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Participation of women scientists in ESA solar system missions: a historical trend

Arianna Piccialli[1], Julie A. Rathbun[2], Anny-Chantal Levasseur-Regourd[3], Anni Määttänen[3], Anna Milillo[5], Miriam Rengel[4], Alessandra Rotundi[5], Matt Taylor[6], Olivier Witasse[6], Francesca Altieri[5], Pierre Drossart[7], and Ann Carine Vandaele[1]

[1]Planetary Aeronomy, Royal Belgian Institute for Space Aeronomy, 3 av. Circulaire, 1180 Brussels, Belgium
[2]Planetary Science Institute, Tucson, USA
[3]LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS, Paris, France
[4]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany
[5]INAF, Istituto di Astrofisica e Planetologia Spaziali, Via del Fosso del Cavaliere 100, 00133 Rome, Italy
[6]ESA, ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, the Netherlands
[7]LESIA, Observatoire de Paris, CNRS, Sorbonne Université, Univ. Denis Diderot, 92195 Meudon, France

Correspondence: Arianna Piccialli (arianna.piccialli@aeronomie.be)

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Abstract. We analyzed the participation of women scientists in 10 ESA (European Space Agency) Solar System missions over a period of 38 years. Being part of a spacecraft mission science team can be considered a proxy to measure the "success" in the field. Participation of women in PI (Principal Investigators) teams varied between 4 % and 25 %, with several missions with no women as PI. The percentage of female scientists as Co-I (Co-Investigators) is always less than 16 %. This number is lower than the percentage of women in the International Astronomical Union from all ESA's Member State (24 %), which can give us an indication of the percentage of women in the field.

We encountered many difficulties to gather the data for this study. The list of team members were not always easily accessible. An additional difficulty was to determine the percentage of female scientists in planetary science in Europe. We would like to encourage the planetary community as a whole, as well as international organizations, universities and societies to continuously gather statistics over many years. Detailed statistics are only the first step to closely monitor the development of achievement gaps and initiate measures to tackle potential causes of inequity, leading to gender inequalities in STEM careers.

1 Introduction

Numerous analyses have revealed that women are underrepresented in science, technology, engineering and mathematics (STEM) careers. Many factors have been cited as potential contributors to this. For example, Dutt et al. (2016) suggested that women are significantly less likely to receive excellent recommendation letters than male applicants in the geosciences. Lerback and Hanson (2017) presented evidence that women of all ages have fewer opportunities to take part in peer reviews for journals on geosciences. Moreover, men are more likely invited to give a colloquium than women at prestigious universities and at symposia (Nittrouer et al., 2018; Schroeder et al., 2013).

In astronomy, similar studies indicate the existence of gender biases and barriers to inclusion (Tuttle, 2017). Female astronomers are leaving the academic labor market at a rate that is 3–4 times higher than male astronomers (Flaherty, 2018). Caplar et al. (2017) applied machine-learning techniques accounting for non-gender specific attributes to a sample of more than 200,000 publications over a 65-year period. In their study, they found that astronomy papers led by women receive 10 % fewer citations than those led by men. Several analysis carried out for a variety of organizations (i.e. the Hubble Space Telescope, the European Southern Observatory, and the National Radio Astronomy Observatory) proposal selection processes revealed that proposals submitted by female PIs show a significantly lower probability of being allocated telescope time (Reid, 2014; Lonsdale et al., 2016; Patat, 2016; Spekkens et al., 2018). A review of seven of the prizes and awards given out by the American Astronomical Society (AAS) for ten or more years for contributions to astronomical research, instrumentation or education shows that the percentage of female recipients remains below 10 %, lower than the fraction of female AAS members (Knezek, 2017). Women ask systematically less questions at astronomical meetings (Davenport et al., 2014; Pritchard et al., 2014; Schmidt and Davenport, 2017).

A recent study by Rathbun (2017) analyzed the participation of female scientists in US planetary science missions as a measure of success in the field. Their analysis shows women scientists to be consistently under-represented on the science teams of NASA's robotic planetary spacecraft missions.

