

# Nowcasting for aviation purposes in South Africa – a case study: Part1 – Satellite and radar based tools

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South African Weather Service

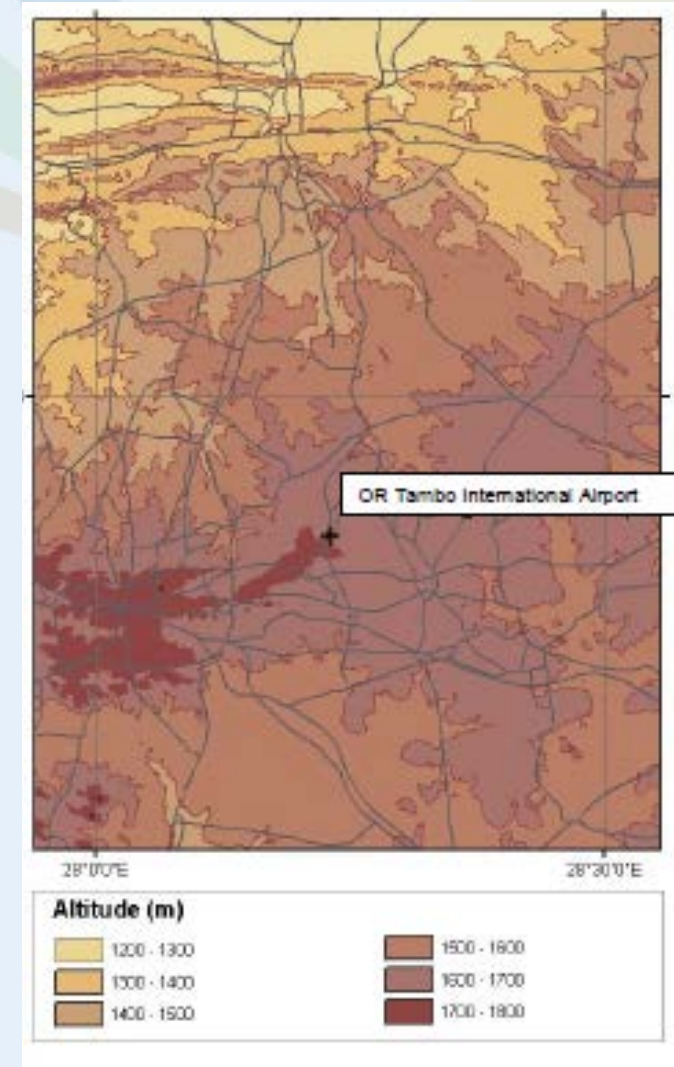


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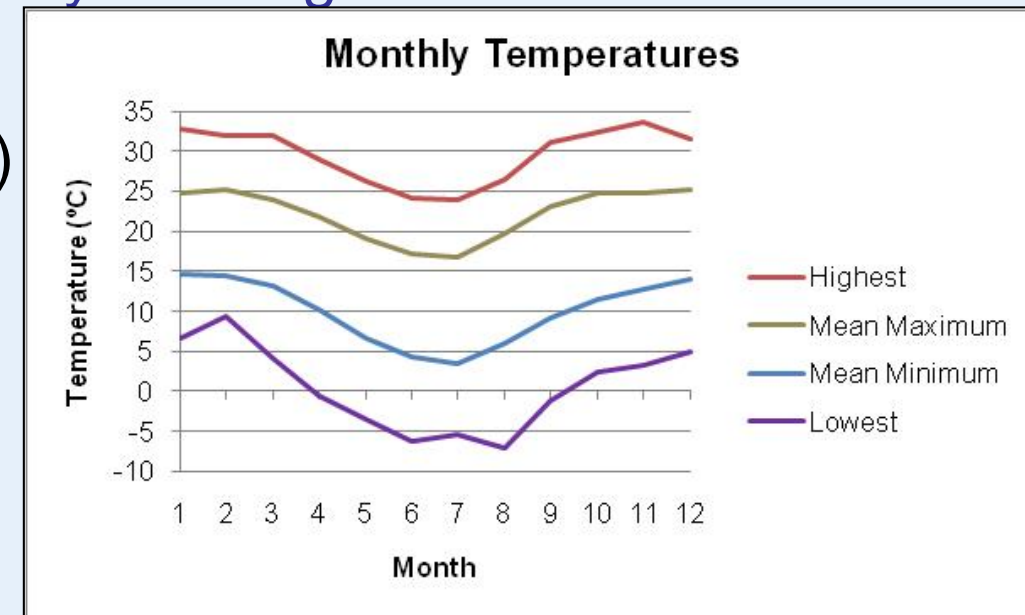
# 1. ORTIA Airport information

- Johannesburg International Airport (ORTIA):
  - 26° 08' 21" S and 28° 14' 46" E
  - 20km east-north-east of the city of Johannesburg and 40km south of Pretoria,
  - situated almost on the plateau of South Africa with two runways, both above 5500ft (1694m) above MSL.
- Surrounding area - sloping gradually from south-west to north-east.
- Highest terrain within a radius of 40km is 1902m to the south of the airport.
- Areas directly around the airport are built up areas.



# 1. Airport local climatology

- Fog: radiation fog/advection from SE, mostly early am (2-3 days per month)
- Low clouds/poor visibility, early am
- Smog: temperature inversion, winter months, early am
- Precipitation: thunderstorms, summer, pm, early evening
- Hail: 5 days per year, Oct-Dec
- Rain: max in Dec/Jan (600-800 mm per year)
- Frost: winter, 30 days per year
- Wind direction: Mostly NW wind
- Wind speed: 3.3-4.6 m/s



