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Tips & Tricks for post-processing OVERFLOW Results with FieldView 13

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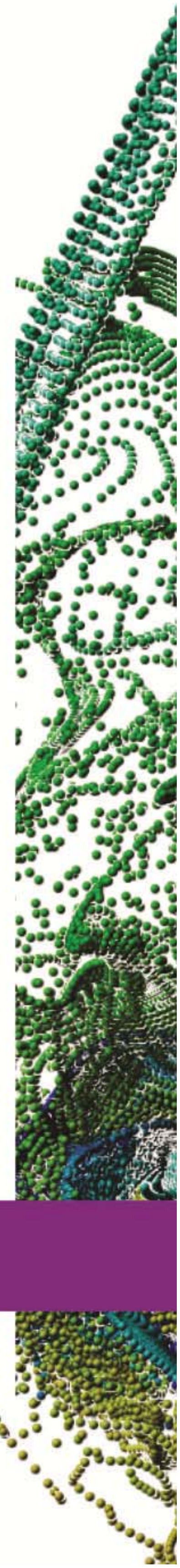

Intelligent Light

Preface

As an OVERFLOW and FieldView user for several years, I'd like to share with you several methods I've used for getting my work done in a more efficient manner. With the most recent version, FieldView 13, you'll find even more features and workflows that will benefit your work. Whether its reading your data more completely using the new OVERFLOW direct reader, using parallel processing to speed up the post-processing, using our XDB technology to reduce your saved data, or using FieldView to post process data from either your laptop or remotely on the "big-iron" like NASA's Pleiades, I'm sure you may find that at least one of the "Tips and Tricks" contained in this write up will be useful to your daily work.

Cheers,

e.

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Tips & Tricks for post-processing OVERFLOW Results with FieldView 13

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Tip #1) Automatically detect the file type using Use the OVERFLOW Reader

If you use the OVERFLOW reader, it will AUTOMATICALLY detect the file type. By default, **FieldView** attempts to auto-detect the values for the **FILE FORMAT**, **COORDS** and **DATA FORMAT**. You still have the option to disable this default behavior by turning the **Auto-Detect Format** option OFF - in this case, explicit setting of the file format and attributes will be required. If FieldView is unable to correctly detect the file format, the Auto-Detect Format button will be turned off, and a pop-up message will appear.

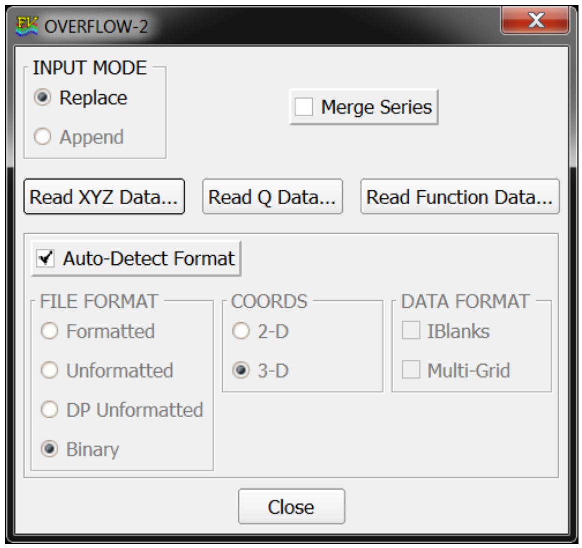

Figure 1 – OVERFLOW-2 Reader Panel

Tip #2) The OVERFLOW Reader gives you access to all of OVERFLOW's turbulence variables and thermodynamically correct derived functions

The OVERFLOW-2 reader also **fully supports all the species and turbulence quantities** contained within the OVERFLOW "q.save" or q.#### solution files. Both the species and turbulence data becomes available as a scalar data that can be chosen like any other scalar quantity. The Thermodynamic derived quantities such as Pressure, Pressure Coefficient, Mach number, etc, are computed using the formulations from Anderson (Anderson 1989).

The direct reader reads the OVERFLOW-specific parameters NQ, NQC and NQT which dictate the total number of Q variables, the number of species components and the number of turbulence modeling variables present in a solution file, respectively. These additional parameters are printed to the console

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window. The following output from the FieldView console or shell window would be shown upon the successful read of an OVERFLOW-2 dataset with 2 species and a 1-equation turbulence model. Figure 2 shows how the OVERFLOW functions are presented in the "Function Selection" panels.

```
NQ = 9 NQC = 2 NQT = 1
Q variable names:
     Density (Q1)
     x-momentum (Q2)
     y-momentum (Q3)
     z-momentum (Q4)
     Stag. energy (Q5)
     gamma (Q6)
     species density 1 (Q7)
     species density 2 (Q8)
     turbulence model quantity 1 (Q9)
```

