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VISION FOR THE WIGOS COMPONENT SYSTEMS IN 2040

WIGOS VISION SURFACE 2040, DRAFT 7.1 (12 Oct 2016)

(Submitted by Secretariat)

Summary and Purpose of Document

To present the status of the Vision for the WIGOS surface-based components in 2040 draft 7.1 (12 October 2016).

ACTION PROPOSED

The session is invited to note the information in this document.

Draft version 7.1, 12 October 2016

VISION FOR THE SURFACE-BASED COMPONENTS OF WIGOS IN 2040

PREAMBLE

This Vision provides high-level goals to guide the evolution of the WMO Integrated Global Observing System (WIGOS) in the coming decades. These goals are intended to be challenging but achievable. The Vision addresses an important area within the WMO Strategic Plan[1].

The future WIGOS will build upon existing sub-systems, both surface- and space-based, and capitalize on existing, new and emerging observing technologies not presently incorporated or fully exploited. Incremental additions to the WIGOS will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs).

WIGOS will be a comprehensive "system of systems" interfaced with WMO co-sponsored and other non-WMO observing systems, making major contributions to the Global Earth Observation System of Systems (GEOSS); and will be delivered through enhanced involvement of WMO Members, Regions and technical commissions. The space-based component will rely on enhanced collaboration through partnerships such as the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS). Portions of the surface- and space-based sub-systems will rely on WMO partner organizations: the Global Terrestrial Observing System (GTOS), the Global Ocean Observing System (GOOS), the Global Climate Observing System (GCOS), and others.

The scope of these changes to the WIGOS will be major and will involve new approaches in science, data handling, product development and utilization, and training.

The Vision addresses the observational needs for all application areas supporting the activities of WMO and the WMO Members. The respective roles of traditional NMHSs, research organisations, other government agencies and entities from the private sector in acquiring, processing and disseminating meteorological information are undergoing very rapid change, and it is impossible to predict future evolutions in this area. The Vision therefore does not prescribe the specific implementation agents. However, it is based on the general WMO principle that meteorological services - in particular weather forecasts, watches and warnings, and guidance on climate change, adaption and mitigation - is a public good and should be provided to the citizens of all nations free of charge.

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[1] WMO Strategic Plan (date), Expected Result no.xx: "Improved observations and data exchange: Enhanced capabilities of Members to access, develop, implement and use integrated and interoperable Earth- and space-based observation systems for weather, climate and hydrological observations, as well as related environmental and space weather observations, based on world standards set by WMO"

This Vision supersedes the “Vision for global observing systems in 2025”[2], which has been an important WMO guidance document but is now becoming less useful for guiding long-term strategy and planning. Also, the new Vision embraces the broadened scope of WIGOS, in terms of application areas supported and their anticipated evolution, and reflects updated information on observing technologies and their expected development.

This document addresses only the surface-based components of WIGOS. It will be merged with the equivalent document for the space-based components of WIGOS to provide a “Vision for WIGOS in 2040”.

1. GENERAL TRENDS AND ISSUES

User requirements for observations, to meet the needs of WMO Programmes and co-sponsored Programmes, will be documented through the Rolling Review of Requirements (RRR) process[3] in the “OSCAR/Requirements” database[4]. This Vision responds to the currently-stated requirements of WMO Applications Areas and attempts to anticipate the major evolutions of these requirements.

The Observing Network Design (OND) Principles of WIGOS now form part of the Manual on WIGOS[5] . The evolution of the observing system components of WIGOS will be guided by these Principles, which are copied as Annex A of this Vision, and will be influenced by the following general tendencies.

Response to user needs

WIGOS will:

- provide observations when and where they are needed in a reliable, stable, sustained and cost-effective manner;
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- respond to users’ requirements for observations with improved spatial and temporal resolutions and timeliness;
- reflect the need for observations of high quality and for improved levels of quality control, including user feedback mechanisms.
- evolve in response to a rapidly changing user and technological environment, based on improved scientific understanding and advances in observational and data-processing technologies.

