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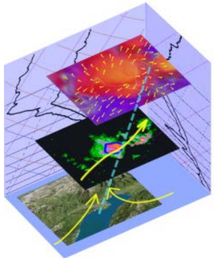


# IDENTIFICATION OF DEVELOPING SEVERE CONVECTIVE CELLS OVER THE ALPINE REGION BY MERGING SATELLITE, RADAR AND NWP DATA

**EUMETSAT Fellowship at MeteoSwiss**

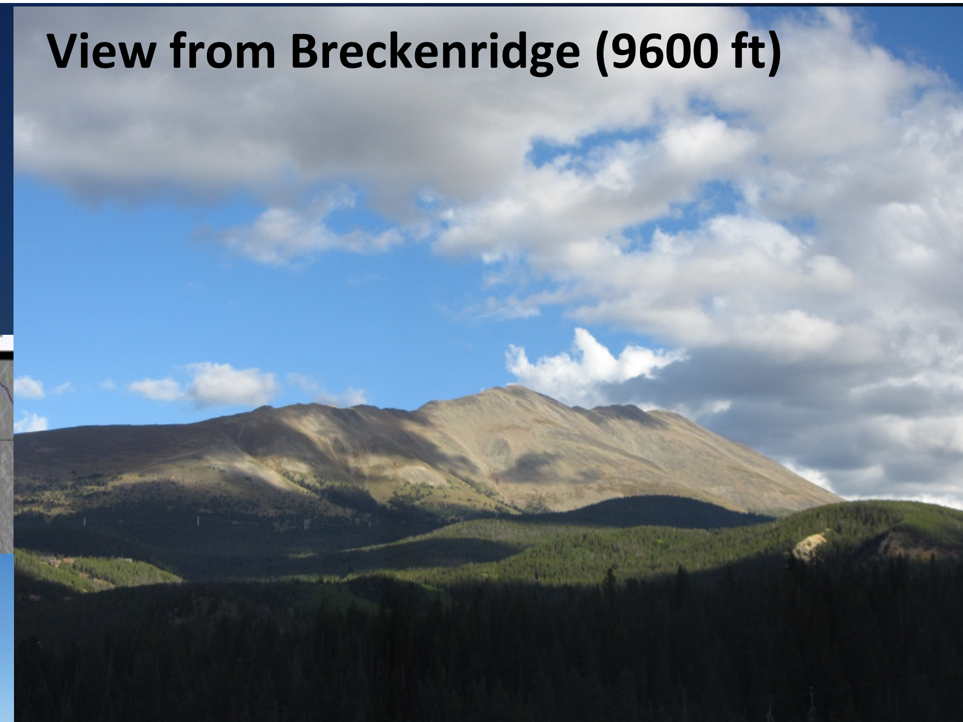
**L. Nisi, P. Ambrosetti, L. Clementi**

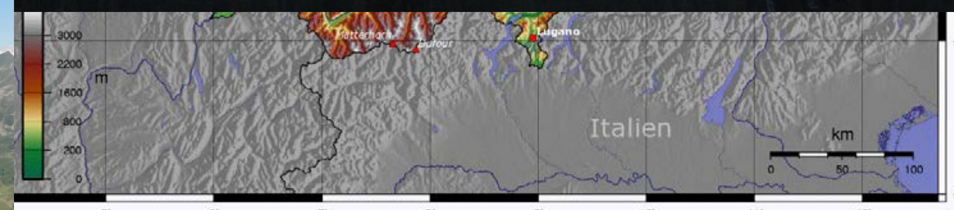
36th Conference on Radar Meteorology, 20th September 2013

# *Severe thunderstorms in Switzerland*

Domain of the Swiss Radar network:

