MAYOR AND CITY COUNCIL OF BALTIMORE	*	IN THE
	*	CIRCUIT COURT
Plaintiff,		
v.	*	FOR BALTIMORE CITY
BP P.L.C., *et al.*	*	Case No. 24-C-18-004219
Defendants.	*	Specially Assigned to the Hon. Videtta A. Brown
	*	

* * * * * * * * * * * * *

PLAINTIFF MAYOR AND CITY COUNCIL OF BALTIMORE'S MEMORANDUM OF LAW IN OPPOSITION TO DEFENDANTS CONSOL ENERGY INC.'S AND CONSOL MARINE TERMINALS LLC'S SUPPLEMENTAL MOTION TO DISMISS FOR FAILURE TO STATE A CLAIM

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

Cases

Statutes

Rules

Other Authorities

I. INTRODUCTION

The Mayor and City Council of Baltimore ("City") states claims against CONSOL Energy Inc. ("CONSOL Energy") and its closely controlled subsidiary CONSOL Marine Terminals LLC ("CONSOL Marine") (collectively, "CONSOL Defendants"). As explained in the City's memorandum in opposition to Defendants' joint motion to dismiss for failure to state a claim ("Opposition"), which the City incorporates by reference here, the Complaint states viable tort and Maryland Consumer Protection Act ("MCPA") claims against CONSOL Defendants and others because they and their predecessors failed to warn about their fossil fuel products' climatic risks, and participated in a campaign to disinform consumers and the public about climate change and its relationship to their fossil fuel products. *See* Opp. at Part IV.D.1–IV.D.5.

CONSOL Defendants' arguments in their motion to dismiss ("Motion") change nothing, and the Court should deny the Motion. The Complaint's allegations notify CONSOL Defendants of the claims against them, and satisfy the heightened pleading requirement applicable to only a portion of the City's MCPA claim. Among other misconduct, the City alleges misrepresentations attributable to CONSOL Defendants under a concert-of-action theory. CONSOL Defendants also ignore the City's allegations when they argue they had no duty to warn about their products' climatic risks because they lacked superior knowledge of those dangers. The Court must credit the Complaint's contrary allegations, and should avoid resolving factual disputes on mere pleadings.

II. ARGUMENT

A. The Complaint Notifies CONSOL Defendants of the Claims Against Them.

CONSOL Defendants say the claims against them must be dismissed because the Complaint does not allege misrepresentations or omissions by them alone. Mot. at 4–7. CONSOL Defendants are wrong because the Complaint alleges the elements of each claim against them, *see* Opp. at Part IV.D.1–IV.D.5, and sufficiently notifies them of these claims. *See Tshiani v. Tshiani*,

436 Md. 255, 270 (2013) ("The primary purpose behind our pleading standards is notice.").

Although CONSOL Defendants were formed recently by a spinoff, their predecessors have mined and sold coal since the 1860s. *See* Compl. ¶ 29(a), (b), (e). The Complaint details how CONSOL Defendants, through their predecessors, and others repeatedly failed to warn about their fossil fuel products' climatic risks, and instead waged a sophisticated campaign of deception about the links between their products and climate change. *See id.* ¶¶ 1, 6–7, 141–70. This strategy has worked as intended, unduly inflating demand for fossil fuels, while substantially increasing greenhouse gas emissions and resulting climate impacts to Baltimore. *See id.* ¶¶ 8–10, 59–102, 169–70, 177–82, 190–217. Through this conduct, CONSOL Defendants and others have actively participated in creating public and private nuisances in Baltimore, caused foreign materials to trespass upon the City's property, breached their duty to issue adequate warnings to protect those foreseeably harmed by their fossil fuel products' intended uses, prevented consumers from understanding their products' risks, and violated the MCPA. *See* Opp. at Part IV.D.1–IV.D.5.

Although CONSOL Defendants seek to write off the Complaint's collective allegations as merely "conclusory" and insufficient to state claims against them, *see* Mot. at 6, no Maryland case law proscribes collective allegations,[1] and federal courts in Maryland and elsewhere have often held that such allegations "provide defendants with fair notice of the claims against them and the

[1] The cases CONSOL Defendants cite do not hold otherwise, and in any event the City's allegations are much more robust than the allegations in those cases. *See Heritage Harbour, L.L.C. v. John J. Reynolds, Inc.*, 143 Md. App. 698, 711 (2002) (dismissal upheld where complaint lacked "any mention of" eight of twenty defendants, and the only allegation that could pertain to those eight defendants was that all twenty "we[re] developers, architects and/or contractors who participated in the design, construction, evaluation and/or repair of" defective buildings); *Proctor v. Metro. Money Store Corp.*, 579 F. Supp. 2d 724, 742–44 (D. Md. 2008) (critiquing collective allegations that multiple defendants had engaged in actions only one person could have done—"deliver[ing] one check, record[ing] one deed, instruct[ing] one buyer to sign a document, and receiv[ing] one fax"—particularly where the plaintiff had initially sued one defendant, and then amended to assert the exact same allegations against two new defendants); *Adams v. NVR Homes, Inc.*, 193 F.R.D. 243, 250, 255–57 (D. Md. 2000) (in a case involving federal particularity pleading, noting a plaintiff must "identify[] each individual defendant's participation in the alleged fraud" for purposes of fraud claims, but not applying that standard to plaintiff's trespass or nuisance claims).

grounds upon which they rest." *State v. Exxon Mobil Corp.*, 406 F. Supp. 3d 420, 476 (D. Md. 2019) (cleaned up) (rejecting defendants' argument that "group pleading" was "improper").[2]

Here, the Complaint's collective allegations are permissible because the City alleges each Defendant engaged in the same wrongful conduct by deploying campaigns to deceive and mislead consumers and the public about the link between their fossil fuel products and climate change. *See, e.g.*, Compl. ¶¶ 1, 6–7, 141–70, 295–96.[3] Further, the Complaint's grouping of CONSOL Defendants with Defendant CNX Resources Corporation ("CNX") as "CONSOL" is only natural because CONSOL Energy was part of CNX until 2017, when CNX spun off "its coal mining and related downstream operations" as CONSOL Energy. Compl. ¶ 29(a). For most of the relevant time period, then, CNX and CONSOL Energy were one and the same. And, as a closely controlled subsidiary of CONSOL Energy that acts on CONSOL Energy's behalf, CONSOL Marine is appropriately included, too. *See id.* ¶ 29(e).

Moreover, contrary to CONSOL Defendants' arguments, *see* Mot. at 9, the Complaint plausibly alleges that CONSOL Energy is liable as a successor to CNX, especially as CONSOL Energy took over entire lines of business from CNX and continued operating them. *See* Compl. ¶ 29(a)–(b). At minimum, the Court should not resolve corporate successorship questions on the pleadings because "successor liability is a mixed question of law and fact, with a 'heavier factual component,'" *Playmark, Inc. v. Perret*, 253 Md. App. 593, 608 (2022) (quoting *Martin v. TWP Enters., Inc.*, 227 Md. App. 33, 49 (2016)), requiring discovery and "an examination of the

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[2] *See also, e.g.*, *Chevron U.S.A. Inc. v. Apex Oil Co.*, 113 F. Supp. 3d 807, 815 n.1 (D. Md. 2015) (collecting cases to show that "[n]othing in [Federal Rule of Civil Procedure] 8 prohibits collectively referring to multiple defendants where the complaint alerts defendants that identical claims are asserted against each defendant" (quotation omitted)); *Lackey v. MWR Investigations, Inc.*, 2015 WL 132613, at *2–3 (D. Md. Jan. 8, 2015) (rejecting argument that complaint improperly grouped defendants and explaining "presum[ption] that all allegations made against the defendants collectively applied equally to the individual defendant" (collecting cases)).

[3] To the extent CONSOL Defendants try to set themselves apart as producers and sellers of coal, the Complaint defines "fossil fuel products" to include coal, Compl. ¶ 3, and alleges that all Defendants failed to warn of, concealed, and participated in efforts to spread disinformation about their fossil fuel products' risks, *see id.* ¶¶ 141–70, 218–98.

corporate entities involved, including a factual comparison of the selling corporation to the purchasing corporation," *Martin*, 227 Md. App. at 49.[4]

B. The Complaint Links CONSOL Defendants to Many Misrepresentations.

The Complaint also links CONSOL Defendants to misrepresentations under a concert-of-action theory. Maryland has long "recognized joint and several liability for 'true' joint tortfeasors" that "act in concert," *Consumer Prot. Div. v. Morgan*, 387 Md. 125, 177 (2005), including when persons "concur[] in making [a tortious] misrepresentation," *Purdum v. Edwards*, 155 Md. 178 (1928). "Those who actively participate in the wrongful act, by cooperation or request, or who lend aid, encouragement or countenance to the wrongdoer, or approval to his acts done for their benefit, are equally liable with him.'" *Morgan*, 387 Md. at 178 (quoting William L. Prosser, *Joint Torts and Several Liability*, 25 Calif. L. Rev. 413, 429–30 (1936)). "Express agreement is not necessary; all that is required is that there shall be a common design or understanding.'" *Id.* (quoting Prosser, 25 Calif. L. Rev. at 430).