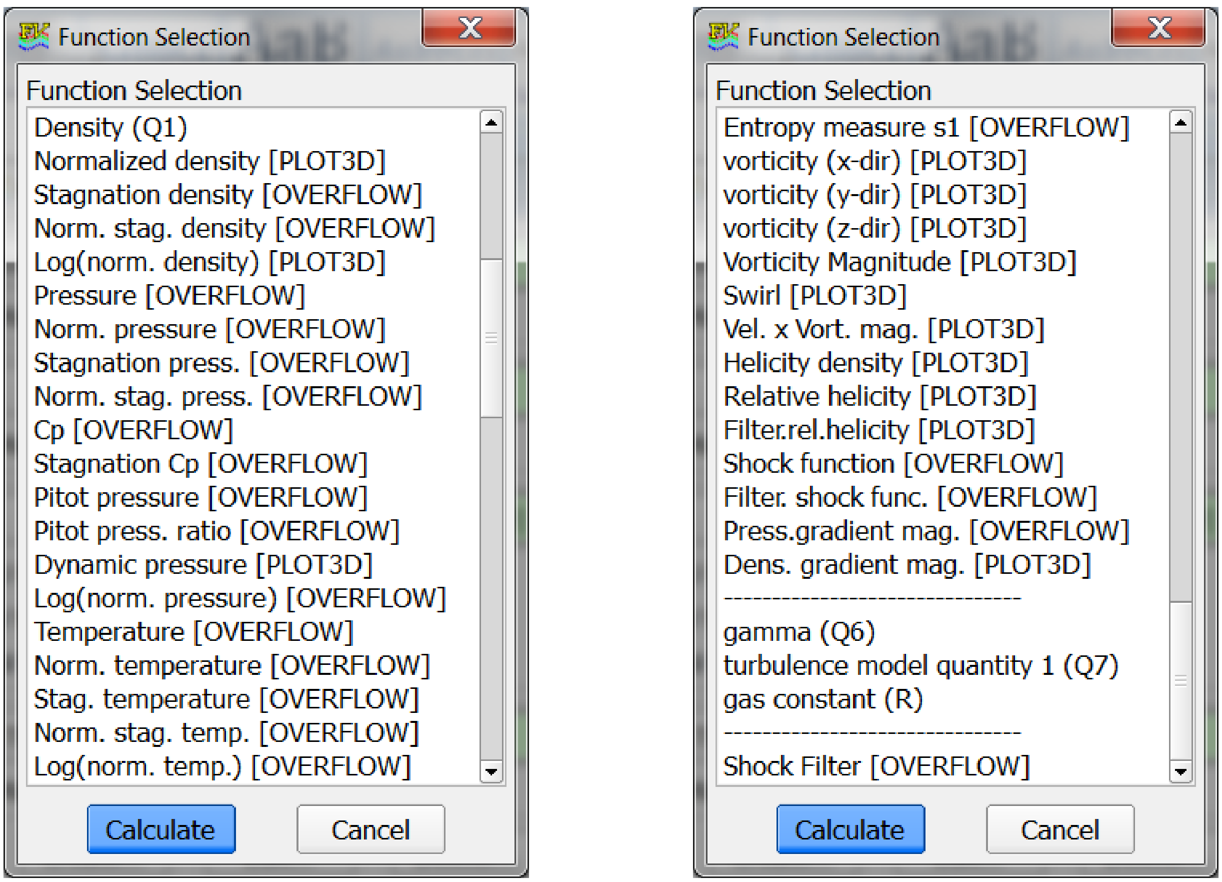

Figure 2: Function selection panel showing OVERFLOW and PLOT3D functions and also turbulence model quantity

Another specific difference between the standard PLOT3D format and the OVERFLOW-2 format is an expanded section of constants used to derive advanced built-in functions. These constants are:

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GAMINF	Freestream specific heat ratio (gamma-inf)
BETA	Sideslip angle
TINF	Freestream dimensional temperature (Rankine)
IGAM	Specifies the thermodynamic model;
HTINF	Freestream stagnation enthalpy (H-inf)
HT1, HT2	The lower and upper stagnation enthalpy limits for IGAM=2
RGAS[NQC]	An array of specific gas constants;
FSMACH	Freestream Mach number;
TVREF	Simulation time (t)
DTVREF	Timestep size (delta-t)

The above constants are available for use in the **FieldView** function calculator, and may be used to create custom functions. The correct syntax for use in the function calculator is to add OVERFLOW as a prefix to the constant, for instance, REFMACH becomes OVERFLOW_FSMACH.

Tip #3) Use Basic Local Parallel to get parallel speed up … "Three for Free".

Parallel Processing of OVERFLOW2 data is very easy. If you're running an overset grid case with OVERFLOW, then your data can be automatically processed using your shared memory workstation or laptop – for Free. Every FieldView license has "3 for free" which allows up to 3 slave processes and 1 master process.

To enable this capability, you simply need to select the "**Local basic parallel**" feature in the "File-> Data Input " panel as shown in Figure 3. You would then select the OVERFLOW2 reader from the Data Input panel as before.

