

Users' guide for locating and importing INMS data from the PDS

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July 2011

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1 Introduction

1.1 Purpose

Data from the Cassini Ion and Neutral Mass Spectrometer (INMS) are archived in the Planetary Data System (PDS). This guide describes how to locate INMS data in the PDS and how to import those data for local processing and analysis. This guide is a companion guide for two other INMS users' guides, one for analyzing neutrals in Titan's atmosphere and one for analyzing ions in Titan's atmosphere. This guide is separate from the other users' guides so that changes in the PDS affect this document, only.

1.2 Overview of this document

Section 2 contains a step-by-step discussion of how to locate and download INMS data. The section includes Internet links and examples. The PDS also contains IDL routines for analyzing INMS data, and Section 2.4 describes how to port those routines for local use.

Section 3 contains references.

2 Locating and retrieving INMS data

2.1 Overview of the PDS archive

NASA stores all the data from all NASA planetary missions at the Planetary Data System (PDS) archive. The PDS has several nodes, each one focusing on a different science area. INMS data are stored at the Plasma Planetary Interactions (PPI) node. All PDS data are extensively documented, but sometimes the wealth of documentation and the format make it difficult for new researchers to find their desired data. This guide contains instructions for finding INMS data.

The top-level PDS site is <http://pds.nasa.gov/>. On this site, there are links to each node, to each planetary body, to documentation, and to tools. From the top-level site there is a link to the PPI node, or you can go directly to the PPI node with this link: <http://pds-ppi.igpp.ucla.edu/>. From the PPI node, the best way to get to the INMS data archive is to follow the path, below, each step available by clicking on the links, in order:

PPI home→Saturn (on the left menu)→Cassini→INMS

This retrieves the INMS page, which links to the latest data set, which is "COINMS_3XXX" and looks like the figure, below:



The right side of the window contains general PDS resources, and it is useful to become familiar with the documentation and resources available at PDS. However, those resources are not required for this tutorial.

Clicking on the INMS archive, COINMS_3XXX, brings up the top-level directory, which has a format common to all PDS archives. (See figure, below.) The top-level directory contains readme files and subdirectories, most notably the documentation and data directories. All data are stored in the DATA directory, which is where to find and download the desired data. The document directory contains the software interface specification (SIS, a document required by PDS), which describes the data files. The INMS SIS is titled VOLSIS and there are versions in several formats (PDF, ascii, etc) in the documents directory. For INMS, the "EXTRAS" directory, which is a non-standard directory, contains software developed by the INMS team for analyzing INMS data.



2.2 Locating INMS Titan data in the PDS archive

INMS count rates and auxiliary data

All the INMS data are stored in files that contain one hour of data and are organized by date. To locate data for a particular pass of Titan, we need the date and time of the encounter. An appendix (Section 6.2) contains the time of each Titan pass up through October 2010. The time of each Titan pass is also on the Cassini site, and the site <http://saturn.jpl.nasa.gov/mission/flybys/> contains data on the most-recent flybys.

To locate data for a pass, click on the DATA directory, then the year of the pass, and then the day of the year, and then the hour. For example, the data for the T5 pass (Titan pass on Cassini orbit 5), which had close approach at 19:11:46 on day 106 of 2005 (16 Apr 2005), the data are located in the subdirectory 106 of year 2005, which can be reached by the following path:

COINMS_3XXX

→DATA

→2005

→106

→200510619_L1A_05, which contains the following two files:

200510619_L1A_05.CSV

200510619_L1A_05.LBL

The INMS data are in the comma-separated-variable (CSV) file. This is the L1A file in INMS nomenclature and represents data that are processed to level 1A, which means that these are raw data that are not calibrated and have no other corrections. The PDS requires that every data file have a label, so there is a separate file with the extension LBL. Depending on the tools that you use for processing the INMS data, you may not need to download the label. For INMS, the most useful data in the label are sources of the auxiliary information used to generate some of the INMS supporting data—data that are in the L1A files—such as velocities, angles, and positions.

