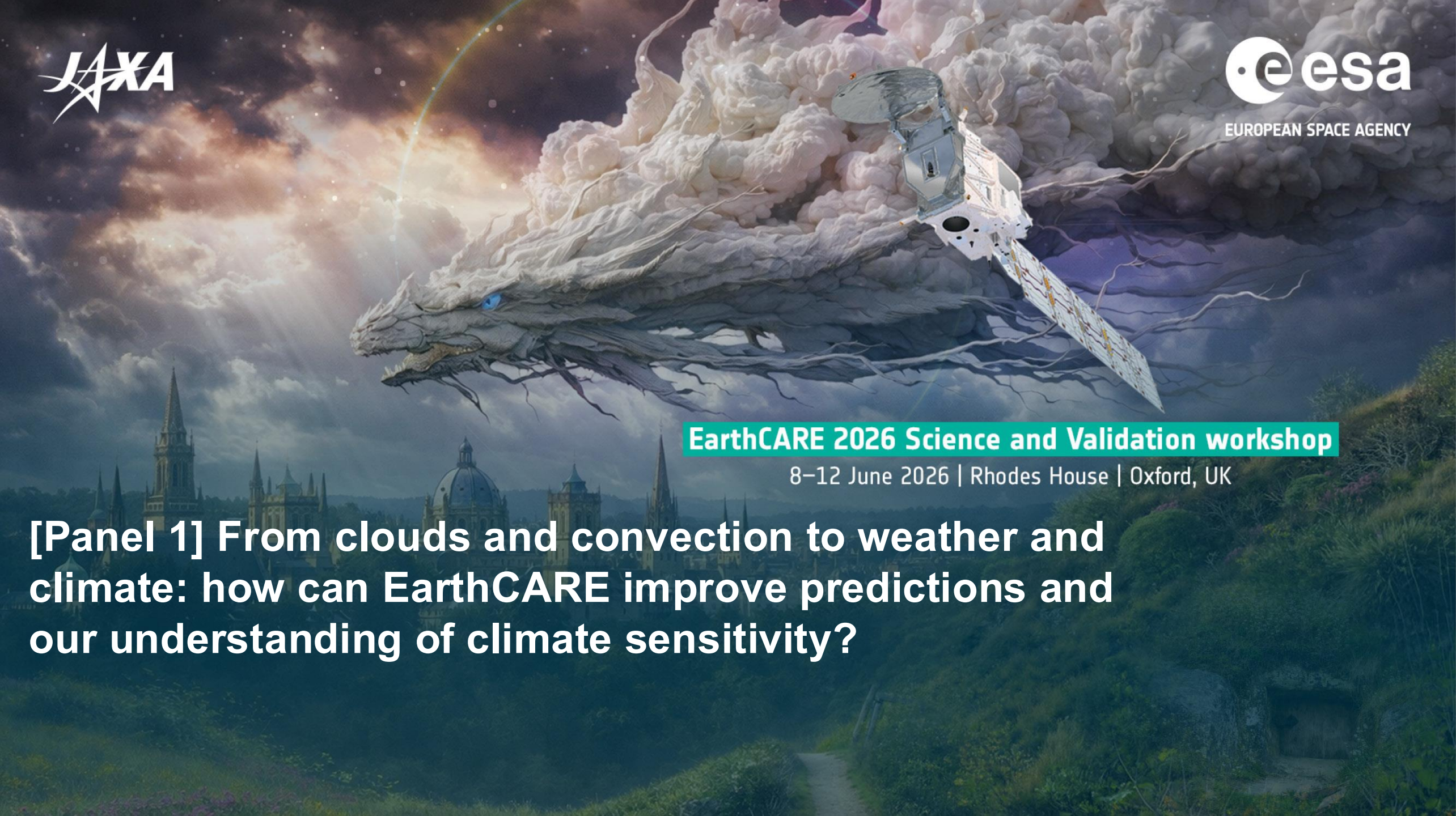


[Panel 1] From clouds and convection to weather and climate: how can EarthCARE improve predictions and our understanding of climate sensitivity?

