Appendix K

THERMISOL
New features and demonstration

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Abstract

Brief presentation of THERMISOL modules:

- Skeleton generator and expander
- Input file pre-processor (reader)
- Solver library
- Post-processing tools: Posther & B-Plot

Brief presentation of new features in THERMISOL 4.3.1

- Extension of implicit Mortran syntax
- Extension of the node specifications of output subroutines
- Automatic conversions of single floats to double precision floats
- New executive blocks: $VTEMPERATURE / $VTIME / $VRESULT
- Management of time events

Demonstration: Example of cold/hot cases study
Using a simplified model of a satellite, we will compute the temperatures in cold and hot case.

THERMISOL

New features in v4.3.1 & Demonstration

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THERMISOL - Versions

- V 4.2.3
  - July 2007

  Presented last year at the 2007 ECLS Workshop
- V 4.3.0
  - March 2008

  Current release
- V 4.3.1
  - November 2008

  Next release

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THERMISOL modules

- Skeleton generator & expander
  - **Easy management** of THERMICA **outputs** for THERMISOL
  - Creation of **generic** skeleton and/or input files for THERMISOL
  - Use of **powerful** `#READ` **instructions**
    (including parametric reading instructions in batch mode)

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THERMISOL modules

- THERMISOL pre-processor
  - **Fast** and **Robust** Pre-processor
  - Handle **very huge input files** in a few minutes
    (with more than a million couplings plus many variables)
  - **Automatic split** of **large Subroutines** for compilation optimization
  - Guaranty of **Double Precision**
  - Handle **complex MORTRAN syntax**

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THERMISOL modules

- Solver Library
  - **Complete set of routines** for network management, outputs, mathematical functions and more
  - **Fast and Robust Solving routines** for Steady-State & Transient analyses (with many optimizations to prevent from divergence)
- POSTHER
  - Extract and Post-process Thermal Results (fluxes analyses, min/max studies…)
  - Export of Excel files
- B-Plot
  - Automatic graph generator (ps format)