Defendants and their predecessors acted "individually and in concert with each other" in "knowingly promoting the sale and use of fossil fuel products [they] knew to be hazardous," and "[d]isseminating and funding the dissemination of information intended to mislead" consumers and others about climate change. Compl. ¶¶ 219, 221(b), (d); *see also id.* ¶¶ 147, 242, 254, 275. CONSOL Defendants' predecessors and their collaborators had a common design: they together

[4] CONSOL Energy also argues it is not liable for any conduct by CONSOL Marine. Mot. at 9. However, a subsidiary's acts may be attributed to a parent through agency principles "where the facts establish control of the subsidiary by the parent." *Copiers Typewriters Calculators, Inc. v. Toshiba Corp.*, 576 F. Supp. 312, 324 (D. Md. 1983) ("*Copiers Typewriters*"). "[T]he existence of an agency relationship is generally a question of fact for the trier of fact," *id.* (citing *P. Flanigan & Sons, Inc. v. Childs*, 251 Md. 646, 652 (1968)), and when the existence of such a relationship "goes to the merits of a particular claim, any question of fact must be resolved by the jury," *id.* at 325. Here, the City alleges that CONSOL Energy tightly controls its subsidiaries, including the extent of their fossil fuel production and sales. Compl. ¶ 29(c)–(d). CONSOL Marine thus acts on CONSOL Energy's behalf and subject to its control, including as to the sale and promotion of fossil fuels. *See id.* ¶ 29(e). At this stage, the Court should not resolve the disputed factual question of whether CONSOL Marine is CONSOL Energy's agent.

"discredited and/or misrepresented information that tended to support restricting consumption of . . . [their] products," including through use of "climate change denialist" front groups and trade associations, *id.* ¶¶ 31, 146–47; *see id.* ¶¶ 141–70. For example, the Global Climate Coalition ("GCC") widely disseminated disinformation about climate change that its members knew to be false and misleading, including by funding an array of efforts to knowingly promote inaccurate climate change science. *Id.* ¶ 161. CONSOL Energy's predecessor Consolidation Coal Company ("Consolidation") was a GCC member,[5] and publicly available documents make clear that GCC's membership reviewed and approved its publications, *see* Compl. ¶ 161 n.185.[6] Drawing reasonable inferences in the City's favor, CONSOL Defendants' predecessors acted in concert with other Defendants and front groups including GCC by funding, encouraging, ratifying, and aiding their false and misleading conduct, and thus CONSOL Defendants are jointly liable for that conduct.

CONSOL Defendants wrongly suggest that the City must allege the elements of agency,

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[5] CNX's submissions to the Securities and Exchange Commission indicate that one of CNX's predecessors (which was formerly also known as CONSOL Energy Inc.) was Consolidation. *See* CNX Res. Corp., *SEC Form 10-K* at 9 (Feb. 7, 2018) (relevant excerpts attached as Ex. 1) (CNX used to be known as CONSOL Energy, Inc., which was incorporated in 1991, and CNX/CONSOL Energy Inc.'s "predecessors had been mining coal . . . since 1864"), *available at* https://www.sec.gov/Archives/edgar/data/1070412/000107041218000031/cnx-123117x10k.htm; CONSOL Energy Inc., *SEC Form 10-K* at 5 (Feb. 10, 2012) (relevant excerpts attached as Ex. 2) ("CONSOL Energy [now known as CNX] was incorporated in Delaware in 1991. Our coal operations began in 1864. CONSOL Energy's beginnings as the 'Consolidation Coal Company' in Western Maryland led to growth and expansion . . . ."), *available at* https://www.sec.gov/Archives/edgar/data/1070412/000107041212000008/cnx-123111x10k.htm. Consolidation's relationship to GCC is verifiable from a submission by GCC to Congress that was incorporated in a congressional hearing record. *See Global Environment: A National Energy Strategy: Hearing on H.R. 5521 Before the Subcomm. on Energy and Power of the Comm. on Energy and Commerce*, Serial No. 101-217 at 181 (U.S. Gov't Printing Off. 1991) (relevant excerpts attached as Ex. 3), *available at* https://hdl.handle.net/2027/pst.000017880244. The City respectfully requests that the Court take judicial notice of these facts, which are "capable of accurate and ready determination by resort to sources whose accuracy cannot reasonably be questioned." Md. Rule 5-201(b); *see Dashiell v. Meeks*, 396 Md. 149, 175 & n.6 (2006). Because CONSOL Energy was part of CNX until 2017, when CONSOL Energy was spun off and took over entire business lines from CNX, *see* Compl. ¶ 29(a), Consolidation is plausibly a predecessor of both CNX and CONSOL Energy. At minimum, the Court should not resolve on the pleadings the factual question of which entity is liable as a successor to Consolidation's liabilities that existed before CONSOL Energy's spinoff. If the Court disagrees, the City respectfully requests leave to amend to provide further allegations about CONSOL Defendants' relationship to Consolidation, and Consolidation's participation in GCC.

[6] GCC's 1996 "Primer on Climate Change Science" cited in the Complaint, *see* Compl. ¶ 161 n.185, is labeled "Approval Draft" and is accompanied by a cover letter directing the document to GCC's membership and noting that the document will be discussed at an upcoming GCC committee meeting, *see* Ex. 4 at AIAM-050773.

"conspiracy," or "aiding and abetting" to hold them jointly liable. Mot. at 7–9. Maryland courts have not used those terms to limit concert-of-action liability, and have instead defined concerted action as a broader concept than agency, conspiracy, or aiding-and-abetting. *See Morgan*, 387 Md. at 184–85. In any event, the Complaint sufficiently alleges each theory of joint liability.

"[A]n agency relationship can be . . . infer[red] from the acts of the agent and principal" and the existence of such a relationship "is ordinarily a question of fact," *Green v. H & R Block, Inc.*, 355 Md. 488, 503–04 (1999) (cleaned up), "for the trier of fact," *Copiers Typewriters*, 576 F. Supp. at 324. The City has not only alleged the elements of agency, Compl. ¶ 32, but also provided a mosaic of facts supporting an inference that CONSOL Defendants' predecessors and other Defendants engaged in a coordinated disinformation campaign whereby they acted as each other's agents, and that GCC and other front groups acted as Defendants' agents in disseminating disinformation about climate change and its links to fossil fuels, *e.g.*, *id.* ¶¶ 31, 150–52, 161–67.

The Complaint also sufficiently alleges that CONSOL Defendants including their predecessors conspired with other Defendants, including through front groups like GCC, to deploy their concerted campaign of deception. Defendants "engaged in a coordinated, multi-front effort to conceal and deny their own knowledge" of their products' climatic risks, "discredit the growing body of publicly available scientific evidence, and persistently create doubt in the minds of" consumers and the public about those risks, *id.* ¶ 1, including through use of front groups and trade associations, *see id.* ¶¶ 31, 167. Defendants and front groups acting at their behest, including GCC, committed numerous tortious acts in furtherance of that conspiracy, including by spreading climate disinformation and misrepresenting the harms of their fossil fuel products. *See id.* ¶¶ 141–70. That conspiracy has significantly exacerbated Baltimore's climate-related injuries and corresponding costs, just as Defendants and their predecessors predicted. *See id.* ¶¶ 59–102, 106–40, 190–217.

The threshold for aiding and abetting is even lower than for conspiracy: if two people "participate in a riot" and one, "although throwing no rocks himself, encourages [the other] to throw rocks," both are liable to a third party who is struck and injured. Restatement (Second) of Torts § 876(b) Illus. 4. At minimum, the Complaint alleges that CONSOL Defendants and their predecessors "g[a]ve substantial assistance or encouragement" to other Defendants and front groups in spreading disinformation they all knew to be false. *See id.* § 876(b).

C. The City Satisfies the Particularity Pleading Requirement Where It Applies.

CONSOL Defendants argue the City does not plead fraud with particularity, and imply that this requires dismissal of *all* the City's claims. *See* Mot. at 4–6. But only the subset of the City's MCPA claim that relies on fraud is subject to particularity pleading, which the Complaint satisfies.

Maryland's particularity pleading requirement for fraud is a "judge-made gloss on the general rules of pleading." *See McCormick v. Medtronic, Inc.*, 219 Md. App. 485, 528 (2014). It applies only where a plaintiff seeks "relief on the ground of fraud," *see Thomas v. Nadel*, 427 Md. 441, 453 (2012) (quotations omitted), meaning fraud is "[t]he basis of . . . the relief sought," *Spangler v. Dan A. Sprosty Bag Co.*, 183 Md. 166, 173 (1944).[7] CONSOL Defendants are wrong to assert that particularity pleading applies to the City's tort claims, which do not include fraud as an element. Mot. at 6–7. As to the City's MCPA claim, Maryland courts have applied particularity pleading to MCPA claims *only* to the extent they rely on Md. Code Ann., Com. Law § 13-301(9), which includes fraud as an element and thus "replicates common-law fraud." *See McCormick*, 219 Md. App. at 529. "Under other provisions of the act, however, a party can allege an 'unfair and

[7] Maryland's judge-made particularity pleading requirement thus differs from Federal Rule of Civil Procedure 9(b)'s particularity pleading requirement, which some courts have interpreted as extending beyond claims that require showing fraud as an element. *See, e.g., Cozzarelli v. Inspire Pharms. Inc.*, 549 F.3d 618, 629 (4th Cir. 2008).

deceptive trade practice' without replicating a claim for common-law fraud." *Id.* at 529–30.[8]

Here, the City alleges *non-fraudulent* MCPA violations under Md. Code Ann., Com. Law § 13-301(1) and (3) based on CONSOL Defendants' and their predecessors' statements and omissions that had the effect, capacity, or tendency to deceive, as well as fraudulent violations under § 13-301(9) based on their deception with the *specific intent* to induce consumer reliance.[9] Under controlling precedent, *McCormick*, 219 Md. App. at 529, only the subset of the City's MCPA claim based on § 13-301(9) is even arguably subject to particularity pleading.