Inspired by these findings, we carried out a study of the participation of women scientists in ESA Solar System missions and discuss how this trend changed over time. Along with a team of volunteers, we counted the science team members of 10 ESA Solar System missions over a period of 38 years and determined the percentage of women on each team.

We describe the method followed for our analysis in Sect. 2. Results are reviewed in Sect. 3. We examined the percentage of women in planetary science in Europe in Sect. 4 and we present the conclusions in Sect. 6.

2 Method

We limited our study to ESA Solar System missions as listed on the ESA Science & Technology web-page (see Table 1 and https://sci.esa.int/web/home/-/51459-missions, last access: 27 July 2020).

A typical ESA Solar System mission team consists of a Principal Investigator (PI) for every instrument included in the payload; in few cases, there are also Co-Principal Investigators (Co-PIs), counted here as PIs. PIs are in charge of proposing the space experiment, with full responsibility for getting funds, building, testing, and analyzing its scientific data. Each instrument team includes moreover several Co-Investigators (Co-Is). A scientist can be Co-Is on more than one instrument within one ESA's mission, in such a case, she/he was counted only once. Team members affiliated to an institution not part of the 22 ESA's Member States were not counted. It should be recalled that in 1980 – at the time of the first Solar System mission's selection – there were only 11 ESA's Member States.

For this study, we counted separately the PIs (including the Co-PIs) and the Co-Is for each ESA mission.

We followed the same methodology described in Rathbun et al. (2015), for consistency with their study. Their goal was to consider only original team scientists (not engineers or members of project management nor students or postdocs) in order to compare it to the composition of the field at that time. Being part of an original spacecraft team can be considered as a measure of success. Moreover, for both NASA and ESA missions, keeping track of changes in science team membership was just too difficult, as often changes are not generally released publicly. We, therefore, aimed to consider only the original team scientists. However, this was not always possible, as often new members are added over time, and the original team composition was lost.

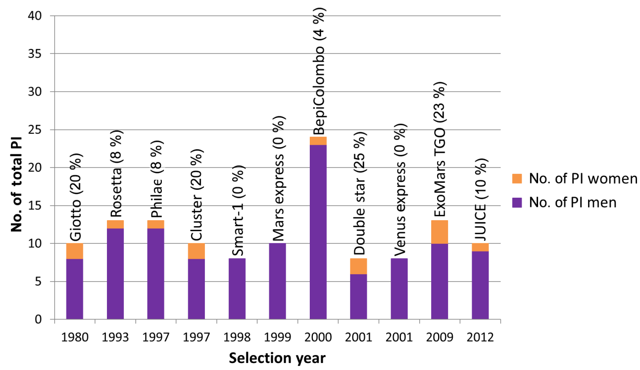

Figure 1. Number of PIs (Principal Investigators) on ESA planetary missions as a function of time. The x axis indicates the year the science mission was selected. Each bar indicates the numbers of men (purple) and women (orange) on the originally selected team on the year the team was selected. The percentage of women for each mission is indicated within parenthesis.

PI names can be easily found in ESA missions web-pages, however, often only the current PI name is indicated. For each team, in order to find the original team members at the time when the mission was selected, we searched team web pages, published articles and when possible, we directly contacted the Principal Investigators and Project Scientists. In order to determine gender, we relied on personal knowledge, first name or photographs. For practical reasons, gender identities outside the male/female binary were not considered in the analysis. In the future, we would like to include studies of self-reported gender that include multiple identities (Zellner et al., 2019). In Appendix A, we indicate the references we used for each ESA mission and each instrument considered in this study.

3 Results

Table 1 presents the percentage of women PIs and Co-Is on ESA Solar System missions. Participation of women in PI teams varied between 4 % and 25 %, with several missions with no women at all as PI. Percentages do not follow any obvious trend with time (Fig. 1).

The percentage of women as Co-Is is always less than 16 % (Fig. 2). In addition, we could analyze the evolution

Table 1. List of ESA's Solar System missions, ordered by year of selection. The target of the mission and the percentage of women PI and Co-I for each mission at the time when the mission was selected is indicated.

