NCM
UAEREP
National Center of Meteorology
UAE Rain Enhancement Program

WWW.UAEREP.AE

6th Cycle Solicitation

UAE RESEARCH PROGRAM FOR RAIN ENHANCEMENT SCIENCE

United for ***Water Security***

UAEREP is an international research initiative designed to advance the science and technology of rain enhancement by offering managed grant assistance to selected teams of researchers.

6th Cycle Solicitation

UAE RESEARCH PROGRAM FOR RAIN ENHANCEMENT SCIENCE

Key Information

Program Contact Information:
The URL of the Program's comprehensive Web Portal is: www.uaerep.ae
For general information about the program, please contact: info@uaerep.ae
For specific questions about application preparation or the use of the web portal, please contact: info@uaerep.ae

Submission Portal Opening:
Date: January 28, 2025

Registration:
Required before pre-proposal submission
Please register by March 13, 2025

Pre-Proposal:
Required
Due Date: March 20, 2025 by Midnight Greenwich Mean Time (GMT)

Full Proposal:
Invitation Only
Due Date: 28 August, 2025 by Midnight GMT

Anticipated Type of Award:
Cooperative Agreement – anticipated commitment of three years.

Estimated Number of Awards:
Up to three awards.

Anticipated Funding Amount:
A total of up to $1.5 Million (U.S.) per award, distributed over three years with a maximum annual amount of $550K.

Indirect Cost (F&A):
A maximum of 20% of the budgeted direct costs.

INDEX

I. INTRODUCTION

UAE Research Program for Rain Enhancement Science (UAEREP):

The UAE Research Program for Rain Enhancement (UAEREP) requests innovative research and technology proposals that advance the field of rain enhancement, particularly in arid regions. To date, the program has funded 14 awards (across 5 award cycles), which have advanced, and continue to advance, the science and technologies that underpin cloud seeding operations in the UAE and have contributed to the global knowledge base on rain enhancement (www.uaerep.ae).

This 6th Cycle proposal solicitation is based on the newly articulated vision and strategic elements of the program. The National Center of Meteorology's (NCM) vision is for UAEREP to become the globally recognized standard for rain enhancement research, development, demonstration, and deployment of technologies and operations that enhance rainfall and water security in the UAE and globally.

To achieve this vision, the UAEREP strives to:

- Establish scientifically validated technology platforms and verification techniques that contribute to enhancing rainfall and water security in the UAE and globally
- Position the UAE as the global leader in the science, technology, and implementation of rain enhancement

The program is built on the following pillars:

- Managed Grant Assistance: Technical oversight and evaluation
- International Collaboration: Industry-government-academia
- Capacity Building and Knowledge Transfer
- Multidisciplinary Research and Innovation

II. PROGRAM SCOPE

A. Priority Research Areas

Over the past year, NCM has undertaken a carefully coordinated strategic planning activity involving external experts in rain enhancement and related fields. Appendix A presents a broad overview of the strategic plan.

For the UAEREP's 6th Cycle, the program will focus on five Strategic Elements / Thrust Areas:

1. Optimized Seeding Materials
2. Novel Cloud Formation and/or Rain Enhancement Systems
3. Autonomous Unmanned Aircraft Systems
4. Limited-Area Climate Interventions
5. Advanced Models, Software, and Data

The chart below shows how the 14 previously funded awards have contributed to these five Thrust Areas (see Appendix A). Awards may contribute to more than one Thrust Area. In particular, integration of results across Thrust Areas is a desirable feature of UAEREP projects, especially as progress is made toward operational readiness.

Thrust Area / **PI Last Name**	Optimized Seeding Material	Novel CF and/or RE Systems	Autonomous UAS	Limited-Area Climate Interventions	Advanced Models, Data and Software
Murakami	■				■
Zou	■				■
Wulfmeyer				■	■
Korhonen					■
Harrison		■	■		■
Lawson					■
Abshaev		■			
Xue					■
Frew			■		
Delle Monache					■
Baker					■
Cantrell	■	■			
Matras		■			
Rosenfeld					■

II. PROGRAM SCOPE

Progress toward operational readiness in the five Thrust Areas proceeds through a series of steps identified as:

1. Fundamental Research (including simulations)
2. Applied Research (including simulations and software/code development)
3. Technology Development and Demonstration (including engineering-scale prototypes and software development)
4. System Demonstrations and Validations
5. Products and Services

In the current funding cycle, projects will be selected based on their potential contribution to advancing the program toward targeted outcomes for 2030. Proposed projects should endeavor to advance the program by generating new knowledge and technologies that will either move technologies forward toward deployment readiness or offer new and innovative insights and approaches to achieving the goals of one or more thrust areas. All proposed projects should describe a clear direction toward operational readiness (e.g. from Fundamental Research to Technology Development, or from Prototype to System Demonstration and Validation). Therefore, articulation of progress toward technology readiness according to the steps shown above is essential. Redundancy or overlap with previously funded awards should be avoided. Proposers are encouraged to review the results from prior awards to ensure new investigations advance the program rather than repeat previous efforts. Furthermore, involvement of the UAE research community in proposed activities is strongly encouraged.

The targeted near-term outcomes, priority research questions and specific research topics for each thrust area are detailed in the following subsections:

II. PROGRAM SCOPE

Thrust Area 1: Optimized Seeding Materials

Targeted Outcomes by 2030

- Establish standardized methodologies for quantifying seeding material properties through cloud chamber measurements and validate these through comprehensive field observations.
- Develop and implement advanced cloud seeding modeling scenarios to evaluate various seeding materials, strategies, and dispersion methodologies under different cloud conditions.
- Produce evidence-based recommendations for optimal seeding materials and methodologies tailored to specific cloud conditions, synthesizing insights from laboratory studies, modeling, and field validations.

Priority Research Questions

- What is the potential for hygroscopic and glaciogenic seeding to initiate/accelerate precipitation formation and enhance rainfall in clouds, particularly in desert environments such as the UAE?
- Can cloud seeding be improved with new and innovative seeding materials? What are the needs and potential for optimized seeding operations?
- What is known about the natural cloud and precipitation formation processes as a basis for targeted rain enhancement operations, particularly in desert environments such as the UAE?

Specific Research Topics

- Experiments in cloud chambers, fog, and natural clouds to improve understanding of cloud physics and precipitation processes (process-level understanding and testing).
- Impact of cloud seeding methods and materials on cloud chemistry, physics, and dynamics (process-level understanding and testing).
- Characterization of physical properties of seeding flares (particles growth rates, ionization state of particles produced).
- Testing and leveraging models of multiple rain enhancement strategies and technologies to gain further fundamental understanding from the observations and experiments.
- Integration of new measurement and numerical tools to gain a clear, scientific understanding of the full chain of events of all the processes involved in cloud formation, rainfall, and rainfall stimulation.
- Creation of testbeds comprising a mix of field campaign data with in-situ upper air, satellite, and ground measurements (monitoring networks).
- Determination of the amounts of seeding materials required to have optimal rainfall enhancement effects.

II. PROGRAM SCOPE

Thrust Area 2: Novel Cloud Formation and/or Rain Enhancement Systems

Targeted Outcomes by 2030

- Building on current UAEREP project outcomes, develop and implement advanced, multi-platform rain enhancement systems integrating aircraft, unmanned aerial vehicles, and ground-based technologies, optimized for UAE's climate conditions and backed by state-of-the-art radar and satellite data for precise targeting and delivery.
- Demonstrate novel, environmentally-friendly materials and/or directed energy sources and delivery systems, for enhanced particle growth and/or ionization yields, tailored to maximize precipitation in arid and semi-arid regions.
- Establish comprehensive atmospheric models incorporating macroscopic aspects like updraft formation and particle chemistry insights from cloud chamber experiments, enabling accurate prediction and optimization of rain enhancement efforts in the UAE and similar climates.

Priority Research Questions

- What are the quantitative and qualitative bases for cloud formation and water phase changes through new techniques/methods beyond conventional cloud seeding?
- What are the mechanisms that could grow aerosol particles into effective Cloud Condensation Nuclei (CCN)?
- Cloud macrophysics: What are the effects of ambient temperature, humidity, and pressure on particle growth rates, and where, when, and how to target existing clouds or clouds derived from enhancement techniques?

Specific Research Topics

- Neutral and/or ion chemistry of CCN formation.
- Laboratory to field studies on enhanced rain-bearing cloud formation, and the adaptation of platforms incorporating on-board sensing techniques for identification of optimal target conditions.

II. PROGRAM SCOPE

Thrust Area 3: Autonomous Unmanned Aircraft Systems (UAS)

Targeted Outcomes by 2030

- Demonstrate a UAS platform capable of replicating precise human seeding operations, with integrated safety and regulatory compliance mechanisms.
- Integrate and validate real-time atmospheric sensing, nowcasting products, and onboard decision-making technologies that enable autonomous identification of seeding locations.
- Develop and test communication protocols that enable reliable Beyond Line-of-Sight (BLOS) operations for multi-agent UAS systems.
- Establish clear performance metrics and use these metrics to refine UAS operations and benchmark against traditional manned seeding methods.
- Develop and demonstrate the operational capability of multi-agent UAS that collaboratively perform seeding tasks (delivering up to 4 kilograms of seeding material) in a region of interest (1 to 5 squared-kilometers with a forecast lead time less than 1 hour), while adapting dynamically to environmental and operational changes.

Priority Research Questions

- How can semi-autonomous UAS be developed to achieve human-level precision in delivering seeding material to a defined region within a defined forecast lead time, while ensuring safety and regulatory compliance?
- What in-situ advanced sensing, nowcasting products, and decision support technologies can be integrated into UAS to autonomously identify and validate optimal seeding conditions and locations within the target area in real-time?
- How can communication systems for BLOS operations be optimized to ensure reliable and secure data transmission and control of multiple UAS agents in semi-operational environments?
- What are effective methods to measure and assess the impact of UAS-delivered seeding on rain enhancement over a 10-year period, and how can these metrics guide operational adjustments?
- How can multi-agent systems be developed and integrated into UAS operations to enhance the scalability and effectiveness of rain enhancement over large geographic areas?

Specific Research Topics

- Development of coordination protocols and communication systems for coordinated, multiple UAS operations.
- Real-time adaptive strategies that enable effective collaboration in complex atmospheric conditions.
- Development of precision delivery mechanisms for established UAS platforms.
- Integration of advanced sensing technologies into established UAS platforms.
- Autonomy in UAS rainfall enhancement decision-making processes.

II. PROGRAM SCOPE

Thrust Area 4: Limited-Area Climate Interventions

Targeted Outcomes by 2030

- Undertake modeling and experimental studies on solar radiation management, seabreeze funneling, landform modifications related to energy and humidity sources, topography modification, localized climate interventions related to aerosols and/or other novel approaches.
- Determine via simulations and limited experiments if considered interventions show the technical and economic potential for further development.

Priority Research Questions

- How may intentional regional solar radiation perturbations affect precipitation enhancement over the UAE?
- How may the sea breeze and its water and energy budgets be leveraged to enhance precipitation of the UAE?
- How may existing and potential landform modifications be leveraged to enhance cloud and precipitation formation over the UAE?
- How may existing artificial topographical interventions be supported to build a comprehensive understanding of its effectiveness, and how can other climate interventions work in a synergetic way towards cloud and precipitation formation?

Specific Research Topics

- The potential, and any negative consequences, of specific Limited-Area Climate Interventions.
- Required legal and governance framework for specific Limited-Area Climate Interventions.
- Logistics and benefit cost analyses of potential upscaling of radiation flux modification approaches.
- Understanding of the sea breeze and its interaction with natural and artificial topographical and landform phenomena relevant to cloud and precipitation formation.
- The potential impact of existing landform modification on moisture and energy fluxes beneficial for cloud and precipitation formation.
- Optimal designed potential landform intervention with comprehensive cost benefit, environmental, and co-benefits considerations.
- Quantification of the effectiveness of existing topographical modifications on cloud and precipitation formation and how these can benefit from leveraging on other interventions.

II. PROGRAM SCOPE

Thrust Area 5: Advanced Models, Software, and Data

Targeted Outcomes by 2030

- Enhance current NCM/UAEREP operational seeding planning models with improved accuracy in predicting location and timing of precipitation events, while increasing the complexity of operational microphysics without compromising model runtime.
- Expand data assimilation capabilities in operational cloud seeding models by incorporating new and future observation technologies, leading to a significant increase in the amount of data processed.
- Develop user-friendly visualization platforms for assessing and planning seeding operations, coupled with improved computational efficiency for faster and more effective decision-making processes.

Priority Research Questions

- How can we develop advanced software that uses cutting-edge algorithms to model cloud microphysics with high precision, efficiency, and reduced uncertainties, while enhancing the accuracy of predictions and assessing the effects of various cloud seeding materials in large-scale, real-time simulations?
- How can we bridge the gap between cloud chamber models and real-world operations by incorporating data-driven models and developing Machine Learning/Artificial Intelligence (ML/AI) approaches based on chamber observations to improve cloud microphysics modeling and seeding effectiveness?
- How can advanced algorithms and specialized software be developed to analyze large datasets of atmospheric observations, cloud properties, and seeding outcomes, leveraging ML/AI techniques to identify key variables, optimize cloud seeding strategies, and enhance process understanding on local scales?
- What approaches can blend data-driven and physics-driven methods, incorporating advanced visualization tools and cloud chamber simulations, to improve the understanding of cloud physics, precipitation processes, and cloud seeding optimization?
- How can we develop interactive simulation and visualization tools, advanced software platforms, and intuitive interfaces to access, visualize, and analyze cloud seeding data, facilitating collaboration and enhancing the understanding of cloud seeding processes?
- What model evaluation tools, guidelines, and validation frameworks can be created to support operational decision-making and determine the success of cloud seeding operations?
- How can big data analytics and ML/AI techniques be used to improve short-term weather forecasting accuracy and support decision-making in cloud seeding operations?
- How can we enhance and standardize observational networks, create a repository for model advancements, and ensure data accessibility for the community to support cloud seeding and weather forecasting?

