CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

MET Symposium 2018

3 October 2018

CIVIL AVIATION AUTHORITY OF NEW ZEALAND

	MET Symposium 2018 - Agenda
1	Opening and introductions (CAA)
2	Open Actions – Status (CAA)
3	International meteorological (MET) system developments and progress (CAA)
4	Pacific update (Fiji Airways)
5	MET in the NSS Programme (CAA)
6	MetService overview and new product review (MetService)
7	Airways overview (Airways)
8	Airports overview (NZAA)
9	~~RNZAF overview (RNZAF~~)
10	Australian perspectives (BoM)
11	NZ MET regulatory matters (CAA)
12	Establishing clear base-line MET (CAA/MetService)
13	Parallel Panel Discussion – Airlines (Airline Chair)
14	Parallel Panel Discussion – GA/Training (GA Chair)
15	Report back from Panel Discussions (All)
16	Review (CAA)
17	Future meeting structure (CAA)

MET Symposium 2018

3. International meteorological (MET) system developments and progress.

- GANIS/2 - The Future of Global Aviation Meteorology
- GANIS/2 – Space Weather System
- GANIS/2 - Transition to a SWIM environment
- WAFS 10 Year Plan
- Outcomes of the WMO Aeronautical Meteorology Scientific Conference 2017
- SO2 Developments
- RHWAC developments
- Regional MET coordination and developments, including VOLCEX
- Amendment 78 changes, effective November 2018

GANIS/2 Meteorology Session

The Future of Global Aviation Meteorology - a quiet revolution gaining pace now.

The Value of MET information

The annual net direct benefit of meteorological information for global air transport operations is around **US$ 20-30 Billion**

(based on UK and IATA data)

Global airline turnover in 2016 was US$705 Billion (IATA)

Global GDP contribution in 2016 was US$2.7 Trillion (IATA)

MET information is critical to aviation safety risk management.

MET information and data is critical to the global economy.

As the level of aviation activity increases, the value and significance of MET increases.

The financial value of MET is around half of the overall global profit margin of airlines.

Global MET data

- The monitoring and modelling of the atmosphere is now at an advanced level and still improving.
  - *Satellite and terrestrial observational data*
  - *Spatial and temporal advances*
  - *Supercomputer and modelling advances*

Air traffic management, aircraft manufacturers, and aircraft operators need to plan for the fully integrated use of big MET data.

Seamless Global MET

- To meet the challenges of tomorrow's aviation world, MET information must be increasingly global and seamless.
- We already have some important global MET systems and products:
  - *World Area Forecast System (WAFS)*
  - *International Airways Volcano Watch System (IAVWS)*
- MET initiatives close to implementation:
  - *Space Weather Warning System (SWXS)*
- MET initiatives under consideration and development:
  - *Hazardous Weather Advisory Centre System*

The changes in MET are gathering pace, reflecting the changing needs of aviation.

Getting MET information to the Users

- Product-centric to data-centric:
  - Traditional alphanumeric coded (TAC) products to GML/XML data streams - IWXXM data.
  - Regional OPMET to a system wide information management environment (SWIM).

In the future, aviation operations will take only the MET data needed to ingest into their systems and build what is wanted - no more no less.

Changing Demands and Drivers for MET

- The aviation industry continues to change with pace
  - ICAO GANP initiatives
  - Commercial structures
  - Technical operations eg: PBN, TBO
  - Aircraft types
    - Longer range and higher operations
    - Supersonic renaissance
    - RPAS/UAS
    - Personal aerial vehicles

The only sure thing is that change will continue - and the pace will be variable.

Some Emerging Initiatives

- High ice water content
- Wake vortex
- Turbulence
- Volcanic ash concentration
- Sulphur dioxide (SO_2) information
- Wide terminal area forecasting (supporting TBO)

As aviation continues to develop, new critical MET factors will continue to arise.

MET is not standing still

- ICAO and the MET Panel are strongly supported by the World Meteorological Organization (WMO).
- This lends a huge scientific development capability and capacity.
- Current and future MET capabilities will continue to undergo relentless, well considered development.
- MET Panel experts here today will explain a number of examples.

Able to change and advance new areas of MET endeavour as rapidly as possible.

Issues and Challenges

- Move to phenomena based MET information
- Funding global MET systems
- State MET capability deficits
- Private MET sector involvement
- MET data transport, access and SWIM
- Global MET system development agility

There will always be scientific, operational and funding challenges, but there is a will to meet and overcome these challenges on a global scale.

GANIS2

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ICAO Air Navigation Commission

Meteorology Panel
(comprising individual Experts – not State representatives)
Peter Lechner
Bill Maynard

METP Management Group
Co-ordination work

WG-1 MET Requirements and Integration (WG-MRI)
Dennis Hart,
Jun Ryuzaki

Job Cards 1,2,5 (ATMRPP6)

- **WS-1 MET for ATM** – Michael Murphy
- **WS-2 GANP Update** – Stephanie Desbios
- **WS -3 PANS MET** – Larry Burch

WG-2 MET Information & Service Development (WG-MISD)
Michael Murphy
CM Shun

Job Cards 6,7,9,12

- **WS-1 RRM** – Harmut Walter
- **WS-2 RHWAC** – Bill Bauman
- **WS-3 Space Weather** – Pat Murphy
- **WS-4 Sulphur Dioxide (SO_2)** – Tammy Flowe

WG-3 MET Information Exchange (WG-MIE)
Sue O'Rourke
Bill Maynard

Job Cards 4, (CP8)

- **WS-1 IWXXM Requirements** – Michael Murphy, Patrick Simon
- **WS-3 MET SWIM Plan** – Aaron Braeckel
- **WS-3 IWXXM Documentation** – Tim Hales
- **WS-4 Support and Co-ord** – Bill Maynard

WG-4 MET Operations Group (WG-MOG)
Colin Hord

Job Cards 3,8,10 OPSG legacy tasks

- **WS-1 IAVW Operations** – TBA
- **WS-2 WAFS Operations** – Matt Strahan
- **WS-3 SADIS Operations** – Karen Shorey

WG-5 MET Cost Recovery Guidance and Governance (WG-MCRGG)
Rodrigo Fajardo

Job Card 11

- **WS-1 White Paper** – Dennis Hart
- **WS-2 TBA**

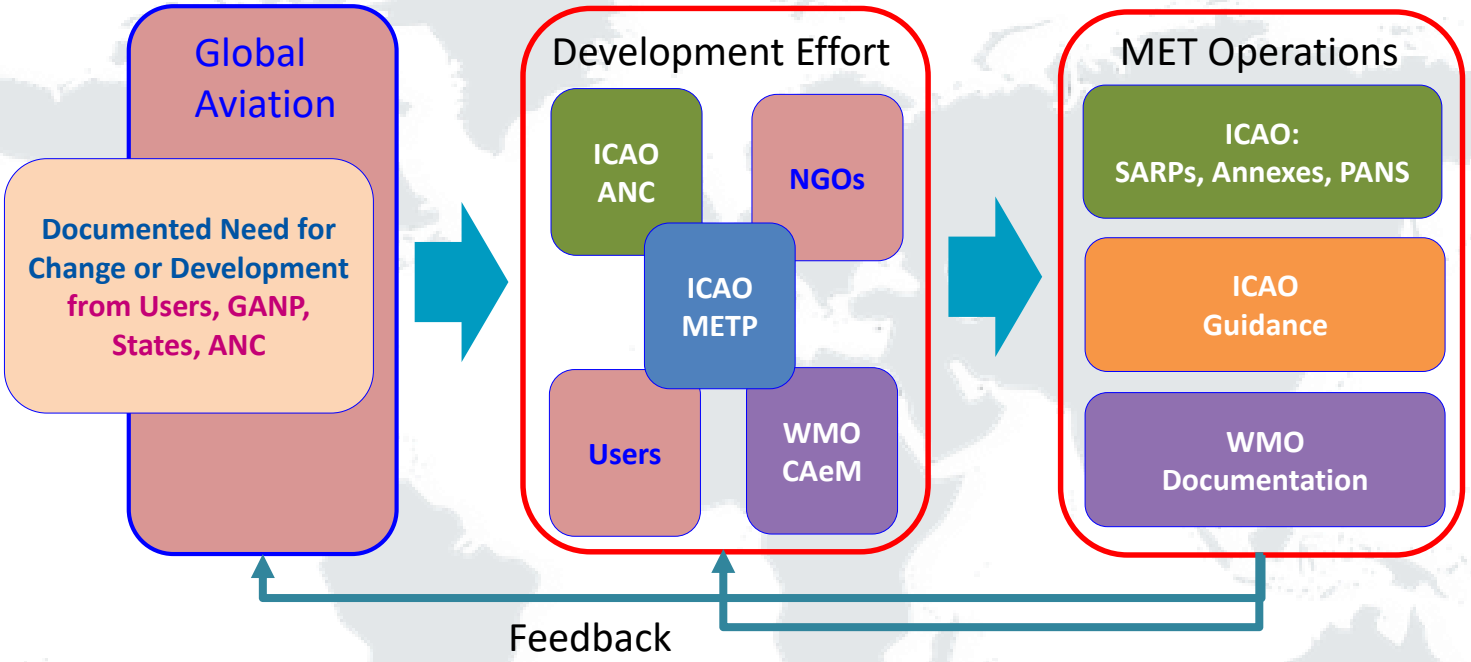
AG – Ad hoc Group
ATM – Air Traffic Management
GANP – Global Air Navigation Plan
IAVW – International Airways Volcano Watch
PANS – Procedures for Air Navigation Services
RRM – Release of Radioactive Material
RHWAC – Regional Hazardous Weather Advisory Centre
SADIS - Secure Aviation Data Information System
Sp Wx – Space Weather
SWIM – System-wide Information Management
VA – Volcanic Ash (and Gases)
WAFS – World Area Forecast System
WG – Working Group
WS – Work Stream

Note – The *primary* JC and WS responsibilities of are the shown. There are numerous areas where several WG and WS teams collaborate.

