

**Finding That Greenhouse Gas
Emissions from Aircraft Cause or
Contribute to Air Pollution That May
Reasonably Be Anticipated to Endanger
Public Health and Welfare**

Response to Comments

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Climate Change Division
Office of Atmospheric Programs
U.S. Environmental Protection Agency

and

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Finding that Greenhouse Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably be Anticipated to Endanger Public Health and Welfare

Response to Comments Document

July 25, 2016

Table of Contents

1. Generally Support Endangerment and Cause or Contribute Findings	5
2. General Approach to the Science.....	6
3. The Endangerment Finding.....	8
3.1 Scope & Proposed Definition of "Air Pollution"	8
3.2 Additional Substances.....	13
3.2.1 Aerosols/black carbon.....	16
3.2.2 Water vapor, contrails	18
3.2.3 High-altitude NOx.....	21
3.3 Climate Science	23
3.4 Sectoral Impacts.....	31
4. The Cause or Contribute Finding.....	34
4.1 Scope & Proposed Definition of "Air Pollutant"	34
4.2 Analysis of Contribution.....	36
4.2.1 Including GHG Emissions from Combustion of International Aviation Bunker Fuels in the U.S. Aircraft GHG Inventory.....	39
4.2.2. Finding Significant Contribution, or Establishing a Bright Line	40
4.2.3. Providing Context in Comparing Aircraft GHG Emissions to Other Sector GHG Emissions	41
4.2.4. Utilizing Multiple Databases for Global GHG Emissions	42
4.2.5. Past Aircraft Industry Fuel Efficiency Trends	43
4.3 Proposed Scope and Description of Covered Aircraft.....	45
4.3.1. Applicability Weight Thresholds Match Those of International CO ₂ Standard	45
4.3.2. Defining U.S. Covered Aircraft	46
4.3.3. Limiting the Contribution Finding to U.S. Covered Aircraft.....	47
4.4 Aircraft Emissions Projections.....	48
5. Miscellaneous Legal, Economic, and Other Comments	52

FOREWORD

This document, together with the U.S. Environmental Protection Agency's (EPA's) *Finding That Greenhouse Gas Emissions From Aircraft Cause or Contribute To Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare*, contains responses to public comments received on the proposed finding, published at 80 Federal Register (FR) 37758 (July 1, 2015). The EPA accepted comments on this proposal via online submission through [regulations.gov](http://www.regulations.gov) as well as mail, e-mail, and fax, and at one public hearing held in Washington, D.C. in August 2015. Copies of all comment letters submitted and the transcript of the public hearing are available at the EPA Docket Center Public Reading Room, or electronically through <http://www.regulations.gov> by searching Docket ID *EPA-HQ-OAR-2014-0828*.

In light of the overlap between many comments, the EPA provided responses to all of the significant issues raised by commenters, but did not provide responses to each individual commenter. Within each comment summary, the EPA provides in parentheses lists of one or more Docket ID numbers for comment letters that raised similar issues; however, these lists are not meant to be exhaustive and the EPA does not individually identify each and every commenter who made a certain point in all instances, particularly in cases where multiple commenters expressed essentially identical arguments.

The EPA's responses to comments are generally provided immediately following each summary of comments. In some cases, the EPA has fully responded to specific comments or groups of similar comments in the Federal Register Notice (FRN) for the final action, in which case the EPA references the FRN rather than repeating those responses in this document. The responses presented in this document are intended to augment the responses to comments that appear in the FRN for the final action and to address comments not discussed in the FRN. Although portions of the Finding are paraphrased in this response to comments (RTC) document, and some comments are discussed in the both documents, to the extent such paraphrasing or overlap in comment responses introduces any confusion or apparent inconsistency it is our intention that the FRN for the final action be viewed as definitive. This document, together with the FRN, docket memoranda and related technical documents, should be considered collectively as the EPA's response to all of the significant comments submitted on the EPA's proposed finding.

List of Organizations Submitting Comments

Organization	Commenter Name(s)	Docket File(s)
Aerospace Industries Association (AIA)	Leslie Riegle	EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797
Aerospace Industries Association of Brazil (AIAB)	Walter Bartels	EPA-HQ-OAR-2014-0828-0857
Aerospace Industries Association of Canada (AIAC)	Mark Beauregard	EPA-HQ-OAR-2014-0828-0858
Airbus S.A.S.	Charles Champion	EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859
Aircraft Owners and Pilots Association (AOPA)	David Oord	EPA-HQ-OAR-2014-0828-0751
AirFair	Steven Taber	EPA-HQ-OAR-2014-0828-0860
Airlines for America (A4A) and the Air Line Pilots Association (ALPA)	Nancy Young	EPA-HQ-OAR-2014-0828-0747
American Airlines, Inc	Howard Kass	EPA-HQ-OAR-2014-0828-0917
Association of European Airlines (AEA)	N/A	EPA-HQ-OAR-2014-0828-0736
Biogenic CO ₂ Coalition	N/A	EPA-HQ-OAR-2014-0828-0916
Boeing Commercial Airplanes	Sheila Remes	EPA-HQ-OAR-2014-0828-0568
California Air Resources Board (ARB)	Richard W. Corey	EPA-HQ-OAR-2014-0828-0861
Cargo Airline Association	N/A	EPA-HQ-OAR-2014-0828-0732
Center for Biological Diversity	Doug Wolf	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
Citizens United and Green	N/A	EPA-HQ-OAR-2014-0828-0915
City of Santa Monica	Kevin McKeown	EPA-HQ-OAR-2014-0828-0786
Climate Viewer News	James Lee	EPA-HQ-OAR-2014-0828-0359, EPA-HQ-OAR-2014-0828-0484
Corporate Company - Climate Environment Confirmation and Responsibility (CECR)	Harry Rhodes	EPA-HQ-OAR-2014-0828-0608
Earth Guardians of Vermont	Nicole Mardin	EPA-HQ-OAR-2014-0828-0920
Earthjustice et al.	Sarah Burt	EPA-HQ-OAR-2014-0828-0863
Embraer Aircraft Holding, Inc	Gary J Spulak	EPA-HQ-OAR-2014-0828-0745
Environmental Defense Fund (EDF)	Pamela Campos	EPA-HQ-OAR-2014-0828-0754, EPA-HQ-OAR-2014-0828-0793
Friends of the Earth	Kate DeAngelis	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
General Aviation Manufacturers Association	Edward Smith	EPA-HQ-OAR-2014-0828-0837
General Electric (GE)	Gary Mercer and Norman Liu	EPA-HQ-OAR-2014-0828-0932
Geoengineering Watch	N/A	EPA-HQ-OAR-2014-0828-0261
Honeywell	Chris Benich	EPA-HQ-OAR-2014-0828-0757
Institute for Policy Integrity	Jason A. Schwartz	EPA-HQ-OAR-2014-0828-0749

Organization	Commenter Name(s)	Docket File(s)
International Air Transport Association (IATA)	Douglas E Lavin	EPA-HQ-OAR-2014-0828-0548
International Council on Clean Transportation (ICCT)	Drew Kodjak	EPA-HQ-OAR-2014-0828-0791
Lissys Ltd.	Dimitri Simos	EPA-HQ-OAR-2014-0828-0203
Mass Comment Campaign sponsored by anonymous 1 (email) - (24,558 duplicates)	N/A	EPA-HQ-OAR-2014-0828-0361, EPA-HQ-OAR-2014-0828-0940
National Air Carrier Association (NACA)	A. Oakley Brooks	EPA-HQ-OAR-2014-0828-0546
National Association of Clean Air Agencies (NACAA)	Nancy Seidman and Barry Wallerstein	EPA-HQ-OAR-2014-0828-0560
National Business Aviation Association (NBAA)	Douglas Carr	EPA-HQ-OAR-2014-0828-0567
National Tribal Air Association (NTAA)	Bill Thompson	EPA-HQ-OAR-2014-0828-0362
Natural Resources Defense Council (NRDC)	David Baake	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
Northeast States for Coordinated Air Use Management (NESCAUM)	Arthur Marin	EPA-HQ-OAR-2014-0828-0770
Pratt & Whitney	Alan Epstein	EPA-HQ-OAR-2014-0828-0569, EPA-HQ-OAR-2014-0828-0794
Private Citizen	Max Bliss	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
Private Citizen	Steve Charnovitz	EPA-HQ-OAR-2014-0828-0147
Private Citizen	Rachael Gutierrez	EPA-HQ-OAR-2014-0828-0173
Private Citizen	Joseph Holmes	EPA-HQ-OAR-2014-0828-0412
Private Citizen	Michael Jimenez	EPA-HQ-OAR-2014-0828-0796
Private Citizen	James Lee	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
Private Citizen	Mark and Leanna McEneaney	EPA-HQ-OAR-2014-0828-0601
Private Citizen	Daniel Paschall	EPA-HQ-OAR-2014-0828-0174
Private Citizen	Michael Saraceno	EPA-HQ-OAR-2014-0828-0357
Private Citizen	Katherine Savarese	EPA-HQ-OAR-2014-0828-0178
Regional Airline Association (RAA)	Liam Connolly	EPA-HQ-OAR-2014-0828-0620, EPA-HQ-OAR-2014-0828-0731
Rolls Royce	Paul Madden	EPA-HQ-OAR-2014-0828-0795
Sierra Club	Andres Restrepo	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
StopSprayingUs-SF.com	Patrick Roddie	EPA-HQ-OAR-2014-0828-0927 (public hearing transcript)
The International Air Cargo Association (TIACA)	N/A	EPA-HQ-OAR-2014-0828-0622
Transport & Environment	Bill Hemmings	EPA-HQ-OAR-2014-0828-0862
UCLArts and Healing	Ping Ho	EPA-HQ-OAR-2014-0828-0763
Union of Concerned Scientists	David Babson	EPA-HQ-OAR-2014-0828-0526

1. Generally Support Endangerment and Cause or Contribute Findings

Organization: AirFair (EPA-HQ-OAR-2014-0828-0860)
California Air Resources Board (ARB) (EPA-HQ-OAR-2014-0828-0861, EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Cargo Airline Association (EPA-HQ-OAR-2014-0828-0732)
Center for Biological Diversity (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
City of Santa Monica (EPA-HQ-OAR-2014-0828-0786)
Earth Guardians of Vermont (EPA-HQ-OAR-2014-0828-0920)
Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)
Embraer Aircraft Holding, Inc (EPA-HQ-OAR-2014-0828-0745)
Friends of the Earth (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Institute for Policy Integrity (EPA-HQ-OAR-2014-0828-0749)
Lissys Ltd. (EPA-HQ-OAR-2014-0828-0203)
National Association of Clean Air Agencies (NACAA) (EPA-HQ-OAR-2014-0828-0560)
National Tribal Air Association (NTAA) (EPA-HQ-OAR-2014-0828-0362)
Natural Resources Defense Council (NRDC) (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Northeast States for Coordinated Air Use Management (NESCAUM) (EPA-HQ-OAR-2014-0828-0770)
Private Citizen (EPA-HQ-OAR-2014-0828-0796)
Private Citizen (EPA-HQ-OAR-2014-0828-0173)
Private Citizen (EPA-HQ-OAR-2014-0828-0178)
Sierra Club (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Union of Concerned Scientists (EPA-HQ-OAR-2014-0828-0526)

Summary of Comments: Many commenters (0173, 0178, 0860, 0861, 0732, 0927, 0786, 0920, 0863, 0745, 0749, 0796, 0203, 0560, 0362, 0770, 0526) stated their general support or strong support for the proposed endangerment and contribution findings. Some commenters discussed the scientific support for the endangerment finding and the emissions data support for the contribution finding. A number of commenters specifically noted that they support the findings because they view them as a first step in establishing emissions standards under Clean Air Act (CAA) section 231; others described how the findings will help address various concerns about the impacts of greenhouse gas (GHG) emissions on the climate or the environment. One commenter, not persuaded that the U.S. Environmental Protection Agency (EPA or the Agency) regulation of aircraft engine emissions is necessary, did not generally object to this action because they recognized it was a part of the process for “future adoption of a CO₂ standard established by ICAO,” which the commenter supports. A few commenters expressed appreciation for the EPA using its authority under the CAA; one describes how the proposed endangerment and contribution findings are consistent with other federal government policies to address climate change.

Response: The EPA agrees with the general statements of support from commenters for the endangerment and contribution findings. The Agency acknowledges in section II.A of the Federal Register Notice (FRN) for the final findings that these final endangerment and cause or contribute findings for aircraft engine GHG emissions are a part of preparing for a subsequent domestic rulemaking process under CAA section 231.

2. General Approach to the Science

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

California Air Resources Board (ARB) (EPA-HQ-OAR-2014-0828-0861)

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

National Association of Clean Air Agencies (NACAA) (EPA-HQ-OAR-2014-0828-0560)

Northeast States for Coordinated Air Use Management (NESCAUM) (EPA-HQ-OAR-2014-0828-0770)

Private Citizen (EPA-HQ-OAR-2014-0828-0796)

Summary of Comments: A number of commenters (0861, 0863, 0796, 0560, 0747) stated general agreement with the EPA's approach to the scientific evidence underlying the endangerment finding. Commenters (0861, 0796, 0560) support the EPA's statements in the proposal that the 2009 endangerment finding¹ is firmly established and well-settled, and that there is no need to reopen or revisit it in order to make an additional finding under section 231. One commenter (0861) states, "Since 2009, new scientific assessments have further substantiated the detrimental effect of GHG emissions." One comment letter (0863) calls GHGs "harmful pollution" and says, "As EPA acknowledges, the science is abundantly clear, and there is no reason to delay any further a finding that reflects the overwhelming scientific consensus." Another commenter (0770) also agrees with the Agency's use of scientific assessments, arguing that they "reflect a robust peer review process, and incorporate thousands of climate studies that have individually been peer reviewed as well...this large body of scientific evidence is consistent with the Agency's peer review policy and OMB guidelines, as well as support[ed] by prior legal precedent in *Coalition for Responsible Regulation, Inc. v. EPA*, 684 F.3d 102 (D.C. Cir. 2012)." One comment letter (0747) states that the "EPA is required to rely upon the best scientific, statistical and economic information available in making an endangerment finding, and EPA's analytical process and the results forming the basis for such a finding must be transparent. The Proposed Endangerment Finding appears to be consistent with that requirement."

Response: The EPA responds to comments stating general support for the Agency's approach to the scientific evidence underlying the endangerment finding in section IV.A.1 of the FRN. In addition to that response in the FRN, the EPA provides further detail here. The EPA agrees that it uses the best available, peer-reviewed science in Agency actions. We followed the EPA's Peer Review Policy,² guidance in the EPA's Peer Review Handbook,³ and Agency guidelines for information quality⁴ with respect to the

¹ U.S. EPA, 2009: *Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the Clean Air Act; Final Rule*, 74 FR 66496 (December 15, 2009) ("2009 Endangerment Finding").

² U.S. EPA, 2006: *Memorandum on Peer Review and Peer Involvement at the U.S. EPA*, 4 pp. Available at <https://www.epa.gov/osa/memorandum-peer-review-and-peer-involvement-epa> (last accessed July 11, 2016).

³ U.S. EPA, 2015: *EPA Peer Review Handbook, Fourth Edition*, 248 pp. Available at <https://www.epa.gov/osa/peer-review-handbook-4th-edition-2015-0> (last accessed July 11, 2016). Also, the EPA Science Advisory Board reviewed this approach to the underlying technical and scientific information supporting this action, and concluded that the approach had precedent and the action will be based on well-reviewed information. A copy of this letter and all other relevant EPA peer review documentation is located in the docket for today's final action (EPA-HQ-OAR-2014-0828).

⁴ Applicable guidance includes U.S. EPA 2012: *Addendum to A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information*, 9 pp. Available at <https://www.epa.gov/risk/guidance-evaluating-and-documenting-quality-existing-scientific-and-technical->

scientific information supporting this action, which is primarily comprised of existing syntheses of the literature by prominent scientific organizations that the EPA considers as highly influential scientific assessments (HISAs). These assessments by the USGCRP, IPCC, and NRC draw synthesis conclusions across thousands of individual peer-reviewed studies that appear in scientific journals, and the reports themselves undergo additional peer review. We considered the processes and procedures employed by the USGCRP, IPCC, and the NRC in terms of the EPA's five general assessment factors and information quality factors of objectivity, integrity, utility, and transparency, including how these scientific organizations have employed rigorous peer review processes. The EPA considers these assessments to represent the best available science that maintains the highest level of adherence to Agency guidelines for information quality. These assessments have been adequately peer reviewed in a manner commensurate with the EPA's Peer Review Policy and guidance in the EPA's Peer Review Handbook. The EPA's Peer Review Handbook explains that there are circumstances when peer review is generally not conducted for HISAs; for example, if the Agency has determined that work has already been subject to adequate peer review, as it has here, then it is generally not necessary to have further peer review of that information. We also cite data from the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks report (U.S. Inventory), which we have determined to have been adequately reviewed in accordance the EPA's Peer Review Handbook. We disaggregated data in one area of the U.S. Inventory for presentation purposes. Though not considered influential scientific information, we chose to have the disaggregation methodology peer reviewed in accordance with the EPA's Peer Review Handbook. The commenters' views are consistent with section IV.A of the FRN, which describes how the Agency's approach to the science provides assurance that the Administrator is basing her judgment on the best available, well-vetted science that reflects the consensus of the climate science research community.

[information](https://www.epa.gov/quality/guidelines-ensuring-and-maximizing-quality-objectivity-utility-and-integrity-information) (last accessed July 11, 2016) and U.S. EPA, 2002: *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by the EPA*, 61 pp. Available at <https://www.epa.gov/quality/guidelines-ensuring-and-maximizing-quality-objectivity-utility-and-integrity-information> (last accessed July 11, 2016).

3. The Endangerment Finding

The EPA summarizes and responds to comments regarding the endangerment finding in the sections below, 3.1, 3.2, 3.3, and 3.4.

