Improving Probabilistic Short-Term Severe Weather Forecasts Using the Warn-On-Forecast System, ProbSevere, and Random Forests

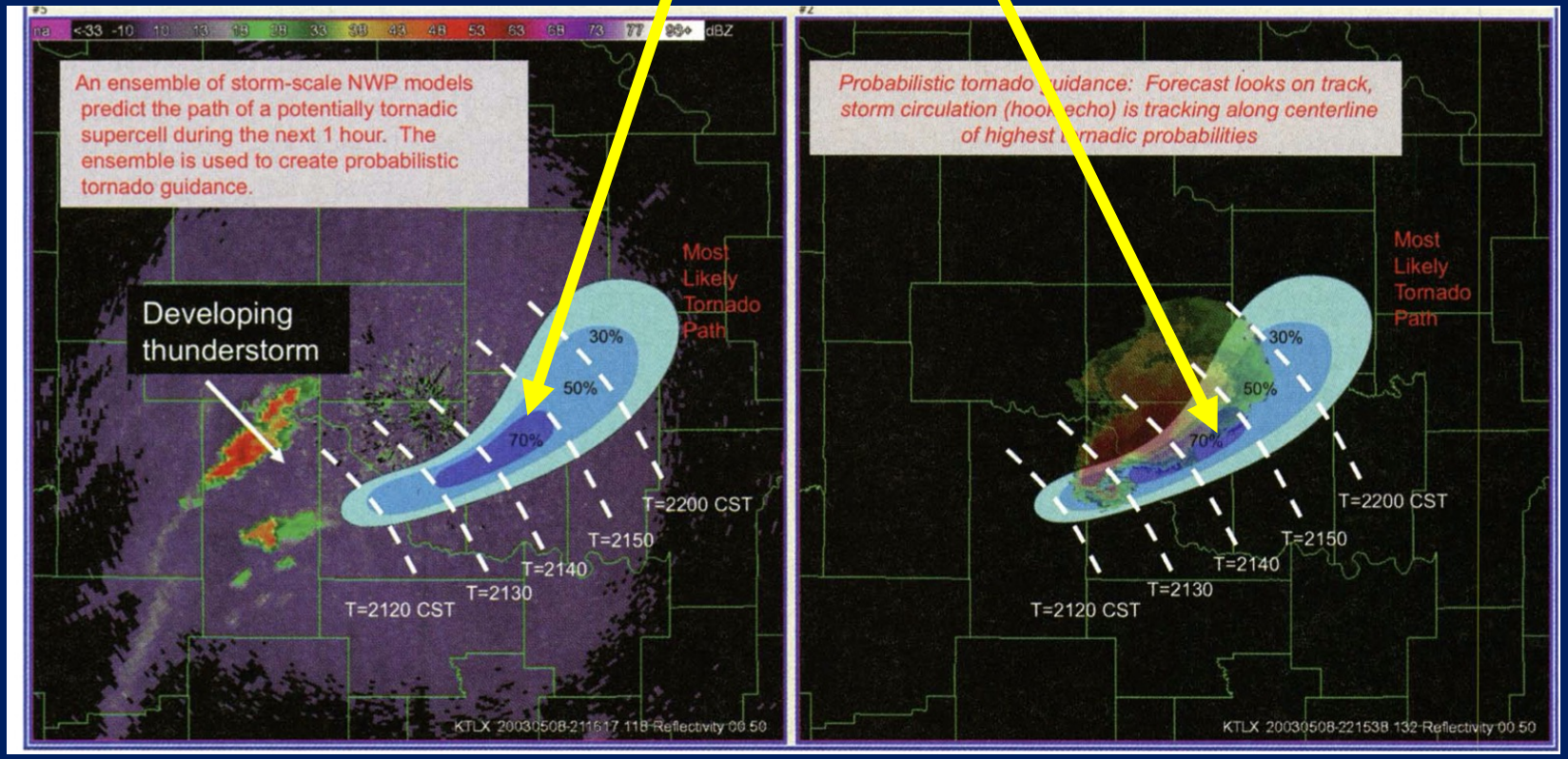
Eric Loken[1], Katie Wilson[1], Thea Sandmael[1], Kristin Calhoun[2], Adam Clark[2], Anthony Reinhart[2], Patrick Burke[2], and Patrick Skinner[1]

[1]University of Oklahoma/Cooperative Institute for Severe and High-Impact Weather Research and Operations

[2]NOAA/OAR/National Severe Storms Laboratory

Can we make the vision a reality?

90-minute tornado probabilities
(rapidly updating)

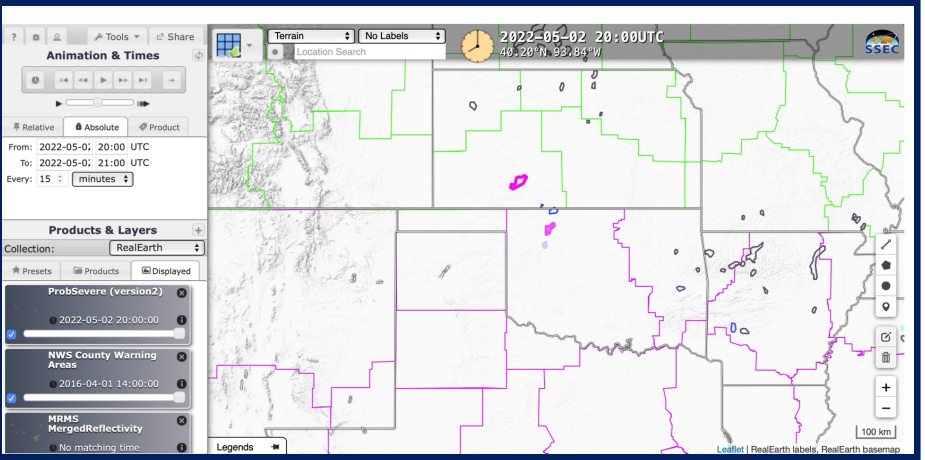


Stensrud et al. 2009

Two products with different strengths

ProbSevere

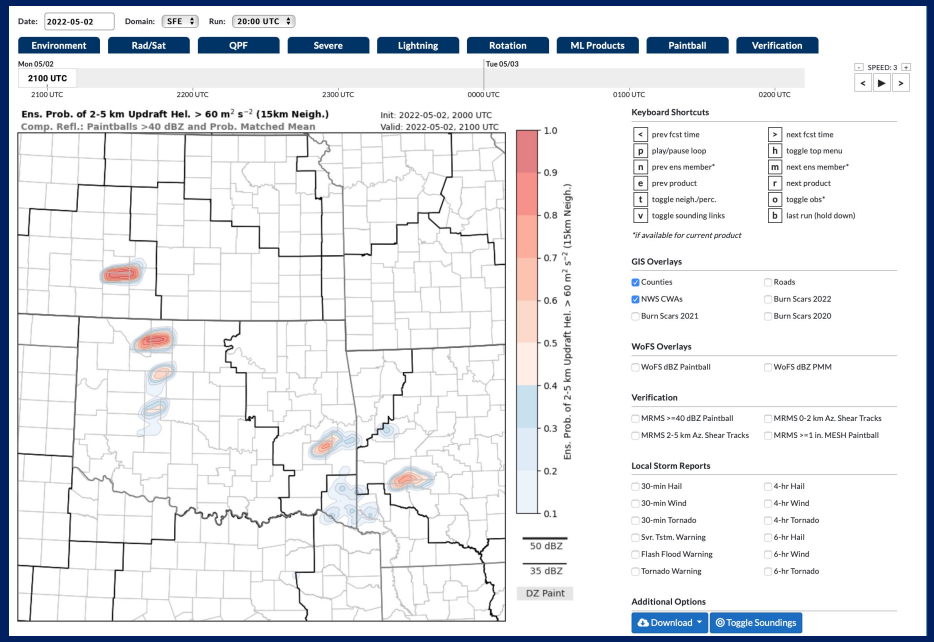
ProbSevere Objects
Valid 2 May 2022 2000 UTC



https://cimss.ssec.wisc.edu/severe_conv/

Warn-on-Forecast System (WoFS)

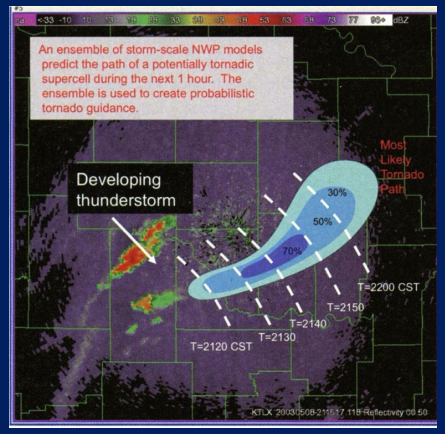
Probability of UH > 60m^2s^{-2}
Valid 2 May 2022, 2000-2100 UTC

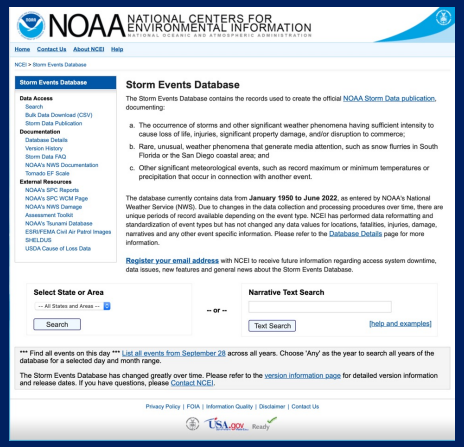


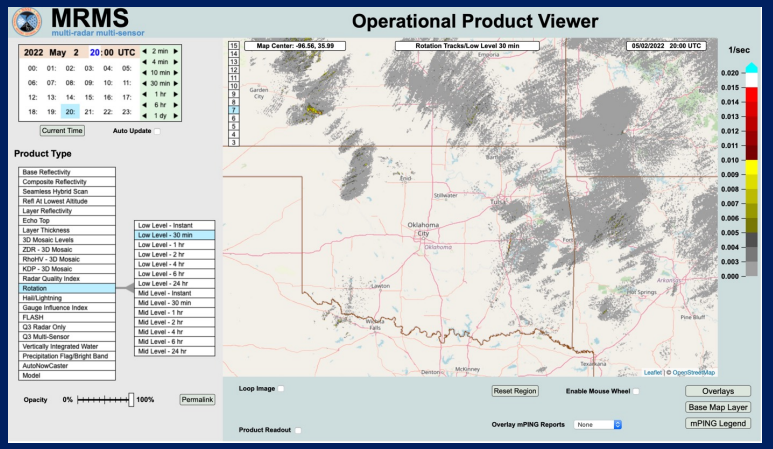
https://cbwofs.nssl.noaa.gov/

Can we combine these to get better short-term severe weather forecasts?

