

All SRM Approaches

Method	Description	Potential Benefits	Challenges & Risks
<u>Stratospheric Aerosol Injection (SAI)</u>	Inserts small particles into the upper atmosphere, which reflects a very small proportion of sunlight back into space.	<ul style="list-style-type: none"> • Fast acting tool to address some types of climate impacts within months. • Scalable and adjustable to achieve targeted levels of cooling. 	<ul style="list-style-type: none"> • Deep uncertainty on impacts to precipitation, agriculture, public health, and other sectors. This also includes potential impacts on social, economic, and political systems. • Effects will vary spatially, with uneven impacts (both harms and benefits) across regions. • Sudden stop could cause rapid warming.
<u>Marine Cloud Brightening (MCB)</u>	Spraying sea salt towards low-lying marine clouds, to brighten them and increase their reflectivity.	<ul style="list-style-type: none"> • Could be applied in specific areas to address localized warming, such as protecting coral reefs or slowing Arctic ice loss. • Intensity and frequency applications could be adjusted based on research findings and climate conditions, offering a degree of control over its effects. 	<ul style="list-style-type: none"> • Impacts not well understood. • Could unintentionally disrupt regional precipitation patterns. • Effects would be unevenly distributed. • May only potentially work for certain types of clouds, limiting geographical availability and scaling potential. • May impact large-scale cyclical climate patterns, eg. El Niño-Southern Oscillation (ENSO).
<u>Cirrus Cloud Thinning (CCT)</u>	Injecting ice-nucleating particles into upper troposphere cirrus clouds reduces their lifetime and optical thickness, allowing more heat to escape from Earth's surface.	<ul style="list-style-type: none"> • Enhances Earth's ability to emit heat into space rather than reflecting sunlight. • May provide regional or global cooling effects. 	<ul style="list-style-type: none"> • Poorly understood cloud dynamics make this highly uncertain, at present. • Scalability is underexplored. • Could disrupt precipitation and weather patterns.



<p>Mixed-Phase Cloud Thinning (MCT)</p>	<p>Aims to thin clouds that contain both ice and liquid water to allow more heat to escape.</p>	<ul style="list-style-type: none"> • Works in the terrestrial radiation spectrum, potentially counteracting greenhouse gas effects. 	<ul style="list-style-type: none"> • Even more uncertain than CCT in terms of feasibility and effectiveness. • Technology for deployment is embryonic. • Could disrupt precipitation and weather patterns. • Unclear if it can achieve global cooling.
<p>Surface Brightening</p>	<p>Increases surface albedo by whitening land or water surfaces to reflect more sunlight.</p>	<ul style="list-style-type: none"> • Could provide localized cooling effects. 	<ul style="list-style-type: none"> • Modeling studies suggest it is unlikely to counteract global warming at large scales. • Scalability and cost – achieving global cooling would require an enormous amount of land and logistics.
<p>Space-Based Methods (SBM)</p>	<p>Positions mirrors or sunshades in space to reflect or block a portion of incoming sunlight before it reaches Earth.</p>	<ul style="list-style-type: none"> • Direct and uniform cooling without altering atmospheric chemistry. • Once operational, provides continuous solar radiation reduction. 	<ul style="list-style-type: none"> • Extremely high cost for engineering, deployment, and maintenance. • Very little research has focused on SBM thus far. • Current technologies are not advanced enough for large-scale implementation. • Could unintentionally alter natural processes such as photosynthesis.

All of the techniques represent innovative but highly experimental approaches to solar geoengineering. For instance, while space-based methods offer a bold vision for global cooling, they face [immense](#) technical, financial, and logistical barriers. Cirrus cloud thinning offers a more atmospheric-focused approach but [remains](#) poorly understood and carries significant uncertainties. Of note SAI and MCB are the most well-studied SRM techniques, although much more research is needed to understand their climate impacts, as well as addressing broader governance and ethical concerns.

Importantly, none of these techniques address the root cause of climate change—greenhouse gas emissions—and all would require much more research before they could be seriously considered as part of a broader climate strategy. This underscores the importance of emissions reductions, adaptation, and carbon removal as primary solutions to combat climate change.