The benefits to climate science of including Early Career Scientists as reviewers

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Abstract. Early Career Scientists (ECS) are a large part of the work force in science. While they produce new scientific knowledge that they share in publications, they are rarely invited to participate in the peer-review process. Barriers to the participation of ECS as peer-reviewers include, among others, their lack of visibility to editors, inexperience in the review process and lack of confidence in their scientific knowledge. Participation of ECS in group reviews, e.g. for assessment reports, provides an opportunity for ECS to advance their skill set and to contribute to policy relevant products. Here, we present the outcomes of a group peer-review of the first order draft of the Intergovernmental Panel on Climate Change Special Report on Ocean and Cryosphere in a Changing Climate (IPCC SROCC). Overall, PhD students spent more time on the review than those further advanced in their careers, and provided a similar proportion of substantive comments. After the review, participants reported feeling more confident about their skills, and 86% were interested in reviewing individually. By soliciting and including ECS in the peer-review process, the scientific community would not only reduce the burden carried by more established scientists, but permit their successors to develop important professional skills relevant to advancing climate science and influencing policy.

1. Introduction

Acting as peer-reviewers is an important opportunity for scientists to recognise the components of strong scientific papers and it can help to improve the quality of their own work (Silver, 2016;Lerback and Hanson, 2017). While several training

opportunities exist for Early Career Scientists (ECS) to bolster their voice and develop writing skills and leadership (Geffers et al., 2017), only 6% of journal articles are reviewed by ECS (Taylor and Francis, 2016).

45 Global assessment reports rely on reviewers from multiple regions and diverse scientific disciplines to ensure that they are scientifically accurate and are widely understandable. Here, we focus on a report produced by the Intergovernmental Panel on Climate Change (IPCC), that provides an assessment of the scientific, technical and socio-economic literature on the current state of knowledge on climate change (IPCC, 2013a). Ensuring effective climate change adaptation and mitigation requires policymakers to be informed by the scientific community through robust and evidence-based reports reflecting the
50 scientific consensus (Bolin, 2007;Tollefson, 2010;Ding et al., 2011;Lewandowsky et al., 2013). To best achieve this goal, the scientific community requires the inclusion of scientists from heterogeneous backgrounds and experience (Maibach et al., 2014;Hallegatte et al., 2016), including ECS, who can provide diverse perspectives. Each IPCC report undergoes a multistage review process by expert and government representatives (IPCC, 2013b). For example, the Working Group I Fifth Assessment Report (WGI AR5) attracted comments from 1089 expert reviewers from 55 countries. While no individual possesses the required expertise to review an entire IPCC report, as a group, ECS have also proven to be efficient and
55 motivated reviewers, providing added value to this type of manuscript (van der Veer et al., 2014). By serving as reviewers, ECS support the IPCC assessment process, and learn more about interdisciplinary endeavours while developing new skills for synthesising their own research into the limited scope of a publishable paper.

Through the Association of Polar Early Career Scientists (APECS), ECS were recruited to participate in a group review of
60 the First Order Draft (FOD) of the IPCC Special Report on Ocean and Cryosphere in a Changing Climate (SROCC). APECS is an international and interdisciplinary network for undergraduate and graduate students, postdoctoral researchers, early career professionals, educators, and others interested in Polar and Alpine Regions, and the wider Cryosphere (Allen et al., 2014). While most ECS in APECS are PhD students or Post-docs, membership also includes Master students, Undergraduate students, Early Academics and other educators. APECS thus organised a group review of the SROCC which included 75
65 ECS from 22 of the countries within the APECS network (Fig. 1a). The pool of reviewers was composed of 38 women and 37 men. Earth Sciences were most represented among the reviewers, while other disciplines included Biology, Geography, Social Sciences and Civil Engineering (Fig. 1b).

