Lightning Detection Possibilities for SADC

SWFDP Training
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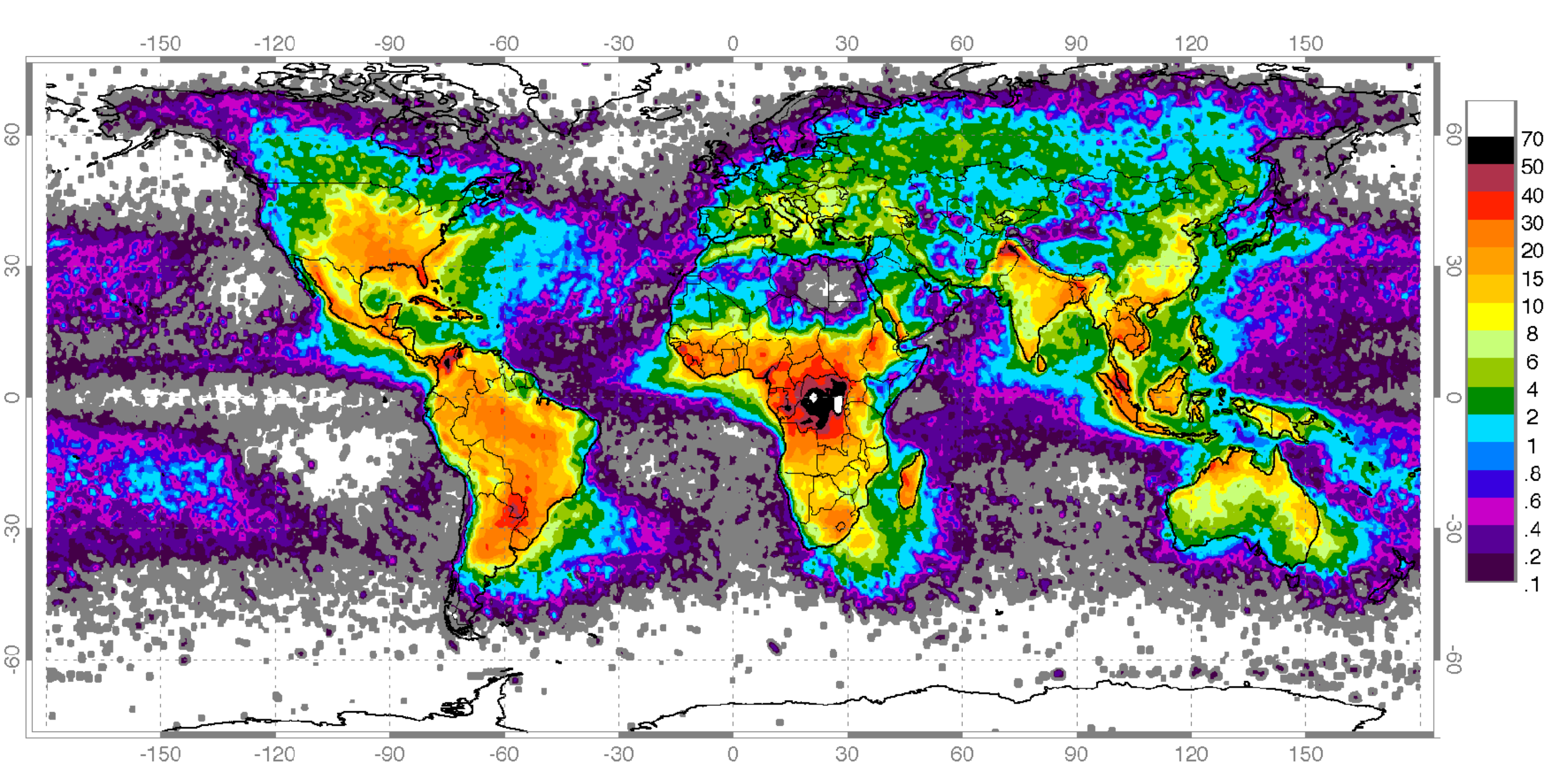
- Conclusion

Introduction

- Lightning is one of the most common severe weather events to affect people directly.
- At any given moment there is around 2000 thunderstorms around the world.
- 100 cloud-to-ground flashes every second (NSSL, 2012)
- 8-million flashes per day.
- It has been estimated that world-wide 24,000 lightning deaths and 240,000 injuries occur annually (Royal Aeronautical Society, 2003)
- Lightning can have potentially lethal consequences to life and cause considerable damage.

Introduction

- Africa is lightning prone continent



http://thunder.msfc.nasa.gov/images/HRFC_AnnualFlashRate_0.5.png

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Introduction

- South Africa is the only country in Africa to own a dense ground based lightning detection network.

- Since Africa is a lightning prone country, and no dense ground based lightning detection networks are available in African countries, alternatives are required.
  - Ground-based global lightning detection networks
  - Satellite based lightning sensors

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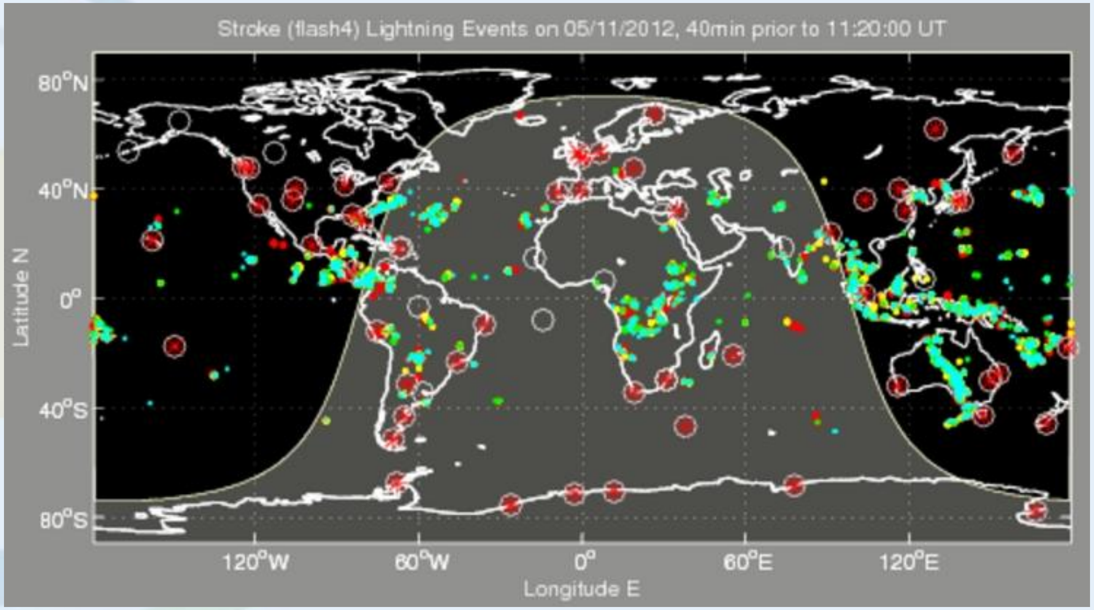
Lightning Detection Possibilities

WWLLN

- World Wide Lightning Location Network (WWLLN)
- Operated by the University of Washington in Seattle
- Consists of over 50 ground-based sensors worldwide
- Each university/institution are responsible for the sensor they host.