3.1 Scope & Proposed Definition of "Air Pollution"

Organization: Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
Biogenic CO₂ Coalition (EPA-HQ-OAR-2014-0828-0916)
Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)
California Air Resources Board (ARB) (EPA-HQ-OAR-2014-0828-0861)
Cargo Airline Association (EPA-HQ-OAR-2014-0828-0732)
Climate Viewer News (EPA-HQ-OAR-2014-0828-0359, EPA-HQ-OAR-2014-0828-0484)
Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)
Embraer Aircraft Holding, Inc (EPA-HQ-OAR-2014-0828-0745)
General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)
General Electric (GE) (EPA-HQ-OAR-2014-0828-0932)
The International Air Cargo Association (TIACA) (EPA-HQ-OAR-2014-0828-0622)
International Air Transport Association (IATA) (EPA-HQ-OAR-2014-0828-0548)
National Association of Clean Air Agencies (NACAA) (EPA-HQ-OAR-2014-0828-0560)
National Tribal Air Association (NTAA) (EPA-HQ-OAR-2014-0828-0362)
Northeast States for Coordinated Air Use Management (NESCAUM) (EPA-HQ-OAR-2014-0828-0770)
Private Citizen (EPA-HQ-OAR-2014-0828-0796)
Private Citizen (EPA-HQ-OAR-2014-0828-0173)
Regional Airline Association (RAA) (EPA-HQ-OAR-2014-0828-0620, EPA-HQ-OAR-2014-0828-0731)

Summary of Comments: A commenter (0916) expressed concern about the EPA's proposed endangerment finding because it does not differentiate between carbon dioxide (CO₂) emissions that result from the combustion of fossil fuels and those that result from the "combustion of biomass or biofuels derived from herbaceous crops or crop residues, as well as biogenic CO₂ emissions associated with the production, gathering and processing of crops or crop residues used in bio-based products including fuels."⁵ They argue that such crop-related biogenic CO₂ emissions should be categorically excluded from the endangerment finding because the CO₂ released back to the atmosphere when emitted from crop-derived biogenic sources contains the same carbon that was previously removed or sequestered from CO₂ in the atmosphere; does not contribute to elevated atmospheric concentrations of the six well-mixed GHGs; and thus is "harmless from a global warming standpoint." The commenter requests that the EPA "expressly confirm that such exclusion prevents any standard of performance for aircraft resulting from any endangerment or cause or contribute finding under section 231 from making such CO₂ 'a pollutant subject to regulation' for purposes of the PSD and Title V permitting programs under the Clean Air Act." The commenter requests that if the EPA does not exclude such CO₂ emissions categorically, the

⁵ Biogenic CO₂ Coalition, 2015: Comments on EPA's Proposed Finding That Greenhouse Gas Emissions From Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare, 80 FR 37757 (July 1, 2015). Docket ID number EPA-HQ-OAR-2014-0828-0916. Available at www.regulations.gov (last accessed April 11, 2016).

Agency should complete the development of and apply its Biogenic Accounting Framework within the context of this endangerment finding and any future standards under section 231. The commenter cites and incorporates by reference their previously submitted comment letter on the EPA's Proposed Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Generating Units (79 FR 1430, January 8, 2014), stating that their letter is the basis for their comments on the CAA section 231 proposal.

Response: The EPA responded to public comments on 79 FR 1430 in the context of that rulemaking; all documents in the record for that action can be found in Docket ID No. EPA-HQ-OAR-2013-0495 at www.regulations.gov. Here, the EPA responds to comments pertaining specifically to the CAA section 231 proposal. The EPA responds to comments regarding crop-related biogenic CO₂ emissions or the source of the air pollution, for defining the relevant air pollution considered in the endangerment finding, in section IV.B.6 of the FRN. In addition to that response in the FRN, the EPA provides further detail here.

The EPA developed the 2014 revised report, *Framework for Assessing Biogenic CO₂ Emissions from Stationary Sources* (hereafter, *Framework*), to present a methodological framework for assessing the extent to which the production, processing, and use of biogenic material at stationary sources for energy production results in a net atmospheric contribution of biogenic CO₂ emissions. The EPA is currently engaged in a second round of targeted peer review with the Science Advisory Board on the *Framework*. However, for the reasons stated in section IV.B.6 of the FRN, any findings reached in the context of the *Framework's* technical process would not change the primary scientific basis of the definition of the air pollution for purposes of this endangerment finding (i.e., that CO₂ and the other well-mixed GHGs share common physical characteristics and that no matter the original source of the CO₂, the behavior of the CO₂ molecules in the atmosphere in terms of radiative forcing, chemical reactivity, and atmospheric lifetime is effectively the same). Thus, the EPA does not agree that the *Framework* is relevant in the context of this endangerment finding.

Because the EPA is not creating such an exclusion in this action, it need not address what the scope or effect of such an exclusion might be for the Prevention of Significant Deterioration (PSD) and title V permitting programs. Regulation of such substances under these permitting programs is a separate issue that the EPA is handling separately. Moreover, as the EPA explained in a 2010 rulemaking, it does not view an endangerment finding or cause and contribute finding under CAA section 202(a) alone as making the requirements of the major source permitting programs applicable to a pollutant. *See* 75 Fed. Reg. 17012-13 (April 2, 2010) (discussing PSD) and *id.* at 17023 (applying a similar approach for title V as for PSD). The same interpretation applies for an endangerment finding under CAA section 231, in light of the analogous language and structure of sections 202 and 231. Moreover, as for the 2009 findings, while the endangerment and contribution findings for aircraft GHG emissions under section 231(a)(2)(A) are a necessary preliminary step to establishing emissions standards under CAA section 231, this action is not establishing such emissions standards or otherwise establishing requirements for the actual control of aircraft GHG emissions.

Summary of Comments: One comment letter (0747) agreed with the Agency's evaluation of the six GHGs based on their common attributes and the fact that according to the commenter, "no new developments in the scientific or technical literature since 2009 support expanding the scope of the endangerment analysis beyond these six GHGs." However, the commenter questioned the EPA's decision to aggregate the six gases rather than considering them individually for purposes of making the findings.

Response: The EPA responds to comments suggesting a separate endangerment analysis for each of the six well-mixed gases individually in section IV.B.6 of the FRN. In addition to that response in the FRN, the EPA agrees with the commenter that the scientific assessment literature supports the Administrator's decision to define the air pollution as the combined mix of the six well-mixed GHGs. The EPA is not at this time taking final action to determine whether other climate forcers should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A).

Summary of Comments: Many commenters (0173, 0362, 0560, 0570, 0770, 0796, 0861, 0863, 0927) stated their general support for the EPA's inclusion of the six well-mixed GHGs in the definition of the "air pollution" for purposes of the endangerment finding under section 231(a)(2)(A) of the CAA. Many of those commenters also supported the EPA's focusing of the scope of this endangerment finding on those six well-mixed GHGs. One commenter states, "no new developments in the scientific or technical literature since 2009 support expanding the scope of the endangerment analysis beyond these six GHGs."

Response: The EPA agrees that the best available science represented by the findings of the recent, major assessments by the U.S. Global Change Research Program (USGCRP), the Intergovernmental Panel on Climate Change (IPCC), and the National Research Council of the National Academies of Sciences, Engineering, and Medicine (referred to interchangeably as NRC or NAS) support the Administrator's decision to define the air pollution as the combined mix of the six well-mixed GHGs. The Administrator's definition of air pollution for purposes of section 231(a)(2)(A) is made in light of (1) the evidence, analysis, and conclusions that led to the 2009 endangerment finding; (2) more recent evidence from scientific assessments published since 2009; and (3) consideration of public comments. The Administrator reasonably and appropriately considered all information before her, and she maintains her view that defining the scope and nature of the air pollution to be these six well-mixed GHGs remains valid and well-supported by the current science.

Summary of Comments: Many commenters (0548, 0570, 0568, 0732, 0745, 0837, 0932, 0620, 0622) highlighted the fact that aircraft engines emit only two of the six GHGs that together are defined as the "air pollution" and "air pollutant" for purposes of the endangerment and contribution findings under section 231 of the CAA. Commenters pointed out that the majority of emissions are CO₂, and they described nitrous oxide (N₂O) emissions as "nominal (< 1 percent)," "trace," or "relatively small." Some commenters ultimately conclude that the scope of the EPA's endangerment finding is acceptable, while others say it would be more logical for the EPA to limit itself to CO₂ or to CO₂ and N₂O (either by limiting the definition of "air pollution" or by limiting the scope of future regulations).

Response: The EPA responds to comments regarding limiting the definition of air pollution in this action to CO₂ (or to CO₂ and N₂O), and limiting the scope of future regulations to CO₂ in section IV.B.6 of the FRN. In addition to that response in the FRN, the EPA provides further detail here. The EPA disagrees with commenters suggesting that the fact that aircraft N₂O emissions are about 1 percent of aircraft GHG emissions means that N₂O should be excluded from the scope of the relevant air pollution in this endangerment finding. The endangerment and contribution findings constitute a two-step test. The first step is for the Administrator to decide whether, in her judgment, the air pollution under consideration may reasonably be anticipated to endanger public health or welfare. Second, the Administrator must decide whether, in her judgment, emissions of an air pollutant from certain classes of aircraft engines cause or contribute to this air pollution.

As part of the endangerment test, the Administrator must define the scope and nature of the relevant air pollution for which she then must make a scientific judgment regarding the potential risks posed to public health and welfare. As explained in section III.A of the FRN, the Administrator is to consider the

cumulative impact of sources of a pollutant in assessing the risks from air pollution, and is not to look only at the risks attributable to a single source or class of sources. In making an endangerment finding, the Administrator is not limited to considering only those impacts that can be traced to the amount of air pollution directly attributable to the subject source classes. Such an approach would collapse the two prongs of the test by requiring that any climate change impacts upon which an endangerment determination is made result solely from the GHG emissions of aircraft. The EPA has defined the air pollution as the aggregate group of the six well-mixed GHGs for five primary reasons detailed in section IV.B of the FRN. In brief, they are: (1) they share common physical properties that influence their climate effects; (2) on the basis of these common physical properties, they have been determined to be the root cause of human-induced climate change, are the best-understood driver of climate change, and are expected to remain the primary driver of future climate change; (3) they are the common focus of climate change science research and policy analyses and discussions; (4) using the combined mix of these gases as the definition (versus an individual gas-by-gas approach) is consistent with the science, because risks and impacts associated with GHG-induced climate change are not assessed on an individual gas-by-gas basis; and (5) using the combined mix of these gases is consistent with past EPA practice, where separate substances from different sources, but with common properties, may be treated as a class (e.g., oxides of nitrogen, particulate matter, volatile organic compounds). The focus on the six well-mixed GHGs as the air pollution is based on their shared physical characteristics and common attributes relevant to climate change science and policy, which are not affected by consideration of the magnitude of the emissions contributing to the air pollution. Accordingly, the EPA reasonably evaluated the six well-mixed GHGs together in this endangerment finding, even though the subject source category for these findings only emits two of those gases and emissions of one of those gases are approximately 1 percent of GHG emissions from this category. The fact that these six substances within the definition of GHGs share common, relevant attributes is true regardless of the subject source categories. Moreover, the reasonableness of grouping these six chemicals as the relevant air pollution does not turn on the particular source category or categories at issue for a particular action. Comments regarding the scope of the definition of air pollutant are addressed in section 4.1 of this response to comments (RTC) document. The EPA responds to comments regarding limiting the definition of air pollutant in this action to CO₂ (or to CO₂ and N₂O) and limiting the scope of future regulations to CO₂ in section V.A.2 of the FRN.

Summary of Comments: A commenter (0359) disagreed with the scope of the endangerment finding and requests a focus on the following: (1) metal particulates (e.g., lead, barium, aluminum); (2) trade-secret, toxic chemicals used as additives in aviation fuel; and (3) cloud formation from jet exhaust (i.e., aviation-induced cloudiness). The commenter argued that these substances or effects associated with aircraft emissions pose a greater risk to human health than the six well-mixed GHGs, and states, “If the EPA is truly concerned about aviation-induced climate change, they will regulate the production of contrails and cirrus clouds which change our climate to a much greater extent than the sum of the six greenhouse gases named in this Proposal.” The commenter cited multiple examples of health risks such as Alzheimer’s disease, autism, and cancer that the commenter claims are associated with the aviation fuel itself, the burning of aviation fuel, and the effects on clouds from burning aviation fuel. The commenter argued that the EPA should consider other sources of scientific information conducted outside of a laboratory setting, and provides links to information that the commenter claims verify the health impacts from the substances listed above. The commenter concludes that such information supports focusing the endangerment finding under CAA section 231 on the three categories identified above rather than the six well-mixed GHGs.

Response: The EPA responds to comments requesting inclusion of other climate forcing substances associated with aircraft emissions beyond the six well-mixed GHGs in section IV.B.7 of the FRN. In addition to those responses, the EPA provides further detail here.

The EPA disagrees with the comments suggesting that the scientific and technical information considered by the Administrator was limited to studies in a laboratory, and that the three categories of substances or effects associated with aircraft emissions mentioned in the comment are more important drivers of climate change than the six well-mixed GHGs. The EPA is giving careful consideration to all of the scientific and technical information in the record, including information provided by the public. However, for the reasons stated in section IV.A of the FRN, the Administrator considers recent, major assessments by the USGCRP, IPCC, and the NRC as the primary scientific and technical basis informing the endangerment finding. These major climate science assessments synthesize thousands of individual peer-reviewed studies published in scientific journals that use a variety of methods (e.g., field observations, computer modeling). The authors evaluate these individual studies in order to draw more general and overarching conclusions about the state of science. The reports themselves then undergo additional peer review to ensure that they accurately convey the consensus conclusions on what the body of scientific literature tells us.

Contrary to the comment's suggestion, as reflected in these major climate science assessments, there is extensive scientific evidence in the climate change assessment literature that the six well-mixed GHGs together constitute the largest anthropogenic driver of climate change. The EPA has no reason to believe that the assessment reports do not represent the best source material to determine the state of science and the consensus view of the world's scientific experts on the issues central to making an endangerment decision with respect to the six well-mixed GHGs. The commenter's suggestion that the scientific and technical information considered by the Administrator was limited to studies in a laboratory is incorrect, since the assessments incorporate many types of studies. The studies cited by the commenter do not provide evidence challenging or refuting the role of the six well-mixed GHGs in driving climate change, and do not support the claim that the Administrator should have drawn a different conclusion regarding the scope of the relevant air pollution. The EPA responds to comments regarding the climate science aspects of how emissions of metal particulates may play a role in cloud formation and the climate effects of contrails/aviation-induced cloudiness in section 3.3 of this RTC document. The EPA responds to comments regarding possible direct health effects of substances or effects associated with aircraft in section 5.3 of this RTC document. The EPA is not at this time taking final action to determine whether substances other than the six well-mixed GHGs that may have climate effects should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A).

3.2 Additional Substances

Organization: Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797)

AirFair (EPA-HQ-OAR-2014-0828-0860)

Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)

General Electric (GE) (EPA-HQ-OAR-2014-0828-0932)

International Air Transport Association (IATA) (EPA-HQ-OAR-2014-0828-0548)

Summary of Comments: A number of commenters (0548, 0570, 0747, 0837, 0932) agree with the EPA's proposal that aerosol particles including black carbon, high-altitude nitrogen oxides (NO_x), and water vapor should not at this time be included in the definition of "air pollution" and "air pollutant" under the endangerment and contribution findings because of significant scientific uncertainties regarding their net effect on the Earth's climate. One commenter (0747) argues that their exclusion is appropriate because "these agents do not fit into the regulatory and policy paradigm represented by the six well-mixed GHGs identified in the Proposed Endangerment Finding: they are short-lived; they are not as well-studied or understood as the six well-mixed GHGs; and the best science available indicates that their effect on climate is either low/negligible or significant uncertainty surrounds their forcing effects." Another commenter (0837) states that in some instances the radiative forcing effects of these substances can be either positive or negative, and thus the "the science is not yet settled" on the contribution of these additional substances to climate change.

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency's basis for not including them in the current action is described in section IV.B.7 in the FRN. The EPA has reviewed the commenters' points and finds that they are generally consistent with the description in section IV.B.7 of the FRN regarding these substances' short-lived nature in the atmosphere, and the scientific uncertainties about their net climate effects (as illustrated by estimates of radiative forcing that span both positive and negative values). In section IV.B.4 in the proposal and in section IV.B.7 in the FRN, the EPA cited evidence from the assessment literature that these other substances have radiative forcing effects that are dependent on a number of factors such as the location and time of emissions, but the EPA did not describe their climate effects as "low" or "negligible" in either section.

Summary of Comments: A joint comment letter (0863) argues that the EPA failed to properly examine water vapor, NO_x, and black carbon in its proposed endangerment and contribution findings, and thus failed to do what the Agency committed to in its response to a 2007 petition from many of the joint commenters.⁶ The commenter concludes that the discussion of the scientific uncertainties contained in the proposal does not constitute careful examination of the issues. The commenter states that the EPA should have quantified and included the effect of these additional substances in the Agency's discussion of drivers of climate change. The commenter requests that the EPA finalize the proposed endangerment finding for the six well-mixed GHGs, and also to "embark upon a second endangerment finding that both

⁶U.S. EPA (2012). *Memorandum in Response to Petition Regarding Greenhouse Gas Emissions from Aircraft*. Available at <https://www3.epa.gov/otaq/documents/aviation/oar-12-001-0157-aircraft-petition-response-memorandum.pdf> (last accessed June 9, 2016).

analyzes the effect of the remaining gases and addresses a broader range of aircraft, including smaller turboprop and jet aircraft, piston-engine aircraft, and helicopters.”

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. In this discussion, the EPA provides a careful examination of the issues that is based on the best available, well-vetted science that reflected the consensus of the climate science research community. As described there, the EPA considered the following assessments to obtain the best estimates of these substances’ radiative forcing: the IPCC Fifth Assessment Report (AR5),⁷ the IPCC 2007 Fourth Assessment Report (AR4),⁸ the IPCC Special Report: Aviation and the Global Atmosphere (IPCC 1999),⁹ the NRC’s Advancing the Science of Climate Change (NRC 2010),¹⁰ and the NRC’s Atmospheric Effects of Aviation: A Review of NASA’s Subsonic Assessment Project (NRC 1999).¹¹ The USGCRP assessments have not dealt specifically with such emissions at high altitude. The EPA presented quantitative estimates of radiative forcing from the assessment literature for aviation-induced cloudiness, aviation-induced particles (including black carbon), and high-altitude NO_x in the proposal and in section IV.B.7 of the FRN. The EPA also cited evidence from the assessments that the climatic impact of these other substances is dependent on a number of factors (including location and time of emission), and that the scientific uncertainty for quantitative estimates of radiative forcing is greater for these other short-lived substances (as illustrated by estimates of radiative forcing that span both positive and negative values) than for the six well-mixed GHGs. The commenter provides no evidence that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts. Accordingly, the EPA disagrees with the comment that it should at this time have included the effects of these additional substances in the analysis of the drivers of climate change in this action. The EPA will take the commenter’s request to undertake a second endangerment finding that addresses the “remaining gases” and a broader range of aircraft, under advisement and consideration among its other duties and priorities, but is not prepared at this time to either reject or grant that request.

Summary of Comments: A commenter (0860) stated that aviation has radiative forcing effects that contribute to climate change not only through the effects of CO₂ emissions, but also through NO_x emissions, emissions of aerosols and their precursors (soot and sulfate), and increased cloudiness in the form of persistent linear contrails and induced-cirrus cloudiness. The commenter noted that the EPA’s estimates of aircraft’s contribution to climate change in terms of radiative forcing would be larger if these other substances were taken into account, but did not ask the EPA to change its analysis or how it defines “air pollution” and “air pollutant” under the endangerment and contribution findings.

⁷ IPCC, 2013: *Climate Change 2013: The Physical Science Basis*. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, 1535 pp.

