



Localization of water resources management technology to adapt to climate change in the Hong-Thai Binh River basin

Activity 4.2 and 4.3 combined report,
Establishment of technology and report on data
quality and management issues for 6 months

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Prepared for: UNFCCC Climate Technology Centre and Network, CTCN
Represented by Ms Clara Landeiro, Regional Manager, Asia-Pacific

NOTE: In addition to Activity 4.3, this report serves as demonstration of successful completion of Activity 4.2 corresponding to the establishment and installation of the selected technology and baseline information in the Hong Thai Binh river basin

Quality Supervisor: Sílvia Leirião
Author: Jannik Anthonj, Nguyen Ngoc Bach and Roar Jessen
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Acronyms

CEWAFO	Centre for Water Resources Planning and Investigation
CFS	Climate Forecast System
CMIP6	Coupled Model Intercomparison Project Phase 6
CTCN	Climate Technology Centre Network
DCC	Department of Climate Change
DEM	Digital Elevation Model
DFS2	2D Data File System
DTM	Digital Terrain Model
EO	Earth Observation
ERA5	fifth generation ECMWF reanalysis for the global climate and weather
ESA	European Space Agency
ESP	Extended Streamflow Prediction
FAO	Food and Agriculture Organization
GCM	Global Climate Models
GFS	Global Forecast System
GHM	Global Hydrological Model
GIS	Geographical Information System
IPCC	Intergovernmental Panel on Climate Change
LAV	Level-Area-Volume
MHB	MIKE HYDRO Basin
MRF	Medium Range Forecast
NASA	National Aeronautics and Space Administration
NAWAPI	National Center for Water Resources Planning and Investigation
NCEP	National Centers for Environmental Prediction
NVWATER	North Division for Water Resources Planning and Investigation
PET	Potential Evapotranspiration
SF	Seasonal Forecast
TA	Technical Assistance

Introduction to this Report

This report is the written deliverable of Activity 4.3 of the technical assistance to Viet Nam entitled '**Localization of water resources management technology to adapt to climate change in Hong-Thai Binh River basin**' (reference number AF-2021000099). The proponent and recipient of the Technical Assistance (TA) is the National Center for Water Resources Planning and Investigation (NAWAPI) via its North Division (NVWATER).

Activity 4.3 is the last activity of Output 4 which corresponds to establishing testing protocols and making any improvements possible to the Forecasting System which aims at improving transboundary flow calculations. The Forecasting System was installed at the Centre for Water Resources Planning and Investigation (CEWAFO), designated staff were trained, and the testing period began in April 2023. The testing was to run until September 2023 before the official closure of the TA in end of October 2023.

This report outlines the testing carried out by the CEWAFO staff members, the testing the DHI team carried out based on the feedback from CEWAFO, the changes to the system that resulted from that and final conclusions and recommendations.

This report and the Technical Reference Manual (both English and Vietnamese versions) delivered in the end of October 2023, correspond to the final deliverable of the CTCN TA.

1 Background

The United Nations awarded funding for a technical assistance (TA) request to the Climate Technology Centre Network (CTCN) to select and customize technologies that can provide science-based information on transboundary water resources in the Hong-Thai Binh River basin in Viet Nam, to ensure more accurate and integrated planning. The proponent is the North Division of the National Center for Water Resources Planning and Investigation (NVWATER). The organization delivering the technical assistance is DHI. The duration of the CTCN TA is from April 2022 to October 2023.

The output of this TA was a Flow Forecasting System that can provide estimates of transboundary flow coming from upstream catchments in China and according to NAWAPI's reporting requirements. The system was developed, delivered, and tested, for the following entities:

- Department of Water Resources Planning
- Department of Water Resources Monitoring
- Center for Water Resources Warning and Forecast (CEWAFO)

All these units are under the National Center for Water Resources Planning and Investigation (NAWAPI). The system was installed at CEWAFO.

The implementation of this CTCN TA was organized into five outputs. Output 1 of the TA corresponded to all the preparatory tasks such as completing CTCN reporting requirements, organizing the kick-off meeting and establishing an approved work plan.

Output 2 led to the identification of the climate change risks and challenges in the Hong-Thai Binh River basin. During Activity 2.1, a kick-off meeting and stakeholder consultations were carried out. It presented the opportunity for face-to-face meetings where the broader group of TA stakeholders were consulted. This was also an effort for information and data collection, needed to inform the remaining activities and a critical step in the identification of climate change risk and challenges to transboundary Water Resource Management (WRM) in the Hong-Thai Binh River basin.

Output 3 (Activities 3.1 and 3.2) served to identify the most appropriate technology to meet the objective of the TA. The selection was fully based on the findings of the stakeholder consultation mission to Hanoi especially the final technical meeting held with technical and high level NAWAPI decision-makers. The meeting included Mr. Tong Ngoc Thanh, General Director of NAWAPI, Mr. Nguyen Ngoc Ha, Deputy General Director of NAWAPI, and the key contact point and proponent for this TA, Mr. Nguyen Chi Nghia, Director General of NVWATER.

The main objective of Output 4 was the customization of the selected technology described in the Activity 4.1 Report. The selected technology was implemented and installed within Activity 4.2.

Lastly, Output 5 resulted in the production of the system's Technical Reference Manual to accompany the system installation in English and Vietnamese languages; as well as the capacity building activities 5.2 and 5.3.

This report constitutes the final deliverable of the TA, submitted at the end of Activity 4.3. Section 2 of this report presents the results of the testing phase. Sections 3 present the updates done to the system as a result of the analysis of the test findings explained in Section 4. Finally, Section 5 presents the key conclusions and recommendations.

2 System testing for 6 months

2.1 CEWAFO testing

From April to September/October 2023, CEWAFO staff member was testing the system, filling out a testing protocol and sharing with the DHI team. The protocol template is in Appendix A and the original filled out protocols are enclosed in Appendix B.

2.2 Issues reported

The forecasting system had been installed and configured successfully in the designated server in CEWAFO computation room. Then, the dispatched group of client's staff took over the system and applied it for the flood season of 2023 year. The purpose of the test phase was to consolidate the capacity of staffs from the client to operate the system in the future. Besides, the test phase is also designed to verify the outcome of forecasting system to meet the requirements.

The first issue came from the client's side with the re-installation of windows system permission. The new account did not allow forecasting system to access the backup folder in the data drive (D:). As result, forecasting system could not create back up data. With support from developers, the client was able to re-configure and made the system running well again.

The second is about the replacement of data server at DHI office. By design, the system will connect to DHI server to get the historical and forecast precipitation periodically. As agreed, DHI will provide those data for free as long as the system active. In some situation, when internet connection is failed, or routine maintenance of server, or server upgrading would cause disconnection for a while. When happened, a quick action will be implemented to recover the connection to keep the forecasting system resume working.

The next issue is related to comparison between forecasting output versus data collected by the client. It is important to make sure that the simulation from the system would fit the natural flow at the border of Vietnam. The client started to check simulated flow of Da river at Lai Chau station/hydro power. This river is attractive because there is a series of cascade hydropower dams located. The closest dam to the border is Lai Chau hydro power. Since no observation is available, the client had to collect the back-calculated discharge from water levels and release of the dam. They did comparison with output from the system and found that there is a discrepancy in term of magnitude. The difference happens not only in dry, but also in wet season. Both medium forecasting (using GFS rainfall) and long term one (using CFS precipitation) face to the same phenomenon. Even though the variation of flood hydrograph is similar, but the mismatched plot could not be solved in the quick assessment. The DHI team had set up several meetings with the client, and internally, to understand the situation and assigned expert to find solutions.

3 Summary of operational system

This chapter summarizes the operation of the Flow Forecasting System focusing on how the system jobs are organized and how the operation is scheduled. For a full description of the system, refer to deliverables **Activity 4.1 Report** and **Activity 5.1 Technical Reference Manual**. Only the relevant aspects to the system testing and improvement are mentioned herein in section 3.1, whereas section 3.2 describes the changes carried out by the team as a result of the testing period and consultation with the CEWAFO expert.

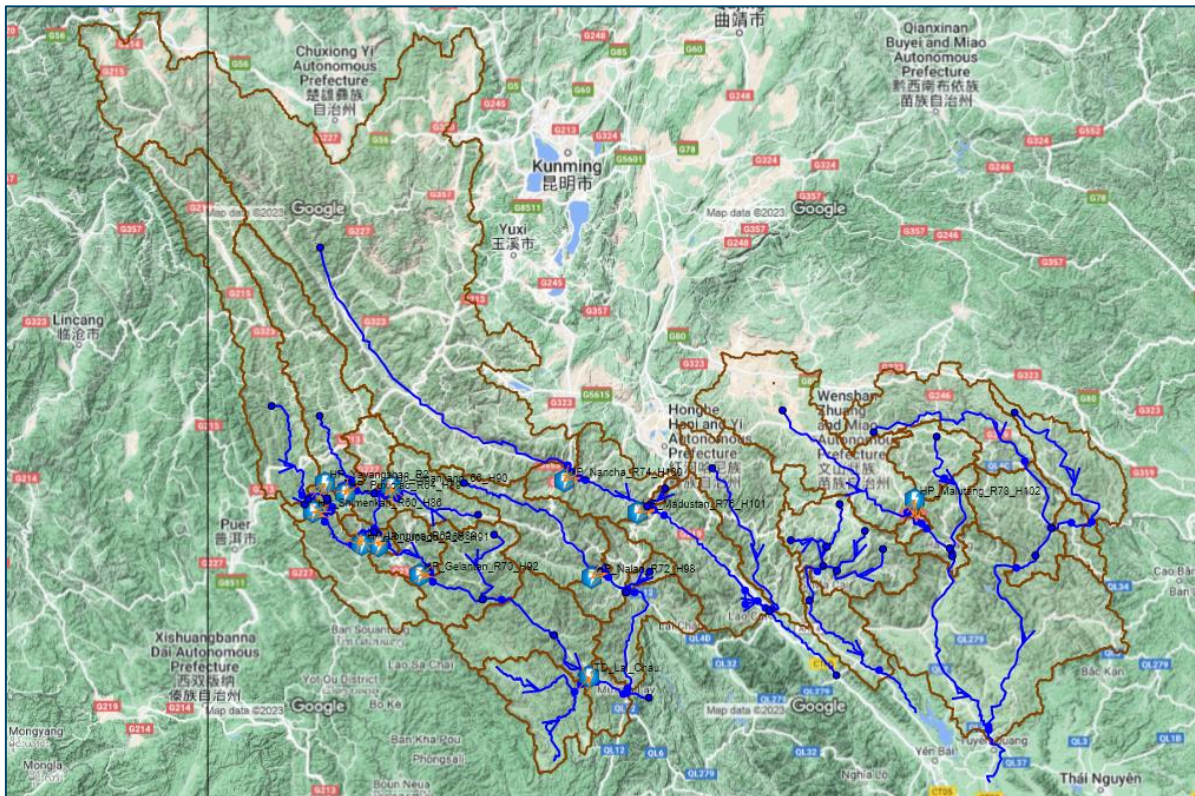


Figure 3.1 Overview map of MIKE Hydro Basin model setup for upper part of Hong – Thai Binh river basin. Catchments are brown polygons, rivers and nodes are in blue, and the reservoirs are indicated by a hydropower symbol (there are 12 in total).

3.1 From Satellite data to MHB simulations

In this study, there are several sources of satellite images are selected. They are Sentinel-1, Sentinel-2 and SAR-1.

Satellite data is downloaded by DHI and converted to Dfs2-tiles, which is the forcing data to the hydrological model of the Hydrological Forecasting Component of the system. The software and model used in this component is the DHI-GHM (the Global Hydrological Model of DHI). In this component there are three types of simulations: hindcast, medium range- forecast and seasonal forecast simulation. For each of the three, datasets of precipitation, temperature and potential evaporation are prepared. The simulation periods associated with each simulation of the Hydrological Forecasting Component are depicted in Figure 3.2.

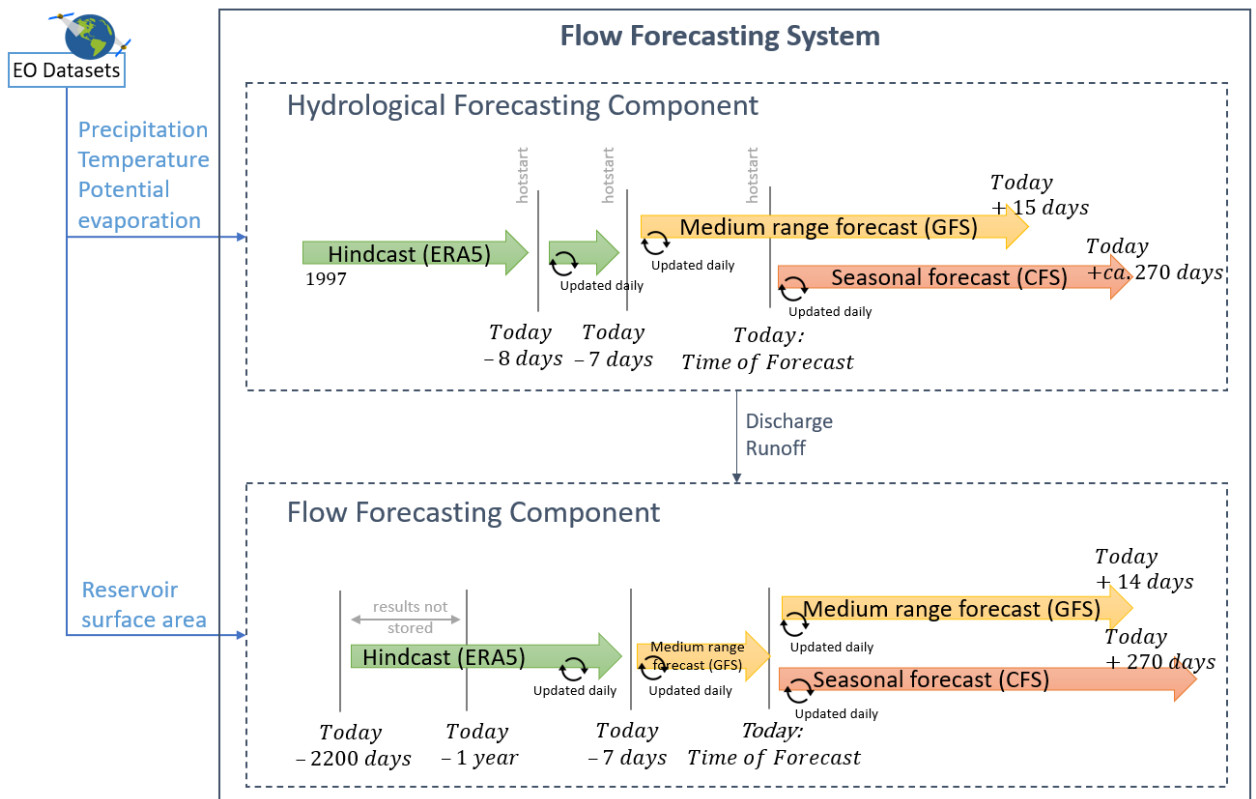


Figure 3.2 Overview of data-input to the simulations of the DHI-GHM and MHB models within their respective forecasting system components.

The DHI-GHM model hindcast simulation is updated daily, where the latest added data is used to run the simulation, hot started from the previous simulation. This simulation produces another hotstart, which replaces the previous as “latest status”. It will be used to hotstart the Medium Range Forecast, MRF, which at the current days’ time at 00:00 will extract its state as hotstart. However, it will continue simulating until 14 days forecast to simulate MRF GHM results (yellow arrow of the hydrological forecast component). The MRF hotstart will then be used as input to the Seasonal Forecast, SF, (orange arrow of the hydrological forecast component), which will simulate all 20 ensemble members of that dataset (the simulation is run 20 times) and up to about 270 days lead time.

At some locations, discharge and intermediate runoff will be extracted, imported into MIKE Workbench and set as an input to the MHB model of the flow forecasting component of the system.

Moving into the Flow Forecasting Component of the system (bottom half of Figure 3.2), as the model is not hotstarted, a warmup-period of 2200 days was introduced. Until 7 days prior to the current day, the outputs of the hydrological hindcast simulation are used (green arrow of the flood forecasting component) in the simulation, followed by the MRF outputs until the current day, which is also Time of Forecast (ToF). After ToF, the MHB simulations run using its respective forecast products (yellow and orange arrows of the flow forecasting component) up until the end of their respective lead times.

Results are stored within a period of one year before the current day until a set number of days after ToF (MRF: 15, SF: 270).

3.2 Updates to the operational system

As a result of the testing period – conclusions to be described in section 4 of this report – the system was improved to include a new option for the Flow Forecasting Component. The water resources model of this component is now registered using two setups of the MHB model:

- With Data Assimilation (DA) at reservoir water levels
- Without DA

Consequently, and in line with the operation described in section 3.1, two MHB simulations are operationalized for each model setup (with and without data assimilation):

- Medium Range Forecast
- Seasonal Forecast

In both cases, as described in the previous section, the same process is carried out and result timeseries from the Hydrological Forecasting Component simulations are combined to one input timeseries to the two MHB models.

3.2.1 Model registration and scenarios

To accomplish MHB simulations for both, with and without data assimilation (DA), the MHB model has been registered twice, see Figure 3.3.

- Upper_Hong_Thai_binh_No_DA: this model is registered and set up to simulate without data assimilation (DA) at reservoirs.
- Upper_Hong_Thai_binh_With_DA: this model is registered and set up to simulate with DA at reservoirs.

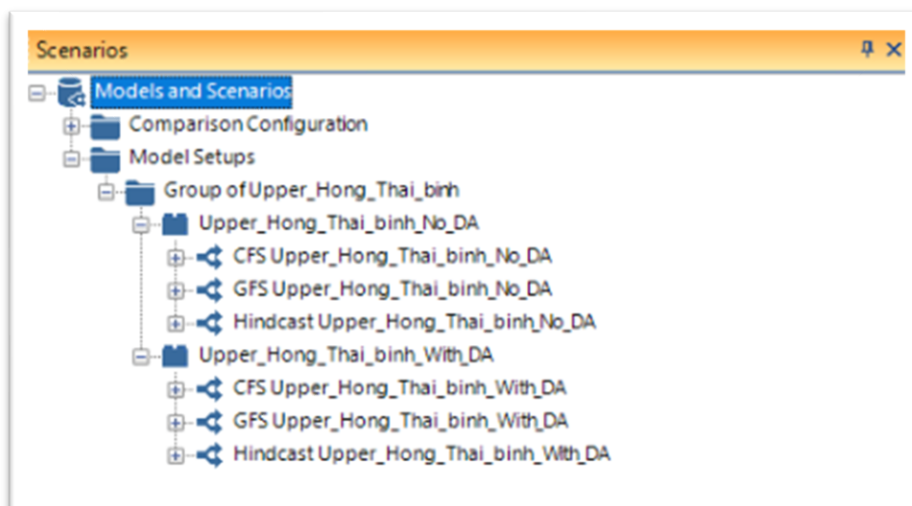


Figure 3.3 Model registrations and scenarios of the MHB in MIKE Workbench.

Each of the model registrations contains 3 scenarios:

- GFS – medium range forecasts
- CFS – seasonal forecast
- Hindcast – this scenario is only run once and used to derive long term statistics and for validation. In the operational runs, CFS and GFS will simulate a longer hindcast period.

The scenario configuration for the GFS with DA is shown in Figure 3.4. GFS scenario without DA has the same configuration. CFS with DA scenario has a similar configuration whereas CFS without DA has the same configuration as CFS with DA.

Table 3.1 Main properties of the MIKE HYDRO Basin scenarios.

Scenario	Hindcast period	Forecast period
GFS Medium Range Forecast with DA	2200 days (= 6 years)	14 days
CFS Seasonal Forecast with DA	2200 days (= 6 years)	270 days
GFS Medium Range Forecast without DA	2200 days (= 6 years)	14 days
CFS Seasonal Forecast without DA	2200 days (= 6 years)	270 days

Table 3.1 gives an overview of the main scenario settings, which differ between the scenarios:

- Hindcast period warmup period used for ensuring proper initial conditions.
- Forecast period that covers the same period as available in the weather/climate forecast.

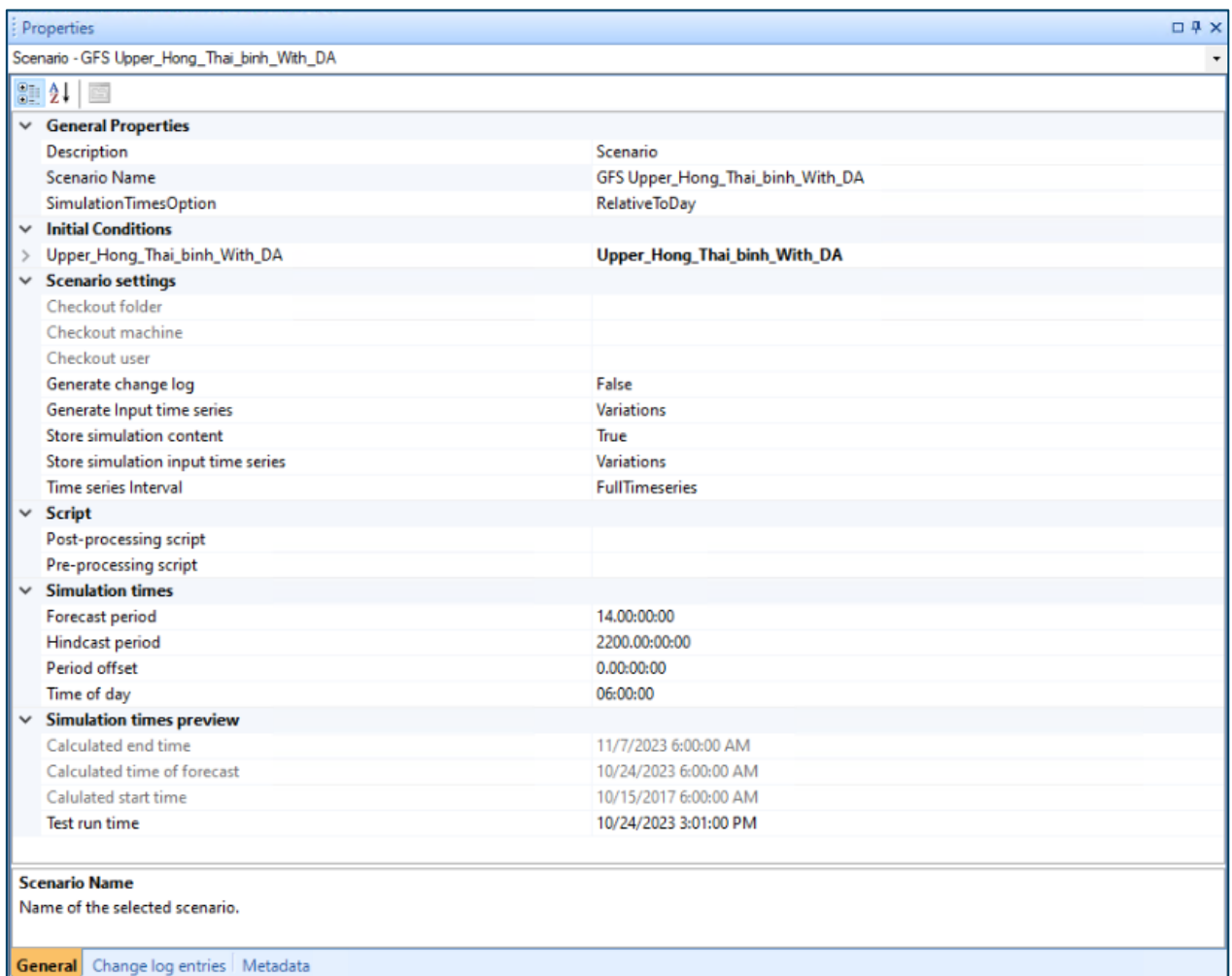


Figure 3.4 Properties of the GFS Scenario with DA (Medium Range Forecast).

