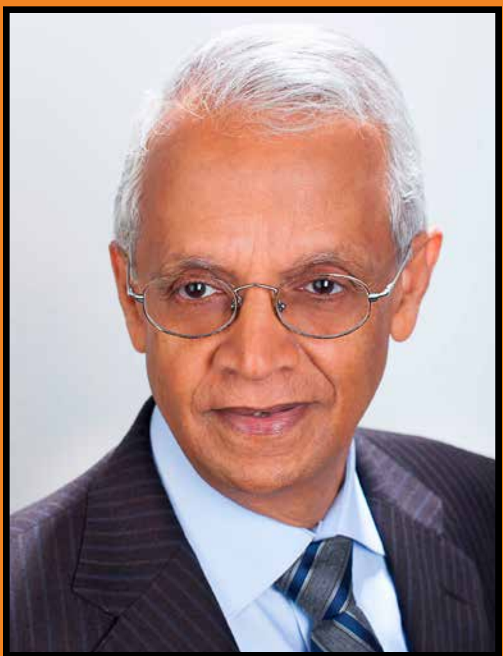
THE Crafoord PRIZE

Crafoord *Days* 2026

18–21 MAY IN LUND AND STOCKHOLM, SWEDEN

PHOTO: SCRIPPS INSTITUTION OCEANOGRAPHY, UC SANDIEGO



VEERABHADRAN RAMANATHAN

The Crafoord *Prize* in Geosciences 2026

Abstracts and Programme

Anna-Greta and Holger Crafoord Fund

THE FUND WAS ESTABLISHED in 1980 by a donation to the Royal Swedish Academy of Sciences from Anna-Greta and Holger Crafoord. The Crafoord Prize was awarded for the first time in 1982. The purpose of the fund is to promote basic scientific research worldwide in the following disciplines:

- Mathematics
- Astronomy
- Geosciences
- Biosciences (with particular emphasis on Ecology)
- Polyarthritis (e.g. rheumatoid arthritis)

Support to research takes the form of an international prize awarded annually to outstandig scientists, and of research grants to individuals or institutions in Sweden. Both awards and grants are today made according to the following order:

year 1: Mathematics and Astronomy
year 2: Polyarthritis
year 3: Geosciences
year 4: Biosciences
year 5: Mathematics and Astronomy
etc.

Part of the fund is reserved for appropriate research projects at the Academy's institutes. The Crafoord Prize presently amounts to 8 million Swedish kronor.

The Crafoord Prize is awarded in partnership between the Royal Swedish Academy of Sciences and the Crafoord Foundation in Lund. The Academy is responsible for selecting the Crafoord Prize Laureates.

ÅTTA45, JÄRFÄLLA 2026
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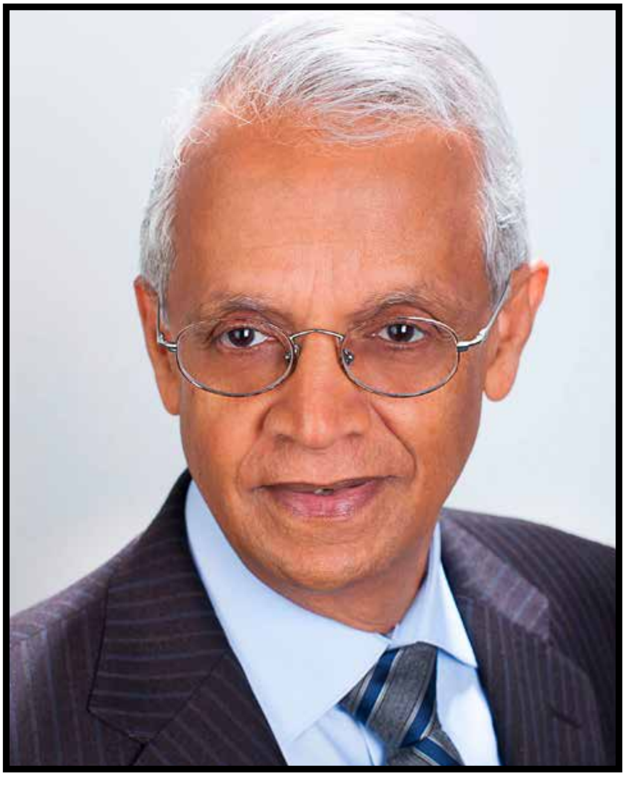
Content

