Prepared by IROWG
Version 1C, 12 Nov 2015
IROWG/DOC/2015/01

A first bibliometric Analysis of the Radio Occultation Publication Record

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1 Introduction

At the 5th ROM SAF User Workshop in June 2014, two recommendations related to a bibliometric analysis were expressed:

- CLIM17: Provide literature data base that lists RO publications by theme
- CLIM18: Evaluate literature with respect to study focuses (bibliometric analysis)

The full report from the workshop is available here. These recommendations resulted from an earlier bibliometric investigation into Climate Engineering Research by C. W. Belter and D. J. Seidel 2013[3].

The present document contains the results of an early analysis done on radio occultations articles at EUMETSAT, covering the years 1990 to 2014; addressing partly CLIM17 and CLIM18 of the aforementioned workshop.

The following bibliographic databases were used:

- Web of Science (1200 records analysed)
- Scopus (1169 records analysed)

Both databases are available internally at EUMETSAT to EUMETSAT employees. The investigated articles/records only include work on RO for the planet Earth. RO observations taken for other planets (e.g. Venus, Saturn) are generally not considered here. The number of records would have been substantially bigger otherwise, especially in the early years of the investigated time range.

The records from Web of Science are made available via Zotero as a publicly available bibliographic database (see Section 1.6 for more details).

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[3] Belter, C. W. and Seidel, D. J. (2013), A bibliometric analysis of climate engineering research. WIREs Clim Change, 4: 417-427. doi: 10.1002/wcc.229, for further information refer here.

1.1 Disclaimer

It should be noted that this work has been done on a best effort basis and does not claim to be 100% accurate or comprehensive.

1.2 Topic Areas

The work by C. W. Belter and D. J. Seidel 2013 included sorting of the articles/records into topic areas, which relied on a manual inspection of about 750 articles. The record of RO is slightly higher, and spans more topics. Both used databases are deficient in the area of subject analysis - hence if a breakdown of the articles into narrower and more meaningful topics is desired it would have to be done manually. Within this early analysis, no further topical areas have thus been implemented.

Several major ones exist that e.g. include:

- Atmospheric Retrieval
- Ionospheric Retrieval
- Numerical Weather Prediction
- Climate
- Receiver Technology
- Retrieval Algorithms

1.3 Citation Analysis Performed

Within this work, a simple analysis by name, institution, year, source titles (title of the journal, report, conference, etc), languages, etc is performed. In addition, Scopus and Web of Science offer capabilities to do a more thorough citation analysis for a given author (see Section 5 for an example). In addition, it is possible to do in Web of Science a detailed citation analysis for a specific article (see Section 6 for an example).

1.4 Data included or missing

Both databases are reasonably complete regarding journal articles. However, coverage of some journals is not complete, in particular for early articles since it depends on whether the full retrospective data record has been included electronically.

Coverage of conference proceedings is far less comprehensive, although both databases include some. These are mainly covering the main publishers such as e.g. IEEE. Not included are smaller or less known meetings, conferences, and workshops, or even EGU and AGU assemblies. The data record for conference proceedings is also changing over time, as more and more conferences do not publish proceedings.

1.5 Import to Citation Managers

Possible options include access via Web of Science to Endnote (e.g. available to EUMETSAT employees); all the data can also be imported into Endnote from Scopus, as well as sharing with other users. Both Scopus and Web of Science data is also compatible with other reference managers such as e.g. RefWork, Mendeley. Otherwise, users can also download the data from Zotero (see Section 1.6 for more details) and import it into a suitable citation manager.

1.6 Availability of the Data to Groups: Zotero

The bibliographic data which has been analyzed in this report forms a database of bibliographic records on radio occultation that can be useful to those interested in the subject. It is available via the free citation manager Zotero.

Zotero is a free, open-source program that can be downloaded as a browser extension for Firefox, Chrome, and Safari and as a standalone program that works with Windows, Mac, or Linux systems. Users need to register and will then be able to access the Group Library entitled *Radio Occultation 1990-* (which contains the bibliographic data). The direct link to this group is here. The search option is available within the Group Library link.

The Group Library can be searched by all words from the title or abstract as well as by author names. Items can be exported in various formats (such as the Research Information System (RIS) one) compatible with other reference managers.

In the present setting the data can be edited only by the Group Administrators (the authors of this report). The data in the Group Library is updated regularly (several times per month) and could be completed for missing records on a manual basis if desired. Note however that this will depend on available EUMETSAT resources and on interest by the RO community, thus it is only a best effort service. In addition, EUMETSAT provides on a best effort basis a monthly publication summary via a mailing list, which will also be feed into the Zotero library.

2 Analysis by Year of Publication

The number of publications in the two data bases over the investigated years is given in Figure 1. Annual numbers have continuously increased, with publication peaks e.g. a few years after the COSMIC-1 launch in 2006.