⁸ IPCC, 2007: *Climate Change 2007: The Physical Scientific Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)] Cambridge University Press, 996 pp.

⁹ IPCC, 1999: *Aviation and the Global Atmosphere*, Special Report to the Intergovernmental Panel on Climate Change [Penner, J.E., D.H. Lister, D.J. Griggs, D.J. Dokken, M. McFarland (eds.)] Cambridge University Press, 373 pp.

¹⁰ NRC, 2010: *Advancing the Science of Climate Change*. The National Academies Press, 528 pp.

¹¹ NRC, 1999: *Atmospheric Effects of Aviation: A Review of NASA’s Subsonic Assessment Project*. The National Academies Press, 54 pp.

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. The EPA finds that the current climate science assessment literature does not support a definitive conclusion that the net climate effects in terms of radiative forcing of aircraft emissions would be larger if the effects of NO_x, water vapor, and aerosols and their precursors were taken into account. The EPA presented quantitative estimates of radiative forcing from the assessment literature for aviation-induced cloudiness, aviation-induced particles, and high-altitude NO_x in the proposal and in section IV.B.7 of the FRN, noting their large uncertainty ranges. The EPA also described in detail the scientific uncertainties regarding these estimates, including that their net climatic impact is dependent on a number of factors such as location and time of emission, and that estimates of their radiative forcing spans both positive and negative values. The radiative forcing effects of these substances are also discussed in greater detail in section 3.3, “Climate Science,” of this RTC document.

3.2.1 Aerosols/Black Carbon

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

International Council on Clean Transportation (ICCT) (EPA-HQ-OAR-2014-0828-0791)

Summary of Comments: A commenter (0747) agrees with the EPA regarding scientific uncertainty of the net climate effects of black carbon and supports not including black carbon in the definition of air pollution for the purposes of this endangerment finding under CAA section 231(a). The commenter's reasons include (1) that there is limited information available on the radiative forcing, global warming potential (GWP) and global temperature potential (GTP) of black carbon; (2) that there are uncertainties with regard to understanding and quantifying the effects of black carbon, which include aerosol-radiation interaction, aerosol-cloud interactions, and albedo; and (3) that despite growing estimates of global mean radiative forcing from black carbon recently, there is "substantial disagreement among experts about the effects and climate impacts of black carbon," and these uncertainties extend to the "human health benefits and climate change mitigation co-benefits associated with reducing black carbon." The commenter also argues that there are no appropriate means, metrics, or methods available for quantifying black carbon emissions from aircraft, which they argue provides further evidence that black carbon "simply does not fit EPA's paradigm for the six GHGs identified in the Proposed Endangerment Finding, all of which can be quantified and compared on a CO₂e basis."

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency's basis for not including them in the current action is described in section IV.B.7 of the FRN. The commenter's arguments regarding scientific uncertainty for quantitative radiative forcing estimates for aircraft black carbon emissions are generally consistent with the EPA's discussion in section IV.B.7. The EPA cited evidence from the assessment literature that the magnitude of aerosol effects can vary immensely with location and season of emissions, and that estimates of their total climate forcing effect have a large uncertainty range. Varying GWP estimates are additional information alongside other measures of radiative forcing demonstrating this variation in aerosol effects. While the GWP is a measure of the heat absorbed over a given time period due to emissions of a gas, the GTP is a measure of the temperature change at the end of that time period (again, relative to CO₂). While the calculation of the GTP is more complicated than that for the GWP, as it requires modeling how much the climate system responds to increased concentrations of GHGs (the climate sensitivity) and how quickly the system responds (based in part on how the ocean absorbs heat), GTP-based estimates also provide similar information. The EPA responds to other comments regarding the global radiative forcing effects of aircraft black carbon emissions in section 3.3, "Climate Science," of this RTC document. The other uncertainties cited by the commenter (e.g., human health co-benefits of potential black-carbon mitigation policies) are outside the scope of the EPA's inquiry in this action, which is focused on climate change risks and impacts.

Regarding the commenter's statements about not being able to measure black carbon using CO₂-equivalent (CO₂e) units not fitting into "EPA's paradigm for the six GHGs," we reiterate that the EPA has defined the air pollution as the aggregate group of the six well-mixed GHGs for five primary reasons detailed in section IV.B of the FRN. In brief, they are: (1) they share common physical properties that influence their climate effects; (2) on the basis of these common physical properties, they have been determined to be the root cause of human-induced climate change, are the best-understood driver of climate change, and are expected to remain the primary driver of future climate change; (3) they are the

common focus of climate change science research and policy analyses and discussions; (4) using the combined mix of these gases as the definition (versus an individual gas-by-gas approach) is consistent with the science, because risks and impacts associated with GHG-induced climate change are not assessed on an individual gas-by-gas basis; and (5) using the combined mix of these gases is consistent with past EPA practice, where separate substances from different sources, but with common properties, may be treated as a class (e.g., NO_x, particulate matter (PM), volatile organic compounds). The ability to quantify and compare substances using CO₂-e units is not one of the foundational reasons for the Agency's focus on the six well-mixed GHGs. As explained in section IV.B.7 of the FRN, the EPA is not at this time including these substances in the definition of air pollution in this action, for reasons including that aerosols such as black carbon do not share these five properties with the six well-mixed GHGs.

Summary of Comments: One commenter (0863) argued that the EPA should have included black carbon in this endangerment finding, stating that the “EPA has noted that black carbon—the most strongly light-absorbing component of PM—‘is an important climate forcing agent.’ As black carbon ‘darkens bright surfaces such as snow and ice,’ it could have severe effects on ice melt and warming in the Arctic.” The commenter requested the EPA to complete a separate endangerment finding analyzing other climate forcers emitted from aircraft, including black carbon. Another commenter (0791) agreed with the EPA's discussion of scientific uncertainties on the climate impact of NO_x and water vapor, but states, “The science regarding the contribution of black carbon to climate change, on the other hand, is clear. Black carbon was identified as the second most important contributor to anthropogenic emissions in 2013. To reflect the latest science, EPA should consider promulgating a separate aviation endangerment finding focusing on black carbon in the near future.”

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the EPA will take the commenter's request to undertake a second endangerment finding focusing on black carbon under advisement and consideration among its other duties and priorities. However, it is not prepared at this time to either reject or grant that request. The Agency's basis for not including climate forcers other than the six well-mixed GHGs in the current action is described in section IV.B.7 in the FRN. The EPA cited evidence from the assessment literature about the direct radiative forcing effects of high-altitude emissions of the two primary aviation-induced particles, sulfates and black carbon, and acknowledged that black carbon can have warming effects through darkening bright surfaces such as snow and ice, which reduces reflectivity. The EPA also cited evidence from the assessment literature that the magnitude of aerosol effects can vary immensely with location and season of emissions and that that estimates of its total climate forcing effect have a large uncertainty range. Thus, the EPA disagrees with comments suggested that the Agency's discussion did not accurately reflect the state of the science, and notes that the commenters provide no evidence that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts, including impacts from black carbon. It is also worth noting that in contrast to the commenter's statement that black carbon is the second, most-important contributor to anthropogenic emissions, the IPCC AR5 estimated the total warming effect of black carbon at 0.64 W/m², which is below both the estimates for CO₂ (1.68 W/m²) and methane (0.97 W/m², including indirect effects).¹²

¹² See Table 8.SM.8 on p. 8SM-13 in IPCC, 2013: *Anthropogenic and Natural Radiative Forcing Supplementary Material*. In: *Climate Change 2013: The Physical Science Basis*. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, 44 pp.

3.2.2 Water Vapor, Contrails

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)

Transport & Environment (EPA-HQ-OAR-2014-0828-0862)

Summary of Comments: A commenter (0747) agreed that the EPA acted appropriately when it did not include water vapor in its proposed endangerment and cause or contribute findings and stated that the rationale given in the 2009 endangerment finding still apply. The commenter argued that the EPA should focus on anthropogenic climate-forcing agents and that “anthropogenic water vapor emissions from aircraft are an insignificant climate forcing agent.” The commenter cites as additional support for these arguments the fact that the EPA’s U.S. National Emissions Inventory, the State of California, and the United Nations Framework Convention on Climate Change (UNFCCC) GHG reporting guidelines all do not require reporting of anthropogenic water vapor emissions. The commenter states that the most recent IPCC assessment (AR5) excludes water vapor from a list of anthropogenic emissions that cause radiative forcing and estimates “negligible” radiative forcing from contrails and contrail-induced cirrus clouds that is “even less than previously thought.” Citing the IPCC AR5, the commenter notes that radiative forcing from contrails is estimated at 0.01 (0.005 to 0.03) W/m², that combined contrails and contrail-induced cirrus radiative forcing is 0.05 (0.02 to 0.15) W/m², and that “[m]ore recent estimates tend to indicate somewhat smaller radiative forcing than assessed in the AR4.”

The commenter states that the IPCC categorizes its radiative forcing estimates for contrails as “very uncertain,” with medium confidence levels and low agreement, and describes the evidence on radiative forcing from combined contrails and contrail-induced cirrus as “even less certain, with low agreement and a low confidence level.” The commenter concludes that EPA’s decision not to include contrails is “entirely consistent with its obligation to use the best available science as required by Information Quality Act,” and that “both the low radiative forcing and the high degree of scientific uncertainty associated with any positive climate forcing consequence supports EPA’s decision to exclude contrails, contrail-induced cirrus clouds and induced cirrus clouds from its Proposed Endangerment and Cause or Contribute Findings.”

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. The commenter’s arguments regarding scientific uncertainty for quantitative radiative forcing estimates for aircraft water vapor emissions are generally consistent with the EPA’s discussion in section IV.B.7. The EPA cited evidence from the assessment literature that aviation-induced cloudiness associated with water vapor emissions has uncertain radiative forcing effects that are dependent on a number of factors such as the location and time of emission, but the EPA did not describe their climate effects as “insignificant” or “negligible.” In addition, the EPA’s basis for not including water vapor in the current action does not include the consideration of emissions inventory reporting guidelines. The EPA responds to comments regarding the radiative forcing effects of anthropogenic water vapor emissions in section 3.3, “Climate Science,” of this RTC document.

Summary of Comments: A commenter (0747) argues that there is no basis for properly including water vapor emissions from aircraft in the endangerment finding because even if man-made water vapor were reduced, this would not materially decrease the concentration of water vapor in the atmosphere. The

commenter argues that it is this background concentration of water vapor that represents the only potentially significant aspect of radiative forcing, not anthropogenic water vapor emissions.

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. The EPA has defined the air pollution as the aggregate group of the six well-mixed GHGs for five primary reasons detailed in section IV.B of the FRN. In brief: (1) they share common physical properties that influence their climate effects; (2) on the basis of these common physical properties, they have been determined to be the root cause of human-induced climate change, are the best-understood driver of climate change, and are expected to remain the primary driver of future climate change; (3) they are the common focus of climate change science research and policy analyses and discussions; (4) using the combined mix of these gases as the definition (versus an individual gas-by-gas approach) is consistent with the science, because risks and impacts associated with GHG-induced climate change are not assessed on an individual gas-by-gas basis; and (5) using the combined mix of these gases is consistent with past EPA practice, where separate substances from different sources, but with common properties, may be treated as a class (e.g., NO_x, PM, volatile organic compounds). The focus on the six well-mixed GHGs as the air pollution is based on their shared physical characteristics and common attributes relevant to climate change science and policy, which does not include the consideration of the potential climate effects of reducing aircraft emissions of specific substances. The EPA responds to comments regarding the radiative forcing effects of anthropogenic water vapor emissions in section 3.3, “Climate Science,” of this RTC document.

Summary of Comments: A commenter (0568) states that water vapor has not been determined to be a pollutant under the CAA, arguing that—in addition to the scientific uncertainties described in the proposal—this is justification to exclude water vapor from the proposed endangerment and contribution findings.

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. The EPA’s rationale does not include consideration of policy effects; rather, it is based on considerations of the state of the science. For water vapor, these considerations include the fact that the state of the science, as represented in the assessment literature at present, continues to highlight significant scientific uncertainties regarding the total net forcing effect of water vapor. Furthermore, as explained in the previous response and in more detail in section IV.B of the FRN, the EPA has defined the air pollution as the aggregate group of the six well-mixed GHGs for five primary reasons; these reasons do not include whether a substance has or has not previously been determined to be an air pollutant under the CAA.

Summary of Comments: A commenter (0862) argues that the climate effects of contrails “cannot be ignored in rulemaking that aims to reduce the impact of aviation on climate change, even though there remains uncertainty about quantifying the effect.”

Response: The EPA is not ignoring potential climate effects from contrails in this action. Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency’s basis for not including them in the current action is described in section IV.B.7 in the FRN. As stated in that section, the state of the science as represented in the assessment literature at present

continues to highlight significant scientific uncertainties regarding the total net forcing effect of water vapor, NO_x, and aerosol particles when emitted at high altitudes. The dependence of the effects on where and when the substance is emitted, and the complex temporal and spatial patterns that result, mean that the current level of understanding regarding these short-lived substances is much lower than for the six well-mixed GHGs. Given these scientific uncertainties at present, the Agency is not including these constituents in the definition of air pollution for purposes of the endangerment finding under section 231(a)(2)(A) of the CAA; rather, the EPA is focusing this action on the six well-mixed GHGs that together constitute the largest anthropogenic driver of climate change.

3.2.3 High-Altitude NOx

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797)

International Air Transport Association (IATA) (EPA-HQ-OAR-2014-0828-0548)

International Council on Clean Transportation (ICCT) (EPA-HQ-OAR-2014-0828-0791, EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Summary of Comments: Some commenters (0548, 0570) state their agreement that the EPA did not include NOx in the definition of air pollution for this endangerment finding under CAA section 231, noting that NOx is already regulated by the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), and by the EPA under CAA section 231 based on local air quality impacts.

Response: The EPA agrees that in 2012, the Agency adopted its revised NOx emissions standards for aircraft gas turbine engines with rated thrusts greater than 26.7 kilonewtons, and the prior NOx standards the EPA had adopted in a series of prior rulemakings, relied on the Agency's prior finding that NOx emissions from aircraft contributed to local air quality impacts. To the extent that the commenters are noting this fact as justification to exclude NOx from the proposed endangerment and contribution findings regarding GHG emissions, the EPA disagrees that the prior findings must have that result. Although the EPA is not at this time taking final action to determine whether climate forcings other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency's basis for not including them in the current action is described in section IV.B.7 in the FRN, including section IV.B.7.d in the FRN, which describes the scientific uncertainties about the net climate effects of NOx.

Summary of Comments: A few commenters (0548, 0747) agree with not including NOx in the definition of air pollution in this endangerment finding given the substantial scientific uncertainties regarding the net climate effects of high-altitude NOx emissions. One comment letter (0747) states that the balance between the climate warming and cooling effects of NOx is "not uniform or predictable" because it depends on geographic, altitude, and temporal factors in addition to local concentrations of ozone and methane. The commenter explains that "NOx is a precursor to ozone formation, which has been recognized to have a warming effect," but "reduces methane lifetimes and contributes to the formation of nitrate aerosols, which has a recognized cooling effect." The commenter also states, that "NOx also likely affects the climate through nitrogen deposition, contributing to increased carbon sinks." The commenter cited the IPCC AR5 and IPCC 1999 Assessment, arguing that their use of two different metrics (radiative forcing and GWP) to quantify the overall climate impact of NOx illustrates "the speculative nature of any effort to evaluate potential climate impacts." Regarding quantifying these various effects to determine an overall net effect of NOx emissions on the climate, the commenter questioned the radiative forcing and GWP estimates that the EPA included in the proposal for this action for aircraft emissions of NOx, but also stated that it does not affect their conclusions that generally agree with the EPA's discussion of scientific uncertainty. In addition, the commenter argues that NOx emissions affect the climate only indirectly via their effects on methane and ozone, and that "Consistent with its overall approach to the endangerment analysis, EPA should therefore continue to focus on emissions that have been determined to directly contribute to climate change."

Response: Although the EPA is not at this time taking final action to determine whether climate forcers other than the six well-mixed GHGs should be found to represent air pollution within the meaning of CAA section 231(a)(2)(A), the Agency's basis for not including them in the current action is described in section IV.B.7 of the FRN. The commenter's arguments regarding scientific uncertainty for quantitative radiative forcing estimates for aircraft NO_x emissions are generally consistent with the EPA's discussion in section IV.B.7. The EPA cited evidence from the assessment literature about the geographic, altitudinal, and temporal factors leading to differential NO_x impacts on methane, aerosol, and ozone formation and destruction, and therefore on the Earth's climate. These factors contribute to the uncertainty regarding net NO_x impacts on climate. The EPA agrees with the commenter that nitrogen deposition may have additional ecosystem effects through fertilization, but also notes that increased ozone concentrations resulting from NO_x emissions may have damaging effects on ecosystems. These effects (and their related climate impacts) are less well-quantified than the radiative forcing effects discussed in the FRN, contributing to the overall scientific uncertainties regarding the net climate effects of aircraft NO_x emissions. This comment is consistent with the EPA not at this time including NO_x in the definition of air pollution in this finding regarding GHG emissions.

Regarding the commenter's questions about the radiative forcing and GWP estimates that the EPA included in the proposal for aircraft emissions, it should be noted that the EPA cites from the same assessment reports that the commenter cites—the IPCC AR5 and the IPCC 1999. The EPA cited the 1999 assessment since no more recent quantitative estimates are available for the globally averaged radiative forcing for high-altitude aircraft emissions of NO_x. The EPA cited the IPCC AR5 report as additional context and more recent evidence of the scientific uncertainties regarding the net climate effects of aircraft NO_x emissions (since the GWP estimates range from negative to positive, indicating uncertainty whether the net effect is one of warming or cooling).

Regarding the commenter's statements about whether NO_x should be excluded because it primarily impacts climate through indirect effects on methane and ozone rather than direct effects of elevated levels of NO_x on climate, we reiterate that the EPA has defined the air pollution as the aggregate group of the six well-mixed GHGs for five primary reasons detailed in section IV.B of the FRN and briefly summarized elsewhere in this RTC document. We note that the fact that the six well-mixed GHGs are directly emitted from a source as a GHG (rather than becoming a GHG in the atmosphere after emissions of a precursor gas) is one aspect of one of the five primary reasons for the aggregate grouping, but does not form the sole basis for including or excluding substances from the definition of air pollution in this finding.

Summary of Comments: One commenter (0927) argues that the understanding of the climate impact of aviation NO_x emissions would be improved by additional emissions data. The commenter suggests that the EPA should collect domestic cruise NO_x data.

Response: Drawing from the scientific assessment literature, the EPA discusses the factors that contribute to scientific uncertainties regarding the net climate effects of aircraft NO_x emissions in section IV.B.7 of the FRN. A lack of cruise emissions data was not identified as one of those factors, and the commenter does not explain exactly how the scientific understanding of climate effects of NO_x would be improved by such data.

