Development of a web-based decision support system (DSS) for water resources management in Vietnam and Mekong region

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1. Web portal: waterportal.vaci.org.vn

Overall objectives: Support water users, practitioners and researchers in understanding character and natural variability of water resources and operational short-term/long-term forecasting for sector-specific water planning in the Greater Mekong region.

2. Web portal – Specific objectives

1. Provide ***long-term mean historical monthly and annual water balances*** of key hydrological stations across different physiography and climate characteristics in the GM region.

2. Provide ***long time series (1980-2009) of historical daily data*** (e.g.: streamflow, precipitation, evaporation, soil moisture, temperature) of all 1120 irregular sub-catchments in the GM that help users to understand character and natural variabilities of water resources so that both societal and environmental concerns can be planned accordingly.

3. Provide ***short-term forecasts (1-16 days ahead and 1-6 months ahead) of streamflow for all sub-catchments*** in the GM, including warning services to help citizens, water planners, reservoir operators and farmers to make water-food-energy plans (storage/release). Short-term forecasts are for immediate actions while seasonal forecasts affect more strategical decisions and market prices. Calculations are made on a daily time step.

4. Provide ***short-term forecasts (1-16 days ahead and 1-6 months ahead) of water and sediment inflow to reservoirs*** in the GM so that reservoir operators can plan their water storage and release accordingly.

5. Provide ***long-term climate change impacts on water resources*** (upcoming years 2011-2040, mid-century 2041-2070 and end century 2071-2100 for two scenarios: low emission rcp45 and high emission rcp85) so actions can be taken to adapt to new conditions.

6. All models, by definition, are wrong but can still be useful if they are close enough to reality. Thus, we provide ***model performance in different performance metrics and hydrograph figures*** so that users can judge if the model performance is good enough before using the model results. GM-HYPE results are compared to time-series of either in-situ measured discharge or altimetry-derived water levels, wherever such data is available.

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These works are the accumulated results of multiple works and collaborations at NAWAPI/Ministry of MONRE, Vietnam with a number of partners worldwide since 2013. Please find list of publications, projects and its operational portals/apps bellow for more details:

- *National water data services: http://waterdata.dawapi.gov.vn; National water prediction and warning http://nwm.cewafo.gov.vn/;*
- *ASEAN waterdata: waterportal.vaci.org.vn/; ASEAN Reservoir monitor Apps https://vacisgu.users.earthengine.app/view/ceresv;*
- *ASEAN Sediment monitor: scised.vaci.org.vn Vietnam International Water Week: viww.vaci.org.vn*

3.1. Home Page: Water balances

Different download options: SVG, PNG, CSV

Interactive web for displaying at each hydrological location either: **Monthly Water balances or Annual Water balances.**

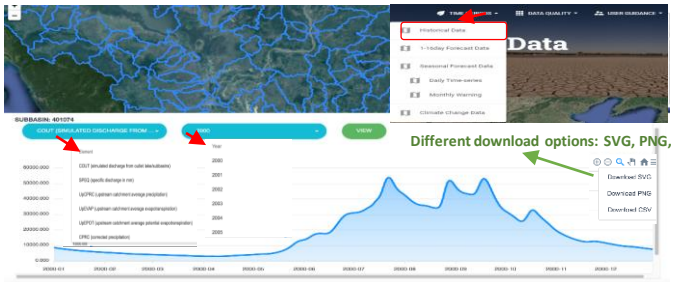
- Monthly Water components: Precipitation, Discharge, Evaporation and Imbalance (Precipitation – Discharge – Evaporation)

→ Help recognize seasonal climate characteristics of that location. Ex: Kratie: Dry season (September – February), Wet season (March – August)

- Annual Water Imbalances: Precipitation - Discharge – Evaporation

→ Help recognize which year is a wet or a dry year.

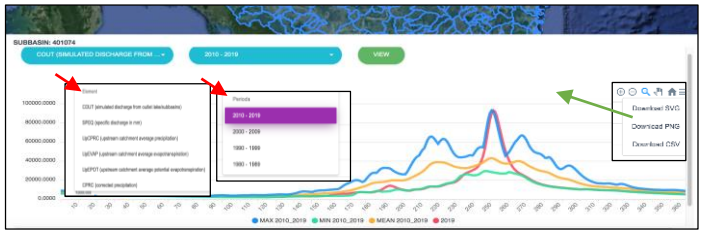
3.2.1. Time Period – Historical data



Interactive web for displaying **daily historical data** at each subbasin

- Data options: Discharge (COUT-m3/s), specific discharge (SPEQ-mm/day), upstream corrected precipitation (UPCPRC-mm/day), upstream actual evaporation (upEVAP-mm/day), upstream potential evaporation (upEPOT-mm/day), local actual evaporation (EVAP-mm/day), local potential evaporation (EPOT-mm/day), local corrected precipitation (CPRC-mm/day), soil moisture root zone (SMRZ-mm/day), and air temperature (TEMP-° C).
- Year options: each year from 1980 to 2009.
- This model is forced with Precipitation MSWEPv1.1 and Temperature NCEP CFSv2, not considering the effect of human activities.