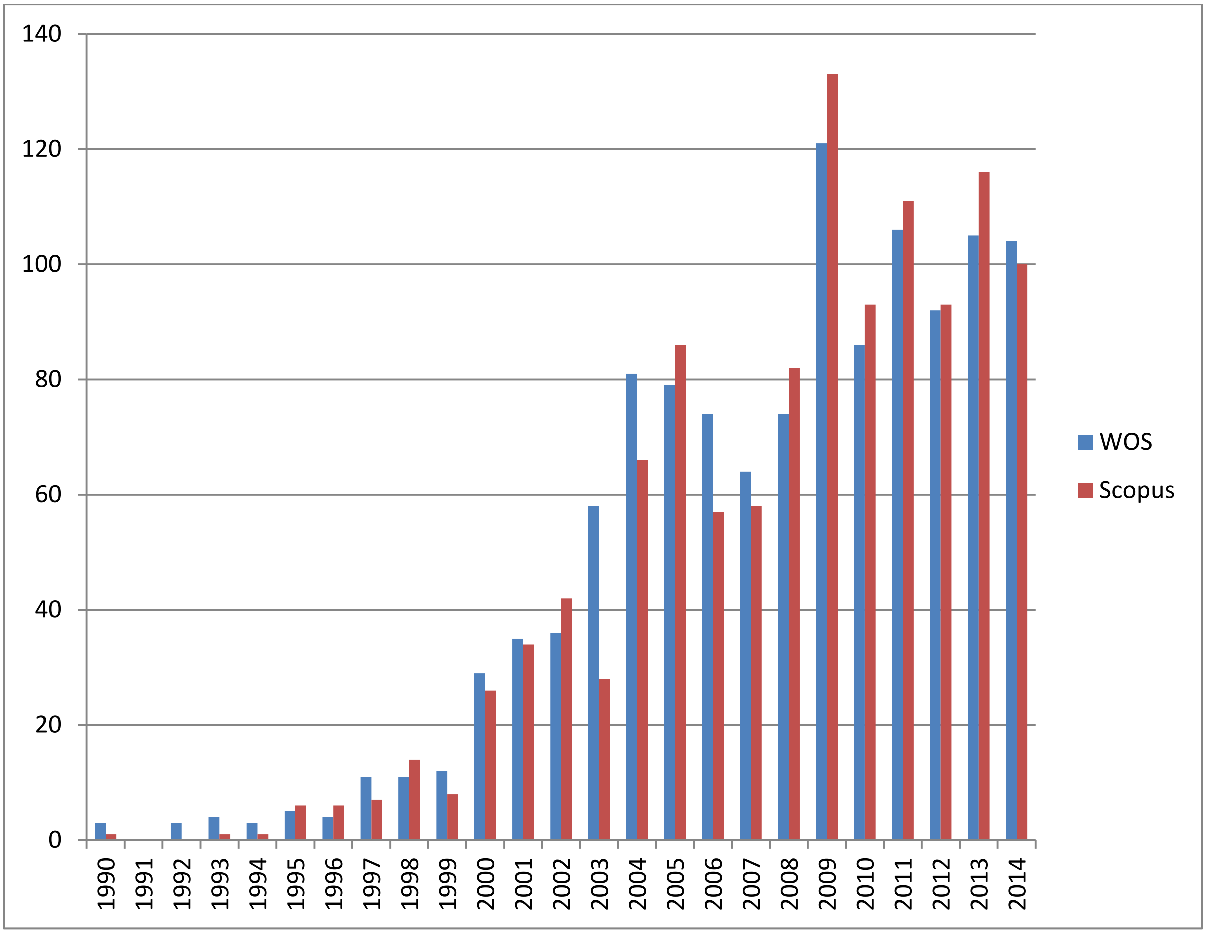

Figure 1 RO publications per year from Web of Science (WOS) or Scopus over the investigated time period.

3 Analysis by Publication Media

Two publication media are investigated: Journals and Books. All books are though a collection of individual articles, the publication being triggered by a major workshop or conference. In addition, a further separation into publisher is also included below.

3.1 Journals

The Table 1 gives the number of RO publications sorted by journal. In total, these journals cover 61.76% (Scopus) and 66.83% (Web of Science) of the total set analyzed.

NB: the list below only represent the first 25 source titles (those that have at least 10 records in Web of Science) as the full listing would be too long for this report.

JOURNAL	WOS	SCOPUS
JOURNAL OF GEOPHYSICAL RESEARCH ATMOSPHERES	121	105
GEOPHYSICAL RESEARCH LETTERS	83	76
JOURNAL OF GEOPHYSICAL RESEARCH SPACE PHYSICS	61	50
RADIO SCIENCE	61	50
ADVANCES IN SPACE RESEARCH	55	50
ATMOSPHERIC MEASUREMENT TECHNIQUES	39	37
JOURNAL OF ATMOSPHERIC AND SOLAR TERRESTRIAL	37	31
GPS SOLUTIONS	34	29
TERRESTRIAL ATMOSPHERIC AND OCEANIC SCIENCES	33	33
SPIE PROCEEDINGS	26	36
MONTHLY WEATHER REVIEW	26	26
ANNALES GEOPHYSICAE	24	22
CHINESE JOURNAL OF GEOPHYSICS CHINESE EDITION	24	19
IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE	23	21
IGARSS SYMPOSIUM	23	25
JOURNAL OF THE METEOROLOGICAL SOCIETY OF JAPAN	18	16
QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL	17	15
ATMOSPHERIC CHEMISTRY AND PHYSICS	16	15
EARTH PLANETS AND SPACE	13	10
JOURNAL OF ATMOSPHERIC AND OCEANIC TECHNOLOGY	13	16
JOURNAL OF CLIMATE	12	6
BULLETIN OF THE AMERICAN METEOROLOGICAL	12	7
JOURNAL OF COMMUNICATIONS TECHNOLOGY & ELECTRONICS	11	11
JOURNAL OF GEODESY	10	7
IEEE AEROSPACE CONFERENCE PROCEEDINGS	10	9

Table 1 RO publications per journal from Web of Science (WOS) or Scopus over the investigated period.

