Assessing Global Change Impact on the US Using National Lightning Data

National Climate Assessment PI Meeting

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(abbreviated version)

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Overview of Project Goals

Develop Assessment Capabilities & Products to monitor, quantify, and provide alerts of climate-induced changes in lightning, and resulting impacts:

- **Evaluate the Sensitivity of Lightning Characteristics to Climate Change**
  - lightning flash counts
  - peak return stroke current
  - multiplicity (# strokes per flash)
  - lightning nitrogen oxides (LNOx)
  - diurnal variations (counts, peak current)

- **Determine & Examine Lightning-Caused Impacts to Several Economic Sectors**
  - Human Health (lightning-caused injury/death)
  - Agriculture (lightning-caused crop damage)
  - Forestry (lightning-caused wildland fires)
  - Personal Property (lightning-caused personal property damage)

Achievement of Goals

- **Lightning Analysis Tool (LAT) Developed & Applied**

  A sustaining assessment tool that provides the assessment capabilities & products for monitoring climate-induced changes in lightning characteristics, and lightning impacts.

- **Science Results Discussed in:**
  - **Journal Articles**
    - Koshak, W. J., K. L. Cummins, D. E. Buechler, B. Vant-Hull, R. Blakeslee, E. R. Williams, and H. S. Peterson, Variability of CONUS Lightning in 2003-2012 and Associated Impacts, submitted to *J. Appl. Meteorol. & Climatol.*, 2014.
    - Chronis, T., R. Said, K. Cummins, W. Koshak, E. McCaul, E. Williams, G. Stano, and M. Grant, Climatological Diurnal Variation of CG Lightning Peak Current, submitted to *Geophys. Res. Lett.*, 2014.
  - **Conference Paper**
    - Koshak, W. J., B. Vant-Hull, E. W. McCaul, and H. S. Peterson, Variation of a Lightning NOx Indicator for National Climate Assessment , *International Conference on Atmospheric Electricity*, June, 2014.
  - **Book Chapter**
    - Koshak, W. J., Global Lightning Nitrogen Oxides Production, to appear in Chapter 19 of the upcoming 2nd edition of The Lightning Flash, editor Vernon Cooray, IEE Power & Energy Series.

Achievement of Goals (cont.)

Found that CG lightning is decreasing!

Why does CG lightning drop by 12.8% when T is trending up?

Answer: Lightning needs heat & moisture. So use long-term Tw (instead of T) to obtain positive correlation.

Achievement of Goals (cont.)

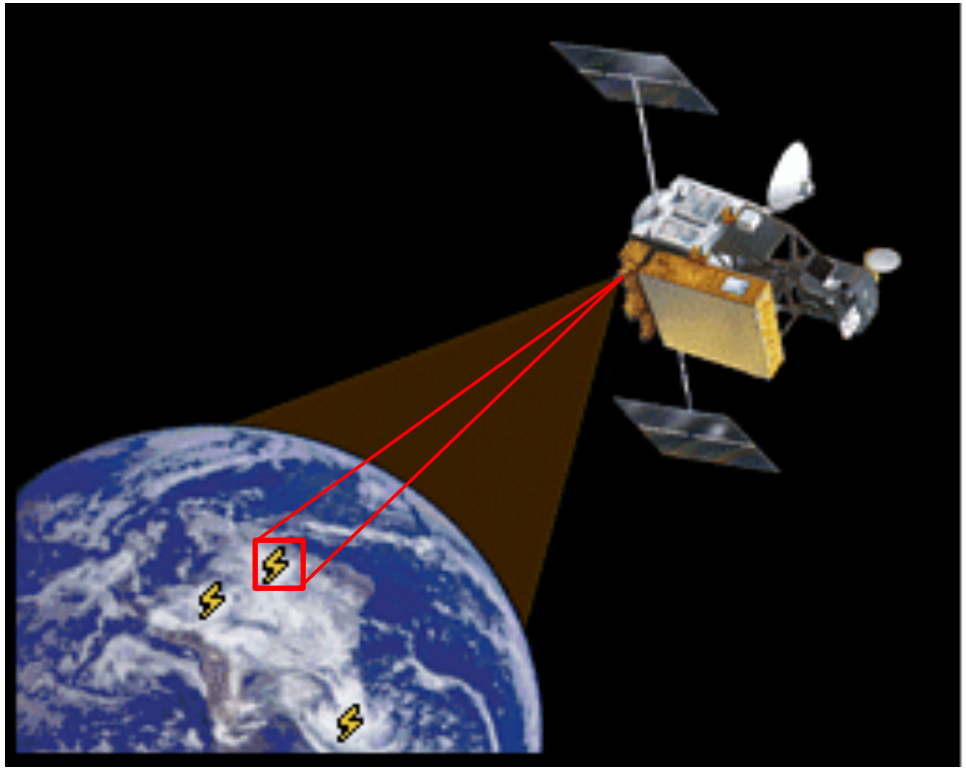
Significant Challenge!

