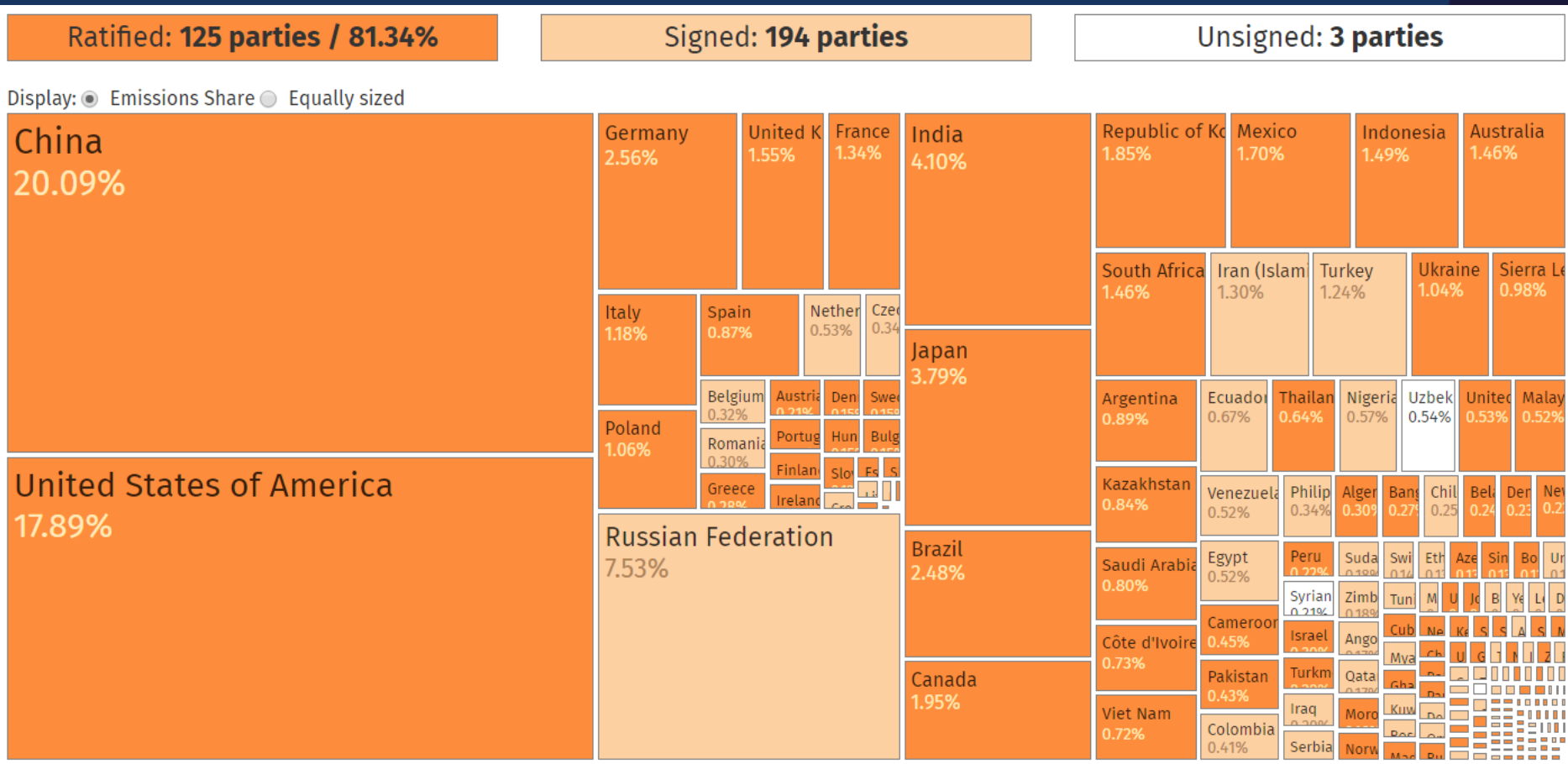
The Paris Agreement and Climate Geoengineering

Wil Burns & Neil Craik
First Annual Research Roundtable on Global Climate Change Governance: Geoengineering
Northwestern University School of Law
April 17, 2017

Berkeley
UNIVERSITY OF CALIFORNIA



Berkeley
UNIVERSITY OF CALIFORNIA

“Climate Geoengineering”

Options involving large-scale engineering of the environment in order to combat or counteract the effects of changes in atmospheric chemistry.

U.S. National Academy of Sciences (1992)

Berkeley
UNIVERSITY OF CALIFORNIA

Categories of Geoengineering

- **Solar Radiation Management [SRM]**

SRM techniques that aim to reflect a small proportion of the Sun's energy back into space, counteracting the temperature rise caused by increased levels of greenhouse gases in the atmosphere that absorb energy and raise temperatures.

- **Carbon Dioxide Removal [CDR]**

CDR techniques that aim to remove carbon dioxide from the atmosphere, directly countering the increased greenhouse effect and ocean acidification.

Berkeley
UNIVERSITY OF CALIFORNIA

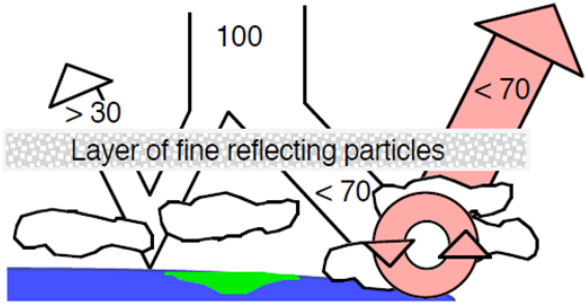
Berkeley
UNIVERSITY OF CALIFORNIA

Solar Radiation Management (SRM) Options

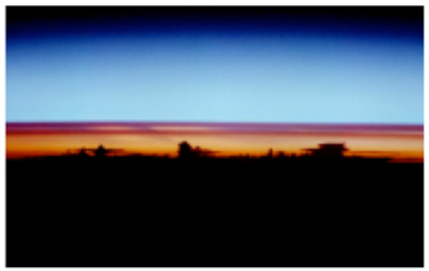
Geoengineering: Sulfur Injection

Stratospheric aerosols

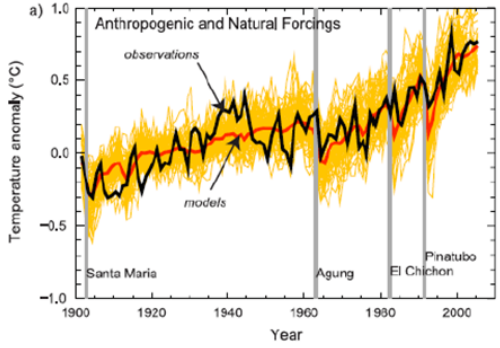
Adding more of the right kind of fine particles to the stratosphere can increase the amount of sunlight that is reflected back into space.

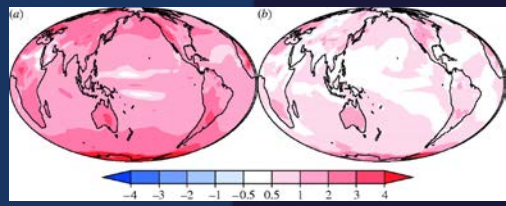


There is clear evidence from many large past volcanic eruptions that this mechanism can cool the planet (Mount Pinatubo produced global scale cooling of about 0.5°C).



Source: NASA and IPCC.





