Radiation Monitor Data as input to Space Weather Applications

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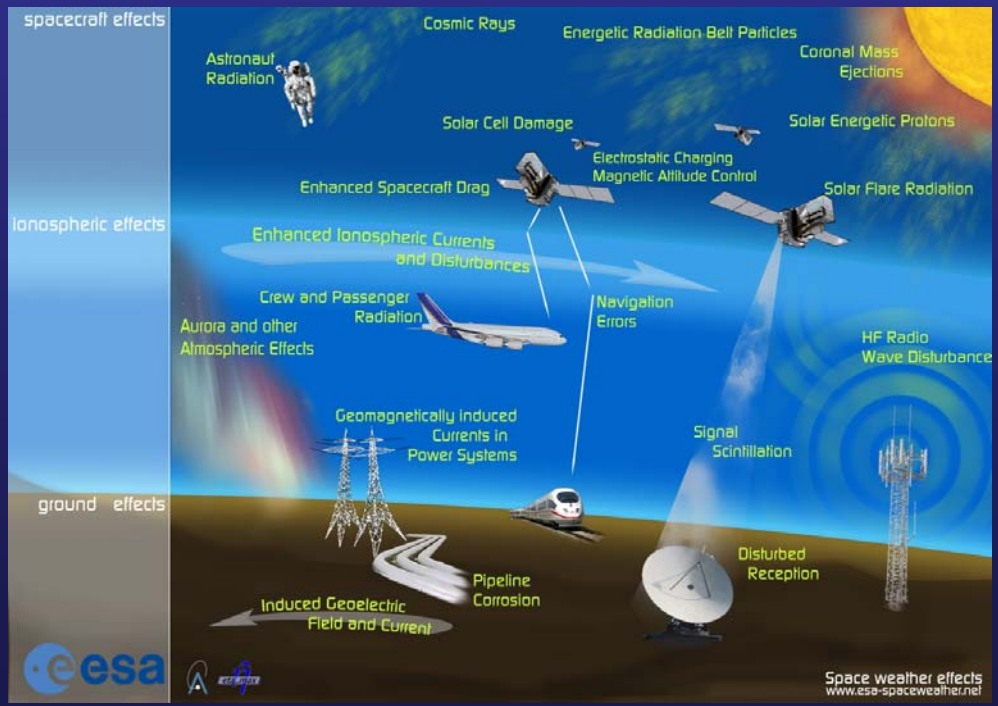
Overview

- Space weather
- User requirements
- Derived measurement requirements for space weather applications
- Current data sources
- Example services based on radiation monitor data
- Summary

Space Weather

Definition: ***"conditions on the sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health."***

- **Some Space Weather Effects..**
- Satellites affected by radiation, plasma, atmosphere, particulates;
- Astronauts - ISS, future exploration missions;
- Radiation hazards to air crew and avionics;
- Ground power outages from currents induced in lines;
- Disruption to communications relying on the ionosphere;
- Disruption of navigation satellite signals (GPS - Galileo);
- Prospecting;
- Climate;



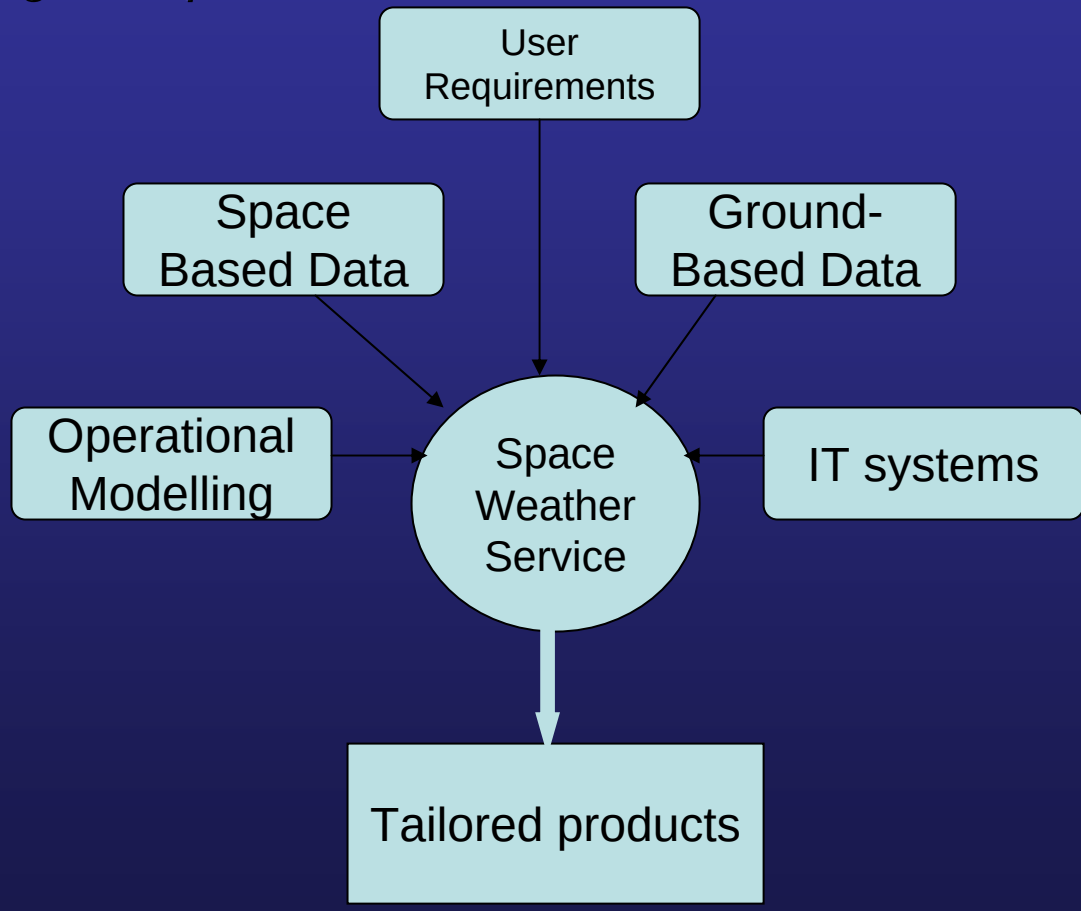
What is a Space Weather Service?

