CGMS

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# EMERGENCY SATELLITE SUPPORT TO DISASTER RISK REDUCTION

HLPP reference: 3.6 and 4.1.2


The use of data and products from meteorological satellites of CGMS Members has a direct societal impact in terms of protection of life and property in disaster situations. It is also an opportunity for CGMS satellite operators to give a visible demonstration of the relevance of satellite programmes and their benefit to society. Effort should thus be made to ensure that National Meteorological or Hydrological Services (NMHSs) can make the best possible use of meteorological satellite capabilities in case of disaster emergencies, including but not limited to, severe weather events such as tropical cyclones.

The International Charter “Space and Major Disasters”, which organizes acquisition of Earth Observation data in emergency mode for disaster management authorities, is typically suited to the provision of high-resolution imagery products. The utilisation scenario of meteorological satellites is notably different since NMHSs are generally using satellite data and products in routine operations, and most meteorological satellite data or products are systematically generated and disseminated. Therefore, provision of extraordinary support in emergency situation can be thought in terms of “enhancing” the routine operations rather than implementing totally new functions.

For some disaster types such as tropical cyclones, or volcanic ash clouds, roles and responsibilities are organized at the international level, with well identified regional centres and alert procedures. It is important to maintain an active dialogue between these regional centres and the satellite community to ensure that advantage is taken of the latest satellite capabilities. For other disaster types for which no organization is formalized at the international level, best practices should be defined to ensure that key satellite data and products are available when needed, in critical situations.


Action/Recommendation proposed:

- To include in the HLPP an objective to enhance satellite support to disaster risk reduction
- To support a review of the actual use and the opportunities for enhancing the use of satellite data and products in early warning and monitoring systems for key identified hazard types.

# EMERGENCY SATELLITE SUPPORT TO DISASTER RISK REDUCTION

## 1 INTRODUCTION

Every new week brings an example, in some part of the world, of disasters where meteorological satellite data and products provide essential information to National Meteorological or Hydrological Services (NMHSs) to perform their official duty to support disaster risk reduction. An illustration of the vital importance of satellite information is given by tropical cyclone events. More generally, 90 % of major disasters recorded worldwide are of hydro-meteorological origin, and the evolution of other disaster types is often affected if not driven by the meteorological situation (e.g. volcanic ash clouds). Satellite observation therefore provides key support in a number of natural or technological disaster situations, either in the early warning phase thanks to their near real time availability, or for monitoring the event (e.g. floods), or to provide meteorological support to rescue and recovery operations.

The use of data and products from "Meteorological satellites" of CGMS Members has thus a direct societal impact in terms of protection of life and property in disaster situations. It is also an opportunity to give a visible demonstration of the relevance of satellite programmes and their benefit to society.

The purpose of this paper is to discuss how NMHSs can make the best possible use of satellite capabilities in case of disaster emergencies including, but not limited to, severe weather events such as tropical cyclones.

## 2 BACKGROUND ON DISASTER RISK REDUCTION

There has been considerable work at the international level to define best practices and guidelines for disaster risk reduction. In 1994, the "Yokohama strategy for a safer world" defined guidelines for Natural Disaster Prevention, Preparedness and Mitigation. In 2003, the 2nd International Conference on Early Warning identified four main components of Early Warning Systems: risk knowledge; monitoring and warning service; dissemination; and response capacity. In 2005, with the goal of "Building the Resilience of Nations and Communities to Disasters", the Hyogo Framework for Action 2005-2015 (HFA) outlined 5 priority areas: institutional basis; risk monitoring and warnings; education to safety; risk factor reduction; and preparedness.

WMO through its crosscutting Disaster Risk Reduction (DRR) Programme, has been working with a diverse network of stakeholders from governments, private sector, academia, United Nations and other international and regional agencies, to develop a comprehensive framework for development and delivery of services through the NMHSs to support: (1) disaster risk analysis and modeling; (2) Multi-Hazard Warning Systems and Emergency Preparedness and Response; (3) Sectoral Risk Management; (4) Disaster Risk Financing and Insurance and (5) Humanitarian planning, preparedness and response. This is being carried out through development of guidelines, recommended practices and standards, training programmes, national capacity development projects and regional cooperation. Applications of satellite products from meteorological or high resolution satellites are yet to be better understood, developed and implemented for these applications.

The United Nations International Strategy for Disaster Risk Reduction (UNISDR) is preparing a Post-2015 Framework for Disaster Risk Reduction (HFA-2). It is anticipated that the post-

2015 framework will consider both the intensive risk (high impact, low frequency) and the extensive risk (low impact, high frequency). It would recognize the risks inherent to development. For instance, climate change adaptation, or risks induced by urban concentration (e.g. air quality) would be fully part of the risk management strategy. It would also recognize the increasingly trans-boundary nature of risk drivers, which requires further cooperative efforts in their assessment and management.