Integration

- WIGOS will provide observations to support the full range of WMO Programmes and co-sponsored Programmes. This include operational weather forecasting, and also other applications within climate monitoring, ocean applications, atmospheric composition, hydrology, space weather, weather and climate research, and other application areas within WMO Programmes as they emerge;

[2] Footnote ref to Vision 2025.
[3] Footnote ref to RRR process
[4] Footnote ref to OSCAR/Requirements
[5] Footnote ref to Manual on WIGOS, section on OND Principles

- Integration will be developed through the analysis of requirements and, where appropriate, through sharing observational infrastructure, platforms and sensors, across systems and with WMO Members and other partners;
- Surface- and space-based observing systems will be planned in a coordinated manner to serve, in a cost-effective way, a variety of user needs. Surface- and space-based systems will increasingly complement each other, both in terms of data coverage and for calibration and quality control;
- As far as is possible, non-NMHS observations will be integrated into WIGOS, consistently with WIGOS principles and technical regulations;
- WIGOS metadata will be collected, exchanged, recorded, standardized and quality monitoring will be implemented across all WIGOS component observing systems.

Expansion

- There will be an expansion in both the user applications served and the geophysical variables observed;
- This will include observations to support the monitoring of Essential Climate Variables, adhering to the GCOS climate monitoring principles;
- Sustainability of new components of the WIGOS will be secured, with some mature R&D systems integrated as operational systems;
- The range and volume of observations exchanged globally (rather than locally) will be substantially increased;
- Regional observing networks will be developed to improve forecasting of mesoscale phenomena.
- Some level of targeted observations will be achieved, whereby additional observations are acquired or usual observations are not acquired, in response to the local meteorological or environmental situation.
- New information will be made available through miniaturization of sensors, cloud technology, crowdsourcing, and the “Internet of Things”. There will be enhanced interactions between observation providers and users, including feedback of information on observation quality from data assimilation centres.

Automation and technology trends

- The trend to develop fully automatic observing systems, using new observing and information technologies will continue, where it can be shown to be cost-effective and consistent with user needs;
- Access to real-time and raw data will be improved;
- Observing system test-beds will be used to compare and evaluate new systems and to develop guidelines for integration of observing platforms and their implementation;
- Observational data will be collected and transmitted in digital forms, highly compressed where necessary. Observation dissemination, storage and processing will take advantage of advances in computing, satellite and wireless data telecommunication, and information technology.
- Efficient and interoperable technologies will be developed to manage and present observational data; products for users will be adapted to their needs.
- Traditional observing systems, providing observations of high quality, will be complemented by small inexpensive sensors that are mass-produced and installed on a variety of platforms; observations from these devices will be communicated automatically to central servers or databases; automated and autonomous calibration systems will be developed for some of these systems;

- Similarly, small inexpensive sensors will be developed to measure a broader range of geophysical variables.

Consistency, continuity and homogeneity

- There will be increased standardization of instruments and observing methods;
- There will be growing reliance on reference networks to develop and establish standards serving as reference baselines.
- There will be improvements in calibration of observations and the provision of metadata, to ensure data consistency and traceability to absolute standards;
- There will be improved methods of quality control and characterization of errors of all observations;
- There will be improvements in procedures to ensure continuity and robustness in the provision of observations, including management of transitions when technologies change;
- There will be increased interoperability, between existing observing systems and with newly implemented systems;
- There will be improved homogeneity of data formats and dissemination via the WIS;

