Introduction to PYTHON Programming
for MODFLOW Modelers

Webinar

Instructors:
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Location:
Your Home or Office!

Cost
Individual: $950
Office: $1,900

Contact Jim Rumbaugh (see above) to Register

Instructor Bio:

Jim Rumbaugh, hydrogeologist and groundwater modeler, has over 35 years of experience in application of groundwater models and in development of groundwater modeling software tools. He is the co-author of the Groundwater Vistas software and is President of Environmental Simulations, Inc., a company that specializes in groundwater modeling. Jim was a past Chairman of ASTM Subcommittee D18.21 on Groundwater and Vadose Zone Investigations. Subcommittee D18.21 was funded by U.S. EPA to develop standards for groundwater modeling practice. Jim was honored by the National Ground Water Association with the 1999 John Hem Excellence in Science and Engineering Award by NGWA. This award is given to those who have made a significant, recent scientific or engineering contribution to the understanding of groundwater. NGWA also presented Jim with the 2014 Technology Award, which is given to those who have made a significant contribution to the groundwater industry in the development of ideas and tools, along with exemplary service to colleagues throughout the industry in sharing these ideas. Jim teaches groundwater modeling seminars throughout the USA, Europe, Australia, and New Zealand. Jim has an active consulting practice and has worked on hundreds of groundwater modeling projects throughout the world.

Rodrigo Herrera, is a civil engineer with over 17 years of consulting experience in hydrogeology/hydrology for mining companies in Chile, specializing in groundwater modelling. He has worked for local and international consulting firms as project engineer, technical lead, and senior consultant, leading up to his role as group/discipline leader of the groundwater modelling group of GeoHidrología/Arcadis Chile from 2012 to 2016. Currently, he provides services as a groundwater modelling consultant through his company SGM Co, based in Santiago, Chile. During his professional career, he has developed numerous conceptual and numerical groundwater flow/transport models for environmental assessment purposes and operational scopes. His work has primarily been in basins located in northern and central Chile where natural water resources are limited. Mining operations there typically develop open pits or underground mines, and often deposit mine residues in large waste rock dumps and large tailings storage facilities. His main expertise lies in numerical modeling where he has continuously specialized in saturated, unsaturated, integrated surface-groundwater flow and solute transport modelling using codes such as MODFLOW-USG (flow and transport), SEEP/W, MODFLOW-SURFACT, MODFLOW 6, MT3D-USGS, among others. Currently, his interests are focused on seepage estimation for large tailings storage facilities using different approaches through inverse modelling (calibration) and other methods assisting the designing of seepage control systems using numerical modelling.

Registration:

To register for this seminar, simply send Jim an email at **JRumbaugh@GroundwaterModels.com,** give us a call at (610) 670-3400, or pay by credit card on our web site at www.groundwatermodels.com and click Online Store. Registration is not confirmed until we receive payment for the Webinar. Cost is $950 for an individual or $1,900 for an office (purchase 2 webinars at the online store for the office registration). Note that "office" means one physical location.

Webinar Information:

- The Webinar is divided into 6 lectures lasting between 1 and 2 hours. There are also 2 question and answer sessions. After each lecture, there will be computer exercises that you may work on at your own pace. Help with exercises is provided by email (support@groundwatermodels.com).

- Lectures are live **but will be recorded** in case you cannot attend all of them. You will call into the Webinar using either VoIP or telephone.

- Computer exercises are based on the Anaconda python development environment. All python-related software for the course is free. Detailed installation instructions will be provided before the webinar so you can get your computer set up for the course. Some references will be made to Groundwater Vistas Version 8 as well so a license to the advanced, professional, or premium versions would be advisable, but not required.

- ESI reserves the right to cancel the Webinar if there are less than 6 participants

- Each lecture will start at **1:00 pm Eastern Time**. **<u>Note that this time is not our usual webinar starting time!</u>** Webinar Lectures will be on Monday, Tuesday, and Wednesday for 2 consecutive weeks. Question & Answer sessions will be held on Thursdays. Consult our webinar schedule for exact dates.

