

Le modèle de données **IMPEX** : un
démonstrateur d'accès aux simulations
héliosphériques du **CCMC**
(*Community Coordinated Modeling Center*)

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S. Hess, L. Beigbeder

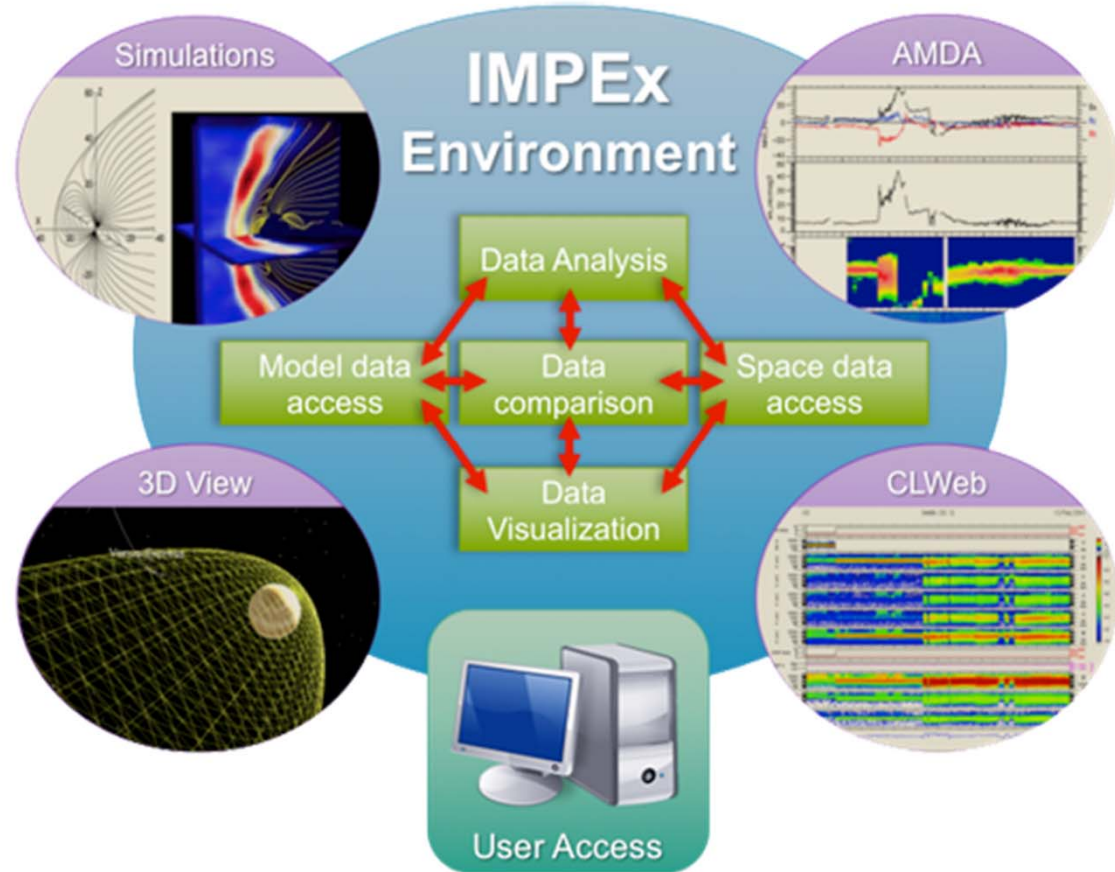


28/01/2014

<http://impex-fp7.oeaw.ac.at/>



- 4 year project (2011-2015)
- 4 partners :
 - LATMOS, CDP
 - FMI (Finland)
 - SINP (Russia)
 - IWF (Austria, coordinator)

