Flood forecasting in an alpine region from perspective of a hydropower trader

Some short insights

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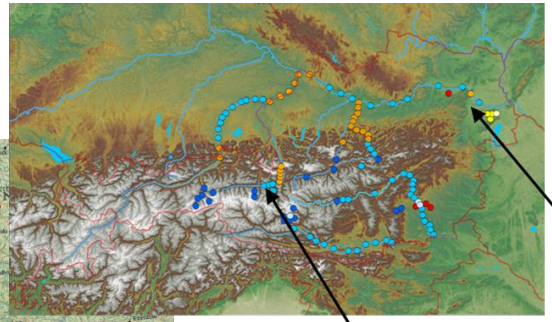
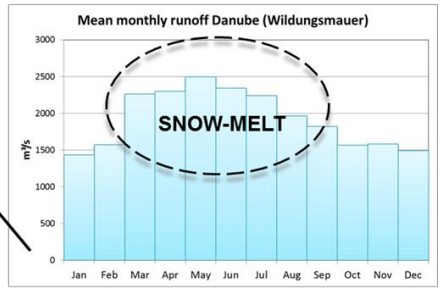
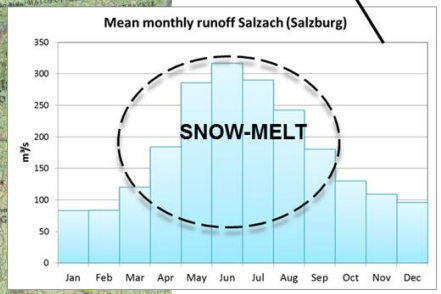
Verbund hydropower - alpine catchments