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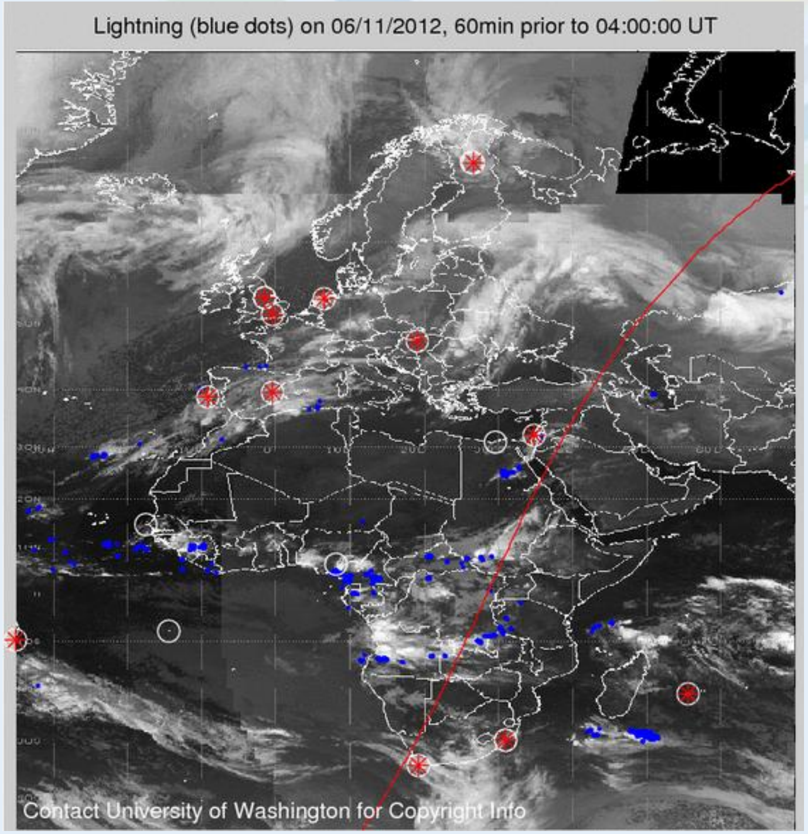
WWLLN

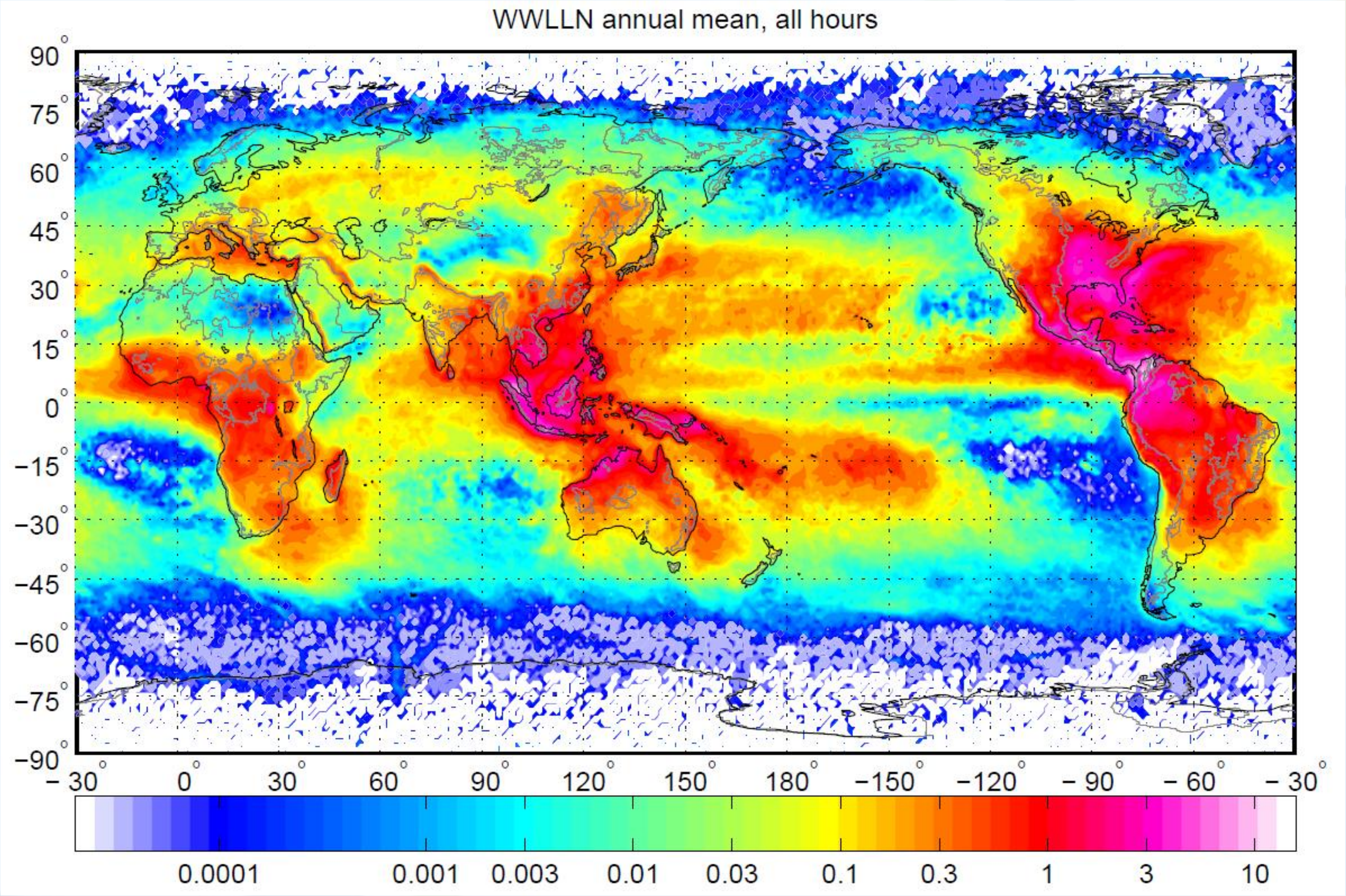
- Detects mostly the stronger lightning strokes.
- Detection efficiency of 30kA strokes ~30%
- Usually the detection efficiency ~15%
- Identifies the location of most thunderstorms.
- Archive data available to subscribers on CD’s - Global data for a month.
- Weekly archive data can also be downloaded by subscribers.

WWLLN

- WWLLN data is available on the internet with a cadence of 10 minutes from University of Washington for research purposes.
- Also available from the commercial reseller with a cadence of 1-minute
- Images available on the website http://wwlln.net/ with a cadence of 60 minutes



WWLLN



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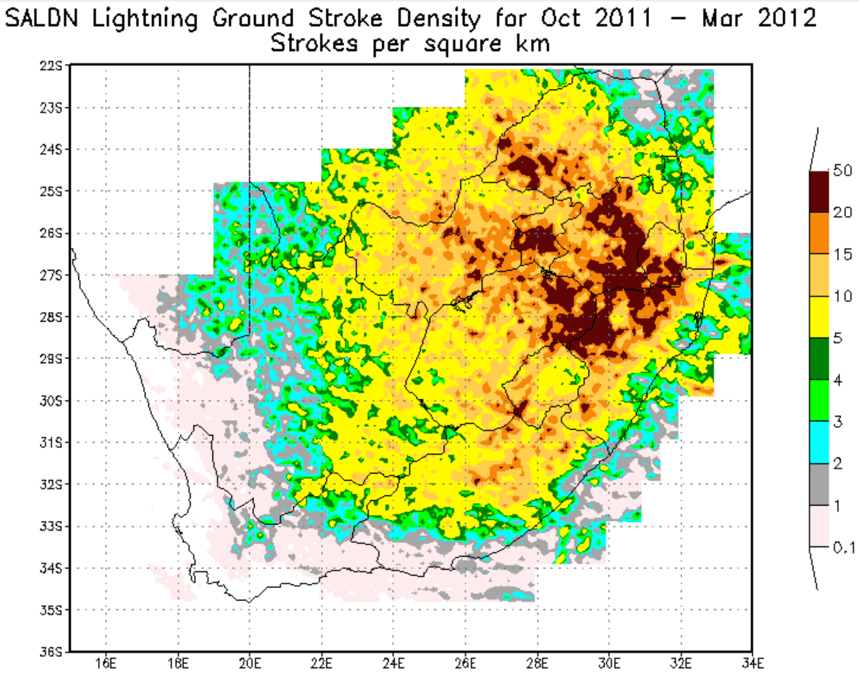
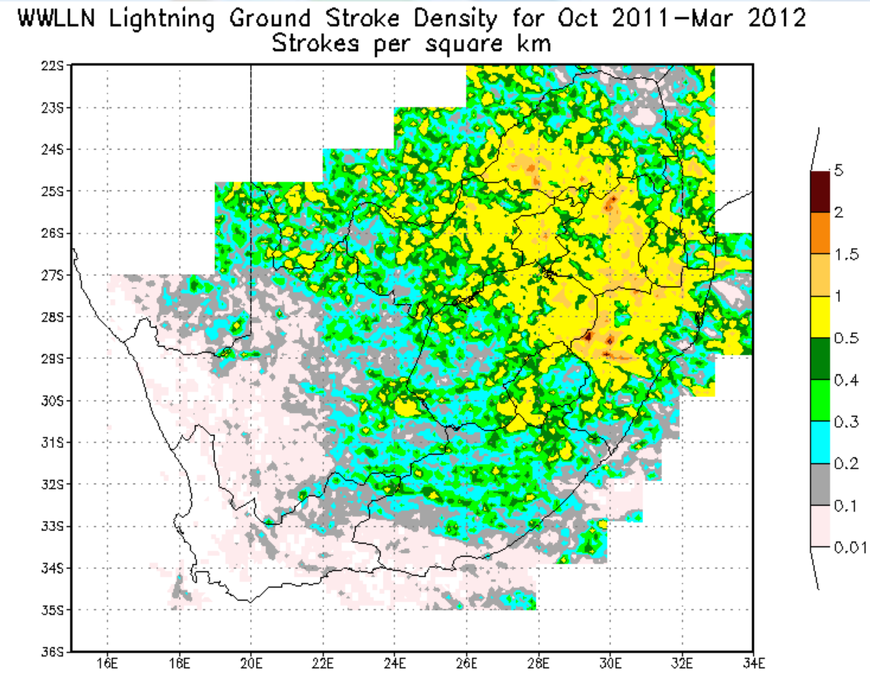
WWLLN





