SOLAR ORBITER **RPW** **ROC**

RPW Science Data User Manual

Prepared by:	Function:	Signature:	Date
RPW Team			16/09/2020

Change Record				
Issue	Rev.	Date	Authors	Modifications
1	0	16/09/2020	RPW Team	First issue

CLASSIFICATION   **PUBLIC**   ☒   **RESTRICTED**   ☐

1 GENERAL

1.1 Scope of the Document

This document is the user manual for the RPW science data. It provides synthetized information about the RPW science data (list of products, short description, point of contact).

A more exhaustive description of the RPW data file content is presented in the "RPW Data Product Description Document" (DPDD) [RD1].

The detailed instrument description can be found in Maksimovic M. et al., The Solar Orbiter Radio and Plasma Waves (RPW) instrument, in press Astronomy & Astrophysics, doi 10.1051/0004-6361/201936214, 2020 [RD2].

1.2 Applicable Documents

This document responds to the requirements of the documents listed in the following table:

Mark	Reference/Iss/Rev	Title of the document	Authors	Date
AD1	SOL-SGS-TN-0009/2/4	Meta data definition for Solar Orbiter science data	SOC	02/09/2019
AD2				

AD3				

1.3 Reference Documents

This document is based on the documents listed in the following table:

Mark	Reference/Iss/Rev	Title of the document	Authors	Date
RD1	ROC-PRO-DAT-NTT-00075-LES1/2	RPW Data Product Description Document (DPDD)	X.Bonnin	16/09/2020
RD2	Astronomy & Astrophysics, doi 10.1051/0004-6361/201936214	The Solar Orbiter Radio and Plasma Waves (RPW) instrument	Maksimovic et al.	2020
RD3				

2 RPW L2 DATA PRODUCTS

This is the list of RPW Level 2 data products. The dataset descriptions are succinct. For more information please contact the corresponding responsible scientist (first name in the contact point box) and/or engineers, with copy to *milan.maksimovic@obspm.fr*

LFR – Low Frequency Receiver				
Dataset ID	**Dataset description**	**Data File period icity**	**Data qualit y flag (as of 30/09/ 2020)**	**Contact Point**
SOLO_L2 _RPW- LFR- SURV- CWF-B	Continuous magnetic waveform data in survey mode: array *3 x nbt* with *nbt measurements* of Bx, By, and Bz waveform in the SCM and RTN frames and in nT, acquired at f3=16Hz and/or 256Hz.	1 file per day		matthieu.kretzschmar@ cnrs-orleans.fr Jean- Yves.Brochot@cnrs- orleans.fr
SOLO_L2 _RPW- LFR- SURV- CWF-E	Continuous electric waveform data in survey mode.	1 file per day		yuri@irfu.se erik.johansson@irfu.se
SOLO_L2 _RPW- LFR- SURV- SWF-B	Snapshot magnetic waveform data in survey mode:): array *3 x nbt* x *m* with *m* timeseries of *nbt=2048* measurements of Bx, By, and Bz waveforms in the SCM and RTN frames and in nT, acquired successively at f2=256Hz, f1=4096Hz and f0=24576Hz.	1 file per day		matthieu.kretzschmar@ cnrs-orleans.fr Jean- Yves.Brochot@cnrs- orleans.fr
SOLO_L2 _RPW- LFR- SURV- SWF-E	Snapshot electric waveform data in survey mode.	1 file per day		yuri@irfu.se erik.johansson@irfu.se
SOLO_L2 _RPW- LFR-	Continuous magnetic waveform data in SBM1 mode (shock crossing): array *3 x nbt* with *nbt*	1 file per SBM1 event		matthieu.kretzschmar@ cnrs-orleans.fr

