16th Session of WMO Commission for Aeronautical Meteorology (CAeM-16) Technical Conference (TECO)

Keynote – Past, Present and Future

CM Shun
President, CAeM

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

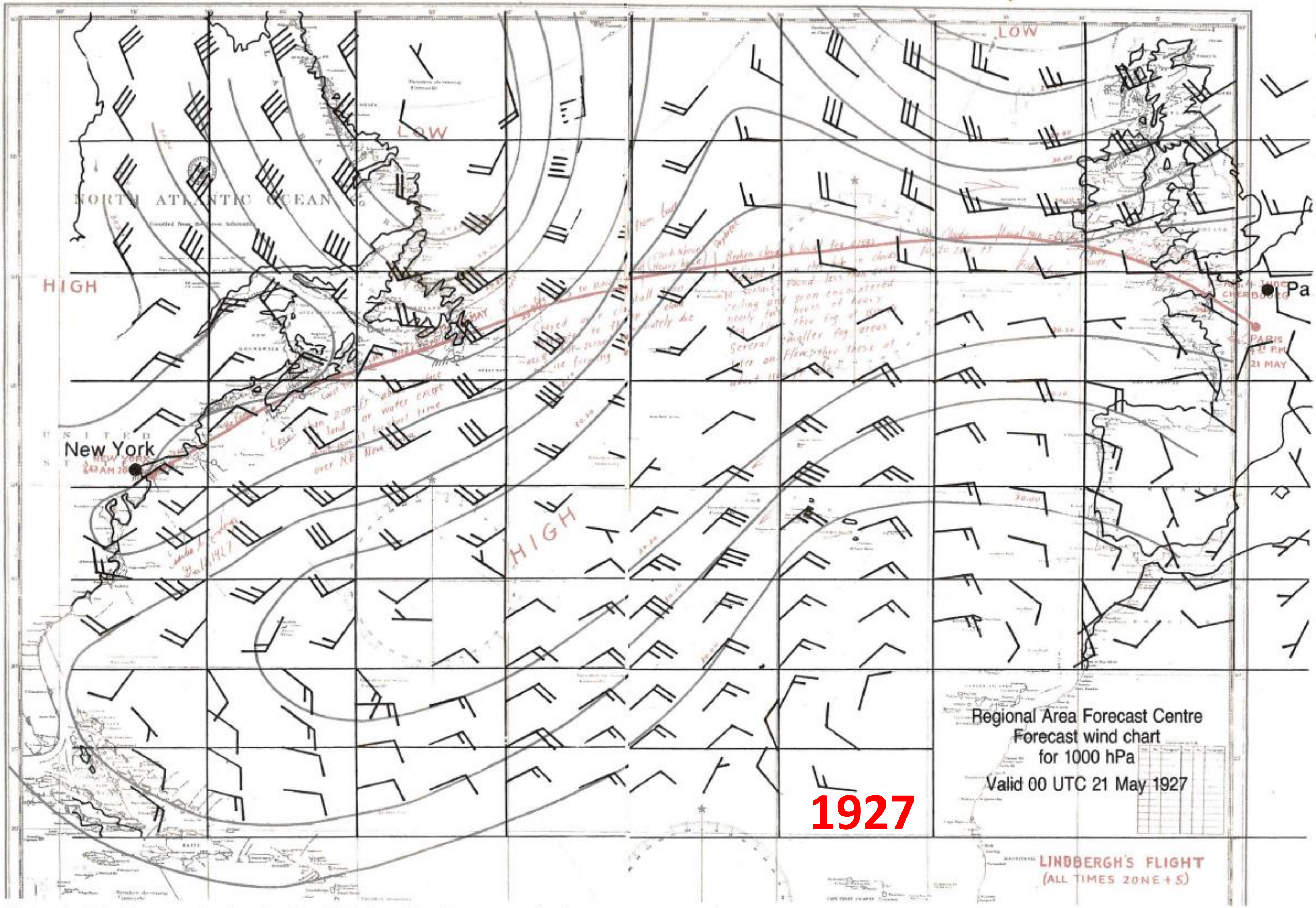
World Meteorological Organization
Organisation météorologique mondiale

23 July 2018

University of Exeter

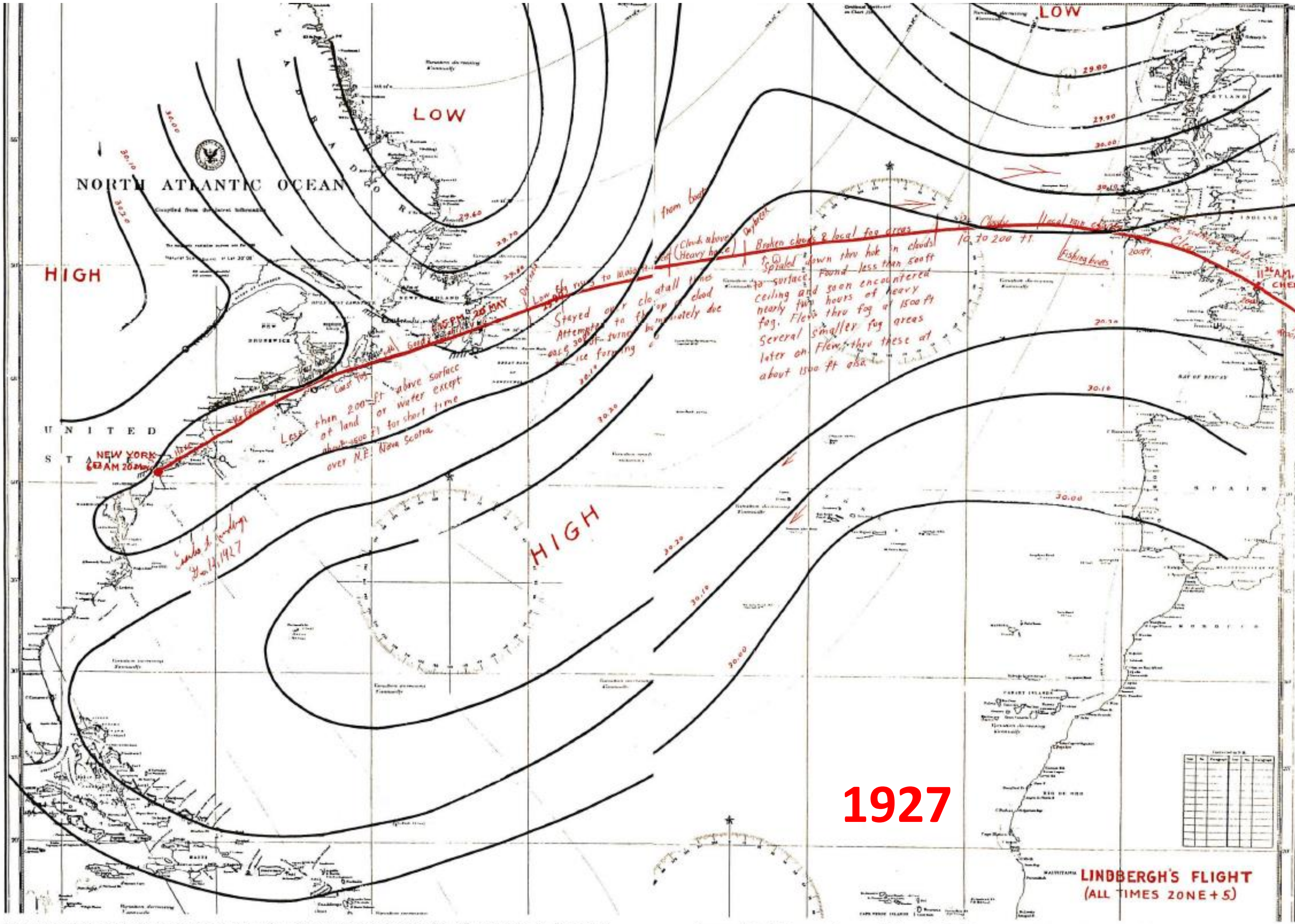
Exeter, United Kingdom

Story begins here… 1903



The meteorological documentation issued to Capt. C. Lindbergh for his attempt at the first eastbound non-stop crossing of the North Atlantic from New York to Paris, 20-21 May 1927. If the meteorological services of today had existed sixty years ago, Capt. Lindbergh's flight

forecast in-flight weather conditions, including areas of hazardous conditions such as icing. The wind information is provided in the form of spot winds, the direction of the axis of the symbol indicating the direction, and the number of barbs the speed of the wind over the location



The meteorological documentation issued to Capt. C. Lindbergh for his attempt at the first eastbound non-stop crossing of the North Atlantic from New York to Paris, 20-21 May 1927. If the meteorological services of today had existed sixty years ago, Capt. Lindbergh's flight documentation would have included — in addition to the spot upper-wind forecast chart shown

forecast in-flight weather conditions, including areas of hazardous conditions such as icing. The wind information is provided in the form of spot winds, the direction of the axis of the symbol indicating the direction, and the number of barbs the speed of the wind over the location

A brief history of AeM

1903	**First powered flight by Wright brothers**
1919	First session of Commission for the Applications of Meteorology to Aerial Navigation (CAMAN) of IMO
1920s	First weather services for aviation
1922	Establishment of International Commission for Air Navigation (ICAN) by Paris Convention, under direction of League of Nations (Annex G)
1935	Establishment of ***intergovernmental*** International Commission for Aeronautical Meteorology (ICAM) of IMO
1939	Adoption of 1st edition of "General Regulations for the International Meteorological Protection of Aeronautics" by IMO
1939	Successful trials of operating air routes over North Atlantic Ocean
1947	Establishment of ICAO by Chicago Convention, replacing ICAN
1948	First agreement of North Atlantic Ocean Stations (NAOS) under ICAO
1951	IMO formally became the World Meteorological Organization on 17th March 1951. The ensuing First Congress of WMO established Commission for Aeronautical Meteorology (CAeM)

Review of IMO status (1939)

"In view of the steadily increasing practical importance of meteorology, it is desirable that the governments of the various countries should have a greater influence on the work of the Organization. The resolutions of the Organization should be binding on the countries to a greater extent. The Organization must be able to rely on adequate resources so that efficient co-operation should not be hampered by financial difficulties. ***It is abnormal for one of the Organization's commissions (the International Commission for Aeronautical Meteorology, which had intergovernmental status -Ed.) to have a more official status than the Organization itself.*** *Similar organizations (the International Commission for Air Navigation, the International Union of Geodesy and Geophysics and others) have a more official status than lMO, a circumstance which has its drawbacks. Governments have not sufficient control over the choice of representatives from their countries."*

– Dr Th. Hesselberg, Director of the Norwegian Meteorological Service, President of the International Meteorological Committee, IMO

