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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

Photo: Jouni Jussila

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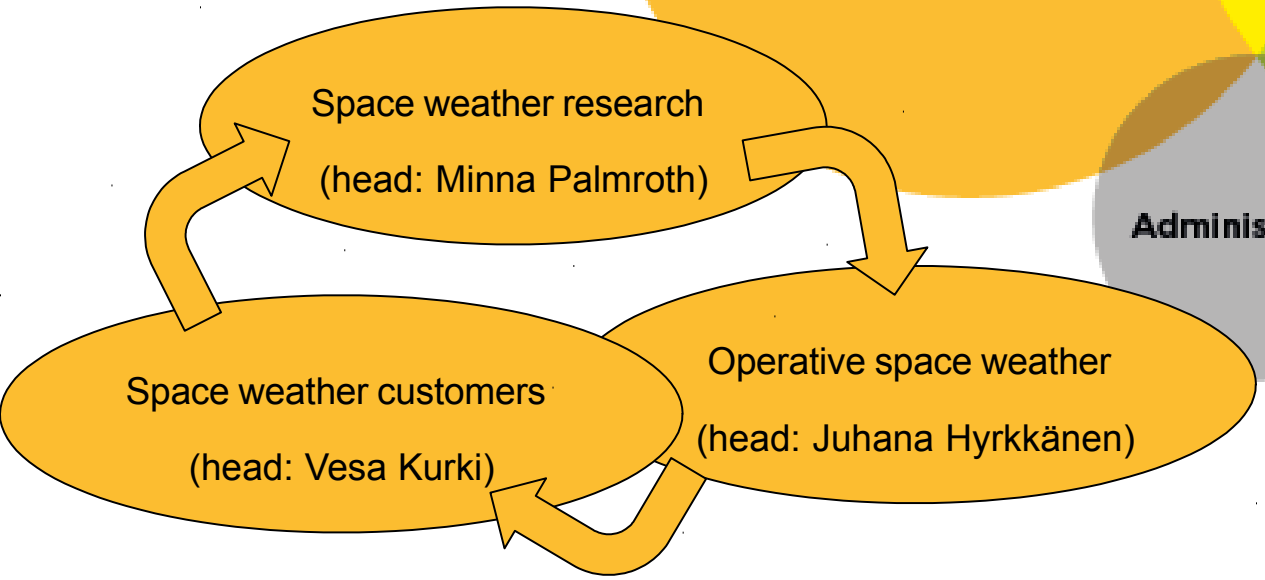
About FMI