Recognising that many of the reviewers had neither published a paper nor participated in a peer-review before, APECS
70 designed a comprehensive training program, providing ECS with a rigorous reviewing frame, ensuring that the reviews produced would all be of equal quality. Here, we report the first results of this program, and highlight that the comments quality of a reviewer is not influenced by the career level. We first describe the methods, how the group review was organised and the statistics applied for this study. We then make use of the statistics and of the response to a survey to explore the quality of comments by career level. Finally, we conclude with a list of propositions for editors to encourage the
75 inclusion of ECS into review processes.

2. Methods

The review itself was separated in two phases: four weeks during which the participants worked individually on their attributed pages (see section 2.3), and three weeks during which the project leaders reviewed the comments, and sorted them into three categories: *substantive, editorial,* and *unfit for submission*.

80 ### 2.1. Organisation and Recruitment

The project was led by ten council members of APECS from various academic levels: Master (1), PhD (4), Post-doc (3), and Early Career Academics (2), representing six different countries (Canada, Chile, France, Germany, Italy and USA). Each chapter was chaired by two to five of these project leaders, whose roles were (a) selecting the applicants, (b) assigning chapter sections to the participants, (c) reviewing and sorting the comments (e.g. finding duplicates), and (d) finalising the
85 global review sent by APECS.

The call for participants, published on the APECS website, received 153 applications. Among the applicants, 72% had already reviewed a scientific document (such as a paper, a proposal or a scientific report). Not all chapters received the same number of applicants (the outline of the report can be found here : https://www.ipcc.ch/site/assets/uploads/2018/11/Decision_Outline_SR_Oceans.pdf). For instance, the chapter on Polar Regions (estimated at 50 pages) was requested by 110 applicants, while the chapter on Changing Ocean, Marine Ecosystems, and Dependent Communities (estimated at 65 pages) was only requested by 33 applicants.

As the number of applications from less experienced scientists (PhD students and below) was roughly equal to the number of Post-docs and Early Career Academics, it was decided to review the applications separately, opening the same number of positions for both categories. The selection criteria were: (1) motivation, (2) experience and relevance of the application, (3) country of residence, and (4) equal distribution amongst chapters, meaning that applicants who applied to more than one chapter were often assigned to a secondary choice.

Table 1: Number of participants and their countries of origin (including the project leaders), see also Figure 1a).

Countries	Number	Countries	Number
Australia	5	Italy	2
Belgium	1	Mexico	1
Brazil	1	New Zealand	3
Canada	8	Norway	3
Chile	3	Poland	1
China	1	Spain	1
Denmark	1	Sweden	2
France	4	Switzerland	1
Germany	10	The Netherlands	2
Iceland	1	United Kingdom	10
India	3	USA	11
		Total	75

The resulting selection of participants in the review process strongly reflects the established network of APECS members and mailing list recipients (Table 1). While gender was not a criterion for selection, 51% of the participants were women. Only 5 of the 22 countries represented are developing countries/economies in transition. The selected participants included a majority of PhD students, a similar number of Post-docs and Early Career Academics, and only two undergraduate and Master students (Table 2).

Table 2: list of academic levels of the participants (including the project leaders)

Level	Number
Undergraduate and Master	2
PhD	31
Post-doc	23
Early Career Academics	19
Total	75

2.2. Training of the reviewers

In order to introduce the review process to participants, a guide was created by the project leaders from APECS, validated by the APECS Executive Director, and reviewed by two members of the IPCC Technical Support Units (TSU) from the two
115 Working Groups (WGs) providing scientific leadership to the SROCC (WGI: The Physical Science Basis and WGII: Impacts, Adaptation and Vulnerability). This guide explained the process including the objectives, timeline, leadership and rules. The guide is available in the supplementary materials.

Two series of online workshops were organised to train the participants in the review process. To facilitate participation
120 from numerous time zones, two sessions were organised for each workshop series at different times and recordings were made available for later viewing (session 1: https://vimeo.com/292679338, session 2.1: https://vimeo.com/292679417 and session 2.2: https://vimeo.com/292679451). Each online workshop lasted between 1.5 and 2 hours.