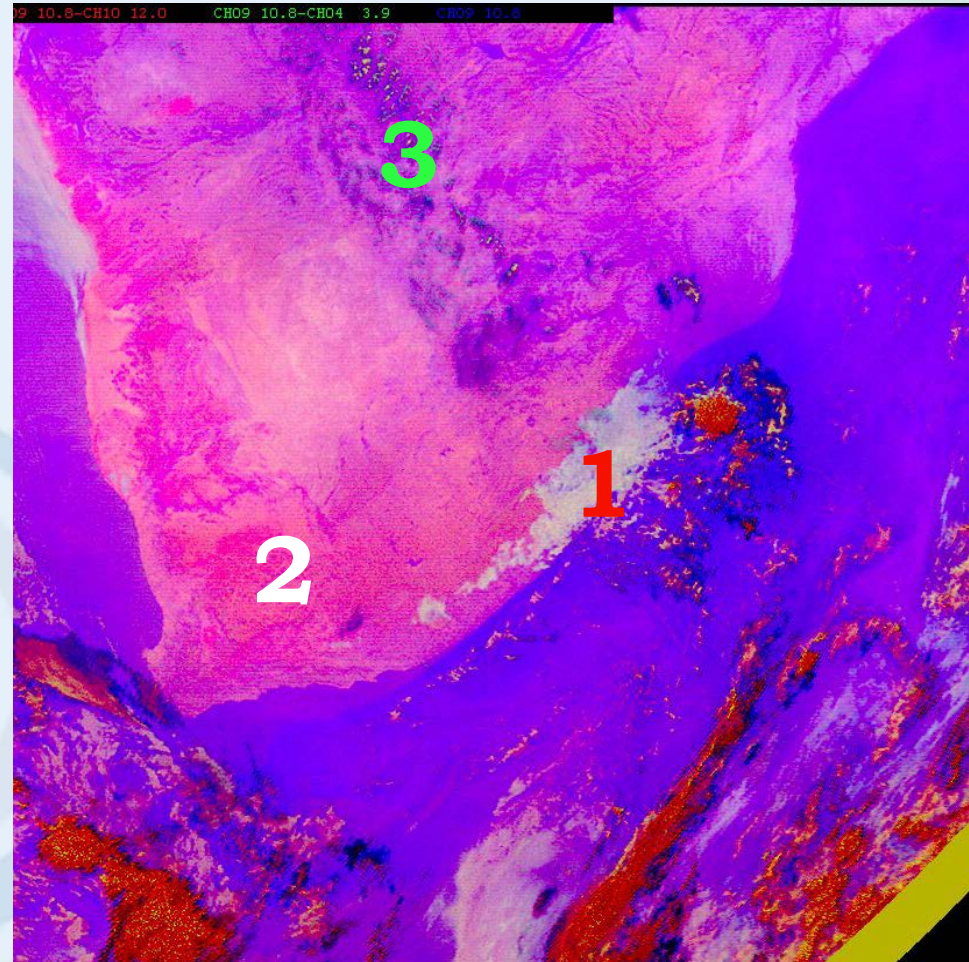
# 2.1 Doppler Weather Radar

- S-band (10.5cm wavelength)
- $\approx 25\text{km}$  N of ORTIA
- Operates with a maximum range of 200km (for the volume scan) with a beam width of  $0.93^\circ$ .
- Twelve elevations - the lowest is  $0.5^\circ$  and highest is  $30^\circ$ .
- 6 minute repeat cycle
- TITAN display system (freeware)



## 2.2 MSG satellite data

- 12 channels
- 3km resolution (1km for HRV)
- Updates every 15 min
- Displayed via locally developed software
- Single channels, Channel differences, RGBs
- Display in SUMO (in house developed software)



**Recommended Red-Green-Blue combination for Monitoring of Night-time Fog**

1= low-level fog or stratus  
2= clear ground  
3 = thin mid-level clouds

## 2.3 Nowcasting Satellite Application Facility (NWC SAF) products

- The v2013 software developed by the Nowcasting SAF has recently been implemented at SAWS.
- The Rapidly Developing Thunderstorms product is operational to identify and track more intense convective systems using MSG (GEO) and NWP data
- This tool has provided good validation against lightning occurrence and radar reflectivities of more than 35 dBz over South Africa

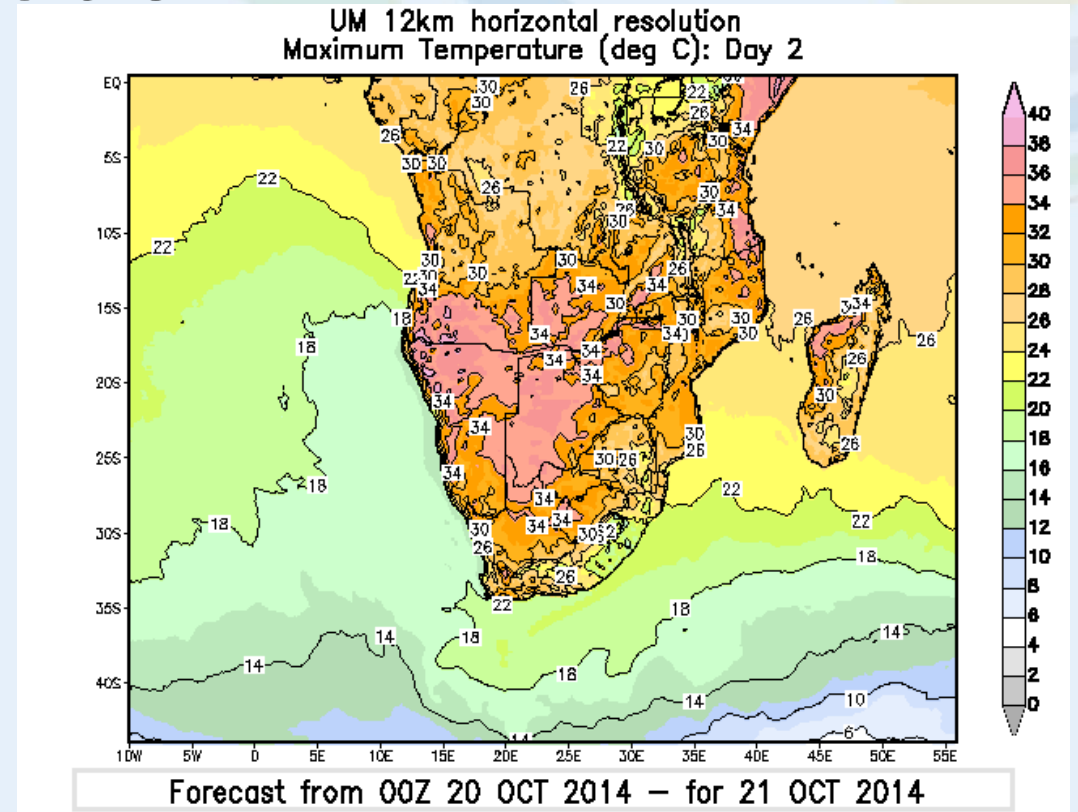


## 2.4 Lightning data

- Lightning detection network consisting of 24 Vaisala ground based sensors distributed across the country.
- The network consists of 19 - LS7000 and 5 - LS7001 sensors.
- These sensors are designed to detect cloud-to-ground lightning with a 90% detection efficiency and 0.5km location accuracy over most parts of South Africa.

