

***Space Weather* Bibliometrics for 2022: Going Beyond Impact Factor**

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Abstract

I discuss the impact factor of *Space Weather* for 2021, its small decrease with respect to the number in 2020, and potential causes for this decrease. The limitations of the impact factor are emphasized as reported in past studies, in particular due to the large weight of highly cited papers. For *Space Weather*, over several years, the median number of citations received by a paper per year is close to the impact factor at the time of publication, with very few papers receiving no citations. I expect that, as the solar cycle ramps up, the impact factor will start to grow again.

Key Point

Space Weather has an impact factor of 4.29 in 2021, a 4% decrease as compared to 2020 but a 49% increase as compared to 2017.

Impact factor has well-documented limitations with the 20% most cited papers contributing half of the citations.

For *Space Weather*, the impact factor represents the median number of citations per year received by a paper over several years.

PLS

I discuss the impact factor of *Space Weather* for 2021, a measure of the number of citations to recent papers, its small decrease with respect to the number in 2020, and potential causes for this decrease. I emphasize the limitations of the impact factor as reported in past studies. For *Space Weather*, over several years, the median number of citations received by a paper per year is close to the impact factor at the time of publication. I expect that, as solar cycle 25 ramps up, the impact factor of *Space Weather* will start to grow again.

Body

The 2021 Journal Citation Reports (JCR) Impact Factor of *Space Weather* is 4.29, a small decrease (<4%) from the 2020 impact factor of 4.46 but an increase of more than 10% per year over the past four years since 2017. First, let me remind us how the (2-year) impact factor is calculated. It is the ratio of the total number of citations that occurred in 2021 for papers published in the journal in 2019 and 2020 to the number of *citable* papers published in 2019 and 2020. As discussed by numerous work (e.g. see Mutz & Daniel, 2012; Larivière et al., 2016), the impact factor is a very imperfect quantification of the impact of a journal. It should certainly not be used to quantify the “impact” of individual articles published in a journal. The derivation of the impact factor is somewhat complex because the numerator includes citations to all papers but the denominator only the total number of citable papers, removing “editorial” and “news”, among others. So, if this editorial gets cited in 2023 or 2024, these citations will appear in the numerator of the impact factor calculation but not the denominator. Obviously, impact factor focuses on relatively recent citations

to recent papers and does not give any information on the longevity of a paper, the total number of citations it may get. Papers on a “fashionable” topic may get more instant citations but may be forgotten more quickly and positive vs. negative citations are not distinguished. More importantly, being an average of total citations, the impact factor does not reflect the average number of citations that a typical paper will receive per year, which is the way the impact factor is usually thought of. As discussed in Larivière et al. (2016), 65-75% of papers receive fewer citations than the impact factor, with ~20% of articles contributing the majority of citations received in one year.

Table 1 highlights bibliometrics for *Space Weather* articles published since 2017. The row, from top to bottom, shows the total number of published articles, the number of citable articles (removing editorial and news), the impact factor of the journal in that year, the number of citations received in the year after publication (Yr+1) with the average per citable article in parentheses, the number of citations received in the second year after publication (Yr+2) with the average per citable article in parentheses, the median and standard deviation of citations received by an article in the year after publication, the median total number of citations received by an article from publication to the end of the second year after publication, the number and percentage of articles that received at least 4 citations during the year after publication, the number and percentage of articles with at least 8 total citations two years after publications and the number of articles without any citations two years after publication. We use the number 4 and 8 as it represents more or less the typical impact factor in the past few years. All citations numbers are given for the total number of articles; however, the citation per year and proportion of articles with a given number of citations are only given for citable articles.

Year	2017	2018	2019	2020	2021
# Articles Published	128	154	111	126	157
# Citable Articles	109	143	103	120	151
Impact Factor Yr	2.89	3.69	3.58	4.46	4.29
Citations Yr+1	424 (3.89)	517 (3.62)	430 (4.17)	365 (3.04)	
Citations Yr+2	510 (4.68)	700 (4.90)	594 (5.77)		
Median Yr+1	2 ± 4.89	3 ± 3.27	3 ± 4.28	2 ± 2.73	
Median Yr+1&2	5 ± 15.3	7.5 ± 7.76	7 ± 11		
# w/ CitYr+1 ≥ 4	39 (36%)	53 (37%)	38 (37%)	40 (33%)	
# w/ CitYr+1&2 ≥ 8	43 (39%)	77 (54%)	51 (50%)		
# 0 citations	13	11	6	≤ 11	

Table 1: Bibliometrics for *Space Weather* from 2017 to 2021. All numbers are from Web of Science and may differ from those used to calculate the impact factor.

2020 is comparable to 2017 in terms of total number of published articles. The difference in citations received by the articles in the year after their publication (365 vs. 424) is due almost exclusively to the difference in the number of citations to top 10% papers (154 in 2017, 101 in 2020 for the top 11 papers). This highlights one of the key issues with the impact factor: the importance of the most cited papers, especially for a journal publishing only about 100-150 articles per year. For *Space Weather*, half of the citations that make up the impact factor are due to the top 20% most cited articles (in 2021). The Year 2018 had a very large number of articles published in the topical collection related to the September 2017 events.

A few more interesting things to note: i) less than 10% of articles have not received any citations two years after publication. The number is, in fact, often lower than the number of non-citable articles, i.e. many news or editorial published by *Space Weather* receive a few citations, which does somewhat artificially increase the impact factor (probably by 0.05 to 0.25). We note that *Space Weather* is publishing fewer of these in recent years (6 in 2020 and 2021 as compared to 19 in 2017) and this could slightly affect the impact factor. ii) About half of the citable articles published in 2018 and 2019 have been cited more than 8 times two years after their publication, i.e. the impact factor does, in fact, represent approximately the number of citations that a typical article shall get per year in the years after publication. *Space Weather* articles continue to be cited more or less at the impact factor rate for years after publication. The median citable article published in 2015 has 16 citations to date (or about 2.5 citations per year), while the 2016 impact factor was 2.58 and the 2015 impact factor was 2.40.

Overall, the small decrease of the impact factor in 2021 seems to be primarily due to having fewer highly cited manuscripts. This may be typical of *Space Weather* publications during solar minimum, when there are no large solar events, coronal mass ejections, geomagnetic induced currents or geomagnetic storms that many researchers study at the same time. Often *Space Weather* is the journal where the initial studies are published, which are rapidly cited and contribute significantly to the impact factor. Studies published in 2019-2020 have tended to be about new models, solar cycle effects or smaller events which are only studied by a few groups. In addition, the journal only published about one editorial per quarter instead of a larger number of news and editorials as in the past. Even with these changes, *Space Weather* still has few articles that do not get any citations (only 11 articles published in 2020 have not been cited yet, even with more than 4 months in 2022 left at the time of writing). As solar cycle 25 ramps up, I expect more manuscripts published on large or impactful events (such as the Starlink loss of earlier this year, see Hapgood et al., 2022) and a continuation of the increase of the impact factor at a rate similar as in the past (10-15% per year). This increase in impact factor (the rate of increases places *Space Weather* in the top half of AGU journals) reflects the increase recognition of the importance of space weather as well as the increased funding for space weather research.

References:

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Data Availability

The impact factors are from Journal Citation Reports of Clarivate. All citation numbers are from Web of Science and may differ from the numbers used to derive the impact factor.

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