WORLD METEOROLOGICAL ORGANIZATION

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OPAG ON INTEGRATED OBSERVING SYSTEMS

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REVIEW AND UPDATE OF STATEMENTS OF GUIDANCE

SOG FOR ATMOSPHERIC CHEMISTRY

(Submitted by the Secretariat)

Summary and Purpose of Document

The purpose of the document is to inform the Expert Team of the revised Statement of Guidance for Atmospheric Chemistry.

ACTION PROPOSED

The meeting is invited to review and approve this document as the Statement of Guidance for Atmospheric Chemistry

Draft Statement Of Guidance For Atmospheric Chemistry

Background

. Long term measurements have clearly shown that human activities are changing the composition of the Earth's atmosphere. Research has demonstrated the important consequences of such changes for climate, human health, the balance of ecosystems and the ability of the atmosphere to cleanse itself of harmful pollutants and greenhouse gases. The awareness that chemical species in the atmosphere are key elements of the Earth system, and public concern about the impact of man, has led international organisations, such as WMO, UNEP and ICSU, to support national and international research programmes and assessments. These in turn triggered international conventions (*e.g.* Vienna Convention on Ozone Depletion, United Nations Framework Convention on Climate Change) and national directives.

On 27 May 2004, the IGOS-partners approved the atmospheric chemistry theme report addressing the rationale and priorities in the next 15 years for an Integrated Global Atmospheric Chemistry Observations (IGACO) system. The report prepared by an expert international group was reviewed independently by eminent scientists including two nobel prize winners.

IGACO is a highly focused strategy for bringing together ground-based, aircraft and satellite observations of 13 chemical species in the atmosphere using atmospheric forecast models that assimilate not only meteorological observations but also chemical constituents. Socio-economic issues related to climate change, ozone depletion/ UV increase and air quality benefit by having such a system in place. The report critically assesses the status of current observing systems, the requirements on accuracy/precision and spatial/temporal resolution, and the current state of modeling chemical cycles in forecast and climate models. It recommends specific steps to be taken in a phased approach over the next 15 years led by the World Meteorological Organization's Global Atmosphere Watch programme in cooperation with other key WMO programmes and the space agencies through CEOS.

Implementation involves utilizing the over-arching plan of IGACO to build the system through key collaborative initiatives supported regionally but having global implications. Maintenance of existing observations, addition of key missing observations and development of mechanisms that glue the system together are major but feasible challenges. WMO/GAW can work through the WMO constituent bodies (the Commission of Atmospheric Science (CAS), the Commission of Basic Science (CBS) and the WMO Executive Council) as well as the WMO Consultative Meetings on High-level Policy on Satellite Matters to promote the implementation of IGACO. IGACO is the framework with which atmospheric composition observations will be brought together in the planned Global Earth Observations System of Systems. The IGACO Theme Report forms the basis of this WMO OAPAG/IOS Statement of Guidance on Atmospheric Chemistry.

1. Introduction

1.1 Changes in atmospheric composition have socio-economic consequences through adverse effects on human and ecosystem health, on water supply and quality, and on crop growth. A variety of abatement measures have been introduced or considered to reduce the effects. However, continued growth in human activities, to expand economies and to alleviate poverty, will ensure that these effects continue to be important for the foreseeable future.

1.2 Four grand challenges in atmospheric chemistry underlie the environmental issues above:

- tropospheric air quality;

- the oxidation efficiency of the atmosphere;
- stratospheric chemistry and ozone depletion; and
- chemistry - climate interactions.

The scientific understanding of each challenge requires long-term observation of the atmosphere, and points firmly to the need to establish an integrated global atmospheric chemistry observation system.

Table 1.1 Key atmospheric chemical species and the relevant environmental issues. The table gives a list of the atmospheric constituents to be targeted in IGACO together with an indication of their importance to the four atmospheric challenges. Also included are aerosol optical properties – a broad categorisation which encompasses the scattering and absorption of solar radiation by particles of all sizes.