# 2.5 NWP Local version of UKMO Unified Model

- UK Met. Office Unified Model (UM)-  
Operational since 2006
- Currently: Resolution 12km, 38 levels, hourly  
output to 48 hours, once a day
- 4km (southern Africa) and 1.5 or 2.2 km (for  
SA only) became operational in 2016, twice  
daily
- Currently no DA



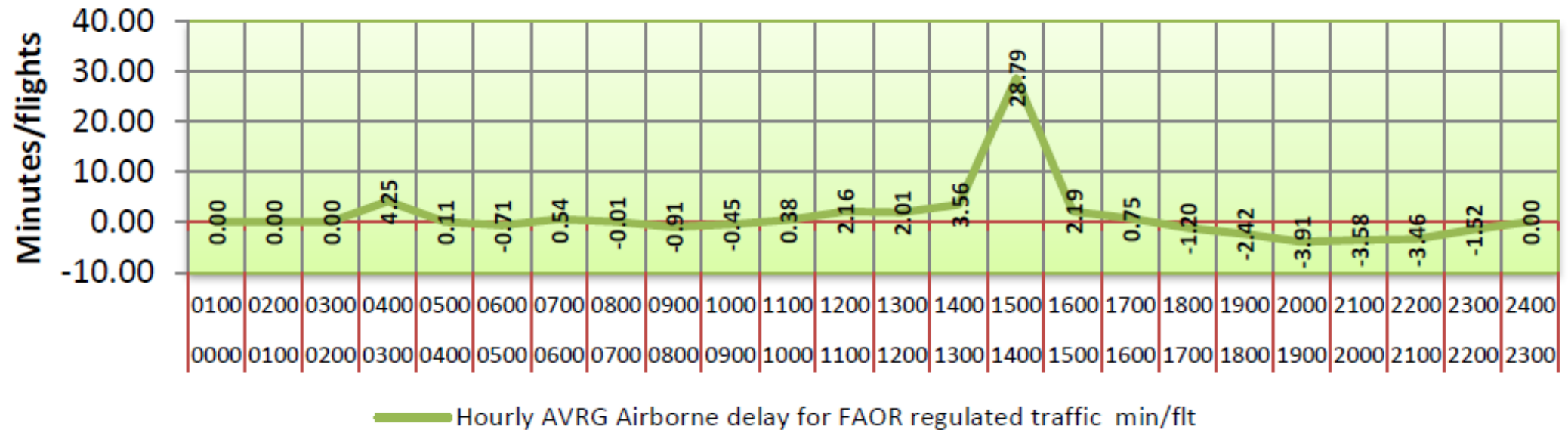
### 3. Case 21 Dec 2015

- A high-impact thunderstorm affected the Johannesburg region around ORTIA on 21 December 2015 around 1400 UTC.
- A first TS had minor effects at ORTIA, but a second storm triggered a gust front which resulted in a dust storm and wind gusts of 31-50 knots were reported at ORTIA
- Hail was reported in the suburbs to the south of the airport. Pea-sized hail was also reported at the airport itself.
- Heavy/intense rain showers followed soon after - visibility as low as 1500m (12mm in total, but 10mm fell within 15 minutes!)

# 3. ATNS reported delays

Macintosh HD:Users:macintoshhd:Desktop:25.2:• ATNS  
letterhead.jpg

Hourly AVRG Airborne delay for FAOR regulated traffic min/flt - December 2015



# 3. NWP

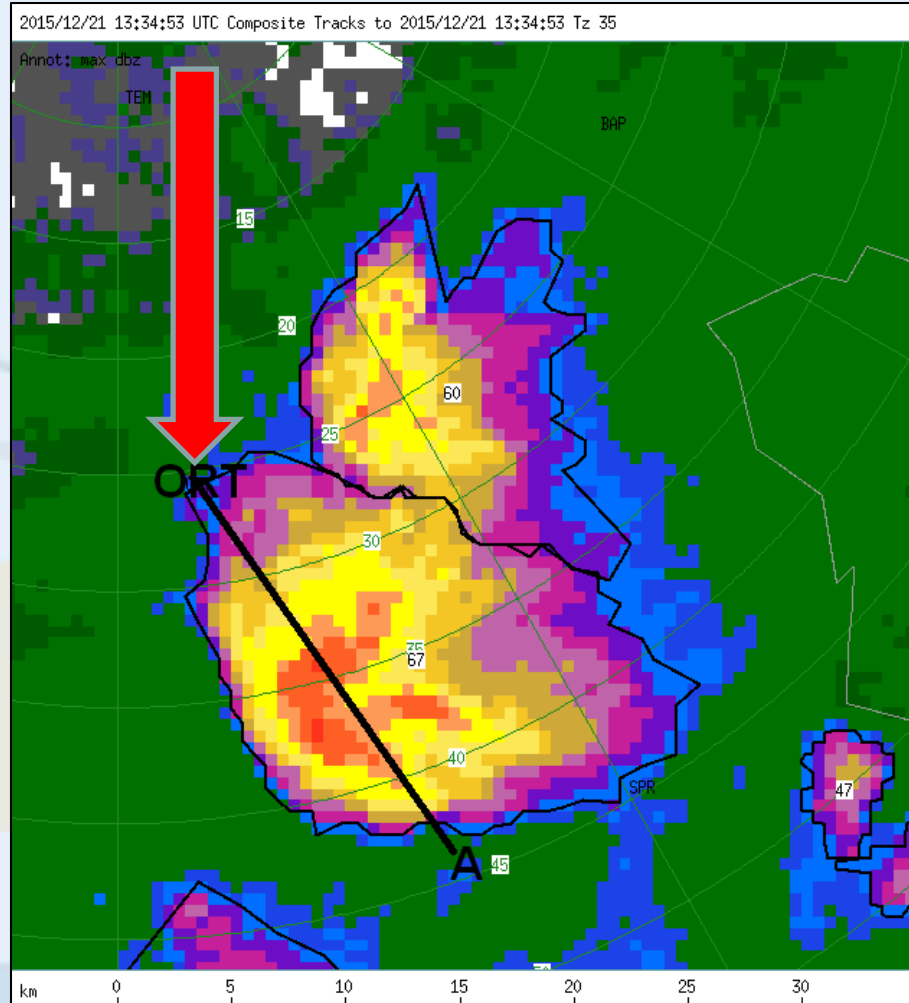
- UM suggested high instability indices over the areas where the severe storms eventually developed (Total Totals  $\geq 52$ , Lifted  $\leq -2$ , KI  $\geq 32$ , Showalter  $\leq -2$ ).
- Moisture levels at 600 hPa and 500 hPa  $> 70\%$  moisture.
- The areas of *convergence and uplift* aligned with these moisture levels and thunderstorms were thus forecasted for the afternoon