- *provides end-users with tailored products to avoid or reduce space weather hazards through design or operation.*

- Service products are diverse, depending on user's field of operation and requirements

- A service can include space and ground based data together with advanced data processing and IT to exploit data and execute simulations of the space weather systems.

- Space Weather European Network: SWENET:



SWENET http://esa-spaceweather.net/swenet

Space Weather Measurements: Science & Services

- Requirements can differ…
  - Science goals:
    - Often aim for measurements of unprecedented accuracy
    - New science implies never done before
    - “one off” missions
    - Data can be delivered weeks/months after observations made
    - Some data may be prioritary
  - Service goals:
    - Timeliness of data delivery
    - Instrumentation capable of resolving large events
    - Reliability important for downstream service(s)
    - Importance of long time series of comparable measurements
    - Replacement strategy

User Requirements

- Previous studies have considered user requirements in detail
  - Parallel SW programme feasibility studies (1999-2001): 2 consortia carried out a broad review based on an initially agreed set of URs
  - Nanosatellite Beacons for space weather monitoring (2006): Built on the derived measurement requirements from parallel studies, updating and assessing which requirements could be accommodated on small s/c
  - the space weather applications pilot project (2003-2006): Built on existing resources only. Service development activities all started from user requirements set out by associated users at start of project and updated as projects progressed
- Need for services dedicated to forecast, monitoring *and* post event analysis demonstrated.
- User requirements ➔ measurement requirements including evaluation of service requirements for observation cadence and timeliness of data delivery

Example Derived Measurement Requirements Relevant for Radiation Monitors

Measurement	Location	Cadence (service)	Timeliness
Solar wind density & bulk velocity	L1	1min	30min
>100MeV ions from heliosphere	GEO/L1	5min	5min
2-100MeV ions from heliosphere	GEO/L1	5min	5min
2-20MeV electrons from heliosphere	GEO/L1	5min	1440min
<40keV ions & electrons (auroral oval)	LEO	60min	5min
10-100keV electrons in msph	Rad belt	1min	60min
2-20MeV electrons in rad belts	Geo/Rad Belt	1min	5min
>10MeV protons	GEO/Rad Belt	1min	5min

(Extracted from SW Nanosats UR review)

Current Radiation Monitors

- NASA-NOAA GOES-POES programme carry SEM/SEM-2 instrument. Part of a US NWS programme allowing real-time data collection and generation of long-time series dataset. Data made publicly available via NOAA/SWPC.

- NASA ACE spacecraft returns real-time data on IMF, speed and composition of the solar wind.