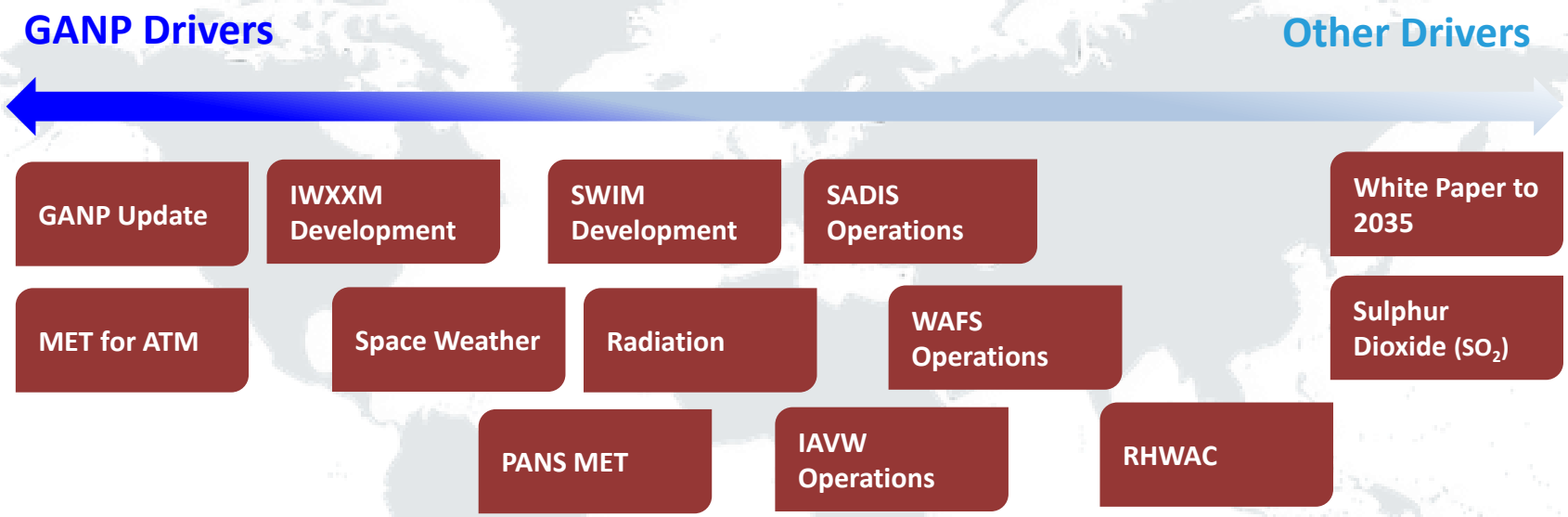
ICAO OACI ИКАО

METEOROLOGY PANEL

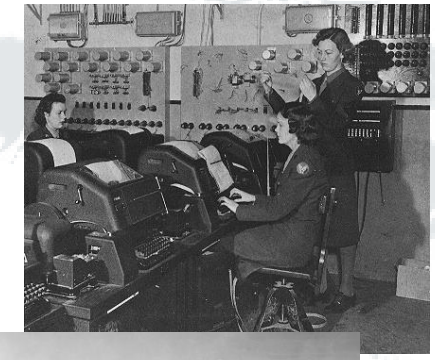
ICAO MET Development Process

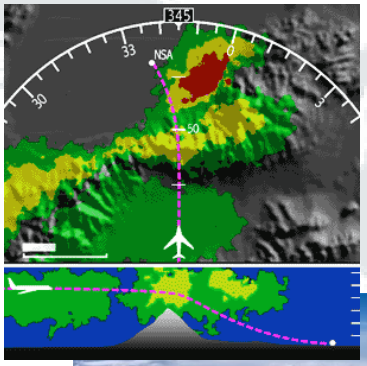


Current MET change programmes



The MET revolution





BIG GLOBAL DATA

Local products

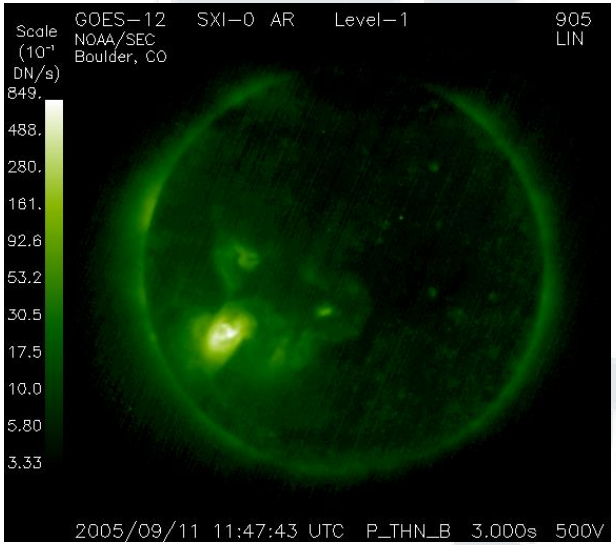
Regional products and data

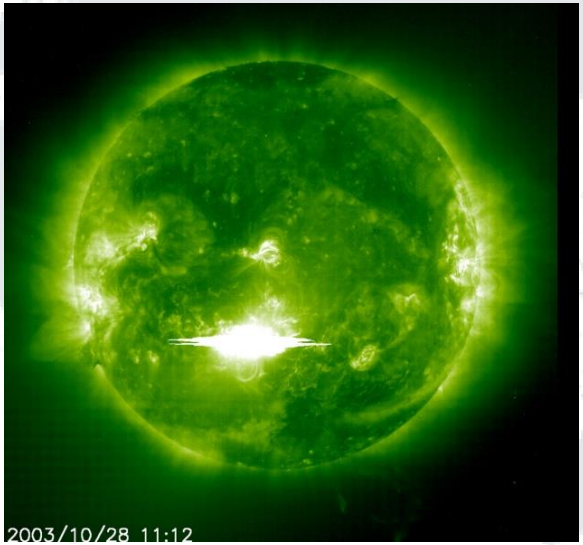
GANIS/2 Meteorology Session

Space Weather System

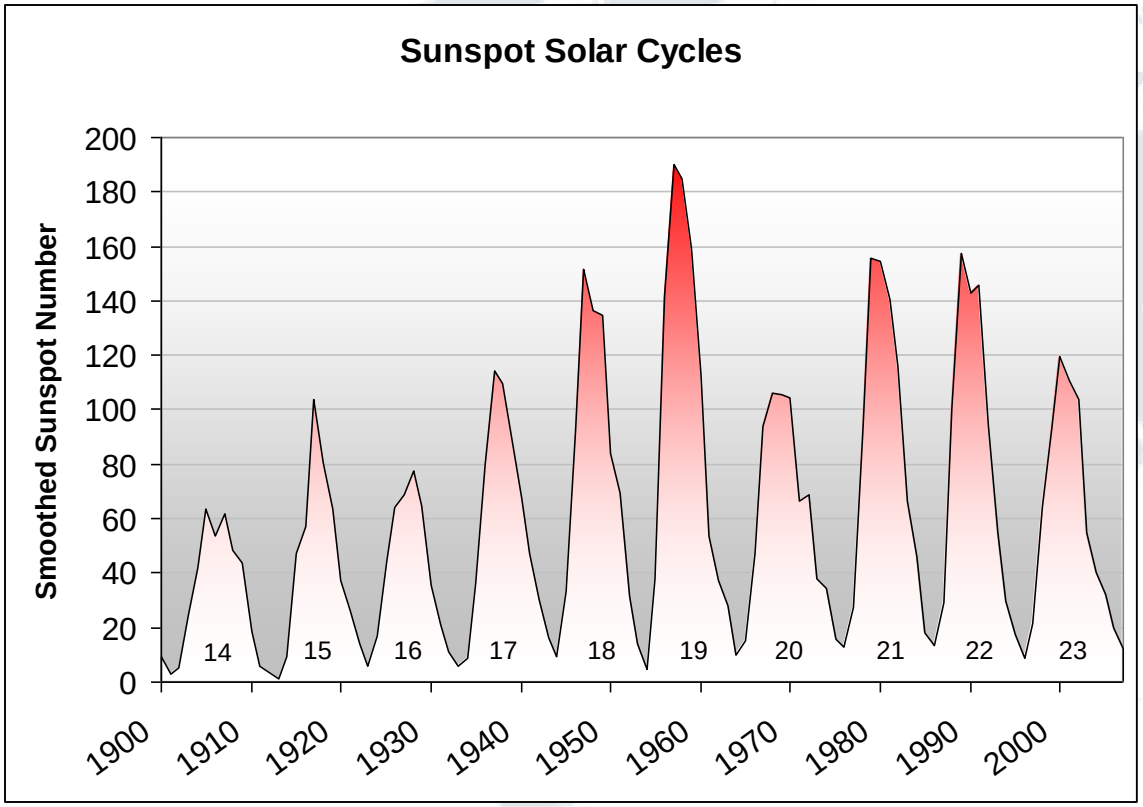
Solar Flares

A violent explosion in the Sun's atmosphere with an energy equivalent of a hundred million hydrogen bombs.





