Sensors and Small Satellite Technologies for Disaster Management (SSTDM) 2016

Opportunities for Global and Indo-US Collaboration: *Seeking Guidance*

@ UN/ India Workshop, Hyderabad, India
10 March, 2016

Maneesha Sudhir, (Amrita Univ., Kollam, India)
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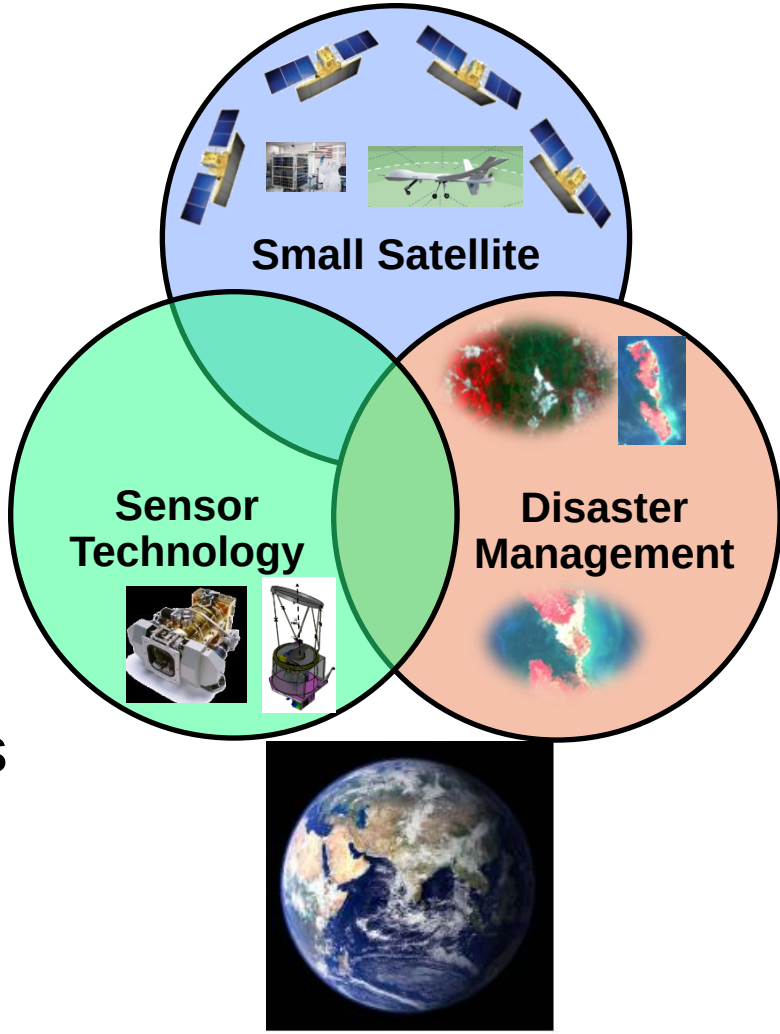
Samantha Edgington (Lockheed Martin Space Systems, USA)

Outline

- **Global Sat for DRR under the UN:**
  - Opportunities and Issues
  - Implementation plan
- **IUSSTF Sponsored: SSTDM**
  - 2014: @ IISC: Outcome
  - **2016: @ Amrita Univ.**
    - Location and Tentative Dates
    - Seeking Guidance from Indian and International Experts at this UN-India Workshop
- **Technical Presentation: Global Lightning Mapper (GLM)-Regional**
  - By Samantha Edgington, Chief Technologist, GLM



GlobalSat Constellation for Disaster Risk Reduction (DRR): - Opportunity and Implementation Path Forward

- **Unique Opportunity**:
  - Under UN Framework to address:
    - Data availability
    - End-to-end data flow: System of Systems
    - Near real-time Disaster alert
- **Implementation Path:**
  - Formulate Global Collaborative Partnership
    - Seeking Guidance and Feedback to Realize the UN Vision

UN Journey of GlobalSat Constellation for DRR:

Concept Proposal
UNOOSA &
UNISDR 3rd World Conf. on DRR
@ Sendai, 2015, March 17

UN GlobalSat

GlobalSat Implementation Plan:
Technical/Policy/Governance/Finance

WCDRR 5th UN-SPIDER Conference
@ Beijing, 2015 September 14-16th

UN Report A/AC.105/1102
Sec 45/46: Need for GlobalSat

GlobalSat Support from Member States

UN Committee on the Peaceful Use
of Outer Space (COPUOS) S&T Subcommittee 53rd Session
@ Vienna 2016 Feb. 15-26th,

Thank India for their interest

UN Journey of GlobalSat Constellation for DRR:

Glimpses of SSTDM 2014 (@IISC)

International Workshop on Small Satellite and Sensor Technology for Disaster Management

31st March - 2nd April 2014

Indian Institute of Science, Bangalore - 560 012

SSTDM 2014: Executive Summary

- **Discussed the technology status and gaps, and address the need of small satellites and sensors for mapping, monitoring, early warning and mitigation of Natural Disasters:**

Plenary Session: DM

Remote Sensing Systems for DM

Natural Disasters

Sensors & Instruments Tech.

