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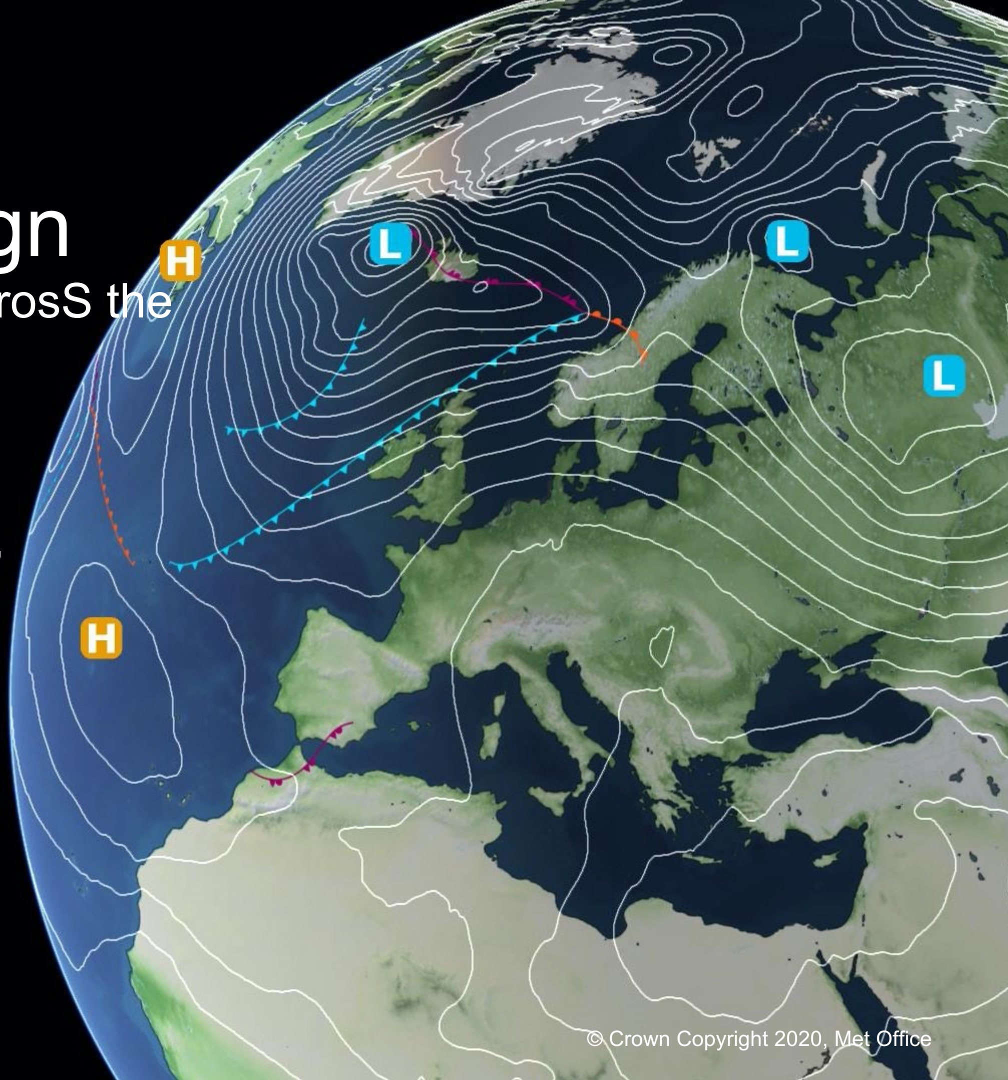
The CCREST campaign

Characterising CirRus and icE cloud acrosS the specTrum



Anthony Baran, Stuart Fox + many others

2nd ESA EarthCARE Validation Workshop, 27 May 2021

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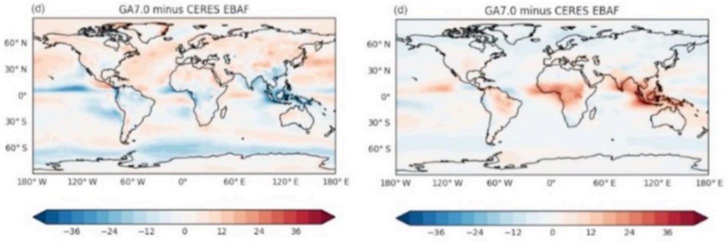
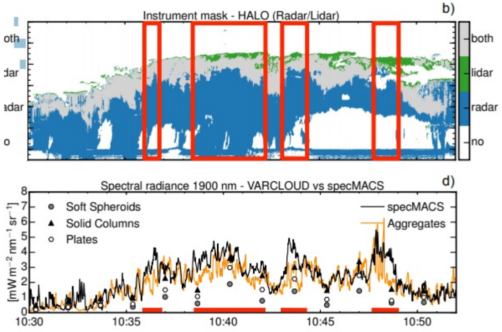
Campaign motivation

