CAPS Storm-Scale Ensemble Forecast in HWT 2011 Spring Experiment: Sensitivity of WRF physics on QPF

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Collaboration with: DTC, HPC, SPC, NSSL, EMC

12th WRF Users' Workshop, Boulder, CO - 22 June 2011

- History
- 2011 configuration highlight
- Example product
- MP & PBL impact on QPF

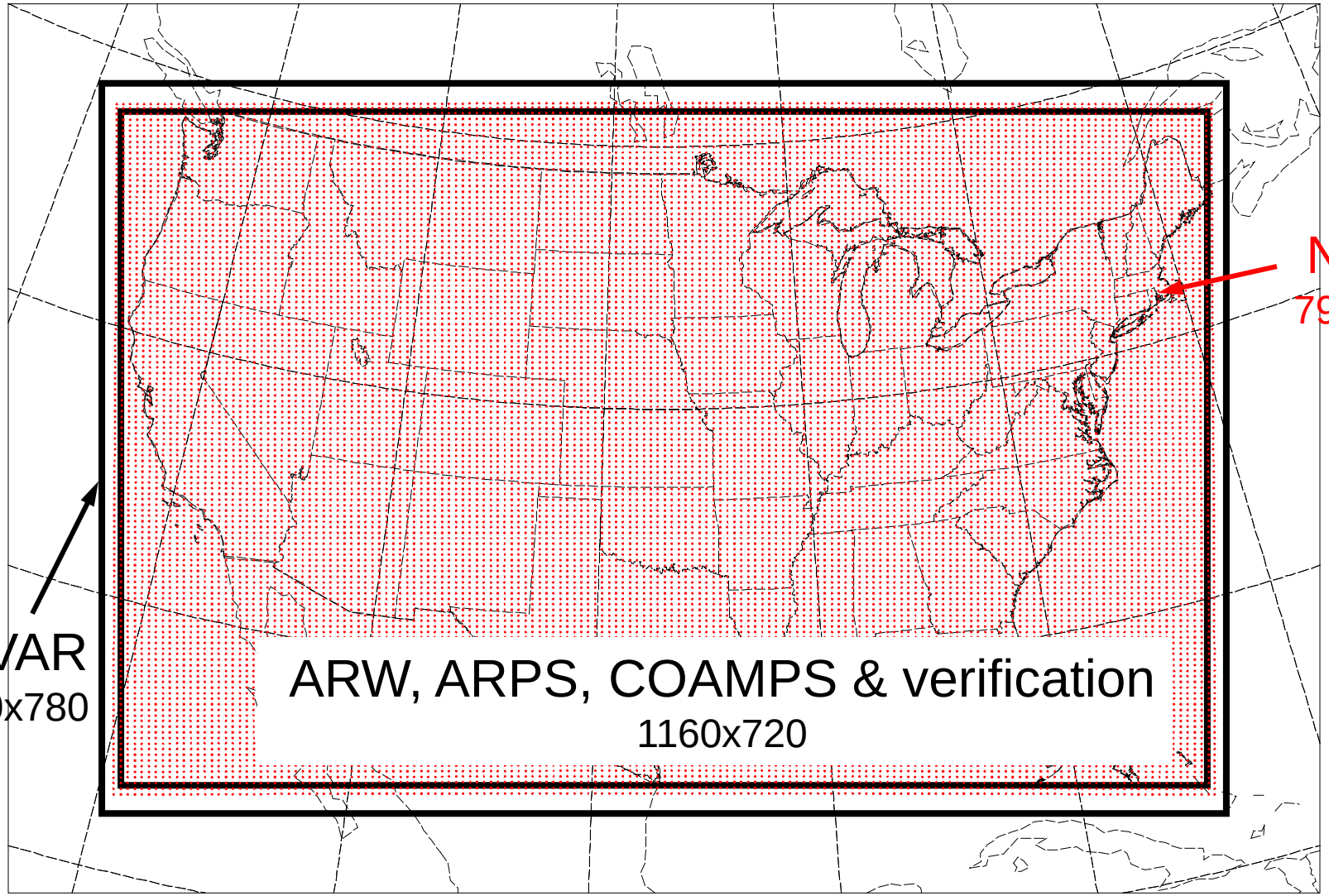
CAPS SSEF history

	2007	2008	2009	2010	2011
member	10	10	20	26	50
domain	2/3 CONUS (4 km)	3/4 CONUS (4 km)	3/4 CONUS (4 km)	Full CONUS (4 km)	Full CONUS (4 km)
forecast	33 h	30 h	30 h	30 h	36 h
model	WRF-ARW	WRF-ARW	WRF-ARW WRF-NMM ARPS	WRF-ARW WRF-NMM ARPS	WRF-ARW WRF-NMM ARPS
radar	No radar	Radial wind, reflectivity	Radial wind, reflectivity	Radial wind, reflectivity	Radial wind, reflectivity

2011 SSEF highlight

- 51 ensemble members (4-km grid spacing)
  - 41 WRF-ARW members
  - 5 WRF-NMM members
  - 4 ARPS member
  - 1 COAMPS member (partial dates, not available to HWT)
- 36h forecast, starting 00 UTC Mon-Fri
- April 25 – June 10 (HWT: May 9 – June 10)

2010/2011 Spring Experiment Domains



51 vertical levels

2011 ARW member configuration (41)

	IC	BC	Radar data	Microphy	LSM	PBL
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_c0 (18h)	00Z ARPSa	00Z NAMf	no	Thompson	Noah	MYJ
arw_cc (18h)	CYCLED	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m4	arw_cn + em-p1_pert	21Z SREF em-p1	yes	Morrison	RUC	YSU
arw_m5	arw_cn + em-p2_pert	21Z SREF em-p2	yes	Thompson	Noah	QNSE
arw_m6	arw_cn – nmm-p1_pert	21Z SREF nmm-p1	yes	WSM6	RUC	QNSE
arw_m7	arw_cn + nmm-p2_pert	21Z SREF nmm-p2	yes	WDM6	Noah	MYNN
arw_m8	arw_cn + rsm-n1_pert	21Z SREF rsm-n1	yes	Ferrier	RUC	YSU
arw_m9	arw_cn – etaKF-n1_pert	21Z SREF etaKF-n1	yes	Ferrier	Noah	YSU
arw_m10	arw_cn + etaKF-p1_pert	21Z SREF etaKF-p1	yes	WDM6	Noah	QNSE
arw_m11	arw_cn – etaBMJ-n1_pert	21Z SREF etaBMJ-n1	yes	WSM6	RUC	MYNN
arw_m12	arw_cn + etaBMJ-p1_pert	21Z SREF etaBMJ-p1	yes	Thompson	RUC	MYNN
arw_m13	arw_cn + rsm-p1_pert	21Z SREF rsm-p1	yes	M-Y	Noah	MYJ
arw_m14	arw_cn + em-n1_pert	21Z SREF em-n1	yes	Ferrier+	Noah	YSU
arw_m15	arw_cn + em-n2_pert	21Z SREF em-n2	yes	WSM6	Noah	MYNN
arw_m16	arw_cn + nmm-n1_pert	21Z SREF nmm-n1	yes	Ferrier+	Noah	QNSE
arw_m17	arw_cn + nmm-n2_pert	21Z SREF nmm_n2	yes	Thompson	Noah	ACM2
arw_m18	arw_cn + rsm-p2_pert	21Z SREF rsm_p2	yes	WSM6	Noah	MYJ
arw_m19	arw_cn + rsm-n1_pert	21Z SREF rsm_n1	yes	M-Y	Noah	MYJ
arw_m20	arw_cn + rsm-n2_pert	21Z SREF rsm_n2	yes	M-Y	RUC	ACM2