2. THE SURFACE-BASED COMPONENT

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
Upper air observations		
Upper-air weather and climate observations	Wind, temperature, humidity, pressure	• Radiosonde networks will be optimized, particularly in terms of horizontal spacing which will increase in data-dense areas, and taking account of observations available from other profiling systems • Profiles from radiosondes will be delivered at higher vertical resolution, as required by applications • The GUAN network will be fully supported as part of RBON • The GRUAN network will be extended and will deliver observations of reference quality in support of climate and other applications • Automated sonde systems will be deployed at remote locations • Targeted dropsondes will continue to be used and may evolved into air-deployed UAVs • Remote radiosondes stations will be retained and protected • Support for small islands and developing states will include: improved communications, sustainable power supplies, and training in measurement methods and instrument maintenance
Aircraft-based observations	Wind, temperature, pressure, humidity, turbulence, icing, precipitation, volcanic ash and gases, and atmospheric composition variables (aerosol variables, ozone, greenhouse gases, precipitation chemistry variables, reactive gases)	• Global coverage from several regional aircraft-based observing (ABO) programmes - expansion of current (regional) programmes, development of new (regional) programmes covering data sparse regions. • The ABO Programme achieves 500,000 vertical profiles per day, with humidity measurements, and almost evenly distributed among all WMO Regions. • ABO systems expected to be among the basic aircraft systems in newly manufactured commercial aircraft to maximize aviation safety and efficiency, for modernized navigation systems and Air Traffic Management (ATM) and to provide high resolution data. Activation on request. • ABO-generated observations transmitted in real-time during flight, to be received by ATM and aircraft flying in neighbouring air space, displayed in cockpit. • Aircraft fly at higher altitudes (environment, separation) providing profiles with data higher in the atmosphere. • Globally integrated NMHS- and non-NMHS ABO system ABO observations (semi-)online distributed on internet for general public information via dedicated apps. • Flexible adaptation of ABO systems to user requirements by the use of geographically distributed optimization systems for optimal and cost-effective global coverage. • Aircraft-to-ground communication to be two-way broadband allowing cheap and constant communication and transfer of ABO data at 3 seconds interval and other flight operations information,

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
		throughout flight . • Optimized data communication protocol and message format. • Aircraft onboard weather radar data is down-linked in ABO to supplement fixed site weather radars. • AMDAR (-equivalent) Onboard Software (AOS) adapted to latest development in avionics and aircraft-to-ground communication and ready for new aircraft generations (digital systems, navigation). • Sensors newly developed and mounted on (commercially applied) Unmanned Aerial Vehicles (UAVs) providing vertical profiles in oceanic regions where commercial aircraft do not provide ascents/descents. • Large commercial aircraft fleet equipped to conduct operationally long-term near real-time in-situ observations of atmospheric composition and cloud particles on a global scale, integrated with ABO data. • Verified and quantified benefits of using water vapour data in on-board anti-icing protection, avoidance of high-altitude ice crystals, and aircraft engine performance optimization.
Remote sensing upper-air observations	Wind, cloud base and top, cloud water, temperature, humidity, aerosols, fog, visibility	• Radar wind profiler networks are well established and will be extended • Wind measurements from cost effective Doppler-Lidar will be increasingly used for measurements in the boundary layer • Raman-Lidar deliver humidity and temperature profiles of high accuracy, operational reliable systems will be available • Differential Absorption Lidar deliver high resolution humidity profiles, first systems for operational use will be available in near future • Microwave Radiometers have been proven to deliver information on temperature and humidity, but with limited vertical resolution • Enhanced automated cloud detection technology to heights above 6000m. • Cloud radar (Ka-band or W-band) will be used for improved measurements of thunderstorm and strong precipitation • Data from automated profile systems nationally disseminated/centrally archived • Establish/maintain training programs for sound manual observations to augment automated and remotely sensed observations for cloud observations. • Improved methods for combining surface and space-based cloud observations • Increased use of video cameras (e.g. at airports) to support local forecasting, including nowcasting and aviation meteorology.

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
Atmospheric composition upper-air observations	Atmospheric composition variables (aerosol variables, ozone, greenhouse gases, precipitation chemistry variables, reactive gases)	• Restore and maintain full global network of operational ozonesondes through GAW and cooperation with international partners. • Expanded use of automated drones for making air quality measurements • Ozone and PM2.5 measurements extended to more developing nations • Aircraft in ABO Programme begin to be equipped to measure these variables – see above.
GNSS receiver observations	Humidity	• Networks of ground-based GNSS receivers extended across all land areas to provide global coverage of total column water vapour observations, and the data exchanged globally.
Lightning detection systems	Lightning variables (location, density, rate of discharge, polarity, volumetric distribution)	• Networks of ground-based lightning detection systems will evolve to be complementary to new space-based systems • Long-range lightning detection systems will provide cost-effective, global data with a high location accuracy, significantly improving coverage in data sparse regions including oceanic and polar areas; • High-resolution lightning detection systems with a higher location accuracy, cloud-to-cloud and cloud-to-ground discrimination will support nowcasting and other applications • Common formats and lightning observation archives will be developed.
Weather radars	Precipitation (hydrometeor size distribution, phase, type), wind, humidity (from refractivity), sand and dust storm variables, some biological variables (e.g. bird densities)	• Expansion of Doppler and polarimetric weather radars to developing nations, including training on processing and interpretation, and capacity development to handle the extremely large amounts of data. • Emerging technologies will gain widespread use: electronically-scanning (phased-array) adaptive radars will acquire data in unconventional ways, necessitating adaptation by data exchange and processing infrastructure. • A weather radar data exchange framework will serve all users and achieve homogeneous data formats for international exchange.
Automated Shipboard Aerological Platform (ASAP) observations	Wind, temperature, humidity, pressure	• Commercial ships will be designed to facilitate the making of metocean observations, including installation and use of ASAP systems
Drone-based observations	Wind, temperature, humidity, pressure	• Facilities for drone-based observations (land, coastal, ships) will be developed
Near-surface observations over land		
Surface weather and climate observations	Surface pressure, temperature, land surface temperature, humidity, wind;	• Tiered networks established; climate reference networks, baseline networks (including RBON), and comprehensive (which include non-NMHS and volunteer observing networks/national mesonets)

