The WRF Lightning Forecast Algorithm for GLM: Refinement and Incorporation into Convection-allowing Ensemble Forecasts

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Photo, David Blankenship
Guntersville, Alabama

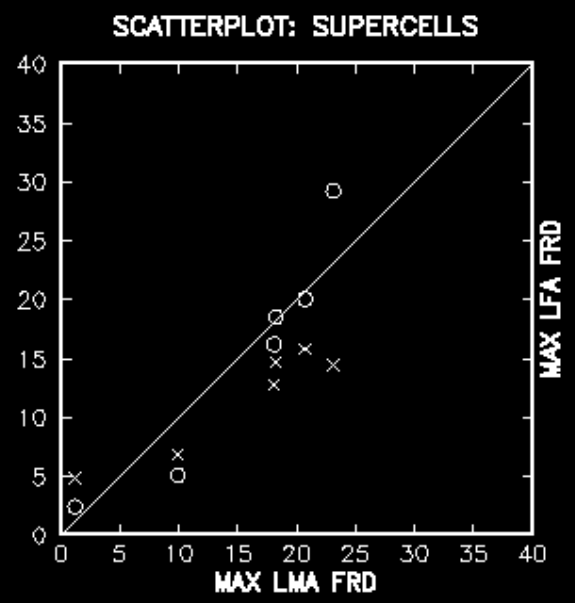
Recent LFA Studies with NSSL,HRRR,SPoRT:

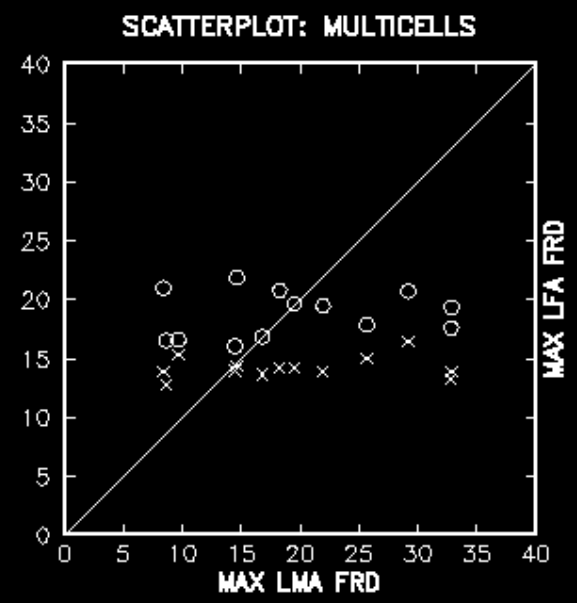
Recent tasks have involved:

1. Examination of LFA performance by season
2. Study of LFA variability in CAPS ensembles
3. Reexamination of LFA threat areal coverage in NSSL WRF
4. Check of LFA calibration in HRRR with Thompson micro
5. Inspection of HRRR LFA output for Hurcn Isaac 2012
6. Study of LFA variability in 8x3 matrix of WRF runs equipped with diverse micro (8) and PBL (3) schemes

2010-11 NALMA, LFA Scatterplots by regime:

O = graupel flux threat; x = vertical ice integral threat





Supercell cases are well-handled by LFA

Unsheared storms less well-handled

WRF may have problems predicting pulse storm strength.

Year-2 LFA studies, CAPS WRF, 2011:

(examined to assess sensitivity to model physics packages)

Preliminary findings for spring weather, AMJ2011

1. CAPS Spring Expt runs used; focus is on severe storms, i.e.,supercells; spring 2011 had good WRF config diversity
2. Spring 2011: several major supercell days, little wx diversity
3. Examined LFA ranges, SDs in the CAPS WRF configurations as a function of ensemble mean peak hourly LFA output
4. LFA range, SD increases slowly as LTG rates increase, with fractional errors bigger at low FRD
5. Assessed average LFA performance for specific microphysics configurations: WSM6, WDM6, Thompson 2-moment
6. WSM6, WDM6 yield LTG FRDs bigger than ensemble mean; Thompson scheme yields LTG FRDs smaller

