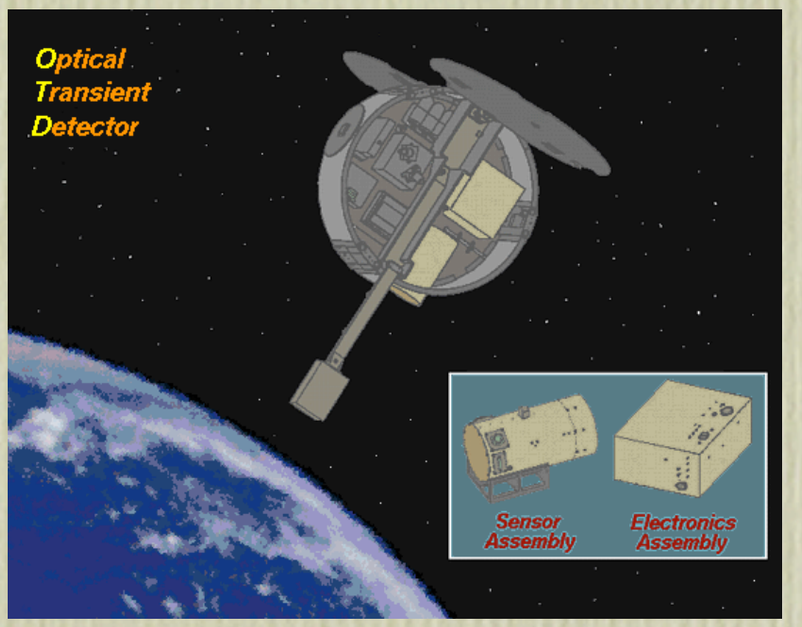
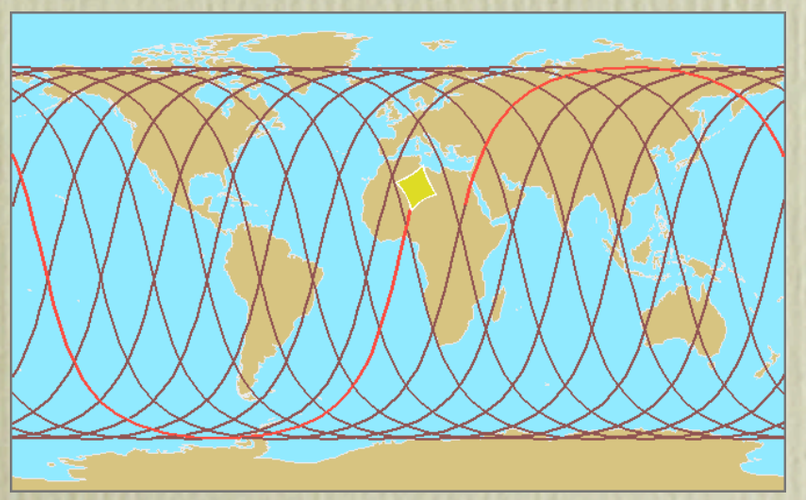
Global Lightning Observations

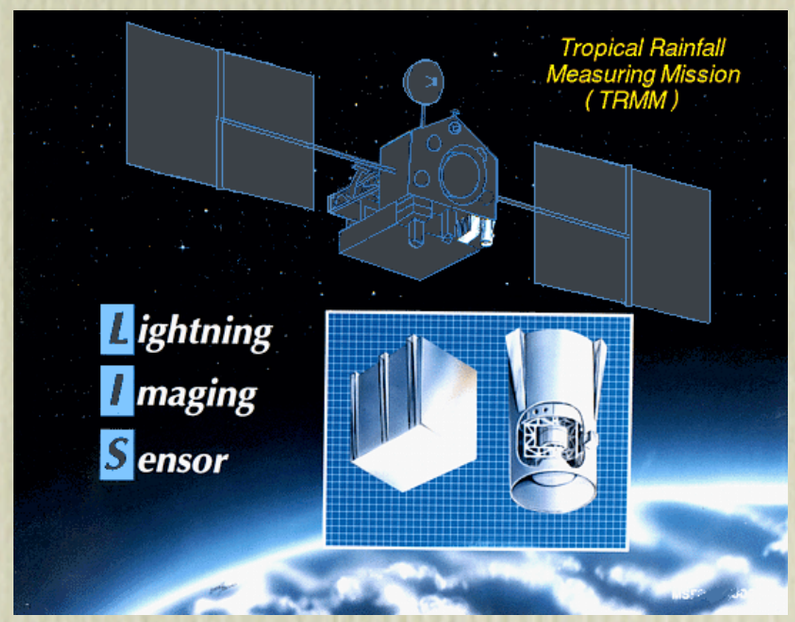
Lightning Detection from Low Earth Orbit

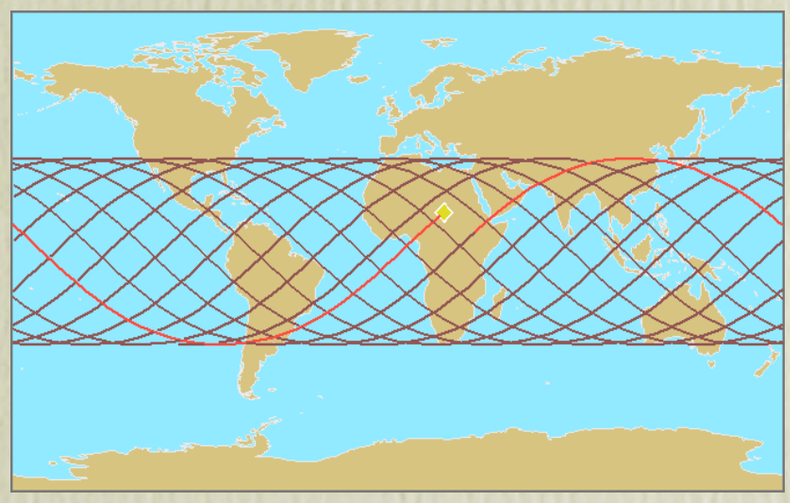
Optical Transient Detector
(launched April, 1995)



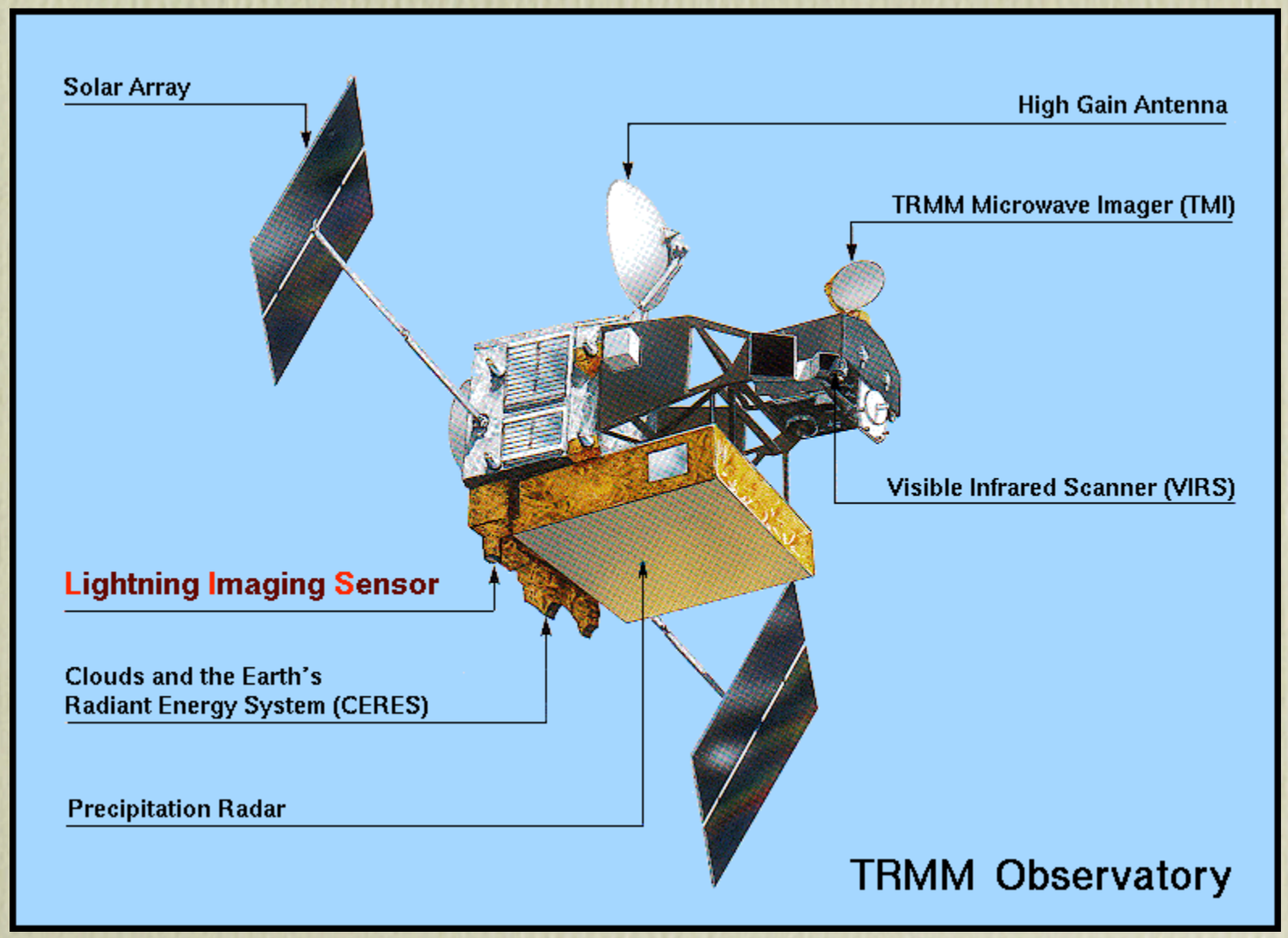


Lightning Imaging Sensor
(launched November, 1997)





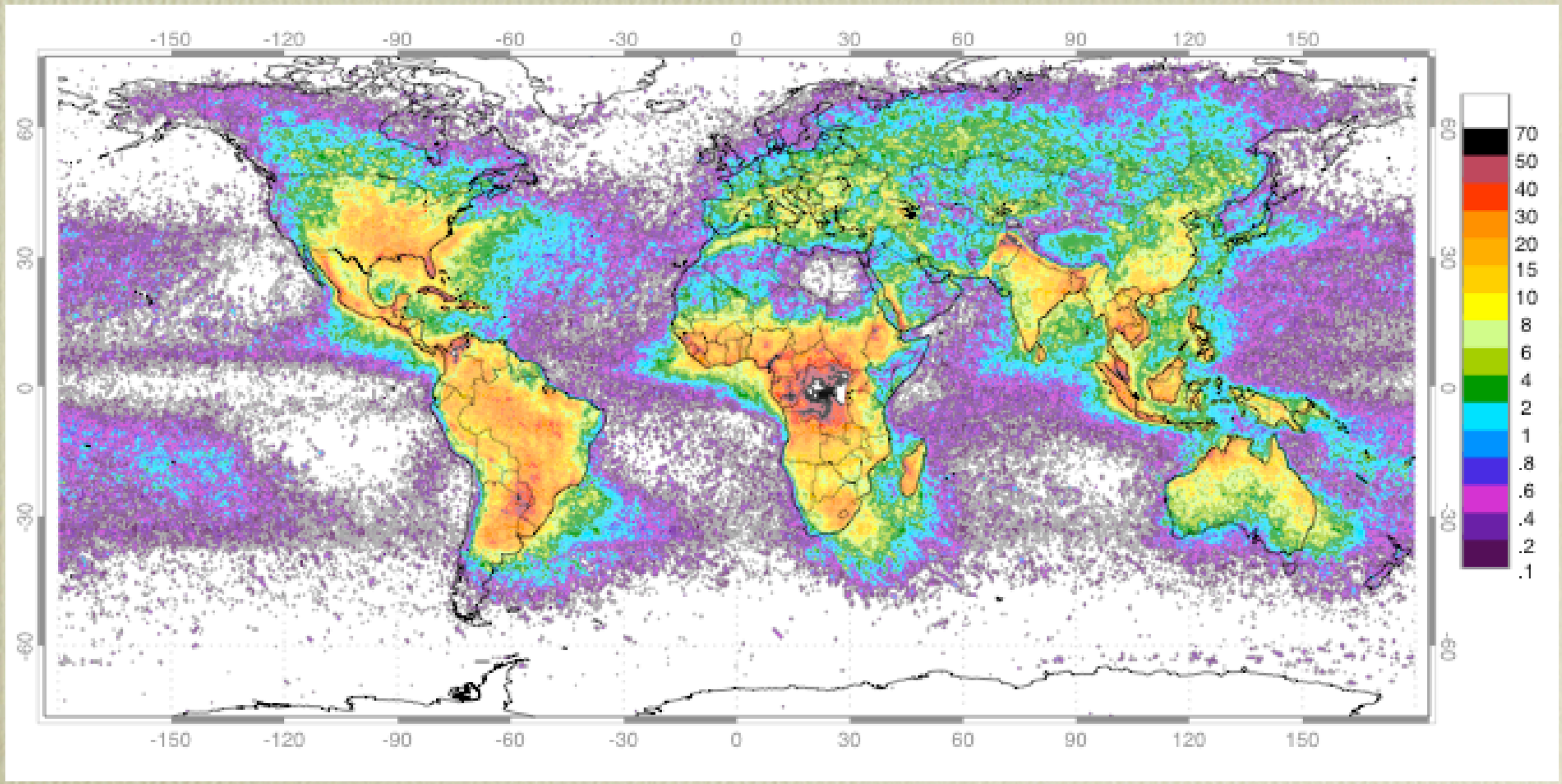
LIS on TRMM


Solar Array
High Gain Antenna
TRMM Microwave Imager (TMI)
Visible Infrared Scanner (VIRS)
Lightning Imaging Sensor
Clouds and the Earth's
Radiant Energy System (CERES)
Precipitation Radar
TRMM Observatory

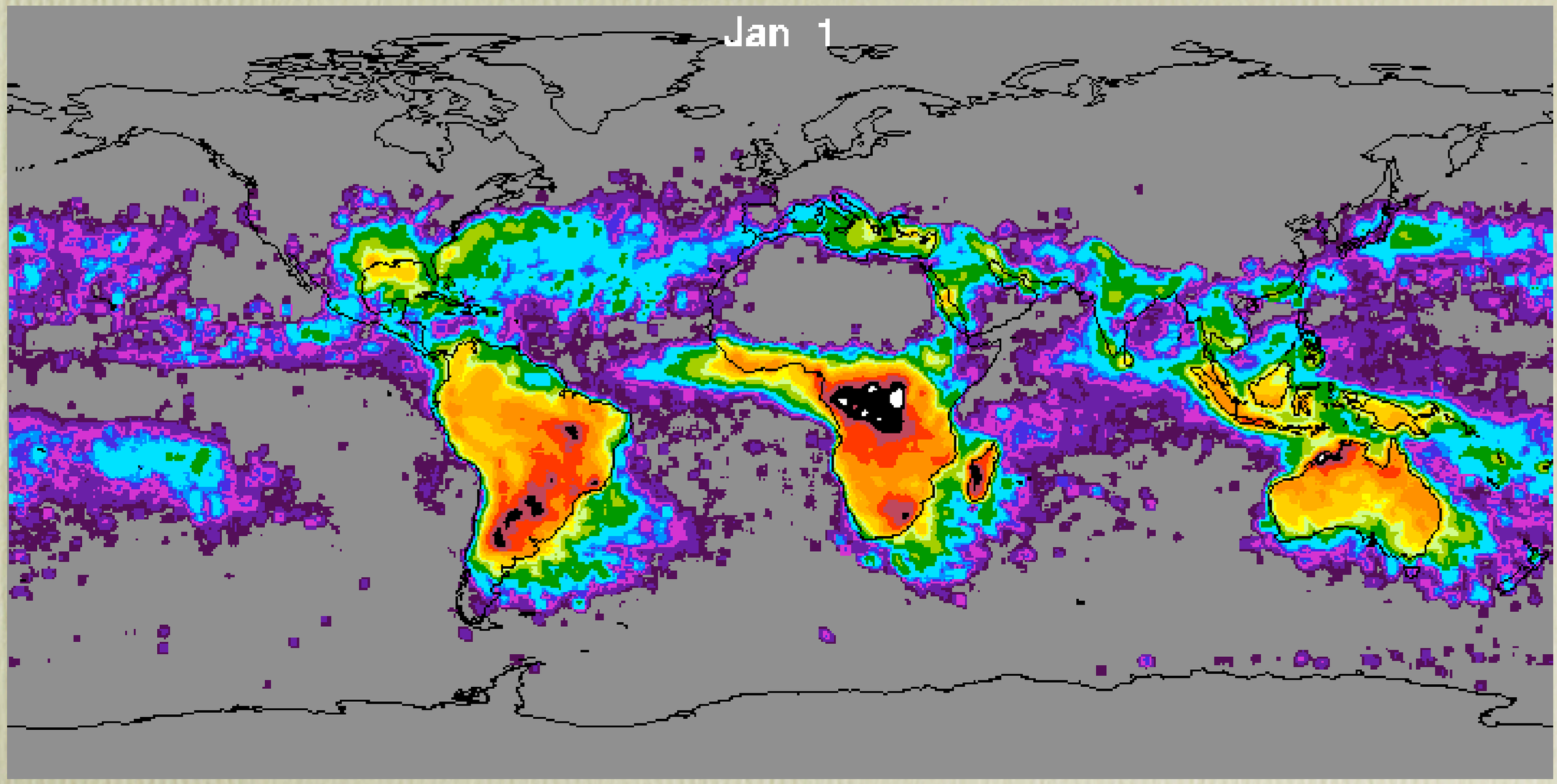
Climatology: Basics

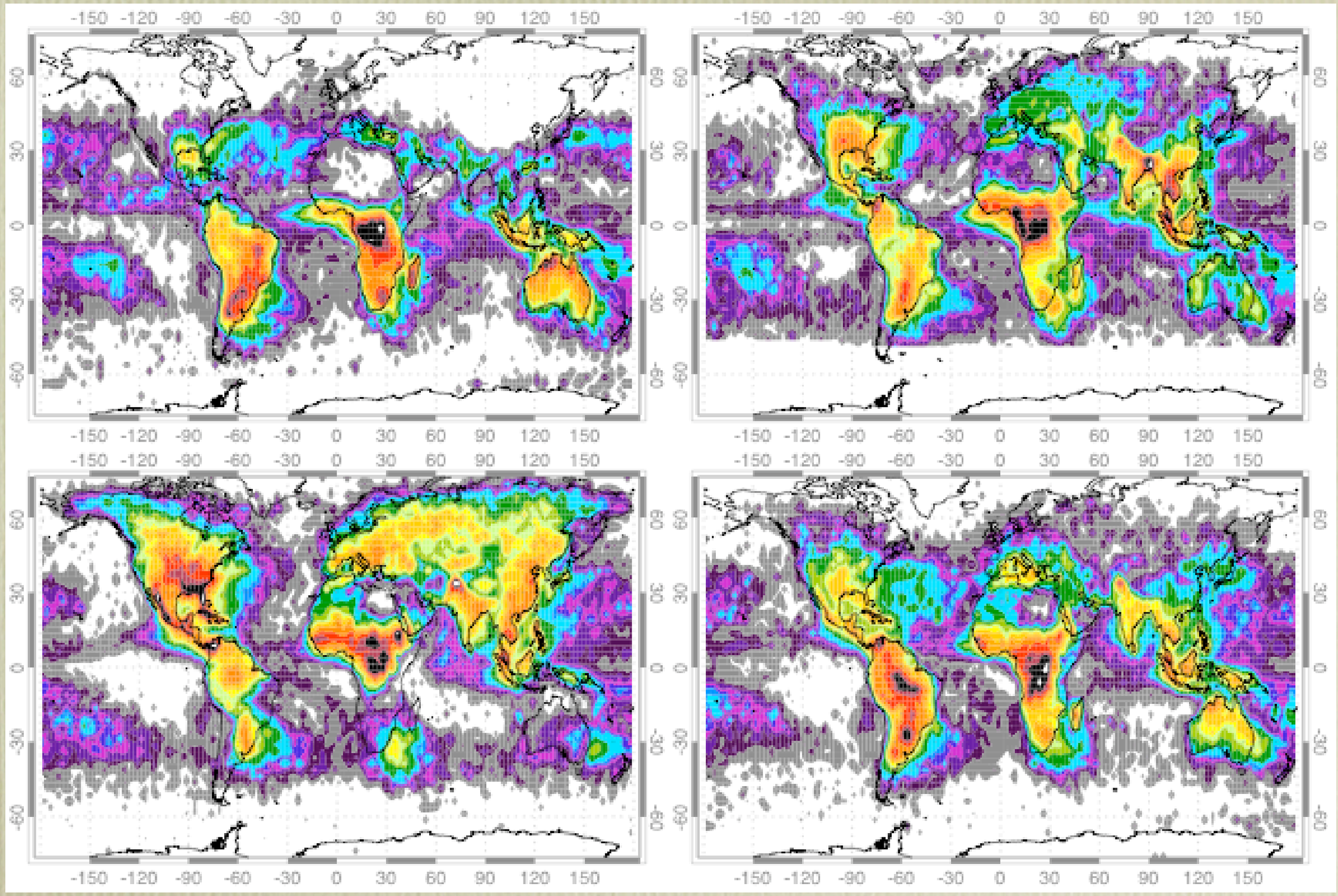
- 5 years of OTD, 6 years of LIS data
- Adjusted for detection efficiency *J. Atmos. Oc. Tech., 2002*
  - diurnally corrected
  - ground-validated
  - intercalibrated
- Scaled by satellite viewing
- Global flash rate: 45 fl / sec ± 10% *J. Geophys. Res., 2003*