- Installed hydropower capacity: 8,215 MW
- Typical alpine regime at all plants





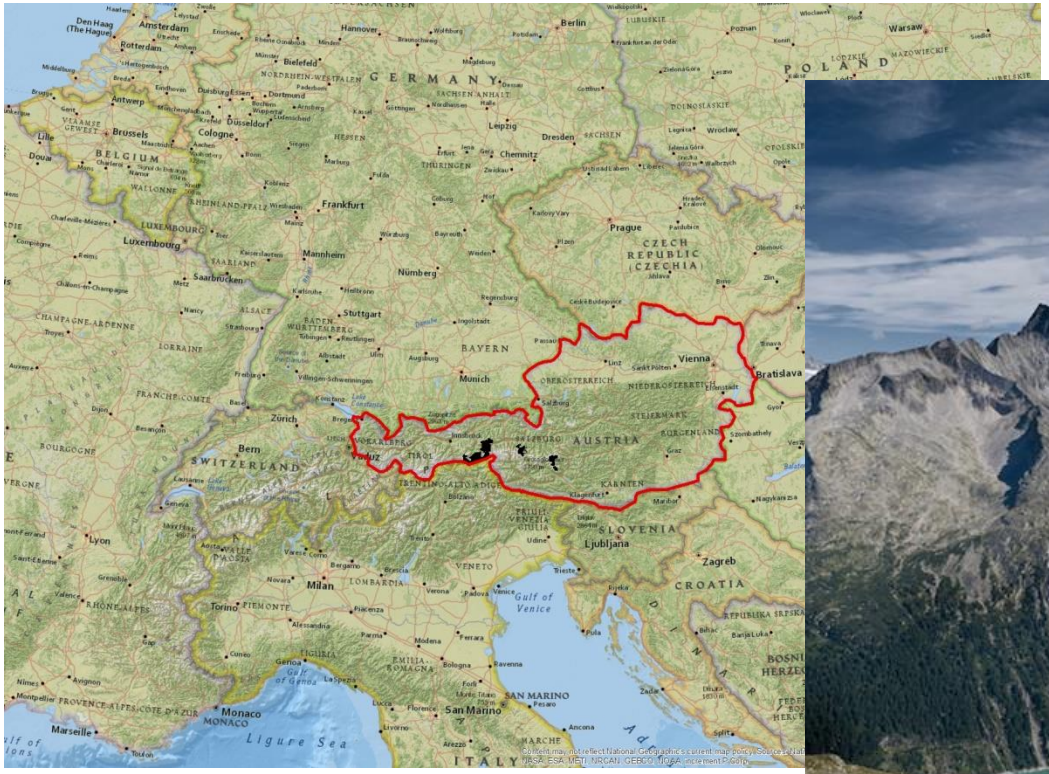


River plants

Pumpstorage plants

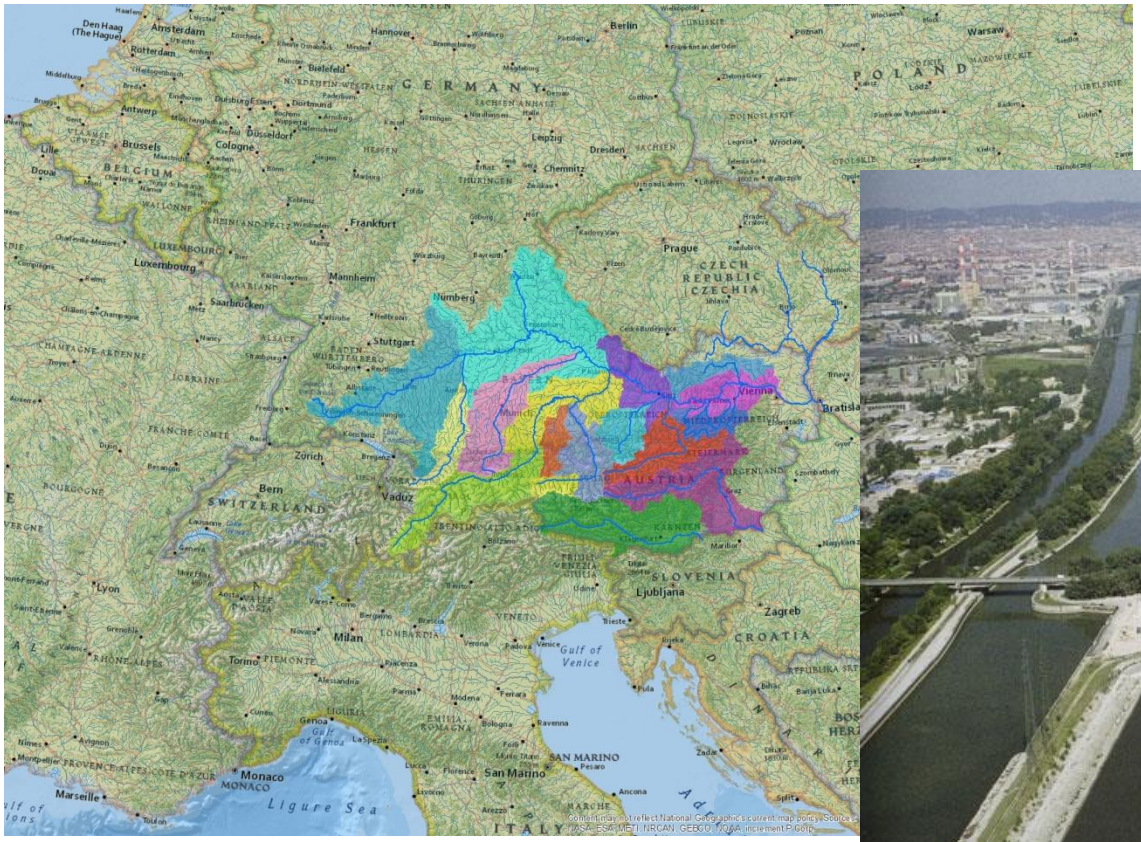
Alpine Storages

- Small catchments (~50 km²) rises up to 3800 m



Danube, Drau & Mur catchment

- Catchment area ~120.000 km²



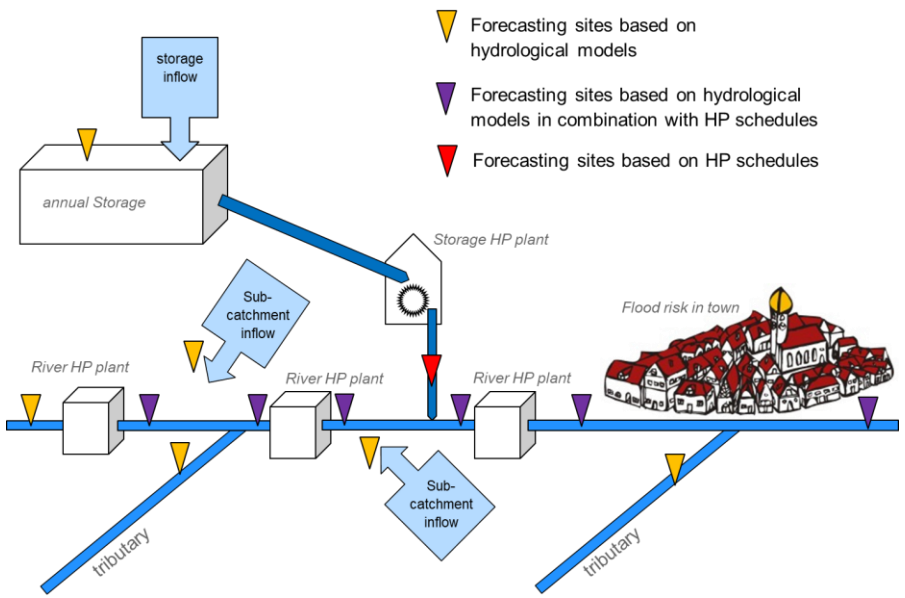
Characteristics of alpine catchments

- Snowhydrology plays an important role
- Very fast and local runoff-generation effects
- Good hydrological information is often rare
  - mountains are shading the radar,
  - measuring point density in high regions is very low because of difficult terrain
- A lot of micrometeorological effects
- Hydrological effects on different scales

All these points together make the hydrological forecasting challenging!

Trading:
daily business & the role of hydrological forecasts

- Databasis for optimization overall production
- Databasis for day-ahead marketing of river powerplant production
- Databasis for managing the storages in extreme situations
- **Flood management (24/7):**
  - Lowering headwater at Drau river based on forecasts
  - Activate standby-staff in flood situations
  - Support crises committee
- Basis for reservoir purching
- Basis for construction- and service-works



Operational challenges

- Jumping forecasts versus hard limits
  - Forecast-failures helps very efficient, that people do not trust in the forecasts…
- Lowering headwater at Drau river based on forecasts > aquatic habitat versus flood protection
  - That is a problem when a forecasted flood does not occur
  - RTC-Tool to determine the latest time to start lowering with turbines again jumping forecast and hard limits are troublemaker…
- Uncertainty of precipitation analysis result in bad hydrological states and further in wrong forecasts
  - Input-correction via What-If Scenarios is necessary: Number of models versus local uncertainties
- Before the Flood versus after the Flood
  - When the flood is gone, everybody would have done the perfect forecast…
  - A good archive of the forecasts is important to find the perfect forecast or helps to make forecasts better
- And what about Climate Change?

Climate Change effecting the forecasting system?

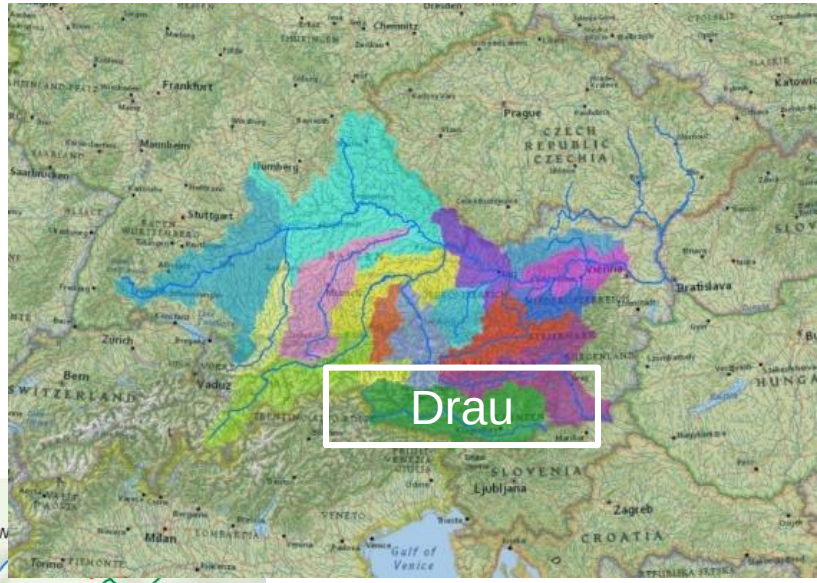
- Parameters for hydrological Model Cosero can change….
- More local weather effects
- Extreme events are quiet hard to hit
- More „false warnings“ – people do not trust the models any more.
- Uncertainty in forecast rise > uncertainty of optimization results (HP schedules) rises.

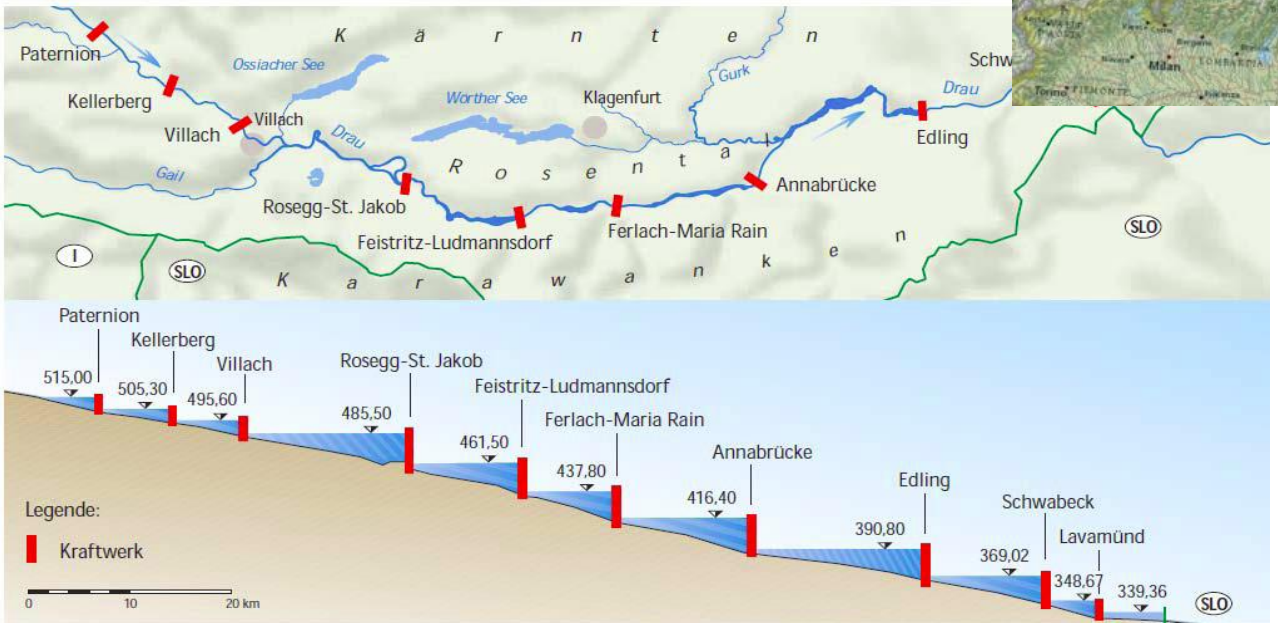
FEWS @ Verbund = PROVIS

- For all these challenges we use Delft-FEWS (PROVIS)
  - Client Server Systems (Test and Production)
  - Around 30 users all over Austria
- Hydrotec
  - FEWS-Configuration
  - Support and Maintenance
- Recent Developments in PROVIS
  - Drawdown-Tool Drau
  - Open Archive

