MEMORANDUM

Ref. AN 10/3.1 WAFSOPSG-Memo/44
17/4/13

To: Members, World Area Forecast System Operations Group (WAFSOPSG)

From: WAFSOPSG Secretary

Subjects: **Summary of WAFC Science Coordination Meeting**

Action: Note the information

As you may be aware, the two world area forecast centres (WAFCs), London and Washington, held a fourth Science Coordination Meeting, from 26 to 27 February 2013, at the United States National Oceanic and Atmospheric Administration (NOAA) Centre for Weather and Climate Prediction in College Park, Maryland, United States. The purpose of the meeting was to exchange information on the current and future scientific-related development plans of the WAFCs

The WAFCs requested the Secretariat to distribute to the WAFSOPSG members, for information, the science coordination meeting summary of presentations provided at the said meeting.

Therefore, I would kindly invite you to note the attached summary (also available on the WAFSOPSG website under "Seminars/Workshops") providing a high-level overview of the scientific presentations that were discussed at the above-mentioned meeting.

Best regards,

(signed by)
Raul Romero

Enclosure:
Summary of presentations

ATTACHMENT

SUMMARY OF PRESENTATIONS GIVEN TO THE WORLD AREA FORECAST CENTRE SCIENCE COORDINATION MEETING/4
(26 – 27 February 2013, College Park, Maryland, United States)

Chapter 1 INTRODUCTION

World Area Forecast Centres (WAFC) London and Washington convened their fourth science meeting from 26 to 27 February 2013 at the US National Oceanic and Atmospheric Administration (NOAA) Center for Weather and Climate Prediction in College Park, Maryland (near Washington DC).

The purpose of the meeting was to exchange information on current work and future development plans of the WAFCs.

The following is a summary of the presentations and discussions from the meeting.

Chapter 2 ALGORITHM ENHANCEMENTS EXCHANGE INFORMATION

Overview of Planned Changes to NOAA's National Weather Service (NWS) National Center for Environmental Prediction (NCEP) models – John Derber - US NWS/NCEP/EMC

An overview of the global model developments planned by NCEP was presented by John Derber. Several upgrades are planned with NCEP's global models which will increase the resolution and provide better physics to the native model which produces the global model forecasts from the WAFC Washington's global model. The native model resolution is planned to increase to 13 kilometer (km) over the globe in 2014, as well as increases to the vertical resolution planned for 2015.

NCEP will also incorporate NWS's Global Forecast Icing Product (GFIP) into NCEP's operational production suite. GFIP is a new global icing forecast algorithm by the NWS and will be run on the Global Forecast System (GFS) model.

WAFC London Research and Development (R&D) Plans for algorithm development – UK Met Office

Paul Maisey, UK Met Office, presented the following overview of WAFC London's research and development plans for turbulence, icing and convection.

1.1.1 Turbulence R&D and Plans – Helen Wells and Debi Turp – UK Met Office

WAFC London has developed a new turbulence algorithm which is currently known as the "combined turbulence predictor". Verification results, using the British Airways (BA) Global Aircraft Data Set (GADS), show that the combined turbulence predictor performs better than current WAFC London clear air turbulence (CAT) forecast which is based on the Ellrod TI1. The combined turbulence predictor is based on Ellrod TI1; mountain wave indicator; Richardson number; Lighthill-Ford Spontaneous Imbalance indicator; and convective precipitation rate.

Further work is planned to improve the reporting of the mountain wave turbulence algorithm, and development and implementation of a system to automatically categorise observed turbulence encounters by their likely sources (e.g., convective, mountain wave) using lightning and satellite observations. This system will be used to verify convective metrics against convective turbulence encounters.

Also planned for this year is a look at the reporting standards for EDR. The Met Office FAAM research aircraft will be used to perform off-line inter-comparison of the turbulence as it would be computed from the aircraft's avionics data with *in-situ* research quality turbulence measurements. UCAR's EDR algorithm will be used to report results using an emulation of the ADS-B/Mode-S concept of operation (recently published by the RTCA).

Long term research (beyond Apr 2014) that were identified include

1. Assessing the benefits of using the US's Global GTG (or some of its components) based on Unified Model output.
2. Test the capability to provide probability of EDR.
3. Develop a more sophisticated combined turbulence algorithm which uses dynamical weights which vary according to latitude and season.
4. Investigate new observation data sets (e.g., Doppler radar, research aircraft) to help in the verification of In-Cloud Turbulence (ICT).