Session #1 Summary

- Major science challenges
  - How can Doppler information improve the climate sensitivity estimate?
  - Better process-based understanding of cloud FB/ACI with dynamical info of EC
  - Detecting/Understanding long-term climate change
- Improving climate/weather models at a fundamental level
  - How can climate state/change be simulated more reliably with enhanced realism of cloud/convection physics?
  - Process-level model constraint: EC removes some “tunable knobs” (e.g. fall speed)
  - Use of simulators to compare models & EC consistently in observation space
- Data integration and long-term records
  - How have aerosol/cloud/precip/radiation profiles changed over past 20+ years?
  - Combining CS/CL & EC for constructing long-term data records

Session #1 Key issues/challenges

- How to link process understandings to constraint on cloud feedback/climate sensitivity
- Development of climate/weather models that give “right answer for right reason”
- Different sensitivities/capabilities b/w CS/CL & EC when combining them into homogeneous data records: Degrading EC algorithms?
- How to use AI: Not just as statistical fit but should complement physics-based understanding
- Bridging satellite and modelling communities closely: Need for coordinated efforts

Session #1 Proposed actions

- Propose some MIPs for EC-specific diagnostics (extended from ECOMIP)
  - FallSpeed-MIP (evaluating/constraining a key “tunable knob”)
  - Drizzle-MIP (addressing “dreary state of precipitation” issue)
  - Simulator-MIP (consistent forward simulations of EC observables)
  - Bridging EC & modelling communities for improving model cloud physics
- Construct long-term climate records of aerosol/cloud/precip/radiation vertical profiles
  - Stitching together CS/CL & EC into homogeneous data records
  - Applying EC operational algorithms (degraded) back to CS/CL data
- Use of AI for efficient retrievals of variables (cloud properties, CCN/INP, …)
  - e.g. 3D retrievals & 3D radiative closure
- Publication: Science highlight paper (on time for IPCC AR7)

[Panel 2] How do we use EarthCARE to better understand the climate impact of aerosols, including aerosol-cloud interactions?

Direct effects (1/3): extinction

ATLID extinction is a gamechanger!

- Still some refinements needed: use lidar ocean surface to get best possible estimate towards the surface (Gerd-Jan), improve cloud contamination, combine/verify with MSI optical depth, check European/Japanese products

We need to generate a Level-3 4D gridded dataset of monthly-averaged 355-nm extinction coefficient, for:

- Evaluating air-quality and climate models
- Generating climatologies for weather forecasting models
- Inferring some processes, e.g. deposition velocity (Konstantinos Rizos & Peter Hill)?
- In the longer term, studying trends, seasonal and inter-annual variability

Action: can we generate a consensus, validated L3 product? Would be of very wide interest!

- Could also store mean lidar ratio and depolarization ratio at each point

Direct effects (2/3): other properties

Extinction is only the start! We also need:

- Single scattering albedo: crucial for solar heating of the atmosphere, drives tropical monsoon flows
- Concentrations of cloud condensation nuclei (CCN) and ice nuclei (IN)
- Mass and size
- Discrete quantities: aerosol type, minerology, chemistry…

We have 3 pieces of information: lidar ratio, depolarization ratio and solar reflectance (daytime, mainly useful over sea), plus also geographic location, temperature and humidity:

- **Can we use field campaigns, AERONET and PACE coincidences (+GRASP, e.g. Oleg, Anton) to estimate the relationship between observables and the quantities we want**, and map them into our monthly means?
- Some are easier than others: which should be prioritized?

Direct effects (3/3): modelling

Model-Observation Intercomparison Projects (MOIPs)!