II. PROGRAM SCOPE

Specific Research Topics

- Advanced software utilizing cutting-edge algorithms to model cloud microphysics with high precision and efficiency.
- Cloud chamber models and real-world operations using data-driven models and ML/AI to improve cloud microphysics modeling and seeding effectiveness.
- Advanced algorithms and specialized software to analyze atmospheric data and cloud properties, leveraging ML/AI to optimize cloud seeding strategies and enhance local process understanding.
- Data-driven and physics-driven methods with advanced visualization tools and cloud chamber simulations to enhance understanding of cloud physics, precipitation processes, and cloud seeding optimization.
- Interactive simulation and visualization tools, advanced software platforms, and user-friendly interfaces for accessing, visualizing, and analyzing cloud seeding data.
- Innovative decision-support systems tailored to support operational decision-making in cloud seeding operations.
- ML/AI and big data analytics to improve short-term weather forecasting accuracy specifically for supporting decision-making in cloud seeding operations.
- Enhancing observational networks, creating a centralized data repository, and ensuring data accessibility to support advancements in cloud seeding operations and weather forecasting.

II. PROGRAM SCOPE

B. Characteristics of a Successful Proposal

Projects should carefully describe the observational, modeling, and data analysis strategies that will be used. The creation and use of comprehensive databases, historical and new data, and the analysis and re-analysis of previous experiments are strongly encouraged, as is the planning and implementation of field experiments and campaigns. A listing of NCM and UAEREP datasets and model configurations that can be made available to awarded projects are provided in Appendix B.

Proposers should carefully review projects funded in the four cycles of the program (links are provided for 2015, 2016, 2017, 2021 and 2023 awarded projects). Emphasis should be given to the development of high-impact, large team projects involving academic, industry, and government collaborators; i.e. multi-institutional, multi-national collaborations, and linkages between universities/colleges, national laboratories, private sector research laboratories, and/or state and local government organizations, as appropriate to the project. Projects that address multiple Thrust Areas in a coordinated manner and effectively leverage resources among partner organizations will be prioritized. Proposals should provide sufficient detail about these resources such that their benefits to the program can be adequately assessed.

As noted above, proposals should aim to achieve an advanced level of technology readiness by the completion of the research program. Prototype and/or model validation in a research environment is the minimum expectation and the most competitive proposals will include technology and/or model validation in a relevant demonstration or production environment. Field testing of a developed technology and/or integration of developed software tools with weather research and forecasting systems is desired. Proposals should specify the initial and targeted technology readiness. The progression from its starting point to a higher level of operational readiness should be described and will be considered in the evaluation of proposals.

II. PROGRAM SCOPE

Successful proposals in this competition will have the following general characteristics:

- A clear description of how the proposed research will build on or enhance previous work in the rain enhancement field, particularly research previously supported by the UAEREP.
- A clear hypothesis on which the work plan is based.
- Clear milestones and deliverables toward focused outcomes and not necessarily solutions to all problems.
- A scope and scale to fully justify the proposed funding request.
- Sufficient expertise and experience of the project team to effectively carry out a multi-institutional, complex project.
- A demonstrated institutional commitment by the lead organization and any partnering institutions.

Additionally, all successful proposals will include the following specific components:

- A project plan that integrates research, capacity building/education, and knowledge transfer activities, with inclusion of all partners and affiliates as appropriate. The knowledge transfer plan should include significant intellectual exchange among various types of institutions and organizations; in particular, collaboration with NCM personnel throughout all stages of the project will ensure seamless transition of research outcomes to cloud seeding operations.
- A plan for social and environmental stewardship through community outreach and environmental impact assessment and mitigation, as appropriate to the project.
- A detailed management plan that describes sound mechanisms for project oversight, team communications, risk mitigation, and financial monitoring.

III. TIMELINE FOR THE PROGRAM SIXTH CYCLE (2025)

Registration:
Due by March 13, 2025

Pre-proposal:
Due by Midnight (GMT) March 20, 2025

Invited full proposals notified:
May 30, 2025

Invited full proposals:
Due by Midnight (GMT) August 28, 2025

Award notification:
January 2026

Anticipated start date of the awards:
March 1, 2026

IV. AWARD INFORMATION

The program will support up to three awards. It is anticipated that the awards will be valued up to $1.5 million each and dispersed over a three-year period. All awards will be selected by a rigorous, two-stage merit review process, and awardees will be announced in January 2026.

The awards are likely to be for projects that are technically and/or managerially complex. Therefore, funds will be awarded through a cooperative agreement, which gives the Program Secretariat a significant oversight engagement with the awardees. The project principal investigator (PI) directs the project with the assistance of any Co-PIs. The PI and the PI's sponsoring organization have fiscal responsibility for the award and primary management responsibility for the conduct of the proposed activities. The cooperative agreement, however, will state the nature and extent of expected Program Secretariat involvement, such as receipt of periodic reports and undertaking of regular progress evaluations. A detailed agreement ensures that the responsibilities of each party are fully understood.

Support for each year of the Cooperative Agreement for the award will be contingent upon satisfactory outcomes as documented in progress reports submitted annually for review by the Program Secretariat. In addition, site visits will be held to evaluate progress and future plans, with an emphasis on the quality of the research and expected ability to meet the project goals and objectives.

Specific Award Conditions are elaborated further in section VIII. AWARD ADMINISTRATION INFORMATION.

V. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Domestic (UAE) or foreign, public or private, non-profit or for-profit organizations are eligible to receive this cooperative agreement award. All eligible entities must clearly demonstrate that they have access to the facilities and infrastructure necessary to carry out the proposed project. Eligible entities must also agree to the fiscal arrangements that the Program Secretariat requires to ensure that awardees are able to responsibly manage the funds.

Who May Serve as Principal Investigator (PI):

The PI must have substantial research and management experience in the associated field of science and/or engineering to lead the Project. Co-PIs may share in the responsibility of the scientific or technical direction of the project. The first name listed on the application will serve as the primary liaison to the Program Secretariat and have responsibility for the project management and the submission of reports.

Limit on Number of Pre-Proposals per Organization:

There are no restrictions to the number of pre-proposals that can be submitted to this competition by a single organization. However, it should be noted that any one organization may only receive one award per competition cycle.

Limit on Number of Pre-Proposals per PI or Co-PI:

There are no restrictions to the number of pre-proposals that can be submitted by a PI or Co-PI, but it should be noted that a PI or Co-PI may only receive one award per competitive cycle.

Additional Eligibility Info:

Proposals submitted to the program must not be either awarded or currently under review by any other entity.

Based on the merit review of the pre-proposals, a select number of PIs will be invited to submit full proposals. Only invited full proposals will be eligible for the award. Uninvited full proposals will be returned without review.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

Applications will be evaluated in a multi-phase merit review process. A pre-proposal will be required, and those pre-proposals judged most promising by a review panel and the Program Secretariat will be invited to submit full proposals.

A. Registration on Online Submission Portal: Required

Registrations from the intended PI/Lead Institution should be done at least one week before the pre-proposal submission deadline. This allows sufficient time to resolve any technical issues related to accessing and submitting the pre-proposal requirements on the online portal. The registration should include a brief description (not exceeding 500 words) of the scope of work, the approach, and the potential list of participants. The Program Secretariat will not be responsible for any technical issues occurring during the submission process for anyone registering after the recommended deadline.

Register by March 13, 2025.

The Registration must be filled-out online at www.uaerep.ae

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

B. Pre-Proposal: Required

Pre-proposals and all referenced documents must be submitted through www.uaerep.ae no later than Midnight, March 20, 2025 (GMT). The submission process requires the completion of online forms for the pre-proposal cover page (basic administrative information) and list of project personnel, followed by uploading the pre-proposal main content (and supplementary documents), in pdf format, to the web portal. A Conflict of Interest (COI) form is also required. The template is downloadable from the web portal, and the completed form must be uploaded to the portal. Once required forms have been submitted, the proposer will receive an e-mail notification that the application was received.

Detailed preparation instructions are given below. Pre-proposals that are not compliant with the provided guidelines may be rejected without review. Pre-proposals must contain the items listed below and adhere strictly to the specified page limitations. No additional information may be provided as an appendix or by links to website pages. Figures and tables must be included within the applicable page limit. Pre-proposals should contain an overview of the proposed research and approach, with sufficient detail to allow assessment of the major ideas and approaches to be used. Anticipated partners and participants should be identified, but their involvement will not be binding. However, neither the PI nor the PI's sponsoring institution may be changed after the submission of the pre-proposal.

The pre-proposal shall comply with the following specifications:

- Written in English
- Paper size when printed: ISO A4
- Margins: 2.5 cm (top, bottom and sides)
- Spacing: single spaced
- Font: no smaller or more condensed than Times New Roman (acceptable fonts also include Arial, Helvetica, Palatino, Linotype or Georgia), 12 point for text and 10 point for figures and tables

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

The pre-proposal will contain the following elements:

1. Cover Page (to be filled out on-line via the web portal)

Consists of project title, PI and Co-PI (if any) information, sponsoring organization information, and list of senior personnel and their institutional affiliations.

2. A pdf file containing the following sections to be uploaded via the web portal.

Project Summary and Description (1-page minimum, 3-page maximum):

The Project Summary and Description should articulate a vision that clearly outlines the research being addressed and breakthroughs being sought. It should provide sufficient information on the UAEREP Thrust Area(s) being specifically addressed, the related research to be conducted (hypotheses, concepts, methods, approaches, data measurements, and analyses) and anticipated outcomes with a clear indication of the progression of technologies and models that will be developed. The proposed approaches must be innovative, and it must be clear how the proposed project will transform or significantly impact the research area and its broader implications for rain enhancement, particularly for arid regions such as the UAE. It should identify the roles and responsibilities of the PI and/or other senior project leadership, if relevant, along with their respective institutions. The project summary and description should be informative to those working in the same or related field(s), and understandable to a scientifically or technically literate reader. Links to URLs or other supplementary information may not be used.

Note: For the pre-proposals, descriptions of facilities, equipment, and other resources are not required. If this information is an essential component of the research being proposed, it should be indicated briefly within the Project Summary and Description. Significant planned in-kind contributions are important and should be included in the Project Summary and Description.

References cited (no minimum, 2-page maximum):

Each reference must include the full citation. Applicants must be especially careful to follow accepted scholarly practices in providing citations for source materials relied upon when preparing any section of the document. This section must include bibliographic citations only and is not to be used to provide parenthetical information outside of the project description. It is important to be succinct and select only those references pertinent to the proposed research. Reference numbers should also be shown in the text of the project description. Use of published works should conform with international copyright treaties and best scholarly practices.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

CVs of PI, Co-PI(s), and senior research personnel (maximum 1-page for each individual)
For the PI, Co-PI(s), and each senior research personnel listed on the project's cover page, one-page should be provided that includes full name and title, institutional affiliation, brief summary of expertise and relevant experience, and several sentences elucidating the investigator's role in the project, along with other information (e.g. publications, patents, etc.) deemed relevant.

3. Required Supplementary Documents:

Conflict of Interest Form (Use Excel template provided via the web portal):
The PI is required to submit a spreadsheet listing conflicts of interest for all persons listed on the Cover Page. The template, which has supplementary instructions, must be downloaded from the web portal, and instructions for use of the template must be strictly followed. The completed form should then be uploaded to the web portal.

Additional Information (in a single pdf document):

- List of suggested reviewers or reviewers not to include (with a brief explanation or justification for why the reviewer should be excluded from consideration).
- Three keywords that describe the research proposal, listed in order of priority.
- Identification of proprietary or privileged information (if applicable).

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

C. Full Proposal: By Invitation Only

For full proposals, all referenced documents must be submitted electronically through www.uaerep.ae no later than midnight August 28, 2025 (GMT).
Questions relating to the submission process may be directed to the Program Secretariat. Once required forms have been submitted, proposers will receive an e-mail notification from the Program Secretariat that the application was received.

Full proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the stated guidelines. Full proposals will be accepted only if invited by the Program Secretariat. When preparing a full proposal for this competition, proposers are advised to review the Program Description and the Proposal Review Information found in this solicitation for general guidance pertinent to this program. Proposers are encouraged to refer to the web portal frequently for updated information and answers to frequently asked questions. In particular, proposers should look for updates on currently funded projects to avoid redundancy and to identify new research opportunities, potential partnerships, and other relevant linkages. Information about on-going projects funded by the UAEREP can be found on the Program website: www.uaerep.ae

The full proposal shall comply with the following specifications:

- Written in English
- Paper size when printed: ISO A4
- Margins: 2.5 cm (top, bottom and sides)
- Spacing: single spaced
- Font: no smaller or more condensed than Times New Roman (other acceptable fonts include Arial, Helvetica, Palatino, Linotype or Georgia), 12 point for text and 10 point for figures and tables

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

The full proposal package includes

1. Cover Page (online form)
2. Executive Summary (online form)

The following pdf documents are to be uploaded via the Web Portal:

1. Project Description
2. Facilities, Equipment, and Other Resources description
3. Biographical Sketches Including Current and Pending Support
4. References Cited
5. Supplementary Documents

And the following .xls (or .xlsx, Microsoft Excel) documents (or other spreadsheet forms, as agreed to by the Program Secretariat) are to be uploaded via the Web Portal:

1. Budget pages for each year and cumulative period
2. Conflict of Interest (COI) spreadsheet

Note that the proposal will be reviewed as a stand-alone document. Links to URLs or other supplementary information not otherwise specifically allowed for this competition shall not be used as part of the evaluation process.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

The full proposal will contain the following elements:

1. **Cover Page (to be filled out on-line via the Web Portal):**
   Consists of project title, PI and Co-PI (if any) information, sponsoring organizational information, proposed total budget, and list of senior personnel and their institutional affiliations.

2. **Executive Summary (Maximum of 500 words, to be filled out on-line via the Web Portal):**
   The Executive Summary should include the rationale, vision, and potential impact of the proposed research program, including how it substantially contributes to advancing the field of rain enhancement, particularly in arid regions. It should be an overall description of the proposed activity with emphasis on UAEREP Thrust Area(s) being addressed, a statement of objectives, methods to be employed, and major partners and their respective integrated contributions. The summary should be targeted towards those working in the same or related fields, but also understandable to a scientific or otherwise technically literate audience.

