涓流细雨

编辑 贾朋群

"Himawari-8 is sending kinds of big data that were not available before. We are now able to build a system that uses those data to improve the way we predict weather. The strength of this system is it gives you accurate weather predictions when natural disasters may happen, and it is updated constantly. For those who are vulnerable to natural disasters, like the elderly and people with disabilities, you want to give them enough time if they have to evacuate their home."

"葵花-8"卫星获得了以前无法得到的大数据。我们现在能够基于这些数据建立改进天气预报的系统，系统定时更新。对于面对自然灾害脆弱的人群，如老人和残疾人，需要从家中转移时就能得到更多的时间。"

——日本理化研究所利用"葵花-8"卫星建立的"红外辐射亮度数据"，可用于天气预报模式，主要能够提供浓云密布时天气系统的分布，从而改变之前这类天气难以有效处理的问题。该项目的负责人Takemasa Miyoshi描述了这个项目可能获得的结果。

"The rapid and dramatic changes we continue to see in the Arctic present major challenges and opportunities. This year's Arctic Report Card is a powerful argument for why we need long-term sustained Arctic observations to support the decisions that we will need to make to improve the economic well-being for Arctic communities, national security, environmental health and food security."

"我们看到的北极快速和强烈的变化带来了巨大的挑战和机会。今年的《北极报告》有力地支持了我们为什么需要长期可持续的北极观测来支持决策，我们需要这些决策改进北极周边经济状况、国家安全、环境健康和粮食安全。"

——美国NOAA连续第12年发布《北极报告》，这份由12个国家85位学者共同完成并且通过同行评议定稿的报告指出，2017年是北极有记录以来第二高温年，升温幅度是全球的两倍。谈到这份报告的价值，NOAA执行局长Gallaudet博士如是说。

"Events like these cause enormous damage. It's important that we have an accurate understanding of how the hazard posed by these events change as the climate changes."

"这样的事件引发巨大损失。我们认识当气候变化发生时这些事件的改变是如何带来灾害的就非常重要。"

——2017年大西洋飓风季，成为美国历史上最具破坏力的飓风季节，在11月30日官方飓风季尚未结束，损失已经超过了2000亿美元。哥伦比亚大学气候学者开发了新的全球飓风模式，能够估计罕见和高影响风暴在不同气候背景下的长期损失。项目负责人，该校气候和社会国际研究所的Chia-Ying Lee阐述了他们这项研究的意义所在。

2017年11月举行的UCAR国会吹风会上，来自美国高校、联邦实验室和私企的专家，面对每年数十亿天气相关的市场，就吹风会主题"研究向产业过渡（MOVING RESEARCH TO INDUSTRY）"发表了各自就天气预报技术、政府投入和天气市场等的观点。

"Thanks to a quiet revolution in modern weather prediction, we can all use forecasts to make decisions in ways that wouldn't have been possible just 10 years ago. Now we are looking to the next revolution, which includes giving people longer lead times and communicating risk as effectively as possible."

"源于现代天气预报静悄悄的革命，我们所有人利用预报进行决策的方式在10年前是不可能的。现在我们关注下一场革命，包括让公众有更长的提前时间以及尽可能有效的风险告知。"

——NCAR资深学者，该机构MMM实验室副主任Rebecca Morss发表了自己的看法。

"The future of weather forecasting is very promising. With strategic investments in observations, modeling, data assimilation, and supercomputing, we will see some remarkable achievements."

"未来天气预报非常值得期待。在观测、模拟、数据同化和超级计算方面的投入，能让我们获得明显的进展。"

——宾州州立大学气象和统计学教授Fuqing Zhang在强调了科学家正在借助更详尽观测和计算模拟，特别是利用NOAA的GOES-R卫星和强有力的FV3模式推进对飓风和其他风暴的认识后，给出了他的展望。

"We have a weather and climate enterprise that we can be extremely proud of as a nation, but it's not where it should be. Weather affects every consumer and business, and the public-private partnership can play a pivotal role in providing better weather information that is critically needed."

