Micro Weather and Space Weather Services for Aviation

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MSW Service feasibility study project team

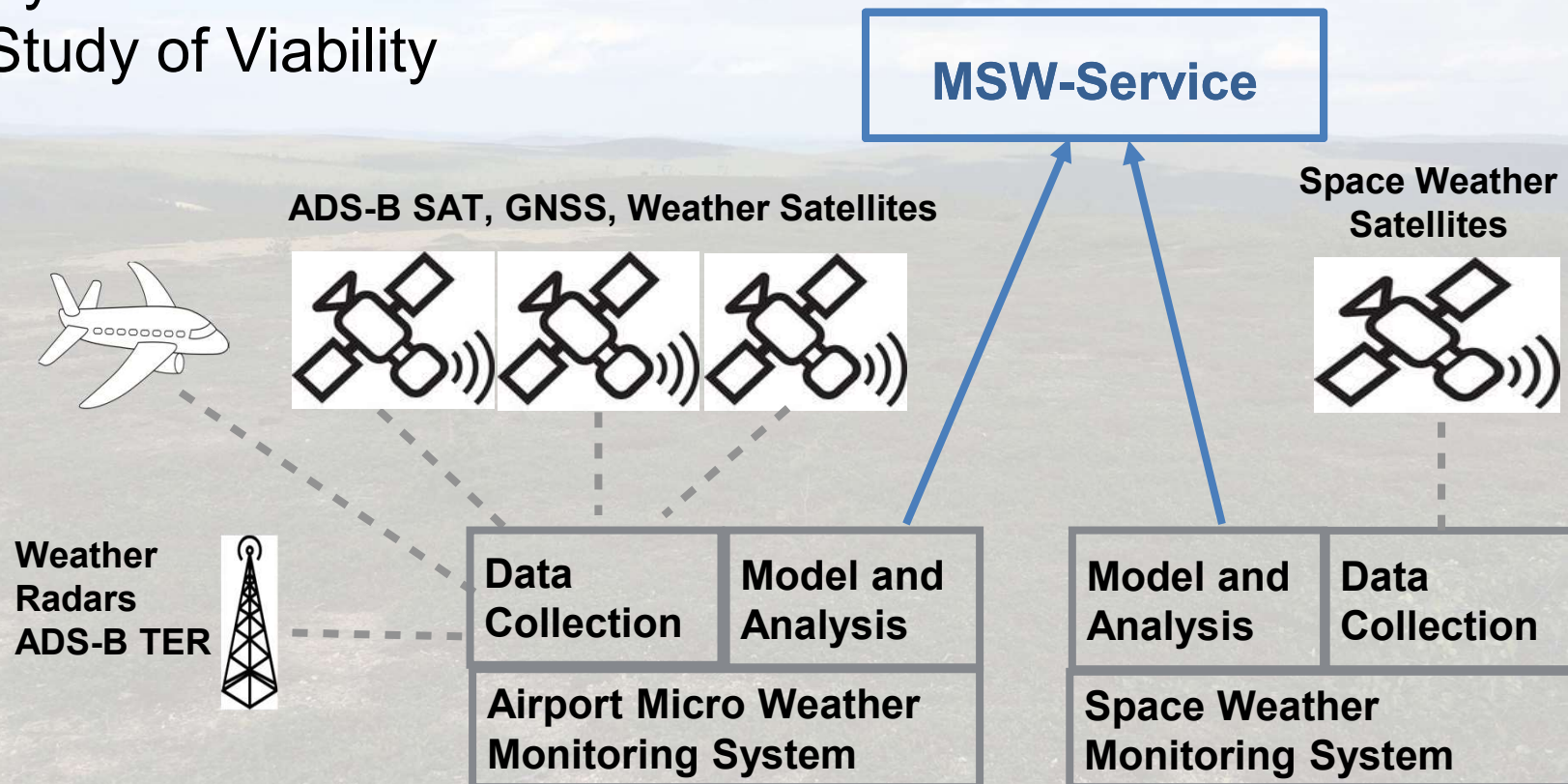# Project goal and objectives

✓ Definition of User Requirements
✓ Assessment of ADS-B Impact
✓ System and Service Definition
✓ Study of Viability

MSW-Service

Space Weather Satellites

ADS-B SAT, GNSS, Weather Satellites

Weather Radars ADS-B TER

Data Collection	Model and Analysis	Model and Analysis	Data Collection
Airport Micro Weather Monitoring System		**Space Weather Monitoring System**	

Phenomena and their impact

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MICROWEATHER	SPACE WEATHER

MICROWEATHER

SCALES

**WEATHER
Resolution:
~ 30-50 km
- hours**

?

WHEN, WHERE ?