A critical point in these discussions, is forging strong partnerships with the DRR mechanisms at the national, regional and international levels pertaining to operational engagement of NMHS and, in particular, the integration of observing network, forecasting and other technical support from the WMO community into capacity development in DRR for the next 10 years.

## 3 CURRENT INITIATIVES IN THE EO COMMUNITY

The International Charter "Space and Major Disasters"[1] organizes the on-demand acquisition of Earth Observation data for civil protection agencies during emergencies caused by major disasters. Although the Charter can apply to meteorological satellite data and multi-satellite information, its most typical scope is high-resolution Earth Observation imagery products, since such products are generally acquired on-demand and are not systematically disseminated in near real time. Therefore the procedures foreseen by the Charter are essential to trigger the acquisition and fast delivery of such products to disaster management authorities.

The Group on Earth Observations (GEO) has identified Disasters as one of its social benefit areas, and aims to enable the global coordination of observing and information systems to support all phases of the risk management cycle associated with hazards (mitigation and preparedness, early warning, response, and recovery). This will be achieved through: more timely dissemination of information from globally-coordinated systems; development of multi-hazard and/or end-to-end approaches;
supporting the implementation of the priorities identified in the Hyogo Framework for Action 2005-2015. Initial focus is put on geohazards, including earthquakes, volcanoes, and wildfires.

CEOS has established a Working Group on Disasters[2] with the aims to increase and strengthen the contribution of Earth Observation satellite to the various disaster risk management phases through a series of coordinated enlarged actions, and to raise the awareness of politicians, decision-makers and major stakeholders on the benefits of using satellite Earth Observation in all phases of Disaster Risk Management. The CEOS Disaster Risk Management strategy focuses initially on three hazards: floods, seismic risks and volcanoes.

The United Nations Platform for Space-based information for Disaster Management and Emergency Response (UN-SPIDER) aims to provide all countries and international and regional organizations with access to, and capacity to use, space-based information (mainly high resolution imagery) to support the full disaster management cycle. As an open network, it serves as a gateway to space information, connecting the disaster management, risk management and space communities, and facilitating capacity-building in particular for developing countries.

[1] http://www.disasterscharter.org/home
[2] See CEOS Working Group on Disasters on http://www.ceos.org

The United Nations Institute for Training and Research (UNITAR) pursues the UNITAR Operational Satellite Applications Programme (UNOSAT) delivering imagery analysis and satellite solutions to relief and development organisations within and outside the UN system to help in critical areas such as humanitarian relief, human security, strategic territorial and development planning. WMO has signed a MOU with UNITAR and its UNOSAT and has developed a task team for enhanced meteorological services to support humanitarian planning, preparedness and response, under the umbrella of the DRR Programme.

The WMO DRR Programme has established four user interface groups including: (1) the User-Interface Expert Advisory Group (UI-EAG) on Hazard/Risk Analysis; (2) UI-EAG Multi-Hazard Early warning System; (3) UI-EAG on Disaster Risk Financing and Insurance; and (4) Task Team for Improved Humanitarian Planning, Preparedness and Response. These groups are involving leading experts from the user community from UN, international and regional agencies, governments, private sector and academia to support a systematic analysis of user requirements for products and services and provide guidance to WMO. These user-driven mechanisms can be leveraged to determine specific needs and requirements for satellite information and utilization to support the respective sectors.

## 4 USE OF METEOROLOGICAL SATELLITE DATA IN DISASTER EVENTS

### 4.1 General remarks

NMHSs are generally using satellite data and products in routine operations, and most of the data or products from meteorological satellites are generated and disseminated systematically, rather than on-demand. There may be however scope for technical actions (e.g. additional data or products) or organisational measures (clear procedures to ensure an efficient flow of information within the region) that could improve the use of satellite capabilities either permanently or specifically during a severe weather event or other emergency situation.

The question of meteorological support in emergency situation is thus two-fold:

- Are we taking full advantage of the potential capabilities of satellite data and products in routine NMHSs operations for disaster risk management? (Including the support to Early Warning as well as other DRR aspects, from preparedness to rescue and recovery phases)

- In anticipation for and during emergency situations, is there scope for “enhancing” on a temporary basis the satellite information in support of disaster risk management?

### 4.2 Regional coordination

For some disaster types, roles and responsibilities are organized at the international level, with well identified regional centres and alert procedures. For instance, Tropical Cyclone Regional Specialized Meteorological Centres (RSMCs) and Tropical Warning Centres are in charge of tropical cyclone monitoring and warning in relevant oceanic areas (See Annex 1); Volcanic Ash Advisory Centres (VAACs) were designated by ICAO to monitor volcanic ash hazards to aviation (See Annex 2); RMSCs were also designated to support emergency response to nuclear or chemical environmental emergency (Annex 3). For sand and dust storms, several regional advisory centres have been implemented (See Annex 4).

