THE BENEFITS OF RAIN ENHANCEMENT

1. **DROUGHT RELIEF**
   One big benefit of rain enhancement is to increase rainfall amount in regions that are most affected by droughts, lessening the impact of harsh climate. Rain enhancement has the potential to make dry areas more water-secure and more hospitable.

2. **UNDERGROUND WATER RECHARGE**
   Increased rainfall helps raise levels of ground water and reservoirs, and thus prevent desertification by protecting the soils and recharging the water tables.

3. **HAIL SUPPRESSION**
   Through rain enhancement, atmosphere water vapor will be better regulated, thus contributing to prevent hailstone accumulation for instance, and then save the crops from damage. Severe weather prevention contributes to protect local production as well as infrastructures.

4. **FOOD SECURITY**
   Through rain enhancement, soils are fertilized and farms can yield more crops since farmers are now able to exploit areas that might not have been previously ideal for agriculture cultivation. This technology could help alleviate droughts in parts of Africa, which holds 60 percent of the world’s arable lands.

5. **ECONOMIC SECURITY**
   If farmers can grow and sell more crops, then the overall economy of a region would be greatly improved. The rain enhancement technology is actually cheaper than desalinization to provide alternative sources of fresh water.

www.uaerep.ae
TWO YEARS OF THE PROGRAM'S INTERNATIONAL EXPANSION

MANAGEMENT OF THE PROGRAM

34
Research Areas

60+
Staff, Including 41 Reviewers

200
Researchers Engaged During Roadshows

SUBMISSIONS

180
Proposals

450
Scientists & Researchers

200
Institutions

OUTREACH

45
Countries Involved

15
Countries Visited

30
Cities Visited

www.uaerep.ae
THE KEY NUMBERS OF RAIN ENHANCEMENT IN THE UAE

CLOUD SEEDING OPERATIONS BY
THE NATIONAL CENTER OF METEOROLOGY AND SEISMOLOGY

- **6** Beechcraft King Air C90 Planes
- **20** Years of Operations
- **40** Cloud Seeding Flares Per Plane
- **230** Staff

- **187** Cloud Seeding Operations in 2015
- **18** Rain Gauges
- **10-30%** Increase in Precipitations
- **75** Automatic Weather Stations

- **8** Air Quality Center Stations
- **34** Dust Measurement Stations
- **6** Radars
- **2** Satellites

[www.uaerep.ae](http://www.uaerep.ae)
THE EVOLUTION OF RAIN ENHANCEMENT RESEARCH

IN-DEPTH LOOK AT THE RESEARCH AREAS COVERED BY THE UAE PROGRAM FOR RAIN ENHANCEMENT SCIENCE

MAIN INNOVATIONS (2015-2016)

Remote Sensing  |  Data and Analysis  |  Aerosol / Cloud Interactions  |  Cloud Dynamics and Physics
Drones  |  Laser Technology  |  Nanotechnology  |  Simulations and Modeling
Electrical Properties of Particles  |  Ionization  |  Rocket Science  |  Land Cover Modification

www.uaerep.ae
FIRST CYCLE AWARDEES

PROF. MASATAKA MURAKAMI (JAPAN)

BIOGRAPHY
Masataka Murakami is a Designated Professor at the Institute for Space-Earth Environmental Research, Nagoya University. Professor Murakami is a scientist in the Cloud Physics section of the Meteorological Research Institute (MRI) Japan Meteorological Agency since 1984, including the last 21 years as Section Head, and involved in cloud physics, mesoscale precipitation systems, numerical modelling and weather modification research. He is now a visiting scientist at MRI. He served as a member of the International Commission on Clouds and Precipitation from 1992 to 2000.

PROJECT BRIEF
“Advanced study on precipitation enhancement in arid and semi-arid regions”

Professor Masataka Murakami’s project focuses on innovative algorithms and sensors dedicated to identifying the most suitable clouds for seeding and their frequency of occurrence. Professor Murakami’s project team will work on developing optimal seeding methods as well as new statistical evaluation methods to study the effects of long-term seeding, using accurate and reliable numerical models developed through laboratory experiments and observations. Researchers from Nagoya University, the University of Tokyo and the Japan Meteorological Agency contributed to this research project. The observation data collected, including details on the seeding schemes and the algorithms for satellite data analysis will be made available to the public at the end of the study.

