Hailstorms in Northern Greece

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The Presentation

• Greek National Hail Suppression Program
• Main entities:
  Meteorological conditions – Hailstorms – Seeding operations
• Typical cases according to different hailstorm types
• Seeding strategies, operational view
Greek National Hail Suppression Program
Greek National Hail Suppression Program
Seeding material & Hailpad network
Hailstorms types

Browning, K. A., 1977

- Unicellular storms of a Single ordinary cell
- Unicellular storms of a Super-cell
- Multi-cell storms
- Line storms
I. Unicellular storm of a Single ordinary cell – 20110615

00Z 15 Jun 2011

University of Wyoming

16622 LGTS Thessaloniki (Airport)

SLAT 40.51
SLON 22.96
SELV 4.00
SHOW 0.74
LIFT -0.29
LFTV -0.36
SWET 106.7
KINX 32.10
CTOT 21.90
VTOT 27.90
TOTL 49.80
CAPE 55.70
CAPV 60.80
CINS -145.
CINV -124.
EQLV 476.0
EQTV 475.0
LFCT 743.4
LFCV 749.9
BRCH 197.5
BRCV 286.4
LCLT 284.1
LCLP 678.6
MLTH 294.8
MLMR 9.49
THCK 5606
PWAT 30.43
I. Unicellular storm of a Single ordinary cell – 20110615

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<th>Temp. (°C)</th>
<th>Pressure (hPa)</th>
<th>GPH (gpm)</th>
<th>Wind (az./kt)</th>
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II. Unicellular storm of a Super cell – 20090811

16622 LGTS Thessaloniki (Airport)

SLAT 40.51
SLON 22.96
SELV 4.00
SHOW 8.26
LIFT 6.93
LFTV 6.70
SWET 92.36
KINX 20.50
CTOT 13.30
VTOT 22.30
TOTL 35.60
CAPE 0.00
CAPV 0.00
CINS 0.00
CINV 0.00
EGLV -9999
EGTV -9999
LFCT -9999
LFCV -9999
BRCH 0.00
BRCV 0.00
LCLT 282.0
LCLP 845.7
MLTH 295.6
MLMR 8.57
THCK 5857.
PWAT 31.52
## II. Unicellular storm of a Super cell – 20090811

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III. Multi cell storm – 20070630

16622 LGTS Thessaloniki (Airport)

12Z 30 Jun 2007

University of Wyoming
### III. Multi cell storm – 20070630

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IV. Line storms – 20050919
### Line storms – 20050919

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<td>4</td>
<td>220° 14</td>
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</table>
Hail Suppression - Cloud Seeding – Conceptual model of “Beneficial competition”

• **Seeding techniques:**
  
  Top seeding (-10°C level)

  Base seeding, seldom because of the terrain

• **Methodology:**

  Cloud seeding is concentrated on the time evolving updraft of ordinary cells or daughter clouds (40%),

  and on the updrafts of developing feeder clouds that flank mature multi-cell storms (60%)
Hail Suppression - Cloud Seeding – Conceptual model of “Beneficial competition”
Seeding strategies, Operational view

*Operational requirement*: Seeding according to conceptual model of “beneficial competition” in every storm that meets the seeding criteria.

*Issue*: The availability of the aircrafts for seeding every candidate storm in the frequent case to be numerous storms simultaneously.
Seeding strategies, Operational view

I. Best possible seeding by one aircraft in many storms

**Neighboring storms**
Seeding strategies, Operational view

I. Best possible seeding by one aircraft in many storms

*Cluster of cells*
Seeding strategies, Operational view

I. Best possible seeding by one aircraft in many storms

*Line storms*
Seeding strategies, Operational view

II. Two aircrafts simultaneously in a project area
(safe separation, by flight level and by azimuth or range)
if there are not restrictions by Air Traffic Control
Seeding strategies, Operational view

II. Two aircrafts simultaneously in a project area

The operational processes of the GNHSP have been analyzed with the development and implementation of a stochastic discrete event simulation model. Operational Research, Simulation (E. Tsagalisidis, 2009)

<table>
<thead>
<tr>
<th>Metrics</th>
<th>1 A/F</th>
<th>2 A/F</th>
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<tr>
<td>Percentage of non seeded storms</td>
<td>19%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Percentage of seeded storms with QS</td>
<td>100%</td>
<td>74%</td>
</tr>
<tr>
<td></td>
<td>≥70%</td>
<td>87%</td>
</tr>
<tr>
<td>The possibility to immediately start seeding</td>
<td>48%</td>
<td>65%</td>
</tr>
<tr>
<td>Average delayed time to start seeding</td>
<td>5.6min</td>
<td>0.6min</td>
</tr>
<tr>
<td>Maximum delayed time to start seeding</td>
<td>17.5min</td>
<td>3.1min</td>
</tr>
</tbody>
</table>

Average required seeding time : 20.1min

Quality of Seeding as a service (QS) : The ratio of the real seeding time of each storm to its required seeding time.
III. Selection of a storm according to the cultivation, defining priorities in parts of the project areas.

Seeding strategies, Operational view
III. Selection of a storm according to the storm type, evolution and development stage of each storm
Seeding strategies, Operational view

III. Selection of a storm according to the storm type, evolution and development stage of each storm
Seeding strategies, Operational view

III. Selection of a storm according to the storm type, evolution and development stage of each storm
Seeding strategies, Operational view

III. Selection of a storm
according to the trend to enter or leave the project area
Seeding strategies, Operational view

IV. Aircraft replacement
Seeding strategies, Operational view

IV. Aircraft replacement
Seeding strategies, Operational view

The availability of the aircrafts for seeding every candidate storm in the frequent case to be numerous storms simultaneously:

I. Best possible seeding by one aircraft in many storms:
   - Neighboring storms,
   - Cluster of cells,
   - Line storms.

II. Two aircrafts simultaneously in a project area (safe separation, by flight level and by azimuth or range)
    if there are not restrictions by Air Traffic Control.

III. Selection of a storm according to
    a. the cultivation defining priorities in parts of the project areas,
    b. storm type, evolution and development stage of each storm,
    c. the trend to enter or leave the project area.

IV. Aircraft replacement

V. Best management of the aircrafts.
   Important the role of weather forecast and nowcasting.
References