The City amply pleads its MCPA claim based on § 13-301(9) by detailing the multi-decade deception and concealment campaign in which CONSOL Defendants and their predecessors participated. *Lloyd v. General Motors Corp.*, 397 Md. 108, 150–54 (2007), similarly involved an MCPA claim alleging automakers' multi-decade effort to fraudulently conceal a product danger. *Id.* The Maryland Supreme Court found particularity pleading satisfied because plaintiffs alleged that defendants "ha[d] known the risk of injury," provided "facts that support that assertion," and alleged that defendants had "engaged in a 30-year cover-up." *Id.* at 153–54 & n.21. The court did not require greater precision. The City's allegations here are more robust than those in *Lloyd*.

CONSOL Defendants' reliance on the Appellate Court's decision in *McCormick*, 219 Md. App. 485, fails for at least two key reasons. *First*, *McCormick* involved only allegations of a

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[8] CONSOL Defendants' reliance on the unreported opinion *Manoogian v. Coppin State University*, 2022 WL 17486761 (Md. App. Dec. 7, 2022), among several others, *see* Mot. at 4, 8, 9, 10, violates Md. Rule 1-104(a)(2). Even if *Manoogian* were citable, that decision simply applied the heightened pleading standard to classic common-law fraud claims, not an MCPA claim or any tort claims like those the City asserts here. 2022 WL 17486761, at *6–8.

[9] *See* Md. Code Ann., Com. Law § 13-301(1) ("False, falsely disparaging, or misleading oral or written statement, visual description, or other representation of any kind which has the capacity, tendency, or effect of deceiving or misleading consumers."); *id.* § 13-301(3) ("Failure to state a material fact if the failure deceives or tends to deceive."); *id.* § 13-301(9) ("Deception, fraud, false pretense, false premise, misrepresentation, or knowing concealment, suppression, or omission of any material fact with the intent that a consumer rely on the same . . . ."). Although the Complaint expressly refers to only § 13-301(1) and (9), *see* Compl. ¶ 292, the City also states a violation of § 13-301(3) by alleging the climatic risks of fossil fuel products are material to Maryland consumers, *see id.* ¶¶ 295–96, and that CONSOL Defendants, their predecessors, and other Defendants failed to warn of their products' risks while marketing and selling those products, *see id.* ¶¶ 141–70, 241, 274, which has deceived consumers, *id.* ¶ 170.

fraudulent, affirmative misrepresentation. *See* 219 Md. App. at 528 (defendants' statements "intended to induce physicians . . . to rely on [certain] alleged misrepresentations"). By contrast, the City—as in *Lloyd*, 397 Md. at 150—also alleges failure to warn, concealment, and omissions. Compl. ¶¶ 295–96; *see also id.* ¶¶ 141–70. CONSOL Defendants' embrace of *McCormick*'s requirement to specify "who made what false statement, when, and in what manner," 219 Md. App. at 528, simply does not fit the City's case, which places equal weight on omissions.[10]

Second, the City's allegations here are far more detailed than those in *McCormick*, where the complaint only "vague[ly] reference[d]" misrepresentations. *See* 219 Md. at 528. The City shows "who made what false statement, when, and in what manner . . . . ; why the statement is false; and why a finder of fact would have reason to conclude that the defendant acted with scienter . . . and with the intention to [induce reliance]." *See id.* CONSOL Defendants' predecessors and others deployed a sophisticated deception campaign that promoted unrestricted use of their fossil fuel products without warning of their risks, while spreading disinformation about climate change. *See* Compl. ¶¶ 141–70. CONSOL Defendants' predecessors relied in large part on trade associations and front groups to disseminate disinformation on their behalf. *See id.* ¶¶ 31, 150–68.

D. CONSOL Defendants' Superior Knowledge Gave Rise to a Duty to Warn.

Lastly, CONSOL Defendants argue that they had no duty to warn because they lacked "special" knowledge about their fossil fuel products' dangers. Mot. at 9–10. The Complaint alleges

[10] CONSOL Defendants also cite *Green v. Wells Fargo Bank, N.A.*, 927 F. Supp. 2d 244 (D. Md. 2013), for the contention that MCPA claims require a plaintiff to allege reliance on a specific misrepresentation. Like in *McCormick*, however, the facts in *Green* involved "affirmative misrepresentation," *id.* at 254, rather than concealment or omissions. The court in *Green* expressly noted that "[i]n cases involving concealment or omissions of material facts," particularity pleading "will likely take a different form," and "an omission likely cannot be described in terms of the time, place, and contents of the misrepresentation or the identity of the person making the misrepresentation." *Id.* at 249 (cleaned up). There, the plaintiffs' suggestions that they refrained from taking action based on certain misrepresentations were insufficient to allege reliance and resulting damages. *Id.* at 255–56. Here, by contrast, the Complaint describes in detail the climate-related injuries and resulting costs the City has suffered as a result of its and other consumers' reliance on Defendants' misconduct. *See* Compl. ¶¶ 59–102, 170, 190–217, 298; Opp. at Part IV.D.5.

otherwise: Defendants, including CONSOL Defendants and their predecessors, had special knowledge that using their fossil fuel products as intended would cause myriad climate-related hazards that the City now faces. *See* Compl. ¶¶ 59–102, 106–40. CONSOL Defendants and their predecessors knew or should have known of their products' climatic hazards based on information shared by the international scientific community and by Defendants' internal research divisions, trade associations, and industry groups. *E.g.*, *id.* ¶¶ 111, 115, 137, 239–40. CONSOL Defendants and their predecessors thus owed a duty to issue adequate warnings to protect the City and others foreseeably harmed by their products' intended uses, *id.* ¶¶ 238, 271, which they breached by failing to warn and concealing their knowledge, *see id.* ¶¶ 141–70, 241, 274; Opp. at Part IV.D.3.

In arguing otherwise, CONSOL Defendants reiterate their flawed arguments against collective allegations and ignore the rule that they are "held responsible for knowing what was generally known in the scientific or expert community about the[ir] product[s'] hazards," including "by scientists or experts employed by other manufacturers." *U.S. Gypsum Co. v. Mayor & City Council of Baltimore*, 336 Md. 145, 165 (1994).[11] Finally, the Opposition explains why the severe risks of Defendants' fossil fuel products were not obvious to average Maryland consumers, which in any event is a factual question for the jury. *See* Opp. at Part IV.D.3.b.

The Court should credit the allegations that CONSOL Defendants and their predecessors knew or should have known of their products' non-obvious hazards, giving rise to a duty to warn.

III. CONCLUSION

For these reasons, the Court should deny the Motion. If the Court finds the allegations deficient in any regard, the City respectfully requests leave to amend. *See* Md. Rule 2-341.

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[11] CONSOL Defendants' reliance on *Mack Trucks, Inc. v. Coates*, 2018 WL 2175932 (Md. App. May 11, 2018), again violates Md. Rule 1-104(a)(2). In any event, that decision relied on *Owens-Illinois, Inc. v. Zenobia*, which explains that a defendant's "knowledge can be established by evidence that the dangerous quality of the product should have been known by a manufacturer because it was known in the scientific or expert community." 325 Md. 420, 433 (1992).

Dated: December 12, 2023

Respectfully submitted,

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Attorneys for Plaintiff the Mayor and City Council of Baltimore

CERTIFICATE OF SERVICE

I hereby certify that on this 12th day of December 2023, a copy of the *Mayor and City Council of Baltimore's Memorandum of Law in Opposition to Defendants' Consol Energy Inc's and Consol Marine Terminals LLC's Motion to Dismiss for Failure to State a Claim* was served upon all counsel of record via email (by agreement of the parties).

/s/ Matthew K. Edling
Matthew K. Edling

EXHIBIT 1

10-K 1 cnx-123117x10k.htm 10-K

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

☒ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934.**

For the fiscal year ended December 31, 2017

OR

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the transition period from _____ to _____

Commission file number: 001-14901

CNX Resources Corporation

(Exact name of registrant as specified in its charter)

Delaware	**51-0337383**
(State or other jurisdiction of incorporation or organization)	**(I.R.S. Employer Identification No.)**

CNX Center
1000 CONSOL Energy Drive Suite 400
Canonsburg, PA 15317-6506
(724) 485-4000
(Address, including zip code, and telephone number, including area code, of registrant's principal executive offices)

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Name of exchange on which registered
Common Stock ($.01 par value)	New York Stock Exchange
Preferred Share Purchase Rights	New York Stock Exchange

Securities registered pursuant to Section 12(g) of the Act: None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes ☒ No ☐

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act. Yes ☐ No ☒

Indicate by check mark whether the registrant: (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes ☒ No ☐

Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data File required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files). Yes ☒ No ☐

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K (§229.405) is not contained herein, and will not be contained, to the best of registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or any amendment to this Form 10-K. ☐

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, or a smaller reporting company. See the definitions of "large accelerated filer," "accelerated filer" and "smaller reporting company" in Rule 12b-2 of the Exchange Act. (Check one):

Large accelerated filer ☒ Accelerated filer ☐ Non-accelerated filer ☐ Smaller Reporting Company ☐

Emerging Growth Company ☐ If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act). Yes ☐ No ☒

The aggregate market value of voting stock held by nonaffiliates of the registrant as of June 30, 2017, the last business day of the registrant's most recently completed second fiscal quarter, based on the closing price of the common stock on the New York Stock Exchange on such date was $1,685,654,421.

