STROKE & Flash Energy Trending Tools

2016 GLM Annual Science Team Meeting

29 September 2016

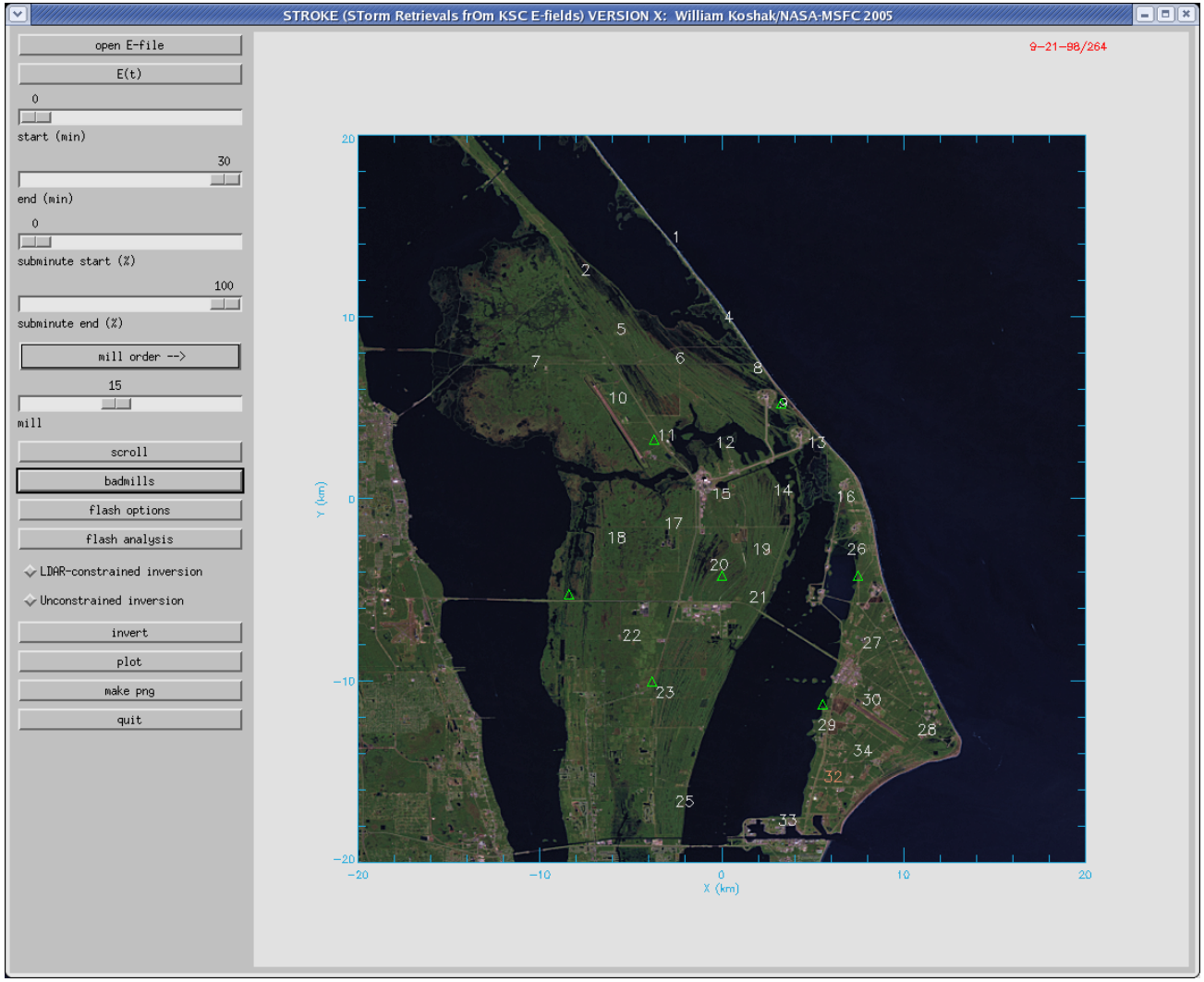
Dr. William J. Koshak
NASA/MSFC

Overview

- **STROKE Tool**
  - STROKE = STorm Retrievals frOm KSC E-fields
- **Flash Energy Trending Tool**
- **Questions**