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
	visibility; clouds; precipitation; surface radiation variables; soil temperature; soil moisture	• Collect, archive, and provide access to crowd-sourced near-surface observations; integrate with NMHS and other observations as part of tiered network design. • Automated Climate Reference Network stations (temperature and precipitation) deployed in all WMO regions to improve measurement of national variability and trends • Climate quality daily, hourly and sub-hourly (to 5-minute) data collected and globally disseminated • Synergy maintained between manual and automated observations, especially for elements such as precipitation as needed to ensure sufficient spatial coverage. • Expanded use of automated networks to improve high temporal resolution observations. • Expansion of wireless or satellite data transmission for real-time dissemination from station to central facility • Expansion of non-NHMS networks, including volunteer and private sector networks; automated dissemination/collection to national archive centers • Maintenance of a measurement lifecycle that recognizes the importance of the full requirement of data stewardship; from data collection, metadata, and archive. • Increased use of video cameras (e.g. at airports) to support local forecasting.
Atmospheric composition surface observations	Atmospheric composition variables (aerosol variables, greenhouse gases, ozone, precipitation chemistry variables, reactive gases)	• Meteorology/climate measurements collocated with air quality measurements • Expand global and regional measurements including through GAW
Application specific observations (road weather, airport/heliport weather stations, agromet stations, urban meteorology, etc)	Application specific variables and phenomena	• Urban reference networks established to measure urban meteorology/climatology • Road weather networks transmit in near-real time; data collected and archived at national archive centres • Soil moisture/temperature measurements at agricultural meteorological stations from near-surface to 100cm
Near-surface observations over rivers and lakes		
Hydrological observing stations	Precipitation, snow depth, snow water content, lake and river ice thickness/date of freezing and break-up, water level, water flow, water	• Automated measurement of snowfall/snow-depth further augments manual measurements • Maintain existing snow monitoring sites, exchange data internationally, and provide global monitoring of that data on the GTS • Expansion of automated soil moisture/temperature measurements by installing sensors at existing sites.

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
	quality, soil moisture, soil temperature, sediment loads	• Volunteer observations of lake/river ice freeze/thaw dates globally disseminated and archived • Establish and maintain reference observing stations
Ground water observations	Ground water measurements	
Near-surface observations over ocean		
Ground-based observing stations at sea (ocean, island, coastal and fixed platform/station locations)	Surface pressure, temperature, humidity, wind, visibility, cloud amount, type and base-height, precipitation, sea-surface temperature, directional and 2D wave spectra, sea ice, surface radiation variables, surface currents	• Higher data rate and cheaper satellite data telecommunication for remote automated stations • More coastal HF radars being used; better standardization of the instruments, and sharing of the data across borders for combining products from different sources and HF radar sources
Ship observations	Surface pressure, temperature, humidity, wind, visibility, cloud amount, type and base-height, precipitation, weather, sea surface temperature, wave direction, period and height, sea ice, salinity, currents, bathymetry, CO2 concentration, surface radiation variables	• Commercial ships designed to facilitate the making of metocean observations • Increased use of X-Band radars for wave observations • More systematic infra-red measurements from ships for satellite validation • High resolution, high accurate data from Research Vessels distributed in real-time • More systematic use of underway Thermosalinograph and of ADCPs (SADCP, LADCP) for near-surface current profiles from Research Vessels • Use of tourist ships sailing in data sparse regions (e.g. polar regions, southern ocean) • Use of fishing vessels, assuming proper data policy can be negotiated • Ship security issue addressed (no ship identification masking to end users) • Autonomous AWS ships sailing predefined or targeted routes • High resolution, high accurate data from Research Vessels distributed in real-time
Buoy observations – moored and drifting	Surface pressure, air temperature, humidity, wind, visibility, sea surface temperature, sea surface salinity, directional and 2D wave spectra, near surface velocity, surface radiation variables, precipitation,	• Development of smart technology for adaptive sampling to address specific environment conditions and optimize endurance of the buoys • Exploitation of renewable energy power sources • Optimized drifters and moored buoys, with more instruments and global and near real-time satellite data telecommunication, yet allowing higher data rate transmission • Provision of high temporal and spatial resolution data • Global fleet of wave & sea state drifters based on GNSS and Micro-Electro Mechanical System (MEMS) multiple degree of freedom technology

