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Attorneys for Plaintiffs

UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

KELSEY CASCADIA ROSE JULIANA; **XIUHTEZCATL TONATIUH M.**, through his Guardian Tamara Roske-Martinez; et al.,

Plaintiffs,

v.

The UNITED STATES OF AMERICA; et al.,

Defendants.

Case No.: 6:15-cv-01517-AA

DECLARATION OF JULIA A. OLSON in Support of Plaintiffs' Response in Opposition to Defendants' Motion to Stay Litigation

I, Julia A. Olson, hereby declare and if called upon would testify as follows:

1. I am an attorney of record in the above-entitled action. I make this Declaration in support of Plaintiffs' Response in Opposition to Defendants' Motion to Stay Litigation. Doc. 419. I have personal knowledge of the facts stated herein, except as to those stated on information and belief.
2. Throughout discovery and during meet and confer sessions in preparation for trial, Defendants have been unwilling to stipulate to any facts outside of those facts that were admitted in their Answer, including facts contained in federal government documents which Defendants admit are authentic. As a result, Defendants' failure to so stipulate needlessly necessitates the introduction of a larger number of documents and testimony than otherwise would be required.
3. Since April 2018, Plaintiffs have incurred significant litigation costs in expectation that trial would commence on the ordered trial date of October 29, 2018. These litigation costs include, but are not limited to: costs of travel to depositions; costs of deposition transcripts and recordings; costs of preparing to submit exhibits; costs of trial demonstratives; and costs of travel and lodging for expert witnesses for trial testimony.
4. Plaintiffs also expended a significant amount of time and resources to ensure that all of the Youth Plaintiffs and their experts will be in Eugene, Oregon, and prepared to testify at trial beginning October 29, 2018. Many of the Youth Plaintiffs arranged their school schedules so that they could attend and testify at trial, with some making arrangements to temporarily live in Eugene so that they can attend the entirety of the trial. All of those plans had to be cancelled, at financial, emotional, and time costs to

Plaintiffs. I witnessed some of the Plaintiffs, who are children, cry when we told them their trial would not begin as planned.

5. Plaintiffs also had made and confirmed travel arrangements for each of Plaintiffs' experts to come to Eugene and testify in accordance with a trial schedule commencing October 29. Experts were to travel to Eugene from throughout the United States, and as far away as the United Kingdom and Australia.
6. All of Plaintiffs' experts are donating their services *pro bono* and have already invested a significant number of hours in preparing expert reports, sitting for depositions, and managing their schedules to be in Eugene to testify, sometimes at great logistical challenge, only to then have to reroute travel and reconfigure plans.
7. As a result of the temporary administrative stay ordered on October 19, Plaintiffs were unable to commence their case-in-chief on October 29. As of the date of this Declaration, a new date for the commencement of trial had not been set. On November 8, 2018 a three-judge panel of the Ninth Circuit Court of Appeals, consisting of Chief Judge Thomas and Circuit Judges Berzon and Friedland, ordered a temporary stay of trial "pending this court's consideration of this petition for writ of mandamus" ("temporary stay order"). A true and correct copy of the temporary stay order is attached to this Declaration as **Exhibit 1**.
8. Plaintiffs anticipate filing their response to Defendants' Petition in the Ninth Circuit on or before November 16, in order to facilitate the Ninth Circuit Court of Appeals' earlier consideration of Defendants' Petition. Plaintiffs also anticipate requesting reconsideration from the Ninth Circuit of its temporary stay order

9. As a practical consequence of the Ninth Circuit's order of a temporary stay of trial, when this stay is lifted Plaintiffs' witnesses for their entire case-in-chief will now need to be rescheduled in order to ensure that this Court has the benefit of a fully-developed factual record where this Court can consider and weigh evidence from both parties. Given the professional obligations and limited availability of Plaintiffs' experts, rescheduling their testimony will be extremely difficult. Plaintiffs have already incurred significant expenses in cancelling and rescheduling travel and accommodation for the Youth Plaintiffs and their experts.

10. The difficulty of rescheduling trial testimony and the expenses incurred so far as a result of the Supreme Court and Ninth Circuit's temporary stay orders will only be compounded by any further delay or stay of litigation.

11. With respect to Plaintiffs' expert witnesses, climate change science is a rapidly-evolving field. Significant developments in climate science have already occurred since the Supreme Court's order of an administrative stay on October 19, 2018. As one example, on October 23, the U.S. National Oceanic and Atmospheric Administration ("NOAA") released updated forecasts projecting significant risks of another mass coral bleaching event in 2019. A true and correct copy of two of NOAA's forecasts for November 2018 to February 2019, retrieved from NOAA's Coral Reef Watch website on October 26, 2018, and included in Plaintiffs' trial exhibits as Exhibits 1939 and 1940, are attached to this Declaration as **Exhibit 2**.

12. As a further example, on November 1, a peer-reviewed journal article entitled "Quantification of ocean heat uptake from changes in atmospheric O_2 and CO_2 composition" was published in the journal *Nature*. A true and correct copy of this

article is **attached** to this declaration as **Exhibit 3**. The article states, in part, that "ocean warming is at the high end of previous estimates, with implications for policy-relevant measurements of the Earth response to climate change, such as climate sensitivity to greenhouse gases and the thermal component of sea-level rise." *Id.* at 1.

13. As a practical matter, therefore, anything other than the briefest of delays of trial will necessitate significant supplementation of a substantial number of Plaintiff's expert reports, due to the constantly-evolving state of the underlying scientific literature.

14. Delay will also require Plaintiffs to update demonstratives and exhibits Plaintiffs are preparing for trial because, as carbon dioxide levels continue to rise, climate impacts worsen, and the very harms suffered by the youth Plaintiffs continue to grow. Thus, the visual evidence will need to be continually updated so that this Court has the most up to date evidence and demonstratives at trial.

15. In correspondence with Plaintiffs' Counsel, Defendants have represented that they will seek to again depose any of Plaintiffs' expert witnesses who supplement their reports. Consequently, a stay of litigation will inevitably increase the litigation expenses of both parties and further delay trial.

16. On December 11, 2017, oral argument was held on Defendants' first Petition of Mandamus to the Ninth Circuit Court of Appeals before Chief Judge Thomas and Judges Kozinski and Berzon. I appeared for Plaintiffs in that oral argument. A true and correct copy of the excerpts of the oral argument transcript cited in Plaintiffs' Response is attached to this Declaration as **Exhibit 4**.

17. On October 22, 2018 Plaintiffs filed their Opposition to Petitioners' Application for a Stay Pending Disposition of a Petition for Writ of Mandamus in the Supreme Court.

In the Opposition, Plaintiffs set out a detailed procedural history of this Proceeding through October 22. A true and correct copy of the excerpts of Plaintiffs' Opposition cited in Plaintiffs' Response is attached to this Declaration as **Exhibit 5**.

18. On November 2, the Ninth Circuit Court of Appeals issued an order disposing of Defendants "Petition for Writ of Mandamus Requesting a Stay of District Court Proceedings Pending Supreme Court Review." A true and correct copy of that order is attached to this Declaration as **Exhibit 6**.

19. Almost exactly two years ago, November 10, 2016, Defendants' Motion to Dismiss was denied. Since then, even using the most conservative estimates, Plaintiffs, and undoubtedly Defendants, have spent *far more* than 50 days briefing Defendants' twelve motions seeking a stay (before this Court, the Ninth Circuit, and the Supreme Court); four Petitions for a Writ of Mandamus to the Ninth Circuit (one of which included oral argument); two Petitions for a Writ of Mandamus and/or Certiorari to the Supreme Court; and numerous other dilatory motions.

In accordance with 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

DATED this 9th day of November, 2018.

Respectfully submitted,

*/s/ Julia Olson*____
Julia Olson

Exhibit 1

UNITED STATES COURT OF APPEALS

FOR THE NINTH CIRCUIT

FILED

NOV 8 2018

MOLLY C. DWYER, CLERK
U.S. COURT OF APPEALS

In re: UNITED STATES OF AMERICA; et al.

UNITED STATES OF AMERICA; et al.,

Petitioners,

v.

UNITED STATES DISTRICT COURT FOR THE DISTRICT OF OREGON, EUGENE,

Respondent,

KELSEY CASCADIA ROSE JULIANA; et al.,

Real Parties in Interest.

No. 18-73014

D.C. No. 6:15-cv-01517-AA
District of Oregon,
Eugene

ORDER

Before: THOMAS, Chief Judge, BERZON and FRIEDLAND, Circuit Judges.

Petitioners' motion for a temporary stay of district court proceedings (contained in Docket Entry No. 1) is granted in part. Trial is stayed pending this court's consideration of this petition for writ of mandamus.

The unopposed motion to file an oversized petition is granted (Docket Entry No. 2).

AT/MOATT

This petition for a writ of mandamus raises issues that warrant an answer. *See* Fed. R. App. P. 21(b). Accordingly, within 15 days after the date of this order, the real parties in interest shall file an answer.

The district court, within 15 days after the date of this order, may address the petition if it so desires. The district court may elect to file an answer with this court or to issue an order and serve a copy on this court. Petitioners may file a reply within 5 days after service of the answer(s).

In addition, the parties, within 15 days after the date of this order, shall file a joint report on the status of discovery and any relevant pretrial matters.

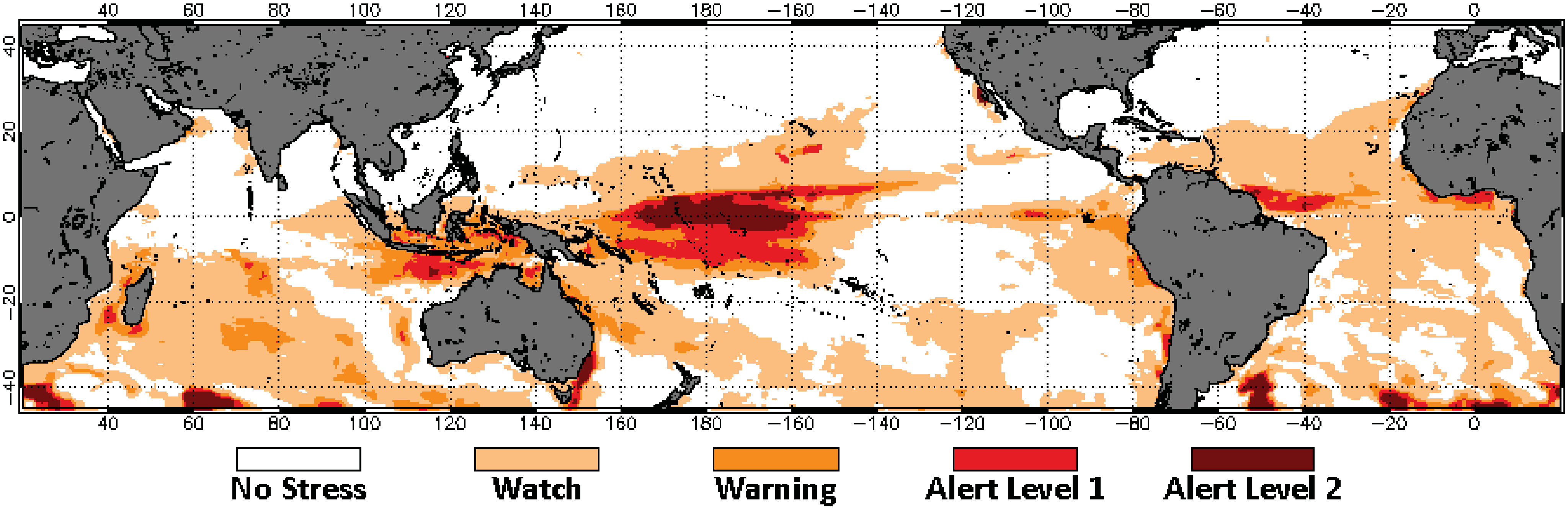
The district court is also requested to promptly resolve petitioners' motion to reconsider the denial of the request to certify orders for interlocutory review. *See* Order, *In re United States, Applicant*, No. 18-065 (U.S. July 30, 2018) (noting that the justiciability of plaintiffs' claims "presents substantial grounds for difference of opinion"); Order, *In re United States, Applicant*, No. 18-410 (U.S. Nov. 2, 2018) (same).

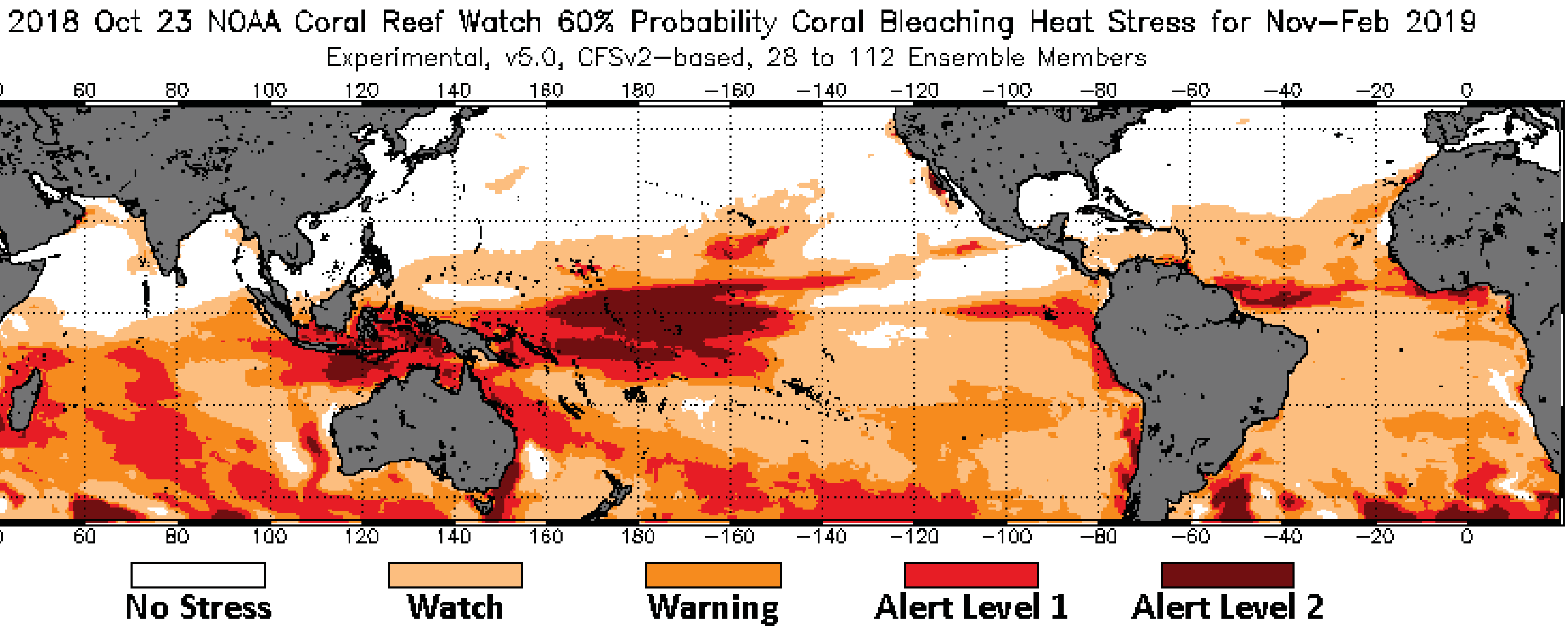
The Clerk shall serve this order on the district court and District Judge Aiken.