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

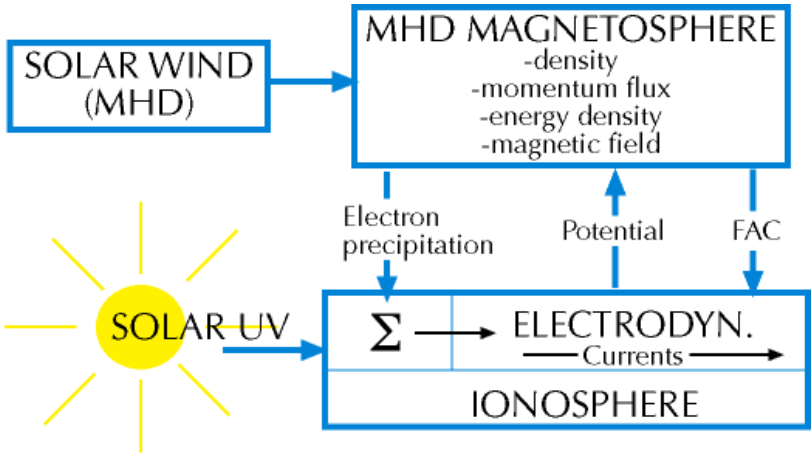


329 peer-reviewed papers in 2013
- 1st out of world's met institutes

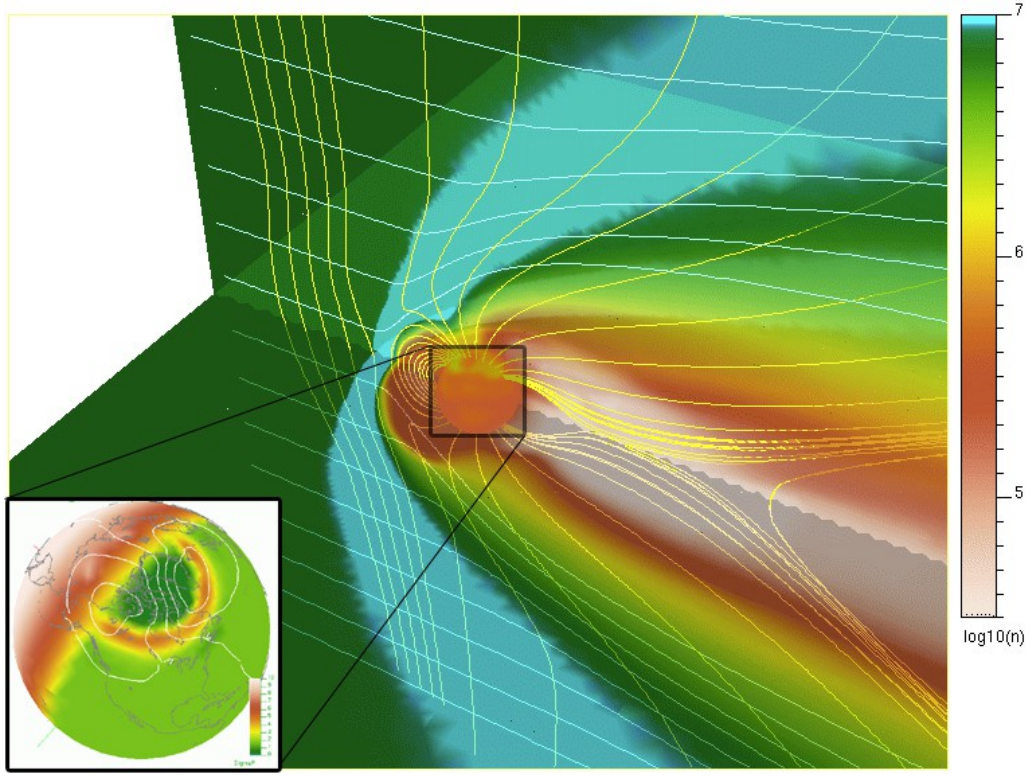
History of FMI is history of space weather

