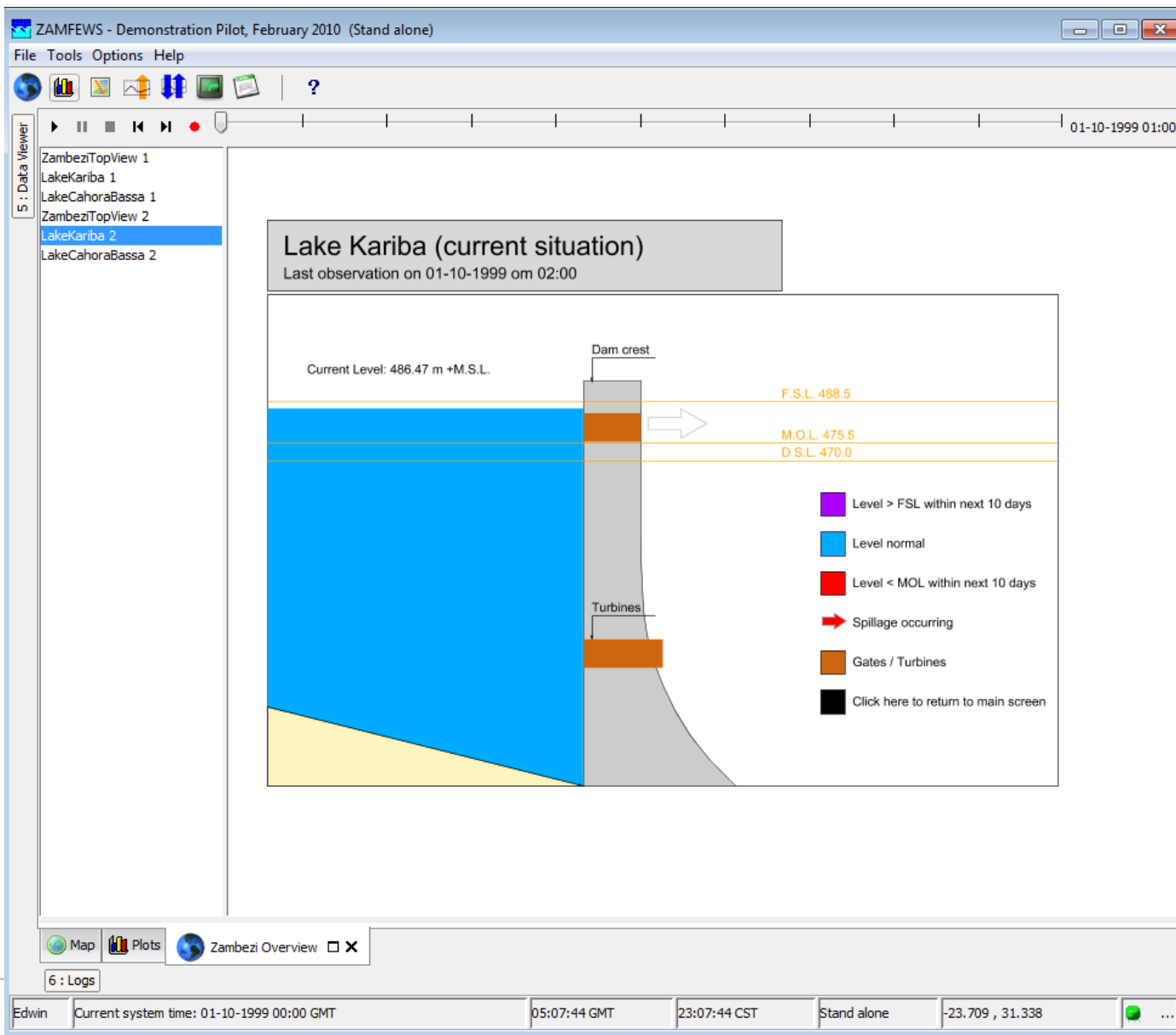
Animation of flow fields



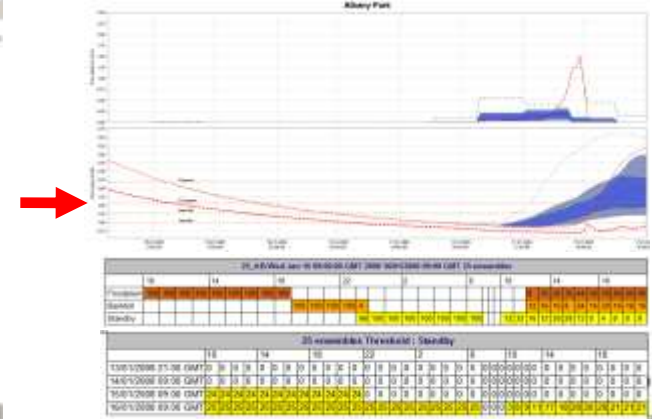
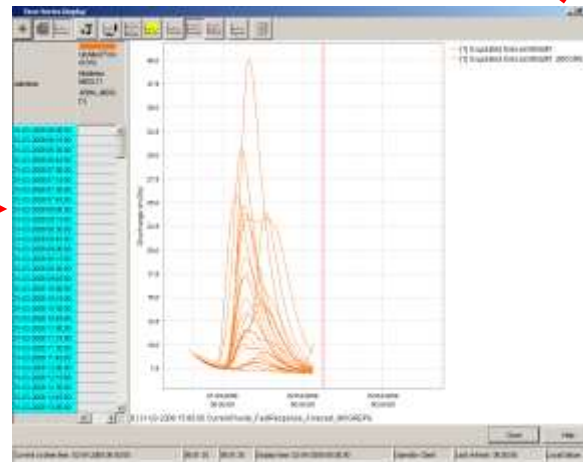
