The 557th Weather Wing

Ensemble efforts for the US Air Force

Evan Kuchera and Scott Rentschler
16th Weather Squadron

Global Ensemble Development

Background

- **USAF made a strategic decision to partner with the United Kingdom's Met Office to run a local instantiation of their Unified Model (UM) driven by USAF-acquired observations**
  - **The AF configuration of the model is called the Global Air-Land Weather Exploitation Model (GALWEM)**
- **Performing the data assimilation locally enables AFW to produce a global ensemble (GE) tailored to its user needs**
  - **UM DA is a hybrid ETKF/4DVAR technique; ensemble ICs come from the output of the DA suite**

Global Ensemble Development

Background

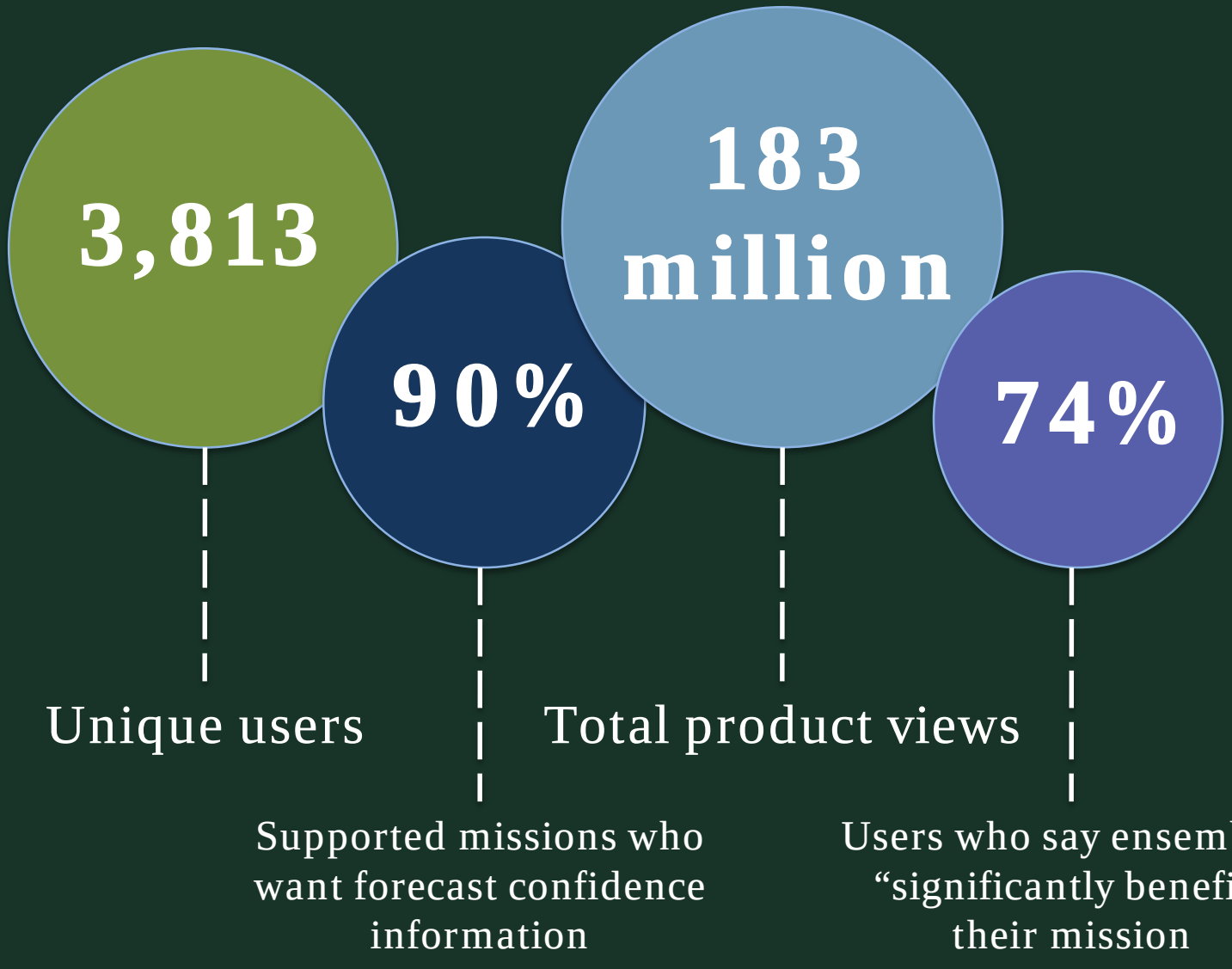
- **In addition, USAF made a strategic decision to mimic other ensembles in the National Earth System Prediction Capability's (ESPC) operational suite with GALWEM-GE**
  - **21 members each from NOAA/NCEP, CMC, FNMOC**
  - **Half-degree output, 384 hour forecasts, 00/12Z cycles**
  - **USAF product line called "GEPS"**
    - **Global Ensemble Prediction Suite**