CAPS 2011 Experiments

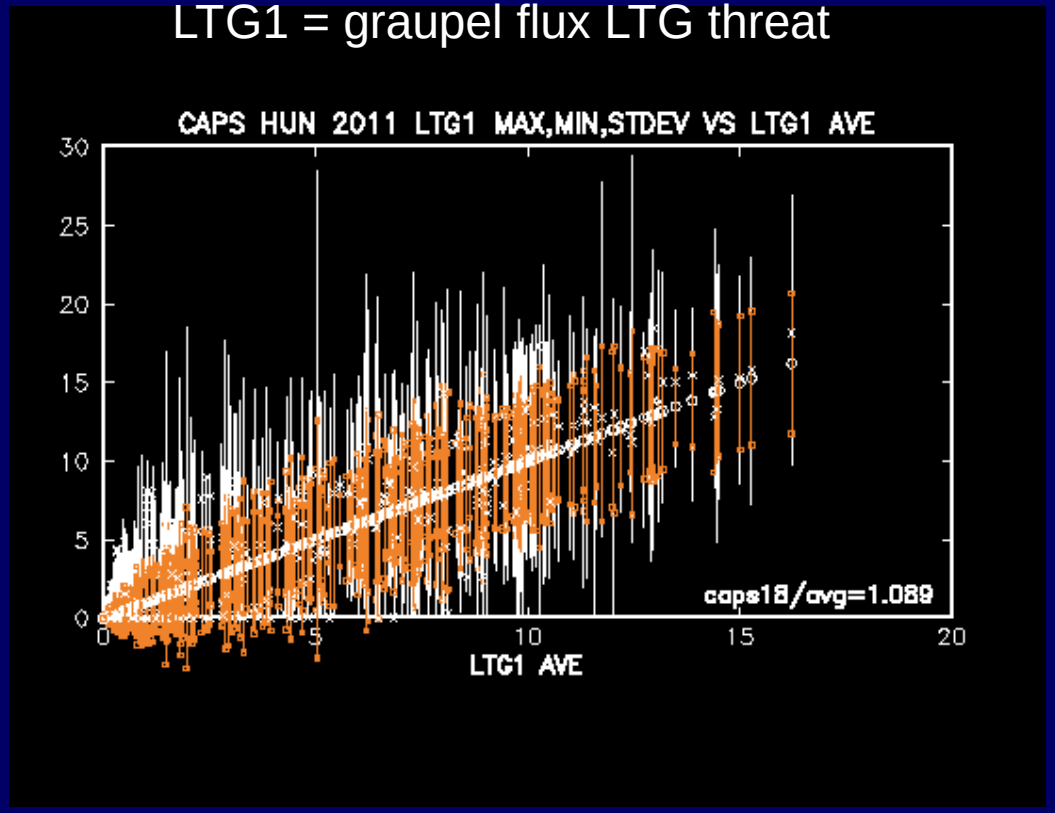
Model	IC (arw_cn+)	BC	micro	LSM	PBL
S4cn	+00zARPSa	00zNAMf	Thompson	Noah	MYJ
S4m4	+em-p1 pert	21zSREF em-p1	Morrison	RUC	YSU
S4m5	+em-p2 pert	21zSREF em-p2	Thompson	Noah	QNSE
S4m6	+nmm-p1 pert	21zSREF nmm-p1	WSM6	RUC	QNSE
S4m7	+nmm-p2 pert	21zSREF nmm-p2	WDM6	Noah	MYNN
S4m8	+rsm-n1 pert	21zSREF rsm-n1	Ferrier	RUC	YSU
S4m9	+eKF-n1 pert	21zSREF eKF-n1	Ferrier	Noah	YSU
S4m10	+eKF-p1 pert	21zSREF eKF-p1	WDM6	Noah	QNSE
S4m11	+eBMJ-n1 prt	21zSREF eBMJ-n1	WSM6	RUC	MYNN
S4m12	+eBMJ-p1 prt	21zSREF eBMJ-p1	Thompson	RUC	MYNN
S4m13	+rsm-p1 pert	21zSREF rsm-p1	M-Y	Noah	MYJ
S4m14	+em-n1 pert	21zSREF em-n1	Ferrier+	Noah	YSU
S4m15	+em-n2 pert	21zSREF em-n2	WSM6	Noah	MYNN
S4m16	+nmm-n1 pert	21zSREF nmm-n1	Ferrier+	Noah	QNSE
S4m17	+nmm-n2 pert	21zSREF nmm-n2	Thompson	Noah	ACM2
S4m18	+rsm-p2 pert	21zSREF rsm-p2	WSM6	Noah	MYJ
S4m19	+rsm-n1 pert	21zSREF rsm-n1	M-Y	Noah	MYJ
S4m20	+rsm-n2 pert	21zSREF rsm-n2	M-Y	RUC	ACM2

