



Satellite-based thunderstorm tracking, monitoring and nowcasting over South Africa

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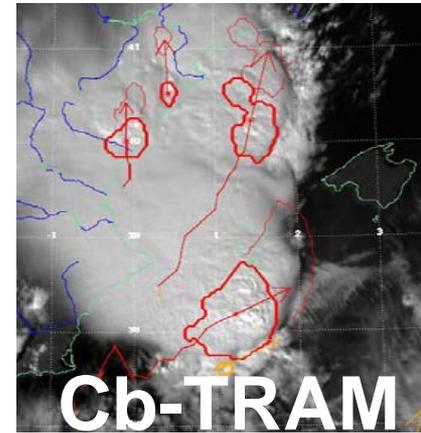
3 Meteorological Institute, University of Munich, Germany



CB-TRAM - Cumulonimbus Tracking And Monitoring

(Zinner, Mannstein, Tafferner, MAP, 2008)

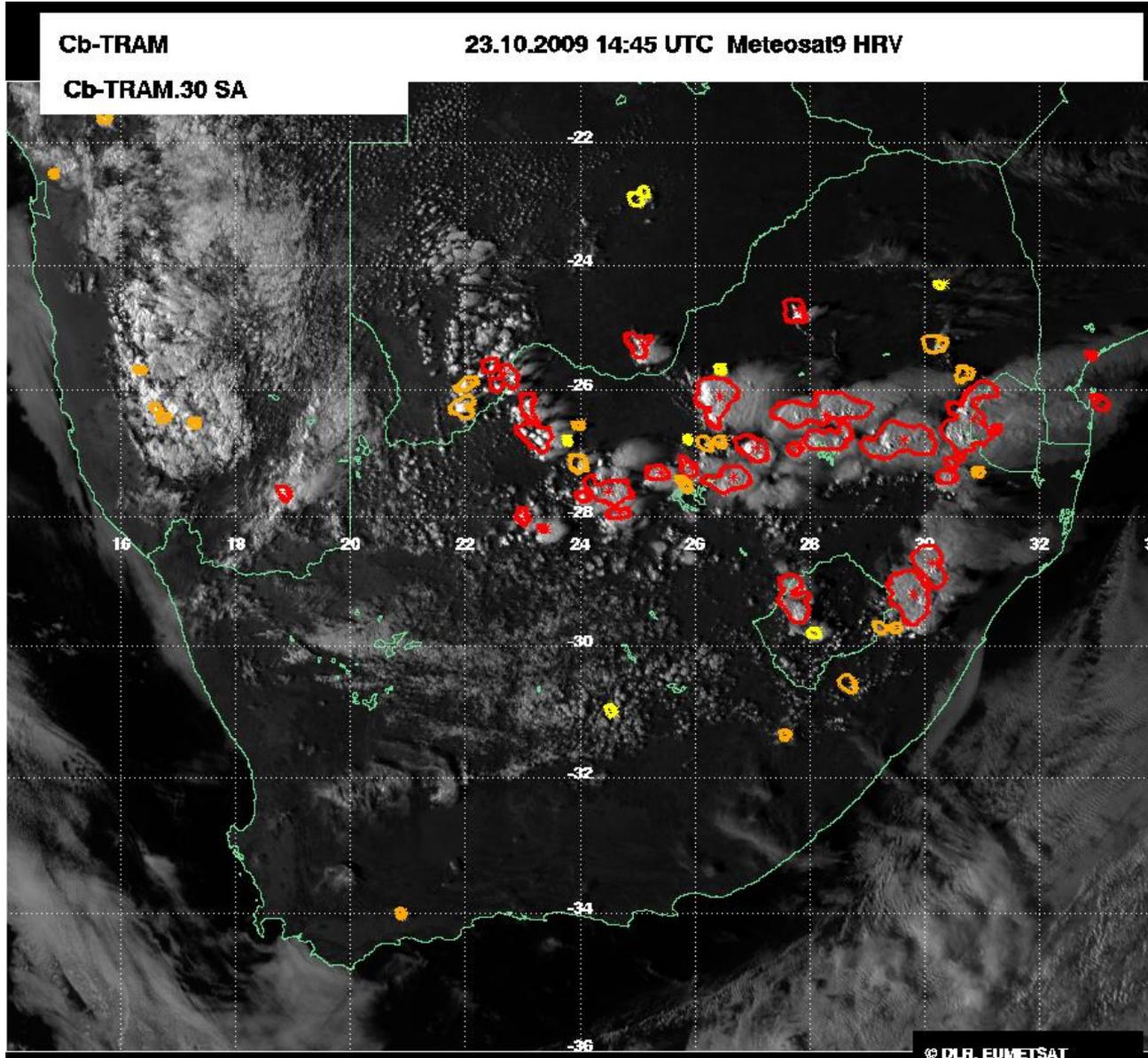
- Algorithm for the detection, monitoring and nowcasting of thunderstorms from space
- Use of Meteosat SEVIRI Data
 - ◆ Combination of HRV, IR10.8, IR12.0 and WV6.2 data for detecting Cb cells
 - ◆ HRV info to localize the most active convective cells (texture in HRV image)
 - ◆ Tracking based on pyramidal image matching algorithm
- Distinction of 3 development stages
 - ◆ (1) First development of clouds (convection initiation)
 - ◆ (2) Rapid development (strong cooling of cloud top)
 - ◆ (3) Mature thunderstorm (reaching or exceeding the tropopause)
- Time resolution 15 min (or even 5 minutes with Meteosat rapid scan data)
- Nowcasts with extrapolation of detected features up to one hour



