



EC - ESA Aerosol Cloud Cluster

The EC-ESA Aerosol Cloud Cluster

Aerosols and their interactions with clouds remain the largest source of uncertainty in predicting climate change. They influence how sunlight is reflected or absorbed, and how clouds form, evolve, and produce rain. Because aerosols respond rapidly to emission changes, reducing the uncertainty in Aerosol-Cloud Interactions is essential to guide effective climate action and ensure that clean-air policies also deliver climate benefits.

The EC-ESA Aerosol Cloud Cluster brings together Europe's leading experts in this field, linking the two EU-funded projects [CleanCloud](#) and [CERTAINTY](#) as well as other ESA-funded initiatives such as [AIRSENSE](#). All three initiatives share the same overarching objective: enhancing our understanding of aerosol-cloud interactions to improve climate predictions and mitigation strategies. Together, they involve more than **220 researchers from nearly 40 institutions**, fostering an **unprecedented level of collaboration**.

[More info on the cluster](#)



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New policy brief: Addressing aerosol-cloud interactions for climate resilience

Based on Im et al. new publication (see below), a [policy brief](#) directed towards European policymakers stresses the need to invest in research to reduce uncertainties in aerosol-cloud interactions to enhance the ability to project near-term climate changes, strengthen resilience to extreme events and support effective mitigation strategies.

Uncertainties in how air pollution interacts with clouds (so-called aerosol-cloud interactions) are now the largest source of uncertainty in projecting near-term climate evolution and risk. Because aerosols respond quickly to emission changes, their

effects unfold over years to decades, the timescales most relevant for adaptation and mitigation planning.

Reducing these uncertainties is therefore essential to guide effective climate action, improve confidence in regional projections, and ensure that mitigation and clean-air policies deliver their intended climate benefits.

Policy brief

Feb. 2026

**From uncertainty to action:
Addressing aerosol-cloud interactions
for climate resilience**



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Introduction

Limiting global warming requires rapid and sustained reductions in greenhouse gas emissions. Yet, our ability to predict the past and regional pattern of climate change remains dominated by uncertainties linked to aerosols and their interactions with clouds. These key airborne particles are often emitted together with greenhouse gases, and influence how sunlight and heat are reflected or absorbed in the atmosphere, shaping cloud formation, rainfall, and temperature extremes. Uncertainties in how air pollution interacts with clouds so-called aerosol-cloud interactions, or ACI are now the largest source of uncertainty in projecting near-term climate evolution and risk. Because aerosols respond quickly to emission changes, their effects unfold over years to decades, the timescales most relevant for adaptation and mitigation planning.

Reducing these uncertainties is therefore essential to guide effective climate action, improve confidence in regional projections, and ensure that mitigation and clean-air policies deliver their intended climate benefits.

Figure 1. Aerosol-cloud interactions (ACI) represent the largest source of uncertainty on the estimated anthropogenic temperature change (im, et al., 2026)

How ACI uncertainty affects policy

Anticipating warming and extreme events demand more reliable near-term projections. In addition to greenhouse gas driven warming, recent record global temperatures have been influenced by air pollution related factors such as reduced sulfur emissions from shipping and China, low Saharan dust, and volcanic effects.

Untangling their influences is however very challenging, because of poorly constrained ACI. As a result of these uncertainties, policymakers cannot yet know how much recent warming stems from cleaner air policies versus greenhouse gases. This complicates estimates of the remaining carbon budget and of near-term regional climate change. Aerosols currently mask some greenhouse gas warming, but as air quality improves, this hidden warming will be revealed. It also limits confidence in climate sensitivity estimates, which determine how much the planet will warm for a given rise in CO₂, leaving open the possibility of both moderate and high-risk futures. At the regional level, ACI uncertainty prevents reliable projections of rainfall, monsoons, and extreme weather, undermining adaptation planning and evaluation of interventions such as Solar Radiation Management. Finally, it blurs the balance between public health gains from cleaner air and the climate risks of reduced aerosol cooling.