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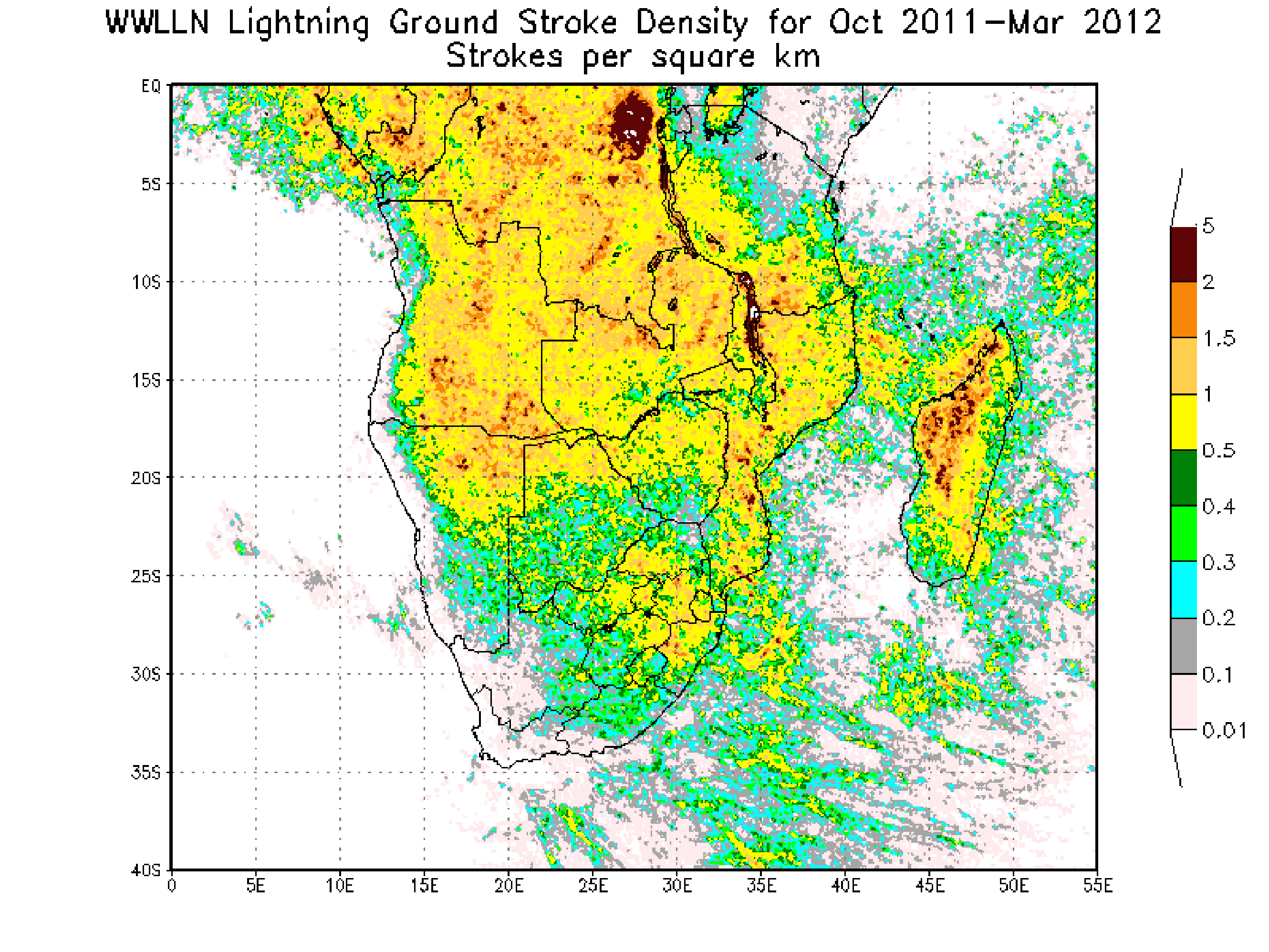
WWLLN



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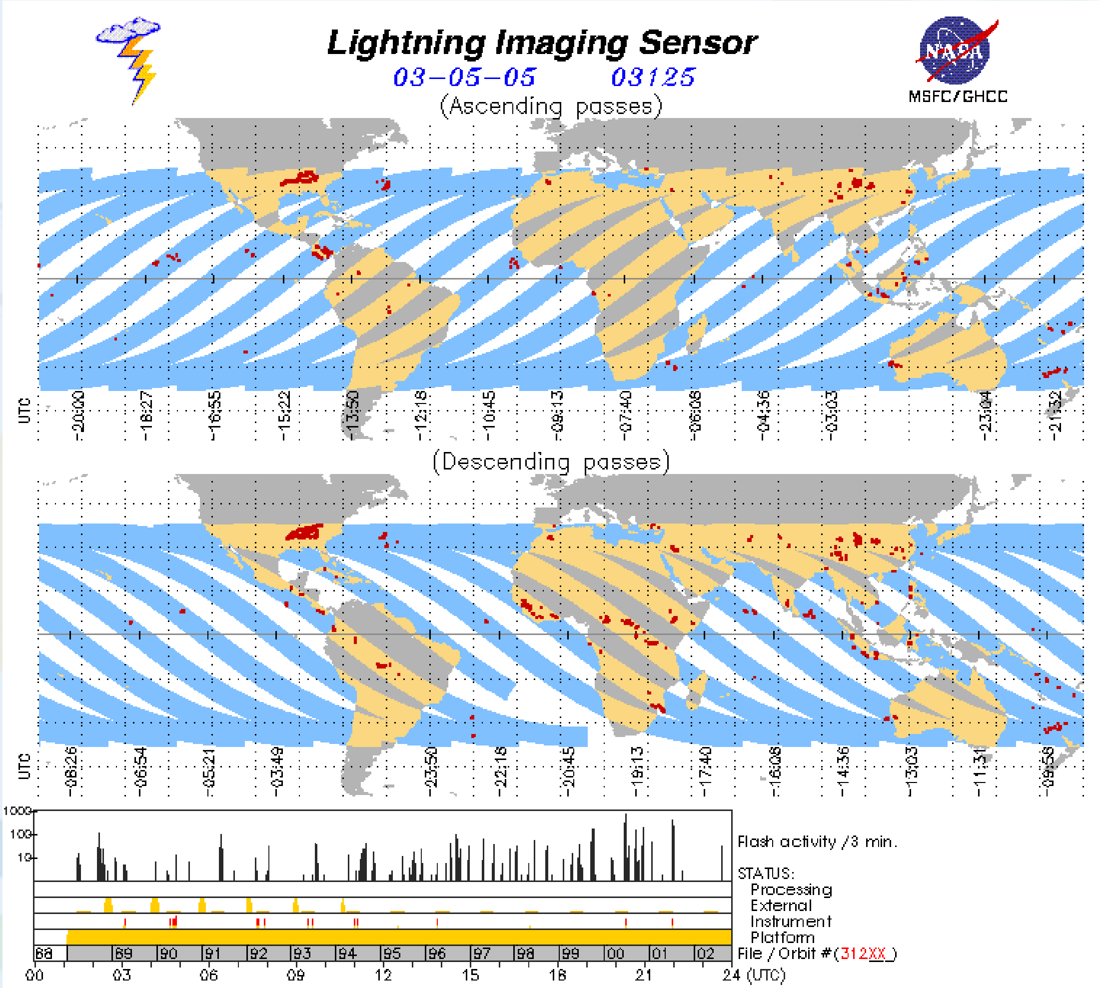
LIS

