

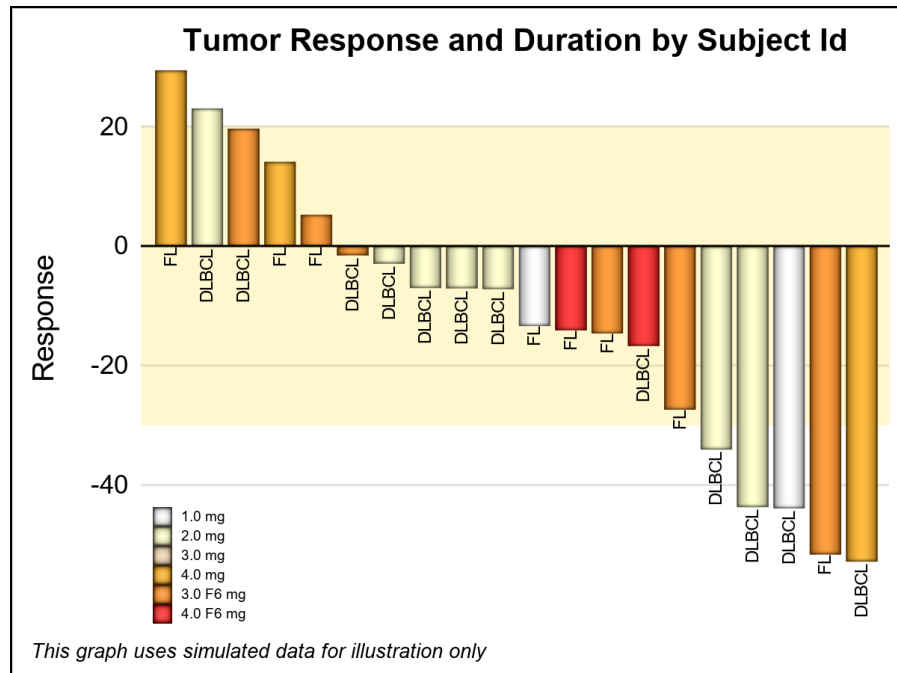


A Combined Waterfall and Swimmer Graph

Sanjay Matange, SAS Institute Inc., Cary, NC, USA

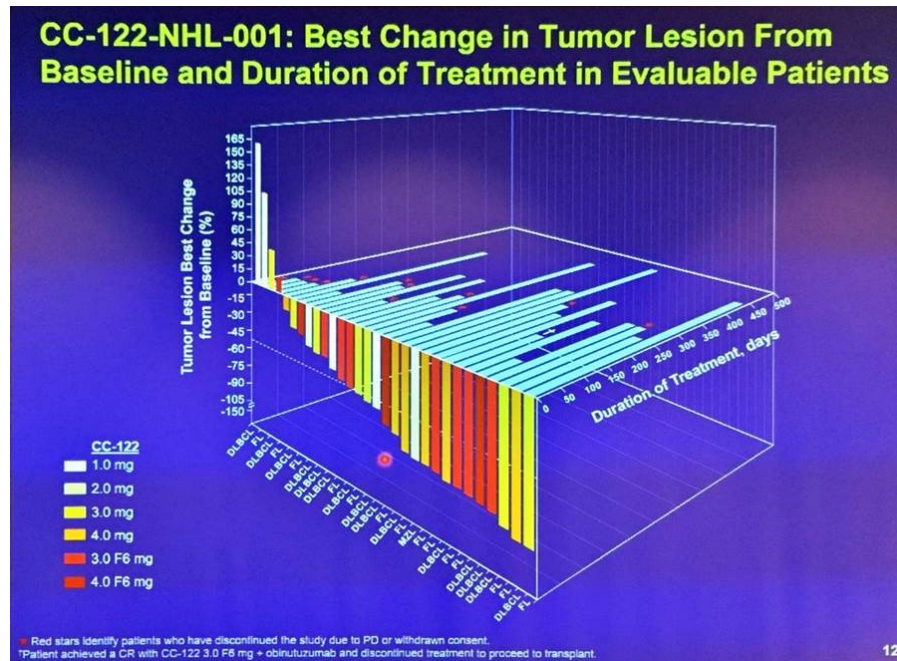
Traditional Waterfall Graph

- Displays the tumor response, sorted by increasing response.
- Displays treatment and lymphoma type for each subject.
- Displays the +20% to -30% band.
- Displays a legend for treatment.



3D Waterfall Graph with Duration of Treatment

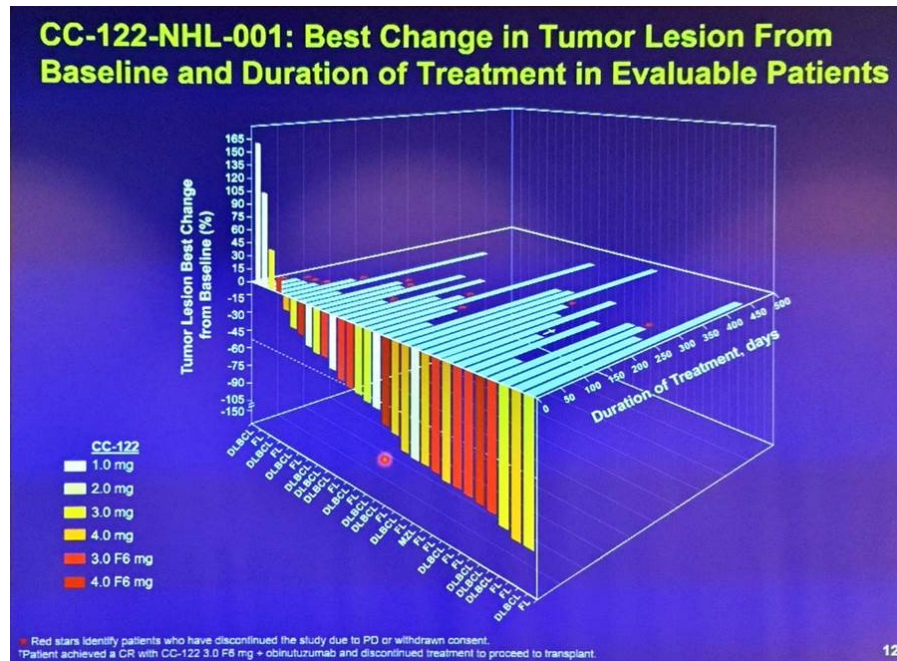
- Some clinical reviewers are now asking to see more data within the waterfall graph.
- In this example, the tumor response by treatment is displayed in the front vertical plane.
- The duration of treatment is displayed in the horizontal plane.
- Lesion type is displayed at the bottom of the front axis.