The challenges

- **Magnitude of uncertainty:** Current IPCC estimates of ACI's relative forcing range from -3.7 to -0.3 W/m², representing the largest uncertainty in human-induced climate change (since pre-industrial times).
- **Changing aerosol regimes:** Clean air policies are reducing anthropogenic aerosols, shifting cloud-aerosol dynamics and amplifying greenhouse gas warming, while natural aerosol types such as particles produced by wildfires, as well as mineral dust and sea spray grow more common in a warmer world.
- **Global complexity:** Different regions will experience distinct aerosol-cloud-cloud regimes, complicating adaptation and mitigation planning.
- **Global modeling:** Remote regions (especially the Global South) remain underrepresented, cloud microphysics and extreme precipitation processes are poorly captured in models.

Opportunities for progress

- **New satellite missions:** e.g. ESA EarthCARE, NASA PACE will deliver breakthrough aerosol-cloud data.
- **Ground estimates:** e.g. ACTRIS, AEROS expand long-term aerosol and cloud observation, especially needed in the Global South.
- **High-resolution models:** At km-scale capture storms and extremes more realistically.
- **Machine learning:** Accelerates model development and improves data interpretation.
- **Collaboration:** across disciplines and countries is key to rapid progress.

Policy recommendations

1. **Prioritize investment in satellite and ground-based observational infrastructure**, with emphasis on underserved regions (especially Global South).
2. **Accelerate high-resolution and aerosol-aware climate modeling**, including investment in computing infrastructure, that can better represent clouds and extreme events.
3. **Integrate new satellite mission data** rapidly into climate assessments and IPCC reports.
4. **Support interdisciplinary research** integrating atmospheric science, data science, and climate impacts.
5. **Promote global collaboration** to ensure rapid, open sharing of data and methods.
6. **Explicitly incorporate aerosol-cloud interactions** uncertainty into climate policies, carbon budget and adaptation & mitigation strategies.

Conclusion

Reducing uncertainties in aerosol-cloud interactions is not just a scientific priority, it is a prerequisite for sound climate policy. Investing in this research will directly enhance our ability to project near-term climate changes, strengthen resilience to extreme events, and support effective mitigation strategies.

References

Im, U., Samset, B. H., Nenes, A., Thomas, J. L., Kokkola, H., Dubovik, O., et al. (2026). Aerosol-cloud interactions: Overcoming a barrier to projecting near-term climate evolution and risk. *AGU Advances*, 7, e2025AV001872.

This project has received funding from the Horizon Europe programme under Marie Skłodowska Curie Grant Agreement No. 101137680 (CERTAINTY) and No. 101137639 (CleanCloud) and from European Coordinated Study on Aerosols and Aerosol/Cloud Interactions No. 4000142902/23/I-NS (AIRSENSE) supported by the European Space Agency. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union, the European Climate, Infrastructure and Environment Executive Agency, or the ESA. None of these entities can be held responsible for them.

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CERTAINTY
CLOUD-AEROSOL INTERACTIONS & THEIR IMPACTS IN THE EARTH SYSTEM

AIRSENSE

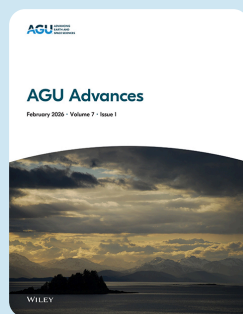
CleanCloud

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Read the policy brief

New joint publication



Im, U., Samset, B. H., Nenes, A., Thomas, J. L., Kokkola, H., Dubovik, O., et al. (2026). **Aerosol-cloud interactions: Overcoming a barrier to projecting near-term climate evolution and risk.** *AGU Advances*, 7, e2025AV001872.

<https://doi.org/10.1029/2025AV001872>

Read the publication

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