Hydropower plants along the river Drau

- Verbund Hydro Power GmbH:
  - 10 hydropower plants along the Drau
  - hydropeaking operation
- Verbund Trading GmbH:
  - operational forecasting
  - responsible for informing operator about required drawdown in case of an expected flood event





Drawdown at the right time

- As late and smooth as possible to not disturb the aquatic habitat
- Early enough to ensure protection of houses and infrastructure
- Not to increase the predicted flood wave

Decision-making

- Operational Forecasts in PROVIS
- Expert Knowledge

Challenges

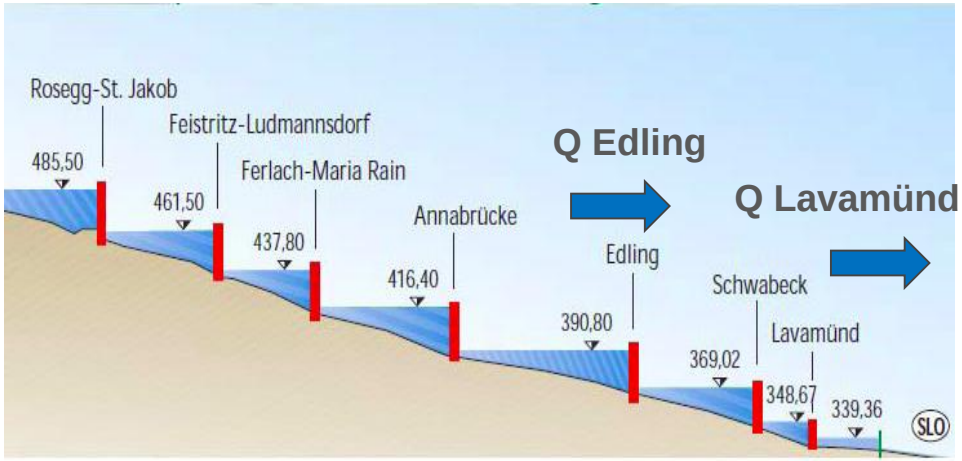
- Very fast and local runoff-generation effects
- Dynamic Predictions
- Hydropeaking Operation

Regulation Rules

- Define trigger of drawdown: threshold Q forecast
- Define drawdown storage level for each reservoir
- Constraint: maximum drawdown rate
- Constraint: maximum discharge at outlet

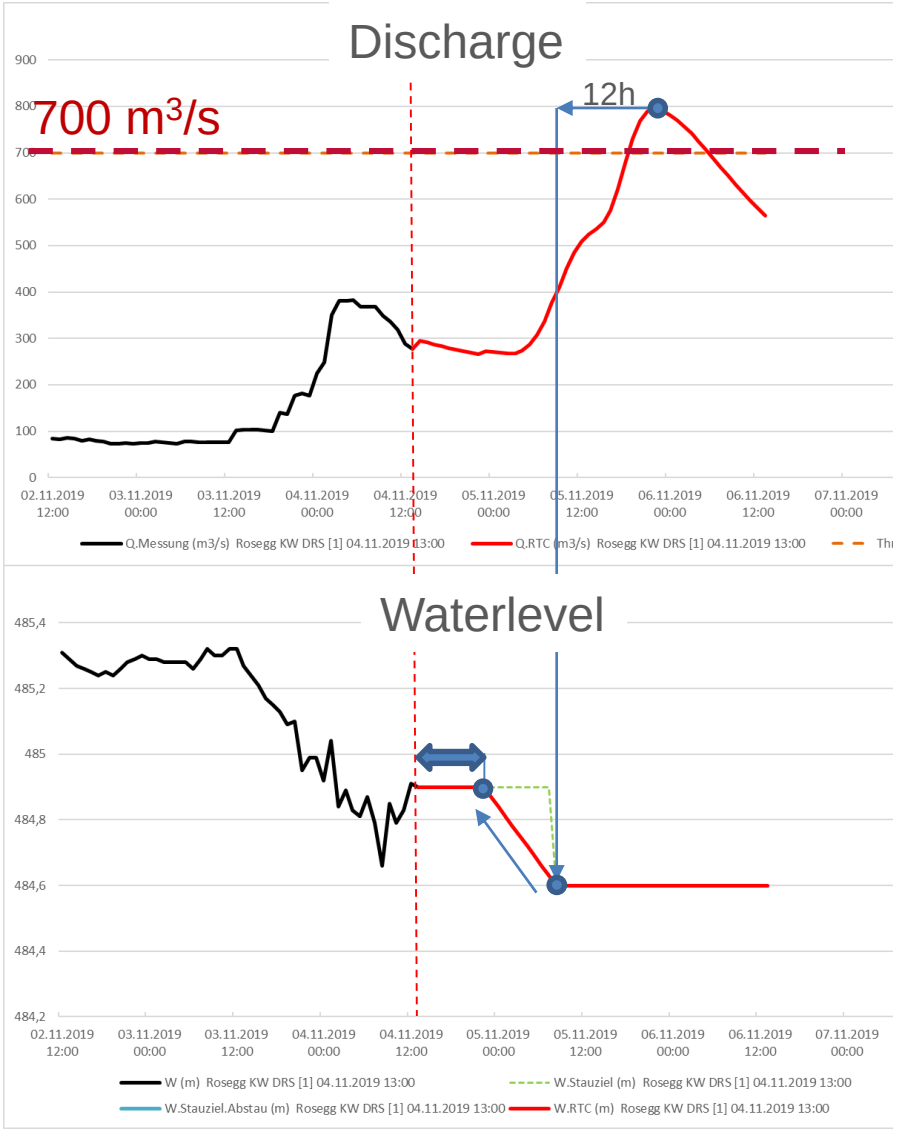
Drawdown-Tool

- Drawdown-Tool
  - support decision-makers,
  - help to understand process of drawdown,
  - based on RTC-Tools,
  - linked to Delft-FEWS