The Crafoord *Prize* Laureate in Geosciences 2026

PHOTO: SCRIPPS INSTITUTION OCEANOGRAPHY, UC SANDIEGO



VEERABHADRAN RAMANATHAN

Veerabhadran Ramanathan, born 1944 in Chennai, India.
Scripps Institution of Oceanography, University of California San Diego and
CALS Ashley School, Cornell University, USA,

"for fundamental contributions to our understanding of how aerosol particles and other climate pollutants influence the atmospheric energy balance and the Earth system".

The Crafoord *Prize* in Geosciences 2026

Crafoord Prize Laureate showed that many factors affect the climate

Veerabhadran Ramanathan has laid the foundation for our understanding of how small particles and gases that accumulate in the atmosphere contribute to climate change.

Carbon dioxide emissions are not solely responsible for climate change. Other substances and small particles, like aerosols, also have an impact on the climate. Veerabhadran Ramanathan has made valuable contributions that show how this complex system is interconnected.

As early as the 1980s, professor Ramanathan played an important role in NASA's use of satellites to measure Earth's energy budget – the balance between energy from the Sun that reaches Earth in the form of radiation and the heat that Earth then emits back into space. The results showed that greenhouse gases from human activities are trapping an increasing proportion of the re-radiation in the atmosphere and thus contributing to global warming.

Ramanathan also studied how CFCs, known as freons from refrigerators and spray cans, not only affected the ozone layer, but the climate as well. He continued to take an interest in various forms of aerosols, tiny particles, in the atmosphere.

In a large experiment in the Indian Ocean, researchers observed that the air contained high levels of pollutants – even far out at sea. Some of these dark aerosols, such as soot particles, absorb radiation and can thus contribute to heating the atmosphere.

This new knowledge has had great practical significance and formed the basis for international agreements. Ramanathan has influenced many people, from politicians to popes.

Crafoord *Days* 2026

Monday 18 May | LUX, HELGONAVÄGEN 3, LUND — 11:00

THE CRAFOORD PRIZE LECTURE IN GEOSCIENCES

Held by the Crafoord *Prize* Laureate **Veerabhadran Ramanathan.**

Registration at www.kva.se

Wednesday 20 May | THE BEIJER HALL, THE ROYAL SWEDISH ACADEMY OF SCIENCES, LILLA FRESCATIVÄGEN 4A, STOCKHOLM — 09:30

THE CRAFOORD PRIZE SYMPOSIUM IN GEOSCIENCES

Earth system impacts of climate pollutants

Lectures by the Crafoord *Prize* Laureate **Veerabhadran Ramanathan** and invited speakers.

Registration at www.kva.se

Thursday 21 May | THE BEIJER HALL, THE ROYAL SWEDISH ACADEMY OF SCIENCES, LILLA FRESCATIVÄGEN 4A, STOCKHOLM — 16:30

THE CRAFOORD PRIZE AWARD CEREMONY

By invitation only.

The Crafoord *Prize* Lecture in Geosciences

LUX, HELGONAVÄGEN 3, LUND

Monday 18 May

Seating is limited. For registration and further information visit:
www.kva.se/crafoordprizelecture2026

11:00	Presentation of the Crafoord *Prize*	Per Persson, chair of the Crafoord Prize Committee in Geociences
11:05	Introduction of the Crafoord *Prize* Laureate **Veerabhadran Ramanathan**	Örjan Gustafsson, member of the Royal Swedish Academy of Sciences
11:15	*The accidental climate scientist – a scientific journey launched at NASA with a safe landing at the Vatican*	CRAFOORD PRIZE LAUREATE Veerabhadran Ramanathan, Scripps Institution of Oceanography, University of California San Diego and CALS Ashley School, Cornell University, USA
11:50	Questions from the audience	CHAIR: Ilona Riipinen, member of the Crafoord Prize Committee in Geociences
12:05	LUNCH	Lunch is served outside the lecture hall and included for registered participants.

