Oily Python: a Reservoir Engineering Perspective

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Outline

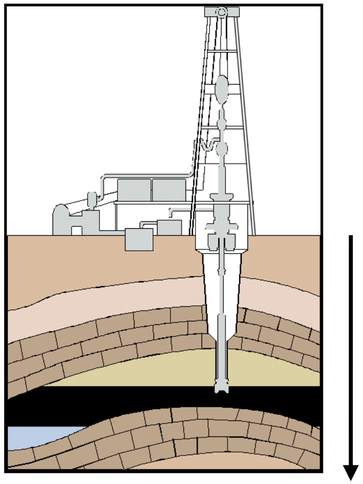
- ✓ What reservoir engineers do
- ✓ Data pre-processing and number crunching – *xlrd* and *numpy*
- ✓ 2D visualizations – *matplotlib*
- ✓ 3D visualizations – *VTK*, *mayavi* and *NetworkX*
- ✓ Integration with the reservoir numerical simulator – *f2py*
- ✓ Automation and N-D interpolation – Python and *scipy*
- ✓ Graphical user interfaces (GUIs) – *wxPython*

Presentation samples: http://www.infinity77.net/pycon/oily.zip

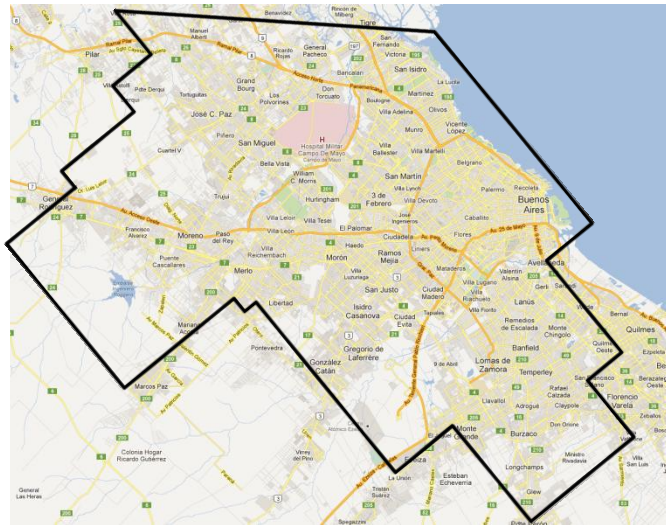
What We Do

- ✓ Using all sorts of real-life measurements:
  - Man-made seismic waves
  - Detailed record of the geologic formations penetrated by a well (*logs*)
  - Rock properties, oil/water/gas content in the reservoir rock
  - Pressure/temperature vs. depth in a well
  - Oil/water/gas production rates measured at the well
  - … and many others …
- ✓ A reservoir engineer:
  - Builds a 3D numerical model representing the reservoir and runs time-dependent fluid flow simulations
  - Tries to calibrate that model, i.e., match the simulated results with the real data
  - Using the calibrated model, tries to predict the future performances of the field

What We Do – Complications



1 – 10 Km



50 – 60 Km

20 – 100 GB

- ✓ Located underground: we can't go and see what's in there
- ✓ Sheer areal size – hard to accurately model numerically
- ✓ Huge amount of data to pre-process and integrate
- ✓ Each simulation can easily generate 100 GB of results to analyze

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Data Pre-Processing

"When fed with garbage data, a simulator is a machine that calculates meaningless results with incredible precision."

- ✓ A big part of the job is to ensure that the input data makes sense
  - Measurements come from many, unrelated sources
  - Data frequency – both in time and depth – varies wildly
  - Deep and thorough data checking needs to be carried out
- ✓ Dense visual representations of the input data are fundamental
  - Nothing beats seeing an image of your data to spot errors
  - Automatic filters and data adjustments (via Python code) are inherently limited
- ✓ Cleaned, sensible data can then be used to feed the simulation
  - One possible source of errors has been removed

Data Pre-Processing – *xlrd*

- ✓ Part of the data comes in Excel format (sigh…) – I am no friend with Excel
- ✓ *xlrd* is a great, multi-platform Python package to read Excel files
  - Fast as a rabbit – faster than Excel itself
  - Works around many Excel bugs (especially *datetime*-related)

```
# Open the Excel file
book = xlrd.open_workbook('example_1.xls')
# Get the first worksheet
sheet = book.sheet_by_index(0)

# Allocate an empty numpy array
values = numpy.zeros((sheet.nrows, 3))

# Loop over all the Excel sheet rows
for row in range(1, sheet.nrows):

    # Get the well name
    well_name = sheet.cell(row, 0).value

    # Column B should be a date...
    cell_type  = sheet.cell(row, 1).ctype
    cell_value = sheet.cell(row, 1).value

    if cell_type == xlrd.XL_CELL_DATE:
        # It's a date!
        date = xlrd.xldate_as_tuple(cell_value, book.datemode)
        date = datetime.date(*date[0:3])

    # Store production data into a numpy array
    for col in range(3):
        values[row, col] = sheet.cell(row, col+2).value
```

- ✓ Smoothly handles different cell types (empty, text, number, boolean, etc…)
- ✓ Various Excel-errors handling (`#REF!`, `#DIV/0!`, `#VALUE!`, etc…)
- ✓ Info on cell fonts, formats, formulae
- ✓ It's the base of *XLSGrid* (an AGW widget in *wxPython*) ☺

Oily sample: ***xlrd_1.py***

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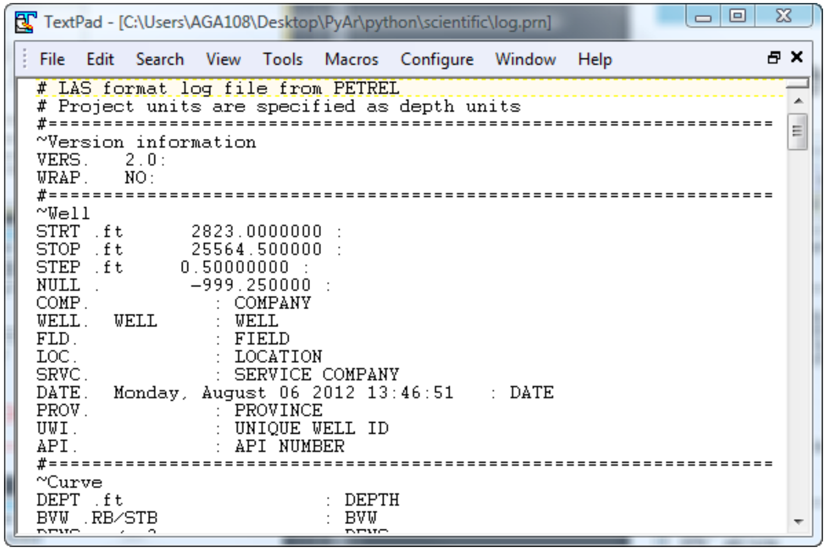
Number Crunching and I/O

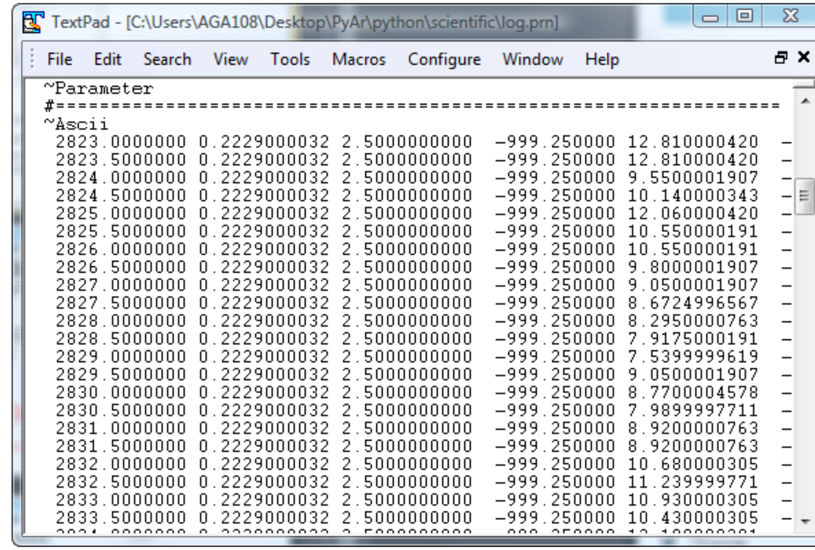
Task of the day

- ✓ Quality check of the electrical measurements on a well (*logs*)
- ✓ Depth-based data at 15cm intervals (well length can be more than 10Km)
- ✓ Free format text file with variable-length headers
  - Data is organized in columns
- ✓ We only care about depth, rock property and water content
  - All other data is discarded
- ✓ Unphysical values must be filtered out ($X < 0$ or $X > 1$)
- ✓ Cleaned data is then exported in another format
  1. Keeping original depth intervals (15cm)
  2. Averaging rock property and water content every 6m

Number Crunching and I/O



Header



Data

Problem size and available resources

- ✓ 860 wells, 4.9 GB of data scattered over a network
- ✓ Python 2.7 on Windows Vista:
  - CPU @ 3.46 GHz, 64 bit architecture
  - 16 cores, 96 GB or RAM

Oily sample: ***numpy_1.py***

Number Crunching and I/O – *numpy*

```
# We skip the first 43 rows of the text file
skip = 43

# Column 0  = Depth
# Column 8  = Rock property
# Column 13 = Water content
columns = (0, 8, 13)

# 1. Load the data using numpy.loadtxt
data = numpy.loadtxt('log.prn', skiprows=skip, usecols=columns)
```

- ✓ *loadtxt* is very handy and fast
- ✓ Returns a 2D *numpy* array
- ✓ Supports a wide range of file formats by tweaking its keyword arguments

```
# 2. Filter out the bad values for rock property
#    and water content
rock_water = data[:, 1:]

rock_water[rock_water < 0] = -999
rock_water[rock_water > 1] = -999

data[:, 1:] = rock_water

# 3. Save the filtered data to a new file
numpy.savetxt('log_out.prn', data, fmt='%-15s')
```

- ✓ Fast and intuitive operations on N-D arrays
- ✓ *savetxt* is as handy and as fast as *loadtxt*

```
# 4. Moving average every 20ft - 6m
# a. Set negative (default) values to NaN
averaged = numpy.where(data < 0, numpy.NaN, data)

# Pre-allocate a matrix for the averaged values
out_averaged = numpy.zeros((5, averaged.shape[1]))

for col in xrange(averaged.shape[1]):
    out_averaged[:, col] = moving_average(averaged[:, col], 40)
```

- ✓ A moving average implementation is a 2-liner with *numpy*

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Number Crunching and I/O – *numpy*

Final results and performances

✓ Looped through all the files in 6.5 minutes

✓ Can we do better?