3D Waterfall Graph Challenges

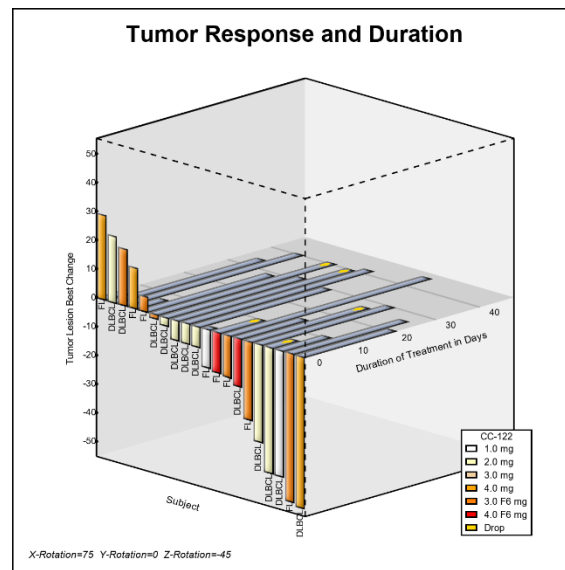
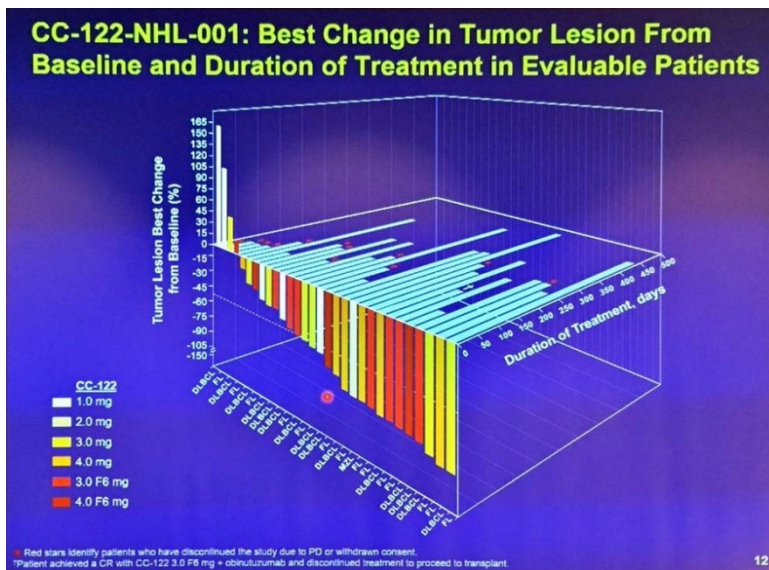
There are some challenges in the visual on the right.

- In this 3D view, some duration values are occluded behind tumor values.
- When displayed in a perspective view, duration bars are harder to compare.
- Heights of the response bars are harder to read against the y-axis.
- Markers depicting some events on the duration bars are harder to see.
- Lesion type at the bottom is harder to align with the bars.
- Display pixels are not used efficiently.



3D Waterfall Graph with Duration of Treatment

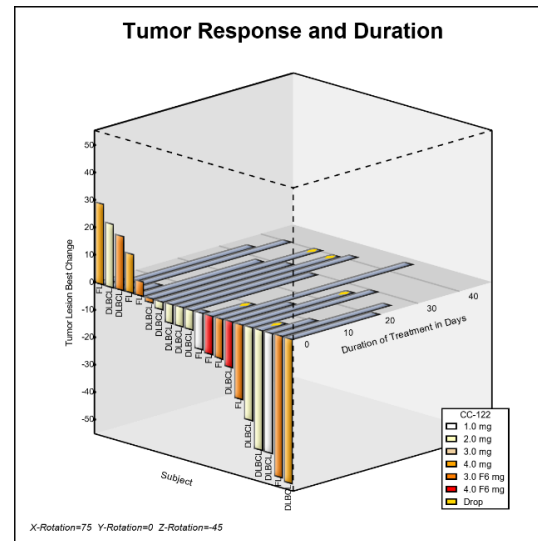
- This data is really 2D, with one independent variable – the subject id.
- A simpler 2D visual can be suggested, but first one has to do what the user wants.
- A SAS Macro for the graph on the right is published in [Graphically Speaking blog](#).



3D Waterfall Graph with Duration of Treatment

- Data for the 3D Waterfall graph with duration is shown on the left.
- Tumor Response, by treatment and increasing change is displayed on the front face.
- Duration is displayed on the horizontal plane.
- Dropped subjects are marked on the duration bars.