Q: What if we add GALWEM-GE to GEPS? (CRPS)

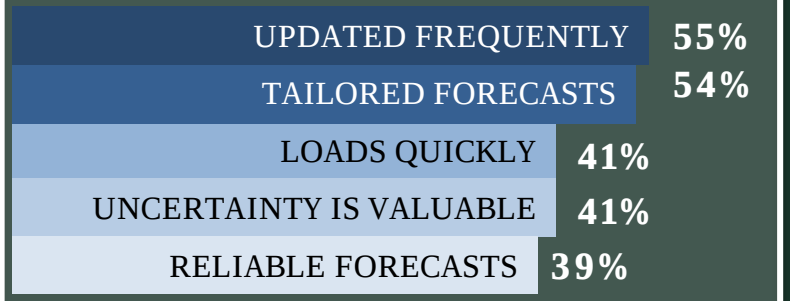
Green: Top-ranked
Yellow: Second-ranked

Variable and Forecast Hour	GEPS	GEPS w/GALWEM
850T 120	0.67	0.61
850T 240	1.00	0.94
SLP 120	0.94	0.87
SLP 240	1.90	1.84
850WS 120	2.10	2.00
850WS 240	2.70	2.60
250WS 120	4.30	4.20
250WS 240	6.60	6.40
500GPH 120	9.37	9.20
500GPH 240	20.20	19.90
All-Variable Average Difference	–	-4.4%

AFWEPS SURVEY AND 2016 USAGE SUMMARY

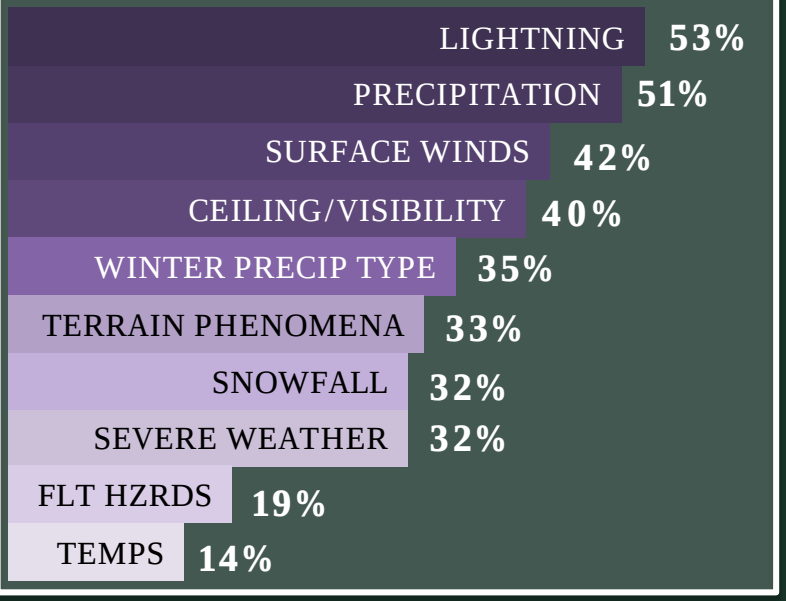


WHY DO YOU USE ENSEMBLE PRODUCTS (% SIGNIFICANT REASON)

