Executive Summary
Highlights of the FAA/NASA/NOAA
Joint Interagency Weather Research Meeting
March 22-24, 2010
NOAA David Skaggs Research Center ~ Boulder, CO
http://www.esrl.noaa.gov/research/events/avi-nextgen/

Joint Interagency Weather Research Agenda

Monday, March 22, 2010 *(Room GC-402)*		**Presenter**
1:00 pm	Welcome/Opening Remark	Roger Pierce
1:15 pm	Interagency Collaboration/Research Themes	D. Davis/J. Haynes/ R.Moy
2:00 pm	R&D considerations for the NextGen Weather and the 4-D Cube	Steve Abelman
2:15 pm	NextGen 4-D Functional Requirements Update/Summary	James Tauss
2:30 pm	AWC – Operations to Research	Bruce Entwistle
2:45 pm	Break	
3:00 pm	Convective Weather and Thunderstorms	Steve Abelman (NOAA), Jenny Colavito (FAA)
	CoSPA Update	M. Wolfson, S. Benjamin
	SPC Perspective	R. Schneider
	NASA SATCAST Project	J. Mecikalski
	Oceanic Convection	C. Kessinger/Huaqing Cai
	NSSL/Warn on Forecast	Howard/Hondl/Stensrud
	LAPS/STMAS gust fronts	S. Albers, Y. Xie
	AutoNowcaster	R. Roberts/J. Wilson
	GPSmet	S. Gutman
	Satellite-detected signatures	K. Bedka
	MDL/LAMP – Thunderstorms	S. Smith/S. Olson
5:15 pm	Wrap-up Day 1	Cecilia Miner

Tuesday, March 23, 2010 *(Room GC-402)*		
7:45 am	Coffee and Rolls	
8:00 am	Observations – Right Sizing	Victor Passetti
8:30 am	Satellite Obs and Products	Steve Goodman, John Murray

	GOES-R Aviation Algorithm Working Group	W. Feltz
	Calipso	C. Trepte
	Cloudsat	G. Stevens
	NASA Decal Survey Mission applications	D. Johnson
10:00 am	Break	
10:15 am	Obscurations	Steve Fine (NOAA)
	LAPS Fog Dissipation	S. Albers
	Visibility, volcanoes, and fires with WRF/Chem variations	G. Grell
	Dust and smoke with HYSPLIT	R. Draxler
11:00 am	Cloud Properties	Pat Minnis
	Crosscutting Cloud Properties Apps at NASA	P. Minnis
	NESDIS Cloud Properties System	W. Feltz
	Dual-pole radar applications	NSSL TBD
12:00 pm	Lunch	
1:00 pm	Precipitation	Cecilia Miner
	HMT Ensemble	I. Jankov
	QPE	K. Howard, J. Zhang
	QPF	TBD
	MDL/NDFD	S. Olson
2:00 pm	Lightning	Steve Goodman (NOAA)
	GOES-R Lightning Mapper and LDN	S. Goodman
	Radar as a proxy for Lightning @Univ Of HI	S. Albers
3:00 pm	Boundary Layer Observations and Forecasts	Tom Schlatter (NOAA)
	TAMDAR	B. Moninger
	Profilers	TBD
	WVSS-IIv3	D. Helms
	Weather radars 88D, dual-pol, and CASA for observing hydrometeors	T. Schuur
	GPS moisture	S. Gutman
	Importance of land surface observations	C. Marshall
5:00 pm	Wrap Up	Steve Abelman (NOAA)

<u>Wednesday, March 24, 2010 *(Room GC-402)*</u>

7:45 am	Coffee and Rolls	
8:00 am	Modeling Improvements	Tom Schlatter (NOAA)
	EMC	G. DiMego
	RUC and the Rapid Refresh	S. Benjamin

	Assimilation techniques to improve convective forecasts	S. Weygant
	ICAO/WAFS Grids	M. Graf
	Postprocessing model output	Z. Toth
	Microphysics: What improvements could benefit aviation	J. Brown
10:00 am	Break	
10:15 am	Icing	Tom Bond (NASA)
	FAA AWRP In-flight Icing Research	M. Politovich
	NASA ASAP Icing	J. Haggerty
	NASA LaRC Icing Support	B. Smith
	HIWC	T. Bond
	Ground Icing	J. Riley
11:15 am	Turbulence	Tammy Farrar (FAA)
	FAA and NASA Turbulence Research	B. Sharman
	WAFS and algorithms for global post-processing	M. Graf
	Satellite based inferences of Turbulence	T. Wimmers
	Remote Sensing of Turbulence	L. Cornman
	GPSmet	S. Gutman
12:00 pm	Lunch	
12:45 pm	Ceiling and Visibility	Jim Hartman (FAA)
	FAA C&V Research	Herzegh
	NOAA OAR C&V Research	S. Albers
	MIT LL C&V Research	D. Clark
	LAMP C&V	S. Smith
2:00 pm	Volcanic Ash	John Murray (NASA)
	Volash data requirements gap analysis process and progress	S. Stepney, FAA
	NASA OMI SO2 Project	Krueger and/or Krotkov
	UW CIMSS Imager Apps	W. Feltz for Pavolonis
	NOAA Volash Research	R. Draxler
	Dual Pole Applications and/or other NOAA Volash Apps	TBD
	Integrated solutions for Volash	Murray
3:00 pm	Break	
3:15 pm	Space Weather	Rodney Viereck (NOAA)
	NOAA SpWC Research and Plans	R. Viereck/W. Murtaugh
	NASA NAIRAS Project	C. Mertens
4:15 pm	Discussions	
5:00 pm	Wrap-up	Darien Davis (NOAA)

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Opening Remarks

Opening Remarks were made by Roger Pierce (NOAA/OAR) who reminded multi-agency attendees of the requirement in FY08 NASA Authorization for NASA and NOAA to collaborate on convection research. In addition to convection, the meeting goal is to examine many aviation weather hazards with strong emphasis on Research-to-Operations (RTO). The future focus: science and technology infusion, improvements in boundary layer observations and forecasting, advances in ensembles and probabilistic forecasting, leveraging each other's observational capabilities, and use of testbeds. Takeaways for participants: work toward broader understanding of current state of weather research across agencies, keep in mind the path to finalizing the NOAA/NASA convection coordination plan mandated by Congress, and strive for insight into agency and interagency research.

