EO-ALERT – EXTREME WEATHER SCENARIO: TOWARDS CONVECTIVE STORM NOWCASTING VIA ON-BOARD SATELLITE PROCESSING

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

Title: Next Generation Satellite Processing Chain for Rapid Civil Alerts

Overview

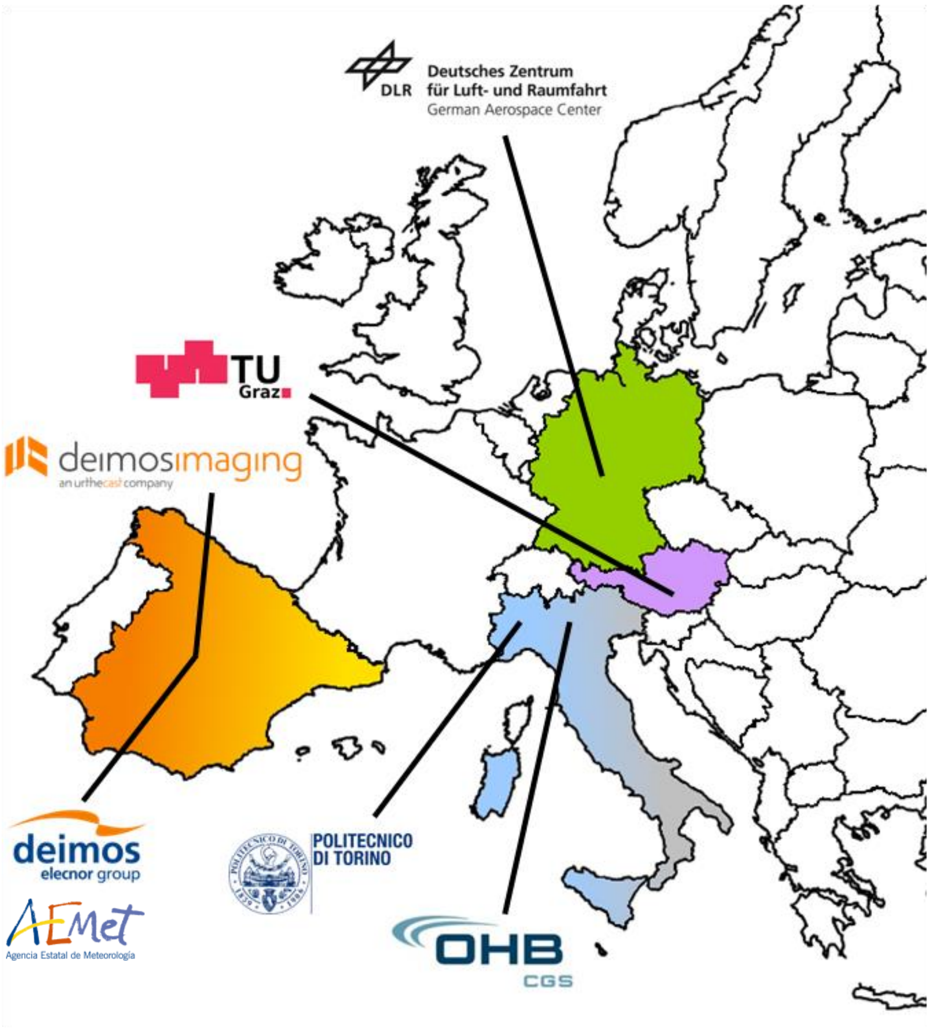
Started in January 2018

Duration three years (2019 – 2021)

6 partners:

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

One consultant: AEMET



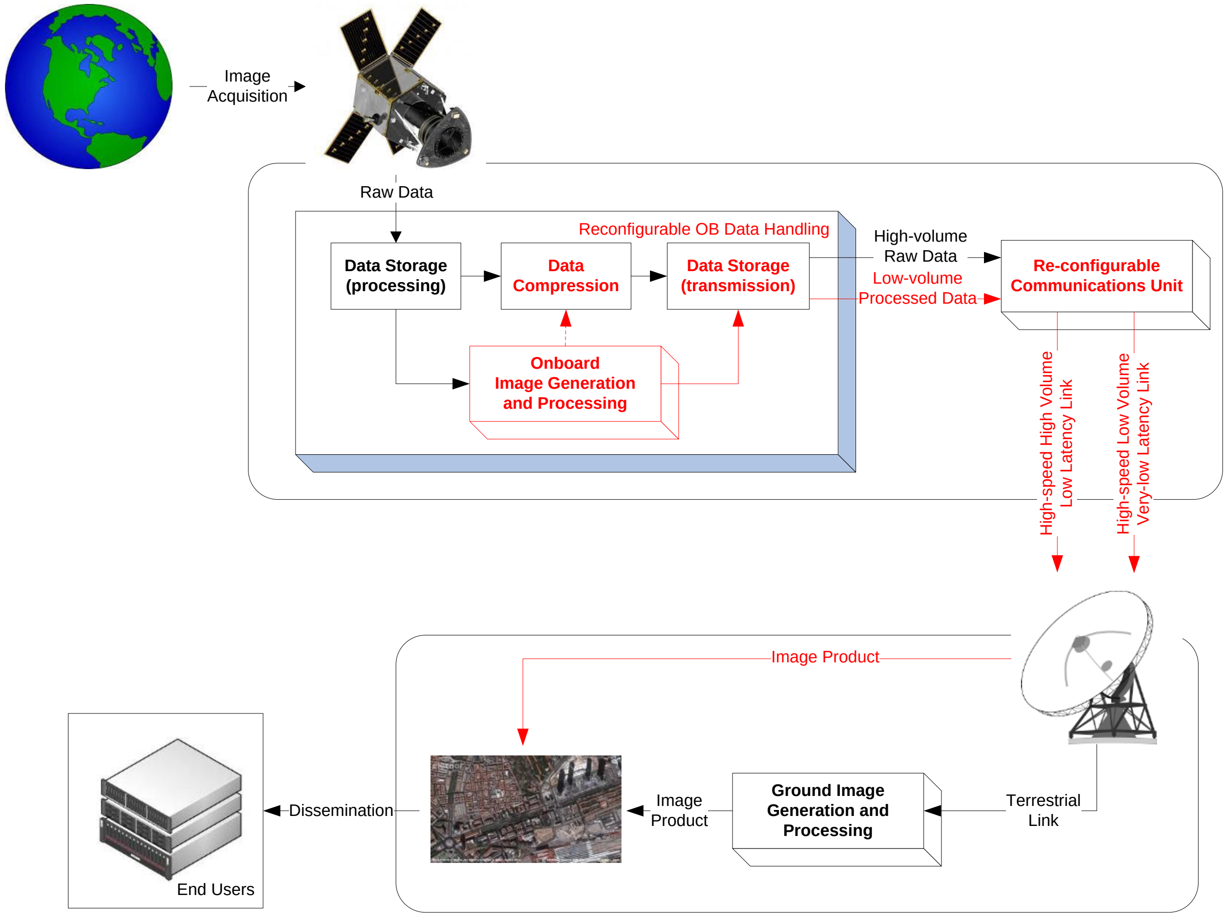
Project Goal and Idea

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 product and what is needed with very low latency

- Move key EO data processing elements from the ground segment to the satellite
- Improve general target and situational awareness
- Applicable generally to scenarios that require near real time information: surveillance, monitoring, etc
- Prove this to TRL 6 via avionics HW testing
- Focused on the **overall capability** (not technology)
- Consider the **full and real problem**
- Prove this for Optical and SAR