1. ECOMIP-Aerosol

- Focus on the period around 13 August 2024
- Evaluate slices of aerosol extinction and possibly radiative effects through Saharan dust, biomass burning from central Africa and Canadian widldfire smoke
- IFS-COMPO (CAMS), NICAM-SPRINTARS, ICON-HAM-lite …

2. Canadian Smoke 2025 MOIP

- Need help to gather the best observations (Moritz, Sergey, Annabel, Xuemei, Holger…)
- Share emission rates from ECMWF's GFAS system, possibly with recommended scaling
- Use this case to evaluate multiple aspects of models: emission rates, injection heights, self-lofting of plumes in the model due to solar heating of the absorbing aerosol, long-range transport, mixing across the tropopause in both directions…
- **What is the climatic effect of the smoke?** Repeat the work of Rosu et al. (2025), but with EarthCARE

3. Any other MOIPs?

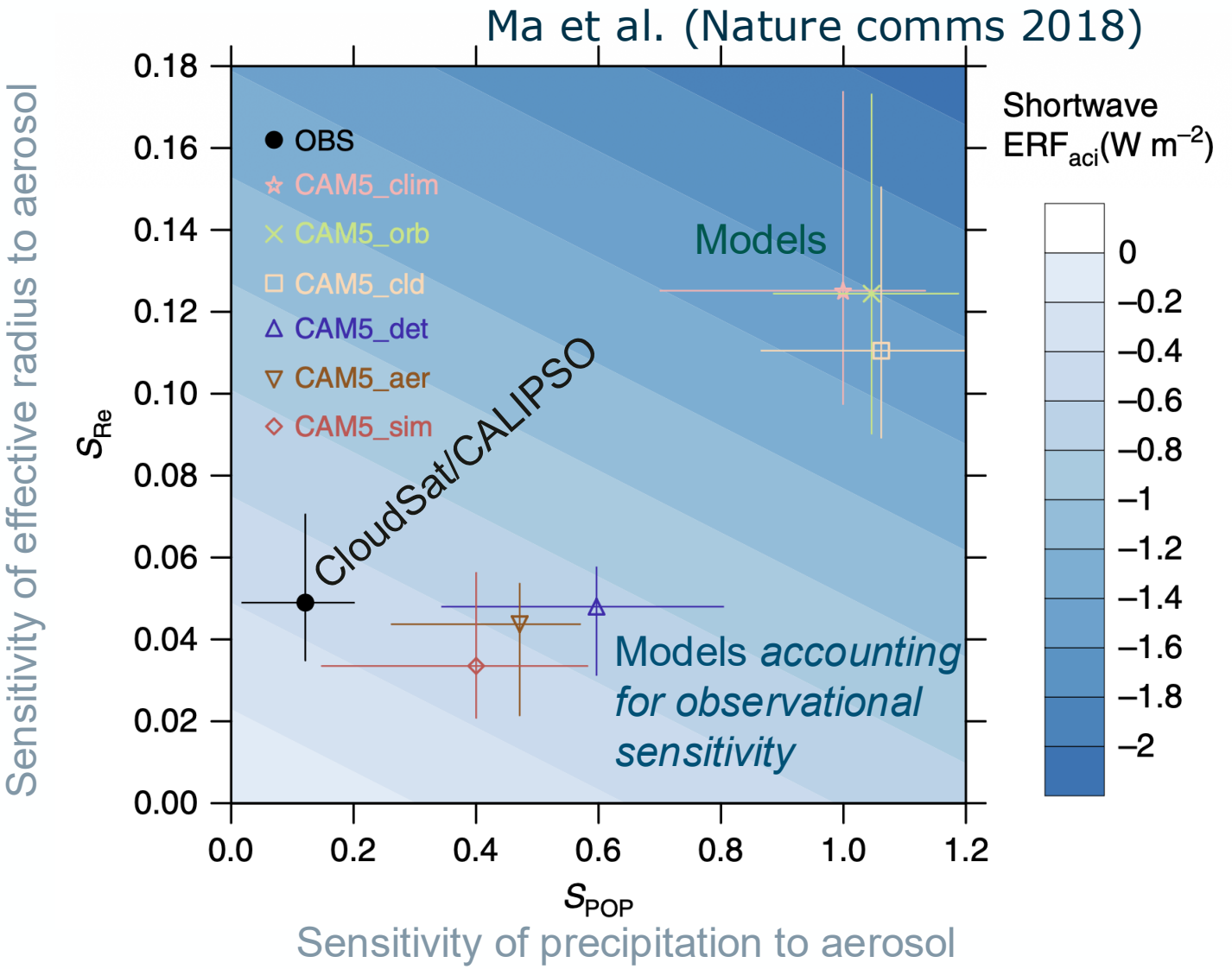
Aerosol-cloud interactions (1/2): liquid