A brief history of CAeM

1951	**Establishment of Commission for Aeronautical Meteorology (CAeM) by 1st Congress of WMO**
1953	Establishment of ICAO/WMO Working Arrangements
1954	1st Session of CAeM, Montreal (conjoint with ICAO MET Div) *Qualification & training of AMP, air-reporting, aerodrome observation, climatological summaries, support high-level operations for jet aircraft*
1957	Introduction of SIGMET
1959	2nd Session of CAeM, Montreal (conjoint with ICAO MET Div) Published guide on qualification & training, drafting manual on aerodrome MET office practices & manual on MET obs on aircraft, study of area forecast system
1964	3rd Session of CAeM, Paris (conjoint with ICAO MET/OPS Div) *Draft manual on aerodrome MET office practices late, consider supersonic transport requirements esp the value of an area forecast system*
1967	4th Session of CAeM, Montreal (conjoint with ICAO ANC) TC warning, special air-reports, use of satellite data
1968	**WMO Scientific & Technical Conference on Aeronautical Meteorology** *1) MET conditions in vicinity of aerodromes, 2) MET conditions in troposphere & lower stratosphere, 3) MET info for Supersonic Transport Operations (SST)*
1969	Ext Session of CAeM, Montreal (conjoint with ICAO ANC) *Turbulence detection, support for SST, centralization of MET services*

First separate CAeM session

A brief history of CAeM

1971	5th Session of CAeM, Geneva (also attended by ICAO, IATA & IFALPA) *Detection & forecasting of clear air turbulence, slant visual range & low-level vertical windshear*
1974	Ext Session of CAeM, Montreal (conjoint with ICAO ANC & MET Div) *Detailed review of SARPs, combining Annex 3 & PANS-MET*
1975	New agreement of North Atlantic Ocean Station (NAOS) under WMO
1976	6th Session of CAeM, Montreal (conjoint with ICAO ANC) *Economic benefits, value of separate CAeM sessions, rapporteur on automated aircraft MET obs*
1982	7th Session of CAeM, Montreal (conjoint with ICAO COM/MET Div) *Established World Area Forecast System (WAFS)*
1986	**8th Session of CAeM, Geneva** *Lack of aircraft observation, first mentioning of nowcasting*
1990	9th Session of CAeM, Montreal (conjoint with ICAO COM/MET/OPS Div) *Centralization of services and automation, cost effectiveness of WAFS*
1994	**10th Session of CAeM, Geneva** *Commercialization, cost recovery and data policy, cost effectiveness of WAFS*
1998	WMO established AMDAR Panel; ICAO established VAACs
1999	**11th Session of CAeM, Geneva** *Final phase of WAFS and training*

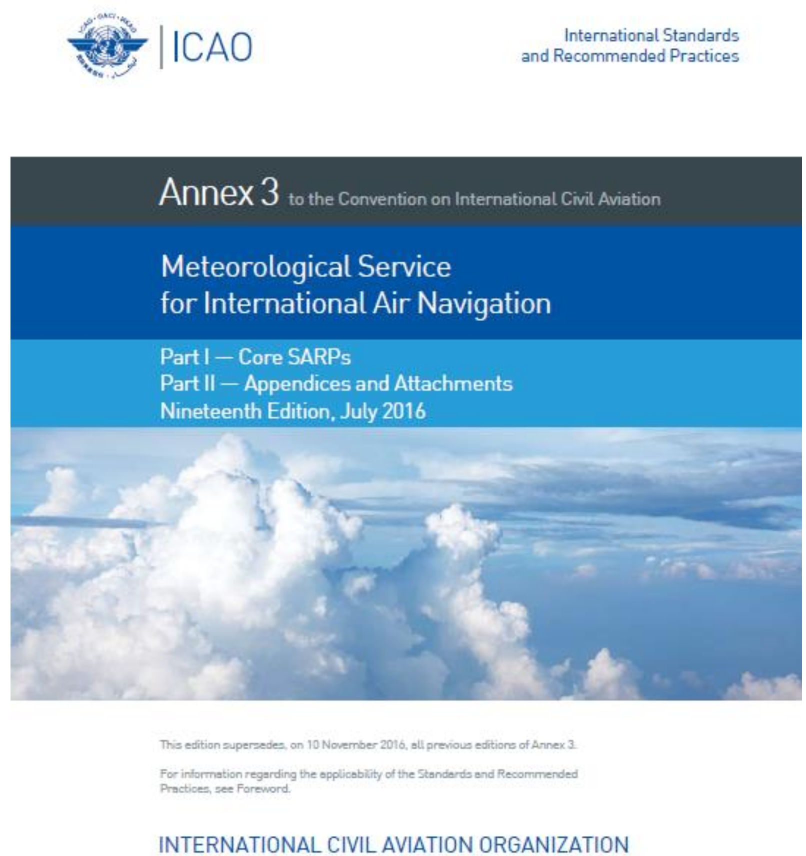
A brief history of CAeM

2002	**12th Session of CAeM, Montreal (conjoint with ICAO MET Div)** ***Established WAFSOPSG, IAVWOPSG, AMOSSG, METWSG & METLINKSG***
2006	**13th Session of CAeM, Geneva** *Established Expert Team on New Terminal Forecast*
2010	**14th Session of CAeM, Hong Kong, China** *Established competency standards for AMP* *Urgent need to address SIGMET deficiencies*
2014	15th Session of CAeM, Montreal (conjoint with ICAO MET Div) *ICAO established MET Panel to develop provisions supporting the Global Air Navigation Plan (GANP) and Aviation System Block Upgrade (ASBU) methodology (WMO established CAeM/CAS AvRDP)*
2017	**Aeronautical Meteorology Scientific Conference** *1) Science underpinning meteorological observations, forecasts, advisories and warnings, 2) Integration, use cases, fitness for purpose and service delivery, and 3) Impacts of climate change and variability on aviation operations and associated science requirements*
2018	**16th Session of CAeM, Exeter, UK**

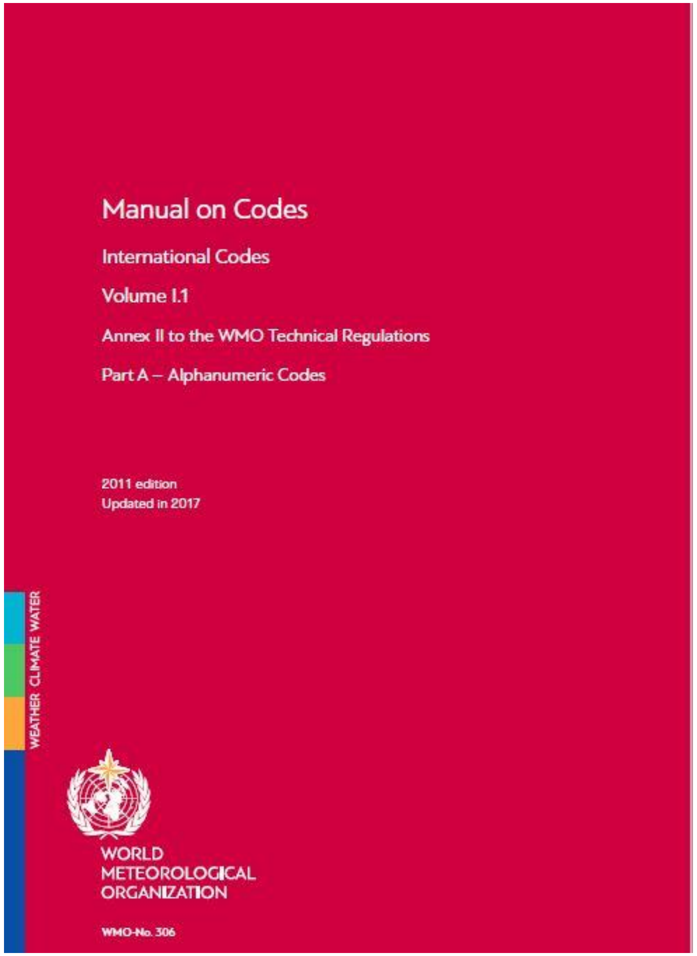
ICAO/WMO Working Arrangements

“Although differences in the internal structures of both organizations have from time to time led to complications, the working arrangements have always been quite effective.”

- John Kastelein, “Meteorology in the Service of Aviation”, WMO-No. 706, 1988



The regulatory material contained in Annex 3 is, except for a few minor editorial differences, identical with that appearing in the *Technical Regulations* (WMO-No. 49), Volume II — *Meteorological Service for International Air Navigation,* Parts I and II (WMO-No.49 Vol II first approved by 2nd Congress (1955) for applicability on 1 Jan 1956).



