# ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

## Science Session Summaries

*Session Chairs*

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- **Alessandro Battaglia,** Politecnico di Torino
- **Anthony Illingworth,** University of Reading
- **Bjorn Stevens,** Max Planck Institute of Meteorology, MPI
- **Dave Donovan,** Koninklijk Nederlands Meteorologisch Instituut, KNMI
- **David Winker,** National Aeronautics and Space Administration, NASA
- **Deborah G. Vane,** Jet Propulsion Laboratory, JPL
- **Jason Cole,** Environment and Climate Change Canada
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- **Nicolas Clerbaux,** Royal Meteorological Institute of Belgium
- **Pavlos Kollias,** Stony Brook University
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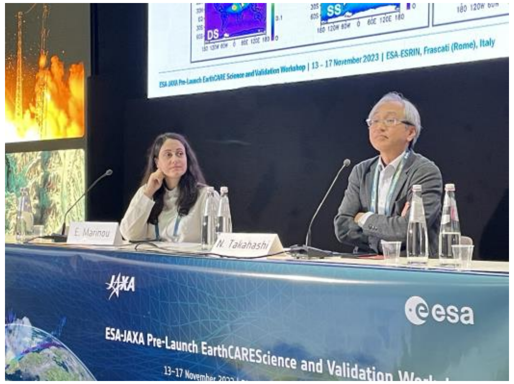
- **Holger Baars,** Leibniz-Institut für Troposphärenforschung e.V., TROPOS
- **Eleni Marinou,** National Observatory of Athens, NOA
- **Almudena Velazquez,** Royal Meteorological Institute of Belgium

## JAXA Scientists:

- **Takashi Nakajima,** Tokai University
- **Teruyuki Nakajima,** Earth Observation Research Center, Japan Aerospace Exploration Agency, JAXA
- **Tomoaki Nishizawa,** National Institute for Environmental Studies
- **Yuichi Ohno,** National Institute of Information and Communications Technology, NICT
- **Hajime Okamoto,** Kyushu University
- **Masaki Satoh,** University of Tokyo
- **Kentaroh Suzuki,** University of Tokyo
- **Nobuhiro Takahashi,** Nagoya University
- **Kozo Okamoto,** Meteorological Research Institute
- **Seiji Kato,** National Aeronautics and Space Administration, NASA

# Science Session Chairs








# Science Sessions

1. Processes and Algorithms 1: Lidar
   - Chairs: Eleni Marinou (NOA), Nobuhiro Takahashi (Nagoya University)
2. Processes and Algorithms 2: Aerosols and Clouds,
   - Chairs:  Ulla Wandinger (TROPOS), Tomoaki Nishizawa (NIES)
3. Techniques 1: Simulator and Corrections,
   - Chairs Alessandro Battaglia (Politecnico di Torino), Teruyuki Nakajima (JAXA)
4. Techniques 2: Missions,
   - Chairs: Silke Groß (DLR), Seiji Kato (NASA)
5. Processes and Algorithms 3+4: Radar and Imagers + Deep Convection and Cirrus,
   - Chairs: Rene Preusker (FU), Kaori Sato (Kyushu University)
6. Processes and Algorithms 5: Cloud µPhysics,
   - Chairs: Pavlos Kollias (Stony Brook University), Takashi Nakajima (University of Tokyo)
7. Long-Term Data Records,
   - Chairs: Nicolas Clerbaux (RMI), Rei Kudo, Meteorological Research Institute, Japan Meteorological Agency
8. Model Assimilation and Parameterisation,
   - Chairs: Jason Cole (ECCC), Kentaroh Suzuki (University of Tokyo) , feat. Graeme  Stephens
9. Radiation and ERB,
   - Chairs: Seiji Kato (NASA), Nicolas Clerbaux (RMI)
10. Summaries and Science Discussion,
    - Chairs: Robin Hogan (ECMWF), Hajime Okamoto (Kyushu University)

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## Science Session: Processes and Algorithms 1: Lidar
## Main Points, findings, and recommendations

*N. Takahashi, E. Marinou, T. Nishizawa, J. Redemann, A. Floutsi, M. Haaring, G. Liberti*

# Main points, findings, recommendations

The speakers presented new retrievals on aerosol properties which will or could be applied to EarthCARE products, and the evaluation of the new retrievals with in-situ measurements or simulators. One talk concentrated on ocean color properties proposing new EarthCARE products.