Combine ProbSevere (PS) and WoFS with Random Forests

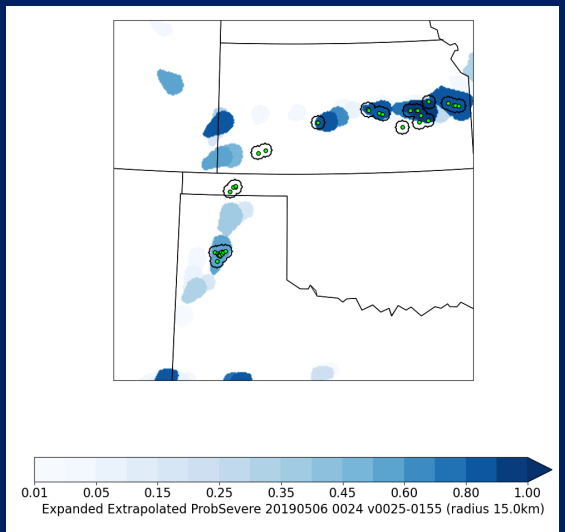


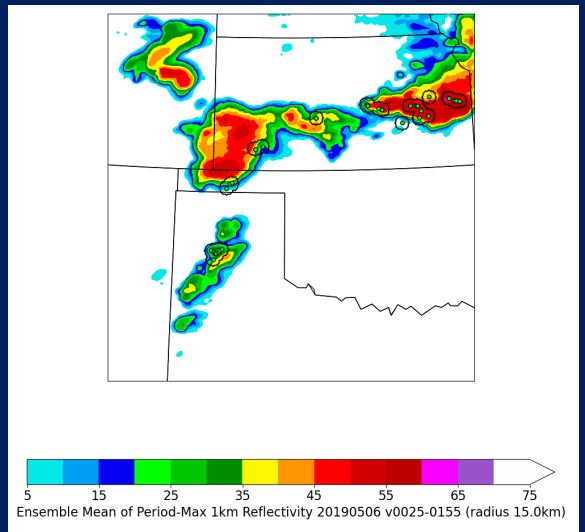




Goal: Spatial hazard probabilities in set time, space

Targets: MRMS-corrected Storm Reports (within a radius)





Predictors: "Representative" PS and WoFS variables

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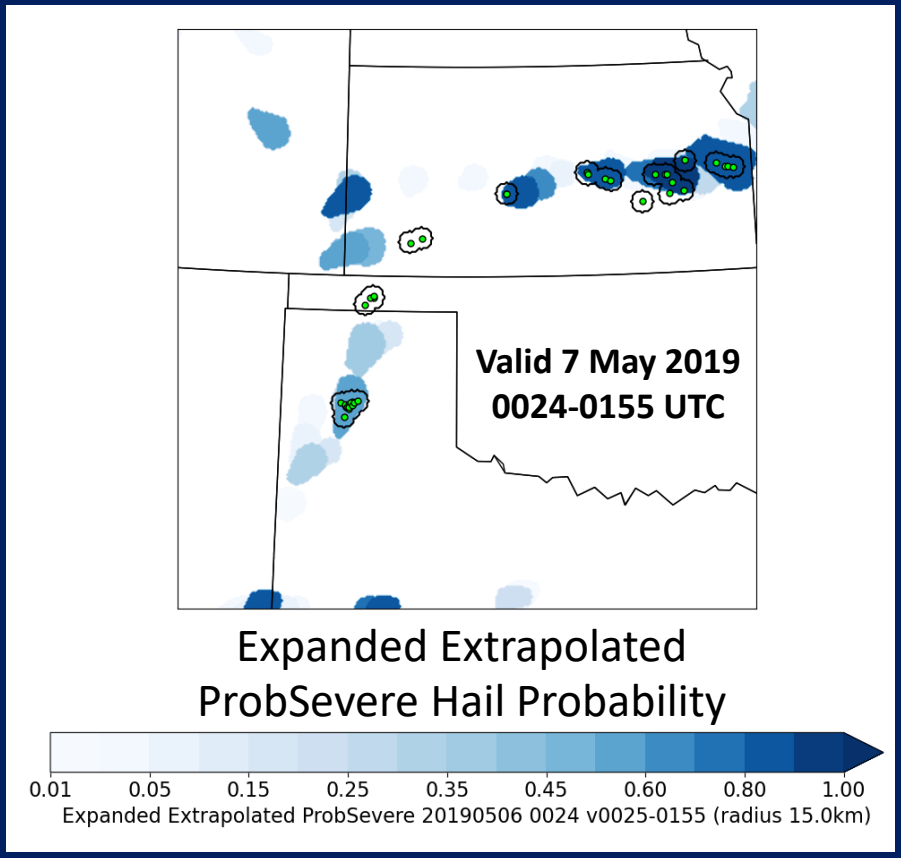
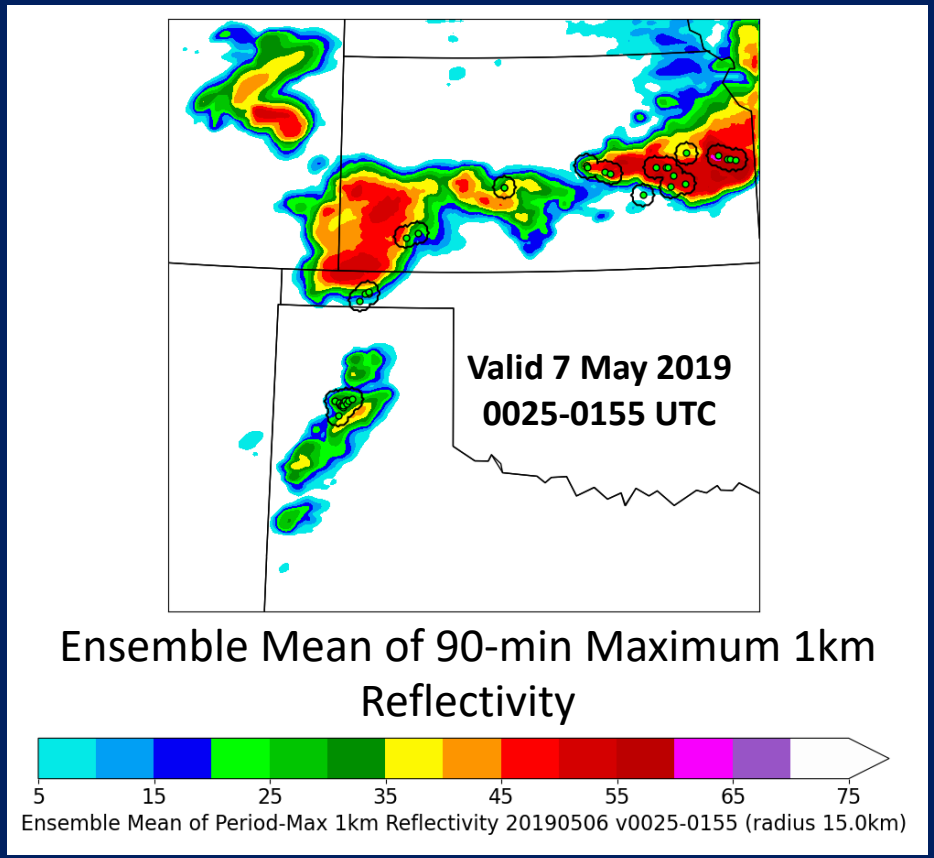
ProbSevere

- Map objects to WoFS grid
- Extrapolate in time using storm motion
- Expand using spatial radius

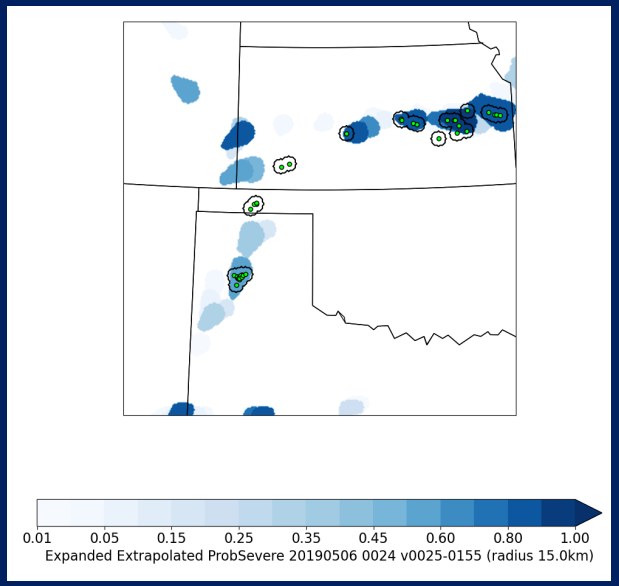


WoFS

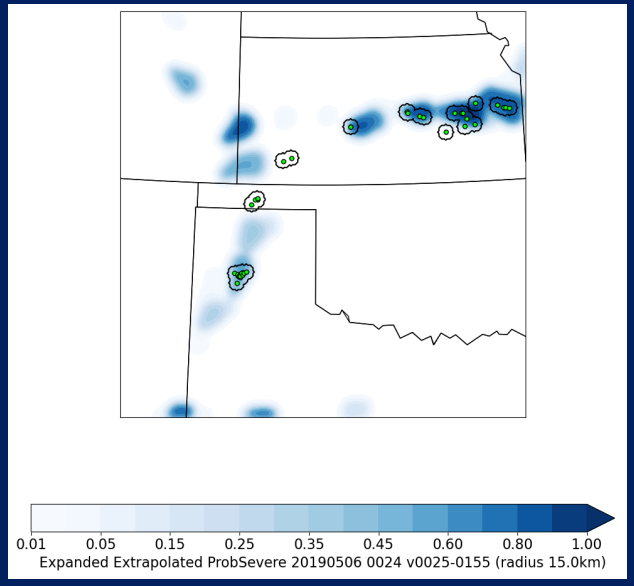
- Aggregate predictors in time
- Take ensemble mean
- Predictors from multiple radii (0- to 45-km)