Course Description:

Introduction to PYTHON Programming for MODFLOW Modelers

There will be 6 lectures and 2 question/answer sessions. Each lecture will use a brief powerpoint presentation introducing the topics to be covered, followed by a Jupyter Notebook to show the step-by-step development of the topic (e.g. building a model in flopy). The following is an outline for the six lectures:

Lecture 1:
Introduction to Python in Anaconda

The first session covers the installation of Anaconda, the python interface we will be using in this course. We will focus on the basics of python programming using Jupyter notebooks and the python language including use of variables, order of operations, and semantics of the python language.
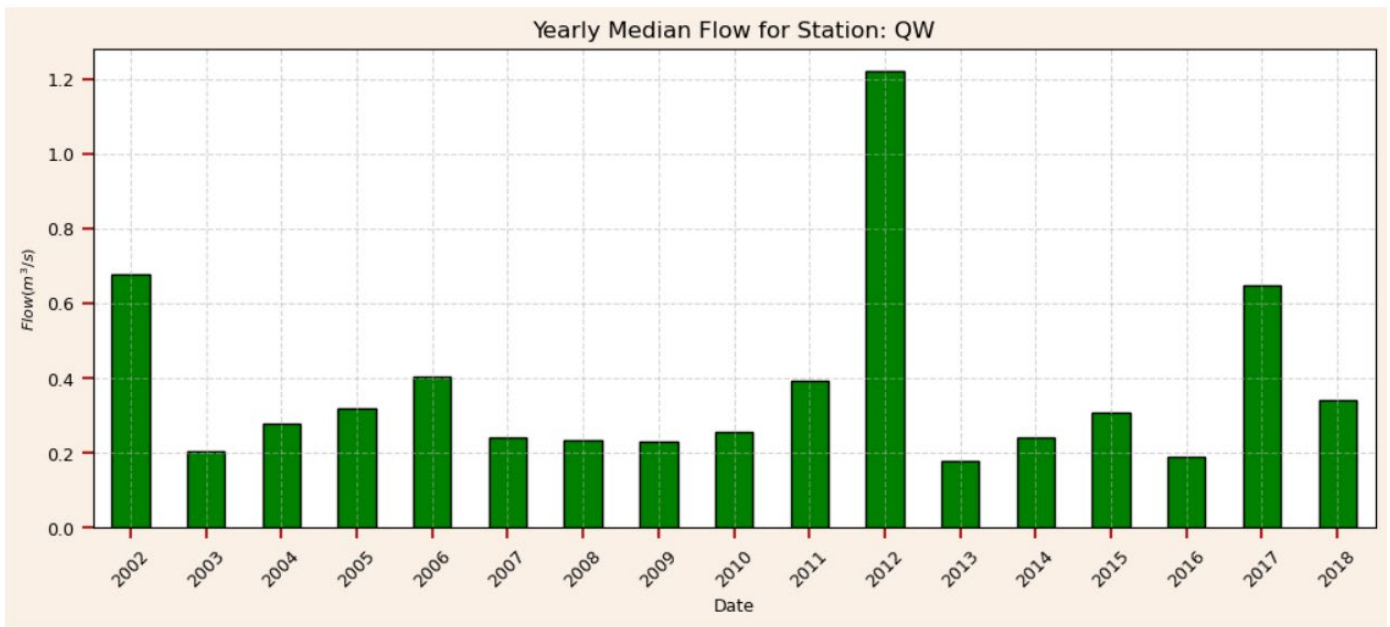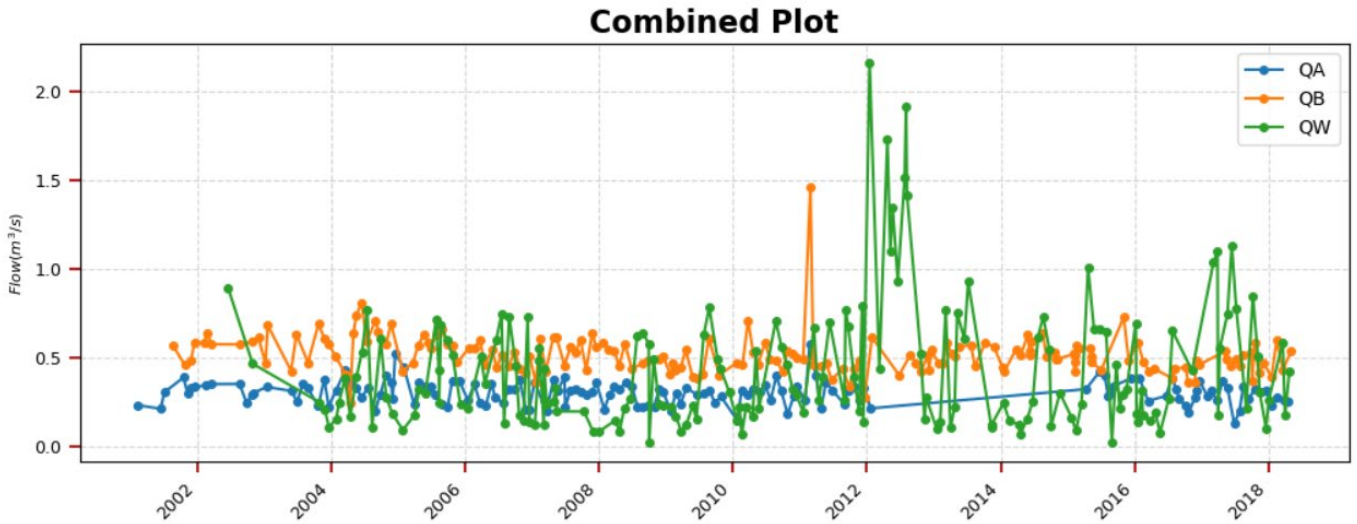
Lecture 2:
Flopy Basics