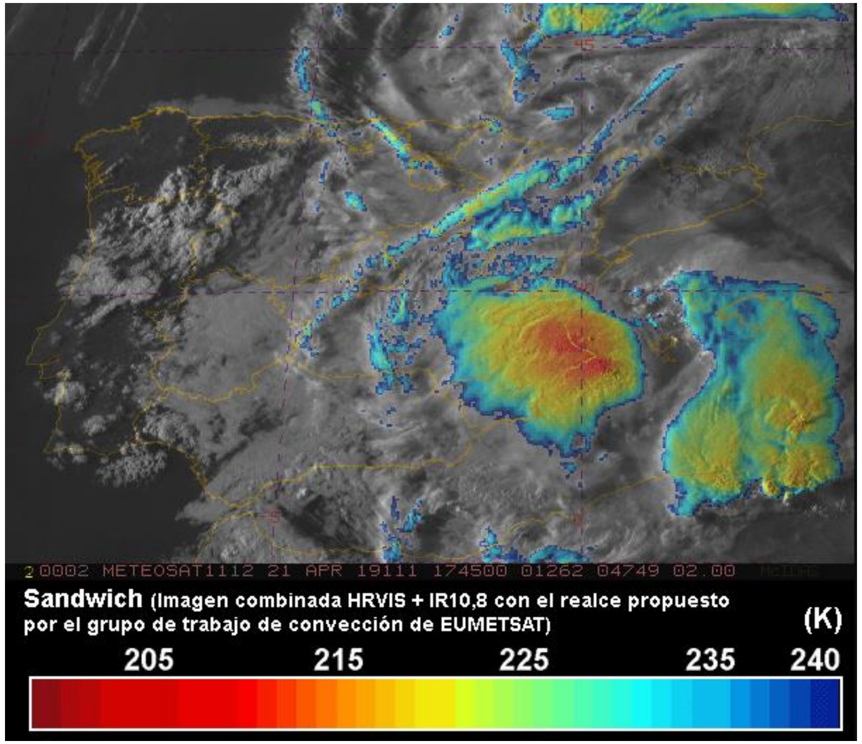
EO scenarios

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

- Maritime surveillance (ship detection)
- Extreme weather (convective storms, maritime wind and waves)

Requirements derived from End users

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



Extreme weather scenario

Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012):

- Storms corresponded to 30% of the reported causes of disasters over Europe during the 1970–2012 period
- 37% of the US$ 375.7 billion lost in Europe in that period were caused by weather-, climate- and water-related hazards, were due to storms

Early alerts for some meteorological events that are difficult to forecast in space and time can reduce the negative impact of these kind of hazardous phenomena

EO ALERT

Extreme Weather
Storm Stage vs Product Availability

- Predictors work with the help of meteorological products
  - Not available in real-time
    - *Data transmission time*
    - *Data processing time*
  - Low precision in pre-convective stages

- EO-ALERT able to detect:
  - Pre-convective environments
  - Convection initiation
  - Storm in a mature stage including Overshooting Tops
  - Storm in a dissipation stage

Storm Stage

Products \ Data	NWP	SEVIRI	Cloud Mask	RTTOV	Cloud type
Pre-convective	x	x	x	x	
Convection-initiation	x	x	x		
Mature-convection	x	x			x
Dissipation Phase	x	x			x