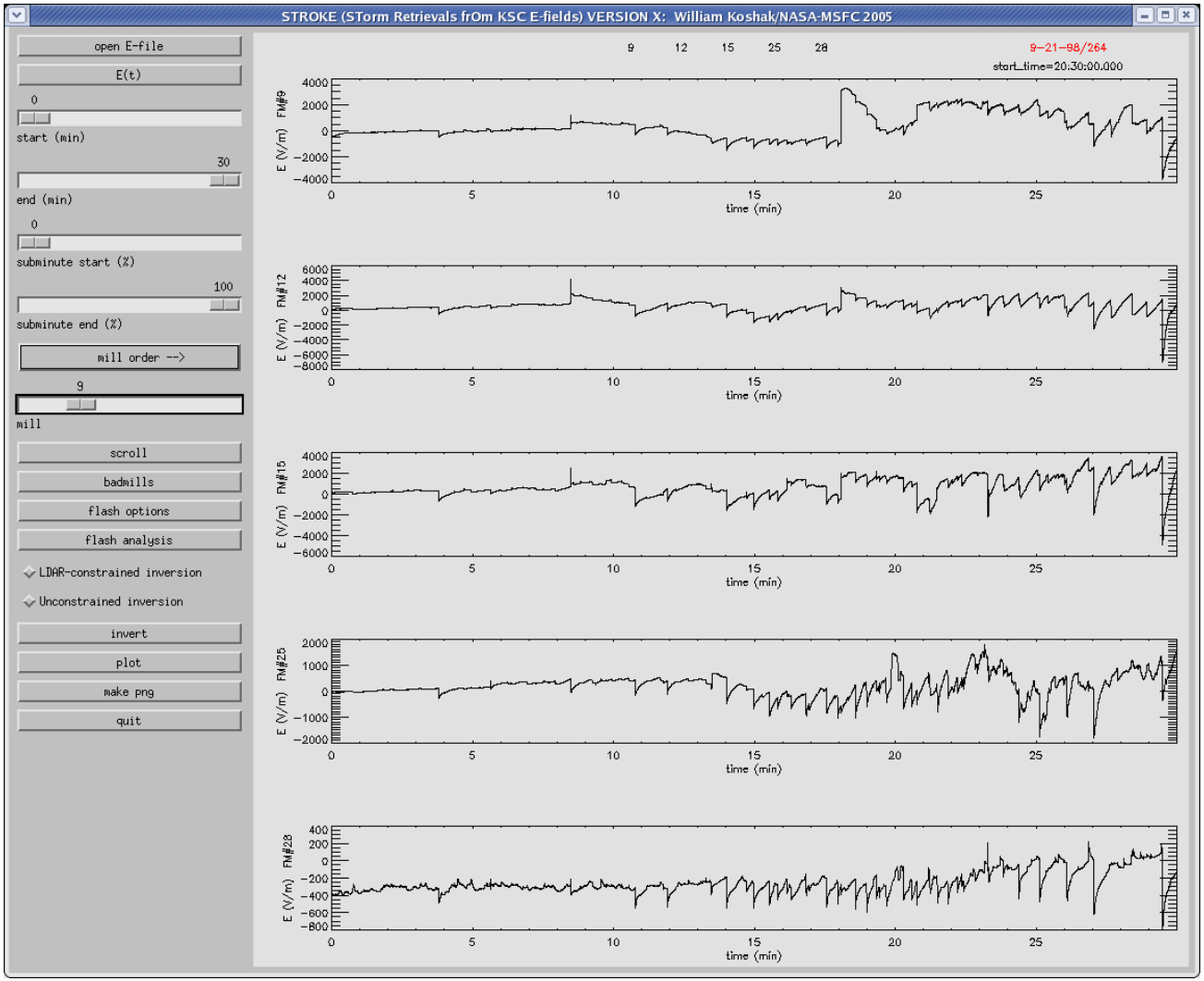

STROKE Tool

STROKE Interface

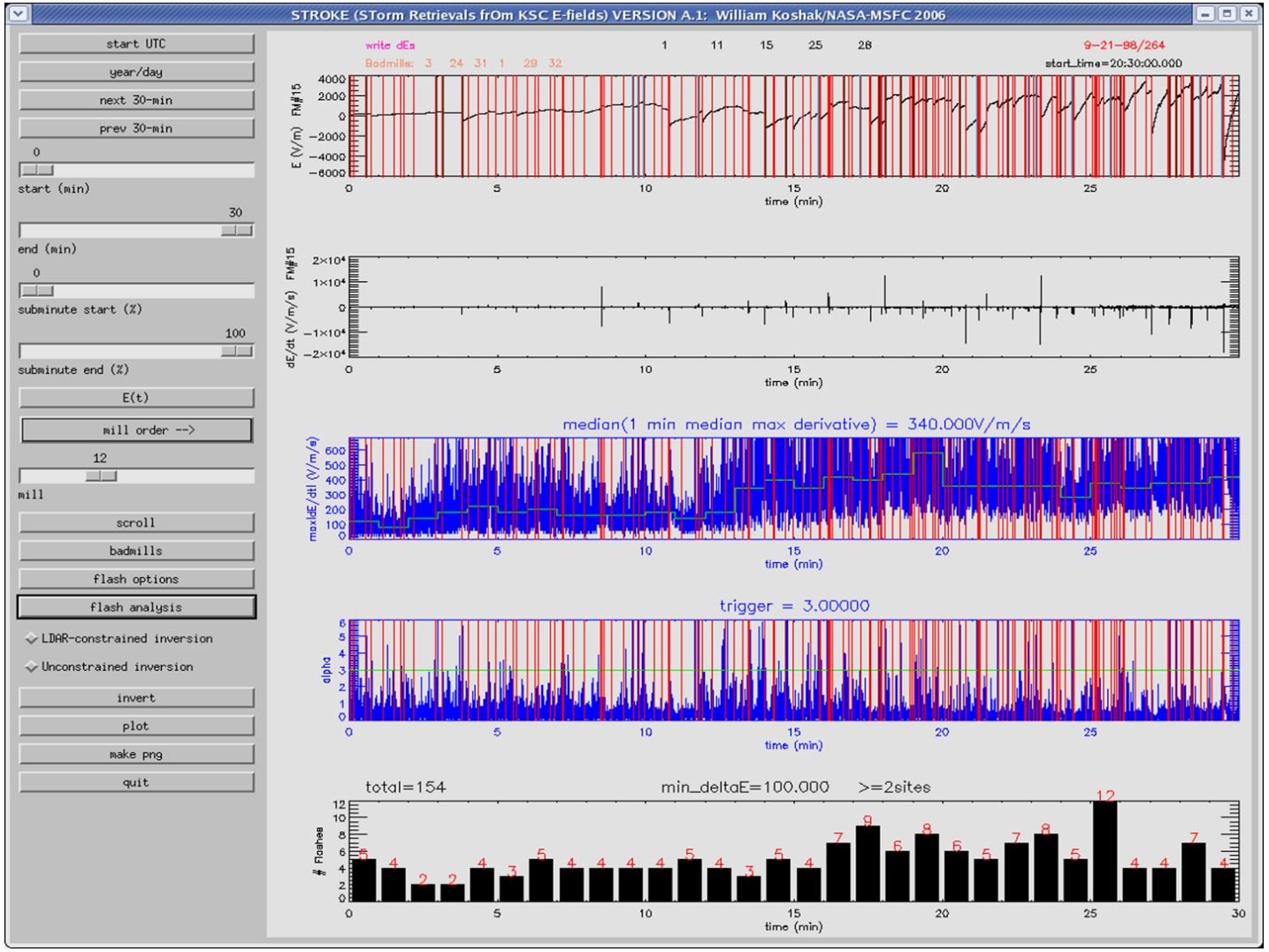


KSC, FL FIELDMILL NETWORK

Field Mill Records (E_z @ Surface)



