renewable energy

Brian J. Etherton, Matthew J. Parker, and Betsy Weatherhead

RESEARCH \ ENGAGEM

sons learned from HWT Oklahoma and for real-time year-round 4km ensemble

- nsemble to span error space of 4km n forecasts
- onditions
- Schemes
- emble for as much as possible
- tive Initiation
- ather
- ive Energy
- ative Precipitation Forecasting

than one agency

- lone can produce many WRF runs
- FOs run high-resolution WRF-NMM
- iversities run high-resolution models
- encies run high-resolution models

D WE CAN CREATE MORE LE MEMBERS THAN ANY ONE LONE

High-Resolution Mid-Atlantic Ensemble (HME) - 28 May 2010

AGENCY	CODE	CONTACT	NX	NY	NZ	DX	DY	GRID	VER	MODEL	INITIAL CONDITIONS	BOUNDARY CONDITIONS	MOIST PHYSICS	LONG WAVE	SHORT WAVE	LAND SURFACE	PBL	CUMULUS
NWS Morehead City, NC	MHX	Carin Goodall	303	329		2.76	2.85	B		WRF NMM	NAM 06/18	NAM 06/18	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
NWS Wakefield, VA	AKQ	John Billet								WRF NMM	NAM 06/18	NAM 06/18	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
NWS Columbia, SC	CAE	Greg Lewis	357	381		2.76	2.85	B		WRF NMM	NAM 00/12	NAM 00/12	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
NWS Greenville-Spartanburg, SC	GSP	Mike Jackson	241	239		4.14	4.28	B		WRF NMM	NAM 06/18	NAM 06/18	Ferrier (5)	RRTM (1)	Dudhia (1)	NOAH (2)	YSU (1)	KF (1)
NWS Sterling, VA	LWX	Steve Zubrick	375	357		2.76	2.85	B		WRF NMM	GFS 06/18	GFS 06/18	Ferrier (5)	GFDL (99)	GFDL (99)	NMM (99)	MYJ (2)	None (0)
NWS Wilmington, NC	ILM	Reid Hawkins	373	331		2.76	2.85	B		WRF NMM	NAM 06/18	NAM 06/18	Lin (2)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
NWS Raleigh, NC	RAH	Barrett Smith	373	331		2.76	2.85	B		WRF NMM	NAM 00/12	NAM 00/12	Lin (2)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
NWS Blacksburg, VA	RNK	Steve Keighton	279	269		4.00	4.00	B		WRF ARW	LAPS 09/21	NAM 06/18	Lin (2)	RRTM (1)	Dudhia (1)	NOAH (2)	YSU (1)	None (0)
Purdue University	PURDUE	Mike Baldwin	790	660	45	4.25	4.25	C	3.0.1	WRF ARW	NAM 00/12	NAM 00/12	Lin (2)	RRTM (1)	Dudhia (1)	NOAH (2)	YSU (1)	None (0)
Rennaiassance Computing Institute	RENCI0	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Lin (2)	RRTMG(4)	RRTMG(4)	NOAH (2)	QNSE(4)	None (0)
Rennaiassance Computing Institute	RENCI1	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Lin (2)	RRTMG(4)	RRTMG(4)	NOAH (2)	QNSE(4)	KF (1)
Rennaiassance Computing Institute	RENCI2	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Goddard(7)	RRTMG(4)	RRTMG(4)	NOAH (2)	YSU (1)	None (0)
Rennaiassance Computing Institute	RENCI3	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Goddard(7)	RRTMG(4)	RRTMG(4)	NOAH (2)	YSU (1)	KF (1)
Rennaiassance Computing Institute	RENCI4	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Goddard(7)	RRTMG(4)	RRTMG(4)	NOAH (2)	QNSE(4)	None (0)
Rennaiassance Computing Institute	RENCI5	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Goddard(7)	RRTMG(4)	RRTMG(4)	NOAH (2)	QNSE(4)	KF (1)