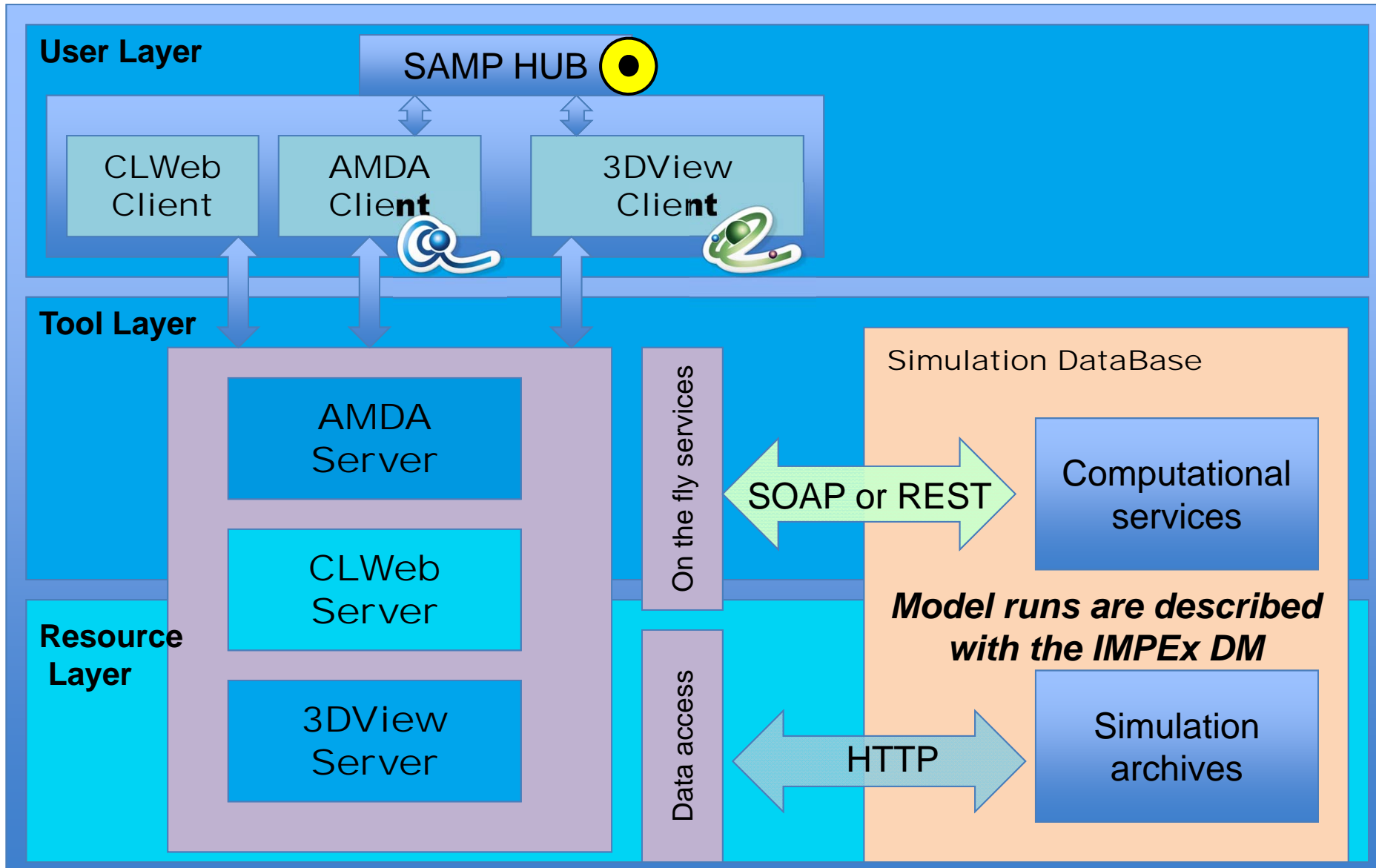


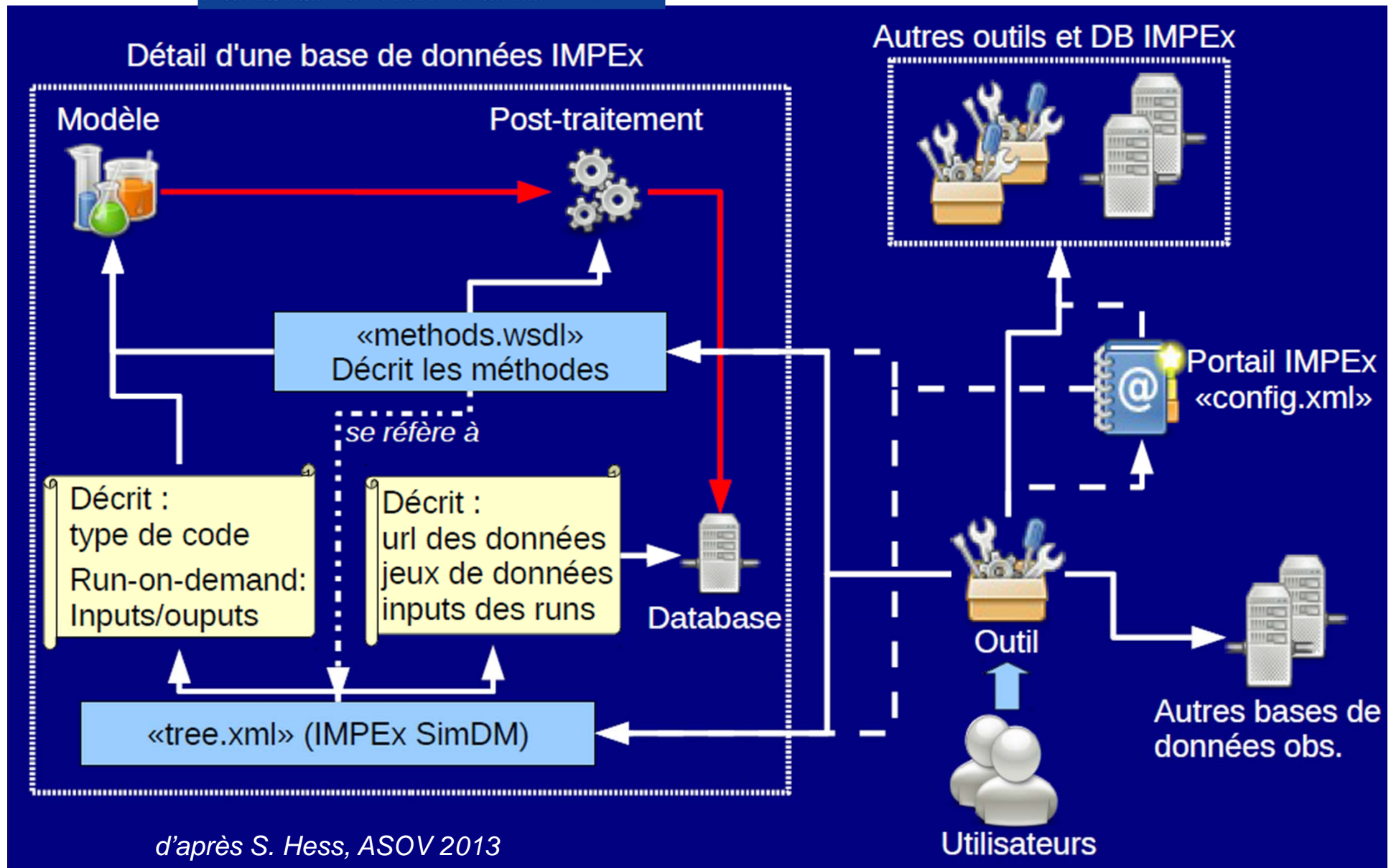
Key IMPEX features

- Goal** : Observations / Models data comparison for planetary sciences
- Mean** : 2D and 3D visualisations
- Analysis tools** : data mining, statistics, event lists
- Access** : large databases (CDAWeb, AMDA, models)
- Commonality** : all models are described with a datamodel based on SPASE



Architecture 1/2





IMPEX DataModel

Basé sur SPASE <http://spase-group.org/>
modèle pour les données en physique spatiale

SPASE DM fournit des ressources

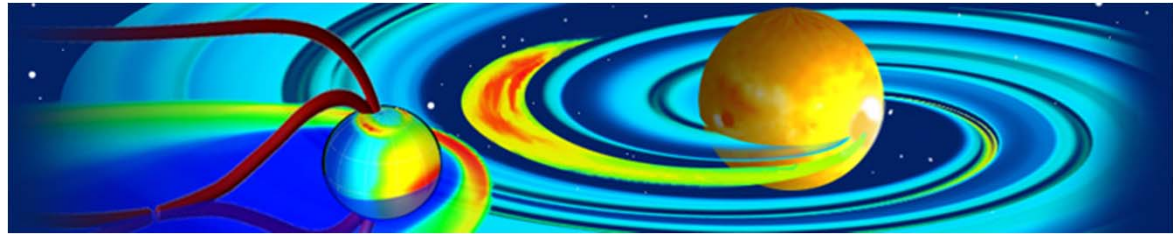
- Pour décrire les données et leur accès:
 - NumericalData,
 - DisplayData,
 - Granule
- Des métadonnées pour l'exploitation des données :
 - Catalog,
 - Observatory,...
- Pour décrire la structure de la base de données :
 - Repository,
 - Service, ...

IMPEX Simulation DM ajoute :

- NumericalOutput, DisplayOutput
clone Spase+ description domaine spatial et propriétés liées au post-traitement
- Granule (overrides Spase's)
ajoute la description du domaine spatial
- SimulationModel
Infos générales sur le modèle (pas sur les algorithmes)
+ liste entrées/sorties pour les RODs
- SimulationRun
Décrit les paramètres des simulations à l'origine des données diffusées

Infos @ <http://impex.latmos.ipsl.fr/tools/DataModel.htm>

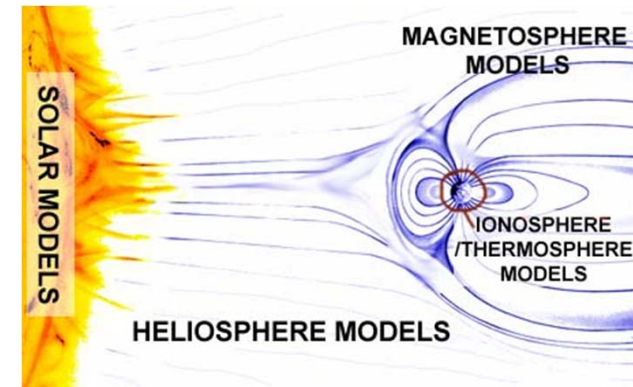
d'après S. Hess, ASOV 2013



<http://ccmc.gsfc.nasa.gov/>

What is CCMC ?

- largest run-on-demand centre in heliophysics
- wide variety of models (MHD, kinetic, ...)
- test runs / event runs
- all runs are accessible to everyone, forever



CCMC in the VO context

- no data model, no web services, no IVOA connexion
- IDL visualisations on their web interface only
- difficulty to retrieve data files
- ... *not really interested by VO issues ... but they're changing*

A prototype to access CCMC simulations

Goals:

- To render CCMC results more easily exploitable by the wider community
- To provide access, visualisation and analysis via CDPP tools (AMDA, 3DView)
- To propose distribution via SAMP to all IVOA tools
- To test the IMPEX SimDM in another context

The prototype *currently* :

- Is limited to one type of simulation :
 - BATSRUS (MHD) code
 - One run with available interpolations along magnetospheric S/C
- Focuses mainly on access (non optimized visualisation)
 - From AMDA
 - From 3DView

CCMC run database

Let's have a look at CCMC runs ...