"我们为国家的天气和气候事业非常骄傲，但是不应停止于此。天气影响每个消费者和商业，公共—私人伙伴在提供更好的所需天气信息方面起到重要作用。"

——美国天气公司科学和预报业务主任Mary Glackin如是说。他认为天气企业界的目标是帮助消费者和业界做出更好的决策，这可以通过提供自己做出的预报和传送国家气象局预警两个渠道实现。天气公司目前正在调整基于NCAR的模式，即MPAS（Model for Prediction Across Scales，跨尺度模式）模式用于全球实时天气预报。

"These essential collaborations between government agencies, universities, and private companies are driving landmark advances in weather forecasting. The investments that taxpayers are making in basic research are paying off many times over by keeping our nation safer and more prosperous."

"这些在政府部门、大学和私企之间关键的合作正在促成天气预报的重大进展。纳税人在基础研究上的投入，可以通过保持国际安全和更加繁荣得到数倍的回报。"

——NCAR主席Antonio Busalacchi，强调了多方合作代理的益处，指出NSF、NOAA和其他联邦机构对研究投入对于改进预报十分关键。

2018年初召开的美国气象学会第98届年会上，首次举办的"小卫星地球观测第一次学术会"（First Conference on Earth Observing SmallSats）引入注目。会议安排的30个报告，分"立方体卫星和小卫星在推进地球科学、天气预报、空间天气预报、水文研究和气候监测中的进展"（Advances in CubeSats and SmallSats to Improve Earth Science, Weather Forecasting, Space Weather Prediction, Hydrology Studies, or Climate Monitoring）、"观测系统理念"（Observing System Concepts）和"可行技术及其成熟"（Enabling Technologies and Their Maturation）和"小卫星地球观测：新常态"（Earth Observing SmallSats: The

New Normal）等4个主题（其中，第2、3个主题为与第22届卫星气象和海洋学会议联合举办），全面评述了小卫星在地球观测领域里的优势、技术开发细节和一些项目规划在未来可能展示的作用。这里介绍几位来自NASA的参会学者的发言。

"RainCube (Radar in a CubeSat) is a technology demonstration mission to enable Ka-band precipitation radar technologies on a low-cost, quick-turnaround platform. Radar instruments have often been regarded as unsuitable for small satellite platforms due to their traditionally large size, weight, and power. The Jet Propulsion Laboratory has developed a novel radar architecture compatible with the 6U form factor. The RainCube mission will validate two key technologies in the space environment – a miniaturized Ka-band precipitation profiling radar that occupies ~3U and a 0.5m Ka-band deployable parabolic antenna stowed within 1.5U."

"RainCube（即立方体卫星上的雷达）技术，展示了Ka波段降水雷达技术可以应用于低造价和快速转向的平台。雷达设备一直被认为不适宜小卫星平台，因为传统上该设备具有大尺寸、大重量和大能耗。JPL研发了新的雷达架构可以装入6U空间。RainCube项目验证了两项空间环境下的关键技术：小型化的Ka波段降水廓线雷达占据3U空间和一个0.5 m的Ka波段可展开的抛物形天线可放入1.5U的空间内。"

——来自NASA喷气推进实验室（JPL）的Shivani S Joshi在会上详细解释了RainCube项目，预计该卫星将在2018年5月送往国际空间站，7月送入轨道。

"The CubeSat Infrared Atmospheric Sounder (CIRAS) employs an MWIR spectrometer operating from 4.08-5.13 μm with 625 channels and spectral resolution of 1.2-2.0 cm^{-1} to achieve lower tropospheric temperature and water vapor profiles. The CIRAS is packaged in a 6U CubeSat and uses less than 14 W. CIRAS is under development at NASA JPL and scheduled for launch in 2019. CIRAS technology can be applied to a future Earth Observing Nanosatellite (EON)-Infrared, to address a loss or gap in coverage of CrIS on orbit."

"立方体卫星红外大气探测器（CIRAS）采用MWIR分光仪，工作谱段为4.08~5.13 μm，拥有625个频道，空间分辨率为1.2~2.0 cm^{-1}，可获得对流层低层温度和水平廓线。CIRAS装入6U立方体卫星，能耗小于14 W。目前CIRAS在NASA JPL开发，计划2019年发射。CIRAS技术可以在未来地球观测超小卫星（EON）—红外项目中应用，作为在轨的CrIS的备份或补足其覆盖的不足。"

——同样来自JPL的Thomas Pagano则在讨论了红外谱段探测对于大气科学研究和气象预报、气候变化监测等的重要意义后，以CIRAS 项目为例，说明红外探测技术也可以通过小卫星平台来实施，且对于未来地球观测体系的设计也具有重要意义。

