Ensembles, Probabilistic Guidance, & Decision Support at the Aviation Weather Center

FPAW October 2014

Pat Murphy & David Bright NWS Aviation Weather Center



- →Ensemble & Probabilistic Forecasts
- →What AWC Is Doing Now
- **→Ensemble Processor**
- →What's In Development (NOAA Aviation Weather Testbed)

Sources of Uncertainty in Weather Prediction Data and Models



🔴 Balloon sondes 🛛 e Aircraft 🔹 Land and ship stations 🔹 Automatic buoys



- Observations
 - Data gaps
 - Measurement Error
 - Representative
 - QC
- Analysis
- Models
- LBCs, etc.



 $\begin{aligned} \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial t} + w \frac{\partial u}{\partial z} + \frac{1}{\rho} \frac{\partial P}{\partial x} &= fv + A_h \left[\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right] + \frac{\partial t_{\pi}}{\partial z} \\ \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial t} + w \frac{\partial v}{\partial z} + \frac{1}{\rho} \frac{\partial P}{\partial y} &= -fu + A_h \left[\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right] + \frac{\partial t_{\pi}}{\partial z} \\ \frac{\partial P}{\partial z} &= -\rhog \end{aligned}$

 $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$

 $\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial t} + w \frac{\partial T}{\partial z} = K_{h} \left[\frac{\partial^{2} T}{\partial x^{2}} + \frac{\partial^{2} T}{\partial y^{2}} \right] + \frac{\partial}{\partial z} K_{v} \frac{\partial T}{\partial z} + S_{r}$ $\frac{\partial S}{\partial t} + u \frac{\partial S}{\partial x} + v \frac{\partial S}{\partial t} = K_{h} \left[\frac{\partial^{2} S}{\partial x^{2}} + \frac{\partial^{2} S}{\partial y^{2}} \right] + \frac{\partial}{\partial z} K_{v} \frac{\partial S}{\partial z} + S_{s}$



Ensembles: Addressing the Uncertainty in Weather Prediction



Weather forecasting: It's impossible to be certain all of the time!

NWP models...

- All forecasts contain errors that increase with time
- Doubling time of small initial errors ~1 to 2 days
- Maximum large-scale (synoptic to planetary) predictability ~10 to 14 days

Ensembles...

- A collection of models that provide information on a range of plausible forecasts
- Extend predictability
- Great for decision support
- Increasing in popularity





Current Ensemble Uses





Impact tuned with airlines via CDM-WET

Ensemble-Based Development of MOTL Guidance

ดแก



- Rapid development cycle (since Jan. 2014) and moving toward version 1.0
 - An ensemble of models post-processed to mimic the CCFP
- CDM-WET & Industry requesting ensemble-based CCFP and shifting human DS
 - AWS = Aviation Weather Statement ("TFM Warnings" for DSS)

Ensemble Processor (EP)

ดแก

Objective: Tool to Build Specialized Applications



Ensemble Processor

- → 2014 EP Deployed in NOAA Aviation Weather Testbed (AWT)
- **→2015 Expect**
 - →Output to AWT and AWC Operational System
 - →Support Meteorologist Evaluation
 - → Develop Graphical User Interface (GUI)
 - → Manage Ensemble Size, Domain, Inputs/Outputs
 - → Deploy Graphical Displays
 - →Web-enabled
 - →Contouring
 - →Time and Cross Sections

Ensemble Processor

- → Develop Suite of Probabilistic Guidance (MOTL)
 →G-AIRMET
 - →LLWS, Sfc Winds, Turbulence, Icing, Mountain Obscn, & IFR
 →Possibly extend this guidance to SREF Grids
- →Add Global Ensemble (GEFS) Capability
- →Improve Ceiling and Visibility Forecasts
- →AWT Experiment
 - →Exploring MOTL Probabilistic Gridded or Object (polygon) 1st Guess
 - →Improve Guidance to Operational Forecasters
 - →Investigate Decision Support Applications

Application Development for DSS Low-Level Wind Shear



"Probability" of Low-Level Wind Shear, Mean PMSL (white), Mean shear (contour) & vector 22-hr Fcst Valid 19Z 26 Nov 2013

Application Development for DSS Mountains Obscured by Clouds



AWC

"Probability" of Mountains Obscured by Clouds 09-hr Fcst Valid 09Z 25 Nov 2013



Application Development for DSS Aircraft Icing





"Probability" of Icing Conditions 12-hr Fcst Valid 15Z 20 Dec 2011



Application Development for DSS Mountain Waves



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



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

Application Development for DSS Mountain Waves



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





Application Development for DSS Clear Air Turbulence (CAT)





"Probability" of Clear Air Turbulence & PIREPS +/- 30 minutes of 21Z 06-hr Fcst Valid 21Z 20 Aug 2014



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

Nowcasting

Weather prediction & communication for a safe and efficient National Airspace System (NAS)

ontinuous Communication

250

300

Warrenton, VA Facility

OD FT MSL



CCFP

Short-term Forecasting

Expert Analysis

Summary

→ Ensemble systems have direct connection to the NWS goals of a Weather-Ready Nation, impactbased decision support, and a consistent and accurate forecast delivery

→ Aviation Weather Center (AWC) is using ensemble systems and probabilistic forecasting techniques to address emerging decision support services

Ensemble development through the Aviation Weather Testbed (AWT) and AWC/AWT partners is ongoing