In all those cases, a priority should be to enable these centres of competence to access and utilize all relevant satellite capabilities on a routine basis. Any information enhancement during disaster events should build upon the existing infrastructure. Active dialogue should be maintained between these regional centres and the satellite community to ensure that advantage is taken of the latest advances in satellite products, and to offer additional training if necessary, in order to support and help improve the valuable service they provide.

For other disaster types which are not operationally coordinated at the regional level. e.g. wildfires, extensive air pollution, dust storms, major floods, a regional coordination is necessary either to deal with transboundary aspects of the event, or even to ensure the best support to the affected country. It might be beneficial to define best practices ensuring that key satellite data and products are available when needed, in critical situations.

### 4.3 Enhanced information

Different ways can be considered to enhance information in emergency situations, for instance:

- On-demand rapid-scan imagery, noting that new generation imaging sensors will offer greater flexibility to provide frequent data over a given region and should thus make targeted observation easier to accommodate in operational procedures.
- Higher-resolution products on a selected area (for products that are normally available on a larger domain at lower spatial/temporal resolution because of optimization of processing or dissemination resources).
- Customized imagery loops for media purpose.
- Imagery or products from a secondary operational satellite.
- Pre-operational products, data or products from R&D missions that are not used in routine operations.
- Temporary access right to information that is normally restricted.

Whilst such additional data may be very useful in principle, it can also be a source of complications for satellite operators, but also for forecasters faced with ad-hoc products that they are not familiar with and which are not incorporated into routine forecasting procedures.

Likewise, operational user systems may not be easily configured to receive additional products that would be transmitted in dedicated broadcast channels. Discussion in the WMO Expert Team on Satellite Utilization and Products (ET-SUP) suggested that making additional products available on a server for consultation would be a way to enhance the information with little impact on operational procedures.

### 4.4 The case of tropical cyclones

Superstorm Sandy, which hit the East coast of the USA in October 2012, was the matter of numerous case studies reported at the 94$^{th}$ AMS meeting (Atlanta, January 2014). More recently, Typhoon Haiyan hitting the Philippines and neighbouring countries in November 2013, caused over 5,000 casualties. It is an imperative to enable the effective use of satellite data to assist in such dramatic situations.

A prerequisite is to secure at least the nominal baseline observations: the WMO-ESCAP Panel on Tropical Cyclones had expressed concern about the long-term coverage of the Indian Ocean, which is the subject of CGMS Action 41.38. CGMS should by all means ensure continued coverage and availability of satellite data throughout the geostationary ring.

The RSMC-Tokyo/Typhoon Centre reported that during the Hayan event a wide range of satellite data had been used to generate operational analyses and forecast (See Annex 5) as indicated below :

- MTSAT-2 infrared, water vapour and visible channel full disc imagery at 30-min intervals was used to estimate Haiyan's position and intensity by the Dvorak technique, which employs a subjective cloud pattern imagery analysis.
- Polar orbital satellite data have been used to analyze the status of Haiyan although they only observe a specific area once every several hours.
- Wind direction and speed data over the oceans from the METOP/ASCAT scatterometer was used to estimate the strong wind areas.
- AMSU-A microwave sounder data from NOAA-18,19 and METOP-A,B was used to derive the warm core temperature and estimate Haiyan's intensity, namely, the minimum central pressure.
- GCOM-W1/AMSR microwave imagery was used to determine the typhoon’s position.
- MHS was also referred to in analysing position.
- TRMM/TMI was used to analyze position and intensity too.

For hurricane events affecting Central America or the Caribbean the relevant RSMC is the Miami Hurricane Center of NOAA/NWS. In addition, there are examples where the VLab Centres of Excellence (CoE) in Costa Rica and Barbados have set up on-line weather briefings to assist in communicating the information and supporting dialogue between the RSMC, satellite experts and national forecasters in the affected countries.

## 5 SUGGESTED ACTIONS

Based on the considerations above, various actions can be considered, involving the relevant programmes of WMO with support of CGMS satellite experts.

a) For tropical cyclones

- Review the list of satellite data used in the various regional tropical cyclone centres to identify any missing sources of useful data and, where needed, consider training actions in the use of new sensor data.
- Organize a new workshop on the use of satellite data for tropical cyclone forecasting, taking into account developments of the space-based observing system, including new generation geostationary and polar-orbiting satellites, as well as active precipitation monitoring and altimetry missions.
- Review the notification procedures between regional tropical cyclone centres, the affected NMHSs, and satellite operators, with a view to identify potential enhancements, including the possibility to request additional information (For instance, frequent imagery when nearing the landfall, or novel products such as upper ocean heat content derived from altimetry, etc).

