Use of ThermPlot Pro Software for Quick Evaluation of Thermal Model Results

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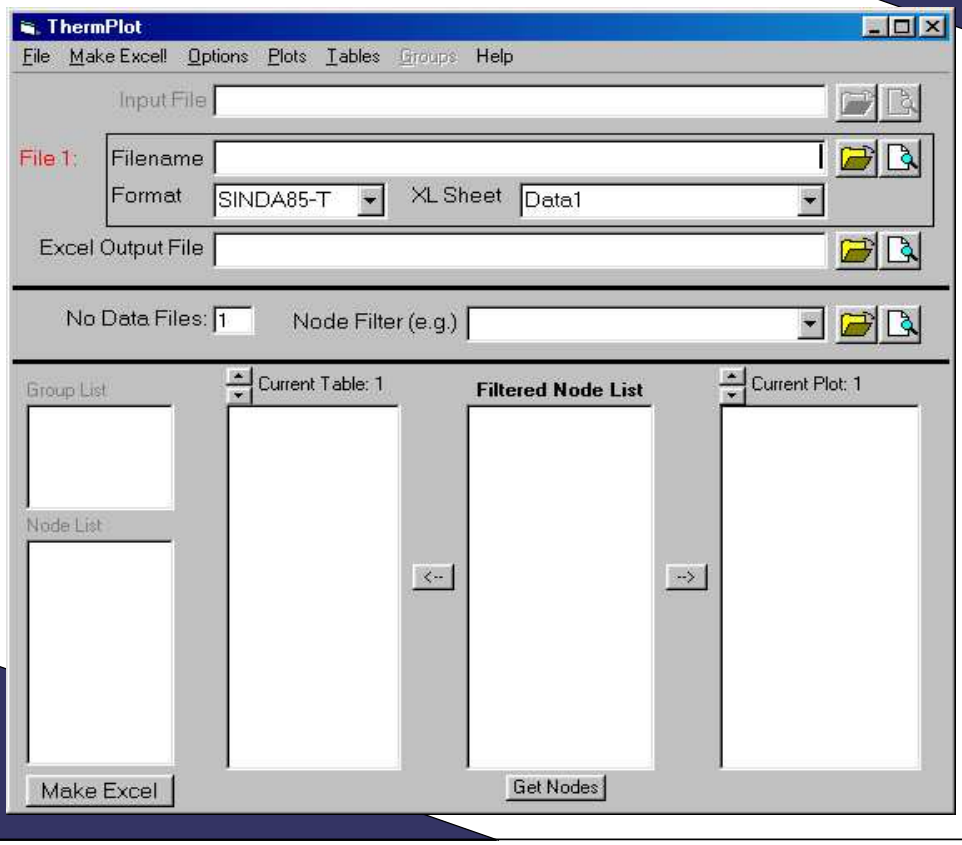
ThermPlot Pro – Overview

- **Few tools exist to allow a thermal analyst to quickly filter thermal model output to areas of interest.**
- **Often thermal analysts write additional logic to output specific information. If new data is needed, the model must be rerun to generate the new information.**
- **ThermPlot Pro uses standard output files and allows the user to define Objects (DataSet, Plot, Table, Parameter, Group) and Options (e.g. Include Descriptions, Selected Nodes Only, HeatMaps)**
- **ThermPlot Pro then processes the input and generates a Microsoft Excel® workbook containing the data and objects specified by the user**
- **All data is then available in Excel for further study**