To use more processors on a single workstation, you would select "**Local licenses parallel**". To enable this feature, you will need to purchase additional licenses. There is currently 8-, 16-, 32-, 64-processor licenses available. For some processes the user may see up to a 5x speed up with 8 processors.

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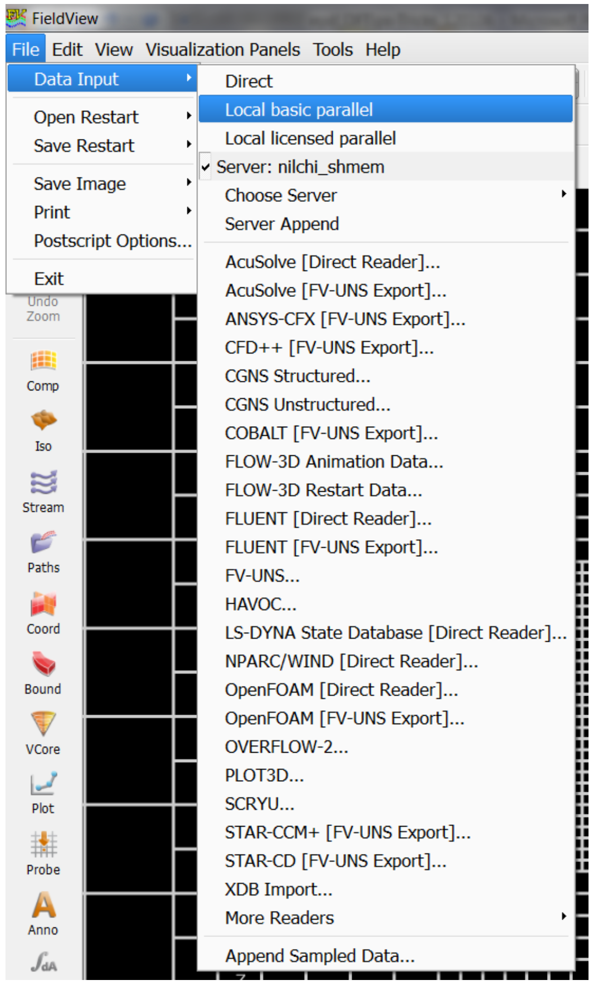

Figure 3: Choosing the Local basic parallel

Tip #4) Get a factor 2 speed up using brkset.restart or brkset.### files

If the brkset.restart file exists in the same directory of the grid file being read, **FieldView** will automatically use it for post-processing the off body grid. In this case, instead of reading the near body grids and off body grids, **FieldView** uses the brkset.restart information to generate the Cartesian topology of the "off-body" grids (or bricks). This operation results in a significant reduction in time required to read the grid.

For static grid calculations where the grids do not change in time, **FieldView** reads the xyz coordinates of only the near-body grids and the Iblanks for all the grids from the x.save or a single x.### for a transient solution. Note that although the brick topologies are static, their associated IBLANK arrays may change.

Tip #5) Use the automatically detected transient dataset feature to manage transient data

FieldView supports the default file name conventions from OVERFLOW-2, for transient grid (x.#) and solution (q.#) data. OVERFLOW-2 grid files have the following default naming convention.

x.1
x.2
x.3
:
:

with .fvbnd files specified as either x.1.fvbnd,... or simply, x.fvbnd. Note that file names used in this transient naming convention must have a single '.'

Tip #6) Use Bobby Nichols fvbnd.f code to automatically generate Boundary Surface (fvbnd) files

For a transient grid case where the bricks change in time, OVERFLOW2 will output transient brick files for which the time step number is specified as a numeric string suffix, i.e. brkset.###. **FieldView** supports this naming convention and will automatically match the brkset.### file with its corresponding x.### grid file. However, a FieldView Boundary Surface File, i.e. x.###.fvbnd, is needed to visualize the grids changing in time and treat them as a transient dataset.

Bobby Nichols from Arnold Engineering and Development Center (AEDC), has contributed a utility to the standard OVERFLOW2 distribution, fvbnd.f, located in over2.2/tools/unsupported/fvbin.f. The program uses over.namelist and the grid filename to create the boundary file.

The resulting fvbnd file contains default boundary surface names based upon the boundary conditions in OVERFLOW. (i.e. "viscous adiabatic wall EXTRAP (5)" & overlap(10)). The boundary surface names will become available in the Boundary Surface visualization panel and can be easily selected for display as shown in Figure 3.