Rennaiassance Computing Institute	RENCI6	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Thompson(8)	CAM(3)	CAM(3)	NOAH (2)	YSU (1)	None (0)
Rennaiassance Computing Institute	RENCI7	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Thompson(8)	CAM(3)	CAM(3)	NOAH (2)	YSU (1)	KF (1)
Rennaiassance Computing Institute	RENCI8	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Thompson(8)	CAM(3)	CAM(3)	NOAH (2)	QNSE(4)	None (0)
Rennaiassance Computing Institute	RENCI9	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Thompson(8)	CAM(3)	CAM(3)	NOAH (2)	QNSE(4)	KF (1)
Rennaiassance Computing Institute	RENCI10	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Morrison(10)	CAM(3)	CAM(3)	NOAH (2)	YSU (1)	None (0)
Rennaiassance Computing Institute	RENCI11	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	RUC 06/18	NAM 06/18	Morrison(10)	CAM(3)	CAM(3)	NOAH (2)	YSU (1)	KF (1)
Rennaiassance Computing Institute	RENCI12	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	NAM 06/18	NAM 06/18	Morrison(10)	RRTM (1)	Dudhia (1)	NOAH (2)	MYJ (2)	None (0)
Rennaiassance Computing Institute	RENCI13	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	NAM 06/18	NAM 06/18	Morrison(10)	RRTM (1)	Dudhia (1)	NOAH (2)	MYJ (2)	KF (1)
Rennaiassance Computing Institute	RENCI14	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	NAM 06/18	NAM 06/18	WSM6 (6)	RRTM (1)	Dudhia (1)	NOAH (2)	QNSE(4)	None (0)
Rennaiassance Computing Institute	RENCI15	Brian Etherton	313	313	45	3.00	3.00	C	3.1	WRF ARW	NAM 06/18	NAM 06/18	WSM6 (6)	RRTM (1)	Dudhia (1)	NOAH (2)	QNSE(4)	KF (1)
National Centers for Environmental Prediction	NCEP0	Matthew Pyle	1295	854	35	4.00	4.00	B	2.2	WRF NMM	NAM 00/12	NAM 00/12	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
National Centers for Environmental Prediction	NCEP1	Matthew Pyle	1295	854	35	4.00	4.00	B	3.1	WRF NMM	NAM 00	NAM 00	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
National Centers for Environmental Prediction	NCEP2	Matthew Pyle	1295	854	35	4.00	4.00	B		NMMB	NAM 00	NAM 00	Ferrier (5)	GFDL (99)	GFDL (99)	NOAH (2)	MYJ (2)	None (0)
National Severe Storms Lab	NSSL	Jack Kain	1200	800	35	4.00	4.00	C	3.1.1	WRF ARW	NAM 00/12	NAM 00/12	WSM6 (6)	RRTM (1)	Dudhia (1)	NOAH (2)	MYJ (2)	None (0)
Savannah River National Lab	SRNL	David Werth	275	232		4.00	4.00	E		RAMS	RUC 06/18	NAM 06/18	Cotton	Harrington	Harrington	LEAF-3	MYJ (2)	KF (1)
TOTAL ACTIVE MEMBERS		29								ARW - 19	NAM - 14	NAM - 28	FERRIER - 7	GFDL - 8	GFDL - 8	NOAH - 27	MYJ - 12	NONE - 19
										NMM - 8	RUC - 13	GFS - 1	LIN - 6	RRTM - 8	DUD - 8	LEAF - 1	YSU - 9	KF - 10
										NMMB - 1	GFS - 1		GODD - 4	CAM - 6	CAM - 6	NMM - 1	QNSE - 8	
										RAMS - 1	LAPS - 1		THOMP - 4	GODD - 6	RRTMG - 6			
													MORRIS - 4	HARR - 1	HARR - 1			
													WSM - 3					
													COTTON - 1					