- **Tomoaki Nishizawa** talk: JAXA L2 aerosol products algorithms have been developed and evaluated using JAXA's Joint-simulator. Research products will be developed for EarthCARE, including products inferring aerosol species. Trend analysis for each aerosol specie using CALIOP-MODIS long-term data was presented, with possible application to EarthCARE. Recommendations: The addition of a dusty-marine aerosol type in the JAXA aerosol target mask could improve the detection of these mixtures which have significant global presence.

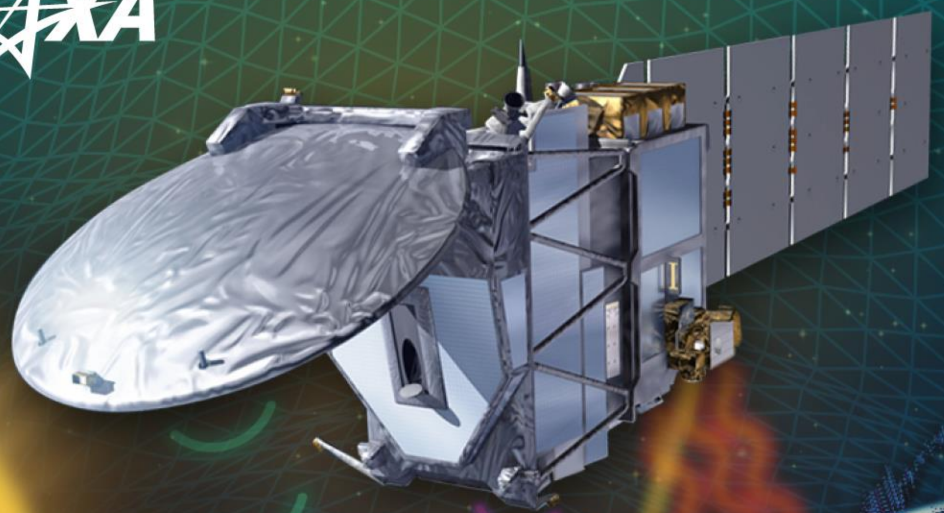
- **Jens Redemann** talk: Towards supporting science studies on ACI (till more knowledge is obtained for retrievals), the use of neural network methodology trained with NASA high-quality dataset, provides promising results for the derivation of CCN concentrations. This methodology could be implemented on satellite measurements. Recommendation: To enhance the training dataset with more dust cases and pristine environment cases and use the developed methodology for separate aerosol species. To consider including higher-level retrievals (e.g. CCN, IN) as new EarthCARE products.

# Main points, findings, recommendations

- **<u>Athena Floutsi</u>** <u>talk</u>: EarthCARE HETEAC and HETEAC-flex typing algorithms are developed and continuously optimized. Higher possibility of typing misclassification is expected for mixture layers. Airborne in situ measurements bellow EarthCARE overpasses would be specifically useful for the evaluation of the retrievals in mixed aerosol layers. <u>Recommendations:</u> (1) A sensitivity study for a better overview of the algorithm's performance with the EarthCARE "noisier" measurements is recomended. (2) EarthCARE under-flights with in-situ airborne measurements on mixture layers is highlited. A fast provision of the cal/val datasets to the algorithm developers (and ESA's EVDC repository) would be highly appreciated.

- **<u>Moritz Haarig</u>** <u>talk</u>: The validation of HETEAC algorithm with airborne in-situ measurements in first cases in the Mediterranean show promising results for effective diameter (withing retrieval uncertainty), underestimation of real and imaginary part of the refractive Index (improvements are ongoing). <u>Recommendations</u>: EarthCARE under-flights with in-situ airborne measurements covering the broad size range (≈10 nm – 50 µm) is appreciated, especially in mixture layers. Again, fast provision of the cal/val datasets to the algorithm developers (and ESA's EVDC repository) is highly appreciated.

- **<u>Gianluigi Liberty</u>** <u>talk:</u> The feasibility of deriving an ocean colour product from ADM-Aladin observations was investigated, using LioC newly-developed physically based retrieval algorithm. The derived products were validated demonstrating the potential of the observations. Applying this approach to ATLID, is of interest from the user community. <u>Recommendations</u>: Expand EarthCARE products with see-related retrievals, utilizing the Aeolus developed expertise. Improve LioC simulator for EarthCARE mission, accounting for atmospheric disturbances, and sea surface reflection contribution due to the EarthCARE geometry.



