Lightning Modeling Grand Challenge Workshop

End-to-end Lightning Model

Phenomenology & Signatures Department, Sandia National Labs

and Eric Bruning, Texas Tech University

1-3 April, 2024, Albuquerque, NM

Lightning Model Expert Panel

Eric Bruning: Panel lead - Texas Tech University/Sandia

Julia Tilles: Lightning Scientist - Sandia

Chris Hogg: USNDS Rep - Sandia

Timothy Lang: NASA Lightning research lead - MSFC

Amanda Back: NOAA weather modeling expert - NOAA Office of Oceanic and Atmospheric Research/Global Systems Lab

Steve Goodman: Retired GOES-R chief scientist - Sandia

Sonja Behnke: Lightning scientist - LANL

Randy Longenbaugh: Facilitator - Sandia

Special thanks

Thom Edwards: Scientist - Sandia

Stephanie Garcia : Organizational support - Sandia

Vision

The Nation does not currently have an end-to-end, validated modeling & simulation capability based on physics for lightning

- Many agencies including DOE, NASA, and NOAA have operational and research missions with a need for detecting the optical and RF output from lightning

Sandia National Labs will lead an effort to develop a model and simulation capability that can be used by the scientific community

We will partner with world class researchers in lightning and related phenomenologies across the broad scientific community

We will focus research to ensure that it is impactful to multiple stakeholders and mission areas

Guiding Principles for the Panel – Year 1

We are not starting from scratch

We will determine what models already exist

We will determine how well those models replicate relevant physics

We will choose the best models to incorporate into the end-to-end model

We will partner with the authors of those models

We will determine what trade-offs there are between local fidelity and large-scale simulation

We will identify gaps in capability and propose future work

The Panel will Deliver a 3-5 Year Lightning M&S Roadmap by the end of FY24

Potential Customers, Stakeholders and Partners

Follow-on Town Hall sessions to share the roadmap with the lightning and meteorology communities will be conducted at the AGU and AMS Annual Meetings in late 2024-early 2025.

NNSA

NASA

NOAA

DOE (Energy Efficiency & Renewable Energy)

National Science Foundation

DoD

National Labs

Relevant Universities

Can we go beyond correlative use of lightning by pursuing a more ambitious physical science program of storm electricity forecasting?

Physical covariances

Lightning data **Measures** Spatial structure of electrification and local discharge rates **Covaries with** Mixed phase hydrometeor count, mass, collision rate **Covaries with** Environment Storm dynamics Draft fluctuations

Grand challenge

Time-evolving retrieval of a storm's electrical structure at the large eddy scale.

Practical application

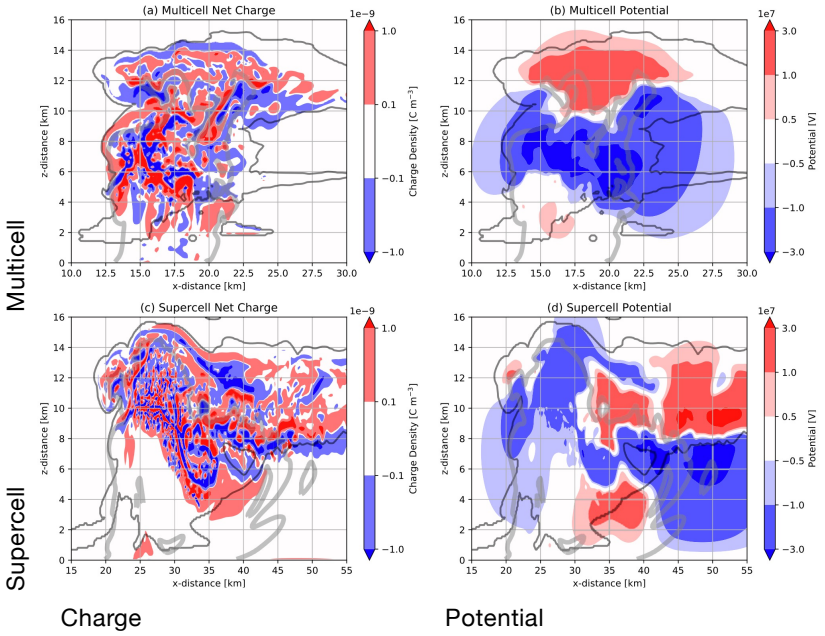
If we can retrieve this picture from observations, we can also *predict* the next flash and its most likely path as it taps the electrical energy in the storm.