CB-TRAM applied over South Africa for the first time



➤ adaption of the algorithm (e.g. to the moving HRV)



yellow:
convection initiation (CI)

orange:
rapid development

red:
mature thunderstorm

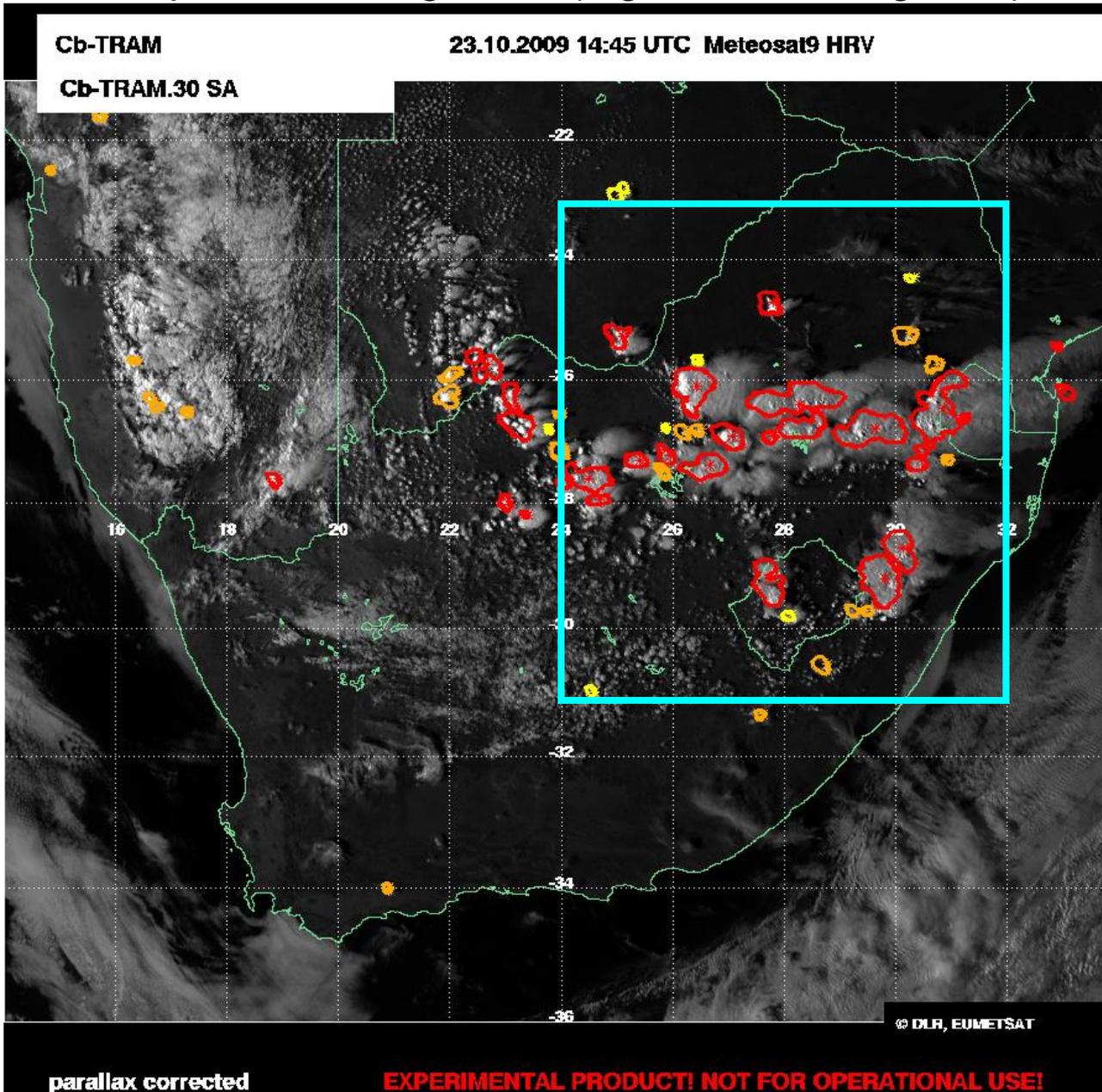
parallax corrected

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CB-TRAM applied over South Africa for the first time



➤ adaption of the algorithm (e.g. to the moving HRV)