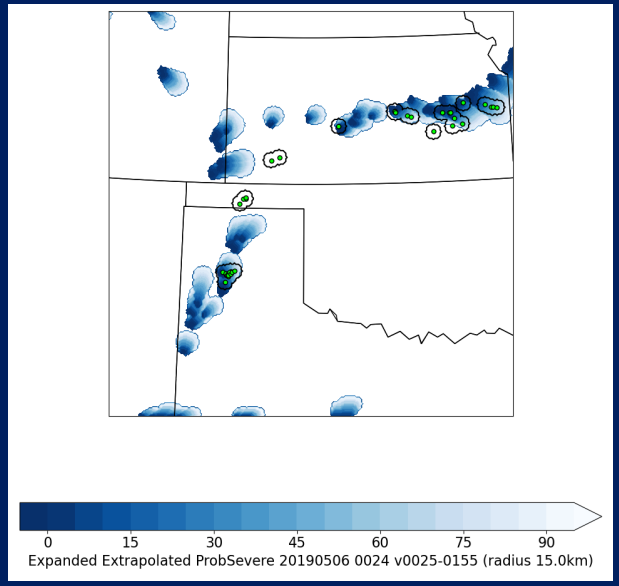
Six ProbSevere (PS) Predictors Per Hazard



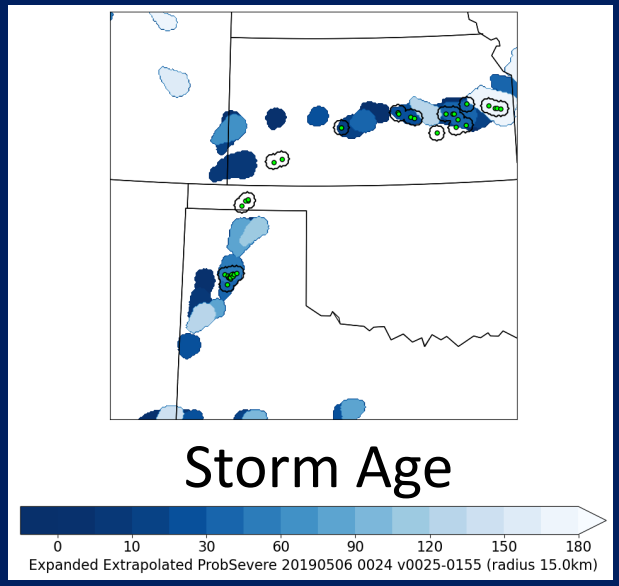
Raw expanded extrapolated PS



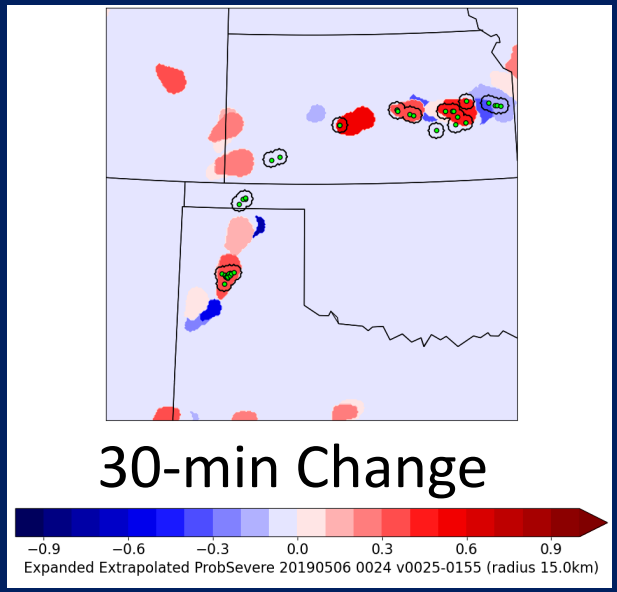
Smoothed expanded extrapolated PS



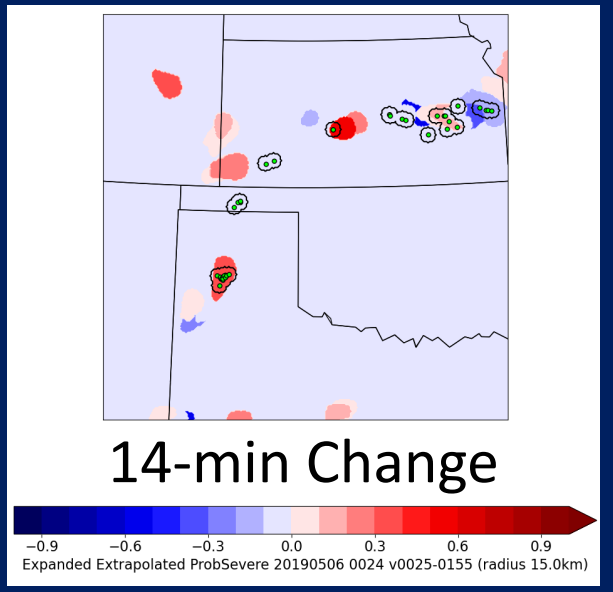
Extrapolation lead time



Storm Age



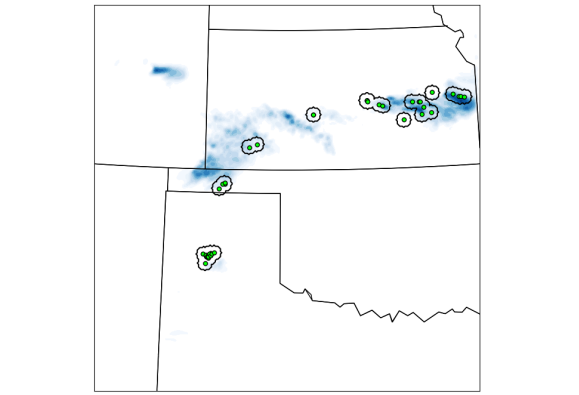
30-min Change



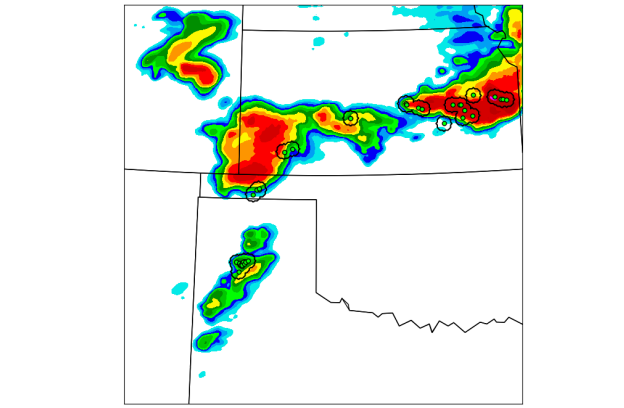
14-min Change

53 WoFS Fields as Predictors

- 80m wind speed
- 1km reflectivity
- 0-2 km vertical vorticity
- 0-2, 2-5km UH
- Maximum updraft speed
- 1km updraft
- 10-500m bulk shear
- FED
- 10m wind components
- 2m temp and dewpoint
- Mid and low level lapse rates
- 0-1, 0-3, 0-6km shear components
- 0-500m, 0-1km, 0-3km SRH
- SBCAPE
- STP
- SCP
- Downdraft speed
- Cloud top temperature
- MSLP
- PSFC
- LCL (surface)
- Hail
- Freezing level
- Member 1-18 2-5km UH

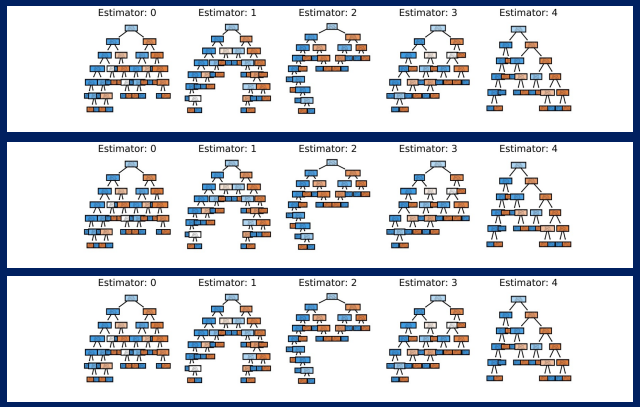


2-5km UH (Ens. Mean)



1km reflectivity (Ens. Mean)

Is there a benefit to combining WoFS and ProbSevere?



https://stackoverflow.com/questions/40155128/plot-trees-for-a-random-forest-in-python-with-scikit-learn

RF trained on all predictors

RF trained on only WoFS predictors

RF trained on only ProbSevere predictors

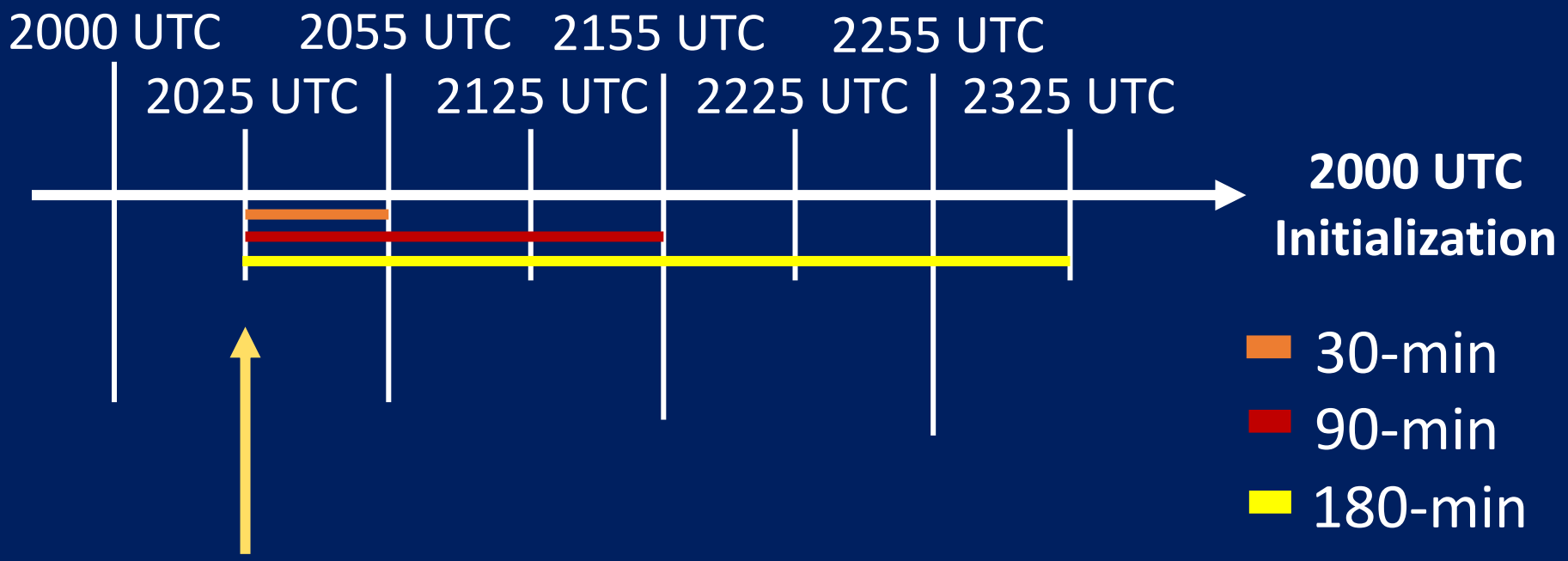
sklearn.ensemble.RandomForestClassifier ¶

class sklearn.ensemble.**RandomForestClassifier**(*n_estimators=100*, ***, *criterion='gini'*, *max_depth=None*, *min_samples_split=2*, *min_samples_leaf=1*, *min_weight_fraction_leaf=0.0*, *max_features='sqrt'*, *max_leaf_nodes=None*, *min_impurity_decrease=0.0*, *bootstrap=True*, *oob_score=False*, *n_jobs=None*, *random_state=None*, *verbose=0*, *warm_start=False*, *class_weight=None*, *ccp_alpha=0.0*, *max_samples=None*) [source]