Berkeley
UNIVERSITY OF CALIFORNIA

Solar Radiation Management (SRM) Options

Marine Cloud-Brightening

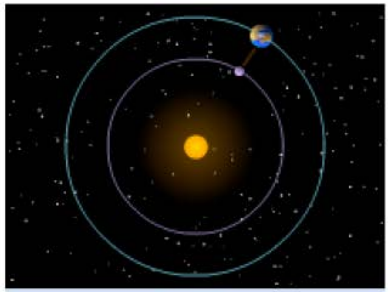
Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley
UNIVERSITY OF CALIFORNIA

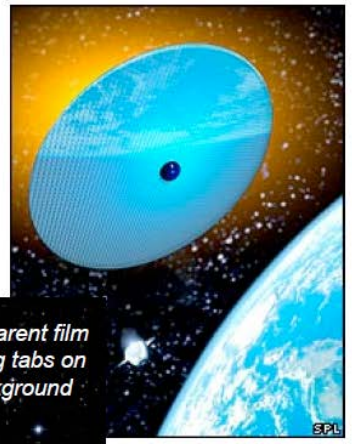
Solar Radiation Management (SRM) Options

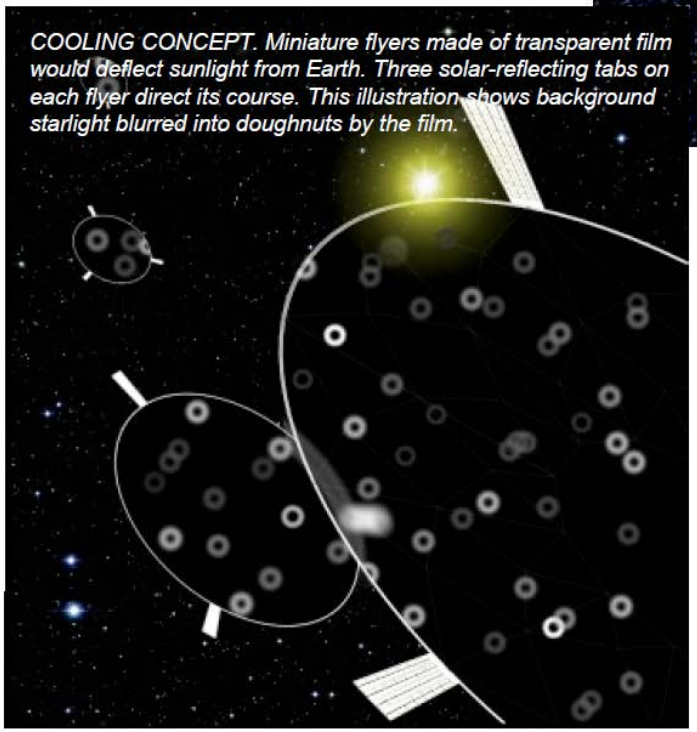
SRM Geoengineering: The Space Option

Reflectors or diffraction gratings in space



Lagrange point 1 is between the Earth and the sun. The solar wind reaches it about one hour before reaching Earth. In 1978, the International