**MICROWEATHER
Resolution:
- 0,1 – 0,5 km
-   minutes**

Precision that enables
new applications

= individual weather element, e.g.
convective storm

SPACE WEATHER

Space Weather Chain

Solar Activity	Solar Wind	Earth
▪ Expanding corona ▪ Flares ▪ CME's ▪ *Solar magnetic field*	Expanding corona ▪ Particles accelerated in flares ▪ CME's and interplanetary shocks ▪ *Interplanetary magnetic field*	Magnetosphere → ionosphere → lower atmosphere → surface *Interplanetary magnetic field ←→ Earth's magnetic field*
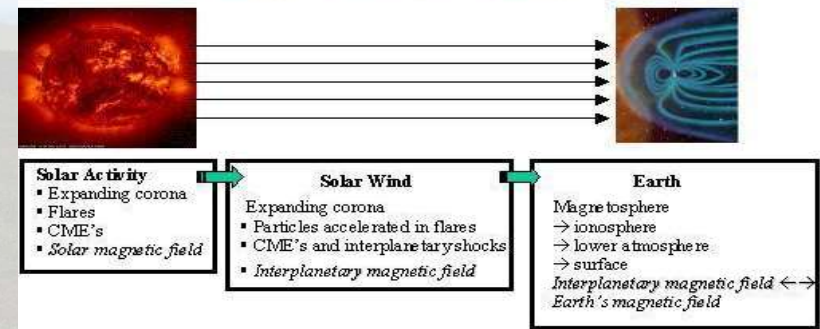
AFFECTS
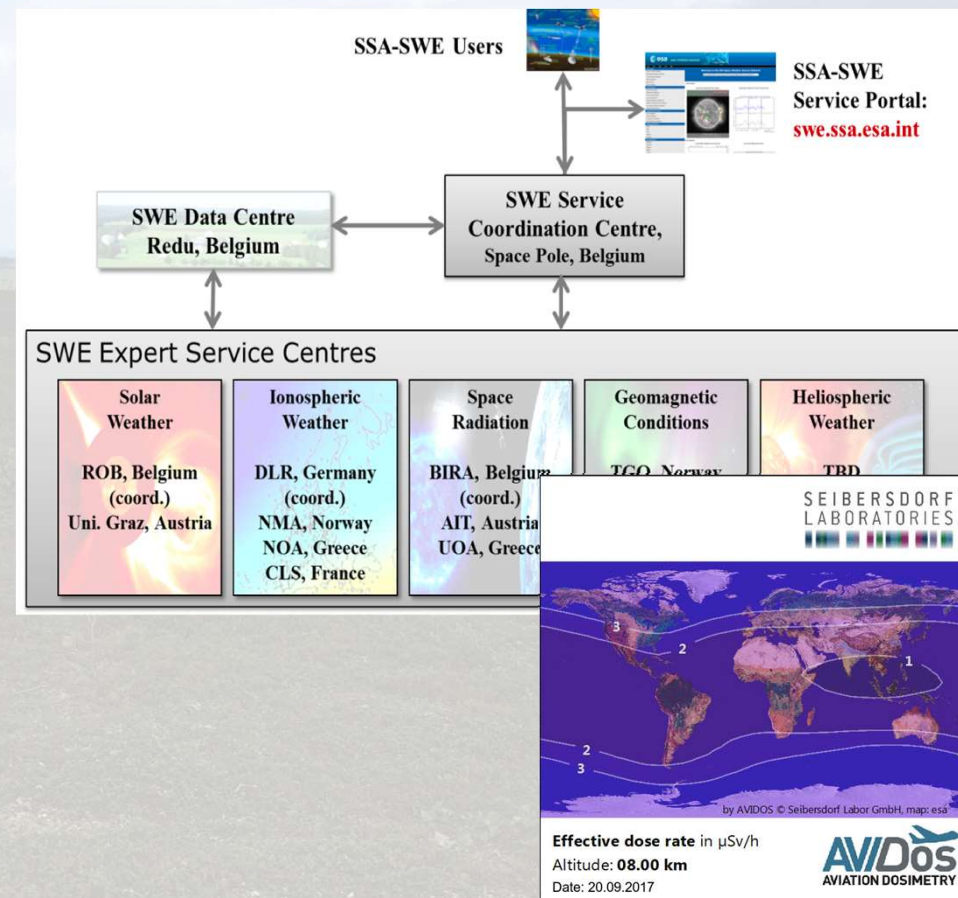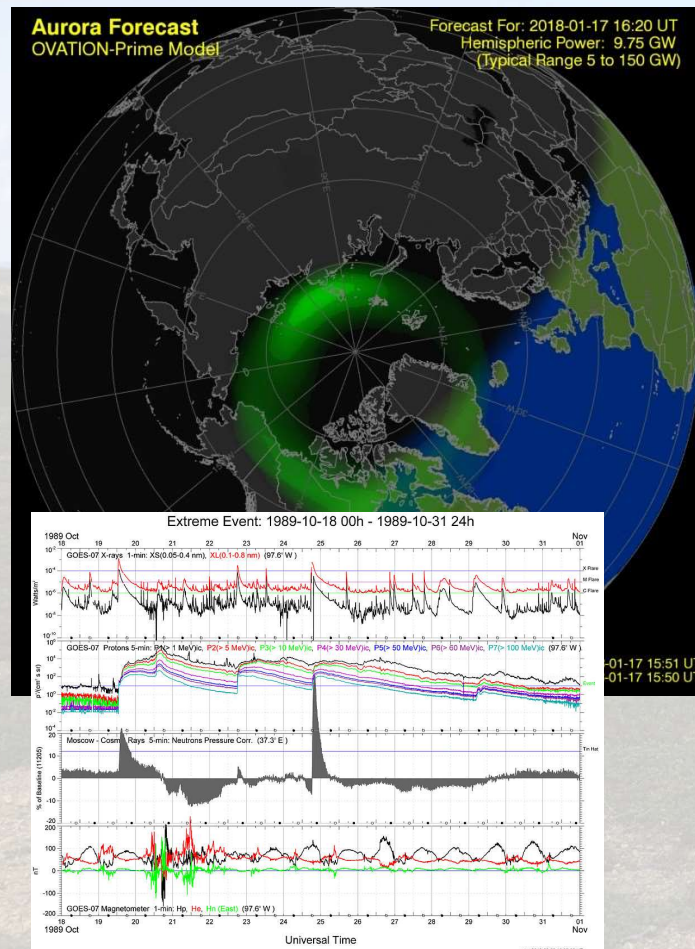- Earth's Climate
- Electric Power Transmission
- GNSS signal
- HF Radio Communications
- Satellite Communications
- Satellite Drag

