Using Ensemble Models to Forecast Turbulence at the AWC

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Domestic & Caribbean Advisories and Warnings

AIRMETs

**Airmen's Meteorological Information
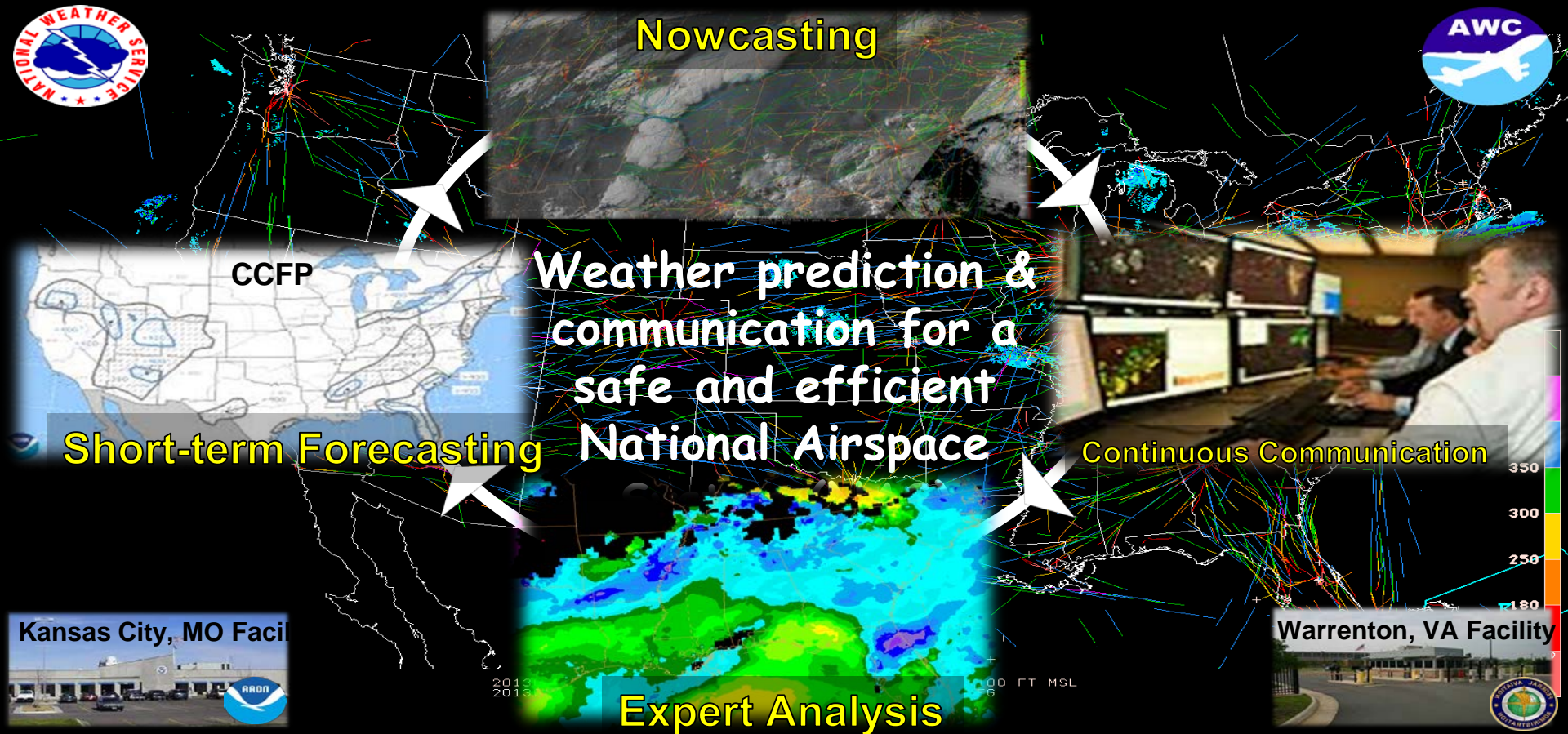Advisories to light aircraft & VFR pilots**

- Ceiling & Visibility
- Lgt/Mod Turbulence
- Lgt/Mod Icing
- Mountain Obscuration
- Surface Winds & Wind Shear
- Freezing Level

