EUREC^{4}A-UK

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EUREC^{4}A

Elucidating the role of cloud-circulation coupling in climate

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MANCHESTER 1824
The University of Manchester

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British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Met Office

Cloud-circulation interactions are the biggest uncertainty in climate projections

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- Trade-wind cumulus clouds are ubiquitous.

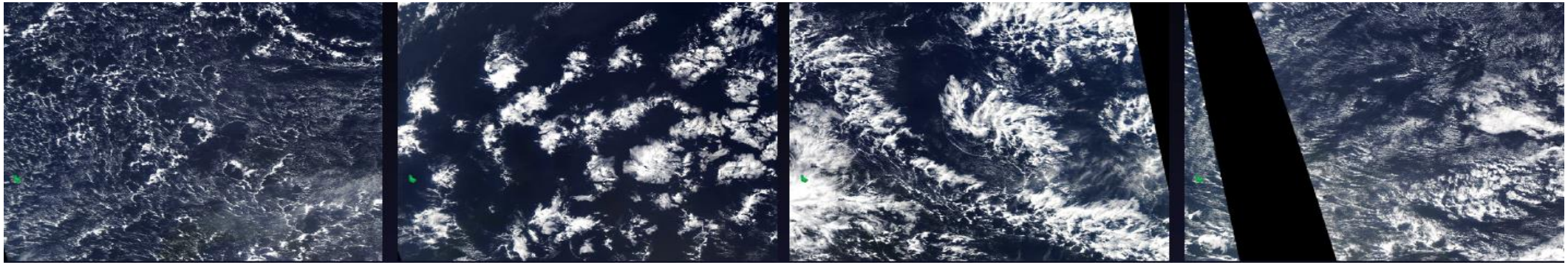
  1.5 to 4.5°C spread in climate model projections: about half of this is due to tropical low clouds*.

- Aerosol, cloud and precipitation processes are sensitively coupled to the larger-scale dynamics.

Goal of Research: understand processes controlling response of trade-wind cumulus clouds to changing environmental conditions in our warming climate.

* e.g. Bony and Dufresne 2005; Vial *et al.* 2013.

Why now?