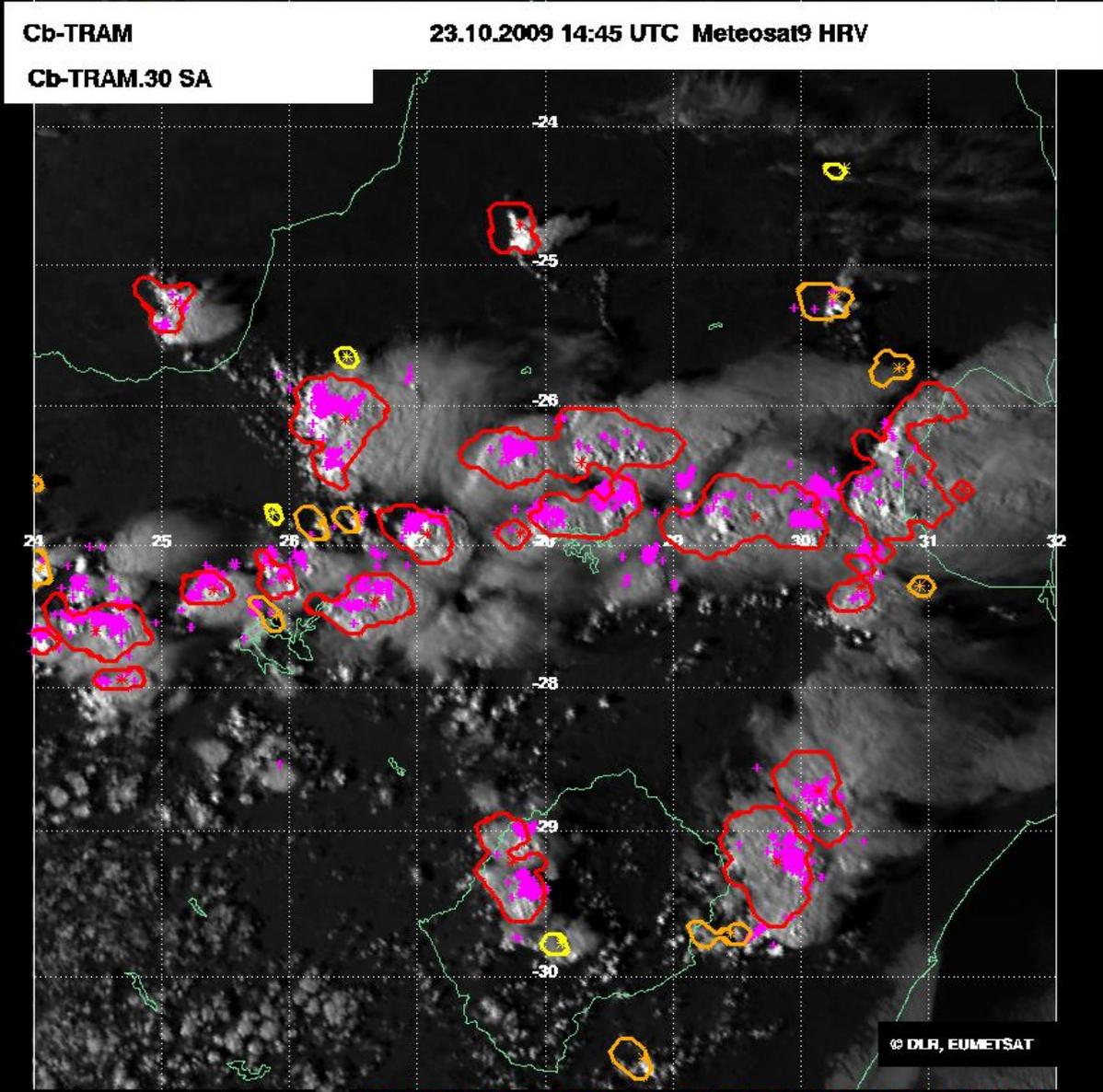


yellow:
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mature thunderstorm

CB-TRAM over South Africa



yellow:
convection initiation (CI)

orange:
rapid development

red:
mature thunderstorm

pink:
lightning incidents

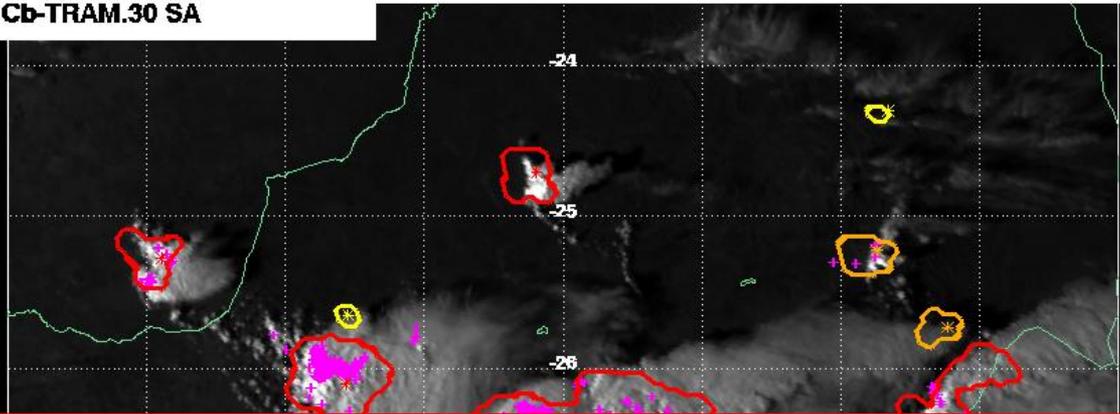
CB-TRAM over South Africa



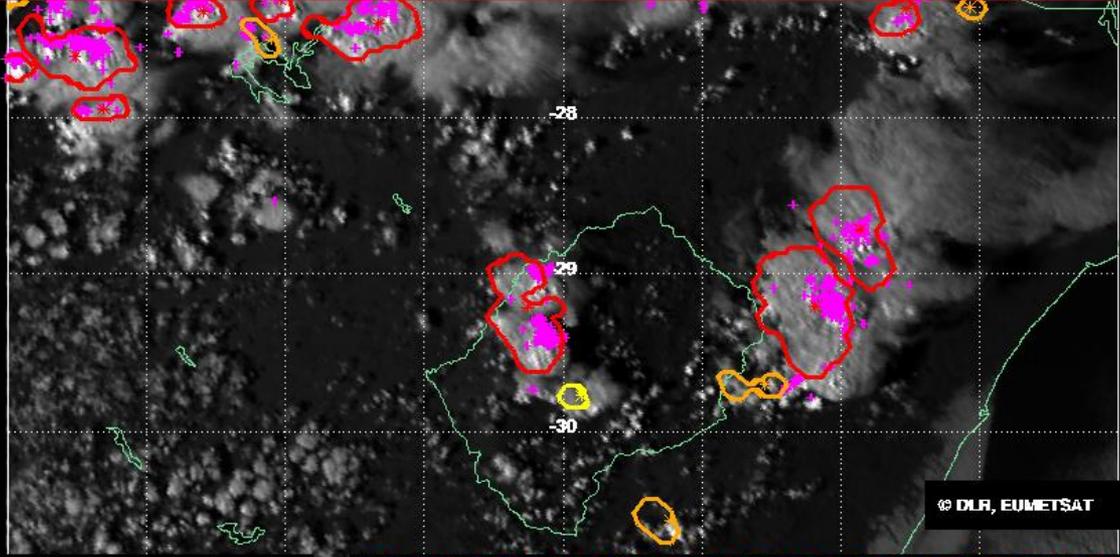
Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



CB-TRAM is able to detect the most turbulent areas within the anvil



yellow:
convection initiation (CI)