3.2 Books

The books listed below have been indexed in Scopus or in Web of Science or both. Both databases index individual chapters and count them as separate records and thus these books account for a substantial amount of entries in the year of their publication in the database which included them (see also Figure 1).

- U. Foelsche et al, Atmosphere and climate: studies by occultation methods. Springer, 2006.
- G Kirchengast et al, Occultations for probing atmosphere and climate. Springer, 2004.
- C. Reigber et al, First CHAMP mission results for gravity magnetic and atmospheric studies. Springer, 2003.
- C. Reigber et al, Earth observations with CHAMP: results from three years in orbit. Springer, 2005.
- A. Steiner et al, A. New Horizons in Occultation Research: Studies in Atmosphere and Climate. Springer, 2009.

They are also partly available as e-books in addition to the printed editions, e.g. also in the EUMETSAT Library.

3.3 Main Publisher

The main publishers, as extracted from Web of Science, are shown in Figure 2.

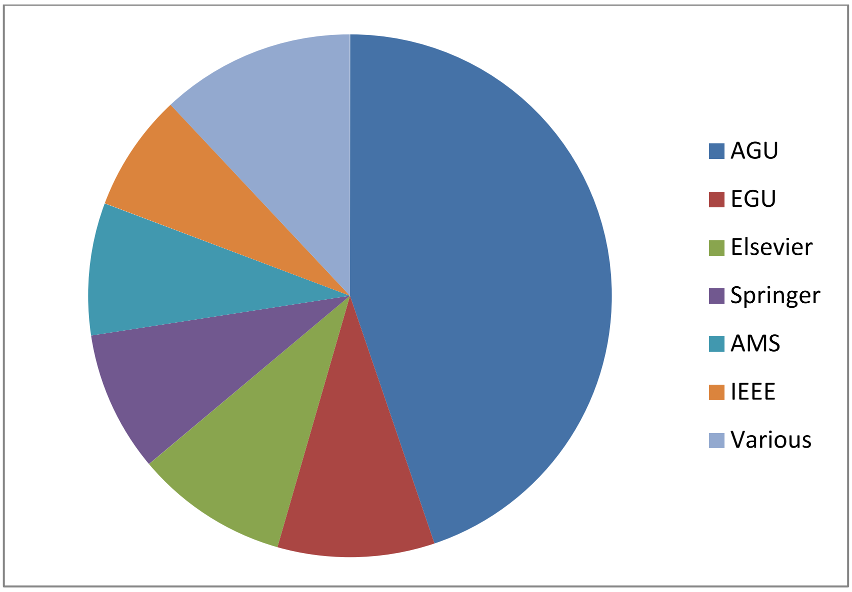

Figure 2 RO publications per publisher from Web of Science (WOS) over the investigated period.

4 Analysis by Author

Table 2 lists all authors with at least 20 Web of Science publications over the investigated period in the 2 data bases. The full list of all authors would be too long to be included here.

AUTHOR	SCOPUS	WOS
WICKERT J	100	114
KUO YH	82	84
SCHMIDT T	71	76
KIRCHENGAST G	49	68
LIOU YA	44	47
BEYERLE G	37	44
TSUDA T	40	41
ROCKEN C	38	39
JAKOWSKI N	35	39
PAVELYEV AG	32	37
SOKOLOVSKIY S	43	33
FOELSCHE U	32	37
AO CO	31	35
REIGBER C	29	33
HEISE S	32	33
HUANG CY	28	33
STEINER AK	26	33
GORBUNOV ME	26	32
MANNUCCI AJ	29	31
HAJJ GA	28	30
KURSINSKI ER	24	30
HOCKE K	21	29
HEALY SB	25	26
SYNDERGAARD S	24	26
SCHREINER WS	40	25
LIU JY	23	25
DE LA TORRE A	28	25
IGARASHI K	17	24
RATNAM MV	20	22
MARQUARDT C	16	22
VON ENGELN A	17	21
HUNT, D.	28	21
LAURITSEN KB	15	20
HO SP	19	20
ANTHES RA	20	20

Table 2 RO publications per author from Web of Science (WOS) or Scopus over the investigated period. Note: author is not necessary the first author.

4.1 Affiliation

The following main affiliations were found for the authors.

NB: the affiliation of an author is included each time he is mentioned as one of the authors of a record, may it be as primary or secondary author.

AFFILIATION	SCOPUS	WOS
UCAR	115	104
NATIONAL CENTRAL UNIVERSITY TAIWAN	110	108
CALTECH	91	93
GEOFORSCHUNGSZENTRUM POTSDAM	75	71

Table 3 RO publications per affiliation from Web of Science (WOS) or Scopus over the investigated period.

4.2 Country

Table 4 shows the analysis by country for the authors.

NB: the country of the affiliation of an author is included each time he is mentioned as one of the authors of a record, may it be as primary or secondary author.