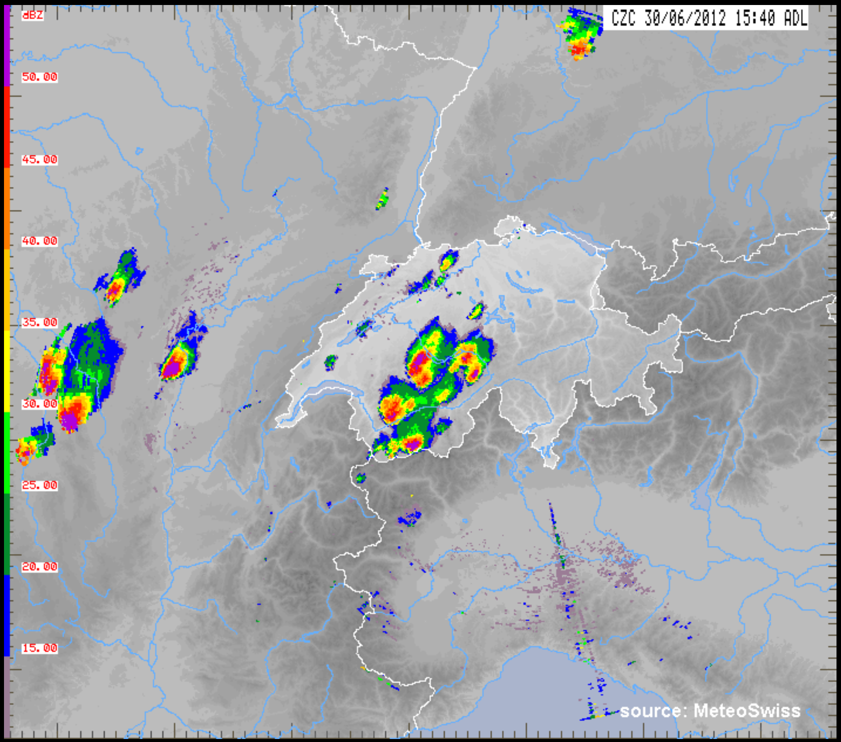

View from Breckenridge (9600 ft)

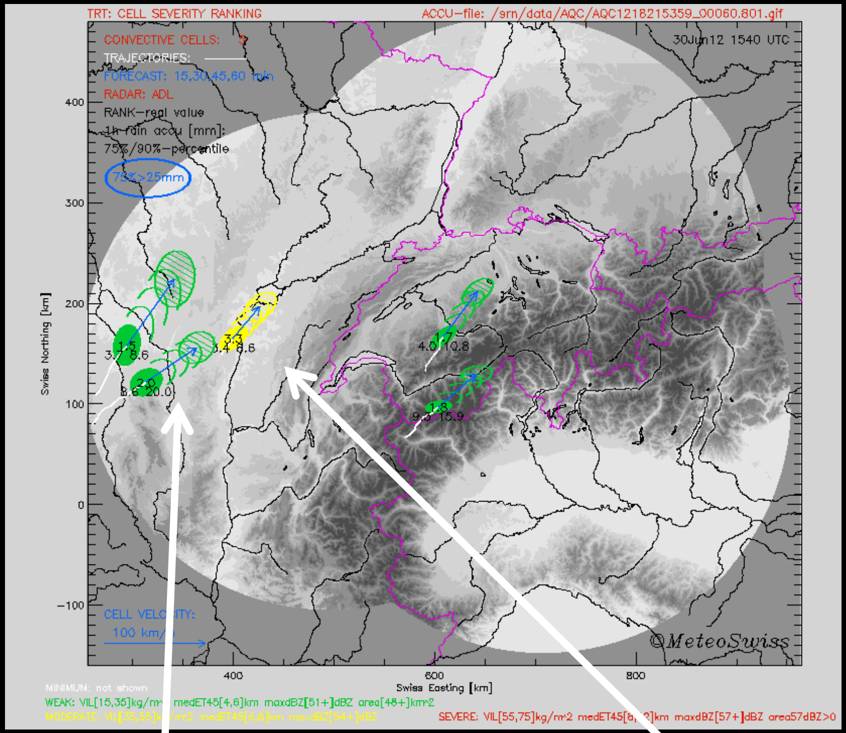





Swiss Alps (view from 8800 ft)

# TRT (Thunderstorms Radar Tracking)




**Cell severity ranking:**

**WEAK (L1)**

**MODERATE (L2)**

**SEVERE (L3)**

based on vertically integrated liquid water **(VIL),** 45 [dBZ] echo top and max echo [dBZ]

**Legend:**

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

***Hering et al., 2004***

# *Severe thunderstorm warning chain*

1. DATA SOURCES → new strategies, new systems, higher resolutions
2. ALGORITHMS → early detection, robust and automatic systems
3. FORECASTERS → build a strong experience using the algorithms
4. WARNINGS → simple, automatic warnings with the supervision by the forecaster
5. BROADCASTING → efficient dissemination system
6. END-USERS → different warnings for different users types

Efficient warnings → all the elements of the chain have to be optimized, first of all the early detection of potential damaging severe thunderstorms

# *Goals*

- ***What are we trying to improve?***

  - early detection of severe thunderstorm cells and nowcast their intensity evolution

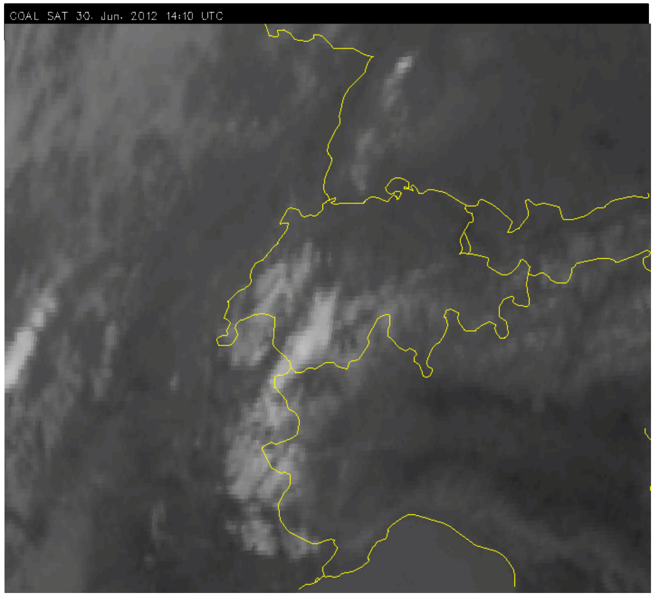
- ***What is the idea behind COALITION?***