Calibration data

Converting count rates to densities requires an additional file, the calibration file, 2004001_CAL_0n.CSV where “n” is the version number. The calibration file is in the COINMS_3XXX/CALIB directory.

COINMS_3XXX

→CALIB

This file has a separate label file and a separate format file in the same directory. The calibration file is an ordered list of calibration factors for the INMS instrument. Each row contains the calibration factors or sensitivity for a particular species with the instrument in a particular configuration. Section 2.2.4 describes how to use the calibration data.

Plots of INMS data

The BROWSE subdirectory contains overview plots on each data set. There are two types of plots in the BROWSE directory

- A line plot, which shows the time history (counts vs. time) for four masses: 12, 18, 28, and 32. For each mass, the plot contains a line that represents the count rate for that mass.
- A stacked mass spectrum, which shows the time history (counts vs. time) for all measured masses by plotting the count rate as a color gradient.

The BROWSE directory is organized in the same way as the DATA directories. Using the same example as above, the T5 plots are located in

COINMS_3XXX

→BROWSE

→2005

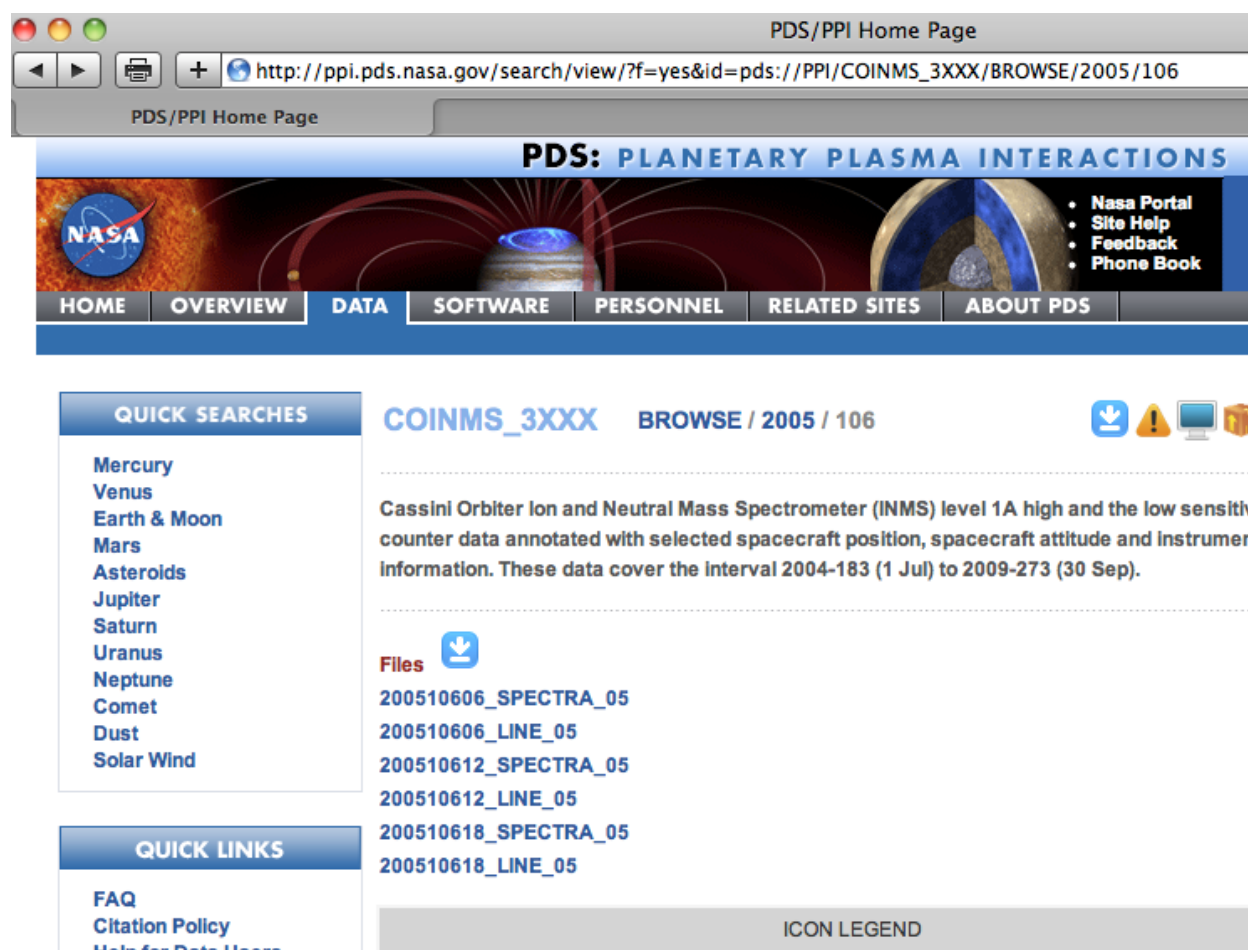
→106

