Introduction to the Space Weather Application Pilot Project

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- Background
- Current activities
- European and international context

Background

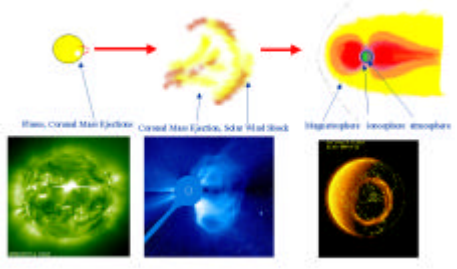
- Definition
- Example
- ESA involvement
- Focus on service
- Feasibility study

What is Space Weather?

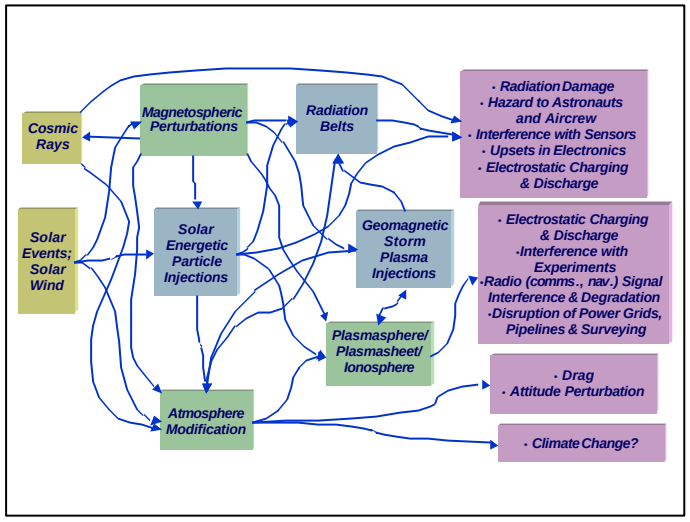
"*conditions on the sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health*"

www.estec.esa.nl/wmwww/wma/spweather/
www.esa.int/spaceweather

Example of space weather phenomena

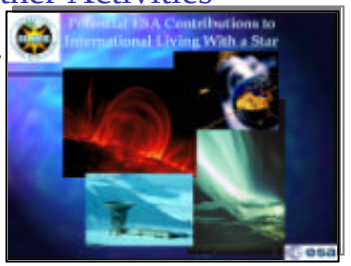


Observation systems:
•Space based
•Ground based



ESA Space Weather Activities

- Science
  - SOHO (-2007), Cluster (-2005),
  - Double-Star, BepiColombo, Solar Orbiter,…, ILWS
  - (there are significant unknowns in the space weather "system" in need of intensive scientific study)

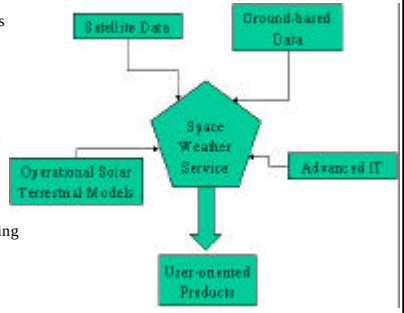


- Engineering and Operations – Project Support and R&D
- Prospective for a space weather activity (following council LSPC action plan, Nov. 1999 action 11)
  - Feasibility study of and requirements for a programme (completed)
  - Pilot project of a coordinated set of applications based on existing data (starting)
  - Support, evaluation and coordination

Focus on Space Weather Service.

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

- A space weather service federates ground and space based measurement of the solar-terrestrial environment, not to perform science, but to derive products.
- A service includes advanced data processing and information technologies to exploit data and execute simulations of the space weather systems.
- Data & services are already proving valuable in certain sectors (e.g. power grids, communication, defence, spacecraft)