  - merge selected data (radar, satellite, NWP, lightning, topography) using blending techniques packed into a heuristic model

- ***What is the output?***

  - a frequent updating map (5 min) where the cells, for which the **COALITION forecast** shows a high probability to increase the intensity, are highlighted

**COALITION forecast:**




strong cloud top cooling in the next 15 min forecasted

convection intensification in the next 30 min forecasted

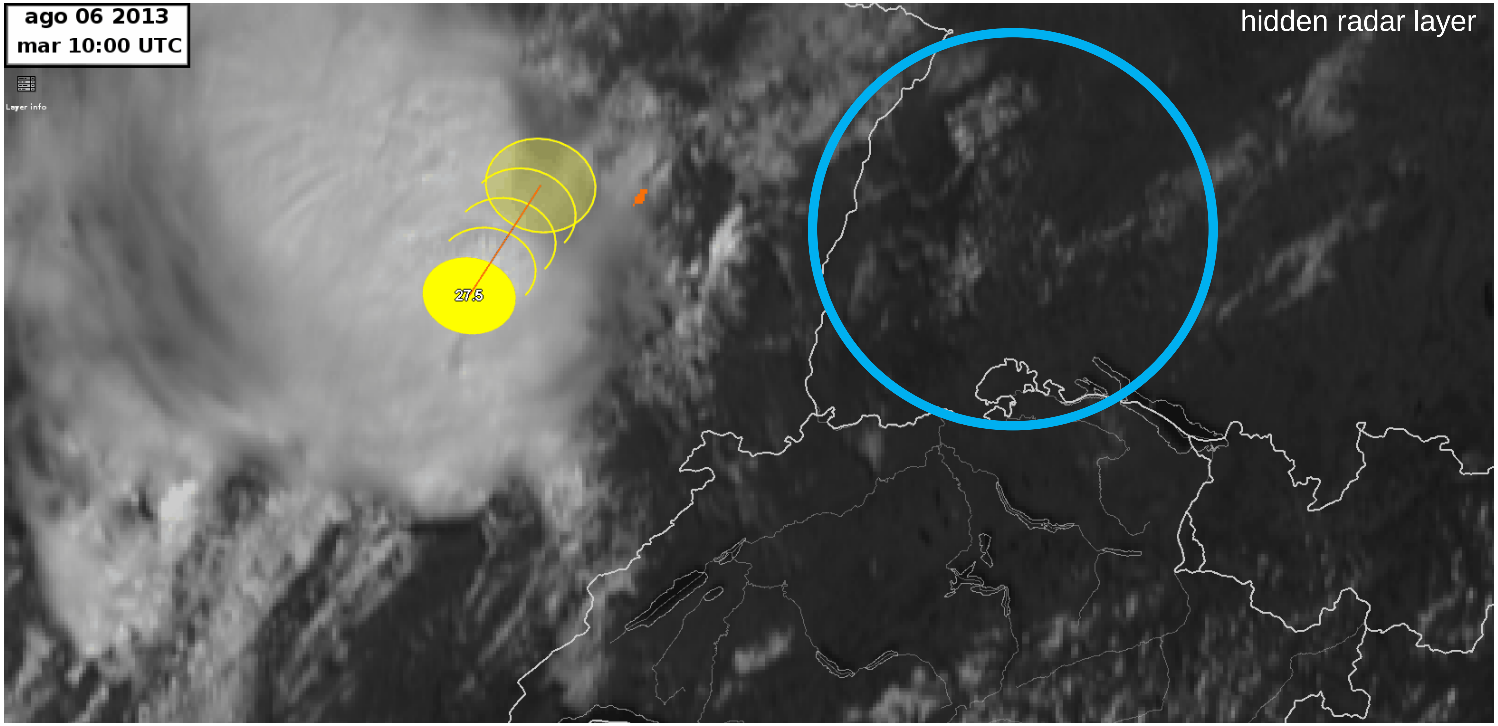
development of severe convection in the next 30 min forecasted

- ***Which are the users?***

  - *weather forecasters* (→warnings)

