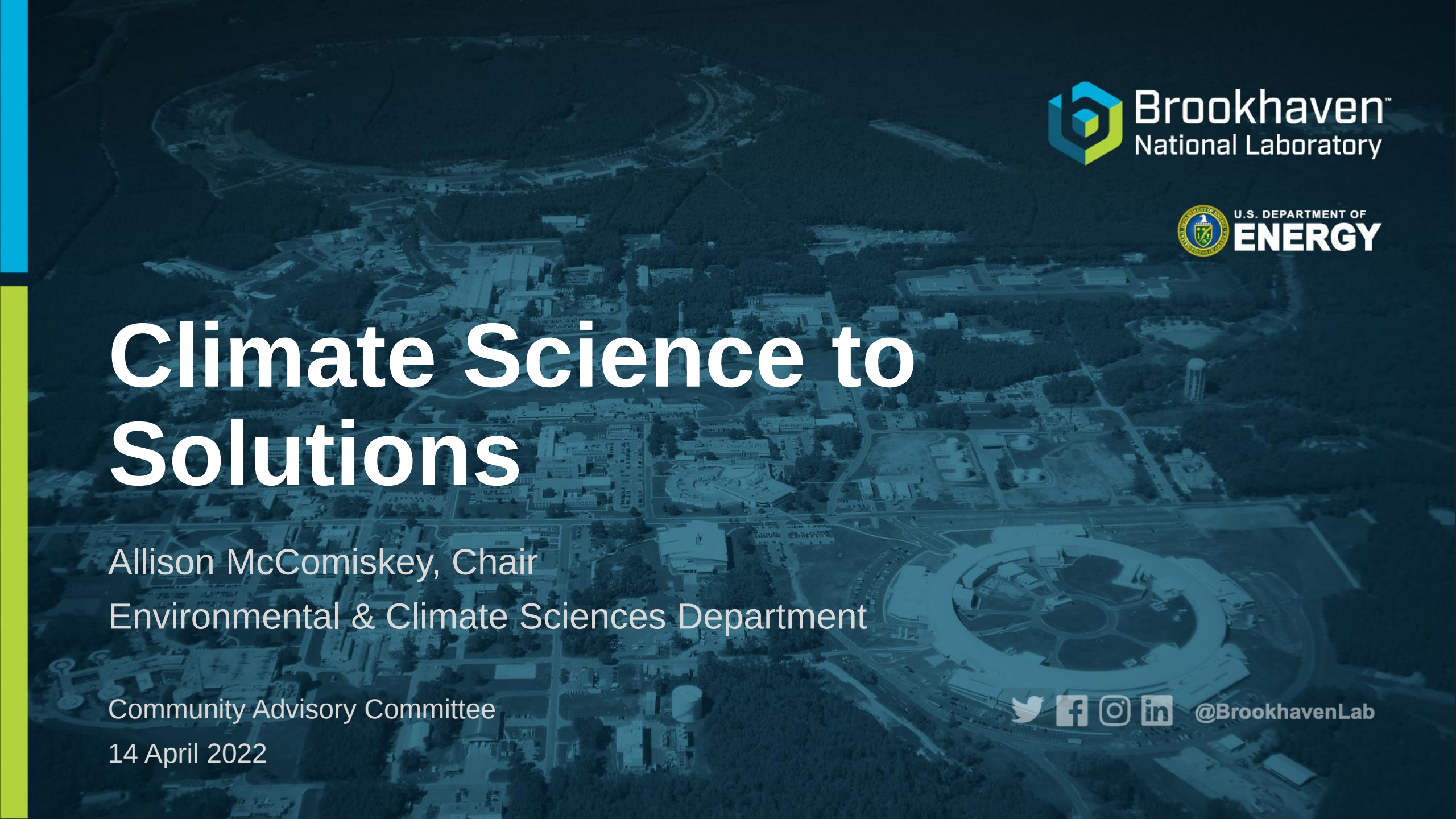


Climate Science to Solutions

Allison McComiskey, Chair
Environmental & Climate Sciences Department

Community Advisory Committee
14 April 2022

@BrookhavenLab

U.S. Plans for Climate Change, Clean Energy, and Environmental Justice

What:

- 50-52% GHG emissions reduction by 2030 (from 2005 levels)
- 100% carbon pollution-free power sector by 2035
- Net-zero economy by 2050

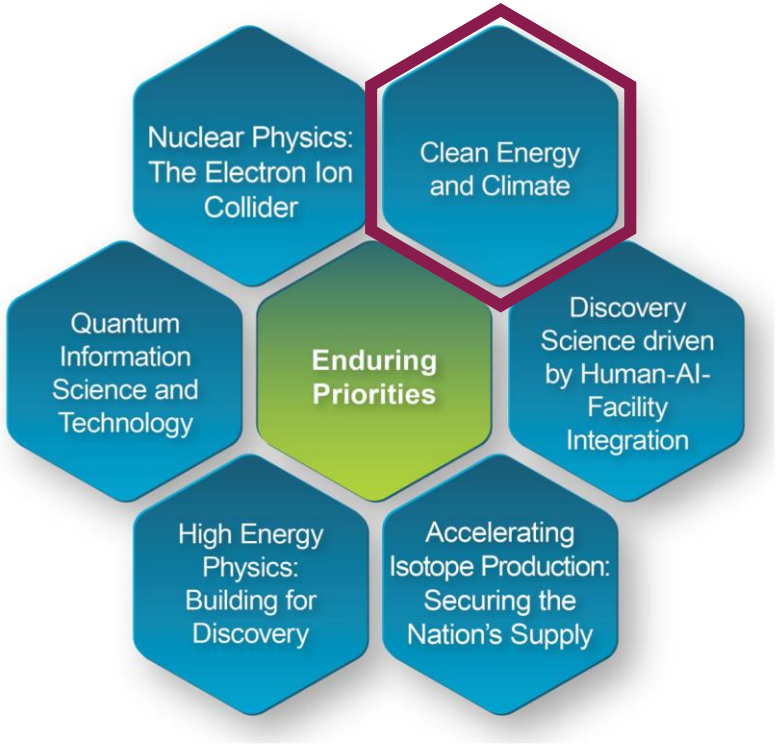
How:

- Decarbonize Electricity
- Electrification of Sectors – requires new infrastructure
- Cut Energy Waste
- Reduce non-CO_2 emissions
- Scale Up CO_2 removal

All of these actions require fundamental knowledge of the climate system from hyper-local to global scales

BNL Clean Energy and Climate Initiative

A cross-laboratory effort to "…address the Nation's needs in developing solutions to clean energy and the climate crisis with its two-part initiative…"



<u>Energy-Climate Nexus</u>

different energy production modes have implications for climate forcers, weather and climate patterns

climate changes feedback on the efficiency and sustainability of energy production

<u>Climate Solutions</u>

urban infrastructure, alternative energy, or climate intervention have varied efficacy under changed climates and affect climate