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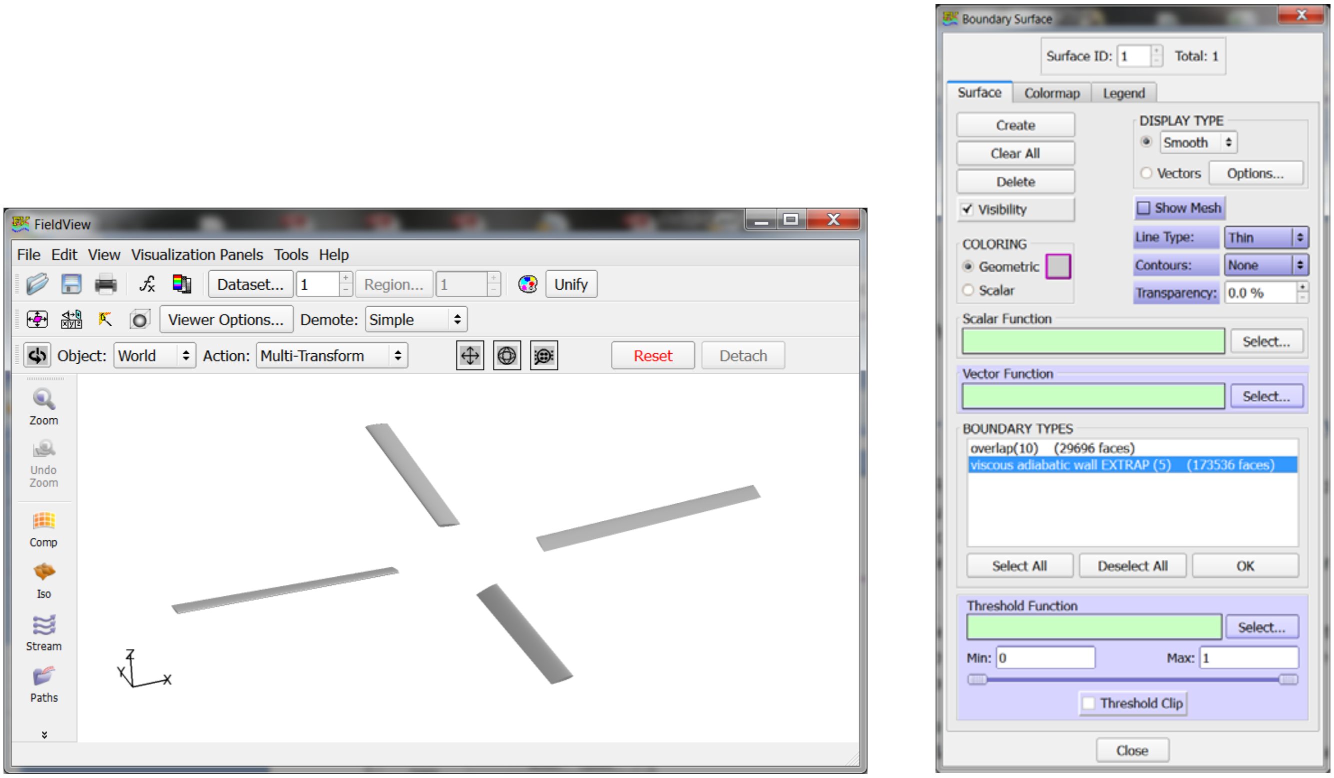

Figure 3 - Boundary Surfaces using Nichols fvbnd tool

Tip #7) Use the fvbnd files to view AMR grids evolve in time

FieldView supports Adaptive Mesh Refinement (AMR) grids from OVERFLOW where the grids (total number and sizes) change in time or with time step. Figure 4 shows coordinate cut plane and boundary surfaces for a cylinder post with the AMR mesh shown at two time steps. Must have a fvbnd file defined.

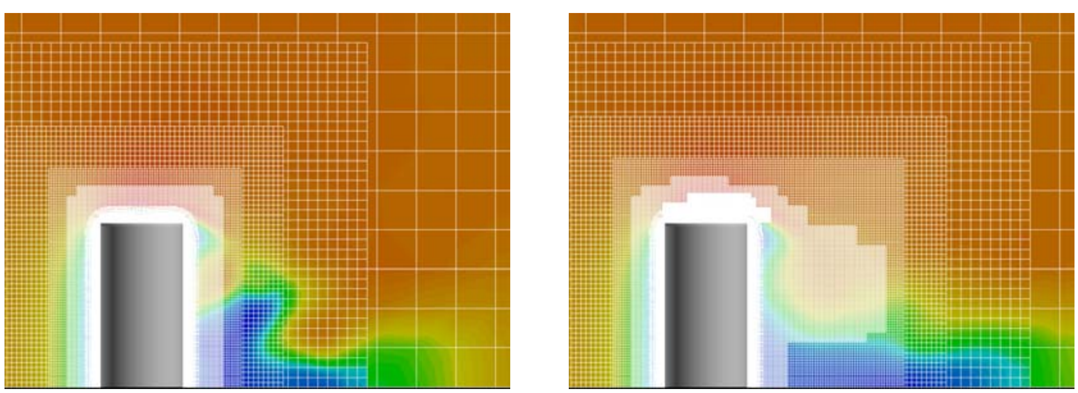

Figure 4 – Display of a Coordinate Cut Plane of an OVERFLOW2 AMR Grid and Solution at 2 different time steps

Tip #8) Use client server to avoid moving for files across slow networks

Growing grid sizes often preclude being able to transfer files from remote computer servers to a local workstations. Using FieldView's Client-Server capability is one way to avoid moving the data. In Client-Server mode, the FieldView Graphics Client controls a Server process which remains on a remote server. The remote server process reads and post-processes the data and then sends to the Graphics Client the graphics information only. This method not only reduces the amount of data sent to the client but it also allows the user to utilize the compute power, large memory and remote storage capabilities.