  - automatic ingest in NWC system TRT

# Example: severe thunderstorms 06.08.2013



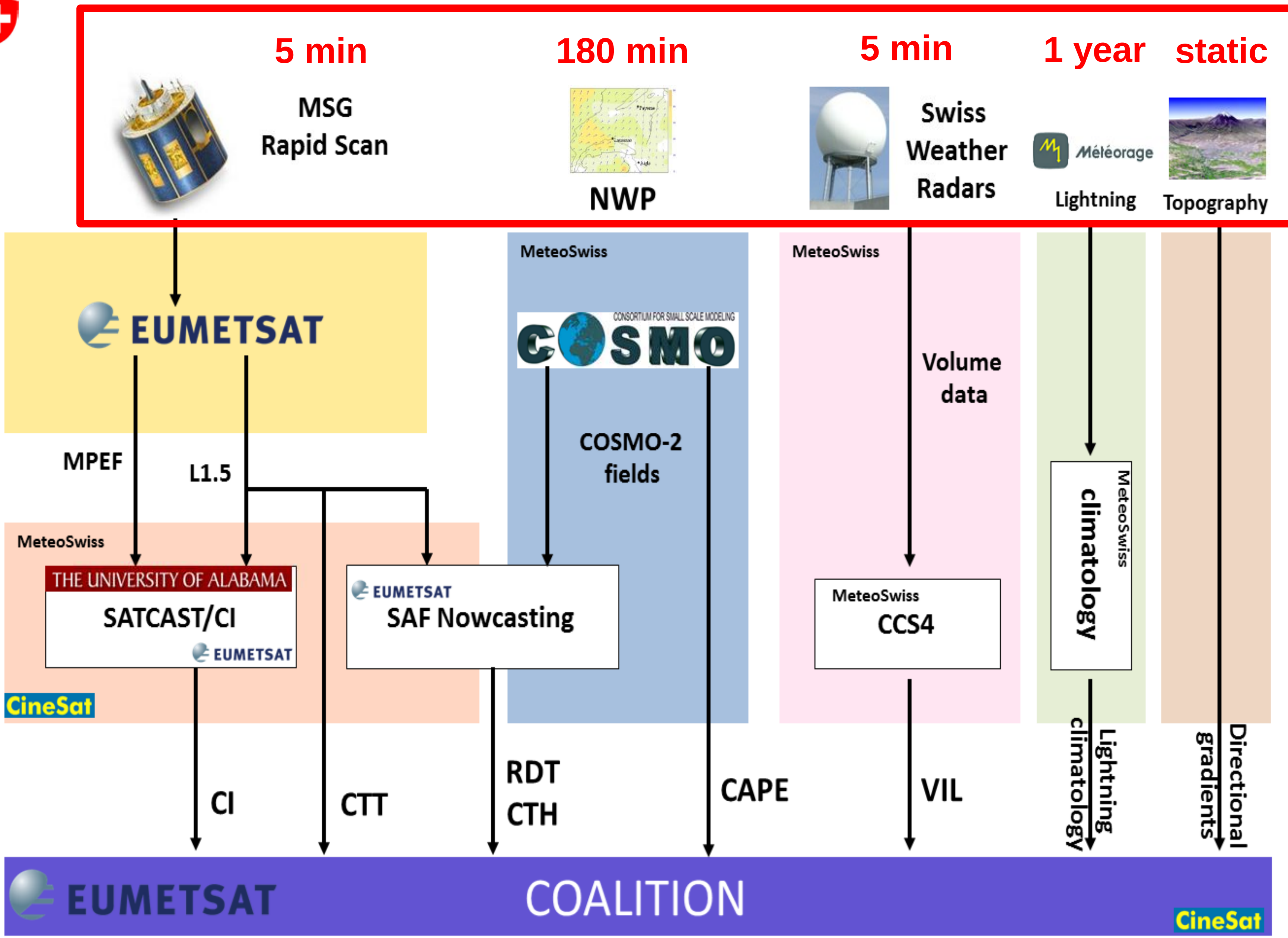

## COALITION:

- considerable cooling of the cloud top expected within the next 15 minutes (forecasted cooling > 5 °C). This doesn't mean the cell necessarily develop into a severe thunderstorm, but convection initiation is very likely to occur
- cell's intensity is likely to increase within the next 30 minutes (expected VIL between 15 and 22 kg/m2)
- cell expected to develop to a severe storm within the next 30 minutes (forecasted VIL > 22 kg/m2)

## TRT:

- WEAK
- MODERATE
- SEVERE

# *Input data*



5 min
MSG
Rapid Scan
180 min
NWP
5 min
Swiss
Weather
Radars
1 year
Météorage
Lightning
static
Topography
EUMETSAT
MPEF
L1.5
MeteoSwiss
THE UNIVERSITY OF ALABAMA
SATCAST/CI
EUMETSAT
CineSat
EUMETSAT
SAF Nowcasting
MeteoSwiss
CONSORTIUM FOR SMALL SCALE MODELING
COSMO
COSMO-2
fields
MeteoSwiss
Volume
data
MeteoSwiss
CCS4
MeteoSwiss
climatology
CI
CTT
RDT
CTH
CAPE
VIL
Lightning
climatology
Directional
gradients
EUMETSAT
COALITION
CineSat