High Resolution Full Climatology Annual Flash Rate

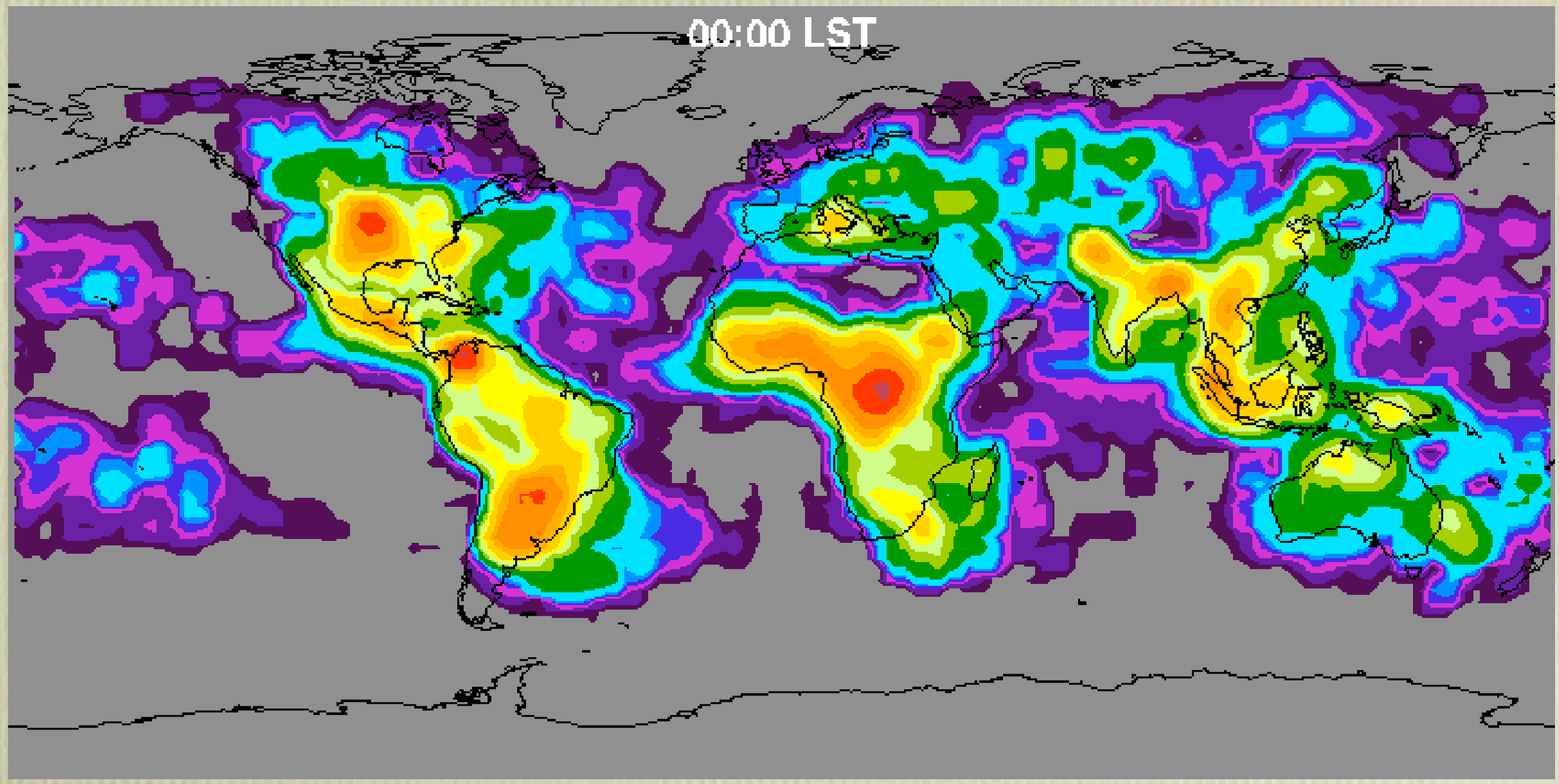


Global distribution of lightning from a combined nine years of observations of the NASA OTD (4/95-3/00) and LIS (1/98-12/03) instruments


Jan 1

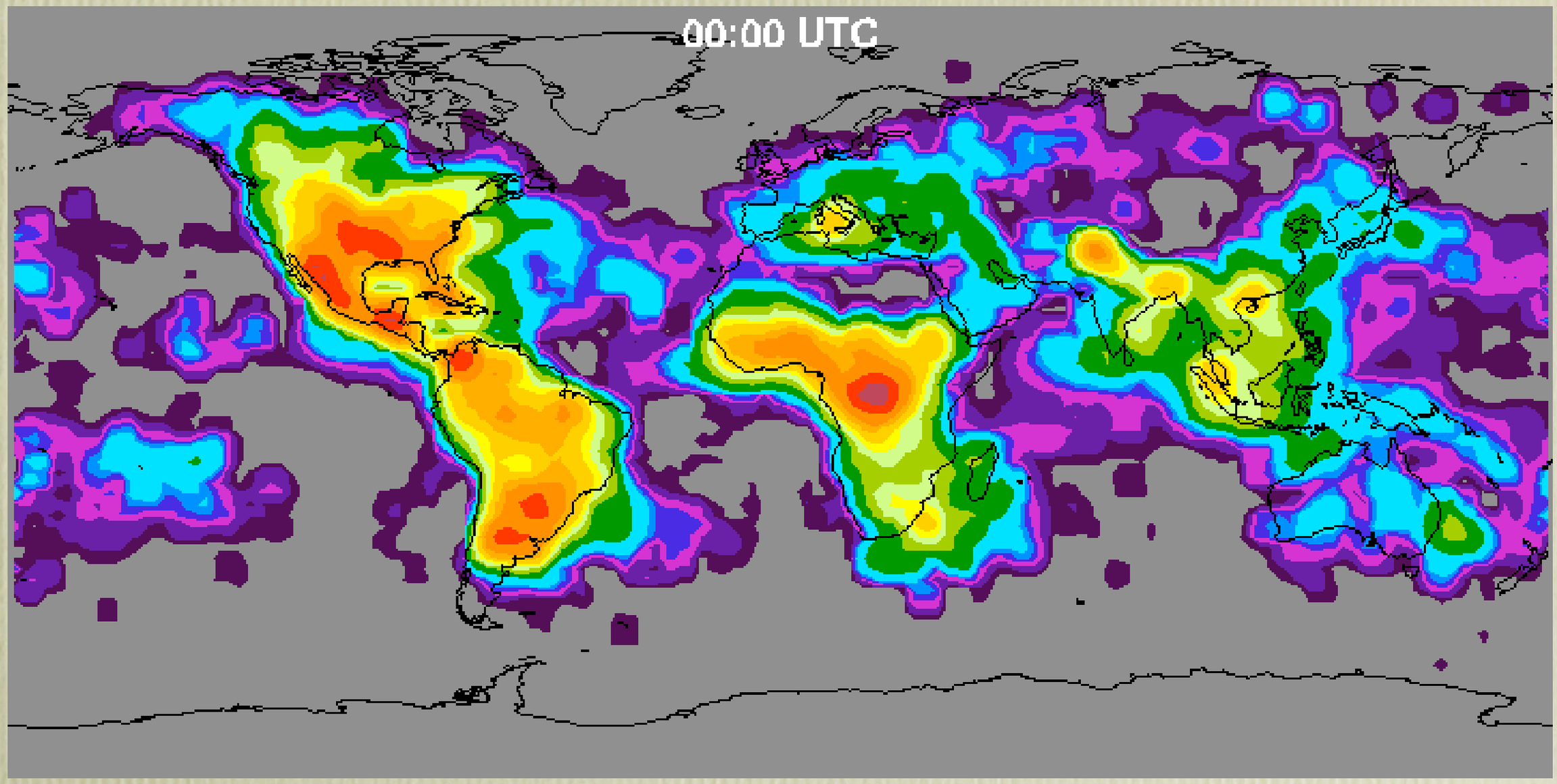

-150 -120 -90 -60 -30 0 30 60 90 120 150
60
30
0
-30
-60

Climatology: Diurnal cycle



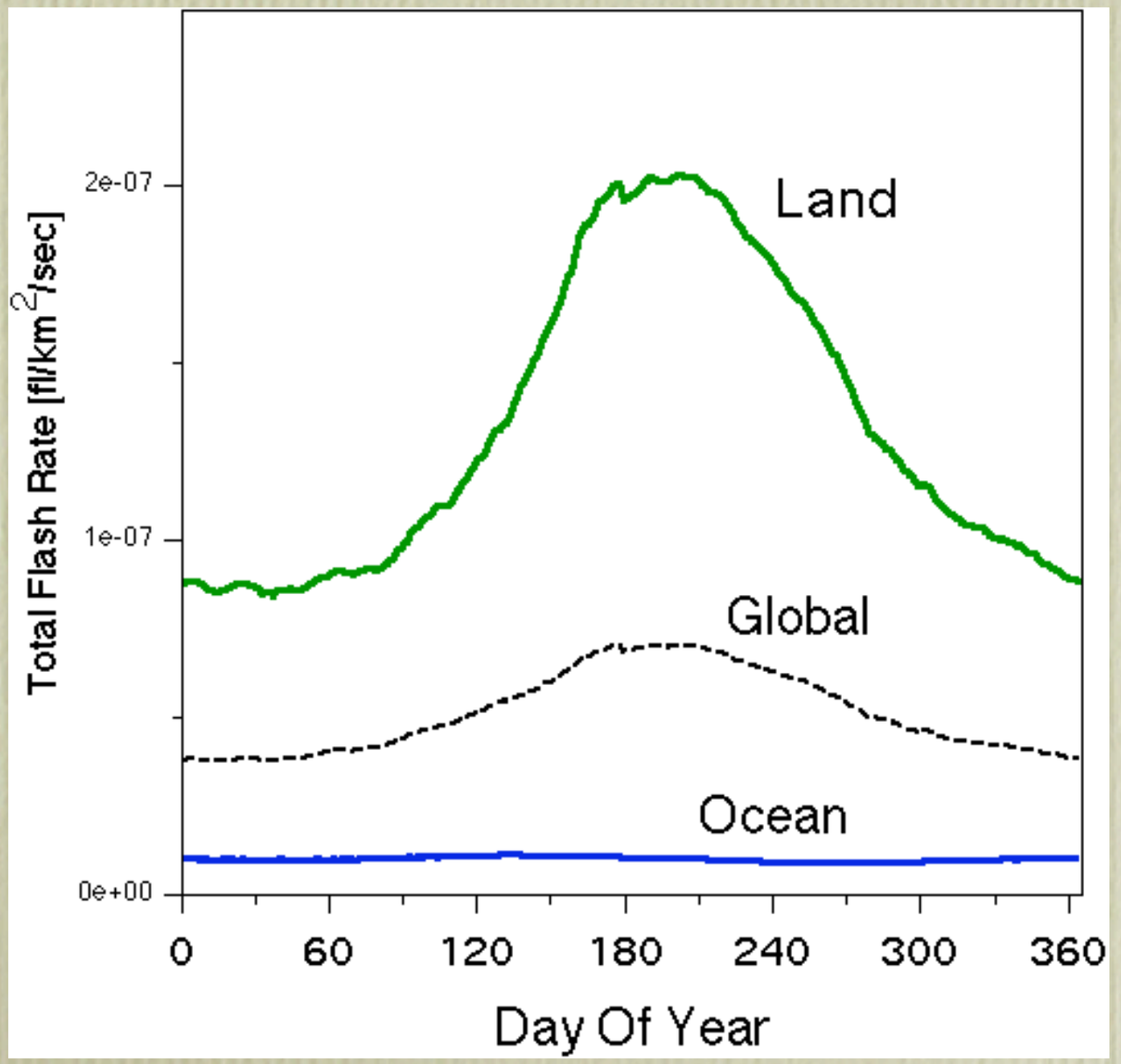
(Local hour)

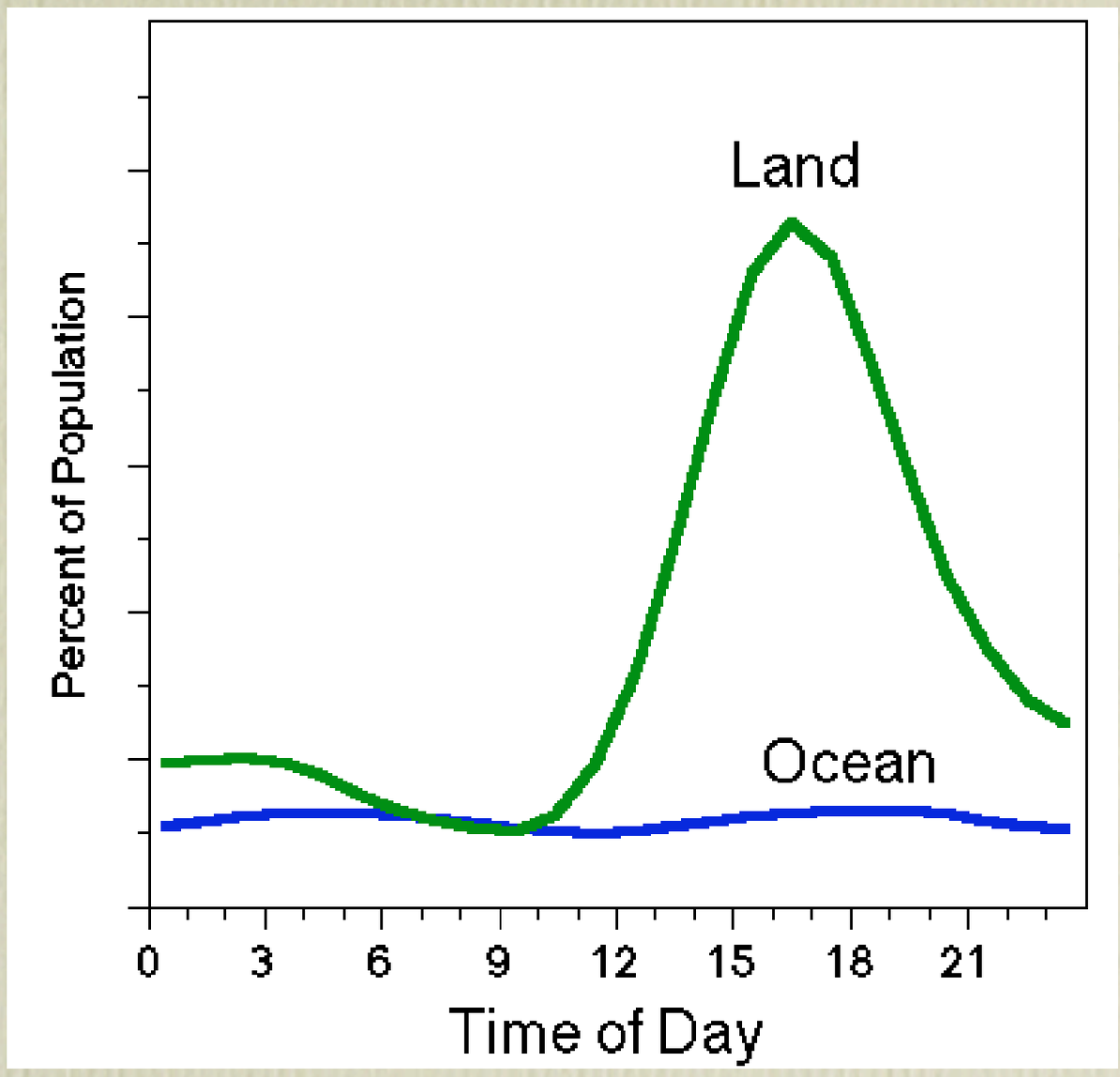
Climatology: Diurnal cycle



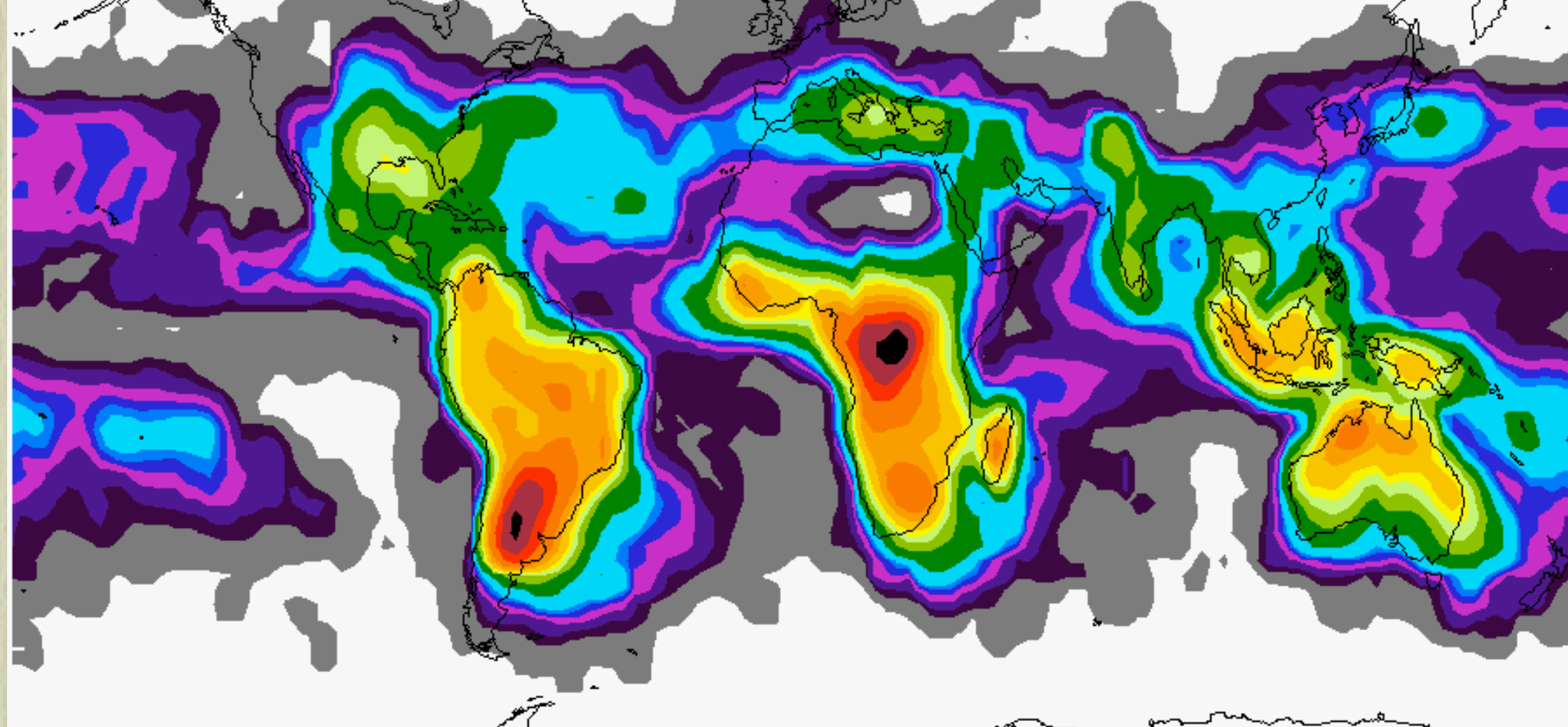
(UTC Hour)

Global lightning is modulated on annual & diurnal time scales, as well as seasonally and interannually