Trees: 200, Max depth: 15, Min_samples_leaf: 20
Max features: $\sqrt{n}$, Criterion: minimize entropy

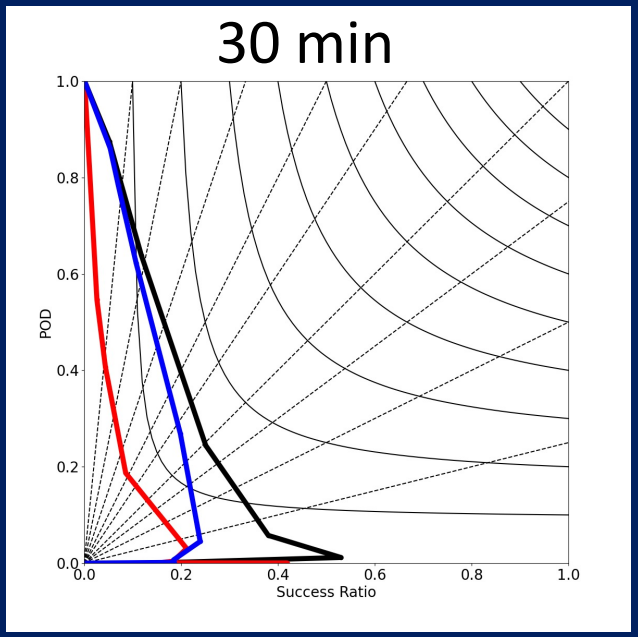
Dataset: 109 days (30 April 2019 – 4 June 2021)

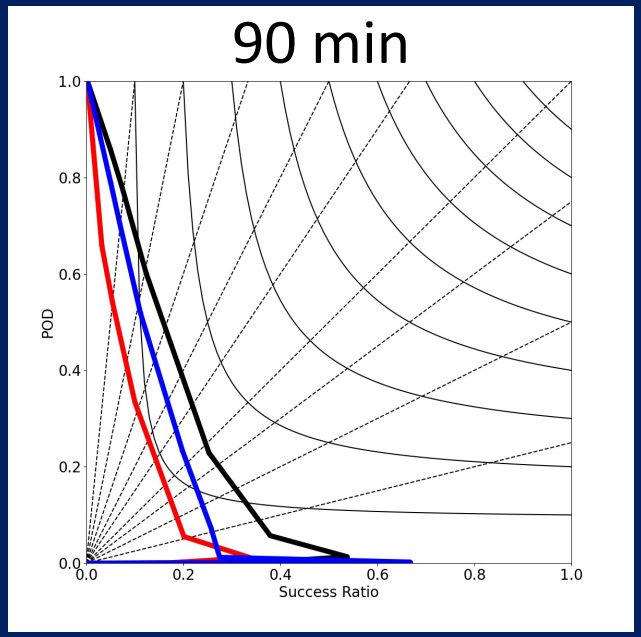
Look at 30-, 90-, 180-min time windows

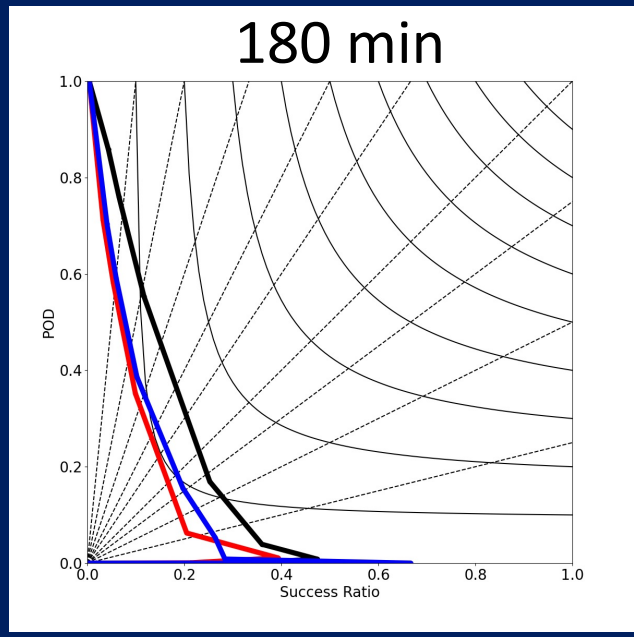


Train using each WoFS initialization time

All-predictor RFs most skillful (15km radius) (30 April 2019 – 29 June 2020)