The Crafoord *Prize* Symposium in Geosciences

Earth system impacts of climate pollutants

THE BEIJER HALL,
THE ROYAL SWEDISH ACADEMY OF SCIENCES,
LILLA FRESCATIVÄGEN 4A, STOCKHOLM

Seating is limited. For registration and further information visit:
www.kva.se/crafoordprizesymposium2026

Wednesday 20 May

09:30	Opening address	Ellen Moons, Secretary General of the Royal Swedish Academy of Sciences
09:35	Presentation of the Crafoord *Prize* Laureate **Veerabhadran Ramanathan**	Henning Rodhe, member of the Royal Swedish Academy of Sciences
09:45	*Atmospheric pollutants, energy balance & climate change* *How instrumented satellites, aircraft, drones, ships, and field experiments, when integrated with models, helped unravel the link between changes in the energy balance and the climate.*	CRAFOORD PRIZE LAUREATE Veerabhadran Ramanathan, Scripps Institution of Oceanography, University of California San Diego and CALS Ashley School, Cornell University, USA
10:35	COFFEE BREAK	
11:05	*Black carbon matters*	Örjan Gustafsson, Stockholm University and member of the Royal Swedish Academy of Sciences
11:45	*On the role of clouds in climate: advances and challenges*	Sandrine Bony, CNRS, Sorbonne University, France
12:25	LUNCH	(included for registered participants)
13:30	*The clouds they are a-changing: human influence on cloud properties and its impact on climate*	Frida Bender, Stockholm University, Sweden
14:10	*Using Earth radiation budget observations to constrain climate models*	Gunnar Myhre, CICERO Center for International Climate Research, Norway
14:50	COFFEE BREAK	
15:20	*Impacts of polluted water on aerosols, climate, and health*	Kimberly A. Prather, Scripps Institution of Oceanography, University of California San Diego, USA
16:00	*Air quality, climate change, and health*	Jos Lelieveld, Max Planck Institute for Chemistry, Germany
16:40	Closing remarks	Ilona Riipinen, member of the Crafoord Prize Committee in Geosciences
16:45	End of the Crafoord Prize Symposium	

CHAIRS: Anna Rutgersson and Ilona Riipinen, members of the Crafoord Prize Committee in Geosciences

ABSTRACTS

Crafoord *Days* 2026

Atmospheric pollutants, energy balance & climate change

How instrumented satellites, aircraft, drones, ships, and field experiments, when integrated with models, helped unravel the link between changes in the energy balance and the climate.

CRAFOORD PRIZE LAUREATE VEERABHADRAN RAMANATHAN
SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA, SAN DIEGO
AND CALS ASHLEY SCHOOL, CORNELL UNIVERSITY, USA

About 71% of the sun's energy is absorbed by the planet. The planet warms in response, increasing the amount of infrared (IR) energy it emits, some of which escapes to space. It keeps warming until the IR radiated to space is balanced by the absorbed energy, a balance known as the energy balance. Pollutant gases (like CO_2) form a blanket around the planet, trapping IR and reducing the IR that escapes to space. Many particles reflect solar energy (like a mirror), reducing the amount absorbed. Thus, pollutants lead to an energy imbalance, and the planet warms or cools to restore balance. This is the theory of climate.

The Earth system became my observatory. I designed space-based and in-situ observing systems to understand energy balance. Pollutant emissions became an inadvertent experiment to refine the theory through the *Detection*, *Attribution*, and *Prediction* framework.

I. Source of Energy Imbalance (Detection and Attribution)

Non-CO_2 Pollutant Gases: In 1975, my discovery that Chlorofluorocarbons (CFCs) are thousands of times more potent than CO_2 in warming the planet led to new research areas focused on non-CO_2 pollutants. The 1989 Montreal Protocol to ban CFCs, became an unintended success in climate mitigation. The discovery also resulted in grouping black carbon, methane, ozone, and HFCs as short-lived climate pollutants (SLCPs). We (with Xu) showed that reducing SLCPs could slow the warming by up to 50%.

Pollutant Aerosols: Using energy-balance observations from satellites, aircraft, and drones, we showed that the net effect of aerosols was to reduce the absorbed solar energy. The exception was black carbon aerosols, which trapped a large amount of solar energy in the atmosphere.