The number of shares outstanding of the registrant's common stock as of January 22, 2018 is 223,758,284 shares.

DOCUMENTS INCORPORATED BY REFERENCE:

Portions of CNX's Proxy Statement for the Annual Meeting of Shareholders to be held on May 9, 2018, are incorporated by reference in Items 10, 11, 12, 13 and 14 of Part III.

TABLE OF CONTENTS

PART I

ITEM 1. Business

General

CNX Resources Corporation, (CNX or the Company) is one of the largest independent oil and natural gas companies in the United States and is focused on the exploration, development, production, gathering, processing and acquisition of natural gas properties in the Appalachian Basin. Our operations are centered on unconventional shale formations, primarily the Marcellus Shale and Utica Shale.

CNX was incorporated in Delaware in 1991 under the name CONSOL Energy Inc. (CONSOL Energy), but its predecessors had been mining coal, primarily in the Appalachian Basin, since 1864. CNX entered the natural gas business in the 1980s initially to increase the safety and efficiency of its Virginia coal mines by capturing methane from coal seams prior to mining, which makes the mining process safer and more efficient. The natural gas business grew from the coalbed methane production in Virginia into other unconventional production, including hydraulic fracturing in the Marcellus Shale and Utica Shale in the Appalachian Basin. This growth was accelerated with the 2010 asset acquisition of the Appalachian Exploration & Production business of Dominion Resources, Inc.

On November 28, 2017, CNX completed the tax-free spin-off of its coal business resulting in two independent, publicly traded companies: CONSOL Energy, a coal company, formerly known as CONSOL Mining Corporation; and CNX, a natural gas exploration and production company. As a result of the separation of the two companies, CONSOL Energy and its subsidiaries now hold the coal assets previously held by CNX, including its Pennsylvania Mining Complex, Baltimore Marine Terminal, its direct and indirect ownership interest in CONSOL Coal Resources LP, formerly known as CNXC Coal Resources LP, and other related coal assets previously held by CNX. To effect the separation, CNX's shareholders received one share of CONSOL Energy common stock for every eight shares of CNX's common stock held as of the close of business on November 15, 2017, the record date for the separation and distribution. The coal company, previously reported as the Company's Pennsylvania Mining Operations division, has been reclassified in the Audited Consolidated Financial Statements in Item 8 of this Annual Report on Form 10-K (the Form 10-K) to discontinued operations for all periods presented.

CNX operates, develops and explores for natural gas primarily in Appalachia (Pennsylvania, West Virginia, Ohio, and Virginia). Our primary focus is the continued development of our Marcellus Shale acreage and delineation and development of our unique Utica Shale acreage and stacked pay opportunity set. We believe that our concentrated operating area, our legacy surface acreage position, our regional operating expertise, our extensive data set from development, as well as from non-operated participation wells and our held-by-production acreage position provides us a significant operating advantage over our competitors. Over the past ten years, CNX's natural gas business has grown by approximately 625% to produce a total of 407.2 net Bcfe in 2017.

Our land holdings in the Marcellus Shale and Utica Shale plays cover large areas, provide multi-year drilling opportunities and, collectively, have sustainable lower risk growth profiles. We currently control approximately 530,000 net acres in the Marcellus Shale and approximately 652,000 net acres that have Utica Shale potential in Ohio, West Virginia, and Pennsylvania. We also have approximately 2.2 million net acres in our coalbed methane play.

Highlights of our 2017 production include the following:

- Total average production of 1,115,523 Mcfe per day;
- 90% Natural Gas, 10% Liquids; and
- 59% Marcellus, 20% Utica, 16% coalbed methane, and 5% other.

At December 31, 2017, our proved natural gas, NGL, condensate and oil reserves (collectively, "natural gas reserves") had the following characteristics:

- 7.6 Tcfe of proved reserves;
- 93.9% natural gas;
- 58.2% proved developed;
- 95.5% operated; and

EXHIBIT 2

10-K 1 cnx-123111x10k.htm FORM 10-K

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

☒ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934.**

For the fiscal year ended December 31, 2011

OR

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the transition period from _____ to _____

Commission file number: 001-14901

CONSOL Energy Inc.

(Exact name of registrant as specified in its charter)

Delaware	**51-0337383**
(State or other jurisdiction of incorporation or organization)	**(I.R.S. Employer Identification No.)**

1000 CONSOL Energy Drive
Canonsburg, PA 15317-6506
(724) 485-4000
(Address, including zip code, and telephone number, including area code, of registrant's principal executive offices)

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	**Name of exchange on which registered**
Common Stock ($.01 par value)	New York Stock Exchange
Preferred Share Purchase Rights	New York Stock Exchange

Securities registered pursuant to Section 12(g) of the Act: None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes ☒ No ☐

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act. Yes ☐ No ☒

Indicate by check mark whether the registrant: (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes ☒ No ☐

Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data File required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files). Yes ☒ No ☐

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K (§229.405) is not contained herein, and will not be contained, to the best of registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or any amendment to this Form 10-K. ☒

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, or a smaller reporting company. See the definitions of "large accelerated filer," "accelerated filer" and "smaller reporting company" in Rule 12b-2 of the Exchange Act. (Check one):

Large accelerated filer ☒ Accelerated filer ☐ Non-accelerated filer ☐ Smaller Reporting Company ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act). Yes ☐ No ☒

The aggregate market value of voting stock held by nonaffiliates of the registrant as of June 30, 2011, the last business day of the registrant's most recently completed second fiscal quarter, based on the closing price of the common stock on the New York Stock Exchange on such date was $10,963,933,121.

The number of shares outstanding of the registrant's common stock as of January 25, 2012 is 227,093,353 shares.

DOCUMENTS INCORPORATED BY REFERENCE:

Portions of CONSOL Energy's Proxy Statement for the Annual Meeting of Shareholders to be held on May 1, 2012, are incorporated by reference in Items 10, 11, 12, 13 and 14 of Part III.

TABLE OF CONTENTS

PART III

PART IV

FORWARD-LOOKING STATEMENTS

We are including the following cautionary statement in this Annual Report on Form 10-K to make applicable and take advantage of the safe harbor provisions of the Private Securities Litigation Reform Act of 1995 for any forward-looking statements made by, or on behalf of us. With the exception of historical matters, the matters discussed in this Annual Report on Form 10-K are forward-looking statements (as defined in Section 21E of the Exchange Act) that involve risks and uncertainties that could cause actual results to differ materially from projected results. Accordingly, investors should not place undue reliance on forward-looking statements as a prediction of actual results. The forward-looking statements may include projections and estimates concerning the timing and success of specific projects and our future production, revenues, income and capital spending. When we use the words "believe," "intend," "expect," "may," "should," "anticipate," "could," "estimate," "plan," "predict," "project," or their negatives, or other similar expressions, the statements which include those words are usually forward-looking statements. When we describe strategy that involves risks or uncertainties, we are making forward-looking statements. The forward-looking statements in this Annual Report on Form 10-K speak only as of the date of this Annual Report on Form 10-K; we disclaim any obligation to update these statements unless required by securities law, and we caution you not to rely on them unduly. We have based these forward-looking statements on our current expectations and assumptions about future events. While our management considers these expectations and assumptions to be reasonable, they are inherently subject to significant business, economic, competitive, regulatory and other risks, contingencies and uncertainties, most of which are difficult to predict and many of which are beyond our control. These risks, contingencies and uncertainties relate to, among other matters, the following:

- deterioration in global economic conditions in any of the industries in which our customers operate, or sustained uncertainty in financial markets cause conditions we cannot predict;
- a significant or extended decline in prices we receive for our coal and natural gas affecting our operating results and cash flows;
- our customers extending existing contracts or entering into new long-term contracts for coal;
- our reliance on major customers;
- our inability to collect payments from customers if their creditworthiness declines;
- the disruption of rail, barge, gathering, processing and transportation facilities and other systems that deliver our coal and natural gas to market;

or produce anticipated proceeds;

- the terms of our existing joint ventures restrict our flexibility and actions taken by the other party in our gas joint ventures may impact our financial position;
- the anti-takeover effects of our rights plan could prevent a change of control;
- risks associated with our debt;
- replacing our natural gas reserves, which if not replaced, will cause our gas reserves and gas production to decline;
- our hedging activities may prevent us from benefiting from price increases and may expose us to other risks;
- other factors discussed in this 2011 Form 10-K under "Risk Factors," as updated by any subsequent Form 10-Qs, which are on file at the Securities and Exchange Commission.