3.2.2 System jobs

Some jobs have received an update during the investigation and adding of an additional model setup. Those jobs are described in the following.

MHB Medium range forecasting

Job 02a_MHB_GFS runs the MHB simulation for the 'Medium range forecast'.

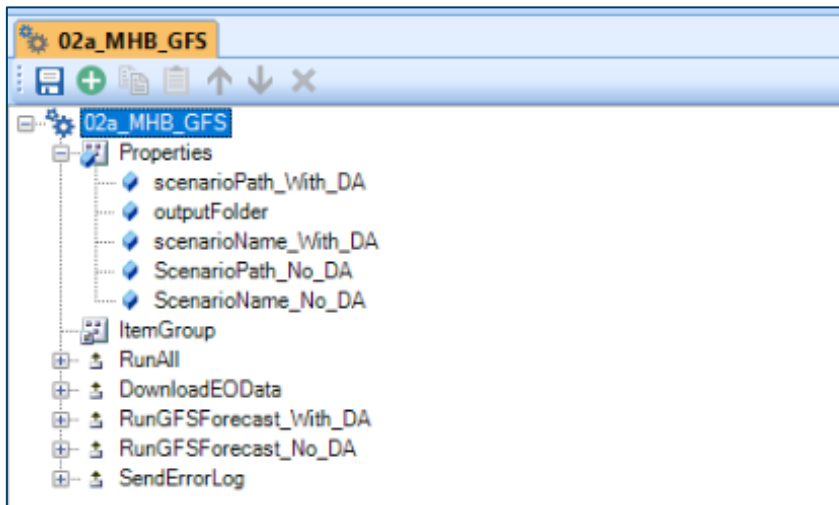


Figure 3.5 Job to run MHB simulation for the 'Medium range forecast'.

The properties of this job are defined as shown in Table 3.2.

Table 3.2 Properties of Job 02a_MHB_GFS.

Properties	Value
scenarioPath_With_DA	/Group of Upper_Hong_Thai_binh/Upper_Hong_Thai_binh_With_DA/GFS Upper_Hong_Thai_binh_With_DA
outputFolder	Model Output
scenarioName_With_DA	GFS Upper_Hong_Thai_binh_With_DA
scenarioPath_No_DA	/Group of Upper_Hong_Thai_binh/Upper_Hong_Thai_binh_No_DA/GFS Upper_Hong_Thai_binh_No_DA
scenarioName_No_DA	GFS Upper_Hong_Thai_binh_No_DA
EO_Filename	China-RK-reservoir-monitoring.csv

The first step is to download the EO data. Data is downloaded from an Azure blob-storage to a temporary directory and then processed using the script "/DataImport/ImportEOData"

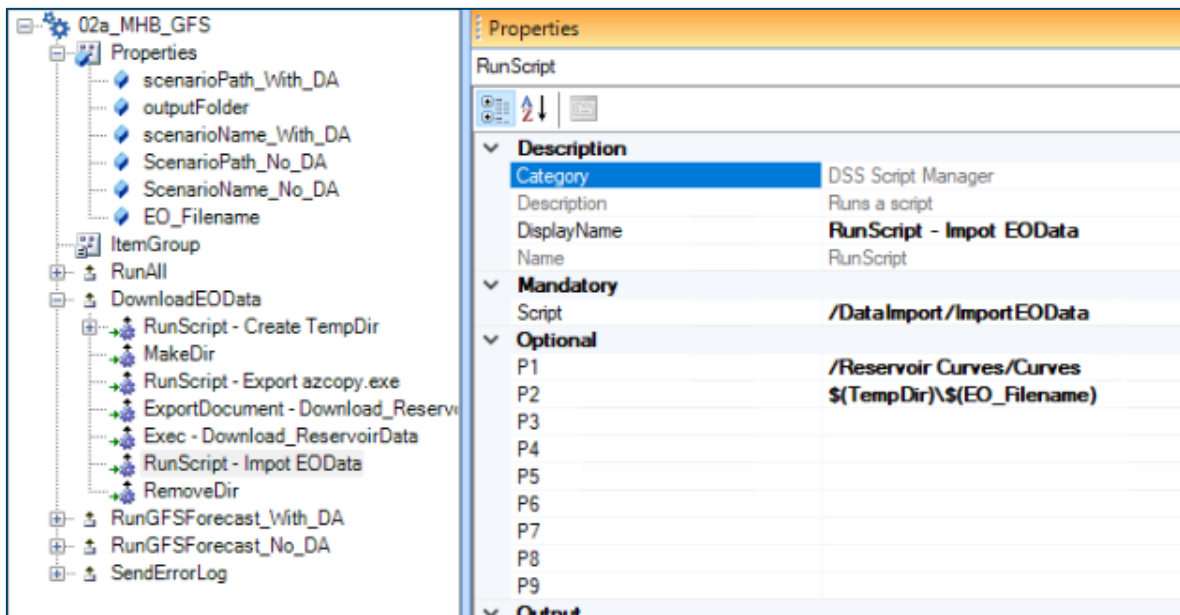


Figure 3.6 Target to download the EO data.

Then both scenarios based on GFS data are run with DA and without DA.

MHB Seasonal forecasting

Job 02b_MHB_CFS runs the MHB simulation for the Seasonal forecast.

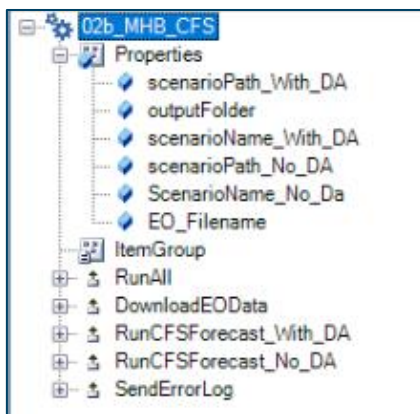


Figure 3.7 Job for running the MHB simulation for the seasonal forecast.

For the job, the properties are defined in Table 3.3

Table 3.3 Properties of Job 02b_MHB_CFS

Properties	Value
scenarioPath_With_DA	/Group of Upper_Hong_Thai_binh/Upper_Hong_Thai_binh_With_DA/CFS Upper_Hong_Thai_binh_With_DA
outputFolder	Model Output
scenarioName_With_DA	CFS Upper_Hong_Thai_binh_With_DA
scenarioPath_No_DA	/Group of Upper_Hong_Thai_binh/Upper_Hong_Thai_binh_No_DA/CFS Upper_Hong_Thai_binh_No_DA

scenarioName_ No _DA	CFS Upper_Hong_Thai_binh_ No _DA
EO_Filename	China-RK-reservoir-monitoring.csv

The first step is to download the EO data. Data is downloaded from an azure blob-storage to a temporary directory and then processed using the script “/DataImport/ImportEOData”.

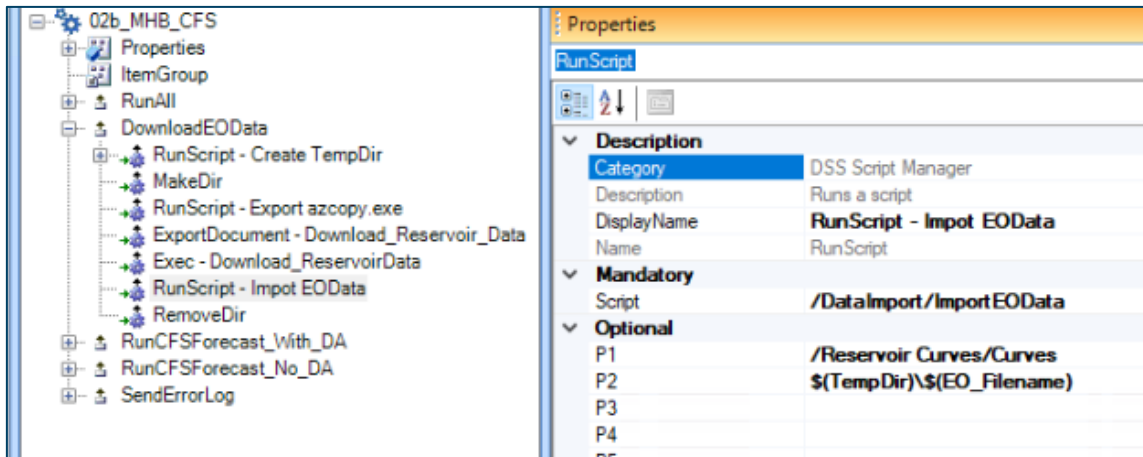


Figure 3.8 Target to download the EO data

Then both scenarios based on CFS data are run: with DA and without DA.

Database maintenance

Job 03_Maintenance ensures the database is maintained.

It is ensured, that old simulations are cleaned up, where the 4 operational scenarios are added see Figure 3.9. Simulations are kept for 2880 hours (120 days).

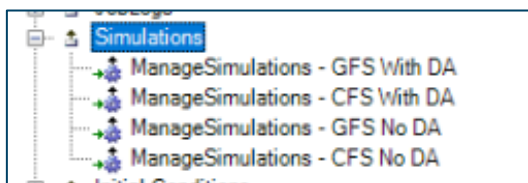


Figure 3.9 Target for managing simulations.

The next step will ensure old initial conditions are cleaned up. Both model setups, with and without DA need to be added, see Figure 3.10.

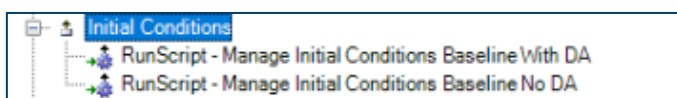


Figure 3.10 Target for managing initial conditions.

Database Backup

Job 04_DatabaseBackup will clean up the database (vacuum) and create a backup.

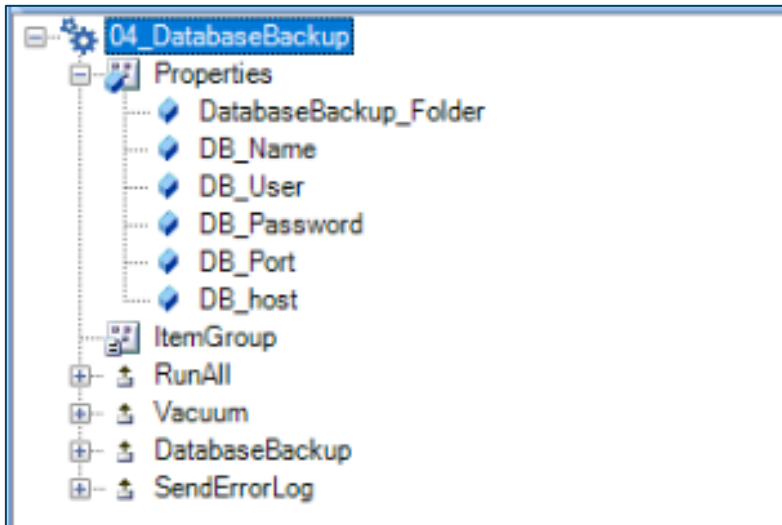


Figure 3.11 Job for database vacuum and backup.

The vacuum and backup are done by batch files run on disk. These batch files are stored in the document manager and are exported on a temporary folder before execution.

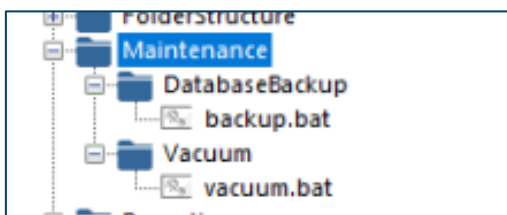


Figure 3.12 Location of DB vacuum and backup in document manager.

The batch files are designed to be able to use parameters:

- DatabaseBackup_Folder
- DB_Name
- DB_User
- DB_Password
- DB_Port
- DB_host

If any of the parameters differs from the fallback values (Table 3.4), it needs to be set.

Table 3.4 Fallback values for database backup parameters.

Parameter	Fallback value
DatabaseBackup_Folder	D:\H_TB\Backup <i>This should be set to match maintenance</i>
DB_Name	H_TB_CTCN
DB_User	postgres
DB_Password	postgres
DB_Port	5432
DB_host	localhost

The batch file execution uses all parameters needed (Figure 3.13 and Figure 3.14), whereby default (parameter is empty), the fallback value is used.

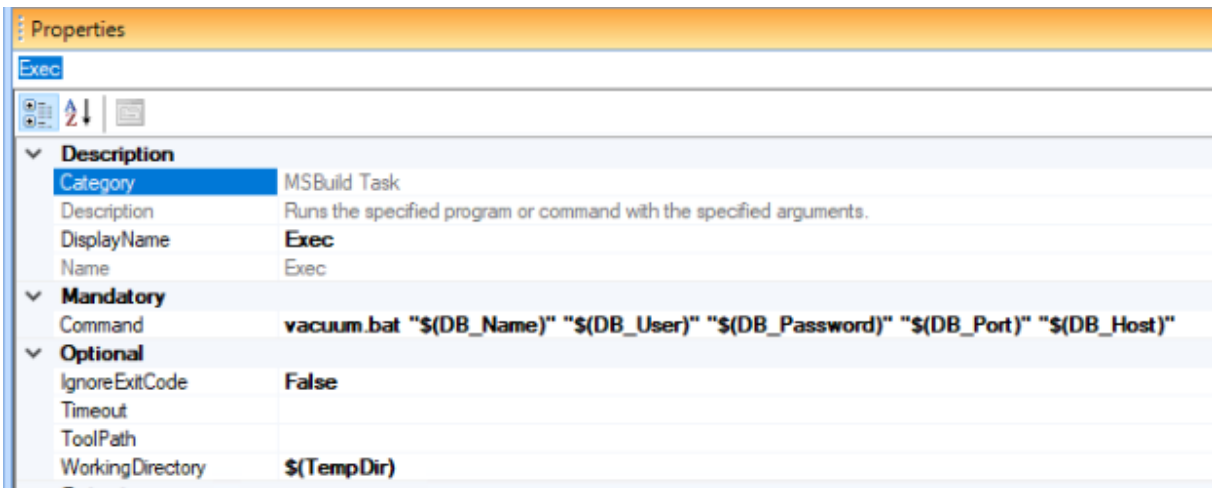


Figure 3.13 Call of the exported vacuum.bat file with parameters.

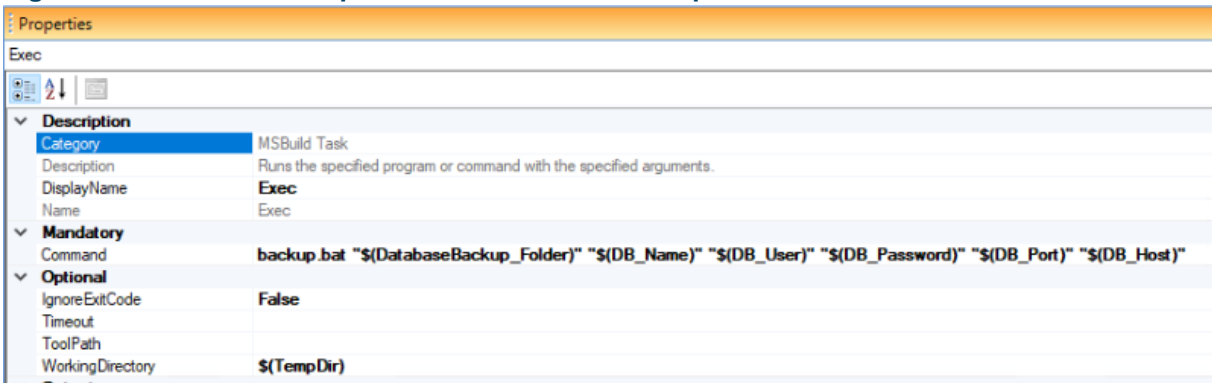


Figure 3.14 Call of the exported backup.bat file with parameters.

4 List of system tests

4.1 Observations from the testing period as received from NAWAPI

Figure 4.1 presents an overview of the water resources model network and the location of the hydrometric stations used to calibrate the model. NAWAPI provided the discharge time series (m^3/s) for these stations namely: at Dao Duc, at Lai Chau and at Lao Cai. According to NAWAPI, the flow discharge is calculated based on the rating curves of the stations. The stations measure water level, and sometimes during the high flow season, discharge is also measured.

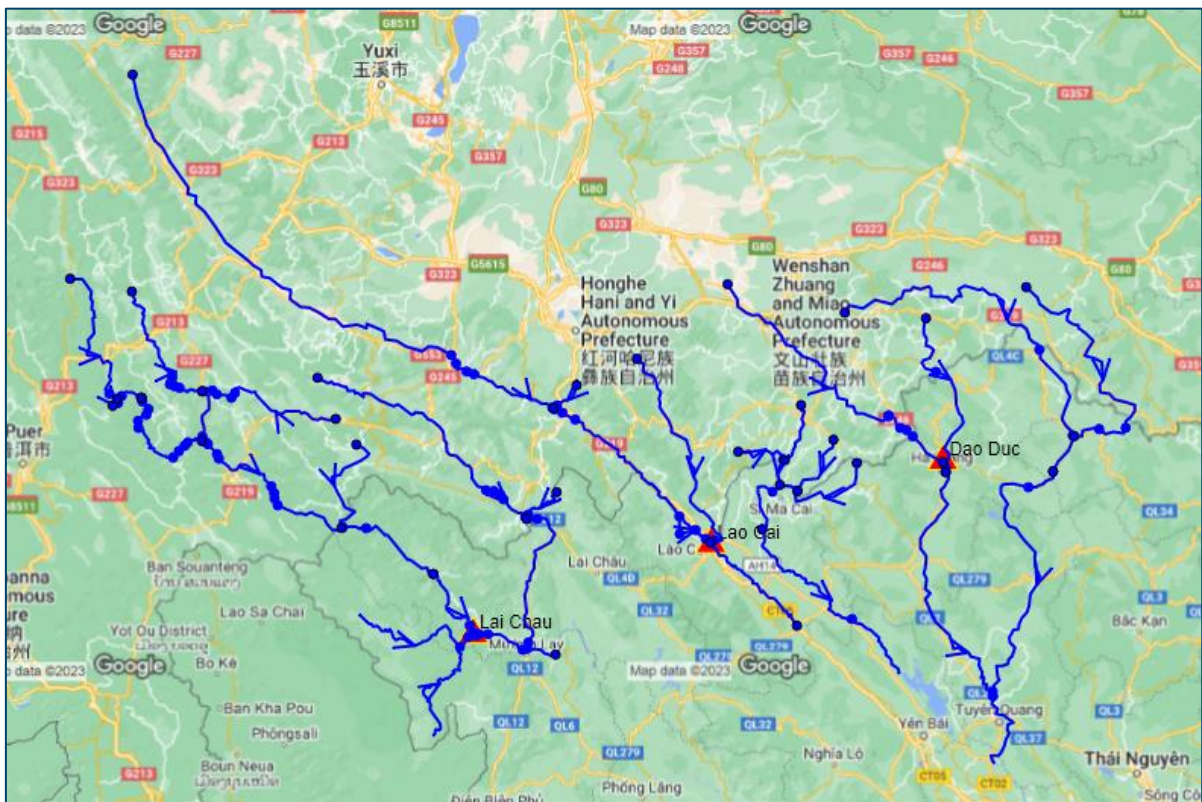


Figure 4.1 Diagram of the water resources model network and the location of the hydrometric stations used to calibrate the model based on flow (m^3/s) time series provided by NAWAPI.

DHI have received timeseries plots for the test period from three stations: Lai Chau, Lai Cao and Dao Duc as shown in the below Figure 4.2, Figure 4.4, Figure 4.6, respectively.

The figures have been compared with respective model calibration and validation plots made during the model calibration phase which are included here as Figure 4.3,

Figure 4.5 and Figure 4.7.

In the testing phase, the calibrated model has been applied to the period after the calibration period. The below table shows the summary of the validation activities:

Table 4.1 List of validation stations, and periods of hindcast and forecast

	Hindcast	Forecast	Station
Period	2000 days	Frequency of 10 days from 2016-2023	Lai Chau, Dao Duc and Lao Cai

For each station, the comparison between simulations (with/without DA) versus observation are presented in below Table 4.2, Table 4.3 and Table 4.4.