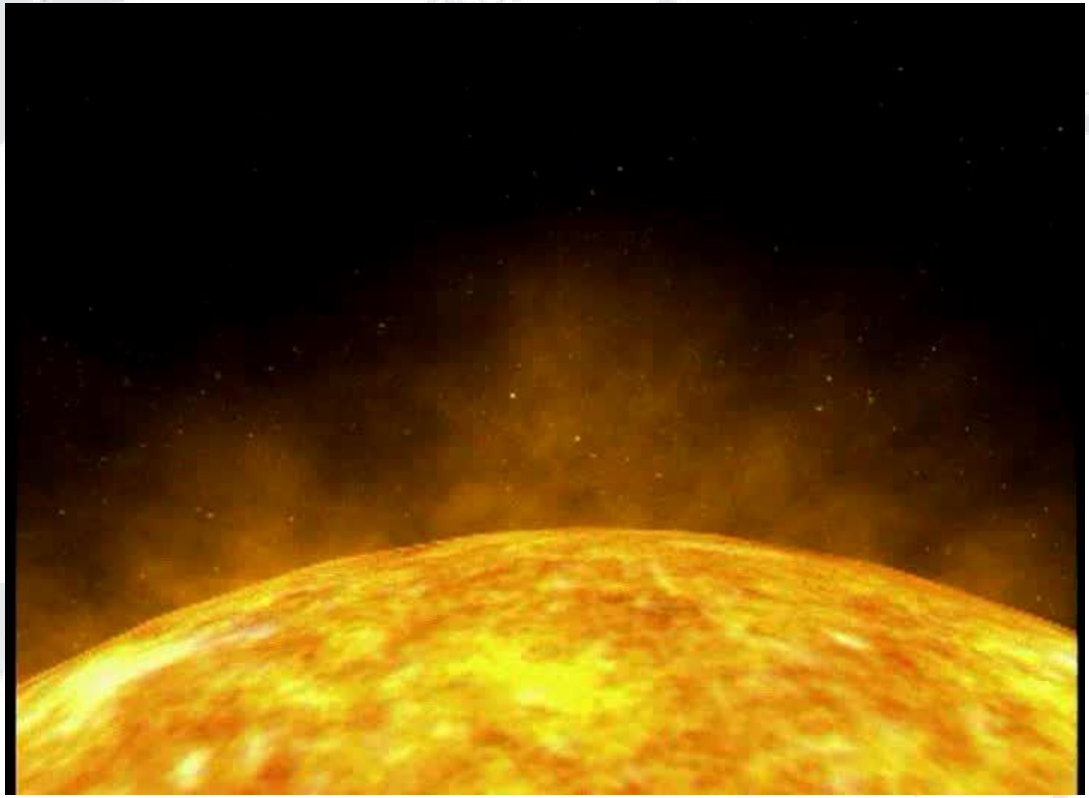
Solar Cycle



- ~ 11 year cycle
- Cycle 24 began in 2007
- Solar Cycle 25 underway

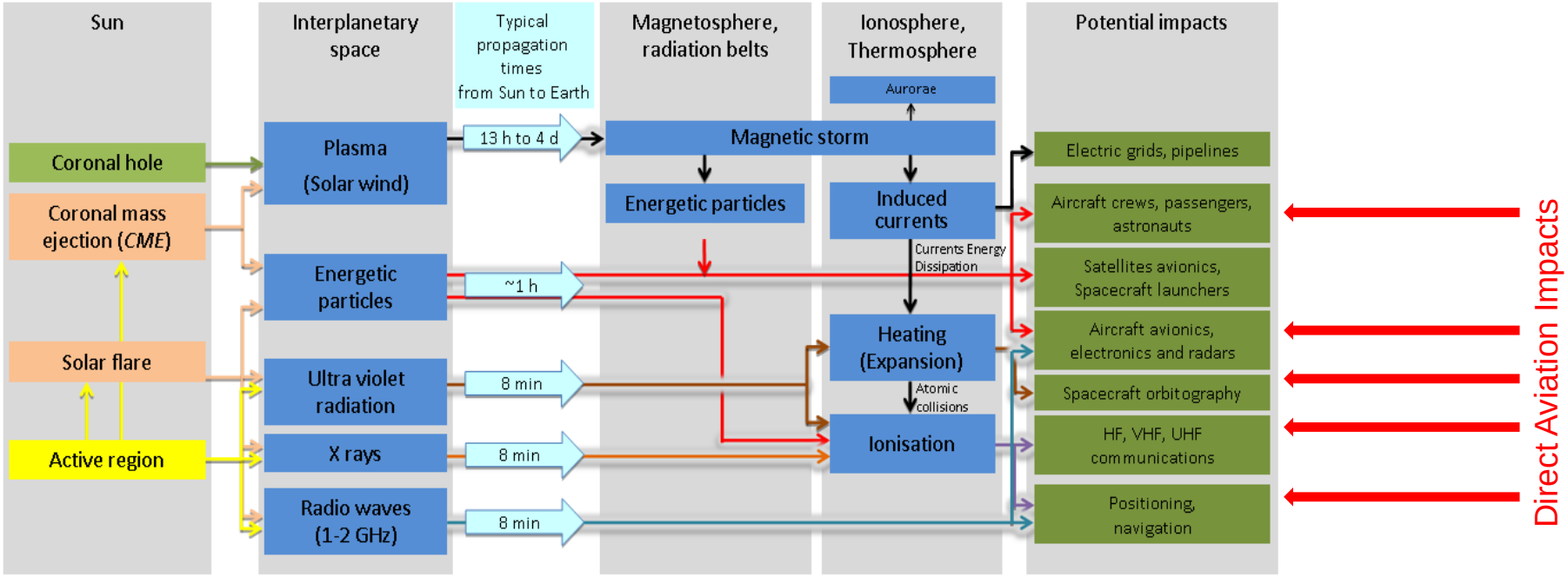
Coronal Mass Ejections (CME)

- Propagate through space at up to 5 million kph
- Geomagnetic storm begins when CME impacts Earth



Attributes of Eruptive SWX

Illustration of Sun-Earth relations : colours in the first column show phenomena varying according to different timescales : coronal holes are stable for several solar rotations (27 days), active regions vary on timescales comparable to the Sun rotation period, while solar flares and mass ejections are explosive phenomena. All of these phenomena vary according to the 11 year activity cycle.



ICAO SWX Information System

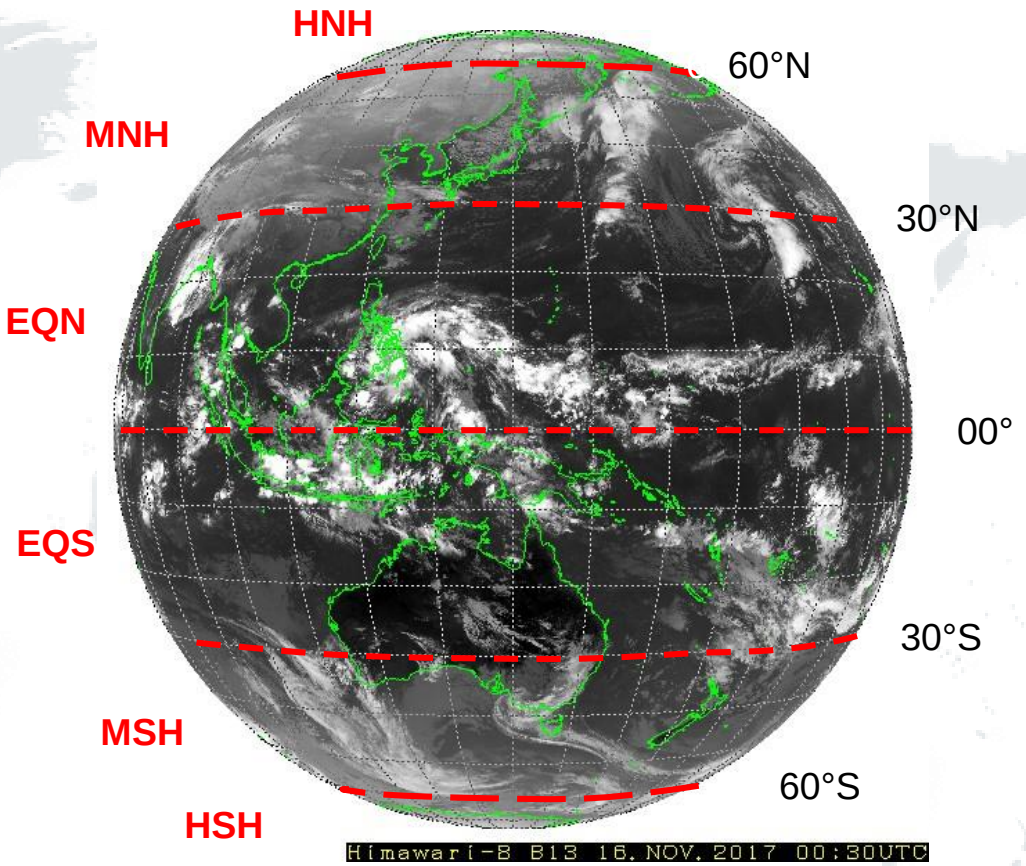
- Met Panel Work Outcome
  - 2 (2018) - 4 (2022) SWX Centres being recommended
    - Selection recommendation process underway jointly with WMO
    - Review of SWX centres in 2027
  - Products specified and in Annex 3 from end 2018
  - SWX Centre operations from later in 2019
  - SWX Manual currently in mature draft form