SBM1-CWF-B	measurements of Bx, By, and Bz waveform in the SCM and RTN frames and in nT, acquired at f1=4096Hz.			Jean-Yves.Brochot@cnrs-orleans.fr
SOLO_L2_RPW-LFR-SBM1-CWF-E	Continuous electric waveform data in SBM1 mode (shock crossing).	1 file per SBM1 event		yuri@irfu.se erik.johansson@irfu.se
SOLO_L2_RPW-LFR-SBM2-CWF-B	Continuous magnetic waveform data in SBM2 mode (in-situ Type III): array *3 x nbt* with *nbt* measurements of Bx, By, and Bz waveform in the SCM and RTN frames and in nT, acquired at f2=256Hz.	1 file per SBM2 event		matthieu.kretzschmar@cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr
SOLO_L2_RPW-LFR-SBM2-CWF-E	Continuous electric waveform data in SBM2 mode (in-situ Type III).	1 file per SBM2 event		yuri@irfu.se erik.johansson@irfu.se
SOLO_L2_RPW-LFR-SURV-ASM	Averaged Spectral Matrix (ASM) data in survey mode : real and imaginary parts of array(nspec, nfreq, 5, 5), where the 5 components auto- and cross-correlated are B1, B2, B3, E1 and E2 (still in the original instrument frame). Computed with data sampled at F2=256Hz, F1=4096Hz and F0=24576Hz. Nominally every 3600s. Frequency resolution 1Hz, 16Hz and 96Hz, respectively. Time resolution 4s. Units nT^2/Hz, V^2/Hz or nT V/Hz.	1 file per day	Set to 2	thomas.chust@lpp.polytechnique.fr rodrigue.piberne@lpp.polytechnique.fr bruno.katra@lpp.polytechnique.fr
SOLO_L2_RPW-LFR-	Basic Parameters set 1 (BP1) data in survey mode: 6 array(nspec, nfreq) for the power	1 file per day	Set to 2 (but 0 for VPHI,	thomas.chust@lpp.polytechnique.fr rodrigue.piberne@lpp.polytechnique.fr

| SURV-BP1 | spectrum of the magnetic field (PB, nT^2/Hz), for the power spectrum of the electric field (PE, V^2/Hz), for the degree of polarization of the waves (DOP, unitless), for the wave ellipticity (ELLIP, unitless), for the radial component of the Poynting flux (SX, V nT/Hn, QF=1), for the phase velocity (VPHI, QF=0 with the current version of FSW) + 1 array(nspec, nfreq, 3) for the wave normal vector (NVEC, unitless). Normal mode data: computed with data sampled at F2=256Hz, F1=4096Hz and F0=24576Hz; nominally every 4s; frequency resolution 8Hz, 128Hz and 768Hz, respectively; time resolution 4s. Burst mode data (if any): computed with data sampled at F1=4096Hz and F0=24576Hz; nominally every 1s; frequency resolution 64Hz and 384Hz, respectively; time resolution 1s. | | and 1 for SX) | bruno.katra@lpp.polytechnique.fr |
| SOLO_L2_RPW-LFR-SURV-BP2 | Basic Parameters set 2 (BP2) data in survey mode: as for SOLO_L2_RPW-LFR-SURV-ASM real and imaginary parts of array(nspec, nfreq, 5, 5), where the 5 components auto- and cross-correlated are B1, B2, B3, E1 and E2 (still in the original instrument frame). Normal mode data: computed with data sampled at F2=256Hz, F1=4096Hz and F0=24576Hz; nominally every 20s; frequency resolution 8Hz, | 1 file per day | Set to 2 | thomas.chust@lpp.polytechnique.fr rodrigue.piberne@lpp.polytechnique.fr bruno.katra@lpp.polytechnique.fr |