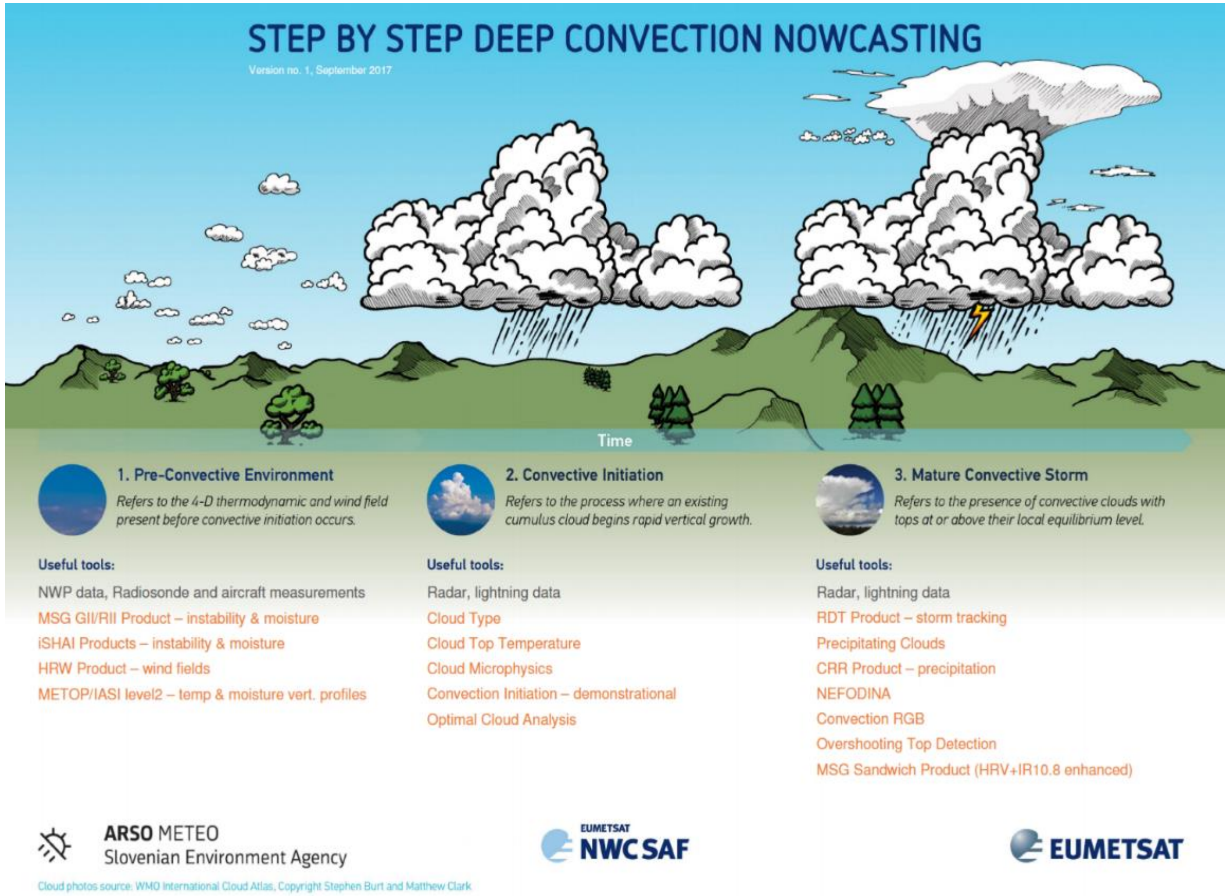
Extreme Weather
OPT Data source

EO-ALERT

OBJECTIVE

- Provide a **very low latency product** to the predictor
  - Before any other source of data or product
  - Use of Machine-Learning to asses the probability of a cloud cell to result in a storm

- Help in the prediction of Extreme-Weather Events
  - Fast alert that complements ground segment products
  - More time to alert the population



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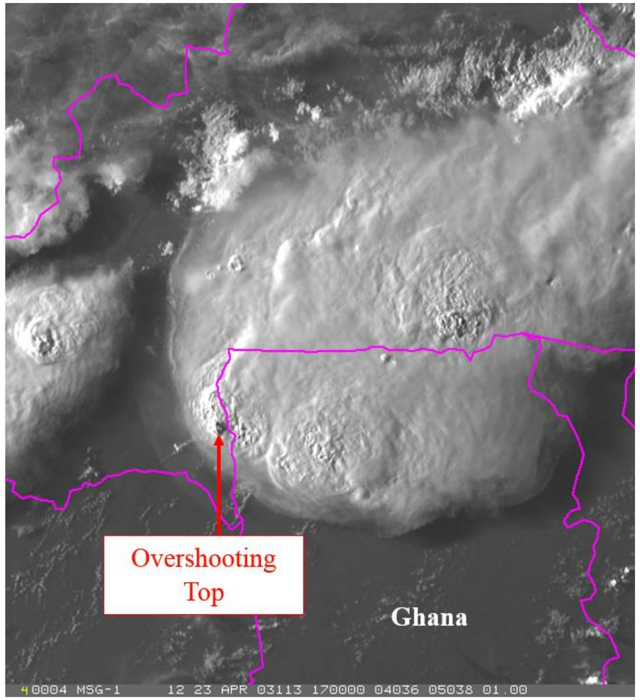
Extreme weather scenario

- Input:
  - Visible and Infrared data from GEO satellite
  - Data collected from 78 storm events
  - 14,892 images from MSG-4 (SEVIRI instrument)

- Ground truth:
  - Built from OPERA weather radar network maximum reflectivity composite
  - Removal of EM interferences in OPERA data
  - 11,202 composites processed with convective cell detection algorithms
  - Convective labels assigned to MSG pixels: re-projection and parallax correction

- Validation:
  - Weather radar on-board a ship for storm detection over seas and oceans



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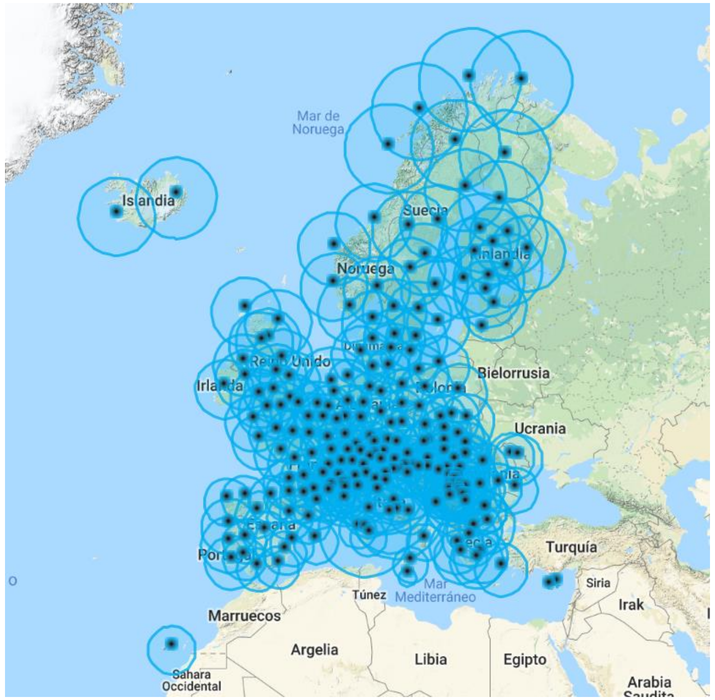