Here's the result of a search with *keyword = genot*

▶ Runs on Request: Simulations Results

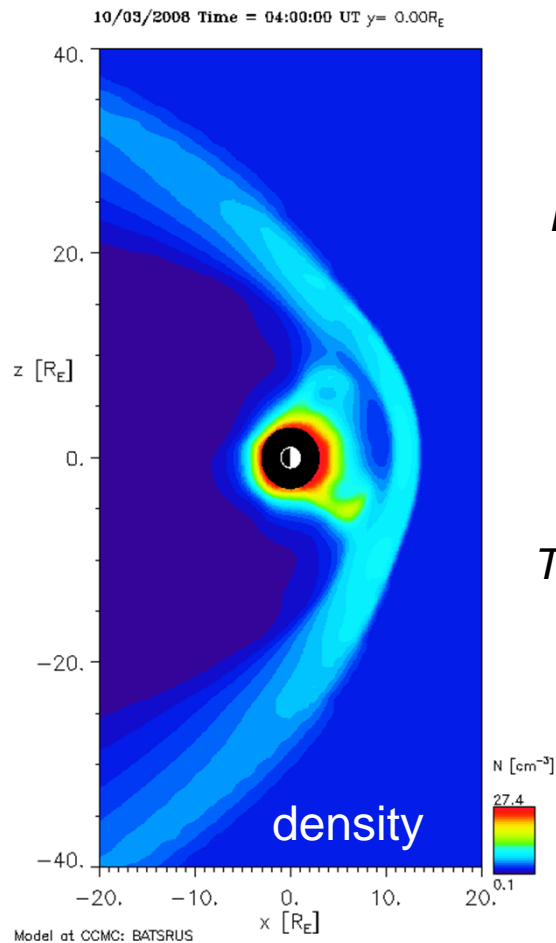
Total Number of Runs in the Database: 3548
 Total Number of Search Results in this Database: 5

Run Number	Key Words	Model	Model Version	Grid	Validation Level	Run Type	SW Input Type	Coordinate System for Input	Coordinate System for Output	Dipole Tilt (in the X-Z Plane) at Start	Dipole Tilt in Y-Z GSE plane)	Update Dipole Orientation with Time
Vincent_Genot_012610_1	geo orbit	BATSRUS with RCM	v8.01	2M cells	--	event	var	GSM	GSM	-15.70	-21.50	yes
Vincent_Genot_033011_1	asym1	BATSRUS	v8.01	700K cells	--	model	fix	GSM	GSM	0.00	0.00	no
Vincent_Genot_033011_2	asym2	BATSRUS	v8.01	700K cells	--	model	fix	GSM	GSM	0.00	0.00	no
Vincent_Genot_043009_1	magnetosheath	BATSRUS	v8.01	2M cells	--	event	var	GSM	GSM	16.40	8.90	yes
vincent_genot_051209_1	magnetosheath ; themis	BATSRUS	v8.01	2M cells	--	event	var	GSM	GSM	24.70	-24.10	yes

▶ Runs on Request: IT Simulations Results

Simulation run : 2008/10/02 04:00 +24h

Magnetospheric response
in a $288 \times 96 \times 96 R_E^3$ box

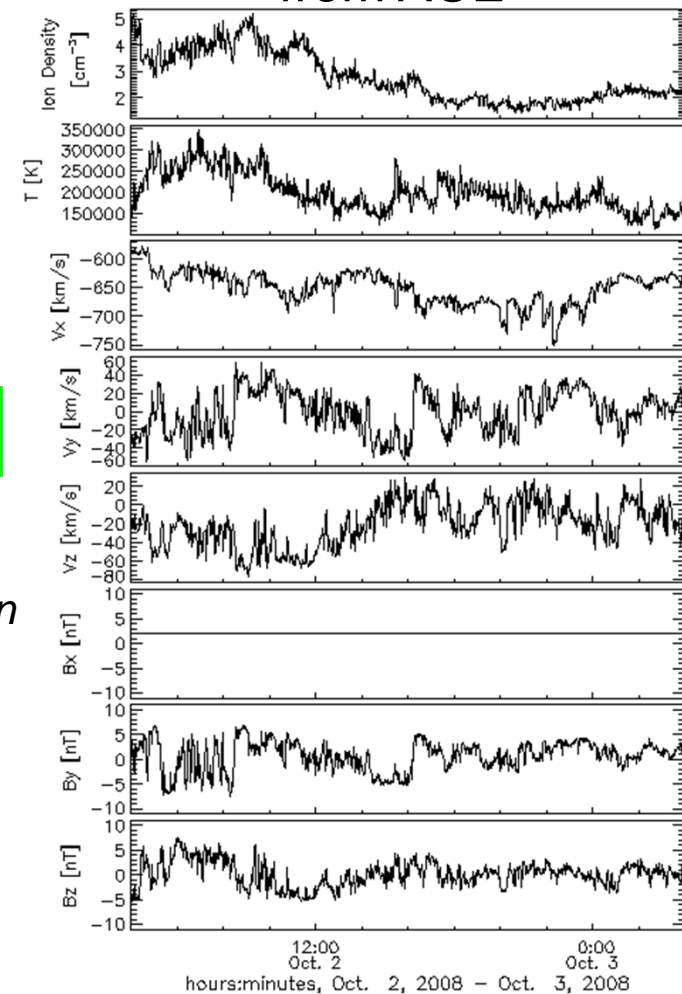


Duration = 24h



Time resolution = 5min

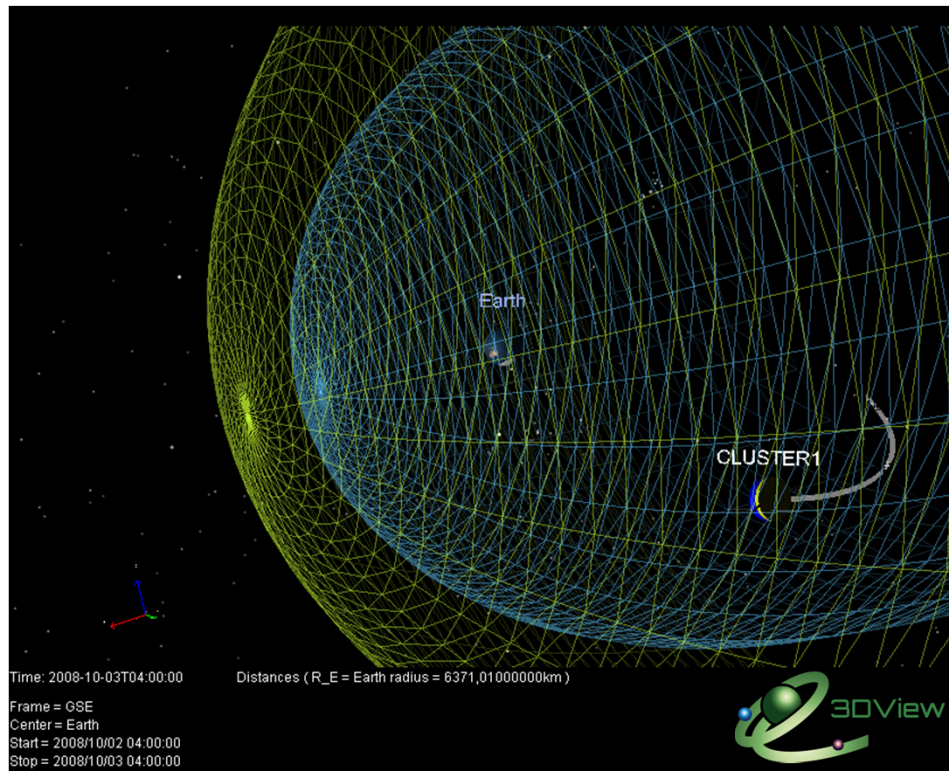
Time varying Solar Wind input
from ACE



CCMC product description 1/2

- CCMC provides interpolation (in the 3D box) of physical quantities (fields and plasma parameters) along spacecraft trajectory (here Cluster 1) → time series which can be directly compared to in-situ observations
- CCMC files are available in ASCII format at given URL