Table 4.2 Summary of comparison for Lai Chau location

Volume	Obs	SIM with DA	Difference in volume	Difference in %	SIM with out DA	Difference in volume	Difference in %
2016	22,783,293,792	18,813,311,912	-3,969,981,880	-17.4	23,646,878,141	863,584,349	3.8
2017	26,614,203,264	14,323,090,668	-12,291,112,596	-46.2	28,397,034,163	1,782,830,899	6.7
2018	25,991,393,513	14,466,680,419	-11,524,713,094	-44.3	29,397,557,602	3,406,164,088	13.1
2019	14,525,222,400	10,125,369,457	-4,399,852,943	-30.3	18,492,402,219	3,967,179,819	27.3
2020	21,156,212,983	11,864,675,715	-9,291,537,268	-43.9	23,973,111,355	2,816,898,372	13.3
2021	18,045,124,102	11,348,068,593	-6,697,055,508	-37.1	21,712,380,354	3,667,256,253	20.3
2022	21,211,562,304	11,078,765,764	-10,132,796,540	-47.8	22,451,450,773	1,239,888,469	5.8
2023	13,945,047,264	9,121,626,407	-4,823,420,857	-34.6	16,776,965,674	2,831,918,410	20.3
2016	22,783,293,792	18,813,311,912	-3,969,981,880	-17.4	23,646,878,141	863,584,349	3.8
2017	26,614,203,264	14,323,090,668	-12,291,112,596	-46.2	28,397,034,163	1,782,830,899	6.7
2018	25,991,393,513	14,466,680,419	-11,524,713,094	-44.3	29,397,557,602	3,406,164,088	13.1
2019	14,525,222,400	10,125,369,457	-4,399,852,943	-30.3	18,492,402,219	3,967,179,819	27.3
2020	21,156,212,983	11,864,675,715	-9,291,537,268	-43.9	23,973,111,355	2,816,898,372	13.3
2021	18,045,124,102	11,348,068,593	-6,697,055,508	-37.1	21,712,380,354	3,667,256,253	20.3
2022	21,211,562,304	11,078,765,764	-10,132,796,540	-47.8	22,451,450,773	1,239,888,469	5.8
2023	13,945,047,264	9,121,626,407	-4,823,420,857	-34.6	16,776,965,674	2,831,918,410	20.3

With data containing Lai Chau, the total difference is from 3.9 to 12.2 billion of m³ (about 17-50% compared to the total observation) for the case with DA. On the contrary, in the simulation case without DA, the error is from 800 million to 3.9 m³ (about 3.5-17% compared to the total measured quantity).

Table 4.3 Summary of comparison for Lao Cai location

Volume	Obs	SIM with DA	Difference in volume	Difference in %	SIM with out DA	Difference in volume	Difference in %
2016	12,485,664,000	14,348,615,057	1,862,951,057	14.9	14,348,615,057	1,862,951,057	14.9
2017	18,269,798,400	9,183,184,425	-9,086,613,975	-49.7	18,212,881,079	-56,917,321	-0.3
2018	15,553,641,600	6,049,672,359	-9,503,969,241	-61.1	15,351,100,784	-202,540,816	-1.3
2019	9,134,121,600	3,821,350,467	-5,312,771,133	-58.2	9,126,092,780	-8,028,820	-0.1
2020	14,225,328,000	3,901,023,727	-10,324,304,273	-72.6	11,665,810,328	-2,559,517,672	-18.0
2021	12,448,738,091	4,080,148,097	-8,368,589,993	-67.2	12,106,029,577	-342,708,514	-2.8
2022	13,723,097,509	3,820,355,734	-9,902,741,775	-72.2	12,395,562,790	-1,327,534,719	-9.7
2023	7,074,961,276	2,544,517,823	-4,530,443,453	-64.0	9,540,848,119	2,465,886,843	34.9
2016	12,485,664,000	14,348,615,057	1,862,951,057	14.9	14,348,615,057	1,862,951,057	14.9
2017	18,269,798,400	9,183,184,425	-9,086,613,975	-49.7	18,212,881,079	-56,917,321	-0.3
2018	15,553,641,600	6,049,672,359	-9,503,969,241	-61.1	15,351,100,784	-202,540,816	-1.3
2019	9,134,121,600	3,821,350,467	-5,312,771,133	-58.2	9,126,092,780	-8,028,820	-0.1
2020	14,225,328,000	3,901,023,727	-10,324,304,273	-72.6	11,665,810,328	-2,559,517,672	-18.0
2021	12,448,738,091	4,080,148,097	-8,368,589,993	-67.2	12,106,029,577	-342,708,514	-2.8
2022	13,723,097,509	3,820,355,734	-9,902,741,775	-72.2	12,395,562,790	-1,327,534,719	-9.7
2023	7,074,961,276	2,544,517,823	-4,530,443,453	-64.0	9,540,848,119	2,465,886,843	34.9

With data from Lao Cai Station, the total difference of the excess amount is from 1.8 billion to 10.3 billion m³ (about 15-70% compared to the total measured amount) in the case with DA.

Whether as for the simulation case without DA, the total difference is from 2.4 billion to 2.5 billion m³ (about 21-25% compared to the total measured amount).

Table 4.4 Summary of comparison for Dao Duc location

Volume	Obs	SIM with DA	Difference in volume	Difference in %	SIM with out DA	Difference in volume	Difference in %
2016	2,944,261,440	3,502,505,798	558,244,358	19.0	4,721,769,167	1,777,507,727	60.4
2017	5,097,245,760	3,607,593,229	-1,489,652,531	-29.2	5,415,333,416	318,087,656	6.2
2018	6,016,144,320	4,323,256,812	-1,692,887,508	-28.1	5,330,645,588	-685,498,732	-11.4
2019	3,941,066,880	4,186,401,019	245,334,139	6.2	4,480,635,479	539,568,599	13.7
2020	4,164,730,560	3,796,153,118	-368,577,442	-8.8	4,886,217,845	721,487,285	17.3
2021	3,302,795,985	4,015,118,264	712,322,279	21.6	5,010,321,286	1,707,525,301	51.7
2022	4,252,952,317	4,415,129,666	162,177,349	3.8	4,889,572,971	636,620,653	15.0
2023	2,389,695,722	2,616,743,711	227,047,989	9.5	2,986,910,978	597,215,256	25.0
2016	2,944,261,440	3,502,505,798	558,244,358	19.0	4,721,769,167	1,777,507,727	60.4
2017	5,097,245,760	3,607,593,229	-1,489,652,531	-29.2	5,415,333,416	318,087,656	6.2
2018	6,016,144,320	4,323,256,812	-1,692,887,508	-28.1	5,330,645,588	-685,498,732	-11.4
2019	3,941,066,880	4,186,401,019	245,334,139	6.2	4,480,635,479	539,568,599	13.7
2020	4,164,730,560	3,796,153,118	-368,577,442	-8.8	4,886,217,845	721,487,285	17.3
2021	3,302,795,985	4,015,118,264	712,322,279	21.6	5,010,321,286	1,707,525,301	51.7
2022	4,252,952,317	4,415,129,666	162,177,349	3.8	4,889,572,971	636,620,653	15.0
2023	2,389,695,722	2,616,743,711	227,047,989	9.5	2,986,910,978	597,215,256	25.0

With data from Lao Cai Station, the total difference of the excess amount is from 700 million to 1.6 billion m³ (about 23-26% compared to the total measured amount) in the case with DA. As for the simulation case without DA, the total excess amount is from 1.7 billion to 600 million m³ lower (about 16-61% compared to the total measured amount).

From the above results it can be seen that for Lao Cai station and Lai Chau hydropower reservoir, simulation results without DA give better total simulation results than with DA. However, for Dao Duc station, this is the opposite.

Table 4.5 Evaluation of simulation results at stations

Year	NSE					
	Lai Chau		Lao Cai		Dao Duc	
	With DA	No DA	With DA	No DA	With DA	No DA
2016	0.73	0.78	0.25	0.25	0.29	-0.74
2017	0.38	0.83	0.24	0.80	0.46	0.65
2018	0.39	0.84	-0.19	0.67	0.32	0.42
2019	0.46	0.24	-0.13	0.26	0.45	0.40
2020	0.47	0.87	-0.10	0.73	0.49	0.37
2021	0.44	0.63	-0.39	0.64	0.44	0.16
2022	0.26	0.74	-0.58	0.69	0.66	0.63

The calculation of NASH coefficients show that No DA simulations give higher reliability than with DA.

Our observations and comments regarding this data are the following:

- a) For the two important stations Lao Cai and Lai Chau, the model's hindcasts and forecasts are consistently lower than the observations during the test period in 2023. This is the case during both dry and wet seasons.

Assuming that the observed timeseries are consistent and since the calibration and validation results do not show biases similar to the ones observed during the test periods at the two locations (Figure 4.3 and

Figure 4.5), the observed biases during the test period could originate either from the runoff data pushed to the water resources model, from the initial conditions used in the water resources model or from problems with the data assimilation at the upstream reservoirs. To detect the cause, long term simulations with and without data assimilation has been carried out on DHI's servers as further elaborated upon in Section 4.2 below.

- b) For the series at Dao Duc the hindcast during the dry season Oct-May is unbiased while the flood season June -Sept is significantly underestimated.

It is noted that the simulated recession during autumn 2022 is matching well but that the wet season is underestimated. This biased performance pattern was found also in the calibration (Figure 4.7) but was not adjusted for. The reason for this choice was that the calibrated parameters were quite similar to the ones giving good results for Hong and the Da rivers (Lao Cai and Lai Chau) and that the parameters showed good performance at Dao Duc during the validation period 2008-2013. Since, the big difference in performance patterns during the calibration and the validation periods was not easily explainable and likely to be due to differences in station rating, the calibration at this station was not adjusted to the latest records.

We have investigated if we can recreate the observed bias and if data assimilation can also have a negative impact at the Dao Duc station.

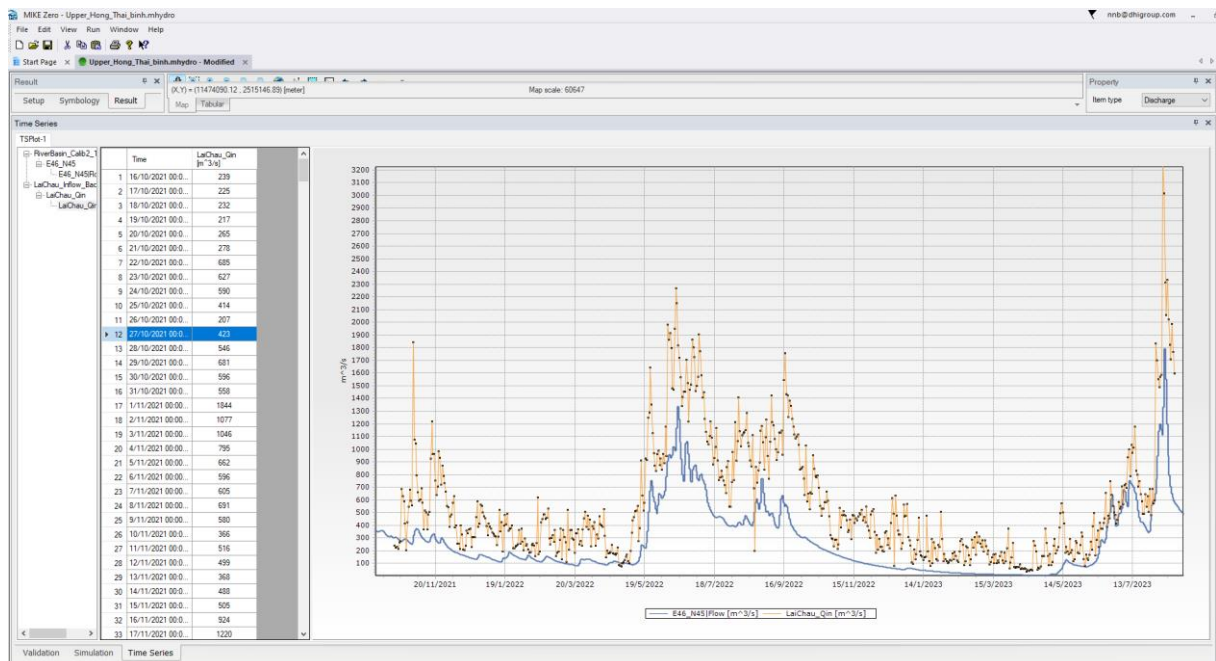


Figure 4.2 Lai Chau performance October 2021-agust 2023 (back calculated).

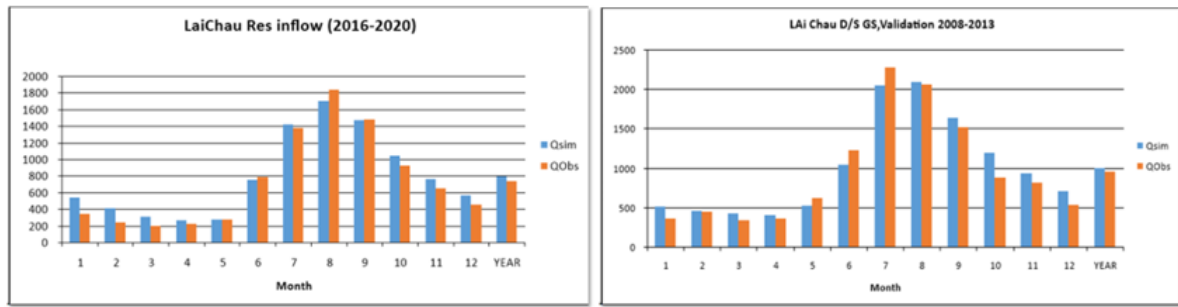


Figure 4.3 Lai Chau performance during calibration and validation does not show bias towards under- estimation of the flows.

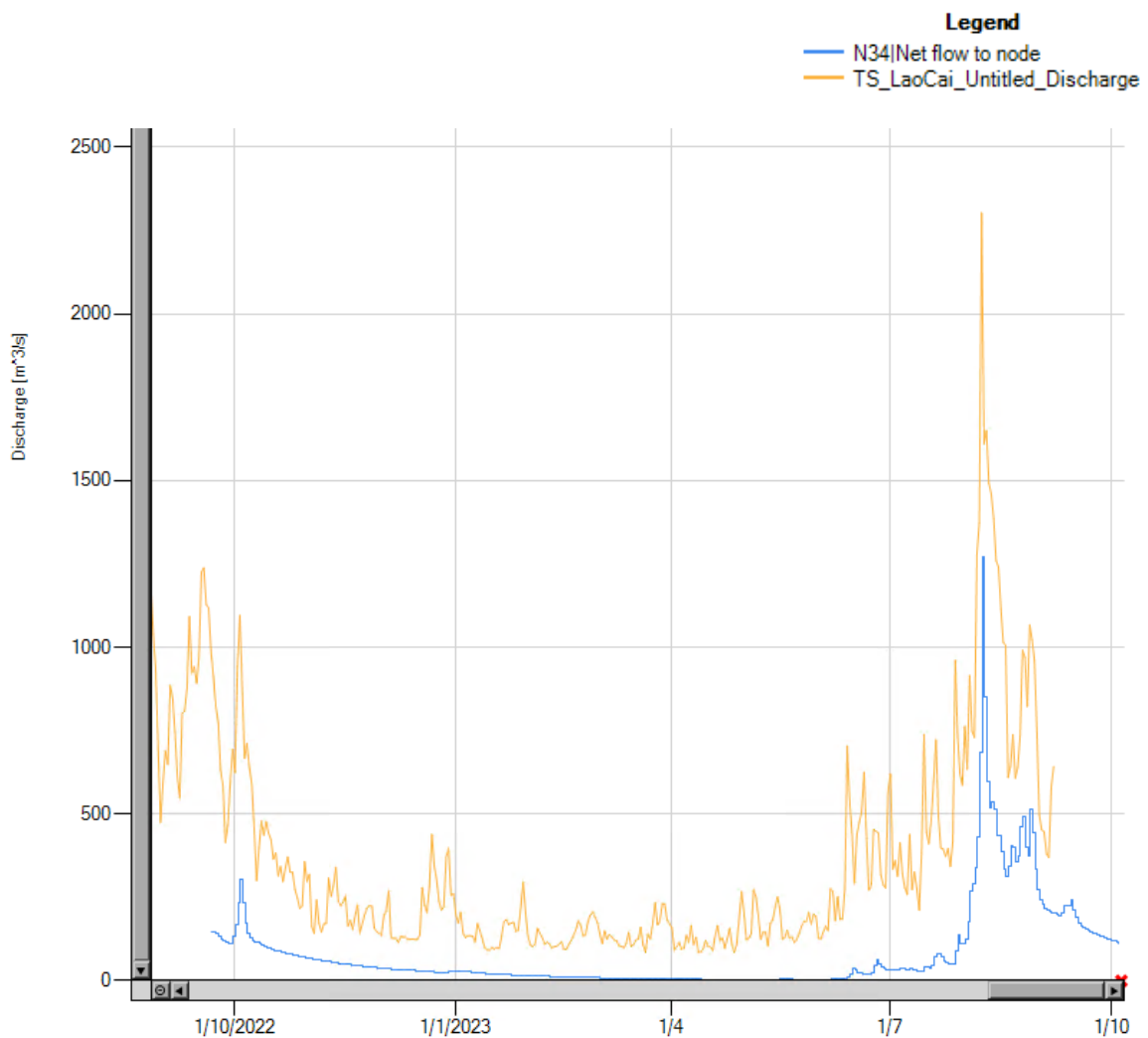


Figure 4.4 Lao Cai performance October 2022 - Aug 2023.

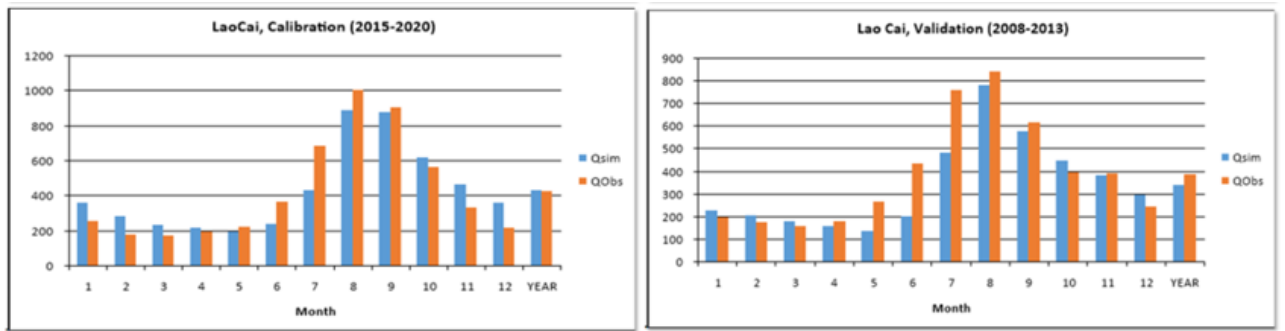


Figure 4.5 Calibration results at Lao Cai, without any water balance bias but with a bit delayed wet season response.

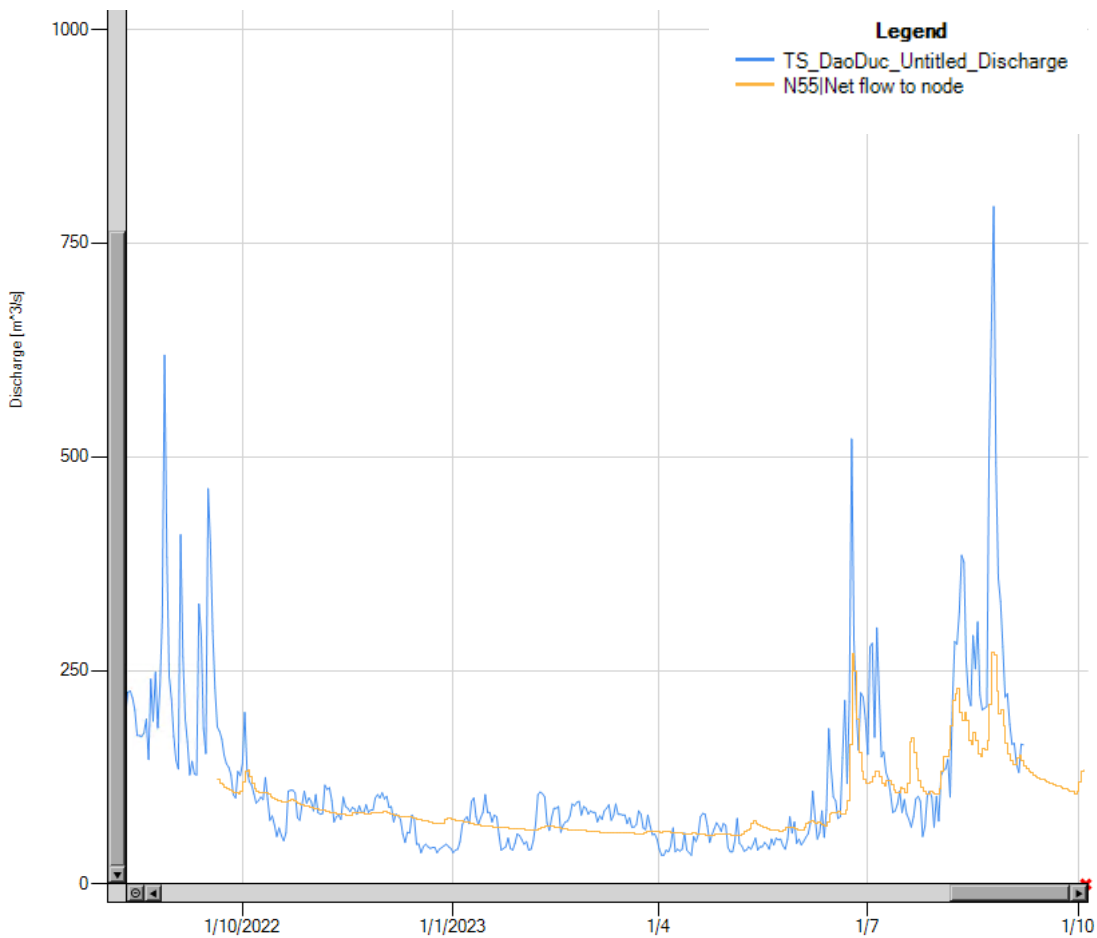


Figure 4.6 Dao Duc Performance Oct 2022 -Sep 2023.

