16th Weather Squadron

Fly - Fight - Win

Air Force Weather Ensembles

Evan Kuchera
Fine Scale and Ensemble Models
16WS/WXN

Background

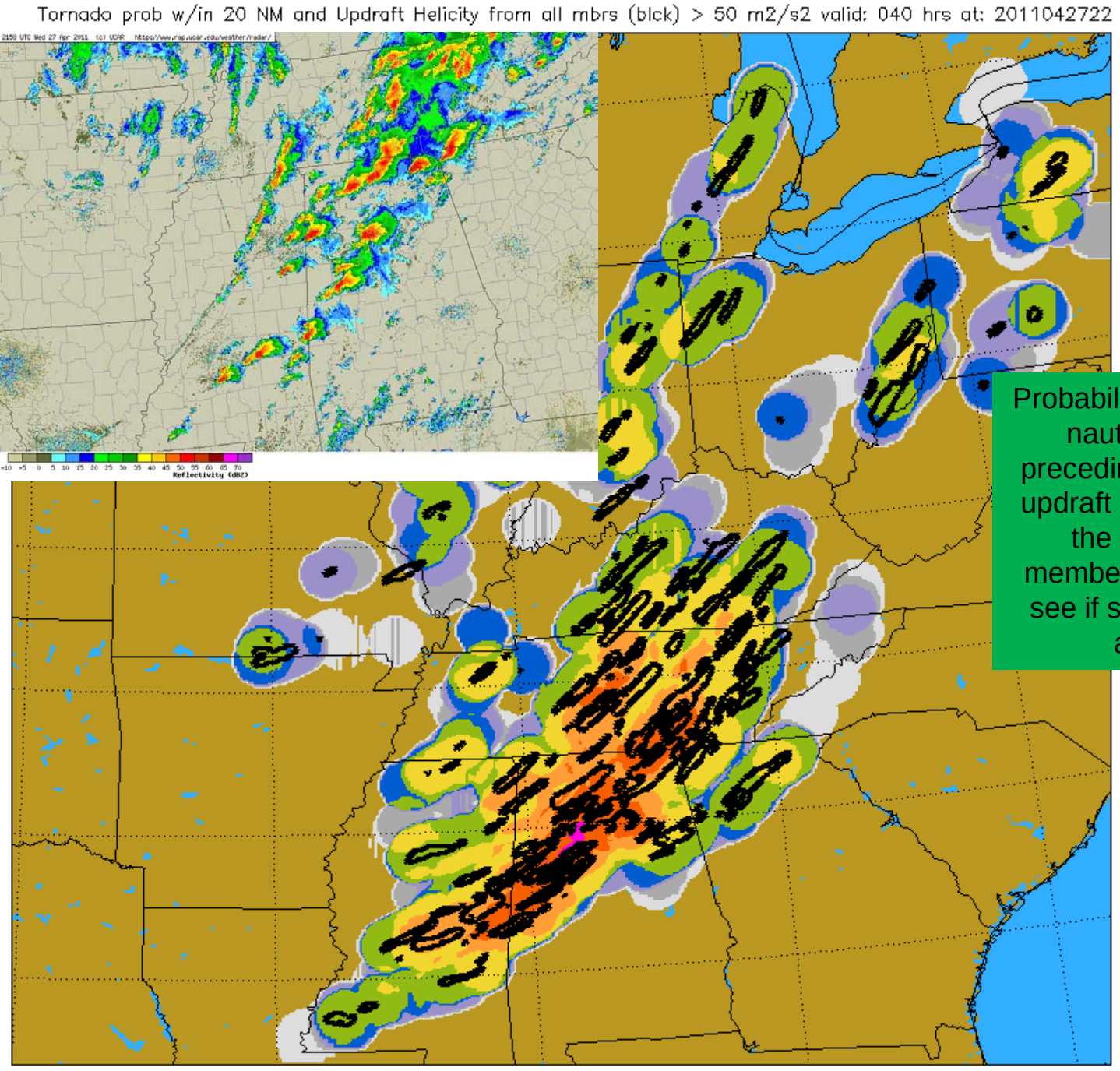
- Air Force Weather **Decision Support**:
  - Weather impacts on specific missions
    - Bombs on target!--Mission planners consult humans
  - Mitigation from weather threat--Protect life and property
    - Humans issue advisories/watches/warnings for specific locations for pre-defined criteria (i.e. “severe” weather)
  - **Modeling goal:** Provide probabilistic information in decision space as much as possible
    - Match weather variables to pre-defined warning criteria
    - Allow mission data to interact with weather data
    - Ensure any output is useful, easy and quick to comprehend