3.3 Climate Science

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Earth Guardians of Vermont (EPA-HQ-OAR-2014-0828-0920)

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

Friends of the Earth (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Geoengineering Watch (EPA-HQ-OAR-2014-0828-0261)

Private Citizen (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Private Citizen (EPA-HQ-OAR-2014-0828-0357)

StopSprayingUs-SF.com (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Summary of Comments: Commenters (0357, 0863) discussed the radiative forcing effects of aircraft emissions, agreeing with the EPA that CO₂ and other GHGs contribute to warming of the global climate system through the greenhouse effect and trapping heat on the Earth. One commenter (0863) specifically noted that N₂O is a powerful, long-lived GHG with a warming effect 300 times that of CO₂. One commenter (0357) noted that other aircraft emissions include soot, sulfur, metals, and nitrogen oxides, and that of these emissions, NO_x and black carbon have also contributed to global warming. Another commenter characterized estimates of the radiative forcing effects of aircraft black carbon emissions as having “significant scientific uncertainties and disparate interpretations,” stating that “Recent research indicates that the radiative forcing from black carbon on snow and ice is weaker than previously thought and has been decreasing over the past several decades. It also reveals that black carbon concentrations in the Arctic atmosphere have been declining.”

Response: The EPA agrees that the six well-mixed GHGs, including N₂O, contribute to warming of the global climate system, and finds that these comments are generally consistent with the discussion in section IV.B.2 of the FRN. Regarding other aircraft emissions, the EPA presented quantitative estimates of radiative forcing from the assessment literature for aviation-induced cloudiness, aviation-induced particles, and high-altitude NO_x in the proposal and in section IV.B.7 of the FRN. The EPA also cited evidence from the assessments that the climatic impact of these other substances is dependent on a number of factors (including location and time of emissions) and that the scientific uncertainty for quantitative estimates of radiative forcing is greater for these other short-lived substances than for the six well-mixed GHGs, reflecting greater uncertainty regarding climate impacts of emissions of these other substances. The commenter is correct that the IPCC AR5 assesses black carbon impacts on snow and ice to have a global radiative forcing effect of 0.04 W/m² (with an uncertainty range of 0.02 to 0.09 W/m²), which is smaller than the IPCC AR4’s estimate of +0.1 W/m² (plus/minus 0.1), and that black carbon concentrations in the Arctic (at least in the Western Hemisphere) have likely declined since the 1980s. However, as the EPA explains in section IV.B.7.c of the FRN, snow and ice albedo forcing is only one aspect of how black carbon affects the climate. Other mechanisms include indirect warming and cooling effects via clouds and a direct warming effect primarily via absorbing incoming and reflected sunlight. Overall, commenters provide no evidence that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts.

Summary of Comments: One comment letter (0863) noted that high-altitude aircraft emissions may have a disproportionately higher warming effect and impact on the Earth’s climate when emitted into the “climatically sensitive upper troposphere and lower stratosphere.”

Response: The EPA recognizes that emissions of some substances such as ozone precursors and aerosols at high altitudes can have different impacts than emissions of the same substances at the surface due to a

longer residence time in the atmosphere and different background conditions. While in some cases, the difference will lead to more warming, in others it could lead to more cooling, and the climate impacts of such emissions can be sensitive to the time and place of emissions. The EPA presented quantitative estimates of radiative forcing from the assessment literature for aviation-induced cloudiness, aviation-induced particles, and high-altitude NO_x in the proposal and in section IV.B.7 of the FRN. The EPA also cited evidence from the assessments that the climatic impact of these other substances is dependent on a number of factors (including location and time of emissions) and that the scientific uncertainty for quantitative estimates of radiative forcing is greater for these other short-lived substances than for the six well-mixed GHGs. The commenter provides no evidence that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts.

Summary of Comments: One comment letter (0863) stated that NO_x “contribute[s] to the formation of ground-level ozone or smog,” which has a significant climate-forcing effect in the upper troposphere and lower stratosphere.”

Response: The EPA recognizes that NO_x emissions can contribute to the formation of tropospheric ozone, which does have a climate warming effect, though NO_x emissions also contribute to the destruction of methane in the atmosphere, creating a counterbalancing cooling effect. The EPA presented quantitative estimates of radiative forcing from the assessment literature for changes in atmospheric chemistry from high-altitude NO_x emissions, among other things, in the proposal and in section IV.B.7 of the FRN. The EPA also cited evidence from the assessments that the climatic impact of these other substances is dependent on a number of factors (including location and time of emissions) and that the scientific uncertainty for quantitative estimates of radiative forcing is greater for these other short-lived substances than for the six well-mixed GHGs. The commenter provides no evidence that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts.

Summary of Comments: Commenters (0357, 0863, 0927, 0747) discussed various views on how aviation emissions affect the formation of contrails or clouds and the resultant radiative forcing effects or other climate or weather effects.

- A commenter stated that aviation-induced contrail cirrus clouds reflect incoming short wave solar radiation, but block outgoing long wave infrared, thereby affecting earth’s climate and temperature. The commenter stated that the warming effect of these contrail cirrus clouds could “increase surface and lower atmospheric temperatures by 0.36 to 0.54 degrees Fahrenheit per decade.”¹³ The commenter also cited Burkhardt and Kärcher (2011)¹⁴ to describe how contrail cirrus clouds prevent other clouds from forming by using the surrounding atmosphere water vapor.
- A commenter stated, “According to various investigations, such as the 1998 subsonic contrail and clouds effects special study, they have noted that, apart from water and CO₂, there are metal particles, including zinc, aluminum, and titanium, also soot, sulfates, etc., found in the [aircraft] exhaust blooms, contributing as nuclei for ice crystals to form contrails. Contrails, haziness, and cloud blankets, which eventually—which certainly do affect changes to the weather, altering rainfall, altering temperatures, reducing droughts, reducing frost, et cetera, and ultimately affecting climate change.”

¹³ Minnis, P., Ayers, J.K., Palikonda, R. and Phan, D., 2004: *Contrails, Cirrus Trends, and Climate*. Journal of Climate, **17**, 1671-1685. [http://dx.doi.org/10.1175/1520-0442\(2004\)017<1671:CCTAC>2.0.CO;2](http://dx.doi.org/10.1175/1520-0442(2004)017<1671:CCTAC>2.0.CO;2)

¹⁴ Burkhardt, U. and Kärcher, B., 2011: *Global radiative forcing from contrail cirrus*. Nature Climate Change **1**, 54–58. doi:10.1038/nclimate1068.

- A commenter stated that the IPCC AR4 only accounted for linear contrails in its estimates of contrail radiative forcing and did not account for aviation-induced contrail cirrus clouds, which can evolve into cirrus clouds indistinguishable from those formed naturally. The commenter cites Boucher (2011)¹⁵ to argue that spreading contrails “may be causing more climate warming today than all the carbon dioxide emitted by aircraft since the start of aviation.”
- A commenter cited the work of Haywood et al. (2009)¹⁶ to describe that “A single aircraft operating in conditions favorable for persistent contrail formation appears to exert a contrail-induced radiative forcing some 5000 times greater than recent estimates of the average persistent contrail radiative forcing from the entire civil aviation fleet.” The commenter concluded, “Cirrus clouds trap heat and likely have a greater climate change impact than CO₂.”
- A commenter stated, “With regard to contrails, the EPA suggests that AR5 shows no net effect of contrails on radiative forcing (p. 37783). However, the AR5 say this: ‘Persistent contrails from aviation contribute a RF of +0.01 (+0.005 to +0.03) W/m² for year 2011, and the combined contrail and contrail-cirrus RF from aviation is assessed to be +0.05 (+0.02 to +0.15) W/m² (IPCC, 2013, p. 574). Though the direct effect of contrails alone is rather small, contrail induced cirrus has a much larger effect and will not develop without contrails.” The commenter suggests that effect could “easily double aviation’s historic CO₂-only contribution to RF.”
- A commenter argued that the “IPCC downplays the effects of contrails on our climate” and that there “are gaping holes in climate science.” The commenter notes that aerosol cloud interactions are one of the main uncertainties in climate research, including how contrails transition into cirrus clouds. The commenter states that scientific understanding is rapidly evolving with recent research results finding evidence of lead (from tetraethyl lead used in light aircraft fuels) in cirrus clouds, as well as “a whole host of different metals.” The commenter cites Czcizo et al. (2013)¹⁷ to note that even small amounts of metal particulates may have major effects on cirrus clouds, stating “because mineral dust and metallic particles are such a small amount of the particulate matter, just a percent or two, it means that you only have to change about a percent or two of the particles to get a big effect on these clouds.” The commenter argues that this recent research challenges the validity of IPCC’s contrail assumptions and that in order to address the real impact of aviation on climate change, the EPA should seriously consider high-altitude metals and cirrus cloud condensation nuclei (which are likely coming from leaded AVGAS and jet exhaust).
- A commenter stated that water vapor “is the most important greenhouse gas responsible for the natural, background greenhouse effect” and that it “could potentially have a larger impact at higher altitudes” when it forms contrails. The commenter quotes a statement from Lee et al. (2009)¹⁸ that compared to only aircraft CO₂ emissions, “aviation has a larger impact on radiative forcing” due to contrails and aviation-induced cirrus cloud formation.
- A commenter stated, “It also should be kept in mind when discussing climate change, especially with respect to aviation, that water vapor is estimate[d] [to] contribute anywhere from 36 percent

¹⁵ Boucher, 2011: *Atmospheric science: Seeing through contrails*. Nature Climate Change, **1**, 24–25. doi:10.1038/nclimate1078.

¹⁶ Haywood, J.M., Allan, R.P., Bornemann, J., Forster, P.M., Francis, P.N., Milton, S., Rädcl, G., Rap, A., Shine, K.P. and Thorpe, R., 2009: *A case study of the radiative forcing of persistent contrails evolving into contrail-induced cirrus*. Journal of Geophysical Research, **114**, D24201. doi:10.1029/2009JD012650.

¹⁷ Czcizo, D.J., Froyd, K.D., Hoose, C., Jensen, E.J., Diao, M., Zondlo, M.A., Smith, J.B., Twohy, C.H. and Murphy, D.M., 2013: *Clarifying the dominant sources and mechanisms of cirrus cloud formation*. Science, **340**, 1320-1324. doi:10.1126/science.1234145.

¹⁸ Lee, D.S., Fahey, D.W., Forster, P.M., Newton, P.J., Wit, R.C., Lim, L.L., Owen, B. and Sausen, R., 2009: *Aviation and global climate change in the 21st century*. Atmospheric Environment, **43**, 3520-3537. doi:10.1016/j.atmosenv.2009.04.024

to 72 percent of the greenhouse effect. This is important because the radiative forcing effect of cirrus cloud formation from the aircraft is a significant contributor to the greenhouse effect.”

- A commenter argued that “any climate forcing effect of water vapor does not arise from *anthropogenic* emissions of water vapor” and that “To the extent water vapor acts as a climate forcing agent, it does so independent of direct aviation emissions. Rather, when other GHGs cause temperature increases, the atmosphere can hold more water vapor. These resulting concentrations of water vapor represent the only potentially significant aspect radiative forcing, not anthropogenic water vapor emissions.” The commenter then stated that the most recent IPCC assessment (AR5) excludes water vapor from a list of anthropogenic emissions that cause radiative forcing and estimates “negligible” radiative forcing from contrails and contrail-induced cirrus clouds that is “even less than previously thought.” They cited the IPCC’s estimates for radiative forcing from contrails: 0.01 (0.005 to 0.03) W/m². They stated that combined contrails and contrail-induced cirrus radiative forcing estimates are 0.05 (0.02 to 0.15) W/m² and that “[m]ore recent estimates tend to indicate somewhat smaller radiative forcing than assessed in the AR4.”

Two commenters also describe what they see as an increasing trend in contrails over the past few decades:

- A commenter stated that “the extra contrails and cloud generation is excessive in correlation with the increasing, growing aviation use” and that “In 2000, NASA scientists demonstrated that the typical width of a contrail was 22Km or 72,178ft (Duda et al. 2004)¹⁹. The commenter went on to describe a study of contrails following the September 11th attack when air traffic was shutdown, which found that the spread of six contrail clouds could cover 7,722sq miles/20,000sqKm (Minnis et al. 2002).²⁰
- A commenter stated, “The dark blue skies of our childhood have been replaced with a milky white haze, crisscrossed with fast expanding persistent contrails, stretching from horizon to horizon, and spreading out to cover the sky. These trails can stretch for thousands of miles and can be seen by anyone visiting NASA.gov. These trails persist, regardless of altitude, temperature, humidity, or other atmospheric conditions. Persistent contrails used to be rare but have now become an everyday phenomenon all over the world. If physics hasn’t changed, what has?”

Response: A number of commenters describe their views regarding the impact of contrails on climate change, the climate effect of water vapor in general, and the observed trends in contrail formation. In the proposal and in section IV.B.7 of the FRN, the EPA presented quantitative estimates of radiative forcing from the assessment literature for aviation-induced cloudiness that results primarily from high-altitude emissions of water vapor and particles. As described in section IV.B.7 of the FRN, aviation-induced cloudiness includes three components: persistent contrails, contrail-induced cirrus, and induced cirrus. The EPA also cited evidence from the assessments that the climatic impact of short-lived substances such as water vapor is dependent on a number of factors (including location and time of emissions) and that the scientific uncertainty for quantitative estimates of radiative forcing is greater for these other short-lived

¹⁹ Duda, D.P., Minnis, P., Nguyen, L. and Palikonda, R., 2004. *A case study of the development of contrail clusters over the Great Lakes*. Journal of Atmospheric Sciences, **61**, 1132-1146. [http://dx.doi.org/10.1175/1520-0469\(2004\)061<1132:ACSOTD>2.0.CO;2](http://dx.doi.org/10.1175/1520-0469(2004)061<1132:ACSOTD>2.0.CO;2)

²⁰ Minnis et al., 2002: *Spreading of isolated contrails during the 2001 air traffic shutdown*. Abstract for the 10th Conference on Aviation, Range, and Aerospace Meteorology, 13- 16 May, Portland, OR. Available at: <http://www-pm.larc.nasa.gov/sass/pub/conference/Minnis.abs.ARAMS.02.pdf> (last accessed July 11, 2016).

substances than for the six well-mixed GHGs. The arguments and information provided by the commenters does not demonstrate that the EPA missed or mischaracterized conclusions of the assessments regarding aviation climate impacts. Moreover, the EPA has explained its reasons for using the major scientific assessments as the primary scientific and technical basis to inform this endangerment finding in section IV.A of the FRN. Contrary to the comments' implications, the EPA continues to find that the appropriate approach with respect to issues related to aviation-induced cloudiness in this endangerment finding, and after reviewing these comments and the cited information, the EPA does not find evidence in them that the Administrator should change the definition of "air pollution" used in this finding. Three overarching issues raised by the commenters are addressed in more detail below.

(1) Contrails and climate:

As explained in greater detail in section IV.B.7.b of the FRN, contrails differ from the six well-mixed GHGs that the Administrator has defined as the air pollution in this action. For example, contrails have different physical properties (contrails are not long-lived or well-mixed, nor are they directly emitted), contrails are not as well-understood nor are they the primary driver of climate change, and contrails are not a primary focus of climate change science and policy communities. Commenters have not provided evidence that the EPA has mischaracterized the ways in which contrails are different from the six well-mixed GHGs that the Administrator has defined as the air pollution in this action.

One commenter claimed that the EPA suggested that the IPCC AR5 shows no net effect of contrails on radiative forcing, but the number that the commenter cites as the IPCC AR5 best estimate of combined contrail and contrail-cirrus radiative forcing of 0.05 W/m^2 , which is the same number that the EPA cited in its proposal (see 80 FR at 37783) and in section IV.B.7.b of the FRN.

Another commenter characterized the estimate of 0.01 W/m^2 from contrails and 0.05 W/m^2 from contrails and contrail-induced cirrus as "negligible" radiative forcing and states that the IPCC AR5 excluded anthropogenic emissions of water vapor from the list of compounds that cause radiative forcing. While the EPA cited evidence from the assessment literature that aviation-induced cloudiness associated with water vapor emissions has uncertain radiative forcing effects that are dependent on a number of factors such as the location and time of emissions, the EPA did not describe their climate effects as "negligible." Regarding the commenter's statement that the IPCC AR5 found a smaller radiative forcing than assessed in the IPCC AR4, the EPA notes that while the AR5 does have a lower estimate of cirrus forcing for an equal quantity of aviation activity, because aviation activity has increased, the best estimate of the contrail effect from AR5 (0.01 W/m^2) is equal to that made in the AR4 report. Moreover, the IPCC AR5 no longer presents the possibility that contrail forcing would be negative. In addition, the IPCC AR5 presents an estimate for forcing from induced cirrus clouds, which IPCC AR4 did not. While the IPCC AR5 does state that water vapor from activities such as irrigation, power plant cooling, and fossil fuel combustion has a negligible effect on concentrations of water vapor in the atmosphere, the IPCC AR5 also explicitly discusses the impacts of water vapor emissions from aircraft in the context of emissions in the stratosphere and as a contributor to contrails. This is because emissions of water vapor at altitude can have different effects from emissions at ground level.

Commenters cited one news article and three peer-reviewed studies for the EPA to consider as evidence that contrails and contrail-induced cirrus have a large impact on climate: Haywood et al. (2009), Lee et al. (2009), Boucher (2011), and Burkhardt and Karcher (2011). Boucher (2011) is a news piece that describes Burkhardt and Karcher (2011). For Haywood et al. (2009), Lee et al. (2009), and Burkhardt and Karcher (2011), commenters do not demonstrate that these studies contradict the assessment literature. The radiative forcing estimate in Burkhardt and Karcher (2011) is 0.038 W/m^2 for the contribution of

spreading contrails. Lee et al. (2009) estimated a contribution of induced cirrus of 0.033 W/m². Haywood et al. (2009) was a case study of a single exceptional event, but the authors noted that 5,000 such events would have to occur a year to generate 0.01 W/m² of forcing. These estimates are generally consistent with the estimate of 0.01 W/m² for contrails and the estimate of 0.05 W/m² for contrails plus cirrus that were developed by the IPCC AR5 and cited by the EPA in the FRN. Moreover, the IPCC AR5 cites all three of the referenced peer-reviewed studies. Accordingly, the IPCC AR5 took these studies into account, and that assessment, which the EPA discusses at length in the FRN, reflects the scientific community's evaluation of these studies in the context of the larger body of scientific research on these topics.

Several commenters have claimed that the forcing from contrails exceeds the forcing from aviation CO₂, with one quoting Boucher (2011). However, Boucher (2011) also stated that "It is important to note, however, that the emitted carbon dioxide would continue to exert a warming influence for much longer than contrails." This means that if aircraft were to be grounded today, the contrail effect would disappear immediately, but the CO₂ forcing from historical emissions from aircraft would remain. Alternatively, if current patterns of aviation were maintained indefinitely, the contrail effect would remain constant while the CO₂ effect would continue to grow.