- 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

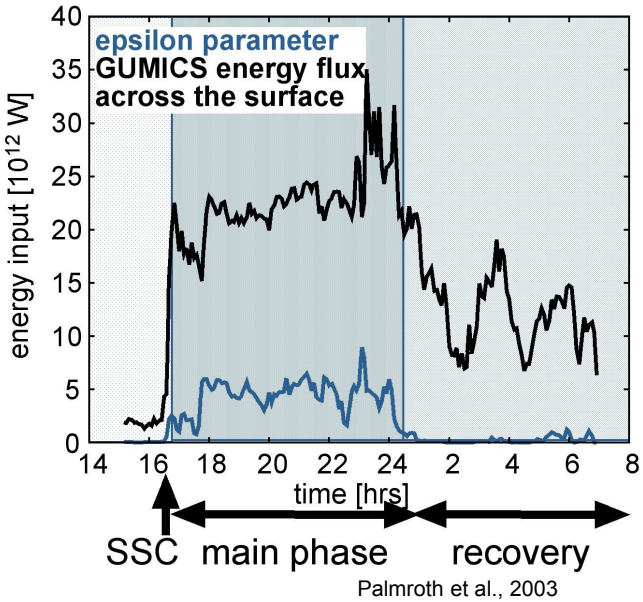


21 years of systematic testing

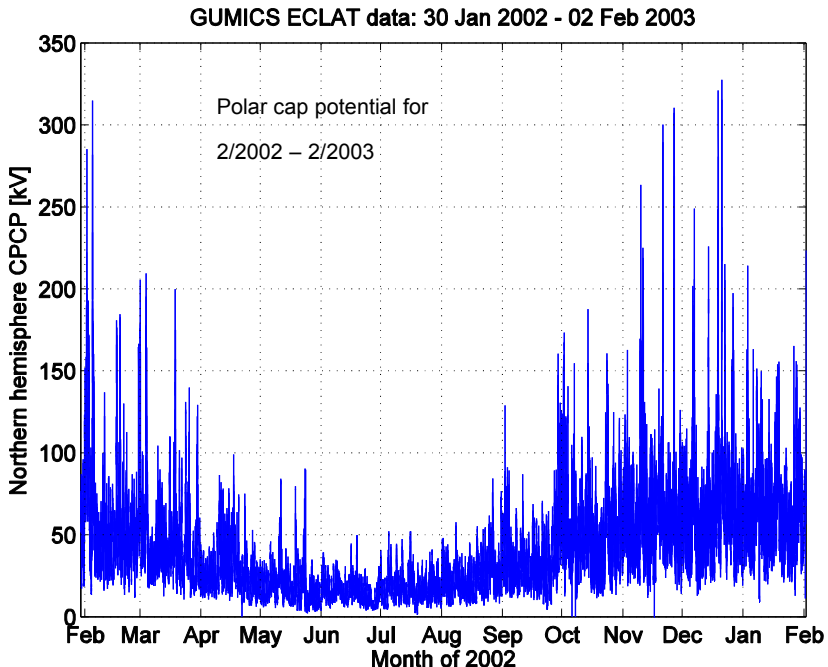
With current GUMICS-4

- 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

April 6-7, 2000, major storm



Palmroth et al., 2003



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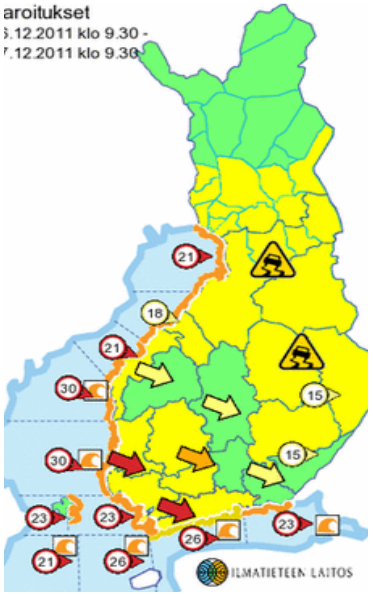
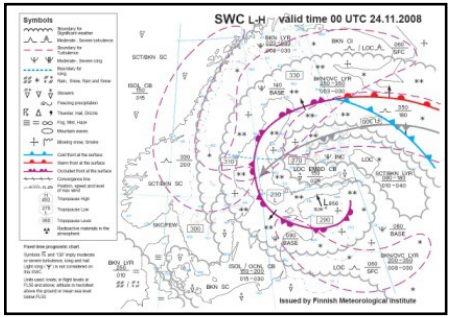
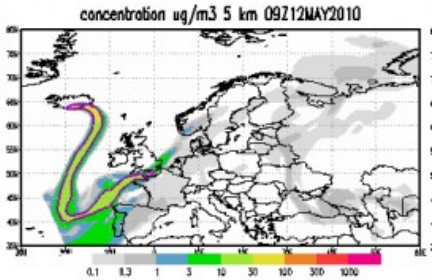
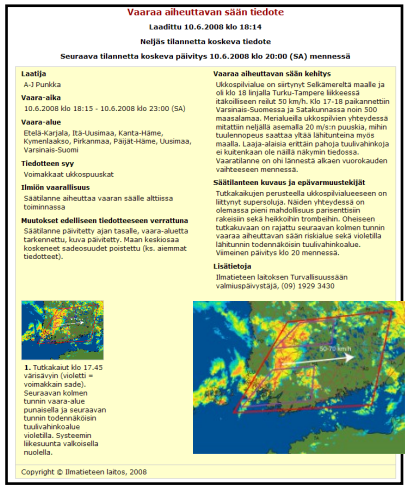
Weather and Safety Center 24/7

