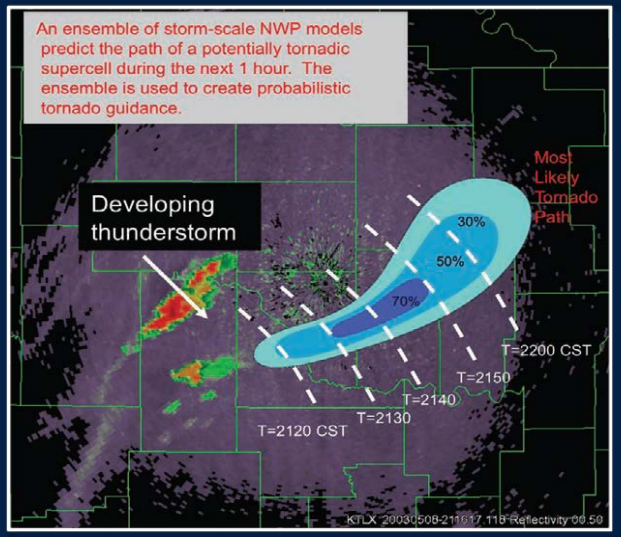
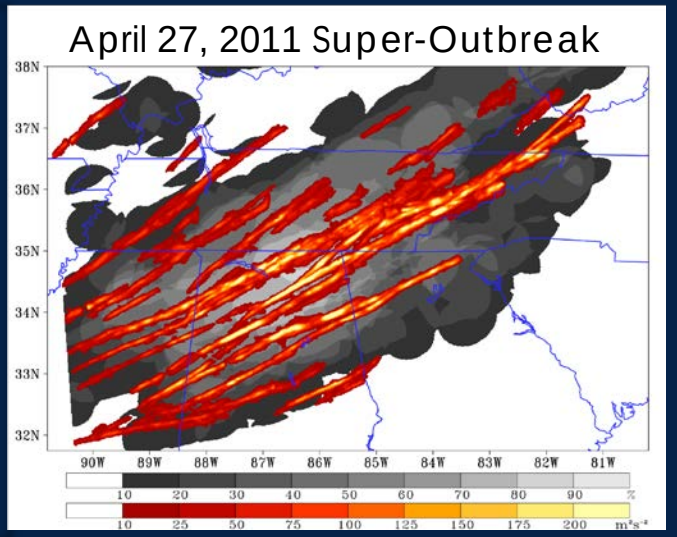




Storm-Scale Modeling at CIMMS – 40 Years of Cutting Edge Science

CIMMS 40th Anniversary Symposium

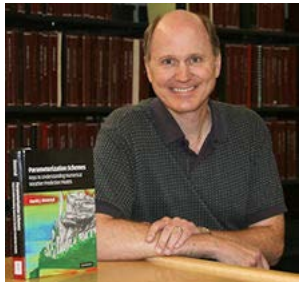
Dr. Adam Clark

November 15, 2018
Norman, OK

Disclaimer: I am just a wee lad!

- **Thanks to:** Lou Wicker, Harold Brooks, Eric Rasmussen, Jack Kain, Dave Stensrud, and Jeff Kimpel for historical info…

Age



>>

Age

Decade #1: 1978-1989

- Research areas in observational studies of storms and weather radar development.

- Not yet any storm-scale modeling… but Lans Rothfusz was playing with a tornado simulator.

A Velocity Measurement Technique for Tornado Vortex Simulators

1987

Lans P. Rothfusz
Cooperative Institute for Mesoscale Meteorological Studies, The University of Oklahoma and NOAA, Norman, OK 73019

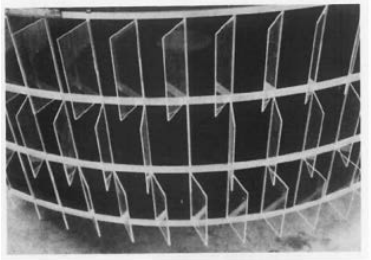
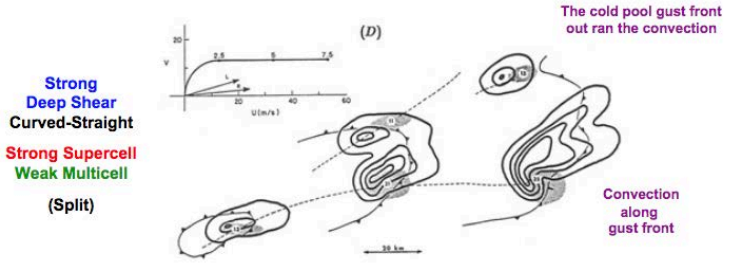


FIG. 2. Photograph of the inflow guide vanes at r_s. Note the vertically veering configuration.

