INTERNATIONAL ASTRONAUTICAL FEDERATION

IAC 2025 Special Session - Early Warnings for All – From Satellites to Action

Detailed Report of outcomes of the session held Tuesday, 30 September, 10:15 – 11:25 AEST, Room C4.4, International Convention Center, 76th International Astronautical Congress, Sydney, New South Wales, Australia

Executive Summary

Early Warnings for All (EW4A) is the audacious goal to ensure that everyone on the planet has access to warnings about severe weather, floods and droughts, geohazards and other extreme events. At the International Astronautical Congress 2025, Sydney, Early Warnings for All Special Session, global experts from space agencies, the United Nations, and the private sector emphasized the critical role of space-based technologies in realizing the vision of the United Nations Initiative **"Early Warnings for All."** The discussions highlighted how satellite data, digital platforms, and international collaboration are transforming disaster management—from prediction and preparedness to response and recovery.

Speakers noted that only a fraction of the world currently benefits from effective early warning coverage, with fewer than 10% of countries operating fully functional, end-to-end systems. This gap leaves vast populations—particularly in Africa and the Pacific—without reliable alerts or response plans. To close this divide, participants called for stronger partnerships between space agencies, governments, and local communities, ensuring that high-tech data is converted into actionable, trusted information on the ground.

The **International Charter on Space and Major Disasters**, involving 17 space agencies, was celebrated as a model for rapid, coordinated response. Alongside it, initiatives like **Copernicus** and **JAXA's GSMap** are advancing global monitoring and forecasting capabilities. Emerging tools such as **digital twins**, **AI-driven modeling**, and **ESRI's real-time GIS platforms** demonstrate how accessible data can empower decision-makers and non-specialists alike to anticipate and mitigate impacts.

Yet, the dialogue repeatedly returned to the "**last mile**" challenge—the human link between sophisticated data systems and community action. Participants stressed that education, training, and trusted communication networks are as vital as the technology itself. Investment in these areas, they argued, ensures that warnings translate into life-saving measures.

Ultimately, the session underscored that achieving Early Warnings for All depends on transparent, and collaborative systems that connect satellites in orbit with people at risk on Earth—transforming information into preparedness, and preparedness into resilience.

Introduction and Context

The SpS Sydney session convened leaders from international space agencies, United Nations bodies, national governments, academia, and the commercial sector with an audience of ~75 people to examine how **space-based technologies can enable Early Warnings for All**. The discussion was framed around the growing urgency of climate-driven hazards, increasing disaster frequency and severity, and persistent global inequities in warning coverage and preparedness.

Early Warnings for All is an ambitious challenge to ensure that everyone on Earth is protected from hazardous weather, water, or geohazard events through life-saving early warning systems by the end of 2027. The international community and space agencies around the word have undertaken efforts to address this challenge, both singly and collectively.

This session was planned to review the ways that observations from space make disaster warning systems possible, efforts planned and underway by a sampling of space Agencies, and the challenges faced by communities in communicating warnings. Through attendee input and collaborative discussion, the conversation focused on pathways to enhance the Agencies efforts or identify new collaborative initiatives.

Discussion was organized around the four pillars framed by the United Nations in 2022– 1) Disaster Risk Knowledge and Management, 2) Detection, Observation, monitoring, analysis and forecasting, 3) Warning Dissemination and Communication, 4) Preparedness and Response capabilities and how space agencies and commercial partners can work together to improve approaches to all four areas. This unique conversation bridged the capabilities of satellites and communities today, with the possibilities for a more resilient future.

The session explored how Earth observation, forecasting models, digital platforms, and partnerships can be aligned across the full disaster lifecycle—**before, during, and after events**—to reduce loss of life, protect livelihoods, and strengthen resilience. Speakers emphasized that early warning is not a single technical system but an **end-to-end process** that must link scientific detection with communication, trust, and action at the community level.

Space-Based Observations and Global Collaboration

A central pillar of the discussion focused on the role of **satellite observations** in disaster risk management. Space agencies described how Earth observation missions support:

- **Hazard monitoring and forecasting** (e.g., storms, floods, fires, earthquakes),
- **Impact assessment and damage mapping** after disasters,
- **Preparedness and prevention**, including understanding environmental saturation and vulnerability before events occur.

Satellite observations provide a range of spatial and spectral coverage, with a range of resolutions providing both demonstrated and potential operational, forensic, and research utility all to aid in EW4A. These can cover needs in all phases from risk knowledge and management to preparedness and response. Cooperation is critical to integrating all the resources necessary to get the best for monitoring and forecasting, impact assessment, and preparedness and prevention. It is also critical to enable data access, and ability to use the data without need for specialized expertise.