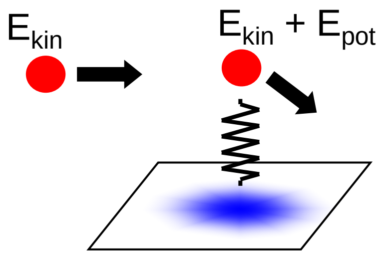
# Predictands and predictors

| Predictands (thunderstorm attributes) | |
|---|---|
| Cloud Top Temperature and Height (CTTH) | dCTT/dt and VIL are selected as identifiers of thunderstorm intensity |
| Vertically integrated liquid content (VIL) | |

| Predictors (convective potentials) | Description | Reference |
|---|---|---|
| **Cloud Top Temperature (CTT)** | - cloud top cooling | *e.g. Roberts and Rutledge, 2003, Zinner et al., 2008* |
| **Convection Initiation (CI)** | - cloud glaciation<br>- cloud growth and cooling<br>- updraft depth | *Mecikalski et al., 2008* |
| **Conv. Av. Potential Energy (CAPE)** | - atmospheric stability | *e.g. Doswell and Bosart, 2001* |
| **Directional Gradients (DGRAD)** | - orographic-induced invigoration | *e.g. Pocakal et al., 2009, Saxen et al., 1999* |
| **Lightning Climatology** | - ''historical information'' to highlight preferred regions for thunderstorms | - |

# *Methodology : an overview*

→ *Nisi L., Ambrosetti P., Clementi L., 2013. Q. J. R. Meteor. Soc. (accepted)*




- The COALITION methodology borrows the approach from the physics of general dynamic systems

- For **analogy**, the interaction of the storm attribute (**predictand**) with the surrounding environment (**predictors**), is modeled as a particle-field interacting system

- A **pseudo-kinetic energy** is estimated from the rate-of-change in time of attributes describing the objects (CTT or VIL, **predictand**)

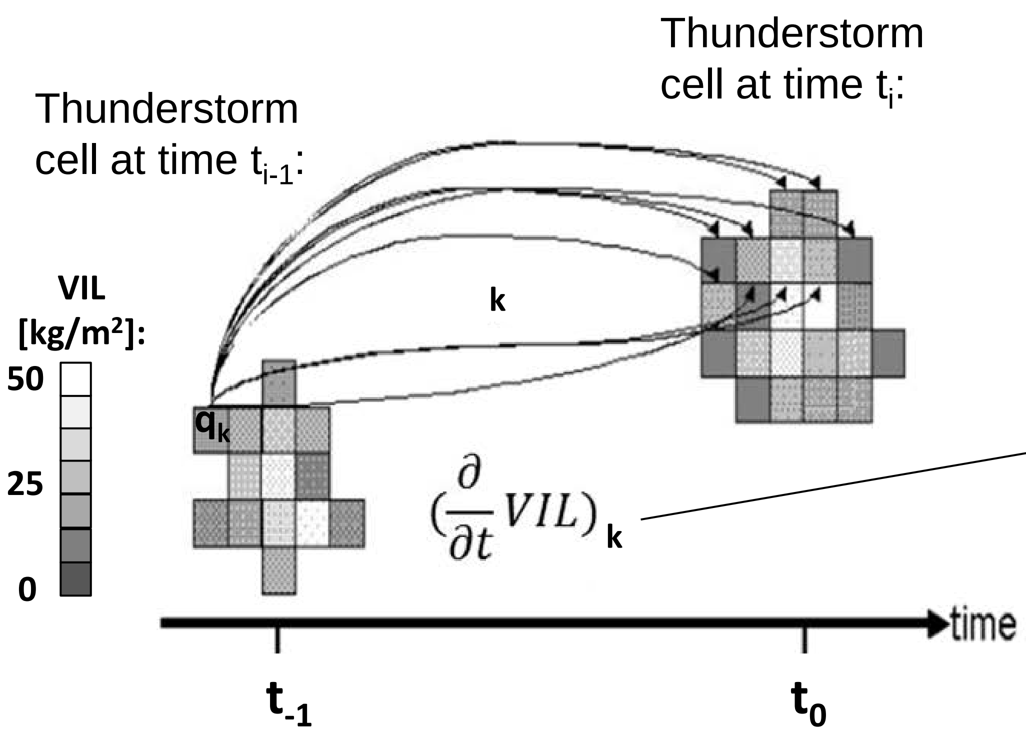
- A **pseudo-potential energy** is estimated by including the evolution of the surrounding environment

- For each convective cell **total energy** conservation is assumed (Hamilton) over the time (i.e. no dissipation):

$$\boxed{E_{tot} = E_{kin} + E_{pot}}$$

# *Methodology: cell based pseudo kinetic energy*

Example considering the **VIL** as predictand:




**Storm kinetic energy:**

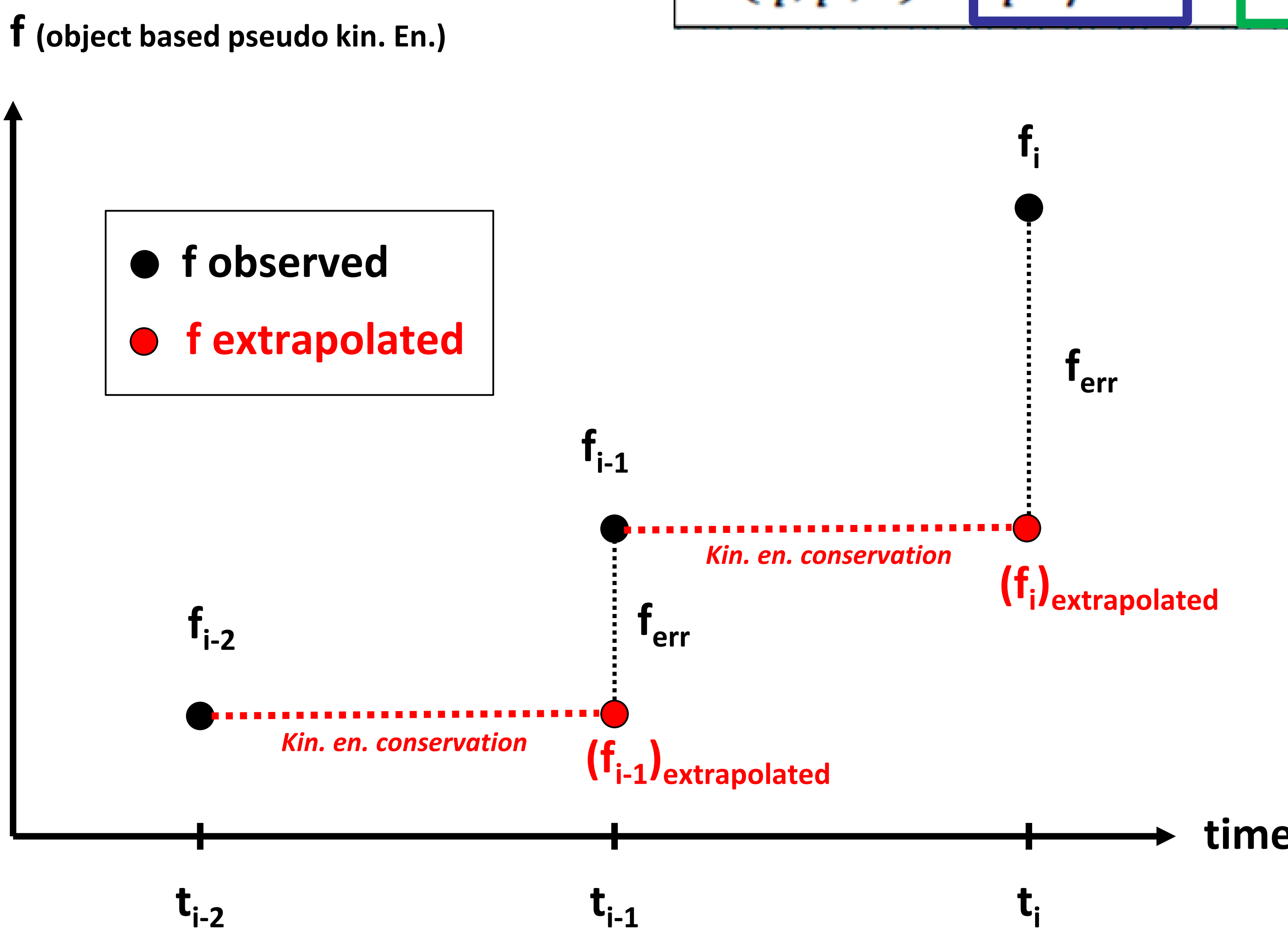
$$f_k = 1/2 * [\dot{q}_k(t_0)/q_k(t_0)]^2$$

