United Nations/Azerbaijan Workshop on the International Space Weather Initiative: The Sun, Space Weather and Geosphere

High-resolution remote sensing satellite data and space weather forecasting models

Sevda IBRAHIMOVA, Azerbaijan

National Aviation Academy

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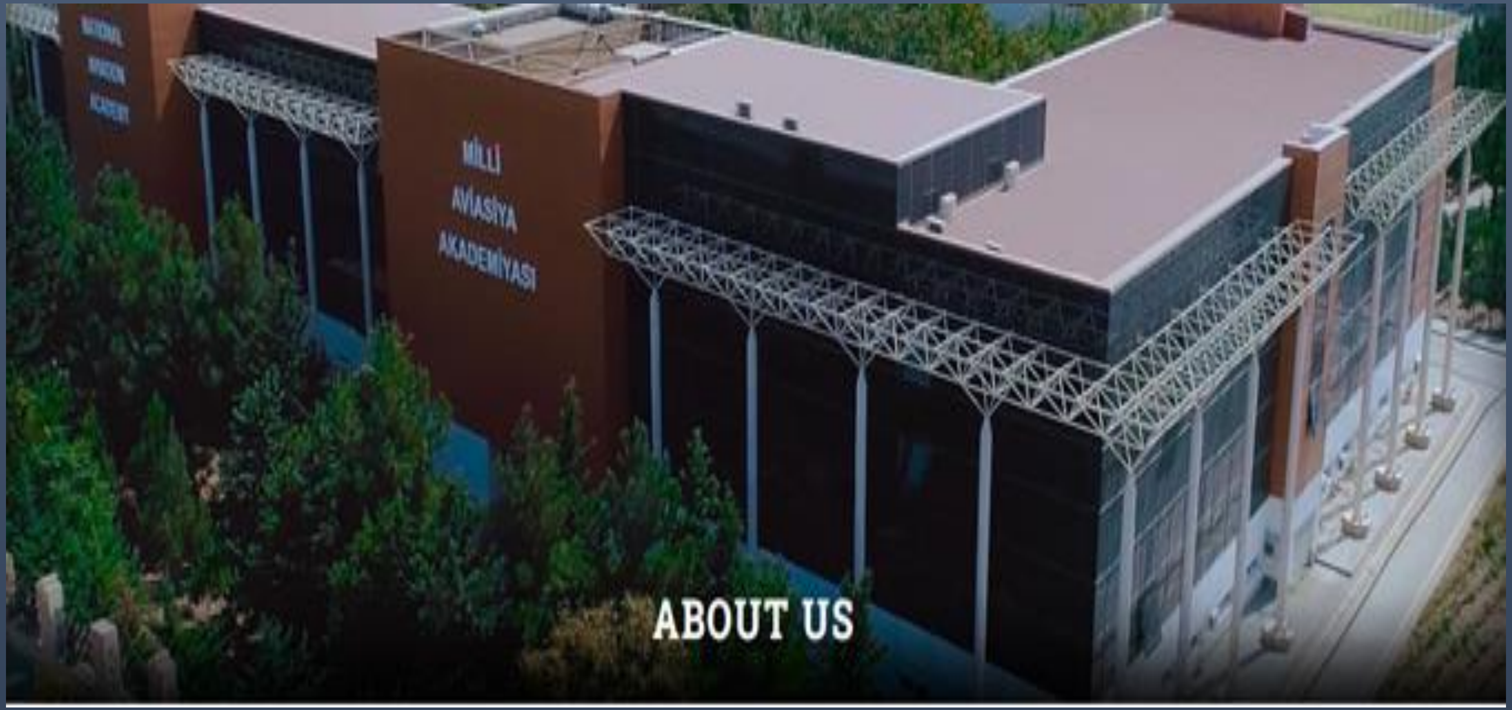
National Aviation Academy