Selection year	Launch year	Mission end	Mission name	Target	% women PI	% women Co-I
1980	1985	1992	Giotto	Small bodies	20	2.4
1993	2004	2016	Rosetta	Small bodies	7.7	15.9
1997	2004	2016	Philae	Small bodies	7.7	12
1997	2000	–	Cluster	Earth's Magnetosphere	20	6.7
1998	2003	2006	SMART-1	Moon	0	12.1
1999	2003	–	MarsExpress	Mars	0	12.6
2000	2018	–	BepiColombo	Mercury	4.2	14.9
2001	2003	2009	Double Star	Earth's Magnetosphere	25	7.8
2001	2005	2014	VenusExpress	Venus	0	7.5
2009	2016	–	ExoMars/TGO + Schiaparelli	Mars	23.1	7.7
2012	2022	–	JUICE	Outer planets	10	14.5

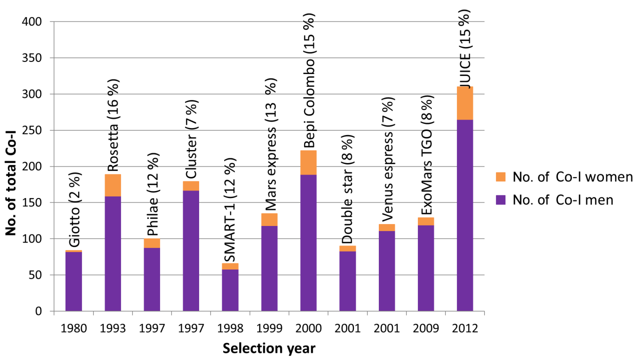

Figure 2. As Fig. 1, but showing the number of Co-Is (Co-Investigators) team members on ESA planetary missions.

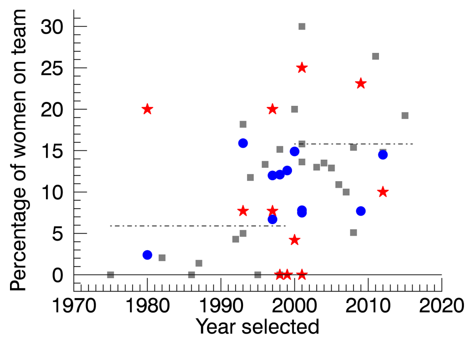

Figure 3. The percentage of women on spacecraft science teams as a function of time, after Fig. 1 in Rathbun (2017). The gray rectangles indicate the NASA missions. The blue circles are for ESA Co-Is and the red stars for ESA PIs.

of the PI team members for two missions: Rosetta and Cluster. For the Rosetta mission, the ratio of female to male PIs changed from 1/13 (in 1993) to 3/13 (in 2019). The PI team of the Cluster mission has been subject to higher fluctuations: 2/11 (in 1997), 3/11 (2010), and 1/11 (in 2014).

We compared our results with NASA statistics. Participation of women in NASA spacecraft science teams varies from none to just over 30 % (Rathbun, 2017). The percentage has been increasing. However, this increase is more similar to a step function than a linear increase, with the pre-2000 average at 5.7 % and post-2000 at 15.8 % (illustrated by dash-dot lines in the Fig. 3). This is well below the percentage of women in the field in the US, which has grown from 20 % to 30 % over the same time range.

Figure 3 also includes the percentage of women PIs and Co-Is on ESA missions to compare to the percentage on NASA missions. The ESA data are consistent with the NASA data, including the jump around the year 2000.

4 Women in the field

To put the previous statistics in the right context, it is important to compare the percentage of women in ESA Solar System missions to the percentage of women in planetary science in Europe. This has proved difficult because there are few global statistics over Europe and it is not always easy to gather these numbers for each European country.

As a preliminary analysis, we investigated the percentage of women in the European Geosciences Union (EGU) and in the International Astronomical Union (IAU). Planetary science is a cross-discipline field including aspects of both astronomy and Earth science, therefore, EGU's and IAU's demographics can give a partial indication of the percentage of women in planetary science in Europe.