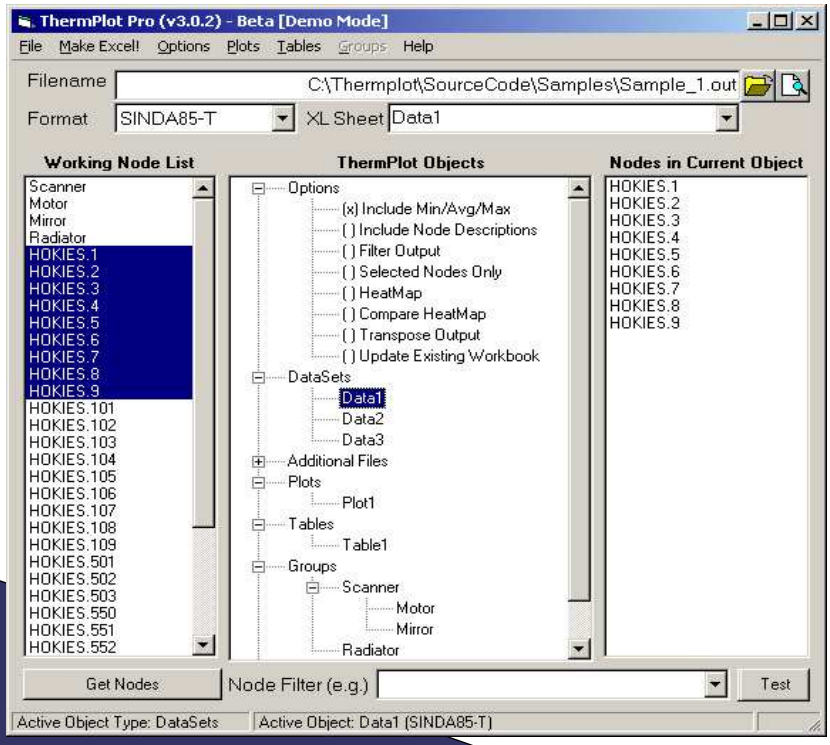
ThermPlot Pro – Features

- **Process wide range of thermal solver formats and multiple files (allowing for comparisons and trend studies)**
- **Options to output only particular nodes of interest**
- **Include Node Descriptions from Input File**
- **Transpose output for dense timestep models**
- **Plot transient data with complete control over line and marker characteristics and axes properties**
- **Tabulate simplified parameters (e.g. Min, Max) including limits and conditional formatting**
- **Group nodes to simplify complicated models**
- **Create interactive HeatMaps or Compare Heatmaps**
  - **Data for any Node/Group or Timestep available**
- **Additional utilities to calculate Backloads/EqSinks and Process Radks**
- **Save settings to session file**

ThermPlot Pro – Main Screen (Classic)



ThermPlot Pro – Main Screen (New)



- **Options set by user**
- **Objects created by user**
  - **DataSets**
  - **Plots**
  - **Tables**
  - **Groups**
  - **Parameters**
- **Data added to Objects from "Working Node List"**
- **Excel® Workbook created based on requested data and objects**