Map with the location of the 224 radar with which OPERA builds the European radar mosaic
(source: http://eumetnet.eu)

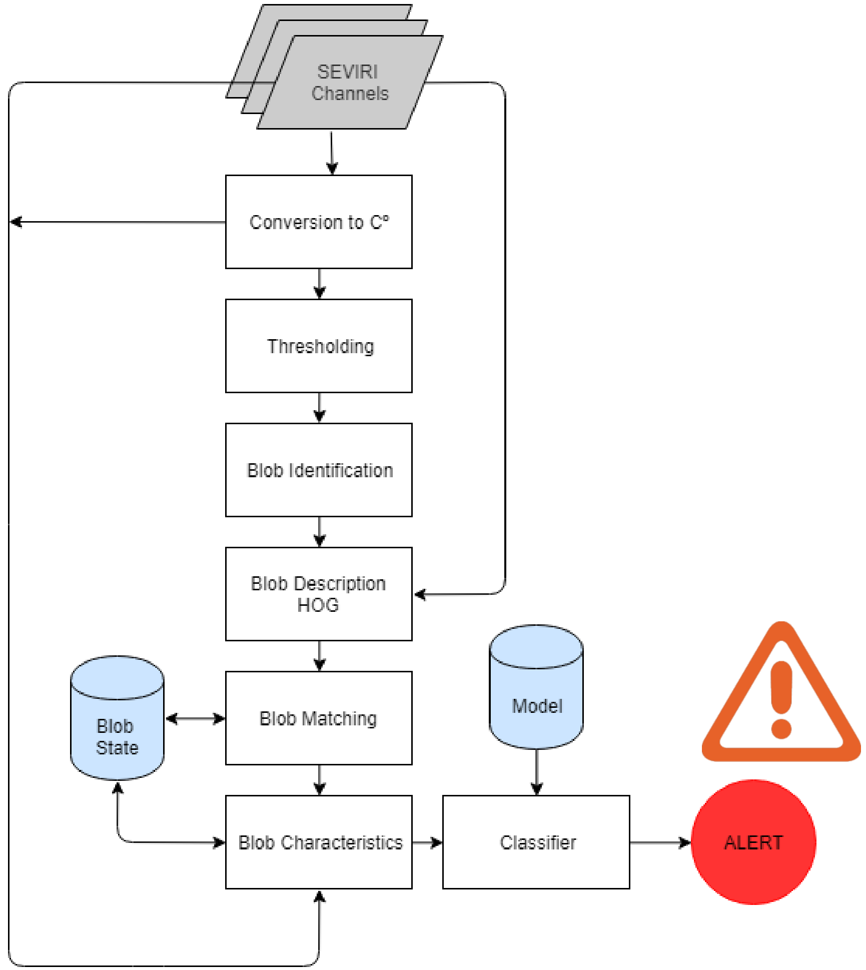
Extreme Weather
OPT Current Solution

Current On-board approach

- Three steps:
  - Identification of candidate cells
  - **Computer-Vision** based cell **tracking**
  - **Machine-Learning** convective/non-convective **discrimination**