- The National Aviation Academy was established in 1992 as the "National Aviation Centre". In 1994, the National Aviation Centre was renamed the National Aviation Academy.
- Today, the National Aviation Academy (NAA) of “Azerbaijan Airlines” («AZAL») is a higher education institution that provides highly qualified specialists meeting the international requirements of the strategically important Aerospace Sector of Azerbaijan, including Civil Aviation and a number of other areas.
- The activities undertaken by the National Aviation Academy are regulated by the Constitution of the Republic of Azerbaijan, the laws of the Republic of Azerbaijan "On Education" and "On Aviation", decrees and orders of the President of the Republic of Azerbaijan, decrees and orders of the Cabinet of Ministers of the Republic of Azerbaijan, orders, instructions, resolutions, regulatory documents of the Ministry of Education of the Azerbaijan Republic, the State Civil Aviation Agency under the Ministry of Transport, Communications and High Technologies of the Republic of Azerbaijan, Azerbaijan Aviation Regulations (AAR), orders, instructions and orders of the AZAL CJSC president, charters of the National Academy of Sciences, higher educational institutions Model Charte. Along with this, in its activities, the National Aviation Academy is guided by the rules, standards, recommendations and procedures adopted by ICAO, SAC as well as international civil aviation organizations, of which the Republic of Azerbaijan is a member, and the obligations arising from the Working Agreement concluded with the European Aviation Safety Agency (EASA).

Academy infrastructure

- A complex consisting of 5 educational and laboratory buildings
- Flight Training Center and Stimulator complex
- Research and Production Association
- Student Training Center
- Student House of Creativity
- Campus
- Student park
- Heydar Aliyev Museum

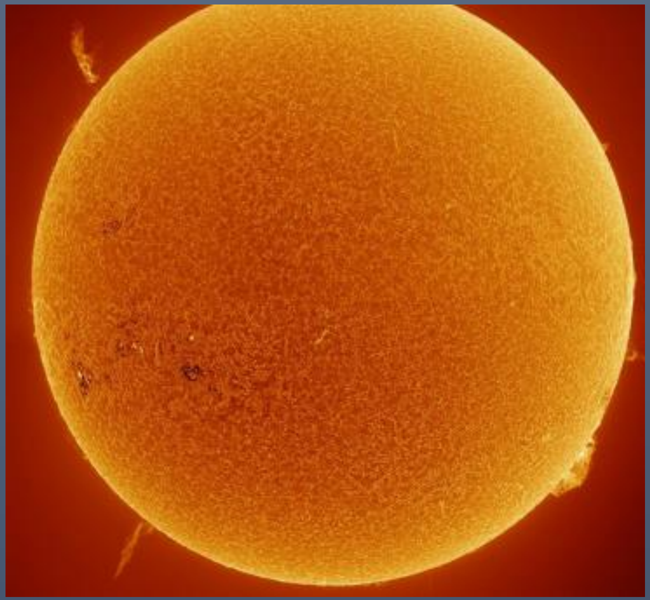
and Civil Aviation Museum

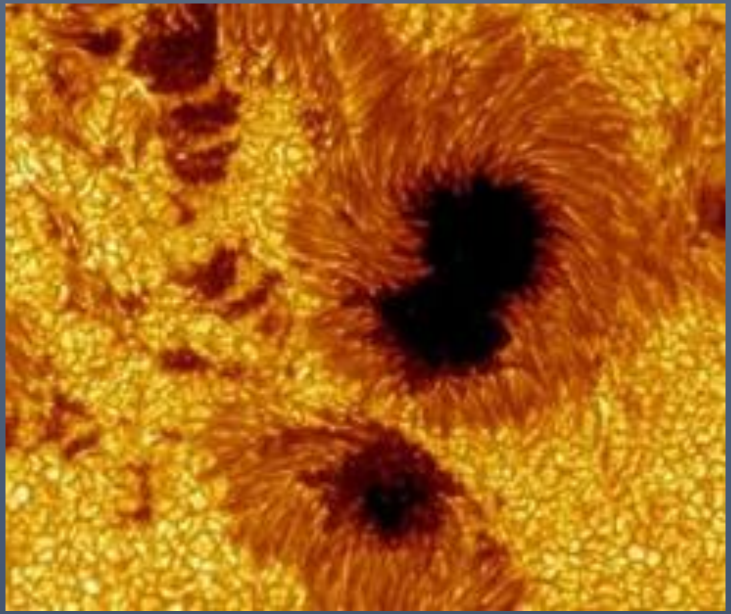


The NAA educational infrastructure

- 6 faculties
- 23 departments
- Pilot Training Centre
- IATA Institute
- Maintenance Training Organization
- Aviation Security Centre
- Information Technologies Center
- Educational-Methodical Department
- Department of Master's and Doctoral Studies
- Quality Assurance Department
- Department of International Relations