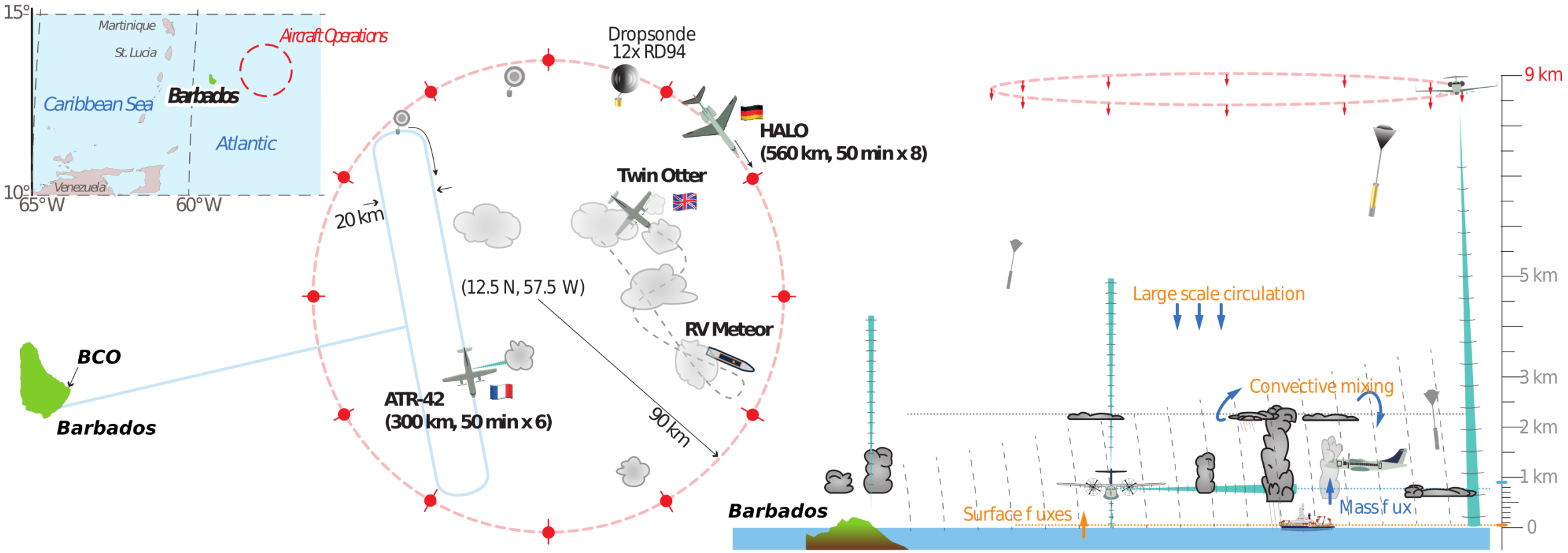


- The WCRP Grand Challenge on Clouds, Circulation and Climate Sensitivity is driving a coordinated international effort right now (France, Germany, Barbados, Netherlands, Switzerland, Poland, Norway, UK, USA). >> € 10 million of committed resources.
  Unique opportunity.

- Recent improvements in modelling: large km-scale simulations.
  <u>We can tackle problems which were never before possible.</u>

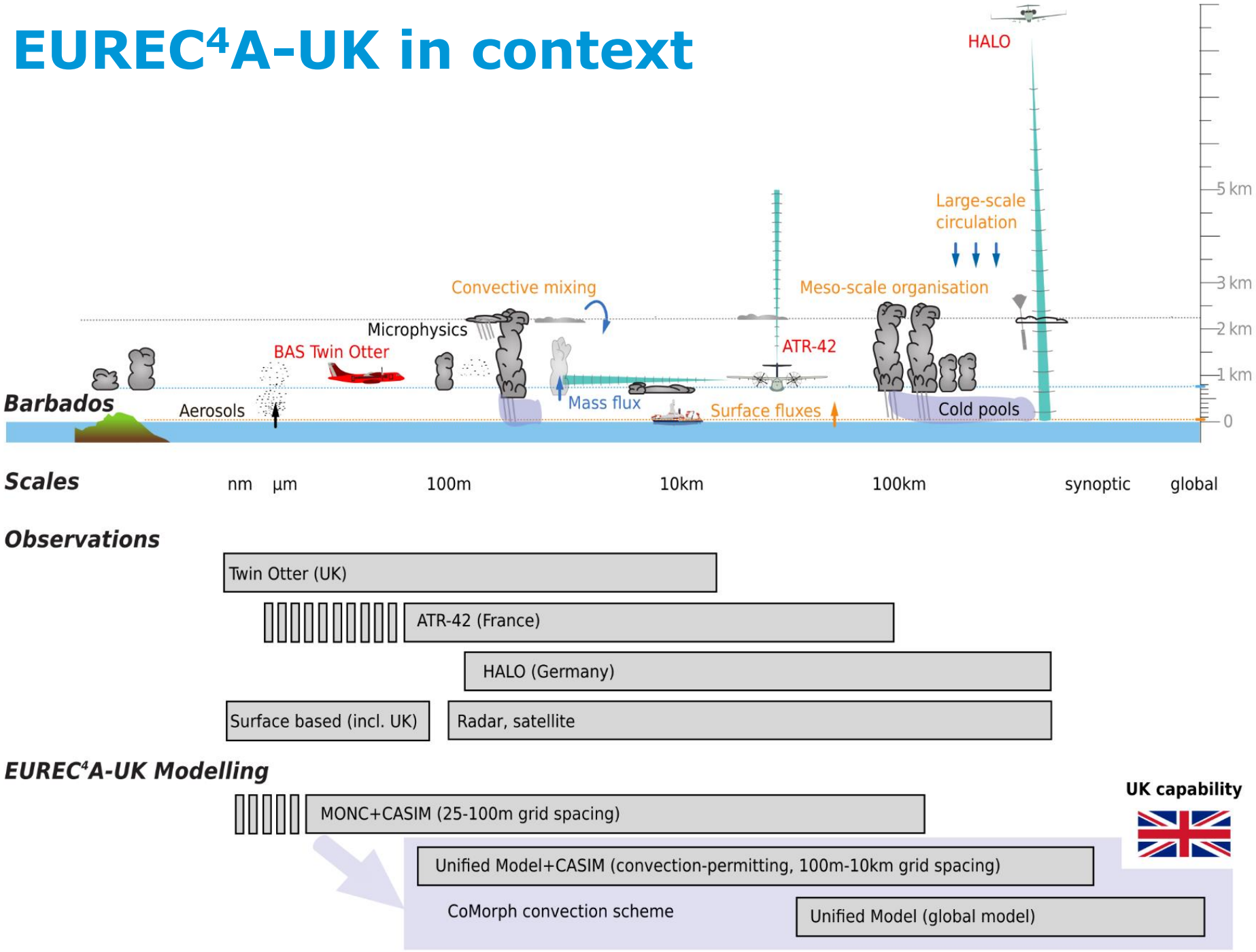
- The UK convection scheme is being rewritten for the first time in 30 years: the best time to improve the UK model.