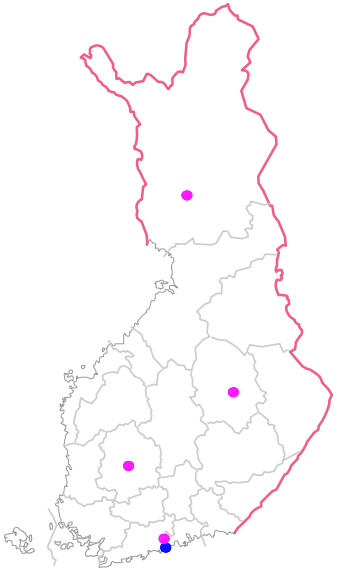
- Responsible for weather and oceanographic services on 24/7 basis
- Customers: general public, authorities, civil aviation, military and business life
- Operational duty hours 150-200 h/day
- 75-80 FTE / year





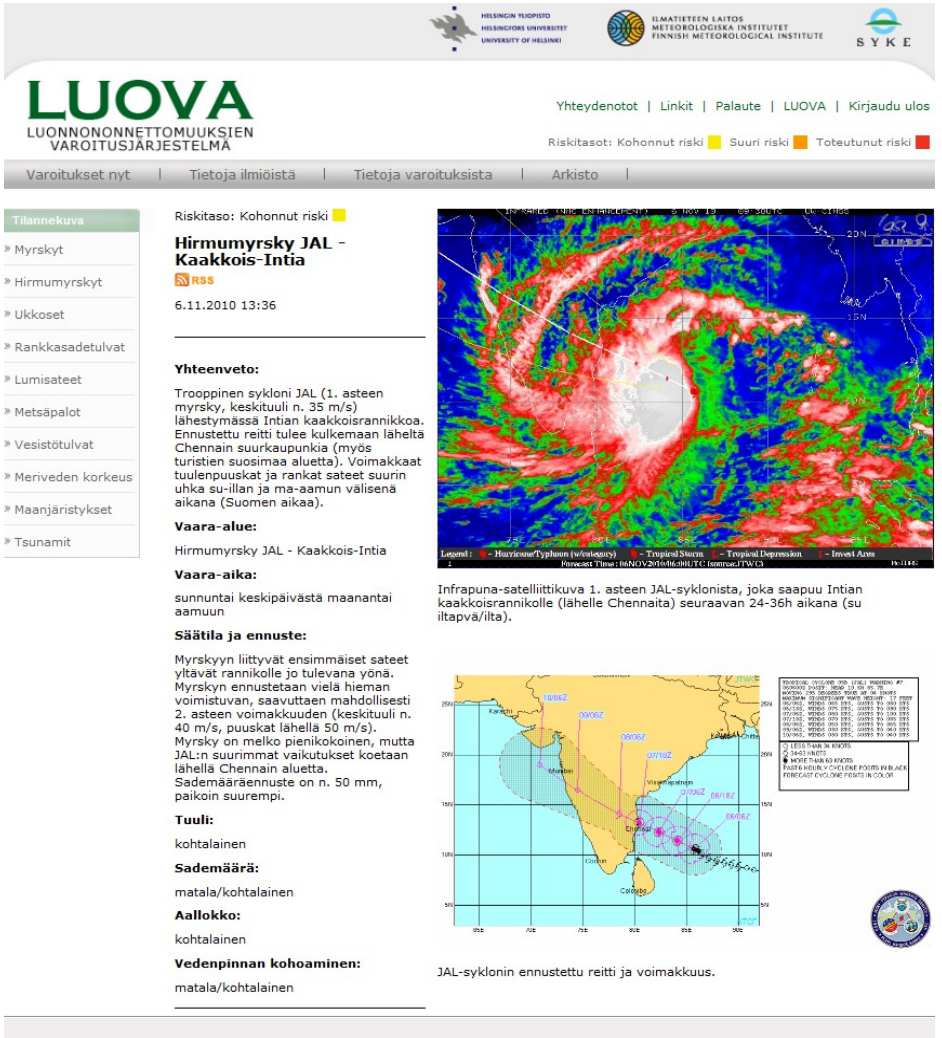






LUOVA: Centre for natural disasters since 2011

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



Forecast for geomagnetic activity

Geomagneettinen aktiivisuusennuste

English

Päivitetty 20131108 10:45:01