electrostatics (J/C)
ϕ
$-\nabla\phi = \vec{E}$
$-\nabla^2\phi = \rho/\epsilon_0$

Potential
(net flash shape)

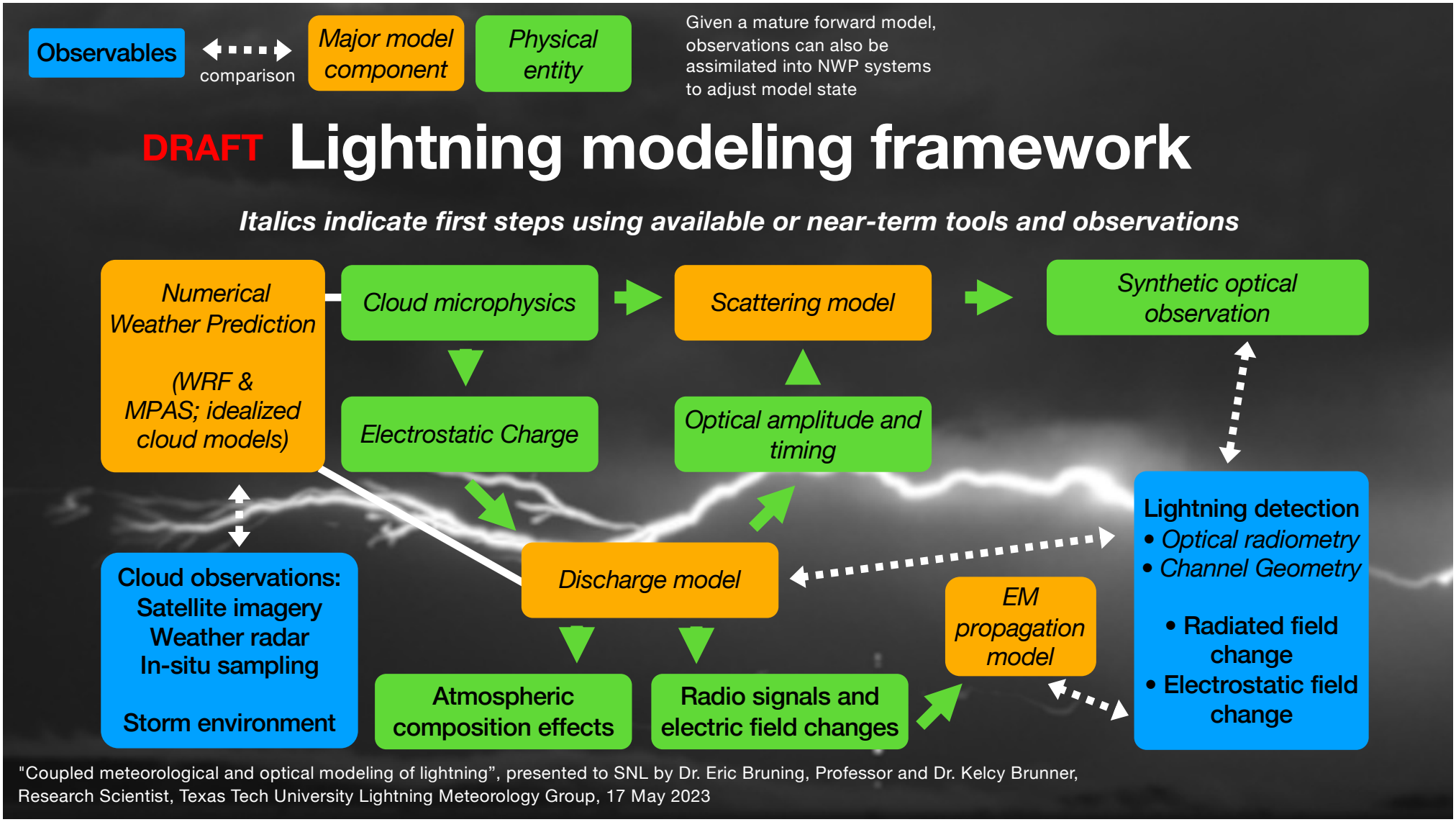
Electric field
(flash origin)