Lightning Detection & △E Analysis



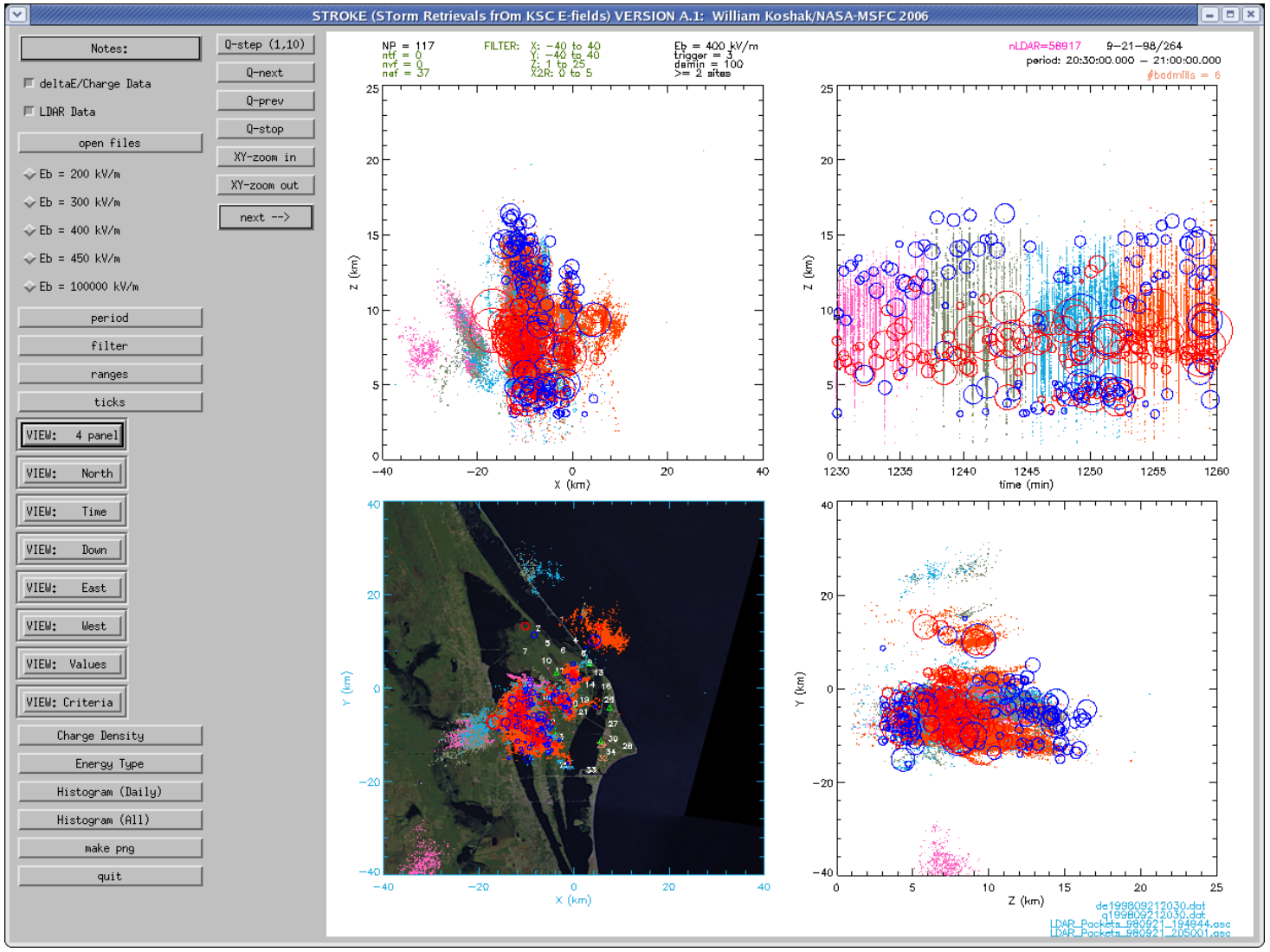
Inversion Theory

$$\Delta E(x,y) = \int_{UHS} K(x,y,\mathbf{r}')\Delta\rho(\mathbf{r}')dV'$$

STROKE Lightning Charge Retrieval

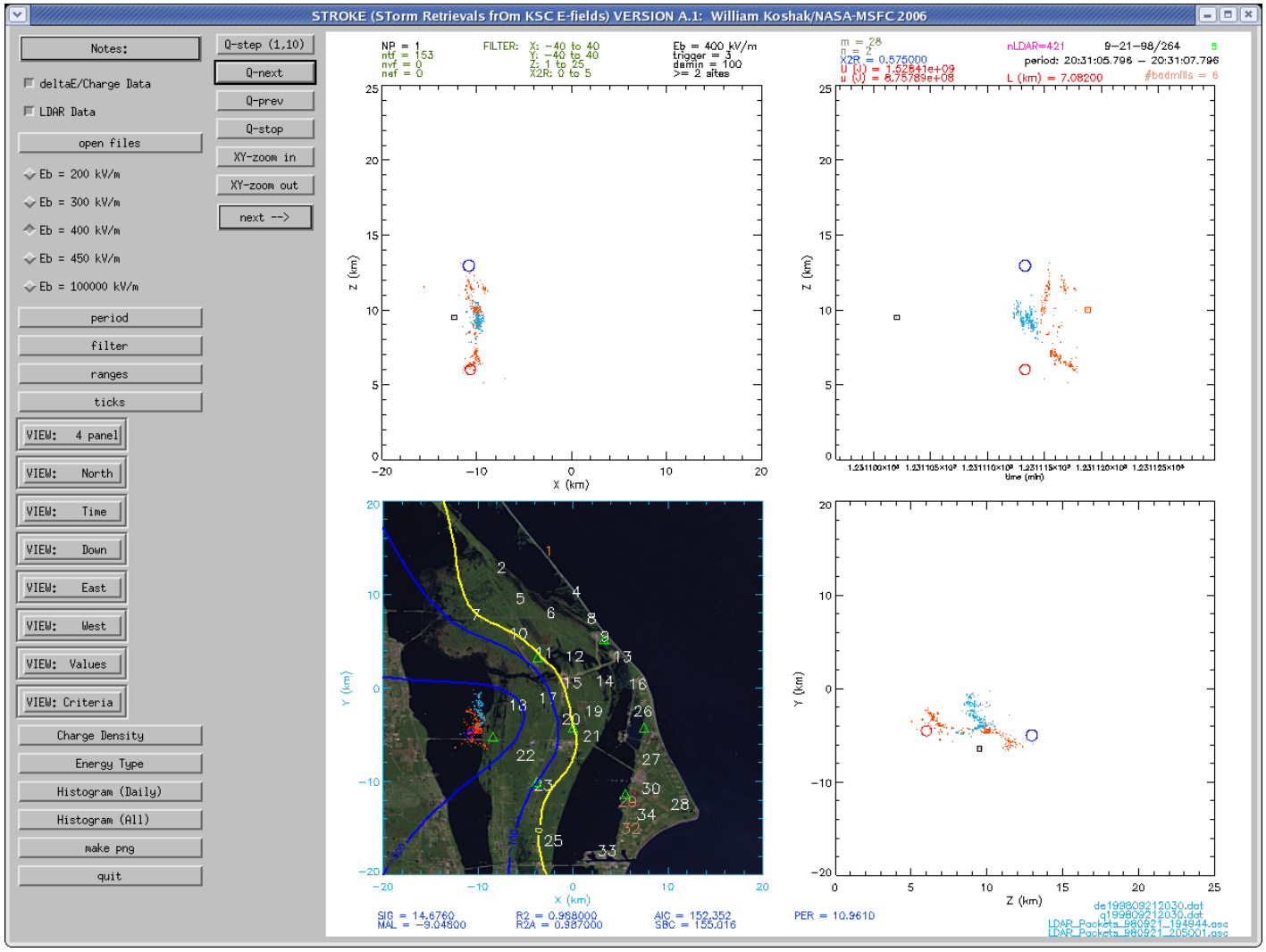
$$\chi^2_\nu = \frac{1}{m-n}\sum_{i=1}^{m}\frac{\left[\Delta E_i - M_i(p_1,\ldots,p_n)\right]^2}{\sigma_i^2}$$

Sample Lightning Charge Retrievals