Flopy is a python interface for MODFLOW created by the USGS. The second session will cover how to use flopy to create models, import existing models, and process output from models created in flopy or Groundwater Vistas. There are two examples provided with this session. The first imports a complex model from the USGS to illustrate how to work with existing models and export a new clean copy that is easier to import back into Groundwater Vistas. The second example is the first tutorial in the GV8 manual. It is more complex than the example notebooks from USGS that come with flopy, showing how to import rasters for properties (eg., bottom elevation) and work with a non-uniform grid. Both MODFLOW2005 and MT3DMS are run from flopy and results are displayed in python.
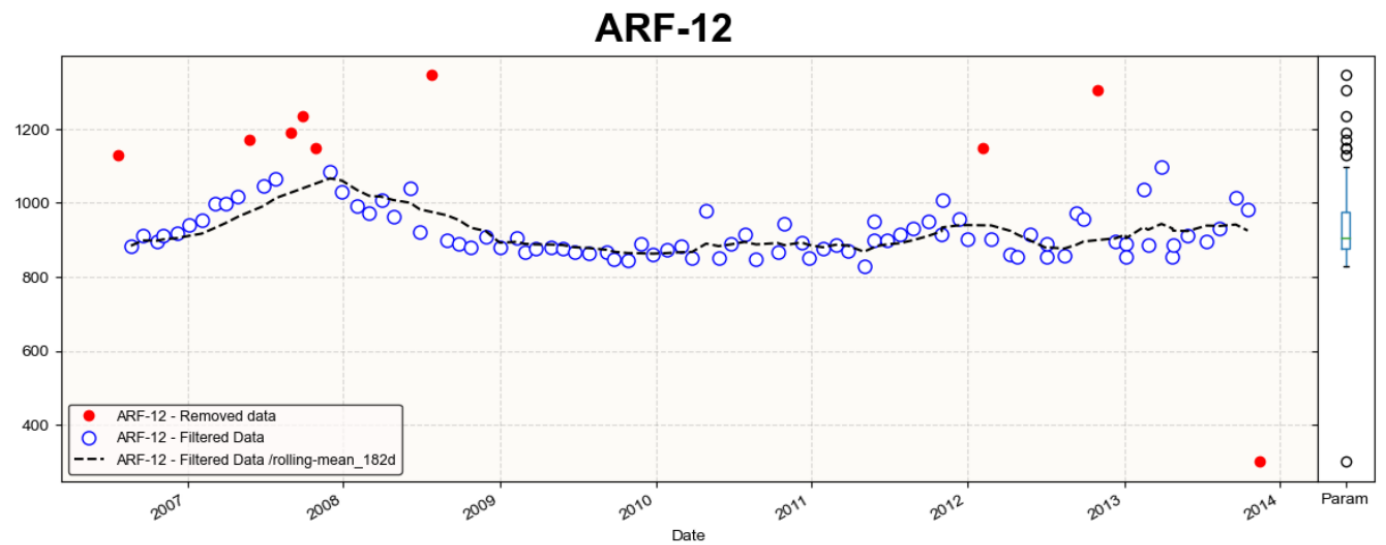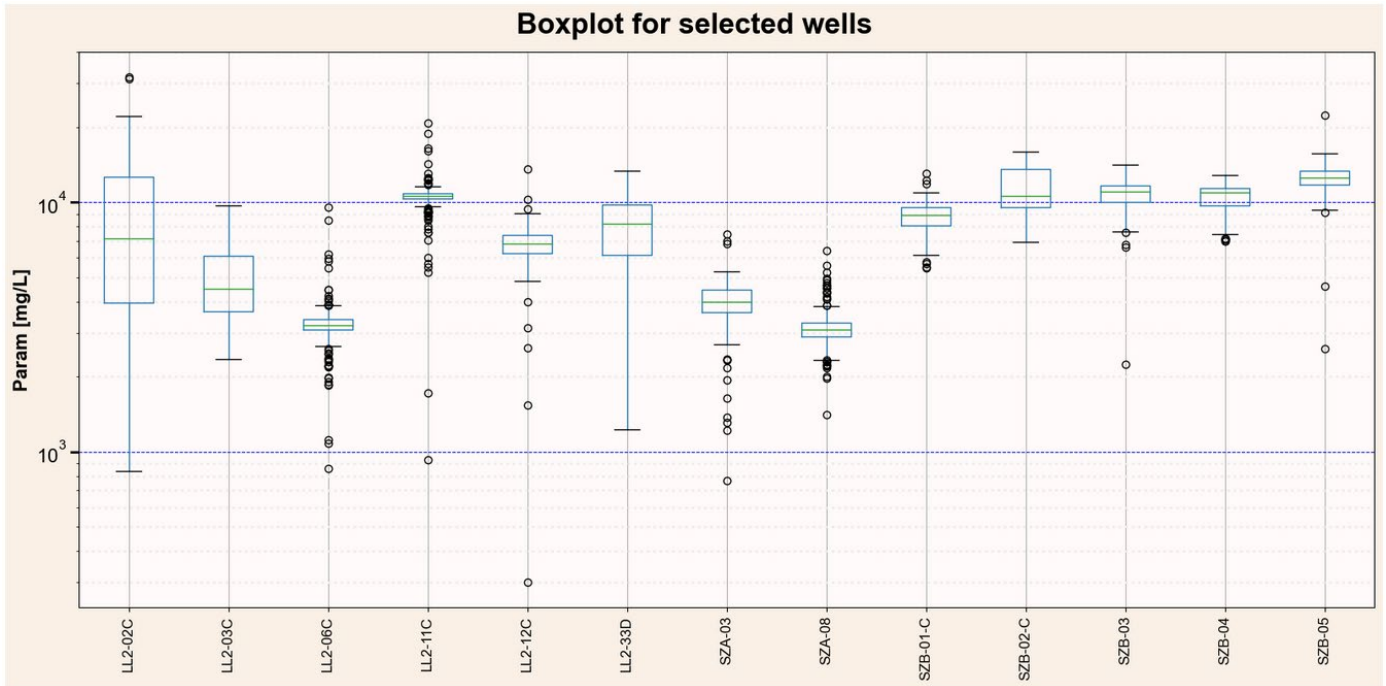
Lecture 3:
Using Pandas to Edit and Manipulate Data