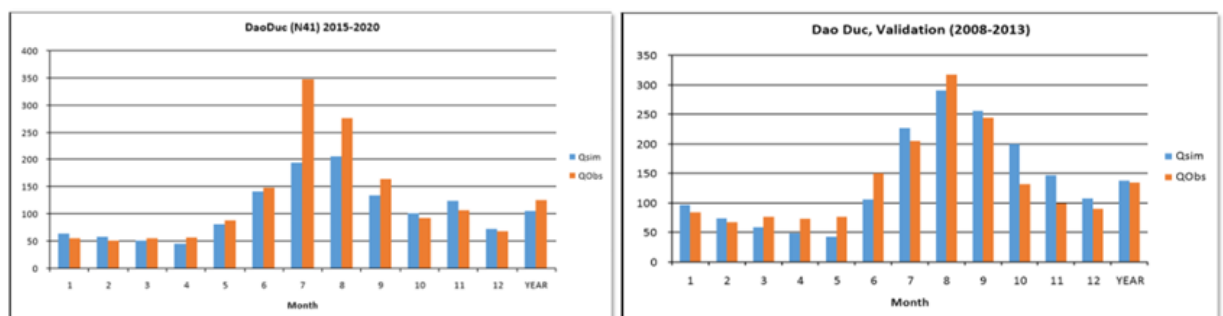


Figure 4.7 Calibration of Dao Duc showing the same tendency for the calibration period, but fine performance during the validation period.

4.2 Test diagnosis and implemented adjustments

4.2.1 Lai Chau Station

A long-term simulation was made without data assimilation at the Chinese reservoirs to ensure independency both of initial conditions and of data assimilation.

Figure 4.8 shows the last 7.5 and the last 2.5 years of this simulation. It is observed that the simulation does not show a general bias. During the last 2.5 years the correspondence with observations is very good and during 2023 (a year for which the observations were not known at the time of model calibration) the fit is almost perfect.

This suggests that the problem could stem from the assimilation to the Earth Observations data at the Reservoirs in China, since no real time Vietnamese data has been available for assimilation.

A similar long-term model simulation was hereafter executed with the data assimilation at the reservoirs reactivated. The result shows a clear tendency of the model underestimating the flows at Lai Chau when compared to the observations.

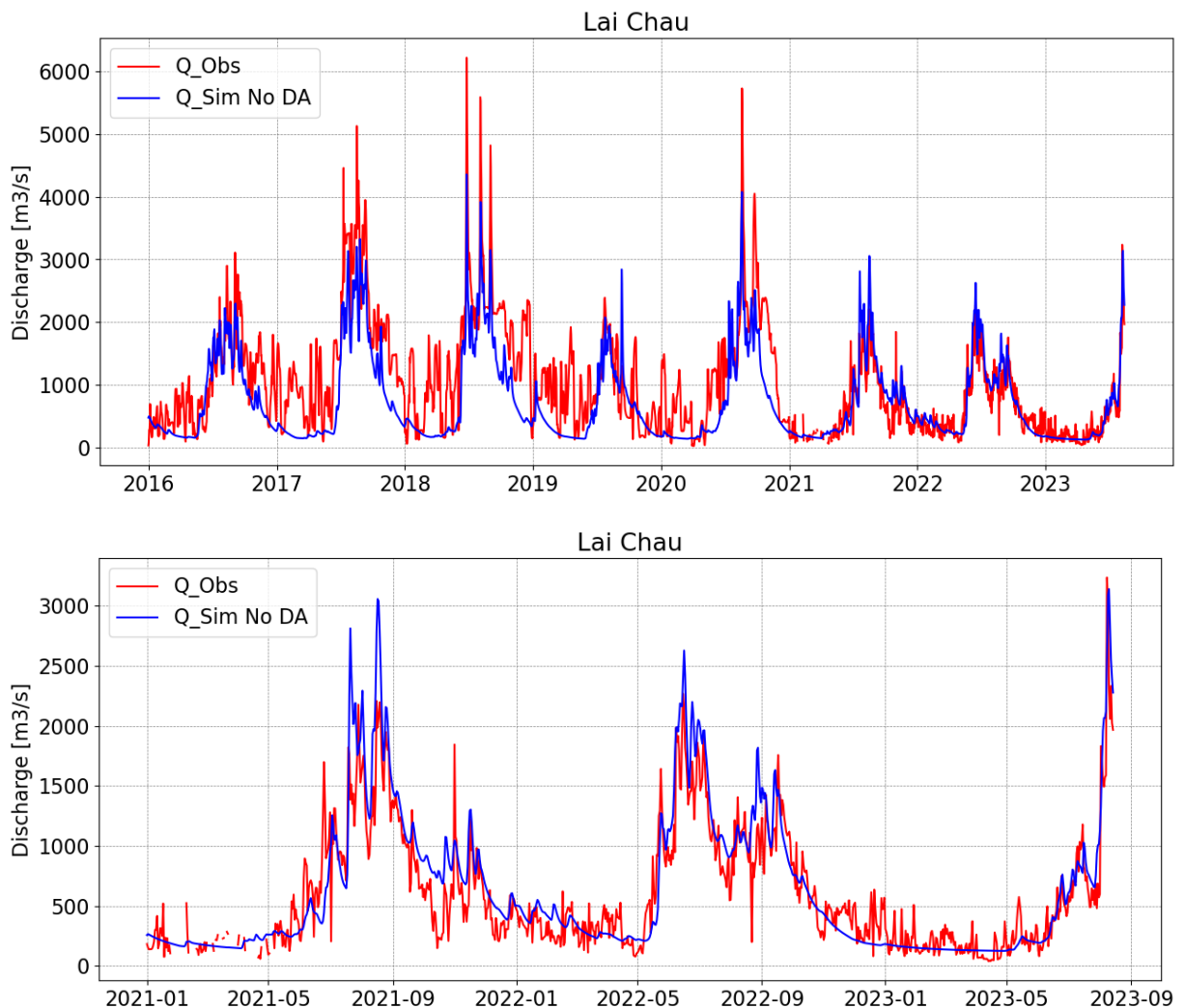


Figure 4.8 Observed flows at Lai Chau vs simulated flows (Model node: N45) without data assimilation for a 7.5- year period (top panel) and for the last 2.5 years (lower panel).

The difference between the results of the two simulation is illustrated in Figure 4.10. The small spikes in the grey curve are traces of the times where the reservoir conditions have been assimilated to Earth observations estimates of the reservoir water levels. At these dates the simulated reservoir water levels are forced down to the observed ones resulting in water being removed from the model, which should not have been the case.

It should be noted that the operation policies of the Chinese reservoirs are not known and that differences between assumed and actual rule curves contribute to such problems.

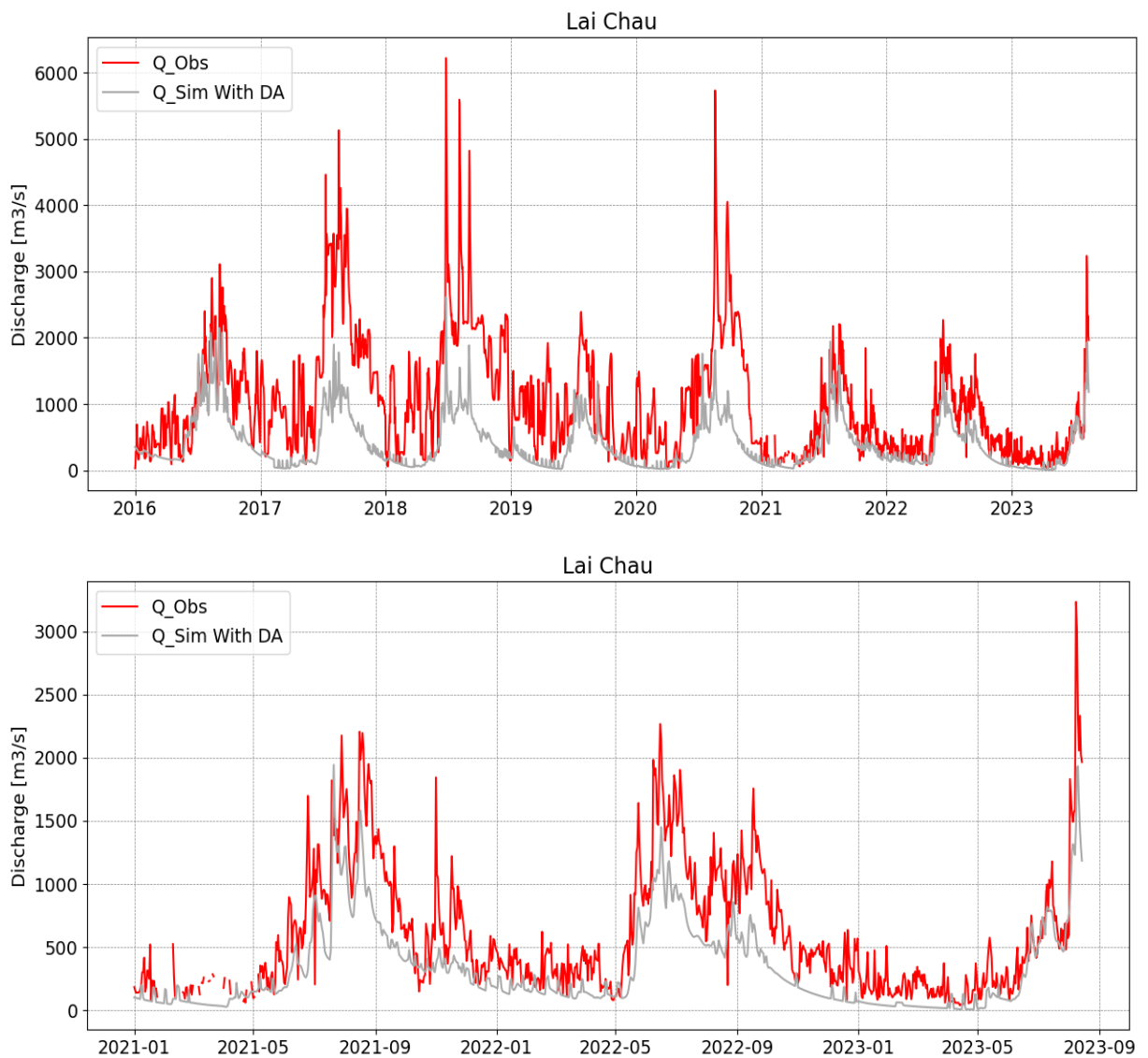


Figure 4.9 Observed flows at Lai Chau vs simulated flows (Model node: N45) with data assimilation for a 7.5- year period (top panel) and for the last 2.5 years (lower panel).

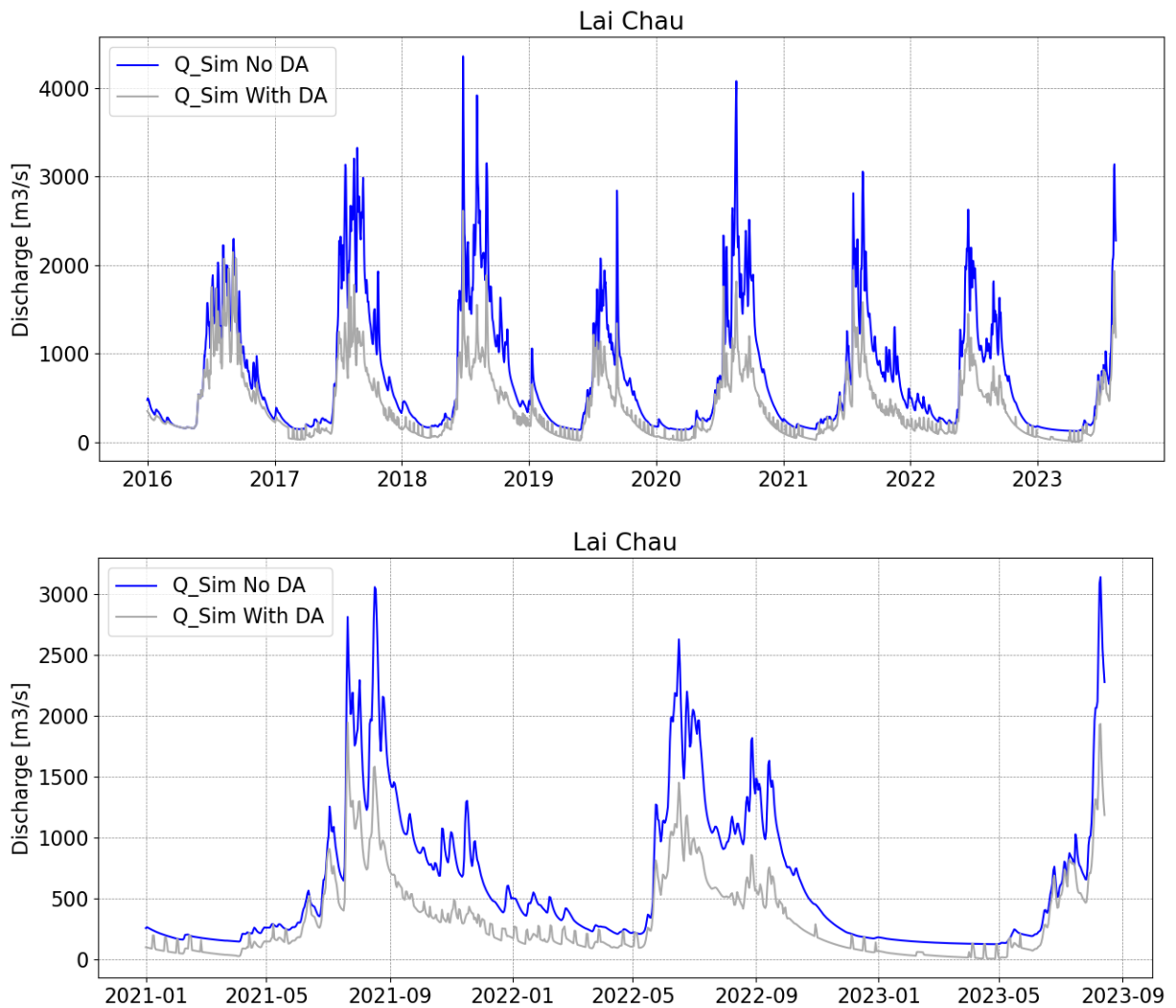


Figure 4.10 Comparison of simulations at Lai Chau with (grey line) and without data assimilation (blue line).

The EO observation technology for detection of reservoir levels is in rapid development and has already improved markedly since the establishment of the model. Since the modelled flows without data assimilation is actually very good it is therefore recommended to put larger emphasis on these and to revisit the model's assumed operation rules after some years of operation where the data series of EO level observations and observed flows in Vietnam provides a better basis for understanding detecting the operation strategies.

4.2.2 Lao Cai Station

Also, at the Lao Cai Station the long-term simulation without data assimilation (Figure 4.11) shows a good and unbiased correspondence to the observations at the Lao Cai Gauging Station. The low-flow estimation is good but the simulation of the wet season hydrograph in 2023 is a bit delayed.

Again, the accuracy drops when introducing data assimilation as clearly indicated in Figure 4.12 and Figure 4.13.

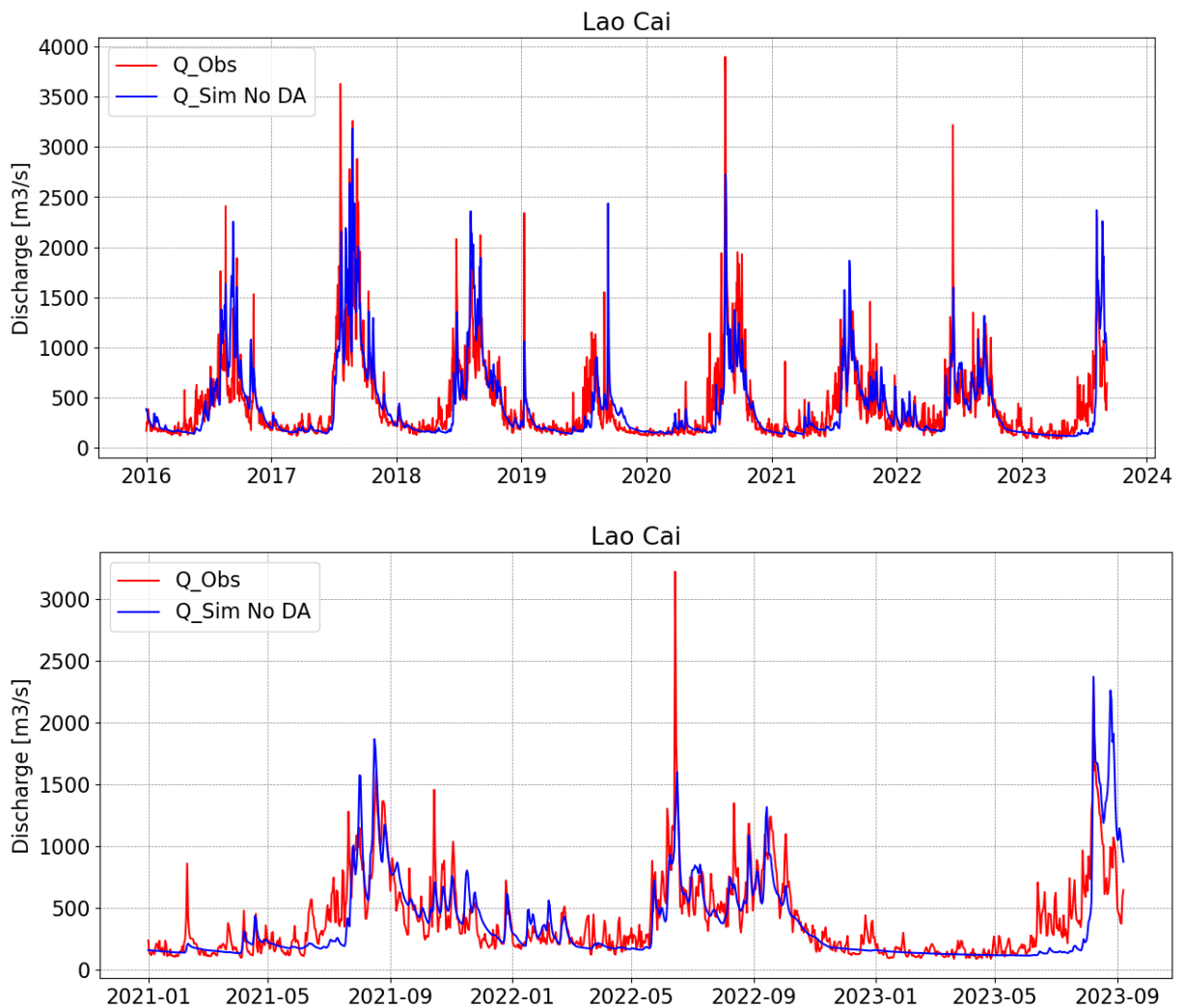


Figure 4.11 Observed flows at Lao Cai vs simulated flows (Model node: N34) without data assimilation for a 7.5- year period (top panel) and for the last 2.5 years (lower panel).

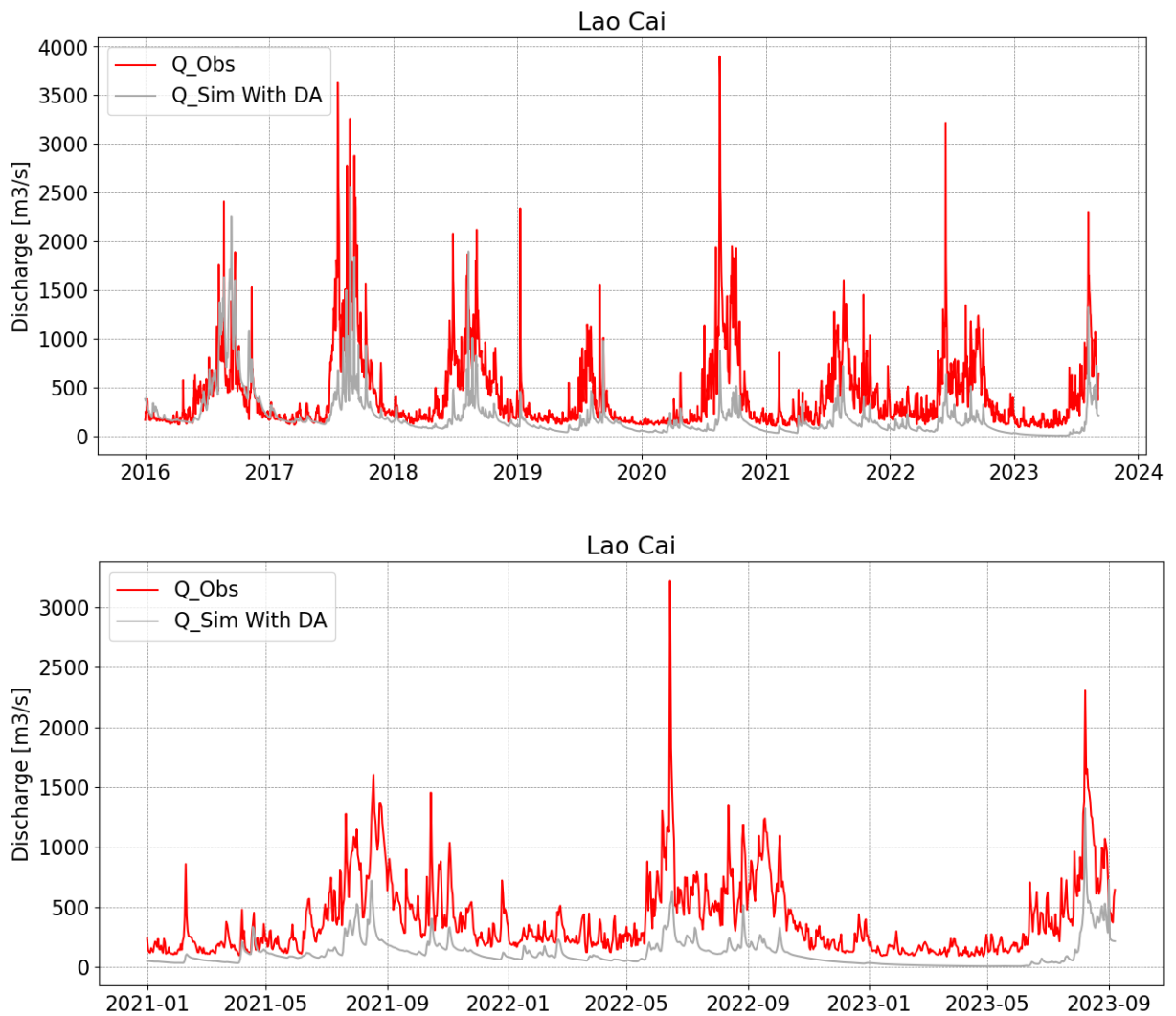


Figure 4.12 Observed flows at Lao Cai vs simulated flows (Model node: N34) with data assimilation for a 7.5- year period (top panel) and for the last 2.5 years (lower panel).