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## Processes and Algorithms 2: Aerosols and Clouds

*Chairs: Ulla Wandinger (TROPOS), Tomoaki Nishizawa (NIES)*

# Processes and Algorithms 2: Aerosols and Clouds

Presentations by: Philip Stier, Rui Song, Detlef Müller, Thanos Nenes, Gerd-Jan van Zadelhoff, Loredana Spezzi

- High-resolution modelling meets high-resolution observations:  EarthCARE comes just in time for using the new opportunities of kilometer-scale modelling; coupling of profiling and geostationary observations needed

- Resolving aerosol microphysical and chemical properties with high vertical resolution is the key for understanding aerosol-cloud interaction processes; potential to combine and use long-term satellite observations (CALIOP, ALADIN, ATLID) and new capabilities of ground-based lidars to improve aerosol characterization

- The new opportunities provided by EarthCARE are going to be used by a large community of researchers working on improving our knowledge on aerosol-cloud interactions, the research is supported by two HORIZON Europe projects (CERTAINTY and CleanCloud, 2024-2027) and one dedicated ESA project (AIRSENSE, 2023-2025)

- EUMETSAT is interested in using EarthCARE data for cross-satellite validation with the perspective of providing quality-assured long-term data on aerosol and clouds; activities also include validation with ground-based network observations (activities supported by ACTRIS/ATMO-ACCESS)

➢ Large community efforts are planned around EarthCARE, good exchange and communication to be established, new ideas to be created

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## Summary of the Session: Techniques: Simulator and corrections

*Chairs:* Alessandro Battaglia and Teruyuki Nakajima

This session had six presentations regarding correction techniques and data use system for the eCARE data:

T.Nakajima: Overview of the last 30 years development of cloud and aerosol remote sensing and modeling.

R. Hogan: Perspective on forward models. An idea of an economical 3D radiative transfer of the 3D cloud modeling. Importance of including radar TB as an additional constraint (on going work, useful for rain/cloud partitioning and ice scattering properties). Any other forward modeling development envisaged for post-launch?

B.P. Treserras: Introduction of the geolocation system for CPR and ATLID instruments. "Continuosly running during commissioning phase" (other techniques on what timescale will it work? Can it improve pointing correction for the Doppler?)

O. Sy: Improved method of retrieving Doppler widths for EarthCARE-like CPR. Can we use this technique? Is there added value in spectral width (dominated by platform Doppler fading?)

D. Donovan: Successful development of the cross talk correction of ATLID. Now implemented and documented, to be tested during commissioning phase. Any strategy to test how effective it will be?

A. Hünerbein: Introduction of Geometrical and spectral correction system for the MSI smile effect. Same as previous.

Science Session: Processes and Algorithms 3: Radar and Imagers, Chairs: Rene Preusker (FU), Kaori Sato (Kyushu University)

1. Kamil Mroz, NCEO, University Of Leicester
   - CPR only algorithm was described for vertical distribution of microphysical parametersconsidering realistic snowflake shapes .
   - Reflectivity was more informative for ice and snow, while mean Doppler velocity was more useful in rain.
   - Validation needs e.g., to improve underestimation for large raindrop sizes (>1mm), and importance of vertical wind estimate was pointed out.
   - Questions from audience (QfA): Uncertainty of measurement (1dB, 0.2 m/s)
2. Minrui Wang, Tokai University:
   - Nicam/joint-simulator Data was used to test cloud retrievals (optical thickness and particle effective radius) for MSI, in particular the effect of MSI's spectral misalignement.
   - Effect on shallow water clouds and deep convective clouds is small (~ 2% for COT, 3-6 % for CDR)
   - QfA: how is the effect on cloud detection (later answer: very little)
3. Takashi Nakajima, University of Tokyo:
   - Analysis of warm-water clouds by the combined use of cloud radar and the imager
   - Doppler Capability will give exciting new insight
   - Combination with NG geostationary will allow observations every 2.5-10min!

Science Session: Processes and Algorithms 3: Radar and Imagers, Chairs: Rene Preusker (FU), Kaori Sato (Kyushu University)

