EarthCARE UK Science Meeting

6 June 2025, University of Reading, UK

A few of the 40 attendees of the meeting, gathered in the Sutcliffe Lecture Theatre.

ACTIONS

1. Survey UK community for which EarthCARE products would be most useful in a shared group workspace and enquire with JASMIN as to available space.
2. TS to follow up with PC and others about building a consortium to exploit EarthCARE data for climate research and model evaluation, including generation of L3 data.
3. AP to coordinate with Chilbolton campaign on EarthCARE overpasses.
4. AP to organise another meeting (early 2026?) with more focus on the aerosol and radiation research.

SUMMARY

- Meeting aims to identify collaborations in the UK enabled by EarthCARE.
- See SM's slides for links to data sources and advice using EarthCARE data or RH's slides for an overview of the types of observation available.
- The campaigns and validation session showed that EarthCARE products are performing well overall, but identified areas for improvement in complex cloud environments.
- The aerosols, clouds, precipitation session highlighted the important context provided by external observations including in situ campaigns, tracking aerosol sources, and understanding the diurnal cycle.

- The plenary discussion brough up the value of L3/4 data for extending the user base into the modelling community and identified interest in using EarthCARE's higher sensitivity to re-examine the features omitted from other datasets, such as unresolved low-level thin cloud.
- The modelling and radiation budget session demonstrated that assimilation of EarthCARE products is providing more value than expected thanks to the extensive preparation work and identified a role for EarthCARE products aggregated by cloud type to understand the drivers of radiation budget trends.
- Recurring themes in the breakout discussions were,
    - The belief that certain types of campaign, particularly a radar intercomparison at Chilbolton, can be easily aligned with EarthCARE overpasses if someone identifies when overpasses happen.
    - The broader importance of integrating EarthCARE observations within other measurements that provide context, such as geostationary imagery for temporal coverage or microwave coincidences for rain and snow retrievals.
    - That there are various opportunities to fund the generation and exploitation of aggregated EarthCARE products. This was of primary importance for the UK due to its ability to bring modelling teams on board.

Final Agenda

Time	*Activity*	*Responsible Person*
09.30 - 10.00	**Registration** (in foyer)	(Chris Westbrook)
10.00 - 10.05	**Welcome** (Lecture theatre GU01) H&S details; goals of the meeting	Adam Povey
10.05 - 10.20	**Introduction** Timeline of EarthCARE for the uninitiated and a preliminary overview of some scientific highlights	Robin Hogan
10.20 - 10.45	**Getting Started with EarthCARE: data products, access and tools**	Shannon Mason
10.45 - 11.15	**Campaigns & validation** 1: Initial comparisons of level-2 EarthCARE products with VERIFY campaign measurements 2: Validation for cloud extinction measurement of ATLID with inversion results from airborne lidar	C: Adam Povey 1: Kamil Mroz 2: Yixuan Pu
11.15 - 11.45	**Break** (room 1L61) Coffee; posters	(Chris Westbrook)

11.45 - 12.30	**Aerosols, clouds, precipitation** (Lecture theatre GU01) 1: Science applications for higher-level aerosol property retrievals based on machine learning models applied to EarthCARE ATLID observations 2: Assessing the non-CO2 impact of aviation using EarthCARE 3: Providing temporal context to spaceborne radar observations using cloud tracking	C: Adam Povey 1: Jens Redemann 2: Ed Gryspeerdt 3: Will Jones
12.30 - 13.00	**Plenary discussion:** Quick wins What are the UK's strengths that EarthCARE is best suited to leverage? What question can't you answer that EarthCARE could help with?	C: Robin Hogan
13.00 - 13.45	**Lunch** (room 1L61) Sandwiches; posters	(Chris Westbrook)
13.45 - 14.30	**Modelling & radiation budget** (Lecture theatre GU01) 1: Data assimilation of EarthCARE at ECMWF: initial impacts on global NWP and atmospheric composition forecasts 2: Recent trends in Earth energy imbalance and the contribution of low clouds 3: Improving the representation of ice and snow processes in the IFS using EarthCARE	C: Adam Povey 1: Mark Fielding 2: Paulo Ceppi 3: Richard Forbes
14.30 - 15.15	**Breakout discussions**: Potential collaborations What scientific questions is EarthCARE essential to answering? Where will the resource be found to facilitate that work?	C: Povey, Hogan, Mason, Stein
15.15 - 15.30	**Consolidation and ways forward** (Lecture theatre GU01) Summary of key points from sessions and discussions	Adam Povey
15.30 - 16.00	**Meeting close** **Drinks reception** celebrating Anthony Illingworth's contribution to EarthCARE (department coffee room)	(Reading)