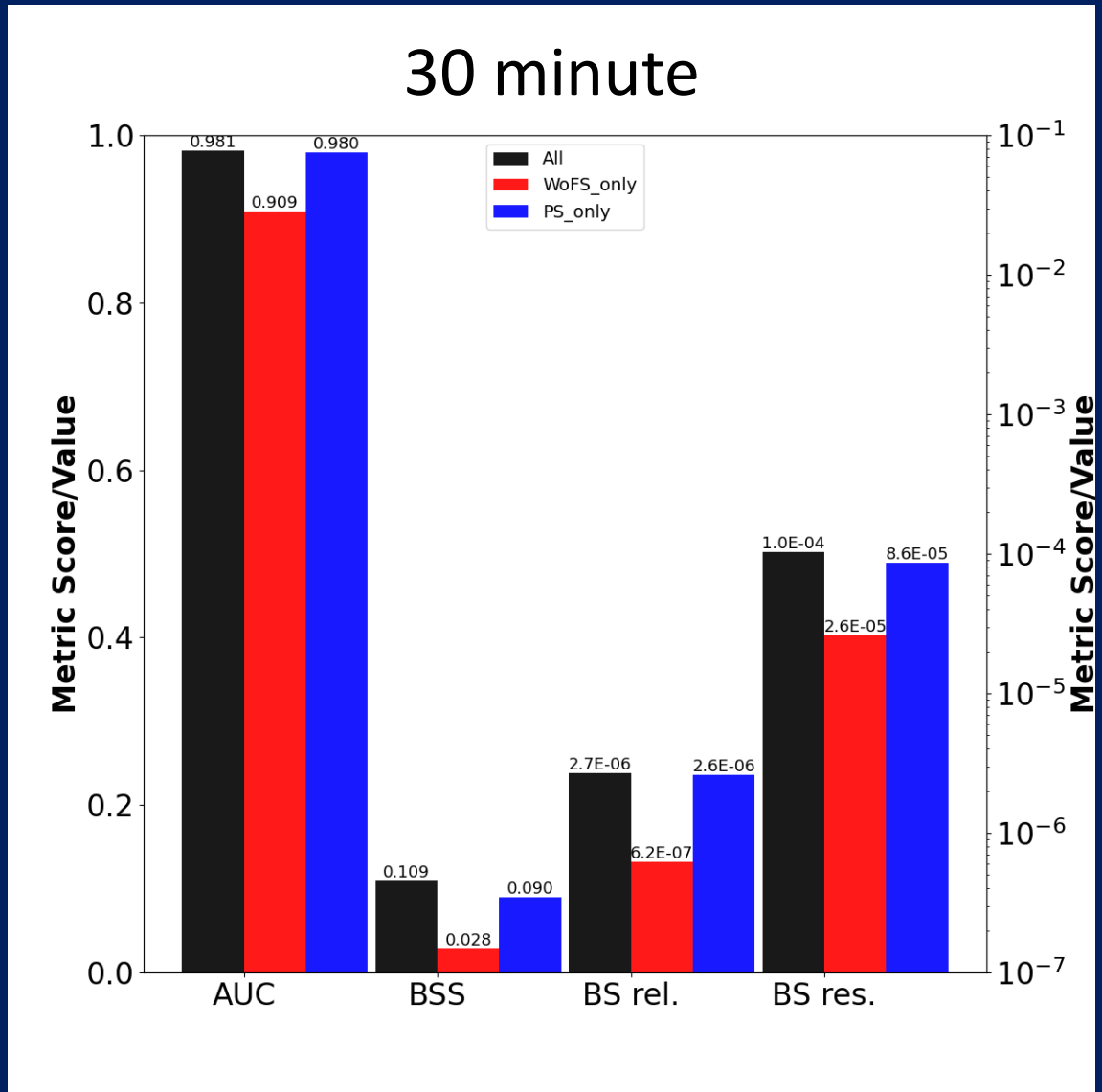




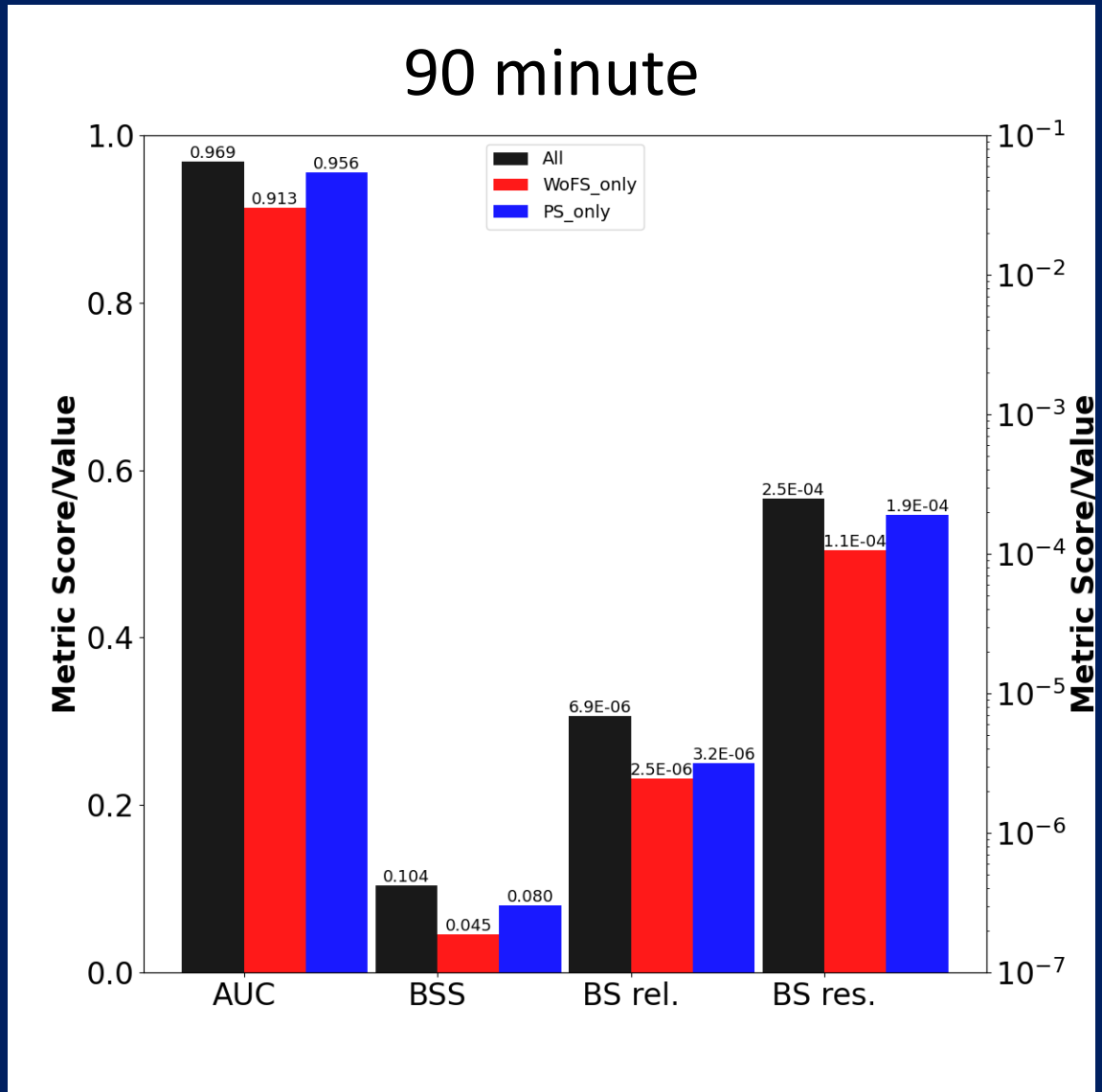


*For all initialization times combined

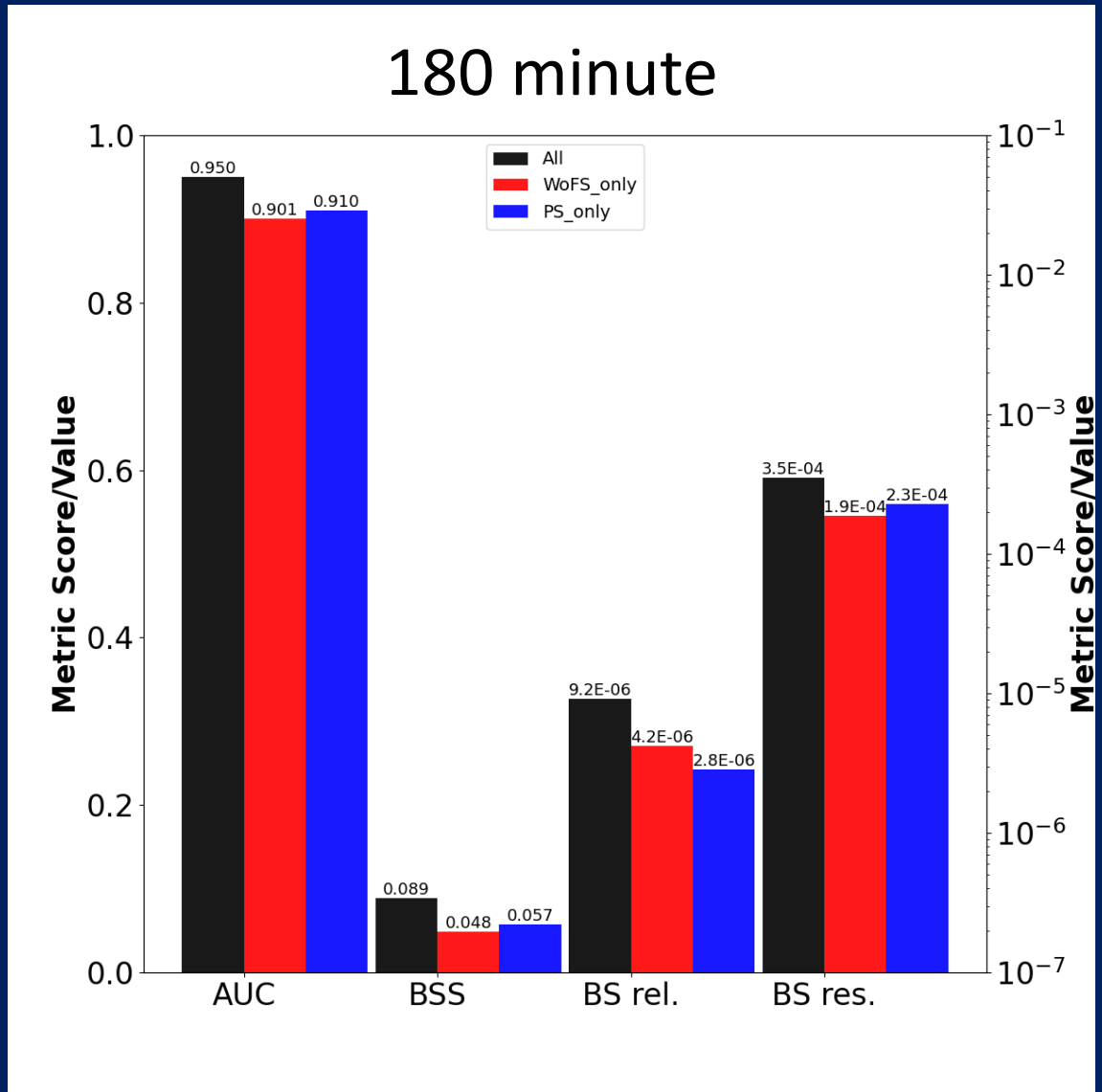
All-predictor RFs most skillful (15km radius) (30 April 2019 – 29 June 2020)



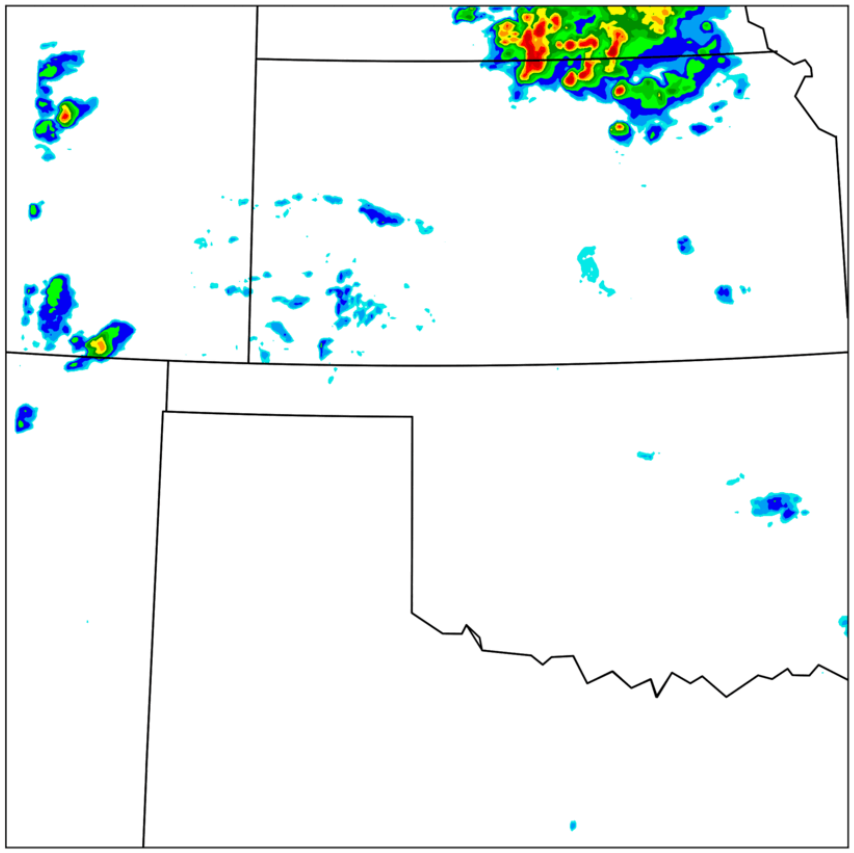
All-predictor RFs most skillful (15km radius) (30 April 2019 – 29 June 2020)



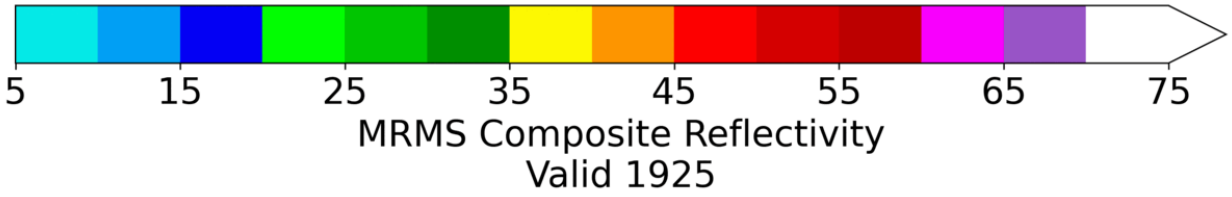
All-predictor RFs most skillful (15km radius) (30 April 2019 – 29 June 2020)