The **International Charter on Space and Major Disasters**, now approaching its 25th anniversary, was highlighted as a cornerstone of international cooperation. With 17 contributing space agencies, the Charter provides a 24/7 operational mechanism that delivers satellite data rapidly to civil protection authorities, UN agencies, and humanitarian responders worldwide when activated by a request. The Charter's ability to combine optical and radar data, archived analysis, and newly tasked observations was repeatedly cited as an example of effective multilateral action.

Complementary services, including the **Copernicus Emergency Management Service**, demonstrate how regional and global systems can operate in tandem, supporting both immediate response and longer-term recovery planning.

Forecasting, Models, and Emerging Technologies

Speakers underscored that modern disaster management increasingly depends on **advanced modeling and predictive tools**, not just raw data. Investments in:

- **Numerical weather prediction**,
- **Nowcasting and short-term forecasting**,
- **Digital twins of the Earth**, and
- **AI-enhanced analytics**

are enabling practitioners to explore "what-if" scenarios and anticipate impacts before hazards become disasters.

Examples included new-generation meteorological satellites that improve hurricane forecasting and rainfall estimation, as well as flood modeling that integrates hydrology, soil saturation, and terrain data. These tools offer critical lead time—if their outputs are delivered in a form that decision-makers can understand and trust.

However, participants emphasized that **technology alone is insufficient**. Models must be validated, transparent, and designed in collaboration with users, particularly when they inform high-stakes decisions involving emergency response, climate finance, insurance, or infrastructure investment.

Early Warnings for All: Current Gaps and Realities

A sobering assessment of global early warning coverage anchored the session. Despite technological progress:

- Only about **38% of countries** have functional hazard monitoring and forecasting systems.
- Fewer than **10%** operate truly **end-to-end early warning systems** that link detection, communication, and response.
- Large portions of **Africa and the Pacific** remain under covered.
- Less than one-third of countries have **clear action plans** that specify what to do when warnings are issued.

Speakers stressed the distinction between having an "early warning system" in name and having one that **actually works**—one that delivers timely, actionable, and trusted information to people at risk. **Early Warnings for All"** requires:

- Expanding coverage of hazard monitoring.
- Ensuring that **warnings lead to action**.
- Strengthening **partnerships** between space agencies, local authorities, and communities.
- Enhancing **reach and access**—bridging the gap between technology producers and end users.

The UN perspective emphasized that Early Warnings for All is not only a technical challenge but a **governance, capacity, and accessibility challenge**, requiring sustained international commitment and broad partnerships.

Communication, Dissemination, and the "Last Mile"

One of the strongest themes throughout the session was the **"last mile" problem**—the persistent gap between sophisticated space-based capabilities and real-world action on the ground.

Participants repeatedly emphasized that:

- Communities are not passive recipients of data; they are **the final decision-makers**.
- Warnings must be **understandable, localized, and trusted**.

- Communication channels—local radio, community leaders, emergency managers—are as important as satellites.

Education and training emerged as top priorities. Many speakers argued that if forced to choose, they would invest first in **capacity building and user education**, ensuring that people know what data exists, how to interpret it, and how to act upon it.

Trust was identified as a critical factor: early warnings are only effective if people believe them and know what actions to take. This requires long-term engagement, not just crisis-time communication.

The recurring theme of the **"last mile" challenge** could be summarized as:

- **Access and impact:** Data and technology exist, but local agencies often lack the capacity or connectivity to use them effectively.
- **Education and training** were repeatedly identified as top priorities—many experts said they would invest in **training and communication channels** before infrastructure.
- **Community trust and partnerships**: Early warnings are only effective if the recipients **understand, trust, and can act** on them. This requires cooperation with **local radio, governments, and educators**.

Role of the Commercial Ecosystem

The commercial sector highlighted its growing role in filling gaps left by public systems, particularly through:

- High-revisit satellite constellations,
- Thermal infrared monitoring for wildfire detection,
- On-demand tasking and rapid imagery delivery,
- Integrated GIS and analytics platforms.

Demonstrations showed how platforms such as **ESRI's Living Atlas** and real-time GIS tools can democratize access to satellite data, enabling non-specialists to visualize change, assess risk, and support decision-making. The emphasis was on **open access, usability, and interoperability**, rather than gatekeeping data. A key point is that there is a wide variety of extremely useful data available, but people are not aware, or do not have the means to access it.