EUREC^{4}A Project

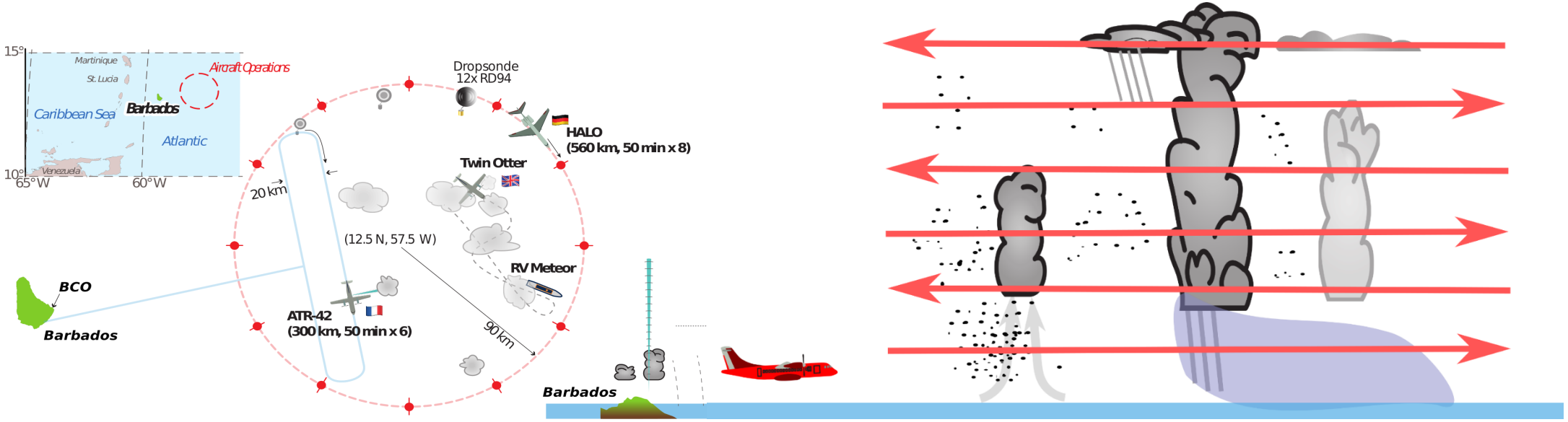


- Microscale processes observed.
- Statistical sampling of many clouds.
- All scales will be well constrained: for the first time.