Space weather



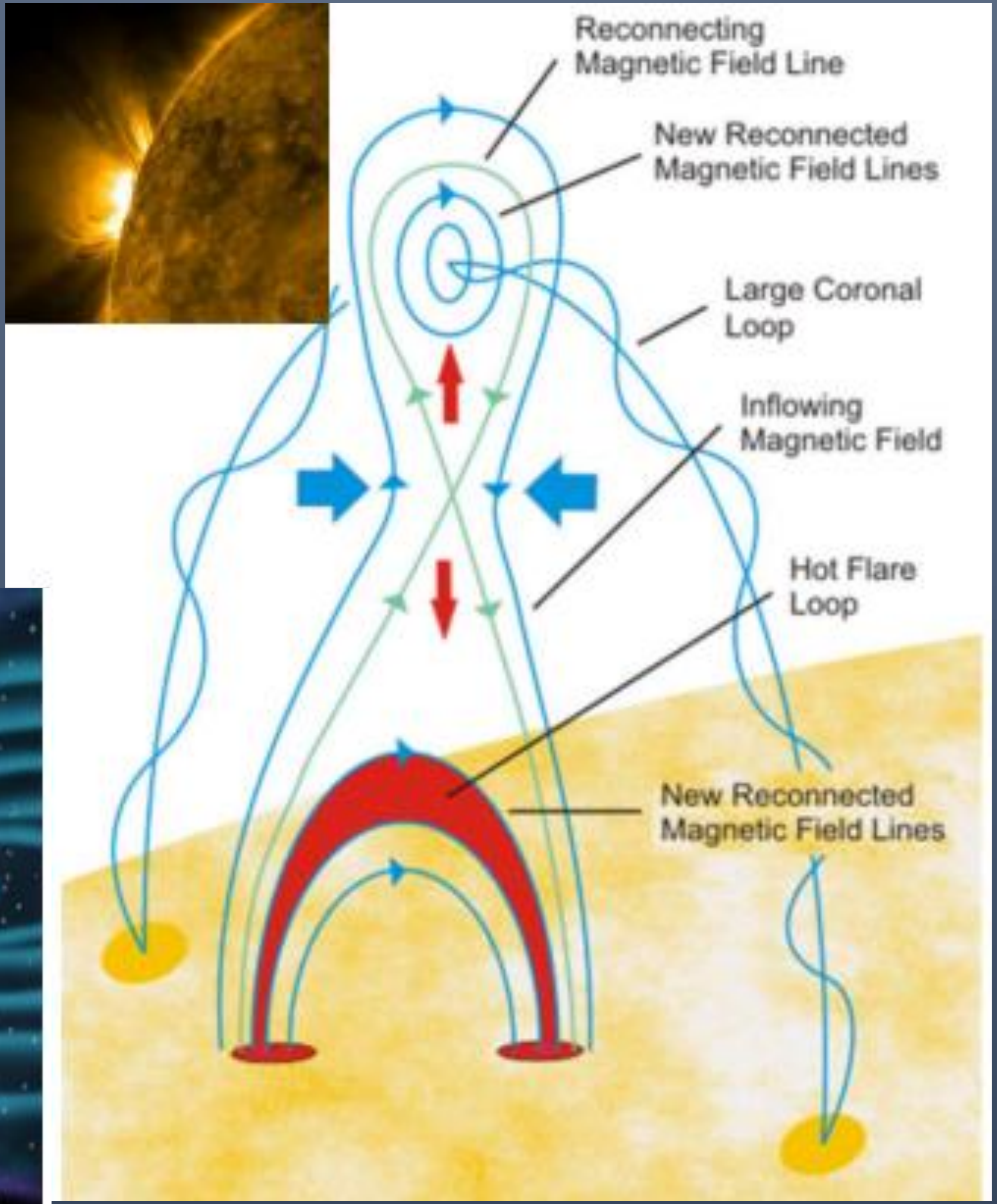


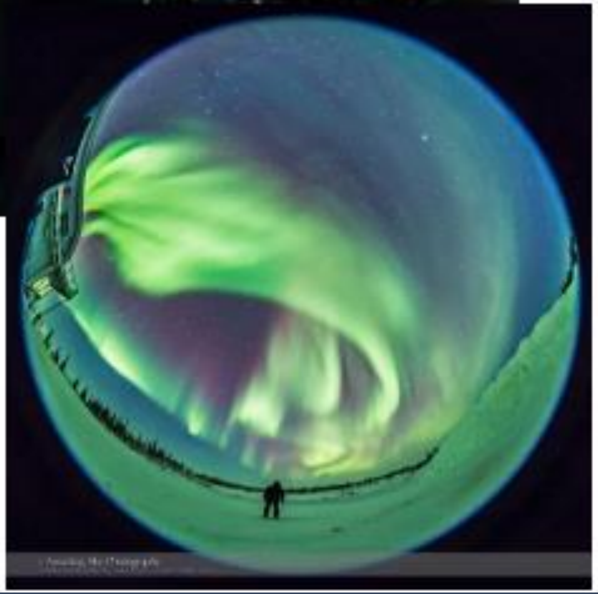
Space weather refers to a variety of phenomena that mostly originate at the Sun and affect the Earth’s atmosphere. Space weather can have adverse effects on technology, such as causing disturbances of Global Navigation Satellite Systems (GNSS). Just like normal weather, space weather cannot be influenced and