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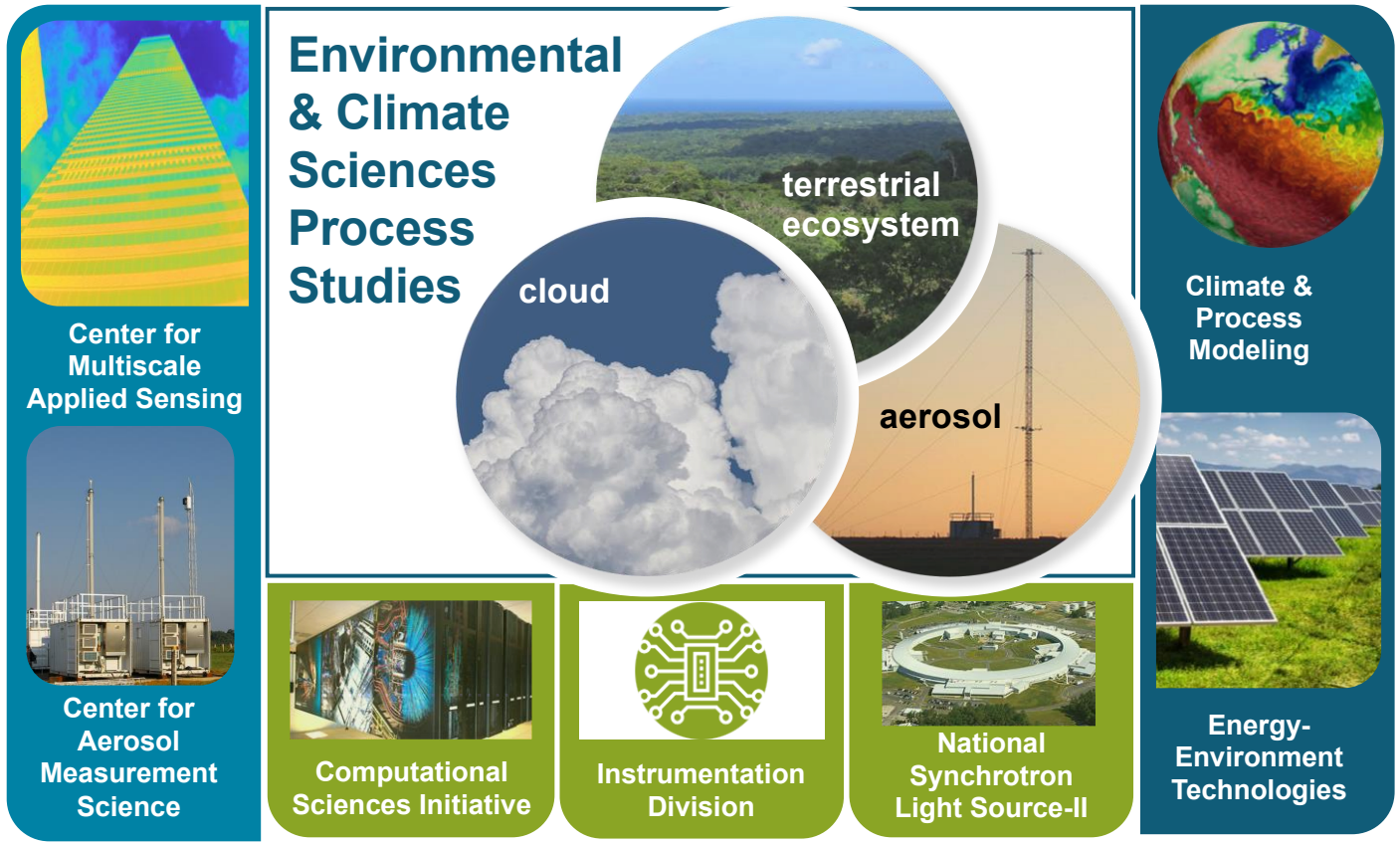
Environmental & Climate Sciences

Advancing process level understanding in atmospheric and terrestrial ecosystem science to improve *predictive capability*



Observations & Environmental Technologies

instrument development and retrieval science from the molecular to mesoscale

Theory & Process Science

aerosol, cloud and terrestrial ecosystems physics, chemistry, and dynamics

Modeling Across Scales

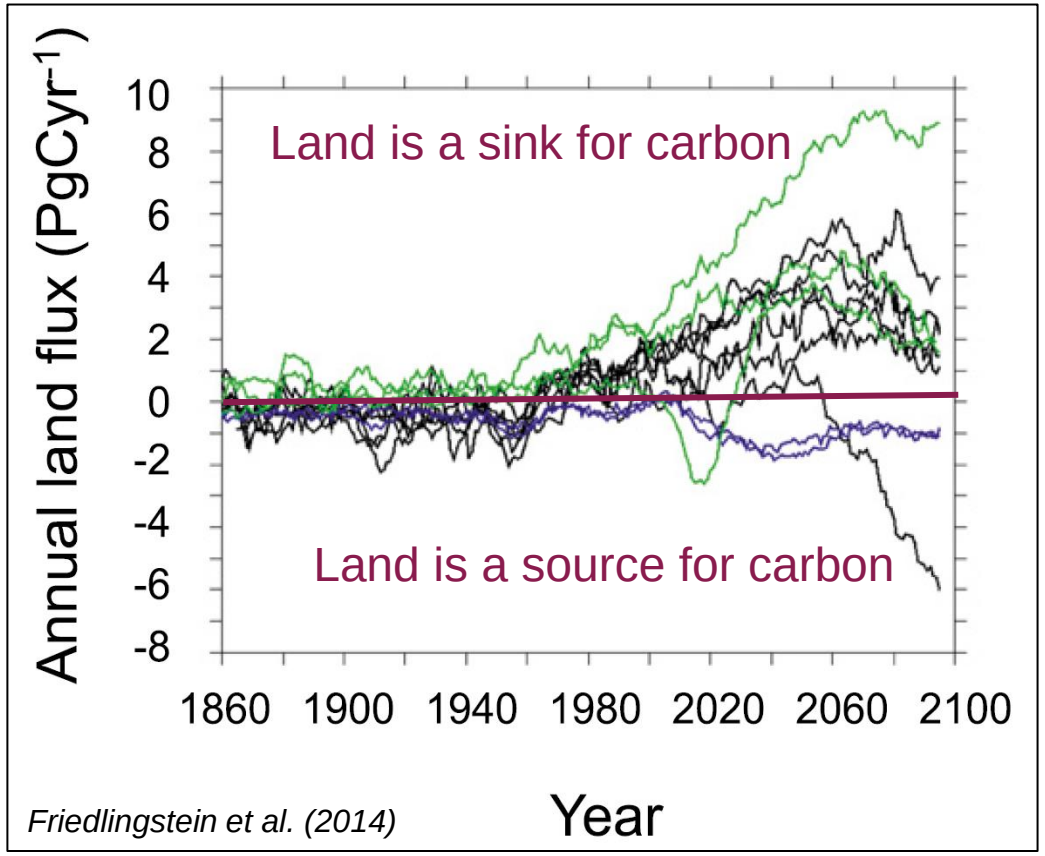
leaf-to-landscape and particle-to-global scale representations of terrestrial and atmospheric processes