Numerous
human activity
sectors suffer
from the
effects of
Space
Weather

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EXISTING SPACE WEATHER SERVICES

USA/NOAA: http://www.swpc.noaa.gov

ESA: General : http://swe.ssa.esa.int/
Aviation: http://swe.ssa.esa.int/nso_air

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Space Weather Service for Aviation

SPECIFICATION

The basis: Usefulness for operational support in aviation

Current radiation level map (3D)
- Horizontal resolution 50-150 km
- Vertical resolution 1-2 km
- Updating cycle 1 minute

Forecasts for up to 12-24 hours, after detection of an event by SW satellite system (*)

**Current long range HF radio and GNSS signal disturbance map**
- Map (2D) resolution 50-150 km
- Updating cycle 1 minute

Forecasts for up to 12-24 hours after detection of an event by SW satellites (*)

(*) Depends on the severity and type of the SW event (Flare, CME)

- **Present Space Infrastructure does not provide the required resolution**
- **New infrastructure for space and updating of Space Weather Models are being developed in collaboration with ESA, and other member states**

Space Weather Satellites

SW Model	Data Collection
Situational Awareness and Forecasting	

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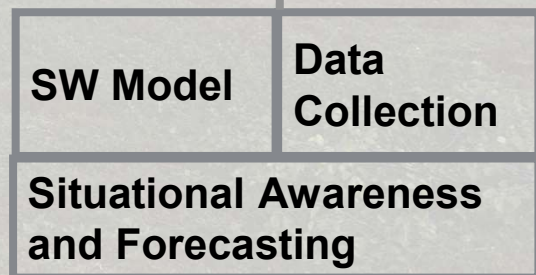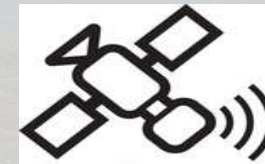
Rapid local mesoscale phenomena

Phenomena

- Thunderstorms at airports:
  - Rain and flooding hazard
  - Wind hazard (shear)
  - Hail hazard
  - Lightning hazard
- Additionally
  - Snowfall and visibility (SESAR 2020)

  - Also: Bird hazards

Nowcasts

Resolution with new model
- 30 second time resolution
- 250 m spatial resolution

Present solutions for advanced aviation Weather Services

- **FAA** is deploying an Integrated Terminal Weather System (ITWS) which provides an integrated convective weather display and nowcasting tool

- **ENAV,** the Italian air navigation service provider is building a testbed in Palermo to observe convective and terrain induced wind shear.

- **DWD (Deutscher Wetterdienst)** has developed, installed and is employing an X-band Weather Radar and LIDAR-based wind shear system in Munich and Frankfurt airports.

- **The Weather Company** provides advanced technology platforms and services leveraging weather and related data.

OUR SOLUTION

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> ## MW Service
> ## Micro Weather Service for Airports

FEATURES

ADS-B SAT, GNSS, Weather Satellites

Micro-meteorological phenomena Detection and Nowcasting

- Time resolution: 30 s – 1 minute
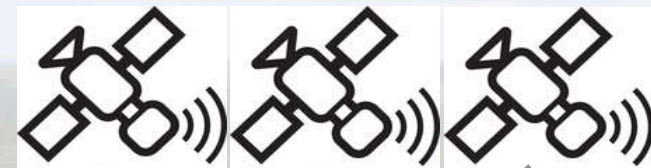- Spatial resolution 200-400 m
- Nowcasting up to 40 minutes

Tracking and Trajectory Prediction of air traffic

- Entire landing zone airspace
- Current 3D map with aircraft in 1 second time resolution
- Projection to future up to 30 minutes until landing