COUNTRY	WOS	SCOPUS
USA	442	405
GERMANY	206	192
TAIWAN	146	160
PEOPLES R CHINA	129	166
RUSSIA	118	113
JAPAN	84	78
UNITED KINGDOM	73	67
AUSTRIA	71	58
ITALY	49	52
DENMARK	46	43
INDIA	40	49
AUSTRALIA	35	41
SPAIN	34	37
CANADA	30	28
ARGENTINA	29	25

Table 4 RO publications per country from Web of Science (WOS) or Scopus over the investigated period.

4.3 Document Type

Table 5 shows the analysis by document type.

TYPE	SCOPUS	WOS
ARTICLE	830	851
CONFEENCE PAPER	247	349
OTHERS*	90	20

Table 5 RO publications per document type from Web of Science (WOS) or Scopus over the investigated period. *Book chapters, Reviews, etc.

4.4 Language

The languages shown in Table 6 were found for the Web of Science (SCOPUS does not provide this information).

LANGUAGE	#
English	1159
Chinese	34
Russian	7

Table 6 RO publications per language from Web of Science over the investigated period.

4.5 Subject

A direct comparison is not possible as subject lists do not agree between the two data bases. Table 7 shows the Web of Science subjects, Table 8 the SCOPUS one. In both databases, several subjects can be assigned to one record.

SUBJECT	WOS
Meteorology atmospheric sciences	652
Remote sensing	304
Geosciences multidisciplinary	264
Geochemistry geophysics	237
Astronomy astrophysics	238
Telecommunications	116
Engineering aerospace	107
Engineering electrical electronic	95
Instruments instrumentation	81
Oceanography	49
Imaging science photographic technology	36
Optics	25
Physics applied	17

Physics multidisciplinary	16
Engineering ocean	13
Computer science artificial intelligence	12
Multidisciplinary sciences	11
Environmental sciences	11
Water resources	10

Table 7 RO publications per Subject from Web of Science over the investigated period (with at least 10 articles assigned to the subject).

SUBJECT	SCOPUS
Earth and Planetary Sciences	890
Engineering	311
Physics and Astronomy	257
Computer Science	186
Environmental Science	71
Social Sciences	32
Materials Science	32
Mathematics	26

Table 8 RO publications per Subject from Scopus over the investigated period with at least 25 articles assigned to the subject).

5 Analysis for "most cited" Articles

The 13 articles with the most citations in Web of Science over the analysed time period are listed in Table 9. For comparison, the citations found in Scopus are also given. The table lists only the title information, the full citation (in the order of appearance in) is given below:

1. Bevis, M. *et al*. GPS meteorology - remote-sensing of atmospheric water-vapor using the global positioning system. *Journal of Geophysical Research-Atmospheres* **97**, 15787-15801 (1992).

2. Kursinski, E., Hajj, G., Schofield, J., Linfield, R. & Hardy, K. Observing Earth's atmosphere with radio occultation measurements using the Global Positioning System. Journal of Geophysical Research-Atmospheres **102**, 23429-23465 (1997).

3. Rocken, C. et al. Analysis and validation of GPS/MET data in the neutral atmosphere. *Journal of Geophysical Research-Atmospheres* **102**, 29849-29866 (1997).

4. Ware, R. *et al*. GPS sounding of the atmosphere from low earth orbit: Preliminary results. *Bulletin of the American Meteorological Society* **77**, 19-40 (1996).

5. Anthes, R. *et al*. The COSMOC/FORMOSAT-3 - Mission early results. *Bulletin of the American Meteorological Society* **89**, 313- (2008).

6. Wickert, J. *et al.* Atmosphere sounding by GPS radio occultation: First results from CHAMP. *Geophysical Research Letters* **28**, 3263-3266 (2001).

7. Tsuda, T., Nishida, M., Rocken, C. & Ware, R. A global morphology of gravity wave activity in the stratosphere revealed by the GPS occultation data (GPS/MET). *Journal of Geophysical Research-Atmospheres* **105**, 7257-7273 (2000).

8. Hajj, G. & Romans, L. Ionospheric electron density profiles obtained with the global positioning system: Results from the GPS/MET experiment. *Radio Science* **33**, 175-190 (1998).

9. Kuo, Y. *et al.* Inversion and error estimation of GPS radio occultation data. *Journal of the Meteorological Society of Japan* **82**, 507-531 (2004).

10. Hajj, G., Kursinski, E., Romans, L., Bertiger, W. & Leroy, S. A technical description of atmospheric sounding by GPS occultation. *Journal of Atmospheric and Solar-Terrestrial Physics* **64**, 451-469 (2002).

11. Schreiner, W., Sokolovskiy, S., Rocken, C. & Hunt, D. Analysis and validation of GPS/MET radio occultation data in the ionosphere. *Radio Science* **34**, 949-966 (1999).

12. Hajj, G. *et al.* CHAMP and SAC-C atmospheric occultation results and intercomparisons. *Journal of Geophysical Research-Atmospheres* **109**, (2004).

13. Rocken, C. *et al.* COSMIC system description. *Terrestrial Atmospheric and Oceanic Sciences* **11**, 21-52 (2000).

Table 10 shows the citation number as they developed over the years.