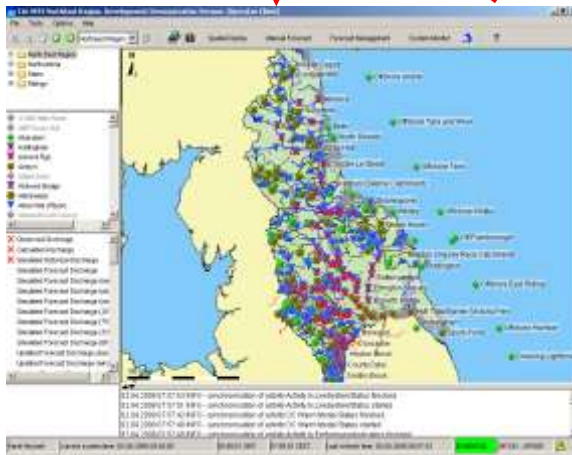
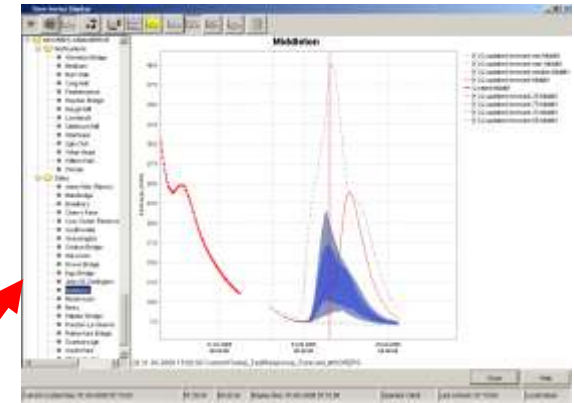
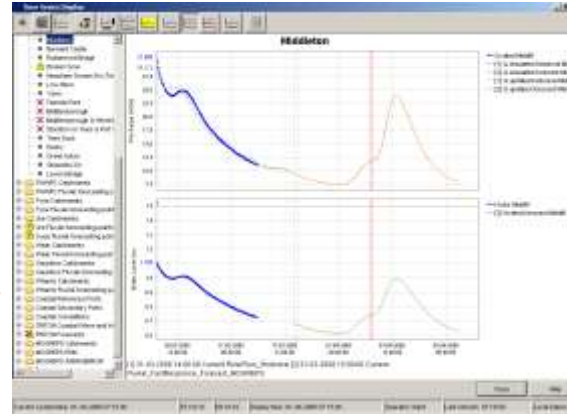
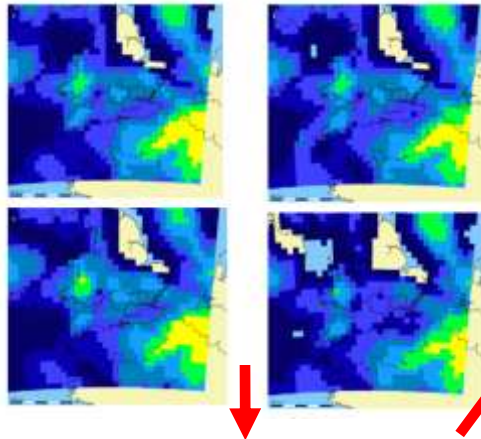
FEWS: System Display (1)



