Planetary Science Research with the IMPEX Infrastructure

*From science cases to an interoperable VO architecture*

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Goals, Objectives

**Major goal:** creation of an **interactive computational framework** where data from planetary missions can be easily related to numerical models providing a possibility to...

- simulate planetary phenomena and interpret space missions measurements
- test models versus experimental data
- fill gaps in the measurements with data from appropriate modelling runs
- perform **preparation of mission operations** and solve technological tasks, including preparation of new missions

IMPEx will provide access to a variety of **space missions data products** and world leading **computing models**, equipped with advanced **visualization tools**

**Target audience:**
- planetary science community (basic researchers)
- data analysts
- mission and instrument designers
Current scientific focus of IMPEx: plasma and magnetic environments of…

- **Mercury** (BepiColombo)
- **Venus** (VenusExpress)
- **Earth** (Cluster, Themis)
- **Mars** (MarsExpress)
- **Jupiter** and **Ganymede** (Galileo, JGO)
- **Saturn** and **Titan** (Cassini)
- **Comet 67P** (Rosetta)

IMPEx will enable

- Selection, downloading, visualization and analysis of data from observations and modelling runs
- Support in finding matching modelling runs and request of specific runs
- Superimposing modelling data with the spacecraft measurements (visual)
- Scientific tools and functionalities for the support of preparation and operation of space missions (virtual spacecraft in modelled environment, 3DView)
Relation between the *current* set of models, tools and databases in IMPEx

**Modelling sector**
- 3D hybrid & MHD platforms (FMI, Finland)
- 3D hybrid code (CNRS/LATMOS)
- Paraboloid Magnetospheric Model (SINP, Russia)

**Data operation sector**
- AMDA sci. data access (CNRS/IRAP-CDPP)
- 3DView Multimission visualization
- CLWeb data analysis
Cornerstones of Development

Mandatory features of IMPEX infrastructure and RTD

• **Extendibility** (easily adding of new models, databases, analysis tools)
• In-line and compatible with **worldwide trends and standards** (e.g. IVOA)
• **Generality** of approaches and **interoperability** with existing tools
• **Web-based** applications in a **service-oriented** environment

Common/General

✓ **Data Model** (observations/model runs, SPASE based)
✓ Shared (virtual) **Workspace**
✓ **User management**, **Single Sign On**
✓ REST based **Web Interface** and standard **exchange formats** (e.g. *NetCDF*)

Can be seen as a prototype for a **general infrastructure** capable of operating a broad spectrum of **data and models**.
Science Case Methodology

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

Development of application scenarios for scientific software

- **Science Cases** are representing snapshots of *scientific workflows*
- Collection of **relevant and needed resources** and **services**
- Definition of **generic use cases** – steps needed to solve the scientific problem – extraction of **system capabilities** to be implemented
- **Search capabilities**: Registry services with searchable XML metadata for simulation runs and observational data
- **Computation capabilities**: Simulation services provided via Web service interfaces
- **Visualization capabilities**: 2D and 3D visualization of all types of data in JAVA clients and in browser applications
Simulated magnetic environment from the 3D hybrid model compared with Venus Express MAG data – Scientific Workflow

1. Model run - IMF/SW input conditions
2. Observed SW properties similar to simulation
3. IMF – VEX MAG and Orbit
4. SC trajectory time-table
5. MAG interpolation along trajectory
6. MAG and model output visualization
7. Model comparison with observational data

Simulation Models
- 3D HYB
- 3D MHD
- 3D PMM

IMPEX Framework
- Data Analysis
- Data comparison
- Space data access
- Data Visualization

CLWeb
AMDA
3D View Multimission

http://impex-fp7.oeaw.ac.at
EC Grant agreement no. 262863
09/14/12
SC4 - Venus Magnetosphere Studies

- Sample plots taken from Kallio et al. (2007) and http://3dview.cesr.fr (2012)
- 2D plots (left) will be possible within AMDA with IMPEx extensions.
- 3D representation of e.g. magnetic field lines (below) will be possible in 3DView with IMPEx extensions.
Simulation chain for determining Mercury’s surface composition

To be included in the IMPEx Framework

Solar Activity (Observations)

3D HYB, MHD or PMM application

Mineralogical surface composition model

Surface Sputter Code

Density distribution of surface elements

3D exosphere model

SW properties, IMF

SW proton flux precipitation

Surface elemental composition

Surface sputter yield
Solar Observations / Magnetic Environment of Mercury - Scientific Workflow

1. SW properties, (modelled)
2. IMF – Messenger MAG
3. Model run or archive access based on input
4. Model visualization
5. Model comparison with observational data

Simulation Models
3D HYB
3D MHD
3D PMM

IMPEX Framework
Data Analysis
Data comparison
Space data access
Data Visualization

CCMC

CLWeb
AMDA
3D View Multimission

1. SW properties, (observed, modelled)
2. Bowshock – Messenger MAG
1.a. Messenger flybys - orbit

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• Virtual User Workspace (with Single Sign on)
• SAMP-Hubs between applications (XML-RPC)
• Compute Services (SOAP/WSDL)
• Data Services (Registries based on SPASE)
• Discovery and Choreography via IMPEx configuration
IMPEEx innovations

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• Simulation data model:
  – Based on the Space Physics Search and Extract (SPASE) XML definition – Extended vocabulary for different simulation resources
  – Simulation runs and input parameter
  – Catalogues of simulation results
  – Output datasets and their included parameters

• Authentication & Authorization:
  – Major task regarding integration – Enhanced usability
  – Simple Single Sign On (SSO) solution with an shared IMPEEx User ID
  – Local tool users can be connected with a unique IMPEEx ID saved in the individual profiles
  – Establishment of a “shared user session” → User access to common workspace → access of saved user data in IMPEEx
Dynamic Connection

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IMPEx Webpage:
http://impex-fp7.oeaw.ac.at

Developed by IWF-Graz Team in Graz base don Typo3 CMS.

Information about
• Project structure and community
• Project activities and news
• Project meetings
• Publications and talks
• Project science news
• Collaborations & projects
• Podcast
The current tool-set

AMDA - http://cdpp-amda.cesr.fr/

CLWeb - http://clweb.cesr.fr/

HWA - http://hwa.fmi.fi/

3DView - http://3dview.cesr.fr/

Paraboloid - http://smdc.sinp.msu.ru/

Find links to all participating tools on the tool page of the IMPEx website.
Expected Results - Summary

In the context of planetary science IMPEx will

• **Provide research infrastructure** that will enhance the efficiency of space mission data exploitation
• **Create an environment for testing/improvement** of existing models
• **Make data and models useful for the broad planetary science community**, i.e. outside of the mission teams or specialized computational modelling groups
• **Create a working prototype** of an infrastructure which bridges the gap between spacecraft data and the scientific modelling tools (joint operation of both)
• **Connect, with the help of global models, different observational data sets** and build a global view of the complex planetary phenomena

**Mid term goal:** Integrate *cloud computing, Big Data and HPC* interfaces and capabilities; Enhance scientific workflows with Web service coordination.

**Long term goal:** Provide a **generic data/model platform** for connection of various data archives and modelling tools.
Thank you...

Questions...?