SUBJECT	WOS	SCOPUS
GPS meteorology - remote-sensing of atmospheric water-vapor using the global positioning system	510	658
Observing Earth's atmosphere with radio occultation measurements using the global positioning system	482	522
Analysis and validation of GPS/MET data in the neutral atmosphere	348	347
GPS sounding of the atmosphere from low earth orbit: Preliminary results	341	350
The COSMIC/FORMOSAT-3 - Mission early results	265	279
Atmosphere sounding by GPS radio occultation: First results from CHAMP	247	239
A global morphology of gravity wave activity in the stratosphere revealed by the GPS occultation data (GPS/MET)	203	217
Ionospheric electron density profiles obtained with the global positioning system: Results from the GPS/MET experiment	193	201
Inversion and error estimation of GPS radio occultation data	186	186
A technical description of atmospheric sounding by GPS occultation	175	186
Analysis and validation of GPS/MET radio occultation data in the ionosphere	173	176
CHAMP and SAC-C atmospheric occultation results and intercomparisons	166	157
COSMIC system description	162	182

Table 9 Overview of the most cited RO articles in Web of Science and Scopus over the investigated period

SUBJECT	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
GPS meteorology - remote-sensing of atmospheric water-vapor using the global positioning system	4	1	5	9	12	11	12	29	40	23	22	24	16	26	33	35	27	29	27	34	48	43
Observing Earth's atmosphere with radio occultation measurements using the global positioning system	-	-	-	-	0	3	8	23	21	25	29	43	24	35	23	28	47	27	33	26	39	48
Analysis and validation of GPS/MET data in the neutral atmosphere	-	-	-	-	0	3	9	24	25	27	28	37	27	26	16	16	27	17	21	15	12	18
GPS sounding of the atmosphere from low earth orbit: Preliminary results	-	-	-	5	7	15	11	26	21	26	18	35	21	20	12	14	28	14	19	12	13	24
The COSMIC/FORMOSAT-3 - Mission early results	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	37	36	53	29	33	66
Atmosphere sounding by GPS radio occultation: First results from CHAMP	-	-	-	-	-	-	-	-	0	11	20	25	24	23	21	20	20	16	19	15	16	17
A global morphology of gravity wave activity in the stratosphere revealed by the GPS occultation data (GPS/MET)	-	-	-	-	-	-	-	0	0	3	12	27	13	28	12	27	20	14	15	11	8	13
Ionospheric electron density profiles obtained with the global positioning system	-	-	-	-	-	0	2	9	6	16	7	14	16	12	11	8	23	12	24	12	10	11
Inversion and error estimation of GPS radio occultation data	-	-	-	-	-	-	-	-	-	-	-	1	9	15	13	17	27	16	31	12	18	27
A technical description of atmospheric sounding by GPS occultation	-	-	-	-	-	-	-	-	-	4	7	18	16	16	13	9	18	7	23	8	17	19
Analysis and validation of GPS/MET radio occultation data in the ionosphere	-	-	-	-	-	-	0	6	6	16	6	10	7	6	8	6	26	17	23	15	10	11
CHAMP and SAC-C atmospheric occultation results and intercomparisons	-	-	-	-	-	-	-	-	-	-	-	7	10	22	13	13	27	17	19	7	9	22
COSMIC system description	-	-	-	-	-	-	-	2	6	2	5	5	6	9	11	12	27	18	20	10	15	14

Table 10 Overview year by year of the most cited RO articles in Web of Science over the investigated period.

6 Analysis for a given Author

Both data bases allow an analysis for a given author. As an example, Jens Wickert, the author with the highest number of records, was selected in the following, and screen shots of the options are provided for Scopus and Web of Science below.

6.1 In Scopus

Please find below some screen shots of what Scopus allows on an analysis for a selected author.

A few remarks:

- the analysis is only available from 2001 onwards.
- there are inconsistencies in naming of authors, duplications, authors with similar names, etc. in Scopus. Hence the total numbers shown here needs to be taken with some care.
- the range of publication years cannot be selected when doing the analysis. Thus at the time the analysis for author J. Wickert was run he already had some papers published in 2015 (while the scope of this document does not include 2015).