1.1.2 A New in-flight icing index for aviation - Cyril Morcrette, Ben Bernstein (Leading Edge Atmospherics) and Helen Wells – UK Met Office

A new icing index was recently developed for inclusion into the operational global model. This work was made possible due to improved cloud forecasts in the model and a new science parameterization concerning sub-grid-scale cloud variability.

The new index has been tested and compared to the existing index using an icing climatology (20 years) for 15 global cities with favorable results. The new index can also be interpreted as a probability and can be incorporated into an ensemble-based forecasting system.

Long term R&D plans include an investigation for the need to develop an R&D program to deliver forecasts and observations of high altitude ice crystals.

1.1.3 Convection: R&D and plans: **Paul Maisey, Helen Wells and Lucy Skinner – UK Met Office.**

An initial qualitative assessment of WAFC cumulonimbus (CB) cloud top height forecasts for various case studies (against Sferics and satellite cloud top heights) indicated that WAFC London, WAFC Washington and harmonised forecasts have a tendency to under forecast CB cloud top heights. Near term planned operational changes (2013) will address this issue.

Longer term plans include moving to an ensemble-based system as well as the development of a technique to compensate for the timing of convection over land in the tropics (diurnal cycle).

Developing calibrated probabilistic WAFC hazard forecasts – a proposal – Helen Wells and Paul Maisey, UK Met Office

Paul Maisey, UK Met Office presented a proposal for developing probabilistic WAFC hazard forecasts based on ensembles.

Ensemble techniques are well suited to give good indications of low probability/high impact events, such as severe turbulence. The benefits for developing the proposal are (1) improves the skill and relative economic value of the forecast, and (2) responds to user requests/requirements from IATA and SESAR for information on the probability and severity of hazards.

There are several challenges with the proposal including (1) defining the new outputs so that the risk values are not extremely small, (2) accessing a source of data to be used to calibrate the output and (3) developing an approach for calibration and data transfer.

Initial proposal includes for:

> **Turbulence and icing**: Probability of encountering moderate and severe turbulence and icing at a 4-D location with respect to the average background turbulence and icing probability. Turbulence to be defined in terms of EDR thresholds (TBD). Icing to be defined in terms of super-cooled liquid water content thresholds (TBD). Suggestion to retire separate CAT and In Cloud Turbulence forecasts and just forecast turbulence (including convective turbulence).
>
> **CB**: Probability of encountering moderate and severe convective activity at this 4-D location. Moderate and severe convection could be defined in terms of radar reflectivity (e.g. ≥ 30dBZ (mod); ≥ 40 dBZ (sev) at 5km altitude) and/or lightning activity (TBD). Retire CB cloud base forecasts (due to the difficulties in verifying CB bases).

Consideration may need to be given to increasing the resolution of the WAFS grids since the hazard phenomena have small spatial scales. Initial thoughts are: Horizontal resolution increased from current 1.25 degree to 0.5 degree. Vertical resolution increased to 25 hPa above 400 hPa and 50 hPa below 400 hPa. Temporal resolution increased from current 3 hours to 1 hour. These changes would increase the data volume by 25 times.

A 4-year timeline was proposed for R&D by the WAFCs for implementing probabilistic calibrated hazard forecasts on a trial basis.

GTG for CONUS and its applicability to global turbulence forecasting – Bob Sharman NCAR/RAL.

Bob Sharman (US NCAR/RAL) discussed the Graphical Turbulence Guidance (GTG) product, which is in use over the contiguous U.S. (CONUS), and its applicability for a global product.

The Graphical Turbulence Guidance (GTG) product is a software package that computes a number of turbulence diagnostics from an NWP model, combines them, and outputs an ensemble mean of the diagnostic suite, which typically includes 10-15 diagnostics. It was originally used with the RUC NWP model but has since been expanded to ingest WRF, WRF RAP, GFS, UKMET, ECMWF, and COSMO NWP model grids. Unlike most automated turbulence forecast systems, the deterministic output of GTG is Eddy Dissipation Rate (EDR) (actually $EDR^{1/3}$), an aircraft independent turbulence intensity metric, that is consistent with in situ turbulence estimates provided by some commercial aircraft. The current operational version (GTG2.5) available on NOAA's ADDS site (http://www.aviationweather.gov/adds/) includes all altitudes 10-45,000 ft. For applications over the contiguous US (CONUS) the product has been rigorously verified against both AIREPs (also known as PIREPs in the US) and in situ EDR data for both CAT and MWT forecasts, and sample performance in terms of ROC curves were presented. The technique is easily applied to global NWP models, and results were shown using both the GFS and UKMET NWP model output. Future versions will include an option for probabilistic forecasts and one technique that could be used for this is to treat the ensemble of GTG generated turbulence diagnostics as an uncalibrated probability. Exactly what a calibrated probability should look like needs to be investigated with input from users, because it must be remembered that moderate and severe turbulence encounters are rare events.