- Yes we can – go parallel with the *multiprocessing* module
- The task is easily parallelizable: one file at a time

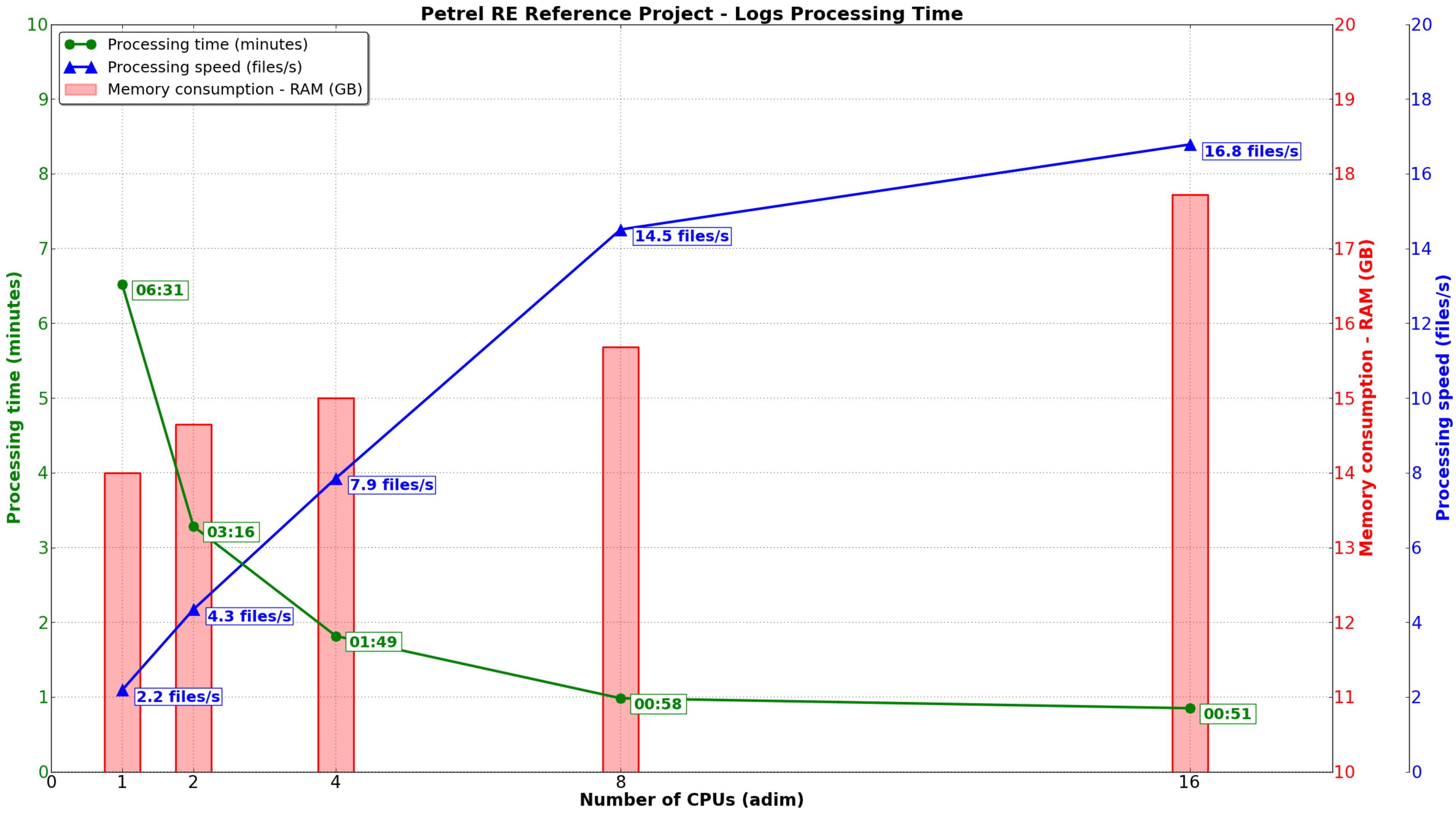
```
import numpy
from multiprocessing import Pool, cpu_count

# Start a multiprocessing pool of processes
# Use all the available CPUs
pool = Pool(processes=cpu_count())

# prn_files is a list of all the text files
# Apply the function to every text file
pool.map(read_log_file, prn_files)
```

✓ Windows is less suited to parallel stuff than other platforms (no *os.fork()*)

✓ Nevertheless, this approach gives stupendous speed gains

✓ If I am I/O-bound… I don't care

Number Crunching and I/O – *numpy*

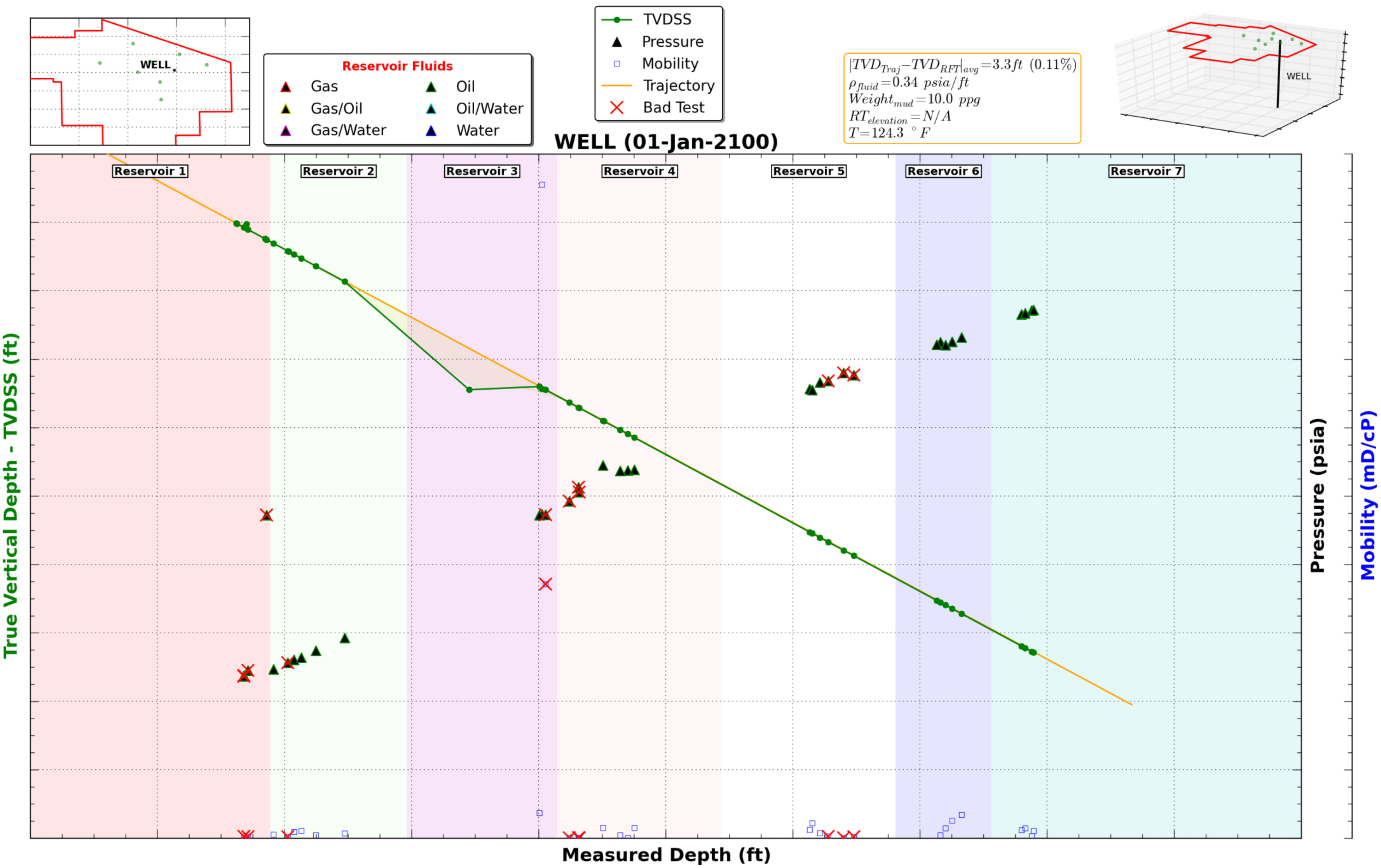


2D Visualizations

"A picture is worth a thousand words."