Exhibit 2

2018 Oct 23 NOAA Coral Reef Watch 90% Probability Coral Bleaching Heat Stress for Nov–Feb 2019

Experimental, v5.0, CFSv2–based, 28 to 112 Ensemble Members




2018 Oct 23 NOAA Coral Reef Watch 60% Probability Coral Bleaching Heat Stress for Nov–Feb 2019
Experimental, v5.0, CFSv2–based, 28 to 112 Ensemble Members
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–80
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–40
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0
40
20
0
–20
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No Stress
Watch
Warning
Alert Level 1
Alert Level 2

Exhibit 3

LETTER

https://doi.org/10.1038/s41586-018-0651-8

Quantification of ocean heat uptake from changes in atmospheric O_2 and CO_2 composition

L. Resplandy[1]*, R. F. Keeling[2], Y. Eddebbar[2], M. K. Brooks[2], R. Wang[3], L. Bopp[4], M. C. Long[5], J. P. Dunne[6], W. Koeve[7] & A. Oschlies[7]

The ocean is the main source of thermal inertia in the climate system[1]. During recent decades, ocean heat uptake has been quantified by using hydrographic temperature measurements and data from the Argo float program, which expanded its coverage after 2007[2,3]. However, these estimates all use the same imperfect ocean dataset and share additional uncertainties resulting from sparse coverage, especially before 2007[4,5]. Here we provide an independent estimate by using measurements of atmospheric oxygen (O_2) and carbon dioxide (CO_2)—levels of which increase as the ocean warms and releases gases—as a whole-ocean thermometer. We show that the ocean gained $1.33 \pm 0.20 \times 10^{22}$ joules of heat per year between 1991 and 2016, equivalent to a planetary energy imbalance of 0.83 ± 0.11 watts per square metre of Earth's surface. We also find that the ocean-warming effect that led to the outgassing of O_2 and CO_2 can be isolated from the direct effects of anthropogenic emissions and CO_2 sinks. Our result—which relies on high-precision O_2 measurements dating back to 1991[6]—suggests that ocean warming is at the high end of previous estimates, with implications for policy-relevant measurements of the Earth response to climate change, such as climate sensitivity to greenhouse gases[7] and the thermal component of sea-level rise[8].

As shown in Fig. 1, recent temperature-based hydrographic estimates of ocean warming[9–12] show good agreement for the years 2007–2016 ($1.09 \pm 0.10 \times 10^{22}$ to $1.16 \pm 0.20 \times 10^{22}$ J yr^{-1}), but a larger spread when extending back to include the sparser data of the 1990s ($0.90 \pm 0.09 \times 10^{22}$ to $1.36 \pm 0.10 \times 10^{22}$ J yr^{-1} for 1993–2015). The spread is mostly caused by gap-filling methods and systematic errors[5,9], which together introduce uncertainties of up to 25%–50% in warming trends[4]. Because temperature-based estimates also use the same upper-ocean observations and linear warming trend for depths below 2,000 m (ref. [11]), they may share additional unknown systematic errors[12]. An alternative method based on the top of the atmosphere energy balance[13] is also not truly independent, because it is subject to large systematic errors when estimating long-term trends and therefore depends on the same hydrographic measurements for calibration[13–15]. Here we introduce a third method, based on changes in the abundances of gases in the atmosphere, which respond to whole-ocean warming through the temperature dependence of gas solubility in sea water. This method is not limited by data sparseness, because fast mixing in the atmosphere efficiently integrates the global ocean signal.

Changes in ocean heat content on seasonal[16] and glacial–interglacial[17] timescales have been reconstructed using measurements of noble gases in modern or ancient air. Our method is similar, but instead of relying on noble gases (for example, ratios of argon to nitrogen), which lack sufficient accuracy as yet[16], we rely on measurements of atmospheric O_2 and CO_2, which can be summed to yield a tracer 'atmospheric potential oxygen' (APO) that responds to warming similarly to a noble gas[18]. When the ocean warms, the solubility of O_2 and CO_2 drops, and the amount of gas lost by the ocean can be quantified with the complementary change observed in the atmosphere. Precise atmospheric O_2 measurements began in 1991 (CO_2 in 1958), enabling APO-based reconstructions of ocean heat content that span nearly three decades[6].

APO ($O_2 + 1.1 \times CO_2$) is computed using observed atmospheric O_2/N_2 molar ratios and CO_2 molar fractions (see Methods)[6,19]. By design, APO is insensitive to exchanges with land ecosystems, which produce changes in O_2 and CO_2 that largely cancel in APO owing to their approximate 1.1 O_2/C oxidative ratio. Time-series measurements at remote sites show a global long-term decline in APO, with ΔAPO_{OBS} being -243.70 ± 10.10 per meg (units defined in the Methods) between 1991 and 2016. ΔAPO_{OBS} is driven by four primary contributors, illustrated in Fig. 2:

$$\Delta APO_{OBS} = \Delta APO_{FF} + \Delta APO_{Cant} + \Delta APO_{AtmD} + \Delta APO_{Climate} \quad (1)$$

where ΔAPO_{FF} is the decrease in APO caused by industrial processes (fossil-fuel burning and cement production), which in aggregate consume more than 1.1 moles of O_2 for each mole of CO_2 released; ΔAPO_{Cant} accounts for the oceanic uptake of excess anthropogenic atmospheric CO_2; ΔAPO_{AtmD} accounts for air–sea exchanges driven by ocean fertilization from anthropogenic aerosol deposition (increased fertilization leads to increased photosynthesis, with a concomitant release of O_2 and uptake of CO_2); and $\Delta APO_{Climate}$ accounts for air–sea fluxes of O_2, CO_2 and N_2 driven by ocean processes, including warming-induced changes in solubility, in ocean circulation, and in photosynthesis and respiration (N_2 influences O_2/N_2 ratios). Here, we derive $\Delta APO_{Climate}$ from equation (1) and show that it tracks ocean warming.

We estimate ΔAPO_{FF} using fossil-fuel and cement inventories[20], finding $\Delta APO_{FF} = -119.70 \pm 4.00$ per meg (Fig. 3). ΔAPO_{Cant} is controlled by the increase in atmospheric CO_2 and by ocean mixing, which is quantified by the distribution of transient tracers including chlorofluorocarbons (CFCs)[21]; we find that $\Delta APO_{Cant} = -154.30 \pm 4.20$ per meg. ΔAPO_{Cant} is relatively precise because it excludes the effects of changing ocean biology and circulation on natural carbon fluxes that are included in $\Delta APO_{Climate}$. ΔAPO_{AtmD} is derived from ocean model simulations with and without aerosol fertilization (phosphate, iron and nitrogen; Extended Data Fig. 1)[22]. ΔAPO_{AtmD} is uncertain, owing in part to uncertainties in iron availability to photosynthetic organisms, but is relatively small compared with the other terms: $\Delta APO_{AtmD} = 7.00 \pm 3.50$ per meg. From equation (1), we thereby find that $\Delta APO_{Climate} = 23.20 \pm 12.20$ per meg, corresponding to a least-squares linear trend of $+1.16 \pm 0.15$ per meg per year—larger than the trends expected from 26-year natural variations alone in four Earth-system models (the Community Earth System Model (CESM) and the Geophysical Fluid Dynamics Laboratory (GFDL), Institut Pierre Simon Laplace (IPSL) and University of Victoria (UVic) models). As shown in Fig. 3, a clear increase in $\Delta APO_{Climate}$ emerges over the period January 1991 to the end of December 2016.

A starting point for understanding $\Delta APO_{Climate}$ is to imagine that O_2 and CO_2 behave like inert gases, such that the air–sea fluxes are dominated by temperature-driven solubility changes. In this case,

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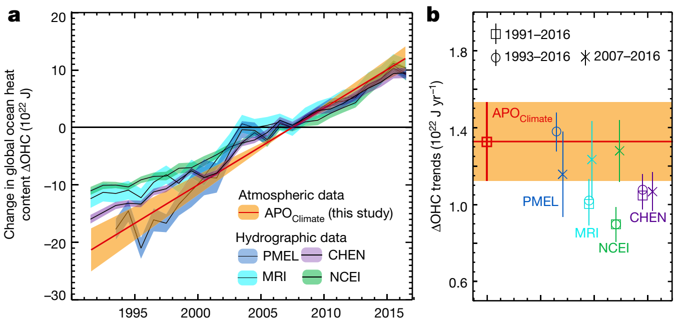

Fig. 1 | Change in global ocean heat content (ΔOHC). a, ΔOHC derived from hydrographic and atmospheric observations (normalized to zero in 2007, $\pm 1\sigma$ uncertainty). **b,** Linear least-squares trends for 1991–2016, 1993–2016 and 2007–2016 ($\pm 1\sigma$ uncertainty). Hydrography-based ΔOHC estimates combine warming rates at ocean depths of 0 to 2,000 m (from Cheng and co-authors (CHEN)[12], Pacific Marine Environmental Laboratory (PMEL)[10], Meteorological Research Institute (MRI)[9] and National Centers for Environmental Information (NCEI)[31] estimates) with the revised deep ocean warming (at depths of more than 2,000 m) of ref. [11] (Extended Data Tables 1 and 2). The atmospheric-based estimate (this study), which uses observed atmospheric potential oxygen trends ($\Delta APO_{Climate}$) and model-based $\Delta APO_{Climate}$-to-ΔOHC ratios, does not resolve interannual variations.

APO would increase by around 0.8 per meg per 10^{22} J of warming, with changes in O_2 and CO_2 solubility accounting for an increase of +1.0 per meg per 10^{22} J, partly offset by the N_2 contribution of −0.2 per meg per 10^{22} J (Methods). Support for the dominance of solubility in $\Delta APO_{Climate}$ can be found in the natural distribution of O_2 and carbon in the ocean. Ocean potential oxygen (OPO) is a dissolved tracer that mirrors $APO_{Climate}$ and tracks changes in air–sea O_2 and CO_2 fluxes[18]. Observed OPO abundance is strongly tied to ocean potential temperature (Fig. 4): warming induces OPO loss, and cooling induces OPO gain. The observed OPO-to-temperature trend of −4.45 nmol J^{-1} is within 17% of the trend of −3.70 nmol J^{-1} expected from solubility alone (OPO_{sat}-to-temperature). Biological effects (related to changes in ocean circulation and photosynthesis/respiration) on CO_2 and O_2 substantially cancel in OPO (Extended Data Fig. 2), while thermal impacts reinforce each other, with warming waters releasing both O_2 and CO_2 to the atmosphere and increasing $\Delta APO_{Climate}$.

Further support for the dominance of solubility in $\Delta APO_{Climate}$ is found on multidecadal timescales in the four Earth-system models mentioned above, which yield OPO-to-temperature ratios of between −4.71 and −4.38 nmol J^{-1}, bracketing the ratio of −4.45 nmol J^{-1}

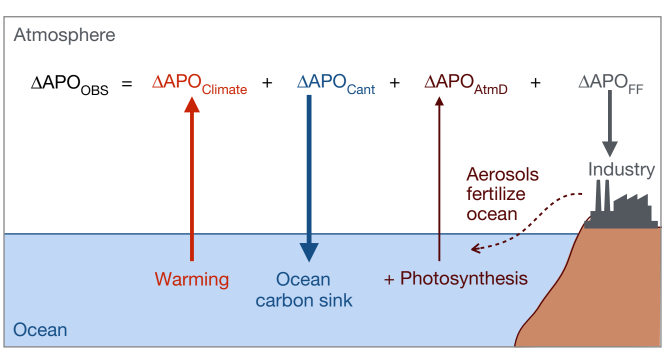

Fig. 2 | Processes contributing to observed changes in atmospheric potential oxygen (ΔAPO_{OBS}). Industrial processes (fossil-fuel burning and cement production; ΔAPO_{FF}) and the ocean sink for anthropogenic carbon (ΔAPO_{Cant}) remove APO from the atmosphere. The fertilization effect of anthropogenic aerosol deposition (ΔAPO_{AtmD})—which promotes marine photosynthesis—and the changes in solubility, biology and ocean circulation due to warming ($\Delta APO_{Climate}$) release APO into the atmosphere. Our study shows that $\Delta APO_{Climate}$ can be used to estimate long-term changes in global ocean warming.

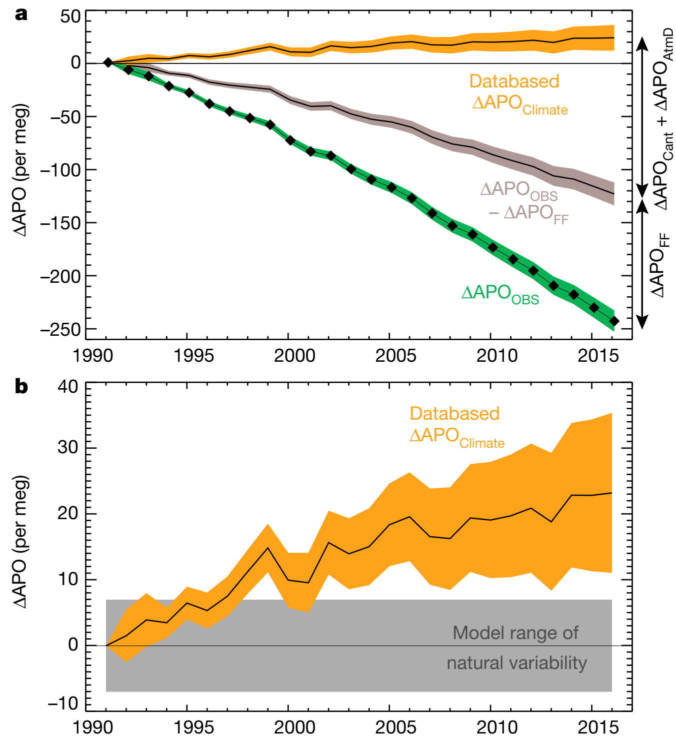

Fig. 3 | Databased estimates of global $\Delta APO_{Climate}$. a, $\Delta APO_{Climate}$ estimated from observed APO (ΔAPO_{OBS}) from the Scripps Institution of Oceanography network (1991–2016), and corrected by taking into account fossil-fuel burning, ocean anthropogenic carbon uptake and anthropogenic aerosol deposition ($\Delta APO_{Climate} = \Delta APO_{OBS} - \Delta APO_{FF} - \Delta APO_{Cant} - \Delta APO_{AtmD}$) and their 1σ uncertainty ranges. **b,** The increase in global $\Delta APO_{Climate}$ ($\pm 1\sigma$ interval) exceeds the range of 26-year trends expected from the natural variations in four Earth system models (CESM, GFDL, IPSL and UVic, shown in grey). Sources of uncertainty and contributions to ΔAPO_{OBS}, ΔAPO_{FF} and ΔAPO_{Cant} are given in Extended Data Tables 3 and 4.

found in hydrographic observations (Extended Data Fig. 3). The models also simulate a very close relationship between $\Delta APO_{Climate}$ and the change in global ocean heat content (ΔOHC) that occurs during the simulations (1920–2100), with an atmospheric build-up in APO of between 0.83 and 0.99 per meg per 10^{22} J (Extended Data Figs. 3, 4)—close to the ratio expected from temperature-driven solubility changes alone (0.8 per meg per 10^{22} J). By dividing the simulated APO change into separate biological and thermal components, we show that solubility changes account for more than 80% of $\Delta APO_{Climate}$, while biologically driven changes account for 5% to 20% (Extended Data Fig. 4). This partitioning found in response to transient warming is very similar to the partitioning found in hydrographic data (where solubility and biology contribute 83% and 17%, respectively, to the OPO-to-temperature ratio; Fig. 4).

