EO-ALERT: VERY-LOW LATENCIES FOR CONVECTIVE STORM NOWCASTING BASED ON A NEXT GENERATION SATELLITE PROCESSING CHAIN

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Overview

European Union's Horizon 2020

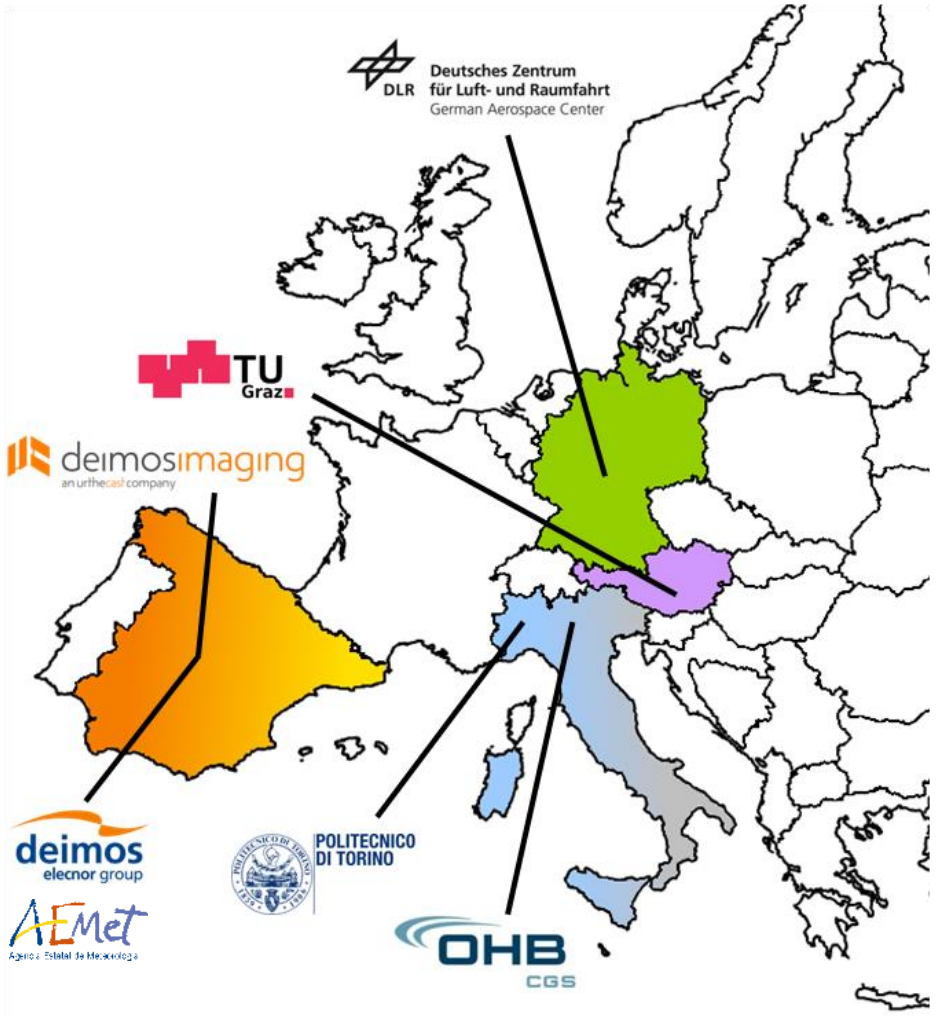
Started in January 2018

Duration three years (2018 – 2020)

6 partners:

- Deimos Space (Spain) – coordinator
- DLR (Germany)
- Technische Universitaet Graz (Austria)
- Politecnico di Torino (Italy)
- OHB Italia (Italy)
- Deimos Imaging SLU (Spain)