A commenter also discussed a recently published paper (Cziczo et al., 2013) about metallic particles and aviation-induced cirrus clouds. This paper was not cited by the IPCC AR5 as it was published after the cut-off date for papers to be included in Working Group I of the IPCC AR5. The study experimentally determined the composition of nuclei in cirrus ice crystals, and found that most of the seed particles were either mineral dust or metallic particles. The research suggests both that metallic particle emissions might be particularly effective at seeding clouds, but also that organic carbon and sulfate emissions might actually coat natural mineral dust in the atmosphere and make the dust less effective as an ice nucleus. While the EPA acknowledges that this research is of interest, it is an emerging area of science, and the results have not yet been demonstrated to be robust by the larger assessment community. Moreover, while the study provided new information about which types of particles emitted by aircraft might be the most effective contributors to cloudiness, this research does not provide any new information regarding net global radiative forcing resulting from contrails or cirrus clouds.

The EPA considered the studies on the climate effects of contrails submitted by commenters and believes that they are consistent with the conclusions of the scientific assessments cited in the FRN regarding the radiative forcing impacts of contrails. The studies cited by commenters do not provide evidence that the EPA mischaracterized the ways in which contrails differ from the six well-mixed GHGs.

(2) Contrail trends:

Some commenters also cited studies examining contrail trends, claiming that the climate effect of contrails has been growing. The commenters do not demonstrate that these studies contradict any of the information relied on by the Administrator, nor do they provide evidence that the Administrator should have changed the definition of air pollution in this endangerment finding. The EPA cited an NRC estimate that contrails had increased cloudiness above the United States by two percent between 1950 and 1988. This is consistent with the work by the researchers that the commenters cited, such as Minnis et al. (2004), which found that observed cirrus coverage in the United States increased from 20.1 percent to 21.9 percent (a difference of 1.8 percent) between 1971 and 1995.

(3) Water vapor other than contrails:

One commenter submitted an argument in favor of the importance of water vapor, asserting that water vapor contributes 36 percent to 72 percent of the greenhouse effect. Another commenter argued that aviation emissions of water vapor would not contribute to radiative forcing because water vapor concentrations are determined by temperatures (i.e., water vapor is a feedback mechanism, not a forcing effect on the global energy balance). The EPA cited evidence from the assessment literature that water vapor emitted at high altitude can contribute to climate change. Importantly, in relation to the submissions by the commenters, this analysis is specific to water vapor emitted at high altitude. In the 2009 endangerment finding, the EPA noted that direct human emissions of water vapor at low altitudes has little effect because the water content of the air is on average a function of temperature and partial pressure (see 74 FR at 66520). However, in the same document, the EPA noted that water produced at higher altitudes could potentially have a larger impact through contribution to contrails (see 74 FR at 66520). In the proposal and in section IV.B.7.b of the FRN for these findings under section 231, the EPA presented estimates of radiative forcing resulting from all aviation emissions contributions to contrails, including emissions of water vapor. Commenters have not demonstrated that the EPA has mischaracterized the estimates of the assessments regarding the impact of water vapor, nor that these assessments were in error.

Summary of Comments: Commenters (0261, 0920, 0927) state that aircraft contrails are a form of geoengineering through modification of the Earth's weather and climate. Commenters argue that climate change is caused by this form of geoengineering rather than by increasing atmospheric concentrations of anthropogenic GHG emissions. One commenter states that, "Climate has always had natural variability and weather extremes" and suggests that weather extremes can be artificially stimulated by such geoengineering. Other commenters state that the climatic effects of such geoengineering include reducing sunlight and heat, reducing global warming, or refreezing the Arctic.

Response: The EPA has reviewed the estimates of the contribution of aircraft contrails to changes in weather and climate provided in the major scientific assessments, as described in section IV.B.7.b of the FRN. The EPA has also compared the magnitude of these estimates (central estimate of 0.05 W/m²) to the magnitude of the forcing from several GHGs, such as CO₂ (central estimate of 1.68 W/m²). While increased cloudiness resulting from contrails could reduce sunlight at the surface by small amounts, contrary to the commenters' suggestions, the EPA finds no credible evidence to suggest that contrails produced by aircraft would cause more climate change than CO₂, which is one of the six well-mixed GHGs included in the definition of air pollution in this notice, or that contrails would reduce global warming or refreeze the Arctic. The commenters provide no evidence that the EPA has mischaracterized the science in the assessments, or that the assessments are mistaken.

Summary of Comments: One commenter (0927) states that CO₂ is a "harmless trace gas essential to all life on Earth." The commenter states that CO₂ represents "just 3 percent of the planet's greenhouse gases, while 95 percent of it is water."

Response: The commenter provides no evidence to support the claim that CO₂ is harmless and does not address or provide criticism of all the evidence provided by the EPA in the proposed endangerment finding regarding the climate effects of elevated atmospheric concentrations of CO₂ and the other well-mixed GHGs. The EPA discusses the evidence from the assessment literature that together, the six well-mixed GHGs constitute the largest and best-understood anthropogenic driver of climate change in section IV.B.2 of the FRN. The commenter provides no support for the assertion that CO₂ represents only 3 percent of the planet's GHGs. Published estimates of the total contribution of CO₂ to global radiative

forcing are about 20 percent (Schmidt et al., 2010).²¹ Moreover, CO₂ and the other long-lived GHGs have collectively been the dominant drivers of changes to global radiative forcing over the past 100 years.

²¹ Schmidt, G.A., Ruedy, R.A., Miller, R.L. and Lacis, A.A., 2010. *Attribution of the present-day total greenhouse effect*. Journal of Geophysical Research: Atmospheres, **115**, D20. doi: 10.1029/2010JD014287

3.4 Sectoral Impacts

Organization: Center for Biological Diversity (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

Environmental Defense Fund (EDF) (EPA-HQ-OAR-2014-0828-0754, EPA-HQ-OAR-2014-0828-0793)

National Tribal Air Association (NTAA) (EPA-HQ-OAR-2014-0828-0362)

Northeast States for Coordinated Air Use Management (NESCAUM) (EPA-HQ-OAR-2014-0828-0770)

Private Citizen (EPA-HQ-OAR-2014-0828-0173)

Private Citizen (EPA-HQ-OAR-2014-0828-0412)

Private Citizen (EPA-HQ-OAR-2014-0828-0796)

Sierra Club (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Summary of Comments: Several commenters (0412, 0927, 0770, 0863) describe multiple impacts of human-induced climate change that are happening now or are projected. One states, “Climate change is already upon us with unprecedented temperature increases, rising sea levels, extraordinary rates of species extinction, and more extreme weather events.” A commenter cites findings from the IPCC on sea level rise, temperature rise, and reduction in snow and ice as support for stating, “there is broad continuing consensus that manmade emissions are contributing to adverse changes in climate and that these impacts will get worse over time without corrective action.” Another commenter cites recent peer-reviewed journal articles (including the USGCRP’s Third National Climate Assessment) as support for stating that “climate change will displace coastal populations as sea levels rise; increase the frequency of flooding, hurricanes, drought and other natural disasters; strain a limited water supply; and threaten food security by fostering spread of disease and pests.” A commenter argues that “action is needed to avoid the worst impacts of climate change, which include rising sea levels, more extreme temperatures and weather events, mass displacement of people, more severe droughts and floods, enhanced formation of harmful air pollution, and widespread extinctions of plant and animal species.” Another commenter states that “human emissions have already set in motion changes in Antarctic land ice which will inundate every coastal community on Earth in catastrophic ways.”

Response: The EPA agrees that the types of higher-level impacts discussed by the commenter, particularly rising temperatures, sea level rise, and changes in precipitation patterns and extreme events, are generally consistent with the discussion of health and welfare impacts of climate change found in sections IV.C.1 and IV.C.2 of the FRN.

Summary of Comments: A commenter (0796) discusses air quality impacts of climate change and agrees with the EPA that “climate change will likely increase regional ozone pollution, and the associated risks in respiratory illnesses and premature death, discounting the fact that the directional effect of climate change on ambient particulate matter levels remains less certain.” In addition, the commenter highlights that the IPCC AR5 found that “ozone and particulate matter have been associated with adverse health effects in many locations in North America, and that ozone concentrations could increase under future climate change scenarios if emissions of precursors were held constant,” and that the NRC Indoor Environment assessment “identifies potential adverse health risks associated with climate-change induced alterations in the indoor environment, including possible exposure to air pollutants like ozone via changes in outdoor air quality.”

Response: The EPA finds that the comments are generally consistent with the discussion of health impacts of climate-induced changes in air quality that can be found in section IV.C.1 of the FRN.

Summary of Comments: A commenter (0754) argued that climate change brings significant risks for the aviation industry and that while the EPA “should consider the full spectrum of the impacts of climate change, impacts to aviation itself have particular relevance under section 231 of the Clean Air Act” and “warrant consideration in EPA’s final Endangerment Finding.” The commenter discusses various climate impacts that could affect airport or airline operations, citing two NRC assessments, the IPCC, the USGCRP National Climate Assessment, and a Delta Airlines annual report:

- The commenter stated, “Higher temperatures will reduce air density, reducing lift and contributing to flight cancellations or more restricted payloads, especially at high-altitude airports. Intense heat can cause runways to buckle. Increased precipitation and sea level rise can submerge runways, disrupting air travel or forcing temporary airport closures. More intense tropical storms can damage or temporarily close airports. Increased wildfires in drought-susceptible regions will reduce visibility and can close airports. In far northern locations, such as Alaska, where air transport use is disproportionately high, warming temperatures will have a deleterious impact on airstrips built on permafrost, and may undermine runway foundations. All of these risks create significant safety concerns for the aviation sector and its regulators.”
- The commenter discussed changes in extreme weather associated with climate change and how this can “cripple multiple airports,” resulting in massive human impacts and economic costs to both the airline industry and the economy as a whole, which the commenter states was observed during Hurricane Katrina and Hurricane Sandy.
- The commenter noted that “13 of the nation’s 47 busiest airports – one in four of these airports – have at least one runway that is low enough to be inundated by a moderate-to-high storm surge.”
- The commenter stated that “increases in frequency, severity or duration of thunderstorms, hurricanes, typhoons or other severe weather events, including from changes in the global climate, could result in increases in fuel consumption to avoid such weather, turbulence-related injuries, delays and cancellations, any of which would increase the potential for greater loss of revenue and higher costs.”
- The commenter stated that “Increased storminess at airports, particularly those located in coastal regions, may increase the number of weather related delays and cancellations and increase maintenance and repair costs. Clear-air turbulence will increase in the Atlantic corridor leading to longer and bumpier trips. The impact of climate change on airport pavement is very similar to paved roads. The effect of temperature and increase[d] precipitation intensity on airports imposes a risk to the entire facility if pavements are not adapted to these increases. Increasing carbon dioxide concentrations in the atmosphere are expected to increase the frequency and intensity of turbulence, which is already responsible for costing airlines tens of millions of dollars and injuring (occasionally fatally) hundreds of passengers each year. ... Increased temperatures, flooding and extreme weather events arising from climate change threaten the health of airport and airline workers, damage airport runways and other critical air traffic control equipment, overwhelm stormwater systems, impair airplane performance, increase the risk of vehicle crashes, and, as a result, disrupt traffic, restrict public transportation, and threaten human lives and local economies.”

Response: The EPA finds that the points raised and information provided by the commenter on climate impacts to airports and the airline industry are helpful examples of some of the potential downstream impacts of climate change. However, the Agency has chosen not to focus the discussion of climate impacts in the endangerment finding on any particular industry or sector of the economy. Instead, the EPA provides a higher-level summary of expected impacts to categories like “energy, infrastructure, and settlements” that would encompass airports and other transportation infrastructure in the course of evaluating the broader question of whether the air pollution may reasonably be anticipated to endanger public health or welfare. The EPA finds that the types of higher-level impacts discussed by the

commenter, particularly rising temperatures and changes in the frequency and severity of extreme weather, are generally consistent with the discussion of health and welfare impacts of climate change found in sections IV.C.1 and IV.C.2 of the FRN.

Summary of Comments: A commenter (0173) highlighted the impacts of climate change on vulnerable populations, specifically identifying the elderly, poor, very young, and indigenous groups. The commenter expressed concern for these communities, citing language from the EPA’s proposed findings that “These groups tend to have ‘limited resources to adapt and recover from climate impacts, as well as existing health disparities’” (see 80 FR at 37761). The commenter stated a desire to see these vulnerable populations “take control of their own environmental future by being engaged in an equal manner to other communities.”

Response: The EPA finds that the comments are generally consistent with the discussion of health and welfare impacts of climate change on vulnerable populations that can be found in sections IV.C.1.a and IV.C.2.a of the FRN.

Summary of Comments: Another commenter (0362) noted that “climate change affects the health of the nation, but that Native American and Alaska Native communities are much more severely and directly impacted by climate change as compared to the general population.” The commenter specifically identified that “Indian Tribes are seeing the effects of climate change through increased storm surges, erosion, and flooding; prolonged droughts never seen in modern times; and increased fires and insect pest outbreaks in their forests.” The commenter stated that “Tribal communities are integrated into the ecosystems of North America; and many Tribal economies are heavily dependent on the use of fish, wildlife, and native plants. Even where Tribal economies are integrated into the national economy, Tribal cultural identities continue to be deeply rooted in the natural environment. As climate change disrupts biological communities, the survival of some Tribes as distinct cultures may be at risk. The loss of traditional cultural practices, due to climate-driven die-off or range shift of culturally significant plant and animal species, may prove to be too much for some Tribal cultures to withstand on top of other external pressures that they face.” The commenter expressed appreciation for the EPA’s discussion of vulnerable populations in the proposal, especially in light of “the federal government’s trust responsibility to Native American tribes, and as recognized by EPA in the 2014 *EPA Policy on EJ for Working with Federally Recognized Tribes and Indigenous Peoples*.”

Response: The EPA finds that the comments are generally consistent with the discussion of health and welfare impacts of climate change on vulnerable populations—in particular for indigenous communities, including those in Alaska—that can be found in sections IV.C.1.a and IV.C.2.a of the FRN.

4. The Cause or Contribute Finding

The EPA summarizes and responds to comments regarding the cause or contribute finding (also referred to as the contribution finding) in the sections below, 4.1, 4.2, 4.3, and 4.4.

4.1 Scope & Proposed Definition of “Air Pollutant”

Organization: Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797)

Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)

AirFair (EPA-HQ-OAR-2014-0828-0860)

Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Biogenic CO₂ Coalition (EPA-HQ-OAR-2014-0828-0916)

Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)

California Air Resources Board (ARB) (EPA-HQ-OAR-2014-0828-0861)

Cargo Airline Association (EPA-HQ-OAR-2014-0828-0732)

Embraer Aircraft Holding, Inc. (EPA-HQ-OAR-2014-0828-0745)

General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)

General Electric (GE) (EPA-HQ-OAR-2014-0828-0932)

The International Air Cargo Association (TIACA) (EPA-HQ-OAR-2014-0828-0622)

International Air Transport Association (IATA) (EPA-HQ-OAR-2014-0828-0548)

Private Citizen (EPA-HQ-OAR-2014-0828-0796)

Regional Airline Association (RAA) (EPA-HQ-OAR-2014-0828-0620, EPA-HQ-OAR-2014-0828-0731)

Summary of Comments: Similar to the discussion in section 3.1 for the definition of “air pollution” for purposes of the endangerment finding under CAA section 231(a)(2)(A), some commenters (0570, 0568, 0747, 0732, 0745, 0837, 0932, 0548, 0620, and 0622) highlighted the fact that aircraft engines emit only two of the six well-mixed GHGs that together are defined as the “air pollutant” for purposes of the cause or contribute finding under section 231(a)(2)(A) of the CAA. Commenters (0570, 0568, 0747, 0732, 0745, 0837, 0932, 0548, 0620, 0622, 0751, and 0861) point out that the majority of emissions are CO₂, while N₂O emissions are described as “nominal (< 1 percent)” or “trace.” Some commenters (0570, 0747, 0745, 0837, 0932, 0620, and 0622) ultimately concluded that the EPA’s approach to defining the air pollutant as an aggregate group of six gases is acceptable, but that the scope of future regulations should be limited to CO₂. One commenter letter (0747) supported the Agency’s evaluation of the six GHGs based on their common attributes, but questioned the EPA’s decision to aggregate the six gases for purposes of making the findings for a sector that emits only two of the GHGs, and where N₂O emissions are < 1 percent of aircraft GHG emissions. Other commenters (0828 and 0837) disagreed with the EPA and requested limiting the definition of air pollutant in this action to CO₂ or to CO₂ and N₂O. Some commenters (0860 and 0796) agreed with the EPA’s definition of air pollutant.

Response: The EPA responds to comments regarding limiting the definition of air pollutant in this action to CO₂ (or to CO₂ and N₂O), and limiting the scope of future regulations to CO₂ in section V.A.2 of the FRN.

Summary of Comments: The Biogenic CO₂ Coalition (0916) expressed concern about the EPA’s proposed contribution finding because it does not differentiate between CO₂ emissions that result from the combustion of fossil fuels and those that result from the “combustion of biomass or biofuels derived from

herbaceous crops or crop residues, as well as biogenic CO₂ emissions associated with the production, gathering and processing of crops or crop residues used in bio-based products including fuels.”²² They argue that such crop-related biogenic CO₂ emissions should be excluded from the contribution finding because the CO₂ released back to the atmosphere when emitted from crop-derived biogenic sources contains the same carbon that was previously removed or sequestered from CO₂ in the atmosphere, and thus does not contribute to elevated atmospheric concentrations of the six well-mixed GHGs.

Response: The EPA responds to comments regarding crop-related biogenic CO₂ emissions or the source of the air pollutant (and air pollution), for defining the relevant air pollutant (and air pollution) considered in the findings, in sections IV.B.6 and V.A.2 of the FRN, as well as in section 3.1 of this RTC document.

²² Biogenic CO₂ Coalition, 2015: Comments on EPA’s Proposed Finding That Greenhouse Gas Emissions From Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare, 80 FR 37757 (July 1, 2015). Docket ID number EPA-HQ-OAR-2014-0828-0916. Available at www.regulations.gov (last accessed April 11, 2016).

4.2 Analysis of Contribution

Organization: Airbus S.A.S. (EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859)
Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)
AirFair (EPA-HQ-OAR-2014-0828-0860)
Environmental Defense Fund (EDF) (EPA-HQ-OAR-2014-0828-0754, EPA-HQ-OAR-2014-0828-0793)
General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)
International Council on Clean Transportation (ICCT) (EPA-HQ-OAR-2014-0828-0791)
National Association of Clean Air Agencies (NACAA) (EPA-HQ-OAR-2014-0828-0560)
National Tribal Air Association (NTAA) (EPA-HQ-OAR-2014-0828-0362)
Natural Resources Defense Council (NRDC) (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Private Citizen (EPA-HQ-OAR-2014-0828-0174)

Summary of Comments: AOPA (0751) commented that the EPA should describe the contribution of general aviation aircraft GHG emissions to the U.S. transportation GHG emissions, particularly discussing the contribution from general aviation aircraft that operate on aviation gasoline (piston-engine general aviation aircraft). AOPA claimed that general aviation aircraft are less than 1.5 percent of total U.S. GHG emissions, and piston-engine general aviation aircraft are 0.09 percent of total U.S. GHG emissions.