Sun-Earth Explorer-3 (ISEE-3) was launched towards L1, where it conducted solar observations for several years. Now the ESA/NASA SOHO solar watchdog is positioned there. *Credit:ESA*





COOLING CONCEPT. Miniature flyers made of transparent film would deflect sunlight from Earth. Three solar-reflecting tabs on each flyer direct its course. This illustration shows background starlight blurred into doughnuts by the film.

Source: Roger Angel, UA Steward Observatory, ESA, BBC.

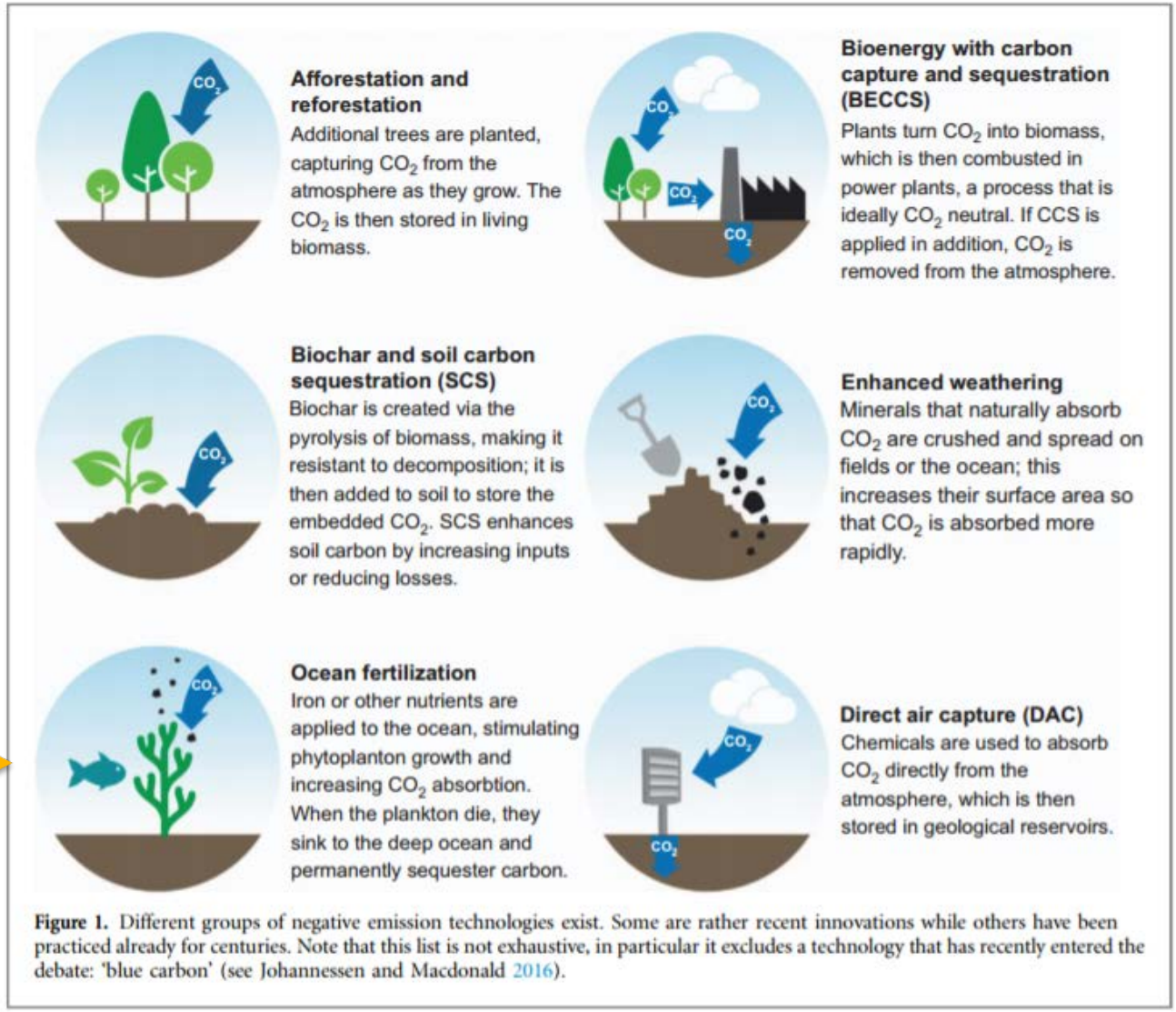
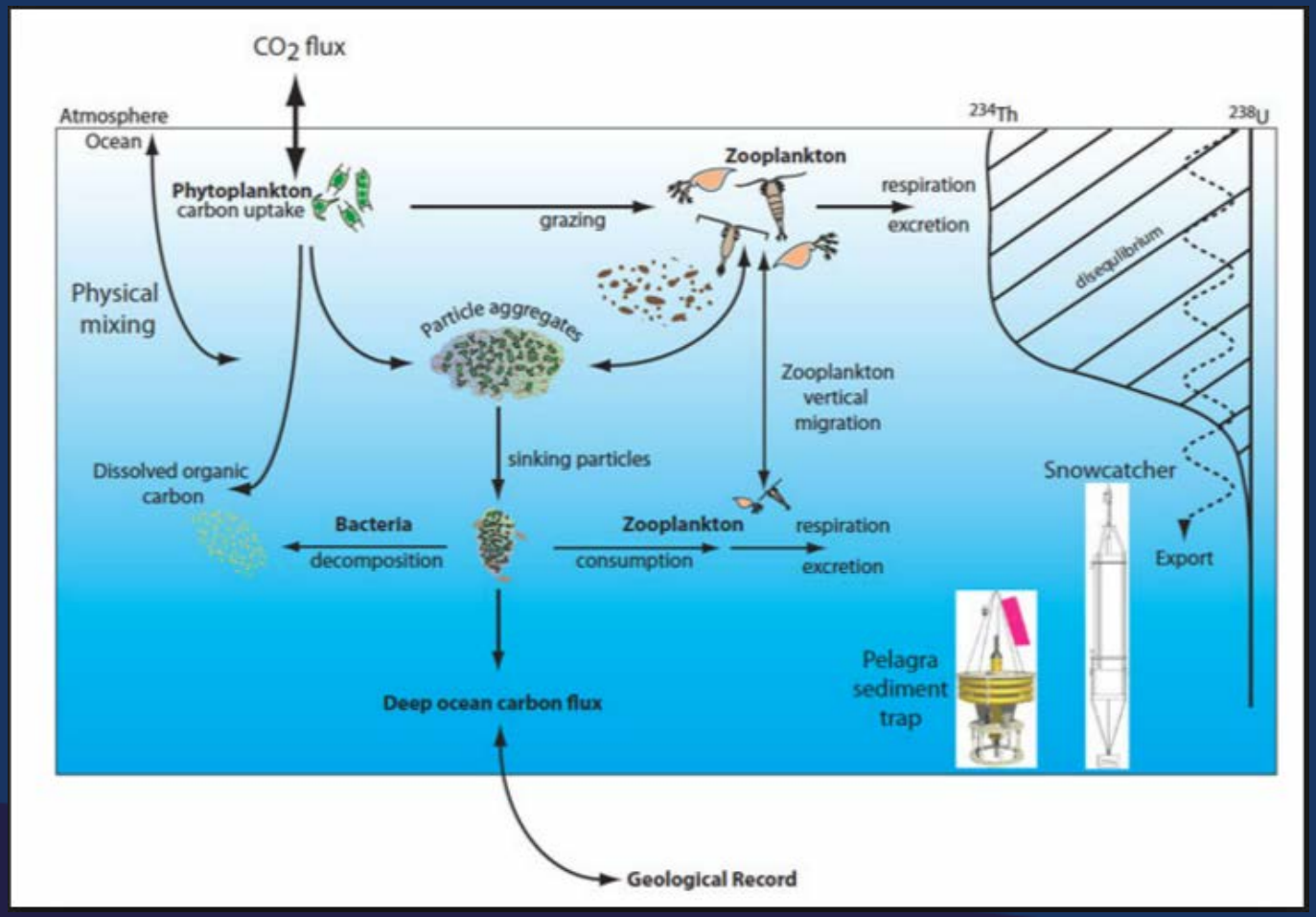