The European Geosciences Union (EGU) is the leading organization for Earth, planetary and space science research in Europe. In 2015, 69 % of members were male and 31 % were female, with the difference between male and female member proportions more pronounced for early

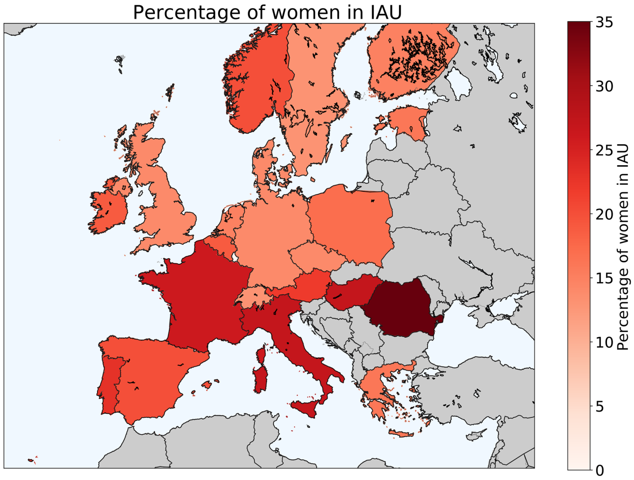

Figure 4. Percentage of women in the International Astronomical Union (IAU) from all ESA's Member State. Colorbar indicates the percentage women for each country.

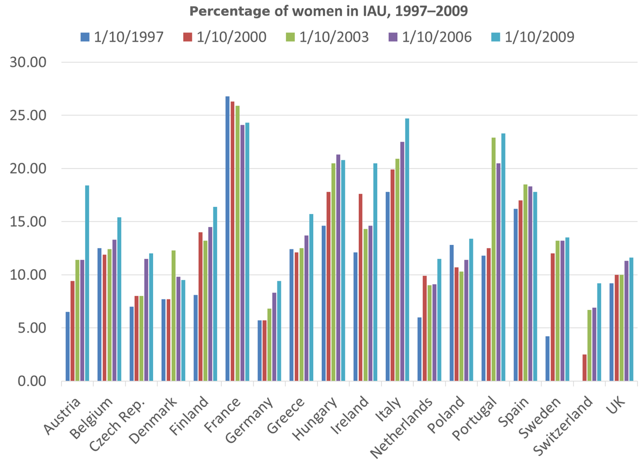

Figure 5. The evolution of women's percentage in the IAU from ESA's Member State over the period 1997–2009.

career scientists (https://blogs.egu.eu/geolog/2016/06/24/gender-equality-in-the-geosciences-is-it-a-numbers-game/, last access: 6 July 2020).

The IAU is an international organization with participation from 68 countries that covers the main areas of astronomy, including planetary science. We limited our analysis only to ESA's 22 Member States.

The percentage of women in the IAU from all ESA's Member State is 24 % (the IAU membership of US is 16 %). This number varies for each country between 13 % in Sweden and Switzerland (notice that Luxembourg has one single male individual member in the IAU) and 35 % in Romania (Fig. 4).

Figure 5 shows how this percentage has changed from triennium to triennium between 1997 and 2009 for some ESA's member states as reported by Cesarsky and Walker (2010). The percentage of women in IAU has increased constantly with the exception of Denmark, France, Hungary, and Spain, where the percentage has been slightly decreasing over time.

We then focused on the demographics of two IAU's Divisions more connected to planetary science: Division E (Sun and Heliosphere) and Division F (Planetary Systems and Astrobiology). The percentage of women in Division E is 22 % (female: 274, male: 1254, and other: 1), while the percentage of women in Division F is 21 % (female: 430, male: 2076, and other: 2) (Madeleine Smith-Spanier, personal communication, 2020). These statistics need to be taken cautiously. Since the recent Divisions started in 2012, the numbers above are the total numbers of members registered in the database between 2012 and now, without taking in account if a member is still active today. Moreover, they cover all IAU's Member States and are not limited to ESA's Member States. Finally, it is important to notice that not all planetary scientists in Europe are members of IAU, therefore most probably these values underestimate the number of women in the field.

For example, in 2019, 27 % of Italy members of the IAU are female. In an earlier study, Matteucci and Gratton (2014) reported figures for Italy, indicating that, in 2014, women in INAF (Istituto Nazionale di Astrofisica) made up 32 % of the research staff (289 out of 908) and 40 % of the technical/administrative staff (173 out of 433). The percentage was slightly lower among the permanent research staff (180 out of 599, about 30 %). The presence of women was lower in the Universities (27 out of 161, about 17 %, among staff).