PART I

ITEM 1. Business

CONSOL Energy's Business Introduction

CONSOL Energy safely and responsibly produces coal and natural gas for global energy and raw material markets, which include the electric power generation industry and the steelmaking industry. During the year ended December 31, 2011, we produced 62.6 million tons of high-British thermal unit (Btu) bituminous coal from 12 mining complexes in the United States. During this same period, our natural gas production totaled 153.5 net billion cubic feet equivalent (Bcfe) from approximately 15,000 gross natural gas wells primarily in Appalachia.

Additionally, we provide energy services, including river and dock services, terminal services, industrial supply services, water services and land resource management services.

CONSOL Energy's History

CONSOL Energy was incorporated in Delaware in 1991. Our coal operations began in 1864. CONSOL Energy's beginnings as the "Consolidation Coal Company" in Western Maryland led to growth and expansion through all major coal producing regions in the United States. CONSOL Energy entered the natural gas business in the 1980s to increase the safety and efficiency of our coal mines by capturing methane from coal seams prior to mining, which makes the mining process safer and more efficient. Over the past five years, CONSOL Energy's natural gas business has grown by over 164% to produce 153.5 net Bcfe in 2011. This business has grown from coalbed methane production in Virginia into other unconventional production, such as Marcellus Shale, in the Appalachian basin. This growth was accelerated with the 2010 asset acquisition of the Appalachian E&P business of Dominion Resources, Inc. (Dominion Acquisition). Subsequently, in August and September

EXHIBIT 3

GLOBAL ENVIRONMENT: A NATIONAL ENERGY STRATEGY

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY AND POWER

OF THE

COMMITTEE ON ENERGY AND COMMERCE HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

H.R. 5521

A BILL TO ESTABLISH A NATIONAL ENERGY STRATEGY THAT REFLECTS CONCERN FOR THE GLOBAL ENVIRONMENTAL CONSEQUENCES OF CURRENT TRENDS IN ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES

SEPTEMBER 13, 1990

Serial No. 101-217

Printed for the use of the Committee on Energy and Commerce

U.S. GOVERNMENT PRINTING OFFICE
41-503 WASHINGTON : 1991

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

COMMITTEE ON ENERGY AND COMMERCE

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HOWARD C. NIELSON, Utah
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JOHN A. RIGGS, *Staff Director*
RICHARD H. COUNIHAN, *Counsel*
JESSICA LAVERTY, *Minority Counsel*

CONTENTS

GLOBAL ENVIRONMENT: A NATIONAL ENERGY STRATEGY

THURSDAY, SEPTEMBER 13, 1990

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ENERGY AND COMMERCE,
SUBCOMMITTEE ON ENERGY AND POWER,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:03 a.m., in room 2322, Rayburn House Office Building, Hon. Philip R. Sharp (chairman) presiding.

Mr. SHARP. The subcommittee will come to order. Today, the Subcommittee on Energy and Power is holding a hearing on the National Energy Policy Act of 1990. This legislation is intended to stake a first cut at reducing the emission of so-called greenhouse gases which threaten to increase the average temperature of our planet.

It's purpose is not to undertake drastic crash programs which may or may not be warranted by the scientific information. Rather, this bill is to start us to take steps doing those that will be helpful in reducing greenhouse gas emissions.

Specifically, this bill promotes energy efficiency and research and development on clean energy technologies. Last year, the subcommittee held two hearings on the scientific understanding of and agreement on global warming. We still know far less than we would like to, but some general consensus appears to have formed over the past year.

The Intergovernmental Panel on Climate Change [IPCC], an international group of scientists and government officials, convened under the auspices of the United Nations with the active support and participation of the United States, recently released as set of reports in Stockholm. One of their conclusions is that there is not a great deal of certainty, but they are certain that emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases and that these increases will enhance the greenhouse effect, resulting, on average, in a gradual warming of the Earth's surface.

Their estimate is that the global mean temperature will increase 1.8°F by the year 2025, and 5.4° by the end of the 21st century, unless mitigating steps are taken. They also identified measures that can help resist global warming in the short term.

The first item was improved energy efficiency. They listed a number of steps which governments should undertake now in order to prepare for more intensive action in the longer run. One of these

should be undertaken through a multilateral approach. We should emphasize flexibility in our energy, agricultural, foreign assistance, and research policies so that we can adjust our programs and our investments as our understanding of the global climate change phenomenon increases and as our multilateral discussions mature.

The Coalition urges the Subcommittee to support these principles and work to ensure that any legislation does as well. We look forward to working with you and your staff as this legislation progresses.

Thank you.

Global Climate Coalition Membership

Aluminum Association
American Electric Power Service Corporation
American Gas Association
American Iron & Steel Institute
American Mining Congress
American Nuclear Energy Council
American Paper Institute
American Petroleum Institute
Amoco Corporation
ARCO
Armco, Inc.
Arizona Public Service Company
Association of Home Appliance Manufacturers
AT&T
Automobile Importers of America
Baltimore Gas and Electric Company
BHP - Utah Minerals International, Inc.
Business Roundtable
Carolina Power and Light Company
Champion International
Chemical Manufacturers Association
Chevron U.S.A., Inc.
Chrysler Corporation
Coalition Opposed to Energy Taxes
Consolidation Coal Company
Consumers Power Company
Council of Industrial Boiler Owners
Dow Chemical Company
Duke Power
E.I. Dupont de Nemours & Company, Inc.
Eastman Kodak
Edison Electric Institute
Electricity Consumers Resource Council
Entergy Corporation
Ford Motor Company
Fusion Power Associates
General Motors Corporation
Georgia Pacific Corporation
Hercules Incorporated
Illinois Power Company
Int'l Business-Government Counsellors, Inc.
Jefferson Energy Foundation
Kaiser Aluminum & Chemical Corporation
Maytag Corporation
Monsanto Company
Motor Vehicle Manufacturers Association
National Association of Manufacturers
National Coal Association
National Steel Corporation
Northern States Power
Occidental Chemical Corporation
Pacific Gas & Electric Company
Peabody Holding Company, Inc.
Pennsylvania Power & Light Company
Petrochemical Energy Group
Petroleum Marketers Association of America
Phillips Petroleum Company
Portland Cement Association
PPG Industries
Process Gas Consumers Group
Public Service Indiana
Rockwell International
Rubber Manufacturers Association
Shell Oil Company
Society of the Plastics Industry, Inc.
Southern Company Services, Inc.
Texaco, Inc.
Union Carbide Corporation
UNOCAL Corporation
U.S. Chamber of Commerce
U.S. Council for Energy Awareness
U.S. Council for International Business

August 20, 1990

EXHIBIT 4

AIAM
The World's Leading Automakers®

TECH-96-29
1/18/96

TO: AIAM Technical Committee

FROM: Gregory J. Dana
Vice President and Technical Director

RE: **GLOBAL CLIMATE COALITION (GCC) - Primer on Climate Change Science - Final Draft**

Enclosed is a primer on global climate change science developed by the GCC. If any members have any comments on this or other GCC documents that are mailed out, please provide me with your comments to forward to the GCC.

GJD:ljf

ASSOCIATION OF INTERNATIONAL AUTOMOBILE MANUFACTURERS, INC.
1001 19TH ST. NORTH ■ SUITE 1200 ■ ARLINGTON, VA 22209 ■ TELEPHONE 703.525.7788 ■ FAX 703.525.8817

Mobil Oil Corporation

ENVIRONMENTAL HEALTH
AND SAFETY DEPARTMENT
P.O. BOX 1031
PRINCETON, NEW JERSEY 08543-1031

December 21, 1995

To: Members of GCC-STAC

Attached is what I hope is the final draft of the primer on global climate change science we have been working on for the past few months. It has been revised to more directly address recent statements from IPCC Working Group I and to reflect comments from John Kinsman and Howard Feldman.

We will be discussing this draft at the January 18th STAC meeting. If you are coming to that meeting, please bring any additional comments on the draft with you. If you have comments but are unable to attend the meeting, please fax them to Eric Holdsworth at the GCC office. His fax number is (202) 638-1043 or (202) 638-1032. I will be out of the office for essentially all of the time between now and the next STAC meeting.

Best wishes for the Holiday Season,

Lenny

L. S. Bernstein

APPROVAL DRAFT

Predicting Future Climate Change: A Primer

In its recently approved Summary for Policymakers for its contribution to the IPCC's Second Assessment Report, Working Group I stated:

> ...the balance of evidence suggests that there is a discernable human influence on global climate.

The Global Climate Coalition's Science and Technical Advisory Committee believes that the IPCC statement goes beyond what can be justified by current scientific knowledge.

This paper presents an assessment of those issues in the science of climate change which relate to the ability to predict whether human emissions of greenhouse gases have had an effect on current climate or will have a significant impact on future climate. It is a primer on these issues, not an exhaustive analysis. Complex issues have been simplified, hopefully without any loss of accuracy. Also, since it is a primer, it uses the terminology which has become popular in the climate change debate, even in those cases where the popular terminology is not technically accurate.