ICAO SWX Information

- One or more of the following space weather effects will be included in the space weather advisory information:
  - HF communication (propagation, absorption) — **HF COM**
  - GNSS-based navigation and surveillance (degradation) — **GNSS**
  - Radiation at flight levels (increased exposure) — **RADIATION**
- The following intensities will be included in space weather advisory information:
  - Moderate — **MOD**
  - Severe — **SEV**

SWX Advisory Spatial Ranges

- Ranges
  - **Flight Levels**
    Resolution 030
  - **Longitudes**
    Resolution 15°
  - **Latitudes**
    by descriptor



SWXA Example 1

SWX ADVISORY
DTG: 20161108/0100Z
SWXC: (to be determined)
SWX EFFECT: **GNSS MOD AND HF COM MOD**
ADVISORY NR: 2016/1
OBS SWX: 20161108/0100Z HNH HSH E18000 – W18000
FCST SWX +6 HR: 20121108/0700Z HNH HSH E18000 – W18000
FCST SWX +12 HR: 20161108/1300Z HNH HSH E18000 – W18000
FCST SWX +18 HR: 20161108/1900Z HNH HSH E18000 – W18000
FCST SWX +24 HR: 20161109/0100Z NO SWX EXP
RMK: LOW-LEVEL GEOMAGNETIC STORMING IS CAUSING INCREASED AURORAL ACTIVITY AND SUBSEQUENT MOD DEGRADATION OF GNSS ACCURACY AND HF COM AVAILABILITY IN THE AURORAL ZONE. THIS STORMING IS EXPECTED TO SUBSIDE IN THE FORECAST PERIOD. SEE WWW.SPACEWEATHERPROVIDER.WEB
NXT ADVISORY: NO FURTHER ADVISORIES

GANIS/2 Meteorology Session

Transition to a SWIM environment

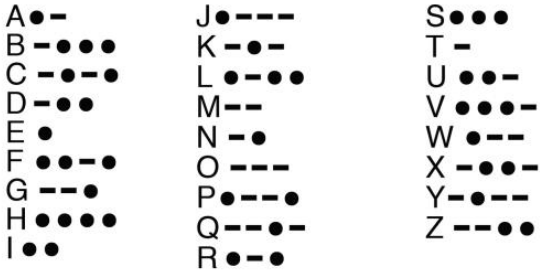
The ICAO Meteorological Information Exchange Model (IWXXM) and the transition to a System Wide Information Management (SWIM) Environment

- The introduction of SWIM will see a complete change in the culture and nature of aviation meteorological (MET) services that will evolve over time.
- It is essential that there is clarity regarding what MET services are required, how users will access MET information in a SWIM environment and what is needed to provide these services.
- Effective engagement between the suppliers and users of this information is crucial to achieving long term objectives.

Traditional Alphanumeric Code (TAC)

- Transmitted by Morse code and tele-printer
- Limited character length
- Human-readable
- Examples: METAR/SPECI, TAF, AIRMET, SIGMET, VAA, TCA
- Inflexible

Nothing much has changed with the MET code forms in the last 70 years



Aerodrome Forecast

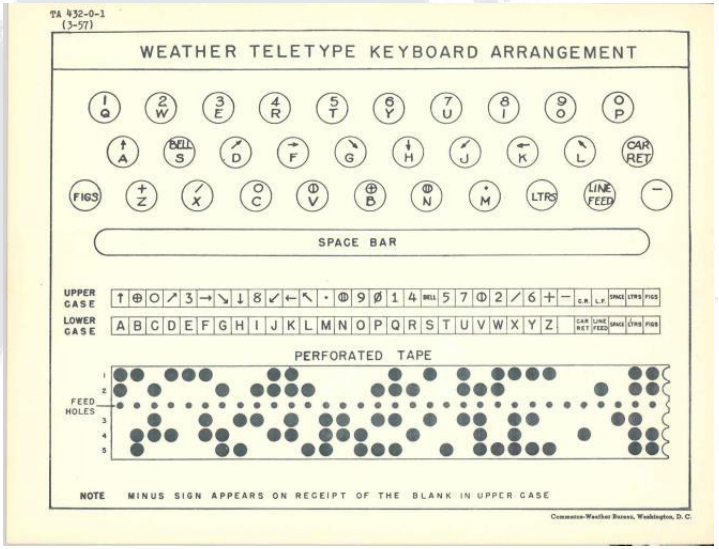
1948: TAMET 00181 UDO 6310 9703/ 88820 43505 55004 92024

2016: TAF YUDO 152300Z 1600/1700 13010 9000 BKN020
BECMG 1606/1608 SCT015CB BKN020
TEMPO 1608/1612 17015G30 1000 TSRA SCT010CB BKN020
FM161230 15010 9999 BKN020

Communications Networks

- AFTN: dedicated lines such as radio-teletype and X.25
- AMHS: move to X.400
- Web Services

There have been steady advances in communications networks



ICAO Meteorological Information Exchange Model (IWXXM)

- MET information in XML/GML
- Supports machine-to-machine
- Integration into decision support tools
- Enables the development of cost-effective MET information displays
- Easy and reliable extraction of specific MET elements
- METAR now 332 lines of code!

Improving situational awareness and operational decisions.

IWXXM translated from TAC

Coded MET Products
(Traditional Alphanumeric Code)

METAR YUDO 221630Z 24008 0600 R12/1000U
DZ FG SCT010 OVC020 17/16 Q1018 BECMG
TL1700 0800 FG BECMG AT1800 9999 NSW

Translation
(IWXXM Schema & Schematron)

IWXXM
(XML / GML)

Graphical MET Products

Gridded MET Products

MET in SWIM

Supporting:

- Flexible airspace management
- Airborne re-routing
- Improved situational awareness
- Collaborative decision-making
- Dynamically optimized flight trajectory planning
- ATM impact conversion and ATM decision support
- Hazard avoidance

Supporting operational efficiency and safety.

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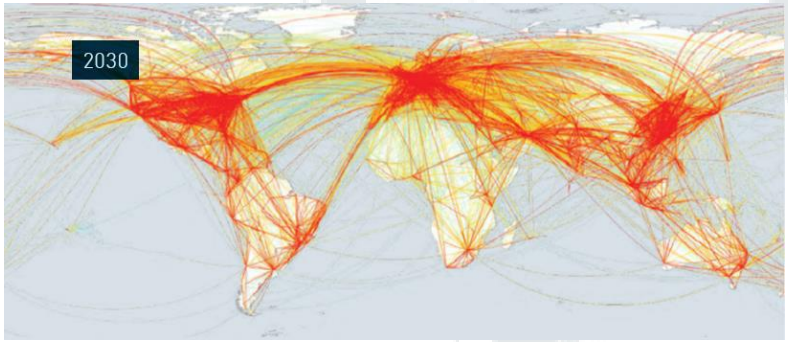
WAFS 10 Year Plan

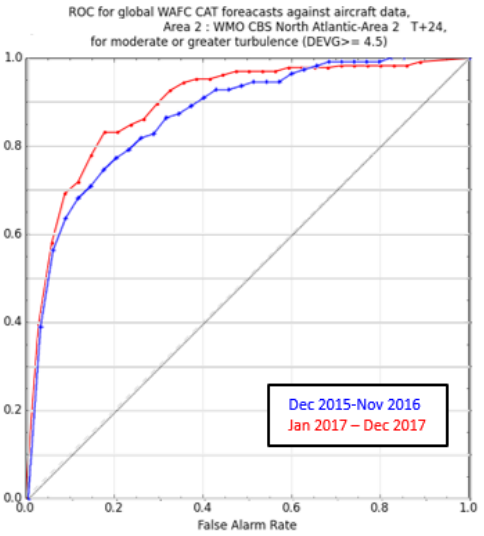
Upcoming improvements to the
World Area Forecast System.

Based on presentation at ICAO METP/4 by Jonathan Dutton, UK Met Office

Drivers for Change…

- Air Traffic growth
- GANP and ASBU framework
- Capacity, Efficiency, Safety, Environment
- Performance-based navigation (CDO, CCO, TBO etc.)