- ✓ We produce visualizations for every data type in our datasets
  - Visual inspection is a powerful solution to spot errors
  - Everyone in the team has a chance to analyze the data
  - Often provide new insights on how to better integrate the data
- ✓ The generated plots contain as much information as possible
- ✓ *matplotlib* is the Python package of choice
  - Almost limitless customizations of plots
  - Very high plot quality and wide range of plot types
  - Easy integration with GUI toolkits (*wxPython*, *Qt*, *PyGtk*, *TkInter*)

2D Visualizations – *matplotlib*



2D Visualizations – *matplotlib*

```
from mpl_toolkits.axes_grid1 import host_subplot
import mpl_toolkits.axisartist as AA
import matplotlib.pyplot as plt

host = host_subplot(111, axes_class=AA.Axes)
plt.subplots_adjust(right=0.75)

par1 = host.twinx()
par2 = host.twinx()

new_fixed_axis = par2.get_grid_helper().new_fixed_axis
par2.axis['right'] = new_fixed_axis(loc='right',
                                    axes=par2,
                                    offset=(60, 0))

par2.axis['right'].toggle(all=True)
```

- ✓ Multiple independent Y-axis
- ✓ Axis location, ticks, colors, labels, etc… can be tweaked
- ✓ *axisartist* supports curvilinear axis as well

Oily sample: ***matplotlib_1.py***

```
fig = plt.figure()
ax = fig.add_subplot(111)

colors = ['r', 'g', 'b', 'm', 'y']

for i in range(5):
    start, end = 10*i, 10*(i+1)
    ax.axvspan(start, end, color=colors[i], alpha=0.1)

    reservoir = 'Reservoir %d'%(i+1)

    ax.text(10*i+5, 8, reservoir, fontweight='bold',
            bbox=dict(fc='w', ec='k'), zorder=100,
            ha='center')

plt.show()
```

- ✓ *axhspan* adds a horizontal span (rectangle) across the axis
- ✓ *axvspan* is its vertical friend

Oily sample: ***matplotlib_2.py***

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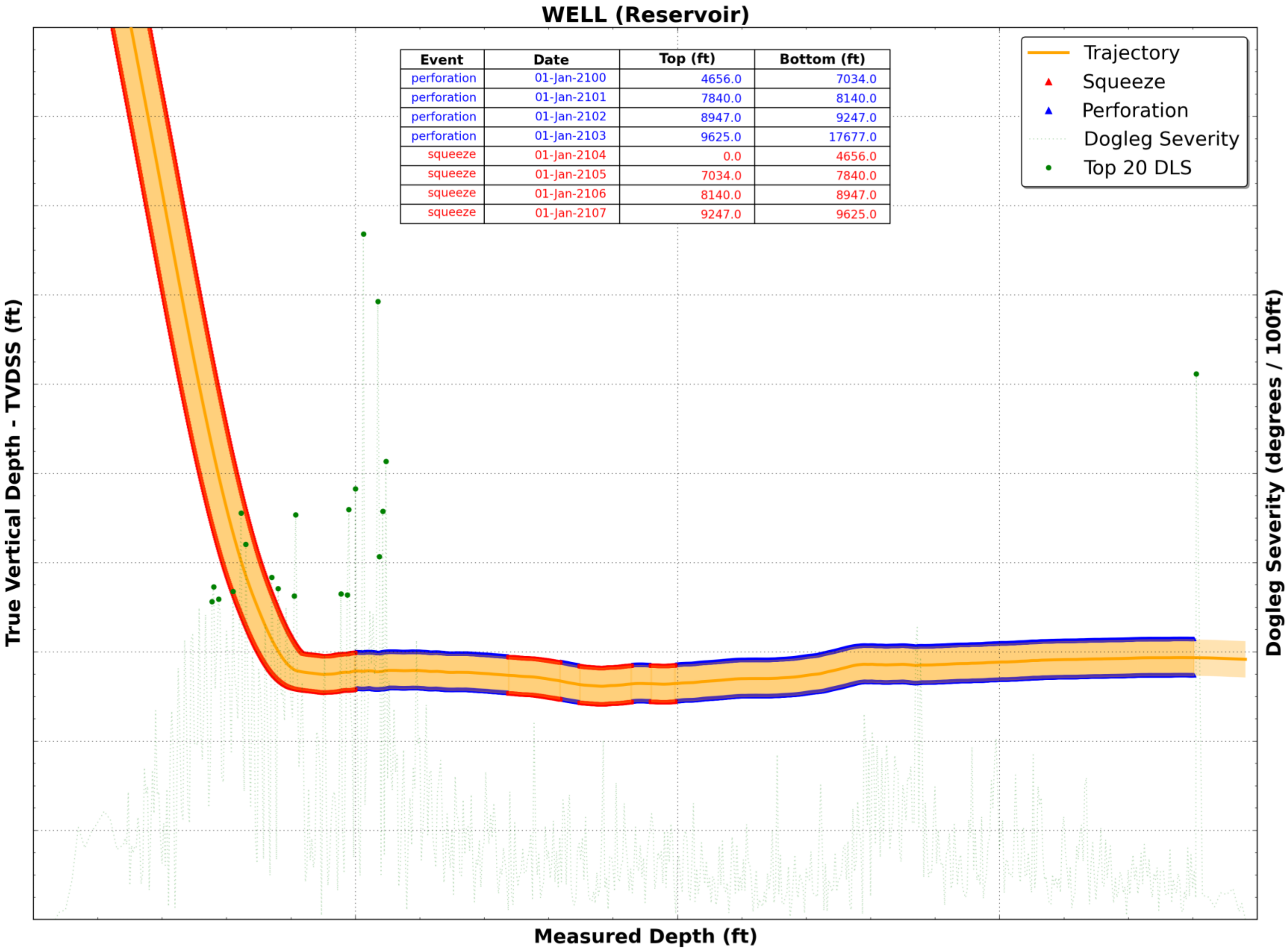
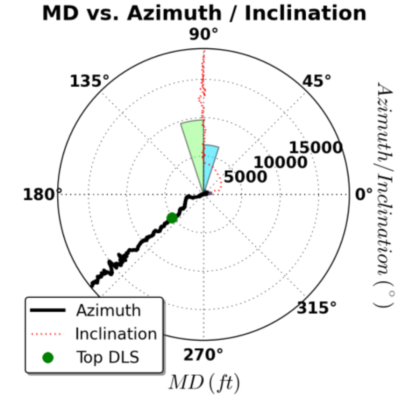
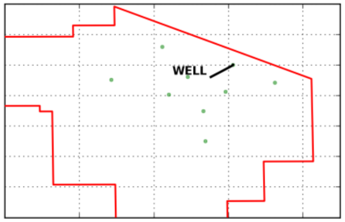
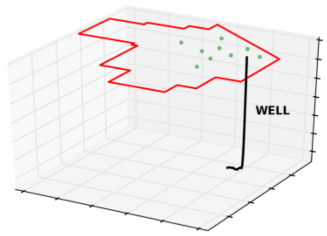
2D Visualizations – *matplotlib*



Event	Date	Top (ft)	Bottom (ft)
perforation	01-Jan-2100	4656.0	7034.0
perforation	01-Jan-2101	7840.0	8140.0
perforation	01-Jan-2102	8947.0	9247.0
perforation	01-Jan-2103	9625.0	17677.0
squeeze	01-Jan-2104	0.0	4656.0
squeeze	01-Jan-2105	7034.0	7840.0
squeeze	01-Jan-2106	8140.0	8947.0
squeeze	01-Jan-2107	9247.0	9625.0







2D Visualizations – *matplotlib*

```python
fig = plt.figure()
ax = fig.add_subplot(111)

colLabels = ['Event', 'Date', 'Top (ft)', 'Bottom (ft)']

# No row labels
rowLabels = ['', '']

cellText = [['Perforation', '01-Jan-2020', '300', '400'],
            ['Squeeze'    , '01-Aug-2030', '0'  , '300']]

table = ax.table(cellText=cellText, rowLabels=rowLabels,
                 colLabels=colLabels, bbox=(0.1, 0.7, 0.8, 0.2))

table.auto_set_font_size(False)

plt.show()
```

- ✓ Tables are a useful addition to *matplotlib* plots
- ✓ Exact formatting, colors and font may sometimes be hard to get right

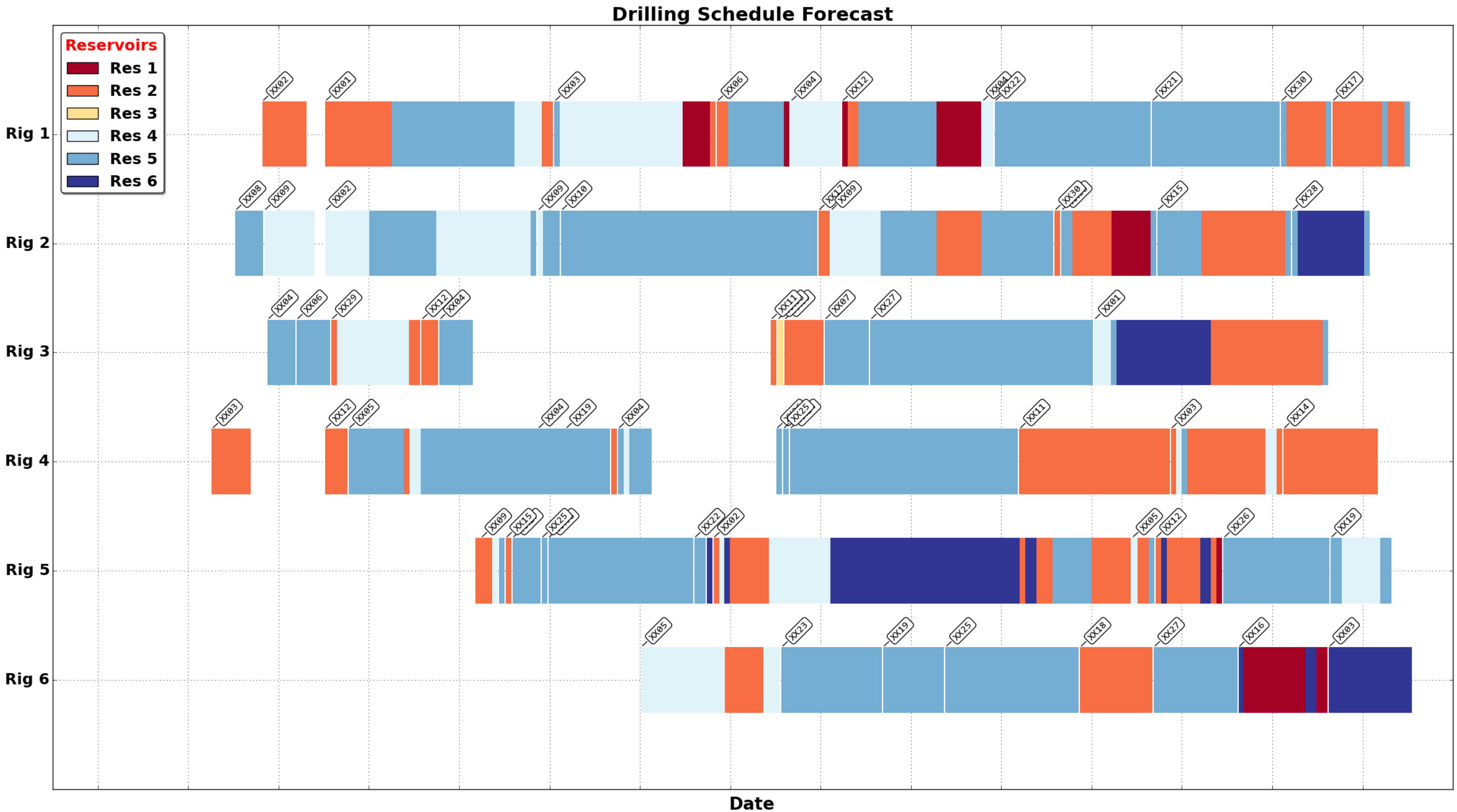
Oily sample: ***matplotlib_3.py***

```python
# Make a square figure
fig = plt.figure(figsize=(6, 6))
# Add polar axes
ax = fig.add_axes([0.1, 0.1, 0.8, 0.8], polar=True)

# Make some data up
r = numpy.arange(0, 3.0, 0.01)
theta = 2*numpy.pi*r
ax.plot(theta, r, color='#ee8d18', lw=3)
ax.set_rmax(2.0)
ax.grid(True)

plt.show()
```