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
	ocean currents, CO2 concentration, pH, ocean colour	• Use of acoustic sensors for the measurement of wind and precipitation • Vandalism prone moored buoy systems with video and/or imagery and detection of incidents and acts of vandalism; enforcement of legal measures • Better understanding of wave measurements from buoys through inter-comparisons in the laboratory and in the field
Sea level observations	Sea surface height, surface air pressure, wind, salinity, water temperature, gravity measurements (for ocean geoid)	• Systematic use of GNSS geo-positioning, and real-time transmission of the data
Autonomous Ocean Surface Vehicles	Surface air pressure, temperature, humidity, wind, visibility, sea surface temperature directional and 2D wave spectra	• More systematic use of autonomous ocean surface vehicles (e.g. wave gliders, sailing drones) for example capable of using renewable energy sources for propulsion and sailing over predefined or targeted routes
Ocean underwater observations		
Profiling floats	Temperature, salinity, current, dissolved oxygen, CO_2 concentration, and various bio-geochemical variables	• Less time at surface allowing longer life-time of the measurements • Systematic measurements in marginal seas • Deeper ocean profiles (6000m and over) • More multi-disciplinary measurements • More higher resolution near-surface observations
Autonomous Underwater Vehicles (e.g. gliders)	Temperature, salinity, current, dissolved oxygen, CO_2 concentration, and various bio-geochemical variables	• Capability of undertaking ocean profiles, and surveys along predefined routes • Capability of operating under the ice, and to transmit data in delayed mode once in reach of real-time data telecommunication system (acoustic, satellite)
Sub-surface observations from drifting and moored buoys	Temperature, salinity, currents, CO2 concentration, pH	• Use of optimized acoustic profiling current meters • Vandalism prone moored buoy systems with video and/or imagery and detection of incidents and acts of vandalism; enforcement of legal measures
Ships of opportunity	Temperature, salinity, ocean colour, currents	• Commercial ships designed to facilitate the making of metocean observations (e.g. installation of XBT/XCTD autolaunchers) • More systematic use of ADCPs (SADCP, LADCP) for current profiles
Observations from	Bottom and sub-surface	• Higher data rates, reduced cost of transmission, no need to transmit data to a surface buoy which

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
platforms hosted at submarine telecommunication cables	multi-disciplinary measurements, Tsunami monitoring (earthquakes, Tsunami wave)	is subject to vandalism and expensive to deploy and maintain (cost of ship time)
Ice tethered platform observations	Temperature, salinity, current	• Higher data rates, reduced cost of transmission • Deeper ocean profiles (6000m) • More multi-disciplinary measurements
Instrumented marine animals	Temperature, salinity	• More systematic use of instrumented marine animals (sea mammals, some fish species being tracked, turtles)
Cryospheric Observations over Sea-ice		
Ice buoy observations	Surface pressure, temperature, wind, ice thickness	• Smaller, cheaper ice-buoys, with more instruments and reduced cost of satellite data telecommunication, yet allowing higher data rate transmission
Cryospheric observations over ice sheets		
		•
Other Cryospheric observations (glaciers, permafrost, frozen lakes and rivers)		
		•
		•
Space weather observations		
Solar Optical observations	White light, H-alpha and Calcium K images. Sunspots, flares, filaments, prominences, coronal holes	•
Solar Radio Observations – Spectrograph and discrete frequencies	Coronal Mass Ejections, radio fadeouts, solar activity (10.7cm flux)	•
Ionospheric Observations - ionosonde	Measurements of the of the ionospheres ability to reflect high frequency radio waves at various frequencies and heights.	•
Ionospheric	Measures the "opacity" of the	•

