Overview of NCA Lightning Indicator Project & Objectives

William Koshak
NASA Marshall Space Flight Center (MSFC), Huntsville, AL

NCA Science Meeting, *6 June 2022*

Meeting Objectives

- ***Review:*** Where have we been? Since meeting participants have been very busy with other projects, and since the NCA activities carried out by each participant are diverse and complex, each participant has been asked to provide a review of their primary activities to date, and main results.

- ***Brainstorm:*** What can we do that is most beneficial? Superposed with the review process mentioned above will be time/discussion devoted to new ideas to benefit/optimize our NCA work.

- ***Plan:*** Where should we go? The review and brainstorming clarifies the best path forward and needed action items for the team. Koshak emphasizes tool building for decision makers.

National Climate Assessment (NCA) Program

- ✓ **Congressionally Mandated: Global Change Research Act (1990)**
- ✓ **Vision:**

> To advance an inclusive, broad based, and sustained process for assessing and communicating scientific knowledge of the impacts, risks, and vulnerabilities associated with a changing global climate in support of decision-making across the US.

So Tool Building Important Objective !

- ✓ **USGCRP Oversees the NCA Process**
  - 13 Federal Depts/Agencies Involved
- ✓ **Culminates in regular NCA Assessment Reports**
  - NCA1 completed in 2000
  - NCA2 completed in 2009
  - NCA3 completed in 2014
  - NCA4 completed in 2018
  - NCA5 in progress

WMO added **lightning** to the Global Climate Observing System (GCOS) list of Essential Climate Variables (ECVs)

NCA5 Timeline

NCA5 Timeline
**Subject to Change*
•**February 2020**
•Federal Steering Committee established
•**Spring/Summer 2020**
•Public call for comment on draft prospectus; public call for nominations for Chapter Leads, Chapter Authors, and Technical Contributors, and call for scientific/technical inputs
•**Spring 2021**
•Coordinating Lead Authors and Chapter Leads selected
•**Summer 2021**
•Chapter Authors selected
•**Fall/Winter 2021**
•Interagency review of chapter outlines
•**Early 2022**
•Public engagement; public call for Review Editor nominations
•**Spring 2022**
•First draft developed
•**Summer 2022**
•Agency review; Review Editors selected
•**Fall 2022**
•Public and National Academies of Sciences, Engineering, and Medicine reviews of draft
•**Spring 2023**
•Authors revise draft in response to reviews
•**Summer 2023**
•Final revisions and final agency reviews
•**Fall 2023**
•Finalization and publication

NCA5 Table of Contents

Fifth National Climate Assessment (NCA5)

Annotated Outlines (Zero Order Draft)

DRAFT

Koshak Inputs On 18 Feb 2022 to NCA5

Climate Trends, Chapter 3:

Under Key Topic 4 one could add a sub-bullet "Lightning".

For the purposes of making **better projections of lightning across the US**, recent advances have been made in better understanding the inter-relationships between cloud-to-ground lightning, CAPE, and precipitation; performance of re-analysis based proxies are introduced.

Details are provided in:

- Tippett, M. K., & Koshak, W. J. (2018). A baseline for the predictability of U.S. cloud-to-ground lightning. Geophysical Research Letters, 45, 10,719–10,728. https://doi.org/10.1029/2018GL079750.

- Tippett, M. K., C. Lepore, W. J. Koshak, T. Chronis, and B. Vant-Hull, 2019: Performance of a simple reanalysis proxy for US cloud-to-ground lightning, Int. J. Climatol., 39, 3932-3946, https://doi.org/10.1002/joc.6049.

Koshak Inputs On 18 Feb 2022 to NCA5 (cont.)

Forests, Chapter 7:

A bullet could be added under Key Topic 1 that states: Advances are being made in **understanding the inter-relationships between dry-lightning, precipitation, and the occurrence of lightning-caused wildfires**.

For specific details, see:

- Vant-Hull, B., T. Thompson, and W. J. Koshak, 2018: Optimizing precipitation thresholds for best correlation between dry lightning and wildfires, J. Geophys. Res. Atmos., 123. https://doi.org/10.1002/2017JD027639.

Koshak Inputs On 18 Feb 2022 to NCA5 (cont.)

Air Quality, Chapter 14:

A Key Topic should be added to the chapter that provides highlights of advances in observation and modeling. For example, **improved modeling techniques have recently been developed for estimating lightning nitrogen oxides (LNOx)** production using flash optical energy and flash optical area observations derived from the GOES-16 and GOES-17 Geostationary Lightning Mapper (GLM). Additional examples exist, and references for some are provided below.