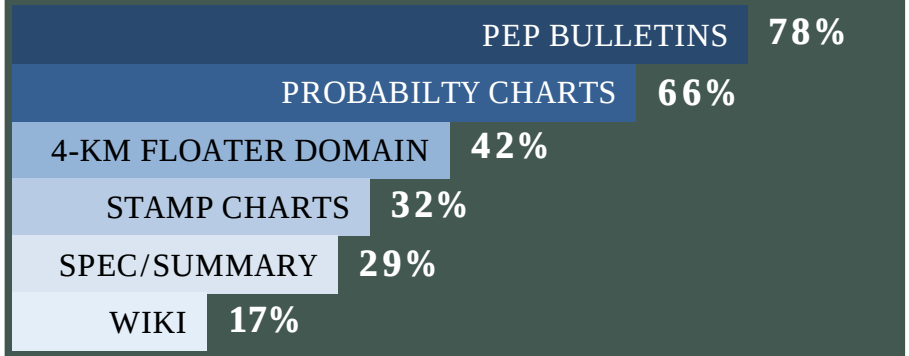


HOW SUPPORTED MISSIONS DESIRE TO RECEIVE FORECAST DECISION INFORMATION

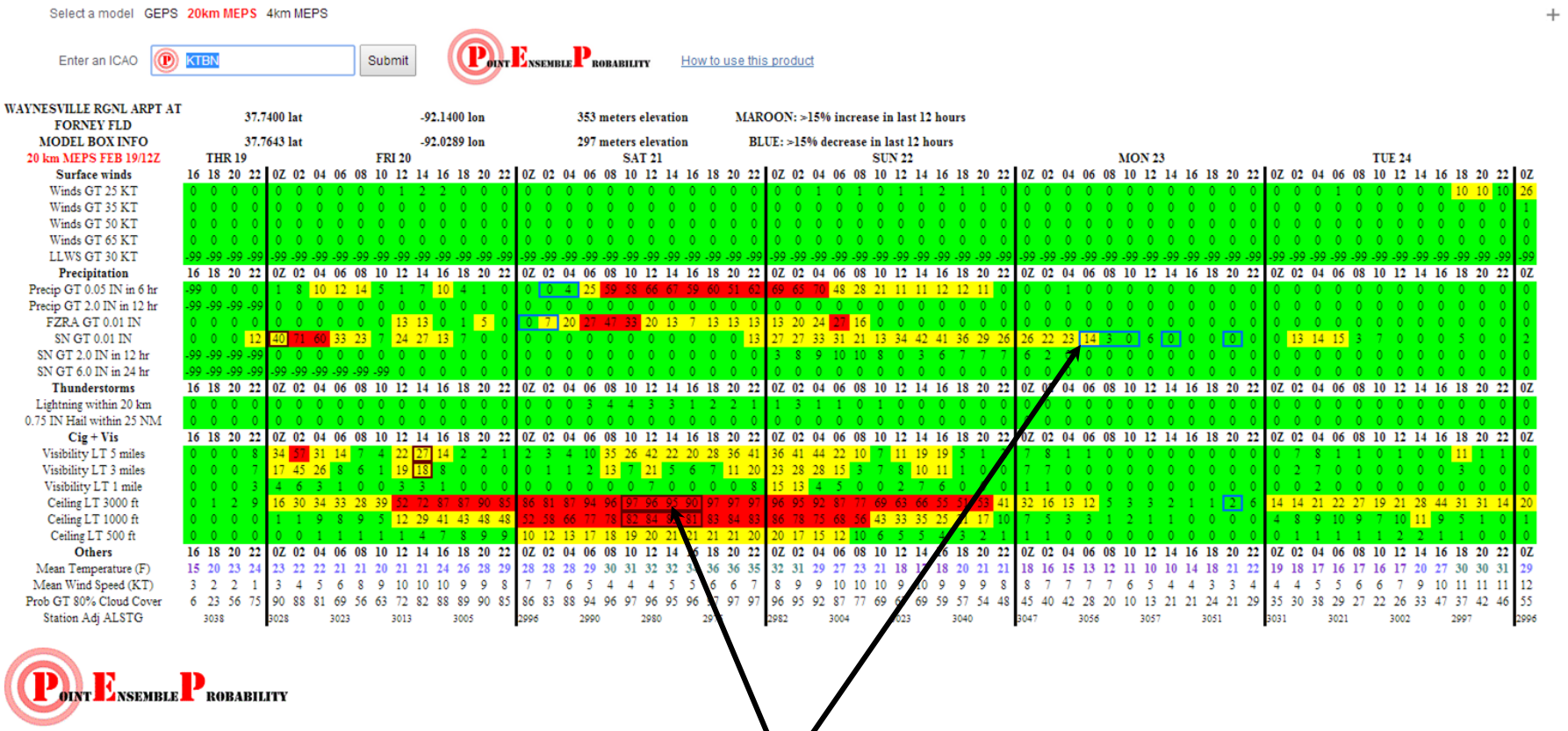
UTILITY OF 4-KM MEPS COMPARED TO OTHER TOOLS (% SIGNIFICANT EXTRA)



HOW USEFUL ARE THE PRODUCTS (% VERY USEFUL)