- Seek representation of CGMS satellite operators in the regional meetings in charge of establishing and updating the operational procedures for tropical cyclone warnings.

b) For other disaster types

- Review the use of meteorological satellite data and products in emergengy situations related to key environmental disaster types (e.g. floods, large fires, etc.).
- Promote increased regional cooperation and information sharing between NMHSs during severe weather events, especially for cross-border events.
- Consider procedures allowing requesting additional information from satellite operators when practical, through a qualified focal point such as an RSMC or a VLab CoE.
- Encourage RSMCs or VLab CoE to establish FTP servers where additional data or products (rapid scan, third-party R&D data, prototype products, etc.) could be uploaded and made available in emergency situations.
- Leverage the users interface mechanisms of the WMO DRR Programme to better understand the user needs and requirements for satellite products for emergency preparedness and Early Warning Systems applications.
- ET-SUP should keep abreast of the activities of groups like International Charter and the CEOS Working Group on Disasters to identify potential best practices which could be applied more widely within the meteorological community (users and satellite operators).

## 6 CONCLUSION

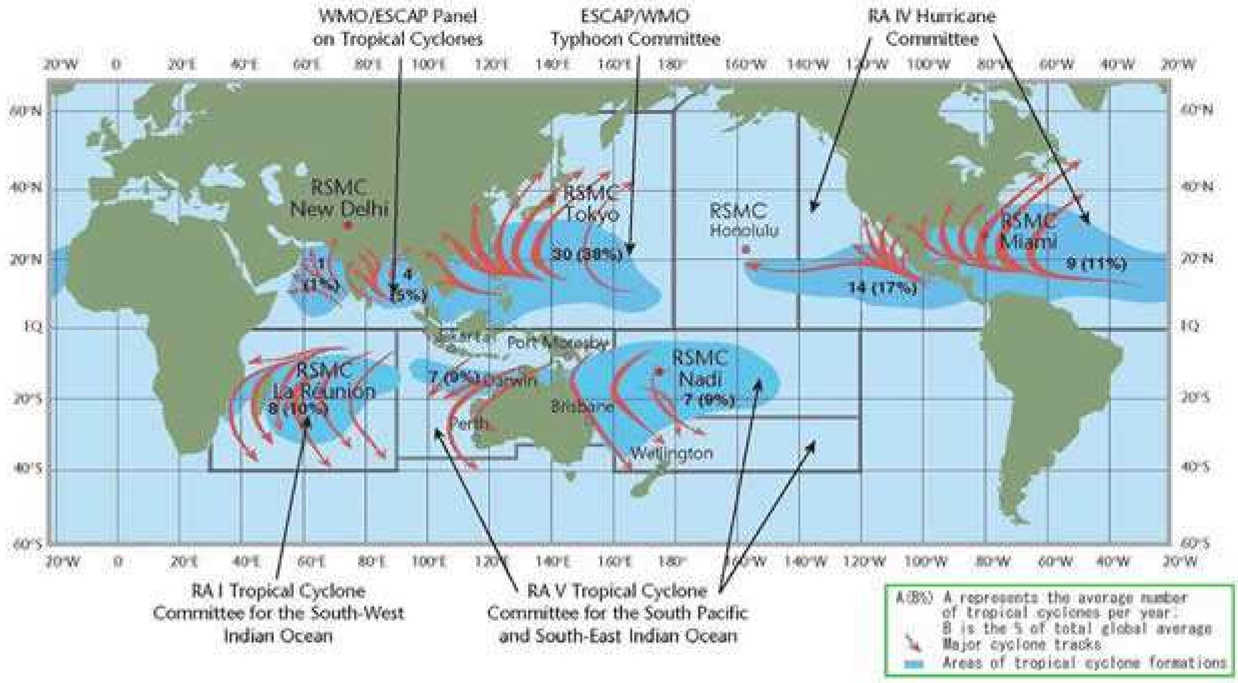
CGMS is invited to comment on the actions suggested above, in particular as concerns a review of the actual use, and potential opportunities for enhancing the use, of data and products from meteorological satellites for key applications such as early warning and monitoring systems for identified hazard types.

It is suggested to include in the CGMS High-Level Priority Plan an objective to enhance satellite support to disaster risk reduction.

## Annex 1: Regional Structure of the Tropical Cyclone Programme

Five regional bodies are in charge of maintaining an Operational Plan or a Manual which records the agreements reached on the sharing of responsibilities for the tropical cyclone warning services, and their infrastructures, throughout its region:

- RA I Tropical Cyclone Committee for the South-West Indian Ocean
- ESCAP/WMO Typhoon Committee
- WMO/ESCAP Panel on Tropical Cyclones
- RA IV Hurricane Committee
- RA V Tropical Cyclone Committee for the South Pacific and South-East Indian Ocean