The first series of workshops was conducted by IPCC TSUs (WGI: Sarah Connors, WGII: Katja Mintenbeck and Elvira
125 Poloczanska) who introduced the IPCC, discussed what was new in the SROCC, and advised participants on what entailed a constructive review. The second workshop involved Vice-Chairs of WGI and WGII and was held after the distribution of the respective chapters and sections to the participants. Greg Flato (Canada, WGI Vice Chair, workshop session 1) and Andreas Fischlin (Switzerland, WGII Vice Chair, workshop session 2) discussed the use of the IPCC uncertainty language (https://www.ipcc.ch/site/assets/uploads/2018/05/uncertainty-guidance-note.pdf). Other tips for reviewers were provided by
130 Carlos Mendez (Venezuela, WGII Vice Chair) and Jan Fuglestvedt (Norway, WGI Vice Chair) for the first and second session, respectively. All documents shared during these workshops (i.e., power point presentation, minutes) were made available to the participants for later viewing. Furthermore, the guide was amended during the training process to include updated information.

2.3. Organisation of the group review

135 Each chapter was distributed by the project leaders to the participants. Depending on the number of participants for each chapter, 10 to 20 pages were assigned to each participant. We attempted to assign whole sections as much as possible. We also attempted to balance the workload and in some instances, reviewers were assigned non-contiguous sections to even out the number pages they were responsible for.

140 Each selection of pages was given to at least two categories of participants: University students (bachelor, master and PhD students), and Post-doc or Early Career Academics. The initial purpose was to promote interactions amongst participants during the review process, and in particular, to encourage more experienced ECS to provide advice. Based on the participants' feedback, it seems that such an exchange between the paired participants did not ultimately occur, and solutions to enhance this mentoring will be applied in the next round of reviews of the SROCC.
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Though participants themselves chose the chapter which they would have to review, a significant number of concerns were raised from participants that felt that the section they were assigned did not correspond to their particular expertise. While this was a valid concern, it was not possible to screen which section would be best suited for each participant and still cover the entire report, as the content of the report was unknown beforehand. As the primary purpose of this report is to inform
150 policymakers, who will not necessarily have the scientific expertise of the content of the report, having peripheral expertise would not preclude participants' ability to review a given section, and instead we deemed this an asset. In the forthcoming round of the group reviews, applicants will request the specific sections that they want to review rather than chapters, in order to have a more specific application process.

155 The participants had a month to review their attributed section. After the deadline, project leaders spent another month compiling the 2155 received comments into one document, removing potential duplicate comments, and filtering those interpreted as out of the scope (see Fig. 1) to ensure the quality of the comments transferred to IPCC. The total workload of

the participants was less than the project leaders, who spent an estimated 40 hours to prepare the project, participate in the webinars, read the different chapters in which they were involved, and sort all the comments. Following discussions with authors of IPCC reports and with members of the IPCC TSU, the 2155 comments were sorted by the project leaders as *editorial*, *substantive*, and *unfit for submission*. *Editorial* comments corresponded to suggestions such as copy editing and reference corrections, *substantive* comments were those indicating errors, the need for new and more relevant references, and new content. *Unfit for submission* included mostly duplicates from several reviewers, and in some rare cases, inappropriate comments. This procedure resulted in a list of 2012 comments submitted to the IPCC. This sorting and organisation was carried out during the three weeks that followed the receipt of comments from the participants, leaving five days to combine the selected comments and to upload them on the IPCC website.

2.4. Analyses of the number of comments

As described above, the comments were sorted by the APECS project leaders, and not by the IPCC. Nonetheless, as the same criteria were endorsed and applied by all project leaders, no obvious difference in the distribution of comments from group review participants was evident.