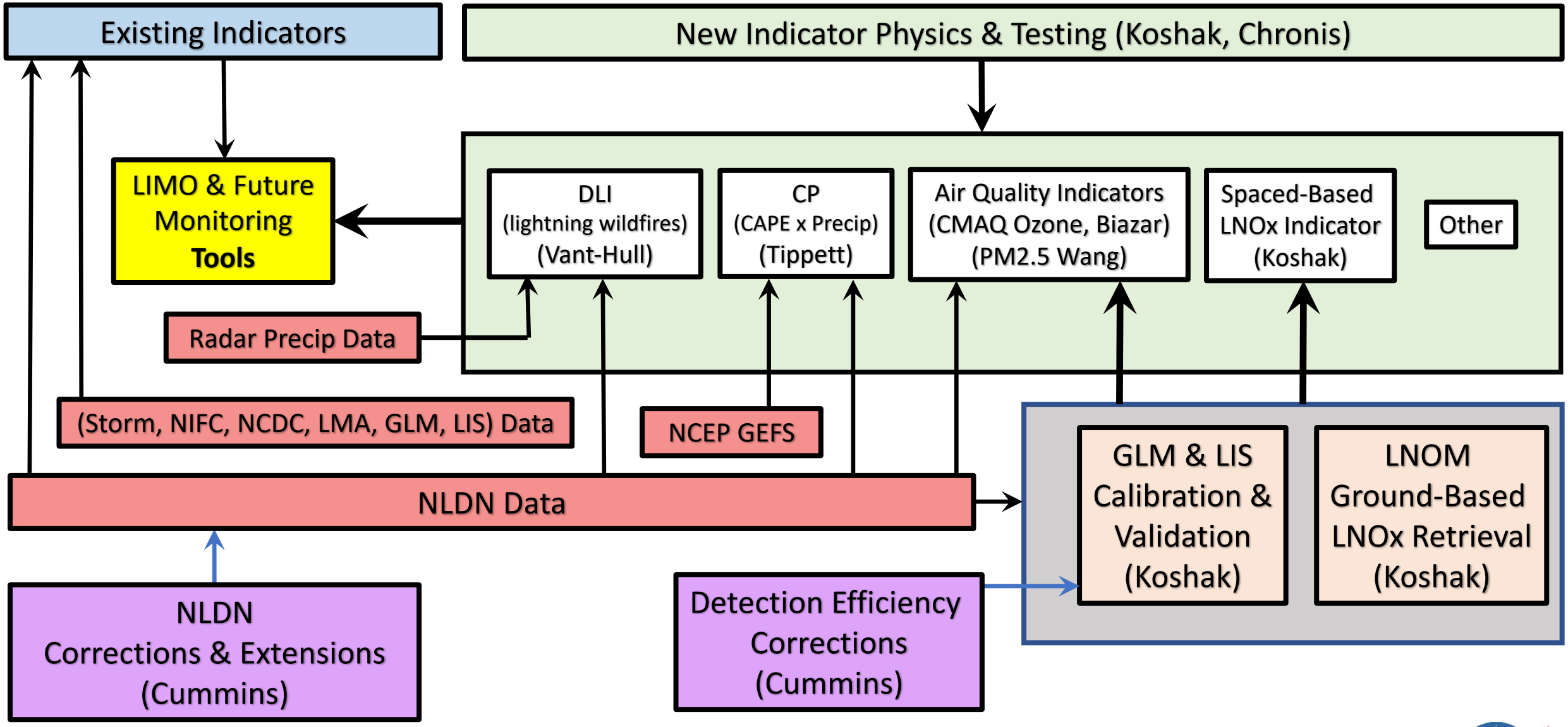
- Koshak, W. J., GLM estimates of LNOx over the continental US: ground and cloud flash differences, 101st American Meteorological Society (AMS) Meeting, Virtual due to COVID-19 pandemic, January 10-15, 2021.

- Allen, D. J., Pickering, K. E., Lamsal, L., Mach, D. M., Quick, M. G., Lapierre, J., et al. (2021). Observations of lightning NOx production from GOES-R post launch test field campaign flights. Journal of Geophysical Research: Atmospheres, 126, e2020JD033769. https://doi.org/10.1029/2020JD033769.

- Lapierre, J. L., Laughner, J. L., Geddes, J. A., Koshak, W. J., Cohen, R. C., & Pusede, S. E. (2020). Observing U.S. regional variability in lightning NO2 production rates. Journal of Geophysical Research: Atmospheres, 125, e2019JD031362. https://doi.org/10.1029/2019JD031362.

- Koshak, W. J., Lightning NOx estimates from space-based lightning imagers, 16th Annual Community Modeling and Analysis System (CMAS) Conference, Chapel Hill, NC, October 23-25, 2017.

MSFC National Climate Assessment (NCA) Project: version: 06 June 2020



Initial Proposed Indicators

CG characteristics

Table 1. The heritage indicators associated with the physical characteristics of NLDN CG lightning. [Note: a +CG is a CG lightning flash that deposits positive charge to Earth, whereas a –CG deposits negative charge to Earth. Means shown are taken over a 0.2° latitude/longitude bin.]