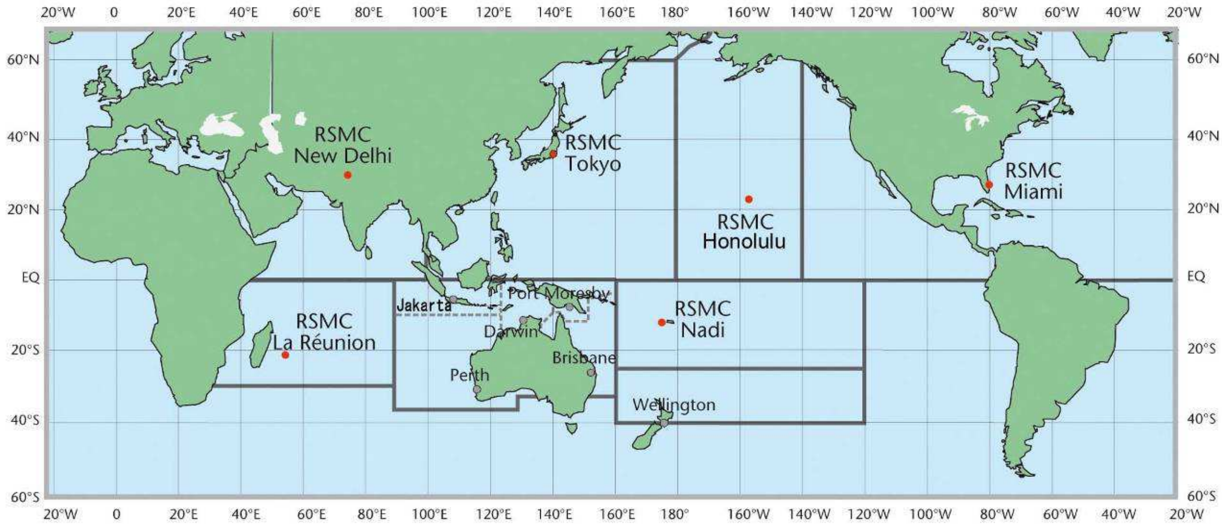

*Regional bodies in charge of Tropical Cyclone warning coordination*

Six Tropical Cyclone Regional Specialized Meteorological Centres (RSMC) are established:

- RSMC Miami-Hurricane Center/NOAA/NWS National Hurricane Center, USA.
- RSMC Tokyo-Typhoon Center/Japan Meteorological Agency.
- RSMC-tropical cyclones New Delhi/India Meteorological Department.
- RSMC La Réunion-Tropical Cyclone Centre/Météo-France
- RSMC Nadi-Tropical Cyclone Centre/Fiji Meteorological Service
- RSMC Honolulu-Hurricane Center/NOAA/NWS, USA.

Six Tropical Cyclone Warning Centres (TCWC) have a regional responsibility:

- TCWC-Perth/Bureau of Meteorology (Western Australia region), Australia
- TCWC-Darwin/Bureau of Meteorology, Australia
- TCWC-Brisbane/Bureau of Meteorology, Australia
- TCWC-Port Moresby/National Weather Service, Papua New Guinea
- TCWC-Wellington/Meteorological Service of New Zealand, Ltd.
- TCWC-Jakarta/ Indonesian Meteorological and Geophysical Agency, Indonesia




*Areas of responsibility of the six Tropical Cyclone Regional Specialized Meteorological Centres and six Tropical Cyclone Warning Centres with regional responsibility.*