Consultant: AEMET



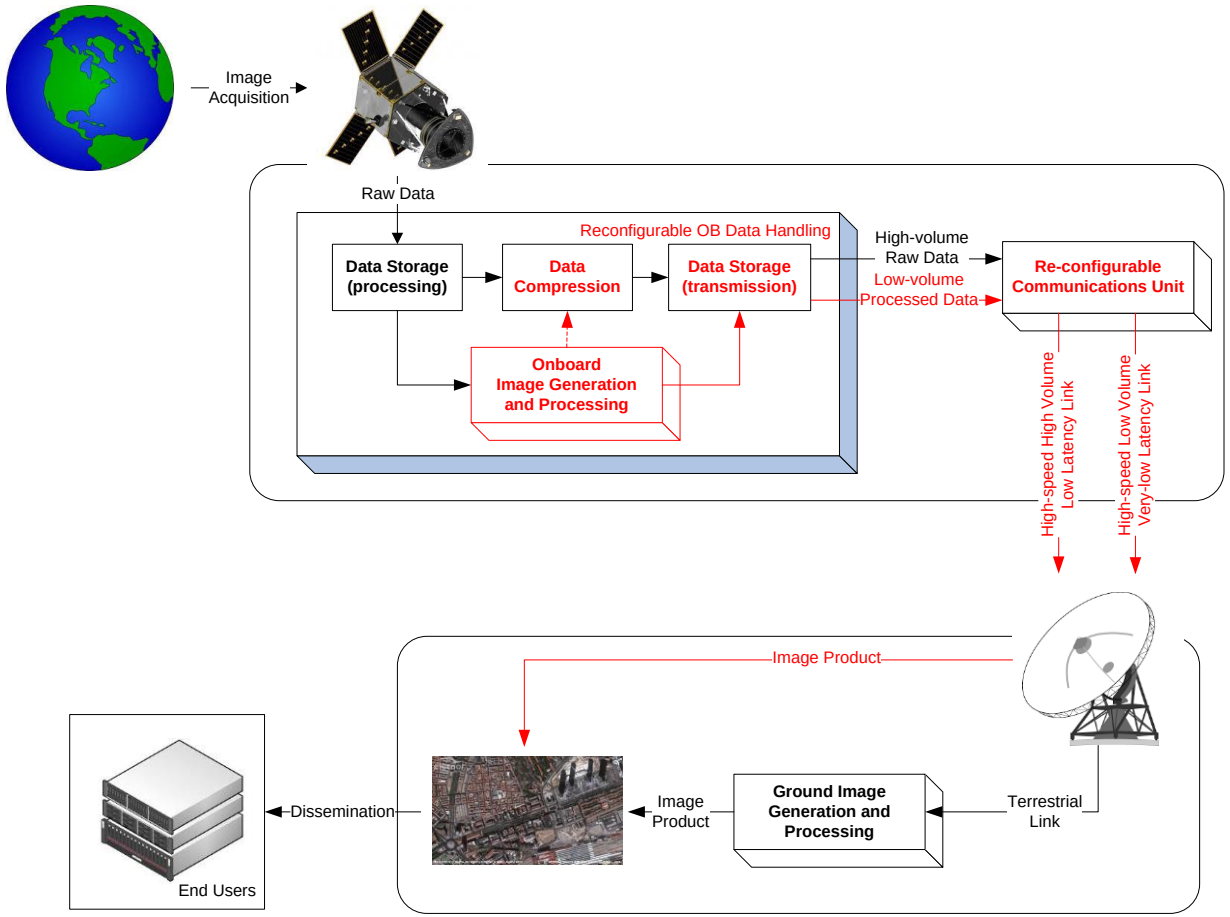
Project Goal and Idea

Goal: Develop a new approach for the provision of very low latency EO data products, exploiting the flight segment processing capabilities

- ✓ Goal latency: **< 1 minute**
- ✓ Requirement latency: **< 5 minutes**

Idea: Focus on the image products which rely on very low latency

- Move key EO data processing elements from the ground segment to the satellite
- Prove this to TRL 5 via avionics HW testing



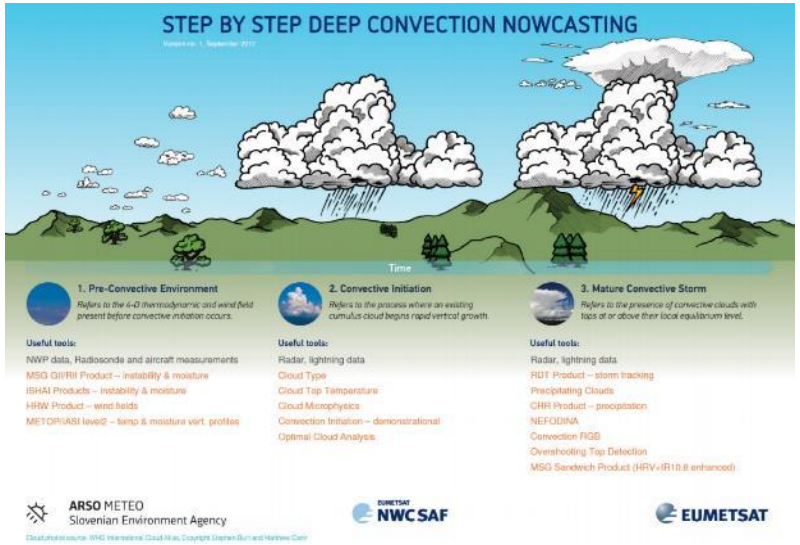
EO scenarios

Two EO scenarios are used to drive the developments and prove development in **operationally relevant scenarios**

- Maritime surveillance (ship detection)
- Extreme weather (convective storms, wind over ocean)

Requirements derived from End Users

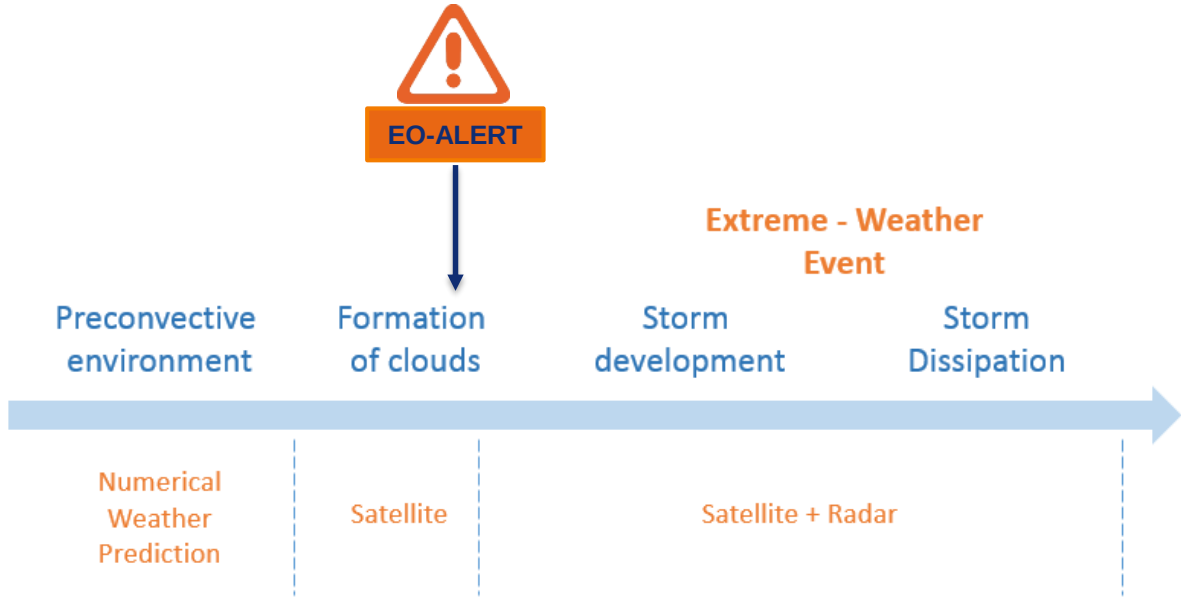
- Maritime surveillance (ship detection)
  - Requirements from EMSA VDS
- Extreme weather (storms, wind)
  - AEMET as provider of service and end user
  - Covers both convective storms service and maritime weather service



Extreme weather scenario
Objectives

OBJECTIVE : Provide a very low latency product for convective storm nowcasting to complement existing solutions

IDEA:
On-board image processing and machine learning/AI to assess and predict probability for convective storms in pre-, mature and decaying stage



Extreme weather scenario
Objectives

EO-ALERT Developed by DEIMOS and AEMET	**Rapidly Developing Thunderstorms (RDT)** Developed for NWCSAF by METEO France
Prototype data processing chain enabling low-latency nowcasting	Operational convective storm detection and tracking
On-board processing, **short latencies (< 5 min)**	Ground processing (latencies 15-25 min, latitude dependent)
Input: • MSG/SEVIRI Images	Input: • MSG/SEVIRI Images • NWP
Ground Truth: Opera Radar Network	Lightning data
3-step algorithmic approach: Candidate cell extraction, tracking, discrimination	