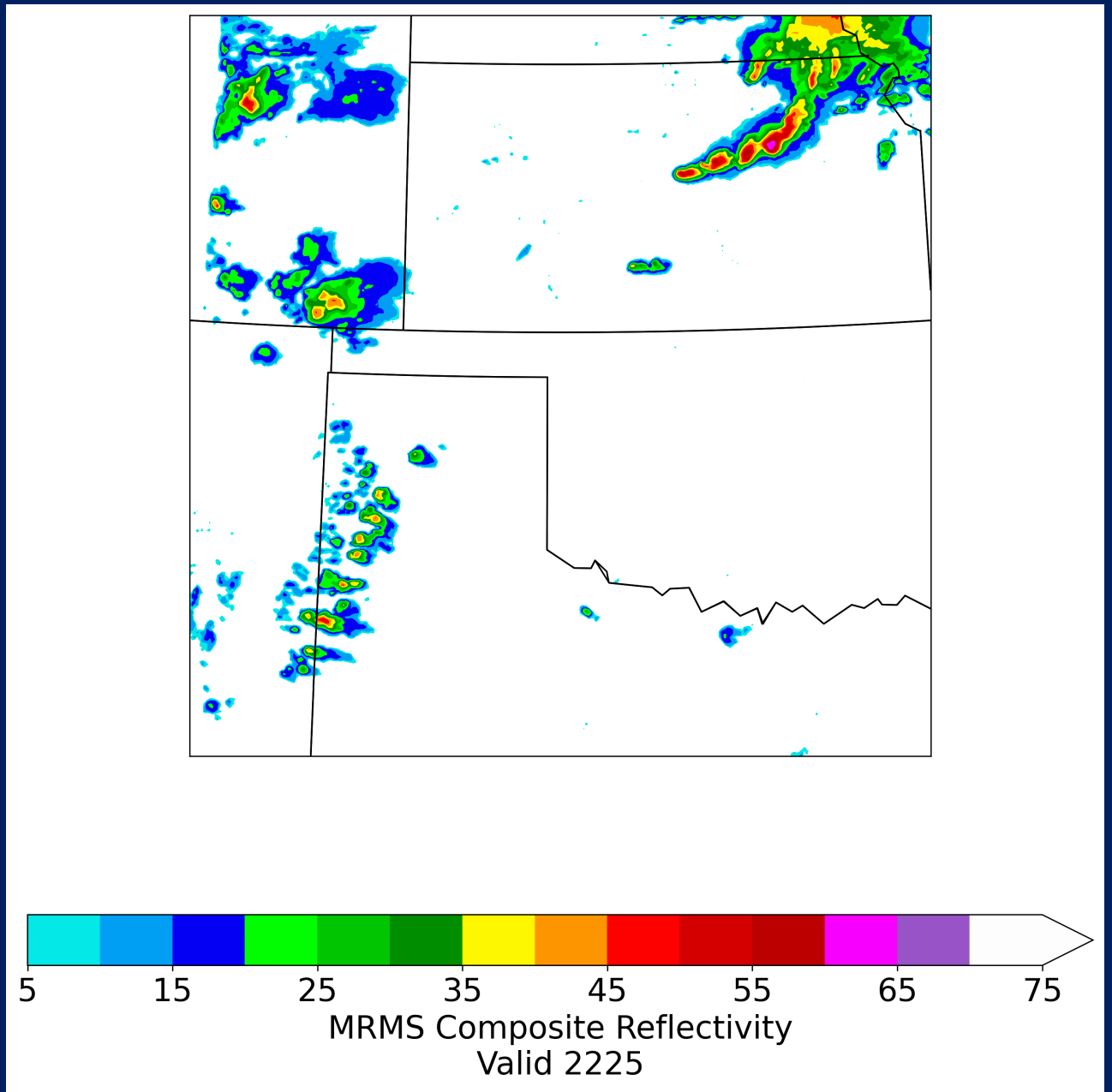
Case study: 6-7 May 2019



https://ezgif.com



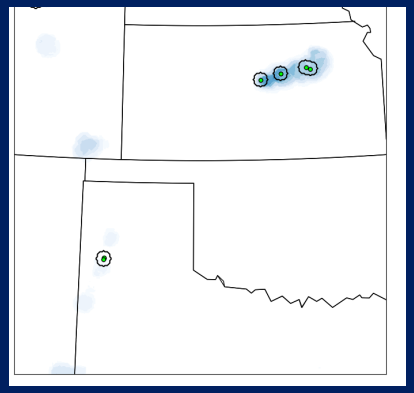
2225 UTC 6 May 2019

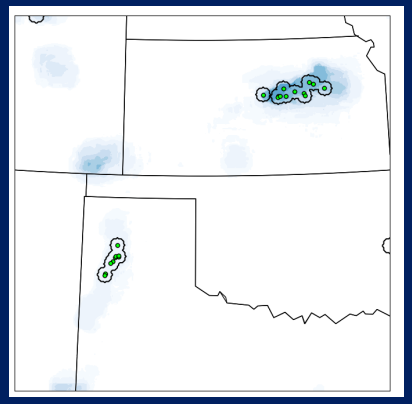


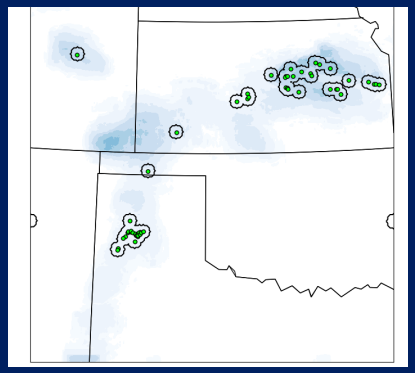
2200 UTC Initialization 6 May 2019

30 min **90 min** **180 min**

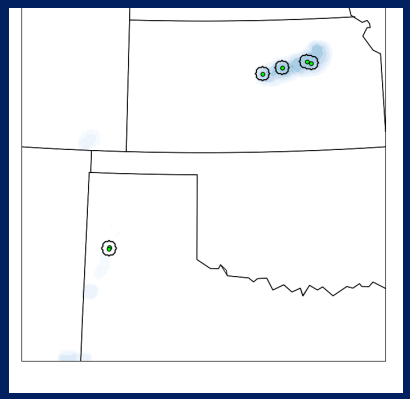
All

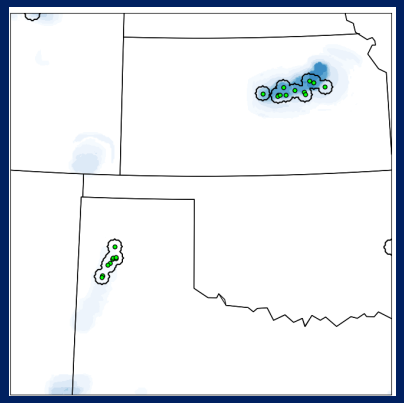


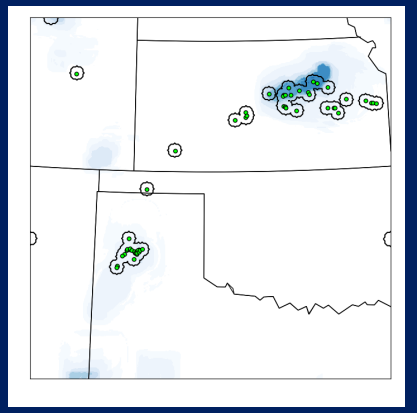




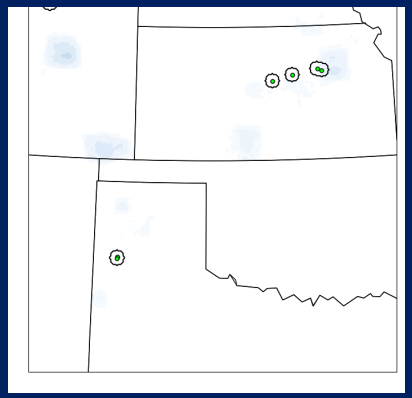
PS Only

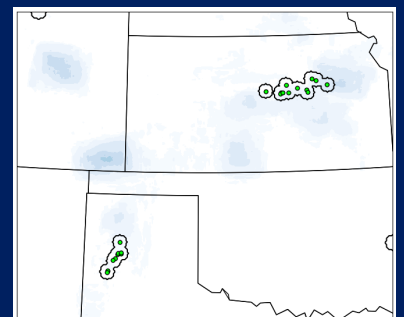