thus space weather effects on GNSS cannot be mitigated. Therefore, it is of vital importance to develop a method for space weather forecasting.

We have an aggressive and dominant neighbor: the Sun

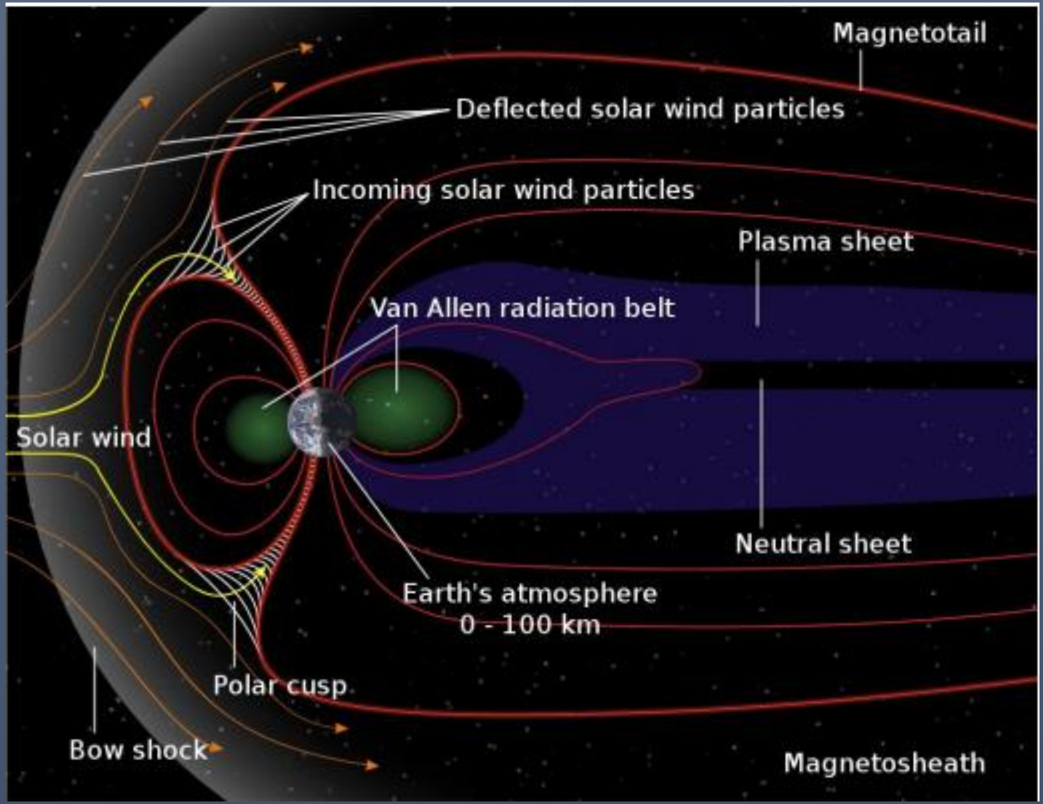
- Our star has magnetic activity and dominates the space nearby (solar wind)
- Its magnetic activity makes serious disturbances in the navigation and the communication