- ✓ Polar plots are not widely used in the oil industry
- ✓ They can be a great tool to analyze a well trajectory

Oily sample: ***matplotlib_4.py***

2D Visualizations – *matplotlib*



2D Visualizations – *matplotlib*

```
fig = plt.figure()
ax = fig.add_subplot(111)

ax.broken_barh([(110, 30), (150, 10)], (10, 9),
                 facecolors='blue')
ax.broken_barh([(10, 50), (100, 20), (130, 10)], (20, 9),
                facecolors=('red', 'yellow', 'green'))

ax.set_ylim(5, 35)
ax.set_xlim(0, 200)
ax.set_xlabel('Drilling Time (days)')
ax.set_yticks([15, 25])
ax.set_yticklabels(['Rig 1', 'Rig 2'])
ax.grid(True)

ax.annotate('Rig stopped', (61, 25),
            xytext=(0.6, 0.9), textcoords='axes fraction',
            arrowprops=dict(facecolor='black', shrink=0.05),
            fontsize=16, ha='right', va='top')

plt.show()
```

- ✓ *broken_barh* is the perfect tool to draw drilling schedules
- ✓ Similar plots can be obtained by using multiple calls to *ax.barh()*
- ✓ Axis annotations add useful info about the data being displayed

Oily sample: ***matplotlib_5.py***

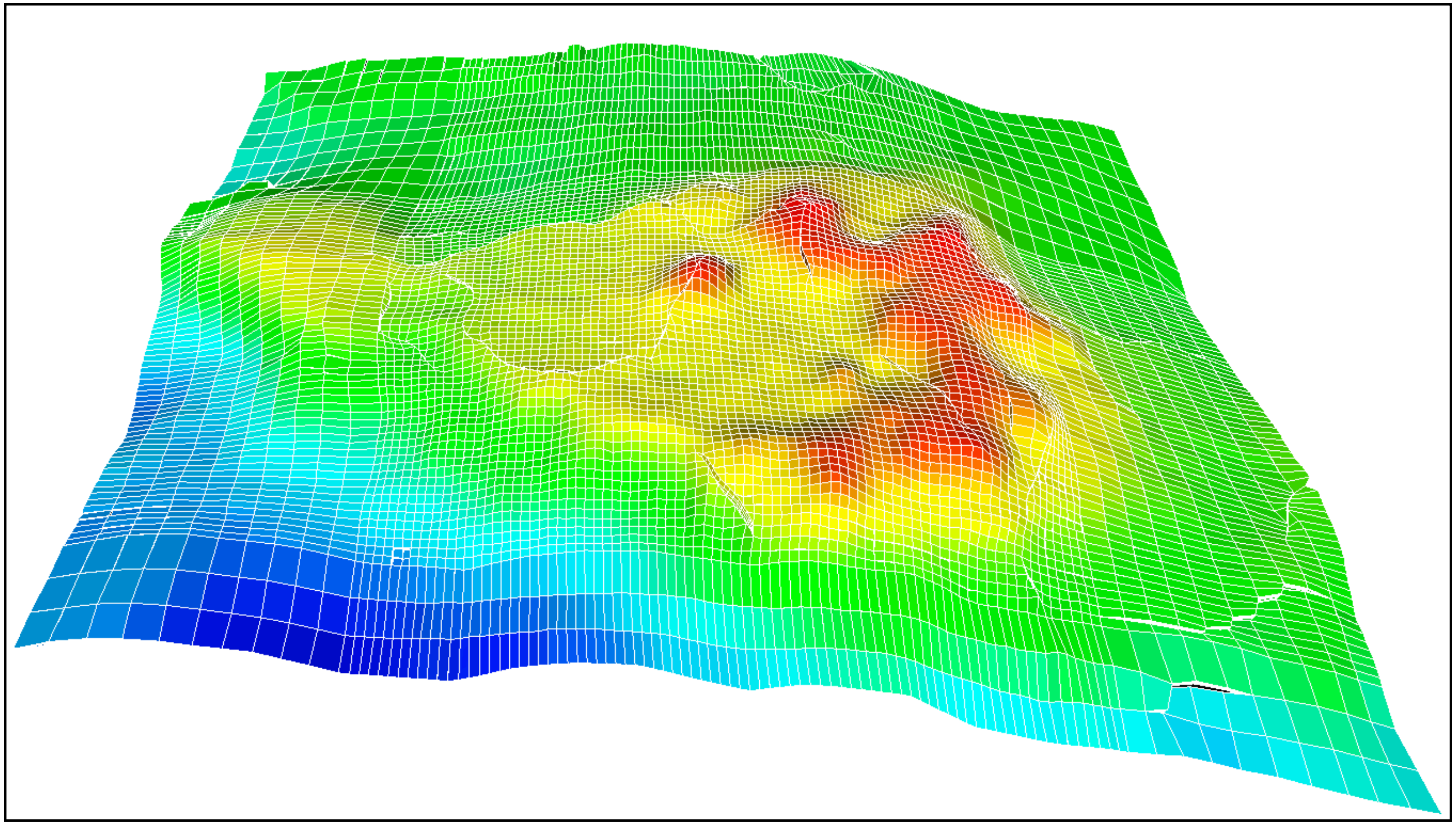
I'll use this occasion to remember John Hunter, the creator of *matplotlib* (1968-2012)

3D Visualizations

"There's something that 3D gives to the picture that takes you into another land and you stay there and it's a good place to be..."

- ✓ Most commercial software handle 3D stuff with no effort
- ✓ 3D visualization in Python is used only for specific, niche problems
  - Simulation results of well production at a specific depth
  - Double-checking input data for the simulation
  - Visualize a relationship between wells, area, reservoir and a project
- ✓ *VTK* and *mayavi* are the most widely used 3D rendering Python packages
  - Scale fairly well on big 3D datasets
  - *VTK* can easily be integrated in a GUI window (*wxPython*, *Qt*, *PyGtk*, etc…)
  - *VTK* figures can be saved as VRML files to let the colleagues play with them

3D Visualizations – *VTK*



- ✓ 3D reservoir model, 500,000 cells (VTK unstructured grid)
- ✓ We easily go up to 10 million cells, interaction is still smooth

3D Visualizations – *VTK*

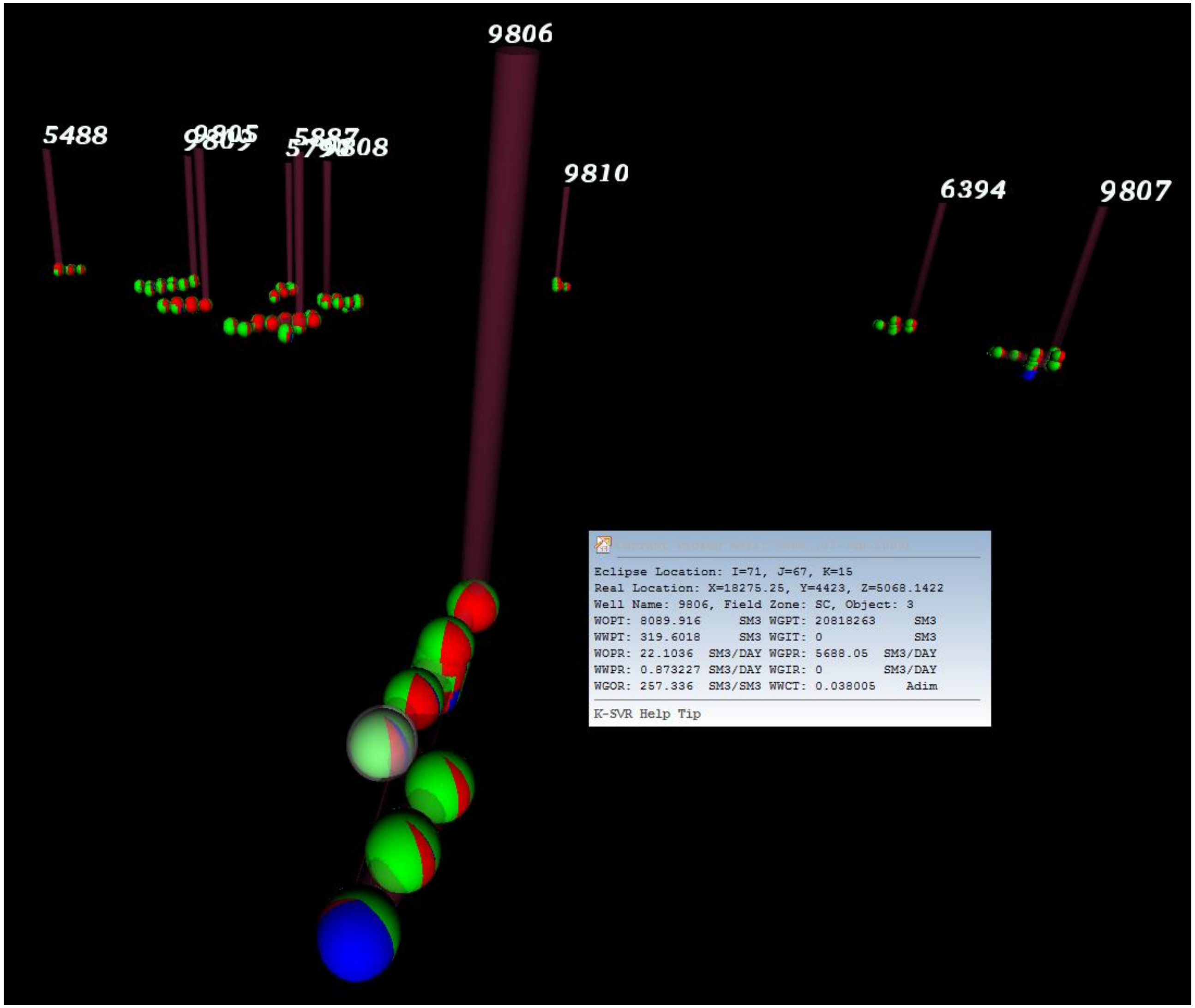
- ✓ *VTK* unstructured grids require explicit point and cell representations
- ✓ 3D Cells can be seen as distorted hexahedrons

```
# matrix is a (8*Nx*Ny*Nz, 3) 2D numpy array
vtk_pts = array2vtkPoints(matrix)

# Create vtk data
grid = vtk.vtkUnstructuredGrid()
grid.SetPoints(vtk_pts)

# Create cells
ids = numpy.arange(0, 8*nx*ny*nz, dtype=numpy.float32)
ids = numpy.reshape(ids, (nx*ny*nz, 8))
cells = array2vtkCellArray(ids)

# Assign cells to unstructured grid
grid.SetCells(12, cells)

# Actually create the unstructured grid
ugrid = vtk.vtkExtractUnstructuredGrid()
ugrid.SetInput(grid)

ugrid = ugrid.GetOutput()
ugrid.Update()
```