http://ccmc.gsfc.nasa.gov/RoR_WWW/VMR/3539/Cluster-1/GSM_extract.txt



```
# Data printout from CCMC-simulation: version 1.3
# Data type: BATSUS magnetosphere
# Run name: Vincent_Genot_012610_1 Missing data: NaN
# Coordinate System: GSM
# Satellite Track: Cluster-1
# Output data: field with 1x289=289 elements
#
it year mo dy hr mn sc msc X Y Z rho ux uy uz Bx(nT) By(nT) Bz(nT)
0 2008 10 2 4 0 0 000 -18.0 3.09 -9.31 0.769 -205. -4.52 5.84 -2.1
1 2008 10 2 4 5 0 000 -18.0 3.07 -9.37 0.716 -202. -5.47 6.83 -2.1
2 2008 10 2 4 10 0 000 -18.0 3.05 -9.43 0.563 -201. -10.5 10.9 -2.1
3 2008 10 2 4 15 0 000 -18.0 3.02 -9.48 0.458 -213. -13.9 13.1 -2.1
4 2008 10 2 4 20 0 000 -18.0 3.01 -9.52 0.365 -222. -9.32 6.02 -2.1
5 2008 10 2 4 25 0 000 -18.0 2.98 -9.57 0.305 -235. -6.85 4.20 -2.1
6 2008 10 2 4 30 0 000 -18.0 2.96 -9.62 0.281 -245. -9.21 5.76 -2.1
7 2008 10 2 4 35 0 000 -18.0 2.93 -9.68 0.250 -250. -8.48 0.494 -2.1
8 2008 10 2 4 40 0 000 -18.0 2.91 -9.73 0.218 -257. -15.1 2.95 -2.1
9 2008 10 2 4 45 0 000 -18.0 2.89 -9.77 0.186 -259. -19.2 -11.7 -2.1
10 2008 10 2 4 50 0 000 -18.0 2.87 -9.82 0.158 -272. -29.2 -21.8 -2.1
11 2008 10 2 4 55 0 000 -18.0 2.84 -9.88 0.150 -272. -7.29 -24.4 -2.1
12 2008 10 2 5 0 0 000 -18.0 2.81 -9.93 0.142 -276. 9.63 -26.6 -2.1
13 2008 10 2 5 5 0 000 -18.0 2.79 -9.98 0.162 -264. 5.39 -40.8 -2.1
14 2008 10 2 5 10 0 000 -18.0 2.76 -10.0 0.182 -252. -1.77 -16.0 -2.1
```

CCMC product description 2/2

- These numerical outputs can be described using the IMPEX DM (see next slides) in a **Tree.xml** (one Tree exists for each database) – *available at CDPP for the moment*

- http://apus.cesr.fr/AMDA-IMPEX/public/trees/Tree_CCMC_chablon5.xml

- We developed a service (CDPP, FMI) to access and transform the CCMC files in VOTables (on the fly)

- http://apus.cesr.fr/AMDA-WS/php/rest/getVotableFromASCII.php?url=http://ccmc.gsfc.nasa.gov/RoR_WWW/VMR/3539/Cluster-1/GSM_extract.txt

- The VOTables are then accessible by all IMPEX tools using the **Tree.xml** description

```
<?xml version='1.0'?>
<VOTABLE version="1.2"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.2 http://www.ivoa.net/xml/VOTable/v1.2"
  xmlns="http://www.ivoa.net/xml/VOTable/v1.2">
  <!--
    ! VOTable written by FMI web service getVOTableURL
    ! 2014-01-26T18:22:02+0000
  !-->
  <RESOURCE>
  <TABLE name="http://ccmc.gsfc.nasa.gov/RoR_WWW/VMR/3539/Cluster-1/GSM_extract.txt" nrows="289">
  <DESCRIPTION>
    # Data printout from CCMC-simulation: version 1.3
    # Data type: BATSUS magnetosphere
    # Run name: Vincent_Genot_012610_1 Missing data: NaN
    # Coordinate System: GSM
    # Satellite Track: Cluster-1
    # Output data: field with 1x289=289 elements
```

IMPEX DM : SimulationModel

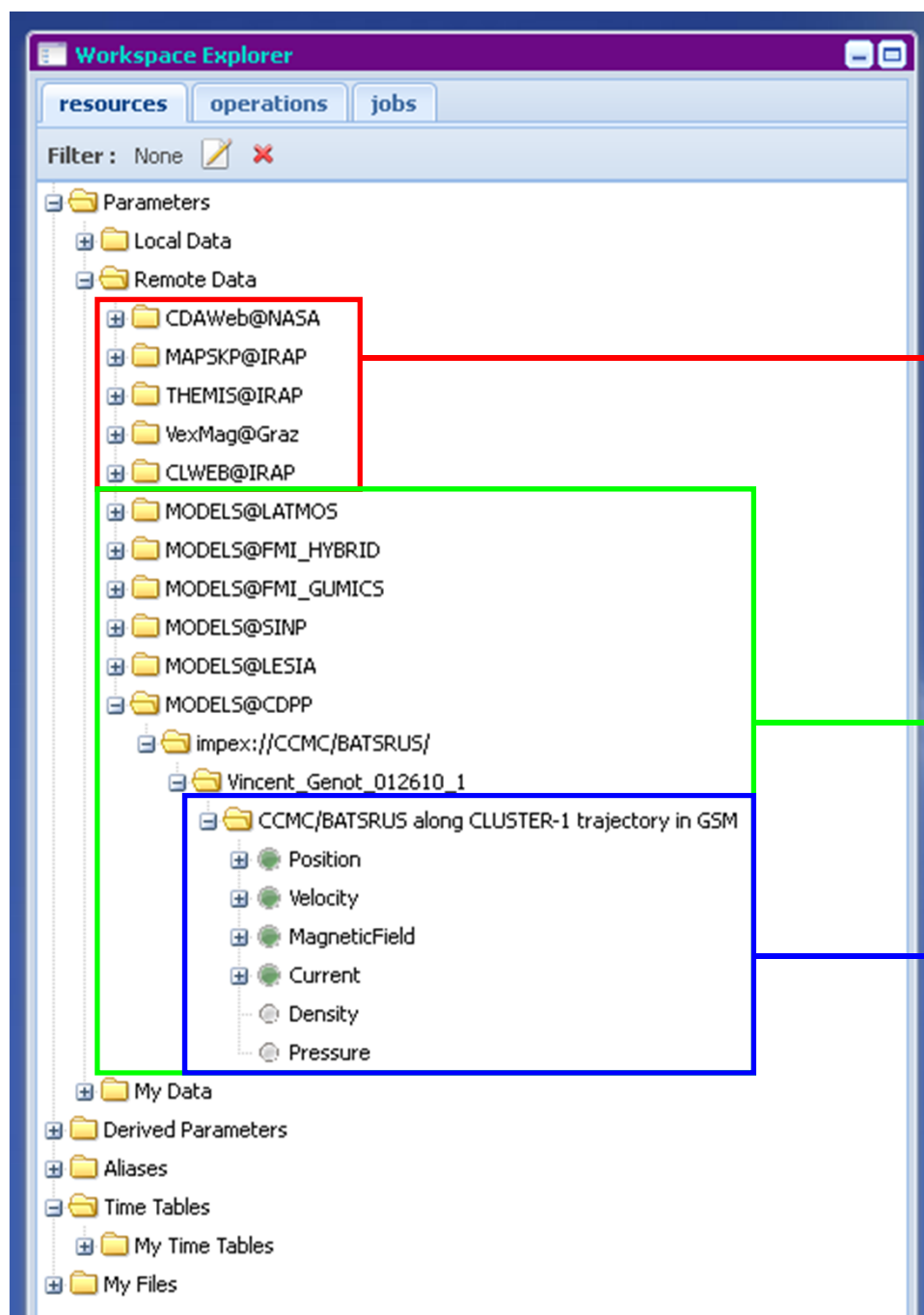
```
<?xml version="1.0" encoding="UTF-8" ?>
- <Spase xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://impex-fp7
  fp7.oeaw.ac.at http://impex.latos.ipsl.fr/doc/impex+spase_latest.xsd">
  <Version>2.2.2</Version>
  - <SimulationModel>
    <ResourceID>impex://CCMC/BATSRUS/</ResourceID>
    - <ResourceHeader>
      <ResourceName>MHD_CCMC</ResourceName>
      <ReleaseDate>2000-01-01T00:00:00.000</ReleaseDate>
      <Description>BATSRUS with RCM v8.01</Description>
      - <Contact>
        <PersonID>CCMC</PersonID>
        <Role>DataProducer</Role>
      </Contact>
      - <InformationURL>
        <URL>http://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=BATS-R-US</URL>
      </InformationURL>
    </ResourceHeader>
  - <Versions>
    - <ModelVersion>
      <VersionID>8.01</VersionID>
      <ReleaseDate>2000-01-01T00:00:00.000</ReleaseDate>
      <Description>First public release</Description>
    </ModelVersion>
  </Versions>
  <SimulationType>MHD</SimulationType>
  <CodeLanguage>Fortran90</CodeLanguage>
</SimulationModel>
```