ACE -satelliitin aurinkotuulihavaintoja viimeisimmän tunnin ajalta			
suure	pienin	suurin	keskiarvo
magneettikenttä Bz [nT]	-0.6	3.7	2.6
nopeus [km/s]	374.9	423.5	396.8
tiheys [cm^{-3}]	1.2	9.4	3.5

Geomagneettinen aktiivisuus (RX [nT])			
paikka	edellinen tunti	seuraava tunti	
Kevo (KEV)	4	4	44
Masi (MAS)	-	4	39
Kilpisjärvi (KIL)	4	5	41
Ivalo (IVA)	4	4	40
Muonio (MUO)	3	4	32
Sodankylä (SOD)	3	4	31

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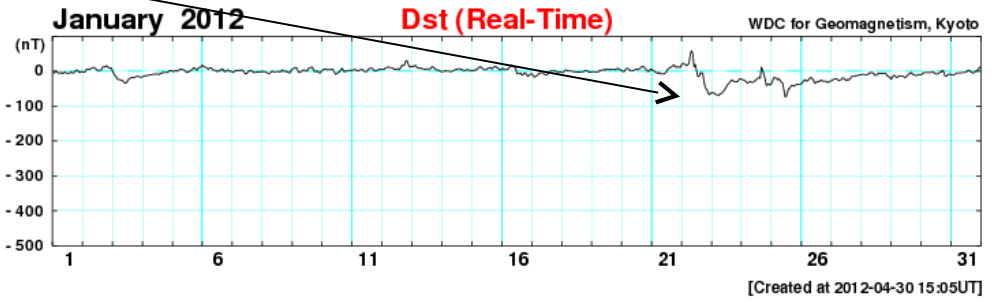
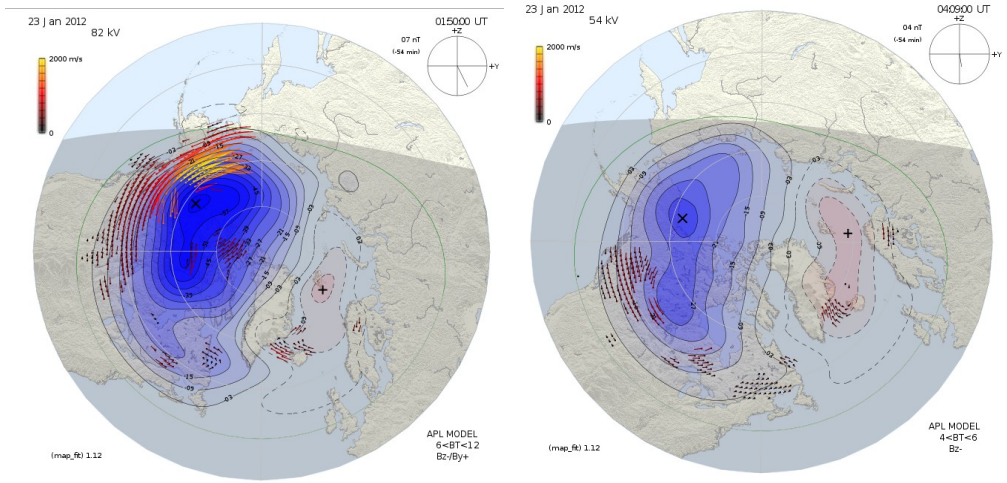
LUOVA example