- ✓ Special techniques exists to handle very large datasets
- ✓ Coincident points can be merged (faster rendering)
- ✓ Highlighted functions are available in the *array_handler.py* module as part of the distributed samples
- ✓ These functions ease the transition between *numpy* arrays and *VTK* arrays

Oily sample: ***vtk_1.py***

3D Visualizations – *VTK*



- ✓ Spheres identify a producing interval in a well
- ✓ Colors represent the produced fluid (oil, water, gas)
- ✓ Spherical slices shows the relative abundance of each fluid
- ✓ Each sphere can be “picked”, i.e. selected with the mouse, to display more data
- ✓ Time based animation are possible

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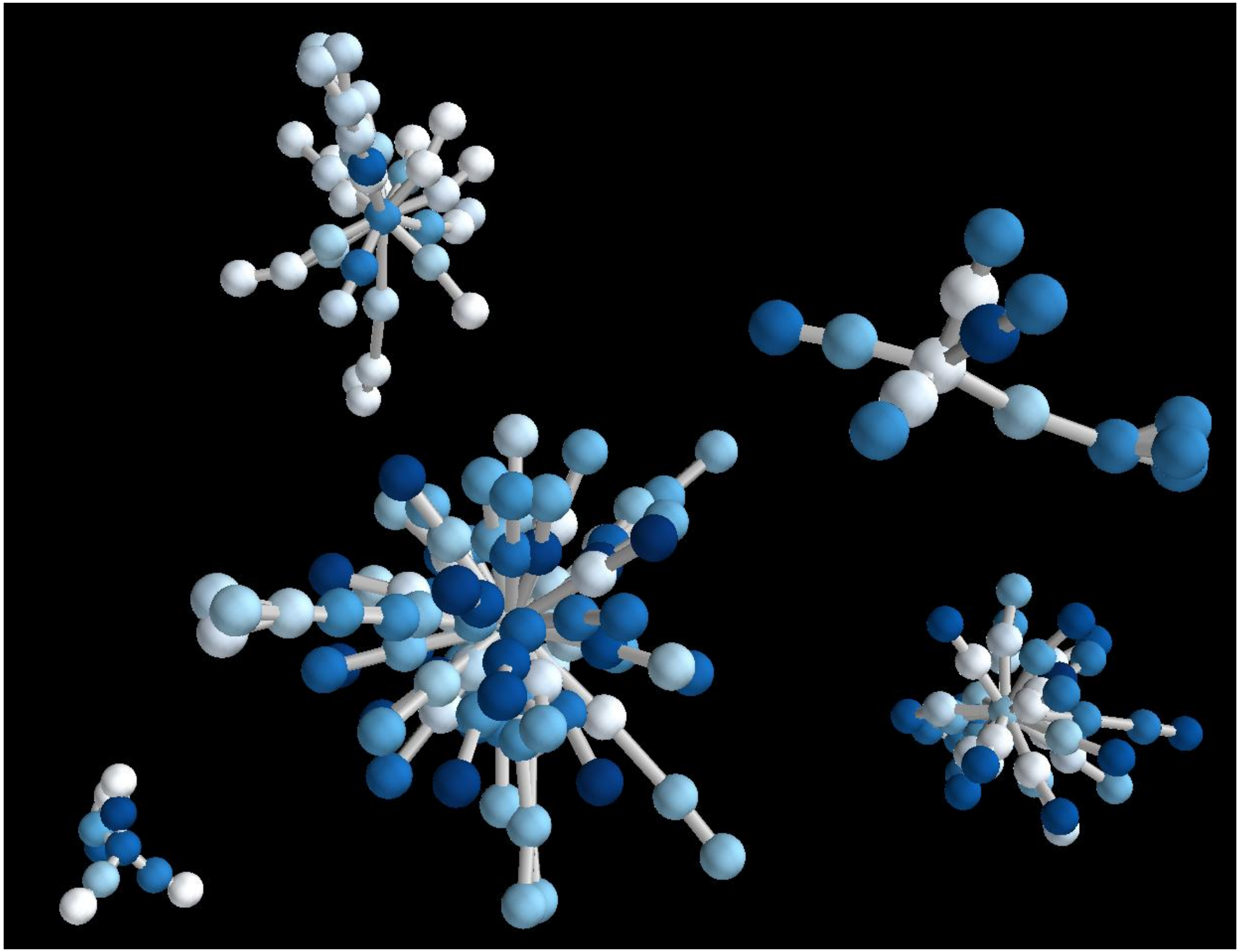
3D Visualizations – *VTK*

```
# x, y, z coordinates of a well trajectory
points = numpy.array(points)
line = [range(len(points))]

# Create the vtk data for the trajectory
vtk_pts = array2vtkPoints(points)
vtk_lines = array2vtkCellArray(line)

poly = vtk.vtkPolyData()
poly.SetPoints(vtk_pts)
poly.SetLines(vtk_lines)

# A filter that generates tubes around lines
profileTubes = vtk.vtkTubeFilter()
# Set the tube radius and resolution
profileTubes.SetRadius(radius)
profileTubes.SetNumberOfSides(20)
profileTubes.SetInput(poly)

# Map vtkPolyData to graphics primitives
wellMapper = vtk.vtkPolyDataMapper()
wellMapper.SetInput(profileTubes.GetOutput())

# Create an "actor" for the well
wellActor = vtk.vtkActor()
wellActor.SetMapper(wellMapper)

# Create a caption "actor" for the well name
textActor = vtk.vtkCaptionActor2D()
textActor.SetCaption(wellName)
```

- ✓ *vtkPolyData* can represent vertices, lines, polygons etc…
- ✓ *vtkTubeFilter* is a very good way to represent wells in a 3D space
- ✓ The well name caption "actor" follows the user view while she interacts with the VTK window
- ✓ Highlighted functions are available in the *array_handler.py* module as part of the distributed samples

Oily sample: ***vtk_2.py***

3D Visualizations – *NetworkX and mayavi*



- ✓ Visualize relationships between wells, areas, reservoirs and projects
- ✓ Shows dependencies between wells and undeveloped areas
- ✓ 3D version of a *GraphViz* inheritance diagram
- ✓ Particularly useful when a project contains 1000s of wells

Oily sample: ***mayavi_1.py***

Integration with the Simulator

"Fast as a rabbit, dumb as a stone."