**Weather Radars ADS-B TER**

Data collection, fusion and intelligent analysis

Situational awareness with projection to the future

Detection and alarming of future hazards

- Automatic alerts on all potential hazards: when an aircraft is in danger of encountering a weather hazard
- Also alerts on bird hazards, if a bird radar is in use (option)
- Projects hazards up to 30 minutes to the future
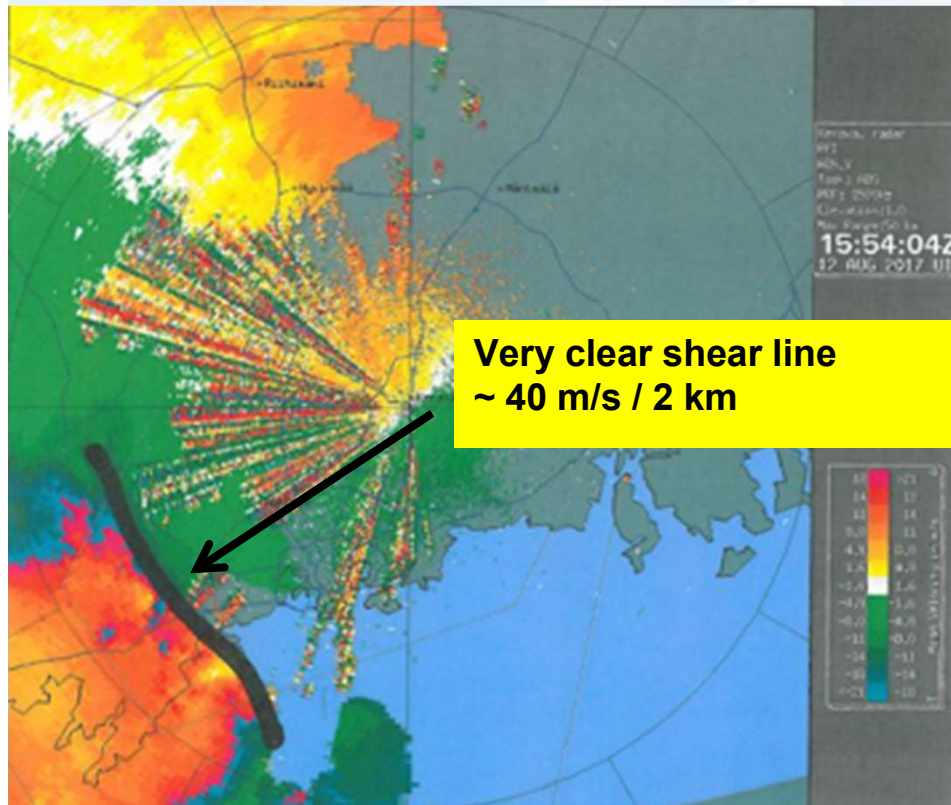
Real life example
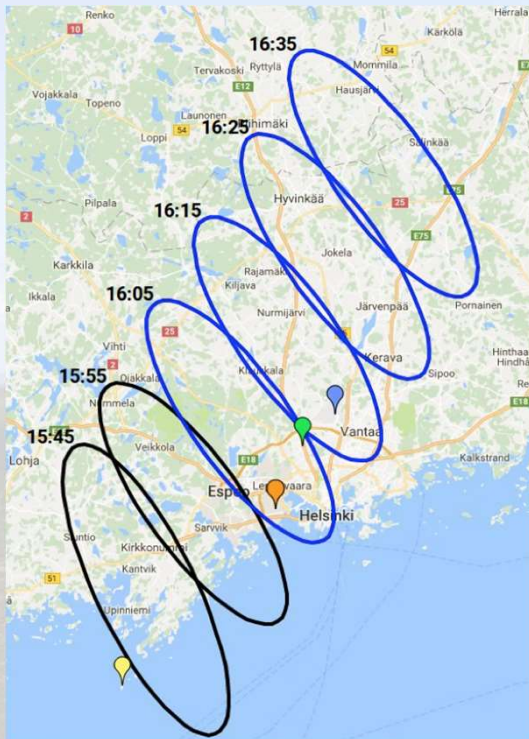
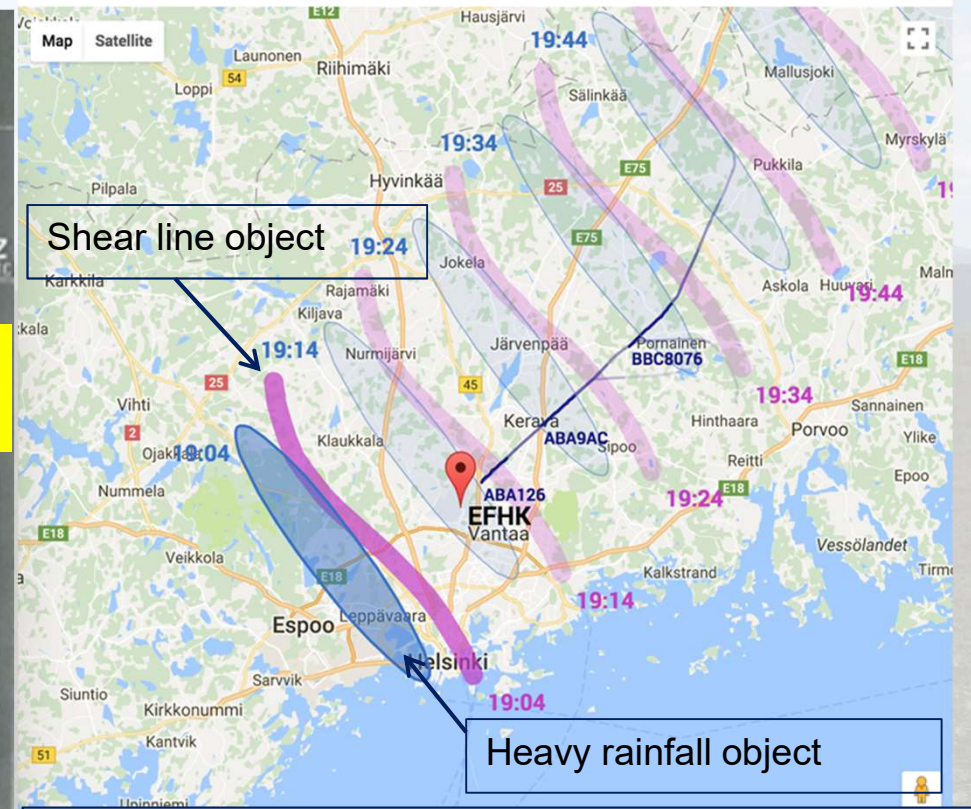