Space Systems

Collaborative Projects and Concept Papers

  - ISRO researchers presented the historical overviews of small satellites, remote sensing systems, electro-optical (EO) payloads/ data for DM Suport
  - The international experts described the specific role of remote sensing systems in monitoring natural hazards: *floods, and drought and assessing its impact on agriculture, crop production, forest fires, and landslides*.
  - India has embarked on Capacity Building for Disaster Management Support.
  - IIRS recognized the need of developing multi-D (6D to7D) [include time, touch (pressure, texture, temperature), sound and smell] visualization in geospatial modeling, for accurate predictions, and early warning.

SSTDM 2014: Executive Summary

- **Discussion of each type of Natural Disaster identified the critical technology need of high precision early warning systems, and developing new sensors:** microwave sensors, SAR systems, wireless sensors, thermal infrared sensors for space-borne assets. Dr. Maneesh Ramesh described first ever installation of wireless sensors for rainfall and landslide monitoring in affected regions**.**
- **A CubeSat Tutorial**
- **Fourteen (14) concept papers** related to the use of **CubeSat/small sats for Disaster Management** were submitted by teams of students from different universities in India, Vietnam and USA.
  - Each team was duly recognized for their contribution, and the cash awards were given to each team**.**

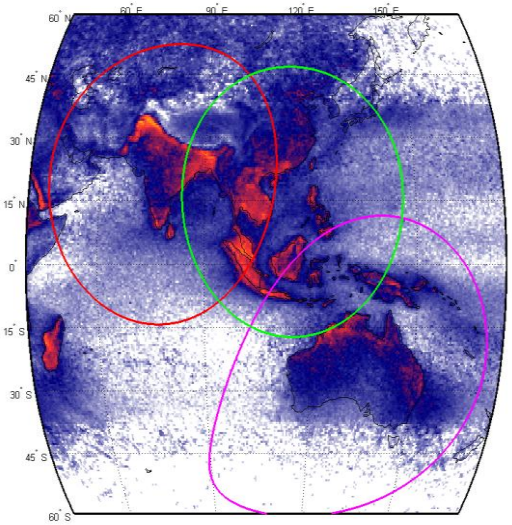
SSTDM 2016 Objectives

- **Identify and Develop Small-Satellites, Sensors, and Wireless Communication Technologies for Disaster Management**
  - Facilitate networking between Indo-US Experts involved in SSTDM
  - Address the socio-economic causes and technology-development needs of Participating countries
  - Encourage Joint development projects through effective sharing of risks, costs and resources.

- **Tracks:**
  1. **Disaster Management: Challenges and Needs**
  2. **Natural Disasters: Small Satellite and Sensor Technology Status**
  3. **Wireless Communication Status**
  4. **Collaborative Missions for DM**

SSTDM 2016: Planning in Progress

- **Location:** Amrita University: Kochi/ Kollam Campus, Kerala
- **Dates (tentative):** August 17-19 (or Aug. 23-25)
- **Seeking Guidance from ISRO/UN SPIDER Leadership:**
  - **Participation from Indo-US and International Experts**
  - **Advisory Committee:**
    - **Chairman Kiran Kumar**
    - **V. Dadhwal, Director NRSC, ISRO**
    - **Dr. David Miller (NASA HQ, Chief Technologist)**
    - **Rick Ambrose (President, LMSSC, USA)**
  - **Discuss areas of collaboration: "*possible list grouped by themes (for example new sensors, multiple source data integration, early warning models, risk mapping, geospatial processing and data models for DM, ground & sensor network data integration, ...) for each of target disasters, and them picking ones which could have largest positive impact.*"**
  - **Topics for Student Competition:**
    - **How to Analyze Satellite Data related to Natural Disaster?**
- **Website: By 20 March 2016**



GLM-R: A Regional Lightning Mapper for Early Warning of Severe Storms

United Nations/India Workshop on the Use of Earth Observation Data in Disaster Management and Risk Reduction