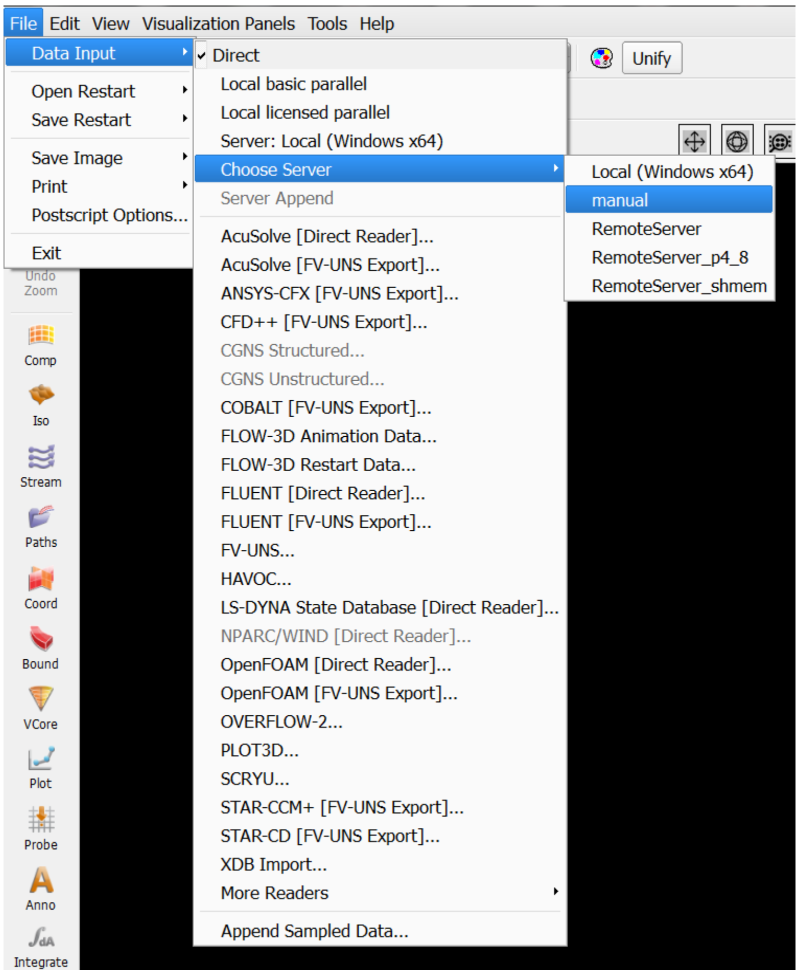

Figure 5: Choosing Client-Server Manual Mode

There are 3 modes for Client-Server operations in FieldView – Manual, Automatic and Parallel.

To use Client-Server, the FieldView servers need to be installed on the remote server. The servers may be downloaded from the Intelligent Light support page, www.ilight.com/support. Follow the instructions in the user manual to install the servers. Note that you DO NOT NEED to install a license server and license on the remote server. FieldView uses the license served to the Client.

To connect via **Client-Server in manual mode**, you would select from the file pull down menu: **File -> Data Input -> Choose Server – manual** as shown in Figure 5. Then when you select the OVERFLOW2 reader from file pull down menu, **File->Data Input -> OVERFLOW2**, you would be presented with a pop-up message the gives the command that would be entered manually on the remote server.

In automatic mode, FieldView would connect automatically to the remote client. Some configuration is required though. To configure, one first needs to create a passwordless login for ssh. Utilize ssh-keygen to create both rsa and dsa public keys (i.e. .ssh/id_rsa.pub & .ssh/id_dsa.pub) and then concatenate the

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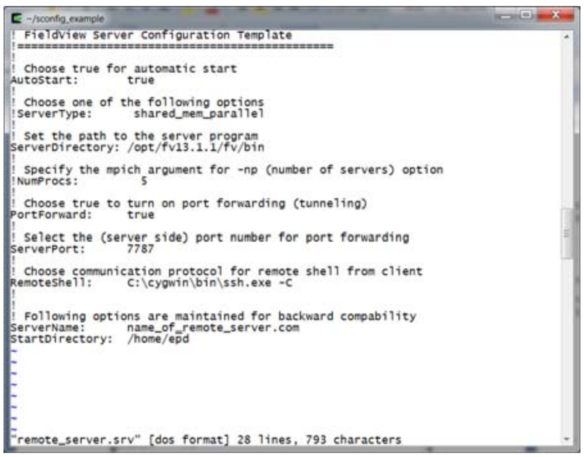
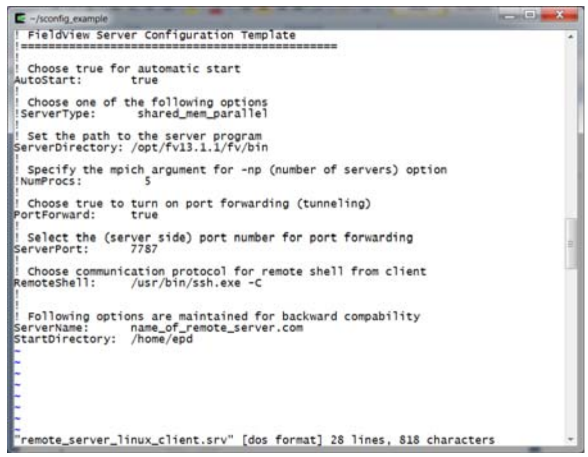
resulting keys to the remote server's keys typically stored in .ssh/ssh-authorized-keys. Make sure that the permissions of the directory .ssh and the files in .ssh only have user read and write permissions; others and groups must not have read/write permissions.

