Spin Average

Data Products Document

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Issue/ Rev.	Issue Date	Sections	Reason for Change
1	30 Sep 2023	All	Initial release
1.1	22 Dec 2023	All	Editorial changes
1.2	08 Jan 2024	3	Description of monthly files added

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1 Introduction

This document describes two of the main data products in this project, namely

- Files with spin period averages of measured MMS data of spacecraft potential, electric field components, ASPOC current, and electron and ion moments from the DES and DIS sensors, respectively, including bulk flow velocity components. Some of these data together with auxiliary data were used to reconstruct electron densities.

and above all,

- Files with spin period averages of electron densities reconstructed from spacecraft potential and auxiliary data. The measured data actually used for the reconstruction are also part of these files.

The files are ASCII tables, readable manually or used as input to the visualisation and analysis programs corrVandFlux, corrVandFluxPredef, or corrVandFluxRec.

There are separate files for each of the four MMS spacecraft.

1.1 Instrument data

Inputs to the data files include data from the following instruments in Fast Survey and/or Slow Survey mode, or Survey Mode.

Acronym	Name	Parameter
ASPOC	Active Spacecraft Potential Control	Ion beam current
		on/off times
EDI	Electron Drift Instrument	Gun beam current
		on/off times
EDP	Electric Field Double Probes, consisting of:	
SDP	Spin Plane Double Probes	Spacecraft potential, Electric field
ADP	Axial Double Probes	Spacecraft potential, Electric field
FGM	Flux Gate Magnetometer	Magnetic field
FPI	Fast Plasma Instrument, consisting of:	
DES	Dual Electron Sensors	Electron moments, energy distributions
DIS	Dual Ion Sensors	Ion moments, energy distributions

2 Files with Measured MMS Data

2.1 Data content

The files contain spin period averages (about 20 seconds) of MMS science data which are necessary to derive electron densities from other measured quantitites, above all the spacecraft potential, but also spin period averages of other quantities such as individual components of the electric field and bulk flow velocities which may be useful for the interpretation of the derived densities.
The files in the distribution cover the time range 2015-09-01 to 2023-05-31.
There are separate files for each of the four MMS spacecraft.
For futher information see [1] and [2].

2.2 Production software

The IDL program mmsedpana, running in the Unix environment at IWF (leo1), has been used to produce the files. Due to the long processing time, the data in Fast Survey mode have been analysed in batches of 2 months, and for electron and ion data separately. The combination of electron and ion data has been performed by the program mmsedpoutput_merge_vel_ei_leo. The concatenation of the 2-month files has been performed by the program mmsedpoutput_concatenate_leo. Data in Slow Survey mode received a similar treatment, but in 4-month junks. All these steps have been performed at IWF (leo1). The results were copied to a Windows environment. Finally, the Fast Survey and Slow Survey data were merged by the program by the program mmsedpoutput_merge_vel_fastslow.

2.3 Nomenclature

The nomenclature of these files is mms*_out_eandivfands.dat.

2.4 Description of data columns

Column 1:
Quantity Time in UTC
Header Time[UT]
Units UTC
Comment This is the time at the start of the spin period interval.

Column 2:
Quantity Phase angle of the SDP probe pair 1 and 2
Header Phase12
Units degree
Comment This is the angle of the SDP probe pair 1 and 2 relative to the Sun direction.

Column 3:
Quantity Amplitude of a sine fit to the voltage difference between the SDP probes 1 and 2, converted to the electric field component.
Header E12ampl
Units mV/m
Comment This quantity is derived from the probe voltages given in the scpot files of EDP. It is present for completeness and will not be used in further processing.

Column 4:
Quantity Amplitude of a sine fit to the voltage difference between the SDP probes 3 and 4, converted to the electric field component.
Header E34ampl
Units mV/m
Comment This quantity is derived from the probe voltages given in the scpot files of EDP. It is present for completeness and will not be used in further processing.

Column 5:
Quantity Amplitude the total electric field derived from E12amp and E34amp.
Header Etotamp
Units mV/m
Comment This quantity is derived from the raw potentials of the electric field probes and is therefore just an approximation to the calibrated data provided by the SDP team.

Column 6:
Quantity X component of the electric field in the de-spun spacecraft L-vector (DSL) coordinate system, derived from the dce files of EDP which contain the calibrated electric field.
Header ExDSL
Units mV/m
Comment DSL may nominally be considered "near GSE".

Column 7:
Quantity Y component of the electric field in the de-spun spacecraft L-vector (DSL) coordinate system, derived from the dce files of EDP which contain the calibrated electric field.
Header EyDSL
Units mV/m
Comment DSL may nominally be considered "near GSE".