PEP bulletins



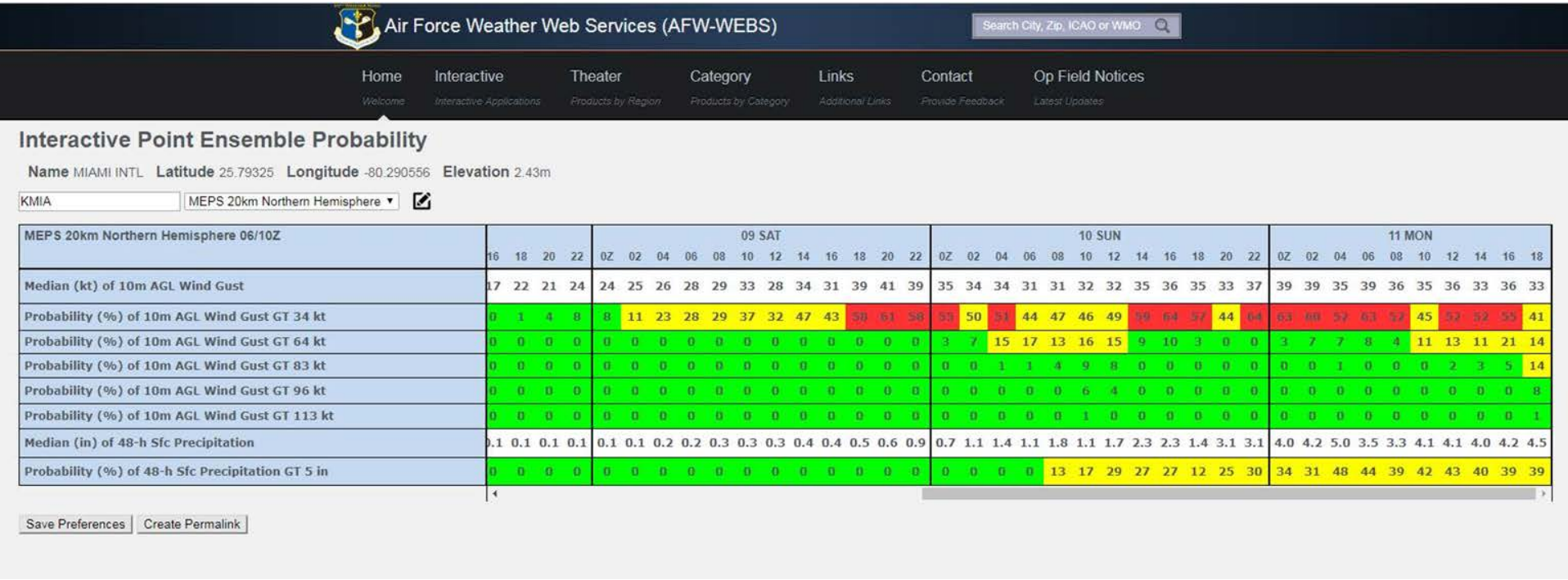
Color-coded probabilities through time with maroon or blue borders when the forecast has changed by 15% or more in the last 12 hours (6 runs). Meant to distinguish meaningful trends from random noise.

Data Exploitation

- Significant interest in USAF about more effectively "reasoning" with ensemble datasets to improve decision making
- Interactive PEP (next slide) prototyped to enable users to set their own probability thresholds
- Looking to a future where raw ensembles are databased in the cloud, and all post-processing is done as a user-requested service that can be called from other machine applications
  - How to define community standards for data storage and post-processing tools?

Data exploitation:

interactive Point Ensemble Probability (iPEP)



Air Force Weather Web Services (AFW-WEBS)

Search City, Zip, ICAO or WMO

Home (Welcome) | Interactive (Interactive Applications) | Theater (Products by Region) | Category (Products by Category) | Links (Additional Links) | Contact (Provide Feedback) | Op Field Notices (Latest Updates)

Interactive Point Ensemble Probability

Name MIAMI INTL **Latitude** 25.79325 **Longitude** -80.290556 **Elevation** 2.43m