In this directory (106), there are links to six plots, three line plots and three mass-spectra plots. The line and spectra plots are paired, each pair covering a six-hour period. The file-name convention is yyyydddhh_LINE_05, where yyyy is the year, ddd is the day of the year, hh is the starting hour for the plot, and 05 is the version number. For the mass-spectra plots, replace LINE with SPECTRA. For example, the names of the two plots that cover day 106 of 2005 from 06:00 to 12:00 are

200510606_SPECTRA_05

200510606_LINE_05

For this particular example directory (subdirectory 2005/106, shown in the figure, below), there are only three pairs of plots because the plots for the time period from 00:00 to 06:00 are not archived. The next section contains examples of the plots in the BROWSE directory.



Housekeeping data

Some analyses of INMS data, including analyses using the archived IDL routines, require housekeeping data. These are not stored with the INMS count-rate data; the housekeeping data are level-0 data and are stored in a separate volume, COINMS_0XXX found at

<http://www.igpp.ucla.edu/cgi-bin/ditdos?dataset=CO-S-INMS-2-PKT-U-V1.0>


Follow the links from COINMS_0XXX to the DATA subdirectory, which has the housekeeping files stored by year and day-of-year, same as the other INMS data. The naming convention is yyyyddd00_HKG_01.csv, and has a label file. There is also a format file (HKG_STRUCT_01.FMT) at the DATA/yyyy/ddd subdirectory. This file does not change, so you only need to download it once.

Most of the important information in the housekeeping files are included in the L1A files, so the housekeeping files may not be required for your analyses.