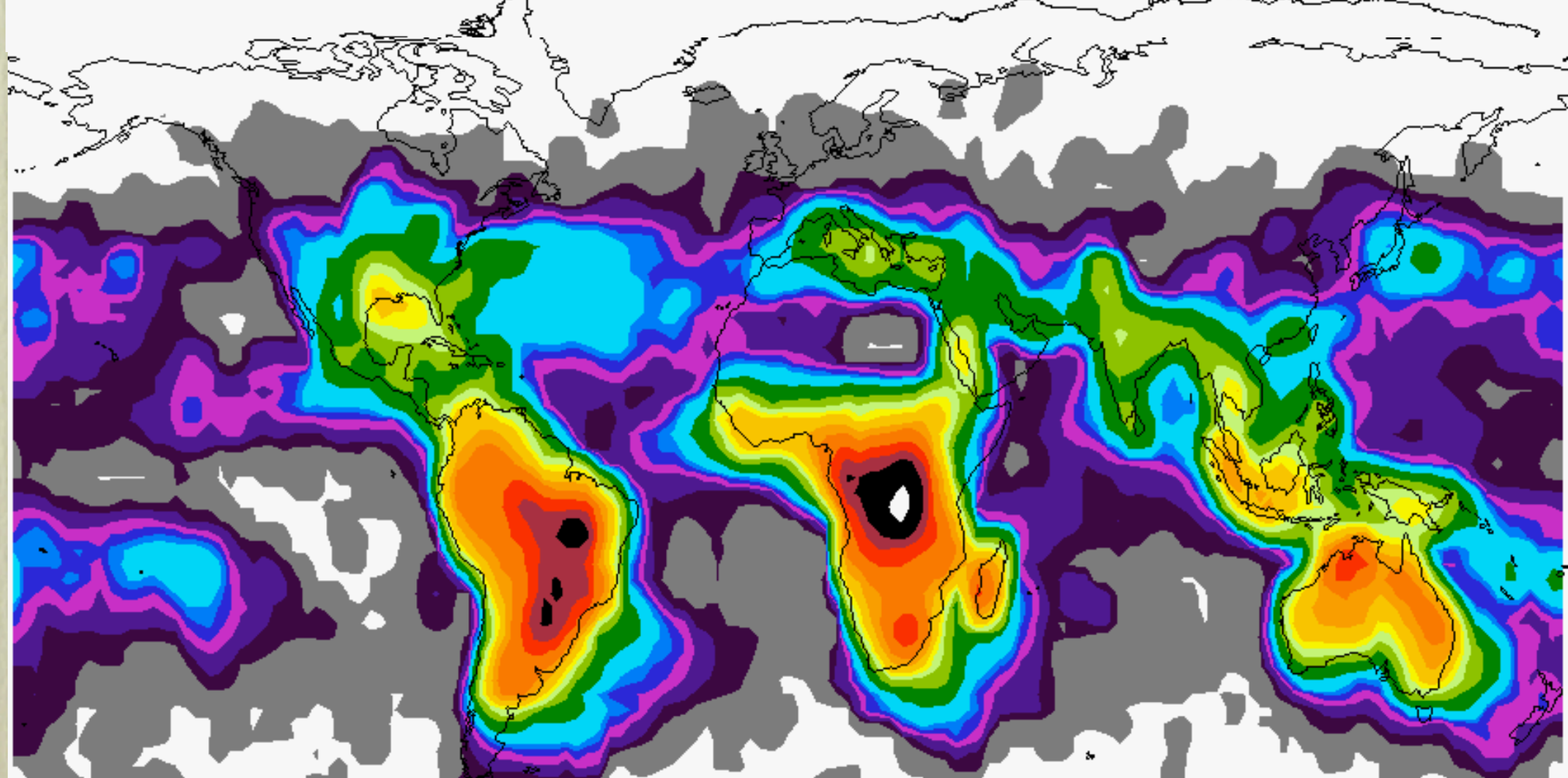




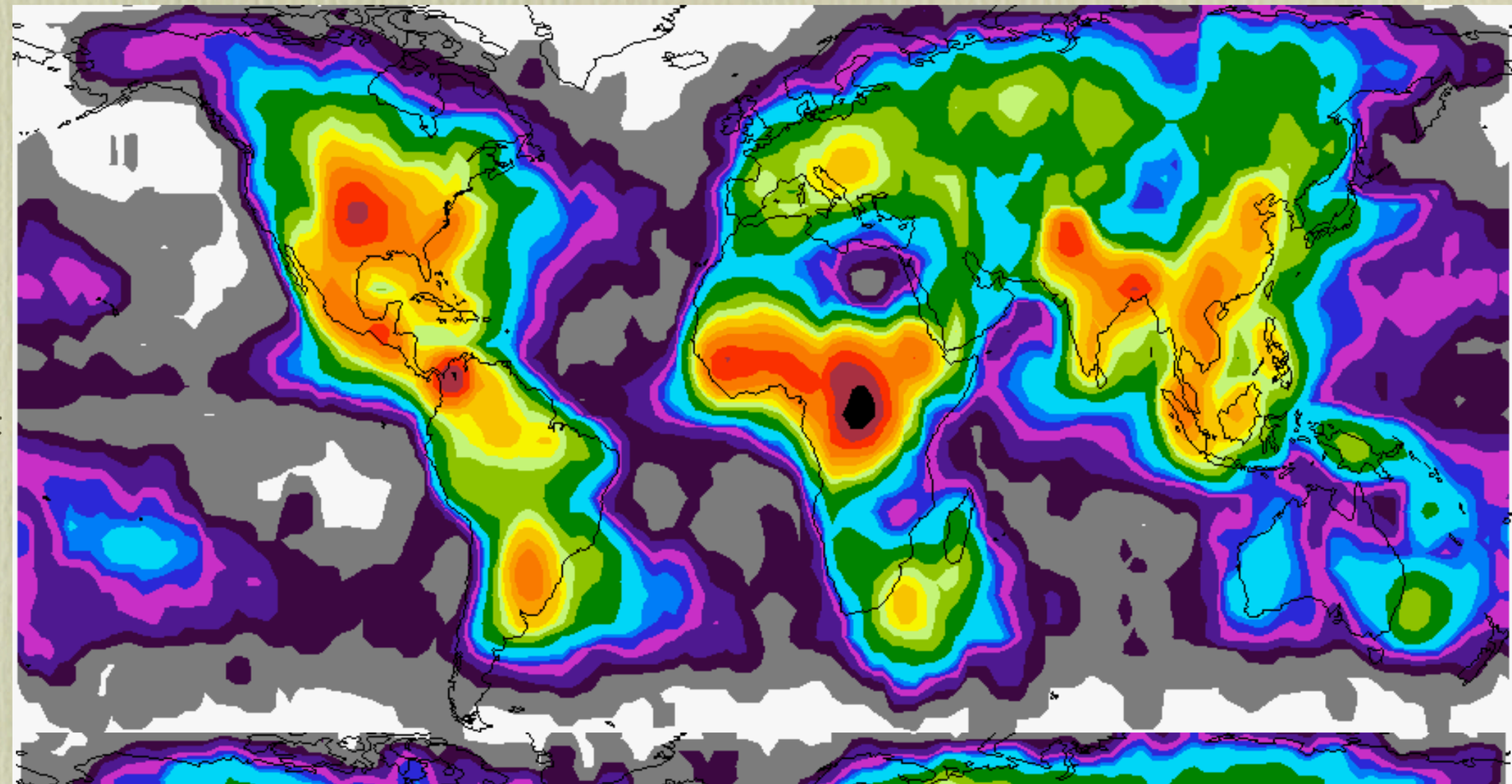
Oct.- Feb., night



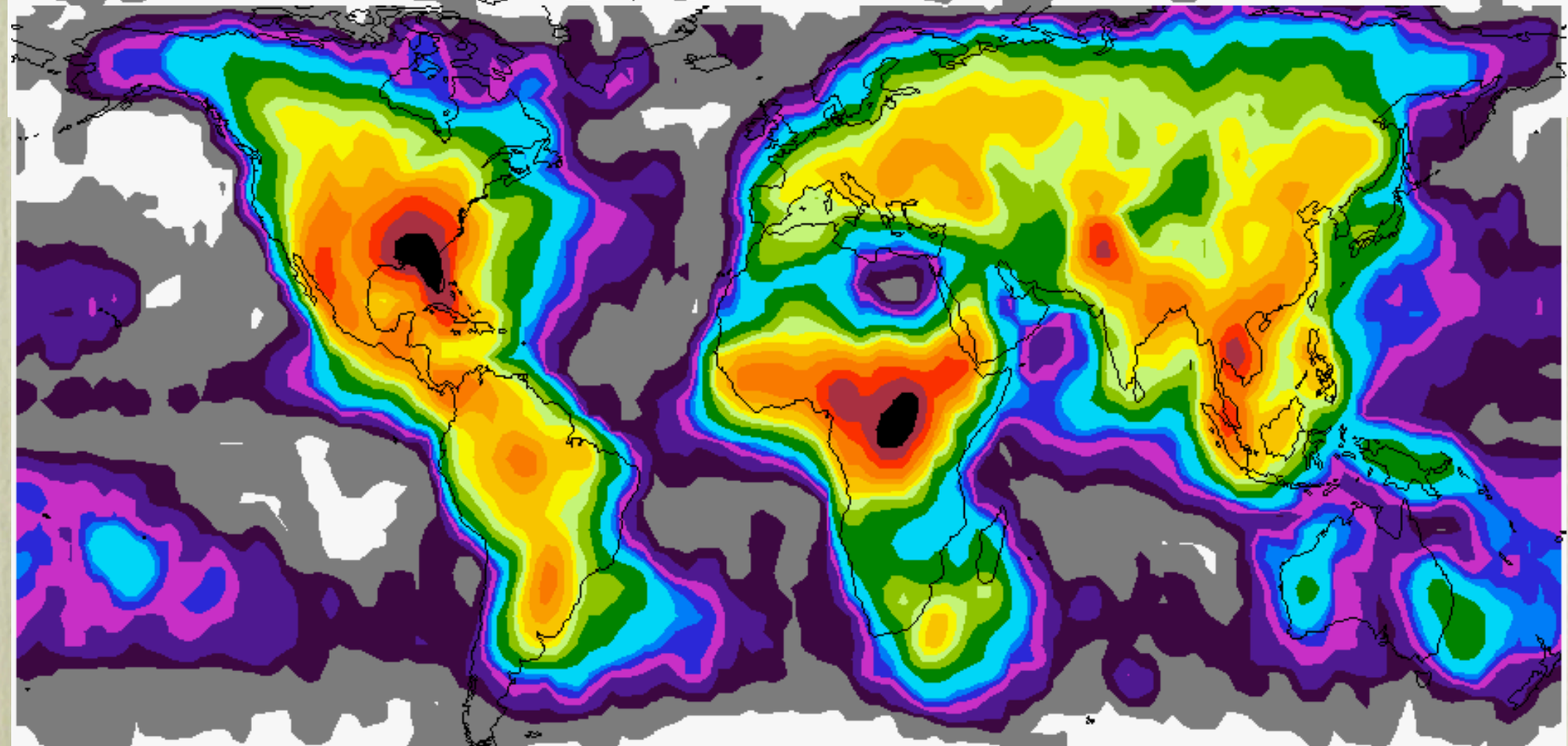
Oct. - Feb., day



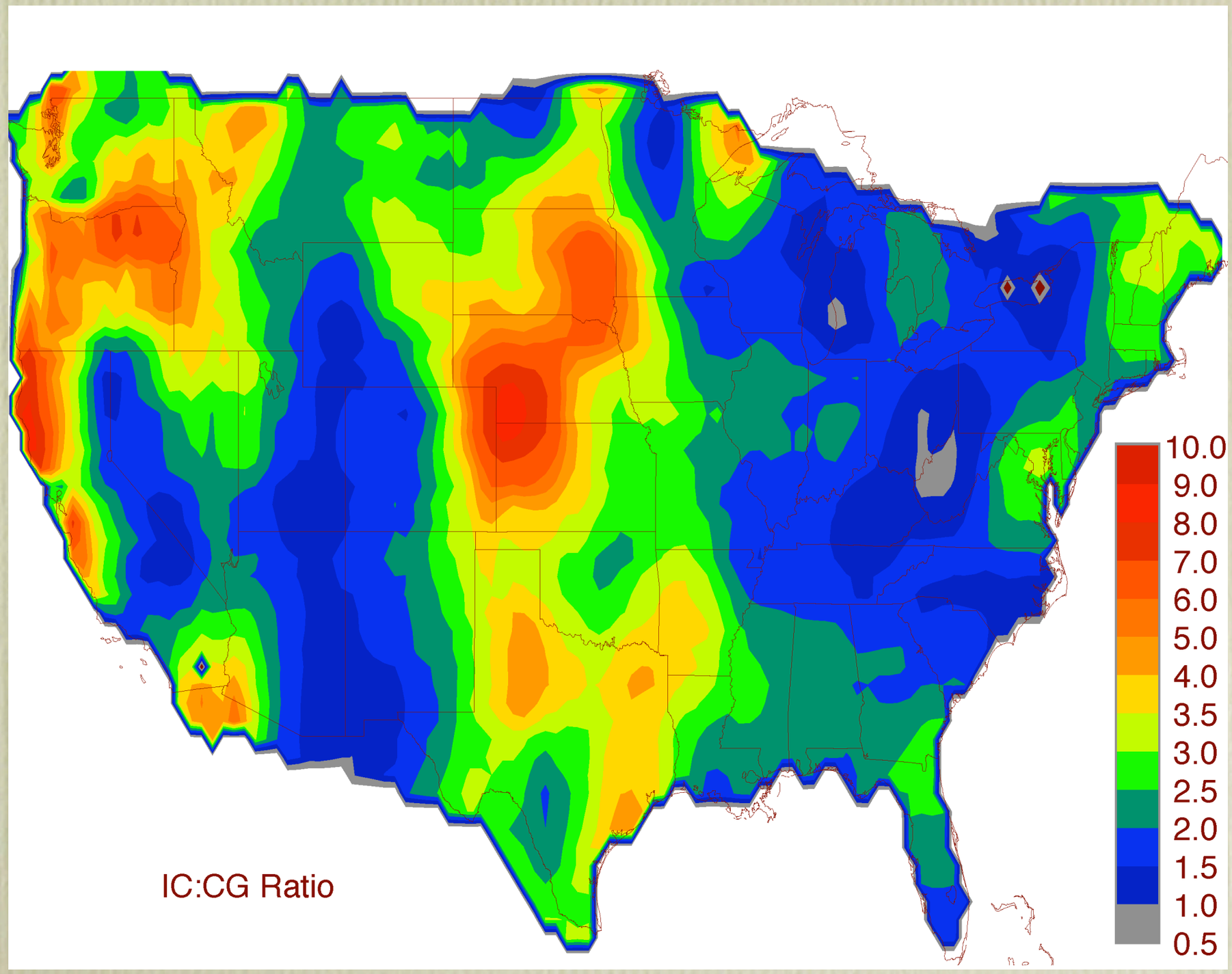
April - Aug., Night



April - Aug., Day

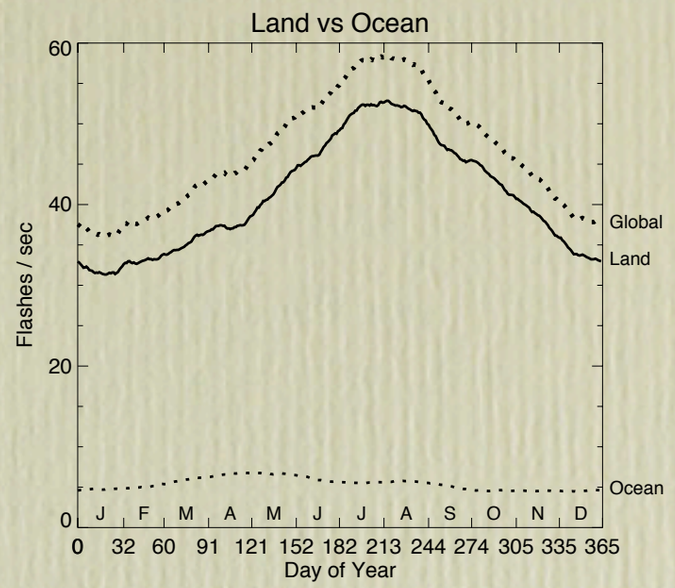


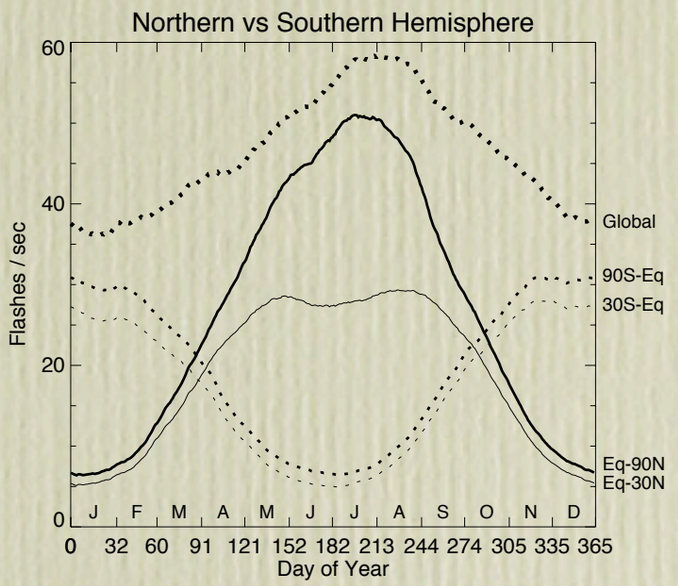
Climatology : IC / CG ratio

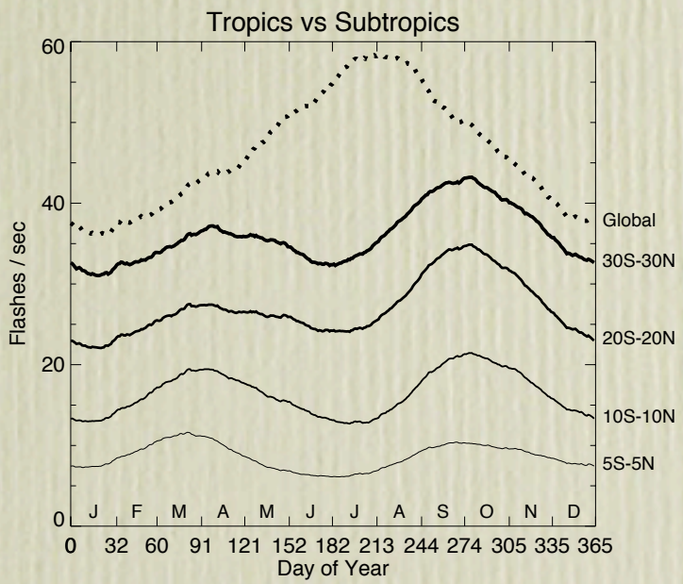


Climatology: Distributions

- NH summer dominates
- Expected semiannual signal in tropics

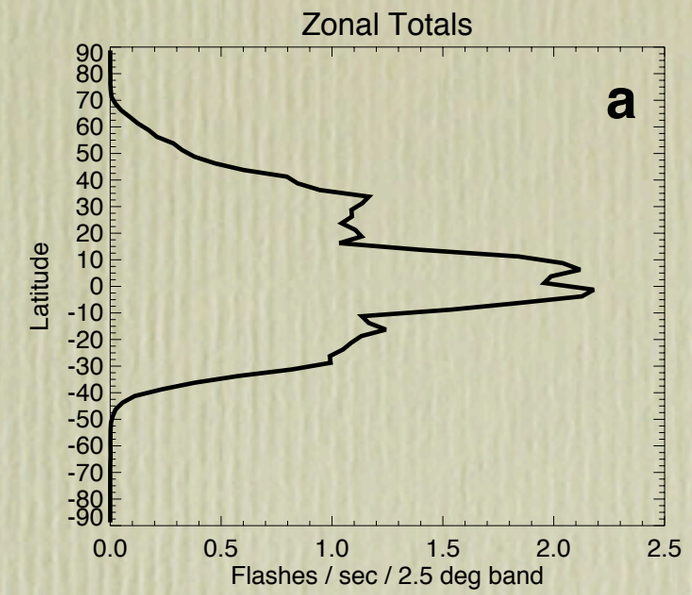


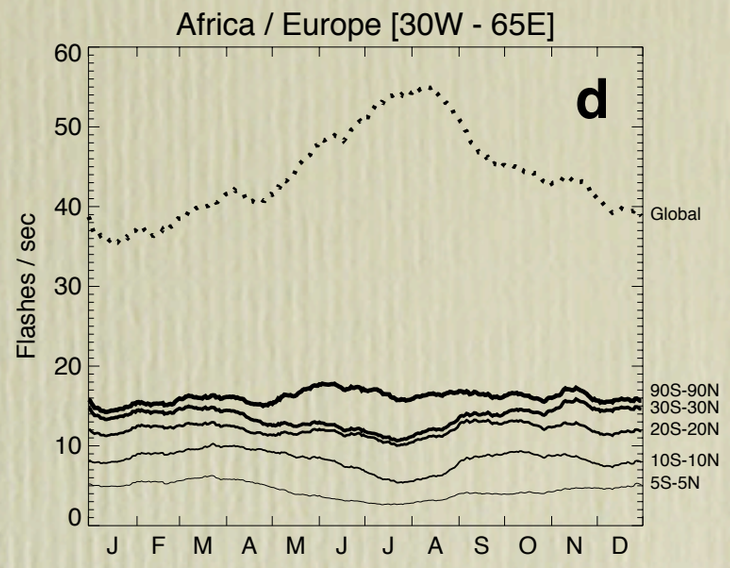