3. **Project Description (an uploaded pdf file that includes sections A-F below):**
   Total maximum page limit for the Project Description is **20 pages**. Within the description, flexibility is given to the PI to adjust the length of the sections as appropriate to the project. However, the description must contain all the sections specified, and it must also conform to the overall page limit.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

A. Table of Contents (TOC)

List project narrative sections and corresponding page numbers. The TOC does not count against the page limit.

B. Research Program (Minimum 8-pages)

This section must address the appropriate elements of the merit review criteria for full proposals. Proposers should carefully review projects funded in the first four cycles of the program (2015, 2016, 2017, 2021 and 2023 awarded projects). Redundancy and duplication of funded awards should be avoided unless proposals can clearly and specifically demonstrate how they will build upon and enhance results already achieved. The following elements are expected:

1. Provide a compelling vision that clearly outlines specific program aims and objectives. Describe in detail the research to be undertaken and specifically how it will build upon and/or complement projects already awarded by the UAEREP while directly addressing one or more of the UAEREP Thrust Areas and research priorities. The narrative should include the overarching goal or question and how it is relevant to the Program. Within the research plan, provide background, objectives, including hypotheses to be tested, and specific aims. Milestones and the overall timeline for completion of the project must be provided along with a clear description of the progression expected for each technology, model, or other relevant deliverable that will be developed.

2. Provide a description of the experimental design, methodologies and techniques, and analyses, as well as proposed assessment and validation methodologies. If available, provide preliminary data to support the feasibility of the proposed work. However, in cases where preliminary results are not available, other means of demonstrating the feasibility of the approach are encouraged. The approach and methods to be employed should be clearly articulated. Address any potential pitfalls and described mitigation approaches that will be employed.

3. Include details of how any data obtained will be validated and analyzed, and offer a full description of any required data management plan, including activities to make data available and widely accessible.

4. Identify major partners and their respective contributions, particularly in-kind contributions, as appropriate. The contribution of each partner to the integrated research goals must show that the total effort is integrated and greater than the sum of the separate efforts.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

5. Identify any potential social or environmental impacts of the project with appropriate plans to mitigate them.
6. 6. Elaborate the significance of the proposed activity on the field of rain enhancement and other disciplines that may benefit.

C. Capacity Building (Minimum, 1-page)

Provide a plan that shows how the research will be integrated with education and training for rain enhancement and, where relevant, related disciplines. Include expected regional impacts of planned activities with regard to research infrastructure. Provide the plan for engaging other partners to enhance regional capability and involvement. Emphasis should be placed on capacity building in the UAE.

D. Knowledge Transfer (Minimum, 1-page)

Discuss how the data, knowledge, technologies and models generated from the research program will be made available to UAEREP and the broader research community. Describe training and educational opportunities that will be created for researchers or workers in the field, especially within the UAE. Describe mechanisms that may attract new small businesses or enhance their capability to undertake activities in the field.

E. Management Plan (Minimum, 2-pages)

Provide a clear description of how the overall program will be managed. Detail should include lines of authority, communication among team members, how decisions will be made and who makes them, how partnerships are integrated, how unforeseen pitfalls and mid-course corrections will be handled (if necessary), how external advice is incorporated, incorporation of outreach to ensure meaningful national and international collaborations, and mechanisms that will be used to integrate and involve various stakeholders.

F. Timeline (1 page)

Provide an anticipated timeline, including planned activities, project milestones, and deliverables for the three years of the award. A Gantt chart to display milestones and deliverables is required. The expected technology progression of deliverables should be noted where appropriate.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

4. Facilities, Equipment and Other Resources (no page limit):

Provide a detailed description of institutional and other resources that will be available to the project, including information on the availability of sufficient infrastructure and technical expertise to ensure effective usage of any major equipment or instrumentation. Include technical specifications of new equipment or instrumentation if the development of these is part of the proposal.
This section is descriptive only, and not to be used as additional space to elaborate the Research Program description.

5. References Cited (no page limit):

Each reference must include the full citation. Applicants must be especially careful to follow accepted scholarly practices in providing citations for source materials relied upon when preparing any section of the document. While there is no established page limitation for the references, this section must include bibliographic citations only and must not be used to provide parenthetical information outside of the project description. It is important to be succinct and select only those references pertinent to the proposed research. Reference numbers should be shown in the text of the research proposal. Use of published works should conform to international copyright treaties and the best scholarly practices.

6. Biographical Sketches (2-page limit per person, in a single pdf document):

Biographical sketches, including listing of prior or ongoing research projects of relevance to the program, are required for the PI, Co-PIs, and all senior research personnel. Biographical sketches should convey information that demonstrates the individual's expertise as related to the proposed research, and should include:

- Vitae, listing professional and academic essentials and present affiliation.
- A brief description (not more than five sentences) on how stated expertise is relevant to the proposal.
- List of up to 5 publications most closely related to the proposed project and up to 5 other significant publications. Patents, copyrights or software systems developed may be included as well. However, only up to 10 items will be considered in the merit review.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

7. Required Supplementary Documents (in a single pdf document):

- Letters of Collaboration/Support: A support letter must be provided and signed by an authorized senior management representative of the lead institution. Include only other letters from individuals or organizations that are integral to the proposed project, whether or not they are receiving financial support. Ensure that the letters specifically address involvement in some aspect of the project. Letters of endorsement alone are not appropriate.
- List of suggested reviewers, or reviewers not to include (with a brief explanation or justification for why the reviewer should be excluded).
- Up to three keywords that describe the project, listed in order of priority.
- Identification of proprietary or privileged information and/or relevant background intellectual property (if applicable).

(8) Budget and Budget Justification (Excel spreadsheet template to be downloaded from the Program Web Portal and completed):

Provide a budget for each of the three years of the project and a cumulative budget in the format specified in the Excel spreadsheet. The proposed budget should be consistent with the needs and complexity of the proposed activity. This competition provides awardees with up to USD $1.5M with an annual cap of USD $550,000. Note that indirect costs are limited to 20%. If additional support beyond what is requested from the UAEREP is necessary and anticipated to complete the proposed project, the PI must identify and provide documentation of the availability of those funds.

The PI's institution receives the full grant amount partitioned into the three annual payments. It is the responsibility of the lead institution (and/or PI) to track budgets and make payments to collaborating institutions (if any). As part of the full proposal submission, a separate budget spreadsheet should be filled in by each collaborating institution's Co-PI. The annual totals from the collaborator budget sheet(s) should be listed in the lead institution's overall project budget spreadsheet under the designated section (Subcontracts, Subawards) for each year.

VI. PREPARATION AND SUBMISSION INSTRUCTIONS

9. Conflict of Interest Form (Excel spreadsheet to be downloaded from the Program Web Portal and completed):

The PI is required to submit a spreadsheet listing conflicts of interest for all persons listed on the Cover Page of the proposal. The template, which has supplementary instructions, must be downloaded from the web portal and instructions for use of the template must be strictly followed. The completed form, which is the same as required for the pre-proposal, must be uploaded to the portal. For the full proposal, an update of the form provided for the pre-proposal, reflecting any changes in proposed personnel, may be used. If there are no changes, simply upload the previous form via the Web Portal.

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

A. Merit Review Principles and Criteria

The UAEREP strives to enhance the level of research and innovation in the field of rain enhancement as well as adjacent fields. To identify which projects to support, the Program Secretariat relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing rain enhancement effectiveness and efficiency, particularly in arid regions. The reviewers will be instructed to base their critique and scores solely on the written materials provided in the application. Therefore, links to URLs or other supplementary information not otherwise specifically allowed for this competition shall not be used as part of the evaluation process.

The reviewers will be selected based on the following criteria: 1. scientific and engineering expertise pertinent to the submitted proposals to ensure ability to evaluate competence, significance, and impact of the proposed activity; 2. generalized knowledge of fields related to atmospheric science, and particularly rain enhancement; and 3. extensive knowledge of the scientific and engineering enterprise, including managing and evaluating large research projects. All reviewers will be instructed in the Program's confidentiality, conflict of interest, and ethics guidelines, and will be required to sign confidentiality and conflict of interest forms to indicate their agreement to abide by these policies.

The Program Secretariat will be responsible for overseeing the proposal submission process, review of conflicts of interests (COIs), panel selection and assignments, and the review and award processes. The Program Secretariat makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects. In all cases, the decisions of the Program Secretariat are final.

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

B. Criteria for Pre-proposals

Given that the evaluation of the pre-proposals will be based on limited written materials, the merit review process will address the critical elements deemed necessary to determine whether the applicants should be invited to submit a full proposal. Pre-proposal evaluations will be based on the following criteria:

1. Alignment with UAEREP Thrust Area(s) and research priorities
2. Research excellence, impact, and quality
3. Experience and/or expertise of the proposers, and potential for success
4. Multidisciplinary collaboration across academic, industry, and government partners
5. Potential to enhance or transform the rain enhancement research community and industry

C. Criteria for Full Proposals

The full proposals will be evaluated via an extensive panel review based on the defined review criteria. Each of the major criteria shown below will be given full consideration during the review and decision-making processes, and provided a numerical score. Each stated criterion is important but none, by itself, is sufficient for a successful proposal. Therefore, reviewers will address all criteria and also provide an overall impact score based on their assessment of likelihood of success in advancing the field and in meeting the UAEREP objectives. Each criterion will receive a number score, and the final score will be calculated based on the percent weight of each criterion. Listed after each individual criterion are some of the questions the reviewers will consider in providing their assessments.

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

Overall Scientific and Technical Merit, Significance, and Innovation: 35%

- How does the proposed activity address important aspects of the UAEREP Thrust Area(s) and related priority research topics?
- If the aims of the proposal are achieved, how will the outcomes be advanced toward practical impact?
- Is the research based on sound and testable physical hypotheses - and if so how?
- Does the planned work clearly challenge or seek to validate current research or technology paradigms - and if so, how?
- How are the concepts, approaches, and technologies proposed novel?
- What is the planned technology progression of technologies, models and other relevant deliverables?
- Is the research distinct from projects already funded through the program?
- What are the expected tangible outcomes of the project, including patents, commercialization opportunities, databases, and observational capabilities?

Approach: 20%

- How well conceived and organized is the proposed activity?
- Does the plan incorporate a mechanism to assess success?
- Does the plan have a clear set of milestones and deliverables with technology progressions indicated?
- If experimental, will the design adequately test, and the evaluation plan adequately validate, the hypotheses?
- Are the computational models, laboratory equipment, or field experimental equipment and infrastructure supported with commitments, appropriate, and well planned?
- Is there a correct use of statistics as a supporting tool?
- Is the data plan consistent with the research proposed and with the solicitation's data principles?
- Does the application identify risks and, if so, are plans in place to mitigate these risks?
- Does the approach identify and account for any potential environmental and social impacts?

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

Investigator/Team: 20%

- How well qualified is the proposer (individual or team) to conduct the project?
- Does the team have a strong balance of academic, industry, and government collaborators capable of delivering a program that is highly coordinated and with significant impact? Are multi-institutional, multi-national collaborations, and linkages between universities/colleges, national laboratories, private sector research laboratories, and/or state and local government organizations included?
- To what extent are UAE personnel, including those from NCM, expected to be involved in the proposed research?
- If early-stage researchers are involved, how adequate is their training and experience?
- For established researchers, have they demonstrated an ongoing record of accomplishments that have significantly advanced the fields of the proposed research?
- If the project is collaborative or multi-PI, do the researchers have complementary and integrated expertise and to what extent does the collaboration show added benefit?
- Is the leadership approach, governance and management structure appropriate for success of the project?

Capacity Building: 15%

- How is capacity building integrated within the research plan and how does it impact the field of rain enhancement globally and in the UAE?
- What is the potential of the work to increase the visibility and reputation of the field, or to grow the field regionally and/or globally?
- Are there educational and experiential opportunities for graduate students, new researchers, and/or technical workforce, especially in the UAE?
- Will important new research infrastructure be established in the UAE?

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

Resources and Budget: 10%

- If needed, have additional sponsors or means of support been identified to complement the proposed project budget?
- Does the research team have access to adequate facilities and infrastructure to conduct the proposed research, and has the team demonstrated the necessary institutional commitment to be successful?
- Does the research team exhibit the ability to manage a complex project?
- Are the project costs complete and fully documented?
- Is the budget fully justified and reasonable in relation to the proposed research?
- Are additional resources and in-kind contributions stated in the proposal logical, justified, and providing clear contribution to the proposed project impact?

D. Review and Selection Process

Both pre-proposals and full proposals submitted in response to this program solicitation will be evaluated by panel review and augmented by ad hoc reviews. Only PIs of pre-proposals recommended by the pre-proposal review panel will be invited to submit the more elaborate full proposals.
The reviewers will be required to base their comments on the review criteria described above. Each application will be evaluated by at least three expert reviewers. The applications will be scored based on the below rating system.

Review Criteria and Scoring Matrix

Criteria Scores for Pre-Proposals & Full Proposals		
Criterion	**Score**	**Description**
High	5	Outstanding/Exceptional
	4	Excellent
Medium	3	Very Good
	2	Good/Satisfactory
Low	1	Fair/Marginal
	0	Poor/Non-compliant

VII. PROPOSAL PROCESSING AND REVIEW PROCEDURES

A limited number of pre-proposals judged the most promising by a panel of experts and agreed upon by the Program Secretariat will be invited to submit full proposals. All applicants will be notified of results. Each applicant will subsequently be provided with the reviewers' comments on the pre-proposal's merits. The Program Secretariat's decision whether to invite is final.

The full proposal review panel will use the above criteria to identify a small number of full proposals deemed worthy to be considered by the Program Secretariat for final selection. After the Program Secretariat selects awards, the selected PI's and their institutions will be contacted. Proposers are cautioned that no commitment should be inferred until the cooperative agreement is officially signed by both the NCM, as funder, and the PI's institution.