### 3. TAFS - Warnings issued?

- TAF FAOR **210400Z** 2106/2212 34015KT CAVOK BECMG 2111/2113 28012KT SCT045 **PROB30 TEMPO 2113/2119 5000 TSRA FEW040CB** BECMG 2203/2205 VRB04KT BECMG 2209/2211 34010KT X31/2113ZTN16/2203Z=
- TAF FAOR **211000Z** 2112/2218 28015KT 9999 SCT035 **PROB30 TEMPO 2113/2119 5000 TSRA FEW040CB** BECMG 2119/2121 CAVOK BECMG 2203/2205 VRB04KT FM220900 34010KT 9999 SCT035 PROB30 TEMPO 2212/2218 5000 TSRA FEW040CB TX31/2113ZTN16/2203Z=

# 3. Radar

1334 UTC

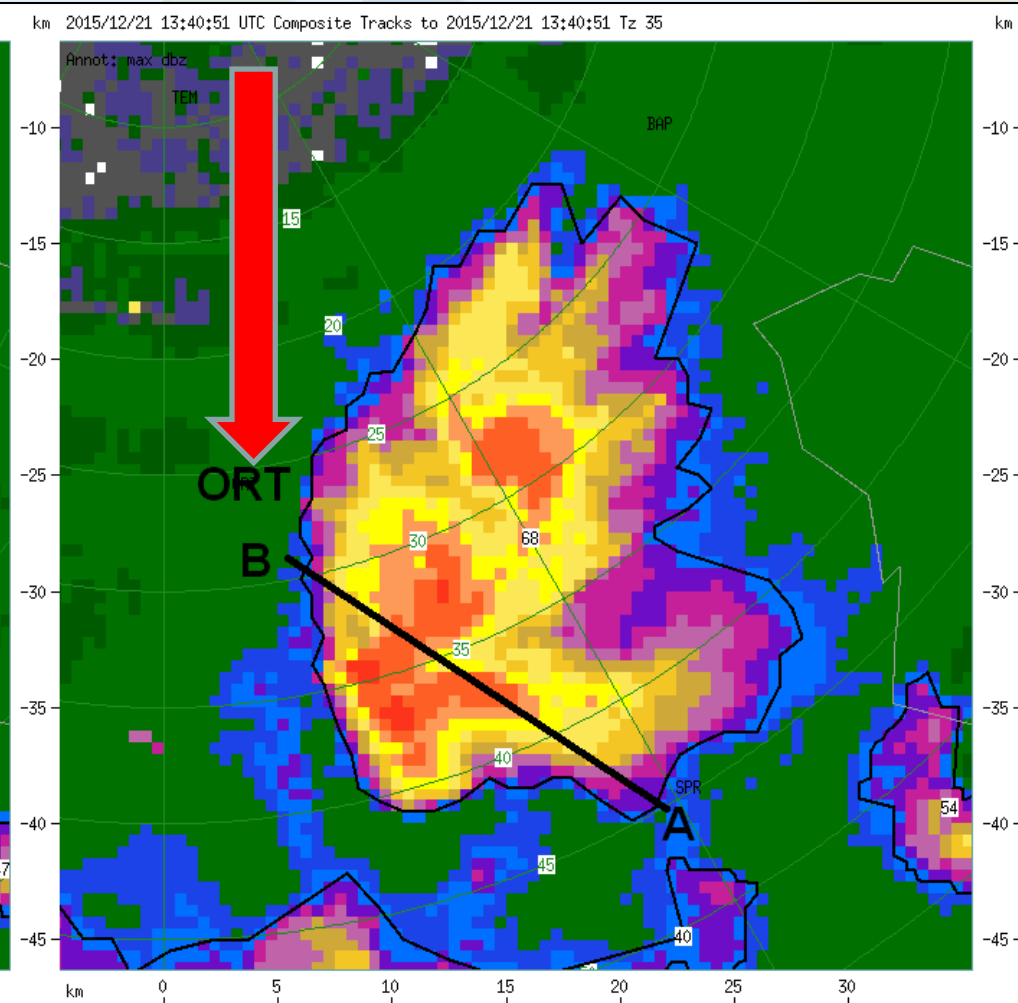


**1334 UTC Storm1:**

Initially appeared on radar about 10 km to the southeast of ORTIA.