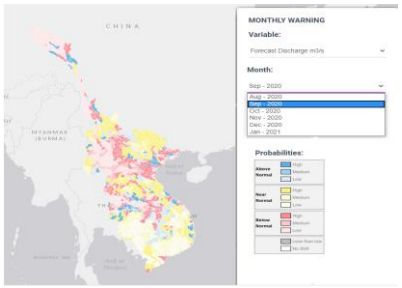
3.2.3. Time Period – Seasonal Forecast data: Daily time-series



Interactive web for displaying **daily seasonal forecasting data** at each subbasin

- Data options: Discharge (COUT-m3/s), specific discharge (SPEQ-mm/day), upstream corrected precipitation (UPCPRC-mm/day), upstream actual evaporation (upEVAP-mm/day), upstream potential evaporation (upEPOT-mm/day), local actual evaporation (EVAP-mm/day), local potential evaporation (EPOT-mm/day), (local corrected precipitation (CPRC-mm/day) soil moisture root zone (SMRZ-mm/day), air temperature (TEMP-° C).
- Year options: forecasted days (lead 1-6 month) compared to historical periods 1980-1989, 200-2009, 2010-2019 (daily time step). Currently, year 2019 is on demonstration. Later, each month will update the next 6 month forecasting.
- This model is forced with Precipitation and Temperature NCEP CFSv2: https://nomads.ncep.noaa.gov/txt_descriptions/CFS_doc.shtml

3.2.3. Time Period – Seasonal Forecasting data: Monthly Warning



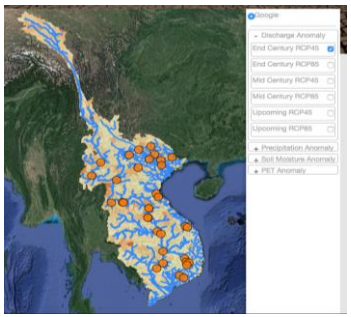
Legend:

ABOVE NORMAL
(ABOVE 33TH PROBABILITIES)
1: High > 75% compared to near normal (NN)
2: Medium 50-75% compared to NN
3: Low < 50% compared to NN

BELOW NORMAL
(BELOW 66TH PROBABILITIES)
4: High <-75% compared to NN
5: Medium -75% <x < -50% compared to NN
6: Low >-50% compared to NN

NEAR NORMAL (BETWEEN 33TH AND 66TH PROBABILITIES)
7: Between 33th and 46th probabilities
8: Between 46th and 56th probabilities
9: Between 56th and 66th probabilities

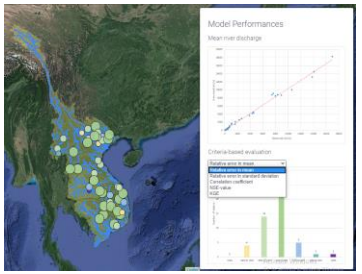
4. Climate Change Impact Data



Interactive web for displaying **climate change impacts** compared to reference historical period (1980-2009):

- Data options: Discharge, Precipitation, Soil Moisture and PET
- Scenario option: Low emission scenario (RCP45), High emission scenario (RCP85)
- Model option: ensemble. More models to come soon
- Projected forcing data (i.e. precipitation and temperature) till 2100 are taken from NASA Earth Exchange Global Daily Downscaled Climate projections (NEX-GDDP)

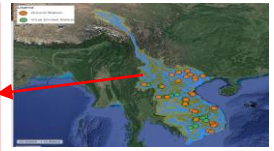
5.1. Model Performances – Performance metrics



Interactive web for displaying **performance metrics** of validated discharge stations

- Performance metric options:
  - Relative error in mean (RE)
  - Relative error in standard error (RESD)
  - Correlation coefficient (CC)
  - Kling-Gupta Efficiency (KGE)
  - NSE (Nash Sutcliffe Efficiency)

5.2. Model Performances – Hydrograph figures



Interactive web for displaying **hydrograph figures** of selected stations

- Hydrograph options:
  - Correlation scatter plot of discharge
  - Flow duration curve
  - Daily hydrograph
  - Correlation scatter plot of water level (if available)
- Period options:
  - Calibration period: 2002-2009
  - Validation period: 1991-2001