Chemical species	air quality	oxidation efficiency	climate	Stratospheric ozone depletion
O_3	✓	✓	✓	✓
CO	✓	✓	-	-
j(NO_2)	✓	✓	-	-
j(O^1D)	✓	✓	-	-
H_2O (water vapour)	✓	✓	✓	✓
HCHO	✓	✓	-	-
VOCs	✓	✓	-	-
active nitrogen: $NO_x = NO+NO_2$ *reservoir species*: HNO_3	✓ ✓	✓ ✓	- -	✓ ✓
N_2O	-	-	✓	✓
SO_2	✓	-	✓	-
active halogens: BrO, ClO, OClO *reservoir species*: HCl, $ClONO_2$ *sources*: CH_3Br, CFC-12, HCFC-22	- - -	- - -	- - -	✓ ✓ ✓
aerosol optical properties	✓	-	✓	✓
CO_2	-	-	✓	-
CH_4	-	✓	✓	✓
Critical Ancillary Parameters				
temperature	✓	✓	✓	✓
pressure	✓	✓	✓	✓
wind speed (u,v,w)	✓	✓	✓	✓
cloud top height	✓	✓	✓	✓
cloud coverage	✓	✓	✓	✓
albedo	✓	✓	✓	✓
lightning flash frequency	✓	✓	✓	✓
fires	✓	✓	✓	-
solar radiation	✓	✓	✓	✓

2. The Targeted Chemical Variables Of IGACO and Measurement Requirements

Target Variables

2.1 It is possible to study and monitor the four grand challenges in atmospheric chemistry issues by observing a number of chemical compounds, aerosol properties and other parameters. A list of these variables and chemical species, and the issues in which they are involved is given in Table 5.1.

The chemical variables were chosen on the basis of the following criteria :

a) Relevance and Added-Value Through Integration: The chemical species or variable plays an important role in one or more of the four key atmospheric chemistry issues and there is added value in its incorporation in an integrated global observation system;

b) Feasibility of Measurement and Integration; It is now possible, or likely to be possible, to measure the atmospheric constituent or parameter globally and on a long term so as to achieve a synergism between satellite ground-based and aircraft observations, and model assimilation systems.

Key ancillary variables required for integration are also listed. The target list is far from exhaustive. There are many other desirable variables such as precipitation chemistry and aerosol composition, some of which are already being addressed in the ground-based networks. Details of why each of the variables chosen are relevant to the grand challenges can be found in the IGACO report.

Measurement Requirements

2.2 Measurement requirements to meet the four grand challenges were reviewed by the IGACO panel and are given for gases and for aerosols in Appendices 1(a,b) and 2. Requirements of some of the target gases in Table x.1 were first set by the review process published in GAW Report #140 “WMO/CEOS Report on a Strategy for Integrating Satellite and Ground-based Observations of Ozone, 2001 (WMO TD No. 1046)”. These were reviewed and adjusted while requirements for additional gases and aerosols were developed by the panel. These requirements currently form the basis for WMO/IOS observational requirements.

3. The Architecture of the IGACO System

3.1 An integrated system for atmospheric chemistry observations is comprised not only of observational networks and satellites but also of quality assurance, data archiving and modelling facilities that are held together with efficient and universally accepted data flow mechanisms.

3.2 The proposed IGACO system is shown as a flow chart in Fig. 3.1. It should be emphasised that, although various components and elements of the IGACO system are presently available or projected, a complete system does not yet exist for any atmospheric constituent in the target list of variables