2.3 Downloading INMS data for local processing

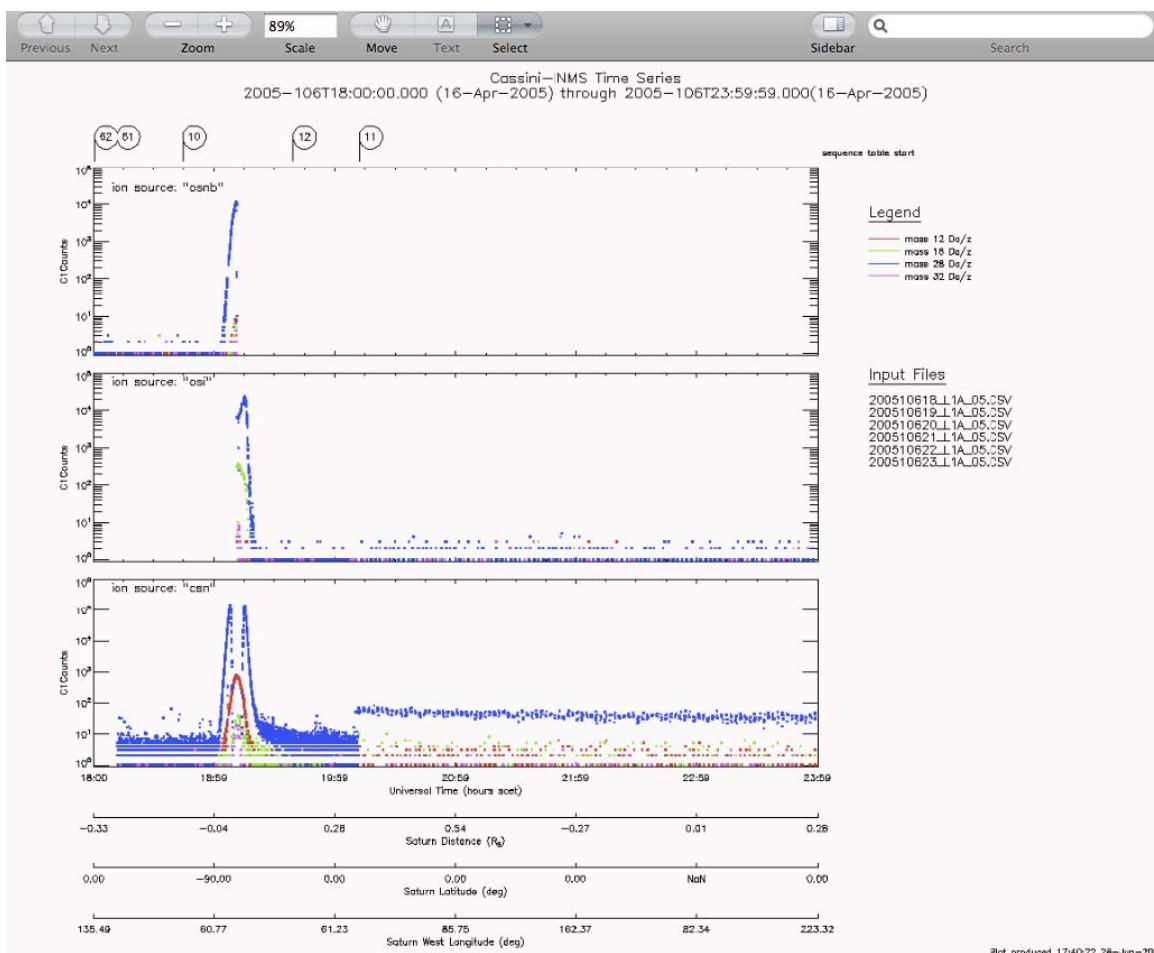
To download a data file, click on it and then download it to your computer. On PCs, the Microsoft operating system will usually ask if you want to open or save the file. Choose “Save” and then choose a location to store the file. On Macs, the files will be sent to the “Download” folder, where they can be opened or moved to a different location.

Usually, the duration of the Titan pass spans more than a single hour, and you probably want to download additional hours. You can download an entire day by using the download icon (see figure, below) at the top of the DOY directory, which was directory 106 in the previous example. Clicking on the download icon compresses the files and delivers them to your computer in a folder labeled COINMS_3XXX. That folder contains all the CSV files and their labels for the given day.

The download icon looks like this: 

To access the BROWSE plots individually, first click on the name of the desired plot; for example, 200510606_LINE_05. This accesses the plot files, which include a label file. The plots have the PNG extension. Click on the file. Depending on the browser settings and whether the computer is a PC or Mac, the file will open, download, or raise a window requesting which action. To retrieve all of the plots, click on the downlink symbol at the 2005-106 directory.

Examples of a BROWSE plot is shown in the next figure. The plot is for the T5 pass.



2.4 Downloading IDL routines developed for INMS

Download the entire INMS IDL library using the download button from this link:
http://ppi.pds.nasa.gov/search/view/?f=yes&id=pds://PPI/COINMS_3XXX/EXTRAS/SOFTWARE. Click on the download button.

This EXTRAS/SOFTWARE directory contains the following

- About 120 IDL analysis routines or programs
- AnalysisGuide.pdf, which describes how to use the IDL routines
- *inms_test.pro*, an IDL routine that runs many of the IDL analysis routines and plots the results.
- INMS_TEST_RESULTS.PDF shows the correct result of running *inms_test.pro*
- *inms_anaysis_help.html* supplies additional information
- Release notes, format files, and a calibration file.