Small differences between individual model $\Delta APO_{Climate}$-to-ΔOHC relationships (0.83 to 0.99 per meg per 10^{22} J) reflect systematic differences in biological fluxes. Models with stronger biological effects (IPSL and UVic) yield stronger oceanic loss of OPO and stronger release of APO for a given ocean warming (more negative OPO-to-temperature and higher $\Delta APO_{Climate}$-to-ΔOHC; Extended Data Fig. 3b). Using this relationship, we find that a $\Delta APO_{Climate}$-to-ΔOHC ratio of 0.87 ± 0.03 per meg per 10^{22} J is compatible with the observed OPO-to-temperature ratio. Combining this constrained $\Delta APO_{Climate}$-to-ΔOHC ratio (0.87 ± 0.03 per meg per 10^{22} J) with the observation-based trend in $\Delta APO_{Climate}$ (1.16 ± 0.18 per meg yr^{-1}) yields a warming trend of $1.33 \pm 0.20 \times 10^{22}$ J yr^{-1} between 1991 and 2016. As shown in Fig. 1, this APO-based estimate of ocean heat uptake agrees well, within uncertainties, with the highest temperature-based estimates (from the Pacific Marine Environmental Laboratory (PMEL)[10], available only for

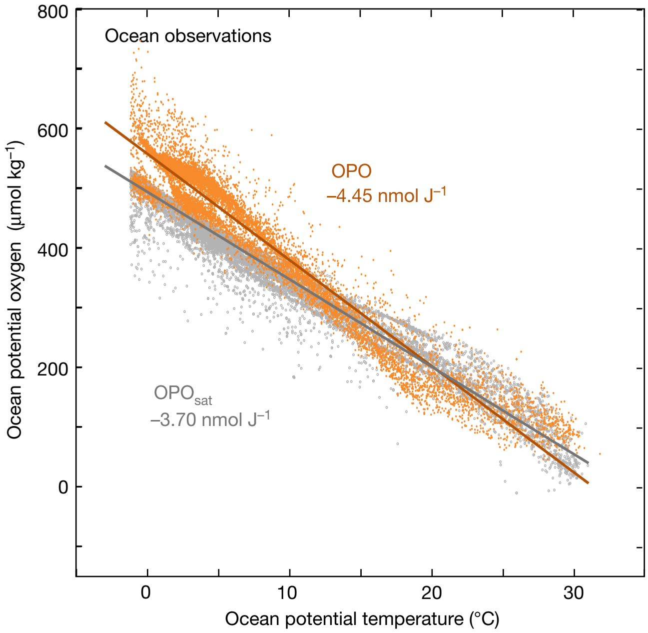

Fig. 4 | Observed link between potential oxygen and ocean heat. OPO concentrations in situ (OPO, yellow) and at saturation based on O_2 and CO_2 solubility (OPO_{sat}, grey) as a function of ocean temperature in the GLODAPv2 database[32].

1993–2015) and marginally with the two next estimates (from Cheng et al.[12] (CHEN) and the Japanese Meteorological Institute (MRI)[9]).

The APO data provide a much-needed independent confirmation of the recent upward revisions in estimates of ocean warming[5,9]. A higher value of ΔOHC compatible with both $APO_{Climate}$ and in situ temperature approaches (1.13 to 1.46 $\times$ 10^{22} J yr^{-1}) calls for a steric sea level rise of 1.34–1.74 mm yr^{-1} (Methods), in full agreement with satellite constraints on thermal expansion, corrected for the freshwater contribution (1.50 $\pm$ 0.40 mm yr^{-1})[8,23].

A higher ΔOHC will also affect the equilibrium climate sensitivity, recently estimated at between +1.5 K and +4.5 K if CO_2 is doubled[1]. This estimated range reflects a decrease in the lower bound from 2 K to 1.5 K owing to downward revision of the aerosol cooling effect (in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, as compared with the Fourth Assessment Report)[1,24], but relied on a low ΔOHC value (0.80 $\times$ 10^{22} J yr^{-1} for 1993–2010). An upward revision of the ocean heat gain by +0.5 $\times$ 10^{22} J yr^{-1} (to 1.30 $\times$ 10^{22} J yr^{-1} from 0.80 $\times$ 10^{22} J yr^{-1}) would push up the lower bound of the equilibrium climate sensitivity from 1.5 K back to 2.0 K (stronger warming expected for given emissions), thereby reducing maximum allowable cumulative CO_2 emissions by 25% to stay within the 2 °C global warming target (see Methods).

We find that the APO–heat coupling ($APO_{Climate}$) is most robust on decadal and longer timescales. Strong cancellation of biological O_2 and CO_2 fluxes is not expected on all temporal scales[25]. On seasonal timescales, air–sea O_2 fluxes driven by marine photosynthesis are around eight times larger than those of CO_2 owing to slow equilibration of CO_2 (ref. [25]). More complex coupling is also possible on interannual timescales[26], such as the weaker lagged air–sea CO_2 flux compared with the O_2 flux during El Niño events[27].

Atmospheric O_2 and CO_2 measurements have been applied previously to estimate global land and ocean CO_2 sinks, but relied on estimates of ocean heat content and model-based oceanic O_2-to-heat ratios to correct for climate-driven O_2 outgassing[28–30]. Here we have reversed this logic, using estimates of other quantities to constrain the ocean heating. Our approach exploits the APO–heat relationship, which is stronger than the O_2–heat relationship. Further work to constrain the separate contributions of O_2 and CO_2 to APO is needed to refine estimates of land and ocean carbon sinks using atmospheric O_2 and CO_2.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, statements of data availability and associated accession codes are available at https://doi.org/10.1038/s41586-018-0651-8.

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METHODS

Observed changes in APO. A change in atmospheric potential oxygen concentration (in per meg) is defined following[19]:

$$(\delta APO) = (\delta O_2/N_2) + \frac{1.1}{X_{O_2}} \times (X_{CO_2} - 350)$$

with

$$(\delta O_2/N_2) = \frac{O_2/N_2(\text{sample})}{O_2/N_2(\text{reference})} - 1$$

where $(\delta O_2/N_2)$ is the atmospheric change in $\delta O_2/N_2$ ratios (in per meg); X_{CO_2} is the CO_2 concentration in the air parcel (in p.p.m., that is, μmol mol^{-1}) and 350 is an arbitrary reference; 1.1 is the approximate O_2/CO_2 ratio of terrestrial ecosystems[33]; and X_{O_2} (= 0.2094) is the reference value of atmospheric mole fraction of O_2 necessary to convert X_{CO_2} from p.p.m. to per meg units.

ΔAPO_{OBS} is computed from in situ atmospheric changes in CO_2 concentrations and O_2/N_2 ratios[19] measured at stations of the Scripps Institution of Oceanography network (available online at http://scrippso2.ucsd.edu)[6]. The global average ΔAPO_{OBS} is based on data from the three stations with longest record (1991 to 2016), that is, La Jolla (32.9° N, 117° W), Alert (82.5° N, 62.5° W) and Cape Grim (40.5° S, 144.5° E) and weighted by the stations' latitudinal distribution[34]. Station annual means are based on bimonthly data fit to a four-harmonic seasonal cycle and a stiff long-term trend[6]. The uncertainty on ΔAPO_{OBS} was computed by generating 10^6 time series with noise scaled to the random and systematic errors of APO data detailed in Extended Data Table 3. The uncertainty is taken as the 1σ interval (±1 standard deviation) from these 10^6 realizations (Fig. 3).

Effects of fossil-fuel burning and cement production on APO. ΔAPO_{FF} is estimated using annual CO_2 emissions from oil, coal, gas, flaring and cement production ($\Delta CO_{2(i)}$ in moles)[20] weighted by their O$_2$/C combustion ratios, R_i (ref. [6]):

$$\Delta APO_{FF}(\text{per meg}) = \sum_i \frac{1.1 - R_i}{X_{O_2}} \times \frac{\Delta CO_{2(i)}}{M_{air}}$$

where M_{air} is the number of moles of dry air in the atmosphere (convert moles of CO_2 to p.p.m.).

The uncertainty on ΔAPO_{FF} includes uncertainties in CO_2 emissions ($\Delta CO_{2(i)}$)[35] and in combustion ratios (R_i in Extended Data Table 3)[36]. Uncertainties on $\Delta CO_{2(i)}$ are not independent in time and were estimated using an autoregressive model[37] (1,000 realizations); uncertainties on R_i were computed using a Monte Carlo approach (1,000 realizations). The uncertainty on ΔAPO_{FF} was then estimated by combining the 1,000 realizations of $\Delta CO_{2(i)}$ and the 1,000 realizations of R_i, yielding a set of 10^6 estimates of ΔAPO_{FF}.

Effect of ocean anthropogenic carbon uptake on APO. We represent the ocean CO_2 uptake (ΔCO_2) as the sum of three contributions:

$$\Delta CO_2 = \Delta Cant_0 + \Delta Cant' + \Delta CO_{2Climate} \quad (2)$$

where $\Delta Cant_0$ is the flux driven by the rise in CO_2 assuming steady ocean circulation ($\Delta Cant_0$ is negative, corresponding to uptake by the ocean); $\Delta CO_{2Climate}$ is the flux driven by the action of climate on natural carbon in the ocean ($\Delta CO_{2Climate}$ is positive, that is, warming reduces the uptake of natural carbon); and $\Delta Cant'$ is the remainder, which accounts for impact of circulation changes on the uptake of carbon driven by rising CO_2 ($\Delta Cant'$ is positive, that is, warming reduces the uptake of C_{ant}). ΔAPO_{Cant} can be expressed as the weighted sum of the two terms $\Delta Cant_0$ and $\Delta Cant'$:

$$\Delta APO_{Cant}(\text{per meg}) = \frac{1.1}{X_{O2} \times M_{air}} \times (\Delta Cant_0 + \Delta Cant')$$

where $\Delta Cant_0$ and $\Delta Cant'$ are in moles. Note that $\Delta CO_{2Climate}$ is accounted for in $\Delta APO_{Climate}$.

$\Delta Cant_0$ is taken from a recent ocean inversion scheme with assimilation of observed potential temperature, salinity, radiocarbon and CFC-11 (ref. [21]), updated to 2016. $\Delta Cant'$ cannot be derived from observations and was estimated at 0.05 Pg C yr^{-1}, equivalent to a trend of +0.2 per meg^{-1}, using model simulations (see 'Model anthropogenic $\Delta Cant'$').

The uncertainty on ΔAPO_{Cant} is related to uncertainties in $\Delta Cant_0$ and $\Delta Cant'$. We allow for uncertainty in $\Delta Cant_0$ following ref. [21], using the ten sensitivity experiments (on ocean vertical and isopycnal diffusivities, data constraint, gas-exchange coefficient and so on) available for the ocean inversion and an estimate of the interannual variability in the ocean sink of a 0.2 Pg C yr^{-1}. We also allow an additional 1% uncertainty (less than 0.03 Pg C yr^{-1}) in $\Delta Cant_0$ resulting from imperfectly known atmospheric CO_2 history[38], taking account of sensitivity to start date (1765 versus 1791), to degree of temporal smoothing, and to using different versions of the record since 1958 (Mauna Loa record versus average of Mauna Loa and South Pole records). This estimate used a variant of the box-diffusion model[39], and CO_2 data from ref. [40] and the Scripps CO_2 program (https://library.ucsd.edu/dc/collection/bb3381541w). Uncertainties on $\Delta Cant'$ are assumed to be 100% of the model-based estimate of $\Delta Cant'$.

Ocean fertilization and atmospheric deposition of aerosols. Deposition of anthropogenic aerosol from fossil fuel, biomass burning and other processes fertilizes the ocean with nutrients and increases surface photosynthesis and subsurface respiration[41–43]. The effect of aerosol fertilization is partly counterbalanced by biological processes such as a decline in nitrogen fixation, which would be immediate, and an increase in denitrification in the water column, which would be on timescales of several hundred years[44]. Fixed anthropogenic nitrogen also fertilizes the land biosphere and coastal oceans by river runoffs, but, in these cases, efficient denitrification returns fixed nitrogen to the atmosphere and has little impact on the APO budget on the decadal timescales considered here. The impact of anthropogenic aerosol on O_2, CO_2 and APO air−sea fluxes is evaluated with the IPSL ocean model NEMO-PISCES v2 (ref. [45]), using the difference between simulations with aerosols and a simulation in which the aerosol deposition is fixed to a constant preindustrial value (equivalent to year 1850, Extended Data Fig. 1)[22]. We use four simulations with varying aerosols: one includes the combined effect of nitrogen (N), iron (Fe) and phosphorus (P) aerosol deposition, whereas the other three include only their individual contributions (N-only, Fe-only or P-only; Extended Data Fig. 1 and Extended Data Table 5). Uncertainties at the 1σ level on ΔAPO_{AtmD} are assumed to be ±50%. See Extended Data Table 4.

Combined, N, Fe and P deposition accounts for an O_2 outgassing of 19.0 Tmol yr^{-1} for the 1980–2007 period (16 Tmol yr^{-1} for the entire 1960–2007 simulation period) and an oceanic CO_2 uptake of 8.3 Tmol yr^{-1} for the 1980–2007 period (6.8 Tmol yr^{-1} for the entire 1960–2007 simulation period; Extended Data Fig. 1 and Extended Data Table 5). The overall impact on ΔAPO_{AtmD} is +0.27 per meg yr^{-1} over 27 years of simulation (1980–2007), which we extrapolate to our 1991–2016 period. Increased O_2 outgassing accounts for an increase in APO of +0.51 per meg yr^{-1}, and CO_2 uptake accounts for a change in APO of −0.24 per meg yr^{-1} ($APO_{AtmD(O2)}$ and $APO_{AtmD(CO2)}$ in Extended Data Table 3).

The overall effect of N, Fe and P is smaller than the sum of the individual effects (Extended Data Fig. 1), because of the interplay between the aerosol deposition pattern and nutrient co-limitations in the ocean. Phytoplankton growth in the ocean depends on the availability of the most limiting nutrient. While more available N will promote photosynthesis in regions where N is limiting (for example, the tropical Atlantic Ocean), the effect is negligible in regions where Fe, P or any other nutrient is limiting (such as the Southern Ocean; see Fig. 2 in ref. [22]).

To our knowledge this is the first estimate of the effect of anthropogenic aerosol deposition on both O_2 and CO_2 air–sea fluxes at the global scale. Note however that ref. [6] used anthropogenic aerosol N inventories and scaling arguments to estimate an ocean O_2 loss due to anthropogenic N deposition only of about 10 ± 10 Tmol yr^{-1}, slightly lower than our model estimate of 15.5 Tmol yr^{-1}.

$\Delta APO_{Climate}$ trends and uncertainty analysis. We compute the APO response to climate change ($\Delta APO_{Climate}$) via:

$$\Delta APO_{Climate} = \Delta APO_{OBS} - \Delta APO_{FF} - \Delta APO_{Cant} - \Delta APO_{AtmD}$$

We combine the estimates of ΔAPO_{FF}, ΔAPO_{Cant} and ΔAPO_{AtmD} to obtain 10^6 time series of $\Delta APO_{FF} + \Delta APO_{Cant} + \Delta APO_{AtmD}$, and obtain 10^6 time series of $\Delta APO_{Climate}$ using the 10^6 time series of ΔAPO_{OBS}. We computed the $\Delta APO_{Climate}$ least-squares linear trend using the standard deviation of the 10^6 realizations of $\Delta APO_{Climate}$ as the error. We find a $\Delta APO_{Climate}$ trend of 1.16 ± 0.15 per meg yr^{-1} for 1991–2016.

Hydrography-based estimates of ocean heat uptake. We used four global-ocean estimates of ΔOHC, based on hydrographic measurements, in Fig. 1. Ocean warming rates from the surface to 2,000 m are from ref. [10] (PMEL), ref. [9] (MRI; https://climate.mri-jma.go.jp/pub/ocean/ts/v7.2/), an updated version of ref. [31] (NCEI; www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/basin_avt_data.html) and ref. [12] (CHEN; http://159.226.119.60/cheng/images_files/TOA_OHC_errorbar_1940_2015_2.txt), with the revised deep-ocean (depths greater than 2,000 m) constant linear warming rate of $0.10 \pm 0.03 \times 10^{22}$ J yr^{-1} of ref. [11] being based on the global ship-based sections program (GO-SHIP; http://www.go-ship.org)[46].