Statistical analyses of the different number of comments were conducted to evaluate the significance of the obtained figures. The average number of comments per person was 31.8 ± 4.6 (errors on the average, sample size n = 61). The average numbers of comments for PhD, Post-docs and Early Career Academics are 39.9 ± 6.9, 28.9 ± 7.7 and 34.9 ± 9.5 respectively (sample sizes n = 26, 21 and 14 respectively). These three figures are not significantly different. However, the comments of only one participant from the Undergraduate and Master academic level were obtained (the second one only acted as a project leader and did not provide comments), thus these were not included in the analyses.

For the proportion of *substantive*, *editorial* and *unfit for submission* comments, no significant differences between either the number or the proportion was found for each of the three academic levels detailed here. As the distribution of number of comments for each category and academic level were not normal, we performed a Kruskall Wallis test and obtained $\chi^2 = 0.080$ and a p-value = 0.957, confirming that there were no significant differences in the proportion of comment types for each academic level.

In contrast, the average time spent by reviewers from each academic levels was significantly different ($\chi^2 = 7.16$, p-value = 0.067) with groups varying by roughly one hour, and the average error for each academic level below ± 0.6 hour.

3. Results and discussion

The participants produced a total of 2155 comments, with a mean of 31.8 comments per participant. Of the 2155 comments collected, 693 were considered *substantive*, 1319 were considered *editorial*, and 143 were considered *unfit for submission*. To explore potential links between the type of comments made by the participants and their academic level, the average numbers of comments (divided by category - *substantive*, *editorial* or *unfit for submission*) were plotted by academic level (PhD, Post-doc, Early Career Academics, see Fig. 1c). PhD students provided the largest number of comments per participant (almost 40), of which 30% were *substantive* comments. Post-docs and Early Career Academics provided a slightly higher percentage of *substantive* comments with 34% and 36% respectively. The number of *unfit for submission* comments was highest for Early Career Academics (10%), followed by PhD students (6%), and Post-docs (4%). Amongst the different academic levels, no significant difference in the total number and category of comments was noticeable between the different career stages (see statistical analyses in Methods).
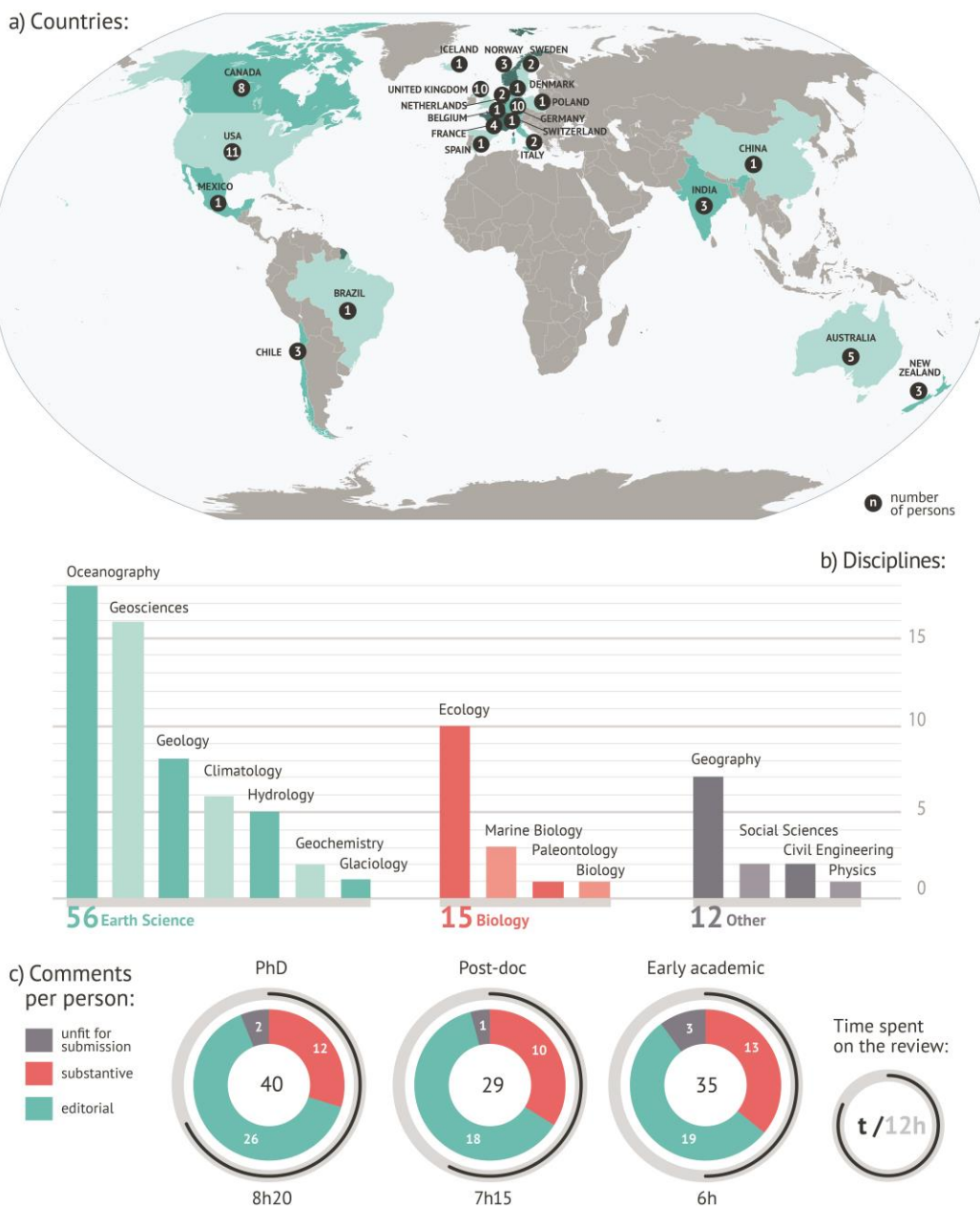
Figure 1: Summary of the results from the APECS group review: a) geographical distribution of ECS who participated in the process, and the number of participants per country, b) disciplines of the participants involved in the group review and c) comments and time spent per participant by academic stage.