FEWS: System Display (2)



Ensemble forecasting in England & Wales



Exporting products



```

File Edit Options Encoding Help
: DeIft-FEWS - exported SHEF file
: Date/time forecast: 20110829

.ER BTUN6GRL 20110829 Z DH00/DC201206061
.E1      0.0/

.ER RAPN6GRL 20110829 Z DH00/DC201206061
.E1      0.0/

.ER WILN6GRL 20110829 Z DH00/DC201206061
.E1      0.0/
    
```



Department of
Environment

New Brunswick
Brunswick
CANADA

Ministère
de l'Environnement

UPPER SAINT JOHN RIVER 3-DAY
FORECAST

WATER LEVEL (W.L.) IN METERS AND ABOVE SEASIDE SEA LEVEL

13/01/2012

The actual water levels are obtained from stations operated by Environment Canada, NB Power and US Geological Survey

** Water level based on computer model. Its value can cause actual water levels to vary significantly from forecast levels

Weather report are provided by Environment Canada, US National Weather Service, Quebec Environment

Location	2008 W.L.	Forecast	Location	10-Jan 07:00	13-Jan 07:00	16-Jan 07:00	19-Jan 07:00
Cornwall	W.L.	164.70	170.70	0.00	166.68	166.06	166.77
Saint-François	W.L.	160.70	160.20	0.00	161.67	162.41	161.63
Saint-Fort	W.L.	156.16	156.20	0.00	148.62	152.33	155.96
Bellevue	W.L.	151.40	150.80	0.00	143.72	145.06	143.73
Saint-Hilaire	W.L.	148.50	142.50	0.00	138.51	139.66	138.12
Edmundston	W.L.	143.50	140.50	0.00	137.87	132.17	132.22
Thompson	W.L.	142.90	140.90	0.00	137.87	130.73	130.80
St. Basile	W.L.	141.30	142.30	0.00	138.96	129.84	129.51
Saint-Amand	W.L.	138.30	136.30	0.00	136.12	131.61	128.90
St. Leonard	W.L.	137.30	136.30	0.00	136.12	129.79	129.45

Weather (Model output)	Forecast	10-Jan 07:00	13-Jan 07:00	16-Jan 07:00	19-Jan 07:00
Forecast	0.03	0.6	0.0	0.0	0.0
Temp (C)	-27.4	-6.16	-6.17	-6.21	-6.21

HISTORIC WATER LEVELS (m)		
YEAR	CLIM	EDMONTON
2008	108.18	143.18
2006	108.27	148.18
2001	-	143.18
1978	107.31	141.41
1973	106.94	-

Note: This forecast is dependent on the development of forecast weather conditions