- Seviri Images as input

- OPERA composites as **ground-truth**
  - Training & Validation

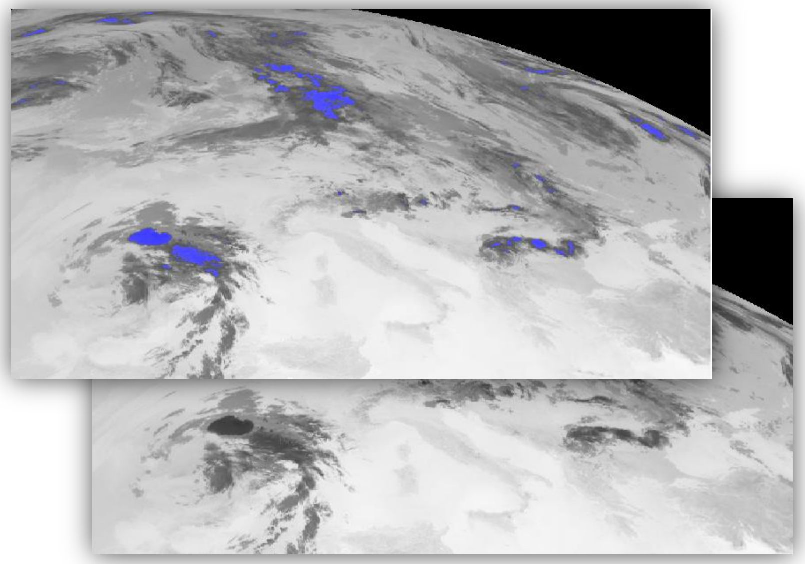


Extreme Weather
OPT Current Solution

PRELIMINARY ALGORITHM

1. Identify candidate cells

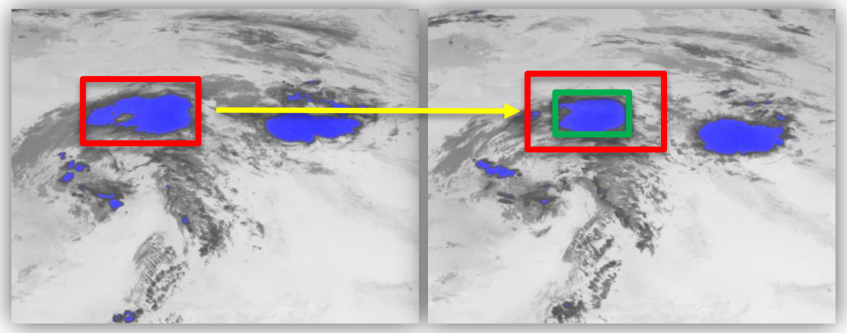
Based on cold top-cloud temperatures retrieved from the infrared 10.8μm



PRELIMINARY ALGORITHM

2. Track & Measure

Based on Computer Vision trackers: shape and texture descriptors



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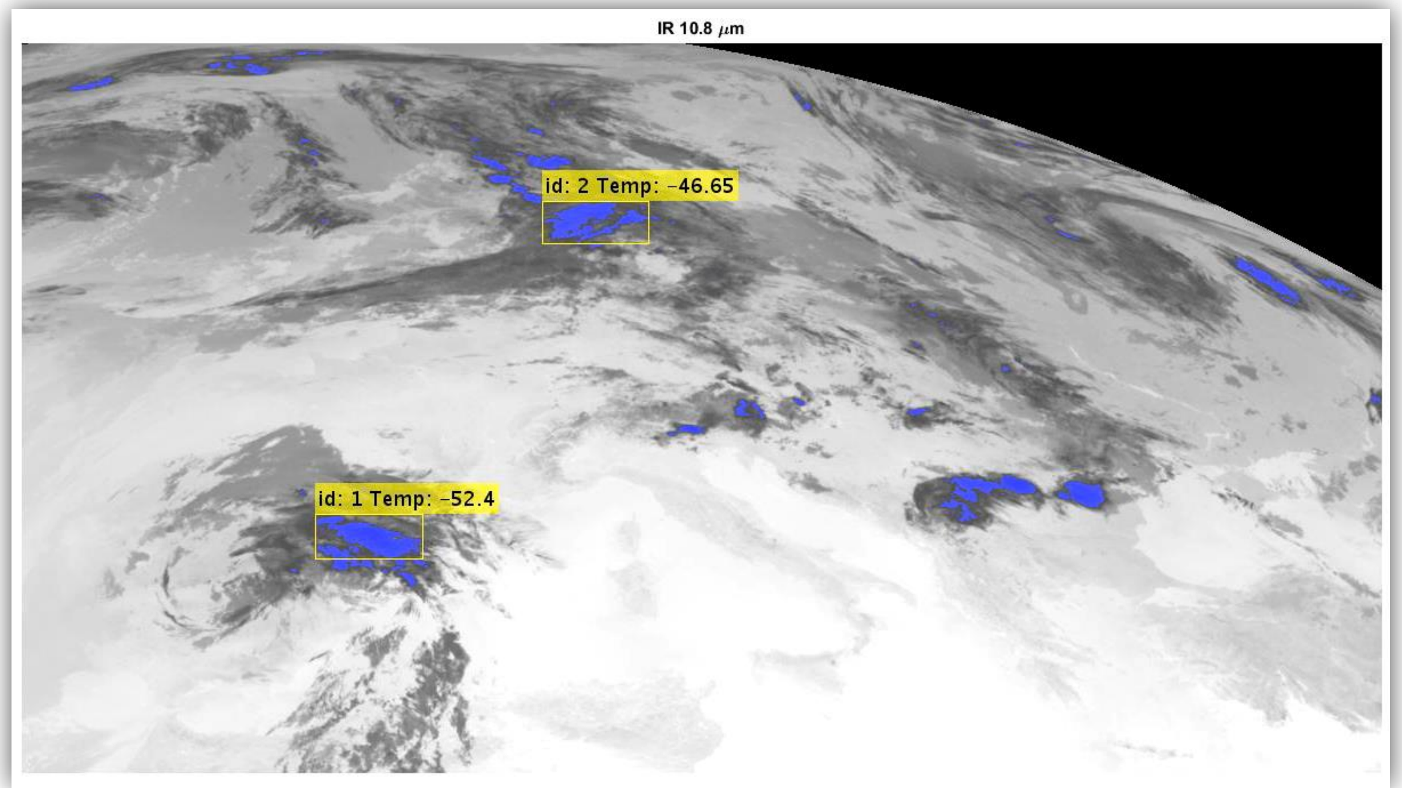
Extreme Weather
OPT Current Solution

