Finnish Meteorological Institute
24/7 space weather service

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Goal: Situational awareness

- About Finnish Meteorological Institute
- FMI’s history in global space weather modelling
- GUMICS: The only European global space weather model
- FMI’s new operational 24/7 space weather service (LUOVA)
- Example cases
- Towards future: GUMICS as operational service by Christmas
About FMI

Approximately 650 FTE
- ~350 in R&D
- Under Ministry of Traffic and Communications

329 peer-reviewed papers in 2013
- 1st out of world’s met institutes
History of FMI is history of space weather

- FMI Established 1838, Tsar Nikolai I
  - In connection to U. Helsinki (mag. obs.)
  - Tsar's theory: Connections between magnetic field and weather variations?
    - Let's measure both!
  - Goal: advantages in warfare

- Ground magnetic records from 1838 in Kaisaniemi station
  - Weather 1844 ->
  - Sea ice observations 1859 ->
  - Sea level observations 1887 ->
  - Flooding forecasts 1902 ->
GUMICS: Europe’s only space weather simulation

- Grand Unified Magnetosphere-Ionosphere Coupling Simulation
  - Developed by Pekka Janhunen
  - Started in 1993 from ionosphere
    - Magnetosphere added in 1996
  - GUMICS-4 in C/C++: 1999
  - Run-time adaptive mesh refinement
  - 2D spherical ionosphere
21 years of systematic testing

With current GUMICS-4
- 2000: Cusp dynamics
- 2002: Energy transfer through magnetopause
- 2003-2005: Energy dissipation in the ionosphere
- 2005-2006: Reconnection efficiency in the tail
- 2006-2007: Reconnection at the magnetopause
- 2008: Signal propagation through the magnetosphere
- 2009: Towards GUMICS-5, going beyond MHD (Vlasiator)
- 2011-2013: Solar wind run library, a year worth of simulations
Weather and Safety Center 24/7

- Responsible for weather and oceanographic services on 24/7 basis
- Customers: general public, authorities, civil aviation, military and business life
- Operational duty hours 150-200 h/day
- 75-80 FTE / year
LUOVA: Centre for natural disasters since 2011

- Early-warning system
- 24/7 monitoring
- Real-time risk assessments, analyses and forecasts
- Storms, floods, forest fires, heavy snowfall, space weather, earthquakes, etc.
LUOVA example

- Solar flare 23 Jan 2012
  - Insignificant magnetic storm
  - Severe radiation storm
  - Re-routings: Delta, United
- FMI’s first space weather warning
- HF conditions

HF-echoes vanished from polar cap (SuperDARN)
Towards real-time physics-based predictions

Solar wind:
- 3 days to Earth

Lagrange 1st point:
- 1 hr to Earth

150 million km

Observations
- B, n, v, T

Real-time calculations

Prediction: FMI’s GUMICS
- Testing 2013 – spring 2014
- Wish: Products by Christmas
• Similar to terrestrial weather prediction
• Chained runs with a new one every 15 to 30 min
• Start from latest results with solar wind available
• 3 h runs: 2 h solar wind + 1 h for prediction
• Assimilation not included
• First runs started in 2013-07-26 at 12:29 local time
Ensemble forecast system in internal testing

Input
- Solar wind from NOAA (http://www.swpc.noaa.gov/ftpdir/lists/ace/…)
  - Undocumented features: 404 Not found, 0.0 density (-999?), 2014-01-25 (503)

Implementation
- Python scripts executed periodically by cron
- Download solar wind data
- Prepare input data for a run, submit to queue
- Post processing
  - Ionospheric parameters (CPCP, FAC, heating), quick-look plots
  - Magnetic indices, GIC
- Backup to tape (0.1 - 1 TB / month)
- Email in case of error
  - Average a few / day
FMI’s strengths in a nutshell

LUOVA 24/7 service
Leading know-how in GIC
Europe's only global space weather model
Leading modeling group with a variety of models (MHD, hPIC, hVlasov, PIC)