ThermPlot Pro – Supported Formats

- **Many formats and parameters are supported in ThermPlot Pro including:**

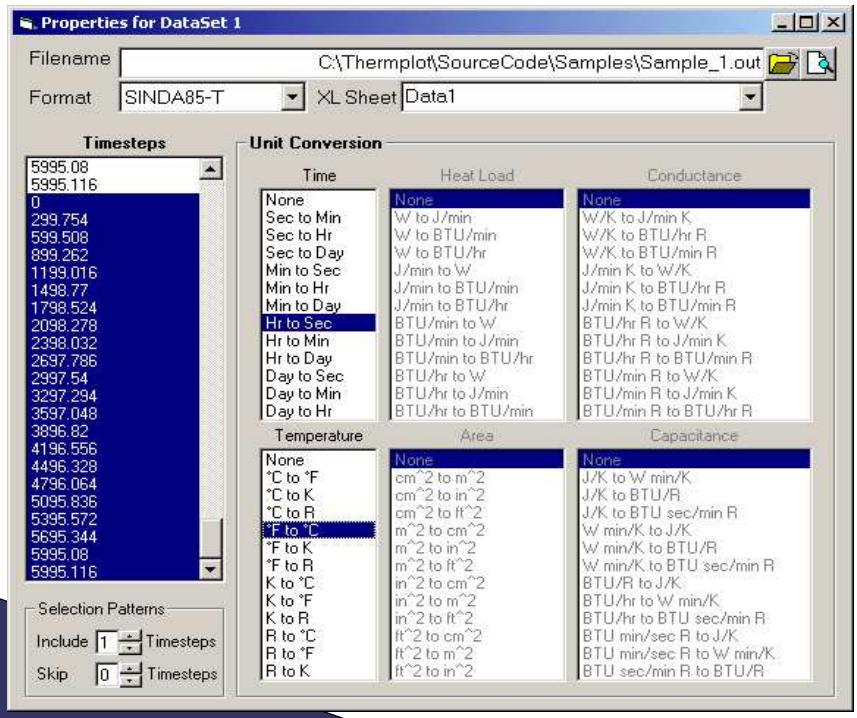
Format	*Parameters*
SINDA85 & SINDA/FLUINT®	T, Q, G, C*
SINDA/G®	T, Q, G, C, F
ESATAN (PRNDBL)	T, Q, QS, QA, QE, QI, QR, G, GL, GR, C*
ESATAN (PRNDTB)	T, Q, QS, QA, QE, QI, QR
TMG®	T, Q (QNODEF), Q (REPF), G
TAK2000®	T, Q, G, C*
TSS®	Q, G*
ThermalDesktop®	Q*, G*
Comma Separated Value	N/A
Space Delimited	N/A

** Planned*

ThermPlot Pro – Options

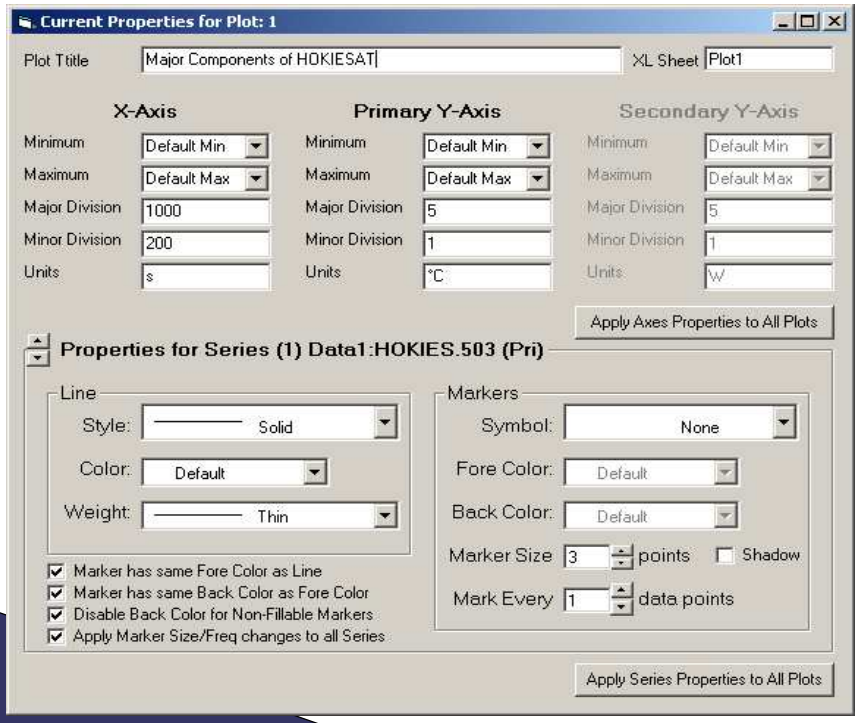
- ***Include Min/Avg/Max*** **– Automatically appends Minimum, Average, and Maximum over *Last Orbit* period to end of data**
- ***Include Node Desciptions*** **– Adds node descriptions from input files to Tables**
- ***Filter Output*** **– Output only data meeting the user specified filter criteria (e.g. 1-100, MAIN.1000-1100)**
- ***Selected Nodes Only*** **– Outputs only nodes referenced by a ThermPlot object (e.g. Group, Plot, etc.) or selected in the "Working Node List" at the time of creation**
- ***HeatMap and Compare Heatmap*** **– Specialized workbook with macros to calculate heat flow between Nodes and Groups**
- ***Transpose Output*** **– Outputs data with Nodes across and Timesteps down, used for output with many data points (Excel limit of 256 cols)**
- ***Update Existing Workbook*** **– Append data to existing Workbook, rather than creating a new Workbook**