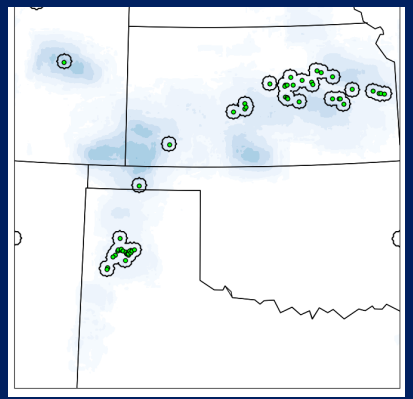




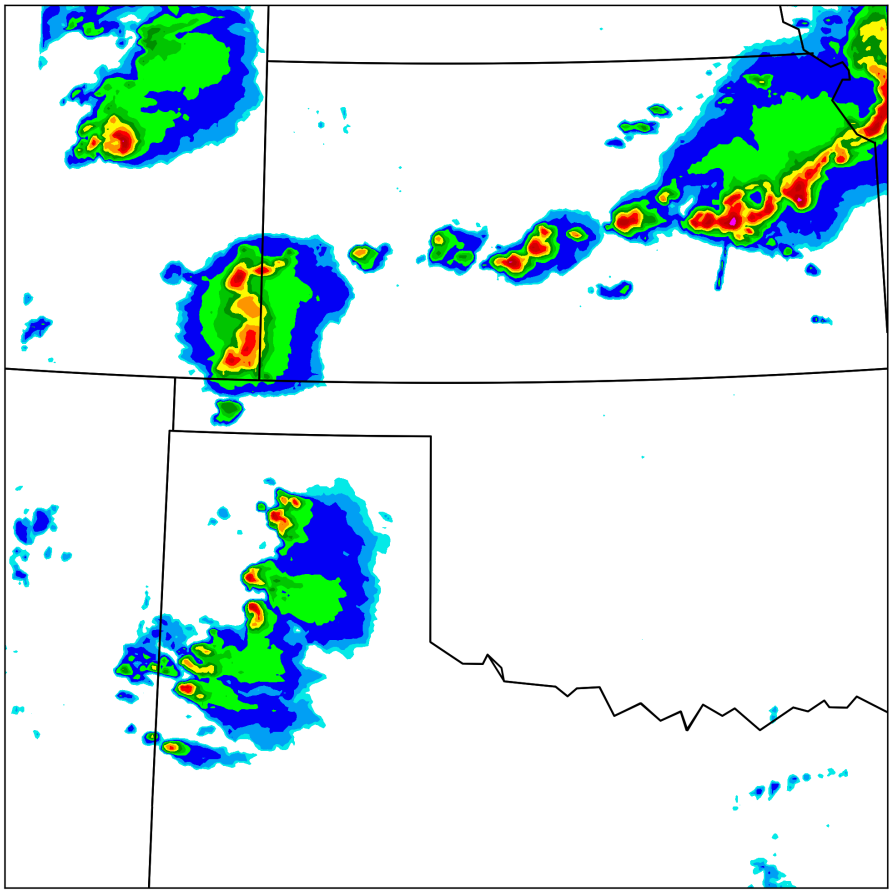
WoFS Only

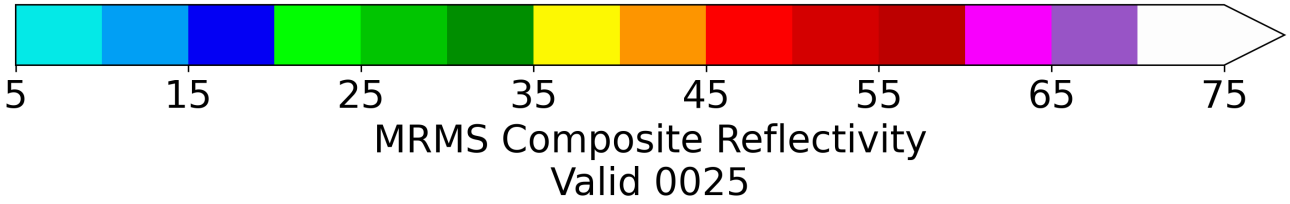




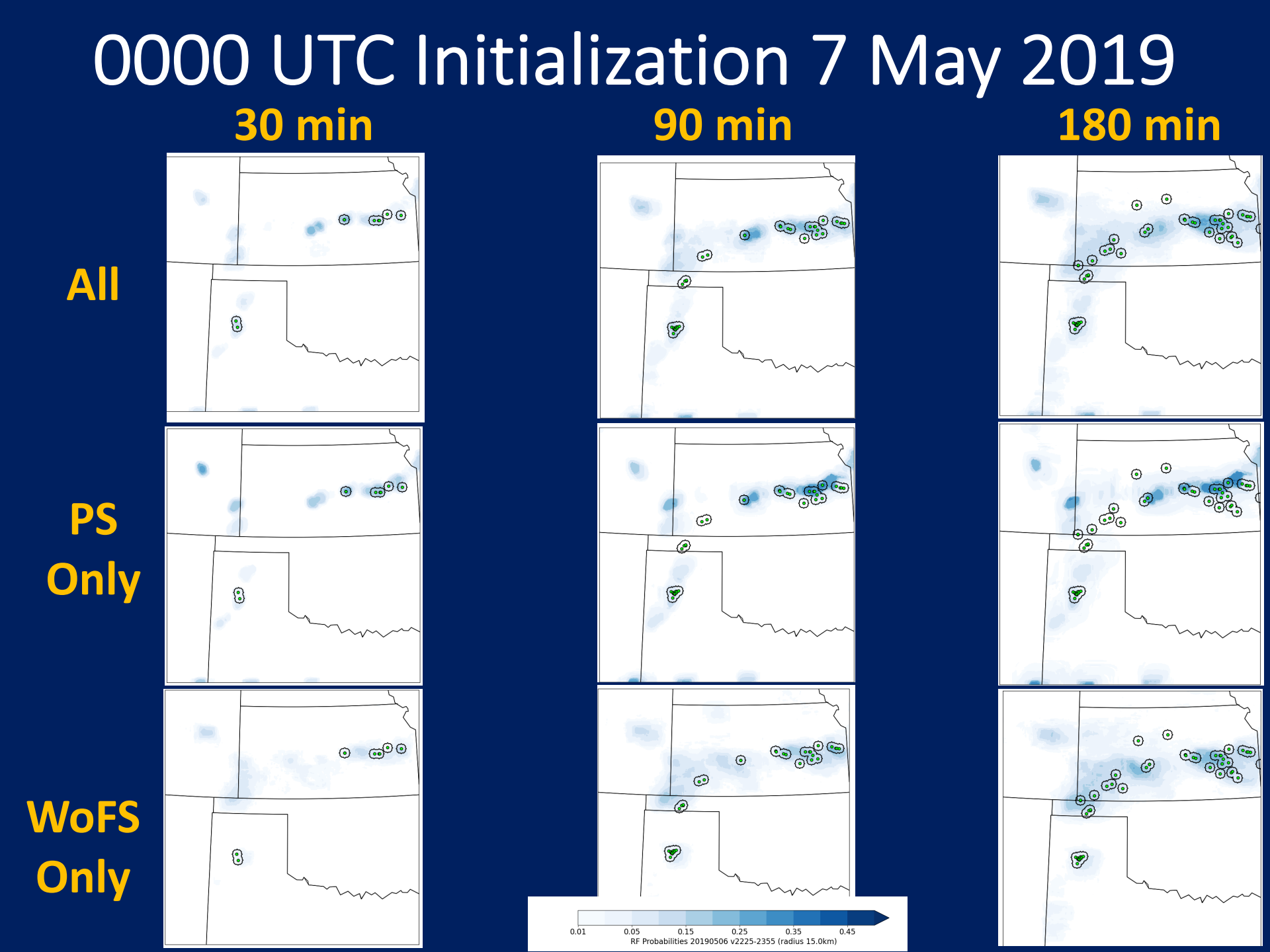


0025 UTC 7 May 2019

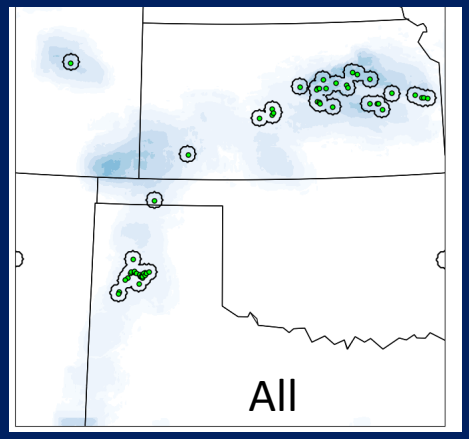


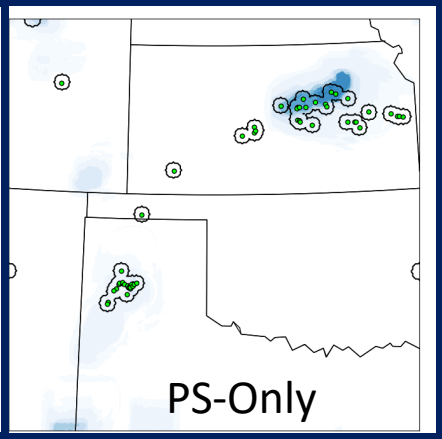


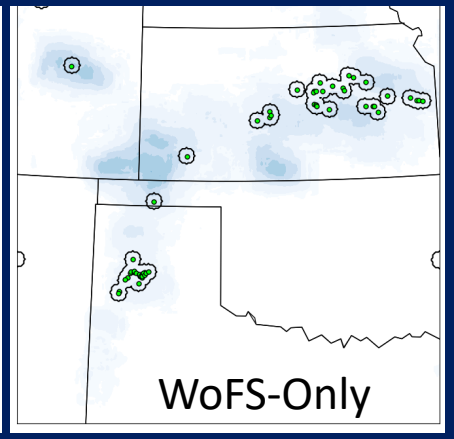
0000 UTC Initialization 7 May 2019

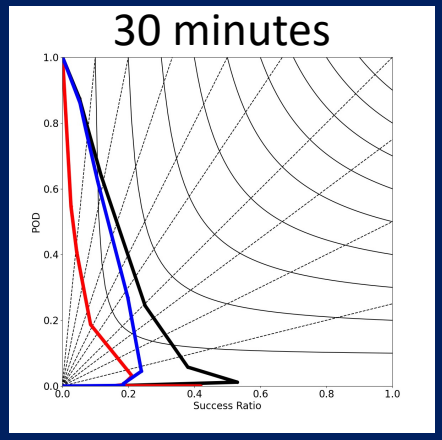


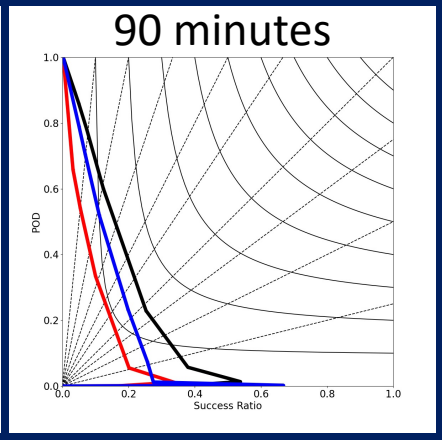
WoFS + PS combination is best, especially for longer time windows