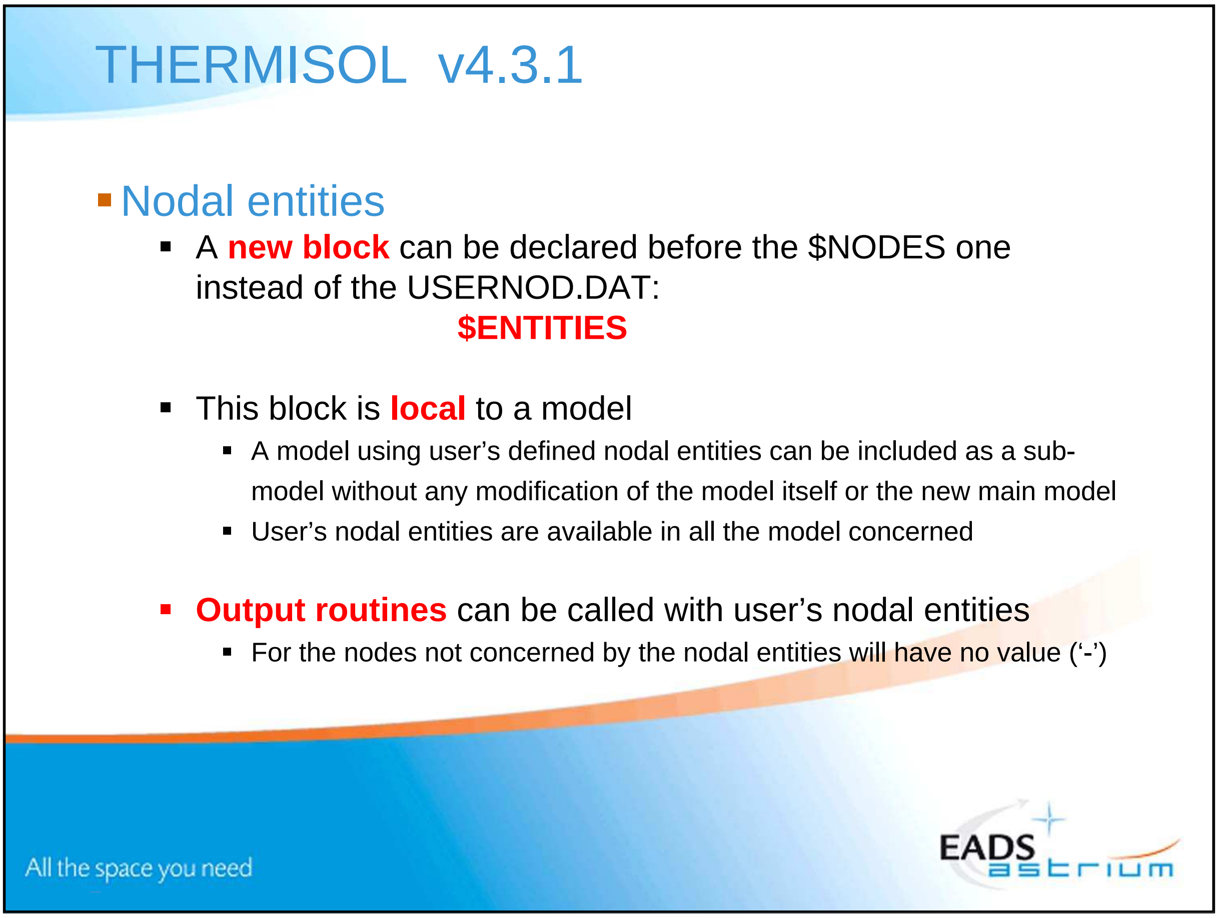
THERMISOL v4.3.1

- Extension of MORTRAN syntaxes
  - Node Data

T 1000		T:SUBMODEL:1000
Tvariable	T:variable	T:SUBMODEL:variable
T:(mathematical expression)		T:SUBMODEL:(mathematical expression)

  - New MORTRAN syntaxes

N	internal node number	
NS	node status	ex: NS 100 = ‘B’
GLS/GRS/GFS	coupling status	ex: GLS(1,2) = ‘X’