AFW Ensemble Prediction Suite (AFWEPS)

- **Global Ensemble Prediction Suite (GEPS)**
  - Combination of GFS, GEM, and NOGAPS ensembles
  - Post-processed at AFWA
- **Mesoscale Ensemble Prediction Suite (MEPS)**
  - 10 members of WRF-ARW with unique physics configurations
  - Initial conditions: deterministic UM, GFS, GEM, and NOGAPS
  - 20 km northern hemisphere and 30 km tropical stripe domains to 144 hours run once per day with online dust
  - Four re-locatable 4 km domains run once per day to 54 hours (1600 by 1600 km) with hourly output; online dust in Asia

Current Efforts

- Air Force Weather Current Efforts:
  - Convection allowing ensembles (4 km resolution)
    - Weather uncertainty due to convection is primary problem
    - Becky Selin poster
  - Algorithms to diagnose sub-grid scale probabilities
    - High-impact phenomena are still sub-grid even at 4 km
  - Inclusion of dust online inside model
    - Dust from convection is #1 problem to solve
    - Also working on dust source regions and uncertainties (Sandra Jones talk)
  - Ensemble regional climatology
    - Same suite of probabilistic products with multi-year WRF runs downscaled from CFSR dataset



Probability of a tornado within 20 nautical miles during the preceding hour. Black lines are updraft rotation (supercell) from the individual ensemble members. This can be used to see if supercells will be strong and/or long-track

4 km MEPS PEP

Huntsville, AL—multiple tornadoes from 20-23Z

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WARNING: Check Cycle Time! 4km may not be current
To change location, enter new ICAO in the URL before the .html (must be within 4 km domain!)

HUNTSVILLE	**34.6500 lat**	**-86.7833 lon**	**191 meters elevation**
MODEL BOX INFO	**34.6566 lat**	**-86.8018 lon**	**186 meters elevation**

4 km MEPS APR 27/06Z — **WED 27** — **THR 28**

Surface winds	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z
Winds GT 25 KT	76	81	90	97	91	71	89	74	90	73	83	83	83	94	95	92	80	47	43	60	17	3	29	6	1	12	8	3	0	0	14	14	19	48	19	23	9	1	0	0	0	0	0
Winds GT 35 KT	37	31	63	68	36	36	77	63	73	64	68	45	53	69	55	58	44	4	14	4	1	0	2	1	0	1	1	0	0	0	2	2	1	3	1	2	0	0	0	0	0	0	0
Winds GT 50 KT	1	7	5	5	7	10	16	11	32	37	25	19	20	28	13	10	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winds GT 65 KT	0	1	0	0	0	2	3	2	5	6	5	6	8	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Precipitation	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z
Precip GT 0.10 IN in 6 hr	12	12	12	2	26	36	52	62	63	71	80	90	96	96	95	92	92	83	82	64	42	20	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Precip GT 2 IN in 12 hr	-99	-99	-99	-99	-99	-99	11	22	26	28	28	42	43	53	66	66	59	55	47	21	17	16	16	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRZR GT 0.01 IN in 3 hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN GT 0.1 IN in 6 hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN GT 2 IN in 12 hr	-99	-99	-99	-99	-99	-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN GT 6 IN in 24 hr	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thunderstorms	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z
Lightning within 20 NM	1	7	1	15	30	38	49	66	92	80	84	89	95	85	61	33	19	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
1.00 in hail within 20 NM	0	0	0	0	0	2	17	14	34	22	35	43	47	45	31	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.00 in hail within 20 NM	0	0	0	0	0	0	1	0	3	4	2	6	7	12	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tornado within 20 NM	0	0	0	0	5	10	8	8	7	5	19	33	26	23	16	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Visibility	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z
Visibility lt 5 miles	10	7	5	5	24	26	50	43	32	13	17	28	29	32	18	4	5	8	11	15	14	20	14	18	12	8	3	2	1	1	1	1	0	0	0	0	1	2	4	5	8	10	13
Visibility lt 3 miles	3	2	1	1	18	20	43	32	23	5	8	14	14	20	10	1	2	3	5	7	6	10	6	8	5	3	1	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	6
Visibility lt 1 mile	1	0	0	0	2	5	9	11	6	0	0	8	7	1	1	0	0	0	1	2	1	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Others	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z	18Z	19Z	20Z	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	06Z
Mean Temperature (F)	69	70	71	72	71	70	69	71	73	75	73	73	73	71	68	67	64	62	60	58	57	55	54	52	52	53	55	58	60	63	65	66	67	67	66	65	62	59	57	57	55	55	54
Mean wind speed (kts)	19	21	22	22	21	18	18	16	20	19	17	17	21	19	17	16	15	14	13	11	10	11	12	10	8	10	10	10	9	9	10	11	13	14	13	12	8	7	7	7	6	5	5

Assuming hourly probabilities are independent (no correlation), there was a 85% chance of a tornado within 20NM of Huntsville over the 15Z-03Z period.