METAR / SPECI

TAF

ARFOR

AIREP

GRID

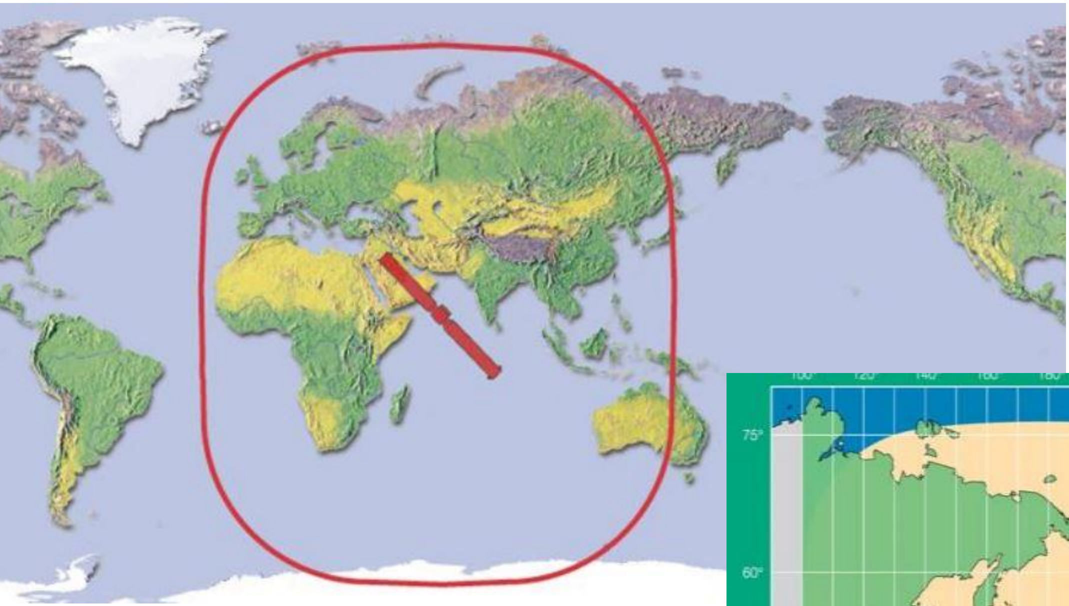
GRIB

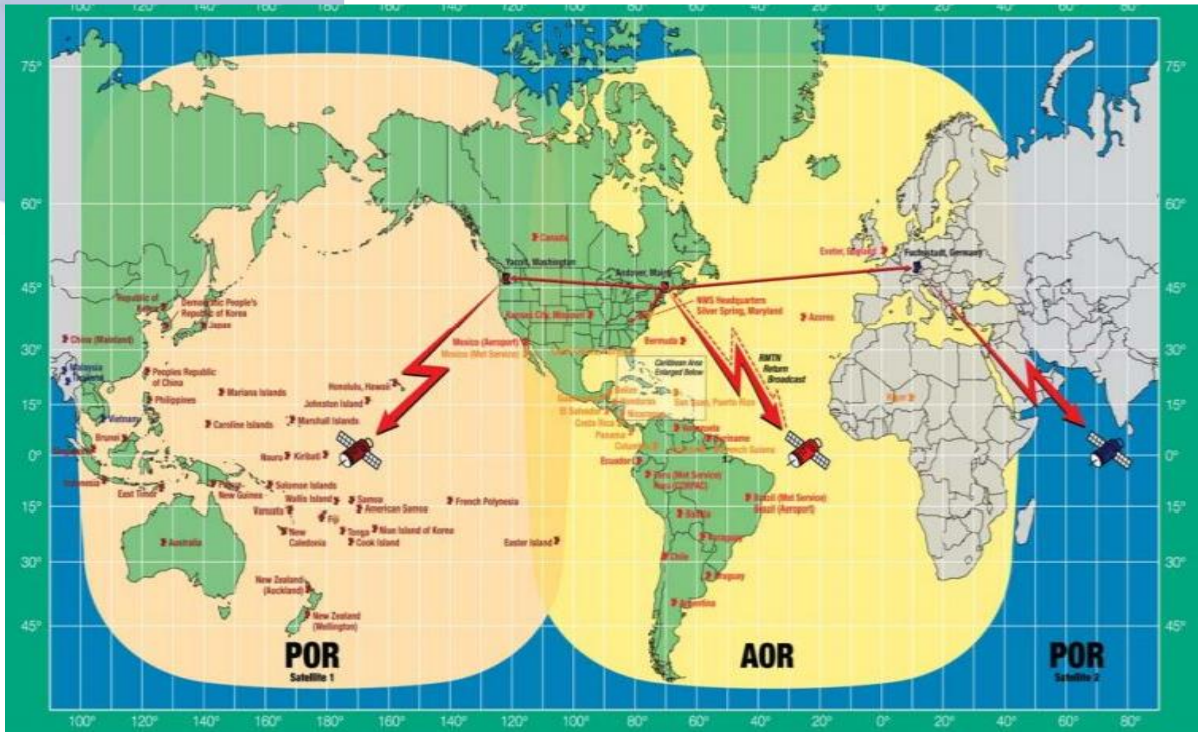
BUFR

IWXXM

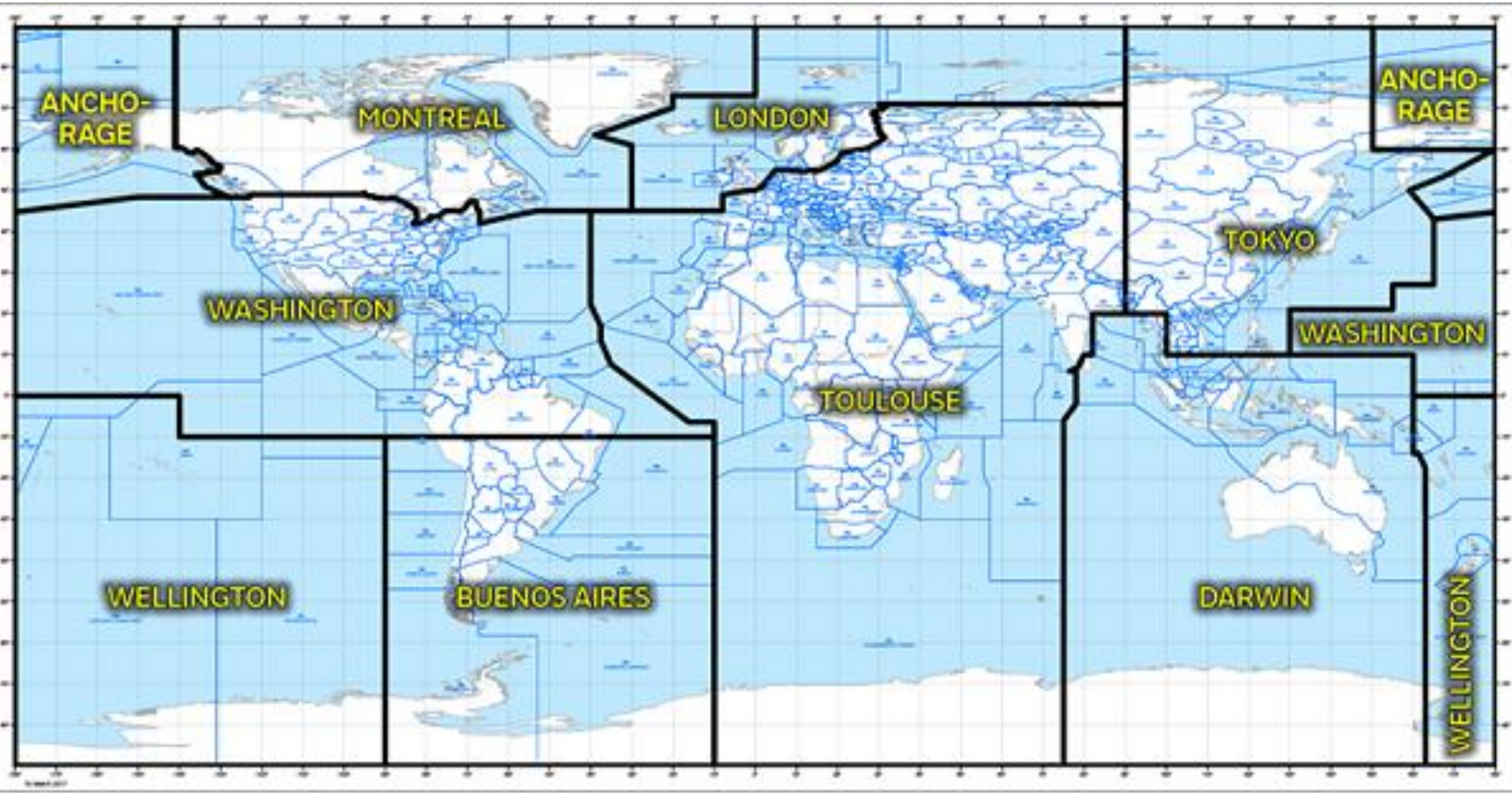
The aeronautical meteorological code forms referred to in Annex 3 are developed by the World Meteorological Organization on the basis of aeronautical requirements contained in this Annex (Annex 3), or stated from time to time by the Council. The aeronautical meteorological code forms are promulgated in the *Manual on Codes* (WMO-No. 306), Volume I — *International Codes*.

WAFS (SADIS & ISCS)