Algorithm Enhancements: Icing Severity (GFIS) – By Marcia Politovich (NCAR)

Marcia Politovich, US NCAR, presented an overview of the work done with icing severity on the US's global GFS model.

NCAR's current global icing product is called Global Forecast Icing Probability (GFIP) which was delivered to NWS in 2010 and runs on the GFS. GFS model's horizontal resolution is 0.3 degree grid spacing with 1051 x 672 grid points. Vertical resolution is 25 mb with 47 vertical levels.

GFIP's algorithm/process analyzes a column of data for clouds. Depending on the global region (e.g., tropic, mid-lat, polar) it identifies the cloud type and uses a fuzzy logic for probability and severity.

Severity definitions are based on aircrafts response to icing. Attempts have been made to match severity to an icing accretion rate. However there are other effects, such as where the ice is accreted, surface roughness, aircraft's anti-ice and de-ice capabilities, and airfoil shape, airspeed and the wing's angle of attack. Forecasters have little guidance for defining severity using meteorological quantities thus they do it indirectly using temperature, relative humidity, condensate and vertical velocity.

Politovich concluded by presenting a strategy for producing a global icing severity product using the GFS.

Porting Icing FIP/CIP/FIS to the global model – Hui-ya Chuang, US NWS/NCEP/EMC

Hui-ya Chuang, US NWS/NCEP/EMC, presented an overview of the US's efforts to transfer the US's Current Icing Product (CIP), Forecast Icing Potential (FIP) and Forecast Icing Severity (FIS) to the global GFS model.

CIP over the US relies on satellite data, AIREPs, METARs and radar. For global CIP, the key contributor will be the satellite, with METARs second, and radar as a distant third. AIREPs for icing, METARs and radar are basically non-existent over the oceans as well as many land areas of the globe.

Early verification results show that the global FIP (GFIP) has slightly more skill than the WAFS blended icing forecasts.

Chapter 3 Verification, BLENDING, THRESHOLDS

In situ EDR data: Background, status, and data sharing – Bob Sharman, Larry Cornman, Greg Meymaris, Gary Blackburn, Julia Pearson – NCAR/RAL

Bob Sharman (US NCAR/RAL) presented an overview of work being done in the US on data sharing of EDR.

Until recently, the only routine reports of turbulence are those provided by pilots, but these can have substantial errors in position and time. In the US, reports by pilots categorize turbulence on subjective intensity scales of "nil"," light"," moderate", "severe", or "extreme[1]", making them ill-suited for providing maps of atmospheric turbulence levels over aircraft flight routes. But more accurate turbulence encounter locations and intensities can be obtained using a new *in situ* turbulence monitoring system now installed on some U.S. commercial air carriers (currently about 200). These reports provide estimates of atmospheric turbulence intensity levels (as $EDR^{1/3}$ or "EDR", the eddy dissipation rate) over each minute of flight. The reports are routine, completely automated, are aircraft independent, and are accurate to within at least about 10 km and 1 min, and are therefore ideal for operational planning purposes. Importantly, they provide a much needed source of turbulence information that can be used to calibrate, tune, and verify turbulence forecast models. To address the costs associated with downlinking this information to the ground for dissemination, infrequent routine downlinks (usually associated with AMDAR meteorological downlinks, typically 15-30 min) along with other downlinks when the turbulence level exceeds some user-specified threshold or "trigger" are performed. The amount of turbulence data gathered is unprecedented - as of Jan 2013 the ~ 200 aircraft outfitted with this system provided well over 140 million archived records of EDR values mostly at cruise levels of commercial aircraft. Probability distribution functions (PDF) of EDR estimates from this data show that moderate-

[1] Extreme is a special category used in the US and is defined in the US's Aeronautical Information Manual (AIM)

severe events are indeed quite rare, and this has to be taken into account when providing probabilistic turbulence forecasts. The in situ EDR estimation algorithm and software is mature and is ready to be deployed on other aircraft. Installation on aircraft flying international routes would be particularly useful for global turbulence forecast verification. Some examples of comparison of derived gust velocity (Ude) measurements were provided based on an earlier study of Qantas-equipped aircraft (Stickland 1998), and statistically there does seem to be a correlation between EDR and Ude, but there is also much scatter in the data. This may or may not be a way to convert BA 747 Ude measurements (GADS) to EDR, but this needs careful investigation.