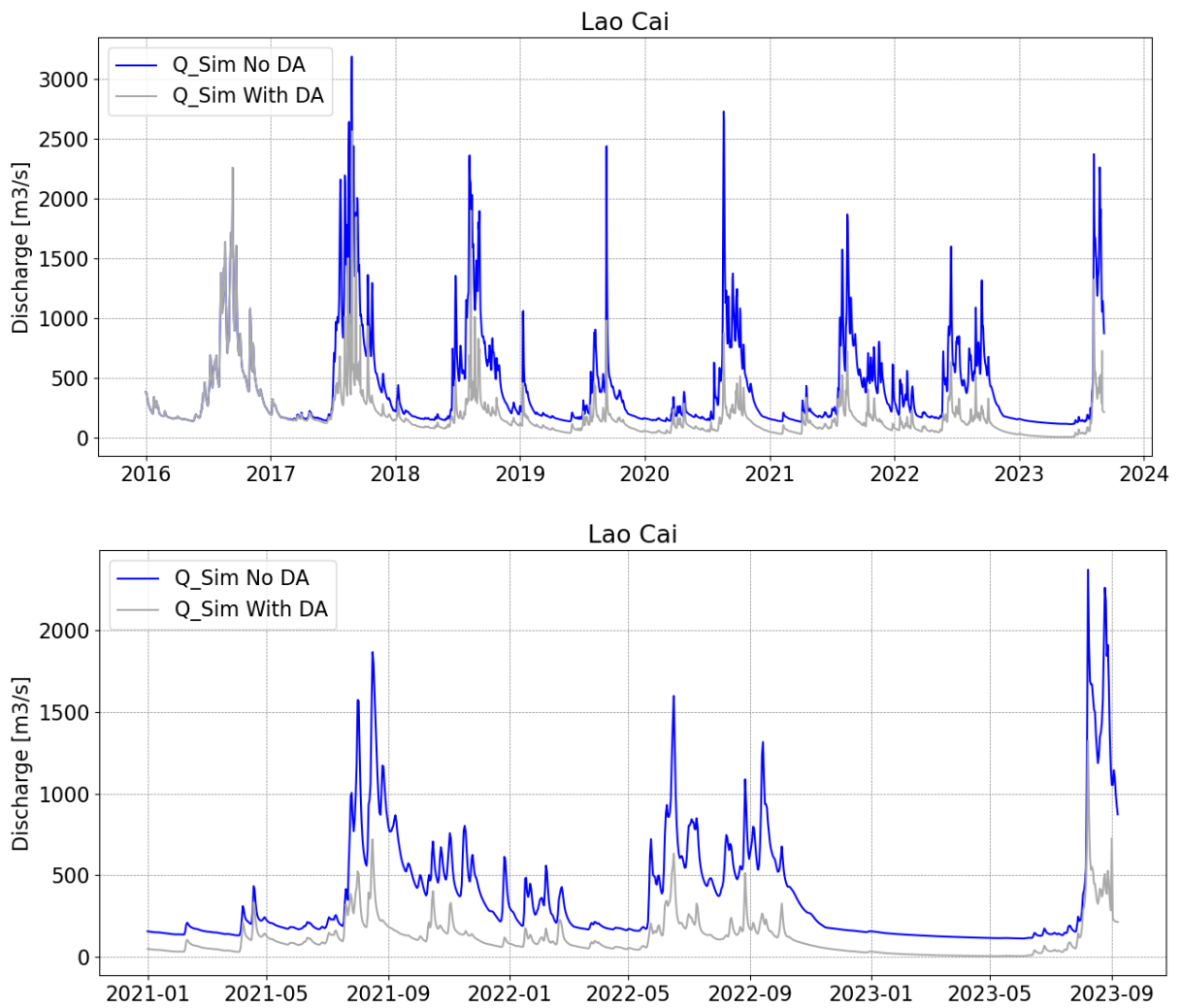


Figure 4.13 Comparison of simulations at Lao Cai with (grey line) and without data assimilation (blue line).

4.2.3 Dao Duc Station

At the Dao Duc Station the long-term simulation without data assimilation also shows a better performance than the results received from NAWAPI. However, at this station the improvement is not as large as in the cases of Lai Chau and Lao Cai. This is probably partly due to the fact that a larger fraction of the catchment of the Dao Duc Station is unregulated (as compared to the situation at the two other stations).

As explained above, the calibration of the model at the Dao Duc Station for the later years of the station records is not as good as for the earlier period, and this certainly also has a bearing on the results.

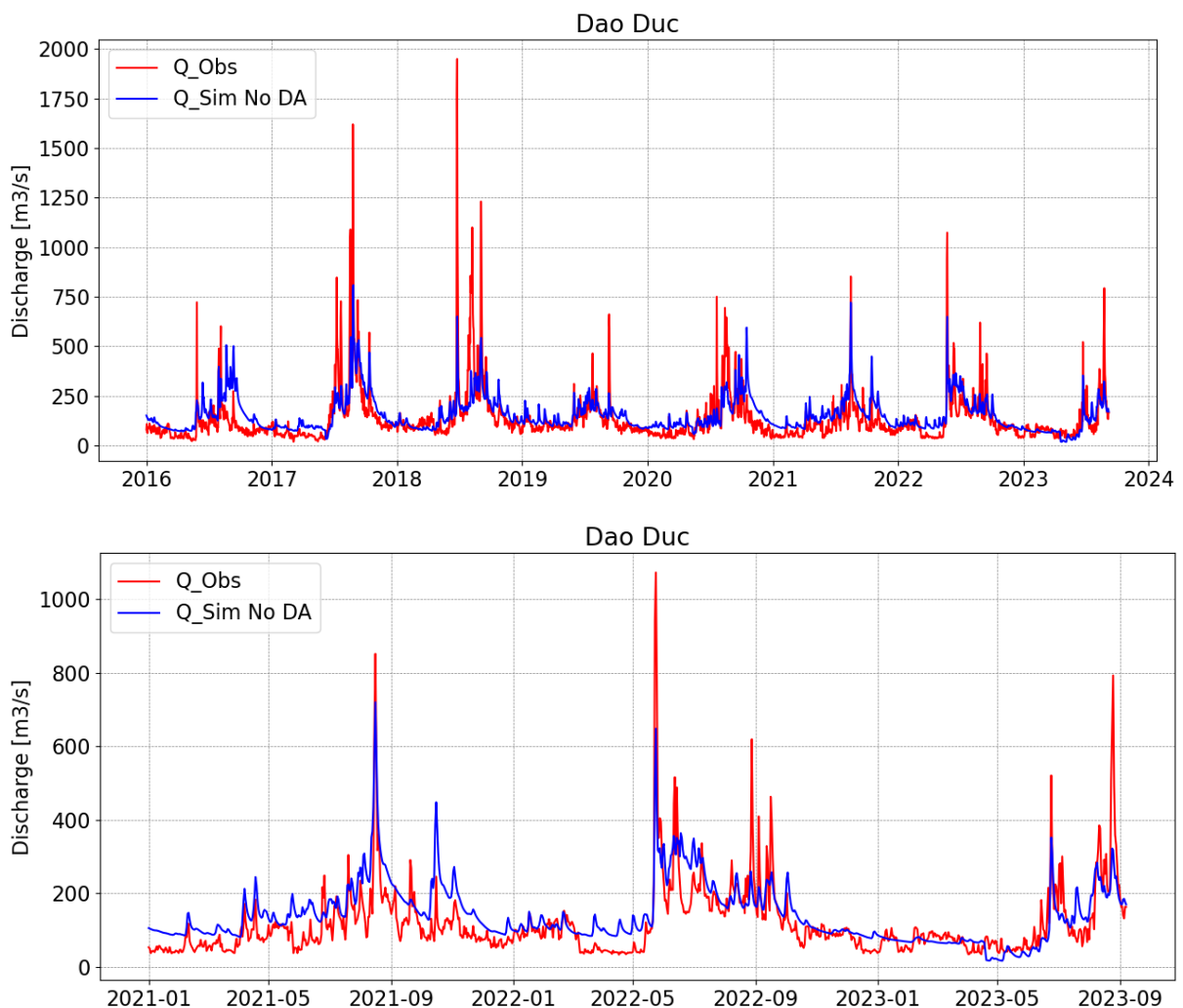


Figure 4.14 Observed flows at Dao Duc vs. simulated flows (Model node: N55) without data assimilation for a 7.5- year period (top panel) and for the last 2.5 years (lower panel).

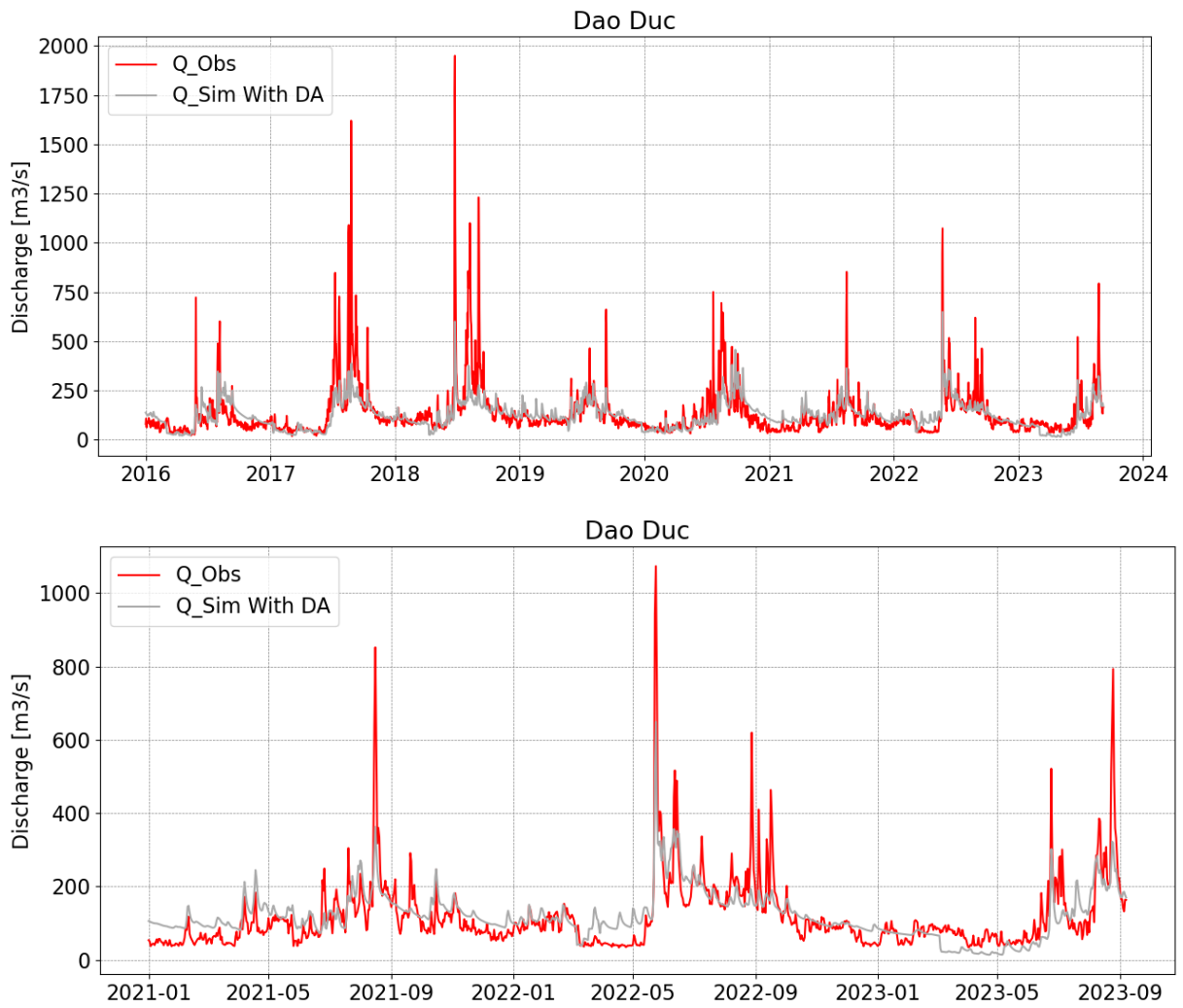


Figure 4.15 Observed flows at Dao Duc vs. simulated flows (Model node: N34) with data assimilation for a 7.5-year period (top panel) and for the last 2.5 years (lower panel).

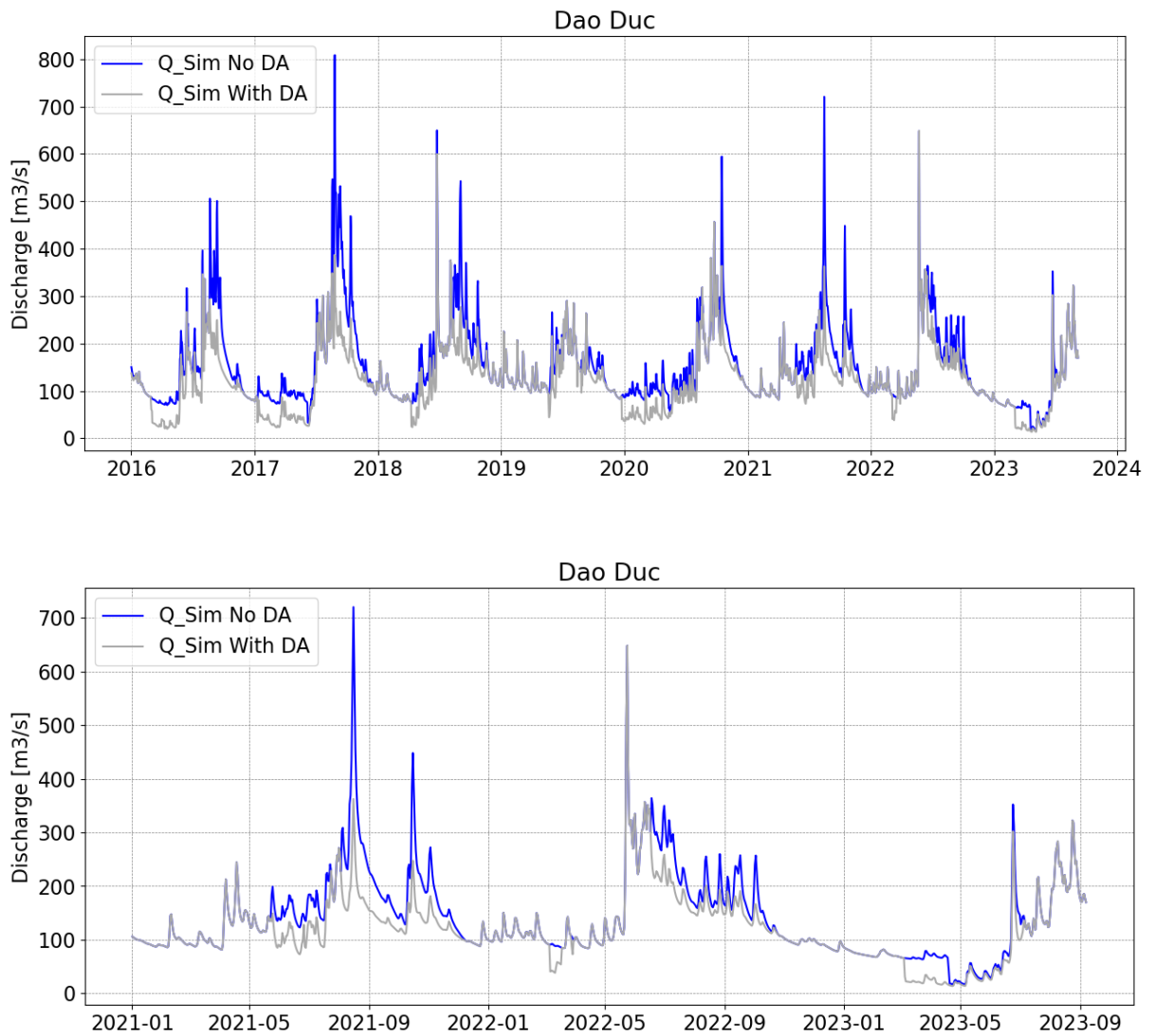


Figure 4.16 Comparison of simulations at Lao Cai with (grey line) and without data assimilation (blue line).

5 Conclusions and recommendations

Long term simulations with the model have been made without data assimilation.

These simulations included both the Calibration period and the additional years up to middle of 2023 (additional flow data and the 6-month test period) that was not part of the calibration, and that therefore can be seen as a new validation period.

On the main rivers (at Lai Chau on the Da River and Lao Cai on the Hong River) the system provides very good results during the latest years and the test period. Together, these two stations account for the largest part for the transboundary inflow to the Basin and the model performance at these locations during the hindcast period corresponds to the good calibration results previously reported.

When activating the model's assimilation to the earth observations of water levels and surface areas of the reservoirs in China the simulation accuracy of the model decreases.

This means that the biases observed during the test period is neither due to initial conditions nor to the input from the hydrological inflows to the water resources model (MIKE HYDRO Basin) but stems from the data assimilation in the reservoirs.

The download and processing of the earth observations of water levels have been checked and works like it is supposed to.

In this context it must be realised, that the operation rules used for the reservoirs are not known and the earth observations available at the time of the model calibration were not sufficiently accurate to generate consistent operation rules (if such rules exist). The EO assessment of reservoir characteristics has imbedded uncertainty. Due to this uncertainty and to the short observations' records, particularly the flood control levels and the assumed rule curves for reservoir operation, could only be roughly assessed at the time of model establishment and such rules may even change over time.

For the reservoir assimilation to work properly the operation rules must be consistent with the observed levels.

However, the technology for EO observations of reservoir water levels is undergoing rapid development and has even improved significantly during the course of this project. We therefore recommend revisiting the reservoir operation rules again after some years of system operation when longer and more precise records of observations have been obtained.

Until then, we recommend running the system without data assimilation which gives very good results, not least for the main rivers, and in parallel run an exact copy of the system with data assimilation in order to benefit from the results of this when the routines are revisited.

At the Dao Duc station a difference in model performance during peak flows has been identified between the validation and the calibration period. We recommend revisiting the rating curve of the station to identify if the rating curve of the station has changed and correcting the rating if necessary. If the observed data are confirmed to be representative, the model calibration may be adjusted by increasing the runoff coefficients, shorten the routing of the over land flow and/or adjusting the flood control level at the Malutang Reservoir.

Adjustments have been made in MIKE Workbench so the Flow Forecasting System now automatically runs two simulations in parallel: one without data assimilation (recommended for reference at this stage) and one with data assimilations (go gain experience with the data assimilation for later improvement).

6 References

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Appendix A Testing protocol template

The established technology was tested during Activity 4.3 using this template with testing requirements including a task's component, action, and success criteria. All tasks are evaluated on their importance in three categories, low, medium, and high. It is expected that the success criteria of each action is checked during the review of the system.

	Component	Action	Success criteria	Importance	Checked?
Hindcast	Input data	Retrieve latest rainfall data, hindcast	Job runs successfully daily	Medium	
	Input data	Retrieve latest temperature data, hindcast	Job runs successfully daily	Medium	
	Input data	Retrieve latest potential evaporation data, hindcast	Job runs successfully daily	Medium	
	NAM execution	Run NAM module, hindcast	Job runs successfully daily	Medium	
	Routing execution	Run Routing module, hindcast	Job runs successfully daily	Medium	
	Hotstart handing	Pre-processing and post-processing, hindcast	Job runs successfully daily	Medium	
	Data postprocessing	Store data and extract model timeseries, hindcast	Job runs successfully daily	Medium	
	Data import to database	Import model timeseries to MIKE Workbench database, hindcast	Job runs successfully daily	Medium	
Medium range forecast	Input data	Retrieve latest rainfall data, gfs forecast	Job runs successfully daily	High	
	Input data	Retrieve latest temperature data, gfs forecast	Job runs successfully daily	High	
	Input data	Retrieve latest potential evaporation data, gfs forecast	Job runs successfully daily	High	
	NAM execution	Run NAM module, gfs forecast	Job runs successfully daily	High	
	Routing execution	Run Routing module, gfs forecast	Job runs successfully daily	High	

	Component	Action	Success criteria	Importance	Checked?
	Hotstart handing	Pre-processing and post-processing, gfs forecast	Job runs successfully daily	High	
	Data postprocessing	Extract model timeseries, gfs forecast	Job runs successfully daily	High	
	Data import to database	Import model timeseries to MIKE Workbench database, gfs forecast	Job runs successfully daily	High	
	MHB Model	Run model, gfs forecast	Job runs successfully daily	High	
Seasonal forecast	Input data	Retrieve latest rainfall data, cfs forecast	Job runs successfully daily	High	
	Input data	Retrieve latest temperature data, cfs forecast	Job runs successfully daily	High	
	Input data	Retrieve latest potential evaporation data, cfs forecast	Job runs successfully daily	High	
	NAM execution	Run NAM module, cfs forecast	Job runs successfully daily	High	
	Routing execution	Run Routing module, cfs forecast	Job runs successfully daily	High	
	Hotstart handing	Pre-processing and post-processing, cfs forecast	Job runs successfully daily	High	
	Data postprocessing	Extract model timeseries, cfs forecast	Job runs successfully daily	High	
	Data import to database	Import model timeseries to MIKE Workbench database, cfs forecast	Job runs successfully daily	High	
	MHB Model	Run model, cfs forecast	Job runs successfully daily	High	
Maintenance	Maintenance	Clean up on database and disk	Job runs successfully daily	High	
	Data base backup	Create backup and handle archive	Job runs successfully weekly	High	

	Component	Action	Success criteria	Importance	Checked?
	Reporting	Send email with job and simulation overview	Job runs successfully daily	Medium	
Model output	Model inputs	Timeseries extraction and accumulation	Data is processed and used by the model.	High	
	Model inputs	Naming of timeseries	Naming convention is met, and data can be found by scripts	High	
	Model outputs	Compare model outputs with observed data	Performance indicators are met	High	

Appendix B Submitted testing protocols

Localization of water resources management technology to adapt to climate change in the Hong-Thai Binh River basin

SYSTEM TESTING PROTOCOL

The established technology should be thoroughly tested during Activity 4.3 from April 2023 to October 2023 (project closes). The test protocol below outlines testing requirements and strategy by including a task's component, action, and success criteria. Furthermore, all tasks are evaluated on their importance in three categories, low, medium, and high. It is expected that the success criteria of each action to be checked during the review of the system.