The magnetic activity of the Sun has an influence on the heliosphere.



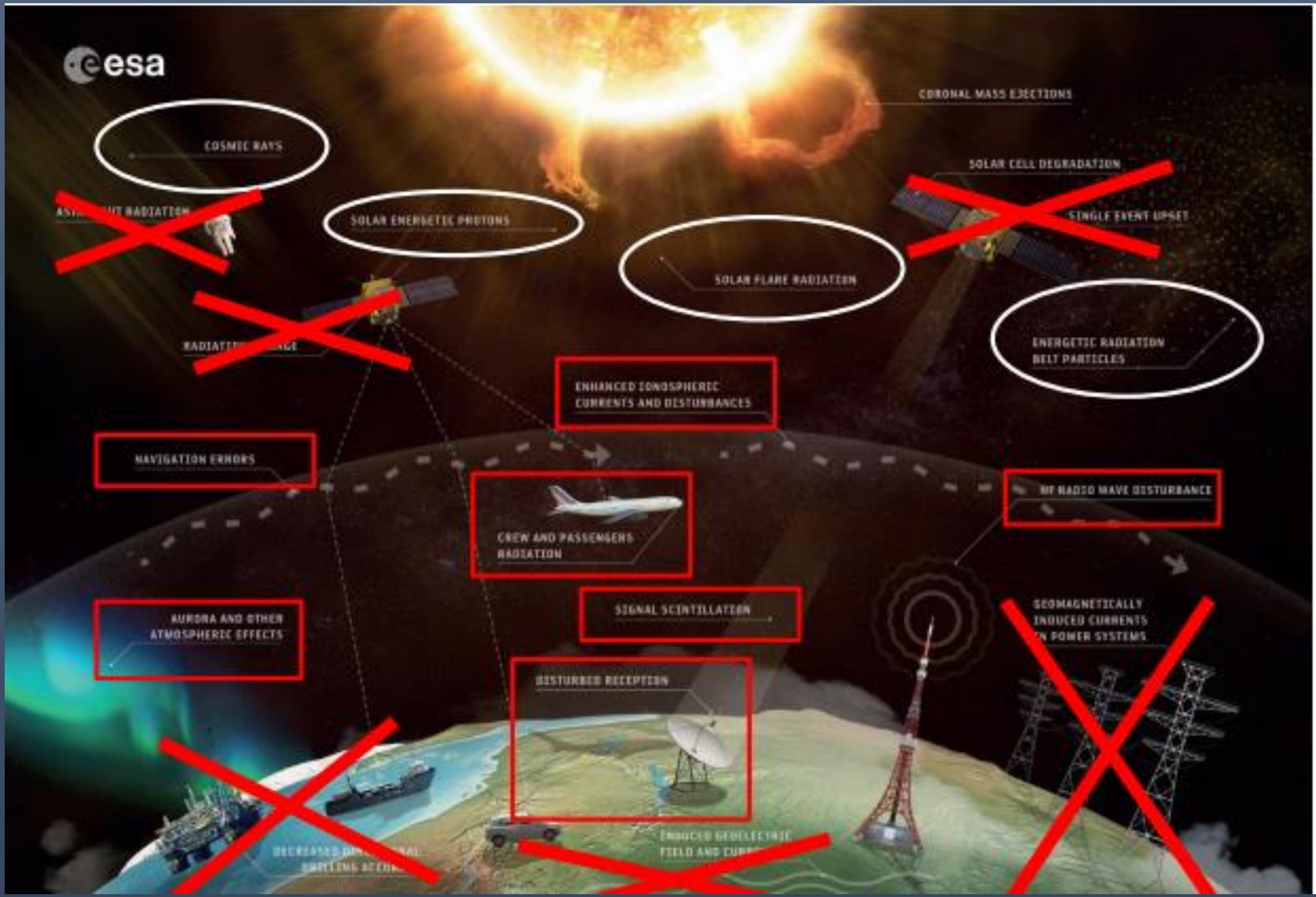


The solar wind enters to the terrestrial magnetosphere and creates aurora, magnetic disturbances, GICs and the radiation belts.



Magnetohydrodynamic (MHD) simulation of a solar storm (CME) from the L1 Lagrange point to the geotail, XY and XZ planes in Geocentric Solar Ecliptic (GSE) system

Space Weather effects on aviation



- The sources of the radiation
  - Cosmic rays
  - Solar Energetic Particles (SEP)
  - Solar Flare Radiation
  - Solar Flare Radio Burst
  - Energetic Particle Belt Particles
- Damages and disturbances
  - Navigation errors
  - Crew radiation
  - Signal scintillation
  - Disturbed reception
  - HF radio wave disturbances
- Aurora
  - Important indicator of the activity
  - Beautiful tourist attraction
- Various nowcast and prediction systems
  - ESA, NASA, NOAA, CIRES, UK MET Office, PECASUS, Auroras Now!

Azerbaijan has three space satellites. Satellite data is used in many areas of the economy and plays a large role in development of telecommunications infrastructure.

The most of telecommunications infrastructure depends on satellite activities. Space agencies use navigation services, and meteorologists and climate change researchers benefit from satellite data. Discussions about solar activity and space weather are becoming increasingly important.

It's necessary to provide attention to international cooperation, become a part of international initiatives in order to move further in space sector. Azerbaijan has been recognized as a reliable partner in this sector, an International Astronautical Congress will be held in Baku next year.