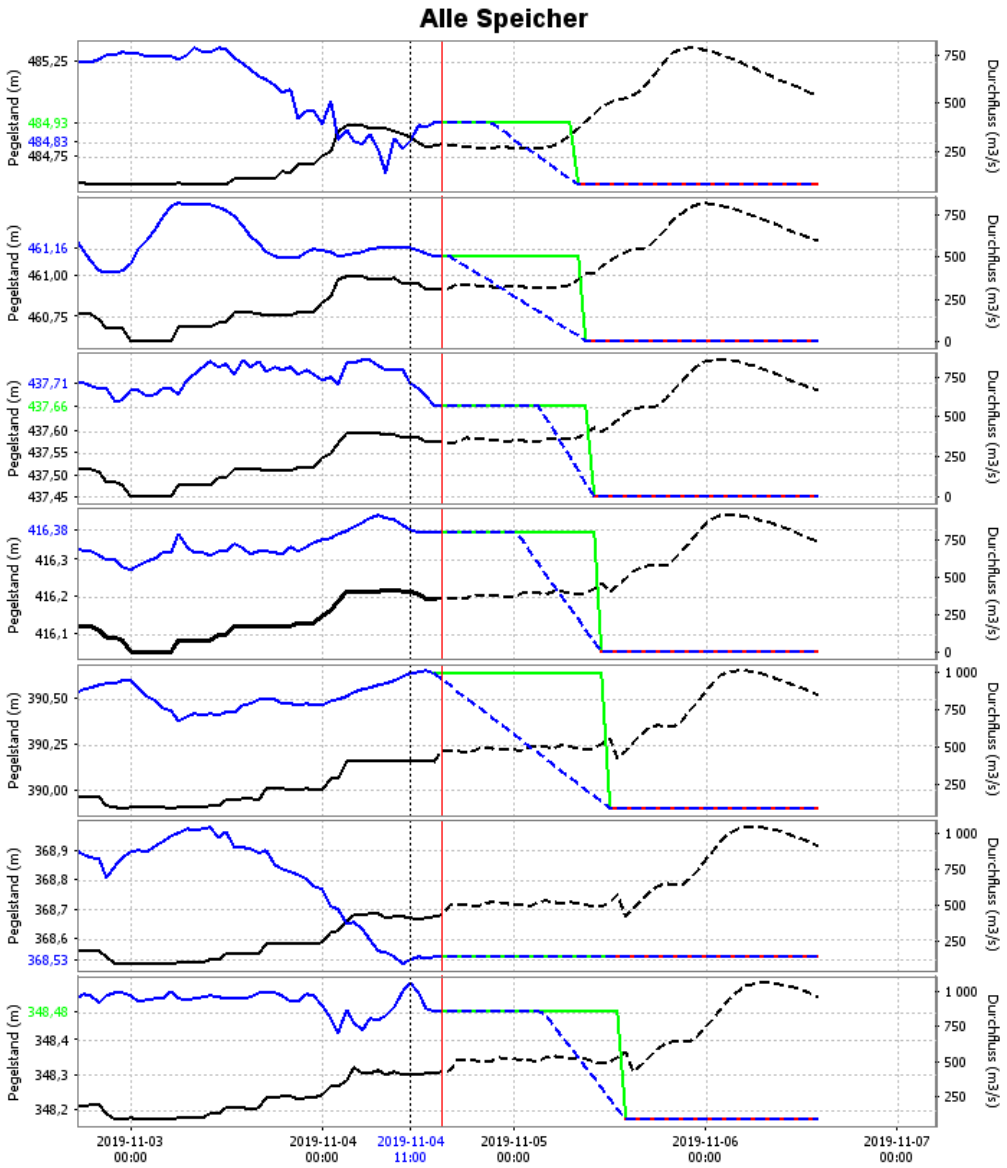
- Requirements, the model must meet:
  - define timing and duration of drawdown within limits of regulation rules
  - main criterion:
    $\text{Peak}(Q_{\text{Lavamünd}} + Q_{\text{Drawdown}}) \leq \text{Peak } Q_{\text{Edling}}$
  - Start as late as possible, but early enough
    - smooth process
    - end 12 h before $Q_{\text{Peak,Edling}}$

Optimisation problem



- Threshold crossing Q forecast
- Define peak Q forecast
- Set end of drawdown 12 h before peak
- Drawdown as late & smooth as possible
- Main output for decision-maker: time left until start of drawdown

Simulation November 2019



Rosegg

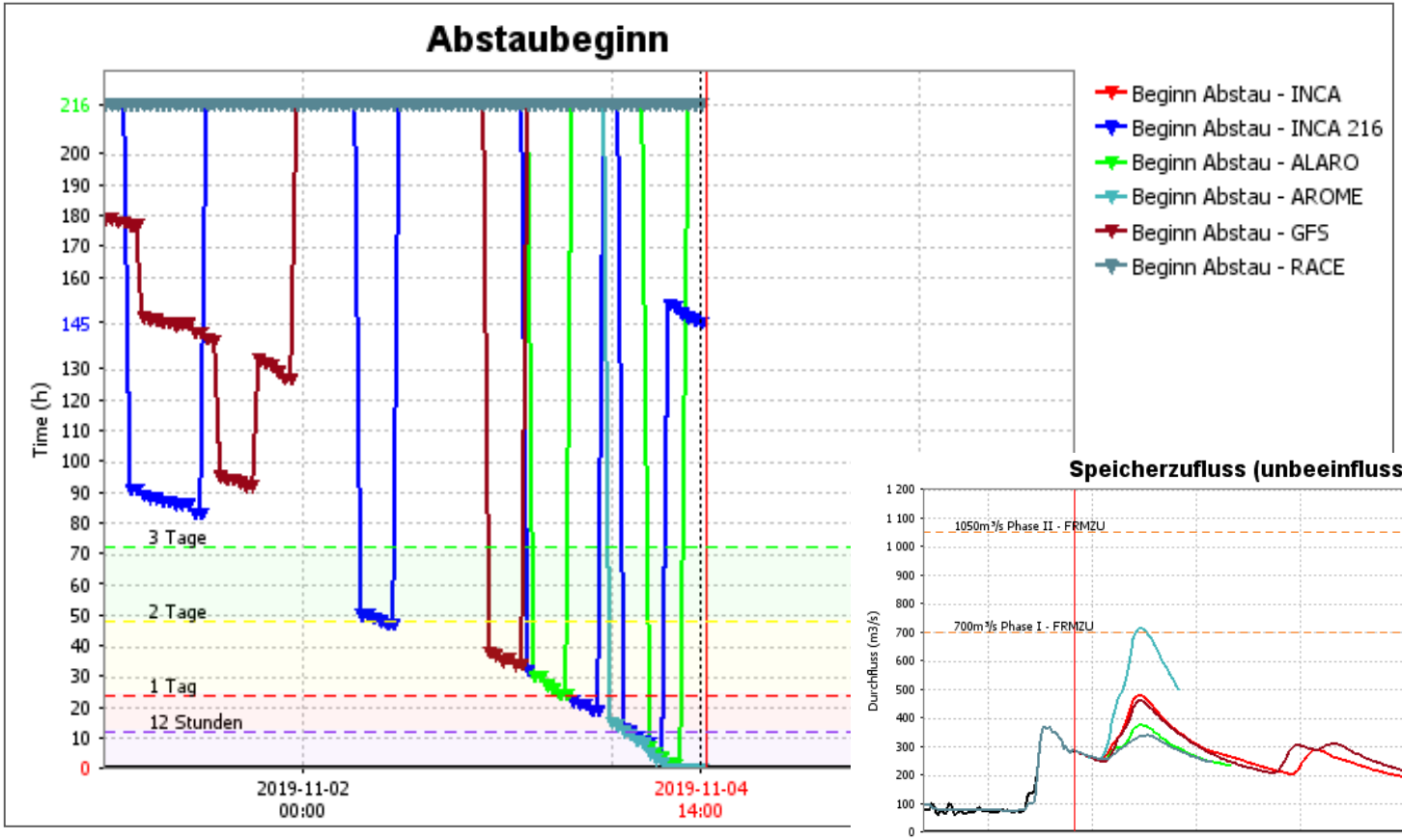
Edling

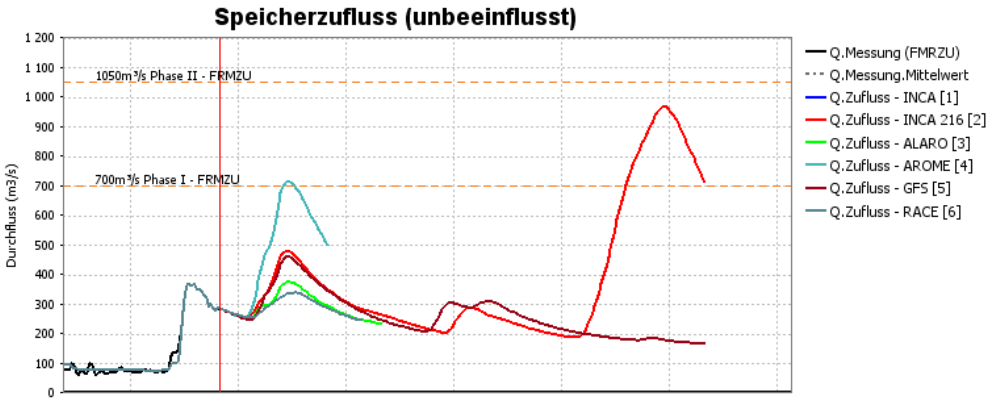
Lavamünd

- W.obs
- W.RTC
- Q.obs
- Q.RTC
- TargetLevel.RTC

Visualisation in PROVIS

- Time until start of computed drawdown
- Minimum of all values for all reservoirs
- Timeseries for each forecast (INCA, ALARO, etc…)