ThermPlot Pro – DataSet Properties



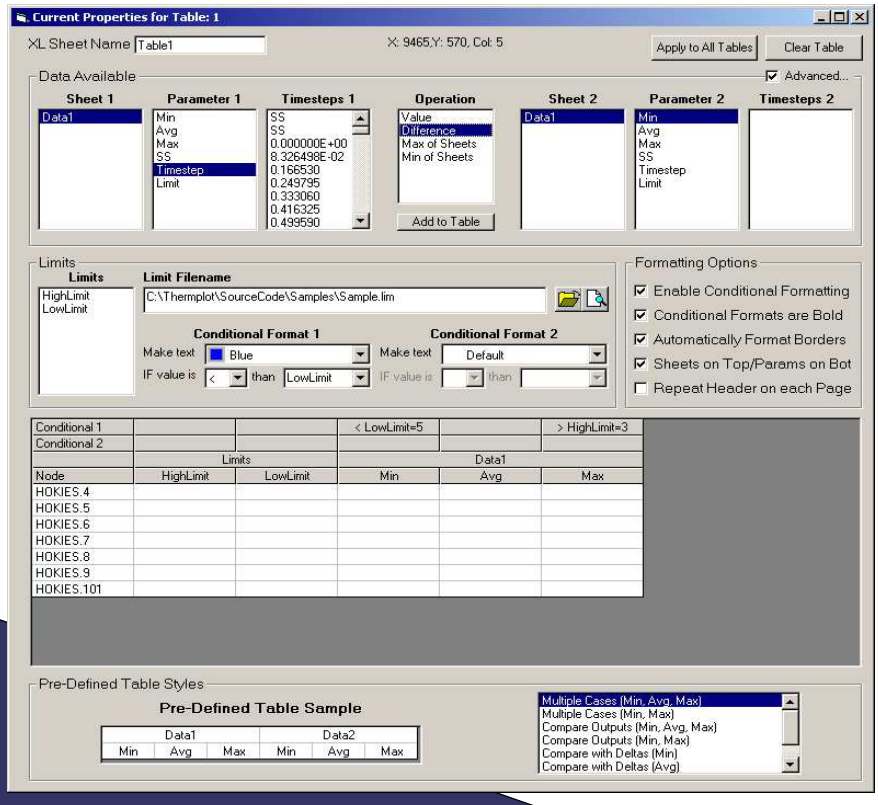
- **Select File, Format, and Data Sheet Name**
- **Specify Timesteps to output**
- **Convert Units**
  - **Time**
  - **Temperature**
  - **Heat**
  - **Area**
  - **Conductance**
  - **Capacitance**
- **Unit conversion options loaded from user-defined file**

ThermPlot Pro – Plot Properties (New and Classic)



- **Complete control over Axes Properties**
  - **Minimum, Maximum, Divisions, Units**
  - **X, Y (Pri), Y (Sec)**
- **Complete control over Series Properties**
  - **Line Color, Style, and Weight**
  - **Marker Color, Style, Size, Frequency**
- **Apply properties from one plot to all other plots for consistency**

ThermPlot Pro – Table Properties (New)



- **Select Tabular Data**
  - **Minimum, Maximum, and Average**
  - **Specific Timestep**
  - **Limits**
  - **Differences between DataSets**
  - **Minimum/Maximum of multiple DataSets**
- **Conditional Formatting to Highlight Out-of-Limit Conditions**
- **Predefined tables for quick creation**