John Haynes (NASA Program Manager for Weather Applications) opened his remarks noting that NASA is currently updating its strategic plan. NASA's Applied Sciences Program was formed to help bridge the "valley of death" between research and operations. Congressionally mandated collaborative research plan is complete and in the concurrence phase at NASA. Takeaways for participants: forum is an excellent opportunity to get updates on current research at and across agencies and to keep an eye open for opportunities to collaborate. NASA will look for potential topics from the community for the NASA ROSES 2010 solicitation.

Ray Moy (FAA Aviation Weather Group) opened his remarks noting that the NextGen concept requires that aviation weather nowcast and forecast information be integrated into user decision support tools. He reminded the forum that the purpose of the Aviation Weather Research Program (AWRP) was applied research aimed at minimizing impact of weather on the National Airspace System and accomplishing NextGen goals. AWRP research areas include storms, turbulence, icing, and ceiling/visibility; weather hazard research is facilitated by advances in modeling and weather radar techniques. Strong collaboration exists between FAA, NOAA, and NASA in AWRP. Takeaway: Focus on ongoing collaborative research and consider participation in FAA RTO efforts to move research solutions into operations.

Steve Abelman (NOAA NWS) then made a presentation on research and development (R&D) considerations for NextGen Weather and the 4-D Cube. He stressed that the need for capability in 2013 and beyond poses R&D challenges for NextGen 4-D Cube. The lead-up up to 2013 capability is a series of demos. FY10 capability evaluation focuses on data dissemination and architecture. At FAA, RTO program replaces the AWTT and RTO's formal assessment component is the NextGen Weather Evaluation Capability (NWEC). Primary R&D challenges are: transitioning models to operations, achieving and maintaining product consistency, introducing and understanding probabilistic information, and maximizing the value of human input in an automated world. Other ideas to keep in mind are overarching ICAO requirements and global harmonization, Operations-to-Research (OTR), to complete the R&D cycle, and overall societal implications.

James Tauss (support to Cheryl Souders) presented a talk summarizing NextGen 4-D Requirements. He began by summarizing the evolution of functional requirements development for the end-state (2025) Single Authoritative Source (SAS) for air traffic management decision making (report released January 18, 2008). He

also reported the status of draft performance requirements (next step in requirements development process) for the end-state SAS. This entails requirements developed by a multi-disciplinary team of various FAA user groups, system engineering experts, and aviation weather providers. It expanded on observing and forecasting functional requirements. The draft document was submitted for agency review and comments adjudication is in progress. Future considerations involve shifting paradigms (e.g., consider a thunderstorm, currently one entity, as a combination of specific hazards, such as lightning, turbulence, etc.) and use of probabilistic forecasts. Next steps are to develop and validate performance requirements for other functional requirements and to finalize weather information to be included in the 4-D Weather SAS.

The Aviation Weather Center (AWC) Testbed was outlined by Bruce Entwistle (AWC) who started his presentation with background information noting that AWC has been long involved in RTO: AWRP algorithms (turbulence, icing, ceiling and visibility, convection); World Area Forecast System global grids; and enhanced CWSU decision support software. AWC is also involved in Operations-to-Research part of R&D. This requires concentration on demonstrated benefits, efficiency, sustainability, and IT compatibility. The new aviation weather testbed will be open to collaboration across agencies and across other NOAA testbeds. It provides a true operational environment and permits access to experts in aviation weather at WFOs, a CWSU, NWS Central Region Headquarters, and the NWS Training Center.

Technical Session - Day 1

The first session covered Convective Weather and Thunderstorms. It was facilitated by Jenny Colavito (FAA) remotely and Steve Abelman on-site. Jenny Colativo opened the session by outlining the problem and focused on the convective storm probability issue and on long/short term goals. The operative question is: given that the NextGen goal is to improve safety, efficiency, and capacity of the NAS, what does the NAS lack in terms of precipitation forecasts? The current convective storm focus is on developing CoSPA, with collaboration by MIT/LL, ESRL, and NCAR. Time-phased goals exist for gradually extending the forecast horizon for convection and increasing spatial resolution. Jenny closed with a discussion of the FAA's RTO Solution Transition Team for convection which is a multi-agency group focused on developing a research management plan to move convective research to operations.

The first presentation was a CoSPA update by Haig Iskendarian (MIT/LL). CoSPA is a combination of storm extrapolation (heuristic nowcasting) (MIT/LL lead) and the HRRR model (NOAA ESRLlead) with a blending module (NCAR lead) between the two. Convective initiation (CI) using NASA SATCAST satellite indicators is being investigated as an improvement to CoSPA heuristics. The team is also working storm decay problem, in which extrapolation does not work well, and trends in cloud-to-ground lightning and echo tops. In addition, storm motion estimation using a wavelet approach is under development. The probabilistic forecasting effort is based on a time-lagged ensemble approach.

This summer, the Convective Storms Team, composed of FAA AJP-68, including FAA HF personnel, as well as research partners (MIT/LL, NCAR, and NOAA ESRL) will conduct a summer evaluation that will put the prototype CoSPA high resolution forecast called in front of operational users for their assessment of its capability to forecast precipitation intensity and echo tops out to 8-hours. CoSPA provides a seamless forecast of precipitation intensity and echo tops out to eight hours by blending storm extrapolations, which are very accurate in the 0-2 hour range, with the High-Resolution Rapid Refresh (HRRR) model, which is very accurate

in longer time horizons. The CoSPA output is deterministic for the 2010 summer evaluation; however, a probabilistic version of CoSPA is currently in development.