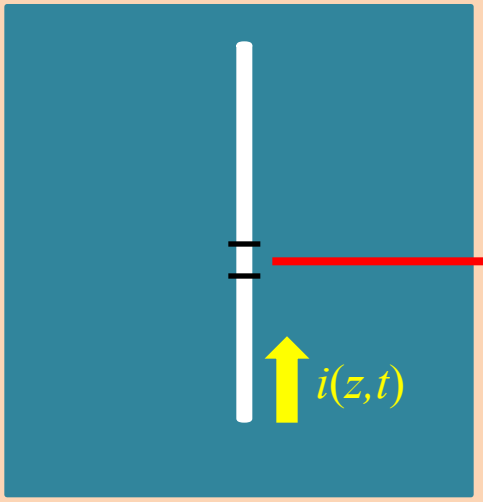
W. Koshak, NASA/MSFC ZP11

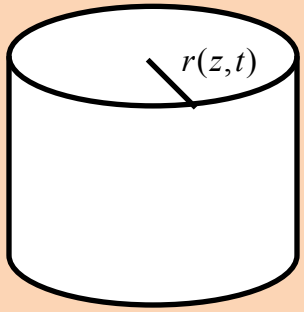
Lightning Charge from One Flash




Flash Energy Trending Tool

Return Stroke LNOx Production





Cylindrical Channel is Heated by Current

Koshak, W. J., R. J. Solakiewicz, H. S. Peterson, 2015: A return stroke NO_x production model, *J. Atmos. Sci.*, **72**, No. 2, 943-954.