Pandas is a Python package that provides numerous tools for data analysis. The DataFrame is a fundamental data structure in Pandas. We will illustrate how to work with DataFrames in the context of modeling data. This session will introduce Pandas by showing how to import and manipulate data from a *.csv file. These data can be generated by the model or represent field data to be imported into the model.

Combined Plot

Yearly Median Flow for Station: QW

Lecture 4:
*Matplotlib and Plotly to load, clean, and display data*

Lecture 4 will expand on the discussion from Lecture 3 and show how to load and clean data from a csv file for time-series information (either from the model or from a monitoring well dataset). We will also cover the plotting of data using MatPlotlib and Plotly to create informative graphs and charts.

Boxplot for selected wells

ARF-12

Lecture 5:
More on Flopy

Lecture 5 will expand on the 2nd session by showing how to manipulate model arrays like hydraulic conductivity and export them to a text file that can be imported into Groundwater Vistas. We will also

cover particle tracking with MODPATH, working with transient models, using ZONEBUDGET for mass balance analysis, and importing shapefiles to assign boundary conditions.
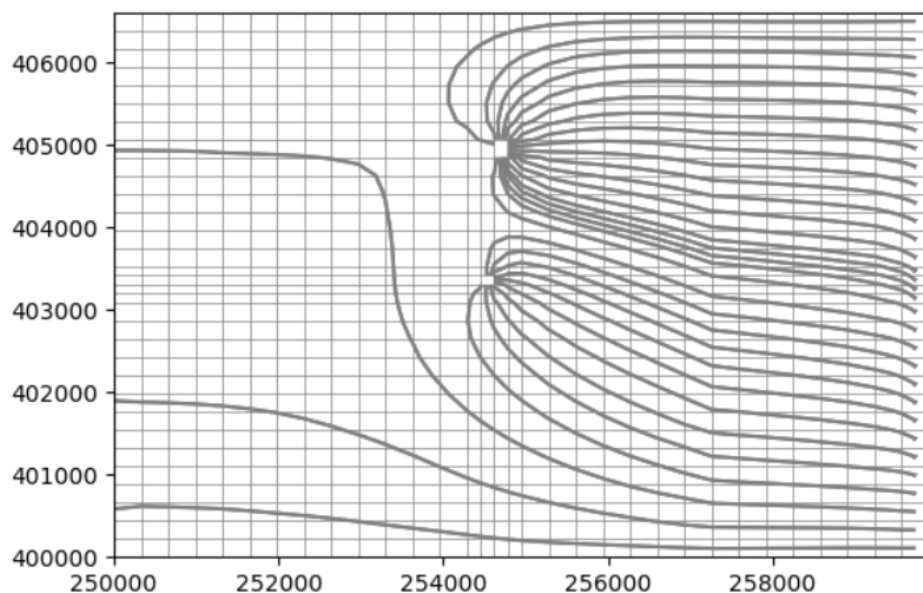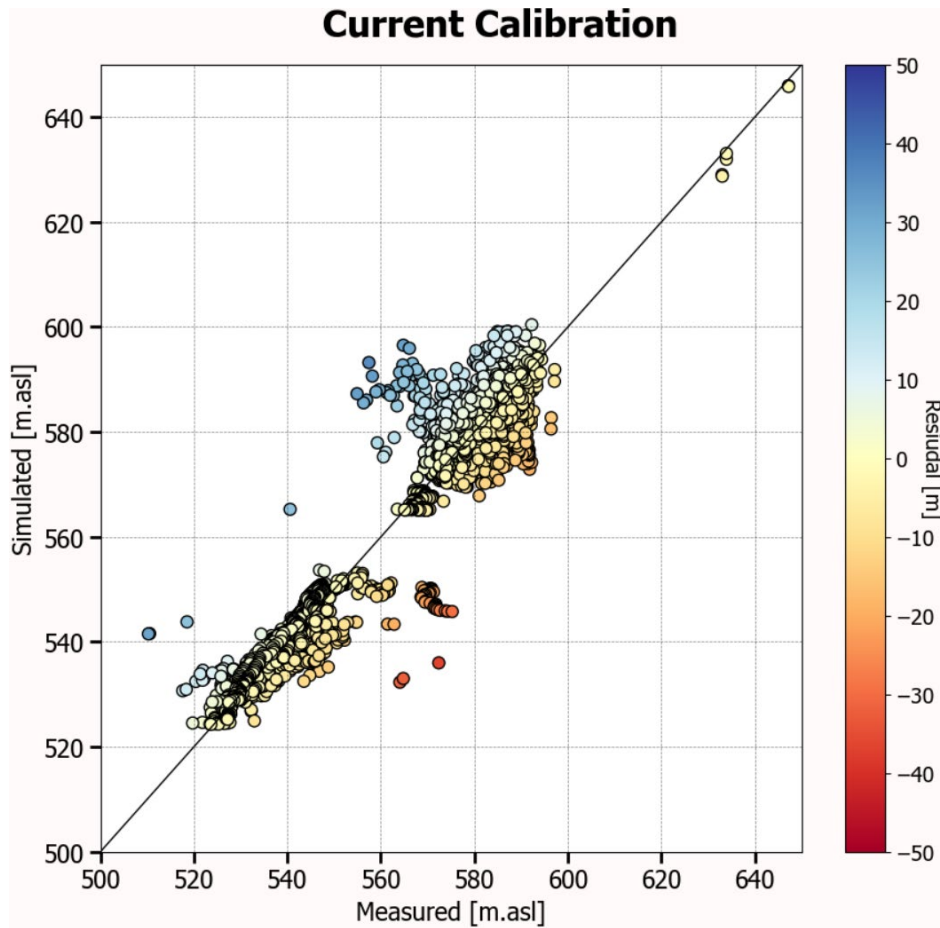