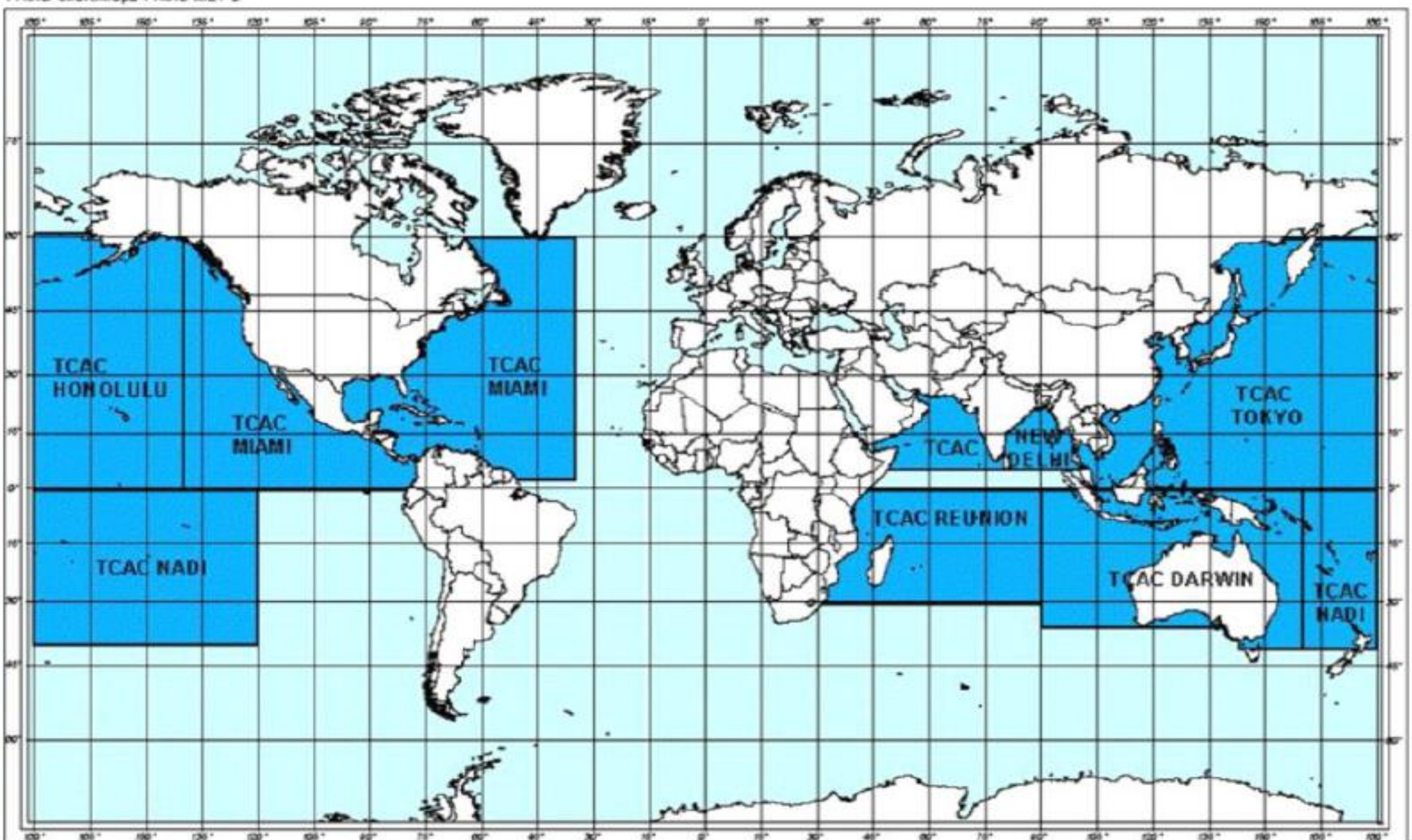


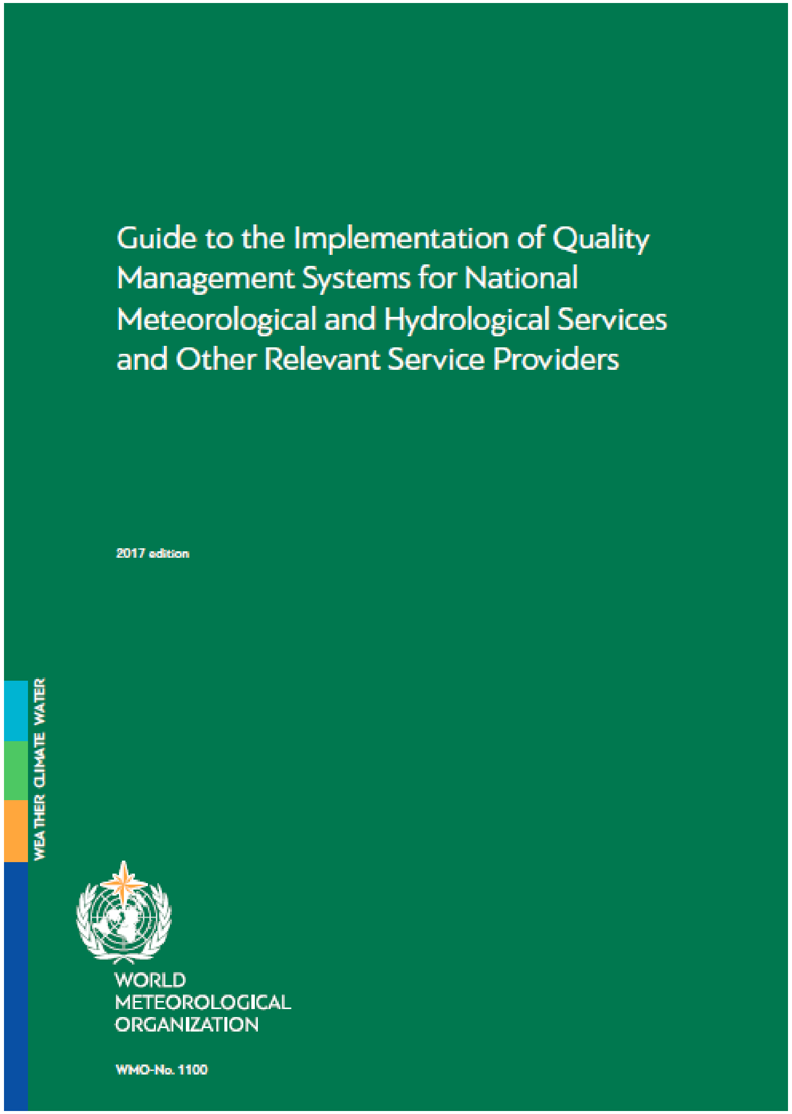
Volcanic Ash Advisory Centres



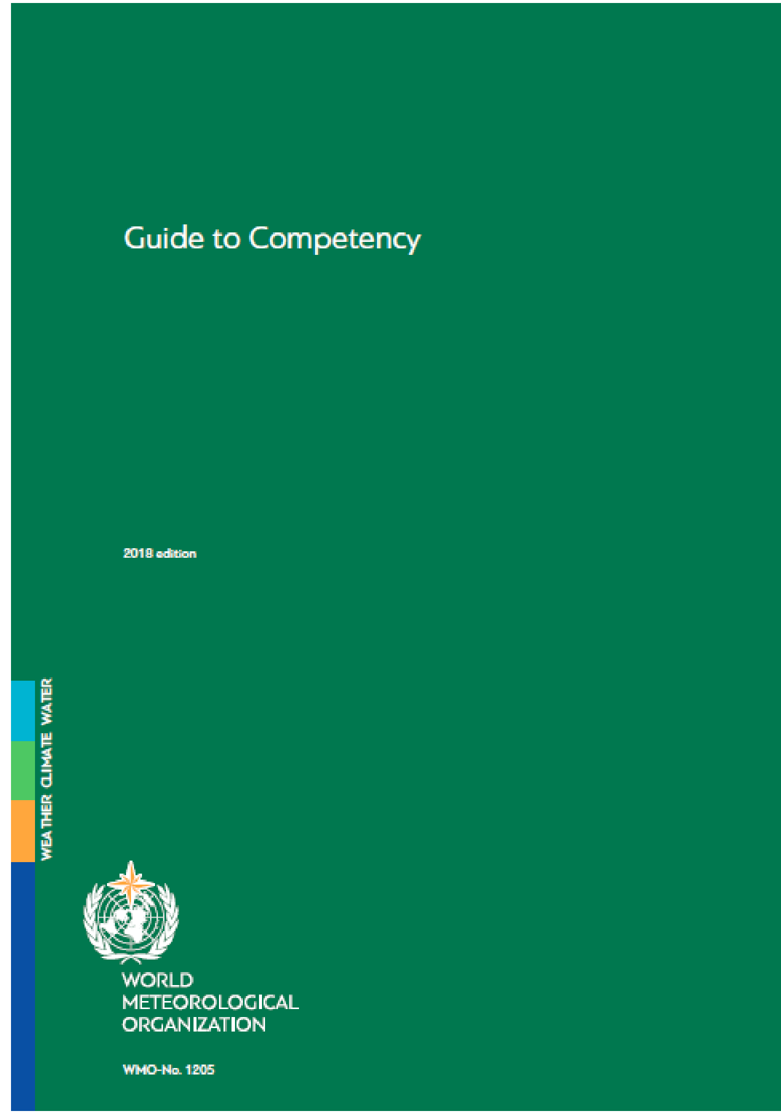
Tropical Cyclone Advisory Centres

FASID Chart/Mapa FASID MET 2





QMS



Competency

Thunderstorm

Icing

Turbulence

Sandstorm

MET Hazards

Mountain wave

Volcanic ash

Windshear

Tropical Cyclone

Gust

The very first series of engine-powered flights by the Wright brothers ended abruptly when a strong gust of wind overturned the aircraft and damaged it.

Windshear

1973	**Ozark Airlines Flight 809 crashed in a thunderstorm on approach to St. Louis' Lambert International Airport**
1975	Eastern Air Lines Flight 66 crashed at John F. Kennedy Airport
1976	Introduction of Low-Level Windshear Alerting System (LLWAS)
1977	University of Chicago's Dr. Ted Fujita and Dr. Horace Byers postulated the downburst causing crash of Flight 66
1982	Introduction of low-level windshear warning in ICAO Annex 3
1985	Delta Flight 191 crashed at Dallas Ft. Worth International Airport. Based on black-box data, Fujita proved the existence of microburst
1993	Near miss of Alaska Airlines 727 at Juneau International Airport due to terrain-induced windshear
Mid-1990s	Operation of Terminal Doppler Weather Radar (TDWR)
2005	Operation of LIDAR Windshear Alerting System (LIWAS)

ICAO Journal Vol 62 (2007)

Ground-based wind shear detection systems have become vital to safe operations

Various warning systems deployed at the most vulnerable locations across the United States provide varying levels of protection against wind shear, with collocation of certain systems offering the most effective safety solution

CHRISTOPHER KEOHAN
FEDERAL AVIATION ADMINISTRATION
(UNITED STATES)

WIND SHEAR-related accidents have caused more than 1,400 fatalitie... 1943, including o... United States alo... period. This loss o... development and... shear detection sy...

Four types of... entered operatio... States, where site... basis of traffic vol... frequency. Those — the terminal D... (TDWR), the low... system (LLWAS),... processor (WSP) and the integrated terminal weather system (ITWS) — collectively serve 121 U.S. aerodromes. Other non-commissioned turbulence and wind shear systems, such as the light detecting and ranging (LIDAR) Doppler and the Juneau airport wind system (JAWS), have recently been evaluated.

The wind shear systems currently in operation detect a change in the wind speed and/or direction and issue an automated alert to an air traffic controller, who then relays this alert to pilots. In general, automated ground-based systems detect wind shear that involves an airspeed change of 15 knots or greater over a distance of one to four kilometres. For alerting purposes, wind shear is classified as a microburst when it involves a speed loss of 30 knots ... efficiency are also highlighted.

TDWR detects wind shear well when the shear is accompanied by rain, but does not perform so effectively when there is little or no rain.

Terminal Doppler weather radar. There are currently 45 TDWRs commissioned in the United States. This five-centimetre radar system, designed to specifically detect wind shear at an aerodrome, achieves better than 90 percent probability of detection (POD) of wind shear loss ... than 10 percent ...n (PFA) — values ...st of the Rocky ...ined in the inter- ...ust front, or wind ...is generally above ...f detection east of ... than 50 percent ...untains.

...DWR outages — ...ch as unreliable ...ications with Air ..., computer limita- ...ar — have been overcome during the past decade. To remedy the problem of antenna wear, the aerodrome pie sector scan strategy has been upgraded to a 360-degree scan; this has increased the scan strategy volume time and gust front update time from five to six minutes, while maintaining the wind shear loss surface scan update time of one minute.

An improvement in TDWR reliability was essential for winning the confidence of ATS. TDWR information is also relayed to many U.S. National Weather Service (NWS) offices, which issue weather warnings and forecasts to aerodromes and the public.

As implied by the POD values above, one concern is the less than desirable wind shear performance in the western United States. TDWR detects wind shear well when the shear is accompanied by rain, but does not perform so effectively when there is little or no rain. Although the scan strategy and clutter maps have

TDWR (left) experienced early problems with outages that have now been resolved. The ASR-9 system, right, has been upgraded with implementation of WSP. Less costly than TDWR, WSP allows for wind shear prediction at medium-capacity airports; however, it does not perform effectively in a dry environment

been optimized, the performance has remained outside of specifications (POD ≥ 90% and PFA ≤ 10%). In an effort to address this shortcoming, the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) and the U.S. Federal Aviation Administration (FAA) have begun developing new TDWR radar data acquisition (RDA) techniques that are expected to improve data quality. Testing of these new techniques is expected in 2007.

LIDAR Doppler. In addition to TDWR improvements, an evaluation of an alternative dry wind shear detection system was performed at Las Vegas in the summer of 2005. The LIDAR Doppler system was provided by Lockheed Martin Coherent Technologies and tested by FAA. Results showed the LIDAR Doppler was effective at detecting dry wind shear, while TDWR performed well at identifying wet wind shear in this high clutter environment.

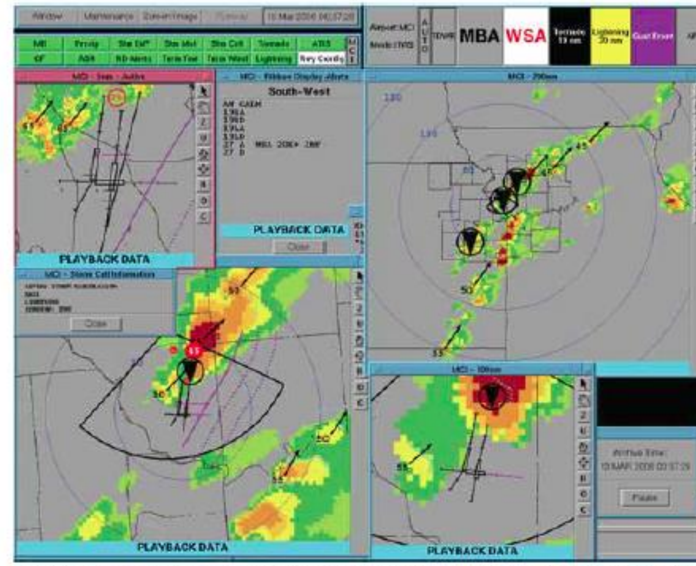
An integration of TDWR and LIDAR Doppler systems can achieve the desired wind shear detection rate of better than 90 percent POD, while also limiting false alarms to under 10 percent, provided the integrated systems incorporate the TDWR RDA upgrade and some modifications to the LIDAR Doppler wind shear detection algorithms.

The ability of LIDAR Doppler in detecting dry wind shear has been proven in Hong Kong, where the system can discern terrain-induced wind shear. Other sensors installed at Hong Kong include the TDWR, anemometers, weather buoys and wind profilers. The information from each of these systems is used in the wind shear and turbulence warning system (WTWS), making the source of the alert transparent to ATS personnel.

According to the Hong Kong Observatory, the use of these various systems results in an integrated wind shear POD rate of greater than 90 percent. The

LIDAR Do... tion of nea... shears. Thi... sition of a... improved ... recent des... WTWS is... http://ww... _PWLi.pdf... obstacle ... caused by... ed by a LII...