- European monitors. Some examples…
  - SREM monitors onboard Proba, Integral (IREM), Rosetta. Consistent measurements in different orbits.
  - GIOVE-A instruments characterising MEO environment in advance of Galileo constellation
  - MetOp. Carries the US SEM-2 instrument, not presently used as service.
  - SOHO particle instruments. Data provided in near-real time. E.g. CELIAS/MTOF/PM (proton monitor) “Shock spotter” algorithm

Services using Radiation Monitor Data

- Taking the SWENET pilot service network as an example
- Total 30 services in 3 main areas
- Services all based on existing resources
- Using radiation monitor data:
  - Ground based systems: 6/12
  - Ionospheric Effects: 7/12
  - Space: 6/6
- Strongly dependent on GOES and ACE data.
- Radiation monitor data used in all areas
  - Ionospheric and ground based services use data in context of forecasting. Timeliness critical in this case

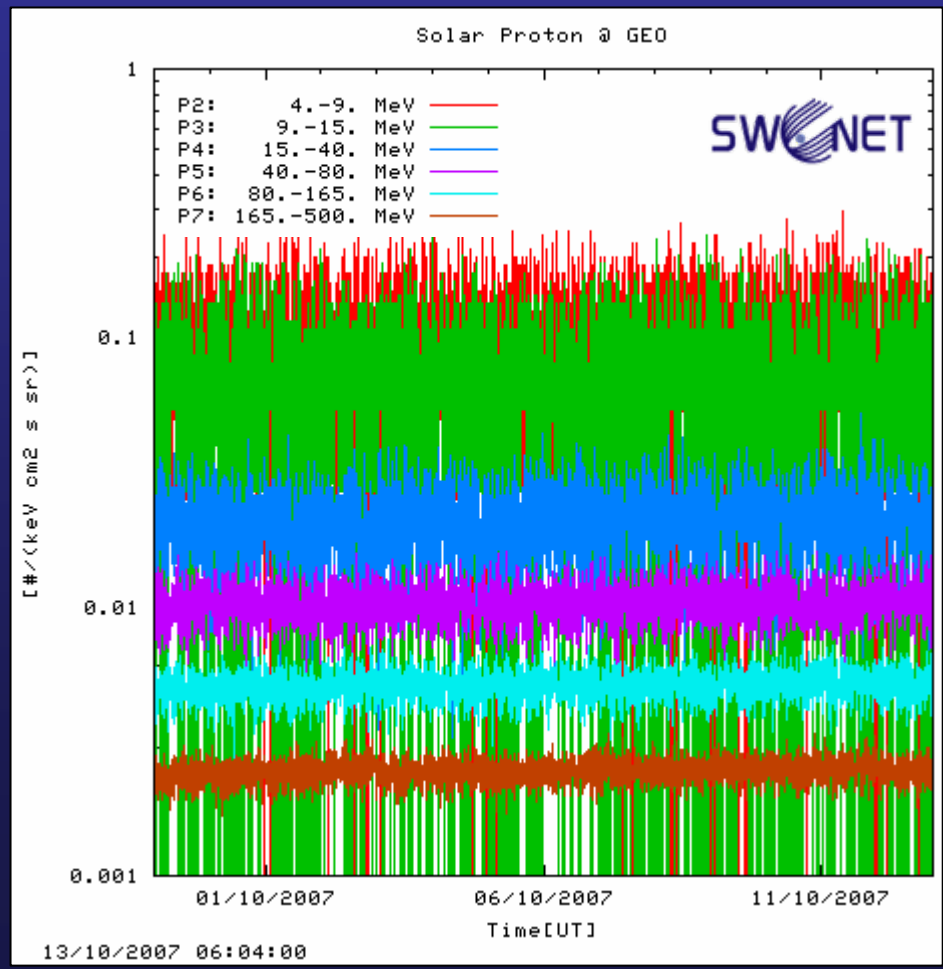
GEISHA:Geosynchronous Environment for Identification of Satellite Hit Anomalies

- Goals:
  - Data assimilation and modelling resource to prototype a space weather service;
  - Integration of Satellite manufacturers and operators requirements and quantification of benefits from the service.

- Products:
  - Electron and proton fluxes in GEO
  - SEE analysis
  - Solar array degradation analysis
  - Surface & deep dielectric charging analysis
  - Public service: Daily updated dynamic plots for electron and proton fluxes at 0 degrees longitude at GEO

- Data and Approach: Radiation monitors flying on US GOES and LANL/GEO series spacecraft. Fusion of data with physical modelling to extrapolate local in-situ measurement to all longitudes on geostationary orbit.

- Consortium: ONERA/DESP, AAS, CNES, CLS.