Propagation of the core of the thunderstorm
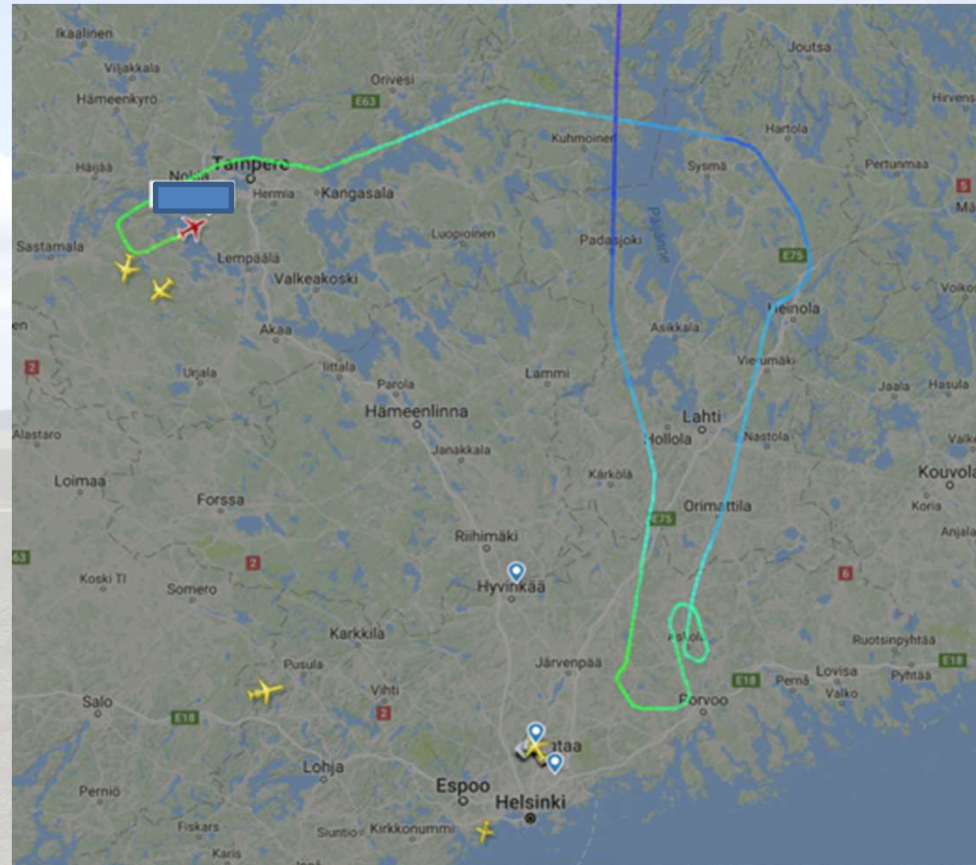
The radar track of a flight from Oulu to Helsinki that had to perform an avoidance manoeuvre and land at Tampere airport due to an approaching thunderstorm. Colors indicate different altitudes and the flight location nearest to the Helsinki-Vantaa airport was at 16:12 UTC.

MSW demonstration: Manual analysis and nowcasting of weather objects utilizing polarimetric weather radars

Nowcast of objects 16:05 UTC

Shear line object

Very clear shear line
~ 40 m/s / 2 km

Heavy rainfall object

At Mäkiluoto the gust front
arrived 15:35 UTC: max wind 62 kt

The nowcast given at 15:54 UTC suggests arrival of the gust front at the airport at 16:12 UTC ± 1 min

MSW demonstration case at Helsinki-Vantaa airport: Severe thunderstorm nowcasting on 12 Aug 2017

What happened?

A very intense wind shear hit the airport at 16:11 UTC (max wind 47-52 kt, maximum 10 min rainfall intensity 71 mm/h, minimum visibility 470 m)

Good luck with the runway selection and arrival times (in time scales of minutes) prevented occurrences of a major catastrophe

16:25 **All departures and arrivals were set to stand by for an undefined period ⇔ A sudden shock impact for ATC (local and EUROCONTROL) and flight companies**

16:50 – 17:50 gradual return to normal flight conditions

The standard aviation weather nowcast (Trend) for Helsinki-Vantaa at 15:50 UTC: BECMG FM1630 20020G40KT 3000 +TSRA (in addition an FMI meteorologist called the head of the ATC).