Introduction and Summary

Since the beginning of the industrial revolution, human activities have increased the atmospheric concentration of CO_2 by more than 25%. Atmospheric concentrations of other greenhouse gases have also risen. Over the past 120 years, global average temperature has risen by 0.3 - 0.6°C. Since the Greenhouse Effect can be used to relate atmospheric concentration of greenhouse gases to global average temperature, claims have been made that at least part of the temperature rise experienced to date is due to human activities, and that the projected future increases in atmospheric concentrations of greenhouse gases (as the result of human activities) will lead to even larger increases in future temperature. Additionally, it is claimed that these increases in temperature will lead to an array of climate changes (rainfall patterns, storm frequency and intensity, etc.) that could have severe environmental and economic impacts.

This primer addresses the following questions concerning climate change:

1) Can human activities affect climate?

   The scientific basis for the Greenhouse Effect and the potential impact of human emissions of greenhouse gases such as CO_2 on climate is well established and cannot be denied.

2) Can future climate be accurately predicted?

   The climate models which are being used to predict the increases in temperature which might occur with increased atmospheric concentrations of greenhouse gases are limited at present both by incomplete scientific understanding of the factors which affect climate and

by inadequate computational power. Improvements in both are likely, and in the next decade it may be possible to make fairly accurate statements about the impact that increased greenhouse gas concentrations could have on climate. However, these improvements may still not translate into an ability to predict future climate for at least two reasons:

- limited understanding of the natural variability of climate, and
- inability to predict future atmospheric concentrations of greenhouse gases.

The smaller the geographic area considered, the poorer the quality of climate prediction. This is a critical limitation in our ability to predict the impacts of climate change, most of which would result from changes in a local or regional area.

3) Have human activities over the last 120 years affected climate, i.e. has the change been greater than natural variability?

Given the limitations of climate models and other information on this question, current claims that a human impact on climate has already been detected, are unjustified. However, assessment of whether human activities have already affected climate may be possible when improved climate models are available. Alternatively, a large, short term change in climate consistent with model predictions could be taken as proof of a human component of climate change.

4) Are there alternate explanations for the climate change which has occurred over the last 120 years?

Explanations based on solar variability, anomalies in the temperature record, etc. are valid to the extent they are used to argue against a conclusion that we understand current climate or can detect a human component in the change in climate that has occurred over the past 120 years. However, these alternative hypotheses do not address what would happen if atmospheric concentrations of greenhouse gases continue to rise at projected rates.

Can Human Activities Affect Climate?

The Sun warms the Earth and is the source of energy for the climate system. However, as shown in Figure 1, the process by which this occurs is complicated. Only about half of the incoming radiation from the Sun is absorbed by the Earth's surface. About a quarter is absorbed by the atmosphere, and the remainder is reflected back into space by clouds, dust and other particulates without being absorbed, either by the surface or atmosphere.

The energy absorbed by the Earth's surface is reradiated to space as longwave radiation. A fraction of this reradiated energy is absorbed by greenhouse gases, a phenomenon known as the Greenhouse Effect. Greenhouse gases are trace gases - such as water vapor, CO_2, methane, etc. - which have the ability to absorb longwave radiation. When a greenhouse gas molecule absorbs longwave energy, it heats up, then radiates energy in all directions, including back down to the Earth's surface. The energy radiated back to the Earth's surface by greenhouse gas molecules is the Greenhouse Effect that further warms the surface. The warmer the surface of the Earth, the more energy it reradiates. The higher the concentration of greenhouse gases, the more energy they will absorb, and the more they will warm the Earth. The average temperature of the Earth depends on the balance between these two phenomena. Naturally occurring greenhouse gases, predominantly water vapor, account for 95-97% of the current Greenhouse Effect. They raise the average temperature of Earth's surface by about 30°C. Without this natural Greenhouse Effect, the Earth would probably be uninhabitable. The science of the Greenhouse Effect is well established and can be demonstrated in the laboratory.

Human activities can affect the energy balance at the Earth's surface in three ways:

- combustion, agriculture and other human activities emit greenhouse gases and can raise their concentration in the atmosphere, which would directionally lead to warming;

- combustion emits particulates, and gases such as sulfur dioxide which form particulate matter in the atmosphere, which would directionally lead to cooling; and

- changes in land-use, such as removing forests, can change the amount of energy absorbed by the Earth's surface, the rate of water evaporation, and other parameters involved in the climate system, which could result in either warming or cooling.

These three factors create the potential for a human impact on climate. The potential for a human impact on climate is based on well-established scientific fact, and should not be denied. While, in theory, human activities have the potential to result in net cooling, a concern about 25 years ago, the current balance between greenhouse gas emissions and the emissions of particulates and particulate-formers is such that essentially all of today's concern is about net warming. However, as will be discussed below, it is still not possible to accurately predict the magnitude (if any), timing or impact of climate change as a result of the increase in greenhouse gas concentrations. Also, because of the complex, possibly chaotic, nature of the climate system, it may never be possible to accurately predict future climate or to estimate the impact of increased greenhouse gas concentrations.

The usual approach to discussing the impact of the increased atmospheric concentrations of greenhouse gases on climate is to convert them to an equivalent amount of CO_2, then discuss

the effect of some fixed increase in equivalent CO_2. Most of the discussion is about doubled equivalent CO_2. The conversion to equivalent CO_2 introduces a number of errors, because the effects of some greenhouse gases depend on their location in the atmosphere, but since the convention is well established, it will be used in this discussion. A more accurate approach is to refer to increased radiative forcing, which is the increase in energy radiated to the Earth's surface, taking into account all of the complexities in the physics of greenhouse gases.

Can Future Climate Be Accurately Predicted?

Climate models, called General Circulation Models (GCMs), are used to predict the change in temperature, rainfall, cloud cover and other climate parameters that would result from a change in equivalent CO_2 and sometimes aerosols. The estimates of climate parameters are then used to predict impacts of climate change, such as frequency and severity of tropical storms, effects on agriculture and biodiversity, etc. While most discussions of models focus on their predictions of changes in average temperature, factors such as changes in maximum and minimum temperature, soil moisture content, and prevalence of conditions which favor the formation of tropical storms are far more important in determining potential climate change impacts.

GCMs are three-dimensional grid models which cover the whole Earth, the atmosphere to a sufficient height to include all climate processes, and the oceans in multiple depth layers. GCMs are also referred to as coupled atmosphere-ocean climate models. Most of the debate about the prediction of climate change centers around the quality of both the models and the input data they use, and the degree to which both can be improved. The concerns about these models can be grouped into five categories:

(1) limits in scientific understanding of climate processes,

(2) how they model "feedbacks,"

(3) how they describe the initial conditions, i.e., the current state of the climate,

(4) how well we understand the natural variability of climate, including the possibility that the climate system is chaotic, and

(5) the computational power required to accurately model climate.

A sixth concern, not directly related to GCMs, but important to the question of whether future climate can be accurately predicted, is whether future atmospheric concentrations of greenhouse gases can be accurately predicted. The problem has two components, economic and scientific. The economic question is whether we can accurately predict both the future

level of global economic activity and the technology which will be employed. Past predictions in both areas have been highly inaccurate. The scientific question is whether we understand the fate of greenhouse gases well enough to accurately predict the effect their emissions will have on atmospheric concentrations. For example, only about half of the CO_2 emitted from human activities ends up in the atmosphere. The remainder is believed to be absorbed by increased plant growth or in the oceans. Estimates of the amount of CO_2 absorbed by these two sinks are highly uncertain. There is also a great deal of scientific debate on what, if any, impact higher temperatures and related climate change will have on the rate of CO_2 absorption by plants and the ocean.

Limited Scientific Understanding of Climate Processes

Quantifying what we don't know about climate processes is an impossible task. However, the huge volume of important new findings about the processes that are critical to climate generated over the past few years make it obvious that there is a great deal more to be learned about the basic science of climate. For example, in 1995, Prof. Cess and his co-workers at the State University of New York published a paper on the energy balance around clouds which indicated that the values being used in climate models were incorrect by 25%. Cess *et al.* were unable to identify the physical processes which led to this different estimate of energy absorption. Since clouds are a critical part of the climate system, a correct characterization of their properties is essential. Other recent studies indicate that vegetation may be absorbing much more CO_2 than previously believed, allowing less of it to accumulate in the atmosphere.

Feedbacks

Climate models predict that the direct effect of doubling equivalent CO_2 from pre-industrial levels is relatively small. Global average temperature would rise by 0.5 - 1°C, an amount which is not generally considered to represent a problem. However, even that rise in temperature would cause a variety of changes, some of which would act to further increase temperature, others of which would act to decrease temperature. These secondary changes are called "feedbacks." The popular usage is that a positive feedback is one which acts to further increase temperature, and a negative feedback is one which acts to decrease temperature. The technical definition is that a positive feedback is one which exaggerates the initial perturbation, which could either increase or decrease temperature, and a negative feedback is one which decreases the initial perturbation. Since the popular usage is so common, it will be used in this paper.

The most important positive feedback is the impact which rising temperatures will have on the amount of water vapor in the atmosphere. Water vapor is the most important natural greenhouse gas in the atmosphere, accounting for the majority of the natural Greenhouse

Effect. As temperature increases, more water evaporates, the concentration of water vapor in the atmosphere rises, the Greenhouse Effect is enhanced, and temperatures rises further. An example of a negative feedback is that more evaporation of water results in the formation of more clouds. Low level clouds reflect sunlight, preventing its energy from reaching the Earth's surface, thus providing a cooling effect. As noted below, high level clouds provide a positive feedback.