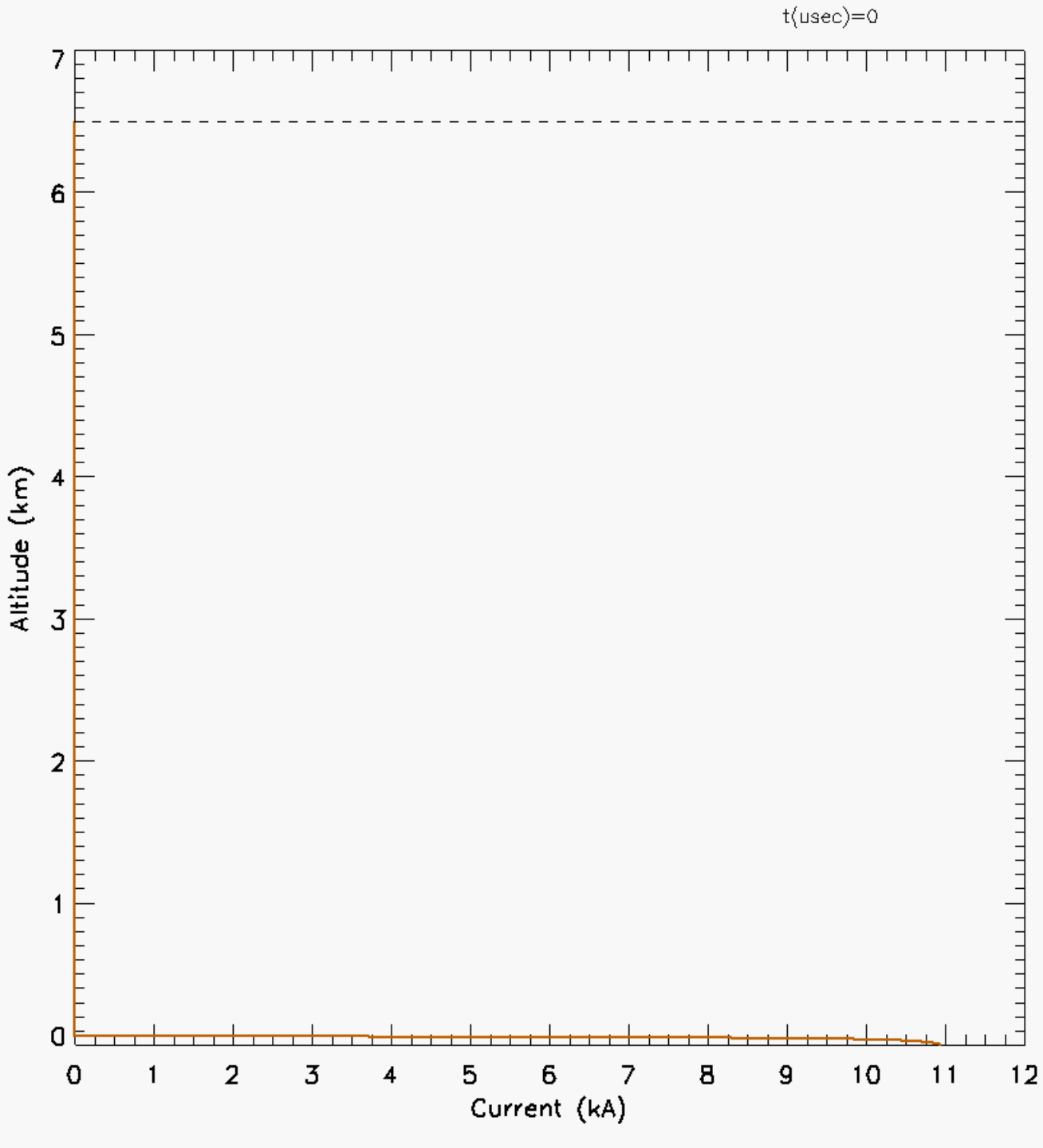
$$r^4 \frac{dr}{dt}\frac{d^2r}{dt^2} + \Gamma r^3 \left(\frac{dr}{dt}\right)^3 + \phi r^3 \frac{dr}{dt} p_e = \psi i^2 \quad , \qquad (1)$$

with the coefficients

$$\phi = \frac{\Gamma}{K\rho_e} \quad , \qquad \psi = \frac{\Gamma - 1}{2\pi^2 K \rho_e \sigma} \quad . \qquad (2)$$