	128Hz and 768Hz, respectively; time resolution 4s. Burst mode data (if any): computed with data sampled at F1=4096Hz and F0=24576Hz; nominally every 5s; frequency resolution 64Hz and 384Hz, respectively; time resolution 1s. Units nT^2/Hz, V^2/Hz or nT V/Hz.			
SOLO_L2 _RPW-LFR-SBM1-BP1	Basic Parameters set 1 (BP1) data in SBM1 mode (shock crossing): same products as in survey mode but computed with data sampled at F0=24576Hz; every 0.25s; frequency resolution 384Hz; time resolution 0.25s.	1 file per SBM1 event	Set to 2 (but 0 for VPHI, and 1 for SX)	thomas.chust@lpp.poly technique.fr rodrigue.piberne@lpp.p olytechnique.fr bruno.katra@lpp.polyte chnique.fr
SOLO_L2 _RPW-LFR-SBM1-BP2	Basic Parameters set 2 (BP2) data in SBM1 mode (shock crossing): same products as in survey mode but computed with data sampled at F0=24576Hz; every 1s; frequency resolution 384Hz; time resolution 0.25s.	1 file per SBM1 event	Set to 2	thomas.chust@lpp.poly technique.fr rodrigue.piberne@lpp.p olytechnique.fr bruno.katra@lpp.polyte chnique.fr
SOLO_L2 _RPW-LFR-SBM2-BP1	Basic Parameters set 1 (BP1) data in SBM2 mode (in-situ Type III): same products as in survey mode but computed with data sampled at F1=4096Hz and F0=24576Hz; every 1s; frequency resolution 64Hz and 384Hz, respectively; time resolution 1s.	1 file per SBM2 event	Set to 2 (but 0 for VPHI, and 1 for SX)	thomas.chust@lpp.poly technique.fr rodrigue.piberne@lpp.p olytechnique.fr bruno.katra@lpp.polyte chnique.fr
SOLO_L2 _RPW-LFR-SBM2-BP2	Basic Parameters set 2 (BP2) data in SBM2 mode (in-situ Type III): same products as in survey mode but computed with	1 file per SBM2 event	Set to 2	thomas.chust@lpp.poly technique.fr rodrigue.piberne@lpp.p olytechnique.fr

	data sampled at F1=4096Hz and F0=24576Hz; every 5s; frequency resolution 64Hz and 384Hz, respectively; time resolution 1s.			bruno.katra@lpp.polytechnique.fr

TDS – Time Domain Sampler				
Dataset ID	**Dataset description**	**Data File periodicity**	**quality flag (as of 30/09/2020)**	**Contact Point**
SOLO_L2_RPW-TDS-LFM-CWF-B	Continuous magnetic waveform data in TDS Low Frequency Mode (LFM) mode. This TDS mode is activated as a backup of LFR and is not being used at present. Array *3 x nbt* with *nbt* measurements of Bx, By, and Bz waveforms in the SCM and RTN frames and in nT, acquired at 1 to 128 Hz sampling rate.	1 file per day	0 (no data)	matthieu.kretzschmar@cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr
SOLO_L2_RPW-TDS-LFM-CWF-E	Continuous electric waveform data in TDS Low Frequency Mode (LFM) mode sampled up to 128 Hz. This TDS mode is activated as a backup of LFR and is not being used at present.	1 file per day	0 (no data)	yuri@irfu.se erik.johansson@irfu.se
SOLO_L2_RPW-TDS-LFM-PSDSM	Power Spectral Density (PSD) and Spectral Matrix (SM) data in TDS LFM mode. LFM mode is not being used at present.	1 file per day	0 (no data)	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2_RPW-TDS-LFM-RSWF-B	Regular Snapshot Waveform (RSWF) magnetic data in TDS LFM mode: array *3 x nbt x m* with *nbt measurements* of Bx, By, and Bz waveforms in the SCM and RTN frames and in nT, acquired	1 file per day	0 (no data)	matthieu.kretzschmar@cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr

	at 32768 Hz. LFM mode is not being used at present			
SOLO_L2 _RPW- TDS-LFM- RSWF-E	Regular Snapshot Waveform (RSWF) electric data in TDS LFM mode acquired at 32768 Hz. LFM mode is not being used at present	1 file per day	0 (no data)	yuri@irfu.se erik.johansson@irfu.se
SOLO_L2 _RPW- TDS- SURV- RSWF-B	Regular Snapshot Waveform (RSWF) magnetic data in survey mode: array *nbt* x *m* with *m* timeseries of *nbt* measurements of Bx in SCM frame and in nT, acquired at a high frequency (262 or 524 ksps). Regular snapshots are acquired periodically with a commanded cadence (typically once every 5 or 10 minutes).	1 file per day	Set to 2	matthieu.kretzschmar@ cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr
SOLO_L2 _RPW- TDS- SURV- RSWF-E	Regular Snapshot Waveform (RSWF) electric data in survey mode: array of M waveform snapshots of 3 E-field components and N samples acquired at high frequency (262 or 524 ksps). Regular snapshots are acquired periodically with a commanded cadence (typically once every 5 or 10 minutes).	1 file per day	Set to 2	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW- TDS- SURV- TSWF-B	Triggered Snapshot Waveform (TSWF) magnetic data in survey mode: array *nbt* x *m* with *m* timeseries of *nbt* measurements of Bx in SCM frame and in nT acquired at high frequency. Triggered snapshots are acquired by the instrument once every second, but only the selected "best" snapshots are sent to ground.	1 file per day	Set to 2	matthieu.kretzschmar@ cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr

SOLO_L2 _RPW-TDS-SURV-TSWF-E	Triggered Snapshot Waveform (TSWF) electric data in survey mode. Triggered snapshots are acquired once every second, but only the selected "best" snapshots are sent to ground.	1 file per day	Set to 2	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW-TDS-SBM1-RSWF-B	Regular Snapshot Waveform (RSWF) magnetic data in SBM1 mode (shock crossing): array *1* x *nbt* x *m* with *m* timeseries of *nbt* measurements of Bx in SCM frame and in nT, acquired at a high frequency (262 or 524 ksps). SBM1 snapshots are taken at a high cadence in SBM1 mode (~1 second). Note: there is not SBM data in cruise phase.	1 file per SBM1 event	0 (no data)	matthieu.kretzschmar@cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr
SOLO_L2 _RPW-TDS-SBM1-RSWF-E	Regular Snapshot Waveform (RSWF) electric data in SBM1 mode (shock crossing). Array of M waveform snapshots of 3 E-field components and N samples acquired at high frequency (262 or 524 ksps). SBM1 snapshots are taken at a high cadence in SBM1 mode (~1 second). Note: there is not SBM data in cruise phase.	1 file per SBM1 event	0 (no data)	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW-TDS-SBM2-TSWF-B	Triggered Snapshot Waveform (TSWF) magnetic data in SBM2 mode (in-situ Type III): array 1 x *nbt* x *m* with *m* timeseries of *nbt* measurements of Bx in SCM frame and in nT,acquired at a high frequency (262 or 524 ksps). Note: there is no SBM data in cruise phase.	1 file per SBM2 event	0 (no data)	matthieu.kretzschmar@cnrs-orleans.fr Jean-Yves.Brochot@cnrs-orleans.fr

SOLO_L2 _RPW-TDS-SBM2-TSWF-E	Triggered Snapshot Waveform (TSWF) electric data in SBM2 mode (in-situ Type III). Same as SOLO_L2_RPW-TDS-SURV-TSWF-E, but more snapshots are taken in SBM2 mode. Note: there is no SBM data in cruise phase.	1 file per SBM2 event	0 (no data)	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW-TDS-SURV-HIST1D	Histogram set 1 (HIST1D) data in survey mode. Histograms built from the on-board statistics of processed waveforms or MAMP data. Up to 4 independent histograms with linear or logarithmic axis can be collected. Typically, one set of histograms is sent every 10 minutes.	1 file per day	Set to 1	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW-TDS-SURV-HIST2D	Histogram set 2 (HIST2D) data in survey mode. Joint two-dimensional histograms built from the on-board statistics of processed waveform. Up to 2 independent histograms with linear or logarithmic axis can be collected. Typically, one set of histograms is sent every 30 minutes.	1 file per day	0 or 1 (TBD)	soucek@ufa.cas.cz dp@ufa.cas.cz
SOLO_L2 _RPW-TDS-SURV-MAMP	Maximum amplitude (MAMP) data in survey mode. This is a continuous waveform of a maximum absolute value (envelope) of the bandpass filtered TDS waveform (bandwidth between ~100Hz and 350 kHz) from 1-4 E/B channels. The rate of the maximum measurement is up to 256 sps. Typically only used in BURST mode.	1 file per day	Set to 1	soucek@ufa.cas.cz dp@ufa.cas.cz