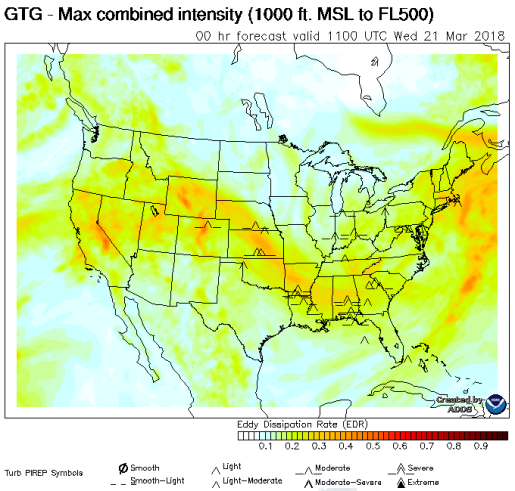
Met developments

- Accuracy increases
- Science and computing advancements

Advances in Meteorological Science

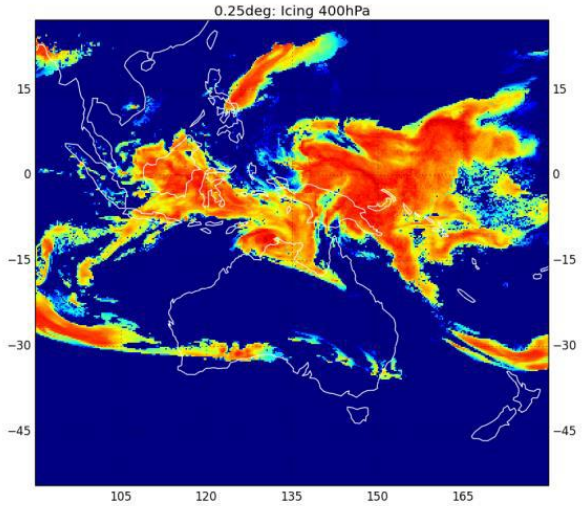
Turbulence

- NOW: Turbulence Potential
- November 2020: Turbulence Severity, units of EDR



Icing

- NOW: Icing Potential
- November 2020: Icing Severity



Increased Spatial Resolution

WAFS gridded data sets: wind, temp, turbulence, icing, CB cloud extent, humidity

Horizontal Resolution

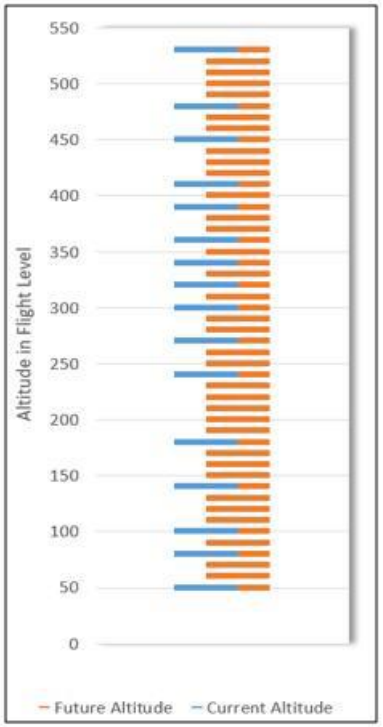
- ✈ WAFS current resolution 1.25°
- ✈ Proposed resolution of 0.25°

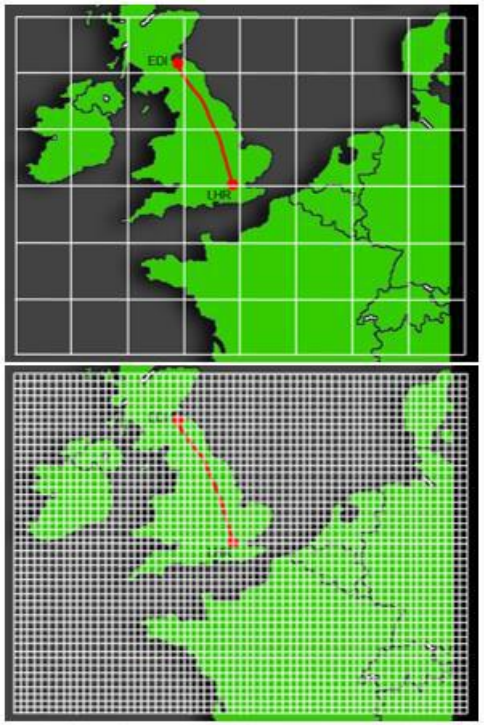
What does this mean?

- ✈ 1.25° ~ 9 minutes flying time
- ✈ 0.25° ~ 1.75 minutes flying time

Vertical Resolution

- ✈ WAFS now: 17 levels between FL050 and FL530
- ✈ Proposed: every 1000FT between FL050 and FL600*



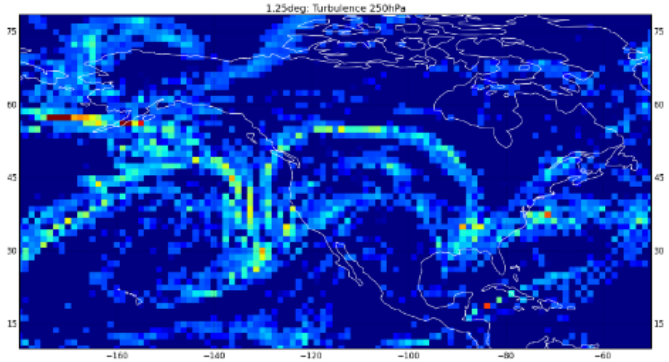


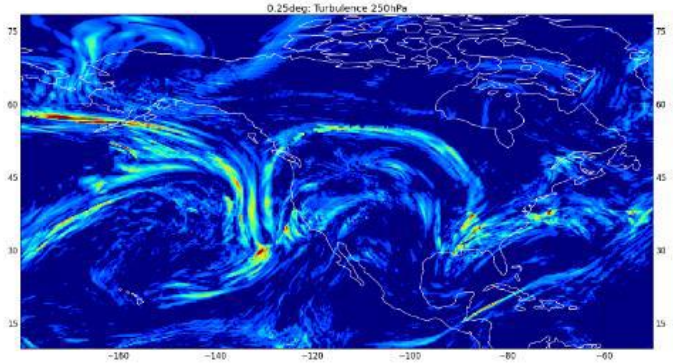
* Turbulence up to FL450, Icing up to FL300, Humidity up to FL180

Increased Spatial Resolution

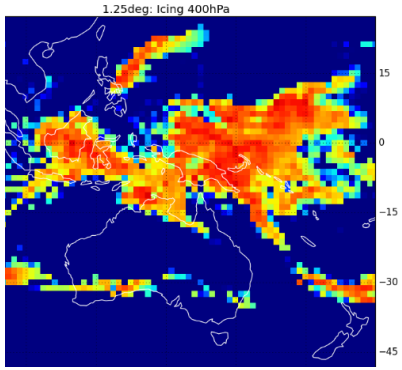
WAFS gridded data sets: wind, temp, turbulence, icing, CB cloud extent, humidity

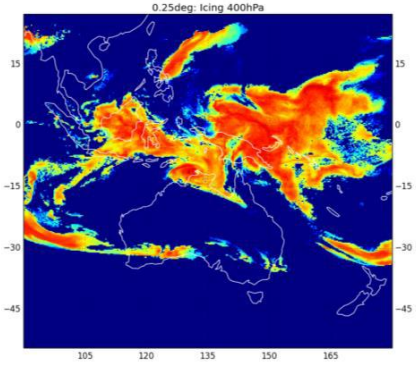
Turbulence



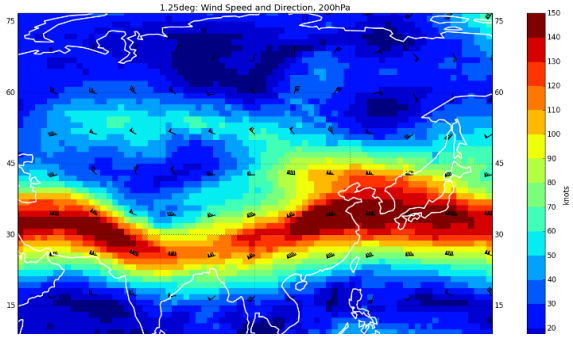


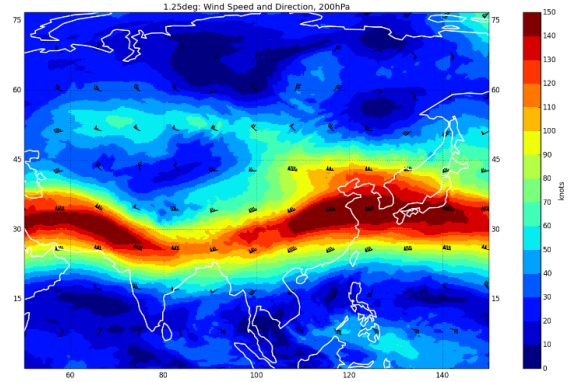
Icing





Wind



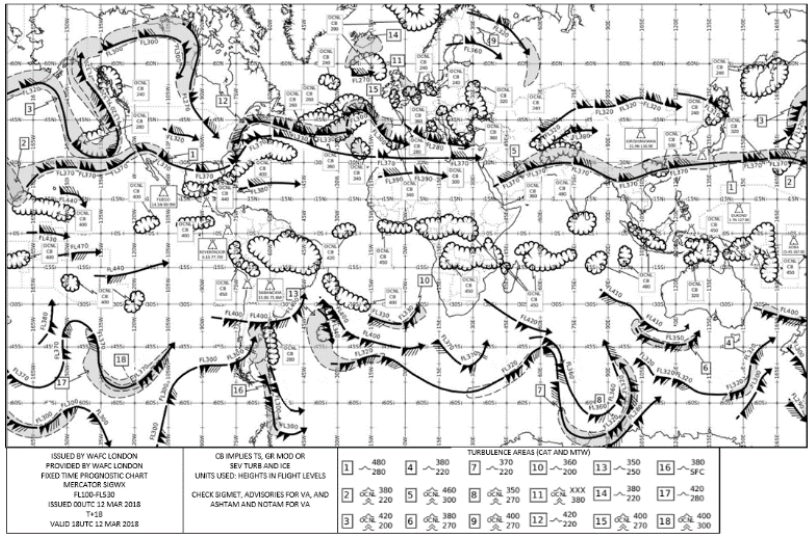


Increased Temporal Resolution

- WAFS current data steps: 3 hourly between T+6 and T+36
- Proposed data steps: Hourly from T+6 to T+18, 3 hourly until T+48, then 6 hourly until T+120