Figure 1. Different groups of negative emission technologies exist. Some are rather recent innovations while others have been practiced already for centuries. Note that this list is not exhaustive, in particular it excludes a technology that has recently entered the debate: 'blue carbon' (see Johannessen and Macdonald 2016).

Berkeley
UNIVERSITY OF CALIFORNIA

Carbon Dioxide Removal (CDR) Options

“Biological Pump”



Berkeley
UNIVERSITY OF CALIFORNIA

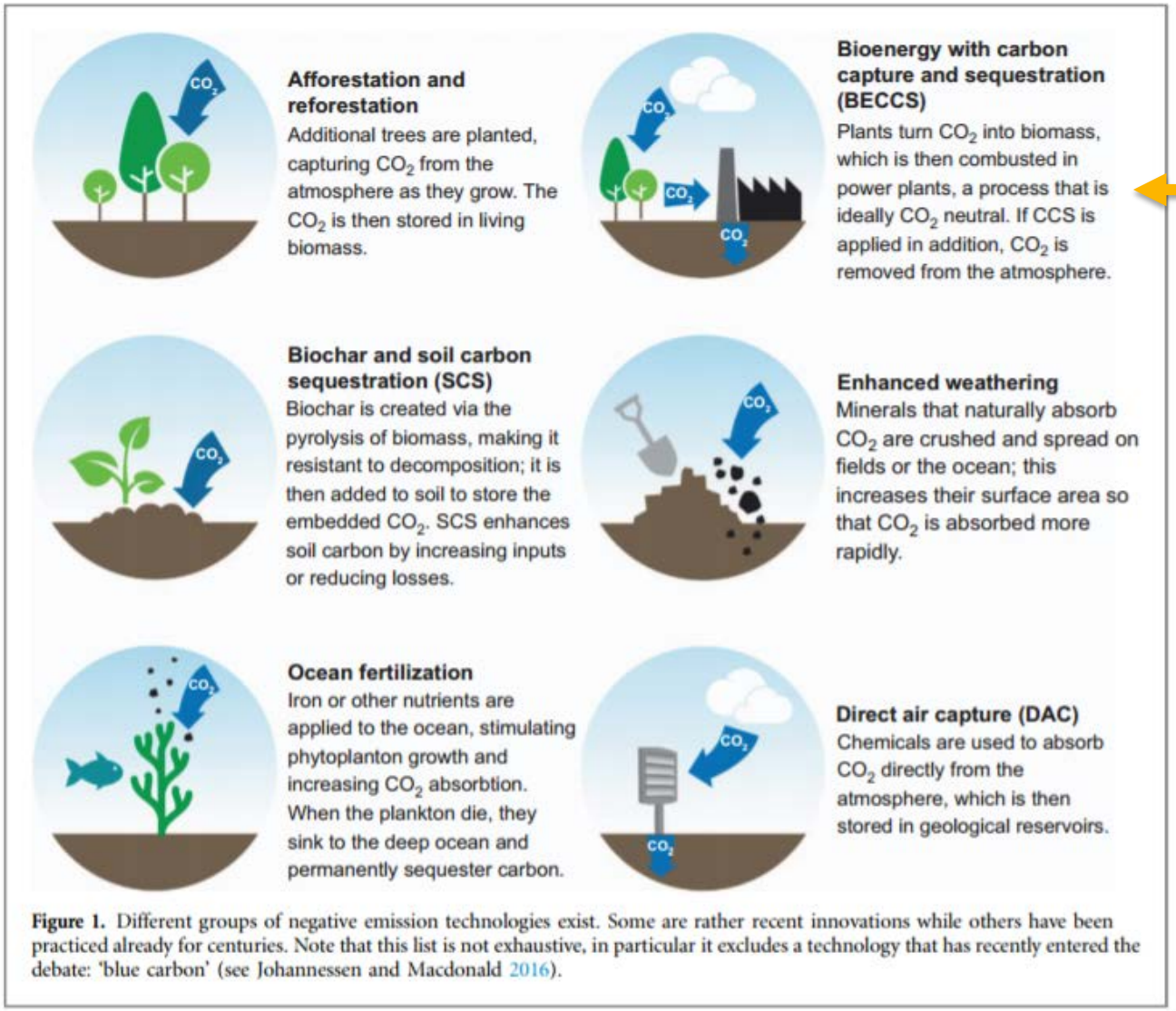
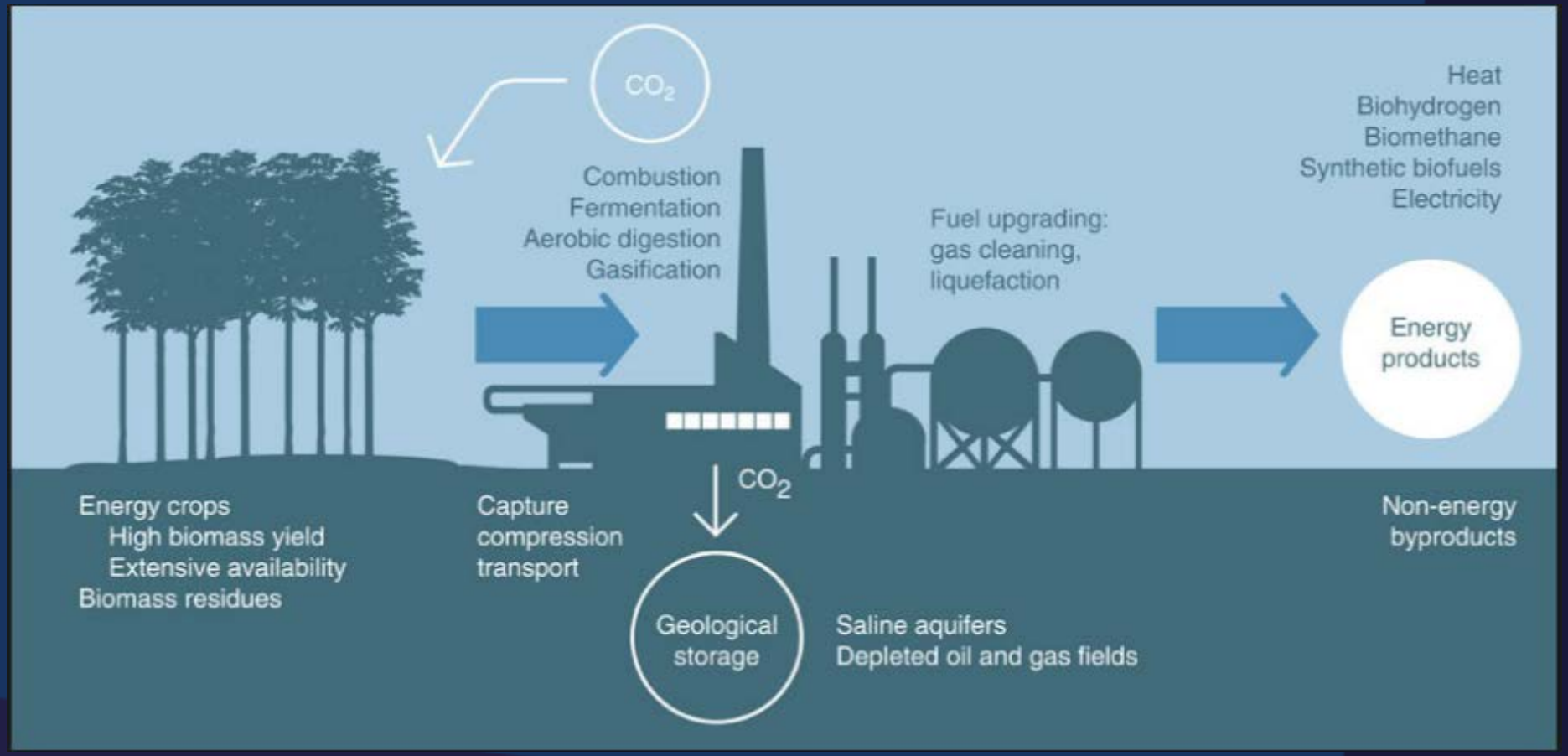


Figure 1. Different groups of negative emission technologies exist. Some are rather recent innovations while others have been practiced already for centuries. Note that this list is not exhaustive, in particular it excludes a technology that has recently entered the debate: 'blue carbon' (see Johannessen and Macdonald 2016).