CAPS 2011 results, HUN

Mean, range, SD vs. LTG1, x = expt 18, WSM6

CAPS 2011 had four WSM6 expts

LTG1 = graupel flux LTG threat



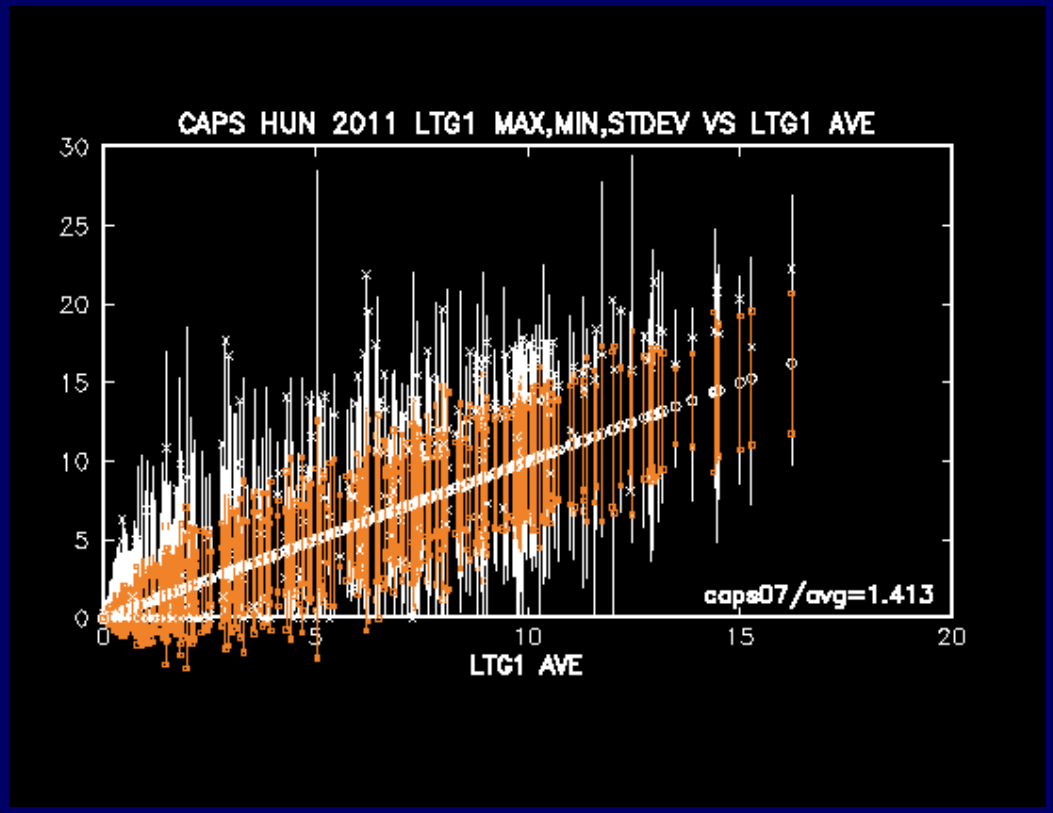
Mean relative to full ensemble = 1.07 (4 expts)

Vertical lines: range of LFA peak output, each hr
Diagonal: sorted means of all LFA members
Orange: LFA mean +/- 1.0 SD
X: results from listed single experiment

CAPS 2011 results, HUN

Mean, range, SD vs. LTG1, x = expt 7, WDM6

CAPS 2011 had two WDM6 expts

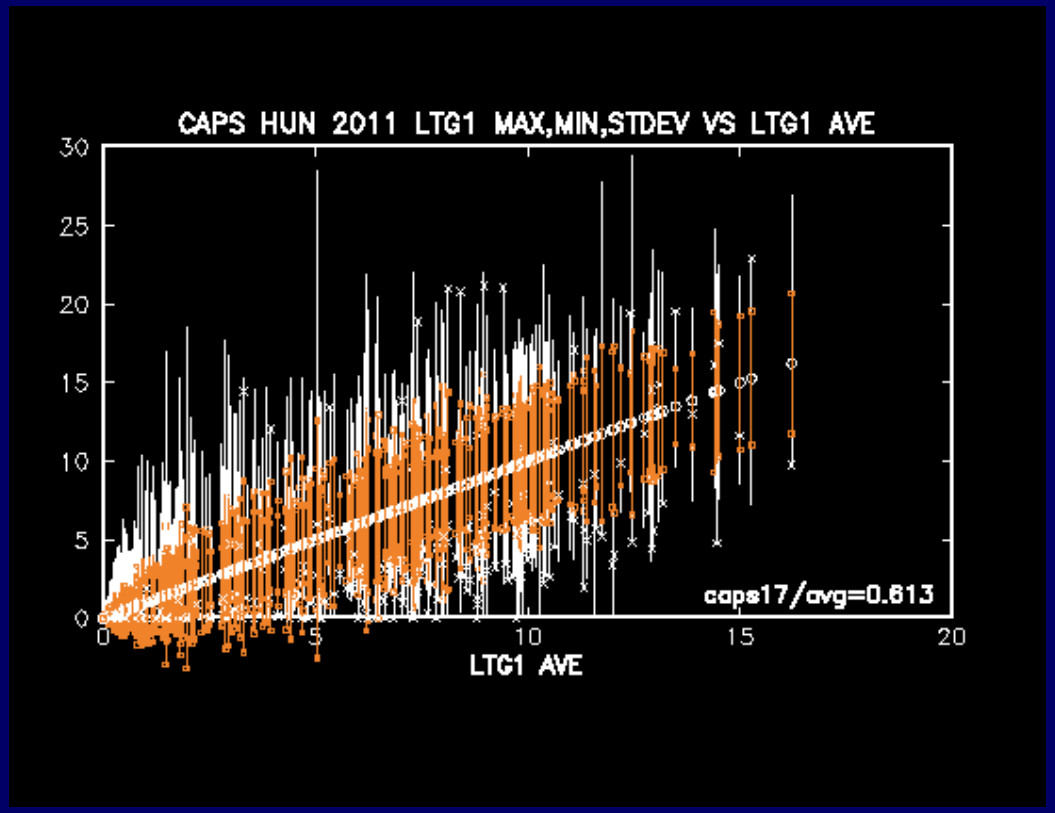


Mean relative to full ensemble = 1.57 (2 expts)

CAPS 2011 results, HUN

Mean, range, SD vs. LTG1, x = expt 17, Thompson

CAPS 2011 had four Thompson expts



Mean relative to full ensemble = 0.71 (4 expts)