- Foundation for storm-scale modeling developed outside CIMMS by Klemp, Wilhelmson, and others.

Klemp and Wilhelmson (1978) – Laid out equations for modeling 3-D convective storms.
Weisman and Klemp (1982) – Dependence of simulated storms on shear and instability.
Rotunno et al. (1988) – "RKW" Theory for long-lived squall lines.



Decade #2: 1990-1999

<u>1988:</u> CIMMS director, Doug Lilly, and OU prof. Kelvin Droegemeier write a proposal for a 11-year NSF Technology Center at OU.

<u>1990:</u> Vision for future storm-scale modeling Lilly (1990) – ***Numerical Prediction of Thunderstorms – Has its Time Come?***

"Weather prediction is the principal reason for the support which we are given by our fellow citizens. I am personally impressed with the quality and dedication of the scientific efforts now being made in operational weather prediction. I believe it is time for convective-storm scientists to apply our knowledge to this purpose and to subject our products to its discipline."

"The key observing system is a Doppler radar network..."

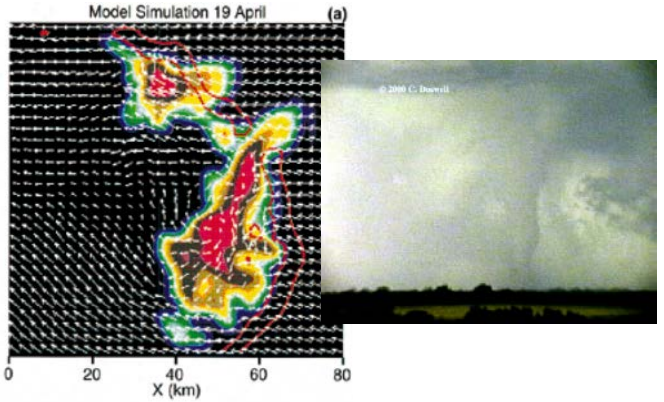
"There is great scope for scientific, technical, and artistic creativity in developing imagery suitable for rapid dissemination of short-term predictions"

Decade #2: 1990-1999

- Still no storm-scale modeling at CIMMS, but Harold Brooks led 1st attempt to use cloud model to generate real-time forecasts

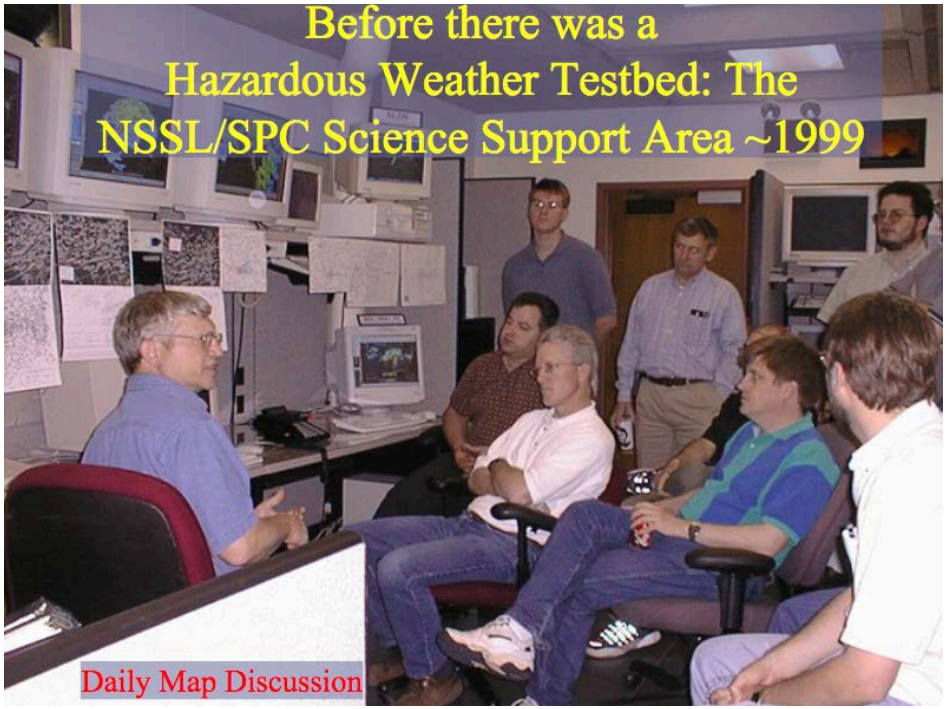
STORMTIPE:

- '91 &'95 collaboration b/w NSSL and NWS WFOs over OK and TX.
- Wicker and Wilhelmson cloud model.
- Homogeneous ICs – forecast environmental sounding.
- Artificial CI (warm bubble) – can model predict mode?