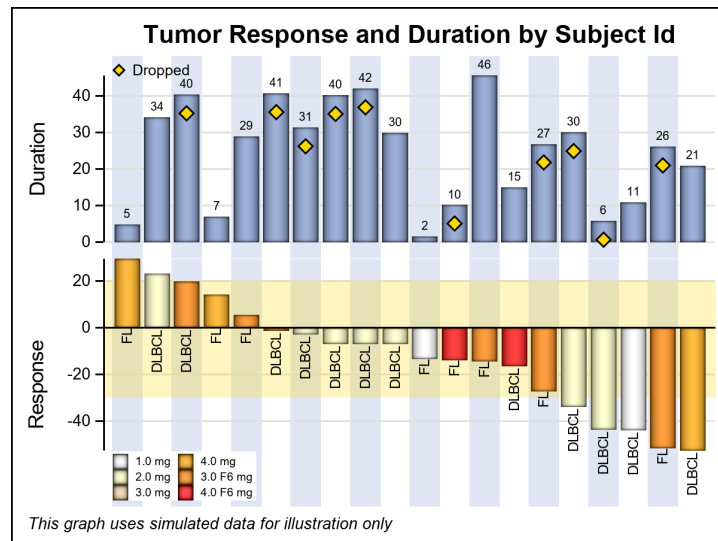
Obs	j	Drug	Code	Response	Duration	Dropped	codeloc
1	1	4.0 mg	FL	29.3978	4.8311	.	0.0000
2	2	2.0 mg	DLBCL	23.0295	33.9761	.	0.0000
3	3	3.0 F6 mg	DLBCL	19.6369	40.1963	.	0.0000
4	4	4.0 mg	FL	14.0812	6.9348	.	0.0000
5	5	3.0 F6 mg	FL	5.2305	28.8763	.	0.0000
6	6	3.0 F6 mg	DLBCL	-1.4493	40.5163	35.5163	-1.4493
7	7	2.0 mg	DLBCL	-2.8468	31.2564	.	-2.8468
8	8	2.0 mg	DLBCL	-6.9270	40.0830	35.0830	-6.9270
9	9	2.0 mg	DLBCL	-6.9796	41.8860	.	-6.9796
10	10	2.0 mg	DLBCL	-7.1062	29.7538	.	-7.1062



2D Waterfall Graph with Duration of Treatment

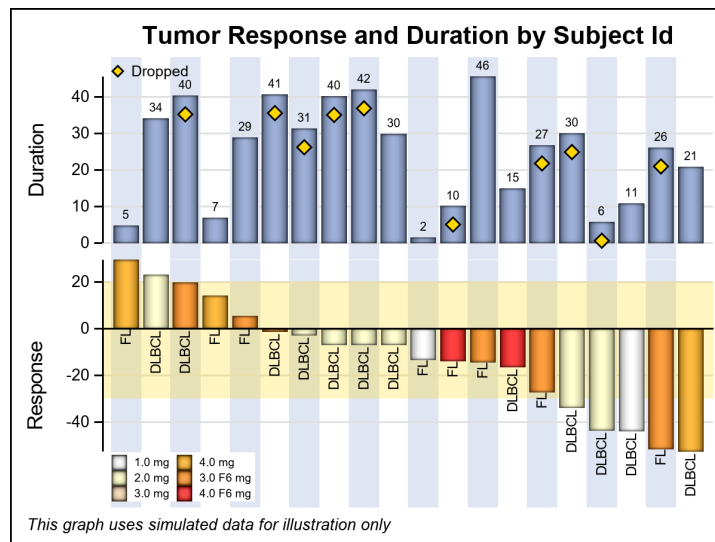
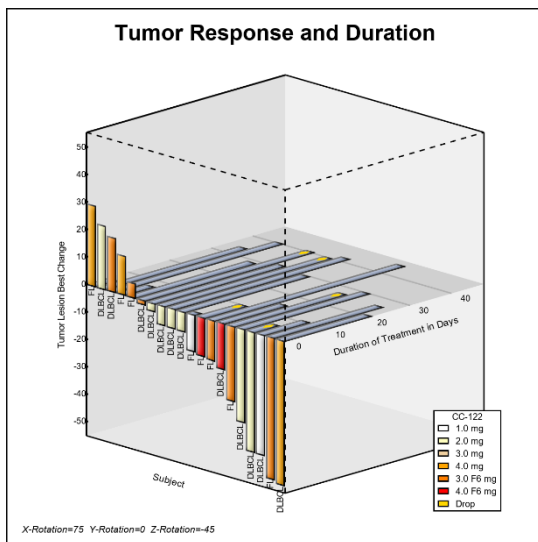
- The same data can be viewed using the 2D graph on the right.
- Tumor response by treatment and increasing change are shown at the bottom.
- Lesion type is labeled at the bottom of each bar with a +20% to -30% band.
- Duration for each subject is displayed at the top, with bar labels and dropped markers aligned with blue vertical bands.

Obs	j	Drug	Code	Response	Duration	Dropped	codeloc
1	1	4.0 mg	FL	29.3978	4.8311	.	0.0000
2	2	2.0 mg	DLBCL	23.0295	33.9761	.	0.0000
3	3	3.0 F6 mg	DLBCL	19.6369	40.1963	.	0.0000
4	4	4.0 mg	FL	14.0812	6.9348	.	0.0000
5	5	3.0 F6 mg	FL	5.2305	28.8763	.	0.0000
6	6	3.0 F6 mg	DLBCL	-1.4493	40.5163	35.5163	-1.4493
7	7	2.0 mg	DLBCL	-2.8468	31.2564	.	-2.8468
8	8	2.0 mg	DLBCL	-6.9270	40.0830	35.0830	-6.9270
9	9	2.0 mg	DLBCL	-6.9796	41.8860	.	-6.9796
10	10	2.0 mg	DLBCL	-7.1062	29.7538	.	-7.1062