Berkeley
UNIVERSITY OF CALIFORNIA

Carbon Dioxide Removal (CDR) Options

BECCS



Berkeley
UNIVERSITY OF CALIFORNIA

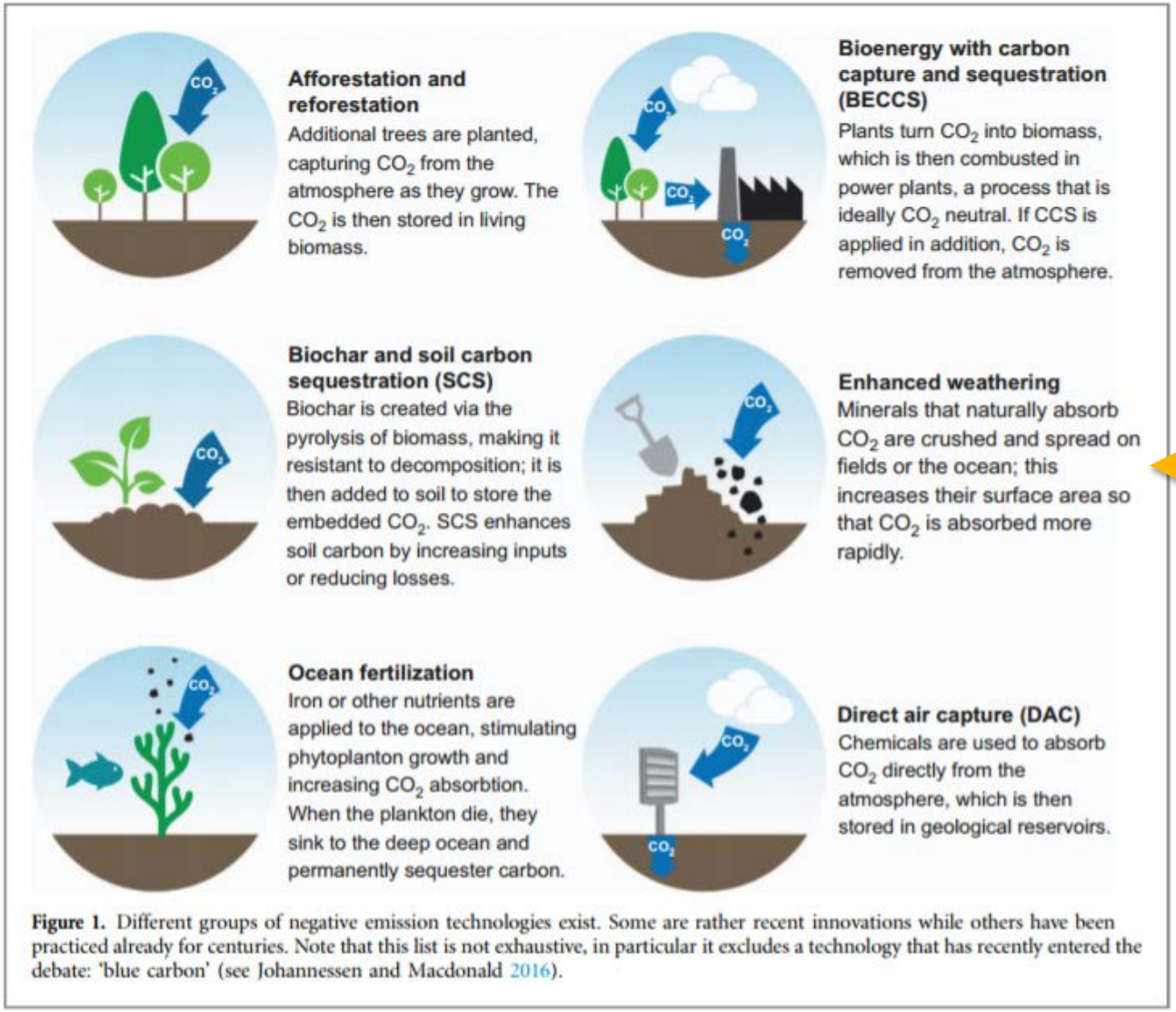


Figure 1. Different groups of negative emission technologies exist. Some are rather recent innovations while others have been practiced already for centuries. Note that this list is not exhaustive, in particular it excludes a technology that has recently entered the debate: 'blue carbon' (see Johannessen and Macdonald 2016).

Berkeley
UNIVERSITY OF CALIFORNIA

Carbon Dioxide Removal (CDR) Options

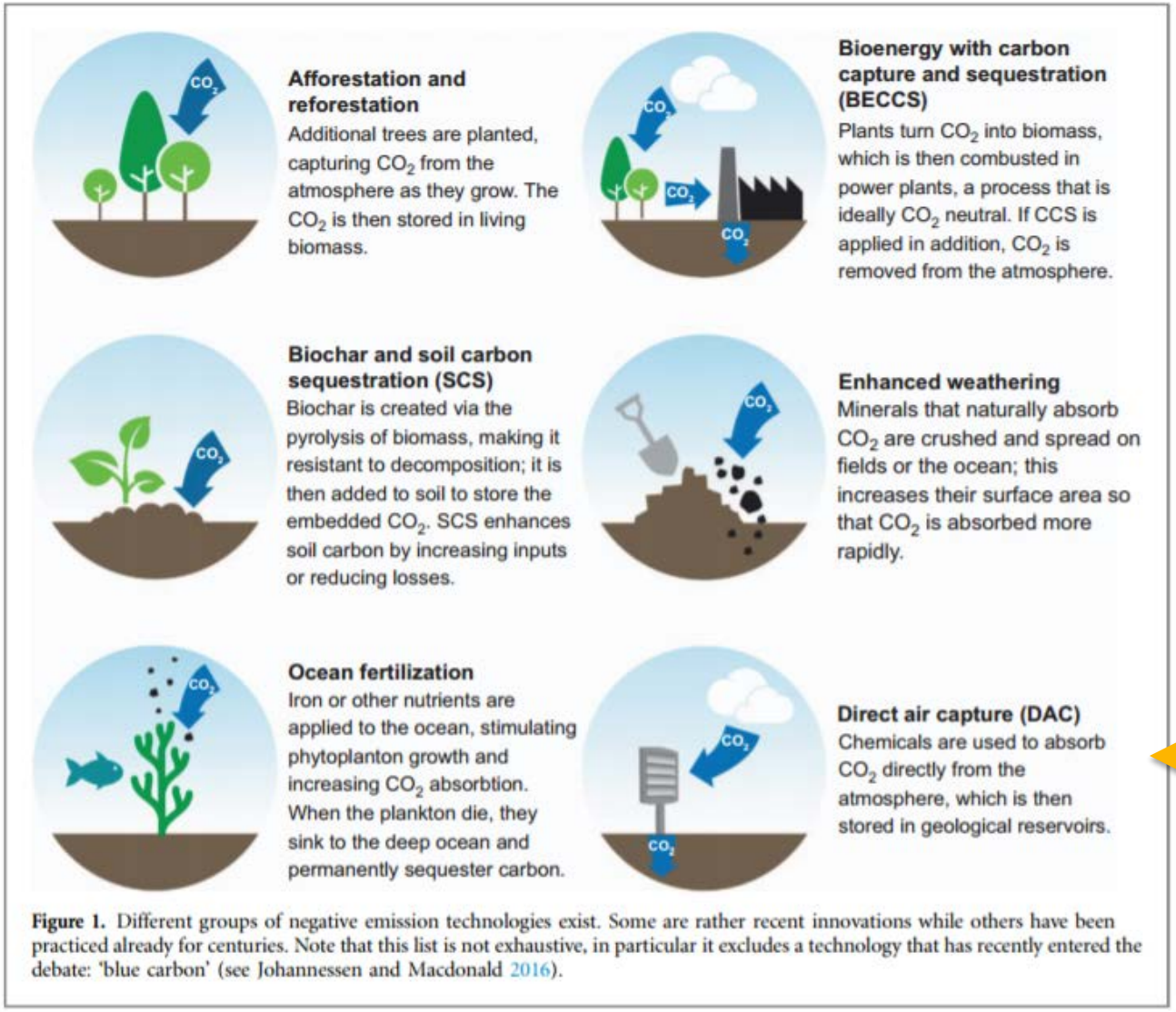
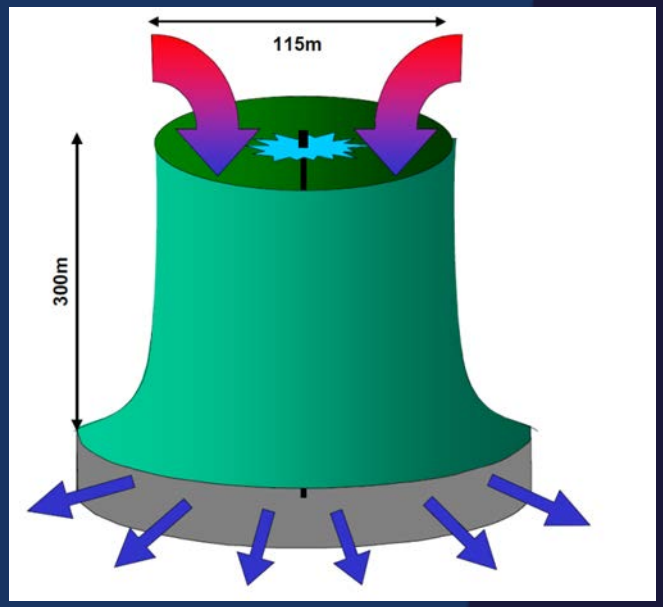


Figure 1. Different groups of negative emission technologies exist. Some are rather recent innovations while others have been practiced already for centuries. Note that this list is not exhaustive, in particular it excludes a technology that has recently entered the debate: 'blue carbon' (see Johannessen and Macdonald 2016).

Berkeley
UNIVERSITY OF CALIFORNIA

Carbon Dioxide Removal (CDR) Options

Air Capture



Berkeley
UNIVERSITY OF CALIFORNIA

ROADMAP

- Key provisions of Paris Agreement potentially pertinent to SRM geoengineering options;
- Key provisions of Paris Agreement potentially pertinent to CDR geoengineering options;
- Potential provisions of Paris that might be used to assess and/ir circumscribe potential deployment of climate geoengineering options

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 2**

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change . . . including by:

(a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 3**

As nationally determined contributions to the global response to climate change, all Parties are to undertake and communicate ambitious efforts . . . with the view to achieving the purpose of this Agreement as set out in Article 2. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 4**

2. Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.