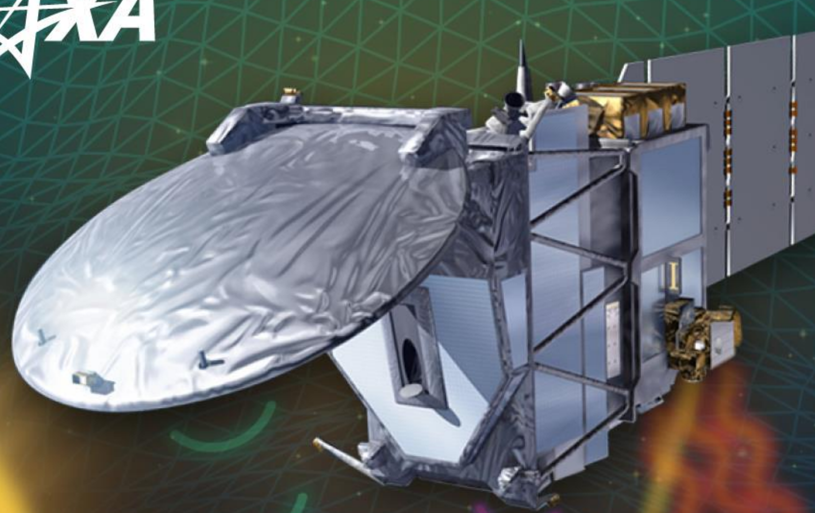
4. Jan Riad El Kassar, FU-Berlin:
   - Split window (11µm and 12µm) of MSI allows retrieval of total column water vapor under clear sky conditions
   - Information content is limited , some conditions very low (e.g. cold surfaces), but it gives information gain (spatially) cmprd to model background
   - QfA: Is NedT sufficient?  (later offline NeDT~ 0.25K,  is ok).
5. Hajime Okamoto, Kyushu University
   - Doppler velocity from HG-SPIDER and wind profiler are introduced. Wind profiler (1.3GHz) had wider frequency distribution of vertical Doppler velocity than 94GHz Doppler radar due to different scattering mechanism.
   - Unfolding correction method to be applied to EarthCARE CPR is developed and demonstrated.
   - HG-SPIDER Dopplerhas rich information but Interpretation of Doppler velocity from CPR is not straightforward.
   - Integration of CPR and global ground-based /aircraft observation-network is a key to understand; (1) global picture of cloud lifetime controlled by ice/snow/liquid precipitation terminal velocity (2) frequency of convective updrafts (3) cloud-aerosol interactions (4) cloud-precipitation processes in relation to vertical velocity at various scales

Science Session: Processes and Algorithms 4: Deep Convection and Cirrus, Chairs: Rene Preusker (FU), Kaori Sato (Kyushu University)

6. Pavlos Kollias, Stony Brook University / McGill University
    - Quality of the EarthCARE Doppler measurements In shallow and deep convection is discussed using hi-resolution (1km) model and Doppler forward simulator including multiple scattering and NUBF effect.
    - EarthCARE can detect shallow and weak updrafts with uncertainty of 1.5 - 2.0 $ms^{-1}$, but decomposition of sedimentation velocity and vertical air motion remains challenging.
    - Convective motions in the upper (3-4) km of deep convective clouds with less multiple scattering and attenuation effects can be observed with 2.0 – 3.0 $ms^{-1}$ uncertainty.
    - Characterization of CPR Doppler showed that columns with $V_{max} > 5ms^{-1}$ was 14% in the subtropics.
    - NUBF is not a source of concern CPR in deep convection.

Science Session: Processes and Algorithms 4: Deep Convection and Cirrus, Chairs: Rene Preusker (FU), Kaori Sato (Kyushu University)

7. Seiji Kato, NASA Langley
    - Uncertainty of the estimated deep convective cloud height of parcel model, and its effect on outgoing longwave irradiance was investigated using CALIPSO and CloudSat observations
    - Difference of observed cloud top height and the level of neutral buoyancy was studied as a function of CAPE. Will EarthCARE vertical velocity help explain the differences ?
    - The cloud top height difference, i.e., ~400m higher/200m lower for large/small convective clouds with large CAPE, produced ~+4 upward longwave irradiance bias.
8. Martin Wirth, DLR Germany
    - Characterization of Arctic Cirrus by DIAL & HSR LIDAR
    - sign of radiative impact depend on details, RH above ice is key parameter, but hard to measure via RS
    - Aerosol trapping (e.g. dessert dust) in the polar vortex
    - heterogeneous formation of ICE particles
    - Joint measurements of optical properties of ice clouds and humidity enable the detailed characterization of cirrus clouds



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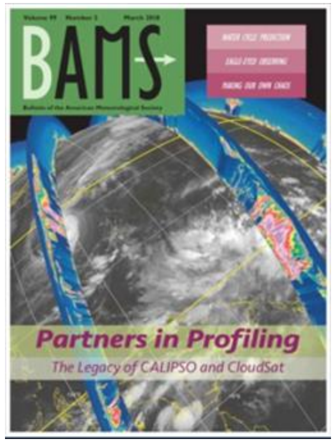
## Summary for Science Session: Techniques 2 – Missions

Chairs: Silke Groß (DLR), Seiji Kato (NASA)

# 5 Talks about past, current and upcoming missions with focus on active remote sensing

‘Past’ missions




Graeme Stephens, NASA:

**CloudSat and CALIPSO and the A-Train: two decades of Earth system science profiling**

→ History and selected highlights of tandem mission

→ A-Train offered a **new paradigm in EO** and demonstrated the **value of an integrated observing** approach

→ Clear and more precise understanding

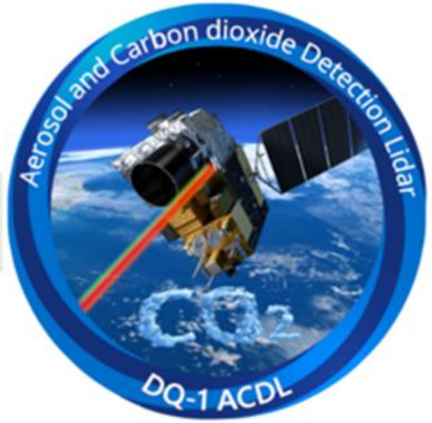
Tommaso Parrinello, European Space Agency:

**Aeolus Overview – ESA‘s wind mission**

→ Overview of mission until deorbiting after almost 5 years of measurements – performance **beyond any expectations**

→ High **impact on weather forecast** > **Follow on mission** planned, flying in the next decades

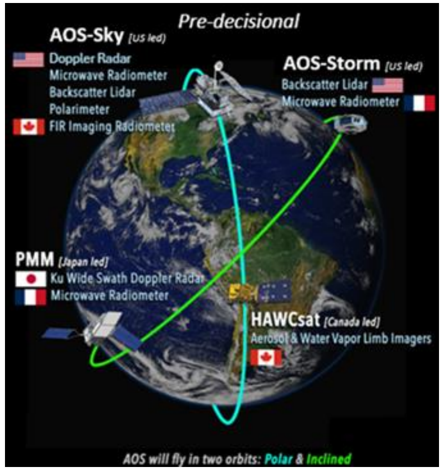
Ongoing missions




Guangyao Dai, Ocean University Of China:
**Aerosol and Carbon dioxide Detection Lidar (ACDL) Overview**

→ First **HSRL and IPDA Lidar (CO2) in Space**
→ Promising examples of first measurements and analysis
→ Overlap with CALIPSO and EarthCARE could **bridge the gap** and help for WL transition

**Future missions**



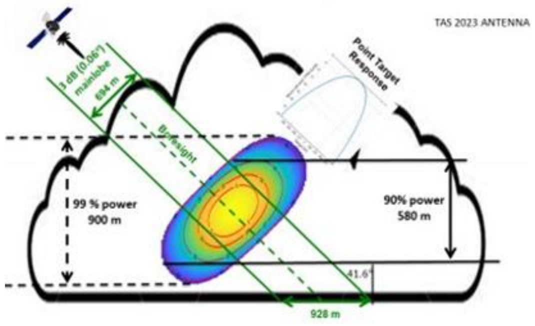

Daniel Cecil, NASA:

**NASA Atmosphere Observing System (AOS)**

→ Overview of planned mission: **two orbits** with different instrumentation (**active and passive**)

→ AOS-Storm launch planned for 2029 including **CALIPSO-like lidar (ALICAT) and PMM Radar** (JAXA)

→ AOS-Sky launch planned for 2031 including backscatter lidar (Italian partnership)




Alessandro Battaglia, Politecnico di Torino:

**WIVERN: A Mission to Observe Global in-cloud Winds, Clouds and Precipitation as part of the ESA Earth Explorer Programme EE11**

→ Overview of WIVERN : Doppler Polarization Radar – conically scanning (**3D Wind – in-cloud)**

→ Impact on weather forecast (**high impact weather**)

→ One of two proposed missions recommended for **PHASE A**

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## Science Session: Processes and Algorithms 5: Cloud µPhysics

**Chairs:**
**Pavlos Kollias (Stony Brook University), Takashi Nakajima (Tokai University)**

**Anthony Illingworth, U Reading - EarthCARE - The story so far: The first thirty years**

Discussed the EarthCARE selection and instrument evolution history.  The name EarthCARE was given in 2001 coined by Jacques Testud. The Doppler was introduced in 2001 and the Lidar was decided to be a 355 nm HSRL. In addition, in 2001 the contributions from the two agencies were decided.  The synergy between the radar and lidar was emphasized in mixed-phase clouds. The mission was not selected in 2001 perhaps because it had 5 instrument (+FTIR). In 2004 at Frascati, EarthCARE was selected and the FTIR was dropped.