Column 8:
Quantity Spacecraft potential
Header Vsc
Units Volt
Comment Values are taken from the scpot files of EDP.

Column 9:
Quantity Electron density
Header El.Dens
Units cm^{-3}
Comment Values are taken from the moments data of FPI's DES sensor.

Column 10:
Quantity Electron temperature
Header El.Temp
Units eV
Comment Values are taken from the moments data of FPI's DES sensor.

Column 11:
Quantity Plasma electron current to the spacecraft
Header El.Curr
Units µA
Comment This value is derived from electron density and temperature, assuming a certain effective area of the spacecraft. This quantity is mainly for internal use.

Column 12:
Quantity Difference between ASPOC ion current and EDI electron current
Header ASP-EDI
Units µA
Comment The EDI current is taken form housekeeping data of the EDI instrument. In general it lies well below 1 µA. The nominal ASPOC current is 20 µA.

Column 13:
Quantity GSE X component of the bulk electron flow velocity
Header veGSEx
Units km/s
Comment This value is taken from the FPI DES data files.

Column 14:
Quantity GSE Y component of the bulk electron flow velocity
Header veGSEy
Units km/s
Comment This value is taken from the FPI DES data files.

Column 15:
Quantity GSE Z component of the bulk electron flow velocity
Header veGSEz
Units km/s
Comment This value is taken from the FPI DES data files.

Column 16:
Quantity Ion density
Header IonDens
Units cm^{-3}
Comment Values are taken from the moments data of FPI's DIS sensor.

Column 17:
Quantity Ion temperature
Header IonTemp
Units eV
Comment Values are taken from the moments data of FPI's DIS sensor.

Column 18:
Quantity Plasma ion current to the spacecraft
Header IonCurr
Units µA
Comment This value is derived from ion density and temperature, assuming a certain effective area of the spacecraft. This quantity is mainly for internal use.

Column 19:
Quantity GSE X component of the bulk ion flow velocity
Header viGSEx
Units km/s
Comment This value is taken from the FPI DIS data files.

Column 20:
Quantity GSE Y component of the bulk ion flow velocity
Header viGSEy
Units km/s
Comment This value is taken from the FPI DIS data files.

Column 21:
Quantity GSE Z component of the bulk ion flow velocity
Header viGSEz
Units km/s
Comment This value is taken from the FPI DIS data files.

3 Files with Reconstructed Electron Densities

3.1 Complete and monthly files

The remainder of this section describes the files covering the complete time interval of the project. They mainly serve as input to the analysis and display software CorrVandFlux, but in principle these ASCII files they are also readable by a text editor. As these files are rather large (1 to 2 GB) they are inconvenient to be read in an editor. Therefore monthly files have been generated in addition and can be found in the directory rec_monthly. Their structure is identical to the complete files, except that the header section is missing. The headers are provided separately under the file name mms*_parameters.txt in the respective directory.

3.2 Data content

The files contain spin period averages (about 20 seconds) of MMS science data with reconstructed electron densities, but include all measured field and plasma data which actually entered into the calculation of the densities.
The files in the distribution cover the time range 2015-09-01 to 2023-05-31.
There are separate files for each of the four MMS spacecraft.
For futher information see [1] and [2].

3.3 Production software

One of the programs corrVandFlux or corrVandFluxPredef, running in a Windows environment, has been used to generate these files. The program corrVandFlux generates this type of files using fitting procedures being valid for one of six possible cases, which contain data under the respective conditions only:

No.	ASPOC Status	Region
0	OFF	Magnetosheath
1	OFF	Magnetosphere
2	OFF	Solar Wind
3	ON	Magnetosheath
4	ON	Magnetosphere
5	ON	Solar Wind

The program corrVandFluxPredef generates this type of files using fitting parameters previously calculated by corrVandFlux and combines all six cases into a single data file for all conditions together. These are the files present in the distribution.

3.4 Nomenclature

The nomenclature of these files is mms*_rec_final.dat.

3.5 Header

There is a lengthy header on top of the data columns specifying all relevant parameters which have been used to calculate the reconstructed electron densities for each of the six cases.
The typical contents of the header for one of the cases is reproduced below.

```
Source: mms1_out_edppeandiv.
Data include velocities
Analysing electrons
Limits (from/to):
2015-11-01T00:00:00/2016-11-01T00:00:00
E-field: 0.00/10.00
S/C potential: 2.0/50.0
```