JPADS and Ensembles

"limit risk exposure—minimize cost"

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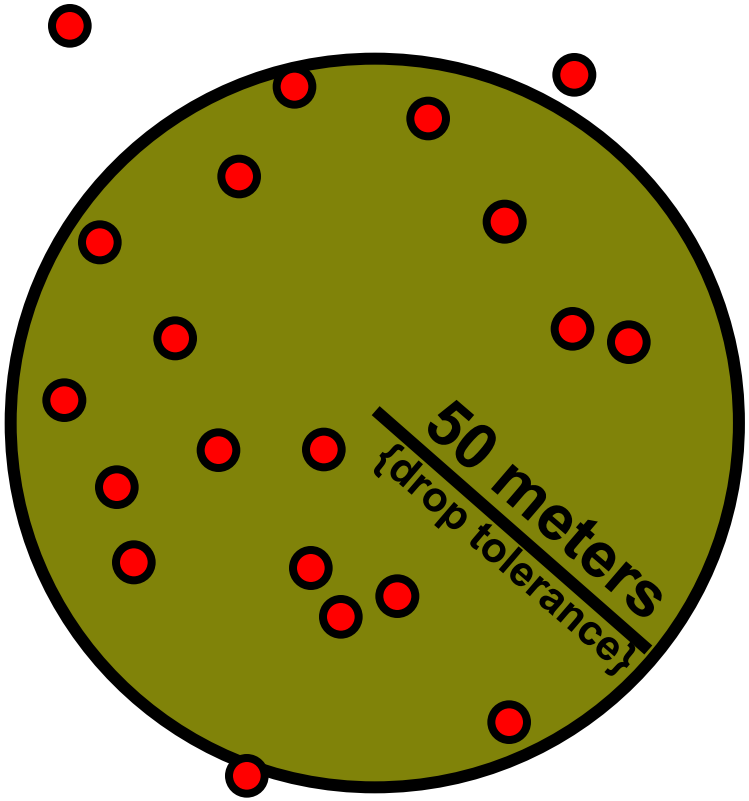
- **Weather/mission interaction example**
  - **Currently, must fly pre-mission over drop area and take a measurement of winds—model accurate enough on average, but outlier forecasts problematic**
  - **With ensembles, decision makers can see if measurement needs to be taken based on uncertainty *that day***
  - **EX→ 85% of simulated drops for 21 May 2011 land in acceptable range—acceptable risk to skip pre-mission—cost savings and improved safety**



4 km vs 12 km Proof of Concept
(Deterministic)