Part of **Tree.xml**

IMPEX DM : NumericalOutput

```
- <NumericalOutput>
  <ResourceID>impex://CCMC/BATSRUS/Vincent_Genot_012610_1/Cluster-1/GSM</ResourceID>
  - <ResourceHeader>
    <ResourceName>CCMC/BATSRUS along CLUSTER-1 trajectory in GSM</ResourceName>
    <ReleaseDate>2010-01-26T00:00:00.000</ReleaseDate>
    <Description>BATSRUS event run from CCMC interpolated along CLUSTER-1 trajectory in GSM</Description>
  - <Contact>
    <PersonID>Vincent Génot</PersonID>
    <Role>DataProducer</Role>
  </Contact>
</ResourceHeader>
- <AccessInformation>
  <RepositoryID>impex://CCMC</RepositoryID>
  - <AccessURL>
    <URL>http://apus.cesr.fr/AMDA-WS/php/rest/getVotableFromASCII.php?url=http://ccmc.gsfc.nasa.gov/RoR_WWW/VMR/3539/Cluster-1/GSE_extract.txt</URL>
  </AccessURL>
  <Format>VOTable</Format>
</AccessInformation>
<MeasurementType>ElectricField</MeasurementType>
- <TemporalDescription>
  - <TimeSpan>
    <StartDate>2008-10-02T04:00:00.000</StartDate>
    <StopDate>2008-10-03T04:00:00.000</StopDate>
  </TimeSpan>
</TemporalDescription>
<SimulatedRegion>Earth</SimulatedRegion>
<InputResourceID>impex://CCMC/BATSRUS/Vincent_Genot_012610_1</InputResourceID>
- <Parameter>
  <Name>Position</Name>
  <ParameterKey>X,Y,Z</ParameterKey>
  <Units>R_E</Units>
  <UnitsConversion>6371200 > m</UnitsConversion>
  - <CoordinateSystem>
    <CoordinateRepresentation>Cartesian</CoordinateRepresentation>
    <CoordinateSystemName>GSM</CoordinateSystemName>
  </CoordinateSystem>
  - <Support>
    <SupportQuantity>Positional</SupportQuantity>
  </Support>
</Parameter>
```

Part of **Tree.xml**



Remote data in AMDA

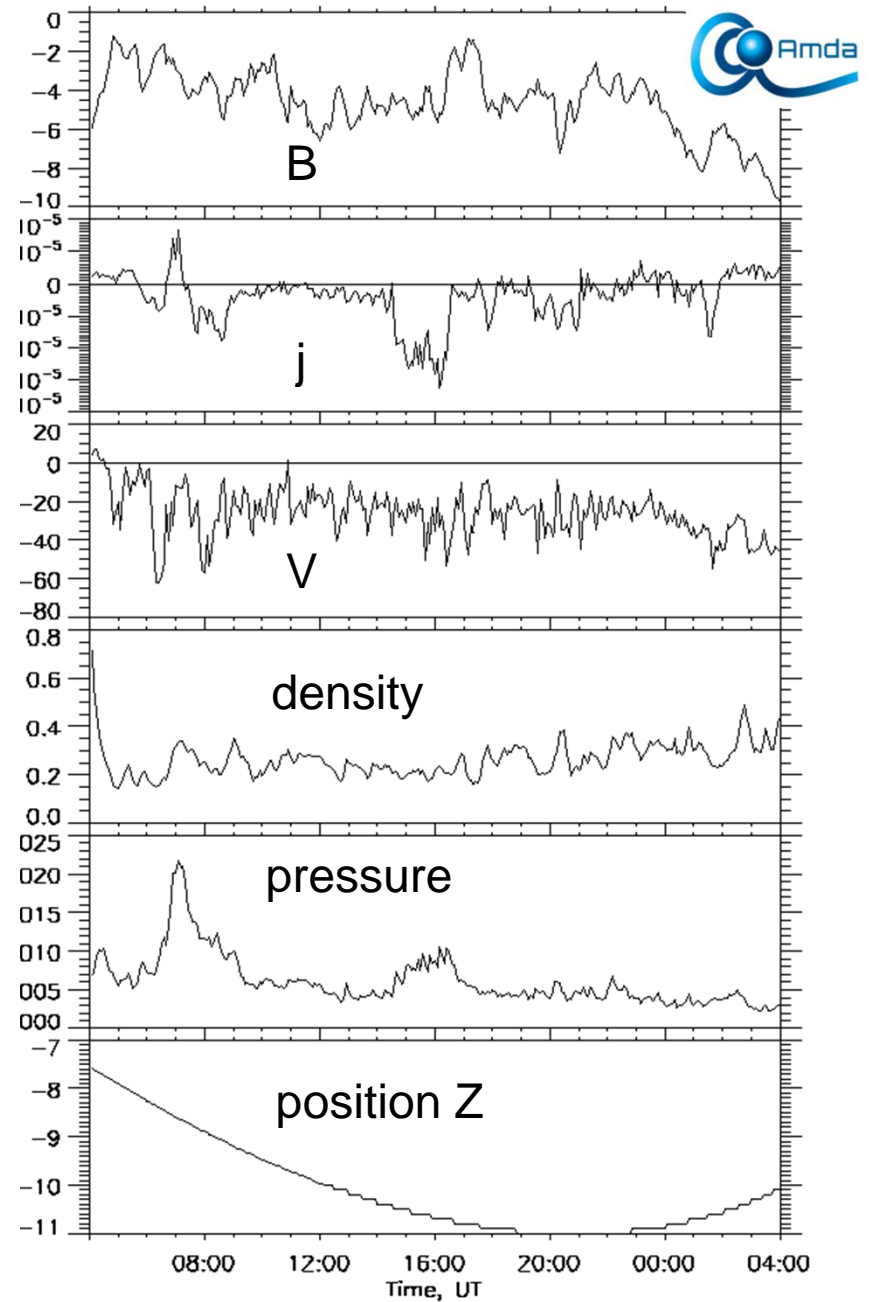
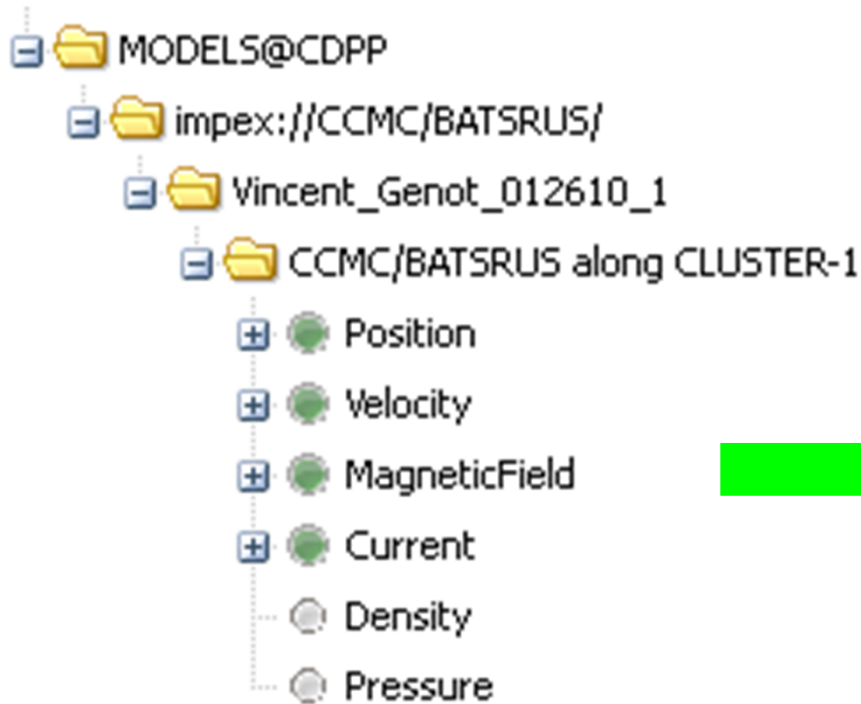
Observational data