ThermPlot Pro – Working with Groups

THERMAL MODELING SOLUTIONS

- **Groups are a method for simplifying results from large, complicated models.**
- **They allow up to three levels of sub-grouping: Major, Minor, and Sub (Instrument:Region:Component) and may be renamed, modified, or deleted.**
- **Options exist to automatically created groups from submodels and to display nodes in sub-groups when parent group is selected.**
- **When combined with HeatMaps, user may examine heat flow at various levels throughout a model. (e.g. spacecraft to instrument, panel to motor, etc.)**
- **Plan to add "Dynamic Groups", where a user may expand or collapse groups within Excel to examine areas of interest, without the need for detail in other groups. For example, a particular major group for an instrument may be expanded to its sub groups, while all other major groups remain collapsed.**

ThermPlot Pro – Working with HeatMaps

THERMAL MODELING SOLUTIONS

- **HeatMaps allow the user to examine heat flow through a model. They are similar to QDUMPS or QMAPS, but do not require massive outputs of data at each call.**
- **To use this feature, a user must have output for all Temperatures, Heat Loads, and Conductors at *EVERY* output timestep and in the same order. In addition, the input data file must also be specified in order to determine the two nodes connected by each conductor. (ESATAN and TMG are exceptions to this rule.)**
- **To enable HeatMaps, *Include Heatmaps* must be checked under *Options*. Upon enabling HeatMaps, the number of files will default to 3 and the format will automatically select *–T for File 1, *-Q for File 2, and *–G for File 3. Selecting a file for any of the three will automatically select the same file for all three cases.**
- **Many of the options for filtering output are disabled since ALL data is needed to calculate the heat flows. The *Include Max/Min/Avg* option is by default unchecked when *Include Heatmaps* is selected.**
- **HeatMaps are a powerful capability when combined with Groups. Heatflow may be examined between two nodes, a group to nodes, a node to groups, and between two groups.**
- **A user must exercise caution when outputting data from the thermal solver since HeatMap files can get very large with T, Q, and G output at every timestep. It is the responsibility of the user to use common sense; it is not uncommon to have a 50+ MB Excel® file, depending on model size.**

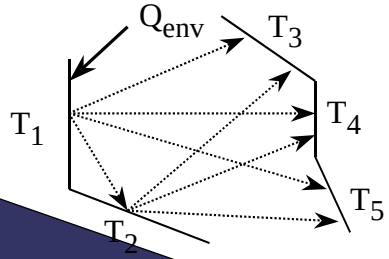
ThermPlot Pro – Working with HeatMaps (cont'd)

- **Once the Workbook is created, the user will specify the Temperature Offset to Absolute Zero (T_{offset}), the Stefan-Boltzman constant (Sigma), the timestep of interest, and the node/group of interest. User entered data is highlighted in Red.**
- **Once T_{offset}, Sigma, and the timestep have been selected, heatflow through all conductors and between groups and nodes is calculated. Once a Node/Group is selected, data specific to the selection is output and sorted according to the header.**
- **The user selects the type of heatflow (e.g. Group-to-Node) by selecting the proper *Heat To* (either Group or Node) and entering a Group or Node as *Node i*.**
- **A Minimum heat value to output may be specified to eliminate negligible heat flows.**
- **A summary of Heatflow into or out of the Group/Node by mode (i.e. Radiative or Conductive) is displayed, as well as the Heat Applied to the Node/Group.**
- **A sample HeatMap Workbook is shown below.**