II. Restoring Energy Balance (Detection and Attribution)

Water Vapor: The thermodynamic link between temperature, water vapor, and its dominant role as a blanket can amplify warming by about a factor of 1.5 to 1.8. Clouds: Quantified from satellite observations, clouds (which have both a blanket and a mirror effect) have a large net-cooling effect so large that it makes them the Gordian Knot of the theory.

III. Predictions:

In 1980, we (with Madden) predicted that warming would be detected by 2000. Confirmed by the IPCC in 2001. In 2018, with Xu and Victor, we predicted that the planet would cross 1.5 °C warming before 2030. The warming is accelerating towards 1.5 °C, and the accompanying increase in humidity has intensified weather extremes worldwide.

Rapid regulation of aerosols, urgently needed to avoid millions of premature deaths/year, will unmask the warming and further accelerate it to reach 2°C before 2050. We must respond by gearing up for climate adaptation and resilience, in addition to mitigation.

Black carbon matters

ÖRJAN GUSTAFSSON
STOCKHOLM UNIVERSITY, SWEDEN

The large international IndoEx campaign led by Ramanathan, Crutzen and co-workers firmly established that soot particles from air pollution, called Black Carbon (BC) aerosols, had a sizeable effect on climate. This has stimulated massive BC research ever since into the multiple roles of BC in the atmosphere and the global carbon cycle. BC is the poorly defined highly condensed carbonaceous matter from incomplete combustion of biomass and fossil fuel. There are many matters of debate wrt BC sources, atmospheric distribution and longevity, its mixing with other substances, optical properties, effects on radiation and thus climate forcing.

To advance BC science, as a follow-up to IndoEx, Ramanathan and colleagues established in the Atmospheric Brown Cloud (ABC) program a set of strategically located receptor observatories. The Maldives Climate Observatory at Hanimaadhoo (MCOH), ideally located to intercept the outflow from South Asia, started in Nov 2004 and has been continuously operated and developed to shine light on atmospheric BC and its role in the climate system.

This presentation will highlight insights from these bidecadal studies to demonstrate how BC matters to a multitude of atmospheric processes. The MCOH-BC studies are combined with other observational records from around the globe, compared with predictions from emission inventories and atmospheric model simulations, to assess how well we today understand atmospheric BC in the climate system.

On the role of clouds in climate: advances and challenges

SANDRINE BONY
CNRS, SORBONNE UNIVERSITY, FRANCE

Few scientists have contributed as much as Prof. V. Ramanathan to our understanding of Earth's radiation budget. His pioneering work has stimulated a new field of research, dedicated to unraveling how water vapor, clouds and aerosols affect climate through their radiative effects. My presentation will focus specifically on the role of clouds in climate change and how this field has evolved over recent decades. I will begin by discussing advances in our understanding of cloud-climate feedbacks, highlighting both resolved issues and new questions.

Among these is the role played by a fascinating phenomenon: the organization of clouds at the mesoscale, a scale ranging from a few kilometers to a few hundred kilometers. This phenomenon challenges our fundamental understanding of atmospheric processes, as well as weather and climate modeling. I will show how the analysis of satellite observations and field campaign data has revealed key physical processes involved in the mesoscale cloud organization. Finally, I will highlight open questions that remain for future research.

The clouds they are a-changing: human influence on cloud properties and its impact on climate

FRIDA BENDER
STOCKHOLM UNIVERSITY, SWEDEN

Clouds are sensitive to their environment, and in response to anthropogenic climate change, cloud properties are changing. This in turn affects the climate, since clouds regulate the surface temperature. The extent, altitude, thickness, and phase of clouds all matter to how much they contribute to cooling (by reflection of incoming solar radiation) and warming (by trapping outgoing terrestrial radiation). The magnitudes and signs of these feedbacks remain central sources of uncertainty in future climate projections. With machine-learning classifications applied to satellite data, we can quantify specific feedback mechanisms, and help constrain total feedback. Global storm resolving models enhance our ability to simulate cloud response to warming, but we find they do not yet resolve inter-model spread in predicted feedback strength.