# Methodology : energy conservation principle

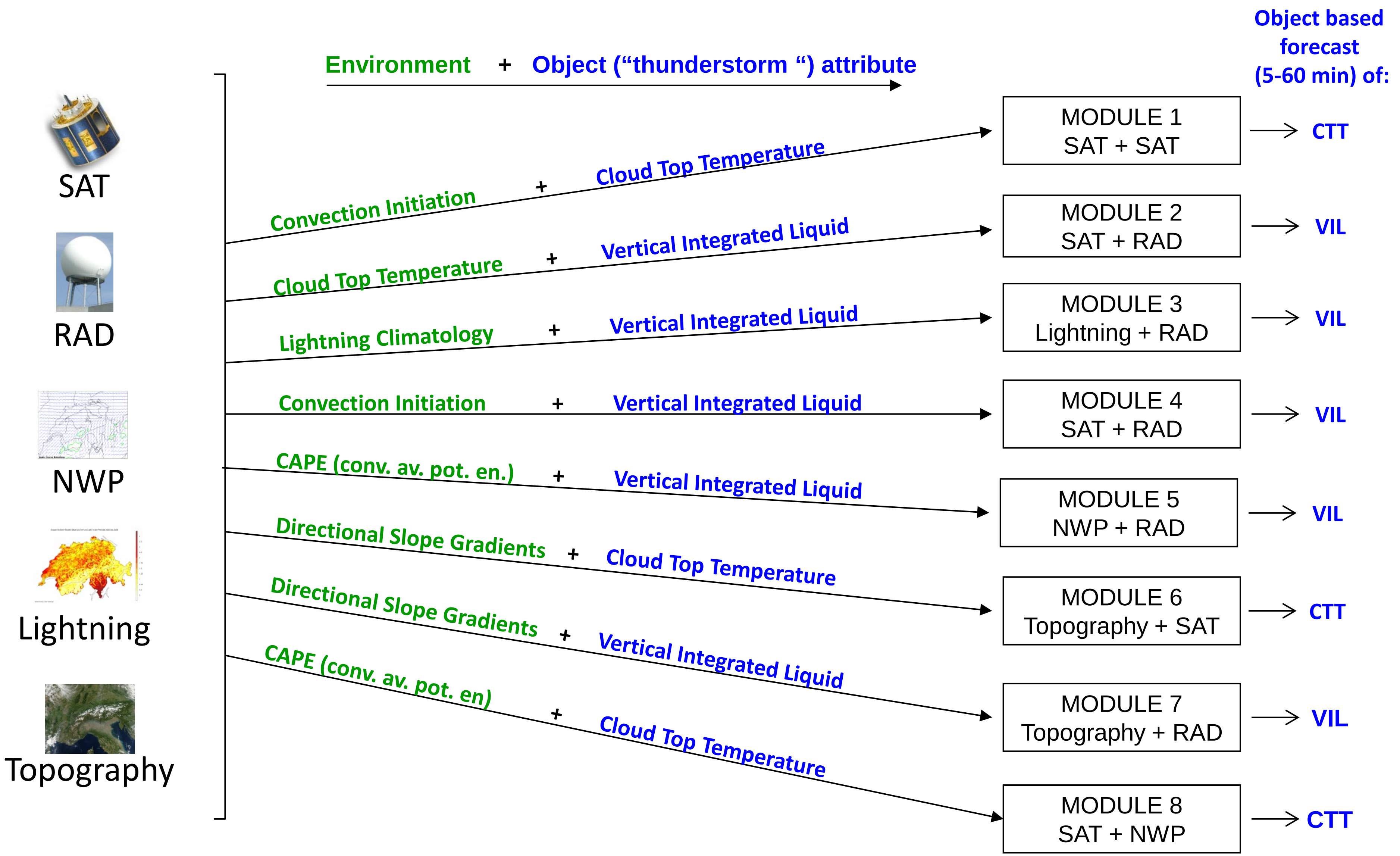
$$H(q,p,t) = \overbrace{\boxed{p^2/2m}}^{E_{kin}} - \overbrace{\boxed{A * f(t)q^2}}^{E_{pot}}$$

corr($f_{err}$, $d\delta$)

where $\delta$: g(predictor)



# Methodology: 8 COALITION integration modules




+ other data for parallax correction, graphical visualization (…)

# *Performance statistics*

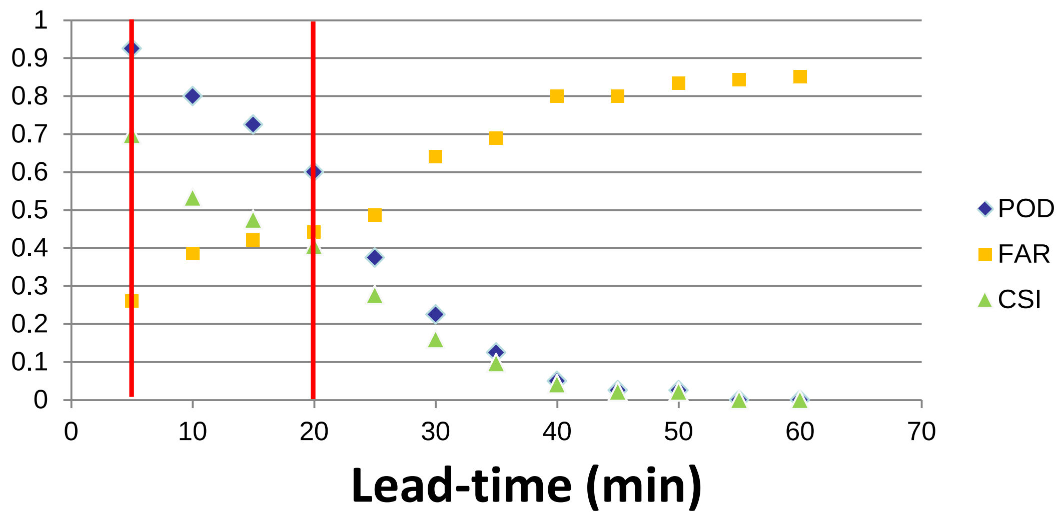
**Population:**
- total **80** thunderstorms (2012) analyzed:
- 40 moderate or severe (→POD)
- 40 weak or not detected by TRT (→FAR)