Simulation Trees

CCMC Simulation run

- *BATSRUS run*
- *interpolation along Cluster 1 in GSM*

CCMC run visualisation in AMDA

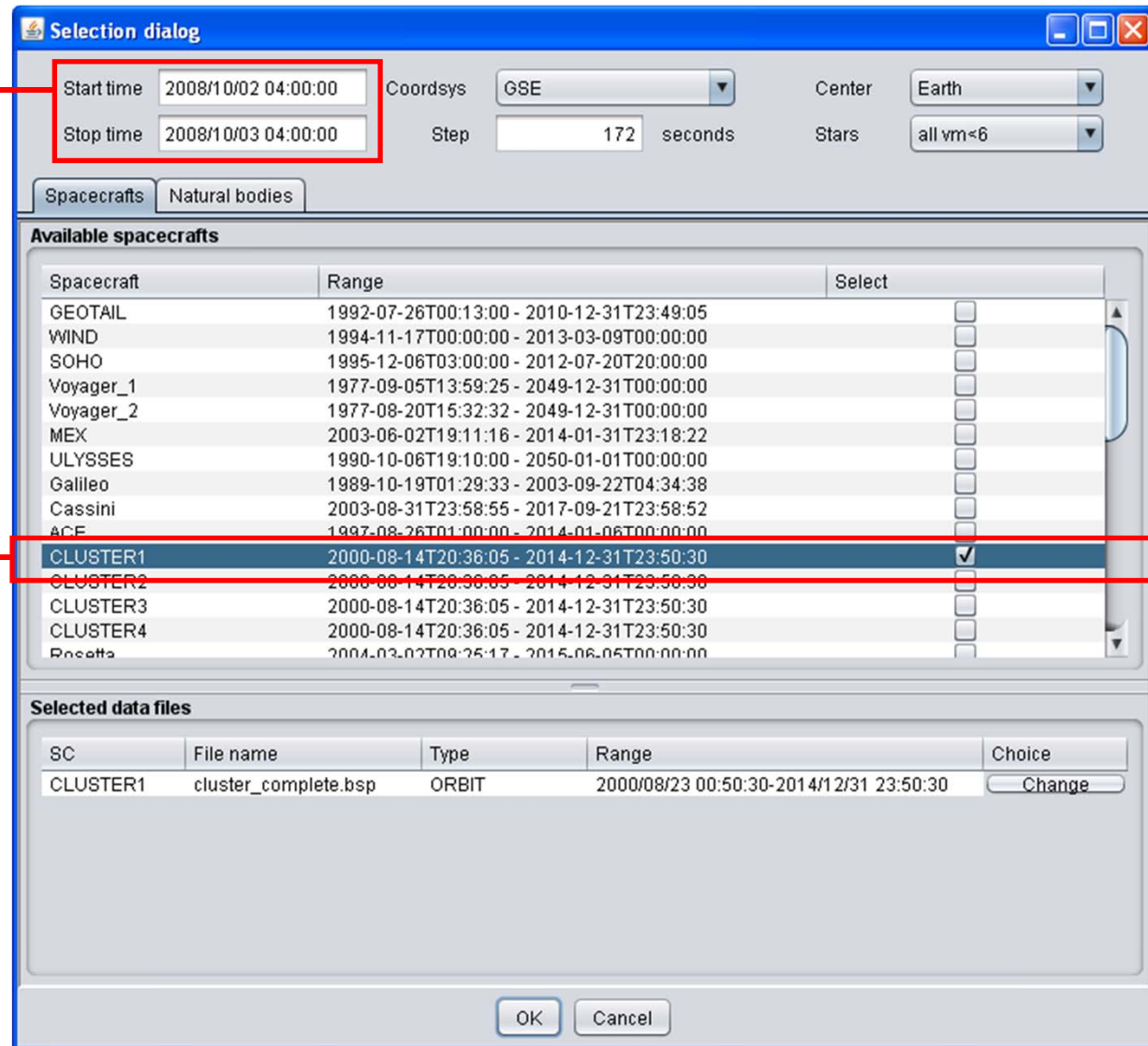


t 2 2008

Created by AMDA(C) 2.0 Tue Jan 2

Scene setup in 3DView : Cluster 1

Simulation interval



Start time 2008/10/02 04:00:00

Stop time 2008/10/03 04:00:00

Coordsys GSE

Center Earth

Step 172 seconds

Stars all vm<6

Spacecrafts Natural bodies

Available spacecrafts

Spacecraft	Range	Select
GEOTAIL	1992-07-26T00:13:00 - 2010-12-31T23:49:05	<input type="checkbox"/>
WIND	1994-11-17T00:00:00 - 2013-03-09T00:00:00	<input type="checkbox"/>
SOHO	1995-12-06T03:00:00 - 2012-07-20T20:00:00	<input type="checkbox"/>
Voyager_1	1977-09-05T13:59:25 - 2049-12-31T00:00:00	<input type="checkbox"/>
Voyager_2	1977-08-20T15:32:32 - 2049-12-31T00:00:00	<input type="checkbox"/>
MEX	2003-06-02T19:11:16 - 2014-01-31T23:18:22	<input type="checkbox"/>
ULYSSES	1990-10-06T19:10:00 - 2050-01-01T00:00:00	<input type="checkbox"/>
Galileo	1989-10-19T01:29:33 - 2003-09-22T04:34:38	<input type="checkbox"/>
Cassini	2003-08-31T23:58:55 - 2017-09-21T23:58:52	<input type="checkbox"/>
ACE	1997-08-26T01:00:00 - 2014-01-06T00:00:00	<input type="checkbox"/>
CLUSTER1	2000-08-14T20:36:05 - 2014-12-31T23:50:30	<input checked="" type="checkbox"/>
CLUSTER2	2000-08-14T20:36:05 - 2014-12-31T23:50:30	<input type="checkbox"/>
CLUSTER3	2000-08-14T20:36:05 - 2014-12-31T23:50:30	<input type="checkbox"/>
CLUSTER4	2000-08-14T20:36:05 - 2014-12-31T23:50:30	<input type="checkbox"/>
Proton	2004-03-02T09:25:17 - 2015-06-05T00:00:00	<input type="checkbox"/>