For all ARW members: *ra_lw_physics*= RRTM; *ra_sw_physics*=Goddard; *cu_physics*=none

2011 ARW member configuration (continue)

arw_m21	00Z ARPSa	00Z NAMf	yes	Ferrier+	Noah	MYJ
arw_m22	00Z ARPSa	00Z NAMf	yes	Ferrier	Noah	MYJ
arw_m23	00Z ARPSa	00Z NAMf	yes	M-Y	Noah	MYJ
arw_m24	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ
arw_m25	00Z ARPSa	00Z NAMf	yes	WDM6	Noah	MYJ
arw_m26	00Z ARPSa	00Z NAMf	yes	WSM6	Noah	MYJ
arw_m27	00Z ARPSa	00Z NAMf	yes	WSM6-M1	Noah	MYJ
arw_m28	00Z ARPSa	00Z NAMf	yes	WSM6-M2	Noah	MYJ
arw_m29	00Z ARPSa	00Z NAMf	yes	WSM6-M3	Noah	MYJ
arw_m30	00Z ARPSa	00Z NAMf	yes	WSM6-M4	Noah	MYJ
arw_m31	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	QNSE
arw_m32	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYNN
arw_m33	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P1
arw_m34	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P2
arw_m35	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P3
arw_m36	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	ACM2
arw_m37	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	ACM2-A1
arw_m38	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	ACM2-A2
arw_m39	00Z ARPSa	00Z NAMf	yes	Thompson-v31	Noah	MYJ
arw_m40	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU
arw_m41	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU-Thompson

2011 NMM member configuration (5)

member	IC	BC	Radar data	mp_phy	lw_phy	sw-phy	sf_phy
nmm_cn	00Z ARPSa	00Z NAMf	yes	Ferrier	GFDL	GFDL	Noah
nmm_m2	nmm_cn + em-n2_pert	21Z SREF em-n2	yes	Ferrier+	GFDL	GFDL	Noah
nmm_m3	nmm_cn + nmm-n1_pert	21Z SREF nmm-n1	yes	Thompson	RRTM	Dudhia	Noah
nmm_m4	nmm_cn + nmm-n2_pert	21Z SREF nmm-n2	yes	WSM 6-class	RRTM	Dudhia	RUC
nmm_m5	nmm_cn + em-n1_pert	21Z SREF em-n1	yes	Ferrier	GFDL	GFDL	RUC

For all NMM members: *pbl_physics*=MYJ; *cu_physics*=none

2011 ARPS member configuration (4)

member	IC	BC	Radar data	Microphy.	radiation	sf_phy
arps_cn	00Z ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore
arps_c0 (18h)	00Z ARPSa	00Z NAMf	no	Lin	Chou/Suarez	Force-restore
arps_c10 (18h)	10-min cycle ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore
arps_c30 (18h)	30-min cycle ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore

For all ARPS members: no cumulus parameterization

Members in red contribute to the **24-member** sub-ensemble for post-processed product

Ensemble product

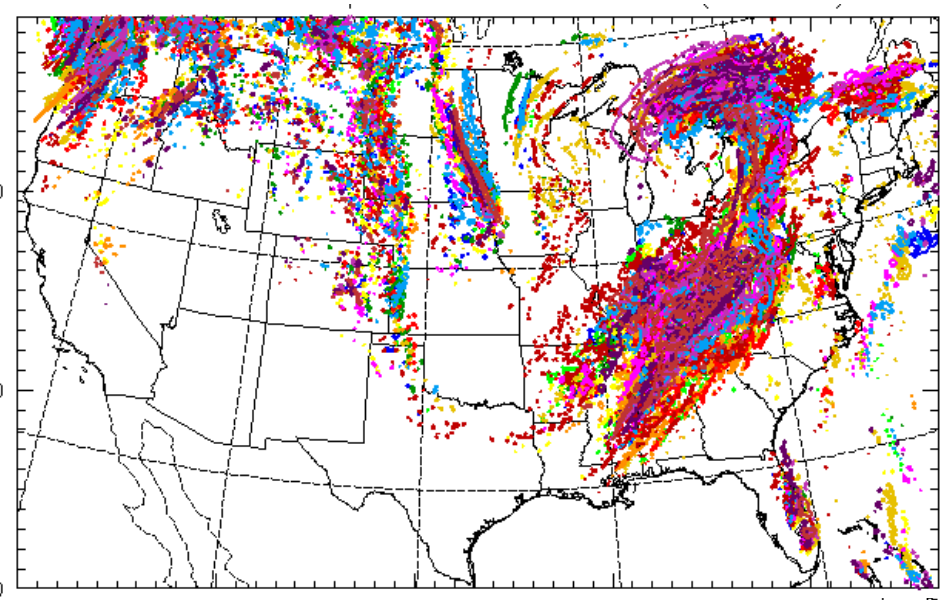
- Ensemble maximum, mean
- Probability matching (PM) mean for accumulated precipitation & reflectivity
- Hourly max & 3-hourly max: updraft helicity, sfc-400hPa updraft velocity, surface wind speed, column graupel
- Frequency-based probability (grid point)
- Neighborhood probability, with 2D Gaussian smoothing (ROI=40km, σ=10)

Ensemble product

- New in 2011 Spring Experiment, added two groups of experimental diagnosed products
  - Lightning threat (McCaul et al. 2009)
  - CI counts (NSSL - Jack Kain et al.)
  - and their probabilities
- Bias corrected QPF

CAPS SSEF Product

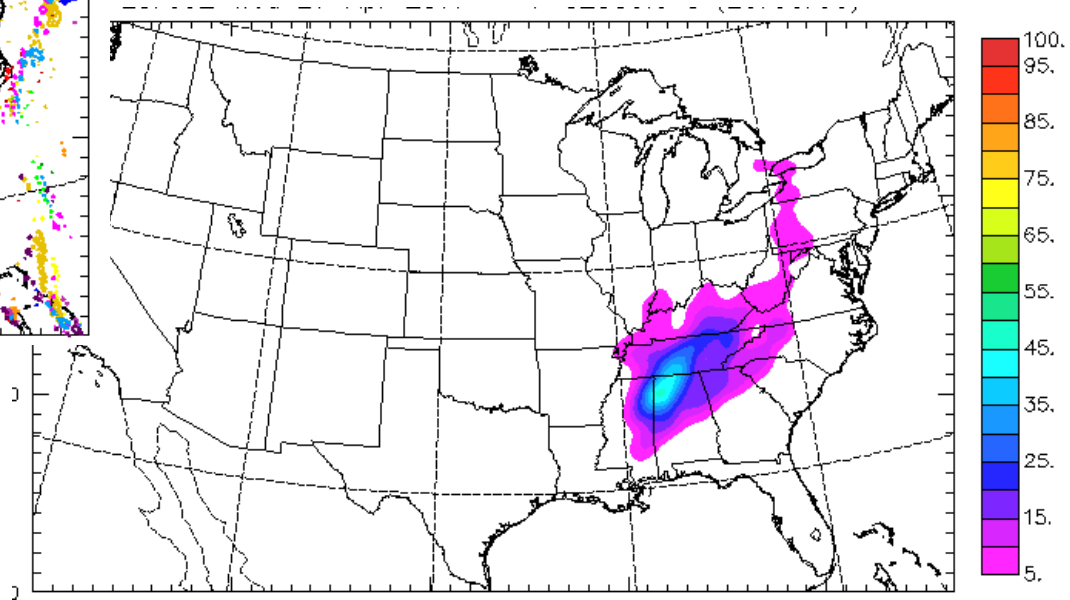
- http://forecast.caps.ou.edu
- http://www.caps.ou.edu/~fkong/sub_atm/spring11.html