SIGMETs

**Significant Meteorological Information
Warnings concerning aircraft safety**

- Convection
- Severe Turbulence
- Severe Icing
- Widespread Duststorm & Sandstorms
- Volcanic Ash Cloud
- Tropical Cyclones

AWC Traffic Flow Management (TFM) and Impact Decision Support Services (IDSS)

Objectives

- Improve hazards forecasting and decision support at the AWC
- Traditionally have relied heavily on a deterministic model of choice and various diagnostics such as Ellrod, Ellrod-Knox, and GTG.
- Time constraints to production
- Forecasters rely heavily on experience and pattern recognition

Objectives

- Address NTSB report to NWS
- Among listed improvements and most wanted
  - Address Unique Characteristics of Helicopter Operation
  - General Aviation: Identify and Communicate Hazardous Weather
  - Specific to the NWS, Improve Forecast Consistency and Mountain Wave Acitivity
- Ensembles can lead to a consistent forecast process

Ensemble Post-Processor (EPP)
Objective: Tool to Build Specialized Applications

- Ensemble framework at center of NWS/NCEP NWP strategy & NextGen (advanced probabilistic forecasting)
- Looking for a tool to rapidly configure and view ensemble systems in the AWT (FY13 to present)

  - Experiment → Research, Explore, Interactive Use

  - Real-time → Automatic processing into NAWIPS (R2O)

- Software capable of adapting to various ensemble systems (e.g., variable membership, resolution)
- Software capable of supporting standard ensemble variables but more importantly, <u>mission specific</u> post-processing
- Applied ensemble research and R2O for aviation applications through the AWT
- Early beta stage for NCEP Short-Range Ensemble Forecast (SREF)

Ensemble Post-Processor Design Schematic
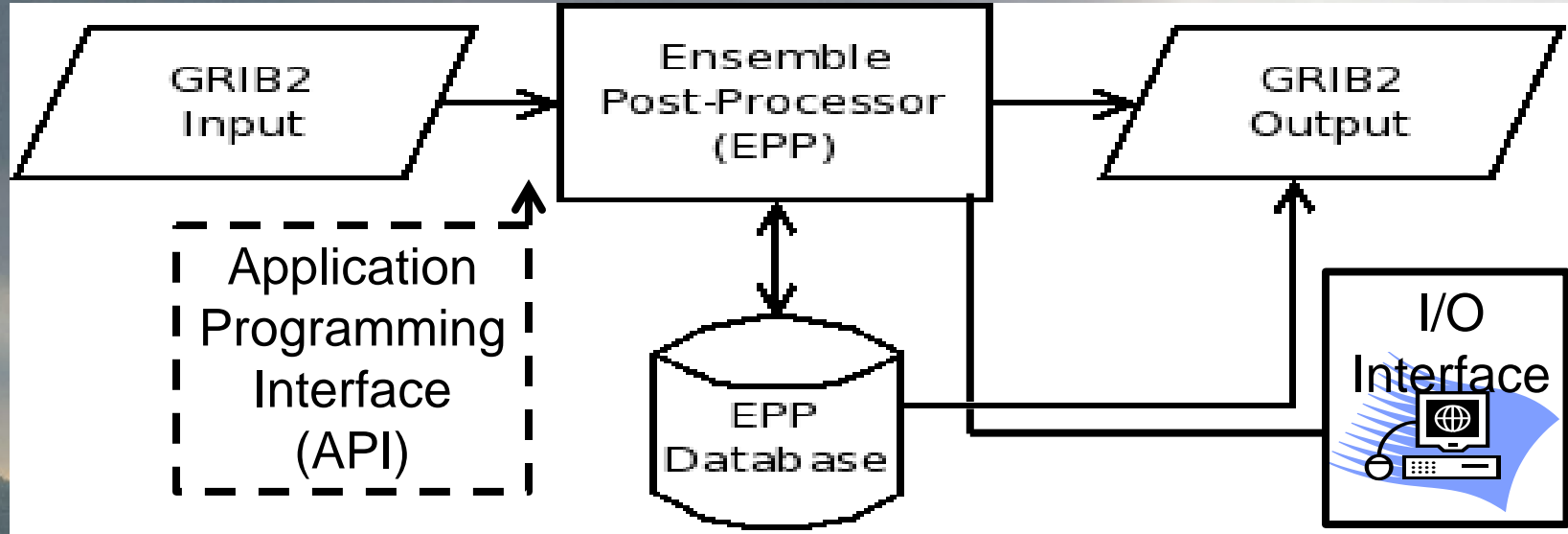
1. Define ensemble
2. Read GRIB2, store members, ensemble calculations
3. Two-way database interaction
4. Automatic or on-demand output to GRIB2 (for NMAP; AWIPS-2)
5. Web real-time interrogation and display
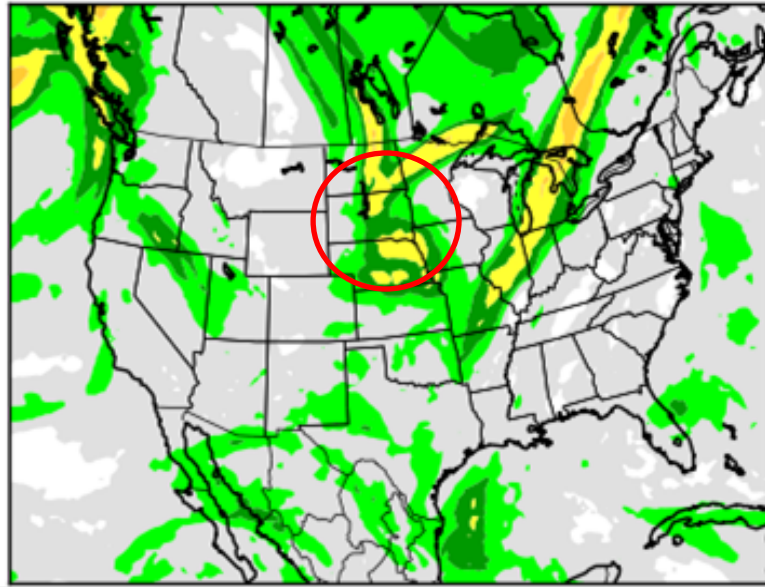
Clear Air Turbulence Guidance