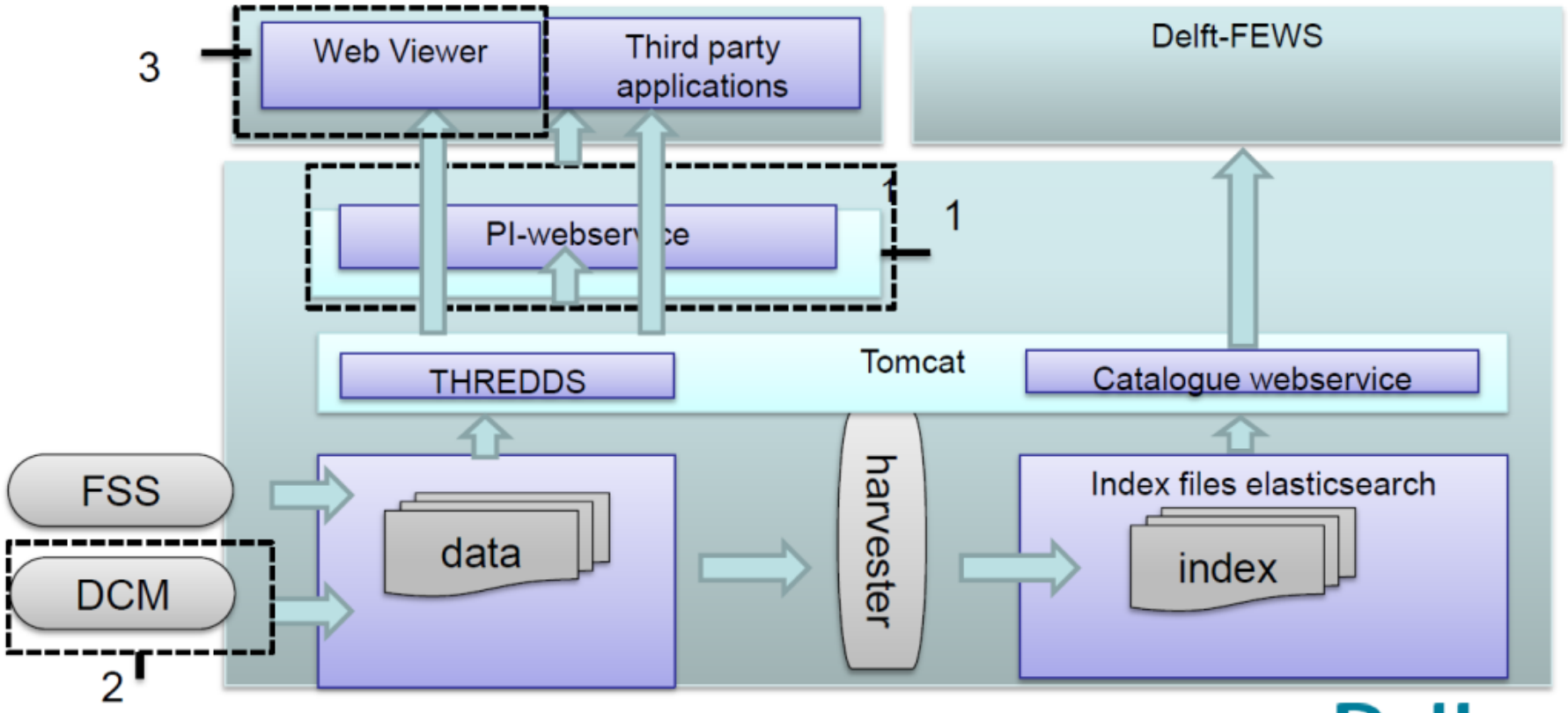


Resume and Outlook

- Drawdown-Tool supports monitoring dynamical development of forecasts in an operational system
- Trends get more visible, which will reassure the decision-maker
- Current version of Drawdown-Tool runs successfully on operational Client Server System
- Next step: Extend tool to also take into account the process of refilling the reservoirs using the flood wave generated by the drawdown-process

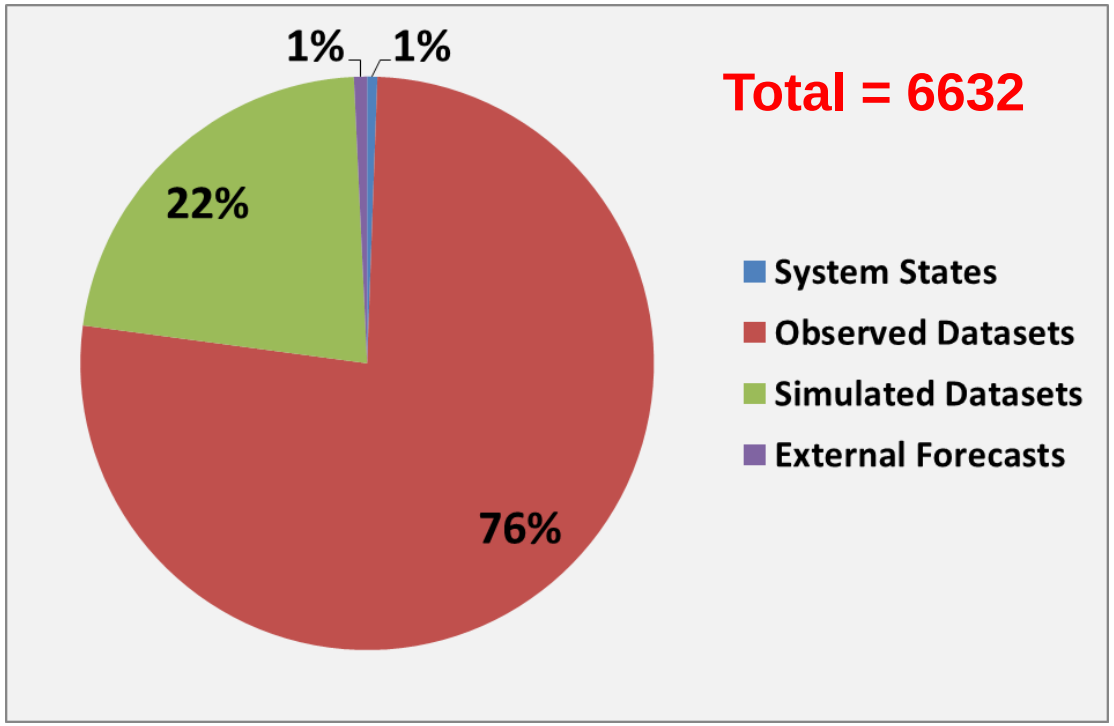
Integration of the Open Archive into PROVIS

- Implementation of the Roadmaps 2020
- Components of the Open Archive



Elaboration of an Archive Plan

- Objective of the Open Archive
- Type of data to be archived
- Frequency
  - Daily
- Storage period
  - Long-term storage (20 years)
  - Short-term storage (2 months)
- Clean-up strategy
  - Lifetimes (DataManagementTool)
- Definition of events
  - Historical events