Russ Schneider (NOAA) and Steve Weiss (NOAA) followed with the NOAA Storm Prediction Center (SPC) Perspective. Thunderstorm outlook: probabilistic, 4-hour outlook that links to CCFP times. Forecaster plays key role. The NOAA Hazardous Weather Testbed (HWT) combines several efforts: the Experimental Warning Program (detects and predicts hazardous weather up to several hours) and the Experimental Forecast Program (predicts hazardous weather from a few hours to a week). The HWT also serves as a key element for the GOES-R Proving Ground in collaboration with NESDIS's GOES-R algorithm working groups. SREF probability of thunderstorms work helps explore and define uncertainty. A spring experiment is currently underway at HWT.

John Mecikalski (UAH) then provided a SATCAST Overview (0-1 hr Convective Nowcasting)**.** SATCAST will be evaluated at HWT in summer 2010 and included in GOES-R Proving Ground and NOAA WFOs in summer 2011. The technique is moving from a pixel-based approach to an object-oriented one. A new project has begun to examine storm intensity coupling to NextGen requirements for monitoring growing and mature storms, especially in radar-void regions.

Huaqing Cai (for Kathy Kessenger, NCAR) then presented an update on Global/Oceanic Convection Diagnosis and Nowcasting. This oceanic research is geared to data sparseness. It also concerns how to make forecasts seamless between the CONUS and global domains. The research specifically advocates getting information to the cockpit, specifically the Convective Diagnosis Oceanic product and the Convective Nowcasting Oceanic product.

Convection research applicable to NextGen which is being conducted at the NOAA NSSL was then covered by Kurt Hondl and Dave Stensrud. This includes how the 3-D multi-radar/multi-sensor system ingests data from the WSR-88D network and updates 3-D grids every 5 minutes to produce severe weather and precipitation products. NSSL is working with NCEP to transition the capability to NWS operations. In the future there are plans to increase resolution, add dual-polarization and other radars and to automate quality control. They also covered warn-on-Forecast, a probabilistic convective-scale analysis and forecast system which entails a high-resolution 3-D analysis produced every 5 minutes and a 1-hour ensemble produced every 5 minutes (probabilistic). It assimilates all available observations.

Yuanfu Xie then presented an update on Space and Time Multiscale Analysis System/Local Analysis and Prediction System (STMAS/LAPS) for Convective Weather Analysis and Short-range Forecast for NOAA ESRL GSD. This included gust front/surface detection and STMAS current capability: real time with 5-km resolution 15-minute latency due to observation data. The goal is 2-km resolution on a 5-minute cycle using 1-minute ASOS data over the CONUS domain. The nowcast/short-range forecast goal is 0.5-1 km resolution analysis and forecast with 30-minute cycle time and assimilation of high-resolution observations. The plan is to transfer the technique to HRRR.

Jim Wilson (NCAR) then covered the Convective AutoNowcaster (ANC) which is running on AWIPS at WFO Fort Worth now and will also be operational at WFO Melbourne, FL soon. It provides gridded fields and boundaries, 60-minute nowcasts of thunderstorm initiation and growth and decay updated every 5-6 minutes. An example of human interaction with and oversight of automated techniques was also provided. The ANC can by viewed by CWSUs at Fort Worth, Jacksonville, and Miami Air Route Traffic Control Centers.

GPS observations were then covered by Seth Gutman (NOAA ESRL). GPS-Met is a remote sensing system used to continuously monitor total perceptible water in high temporal resolution. GPS measurements are very sensitive to conditions associated with CI and thunderstorm development since most atmospheric moisture is near the Earth's surface.

Kris Bedka (NAAS LaRC) then presented an overview of monitoring and Prediction of Hazardous Convective Cloud Object Properties. It is difficult to handle cloud movement in a pixel-based system. Methods are available for clustering cloud pixels into coherent objects. The focus includes overshooting tops and enhanced-V signatures. These techniques will be evaluated in 2010 NSSL Spring Experiment.

Localized Aviation Model Output Statistics (MOS) Program (LAMP) were discussed by Steve Smith for Judy Ghirardelli (ESRL). LAMP is based on objective analysis, simple models, regression equations, and related thresholds. LAMP provides guidance for aviation elements and bridges the gap between MOS forecast and observations. An example was presented which covered the probability of thunderstorm occurrence in a 2-hour period in a 25-km box. Forecasts are issued for METAR stations except for gridded thunderstorm forecasts (20-km grid).

Cecilia Miner (NOAA NWS) then presented a summary of the session which was then closed by Steve Abelman. This concluded the first technical session of the meeting and Day 1.

Technical Sessions - Day 2

Day 2 began with a presentation by Victor Passetti of the FAA Technical Center on Observations and Right Sizing. Right-Sizing falls under the FAA's Reduce Weather Impact (RWI) portfolio and has as its goal to provide for an optimized aviation weather sensor network. A network with the right mix of sensors among ground-based, airborne, and satellite to provide weather data of the required space and time resolution to support NextGen and legacy functionality. Operational needs will drive the need for advanced weather information and modeling, which in turn will drive the need for an optimized aviation weather sensing network. Jeff Broadsky of Oklahoma University then followed with a summary of plans for right sizing demonstrations and application strategies and Beth Plale of Indiana University covered right sizing metadata activities in the SOA.

The next session concerned Satellite Observations and Products. It was facilitated by Steve Goodman and John Murray. Steve Goodman is the GOES-R Program Senior Scientist at NOAA NESDIS. He discussed the GOES-R schedule, planned improvements, and aviation capabilities. October of 2015 is the latest launch date. The program is taking steps to collaborate with NextGen testbeds through NESDIS's GOES-R Proving Ground.