**Takashi M. Nagao, Atmosphere and Ocean Research Institute, The University of Tokyo - Combined use of passive and active remote sensing to characterize the vertical stratification of the cloud thermodynamic phase**

Discussed the synergy between passive and active sensors to characterize the hydrometeor (cloud) phase. Use CALIOP, and MODIS/SWIR (using NIR). These two sensors have complimentary use especially when comes to tackling the vertical inhomogeneity of the clouds and were combined to develop a new algorithm for cloud thermodynamic phase. CloudSat CPR observations were used to verify the vertical stratification classification. Additional comparison were made using the POL GCOM observations.

**Beyond number concentration: Application of adiabatic cloud models to infer complete vertical profiles of warm cloud microphysical properties - Matthew Lebsock, NASA Jet Propulsion Laboratory**

Radar-based retrievals have shortcomings: missed detections and precipitation contamination. Approach: Use Sub-adiabatic theory and VIS/NIR to derive profiles even when there is no radar observations. Use adiabatic model, use CALIOP to get the cloud top height and MODIS to get effective radius and optical depth.

**Multi-sensor diagnostics of mixed-phase cloud microphysical processes with implication for EarthCARE - Kentaroh Suzuki, University of Tokyo**

Extend cloud microphysical processes to mixed-phase clouds (MPC) and add dynamical context to process diagnostics. Approach: use the cloud phase classification from SWIR. Phase dependence of precipitation varies with model precipitation physics. He did not use the CPR to detect ice and CALIOP to detect liquid.

**Global analysis of cloud-particle categories with their physical properties - Kaori Sato, Research Institute for Applied Mechanics, Kyushu University, Kyushu University**

Ice optical property parameterizations in climate models. How can we use EarthCARE observations to assess the ice particle categories? There is considerable latitudinal dependency in the ice particle types as detected by the CALIPSO lidar. This has implication for ice production microphysical processes.

**Retrieving 3D Microphysical Properties of Marine Low Clouds Using Passive-Active Synergistic Satellite Observations  - Christine Chiu, Colorado State University**

Discussed the importance of 3D effects in microphysical retrievals. Use the Barker et al., 2011 technique to project the radar profiles information to 3D sing the shortwave reflectance. Use particle flow technique to improve the retrievals. Use synthetic data and a CloudSat overpass during VOCALS to showcase the performance of the retrieval algorithm.

**Evaluations of a microphysics scheme using the ground observation data and EarthCARE-like data - Woosub Roh, Atmosphere and Ocean Research Institute, The University of Tokyo**

Focus on the value of the Doppler velocity for evaluating microphysical schemes. Use ground-based observations to get a sense of the magnitude and variability of Doppler velocity in precipitation. Compare these estimates against the forward simulated Doppler velocities from two microphysical schemes (1 and 2 moments microphysical schemes).

**K2W, a methodology for evaluating spaceborne W-band Doppler radar using Micro Rain Radar and disdrometer: results from an Italian station in Antarctica - Alessandro Bracci, CNR-ISAC**

Observations over the Antarctica with an MRR to evaluate the EarthCARE Doppler velocities. There are many MRR radar in Antarctica to use to emulate from Ka-band the W-band radar Doppler spectrum. First, the K-band radar profiles are converted to N(D) and then to W-band reflectivity and Doppler velocity.