Distribution of datasets to be archived per type

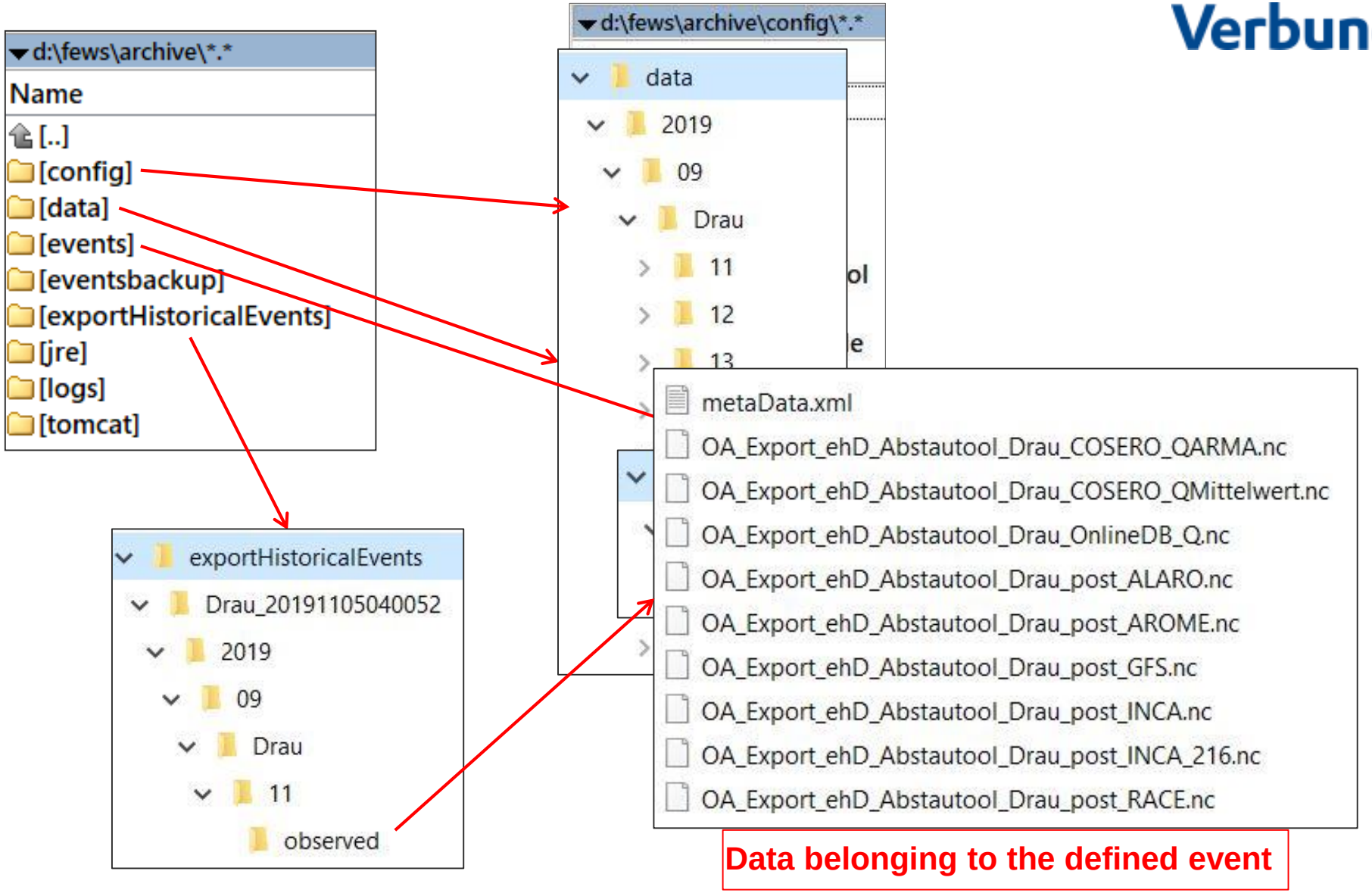
Archiving and importing data (Drawdown tool)

Workflows to archive data and to import archived data into Delft-FEWS

- External historical datasets
  - Time until drawdown of all forecasts (INCA, INCA 216, ALARO, AROME,GFS, RACE)
  - Water discharge (instantaneous, mean and ARMA corrected)

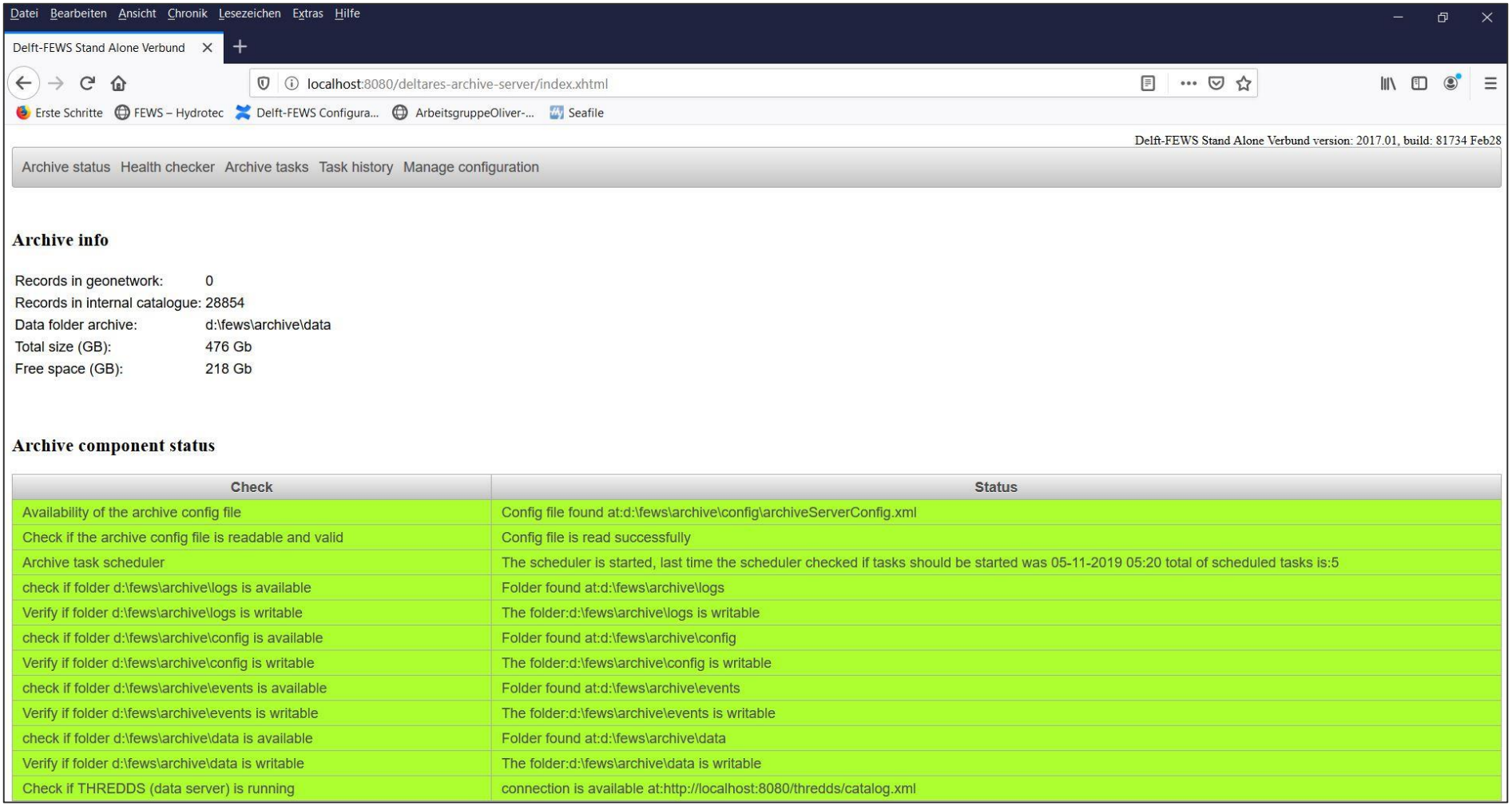
- Simulated datasets
  - *Historical*
    - Simulated water discharge (COSERO)
  - *Forecasting*
    - ARMA corrected straightened discharges
    - Reservoir level (actual, target level and target pre-release level)
    - Drawdown, Time to drawdown and time to drawdown (sum)
  - Advised discharge, advised water level