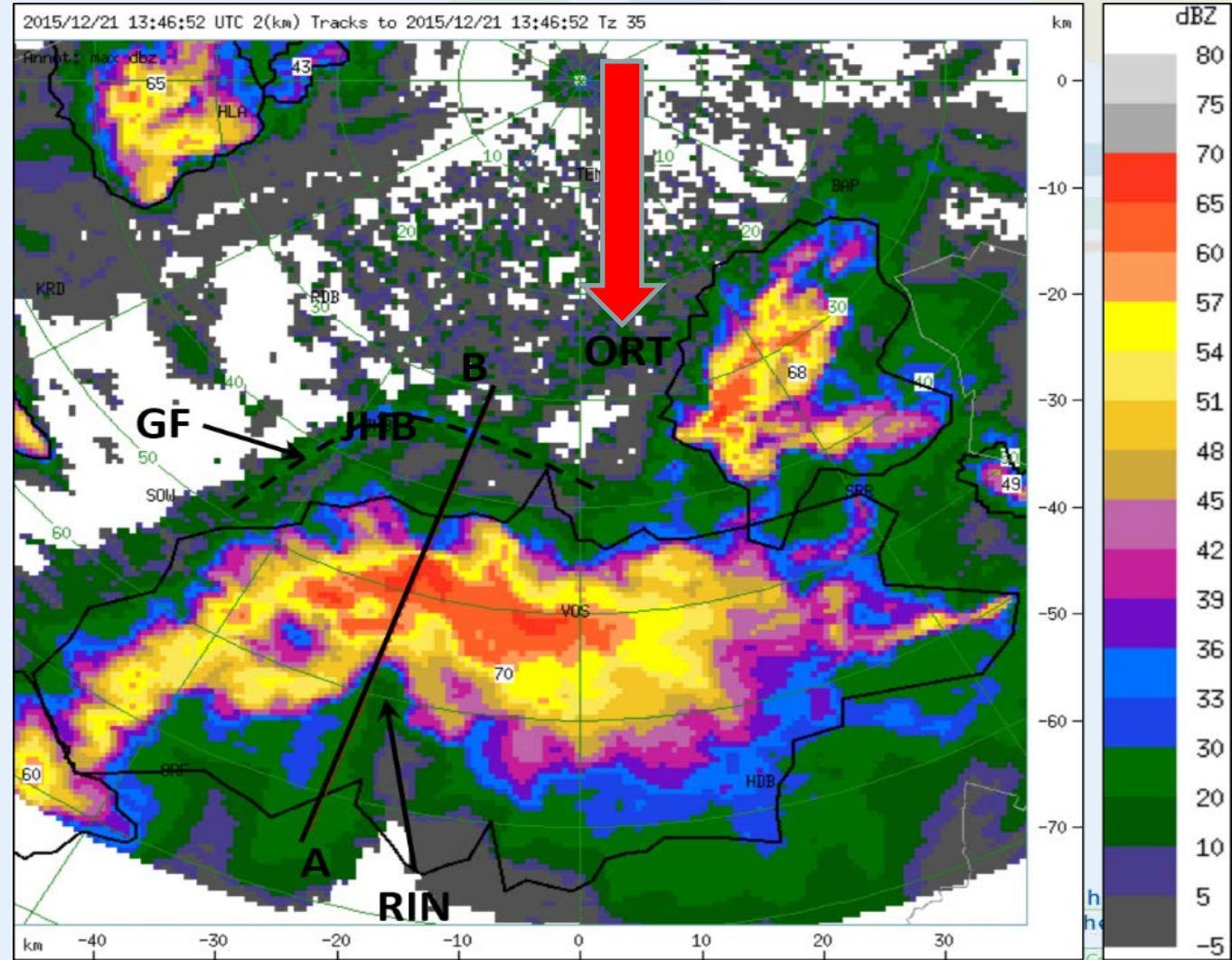
Its effect on ORTIA was limited to light rain and the change in wind direction.