- Clear air turbulence algorithm in the EPP
- Uses a multi-diagnostic approach
- 3D Isobaric levels on 40-km grid
- 21 diagnostics above 500 mb (~FL180) and 8 diagnostics below
- Calculated on the 21-members of the ensemble

Clear Air Turbulence Guidance

- Result is a relative frequency ("probability") of weighted diagnostics across all predictors and ensemble members
  - Currently equal weights
  - Future optimization/calibration
- Data displayed in N-AWIPS
  - Available in real-time operationally and in our testbed

Clear Air Turbulence Guidance

Probability of CAT above FL200, 6hr Forecast Valid at 2100 UTC 20140820

Clear Air Turbulence Guidance

CAT Probability2014070209f06 Level: 500-200mb (> FL180)
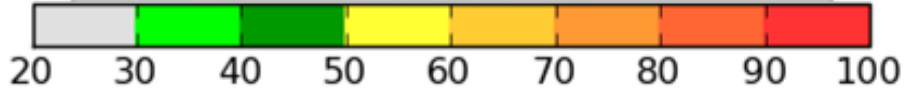
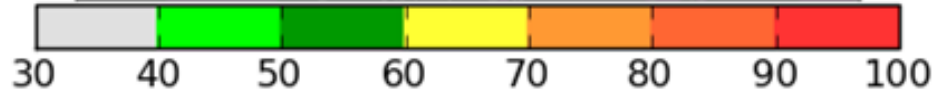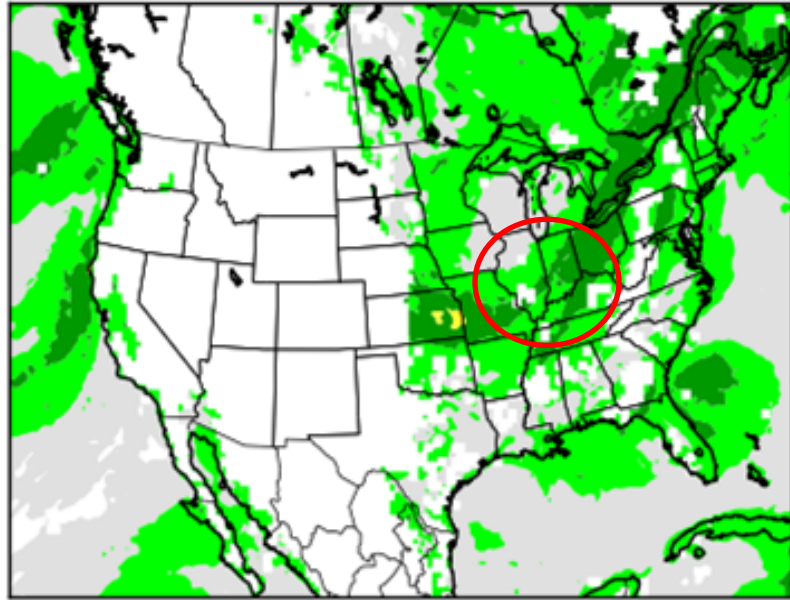**Upper level guidance 6-hr Fcst Valid at 1500 UTC 20140702**