Once an award decision has been announced, all proposal PIs are provided feedback about their full proposals. In all cases, reviews are treated as confidential documents. Copies of reviews and a panel summary for the full proposals, excluding the names of the reviewers or any reviewer-identifying information, are sent to the PI by the Program Secretariat.

VIII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Up to three Awards will be announced in January of 2026.

B. Award Conditions

The Award consists of: (1) the award letter, which includes any special provisions applicable to this cooperative agreement; and (2) the budget, which indicates the amounts, by categories of expense, on which the Program Secretariat has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures).

The awards are made in the form of Cooperative Agreements issued by NCM (the funder). The Cooperative Agreements will have an extensive section of negotiated conditions relating to the period of performance, statement of work, awardee responsibilities, NCM responsibilities, joint NCM-awardee responsibilities, funding and funding schedule, reporting requirements, management and performance indicators, key personnel, and other conditions. NCM has responsibility for providing general oversight and monitoring to help assure effective performance and administration. Although individual awards are negotiated, and thus will vary depending on the requirements of the project and performers, all will comply with the following basic agreement policies:

Roles and Responsibilities

The agreement will elaborate the roles and responsibilities between the funder and the awardee and among awardee partners, including who has final managerial and decision authority within the project if disputes arise, how decisions are made, how and when funds are distributed, and under what conditions, and how disagreements are handled.

Data Policy

Data generated are expected, except in rare circumstances, to be available for open dissemination and use after validation and initial analysis.

VIII. AWARD ADMINISTRATION INFORMATION

Intellectual Property (IP) and Property Rights

Terms for tangible and intellectual property generated are specified in the Cooperative Agreements. However, no funds will be awarded until the funder is convinced that the project partners have negotiated and agreed on divisions of roles and funding, and on IP ownership matters. Timely notification of discoveries and inventions will be required.

Allowable Uses of Award Funds

The award should be restricted to a maximum of 20% overhead for any institution, and budget items related to fees or profits will not be allowed. It is important to note that the 20% overhead may be applied to all direct costs. Equipment purchased in excess of $5,000 (US) will be exclusively for the use of the project during the duration of the award. Expenditures must meet a "fair and reasonable" standard, and the Program Secretariat retains the right to audit awardees to determine acceptable use of funds.

Settlement of Disputes

The award must stipulate how disputes and disagreements between performers will be settled. Between awardee and funder, appeals will be allowed on decisions made relevant to evaluations, but the funder may limit the number of such appeals and retains ultimate decision authority.

Changes to Personnel

The PI or Co-PIs on the project must not be changed without the express agreement of the funder. Funder must also be notified in a timely fashion of any changes to senior personnel or partner roles.

Reporting Requirements and Evaluations of Performance

Discussed separately below but detailed as elements of the cooperative agreements.

C. Reporting and Evaluation Requirements

The Principal Investigator must submit an annual project report to the Program Secretariat at least 60 days prior to the end of each year's current budget period. The report must include details of both progress and future plans as the information provided will serve as the basis for annual performance assessment and continued funding. To augment this review, during the course of the three-year cooperate agreement, the Program Secretariat will conduct site visits that may also involve other experts in the field. This team of visitors will prepare site visit reports, evaluating progress and highlighting any concerns. The PI will be asked to provide written responses to questions raised by the site visit panel. Within 60 days following expiration of the award, the PI also is required to submit a final project report, and, as requested, a project outcomes report for the general public, which is intended to be made available on the UAEREP website.

IX. Appendices

We have attached two appendices to this solicitation in PDF format. The following are the names of each appendix:

APPENDIX A:
UAEREP STRATEGIC PLAN OVERVIEW

APPENDIX B:
NCM-UAEREP DATASETS AND MODELS

Please refer to these documents for additional details and supporting information related to this solicitation.

NCM UAEREP

Appendix “A”

UAEREP Strategy

United for ***Water Security***

UAEREP STRATEGIC PLAN

VISION

Become the **globally recognized** model for **rainfall enhancement research**, **development**, **demonstration** and **deployment** of technologies and operations in the **UAE** and **globally**

MISSION

To establish scientifically validated technology platforms and verification techniques that contribute to enhancing rainfall and water security in the UAE and globally.

To position the UAE as the global leader in the science, technology and implementation of rain enhancement.