- ✓ The reservoir simulator can easily generate 100 GB of results per simulation
- ✓ Each result set is made of 5-8 interesting files
  - Results are stored in heavily compressed, unformatted binary files
  - These files are generated by a Fortran-based simulator
  - File structure is relatively simple and straightforward
- ✓ We can use Python to extract the simulation results from these files
  - Performances are generally poor (code is slow)
  - Does not scale well when files are big
- ✓ Can we write a small Fortran routine and interface it with Python to read these large, binary files?
  - Enter *f2py*

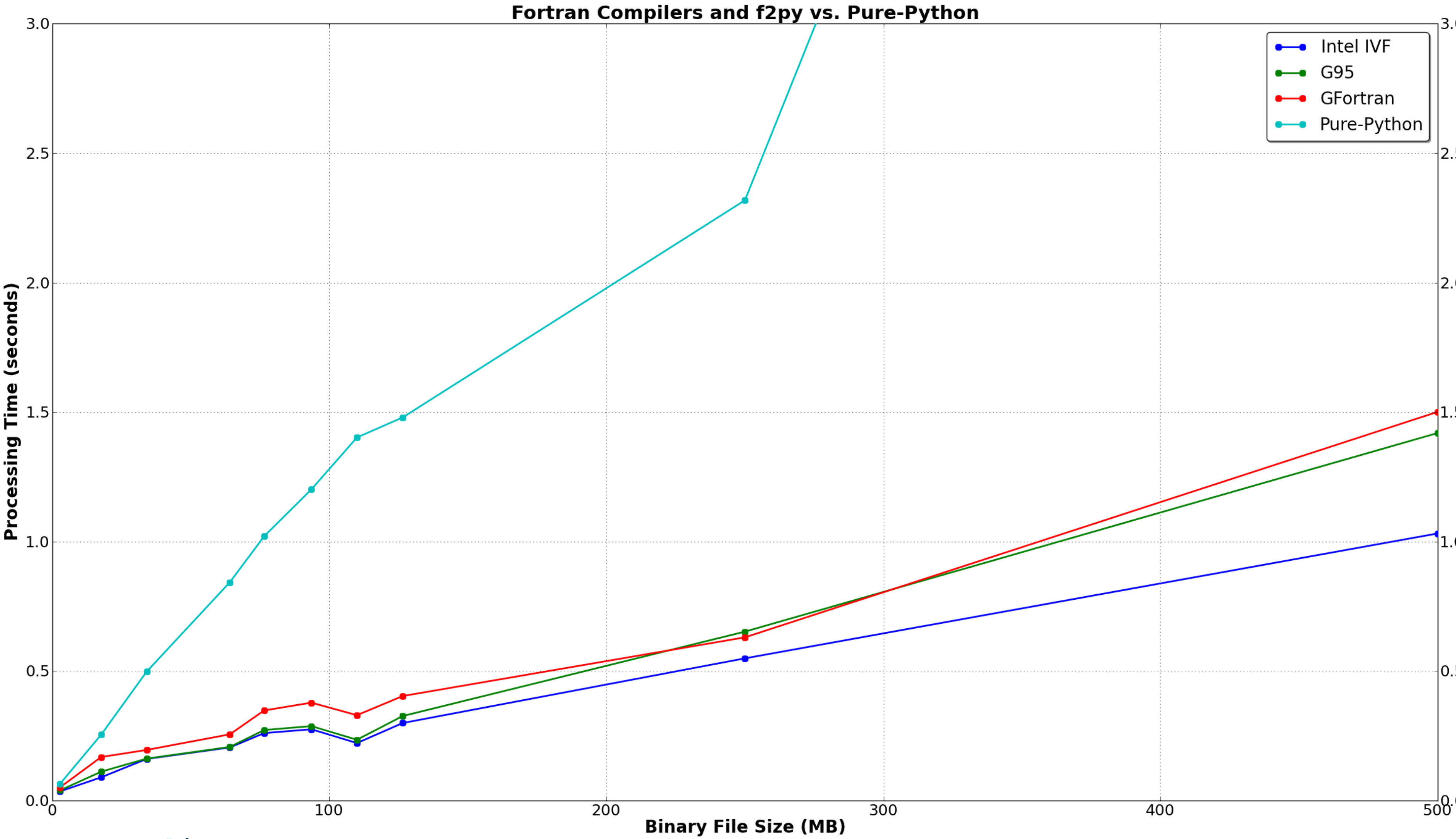
Integration with the Simulator – *f2py*

- ✓ Fortran to Python interface generator
- ✓ Connects the two languages:
  - Creates Python C/API modules from Fortran 77/90/95
  - Works directly on Fortran sources
  - Automatically handles the difference in the data storage order of multi-dimensional Fortran and *numpy* arrays
- ✓ Requires a Fortran compiler installed – supports many major compilers, such as gfortran, Intel IVF, Absoft, NAG, etc…

```
f2py -c fortran_file.f90 -m  py_module
```

- ✓ Now every Fortran subroutine/function in *fortran_file.f90* is accessible in Python by importing *py_module*

Integration with the Simulator – *f2py*



Automation and N-D Interpolation

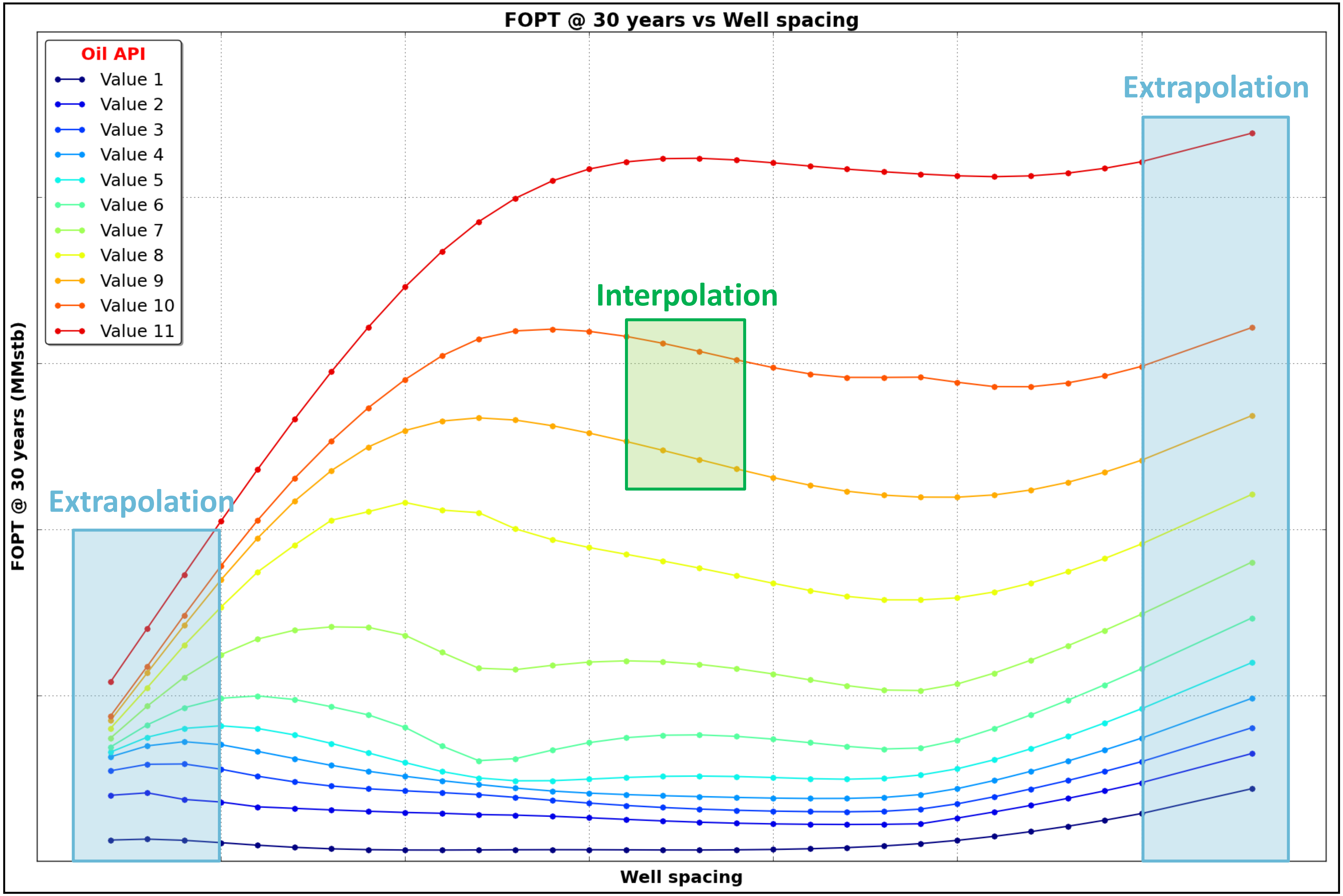
"Besides black art, there is only automation and mechanization."

Task of the day

- ✓ We have 16,000 new simulations available (sensitivities)
  - Each of them represents a unique combination of 13 parameters (oil gravity, rock properties, distance between wells etc…)
  - Simulation results could give insights on the numerical model sensitivity to the parameters variations
- ✓ The 13 parameters form a discrete set of known data points
- ✓ Use a *f2py*-generated module to read results from all the simulations
- ✓ Use interpolation to estimate results at intermediate values of the parameters
  - *scipy* offers multi-dimensional interpolation/extrapolation capabilities
  - *scipy.interpolate.rbf*: uses Radial Basis Function interpolation of N-dimensional scattered data

Oily sample: ***scipy_1.py***

Automation and N-D Interpolation – *scipy*



Graphical User Interfaces

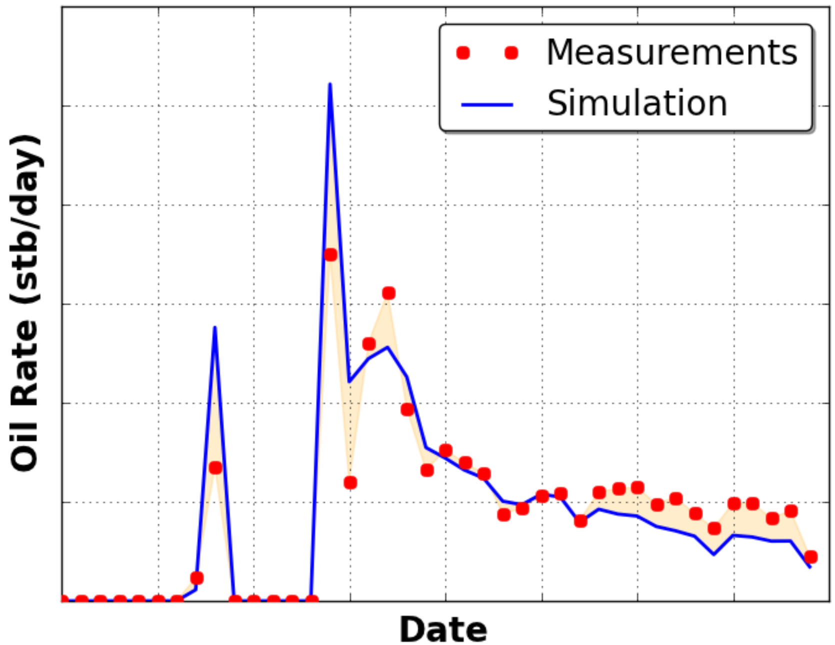
“A picture is worth a thousand words. An interface is worth a thousand pictures.”