- 1997: Key Event. SPC move from Kansas City, MO to Norman, OK.

- NSSL creates Mesoscale Applications Group (MAP) - small group of NSSL and CIMMS staff to collaborate with SPC.
- Science Support Area created, which duplicated operational SPC workstations.



Decade #3: 2000-2009

- **The "Spring Program" – now the Spring Forecasting Experiment (SFE) was formalized in 2000**

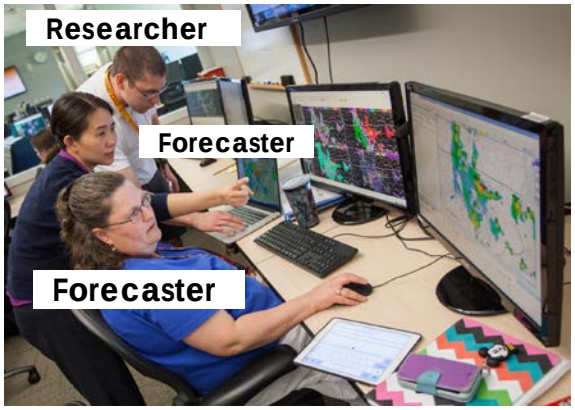
  - SFE pioneers: Jack Kain (CIMMS/NSSL), Mike Baldwin (CIMMS/SPC/NSSL), Paul Janish (SPC), Steve Weiss (SPC), and Russ Schneider (SPC)

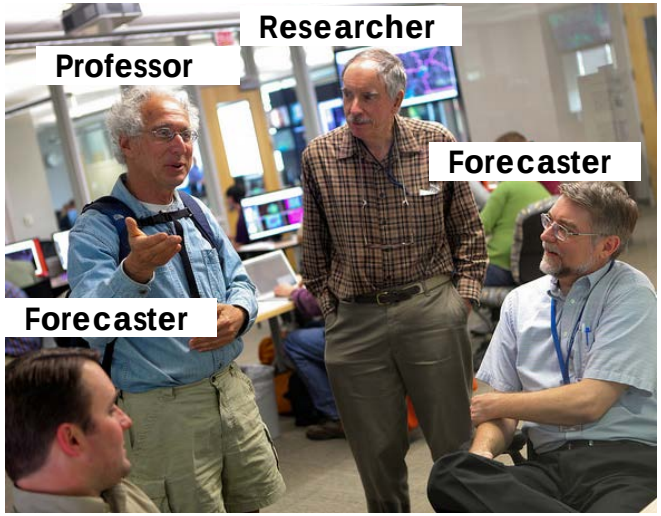
What is it?

- 5-week forecasting experiment
- Emerging concepts and new technologies for improving severe weather prediction are tested to accelerate R2O.
- Document sensitivities and performance of CAMs.

Keys to success

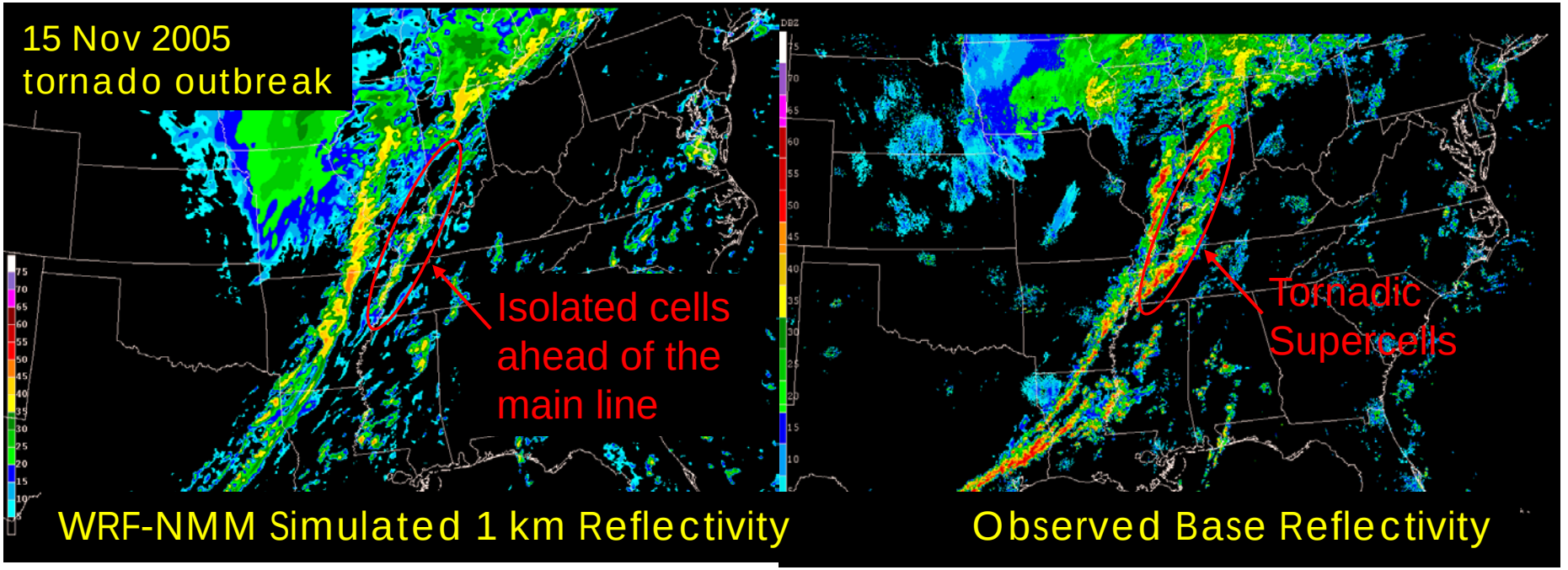
- Sense of realism and operational urgency
- Diverse participants
- R2O←→O2R pathways