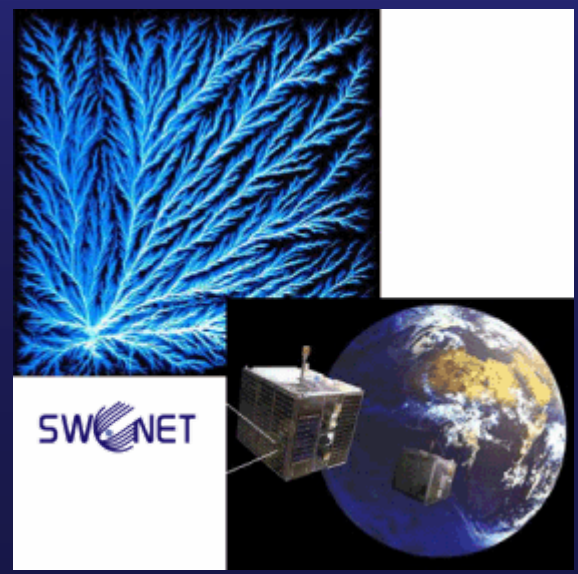
GEOSHAFT: Spacecraft Hazard and Anomaly Forecast Tool

- Goals
  - Develop a pilot service to monitor and predict the hazard from internal charging to satellites in geostationary orbit
  - Delivery of different alerts and forecasts to different users via e-mails and client viewer

- Products:
  - Real-time running averages of electron flux based on timescales associated with internal charging
  - Real-time calculation and display of internal charging currents for given shielding level(s)
  - Real-time display of charging levels for typical materials
  - Short term forecasts of hazardous conditions

- Data and Approach:
  - Input data GOES 5minute electron data. Fed through time averaging algorithm, DICTAT running in real-time for charging physics.

- Developed by: QinetiQ



SEISOP: Space Environment Information System for Operations

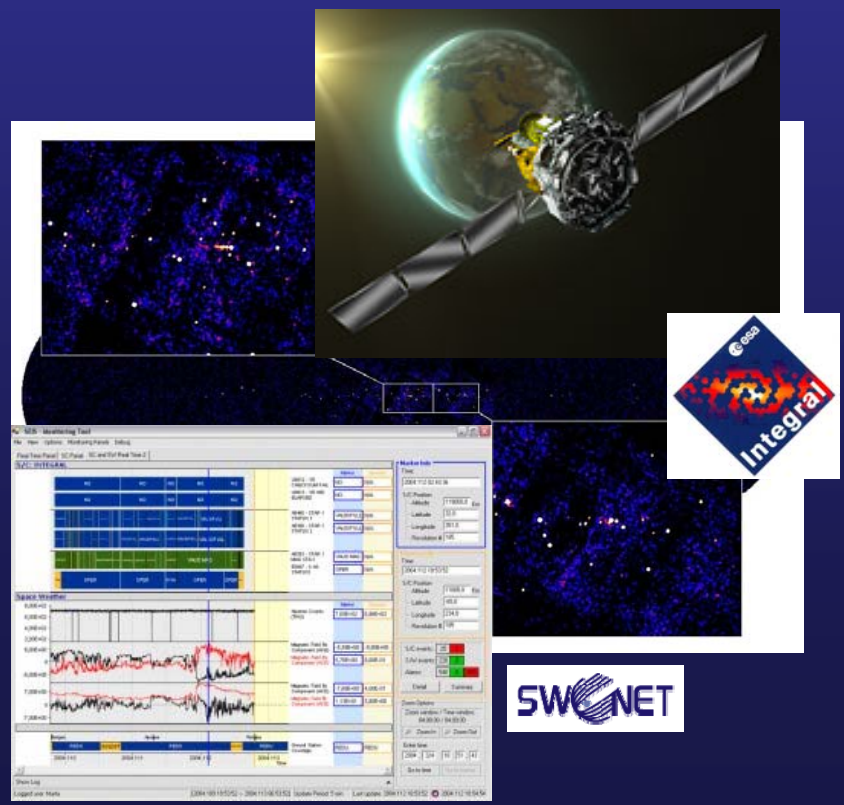
- **Goals:**
  - Integrated data solution for Flight Control Teams to support decision-making processes allowing rapid response to space weather conditions.

- **Products**
  - Integrated Space Weather historical, real-time and forecasted data collection archive
  - Automatic Report Generator
  - Monitoring Tool
  - Forecast module
  - Alarm generator

Data and Approach:

  - Generic infrastructure developed to support operations in space weather monitoring and forecasting. Data collected from a variety of external sources. Combined with telemetry data and modelling capability.

- Currently in use by Integral FCT at ESOC. Plans for extension
- **Developed by:** Uninova, Deimos Engenharia



Summary

- Radiation monitor data forms a key element of many existing space weather services
  - e.g.s seen in SWENET network
- Heavily reliant on US data provision for long time-series of data and real-time availability
- European data not typically available in real-time outside individual projects, but can be incorporated into useful space weather services if available
- Instrumentation often selected on a project-by-project basis, complicating combined analysis/incorporation into modelling activities.
- long-term framework for applying European data in SW context does not exist in Europe