Spaghetti of cref = 35 dBZ

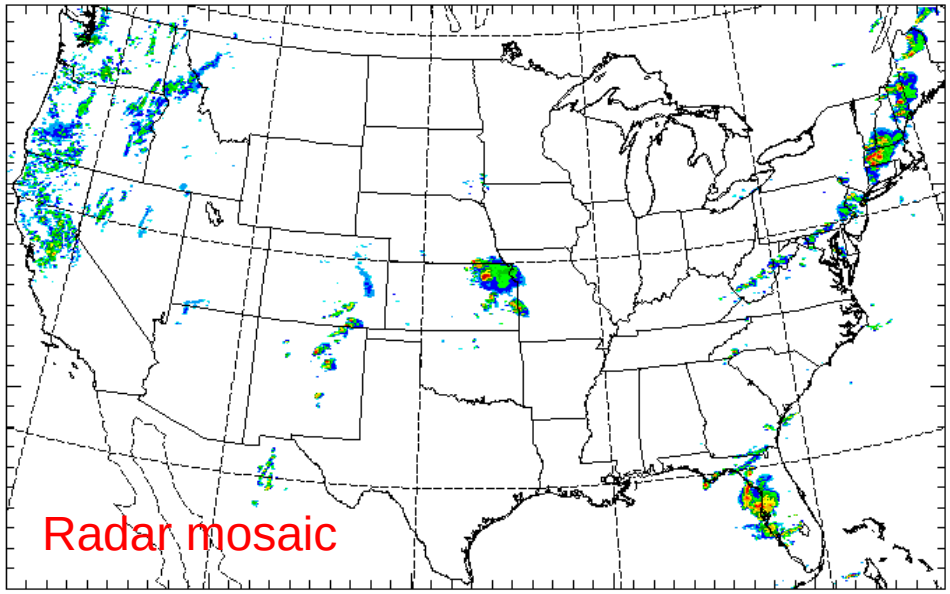
(23-h fcst, valid 23Z April 27)

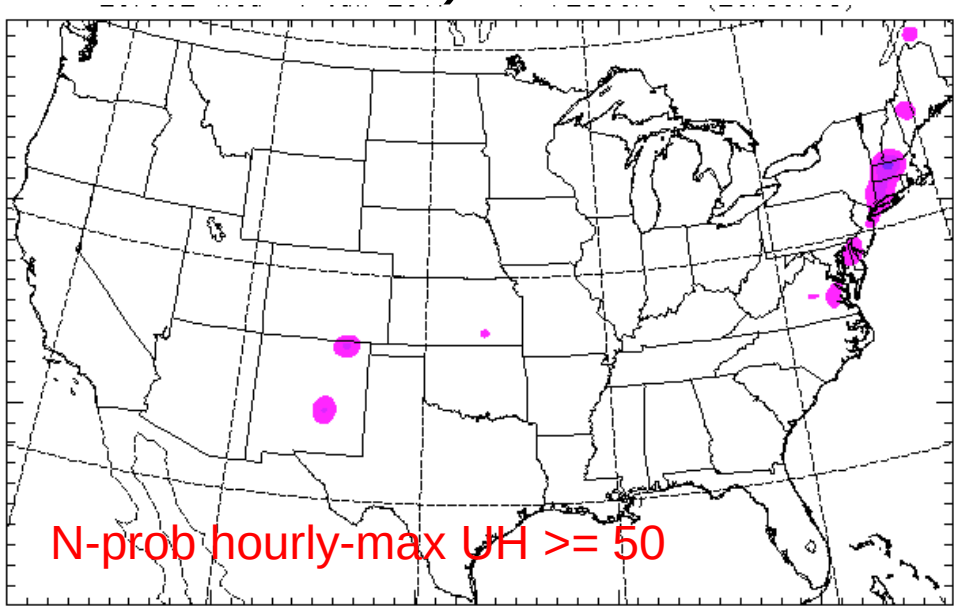
Neighborhood probability:
UH >= 50

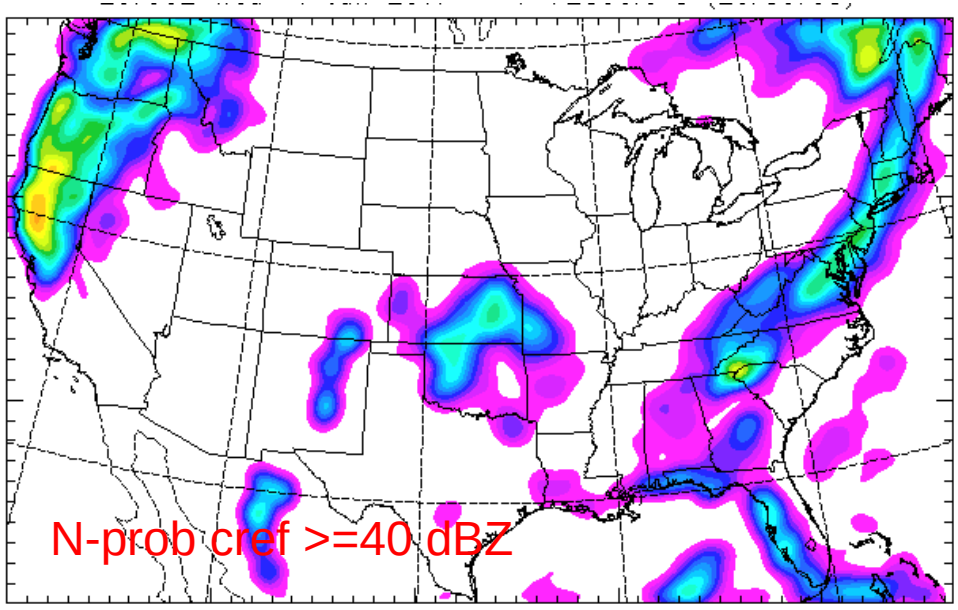


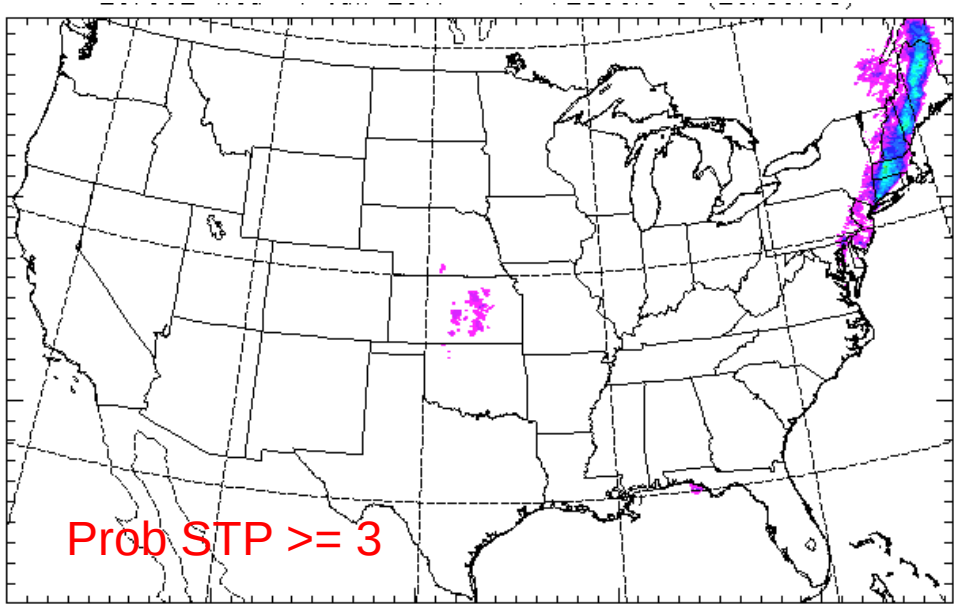
June 1 Massachusetts Tornado

(valid 20 UTC June 1, 2011)