Decade #3: 2000-2009

- **Initial testing of storm scale models occurred in 2003-04 (Kain et al. 2006)**



"The WRF-NMM4 provided very useful input regarding the mesoscale organization and character of storms…I used it to help delineate where/when watches would be required." *John Hart - SPC Day Shift Lead Forecaster*

"A turning Point in the use of model output"

Decade #3: 2000-2009

- **2006: Jack Kain establishes the NSSL-WRF, which is managed by Scott Dembek (CIMMS)**

- NSSL-WRF: Permanent experimental modeling framework to provide storm-scale guidance to SPC forecasters and serve as a testing ground for the development of storm scale model diagnostics.

- Most storm-scale diagnostics used today (e.g., updraft helicity) originated from the NSSL-WRF.

- NSSL-WRF archive goes back to 2007. This is by far the longest running CAM dataset, which makes it extremely valuable.

- Adam Clark took over management duties of NSSL-WRF in 2014 and Scott Dembek still manages the real-time runs. Original configuration still runs, but now we have an enhanced configuration along with FV3.

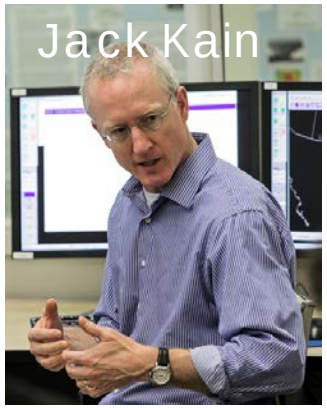
- NSSL-WRF also runs operationally at NCEP.

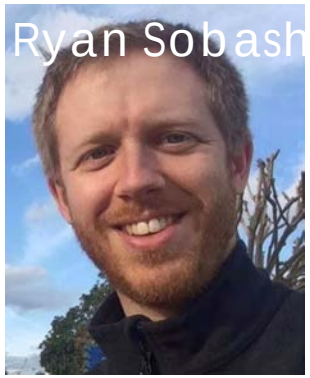
- Nearly 100 publications have used NSSL-WRF data.

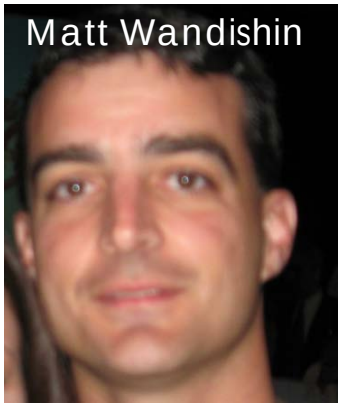
Decade #3: 2000-2009

- **2006:** National Weather Center completed. Hazardous Weather Testbed created.