14 % of UK members of the IAU are female. In 2016 the Royal Astronomical Society commissioned a general demographic survey of the UK astronomy and geophysics research community (McWhinnie, 2017). Their results show that 21 % of professors, 22 % of Senior Lecturers/Readers and 27 % of lecturers in Solar System science are female. Comparing the data for 2010 and 2014 shows that in most staff grade the proportion of staff who are female has risen (Massey, 2015).

26 % of IAU members in France are women. We have also tried to estimate the percentage of women in planetology in France relying in particular on the statistics made by the National Planetology Program (PNP, Programme national de planétologie: Alessandro Morbidelli, personal communication, 2018). According to the statistics made based on lists of permanent research personnel active in planetary science in French research laboratories, about 22 % are women. We also compared this number to two separate studies, conducted by Bot and Buat (2018, 2020). They collected the statistics on women among university teachers in astronomy and astrophysics (section 34 of the Conseil national des universités) and compared them to the statistics among other permanent research personnel: CNRS (Centre national de la recherche scientifique) research scientists and CNAP (Conseil National des Astronomes et Physiciens) astronomers. Their statistics showed that women comprise 22 %–23 % of the permanent research personnel in the field in France, in line with the

numbers from the PNP and IAU. Finally, a recent national survey on behalf of the French Society of Astronomy and Astrophysics suggests that at least two forms of bias, namely elitism and gender bias, exist in hiring in French astronomy (Berné and Hilaire, 2020).

Getting a global vision regarding the situation of women in planetary science in Europe is very difficult. The European Commission and the European Institute for Gender Equality (EIGE) are gathering data to support better informed and evidence based policies to achieve gender equality. According to the European Commission's She Figures 2018 (European Commission, 2019) women accounted for only 33 % of European researchers in 2015 (with lower proportions in many STEM fields), a number similar to 2009 statistics. This number is in good agreement with the percentage of women researchers in planetary science in Europe. Even if European research still shows a pronounced under-representation of women, the She Figures 2018 publication is a testimony of a overall improvement in the EU.

In 2017, ESA Director General Jan Wörner published a Policy Statement on Diversity and Inclusiveness in which he stated: "ESA is also increasing its efforts to create a modern, inclusive working environment where people value diversity in teams, take others' perspectives into account and feel comfortable being themselves – regardless of gender, gender identity and expression, age or working experience, sexual orientation, physical or mental challenges, ethnicity and educational, religious or social background." Hopefully, the initiatives implemented in the framework of diversity and inclusiveness at ESA will result in an increase in the participation of women on the mission teams.

As noted in the American Astronomical Society (AAS) document Inclusive Astronomy Recommendations (Nashville Recommendations, 2015) "Research shows that diversity leads to greater innovation, more creative thinking, and higher quality science". As scientists, we should consider further ways to create an inclusive workplace for all.

5 Discussion

We have attempted to gather all information available to study the question of the representation of women in ESA missions, but this was not a straightforward task

One difficulty we encountered was to find the original team members, as often this information is not available and new members are added over time. An additional difficulty was to determine the percentage of women in the field during the missions' selection year, as this information is not easy to obtain, especially for different European countries.

Moreover, our research does not explain the mechanisms causing the observed gender gap or any of the underlying factors. Further research and data are needed to understand these mechanisms better and refine implications and recommendations for policy. As a general suggestion, all planetary scientists should consider the demographic makeup of teams they work with, including mission teams, conference convener groups, panels, etc. If the group is all or predominantly male, the group should work to increase their networking size and add women to the group.

As a next step, we would like to encourage international organizations, universities, societies and the planetary community as a whole to continuously gather statistics over many years. Detailed statistics are necessary to understand the situation, and they need to be gathered regularly on long periods of time to monitor the trends.

6 Conclusions

As a way of measuring success in the field, we analyzed the participation of female scientists in ESA Solar System missions: we counted the original science team members of 10 missions over a period of 38 years and determined the percentage of women within each team. Although the number of female scientists in the field has been constantly increasing in Europe, we did not observe a similar increase in their participation in ESA Solar System missions.