NOW:	T+6	T+9	T+12	T+15	T+18	T+21	T+24	T+27	T+30	T+33	T+36	
NOV 2022	T+6	T+7	T+8	T+9	T+10	T+11	T+12	T+13	T+14	T+15	T+16	T+17
	T+18	T+21	T+24	T+27	T+30	T+33	T+36	T+39	T+42	T+45	T+48	
	T+54	T+60	T+66	T+72	T+78	T+84	T+90	T+96	T+102	T+108	T+114	T+120

Next-generation SIGWX forecasts



NOW:	T+24			
NOV 2022	T+6	T+9	T+12	T+15
	T+18	T+21	T+24	T+27
	T+30	T+33	T+36	T+39
	T+42	T+45	T+48	

- Increased time-steps, available earlier and available also as objects
- WAFC London and Washington SIGWX forecasts will be harmonised
- SIGWX and WAFS gridded data sets will be consistent
- Improved accuracy, using upgraded science

More distant future…

- Proposed NOV 2024: New probabilistic forecasts of CB, icing and turbulence
- Proposed NOV 2028: Potential retirement of deterministic hazard forecast data.

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WMO Aeronautical Meteorology Scientific Conference 2017

Toulouse, 6-10 November 2017

Aviation, weather and climate: *Scientific research and development for future aeronautical meteorological services in a changing atmospheric environment*

Based on presentation at ICAO GANIS/2 by Greg Brock, Scientific Officer, Aeronautical Meteorology Division, WMO

WMO AeroMetSci

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Science R&D

- Ice crystal icing and airframe icing research
- Turbulence research
- Significant convection research
- Wake vortex detection and prediction
- Fog/low visibility research
- Space weather research
- Atmospheric aerosols and volcanic ash research
- Advances in observing methods and use of observations
- Seamless nowcast and numerical weather prediction, probabilistic forecast and statistical methods

Service Delivery

- In-cockpit and on-board MET capabilities
- Terminal area and impact-based forecast
- Enroute hazards information systems
- Collaborative decision-making (CDM), air traffic flow management (ATFM) and network management
- Trajectory-based operations (TBO), flight planning and user-preferred routing
- Use of MET information for climate-optimized trajectories

Climate change & variability

- Jet stream position and intensity and related phenomena
- Extreme weather events and airports, changes to established scenarios
- Re-evaluation of airframe/avionics resilience standards and certification

WMO AeroMetSci

Science R&D

- Ice crystal icing and airframe icing research
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High-Altitude Ice Crystal Icing Research


Graphic: NASA

- Infrequent but high impact events
- Meteorologically complex to parameterize
- Observation/detection
- Nowcast and forecast
- Experimental trials ongoing
- **More encounter reports needed to validate observations and calibrate forecasts**

Atmospheric turbulence research


Graphic: KLM blog

- Multiple types/sources
- Often localized, often transient but often high impact
- Observation/detection
- Nowcast and forecast
- **More encounter reports needed to validate observations and calibrate forecasts**

Significant convection research


Graphic: WMO

- Towering Cumulus (TCU) and Cumulonimbus (CB)
- Pose multiple aviation hazards
- Observation/detection
- Nowcast and forecast

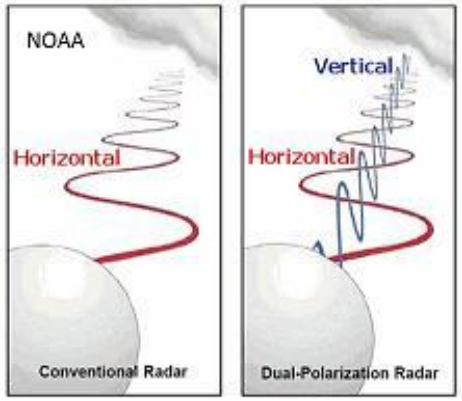
Wake vortex detection and prediction


Graphic: Thales

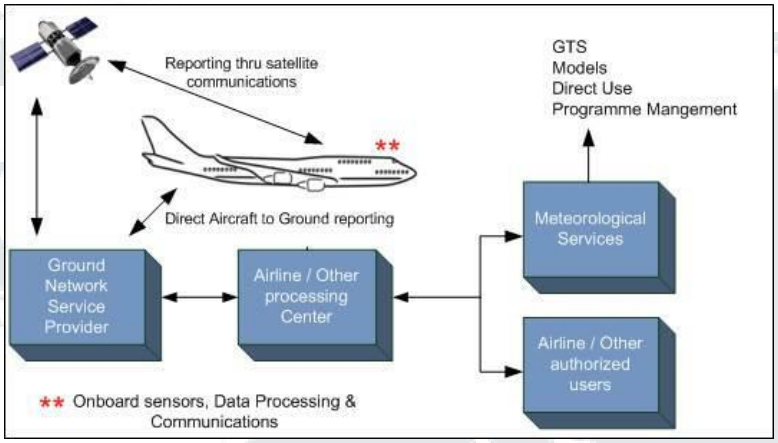
- Ground/near-ground and enroute hazard
- Prevailing meteorological conditions important
- Aircraft parameters important
- Wake vortex or low-level wind shear?
- Experimental trials ongoing
- More encounter reports needed to validate observations and calibrate forecasts

Advances in observing methods

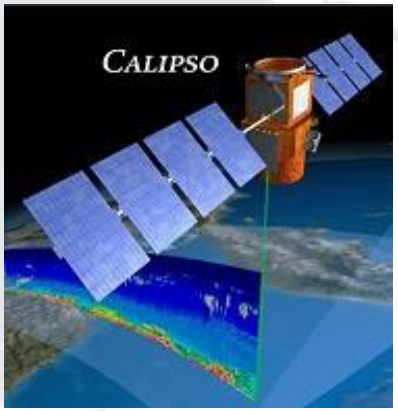
Dual-polarisation radar

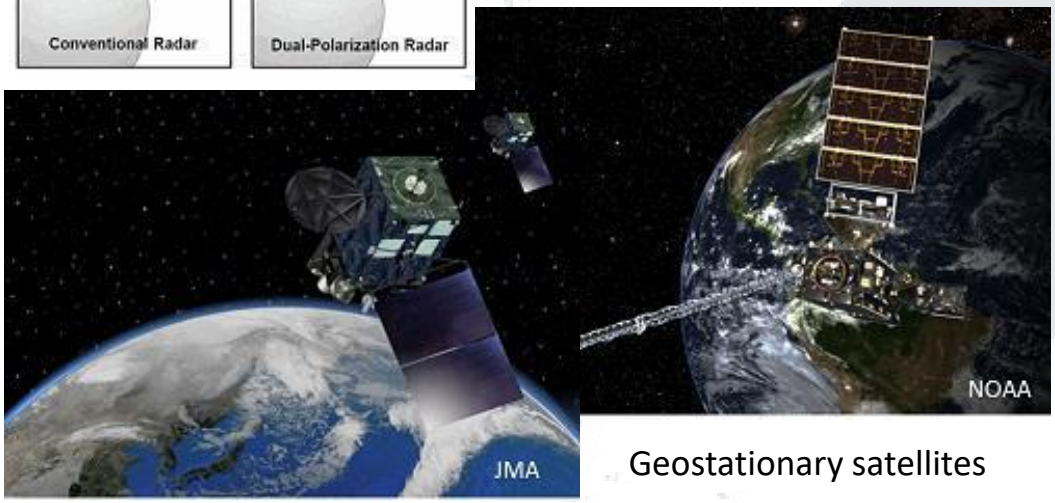


Aircraft-derived MET data including moisture



Ground-based, aircraft-based and satellite-based LIDAR vertical profiles



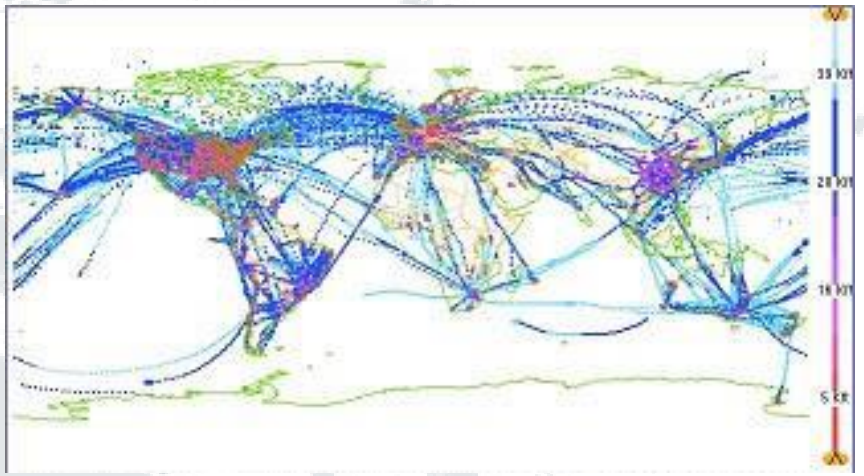


Geostationary satellites

- Complementing or even replacing ‘traditional’ methods of observation
- Direct support to NWP and in-cockpit user applications