El. Density: 0.080/1000.000
El. Temp.: 5.0/10000.0
El. Current: 0.100/1000.000
ASPOC current: -1.00/1.00
LyA: 0.0000/0.0098
Orbit radius: 10.00/30.00
Orbit phase (Sun=0): 0/360
|ne-ni|<999.0 OR ne/ni<2.00
In Magnetosphere
Transition width: 2.5
T-exponent: -0.25
applies for T< 50.0
and exp: 0.00
for higher T up to: 0.0
E-field correction term for Vsc: 0.00
v(ion) correction term for Vsc: 0.00
Fudge factor for maxcurrent: 1.00
Fudge factor for Iplasma: 1.00
Use set low-E-Maxw for Maxw-fit: No
coefs:j0: 31.90
V0: 1.610
Fit I vs V: Power i~V^x
or n vs V: No
#Terms: 1
Limits: Yes
Method: Simple
Error exp: 0
in: Y
Break V: Variable
Vbreak1e: 6.0
Vbreak2e: 14.0
T for n-fit: Variable
at 2V: 20.0
at 7V: 40.0
at 10.5V: 70.0
at 20V: 300.0
fixed: 150.0
jph=30.762*V^(-1.708)
T=10.000 :
n=213.832*V^(-1.708)
T=100.000 :
n=67.620*V^(-1.708)
T=1000.000 :
n=21.383*V^(-1.708)
END OF PARAMETERS

3.6 Description of data columns

Column 1:
Quantity Time in UTC
Header Time[UT]
Units UTC
Comment This is the time at the start of the spin period interval.

Column 2:
Quantity Measured spacecraft potential
Header Vsc
Units Volt
Comment Values are taken from the scpot files of EDP.

Column 3:
Quantity Amplitude the total electric field
Header Etotamp
Units mV/m
Comment

Column 4:
Quantity Measured electron density
Header El.Dens
Units cm^{-3}
Comment Values are taken from the moments data of FPI's DES sensor.

Column 5:
Quantity Measured electron temperature
Header El.Temp
Units eV
Comment Values are taken from the moments data of FPI's DES sensor.

Column 6:
Quantity Plasma electron current to the spacecraft
Header El.Curr
Units µA
Comment This value is derived from measured electron density and temperature, assuming a certain effective area of the spacecraft. This quantity is mainly for internal use.

Column 7:
Quantity Difference between ASPOC ion current and EDI electron current
Header ASP-EDI
Units µA
Comment The EDI current is taken form housekeeping data of the EDI instrument. In general it lies well below 1 µA. The nominal ASPOC current is 20 µA.

Column 8:
Quantity Sum of ASPOC ion current and internally used plasma electron current
Header Ie+afit
Units µA
Comment This quantity is mainly for internal use.

Column 9:
Quantity Derived electron density, using the electron temperature measured by the FPI DES sensor
Header neTmeas
Units cm^{-3}
Comment Values are present only when FPI is ON

Column 10:
Quantity Derived electron density, assuming an electron temperature of 10 eV.
Header neT0010
Units cm^{-3}
Comment Values are applicable mainly in Solar wind and magnetosheath.

Column 11:
Quantity Derived electron density, assuming an electron temperature of 100 eV.
Header neT0100
Units cm^{-3}
Comment Values are applicable mainly in the magnetosheath and magnetosphere.

Column 12:
Quantity Derived electron density, assuming an electron temperature of 1000 eV.
Header neT1000
Units cm^{-3}
Comment Values are applicable mainly in som regions of the magnetosphere.

Column 13:
Quantity Total bulk ion flow velocity
Header Vion
Units km/s
Comment This value is taken from the FPI DIS data files.

Column 14:
Quantity Ion Mach number
Header MachIon
Units
Comment This value is derived from ion bulk velocity and ion temperature.

Column 15:
Quantity Spacecraft potential, modified by various correction terms for electric field, solar activity, bulk velocity, or Mach number.
Header modVsc
Units Volt
Comment

Column 16:
Quantity Flag indicating the region
Header IDs
Units R
Comment 0=any, 1=magnetosphere, 2=solar wind, 3=magnetosheath

Column 17:
Quantity Flag for the number of the parameter set used
Header IDs
Units P
Comment 0 = ASPOC off, magnetosheath, 1 = ASPOC off, magnetosphere, 2 = ASPOC off, Solar wind, 3 = ASPOC on, magnetosheath, 4 = ASPOC on, magnetosphere, 5 = ASPOC on, Solar wind

Column 18:
Quantity Flag indicating whether some interpolation of the results around boundaries has been performed
Header IDs
Units I
Comment 0=no, 1=yes

Column 19:
Quantity Flag set when values in the interpolation region have been replaced by values derived from measured electron densities
Header IDs
Units F
Comment 0=no, 1=yes

4 References

[1] MMSEDPana User Manual, IWF-KT-0001.

[2] corrVandFlux User Manual, IWF-KT-0002.

[3] corrVandFluxRec User Manual, IWF-KT-0003.

[4] corrVandFluxPredef User Manual, IWF-KT-0004.