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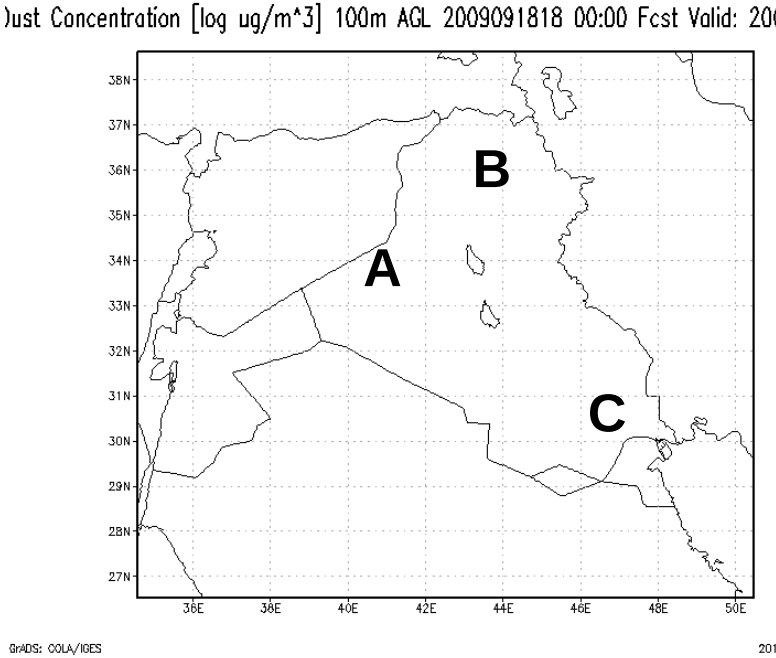
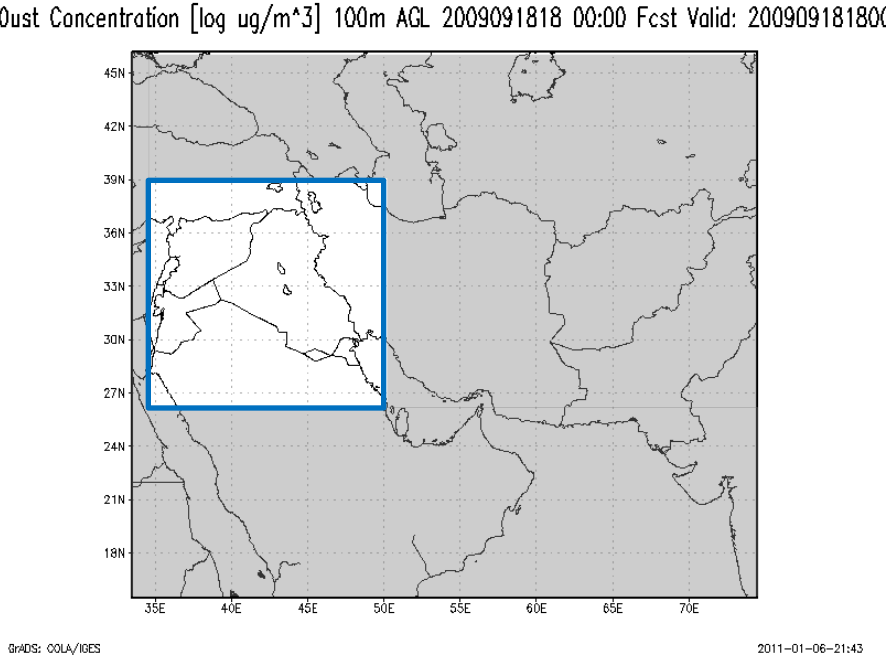




4 km proof of concept #1

12 km proof of concept #1

A--Convective activity mid-simulation (not in 12 km)
B—Mesoscale wind perturbation (in both 4 km and 12 km)
C– Sea breeze front from Persian Gulf (in both 4 km and 12 km)