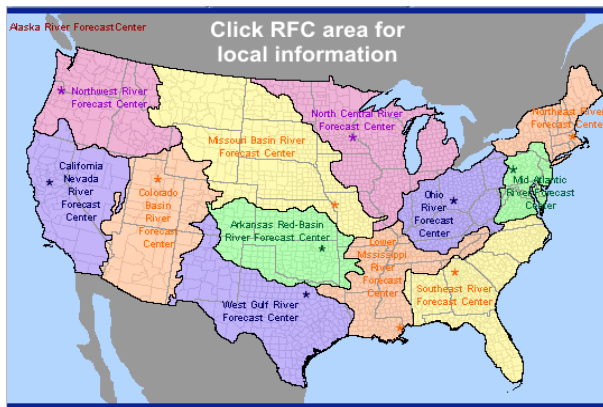
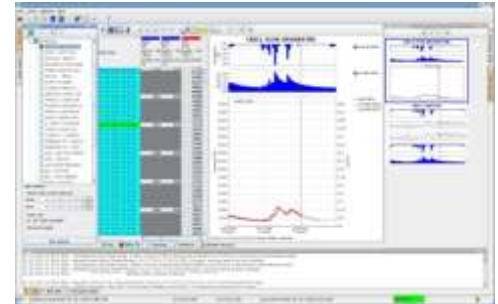
An aerial photograph of a coastal area. A large body of water, likely a river or estuary, flows from the top left towards the bottom. A prominent green dike or levee runs along the right side of the water, separating it from a patchwork of agricultural fields. The fields are in various stages of cultivation, showing shades of green, brown, and tan. In the distance, a small town or village is visible on the left side of the water. The sky is clear and blue.

FEWS: Model integrator

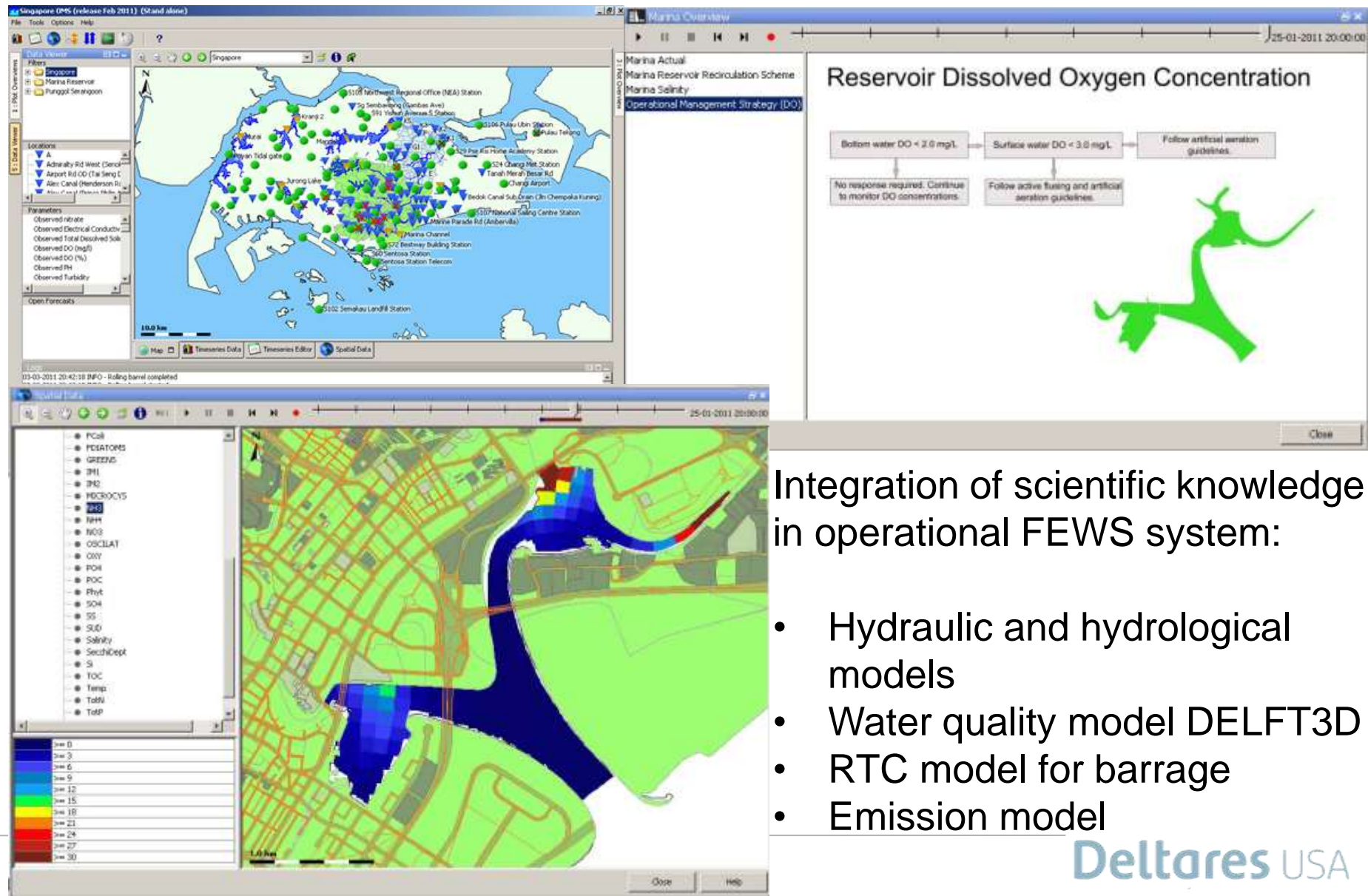
Community Hydrologic Prediction System (CHPS)