PRELIMINARY ALGORITHM

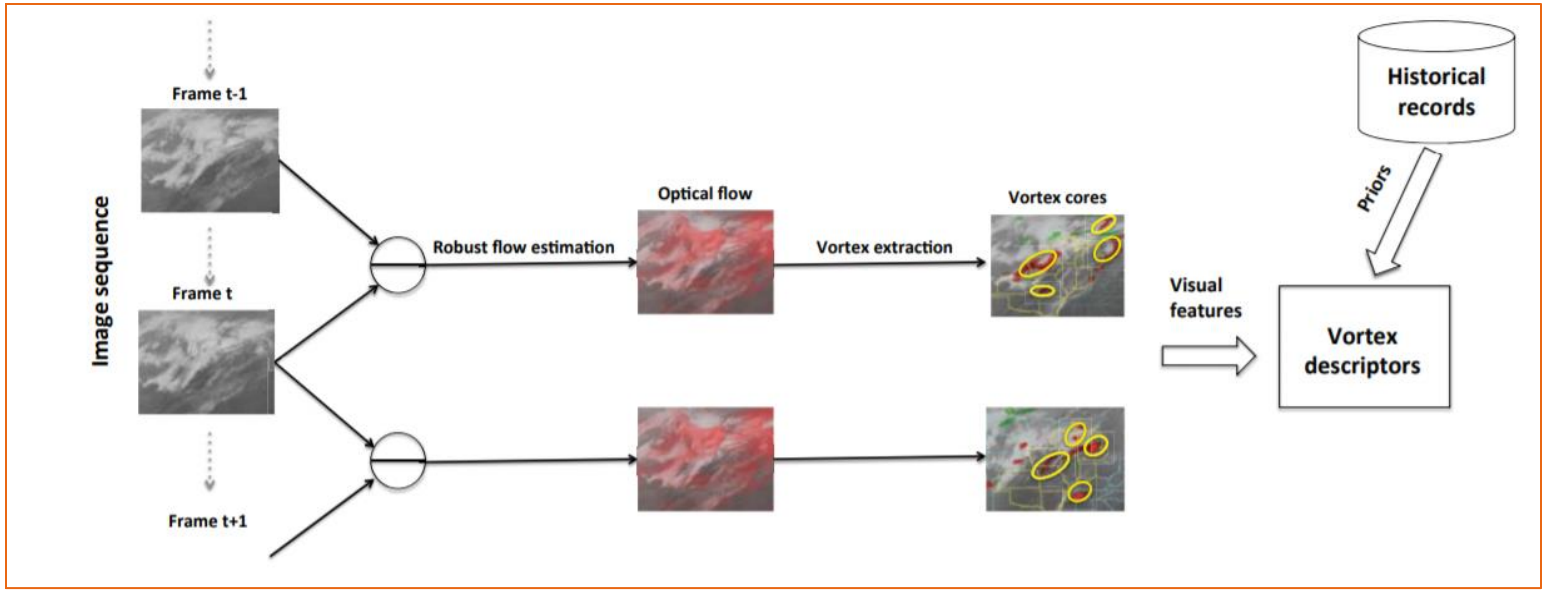
3. Classify based on temporal feature evolution



OPEN LINES OF RESEARCH – I

- Based on the article: “Locating **Visual Storm** Signatures from Satellite Images”
- Detection of vortices from fluid **optical-flow features**
- Machine-learning classification of vortex features for storm detection

