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Recent trends in the use of remote sensing to address environmental issues

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Abstract **:** In this study, we investigated trends in the use of remote sensing (RS) to address some major global environmental issues to see if it is being increasingly or decreasingly used to address each issue. We considered several land, water, air, and integrated Earth system issues. Of the 12 environmental issues we considered, there was an increasing trend in the use of RS in 5 (deforestation, urban heat island, air pollution, water pollution, and biodiversity loss), a flat trend in 4 (forest degradation, greenhouse gas emissions, sustainable development, and ecosystem services) and a decreasing trend in 3 (desertification, ocean acidification, and climate change/global warming) from 2000-2013. The issues with flat or decreasing trends (except desertification) are generally difficult to directly observe using current RS instruments alone, which may have limited the wider use of RS in these areas. Development of new sensors or new methods for combining remote sensing with other information sources are probably needed to promote wider use of remote sensing in these areas.
Keywords **:** global environmental issues; deforestation; air pollution; water pollution; climate change; sustainability

1. Introduction

Over the past several decades, remote sensing (RS) has been used to investigate a variety of environmental issues at local to global scales. At the global scale, some important land-related environmental issues include deforestation, forest degradation, desertification, and urban heat island (UHI) effect. Some important water-related issues include water pollution and ocean acidification. Some important atmospheric issues include air pollution and greenhouse gas emissions. Finally, some integrated Earth system issues include biodiversity loss, climate change, sustainable development, and ecosystem service quantification.

The objective of this study is to investigate whether RS is having an increasing or decreasing impact on the science related to these different global issues, with the eventual goals being (i) to identify possible reasons for these trends, and (ii) to determine how to encourage RS use in the areas where it is decreasing (or lacking in general).

2. Methodology

To investigate the trends in the use of RS, we performed "title, keyword, abstract" searches in Scopus[1)], the largest data base of peer-reviewed literature, to calculate the percentage of academic studies on each issue that used (or at least discussed) remote sensing. The searches included some relevant terms for each issue (e.g. we also searched for "air quality" when considering "air pollution"). For example, to calculate the percentage of academic studies related to air pollution that involved RS, we performed the two searches below, and then for each year we divided the result of search 1 by the result of search 2.

Search 1: **"air pollution"** OR **"air quality"**
Search 2: (**"air pollution"** OR **"air quality"**) AND **("remote sensing"** or **"earth observation")**

3. Results

Trends in the use of RS to address each issue are given in Fig. 1-4. From these figures, it is clear that the trends showed significant differences even within each part of the Earth system (land, water, air, integrated). For example, among the land issues, two showed increasing use of RS (deforestation and UHI), one showed a flat trend (forest degradation), and one showed a decreasing trend (desertification).

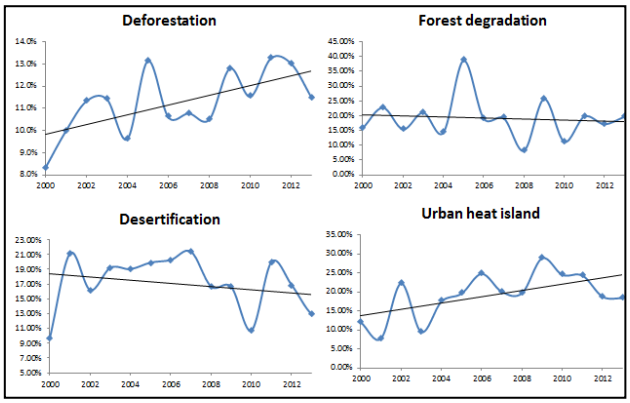

Fig. 1. Percentage of peer-reviewed papers on land-related environmental issues that involved remote sensing (RS).

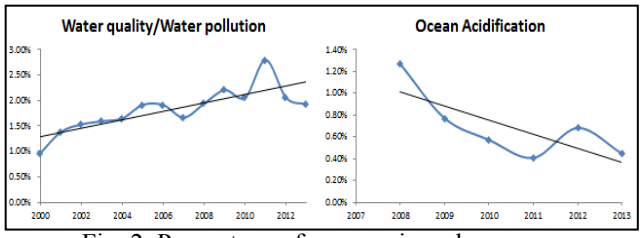

Fig. 2. Percentage of peer-reviewed papers on water-related environmental issues that involved RS. No papers on ocean acidification and RS from 2000-2007.