- ✓ User interfaces are an obvious choice when it comes to sharing your findings with non-Pythonistas colleagues
- ✓ Although many high quality GUI frameworks are available…
- ✓ *wxPython* is ***the*** tool I use
    - Almost effortlessly integrate with *matplotlib* and *VTK* (2D and 3D)
    - Easy to build practical, responsive and sexy user interfaces
    - GUIs look (and are) native, whatever the platform
    - Number of widgets available far surpass all other toolkits
- ✓ Distribution to colleagues is done via *py2exe* / *PyInstaller* and *InnoSetup* to generate a standard Windows installer

Graphical User Interfaces

Task of the week/month

✓ Create a GUI that evaluates the quality of a calibrated reservoir model



✓ Calibration is good when simulation results are close to measurements (shaded area)

✓ Errors in the calibration are measured by different formulas such as:

$$Error = \frac{1}{N}\sqrt{\sum_{i=1}^{N} \omega_i \left(\frac{s_i - o_i}{o_i}\right)^2}$$

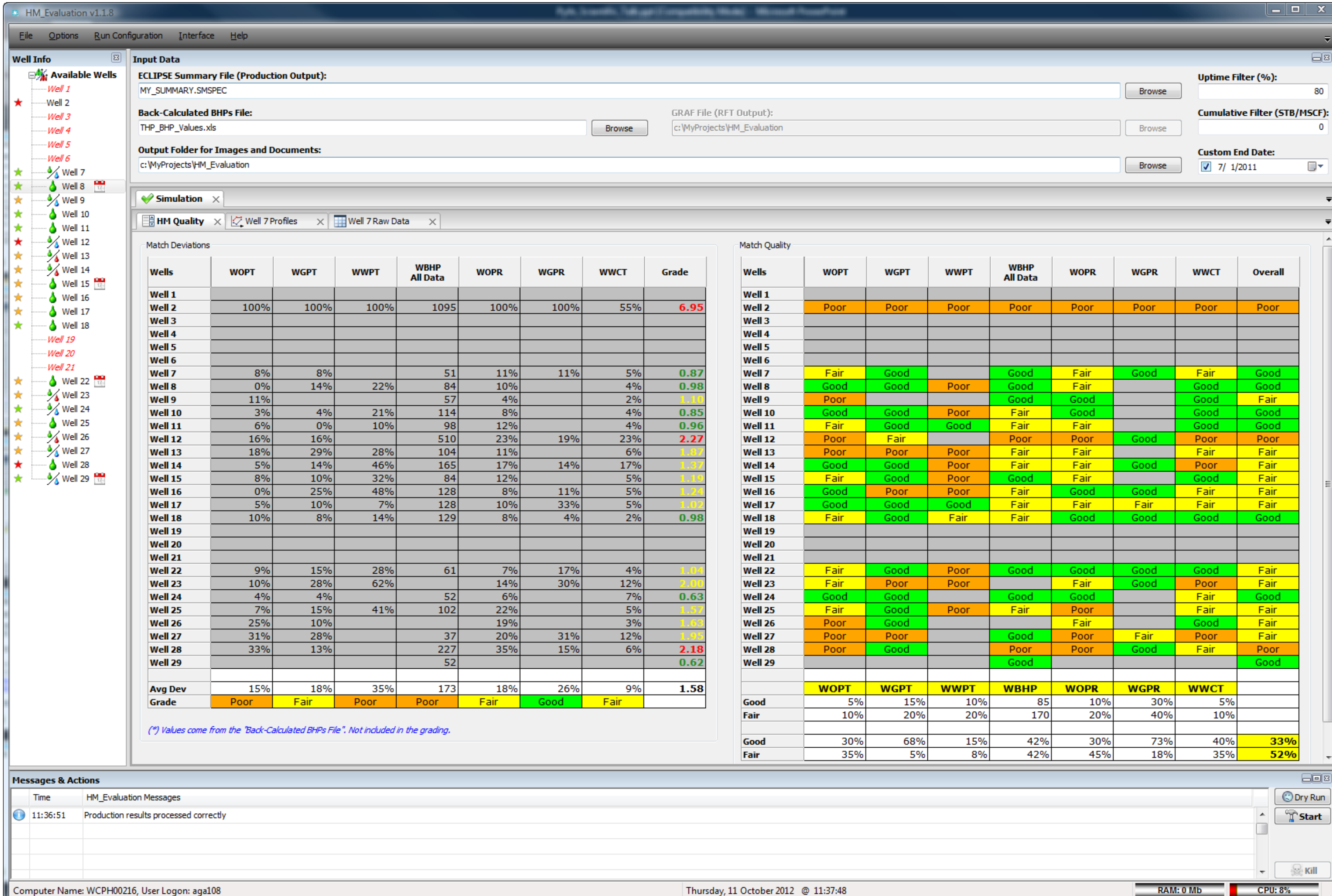
✓ The GUI should allow the user to explore the numerical calculations and to quickly plot the simulation results against the measurements

Graphical User Interfaces

Complications

- ✓ Number of data points: 17 years of historical measurements
- ✓ Number of wells and simulation time steps (thousands)
- ✓ The user would like to be able to:
  - Filter out values outside a user-defined date window (per well)
  - Apply a custom multiplier to some of the measurements
  - Exclude some values if a well has been closed for more than X days in a month
  - Modify the error function if a well has been using some gas to ease production
  - Many, many other customizations…
- ✓ The GUI puts together the power of *numpy*, *f2py*, *matplotlib*, *scipy*, *multiprocessing* and *wxPython* to deliver all that and much more ☺

Graphical User Interfaces



Match Deviations

Wells	WOPT	WGPT	WWPT	WBHP All Data	WOPR	WGPR	WWCT	Grade
Well 1								
Well 2	100%	100%	100%	1095	100%	100%	55%	6.95
Well 3								
Well 4								
Well 5								
Well 6								
Well 7	8%	8%		51	11%	11%	5%	0.87
Well 8	0%	14%	22%	84	10%		4%	0.98
Well 9	11%			57	4%		2%	1.10
Well 10	3%	4%	21%	114	8%		4%	0.85
Well 11	6%	0%	10%	98	12%		4%	0.96
Well 12	16%	16%		510	23%	19%	23%	2.27
Well 13	18%	29%	28%	104	11%		6%	1.87
Well 14	5%	14%	46%	165	17%	14%	17%	1.37
Well 15	8%	10%	32%	84	12%		5%	1.19
Well 16	0%	25%	48%	128	8%	11%	5%	1.24
Well 17	5%	10%	7%	128	10%	33%	5%	1.02
Well 18	10%	8%	14%	129	8%	4%	2%	0.98
Well 19								
Well 20								
Well 21								
Well 22	9%	15%	28%	61	7%	17%	4%	1.04
Well 23	10%	28%	62%		14%	30%	12%	2.00
Well 24	4%	4%		52	6%		7%	0.63
Well 25	7%	15%	41%	102	22%		5%	1.57
Well 26	25%	10%			19%		3%	1.63
Well 27	31%	28%		37	20%	31%	12%	1.95
Well 28	33%	13%		227	35%	15%	6%	2.18
Well 29				52				0.62
Avg Dev	15%	18%	35%	173	18%	26%	9%	1.58
Grade	Poor	Fair	Poor	Poor	Fair	Good	Fair	

(*) Values come from the "Back-Calculated BHPs File". Not included in the grading.

Match Quality

Wells	WOPT	WGPT	WWPT	WBHP All Data	WOPR	WGPR	WWCT	Overall
Well 1								
Well 2	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Well 3								
Well 4								
Well 5								
Well 6								
Well 7	Fair	Good		Good	Fair	Good	Fair	Good
Well 8	Good	Good	Poor	Good	Fair		Good	Good
Well 9	Poor			Good	Good		Good	Fair
Well 10	Good	Good	Poor	Fair	Good		Good	Good
Well 11	Fair	Good	Good	Fair	Fair		Good	Good
Well 12	Poor	Fair		Poor	Poor	Good	Poor	Poor
Well 13	Poor	Poor	Poor	Fair	Fair		Fair	Fair
Well 14	Good	Good	Poor	Fair	Fair	Good	Poor	Fair
Well 15	Fair	Good	Poor	Good	Fair		Good	Fair
Well 16	Good	Poor	Poor	Fair	Good	Good	Fair	Fair
Well 17	Good	Good	Good	Fair	Fair	Fair	Fair	Fair
Well 18	Fair	Good	Fair	Fair	Good	Good	Good	Good
Well 19								
Well 20								
Well 21								
Well 22	Fair	Good	Poor	Good	Good	Good	Good	Fair
Well 23	Fair	Poor	Poor		Fair	Good	Poor	Fair
Well 24	Good	Good		Good	Good		Fair	Good
Well 25	Fair	Good	Poor	Fair	Poor		Fair	Fair
Well 26	Poor	Good			Fair		Good	Fair
Well 27	Poor	Poor		Good	Poor	Fair	Poor	Fair
Well 28	Poor	Good		Poor	Poor	Good	Fair	Poor
Well 29				Good				Good
	WOPT	WGPT	WWPT	WBHP	WOPR	WGPR	WWCT	
Good	5%	15%	10%	85	10%	30%	5%	
Fair	10%	20%	20%	170	20%	40%	10%	
Good	30%	68%	15%	42%	30%	73%	40%	33%
Fair	35%	5%	8%	42%	45%	18%	35%	52%

Graphical User Interfaces

Final outcome

- ✓ We have a fast, practical and nice GUI to examine the quality of model calibration
- ✓ Colleagues can independently run the GUI and examine the results
- ✓ Multiple simulations can be analyzed and compared
- ✓ The interface automagically exports *matplotlib* figures for all the wells and Excel reports (and it does it on multiple processors…)
    - Findings and insights can easily be shared outside the team
    - Consistent, fixed (and beautiful) format for pictures in reports and documents
- ✓ We have the source code ☺ – any modification is embarrassingly fast

Graphical User Interfaces

Graphical User Interfaces

Task of the week/month

✓ The reservoir simulator we use is called ECLIPSE

- It's keyword-based – you enter inputs in a text file with keywords and sub-keywords
- 1983: first release of ECLIPSE (**ECL**'s **I**mplicit **P**rogram for **S**imulation **E**ngineering)
- ECLIPSE currently handles ≈1,600 keywords
- On average, each keyword has 3 switches/sub-keywords (≈4,200 in total)
- No editor with syntax highlighting, error checking capabilities and integrated help system exists for the input files (after 30 years!!)

