Chapter Descriptions, Parties' Request, and Timetable
2010 WMO/UNEP Ozone Assessment

3 June 2010

A. CHAPTER DESCRIPTIONS

PROLOGUE: STATE OF THE SCIENCE THROUGH THE 2006 WMO/UNEP ASSESSMENT
CHAPTER 1: OZONE-DEPLETING SUBSTANCES (ODSS) AND RELATED CHEMICALS
CHAPTER 2: STRATOSPHERIC OZONE AND SURFACE ULTRAVIOLET RADIATION
CHAPTER 3: FUTURE OZONE AND ITS IMPACT ON SURFACE UV
CHAPTER 4: STRATOSPHERIC CHANGES AND CLIMATE
CHAPTER 5: A FOCUS ON INFORMATION AND OPTIONS FOR POLICYMAKERS
TWENTY QUESTIONS AND ANSWERS ABOUT THE OZONE LAYER: 2010 UPDATE

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PROLOGUE: STATE OF THE SCIENCE THROUGH THE 2006 WMO/UNEP ASSESSMENT

A.R. Ravishankara, Paul A. Newman, John A. Pyle, and Ayité-Lô Ajavon

This introductory summary describes in more "non-technical terms" the state of current understanding related to the ozone layer as of the time of the prior (2006) ozone assessment, with a brief history of the evolving understanding. The aim is to cover major points but not go into great detail. This summary also focuses more specifically on the major findings from the 2006 assessment, as the starting point for the chapters that will follow in the 2010 assessment. It also lays out the rationale for the 2010 assessment structure and describes the emergence of some key issues for policy makers.

CHAPTER 1: OZONE-DEPLETING SUBSTANCES (ODSS) AND RELATED CHEMICALS

Stephen Montzka and Stefan Reimann, CLAs

Lead Authors: S. O'Doherty, A. Engel, K. Krüger, W.T. Sturges
Coauthors: D. Blake, M. Dorf, P. Fraser, L. Froidevaux, K. Jucks, K. Kreher, M.J. Kurylo, W. Mellouki, J. Miller, O.-J. Nielsen, V. Orkin, R. Prinn, R. Rhew, M. Santee, A. Stohl, D. Verdonik
Contributors: E. Atlas, P. Bernath, T. Blumenstock, J. Butler, A. Butz, B. Connor, P. Duchatelet, G. Dutton, F. Hendrick, L. Kuijpers, E. Mahieu, A. Manning, J. Mühle, K. Pfeilsticker, B. Quack, M. Ross, S. Schauffler, I. Simpson, D. Toohey, M.K. Vollmer, T. Wallington, R. Wang, R. Weiss, Y. Yokouchi, S. Yvon-Lewis

Focus: Long-lived and short-lived substances that deplete the ozone layer (e.g., CFCs, HCFCs, methyl bromide) and other molecules of special interest to the Parties (e.g., PFCs, HFCs, HFOs, other recent substitutes, methane, nitrous oxide, and very short-lived substances). Major sections address updated information on trends and budgets of ozone-depleting substances and substitute chemicals, based on observations and models. This includes updating the 2006 picture of the trends in calculated stratospheric total chlorine as a function of altitude and a closer look at carbon tetrachloride lifetime, budget, and trends as specifically requested by the Parties. Shorter sections include updates regarding carbon dioxide, nitrous oxide, methane, and SF_6. A section on carbonyl sulfide, which provides sulfur for the stratospheric sulfate layer, is updated to reflect the recent findings. The information will take into account and draw from the data and analyses in the 2006 ozone assessment and the AR4 report by the IPCC. The chapter provides basic information that will allow the 2010 ozone assessment to describe, in following chapters, the interactions of climate change and ozone depletion, including estimates of the cooling of the stratosphere caused by greenhouse gases and other source gases. In addition, the chapter (via interactions with the Technology and Economics Assessment Panel) provides updated estimates of banks and emissions needed for the future scenarios described in Chapter 5 (below) of this 2010 ozone assessment. It provides updated information on degradation products which could have potential for adverse effect or accumulation in the environment (e.g. TFA). It also covers the status of understanding on ODS degradation products in the stratosphere (e.g., HCl, HF, BrO, CF_2O), examines how these degradation products change with time, and discusses whether these changes are consistent with observed ODS trends in the troposphere and the Montreal Protocol. For short-lived substances, there are two major emphases of the chapter: (i) updating the understanding of the contribution of short- to very-short-lived gases (those that are regulated and those that are predominantly natural in origin) to the halogen loading of the stratosphere; and (ii) providing a framework for assessing the overall impacts of "very" short-lived substances (atmospheric lifetimes of less than about 0.5 yr and some times of the order of a few days) being considered as ODS substitutes and for which the traditional concept of a single, geography-independent Ozone Depletion Potential does not apply (see Section B, Terms of Reference from the Parties to the Montreal Protocol, which specifically requested this information).