Wayne Feltz of the NOAA/UW CIMSS at the University of Wisconsin, Madison then presented an overview of aviation algorithms for GOES-R including convective initiation, SO_2 detection, overshooting tops, turbulence, fog/low clouds, volcanic ash. Steve Albers of NOAA ESRL covered applications of satellite data for Local Analysis Prediction Systems (LAPS) and model assimilation. Chip Trepte of NASA Langley covered CALIPSO satellite applications for detection of aerosol and cloud heights, layer heights, retrieval development, ocean surface winds, and model development. Graham Stevens of Colorado State University discussed how Cloud Sat is employed for studying convection and how it measures the vertical structure of clouds to quantify ice and water content. It was noted that CloudSat and Calipso are nearly coincident in space and time and that they are important tools for GOES-R algorithm development. They will be essential for data validation and

tuning of the algorithms. Dave Johnson of NCAR then provided an overview of NASA Decadal Survey Missions. Upcoming missions will focus on climate change; however, the Global Precipitation Mission (GPM) will provide microwave measurements that will build on the significant applications development and model improvement legacy of NASA's Tropical Rainfall Measurement Mission (TRMM). This will be followed by the Soil Moisture Monitoring Platform (SMAP) which also has the potential to substantially improve weather model parameterizations. He closed with an overview of weather and aviation applications for these missions.

The next session covered obscuration requirements. It was facilitated by Steve Fine of the NOAA Air Research Lab (ARL). Steve opened with an overview which outlined ARL's direction for global and regional modeling. George Grell of NOAA ESRL covered WRF-RR Chemistry and focused on its applicability to the wildfire and volcano threats. Roland Draxler of NOAA ARL then gave a presentation on Operational Dust and Smoke Forecasts which are provided via NOAA's Air Quality Web Page: http://www.arl.noaa.gov/AirQual.php.

The next session concerned satellite-derived cloud properties. Radar applications were covered phenomenologically in the next and other subsequent sessions. This session was facilitated by Pat Minnis of the NASA LaRC. He provided an overview of NASA's satellite derived cloud properties in near real time. These retrievals provide accurate cloud and radiation properties to NOAA ESRL for assimilation into the operational RUC model and to NCAR for improvement of the Current Icing Potential (CIP) nowcasting product. New methods are currently being implemented to provide 3D characterization of clouds and more accurate estimates of cloud bases and heights. Wayne Feltz (NOAA/UW CIMSS) then provided an overview of cloud properties algorithms being developed by the GOES-R Cloud algorithm working group. NASA Langley and CIMSS are collaborating in these efforts to develop GOES-R cloud type properties.

The next session covered precipitation. It was facilitated by Cecilia Miner (NWS Office of Climate Weather and Water Services). Tim Schneider (NOAA ESRL) presented an overview of the Hydromet Testbed (HMT). The presentation focused on verification, observation network, OPE, QPF, snow information, hydro applications, debris flow, and decision support tools. Isadora Jankov (NOAA ESRL) covered HMT ensemble precipitation forecasts and convective QPF. Allen White of the NOAA ESRL Physical Sciences Division gave a presentation on HMT observations and observing systems including HMT remote sensing systems. Ken Howard (NSSL) covered Multi Radar Multiple Sensors (MRMS), which is scalable, integrates satellite and radar observations, and has 3D capability. He also covered MRMS QPE. Steve Olsen of NWS MDL gave a presentation on NDFD Precipitation Elements which predominate weather including POP, QPF and 6 hour snow accumulation.

The next session concerned Lightning, facilitated by Steve Goodman, NOAA NESDIS. Steve described the Geostationary Lightning Mapper which will be manifested on GOES-R. He also provided some background information on the relationship of lightning flashes to storm structure and storm tendencies and discussed how this information can be used to improve forecasts. Weibke Dierling (NCAR) gave a presentation on using lightning products to improve deep convection forecasts especially for storm severity. She also stressed the importance of lightning information for forecasting oceanic convective storms and the need for a composite lightning forecast system which integrates ground and space-based observations. John Mecicalski of the University of Alabama Huntsville (formerly at UW CIMSS) covered the use of lightning initiation precursors from geostationary satellites to develop a nowcast of lightning initiation which is needed for a robust CoSPA forecast capability. Steve Albers of NOAA ESRL covered the use of lightning data in the Local Analysis and Prediction System (LAPS) and Space-Time Mesoscale Analysis System (STMAS).

The final session of Day 2 concerned Boundry Layer Observations and Forecasts. It was facilitated by Tom Schlatter of NOAA ESRL. The first presentation was by Bill Moninger of NOAA ESRL GSD who provided an update on TAMDAR. The TAMDAR sensor provides airborne measurements of temperature, wind vectors, RH, Turbulence (EDR via McReady Algorithm) and Icing (icing initiation is accurate, otherwise needs further research or TAMDAR sensor/software improvements). TAMDAR is an important data filler below flight level 150 and provides critical soundings away from major airline hubs. The data has been shown to improve RUC model forecast accuracy. Bruce Baker of NOAA ARL covered radar and wind profilers, Lidar and Sodar. He emphasized that they provide important boundary layer measurements (more than just wind). Dave Helms, NWS Office of Science and Technology, covered the airborne Water Vapor Sensing System II currently installed on 21 commercial aircraft (passenger and package carriers) with focus on moisture/RH. Dave provided an update on improvements which were made in the 2008 redesign and subsequent installation. Terry Schuur of the University of Oklahoma CIMMS gave a talk on the Dual Pol addition to WSR-88D. The upgrade is scheduled for early next year. The data will discriminate precipitation types and non-meteorological targets. Seth Gutman of NOAA ESRL GSD covered GPS-derived moisture fields. GPS moisture data is currently assimilated into RUC and WRF RR. Curtis Marshall of the NWS Office of Science and Technology presented land-surface observations and their impacts on the boundary layer. The concentration was on surface fluxes of solar radiation, precipitation, soil moisture, soil temperature, and vegetation.