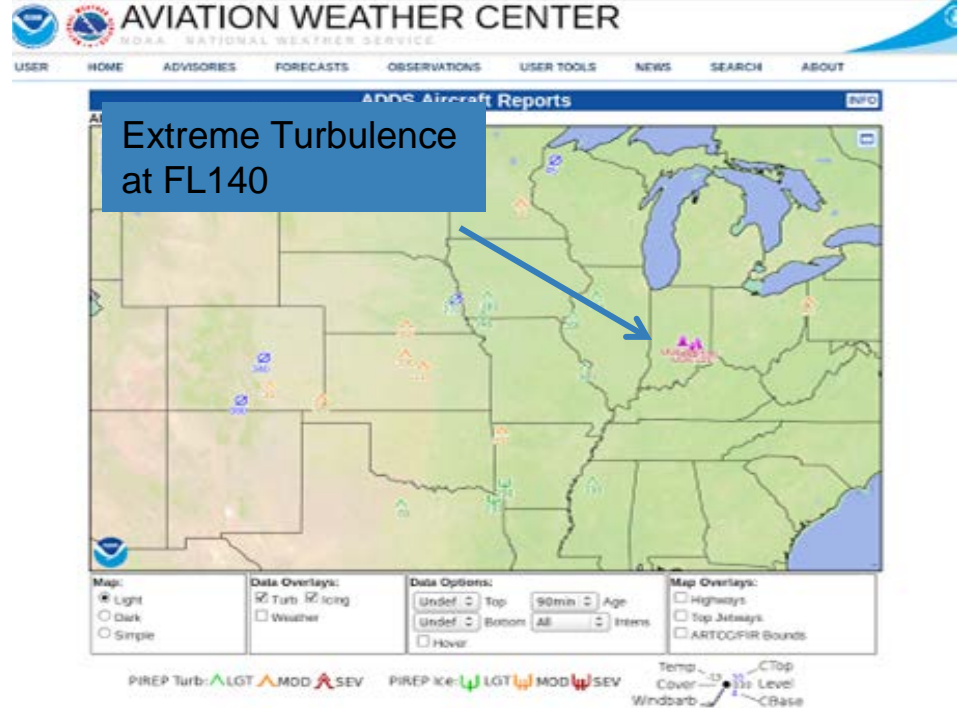More EDR Obs would provide more value to warning and forecast process!