Can we **re-do** earlier ACI analysis for boundary-layer liquid clouds with EarthCARE now that we have:

- Better aerosol measurements (inc. type & sensitivity to AOD < 0.1)
- Better clouds (inc. updrafts & drizzle)
- Better models (high resolution)?

Other examples? Volunteers to do this?

- What can we learn from natural laboratories, e.g. ship tracks, and from natural aerosol variability?
- How can we exploit GEO and other satellite imagery for lifecycle and regime changes such as open/closed cells (e.g. Johanna)?



ACI (2/2): ice clouds and convection

Ice clouds

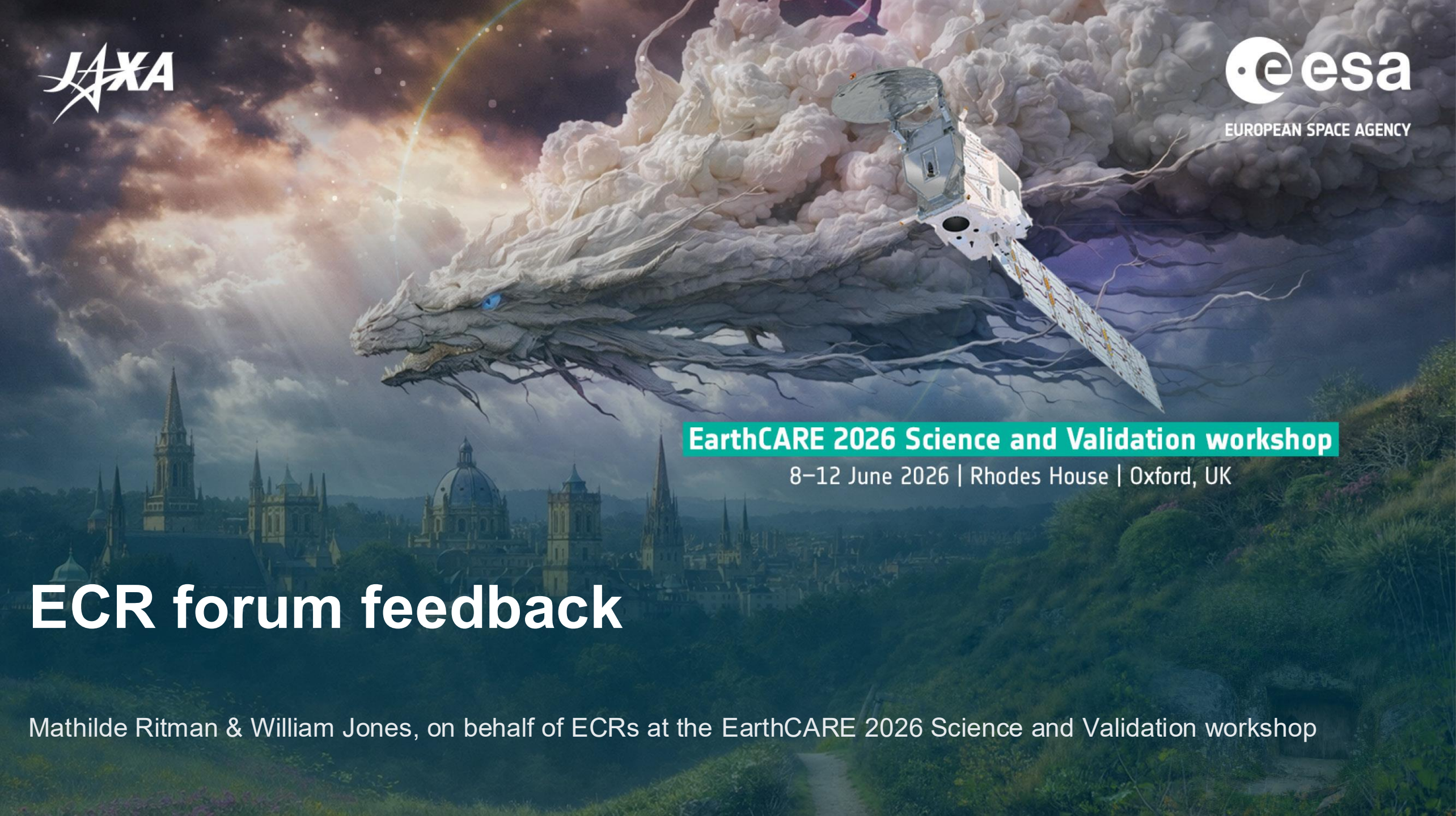
- We have fantastic measurements in desert dust and wildfire smoke, and more accurate ice cloud retrievals
- **Can we see a difference between ice clouds embedded in aerosol and in clean air?**
- Hints of increased ice number due to smoke (Kallista Angeloff) but is it robust, is it seen with desert dust, what is its radiative effect, how does it match model predictions, and how about ice cloud *occurrence*?
- What is the **role of dynamics**? Wave activity in ice clouds has been seen to trigger homogeneous nucleation, but does it have other effects?