EO-ALERT results are compared to RDT

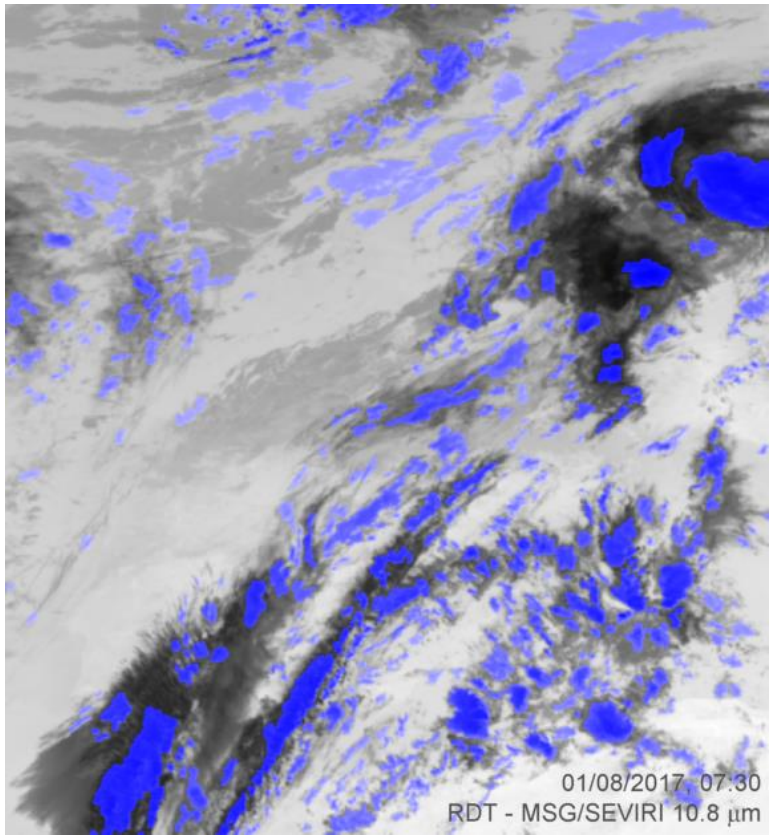
Optical Processing Chain
Image Processing

Extreme Weather Detection

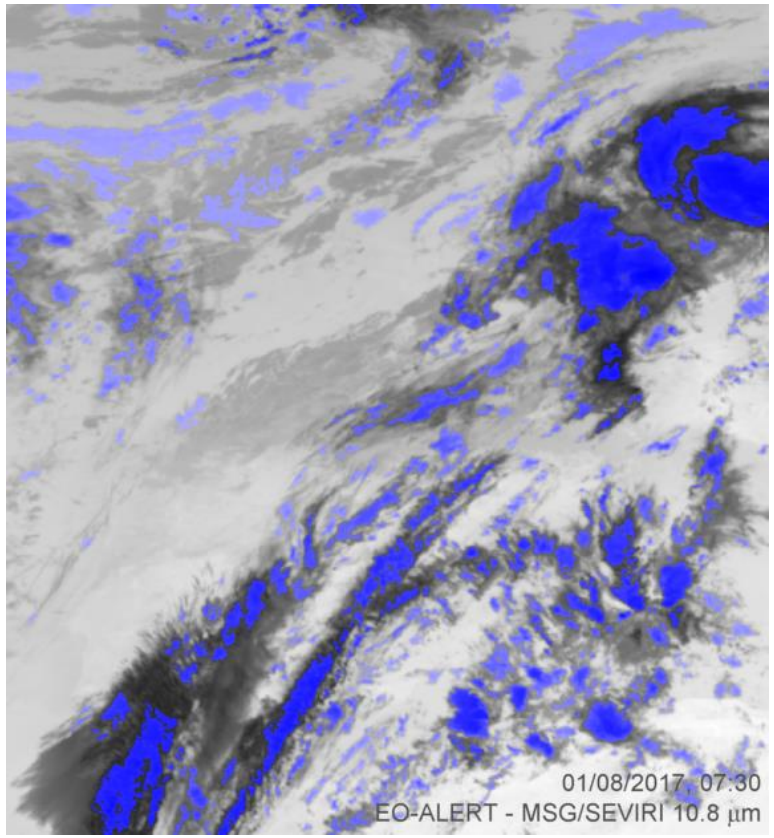
Three step solution:

1. Identification of candidate convective cells

EUMETSAT RDT (v2013)



EO-ALERT RDT-like



Optical Processing Chain
Image Processing

Extreme Weather Detection

Three step solution:

1. Identification of candidate convective cells
2. Track and extract features

Image captured at time -1

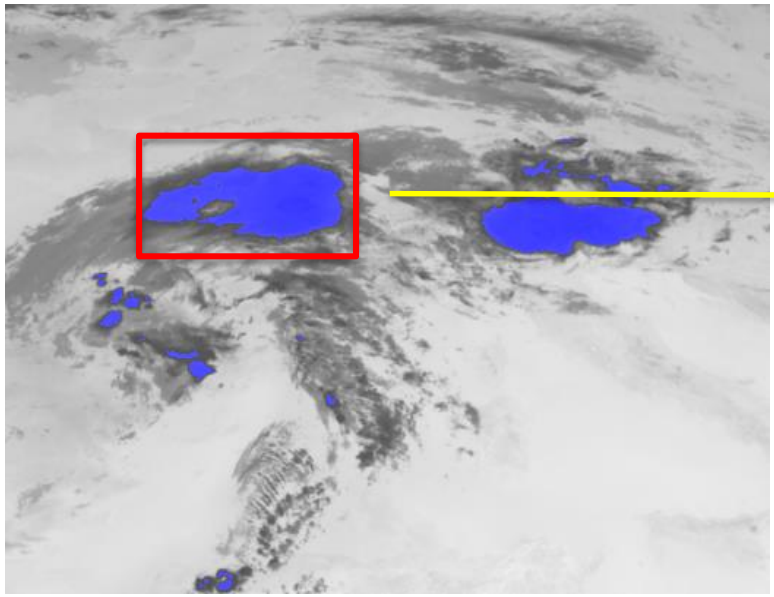
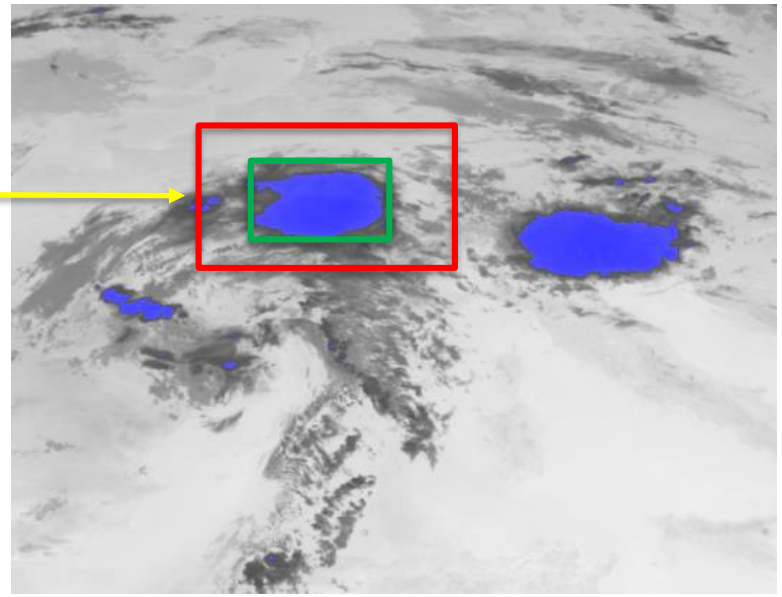