NOTES FROM PLENARY DISCUSSION

RH: What are the UK's strengths that EarthCARE is best suited to leverage?
PC: Global and regional climate modelling is a strength that can be supported by L3/4 data, if that is being created.
ME: While such data is not funded as part of the mission, it could be funded from the Climate Office.

PSr: Flags tools such as CIS that make satellite or model data look like the other (in terms of grid, sampling, etc) to facilitate meaningful intercomparisons.
RH: Highlights the importance of subsetting orbits to simplify data handling.

AI: Thin layers of supercooled water above other clouds were a problem for the A-train.
RH: Unresolved clouds are important in general.
EG: EarthCARE is important because it is currently operational, and so captures new

events and overlaps with the MTG.
RT: It also contributes to real-time decision making.

JR: The Arctic is difficult to sample. If tracking is available, one can assess the longevity of mixed phase clouds. Also optically thin, low-level clouds that are a challenge to sense passively. EarthCARE provides data with which to train detection algorithms.
EG: We should utilise the International Polar Year coming in 2032.
HB: Work is already been done in this area that needs support.

MM: There is a campaign at Chilbolton to compare K and S band radars which could run during EarthCARE overpasses if someone would say when they are. That team is also interested in measurements of updrafts.

NOTES FROM BREAKOUT GROUP 1

Participants: AP (chair), AI, CWn, CR, KA, MF, RM, RF, YP
AI asked how sound was the result that cloud amount has changed (from the last presentation). AP hadn't seen it in passive records. CR mentioned a recent Chris Merchant paper.

AP asked what campaigns could be coordinated with EarthCARE for mutual benefit. CW mentioned the Chilbolton radar comparison. MF mentioned ACTRIS activities for the coming year and is interested in using ground-based observations to understand the diurnal cycle at a site to provide context for the EarthCARE overpasses. AI brings up the extensive coverage of rain radar in the UK and wondered how we reconcile that with satellite measurements' poor sensitivity near the surface; RF agreed. MF mentioned microwave but that has a much larger footprint. RM wondered if things are better over sea; RF says yes. Pointed out drizzle is important in cloud breakup. RM is using Chilbolton to understand mean Doppler velocity and would like to use EarthCARE as an independent source.

CR noted that aerosols went relatively unmentioned today, which AP apologised for. AI pondered the sensitivity of ATLID to ice nuclei. CWn mentioned that Chilbolton has a new 355nm lidar that's much less effort to run than the previous one. CR described the sensitivity to speciation.

AP asked if EarthCARE is being assimilated for dust? MF said AOD is still being used for that, though classification is an issue so they haven't tried using MSI's product yet. That was more due to time than lack of interest. KA would like to know more about the methods of aerosol classification. MF would like to see radiative closure from the ground to really understand the biases on the satellite before additional products are assimilated.