THERMISOL v4.3.1
Nodal entities
A new block can be declared before the $NODES one instead of the USERNOD.DAT:
$ENTITIES
This block is local to a model
A model using user's defined nodal entities can be included as a sub-model without any modification of the model itself or the new main model
User's nodal entities are available in all the model concerned
Output routines can be called with user's nodal entities
For the nodes not concerned by the nodal entities will have no value ('-')
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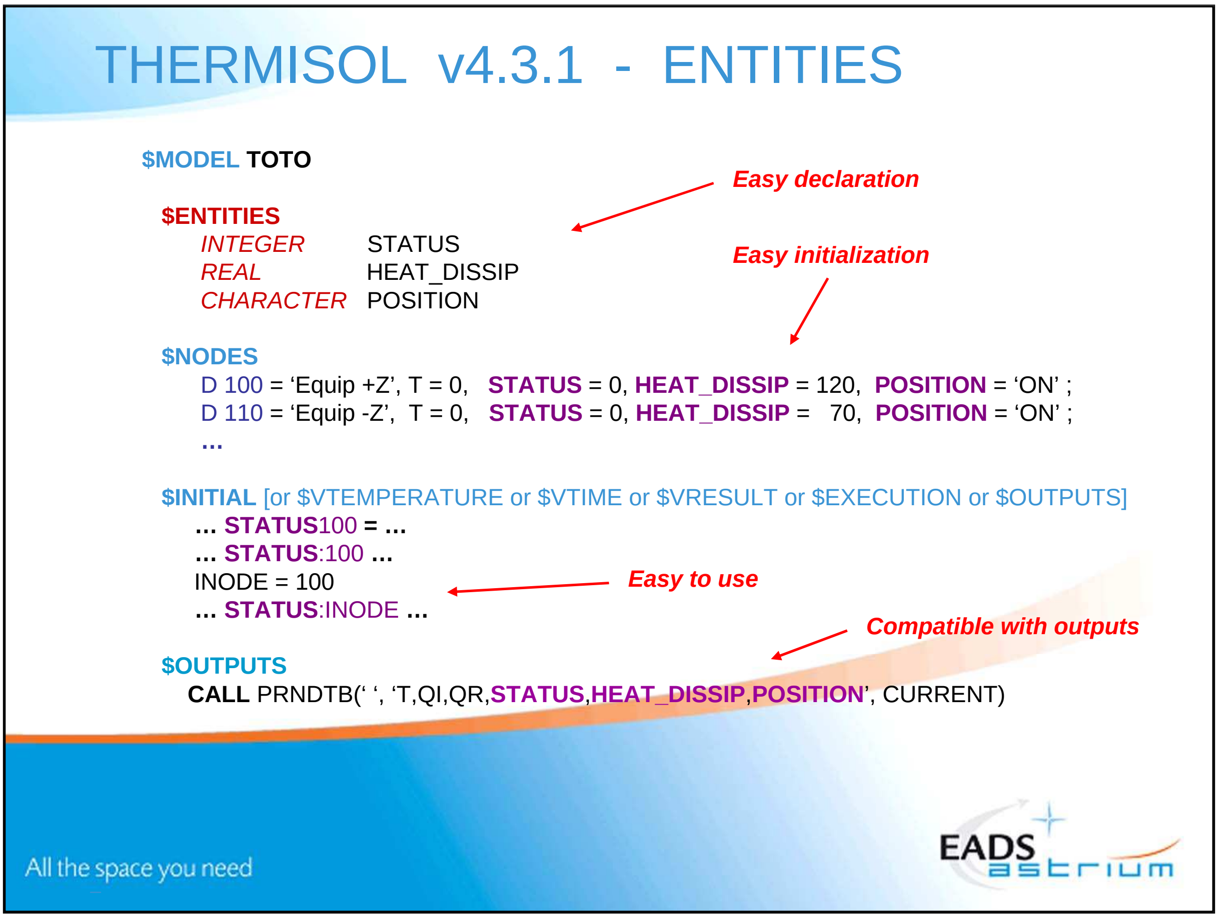
THERMISOL v4.3.1 - ENTITIES
$MODEL TOTO
$ENTITIES
INTEGER STATUS
REAL HEAT_DISSIP
CHARACTER POSITION
Easy declaration
Easy initialization
$NODES
D 100 = 'Equip +Z', T = 0, STATUS = 0, HEAT_DISSIP = 120, POSITION = 'ON' ;
D 110 = 'Equip -Z', T = 0, STATUS = 0, HEAT_DISSIP = 70, POSITION = 'ON' ;
...
$INITIAL [or $VTEMPERATURE or $VTIME or $VRESULT or $EXECUTION or $OUTPUTS]
... STATUS100 = ...
... STATUS:100 ...
INODE = 100
... STATUS:INODE ...
Easy to use
Compatible with outputs
$OUTPUTS
CALL PRNDTB(' ', 'T,QI,QR,STATUS,HEAT_DISSIP,POSITION', CURRENT)
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THERMISOL v4.3.1

- Nodal specifications

The user can specify a group of nodes by

- **Node numbers** / **Range** of node numbers
  (where the upper limit doesn't need to exist)
- A model path (with the use of the optional keyword ONLY)
- A sub-string of the node labels

All this options can be mixed (using ';')

And all can be additive or subtractive (using '!')

```
'#100,200-300;!#235;SUBMODEL;@equipment'
```

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THERMISOL v4.3.1

- New executive blocks
  - In order to optimize the dependencies, new blocks have been defined
  - $VTEMPERATURE
    For all data depending on temperatures.

    This block is often called (almost at each convergence loop with some optimizations to prevent from divergence behavior)

    This block is almost like $VARIABLES1 for steady-state analyses
    Is called much more often for transient routines

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THERMISOL v4.3.1

- $VTIME
  For all data depending on the simulation time

  This block is suitable for
  continuous time dependant phenomena
  (like external fluxes interpolations)
  and for time discrete phenomena
  (may require a use of an EVENT for a better numerical integration)

- $VRESULT
  For data that need to be updated after the temperatures have converged