Image captured at time 0

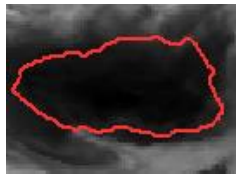


Optical Processing Chain
Image Processing

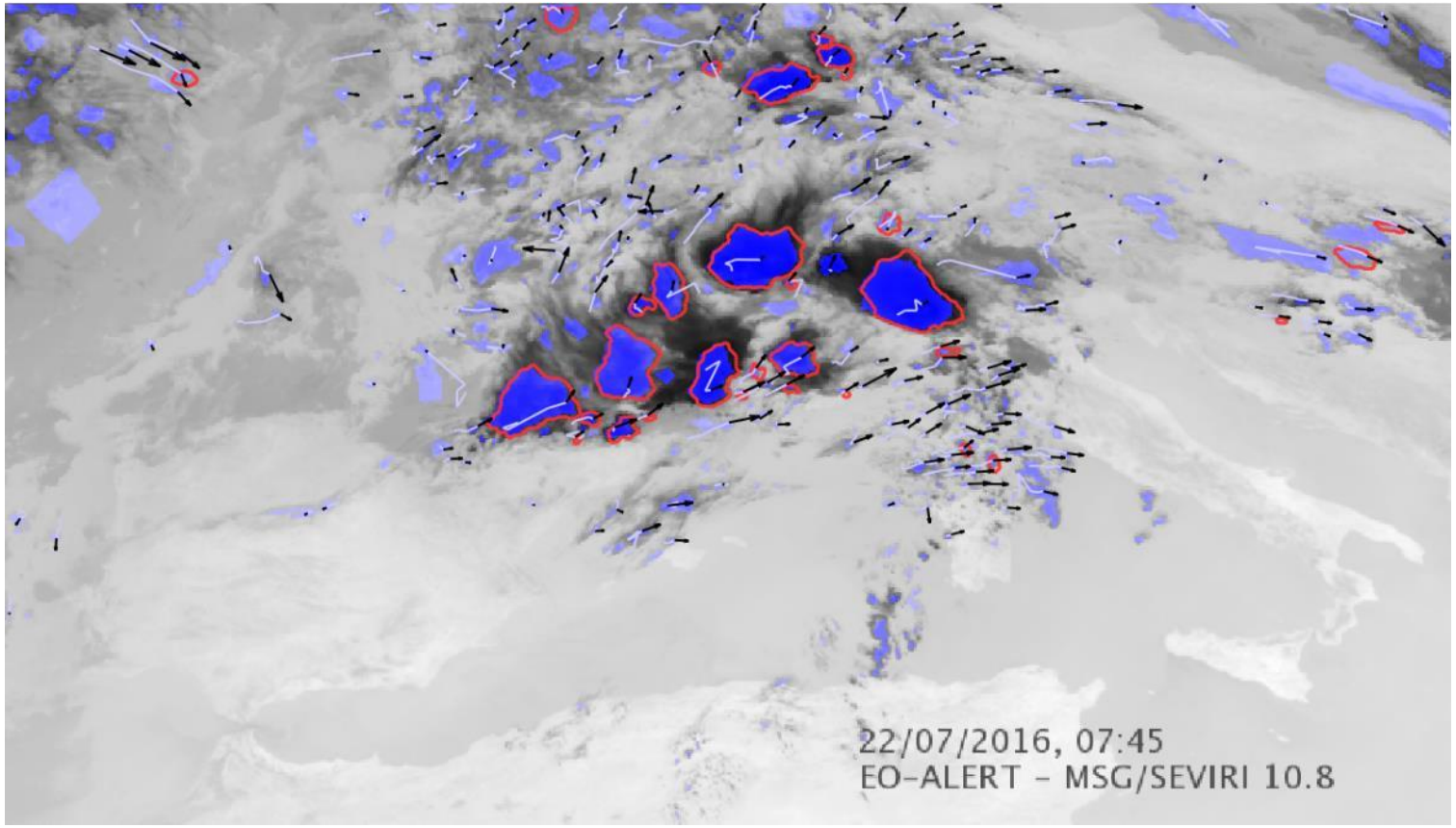
Extreme Weather Detection

Three step solution:

1. Identification of candidate convective cells
2. Track and extract features
3. Discriminate convective/non-convective



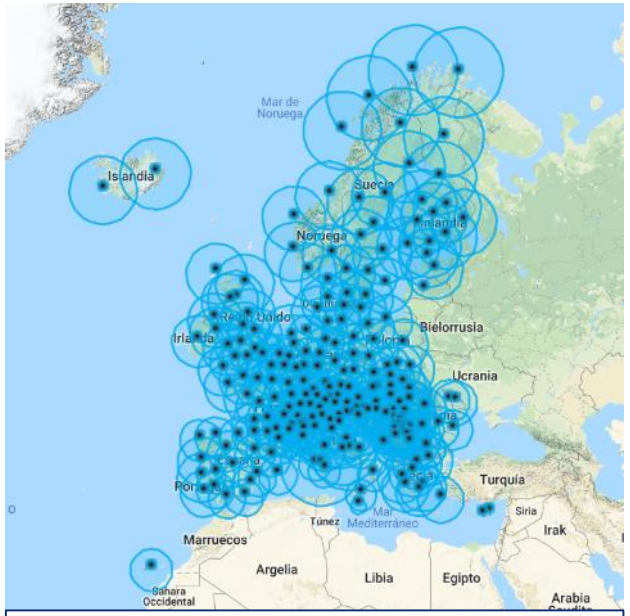
LAT
LON
Extension
Cooling Rate
Min Temperature
Max Temperature