name	Zone1	Zone2	Zone3
FROM_CONSTANT_HEAD	0.000000	0.000000	0.000000
FROM_WELLS	0.000000	0.000000	0.000000
FROM_RECHARGE	126324.000000	0.000000	0.000000
FROM_Zone1	0.000000	100397.242188	0.000000
FROM_Zone2	33244.195312	0.000000	82168.070312
FROM_Zone3	0.000000	16207.720703	0.000000
TOTAL_IN	159568.187500	116604.960938	82168.070312
TO_CONSTANT_HEAD	55238.921875	0.000000	0.000000
TO_WELLS	0.000000	0.000000	70000.000000
TO_RECHARGE	0.000000	0.000000	0.000000
TO_Zone1	0.000000	33244.195312	0.000000
TO_Zone2	100397.242188	0.000000	16207.720703
TO_Zone3	0.000000	82168.070312	0.000000
TOTAL_OUT	155636.156250	115412.265625	86207.718750
IN-OUT	3932.031250	1192.695312	4039.648438
PERCENT_DISCREPANCY	2.494909	1.028109	4.798372

Lecture 6:
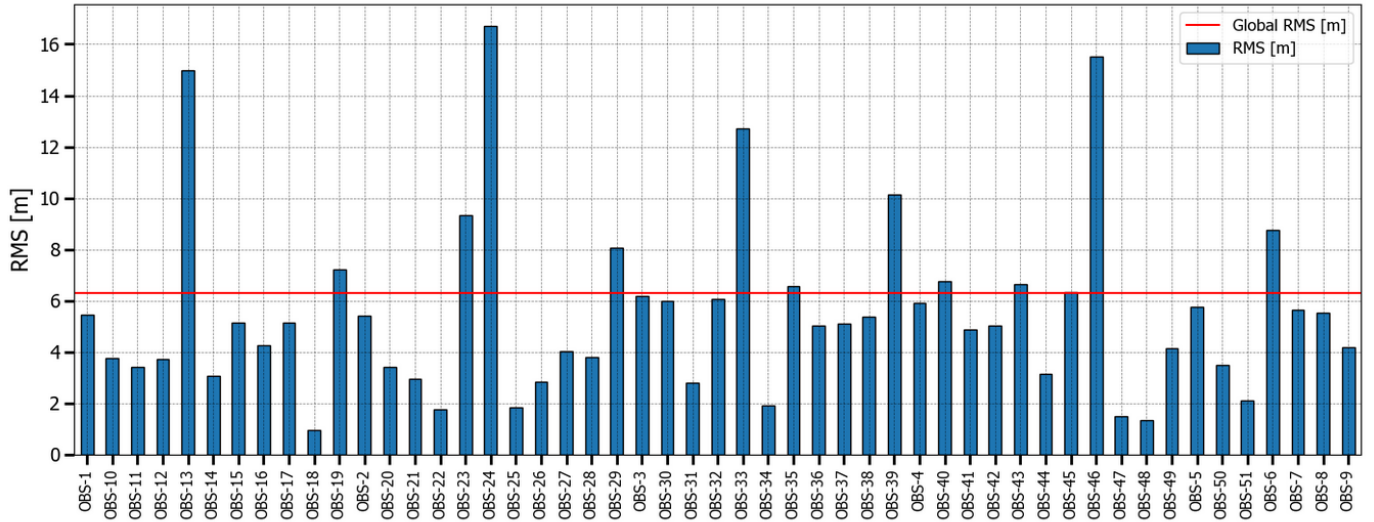## *Geopandas and Folium for Creation of Interactive Maps*

The last session uses the combination of Geopandas and Folium to create interactive maps of model and site data. These maps can be created as pdf format or in html that can be provided to others for viewing in a web browser. We will also cover the changes made to Groundwater Vistas to facilitate creation of these maps from model output.

Current Calibration plot showing Simulated [m.asl] versus Measured [m.asl] with points colored by Residual [m].

RMS by Well

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