Modeling feedbacks is one the major challenges in developing accurate climate models. The role of clouds is a particularly difficult modeling task. Low level clouds reflect sunlight and therefore are a negative feedback. However, clouds are made up of water vapor and therefore also absorb radiation. For high level clouds the absorption of radiation is more important than the reflection of radiation; they provide a positive feedback. Better estimates of the energy balance around clouds are becoming available, and preliminary modeling results indicate that the use of these better estimates improves the ability of GCM's to match current conditions.

Prediction of Current Conditions

GCMs are supposed to be theory-based models, not empirical models. As such they should be able to match current climate conditions using only the independent variables that determine climate (solar radiation, greenhouse gas concentrations, the current temperature of the oceans, etc.) as inputs. GCMs fail this test because they do not accurately predict the transfer of energy from the oceans to the atmosphere, a critical climate parameter. To correct this error, most GCMs are adjusted with "flux corrections," that on a point-by-point basis adjust the amount of heat being transferred from the oceans to the atmosphere to match actual conditions. The "flux corrections" can be quite large, as much as 10 - 20 times the effect of doubling equivalent CO_2. Having to make this large a correction to obtain model results which provide a reasonable description of the baseline is a cause for serious concern.

Flux corrections are correcting for one of two possible errors: missing climate processes, or errors in the description of the climate processes used in the model. New data, such as a better description of the energy balance around clouds, should lead to improvements in models and a reduction in the flux corrections.

Whether modeling capability will improve to the point where the flux corrections can be eliminated or reduced to a more reasonable level is an open question. To eliminate the flux corrections it is necessary to accurately model all climate processes and have an accurate description of initial conditions. Distribution of heat in the oceans is poorly understood, and the cost of collecting the necessary data makes it unlikely that a better understanding will be developed anytime soon.

Natural Variability and the Possibility that Climate is Chaotic

Thus far, GCMs have been described as relatively mechanical models - plug in the right processes and initial conditions and the model will describe climate. However, climate has natural variability, on both long and short time scales. The existence of Ice Ages and the warm periods between them is proof of climate's natural variability on very long time scales. But climate is also naturally variable on shorter time scales. For example, the milder temperatures in the North Atlantic at about 1000 AD allowed the Vikings to settle Iceland and Greenland, and explore the North American coast. The colder temperatures of the Little Ice Age after 1400 wiped out the Viking settlement in Greenland and nearly did the same to Iceland. This was climate variability on a time scale of several centuries. To accurately model future climate, we need an good estimate of the natural variability of climate on still shorter periods, decades to a century, which is currently unavailable.

Understanding the natural variability of climate on a decadal time scale and its causes would greatly improve our understanding of current climate data. Reasonable temperature records exist for only the last 120 years. Data on factors which could be causes for the variability of climate, such as changes in ocean circulation, is either non-existent or available for much shorter time periods. Until we have a better understanding of natural variability, it will be impossible to determine whether a part of the rise in average temperature experienced over the past century is due to human activities.

In addition, climate may be a chaotic system, which is extremely sensitive to very small changes in initial conditions. Weather is known to be chaotic, and since climate is the long-term average of weather, it, too, may be chaotic. In discussing the ability of GCMs to simulate climate, IPCC WG I, in section 6.2.6 of its Second Assessment Report, does not use the term chaotic, but states

> The models produce a high level of internal variability, as observed (Chapter 5), leading to a spread of possible outcomes for a given scenario, especially at the regional level.

This is a functional definition of chaotic behavior. The reference to Chapter 5 is to a discussion of the ability of models to describe observed climate over the last 120 years. If climate is chaotic, our ability to predict future climate or the effect of anthropogenic changes such as the increase in greenhouse gas emissions will be limited.

Computational Limits

GCMs are huge models which require supercomputers to run in any reasonable time. Computational limitations require that they use large grid sizes, typically 500 km. on a side. These cells are larger than many of the important physical features in the system they are trying to model, for example, the width of the Gulf Stream. Computational limits also mean

that some critical factors, such as the atmospheric interactions between greenhouse gases and the chemistry of aerosol formation, are not included in the model. The rapid increase in computational power may make it possible to overcome these limitations in the future, but at present they severely limit the quality of GCM predictions.

Capabilities of GCMs

Even with flux corrections, GCMs still cannot describe climate features on a 1000 mile scale which are critical to any discussion of the impacts of climate change. Also, there is considerable concern about the ability of GCMs to predict future climate because the flux correction is constant with changing equivalent CO_2. There is no reason to assume that the flux correction should remain the same if climate changes in response to increased CO_2. As a result, statements such as: "Doubling CO_2 will lead to x°C. increase in temperature." do not seem justified.

While climate models currently are incapable of accurate predictions of future climate, rapid improvement in their capability is possible. Better understanding of climate processes, such as the role of clouds, could significantly improve the models as could the ever increasing power of computers. Whether we can ever accurately predict future climate is still uncertain because of two problems. First, as mentioned above, climate may be chaotic. Second, even if climate is not chaotic, a model's predictions are only as good as the input data used. Our ability to predict future greenhouse gas emission rates depends on being able to predict the future level of global economic activity and the technology which will be used to generate that activity. Past predictions in both areas have been highly inaccurate.

A critical problem in climate modeling is the prediction of regional climate change. Most of the impacts of climate change will be felt on the regional or local level. The change in global average temperature and rainfall will not help predict the effect of climate change on farmers in the mid-West. The ability to predict regional climate change is poorer than the ability to predict global climate change. The IPCC sums up the situation as follows:

> Confidence is higher in hemispheric-to-continental scale projections of coupled atmospheric-ocean models than in the regional projections, where confidence remains low.

Have Human Activities Over the Last 120 Years Affected Climate?

As part of its contribution to the IPCC (Intergovernmental Panel on Climate Change, the UN body charged with assessing the peer-reviewed literature on the science, impacts and economics of climate change) Second Assessment Report, WG I (Working Group I, the sub-group assessing science), after considering the uncertainties in the scientific information,

concluded:

> Nevertheless, the balance of evidence suggests that there is a discernable human influence on global climate.

This statement is stronger than those which appeared in the draft of the underlying report, where the authors stated:

> Any claims of positive detection and attribution of significant climate change are likely to remain controversial until uncertainties in the total natural variability of (the) total climate system are reduced.

As used by the IPCC,

> "Detection of change" is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense, but does not provide a reason for the change. "Attribution" is the process of establishing cause and effect relations, including the testing of competing hypotheses.

At the conclusion of the WG I Plenary Session that approved the statement on a human impact on climate, the authors of the underlying report were instructed to modify their report to bring it into agreement with the summary statement. This process is the reverse of what is called for by the IPCC rules of procedure and normal scientific practice.

WG I considered four types of information in evaluating whether the observed change in climate was in fact "highly unusual in a statistical sense," and whether it could be attributed to human influences. A discussion of each type of information follows. Specific scientific studies are mention in three cases; they are the studies which have received the most publicity, but are not the only studies in the category.

1) Model-based estimates of natural variability - The Max Planck Institute (MPI), a German government laboratory and developer of one of the GCMs, ran their model for 1000 years into the future with only random perturbations to assess "natural" variability of temperature. They then determined, with 95% confidence, that the changes in temperature observed over the last 100 years could not be explained by their measure of "natural" variability. German politicians and press have reported this result as meaning that there is 95% confidence that the temperature changes of the last 100 years have been caused by human emissions of greenhouse gases, a significant overstatement of the scientific finding.

   The MPI finding does not prove that the temperature changes of the last 100 years are

due to human greenhouse gas emissions for two reasons:

- Models are simplifications and therefore less variable than the real world. Actual "natural" variability of temperature is almost certain to be larger than the estimate from the MPI computer study.

- The temperature change of the past 100 years may be due to natural changes in climate. Changes of this magnitude have occurred naturally in the past without any human influence. Section 3.6.3 of IPCC WG I's contribution to the Second Assessment Report states:

  "The warming of the late 20th century appears to be rapid, when viewed in the context of the last millennium. But have similar, rapid changes occurred in the past? That is, are such changes a part of the natural climate variability? Large and rapid changes did occur during the last ice age and in the transition toward the present Holocene period which started about 10,000 years ago. Those changes may have occurred on the time scale of a human life or less, at least in the North Atlantic, where they are best documented. Many climate variables were affected: atmospheric temperature and circ, precipitin patterns and hydrological cycle, temperature and circulation of the ocean."

2) Pattern-based studies - The Hadley Centre, a U.K. government laboratory and the developer of another GCM, has added sulfate aerosol effects to its model and calculated temperature from 1860 to 2050. The addition of aerosol effects provides an improved, but still relatively poor, match for observed temperature from 1860 to the present, and addresses one of the key concerns about climate models, their inability to "backcast" the temperature record. The study ties the increase in temperature over the past 100 years to emissions of greenhouse gases and aerosols.

There are two concerns about the Hadley Centre's work:

- They considered only the direct effect of sulfate aerosols, i.e., their scattering of incoming sunlight. They did not consider the indirect effects of the aerosols - their impact on cloud formation - which could have an equally large impact on temperature.

