Satellite-Based Detection of Fog and Very Low Stratus
A High-Latitude Case Study Centred on the Helsinki Testbed Experiment

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7 September 2006
Outline

1 Introduction
   - Fundamentals
   - The Problem

2 Approach and Data
   - Helsinki Testbed
   - Satellite Algorithm

3 Tests and Analysis
   - Data Comparison
   - Conclusions
4 killed in 250-vehicle pileup in Italy

Web posted Saturday, June 19, 2004

Heavy fog leads to fatal boat crash
Signs of alcohol found in boat that sped head-on into pier; Autopsy planned
By RICHARD HARROL Staff writer

A 20-year-old Saugeen of Holland sustained his and was treated and released at Community Hospital.

Fog blamed in Uzbek plane crash

Wednesday, January 14, 2004 Posted: 10:00 PM EST (0000 GMT)

TASHKENT, Uzbekistan (AP) — An airliner was making its second attempt to land in heavy fog when it crashed just short of the runway, killing all 37 people on board, including the top U.N. official in this Central Asian country.

Four foreigners were among the passengers on the Uzbekistan Airways flight that crashed Tuesday evening, Prosecutor General Rashid Kadyrov said. They were Richard Conroy, a

BBC NEWS WORLD EDITION

Last Updated: Thursday, 10 July, 2003, 11:52 GMT 12:52 UK

Crash pilot 'confused by fog'

A motor racing millionaire may have become confused just before the plane he was piloting crashed in thick fog killing all five people on board, a report has said.

Guernsey racing promoter Brian Kreisky was taking family and friends on a festive break to Majorca when the light aircraft crashed on 23 December, 2000.

The Beech 200 plane had just taken off from Blackbushe airport near Camberley, in Surrey, when the left propeller lost the power, a report from the Air Accidents Investigation Branch (AAIB) said.

Greater London, 19

Deaths per day

- Smoke
- Sulphur dioxide
- Deaths

Uzbek officials inspect the crash site at Tashkent airport.
Aims

Fog detection system should offer

- High spatial resolution (fog margins)
- High temporal resolution (nowcasting)
- Long time series (climatology)
Fog detection system should offer

- High spatial resolution (fog margins)
- High temporal resolution (nowcasting)
- Long time series (climatology)

Only geostationary satellite data suited!
Satellite system: Meteosat 8 SEVIRI

- 3 km spatial resolution
- 15 min repeat rate
- 11 spectral channels
- Operational since 2004
High Latitudes: Finland

- Latitude southern Finland: \( \approx 61^\circ \)
- Satellite zenith angle: \( \approx 70^\circ \)
- Reduced spatial resolution
- Low solar elevation
- Enhanced atmospheric effect
High Latitudes: Difficulties

Atmospheric absorption

Earth surface

Satellite
High Latitudes: Difficulties

- Sensor sensitivity
- CO₂ absorbance
- Wavelength (μm)
- Terra MODIS ch. 20
- NOAA 16 AVHRR ch. 3
- Meteosat SEVIRI ch. 4
- CO₂ absorbance
High Latitudes: Difficulties

Spatial resolution

Earth surface

Satellite
Research Question

Problem

Is the detection of fog and very low stratus possible

- from a geostationary platform
- at high latitudes?

To be investigated with detailed measurements.
Helsinki Testbed

Figure: J. Poutiainen, 2006
Helsinki Testbed

- 2005–2007
- Mesoscale weather research
- System integration
- Model development
- Data and info on www.fmi.fi/testbed

Figure: J. Poutiainen, 2006
Targeted measurements for
- Nowcasting applications
- Precipitation type
- Sea breeze
- Convection
- Stable boundary layer

Figure: J. Poutiainen, 2006
SOFOS – Satellite-Based Operational Fog Observation Scheme

Fog as a

- cloud
- in the water phase
- low above ground
- with a stratiform surface
- impairing visibility at the ground.
SOFOS – Satellite-Based Operational Fog Observation Scheme

- Exclusion of clear areas and ice clouds
  - Spectral tests

- Cloud top height and structure
  - Spatial tests

- Microphysical cloud profile model

Very low stratus

Satellite

Other cloud

Low stratus cloud

Ground fog

No fog

Snow

Ground surface
SOFOS – Satellite-Based Operational Fog Observation Scheme

Exclusion of clear areas and ice clouds

Spectral tests

Cloud top height and structure

Spatial tests

Microphysical cloud profile model

Ground fog

Satellite

Other cloud

Low stratus cloud

Ground fog

No fog

Ground surface

Snow
Test Procedure: Data Selection

12 days, November 2005 – February 2006

- Data availability
- Data quality
- Includes fog / low stratus situations
Test Procedure: Point/Pixel Comparisons

- Visibility and ceilometer data for low cloud presence
- Compared with satellite classification (no cloud / very low stratus cloud / high cloud)
Test Procedure: Contingency Tests

<table>
<thead>
<tr>
<th>Classification</th>
<th>Observation Yes</th>
<th>Observation No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>No</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Hit Rate: \( HR = \frac{A}{A+C} \) \([0 \cdots 1]\)

False Alarm Rate: \( FAR = \frac{B}{A+B} \) \([0 \cdots 1]\)

Critical Success Index: \( CSI = \frac{A}{A+B+C} \) \([0 \cdots 1]\)
# Test Results: By Day

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
<th>Best</th>
<th>Worst</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>0.66</td>
<td>1.00</td>
<td>0.52</td>
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<tr>
<td>FAR</td>
<td>0.25</td>
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<tr>
<td>CSI</td>
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<td>1.00</td>
<td>0.31</td>
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<tr>
<td>n</td>
<td>9374</td>
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</table>

**Figure:** Results by day
### Test Results: By Station

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
<th>Best</th>
<th>Worst</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>n</td>
<td>9374</td>
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</tr>
</tbody>
</table>

**Figure:** Results by station
Possible reasons for misclassifications:

- Missed situations:
  - Cloud overlap
  - Low cloud cover

- False alarms: Station data not representative of pixel

- Station data quality (Visibility and ceiling don’t always agree)
Test Results: CSI Distribution

- Lowest category not present
- No obvious spatial pattern
European Context: CSI Distribution

- 583 METAR stations
- 24 days 2\textsuperscript{nd} half 2005
- 1030 satellite scenes
- \textit{No latitudinal effect!}

Cermak et al. (LCRS, FMI)
High Latitude Fog Detection
7 September 2006
Conclusions

- High latitude detection of very low stratus works well
- Small-scale situations may be missed
- Coordinated measurement efforts useful
Ground fog will be tested for Helsinki testbed
Qualitative analysis of cases to follow
Contact

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www.fmi.fi/testbed

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