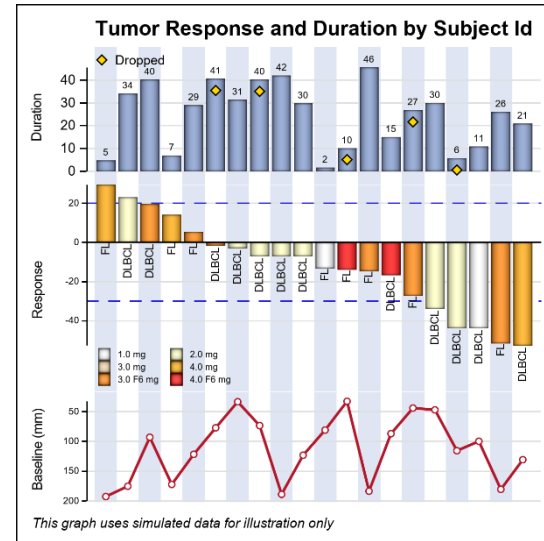
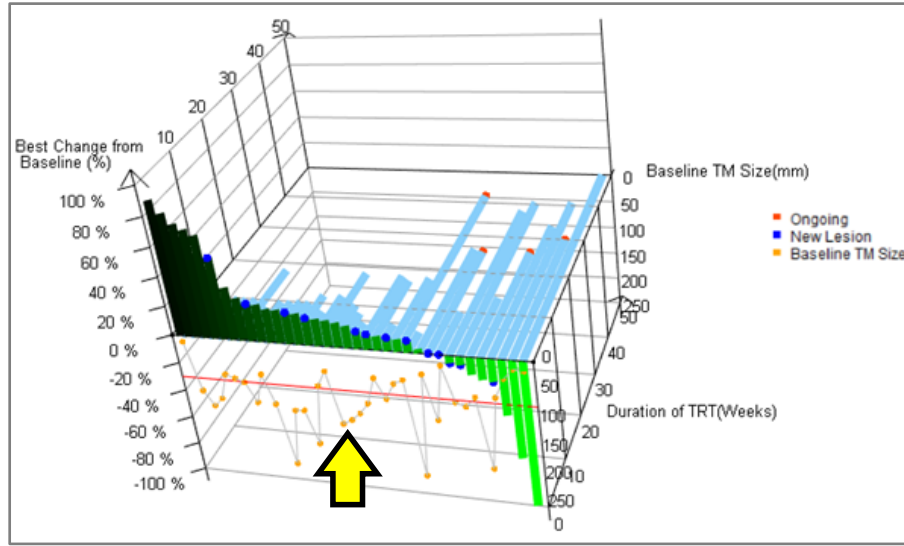
2D Waterfall Graph with Duration of Treatment

- The 2D bar shows the same information as the 3D bar in an effective display.
- More information is displayed in 2D graph such as the band and bar labels.
- Duration and Response bars are aligned by the alternate blue vertical bands.
- Bar values can be easily compared and measured against the y-axes.

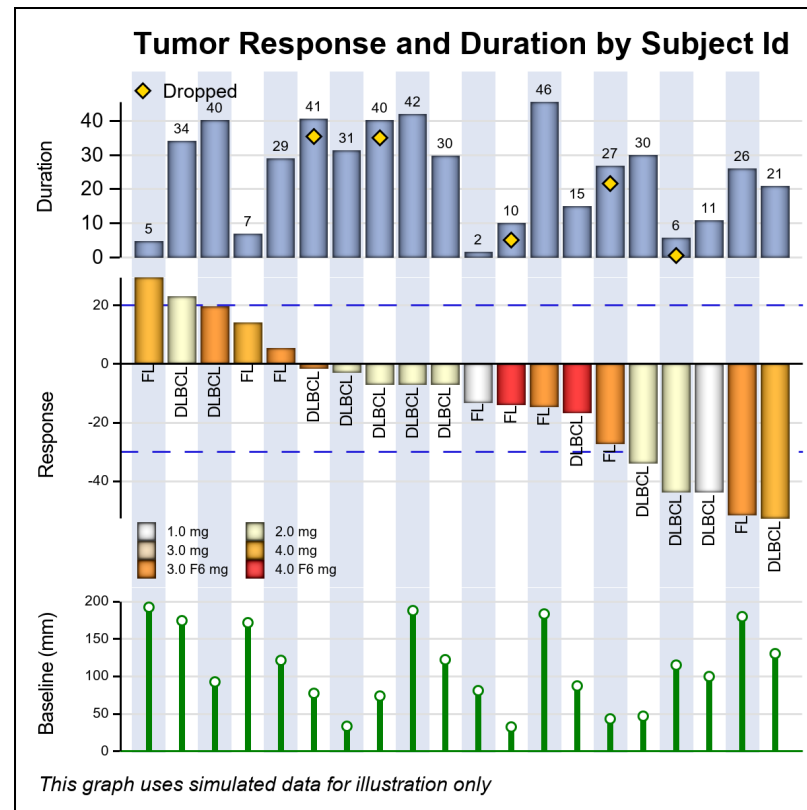
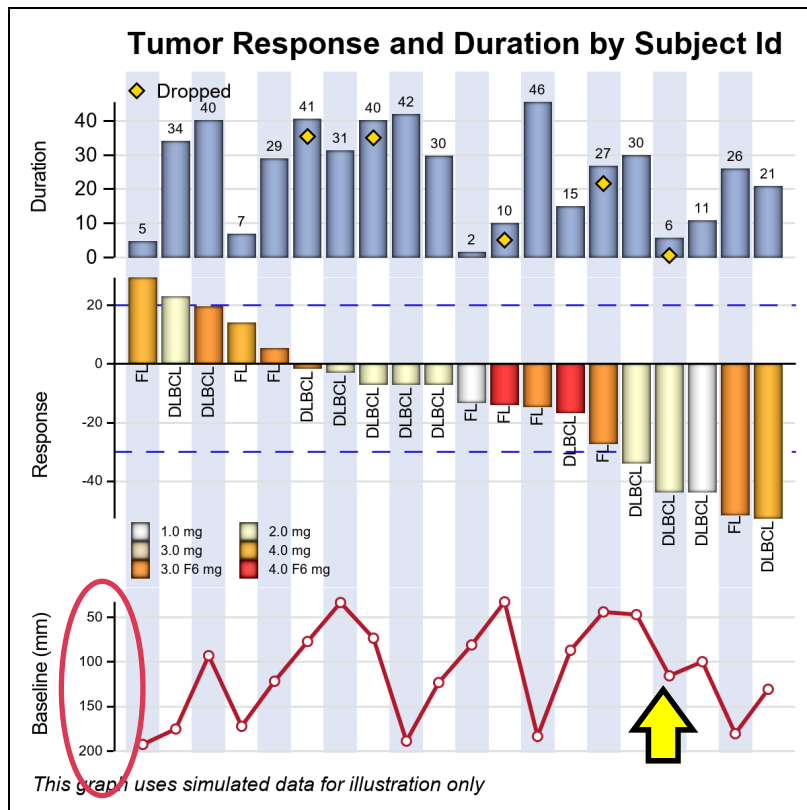