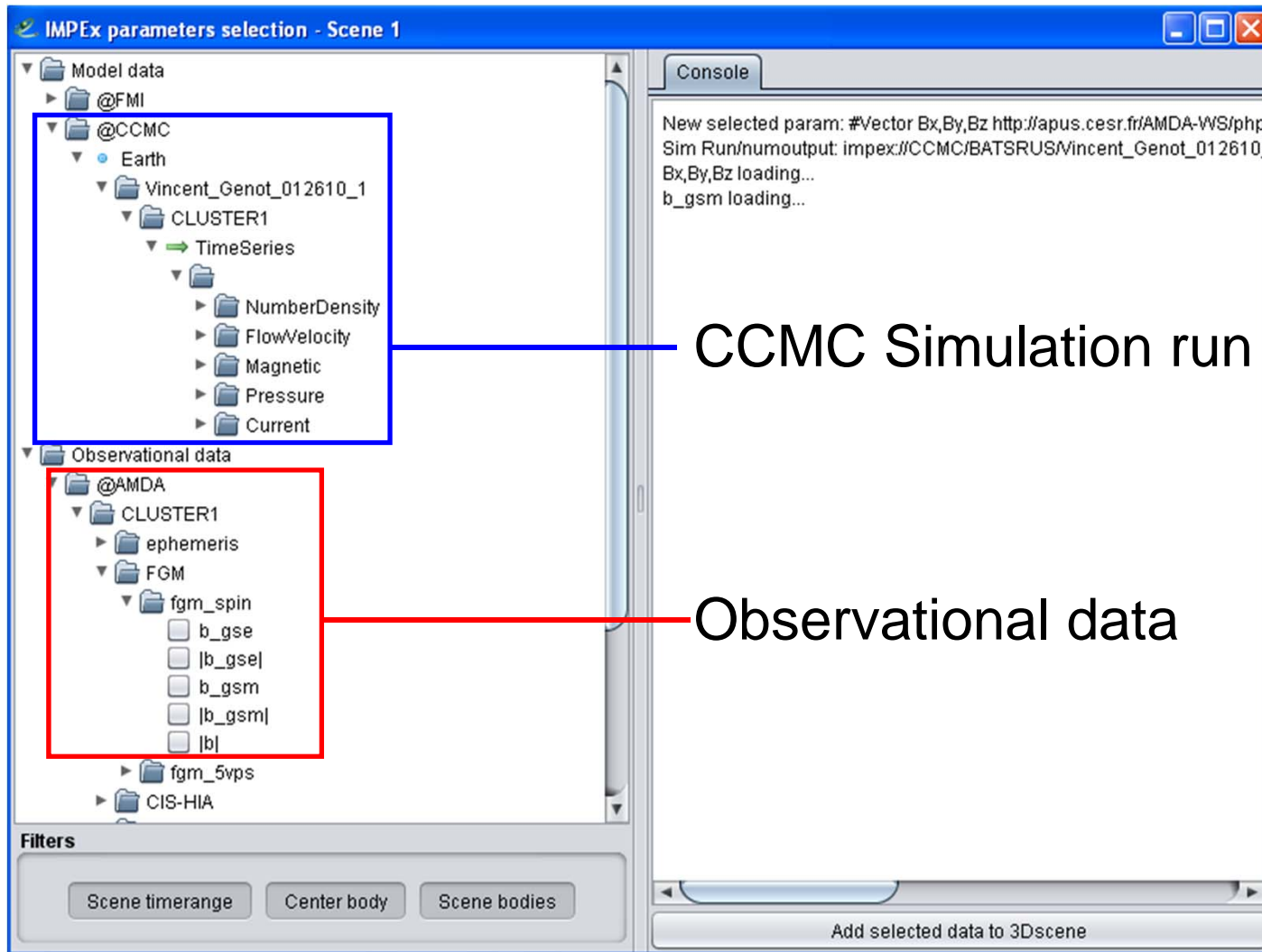
Selected data files

SC	File name	Type	Range	Choice
CLUSTER1	cluster_complete.bsp	ORBIT	2000/08/23 00:50:30-2014/12/31 23:50:30	Change

OK Cancel

Spacecraft choice

Adding CCMC+in-situ data in 3DView



The screenshot displays the 'IMPEX parameters selection - Scene 1' window. The left pane shows a hierarchical tree of data sources. A blue box highlights the CCMC simulation data path: @CCMC > Earth > Vincent_Genot_012610_1 > CLUSTER1 > TimeSeries. A red box highlights the observational data path: @AMDA > CLUSTER1 > FGM > fgm_spin. The right pane shows the console output with the message: 'New selected param: #Vector Bx,By,Bz http://apus.cesr.fr/AMDA-WS/php/SimRun/numoutput: impex://CCMC/BATSRUS/Vincent_Genot_012610_Bx,By,Bz loading... b_gsm loading...'. A blue arrow points from the CCMC path to the text 'CCMC Simulation run', and a red arrow points from the observational data path to the text 'Observational data'. At the bottom, there are buttons for 'Scene timerange', 'Center body', and 'Scene bodies', and a button labeled 'Add selected data to 3Dscene'.

Model data

- @FMI
- @CCMC
 - Earth
 - Vincent_Genot_012610_1
 - CLUSTER1
 - TimeSeries
 - NumberDensity
 - FlowVelocity
 - Magnetic
 - Pressure
 - Current

Observational data

- @AMDA
 - CLUSTER1
 - ephemeris
 - FGM
 - fgm_spin
 - b_gse
 - |b_gse|
 - b_gsm
 - |b_gsm|
 - |b|
 - fgm_5vps
 - CIS-HIA

Console

```
New selected param: #Vector Bx,By,Bz http://apus.cesr.fr/AMDA-WS/php/SimRun/numoutput: impex://CCMC/BATSRUS/Vincent_Genot_012610_Bx,By,Bz loading...
b_gsm loading...
```