Wanted to go beyond the simple Lightning NOx Indicator

$$\mathrm{LNI} = \sum_{i=1}^{N} A_i B_i \quad .$$

Solution:

Derived a way to use TRMM/LIS data to estimate flash energy and then convert this energy to Lightning NOx Production P.



Lightning Nitrogen Oxides (LNOx) affect greenhouse gases & hence climate.

$$P = \sum_{k=1}^{N_O} P_k + N_u \left(\frac{1}{N_o} \sum_{k=1}^{N_o} P_k \right) \quad , \qquad P_k = \frac{CYA\Delta\lambda}{\beta N_A} \sum_{i=1}^{m_k} \sum_{j=1}^{n_k} \left[\frac{a_{jk} \cos \alpha_{jk}}{r_{jk}^2} \right] \overline{\xi}_{\lambda ijk}$$

Achievement of Goals (cont.)

- Obtained LIS-inferred LNOx 1998-2013.
- Found that it trended downward in this period.

Achievement of Goals (cont.)

Completed Assessment of Climate-Induced Changes in CG Lightning-Caused Impacts.

$$\text{Sensitivity} = \frac{\partial I}{\partial T_w} = \frac{\partial I}{\partial N}\frac{\partial N}{\partial T_w}$$

I = Impact to a Sector

N = CG Lightning Count

T_w = Wet-Bulb Temperature

Human Health

Fatalities: 13.7 deaths/^{o}C

Injuries: 85.4 injuries/^{o}C

Agriculture

Crop Damage: $63,198/^{o}C

Personal Property

Homeowners Insurance Claims: $367.3M/^{o}C

Forestry

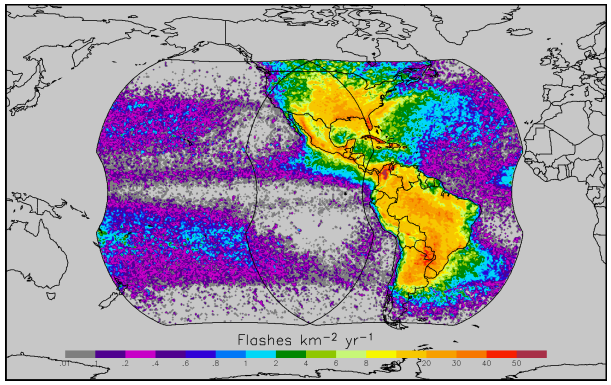
Wildfires (number): 4158/^{o}C

Wildfires (acres): 1.2M/^{o}C

Future Evolution & Benefits

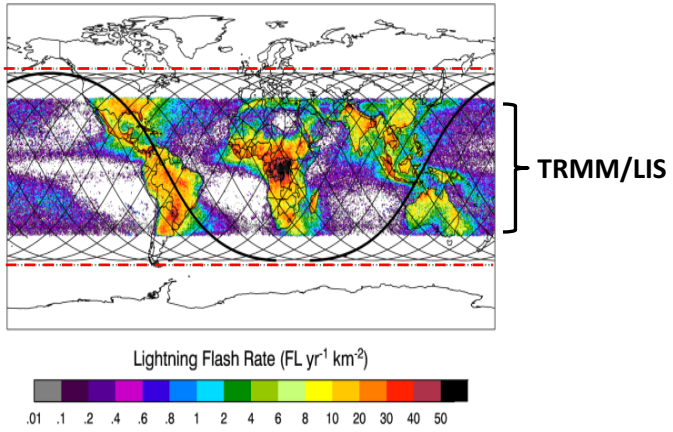
- **Employ GOES-R Geostationary Lightning Mapper (GLM) Data**
  - Launch early 2016.
  - Offers continuous monitoring of total lightning over all of CONUS.
  - Data will be implemented into this project's Lightning Analysis Tool (LAT) for NCA studies.
  - Will apply LNOx production *P* equation for improved (i.e. continuous) LNOx monitoring.

GLM field-of-view (East park better)



- **Employ International Space Station Lightning Imaging Sensor (ISS/LIS) Data**
  - Launch early 2016.
  - Views all of CONUS (TRMM/LIS only up to 38°N).
  - Data will be implemented into this project's Lightning Analysis Tool (LAT) for NCA studies.
  - Will apply LNOx production *P* equation for improved & cross-sensor LNOx monitoring.

ISS/LIS field-of-view (red-dotted)



… Present NCA work represents important preparation & proving ground for analyzing these future data!

W. Koshak, NASA/MSFC ZP11