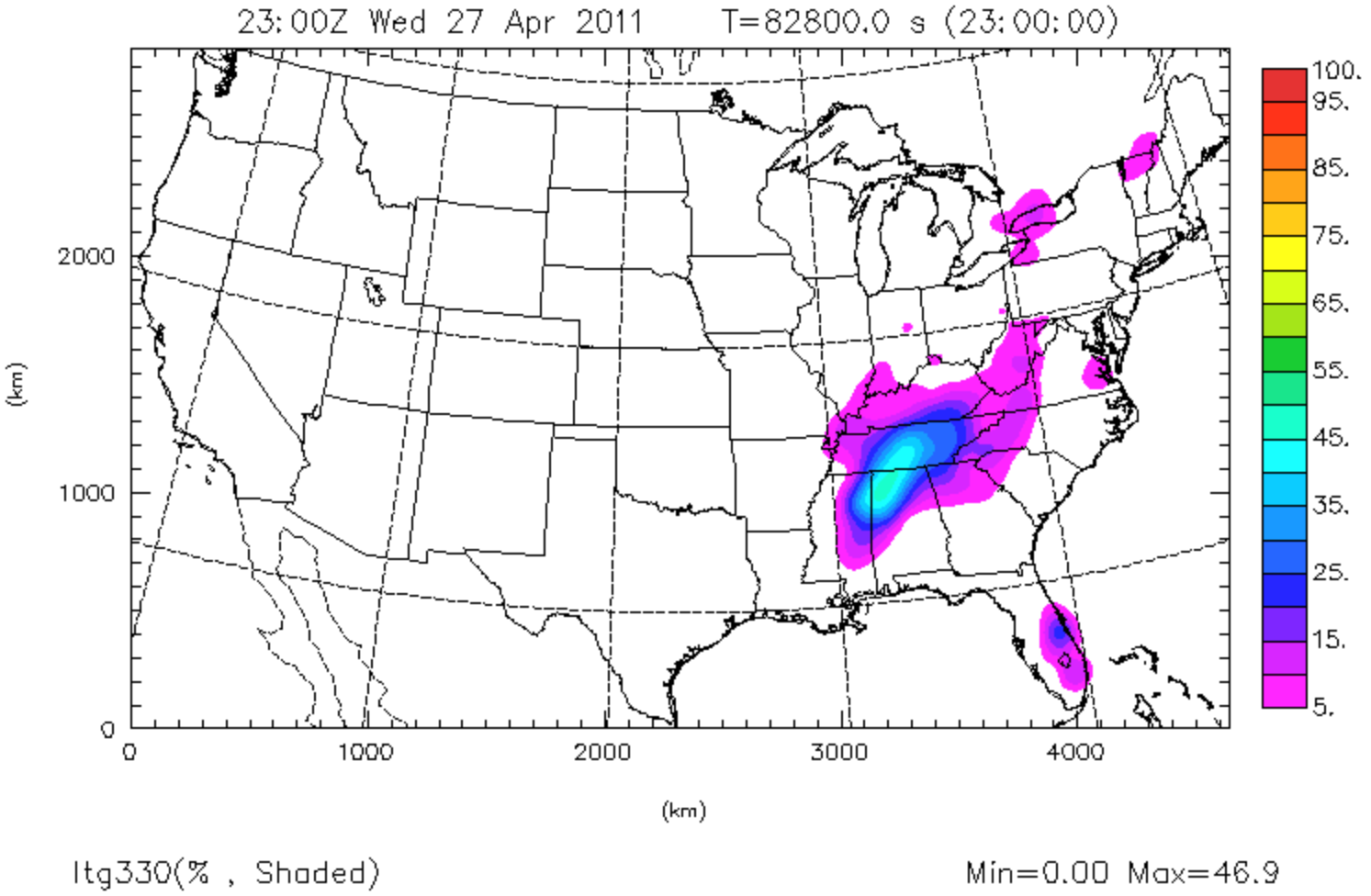








Neighborhood Probability of Hourly-max Lightning Threat-3 ≥ 3.0 flashes/5min/km^2



Microphysics sub-group members (11)

arw_cn	Thompson
arw_m21	Ferrier+
arw_m22	Ferrier
arw_m23	Milbrandt-Yau
arw_m24	Morrison
arw_m25	WDM6
arw_m26	WSM6
arw_m27	WSM6-M1
arw_m28	WSM6-M2
arw_m29	WSM6-M3
arw_m30	WSM6-M4

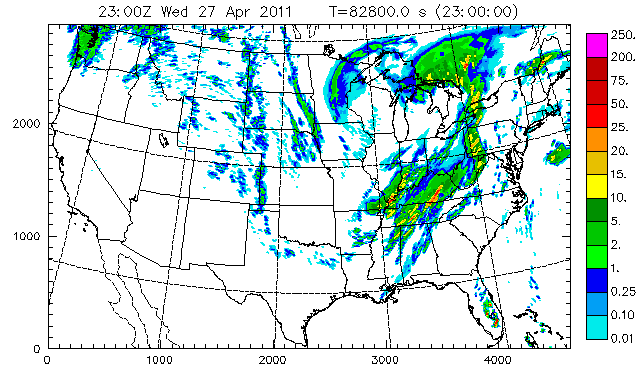
Ferrier+ refers to a subset of changes in the updated version now in NEMS/NMMB. Two recommendations by Brad Ferrier: 1) remove artificial delay in ice initiation; 2) faster falling rimed ice

Physics parameter perturbation

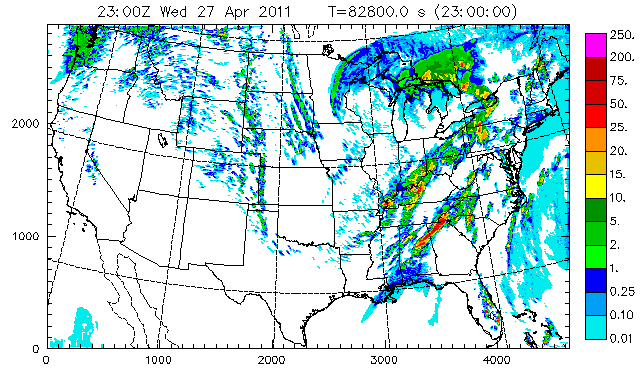
- WSM6 with M1 to M4 refers to various perturbations on intercept parameter N0 and density parameter
  - WSM6: n0rain=8×10^{6} m^{-4}, n0graupel=4×10^{6} m^{-4}, dengraupel=500 kg/m^{3}
  - WSM6-M1: n0rain=8×10^{6} m^{-4}, n0graupel=4×10^{4} m^{-4}, dengraupel=913 kg/m^{3}
  - WSM6-M2: n0rain=8×10^{7} m^{-4}, n0graupel=4×10^{6} m^{-4}, dengraupel=500 kg/m^{3}
  - WSM6-M3: n0rain=8×10^{5} m^{-4}, n0graupel=4×10^{2} m^{-4}, dengraupel=913 kg/m^{3}
  - WSM6-M4: n0rain=8×10^{5} m^{-4}, n0graupel=4×10^{3} m^{-4}, dengraupel=913 kg/m^{3}