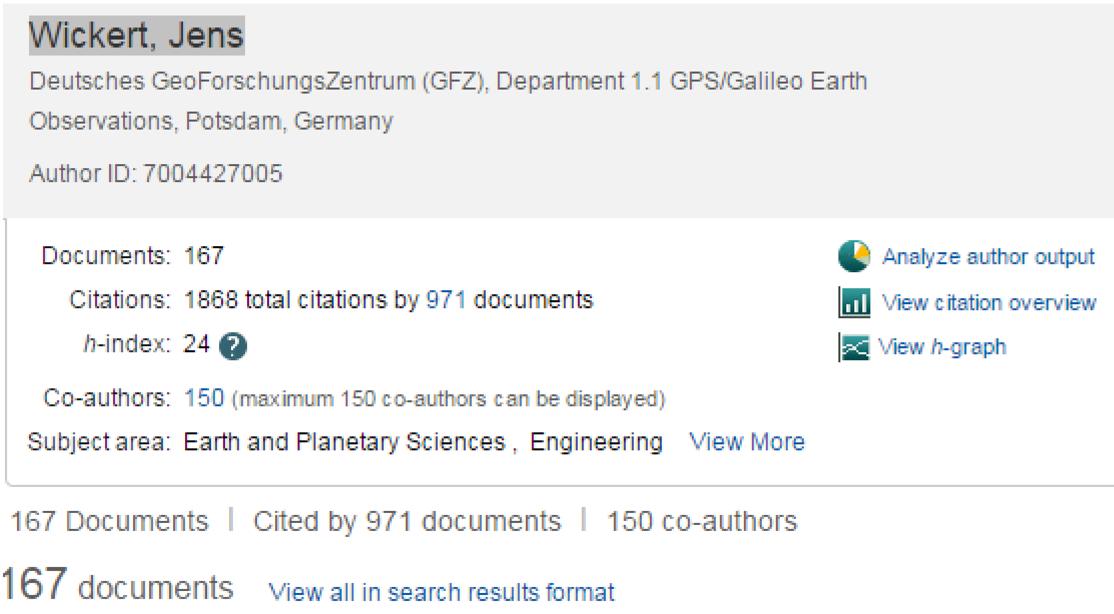

Figure 2 Overview of the author's records in Scopus with citation information

NB: for explanations on the h-index see Section 5.2.

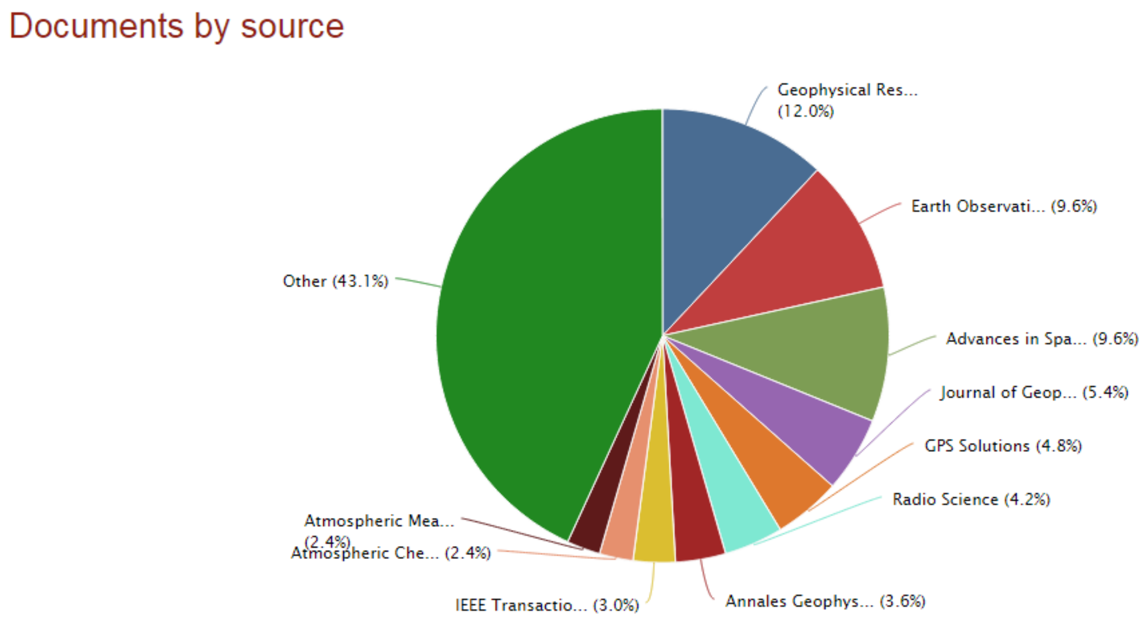

Figure 3 Distribution of the author's papers in journals by journal title

6.2 In Web of Science

Please find below some screen shots of what Web of Science allows on analysis for the selected author.

Results found:	193
Sum of the Times Cited [?] :	1658
um of Times Cited without self-citations [?] :	1243
Citing Articles [?] :	795
Citing Articles without self-citations [?] :	693
Average Citations per Item [?] :	14.42
h-index [?] :	23

Figure 4 Overview of the authors records in WOS with citation information

The entries shown in Figure 6 are:

- *Results Found*: total number of articles by this author found in Web of Science.

- *Sum of Times Cited*: displays the total number of citations (cited references) to all of the items found in the results set.
- *Sum of Times Cited without Self-Citations*: the total number of citations (cited references) to all of the items found in the results set minus any citation from articles in the set.
  For example, Smith AJ has published seven articles that were cited a total of nine times. Two of these articles, however, have cited three of the articles in the results set:

Times Cited Count	= 9
Cited References	= 3 (self-citations)
Sum of Times Cited without Self-Citations	= 6

- *Citing articles*: the number of articles that cite the author.
- *Citing articles without self-citation*: the total number of articles citing the author minus any article by the author citing himself.
- *Average Citations per Item*: a simple formula that calculates the average number of citing articles for all items in a set. It is the *Sum of the Times Cited* count divided by the number of results found.
- *h-index*: index that attempts to measure both the productivity and citation impact of the published body of work of a scientist or scholar. The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications.

  In other words, a scholar with an index of *h* has published *h* papers each of which has been cited in other papers at least *h* times. Thus, the *h*-index reflects both the number of publications and the number of citations per publication.

  The index is designed to improve upon simpler measures such as the total number of citations or publications. It serves as an alternative to more traditional journal impact factor metrics in the evaluation of the impact of the work of a particular researcher. A lot of information on its pro and cons can be found online. For the article by its author presenting the concept see here.