- **2007 - present:** SFEs focus on storm-scale ensembles, starting w/ collaboration with CAPS. *A full 10 years before first formal CAM ensemble at EMC!*



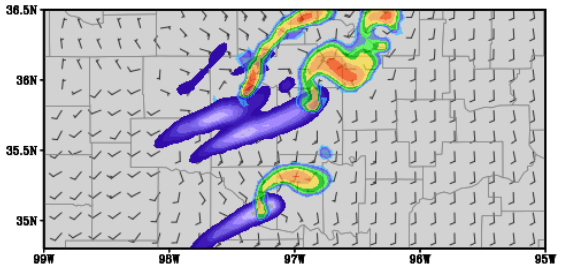




Decade #4: 2010-present

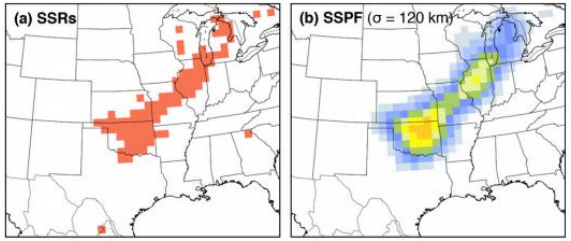
❑ **Diagnostics:**

"Hourly-maximum" technique (Kain et al. 2010), Updraft Helicity, simulated reflectivity, simulated satellite, HAILCAST, lightning, and many others.



❑ **CAM Verification:**

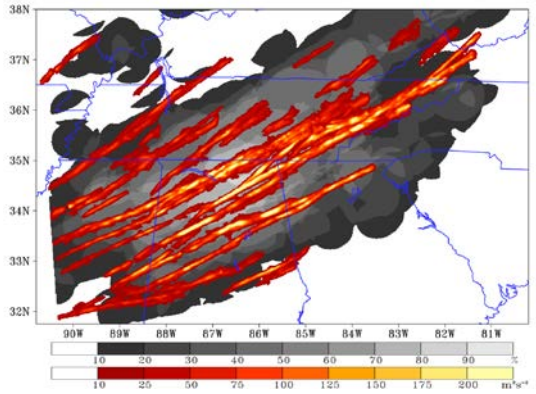
"Surrogate Severe", Neighborhood methods, value relative to convection parameterizing models, resolution sensitivity, etc. (Sobash, Stratman, Clark, Schwartz)



❑ **CAM Ensemble Visualization:**

Spaghetti plots, Maximum from any member, Neighborhood probabilities, and many others.

- Roberts et al. (BAMS; 2019) summarizes ensemble visualization work.
- Web viewer launches 1 November 2017 – techniques from last decade applied to first CAM ensemble at NCEP.