Waterfall Graph with additional data

- Additional data is plotted in the 3D graph, adding more clutter and confusion.
- The tumor baseline is displayed over tumor response on the front face.
- Same data can be easily displayed clearly in the 2D graph.



2D Waterfall Graph with additional data



GTL Template to Create Graph

```
proc template;
  define statgraph Waterfall_Baseline_Needle;
    begingraph / axislineextent=data;
      layout lattice / columndatarange=union rowweights=(0.3 0.45 0.25) rowgutter=0;
        columnaxes;
          columnaxis / display=none discreteopts=(colorbands=odd);
        endcolumnaxes;
        layout overlay / yaxisopts=(griddisplay=on) walldisplay=none;
          /*--<Plot Statements--*/
        endlayout;
        layout overlay / yaxisopts=(griddisplay=on) walldisplay=none;
          /*--<Plot Statements--*/
        endlayout;
        layout overlay / yaxisopts=(griddisplay=on) walldisplay=none;
          /*--<Plot Statements--*/
        endlayout;
      endlayout;
    endgraph;
  end;
run;
```

Top Cell

```
layout overlay / yaxisopts=(griddisplay=on walldisplay=none;  
    barchartparm category=j response=duration / datalabel=duration;  
    scatterplot x=j y=dropped / markerattrs=(symbol=diamondfilled)  
        filledoutlinedmarkers=true name='d' legendlabel='Dropped';  
    discretelegend 'd' / location=inside valign=top halign=left border=false;  
endlayout;
```

Top Cell

- The middle and bottom cells are populated in a similar manner.
- The SGRENDER code below is used to associate the data set with the template to produce the graph output.

```
proc sgrender template=Waterfall_Baseline_Needle  
  data=tumorsorted dattrmap=attrmap;  
  format duration 3.0;  
  label baseline='Baseline (mm)';  
  dattrvar drug="Resp";  
run;
```

Adding Tumor Response Data to Swimmer Plot

- In the previous examples, we added duration of treatment to a Waterfall graph.
- Here, we add tumor response data to a Swimmer Plot.
- Now, let us use this data to create a combined graph

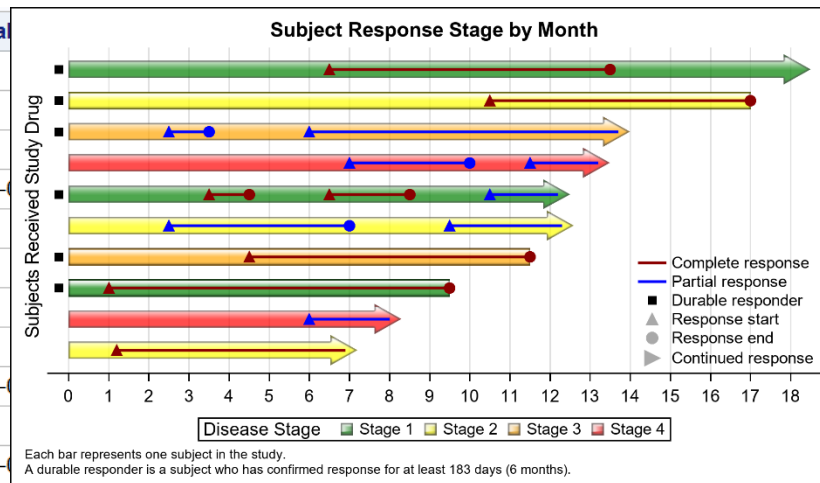


Obs	id	item	stage	low	high	highcap	status	start	end	durable	response	startline	endline
1	1	9	Stage 4	0	8.3	FilledArrow	Partial response	6.0	.	.	20	6.0	8.0
2	2	6	Stage 2	0	12.6	FilledArrow	Partial response	2.5	7.0	.	10	2.5	7.0
3	2	6		0	12.6	FilledArrow	Partial response	9.5	.	.	10	9.5	12.3
4	3	5	Stage 1	0	12.5	FilledArrow	Complete response	3.5	4.5	-0.5	-15	3.5	4.5
5	3	5		0	12.5	FilledArrow	Complete response	6.5	8.5	.	-15	6.5	8.5
6	3	5		0	12.5	FilledArrow	Partial response	10.5	.	.	-15	10.5	12.2
7	4	4	Stage 4	0	13.5	FilledArrow	Partial response	7.0	10.0	.	-20	7.0	10.0
8	4	4		0	13.5	FilledArrow	Partial response	11.5	.	.	-20	11.5	13.2
9	5	3	Stage 3	0	14.0	FilledArrow	Partial response	2.5	3.5	-0.5	-22	2.5	3.5
10	5	3		0	14.0	FilledArrow	Partial response	6.0	.	.	-22	6.0	13.7
11	6	8	Stage 1	0	9.5		Complete response	1.0	9.5	-0.5	-25	1.0	9.5