  This block behaves exactly like $VARIABLES2

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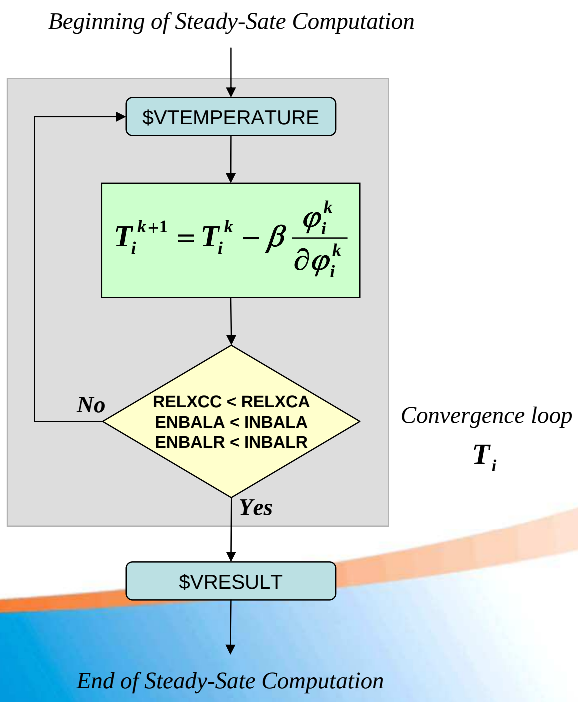
THERMISOL v4.3.1 – Steady State Process