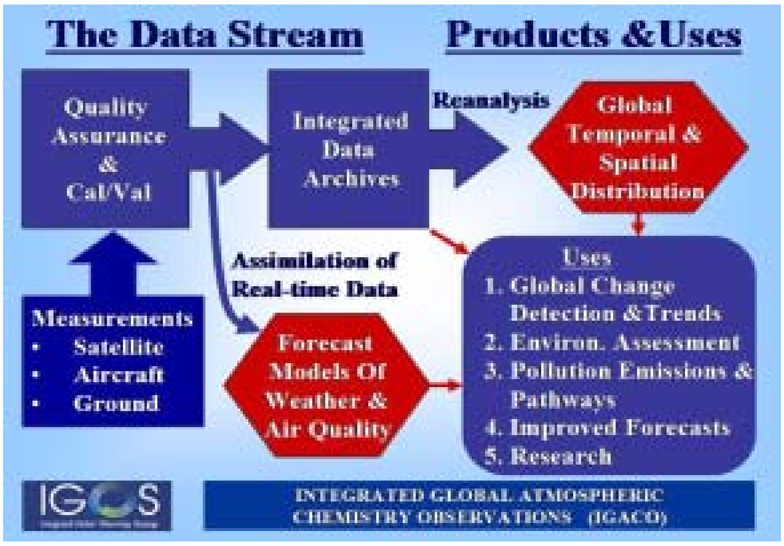

Figure 3.1 The major components and critical elements of the IGACO system.

Essential to the proper functioning of IGACO is a system for data collection from various sources, a system for distribution of the data to users and of archiving these data for establishing long-term records, as well as an end-to-end quality assurance and quality control system to quantify the uncertainties in the data.

Appendix 1a Atmospheric species to be measured by an Integrated Global Observing System - a

Atmospheric region	Requirement	Unit	H_2O	O_3	CH_4	CO_2	CO	NO_2	BrO	ClO	HCl	CFC-12
1	Δx	km	5/25	<5/50	10/50	10/500	10/250	10/250	50			
Lower	Δz	km	0.1/1	0.5/2	2/3	0.5/2	0.5/2	0.5/3	1			
troposphere	Δt											
	precision	%	1/10	3/20	1/5	0.2/1	1/20	10/30	10			2*
	trueness	%	2/15	5/20	2/10	1/2	2/25	15/40	15			4*
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)	(2)			
2	Δx	km	20/100	10/100	50/250	50/500	10/250	30/250				
Upper	Δz	km	0.5/2	0.5/2	2/4	1/2	1/4	0.5/3				
troposphere	Δt											
	precision	%	2/20	3/20	1/10	0.5/2	1/20	10/30				N/R
	trueness	%	2/20	5/30	2/20	1/2	2/25	15/40				N/R
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)				
3	Δx	km	50/200	50/100	50/250	250/500	50/250	30/250	100	100		1000
Lower	Δz	km	1/3	0.5/3	2/4	1/4	2/5	1/4	1	1		
stratosphere	Δt											
	precision	%	5/20	3/15	2/20	1/2	5/15	10/30	10	10		6
	trueness	%	5/20	5/20	5/30	1/2	10/25	15/40	15	15		15
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(2)/(3)	(2)/(3)	(1)	(2)	(2)		
4	Δx	km	50/200	50/100	50/250	250/500	100/500	30/250	100	100		
Upper	Δz	km	2/5	0.5/3	2/4	2/4	3/10	1/4	1	1		
stratosphere,	Δt											
mesosphere	precision	%	5/20	3/15	2/4	1/2	10/20	10/30	10	10		
	trueness	%	5/20	5/20	5/30	1/2	10/25	15/40	20	20		
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(2)/(3)	(2)/(3)	(1)/(2)	(2)	(2)		
5	Δx	km	50/200	10/50	10/250	50/500	10/250	30/250	100			1000
Total	Δt											
column	precision	%	0.5/2	1/5	1/5	0.5/1	1/10	1/10	1			4
	trueness	%	1/3	2/5	2/10	1/2	2/20	2/20				10
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(2)/(3)	(1)/(2)	(1)	(2)			
6	Δx	km	10/200	10/50	10/50	10/500	10/250	10/250				1000
Tropospheric	Δt											
column	precision	%	0.5/2	5/15	1/5	0.5/1	2/20	1/10				4
	trueness	%	1/3	5/15	2/10	1/2	5/25	2/10				10
	delay		(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)/(2)	(1)				

Appendix 1b Atmospheric species to be measured by an Integrated Global Observing System - b