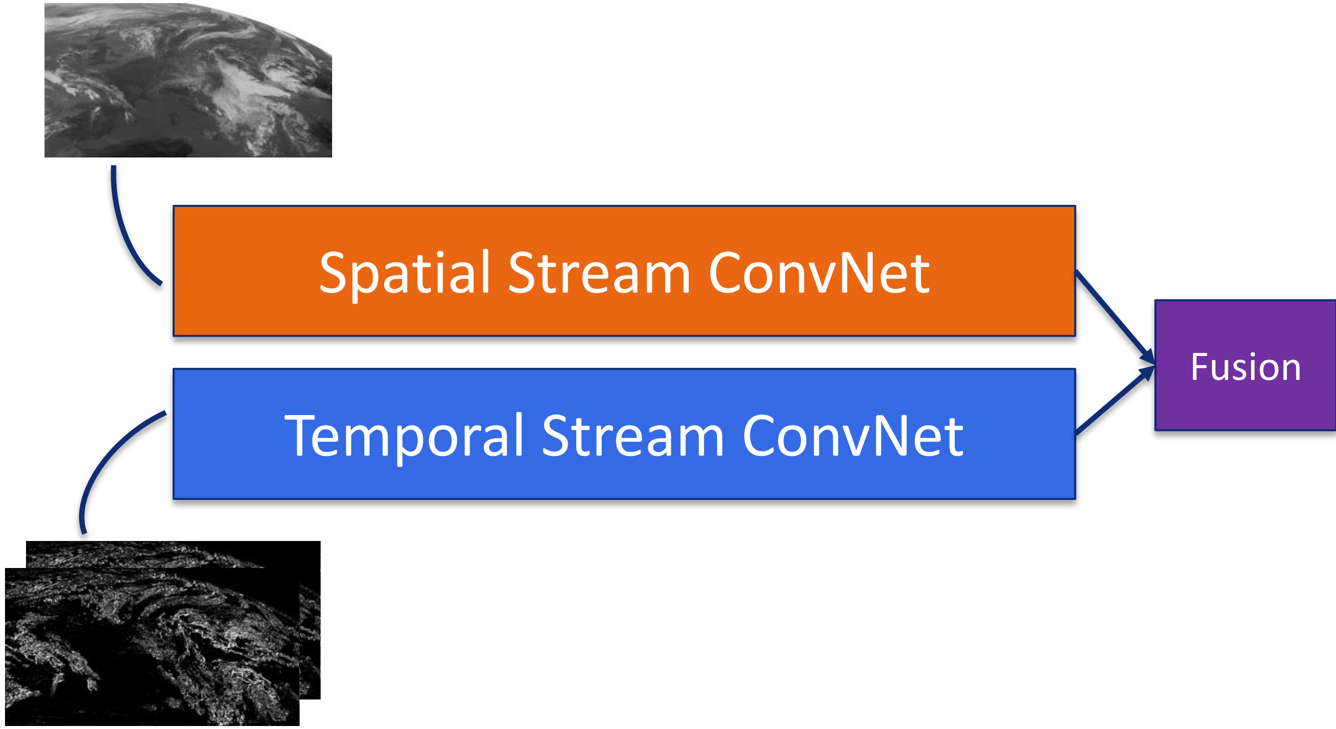
Extracted from: “Locating Visual Storm Signatures from Satellite Images”



OPEN LINES OF RESEARCH – II

- **Two stream Convolutional Neural Networks**:
  - Separation of motion and appearance
  - Temporal ConvNet for temporal modelling
  - Spatial ConvNet for static image feature extraction

- Temporal ConvNet:
  - Analyzes motion from Optical-Flow
- Spatial ConvNet:
  - Extracts static image features from SEVIRI composites



Current Status

- Latency requirement is considered feasible based on preliminary design
  - Latency in **Extreme Weather Detection in Optical ~3 to 5 minutes** for half disc of Earth (MSG)
  - Further paralelisation can improve these times (HW vrs latency trade)

- Key open points
  - A combination of temperature and visual features has been considered, different strategies could result in better detection
  - MSG visible and IR (10.8µm) are used, the use of other channels could improve detection
  - The use of different products from ground could improve detection performance

Way forward

- 2019
  - Detailed design: SW-HW implementation
  - Individual technologies verification
    - Ready for exploitation
  - Workshop 1 – End User outreach (commercial & insitutional) (Madrid)

- 2020
  - Full data chain ATB testing
  - Archive data and EO-ALERT experiment data testing
  - Workshop 2 – Satellite developers and End Users (Madrid)

Planned Exploitation

- Actively searching for an IOD opportunity
- Pursuing commercial uptake
  - Individual techologies
  - Full data chain solution
- Core customer
- Planning evolutions of EO-ALERT solution

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 (ATB) and EO experiment
- Technologies and solution ready for exploitation starting end of 2019

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AEMET — Agencia Estatal de Meteorología

EUMETNET — European Meteorological Services Network

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