Steve Abelman presented a summary of the session which was then closed by Tom Schlatter. This concluded Day 2.

Technical Sessions - Day 3

The first session of the final day of the meeting began with an overview of the NAM and RUC by Geoff Dimego of NOAA ESRL. He opened with a summary of 2009 updates and future plans for the NAM and operational RUC (NAM 4k CONUS, 6km AK and 3 km HI). It is anticipated that the Weather Research and Forecasting Rapid Refresh (WRF-RR) will be operational at NCEP, 1st quarter FY11. Concerns over computing resources remain and HPCC availability is a critical issue. Stan Benjamin (NOAA ESRL GSD) echoed this in his talk which followed.

Stan Benjamin provided an update on the status and plans for the RUC and HRRR. There are currently plans for the 3km HRRR to go operational in 2012. He also summarized plans for the North American Rapid Refresh Ensemble (NARRE) which is a 10 to 12 km, 6 member ensemble for 24 hour forecasts. NARRE is planned for 2012-13 if computing capabilities do not fall behind schedule. HRRRE is a 3 km CONUS subset planned for 2012-2015 if resources are available. NARRE and HRRRE will generate an analysis of record using 4D data assimilation and will likely be a hybrid of ensemble kalman filter and a 3D/4D variational assimilation. Ensembles will include initial conditions perturbation and dynamics/physics could be altered as well. One concern is that the model of reflectivity looks so realistic that it can lead forecasters astray and encourage them to not be as cautious in analyzing the models and the output before issuing forecasts. It cannot be overemphasized (again) that a major concern for these models' development and operational capability is available computing time. Upcoming data assimilation capabilities are to run the RUC and RR hourly and to expand the data types which will be assimilated. There is a significant array of new data included in the expanded use of radar and lighting, satellite radiances and SATCAST or similar data, i.e., convective initiation fields. A near term milestone is a 3 km CONUS HRRR (March 2010). Rapid Refresh versions of the WRF-ARW and GSI are running and GSD is in the transfer process to NCEP. Stan discussed a few initialization highlights that Steve Wegant later covered in detail including that incorporating (finding) radar data improves

short range RUC Forecasts and HRRR low ceiling and visibility forecasts. Improved model performance due to the use of better physics such as two-moment rain, improvements in the micro physics, plans to use dual polarization radar and land surface modeling improvements were also presented. Regarding chemistry, satellite data is proving to be very important. WRF-CHEM model improvements are building off of George Grell's work. Additional satellite data to perform initialization will likely improve this capability.

Steve Weygant (NOAA) then gave a presentation which focused on model assimilation improvements and plans. The focus is on convection and radar data. Collaboration with other aviation weather research labs (MIT/LL, NCAR, NASA Langley, UAH, UW CIMSS) is a key factor. Improving storm and meso-scale assimilation and forecasts continues to present challenges. Mesoscale forcing and radar assimilation improvements are expected to improve on this problem. Cloud analysis shows improvements with assimilating additional high value fields such as lighting, cloud property retrievals and convective interest fields. Lightning data in place of radar data in some instances is a benefit. ENKF assimilation scheme helps with forecasting mesoscale features. Chemistry assimilation for air quality forecasts is a goal. Future opportunities and plans for post processing and ensembles were subsequently covered by Zoltan Toth (NOAA). It is important to recognize errors in both initial conditions and in the model. We need better statistics and knowledge of the nature of these errors and we need them quantified. How to address the errors: statistically – employ one forecast at a time and statistically assess the errors – from this generate ensembles; dynamic approach for ensembles – employ a Monte Carlo approach; and/or multiple analysis and forecasts – error estimates. There are limitations with the dynamic models so the intent is to go with a hybrid dynamical / statistical approach. In post processing, coarse resolution results in biased forecasts. Observations-based truth at the appropriate resolution is needed. Downscale bias-corrected ensembles and derive additional variables is needed. Also need to develop better interrogation tools for the forecaster and the 4D cube.

Roy Rasmussen (NCAR) covered microphysics parameterizations and began by summarizing work from the late 90's through today. He described the use of water phase at the surface and aloft to improve icing forecast capabilities. This gets at not just physics improvements, but takes advantage of a number of field programs. Current work indicates that dust and ice microphysical parameters are also critical, i.e., aerosols in general. A new specialist has been brought on to assist in aerosol parameterization research. The focus is currently to look at hot spots for this activity in the southwestern US and to key on microphysics of the cold pool. Incorporation of two-moment rain is showing promise. Traditionally a single moment (mixing ratio) had been employed. Two moment rain is both mixing ratio and precipitation concentration (LWC or LWP). Dual polarization, phased array radar will be a new tool that may help with a better understanding of microphysics.

Mike Graff (NOAA) covered the WMO World Area Forecast Centers (WAFC). Forecasts are issued from Washington Center and the UKMET office for the globe. It is currently a fee for service enterprise. There are concerns that the rudimentary products that are employed may not meet customer's needs, e.g., Elrod index is the agreed-upon turbulence forecast. Approved composite products which employ Elrod, Knapp, EDR observations, Richardson Number, etc., are not yet available operationally at both forecast centers. Future plans include Grib2 grids later this year; icing (forecasting currently employs using just 70% rh and temperatures less than 0°C); turbulence forecasts will employ an Ellrod and Knapp scheme; and convection forecasts will be improved.