23h forecast 1-h accum. precipitation valid 2300 UTC April 27, 2011

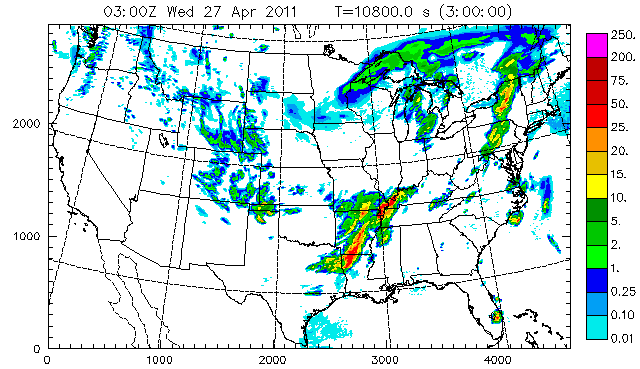
Thompson



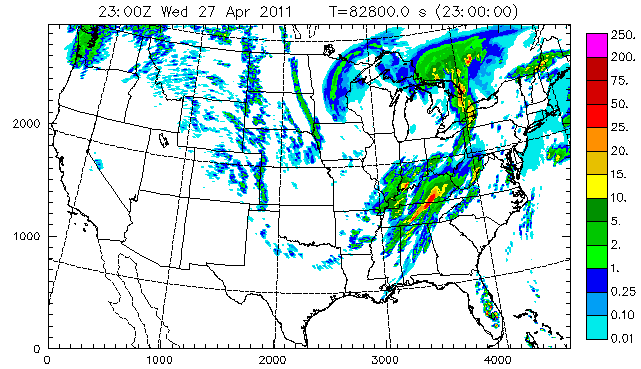
Ferrier



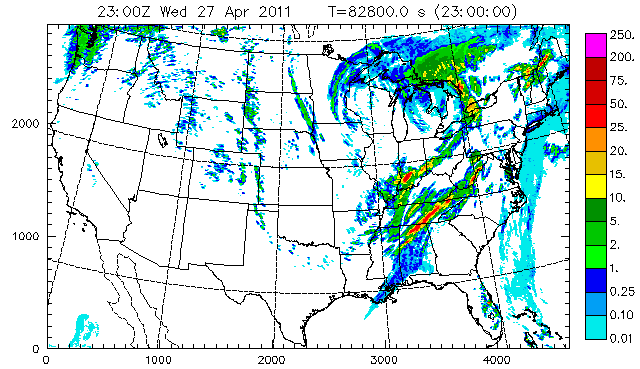
M-Y



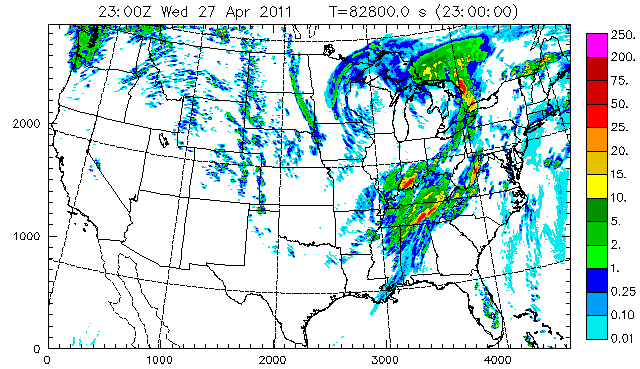
Morrison



WDM6

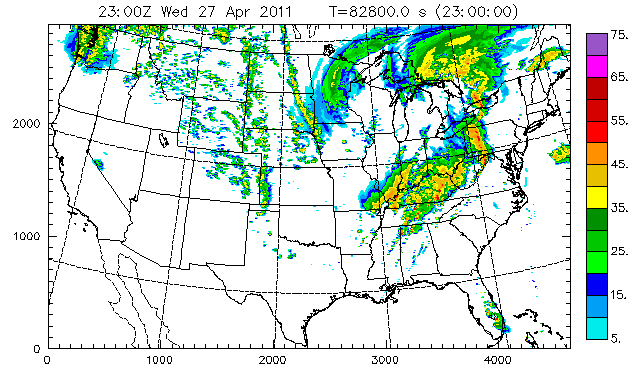


WSM6

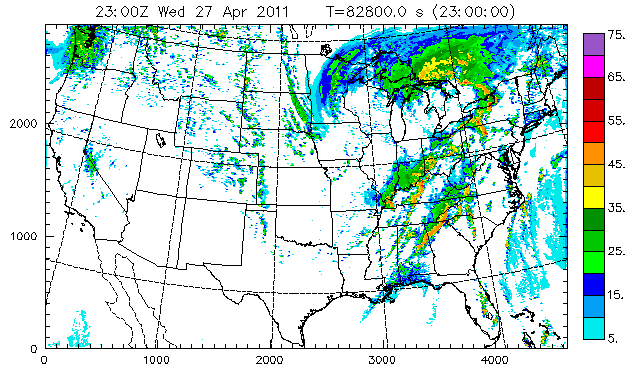


23h forecast composite reflectivity valid 2300 UTC April 27, 2011