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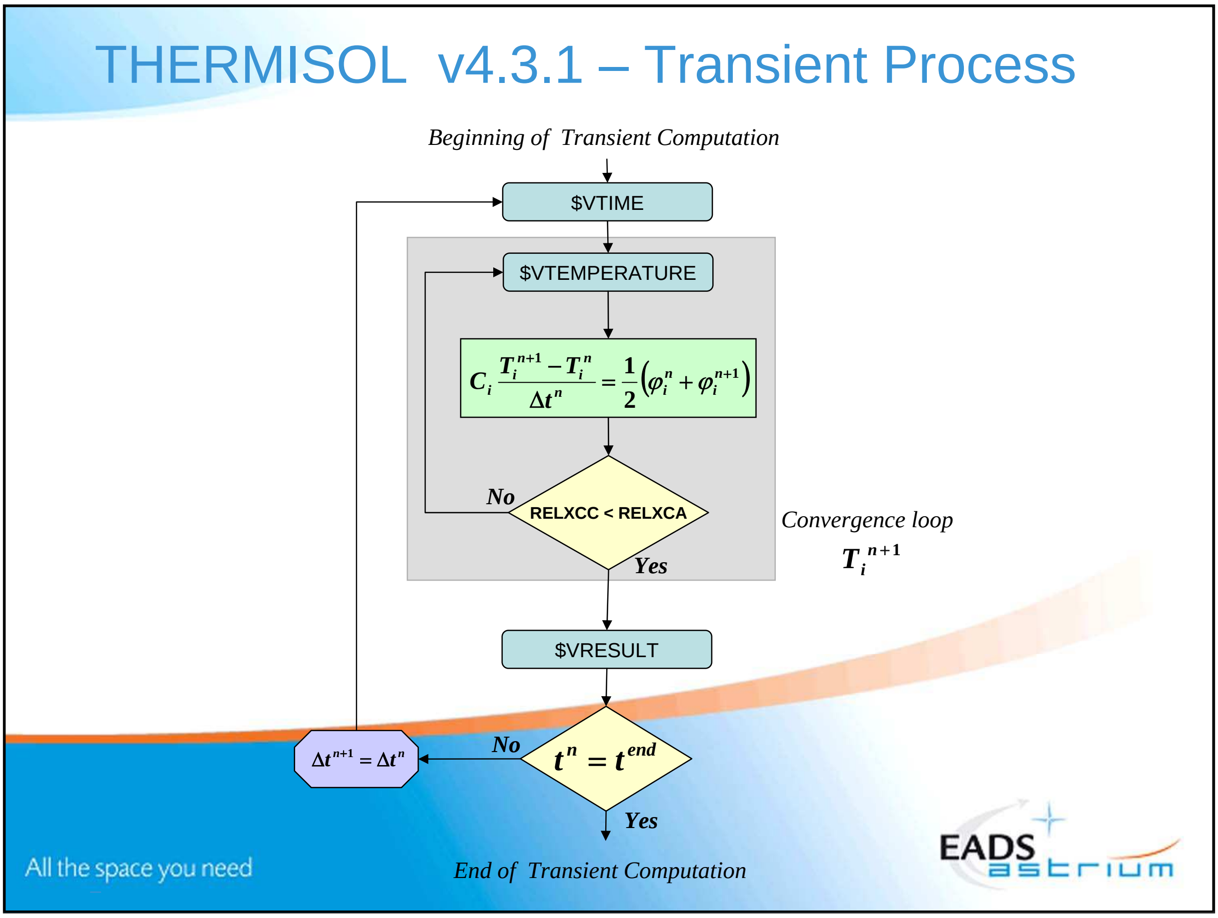
THERMISOL v4.3.1 – Transient Process
Beginning of Transient Computation
$VTIME
$VTEMPERATURE
$C_i \frac{T_i^{n+1} - T_i^n}{\Delta t^n} = \frac{1}{2}(\varphi_i^n + \varphi_i^{n+1})$
No
RELXCC < RELXCA
Yes
Convergence loop
T_i^{n+1}
$VRESULT
$\Delta t^{n+1} = \Delta t^n$
No
$t^n = t^{end}$
Yes
End of Transient Computation
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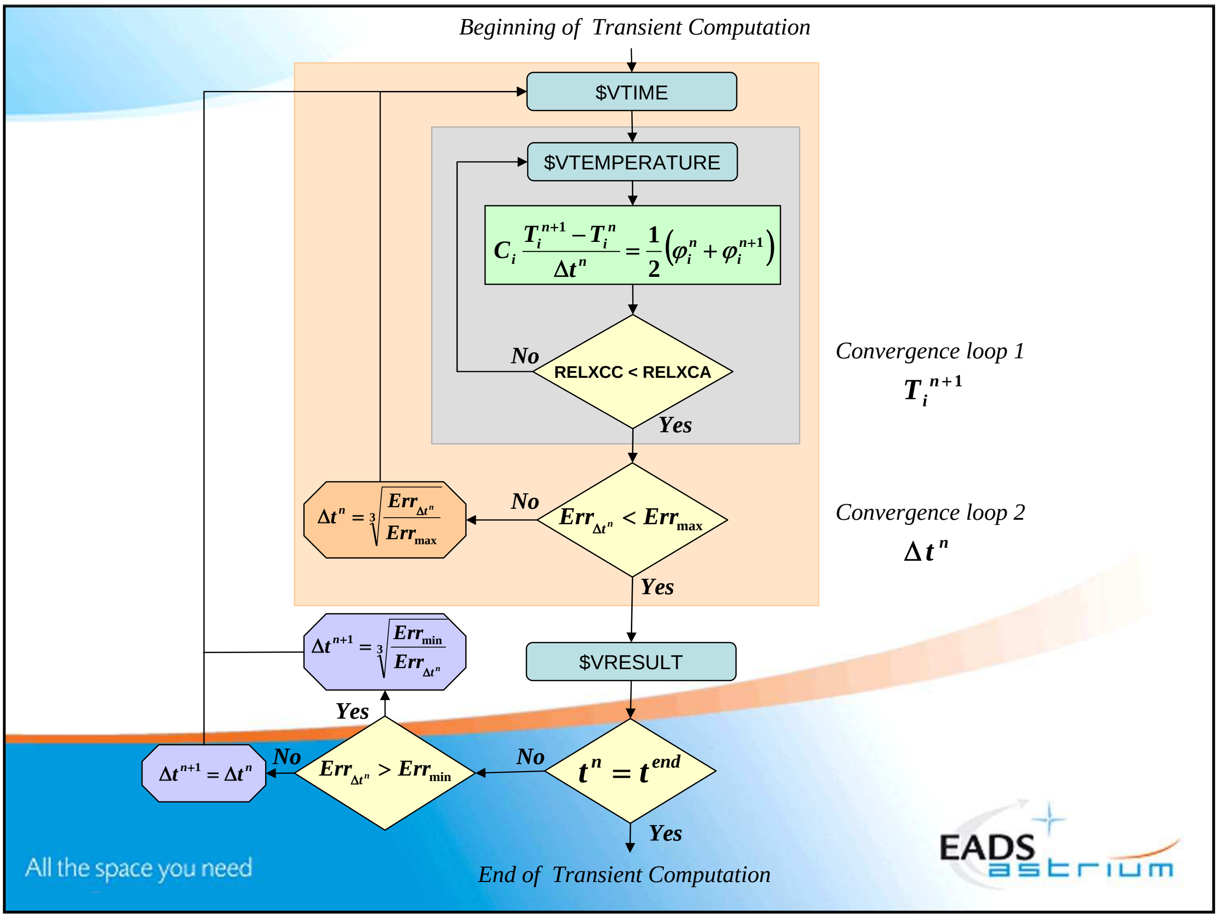
Beginning of Transient Computation
$VTIME
$VTEMPERATURE
$C_i \frac{T_i^{n+1} - T_i^n}{\Delta t^n} = \frac{1}{2}(\varphi_i^n + \varphi_i^{n+1})$
No
RELXCC < RELXCA
Yes
Convergence loop 1
T_i^{n+1}
$\Delta t^n = \sqrt[3]{\frac{Err_{\Delta t^n}}{Err_{max}}}$
No
$Err_{\Delta t^n} < Err_{max}$
Yes
Convergence loop 2
Δt^n
$\Delta t^{n+1} = \sqrt[3]{\frac{Err_{min}}{Err_{\Delta t^n}}}$
$VRESULT
Yes
$\Delta t^{n+1} = \Delta t^n$
No
$Err_{\Delta t^n} > Err_{min}$
No
$t^n = t^{end}$
Yes
End of Transient Computation
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THERMISOL v4.3.1