EUREC^{4}A-UK in context

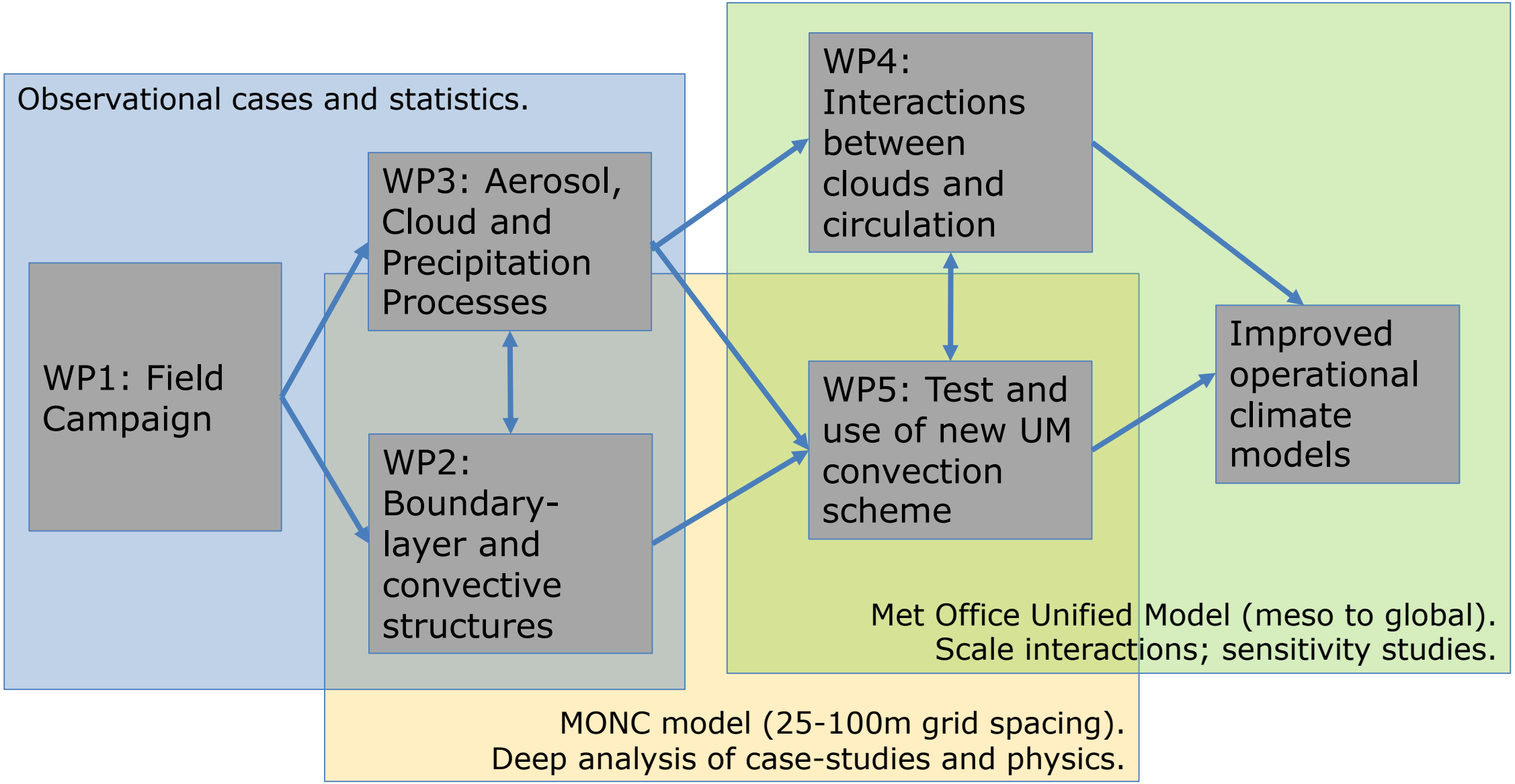


BAS Twin Otter Aircraft Observations



- Long flight legs at several altitudes, targeting clouds and BL features; occasional sampling of individual clouds.
- Key observations: BL structures aerosols (CCN and Ultra-giant CCN); cloud base; cloud droplet number concentration; cloud properties; formation of warm rain; development of rain and rainshaft; downdraughts; gust front and cold pools; new cloud formation; detrainment layer.

