Development of visualization tools for KPOM

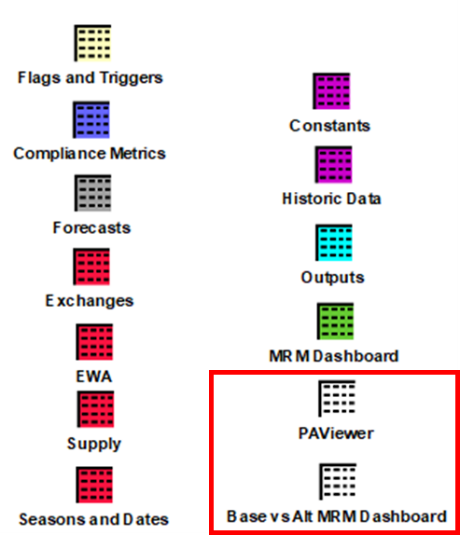
Model change log

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**Introduction**

I have **added three functionalities to KPOM**. First is the ability to **export results from a KPOM simulation for visualization in the PA Viewer** excel workbook(section 1, ‘PA Viewer excel workbook’ henceforth called ‘PA Viewer workbook’). Second is the ability to **visualize the same plots that exist in the PA Viewer workbook in KPOM for one simulation** (section 2). Third, I have added the functionality to **plot the results of multiple simulations in KPOM** (section 3). Central to these new functionalities is two new data objects, indicated in red in the figure below. As described in sections 2 and 4, the ‘PAViewer’ data object is central to the workflow of exporting KPOM results to the PA Viewer workbook, and the ‘Base vs Alt MRM Dashboard’ data object plays a parallel role in plotting the results of multiple simulations within KPOM. In the sections below, every letter in the list (a., b., c., etc.) corresponds to one change I made to the model and thus will need merged with the main KPOM GitHub branch. For clarity, **I have also bolded and underlined each addition**. Sub-lists to each letter (for example, a.i) are descriptions of each model change.