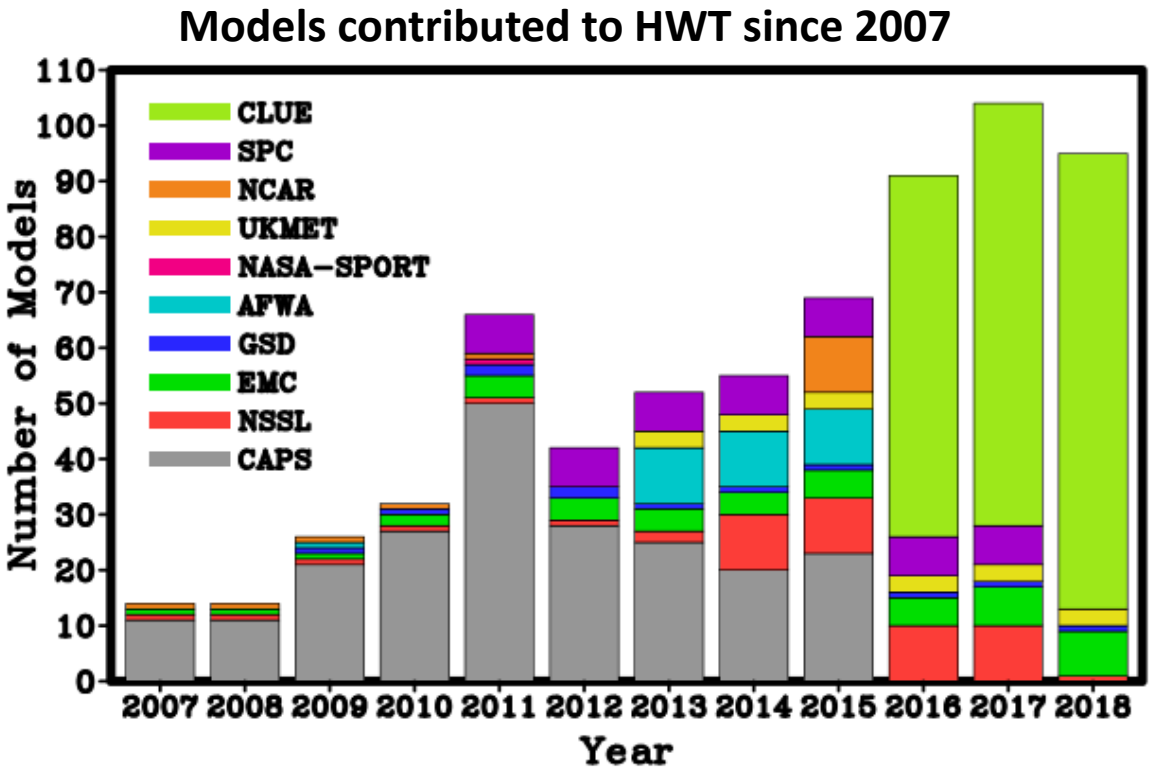


The first web viewer for operational CAM Ensemble

https://www.spc.noaa.gov/exper/href/

Community-Leveraged Unified Ensemble (CLUE)

- Unprecedented effort to leverage external community to help guide NWS storm-scale modeling efforts.
- *Inspired by the international UCAR Model Advisory Committee to provide **evidence-based decision making** for design of a future operational convection-allowing ensemble.*
- GOAL: Design HWT experiments to provide more controlled datasets that can be better utilized to inform configuration of near-future operational systems (HREFv2)



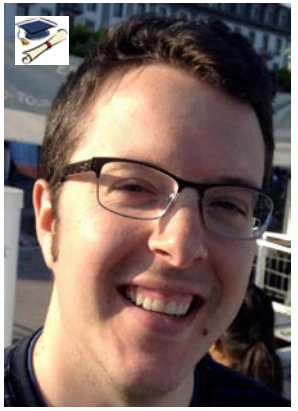
Contributors agreed on a set of model specifications and post-processing methods and data formats.

Clark et al. (2018; BAMS)

The 2010s has seen large increase in people supported by CIMMS for HWT-related work advancing storm scale modeling!





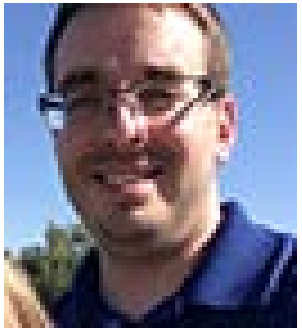








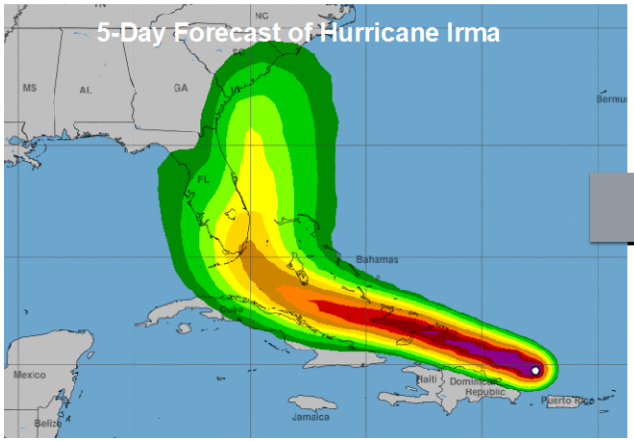


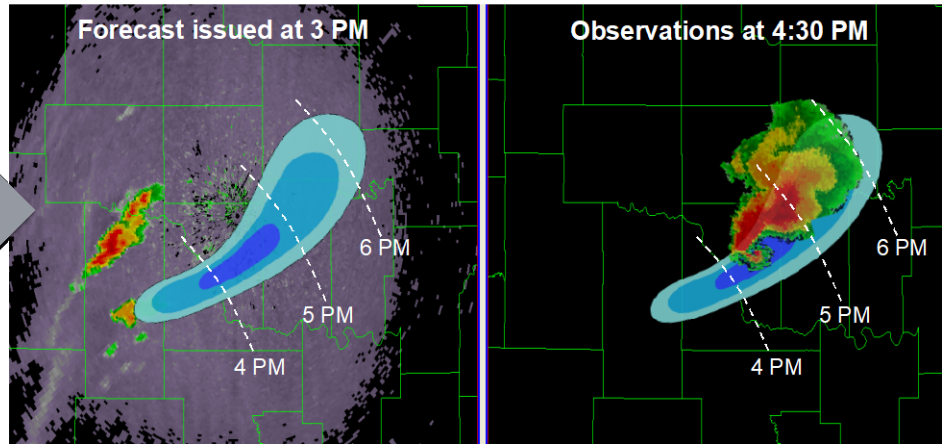

Warn-on-Forecast – The Grand Challenge!

Can individual thunderstorms be accurately predicted using weather models?