Integrated structure to deliver improved models from observations



Management Arrangements

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International management structure
Co-chairs: Sandrine Bony, Bjorn Stevens.
Purpose: Coordinate data sharing, IP, publication strategy, comms etc.
International Organising Committee, including UK scientists.

EUREC^{4}A-UK Project Management
Coordinator: Alan Blyth.
Purpose: Delivery of facilities and work packages; NERC Output and Performance Measures and reports.
Meetings: Two EUREC^{4}A-UK science meetings per year.
Two whole-project EUREC^{4}A science meetings.

EUREC^{4}A-UK Project Board
Co-chairs: Alan Blyth, Doug Parker.
Committee Members: Co-Is, Project Partners, NERC.
Purpose: Internal project management.
External collaboration, impact and communications.

WP1 Field campaign

International working groups.

WP 2-5

International working groups.

Summary

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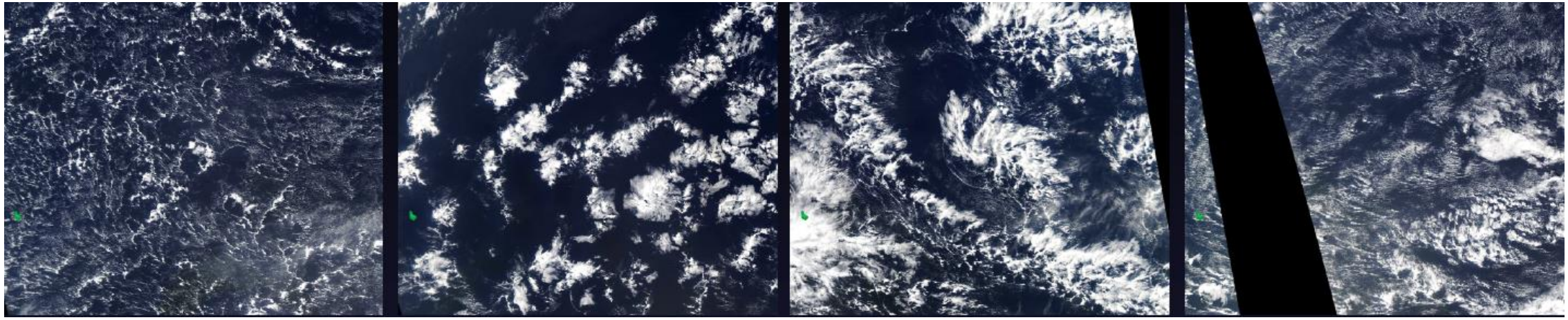
- We are tackling the biggest scientific uncertainty in Global Climate Prediction:
  - If we don't address this problem, then the climate uncertainty will remain.
- This UK project is a key part of a major coordinated international effort, to provide integrated observations and modelling studies:
  - The opportunity is now.
- Multiscale modelling allows us to bring microscale processes through to improvements in the UK's global climate models.