- Model differences fall naturally from sourc diversity
  - NWS offices usually use NAM ICs, RENCI RUC
  - NWS offices usually use cheaper physics, F does not
  - NWS offices usually use WRF NMM, RENC not
- Partnership accomplished by having com spatial and temporal attributes of model o
  - Regardless of model start time, run out to 1 for morning run, 0000 UTC for evening run.
  - Regardless of native domain, be sure it spa common grid featured below.
  - In post-processing, be sure to produce com requested fields (see below left)
  - Begin model run such that it finishes by an upon time, that time chosen based on NWS requirements.
- COMBINED WE CAN CREATE MORE ENSEMBLE MEMBERS THAN ANY ONE GROUP ALONE

limited subsets of del output

- entional fields only
- lated Precipitation,
- ry Layer Height
- temperature
- dewpoint
- er winds
- el Pressure
- ave Radiation
- ed Radar Reflectivity at d 4km above gronud level

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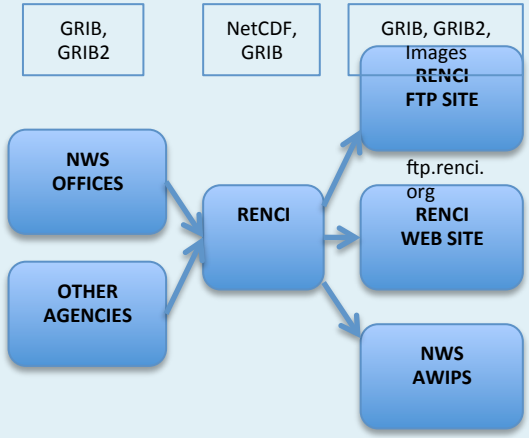
F O       A H T D U V C C M S R R
H F       P P M P 1 1 A I S W E E
R S       C B P T 0 0 P N L R F F
  E       P L 2 2 M M E   P A 1 4
  T         M M       D K K