PILLARS

Managed Grant Assistance: Technical oversight & evaluation

International Collaboration: Industry-government-academia

Capacity Building and Knowledge Transfer

Multidisciplinary Research and Innovation

STRATEGIC ELEMENTS

Optimized Seeding Materials

Novel CF* and/or RE* Systems

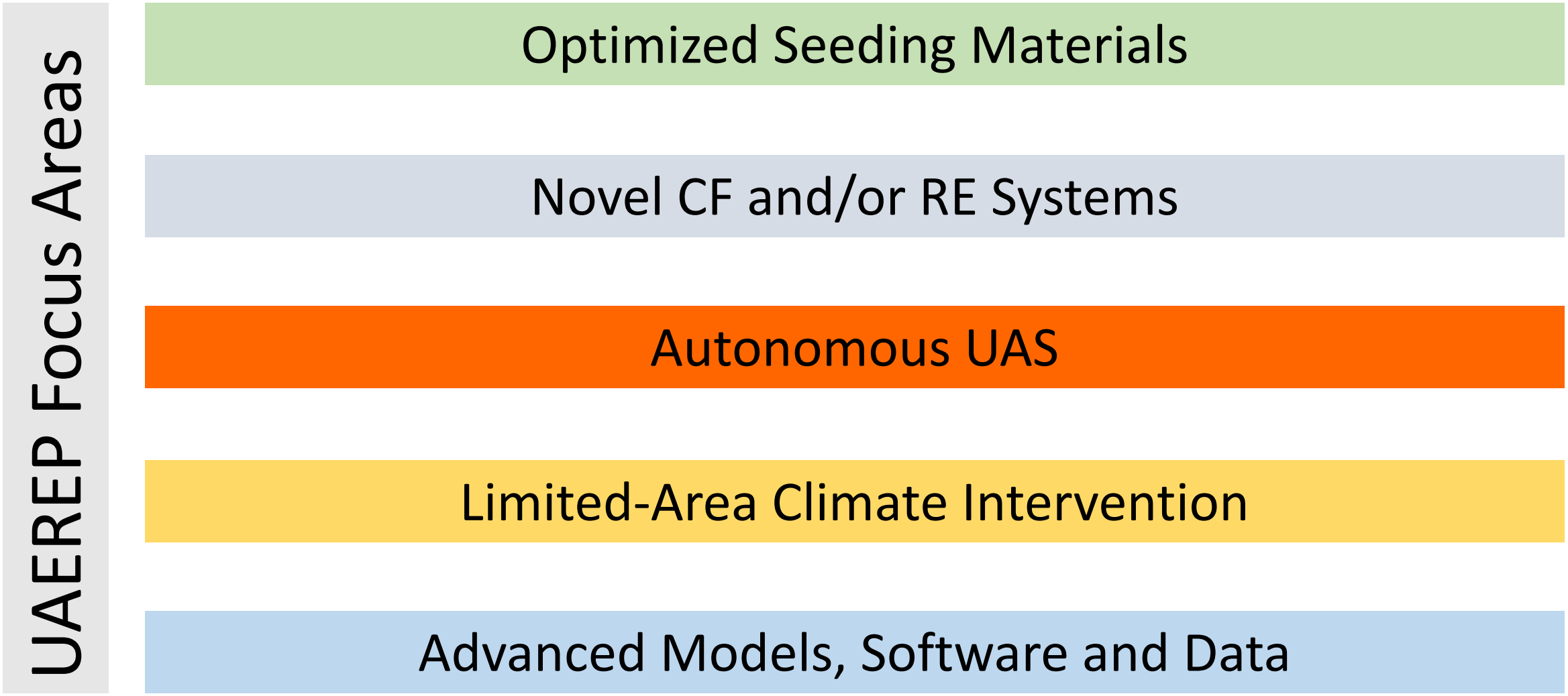
Autonomous UAS

Limited-Area Climate Interventions

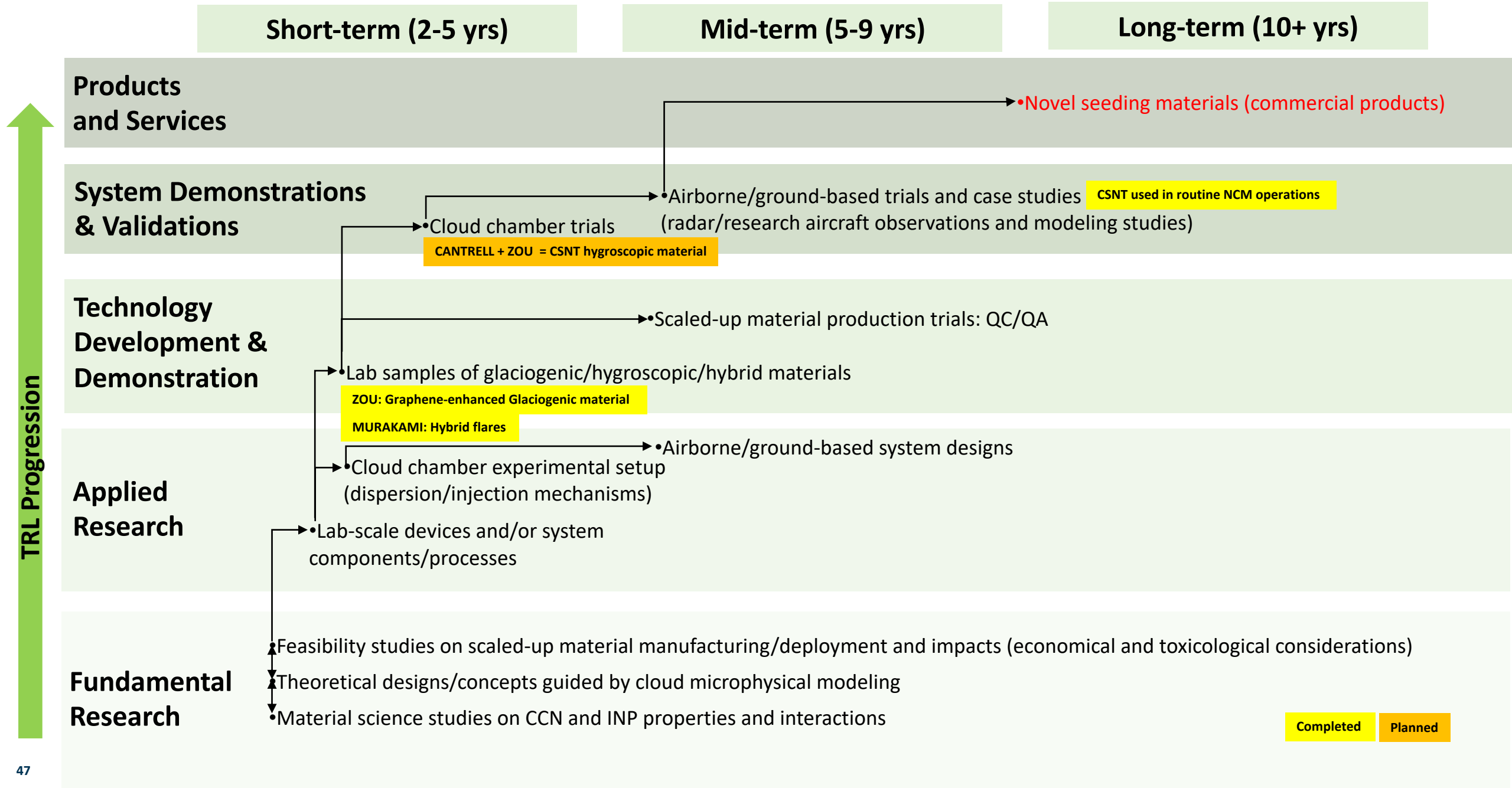
Advanced Models, Software and Data

***CF: Cloud Formation**
***RE: Rainfall Enhancement**

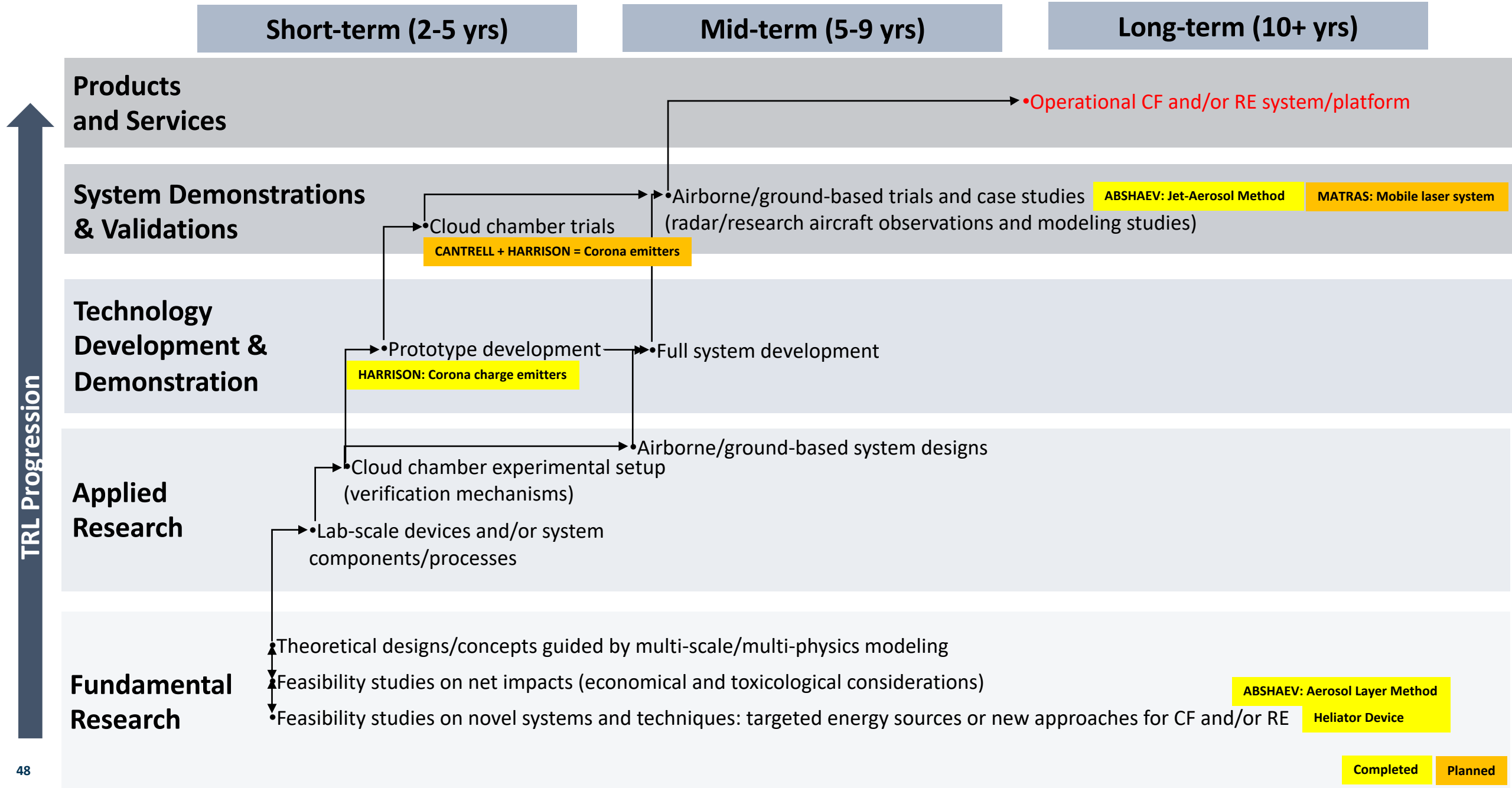
Roadmaps for UAEREP Strategic Elements



Optimized Seeding Materials



Novel CF and/or RE Systems



Autonomous UAS

	Short-term (2-5 yrs)	Mid-term (5-9 yrs)	Long-term (10+ yrs)
Products and Services			•Autonomous UAV swarms for real-time in situ cloud observations and rainfall enhancement
System Demonstrations & Validations	•Low-altitude/controlled airborne trials (fog targeting) and validation	•Beyond visual line of sight trials (cloud targeting) and validation	FREW: US Great Plains – ongoing project for UAE field demonstrations with KUCARS
Technology Development & Demonstration	•Autonomy integration (flight control and decision making) •Payload/component development		HARRISON: Corona emitters integrated with UAS platform
Applied Research	•Autonomous algorithms (command/control) •Miniaturized sensor/system payload design		
Fundamental Research	•Feasibility studies on UAVs for RE operations (local regulatory and operational constraints)		

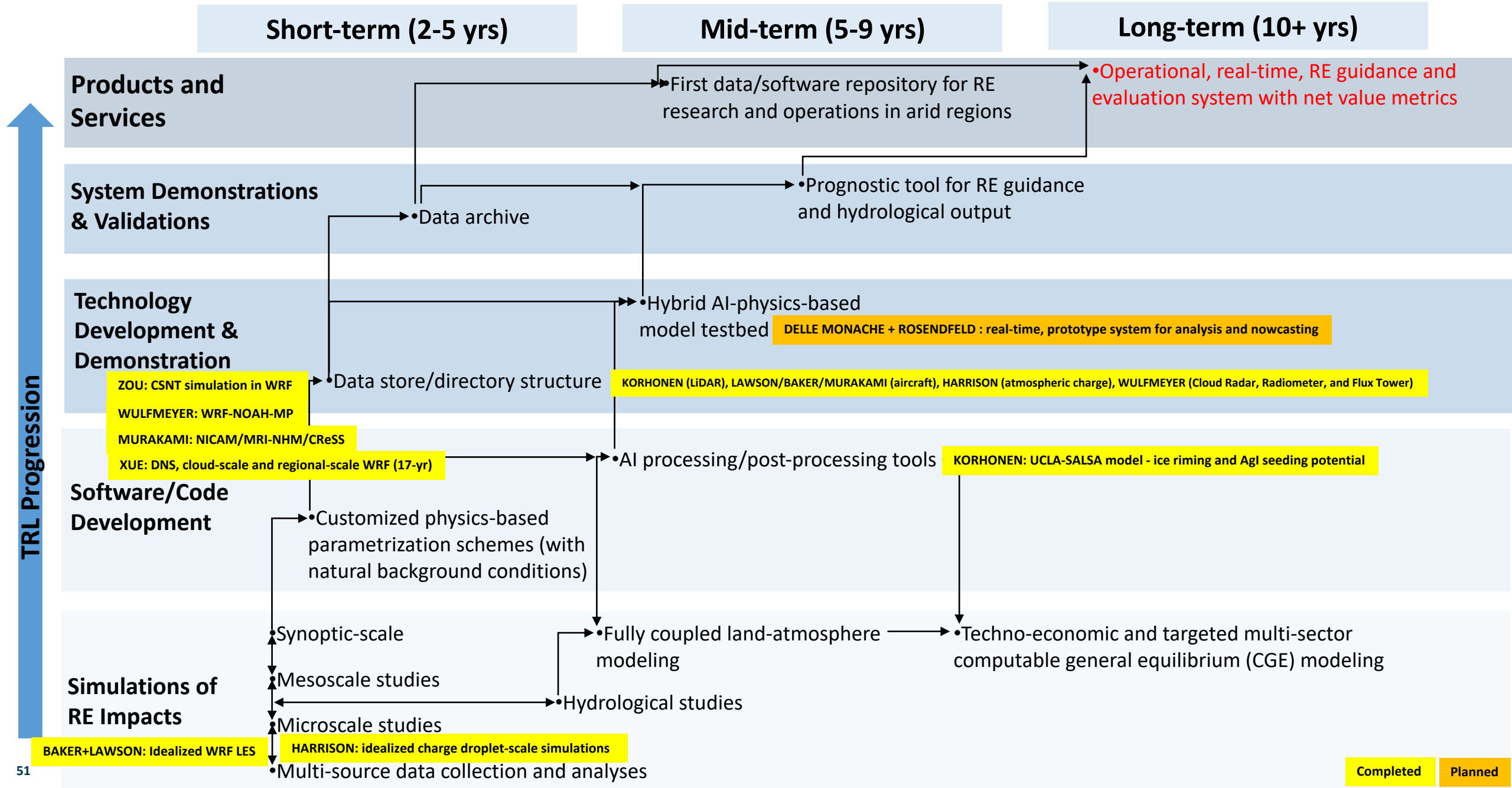
TRL Progression

Limited-Area Climate Interventions

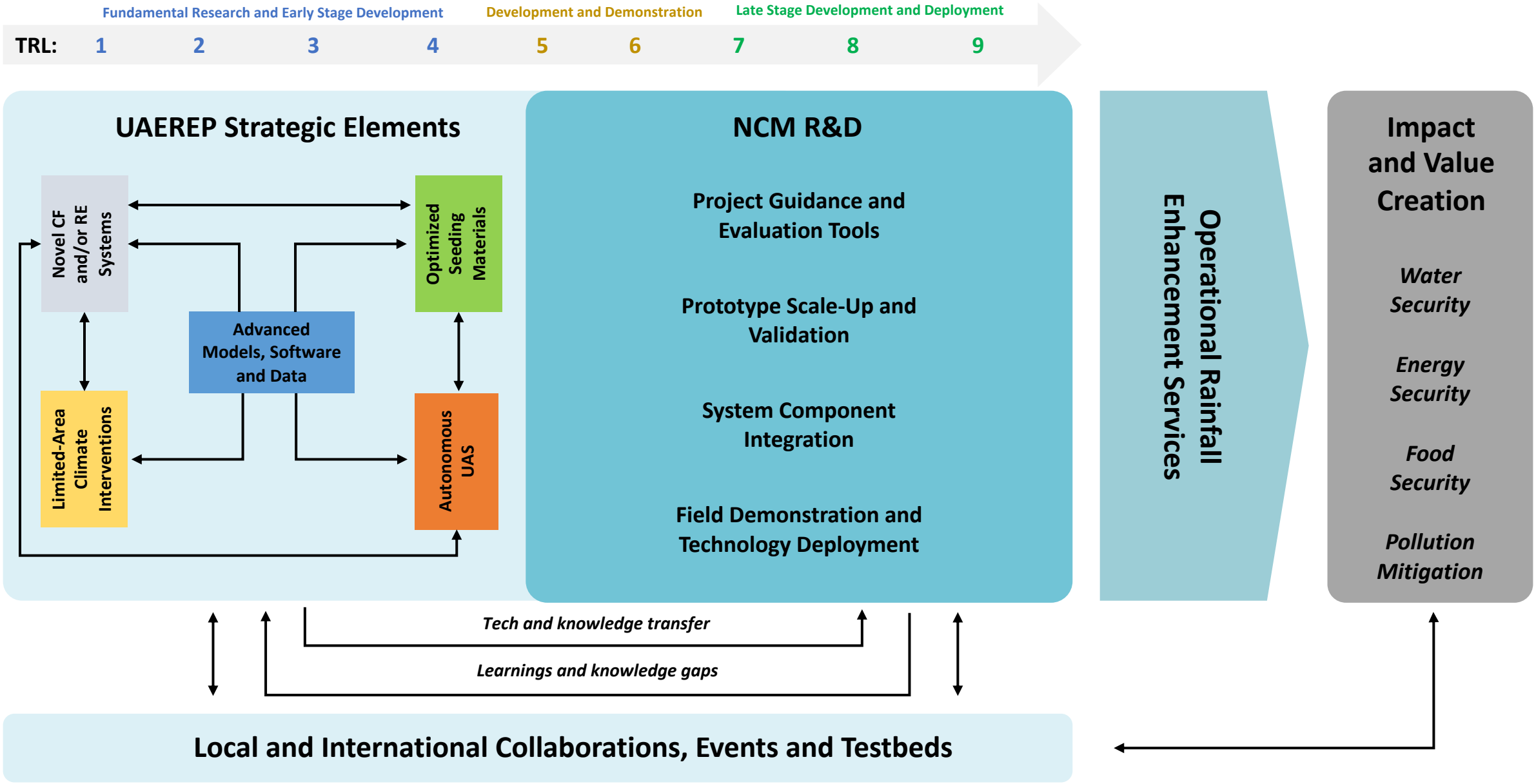
	Short-term (2-5 yrs)	Mid-term (5-9 yrs)	Long-term (10+ yrs)
Products and Services			•Nature-based CF/RE eco-park
System Demonstrations & Validations	•Pilot project	•Monitoring, Reporting and Verification (MRV) framework	
Technology Development & Demonstration		•Field surveys/trials, multi-agency stakeholder coordination and site selection for proposed landform modification	
Applied Research		•Digital twin-based impact assessment (and/or hybrid AI-physics-based modeling) WULFMEYER: Cloud-Precipitation-Reactor (CPR)	
Fundamental Research	•Feasibility studies (local regulatory and techno-economic constraints)		

TRL Progression

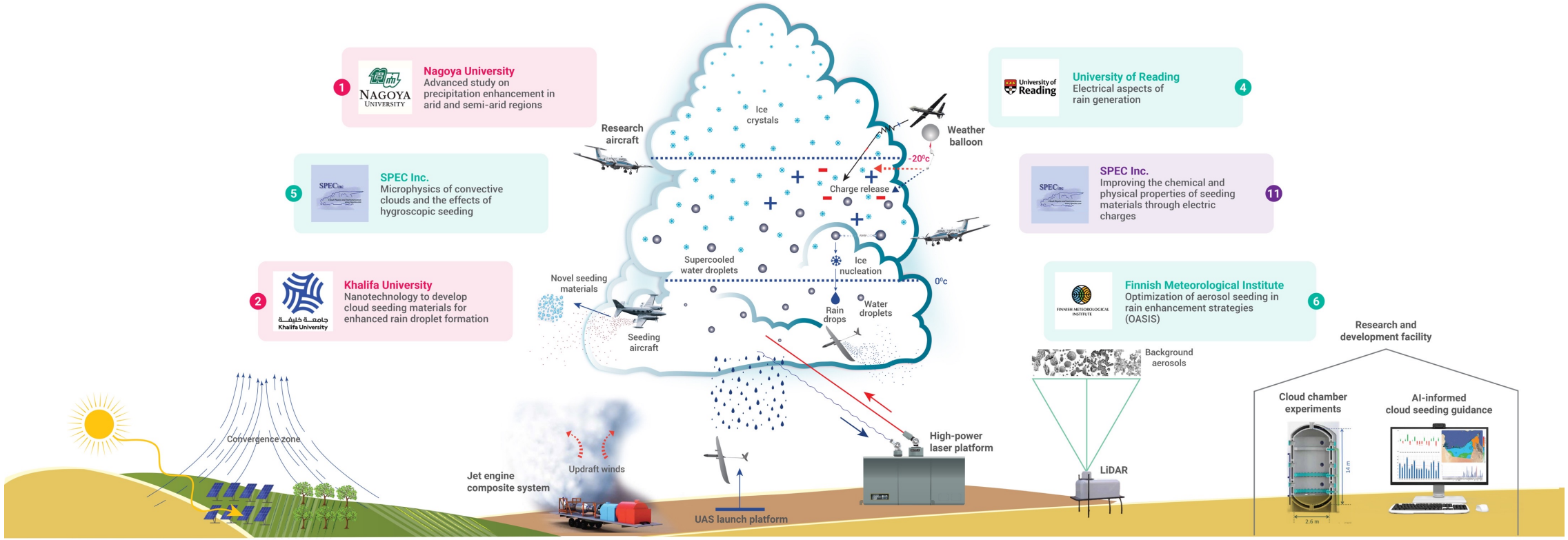
Advanced Models, Software and Data



Thrust Area Feedbacks and Impact Pathways



UAEREP Projects 2016 - 2024



1 **Nagoya University**
Advanced study on precipitation enhancement in arid and semi-arid regions