March 8-11, 2016

Dr. Samantha F. Edgington
GLM Chief Scientist
Lockheed Martin, ATC

Clemens Tillier
GLM Instrument Principal Engineer
Lockheed Martin, ATC

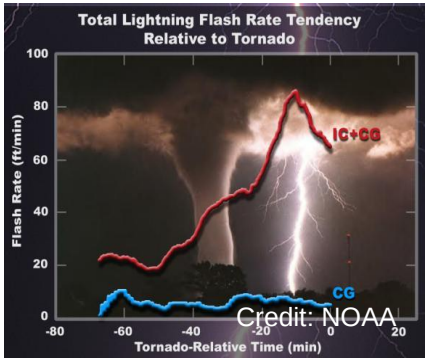
Dr. Hugh Christian
Research Professor
University of Alabama, Huntsville

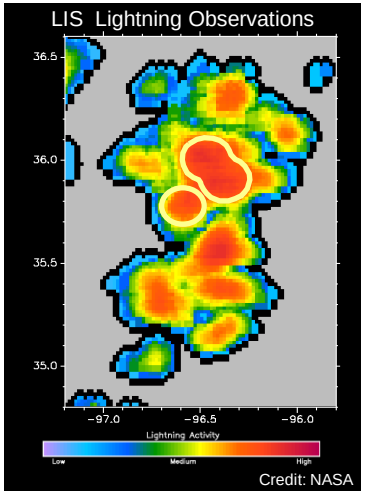
Lightning and Disaster Management

- Most of the electrical energy generated by a thunderstorm is dissipated by lightning – lightning flash rate is quantitatively related to the electrical energy generation
- The electrical generator is active during the updraft - lightning activity mirrors thunderstorm development
- Electrical energy is generated during ice production - amount of lightning is quantitatively related to the amount of ice
- Lightning is detected optically by observing emission lines in the near infrared from ionized Oxygen against the bright cloud background

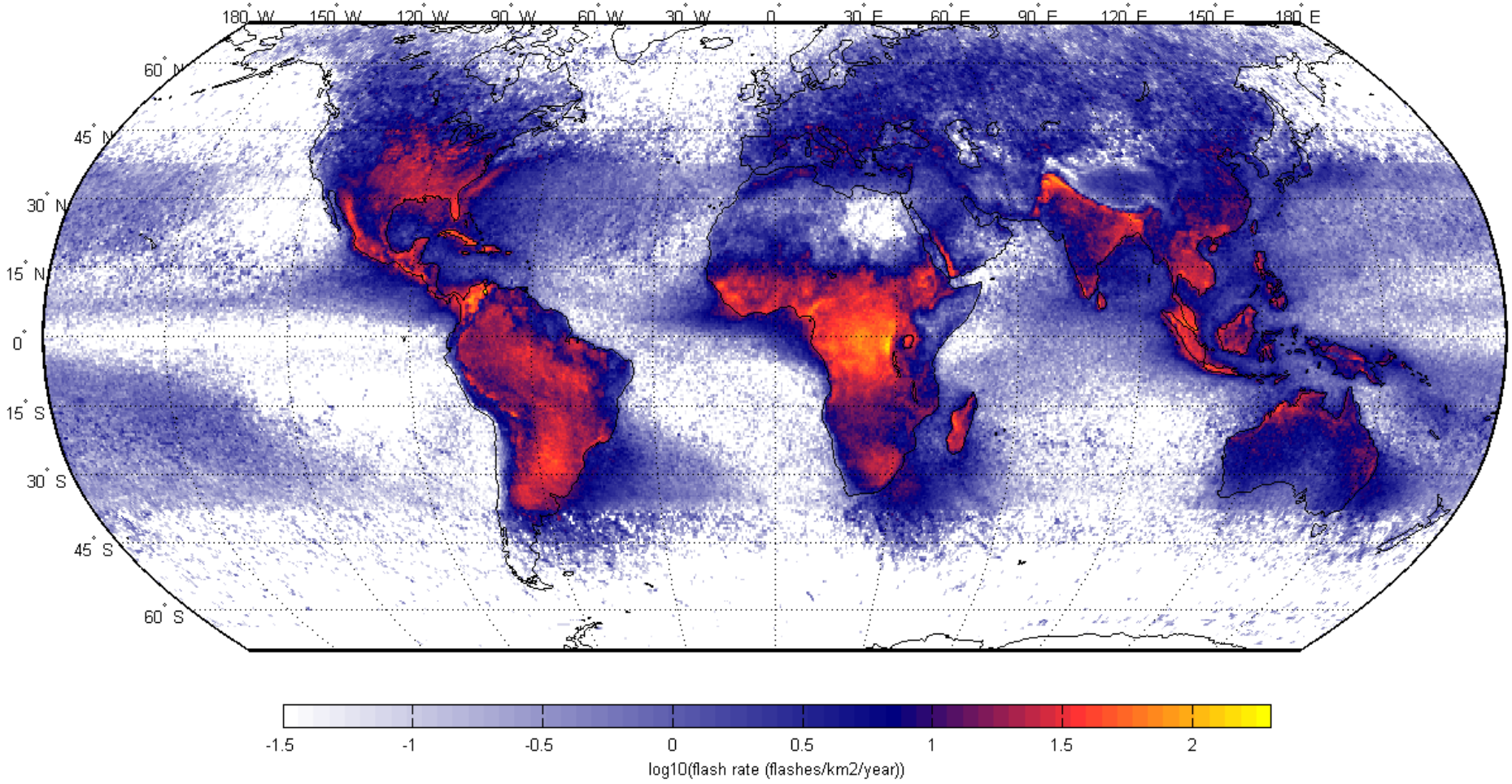
Why Map Lightning?