A discussion period ensued which highlighted concerns over how to resolve differences in information and capabilities between the two WAFC's. Then techniques on microphysics in the models were discussed and referenced back to Geoff DiMego's "Wheel of pain" a cartoon which highlighted the myriad complexities

involved in accurate forecasting. It was offered that the ultimate milestone in forecasting will be achieved only when the models can accurately operate at “convective scales”. It was also noted that the linkages between the various physics schemes and coupling will have to be reviewed carefully to achieve the model improvement goals necessary to support NextGen. Zoltan Toth then discussed the potential use of the operational ensemble at NCEP. It was noted that there is considerable physics diversity required depending on the application of the information, and differing resolutions, e.g., finest resolution (for fire weather versus convective weather) and the ensemble members need to be different for fire weather with more members with different boundary layers and fewer convective options. Steve Abelman reiterated concerns over computer resources and noted that awareness of potential shortfalls needs to be communicated to appropriate stakeholders to help stem their possible occurrence. The need to better market the RUC was also discussed – many forecasters were not aware of its improved capabilities over the last few years. $5 to $20M in computer hardware upgrades are needed. Risk reduction planning is also needed since with currently planned computer capabilities NOAA will not be able to run the HRRR at its required (highest) available resolution operationally. A cost benefit analysis is needed to support running the higher resolution. Ad hoc benefits analyses have been done in the past for the socio-economic benefits of improved aviation weather information but an actual cost – benefit analysis would be much more difficult. MCR Federal, a beltway firm, produced impact studies for the AWRP early in the last decade to estimate the benefits of improved forecast products and for justification for the program. This type of study is insufficient by itself but would be needed to address the benefit side of a cost – benefit analysis. This should be considered as an option for the near future. A business case for improving global wind forecasts for routing was suggested in 1995 but it was decided that it did not entail a justifiable cost – benefit case, i.e. a 5-10% improvement in wind accuracy does not yield commensurate fuel savings for the costs of improved information, routing DSS software upgrades, changes in dispatch procedures, etc., so this is an example of a business case that should not be explored to support increased computer requirements for NOAA. It was also noted that NextGen is sort of “selling itself”; reflectivity data is great for verification; and RTVS is taking on some of these issues.

The next session was Icing. It was facilitated by Tom Bond of the FAA who serves as Chief Scientist for the FAA Icing Program. Like the other disciplines good measurements are needed, meaning this is both a sensor problem and a forecast problem. The first presentation was made by Dr. Walter Strapp of Environment Canada. Environment Canada and the National Research Council of Canada together with NASA, NCAR and others are currently conducting High Ice Water Content (HIWC) efforts under the auspices of the Atlantic Icing Research Alliance (AIRA) treaty. AIRA has been a linchpin in in-flight icing research over the past two decades having conducted regular field campaigns to better understand and forecast the ice accretion hazard which occurs when aircraft fly into areas of Super-cooled Large Drops (SLD). HIWC addresses the loss of engine compression and failure when aircraft flying near deep convection ingest high concentrations of ice crystals theorized to be associated with divergent flow outward from anvil type clouds. Jets often encounter deep convection on decent. 75% of these encounters are in oceanic environments. It affects all jet engine types. High ice water mass and not super-cooled water is the threat. Red echo region on aircraft radar which are normally associated with hazardous conditions is not observed. Expected conditions are high altitude with very cold temps, i.e., common in tropical type atmosphere, little lightning due to small size but large concentration of ice crystals, mostly observed with rain reports which are actually high concentrations of ice crystals melting on warm windshields. There does not appear to be an obvious way of forecasting this hazard. Some questions and cases were presented which included low lighting and low radar reflectivity, deep clouds not strong aloft, oceanic convection, aircraft descent from high altitude and some (30%) are in level flight.

Bill Smith of NASA LaRC gave a presentation on in-flight airframe icing from super cooled water and the use of satellite microphysical retrievals to determine likely locations for icing. Good statistics on POD were indicated. Using a multilayer technique, statistics as good as those for single layer icing (POD ~ 90%) are obtained. Conclusions: Satellite derived microphysical parameters improve nowcast (CIP) and forecast (RUC) model performance. NASA NIRSS – Ice Remote Sensing System is useful for satellite data verification of icing products and for planning and real-time vectoring of research aircraft during field campaigns. The question was asked about the use of TAMDAR data. This needs to be explored if some of the current shortcomings in the TAMDAR data can be overcome. Earle Williams suggested that glory data should also be used wherever available for detection of super cooled water and the droplet size from this system.

Julie Haggerty covered NCAR RAL aviation applications for in flight icing, sponsored by the FAA. The goal is to have a 3D picture of the icing. The products which were developed at NCAR and are available on ADDS are the Current Icing Product (CIP) and the Forecast Icing Product (FIP). Uses all available data sets, e.g., RUC, surface observations, radar, satellite, lightning and PIREPS, in a weighted fuzzy-logic algorithm to generate an icing probability and severity product. The group is also considering using the data from other sources (raw satellite output and additional information) to improve the CIP algorithm. FAA AWRP Icing researchers have been collaborating with NASA Langley Research Center (LaRC) through the NASA Advanced Satellite Aviation-weather products (ASAP) Project. Improving the CIP/FIP algorithms involves selecting satellite cloud products that are likely to enhance the quality of the icing diagnoses/forecasts in certain situations. Geostationary (GOES)-derived satellite cloud products are a natural fit for supplementing the data used in the NAS application. The NASA LaRC currently produces a suite of satellite-based cloud products that have shown potential for enhancing diagnoses of icing conditions: they can detect some icing conditions ~90% of the time during the day, and some icing cloud boundaries to within $\pm$ 1 km. Satellites can be used/assimilated into other nowcasting/forecasting systems: NCAR CIP/FIP and NOAA GSD Assimilation and Modeling System.