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205 Compared to the 388 other expert reviewers of the SROCC FOD, the APECS group review (accounting for a single reviewer) provided 2012 comments to the SROCC authors, which is 18% of the 12002 total number of comments (Personal communication, IPCC). The 388 other experts produced on average 26 comments per person, slightly less than the ECS

participants (31.8, the difference being above 1 standard deviation) who had only 10 to 20 pages each to review, rather than an entire chapter.

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The PhD students provided as many substantive comments as the more experienced participants of the group review (i.e. Post-docs and Early Career Academics), thus the length of the academic career was ruled out as a factor in the ability to effectively produce reviews. The comparison with other expert reviewers also supports that ECS are as productive and efficient reviewers as their more senior peers (Schiermeier, 2016). As 20% of researchers take on 70 to 90% of the peer-

215   review burden (Kovanis et al., 2016;Taylor and Francis, 2016), the peer-review process would be more equitably distributed across the scientific community by the solicitation and inclusion of PhD students and other ECS as peer reviewers. Widening the reviewer pool could also reduce potential conflicts of interest in the review process and increase its quality. This latter aspect is particularly relevant for the climate change community considering the need for transparency in the peer-review process (Edwards and Schneider, 2001).

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Following the completion of the group review, participants were surveyed on their experiences. On average, the participants spent 7 hours preparing prior to the review. Half of this time was spent reviewing the guide. The other half was spent attending the two training webinars on the review process and answering pending questions. Nearly all (98%) of the participants stated that the amount of training provided was adequate.