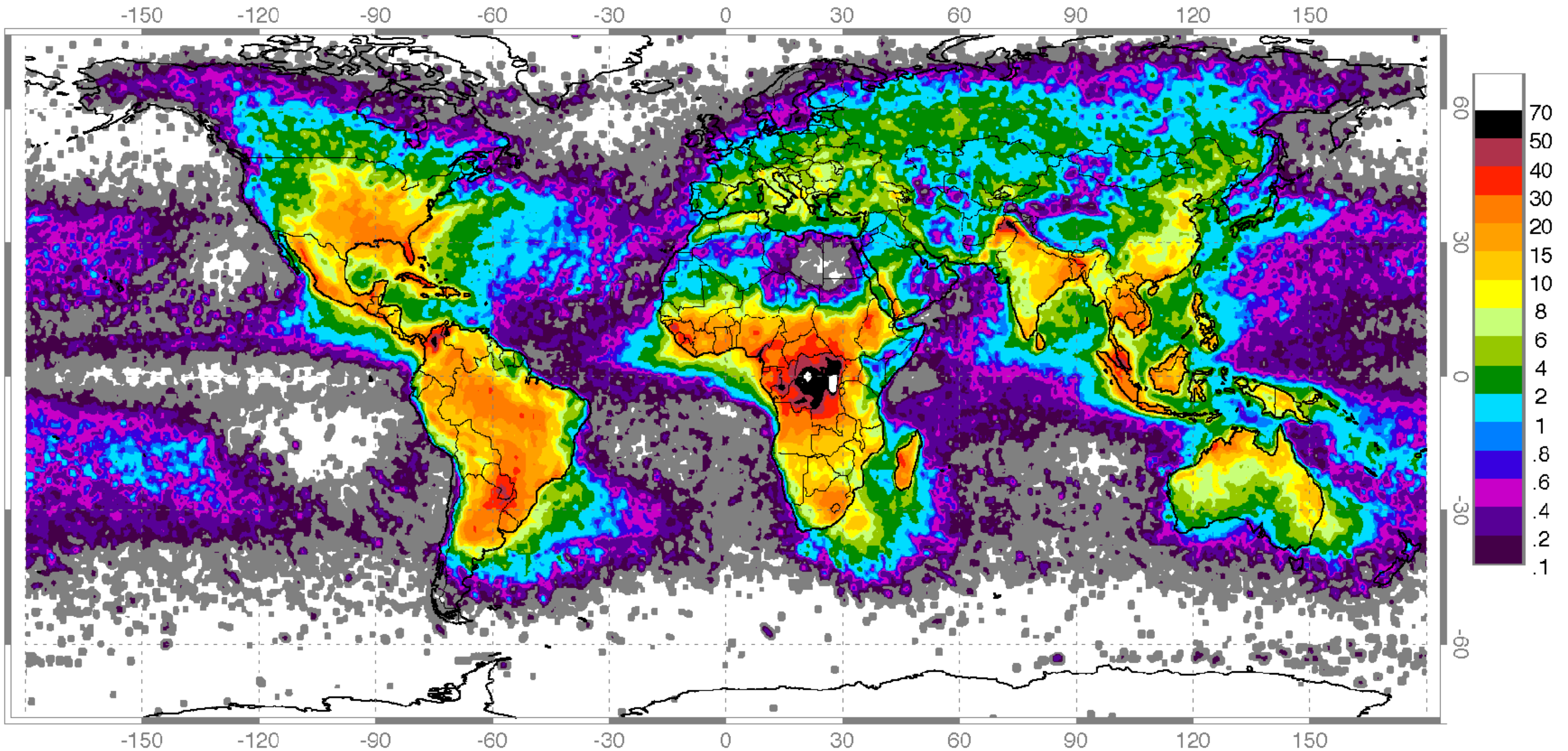
- Lightning Imaging Sensor (LIS)
- Lightning sensor onboard the Tropical Rainfall Measuring Mission (TRMM) observatory.
- 14 orbits per day
- Locate and detect lightning with storm scale resolution of 5-10km over a large region (600 X 600 km) of the earths surface.
- Observe a point on the earth or a cloud for 80 seconds, adequate to estimate the flash rate of a storm.

LIS

- LIS however only observes a point twice per day and thus can miss storms in between satellite overpasses.



LIS



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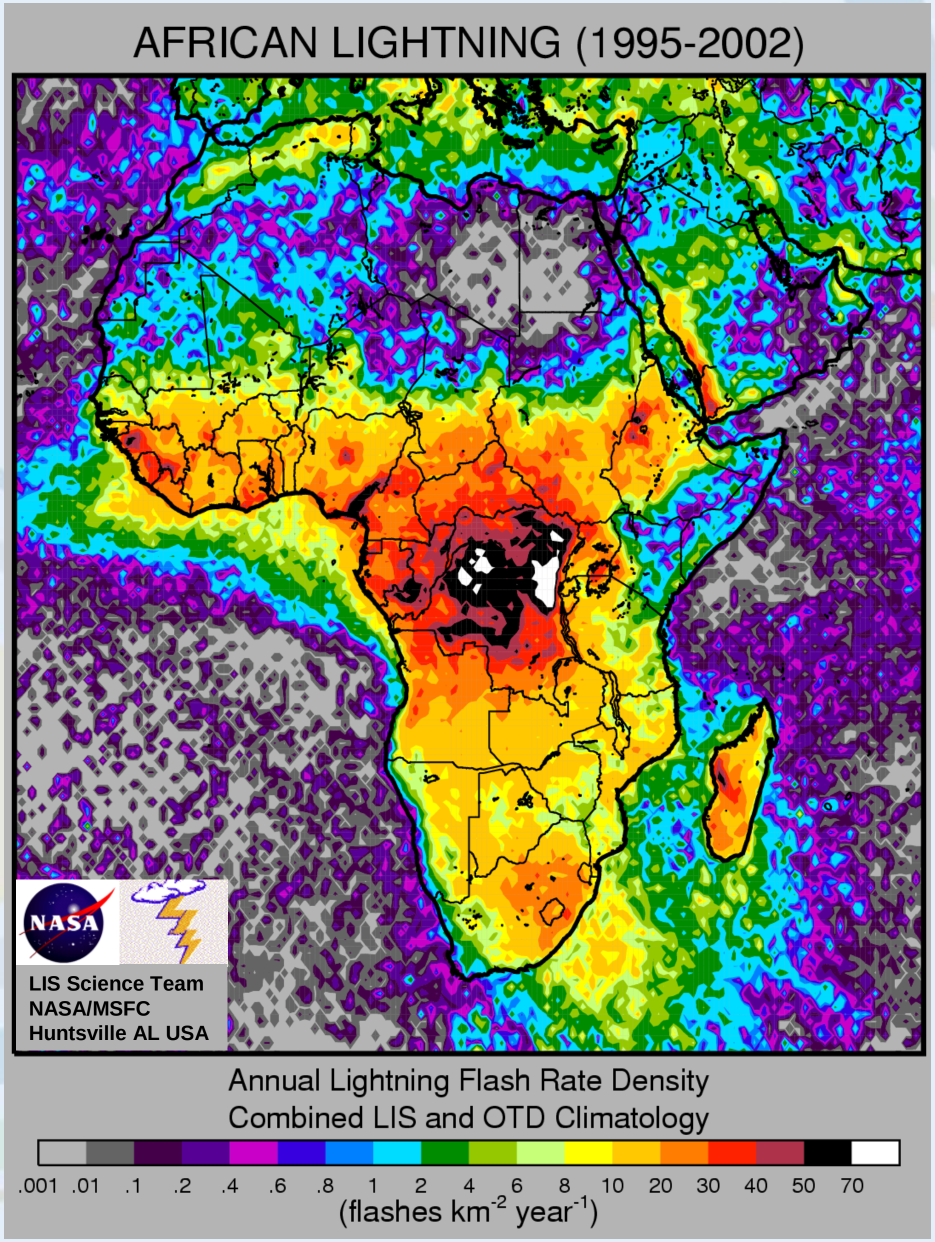
LIS