Next a server file, (*.srv), needs to be created. We recommend that each user maintains a personal collection of srv files. In the FieldView installation directory $FV_HOME/sconfig you will find srv.template which you can modify for your own situation. There are 3 types of servers that is set via the "ServerType:" – single processor (standard), shared memory(shared_mem_parallel), or distributed (cluster_parallel). Figure 5a shows the server config file for a Windows client using the Cygwin ssh (remote_server.srv) and Figure 5b shows the server config file for a Linux client. Note the only difference is the ssh executable location.



a) Windows Client using Cygwin ssh



b) Linux Client using SSH

Figure 5: Client Server srv file

The server configuration files are installed on the client side and may be installed either in $FV_HOME/sconfig or in your own local directory. By default, FieldView will look at $FV_HOME/sconfig. It's recommended that users maintain their own server config files defined by the Environment Variable FV_SERVER_CONFIG_DIR. In Linux, you would simply include the following in there .bashrc or .cshrc files, respectively.

```
export FV_SERVER_CONFIG_DIR=/home/username/fv_sconfig   (in bash or ksh)

setenv FV_SERVER_CONFIG_DIR /home/username/fv_sconfig   (in csh or tcsh)
```

In windows you would specify the User Variable through **System Properties -> Advanced -> Environment Variables** as illustrated in Figure 6. Then to choose the server, you would choose the server of choice as shown in Figure 7. The shared memory server config file is shown in Figure 8a. In Figure 8b, the parallel cluster configuration file for post-processing distributed over 8 processors is

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shown. For more details on configuring your systems for Running Client-Server Mode and Running FieldView Parallel Mode, see Pages 36 – 55 of the FVUsers_Guide.pdf.