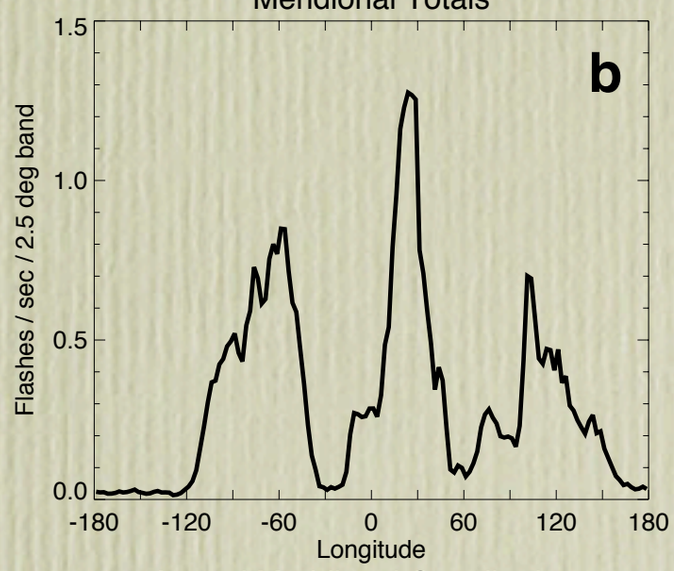


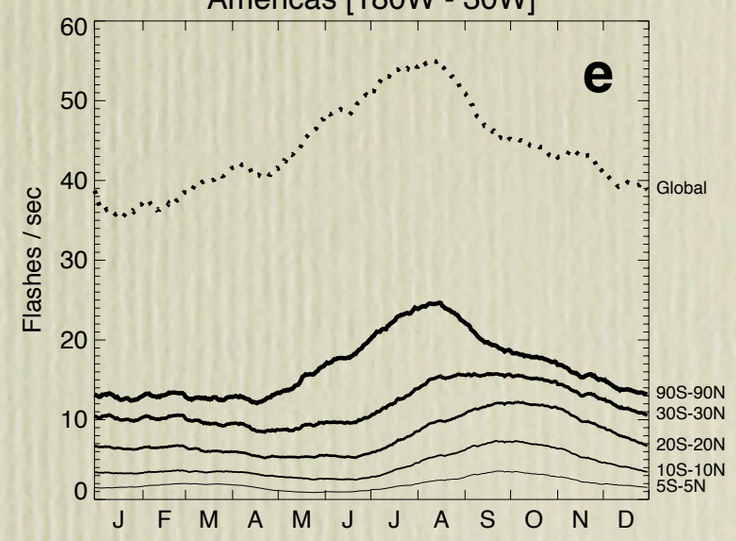
Climatology: Distributions

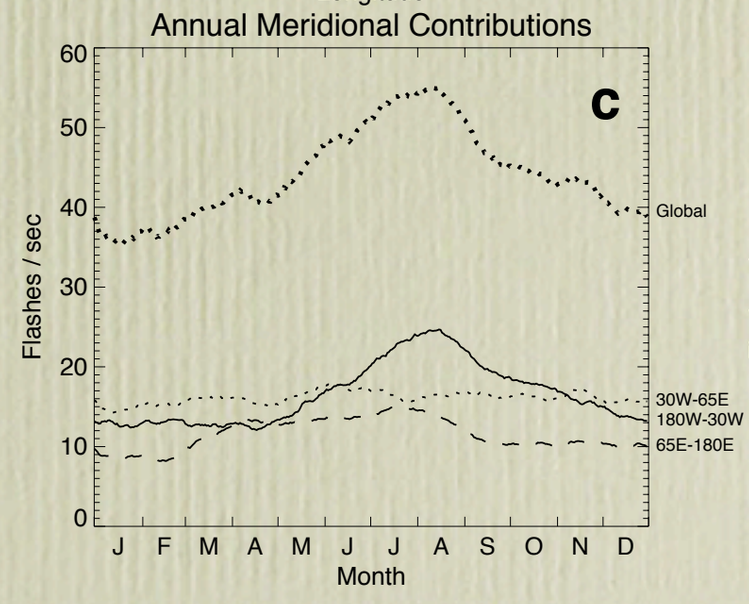
- Deep tropics ~ 2x subtropics
- Three tropical "chimneys" dominate (Carnegie curve)
- Americas dominate annual cycle

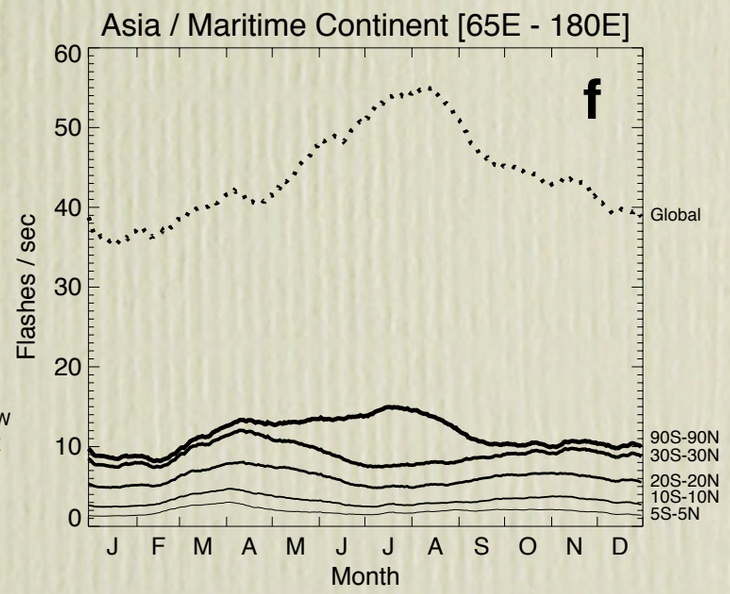




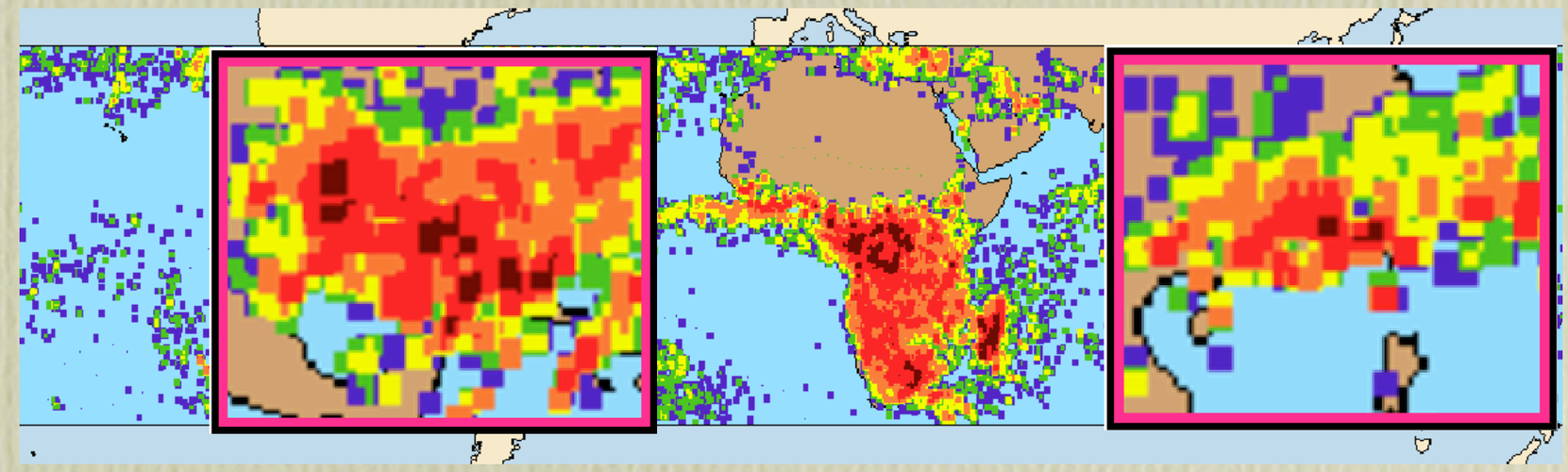




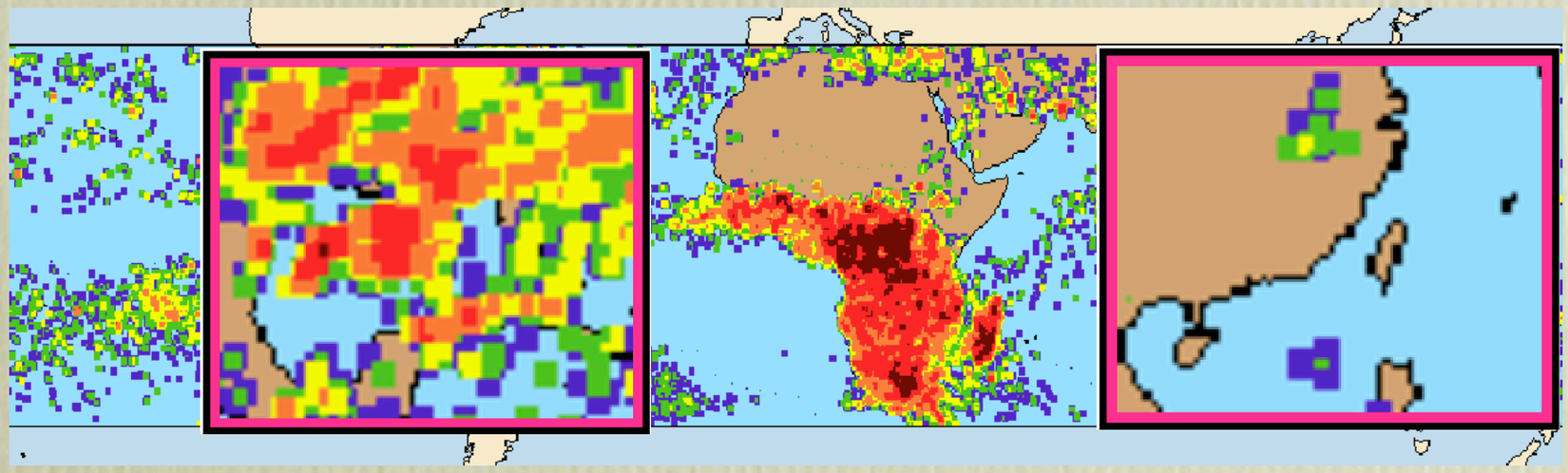




Lightning Responsive to Interannual Variability

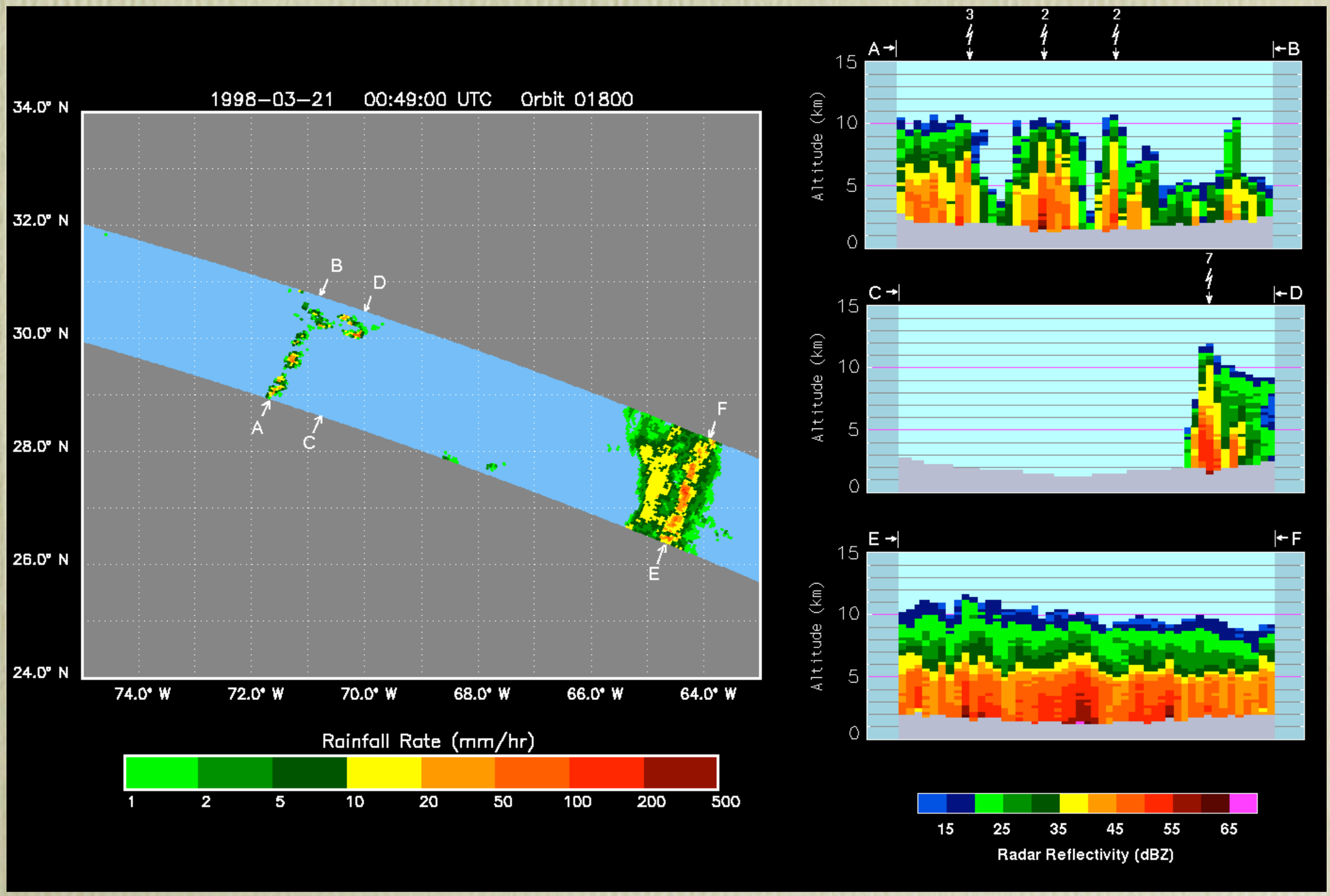


Winter 1997-98 (El Niño)

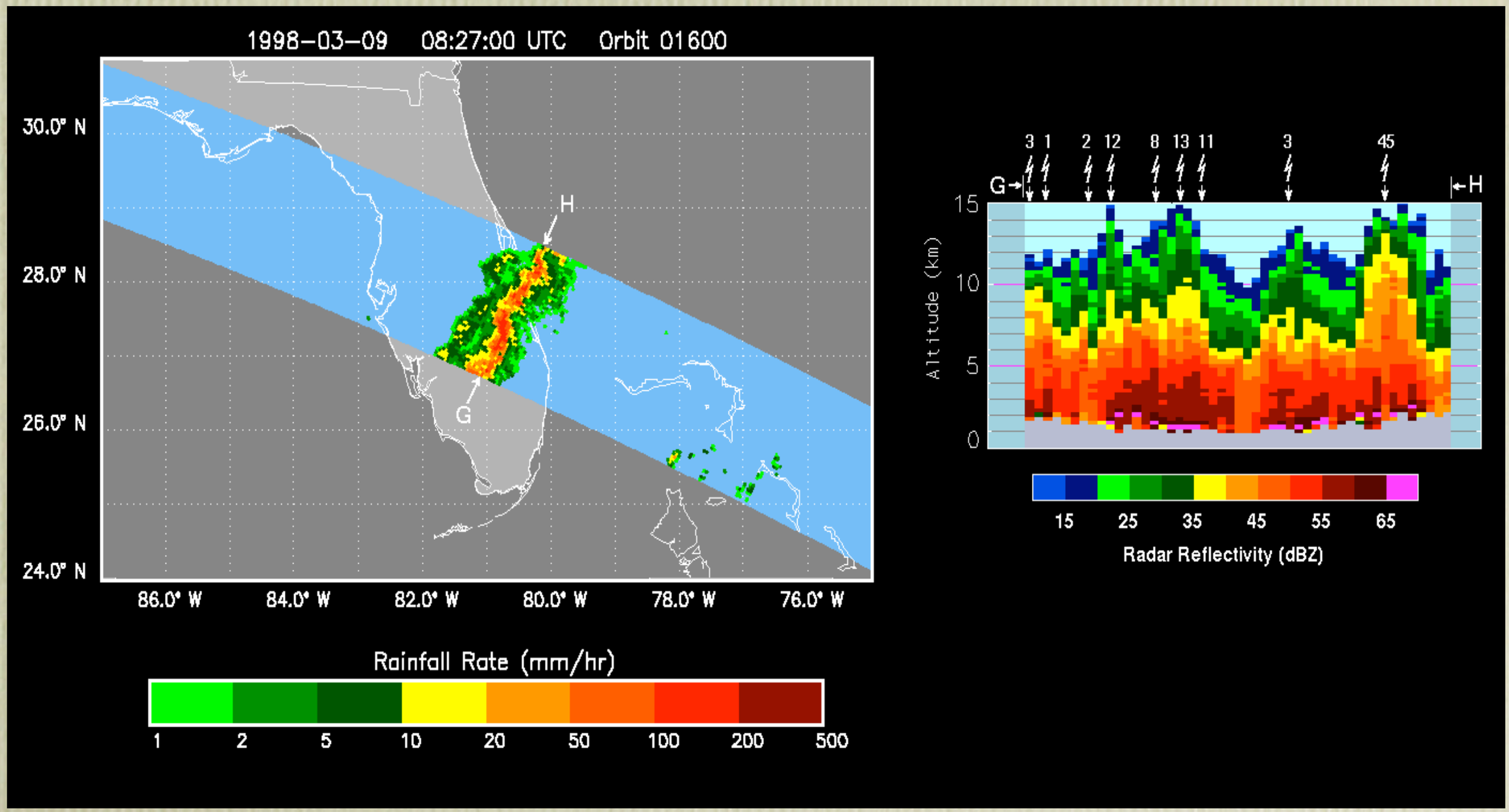


Winter 1998-99 (La Niña)