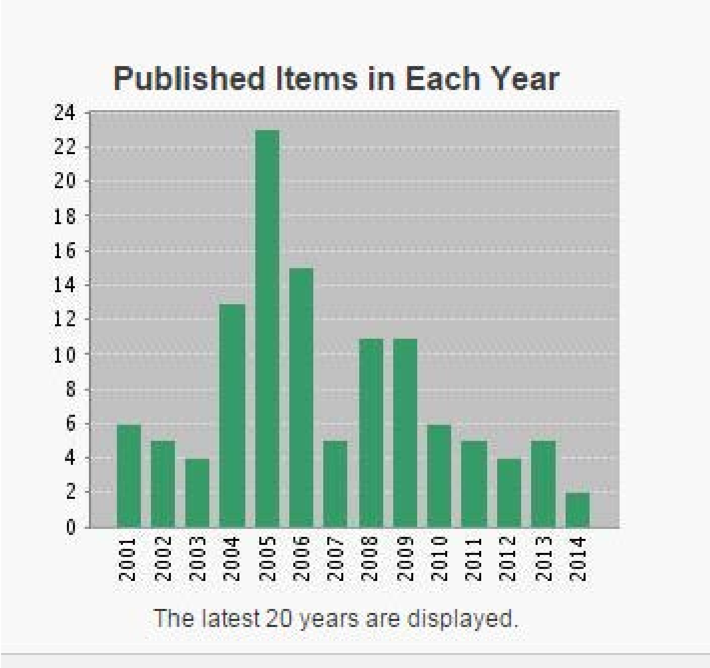

Figure 5 Distribution of selected author's papers by year of publication

7 Analysis for a given Article

This option is only available in Web of Science. Here it is possible to draw citation maps for any given article (called the target record). Due to the density of data this works best for articles with no more than 15 citations in forward or backward direction, where however most articles have more than 15 backward citations in this particular case.

Two types of maps are available:

- Forward map: to see records that cite the target record
- Backward map: to see records the target record cites

And in each case for one or two generations:

- 1st generation: the records that directly cite or are directly cited by the target record
- 2nd generation: the records citing the 1st generation records or are cited by the 1st generation records.

Within each of these generations, a variety of display options are also possible: titles of journals, years of publication, author names, etc. depending on which aspects one wishes to study.

The following target record was chosen:

Comparison of Water Vapor and Temperature Results From GPS Radio Occultation Aboard CHAMP With MOZAIC Aircraft Measurements by S. Heise; J. Wickert; G.

Beyerle; T. Schmidt; H. Smit; J. Cammas; M. Rothacher, IEEE Transactions on Geoscience and Remote Sensing, Vol. 46, No. 11, pp. 3406-3411, 2008

Example citation map for the selected target record (cited 10 times) are shown below in Figure 6 for the first generation forward and backward map and in Figure 7 for the second generation maps. Note that the full capability of such an analysis is best explored on a computer, in cooperation with a librarian as it has numerous interactive features.