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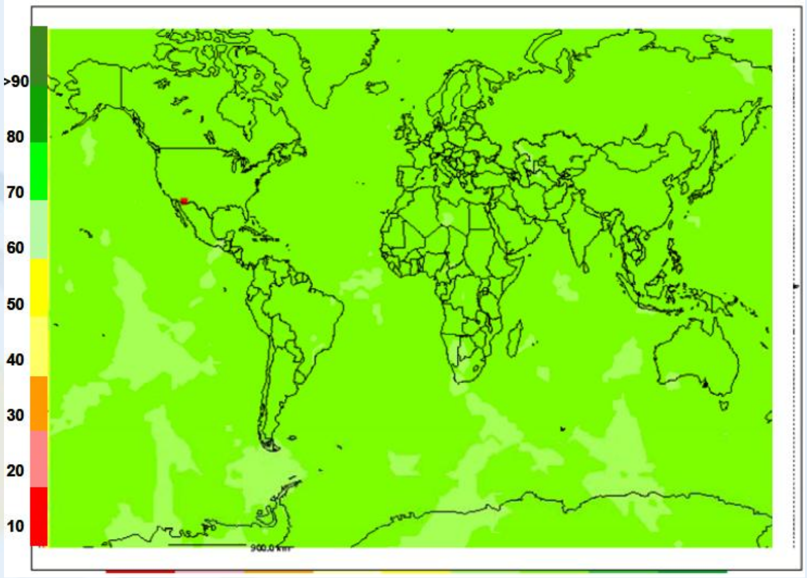
GLD360

- GLD360 is VAISALA’s global lightning data set.
- Sensors are placed around the world to detect cloud-to-ground lightning.
- Detection efficiency of 60% - 70%

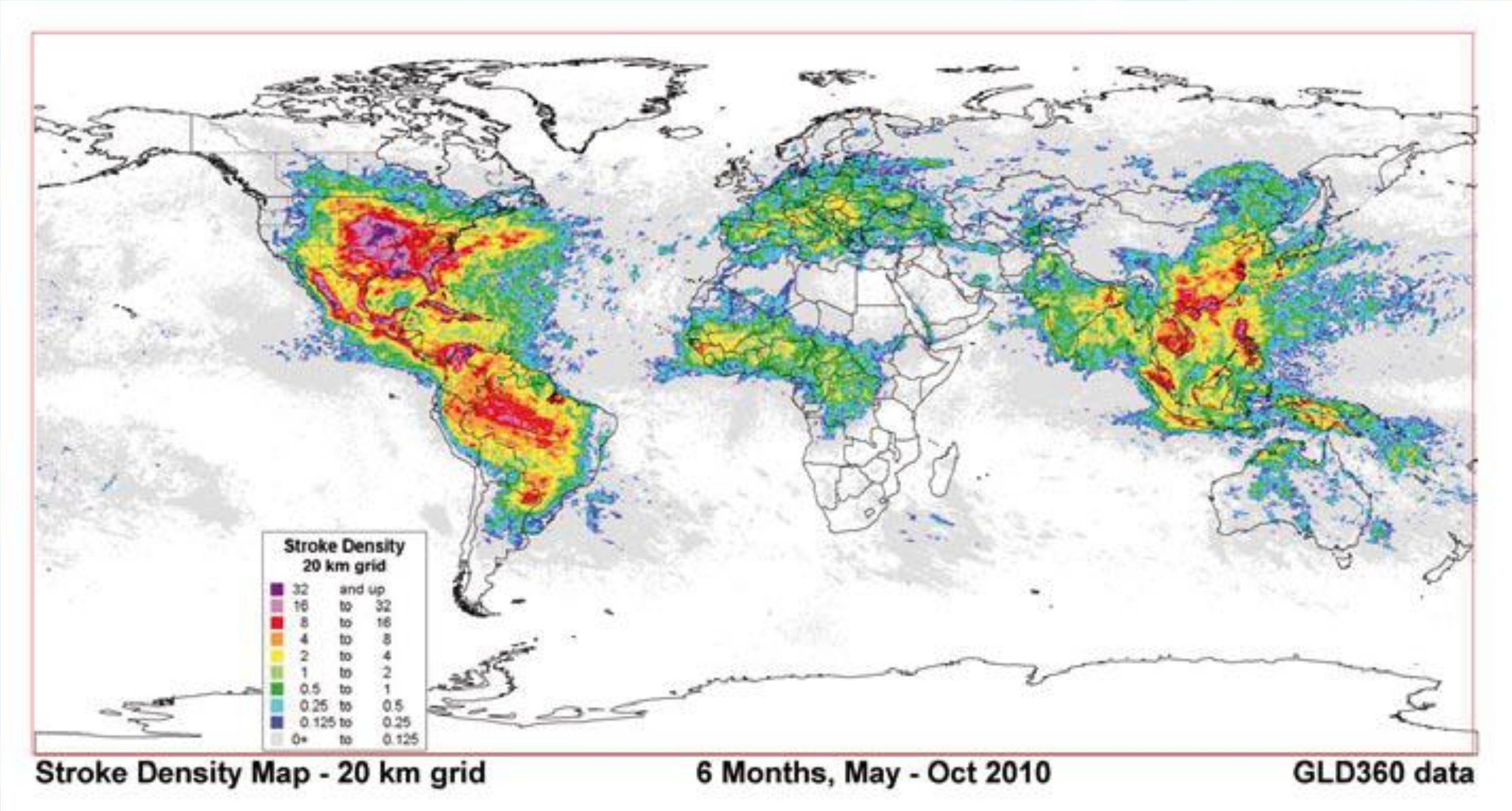


- Location accuracy of 5-10km

GLD360

- GLD360 is the only long range network capable of providing polarity and peak amplitude of each stroke.
- VAISALA owns and operates the network
- Data is streamed to customers
- When lightning is detected the data can reach the customer within 2-minutes.
- The service is offered at an annual fee that depends on the size of the area.
- More information available at: www.vaisala.com/weather/products/gld360.html

GLD360



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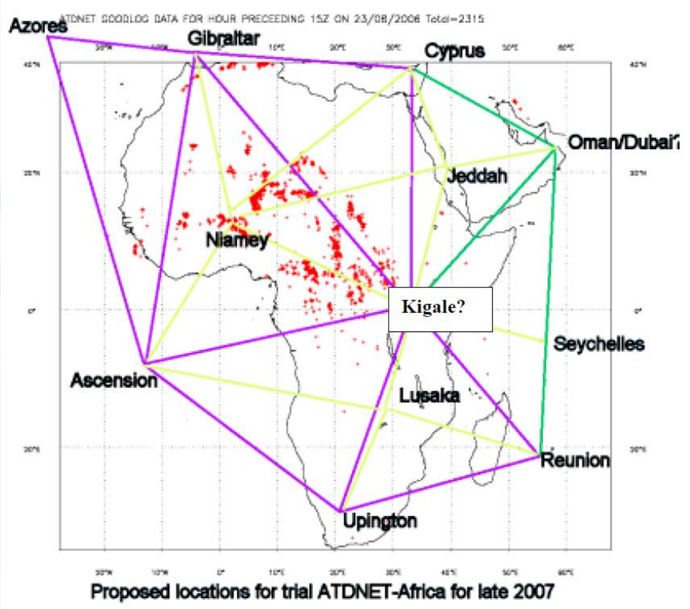
ATDnet

- The UK Met Office Arrival Time Difference (ATD) long range lightning location network.
- Also covers Africa



- Typical locations of 20km over Africa will improve to 5km when all the new sensors are put in.