Time test (1/July – 15/July/2023)

	Component	Action	Success criteria	Importance	Checked?
Hindcast	Input data	Retrieve latest rainfall data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest temperature data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest potential evaporation data, hindcast	Job runs successfully daily	Medium	Completed
	NAM execution	Run NAM module, hindcast	Job runs successfully daily	Medium	Completed 13/15 days (3,4,7 Job stop at step Run Nam)
	Routing execution	Run Routing module, hindcast	Job runs successfully daily	Medium	Completed 13/15 days (3,4,7 Job stop at step Run Nam)
	Hotstart handing	Pre-processing and post-processing, hindcast	Job runs successfully daily	Medium	Completed 13/15 days (3,4,7 Job stop at step Run Nam)
	Data postprocessing	Store data and extract model timeseries, hindcast	Job runs successfully daily	Medium	Completed 13/15 days (3,4,7 Job stop at step Run Nam)
	Data import to database	Import model timeseries to MIKE Workbench database, hindcast	Job runs successfully daily	Medium	Completed 13/15 days (3,4,7 Job stop at step Run Nam)

	Component	Action	Success criteria	Importance	Checked?
Medium range forecast	Input data	Retrieve latest rainfall data, gfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest temperature data, gfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, gfs forecast	Job runs successfully daily	High	Completed
	NAM execution	Run NAM module, gfs forecast	Job runs successfully daily	High	Completed 14/15 days (3/7 Job stop at step Run Nam)
	Routing execution	Run Routing module, gfs forecast	Job runs successfully daily	High	Completed with error*
	Hotstart handing	Pre-processing and post-processing, gfs forecast	Job runs successfully daily	High	Completed with error*
	Data postprocessing	Extract model timeseries, gfs forecast	Job runs successfully daily	High	Completed with error*
	Data import to database	Import model timeseries to MIKE Workbench database, gfs forecast	Job runs successfully daily	High	Completed with error*
	MHB Model	Run model, gfs forecast	Job runs successfully daily	High	Completed with error*
Seasonal forecast	Input data	Retrieve latest rainfall data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest temperature data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, cfs forecast	Job runs successfully daily	High	Completed

* Completed with error – NAM in the 1a, 1b, 1c broken but the next step for running 2a, 2b is can running without error

	Component	Action	Success criteria	Importance	Checked?
	NAM execution	Run NAM module, cfs forecast	Job runs successfully daily	High	Completed 12/15 days (3,4,5/7 Job stop at step Run Nam)
	Routing execution	Run Routing module, cfs forecast	Job runs successfully daily	High	Completed with error*
	Hotstart handing	Pre-processing and post-processing, cfs forecast	Job runs successfully daily	High	Completed with error*
	Data postprocessing	Extract model timeseries, cfs forecast	Job runs successfully daily	High	Completed with error*
	Data import to database	Import model timeseries to MIKE Workbench database, cfs forecast	Job runs successfully daily	High	Completed with error*
	MHB Model	Run model, cfs forecast	Job runs successfully daily	High	Completed with error*
Maintenance	Maintenance	Clean up on database and disk	Job runs successfully daily	High	Completed
	Data base backup	Create backup and handle archive	Job runs successfully weekly	High	Completed
	Reporting	Send email with job and simulation overview	Job runs successfully daily	Medium	Need Jannick fix it.
Model output	Model inputs	Timeseries extraction and accumulation	Data is processed and used by the model.	High	Checking with Mr. Bach
	Model inputs	Naming of timeseries	Naming convention is met, and data can be found by scripts	High	Checking with Mr. Bach
	Model outputs	Compare model outputs with observed data	Performance indicators are met	High	Checking with Mr. Bach

Localization of water resources management technology to adapt to climate change in the Hong-Thai Binh River basin

SYSTEM TESTING PROTOCOL

The established technology should be thoroughly tested during Activity 4.3 from April 2023 to October 2023 (project closes). The test protocol below outlines testing requirements and strategy by including a task's component, action, and success criteria. Furthermore, all tasks are evaluated on their importance in three categories, low, medium, and high. It is expected that the success criteria of each action to be checked during the review of the system.

Time test (15/July – 30/July/2023)

	Component	Action	Success criteria	Importance	Checked?
Hindcast	Input data	Retrieve latest rainfall data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest temperature data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest potential evaporation data, hindcast	Job runs successfully daily	Medium	Completed
	NAM execution	Run NAM module, hindcast	Job runs successfully daily	Medium	Completed
	Routing execution	Run Routing module, hindcast	Job runs successfully daily	Medium	Completed
	Hotstart handing	Pre-processing and post-processing, hindcast	Job runs successfully daily	Medium	Completed
	Data postprocessing	Store data and extract model timeseries, hindcast	Job runs successfully daily	Medium	Completed
	Data import to database	Import model timeseries to MIKE Workbench database, hindcast	Job runs successfully daily	Medium	Completed
Medium range forecast	Input data	Retrieve latest rainfall data, gfs forecast	Job runs successfully daily	High	Completed

10/08/2023

1/3

	Component	Action	Success criteria	Importance	Checked?
	Input data	Retrieve latest temperature data, gfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, gfs forecast	Job runs successfully daily	High	Completed
	NAM execution	Run NAM module, gfs forecast	Job runs successfully daily	High	Completed
	Routing execution	Run Routing module, gfs forecast	Job runs successfully daily	High	Completed
	Hotstart handing	Pre-processing and post-processing, gfs forecast	Job runs successfully daily	High	Completed
	Data postprocessing	Extract model timeseries, gfs forecast	Job runs successfully daily	High	Completed
	Data import to database	Import model timeseries to MIKE Workbench database, gfs forecast	Job runs successfully daily	High	Completed
	MHB Model	Run model, gfs forecast	Job runs successfully daily	High	Completed with error*
Seasonal forecast	Input data	Retrieve latest rainfall data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest temperature data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, cfs forecast	Job runs successfully daily	High	Completed
	NAM execution	Run NAM module, cfs forecast	Job runs successfully daily	High	Completed
	Routing execution	Run Routing module, cfs forecast	Job runs successfully daily	High	Completed

10/08/2023

2/3

	Component	Action	Success criteria	Importance	Checked?
	Hotstart handing	Pre-processing and post-processing, cfs forecast	Job runs successfully daily	High	Completed
	Data postprocessing	Extract model timeseries, cfs forecast	Job runs successfully daily	High	Completed
	Data import to database	Import model timeseries to MIKE Workbench database, cfs forecast	Job runs successfully daily	High	Completed
	MHB Model	Run model, cfs forecast	Job runs successfully daily	High	Completed
Maintenance	Maintenance	Clean up on database and disk	Job runs successfully daily	High	Completed
	Data base backup	Create backup and handle archive	Job runs successfully weekly	High	Completed
	Reporting	Send email with job and simulation overview	Job runs successfully daily	Medium	Need Jannick fix it.
Model output	Model inputs	Timeseries extraction and accumulation	Data is processed and used by the model.	High	Checking with Mr. Bach
	Model inputs	Naming of timeseries	Naming convention is met, and data can be found by scripts	High	Checking with Mr. Bach
	Model outputs	Compare model outputs with observed data	Performance indicators are met	High	Checking with Mr. Bach

* Completed with error – NAM in the 1a, 1b, 1c broken but the next step for running 2a, 2b is can running without error

Localization of water resources management technology to adapt to climate change in the Hong-Thai Binh River basin

SYSTEM TESTING PROTOCOL

The established technology should be thoroughly tested during Activity 4.3 from April 2023 to October 2023 (project closes). The test protocol below outlines testing requirements and strategy by including a task's component, action, and success criteria. Furthermore, all tasks are evaluated on their importance in three categories, low, medium, and high. It is expected that the success criteria of each action to be checked during the review of the system.

	Component	Action	Success criteria	Importance	Checked?
Hindcast	Input data	Retrieve latest rainfall data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest temperature data, hindcast	Job runs successfully daily	Medium	Completed
	Input data	Retrieve latest potential evaporation data, hindcast	Job runs successfully daily	Medium	Completed
	NAM execution	Run NAM module, hindcast	Job runs successfully daily	Medium	Completed 27/30 days (21,22,27/6 Job stop at step Run Nam)
	Routing execution	Run Routing module, hindcast	Job runs successfully daily	Medium	Completed 27/30 days (21,22,27/6 Job stop at step Run Nam)
	Hotstart handing	Pre-processing and post-processing, hindcast	Job runs successfully daily	Medium	Completed 27/30 days (21,22,27/6 Job stop at step Run Nam)
	Data postprocessing	Store data and extract model timeseries, hindcast	Job runs successfully daily	Medium	Completed 27/30 days (21,22,27/6 Job stop at step Run Nam)
	Data import to database	Import model timeseries to MIKE Workbench database, hindcast	Job runs successfully daily	Medium	Completed 27/30 days (21,22,27/6 Job stop at step Run Nam)

	Component	Action	Success criteria	Importance	Checked?
Medium range forecast	Input data	Retrieve latest rainfall data, gfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest temperature data, gfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, gfs forecast	Job runs successfully daily	High	Completed
	NAM execution	Run NAM module, gfs forecast	Job runs successfully daily	High	Completed with error*
	Routing execution	Run Routing module, gfs forecast	Job runs successfully daily	High	Completed with error*
	Hotstart handing	Pre-processing and post-processing, gfs forecast	Job runs successfully daily	High	Completed with error*
	Data postprocessing	Extract model timeseries, gfs forecast	Job runs successfully daily	High	Completed with error*
	Data import to database	Import model timeseries to MIKE Workbench database, gfs forecast	Job runs successfully daily	High	Completed with error*
	MHB Model	Run model, gfs forecast	Job runs successfully daily	High	Completed with error*
Seasonal forecast	Input data	Retrieve latest rainfall data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest temperature data, cfs forecast	Job runs successfully daily	High	Completed
	Input data	Retrieve latest potential evaporation data, cfs forecast	Job runs successfully daily	High	Completed
	NAM execution	Run NAM module, cfs forecast	Job runs successfully daily	High	Completed with error*

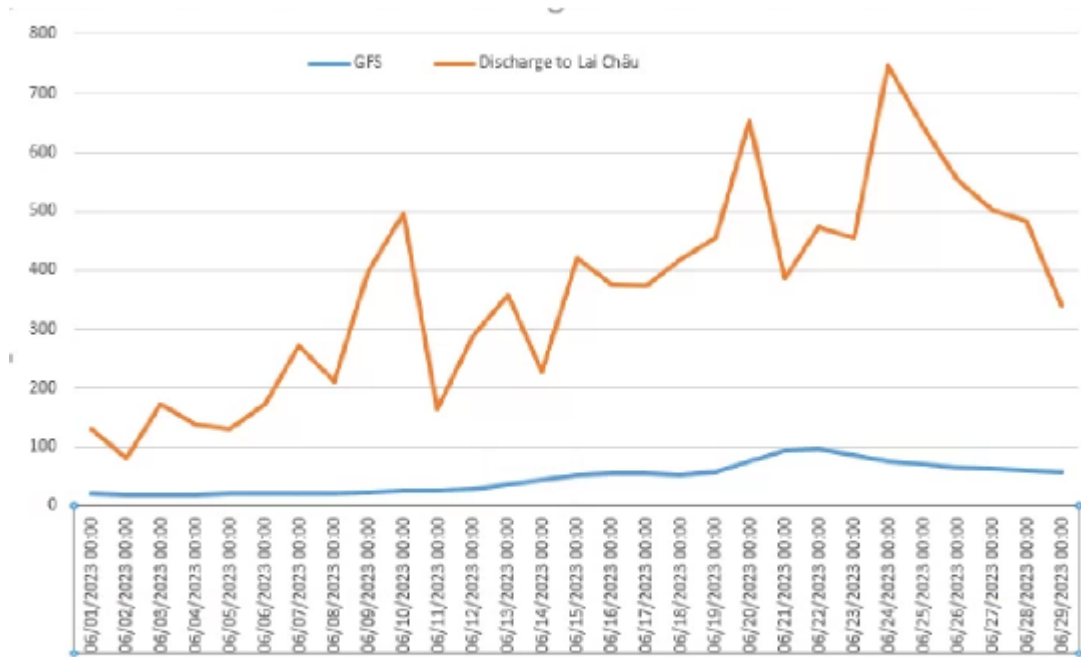
23/06/2023

2/3

	Component	Action	Success criteria	Importance	Checked?
	Routing execution	Run Routing module, cfs forecast	Job runs successfully daily	High	Completed with error*
	Hotstart handing	Pre-processing and post-processing, cfs forecast	Job runs successfully daily	High	Completed with error*
	Data postprocessing	Extract model timeseries, cfs forecast	Job runs successfully daily	High	Completed with error*
	Data import to database	Import model timeseries to MIKE Workbench database, cfs forecast	Job runs successfully daily	High	Completed with error*
	MHB Model	Run model, cfs forecast	Job runs successfully daily	High	Completed with error*
Maintenance	Maintenance	Clean up on database and disk	Job runs successfully daily	High	Completed
	Data base backup	Create backup and handle archive	Job runs successfully weekly	High	Completed
	Reporting	Send email with job and simulation overview	Job runs successfully daily	Medium	Need Jannick fix it.
Model output	Model inputs	Timeseries extraction and accumulation	Data is processed and used by the model.	High	Checking with Mr. Bach
	Model inputs	Naming of timeseries	Naming convention is met, and data can be found by scripts	High	Checking with Mr. Bach
	Model outputs	Compare model outputs with observed data	Performance indicators are met	High	Checking with Mr. Bach

* Completed with error – NAM in the 1a broken but the next step for running 1b, 1c, 2a, 2b is can running without error

Compare model GFS outputs with observed data



Compare model CFS outputs with observed data

I have question about this, In site the data table result of CFS have 20 case can appear in real. We should compare with which data? Average of 20 cases or per case in 20 cases?

Appendix C LAV curve for reservoirs in China

Gelantan			Jupudu		
Level (m)	Area (km ²)	Volume	Level (m)	Area (km ²)	Volume
371	0.02827	0.068532	458	0.0359794	0.125928
376	0.098515	0.423187	463	0.129355	0.560251
381	0.205597	1.213877	468	0.258709	1.60108
386	0.378641	2.689033	473	0.421473	3.35808
391	0.617647	5.244429	478	0.627927	6.06168
396	0.943175	9.324666	483	0.917475	10.0323
401	1.295259	15.02141	488	1.28669	15.7504
406	1.719302	22.72272	493	1.73301	23.45
411	2.158765	32.6479	498	2.23672	33.627
416	2.678753	44.96057	503	2.82781	46.5599
421	3.29126	60.19442	508	3.48829	62.7233
426	3.8952	78.42314	513	4.20017	82.344
431	4.571956	99.92684	518	4.87864	105.397
436	5.303538	124.9231	523	5.48343	131.668
441	6.078808	153.7401	528	6.05654	160.85
446	6.878065	186.4985	533	6.53112	192.545
451	7.776694	223.5264	538	7.01941	226.676
456	8.748138	265.3559	543	7.45716	263.097
461	9.6639	311.8225	548	7.89063	301.696
466	10.54197	362.7111	553	8.25214	342.279
471	11.38834	418.0449	558	8.64363	384.717
476	12.23129	477.5548	563	8.95459	428.874
481	13.01427	541.0688	568	9.22786	474.448
486	13.77926	608.424	573	9.48058	521.414
491	14.44574	679.318	578	9.70245	569.462
496	15.08052	753.4767	583	9.82495	618.356
501	15.63734	830.6217	588	9.93632	667.839
506	16.12563	910.3384	593	10.0228	717.802
511	16.50342	992.141	598	10.0717	768.06
516	16.82123	1075.613	603	10.1162	818.576
521	17.08594	1160.528	608	10.1342	869.205
526	17.28468	1246.605	613	10.1462	919.915

Longma			Yayangshan		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
531	0.038549	0.114791	769	0.01028	7.905192
536	0.115648	0.511422	774	0.016276	7.969441
541	0.239006	1.477726	779	0.047973	8.126209
546	0.358081	2.999141	784	0.182467	8.694169
551	0.521702	5.280408	789	0.542261	10.55653
556	0.765848	8.593941	794	1.183038	15.1499
561	1.097372	13.37235	799	1.978868	23.44744
566	1.506852	20.03625	804	2.707023	35.51854
571	1.978868	28.95144	809	3.490004	51.37433
576	2.46459	40.25497	814	4.440888	71.57763
581	2.922043	53.94086	819	5.493714	96.89257
586	3.482294	70.2224	824	6.62364	127.7141
591	4.061391	89.2598	829	7.756135	164.1492
596	4.722727	111.5413	834	8.890343	206.2829
601	5.410619	137.2452	839	9.848081	253.6592
606	6.117358	166.4451	844	10.63192	305.2845
611	6.859219	199.2446	849	11.34894	360.6765
616	7.620783	235.7997	854	12.02227	419.4472
621	8.397767	276.2388	859	12.57052	481.2444
626	9.223581	320.6974	864	13.00313	545.412
631	10.07338	369.2867	869	13.31924	611.388
636	11.01142	422.4446	874	13.54625	678.7037
641	11.97943	480.3115	879	13.71844	746.9755
646	13.05967	543.4717	884	13.81867	815.8976
651	14.20159	612.2138	889	13.89148	885.2136
656	15.24671	686.3245	894	13.93774	954.8252
661	16.18902	765.4613	899	13.9643	1024.598
666	17.06195	849.0354	904	13.99771	1094.508
671	17.89633	936.9572	909	14.01227	1164.548
676	18.63306	1028.726	914	14.02426	1234.648
681	19.30981	1123.97	919	14.03026	1304.788
686	19.89148	1222.259	924	14.0354	1374.955
691	20.38148	1323.202	929	14.04054	1445.142
696	20.7764	1426.371	934	14.04568	1515.359
701	21.12334	1531.319	939	14.04825	1585.599

Longma			Yayangshan		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
706	21.40347	1637.791	944	14.05253	1655.852
711	21.64333	1745.534			
716	21.82409	1854.318			
721	21.97828	1963.895			
726	22.10935	2074.169			
731	22.20273	2185.016			
736	22.27897	2296.262			
741	22.33208	2407.821			
746	22.36806	2519.577			
751	22.3989	2631.506			

Sinanjiang			Shimenkan		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
814	0.026556	0.096802	675	0.001713	0.001713
819	0.083952	0.38892	680	0.037693	0.089949
824	0.166191	1.04169	685	0.177327	0.657909
829	0.270702	2.178468	690	0.341804	2.030267
834	0.411193	3.93889	695	0.574814	4.390346
839	0.631353	6.627066	700	0.807824	7.915472
844	0.896915	10.55739	705	1.144488	12.96287
849	1.262706	16.13249	710	1.508566	19.70987
854	1.618217	23.47143	715	1.900913	28.4186
859	2.086806	32.90403	720	2.248714	38.9126
864	2.558822	44.78324	725	2.659907	51.42058
869	3.047971	59.02252	730	3.054824	65.91087
874	3.578239	75.82834	735	3.451454	82.36888
879	4.111933	95.33175	740	3.986006	101.1416
884	4.792972	117.92	745	4.529123	122.7129
889	5.480008	143.8509	750	5.082521	147.0256
894	6.316101	173.7129	755	5.581093	173.9476
899	7.130778	207.7751	760	6.067672	203.3702
904	7.947168	245.9073	765	6.519128	235.1135
909	8.65562	287.8319	770	6.929465	268.9641
914	9.353792	333.2491	775	7.262702	304.6086
919	10.02455	382.038	780	7.569384	341.849

Sinanjiang			Shimenkan		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
924	10.64905	434.0703	785	7.822953	380.4455
929	11.22901	489.0999	790	8.008847	420.1488
934	11.73357	546.7869	795	8.151051	460.6642
939	12.17389	606.7672	800	8.24357	501.7176
944	12.52598	668.7683	805	8.302679	543.105
949	12.77869	732.1889	810	8.336945	584.7195
954	12.99542	796.7993	815	8.360075	626.4822
			820	8.376351	668.3408
			825	8.389201	710.2705
			830	8.391771	752.2251
			835	8.394341	794.196
			840	8.395197	836.1685
			845	8.395197	878.1445
			850	8.396054	920.1248
			855	8.396054	962.1051
			860	8.396911	1004.087
			865	8.396911	1046.072
			870	8.396911	1088.056
			875	8.396911	1130.041
			880	8.396911	1172.025
			885	8.396911	1214.01
			890	8.396911	1255.994

Puxiqiao			Nansha		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
617	0.01799	11.09965	207	0.006853	0.02056
622	0.035123	11.22986	212	0.035123	0.125928
627	0.069389	11.50399	217	0.105368	0.494289
632	0.136208	12.0531	222	0.368361	1.673043
637	0.251856	13.09479	227	0.940605	5.139917
642	0.39149	14.7627	232	1.660193	12.00171
647	0.587664	17.2864	237	2.330952	22.33551
652	0.794974	20.81752	242	3.152482	36.38119
657	1.02113	25.47857	247	4.074241	54.87375

Puxiqiao			Nansha		
Level (m)	Area (km2)	Volume	Level (m)	Area (km2)	Volume
662	1.267846	31.29781	252	4.979723	77.90401
667	1.538548	38.41403	257	5.987146	105.8523
672	1.899199	47.12533	262	7.044256	138.9499
677	2.276127	57.71784	267	8.127065	177.4959
682	2.735292	70.45969	272	9.03169	220.8896
687	3.286977	85.78436	277	9.714443	268.1854
692	3.884064	103.9831	282	10.38863	318.823
697	4.589946	125.4611	287	10.95659	372.4795
702	5.303538	150.4771	292	11.44745	428.7162
707	6.149054	179.5253	297	11.93317	487.4483
712	6.955164	212.7266	302	12.31267	548.2998
717	7.8161	250.1092	307	12.65362	610.8748
722	8.652193	291.7066	312	12.95259	675.1135
727	9.47972	337.4561	317	13.20702	740.6749
732	10.22244	387.1068	322	13.41347	807.3447
737	10.87178	440.2305			
742	11.49371	496.4963			
747	12.02055	555.5907			
752	12.52255	617.2715			
757	12.95173	681.188			
762	13.36293	747.2308			
767	13.69103	815.0666			
772	13.98914	884.4383			
777	14.25042	955.233			
782	14.47401	1027.185			
787	14.65562	1100.083			
792	14.82523	1173.897			
797	14.94002	1248.39			