RESEARCH PROGRESS
Geophysical mapping of seedable clouds became available through the analysis of NCMS ground and satellite data, which enabled us to select suitable clouds for year-round ground-based observation sites. Physico-chemical properties of seeding materials have been investigated by using the world’s highest-level cloud simulation chamber, cloud condensation nuclei and ice nucleation probes, and several aerosol instruments, which will be incorporated into numerical models in order to conduct accurate and reliable cloud seeding experiments. Numerical models performance has been tested over the UAE area. Additionally, land surface processes have been tuned so as to properly reproduce cloud formation and precipitation developments over the desert areas as well as mountainous areas.

PROF. LINDA ZOU (UNITED ARAB EMIRATES)

BIOGRAPHY
Linda Zou is a Professor of Chemical and Environmental Engineering at the Masdar Institute of Science and Technology. Professor Linda Zou received her PhD degree in Applied Chemistry from Monash University in Australia in 1998, with background in water treatment. She commenced her academic and research career in 1999 at Deakin University Australia, and became in 2010 a research professor at the University of South Australia.

Professor Zou’s research interests include applying nanotechnology and membrane science to the development of low energy and high efficiency desalination and water purification solutions. Her research outcomes have been published in more than 100 journal articles and conference presentations. Professor Zou currently serves as the chief investigator of several frontier research projects in desalination sponsored by ADEC Award for Excellence (A2RE), Veolia Water, and collaborative research program between Masdar Institute and University of Manchester.

PROJECT BRIEF
“Nanotechnology to accelerate water condensation nucleation and growth”

Professor Linda Zou’s project intends to improve the effectiveness of technologies used to increase rain precipitation, through engineering nanostructured properties of the cloud seeding materials to help water vapor in clouds condense which is the process needed for raindrops to form. In addition, new methods of real-time observation and evaluation of water condensation and crystallization will be developed by Dr Mustapha Jouaid in this project. The goal of the project is to explore the different ways of employing current knowledge of nanotechnology to fabricate innovative cloud seeding materials, to increase the efficiency of rain droplet formation. The path-breaking project will also develop innovative in-situ observation method to evaluate water condensation using microscale. The numeric cloud models will be developed first for the inclusion of new cloud seeding materials and later to predict rain fall formation and precipitation. Professor Zou received support for her work from the National University of Singapore and the University of Belgrade.

RESEARCH PROGRESS
• It is first time nanotechnology is employed to enhance rainfall by cloud seeding methods, which innovative sub-micron hygroscopic cloud seeding materials were designed and fabricated.
• Experimental results suggests that nanocomposite particles can adsorb water vapor more efficiently and show greater potential for the formation of larger water droplets thus enhancing rainfall.

PROF. VOLKER WULFMUEYER (GERMANY)

BIOGRAPHY
Volker Wulfmeyer is University Professor, Managing Director and Chair of Physics and Meteorology at the Institute of Physics and Meteorology of the University of Hohenheim in Stuttgart, Germany. Prior to his current affiliation, Professor Wulfmeyer worked for the United States National Center for Atmospheric Research, the National Oceanic and Atmospheric Administration, and the Max Planck Institute for Meteorology in Hamburg.

He was a member of the Scientific Advisory Council of the German Meteorological Service and currently participates in working groups of the World Weather Research Programme and the World Climate Research Programme of the World Meteorological Organisation (WMO).

His research areas cover high-resolution weather forecasting and regional climate simulations; land-atmosphere interaction; atmospheric boundary layer turbulence and transport; initiation of convection; quantitative precipitation forecasting and 3D active remote sensing.

Volker Wulfmeyer recently received a Visiting Fellows Award from the Cooperative Institute for Research in Environmental Sciences (CIRES) in Boulder, United States.

PROJECT BRIEF
“Optimizing cloud seeding by advanced remote sensing and land cover modification”

Professor Volker Wulfmeyer’s project aims to specifically study convergence zones and land covers as a prerequisite for significant precipitation. For optimal cloud seeding deployment, these convergence zones need to be identified prior to the development of clouds. Professor Wulfmeyer’s work will focus on improved detection and forecasting of convergence zones and convection initiation through new-generation active remote sensing, particularly Doppler lidar and cloud radar, and advanced high-resolution modelling. Modification of convergence zones is the key to enhancing precipitation and to cloud seeding guidance.