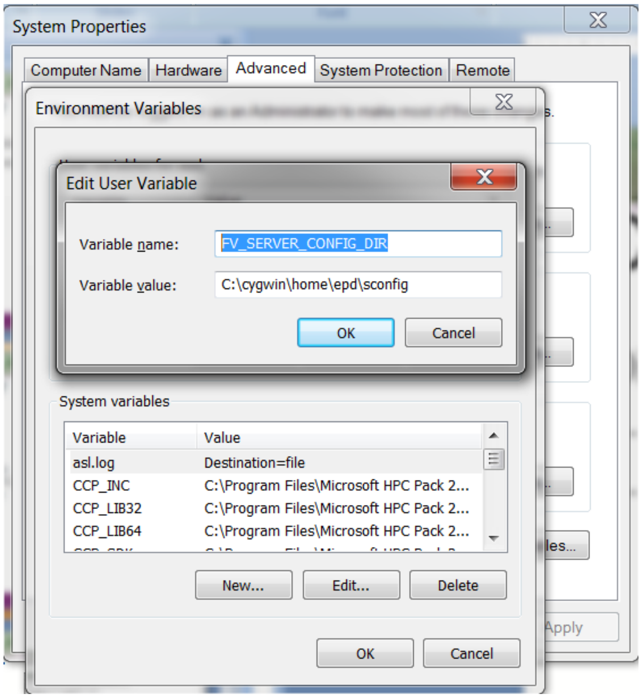


Figure 6: Setting FV_SERVER_CONFIG_DIR in Windows

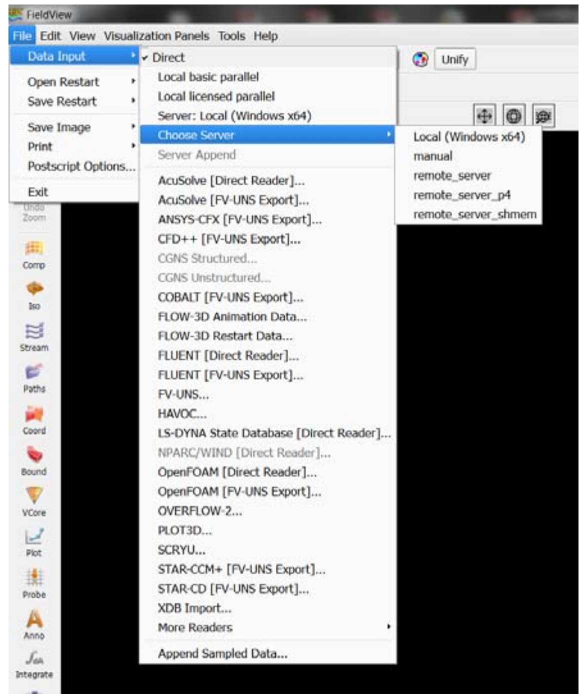
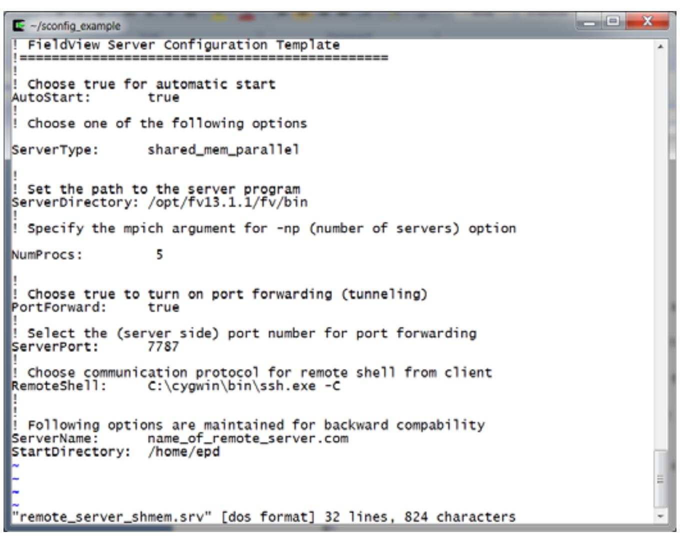
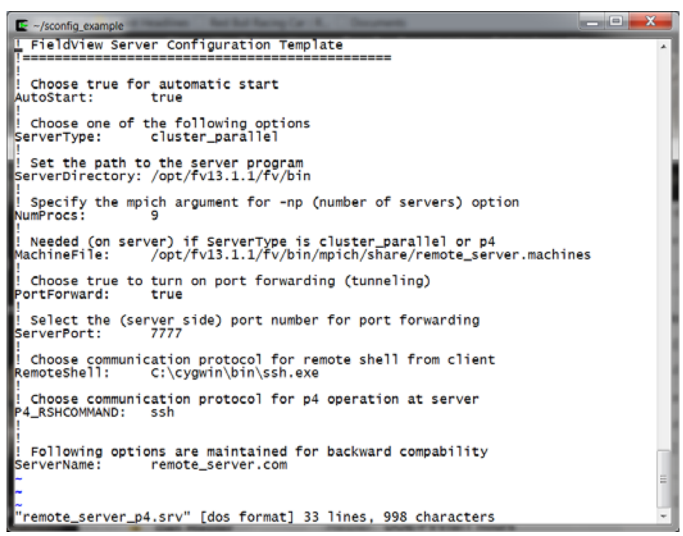


Figure 7: Choosing Server Type





a)Shared Memory srv **b) Distributed Processing on a Cluster**

Figure 8: Parallel srv files for shared memory and cluster distributed parallel

Tip #9) Use Client-Server with interactive PBS queues to post-process very large datasets

Often times, users need to go through some sort of queuing system to utilize compute nodes behind a cluster login node. By running in Client-Server Manual mode and using a "double ssh tunnel", the user can make use of the processors and memory of a large cluster to post-process their data and interactively explore their data. If the local systems allows an interactive queue (i.e. qsub –I) the following method may work on your system.

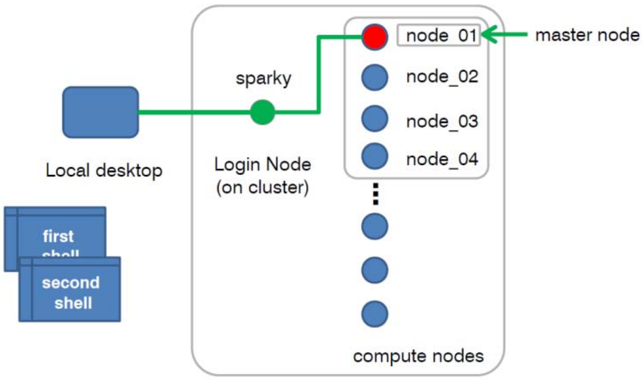


Figure 9: Parallel Setup

In the example parallel cluster setup, there is a "Local desktop" which acts as the client. The Login Node (Sparky) also serves as the PBS server and node_01 serves as the master node of the job which commands the remaining nodes. The following steps outline how to use an interactive queue session to interactively explore with FieldView.