"The National Aeronautics and Space Administration (NASA) Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) mission is a constellation of state-of-the-science observing platforms that will measure temperature and humidity soundings and precipitation with spatial resolution comparable to current operational passive microwave sounders but with unprecedented temporal resolution. TROPICS is a cost-capped ($30M) Venture-class mission funded by the NASA Earth Science Division. The mission is comprised of a constellation of 3 unit (3U) SmallSats, each hosting a 12-channel passive microwave spectrometer based on the Micro-sized Microwave Atmospheric Satellite 2 (MicroMAS-2) developed at MIT LL. TROPICS will provide imagery near 91 and 205 GHz, temperature sounding near 118 GHz, and moisture sounding near 183 GHz. Spatial resolution at nadir will be around 27 km for temperature and 17 km for moisture and precipitation. The swath width is approximately 2000 km. TROPICS enables temporal resolution similar to geostationary orbit but at a much lower cost, demonstrating a technology that could impact the design of future Earth-observing missions. The TROPICS satellites for the mission are slated for delivery to NASA in 2019 with potential launch opportunities in 2020. The primary mission objective of TROPICS is to relate temperature, humidity, and precipitation structure to the evolution of tropical cyclone (TC) intensity."

"NASA的小卫星星座降水结构和风暴加强时间解析观测（TROPICS）项目是一个科学领先的卫星星座观测平台，将以空间分辨率等同于目前业务被动微波探测和空前的时间分辨率实施温度、湿度和降水探测。TROPICS是NASA地球科学部资助的成本设定（3000万美元）的企业级项目，项目包括一个含有3个单位（3U）小卫星的星座，每个小卫星载有一个在MIT LL开发的基于MicroMAS-2的12通道被动微波光谱仪，将提供91和205 GHz附近的图像、118 GHz附近的温度探测和183 GHz附近的湿度。星下点空间分辨率温度为27 km，水汽和降水为17 km，扫描带的宽度约2000 km。TROPICS的时间分辨率类似与地球静止轨道，但费用低很多，显示出是对未来地球观测设计可能产生影响的技术。NASA计划于2019年或2020年发射TROPICS卫星。TROPICS的主要任务目标，是热带气旋（TC）加强时的温度、湿度和降水结构演化。"

——来自NASA马歇尔太空飞行中心（MSFC）的Bradley T. Zavodsky关注的针对热带TC加强的小卫星观测项目，让小卫星项目走向面对需求进行设计和实施。

"Cloud ice plays important roles in Earth's energy budget and cloud-precipitation processes. Knowledge of global cloud ice and its properties is critical for understanding and quantifying its roles in Earth's atmospheric system. It remains a great challenge to measure these variables accurately from space. Submillimeter (submm) wave remote sensing has capability of penetrating clouds and measuring ice mass and microphysical properties. In particular, the 883-GHz frequency is a highest spectral window in microwave frequencies that can be used to fill a sensitivity gap between thermal infrared (IR) and mm-wave sensors in current spaceborne cloud ice observations. IceCube is a cubesat spaceflight demonstration of 883-GHz cloud radiometer technology. Its primary objective is to raise the technology readiness level (TRL) of 883-GHz cloud radiometer for future Earth science missions."

"云冰在地球能量收支和云—降水过程中起重要作用，全球云冰及其属性的知识对于认识和量化其在地球大气系统中的作用十分关键。从空间准确测量这些变量还是巨大挑战。亚毫米（submm）波遥感能够穿透云测量冰体及微物理属性。特别是，883 GHz频率是毫米频率中的最高谱窗，可用来填补目前天基云冰观测从热红外（IP）到毫米波传感器的空白。IceCube是一个展示883 GHz云辐射计技术立方体卫星平台，其主要目标是提升未来地球科学使命883 GHz云辐射计的技术储备水准（TRL）。"

——来自GSFC 的Dong L. Wu，介绍了NASA针对云中冰晶观测已经完成实施的小卫星项目——冰立方（IceCube）。据悉，IceCube为3U立方体卫星，经过两年半的研发，于2017年4月成功送往国际空间站，并于5月进入轨道。IceCube中的云冰辐射计（ICIR）已经开始白天运作并获取数据。2017年6—7月，ICIR获得的云图清晰地展示了ITCZ分布。