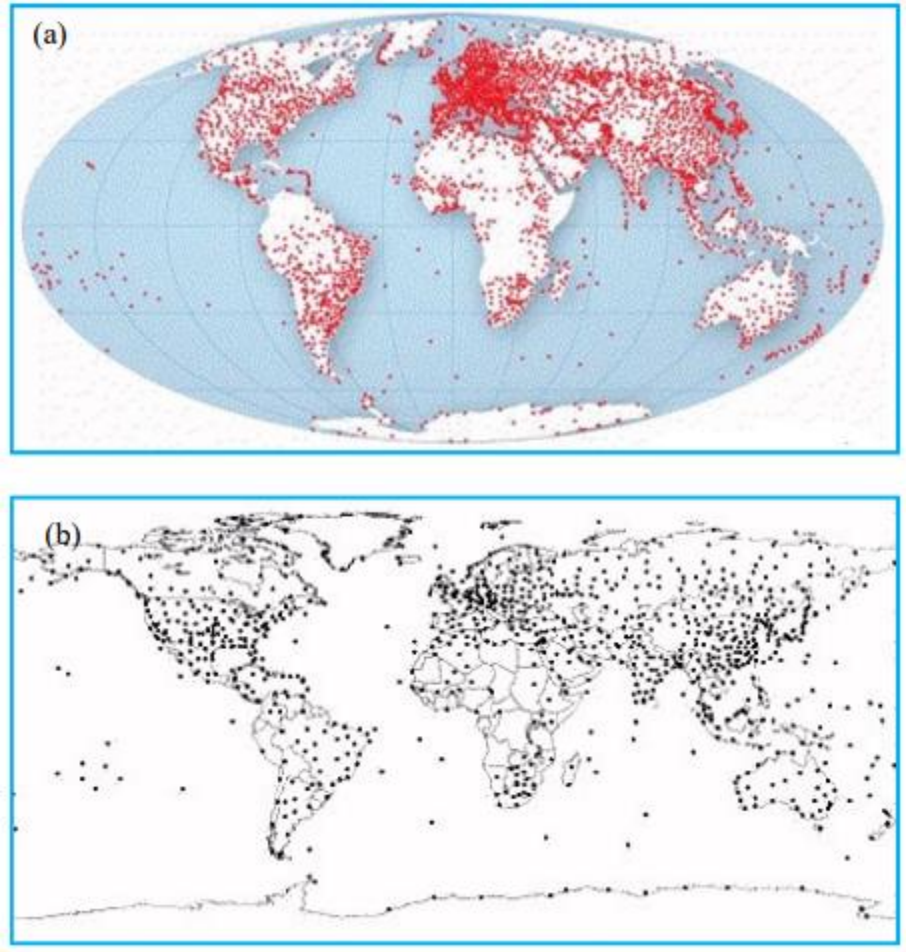
Space weather information center

- Recent advance of information and communications technology enables to collect large amount of data in real-time. This expands application of the data in operation and research of space weather. It is important for space weather to collect ground-based observation data.
- Satellite communication is also useful for the data collection although its cost is still expensive.
- Resent ground-based observations tend to produce a large amount of data such as atmospheric imagers. A low-cost high-speed communication service with global coverage is necessary to construct a dense real-time space weather monitoring network. This will be realized by a satellite communication system. Development of a small low-power transmitter is necessary for this.