Predictive Earth System Models ☆ Renewable Energy ☆ Urban Planning & Health

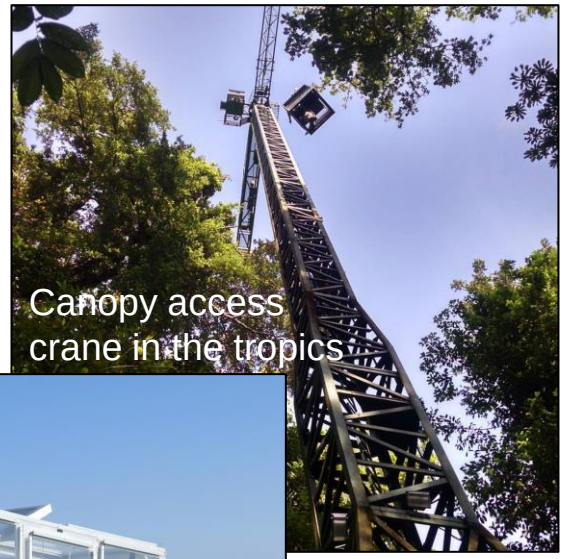
National Security and Intelligence Support

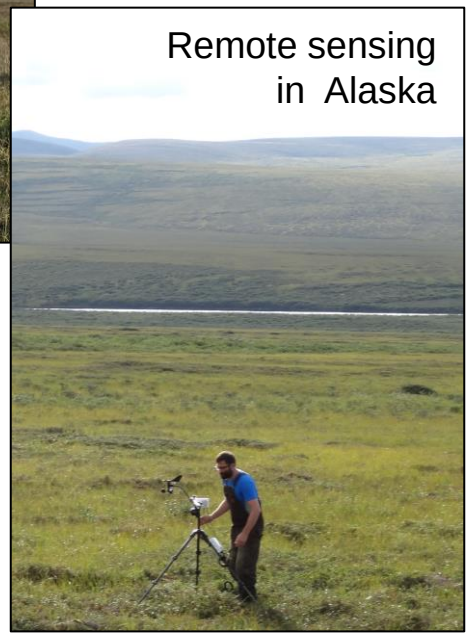
Terrestrial Ecosystem Science: Improved climate prediction through model-experiment interaction

How plants respond to environmental/climate changes and the impact of their ability to uptake carbon dioxide.



Friedlingstein et al. (2014)





We are working in understudied, globally important, and climatically sensitive biomes to improve model representation of key processes and enable improved model prediction of carbon dioxide uptake and storage.

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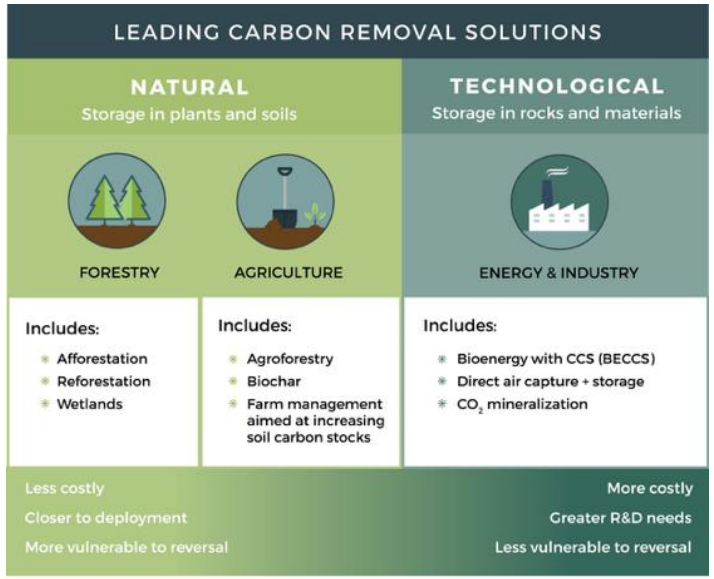
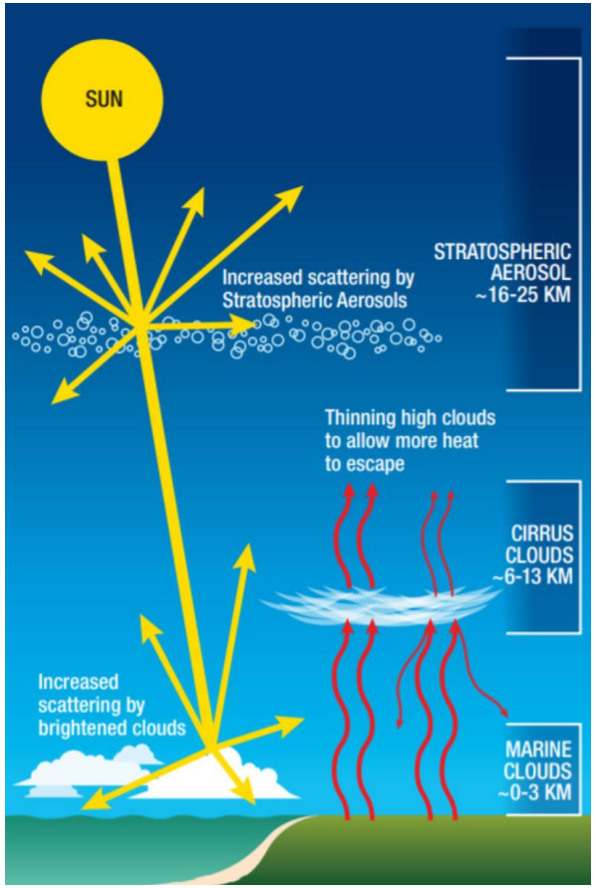
Climate Intervention/Geoengineering 101



- Geoengineering
  - Carbon Dioxide Removal (CDR)
    - Natural: Forestry Agricultural
    - Technological: Bioenergy Direct Capture
  - Solar Radiation Management (SRM)
    - Stratospheric Aerosol Injection (SAI)
    - Marine Cloud Brightening (MCB)
    - Cirrus Cloud Thinning (CCT)