Science vs. Service

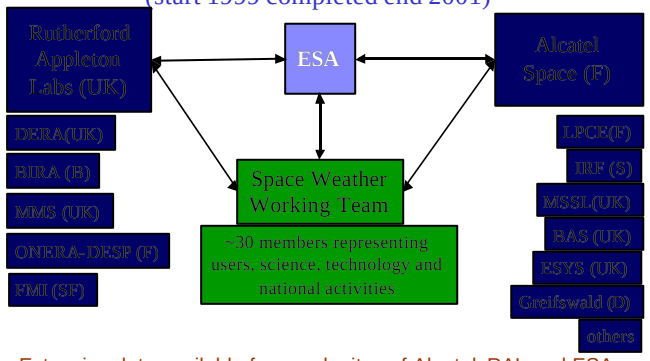
- Science requirements are NOT (necessarily) service compatible, e.g.
  - delay to downlinks (cf Cluster)
  - processing delay
  - availability
  - continuity
  - longevity
  - instrument performance requirements
- Space weather services in the long run should not rely on science missions
- Synergies are nevertheless necessary (e.g., shared infrastructure, space weather service to scientific campaign,…).

NOAA/Space Weather Centre

Feasibility Study

- Investigate **needs for & benefits** of a user-oriented Space Weather Programme
- Establish detailed **data requirements** w.r.t. quantification of effects
- Detailed analysis of potential programme contents:
  - Detailed definition of the **space-segment**
  - Detailed definition and proto-typing of the **service-segment**
  - Analysis of collaborative & organisational structures which need to be implemented by ESA and member states
- **Proposal of a programme**, including project implementation plan,
  cost estimate and risk analysis
- 1999: Two parallel contracts to consortia led by
  - Rutherford Appleton Laboratories (UK) and
  - Alcatel Space (France).

Feasibility Study
(start 1999 completed end 2001)



Extensive data available from web sites of Alcatel, RAL and ESA
www.estec.esa.nl/wmwww/wma/spweather/
www.esa.int/spaceweather/

Publications-1

1. A Catalogue of Space Weather Effects, ESWS-FMI-RP-0001, Issue 2.2 January 2, 2001 , by H. Koskinen, E. Tanskanen, R. Pirjola , A. Pulkkinen, C. Dyer, D. Rodgers, P. Cannon, J.-C. Mandeville, D.Boscher.
2. Benefits of a European Space Weather Programme , by David J. Rodgers, Lesley M.Murphy, Clive S.Dyer, DERA report no. DERA/KIS/SPACE/TR000349.
3. Benefits of a Space Weather Programme wp1100 (Version 3.1) , by Richard B. Horne, Alcatel Consortium, British Antartic Survey, Cambridge, UK.
4. Space Weather Parameters Required by the Users and Synthesis of User Requirements wp1300 and wp1400 (Version 3.1) , by Richard B. Horne, Alcatel Consortium, British Antartic Survey, Cambridge, UK.
5. Rationale for European Space Weather Programme (Issue 2.3, 30-3-2001) , by H. Koskinen, E. Tanskanen, R. Pirjola, A. Pulkkinen, C. Dyer, D. Rodgers, P. Cannon, J.-C. Mandeville, D.Boscher .
6. System Requirement Definition (Issue 1.0, 20-4-2001, Final version) , by Lesley M. Murphy and David J. Rodgers, DERA report no. DERA/KIS/SPACE/CR010157.
7. Space segment - Measurement and system requirements WP 2200 and 2300 reports (Issue-2, 29 November 2001) by A. Coates et al.
8. Ground Based Measurements, WP 3120, November 30, 2001, by J. Lilensten and C. Lathuilliere.

Publications-2

1. ESA Space Weather Programme Study Market Analysis - Final Report, Issue 1.1, ESYS-2000260-RPT-02 28 September 2001.
2. Space Segment Definition and Analysis, issue 1.0, 3-12-2001, ALCATEL report ASPI-2001-OSM/IF-191.
3. Space Weather Market Analysis Summary Report for the ESA Space Weather Working Team (Issue 2.0, 11 July 2001) by D. Flynn, E. Taylor and M. Snelling.
4. A definition of instruments needed for space weather measurements, ESWS-RAL-TN-0001, Issue 1.4, 18 November 2001 by M. Hapgood and M. Oliver.
5. Space Weather Space Segment Options, Technical Note for WP420, DRAFT 08 dated 10 September 2001, Astrium report by S. Eckersley.
6. Ground segment interface with space-based space weather measurements, ESWS-RAL-TN-0004, Issue 1.2, dated 25 November 2001.
7. Interface between spacecraft ground segment and space weather service, ESWS-RAL-TN-0002, Issue 1.1, 26 November 2001 by M. Hapgood.
8. Space Weather Service, ESWS-RAL-TN-0003, Issue 1.1, November 6, 2001, by M. Hapgood.
9. Space Weather Prototype System, ESWS-BIR-TN-0001, by M. Kruglanski, D. Heynderickx (BIRA/IASB), November 2001.