Instrument / observation type:	Geophysical variables and phenomena:	Evolution and trends
observations - riometer	ionosphere to radio noise. Absorption events.	
Ionospheric Observations - GNSS	Total electron content of ionosphere. Ionospheric gradients, ionospheric scintillation.	•
Geomagnetic Observations	Measurements of earth's magnetic field. Geomagnetic disturbances.	•
Cosmic ray observations	Neutron monitors. Radiation measurements.	•
R&D and Operational pathfinders – examples		
Unmanned Aerial Vehicles (UAVs)	Wind, temperature, humidity, atmospheric composition	
Aircraft based observations	Thunderstorms, total water content, radiation in different spectral ranges and directions, dust/sand particles	• Lightning detection (EM Field & RF) • Avoidance of fuselage/engine damage, similar to volcanic ash detection • Extension usage WVM system, severe weather forecasting (rainfall)
Observations from gondolas	Wind, temperature, humidity	• Constant pressure balloons operating in the lower stratosphere
Chemistry, aerosol, wind (lidar), clouds (rain, Doppler radar)	Chemistry, aerosol, wind (lidar), clouds (rain, Doppler radar)	• Chemistry, aerosol, wind (lidar), clouds (rain, Doppler radar)

3. APPLICATION-SPECIFIC AND SYSTEM-SPECIFIC TRENDS AND ISSUES

[This is draft material only – the intention is to have here sub-sections covering all/most of the key Application Areas and to make generic statements about major evolutions in these Areas which will affect requirements for observations.]

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[Some possible items – taken from Vision 2040 Space]

- Growing role of integrated numerical Earth system modeling, which will serve many applications and cover a seamless range of forecast ranges.
- More data streams are expected to be assimilated in numerical modeling frameworks, as a result of improvements in Earth system process understanding, refined assimilation methods, and better handling of observation uncertainty.
- Sustained observations of the GCOS ECVs will provide the baseline for global climate monitoring and related climate applications.
- Seasonal-to-decadal predictions will, among others, require higher-resolution ocean sub-surface observations.
- Nowcasting, severe weather forecasting, disaster risk reduction and climate adaptation will particularly require … [Specifics?].
- Managing and monitoring climate change mitigation as follow-up to the 2015 Paris Agreement will need … [Specifics?].
- The integrity of the radio frequency spectrum, which is critical for remote sensing and telecommunications, needs to be preserved;
- Data processing infrastructures require protection against damage or intrusion through appropriate IT security measures.

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Potential new application areas may require special new observing systems: road meteorology, urban meteorology, chemical weather, space weather, renewable energies.

Increase in spatial and temporal resolutions towards mesoscale resolution. Networks of weather radars will be used to generate regional radar composites in near-real time in order to obtain a full ‘global’ picture of the ‘present weather’.

Observations in the PBL will be greatly improved, denser in horizontal, vertical and temporal space.

National regulations will prevent frequency interferences with illegal sources.

The surface-based WIGOS components will provide:

- Improved detection (e.g. earlier or more detailed) of mesoscale phenomena;
- High vertical resolution profiles world-wide to represent the atmospheric structure;

Building resilient systems

High quality information requires that the knowledge about the design and specification of the observing systems, and installation and maintenance of the observing networks will continue to lie with the NMHSs and partner organizations.

Data generation and delivery

For better understanding of the data, more information about the surface-based observing systems and the instrument, including opensource software for data processing will be encouraged and increasingly used.

Other?

Application specific topics:

Aerosol, atmospheric pollution, atmospheric chemical composition monitoring
By 2040 the surface observing component of WIGOS will serve a number of new application areas (e.g. chemical weather).

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Annex A Observing Network Design Principles (from Manual on WIGOS)

[To be added]