KMIA | MEPS 20km Northern Hemisphere

MEPS 20km Northern Hemisphere 06/10Z	16	18	20	22	09 SAT 0Z	02	04	06	08	10	12	14	16	18	20	22	10 SUN 0Z	02	04	06	08	10	12	14	16	18	20	22	11 MON 0Z	02	04	06	08	10	12	14	16	18
Median (kt) of 10m AGL Wind Gust	17	22	21	24	24	25	26	28	29	33	28	34	31	39	41	39	35	34	34	31	31	32	32	35	36	35	33	37	39	39	35	39	36	35	36	33	36	33
Probability (%) of 10m AGL Wind Gust GT 34 kt	0	1	4	8	8	11	23	28	29	37	32	47	43	58	61	58	53	50	51	44	47	46	49	59	64	57	44	64	63	60	52	63	52	45	52	52	55	41
Probability (%) of 10m AGL Wind Gust GT 64 kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	15	17	13	16	15	9	10	3	0	0	3	7	7	8	4	11	13	11	21	14
Probability (%) of 10m AGL Wind Gust GT 83 kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	9	8	0	0	0	0	0	0	0	1	0	0	0	2	3	5	14
Probability (%) of 10m AGL Wind Gust GT 96 kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Probability (%) of 10m AGL Wind Gust GT 113 kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Median (in) of 48-h Sfc Precipitation	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.9	0.7	1.1	1.4	1.1	1.8	1.1	1.7	2.3	2.3	1.4	3.1	3.1	4.0	4.2	5.0	3.5	3.3	4.1	4.1	4.0	4.2	4.5
Probability (%) of 48-h Sfc Precipitation GT 5 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	17	29	27	27	12	25	30	34	31	48	44	39	42	43	40	39	39

Save Preferences | Create Permalink

- **Choose your product, thresholds, units, etc.**
- **Create powerful joint probabilities (e.g. snow AND wind)**
- **User-defined RYG thresholds (tailored risk tolerance)**

Supplementary Material

Q: How does GALWEM-GE compare to the other ESPC global ensembles using CRPS?

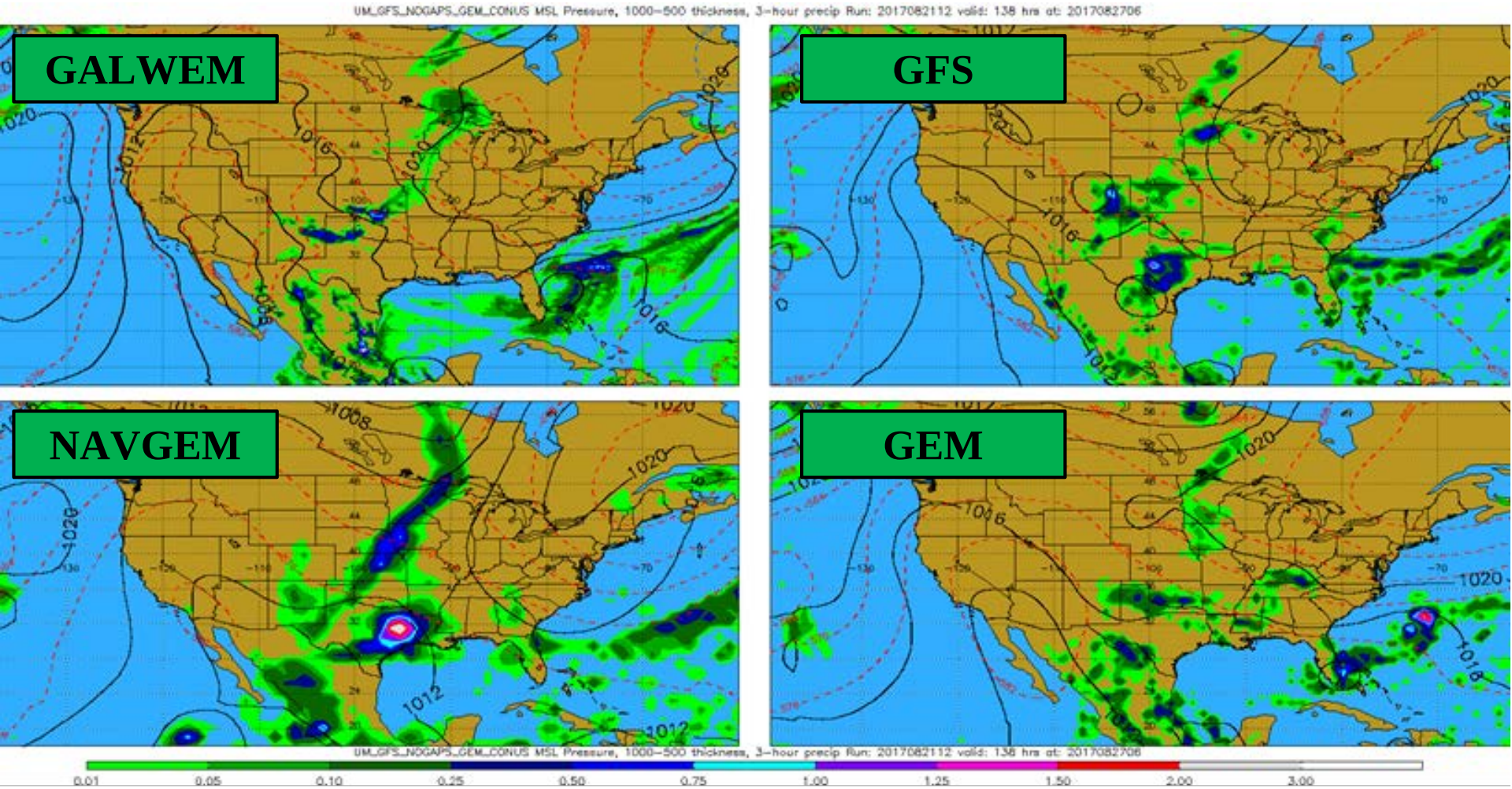
Green: Top-ranked
Yellow: Second-ranked
Orange: Third-ranked
Red: Fourth-ranked