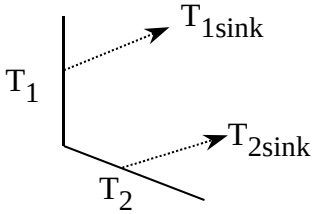
	Description	BASEPLATE FOOT - MX/MY											
	Node i	55701		Temp	11.20					SUMMARY:		In	Out
	Time	6000		Time Col	Y					Conduction		0.462	0.462
	Sigma	5.67E-08		Min Heat	0.0					Radiation		-	-
	Toffset	273.15		Heat to	Node					Source		0.000	-
										Sum		0.462	0.462
	Low (Out) to High (In):						*High (In) to Low (Out):*						
	Description j	Node j	Type	Cond	Temp j	Heat j	Description j	Node j	Type	Cond	Temp j	Heat j	
	AVHRR bracket	40707	Lin	2.28E+00	11.00	-0.45	BASEPLATE UNDER SCAN CAV	55711	Lin	5.44E-01	11.73	0.29	
	SIDE EXTERNAL PANEL	55757	Lin	1.18E-02	10.88	0.00	BASEPLATE UNDER SCAN CAV	55711	Lin	1.10E-01	11.73	0.06	
	SIDE EXTERNAL PANEL	55758	Lin	3.29E-03	10.42	0.00	BASEPLATE UNDER SCAN CAV	55718	Lin	4.02E-02	11.83	0.03	

ThermPlot Pro – Backload/EqSink Calculation

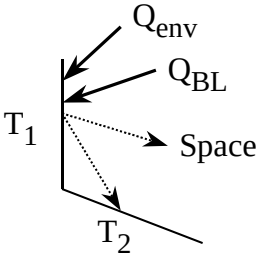
- **Backloads are a method for providing a spacecraft environment to instrument contractors via a simple set of heat loads.**
- **The RadKs from any Node i (in the "Backload" Range) to any Node j are processed along with sigma and the T_j^4. All of these terms are summed for each Node i in the "Backload" range and a set of heat loads generated.**
- **To use the backloads, the instrument contractor simply runs the free-flying instrument model to generate a new set of radiation couplings with increased views to space (since spacecraft blocking surfaces are not present in the instrument model).**
- **These increased views to space are offset by the backload heat added to the surface.**
- **Environment heat loads are also provided to provide the complete S/C environment.**
- **Equivalent sinks are similar, but produce a Sink Temperature/RadK set for each node.**