- **Lightning Strikes**
  - Hazard is highest where high lightning rates and high population coincide
- **Flash Floods**
  - Storms with high lightning flash rates cause the most flash floods, lightning mapper data can provide timely and accurate warnings
- **Tornadoes**
  - Lightning data provides 15 – 30 minute advanced warning
- **Forest Fires**
  - Lightning mappers can detect continuing current strikes which cause forest fires
- **Wind Shear and Turbulence**
  - Real time data on convection in individual storm cells contributes to efficient air traffic management
- **Cyclone Strength**
  - Lightning flash rate data can provide ~24 hours warning of maximum cyclone wind strength

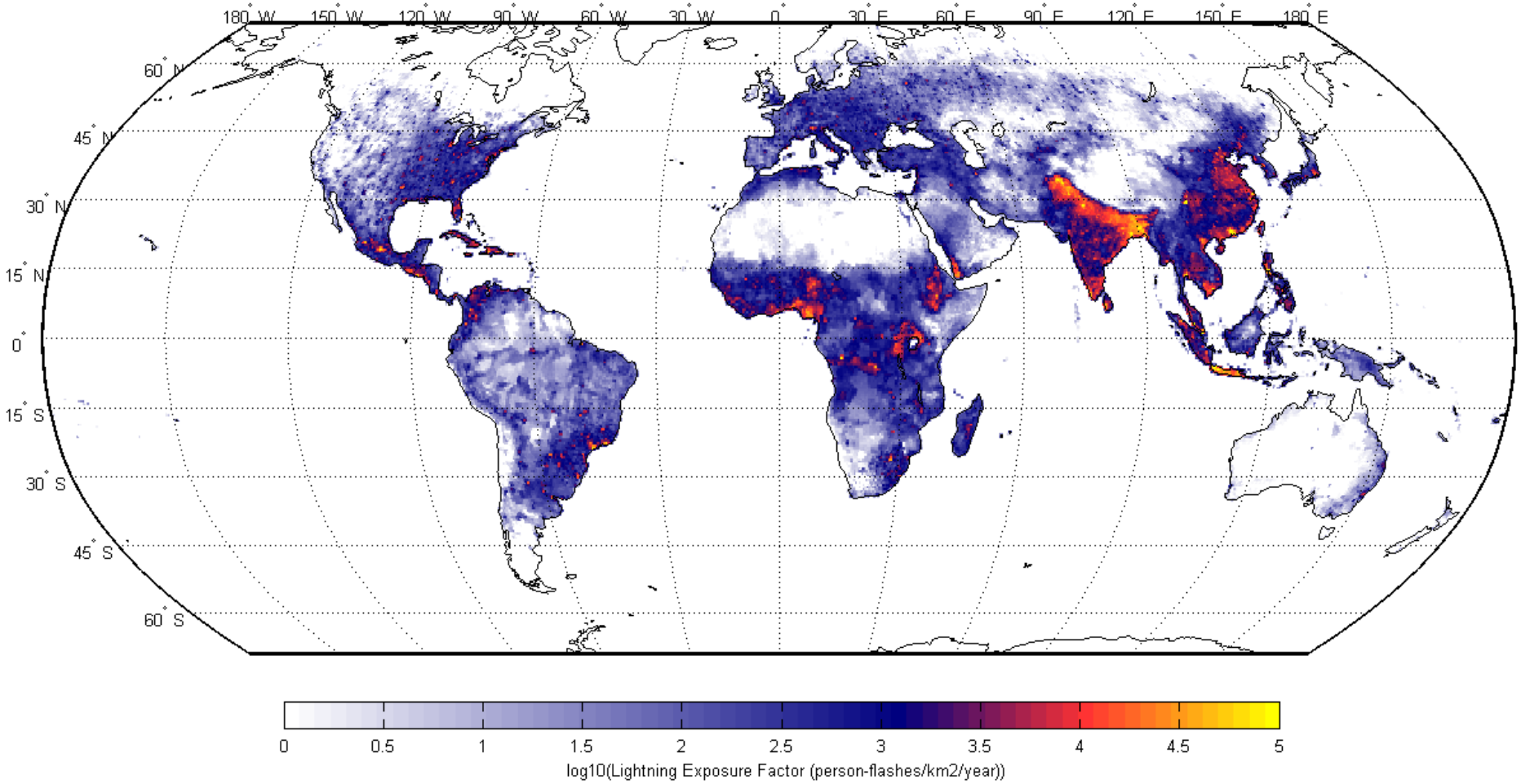




Global Distribution of Lightning



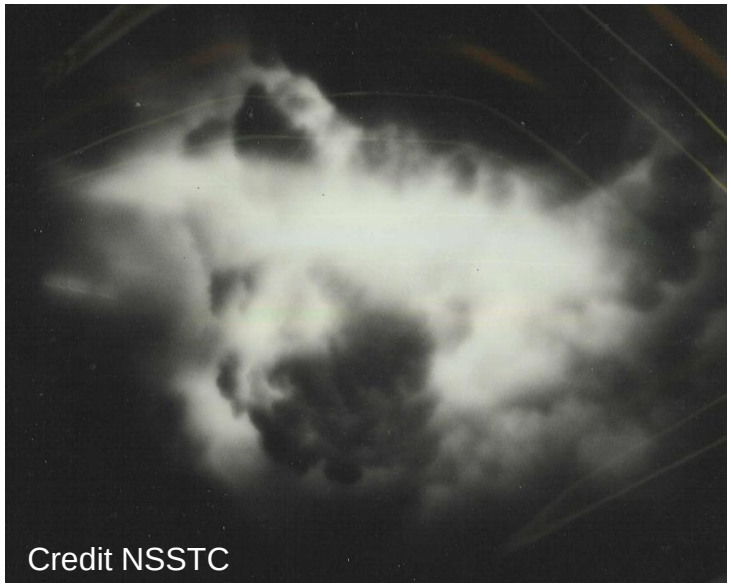
Need for Regional Coverage



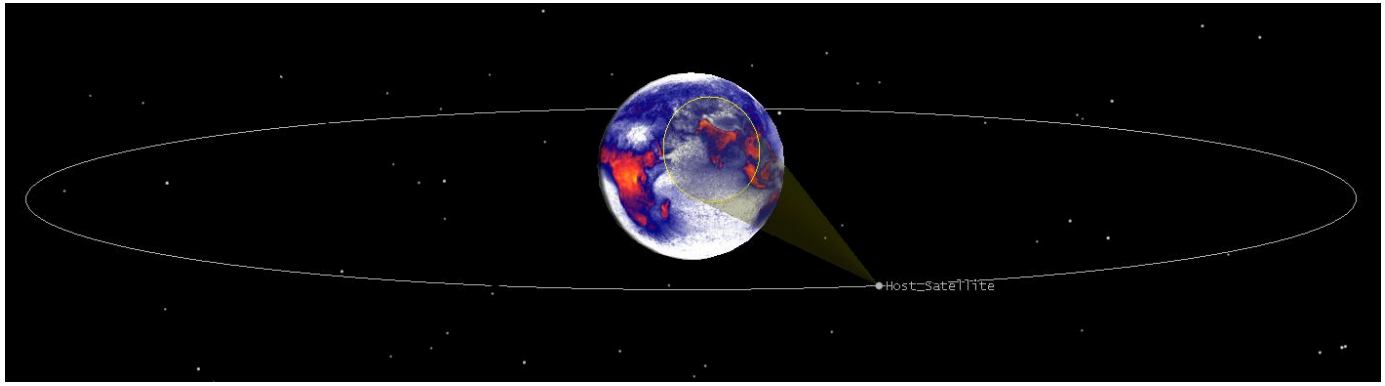
Flash rate times population density gives a metric of human exposure to lightning related hazardous weather