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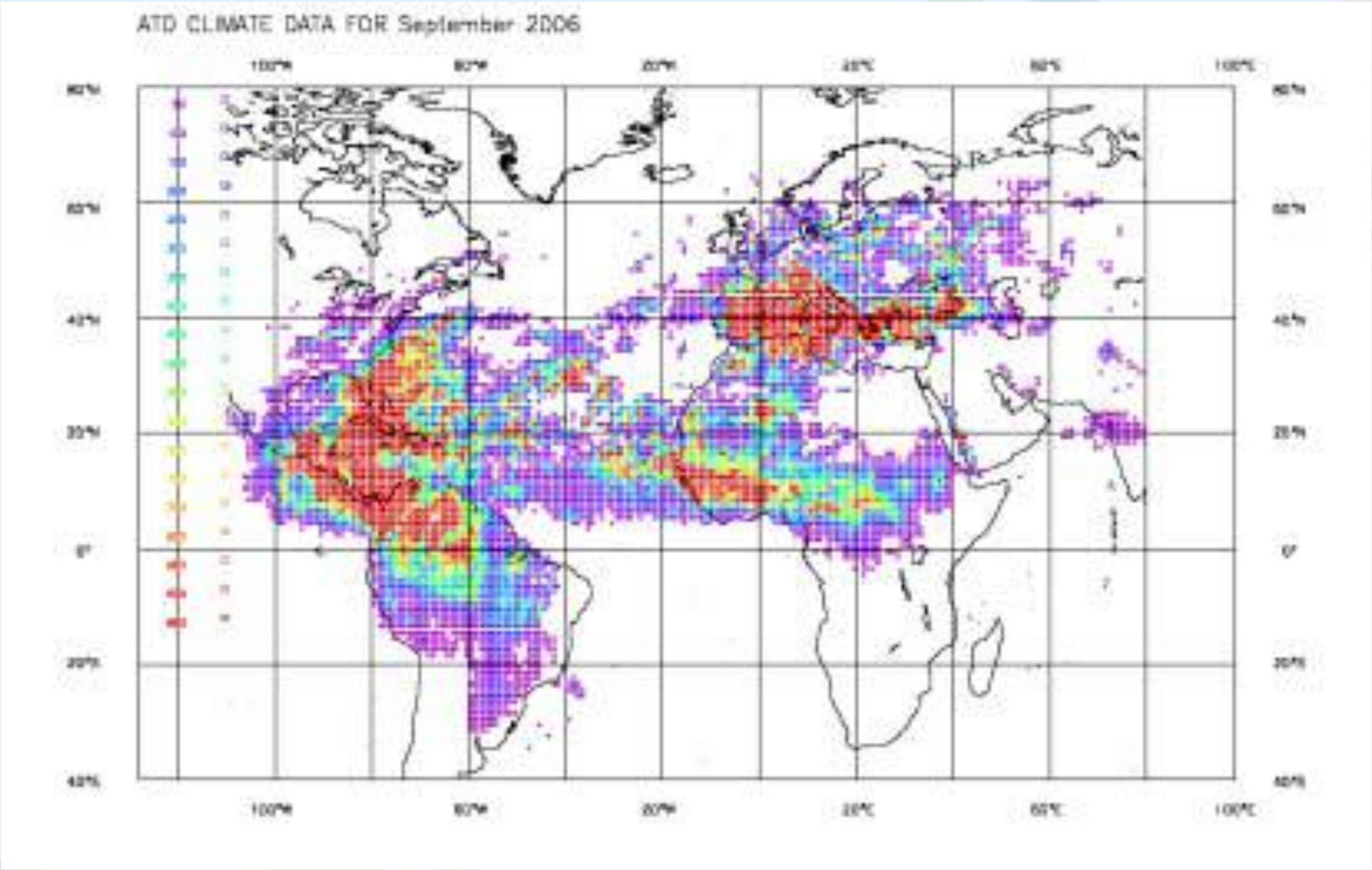
ATDnet



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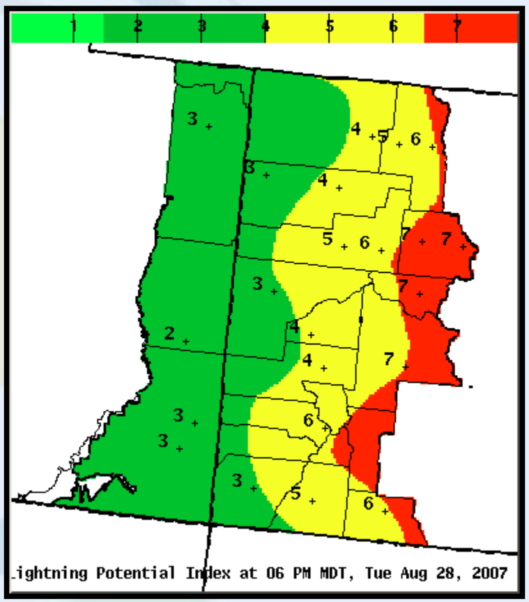
Lightning Forecasting?

Lightning Threat Index

Introduction

- Many lightning detection systems are available to accurately determine the impact locations of lightning (like in South Africa).
- These sensors however only display in real-time where lightning is occurring by which time the lightning threat is already present.
- There has been however a much lower capability in forecasting the potential for lightning occurrence in short range forecasts.

- Frisbie *et al.* developed a product that uses model produced fields to calculate a lightning threat index.
- The product gives an outlook for the day of where the lightning threat can be considered high.



Color Key and Explanation

Low Risk	Low Risk: The lightning threat may either be negligible or low. Isolated thunderstorms may occur, but the probability of thunderstorms is low.
Moderate Risk	The lightning threat is considered moderate. Isolated thunderstorms are expected within the green area.
High Risk	The lightning threat is considered high. Expect scattered thunderstorms within the yellow area. Plan accordingly, as there is a high probability of lightning in the yellow area. Be aware of lightning safety guidelines.
Extreme Risk	Lightning in the red area will occur. Practice lightning safety, as the threat of lightning is imminent.