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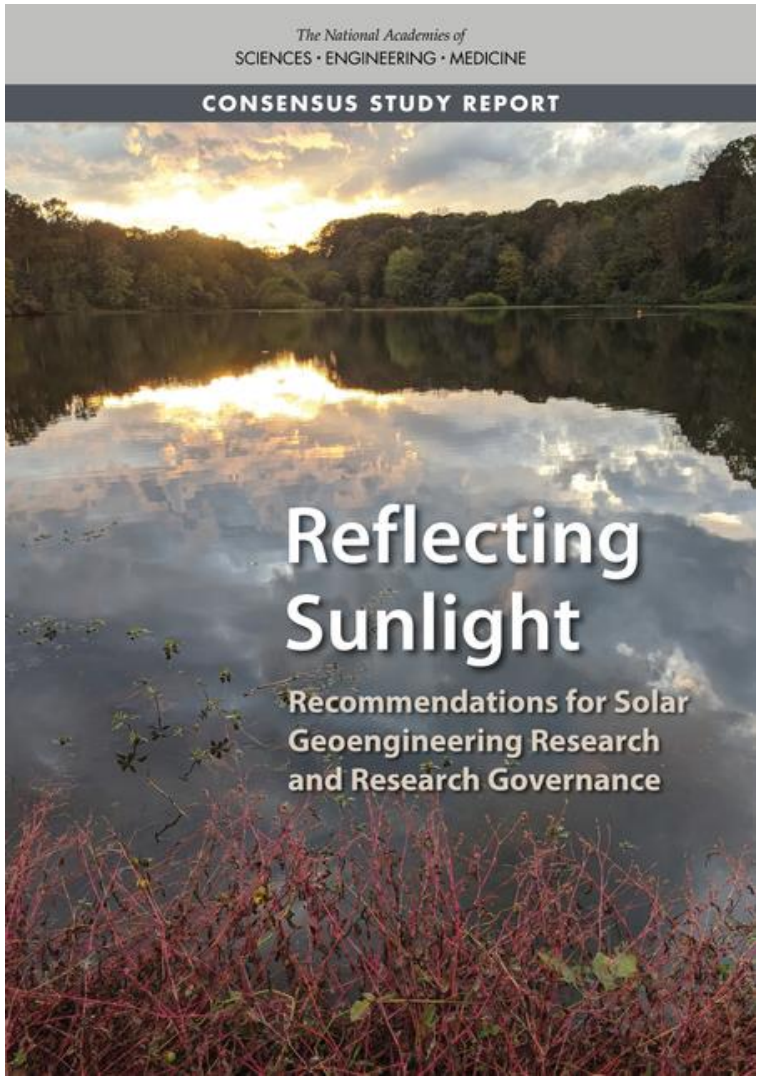
NASEM Reflecting Sunlight Report

A study on Solar Geoengineering:

- Calls upon US to implement a robust portfolio of climate mitigation and adaptation strategies
- Establish a national solar geoengineering research program ($100-200M over 5 years)
- Highlights the coordinated, cross-disciplinary research required
- Recommendations on solar geoengineering research and research governance



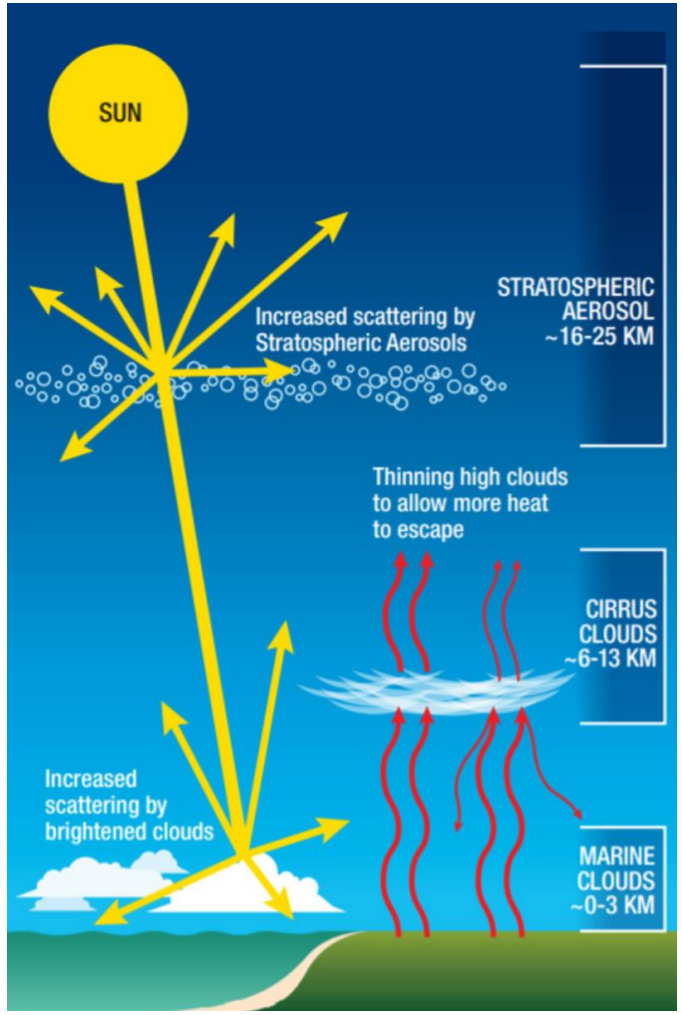
Climate Intervention Risks & Challenges

Risks:

- Outcomes of intervention are not commensurate with investment
- Negative unintended consequences (weather/climate impacts leading to social, economic impacts)
- Inability to detect and track impacts of the intervention

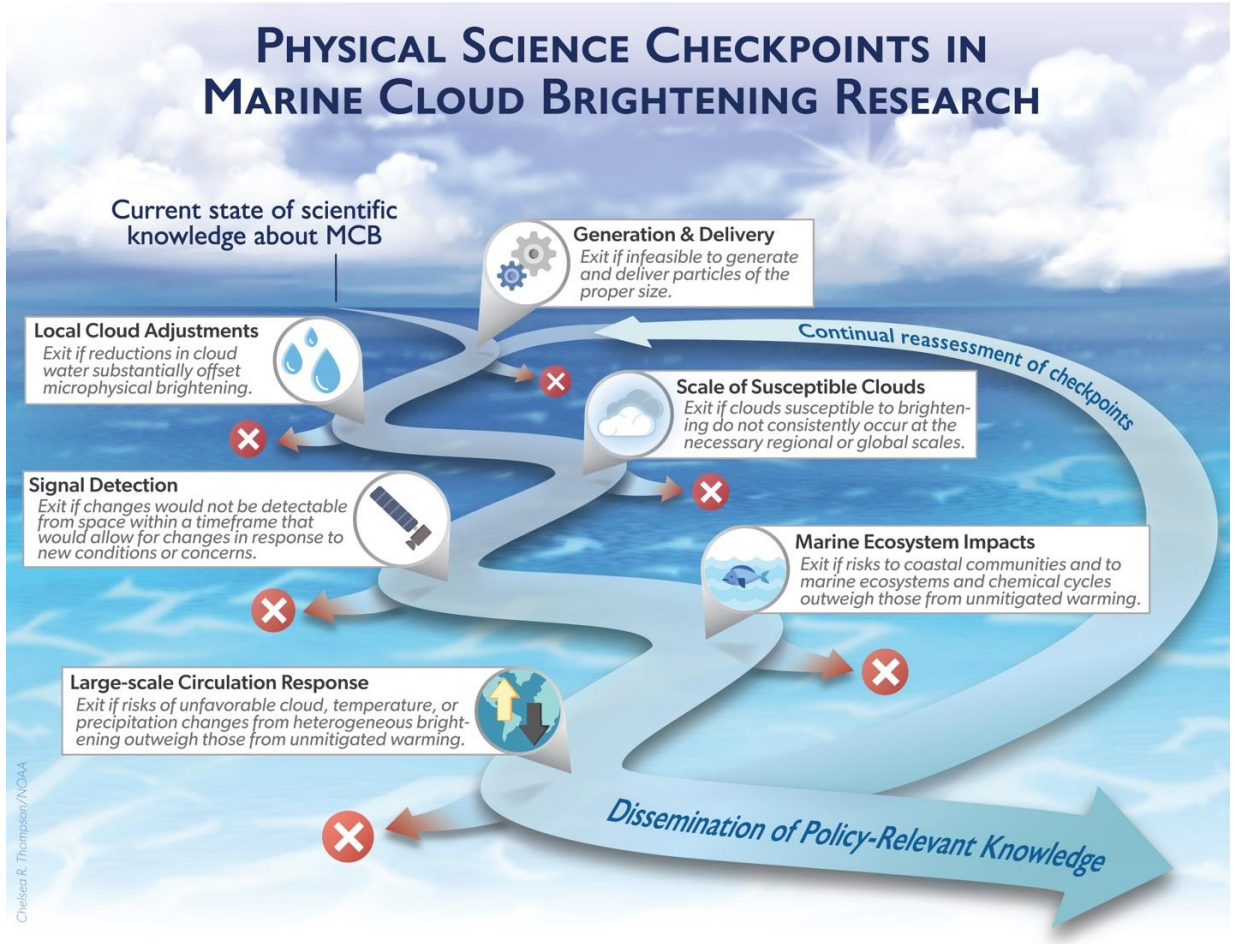
Challenges:

- Technical challenges associated with aerosol emission/injection (e.g., distributing in the right location, achieving the needed size distribution)
- Eliciting the needed local response (cloud or aerosol microphysical evolution)
- Eliciting a regional to global radiative response
- Detection of radiative flux perturbation
- Large-scale circulation responses and feedbacks (e.g., connecting to remote regional changes in weather/climate)



To assess marine cloud brightening's technical feasibility, we need to know what to study–and when to stop

Michael S. Diamond[a,b,1], Andrew Gettelman[c], Matthew D. Lebsock[d], Allison McComiskey[e], Lynn M. Russell[f], Robert Wood[g], and Graham Feingold[b]

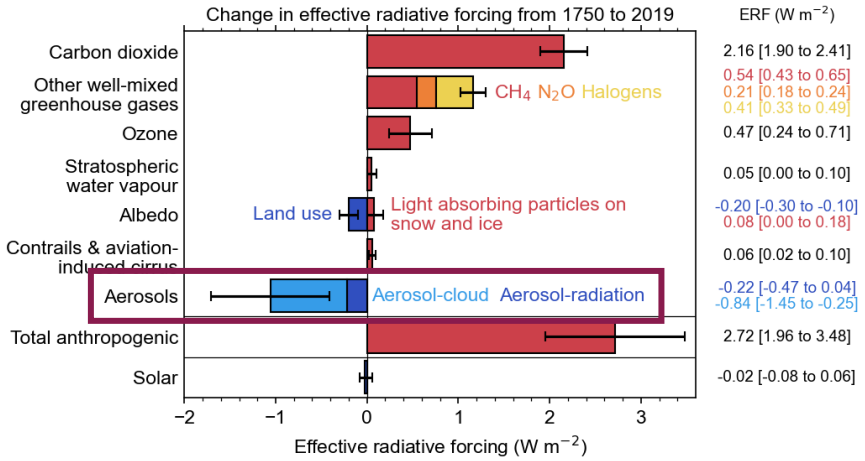


Aerosol Processes: Wildfire Impacts on Climate and Solar Power

Warming temperatures

- Precipitation change → Drying of vegetation
- Earlier springs extend wildfire season
- Impact winds that drive wildfires
- Wildfires release carbon into the atmosphere

positive feedback loop



- **~80% of U.S. wildfires are anthropogenic**
- Number and intensity of mid-latitude fires is increasing
- Biomass burning estimated to account for ~40% of black carbon (BC) emissions
- US sampling network suggests that aerosol mass and year-to-year variability is primarily driven by emissions from fires

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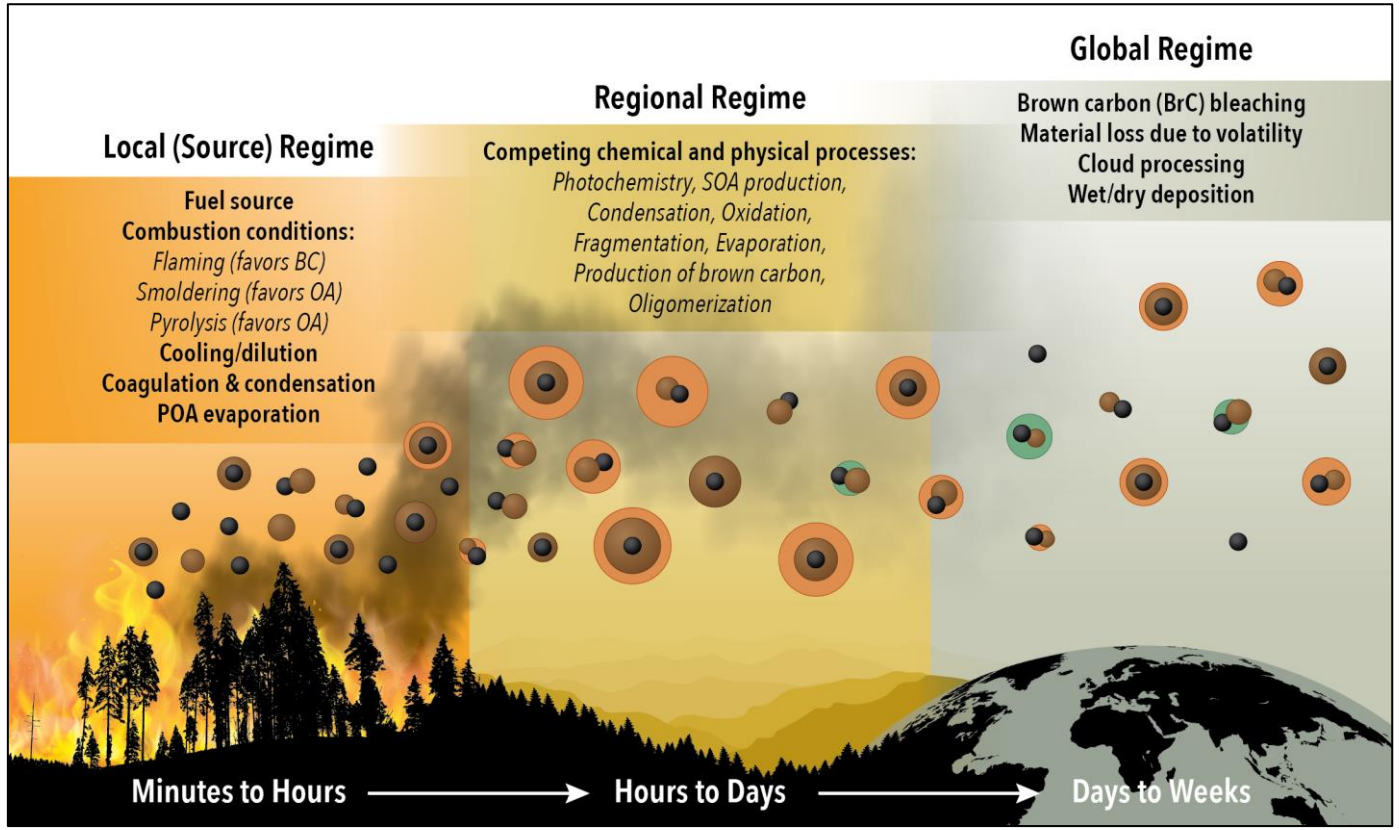
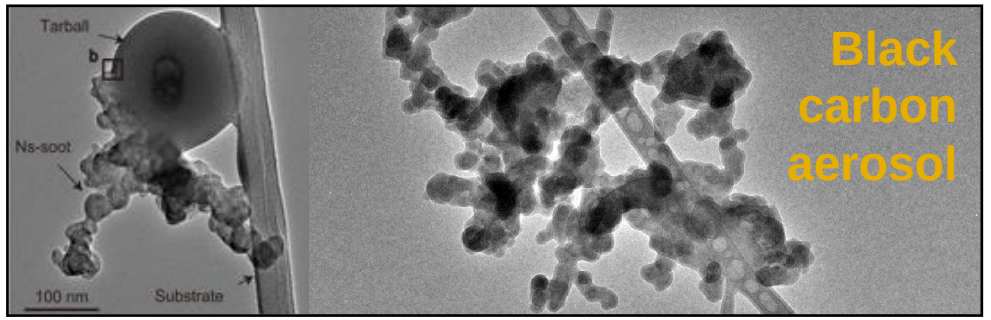
Aerosol Processes: Wildfire Impacts on Climate and Solar Power