Nalan			Malutang			Madushan		
Level (m)	Area (km ²)	Volume	Level (m)	Area (km ²)	Volume	Level (m)	Area (km ²)	Volume
334	0.006853	0.01542	494	0.009423	0.027413	150	0.099372	0.321245
339	0.051399	0.172187	499	0.048829	0.192747	155	0.257852	1.26442
344	0.144774	0.673329	504	0.128498	0.64763	160	0.627927	3.530266
349	0.292975	1.803254	509	0.254426	1.691889	165	1.169331	8.204164
354	0.442033	3.696457	514	0.449743	3.540546	170	1.970301	16.30553
359	0.6245	6.430893	519	0.636493	6.35979	175	2.915189	28.9009
364	0.83181	10.16162	524	0.860936	10.20873	180	3.991145	46.66959
369	1.097372	15.10964	529	1.066533	15.14562	185	5.145057	70.0425
374	1.356938	21.34093	534	1.255853	21.03168	190	6.437746	99.63472
379	1.716732	29.1973	539	1.496572	28.03396	195	7.733005	135.6364
384	2.091946	38.86976	544	1.761278	36.33322	200	9.355505	179.1038
389	2.46202	50.44314	549	1.999428	45.85748	205	11.5117	232.1169
394	2.88692	64.00139	554	2.336949	56.84491	210	14.06538	297.2508
399	3.30925	79.69355	559	2.653054	69.48825	215	16.6242	375.2559
404	3.856651	97.80748	564	3.006851	83.79435	220	19.04682	465.9429
409	4.50428	118.9951	569	3.409478	100.0356	225	20.76441	566.4857
414	5.273555	143.7575	574	3.831808	118.3389	230	22.13334	674.495
419	6.186747	172.9205	579	4.243001	138.7418	235	23.35664	788.9318
424	6.980007	206.3291	584	4.674754	161.2075	240	24.3692	908.8281
429	7.776694	243.6081	589	5.132207	185.9639	245	25.21386	1033.269
434	8.486003	284.6195	594	5.667615	213.1849	250	25.93688	1161.551
439	9.181605	329.0875	599	6.315244	243.3939	255	26.52283	1293.058
444	9.857504	377.0377	604	7.008277	277.0072	260	26.99484	1427.151
449	10.52141	428.3812	609	7.723582	314.1894	265	27.37263	1563.31
454	11.12792	482.7847	614	8.432033	355.026	270	27.67246	1701.049
459	11.71301	540.2387	619	9.094226	399.2225	275	27.95172	1840.231
464	12.25099	600.4245	624	9.775265	446.7487	280	28.1359	1980.56
469	12.72044	663.0647	629	10.42375	497.5979	285	28.27383	2121.615
474	13.10679	727.8996	634	10.97715	551.3589	290	28.39376	2263.321
479	13.47429	794.596	639	11.51256	607.8414	295	28.46657	2405.526
484	13.75185	862.8558	644	11.95716	666.7637	300	28.51455	2547.992
489	13.96515	932.273	649	12.36064	727.8062	305	28.57023	2690.729
494	14.1065	1002.566	654	12.70245	790.6683	310	28.59421	2833.658
			659	12.97572	855.0097	315	28.61734	2976.699
			664	13.19931	920.6019	320	28.63276	3119.823

Nalan			Malutang			Madushan		
Level (m)	Area (km ²)	Volume	Level (m)	Area (km ²)	Volume	Level (m)	Area (km ²)	Volume
			669	13.36892	987.145	325	28.64818	3263.039
			674	13.47087	1054.31	330	28.65589	3406.3
			679	13.5394	1121.882	150	0.099372	0.321245
			684	13.58309	1189.724	155	0.257852	1.26442
			689	13.60536	1257.711	160	0.627927	3.530266
			694	13.62763	1325.816	165	1.169331	8.204164
			699	13.63449	1393.975	170	1.970301	16.30553
			704	13.63963	1462.167	175	2.915189	28.9009
			709	13.64562	1530.382	180	3.991145	46.66959
			714	13.64991	1598.623	185	5.145057	70.0425
			719	13.65162	1666.875	190	6.437746	99.63472
			724	13.65162	1735.133	195	7.733005	135.6364
			729	13.65248	1803.393	200	9.355505	179.1038
			734	13.65248	1871.655	205	11.5117	232.1169
			739	13.65248	1939.918	210	14.06538	297.2508
			744	13.65248	2008.18	215	16.6242	375.2559
			749	13.65333	2076.447	220	19.04682	465.9429
			754	13.65333	2144.713	225	20.76441	566.4857
						330	28.65589	3406.3

Appendix D Operational rules for reservoirs

Yayangshan_R2	H	Shimenkan_R60	H	Longma_R62	H
1/1/2022 00:00	851	1/1/2022 00:00	785	1/1/2022 00:00	660
1/6/2022 00:00	851	1/6/2022 00:00	759	1/6/2022 00:00	660
1/10/2022 00:00	851	1/10/2022 00:00	759	1/10/2022 00:00	660
1/4/2023 00:00	851	1/1/2023 00:00	785	1/1/2023 00:00	660

Puxiqiao_R64	H	Sinanjian_R66	H	Jupudu_R68	H
1/1/2022 00:00	755	1/1/2022 00:00	923	1/4/2022 00:00	547
1/6/2022 00:00	755	1/6/2022 00:00	923	1/5/2022 00:00	547
1/10/2022 00:00	755	1/10/2022 00:00	923	1/10/2022 00:00	547
1/1/2023 00:00	755	1/1/2023 00:00	923	1/12/2022 00:00	547
				1/4/2023 00:00	547

Gelantan_R70	H	Nalan_R72	H	Nansha_R74	H
1/4/2022 00:00	478	1/1/2022 00:00	437	1/1/2022 00:00	286
1/5/2022 00:00	478	1/6/2022 00:00	433.5	1/6/2022 00:00	286
1/10/2022 00:00	478	1/8/2022 00:00	433.5	1/9/2022 00:00	286
1/12/2022 00:00	478	1/10/2022 00:00	437	1/1/2023 00:00	286
1/4/2023 00:00	478	1/1/2023 00:00	437		

Madusthan_R76	H	Malutang_R78	H	HC_TD_Lai_Chau	H
1/1/2022 00:00	252	1/1/2022 00:00	642	1/10/2020 00:00	295
1/6/2022 00:00	252	1/6/2022 00:00	642	1/10/2021 00:00	295
1/9/2022 00:00	252	1/8/2022 00:00	642		
1/10/2022 00:00	252	1/10/2022 00:00	642		
1/1/2023 00:00	252	1/1/2023 00:00	642		

Appendix E Reservoir EO based water levels

Time	DA_R2 [m^2]	DA_R60 [m^2]
10/31/2015 12:00:00 AM	7.63948	5.188382
2/10/2017 00:00	5.919466	4.883719
2/22/2017 12:00:00 AM	4.867586	5.013471
3/6/2017 00:00	4.71996	5.013471
3/18/2017 12:00:00 AM	5.778369	4.321778
3/30/2017 12:00:00 AM	4.658281	4.407614
4/11/2017 00:00	6.281276	4.577622
4/23/2017 12:00:00 AM	6.167924	4.386732
5/5/2017 00:00	6.281276	4.025404
5/17/2017 12:00:00 AM	5.641794	4.025404
5/29/2017 12:00:00 AM	4.658281	4.073359
6/10/2017 00:00	4.605477	3.96939
6/22/2017 12:00:00 AM	4.71996	4.058933
7/4/2017 00:00	4.794652	4.208964
8/9/2017 00:00	5.848454	4.476951
8/21/2017 12:00:00 AM	5.778369	4.688955
9/2/2017 00:00	5.742128	4.688955
9/14/2017 12:00:00 AM	5.446901	4.782016
9/26/2017 12:00:00 AM	5.396788	4.998909
10/8/2017 00:00	6.9436	4.921417
10/20/2017 12:00:00 AM	8.100632	4.989606
11/1/2017 00:00	7.927464	5.148582
11/13/2017 12:00:00 AM	8.069998	5.202362
11/25/2017 12:00:00 AM	7.701333	5.213325
12/7/2017 00:00	7.701333	5.113619
12/19/2017 12:00:00 AM	6.834124	5.262221
12/31/2017 12:00:00 AM	6.54808	4.782016
1/12/2018 00:00	7.701333	4.763067
1/24/2018 12:00:00 AM	6.35955	5.069907
2/5/2018 00:00	5.641794	5.113619
2/17/2018 12:00:00 AM	5.742128	5.113619
3/1/2018 00:00	5.742128	5.060186
3/25/2018 12:00:00 AM	4.658281	5.202362
4/6/2018 00:00	5.641794	5.084909
4/18/2018 12:00:00 AM	4.867586	5.13745
4/30/2018 12:00:00 AM	5.687473	5.188382
5/12/2018 00:00	6.703661	5.262221

Time	DA_R2 [m^2]	DA_R60 [m^2]
5/24/2018 12:00:00 AM	5.488083	4.998909
6/5/2018 00:00	4.71996	4.359902
6/17/2018 12:00:00 AM	6.54808	4.438048
7/11/2018 00:00	5.598144	4.658624
7/23/2018 12:00:00 AM	5.396788	4.28105
8/4/2018 00:00	5.778369	4.602532
8/16/2018 12:00:00 AM	5.778369	4.602532
8/28/2018 12:00:00 AM	5.446901	4.552724
9/9/2018 00:00	5.687473	4.602532
9/21/2018 12:00:00 AM	5.446901	4.658624
10/3/2018 00:00	6.54808	4.921417
10/15/2018 12:00:00 AM	3.529412	5.230657
10/27/2018 12:00:00 AM	7.927464	5.113619
11/8/2018 00:00	7.927464	5.188382
11/20/2018 12:00:00 AM	8.069998	4.989606
12/2/2018 00:00	7.887889	4.871066
12/14/2018 12:00:00 AM	8.100632	5.026187
12/26/2018 12:00:00 AM	6.9436	5.230657
1/7/2019 00:00	5.687473	4.989606
1/19/2019 12:00:00 AM	6.167924	5.13745
1/31/2019 12:00:00 AM	5.742128	5.230657
2/12/2019 00:00	6.703661	5.113619
2/24/2019 12:00:00 AM	5.919466	4.975682
3/8/2019 00:00	5.488083	4.796076
3/20/2019 12:00:00 AM	5.085127	4.921417
4/1/2019 00:00	4.71996	4.961791
4/13/2019 12:00:00 AM	5.085127	5.013471
4/25/2019 12:00:00 AM	5.488083	5.13745
5/7/2019 00:00	5.212292	4.989606
5/19/2019 12:00:00 AM	4.504078	4.527474
5/31/2019 12:00:00 AM	4.261277	4.058933
6/12/2019 00:00	4.504078	3.993747
6/24/2019 12:00:00 AM	4.307494	3.96939
7/6/2019 00:00	4.344377	3.874104
7/18/2019 12:00:00 AM	4.504078	3.993747
7/30/2019 12:00:00 AM	4.307494	4.058933
8/11/2019 00:00	4.38254	4.260157
8/23/2019 12:00:00 AM	4.476621	4.073359
9/4/2019 00:00	4.476621	4.186744
9/16/2019 12:00:00 AM	4.658281	4.359902

Time	DA_R2 [m^2]	DA_R60 [m^2]
9/28/2019 12:00:00 AM	4.344377	3.947065
10/10/2019 00:00	5.150557	4.244513
10/22/2019 12:00:00 AM	4.440014	4.840853
11/3/2019 00:00	4.54947	4.871066
11/15/2019 12:00:00 AM	4.54947	5.060186
11/27/2019 12:00:00 AM	4.504078	4.975682
12/9/2019 00:00	4.504078	4.998909
12/21/2019 12:00:00 AM	4.476621	4.763067
1/2/2020 00:00	4.175431	4.552724
1/14/2020 12:00:00 AM	5.687473	4.714593
1/26/2020 12:00:00 AM	6.167924	4.883719
2/7/2020 00:00	5.778369	4.883719
2/19/2020 12:00:00 AM	5.276898	4.951209
3/2/2020 00:00	5.919466	4.921417
3/14/2020 12:00:00 AM	5.742128	4.738487
3/26/2020 12:00:00 AM	4.344377	4.577622
4/7/2020 00:00	4.261277	4.438048
4/19/2020 12:00:00 AM	4.235011	4.163884
5/1/2020 00:00	4.794652	3.874104
5/13/2020 12:00:00 AM	4.261277	4.186744
5/25/2020 12:00:00 AM	4.344377	4.073359
6/6/2020 00:00	4.307494	3.947065
6/18/2020 12:00:00 AM	3.815005	3.96939
6/30/2020 12:00:00 AM	4.175431	4.058933
7/12/2020 00:00	4.235011	4.025404
7/24/2020 12:00:00 AM	4.71996	4.359902
8/5/2020 00:00	4.344377	3.96939
8/17/2020 12:00:00 AM	5.018599	4.407614
8/29/2020 12:00:00 AM	4.658281	4.630436
9/10/2020 00:00	4.605477	4.688955
9/22/2020 12:00:00 AM	6.703661	4.961791
10/4/2020 00:00	8.069998	5.173697
10/16/2020 12:00:00 AM	8.069998	5.113619
10/28/2020 12:00:00 AM	8.069998	5.113619
11/9/2020 00:00	7.701333	5.213325
11/21/2020 12:00:00 AM	7.701333	5.202362
12/3/2020 00:00	7.05904	5.084909
12/15/2020 12:00:00 AM	6.834124	5.042006
12/27/2020 12:00:00 AM	4.867586	4.796076
1/8/2021 00:00	5.396788	4.809064

Time	DA_R2 [m^2]	DA_R60 [m^2]
1/20/2021 12:00:00 AM	4.71996	5.013471
2/1/2021 00:00	5.340012	4.763067
2/13/2021 12:00:00 AM	5.919466	4.688955
2/25/2021 12:00:00 AM	6.703661	4.782016
4/2/2021 00:00	4.658281	4.896307
4/14/2021 12:00:00 AM	4.71996	4.909057
4/26/2021 12:00:00 AM	4.504078	4.658624
5/8/2021 00:00	4.307494	4.186744
5/20/2021 12:00:00 AM	4.941437	4.208964
6/1/2021 00:00	4.54947	3.947065
6/13/2021 12:00:00 AM	4.71996	4.386732
6/25/2021 12:00:00 AM	4.605477	4.058933
7/7/2021 00:00	4.605477	4.058933
7/19/2021 12:00:00 AM	4.307494	4.058933
7/31/2021 12:00:00 AM	4.476621	4.058933
8/12/2021 00:00	4.344377	4.073359
8/24/2021 12:00:00 AM	4.794652	4.527474
9/5/2021 00:00	4.794652	4.738487
9/17/2021 12:00:00 AM	4.658281	3.874104
9/29/2021 12:00:00 AM	4.605477	4.025404
10/11/2021 00:00	5.778369	4.260157
10/23/2021 12:00:00 AM	7.300202	4.455065
11/4/2021 00:00	8.069998	5.188382
11/28/2021 12:00:00 AM	7.701333	5.188382
12/10/2021 00:00	7.701333	5.230657
12/22/2021 12:00:00 AM	8.069998	5.230657
1/3/2022 00:00	7.63948	5.148582
1/15/2022 12:00:00 AM	7.190699	4.989606
1/27/2022 12:00:00 AM	7.510925	4.921417
2/8/2022 00:00	8.100632	4.951209
2/20/2022 12:00:00 AM	8.100632	4.714593
3/4/2022 00:00	8.100632	4.577622
3/16/2022 12:00:00 AM	7.300202	4.714593
3/28/2022 12:00:00 AM	7.05904	5.160223
4/9/2022 00:00	8.069998	4.871066
4/21/2022 12:00:00 AM	7.63948	5.042006
5/3/2022 00:00	5.919466	4.961791
8/7/2022 00:00	4.476621	4.208964
8/19/2022 12:00:00 AM	4.476621	4.105694
9/12/2022 00:00	4.504078	4.13531

Time	DA_R2 [m^2]	DA_R60 [m^2]
9/24/2022 12:00:00 AM	7.701333	4.883719
10/30/2022 12:00:00 AM	8.069998	4.998909
12/5/2022 00:00	5.742128033	4.73848726
12/17/2022 12:00:00 AM	5.276898048	4.658624218
12/29/2022 12:00:00 AM	4.549470153	4.501390875
4/4/2023 00:00	5.886707074	4.961791241
4/16/2023 12:00:00 AM	5.778368792	4.577622002
4/28/2023 12:00:00 AM	4.867585782	4.55272452
5/10/2023 00:00	4.605477018	4.281049512
5/22/2023 12:00:00 AM	4.344376731	4.455064695
6/3/2023 00:00	4.549470153	4.105694293
7/9/2023 00:00	4.175430563	3.969389665
8/14/2023 12:00:00 AM	4.344376731	4.07335907
9/7/2023 00:00	4.175430563	3.969389665
9/19/2023 12:00:00 AM	4.261276962	3.969389665
10/1/2023 00:00	4.794651801	3.993746663
10/13/2023 12:00:00 AM	4.549470153	4.989605723

Time	DA_R64 [m^2]
10/21/2014 12:00:00 AM	11.24114
2/6/2015 00:00	10.31835
2/18/2015 12:00:00 AM	11.6519
3/2/2015 00:00	11.6519
3/26/2015 12:00:00 AM	10.20295
4/19/2015 12:00:00 AM	10.68054
5/13/2015 12:00:00 AM	10.31835
6/6/2015 00:00	8.476627
6/30/2015 12:00:00 AM	11.70637
7/24/2015 12:00:00 AM	7.513831
11/21/2015 12:00:00 AM	10.97204
12/15/2015 12:00:00 AM	10.4337
1/8/2016 00:00	11.19319
2/1/2016 00:00	10.4976
2/25/2016 12:00:00 AM	9.97617
3/20/2016 12:00:00 AM	9.048682
4/1/2016 00:00	9.841372
4/13/2016 12:00:00 AM	8.859446
4/25/2016 12:00:00 AM	8.629447
5/7/2016 00:00	10.04603
5/19/2016 12:00:00 AM	7.513831
5/31/2016 12:00:00 AM	7.759975
6/12/2016 00:00	7.759975
7/6/2016 00:00	10.04603
7/18/2016 12:00:00 AM	10.11474
7/30/2016 12:00:00 AM	10.81419
8/11/2016 00:00	10.86311
8/23/2016 12:00:00 AM	11.6108
9/4/2016 00:00	10.68054
9/16/2016 12:00:00 AM	11.41456
9/28/2016 12:00:00 AM	11.41456
10/10/2016 00:00	11.13527
10/22/2016 12:00:00 AM	11.6108
11/3/2016 00:00	11.41456
11/15/2016 12:00:00 AM	11.29774
11/27/2016 12:00:00 AM	11.56267
12/9/2016 00:00	11.6108
12/21/2016 12:00:00 AM	11.56267
1/2/2017 00:00	11.1067
1/14/2017 12:00:00 AM	11.0343

1/26/2017 12:00:00 AM	11.0343
2/7/2017 00:00	10.4976
2/19/2017 12:00:00 AM	11.24114
3/3/2017 00:00	10.4976
3/15/2017 12:00:00 AM	10.4337
3/27/2017 12:00:00 AM	10.20295
4/8/2017 00:00	10.11474
4/20/2017 12:00:00 AM	9.048682
5/2/2017 00:00	7.456054
5/14/2017 12:00:00 AM	7.759975
5/26/2017 12:00:00 AM	7.972617
6/7/2017 00:00	8.555625
6/19/2017 12:00:00 AM	7.656162
7/1/2017 00:00	7.656162
7/13/2017 12:00:00 AM	10.56646
7/25/2017 12:00:00 AM	11.0343
8/6/2017 00:00	11.36758
8/18/2017 12:00:00 AM	11.41456
8/30/2017 12:00:00 AM	10.97204
9/11/2017 00:00	11.36758
9/23/2017 12:00:00 AM	11.41456
10/5/2017 00:00	10.97204
10/17/2017 12:00:00 AM	11.6108
11/10/2017 00:00	11.6108
11/22/2017 12:00:00 AM	11.41456
12/4/2017 00:00	11.36758
12/16/2017 12:00:00 AM	11.41456
12/28/2017 12:00:00 AM	10.56646
1/9/2018 00:00	10.56646
1/21/2018 12:00:00 AM	10.31835
2/2/2018 00:00	9.841372
2/14/2018 12:00:00 AM	9.694464
2/26/2018 12:00:00 AM	8.408307
3/10/2018 00:00	7.456054
3/22/2018 12:00:00 AM	8.555625
4/3/2018 00:00	7.412348
4/15/2018 12:00:00 AM	6.885198
4/27/2018 12:00:00 AM	7.163631
5/9/2018 00:00	8.053868
5/21/2018 12:00:00 AM	7.759975
6/2/2018 00:00	7.163631