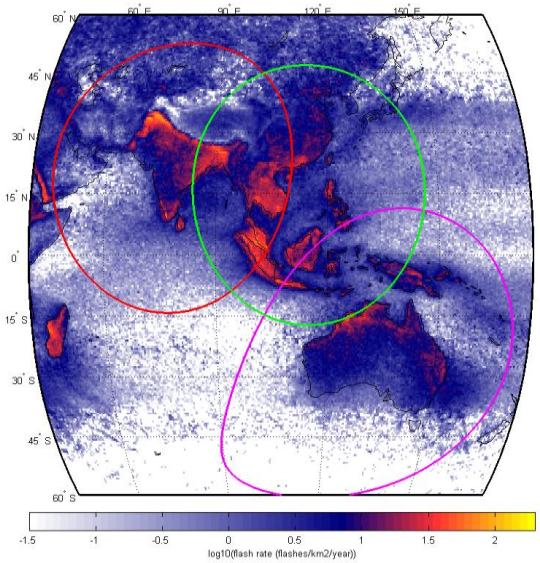
Why Detect Lightning from Geostationary Orbit?

- **High detection efficiency**
  - Detect a larger percentage of the total lightning activity
- **Coverage**
  - Widespread, persistent and uninterrupted coverage over large areas including oceans
- **Improved warning times and decreased false alarm rates**
  - Double warning time and halve false alarm rates compared to current Doppler radar based systems
- **Virtual radar**
  - Providing areas with limited radar coverage with tracking of thunderstorm development, propagation and evolution, based on total lightning measurements
- **Climate change monitoring**
  - Long term monitoring of lightning, which is dependent upon the ground temperature