Another... movement... increas... goal of safe... certain win... ues with op... allel runwa... Francisco,... When win... capacity ga... ing the nu... must be ... threshold f... way to de... induced ai... runway (i...



Example of ITWS display of severe weather containing microbursts, a gust front and tornados (Kansas City, 13 March 2006). ITWS features a prediction product that forewarns of a microburst

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IFALPA

民航處
CIVIL AVIATION DEPARTMENT

香港國際機場
HONG KONG INTERNATIONAL AIRPORT

FEDERAL AVIATION ADMINISTRATION

MIT Lincoln Laboratory

Raytheon

NASA

CLR Photonics, Inc.

NCAR | National Center for
UCAR | Atmospheric Research

香港天文台
HONG KONG OBSERVATORY

NOAA Earth System Research Laboratory
Serving Society through Science

NSSL The National Severe Storms Laboratory

Mitsubishi Corporation

Turbulence

*"In **1915**, an official of the U.S. Weather Bureau in San Diego, California, was a passenger in a military biplane on a flight from San Diego for the express purpose of **investigating atmospheric turbulence** over Point Lama near San Diego. The hills on this narrow peninsula are almost 500 feet above sea-level, and pilots had noticed an upward surge of the air to as high as 4000 feet due to the deflection of the prevailing north-westerly winds."*

- N.A. Lieurance, President, CAeM, "Proceedings of the WMO Scientific and Technical Conference on Aeronautical Meteorology, London, March 1968", WMO-No. 227, 1969

Turbulence

"Clear air turbulence (CAT) has continued to be a vexing problem. The primary goal associated with CAT is its detection. ***So far, no satisfactory detection system, airborne or ground-based, has been developed****. The accuracy and usefulness of CAT forecasts leave much to be desired, primarily because the physical causes and characteristics of the CAT phenomena are not understood."*

- N.A. Lieurance, President, CAeM, "Proceedings of the WMO Scientific and Technical Conference on Aeronautical Meteorology, London, March 1968", WMO-No. 227, **1969**

Turbulence forecast

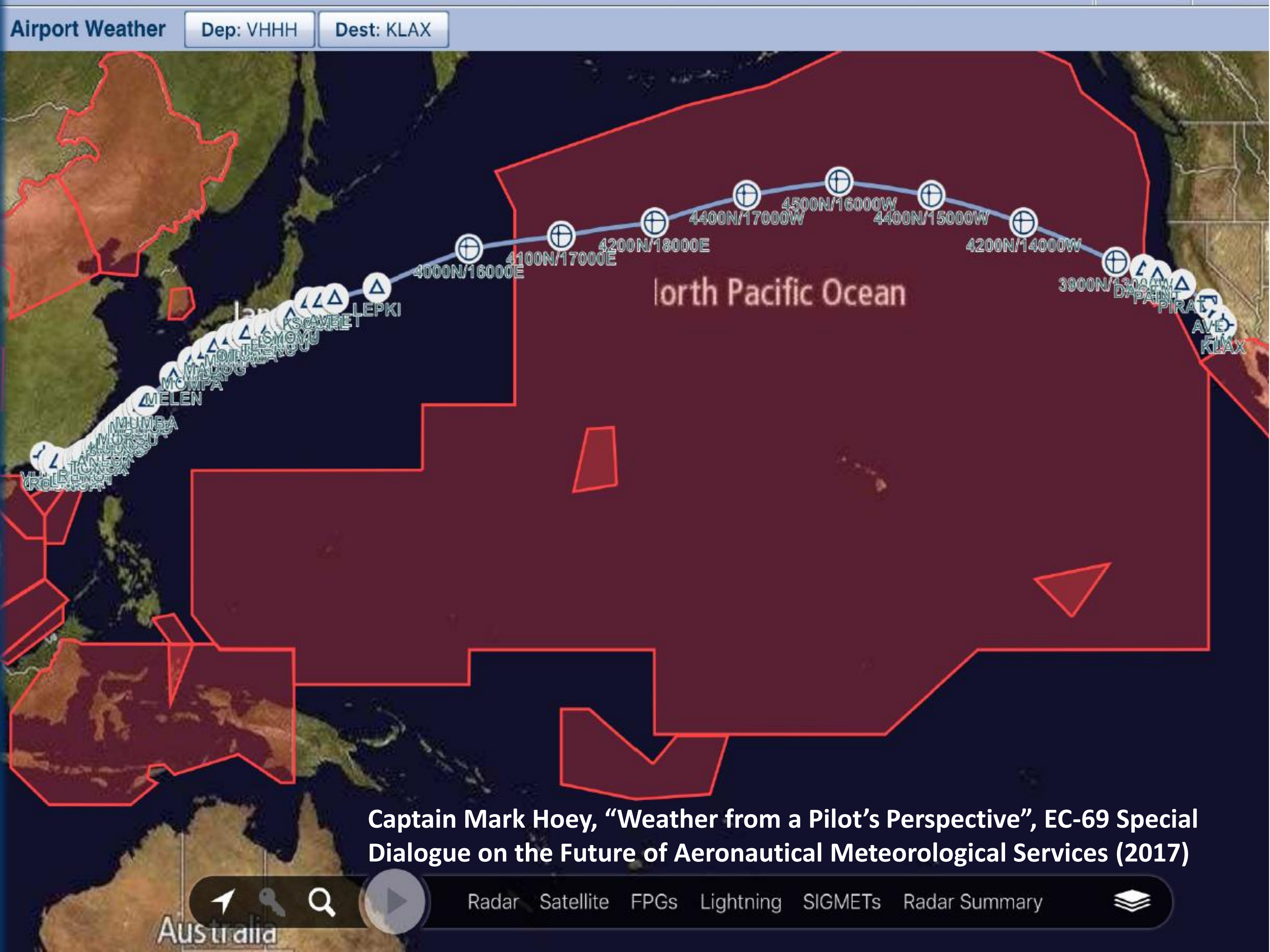
*"**The reliability of CAT forecasts has been problematic since the introduction of jet traffic** because the phenomenon is very difficult to forecast. Fortunately, the **numerical simulation of clear-air turbulence production, at present under development, promises to give better results**."*

- John Kastelein, "Meteorology in the Service of Aviation", WMO-No. 706, **1988**

Turbulence reports

"… the validation of icing and turbulence forecasts required upper-air observations such as ***radio pilot reports (PIREPs)****. However,* ***the use of those reports as a primary source of verification was problematic*** *because they were, among other things, very."* ***subjective, not systematic in time and space, and tended to be located in high traffic regions and biased toward the worst conditions***

- Abridged final report, 11th Session of CAeM, Geneva, 2-11 March **1999**



Captain Mark Hoey, “Weather from a Pilot’s Perspective”, EC-69 Special Dialogue on the Future of Aeronautical Meteorological Services (2017)

Turbulence reports

"There is an evident and important need for observations of meteorological and other atmospheric parameters, especially those pertaining to aviation hazards, to be available to validate forecast guidance. However, often there are ***important observational datasets which are not available or accessible to the scientific research community due to intellectual property or other such data protection rights.*** *Examples include* ***aircraft-derived atmospheric turbulence*** *(e.g. eddy dissipation rate, EDR) datasets and high-altitude ice crystal icing datasets."*

- "Proceedings of the 2017 WMO Aeronautical Meteorology Scientific Conference", Toulouse, France, 6-10 November **2017**

Automated turbulence reports

*"The **unavailability of commercially-provided turbulence reports** to the wider meteorological and aviation communities is a highlighted issue that needs attention by WMO, ICAO and IATA to achieve a "win-win" outcome benefiting all stakeholders concerned, which perhaps could be a good demonstration of **public-private-partnership**."*

- CM Shun, "Proceedings of the 2017 WMO Aeronautical Meteorology Scientific Conference", Toulouse, France, 6-10 November **2017**

WMO works with air transport industry on data gathering system

Tags: Partnership

7 Published 7 July 2017

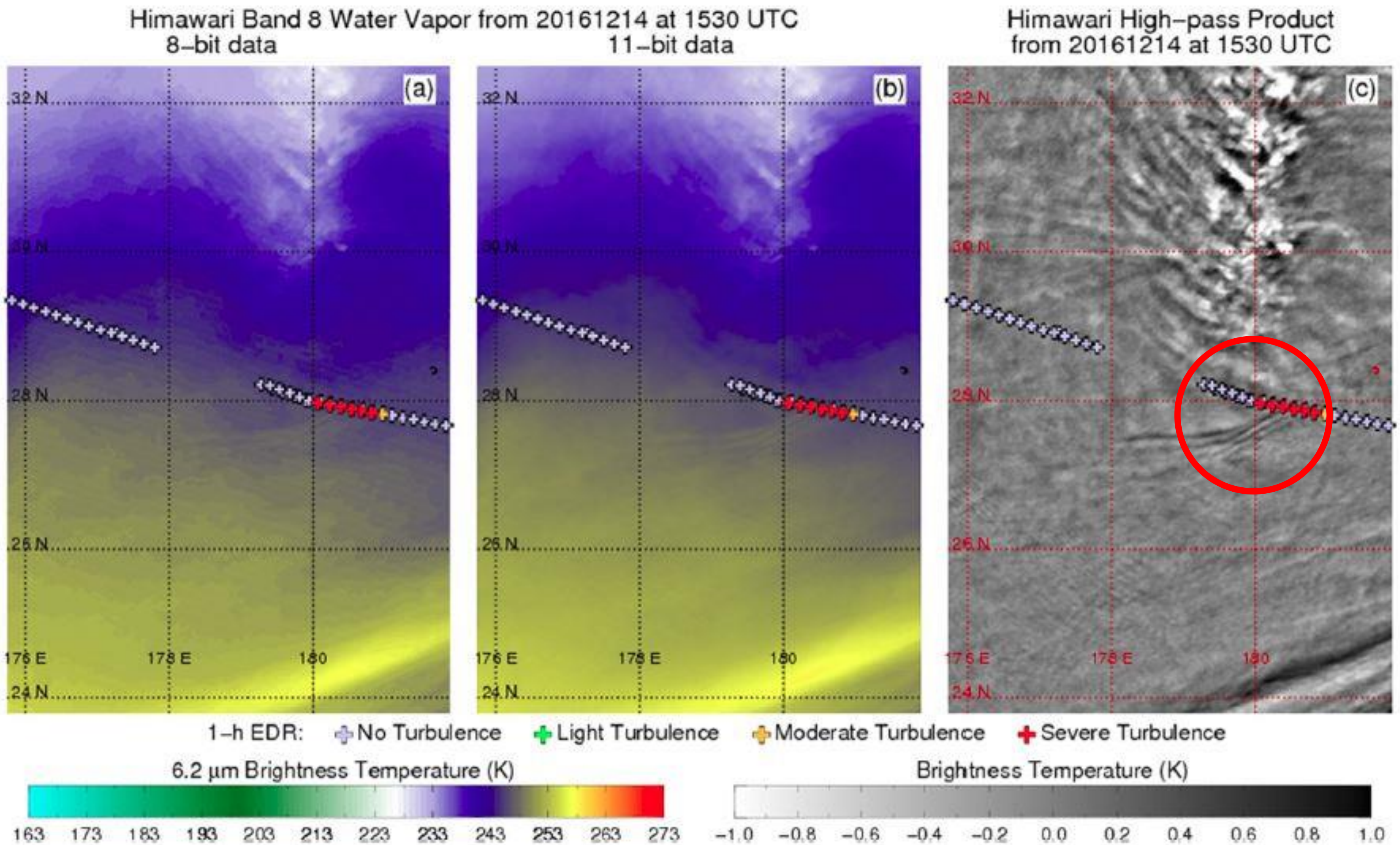


FIG. 1. Examples of the differences in gravity wave visualization between (a) a traditional 8-bit rendering of brightness temperature in the upper-level water vapor band, (b) a full 11-bit rendering, and (c) the high-pass product applied to the same data. Cross-shaped symbols along the flight track are automated EDRs (turbulence) peaking at 0.620 $m^{2/3} s^{-1}$ (severe turbulence). Here and elsewhere, turbulence reports fall within 0–1 h before the image time. (See Animation A in the online supplement.)