1340 UTC



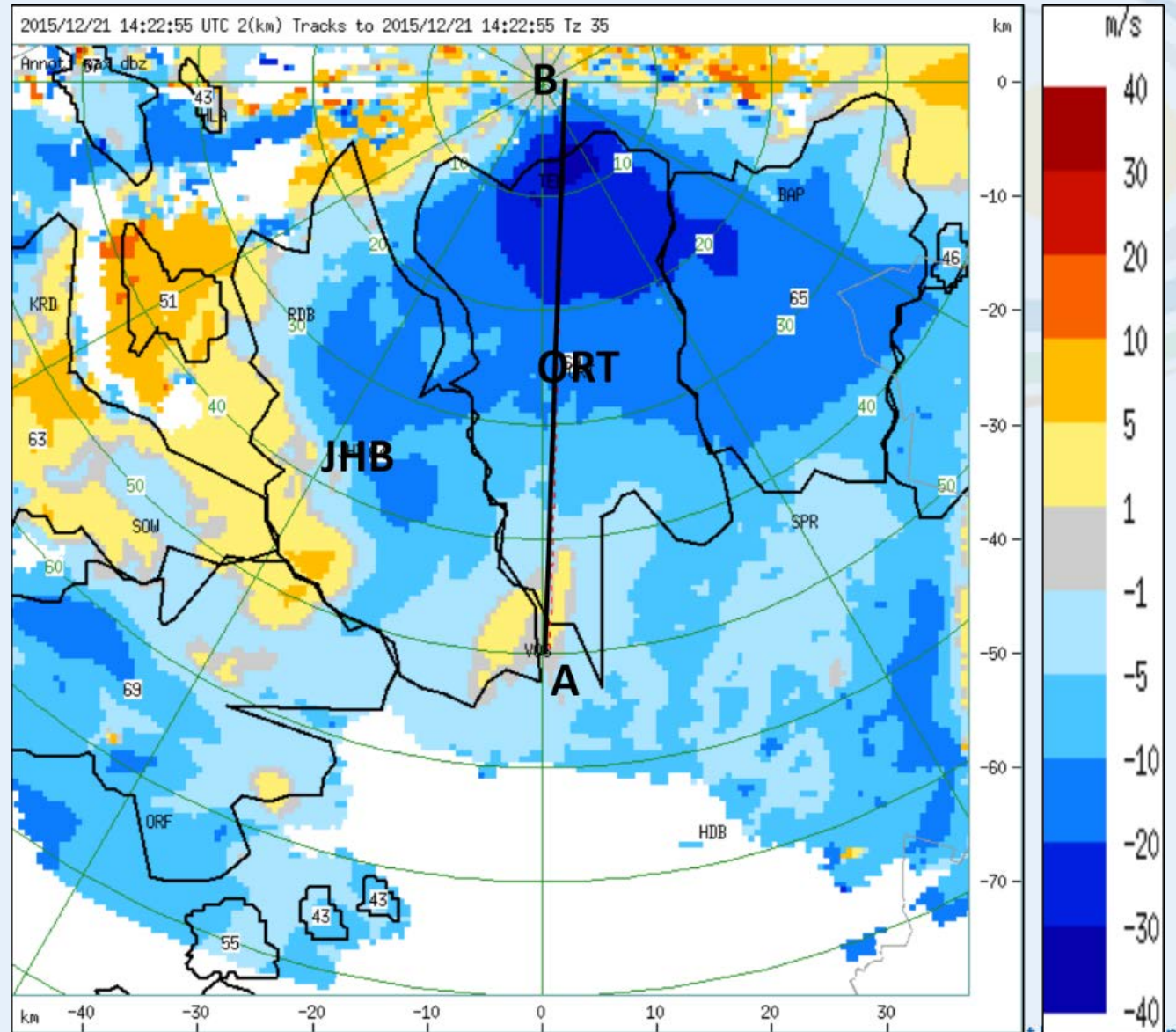
# 3. Radar

- Storm 2: **1346 UTC**: Significant both in terms of size and intensity.
- An intense **multi-cell storm** complex and apparent **rear inflow notch** which indicates the region where the **strongest downbursts** are likely to occur
- A **gust front** is clearly evident ahead of the section of the storm which has the trailing RIN
- So... what happens next??



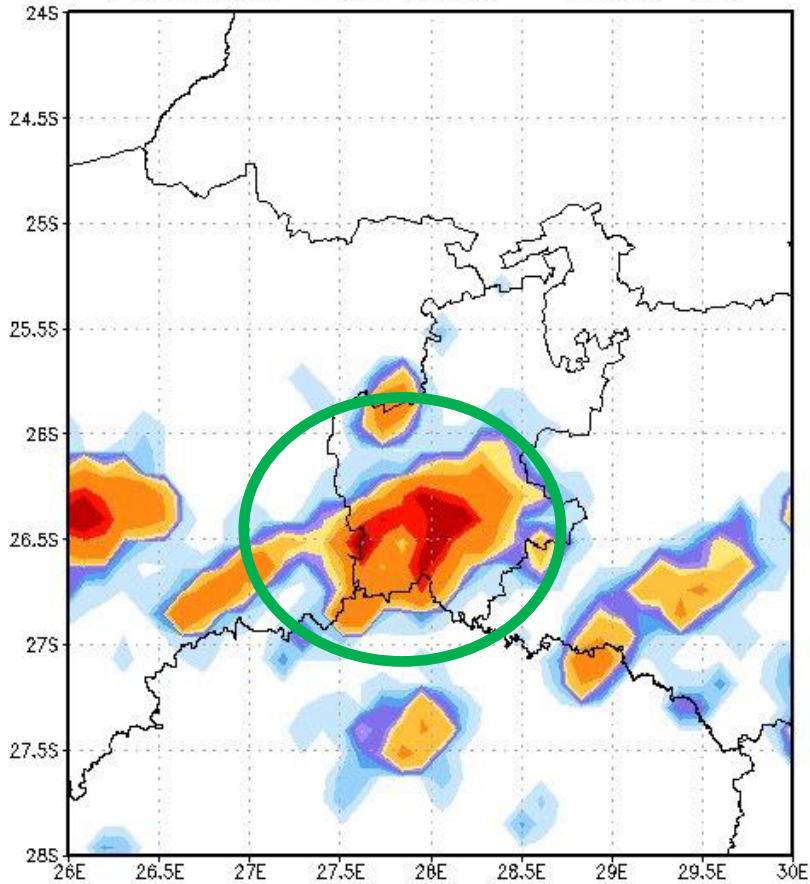


- Radar off line from 1346 UTC and came back online at 1422 UTC
- At 1422 UTC the leading edge and most intense part of the storm had already passed over ORTIA and was situated about 10 to 20 km north of the airport.
- Low level Doppler velocities observed by the radar in this region were between 30 and 40 with a maximum of **34.6 m/s**.