orange:
rapid development

red:
mature thunderstorm

pink:
lightning incidents

parallax corrected

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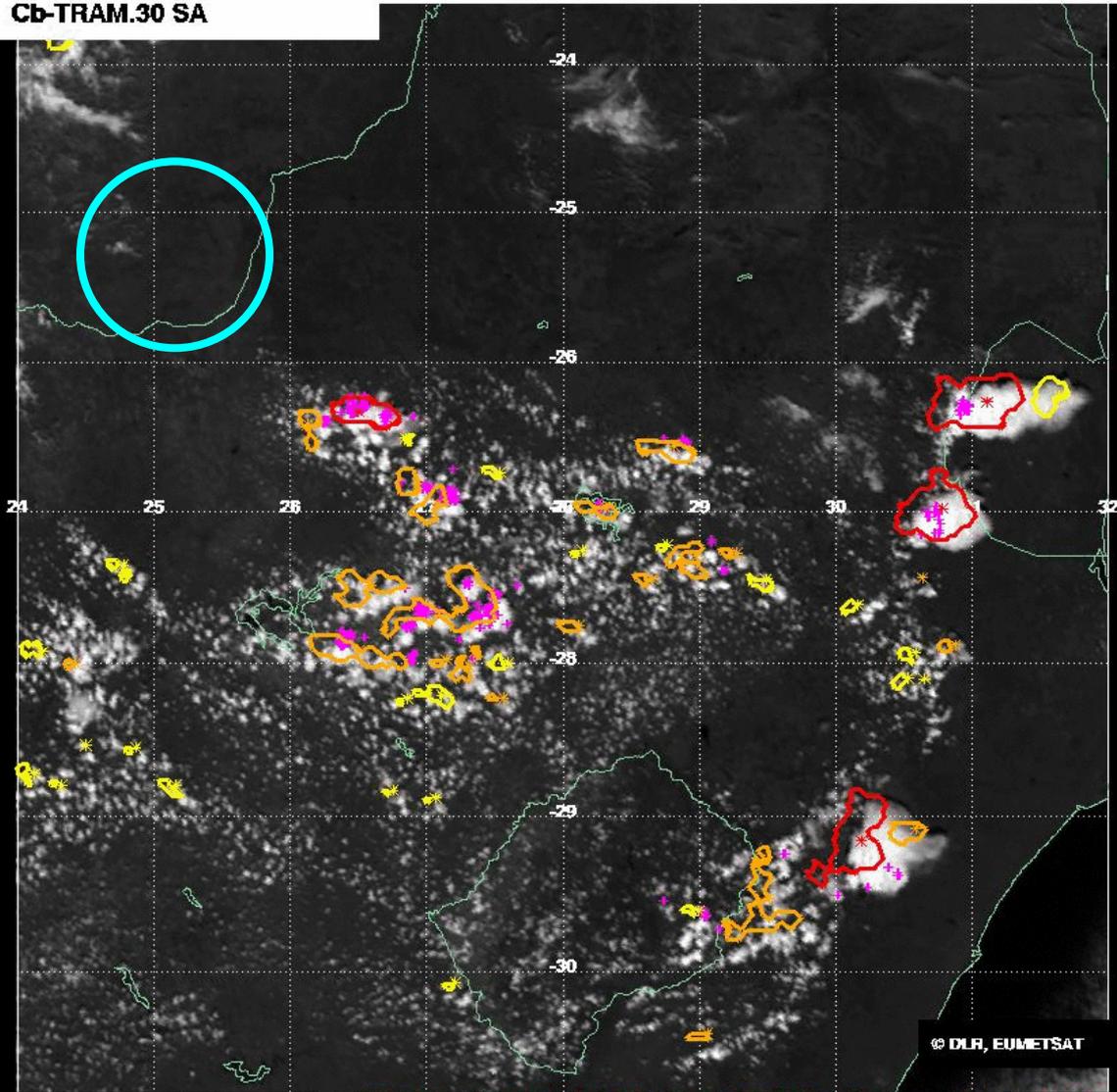
CB-TRAM applied over South Africa



Cb-TRAM

23.10.2009 12:00 UTC Meteosat9 HRV

Cb-TRAM.30 SA



yellow:
convection initiation

orange:
rapid development

red:
mature thunderstorm

pink:
lightning incidents
(0-10 min after image time)

parallax corrected

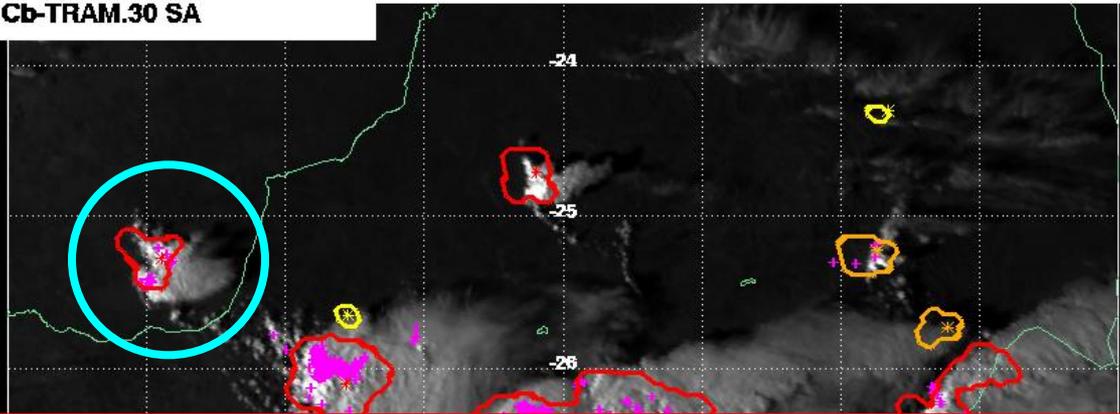
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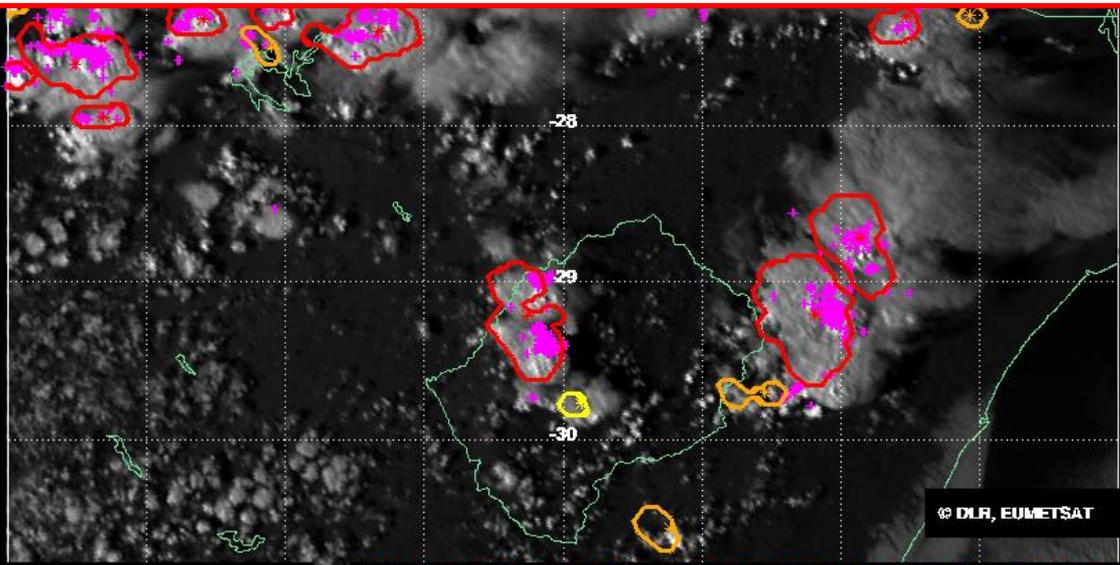
Cb-TRAM over South Africa