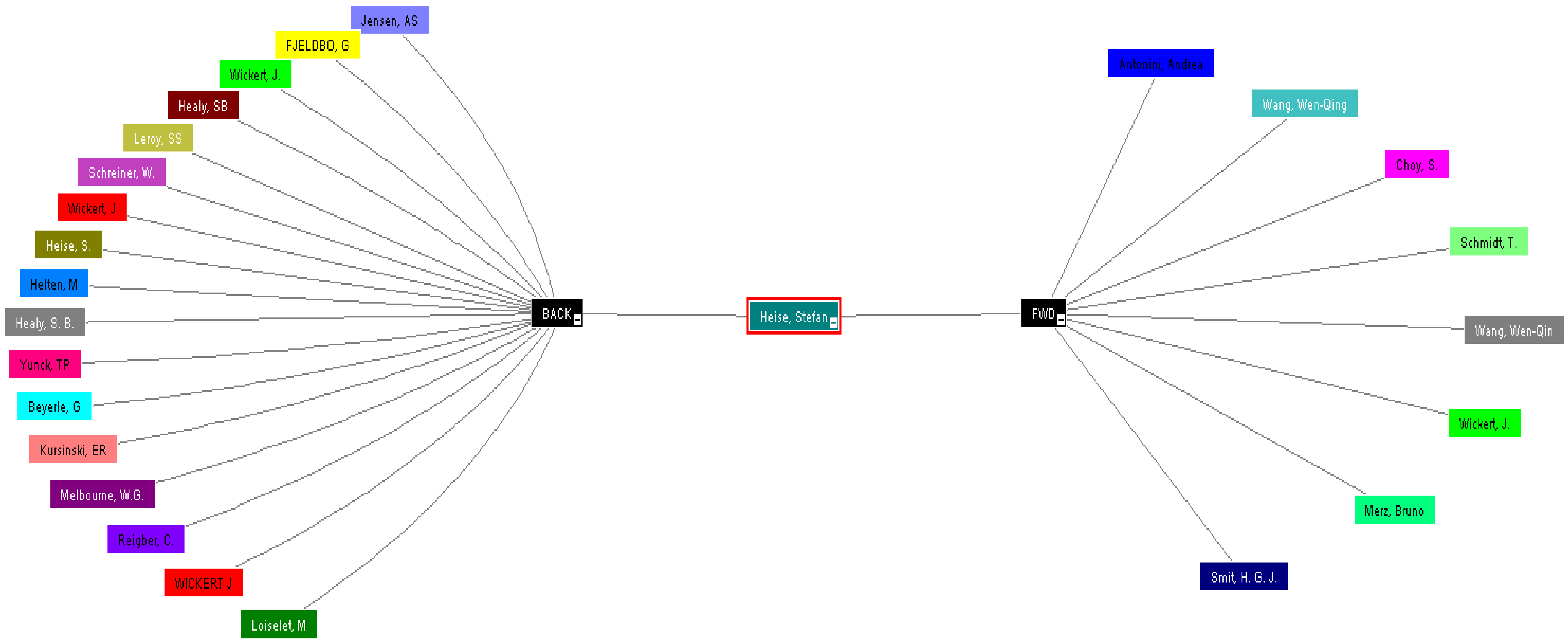

Figure 6 First Generation Forward and Backward map (nodes are the author names, colour coding is by author name)

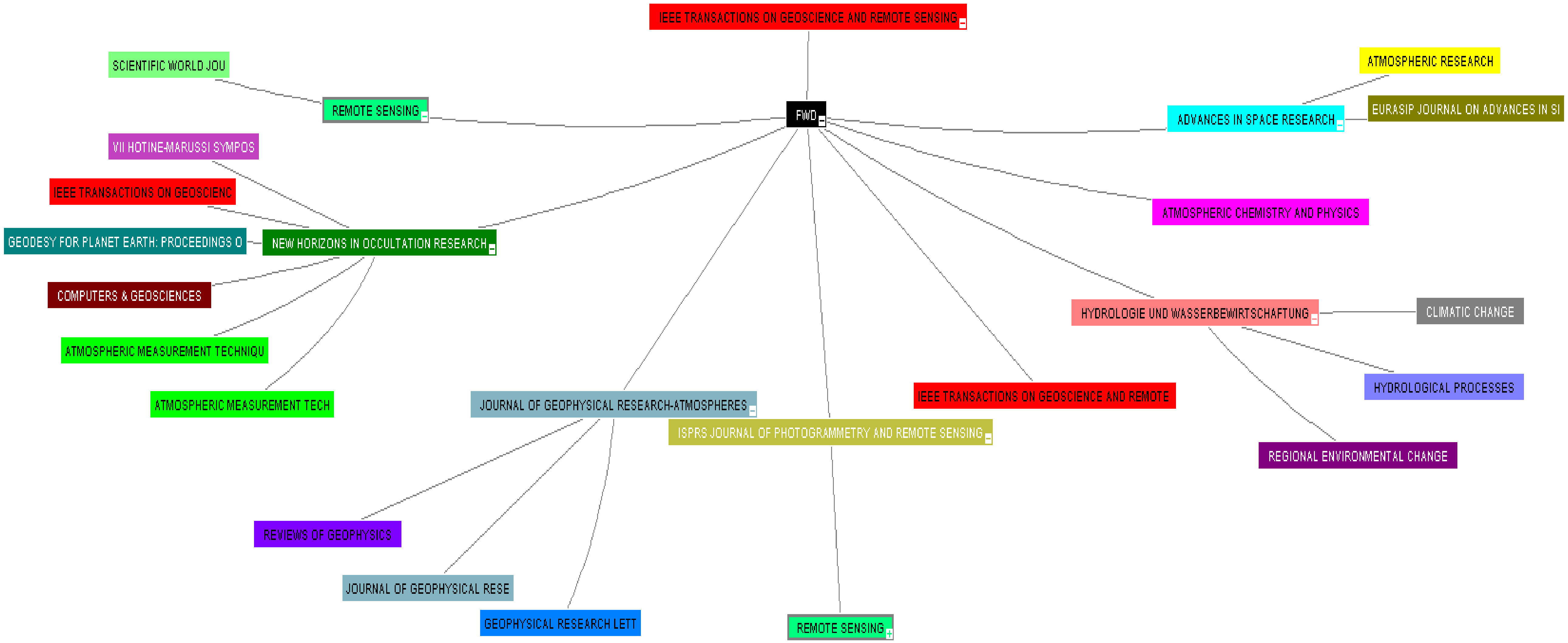

Figure 7 Second Generation Forward map (nodes are arranged and colour-coded by journal title).

8 Conclusion

The present document is a first step towards a full bibliometric analysis of Radio Occultation (RO) publication record; the idea to this bibliometric analysis was triggered by 2 recommendations made at the 5th ROM SAF User Workshop in June 2014 on use of the RO publication records. The focus of this work is on the 1990 to 2014 period, where the following bibliographic databases were used: (a) Web of Science (1200 records analysed); (b) Scopus (1169 records analysed).

The records from Web of Science are made available via Zotero as a publicly available bibliographic database and, in addition, monthly updates are provided on a best effort basis through a mailing list (see Section 1.6 above for more details).

The authors look forward to receiving feedback on and suggestions about how future editions of such a bibliographic/bibliometric analysis can be improved and updated. Please note however that this is a best effort service and EUMETSAT cannot take any commitment to provide updated records in the future.