Variable and Forecast Hour	GALWEM	GEM	GFS	FNC
850T 120	0.62	0.75	0.65	0.84
850T 240	0.96	1.10	1.00	1.16
SLP 120	0.86	1.10	1.00	1.22
SLP 240	1.80	2.00	2.00	2.10
850WS 120	2.13	2.21	2.24	2.40
850WS 240	2.91	2.96	3.00	3.00
250WS 120	4.42	4.39	4.52	5.00
250WS 240	6.70	7.03	7.16	7.50
500GPH 120	8.70	9.80	9.80	11.80
500GPH 240	20.10	21.00	22.30	22.90
All-Variable Average Difference	–	**9.3%**	**7.3%**	**19.6%**

Q: What if we exclude the lowest performing ensemble? (CRPS)

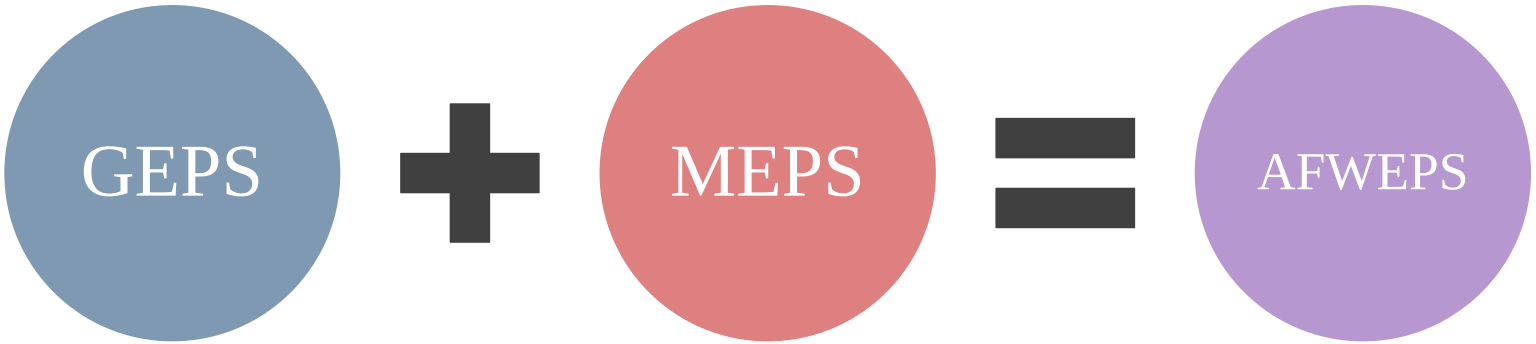
Variable and Forecast Hour	GALWEM/GFS/GEM	GALWEM/GFS/GEM/FNC
850T 120	0.57	0.61
850T 240	0.93	0.94
SLP 120	0.84	0.87
SLP 240	1.78	1.84
850WS 120	1.98	2
850WS 240	2.79	2.6
250WS 120	4.01	4.2
250WS 240	6.57	6.4
500GPH 120	8.74	9.2
500GPH 240	20.16	19.9
All-Variable Average Difference	-	**1.4%**