Impact Plan

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EUREC^{4}A-International

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Field campaign

IPCC and community

Met Office Hadley Centre
NCAS

Governments
Business
NGOs
Public

Operational forecasting

Caribbean Meteorological Agency (CMO)

Improved models

Workshops:

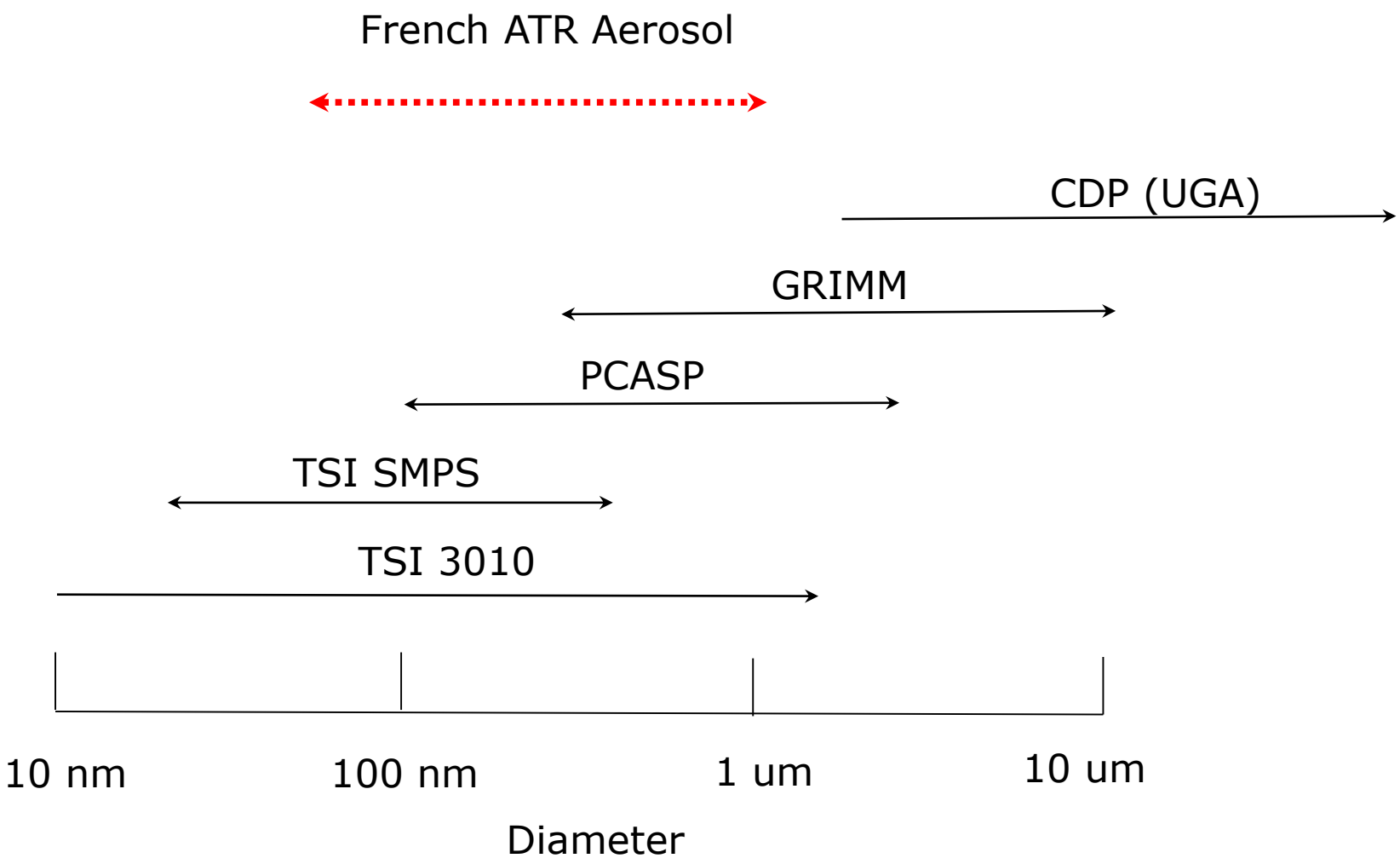
- High-impact weather prediction.
- Increased resilience to climate change.
- Forecaster training resources .

Dominica: Christmas Eve flooding, 2013: A warm-rain event.