Cloud properties are also modified by anthropogenic aerosol emissions. Since each cloud droplet forms on an aerosol particle, the amount and physical and chemical properties of air-borne particles matter to cloud formation, and subsequent interaction with radiation and climate. Some of the pathways for aerosol-cloud interaction are well-documented; others remain more hypothetical. Common to all is the difficulty of extracting a signal attributable to aerosol, from a noisy meteorological background — a challenge also for models to represent correctly. This is relevant for estimates of total anthropogenic forcing, as well as for proposed aerosol-mediated methods of deliberate climate intervention. With natural experiments and machine-learning methods, we can better distill the aerosol signal on clouds.

In this lecture I will discuss observed cloud changes, as well as cloud feedbacks and their representations in global climate model simulations, and constraints on aerosol impacts on cloud properties. This will give insight into some of the great remaining challenges in climate science today, and new approaches to solving them.

Using Earth radiation budget observations to constrain climate models

GUNNAR MYHRE
CICERO CENTER FOR INTERNATIONAL CLIMATE RESEARCH, NORWAY

Climate forcing and climate sensitivity remain major sources of uncertainty in explaining past climate change and projecting future global warming. Uncertainty in forcing is dominated by aerosols, while climate sensitivity is the degree of warming from greenhouse gases, commonly defined as the global mean warming following a doubling of atmospheric CO_2. Long-term satellite observations of Earth's Energy Imbalance (EEI), defined as the difference between absorbed solar radiation and outgoing longwave radiation, provide a unique opportunity to better constrain both forcing and sensitivity.

Since the early 2000s, CERES satellite data show a strong increase in the EEI. Most climate models underestimate this trend. We show that a reversal of the aerosol effect is required for climate models to produce a strong increase in EEI. This implies that the general cooling effect of anthropogenic aerosols has turned into a warming effect over the last 10–15 years. Aerosol emissions have declined due to air-quality regulations.

The CERES satellite data show a strong increase in the absorbed solar radiation, making the planet darker as well as Earth is increasing the outgoing longwave radiation to space. We demonstrate that climate models with low climate sensitivity (<2.5K) are unable to reproduce the CERES trend with strong increase in the absorbed solar radiation. We explore whether the CERES satellite data can be used as a constraint for aspects of the cloud feedback.

Impacts of polluted water on aerosols, climate, and health

KIMBERLY A. PRATHER
SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA SAN DIEGO, USA

Aerosols play a fundamental role in the Earth system, profoundly impacting climate and human health — yet as human activities alter our planet, aerosol sources and composition are changing in ways we are only beginning to understand. In the atmosphere, these tiny particles shape clouds, alter the planet's energy balance, and represent the largest source of uncertainty in climate projections. In the body, aerosols are key components of air pollution contributing to cardiovascular disease, respiratory illness, and cognitive decline. Over the past two decades, our team has reproduced the ocean-atmosphere system in the laboratory — with breaking waves, winds, temperature control, and biology — to study how these factors influence sea spray aerosol production, composition, and climate-relevant properties. During these studies, it became apparent that our local coastal ocean composition is changing due to human pollution inputs — leading us to ask: are these changes altering the aerosols and air quality in coastal regions?

In this presentation, I will describe how this question led to a recent local discovery with global implications. In San Diego, California, along the U.S.–Mexico border, tens of millions of gallons of untreated sewage and industrial waste flow through the Tijuana River each day, releasing toxic gases at thousands of times above typical urban levels, along with aerosolized heavy metals, forever chemicals, and airborne pathogens. For nearly a century, this was dismissed as solely a water pollution issue, yet our work shows it has also created an air quality crisis, exposing people across the region to bacteria, viruses, and a vast array of chemicals. A polluted river and coastal ocean can produce aerosols and gaseous species not included in any air quality or climate model or health assessment — yet with the potential to affect atmospheric composition, climate forcing, and human health. As pollutants increasingly contaminate waterways worldwide, understanding the Earth system impacts of changes in water composition is essential to protecting both our climate and public health.

Air quality, climate change, and health

JOS LELIEVELD
MAX PLANCK INSTITUTE FOR CHEMISTRY, GERMANY

Air pollution, mainly caused by fossil fuel use and industrial activities, includes particulate matter and oxidant gases that pose serious health risks. Short-term exposure can irritate the respiratory system and worsen asthma, while long-term exposure is linked to chronic conditions like cardiovascular disease, COPD, and lung cancer. Globally, air pollution leads to millions of early deaths each year. Measures such as setting air quality standards, expanding renewable energy, reducing greenhouse gas emissions, and promoting electric transportation improve air quality and extend life expectancy. It may seem a dilemma: particulate matter can cool the climate by scattering sunlight and brightening clouds, and reducing it to improve air quality can accelerate warming in the short term. However, cleaner air is crucial for human and planetary health, providing co-benefits for public well-being and long-term climate stability.