✓ How about a *wxPython*-based editor with all these capabilities?

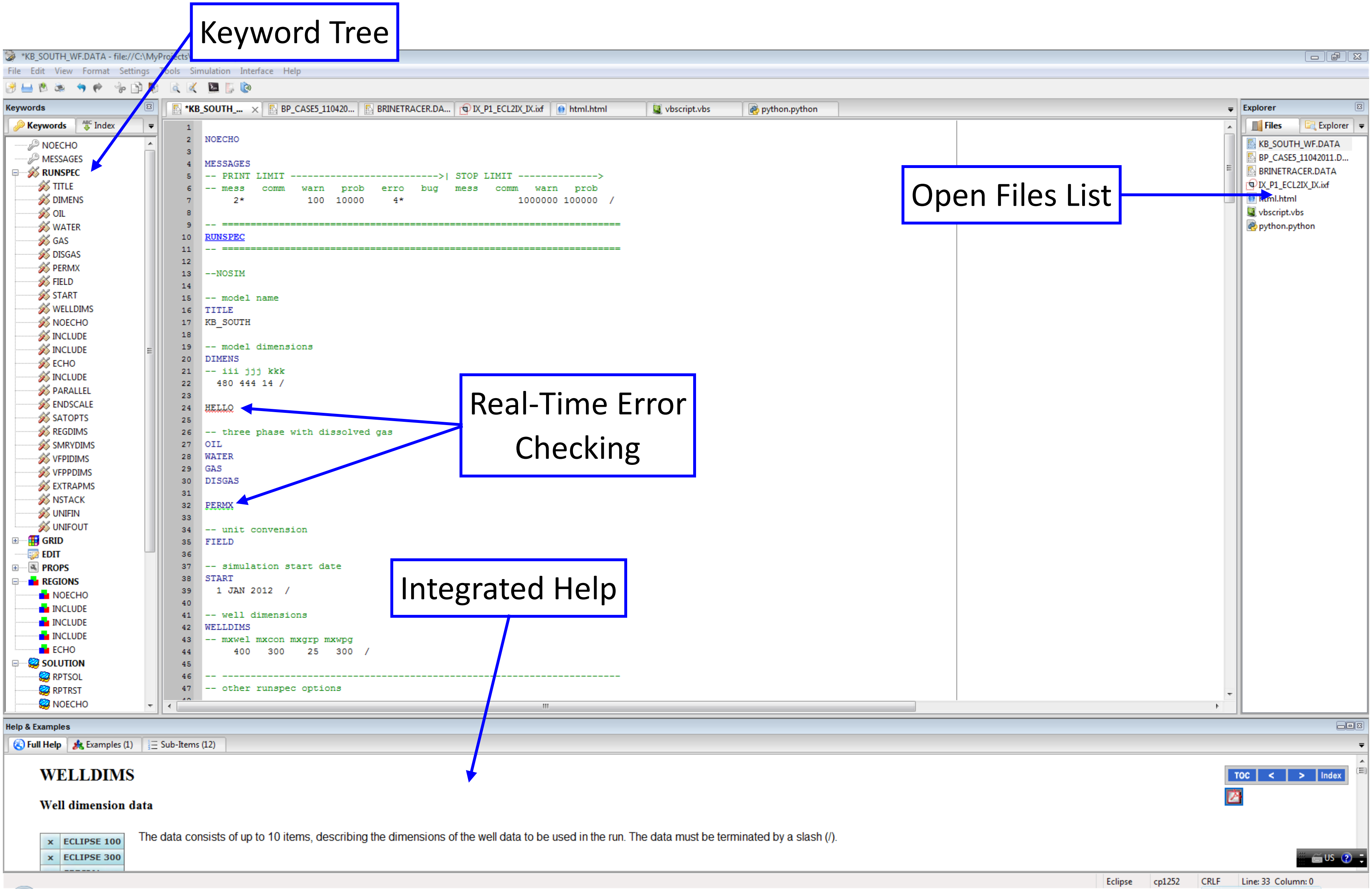
- The *wx.StyledTextCtrl* (Scintilla-based) already provides excellent syntax highlighting for various programming languages
- *wxPython* 2.9 contains powerful HTML viewing capabilities (via *wx.html2* module)
- The ECLIPSE input files syntax is very similar to the programming language *Lua*

Graphical User Interfaces

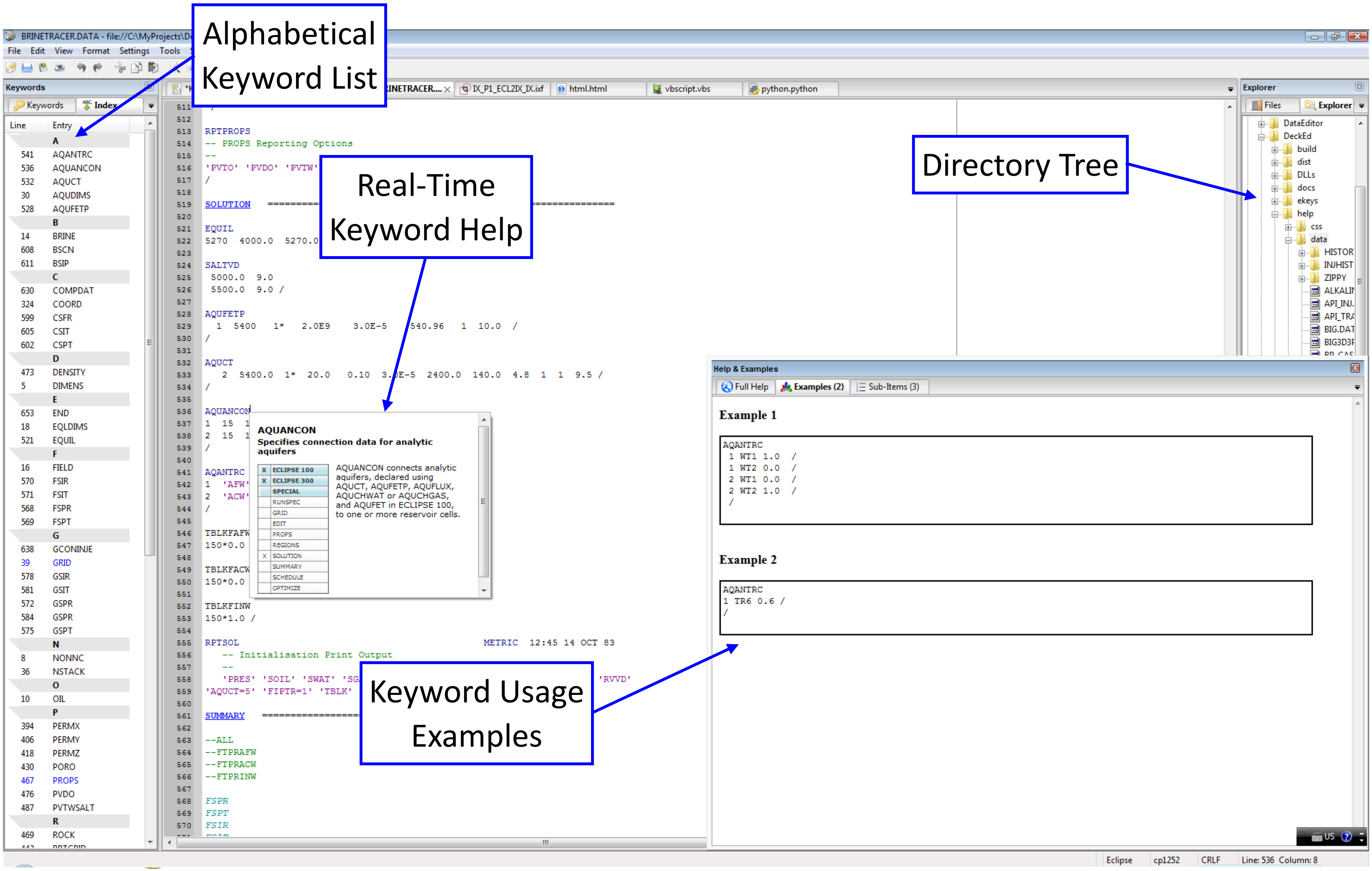
Another GUI: *DeckEd*

- ✓ *DeckEd* is a text editor based on *wx.StyledTextCtrl*
- ✓ Syntax highlighting for the reservoir simulator ECLIPSE and more than 60 other programming languages (Python, C++, Java, HTML, PHP, Ruby, etc…)
- ✓ Integrated help for the reservoir simulator keywords and sub-keywords
- ✓ Runtime monitoring of simulation status and progress
- ✓ Runtime error checking for ECLIPSE input files keywords
- ✓ Plugin-based architecture – you can add a Python debugger, a spell checker, a code browser, etc…

Graphical User Interfaces



Graphical User Interfaces



Conclusions

- ✓ Many, many more examples of the usage of Python in the oil industry that I couldn't show
- ✓ Python is becoming increasingly popular amongst reservoir engineers
  - Automation improves working effectiveness a hundredfold
  - Beauty and elegance of the language – easy to grasp even for newcomers
- ✓ Third-party packages add great value to the standard library:
  - *matplotlib* – plot customization and unbeatable figure quality
  - *numpy* and *scipy* – fast numerical manipulation of multi-dimensional arrays
  - *f2py* – when you need Fortran raw speed with Python elegance
  - *VTK* and *mayavi* – scalable 3D visualization
  - *wxPython* – the glue to keep all the above together in a nice, point-and-click GUI
- ✓ Presentation samples: http://www.infinity77.net/pycon/oily.zip

PYCON AR 2012

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Thank You

Questions?

Comments?

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