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APECS participants spent an average of 7.3 hours reviewing their assigned content (10 to 20 pages, Fig. 1). However, 6% of the participants spent less than 3 hours on the review, and 35% spent 10 hours or more. Overall, participants spent less time than they had anticipated (35 hours) on the review. The relatively reduced time commitment might make participating in future IPCC reviews more appealing to ECS. Indeed, based on the survey responses, the time spent to review a chapter of an

230   IPCC report (between 80 and 120 pages) can be estimated at less than one week for reviewers of all career stages.

Participants were asked about their willingness to take part in another review as part of a group, or individually (Fig. 2a). The majority (92%) of participants stated that they would take part in another group review and 86% reported that they would participate in an individual review, adding more than 60 potential reviewers to the Climate Change community.

235   Compared to the total number of experts who reviewed the FOD of the SROCC (389, including participants of the APECS group review), this means including more ECS in the peer-review process is a significant addition to the pool of expert reviewers.. We expect similar results for other scientific fields, and hope that other professional societies will consider collaborating in such group reviews in the future.

240   The most common motivations that ECS stated for participating in this review process were learning more about the IPCC (59%) and experience building (53%) (Fig. 2b). These survey responses, combined with the time commitment that reviewers within our group were ready to invest in this project (7 hours of preparation, and up to 35 hours on the review), indicate that ECS are highly committed to opportunities that involve international policy-relevant processes. ECS also value the experience of learning how to review and improve manuscripts. For example, 82% declared having achieved personal goals

245   by participating in this review.

Prior to the review, one major concern of many participants was a lack of confidence in the value of their feedback to IPCC, either because they were unsure about the quality of their comments or the sufficiency of their expertise, as the report covers a large ensemble of disciplines that might not fit their breadth of experience. Because the primary audience of IPCC reports are policymakers and stakeholders who may not have scientific backgrounds, IPCC reports should be written

250   unambiguously. Even ECS who do not have expertise in a particular topic can still provide constructive comments that strengthen the clarity of a report and the discussion of key concepts. Thus, in our group review, participants could choose the chapter they wished to review, but we randomly attributed within this chapter the sections they actually reviewed, regardless of their expertise or desire. There is no evidence that this attribution process influenced the quality of their comments.

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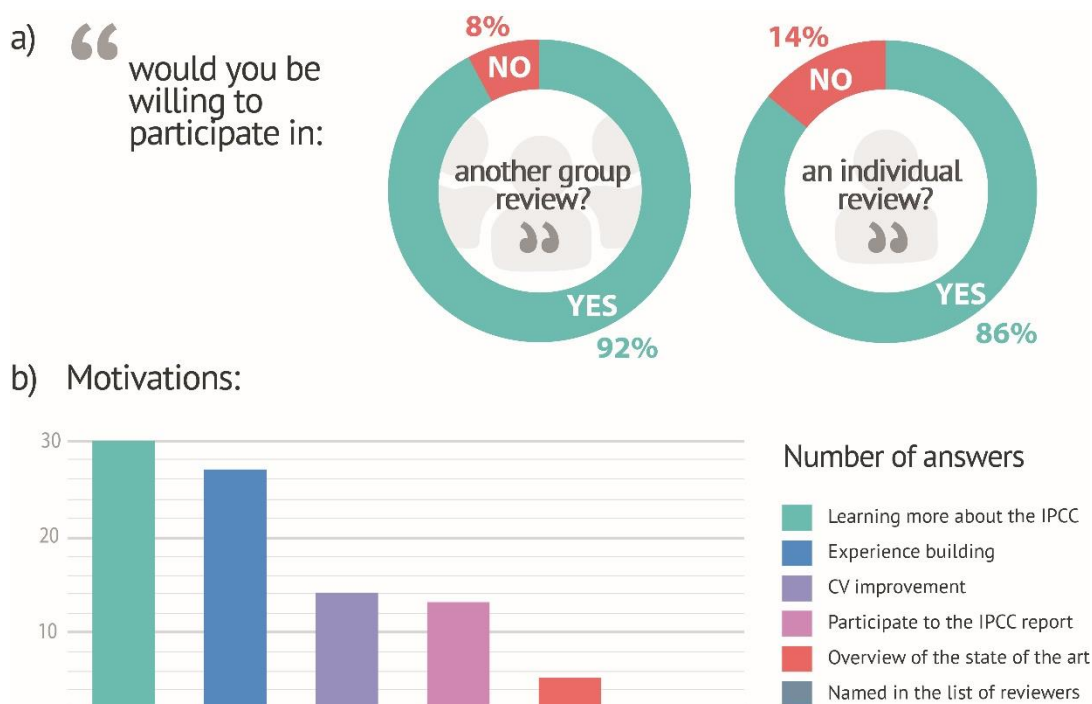
Figure 2: a) Participants' answers to the questions: "Would you be willing to participate in another group (left panel) and/or individual (right panel) review?", and b) motivations to participate in such a review.

