PECASUS
Global Operational Space Weather Forecasting Center for the mitigation of SWX Effects

Prof. Ari-Matti Harri
FMI - Finnish Meteorological Institute
Coordinator of the PECASUS Consortium
Ten ICAO member countries (European & South Africa)
Consortium Lead Finland (FMI)
ICAO SWXC to improve aviation safety and efficiency
Global SWXC services
✓ HF communication
✓ Radiation levels at flight altitudes
✓ GNSS & SatCOM

(2) PECASUS: ICAO-designated Global Aviation Space Weather Center
Space Weather Effects

Propagation times:
- X-rays & EUV: 8 min
- Energetic particles: Some hours
- Coronal Mass ejections: 1-2 days

Geoeffectivity can be confirmed by satellite measurements of solar wind at L1-point.

From L1 measurement it takes ~1 hour to see the impact by ground-based measurements.

Which of the sunspot groups can cause a flare?

Are there coronal holes which are associated with high speed solar wind?

Is the coronal mass ejection directed towards Earth?

Does the solar wind structure have correct magnetic structure?

What is the previous state of magnetosphere?
(4) PECASUS – Global Aviation SWX Center

Hazards

- Satellite and ground-based data
- Computer simulations
- Collab. UK MetOffice, STCE, NOAA

Auroras

Security Duty Officer

Space Weather Officer

Alerts and Warnings

Tailored guidance

@FMI-space
(5) PECASUS – Operations Mngmnt

Advisory verification and dissemination

Scientific & Technical Assembly of SWx Advisories

Flight radiation domain services

HF user domain services

GNSS user domain services

Space physics data is collected, analysed, forecasted 24h/7d

All relevant data worldwide. Data & services from all European states are welcome and will be given proper visibility
The Three ICAO Global Space Weather Centers

- PECASUS consortium
- ACFJ consortium
- NOAA Space Weather Prediction Service

- Two week shifts in the responsibility of advisory generation and dissemination
- All centers will monitor space weather continuously.
(7) PECASUS HF service

<table>
<thead>
<tr>
<th>HF</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kp-index</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>dB from 30 MHz riometer data</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>X-ray flux (0.1-0.8 nm) (W/m²)</td>
<td>$1 \times 10^{-4}$ (X1)</td>
<td>$1 \times 10^{-3}$ (X10)</td>
</tr>
<tr>
<td>MUF depression</td>
<td>30%</td>
<td>50%</td>
</tr>
</tbody>
</table>

GFZ Potsdam & UKMO Riometers in Finland and Sweden
GOES from NOAA

D-RAP model

Network of ionosonde stations:
- Owned by PECASUS partners
- Available through collaboration
- Open access
(8) PECASUS GNSS service

<table>
<thead>
<tr>
<th>GNSS</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude Scintillation (S4) (dim.)</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Phase Scintillation (Sigma-Phi) (rad)</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Total Electron Content (TEC) (TEC Units)</td>
<td>125</td>
<td>175</td>
</tr>
</tbody>
</table>

Scintillation measurement stations

GNSS receivers (1Hz)
(9) Product verification and User Feedback

- External data
- EG SOL
- EG RAD
- EG HF
- EG GNSS

Advisory Production Hub

Main Hub

Dissemination Advisories

Users

Product Verification

Actual data

Advertising

QMS FMI

Emergency reporting based on enhanced user feedback

Reporting

Reporting

User feedback

Identification

Emergency reporting based on enhanced user feedback
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IMAGE by NASA
Thank You!

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IMAGE by NASA