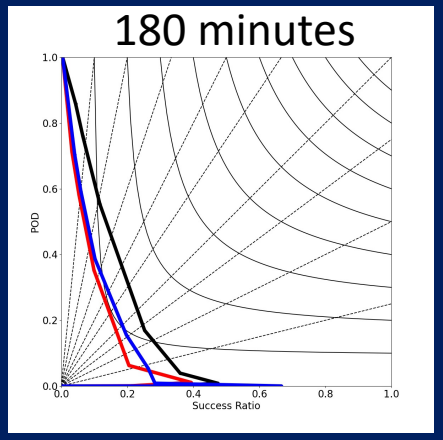


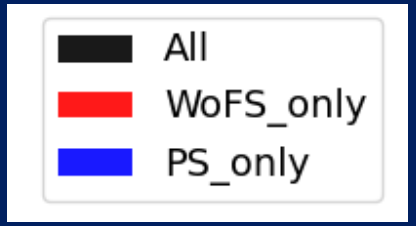




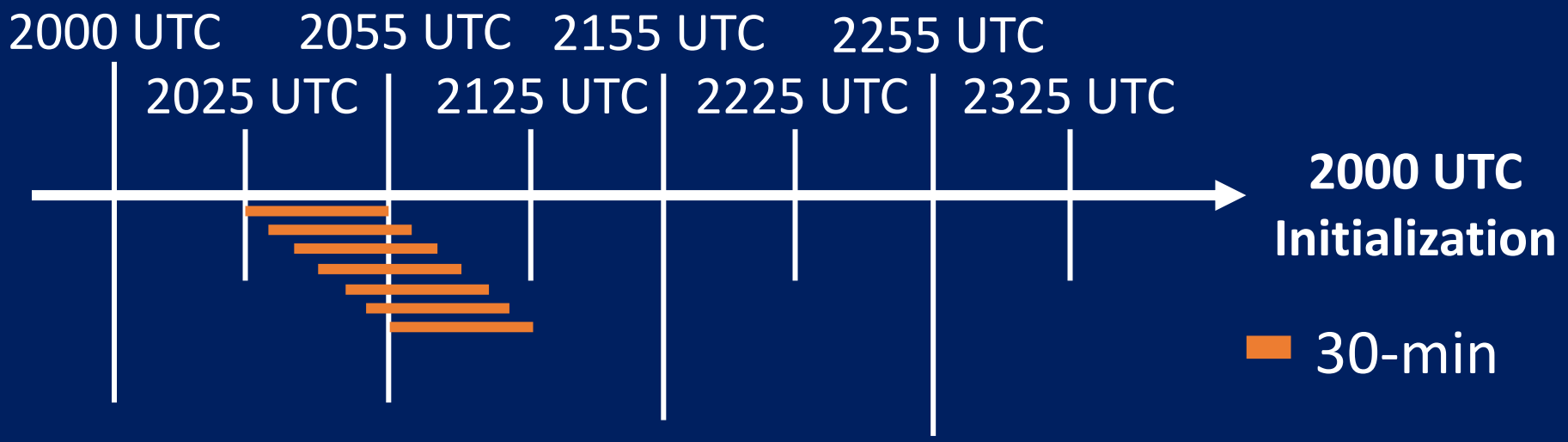




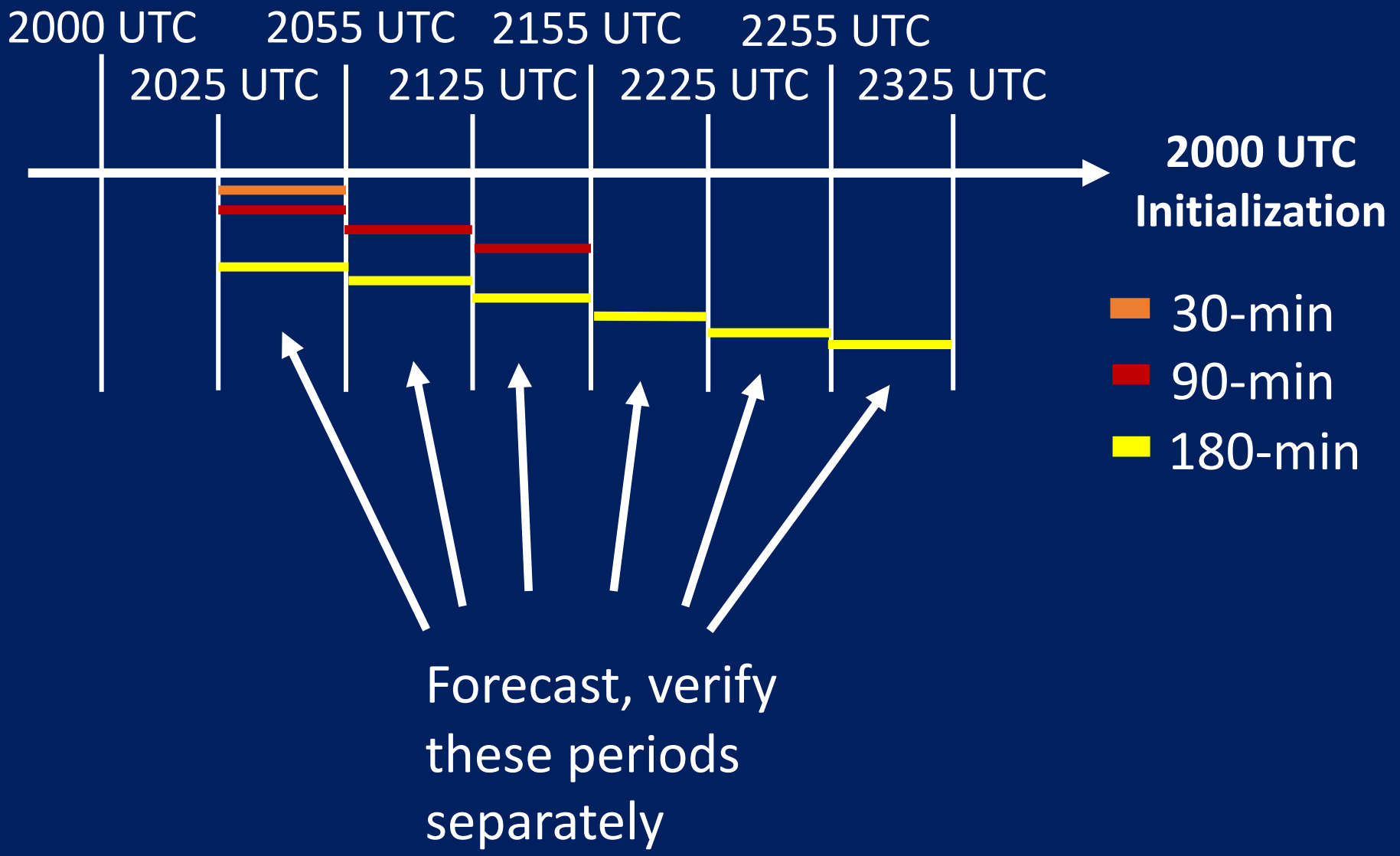




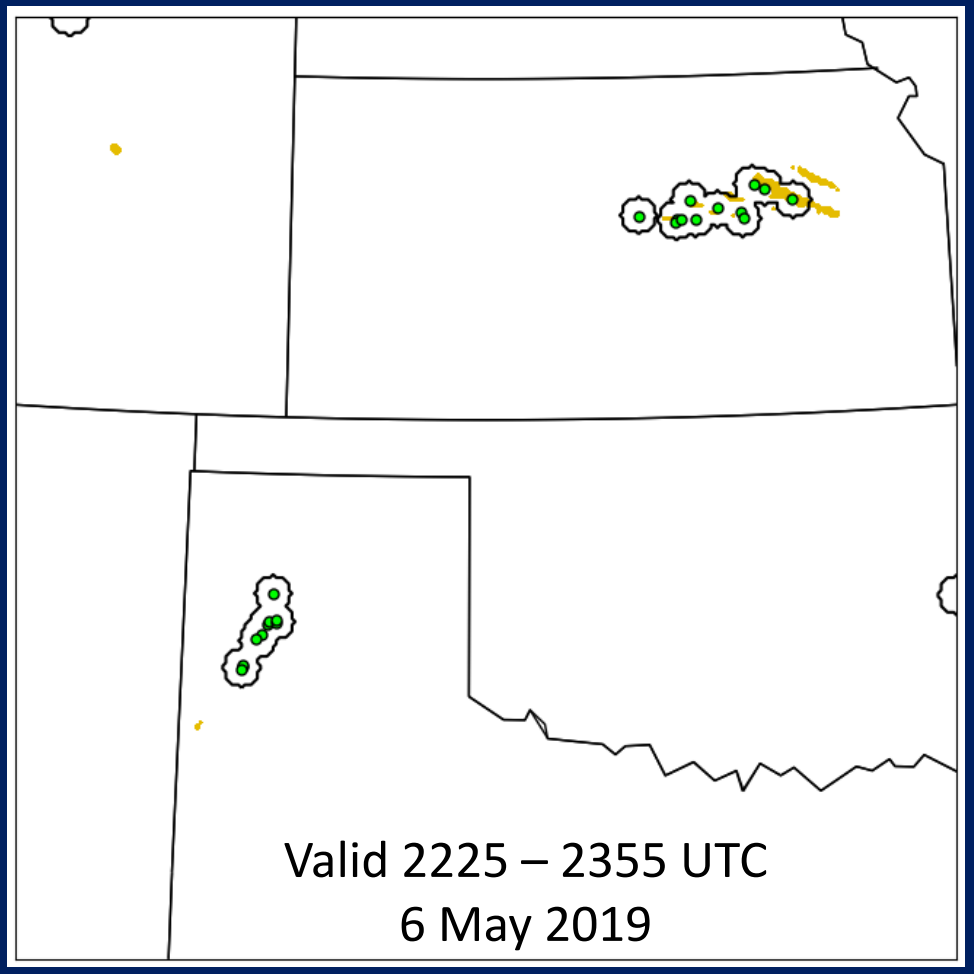
Future: Sliding 30-min prediction windows



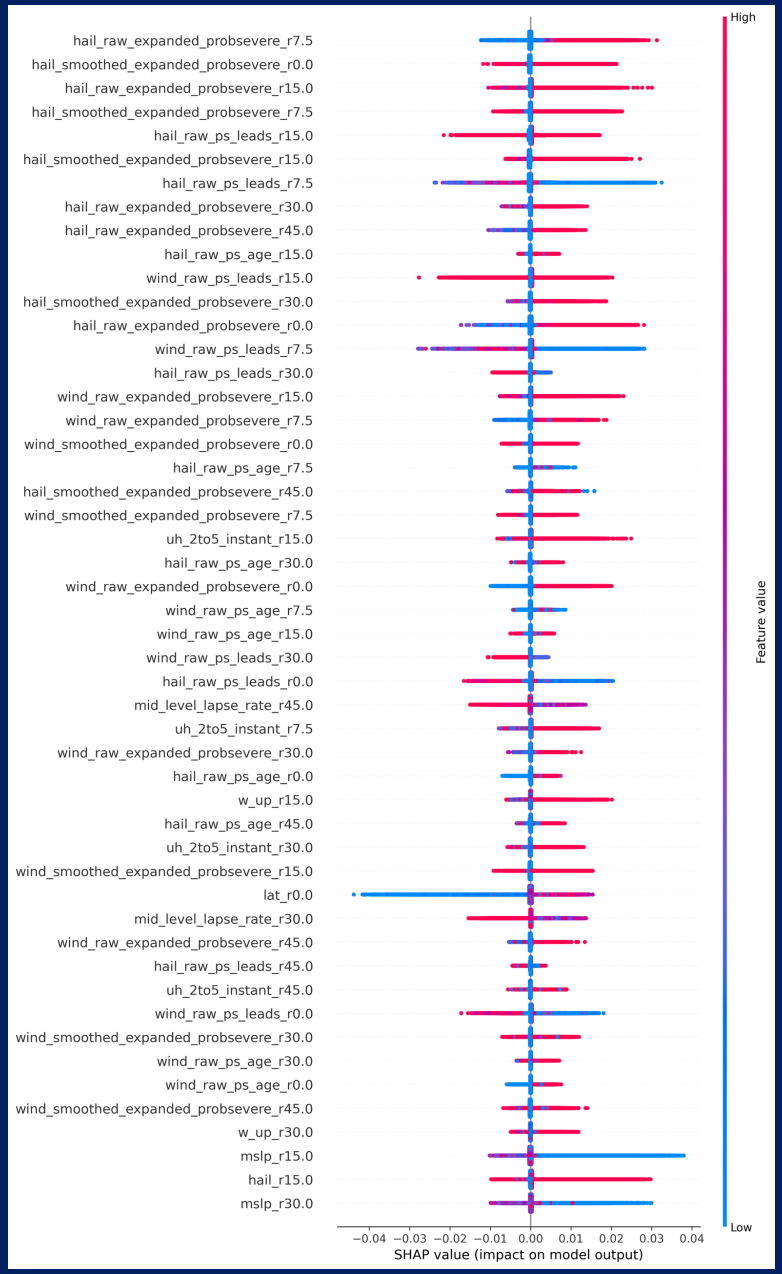
Future: Segment time windows by lead time



Future: Test impact of MRMS variables (e.g., MESH) as targets



Future: Variable importance



Which variables are most important?

How do variables impact RF probabilities?

Future: Incorporate into PHI Tool, Test Multiple Versions in HWT