IT WAS NOT POSSIBLE TO GENERATE PROPER ACTION, BECAUSE THE EXACT TIME, LOCATION AND PROBABILISTIC QUANTIFIED NOWCASTS OF A REALLY DETECTED AND APPROACHING WEATHER HAZARD PHENOMENON WAS NOT AVAILABLE

Tool for fast automatic diagnosis, nowcasting and services: hazard objects
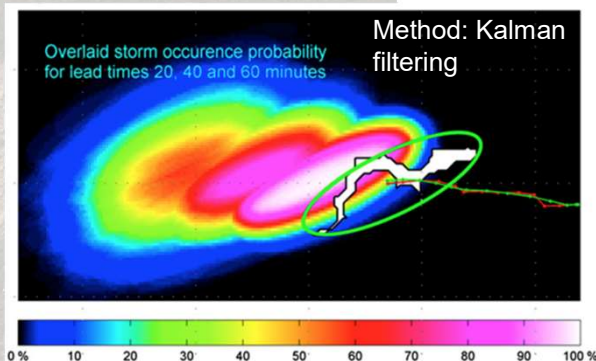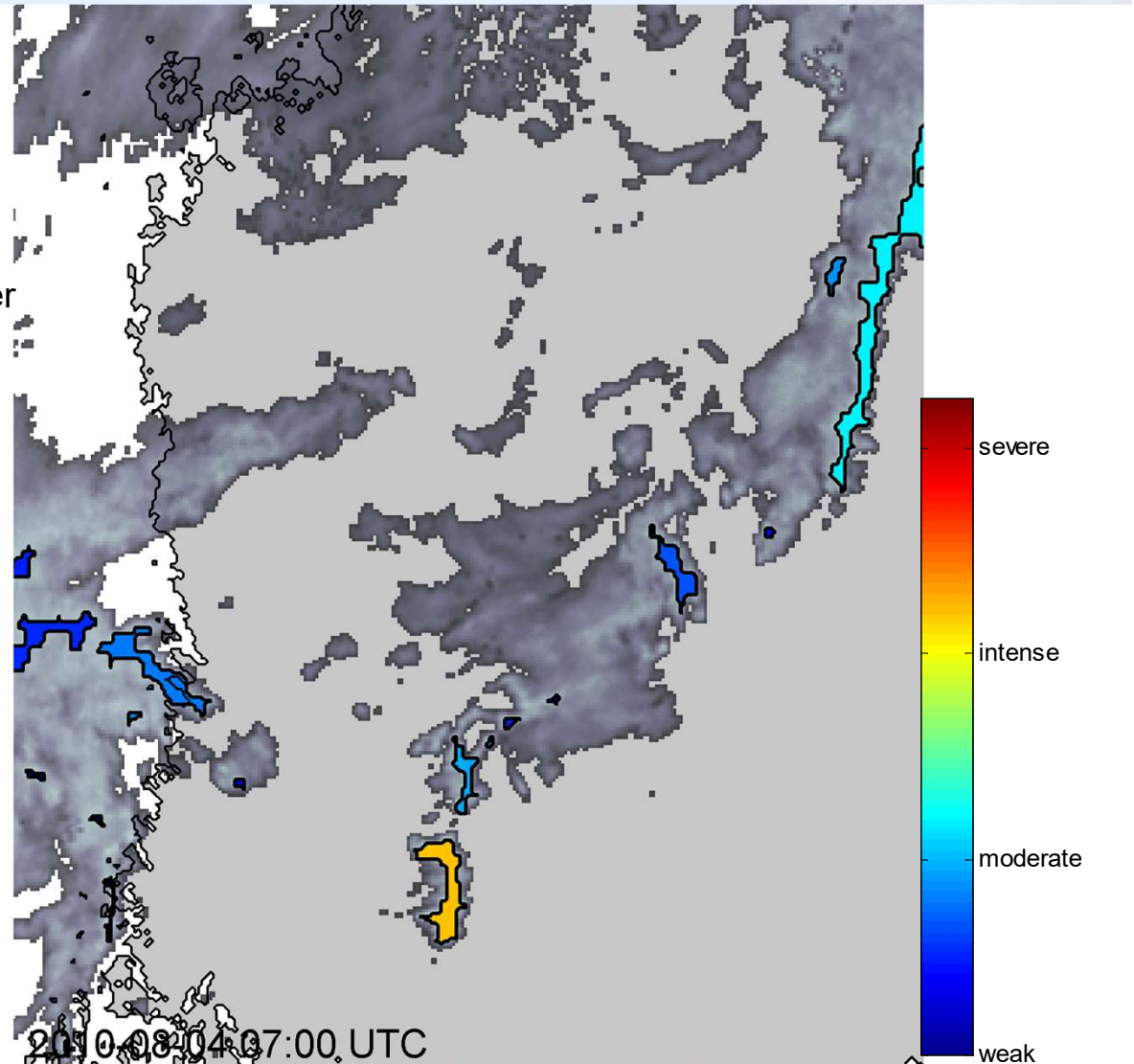
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Hazard objects – forget viewing