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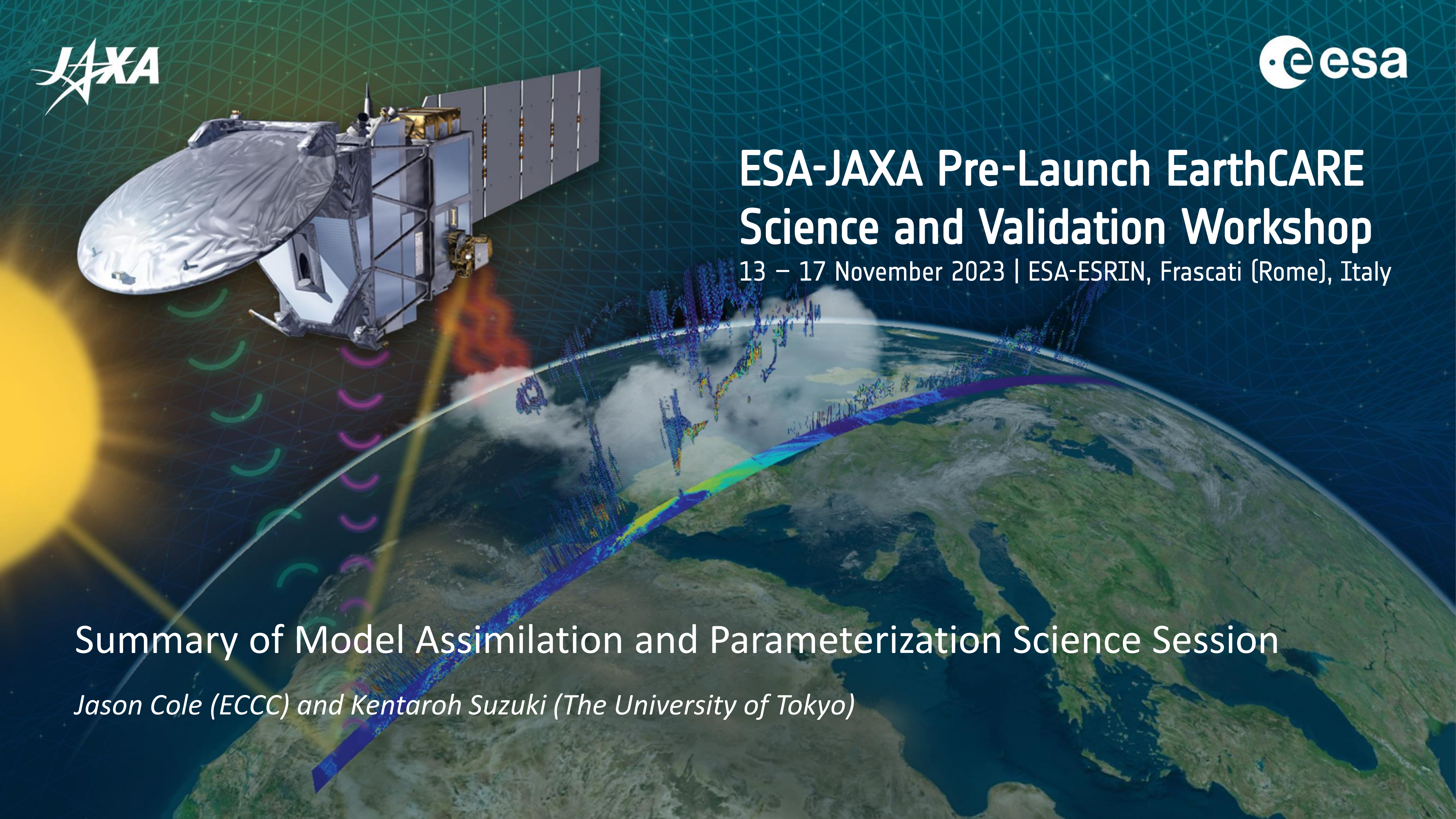
Session on long data records
Rei Kudo , Nicolas Clerbaux

# Session on long data records

- High quality (climate) records available from CloudSat and Caliop.
- Reprocessing efforts to improve stability (e.g. CloudSat sensitivity correction)
- Several climate trends visible in these records, e.g. cloud top height or aerosol composition
- Trends sometime not consistent with passive instrument findings (e.g. MODIS), especially in polar regions.
- Relatively short records -> care needed to limit ENSO influence
- Good consistency with reanalysis -> possible use in future reanalysis (e.g. ERA-7).
- Target is still +20 years datasets -> efforts needed to join A-train, EarthCARE and AOS (e.g. processing of CCM-CAP).



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## Summary of Model Assimilation and Parameterization Science Session

*Jason Cole (ECCC) and Kentaroh Suzuki (The University of Tokyo)*

**Assimilation**
Marta Janiskova, ECMWF
Laaziz El Amraoui, CNRM, Université de Toulouse, Météo-France, CNRS
Mark Fielding, ECMWF
- Assimilation of lidar (CloudSat/CALIPSO/Aeoulus) have a positive impact on NWP and aerosol/cloud predictions. This suggests that EarthCARE will also have a positive impact. Evaluating and improving model physics with profile observations remain important.

**Instrument simulator and diagnostics**
Yuhi Nakamura, The University of Tokyo
- An emulator of the CPR Doppler has been developed and is available to the larger modelling community for use in consistent comparisons of GCMs with EarthCARE

**Global LES**
Masaki Satoh, The University of Tokyo
- It is possible to simulate the global at resolution less than 1 km up to 220m. This results in notable changes in precipitation and can be used for EarthCARE preparations. Synthetic data for EarthCARE has been created. Simulations will also be run for EC-TOOC for validation of EarthCARE

# Summary of Radiation and ERB session

- Shan Zeng of Coherent Application Inc presented a plan to use satellite data and ML technique to develop parametrization for climate models.
- Carola Barrientos-Velascco of Leibnitz Institute presented a surface irradiance validation plan using surface data, focusing on validation on 3D cloud fields.
- Carola Barrientos-Velascco of Leibnitz Institute presented surface irradiance validation plan for polar regions using MOSAiC data.
- Zhipeng Qu presented comparison of TOA irradiances computed with EarthCARE radiation algorithm with CERES data. He also show 1D-3D irradiance differences.