Berkeley
UNIVERSITY OF CALIFORNIA

UNFCCC (1992)

- **Article 4: Commitments**

2. The developed country Parties and other Parties included in Annex I commit themselves specifically as provided for in the following:
(a) Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

UNFCCC Secretariat: Fact Sheet (2009)

Mitigation involves human interventions to reduce the emissions of greenhouse gases by sources or enhance their removal from the atmosphere by “sinks”

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 4**

13. Parties shall account for their nationally determined contributions. In accounting for anthropogenic emissions and removals corresponding to their nationally determined contributions, Parties shall promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting … [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 4**

4. Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances . . .
6. The least developed countries and small island developing States may prepare and communicate strategies, plans and actions for low greenhouse gas emissions development reflecting their special circumstances. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 4**

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 8**

1. Parties recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.

2. The Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts shall be

subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to the

Paris Agreement and may be enhanced and strengthened, as determined by the Conference of the Parties serving

as the meeting of the Parties to the Paris Agreement. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 4**

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 5**

1. Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases as referred to in Article 4, paragraph 1(d), of the Convention, including forests. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

UNFCCC (1992)

- **Article 1**

8. “Sink” means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 6**

1. Parties recognize that some Parties choose to pursue voluntary cooperation in the implementation of their nationally determined contributions to allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity.
2. Parties shall, where engaging on a voluntary basis in cooperative approaches that involve the use of internationally transferred mitigation outcomes towards nationally determined contributions, promote sustainable development and ensure environmental integrity and transparency, including in governance . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Article 10**

2. Parties, noting the importance of technology for the implementation of mitigation and adaptation actions under this Agreement and recognizing existing technology deployment and dissemination efforts, shall strengthen cooperative action on technology development and transfer.

3. The Technology Mechanism established under the Convention shall serve this Agreement.

4. A technology framework is hereby established to provide overarching guidance to the work of the Technology Mechanism in promoting and facilitating enhanced action on technology development and transfer in order to support the implementation of this Agreement, in pursuit of the long-term vision referred to in paragraph 1 of this Article.

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Preamble**

Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity . . . [emphasis added]

Paris Agreement (2015)

- **Preamble:**

Recognizing that Parties may be affected not only by climate change, but also by the impacts of the measures taken in response to it,

- **Article 4**

15. Parties shall take into consideration in the implementation of this Agreement the concerns of Parties with economies most affected by the impacts of response measures, particularly developing country Parties. [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

PARIS AGREEMENT (2015)

- **Article 2**

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty . . . [emphasis added]

- **Preamble:**

Emphasizing the intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Preamble**

Noting the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognized by some cultures as Mother Earth . . . [emphasis added]

UNFCCC, 17TH COP, DECISION 8/CP.17 (2011)

Forum and work programme on the impact of the implementation of response measures

The Conference of the Parties,

1. Adopts a work programme on the impact of the implementation of response measures under the subsidiary bodies . . .

Berkeley
UNIVERSITY OF CALIFORNIA

Paris Agreement (2015)

- **Section 18**

The Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation established by Articles 9 and 10 of the Convention shall serve, respectively, as the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Agreement. The provisions of the Convention relating to the functioning of these two bodies shall apply mutatis mutandis to this Agreement.

Berkeley
UNIVERSITY OF CALIFORNIA

UNFCCC, 17TH COP, DECISION 8/CP.17 (2011)

Forum and work programme on the impact of the implementation of response measures

The Conference of the Parties,

1. Adopts a work programme on the impact of the implementation of response measures under the subsidiary bodies, with the objective of improving the understanding of the impact of the implementation of response measures in the following areas:

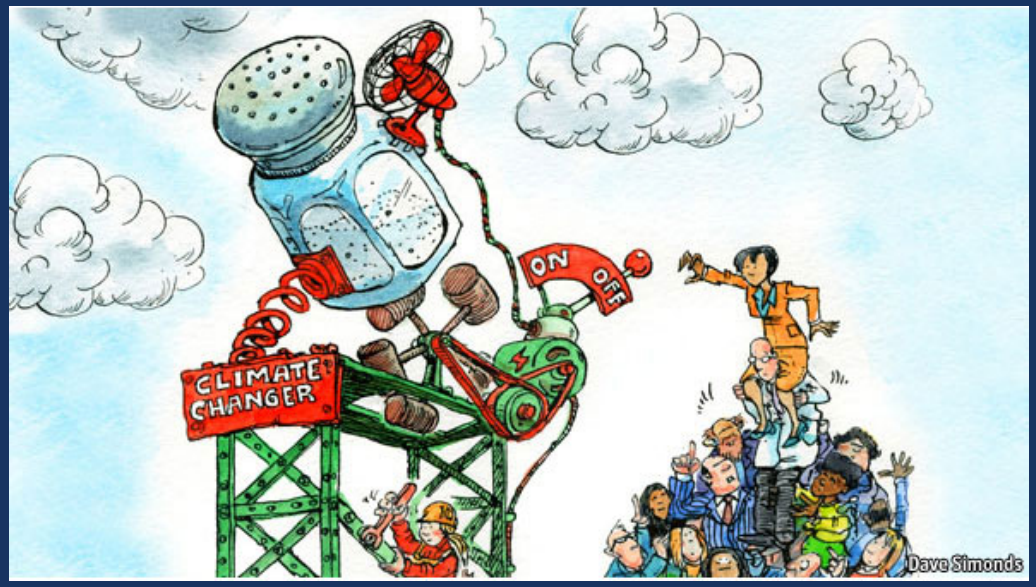
(a) Sharing of information and expertise, including reporting and promoting understanding of positive and negative impacts of response measures;

(b) Cooperation on response strategies;

(c) Assessment and analysis of impacts . . . [emphasis added]

Berkeley
UNIVERSITY OF CALIFORNIA

Thank you!



?

wburns@american.edu

Berkeley
UNIVERSITY OF CALIFORNIA

Geoengineering and the Paris Agreement

- The purpose of this presentation is to examine how a potential suite of emerging climate response measures, collectively known as "geoengineering" might be addressed under the Paris Agreement, the global community's long-term commitment to addressing climate change, which entered into force in November of last year.
    - At the time, the Paris Agreement was hailed as a momentous achievement in the titanic struggle to avert potentially catastrophic climate change during this century and beyond
        - And, indeed, one highly positive development is in terms of participation in the regime, with countries that have already ratified it representing the lion's share of the world's GHG emissions

[SLIDE 2]

- However, an abiding question is whether the Member States to Paris have the political will to achieve the treaty's objective of holding temperatures to well below 2°C from pre-industrial levels, while aspiring to not exceed 1.5°C.
    - At this point, the trends are discouraging: the pledges made by its Parties to achieve the Paris temperature goals, the so-called Nationally Determined Contributions, currently put the world on track to temperature increases of 2.7°-3.5°C

    - And this could even be an underestimation, as concentrations of GHGs in the past couple of years have risen at a rate of 3ppm, the highest in recorded history
    - Increases in temperatures of this magnitude would be extremely foreboding for human institutions and ecosystems:
        - For example, a 3ºC increase in temperatures could result in the complete melting of the Greenland Ice Sheet over the course of 1000 years, raising sea level an astounding 7 meters
        - Virtually all coral reefs, which provide habitat for at least one third of all marine species, would be lost under a 3°C scenario
        - A 3-4ºC increase in temperatures would threaten 60% of species with extinction
        - 3-4ºC increase would results in potentially catastrophic declines in agricultural production in developing countries
        - A number of studies project that the thermohaline circulation system could be shut down by temperature increases between 3-4ºC, potentially casting much of Europe into Arctic conditions
        - And once we cross threshold, we're stuck for hundreds to thousand years

- The specter of climatic changes of this magnitude has substantially increased interest in the past decade in so-called geoengineering schemes that might help us avert crossing

critical thresholds, or buy us time to develop the will and technological capabilties for to effectuate effective mitigation and adaptation responses.