GLM-R Reference Design

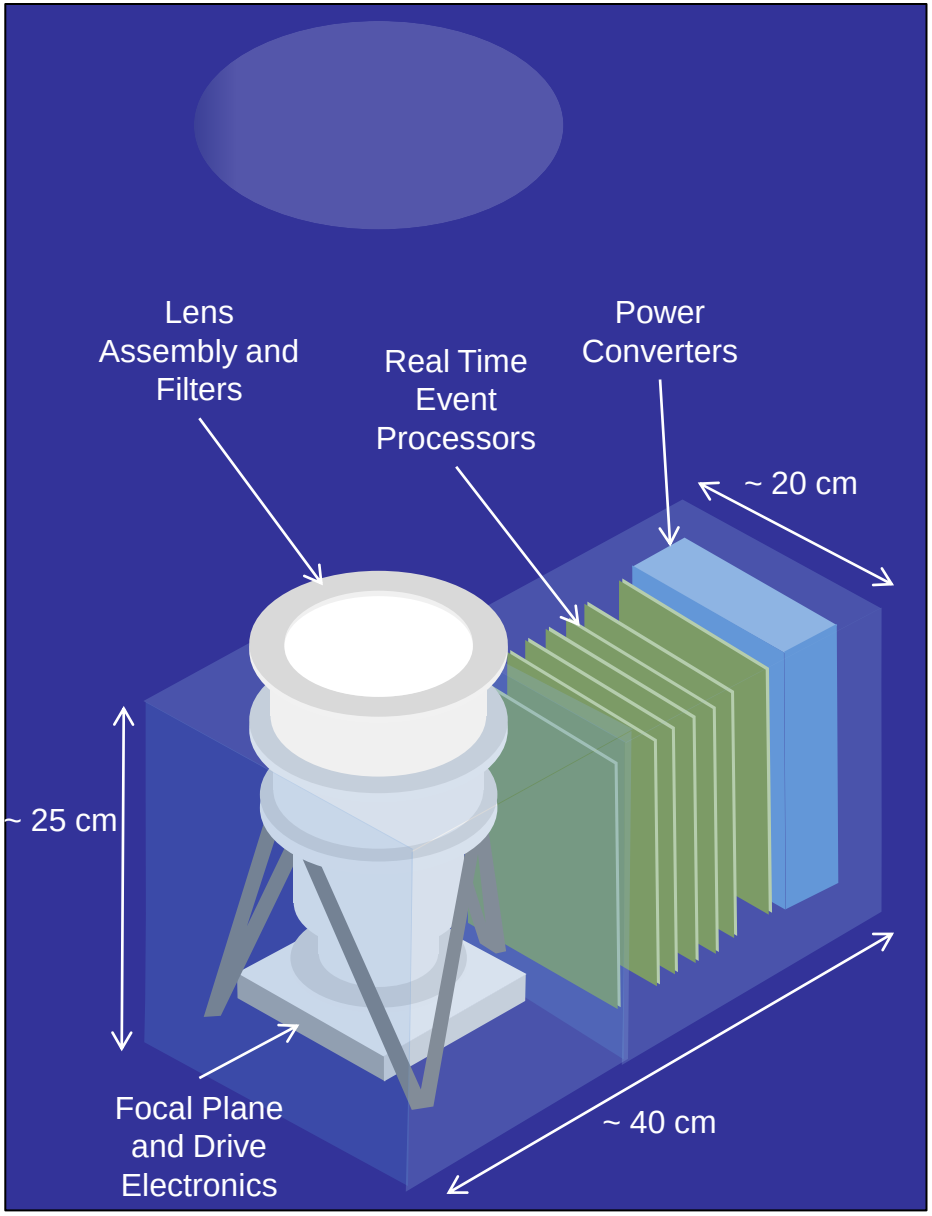




10 degree full angle field of view provides regional coverage

Geostationary orbit provides persistent coverage

GLM-R Reference Design

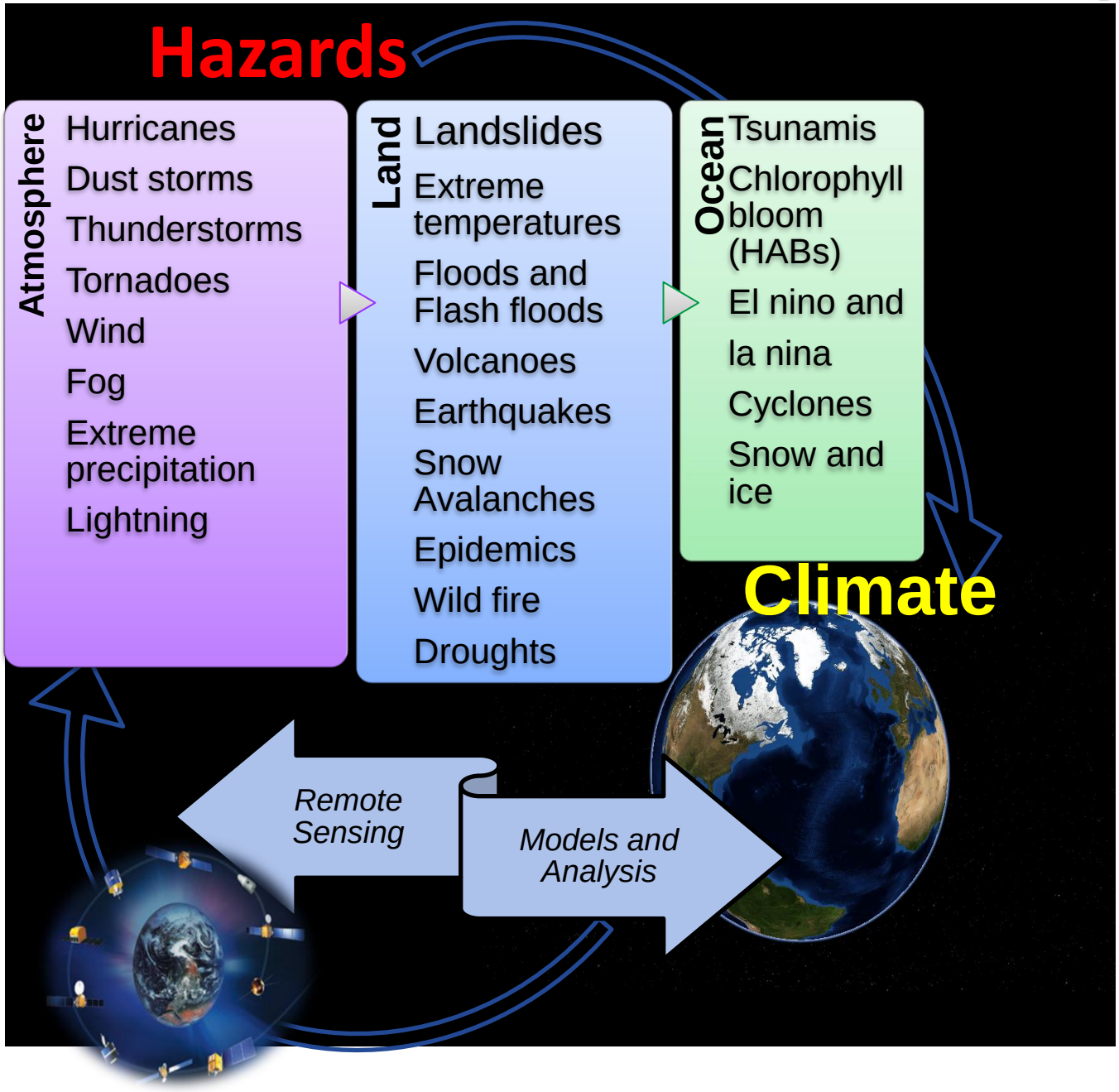


- Focal plane runs at 500-1000 frames per second to capture lightning strokes
- 1 nm wide interference filter captures the Oxygen emission line against bright cloud background
- Flexible on-board real time event processing enables limited downlink bandwidth
- Ground based algorithms used to detect lightning and produce weather products
- Low mass/power/size requirements enable use as a hosted payload