National River Forecasting System for National Weather Service (NWS / OHD), USA

- 13 River Forecast Centers (RFC)
- > 1000 models per RFC (snow, rainfall-runoff, routing, hydrodynamic)
- Interactive forecasting



Real time water quality management and forecasting for Marina Bay, Singapore



Integration of scientific knowledge in operational FEWS system:

- Hydraulic and hydrological models
- Water quality model DELFT3D
- RTC model for barrage
- Emission model

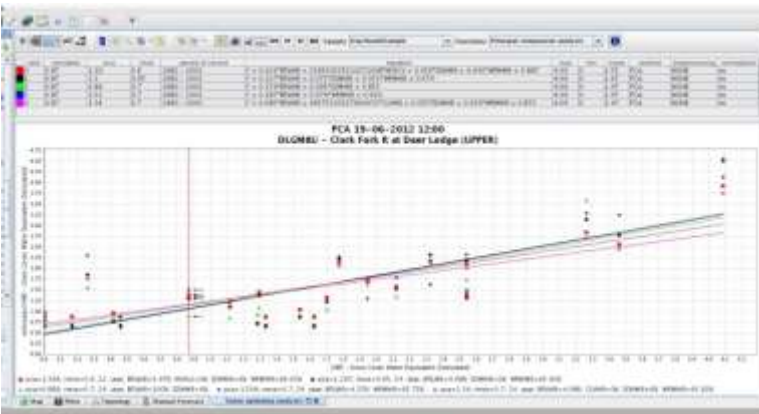
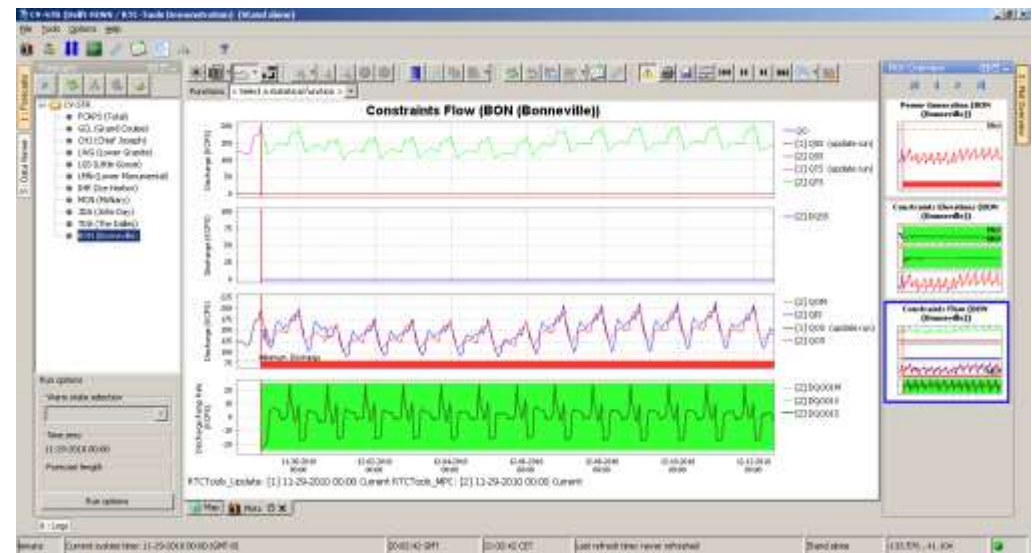
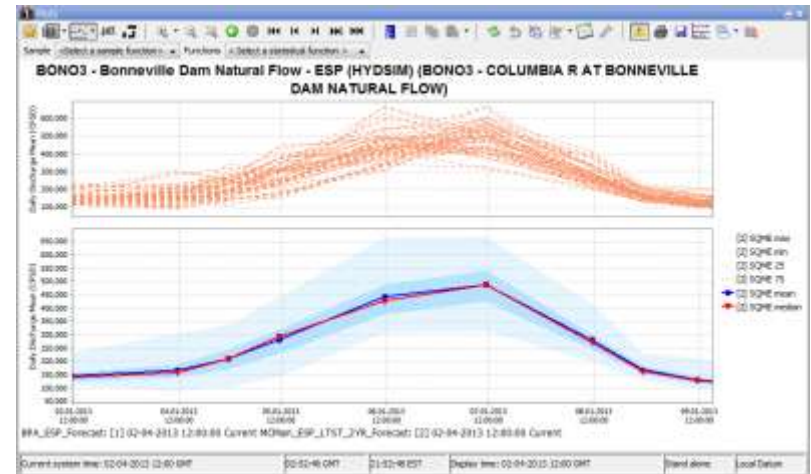
Reservoir operations: BPA