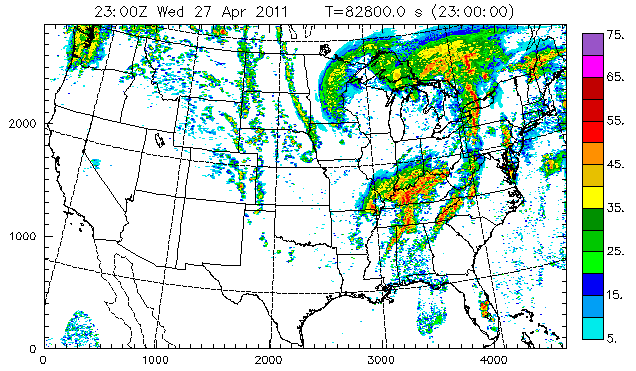
Thompson



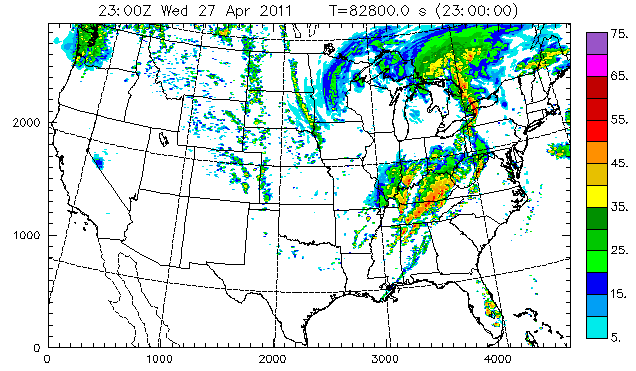
Ferrier



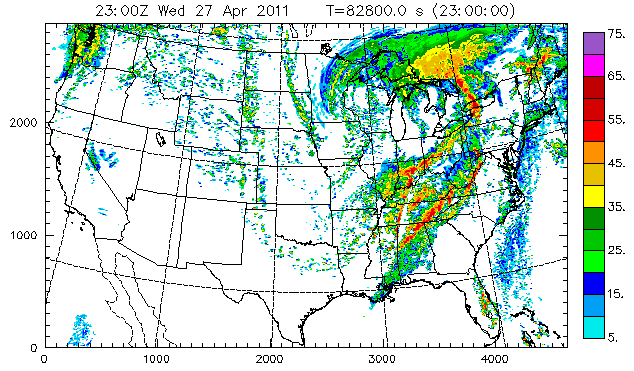
M-Y



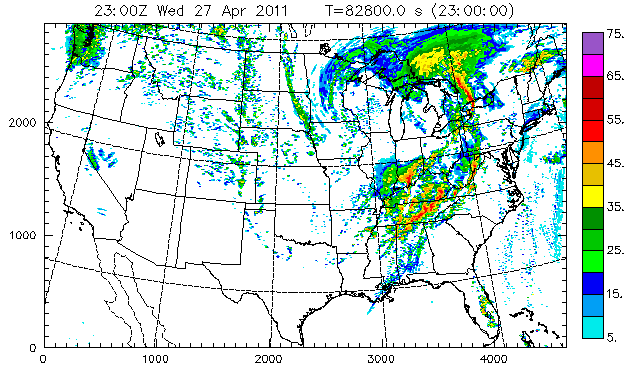
Morrison



WDM6



WSM6



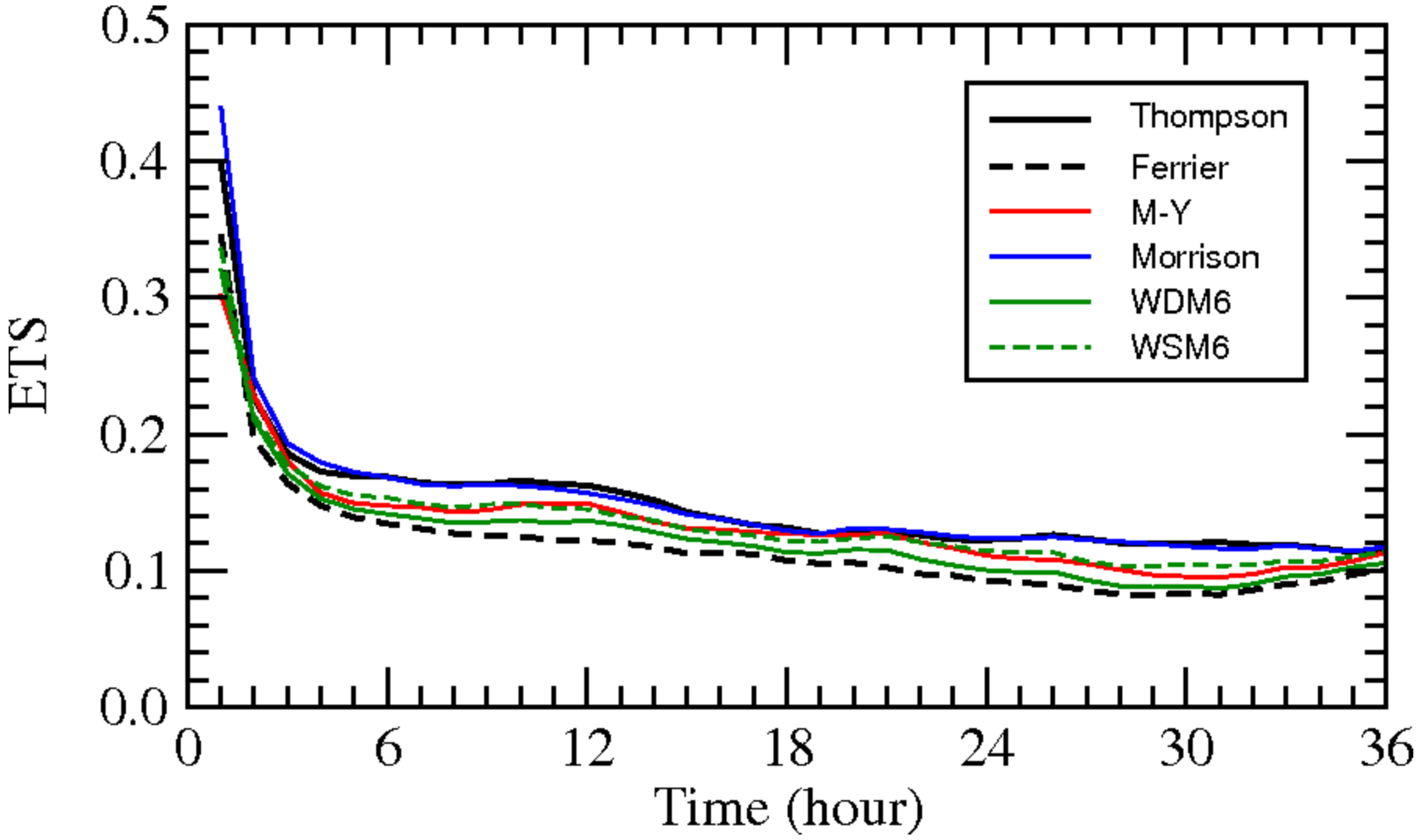
PBL sub-group members (10)

arw_cn	MYJ
arw_m31	QNSE
arw_m32	MYNN
arw_m33	MYJ-P1
arw_m34	MYJ-P2
arw_m35	MYJ-P3
arw_m36	ACM2
arw_m37	ACM2-A1
arw_m38	ACM2-A2
arw_m40	YSU