Publications-3

1. Space Weather Service, WP3110 by Henrik Lundstedt, Version October 2100.
2. A Prototype Real-Time Forecast Service of Space Weather and Effects Using Knowledge-Based Neurocomputing, WP3220 and WP3210 by Henrik Lundstedt, Version October, 2100.
3. Perspectives for a European Space Weather Programme System Scenarios, Development Plan, Programmatics, Issue 1.1, 14-12-2001, Alcatel report by B. Huet.
4. Recommendation for the co-ordination of a European Space Weather Programme by F. Lefeuvre, P. Gille, Issue 1.1 - 3/12/2001.
5. Roadmap for European co-ordination in space weather ESWS-RAL-RP-0003, Issue 1.0, 19 November 2001 by M. Hapgood.
6. Project Implementation Plan and Final Report, ESWS-RAL-RP-0002, Issue 1.0, 23 November 2001 by M. Hapgood.
7. Space Weather Cost and Risk Assessment, Technical Note for WP620, DRAFT 01, CI CODE: XXX, Astrium report.
8. CDF study report: Space Weather, 3 elements monitoring the solar-terrestrial environment as part of a service, ESA CDF team.

Programme study: Achievements

- Economic benefits exists but market is spread over several disconnected domains (no one major user was identified) and European space weather applications are currently based on a US service.
- Identified strong European assets and capabilities (observatory infrastructure, science, modelling…) but lack of coordination.
- Full scale ground and space segments has been defined and costed (// review by CDF) and can be built at reasonable cost although reliability requirements can push it up.
- A strong European dynamics has been initiated, is still maintained (via SWWT), needs support from existing agencies.

Areas in Need of Attention

- Data Coverage:
  - Some measurements are lacking (e.g., eV to keV electron environment at high altitude, Radiation environment from 100keV to 1MeV at high altitude, thermospheric flux,…)
  - Planetary coverage not always achieved (e.g., magnetometers, radars, …).
- Long Term Continuity
  - Scientific data sources end with individual missions (e.g. Yohkoh, SOHO, ACE.)
  - Ground observatories may also cease operation (e.g., collapse of former Soviet Union ground based solar-terrestrial monitoring)
- Reliability
  - Mainly depending on US data and data provision system
  - Distribution to Europe mainly via internet.
- Model Accuracy
  - 'First principle' models are not generally intended for operational use.
  - Empirical Models can be run quickly but are still in their infancy, requiring more data.
- Risk management: Increasing sensitivity of technologies and awareness of society to space weather;

Current activities

- ESA management requirements
- Space weather roadmap
- Pilot project
- International context

ESA management requirements

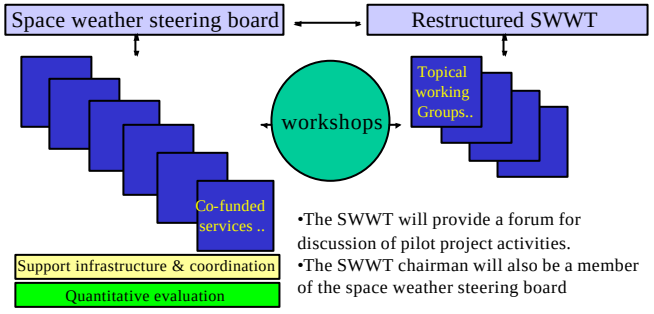
Noting that management board though that case was not made for starting a programme it was decided to:

- Focus on developing the community (users, providers) in Europe: Application Pilot Project, SWWT, outreach,…
- Get detailed data on cost, impact of effects , cost of services and value (economic, strategic, …) of services.
- Continue to assess user requirements for future development and identify technology requirements (esp. space based measurements).
- Continue the engineering work (develop technology required for addressing effects).
- Continue studying improvement of space weather architecture.
- Continue investigating coordination infrastructure.
- Report back to management board at end of application pilot project.