REAL-TIME DATA AS INPUT TO FORECAST MODEL

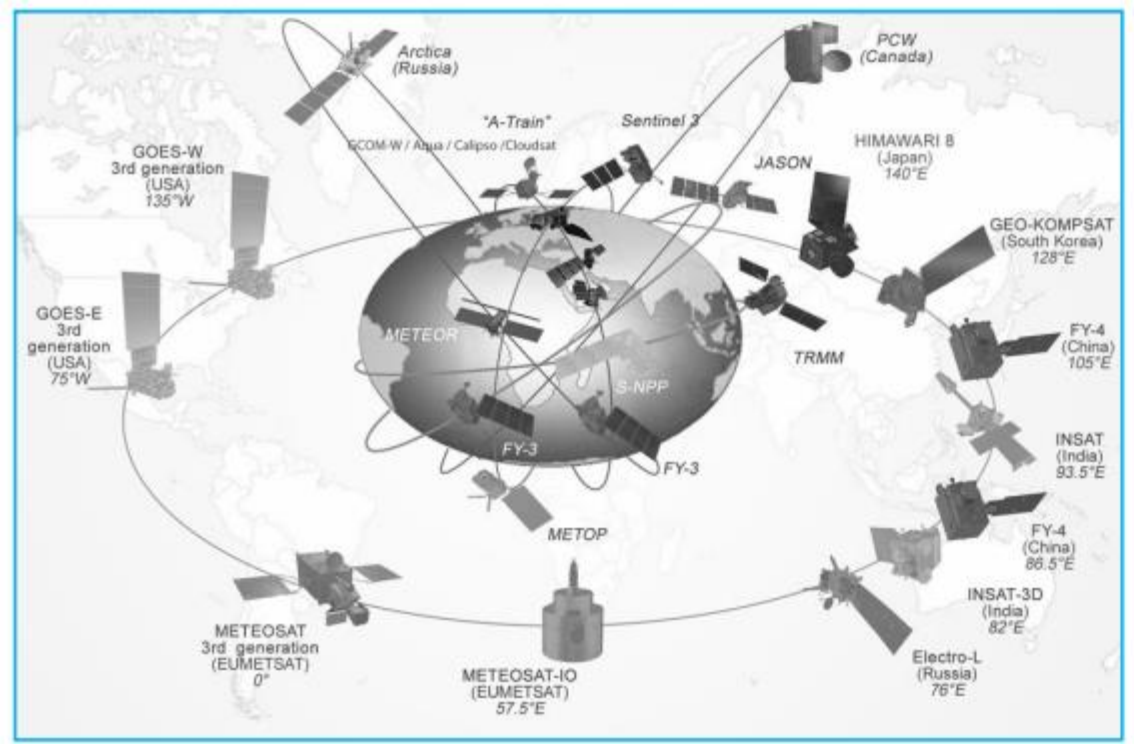
- Utilization of models has a possibility to improve forecasts of space weather. The real-time data are used not only to understand present condition but also to drive models as input parameters.
- Data Centre for Space Weather medium-term and short-term forecast combines remote sensing and in situ open-access data relative to the Sun, the Heliosphere and the Earth's magnetosphere. This is done with the novel big data technologies, to provide scientists with the possibility to design, implement and validate Space Weather algorithms on extensive datasets.