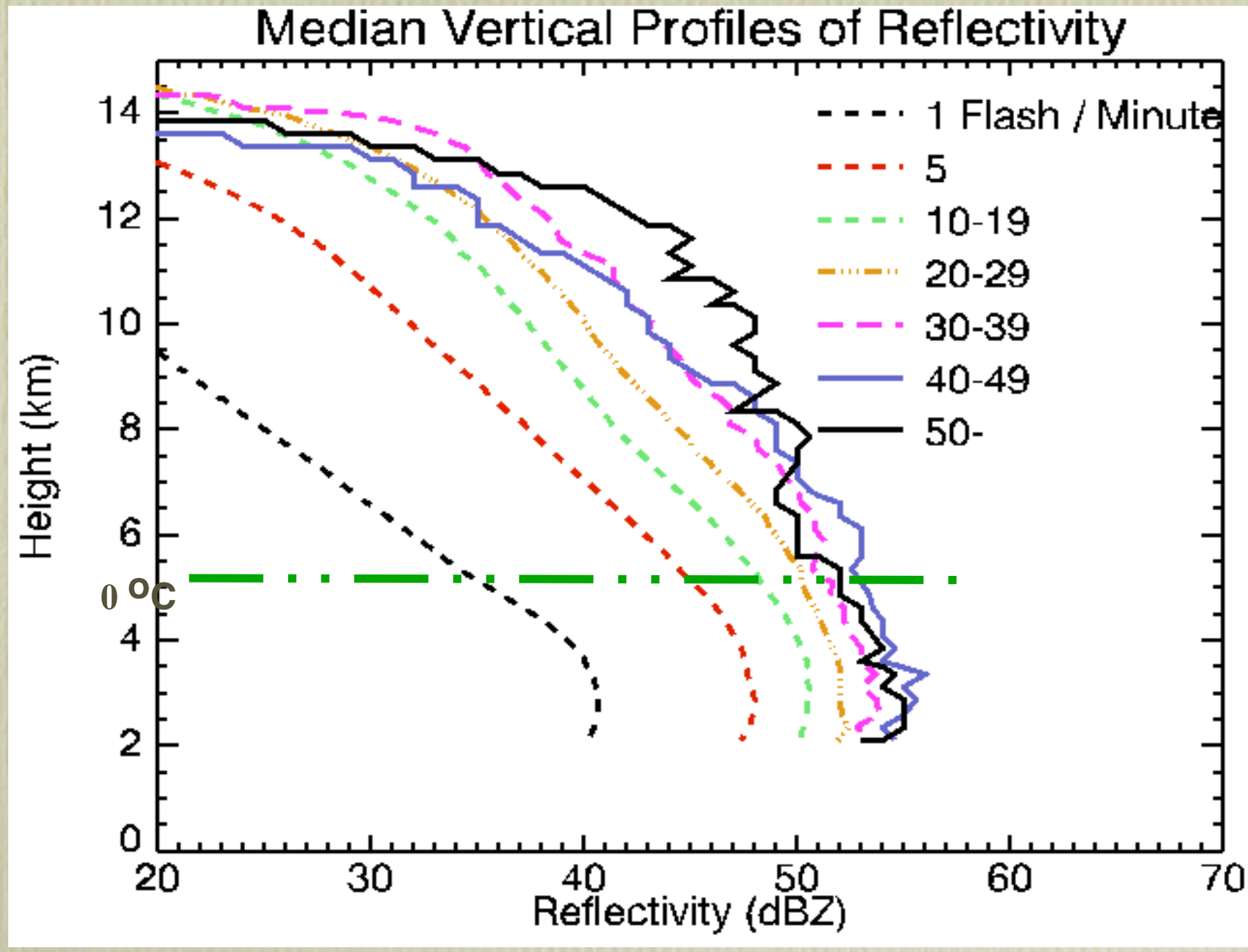
LIS Ocean Overpass



LIS Land Overpass



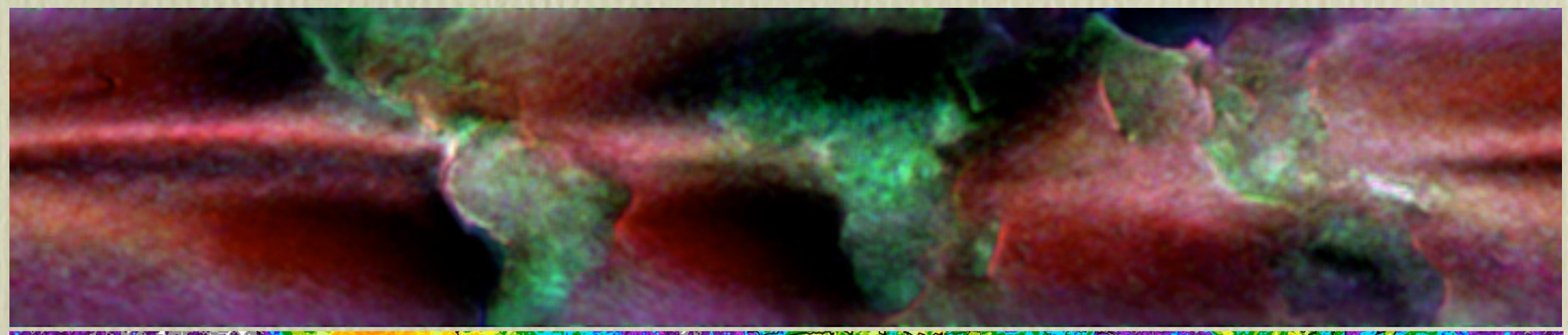
Flash Rate Coupled to Mass in the Mixed-phase Region



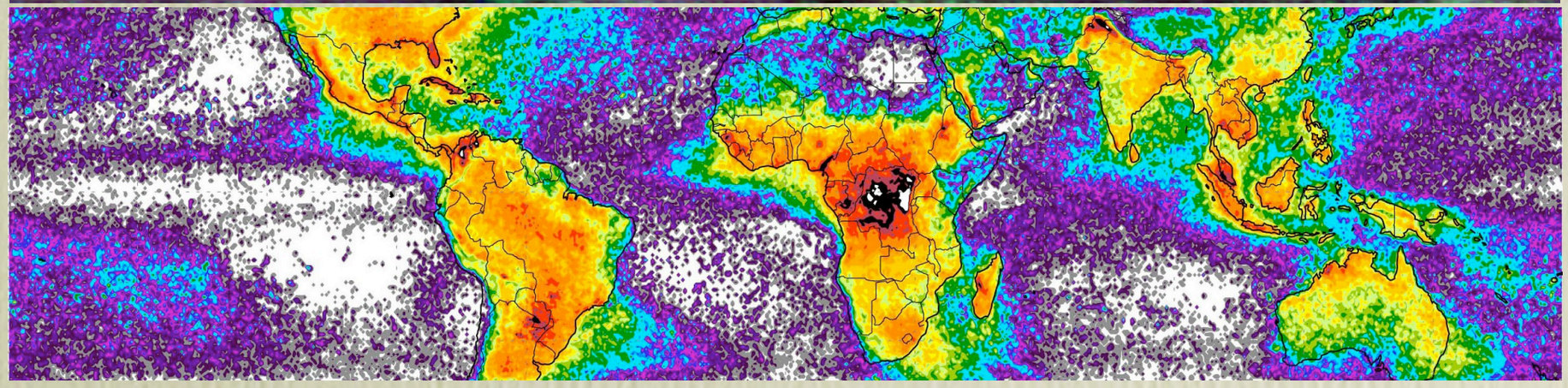
Deep convective frequency and lightning production

Warm / non-mixed-phase
Mid / deep convective
Mid / deep stratiform

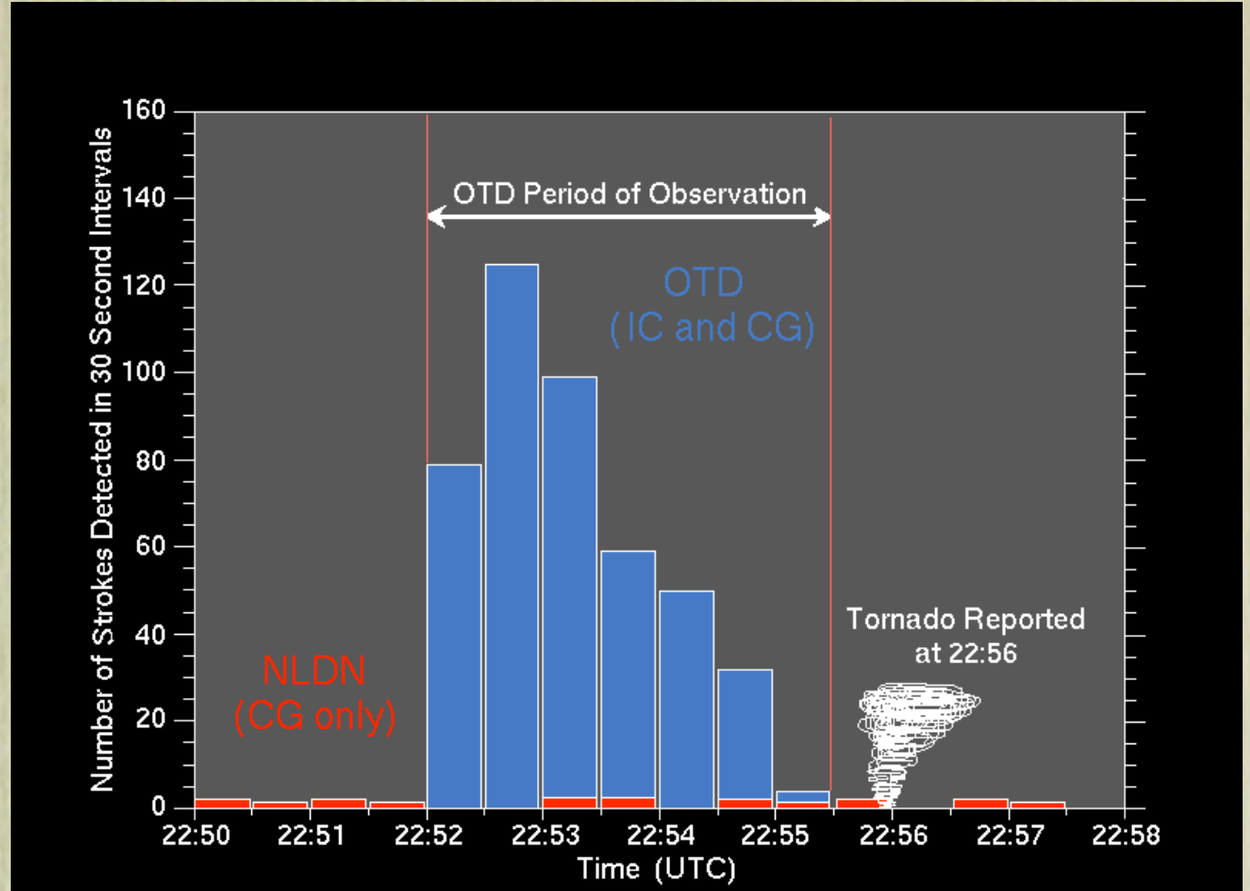
- Convective spectrum *(radar-based)*

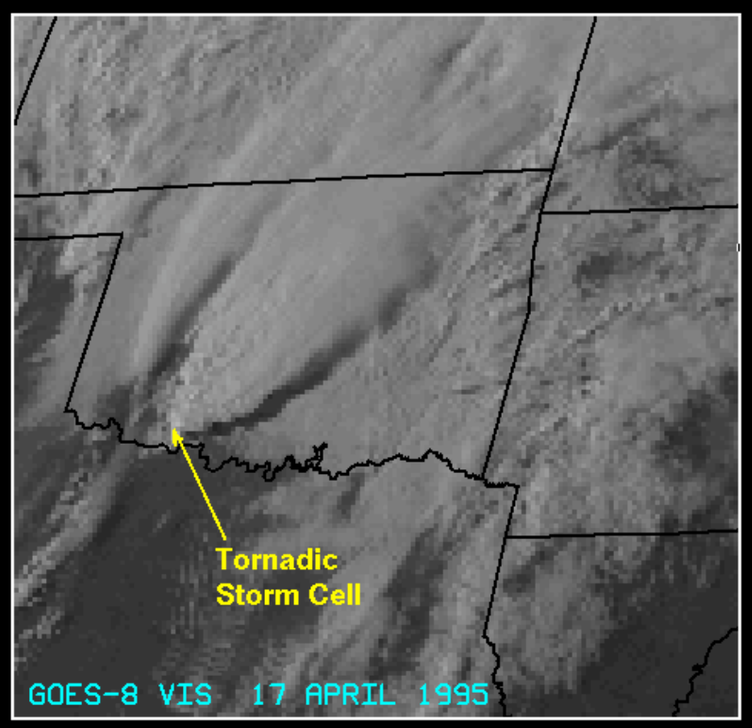


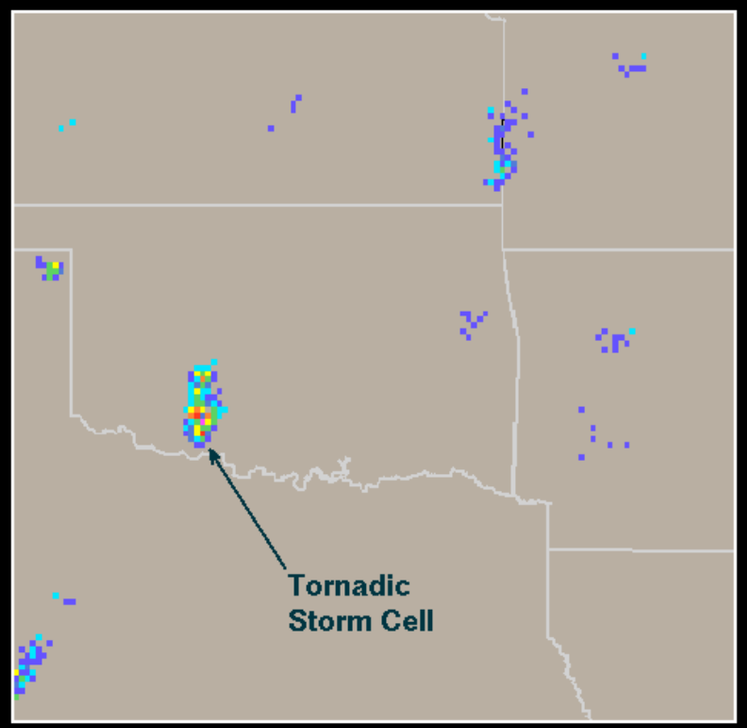
- Lightning production



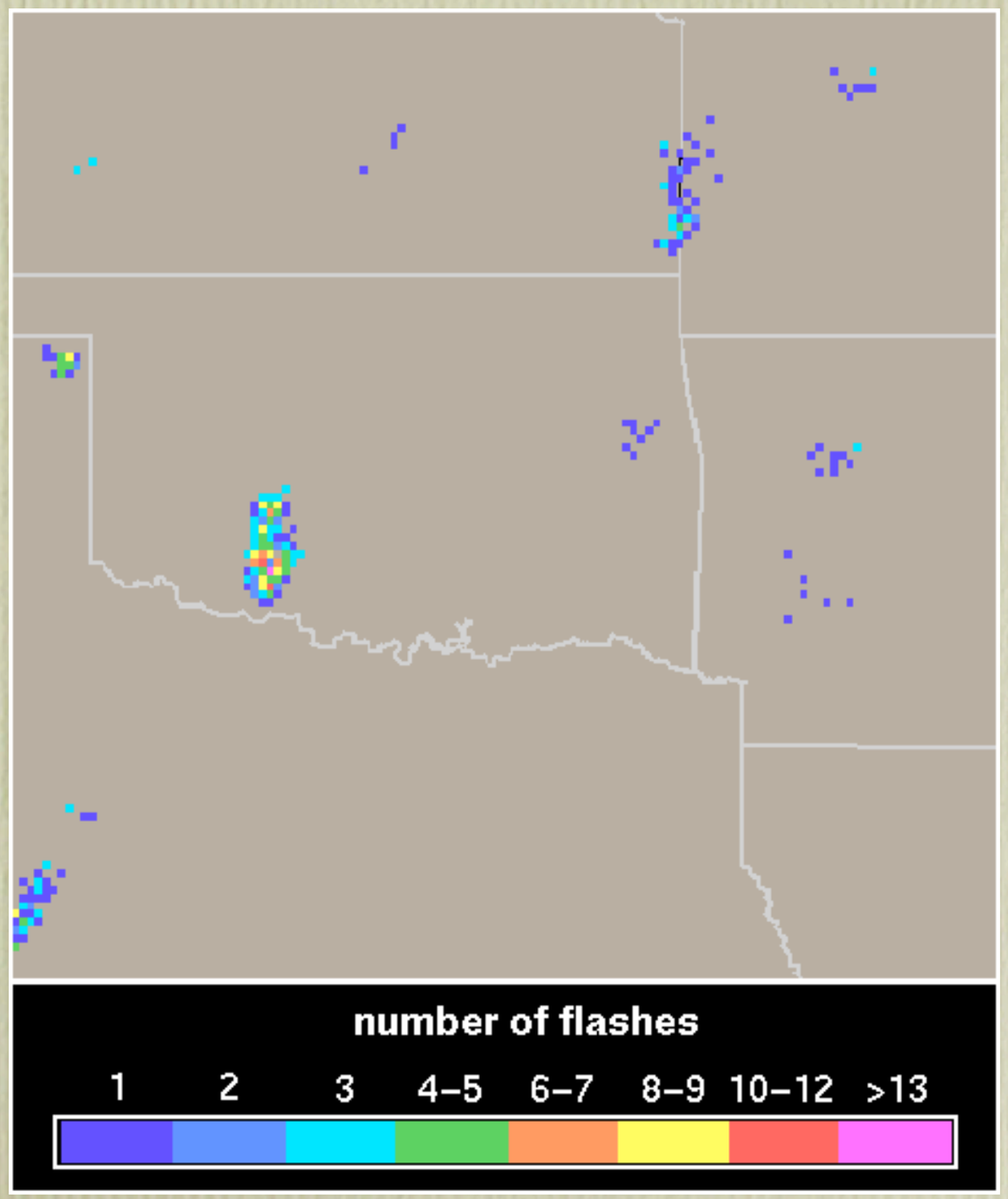
OTD Overpass of Tornadic Storms in Oklahoma, 1995