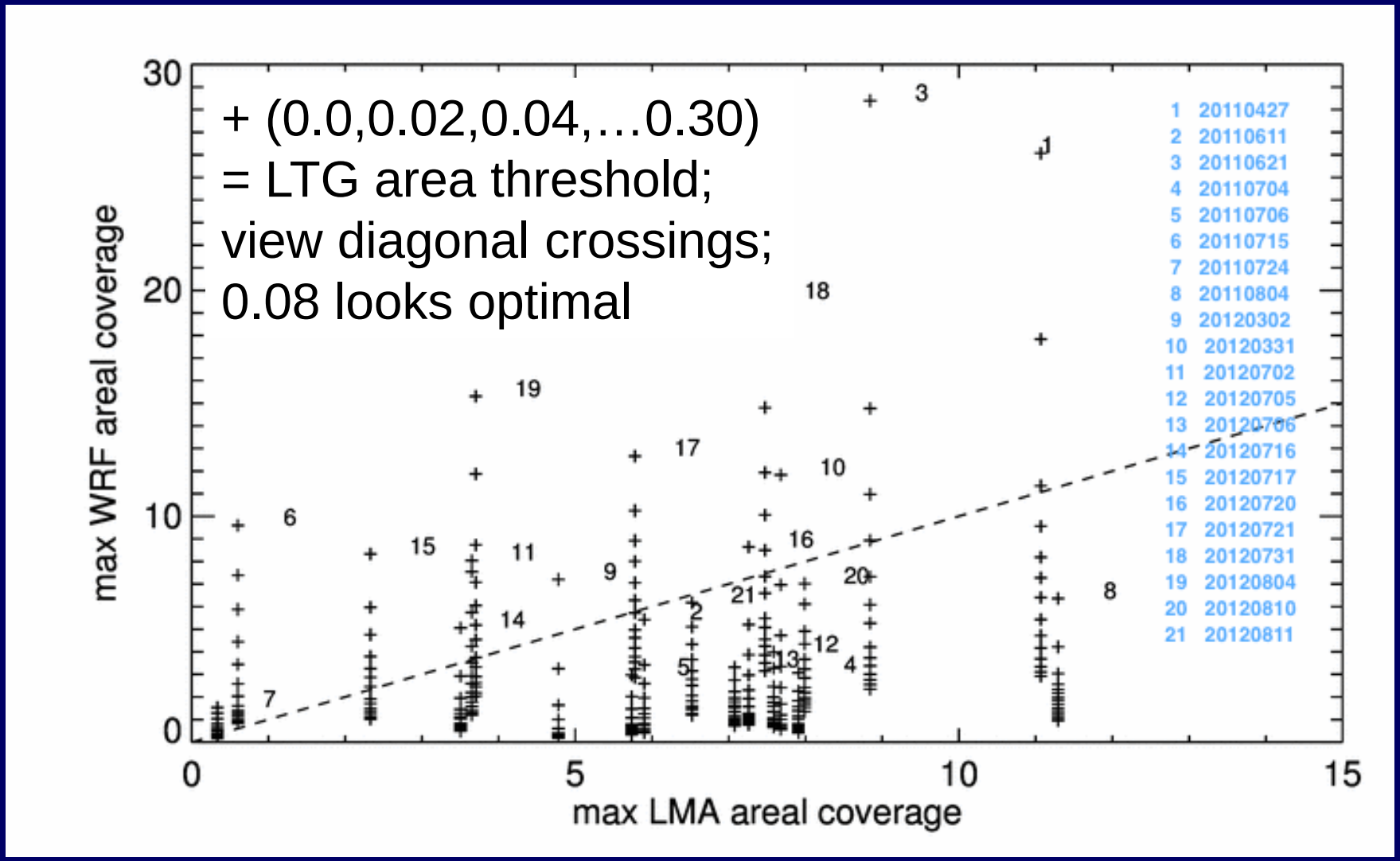
CAPS 2011 HUN findings (preliminary):

expt	micro	LSM	PBL	mean/ensemble
3	Thompson	Noah	MYJ	0.831
5	Thompson	Noah	QNSE	0.808
12	Thompson	RUC	MYNN	0.590
17	Thompson	Noah	ACM2	0.613
6	WSM6	RUC	QNSE	1.257
11	WSM6	RUC	MYNN	0.920
15	WSM6	Noah	MYNN	0.998
18	WSM6	Noah	MYJ	1.089
7	WDM6	Noah	MYNN	1.413
10	WDM6	Noah	QNSE	1.726