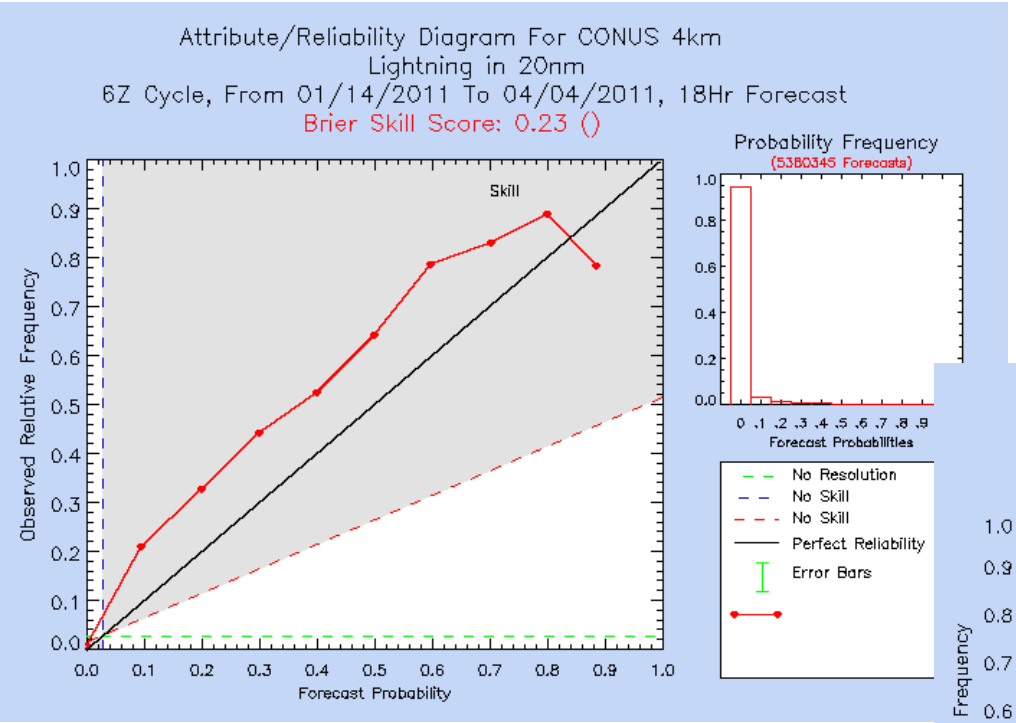
Partnering with Users

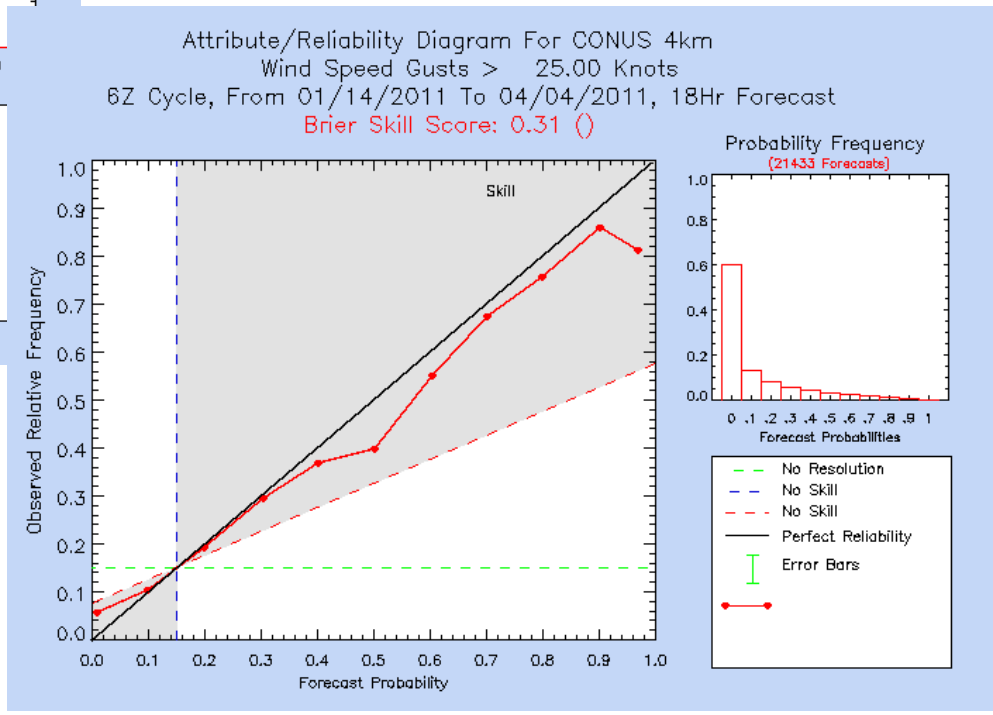
- **Air Force Weather Dialog with users:**
  - **Prototype web page with products in real-time**
    - **Rapid prototyping when users make requests**
    - **Users prefer to judge utility for themselves—objective stats or theoretical arguments not compelling**
  - **Site visits for us to learn what the user needs are, and to explain what we have to offer**
  - **Solicit feedback and continue the conversation**

Partnering with users

- **Feedback from users of test information:**
  - **21 OWS (Europe):** ***"We have started integrating some of your products into our daily forecast process and they are kicking ass. I/we are most impressed with this…Do we sound excited? We are!"***
  - **51 OSS/OSW (South Korea):** ***"Looks like the ensemble nailed the rain/snow event we had today. The <1 mile Vis probability was instrumental in deciding if the first goes of the day should be scrubbed which included the 7th AF CC flying."***
  - **28 OWS (SW Asia):** ***"However, I applaud the efforts of the Ensemble folks and their ability to do, whatever they are doing to the model (feeding it crackers?) to make it more accurate as to severe weather potential…their model physics are proving to be a more and more valuable component over the model suites we currently use."***
  - **25th OWS (SW US):** ***"…we had a remarkable performance improvement during the convective season for the flight most affected by convection. The capability that the 06Z model run presented for us during the monsoon allowed us to issue the necessary WWA's with more lead time…"***
    - ***Metrics: 16% increase in warning forecast skill, 24% decrease in false alarms with ensembles compared to without ensembles***

Verification





Future

- Moving diagnostics within WRF itself
  - Allows for improved temporal resolution for key variables without outputting the entire 3-D dataset
  - Radar reflectivity, simulated satellite, accumulated snow/ice/rain, lightning, etc
- Migration to Unified Post Processor
  - Community inputs for diagnostic algorithms, statistical corrections to datasets
- Ensemble post-processing
  - Create master database of all ensemble members
  - Users can do joint probabilities, any time period of choice, etc

Summary

- Air Force Weather is actively pursuing operational ensemble systems
  - Focus on first 48 hours, convective scale, dust inclusion
- Development goal is to improve Air Force decisions
  - Information presented in decision space
  - Integrate with non-weather variables for optimization
- Continuous dialog with users
  - Ensures buy-in, relevance to mission
  - Improves final products