Regime-based Model of Wildfire Aerosol Lifecycle





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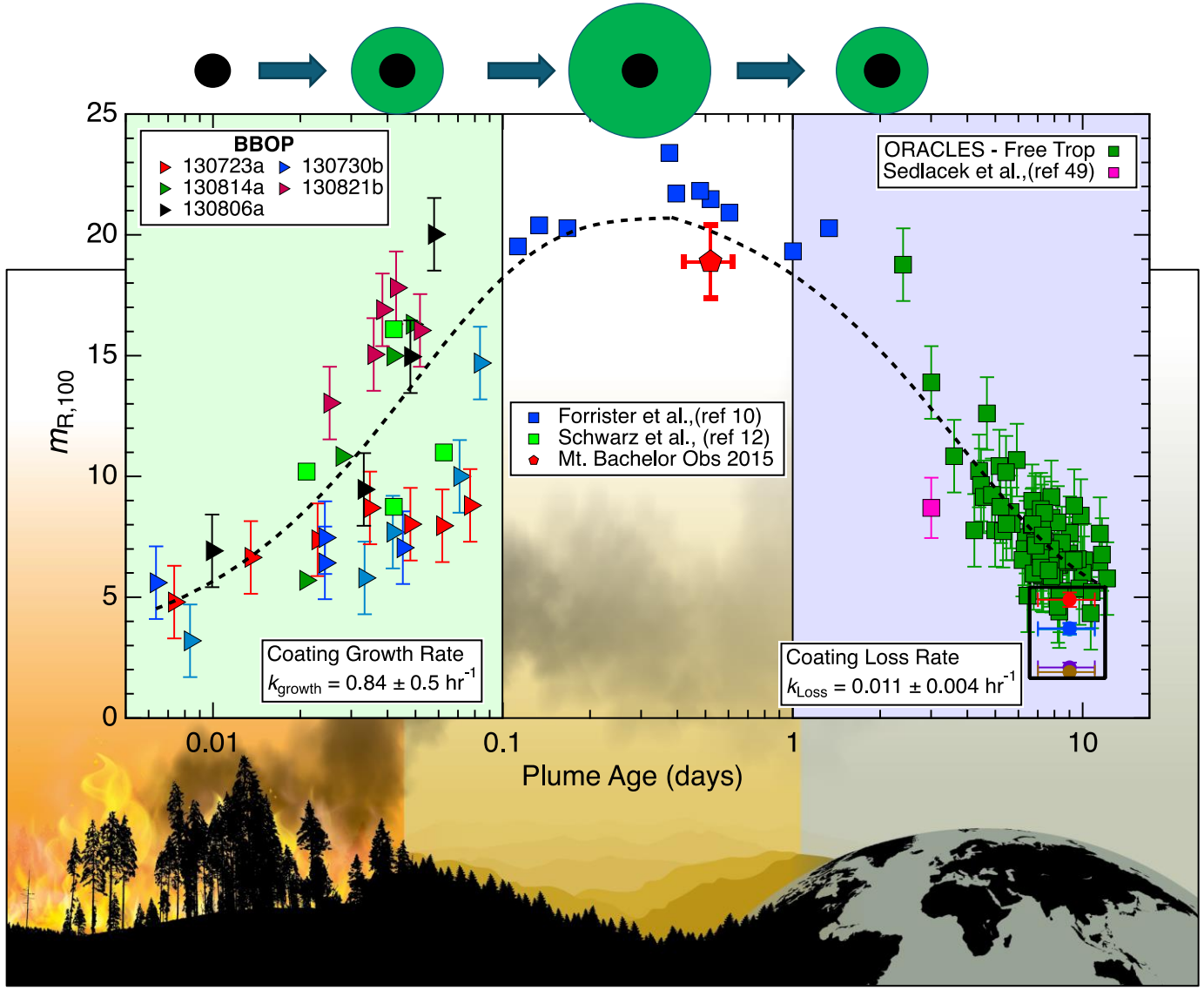
Aerosol Processes: Wildfire Impacts on Climate and Solar Power

Coating (green) on Black carbon (BC) initially grows and but then is lost with further aging.