Cb-TRAM 23.10.2009 14:45 UTC Meteosat9 HRV
Cb-TRAM.30 SA



Cb-TRAM is able to detect convection initiation before any lightning incidents occur



yellow:
convection initiation (CI)

orange:
rapid development

red:
mature thunderstorm

pink:
lightning incidents
(0-10 min after image time)

parallax corrected

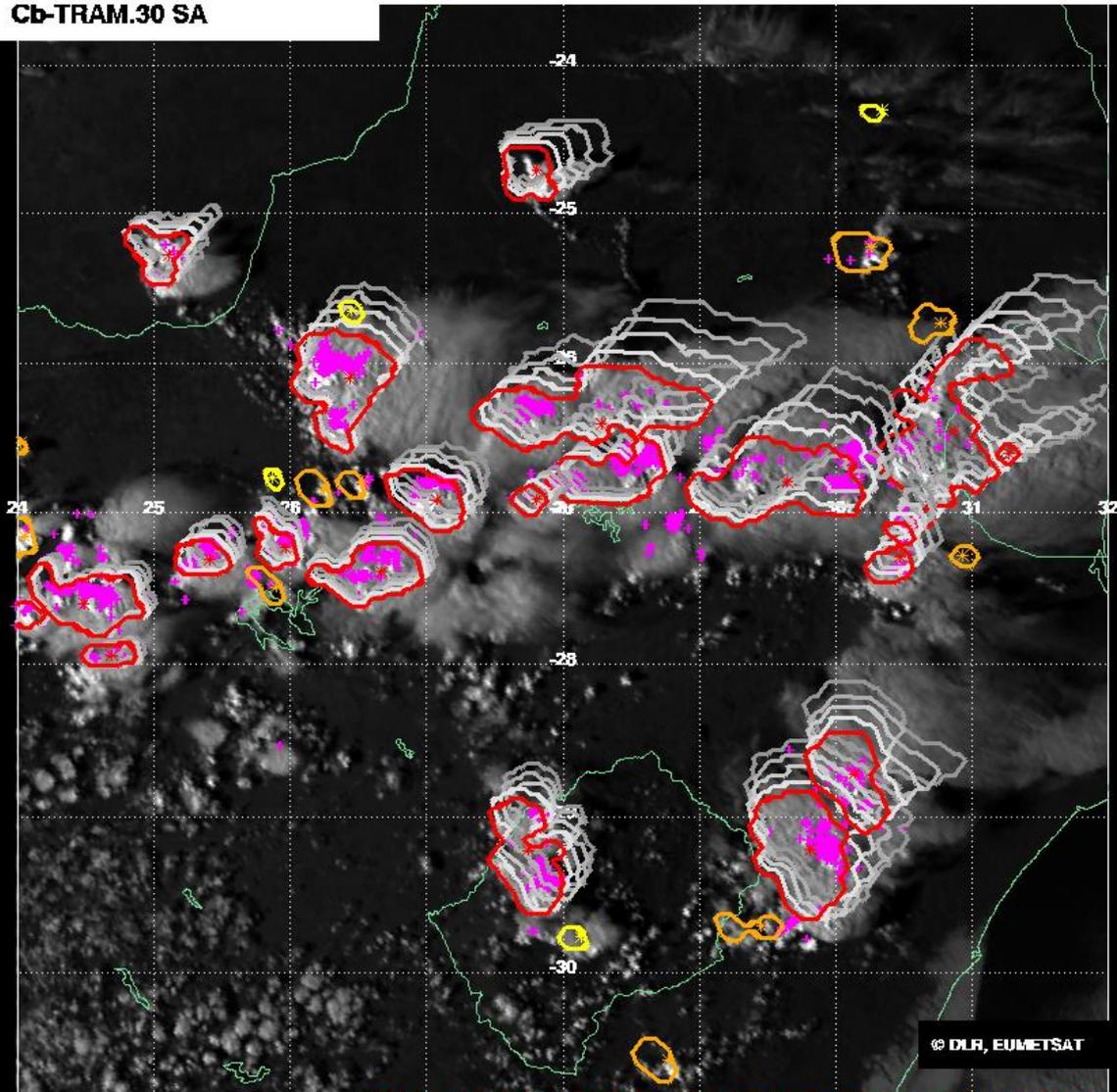
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CB-TRAM over South Africa



Cb-TRAM
Cb-TRAM.30 SA
23.10.2009 14:45 UTC Meteosat9 HRV



yellow:
convection initiation (CI)

orange:
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red:
mature thunderstorm

pink:
lightning incidents
(0-10 min after image time)

grey:
15, 30, 45, 60 Min.
nowcast

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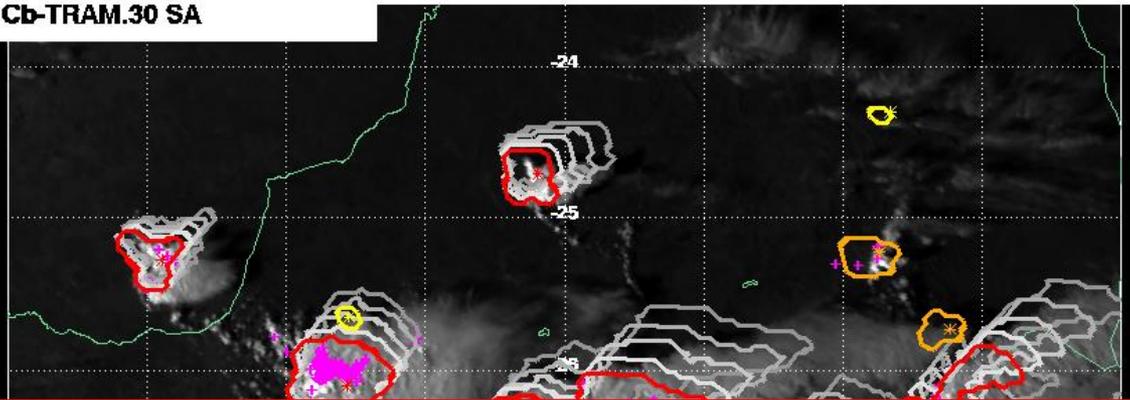
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parallax corrected