CCMC Simulation run

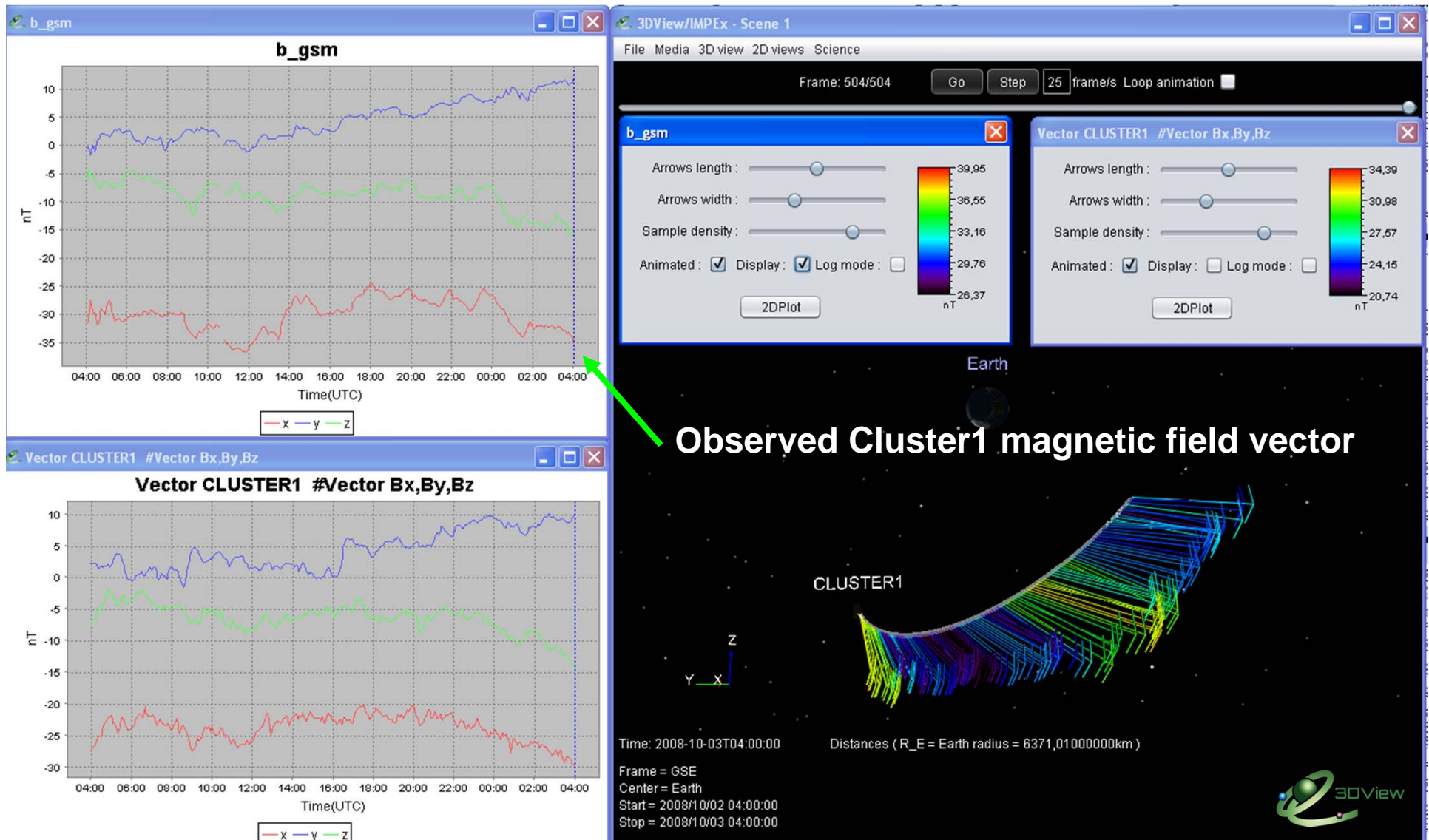
Observational data

Filters

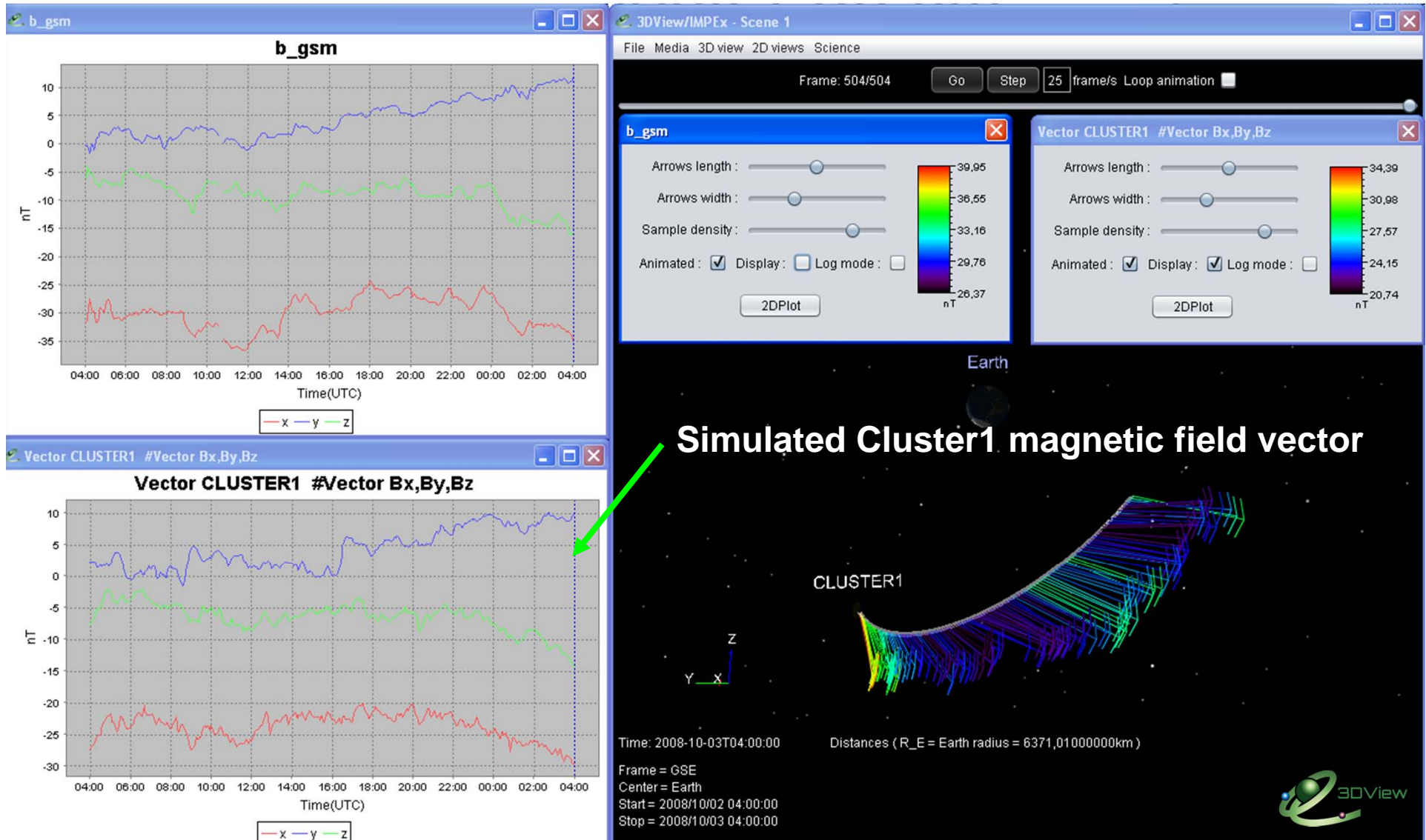
Scene timerange Center body Scene bodies

Add selected data to 3Dscene

Observed/simulated time series + observed 3D field



Observed/simulated time series + simulated 3D field



Conclusions / perspectives

- From information available at CCMC, describing a simulation run with the IMPEX DM is relatively easy
- However doing it systematically for the whole CCMC holdings would be very much time consuming
 - 1000's of runs, numerous spacecraft, several coordinate systems
 - Each combination [run+S/C+coord.syst.] is one output file
- Some steps could be simplified (with CCMC help), for instance
 - CCMC could propose VOTable outputs in addition to their ASCII formats
 - CCMC could automatically generate **Tree.xml** (describing their runs with the IMPEX DM)
- Next steps
 - Describe a few more runs ourselves
 - Get CCMC feedback