Anna-Greta and Holger Crafoord

Holger Crafoord (1908–1982) was prominent in Swedish industry and commerce. He began his career with AB Åkerlund & Rausing and devoted a larger part of his working life to this company. In 1964, Holger Crafoord founded Gambro AB in Lund, Sweden, where the technique of manufacturing the artificial kidney was developed. This remarkable dialyser soon became world famous. Since then, a series of medical instruments has been introduced on the world market making Gambro a leading company in this field.

HOLGER AND ANNA-GRETA CRAFOORD

In 1980, Holger Crafoord founded the Crafoord Foundation, which annually contributes greatly to the Anna-Greta and Holger Crafoord Fund.

Holger Crafoord became an honorary doctor of economics in 1972 and in 1976 an honorary doctor of medicine at Lund University.

Anna-Greta Crafoord (1914–1994) took, as Holger Crafoord's wife, part in the development of Gambro AB. Through generous donations and a strong commitment in the society around her, she contributed to the scientific and cultural life. In 1986 she founded the Anna-Greta Crafoord foundation for rheumatological research and in 1987 Anna-Greta Crafoord became an honorary doctor of medicine at Lund University.

Over the years, the Crafoords have furthered both science and culture in many ways and it is noteworthy that research in the natural sciences has received an important measure of support from the Anna-Greta and Holger Crafoord Fund.

THE ROYAL SWEDISH ACADEMY OF SCIENCES was founded in 1739 and is an independent non-governmental organisation, whose overall objective is to promote the sciences and strengthen their influence in society. The Academy has a particular responsibility for natural science and mathematics, but its work strives to increase interaction between different disciplines. The activities of the Royal Swedish Academy of Sciences primarily focus on:

- being a voice of science in society and influencing research policy (policy for science)
- providing a scientific basis for public debate and decision-making (science for policy)
- recognizing outstanding contributions to research
- being a meeting place for science, within and across subject boundaries
- providing support for young researchers
- stimulating interest in mathematics and natural science in school
- disseminating knowledge to the public
- mediating international scientific contacts
- preserving scientific heritage

THE ACADEMY has around 480 Swedish and 175 foreign members who are active in classes, committees and working groups. They initiate enquiries, consultation documents, conferences and seminars. The Academy has General Meetings about seven times each year.

THE ACADEMY´S INSTITUTES offer unique research environments in ecological economics, the history of science and mathematics.

Every year, the Academy awards a number of prizes and rewards. The best known are the Nobel Prizes in Physics and Chemistry and the Sveriges Riksbank Prize in Economic Science in Memory of Alfred Nobel (the Prize in Economic Sciences). Other major prizes are the Crafoord Prize, the Sjöberg Prize, the Göran Gustafsson Prizes, the Söderberg Prize and the Rolf Schock Prizes. The Göran Gustafsson Prizes are awarded to outstanding young researchers and are a combination of a personal prize and research funding. Since 2012, the Royal Swedish Academy of Sciences is involved in the Wallenberg Academy Fellows career programme, which provide long-term funding to the most promising young researchers. As well as a comprehensive range of scholarships, the Academy is also involved in appointments to research posts in a number of programmes funded by external foundations.

The Academy's committees work to promote sustainable, science-based societal development in areas such as energy and the environment. The committees also examine issues surrounding research policy, international relations, health, human rights and education. In addition, the Academy awards the Ingvar Lindqvist Prize, recognising teachers who encourage their students' interest and learning in the fields of mathematics and science.

THE CRAFOORD PRIZE IS AWARDED IN PARTNERSHIP BETWEEN THE ROYAL SWEDISH ACADEMY OF SCIENCES AND THE CRAFOORD FOUNDATION IN LUND. THE ACADEMY IS RESPONSIBLE FOR SELECTING THE CRAFOORD PRIZE LAUREATES.

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THE ROYAL SWEDISH ACADEMY OF SCIENCES

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