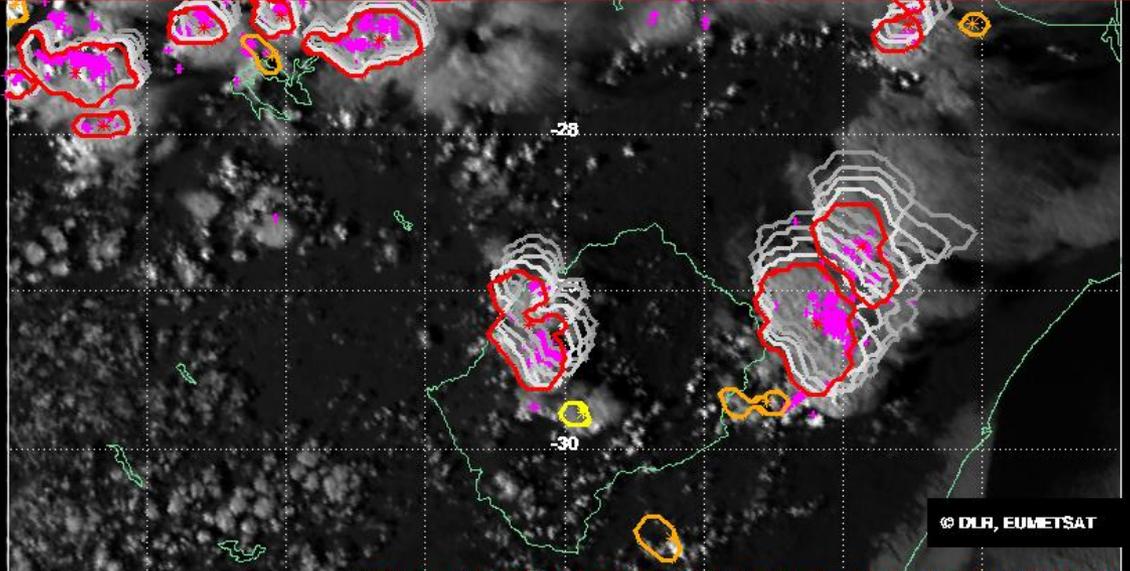
CB-TRAM over South Africa



Cb-TRAM
Cb-TRAM.30 SA
23.10.2009 14:45 UTC Meteosat9 HRV



Cb-TRAM is able to nowcast the development and movement of the Cb cells up to one hour



yellow:
convection initiation (CI)

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pink:
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(0-10 min after image time)

grey:
15, 30, 45, 60 Min.
nowcast

parallax corrected

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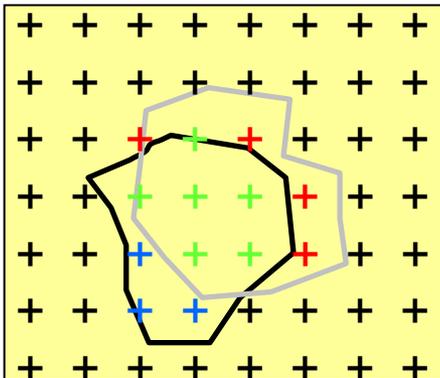
Evaluation of nowcast with detected Cb TRAM cells

pixel-based analysis (requires exact match of objects)

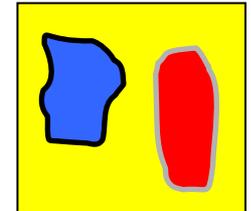
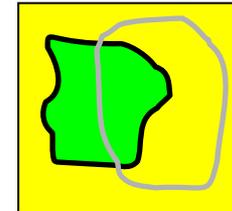
- hit = nowcast matches observation at a pixel
- miss = observation which is not nowcast at a pixel
- false alarm = nowcast which is not observed at a pixel

object-based analysis (does not require exact match of objects)

- hit = nowcast object overlaps observed object
- miss = observed object which is not nowcast
- false alarm = nowcast object which is not observed



black: observed object at time t
grey: nowcast object for time t
blue: misses
red: false alarms
green :hits