Ground Icing was then covered by Jim Riley of the FAA. Current ground de-icing and anti-icing procedures for airlines concerning holdover times and allowance times use visibility that often results in either too much or too little holdover time because the visibility criteria does not correlate well with the regression curves for LWE rates. Need to provide LWE rates for freezing and frozen precipitation; currently the rates for LWE in operations are not available. The need is to provide LWE rates in vicinity of airport de-icing and anti-icing pads and the take-off runway, rather than at regular spacing intervals throughout the terminal area as indicated in the performance and functional requirements for FOC document (September 2009).

The next session covered Turbulence and it was facilitated by Tammy Farrar (FAA). The first presenter was Bob Sharman of NCAR RAL. He noted that NextGen is a major driver and that breakthroughs in atmospheric science will need to be incorporated and new findings resolved to meet NextGen requirements. In-situ observations, onboard observations, and remote sensing data are needed to support turbulence forecasts, noting the differences in requirements between IOC, MOC and FOC. Development of additional onboard systems are needed as well as GPS scintillation measurements, and satellite-based turbulence interest fields for turbulence algorithms. Nowcasting and forecast products in the form of deterministic and probabilistic data in gridded format are also required with the recognition that “human in the loop is still a focus”. An outline of the state-of-the-art graphical turbulence guidance which employs NWP output fields with improved capabilities, eddy dissipation rate observations, satellite interest fields, PIREPS and various turbulence indices in a fuzzy-logic scheme was then presented. There was a note of interest that IOC does include mountain and jet stream turbulence and that the eventual inclusion of convective turbulence is also needed.

Mike Graf then gave a presentation with a focus on human over the loop for WAFC turbulence global grids and noted that for icing, turbulence, convection and winds, the WAFC Grids' machine to machine interface is good. Requirements include the AWC, AK, and HI – all centers for aviation forecasting.

Tony Wimmers (UW CIMSS) then gave a presentation on satellite-based inferences of turbulence. Due to scale differences between turbulence (tens of meters) and satellites (hundreds of meters), satellites don't see the air acting in a turbulent way, they see the things that are impacted by the turbulence. The first and most well known satellite interest field for turbulence is associated with mountain waves and the detection of the "hydraulic jump" associated with mountain wave turbulence. These are standing waves which are semi-stable. Water vapor channel wave patterns are clearly evident in these cases. In the dry area near the mountains, 70% POD and 20% FAR is optimum. The second type of satellite interest field is tropopause folding which can readily be seen as a deformation in moisture fields associated with atmospheric divergence near the jet stream. Tropopause folding is a synoptic scale event which produces turbulence. Overshooting tops occur mainly in southern US and the Great Plains. They can penetrate the tropopause and lead to gravity wave production. Turbulence interest fields in satellite data are often indicated by transverse banding, i.e., cirrus bands well outside of main convection. Transverse cirrus bands associated with rapid anvil expansion are often and early warning opportunity for turbulence forecast. There are requirements gaps for NextGen. Latency is a major concern. Horizontal resolution is currently only 4 km from geostationary satellite data. Vertical resolution is also too low currently even though activity is very deep. Finally, coverage needs to be global.

Larry Cornman (NCAR RAL) then covered remote sensing of turbulence and noted that the problem is what we measure is the sensor output, not the actual turbulence. We need to work on the sensor filters to do a better job of looking at the issue. Working with a NASA geodesy project on low earth orbit GPS. An example was given using the recent Air France incident. NCAR is also working with UW CIMSS and UAH through the NASA ASAP Project to use satellites to infer turbulence. Also, NCAR collaborated with the NASA Aviation Safety Program to evaluate commercial aircraft with doppler radars for convective turbulence in cloud. There was some success 1 minute to 90 seconds out but more time (~ 5 min) is needed to properly prepare aircraft cabins for turbulence. Also for wake vortex, NCAR, GTRI and Hampton University are evaluating the use of forward-looking interferometry to detect signatures directly or from resonance bands of atmospheric constituent gases.

Seth Guthman (NOAA) then provided an overview of GPS Met observation of turbulence which was first done by JPL in the mid 90's. It is difficult to get this research knowledge into operations in the aviation community. The geometry may not often be optimal. Dual use of ground based sensors is made to provide the data.

The next session on Ceiling and Visibility was facilitated by Jim Hartman of the FAA. Paul Herzog (NCAR-RAL) gave the first presentation on FAA ceiling and visibility concerns and noted that they are terminal-centric (part 121) and not just for severe cases. Approximately 1/3 of NAS weather-related delays are due to ceiling and visibility. For GA, the issue is IFR avoidance in the 0-6 hour time frame whereas for helicopter operations the 0-3 hr forecast is the issue. NCV affects the NAS constituency and runs the gamut of aviation impacts. The biggest hazard is part 91 pilots inadvertently flying from VFR to IFR conditions; which has lead to the most common cause of fatalities. The use of the NCV analysis product was approved for the HEMS community as a No-Go decision aid. A helicopter departs on a mission as part 91 and often returns as part 135 carrying patients. New capabilities are being developed to improve the NCV forecast which includes the latest versions of the Localized Aviation MOS Program (LAMP), RUC, RR, HRRR, NAM, Short Range Ensemble Forecast (SREF), and the Very-short Range Ensemble Forecast (VSREF) with the North American Rapid Refresh Ensemble (NARRE) and HRRR Ensemble (HRRRE) in the future. The FAA is also funding a NCV forecast capability.

This forecast will utilize the probability-based LAMP product, and the RUC/RR to enhance algorithm capability through weighted blending (forecaster interface control of inputs/trial runs) to populate grids as better initial conditions for the models. The RVR gap is one of the most glaring areas of needed research. The bottom line is for NCV forecasts to work, probabilistic information is needed on a forecast grid. NASA LaRC cloud products are useful interest fields. GOES R capability (increased resolution and decreased latency) is needed. Runway visual range (RVR) forecast research is needed.