$EVENTS:

There are 2 types of EVENTS:

- $TIMESTEP
  Useful for discrete time phenomena
  Forces an update of fluxes in order to immediately take into account the discrete phenomena (no numerical inertia)

- $OUTPUT
  To add specific output times
  Forces a call to $OUTPUTS at that time

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THERMISOL v4.3.1

$EVENTS declarations

```
$EVENTS
  $PERIOD                                   # Those are a real local constants
    ORBITAL_PERIOD = 5250.4;
    P_EQUIP = ORBITAL_PERIOD / 20;

  $TIMESTEP
    My_event = 123.45;                      # A time-step event
    New_event = My_event + 300;             # Another time event
    SWITCH_EQUIP = 32.0 [P_EQUIP1];         # A periodic time-step event

  $OUTPUT
    Out_event = 680.0;                      # A output event
    Periodic_out = 500.0 [500.0];
```

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THERMISOL v4.3.1

Use of EVENTS

```
AT My_event DO                          # The instructions will be executed only
   [instructions]                       #    if the current time is after the event
ENDDO

BEFORE SWITCH_EQUIP DO                  # The instruction will be executed only
   [instructions]                       #    if the current time is before any odd
ENDDO                                   #    occurrence of the periodic event

AFTER (SWITCH_EQUIP,2) DO               # The instruction will be executed only
   [instructions]                       #    if the current time is after the 2nd
ENDDO                                   #    occurrence of the periodic event

BETWEEN My_event & New_event DO              # The instructions will be
   [instructions]                            # executed between the two
ENDDO                                        # events
```

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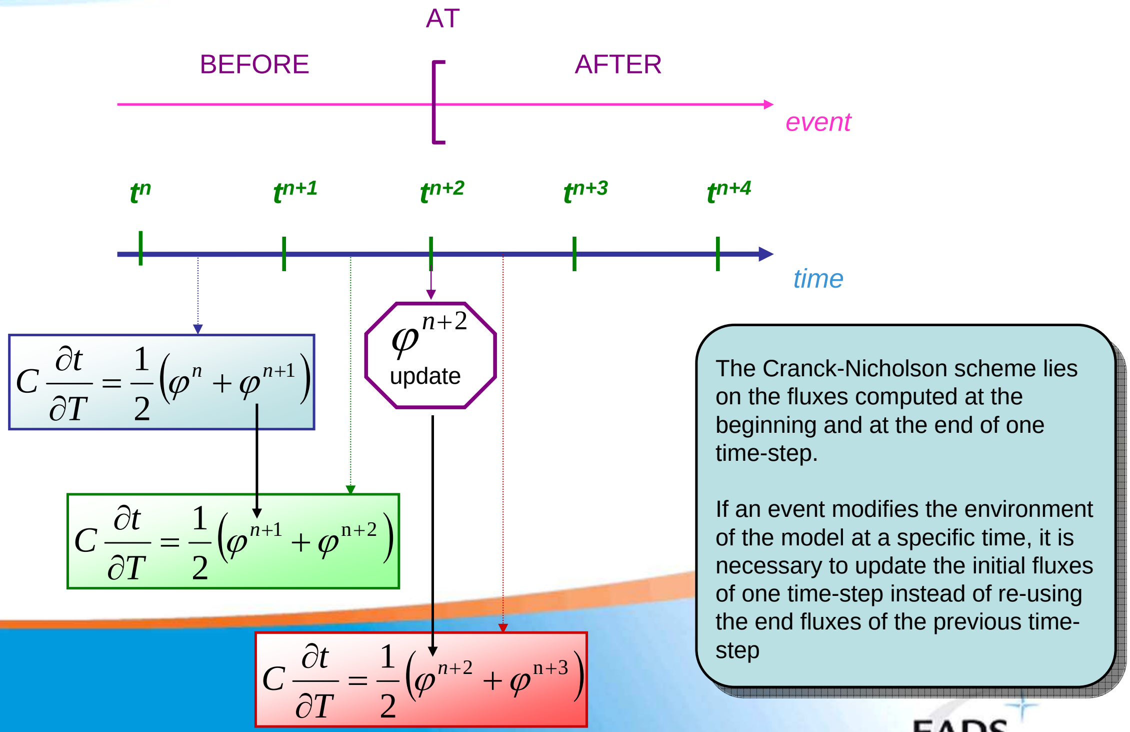
Crank-Nicholson with TIMESTEP events