$$\text{POD} = \text{hits} / (\text{hits} + \text{misses})$$

$$\text{FAR} = \text{false alarms} / (\text{hits} + \text{false alarms})$$

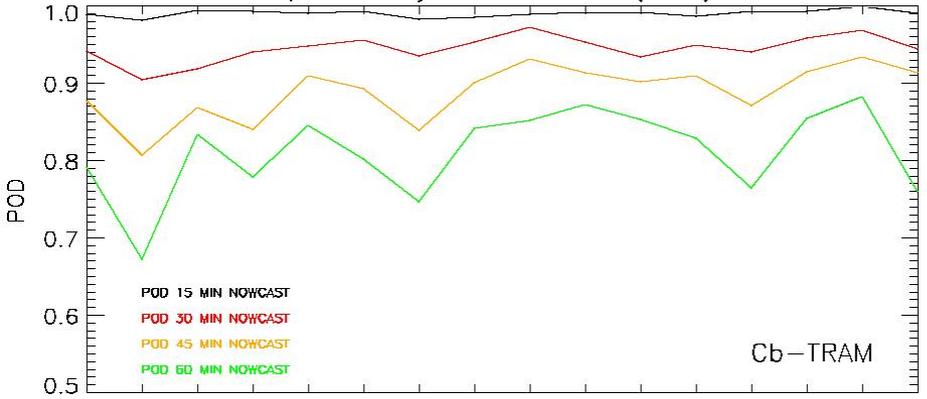
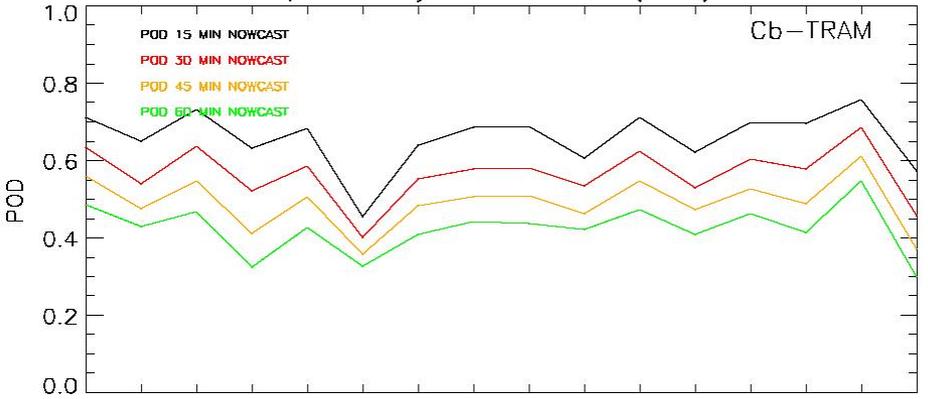
Evaluation of nowcast with detected Cb TRAM cells

pixel-based analysis

object-based analysis (note the scale!)

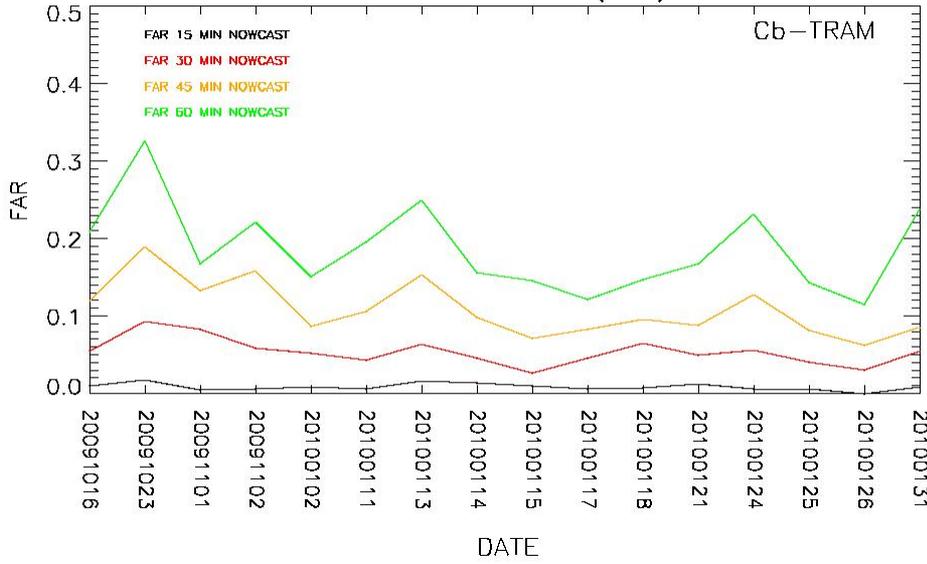
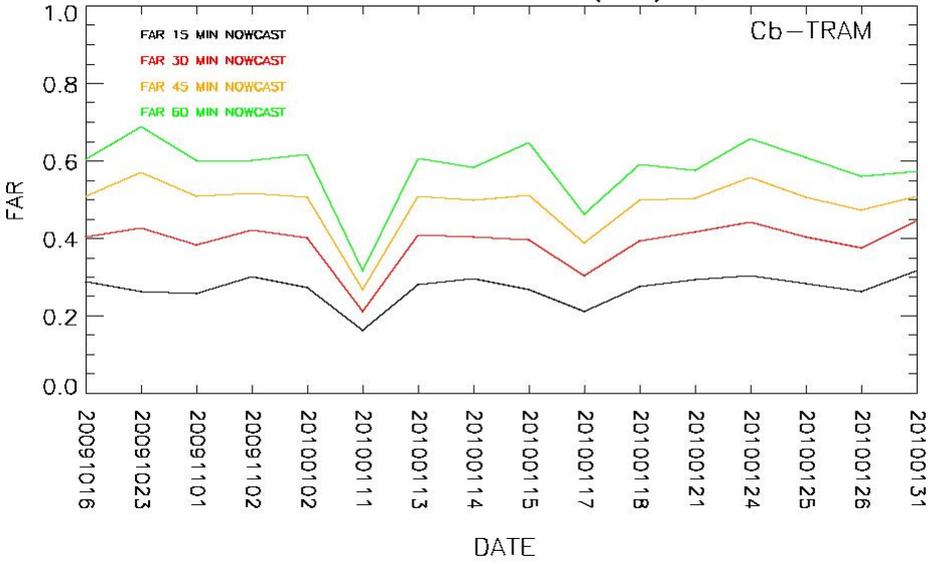
probability of detection (POD)

probability of detection (POD)



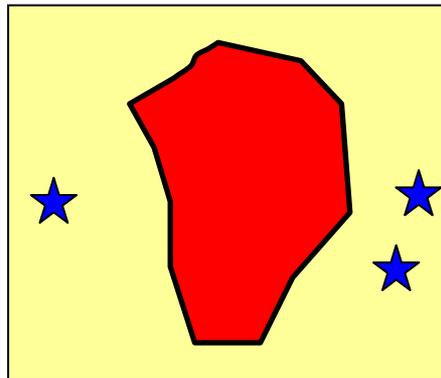
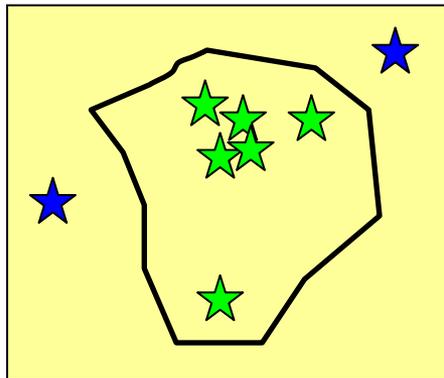
false alarm ratio (FAR)

false alarm ratio (FAR)