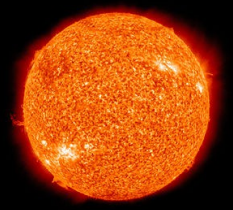
- Solar flare 23 Jan 2012
  - Insignificant magnetic storm
  - Severe radiation storm
  - Re-routings: Delta, United
- FMI's first space weather warning
  - HF conditions



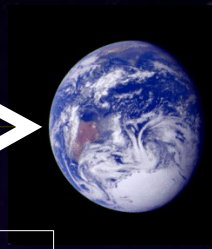
HF-echoes vanished from polar cap (SuperDARN)



Towards real-time physics-based predictions



150 million km

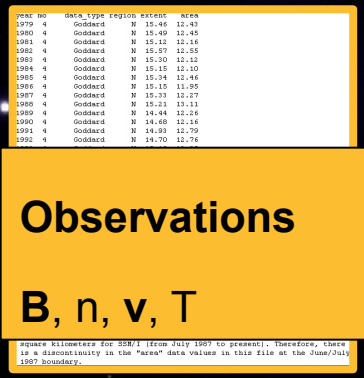


Solar wind:

3 days to Earth

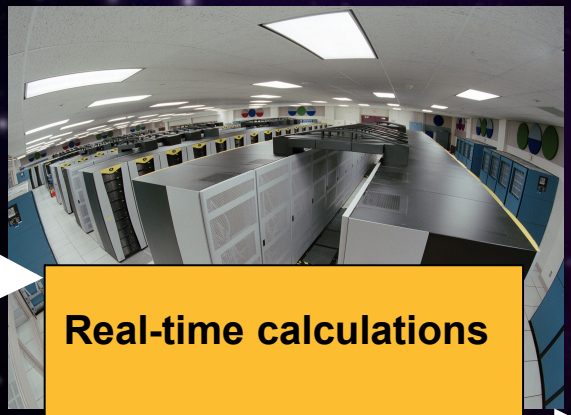
Lagrange 1st point:

1 hr to Earth

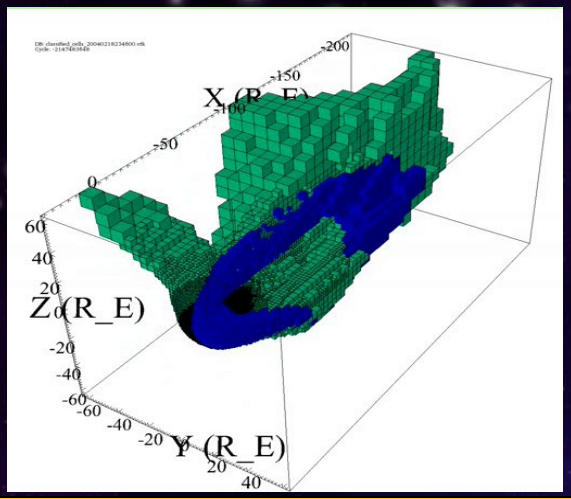


Observations

B, n, **v**, T



Real-time calculations

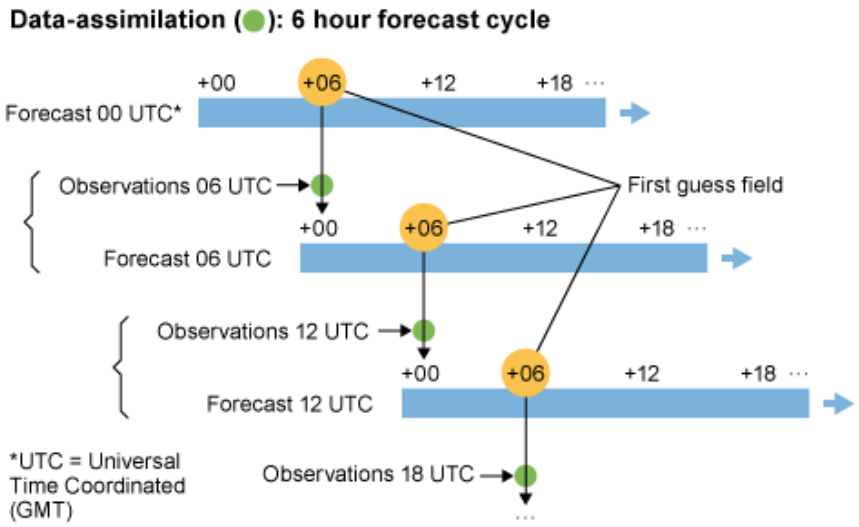


Prediction: FMI's GUMICS

- **Testing 2013 – spring 2014**
- Wish: Products by Christmas

Ensemble forecast system in internal testing

- 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

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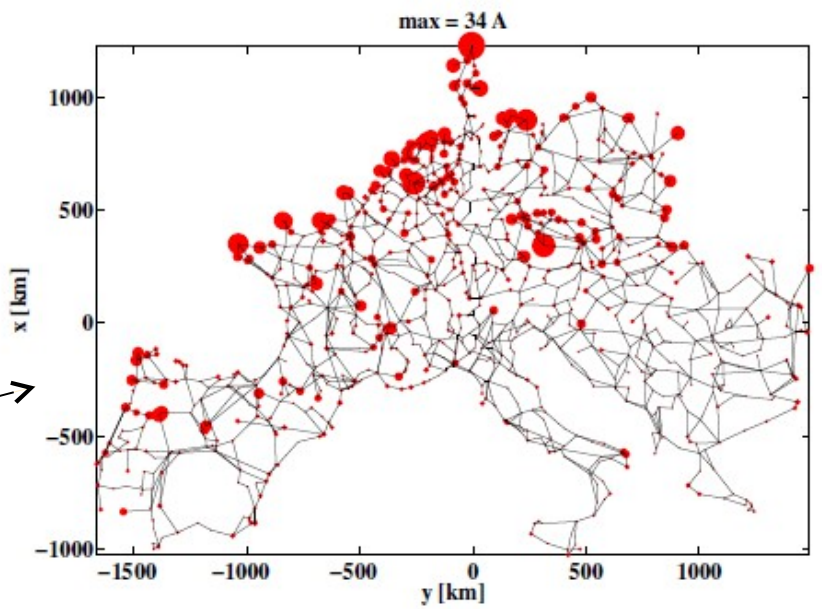
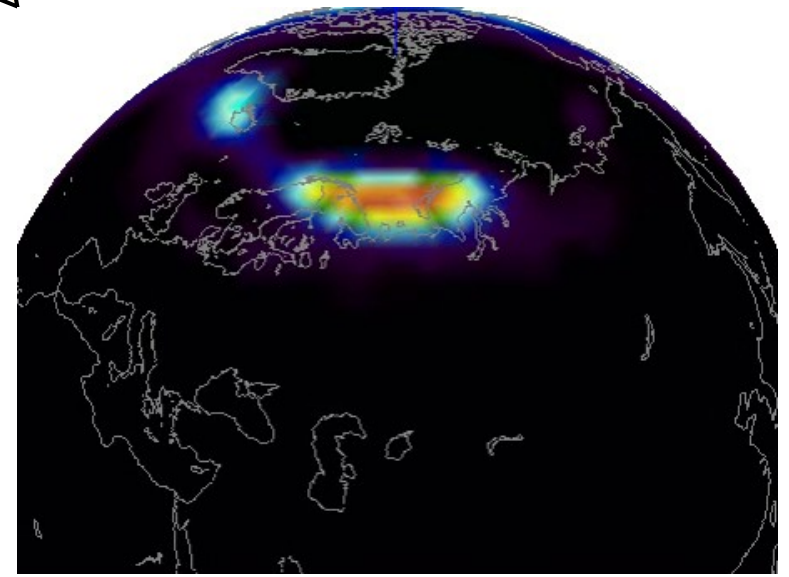
FMI's strengths in a nutshell

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)