Sharman also noted that the current thresholds in Annex 3 – *Meteorological Service for International Air Navigation* are high relative to their studies comparing PIREPS to in situ EDR estimates from the same or nearby aircraft (~160,000 DAL737 and ~68,000 UAL comparisons). The thresholds in Annex 3 are for a medium-sized aircraft (units are $m^{2/3}s^{-1}$):

Light = 0.10
Moderate = 0.40
Severe = 0.70

Per the work done by Sharman, et al, they find the following: (the median value is followed by the observed range in parentheses):

Light : 0.06 (<0.1)
Moderate : 0.22 (0.1-0.25)
Severe : 0.5 (0.1-0.7)

Sharman also noted that the values of severe turbulence vary per aircraft size/type per the following, based on a simple aircraft response model:

Severe for B-747 = 0.6
Severe for B-737 = 0.5
Severe for small business jet = 0.4

Finally, it was noted that the mean error on a pilot report location is about 30km.

Quality control and monitoring of harmonised and unharmonised forecasts -

Paul Maisey, UK Met Office

Paul Maisey presented an overview of the monitoring and quality control program by WAFC London for the WAFC gridded forecasts.

The UK Met Office / WAFC London has been developing a monitoring system that examines both US and UK data files. Alerts are raised to the 24x7 Operations Centre when the harmonization process is late or has errors; and when US or UK data is late or has missing files. Comparisons are done with the two blended outputs (forecasts), i.e. US/UK output by US with same blended by UK. Unblended output is also compared.

Recent CB monitoring statistics were presented and discussed. Plans include the expansion of the routine monitoring to CAT, ICT and icing by Sept 2013. The establishment of a regular bulletin to report the output was also discussed.

Application of Global Ensemble Forecasts – Matthias Steiner, US NCAR/RAL

Matthias Steiner, US NCAR/RAL, presented an overview of NCAR/RAL's work in support of global ensemble forecasts.

Initial studies used the THORPEX Interactive Grand Global Ensemble (TIGGE) datasets. NCAR is currently assessing NCEP and Canadian ensemble forecasts via NOAA's Operational Model Archive and Distribution System (NOMADS). Future plans include the inclusion of the ECMWF and UK Met Office ensemble forecasts.

The initial focus will be on the northern Pacific to address the increasing air traffic to Asia and to provide guidance to Meteorological Watch Offices in Honolulu and Anchorage. Some challenges include the limited observations covering the oceanic airspace which may result in satellite-based proxies.

Prototype processing elements were shown as well as an example case from December 2012. Preliminary evaluations for a 2 month period (08 Dec 2012 – 08 Feb 2013) were shown as well as the effects of calibration efforts. Additional statistics were also presented.

An outline of the next steps for R&D efforts was presented, including ideas for creating a weighted ensemble system that would improve the current method for blending WAFS grids. This weighted ensemble system would give more weight to the ensemble members with the best recent performance in similar icing, turbulence or CB conditions.

Discussion on Using Ensembles to Create WAFS Grids – David Bright, US NCEP/AWC

David Bright, US NCEP/AWC, gave an overview of the ensemble processes currently supported by the NWS. This included a description of the NCEP Ensemble System which involves the national meteorological services of the US, Mexico and Canada.

A description of the Aviation Weather Testbed (AWT) at NCEP/AWC was provided, including a discussion of their plans and milestones. The goal of the AWT is to become an integral component of the operational aviation-weather research to operations (R2O) and operations to research (O2R) process, expand partnerships, modernize services, increase the efficiency of the forecaster, and become a key player in US's NextGen.

The AWT has also been looking into the use of ensembles to create the WAFS gridded forecasts.

WAFC Verification - recent results and future plans – Phil Gill, UK Met Office

An overview of the verification process and system for the WAFC CB clouds and turbulence was presented. Recent verification results were also presented and discussed for the WAFS CB clouds and turbulence.

It was agreed that one of the challenges is that in some ICAO Regions there are a lack of sufficient reports for verification. It was noted that the WAFCs with support from the WAFSOPSG need to overcome this challenge.

Icing Verification – recent results and future plans – Hui-ya Chuang – US NWS/NCEP/EMC

The NCEP-WAFS G2G Verification System for WAFS icing verification was presented and discussed. "G2G" is a grid-2-grid approach which verifies any model against gridded analysis at EMC/NCEP.

An overview was also given on NCEP-WAFS Verification Display System, which is a web-based service. Icing output files generated from EMC verification package are stored in a database. Verification results are updated in the database every day for forecast products one day before. Users can generate various statistical outputs for the various forecasts.

— END —