EDR and PIREPs valid at 1500 UTC along with valid 1500 UTC G-AIRMET on 20140702

Clear Air Turbulence Guidance

Low Level Turbulence (<FL180) Probability2014070209f09

Extreme Turbulence at FL140

| 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |

Low level guidance 9-hr Fcst Valid at 1800 UTC 20140702

PIREPs valid at 1740 UTC 20140702

Mountain Wave Guidance

- Identifies *environments* conducive to the formation of mountain waves
- Winds +/- 40 degrees of high-resolution terrain upslope gradient
- Minimum ridge top wind speed of 15 m/s
- Stability immediatley above ridge
- Sufficient vertical wind shear in 200 mb layer above ridge level
- Condition identified in each SREF member
- Relative frequency (or "uncalibrated probability") plotted in NAWIPS system
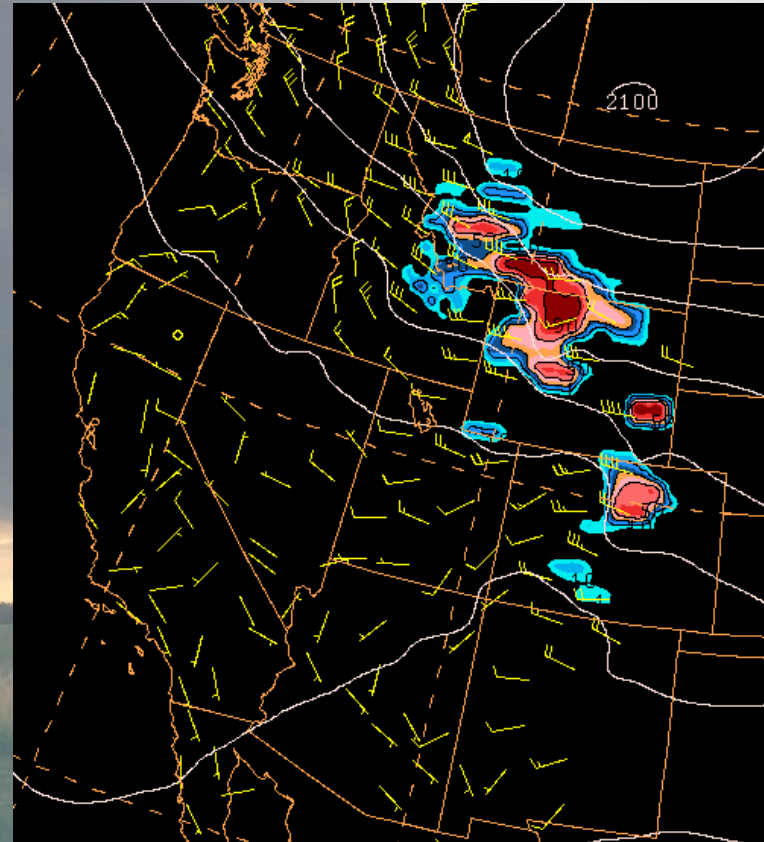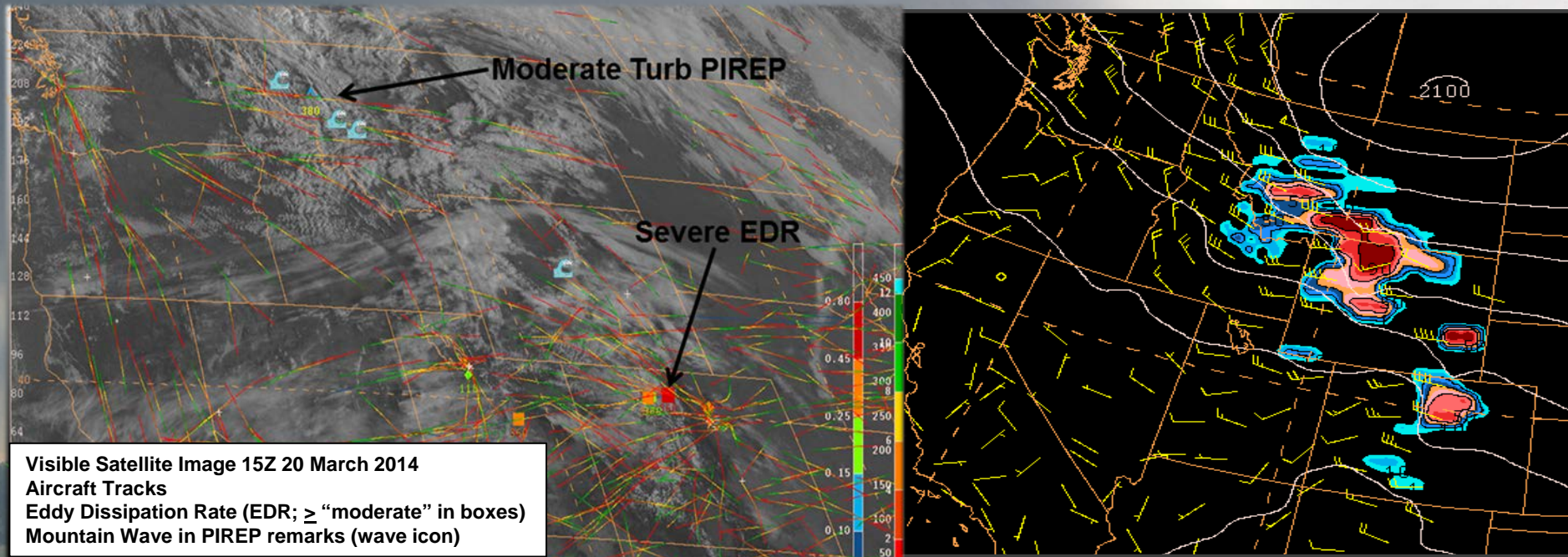
Mountain Wave Guidance
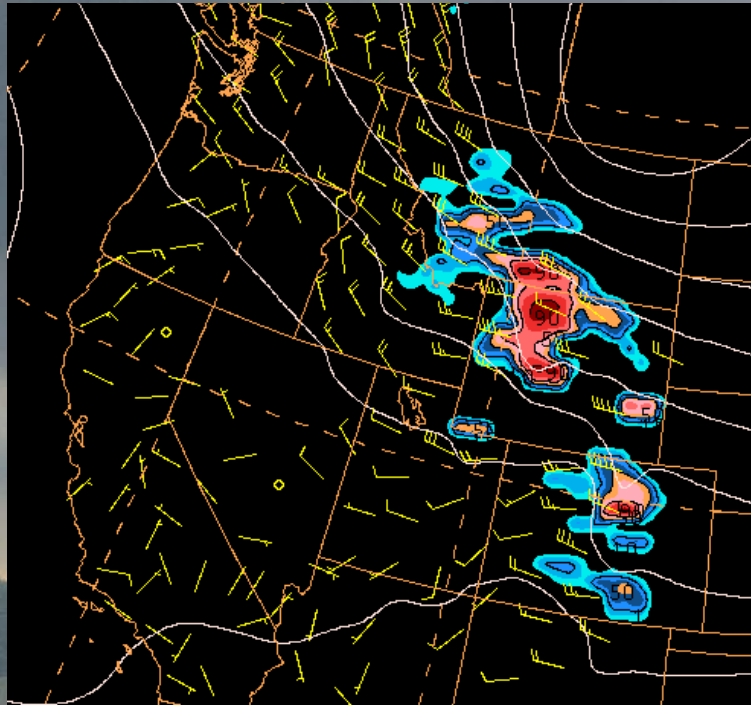
Ensemble Mean Ridgle Top Winds
Ensemble Mean GeoHgt (LyrAve: 850/700 mb)
Raw SREF Probability (Shaded)