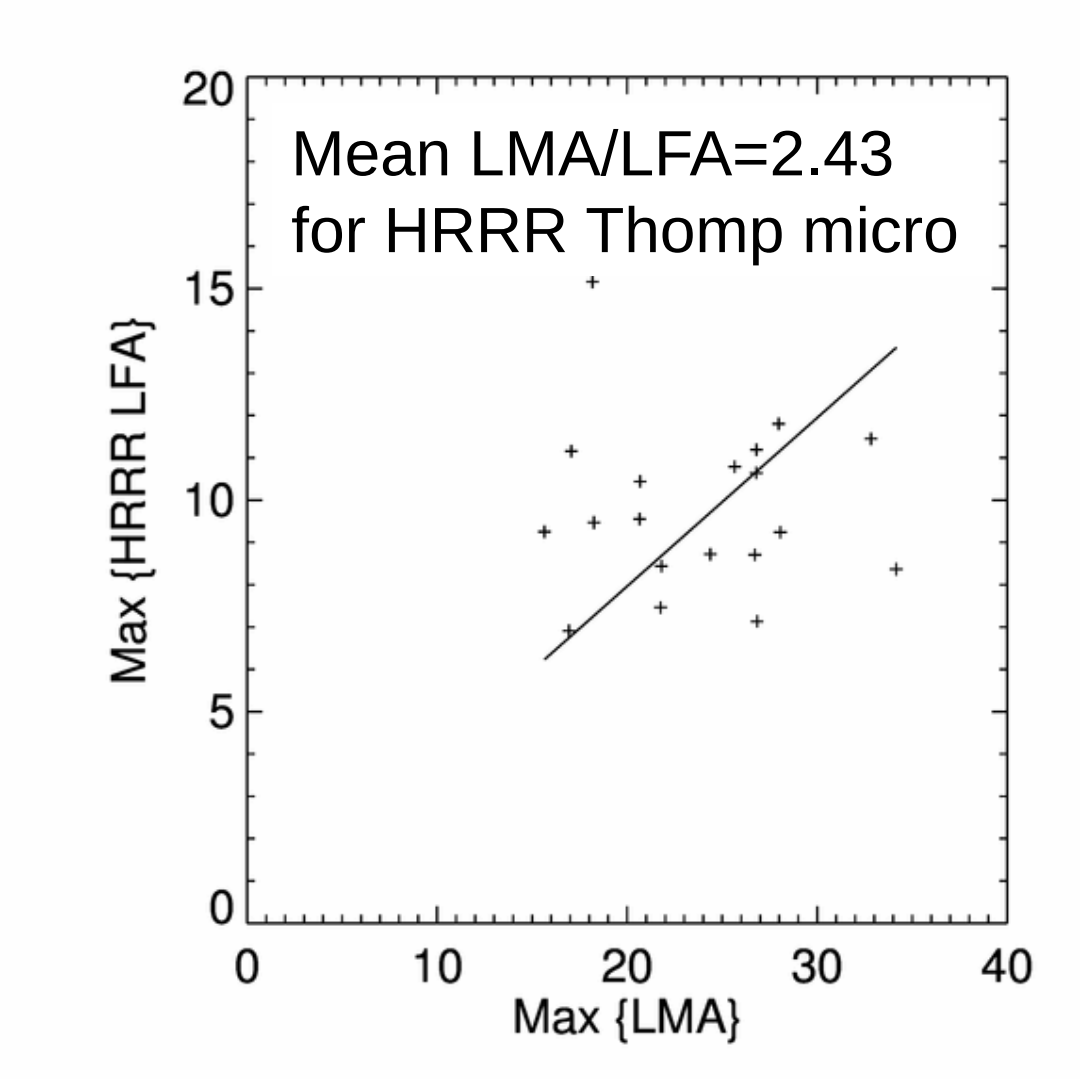
CAPS 2011 findings (preliminary):

1. Variations in LFA flash rate estimates display sensitivity to choices of microphysics and other physics packages;
2. CAPS 2011 offers desirable set of 1- and 2-moment micro choices, facilitating intercomparisons (2012 all 2-moment);
3. WDM6 produces the most graupel, so that LFA peak values are 1.57 times bigger than grand ensemble average; WSM6 average is 1.07 times bigger; Thompson 2-moment scheme is only 0.71 times as large;
4. For recalibration of Thompson to match WSM6, must boost Thompson results by an estimated factor (1.07/0.71) = 1.50;
5. 2011 CAPS runs offer few storm days, too little storm type diversity; full calibration may be problematic; examine HRRR data from a variety of cases, if possible

NSSL 2011-2012 LFA area coverage checks:

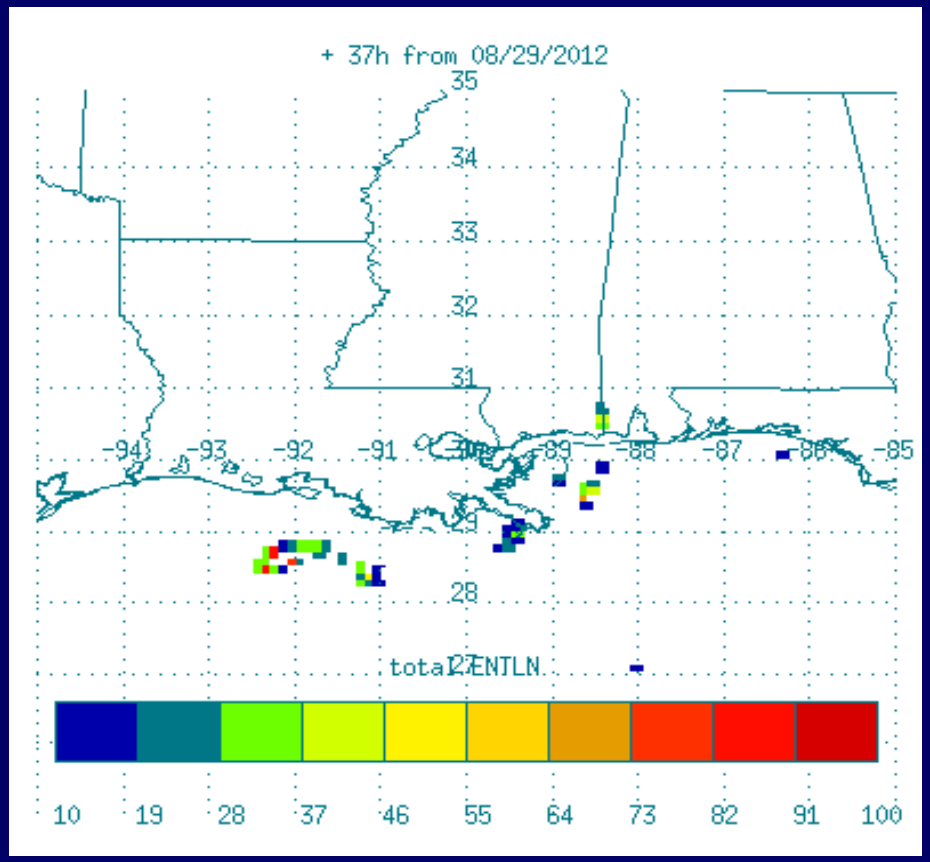


HRRR 2012 LFA recalibration (preliminary):



HRRR 2012 LFA in tropical cyclones:

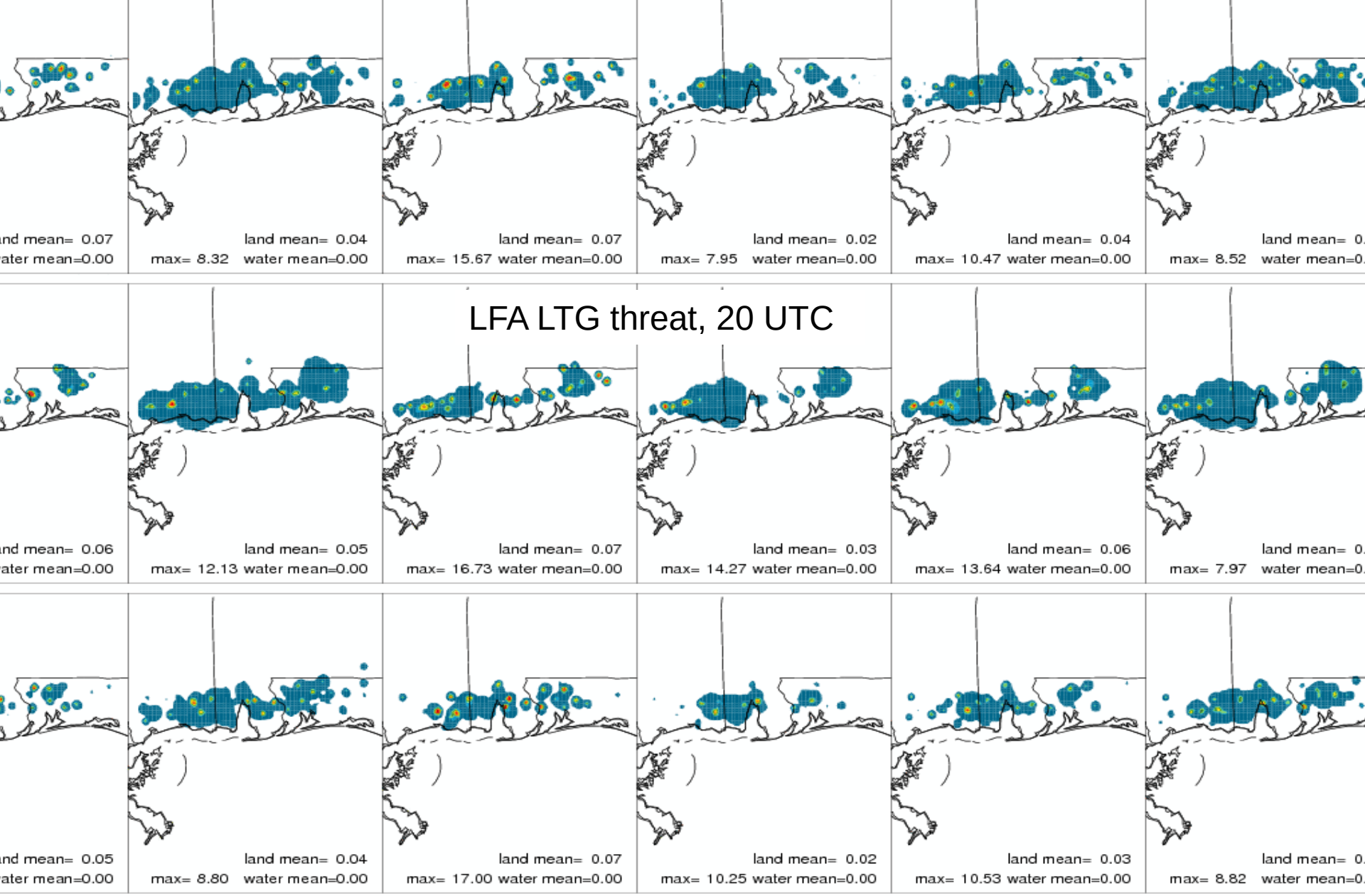
1. HRRR LFA shows LTG threat in most of the hourly forecasts on 28-31 Aug 2012 in Isaac, with max of 7.23 fl/km2/(5 min); no LMA, but ENTLN obs show:



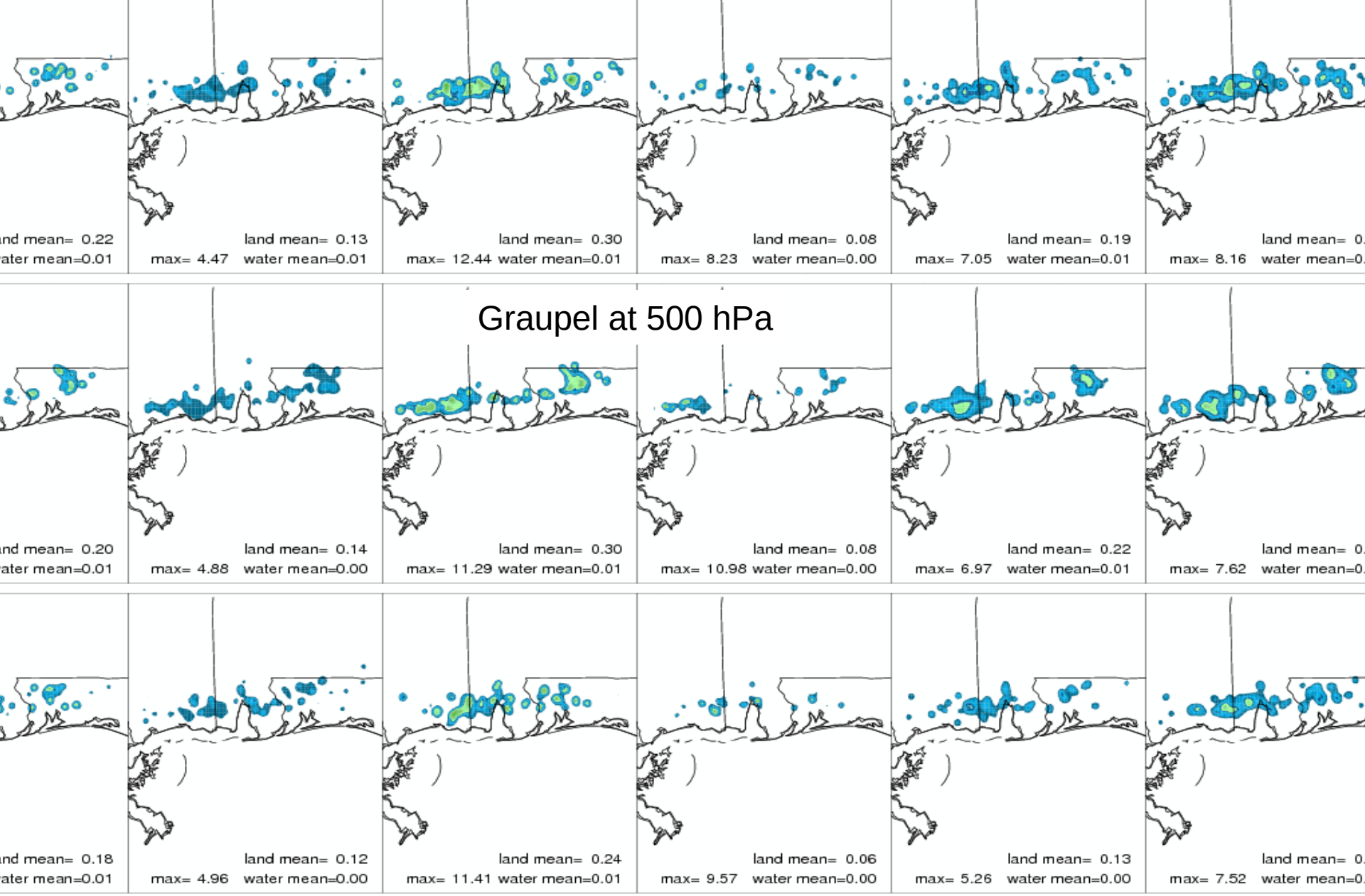
SPoRT WRF LFA 20120703 matrix:

1. Study variations in LFA flash rate estimates to systematic variations in microphysics (8), PBL (3) packages: micro = {WSM6,LIN,GODD,WDM6,THOM,MORR,MIL,NSSL}; PBL = {MYJ,QNSE, MYNN}
2. All 24 runs otherwise identical (more specificity than CAPS);
3. Consider weakly-forced summer convection in MOB, HGX;
4. LFA starts threat earliest in WSM6,GODD,MIL,NSSL micro; especially with QNSE PBL; fades soonest for NSSL-MYNN, and LIN,GODD,WDM6 with QNSE
5. LTG threat is biggest for WDM6, small for THOM,MIL,NSSL
6. LTG threat seems to depend more on midlevel graupel than on midlevel VVEL; WDM6 has largest graupel amounts and moderately large VVEL; LTG max is especially sensitive to PBL choice for THOM microphysics

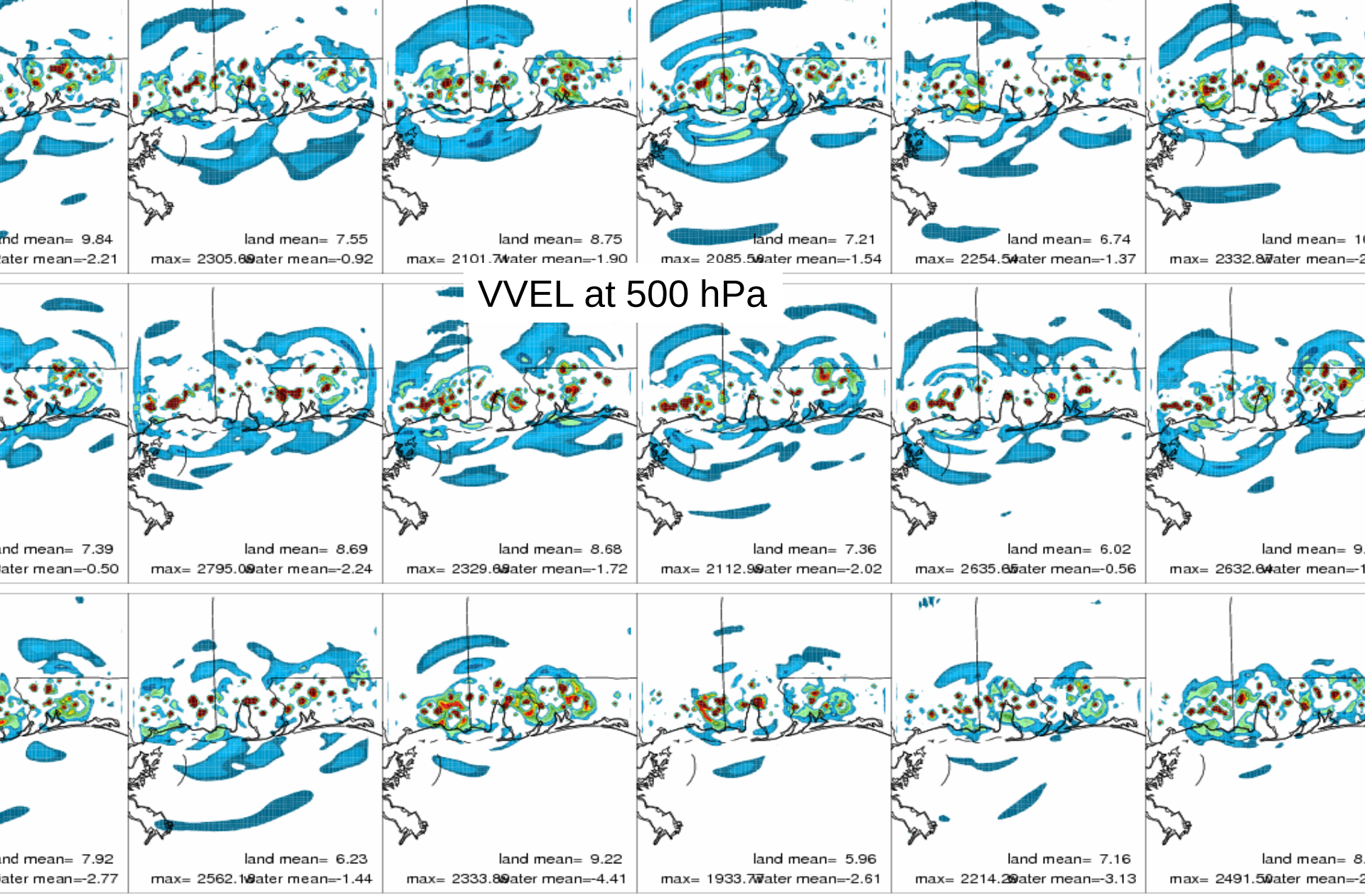
LFA LTG threat, 20 UTC



Graupel at 500 hPa



VVEL at 500 hPa



Future Work:

1. Continue collaborations with NSSL, CAPS, HRRR, others to implement, validate revised LFA;
2. Complete study of LMA cases from 2010-2012 NSSL and CAPS WRF runs, using full data (in progress);
3. Continue study of revised LFA in SPoRT matrix of runs, CAPS ensembles to assess varying model configurations;
4. Assess LFA for dry summer LTG storms in w USA;
5. Examine HWRF, HRRR runs to assess LFA in TCs;
6. Study ways of adding CG forecasts to LFA threat field, without compromising simplicity, if possible.

Acknowledgments: NOAA GOES-R R3, NASA SPoRT