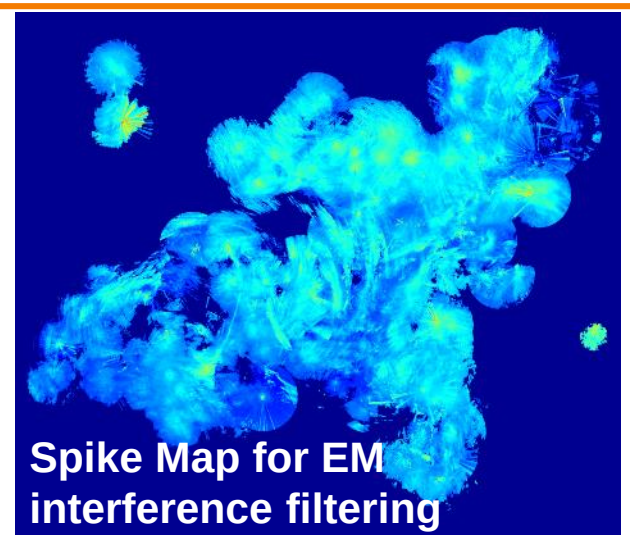
Datasets: Input & Ground Truth

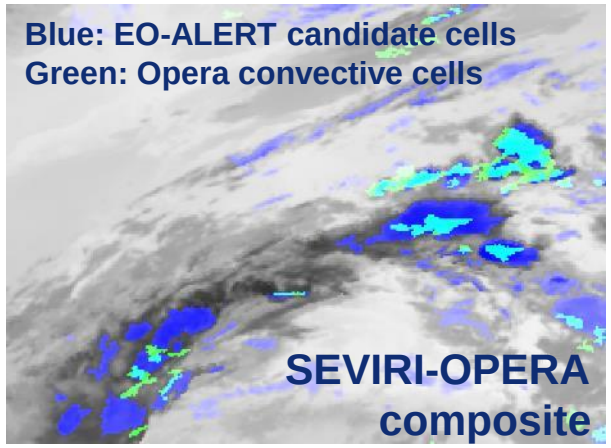
- Input:
  - Visible and Infrared data GEO satellite
  - Data collected from 86 storm events (2016-2018)
  - 8000 images from MSG-4 (SEVIRI instrument)

- Ground truth:
  - Built from OPERA weather radar network maximum reflectivity composite
  - Removal of EM interferences in OPERA data
  - OPERA composites are processed with convective cell detection algorithm
  - Parallax correction of MSG images
  - Convective labels assigned to SEVIRI pixels in SEVIRI-OPERA composites



224 radar stations of the OPERA European radar mosaic
(source: http://eumetnet.eu)

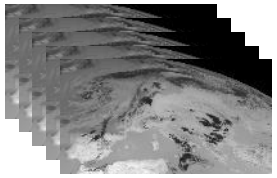




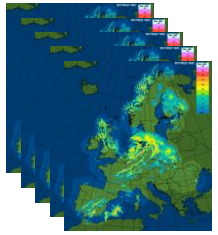
Cell Discrimination

estofex

EUMETSAT



EUMETNET



Selection of dates containing storms

2016-2018

Detection of candidate convective cells

Tracking of cells across images

Convective detection in radar data

Reprojection in SEVIRI grid

Extreme Weather DATASET

86 days
~8000 images
~10^6 cells

Data

+

Ground-truth

Machine Learning

Manual feature extraction
+
Machine learning classifier

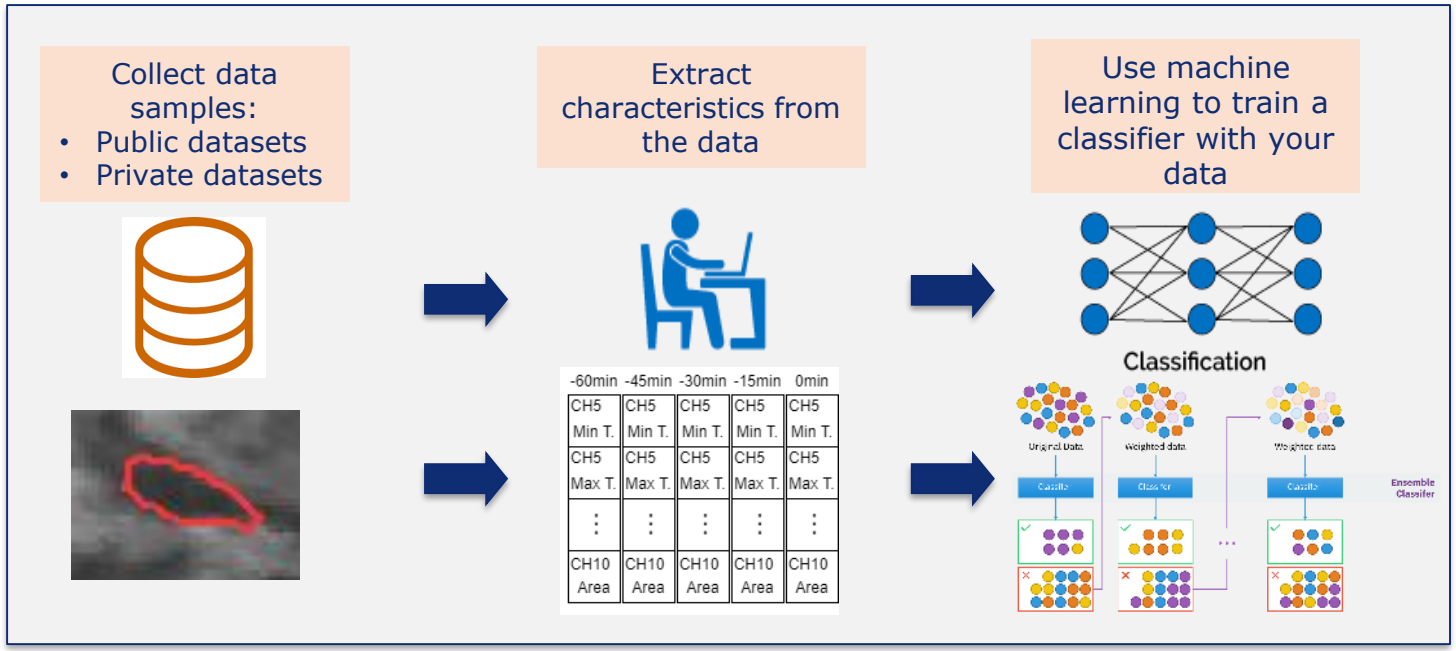
Next slides

AI based solution

Automatic feature extraction Convolutional Neural Network
+
LSTM classifier

In progress, results 2020

Cell Discrimination
Performance: Machine Learning based solution



Available history	Probability of Detection	False Alarm Ratio
>=60 min	0.79	0.21
45 min	0.76	0.29
30 min	0.75	0.3
15 min	0.73	0.32
0 min	0.74	0.39