2 **Khalifa University**
Nanotechnology to develop cloud seeding materials for enhanced rain droplet formation

3 **University of Hohenheim**
Optimizing cloud seeding by advanced remote sensing and land cover modification

4 **University of Reading**
Electrical aspects of rain generation

5 **SPEC Inc.**
Microphysics of convective clouds and the effects of hygroscopic seeding

6 **Finnish Meteorological Institute**
Optimization of aerosol seeding in rain enhancement strategies (OASIS)

7 **Hail Suppression Research Center**
On the creation of updrafts for the formation of artificial clouds and rainfall

8 **University of Colorado, Boulder**
Targeted observation and seeding using autonomous unmanned aircraft systems

9 **Hua Xin Chuang Zhi Science and Technology**
Using Advanced Experimental Numerical Approaches to Untangle Rain Enhancement UAE-NATURE

10 **University of California, San Diego**
A Hybrid Machine Learning Framework for Enhanced Precipitation Nowcasting

11 **SPEC Inc.**
Improving the chemical and physical properties of seeding materials through electric charges

12 **Michigan Technological University**
Laboratory and Modelling Studies of Cloud Susceptibility to Hygroscopic Seeding

13 **Hebrew University of Jerusalem**
Identification of Clouds' Microphysical Seedability in an Actionable Manner

14 **Technology Innovation Institute**
Laser-based rain triggering demonstrator with remote sensing technology

Cycle 1 | Cycle 2 | Cycle 3 | Cycle 4 | Cycle 5

NCM UAEREP

Appendix “B”

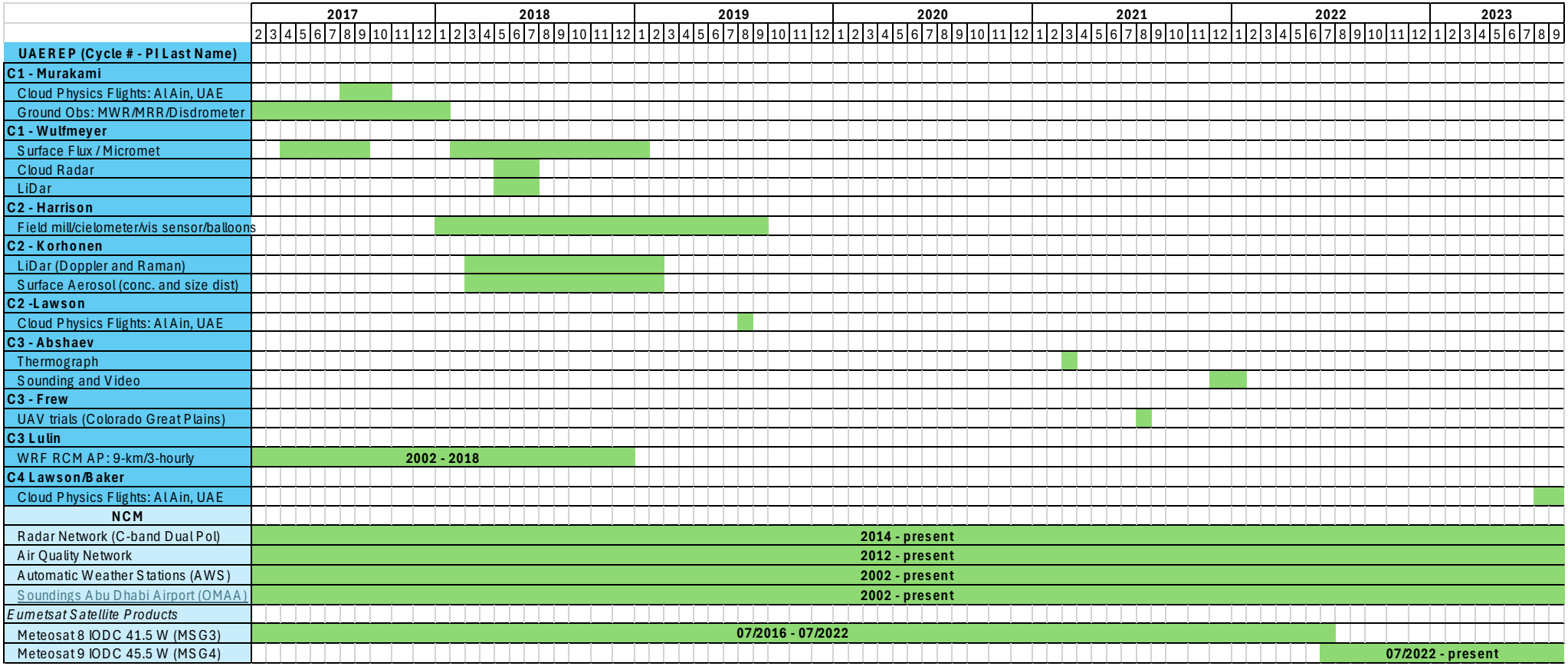
NCM-UAEREP Datasets and Models

United for ***Water Security***

NCM-UAEREP Datasets and Models

Fact Sheet - August 2024

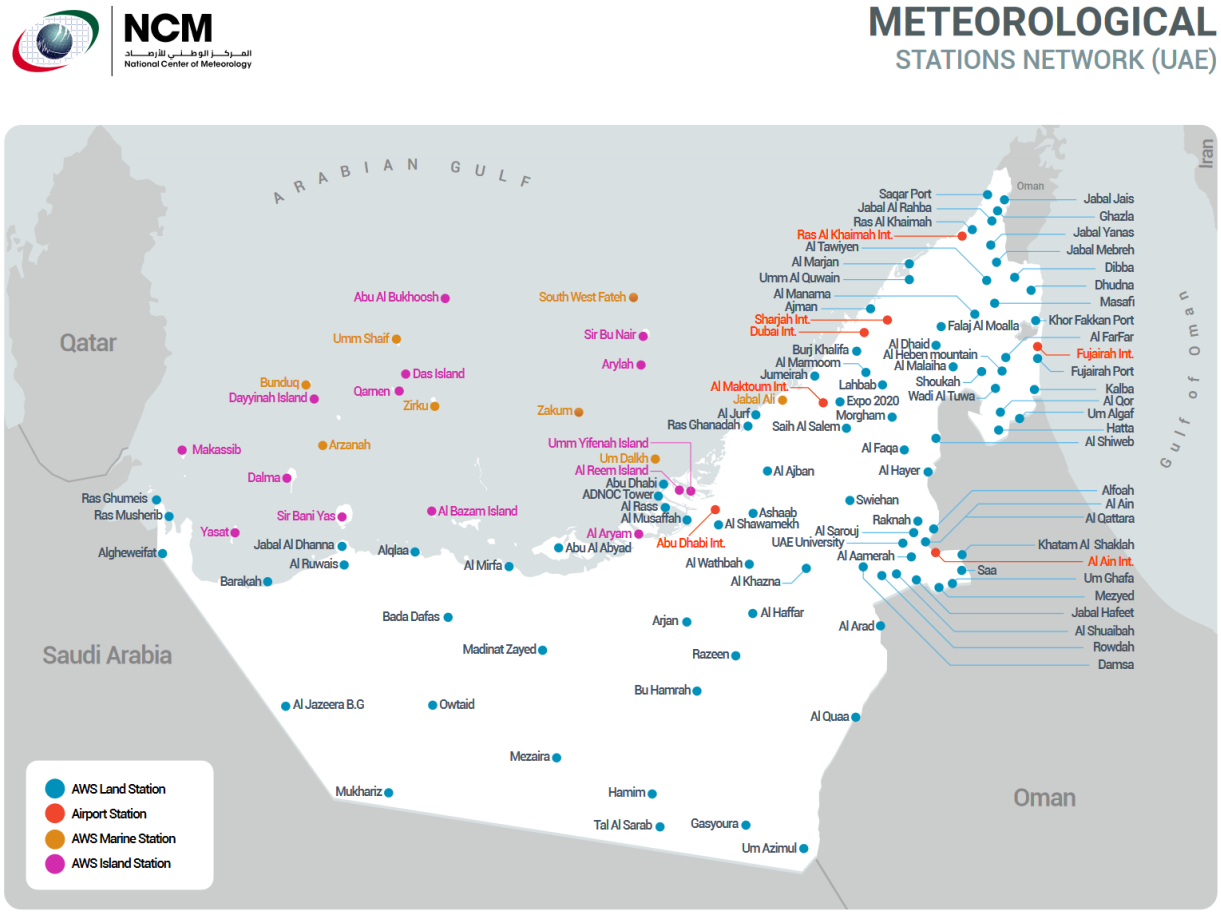
Dataset Coverage Periods



NCM datasets

1. Automatic Weather Station (AWS) Network

Webpage link here

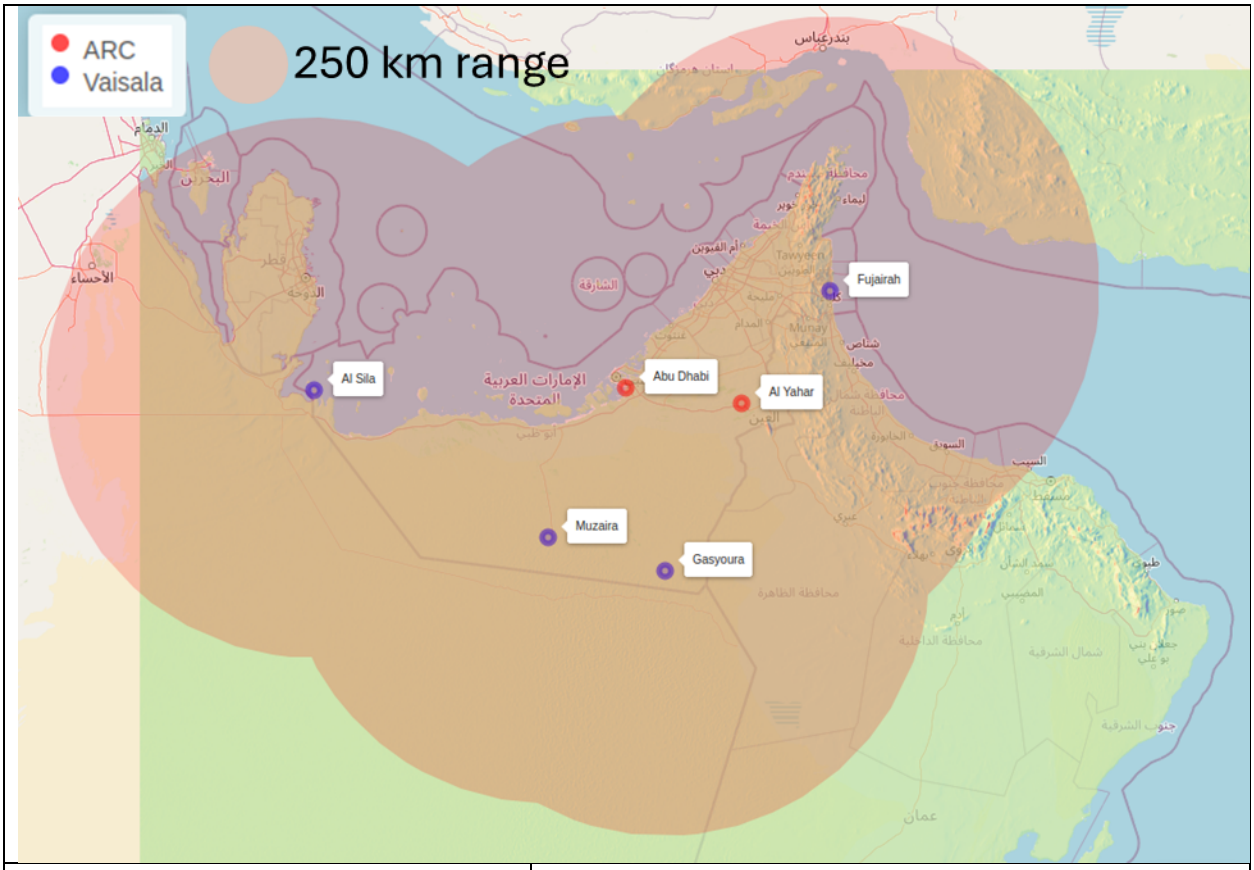


2. Upper Air Soundings: Abu Dhabi Airport (00 and 12 UTC)

Webpage link here: Station Code OMAA

3. Radar Network

Webpage link here



Technology

- 6 Radar
- C-Band
- Dual polarization
- 250 km range
- 11 scan heights
- 6 minute scan duration
- Top down scan
- 1 degree beam width

Primary data

- Radial dBZ
- Radial Velocity (up to 32 m/s)