Participation of women in PI teams varied between 4 % and 25 %, with several missions with no women at all as PIs. The percentage of female scientists as Co-Is is always less than 16 %. This number is lower than the percentage of women in the International Astronomical Union from all ESA's Member State (24 %), itself likely to be an underestimate compared with the proportion in the whole astronomy research community.

We found that gender gaps that existed 38 years ago have persisted into the present, with almost no increase of gender equality in ESA planetary missions. While there are limitations to our sample, this study wants just to be a first step to promote further discussions within the planetary community.

Appendix A: ESA Solar System missions overview

We restricted our study to 10 ESA Solar System missions as listed on the ESA Science & Technology web-page (Table 1) and ESA missions (2020). In order to find the original team members for each team, we directly contacted the PIs and Project Scientists, we searched web-pages, and published papers. Finding the original team members was very difficult, as often new members are added over time. We are aware that the team member lists we gathered may include omissions or members that were not part of the original team. We would like to invite the planetary community to contact us if they have first hand knowledge, particularly of older missions. In Tables A1–A11, we report the references for the team members of each ESA Solar system missions.

Table A1. Giotto's instruments and references for team members lists.

Instrument	Reference(s)	
Magnetometer (MAG)	NASA NSSDCA (MAG)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-07 (last access: 27 July 2020)
Halley Multicolour Camera (HMC)	NASA NSSDCA (HMC)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-01 (last access: 27 July 2020)
Dust Impact System (DID)	NASA NSSDCA (DID)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-08 (last access: 27 July 2020)
Rème Plasma Analyser (RPA)	NASA NSSDCA (RPA)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-06 (last access: 27 July 2020)
Johnstone Plasma Analyser (JPA)	NASA NSSDCA (JPA)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-05 (last access: 27 July 2020)
Particulate Impact Analyser (PIA)	NASA NSSDCA (PIA)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-04 (last access: 27 July 2020)
Optical Probe Experiment (OPE)	NASA NSSDCA (OPE)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-09 (last access: 27 July 2020)
Energetic Particles (EPA)	NASA NSSDCA (EPA)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-10 (last access: 27 July 2020)
Neutral Mass Spectrometer (NMS)	NASA NSSDCA (NMS)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-02 (last access: 27 July 2020)
Ion Mass Spectrometer (IMS)	NASA NSSDCA (IMS)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-03 (last access: 27 July 2020)
Giotto Radio-Science Experiment (GRE)	NASA NSSDCA (GRE)	https://nssdc.gsfc.nasa.gov/nmc/experimentDisplay.do?id=1985-056A-11 (last access: 27 July 2020)

Table A2. Rosetta's instruments and references for team members lists.

Instrument	Reference(s)	Notes
Alice		PI is not from ESA member states
CONSERT	Personal communication	(Alessandra Rotundi, 2018)
COSIMA	https://www2.mps.mpg.de/en/projekte/rosetta/cosima/team.html (last access: 27 July 2020)	
GIADA	http://www.iaps.inaf.it/solarsystem/it/rosetta/giada-team/ (last access: 27 July 2020)	
MIDAS	Riedler et al. (2007)	
MIRO		PI is not from ESA member states
OSIRIS	Keller et al. (2007) + personal communication (Alessandra Rotundi, 2018)	
ROSINA	https://www.space.unibe.ch/research/research_groups/rosina/team/index_eng.html (last access: 27 July 2020)	
RPC:	Personal communication (Alessandra Rotundi, 2018)	
Ion Composition Analyser (ICA)		
Ion and Electron Sensor (IES)		
Langmuir Probe (LAP)		
Fluxgate Magnetometer (MAG)		
Mutual Impedance Probe (MIP)		
Plasma Interface Unit (PIU)		
RSI	Personal communication (Alessandra Rotundi, 2018)	
VIRTIS	http://www.iaps.inaf.it/solarsystem/it/rosetta/virtis-team/ (last access: 27 July 2020)	

Table A3. Philae's instruments and references for team members lists.