Space Weather Roadmap Main items

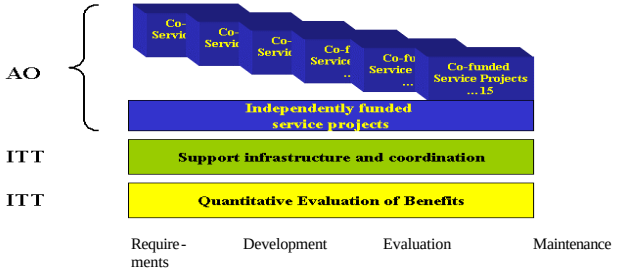
- Space Weather Working Team - Continuation
- Space weather pilot project (SDA, Support, Evaluation).
- Other ESA R&D - Collaboration
  - TOS (TRP, GSTP)
  - Science (instr., data access)
  - Navigation (Galileo)
  - Telecom (Artes)
  - Earth Observation (GMES)
- EU (COST, FP6, GMES)
- National activities
- EUMETSAT collaboration
- ISES + Interagency collaborations

SWWT coordination (Next meeting on 18-19 December)



•The SWWT will provide a forum for discussion of pilot project activities.
•The SWWT chairman will also be a member of the space weather steering board

Application Pilot Project



Space Weather Applications Pilot Project

- Aims to create a network of service development activities for space weather applications with close links to users.
- Objectives: to develop a user community, establish evidence of viability for a future programme and identify future priorities;
- **Several** (15 to 17) **small sub-projects:** teaming user+service providers, who:
  - Become part of a coordinated network.
  - Establish user requirements and develop services over a period of ~1 year
  - Evaluate the usefulness and value of the resulting products (~1 year)
  - Establish viability of continued activity and priority developments
  - Establish requirements for a common SW architecture.
  - Participate in meetings, coordination and outreach
  - Contribute to the cost-benefit analysis
  - Contribute to analysis of requirements for future systems.
  - Propose business plan for continuous service.
- **Infrastructure, Support and Evaluation (gather requirements, develop data and service distribution infrastructure for public part, organise meetings,…).**
- **Assessment of Economic and Other Benefits**

Pilot project status

- SDA's:
  - First step abstract proposal: Good response.
  - After full submission on AO, 17 selected for negotiation on funding.
  - Other programmes will be solicited (TTP, EO, Artes, Galileo, TRP, Education, Science).
  - Announcement of Results: In progress
  - Planned contract start activity: February 2003
- Support Contract: ITT January 2003.
- Benefit Evaluation contract: ITT January 2003.

Field covered so far in response to AO

- Ground and atmosphere
  - electric power distribution network, pipeline operators;
  - drilling
  - Atmospheric models
  - Tourism in high latitude region
  - Radiation in airplanes
- Telecom & Navigation
  - HF telecommunication(radio-amateurs, Civilian or military security).
  - Navigation
  - Scintillation
- Space:
  - Drag
  - Radiation
  - Plasma
- Science: Indices, Infrastructure
- Education & Outreach

European and International Context

- ESA & EUROPE
  - Space Science Missions (SOHO, Cluster, Solar Orbiter, International Living with a star…)
  - ESA – GSE: IEAA proposal on behalf of SWWT for interfacing with pilot project. National science missions; national technology missions
  - EU FP6: Space weather appears in space and aeronautics work plan under GMES (~11 EoI's).
  - COST Action 724 "Developing the scientific basis for monitoring, modelling and predicting space weather" accepted in July 2002)
  - COST Action 271 dedicated to the effects that space weather has on communication and navigation.
- US:
  - NOAA Space Environment Centre and Data System
  - NASA Manned Programme
  - DoD!
  - International Living with a Star programme
- Japan:
  - Study of an "L5" mission + others
- Other nations are active
- A coordinated world approach seems the natural way forward

ISES

- International Space Environment Service based on RWC and Specialised Centres.

- Chairman: David Boteler (Canada).
- Vice-Chairman: Henrik Lundstedt (Sweden).
- Last meeting: 14 April 2002 at NOAA, Boulder.
- Approved ESA participation to ISES as Special Support Agency.
- Will create a working group on spacecraft effects.

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Purpos…

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- To …