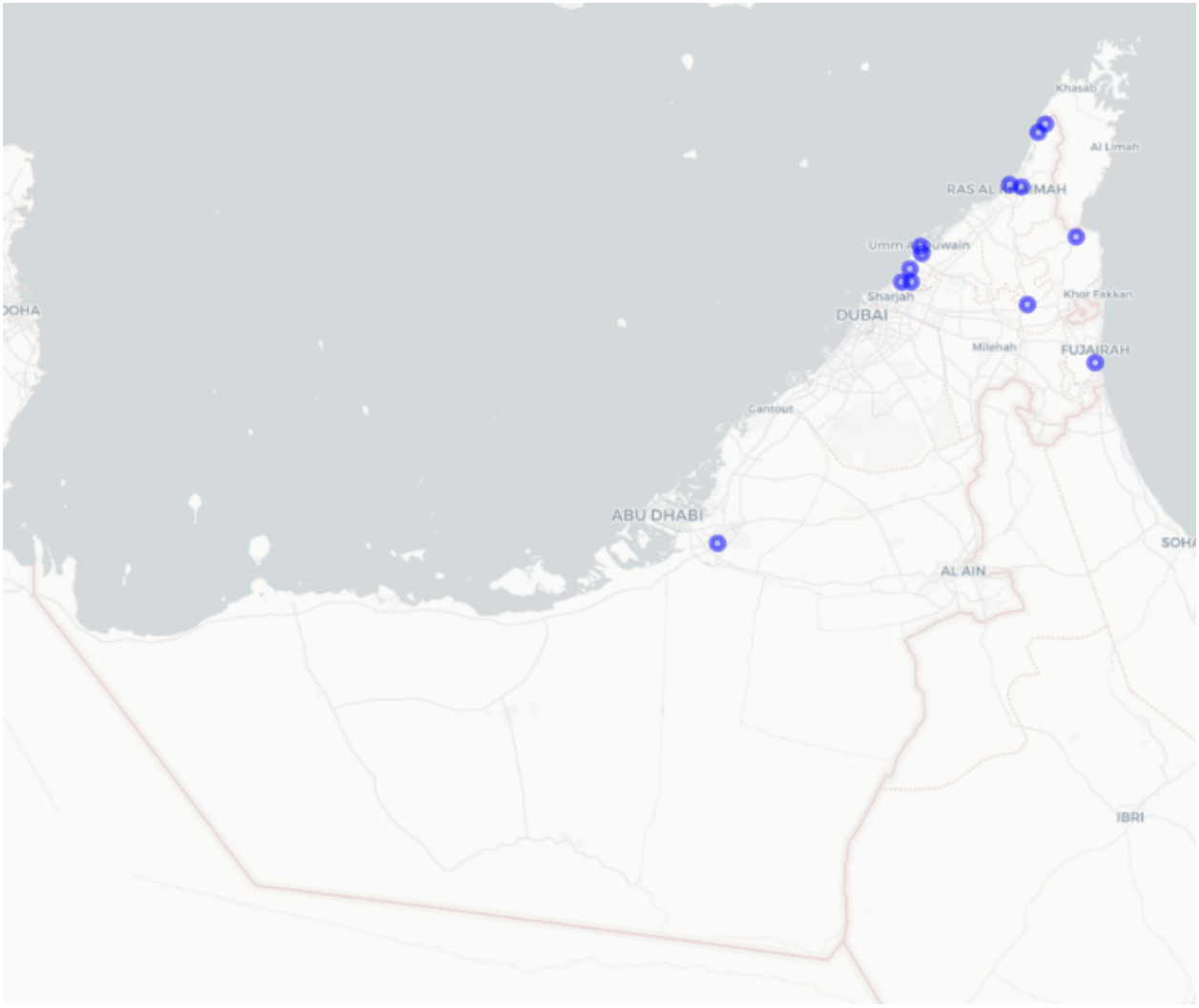
Secondary data

- Precipitation Accumulation (ZR)
- Precipitation Hybrid-rate from Dual-Pol, used for Quatitive Precip. Estimation. (QPE)
- QPE Accumulation
- **V**ertically **I**ntegrated **L**iquid Water (VIL)
- **V**elocity **A**zimuth **D**isplay (VAD, Wind profile)
- Particle identification from Dual-Pol data

4. Air Quality

Webpage link here

In general, most sites are urban and are indicative of background + local sources



					Elements									
N°	**Stations**	**Lat**	**Lon**	**Period**	SO2	H2S	NO	NO2	NOx	CO	O3	BTEX	PM2.5	PM10
1	Al Burairat	25.78	56.00	Oct 2012-pres	x		x	x	x	x			x	x
2	Al Hamra UQ	25.54	55.55	Feb 2020-pres	x			x			x	x	x	x
3	Al Hamriyah	25.45	55.50	Oct 2012-pres	x		x	x	x	x			x	x
4	Al Jeer	26.03	56.10	Oct 2012-pres	x	x	x	x				x	x	x
5	Al Maqta UQ	25.51	55.55	Feb 2020-pres	x			x	x	x			x	x
6	Al Qasimiyah	25.79	55.94	Oct 2012-pres	x			x	x	x	x		x	x
7	Al Shawamikh	24.33	54.64	Aug 2019-pres	x			x			x	x	x	x
8	Ghalilah	25.99	56.07	Oct 2012-pres	x		x	x	x	x	x		x	x
9	Kalba	25.07	56.32	Oct 2012-pres	x	x	x	x	x	x	x		x	x
10	Mushiref	25.40	55.46	Oct 2012-pres	x		x	x	x	x	x		x	x
11	Al hameidah	25.39	55.50	Oct 2012-pres	x		x	x	x	x	x		x	x
12	Dibba	25.57	56.24	Oct 2023-pres	x	x		x				x	x	x
14	Thoban	25.30	56.02	Feb 2024-pres	x			x			x		x	x

5. Satellite

Meteosat 8 IODC 41.5 W (MSG3) available from July 2016 to July 2022

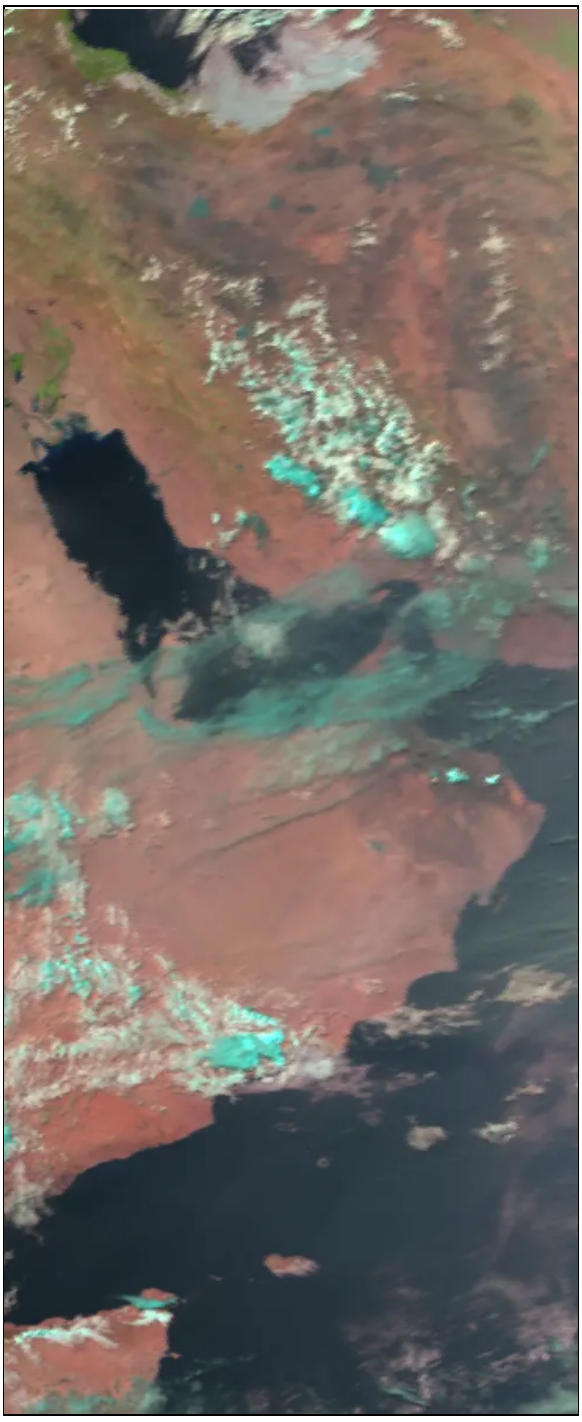
Meteosat 9 IODC 45.5 W (MSG4) available from July 2022 to Present

Primary data

- MSG4 IODC
- Near real time
- Every 15 minutes

Secondary data

- Optimal Cloud Analysis (OCA) Effective Radius
- 1 per hour

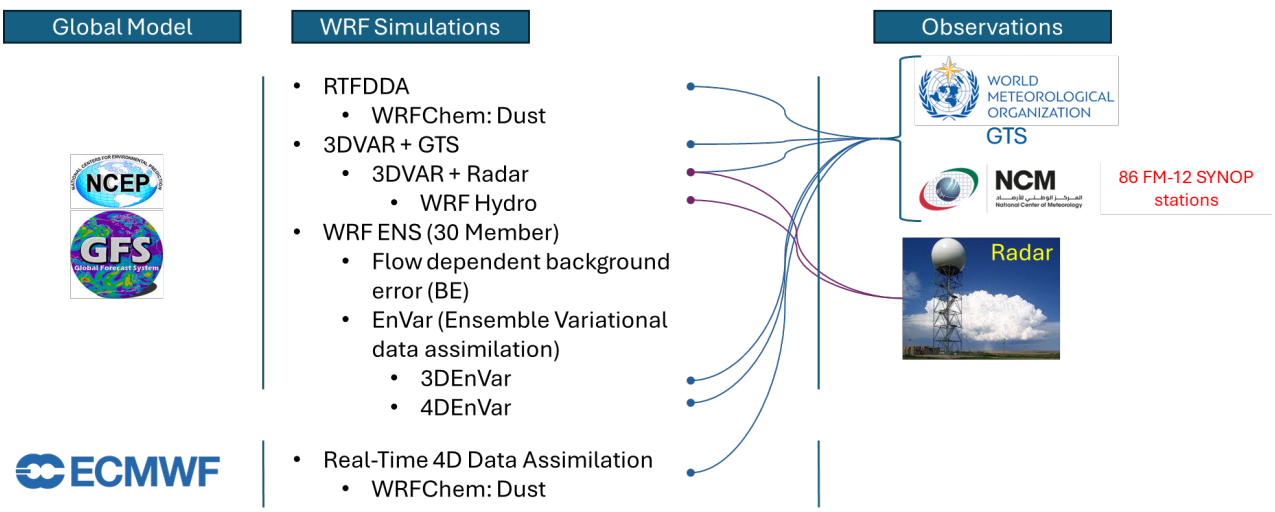


6. Models and Data Assimilation

Available input data sets:

- GFS 0.25 degree
- ECMWF HRES
- GTS

WRF Simulations



UAEREP Datasets

NOTE: See full information in final reports for each project here.

C1 - Murakami

https://japan2016uaerep.wordpress.com/

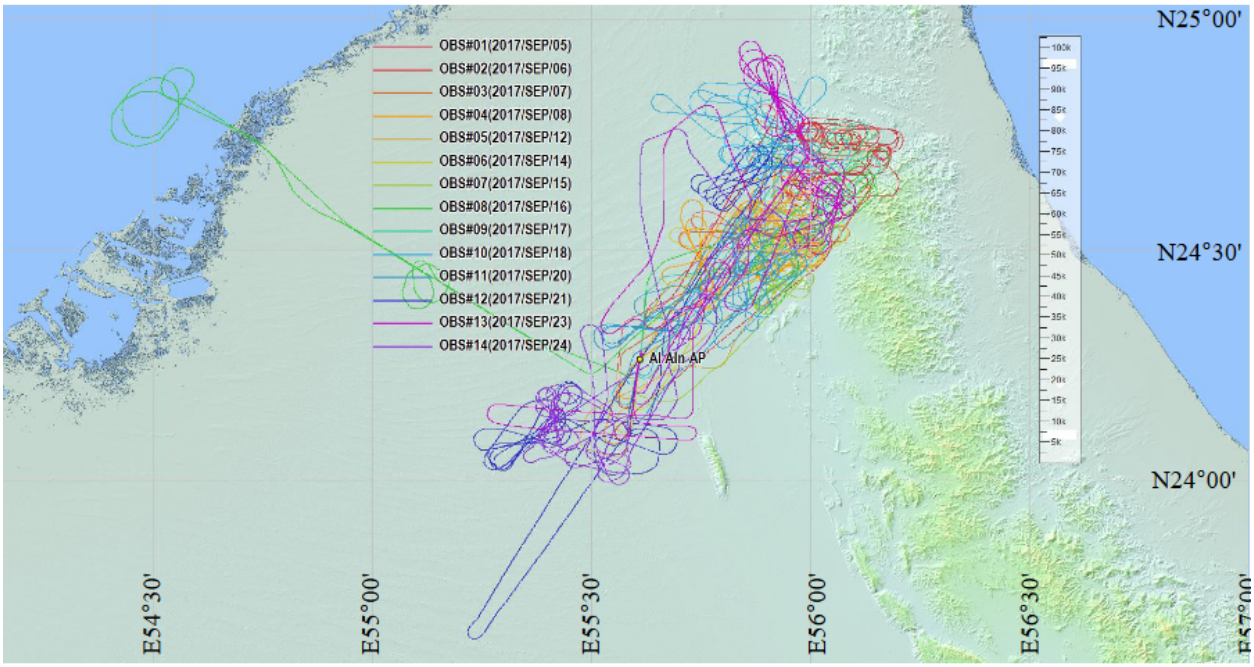
Observations

Cloud Physics Research Aircraft

14 research flights in September 2017.

Most flights over the Al Ain region and Hajar Mountains.

Flight Track - All Obs. (2017/Sep/05-24)



Instrument	Variable
PCASP	Size distribution off aerosols / 30 bins / 0.095 to 2.9 μm
FSSP	Size distribute on of cloud droplets / 15 bins / 3.5 to 45.5 μm
CAS	30 bins / 0.0575 to 47.5 μm
CIP	Cloud droplet imager / 62 bins / 25 to 1550 μm
Probes	Temperature / Pressure / LWC / Dew point T / Water vapour density

Ground

https://japan2016uaerep.wordpress.com/ground-based-obs/

Observations site: Al Ain Airport

Dates: Deb 2017 to Jan 2018

Instrument	Variable
Microwave Radiometer	Cloudbase / LWC / Liquid water path / Temperature profile
Micro Rain Radar	Radar Reflectivity
Optical Disdrometer	Precipitation

Laboratory

Size distribution and hygroscopicity of 3 seeding flares. Later compared to field measurements.

Models

The modelling system comprised:

NICAM: Nonhydrostatic I Cosahedral Atmospheric Model. (Global model)

MRI-NHM (Regional/mesoscale model)

Japanese Meteorological Agency (JMA) Numerical Prediction Division (NPD) and Meteorological Research Institute (MRI) Nonhydrostatic Model.

Idealized model to investigate seeding material effect on cloud.

CReSS: Cloud Resolving Storm Simulator (High resolution model)

The new hygroscopic seeding scheme for double-moment cloud microphysics model was built on the CCN activation scheme newly introduced into CReSS to simulate hygroscopic seeding from below cloud base in a realistic way.