Importance of aircraft-based observations

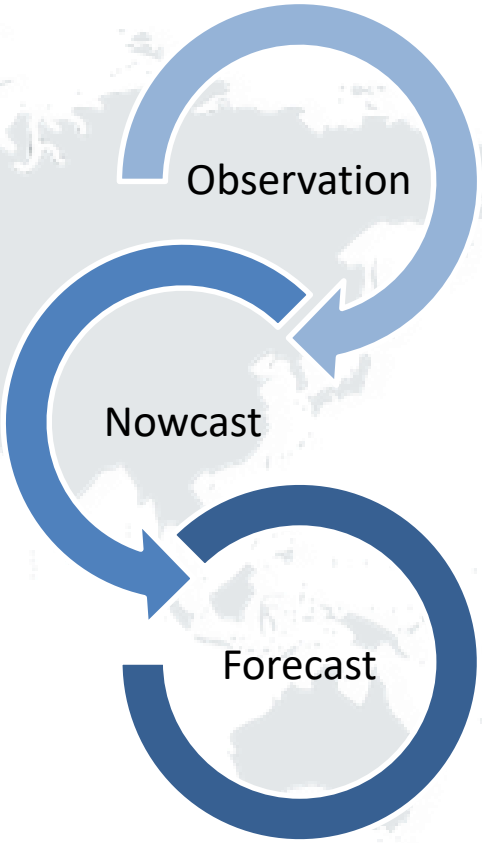
- **A**ircraft **M**eteorological **DA**ta **R**elay (AMDAR)
- Low cost, high benefit
- Wind and temperature via AMDAR are amongst the most important data sources
- Other key parameters include pressure, turbulence and moisture
- In-situ moisture measurements/water vapour datasets important for climate studies



WMO AMDAR SYSTEM

Seamless nowcast and forecast

- **Observation**: 'Now' with reduced latency
  - Ground-based
  - In-situ/aircraft-based
  - Satellite-based
- **Nowcast**: Next few minutes up to next few hours
  - Advection/extrapolation + NWP
  - Rapid refresh
- **Forecast**: Several hours up to several days or weeks
  - Blending, ensembles, probabilistic
  - NWP + climatology
  - Regular update



Impact-based forecasting

MET PROVIDER DOMAIN -> **MET CONSUMER DOMAIN**

- Many solutions emerging tailored to the various ATM users' needs
- 'Playbook' scenarios

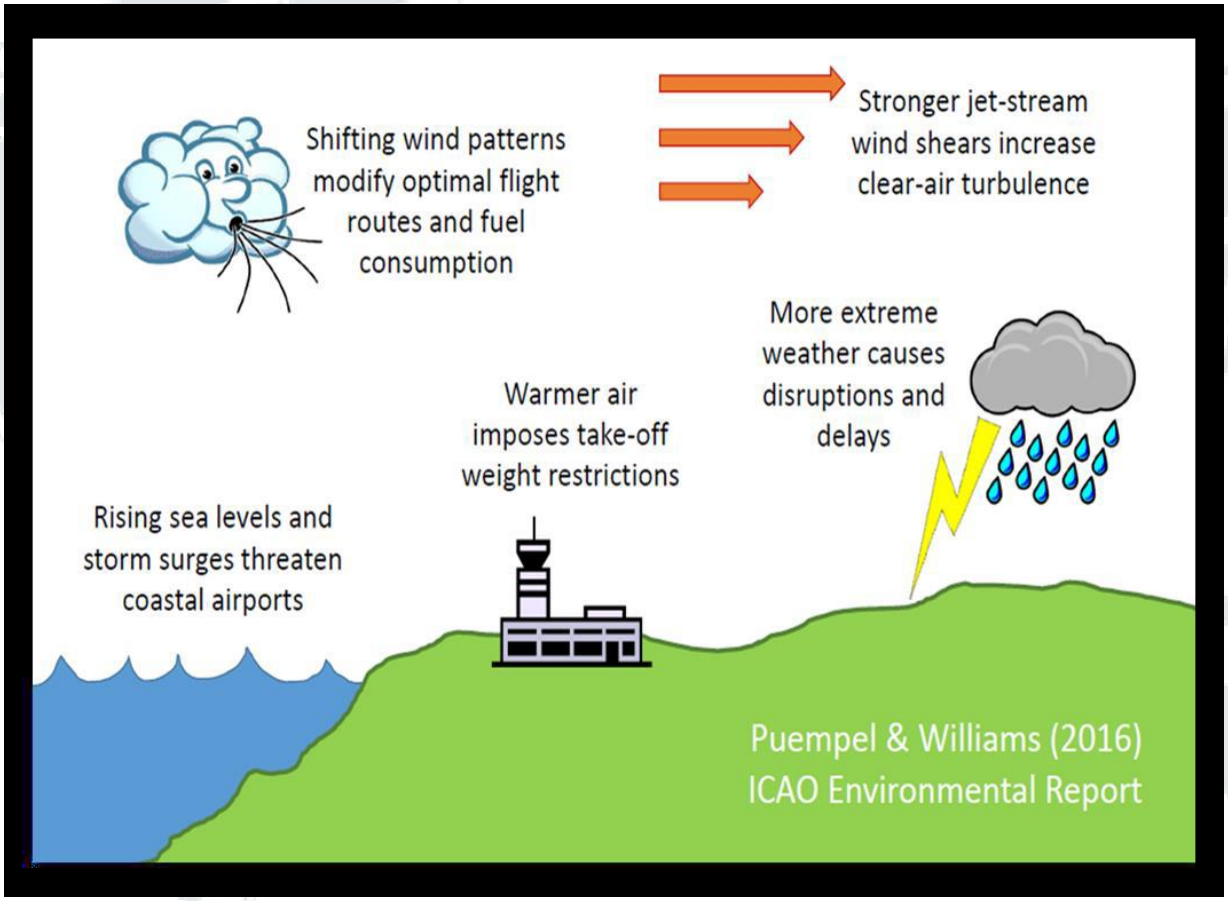
- Pro-active management of weather impacts on ATM system
- **MET-ATM COLLABORATION KEY**

Extreme weather and climate events

Excerpt of IPCC Fifth Assessment Report, 2013

Phenomenon	Early 21st century (2016-2035)	Late 21st century (2081-2100)
Warmer and/or **fewer cold days and nights** over land areas	Likely	**Virtually certain**
Warmer and/or **more frequent hot days and nights** over most land areas	Likely	**Virtually certain**
Warm **spells/heat waves**. **Frequency and/or duration increases** over most land areas	Not formally assessed	**Very likely**
Heavy precipitation events. **Increase in the frequency, intensity and/or amount** of heavy precipitation	Likely over many land areas	**Very likely** over most of the mid-latitude land masses and over wet tropical regions
Increase in **intense tropical cyclone activity**		**More likely than not** in the Western North Pacific and North Atlantic
Increased incidence and/or magnitude of **extreme high sea level**	Likely	**Very likely**