Streamflow (Ensemble) forecasting

- Data Quality Control
- Snow Updating
- Hydrology and reservoir modeling
- Ensemble pre- and postprocessing

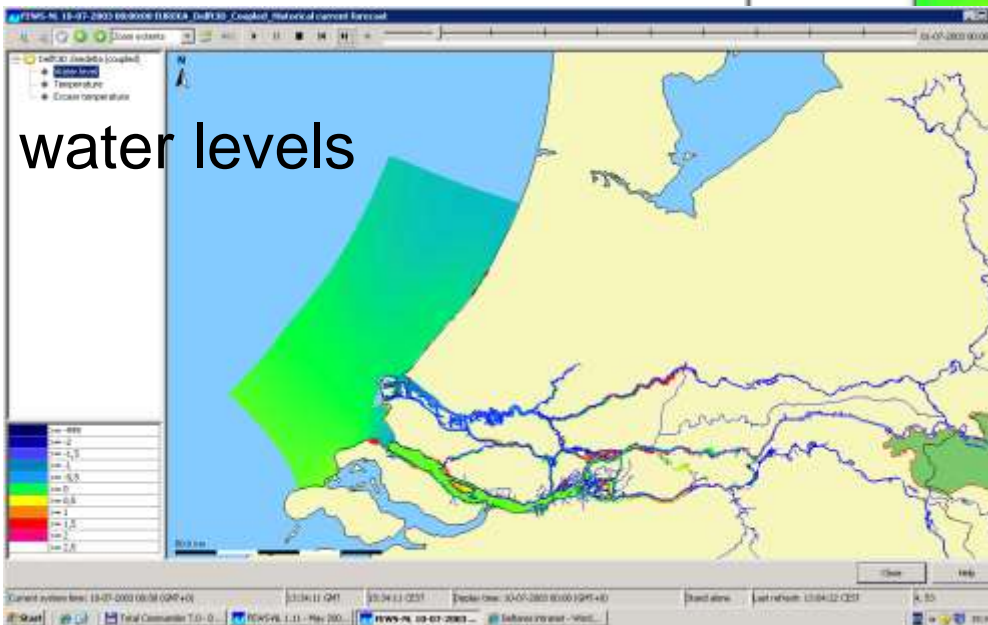
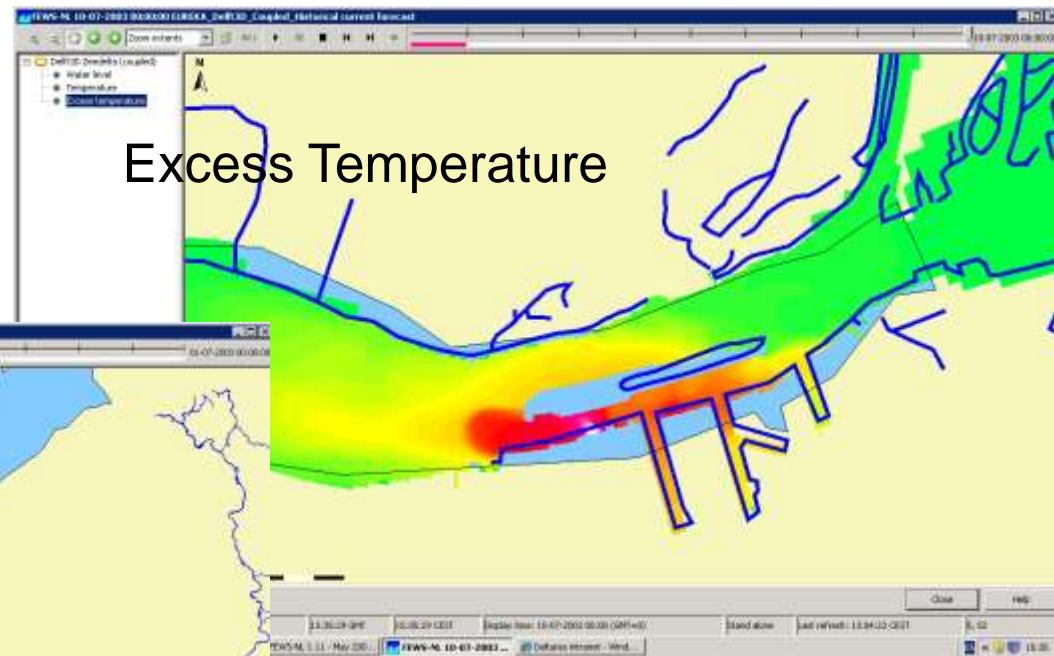
Reservoir system optimization

- RTC-Tools

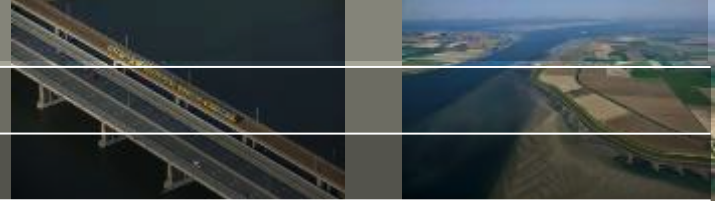


Prototype forecast system for cooling water

- From North Sea to Basel
- 3D in part of Hollandsch Diep estuary
- 2D till Hagestein and Dreumel
- 1D-2D-3D coupling under FEWS!



Can also model
salinity with this setup



DELFT-FEWS:

- Is a world wide flexible forecasting tool
- Open to external data and models
- Creates collaboration
 - between forecasters and research groups
 - between forecast organizations
- Allows organizations to expand services and improve forecasts

An aerial photograph of a coastal region. A large body of water, likely a river or estuary, flows from the top left towards the bottom. A prominent dike or levee runs along the right side of the water, separating it from a vast area of agricultural land. The land is divided into numerous rectangular plots of varying colors, including green, brown, and tan, indicating different crops or land uses. In the distance, a small town or village is visible on the left side of the water. The sky is clear and blue.

Thank You

Deltares