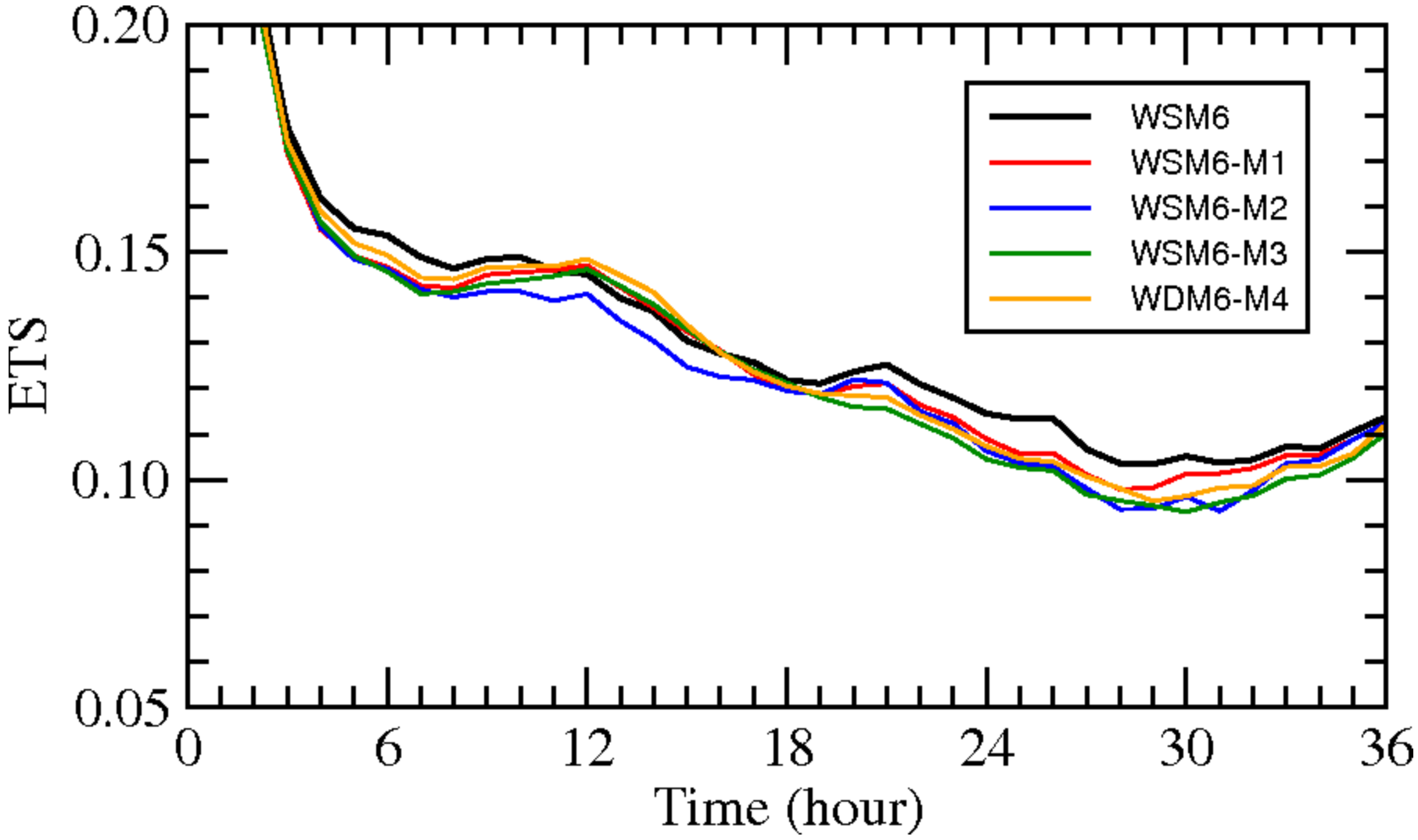
Physics parameter perturbation

- WSM6 with M1 to M4 refers to various perturbations on intercept parameter N0 and density parameter
  - WSM6: n0rain=$8x10^6$ m^{-4}, n0graupel=$4x10^6$ m^{-4}, dengraupel=500 kg/m^3
  - WSM6-M1: n0rain=$8x10^6$ m^{-4}, n0graupel=$4x10^4$ m^{-4}, dengraupel=913 kg/m^3
  - WSM6-M2: n0rain=$8x10^7$ m^{-4}, n0graupel=$4x10^6$ m^{-4}, dengraupel=500 kg/m^3
  - WSM6-M3: n0rain=$8x10^5$ m^{-4}, n0graupel=$4x10^2$ m^{-4}, dengraupel=913 kg/m^3
  - WSM6-M4: n0rain=$8x10^5$ m^{-4}, n0graupel=$4x10^3$ m^{-4}, dengraupel=913 kg/m^3
- A1 and A2 refer to modifying the ACM2 to account for weaker and stronger vertical mixing via the “p” parameter - Hu et al. (2010); Nielsen-Gammon et al. (2010)
  - ACM2: (p =2)
  - ACM2-A1: (p =1.33)
  - ACM2-A2: (p =2.67)
- P1 to P3 refers to modifying the MYJ surface exchange coefficient for stronger, weaker, and *f(surface roughness from vegetation*) - Trier et al. (2011) and Chen and Zhang (2009)
  - MYJ: (czil=0.1, iz0tlnd=0)
  - MYJ-P1: (czil=.01, iz0tlnd=0)
  - MYJ-P2: (czil=1.0, iz0tlnd=0)
  - MYJ-P3: (iz0tlnd=1)

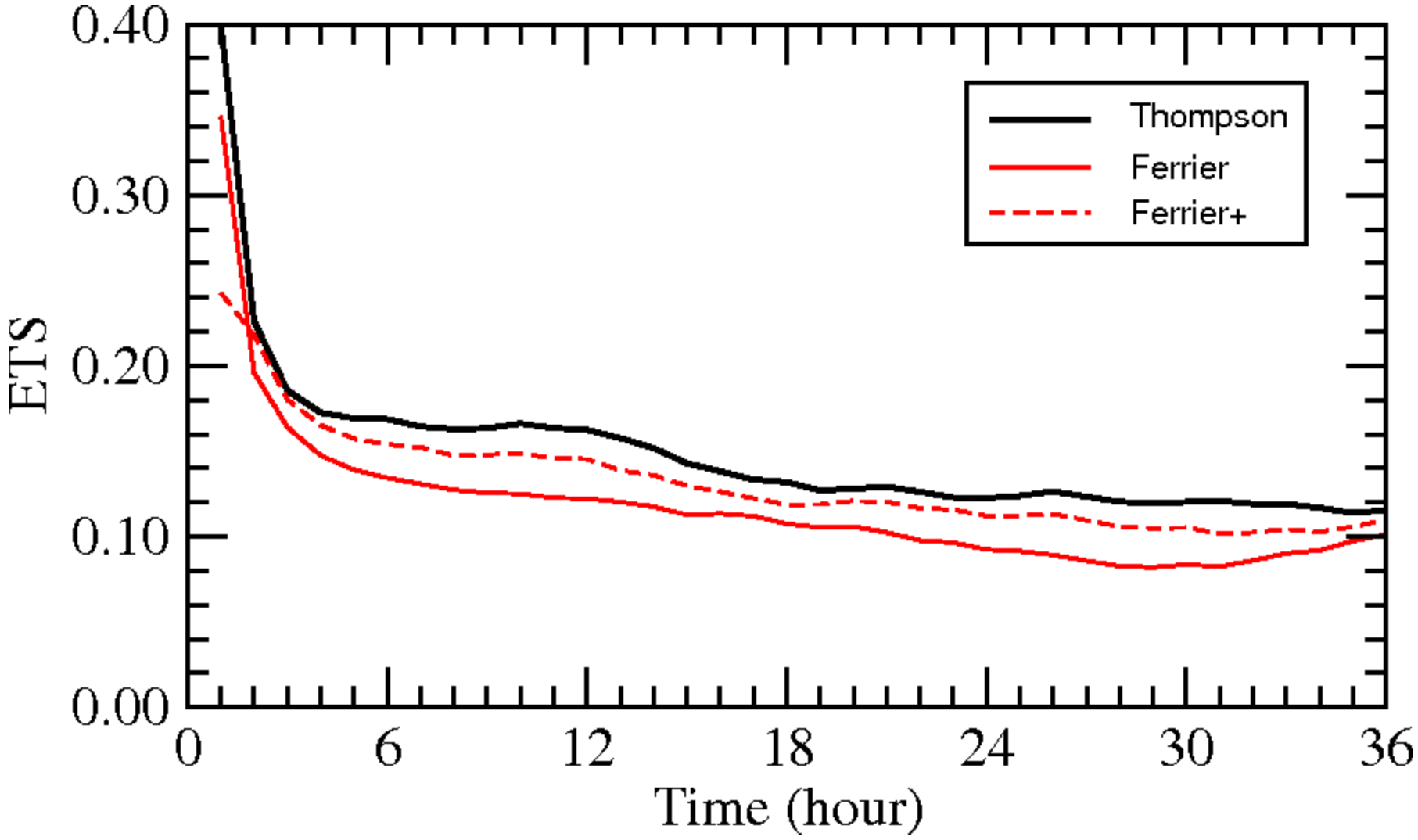
1-h accumulated precipitation ≥ 0.01” (33-day)