Item	Heritage Indicator	Description	General Vision
1	NUMALL	NLDN CG Count	Increase is indicative of warming climate, & more fatalities/damage.
2	NUMPOS	NLDN +CG Count	Increase is indicative of warming climate, & more fires, & more severe weather.
3	NUMNEG	NLDN –CG Count	Increase is indicative of warming climate, & more fatalities/damage.
4	PRATIO	NLDN Fraction of +CGs (ratio of NUMPOS to NUMALL)	Increase is an additional indicator of warming climate & more fires & more severe weather.
5	DENALL	NLDN CG Density (NUMALL per km^2)	Area normalization aids regional inter-comparisons.
6	DENPOS	NLDN +CG Density (NUMPOS per km^2)	Area normalization aids regional inter-comparisons.
7	DENNEG	NLDN –CG Density (NUMNEG per km^2)	Area normalization aids regional inter-comparisons.
8	CURALL	NLDN mean of |CG peak current| (in kiloamps)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).
9	CURPOS	NLDN mean peak current of +CGs (in kiloamps)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).
10	CURNEG	NLDN mean of |–CGs peak current| (in kiloamps)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).
11	MULALL	NLDN mean multiplicity of CGs (# of strokes in CG flash)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).
12	MULPOS	NLDN mean multiplicity of +CGs (# of strokes in +CG flash)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).
13	MULNEG	NLDN mean multiplicity of –CGs (# of strokes in –CG flash)	Increase implies more power outages & fires, and more NOx/O_3 (all else being the same).

CG impacts

Table 2. The heritage indicators associated with CG-caused impacts.

Item	Heritage Indicator	Description	General Vision
14	NFAT	Number of fatalities due to lightning as reported in *Storm Data*.	Increases with increasing # of CGs (all else being the same).
15	NINJ	Number of injuries due to lightning as reported in *Storm Data*.	Increases with increasing # of CGs (all else being the same).
16	DCROP	Crop damage ($M) due to lightning as reported in *Storm Data*.	Increases with increasing # of CGs (all else being the same).
17	DPROP1	Damage to property ($M) due to lightning as reported in *Storm Data*.	Increases with increasing # of CGs (all else being the same).
18	DPROP2	Damage to property ($M) due to lightning as reported by personal homeowners insurance claims.	Increases with increasing # of CGs (all else being the same).
19	NFIRE	Number of lightning-caused wildfires [from National Interagency Fire Center, NIFC; and National Fire Incident Reporting System (NFIRS)]	Increases with increasing # of CGs (all else being the same).
20	NACRES	Number acres burned due to lightning-caused wildfires [from NIFC, NFIRS]	Increases with increasing # of CGs (all else being the same).

LIS Related (LNOx, Precip)

Table 3. The heritage indicators associated with space-based TRMM/LIS observations, and combinations of national CG lightning data with national radar data.

Item	Heritage Indicator	Description	General Vision
21	NUMLIS	LIS Total Lightning Count	Increase is indicative of a warming climate.
22	DENLIS	LIS Total Lightning Density (NUMLIS per km^2)	Area normalization aids regional inter-comparisons.
23	NOXLIS	LIS Lightning NOx Estimate (estimated moles of LNOx in a region)	Increase drives, and is indicative of, a warming climate.
24	DLI	Dry Lightning Indicator (# CG strokes for precipitation below a 0.5 mm/hr threshold)	Increase implies more lightning-caused wildfires.
25	ICI	Intense Convection Indicator (# CG strokes x mm of precipitation)	Increase implies more extreme weather.

GLM Related (LNOx, Precip)

Table 4. The new indicators associated with space-based GLM observations (first six), a recent parameter examined in Romps et al. (2014), and a regional LNOx indicator (last row).

Item	New Indicator	Description	General Vision
26	NUMGLM	GLM Total Lightning Count	Increase is indicative of a warming climate.
27	NUMCF	Cloud Flash Count (NUMGLM - NUMALL)	Changes in this parameter provide insight into the relative impact of climate warming on CGs and
28	DENGLM	GLM Total Lightning Density (NUMGLM per km^2)	Area normalization aids regional inter-comparisons.
29	DENCF	Cloud Flash Density (NUMGLM per km^2)	Area normalization aids regional inter-comparisons.
30	Z	Z-ratio (NUMCF/NUMALL)	Increase is indicative of severe weather.
31	NOXGLM	GLM Lightning NOx Estimate (estimated moles of LNOx in a region)	Increase drives, and is indicative of, a warming climate.
32	ROMPS	Romps Indicator (const) x Precipitation x CAPE	Increases in a warming climate and implies more available energy for lightning production.
33	NOXLNOM	Regional ground-based LNOx Estimate	See description in section 1.3.3 (*Enhancing Outreach to Decision Makers*).

Communicating Our NCA Results to NASA HQs

A NASA **Earth Science Research Results (ESSR)** Portal has been developed that allows NASA Civil Servants to communicate project results to their respective NASA Hqs Project Manager:

- Results can be communicated (i.e. uploaded) any time by the civil servant PI.
- Results should be typically a single Power Point slide with a figure and high-level text describing the importance or impact of a new result.
- Avoid acronyms, and make sure things are reasonably self-explanatory.
- I have created and uploaded several slides already in the past year, based on our published work.
- *Moving forward, I encourage you to send me summary slides of any recent results whenever you like, and I will get it uploaded to the ESSR portal.*