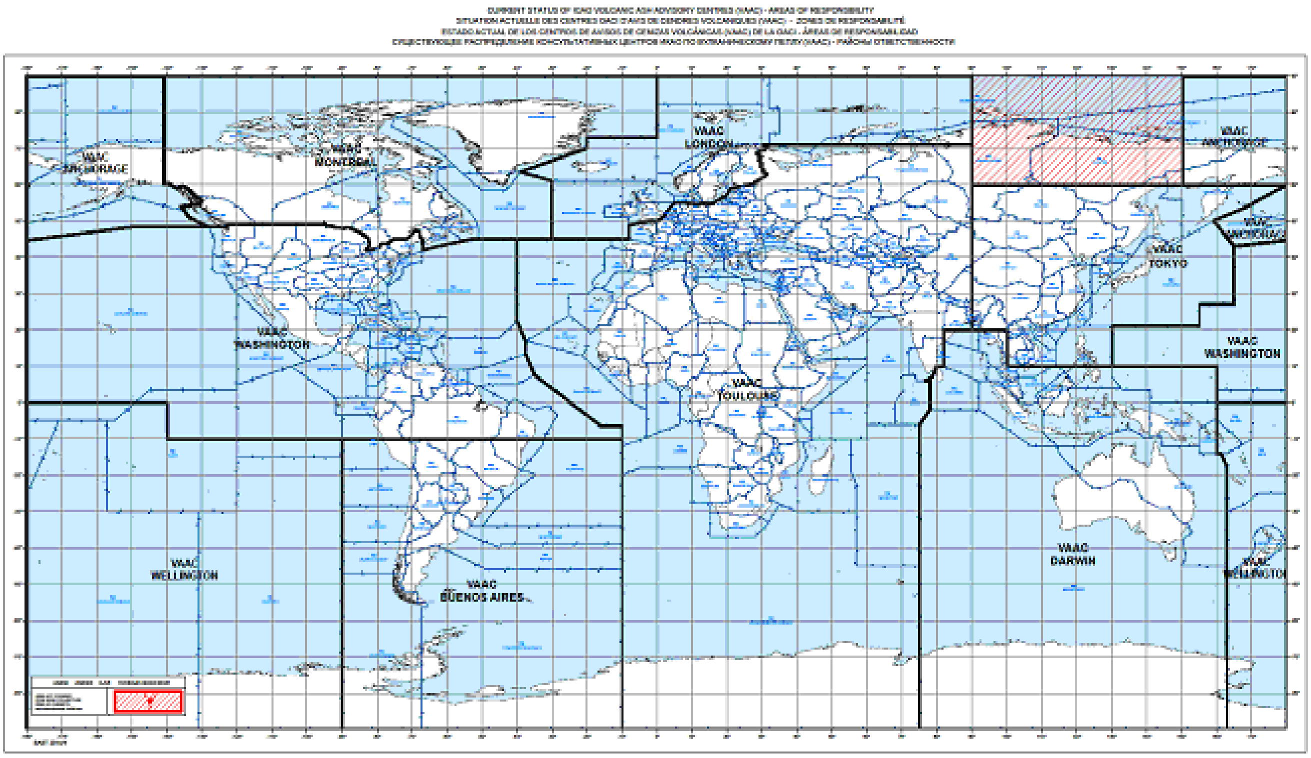
The six tropical cyclone Regional Specialized Meteorological Centres (RSMCs) together with six Tropical Cyclone Warning Centres (TCWCs) having regional responsibility, provide advisories and bulletins with up-to-date first level basic meteorological information on all tropical cyclones, hurricanes, typhoons everywhere in the world.

The first-level basic information comprises reliable information from a clearly defined source on the tropical cyclone's location and size and its present and forecast movement and intensity. Where available to the RSMC, summaries of the official National Warnings may be included in their advisory.

## Annex 2: Volcanic Ash Advisory Centres

The ICAO has established nine Volcanic Ash Advisory Centres (VAACs):

- Anchorage, AK, United States
- Buenos Aires, Argentina
- Darwin, Australia
- London, United Kingdom
- Montreal, Canada
- Tokyo, Japan
- Toulouse, France
- Washington, DC, United States
- Wellington, New Zealand




ICAO Volcanic Ash Advisory Centres (VAAC) areas of responsibility (March 2014.)

## Annex 3: WMO Emergency Response Activities (for nuclear and chemical environmental emergencies)

WMO's Emergency Response Activities (ERA) programme involves the application of specialized atmospheric dispersion-modelling techniques to track and predict the spread of airborne hazardous substances in the event of an environmental emergency. This kind of specialized application depends directly on the operational infrastructure of the numerical weather prediction systems that are implemented and maintained at many of the global, regional or national meteorological centres within WMO's World Weather Watch system.

The ERA programme was established to assist National Meteorological and Hydrological Services, their respective national agencies and relevant international organizations to respond effectively to environmental emergencies involving large-scale dispersion of air-borne hazardous substances.

Following the Chernobyl nuclear power plant accident in 1986, the programme has focused its operational arrangements and support on nuclear facility accidents. In addition, where possible, the programme has also included emergency response to the dispersion of smoke from large fires, ash and other emissions from volcanic eruptions, and chemical releases from industrial accidents.

WMO has implemented and maintains a system of 10 Regional Specialized Meteorological Centres (RSMCs) that provide real-time 24/7 specialized atmospheric dispersion model products for environmental emergency response and/or backtracking. These specialized centres, providing complete global coverage 24 hours a day, every day, are located in National Meteorological Centres at:

- Beijing (China)
- Exeter (United Kingdom)
- Melbourne (Australia)
- Montreal (Canada)
- Obninsk (Russian Federation)
- Offenbach (Germany) - backtracking only
- Tokyo (Japan)
- Toulouse (France)
- Vienna (Austria) - backtracking only
- Washington (USA) - excluding backtracking

The system also includes a telecommunication gateway at Offenbach (Germany) to provide notification and real-time information linkage between the Incident and Emergency Centre of the International Atomic Energy Agency (IAEA) and WMO. When requested, the centres will provide the specialized products within three hours to National Meteorological Centres and the IAEA.

WMO is expanding the scope and capabilities of its ERA programme to include non-nuclear environmental emergencies - the area of chemical incidents and emergencies is one under exploration and development.