Deterministic Models
Hurricane Harvey Remnants

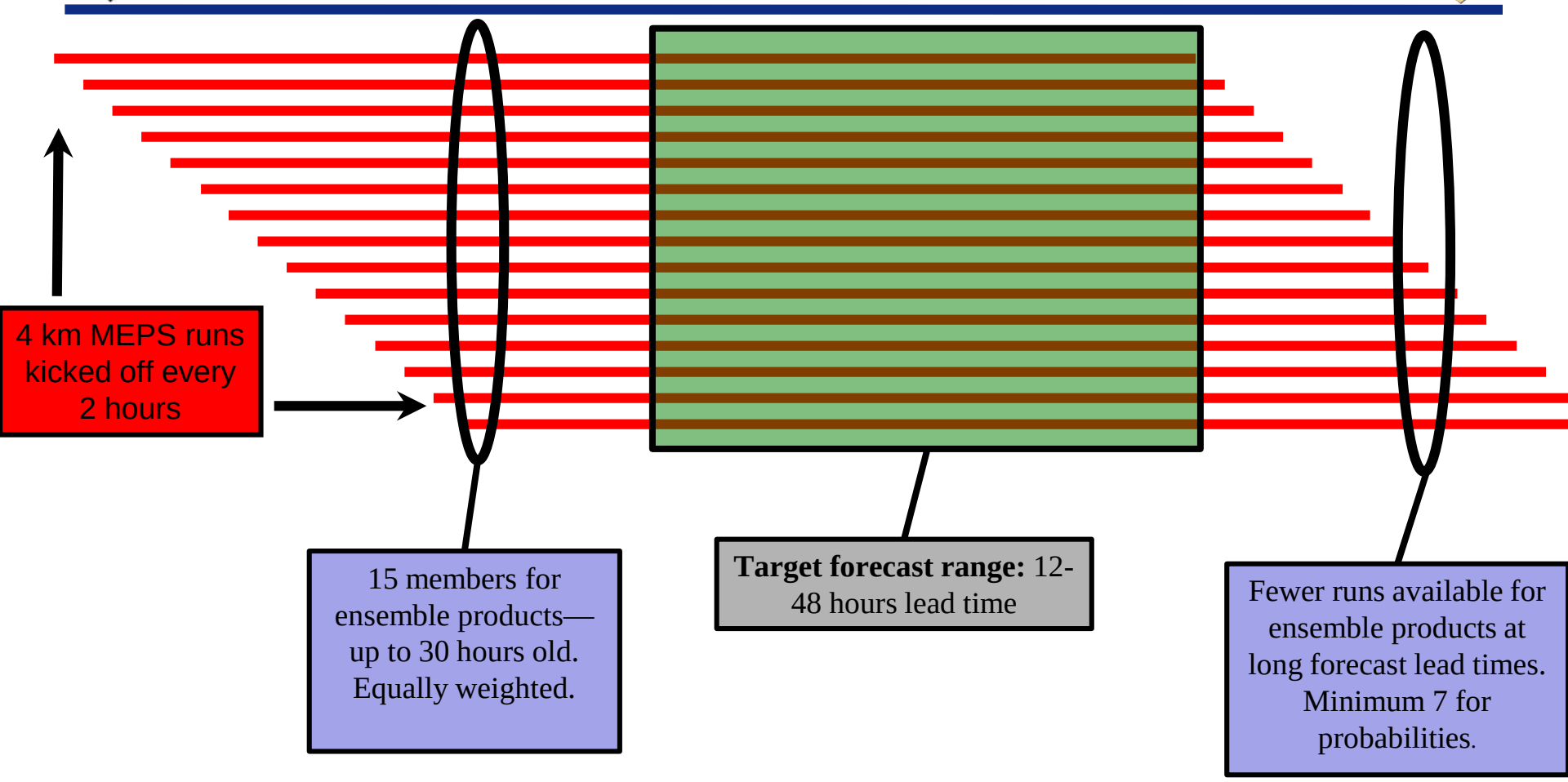


AFW Operational Ensembles

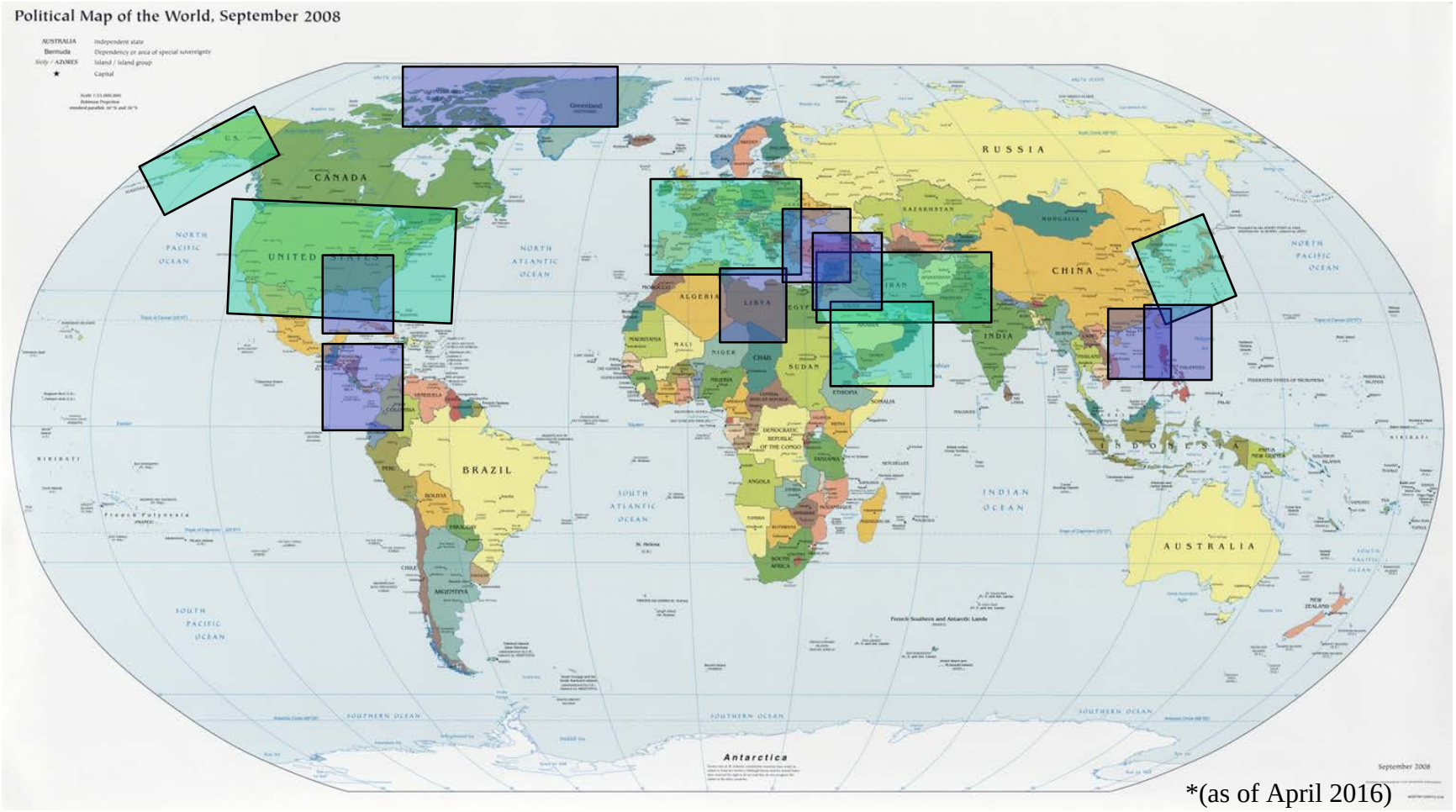
- **Global Ensemble Prediction Suite (GEPS)**
  - **63 members from NCEP, CMC, FNMOC**
- **Mesoscale Ensemble Prediction Suite (MEPS)**
  - **“Rolling” ensemble with 16 members of WRF-ARW with diverse initial conditions and physics**
  - **144 hour “global” at 20 km, 72 hour regional at 4 km**
    - **MAJCOMs own keys to 8 re-locatable domains**



Rolling Ensemble post-processing
4 km MEPS



USAF Regional Ensembles Current Ops



*(as of April 2016)

Green—static; Blue—relocatable (positions subject to change)
Each domain runs to 84 hours every two hours

Variables Unique to MEPS

Computed inside model code

Calculated every time step:

Tornado intensity
Hail size
Lightning frequency
Maximum surface wind and adjustment in convection
Surface Visibility
Precipitation Type (Rain, Freezing Rain,
Ice Pellets, Snow)
Snowfall Accumulation
Vertically Integrated Cloud Ice
Maximum Graupel Flux at -15C
Updraft Helicity
Maximum Updraft and Downdraft Velocity

RED = Unique to 4 km MEPS

Calculated at output time step:

Summer experiment design

June-August 2017 over Nevada/New Mexico

- **Download HRRR 1,2,3 hour forecasts as soon as possible each hour**
- **As soon as HRRR 1 hour forecast arrives, initialize 3 new runs**
  - **Member 1 (WDM6, YSU/MM5, NOAH LSM, RRTM): 11Z HRRR, 1 hour forecast**
  - **Member 2 (Thompson, MYJ/ETA, NOAH LSM, Goddard): 10Z HRRR, 2 hour forecast**
  - **Member 3 (Morrison, ACM2/MM5, PX LSM, RRTMG): 09Z HRRR, 3 hour forecast**
- **Generate time-lagged ensemble w/previous 3 cycles (12 members total)**
  - **3 km: 24 hours**
  - **1 km: 12 hours**
- **Provide ensemble imagery in real-time and ask forecasters to compare to operational tools they have (global models, 4 km ensembles updated with new global models, etc)**

Summer experiment design