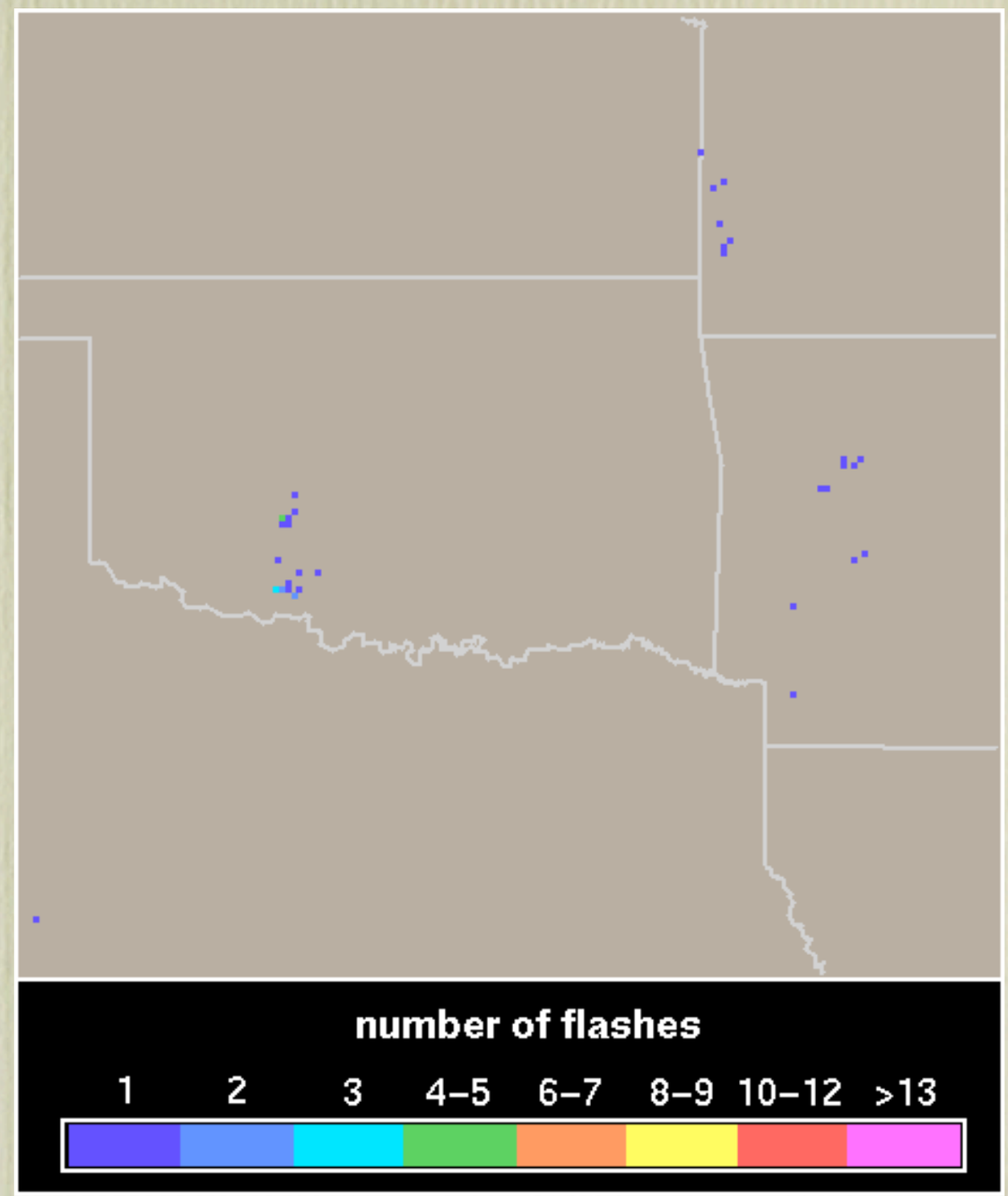




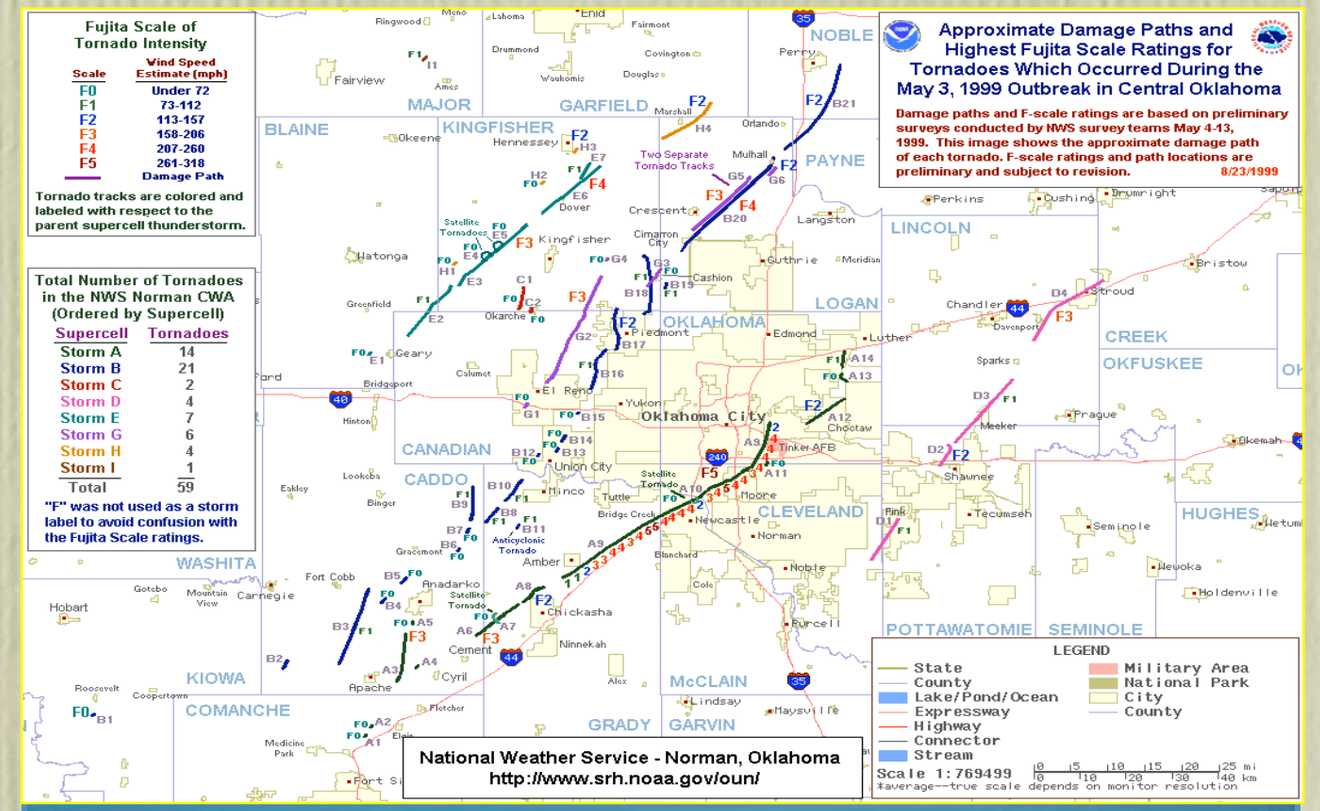


OTD Total Lightning vs. NLDN CGs





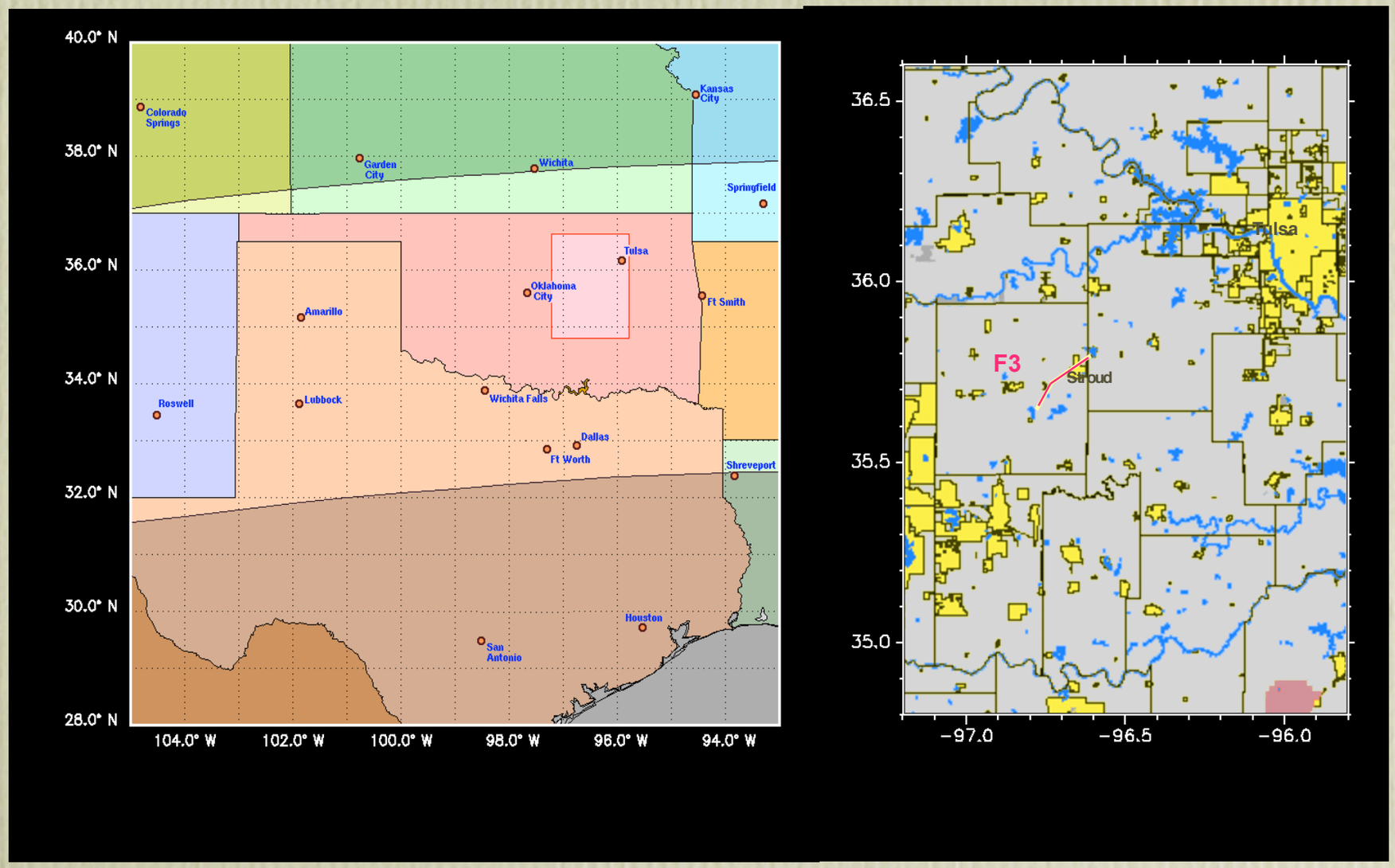
The Central Oklahoma Tornado Outbreak of May 3, 1999



- 40 people died in Oklahoma due to the twisters and 675 were injured.
- Total damage of $1.2 billion.
- Five deaths, 100 injuries and heavy damage also incurred in the Wichita, Kansas metro area.

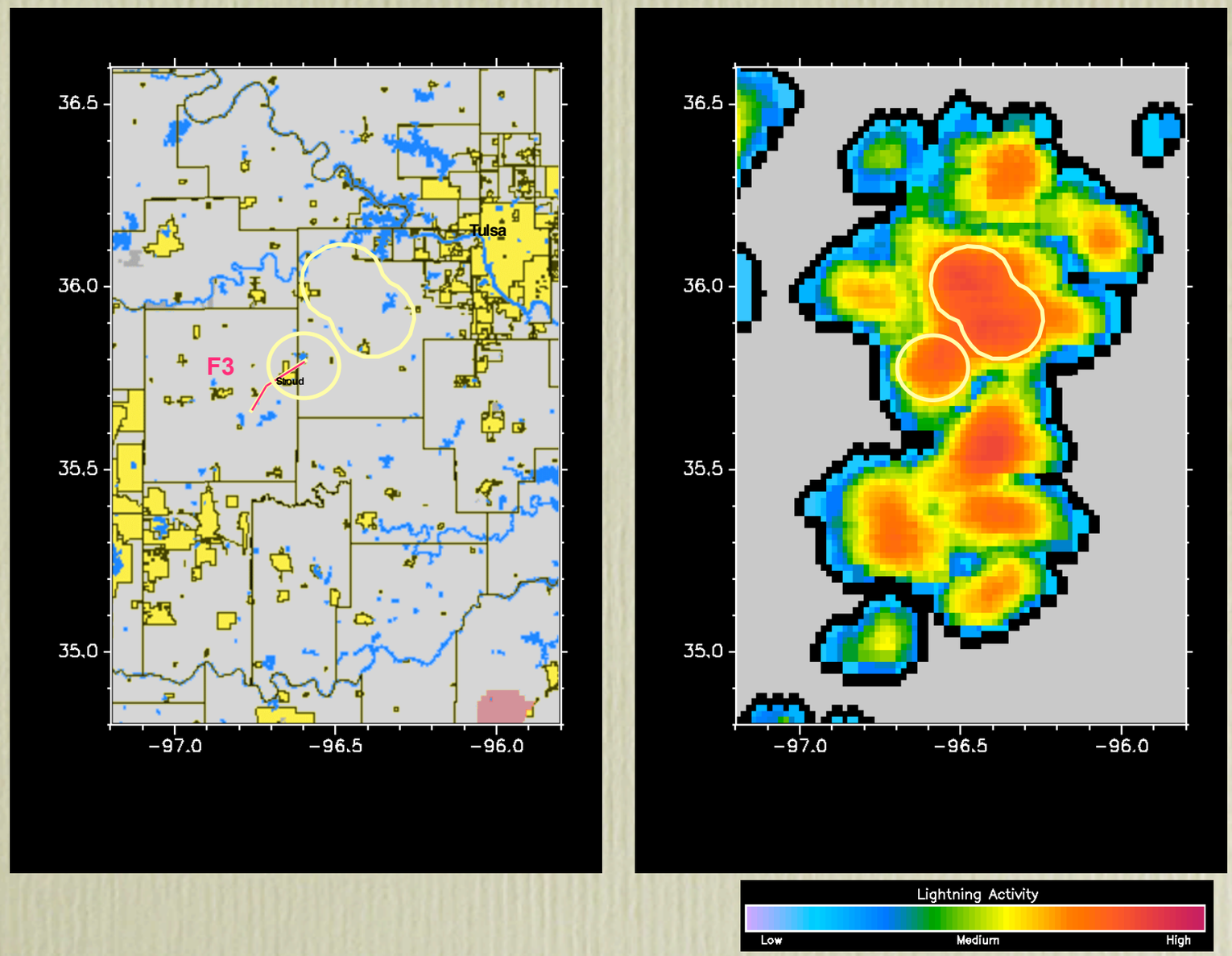
- Six supercells at time of LIS overpass dominated by in-cloud (IC) lightning: >96% of all lightning
- IC:CG ratio ranges from 20-28:1
- One of the more extreme storm total flash rates worldwide during TRMM

TRMM/LIS Overpass During May 3, 1999 Tornado Outbreak



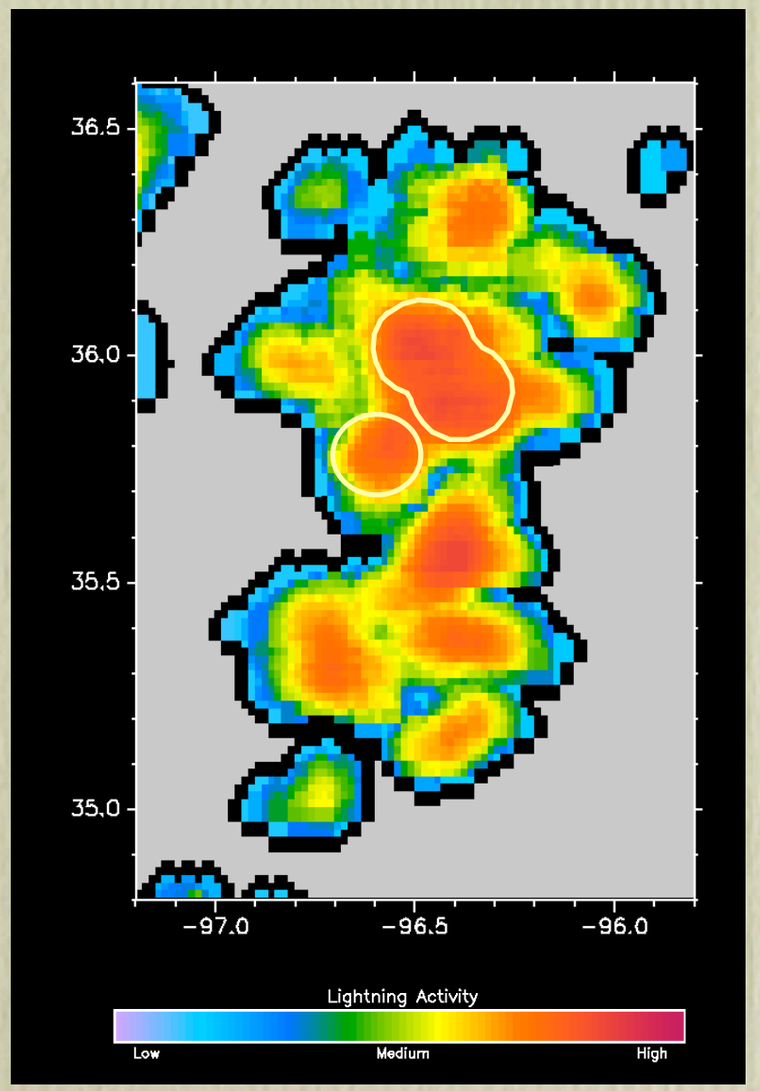
- Overpass between 04:03 and 04:04 UTC -
- Tornado on ground between 03:50 and 03:57 UTC -