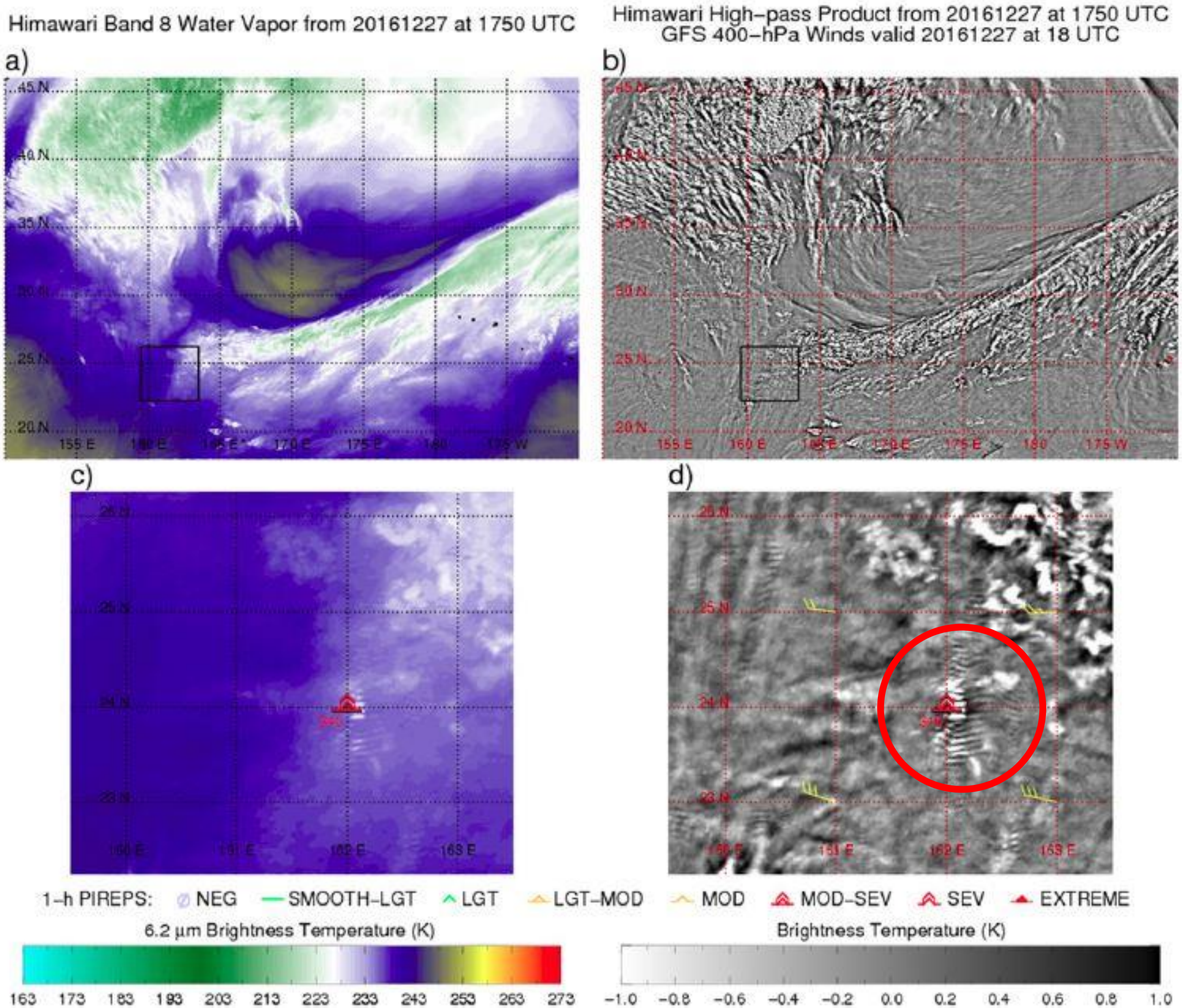
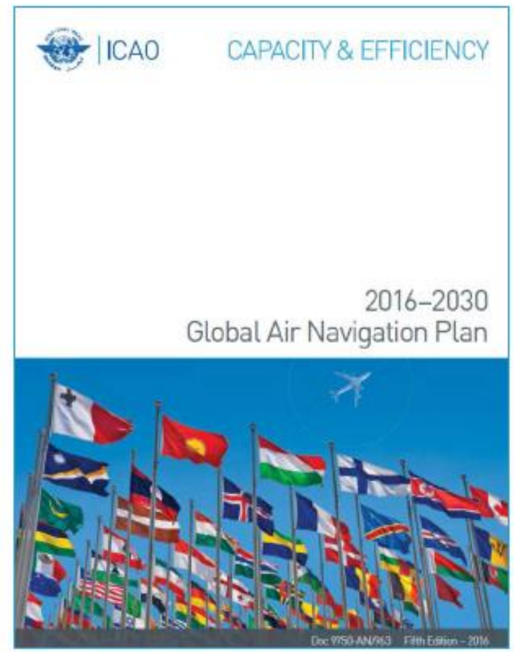


FIG. 4. Example of enhanced viewing of gravity waves in a turbulent environment. (a),(b) The larger context of the event in the mid-Pacific, and (c),(d) the gravity wave activity can be seen to extend over a wider area using the high-pass product. A moderate-to-severe (MOD-SEV) pilot report (red) at 34 kft (10.4 km) in elevation is coincident with the highest-amplitude section of the waves. The GFS analysis winds (yellow barbs) show that the gravity wave propagation is roughly orthogonal to the dominant flow in the image. (See Animation C in the online supplement.)

ICAO UNITING AVIATION

Global Air Navigation Plan (GANP)



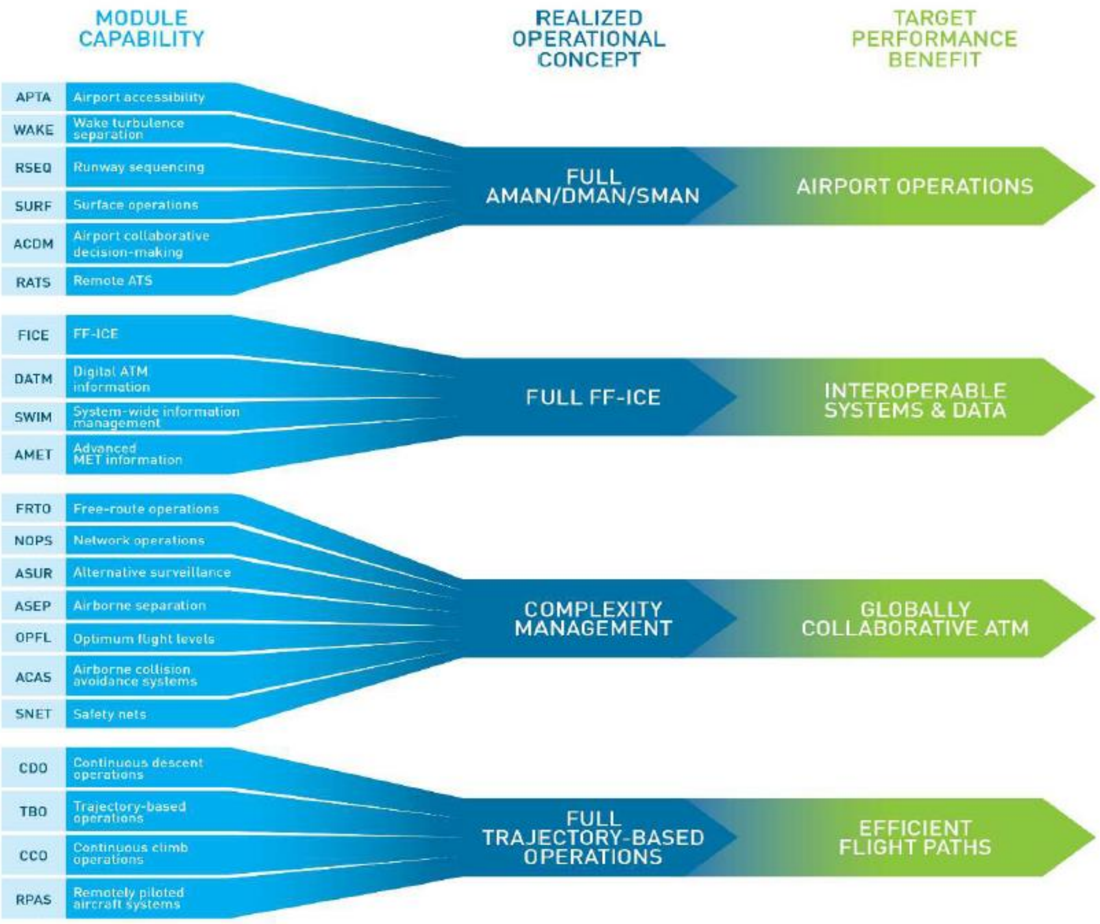
GANP Modules

Operational Thread

Enabler Thread

Operational Thread

Operational Thread



New AMET B2 & B4 (draft)

AMET-B0 (from 2013): Global, regional and local meteorological information to support flexible airspace management, improved situational awareness, collaborative decision-making and dynamically optimized flight trajectory planning.

ATM

Impact based

AMET-B1 (from 2019): Meteorological information supporting automated decision process or aids, involving meteorological information, **meteorological information translation, ATM impact conversion and ATM decision support**.

AMET-B2 (from 2025): *Integrated meteorological information in support of enhanced operational* ***ground and air*** *decision-making processes, particularly in the planning phase and* ***near-term****.*

Nowcasting

AMET-B3 (from 2031): Integrated meteorological information in support of enhanced operational **ground and air** decision-making processes, **for all flight phases** and corresponding air traffic management operations.