0 12    CAE  1 1 1 1 1 1 1 1 1 1 1 1
0  3    GSP  1 1 1 1 1 1 1 1 1 0 1 1
0  3    ILM  1 1 1 1 1 1 1 1 1 1 1 1
0  6    LWX  1 1 1 1 1 1 1 1 1 1 1 1
0 12  NCEP0  1 0 1 1 1 1 1 1 1 1 1 1
0 12  NCEP1  1 0 1 1 1 1 1 1 1 1 1 1
0 12  NCEP2  1 0 1 1 1 1 1 1 1 1 1 1
0 12   NSSL  1 1 1 1 1 1 1 1 1 1 1 1
0  6    RAH  1 1 1 1 1 1 1 1 1 1 1 1
0  6    RNK  1 1 0 0 1 1 1 1 1 0 0 1
0  6   SRNL  1 1 1 1 1 1 1 1 1 1 0 0
0  6  RENCI0  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI10  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI11  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI12  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI13  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI14  1 1 1 1 1 1 1 1 1 1 1 1
0  6 RENCI15  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI1  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI3  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI4  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI5  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI6  1 1 1 1 1 1 1 1 1 1 1 1
0  6  RENCI7  1 1 1 1 1 1 1 1 1 1 1 1
```

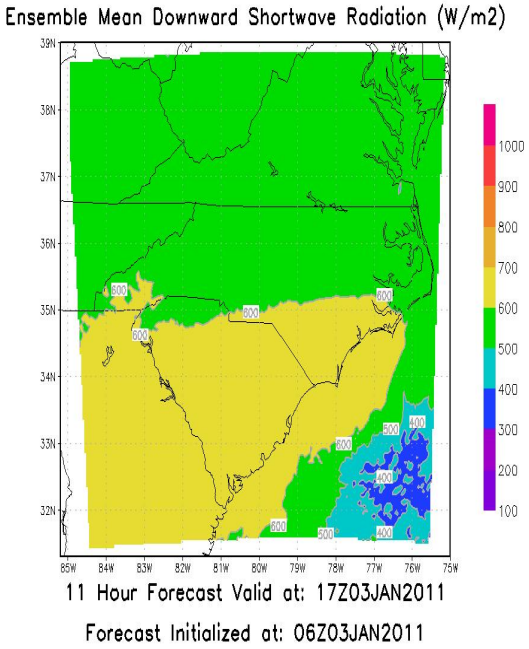
- Exchange limited subsets of entire model output
  - Each agency uploads their output onto an FTP site.
  - RENCI retrieves all files (GRIB or GRIB2), unzips, converts to GRIB-1, and interpolates to common domain.
  - Model forecasts (regardless of initialization) complete at about 8AM/ PM
  - Combination of runs takes place at 9 AM/PM
  - Ensemble output available at 9:30 AM/ PM (1330 UTC/0130 UTC

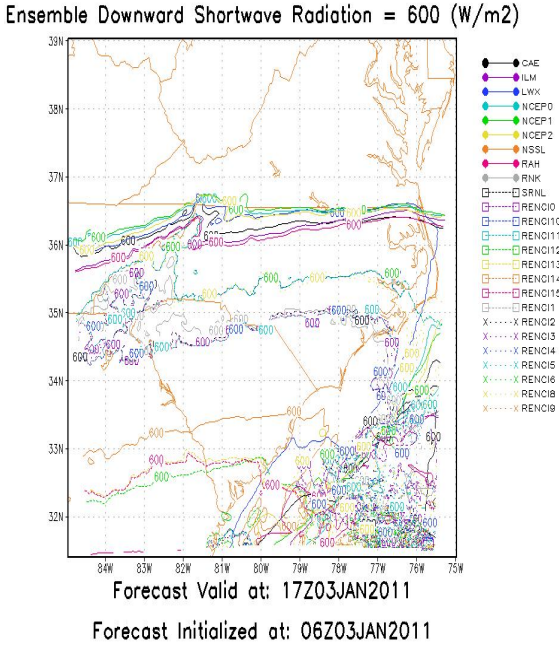


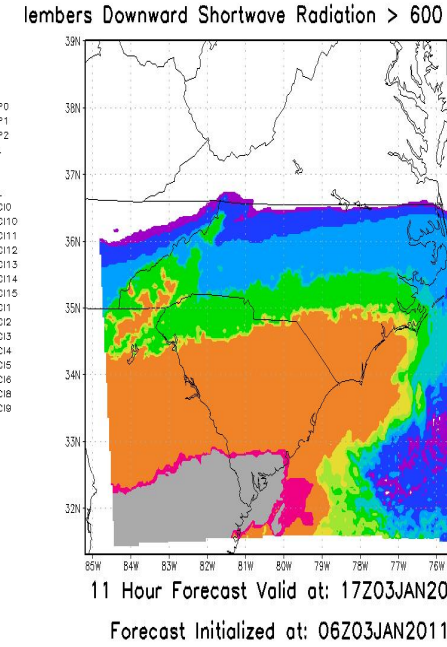
Ensemble Status

DateTime	
8/6/2010 2:51:36 PM	BEGIN GRIB CREATION RUN 14
8/6/2010 2:51:34 PM	BEGIN WRFOUT NETCDF CREATION RUN 14
8/6/2010 2:49:08 PM	BEGIN GRIB CREATION RUN 13
8/6/2010 2:49:06 PM	BEGIN WRFOUT NETCDF CREATION RUN 13
8/6/2010 2:46:52 PM	BEGIN GRIB CREATION RUN 12
8/6/2010 2:46:52 PM	BEGIN WRFOUT NETCDF CREATION RUN 12
8/6/2010 2:44:33 PM	END RUC REAL
8/6/2010 2:43:31 PM	BEGIN RUC REAL
8/6/2010 2:42:30 PM	END NAM REAL
8/6/2010 2:40:36 PM	BEGIN NAM REAL
8/6/2010 2:40:30 PM	END RUC METGRID
8/6/2010 2:39:08 PM	BEGIN RUC METGRID
8/6/2010 2:39:08 PM	END RUC UNGRIB
8/6/2010 2:38:05 PM	BEGIN RUC UNGRIB
8/6/2010 2:38:04 PM	END RUC DOWNLOAD

ut files are in GRIB and GRIB2 format
x files (as per NCEP) also available
ean of all members
pread of all members
aximum value of all members
nimum value of all members
ercent exceeding threshold
vidual members also available