LIS Total Lightning Identifies Cellular Storm Structure

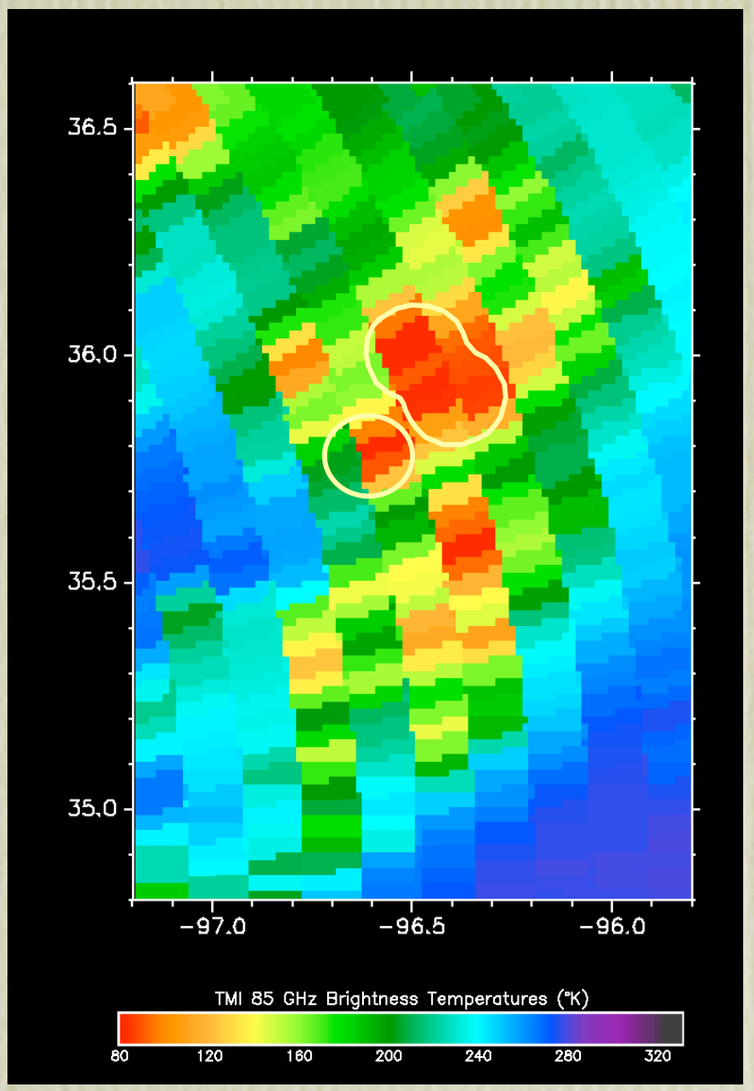


LIS and TMI 85 GHz Microwave match: lightning tracks cloud ice

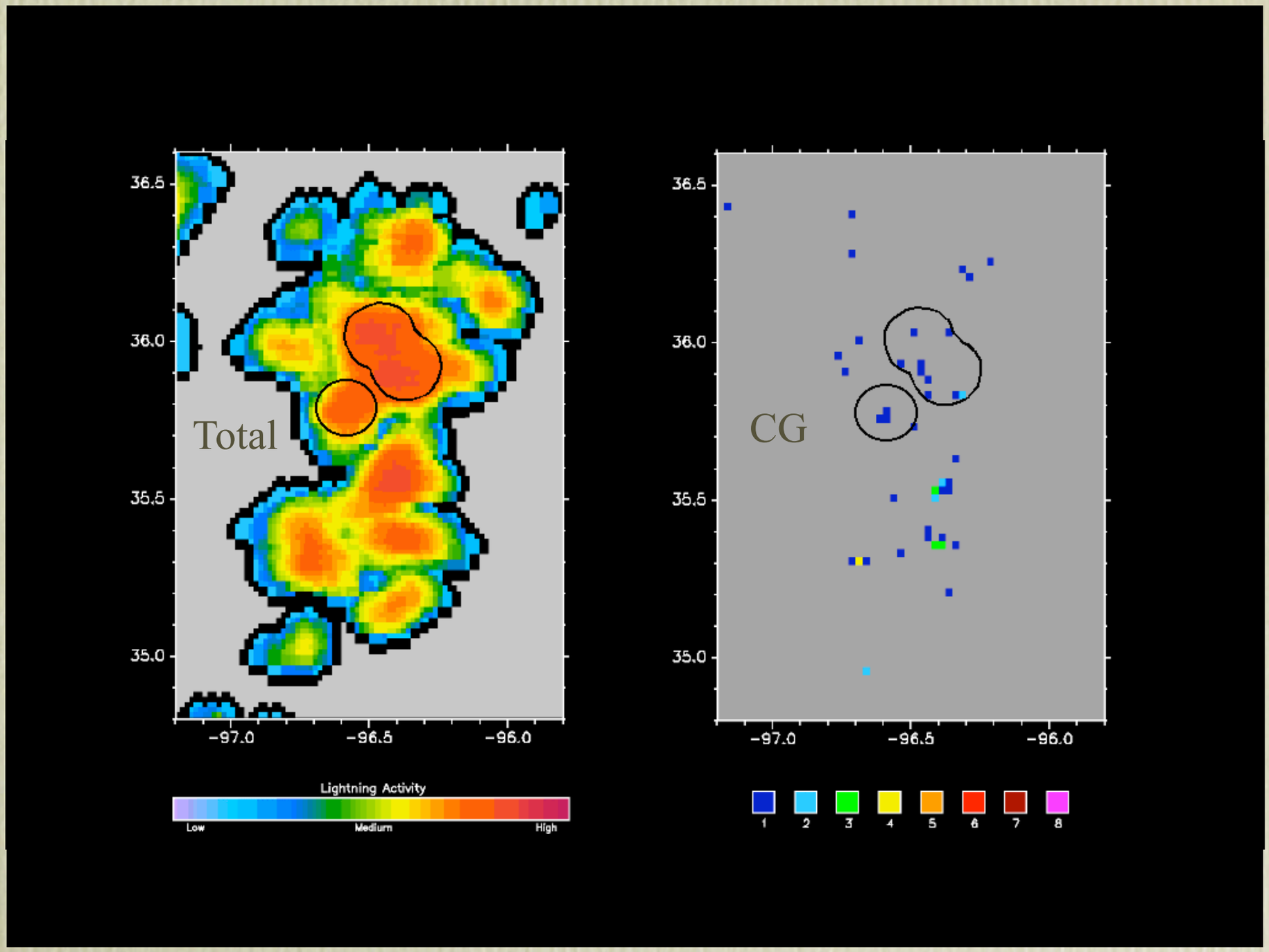
LIS Lightning Observations



TMI Microwave

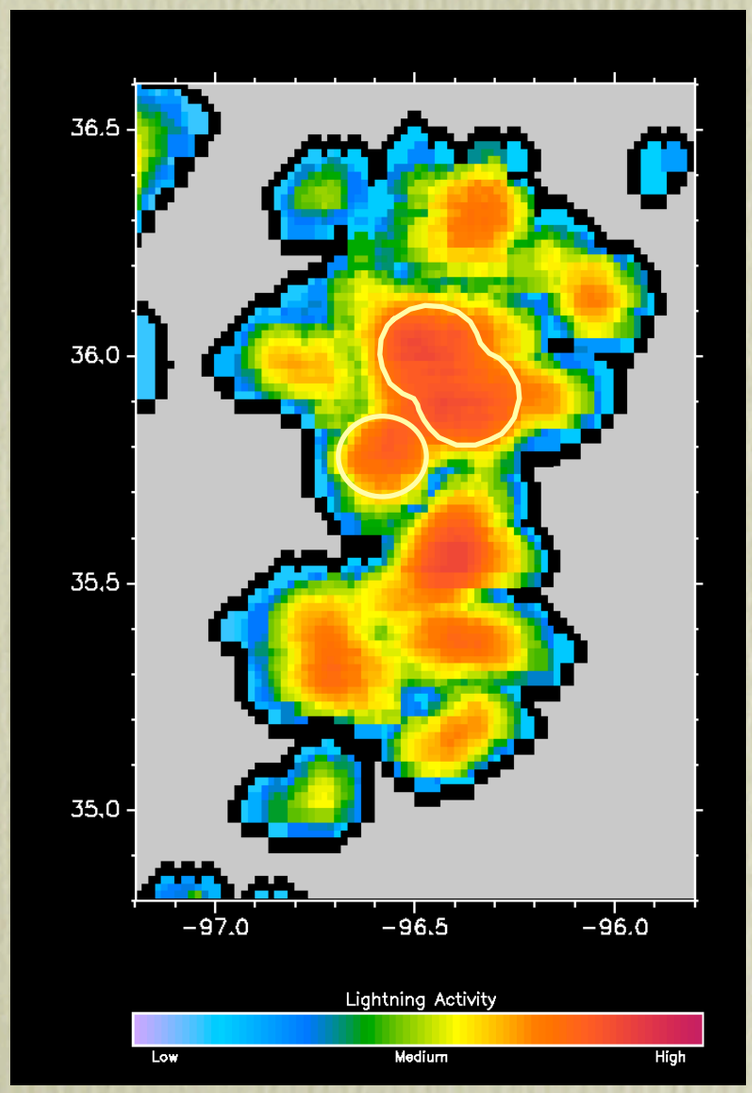


Oklahoma Storms Dominated by In-cloud Lightning

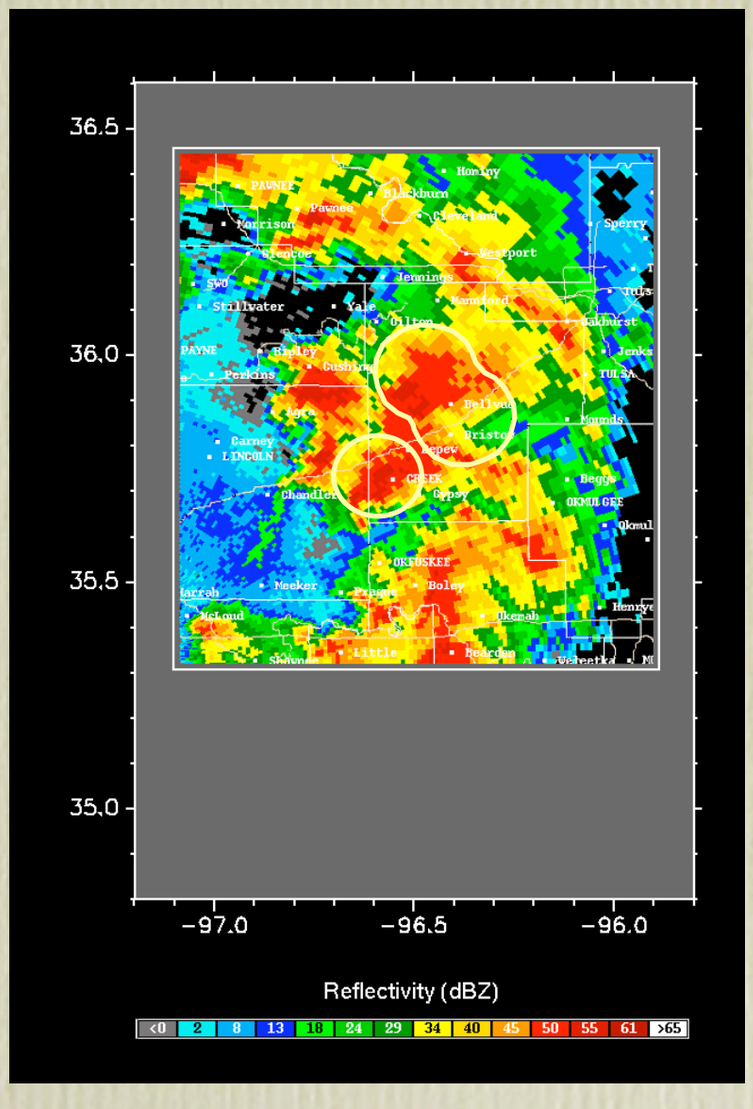


LIS and NEXRAD

LIS Lightning Observations

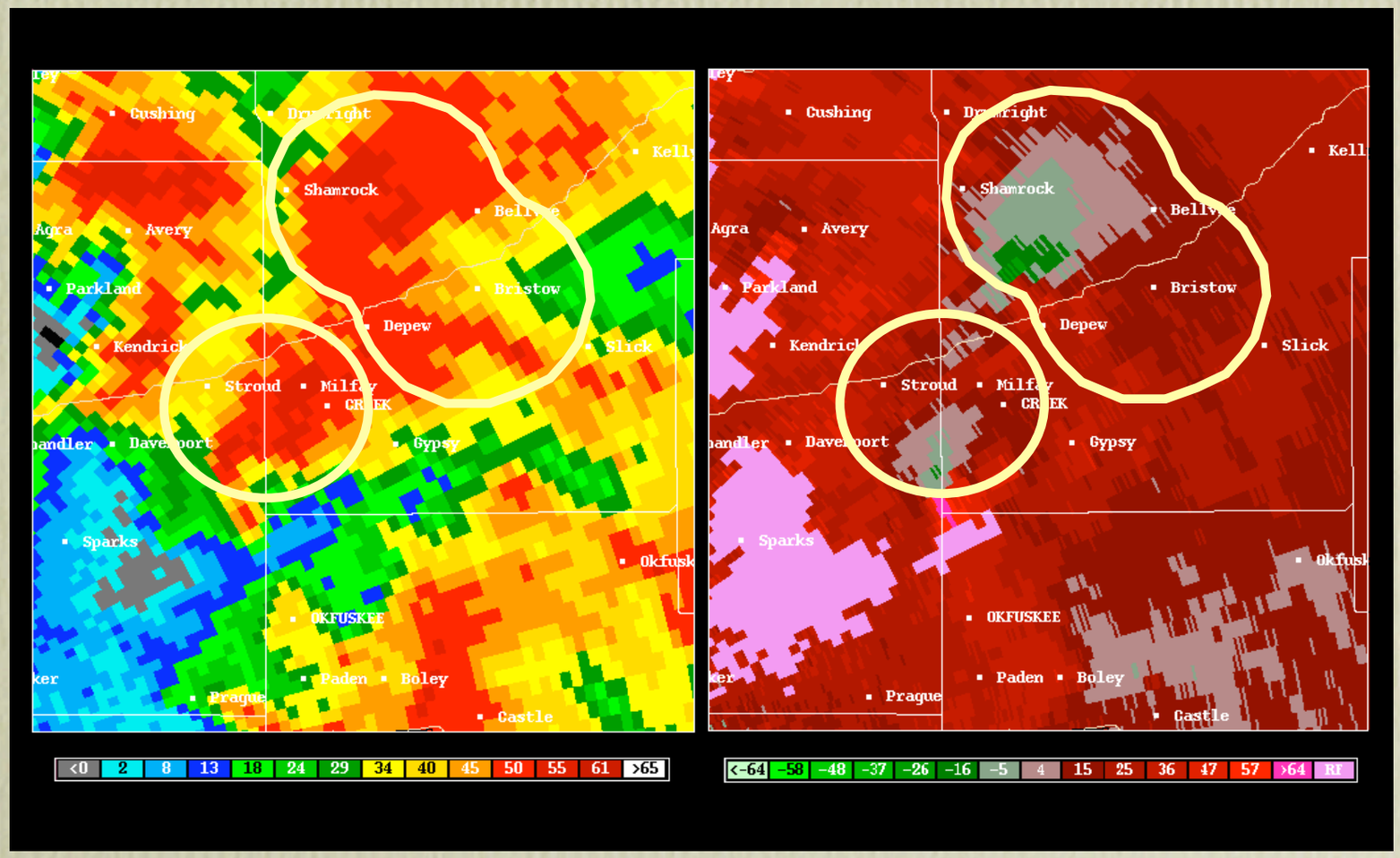


NEXRAD Reflectivity



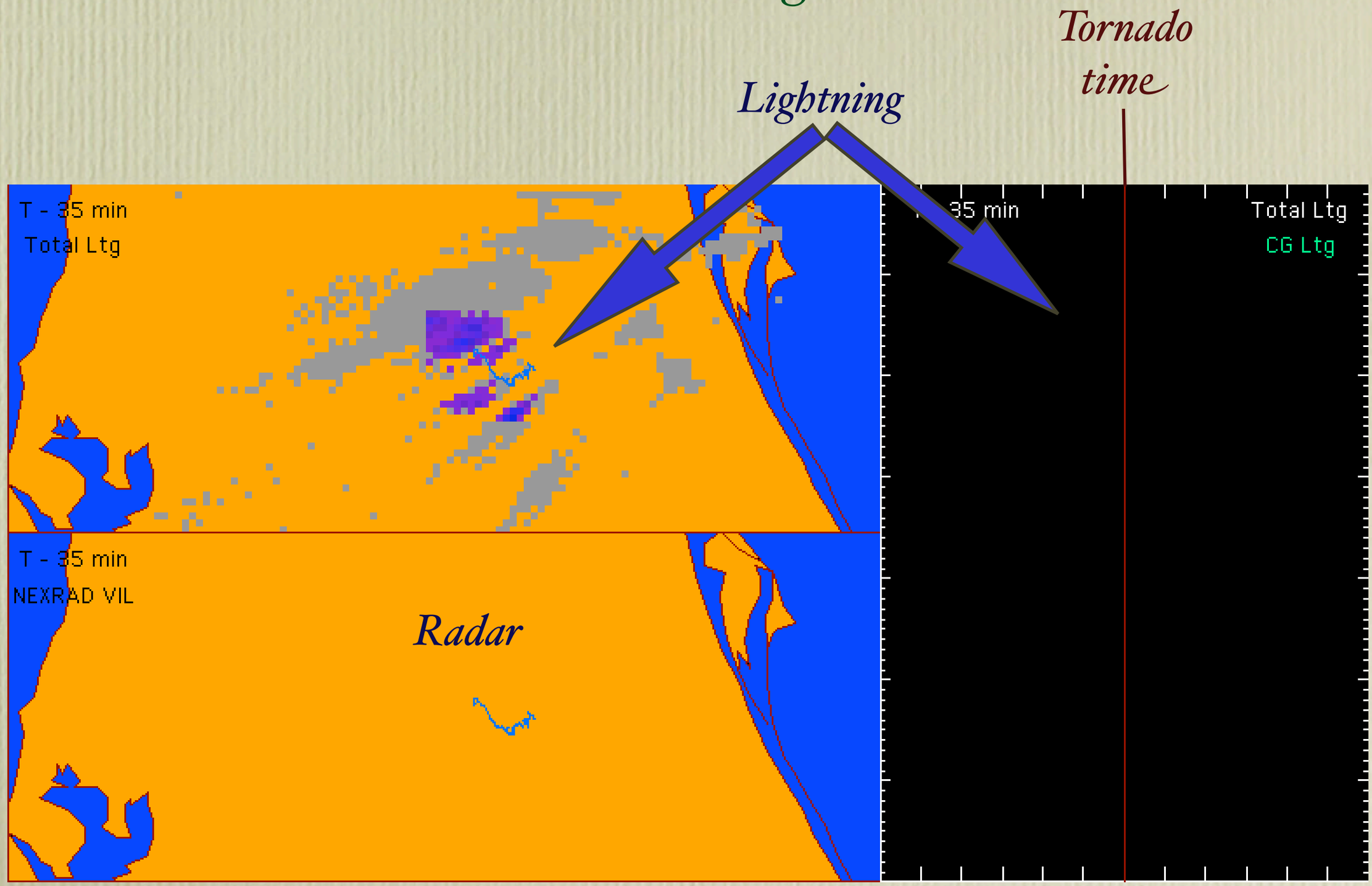
NEXRAD observes rotation in the LIS-identified cells

NEXRAD Reflectivity **NEXRAD Velocity**



Why observe lightning?

(Forecasting)



Major Points for Severe Weather

- **Primary lightning signature is high flash rates and the "jump"**

- **Lightning flash rate is correlated storm intensity - higher rate implies stronger storm.**

  Evolution of the lightning activity follows the updraft. Increasing activity means the storm intensifying; decreasing activity means the updraft is weakening.

  A jump in lightning activity is associated with a pulse in updraft intensity

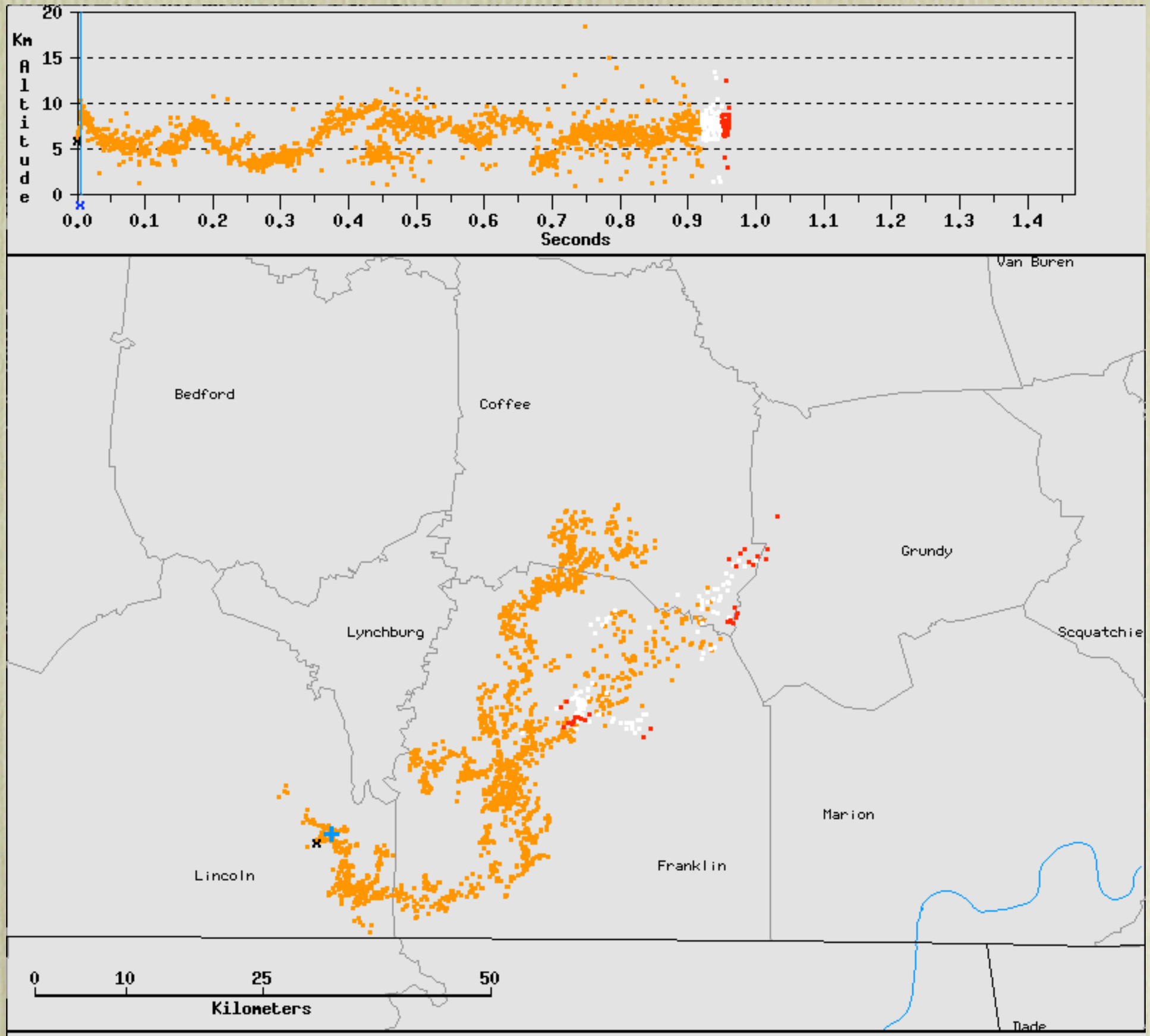
- **These signatures, in conjunction with other NWS assets can be used to:**

  Separate intensifying from weakening storms
  Identify storms in process of going severe