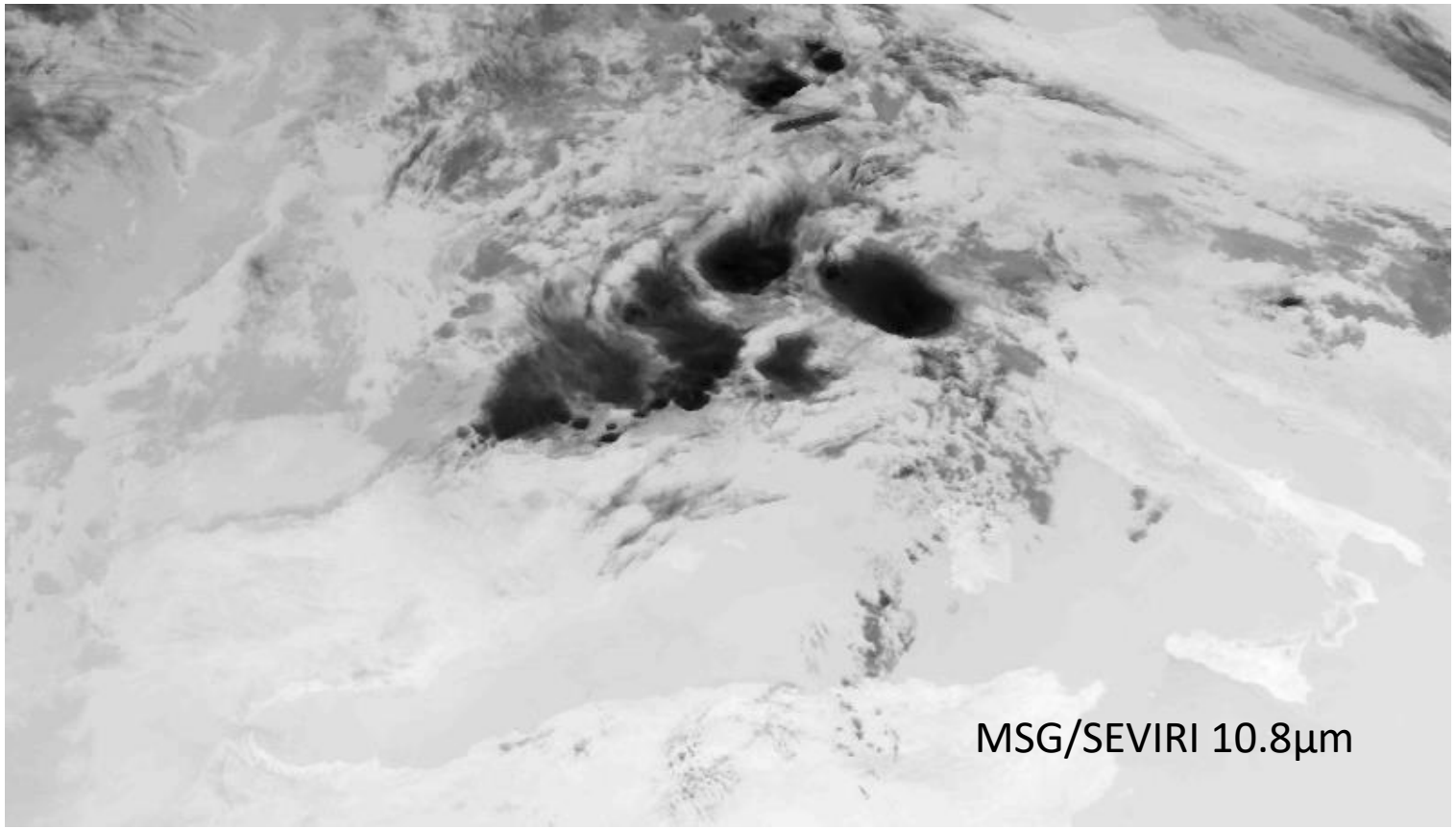
* Shown results: No distinction between pre-convective, mature and decaying stage

Planned improvements:

- Optimize detection of different stages of convection
- Add features from aiding data (NWP)
- Enhanced ground truth (MODE - Model Evaluation Tools, NCAR)