Swimmer Plot with Tumor Response Data

- We start with the data for the Swimmer Plot with one observation per subject.
- Each observation has duration of treatment by stage and status.
- Additional observations are added for more response periods for a subject.
- For each subject, we add the tumor response in %.
- The data is sorted by increasing tumor reduction.

Obs	id	item	stage	low	high	highcap	status	start	end	dural
1	1	9	Stage 4	0	8.3	FilledArrow	Partial response	6.0	.	
2	2	6	Stage 2	0	12.6	FilledArrow	Partial response	2.5	7.0	
3	2	6		0	12.6	FilledArrow	Partial response	9.5	.	
4	3	5	Stage 1	0	12.5	FilledArrow	Complete response	3.5	4.5	
5	3	5		0	12.5	FilledArrow	Complete response	6.5	8.5	
6	3	5		0	12.5	FilledArrow	Partial response	10.5	.	
7	4	4	Stage 4	0	13.5	FilledArrow	Partial response	7.0	10.0	
8	4	4		0	13.5	FilledArrow	Partial response	11.5	.	
9	5	3	Stage 3	0	14.0	FilledArrow	Partial response	2.5	3.5	
10	5	3		0	14.0	FilledArrow	Partial response	6.0	.	
11	6	8	Stage 1	0	9.5		Complete response	1.0	9.5	