After downloading the routines, make any necessary adjustments to your IDL settings, which may include modifying the IDL setup to recognize the location of the new IDL

routines and the data files. Although it is not necessary to run the *inms_test.pro* routine, it helps identify problems in IDL settings or directory locations. To run *inms_test.pro*, first download the L1A files for the TA Titan pass, which are the data that *inms_test.pro* uses. Run *inms_test.pro*, and then compare the results to the INMS_TEST_RESULTS.PDF file. When running *inms_test.pro*, select the INMS data for hour 15 (TA was on day 300 of 2004, so the L1A filename for hour 15 is 200430015_L1A_05), the housekeeping file downloaded with the IDL routines, and the calibration file (if requested) downloaded with the IDL routines.

The IDL AnalysisGuide is extensive, well organized, and full of examples. Researchers who have access to IDL will find that the IDL AnalysisGuide provides most of the information that they need to do detailed research using INMS data. The IDL AnalysisGuide has been used solely by INMS team members who are experienced with the INMS and the IDL routines. There may be undiscovered errors in the IDL AnalysisGuide, and new users should use the contact information in Section 5 if they have difficulty with a routine.

3 Contacts and additional information

Please send comments or questions on this document to

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For additional, detailed information, please see the documentation listed under the following topics:

- The INMS instrument and science objectives:
 - The INMS instrument paper,
Waite *et al.* 2004, The Cassini Ion and Neutral Mass Spectrometer (INMS) investigation, *Space Sci. Rev.* **114**, 113.
 - The INMS flight calibration paper
In preparation
 - Information and analysis on wall interactions
Teolis, *et al.* 2010, Detection and measurement of ice grains and gas distribution in the Enceladus plume by Cassini's Ion Neutral Mass Spectrometer, *J. of Geo. Res.* **115**, A09222.
 - Documentation at the INMS PDS site, particularly the INMS software interface specification (SIS) provided information on the INMS data and data sets
The SIS, labeled VOLSIS is archived in several formats (PDF, MSword, etc.) at http://ppi.pds.nasa.gov/search/view/?f=yes&id=pds://PPI/COINMS_3XXX/DOCUMENT/VOLSIS/VOLSIS
 - The instrument description document, CO_INMS_INST.CAT found at http://ppi.pds.nasa.gov/search/view/?f=yes&id=pds://PPI/COINMS_3XXX/CATALOG
- Titan neutral analyses:
 - Users' guide for analyzing INMS data on Titan's neutral atmosphere.
Magee *et al.* 2009, INMS-derived composition of Titan's upper atmosphere: analysis methods and model comparison. *Planetary and Space Science* **57**, 1895-1916.
 - Cui *et al.* 2009, Analysis of Titan's neutral upper atmosphere from Cassini Ion Neutral Mass Spectrometer measurements. *Icarus* **200** (2), 581-615.
 - Mandt *et al.* 2009. Isotopic evolution of the major constituents of Titan's atmosphere based on Cassini data. *Planetary and Space Science* **57** (14-15), 1917-1930
- INMS IDL routines
 - IDL users' guide, found on the PDS site as part of the IDL files in the Extras directory. The link directly to the file is http://ppi.pds.nasa.gov/ditdos/download?id=pds://PPI/COINMS_3XXX/EXTRAS/SOFTWARE/AnalysisGuide.pdf
- General error analysis
 - Bevington, "Data reduction and error analysis for the physical sciences," any edition.
- The Cassini-Huygens mission:
 - The Cassini site, at <http://saturn.jpl.nasa.gov/index.cfm>, contains information on the mission, the spacecraft bus, the instruments, the plan, the team members, Saturn, Saturn's moons and rings, and the latest research.

- The software interface specification (SIS), VOLSIS, for INMS data
http://ppi.pds.nasa.gov/search/view/?f=yes&id=pds://PPI/COINMS_3XXX/DOCUMENT