Response: The EPA describes in section V.B of the FRN that for the purposes of this cause or contribute finding under CAA section 231(a)(2)(A), the EPA is including emissions of the six well-mixed GHGs from classes of engines used in U.S. covered aircraft, which are subsonic jet aircraft with a maximum takeoff mass (MTOM) greater than 5,700 kilograms and subsonic propeller driven (e.g., turboprop) aircraft with a MTOM greater than 8,618 kilograms. The cause or contribute finding is a prerequisite under CAA section 231 for the EPA to adopt standards of at least equivalent stringency to those set by ICAO. Accordingly, in this finding, the EPA is focusing on matching the scope of its contribution finding to the applicability thresholds of the international standard. The covered aircraft match the applicability (or MTOM) thresholds of the international aircraft CO₂ standard. Also, we have identified aircraft that are not covered aircraft for the purposes of this contribution finding. This includes aircraft that fall below the international applicability thresholds: smaller turboprop aircraft, such as the Beechcraft King Air 350i; and smaller jet aircraft, such as the Cessna Citation M2. In addition, similar to ICAO, we are not in this action addressing “piston-engine aircraft,” “helicopters,” and “military aircraft.”²³

The MTOM thresholds for covered aircraft include some (but not all) general aviation aircraft using jet fuel but, as described earlier, general aviation aircraft using aviation gasoline (piston-engine general aviation aircraft) would not be covered. According to the *Inventory of U.S. Greenhouse Gas Emissions*

²³ U.S. EPA, 2016: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014*, 558 pp. Available at <http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf> (last accessed April 22, 2016). The EPA has determined that the U.S. Inventory has been adequately reviewed in accordance with the EPA’s Peer Review Handbook. For the presentation of emissions inventory information in this contribution finding, the EPA disaggregated the existing data in one area of the U.S. Inventory (for the General Aviation Jet Fuel Category) and had the disaggregation methodology peer reviewed in accordance with the EPA’s Peer Review Handbook. The EPA Science Advisory Board reviewed this approach to the underlying technical and scientific information supporting this action, and concluded that the approach had precedent and the action will be based on well-reviewed information. All relevant peer-review documentation is located in the docket for today’s final action (EPA-HQ-OAR-2014-0828).

and Sinks Report,²⁴ in 2014 GHG emissions from all U.S. general aviation aircraft using jet fuel and aviation gasoline represent 1 percent of total U.S. transportation GHG emissions and 9 percent of total U.S. aircraft GHG emissions. General aviation aircraft using jet fuel represent 8 percent of total U.S. aircraft GHG emissions. General aviation aircraft that use jet fuel and are above the MTOM thresholds (as described above) represent 6 percent of total U.S. aircraft GHG emissions and 7 percent of U.S. covered aircraft GHG emissions.²⁵ General aviation aircraft that use aviation gasoline (portion of non-covered aircraft) represent 1 percent of total U.S. aircraft GHG emissions and 0.1 percent of U.S. transportation GHG emissions.

The FRN describes the contribution of aircraft above the MTOM thresholds without specifically discussing the contribution from the general aviation category that is above the MTOM thresholds, so that the scope of the findings is not inadvertently mischaracterized. The term “general aviation aircraft” is not specifically defined in EPA and FAA regulations and, thus, describing the general aviation contribution in the findings could lead to varying interpretations of the scope of the findings. By mainly describing covered aircraft as those aircraft above the MTOM thresholds, the EPA believes it is appropriately identifying the aircraft covered by the findings, while avoiding any potential confusion on the scope of the findings. This action makes no judgment regarding whether the GHG emissions of aircraft such as “piston engine aircraft,” “helicopters,” and “military aircraft” contribute to endangering GHG air pollution, or whether other aircraft that are below the MTOM thresholds so contribute.

Summary of Comments: Some commenters (0754, 0791, 0560, 0362, 0927, 0837, and 0174) support the cause or contribution analysis in the proposed findings. They agree with the percentages of contribution provided -- including total U.S. aircraft GHG emissions and U.S. covered aircraft GHG emissions relative to total U.S. GHG emissions, U.S. transportation GHG emissions, and global GHG emissions (global aircraft, global transport, and total global GHG emissions). Also, they support the percentages provided of global aircraft GHG emissions in relation to global transport and total global GHG emissions. In contrast, some commenters (0834 and 0860) disagreed with the EPA's description of the contribution of aircraft GHG emissions for these same comparisons. These commenters either indicated that the EPA overstated or understated the contribution from aircraft GHG emissions.

Response: Section V.B of the FRN has the EPA's description and analysis of aircraft's contribution to U.S. and global GHG emissions. For the U.S. GHG emissions inventories in the FRN, the EPA relied upon the *Inventory of U.S. Greenhouse Gas Emissions and Sinks Report* (U.S. Inventory).²⁶ The EPA has determined that the U.S. Inventory has been adequately reviewed in accordance with the EPA's Peer Review Handbook. For the presentation of emissions inventory information in this contribution finding, the EPA disaggregated the existing data in one area of the U.S. Inventory (for the General Aviation Jet Fuel Category)²⁷ and had the disaggregation methodology peer reviewed in accordance with the EPA's Peer Review Handbook. The EPA Science Advisory Board reviewed this approach to the underlying technical and scientific information supporting this action, and concluded that the approach had precedent

²⁴ ICAO regulations only apply to civil aviation (aircraft and aircraft engines); consequently, ICAO regulations do not apply to military aircraft.

²⁵ ERG, 2015: *U.S. Jet Fuel Use and CO₂ Emissions Inventory for Aircraft Below ICAO CO₂ Standard Thresholds*, Final Report, EPA Contract Number EP-D-11-006, 38 pp.

²⁶ U.S. EPA, 2016: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014*, 558 pp. Available at <http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf> (last accessed April 22, 2016).

²⁷ ERG, 2015: *U.S. Jet Fuel Use and CO₂ Emissions Inventory for Aircraft Below ICAO CO₂ Standard Thresholds*, Final Report, EPA Contract Number EP-D-11-006, 38 pp.

and the action will be based on well-reviewed information. A copy of this letter and all other relevant EPA peer review documentation is located in the docket for the FRN (EPA-HQ-OAR-2014-0828).

For the global GHG emissions inventories, we were informed by IPCC's 2013-2014 Fifth Assessment Report (AR5)²⁸ and place considerable weight upon the IPCC AR5 data on global GHG emissions. We also considered but placed less emphasis on the World Resources Institute's (WRI) Climate Analysis Indicators Tool (CAIT), and the International Energy Agency (IEA)²⁹ emissions data, which in comparison have a different aggregation of underlying data, but are available for more recent years. The approach of considering the major scientific assessments, including IPCC's assessments, provides assurance that the Administrator's judgment is informed by the best available, well-vetted science that reflects the consensus of the climate science research community. The major findings of the assessments, including IPCC's assessment, support the Administrator's findings in this action. While the EPA uses the IPCC data as the primary data source for informing this contribution finding, it has reasonably used additional data sources from widely used and recognized global datasets to provide context and information from more recent years. These additional data supplement and confirm the IPCC data, as they are generally in line with IPCC. Ultimately, whether the Agency utilizes the IPCC data alone or the WRI/CAIT dataset (and IEA data) alone, or both datasets together, it would have no material effect on the emissions comparisons discussed in the FRN, and the Administrator would make the same contribution finding.

²⁸ IPCC, 2014: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, 1435 pp.

²⁹ World Resources Institute (WRI) Climate Analysis Indicators Tool (CAIT) Data Explorer (Version 2.0). Available at <http://cait.wri.org> (last accessed January 19, 2016). International Energy Agency, Data Services. Available at <http://data.iea.org> (last accessed January 21, 2016).

4.2.1 Including GHG Emissions from Combustion of International Aviation Bunker Fuels in the U.S. Aircraft GHG Inventory

Organization: Airbus S.A.S. (EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859) Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)

Summary of Comments: Some commenters (0834, 0747, and 0837) claimed that the EPA's choice of data for the cause or contribute analysis was selective and biased. They contended that emissions resulting from the combustion of international aviation bunker fuels should not be a part of the U.S. covered aircraft GHG inventory or of the total U.S. aircraft GHG inventory, since the EPA's own U.S. Inventory for UNFCCC reporting purposes does not include emissions from combustion of these fuels in the national GHG totals and reports them separately to the UNFCCC, pursuant to UNFCCC inventory reporting guidelines.³⁰ Consequently, the commenters asserted that the total emissions from domestic commercial aircraft account for less than 2 percent (1.7 percent) of total U.S. aircraft GHG emissions. Because of this, some commenters believe that EPA inappropriately specified that the U.S. covered aircraft GHG emissions represent 3 percent of the total U.S. GHG emissions.

Response: The EPA responds to comments regarding the inclusion of GHG emissions from the combustion of international aviation bunker fuels in U.S. covered aircraft GHG emissions (and total U.S. aircraft GHG emissions) in section V.C.2.a of the FRN.

³⁰ EPA GHG Emissions Inventory at A-31 (reporting and methods) is available at: <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Annex-2-Emissions-Fossil-Fuel-Combustion.pdf> (last accessed April 8, 2016).

4.2.2. Finding Significant Contribution, or Establishing a Bright Line

Organization: Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)

General Electric (GE) (EPA-HQ-OAR-2014-0828-0932)

Summary of Comments: Some commenters (0751, 0747, 0568, and 0932) stated that aircraft GHG emissions are extremely small relative to both domestic and global GHG emissions in the aggregate. Also, one comment letter (0747) questioned whether there is a reasoned basis for EPA to find that GHG emissions from U.S. aircraft cause or contribute to air pollution that endangers public health and welfare when assessed not only relative to contributions from other sectors, but also relative to climate impacts. For example, this comment letter indicated the EPA estimates that total U.S. aircraft GHG emissions accounted for about 0.5 percent of total global GHG emissions in 2010. Thus, the commenters (0751, 0747, 0568, and 0932) stated that the total U.S. aircraft GHG emissions contributions from the U.S. aviation sector are extremely small relative to total global GHG emissions, or negligible as a percentage of total global GHG emissions.

Response: The EPA responds to comments regarding whether finding a contribution for purposes of CAA section 231 requires that the EPA find a “significant” contribution or establish a bright line threshold of contribution in section V.C.2.b of the FRN.

4.2.3. Providing Context in Comparing Aircraft GHG Emissions to Other Sector GHG Emissions

Organization: Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
Center for Biological Diversity (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)
Environmental Defense Fund (EDF) (EPA-HQ-OAR-2014-0828-0754, EPA-HQ-OAR-2014-0828-0793)
Friends of the Earth (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Northeast States for Coordinated Air Use Management (NESCAUM) (EPA-HQ-OAR-2014-0828-0770)
Private Citizen (EPA-HQ-OAR-2014-0828-0357)
Sierra Club (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Summary of Comments: Some commenters (0751 and 0747) asserted that the EPA did not show important context in comparing covered aircraft GHG emissions to other mobile source categories' GHG emissions. They claimed the EPA does not describe what they consider the very low level of aircraft emissions in general relative to emissions from other sources. The commenters assert that, for example, the EPA does not point out that the growth in emissions from U.S. medium-duty and heavy-duty trucks since 1990 is 53 percent greater than the GHG emissions from the U.S. commercial aircraft sector today, and 18 percent higher than the total U.S. aircraft (or entire U.S. aviation sector) GHG emissions today. Some commenters (0927, 0863, 0754, 0770, and 0357) supported the context that the EPA provided for such comparisons, including the statement that aircraft GHG emissions are the third-largest source of GHG emissions in the U.S. transportation sector.

Response: The EPA responds to comments regarding providing context in comparing aircraft GHG emissions to other sector GHG emissions in section V.C.2.c of the FRN.

Summary of Comments: One comment letter (0747) stated that it is inappropriate and misleading to compare U.S. aircraft GHG emissions with those of other, individual countries. They indicated that to fairly compare the U.S. airlines' GHG emissions contribution, EPA should analyze, as ICAO does, contributions from other world regions with comparable land masses and levels of economic activity. (In terms of landmass, the U.S. ranks third globally, behind only Russia and Canada.) However, some commenters (0927, 0863, 0754, and 0770) supported the EPA's comparison of U.S. aircraft GHG emissions to those of individual countries.

Response: The EPA responds to comments regarding comparing U.S. aircraft GHG emissions to other, individual countries GHG emissions in section V.C.2.c of the FRN.

Summary of Comments: One comment letter (0747) asserted that the methodology EPA and its consultant, Eastern Research Group (ERG), utilized to determine emissions from "non-covered aircraft" is unclear.

Response: In a memorandum to the docket (EPA-HQ-OAR-2014-0828) entitled, *Methods Utilized in Calculations for GHG Emissions Inventories for Final Aircraft GHG Contribution Finding* (July 20, 2016), the EPA has provided additional description of the methods utilized to calculate U.S. covered aircraft GHG emissions, and through that description has also provided additional information on what it considered non-covered aircraft GHG emissions for purposes of these findings. These additional details will make the EPA's methods clearer.

4.2.4. Utilizing Multiple Databases for Global GHG Emissions

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)

Summary of Comments: Some commenters (0747 and 0837) claimed that the mix of data from different years utilizing emissions data from IPCC, WRI/CAIT, and IEA was confusing and potentially misleading. They allege that the EPA assertion that the different datasets are “generally consistent” is not supported by a reasoned analysis tied to the record, and they claim that this calls EPA’s overall analysis into question.

Response: The EPA responds to comments regarding the use of multiple databases for the cause or contribute finding in section V.C.2.d of the FRN.

4.2.5. Past Aircraft Industry Fuel Efficiency Trends

Organization: Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570)
Airbus S.A.S (EPA-HQ-OAR-2014-0828-0834)
AirFair (EPA-HQ-OAR-2014-0828-0860)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
American Airlines, Inc. (EPA-HQ-OAR-2014-0828-0917)
Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)
Cargo Airline Association (EPA-HQ-OAR-2014-0828-0732)
Embraer Aircraft Holding, Inc. (EPA-HQ-OAR-2014-0828-0745)
General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)
General Electric (EPA-HQ-OAR-2014-0828-0932)
Honeywell (EPA-HQ-OAR-2014-0828-0757)
National Air Carrier Association (NACA) (EPA-HQ-OAR-2014-0828-0546)
National Business Aviation Association (NBAA) (EPA-HQ-OAR-2014-0828-0567)
Regional Airline Association (RAA) (EPA-HQ-OAR-2014-0828-0620)
The International Air Cargo Association (TIACA) (EPA-HQ-OAR-2014-0828-0622)

Summary of Comments: Some commenters (0747, 0837, 0570, 0917, 0568, 0732, 0745, 0932, 0757, 0546, 0567, and 0620) claimed that the U.S. aviation industry has a strong environmental track record and has significantly improved fuel efficiency and decreased emissions compared to 40 to 60 years ago, and that the EPA barely acknowledges industry's strong fuel efficiency record. Some commenters (0568, 0570, 0745, and 0622) asserted that current commercial aircraft are 70 percent more fuel efficient than aircraft from 50 to 60 years ago with lowered emissions. Also, some commenters (0747, 0620, 0546, 0732, and 0917) argued that the U.S. airlines have achieved these significant improvements in fuel efficiency and decreased emissions while adding capacity. In 2014, according to some commenters (0747, 0732, 0546, and 0620), the U.S. airlines carried 20 percent more passengers and cargo compared to 2000, while emitting 8 percent less CO₂ and improving their fuel efficiency by 31 percent during this same time period. Furthermore, one comment letter (0747) claimed that in comparison to 1972, the North American airlines now carry 6 times more payload using 60 percent less fuel per flight. One commenter (0834) asserted that absolute fuel consumption and emissions from U.S. domestic aircraft operations have decreased in the last 8 to 10 years, while emissions from international aviation bunker fuels has increased. Another commenter (0837) asserted that U.S. commercial aircraft emissions increased slightly between 2012 and 2013, but have decreased 18 percent since 2007. One comment letter (0747) claimed that when considering the relative contribution of U.S. aircraft, it is important to recognize that the United States has commercial airline fleets that are among the most efficient fleets worldwide.

In contrast, another commenter (0860) stated that industry claims of fuel-efficiency progress need to be evaluated closely and may be overstated, due to the choice of baseline aircraft by industry. Instead, the 2005 study by the Netherlands National Aerospace Laboratory (NLR) entitled, *Fuel Efficiency of Commercial Aircraft: An Overview of Historical and Future Trends*, indicated that this fuel-efficiency improvement is about 55 percent. Thus, relying on improvements in fuel efficiency may not be an effective method to compensate for the impact that aviation has on climate change. Also, the commenter indicated that environmental groups state that aviation is more climate-intensive than surface transportation. They specified that the aviation industry's results include assumptions regarding load factors, occupancy rates, and fuel-efficiency rates in comparison to those of surface transportation that skew the results.

Response: Section V.B of the FRN describes past improvements in U.S. aircraft GHG emissions. In particular, U.S. covered aircraft GHG emissions grew by 15 percent between 1990 and 2014, but total U.S. aircraft GHG emissions decreased by 3 percent over this same time period. Also, section V.B. of the FRN indicates that total U.S. aircraft GHG emissions and U.S. covered aircraft GHG emissions were from 10 to 15 percent greater in 2000 and 2005 than in 2014. The EPA provided the accompanying explanation that these decreases in aircraft GHG emissions are partly because aircraft operations decreased by similar amounts during this time period. Also, the EPA indicated that these decreases in aircraft GHG emissions are due in part to improved operational efficiency that results in more direct flight routing, improvements in aircraft and engine technologies to reduce fuel burn and emissions, and the accelerated retirement of older, less fuel-efficient aircraft. (In fact, the EPA explained that U.S. covered aircraft emissions decreased from 2000 to 2010 (13 percent), but then have increased from 2010 to 2014 (3 percent).)³¹ The EPA has considered these comments and the cited information about improvements in U.S. aircraft GHG emissions and fuel efficiency in making this contribution finding.

In addition, according to the 2009 study by the International Council on Clean Transportation (ICCT),³² the average fuel efficiency of new passenger aircraft has about doubled on both a seat-km (passengers only) and ton-km (passengers plus freight) basis since 1960. New aircraft fuel efficiency has improved substantially in two of the last five decades, but it has stagnated in recent years. Fuel efficiency, on average, has remained flat on a seat-km basis, and it has shown limited improvement annually on a ton-km basis since 2000. Thus, the ICCT study indicates that the rate of fuel-burn improvement has decreased in recent years.

³¹ U.S. EPA, 2016: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014*, 558 pp. Available at <http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf> (last accessed April 22, 2016).