Take Hurricane forecast track concept



And apply it to thunderstorms



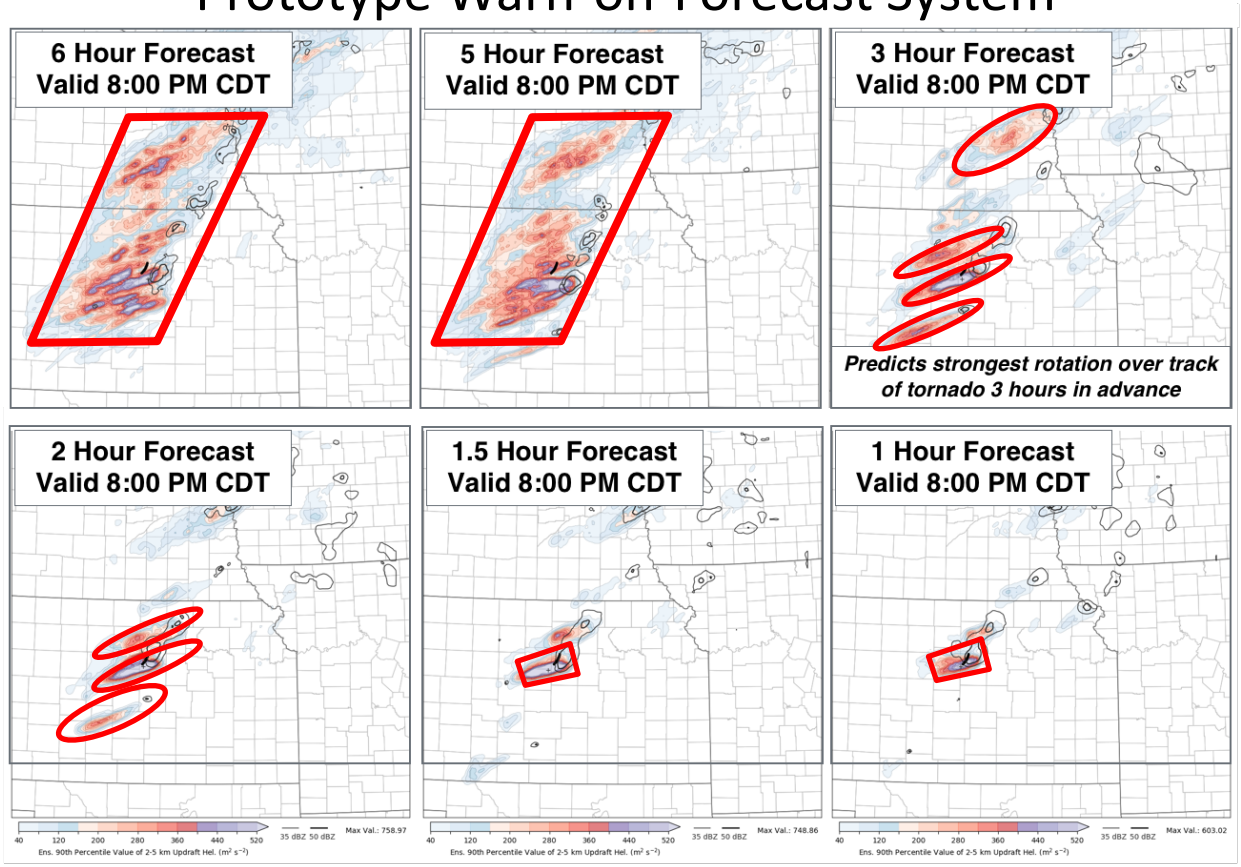
Go from "warn-on-detection" to "warn-on-forecast"

- Jeff Kimpel and NWS Director, Jack Hayes, proposed program in 2000s – NSSL would lead it.
- Merged deterministic storm-scale successes of CAPS with probabilistic forecast perspective from NSSL.
- Opened the door for storm-scale ensemble data assimilation.
- Current motivation: Address gap in guidance between Watch (~ 6 hours) and Warning (0-15 minutes).

What does Warn-on-Forecast look like today?