- Hail, rainfall, snowfall intensity
- Lightning
- Visibility in snowfall
- Rain, snow accumulation
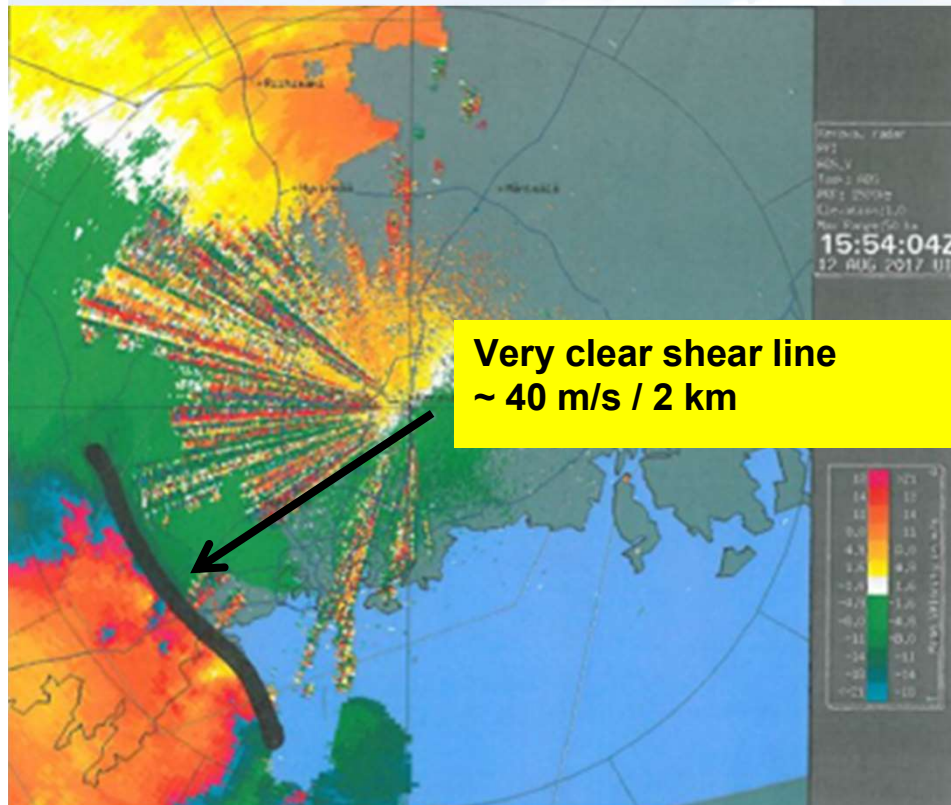- Wind shear
- Tailored combinations

Objects can be packed into short messages of attributes:

- Severity classes (climatological or user scaling)
- Exceedance probabilities
- Individual predicted tracks
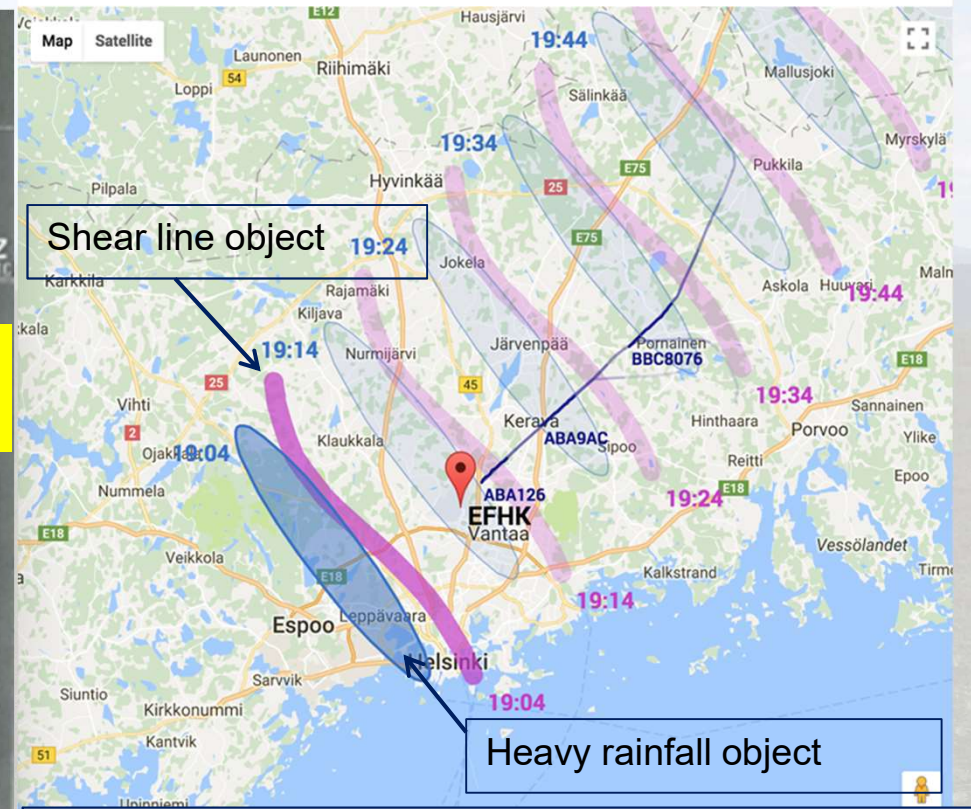- Approximated shapes
- Impact nowcasts