Ocean observations of ocean potential oxygen. We used in situ ocean observations from GLODAPv2 (ref. [32]) combined with an anthropogenic carbon estimate[21] interpolated at the location of each sample to compute 78,456 values (GLODAPv2 quality control = 0; marginal seas and coastal waters were removed) of OPO[18] as follows:

$$OPO = O_2^* + 1.1 \times C_{pi}^*$$

where O_2* and C_{pi}* are ocean conservative tracers related to air–sea fluxes of O_2 and preindustrial carbon[47]. The thermal component (solubility-driven) of OPO (OPO_{sat}) is computed as:

$$OPO_{sat} = O_{2sat} + 1.1 \times C_{pisat}$$

where O_{2sat} is the dissolved O_2 concentration at saturation with the observed temperature and salinity[48]; and C_{pisat} is the dissolved inorganic carbon concentration expected at the observed temperature and salinity and assuming equilibrium with a preindustrial partial pressure of CO_2 of 280 p.p.m., using pre-formed alkalinity[49].

Solubility-driven changes in OPO and APO. Extended Data Fig. 2 shows a tight and quasilinear link between observed OPO and potential temperature (-4.4 nmol J^{-1}; $r^2 = 0.95$), similar to the link found between OPO_{sat} and potential temperature (-3.7 nmol J^{-1}; $r^2 = 0.93$). This suggests that changes in OPO and hence $\Delta APO_{Climate}$ are driven primarily by changes in thermal air–sea fluxes. In these observations, departures of dissolved oxygen and carbon concentrations (O_2* and C_{pi}*) from their respective saturation curves (O_{2sat} and C_{pisat}) due to biological activity tend to balance (Extended Data Fig. 2). By contrast, thermal effects reinforce each other (O_{2sat} and C_{pisat} both decrease with increasing temperature) and biological effects compensate for each other ($O_2^* > O_{2sat}$ and $C_{pi}^* < C_{pisat}$).

The change in APO expected from changes in gas solubility in the ocean is an increase of 3.0 nmol per J of warming, which includes the outgassing of O_2 and CO_2 following OPO_{sat} (3.7 nmol J^{-1}) and the release of N_2 (0.7 nmol J^{-1}) (Extended Data Fig. 2b). A change of 3.0 nmol per J of warming is equivalent to an increase of 1.0 per meg per 10^{22} J ($= (3.0 \times 10^{-9}) / (3.7 \times 10^{19}) \times 10^{22} = 0.8 \times 10^{-6} = 1.0$ per meg per 10^{22} J, with 3.7×10^{19} being the number of moles of O_2 in the atmosphere). O_2 and CO_2 solubility alone yields an increase in APO of 1.0 per meg per 10^{22} J, which is partly counterbalanced by the outgassing of N_2 that decreases APO by 0.2 per meg per 10^{22} J (via the increase in the O_2/N_2 ratio).

Earth system model experiments. We used four Earth-system models (ESMs): the Geophysical Fluid Dynamics Laboratory Earth System Models with a nominally level vertical coordinate version, GFDL-ESM2M (called GFDL here)[50,51], the Institut Pierre-Simon Laplace Coupled Model 5 version IPSL-CM5A-LR (IPSL here)[52], the Community Earth System Model large ensemble CESM-LE (CESM here)[53] and the UVic model version 2.9 (UVic here)[54]. Evaluation of these models and their biogeochemical components can be found in previous studies[51,55–57]. GFDL, IPSL and UVic participated in the Coupled Model Intercomparison Project Phase 5 (CMIP5)[58].

For GFDL, IPSL and UVic, we used the CMIP5 business as usual 'historical-RCP8.5' scenario, the feedback experiment 'esmFdbk3' (which includes only warming-driven changes associated with anthropogenic emissions, such as radiation effects), and the fixed-climate experiment 'esmFixClim3', which includes only the direct biogeochemical effects of increasing atmospheric CO_2 (for example, uptake of anthropogenic carbon, acidification and so on). For CESM, we also used the historical-RCP8.5 experiment and the separation between anthropogenic carbon from the natural carbon available in this model (carbon tracer separation approach). The feedback approach used for GFDL, IPSL and UVic removes all direct biogeochemical effects of rising atmospheric CO_2 on the air–sea O_2 and CO_2 exchanges, whereas the natural carbon tracer separation approach used for CESM still includes the biogeochemical impacts of increasing atmospheric CO_2 on the carbon cycle (for example, acidification) even while it excludes the anthropogenic carbon itself. However, we expect the effect on our results to be small and negligible.

We also used the multicentury preindustrial control simulation 'piControl' with no increase in atmospheric CO_2 to correct for model drift and to estimate the natural internal variability of $\Delta APO_{Climate}$ (Fig. 2). We used model results over the 1920–2100 period, which were available for the four models.

Model OPO was computed as for the observations. Note that for CESM we removed subsurface regions of high denitrification in the Eastern Equatorial Pacific Ocean and the Bay of Bengal, where oxygen and O_2* in this model have unrealistic values[59].

Model anthropogenic ΔCant′. The component ΔCant′ was derived from equation (2) ($\Delta Cant' = \Delta CO_2 - \Delta Cant_0 - \Delta CO_{2Climate}$) using CMIP5 model simulations. ΔCO_2 was taken from experiment RCP8.5, $\Delta Cant_0$ from experiment esmFixClim3, and $\Delta CO_{2Climate}$ from experiment esmFdbk3. Note that the control simulation was also used to correct model drift. We estimated ΔCant′ to be 0.05 ± 0.05 Pg C yr^{-1} for 1991–2016, based on the results of the three models—which individually yielded ΔCant′ values of 0.0 Pg C yr^{-1} (IPSL), 0.12 Pg C yr^{-1} (GFDL) and 0.12 Pg C yr^{-1} (UVic)—and assuming an uncertainty of ±100%. This corresponds to a trend of 0.12 ± 0.12 per meg yr^{-1}.

Model $\Delta APO_{Climate}$-to-ΔOHC ratios and uncertainty. Model $\Delta APO_{Climate}$ is computed using individual contributions from O_2, CO_2 and N_2 as follows:

$$APO_{Climate}(\text{per meg}) = APO_{O_2} + APO_{CO_2} + APO_{N_2}$$

$$\Delta APO_{Climate}(\text{per meg}) = \frac{1}{X_{O_2} 2 p M_{air}} \times \left(\Delta F_{O_2} + 1.1 \times \Delta F_{CO_2} - \frac{X_{O_2}}{X_{N_2}} \times \Delta F_{N_2} \right)$$

where ΔF_{O_2}, ΔF_{CO_2} and ΔF_{N_2} are the changes in air–sea fluxes of O_2, CO_2 and N_2 respectively (in moles); M_{air} is the number of moles of dry air in the atmosphere; and X_{N_2} and X_{O_2} are the reference atmospheric mixing ratios of N_2 and O_2 respectively[60]. O_2 and CO_2 fluxes are simulated in the models. N_2 air–sea fluxes, which affect the O_2 atmospheric mixing ratio (because O_2 constitutes around 20% of the atmospheric composition), are quantified from the global ocean temporal changes in N_2 solubility computed from model changes in temperature and salinity[61].

The link between long-term changes in $APO_{Climate}$ and ocean heat content—that is, $\Delta APO_{Climate}$-to-ΔOHC ratios—were computed for each model using the 180 years of simulations (1920–2100). Resulting $\Delta APO_{Climate}$-to-ΔOHC ratios vary between 0.83 and 0.99 per meg per 10^{22} J of warming (Extended Data Fig. 3). These ratios include uncertainty in the natural climate variations on interannual and decadal timescales and uncertainty in the O_2/C oxidative ratio associated with global gains and losses of O_2 and CO_2 by terrestrial ecosystems. The uncertainty due to interannual variations was evaluated by computing $\Delta APO_{Climate}$-to-ΔOHC ratios using multiple 26-year-long segments from the 180-year simulations. We obtained 616 $\Delta APO_{Climate}$-to-ΔOHC ratios (154 time series of 26 years per model), and used the standard deviation between these ratios as a measure of the uncertainty.

The O_2/C ratio is assumed to be 1.1 in our computation to follow the widely accepted definition of APO ($APO = O_2 + 1.1 \times CO_2$), but is shown to have variations between 1 and 1.1 (ref. [33]). An oxidative ratio lower than 1.1 would yield a weaker $\Delta APO_{Climate}$-to-ΔOHC slope and hence a slightly higher estimate of ΔOHC for a given $\Delta APO_{Climate}$. We evaluated the influence of the O_2/C ratio for each model by using the difference between $\Delta APO_{Climate}$ computed with a ratio of 1.1 and $\Delta APO_{Climate}$ computed with a ratio of 1. The two contributions to the uncertainties on the simulated $\Delta APO_{Climate}$-to-ΔOHC ratios (interannual variations and O_2/C ratio) combine to yield ±0.01 per meg per 10^{22} J for the CESM and GFDL models, ±0.02 per meg per 10^{22} J for the UVic model, and ±0.05 per meg per 10^{22} J for the IPSL model (1σ). These uncertainties are used in Extended Data Fig. 3.

Steric component of sea-level rise. We evaluated the steric component of sea-level rise associated with a ΔOHC compatible with both $APO_{Climate}$ and existing in situ temperature constraints (that is, between 1.13×10^{22} J yr^{-1} and 1.46×10^{22} J yr^{-1}) to be between 1.34 mm yr^{-1} and 1.74 mm yr^{-1}. Following ref. [62], this calculation assumes that 45% of the warming occurs below 700 m, and that the steric rise is 1 mm per 0.60×10^{22} J above 700 m, and 1 mm per 1.15×10^{22} J below 700 m (that is, a global steric rise of 1 mm per 0.84×10^{22} J). Assuming that 48% of the warming occurs below 700 m (ref. [10]) would yield a global steric rise of 1 mm per 0.86×10^{22} J and change our estimate by less than 3%. Our estimate is also consistent with the recent hydrography-based estimate of the WCRP Global Sea Level Budget Group[63].

Ocean heat uptake, sea level and climate sensitivity. Climate sensitivity has been estimated to fall within the range of +1.5 K to +4.5 K for a doubling of CO_2 (ref. [1]). The impact of an increase in the ocean heat uptake on the effective equilibrium climate sensitivity (the apparent equilibrium climate sensitivity diagnosed from nonequilibrium conditions) can be estimated using a cumulative approach on the Earth energy balance (see Fig. 2 in ref. [1]):

$$N = F - \alpha \Delta T \quad (3)$$

where N is the global heat imbalance, which mostly consists of the ocean heat uptake; F is the radiative forcing (in W m^{-2}); ΔT is the increase in surface temperature (in K) above a natural steady state; and α is the climate feedback parameter (in W m^{-2} K^{-1}), which is inversely proportional to the effective equilibrium climate sensitivity[1]. All terms in equation (3) are time integrated over the period of interest.

The IPCC Fifth Assessment Report gives a ΔOHC of 0.80×10^{22} J yr^{-1} for 1993–2010, which is about 0.5×10^{22} J yr^{-1} lower than the ΔOHC that is compatible with both APO and hydrographic constraints. By applying equation (3)[1] to surface temperature data over the period 1991–2016 (HadCrut4 version 4.5, ref. [64], with a 1860–1879 preindustrial baseline), we found that the upward revision of the global heat imbalance, N, by $+0.5 \times 10^{22}$ J yr^{-1} pushes up the lower bound of the equilibrium climate sensitivity from 1.5 K back to 2.0 K. An increase of the lower bound from 1.5 K to 2 K corresponds to a need to reduce maximum emissions by 25% to stay within the 2 °C global warming target (because of the almost linear relationship between warming and cumulative emissions; see Fig. SPM.10 in ref. [1]). This corresponds to a reduction in maximum allowable cumulative CO_2 emissions from 4,760 Gt CO_2 to 3,570 Gt CO_2.

We tested the sensitivity of the climate sensitivity by using three alternate temperature datasets (NASA GISS Surface Temperature Analysis GISTEMP[65], available at https://data.giss.nasa.gov/gistemp; the NOAA/OAR/ESRL global surface temperature data[66] v4.0.1, available at https://www.esrl.noaa.gov/psd; and the ocean + land product of Berkeley Earth, available at berkeleyearth.lbl.gov/auto/Global; all data were accessed on 7 August 2018) as well as two preindustrial baseline periods (1860–1879 and 1880–1899). We find changes in the climate sensitivity of the order of 5% owing to the choice of temperature dataset, and less than 1% due to the choice of preindustrial baseline.

Link to global ocean deoxygenation. Our application of O_2 atmospheric measurements to constrain long-term ocean warming can be compared with earlier work that considers warming-driven oceanic O_2 outgassing. Multiplying our warming rate of $1.33 \pm 0.20 \times 10^{22}$ J yr^{-1} by the O_2-to-heat ratios simulated by the four ESMs (-3.70 ± 0.80 nmol O_2 J^{-1}) yields an ocean loss of 49 ± 13 Tmol O_2 yr^{-1}. Adding a loss of around 19 ± 19 Tmol O_2 yr^{-1} due to anthropogenic aerosols (Extended Data Table 5) yields a global ocean outgassing of 68 ± 23 Tmol O_2 yr^{-1}, in the range of previous estimates based on atmospheric data[67] (about 40 Tmol O_2 yr^{-1}), ocean data above 1,000 m (55–65 Tmol O_2 yr^{-1}, refs [68,69]) and global ocean data[70] (96 ± 42 Tmol O_2 yr^{-1}). This calculation suggests that ocean CO_2 uptake is reduced by warming at a ratio of around 0.70 nmol of CO_2 per joule (the difference between the O_2-to-heat ratio of 3.70 nmol J^{-1} and the OPO-to-heat ratio of 4.45 nmol J^{-1}).

Code availability. ESM codes are available online for IPSL-CM5A-LR (cmc.ipsl.fr/ipsl-climate-models), GFDL-ESM2M (mdl-mom5.herokuapp.com/web/docs/project/quickstart), UVic (climate.uvic.ca/model) and CESM (www.cesm.ucar.edu/models/).

Data availability

Scripps APO data are available at http://scrippso2.ucsd.edu/apo-data. $APO_{Climate}$ data, contributions to APO_{OBS} and ocean heat content time series are available in Extended Data Figs. 1–4 and Extended Data Tables 1–5. Model results are available upon reasonable request to R.W. (IPSL anthropogenic aerosol simulations), L.B. (IPSL-CM5A-LR), M.C.L. (CESM-LE), J.P.D. (GFDL-ESM2M) or W.K. (UVic).