³² International Council on Clean Transportation, 2009: *Efficiency Trends for New Commercial Jet Aircraft 1960 to 2008*, 20 pp., Available at http://www.theicct.org/sites/default/files/publications/ICCT_Aircraft_Efficiency_final.pdf (last accessed May 24, 2016).

4.3 Proposed Scope and Description of Covered Aircraft

The EPA summarizes and responds to comments regarding the scope of the contribution finding and the definition of covered aircraft for the finding in subsections 4.3.1, 4.3.2, and 4.3.3.

4.3.1. Applicability Weight Thresholds Match Those of International CO₂ Standard

Organization: Aerospace Industries Association (AIA) (EPA-HQ-OAR-2014-0828-0570, EPA-HQ-OAR-2014-0828-0797)

Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)

Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)

General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)

Summary of Comments: One comment letter (0863) stated that the EPA should undertake another cause or contribute finding for a broader range of aircraft not covered in our proposed finding, including smaller turboprop aircraft (such as the Beechcraft King Air 350i), smaller jet aircraft (such as the Cessna Citation M2), piston-engine aircraft, and helicopters. These commenters stated, however, that this comment did not affect the validity of the conclusions in the proposed finding. Other commenters (0570, 0751, and 0837) indicated that they support the scope of our proposed cause or contribute finding matching the applicability (MTOM) thresholds of the international CO₂ standard.

Response: The EPA responds to comments regarding the scope of the cause or contribute finding matching the applicability thresholds of the international CO₂ standard in section V.C.1.a of the FRN.

Summary of Comments: One comment letter (0837) indicated that the EPA's example of Cessna Citation CJ2+ as an example of smaller jet aircraft that is a U.S. covered aircraft was incorrect, because the CJ2+ has an MTOM below the proposed applicability threshold for subsonic jet aircraft, which is 5,700 kilograms.

Response: The EPA agrees that this smaller jet aircraft example of the CJ2+ was in error in the proposed findings, and in the FRN this has been corrected by using the example of a Cessna Citation CJ3+, which has an MTOM of 6,291 kilograms.

4.3.2. Defining U.S. Covered Aircraft

Organization: Airbus S.A.S. (EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859)

Summary of Comments: A commenter (0834) stated that they understand that the scope of the finding corresponds to the aircraft engine GHG emissions that are from aircraft that match the applicability thresholds (or MTOM thresholds) for the international aircraft CO₂ standard; however, they requested clarification on the difference between “U.S. covered aircraft” and “non-U.S. covered aircraft.” This commenter requested clarification on whether U.S. covered aircraft means aircraft made in the United States, registered in the United States, operated by an entity holding an air carrier certificate issued by the United States, operated by an air carrier in the National Air Space, or operated by anyone in the U.S. (National) Air Space. The commenter expressed that the EPA must explain the basis for its definition, and its claimed authority to regulate U.S. covered aircraft.

Response: The EPA responds to these comments regarding defining U.S. covered aircraft in section V.C.1.b of the FRN.

4.3.3. Limiting the Contribution Finding to U.S. Covered Aircraft

Organization: Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)

Summary of Comments: One comment letter (0747) questioned whether the EPA should limit the scope of the contribution finding to those aircraft matching the MTOM applicability thresholds adopted by ICAO, and asserted that the EPA should wait until the standard setting phase to exercise discretion as to what classes of aircraft engines should be covered by standards. These commenters argued that the EPA has authority to set aircraft engine GHG emissions standards, following a cause or contribute finding, that do not impose requirements on every engine or class of aircraft engine within the scope of that finding. They also argued that in this instance there does not seem to be a sufficiently reasoned basis for EPA to exclude the non-covered aircraft for purposes of making the cause or contribute finding.

Response: The EPA responds to comments on limiting the cause or contribute finding to U.S. covered aircraft in section V.C.1.c of the FRN. In addition, the EPA stresses that it is not in this action making a finding that emissions from the non-covered aircraft do not contribute to the GHG air pollution, or making any other final decision regarding those aircraft. Consequently, whether the EPA would have discretion to not establish emissions standards for such aircraft were they included within the set of aircraft subject to the present finding is a question that is outside the scope of this action.

4.4 Aircraft Emissions Projections

Organization: Airbus S.A.S. (EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859)
Aircraft Owners and Pilots Association (AOPA) (EPA-HQ-OAR-2014-0828-0751)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
Center for Biological Diversity (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Environmental Defense Fund (EDF) (EPA-HQ-OAR-2014-0828-0754, EPA-HQ-OAR-2014-0828-0793)
International Council on Clean Transportation (ICCT) (EPA-HQ-OAR-2014-0828-0791)
Natural Resources Defense Council (NRDC) (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Sierra Club (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))

Summary of Comments: One comment letter (0834) raised an issue with the EPA’s use of the 2014 FAA Aerospace Forecast³³ (hereinafter, 2014 FAA forecast), saying that the EPA does not correlate increased fuel burn with increased traffic. It indicated that the 2014 FAA forecast states that air carrier “revenue passenger miles (‘RPMs’) are forecast to grow at an average of 2.8 percent per year through 2034. That is, American carriers will be carrying more people and more cargo farther when compared to the amount of fuel the airlines burn getting them there.” It cited its company traffic forecast to show that the majority of growth will occur outside of the United States, and projected that worldwide traffic will increase at a rate of 4.6 percent annually while the United States traffic will increase at 2.5 percent, thus decreasing the U.S. share of global emissions. It stated that the majority of growth in emissions will therefore be outside the reach of U.S. federal regulation. Therefore, the comment letter concluded that the EPA’s finding exaggerates the contribution of the U.S. industry and makes it appear to be more responsible for global GHG emissions.

In addition, another comment letter (0747) stated that the EPA has not demonstrated that the assumptions underlying the 2015 FAA forecasts³⁴ are well-founded and how projections of GHG emissions were made. It noted that past FAA traffic growth and jet fuel consumptions forecasts have been shown to over-predict the traffic. Further, it stated that demand for air travel is contingent on a number of factors, thus making accurate estimates of future air traffic, and therefore fuel burn and GHG emissions, not feasible. Consequently, the comment letter claimed that the EPA’s use of a scaling factor and extrapolation to predict future emissions rates is insufficient.

Also, the comment letter (0747) questioned the EPA’s authority under section 231 of the CAA to consider future emissions while making a cause or contribute finding. It argued that the statutory language appears to apply to current aircraft emissions instead of future emissions.

Response: The EPA acknowledges, as described in section V.B.4.c of the FRN, that there are differing growth rates between U.S. markets and international markets due to the maturity of the U.S. market.

³³ FAA, 2014: *FAA Aerospace Forecast Fiscal Years 2014-2034*, pages 5, 13, and 15. Available at http://www.faa.gov/data_research/aviation/aerospace_forecasts/media/2014_faa_aerospace_forecast.pdf (last accessed April 8, 2016). This 2014 FAA forecast and the 2015 FAA forecast were both referenced in the proposed findings.

³⁴ FAA, 2015: *FAA Aerospace Forecast Fiscal Years 2015-2035*, 132 pp. Available at https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/2015_National_Forecast_Report_Final.pdf (last accessed July 5, 2016).

However, in regard to the comments that the U.S. share of global GHG emissions is expected to decrease, as a percentage, we believe this obscures the fact that on an absolute basis the U.S. aircraft GHG emissions (total U.S. aircraft GHG emissions and U.S. covered aircraft GHG emissions) are still expected to grow significantly (increase by 43 percent over the next two decades) in the foreseeable future.³⁵

In regard to the comments that question the underlying assumptions of the 2015 FAA forecast, the EPA believes that, as of July 1, 2015 (the date the proposed findings were published), the 2015 FAA forecast was the best publicly available data on projections for U.S. aircraft fuel consumption (utilized as a surrogate for projections in aircraft GHG emissions). Currently, the 2016 FAA forecast is the latest and best publicly available data on forecasts for U.S. aircraft fuel consumption. Similar to the 2015 FAA forecast (page 76), the 2016 FAA forecast report (page 39) states that, “[t]he forecasts in this document are forecasts of aviation demand, driven by models built on forecasts of economic activity. There are many assumptions in both the economic forecasts and in the FAA models that could impact the degree to which these forecasts are realized.” In addition, the 2016 FAA forecast (as well as the 2015 FAA forecast) report discusses the assumptions in the FAA models and how they may affect the projections, and as with any model or study, this is appropriate for describing the potential uncertainty with the forecast. Moreover, the FAA forecast has been published annually for many years, and each year FAA takes into account stakeholder input to improve the forecast. Therefore, the EPA believes this reaffirms that the 2015 FAA forecast was the best available data on U.S. aircraft fuel consumption projections in the public domain, as of July 1, 2015, and the 2016 FAA forecast is currently the best available data on U.S. aircraft fuel consumption projections.

For the comments on the EPA’s authority to consider future emissions projections for the contribution finding, as described in section V.B.3 of the FRN, given the projected growth in aircraft emissions compared to other sectors, it is reasonable for the Administrator to consider future emissions projections as further support for her assessment of historical and current annual emissions (recent emissions from the current fleet), and informing her contribution determination under CAA section 231(a)(2)(A). Also, because the projected growth in aircraft engine GHG emissions from U.S. covered aircraft is greater in percentage terms than percentages from other transportation sources, this consideration of projected future emissions adds further support to the Administrator’s cause or contribute finding. Ultimately, the historical annual and current GHG emissions inventories from U.S. covered aircraft are sufficient to support the Administrator’s cause or contribute finding in the FRN. That is, the Administrator’s contribution finding is also supported by the historical and current annual GHG emissions from U.S. covered aircraft to GHG inventories, alone, even without considering projected future emissions. But it is appropriate and reasonable for the EPA to also address and rely upon projected future emissions as an additional basis for the contribution finding, partly because the future standards the EPA will promulgate may apply to future aircraft types and future manufactured aircraft that are not yet in use and that have not yet begun emitting GHGs. The EPA’s treatment of historical and current annual aircraft GHG emissions is a reasonable set of information for the EPA to consider in making its contribution finding under CAA section 231, just as using the emissions inventory from the current fleet of motor vehicles as a surrogate for a projection of the inventory from new motor vehicles was reasonable in the 2009 Endangerment Finding under CAA section 202 (see 74 FR at 66543). But as the EPA is able in this action to also project future aircraft GHG emissions (including those expected from future manufactured aircraft), there is no

³⁵ FAA, 2016: *FAA Aerospace Forecast Fiscal Years 2016-2036*, 94 pp. Available at https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf (last accessed July 11, 2016). This 2016 and 2014 FAA forecasts are referred to in the FRN, and the 2014 and 2015 FAA forecasts were referred to in the proposed findings.

reason for the EPA to not include discussion of this projection in its contribution finding and consider whether it further supports the contribution finding.

Summary of Comments: One comment letter (0751) indicated that general aviation aircraft emissions are projected to only contribute between 1 and 3 percent to the worldwide aviation sector’s fuel consumption and CO₂ emissions in 2050. It also stated that general aviation aircraft’s contribution to global transportation emissions is likely to be orders of magnitude smaller.

Response: The EPA explains elsewhere in this document that the contribution finding’s scope is not defined by the use of terms such as “general aviation,” but rather by MTOM thresholds that result in some general aviation aircraft being considered covered aircraft. The EPA acknowledges the commenter’s statements about global percent contributions projected for general aviation aircraft GHG emissions in 2050. According to the 2016 FAA forecast,³⁶ the U.S. fuel consumption for total general aviation aircraft (using jet fuel and aviation gasoline) is projected to increase by 50 percent from 2010 to 2036, and the U.S. fuel consumption for general aviation aircraft using only jet fuel is estimated to increase by 58 percent in this same time period. As mentioned previously in this section, total U.S. aircraft GHG emissions and U.S. covered aircraft GHG emissions are projected to grow by 43 percent over this same timeline. Given this estimated growth in U.S. GHG emissions and the projected increases in U.S. general aviation aircraft fuel consumption, we anticipate that U.S. general aviation aircraft will have a similar contribution to U.S. aircraft GHG emissions (total U.S. aircraft GHG emissions and U.S. covered aircraft GHG emissions) in the next few decades as they do today. We do not currently have access to global GHG emissions projections for general aviation aircraft, but we anticipate that general aviation aircraft’s percent global contribution in the long-term would follow similar trends as in the United States.

In regard to the comment letter’s statements about the significance of general aviation aircraft’s contribution to total GHG emissions, the EPA responds to these comments in section 4.2.2 (also see section 4.2 for further details).

Summary of Comments: One comment letter (0747) noted that the “US airline industry is part of a global aviation coalition that aims to achieve 1.5 percent annual fleet average fuel efficiency improvements through 2020” and to achieve carbon neutral growth after 2020. As part of this effort, it stated that it is committed to working with other stakeholders to deploy “commercially viable, environmentally friendly alternative jet fuel” to reduce GHG emissions.

Response: The EPA commends the airline industry on its goal of carbon neutral growth after 2020. The EPA is encouraged that the airline industry recognizes the public health and welfare concerns from aircraft engine GHG emissions. However, the goals mentioned by the commenter do not change the contribution finding. The EPA notes that this goal as articulated relies significantly on the use of alternative jet fuels to make up the balance of the GHG emissions deficit created by increased air traffic.³⁷

³⁶ FAA, 2016: *FAA Aerospace Forecast Fiscal Years 2016-2036*, 94 pp. Available at https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf (last accessed April 8, 2016). This FAA forecast is referred to in the FRN.

³⁷ ICAO CAEP, 2013: *ICAO Environmental Report 2013, Aviation and Climate Change*, 212 pp., Chapter 1 – Aviation and Environment Outlook. Available at <http://cfapp.icao.int/Environmental-Report-2013/> (last accessed April 8, 2016).

The alternative fuel market (or suppliers) is not expected to have the production capacity needed for this deficit in the foreseeable future.³⁸

The EPA would also encourage the airline industry to review its GHG emissions reduction targets as well. Setting an ambitious, long-term goal sufficiently in the future (20–30 years), with near- and mid-term goals would be a proactive approach to move forward with the industry’s commitments to reduce growth in GHG emissions from aviation.

Summary of Comments: Some commenters (0927, 0754, and 0791) stressed the importance of the projected growth in aircraft GHG emissions and the importance of trying to curb it. These commenters indicated how light-duty and heavy-duty vehicles are expected to see significant reductions in GHG emissions by 2035, while there is expected to be substantial growth in air traffic, operations, and aircraft GHG emissions by 2030 and continuing to 2050.

Response: The EPA agrees with these commenters about the importance of the projected substantial growth in aircraft GHG emissions. These comments reaffirm the EPA’s consideration of future emissions projections as information to further support its assessment of historical and current annual actual emissions (recent emissions from the current fleet) for the contribution finding.

³⁸ US DOT, 2012: *Alternative Jet Fuel Scenario Analysis Report*, 7-13 pp., Executive Summary. Available at <http://ntl.bts.gov/lib/46000/46500/46597/DOT-VNTSC-FAA-12-01.pdf> (last accessed July 8, 2016)

5. Miscellaneous Legal, Economic, and Other Comments

Organization: Airbus S.A.S. (EPA-HQ-OAR-2014-0828-0834, EPA-HQ-OAR-2014-0828-0859)
AirFair, Inc. (EPA-HQ-OAR-2014-0828-0860)
Airlines for America (A4A) and the Air Line Pilots Association (ALPA) (EPA-HQ-OAR-2014-0828-0747)
Biogenic CO₂ Coalition (EPA-HQ-OAR-2014-0828-0916)
Boeing Commercial Airplanes (EPA-HQ-OAR-2014-0828-0568)
Cargo Airline Association (EPA-HQ-OAR-2014-0828-0732)
Citizens United and Green (EPA-HQ-OAR-2014-0828-0915)
Climate Viewer News (EPA-HQ-OAR-2014-0828-0359, EPA-HQ-OAR-2014-0828-0484)
Corporate Company - Climate Environment Confirmation and Responsibility (CECR) (EPA-HQ-OAR-2014-0828-0608)
Earth Guardians of Vermont (EPA-HQ-OAR-2014-0828-0920)
Earthjustice et al. (EPA-HQ-OAR-2014-0828-0863)
Friends of the Earth (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
General Aviation Manufacturers Association (EPA-HQ-OAR-2014-0828-0837)
Geoengineering Watch (EPA-HQ-OAR-2014-0828-0261)
Institute for Policy Integrity (EPA-HQ-OAR-2014-0828-0749)
Lissys Ltd. (EPA-HQ-OAR-2014-0828-0203)
National Tribal Air Association (NTAA) (EPA-HQ-OAR-2014-0828-0362)
Private Citizen (EPA-HQ-OAR-2014-0828-0357)
Private Citizen (EPA-HQ-OAR-2014-0828-0173)
Private Citizen (EPA-HQ-OAR-2014-0828-0147)
Private Citizen (EPA-HQ-OAR-2014-0828-0601)
Private Citizen (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Sierra Club (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
StopSprayingUs-SF.com (EPA-HQ-OAR-2014-0828-0927 (public hearing transcript))
Transport & Environment (EPA-HQ-OAR-2014-0828-0862)
UCLArts and Healing (EPA-HQ-OAR-2014-0828-0763)
Union of Concerned Scientists (EPA-HQ-OAR-2014-0828-0526)

Summary of Comments: Some commenters (0860, 0927, and 0362) strongly supported the proposed GHG endangerment and contribution findings, stating that the CAA clearly authorizes the EPA to make these findings under section 231(a)(2)(A) and pointing to the previous 2009 Endangerment Findings under section 202(a)(1) as precedent for doing so, given the identical language found in each section. Most commenters (0747, 0568, and 0732) stated that the CAA authorized the EPA to make the proposed aircraft endangerment finding. One commenter (0732), while agreeing that the EPA possessed authority under CAA section 231(a) to make such findings, also stated that the EPA's jurisdiction that follows from such authority is limited to then setting standards for the emissions emanating from aircraft engines and does not authorize the EPA to, "otherwise regulate air transportation."

Joint commenters (0747) questioned whether EPA had adequately set forth the basis for its authority under CAA section 231 to address pollutants other than pollutants for which the EPA has established National Ambient Air Quality Standards (NAAQS), and asked that the EPA address this issue in light of the recent Supreme Court opinion in *Utility Air Regulatory Group v. EPA*, which they quote as stating that *Massachusetts v. EPA* "does not strip EPA of authority to exclude greenhouse gases from the class of

regulable air pollutant under other parts of the Act where their inclusion would be inconsistent with the statutory scheme.” 134 S. Ct. 2427, 2441 (2014). These commenters argued that the use of the term “air quality control regions” in CAA sections 231(a)(1)(A) and 231(a)(3) suggests that Congress intended to authorize the EPA to issue standards only for pollutants for which a NAAQS has been established.

Finally, a commenter (0834) stated that if the EPA issued standards more stringent than ICAO and the European Aviation Safety Agency (EASA), the United States would be substituting its judgment for that of ICAO and would have seized EASA’s role as the certifying agency of aircraft developed by the commenter under European authority.