1 May 2018 NEWS-e Forecast: From Watch to Warning

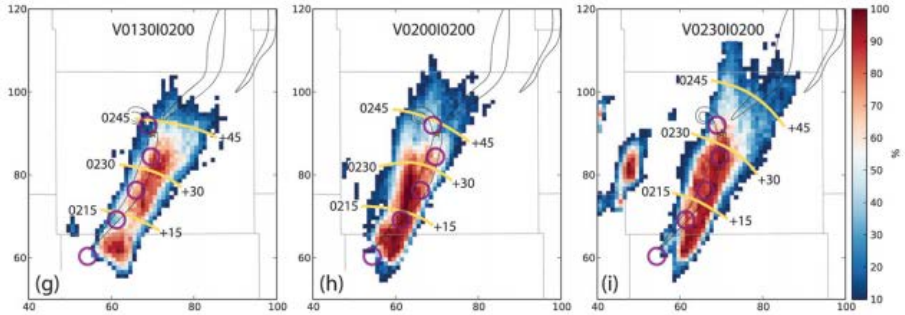
Prototype Warn-on-Forecast System



How did we get there?

Proof of concept:

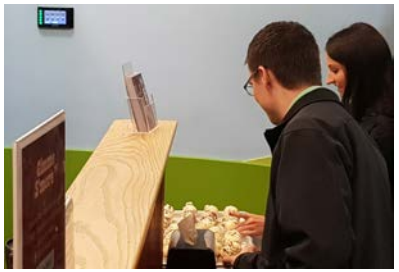
- Dawson et al. (2012; 2013) Greensburg, KS tornado simulations



WoF is possible! Large sensitivity to microphysics.

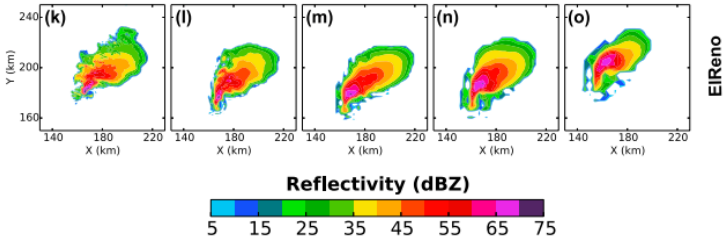
PECASE Winner

Ice Cream Thief



Resolution sensitivity and predictability research:

- Potvin and Flora (2015) – resolution sensitivity.



3-km dx "good enough", 1-km dx needed to simulate rapid changes

- Potvin and Wicker (2013) – Idealized modeling study. Accurate prediction still possible with sub-optimal radar-storm distances/beam angles.
- Potvin et al. (2017) – Important result: **Storm evolution insensitive to IC resolution. Could do ensemble DA at coarser resolution than forecasts saving $$$!**
- Flora et al. (2018) – Practical predictability of supercells.

How did we get there?

Data Assimilation Research:

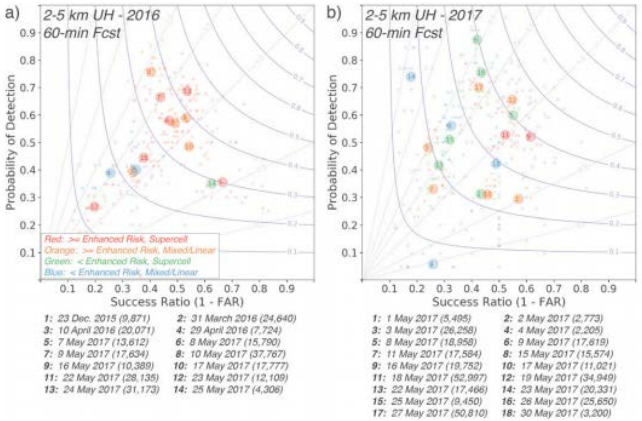
- Wheatley et al. (2015), Jones et al. (2015, 2018), Yussouf et al. (2013, 2015), and many others!

How to we get storms in the models and reliably depict uncertainty? How can we incorporate new sources of satellite data in the model? Lots of important work.




Verification, Visualization, Post-processing:

- Skinner et al. (2016; 2018) – Robust, object-based system for verifying WoF



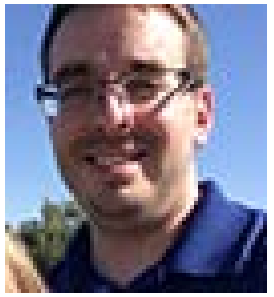
NEWSe website developed by Jessie Choate:

Social Science Research: Forecaster use and interpretation

Many CIMMS people have contributed to Warn-on-Forecast!

= student



















A vision for the future…

- CIMMS scientists will have increasingly large influence on NWS CAM ensemble configurations through work with UFS (FV3) at convective scales.
- Warn-on-Forecast will go operational!
- Huge research opportunities as HPC allows grid-spacing below 1-km. Diagnostics, visualization, post-processing, etc.
- Storm-scale modeling at CIMMS will continue to grow and be awesome!
- New research opportunity: S2S (sub-seasonal to seasonal) forecast of severe weather.
- Questions?