1. Model changes to accommodate KPOM results visualization in the PA Viewer workbook
   1. **PAViewer data object**
      1. The PAViewer data object uses expression slots to reproduce the WRIMS variables plotted on the ‘Alt\_Year\_Select\_Plots’ sheet in the PA Viewer workbook. Some slots in this data object are calculating slots that do not already exist in KPOM, but do in WRIMS (e.g., PAViewer.Ady canal FFF offsets). Other slots in this data object are performing either a volume to flow conversion or unit conversion of an existing slot in KPOM to match the format used in the PA Viewer workbook (e.g., PAViewer.IGD Storage). Please note that several slots needed for the PA Viewer workbook already existed in KPOM with the correct units, so there was no need to add them to the data object (e.g., UKL.Outflow).
   2. **‘AccretionsExceedDemand’ global function**
      1. One Global Function called ‘AccretionsExceedDemand’ was added to the KPOM ruleset to facilitate calculation of slots in the PAViewer data object that perform accounting for UKL, F/FF offsets, Station 48 offsets, and Miller Hill offsets. This global function is placed inside the ‘PA Viewer Functions’ policy group, which can be found by opening the “Global Functions Set Editor” in KPOM.
   3. **‘KPOM to PA Viewer’ output database DMI**
      1. I created an output database DMI called ‘KPOM to PA Viewer’ to export slots from the PAViewer data object and other pre-existing slots to the PA Viewer workbook. This DMI uses a new Excel dataset within KPOM called ‘PAViewer’, described below.
   4. **‘PAViewer’ Excel dataset**
      1. The dataset does NOT use a Name Map, but instead relies on a new row in the PA Viewer workbook, ALT\_OUTPUT sheet where I have added the object.slot (unit) specification corresponding to each WRIMS variable. These changes to the PA Viewer workbook are reflected in the version I have uploaded to the PA Viewer branch of our GitHub, located at KROM-KPOM\_Development/PAViewer/ Final\_Interim\_Ops\_Viewer\_20200326.xlsm. After creating the ‘PAViewer’ Excel dataset, several settings need set on the ‘Excel’ tab of the ‘Excel Dataset – PAViewer’ window. The header offset needs set to 12 rows and 1 column, and the single run name needs set to ‘ALT\_OUTPUT’. Check ‘Use Unit Name with Slot Name’. Please note that the environment variable $KLAMATH\_OPS points to the ‘KROM-KPOM\_Development’ directory on your machine.
2. Plots that mimic the PA Viewer workbook.
   1. **I added 7 plots to mimic plots in the PA Viewer workbook on the ALT\_Year\_Select\_Plots sheet.**
      1. These plots show the results of one simulation, NOT using the iterative MRM configuration described in 3.b below. The plots are:
         1. EWA used vs UKL Supply
         2. Allocation vs Supply
         3. Project Ag Deliveries by Account
         4. Project Supply and UKL Credit
         5. Flow Gains Link to Iron Gate
         6. Link Release to River
         7. Project and Refuge Deliveries
3. Model changes to plot multiple alternatives in KPOM
   1. **‘Base vs Alt MRM Dashboard’ data object**
      1. This data object consists of many AggSeries slots of 5 columns each. The purpose of these slots is to store the results of multiple simulations as facilitated by a new iterative MRM configuration (see 3.b below). Each column represents a different simulation, and each simulation represents a different operation policy (e.g. Base vs. Alt.), or simulating the same operation policy using different exogenous factor s(system inflow, accretions, etc.). Each column is then plotted in several plot pages (see 3.d below).
   2. **‘Plot multiple alternatives’ iterative MRM configuration**
      1. This iterative MRM configuration uses several iterative MRM rules (see 3.c. below) to store the results of each simulation in slots in the data object described previously in 3.a.
      2. Currently, I have set a maximum of two iterations, which corresponds to the ‘Base’ and ‘Alt1’ columns in the Base vs Alt MRM Dashboard slots described in 3.a above. By increasing the number of iterations (up to a max of 5), additional alternatives can be simulated, and their results recorded/visualized in KPOM.
   3. **5 New rules in iterative MRM Rules Set under groups ‘Record slots for Base vs Alt plots’ and ‘Some logic for different alternatives’**
      1. I created four iterative MRM rules that are called by the iterative MRM configuration described above in 3.b to save the results of each KPOM simulation in the Base vs Alt MRM Dashboard data object. The rules reside in the ‘Record slots for Base vs Alt plots’ policy group within the Iterative MRM Rules Set. The rules are indexed 16-20, but their priority should not matter. The rules are:
         1. PAViewer Yearly
         2. PAViewer Daily
         3. UKL slots
         4. All slots not in slot set
      2. The first three rules use three slots sets that I added to the Slot Set Manager to reduce repeated RPL code. The slot sets are described in 3.d below.
      3. I added a placeholder rule called ‘Some rule to switch operating policies’, currently located at index 20. This rule is strictly a placeholder, indicating the [potential] location where rules can be added to switch from one operating policy (e.g., Base) to an alternative operating policy (e.g., Alt1). This rule would be invoked by the iterative MRM configuration described in 3.b above. I have added this placeholder rule to the ‘Pre-Run Rules’ section of the iterative MRM, but have turned the rule off within the ruleset since it currently contains no logic. Using this setup, the iterative MRM will successfully run two KPOM simulations and store the results in the Base vs Alt MRM Dashboard data object. However, the results will be identical since each simulation was identical. Section 3.e below describes the plot pages I created to visualize the results.
   4. **Three slot sets**
      1. Under Workspace > Slots > Slot set management, I created three slot sets. The slot sets are:
         1. Base vs ALT MRM Dashboard UKL
         2. Base vs ALT MRM Dashboard PAViewer yearly
         3. Base vs ALT MRM Dashboard PAViewer daily
      2. As the names indicate, these slot sets contain all the slots within the Base vs ALT MRM Dashboard data object that 1) record slots from the UKL object, 2) record yearly timestep slots from the PAViewer data object, and 3) record daily timestep slots from the PAViewer data object. The rules described in Section 3.c above loop through these slot sets to record the results of each iterative simulation for every slot needed to create the plots described in 3.e below.
   5. **5 ‘Multiple alternatives’ plot pages**
      1. I created 5 plot pages that plot the results of multiple simulations as performed using the ‘Plot multiple alternatives’ iterative MRM. These plots mimic the plots in the PA Viewer workbook on the ALT\_Year\_Select\_Plots sheet. The plot pages are:
         1. Multiple Alternatives UKL Pool Elevation
         2. Multiple Alternatives IGD Flow
         3. Multiple Alternatives Project and Refuge Deliveries
         4. Multiple Alternatives UKL for river
         5. Multiple Alternatives Ag Deliveries by Account
      2. Notice that each plot page shows the results of Base and Alt1 in the plot and the legend. In addition, I have added the results of Alt2, Alt3, and Alt4 to each plot, but I have removed them from the legend because the iterative MRM is currently set to run only two iterations (for Base and Alt1). In the future, you can ‘unhide’ Alt2 – Alt4 if you want to visualize more than two alternatives.