Optical Processing Chain
Image Processing Execution Flow

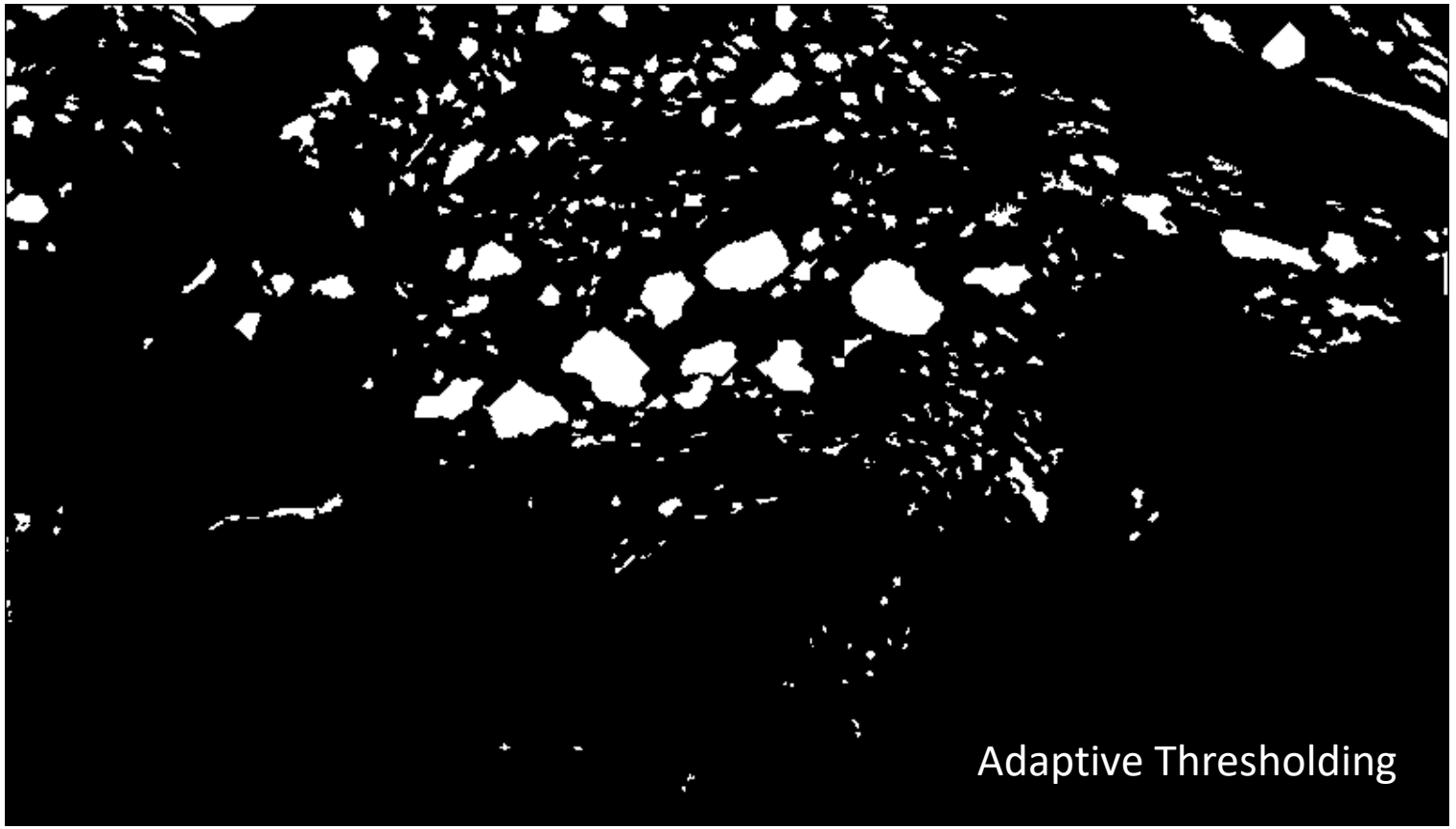
Data:
L1.5 MSG/SEVIRI
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)



Optical Processing Chain
Image Processing Execution Flow

Data:
L1.5 MSG/SEVIRI
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

Image Processing:
Candidate Extraction
(10.8µm)



Optical Processing Chain
Image Processing Execution Flow

Data:
L1.5 MSG/SEVIRI
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

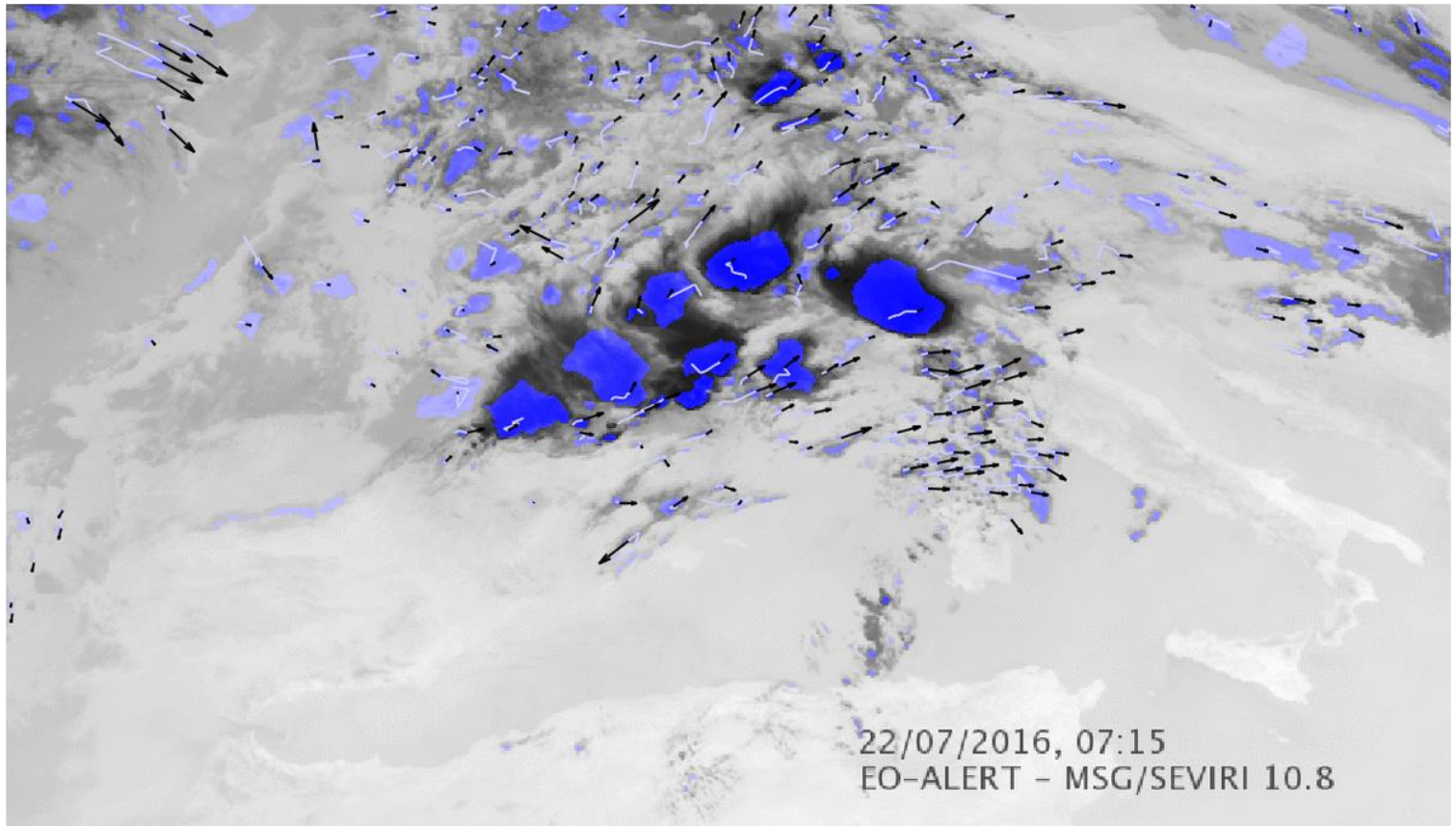
↓

Image Processing:
Candidate Extraction
(10.8µm)