# Science discussion

## What post-launch science needs to be done?
## How can we best plan for it now, build the collaborative teams and obtain funding?

- Science opportunities
- Model evaluation and improvement
- Multi-mission analysis
- Papers and meetings

Robin Hogan & Hajime Okamoto

JMAG co-chairs

ECMWF

# Scientific opportunities to be exploited with EarthCARE – what are the scientific questions that need answering?

- (model evaluation on next page)
- Doppler opportunities
  - Convective updrafts (Kollias/Battaglia/Kato) – how can we overcome attenuation, multiple scattering and the diurnal cycle to make the most of this highly anticipated dataset?—need overpassed by other “Doppler networks” (wind profiler, Doppler velocity, precipitation Doppler radar..)?
  - Best every snow rates from space (Bracci) – link to other communities?
  - Ice particle density (riming), ice particle categories of habit (Sato), raindrop size (warm rain versus frontal)
- HSRL opportunities
  - Cloud-aerosol interactions – massive uncertainties, what analysis is needed? Analyses with Upward motion?
  - Aerosol typing, extinction profiles – how can the new information be exploited for wider aerosol science?/Construct long term records with MODIS/CALIPSO(Nishizawa/Kudo) to Aeolus. Same for ice with CALIPSO (Sato)
- Radiative closure opportunities
  - What can we learn when radiative closure is not achieved (fix retrievals, improve assumptions, 3D effects)?
- Other opportunities & challenges? What additional experimental products are needed?

# What tools/analysis/projects needed to best exploit EarthCARE for improving models?

- Low-resolution climate models (CMIP/IPCC)
  - EarthCARE-ready “COSP” simulator: additions needed (Doppler(Nakamura), HSRL)?
  - Level-3 lon-lat averaged datasets? (but “excessive aggregation not useful” – Stier)
- Evaluating kilometre-scale weather and climate models
  - How can we use radiative closure information and radiative products to improve models?
  - Should the modellers have responsibility for using EarthCARE to evaluate their models?
  - Better would be to analyse all models objectively in the same place, but needs funding and linking up to existing activities
  - How horizontal scale (from km to sub kms) difference produces different results for the clouds/precipitation/upward motion patterns (Satoh)?
- Data assimilation (Janiskova, El Amraoui, Fielding)
  - What can we do to encourage wider assimilation activities?

# Multi-mission analysis

- Multi-mission algorithm and analysis platform (MAAP)
- What products needed spanning A-Train/EarthCARE/AOS?
  - Synergy retrievals, e.g. ACM-CAP/CCM-CAP (Mason) /JAXA EarthCARE-A-train products/ EarthCARE L2 standard and research products(Kubota)
  - Constant sensitivity products (Richardson), could be applied to EarthCARE?
  - Other products?
- What multi-mission analysis is needed for climate science?
  - Effects of changing sea-ice on cloud radiative effect (Dolinar)
  - Use of Aeolus and differences from CALIPSO (Feilding)
  - Use of ACDL to bridge the gap between CALIPSO and ATLID (Dai)
  - 20-30 year cloud trends (Richardson, Ham)
  - How can we reconcile the different sources of information and use to constrain climate sensitivity?
  - Other analysis?
- What combined analysis is needed with simultaneous satellites to EarthCARE?
  - Informing improvement of GEO passive cloud retrievals (Spezzi)

# Dissemination and collaboration

- Publications: please tell us what you publish!
  - AMT special issue on EarthCARE L2 algorithms: 25 papers so far, but will be closed at launch
  - Post-launch special issue on science outcomes is planned, likely Copernicus multi-journal: AMT, ACP, possibly Aerosol Research (AO) and GMD?
  - High profile “first results” paper planned a year into launch, probably BAMS
  - Please spread EarthCARE science far and wide! Nature and Science welcome too ☺
- Conferences & workshops
  - EGU 2024 session on EarthCARE planned
  - 2024 Cal/Val workshop
  - 2025 Science workshop
  - Please initiate special sessions on EarthCARE at other conferences!
  - Should we consider a joint A-Train/EarthCARE/AOS workshop?
- Social media, email lists…
- Wider communication of EarthCARE results to the general public?