Data and Methods: Index

- Used Unified Model fields as input:
  - Most unstable CAPE (1-3km AGL)
  - Lifted Index
  - Theta-E Lapse Rates (at 600mb)

  } Instability parameters

  - 850mb temperature

  } To prevent over prediction in the cold months

  - Relative humidity (at -10^{o}C)
  - Precipitable Water

  } Moisture

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Data and Methods: Index

- The following equations was used:

$$LTI = RH + (\Theta e\Gamma)^2 + (LI)^2 + muCAPE + PW + (T_{850} - 273.15)$$

- The result was divided into 4 risk categories:
  - Low risk (white)
  - Moderate risk (green)
  - Severe risk (yellow)
  - Extreme risk (red)

- Get the following outlook maps:
  - 09AM to 15PM
  - 15PM to 21PM
  - 09AM to 21PM
  - Hourly

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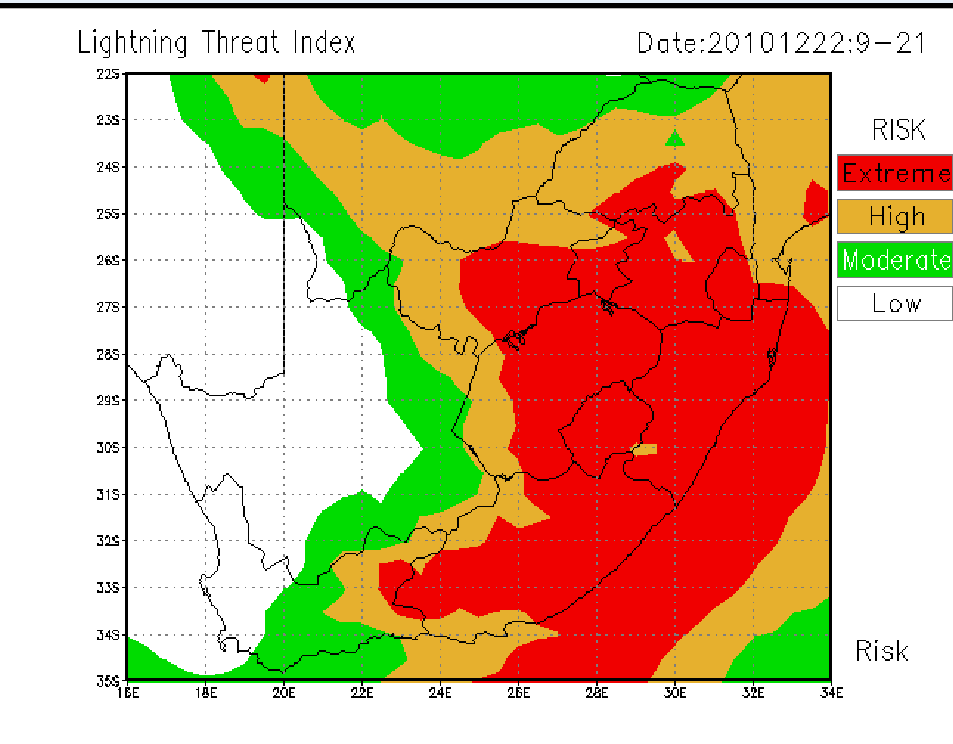
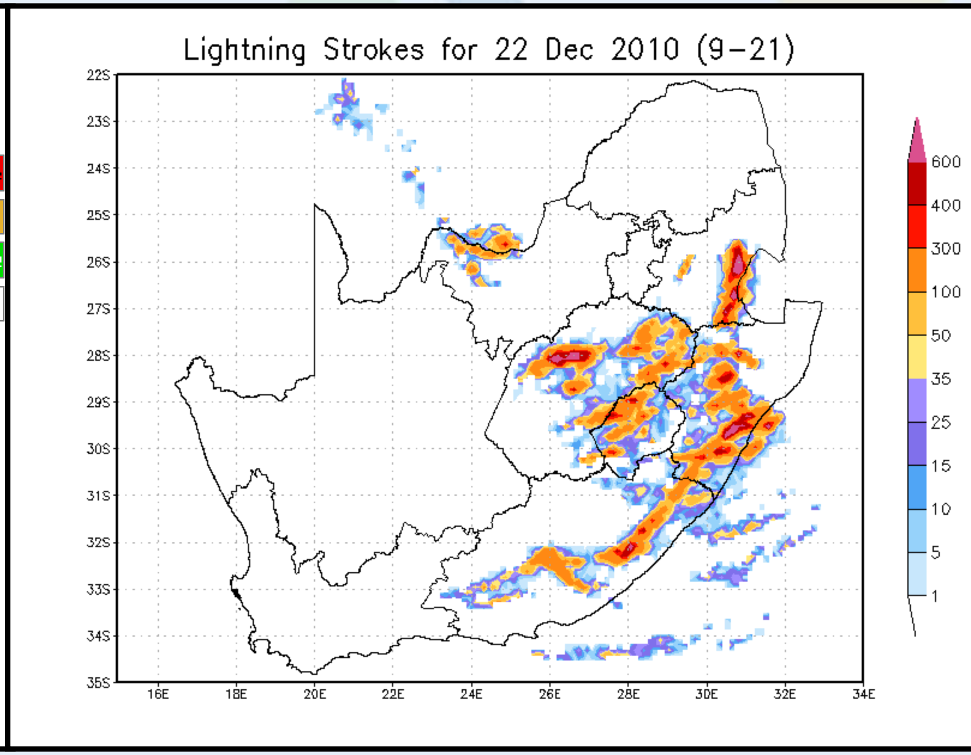
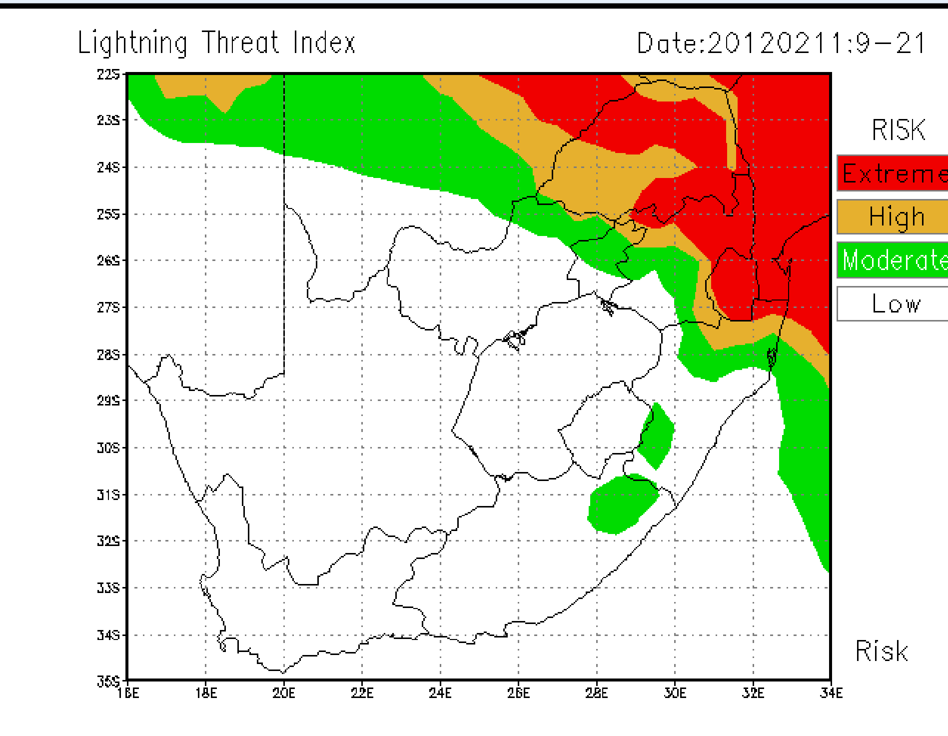
Examples

