Early detection of thunderstorms using satellite, radar and lightning observations

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Nowcasting strategy of Meteoswiss

- **Swiss Radar Network**
  - Tracking and monitoring
  - Statistical learning
  - Turbulence
  - Cloud physics
  - Climatological data
  - Topography
  - Weather types

- **Meteosat Second Generation**

- **Vaisala Lightning Sensors**

- **COALITION**

- **Nowcasting**
  - Radar tracking

- **Wind**
  - Hail
  - Lightning
  - Flash Floods
What is available ... and what is missing

TRT (Thunderstorms Radar Tracking)

Legend:
Solid: present position
Hatched: 1 hour forecast
Blue vector: cell velocity
White line: past trajectory

Cell severity ranking:
WEAK (L1)
MODERATE (L2)
SEVERE (L3)
based on vertically integrated liquid water (VIL), 45 [dBZ] echo top and max echo [dBZ]

“Flash Orage”: severe thunderstorm cell → warning (MeteoSwiss)

COALITION First Generation

- **Goals**
  - Forecast of Severeness
  - Early detection
  - High POD, low FAR

- **Input**
  - Satellite, Radar, NWP, lightning, topography

- **8 modules for VIL or CTT**

- **Forecasting method**
  - Pseudo kinetic energy approach

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COALITION Second Generation

- **Goals**
  - Forecast of Severeness
  - Early detection
  - High POD, low FAR

- **Input**
  - Satellite, Radar, NWP, lightning, topography

- **Methods**
  - Logistic and Linear Regressions
  - Neural Networks


MSG SEVIRI observations
12 SEVIRI channels, channel differences, cloud top structure, temporal derivations

NWC-SAF products
Cloud Mask, Cloud Type, Cloud Phase, Cloud Top Temperature/Height/Pressure, precipitable water (total, boundary, mid, high layer), CAPE, instability indices (KI, LI, SHW)

COSMO
CAPE, CIN, precipitable water, tropopause height, freezing level, surface temperature etc.

Radar observations
maximum reflection, precipitation, CombiPrecip, Probability of Hail, Maximum Expected Hail Size, EchoTops, Hydrometeors

Temporal Derivatives
consider Advection SEVIRI High Resolution Winds

co-located multi sensor database

Parallax Correction
Cloud Top Height

Temporal Derivatives
consider Advection Radar Winds (Maple)

Lightning observations
Lightning density, Lightning Current, Polarization, Cloud-Ground Intra-Cloud
COALITION Second Generation

- Logistical Regression
- Linear Regression or Neural Networks
- Probability maps for Hail, Lighting, Precipitation, VIL etc.
- Intensity estimate for Hail, Lighting, Precipitation, VIL etc.

co-located multi sensor database
COALITION Second Generation

MSG SEVIRI observations
12 SEVIRI channels, channel differences, cloud top structure, temporal derivations

Processing with PyTROLL

NWC-SAF products
Cloud Mask, Cloud Type, Cloud Phase, Cloud Top Temperature/Height/Pressure, precipitable water (total, boundary, mid, high layer), CAPE, instability indices (KI, LI, SHW)

12 SEVIRI channels, channel differences, cloud top structure, temporal derivations

Parallax Correction
Cloud Top Height

Temporal Derivatives
consider Advection
SEVIRI High Resolution Winds

Temporal Derivatives
consider Advection
Radar Winds (Maple)

Temporally co-located multi sensor database

Location: Switzerland and Alpine Region

2 months of data

Long term archive

Radar observations
maximum reflection, precipitation, CombiPrecip, Probability of Hail, Maximum Expected Hail Size, EchoTops, Hydrometeors

Long term archive

Lightning observations
Lightning density, Lightning Current, Polarization, Cloud-Ground Intra-Cloud

Long term archive

COSMO
CAPE, CIN, precipitable water, tropopause height, freezing level, surface temperature etc.

Long term archive

2 months of data
Tests for Convective Initiation

Table 8. Mean and std dev values for the interest fields in Tables 5–7. These fields are grouped by category as they pertain to estimating cloud depth, cloud-top glaciation, and updraft strength. Fields are listed by order of the ranking as shown in Tables 5–7.

<table>
<thead>
<tr>
<th>Rank</th>
<th>CI interest fields</th>
<th>Mean (K)</th>
<th>Std dev (K)</th>
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<td>Cloud depth</td>
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<tr>
<td>1</td>
<td>6.2–10.8 μm</td>
<td>−14.6</td>
<td>11.27</td>
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<tr>
<td>2</td>
<td>6.2–7.3 μm</td>
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<td>3</td>
<td>10.8-μm $T_B$</td>
<td>242.5</td>
<td>16.79</td>
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<td>4</td>
<td>7.3–13.4 μm</td>
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<tr>
<td>6</td>
<td>8.7–12.0 μm</td>
<td>0.3</td>
<td>1.92</td>
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<td>Glaciation indicators</td>
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<td>15-min tripectral</td>
<td>0.7</td>
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<td>6</td>
<td>15-min 3.9–10.8 μm</td>
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<td>7</td>
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<td>Updraft strength</td>
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<td>8</td>
<td>15-min 7.3–9.7 μm</td>
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Tests for Convective Initiation according to Mecikalsky

- Radar instantaneous precipitation rate
- TRT cell detection
- WV062-IR108
- Number of CI tests
- Cloud Type

<table>
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<tr>
<th>Time</th>
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<th>TRT</th>
<th>WV062</th>
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</table>
Combined satellite, radar, and lightning observations for 23rd July 2014

- **Radar**
  - Total precipitation and precipitation area
  - Mean precipitation rate

- **Lightning**
  - Lightning rate in Ticino

- **MSG SEVIRI**
  - Thermal channels
  - Thermal channel differences

- **MSG SEVIRI**
  - Brightness temperature (K)

Images for 06UTC, 09UTC, 12UTC, 15UTC, 18UTC, 21UTC, 24UTC
Summary

- Nowcasting Algorithms at MeteoSwiss
  Thunderstorm Radar Tracking
  COALITION First Generation
  COALITION Second Generation (in preparation)

- Goals of COALITION
  Input datasets: Radar, satellite, lightning, NWP
  Increase lead-time for warnings
  Forecast of intensification of thunderstorms

- COALITION SG
  Replacing pseudo-kinetic energy with regression and neural network technics
  Making use of long term statistics

- Multi-sensor analysis
  Satellite: Brightness temperatures, reflectivity, channel differences, temporal tendencies
  Radar: Maximum reflectivity, ECHOTOPS, MESH, POH
  Lightning: lightning density, cloud-ground, intra-cloud, current
  COSMO: CAPE, CIN, wind shear, tropopause height, freezing level