- As defined by the U.S. National Academies of Science, geoengineering refers to "options involving large-scale engineering of the environment in order to combat or counteract the effects of changes in atmospheric chemistry" **[SLIDE 3]**

- Climate geoengineering options fall into two broad categories:
  - SRM **[SLIDE 4A]**
  - CDR **[SLIDE 4B]**

- Examples of each option:
  - **SRM options:**
    - **SAI:** **[SLIDE 5]** Probably most widely discussed geoengineering proposal a process known as **sulfur aerosol injection, which would involve** dispersion sulfur dioxide into the stratosphere, which when combined with water vapor, would form sulfate aerosols
      - Sulfate aerosols would reflect incoming solar radiation back to space **[SLIDE 6]**
      - In the parlance of climate science, this would reduce "insolation," i.e. decrease the amount of solar radiation received on Earth's surfaces
        - Study by researchers Ken Caldeira & Lowell Wood concluded that we would have to reduce total insolation by 1.84% to restore annual mean temperatures and precipitation to levels seen when concentrations of GHG were approximately 280ppm, i.e. start of Industrial Revolution
        - A couple of recent studies have concluded that we could achieve this goal by introducing approximately 5 Tg S/year (5 trillion grams of sulfur) of sulfate aerosols into stratosphere to offset the warming impacts of a doubling of atmospheric carbon dioxide levels
    - **Marine Cloud Brightening** **[SLIDE 7]**
      - **[SLIDE 8]** Several researchers in recent years have advocated for dispersing sulfates in the area of low-level maritime clouds
        - This would result in the Twomey effect, i.e., development of extra condensation nuclei for new water drops in such clouds, increasing their albedo, and thus reflecting more incoming radiation back to space

        - Research indicates that this technique could reduce insolation by enough to return temperatures back to pre-industrial levels
    - **Space mirrors [SLIDE 9]**
        - **[SLIDE 10]** This approach would involve mounting mirrors on satellites to reflect incoming solar radiation back to space, or use of billions of reflective "space frisbees"
        - Could reduce insolation enough to substantially reduce temperatures
        - But very costly
- **CDR options**
    - **[SLIDE 11] Ocean iron fertilization:**
        - Ocean Iron Fertilization (OIF) seeks to stimulate production of phytoplankton, microscopic plants found in the world's oceans
            - Phytoplankton obtain energy through the process of photosynthesis, whereby they absorb carbon dioxide from the oceans and convert it to organic carbon, which is stored in the organisms' tissues
                - Overall, approximately half of the world's photosynthesis occurs in phytoplankton
        - **[SLIDE 12]** Most of the organic carbon produced in the photosynthetic process is immediately consumed at the surface and converted back to CO_2 and then released into the atmosphere.
            - However, a small portion of the remainder of the carbon is effectively removed from the system and transported to the deep ocean for storage when the organisms die in a process called the "biological pump," or when fecal pellets fall to sea floor
        - A number researchers in the past decade have argued that stimulating the growth of phytoplankton would be great way to reduce concentrations of CO_2 by enhancing sequestration via the biological pump
            - Also, some research indicates that increased plankton growth also results in substantial increases in the release of methyl sulfides by the phytoplankton, which would produce more clouds, that could deflect more solar radiation from the Earth
        - Where Would It Be Done?:
            - Most researchers who advocate ocean fertilization argue that there are certain areas of the world's oceans, primarily the Southern Ocean, that have high levels of the major macronutrients (especially phosphorous and nitrogen) critical for high levels of phytoplankton productivity, but low levels of a critical micronutrient, iron
                - This iron deficiency, it's argued, severely limits phytoplankton production in these regions, resulting in the characterization of such ocean areas as "High Nutrient-Low Chlorine" (HNLC) water bodies

- So, proponents of iron fertilization argue that introducing substantial amounts of dissolved iron (usually ferrous sulfates) in these areas to supplement the natural supplies would:
  - Stimulate phytoplankton growth, in turn resulting in more uptake of carbon dioxide
  - Ultimately, when the phytoplankton dies, some will drop to the bottom of the ocean below the mixing zone, purportedly sequestering huge amounts of carbon for a century or more
- Purported Impact of Iron Fertilization:
  - Some proponents claim that iron fertilization could sequester as much as 25% of world's carbon dioxide
  - Argument also made that iron fertilization would be relatively cheap, costing about $2-$5 per ton of carbon sequestered

- **[SLIDE 13] BECCS:**
  - **[SLIDE 14]** How BECCS works:
    - Energy production via bioenergy feedstocks, e.g. energy crops, forest resources, industrial waste, or second generation sources, e.g. algae
    - Capture of carbon dioxide from flue gas in energy production, compression, shipment and storage, e.g. in saline aquifers, abandoned coal mines
  - "Negative emissions" are possible, which makes it a highly desirable climate mitigation strategy, since most of the scenarios (184 of 208) that avoid 2°C in AR5 contemplate substantial negative emissions, and most contemplate large-scale deployment of BECCS
    - Estimates are might need as much as approximately 13 GtCO2e/yr. by 2100 to hold temperatures to below 2C
- **[SLIDE 15] Enhanced mineral weathering:**
  - The geoengineering concept of "Enhanced Weathering" proposes the application of powdered minerals, e.g. olivine to the land or ocean surface to accelerate the natural chemical weathering of silicate rocks that has regulated the global carbon cycle (and thus climate) for several eons
    - Proponents argue that such "enhanced" chemical weathering would help remove CO_2 from the atmosphere by accelerating the natural geological processes that transfer carbon and other elements from the rock and atmospheric reservoirs into the biosphere and ocean over time.
- **[SLIDE 16] Direct Air Capture**:
  - **[SLIDE 17]** Direct Air Capture Systems would seek to capture carbon dioxide from ambient air through the use of

sorbent materials (e.g. plastic resins, or calcium hydroxide or calcium oxide), much as leaves on a tree do
    - This carbon dioxide would then be compressed and transported and sequestered
- Proponents argue that we could sequester enough carbon dioxide to return atmospheric concentrations to pre-industrial levels if we wished to

Given the fact that Paris will likely guide the international climate policy agenda throughout this century (at least other, then maybe in the United States), I think it's germane to briefly examine whether climate geoengineering might be incorporated into the commitments of the agreement and/or regulated by its mandates.