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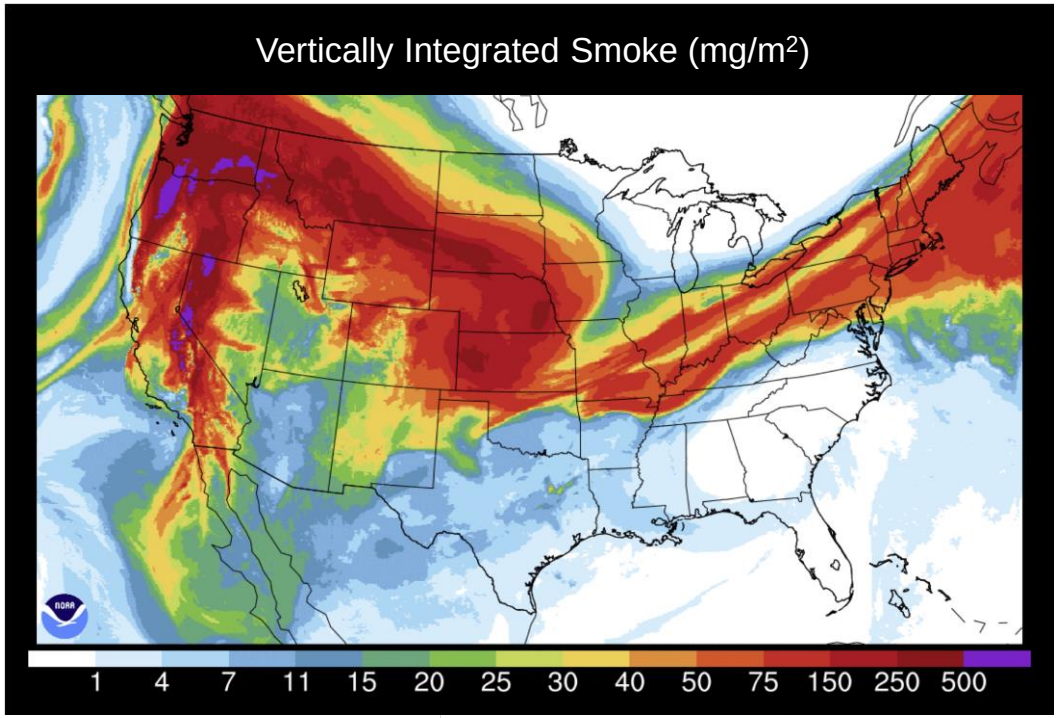

Wildfire haze
in NYC
15 Sept 2020

▲ The sun rises behind the Empire State Building in New York City in a haze created by smoke from the west coast wildfires, 15 September 2020. Photograph: Gary Hershorn/Getty Images

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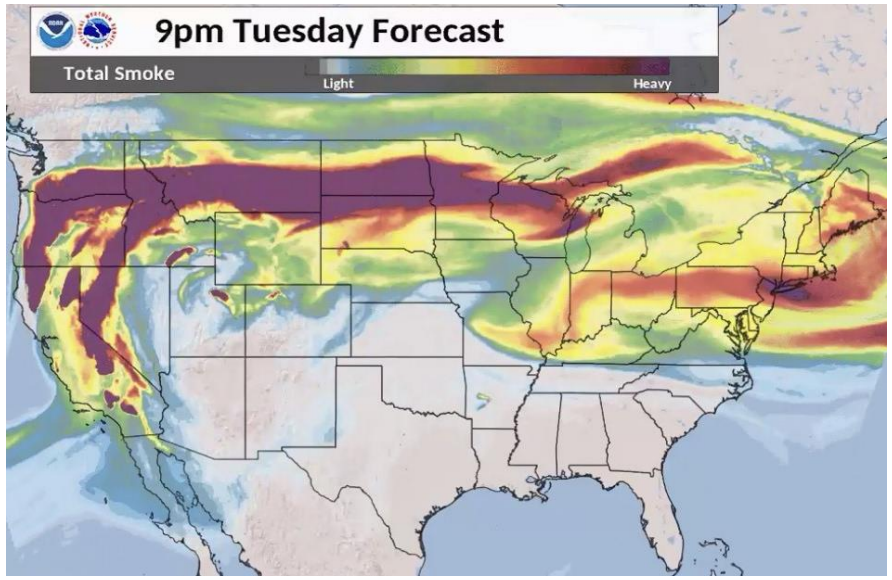
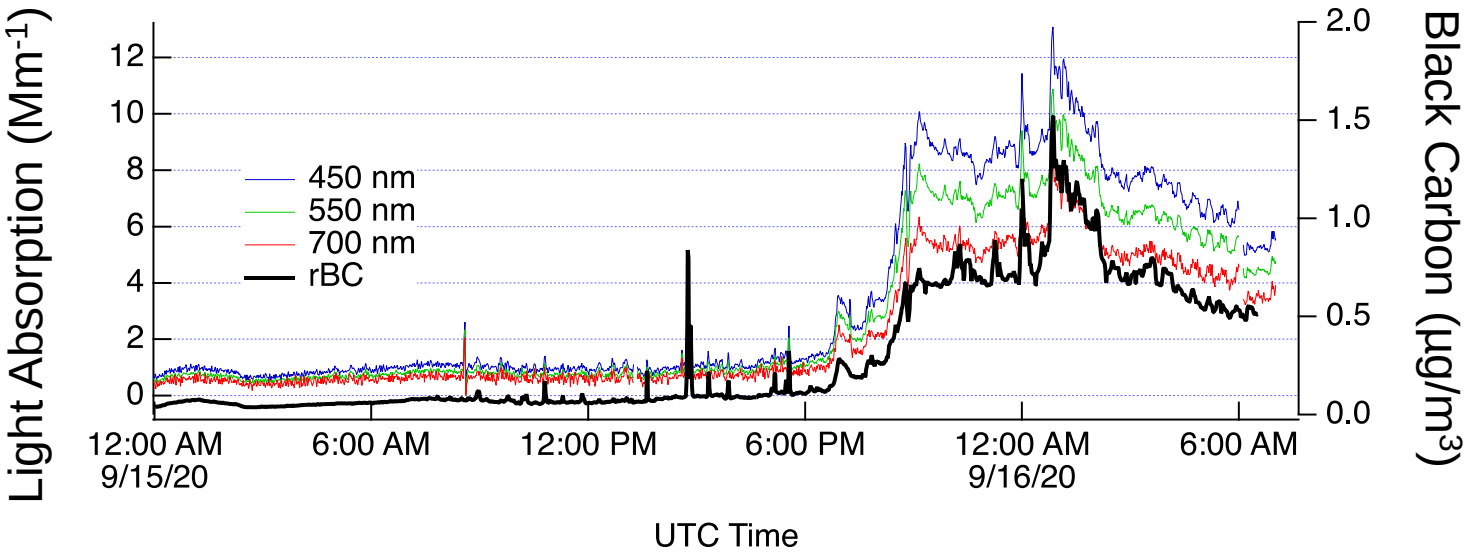
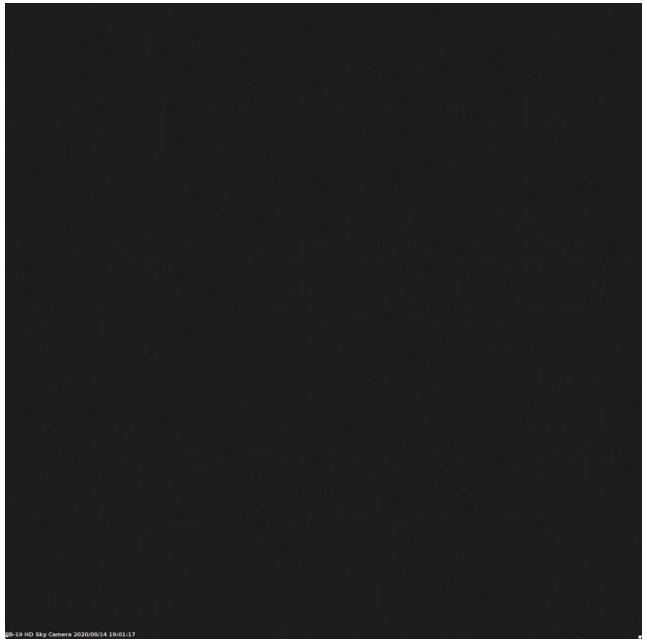
Aerosol Processes: Wildfire Impacts on Climate and Solar Power