Simple evaluation of detected/nowcast Cb TRAM cells with lightning data

- hit = lightning incident inside of Cb-TRAM cell
- miss = lightning incident outside of Cb-TRAM cell
- false alarm = Cb-TRAM cell without lightning

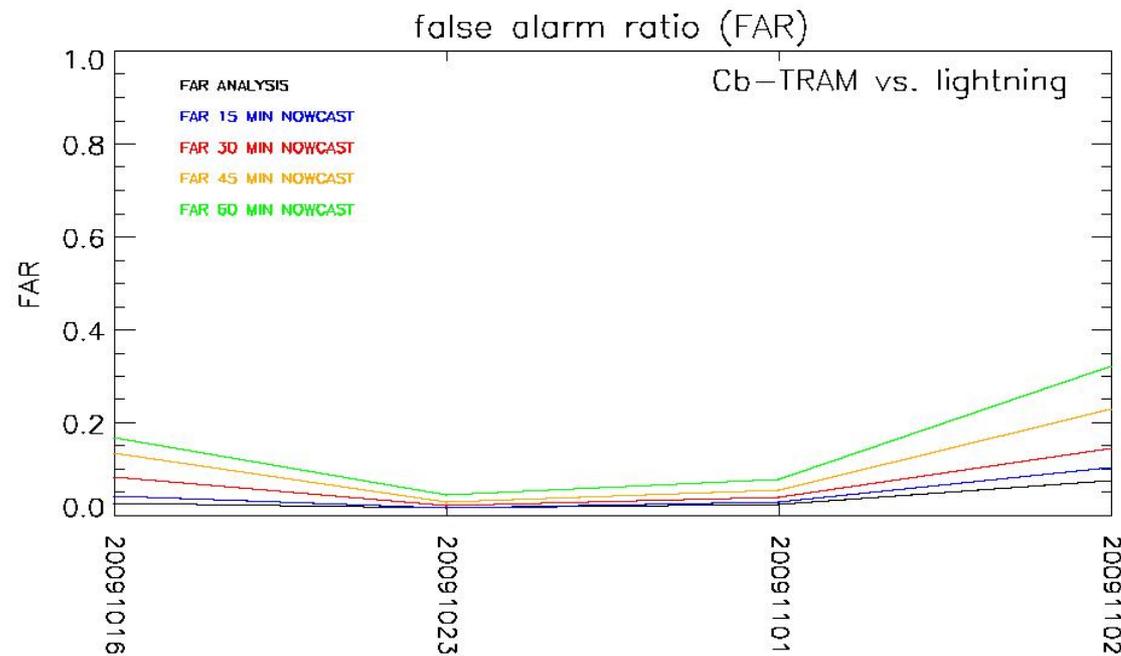
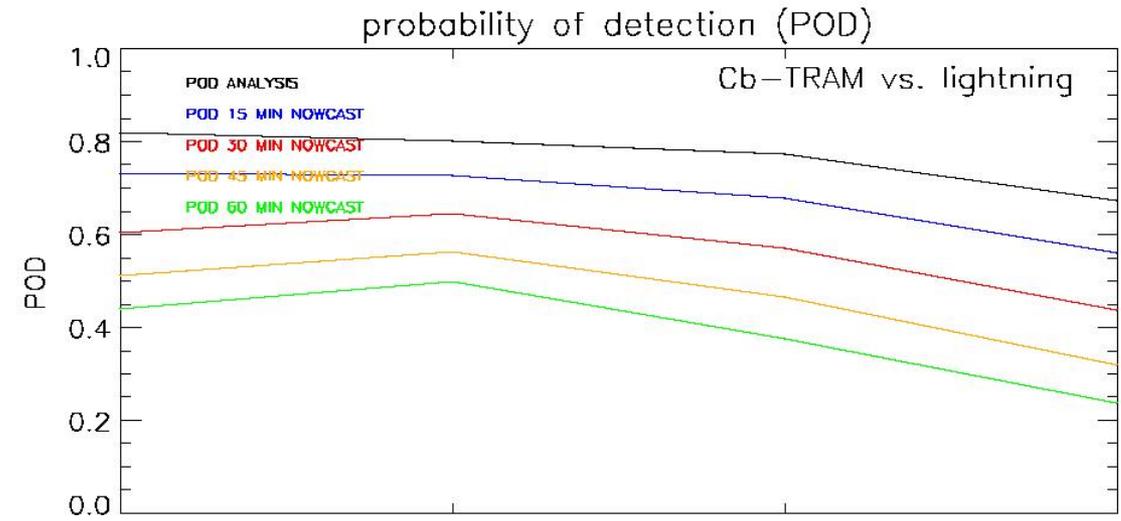


black contour: observed Cb object at time t
green stars: lightning incidents (hits)
blue stars: lightning incidents (misses)
red object: object without lightning (false alarm)

$$\text{POD} = \text{hits} / (\text{hits} + \text{misses})$$

$$\text{FAR} = \text{false alarms} / (\text{hits} + \text{false alarms})$$

Simple evaluation of detected/nowcast Cb TRAM cells with lightning data



note that cells indicating CI and do (correctly) not (yet) contain lightning are also included in this analysis and are counted as false alarms

also single lightning events that do not belong to lightning clusters and are typically not related to Cb-TRAM cells are included and counted as misses

Summary and conclusions

➤ Cb-TRAM

- has successfully been applied over South Africa for the first time
- detects the most active regions within a thunderstorm
- is able to detect convection initiation before any lightning incident occurs
- is able to nowcast the movement and development of thunderstorms up to one hour

➤ The evaluation of nowcast with detected Cb-TRAM cells shows that

- pixel-based POD = 75%, FAR = 25% (15 min nowcast)
- object-based POD = 98%, FAR = 3% (15 min nowcast)
- POD decreases with increasing lead time, while FAR increases
- the nowcasting for lead times greater 30 minutes has to be improved

➤ The evaluation of Cb-TRAM detections and nowcasts with lightning data shows that

- Cb-TRAM agrees generally well with lightning data (POD = 80%, FAR = 5%)

Cb-TRAM is a useful tool for the (early) detection, tracking and nowcasting of thunderstorms over South Africa