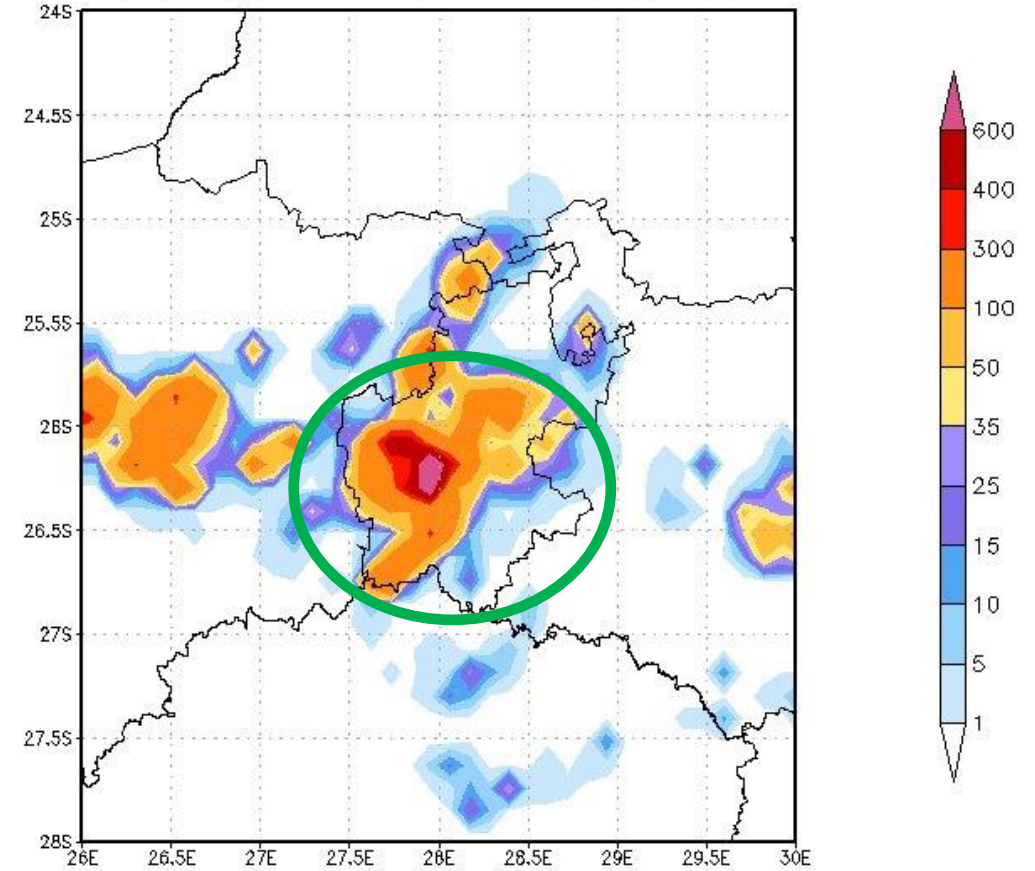


# 3. Lightning

Total amount of Lightning Strokes on 20151221 from 13:00 - 14:00 UTC

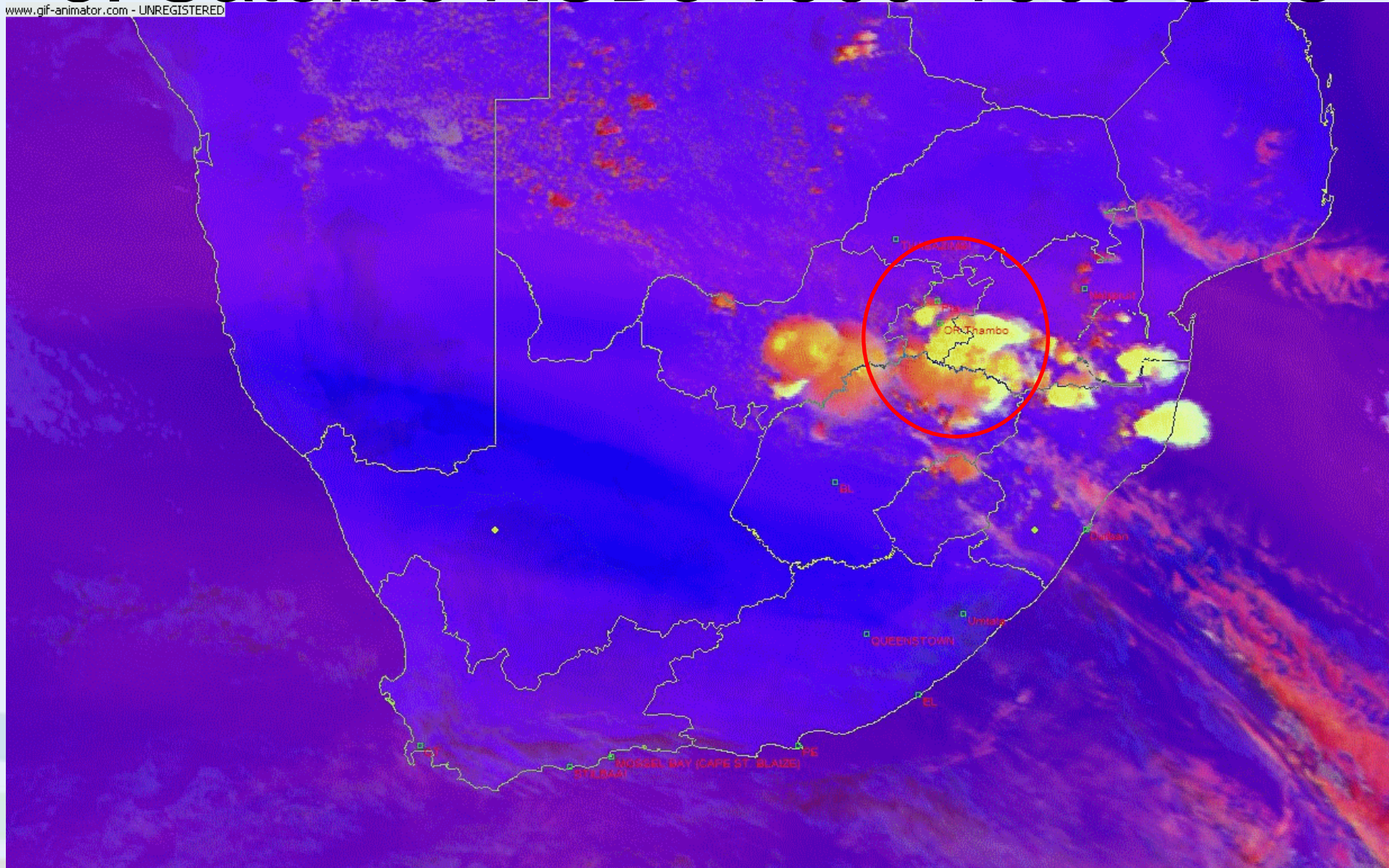


Total amount of Lightning Strokes on 20151221 from 14:00 - 15:00 UTC



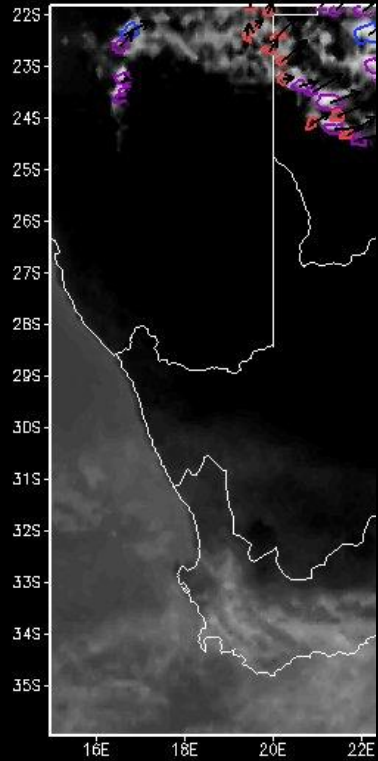
# 3. Satellite RGBs 1300-1500 UTC

www.gif-animator.com - UNREGISTERED

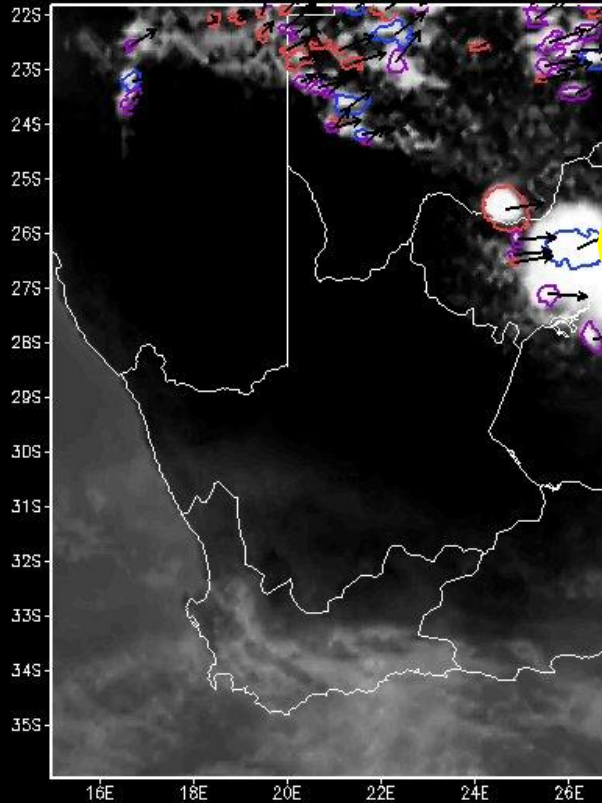


# 3. NWC SAF RDT

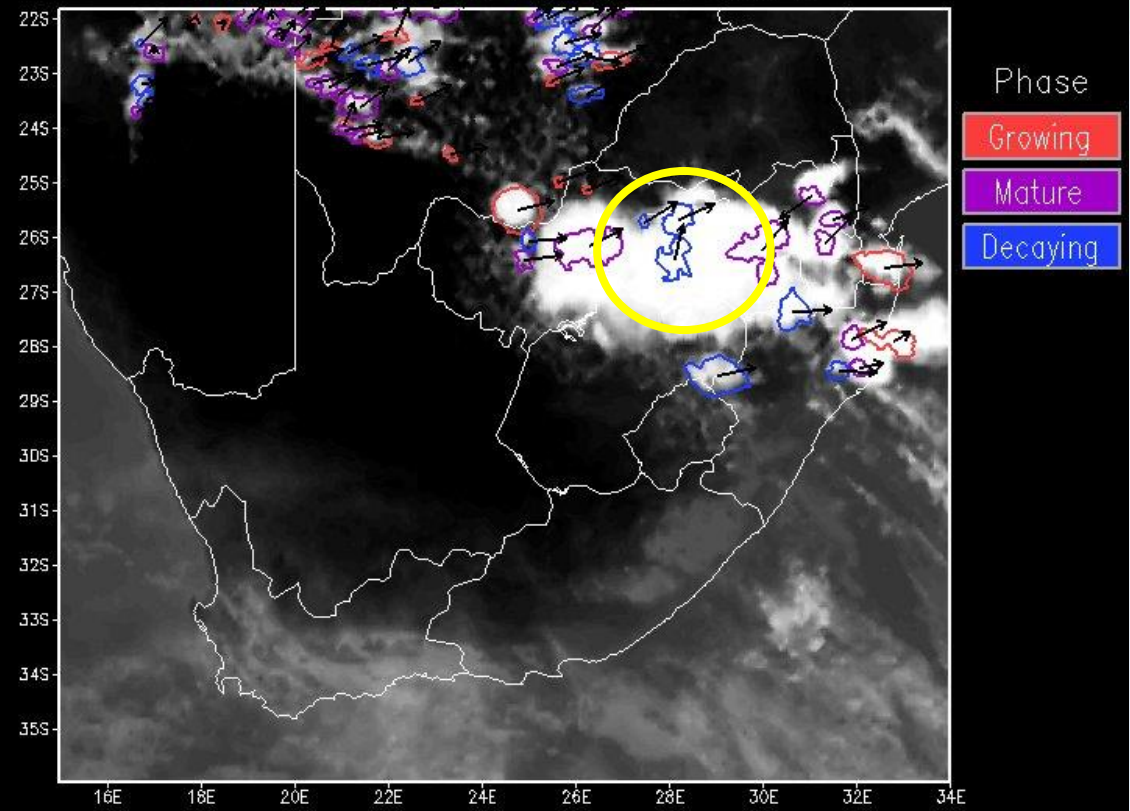
RDT for 20151221 at 1345UTC



RDT for 20151221 at 1400UTC



RDT for 20151221 at 1415UTC



# 3. Feedback from ATNS

- The variation in the intensity between the predicted and the actual weather, resulted in a major increase in delays and an obvious shift in traffic patterns. It also contributed to the increased network reactionary impacts.
- In addition to the considerable number of diverted flights during the period of adverse weather, the estimated average airborne delay for the 21 December 2015 is higher than operationally accepted average delay level.
- At the same time, ground delay levels were very high compared to the average monthly levels.

# 4. Summary and conclusions

- The storm which affected ORTIA on 21 Dec had a huge impact on aviation and caused many ground/airborne delays
- The intensity of the rainfall, the amount of lightning, the strong wind (and gust front), dust and hail all added to the adverse weather which lasted longer than expected
- Forecasters could perhaps have monitored/analyzed the situation better, even if only with satellite images, RDT product to issue warnings
- Improved practices will be accomplished only if it remains a two way street between meteorologists and air traffic managers.
- My colleague will tell you more about possible improvements in the scientific side which we envisage for an improved service to ATM.