Open Archive folder structure



Data belonging to the defined event

Open Archive Server



Check	Status
Availability of the archive config file	Config file found at:d:\fews\archive\config\archiveServerConfig.xml
Check if the archive config file is readable and valid	Config file is read successfully
Archive task scheduler	The scheduler is started, last time the scheduler checked if tasks should be started was 05-11-2019 05:20 total of scheduled tasks is:5
check if folder d:\fews\archive\logs is available	Folder found at:d:\fews\archive\logs
Verify if folder d:\fews\archive\logs is writable	The folder:d:\fews\archive\logs is writable
check if folder d:\fews\archive\config is available	Folder found at:d:\fews\archive\config
Verify if folder d:\fews\archive\config is writable	The folder:d:\fews\archive\config is writable
check if folder d:\fews\archive\events is available	Folder found at:d:\fews\archive\events
Verify if folder d:\fews\archive\events is writable	The folder:d:\fews\archive\events is writable
check if folder d:\fews\archive\data is available	Folder found at:d:\fews\archive\data
Verify if folder d:\fews\archive\data is writable	The folder:d:\fews\archive\data is writable
Check if THREDDS (data server) is running	connection is available at:http://localhost:8080/thredds/catalog.xml

- The Open Archive Server is used to transfer the file system into a catalog which can be used in FEWS to display the archived data

Overview of the archived data (Catalog)

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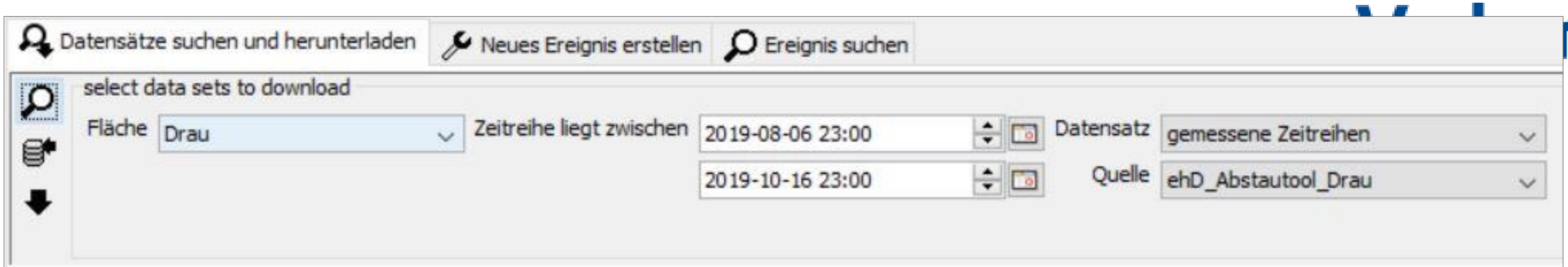
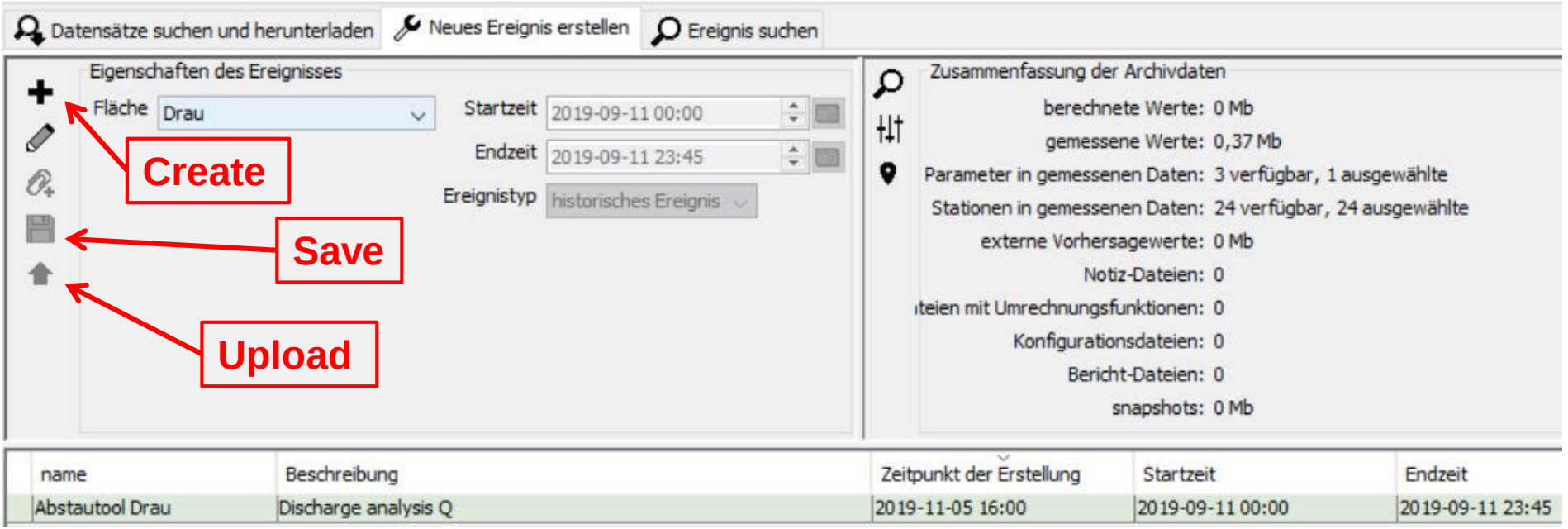


Datensatz	Fläche	Quelle	Archivierungszeitpunkt	Nul
OA_Export_ehD_Abstautool_Drau_COSERO_QARMA.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QARMA.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QARMA.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QARMA.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QARMA.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QMittelwert.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QMittelwert.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QMittelwert.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QMittelwert.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_COSERO_QMittelwert.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_OnlineDB_Q.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_OnlineDB_Q.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_OnlineDB_Q.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_OnlineDB_Q.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_OnlineDB_Q.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_post_ALARO.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_post_ALARO.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_post_ALARO.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_post_ALARO.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--
OA_Export_ehD_Abstautool_Drau_post_ALARO.nc	Drau	ehD_Abstautool_Drau	2019-11-05 09:26	--