0. Startup fieldview and go into manual mode
1. from the client workstation, ssh onto headnode (sparky.ilight.com is the headnode assumed in this example)
2. qsub -I interactive.pbs

where interactive.pbs is:

```
#!/bin/bash
#PBS -l nodes=2:ppn=2
#
cat $PBS_NODEFILE > machinefile
# end of script
```

3. Step 2 will start up an interactive shell on the first node that was assigned. Make note of that node. We'll assume for this example the first node is "node_01"
4. From the client workstation, execute the following command:

```
ssh -f -N -C -L 22222:node_01:22 username@sparky.ilight.com
```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Enter password for the head node (sparky.ilight.com)
5. Then on the client workstation, execute the following command:
ssh -C -R 7777:desktop_IP:12345 -p 22222 epd@localhost "/opt/fv12.3/fv/bin/fvsrv localhost -port 7777

At this point, the user would then utilize an automatic client server mode that establishes a client server connection to Sparky. When the user goes to select a file, the login node (Sparky) will forward the command to start the FieldView server on the master node (in this case node001). The master node would then start the FieldView server process and the slave processes on the allocated machines. The user would then post-process as usual.

Tip #10) Reduce the amount of volume data saved to disk by using XDB workflow

Large unsteady OVERFLOW2 simulations often require the post-processing of a large amount of grid and solution datafiles which can become difficult to manage. The volumetric data requires large amount of storage space that can exceed terabytes of data and strain the available storage capacity. Moving the data between remote and local workstations may be prohibitive because of the wall time required to move across computer networks. As presented in Tip #9), FieldView Client-Server mode can alleviate this issue. However, for transient cases, the time to interactively sweep through a large unsteady dataset could become tedious. A technique that reduces the amount data stored, moved and processed interactively is the “eXtract DataBase - XDB” workflow.

In the following example of a helicopter rotor simulation, FieldView was executed sequentially with the OVERFLOW flow solver via a “bash” script. OVERFLOW executed for 5-degrees of rotor rotation, saved the grid and solution data to disk and then exited. Upon exit, FieldView then ran in batch to create two Iso-Surfaces of Vorticity Magnitude. The purpose was to avoid saving all the transient volume data and save only the transient XDB files.

In this example, a full rotor revolution of data saved every 5-degrees for rotation would of required 93.55 GB of disc space in comparison to 1.575GB for the XDB with two Iso-Surfaces (**a data reduction of 60 times**). Figure 10 presents the workflow as outlined below:

Create an XDB for every 5 degrees of rotor rotation of OVERFLOW using the following process:

1. OVERFLOW runs then stops saving off x.###, brkset.restart, q.###
2. FieldView runs in batch mode executes an fvx file (fv –batch –fvx iso.fvx) which generates an xdb (xdb.###) The XDB contains 2 iso surfaces designed to highlight 2 levels of vorticity magnitude. One scalar (Velocity Magnitude) was written out. xdb is on the order of 45MB.
3. OVERFLOW job restarts and it keeps going.

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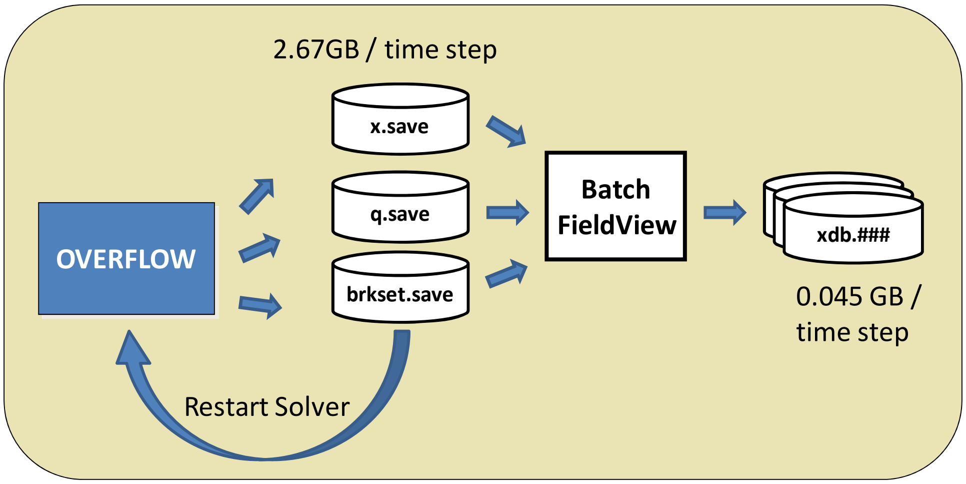

Figure 10 - Iso-Surface XDB Workflow Schematic

Once the batch job of FieldView has complete then the series of XDB files can be transferred to a local client for interactive exploration. For the present example, a total of thirty-five (35) xdb's were created and then transferred via sftp to a local machine. The XDB files were then read as a transient dataset into interactive FieldView and then viewed as a transient dataset. For more complete benchmark and explanation of this example in www.ilight.com.

Works Cited

Anderson, John D. *Hypersonic and High Temperature Gas Dynamics.* Reston, Virginia: American Institute of Aeronautics and Astronautics, Inc., 1989.

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