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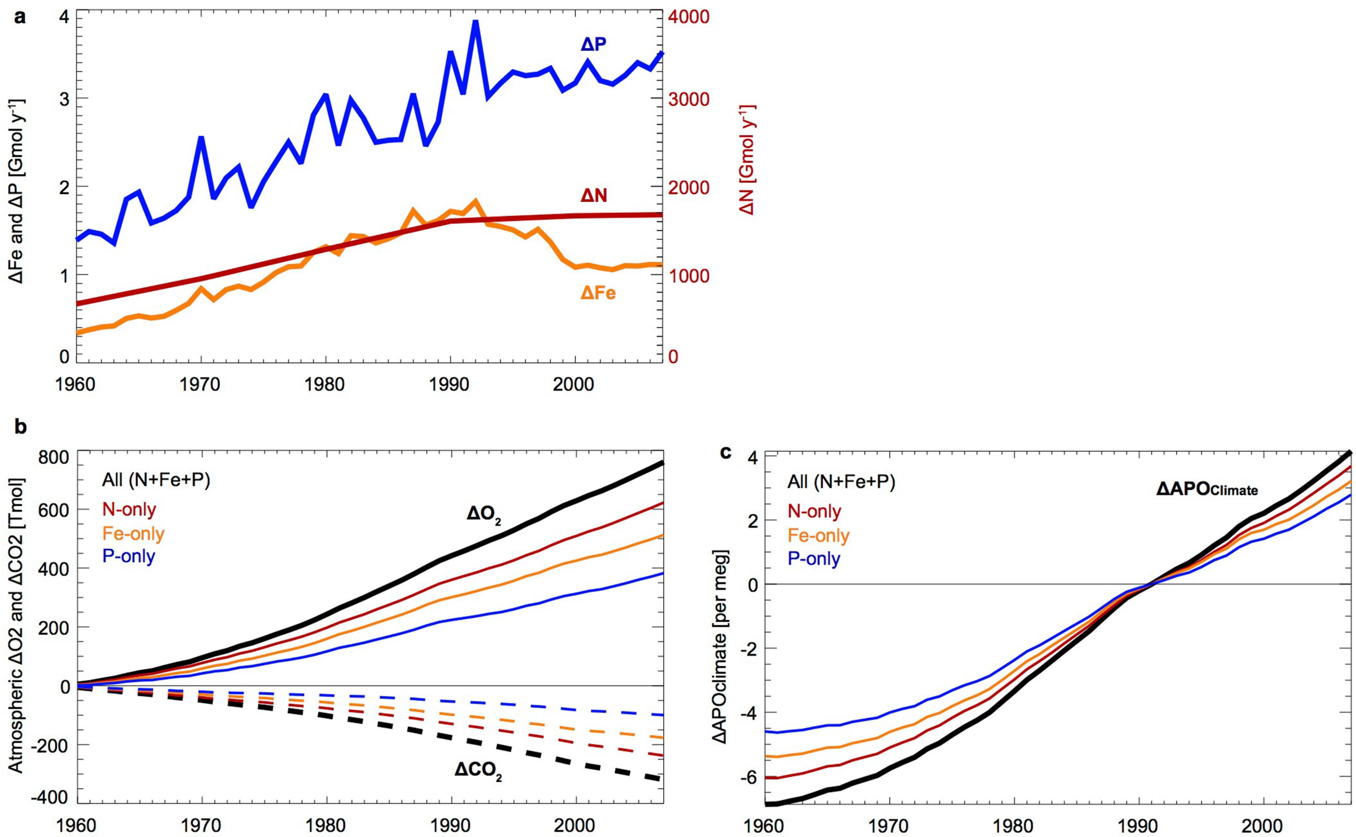
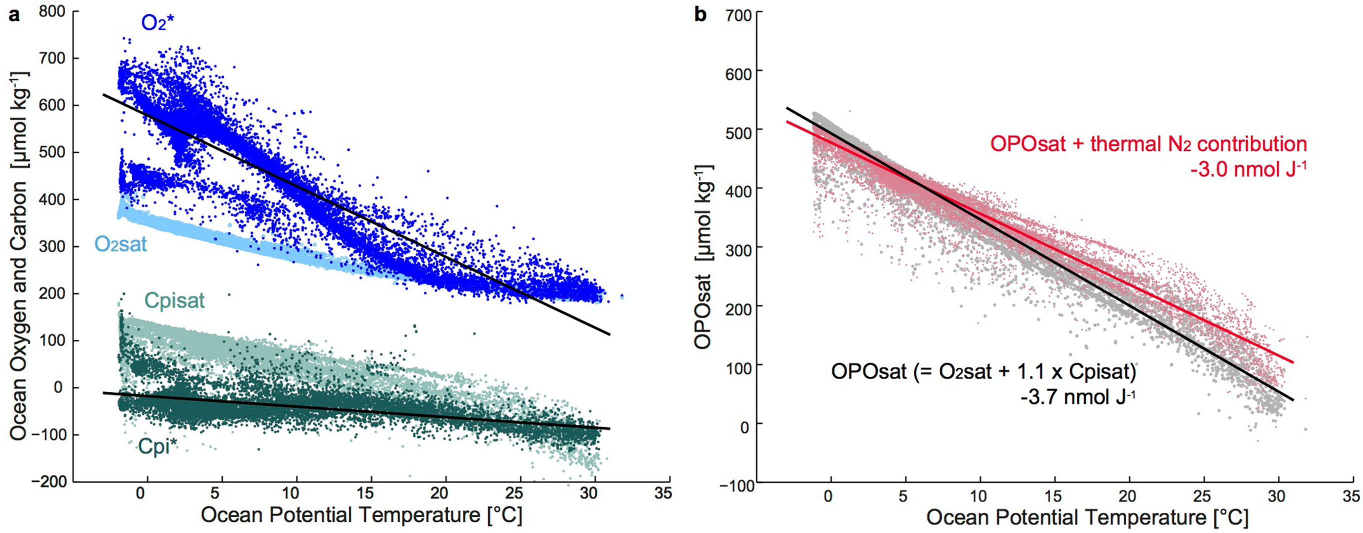
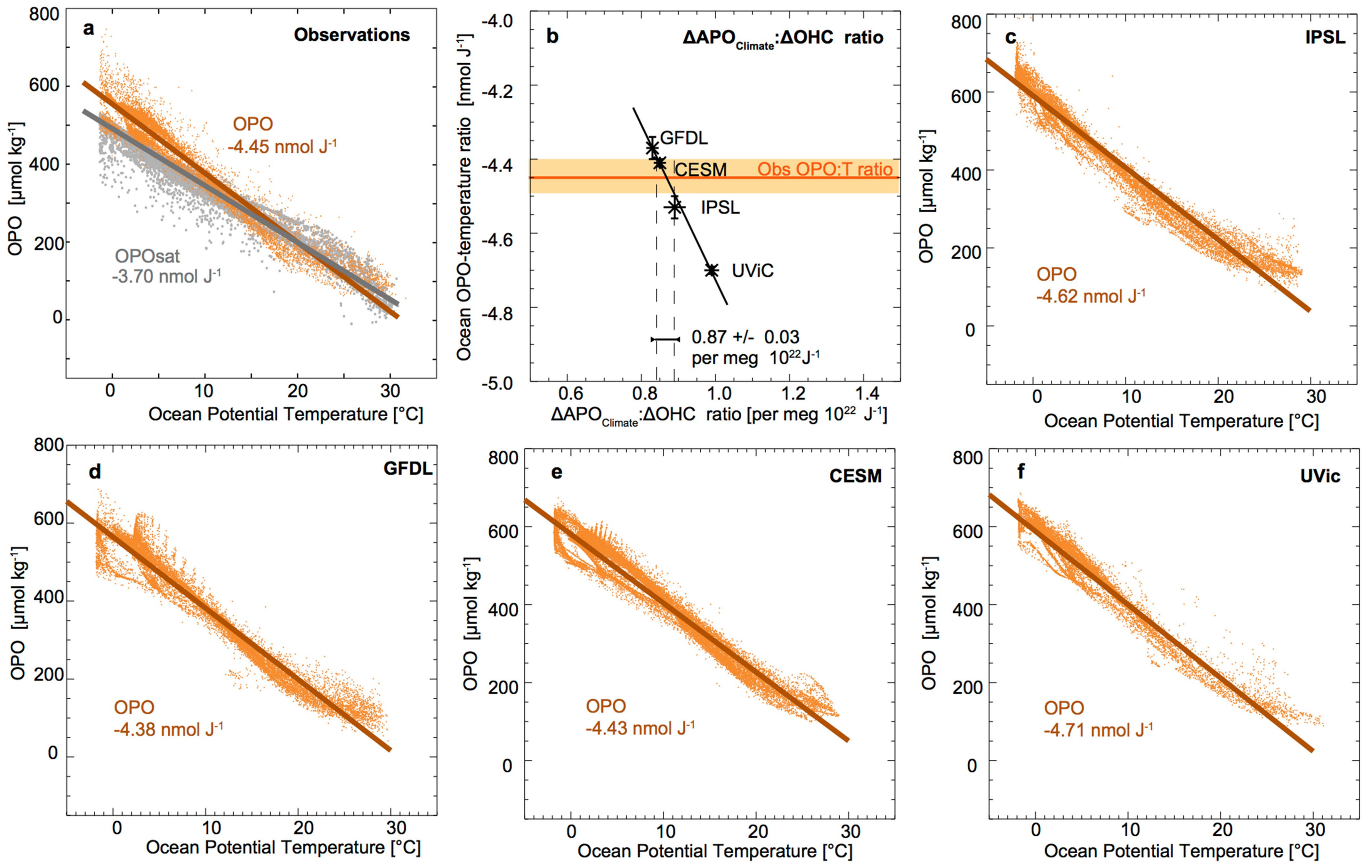


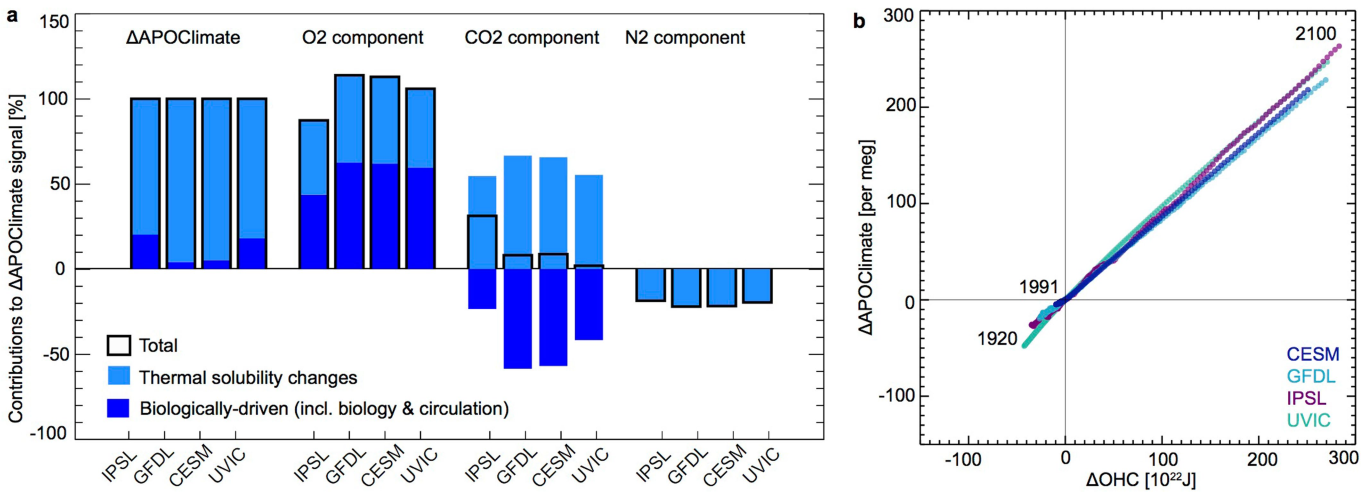
Extended Data Fig. 1 | Effects of anthropogenic aerosols on APO. **a**, Anomaly, relative to 1850 levels, in deposition of atmospheric anthropogenic aerosols (N, P and Fe) at the air–sea interface between 1960 and 2007, derived from model simulations with and without aerosols[22]. **b**, Impact of aerosol eutrophication on atmospheric O_2 (solid lines) and CO_2 (dashed lines) for all aerosols (black lines) and for each aerosol taken individually (coloured lines). **c**, Overall impact of aerosol eutrophication on $\Delta APO_{Climate}$ referenced to the first year that has observations (1991).



Extended Data Fig. 2 | Solubility-driven changes in ocean oxygen and carbon concentrations. a, Ocean observations of O_2*, O_{2sat}, C_{pi}* and C_{pisat} as a function of potential temperature in the Glodapv2 database[32]. **b**, OPO_{sat} ($= O_{2sat} + 1.1C_{pisat}$, in grey) and the expected effects on APO owing to the combined effects of OPO_{sat} and the thermal exchanges of N_2 ($= O_{2sat} + 1.1C_{pisat} - X_{O2} / X_{N2}$ [N_2 – mean(N_2)], in red). For clarity only 16×10^3 points randomly picked out of the 78,456 data points available are shown for each variable. Note that very low values of O_2* (around 450 µmol kg^{-1}) at low temperature (less than 10 °C) correspond to data collected in the Arctic Ocean, where phosphate concentrations (used for O_2* calculation) are comparatively lower than in other cold ocean regions. Low O_2* values in the Arctic explain the relatively low values of OPO shown in Extended Data Fig. 3a at temperatures below 10 °C.



Extended Data Fig. 3 | Link between OPO, $APO_{Climate}$ and ocean heat. **a**, **c–f**, OPO concentrations (yellow) and OPO concentrations at saturation based on O_2 and CO_2 solubility (OPO_{sat}, grey) as a function of ocean temperature in the GLODAPv2 database[32] (**a**) and four Earth-system models (IPSL, GFDL, CESM and UVic; **c–f**). Slopes give the OPO-to-temperature ratios in nmol J^{-1}. **b**, The link between $\Delta APO_{Climate}$ and changes in ocean heat content (that is, $\Delta APO_{Climate}$-to-ΔOHC ratio) in the four models is tied to their OPO-to-temperature ratios and can be constrained using the observed OPO-to-temperature of 4.45 nmol J^{-1} (vertical dashed lines). To avoid visual saturation, only 16,000 points, picked randomly, are shown for OPO.



Extended Data Fig. 4 | Changes in $APO_{Climate}$ ($\Delta APO_{Climate}$) and ocean heat content (ΔOHC) in four Earth-system models. a, Simulated $\Delta APO_{Climate}$ (black outlines) are decomposed into the contributions (percentage of total) from changes in ocean thermal saturation (light blue) and biologically driven changes (dark blue), the latter including changes in photosynthesis/respiration and changes in ocean circulation that transport and mix gradients of biological origin. For each model, $\Delta APO_{Climate}$ is further decomposed into its O_2, CO_2 and N_2 components—that is, how much of $\Delta APO_{Climate}$ is explained by changes in O_2, CO_2 and N_2 air–sea fluxes due to ocean saturation changes and biologically driven changes. **b**, Model $\Delta APO_{Climate}$-to-ΔOHC ratios over the 180 years of simulation (referenced to year 1991) in per meg per 10^{22} J units are: 0.85 ± 0.01 (CESM), 0.83 ± 0.01 (GFDL), 0.89 ± 0.03 (IPSL) and 0.99 ± 0.02 (UVic).

Extended Data Table 1 | Sources of the hydrographic databased estimates of global changes in ocean heat content (∆OHC) used in Fig. 1

Label in Fig 1	0 to 2000 m depth range	2000 to 6000 m depth range
PMEL	Ref. 10	Ref. 11
MRI	Ref. 9	Ref. 11
NCEI	Update of Ref. 31	Ref. 11
CHEN	Ref. 12	Ref. 11

The estimates are taken from refs 9–12.

Extended Data Table 2 | Linear trends in global ocean heat content

	1991-2016 ΔOHC trend (±1-σ)	1993-2016 ΔOHC trend (±1-σ)	2007-2016 ΔOHC trend (±1-σ)
$APO_{Climate}$	1.33 ± 0.20	-	-
PMEL	-	1.35 ± 0.10	1.16 ± 0.20
MRI	1.00 ± 0.11	1.03 ± 0.12	1.23 ± 0.22
NCEI	0.89 ± 0.08	0.90 ± 0.09	1.28 ± 0.16
CHEN	1.07 ± 0.07	1.10 ± 0.08	1.09 ± 0.10

Units are 10^{22} J yr^{-1}. Trends and $\pm 1\sigma$ uncertainty ranges are given for hydrographic (in situ temperature) and atmospheric (APO) data over the depth range 0–6,000 m. See Extended Data Table 1 for literature sources of estimates.