Atmospheric region	Requirement	Unit	NO	HNO_3	C_2H_6	CH_3Br	Halons	HCFC-22	$ClONO_2$	HCHO	SO_2	UVA JNO_2 UVB JO_3
1	Δx	km	10/250	10/250	50	500*				1	1	
Lower	Δz	km	0.5/3	1/3	?					0.5	0.5	
troposphere	Δt											
	precision	%	10/30	10/30	10	4*	15*	2*		10	5	7/10*
	trueness	%	15/40	15/40	15	8*	20*	4*		15	10	15*
	delay		(1)	(1)/(2)						(1)	(1)	
2	Δx	km	30/250	10/250	50	N/R	N/R	N/R		10	10	50/500
Upper	Δz	km	0.5/3	1/3	2					0.5	0.5	3**
troposphere	Δt											
	precision	%	10/30	10/30	10	N/R	N/R	N/R		10	5	10
	trueness	%	15/40	15/40	15	N/R	N/R	N/R		15	10	15
	delay		(1)	(1)/(2)						(1)	(1)	
3	Δx	km	30/250	50/250		500	500	1000				N/A
Lower	Δz	km	1/4	1/4		5	5					
stratosphere	Δt											
	precision	%	10/30	10/30		4	4	8				
	trueness	%	15/40	15/40		8	8	15				
	delay		(1)	(1)/(2)								
4	Δx	km	30/250	50/250								
Upper	Δz	km	1/40.5	1/4								
stratosphere,	Δt											
mesosphere	precision	%	10/30	10/30								
	trueness	%	15/40	15/40								
	delay		(1)/(2)	(2)/(3)								
5	Δx	km	30/250	30/250	50			1000			50	
Total	Δt											
column	precision	%	1/10	1/10	1			5			1	
	trueness	%	2/20	2/20				15				
	delay		(1)	(2)/(3)							(2)	
6	Δx	km	10/250	10/250		1000	1000	1000				
Tropospheric	Δt											
column	precision	%	1/101	1/10		4	4	6				
	trueness	%	2/20	2/20		8	8	15				
	delay		(1)	(1)/(2)								

Appendix 2. Target and threshold requirements for aerosol (mostly optical) properties. Note that these quantities are not independent (for instance aerosol extinction coefficient and sometimes aerosol optical depth can serve as a proxy for the concentration of particulate matter (PM) at the surface). Here precision and trueness are given in absolute values. Note that "Aerosol Optical Depth" and "Extinction Coefficient" are not independent quantities but are specified here separately to allow for column and profile information, respectively.

Theme		**Unit**	**Aerosol Optical Depth (VIS+IR)**	**Aerosol Extinction Coefficient (VIS)**	**Aerosol Absorption Optical Depth (VIS)**	**PM1, PM2.5, PM10**
a, d	Δx	km	1 / 10	10 / 100	1 / 10	N/A
Climate	Δz	km	N/A	0.5 / 1	N/A	N/A
studies	Δt		global daily	global weekly	global daily	N/A
and	precision		0.005 / 0.01	0.005 / 0.01 km^{-1}	0.002 / 0.01	N/A
oxidising	trueness		0.01 / 0.02	0.01 / 0.02 km^{-1}	0.004 / 0.02	N/A
capacity	delay		weeks	weeks	weeks	N/A
b	Δx	km	0.25 / 1	0.5 / 2	N/A	0.25 / 1
Air	Δz	km	N/A	0.1 in PBL	N/A	0.1 in PBL
quality	Δt		regional hourly	regional daily	N/A	regional sub-daily
(PBL and	precision		0.005 / 0.01	0.005 / 0.01 km^{-1}	N/A	1 / 10 µg m^{-3}
free trop)	trueness		0.01 / 0.02	0.01 / 0.02 km^{-1}	N/A	1 / 10 µg m^{-3}
	delay		near real-time	near real-time	N/A	near real-time
c	Δx	km	10 / 100	10 / 100	N/A	N/A
Ozone	Δz	km	N/A	1 / 2	N/A	N/A
depletion	Δt		10 d	10 d	N/A	N/A
(UT/LS)	precision		10^{-5} / 10^{-4}	10^{-6} / 10^{-5} km^{-1}	N/A	N/A
	trueness		10^{-5} / 10^{-4}	10^{-6} / 10^{-5} km^{-1}	N/A	N/A
	delay		days	days	N/A	N/A