ROADMAP [SLIDE 18]

1. COULD CLIMATE GEOENGINEERING OPTIONS BE USED TO FULFILL MITIGATION OPTIONS UNDER THE PARIS AGREEMENT?

A. SRM Options: [SLIDE 19]

a. Ostensibly, it might appear that SRM approaches could be used to meet the temperature targets under the Paris agreement, since they could, as indicated above, substantially reduce temperatures if proved effective in implementation

b. [SLIDE 20] However, since the authorized means to achieve these goals under Paris is through the Nationally Determined Contributions of the Parties, the initial question is to determine whether SRM options would fall under the rubric "NDCs":

i. [SLIDE 21] As provided for under Article 4 of the Paris Agreement, Nationally Determined Contributions are to be effectuated through domestic **mitigation measures**

1. So, the most pertinent question here is what constitutes "mitigation" under the Paris Agreement:

a. While the Paris Agreement does not define this term, given its relationship to the UNFCCC, it would appear appropriate to look at how it's defined in that instrument:

i. [SLIDE 22] Under Art. 4 of the UNFCCC, the term "mitigation" encompasses measures to reduce emissions, as well as enhancement of

sinks and reservoirs, i.e. mechanisms to storage carbon

ii. **[SLIDE 23]** The UNFCCC Secretariat in its guidance to the Parties also defines "mitigation" this way

iii. Moreover, several provisions of Paris Agreement appear to limit the ways that the Parties can fulfill their NDCs to these options:

1. **[SLIDE 24]** Provisions for accounting for NDCs under Article 4 indicate that Parties must account for two things: emissions and sinks
2. **[SLIDE 25]** Moreover, under Article 4, "Mitigation efforts" defined as emissions reductions commitments by the Parties
3. **[SLIDE 26]** Finally, achievement of the temperature goals under Paris is tied to commitments to emissions reductions and drawdown of atmospheric levels of GHGs by the Parties

iv. By these terms, it would appear that SRM options could **not** be used to meet a Party's Nationally Determined Contributions under Paris because they would not reduce emissions or enhance storage of carbon

1. Rather, SRM options, by their terms, reduce the amount of incoming solar radiation

v. **[SLIDE 27]** One possible alternative argument is that SRM approaches could be deployed to avert loss and damage, i.e. impacts that can't be realistically addressed by mitigation and adaptation responses

1. But that's a third rail for many developed countries, so not sure they will want to go there

B. CDR Options:

a. **[SLIDE 28]** By contrast, it seems a relatively straightforward proposition that CDR options *could* be deployed to help fulfill a Party's NDCs under Paris:

i. As under the terms of Paris, the agreement's objectives can be effectuated by both reducing emissions and mechanisms to draw down atmospheric levels of carbon, via "sinks"
    1. **[SLIDE 29]** This approach is also encouraged in Section 5 of the Agreement

ii. **[SLIDE 30]** As defined in the Paris Agreement's parent agreement, the UNFCCC, "sinks" are processes or mechanisms draw down greenhouse gases
    1. As indicated above, carbon dioxide removal options, by their terms, seek to enhance sinks by drawing down carbon dioxide, and under some circumstances, under GHGs
    2. Thus, I believe that a Party could seek to fulfill at least part of their NDCs through deployment of CDR technologies

C. Other Paris Provisions that might be pertinent to facilitation of deployment of geoengineering options include the following:
    a. **[SLIDE 31]** Market-based mechanisms, so-called <u>internationally transferred mitigation outcomes</u>
    b. **[SLIDE 32]** Technology development and transfer

2. COULD CLIMATE GEOENGINEERING OPTIONS BE REGULATED UNDER THE PARIS AGREEMENT, EVEN IN CASES WHERE THEY COULDN'T BE USED TO MEET PARIS COMMITMENTS?

A. The Paris Agreement includes several provisions that address the appropriateness of **responses** to climate change, and thus might mediate deployment of geoengineering options, including their scope:
    a. **[SLIDE 33]** Provisions to respect human rights in terms of climate response measures
        i. Pertinent to many climate geoengineering options given potential adverse impacts on human rights, especially of world's most vulnerable:
            1. Example: Sulfur Aerosol Injection:
                a. Might shut down or imperil monsoon in South Asia, responsible for providing precipitation that sustains crops for 1 billion people

i. This has implications for right to life, right to food, right to water
b. Could result in dieback of areas of Amazon, could threaten right to development, subsistence, indigenous rights
c. SAI could delay replenishment of ozone layer for 30-70 years, resulting in millions of additional cases of skin cancer, especially in southern hemisphere
i. Right to life; right to health

2. Example: BECCS:
a. Large-scale deployment could require as much as a quarter of net primary productivity to provide biomass feedstock. This could result in:
i. Diversion of land for growing crops, substantially increasing food prices for the most vulnerable, and denial of physical access to food
1. Potential impacts on right to food, subsistence, life
b. Water needs:
i. Could require as much water as we currently use for all irrigation of crops, so right to water might be imperiled, right to development
c. Could have biodiversity impacts of 2.8C:
i. Right of development, indigenous rights

3. Example: mineral weathering:
a. Fine particulates associated with spreading large amounts of silicate on land, right to health

4. Example: OIF:
a. Might imperil productivity of ocean ecosystems:
i. Create aggressive non-palatable phytoplankton assemblages, imperiling right to development, food;
ii. Could divert nutrients from downstream areas, imperiling right to development, food

ii. Of course, this is Preambular language only, and absent evidence that Parties intend it to be binding, not legally binding, but:
1. It can guide interpretation of legally binding provisions; and
2. Paris has Article mandating that impacts of response measures be taken into consideration **[SLIDE 34]**
a. So preambular language could help guide which responses are pertinent, including human rights

iii. Of course, this might have to be viewed comparatively, i.e. what BAU scenarios would mean in terms of human rights

b. Other interests to protect in terms of response measures:

i. **[SLIDE 35]** Sustainable development

1. Geoengineering options could imperil SD, or help further if done carefully

ii. **[SLIDE 36]** Impacts on ecosystems

1. Biodiversity impacts possible with SAI, OIF, BECCs

B. Paris also has a mechanism that could potentially be used to facilitate assessment of response measures, including geoengineering options:

a. [SLIDE 37] At the 17th COP, the Parties to the UNFCCC established a "forum on the impact of the implementation of response measures," which was mandated to meet twice annually under the rubric of the SBI and SBSTAs,

i. [SLIDE 38] Subsidiary bodies have been incorporated into Paris to serve same purposes as under UNFCCC

b. **[SLIDE 39]** The Forum is tasked, *inter alia*, with assessment of the impacts of climate response measures, and engendering cooperation on response strategies.

i. The Forum's mandate was extended at COP21, and enhanced by establishing ad hoc technical expert groups.

c. The Forum was specifically referenced in the decision adopting the Paris Agreement, so it now also incorporated into the Agreement's operation

d. While Forum may have been developed for other purposes, by its terms of reference, I believe that it could be purposed to address climate geoengineering in the future:

i. One option would be to establish an ad hoc technical expert group on geo. options

ii. This group, the broader forum, and the Parties to Paris could play salutary role in ensuring that if geoengineering options are deployed, we seek to minimize potential adverse impacts and maximize benefits from perspective of distributive justice:

1. For example, might be possible to deploy SRM technologies at smaller scale to merely slow down temperature increases and minimize potential adverse impacts
2. Could seek to avoid BECCS deployment n areas of high biodiversity, or where rights of indigenous peoples might be impacted, or to encourage more research of second-generation biofuels

B. Paris Agreement also provides for the establishment of transparent processes for assessment of NDCs, including providing information on assumptions,

methodological approaching for estimating and accounting for anthropogenic greenhouse gases, including removals, and Party assessments of the fairness and ambitiousness of responses

THANK YOU [SLIDE 40]