RESEARCH PROGRESS
• Set up of unique high-resolution model chain over the UAE;
• Incorporation of new observations in the UAE weather forecasts such as radar and data from surface stations;
• A new field site will be chosen for the observation of wind and clouds over the Hajar mountains during the summer 2017;
• New studies on the localization and amplification of convection initiation and cloud formation by plantations and terrain modification;

www.uaerep.ae
CALL FOR CYCLE 3 SUBMISSIONS

WANT TO ADVANCE GLOBAL RAIN ENHANCEMENT RESEARCH?

We’re welcoming researchers, scientists and technologists to take part in the United Arab Emirates Research Program for Rain Enhancement Science, an innovative initiative of the UAE Ministry for Presidential Affairs overseen by the National Center of Meteorology and Seismology (NCMS), in Abu Dhabi.

The Program offers a grant of 5 million US dollar over a three year period to be shared by up to five winning research proposals, selected by a two-stage merit review decision process. Registrations are currently open for the Third Cycle of the Program at www.uaerep.ae

- Potential applicants are invited to participate in the grant by submitting a Letter of Intent by **February 16, 2017**;
- Pre-proposals must be submitted by **March 16, 2017**;
- Full proposals must be submitted by **August 17, 2017**.

We look forward to receiving your innovative proposals!

For further information on the UAE Research Program for Rain Enhancement Science, please visit www.uaerep.ae or contact programsecretariat@uaerep.ae

www.uaerep.ae
During this research collaboration visit, the delegation interacted with 17 governmental and research entities, and universities. They met with over 74 scientists and researchers in different scientific fields related to rain enhancement, such as physics, atmosphere and cloud physics, earth sciences, geology, and numeric modeling, among others.

In Japan, the delegation visited some of the most prominent scientific and research organizations, such as the Japan Meteorological Agency, the National Research Institute for Earth Science and Disaster Resilience, the Asian Association for Geology, and Nagoya University.

Delegation members also interacted with researchers from the Japan Aerospace Exploration Agency, Research Institute for Global Change, the Japan Agency for Marine-Earth Science and Technology, and Diamond Air Service.

In China, the Program’s delegation visited some of the most important universities, institutes, and scientific organizations, including the China Meteorological Administration, the Chinese Academy of Meteorological Sciences, the Weather Modification Centre, the National Satellite Meteorological Centre, the China Meteorological Administration’s training center, the Public Weather Service Centre, Beijing University, Tsinghua University, and the Nanjing University of Science and Technology.
A roadshow to promote the Program included visits to Bologna and Trieste in Italy, as well as Stuttgart and Karlsruhe in Germany, and Brussels in Belgium.

The UAE delegation met with over 38 scientists and researchers from several climatology research groups across scientific disciplines such as atmospheric modeling, cloud physics, dynamics and chemistry, aerosol science, earth sciences, hydrology and geology.

The team also interacted with 15 government entities, universities and research facilities across Italy, Germany and Belgium.

The delegation also participated in the 16th European Meteorological Society Annual Meeting and the 11th European Conference on Applied Climatology (ECAC) in Trieste. At the event, the UAE delegation discussed meteorological monitoring, forecasting and modeling, and provided extensive information on the UAE Research Program for Rain Enhancement Science.
The roadshow at COP22 in Marrakech enabled the team to reach 35 key stakeholders from 30 leading institutions and international organisations, like the United Nations, the African Union, the African Bank, Maroc Meteo or the International Water Association.

These meetings and engagements in Morocco provided the Program team with a wealth of insights and shed light on an abundance of opportunities for collaboration with leading research and policy institutions all across Africa.

There were major spillovers as well, for what NCMS can do beyond the Program itself.
The principal objectives of the UAEREP team's annual participation at the American Geophysical Union (AGU) each year are to reach out to potential stakeholders and expand the pool of candidates, evaluate potential reviewers for different stages of the Program, generate sustained interest in the UAE Research Program for Rain Enhancement Science and identify opportunities of collaboration with specialized entities in the US and beyond.

This year, the Program delegation met with 18 researchers from 15 prestigious institutions including Yale University, Caltech, the Massachusetts Institute of Technology, the US National Science Foundation, Weather Modification Inc., the German Research Foundation and the Japan Society for the Promotion of Science.