↓

Image Processing:
Tracking

→



Optical Processing Chain
Image Processing Execution Flow

Data:
L1.5 MSG/SEVIRI
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

↓

Image Processing:
Candidate Extraction
(10.8µm)

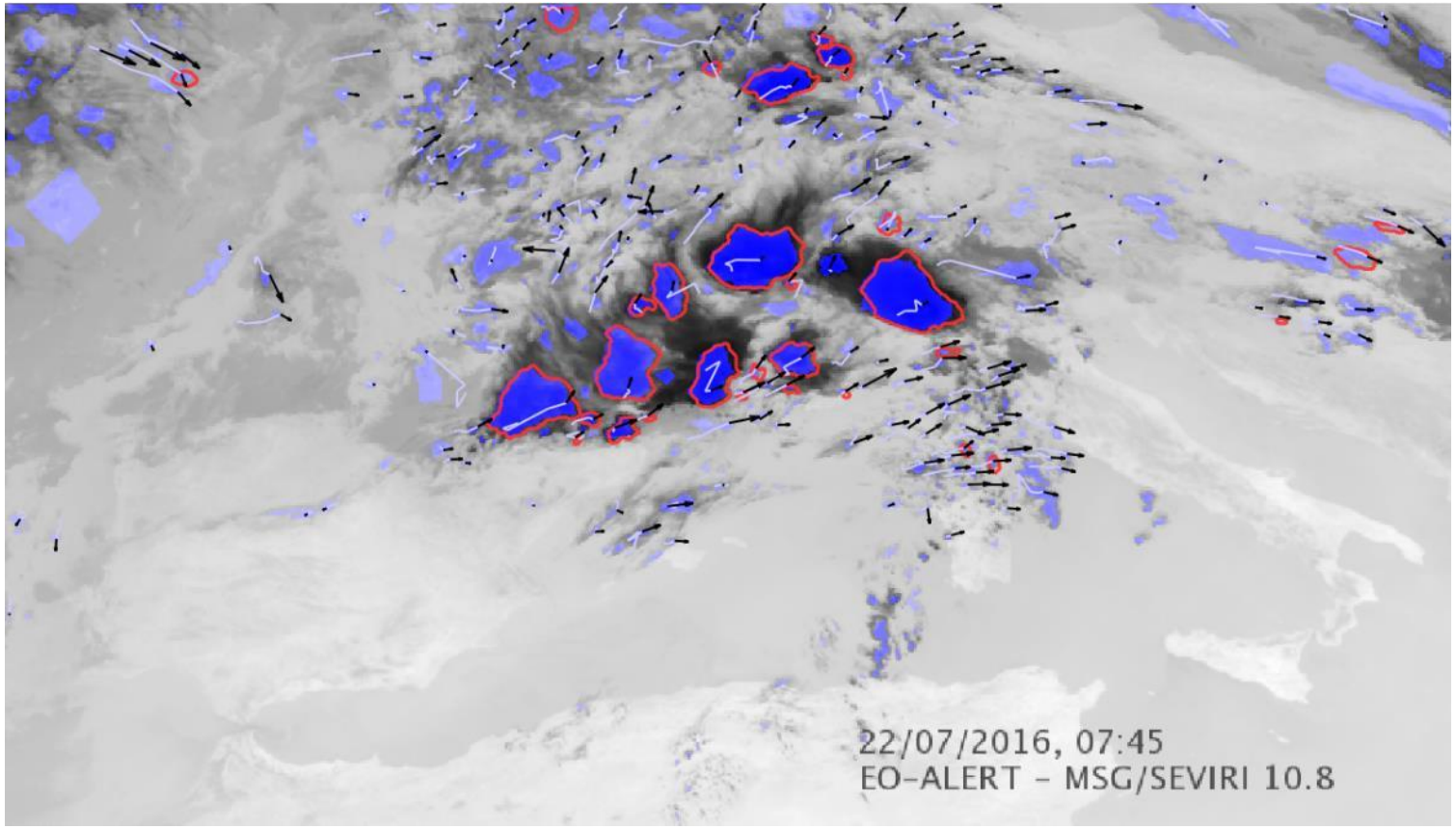
↓

Image Processing:
Tracking

↓

Candidate
Discrimination
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

→



Optical Processing Chain
Image Processing Execution Flow

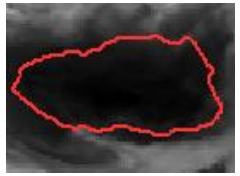
Data:
L1.5 MSG/SEVIRI
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

Image Processing:
Candidate Extraction
(10.8µm)

Image Processing:
Tracking

Candidate
Discrimination
(6.2µm, 7.3µm, 8.7µm
10.8µm, 12µm)

Alert Generation

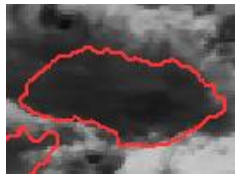


ID 1
LAT 31.196908
LON 29.622436

Min Temp. -35.4
Max Temp. -24.9
…

ID 2
LAT 31.182698
LON 29.555137

Min Temp. -31.1
Max Temp. -25.3
…



ID 3
LAT 31.186459
LON 29.566574

Min Temp. -38.2
Max Temp. -25.3
…

Summary

- EO-ALERT is an EC H2020 project of European partners, furthering European excellence in EO and satellite technologies
- EO-ALERT aims at addressing **very low latency** End User needs for EO image products, exploiting on-board processing capabilities
- It covers the whole acquisition chain, including data handling, processing and transmission to ground, **targeting latencies below 5 minutes**
- It will demonstrate the architecture and HW-SW solutions to TRL6, employing a representative avionics test bench and EO experiment
- The EO-ALERT extreme weather product demonstrates the readiness of the novel architecture for the use in **nowcasting applications** like convective storm detection.

Special thanks to

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776311

Call: COMPET-3 2017 Call on "High speed data chain"

Title: Next Generation Satellite Processing Chain for Rapid Civil Alerts

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