Hazard objects (Rossi et al. 2013-2015, Pulkkinen et al. 2017)

Method: Kalman filtering

Overlaid storm occurence probability for lead times 20, 40 and 60 minutes

0 %   10   20   30   40   50   60   70   80   90   100 %

2010 08 04 07:00 UTC

severe

intense

moderate

weak

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MSW demonstration: Manual analysis and nowcasting of weather objects utilizing polarimetric weather radars

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Very clear shear line ~ 40 m/s / 2 km

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In Finland

- 10 C-band Doppler Radars (with dual polarization capability)
- System utilization rate >98 %
- 10 x 500 x 360 precipitation estimates every 5 minutes
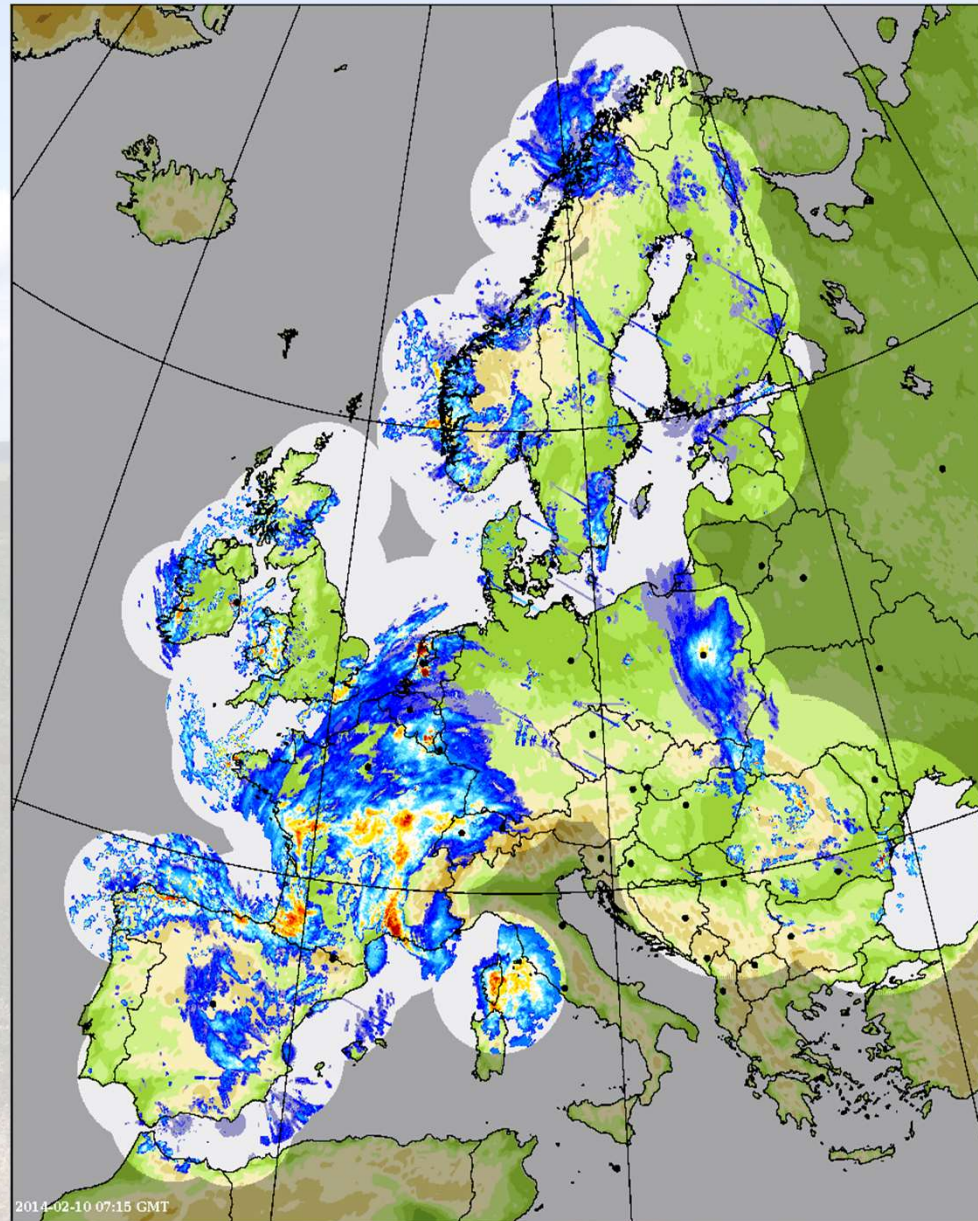- ~10 TB/year

Radar data exchange

OPERA, BALTRAD, NORDRAD

   www.knmi.nl/opera

EU/Baltrad(+)

   http://baltrad.eu/

- Open source

2014-02-10 07:15 GMT

SWE SERVICE IN FINLAND

Finnish Meteorological Institute