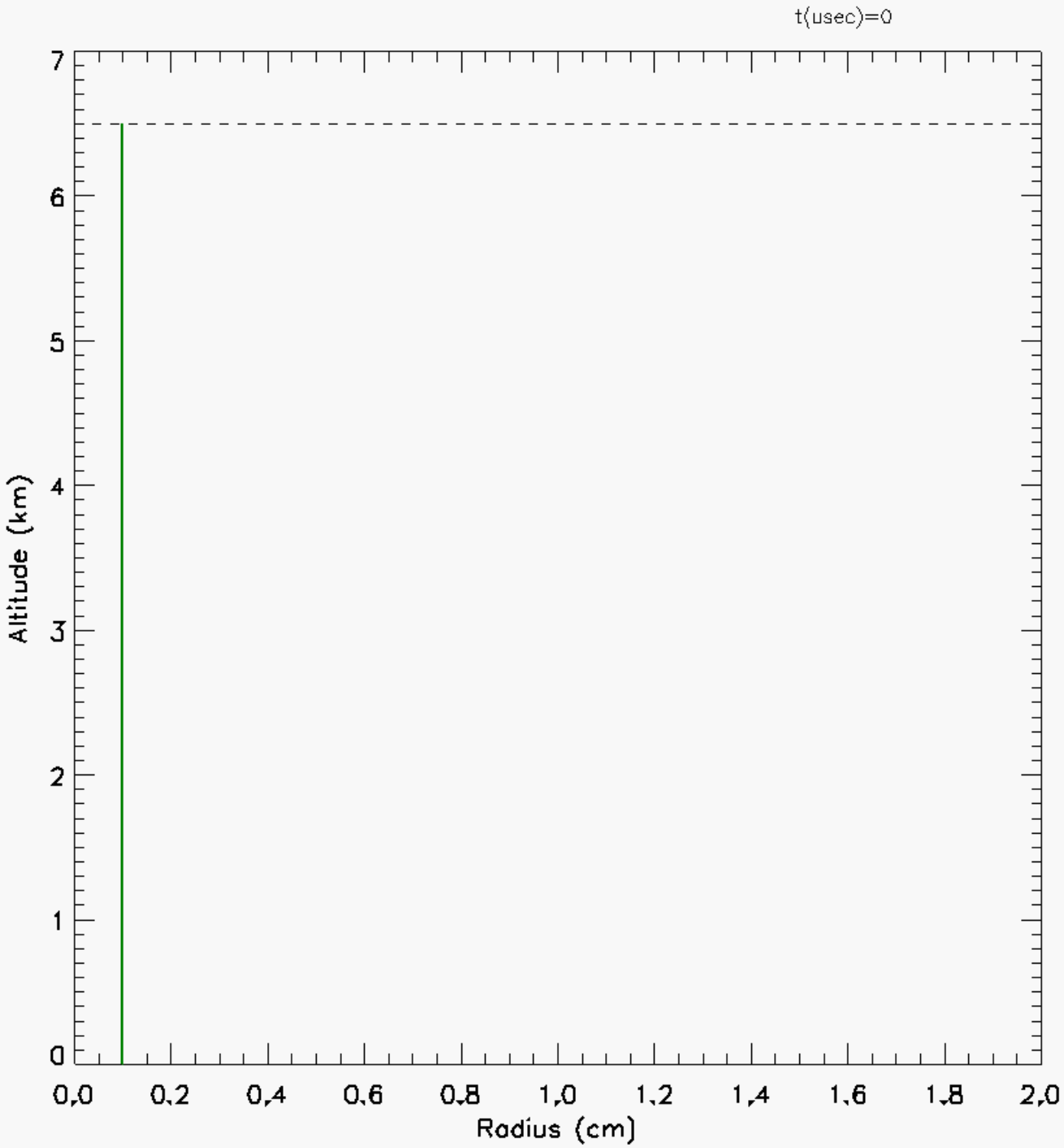
Run #1 Output

Channel Current

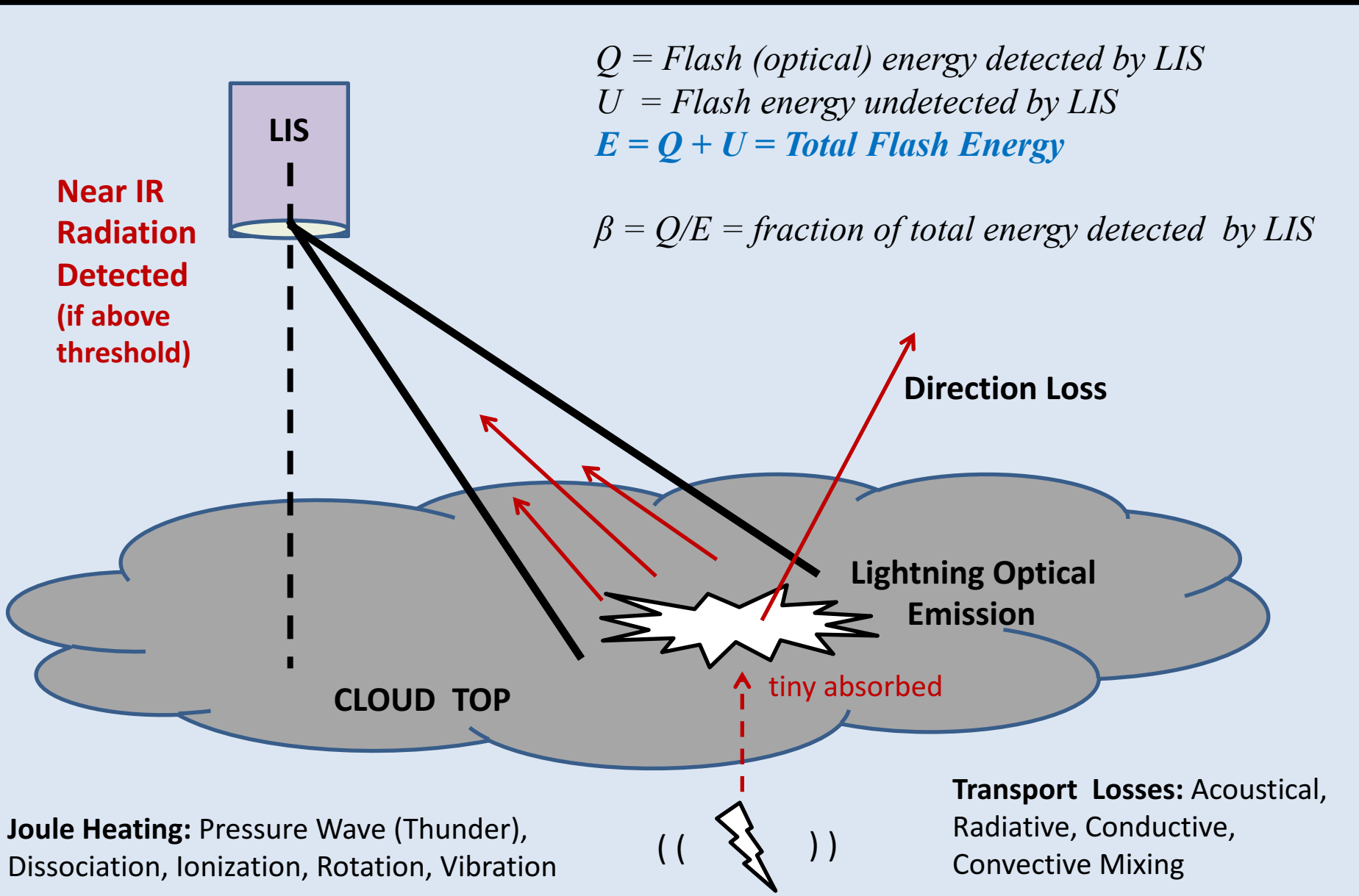


Run #1 Output

Channel Radius



LNOx


Q = Flash (optical) energy detected by LIS
U = Flash energy undetected by LIS
E = Q + U = Total Flash Energy
β = Q/E = fraction of total energy detected by LIS
LIS
Near IR Radiation Detected (if above threshold)
Direction Loss
Lightning Optical Emission
tiny absorbed
CLOUD TOP
Joule Heating: Pressure Wave (Thunder), Dissociation, Ionization, Rotation, Vibration
Transport Losses: Acoustical, Radiative, Conductive, Convective Mixing

LIS-Intercepted Optical Energy from kth Flash

$$Q_k = CA\Delta\lambda \sum_{i=1}^{m_k}\sum_{j=1}^{n_k} \Delta\omega_{jk}\bar{\xi}_{\lambda ijk} = CA\Delta\lambda \sum_{i=1}^{m_k}\sum_{j=1}^{n_k} \left[\frac{a_{jk}\cos\alpha_{jk}}{r_{jk}^2}\right]\bar{\xi}_{\lambda ijk} \quad .$$