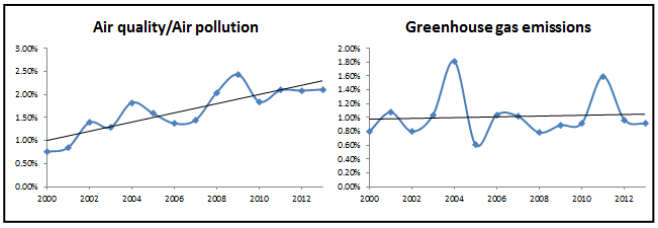

Fig. 3. Percentage of peer-reviewed papers on air-related environmental issues that involved RS.

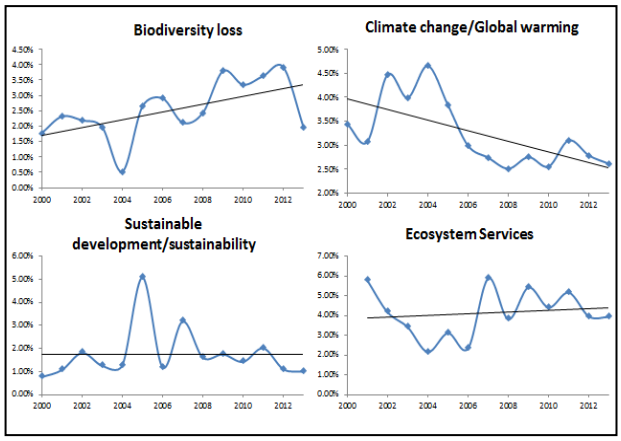

Fig. 4. Percentage of peer-reviewed papers on integrated Earth system environmental issues that involved RS. No papers on ecosystem services and RS in the year 2000.

Of the 12 issues we considered, there was an increasing trend in the use of RS in 5 (deforestation, urban heat island, air pollution, water pollution, and biodiversity loss), a flat trend in 4 (forest degradation, greenhouse gas emissions, sustainable development, and ecosystem services) and a decreasing trend in 3 (desertification, ocean acidification, and climate change/global warming) since the year 2000.

One possible reason for the increasing trends for some issues may be due to improvement in the resolution (spatial, spectral, or temporal) of optical (i.e. visible, near infrared, and shortwave infrared) and thermal-infrared sensors, or the increasing availability of free optical and thermal data (e.g. Landsat, MODIS imagery). For example, deforestation and UHI studies are now being done at spatial scales of ~1m resolution or finer using commercial satellite data.

Reasons for flat or decreasing trends in some areas may be due to the difficulty of directly observing the phenomenon using current sensors, either due to the design of the current sensors or the need to incorporate non-RS data for analysis (e.g. economic statistics). For example, in terms of sensor specifications/data availability, forest degradation is still difficult to accurately map using current optical and synthetic aperture radar (SAR) sensors, and the availability of free SAR data has not increased significantly (aside from free historical ALOS-PALSAR data made available by JAXA [2)]). It is anticipated that the recent (ALOS-2) and next generation (e.g. NISAR) high resolution L-band SAR sensors will improve forest degradation mapping accuracy. Desertification is not necessarily difficult to detect using current sensors, but desertification studies may have benefitted little from improvements in sensor resolution due the relatively coarse scale at which it often occurs, which may have limited the expanded use of RS in this area. In terms of the integrated Earth system issues, most of which require the additional use of non-RS data for analysis (i.e. climate change, sustainable development, ecosystem services, and in some cases biodiversity loss), it seems that RS is not making significant progress, as there was a flat or decreasing trend for all but biodiversity loss. So, there is a need to increase interdisciplinary research if we want RS to play an increasingly important role in the science and knowledge related to these issues, as simply improving sensor specifications is unlikely to lead to wider usage.

4. Conclusions

In this study, we investigated the trends in the use of RS to address some important global environmental issues in the 21st century (2000-2013). We found the trends varied widely from issue to issue. It is likely that the increasing trends for some issues (e.g. deforestation) were due the improvements in sensor resolution or better access to (free) data, while flat or decreasing trends were likely due to: (a) lack of sensor improvement to address that specific issue, (b) a relatively slow pace at which interdisciplinary research is increasing, or (c) a combination of both (a) and (b). Improvements in sensor and/or study design are necessary to ensure RS plays an increasingly important role in the science related to these global environmental issues.

5. Acknowledgments

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6. References

1) http://www.scopus.com/
2) http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm

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