### Annex 4: Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

The WMO SDS-WAS, as an international framework linking institutions involved in SDS research, operations and delivery of services, addresses the following objectives:

- Provide user communities access to forecasts, observations and information of the SDS through regional nodes to be connected to the WMO Information System (WIS) and the World Wide Web.
- Support research for better understanding and modelling the atmospheric dust process
- Identify and improve SDS products to be delivered to user communities
- Enhance operational SDS forecasts through technology transfer from research
- Improve forecasting and observation technology through coordinated international research and assessment
- Build capacity of relevant countries to be trained to utilize SDS observations products for meeting societal needs
- Build bridges between SDS-WAS and other communities conducting aerosol related studies (air quality, biomass burning, etc.)

The SDS-WAS comprises two regional nodes and plans for a third one:

- Regional Node for Asia (SDS-WAS RC A).
  The Centre for the Atmospheric Watch and Services of the National Satellite Meteorological Centre and National Meteorological Centre of CMA, China, supports the regional node of SDS-WAS for Asia consisting of a consortium of partners from China, Korea, Japan, Mongolia and other interested countries.

- Regional Node Northern Africa - Middle East - Europe (SDSWAS RC NAMEE)
  The SDSWAS NAMEE Regional node is composed of a consortium including the Meteorological State Agency of Spain (AEMET), the Barcelona Supercomputing Center (BSC-CNS) and the National Research Council (CSIC) and a number of partners : Meteo-France, LISA, University of Athens, University of Tel Aviv, Egyptian Meteorological Agency, METU and other NMHSs.

- WMO-UNEP Regional node for West Asia is being planned, involving Turkey, the Islamic Republic of Iran, and regional partners to be determined.