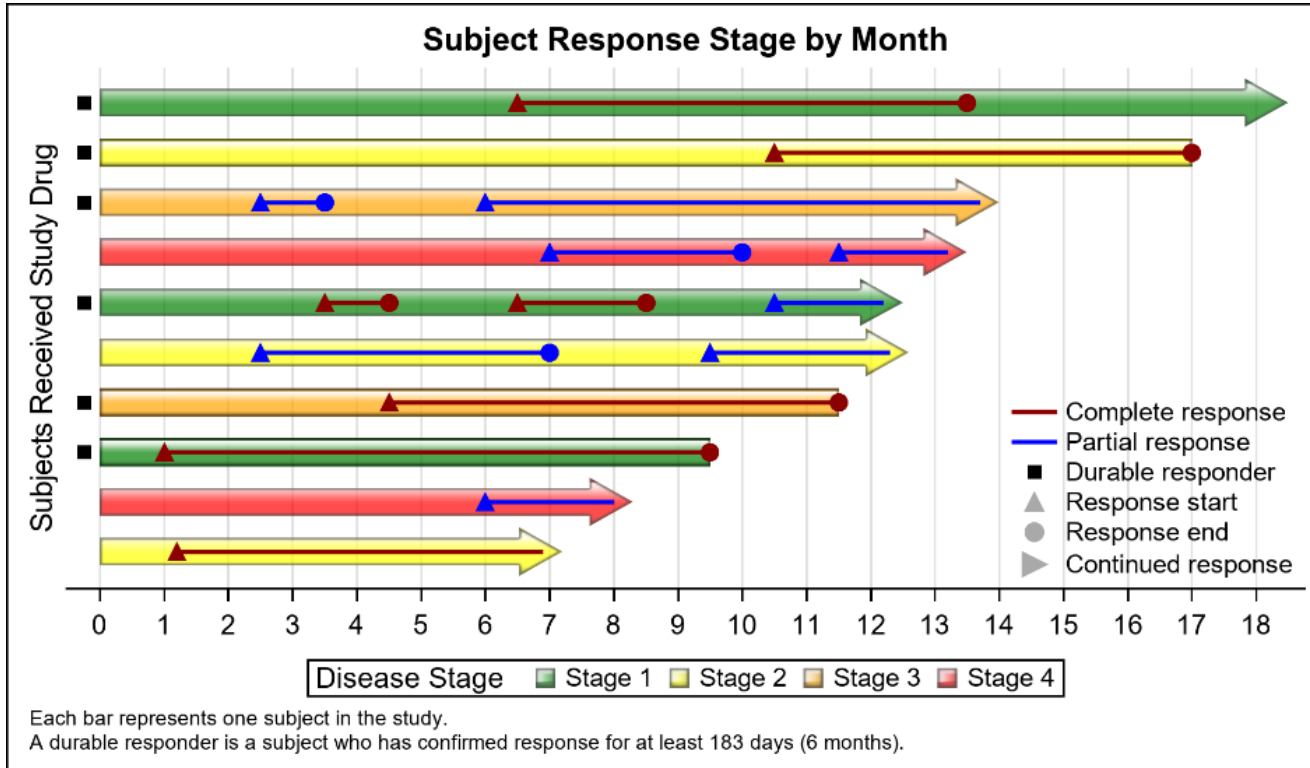


SGPLOT code for Swimmer Plot Only

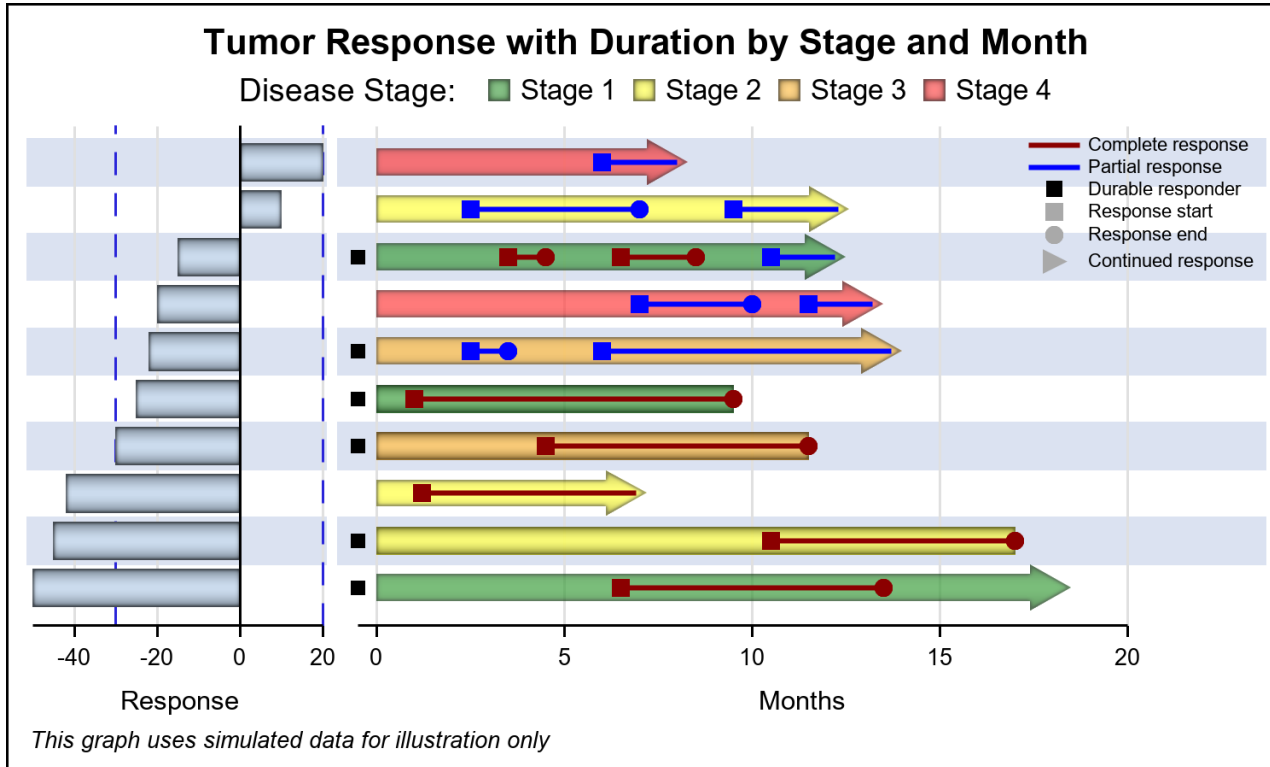
```
proc sgplot data= swimmer dattrmap=attrmap nocycleattrs noborder;
  legenditem type=marker name='ResStart' / markerattrs=(symbol=trianglefilled color=darkgray) label='Response start';
  legenditem type=marker name='ResEnd' / markerattrs=(symbol=circlefilled color=darkgray) label='Response end';
  legenditem type=marker name='RightArrow' / markerattrs=(symbol=trianglerightfilled color=darkgray)
    label='Continued response';
  highlow y=item low=low high=high / highcap=highcap type=bar group=stage fill nooutline dataskin=gloss
    lineattrs=(color=black) name='stage' barwidth=1 nomissinggroup transparency=0.3 attrid=stage;
  highlow y=item low=startline high=endline / group=status lineattrs=(thickness=2 pattern=solid)
    name='status' nomissinggroup attrid=status;
  scatter y=item x=durable / markerattrs=(symbol=squarefilled size=6 color=black) name='Durable'
    legendlabel='Durable responder';
  scatter y=item x=start / markerattrs=(symbol=trianglefilled size=8) group=status attrid=status;
  scatter y=item x=end / markerattrs=(symbol=circlefilled size=8) group=status attrid=status;
  xaxis display=(nolabel) values=(0 to 20 by 1) valueshint grid;
  yaxis reverse display=(noticks novalues noline) label='Subjects Received Study Drug' min=1;
  keylegend 'stage' / title='Disease Stage';
  keylegend 'status' 'Durable' 'ResStart' 'ResEnd' 'RightArrow' /
    noborder location=inside position=bottomright across=1 linelength=20;
run;
```

Obs	id	item	stage	low	high	highcap	status	start	end	durable	response	startline	endline
1	1	9	Stage 4	0	8.3	FilledArrow	Partial response	6.0	.	.	20	6.0	8.0
2	2	6	Stage 2	0	12.6	FilledArrow	Partial response	2.5	7.0	.	10	2.5	7.0
3	2	6		0	12.6	FilledArrow	Partial response	9.5	.	.	10	9.5	12.3
4	3	5	Stage 1	0	12.5	FilledArrow	Complete response	3.5	4.5	-0.5	-15	3.5	4.5