Spacecraft Environment

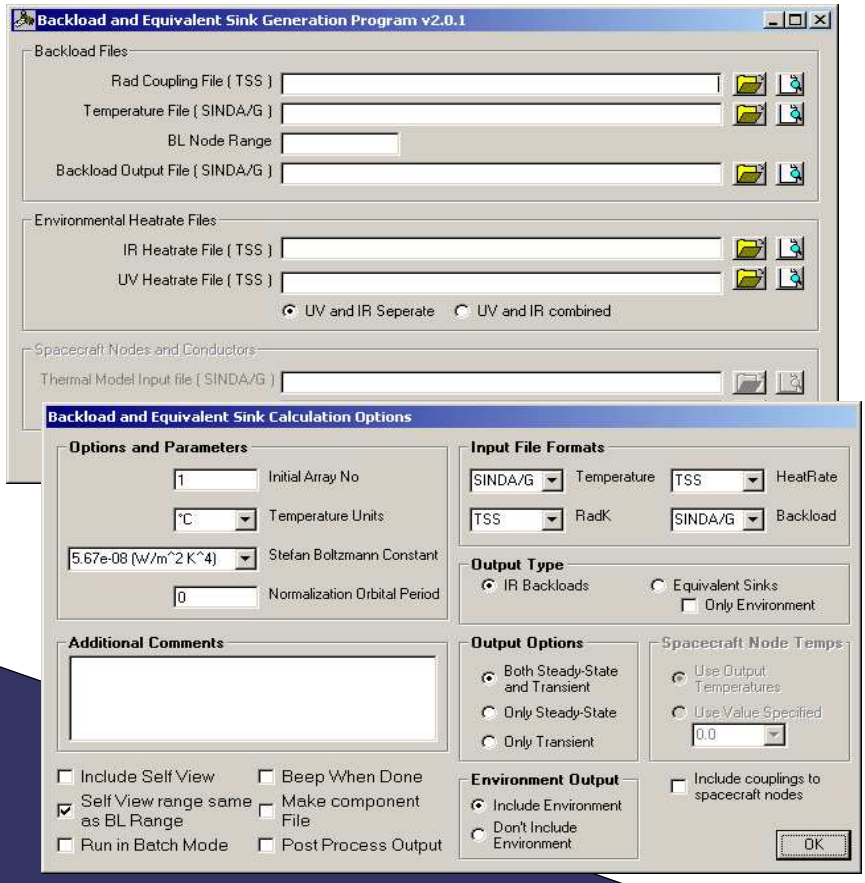


Equivalent Sink (TV)



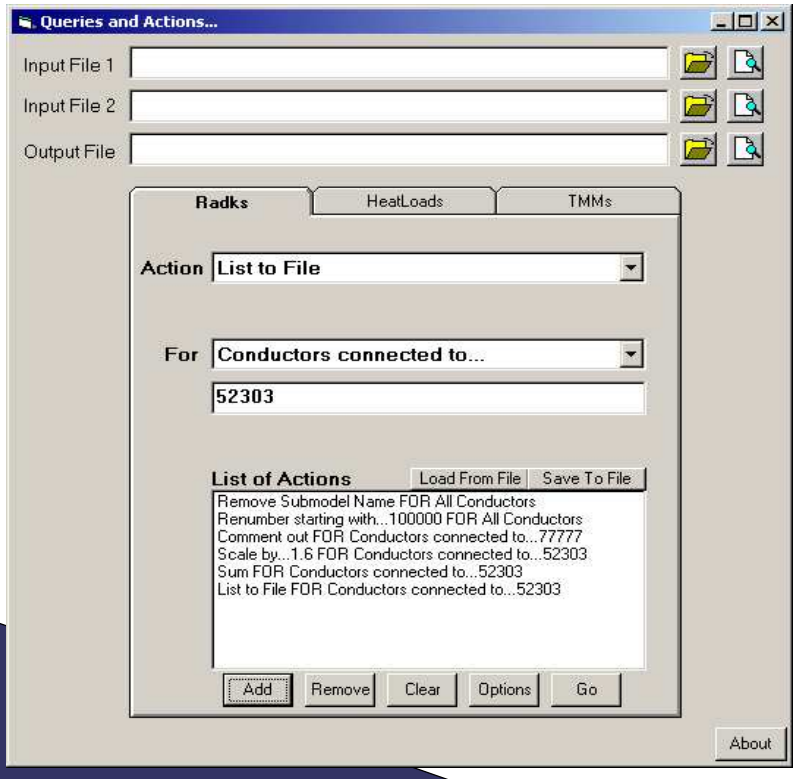
Backload (Instrument)

ThermPlot Pro – Backload/EqSink Calculation (cont'd)



- Requires RadK and Temperature Output
- Option to include Environment (UV and IR or Combined)
- Supports SINDA85, SINDA/G, ESATAN TAK2000
- Component file for traceability
- Include Spacecraft interface couplings (e.g. mounting feet, MLI closeouts)

ThermPlot Pro – Radk/HeatLoad Post-Processing



- Variety of Options to:
  - Remove Submodel
  - Renumber
  - Scale
  - Sum
  - List
  - Comment or Delete
- For conductor sets:
  - All Conductors
  - Connected to Node i
  - Between Nodes i and j
- Currently supports TSS output only

THERMAL MODELING SOLUTIONS

- **Support for TSS variable conductors, and RadCad Conductor and Heat Load output**
- **Unit conversion for Conductors, Capacitances**
- **Output matrix of group-to-group heatflows for entire model within HeatMap workbook**
- **Reduction in conductor output for non-varying conductors**
- **Dynamic groups allowing user to specify complexity of grouping as needed for different areas of a model**
- **QuickPlot and QuickTable capabilities which will allow a user to preview the data within the ThermPlot environment before writing to an Excel workbook**
- **Radk Evaluation and Compare Utility**