  Quickly determine the most intense storms in a complex system

  Improved warning times

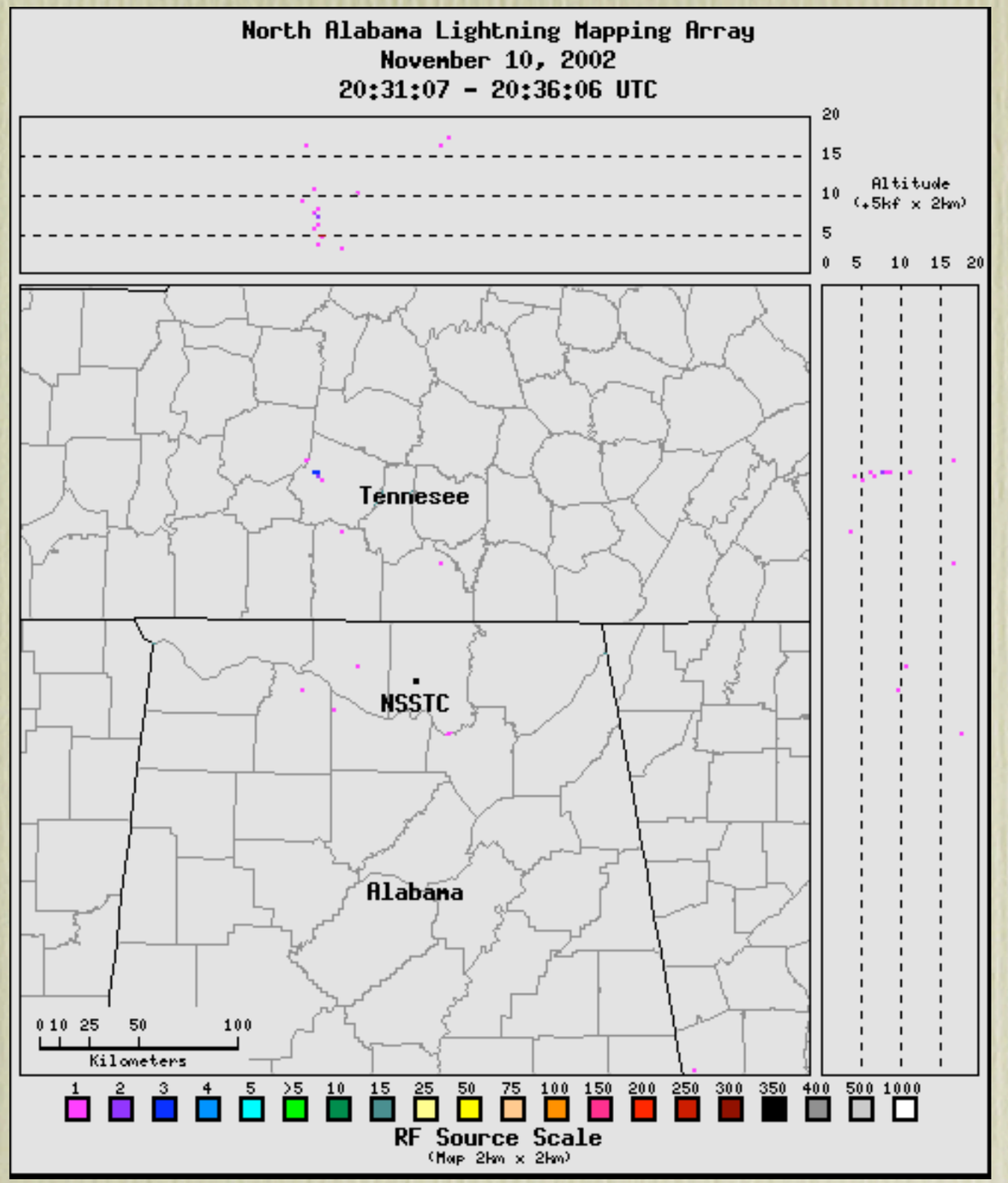
  Reduced false alarms rates

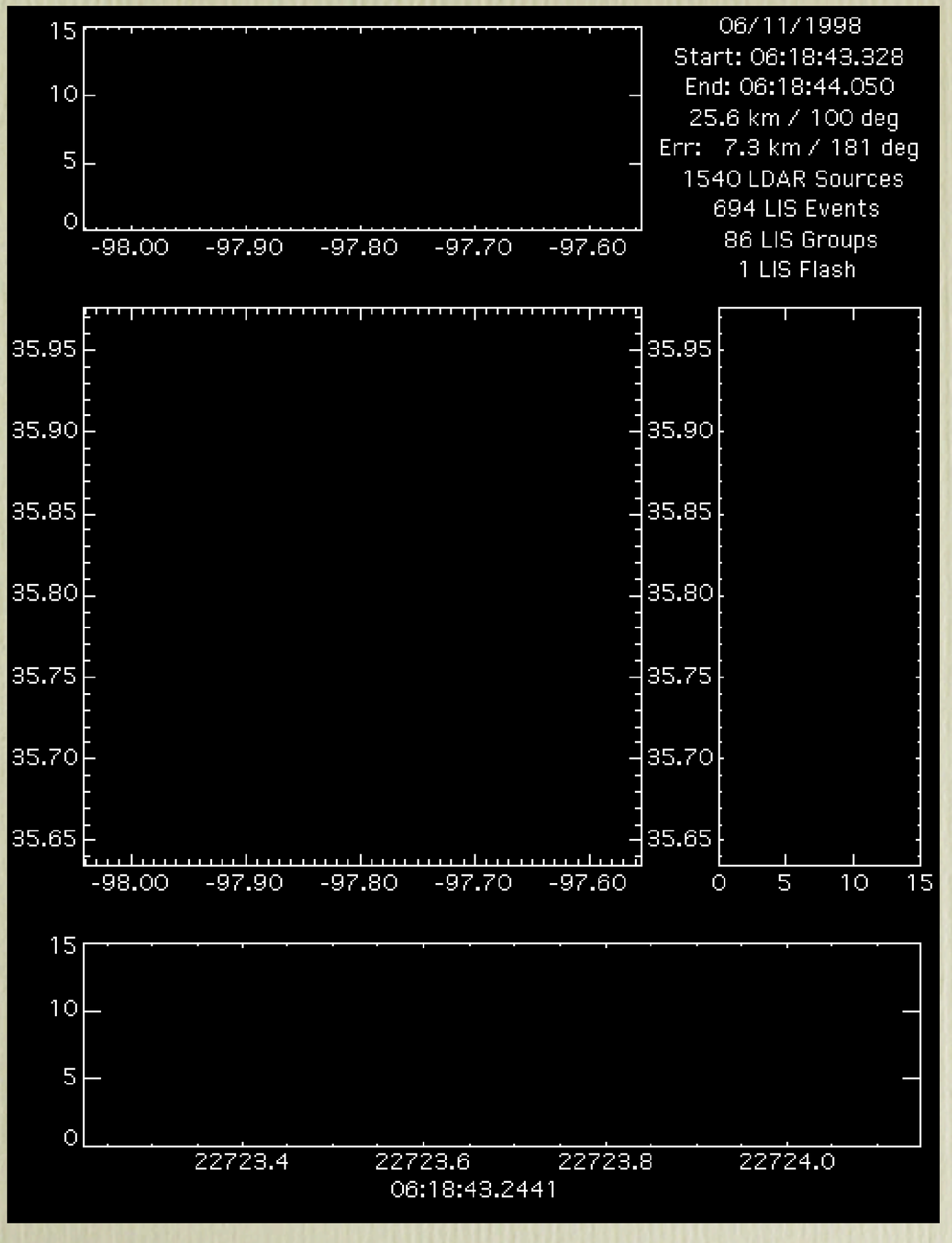


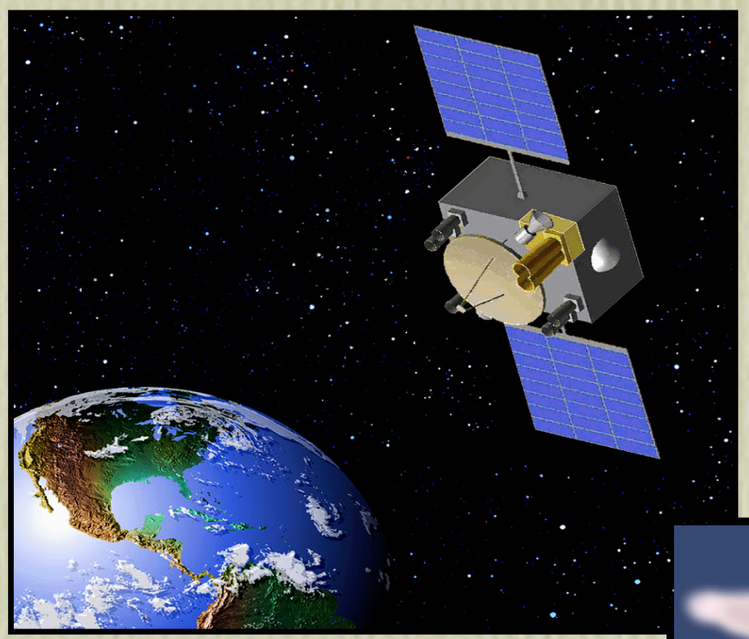
March 30, 2002
05:00:39.49275Z - 05:00:40.96154Z
Duration 1.468790 Seconds
NLDN N 1 P 1 LMA 2745

Lightning Mapping Array
0.95000
NLDN N 0 P 0 LMA 31

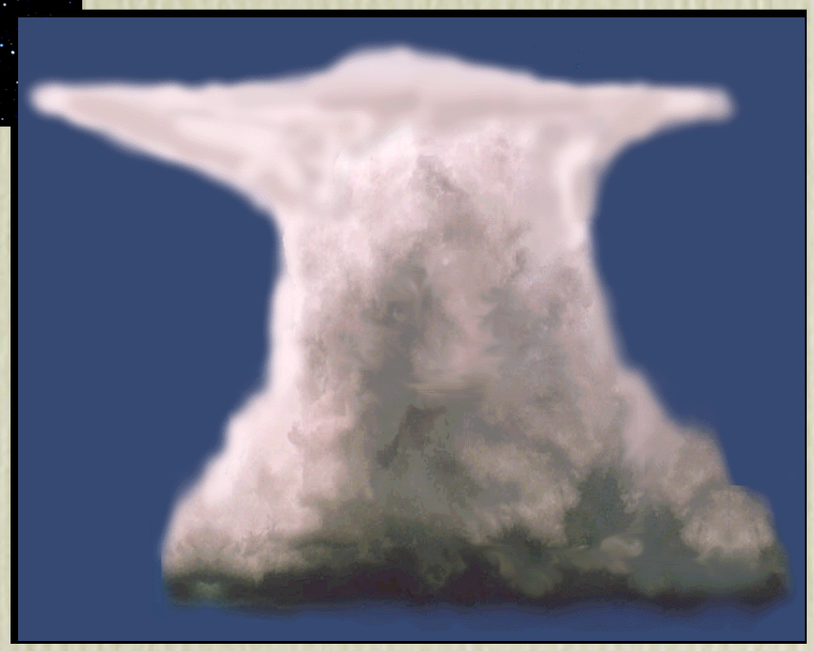
MSFC


North Alabama Lightning Mapping Array
November 10, 2002
20:31:07 - 20:36:06 UTC
20
15
10
5
Altitude
(.5kf x 2km)
0 5 10 15 20
Tennessee
NSSTC
Alabama
0 10 25 50 100
Kilometers
1 2 3 4 5 >5 10 15 25 50 75 100 150 200 250 300 350 400 500 1000
RF Source Scale
(Map 2km x 2km)


06/11/1998
Start: 06:18:43.328
End: 06:18:44.050
25.6 km / 100 deg
Err: 7.3 km / 181 deg
1540 LDAR Sources
694 LIS Events
86 LIS Groups
1 LIS Flash
15
10
5
0
-98.00
-97.90
-97.80
-97.70
-97.60
35.95
35.90
35.85
35.80
35.75
35.70
35.65
0
5
10
15
22723.4
22723.6
22723.8
22724.0
06:18:43.2441



Geostationary
Vantage
Point

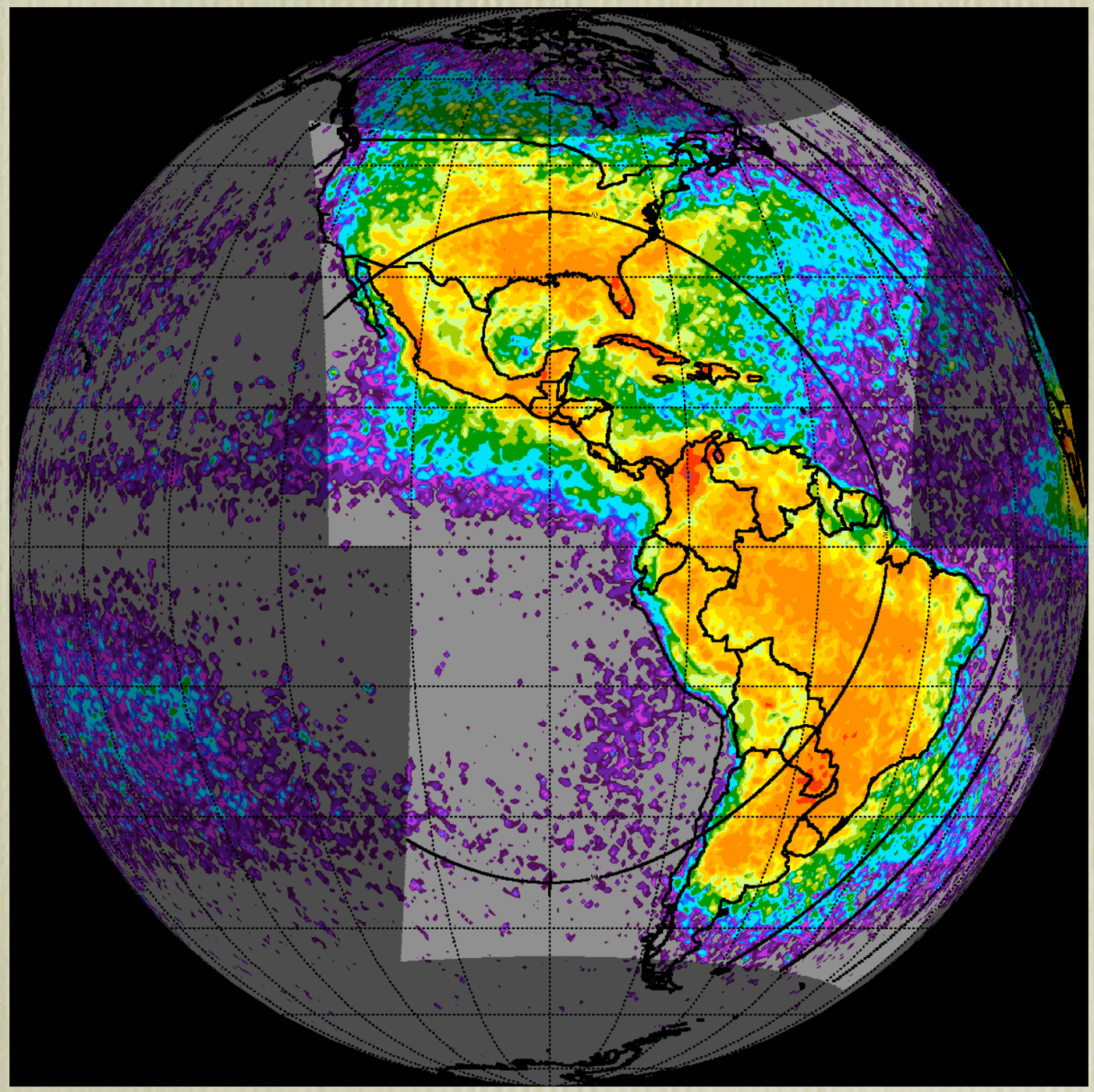


Observe
Storm
Evolution

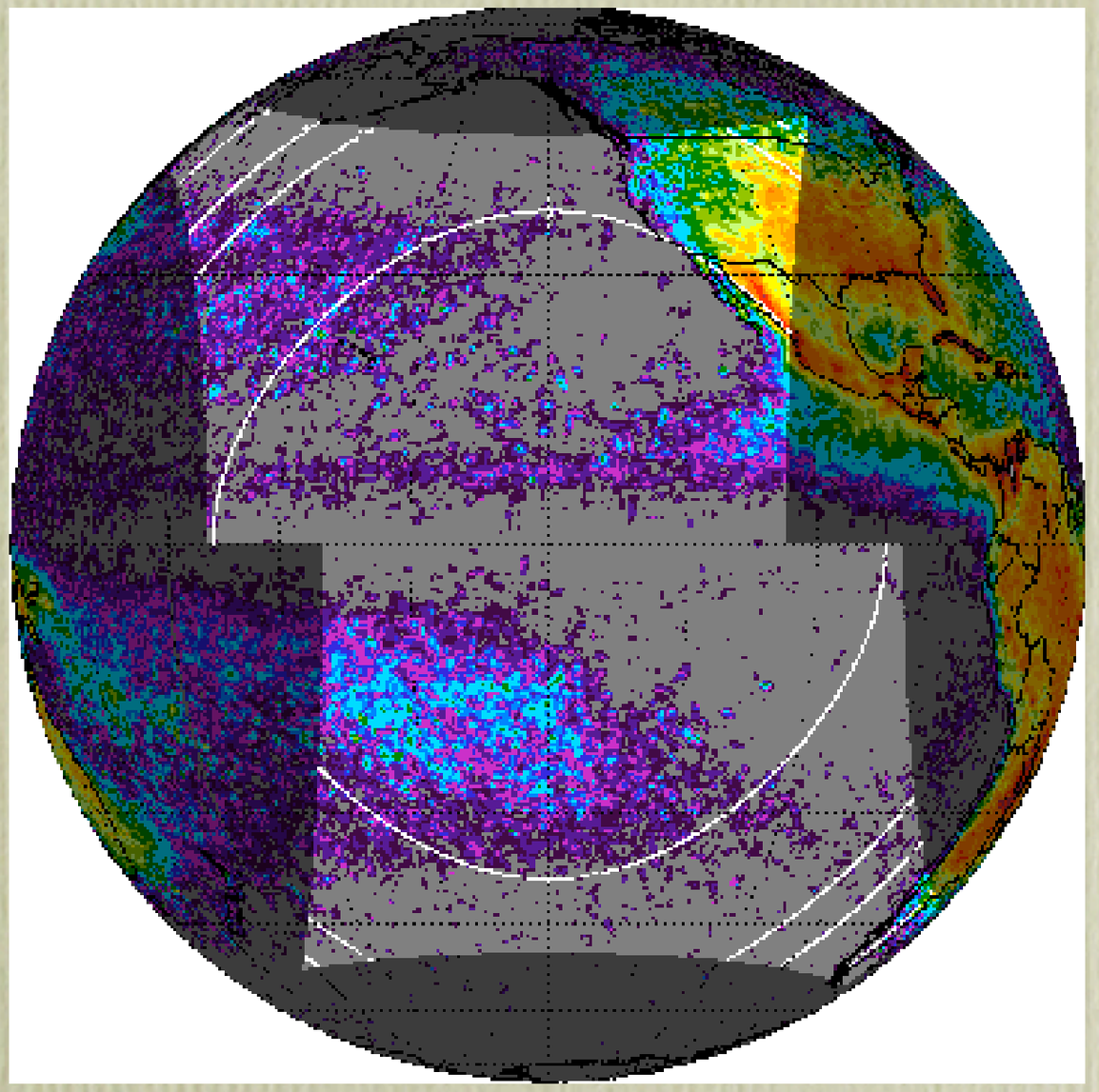
Lightning Sensing from GEO

- Climate Monitoring
- Storm Development
- Ice-phase precipitation estimates
- Severe Weather Now-casting
- Data assimilation and model inputs
- Atmospheric chemistry

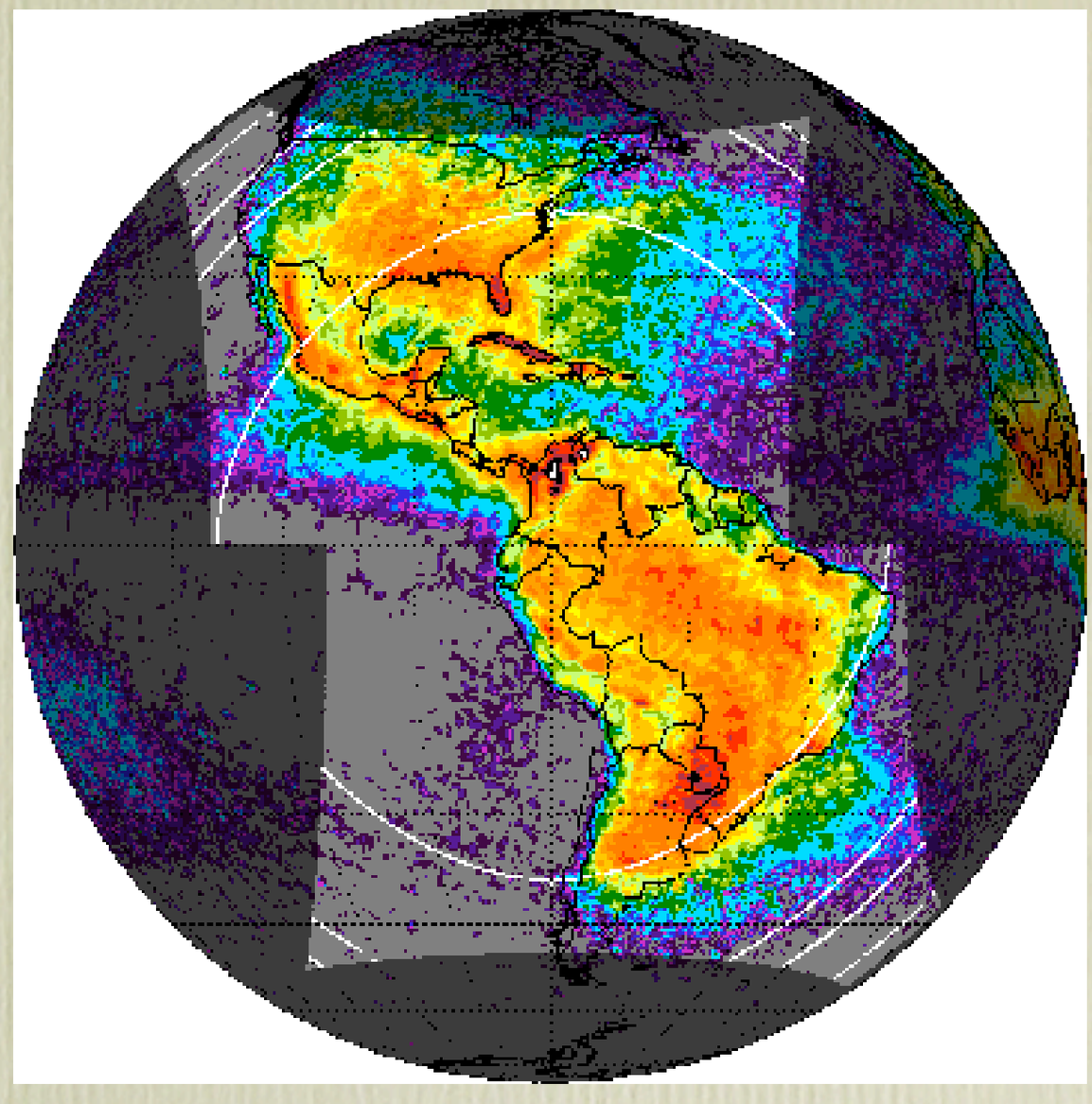
GEO



LMS : Field of View at GOES West and East



GOES W (75ºW)



GOES E (135ºW)

- OTD climatology indicates lightning density
- Range rings indicate limits of 10, 15, 20, & 50 km pixel footprint

GEO -East