SPACE WEATHER EFFECTS ON GNSS PERFORMANCE AND OPERATION: A FUNDAMENTAL COMPONENT OF GNSS CURRICULUM

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- Content of presentation:
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  - Aim and methodology
  - Course programme
  - Resources
  - Conclusion
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Courtesy: NOAA
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Introduction

- Space weather
- Earth-related environment
- SW effects on GNSS

<table>
<thead>
<tr>
<th>Error source</th>
<th>Equivalent positioning error (bias - random - total) [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Satellite and control component errors</strong></td>
<td></td>
</tr>
<tr>
<td>Satellite ephemeris error</td>
<td>2.1 - 0.0 - 2.1</td>
</tr>
<tr>
<td>Satellite clock error</td>
<td>2.0 - 0.7 - 2.1</td>
</tr>
<tr>
<td><strong>User component errors</strong></td>
<td></td>
</tr>
<tr>
<td>Multipath</td>
<td>1.0 - 1.0 - 1.4</td>
</tr>
<tr>
<td>Receiver noise</td>
<td>0.5 - 0.2 - 0.5</td>
</tr>
<tr>
<td><strong>Propagation media errors</strong></td>
<td></td>
</tr>
<tr>
<td>Ionospheric delay</td>
<td>4.0 - 0.5 - 4.0</td>
</tr>
<tr>
<td>Tropospheric delay</td>
<td>0.5 - 0.5 - 0.7</td>
</tr>
</tbody>
</table>
Aim and methodology

- More detailed understanding of the subject among the GNSS professionals
- More successful mitigation of space weather and ionospheric effects on GNSS and GNSS-based systems performance and operation
- Methodology of work: lectures and practical (experimental field) work - an university course
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- Course programme - general outline
  - Space weather
  - Space weather effects on GNSS operation
  - Space weather effects on GNSS performance
  - GNSS-related space weather monitoring
  - Mitigation of space weather effects on GNSS
Course programme - Space weather

- Nature and origins of space weather
- Solar-terrestrial relationship
- Geomagnetic environment
- Ionosphere
- Modelling the ionosphere
Course programme - Space weather effects on GNSS operation

- GNSS architecture
- Satellite component
- Control component
- Propagation media
Course programme - Space weather effects on GNSS performance

- GNSS ionospheric error
- GPS ionospheric delay
- Ionospheric scintillation
- Local ionospheric dynamics
- Other sources of GNSS performance disruptions
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- Course programme - GNSS-related space weather monitoring
  - Essential space weather parameters
  - Instrumentation
  - Satellite observations
  - Terrestrial observations
  - Internet archives of observables
  - Data analysis principles
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- Course programme - Mitigation of space weather effects
  - Modernised GNSS
  - Advanced DSP
  - Assisting and augmenting systems
  - Identification of service disruptions
  - Correction models
  - Alerts and notifications
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- Resources - Books
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- **Resources - Internet materials**
  - Earth-prints. Internet repository of scientific papers. Available at: http://www.earth-prints.org/
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- **Resources -** Space weather and GNSS observables data on internet


Resources - Tools

- The R project for statistical computing and graphics (free software, manuals and tutorials). Available at: http://www.r-project.org/
- GPStk (GPS Toolkit, University of Texas in Austin). Available at: http://bit.ly/JMGpy
Conclusion

- Space weather has considerable effects on GNSS operation and performance
- Importance of proper education and professional advancement of GNSS professionals
- Course programme presented with a detailed list of references - suitable for graduate studies and professional advancement
THANK YOU FOR YOUR ATTENTION!

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