Seamless

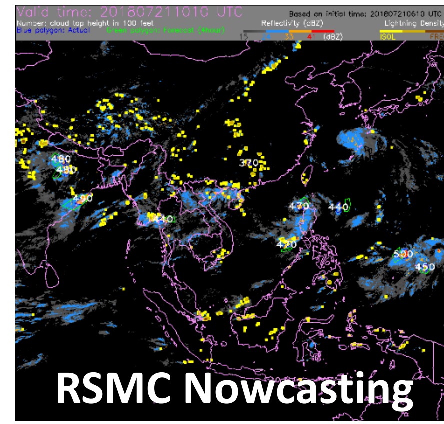
AMET-B4 (from 2037): *Integrated meteorological information supporting both* ***air and ground*** *decision making for* ***all phases of flight*** *and ATM operation, especially for implementing* ***immediate*** *weather mitigation strategies.*

AMET B1

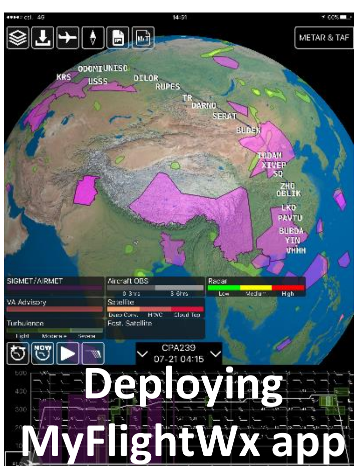
MET-ATM integration for CDM (B1, ACDM, B1-DATM, B1-SWIM, B1-AMET)

RVR forecast to optimize airport accessibility (B1-APTA)

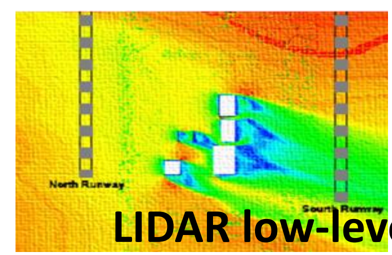
Improved upper air winds and thunderstorm forecast to optimize departure, surface and arrival management (B1-RESQ, B1-CDO)



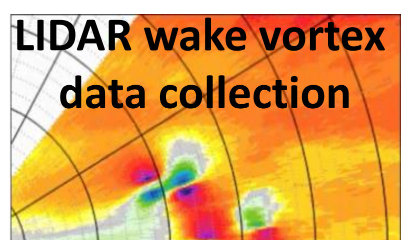
Improved en-route weather forecast to optimize ATS routing (B1-FRTO, B1-NOPS, B1-TBO)



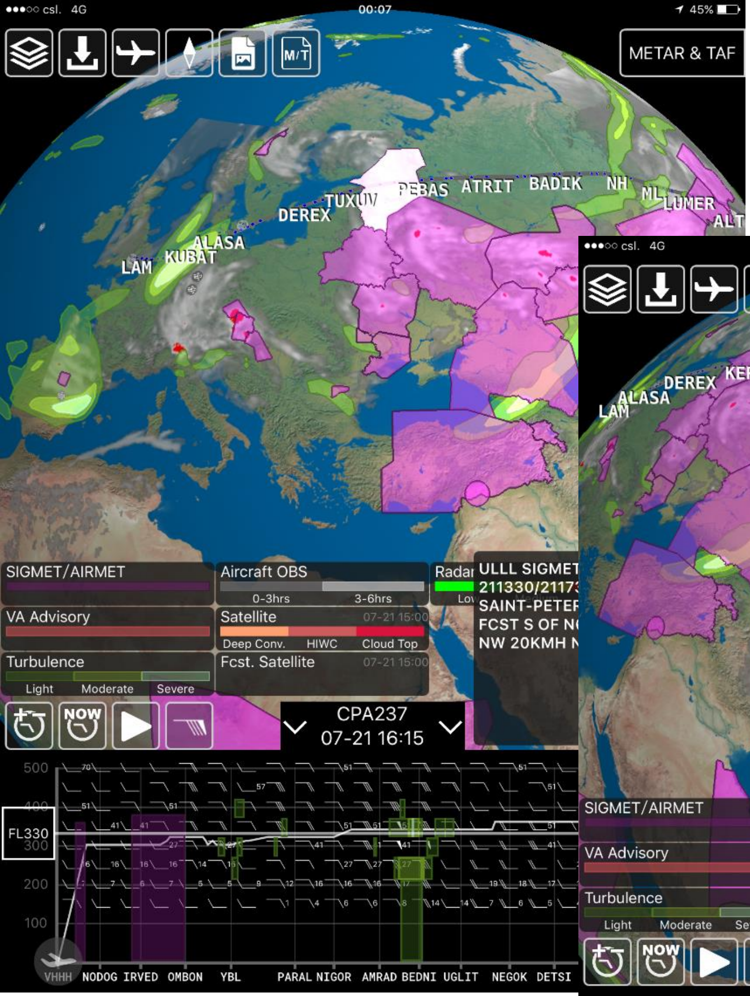
Improved wind and thunderstorm forecast to optimize airport accessibility (B1-APTA)

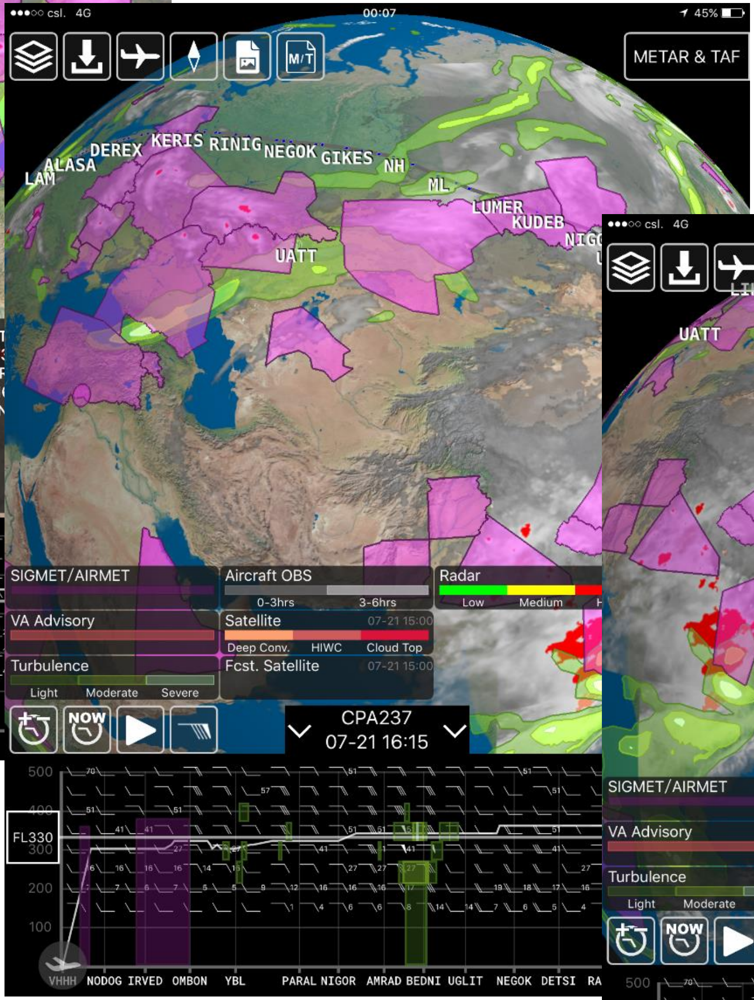


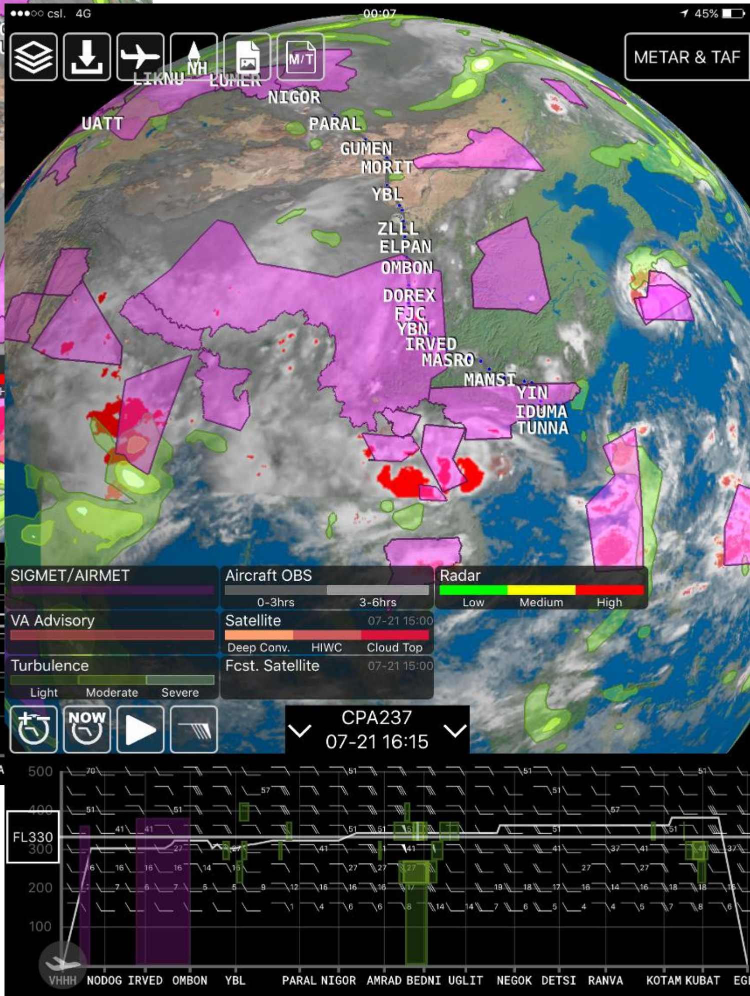
Wake turbulence, wind forecast to increase runway throughput (B1-WAKE)



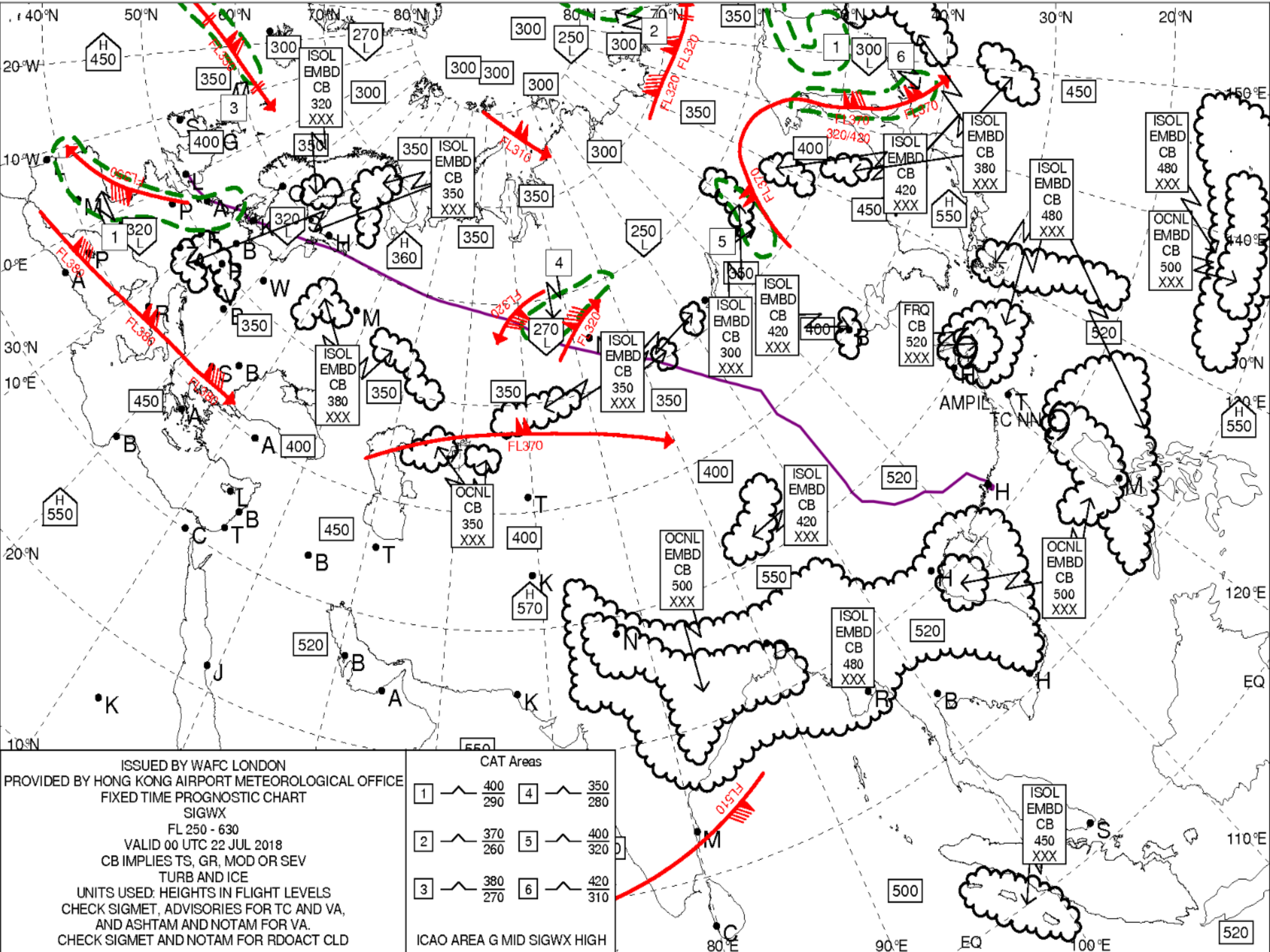
To be deployed to whole CX & KA fleet
in September 2018