Swimmer Plot Only

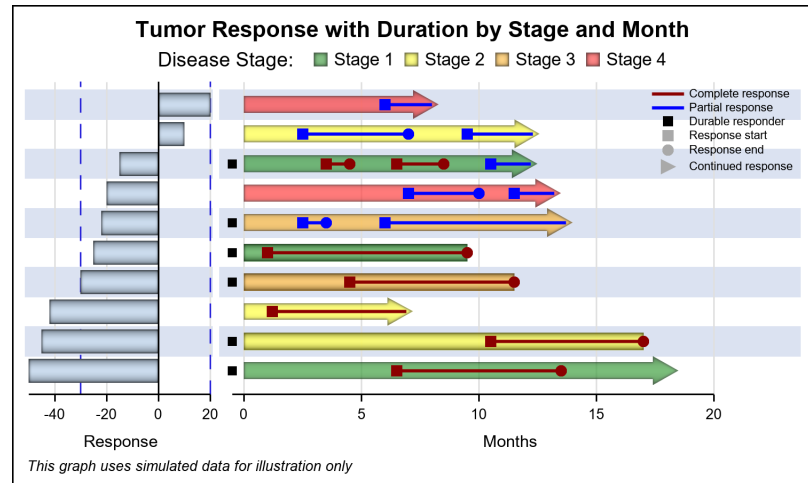


Swimmer Plot with Tumor Response

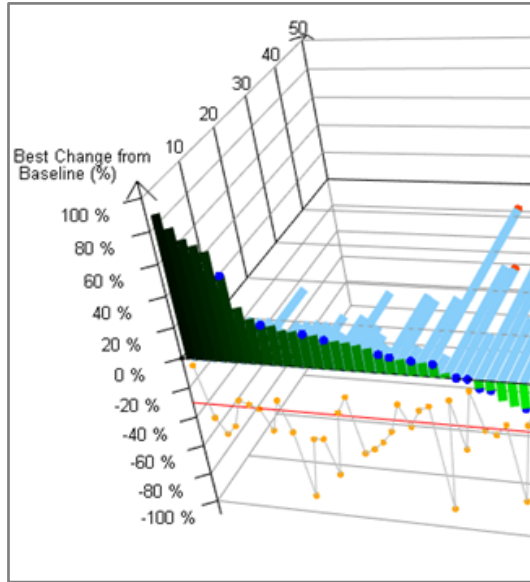


GTL Template to Create Graph

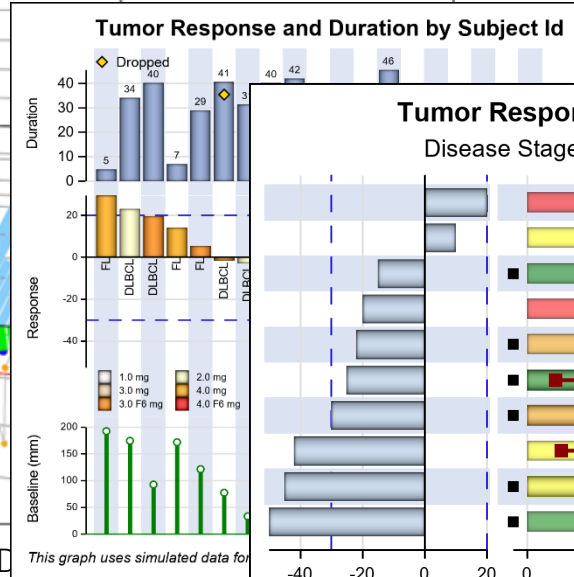
- GTL template for this graph is created in a manner similar to the 2D Waterfall Graph with Duration of Treatment data.
- We use a 2-column Lattice Layout, with 25% and 75% widths
- The first cell displays the sorted tumor response.
- The second cell displays the Swimmer Plot.



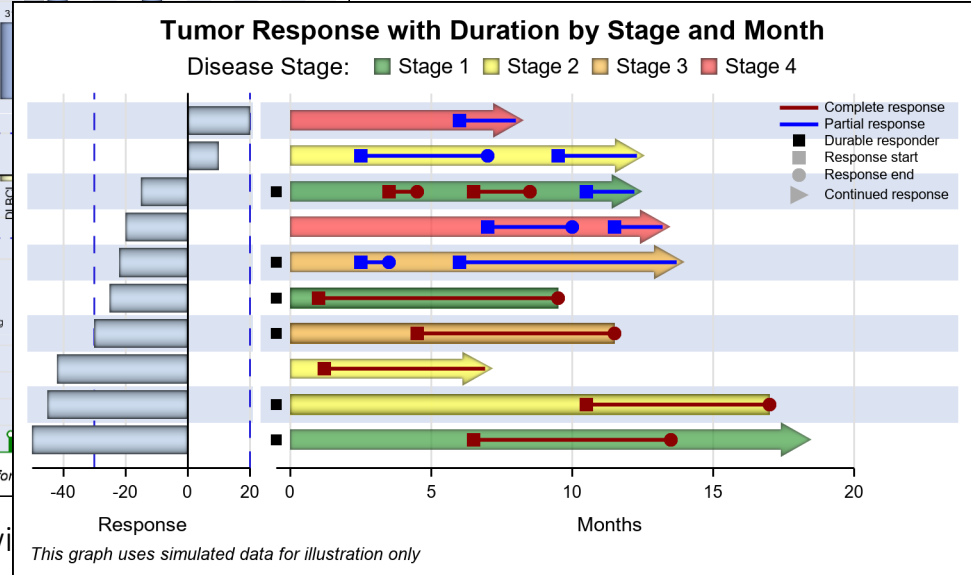
Review of Tumor Response and Duration Graphs



3D Graph with Tumor Response, of treatment and Baseline load



2D graph showing (and more) in a simpler view



2D graph showing Swimmer Plot of Subject's Response History sorted by Tumor reduction.

Conclusion

A reviewers task is made easier by displaying more information in one graph.

- 3D graphs have been suggested for displaying additional data.
- 3D graphs pose some challenges for occlusion of some data or interpretation or comparison of data using the perspective projection.
- Simple 2D visuals can display additional data clearly and effectively.
- The 2D visuals are easily extended to add more data.
- Alternative visual are shown in this presentation for:
 - Add Duration of Treatment data to a Waterfall Graph.
 - Add Tumor Response data to a Swimmer Graph.