6/14/2018 12:00:00 AM	6.854293
6/26/2018 12:00:00 AM	8.986167
7/8/2018 00:00	10.56646
7/20/2018 12:00:00 AM	11.36758
8/1/2018 00:00	11.41456
8/13/2018 12:00:00 AM	11.6519
9/6/2018 00:00	11.41456
9/18/2018 12:00:00 AM	11.13527
9/30/2018 12:00:00 AM	11.36758
10/12/2018 00:00	11.6108
10/24/2018 12:00:00 AM	11.50997
11/5/2018 00:00	11.41456
11/17/2018 12:00:00 AM	11.29774
11/29/2018 12:00:00 AM	10.68054
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9/25/2019 12:00:00 AM	9.612944
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2/28/2020 12:00:00 AM	7.282946
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7/9/2020 00:00	7.282946
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1/24/2022 12:00:00 AM	11.19319
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6/5/2022 00:00	7.972617
6/17/2022 12:00:00 AM	9.048682
6/29/2022 12:00:00 AM	9.048682
7/11/2022 00:00	8.800952
7/23/2022 12:00:00 AM	7.693028
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8/26/2022 12:00:00 AM	3.920335
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3/28/2021 12:00:00 AM	4.37289
4/9/2021 00:00	4.22031
4/21/2021 12:00:00 AM	4.145947
5/3/2021 00:00	5.002147
5/15/2021 12:00:00 AM	4.169711
5/27/2021 12:00:00 AM	4.169711
6/8/2021 00:00	4.035125
6/20/2021 12:00:00 AM	4.332438
7/2/2021 00:00	3.895435
7/14/2021 12:00:00 AM	4.06963
7/26/2021 12:00:00 AM	4.06963
8/7/2021 00:00	4.332438
8/19/2021 12:00:00 AM	4.169711
8/31/2021 12:00:00 AM	4.353793
9/12/2021 00:00	4.200144
9/24/2021 12:00:00 AM	4.332438
10/6/2021 00:00	4.332438
10/18/2021 12:00:00 AM	4.472234
10/30/2021 12:00:00 AM	4.332438
11/11/2021 00:00	4.807563
11/23/2021 12:00:00 AM	5.114614
12/5/2021 00:00	4.312708
12/17/2021 12:00:00 AM	4.487786
12/29/2021 12:00:00 AM	4.636946
1/10/2022 00:00	4.71234
1/22/2022 12:00:00 AM	4.886323
2/3/2022 00:00	4.536986
2/15/2022 12:00:00 AM	5.002147
2/27/2022 12:00:00 AM	4.667468
3/11/2022 00:00	4.572691
3/23/2022 12:00:00 AM	4.572691
4/4/2022 00:00	4.200144
4/16/2022 12:00:00 AM	4.71234
4/28/2022 12:00:00 AM	4.37289
5/10/2022 00:00	4.262437
5/22/2022 12:00:00 AM	4.169711
6/3/2022 00:00	3.994099
6/15/2022 12:00:00 AM	4.145947
6/27/2022 12:00:00 AM	4.249149

7/9/2022 00:00	4.39159
7/21/2022 12:00:00 AM	4.169711
8/2/2022 00:00	4.249149
8/14/2022 12:00:00 AM	4.035125
8/26/2022 12:00:00 AM	3.84417
9/7/2022 00:00	4.169711
9/19/2022 12:00:00 AM	4.353793
10/1/2022 00:00	4.249149
10/13/2022 12:00:00 AM	3.994099
10/25/2022 12:00:00 AM	4.169711
11/6/2022 00:00	4.39159
11/18/2022 12:00:00 AM	4.249148818
11/30/2022 12:00:00 AM	4.391590085
12/12/2022 00:00	4.249148818
12/24/2022 12:00:00 AM	5.114613925
1/5/2023 00:00	4.823234986
4/11/2023 00:00	4.391590085
4/23/2023 12:00:00 AM	4.200143584
5/5/2023 00:00	4.33243778
5/17/2023 12:00:00 AM	4.249148818
5/29/2023 12:00:00 AM	4.249148818
8/9/2023 00:00	4.112580743
8/21/2023 12:00:00 AM	3.895435038
9/2/2023 00:00	4.069629567
9/14/2023 12:00:00 AM	4.112580743
9/26/2023 12:00:00 AM	4.03512487
10/8/2023 00:00	4.145946527
10/20/2023 12:00:00 AM	3.994099163

Time	DA_R70 [km^2]
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2/22/2017 12:00:00 AM	8.48971
3/6/2017 00:00	7.930149
3/18/2017 12:00:00 AM	8.416524
3/30/2017 12:00:00 AM	8.200315
4/11/2017 00:00	7.686934
4/23/2017 12:00:00 AM	7.551731
5/5/2017 00:00	8.376819
5/17/2017 12:00:00 AM	7.350492
5/29/2017 12:00:00 AM	7.647036
6/10/2017 00:00	7.0724
6/22/2017 12:00:00 AM	7.686934
7/4/2017 00:00	7.794962
8/9/2017 00:00	8.284863
8/21/2017 12:00:00 AM	7.974857
9/2/2017 00:00	8.376819
9/14/2017 12:00:00 AM	7.722031
9/26/2017 12:00:00 AM	8.228483
10/8/2017 00:00	8.600705
10/20/2017 12:00:00 AM	8.55479
11/1/2017 00:00	8.429966
11/13/2017 12:00:00 AM	8.346021
11/25/2017 12:00:00 AM	8.284863
12/7/2017 00:00	8.257293
12/19/2017 12:00:00 AM	8.600705
12/31/2017 12:00:00 AM	7.647036
1/12/2018 00:00	8.023377
1/24/2018 12:00:00 AM	7.897371
2/5/2018 00:00	7.828434
2/17/2018 12:00:00 AM	7.897371
3/1/2018 00:00	7.974857
3/25/2018 12:00:00 AM	8.054442
4/6/2018 00:00	7.551731
4/18/2018 12:00:00 AM	7.227353
4/30/2018 12:00:00 AM	7.551731
5/12/2018 00:00	7.897371
5/24/2018 12:00:00 AM	8.200315
6/5/2018 00:00	8.200315
6/17/2018 12:00:00 AM	7.930149

7/11/2018 00:00	8.376819
7/23/2018 12:00:00 AM	7.860608
8/4/2018 00:00	8.110963
8/16/2018 12:00:00 AM	7.994628
8/28/2018 12:00:00 AM	8.284863
9/9/2018 00:00	8.228483
9/21/2018 12:00:00 AM	8.376819
10/3/2018 00:00	7.647036
10/15/2018 12:00:00 AM	8.416524
10/27/2018 12:00:00 AM	8.48971
11/8/2018 00:00	8.55479
11/20/2018 12:00:00 AM	8.416524
12/2/2018 00:00	8.55479
12/14/2018 12:00:00 AM	8.284863
12/26/2018 12:00:00 AM	8.416524
1/7/2019 00:00	8.284863
1/19/2019 12:00:00 AM	8.228483
1/31/2019 12:00:00 AM	8.257293
2/12/2019 00:00	8.200315
2/24/2019 12:00:00 AM	7.930149
3/8/2019 00:00	8.284863
3/20/2019 12:00:00 AM	7.686934
4/1/2019 00:00	8.316241
4/13/2019 12:00:00 AM	8.257293
4/25/2019 12:00:00 AM	8.429966
5/7/2019 00:00	7.994628
5/19/2019 12:00:00 AM	8.257293
5/31/2019 12:00:00 AM	7.686934
6/12/2019 00:00	7.473954
6/24/2019 12:00:00 AM	7.686934
7/6/2019 00:00	7.591828
7/18/2019 12:00:00 AM	7.551731
7/30/2019 12:00:00 AM	7.473954
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8/23/2019 12:00:00 AM	7.686934
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9/16/2019 12:00:00 AM	8.200315
9/28/2019 12:00:00 AM	7.686934
10/10/2019 00:00	7.860608
10/22/2019 12:00:00 AM	8.023377
11/3/2019 00:00	8.023377

11/15/2019 12:00:00 AM	8.200315
11/27/2019 12:00:00 AM	8.376819
12/9/2019 00:00	8.178494
12/21/2019 12:00:00 AM	8.376819
1/2/2020 00:00	7.591828
1/14/2020 12:00:00 AM	7.551731
1/26/2020 12:00:00 AM	8.054442
2/7/2020 00:00	7.551731
2/19/2020 12:00:00 AM	7.686934
3/2/2020 00:00	8.023377
3/14/2020 12:00:00 AM	8.054442
3/26/2020 12:00:00 AM	7.897371
4/7/2020 00:00	7.0724
4/19/2020 12:00:00 AM	8.200315
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5/13/2020 12:00:00 AM	8.023377
5/25/2020 12:00:00 AM	7.264608
6/6/2020 00:00	6.828127
6/18/2020 12:00:00 AM	7.828434
6/30/2020 12:00:00 AM	7.227353
7/12/2020 00:00	7.304704
7/24/2020 12:00:00 AM	7.897371
8/5/2020 00:00	8.200315
8/17/2020 12:00:00 AM	7.758209
8/29/2020 12:00:00 AM	8.054442
9/10/2020 00:00	8.200315
9/22/2020 12:00:00 AM	7.722031
10/4/2020 00:00	8.083494
10/16/2020 12:00:00 AM	8.257293
10/28/2020 12:00:00 AM	8.284863
11/9/2020 00:00	8.141024
11/21/2020 12:00:00 AM	7.974857
12/3/2020 00:00	7.897371
12/15/2020 12:00:00 AM	8.316241
12/27/2020 12:00:00 AM	8.054442
1/8/2021 00:00	8.083494
1/20/2021 12:00:00 AM	8.200315
2/1/2021 00:00	8.054442
2/13/2021 12:00:00 AM	8.257293
2/25/2021 12:00:00 AM	7.794962
4/2/2021 00:00	7.437201

4/14/2021 12:00:00 AM	7.930149
4/26/2021 12:00:00 AM	7.591828
5/8/2021 00:00	7.828434
5/20/2021 12:00:00 AM	8.141024
6/1/2021 00:00	7.227353
6/13/2021 12:00:00 AM	7.828434
6/25/2021 12:00:00 AM	7.164125
7/7/2021 00:00	8.200315
7/19/2021 12:00:00 AM	8.023377
7/31/2021 12:00:00 AM	7.994628
8/12/2021 00:00	7.164125
8/24/2021 12:00:00 AM	8.141024
9/5/2021 00:00	7.860608
9/17/2021 12:00:00 AM	7.974857
9/29/2021 12:00:00 AM	7.591828
10/11/2021 00:00	7.794962
10/23/2021 12:00:00 AM	7.794962
11/4/2021 00:00	7.974857
11/28/2021 12:00:00 AM	7.994628
12/10/2021 00:00	8.257293
12/22/2021 12:00:00 AM	8.518557
1/3/2022 00:00	8.257293
1/15/2022 12:00:00 AM	8.054442
1/27/2022 12:00:00 AM	7.994628
2/8/2022 00:00	8.054442
2/20/2022 12:00:00 AM	8.284863
3/4/2022 00:00	8.083494
3/16/2022 12:00:00 AM	8.083494
3/28/2022 12:00:00 AM	8.023377
4/9/2022 00:00	7.551731
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8/19/2022 12:00:00 AM	7.551731
9/12/2022 00:00	8.054442
9/24/2022 12:00:00 AM	8.284863
10/30/2022 12:00:00 AM	7.930149
12/5/2022 00:00	7.994627786
12/17/2022 12:00:00 AM	8.054442011
12/29/2022 12:00:00 AM	7.758208528
4/4/2023 00:00	8.200315417

4/16/2023 12:00:00 AM	8.141023962
4/28/2023 12:00:00 AM	8.141023962
5/10/2023 00:00	8.376818626
5/22/2023 12:00:00 AM	7.828434073
6/3/2023 00:00	7.227352874
7/9/2023 00:00	7.647035403
8/14/2023 12:00:00 AM	8.200315417
9/7/2023 00:00	7.551730735
9/19/2023 12:00:00 AM	7.930148742
10/1/2023 00:00	7.994627786
10/13/2023 12:00:00 AM	8.376818626

Time	DA_R72 [km^2]
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3/1/2017 00:00	4.764217
3/13/2017 12:00:00 AM	5.084038
3/25/2017 12:00:00 AM	4.703593
4/6/2017 00:00	5.218187
4/18/2017 12:00:00 AM	4.992167
4/30/2017 12:00:00 AM	3.132477
5/12/2017 00:00	3.778555
5/24/2017 12:00:00 AM	2.716522
6/5/2017 00:00	3.990392
6/17/2017 12:00:00 AM	4.270263
6/29/2017 12:00:00 AM	5.346484
7/11/2017 00:00	6.358473
7/23/2017 12:00:00 AM	6.16106
8/4/2017 00:00	6.070567
8/16/2017 12:00:00 AM	6.038378
8/28/2017 12:00:00 AM	6.258609
9/9/2017 00:00	5.927925
9/21/2017 12:00:00 AM	6.202008
10/3/2017 00:00	6.358473
10/15/2017 12:00:00 AM	6.111324
10/27/2017 12:00:00 AM	6.296902
11/8/2017 00:00	5.703282
11/20/2017 12:00:00 AM	5.439336
12/2/2017 00:00	6.111324
12/14/2017 12:00:00 AM	6.202008
12/26/2017 12:00:00 AM	5.084038
1/7/2018 00:00	6.258609
1/19/2018 12:00:00 AM	6.398061
1/31/2018 12:00:00 AM	6.202008
2/12/2018 00:00	5.611332
2/24/2018 12:00:00 AM	6.296902
3/8/2018 00:00	5.475638
3/20/2018 12:00:00 AM	5.084038
4/1/2018 00:00	5.039167
4/13/2018 12:00:00 AM	5.039167
4/25/2018 12:00:00 AM	3.647304
5/7/2018 00:00	3.778555
5/19/2018 12:00:00 AM	4.270263

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6/12/2018 00:00	4.866417
6/24/2018 12:00:00 AM	5.611332
7/18/2018 12:00:00 AM	5.811834
7/30/2018 12:00:00 AM	5.749035
8/11/2018 00:00	5.703282
8/23/2018 12:00:00 AM	6.202008
9/4/2018 00:00	5.659209
9/16/2018 12:00:00 AM	5.971797
9/28/2018 12:00:00 AM	5.475638
10/10/2018 00:00	5.392461
10/22/2018 12:00:00 AM	6.258609
11/3/2018 00:00	6.038378
11/15/2018 12:00:00 AM	6.16106
11/27/2018 12:00:00 AM	6.038378
12/9/2018 00:00	6.358473
12/21/2018 12:00:00 AM	6.604108
1/2/2019 00:00	6.111324
1/14/2019 12:00:00 AM	6.507117
1/26/2019 12:00:00 AM	6.038378
2/7/2019 00:00	5.302064
2/19/2019 12:00:00 AM	5.392461
3/3/2019 00:00	6.111324
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3/27/2019 12:00:00 AM	5.475638
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5/2/2019 00:00	5.084038
5/14/2019 12:00:00 AM	3.647304
5/26/2019 12:00:00 AM	5.17514
6/7/2019 00:00	4.270263
6/19/2019 12:00:00 AM	4.270263
7/1/2019 00:00	2.657593
7/13/2019 12:00:00 AM	4.955073
7/25/2019 12:00:00 AM	5.83495
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8/18/2019 12:00:00 AM	5.084038
8/30/2019 12:00:00 AM	5.039167
9/11/2019 00:00	4.955073
9/23/2019 12:00:00 AM	5.084038
10/5/2019 00:00	5.084038

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10/29/2019 12:00:00 AM	5.611332
11/10/2019 00:00	5.259113
11/22/2019 12:00:00 AM	5.084038
12/4/2019 00:00	5.039167
12/16/2019 12:00:00 AM	5.039167
12/28/2019 12:00:00 AM	5.17514
1/9/2020 00:00	5.140634
1/21/2020 12:00:00 AM	5.611332
2/2/2020 00:00	5.475638
2/14/2020 12:00:00 AM	5.611332
2/26/2020 12:00:00 AM	5.084038
3/9/2020 00:00	5.039167
3/21/2020 12:00:00 AM	3.260977
4/2/2020 00:00	3.778555
4/14/2020 12:00:00 AM	1.979434
4/26/2020 12:00:00 AM	2.657593
5/8/2020 00:00	2.657593
5/20/2020 12:00:00 AM	2.657593
6/1/2020 00:00	2.423906
6/13/2020 12:00:00 AM	2.474667
6/25/2020 12:00:00 AM	4.079422
7/7/2020 00:00	5.218187
7/19/2020 12:00:00 AM	5.811834
8/12/2020 00:00	5.749035
8/24/2020 12:00:00 AM	5.659209
9/5/2020 00:00	5.572
9/17/2020 12:00:00 AM	5.83495
9/29/2020 12:00:00 AM	5.83495
10/11/2020 00:00	6.202008
10/23/2020 12:00:00 AM	6.038378
11/4/2020 00:00	5.883701
11/16/2020 12:00:00 AM	5.17514
11/28/2020 12:00:00 AM	5.140634
12/10/2020 00:00	5.218187
12/22/2020 12:00:00 AM	5.218187
1/3/2021 00:00	5.17514
1/15/2021 12:00:00 AM	5.218187
1/27/2021 12:00:00 AM	5.572
2/8/2021 00:00	5.140634
2/20/2021 12:00:00 AM	5.259113

3/4/2021 00:00	4.413069
3/16/2021 12:00:00 AM	5.218187
3/28/2021 12:00:00 AM	5.218187
4/9/2021 00:00	5.084038
4/21/2021 12:00:00 AM	5.039167
5/3/2021 00:00	4.955073
5/15/2021 12:00:00 AM	4.627007
5/27/2021 12:00:00 AM	2.996824
6/8/2021 00:00	4.703593
6/20/2021 12:00:00 AM	2.423906
7/2/2021 00:00	5.084038
7/14/2021 12:00:00 AM	5.439336
7/26/2021 12:00:00 AM	5.611332
8/7/2021 00:00	5.515927
8/19/2021 12:00:00 AM	5.659209
8/31/2021 12:00:00 AM	5.659209
9/12/2021 00:00	5.515927
9/24/2021 12:00:00 AM	5.140634
10/6/2021 00:00	5.039167
10/18/2021 12:00:00 AM	5.811834
10/30/2021 12:00:00 AM	5.811834
11/11/2021 00:00	5.611332
11/23/2021 12:00:00 AM	5.439336
12/5/2021 00:00	5.749035
12/17/2021 12:00:00 AM	5.611332
12/29/2021 12:00:00 AM	5.572
1/10/2022 00:00	5.83495
1/22/2022 12:00:00 AM	5.439336
2/3/2022 00:00	5.475638
2/15/2022 12:00:00 AM	5.346484
2/27/2022 12:00:00 AM	5.475638
3/11/2022 00:00	5.259113
3/23/2022 12:00:00 AM	5.302064
4/4/2022 00:00	5.218187
4/16/2022 12:00:00 AM	5.084038
4/28/2022 12:00:00 AM	4.627007
5/10/2022 00:00	3.948722
5/22/2022 12:00:00 AM	5.084038
6/3/2022 00:00	5.392461
6/15/2022 12:00:00 AM	5.346484
6/27/2022 12:00:00 AM	5.346484

7/9/2022 00:00	5.811834
7/21/2022 12:00:00 AM	5.749035
8/2/2022 00:00	5.039167
8/14/2022 12:00:00 AM	5.084038
8/26/2022 12:00:00 AM	4.509075
9/7/2022 00:00	5.084038
9/19/2022 12:00:00 AM	5.302064
10/1/2022 00:00	5.084038
10/13/2022 12:00:00 AM	5.392461
10/25/2022 12:00:00 AM	5.439336
11/6/2022 00:00	5.611332
11/18/2022 12:00:00 AM	5.515927
11/30/2022 12:00:00 AM	5.439336
12/12/2022 00:00	5.392461
12/24/2022 12:00:00 AM	5.346484
1/5/2023 00:00	5.475639
4/11/2023 00:00	2.657594
4/23/2023 12:00:00 AM	3.778555
5/5/2023 00:00	3.778555
5/17/2023 12:00:00 AM	2.474667
5/29/2023 12:00:00 AM	2.474667
8/9/2023 00:00	4.992166
8/21/2023 12:00:00 AM	5.611332
9/2/2023 00:00	5.259113
9/14/2023 12:00:00 AM	5.17514
9/26/2023 12:00:00 AM	5.611332
10/8/2023 00:00	5.611332
10/20/2023 12:00:00 AM	5.572

Time	DA_R74 [km ²]
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3/1/2017 00:00	6.10626
3/13/2017 12:00:00 AM	5.927901
3/25/2017 12:00:00 AM	6.07106
4/6/2017 00:00	6.000204
4/18/2017 12:00:00 AM	6.250167
4/30/2017 12:00:00 AM	5.865273
5/12/2017 00:00	6.031541
5/24/2017 12:00:00 AM	5.748631
6/5/2017 00:00	5.748631
6/17/2017 12:00:00 AM	5.437095
6/29/2017 12:00:00 AM	5.66804
7/11/2017 00:00	6.626879
7/23/2017 12:00:00 AM	6.932812
8/4/2017 00:00	6.830011
8/16/2017 12:00:00 AM	7.147813
8/28/2017 12:00:00 AM	6.356387
9/9/2017 00:00	6.830011
9/21/2017 12:00:00 AM	6.830011
10/3/2017 00:00	6.830011
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10/27/2017 12:00:00 AM	6.726905
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7/23/2017 12:00:00 AM	16.08163
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8/28/2017 12:00:00 AM	16.49512
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1/23/2019 12:00:00 AM	8.6192
2/4/2019 00:00	8.761065
2/16/2019 12:00:00 AM	8.525103
2/28/2019 12:00:00 AM	8.280838
3/12/2019 00:00	8.116466
3/24/2019 12:00:00 AM	7.301397
4/5/2019 00:00	6.808702

4/29/2019 12:00:00 AM	5.572775
5/11/2019 00:00	5.010907
5/23/2019 12:00:00 AM	3.635589
6/4/2019 00:00	3.713463
8/15/2019 12:00:00 AM	4.088533
8/27/2019 12:00:00 AM	3.801962
9/8/2019 00:00	4.56768
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10/14/2019 12:00:00 AM	5.868344
10/26/2019 12:00:00 AM	6.142809
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1/6/2020 00:00	3.167665
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5/5/2020 00:00	2.411963
6/10/2020 00:00	2.498543
6/22/2020 12:00:00 AM	2.498543
7/4/2020 00:00	2.173205
7/16/2020 12:00:00 AM	2.266016
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8/9/2020 00:00	2.498543
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9/14/2020 12:00:00 AM	4.827404
9/26/2020 12:00:00 AM	6.43265

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11/13/2020 12:00:00 AM	8.714371
11/25/2020 12:00:00 AM	8.575836
12/7/2020 00:00	8.796401
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4/6/2021 00:00	7.301397
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9/7/2021 00:00	6.290655
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11/18/2021 12:00:00 AM	8.889266
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12/12/2021 00:00	9.034616
12/24/2021 12:00:00 AM	9.034616

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