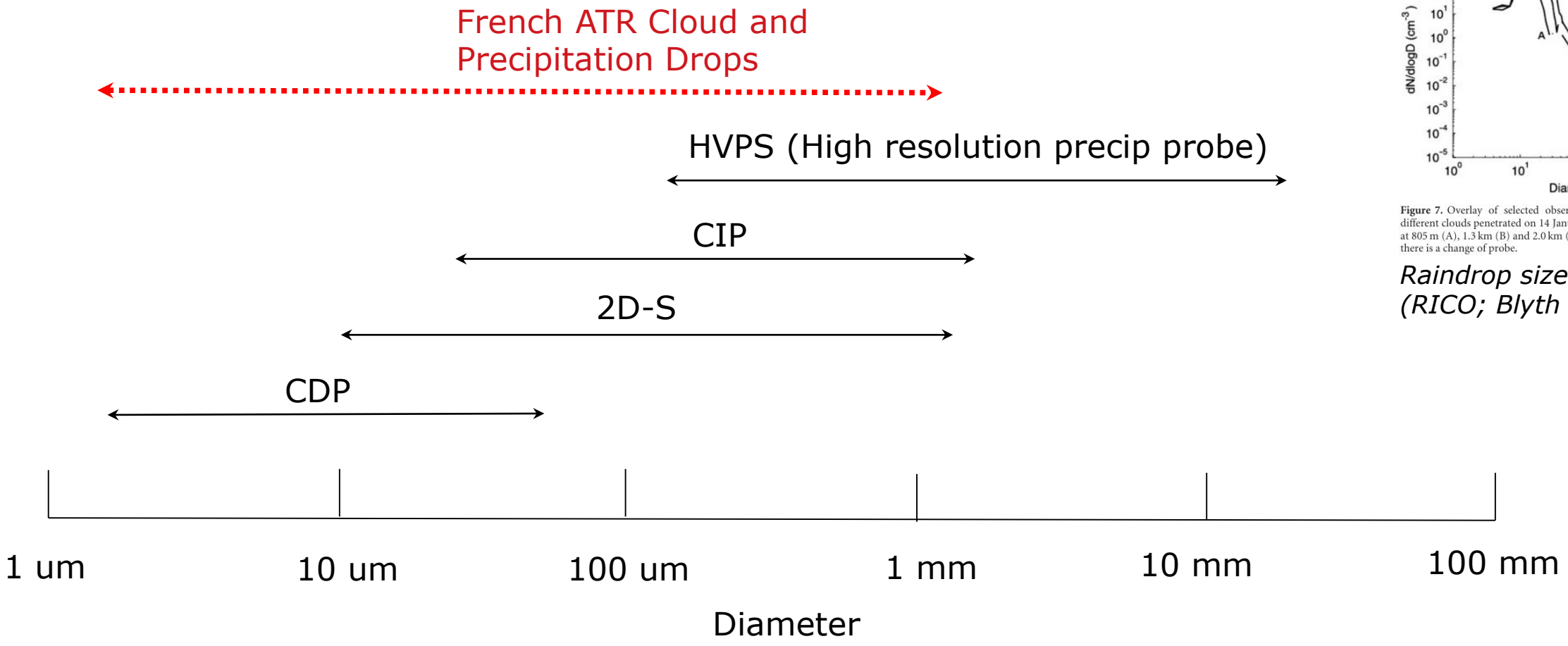
Schedule

Work packages	Year 1				Year 2				Year 3			
WP1. Field Campaign (Lachlan-Cope, Gallagher)												
Pre-campaign	■	■										
Field campaign	■	■										
Forecast support	■	■										
QA database		■										
WP2. BL and convective structures (Blyth, Denby)												
Conv structures	■		■	■	■	■	■					
BL structures	■						■	■	■	■	■	■
WP3. Aersosols, clouds and precip. (Choularton and Cui)												
Aerosols				■	■	■	■					
Warm rain			■	■	■	■	■	■	■	■	■	■
Downdrafts			■	■	■	■	■	■	■	■	■	■
Detrainment layers	■	■	■	■	■	■	■	■	■	■	■	■
WP4. Interactions betn clouds and large scales (Parker and Tomassini)												
Large-scale influence on clouds	■	■	■	■	■	■						
Clouds influence on large-scale						■	■	■	■	■	■	■
WP5. New convection scheme (Marsham and Stirling)												
Compare model and obs					■	■	■					
Obs relations into conv param							■	■	■	■		
Dominant physical controls									■	■	■	■

Aerosol Size Distribution Instruments



Cloud and Precipitation Size Distribution Instruments



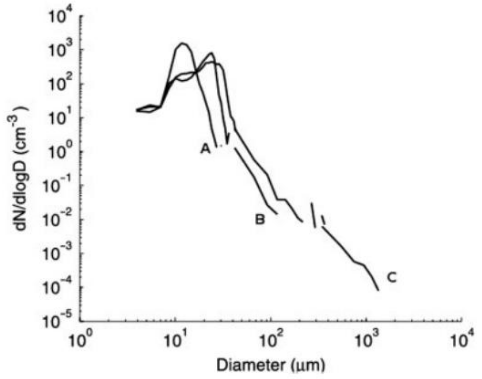


Figure 7. Overlay of selected observed DSDs at several altitudes for different clouds penetrated on 14 January 2005. The DSDs were measured at 805 m (A), 1.3 km (B) and 2.0 km (C). The gap in curve B occurs where there is a change of probe.

Raindrop size distribution (RICO; Blyth et al, 2013)

Facilities and instruments

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German Halo: Upper-level circles; Remote sensing; Dropsondes
French ATR-42: BL and cloud layer; Cloud macrophysics; Racecourse tracks
BAS Twin Otter: BL and cloud layer; Aerosols and cloud microphysics; Target clouds, rain and BL features