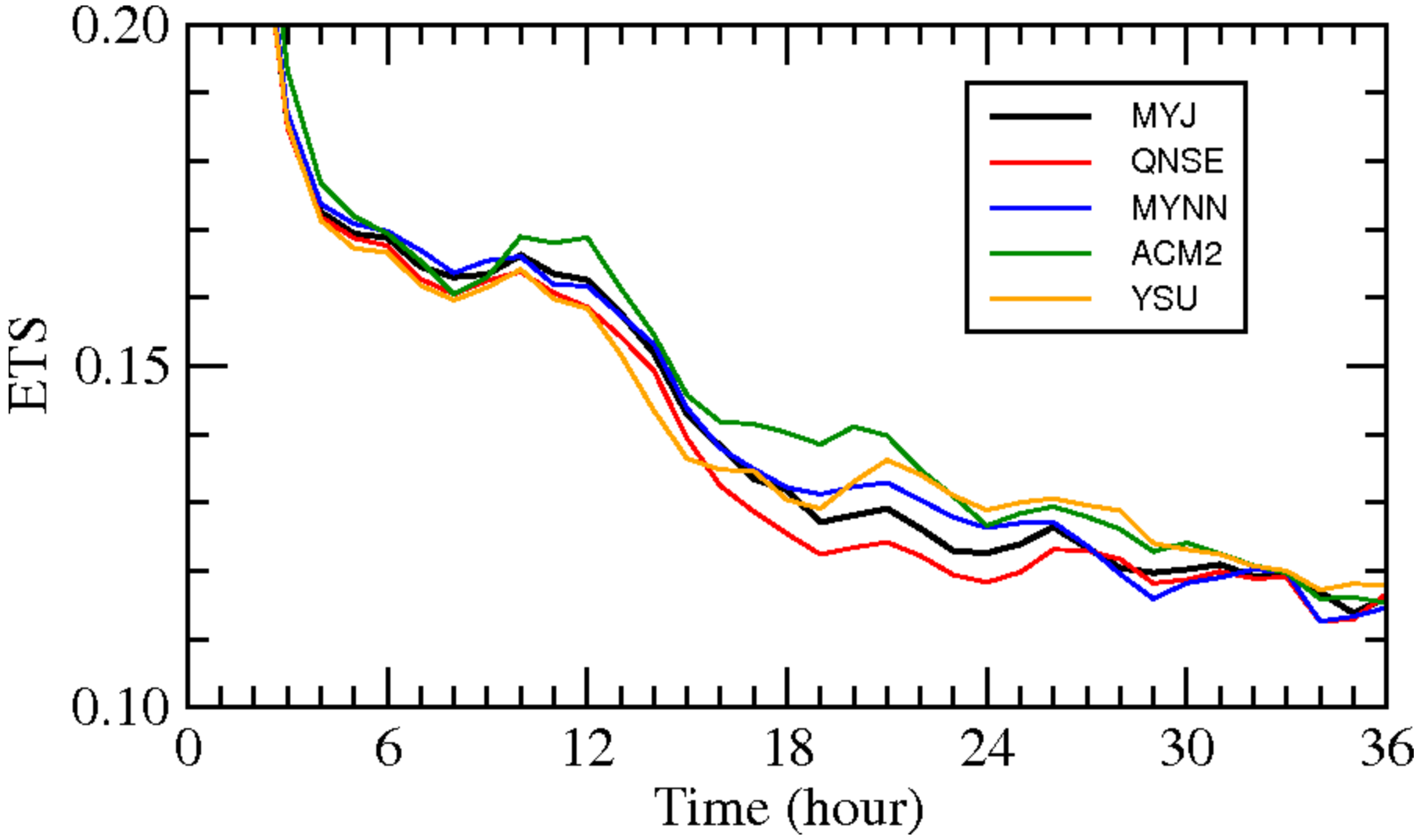
1-h accumulated precipitation ≥ 0.01” (33-day)



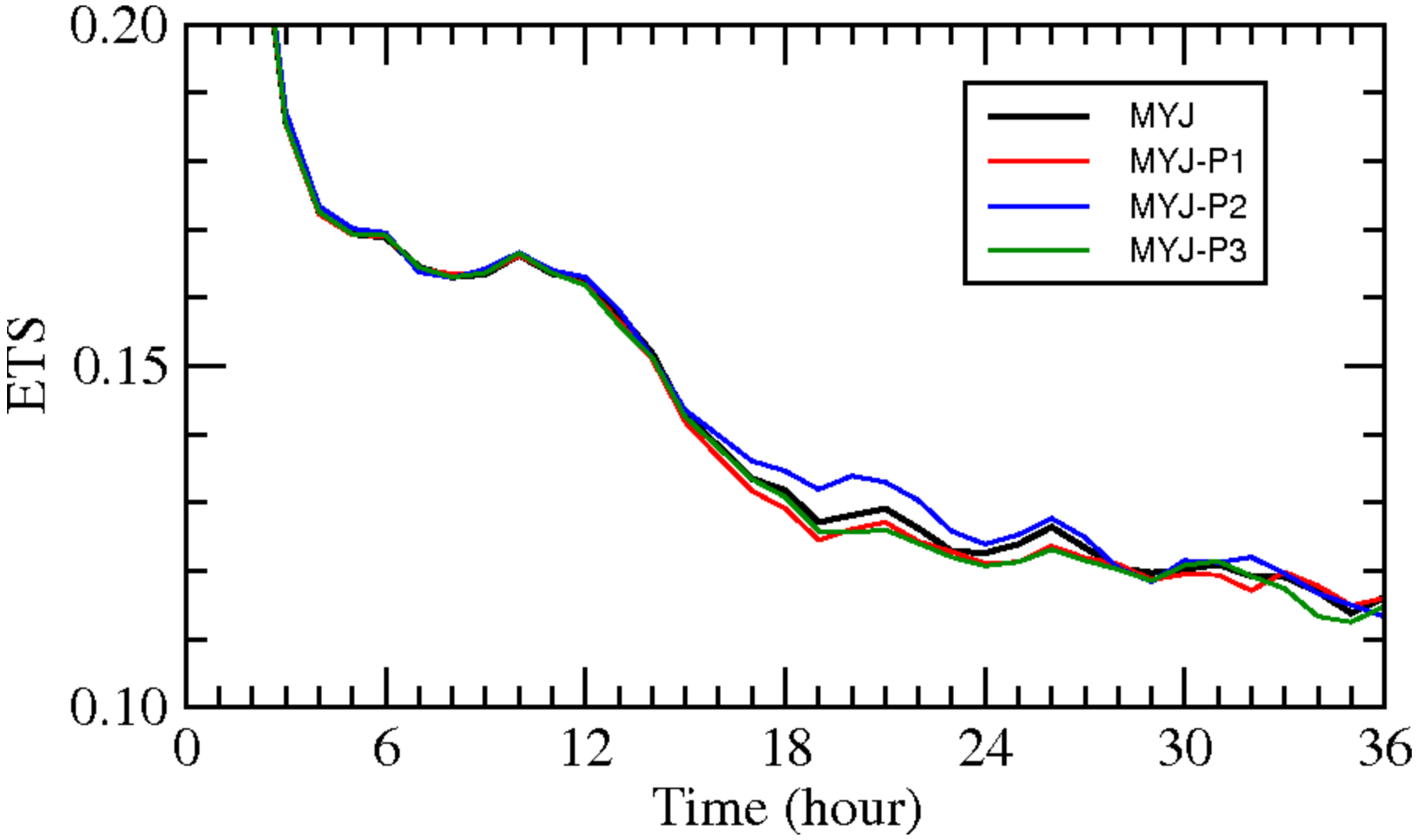
1-h accumulated precipitation ≥ 0.01” (33-day)



1-h accumulated precipitation ≥ 0.01” (33-day)



1-h accumulated precipitation ≥ 0.01” (33-day)



Tuscaloosa tornado

S4CN (1160x720x50, dx=4 km)

WRF Forecast starting at 00Z Wed 27 Apr 2011