Response: The EPA agrees with commenters that the CAA clearly authorizes the EPA to make GHG endangerment and contributions findings with regard to aircraft GHG emissions under 231(a)(2)(A). The text of the CAA section concerning aircraft emissions in section 231(a)(2)(A) mirrors the text of CAA section 202(a) that was the basis for the 2009 Endangerment Finding. In the 2009 Endangerment Finding, the EPA explained its legal framework for making an endangerment finding under section 202(a) of the CAA (74 FR 18886, 18890-94 (April 24, 2009), and 74 FR 66496, 66505-10 (December 15, 2009)). The text in section 202(a) that was the basis for the 2009 Endangerment Finding addresses “the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in [the Administrator’s] judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.” Similarly, section 231(a)(2)(A) concerns “the emission of any air pollutant from any class or classes of aircraft engines which in [the Administrator’s] judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare.” The legal framework for these findings is discussed in section III of the FRN.

With regard to the commenter who stated that the EPA’s jurisdiction to regulate aircraft emissions is limited to setting standards for emissions emanating from aircraft engines and does not authorize the EPA to “otherwise regulate air transportation,” we note that section 231(a)(2)(A) of the CAA directs the Administrator of the EPA to, from time to time, propose aircraft engine emissions standards applicable to the emissions of any air pollutant from any classes of aircraft engines which in her judgment causes or contributes to air pollution, which may reasonably be anticipated to endanger public health or welfare. As required by the CAA, the EPA has been engaged in reducing harmful air pollution from aircraft engines for over 40 years, regulating gaseous exhaust emissions, smoke, and fuel venting from aircraft engines. (See U.S. EPA, 1973: Emissions Standards and Test Procedures for Aircraft; Final Rule, 38 FR 19088 (July 17, 1973).) The Administrator’s decisions regarding the GHG air pollution and the GHG air pollutant for these findings under section 231(a)(2)(A) are explained in detail in sections IV and V of the FRN, respectively. To the extent this commenter is suggesting that these findings should only include substances emitted by aircraft engines, section V.A.2 of the FRN explains that the definition of the relevant air pollutant under section 231(a)(2)(A) may group into a single class multiple substances that possess shared relevant properties, even though they are not all emitted from section 231(a)(2) sources. Finally, we note that these final GHG endangerment and contribution findings trigger new duties that apply to the EPA but do not themselves apply new requirements to other entities outside the federal government. Specifically, in issuing these final findings that emissions of the six well-mixed GHGs from certain classes of engines used in certain aircraft cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, the EPA is triggering a duty under CAA section 231 to propose and promulgate aircraft engine emissions standards applicable to emissions of that air pollutant from those classes of engines.

After consideration of comments claiming that EPA’s authority to address aircraft engine emissions is restricted to NAAQS pollutants, the EPA disagrees with the argument that Congress intended to only authorize the EPA to address NAAQS pollutants under section 231(a)(2)(A). The EPA fully responds to this comment in section III.A.4 of the FRN. Finally, with regard to the comment warning EPA against

issuing standards more stringent than those selected by ICAO, the EPA notes that this rulemaking does not set any emissions standards for aircraft engines. In this final action, the EPA is promulgating findings under section 231(a)(2) that emissions of the six well-mixed GHGs from certain classes of engines used in covered aircraft cause or contribute to endangering air pollution, but the EPA is not yet issuing proposed or final aircraft engine emissions standards. Nor is the EPA taking final action that prejudices what future standards will be, nor that determines that the EPA's future standards will be the same as ICAO's expected standards. Instead, the EPA's final endangerment and cause or contribute findings for aircraft GHG emissions are in preparation for a subsequent, expected domestic rulemaking process to adopt future aircraft engine GHG standards. If the ICAO Assembly, in October 2016, approves the final CO₂ standards and subsequently ICAO formally adopts the final CO₂ standards in March 2017, the EPA's standards will need to be at least as stringent as the ICAO aircraft CO₂ standards for the United States to meet its treaty obligations under the Chicago Convention. As a result of these positive findings, the EPA is obligated under section 231(a) of the CAA to set emissions standards applicable to GHG emissions from the classes of aircraft engines included in the contribution finding, no matter the outcome of ICAO's future actions in October 2016 and March 2017.

Summary of Comments: A commenter (0834) stated that their company seeks to ensure air transport continues to be an eco-efficient means of transport while noting that millions of jobs and the U.S. GDP are supported by the air travel industry. A commenter (0927) noted that because jet fuel is the number one cost for commercial airlines their members have a powerful incentive to continue to reduce CO₂ output in addition to the need to act responsibly toward the environment. Another commenter (0863) urged EPA to promptly set greenhouse gas emissions standards for aircraft arguing that immediate action is more cost-effective than deferred action which will necessitate additional mitigation costs and also increase the difficulty of the transition to low longer-term emissions levels. A commenter (0837) noted their commitment to health and development of a sustainable general aviation industry worldwide and explained that general aviation plays an important role in economic growth by serving the transportation needs of communities, companies, and individuals worldwide. They reported on a study they had commissioned and which was released in February 2015. This report found that general aviation in the U.S. employs or supports about 1.1 million jobs and \$219 billion dollars in US economic output every year. They also noted that general aviation manufacturers shipped 1,631 airplanes, worth \$11.69 billion dollars with the majority being of the type and size that would be covered aircraft under the EPA's proposed contribution finding.

Response: The EPA appreciates the economic data submitted by these commenters. Under CAA section 231(b), we will be required in promulgating future aircraft GHG standards to give appropriate consideration to the cost of compliance with the standards. The endangerment and contribution findings, however, are based on scientific considerations, and do not themselves impose burdens or costs on any non-federal entity. Therefore, the comments on anticipated costs and benefits of future standards are not within the scope of this action. As we discuss in section II.C. of the FRN, CAA section 231(a)(2)(A) directs the EPA to first identify whether emissions of aircraft engine air pollutants cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare. Then CAA section 231(b) requires that the EPA's standards, which may require improved emissions performance over the status quo, provide sufficient time for the development and application of requisite technology to meet emissions standards, after appropriate consideration of the cost of compliance within that period.

Summary of Comments: One commenter (0747) expressed surprise that U.S. airlines were not included in the Federal Register list of entities that the EPA believes would be affected by the proposed Endangerment Finding and ANPR, stating that both US airlines and pilots have an interest in the potential environmental impacts of the findings and any standards that result from them—including the costs of meeting standards, the impact of such on aircraft pricing, and insuring that the U.S. approach is consistent

with the international standards. Several commenters (0862, 0927) discussed the scientific consensus surrounding the reality of climate change as well as the type of actions that will be necessary to reduce the risks and well as the worst impacts of climate change. These commenters urged the Obama Administration to take decisive action to address climate change while also acknowledging that the Administration has recognized the need for urgent action, regulations, and executive action.

A number of commenters discussed the importance of transparency (0173, 0203, 0362). One of these commenters, noting the technical and complex nature of studies associated with the 2009 Endangerment Finding and the technical nature of the current proposal, urged the EPA to ensure the general public can understand the goals of the proposal and how it would be implemented. Another commenter spoke of the need for transparency when quantifying aviation CO₂ emissions to ensure that they are technically meaningful and urged the EPA to assemble a more complete inventory than what was attempted by ICAO.

Response: With regard to the commenter who indicated they should be included in the list of entities that would be affected by the proposed endangerment finding, the EPA notes that the table found in section I.A of the FRN is not intended to be exhaustive, but rather provides a guide for readers. We acknowledge in section I.A of the FRN that other type of entities, not listed in the table, could also be interested and potentially affected by subsequent actions at some future time. In this regard, this final endangerment finding triggers new duties that apply only to the federal government and do not apply any new requirements to other entities outside the federal government. Section I.A provides additional discussion on this topic.

The EPA agrees with commenters who stated that addressing climate change is an urgent matter. Section II.C.1 of the FRN describes the many actions undertaken by EPA to address climate change since 2007, as well as the efforts by the Obama Administration through the Climate Action Plan and Presidential Memorandum to develop additional executive actions to further reduce GHGs. The EPA also agrees with commenters who discussed the importance and need for transparency when discussing climate change science and when proposing and finalizing GHG-related rulemakings. The 2015 ANPR discussed the issues arising from the ICAO/CAEP international process, including a range of technical issues regarding aircraft CO₂ emissions standards, to assist the Agency in developing its position with regard to these issues, and also to help ensure transparency, and obtain views on aircraft engine GHG emissions standards that it might potentially adopt under the CAA. With regard to comprehensive emissions inventories for aircraft emissions, the EPA believes it has quantified the GHG emissions of aircraft in a meaningful, clear, and comprehensive manner. In addition to relying on the latest IPCC data for associated aircraft emissions, to ensure completeness and the most up-to date information, the EPA also provided 2012 estimates from other widely used and recognized global datasets, the World Resources Institute's Climate Analysis Indicators Tool (WRI CAIT). To further inform the Administrator's assessment, section V.B.4 of the FRN presents various comparisons of covered U.S. aircraft emissions: as a share of current total U.S. GHG emissions; as a share of current U.S. transportation GHG emissions; as a share of current total global GHG emissions; and as a share of the current global transportation GHG emissions.

Summary of Comments: One commenter (0362) wrote that the proposal has implications for Native American tribes with regard to environmental justice communities and because climate-driven disruptions of biological communities are having an effect on the treaty rights of Indian Tribes, especially those treaties that preserve hunting, fishing, and gathering rights for tribes on their lands and in the usual and accustomed areas. The commenter noted that some tribes are finding that animals and/or plants on which they depend for their cultural practices and identity have either migrated onto other lands or disappeared altogether. Pointing to Executive Order (EO) 13175, the commenter stated that the EPA was required to

develop a process to ensure “meaningful and timely input” by tribes into regulatory policies that have tribal implications, and the commenter urged the EPA to provide significant opportunities for consultation with tribes regarding finalizing these findings and subsequently when developing regulations to control aircraft emissions and other sources of GHGs. This commenter strongly supported the proposed endangerment finding.

Response: With regard to comments regarding environmental justice and Native American tribes, the EPA addresses comments regarding climate change impacts that tribes are facing, such as those to culturally important plant and animal species, in section 3.4 “Sectoral Impacts” of this RTC document. These findings were developed in accordance with the EPA Policy on Consultation and Coordination with Indian Tribes.³⁹ The Agency engaged in coordination activities with the National Tribal Air Association. The EPA stated in the proposal and in the final findings in the FRN that this action will not have potential disproportionately high and adverse human health or environmental effects on minority, low-income, or indigenous populations and that EO 13175 does not apply to this action. The EPA made these determinations because this action does not affect the level of protection provided to human health or the environment, and thus it does not have tribal implications as specified in EO 13175. The final endangerment and cause or contribute findings under CAA section 231(a)(2)(A) do not themselves impose any new requirements but rather set forth the Administrator’s determination that GHG emissions from certain classes of aircraft engines—those used in U.S. covered aircraft—cause or contribute to air pollution that may be reasonably anticipated to endanger public health and welfare. However, the Administrator did consider climate change risks to minority, low-income, and indigenous populations as part of these endangerment and contribution findings under CAA section 231(a)(2)(A). In addition, the EPA wishes to assure the commenter that it is committed to continued dialogue with regard to issues, including climate change related matters, that impact tribes in the U.S. This action’s discussion of climate change impacts on public health and welfare is found in section IV.C of the FRN. Specific discussion with regard to minority, low-income, and indigenous populations is found in sections IV.C.1.a and IV.C.2.a of the FRN.

Summary of Comments: A commenter (0749) described a petition that they submitted to the Agency in 2009, which made several requests including for the EPA to make endangerment and contribution findings under CAA section 231. This commenter asks the Agency to clarify whether it considers these final findings to respond to that part of their petition request. Another commenter (0927) requested that the EPA adopt the proposed endangerment finding “within no more than three months of the comment period.”

Response: The EPA’s final endangerment and contribution findings come in response to a separate earlier citizen petition submitted by Friends of the Earth, Oceana, the Center for Biological Diversity, and Earthjustice requesting that the EPA issue a GHG endangerment finding and standards under section 231(a)(2)(A) of the Act for GHG emissions from aircraft engines. The portion of the 2009 petition submitted by the commenter referenced above is the same request made previously by the first petitioners. Regarding the comment about timing for adopting the proposed endangerment findings, the Agency

³⁹ EPA (2011). EPA Policy on Consultation and Coordination with Indian Tribes. Available at: <https://www.epa.gov/sites/production/files/2013-08/documents/cons-and-coord-with-indian-tribes-policy.pdf> (last accessed June 9, 2016).

finalized this action according to the regulatory development processes outlined in the EPA's Action Development Process Guidelines.⁴⁰

Summary of Comments: Many commenters (0147, 0916, 0747, 0834, 0863, 0860, 0568, 0732, 0526, 0601) discuss the EPA's future regulatory standards for GHG emissions from aircraft engines, including, for example, their views on the EPA's duty or authority under the Clean Air Act to undertake regulation, what types of pollutants and what types of aircraft the future standards should cover, and various considerations that the Agency should take into account when establishing aircraft emissions standards, such as aircraft safety, engine and aircraft efficiency, and the carbon intensity of aircraft fuels.

Response: Comments related to future regulations under CAA section 231 are outside of the scope of this action because the EPA has neither proposed nor is finalizing in this action any such regulatory standards. This final action does not itself impose any requirements on source categories under CAA section 231. Thus, the EPA anticipates that these questions could be raised and considered, as needed, in the standard-setting phase of the regulatory process, and the EPA will consider comments submitted on the issue of the appropriate form of emissions standards and other related issues in response to EPA's anticipated future notice of proposed rulemaking on standards. Although this final action trigger a duty for the EPA to promulgate standards for the GHG emissions from engines used by covered aircraft, the findings do not pre-judge the standards.

Summary of Comments: Some commenters (0927, 0915, 0359, 0608, 0920, 0261) argued that the EPA's proposal does not address the negative human health effects of exposure to chemicals, heavy metals, metal particulates/aerosols, biological agents or other toxic substances that the commenters contend are associated with aircraft fuel, fuel additives, emissions, aviation-induced cloudiness/contrails, and/or intentional spraying or geoengineering activities. These commenters describe a number of health conditions—including Alzheimer's disease, cancer, autism, respiratory and heart disease, migraines, nosebleeds, and ear ringing—that they argue result from exposure to these substances. In addition to health impacts, one commenter (0920) notes loss of wildlife and trees in the State of Vermont from exposure to these substances, while another commenter (0359) notes impacts from aviation-induced cloudiness on the solar energy industry, tourism industry, and astronomy activities. This commenter requests that the EPA participate in both domestic and international discussions about aircraft geoengineering activities.

Response: The EPA's findings address the questions of whether concentrations of the six well-mixed GHGs in the atmosphere may reasonably be anticipated to endanger public health and welfare and whether emissions of the same six well-mixed GHGs from certain classes of engines used in covered aircraft cause or contribute to the endangering air pollution. Thus, in this final action the EPA summarizes the key findings from the scientific assessment literature regarding the role of the six well-mixed GHGs in driving climate change and the observed and projected impacts of that climate change, including to public health. Specifically, in section IV.C.1 of the FRN, the EPA summarizes the key findings of the more recent assessments regarding a range of health risks associated with climate change-induced changes in air quality, increases in temperatures, changes in extreme weather events, increases in food and water borne pathogens, and changes in aeroallergens; and that certain populations are more vulnerable to climate change health risks and impacts. The question of whether other substances that may be emitted by aircraft engines cause or contribute to air pollution which may reasonably be anticipated to endanger

⁴⁰ EPA (2011). Guidance for EPA Staff on Developing Quality Actions. EPA Office of Policy. [https://yosemite.epa.gov/sab/5CSABPRODUCT.nsf/5088B3878A90053E8525788E005EC8D8/\\$File/adp03-00-11.pdf](https://yosemite.epa.gov/sab/5CSABPRODUCT.nsf/5088B3878A90053E8525788E005EC8D8/$File/adp03-00-11.pdf) (last accessed June 6, 2016).

public health or welfare is outside the scope of this final action. The request for involvement in domestic or international discussions about geoengineering is also not within the scope of the EPA's final endangerment and contribution findings for the six well-mixed GHGs.

Summary of Comments: Some commenters (0357, 0763) voiced concern with the negative health effects due to the air quality impacts of aircraft emissions occurring near airports or when aircraft are idling or taxiing on the ground, or departing or arriving. These commenters discussed the impact of aircraft emissions of ultra-fine particulates, carbon monoxide, sulfuric acid, volatile organic compounds and nitrogen dioxide and urged the EPA to take action to address these threats to human health and local air quality. Another commenter (0359) noted the negative health impacts of lead and argues that the EPA has a misplaced focus on climate change while “doing nothing to address ongoing lawsuits over leaded aviation gasoline.”

Response: For informational purposes, the EPA provides the following discussion regarding its current program addressing aircraft emissions' impacts on local air quality. However, this final action does not address local air quality impacts of aircraft non-GHG emissions, and takes no action regarding the existing program. Consequently, comments on that program are outside the scope of this final action. Regarding comments on the local air quality impacts of aircraft, jet aircraft contribute much less air pollution than that from motor vehicles; however, their overall emissions are increasing every year as air travel becomes more popular. In addition, jet aircraft can contribute significantly to ground-level ambient air pollution in the immediate vicinity of an airport, especially emissions of NO_x and hydrocarbons (HCs) which contribute to the formation of ozone. Additional detailed information on aircraft emissions can be found in an EPA report, "Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft" (April 1999). This report is also available at EPA's aviation web site at: www.epa.gov/otaq/aviation.htm. It provides an estimation of the contribution of aircraft to air quality emissions in ten urban areas.

The aircraft emissions standards for gas turbine (jet) engines which power civil aircraft have been in place for about twenty years. Before an engine type can be sold or installed on an aircraft, the manufacturer must test its emissions on the ground by simulating in-use conditions. The EPA sets the emissions standards for the engines, and the FAA monitors the certification process and enforces the standards. Emissions standards apply to essentially all commercial aircraft, comprising scheduled and freight airlines. Controls on engine smoke and prohibitions on fuel venting were instituted in 1974 and have been revised several times since then. Beginning in 1984, limits were placed on the amount of unburned HCs which turbine engines can emit per landing and takeoff cycle. In May of 1997, the EPA adopted the then existing emissions standards for gas turbine engines of the ICAO for NO_x and carbon monoxide (CO). In addition, in November 2005 and May 2012, EPA adopted more stringent NO_x standards, which were previously adopted by ICAO.

With regard to lead emissions, EPA has been petitioned to issue an endangerment finding for aircraft lead emissions and currently intends to issue a 2017 notice of proposed rulemaking. If the endangerment finding is positive, then we would subsequently evaluate and propose engine emissions standards. For more information, go to: <https://www3.epa.gov/otaq/aviation.htm#lead>.