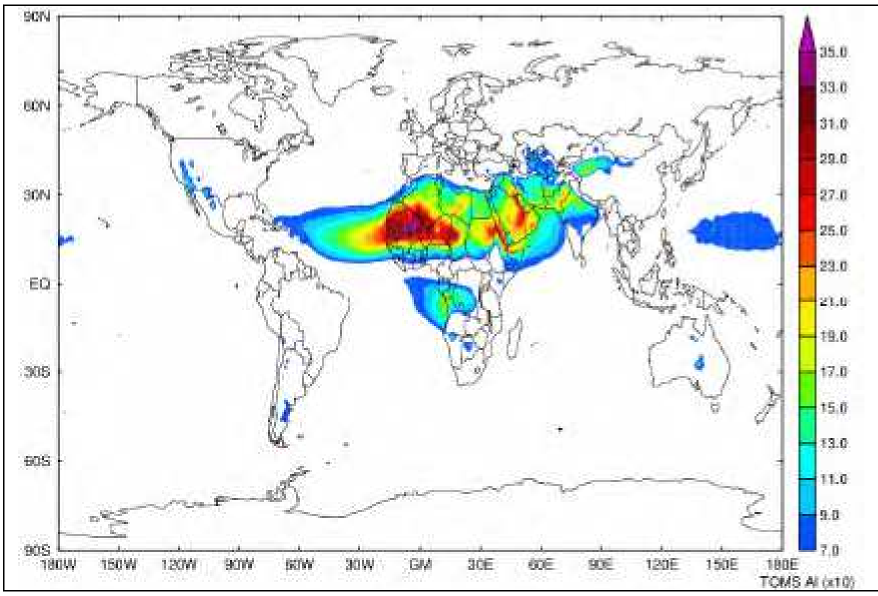
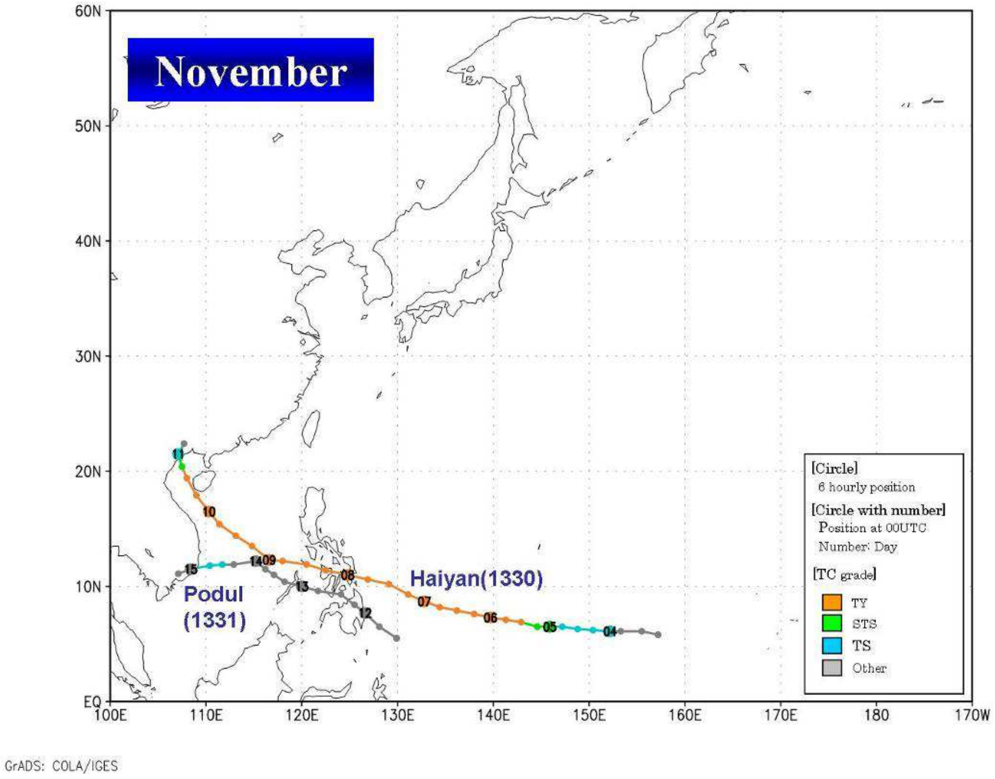
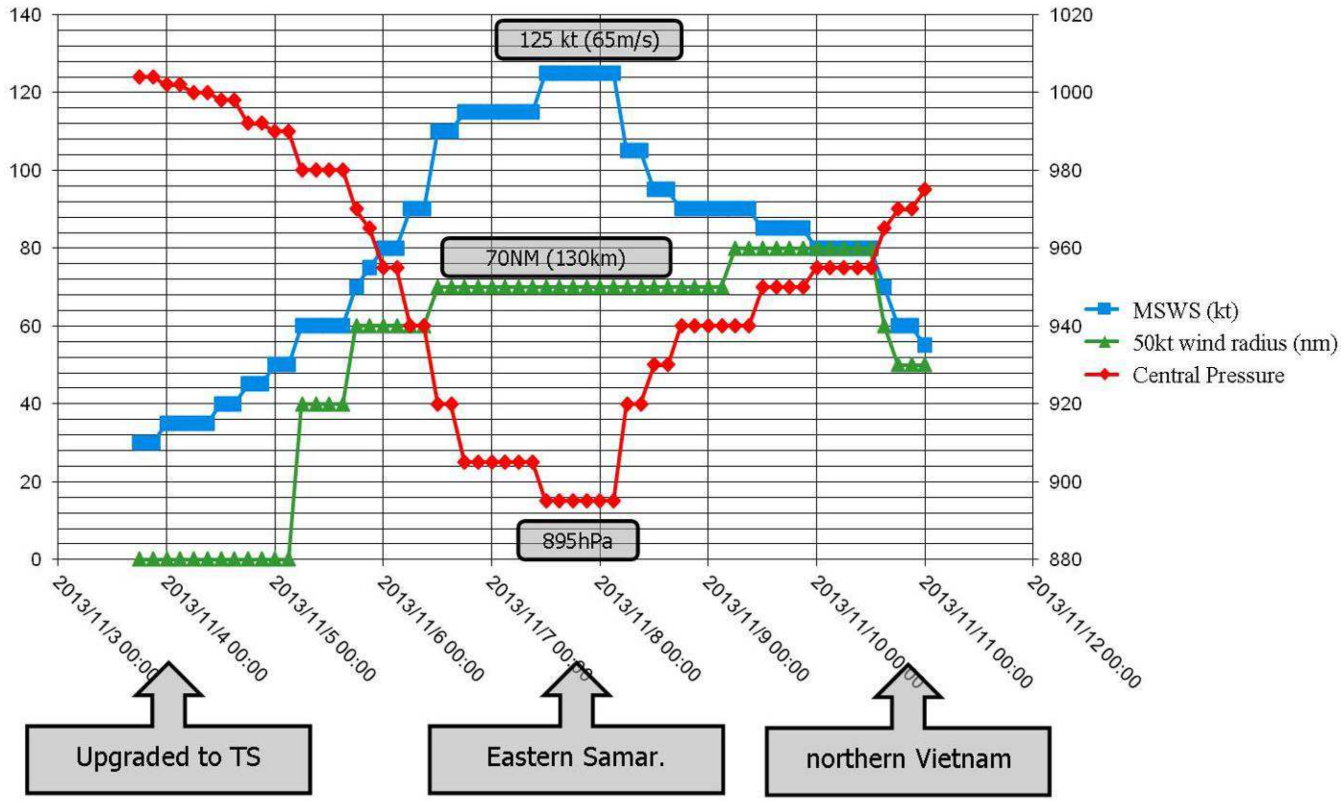



Figure: May–July seasonal mean for the period 1980–1992 of aerosol index (AI) derived from TOMS satellite observations, showing the main dust sources on the global scale forming the dust belt (after Engelstaedter et al., 2006)

**Annex 5: Typhoon Hayan**
(Source: RSMC Tokyo – Typhoon Center, JMA)




Above: tracks of Typhoon Hayan and Tropical Storm Podul in November 2013.
Below: operational analysis of the Typhoon Hayan event.