Extended Data Table 3 | Contributions to ΔAPO_{OBS}, ΔAPO_{FF} and ΔAPO_{Cant} and associated uncertainties ($\pm 1\sigma$) during the observation period 1991–2016

	Mean value	References	1-σ uncertainty	References
		ΔAPO_{OBS}		
Corrosion			± 0.3 per meg yr^{-1}	
Leakage			± 0.2 per meg yr^{-1}	
Desorption			± 0.1 per meg yr^{-1}	
Thermal fractionation			± 2 per meg (± 4 before July 1992)	Ref. 36
Scale systematic error			2% on $\delta(O_2/N_2)$ contribution	
		ΔAPO_{FF}		
		Oxidative Ratios R_i		
Coal	1.17		± 0.03	
Oil	1.44	Ref. 36	± 0.03	Ref. 36
Gas	1.95		± 0.04	
Cement	0.0		± 0.00	
Flaring	1.98		± 0.07	
		Emissions $\Delta CO2_i$		
Coal			± 7.0%	
Oil	Time varying	Ref. 20	± 5.5%	Ref. 35
Gas			± 6.5%	
Cement			±12%	
Flaring			±12%	
		ΔAPO_{Cant}		
$\Delta Cant_0$	Time varying (~2 to 3 PgC yr^{-1})	Ref. 21	1-σ of 10 experiments (<0.3 PgC yr^{-1})	Ref. 21
			+ 1% uncertainty (<0.03 PgC yr^{-1}) (atmospheric CO_2 history)	*this study*
ΔCant'	0.05 PgC yr^{-1} (0.12 per meg yr^{-1})	*this study*	± 0.05 PgC yr^{-1} (± 0.12 per meg yr^{-1})	*this study*

The estimates are taken from refs 20,21,35,36.

Extended Data Table 4 | Temporal evolution of the cumulative contributions to global APO changes and their 1σ uncertainties

year	$\Delta APO_{Climate}$	1-σ	ΔAPO_{OBS}	1-σ	ΔAPO_{FF}	1-σ	ΔAPO_{Cant}	1-σ	ΔAPO_{AtmD}	1-σ
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	1.50	4.00	-6.80	4.00	-4.00	0.30	-4.90	0.10	0.50	0.30
1993	3.90	4.10	-12.90	4.00	-8.00	0.40	-9.70	0.30	0.80	0.40
1994	3.50	2.30	-22.30	2.20	-12.10	0.50	-14.80	0.40	1.10	0.50
1995	6.50	2.50	-28.40	2.30	-16.20	0.60	-20.10	0.50	1.30	0.70
1996	5.40	2.70	-39.00	2.50	-20.40	0.70	-25.50	0.70	1.60	0.80
1997	7.50	3.00	-46.10	2.70	-24.70	0.80	-30.80	0.90	1.90	0.90
1998	11.30	3.40	-52.40	2.90	-29.00	0.90	-36.80	1.10	2.10	1.10
1999	14.90	3.70	-58.70	3.20	-33.40	1.10	-42.60	1.20	2.40	1.20
2000	10.00	4.20	-73.40	3.60	-37.90	1.20	-48.20	1.40	2.70	1.30
2001	9.60	4.50	-83.90	3.90	-42.50	1.30	-54.00	1.60	2.90	1.50
2002	15.70	4.80	-87.90	4.10	-47.10	1.40	-59.80	1.70	3.20	1.60
2003	14.00	5.40	-100.40	4.50	-51.80	1.60	-66.10	1.90	3.50	1.70
2004	15.10	5.80	-110.20	4.90	-56.70	1.70	-72.40	2.00	3.70	1.90
2005	18.40	6.30	-117.80	5.20	-61.70	1.80	-78.60	2.30	4.00	2.00
2006	19.60	6.70	-127.90	5.60	-66.80	2.00	-85.10	2.40	4.30	2.10
2007	16.60	7.30	-142.10	6.10	-71.90	2.20	-91.60	2.60	4.50	2.30
2008	16.30	7.80	-153.90	6.50	-77.10	2.40	-98.10	2.90	4.80	2.40
2009	19.40	8.20	-162.00	6.80	-82.20	2.60	-104.50	3.00	5.10	2.50
2010	19.10	8.80	-174.30	7.20	-87.40	2.80	-111.50	3.20	5.40	2.70
2011	19.70	9.30	-185.40	7.60	-92.70	3.00	-118.30	3.40	5.60	2.80
2012	20.90	9.80	-196.20	8.10	-98.10	3.20	-125.10	3.50	5.90	3.00
2013	18.80	10.50	-210.30	8.60	-103.40	3.40	-132.10	3.80	6.20	3.10
2014	22.90	11.00	-218.70	9.00	-108.70	3.60	-139.50	3.90	6.50	3.20
2015	22.90	11.50	-231.10	9.50	-114.20	3.80	-146.70	4.20	6.70	3.40
2016	23.20	12.20	-243.70	10.10	-119.70	4.00	-154.30	4.20	7.00	3.50

Units are per meg.

Extended Data Table 5 | Trends in air–sea flux of O_2, CO_2 and APO due to anthropogenic aerosol deposition

Trends 1980 to 2007	N-only	Fe-only	P-only	All (N+Fe+P)
O_2 [Tmol y^{-1}]	15.5	12.9	9.6	19.0
CO_2 [Tmol y^{-1}]	-6.1	-4.6	-2.6	-8.3
$APO_{AtmD(O2)}$ [per meg y^{-1}]	0.42	0.35	0.26	0.51
$APO_{AtmD(CO2)}$ [per meg y^{-1}]	-0.18	-0.14	-0.08	-0.24
APO_{AtmD} [per meg y^{-1}]	0.24	0.21	0.18	**0.27**

Trends in APO due to atmospheric deposition (ΔAPO_{AtmD}) are decomposed into contributions from the O_2 flux only ($APO_{AtmD(O2)}$) and the CO_2 flux only ($APO_{AtmD(CO2)}$). Results are from model simulations[22]. Anomalies in air–sea flux are positive towards the atmosphere. The total trend used in this study is in bold type.

Exhibit 4

United States of America

v

United States District of Oregon

and

Juliana, et al.

December 11, 2017

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IN THE UNITED STATES COURT OF APPEALS

FOR THE NINTH CIRCUIT

JAMES R. BROWNING U.S. COURTHOUSE

SAN FRANCISCO, CALIFORNIA

COURTROOM NO. 1

BEFORE JUSTICE SIDNEY THOMAS, JUSTICE MARSHA BERZON, and JUSTICE ALEX KOZINSKI

In re: United States of America

UNITED STATES OF AMERICA, et al.,

Petitioners,

v.

UNITED STATES DISTRICT COURT FOR THE DISTRICT OF OREGON,

Respondent,

and

KELSEY CASCADIA ROSE JULIANA, et al.,

Real Parties in Interest.

No. 6:15-cv-01517-TC-AA

TRANSCRIPT OF PROCEEDINGS

MONDAY, DECEMBER 11 2017

(Appearances: See next page)

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MONDAY, DECEMBER 11, 2017

-o0o-

JUSTICE THOMAS: Good morning, ladies and gentlemen. We are here for consideration of the case of the United States versus the United States District Court for the District of Oregon.

Mr. Grant, are you ready to proceed?

MR. GRANT: Good morning, your Honors. Eric Grant, U.S. Department of Justice, for the mandamus petitioners/defendants below. I hope to save five minutes of my time for rebuttal.

Echoing the Supreme Court, this Court has said that the remedy of mandamus is a drastic and extraordinary remedy reserved only for truly extraordinary cases. This is such a case.

It is really extraordinary because plaintiffs seek unprecedented standing to pursue unprecedented claims in pursuit of an unprecedented remedy. According to plaintiffs' complaint, virtually every single inhabitant of the United States has standing to sue virtually the entire executive branch to enforce an unenumerated constitutional right to a climate where a complaint is filed, an administrative record is prepared, and parties do cross-motions for summary judgment.

JUSTICE BERZON: There's motions for summary judgment all the time without having administrative records in all kinds of cases.

MR. GRANT: Certainly, your Honor. But our position -- again, the position of both the previous administration and the current administration is accepting all of the allegations pled by plaintiffs as true, these claims lack merit as a matter of law. It should not be necessary to go through discovery, to go through summary judgment proceedings.

JUSTICE BERZON: Well, but if we granted the motion here, why don't we grant it to the next person who comes in and says the same thing?

JUSTICE THOMAS: I mean, we'd be flooded, I think, with those -- if that were true, we'd be absolutely flooded with appeals from people who think that their case should have been dismissed by the District Court. I mean, if we allow -- I mean, if we set the precedent in this kind of a case, there's -- there's no logical boundary to it.

MR. GRANT: There is a logical boundary, your Honor, and those other cases do not involve, again, virtually the entire executive branch.

JUSTICE THOMAS: Well, it may surprise you, but we do get a lot of suits that are filed in this circuit and other circuits against everybody in the government, and lots of the time they're dismissed by the District Court, but sometimes they're allowed to amend, sometimes they're allowed to go forward.

It's not -- it's not -- the subject matter may be unusual and it may be more substantive than those cases, but it's not unusual for plaintiffs to allege all sorts of ills against everybody --

MR. GRANT: The District Court --

JUSTICE THOMAS: -- and the government.

MR. GRANT: With respect, your Honor, the District Court itself on page 52 of its order called this case unprecedented, and it is the combination of the defendants, the combination of the vastly broad remedy sought by plaintiffs

Exhibit 5

No. 18A410

IN THE SUPREME COURT OF THE UNITED STATES

IN RE UNITED STATES OF AMERICA, ET AL.

RESPONSE BRIEF OF RESPONDENTS JULIANA, ET AL., TO PETITIONERS' APPLICATION FOR A STAY PENDING DISPOSITION OF A PETITION FOR A WRIT OF MANDAMUS TO THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF OREGON AND ANY FURTHER PROCEEDINGS IN THIS COURT AND REQUEST FOR AN ADMINISTRATIVE STAY

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CORPORATE DISCLOSURE STATEMENT

Pursuant to Rule 29.6 of the Rules of the Supreme Court of the United States, Respondent Earth Guardians states that it does not have a parent corporation and that no publicly-held companies hold 10% or more of its stock.

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stake. They include: (1) the courts have a duty to interpret the Constitution and weigh the conduct of the political branches against it; (2) the Constitution does not protect government institutions at the expense of individual liberty; (3) it would take an extraordinary circumstance and a clear showing of irreparable harm to the operation of the federal government during trial to deprive these children of their right to have their constitutional claims determined in the light of a full factual record; and (4) the government's harm would have to outweigh the irreparable harm to these children as well as the public interest if this Court were to stay this case.

For the foregoing reasons, and as set forth below, this Application should be swiftly denied and the stay of discovery and trial lifted so that these children, who are on their way to Eugene, Oregon this week, may begin their trial on October 29, 2018.

STATEMENT

1. These young Plaintiffs commenced this action on August 12, 2015 and filed their First Amended Complaint ("FAC") on September 10, 2015. D. Ct. Doc. 7.[8] Plaintiffs allege that Petitioners' systemic affirmative ongoing conduct, persisting over decades, in creating, controlling, and perpetuating a national fossil fuel-based energy system, despite long-standing knowledge of the resulting destruction to our Nation and profound harm to these young Plaintiffs, violates Plaintiffs' constitutional

[8] Plaintiffs refer to the District Court docket as "D. Ct. Doc."; the Ninth Circuit docket from Petitioners' first petition for writ of mandamus as "Ct. App. I Doc."; the Ninth Circuit docket for Petitioners' second petition for writ of mandamus as "Ct. App. II Doc."; the Ninth Circuit docket for Petitioners' third petition for writ of mandamus as "Ct. App. III Doc."; the Supreme Court docket for Petitioners' first for application for stay as "S. Ct. I Doc."; and the Supreme Court docket for Petitioners' instant petition and application for stay as "S. Ct. II. Doc."

due process rights. Specifically, Plaintiffs allege Petitioners' conduct violates their substantive due process rights to life, liberty, and property, to dignity, to personal security, to a stable climate system capable of sustaining human lives and liberties, as well as other previously recognized unenumerated liberty interests, and has placed Plaintiffs in a position of danger with deliberate indifference to their safety under a state-created danger theory. *Id.* ¶¶ 277-89, 302-06. Further, Plaintiffs allege Petitioners' conduct violates their rights as children to equal protection by discriminating against them with respect to their fundamental rights and as members of a quasi-suspect class. *Id.* ¶¶ 290-301. Finally, Plaintiffs allege Petitioners' conduct violates their rights as beneficiaries to public trust resources under federal control and management. *Id.* ¶¶ 307-10. With respect to all claims, the FAC seeks a declaration of Plaintiffs' rights and the violation thereof and an order directing Petitioners to cease their violations of Plaintiffs' rights, prepare an accounting of the nation's greenhouse gas emissions, and prepare and implement an enforceable national remedial plan to cease the constitutional violations by phasing out fossil fuel emissions and drawing down excess atmospheric CO_2, as well as such other and further relief as may be just and proper. *Id.* at Prayer for Relief.

2. Three trade organizations collectively representing the United States' fossil fuel industry successfully moved to intervene. D. Ct. Doc. 14. On November 12, 2015, these Intervenors moved to dismiss Plaintiffs' claims, arguing that there is no federal public trust doctrine, that any such federal public trust is displaced by the Clean Air

Act, that Plaintiffs' claims present non-justiciable political questions, and that Plaintiffs lack standing. D. Ct. Doc. 20.

3. On November 17, 2015, Petitioners moved to dismiss all of Plaintiffs' claims, arguing that Plaintiffs lack standing, that Plaintiffs failed to state constitutional claims, and that there is no federal public trust doctrine. D. Ct. Doc. 27-1.

4. After hearing oral argument on March 9, 2016, Magistrate Judge Thomas Coffin recommended, on April 8, 2016, that Petitioners' and Intervenors' motions to dismiss be denied and Plaintiffs' claims proceed to trial. D. Ct. Doc. 68. Petitioners and Intervenors objected to Judge Coffin's findings and recommendations. D. Ct. Doc. 73, 74.

5. After a second round of oral argument on September 13, 2016, Judge Ann Aiken, then Chief Judge for the District of Oregon, denied the motions to dismiss on November 10, 2016. *Juliana v. United States*, 217 F.Supp.3d 1224 (D. Or. 2016). Judge Aiken recognized that, "[a]t its heart, this lawsuit asks this Court to determine whether [Petitioners] have violated plaintiffs' constitutional rights. That question is squarely within the purview of the judiciary." *Id.* at 1241. By allowing Plaintiffs' claim of infringement of an unenumerated right to a stable climate system capable of sustaining human life to proceed to trial, along with Plaintiffs' other claims, Judge Aiken recognized that such a right, if supported by evidence at later stages of litigation, would be, like the right in *Obergefell*, a right "underlying and supporting other liberties" and "quite literally the foundation 'of society, without which there would be neither civilization nor progress.'" *Id*. at 1250 (quoting *Obergefell v. Hodges*,

_U.S. _, 135 S. Ct. 2584, 2601 (2015)). Regarding redressability and remedy, Judge Aiken acknowledged that the district court "would no doubt be compelled to exercise great care to avoid separation-of-powers problems in crafting a remedy. The separation of powers might, for example, permit the Court to direct [Petitioners] to ameliorate plaintiffs' injuries but limit its ability to specify precisely how to do so." *Id*. at 1241 (citations omitted). Ultimately, Judge Aiken concluded that "speculation about the difficulty of crafting a remedy could not support dismissal at this early stage." *Id*. at 1242 (citing *Baker v. Carr*, 369 U.S. 186, 198 (1962)).

6. On December 15, 2016, Intervenors filed their Answer, denying virtually all of Plaintiffs' allegations. D. Ct. Doc. 93. On January 13, 2017, Petitioners filed their Answer, admitting many of Plaintiffs' factual allegations. Notably, Petitioners' admissions in their Answer to the FAC directly support the claim that Plaintiffs will suffer substantial harm if this Application is granted. Petitioners admit, among other significant facts:

- "for over fifty years some officials and persons employed by the federal government have been aware of a growing scientific body of research concerning the effects of fossil fuel emissions on atmospheric concentrations of CO_2—including that increased concentrations of atmospheric CO_2 could cause measurable long-lasting changes to the global climate, resulting in an array of severe and deleterious effects to human beings, which will worsen over time";

- "global atmospheric concentrations of CO_2, methane, and nitrous oxide are at unprecedentedly high levels compared to the past 800,000 years of historical data and pose risks to human health and welfare";
- Petitioners "permit, authorize, and subsidize fossil fuel extraction, development, consumption, and exportation";
- "fossil fuel extraction, development, and consumption produce CO_2 emissions and . . . past emissions of CO_2 from such activities have increased the atmospheric concentration of CO_2";
- "EPA has concluded . . . that, combined, emissions of six well-mixed [greenhouse gases] are the primary and best understood drivers of current and projected climate change";
- "the consequences of climate change are already occurring and, in general, those consequences will become more severe with more fossil fuel emissions";
- "[T]hat current and projected atmospheric concentrations of . . . [greenhouse gases], including CO_2, threaten the public health and welfare of current and future generations, and thus will mount over time as [greenhouse gases] continue to accumulate in the atmosphere and result in ever greater rates of climate change."