- Adding historical sulfate aerosol effects to the model requires a large number of assumptions about fuel usage rates and emission factors which cannot be tested. The validity of this approach is suspect.

The draft IPCC report discussed the Hadley Centre study and similar work and concluded:

> While some of the pattern-based studies discussed here have claimed detection of a significant climate change, no study to date has positively attributed all or part of that change to anthropogenic causes. Nor has any study quantified the magnitude of a greenhouse gas effect or aerosol effect in the observed data ...

This statement may also change as a result of the instructions given to authors to bring their report into agreement with the summary statement.

3) Studies of the vertical temperature profile of the atmosphere - Climate models predict that an increase in greenhouse gases should lead to a warmer troposphere but a cooler lower stratosphere. The fact that this pattern has been observed is being used to argue for the fundamental correctness of climate models and for the validity of their predictions that human emissions of greenhouse gases will cause changes in climate. However, the effect may be due to stratospheric ozone depletion rather than to the buildup of greenhouse gases in the troposphere. IPCC WG I's part of the Second Assessment Report (Section 8.4.2.1) cites two studies which could be interpreted as supporting this conclusion. If stratospheric ozone depletion is the cause it is "a human forcing of climate" but a different one from the buildup of greenhouse gases in the troposphere. Model agreement with the stratospheric ozone effect does not "prove" that the model is correct in predicting the effects of greenhouse gases in the troposphere.

4) Statistical models fitted to observations - T. R. Karl and three other researchers at National Climatic Data Center (NCDC) evaluated U.S. climate data since 1910 using an index of specific weather events which included: above normal minimum temperatures, above normal precipitation from October to April, below normal precipitation from May to September, and a greater than normal proportion of precipitation coming from heavy rainfalls. These are the types of climate "signature" that many scientists believe will be the first indication of climate change. Karl *et al.* concluded that there is a 90 - 95% probability that climate in the U.S. since 1976 has been affected by the increase in greenhouse gases in the atmosphere.

MIT researchers question the choice of factors included in the NCDC index, since the index is strictly empirical and has not been developed from basic principles. However, the parameters in the index are variables which other researchers have claimed could change as the result of climate change. As in the case of the other studies claiming to show that there has already been a human impact on climate, one can question whether the observed changes are the result of greenhouse gases or other climate influences.

The limitations which prevent climate models from accurately predicting future climate also limit their ability to assess whether a human impact on climate has already occurred. Claims that human activities have already impacted climate are currently unjustified. However, the improvements in climate models could make an assessment of human impacts on climate possible. Alternatively, a sufficiently large, short term change in climate consistent with model predictions could be used as proof of a human impact on climate.

Are There Alternate Explanations for the Climate Change Which Has Occurred Over the Last 120 Years?

Several arguments have been put forward attempting to challenge the conventional view of greenhouse gas-induced climate change. These are generally referred to as "contrarian" theories. This section summarizes these theories and the counter-arguments presented against them.

Solar Variability

Contrarian Theory

Solar radiation is the driver for the climate system. Any change in the intensity of the solar radiation reaching the Earth will affect temperature and other climate parameters. Dr Robert Jastrow, Director of the Mt. Wilson Observatory, and others have shown a close correlation between various sun spot parameters, which they believe are a measure of solar intensity, and global average temperature for the past 120 years, the period for which reasonable quality data exist for both sun spots and global average temperature. The correlation has been pushed back to about 1700 using less accurate data for both temperature and sun spots. In addition, observations of Sun- like stars indicate that they show the amount of variability in radiation intensity needed to account for recent changes in the Earth's climate.

More recently, Tinsley and Heelis at the Univ. of Texas have proposed a mechanism by which changes in solar activity can impact on climate in by a mechanism other than the direct change in the intensity of solar radiation impacting on the Earth's atmosphere.

Counter-arguments

Direct measures of the intensity of solar radiation over the past 15 years indicate a maximum variability of less than 0.1%, sufficient to account for no more than 0.1°C temperature change. This period of direct measurement included one complete 11 year sun spot cycle, which allowed the development of a correlation between solar intensity and the fraction of the Sun's surface covered by sun spots. Applying this correlation to sun spot data for the past 120 years indicates a maximum variability on solar intensity of 0.1%, corresponding to a maximum temperature change of 0.1°C, one-fifth of the temperature change observed during that period.

If solar variability has accounted for 0.1°C temperature increase in the last 120 years, it is an interesting finding, but it does not allay concerns about future warming which could result from greenhouse gas emissions. Whatever contribution solar variability makes to climate change should be additive to the effect of greenhouse gas emissions.

The Tinsley and Heelis proposed mechanism may revive the debate about the role of solar variability. To date is has not entered the climate change debate.

Role of Water Vapor

Contrarian Theory

In 1990, Prof. Richard Lindzen of MIT argued that the models which were being used to predict greenhouse warming were incorrect because they predicted an increase in water vapor at all levels of the troposphere. Since water vapor is a greenhouse gas, the models predict warming at all levels of the troposphere. However, warming should create convective turbulence, which would lead to more condensation of water vapor (i.e. more rain) and both drying and cooling of the troposphere above 5 km. This negative feedback would act as a "thermostat" keeping temperatures from rising significantly.

Counter-arguments

Lindzen's 1990 theory predicted that warmer conditions at the surface would lead to cooler, drier conditions at the top of the troposphere. Studies of the behavior of the troposphere in the tropics fail to find the cooling and drying Lindzen predicted. More recent publications have indicated the possibility that Lindzen's hypothesis may be correct, but the evidence is still weak. While Lindzen remains a critic of climate modeling efforts, his latest publications do not include the convective turbulence argument.

Anomalies in the Temperature Record

Contrarian Argument	Counter-arguments
The temperature record of the last 120 years cannot be explained by greenhouse gas emissions, which rose steadily through that period. If greenhouse gases were the explanation for recent climate, one would have expected temperature also to have risen steadily through the period. However, temperature rose from 1870 to 1930, then the leveled off to 1940, dropped between 1940 and 1970, and has been rising since 1970.	While atmospheric concentrations of greenhouse gases have risen steadily since 1870, their total increase has been too small for greenhouse warming to be distinguishable above the cooling effect of aerosols and the variability caused by all of the other factors which affect climate (volcanic eruptions, solar variability, random variability possibly due to the chaotic nature of climate, etc.). This does not mean that a further increase in greenhouse gas concentrations will not add to measurable warming.
Satellite measurements covering over 98% of the globe indicate that global average temperature has decreased slightly over the past 15 years, during a time when land-based temperature measurements indicated a series of record high temperatures.	Satellites measure the average temperature of a column of air from the surface to about 6 km. above the surface, while the land-based measurements are surface measurements. Also, the land-based measurements are for land only. The oceans, which cover 70% of the Earth's surface, are not included. The oceans would be expected to warm more slowly than the land surface, lowering global average temperature. While raw data from the satellite measurements indicate a cooling of 0.06°C/decade, correcting the raw data for known effects (volcanos and periodic warming of the Eastern tropical Pacific Ocean as part of the El Nino cycle), yields 0.09°C/decade warming. The corrected satellite measurements still do not agree with the land-based temperature record, but they both show warming.

Detailed temperature records do not agree with predictions about greenhouse warming. Prof. Patrick Michaels of the University of Virginia presented a series of hypotheses about how greenhouse warming should affect temperature. Only two will be discussed in detail.

First, if greenhouse gases were responsible for the increase in global average temperature, one would expect daytime maximum temperatures to increase. What is actually happening is that daytime maximum temperatures are staying constant, while nighttime temperatures are increasing. Michaels argues that the increase in nighttime temperatures is due to the urban heat island effect.

Second, one would also expect Northern Hemisphere temperatures to have increased more than Southern Hemisphere temperatures, since greenhouse gas concentrations are higher in the Northern Hemisphere. However, Southern Hemisphere temperatures have increased more than Northern Hemisphere temperatures. Michaels argues that the smaller increase in the Northern Hemisphere is due to cooling by aerosols, a position which is now becoming generally accepted.

While some scientist argue that greenhouse warming has already occurred, most say that it cannot be separated from all of the other factors affecting climate, including the urban heat island effect and aerosol cooling. Thus, the fact that the recent temperature record does not agree in detail with a greenhouse gas warming scenario does not diminish the potential threat from substantially higher atmospheric concentrations of greenhouse gases.

Conclusions about the Contrarian Theories

The contrarian theories raise interesting questions about our total understanding of climate processes, but they do not offer convincing arguments against the conventional model of greenhouse gas emission-induced climate change. Jastrow's hypothesis about the role of solar variability and Michaels' questions about the temperature record are not convincing arguments against any conclusion that we are currently experiencing warming as the result of greenhouse gas emissions. However, neither solar variability nor anomalies in the temperature record offer a mechanism for off-setting the much larger rise in temperature which might occur if the

atmospheric concentration of greenhouse gases were to double or quadruple.

Lindzen's hypothesis that any warming would create more rain which would cool and dry the upper troposphere did offer a mechanism for balancing the effect of increased greenhouse gases. However, the data supporting this hypothesis is weak, and even Lindzen has stopped presenting it as an alternative to the conventional model of climate change.

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