Dataset ID	Dataset description	Data File periodicity	Data quality flag (as of 30/09/2020)	Contact Point
SOLO_L2_RPW-TDS-SURV-STAT	Statistical (STAT) data in survey mode. A short structure with statistical information about processed waveform snapshot (maximum amplitudes, median wave frequency, number of waves/dust). One structure is sent every 16 seconds.	1 file per day	Set to 1	soucek@ufa.cas.cz dp@ufa.cas.cz

TNR/HFR – Thermal Noise Receiver / High Frequency Receiver

Dataset ID	Dataset description	Data File periodicity	Data quality flag (as of 30/09/2020)	Contact Point
SOLO_L2_RPW-TNR-SURV	Thermal Noise Receiver (TNR): • `data.`*`auto1/2:`* electric/magnetic power spectral density. They are expressed in *V^2/Hz* at receiver+PA for channels 1/2 before applying the antenna gain. • `data.magnetic_spectral_power1/2:` Magnetic power spectral density in nT/sqrt/(Hz) from the MF SCM sensor • `data.`*`cross_r`* & `data.`*`cross_i:`* normalized cross-products • `data.phase` : phase difference between channel 1 and 2 in degrees • `data.flux_density 1/2` : fluxes of power spectral densities expressed in *$W/m^2/Hz$* for channels 1/2 after applying the antenna gain. Note that, for data with quality factor 1 or 2, the antenna gain is set to the theoretical value expected from	1 file per day	Set automatically to 1	Antonio.vecchio@obspm.fr Milan.Maksimovic@obspm.fr Quynh-Nhu.Nguyen@obspm.fr

	numerical simulations (*Maksimovic et al. 2020*). Each of the above data products is provided in an Array [32, nb data points] where the 32 corresponds to the 32 frequencies in each of the TNR A,B,C,D bands, all covering the frequency range between 4 and 1024 kHz. (see table 6 in *Maksimovic et al. 2020*). The band of measurement is provided in the variable `data.tnr_band.data`. The variable `data.SENSOR_CONFIG.data` indicates the THR sensor configuration. All TNR data are acquired in SURVEY mode.			
SOLO_L2 _RPW- HFR- SURV	High Frequency Receiver (HFR): • `data.agc1/2:` electric power spectral density. They are expressed in V^2/Hz at receiver+PA for channels 1/2 before applying the antenna gain. • `data.flux_density 1/2` : fluxes of power spectral densities expressed in $W/m^2/Hz$ for channels 1/2 after applying the antenna gain. Note that, for data with quality factor 1 or 2, the antenna gain is set to the theoretical value expected from numerical simulations (*Maksimovic et al. 2020*). Each of the above data products is given for the HFR frequency range between 0.4 and 16.4 MHz. The frequencies of measurement are provided	1 file per day	Set automatic ally to 1	Antonio.vecchio@obspm.fr Milan.Maksimovic@obspm.fr Quynh-Nhu.Nguyen@obspm.fr

	in the variable `data.`*`frequency`*`.data`. The variable `data.`*`SENSOR_CONFIG.data`* indicates the THR sensor configuration. All HFR data are acquired in SURVEY mode.			

3 LIST OF ACRONYMS

Acronym	Definition
ANC	Ancillary data
CDF	Common Data Format
CDPP	Centre de Données de Physique des Plasma
CWF	Continuous Waveform
ESA	European Space Agency
ESAC	European Space Astronomy Centre
HFR	High Frequency Receiver
ID	Identifier
L2	Level 2 data processing
LFR	Low Frequency Receiver
RPW	Radio and Plasma Waves
RTN	Radial Tangential Normal reference frame
RSWF	Regular Snapshot Waveform
TDS	Time Domain Sampler
TNR	Thermal Noise Receiver
TSWF	Triggered Snapshot Waveform
SBM	Selected Burst Mode
SCM	Search Coil Magnetometer
SOLO	Solar Orbiter