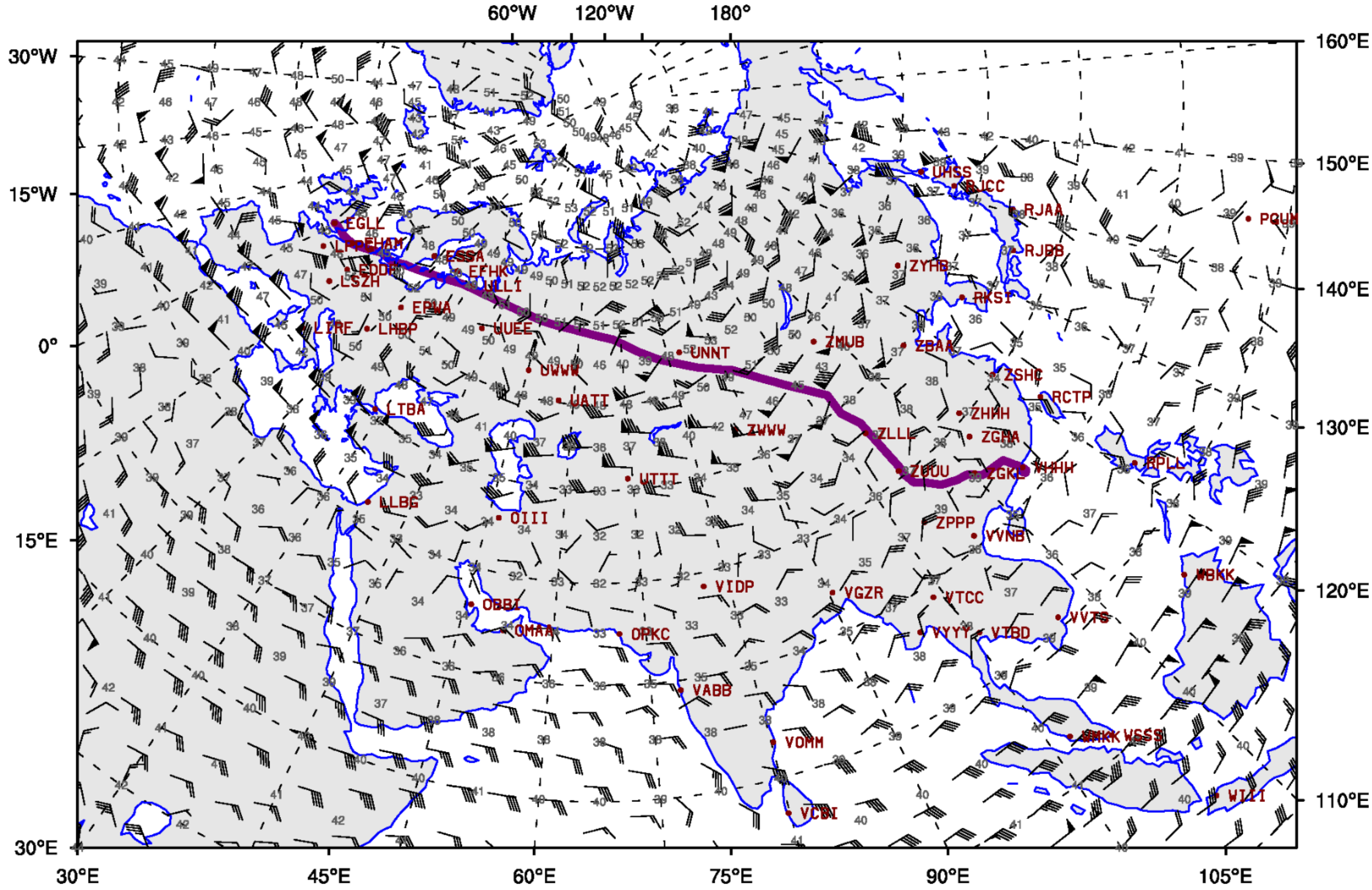


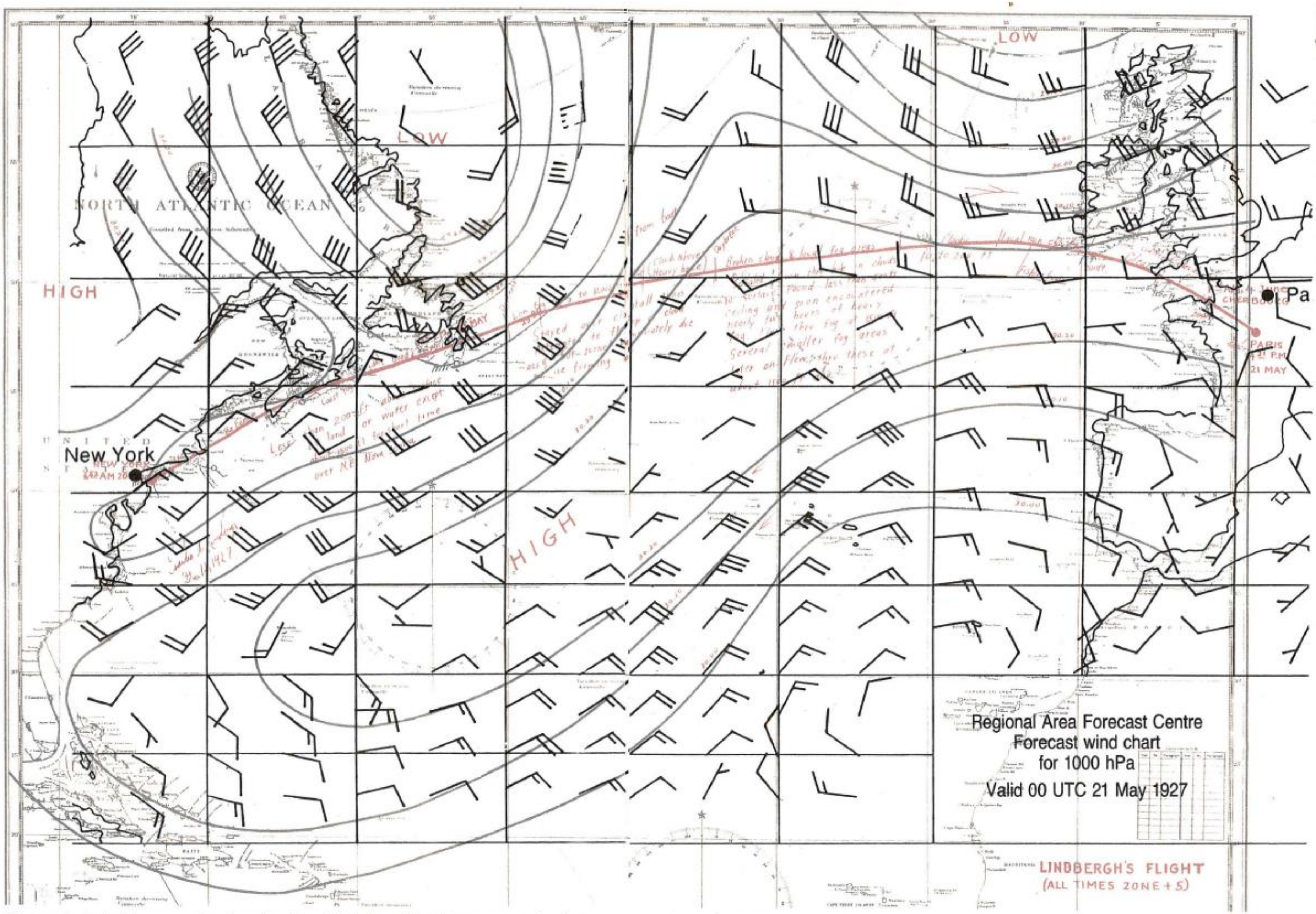
To replace all paper
flight documentation from December 2018


ISSUED BY WAFC LONDON
PROVIDED BY HONG KONG AIRPORT METEOROLOGICAL OFFICE
FIXED TIME PROGNOSTIC CHART
SIGWX
FL 250 - 630
VALID 00 UTC 22 JUL 2018
CB IMPLIES TS, GR, MOD OR SEV
TURB AND ICE
UNITS USED: HEIGHTS IN FLIGHT LEVELS
CHECK SIGMET, ADVISORIES FOR TC AND VA,
AND ASHTAM AND NOTAM FOR VA.
CHECK SIGMET AND NOTAM FOR RDOACT CLD
CAT Areas
1 400/290
2 370/260
3 380/270
4 350/280
5 400/320
6 420/310
ICAO AREA G MID SIGWX HIGH

TYPE OF CHART FL340 WIND/TEMPERATURE 24-HR PROG
FOR 06 UTC (SUN) 22 JUL 2018
UNITS WIND SPEED IN KNOTS
TEMPERATURE IN DEGREES C NEGATIVE UNLESS
PREFIXED BY + OR PS
REF.: ICAO AREA G MID

ISSUED BY WAFC LONDON
PROVIDED BY HONG KONG AIRPORT METEOROLOGICAL OFFICE
AT 1026 UTC 21 JUL 2018
BASED ON 06 UTC DATA ON 21 JUL 2018
PREPARED BY: FSS





The meteorological documentation issued to Capt. C. Lindbergh for his attempt at the first eastbound non-stop crossing of the North Atlantic from New York to Paris, 20-21 May 1927. If the meteorological services of today had existed sixty years ago, Capt. Lindbergh's flight

forecast in-flight weather conditions, including areas of hazardous conditions such as icing. The wind information is provided in the form of spot winds, the direction of the axis of the symbol indicating the direction, and the number of barbs the speed of the wind over the location

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Thank you