Instrument	Reference(s)
APXS	Klingelhöfer et al. (2007)
CIVA	Bibring et al. (2007)
CONSERT	Personal communication (Matt Taylor, 2019)
COSAC	Goesmann et al. (2007) + personal communication (Anni Määttänen, 2019)
Ptolemy	Personal communication (Matt Taylor, 2019)
MUPUS	Spohn et al. (2007)
ROLIS	Mottola et al. (2007)
ROMAP	Auster et al. (2007)
SD2	Finzi et al. (2007)
SESAME/CASSE/DIM/PP	Seidensticker et al. (2007) + personal communication (Anni Määttänen, 2019)

Table A4. Cluster's instruments and references for team members lists.

Instrument	Reference(s)
Active Spacecraft Potential Control (ASPOC)	Escoubet et al. (1997)
Cluster Ion Spectrometer experiment (CIS)	Escoubet et al. (1997)
Digital Wave Processor (DWP)	Escoubet et al. (1997)
Electron Drift Instrument (EDI)	Escoubet et al. (1997)
Electric Field and Wave experiment (EFW)	Escoubet et al. (1997)
Fluxgate Magnetometer (FGM)	Escoubet et al. (1997)
Plasma Electron and Current Experiment (PEACE)	Escoubet et al. (1997)
Research with Adaptive Particle Imaging Detectors (RAPID)	Escoubet et al. (1997)
Spatio-Temporal Analysis of Field Fluctuations (STAFF)	Escoubet et al. (1997)
Wide Band Data instrument (WBD)	Escoubet et al. (1997)
Waves of High frequency and Sounder for Probing of Electron density by Relaxation experiment (WHISPER)	Escoubet et al. (1997)

Table A5. SMART-1's instruments and references for team members lists.

Instrument	Reference(s)	Notes
EPDP	ESA EPDP, https://sci.esa.int/web/smart-1/-/31415-instruments?section=epdp-and-spede (last access: 31 July 2020)	Technology demonstration
SPEDE	Mälkki et al. (2003)	
KaTE	ESA KaTE, https://sci.esa.int/web/smart-1/-/31415-instruments?section=kate-and-rsis (last access: 31 July 2020)	Technology demonstration
RSIS	–	Technology demonstration
OBAN	–	Technology demonstration
AMIE	Josset et al. (2006)	
SIR	Basilevsky et al. (2004)	
D-CIXS	Grande (2001)	
XSM	Huovelin et al. (2002)	

Table A6. Mars Express's instruments and references for team members lists.

Instrument	Reference(s)
Anlyser of Space Plasmas and Energetic Atoms (ASPERA-3)	http://aspera-3.irf.se/Aspera-3-old/co_i.html.1.html (last access: 31 July 2020)
High Resolution Stereo Camera (HRSC)	Neukum and Jaumann (2004)
MArs Radio Science (MARS)	Personal Communication (Silvia Tellmann, 2018)
Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS)	Picardi et al. (2005)
Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA)	Bibring et al. (2004)
Planetary Fourier Spectropmeter (PFS)	Formisano et al. (2005)
Spectroscopy for the Investigation of Characteristics of the Atmosphere of Mars (SPICAM)	Bertaux et al. (2006)

Table A7. Bepi Colombo's instruments and references for team members lists.

Instrument	Reference(s)	Notes
BELA	Thomas et al. (2007)	
ISA	Santoli (2010)	
MPO-MAG	Glassmeier et al. (2010)	
MERTIS	Hiesinger et al. (2010)	
MGNS		Not included as the main PI is not from ESA member states
MIXS	Fraser et al. (2010)	
MORE	Iess (2020)	
PHEBUS	Chassefière et al. (2010)	
SERENA	http://www.serenabc.altervista.org/team.html (last access: 27 July 2020)	
SIMBIO-SYS: HRIC, STC, VIHI	Flamini et al. (2010)	
SIXS	Huovelin et al. (2010)	

Table A8. Double Star's instruments and references for team members lists.