a_{jk} = event footprint (j^{th} event in the k^{th} flash)

θ_{jk} = event boresight angle

$\bar{\xi}_{\lambda ijk}$ = event energy density

m_k = # frames occupied by kth flash

n_k = # pixels illuminated by kth flash.

z = LIS orbital altitude

A = LIS entrance aperture area

$\Delta\lambda$ = LIS bandwidth

R = Earth Radius

C = conversion factor

$$\alpha_{jk} = \sin^{-1}\left[\left(\frac{R+z}{R+H}\right)\sin\theta_{jk}\right] \quad , \quad r_{jk} = (R+H)\frac{\sin(\alpha_{jk}-\theta_{jk})}{\sin\theta_{jk}} \quad .$$

(foreshortening angle)

(range from event footprint to LIS)

LNOx

$$\text{LNOx Production} = \underbrace{\frac{Y}{N_A}}_{\text{[moles/Joule]}} \underbrace{\frac{Q}{\beta}}_{\text{[Joules/flash]}}$$

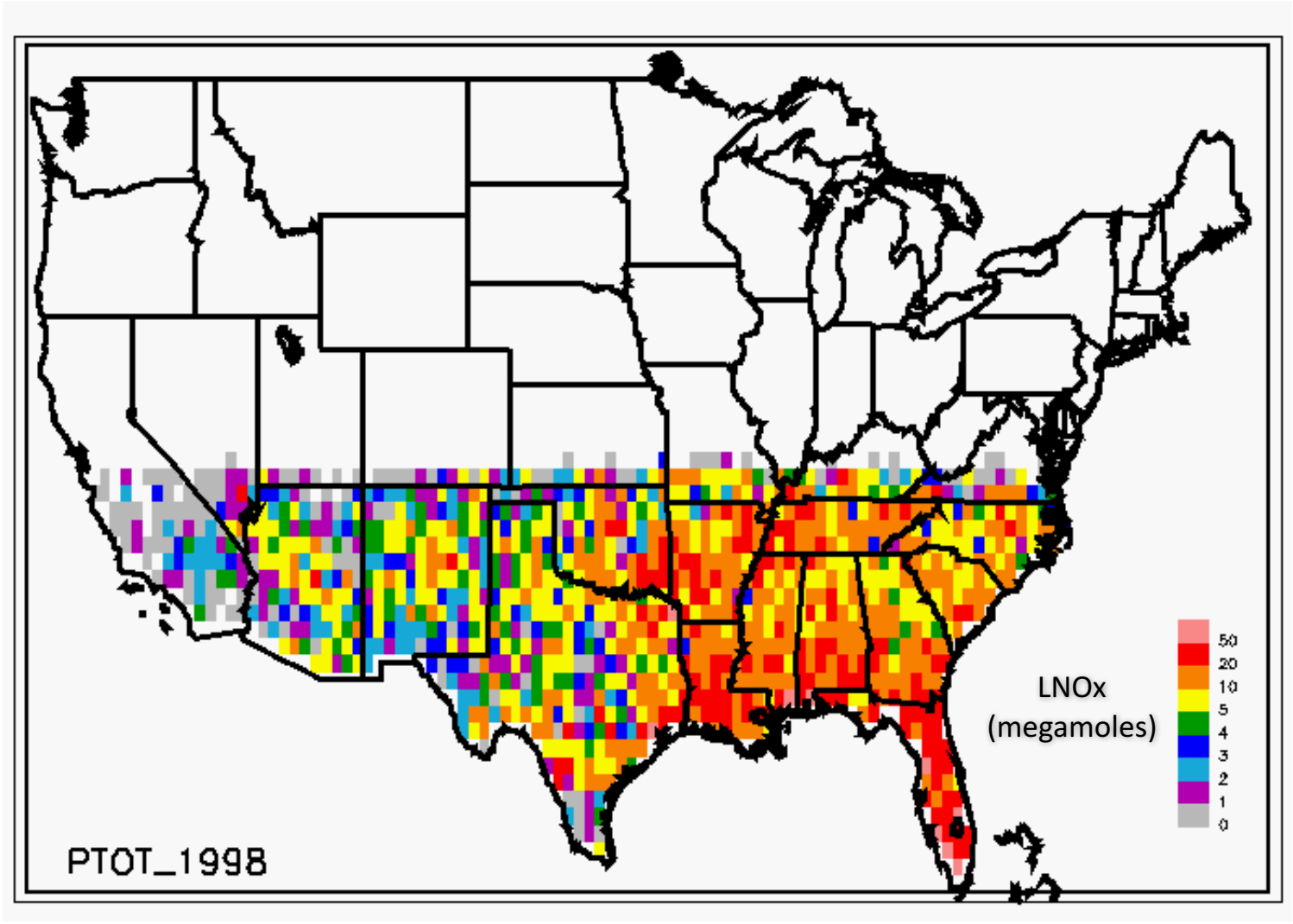
[moles/flash]