Some of the tools in development or currently available include:

- **Digital twins**, **machine learning**, and **AI-enhanced forecasting** were noted as future-critical tools for modeling disaster scenarios and supporting decision-making.

- **ESRI** demonstrated real-time GIS tools and platforms (like *Living Atlas*) that democratize access to:
    - **Live imagery**, **temporal change detection**, and **disaster mapping**.
    - On-demand satellite tasking for specific locations (for as little as $12–25).
    - **Open, free access** to geospatial data for emergency use.

The goal: **make data "smart" and usable** for non-specialists, enabling rapid risk analysis and visualization. However, challenges remain around business models, sustainability, and clarity of roles between public agencies and private providers—especially during emergencies when expectations of "free" data often conflict with commercial realities.

Data Governance, AI, and Responsibility

The increasing use of **AI and automated analytics** prompted important discussions about responsibility, transparency, and trust. Participants noted that decisions informed by space data and AI can involve **billions of dollars** and profound societal consequences.

Key principles emphasized included:

- The need for **validated and auditable AI systems**,
- Clear understanding of what data is included or excluded,
- Shared responsibility between data providers, analysts, and users,
- Ethical and broad approaches to innovation.

Rather than viewing AI as a replacement for human judgment, speakers framed it as an **enabler**, supporting—but not substituting—decision-making.

Key Takeaways and Way Forward

Challenges

- Fragmentation of data sources and unclear responsibilities across agencies.
- Gaps in user understanding—end-users are not always trained to interpret complex geospatial information.
- The need for **ethical AI** and **data verification**—trusted AI systems must ensure transparency, especially when decisions involve billions in climate financing or infrastructure recovery.

Recommendations

- Strengthen **multi-level partnerships**: global–national–local integration of space data.

- Develop **impact-based early warning systems** that translate data into actionable community alerts.
- Increase **education, training, and communication access** as foundational investments.
- Encourage **open data policies** balanced with data security and reliability.
- Promote **collaborative design** — engaging local communities, scientists, and decision-makers in co-creating solutions.

The session concluded with a strong consensus between the panel and audience on several points:

1. **Early warnings must be end-to-end**, connecting space-based detection to community-level action.
2. **Partnerships are essential**—across agencies, sectors, and scales.
3. **Education, training, and communication** are as critical as technology.
4. **Open, accessible, and trusted data systems** are foundational to resilience.
5. The "last mile" remains the defining challenge—and opportunity—for Early Warnings for All.

Achieving universal early warning coverage demands:

- **Satellite-enabled monitoring**, open access to geospatial data, and trusted AI analysis.
- **Institutional collaboration** (UN, space agencies, private sector, local governments).
- **Community empowerment** through education and localized communication channels.
- Moving beyond data collection to **preparedness, action, and resilience**—turning "warnings" into **saves**.

Ultimately, the session reinforced that space technologies already offer extraordinary capabilities. The task ahead is to ensure those capabilities are **integrated, far-reaching, and actionable**, transforming data into preparedness, preparedness into response, and response into long-term resilience.

Topic / Functional Roles, Panelists and Organizers

Moderator - Dr. Karen St Germain, - NASA Director for Earth Science Division, United States

Dialogue - Guennadi Kroupnik -CSA/ASC Director General, Space Utilization, Canada

Disaster Risk Knowledge and Management – Dr. Alex Held, - CSIRO Space and Astronomy Chier Research Scientist, Earth Observation and AquaWatch, Australia

Detection, Observation, Monitoring, Analysis and Forecasting - Simonetta Cheli – ESA Director of Earth Observation Programmes and Head of ESRIN

Warning, Dissemination and Communication - Futoshi Takiguchi – JAXA Vice President and Director General Space Technology Directorate, Japan

Preparedness and Response Capabilities - Hamid Mehmood – UNOOSA, Scientific Affairs Officer and Head of UN-SPIDER Beijing Office

Commercial Role - Thomas Gruebler – OroraTech Chief Strategy Officer and Co-Founder, Germany

Commercial Role - Marina Schumacher – ESRI Sector Lead and Principal Consultant, Australia

Organizer – James Graf – NASA JPL, Director, Earth Science and Technology, United States

Organizer – Harry Cikanek – NOAA (retired), Director Satellite Applications and Research, United States

Use of AI in developing this report: AI was used to transcribe notes from recordings taken during the meeting. AI was further used to extract an initial draft report. The report was edited by participants, adding and organizing content, and checking accuracy.