GLM-R: Regional Lightning Mapper

- Lightning is a timely and accurate indicator of severe weather
- Contributes to climate change monitoring using lightning flash frequency
- Regional lightning mappers will save lives

- **Backup**


Hazards
Atmosphere
Hurricanes
Dust storms
Thunderstorms
Tornadoes
Wind
Fog
Extreme precipitation
Lightning
Land
Landslides
Extreme temperatures
Floods and Flash floods
Volcanoes
Earthquakes
Snow Avalanches
Epidemics
Wild fire
Droughts
Ocean
Tsunamis
Chlorophyll bloom (HABs)
El nino and
la nina
Cyclones
Snow and ice
Climate
Remote Sensing
Models and Analysis

Objectives

- **Identify and Develop Small-Satellites, Sensors, and Wireless Communication Technologies for Disaster Management**
  - Uniqueness of the proposed workshop: Ability to network experienced Indo US groups
  - Address the socio-economic causes and technology-development needs of Participating countries
  - Joint development projects are engendered through effective sharing of risks, costs and resources.
- **In SSTDM 2014*:** *Internationally recognized experts from ISRO, and researchers, technologists, stakeholders, and students from India and US, shared the status and emerging trends in areas of small satellites, sensors, wireless technologies, and disaster management.*

* At IISC, Bangalore, Dr. Mohan Rao, Co-Chair, India

SSTDM 2014: Outcome

- Identified the technology status and gaps, and address the need of small satellites and sensors for mapping, monitoring, early warning and mitigation of Natural disasters.
- Presentations addressed the specific natural disasters, and the role of existing, and future small satellites in monitoring terrestrial hydrology, hurricanes, floods and drought, dust storms, earthquakes, Tsunami early warning system, subsurface coal fires, and forest fires.
- Discussions covered each type of disaster, the critical technology need of developing new sensors and the critical need of high precision early warning systems

SSTDM 2014: Executive Summary

- **Discussed the technology status and gaps, and address the need of small satellites and sensors for mapping, monitoring, early warning and mitigation of Natural disasters:**

- ISRO researchers (ISRO) presented the historical overviews of small satellites, remote sensing systems, electro-optical (EO) payloads design and development, and the use of EO data for disaster management support.
- The international experts also described the specific role of remote sensing systems in monitoring natural hazards such as floods, and drought and assessing its impact on agriculture, crop production, forest fires, and landslides.
  - Indian sub-continent is one of the world's most disaster-prone area; therefore it has embarked on Capacity Building for Disaster Management Support. Leveraging upon the state of the art 2D and 3D visualization models, IIRS has recognized the need of developing multidimensional (6D to7D) [include time, touch (pressure, texture, temperature), sound and smell] visualization in geospatial modeling, for accurate predictions, and early warning.
- **Later, the presentations focused on specific natural disasters, and the role of existing, and future small satellites in monitoring terrestrial hydrology, hurricanes, floods and drought, dust storms, earthquakes, Tsunami early warning system, subsurface coal fires, and forest fires. Discussion of each type of disaster identified the critical**

SSTDM 2014: Executive Summary

- **Presentations also focused on specific natural disasters, and the role of existing, and future small satellites in monitoring terrestrial hydrology, hurricanes, floods and drought, dust storms, earthquakes, Tsunami early warning system, subsurface coal fires, and forest fires.**
  - Discussion of each type of disaster identified the critical technology need of developing new sensors.
  - Subsequent presentations discussed the need and development of microwave sensors, SAR systems, wireless sensors, thermal infrared sensors for space-borne assets.
    - For example, Dr. Maneesh Ramesh described first ever installation of wireless sensors for rainfall and landslide monitoring in affected regions.
- **Identified the critical need of high precision early warning systems for each type of disaster.**
  - For example, an early warning system for floods/drought will help reduce the risk of agricultural products. India is leading an international effort to develop early warning system for Tsunami.
- **A CubeSat Tutorial**
- **Fourteen (14) concept papers related to the use of CubeSat/small sats for Disaster Management were submitted by teams of students from different universities in India, Vietnam and USA.**
  - Each team was duly recognized for their contribution, and the cash awards were given to each team**.**