**5 min** leadtime:
**POD: 0.92**
**FAR: 0.26**
**CSI: 0.70**

**20 min** leadtime:
**POD: 0.60**
**FAR: 0.44**
**CSI: 0.40**

**POD: Probability of Detection**
**FAR: False Alarm Ratio**
**CSI: Critical Success Index**

| Lead-time | POD | FAR | CSI |
|---|---|---|---|
| **5** | 0.925 | 0.260 | 0.698 |
| **10** | 0.800 | 0.385 | 0.533 |
| **15** | 0.725 | 0.420 | 0.475 |
| **20** | 0.600 | 0.442 | 0.406 |
| **25** | 0.375 | 0.487 | 0.276 |
| **30** | 0.225 | 0.640 | 0.160 |
| **35** | 0.125 | 0.689 | 0.097 |
| **40** | 0.050 | 0.800 | 0.041 |
| **45** | 0.025 | 0.800 | 0.022 |
| **50** | 0.025 | 0.834 | 0.022 |
| **55** | 0.000 | 0.843 | 0.000 |
| **60** | 0.000 | 0.850 | 0.000 |




| | | OBSERVATION | |
|---|---|---|---|
| FORECAST | | SEVERE | WEAK |
| | SEVERE | A | B |
| | WEAK | C | D |

POD = A / ( A + C)

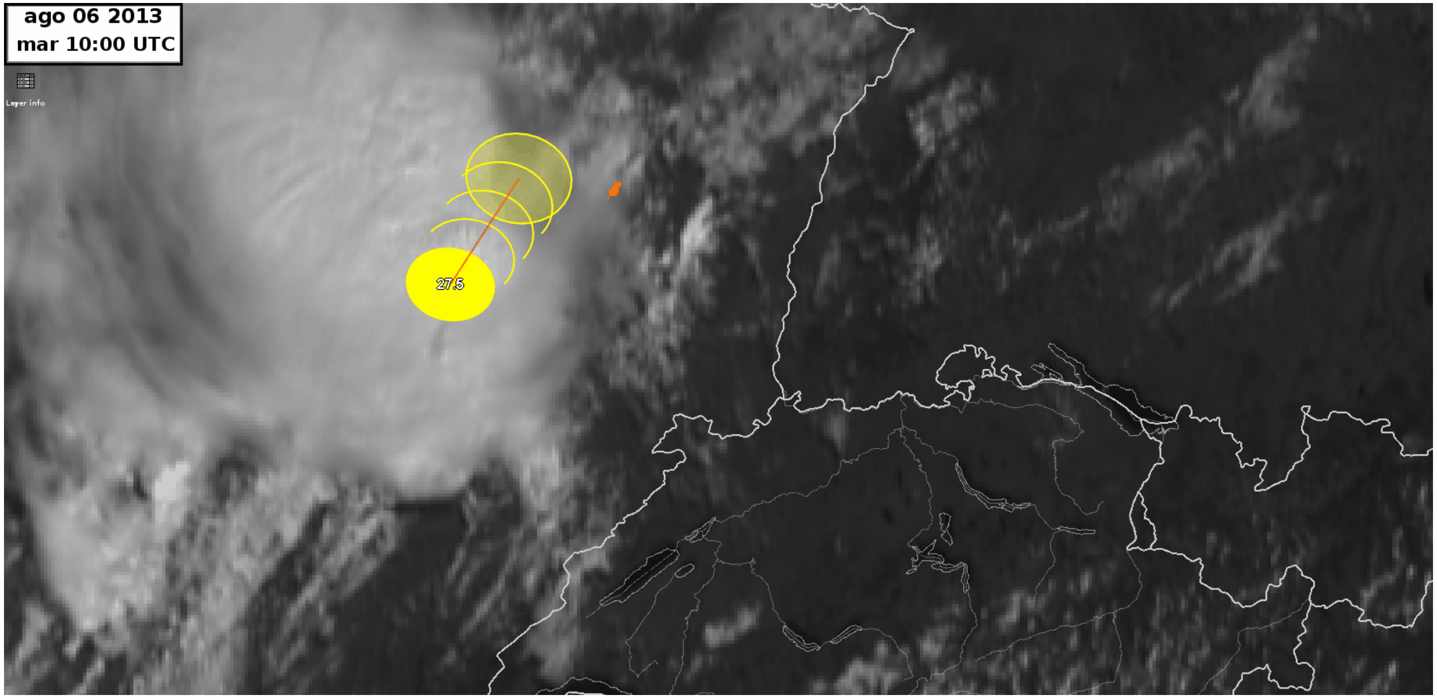
FAR = B / ( A + B)

# Conclusions and outlook

- COALITION is a Nowcasting system for the identification of developing severe thunderstorms
- Integrates data from MSG-RSS, radar, NWP, lightning and DHM
- Designed for the operational use, satisfies Nowcasting requests → operational at MeteoSwiss since May 2013
- Integration in a single Nowcasting system "TRT + COALITION"
  → POSTER NR. 348 (Hering et al.)
- Additional modules with other environmental parameters (low level moisture convergence, real time lightning, PV fields, ..)
- Tuning for later convection phase (decaying phase)
- *Nisi L., Ambrosetti P., Clementi L., 2013. Q. J. R. Meteor. Soc. (accepted)*

*Acknowledgements*

# Thank you!

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