Likelihood of Mountain Wave Conditions
48-hr Fcst Valid 15Z 20 Mar 2014

Likelihood of Mountain Wave Conditions
12-hr Fcst Valid 15Z 20 Mar 2014

Mountain Wave Guidance

Moderate Turb PIREP

Severe EDR

Visible Satellite Image 15Z 20 March 2014
Aircraft Tracks
Eddy Dissipation Rate (EDR; > "moderate" in boxes)
Mountain Wave in PIREP remarks (wave icon)

SREF Mean Ridge Top Winds (kts)
SREF Mean Height (Layer Ave: 850-700 mb)
SREF Likelihood (i.e. % of members meeting M.W. Environment; shaded)
SREF Runs 4x/day (03, 09, 15, 21 UTC)
Guidance available hourly through 39 hours, then 3-hrly through 3.5 days

Summary and Evaluation

- Ensemble forecast approach becoming basis for NWS numerical prediction
- Ensemble usage increasing at AWC and AWT
- Building ensemble-based tools to support AWC's Domestic and International forecast, advisory, and warning operations
- Ensemble output available for forecasters training in the AWT experimentally and in real-time operationally
  - Engaging forecasters in the R20 process provides signficant feedback

- Collecting data to perform a statistical verification and calibration of turbulence guidance

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