Charge density
(channel density)



125 m electrified simulations from Brothers, Bruning and Mansell (2018, JAS)

"Integrated lightning observations for operational calibration/validation, data assimilation, and process understanding", presented to NOAA/CIWRO by Dr. Eric Bruning, Professor, Texas Tech University, 6 December 2021



"Coupled meteorological and optical modeling of lightning", presented to SNL by Dr. Eric Bruning, Professor and Dr. Kelcy Brunner, Research Scientist, Texas Tech University Lightning Meteorology Group, 17 May 2023

Too ambitious?

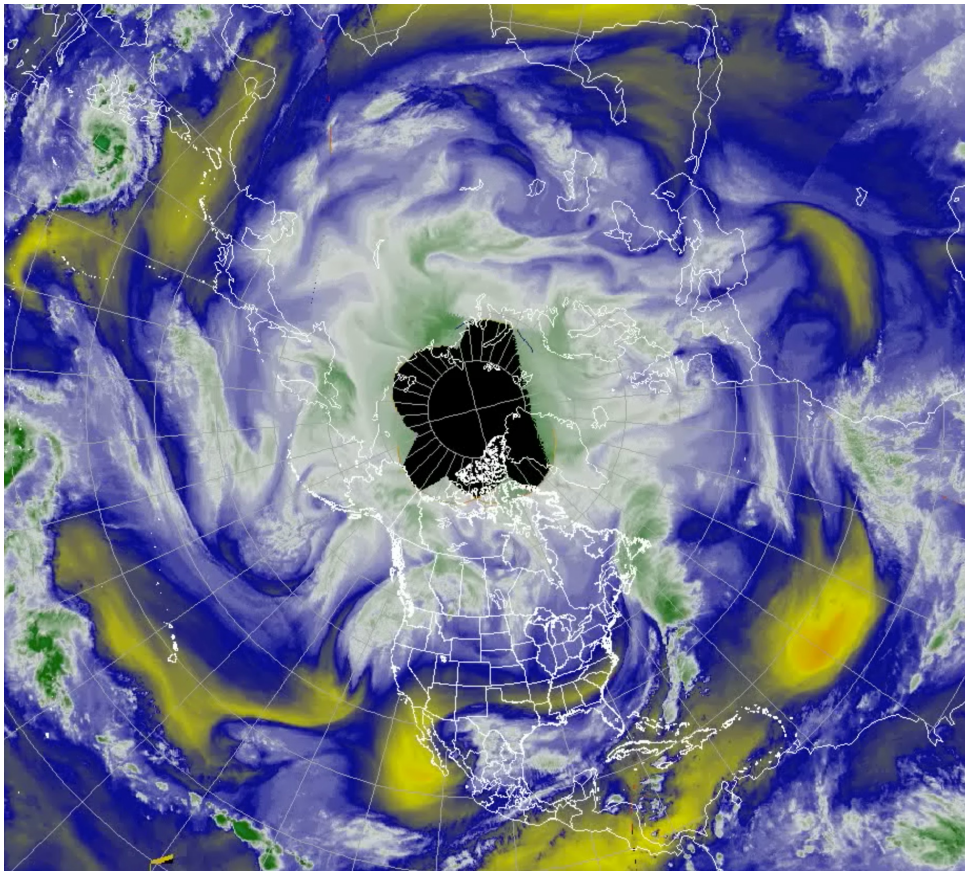
Consider the history of meteorology

We've used theory, an ambitious global observing infrastructure, and computing to make progress where there are physical reasons for severe, well-founded doubts.

Lorenz (1963, JAS, Deterministic Nonperiodic Flow)

When our results concerning the instability of nonperiodic flow are applied to the atmosphere, which is ostensibly nonperiodic, they indicate that prediction of the sufficiently distant future is impossible by any method, unless the present conditions are known exactly. In view of the inevitable inaccuracy and incompleteness of weather observations, precise very-long-range forecasting would seem to be non-existent.

N. Hemisphere Water Vapor Composite (UW/SSEC)



Synoptic eddies sure look hard to forecast!
But their prediction is now routine.

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Next: Icebreaker