Using Ensemble Models to Forecast Turbulence at the AWC

Brian Pettegrew and David Bright
Aviation Weather Center
Kansas City, MO
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) for weather prediction & communication for a safe and efficient National Airspace System.
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 Activity
• 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, mission specific post-processing
- Applied ensemble research and R2O for aviation applications through the AWT
- Early beta stage for NCEP Short-Range Ensemble Forecast (SREF)
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

Upper level guidance 6-hr Fcst Valid at 1500 UTC 20140702

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

More EDR Obs would provide more value to warning and forecast process!
Clear Air Turbulence Guidance

Low level guidance 9-hr Fcst Valid at 1800 UTC

PIREPs valid at 1740 UTC 20140702

Extreme Turbulence at FL140
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 immediately 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 Ridgeline 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

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

Visible Satellite Image 15Z 20 March 2014
Aircraft Tracks
Eddy Dissipation Rate (EDR; ≥ “moderate” in boxes)
Mountain Wave in PIREP remarks (wave icon)
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 significant feedback
• Collecting data to perform a statistical verification and calibration of turbulence guidance

Brian.p.pettegrew@noaa.gov