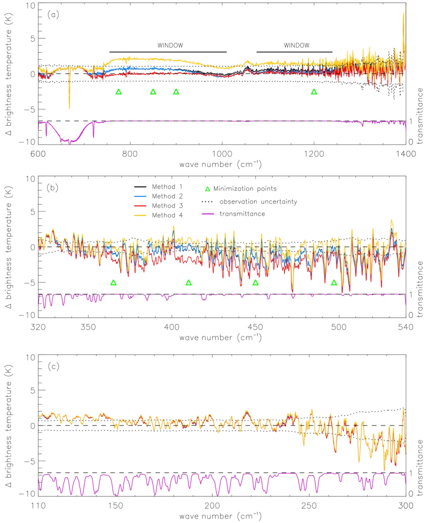
- Ice clouds play an important role in the earth-atmosphere radiation balance for both weather forecasting and climate modelling
- Significant uncertainties in understanding of ice cloud radiative impact:
  - Diversity of ice crystal size and shape
  - Mass-dimension and area-dimension relationships
  - Shape and extent of size distribution (particularly small ice)
- Retrieval of ice microphysics from remote sensing requires realistic ice optical models across the spectrum
- Also needed for all-sky assimilation in NWP models
- Existing scattering databases are not fully consistent with observations



The long-term averaged Met Office ES model (GA 7) predictions of (a) short-wave and (b) long-wave TOA irradiances minus the CERES EBAF product from Walters et al. gmd-12-1909-2019



Radar/lidar/SW radiative closure study from Ewald et al. amt-2020-448



Mid- and far-infrared closure study from Bantges et al. acp-20-12889-2020

Objectives (wider project, airborne campaign is one component)

- Constrain the shape of the small ice and large ice modes in the PSD
- Determine which shapes of ice crystals and their aggregations mostly contribute to the observed mass– and area–dimension power laws
- Determine whether it is possible to obtain consistent representations of cirrus and ice cloud through generalisations of mass– and area–dimension relationships and their single-scattering properties. To apply optimal representations to improve all-sky data assimilation of cloudy radiances
- Reduce uncertainty in the globally-averaged short-wave and long-wave irradiances at the TOA to within current observational uncertainties of ±10 W m^{-2}
- Reduce uncertainty in solar and infrared heating rate profiles of cirrus and ice cloud to within several K d^{-1}
- Reduce modelled zonally-averaged temperature biases through improved ice cloud representation
- Understand and quantify the contributions of cirrus and ice cloud to uncertainties in global cloud feedbacks and climate sensitivity

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Observation requirements

Simple scenes
- Single-layer cirrus
- Well-characterised surface

Simultaneous in-situ and remote sensing observations

Multiple aircraft required
- Simultaneous in-situ/remote
- Instrument payloads

Passive and active remote sensing
- Radiometer, radar, lidar
- Fully-characterised cloud scenes

Comprehensive in-situ microphysics observations
- Full size distributions
- Reliable small ice measurements
- Bulk liquid/ice water content

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FORUM

Spectrally-resolved observations across the electromagnetic spectrum
- microwave/sub-mm, far-ir, mid-ir, SW

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Planning status

- **May 2020**
  - Campaign proposal approved by internal Met Office advisory group
- **September 2020**
  - First CCREST workshop held to bring together interested parties, introduce the campaign and discuss next steps
  - Following the workshop, a campaign White Paper was produced
  - Interested parties to explore options for funding participation
- **April 2021**
  - Second CCREST workshop held
  - Campaign timing/locations discussed
- **2021-2022**
  - Prepare funding/grant proposals, confirm participation of partners
  - Choose campaign location
  - Ongoing instrumentation development
- **2023**
  - Detailed campaign planning
- **March 2024**
  - Preferred time for CCREST

- Aircraft availability
- Occurrence of single-layer cirrus
- Low cloud-top height
- Sufficient solar zenith angle

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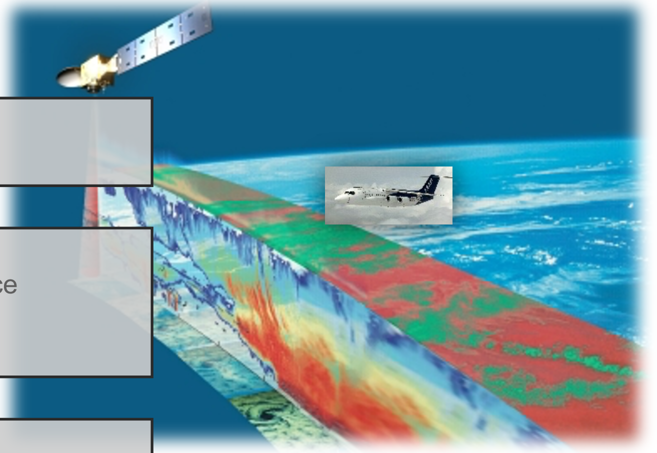
EarthCARE co-ordination/synergy



Definite

- Co-ordinate with EarthCARE track when it coincides with CCREST scene of interest

Possible

- Perform additional cloud observations coincident with EarthCARE where they are of relevance to CCREST goals e.g.:
  - In-situ cloud microphysical measurements to constrain mass-area-dimension relationships

Unlikely

- Dedicated EarthCARE flights observing scenes with no CCREST interest, e.g. clear sky/aerosol

Questions

- What cloud scenes are of most interest for EarthCARE cal/val?
- What observations types (e.g. in-situ or remote sensing) are most useful? Which are preferred to have the closest co-incidence to the satellite overpass?