Hence, the development of the meteorological observation networks was considered as important as the development of weather prediction models. This emphasis on the atmospheric observations led to a continuous development of ground based observation network of surface as well as upper air weather parameters. Although the ground based observation network provides very critical input to the weather prediction and climate monitoring, it provides very limited observations over inaccessible areas like mountains, deserts and vast oceanic areas



Global distribution of (a) AWS stations
(b) Stations for upper air meteorological observations

Satellites provide valuable earth observations from low-earth orbit as well as geostationary orbits. Fig shows the constellation of current geostationary and Low Earth Orbiting (LEO) meteorological satellites. Satellites in low earth orbits that vary in altitude in the range 300- 850 km provide high resolution measurements of the atmospheric and oceanic parameters e.g., vertical structure of temperature and humidity, atmospheric moisture, cloud liquid water, vertical structure of clouds and rain, sea surface and land surface temperature, atmospheric aerosols and trace gases, air quality parameters, ocean surface winds, ocean salinity, soil moisture, rainfall, etc



Applications of imager observations for nowcasting

Availability of observations of weather systems at short time interval from geostationary satellites (10-15 minutes) is highly beneficial for very short range (few minutes to couple of hours) forecasting or “nowcasting”. In general, the techniques of nowcasting are different from those of NWP models and nowcasting mostly relies on tracking the movement and evolution of weather features in rapid sequence of images from Radars or satellites (Kober and Tafferner, 2009). For short term prediction of precipitation (0-3 h), nowcast methods based on Lagrangian advection of radar and satellite images of convective systems offer the most robust and accurate prediction at mesoscale resolution, as the initial conditions are known accurately.

Satellite observations are undoubtedly the most important source of observations for numerical weather prediction in present time. Satellites provide valuable observations of temperature and humidity profiles, surface temperature, winds etc. using different sensors and orbital configurations. Satellite observations play very important role in operational synoptic scale analysis and prediction, as well as in nowcasting of important weather events. Data assimilation experiments clearly indicate the value and advantage of satellite observations for weather prediction. On global scale, the assimilation of satellite observations like those from microwave sounders, infrared hyperspectral sounders, atmospheric motion vector winds, ocean surface scatterometer winds and thermodynamic profiles from GPS-RO show very high impact on numerical weather prediction. One of the main reasons that satellite observations have large impact on weather forecast at global scale is their ability to observe vast oceanic regions and parts of southern hemisphere where conventional observations are sparse.

Summary

- Operational satellite systems provide valuable information on atmospheric parameters at regular intervals on a global scale. This satellite-based information about the Earth-atmosphere system and its components greatly enhance our knowledge and understanding of the processes and dynamics within the Earth-atmosphere system.
- Successful instruments from experimental LEO systems have been improved and transferred to the next generation of operational LEO systems, while proven instruments from operational LEO systems have made it on board follow-up GEO systems.
- Future satellite systems must sustain the observational capabilities of key global climate parameters. On the one hand this involves the improvement and further development of operational missions, critical for routine weather observation and numerical weather forecast. On the other hand this also implies the continuation of existing and established systems to assure the provision of long-term data sets for climate monitoring.
- In general the assimilation of HR data and GNSS derived variables always resulted into an improvement in the weather forecast
- Thus, it is worth further exploring the synergy between HR Sentinel observations and weather

THANK YOU FOR ATTENTION!