Instructions for Running PyICM for an Idealized Estuary

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pyICM is a simplified version of the estuarine and coastal mechanistic model developed by the Army Corps of Engineers for Chesapeake Bay, called CE-QUAL-ICM (Cerco and Cole, 1993). It can be used to better understand estuarine water quality and biogeochemistry and to test new formulations. It has been modified to calculating the fully hyperspectral underwater light field (Clark et al. 2020) using spectral data from Chesapeake Bay collected in the Rhode River, MD (Rose et al. 2018). Clark et al. 2020 contains a full model description in the Appendices that are used in pyICM

1. Cerco, C. F., & Cole, T. (1993). Three-dimensional eutrophication model of Chesapeake Bay. *Journal of Environmental Engineering*, *119*(6), 1006–1025.
2. Clark, J. B., Long, W., & Hood, R. R. (2020). A comprehensive estuarine dissolved organic carbon budget using an enhanced biogeochemical model. *Journal of Geophysical Research*. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019JG005442
3. Rose, K. C., Neale, P. J., Tzortziou, M., Gallegos, C. L., & Jordan, T. E. (2018). Patterns of spectral, spatial, and long-term variability in light attenuation in an optically complex sub-estuary. *Limnology and Oceanography*. https://aslopubs.onlinelibrary.wiley.com/doi/abs/10.1002/lno.11005

This software has been tested on macOS Catalina version 10.15.7.

**Before we start**

**Open a terminal by searching in the finder for “Terminal” and opening the window**

The terminal is the primary way to install and run the programs for pyICM. In a future release it will be packaged with a simple graphical user interface but until then the terminal is necessary. These instructions are geared for Mac of Linux (i.e. Unix) based OS’s so apologies for the lack of specific information for those that use Windows. In the near future I will test and update for Windows.

**Having a code editor to edit the software easily**

**Visual Studio Code** is the best open-source code visualization and editing software which is free to download at <https://code.visualstudio.com/>

**Spyder** is the other tool we will use which comes with Anaconda

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1. **Install Anaconda**
   1. <https://docs.anaconda.com/anaconda/install/> and follow instructions for your specific OS and version of pythoni,ii
      1. Python comes pre-installed on Mac and most Linux OS’s, but may need to check version to make sure you install the correct Anaconda package
         1. To **check version type** into the terminal window ***python --version***
      2. Windows does not come with python pre-installed, so navigate to the link <https://docs.python.org/3/using/windows.html> to install the most up-to-date version of python
   2. Once installed can type ***conda help*** to see what commands are available
   3. Type ***conda update*** to make sure that everything is up to date (even if you just installed it)
   4. Type ***conda list***to list the packages that are currently installed with the base installation
2. **Make sure packages are installed that are needed for pyICM**
   1. Most of the packages need are standard with the conda install, to see all packages open the ICM\_main.py file. At the top, the packages are visible. Many of them are files that are contained within the code directory and are specific to pyICM. A brief description of the other packages are below, along with the current (as of Sep 2021) list from ICM\_main.py

**Graphical user interface, text, chat or text message

Description automatically generated**

* **The following four come with python/conda and don’t need to be installed**
  + **sys** system-specific parameters and functions <https://docs.python.org/3/library/sys.html>
  + **numpy** used for many numerical calculations and operators <https://numpy.org/>
  + **matplotlib** used for plotting things <https://matplotlib.org>
  + **pandas**used for data storage and manipulation <https://pandas.pydata.org/>
* **The rest (Density - Oxygen) are part of the source code of pyICM and descriptions of each file can be found at the top in the source code for each. A brief description is provided below**
  + **Density**calculates the density of water based on temperature and salinity
  + **functions** contains functions that are needed in multiple modules of pyICM
  + **DefVars** defines global parameters that are used across pyICM
  + **Ligh**tcalculates formulations for the prediction and propagation of light through the water column
  + **Sediment** calculates sediment sinking and transport
  + **Nutrients** calculates reactions of nutrients (NH4+, NO3-, and PO43-)
  + **DOM** calculates reactions of dissolved organic matter (dissolved organic carbon and nitrogen)
  + **POM** calculates reactions of particulate organic matter (particulate organic carbon and nitrogen)
  + **Algae** calculates reactions of phytoplankton (2 groups, cold and warm seasons)
  + **Oxygen** calculates reactions of dissolved oxygen
* **Additional packages that are needed** (in the light module)
  + **Pysolar** used to calculate the position of the sun based on latitude, longitude, and date <https://pysolar.readthedocs.io/en/latest/>
    - To install in the terminal type **pip install pysolar**
  + **Datetime** used to manipulate dates
    - To install in the terminal type **pip install datetime**

1. Now that all software and packages are installed, we can run the model in its initial configuration