D. Ct. Doc. 98 ¶¶ 1; 5; 7; 10; 213; 217; *see also* D. Ct. Doc. 146 at 2-4 (District court setting forth "non-exclusive sampling" of significant admissions in Petitioners' Answer to the FAC).[9]

7. As a result of Intervenors' denial of a substantial portion of the allegations in the FAC, Plaintiffs were forced to engage in significant discovery against all parties to prepare for trial because of the scope of the contested facts. *See* D. Ct. Doc. 146 at 2-4 (Judge Coffin illustrating non-exhaustive comparison between Answers filed by Petitioners and Intervenors).

8. Four months after the denial of their motions to dismiss, Petitioners and Intervenors asked the district court to certify its November 10, 2016 order denying their motions to dismiss for interlocutory appeal, restating the arguments in their previous motions and objections. D. Ct. Doc. 120-1, 122-1.

9. On May 1, 2017, Judge Coffin recommended denial of the motions for certification for interlocutory appeal, in part because:

> [A]ny appellate review of the Order of the District Court allowing plaintiffs to proceed on their public trust and due process constitutional claims will only be aided by a full development of the record regarding the contours of those asserted rights and the extent of any harm being posed by the [Petitioners'] actions/inactions regarding human-induced global warming. This case, the issues herein, and the fundamental constitutional rights presented are not well served by certifying a

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[9] The best available climate science further illustrates that even a modest delay in resolution of Plaintiffs' claims could substantially injure Plaintiffs. Atmospheric CO_2 concentrations are already well above the level necessary to maintain a safe and stable climate system, dangerous consequences of climate change are already occurring, CO_2 emissions persist for hundreds of years and affect the climate system for millennia, impacts such as sea level rise register non-linearly, and additional emissions could exceed irretrievable climate system tipping points. *See* Decl. of Dr. James E. Hansen, D. Ct. Doc. 7-1. Absent rapid emissions abatement, sea levels could rise by as much as fifteen meters, with dire consequences to Plaintiffs such as Levi D. Decl. of Dr. Harold R. Wanless, Ct. App. II Doc. 5-4 ¶¶ 14-15.

> hypothetical question to the Court of Appeals bereft of any factual record or any record at all beyond the pleadings.

D. Ct. Doc. 146 at 9. With respect to the public trust doctrine, addressing *PPL Montana LLC v. Montana*, 565 U.S. 576 (2012), Judge Coffin concluded the federal public trust doctrine would not be extinguished in a case "that did not even involve the question of whether the federal government has public trust obligations over its sovereign seas and territories." *Id*. at 12-13. Judge Coffin further found that any separation of powers concerns were "purely hypothetical and ignore[d] the court's ability to fashion reasonable remedies based on the evidence and findings after trial." *Id*. at 9. Petitioners and Intervenors objected to Judge Coffin's findings and recommendations. D. Ct. Doc. 149, 152. On June 6, 2017, with their objections having been fully briefed for a mere two weeks, Petitioners demanded the district court resolve their objections by June 9, 2017. D. Ct. Doc. 171. After reviewing Petitioners' and Intervenors' motions for interlocutory appeal *de novo*, Judge Aiken denied the motions on June 8, 2017. D. Ct. Doc. 172.

10. On June 9, 2017, Petitioners filed their first petition for writ of mandamus with the Ninth Circuit. Ct. App. I Doc. 1. Just as they do here, Petitioners claimed separation of powers harms from general participation in the discovery and trial process and sought dismissal of Plaintiffs' claims on the basis of standing, the Administrative Procedure Act ("APA"), separation of powers, and the merits of Plaintiffs' constitutional and public trust claims, offering arguments and authorities previously offered in their motions to dismiss and for interlocutory appeal.

11. On June 28, 2017, Judge Coffin granted the motions of all three Intervenors to withdraw. D. Ct. Doc. 182. As a result of the withdrawal of Intervenors, who had denied substantially all of the factual allegations in the FAC, the scope of issues for trial was substantially narrowed, thereby reducing the scope of discovery.

12. On July 20, 2017, Plaintiffs took the deposition testimony of Dr. Michael Kuperburg, biologist for Petitioner Department of Energy and director of the U.S. Global Change Research Program. App. at 30a-31a, ¶¶ 52, 54; App. at 38a-41a. Petitioners did not object to this deposition. Dr. Kuperberg testified that the United States is currently in the "danger zone" with respect to climate change and that he is "fearful," that "increasing levels of CO_2 pose risks to humans and the natural environment," and that he does not "think current federal actions are adequate to safeguard the future." App. at 31a, ¶ 54; App. at 39a-41a.

13. On July 21, 2017, Plaintiffs took the deposition testimony of Dr. C. Mark Eakin, Oceanographer with the National Oceanic and Atmospheric Administration ("NOAA"), a division of Petitioner Department of Commerce. App. at 30a, ¶¶ 52-53; App. at 32a-37a. Petitioners did not object to this deposition. Dr. Eakin similarly testified that NOAA "consider[s] the impact of carbon dioxide and climate change on our oceans to be dangerous." App. at 30a, ¶ 53; App. at 33a.

14. On July 25, 2017, a panel of the Ninth Circuit stayed proceedings in the district court pending consideration of Petitioners' first Ninth Circuit petition. Ct. App. I Doc. 7.

15. On August 25, 2017, Judges Aiken and Coffin submitted a letter to the Ninth Circuit, explaining the district court's view that:

> [A]ny error that [it] may have committed (or may commit in the future) can be corrected through the normal route of direct appeal following final judgment. Indeed, we believe that permitting this case to proceed to trial will produce better results on appeal by distilling the legal and factual questions that can only emerge from a fully developed record.

Ct. App. I Doc. 12.

16. On August 28, 2017, Plaintiffs answered Petitioners' first Ninth Circuit petition. Ct. App. I Doc. 14-1. On September 5, 2017, over 90 *amici* filed eight *amicus* briefs in support of Plaintiffs in the Ninth Circuit. Ct. App. I Doc. 17, 19-24, 30 (available at 2017 WL 4157181-86, 4157188). The *amici* included the Global Catholic Climate Movement, Leadership Conference of Women Religious, The Sisters of Mercy of the Americas' Institute Leadership Team, Niskanen Center, League of Women Voters of the United States, Center for International Environmental Law, Union of Concerned Scientists, Sierra Club, and Food & Water Watch. The *amici* also included over 60 legal scholars and law professors, including Dean Erwin Chemerinsky and Dean David Faigman, many of whom are teaching about this case in their classes due to its constitutional import.

17. On December 11, 2017, a panel of the Ninth Circuit consisting of Chief Judge Sidney Thomas and Judges Marsha Berzon and Alex Kozinski heard oral argument on Petitioners' first Ninth Circuit petition. Judge Michelle Friedland joined the panel upon Judge Kozinski's retirement. *In re United States*, 884 F.3d 830, 833 n.* (2018).

18. On March 7, 2018, Chief Judge Thomas, writing for the Ninth Circuit, denied Petitioners' first petition, ruling that Petitioners had not satisfied any of the factors for mandamus. *In re United States*, 884 F.3d 830. The Ninth Circuit rejected Petitioners' contention that all discovery is categorically improper (which Petitioners repeated unaltered in their second petition to the Ninth Circuit and in their first application to this Court), stating: "If a specific discovery dispute arises, [Petitioners] can challenge that specific discovery request on the basis of privilege or relevance." *Id*. at 835 (citation omitted). Both at oral argument and in its order, the panel made clear that the primary cases on which Petitioners rely for dismissal via mandamus are inapposite. *Id*. at 835 ("In both cases, the district court had issued orders compelling document production.") (citing *Cheney v. U.S. Dist. Ct.*, 542 U.S. 367, 376, 379 (2004); *Credit Suisse v. U.S. Dist. Ct. for Cent. Dist. of California*, 130 F.3d 1342, 1346 (9th Cir. 1997)); *id*. at 835 n.1 (finding *In re United States*, 138 S. Ct. 443 (2017) inapposite because there the district court had "deferred ruling on the defendants' earlier motion to dismiss."). The panel also held that any merits errors were correctable through the ordinary course of litigation and that the district court's denial of Petitioners' motion to dismiss did not present the possibility that the issue of first impression raised by the case would evade appellate review. *In re United States*, 884 F.3d at 836, 837. In finding Petitioners did not satisfy any of the factors for mandamus, the panel stated that, as in all cases, Petitioners would be able "to raise legal challenges to decisions made by the district court on a more fully developed record." *Id.* at 837. However, at that point, discovery was still underway, and the

parties had not yet had sufficient time to develop a full record upon which summary judgment would be appropriate. App. at 27a-28a, ¶¶ 12-17. The panel concluded that the issues Petitioners raised were better addressed through the ordinary course of litigation and emphasized that mandamus is not to be "used as a substitute for appeal even though hardship may result from delay and perhaps unnecessary trial." *In re United States*, 884 F.3d at 834 (quoting *Schlagenhauf v. Holder*, 379 U.S. 104, 110 (1964)). Finally, the panel was "not persuaded" by Petitioners' argument, repeated here, that "holding a trial on the plaintiffs' claims and allowing the district court potentially to grant relief would threaten separation of powers," concluding that "simply allowing the usual legal process to go forward will [not] have that effect in a way that is not correctable on appellate review." *Id.* at 836. In ushering Plaintiffs' claims towards trial, the Ninth Circuit noted: "There is enduring value in the orderly administration of litigation by the trial courts, free of needless appellate interference. In turn, appellate review is aided by a developed record and full consideration of the issues by the trial courts." *Id.* at 837.

19. On April 12, 2018, the district court set this matter for trial on October 29, 2018. For purposes of scheduling the length of trial, Plaintiffs initially projected 20 days for their case in chief. App. at 28a, ¶ 18. Petitioners responded that 20 days would not be enough for Petitioners' case and stated that it would be better to ask for more time than less for trial. *Id.* Thus, as a result of meet and confer efforts, the parties agreed jointly to request 50 trial days, 4 days a week, 6-hour days (approx. 12 weeks). *Id.* The next day, at the April 12 Status Conference, Petitioners confirmed

the parties' agreement of 5 weeks per side with the district court. D. Ct. Doc. 191 at 8:3-5 (Apr. 12, 2018 Tr.) (Petitioners' counsel stating: "Yes, Your Honor, with the understanding that if we don't need five weeks, we don't use five weeks.").

20. Following the Ninth Circuit's denial of Petitioners' first petition, Petitioners did not seek review with this Court. Rather, Petitioners filed a series of motions with the district court, each substantively and procedurally duplicative of defenses raised in their motion to dismiss, and all previously rejected by the district court and by the Ninth Circuit on mandamus, with a single exception regarding dismissing the President specifically.

21. First, on May 9, 2018, Petitioners filed a motion for judgment on the pleadings under Federal Rule of Civil Procedure 12(c). D. Ct. Doc. 195. In their Rule 12(c) motion, Petitioners for the first-time sought dismissal of the President as an unnecessary party, and reasserted previously rejected defenses repackaged with slightly different arguments for dismissal, whether Plaintiffs' claims must be pled under the APA and separation of powers concerns. *Id*. On July 18, 2018, Judge Aiken heard oral argument on Petitioners' Rule 12(c) motion. D. Ct. Doc. 325; *see also* App. at 11a-19a (excerpts).

22. Second, on May 9, 2018, the same day they filed their Rule 12(c) motion, Petitioners moved for a protective order and stay of all discovery pending resolution of their Rule 12(c) motion, similarly arguing, that Plaintiffs' claims must be pled under and subject to the strictures of the APA and that separation of powers principles preclude discovery. D. Ct. Doc. 196.

23. Third, on May 22, 2018, Petitioners filed a motion for partial summary judgment, arguing that Plaintiffs lack standing, that two of Plaintiffs' constitutional claims fail on the merits, that there is no federal public trust doctrine, that Plaintiffs' claims must be pled under the APA, and that separation of powers concerns bar Plaintiffs' claims and requested relief. D. Ct. Doc. 207. Petitioners did not move for summary judgment on Plaintiffs' other substantive due process and equal protection claims. Importantly, Petitioners did not dispute any material facts relevant to summary judgment despite their denials of material facts in their Answer. *Id.*; *see also* D. Ct. Doc. 98.[10]

24. On May 24, 2018, Petitioners applied to this Court for an extension within which to file a petition for a writ of certiorari to review the Ninth Circuit's denial of their first petition. D. Ct. Doc. 211-1. Notably, Petitioners conceded that they had presented their APA arguments in their first petition to the Ninth Circuit, which was denied. *Id.* ¶ 3 ("The government petitioned the Ninth Circuit for a writ of mandamus ordering dismissal, contending that the district court's order contravened fundamental limitations on judicial review imposed by . . . the Administrative Procedure Act."). Further, Petitioners made no reference to any urgency. Justice Kennedy granted Petitioners' application for an extension on May 29, 2018, Ct. App. I Doc. 70, and granted Petitioners' application for a further extension (filed on June

[10] Petitioners failed to support their motion for partial summary judgment with any evidence. For example, in denying summary judgment as to numerous claims, the district court observed: "plaintiffs have proffered uncontradicted evidence showing that the government has historically known about the dangers of greenhouse gases but has continued to take steps promoting a fossil fuel based energy system, thus increasing greenhouse gas emissions." Pet. App. 46a.

25, 2018), to and including August 4, 2018. Ct. App. I Doc. 71. Even though Petitioners' second application for an extension was brought barely three weeks before their first Application for a stay with this Court (filed on July 17, 2018), Petitioners' second application for an extension also did not reference any urgency in addressing the underlying proceedings.

25. On May 25, 2018, Magistrate Judge Coffin denied Petitioners' motion for protective order and stay of all discovery, reasoning that the APA is not the exclusive means for bringing Plaintiffs' constitutional claims, that the district court had already denied Petitioners' motion to dismiss these claims, and that Petitioners' arguments failed because they were not directed at a "specific discovery request." D. Ct. Doc. 212 at 2-3. Petitioners objected to Judge Coffin's ruling. D. Ct. Doc. 215. On June 29, 2018, Judge Aiken affirmed Judge Coffin's ruling. D. Ct. Doc. 300.

26. On June 8, 2018, Plaintiffs moved to defer consideration of Petitioners' motion for summary judgment until after the conclusion of discovery and in conjunction with trial. D. Ct. Doc. 226. On July 13, 2018, the district court denied Plaintiffs' motion and simultaneously granted Petitioners' request that the district court hold oral argument on Petitioners' motion for summary judgment on July 18, 2018 in conjunction with argument on Petitioners' Rule 12(c) motion. D. Ct. Doc. 316.

27. There was only one issue raised in Petitioners' Rule 12(c) and summary judgment motions, their second petition before the Ninth Circuit, and the instant Application that had not previously been determined by the district court at the motion to dismiss stage and affirmed on mandamus by the Ninth Circuit: their

argument in the Rule 12(c) motion that the President should be dismissed from the case. On July 16, 2018, prior to Petitioners' submission of their first Application to this Court, Plaintiffs met and conferred with Petitioners and agreed to Petitioners' requested dismissal of the President, provided that such dismissal is without prejudice. App. at 17a, 22a. On July 17, 2018, Plaintiffs informed the district court of this offer to agree during the status conference, also prior to Petitioners' filing with this Court. *Id*. Finally, at oral argument on Petitioners' motions for judgment on the pleadings and summary judgment on July 18, 2018, Plaintiffs reiterated their offer to agree with Petitioners' request to dismiss the President, provided that such dismissal is without prejudice. App. at 17a, 22a.