Changes to established scenarios



More information…

www.meteo.fr/cic/meetings/2017/aerometsci/

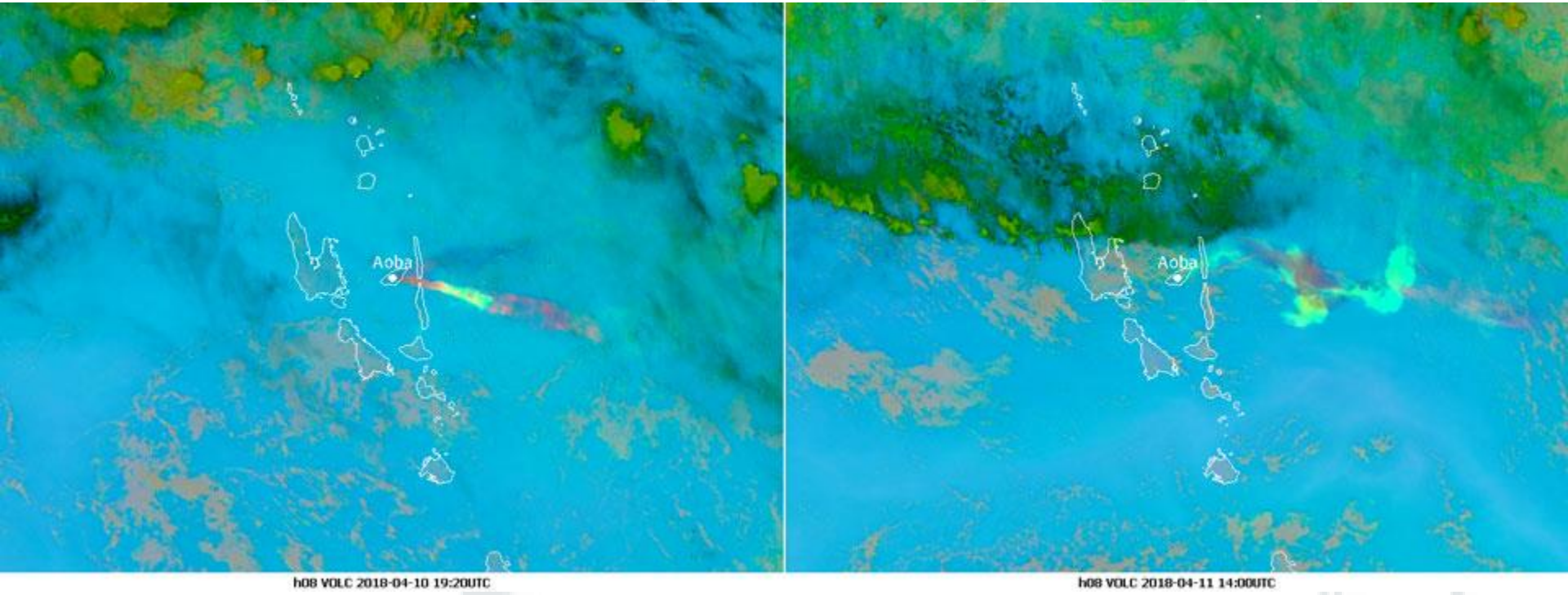
www.wmo.int/aemp/AMSC-2017

CIVIL AVIATION AUTHORITY OF NEW ZEALAND

SO2 Developments

Latest work on SO2 information provision

SO2 Emissions



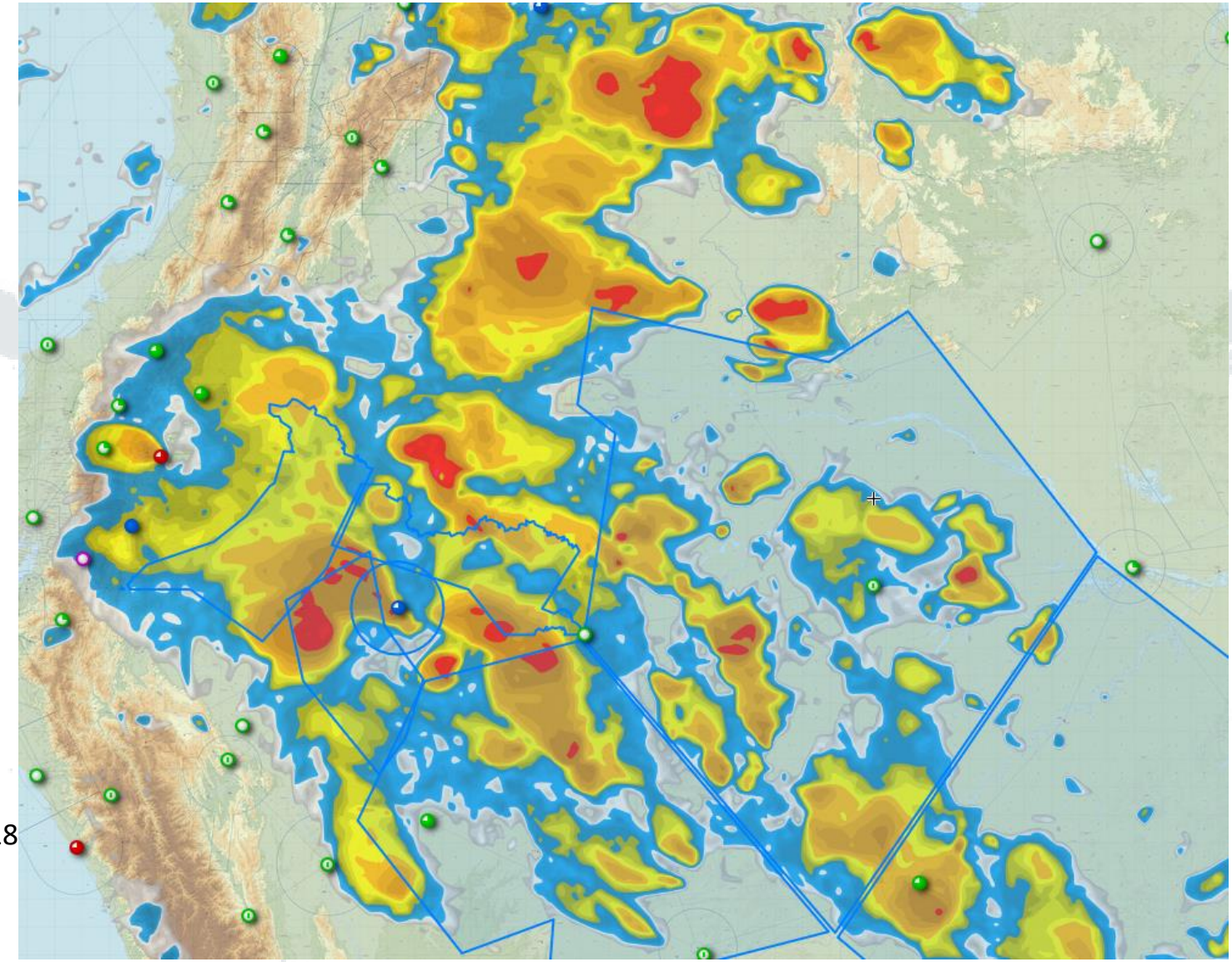
Graphic: Himawari-8 courtesy of JMA

SO2 Effects

- Focus on affect on crew and passenger health at altitude.
  - Guidelines available for maximum exposure for people at ground level - but what about in the cabin? More research needed…
- Aircraft encounters have resulted in various impacts, including reports of corrosion in engines, however considered these may be more in the realm of economic and efficiency impacts, rather than safety.

RHWAC developments

For the provision of globally harmonised, phenomena-based, hazardous weather information.



2345Z 30th September 2018 – SkyVector

Weather doesn't recognise boundaries!

Hazardous meteorological phenomena often extend over large geographic areas affecting aviation operations in multiple FIRs. SIGMETs can only be issued within the boundaries of a single FIR. The result can inhibit the safety and efficiency of aviation operations.

Mismatched/missing SIGMETs may be due to:

- MWOs using different model guidance/thresholds for SIGMET issuance.
- Lack of coordination by MWOs about their common FIR boundaries due to time pressures, language difficulties.
- Lack of resources/technical capabilities to provide a SIGMET service

The plan…

- Phenomena-based, regional hazardous weather information that is not constrained by FIR boundaries.
- Will replace the SIGMET for all phenomena except, initially, volcanic ash, tropical cyclone and radioactive cloud.
- Proposed to be only in IWXXM format.
- Roadmap to be developed.

Regional MET coordination and developments

- ICAO Asia Pacific Region (APAC) – 39 Countries (incl Australia and NZ), 13 Territories, 7 International Organisations, 49 FIRs. Regional office in Bangkok and a Sub-regional office in Beijing.
- Primary role of the APAC office – foster the planning and implementation by States in the region of ICAO Standards and Recommended Practices and regional air navigation planning for the safety, security and efficiency of air transport.
- One fulltime MET officer in the Regional Office (Bangkok).
- Five APAC MET Working Groups WGs) meet annually (usually in Bangkok) and are aligned with the METP Working Groups. Work is also conducted by correspondence between meetings. The WGs also arrange and conduct SIGMET tests, Volcanic Ash exercises, monitor OPMET exchange and review registered MET deficiencies in the Region.
- Most Asian States actively participate in the APAC MET WGs, but the Pacific States generally don't (mainly a lack of funding). There are MET deficiencies in several Pacific States (quality of observations, lack of QMS and/or qualified and competent staff, lack of or poor quality SIGMETs).

CIVIL AVIATION AUTHORITY OF NEW ZEALAND

Annex 3 Amendment 78

Significant changes, effective 8 November 2018

- Introduction of Space weather centres (SWXC) and space weather advisory information (SWX ADVISORY), and the inclusion of advisories in pre-flight MET documentation.
- Improvement in the provision of SIGMET information by meteorological watch offices (MWOs) including guidance on implementing arrangements between MWOs for handling SIGMET phenomena across FIR boundaries.
- A clearer description of the forecast position of tropical cyclones and also the location of CB cloud associated with tropical cyclones in SIGMETs;
- Information on the release of radioactive material into the atmosphere;
- Extending the use of IWXXM representations for METAR, SPECI, TAF, SIGMETs, VAA and TCA;
- Clarification of the requirements concerning aeronautical meteorological personnel qualifications and competency, education and training.