NOTES FROM BREAKOUT GROUP 2

Participants: RH (chair), PSr, HB, DR, ME, HR

Funding opportunities:

- PSr said he had asked NERC about whether new Highlight Topics were being considered, since this could be a way to support a substantial UK activity on EarthCARE. NERC have since replied to the effect that new Highlight Topics were not currently being considered but advised us to look out for Large Grant opportunities coming in the autumn. Note that Large Grants are not actually very large, although should definitely be considered when the time comes.
- RH is enquiring with ESA about current and up-coming funding opportunities, although typically ESA's open calls for data analysis are fairly small (e.g. 1 postdoc for 18 months). In 2026, there are likely to be two opportunities: the EarthCARE+ Innovation opportunity and an EO open call.
- ME said that, in principle, it is possible for the ESA Climate Office at ECSAT to fund the production of EarthCARE level-3 (global gridded) datasets, although they would need to be aligned with wider user needs, and be sufficiently mature.
- NCEO has already supported EarthCARE work (and continues to) via its co-funding of the VERIFY flights.

We discussed the mutual benefits between EarthCARE and geostationary satellite products. The Geo-ring dataset will consist of a unified dataset of L1 geostationary radiances with a time resolution of 30 minutes – test data are already available. Such a dataset could be useful for storm tracking to put the EarthCARE observations in context. RAL has plans to apply the ORAC aerosol/cloud retrieval to Geo-ring data, and are also interested to use EarthCARE data to validate their retrievals particularly in multi-layer situations.

We also discussed the potential for EarthCARE to study aerosol-cloud interactions (ACI). EarthCARE is particularly well suited to study "top-fed" ACI, where the properties of boundary-layer clouds are modified by free-troposphere aerosols entrained through the cloud top. It would be interesting if we could verify aerosol types in models using EarthCARE products, although this might require the ability to forward-model lidar ratio and depolarization ratio. There is also the potential to study the effect of aerosols on ice clouds and, indeed, cases have been identified where aerosols from Canadian wildfires have been entrained into both liquid and ice clouds. Polar clouds (both in the Arctic and near the coast of Antarctica) are also of particular interest, being typically mixed-phase and also poorly represented in models, while also being well sampled by EarthCARE's polar orbit. It would be interesting to coordinate with any NERC polar campaign, and also with ship campaigns led by CSIRO.

NOTES FROM BREAKOUT GROUP 3

Attendance: SM (chair), BL, CH, EG, JR, MM, PSk, RT, WJ

Our group discussion didn't cover all the seed questions topics, but returned several times to a few common areas of scientific interest relating to studies that would use the intersections of EarthCARE products with other satellite or ground-based observations, approaches that would take a high degree of technical preparation. I think there would be significant interest in cooperative efforts to facilitate the production of workflows or datasets such as:

- Intersections with UK Met Office merged precipitation radar network dataset (RT, BR, MM)
    - Validation of EarthCARE rain retrievals over land and sea
    - Verification of EarthCARE hydrometeor classification & retrievals using polarimetric observations
    - Putting EarthCARE products into a larger spatial and temporal context (e.g. evaluating EarthCARE's ACM-3D scene reconstruction)
- EarthCARE-GPM intersects (RT, BL, MM):
    - GPM Ku & Ka-band radar with wide swath and sun-asynchronous orbit; similar intersect products produced for CloudSat
    - Enables "triple-frequency" radar observations critical for microphysical and PSD information in snow
    - Would help inform the use of EarthCARE Doppler inference of riming
- Extracting GEO or other satellite products in the spatial & temporal vicinity of EarthCARE overpasses to place EarthCARE's observations and retrievals within a timeseries that complements EarthCARE's fixed overpass times (CH, WJ, JR, EG). Could be used to study:
    - Cloud-aerosol-precipitation interactions (e.g. evolution of ship tracks & contrails)
    - Convective evolution, structure & organisation

NOTES FROM BREAKOUT GROUP 4

Participants: TS (chair), RA, PS, RS, PH, MR, AM, DH, CWk, KM

Process-level questions:

- Consider RF's talk: process-level aspects are fundamental to how well models can produce longer term changes.
- Consider that EarthCARE follows on from A-Train, with Doppler and better lidar. Focus on convection seems sensible. But also aerosol-cloud interactions.
- Recall CloudSat: snow, precipitation were best observations. EarthCARE will be even better, Doppler drives snowfall rate.
- What's left to do? ECMWF is "easy", need to consider different configurations of Met Office model, centres? Alejandro did a lot on COSP evaluation.