28. After Judge Aiken affirmed Judge Coffin's denial of Petitioners' motion for protective order and stay of all discovery, Petitioners filed their second petition in the Ninth Circuit on July 5, 2018. Ct. App. II Doc. 1. The second petition reproduced Petitioners' arguments from their motion to dismiss and first petition, arguing that Plaintiffs' claims should be dismissed on the basis of standing, separation of powers concerns, the merits of Plaintiffs' claims, that Plaintiffs' claims must be pled under the APA, and asserting unsubstantiated harms stemming from the general process of participating in discovery and trial. Ct. App. II Doc. 1. Petitioners admitted the arguments advanced in their second petition were duplicative and raised under the same standard applicable to their first petition. *Id*. at 10. As part of their second petition, Petitioners made an emergency motion to the Ninth Circuit to stay the proceedings in the district court pending its consideration of the petition. *Id*.

Petitioners also concurrently submitted a motion to the district court to stay proceedings pending the Ninth Circuit's disposition of the second petition. D. Ct. Doc. 317. On July 16, 2018, The Ninth Circuit denied Petitioners' request for a stay. Ct. App. II Doc. 9. Later the same day, the district court denied Petitioners' motion for stay pending the Ninth Circuit's disposition of their second petition. D. Ct. Doc. 307.

29. On July 17, 2018, the Solicitor General filed the first application with this Court, docketed at *United States v. U.S. District Court for the District of Oregon*, Supreme Court No. 18A65. The first application suggested that it could be construed as a petition for writ of mandamus directing the district court to dismiss the lawsuit or as a petition for a writ of certiorari to review the Ninth Circuit's first mandamus decision.

30. On July 20, 2018, the Ninth Circuit denied Petitioners' second mandamus petition as Petitioners had not met the standard to qualify for mandamus relief, concluding:

> The government's fear of burdensome or improper discovery does not warrant mandamus relief in the absence of a single specific discovery order. The government's arguments as to the violation of the APA and the separation of powers fail to establish that they will suffer prejudice not correctable in a future appeal. The merits of the case can be resolved by the district court or in a future appeal.

In re United States, ___ F.3d ___, 2018 WL 3484444, at *1 (9th Cir. July 20, 2018). The Ninth Circuit concluded that, because "no new circumstances justify this second petition," it "remains the case that the issues the government raises in its petition are better addressed through the ordinary course of litigation." *Id.*

30. Justice Kennedy referred the application for a stay to the entire Supreme Court. On July 30, 2018, this Court denied Petitioners' first application. *United States v. U.S. Dist. Court*, No. 18A65, 2018 WL 3615551, at *1.

31. On October 5, 2018, Petitioners filed another stay request with the district court. Petitioners informed the district court that they planned to file a petition for a writ of mandamus (or, in the alternative, a petition for a writ of certiorari) with this Court, and asked the district court to stay discovery and trial pending this Court's resolution of that petition. D. Ct. Doc. 361. The district court denied the request on October 15, 2018. D. Ct. Doc. 374.

32. On October 12, 2018, Petitioners petitioned the Ninth Circuit to stay discovery and trial pending this Court's review of the government's petition. Ct. App. II Doc. 1-2. At the time this opposition was filed, the Ninth Circuit had not yet acted on that request.

33. On October 15, 2018, the district court issued an opinion on the Rule 12(c) and summary judgment motions and declined to certify its ruling for interlocutory appeal. Pet. App. 1a-77a (D. Ct. Doc. 369). The district court granted Petitioners' request to dismiss the President "without prejudice,"[11] *id.* at 23a, granted summary judgment in favor of Petitioners on Plaintiffs' claim under the Ninth Amendment, *id.* at 69a, and rejected Plaintiffs' arguments that children are a suspect class under the Equal

[11] The order stated that "on the current record, it appears that this is a case in which effective relief is available through a lawsuit addressed only to lower federal officials," but added that it "is not possible to know how developments to the record in the course of the litigation may change the analysis" and that the district court could "not conclude with certainty that President Trump will never become essential to affording complete relief." Pet. App. at 23a.

Protection Clause, *id.* at 70a-72a. The district court otherwise denied Petitioners' motions. The district court began her order by noting that the significant admissions in Petitioners' Answer and Petitioners' other filings

> make clear that plaintiffs and [Petitioners] agree on the following contentions: climate change is happening, is caused in significant part by humans, specifically human induced fossil fuel combustion, and poses a "monumental" danger to Americans' health and welfare. (Citation omitted). The pleadings also make clear that plaintiffs and [Petitioners] agree that [Petitioners'] policies regarding fossil fuels and greenhouse gas emissions play a role in global climate change, though [Petitioners] dispute that their actions can fairly be deemed to have caused plaintiffs' alleged injuries.

Id. at 6a. The district court rejected Petitioners' argument that Plaintiffs were required to assert their claims under the APA, which the court construed as follows: Petitioners' "APA argument succeeds only if they can demonstrate that the APA is the only available avenue to judicial review of the government's conduct that plaintiffs challenge in this lawsuit." *Id.* at 25a. The district court found the "APA contains no express language suggesting that Congress intended it to displace constitutional claims for equitable relief," *id.* at 28a, and held the "APA does not govern" claims seeking equitable relief for alleged constitutional violations, *id.* at 31a. The district court then noted that:

> the allocation of power among the branches of government is a critical consideration in this case and reiterate that, "[s]hould plaintiffs prevail on the merits, this Court would no doubt be compelled to exercise great care to avoid separation-of-powers problems in crafting a remedy." *Juliana*, 217 F. Supp. 3d at 1241. The Court recognizes that there are limits to the power of the judicial branch, as demonstrated by the Court's determination that President Trump is not a proper defendant in this case.

Id. at 32a. The district court concluded its denial of the Rule 12(c) motion with the following observation:

> Due respect for the separation of powers has informed, and will continue to inform, the Court's approach to this case at every step of the litigation. The Court remains mindful, however, that it is "emphatically the province and duty of the judicial department to say what the law is." *Marbury v. Madison*, 5 U.S. 137, 177 (1803). Courts have an obligation not to overstep the bounds of their jurisdiction, but they have an equally important duty to fulfill their role as a check on any unconstitutional actions of the other branches of government.

Id. at 34a.

34. The district court then turned to Petitioners' motion for summary judgment, first considering standing. As to injury in fact, the district court found: "Plaintiffs have filed sworn declarations attesting to a broad range of personal injuries caused by human induced climate change." *Id.* at 37a. "Plaintiffs further offer expert testimony tying injuries alleged by plaintiffs to fossil fuel induced global warming." *Id.* at 38a-39a. Noting Petitioners argued this evidence merely showed a generalized grievance, the district court stated:

> Further, denying "standing to persons who are in fact injured simply because many others are also injured, would mean that the most injurious and widespread Government actions could be questioned by nobody." *United States v. Students Challenging Regulatory Agency Procedures*, 412 U.S. 669, 687 (1973). [Petitioners] have presented no new controlling authority or other evidence which changes the Court's previous analysis.

Id. at 41a. The district court concluded its analysis of injury in fact as follows:

> In sum, the Court is left with plaintiffs' sworn affidavits attesting to their specific injuries, as well as a swath of extensive expert declarations showing those injuries are linked to fossil fuel-induced climate change and if current conditions remain unchanged, these injuries are likely to continue or worsen. [Petitioners] offer nothing to contradict these

> submissions, and merely recycle arguments from their previous motion. Thus, for the purposes of this case, the declarations submitted by plaintiffs and their experts have provided "specific facts," of immediate and concrete injuries. (Citations omitted).

Id. at 43a. As to causation for purposes of standing, the district court found: "Plaintiffs' expert declarations also provide evidence that [Petitioners'] actions have led to plaintiffs' complained of injuries." *Id*. at 49a.

> At this stage of the proceedings, the Court finds that plaintiffs have provided sufficient evidence showing that causation for their claims is more than attenuated. Plaintiffs' "need not connect each molecule" of domestically emitted carbon to their specific injuries to meet the causation standard. *Bellon*, 732 F.3d 1142-43. The ultimate issue of causation will require perhaps the most extensive evidence to determine at trial, but at this stage of the proceedings, plaintiffs have proffered sufficient evidence to show that genuine issues of material fact remain on this issue. A final ruling on this issue will benefit from a fully developed factual record where the Court can consider and weigh evidence from both parties.

Id. at 50a-51a. As to redressability, the district court concluded:

> As mentioned elsewhere in this opinion, should the Court find a constitution violation, it would need to exercise great care in fashioning any form relief, even if it were primarily declaratory in nature. [Footnote omitted]. The Court has considered the summary judgment record regarding traceability and plaintiffs' experts' opinions that reducing domestic emissions, which plaintiffs contend are controlled by [Petitioners'] actions, could slow or reduce the harm plaintiffs are suffering. The Court concludes, for the purposes of this motion, that plaintiffs have shown an issue of material fact that must be considered at trial on full factual record.
>
> Regarding standing, [Petitioners] have offered similar legal arguments to those in their motion to dismiss. Plaintiffs, in contrast, have gone beyond the pleadings to submit sufficient evidence to show genuine issues of material facts on whether they satisfy the standing elements. The Court has considered all of the arguments and voluminous summary judgment record, and the Court finds that plaintiffs show that genuine issues of material fact exist as to each element. As the Court notes elsewhere in this opinion, the Court will revisit all of the elements

> of standing after the factual record has been fully developed at trial. For now, the Court simply holds that plaintiffs have met their burden to avoid summary judgment at this time.

Id. at 55a. Regarding summary judgment on the APA and separation of powers issues, the district court reiterated its analysis from its denial of the Rule 12(c) motion, and reaffirmed:

> As the Court noted above, the allocation of powers between the branches of government is a critical consideration in this case, but it is the clear province of the judiciary to say what the law is. *Marbury*, 5 U.S. at 177. After a fuller development of the record and weighing of evidence presented at trial, should the Court find a constitutional violation, then it would exercise great care in fashioning a remedy determined by the nature and scope of that violation. Additionally, many potential outcomes and remedies remain at issue in this case. The Court could find that there is no violation of plaintiffs' rights; that plaintiffs fail to meet one or more of the requirements of standing; or, after the full development of the factual record, that the requested remedies would indeed violate the separation of powers doctrine. As has been noted before, even should plaintiffs prevail at trial, the Court, in fashioning an appropriate remedy, need not micromanage federal agencies or make policy judgments that the Constitution leaves to other branches. The record before the Court at this stage of the proceedings, however, does not warrant summary dismissal. To grant summary judgment on these grounds at this stage—when plaintiffs have supplied ample evidence to show genuine issues of material fact—would be premature.

Id. at 57a-58a. Finally, the district court addressed the equal protection claim, holding that children are not a suspect class, but allowing the claim to proceed because it "would be aided by further development of the factual record." *Id*. at 72a-73a.

35. The district court did not certify its order for interlocutory appeal under 28 U.S.C. § 1292(b). *Id*. at 73a-77a.

36. This case is ready to proceed to trial. There is no evidence of any discovery burden substantiating a stay. Petitioners will suffer no cognizable burden in finalizing the remaining, extremely limited discovery and proceeding through trial. As of October 19, 2018, the date this Court granted stay, the parties had completed the following discovery and pre-trial matters in preparation for trial:

a. Plaintiffs completed and served expert reports and all of their experts were deposed. Olson Decl. ¶ 9.

b. Petitioners completed and served rebuttal expert reports and each of their rebuttal experts who had submitted rebuttal reports were deposed.[12] *Id.*

c. Plaintiffs completed and served rebuttal expert reports and all but two of their rebuttal experts were deposed. *Id.*

d. Petitioners completed and served one sur-rebuttal expert report. *Id.*

e. Plaintiffs served one set of interrogatories, to which Petitioners responded. *Id.*

f. Petitioners served one set of interrogatories, to which Plaintiffs responded. *Id.*

g. 15 of the 21 Youth Plaintiffs were deposed. *Id.*

h. There is only one pending discovery motion: a motion to compel responses to interrogatories, filed by Plaintiffs. D. Ct. Doc. 388.

i. The parties have exchanged and filed exhibit lists and witness lists. D. Ct. Doc. 373, 387, 396, 402.

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[12] Petitioners were granted leave of court to serve one rebuttal report on October 26, 2018. D. Ct. Doc. 337. That rebuttal expert has yet to be deposed as to his rebuttal report.

j. The parties filed various motions *in limine*. D. Ct. Doc. 254, 340, 371, 372, 379, 380.

k. The parties filed proposed trial memoranda. D. Ct. Doc. 378, 384.

l. Plaintiffs filed a proposed Pre-Trial Order. D. Ct. Doc. 394.

37. The only remaining procedural matters for the district court to conduct are the pre-trial conference on October 26, 2018 and to commence trial on October 29, 2018.

ARGUMENT

A stay of proceedings "is appropriate only in those extraordinary cases where the applicant is able to rebut the presumption that the decisions below—both on the merits and on the proper interim disposition of the case—are correct." *Rostker v. Goldberg*, 448 U.S. 1306, 1308 (1980). This Court affords considerable deference to a lower court's decision granting or denying a stay. *See, e.g.*, *Bonura v. CBS, Inc.*, 459 U.S. 1313, 1313 (1983); *Ruckelshaus v. Monsanto Co.*, 463 U.S. 1315, 1316 (1983); *Holtzman v. Schlesinger*, 414 U.S. 1304, 1314 (1973). Petitioners bear the "heavy burden" of justifying the "extraordinary" relief occasioned by a stay. *Whalen v. Roe*, 423 U.S. 1313, 1316 (1975); *see also* Robert S. Stern, et al., Supreme Court Practice 907 (8th ed. 2002) (A lower courts' disposition of an application for stay "is essentially an act of discretion . . . it is entitled to *prima facie* respect, to be set aside only if deemed clearly erroneous.").[13]

[13] During a recent eight-year period, this Court received more than 1,900 applications for extraordinary writs and granted none. Stephen M. Shapiro, et al., Supreme Court Practice § 11.1, at 661 n. 9 (110th ed. 2013).

Exhibit 6

FILED

NOV 02 2018

MOLLY C. DWYER, CLERK
U.S. COURT OF APPEALS

UNITED STATES COURT OF APPEALS

FOR THE NINTH CIRCUIT

In re: UNITED STATES OF AMERICA; et al., UNITED STATES OF AMERICA; et al., Petitioners, v. UNITED STATES DISTRICT COURT FOR THE DISTRICT OF OREGON, EUGENE, Respondent, KELSEY CASCADIA ROSE JULIANA; et al., Real Parties in Interest.	No. 18-72776 D.C. No. 6:15-cv-01517-AA District of Oregon, Eugene ORDER

Before: THOMAS, Chief Judge, and BERZON and FRIEDLAND, Circuit Judges.

The government filed with us on October 12, 2018, a document entitled "Petition for Writ of Mandamus Requesting a Stay of District Court Proceedings Pending Supreme Court Review." As the title indicates, no substantive Petition for Writ of Mandamus or other substantive pleading was filed with us. The only request was that although nothing substantive was or would be pending before us, we stay the trial, scheduled to begin on October 29, 2018, "[t]o assure that the Supreme Court has adequate time to consider the government's request for relief."

The government filed a request for a stay and a substantive Petition for Writ of Mandamus with the Supreme Court. Although we have not been so informed by the government, Chief Justice Roberts issued a temporary stay of the start of the trial, and the Court is now considering the government's requests. *In re United States, et al.*, No. 18A410 (October 19, 2018). Given the issuance of the temporary stay order and the fact that there is no request before us other than for a stay pending Supreme Court consideration, Petitioner's non-substantive emergency motion for a stay is DENIED as moot. We request that, in the future, the government promptly inform this Court of developments affecting its pending motions.