Steve Albers (NOAA ESRL) presented ceiling and visibility research at GSD with a focus on Laps cloud analysis. For C&V and icing, METAR, satellite data and aircraft data are paramount. A LAPS DA ensemble system has been running since 1989. STMAS 3-D analysis was developed. Cloud analysis involves an elaborate process (see presentation). GOES is a major component. Italian SEVIRI data is also employed where available (mid-Atlantic Ocean through Europe and MidEast). Satellite fog dissipation is obtained from visible imagery. Cloud/reflectivity/precipitation type simulations are also available.

Dave Clark (MIT/LL) provided an overview of San Francisco GDP parameters selection model GPSM field evaluation. Not really a science presentation but would be of interest for a JPDO NextGen DSS forum. Presentation noted that forecasts were good but they didn't see the impact with the traffic managers. Cost analysis with Monte Carlo simulation was performed. Benefits model indicated delays reduced with better forecast information.

Steve Smith (NOAA MDL) covered LAMP probabilities. How do we get the categorical ceiling heights? Experience and data over time. He noted that virtually all the data gets into MADIS but there are quality checks. Different airports have different requirements. One solution might be to develop probabilistic information.

The next session covered Volcanic Ash. It was facilitated by John Murray. The first presentation was made by Arlin Krueger of the University of Maryland Baltimore Campus. He discussed hazard mitigation using retrievals of total SO_2 column measurements from the Ozone Monitoring Instrument (OMI) on the NASA Aura satellite as a proxy for aerosol index. These hyper spectral data provide both IR and UV detection. The IR problems include plume transport errors due to temperature contrast issues and water can also be a problem. In the UV, rayleigh scattering is the issue. Ash is gone in 2-4 days, but the SO_2 can be present for weeks up to a month. It is generally considered to be a good marker for 24 to 72 hours depending on ambient conditions, deposition rate due to ash load and particle size and on dispersion.

Rolland Draxler (NOAA) covered NOAA issues including source detection, transport and dispersion, verification, data assimilation and remote sensing. Volcanic ash arises from a point source and it gets injected into a continuous stream. Transport and dispersion is provided via ARL gridded models. It is sub grid scale. An interim solution might be to do ensemble forecasts. Verification depends on others with larger data sets and evaluating a larger part of the whole forecast concept. Data assimilation is a particular challenge. Remote sensing issues can give false indications or mask detections if not properly applied.

Mike Pavolonis (NOAA NESDIS/UW CIMSS) provided a summary of AVHRR, GOES, GOES R and GOES R-SO_2 work which was delivered by Kris Bedka (currently NASA LaRC, recently UW CIMSS). AVHRR is analyzed and automated e-mail warnings based on the information sent to the VAACs. The GOES imagers are similarly employed and they are preparing for regular usage soon. NESDIS's GOES-R aviation algorithm working group has a strong focus on volcanic ash applications for the imager. The product list and examples of each were shown.

John Murray (NASA LaRC) gave a presentation on integrated solutions for volcanic ash. He used several recent Alaskan volcano eruptions as examples (Okmok, Kasatochi and Mt. Redoubt). The presentation showed the value of integrating operational satellite data from NOAA GOES and AVHRR as well as imagery from NASA MODIS, SO_2 from Aura OMI data, and aerosol measurements from the NASA CALIPSO satellite and integrating them with NOAA HYSPLIT model output. He then fielded several questions concerning the Federal Volcanic Ash Working Group and the national Volcanic Ash Operations Plan.

The last session of the meeting concerned space weather. It was facilitated by Rodney Vheric of the NOAA Space Weather Center. Rodney opened the session noting that there is a special need for this information by aviation both for communications and navigation and for human exposure estimates. GPS data are particularly vulnerable to scintillation effects. They are critical for aircraft location. Travel over the Polar Regions is particularly impacted. HF communications is also difficult near the poles. FAA regulations require that they must be continuously available or aircraft cannot operate on that route. If there is no HF communications available, rerouting or cancellation results. It was also noted that radio blackout can occur with only 8 minutes notice with a flare. In the case of a radiation storm (protons from a coronal mass ejection), 15 minutes to 24 hours lead time is available. In a geomagnetic storm, 1-4 days is the norm. Satellite data is heavily relied upon. Most of it is provided by NASA SOHO (which monitors the sun's surface), ACE (which measures the solar wind) and SDO. NOAA GOES and POES provide proton flux measurements and spectral data. The ACE satellite is particularly important since it resides at a LaGrange point between the Earth and Sun to provide the only early warning of a severe solar storm. ACE is long past its expected life cycle but it is still operating. The ACE replacement will be a NASA Satellite. It will be launched by DOD for NOAA to operate. This will provide data with a 2-3 day detection and enable solar flare forecasts. How space weather is currently fit to NextGen requirements was also summarized.

Chris Mertens (NASA LaRC) covered the status of the development of the Nowcasting of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) model which will be completed within the next 12 months. NAIRAS uses all the data possible to run physics based models for prediction. This includes neutron monitor data to measure Galactic Cosmic Ray (GCR) background fluxes, GOES and ACE data for Solar Energetic Particles (SEP), i.e., solar storms, ACE data for solar wind perturbations of the magnetosphere, an accurate model of the Earth's magnetosphere and the NOAA NCEP reanalysis for the Earth's atmospheric density. This constitutes the first full-physics model of AIR for aviation. Model output is for all altitudes where routes are planned at 2.5 degree horizontal resolution globally. Since heavy ions and particles are more biologically damaging that smaller particles such as beta and gamma radiation, the model output is provided in tissue equivalent dosages for effective route planning, and monthly, annual or lifetime dosage assessments.

Kent Tobiska (Utah State University) summarized the three areas of primary interest for aviation regarding space weather. These are space weather affects on radiation environments, i.e., human exposure, GPS navigation, and HF radio communications. Better forecasts provide better dose estimates for crews in real time and after flying they also reduce GPS navigation uncertainties and improve communications capabilities for HF.