r the 2D fields mentioned earlier
e mechanisms of access
TP SITE ftp.renci.org
EB PAGE www.sensordatabus.org/wrf
WIPS (Josh Watson, NWS ER HQ)
acity exists to convert files to requested
at



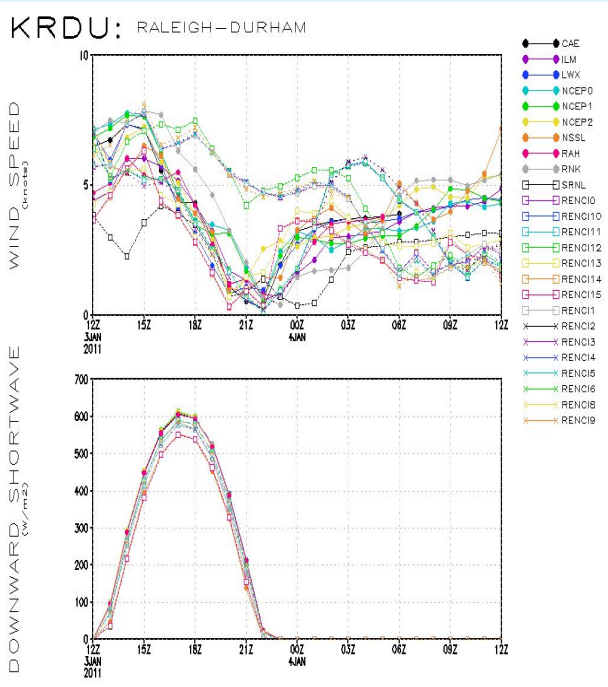




: RALEIGH–DURHAM

AM

FCPRS	TEMP	DEWP	WSPD	WDIR	PRCP	SWRAD
HPA	F	F	KTS	DEG	IN	W/M2
1007.0	25.7	22.0	2.4	175.4	0.00	0.0
1007.6	29.7	21.0	3.3	146.7	0.00	26.4
1008.7	35.7	19.5	5.5	206.6	0.00	191.1
1005.0	39.3	18.9	8.8	202.2	0.00	309.6
1006.9	42.0	21.8	9.9	227.0	0.00	276.7
1005.0	45.1	24.5	10.9	217.3	0.00	422.9
1004.8	47.3	26.4	10.5	222.0	0.00	352.4
1004.0	48.8	26.8	9.7	229.0	0.00	371.9
1001.8	49.1	28.5	10.2	227.9	0.00	274.4
1001.2	48.2	28.7	9.2	221.7	0.00	144.6
1001.4	44.6	30.3	6.3	220.9	0.00	11.9
1001.2	39.8	31.2	4.7	222.9	0.00	0.0
1000.9	39.2	31.1	5.6	236.7	0.00	0.0



- The initial goal in creating this model ensemble is to provide advanced and detailed weather forecast information to all participants. This includes operational weather support including improved precipitation forecasts and fire weather support (prescribed burns and wild land fires).
- For wind energy applications, more accurate wind forecasts, especially in coastal areas, can help support successful wind energy and energy infrastructure operations.
- For solar, improved cloud cover forecasts can greatly improve the management of grid operations for impacts to solar powered local and/or home power systems. In particular, grid operations can be maintained properly as incoming or developing predicted clouds attenuate the energy from the sun, thus decreasing power generation. Both direct beam and total irradiance can be evaluated with a number of forecasting tools and radiation data. Advanced warning of these impacts can be used to delineate alternative power resources and can expand the ability to generate power over a wide region rather than through large power plants alone.
- The sun and wind are largely untapped power resources in the Southeastern US, yet, the need for power companies to diversify their portfolios and remain environmentally in compliance remain “hard” drivers for the development of these resources.

- Many thanks to all the partners in th
  - National Weather Service Forecast C
    - Raleigh, NC
    - Wilmington, NC
    - Blacksburg, VA
    - Sterling, VA
    - Greenville-Spartanburg, SC
    - Columbia, SC
    - CIN
    - Sea level Pressure
  - National Centers for Environmental P - EMC
  - National Severe Storms Laboratory
  - Department of Energy - SRNL