Research Ships: Cloud macrophysics, Precipitation, Radiosondes every 3 hours, Quadcopter (profiling), Ocean state and chemistry.
Barbados GB: CCN and filters, Surface met and radiation, Cloud macrophysics, Precip – Scanning S-band precip radar (POLDIRAD)
US Proposal (NOAA, NSF, ONR): Ron Brown research vessel, 2 aircraft, focus on ocean processes.
UK GB @ RP: Aerosols: AMS (Aerosol mass/size/comp. Organic, nitrate, sulphate, ammonium; Laser ablation aerosol particle time-of-flight (LAAP-ToF) Mass Spec (Aerosol comp. Sea-salt, silicate-mineral, biognc, carbon, mix-state); TSI SMPS-3936, (2.5 1000 nm); TSI APS-3321 (0.5 20 μm); PLAIR UV-fluores. Spec (Aerosol/sea-spray PSD organic number fraction, 0.5 100 μm); Filter samples (elemental composition and PSD).

Work Packages and Need for a Large Grant

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WP1: Field Campaign – Tom Lachlan-Cope, Alan Blyth
WP2: Boundary-layer and convective structures – Alan Blyth, Leif Denby
WP3: Aerosol, Cloud and Precipitation Processes – Tom Choularton, Alan Blyth
WP4: Interactions between clouds and circulation – Doug Parker, Lorenzo Tomassini
WP5: Test and use of new UM convection scheme – John Marsham, Alison Stirling

Naturally integrated set of WPs requiring a Large Grant

The aims of EUREC4A-UK are to:

a) quantitatively explain the development and characteristics of the BL structures, updraughts, warm rain, downdaughts, gust fronts, secondary clouds and the detrainment layer; and
b) determine the two-way interactions with the large scale dynamics and thermodynamics. This means being able to model each stage of the cloud life cycle to improve the confidence in the projections of low-level cloud response in a warming climate.