Deep convection

- Models often show clear and theoretically detectable effects of aerosols, but very difficult to show in observations due to multiple confounding effects and chain of uncertain processes
- What are the natural laboratories we can use to detect an effect from EarthCARE? Use GEO for lifecycle (Mathilde & Will). *Cloud seeding is popular in some countries but is there a measurable difference between seeded and non-seeded clouds??!!*
- We have seen a **massive clean-up in East Asia**: so is there a difference between CloudSat/CALIPSO and EarthCARE convective (and other) clouds in this area, but not in areas where aerosols are unchanged?

Action summary

- Produce a **consensus L3 monthly-mean aerosol extinction product**
- **Extend to climatology of other properties**: single scattering albedo, minerology, type, size, mass, CNN/IN…
- **Model-Observation Intercomparison Projects**: ECOMIP-Aerosol, Canadian Smoke 2025… others
- **Re-do classic aerosol-cloud interaction studies** with better data
- **Compare ice cloud properties in clean and polluted air**
- **Consistent CloudSat/CALIPSO/MODIS to EarthCARE datasets** to study trends including effect of East Asian clean-up on convective clouds
- **Who will do this?** Can we setup working groups to tackle individual challenges?
- **How do we engage with other aerosol communities**, particularly modelling (e.g. AeroCom) and climate?



ECR forum feedback

Mathilde Ritman & William Jones, on behalf of ECRs at the EarthCARE 2026 Science and Validation workshop

Early career event

Key themes and motivation

How do we enable ECRs to think about the big questions in cloud and aerosol physics?

How do we connect ECRs – *particularly between Japan and Europe* – to work on the more important topics that EarthCARE can address?

Community visions for developing early career research using EarthCARE

1. EarthCARE young scientist network

- Create a directory of ECRs to foster collaboration
- Formulate key research questions and structured working groups
- Formal recognition from ESA/JAXA
- Representatives involved in workshop/hackathon planning

2. Knowledge exchange and development opportunities

- Share knowledge between ECRs
- Mentoring
- Highlight ECR topics with lightning presentations
- ECRs on review committees, panel discussions and co-convening workshop sessions

3. Travel support, research visits and fellowships

- Travel support for EarthCARE meetings
- Funding for research placements; promoting inter-disciplinary activities
- Independent research fellowships enabling blue-sky research