$\beta = Q/E$ = fraction of total energy detected by LIS
~ 1.8675×10^{-19} implies 250 moles/flash on average in 1998.

Y = Thermo-chemical Yield = 10^{17} molecules/Joule

N_A = Avogadro's Constant = 6.022×10^{23} molecules/mole

LNOx

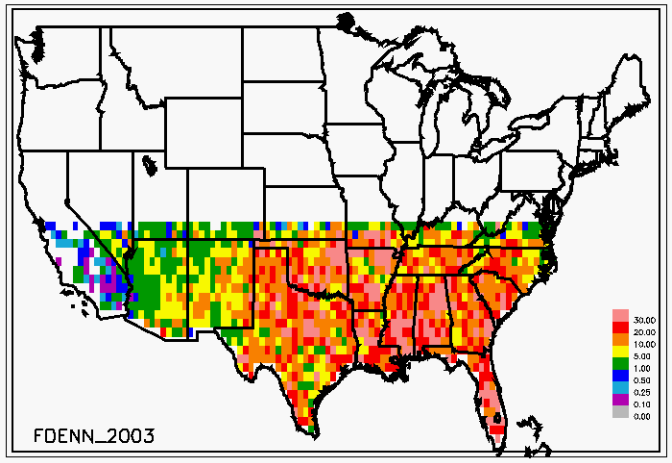


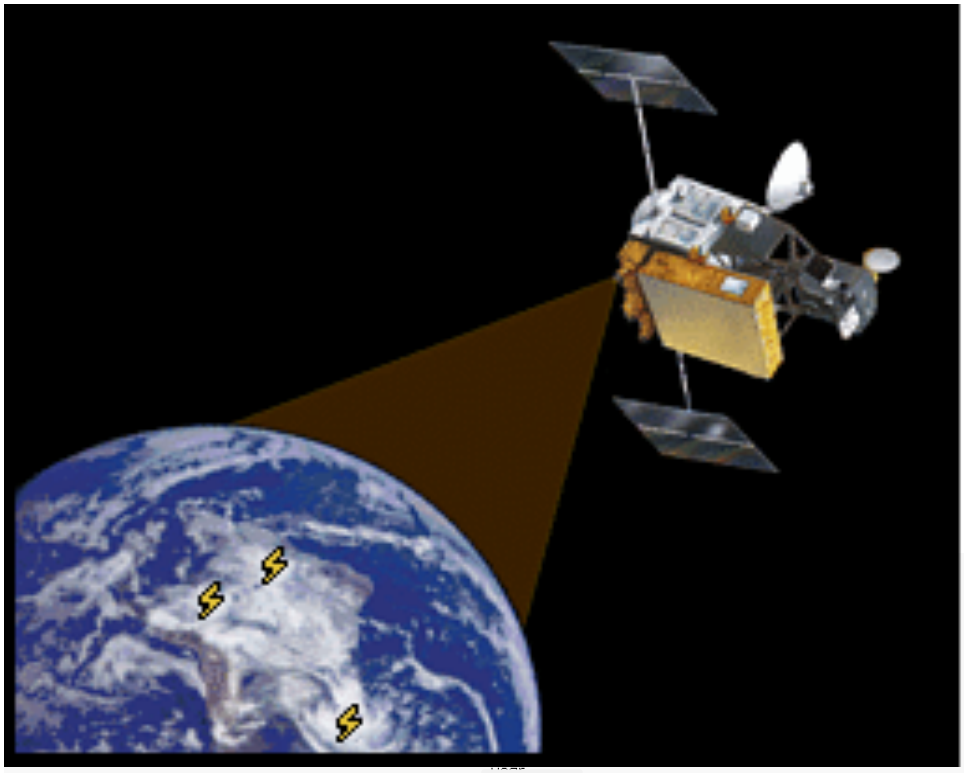
W. Koshak, NASA/MSFC ZP11

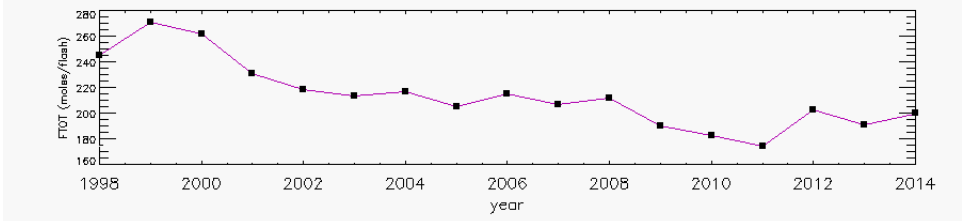
National Climate Assessment

- Lightning Nitrogen Oxides (LNOx) affect greenhouse gases & hence climate.
- Use Space-Based Flash Optical Data
- Optical → Flash Energy → Flash LNOx Production

TRMM/LIS Flash Density (#/km^2)







TRMM/LIS: LNOx trended downward, but upward more recently


Questions