External historical datasets **AreaId** **SourceId**

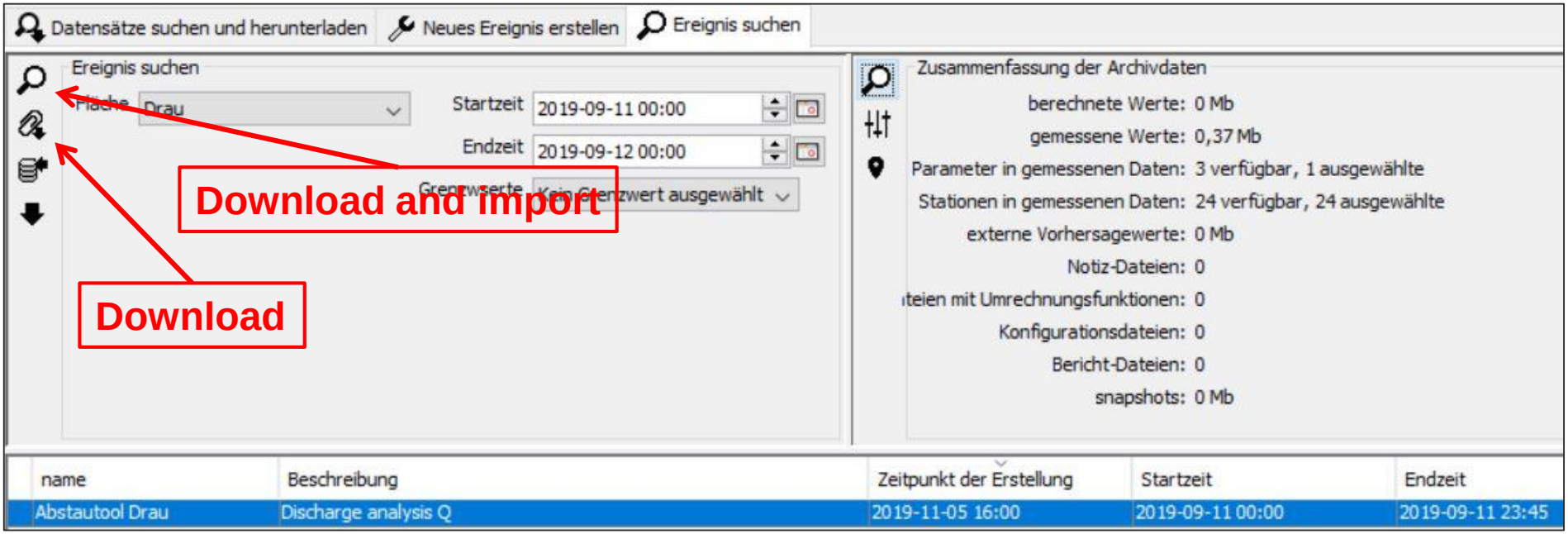
Creating historical events



Creating historical events

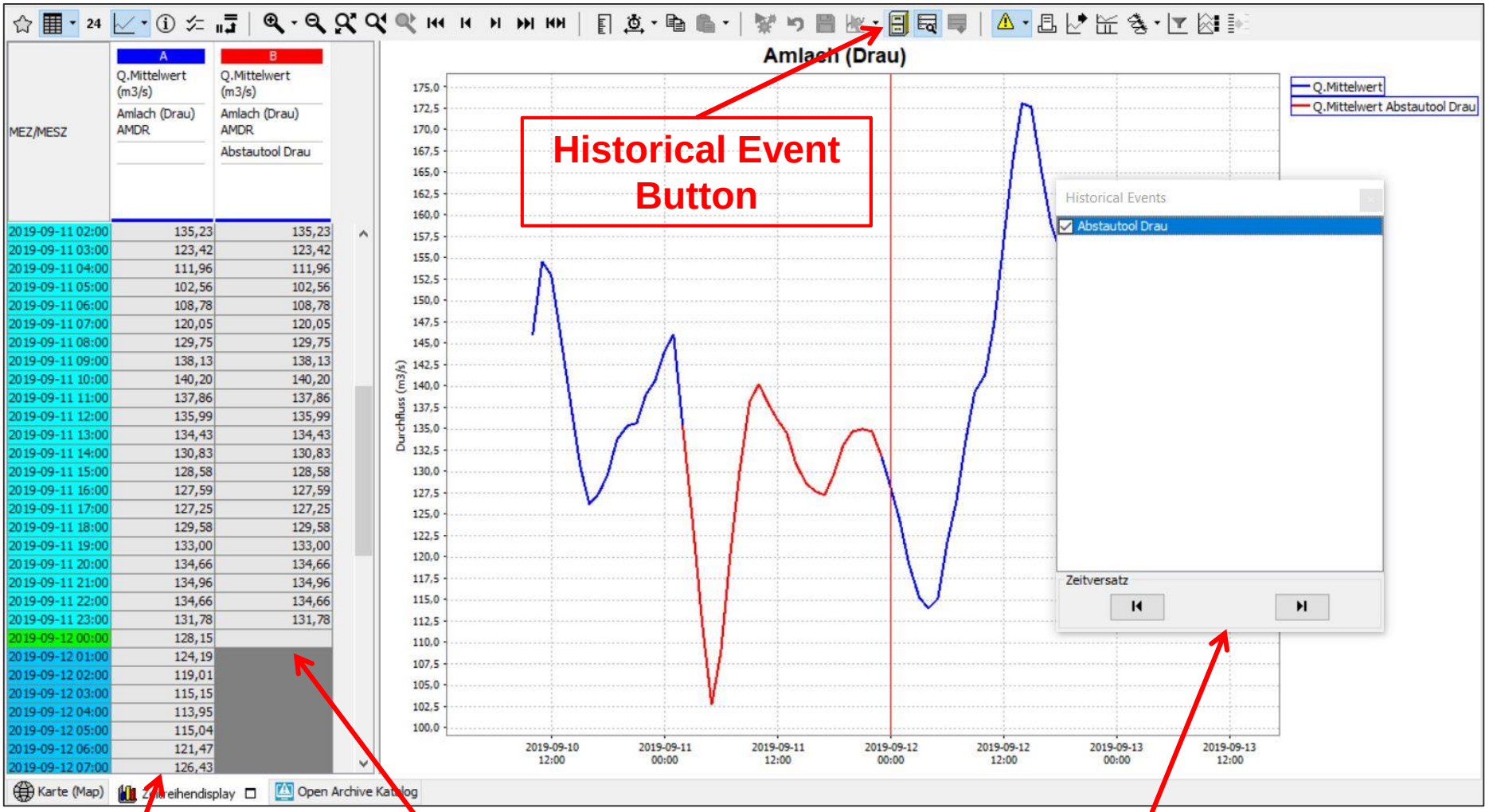
- Within the catalog historical events are defined in order to tag the archived data. These datasets are afterwards imported into a Delft-FEWS Client Server System

Searching, downloading and importing historical events



Searching, downloading and importing historical events

Displaying historical events



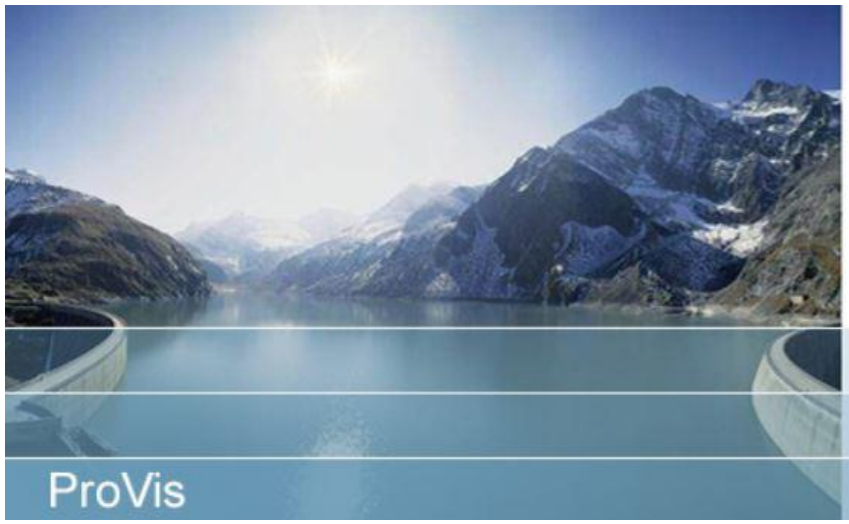
Current Timeseries

Archived Timeseries

Imported historical events

Experiences configuration Open Archive

- Complexity of the configuration for larger systems (also with use of templates)
- Limitations for the operational display of the archived data in the Version 2017.01
  - Forecasts
  - Rasters (available from the Version 2018.02)
  - Import of system states (available from the Version 2019)
- When changing or adding new configuration in FEWS also the archive configuration has to be updated



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Any questions?

Thank you for your attention!