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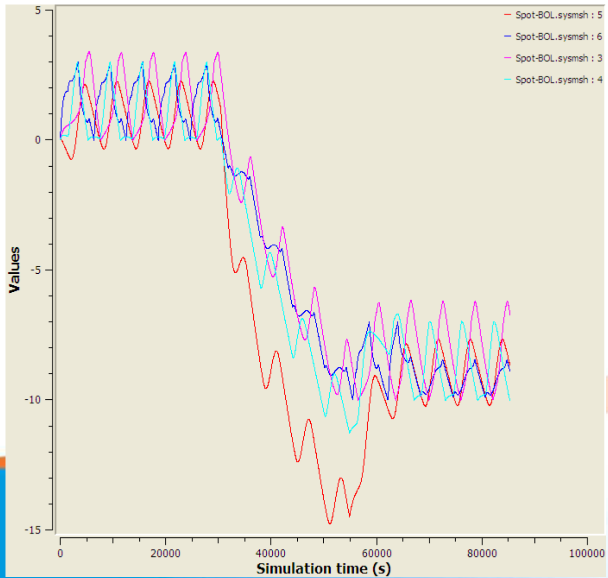
THERMISOL v4.3.1 - Demonstration

- Spot – Cold Case Study



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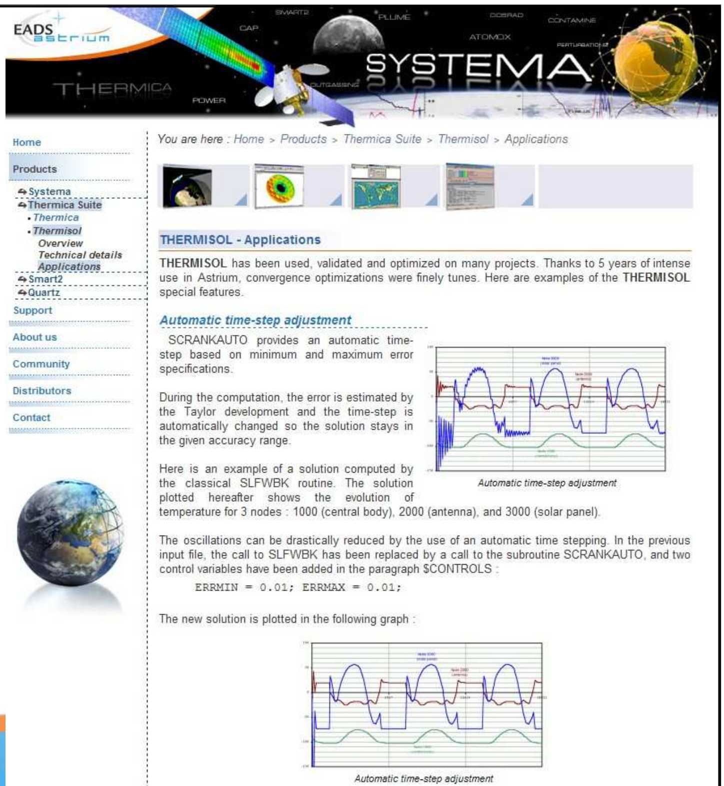

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