Instrument	Reference(s)
Equatorial Double Star (TC-1)	
Active Spacecraft Potential Control (ASPOC)	personal communication (Philippe Escoubet, 2019)
Fluxgate Magnetometer (FGM)	Carr et al. (2005)
Plasma Electron and Current Experiment (PEACE)	personal communication (Philippe Escoubet, 2019)
Hot Ion Analyzer (HIA)	personal communication (Philippe Escoubet, 2019)
Part of Spatio-Temporal Analysis of Field Fluctuations (STAFF)	personal communication (Philippe Escoubet, 2019)
Digital Wave Processor (DWP)	personal communication (Philippe Escoubet, 2019)
High Energy Electron Detector (HEED)	personal communication (Philippe Escoubet, 2019)
High Energy Proton Detector (HEPD)	personal communication (Philippe Escoubet, 2019)
Heavy Ion detector (HID)	personal communication (Philippe Escoubet, 2019)
Low Energy Ion Detector (LEID)	personal communication (Philippe Escoubet, 2019)
Polar Double Star (TC-2):	personal communication (Philippe Escoubet, 2019)
Neutral Atom Imager (NUADU)	personal communication (Philippe Escoubet, 2019)
Fluxgate Magnetometer (FGM)	personal communication (Philippe Escoubet, 2019)
Plasma Electron and Current Experiment (PEACE)	personal communication (Philippe Escoubet, 2019)
Low Energy Ion Detector (LEID)	personal communication (Philippe Escoubet, 2019)
Low Frequency Electromagnetic Wave Detector (LFEW)	personal communication (Philippe Escoubet, 2019)
High Energy Proton Detector (HEPD)	personal communication (Philippe Escoubet, 2019)
Heavy Ion Detector (HID)	personal communication (Philippe Escoubet, 2019)

Table A9. Venus Express's instruments and references for team members lists.

Instrument	Reference(s)	Notes
ASPERA-4	Titov et al. (2001)	Mission proposal
MAG	Titov et al. (2001)	
PFS	Titov et al. (2001)	
SPICAV	Titov et al. (2001)	
VeRa	Silvia Tellmann, personal communication, 2018	
VIRTIS	Pierre Drossart, personal communication, 2018	
VMC	Titov et al. (2001)	

Table A10. ExoMars's instruments and references for team members lists.

Instrument	Reference(s)
TGO:	Considering only instruments with European PIs
NOMAD	Personal communication (Ann Carine Vandaele, 2019) for the original list. For an updated version: Vandaele et al. (2015)
CaSSIS	https://www.cassis.unibe.ch/about_us/science_team/ (last access: 27 July 2020)
Schiaparelli:	
DREAMS	Bettanini et al. (2018)
AMELIA	Ferri et al. (2019)
COMARS+	Gülhan et al. (2018)
DECA	–
INRRI	Dell'Agnello et al. (2017)

Table A11. JUICE's instruments and references for team members lists.

Instrument	Reference(s)
Camera system (JANUS)	Personal communication (Olivier Witasse, 2018)
Moons and Jupiter Imaging Spectrometer (MAJIS)	Personal communication (Olivier Witasse, 2018)
UV imaging Spectrograph (UVS)	Personal communication (Olivier Witasse, 2018)
Sub-millimeter Wave Instrument (SWI)	Personal communication (Olivier Witasse, 2018)
GAnymede Laser Altimeter (GALA)	Personal communication (Olivier Witasse, 2018)
Radar for Icy Moons Exploration (RIME)	Personal communication (Olivier Witasse, 2018)
A magnetometer for JUICE (J-MAG)	Personal communication (Olivier Witasse, 2018)
Particle Environment Package (PEP)	Personal communication (Olivier Witasse, 2018)
Radio & Plasma Wave Investigation (RPWI)	Personal communication (Olivier Witasse, 2018)
Gravity & Geophysics of Jupiter and Galilean Moons (3GM)	Personal communication (Olivier Witasse, 2018)
Planetary Radio Interferometer & Doppler Experiment (PRIDE)	Personal communication (Olivier Witasse, 2018)

Data availability. In Appendix A, we indicate the references we used for each ESA mission and each instrument considered in this study.

Author contributions. AP and JAR initiated the project. AP carried out the data analysis, and wrote the paper. ACLR, AM, AMi, MR, AR, MT, OW, and ACV collected the missions statistics. AMä gathered the data about French statistics. FA and PD provided support and contextual information on the ESA missions data. All authors discussed the results and commented on the manuscript.

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