- More generally, useful for high resolution model. But for global climate model time and spatial scales, how could new data be used to improve climate projections or at least climate model physics?
- CALIPSO – GOCCP type products? Yes, Level 3 type products would help, including satellite simulator.
- Validation of global models can still be on weather time scales, many centres run the same model for weather and climate. EC Earth. COSP simulator.
- Aerosol-cloud interactions. Better sensitivities especially in the stratosphere. Long term analysis, EC retrievals to pick up trends. See processes that were not observed before.
- Remaining issues with classifying clouds and aerosols. Extreme aerosol cases, smoke can be classified as clouds.
- Talking about the vertical wind – what about turbulence? Can we use EarthCARE to verify? Not easily. Small scale turbulence, noisy is too large. But perhaps that is a diagnostic? Extreme updrafts are of interest, but then suffer folding. Convective events Doppler are so "scrambled", difficult to say something quantitative, identify extreme updrafts. Quantifying the width of the convective core.
- Another science meeting regarding rate process of aerosol retrievals. Global lidar maps from different maps. WALES comparison different spatial resolutions?
- Arctic clouds: follow on from CloudSat and CALIPSO. 83 degrees North is further than A-Train. Low-level supercooled liquid clouds, interactions with sea ice, microwave radiometer interactions. Global snowfall work over Greenland, very easily verified with EarthCARE.
- Outstanding question: reconciling global precipitation with net radiative cooling. Missing precip, particularly snow? EarthCARE on hydrological cycle.
- Question about sampling range: Surface to 40 km ATLID, radar depends, 20km close to equator, 16km to poles. Relative to latitude not to surface.
- CPR, compared to CloudSat, has better sampling (100m vertical). Ground clutter less of an issue. Better capture of low-level clouds.

Validation:

- FAAM and Chilbolton seem to be the obvious facilities to verify or validate.
- Raman lidar new at NCAS, at Chilbolton at the moment. Pick out specific discrete layers e.g. Saharan dust. Distance from EarthCARE track? Saharan dust captured with Raman lidar
- Also sun photometer and radiometer even without the radars.
- FAAM workshop early September. Represent EarthCARE.
- Mobile facilities this summer? Ka band will go to Leeds eventually for COBALT project. There are costs associated with using mobile facilities.
- Vertical pointing underneath the track, rather than oblique angle? Scan across the track would be perfect.

Resources:

- FAAM workshop makes sense for follow up.
- Met Office K-scale steering group – requires COSP to be valuable, but also CASIM sensitivity.
- NERC highlight topic on EarthCARE? Would require a specific focused question.
- Aeolus "plus" was possible with ESA funding, similar mechanism available for EarthCARE?
- NERC Doctoral Focal Award? 3-year PhD cohorts of 8 students per Cohort. Scheme did not run for 2025 as was oversubscribed, but may run again for 2026. Could cover themes of:
    a. Riming (Met Office and ECMWF, get aviation involved?)
    b. Climate (get CMIP International Project Office ESA involved?)
    c. Machine learning
    d. Aerosol science
    e. Radar and FAAM process-level understanding with field work
- ESA fellowships, £200k

Other:

- Importance of stratocumulus! Key science area. Perhaps better captured by CPR. Drizzle was terrible, is that still the case? EarthCARE should do a better job…
- Lack of cloud over the Black Sea. 500m high, not fog. CPR still stopped from seeing? But pulse length 500m, so see clouds at 700m instead!
- Level 3 products, long term vision, plus CloudSat-CALIPSO. Consider level 3 EarthCARE, but also reanalysis of CloudSat-CALIPSO. Funding for CMIP at ESA? Focus on level 3 product workshops maybe facilitated by CMIP International Office?

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