BNL Solar Base Station Measurements for quantifying wildfire smoke plume impacts on solar energy







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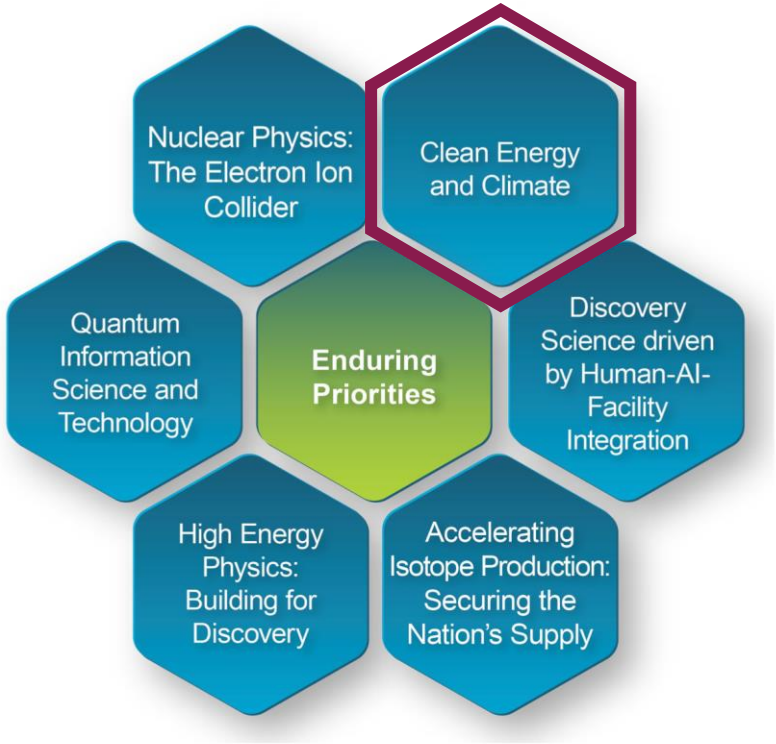

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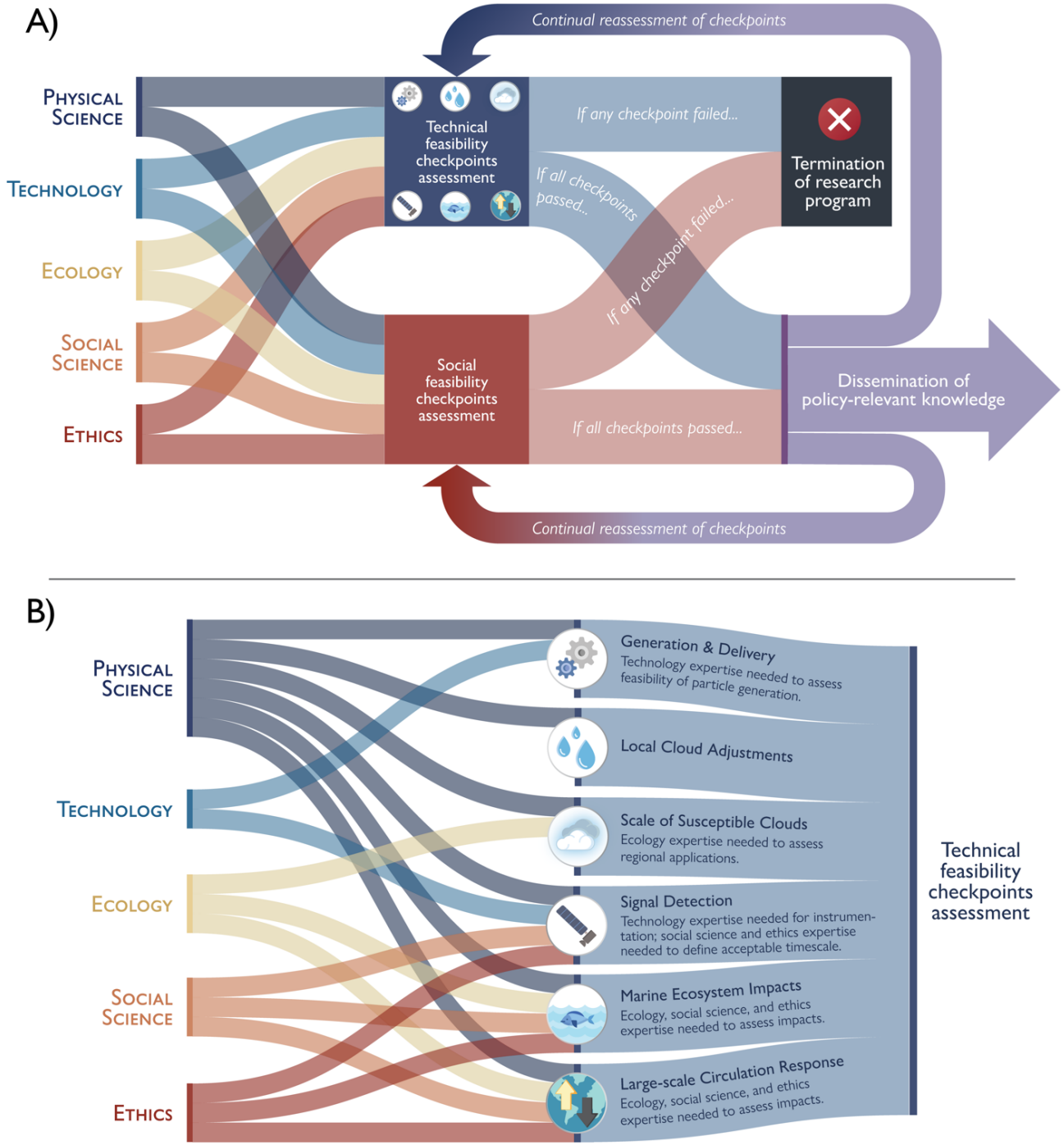
OPINION

Information flows that will inform

- the assessment of technical and social feasibility checkpoints, and thus
- decisions to take an exit ramp or to continue research, and
- the dissemination of policy-relevant knowledge



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