4. Conclusion

This review included a large and diverse group of ECS, both in terms of disciplines and countries represented. Participating in such a project furthers ECS career development (Moore et al., 2018), particularly in building skills towards connecting science and policy (Petes and Meyer, 2018). It was also an opportunity for ECS to gather ideas for their future research projects as knowledge gaps are clearly identified in the reports. The climate change scientific community needs to train more scientists to tackle future challenges (Goswami et al., 2015), and this type of initiative represents a valuable mechanism to prepare future IPCC authors. Influencing the policy making process requires persistence (Weible et al., 2012), thus, by including ECS in the review of IPCC reports, which are mandated by the United Nations Environmental Program (UNEP) and the World Meteorological Organization (WMO), the probability that they have an impact on climate related policy during their careers increases (Evans and Cvitanovic, 2018).

Participating as reviewers has many benefits for ECS, and ultimately increases the reviewer pool, which could alleviate the workload of senior scientists. Benefits may include, but are not limited to: 1) enhancing the scientific rigour of journal articles and reports that support policy making processes; 2) developing skills such as time management, responsible authorship, review and publication practices; and 3) getting recognition for critical review skills within the scientific community

APECS is a volunteer-driven, professional society that seeks to provide career development opportunities for ECS. APECS recognises the valuable contributions that ECS make to furthering international scientific efforts and communicating the results of these studies to policymakers and the public. APECS organised and trained ECS to review a large policy relevant scientific report because there are few peer-review trainings for ECS. APECS hopes that this initiative, which demonstrated

that ECS can serve as adequate peer-reviewers, will inspire journal editors and report managers to include more ECS as reviewers.

285 There are several scientific societies, that support climate change research and ECS, which could organise their own group review of future IPCC draft reports. While we use the review of the IPCC report as a case study for the climate change community, we expect that similar results would be found for ECS across scientific disciplines. We note that advice for ECS to produce robust reviews can easily be found (Schiermeier, 2016;Silver, 2016), so instead, we offer recommendations to editors of journals and managers of assessment reports to include more ECS in their review processes:

290 - Proactively seek to include at least one ECS when inviting reviewers for a manuscript. This could be accomplished by requesting that senior reviewers suggest a suitable ECS to review the manuscript,
- Include ECS as guest editors. This would diversify perspectives of editorial boards,

- Encourage reviewers to review the sections of a manuscript they feel most comfortable with. This may facilitate participation both for new reviewers and senior scientists who may be too busy to review the entire manuscript,

295 - Keep reviewers blind to other reviewers' comments during the review phase. This will facilitate independent feedback, especially for ECS, who may hesitate to disagree with more senior reviewers, and
- Ask the senior reviewers of a group review to supervise ECS as an efficient training method (De Vries et al., 2009;Walker, 2018) – potentially using ECS-based networks (e.g. APECS) as a focal point for such trainings, in particular for thematic special issues.

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