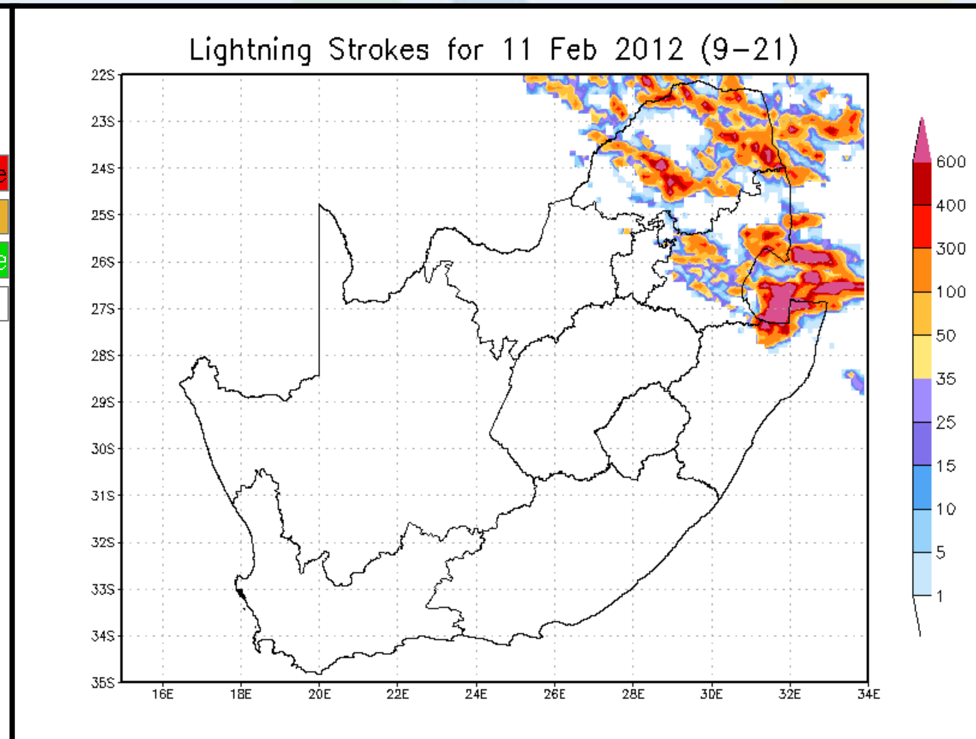
Case 1: 22 December 2010





Case 2: 11 February 2012





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Lightning Potential Index

Data and Methods: Index

- Calculated within the charge separation area of a cloud between $0^{o}C$ & $-20^{o}C$ where the non-inductive mechanism by collisions of ice and graupel particles in the presence of supercooled water is most effective.
- WRF model with explicit microphysics at 1km resolution. But for operations (computation time) use 4km resolution – 2x daily. If possible will run it from Unified Model.
- Derived from model simulated grid-scale updraft velocity & the mass mixing ratios of liquid water, cloud ice, snow and graupel
- Volume integral of the total mass flux of ice & liquid water within the charging zone in a developing thundercloud.
- Non-zero only in the charging zone
- Non-zero when a majority of cells within a 5 grid-radius of that grid point have a vertical velocity > 0.5 m/s indicating the growth phase of the thunderstorm.

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Data and Methods: Index

- LPI has units [J/kg] and defined by:

$$LPI = \frac{1}{v}\iiint \epsilon\, w^2 dxdydz$$

Where v is the model unit volume and w the vertical wind component in m/s.

- The integral is computed within the cloud volume from the freezing level (altitude in km above the surface) to the height of the -20^{o}C isotherm; the model computed mass mixing ratios for snow (q_s), cloud ice (q_i) & graupel (q_g) are in units (kg/kg) and ε is a dimensionless number which has a value between 0 and 1 defined by:

$$\epsilon = 2(Q_i Q_1)^{0.5}/(Q_i + Q_1)$$

- Where Q_1 is the total liquid water mass mixing ration and Q_i the ice fractional mixing ratio.

$$Q_i = q_g[\left(\frac{(q_s q_g)^{0.5}}{(q_s + q_g)}\right) + \left(\frac{(q_i q_g)^{0.5}}{(q_i + q_g)}\right)]$$

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Data and Methods: Index

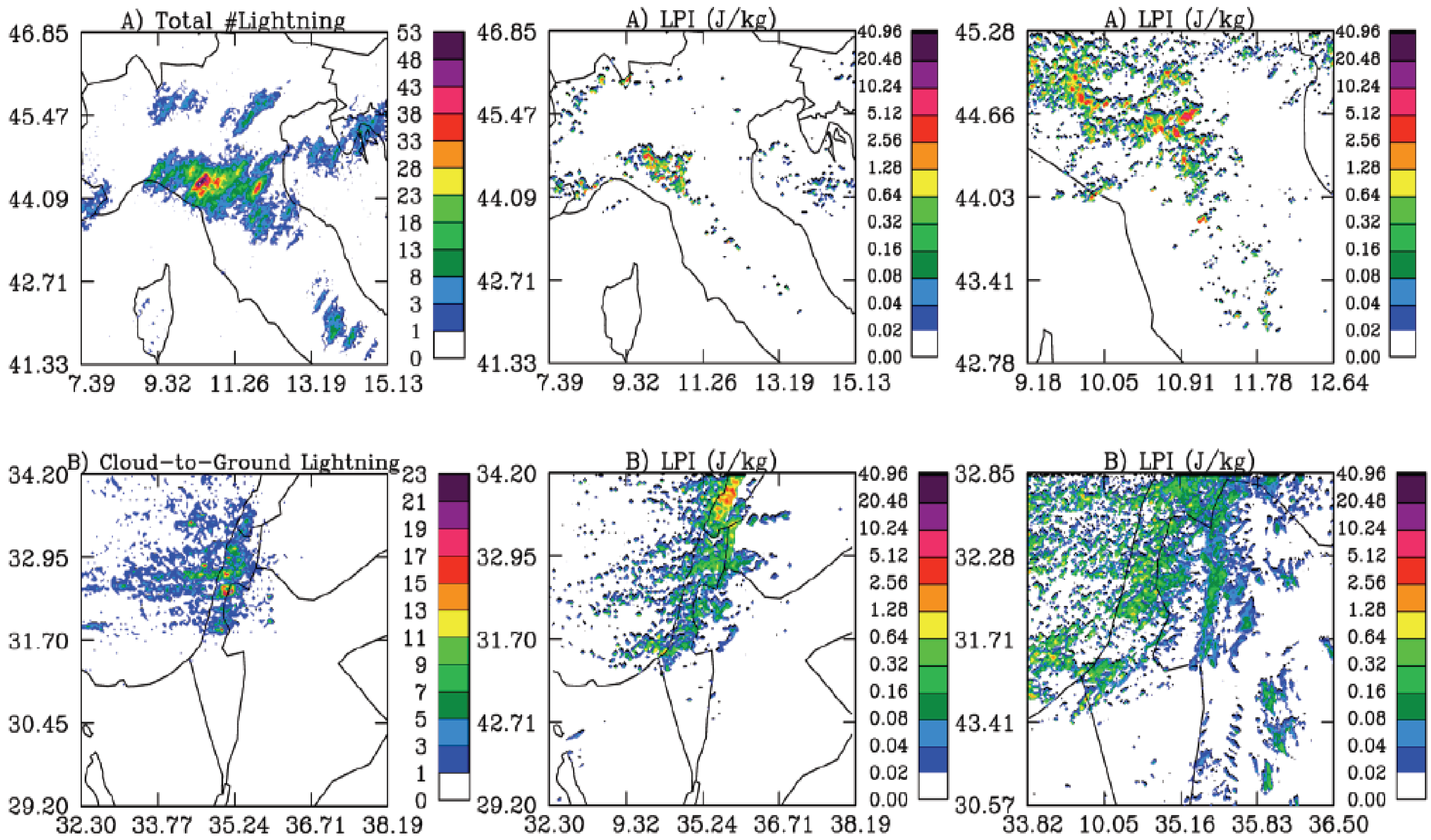

Fig. 1. Observed 24 h lightning is two case studies for Italy and Israel. The upper row is for case study **(A)** 9 September 2008 (ZEUS network), and the lower row for case study **(B)** 28 February 2009 (LPATS network), respectively. WRF model calculated, 24 h averaged, Lightning Potential Index (LPI) for both cases at 4 km (center) and 1.33 km (right) grid resolution for the same dates.

Conclusions

- Lightning can have potentially lethal consequences to life and cause considerable damage.
- Africa is a lightning prone continent, but most African countries don't have ground-based lightning detection networks
- Global (remote sensed) lightning networks:
  - can be alternatives
  - not as accurate
  - identifies the location of most thunderstorms.
  - GLD360, WWLLN and LIS best options.
- The LTI might be a good option to forecast the overall threat of lightning for the day.
- The LPI will also be a good indicator of lightning activity

Thank you

Questions?