C1 - Wulfmeyer

https://ocal.uni-hohenheim.de/en

Observations

Micromet

Observation site: Al Alin Airport

Dates: April 2017 to Oct 2017; February 2018 to January 2019

Instrument	Variable
Eddy covariance	Air temperature / Relative humidity / Surface radiation fluxes / Horizontal and vertical wind components / sensible heat flux / Water vapour content / latent heat flux / Surface pressure / Soil temperature / Soil humidity / Soil heat flux

Quicklook:

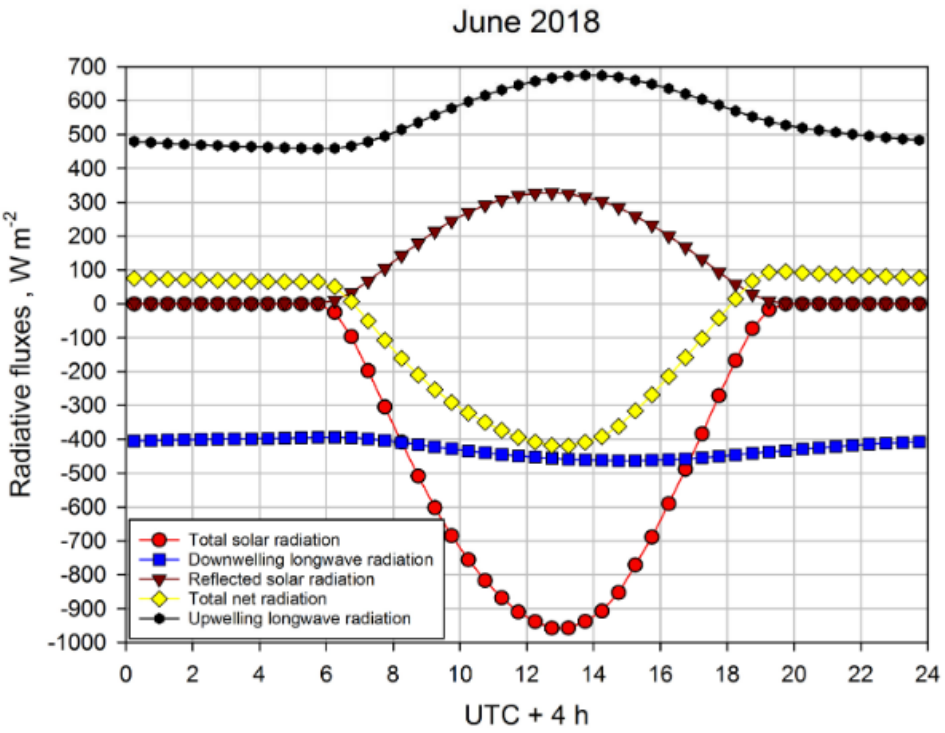


Fig. RC1+1: Typical diurnal cycle of all shortwave and longwave radiation components and the derivation of the resulting incoming net radiation.

Cloud radar and wind lidar

Observation Site: Hajar mountains

Dates: May to July 2018

Plots available at: http://guest.metek.de/mbc2/scan/domescan.html

Highlights of measurements:

https://ocal.uni-hohenheim.de/fileadmin/einrichtungen/ocal/Highlights_OCAL_field_measurements.pdf

Models

WRF

Highlights of model work package:

- Inclusion of local soil and LULC data (available in the WRF Blended section)
- GNSS data assimilation (moisture profiles from GPS signals)
- Use of shallow convection scheme
- High resolution in the vertical (100 levels)
- High resolution modelling over the Hajar Mountains to identify pre-convection environment

C1 - Zou

Model

The focus of this project was the modification of seeding material using nano-technology. A new seeding material was developed in the lab. Some simulations were conducted using a NWP (WRF), to demonstrate the potential effect of the new seeding material on cloud growth. The code of this scheme is included in the WRF Blended code.

C2 - Harrison

Observations

Observation site: AL Ain Airport

Dates: January 2018 to September 2019

Instrument	Variable
Ceilometer (Vaisala CL 31)	Cloud base height / Back scatter
A Campbell CS110 electric field mill	Electrical charge
Biral SWS100 visibility sensor	Visibility

C2 - Korhonen

Observations

Observation site: Sharjah

Dates: Mar to May 2018 / Aug to Sep 2018 / Nov 2018 to Feb 2019

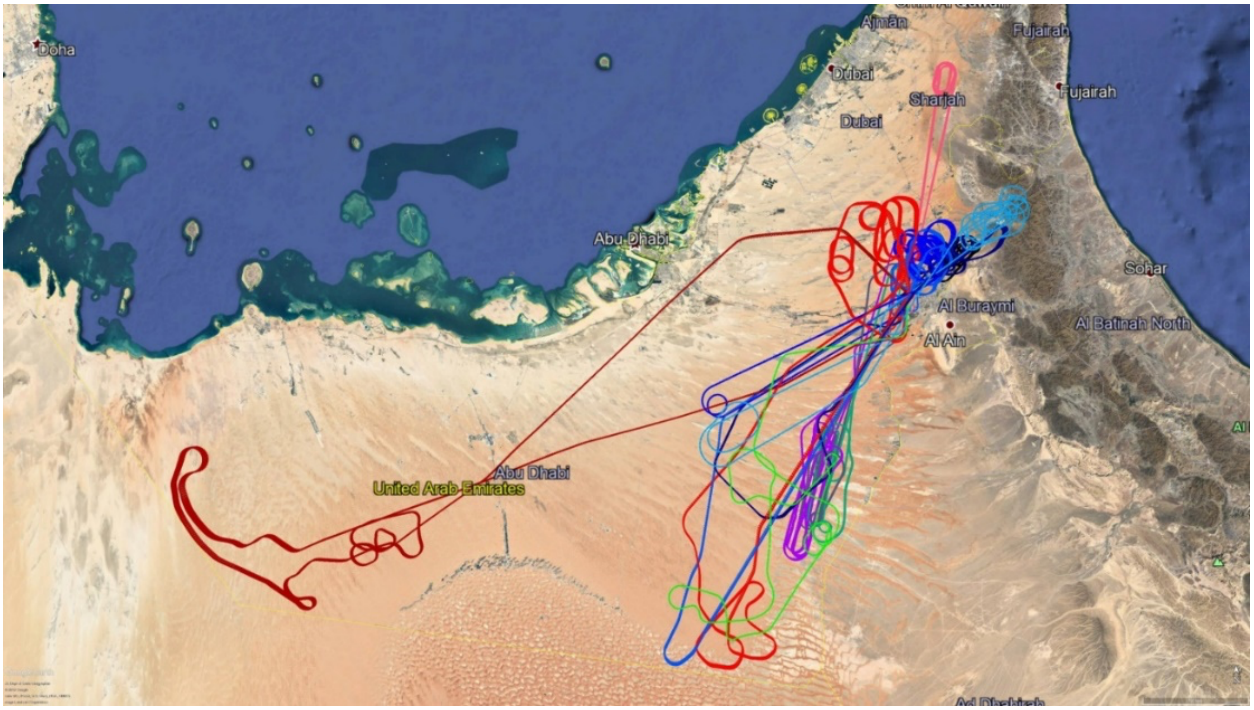
Instrument	Variable	Notes
Raman Lidar	Backscatter. Points vertically	Elastic backscatter channels at 355, 532, and 1064 nm, Two rotational–vibrational Raman channels at 387 and 607 nm, Two linear depolarization channels at 355 and 532 nm, One water vapour detection channel at 407 nm. Two near-field elastic backscatter channels at 355 and 532nm Two near-field rotational–vibrational Raman channels at 387 and 607 nm. Vertical resolution of 7.5m in temporal steps of 30 s
Doppler Lidar (HALO)	Vertical profiles: attenuated backscatter, Doppler velocity, dissipation rate, horizontal winds, wind shear, boundary layer classification.	
CCN Counter (DMT CCN-100)	Total concentration of CCN	Size segregation: 10–250 nm; 20 bins; Measured at supersaturations of 0.1, 0.2, 0.3, 0.6, and 1.
Differential Mobility Particle Sizer	Aerosol size distribution	7 to 800 nm (0.007 to 0.8 µm). 30 bins

References:
Raman Lidar: https://doi.org/10.5194/acp-20-8909-2020
Doppler and CCN: https://doi.org/10.5194/acp-22-481-2022

C2 - Lawson

Cloud Physics Research Aircraft

Six cloud and aerosol sampling flights during August 2019 over the UAE (primarily northeast)



Instrument	Variable	Notes
CPC	Ultra fine mode aerosol	0.01-3 um
PCASP	Aerosol size dist and conc	0.1-3 um
FCDP	Coarse mode aerosol spectra and conc	1.5-50 um
FFSSP	Cloud particle spectra and conc.	3-100 um
2D-S10Hva	Cloud particle shapes and spectra	10-3000 um
2D-S50Hb-Hawkeye	Cloud particle shapes and spectra	50 – 6400 um
CPI-Hawkeye	Cloud Particle shapes	2.3 – 2300 um
HVPS	Precip particle shape and spectra	150 um – 2 cm
Nevzorov	Liquid and total water content	
AIMMS	State parameters (T, pressure, humidity)	

Model

Idealized seeding microphysics code for WRF.

C3 - Xue

Laboratory

Cloud chamber experiments and DNS modelling

Model

Microphysics scheme available in WRF Blended code.

- Xue/ University of Pecs/NCAR bin scheme mp_physics=99

Datasets

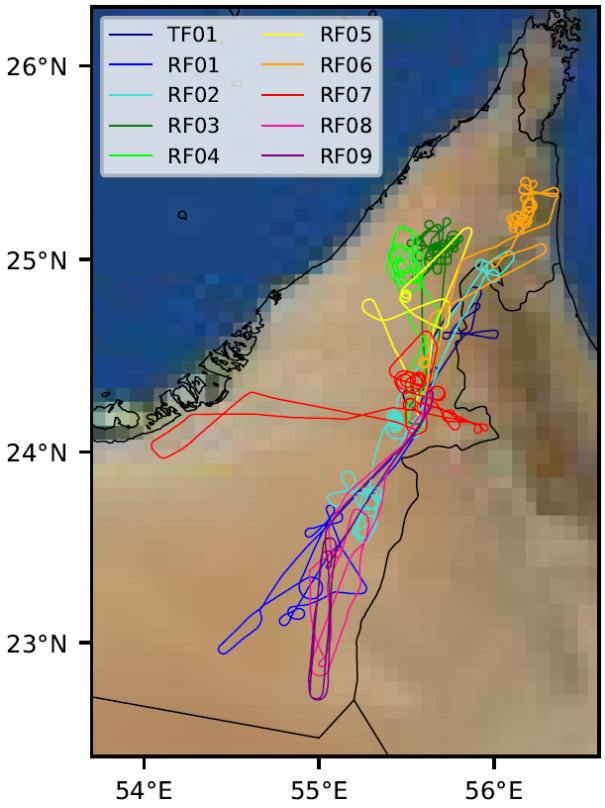
- Climate run of 17 years (2002 - 2019) using WRF at 9km resolution

C4 - Baker

Cloud Physics Research Aircraft

Nine flights with limited cloud and aerosol sampling during August-September 2023.

Same instruments as in C2 – Lawson (above), in addition to a K-band radar.



KU-NCM WRF Model Integration Project: "WRF Blended"

A collaborative project between NCM and Khalifa University's ENGEOS lab. The aim was to incorporate all UAEREP project's modeling work into a single WRF-compatible code base. Below is a description of the datasets and codes available on the NCM HPC.

Model

Surface roughness

Change to surface roughness based on the micrometeorological measurements of Wulfmeyer et al.

- The value of 1.3-2.2 mm is roughly an order of magnitude smaller than that employed in numerical models such as WRF, but is in the range of in situ estimates in other arid regions.
- The sensitivity of the model's predictions to a change in the roughness length is explored, and it is found to be considerable in this region: for otherwise the same experimental set up, a decrease in the hard-coded roughness length by an order of magnitude led to
    - an increase in the horizontal wind speed by up to 1 m/s,
    - a drop in the sensible heat flux by as much as 10 W/m^2
    - an increase in the daytime surface and air temperature by up to 2.5 K and 0.5 K, respectively.
    - When compared against observed values, the usage of a more realistic roughness length improves in particular the model wind speed forecasts for strong winds (> 6 m/s).

Soil Texture and LULC changes

There is a clear increase in the skill of the model forecasts. In particular:

- The air temperature bias is typically reduced by 0.5-1.5 K, but up to 2.5 K at some sites such as Dubai where the change from desert to urban LULC substantially improved the model's cold bias;
- At Abu Dhabi's Airport where radiosonde profiles are available for evaluation, the temperature and humidity bias are reduced between 950 and 750 hPa likely a result of a better simulation of the vertical mixing in the bottom 3 km of the atmosphere.

Seeding Schemes

Zou/Curic

- Realtime seeding scheme in WRF.
- Found to run too slowly for operational purposes but suitable for research runs.

Lawson/TAU liquid bin scheme microphysics

- Idealized microphysics scheme.
- No ice phase.
- The standard 2D squall line test case has been modified and can be run in test/em_squall2d_x/.
- Register to use the code.

Harrison Electrification Scheme

- Idealized scheme for simulating in-cloud electrical interactions.

Xue/University of Pecs/NCAR bin scheme mp_physics=99

- A bin/spectral double-moment cloud microphysics scheme.
- Six hydrometeor species (cloud water, ice water, rain, snow and graupel, besides water vapour).
- 36 mass-doubling size bins.
- 10-12 times more computationally expensive than commonly used microphysics schemes such as the Thompson-Eidhammer scheme.

Program Contact Information:

The URL of the Program's comprehensive Web Portal is:

www.uaerep.ae

For specific questions about application preparation or the use of the web portal please contact:

info@uaerep.ae

For general information about the Program please contact:

info@uaerep.ae

uaerep uaerepofficial info@uaerep.ae www.uaerep.ae

*United for **Water Security***