CHAPTER 2: STRATOSPHERIC OZONE AND SURFACE ULTRAVIOLET RADIATION

Anne Douglass and Vitali Fioletov, Coordinating Lead Authors

Lead Authors: S. Godin-Beekman, R. Müller, R. Stolarski, A. Webb
Coauthors: A. Arola, J. Burkholder, J. Burrows, M. Chipperfield, J. Valverde Canosso, R. Cordero, C. David, P. den Outer, S. Diaz, L. Flynn, M. Hegglin, J. Herman, P. Huck, S. Janjai, I. Janosi, J. Krzyscin, Y. Liu, J. Logan, R. McKenzie, K. Matthes, N.J. Muthama, I. Petropavlovskikh, M. Pitts, S. Ramachandran, M. Rex, R. Salawitch, B.-M. Sinnhuber, J. Staehelin, S. Strahan, K. Tourpali, C. Vigouroux
Contributors: G. Bodeker, T. Canty, P. Demoulin, S. Frith, J.-U. Grooβ, F. Hase, J. Klyft, M. Kurylo, D. Loyola, I. Megretskaia, C. McLinden, P.J. Nair, M. Palm, D. Papanastasiou, L. Poole, M. Schneider, R. Schofield, H. Slaper, S. Tilmes, D. Vyushin, M. Weber, E.-S. Yang

Focus: Observations to date and understanding of trends/changes in global ozone, polar ozone, and surface ultraviolet radiation, including the potential roles of climate change and other non-halogen effects. This chapter includes four sections: Observations of ozone, polar ozone, surface ultraviolet radiation as related to stratospheric ozone, and interpretation of observed ozone changes. Each section begins with a summary of the status of the topic as of the 2006 assessment.

The chapter gives an updated status of the observations of global ozone and rationalization of the variance (all scales) of the observations, including the role of halogen loading but also examining the roles of climate change, aerosols, dynamical changes, the solar cycle, and other non-halogen effects. The chapter includes an update on total ozone changes using a combination of ground-based and satellite measurements and an update on profile changes using data from ground-based instruments and satellite. Efforts are made to provide trends in ozone as a function of altitude.

The chapter updates the status of polar ozone depletion in both the Arctic and Antarctic winter/spring season, building upon recent observations, field studies, and theory. Trends and variance are both major foci. The climatology of polar stratospheric clouds (PSCs) is discussed in the context of both polar regions. Any new updated information on the contributions of the polar ozone depletion to global and mid-latitude ozone depletion is provided. An important part linking to Chapter 3 is the growing number of studies that project future Arctic ozone behavior based on the temperature changes associated with greenhouse gases, climate, and linkages to the troposphere. The Antarctic section is similar to that above, but also emphasizes recent changes and near-term expectations. Past assessments have underscored the fact that small year-to-year variability is expected (e.g., changes in vortex patterns and early formation and/or breakup), but that the overall picture is for a persistent ozone hole for decades. Information on any new understanding regarding the photochemistry and dynamics related to polar ozone depletion, e.g., discussion of the ClO dimer including the photolysis rate and the rate of formation, is included in the section.

On the topic of surface ultraviolet radiation, the chapter updates the work since 2006 on the factors that influence surface UV, particularly emphasizing the role of changes in stratospheric ozone. Other factors such as tropospheric gases, albedo, aerosols and clouds are mentioned but not considered in detail. A possible approach is to combine available information about long-term changes in UV estimated from various sources (ground-based measurements, satellite and ground-based reconstructions) together. Satellite estimates for zonal mean UV can demonstrate ozone-related signal in UV that is a specific concern to the Parties of the Montreal Protocol.

The scientific community has accumulated more experience with combination of different satellite data sets, and may have more insights into causes of ozone change including the role of large-scale, longer-term dynamics in the ozone changes of the lower stratosphere. Discussion of causes of past ozone changes will be included through the analysis of observations and help of model simulations, drawing heavily on three-dimensional model simulations. Information on any new understanding regarding the photochemistry and dynamics related to global ozone depletion is included in this section. Possibilities include HO_2 + NO reaction kinetics; polar influence on middle latitude trends, improved understanding of the tropical tropopause layer; etc.

CHAPTER 3: FUTURE OZONE AND ITS IMPACT ON SURFACE UV

Slimane Bekki and Greg Bodeker, Coordinating Lead Authors

Lead Authors: A.F. Bais, N. Butchart, V. Eyring, D.W. Fahey, D.E. Kinnison, U. Langematz, B. Mayer, R.W. Portmann, E. Rozanov
Coauthors: P. Braesicke, A.J. Charlton-Perez, N.Y. Chubarova, I. Cionni, S.B. Diaz, N.P. Gillett, M.A. Giorgetta, N. Komala, F. Lefèvre, C. McLandress, J. Perlwitz, T. Peter, K. Shibata
Contributors: H. Akiyoshi, J. Austin, F. Cheroux, M. Chipperfield, M. Dameris, S. Dhomse, S. Frith, R. Garcia, H. Garny, A. Gettelman, S. Hardiman, P. Jöckel, A. Jonsson, A. Kazantzidis, A. Kubin, J-F. Lamarque, E. Mancini, M. Michou, O. Morgenstern, L. Oman, S. Pawson, G. Pitari, D. Plummer, J. Pyle, J. Scinocca, T. Shepherd, D. Smale, R. Stolarski, H. Teyssedre

Focus: Expectations for future changes in ozone, its effect on surface ultraviolet radiation in the 21st century, and potential anthropogenic and natural influences. This chapter continues the discussion of Chapter 6 of the 2006 ozone assessment regarding the definition and identification of ozone-layer recovery, a discussion of when the full recovery of the ozone layer from the effects of ozone-depleting substances (ODSs) is likely to occur, and a discussion of when ozone is projected to return to 1960 and 1980 levels. This is a key "closure" issue for the Montreal Protocol. The chapter will focus on the 3rd stage of ozone recovery (full recovery from ODSs controlled under the Montreal Protocol), while Chapter 2 will focus on stages 1 and 2. This chapter addresses the question of how climate change will affect the evolution of the ozone layer and ozone recovery, with an emphasis on the mechanisms and key processes involved. The uncertainty in future climate change, as represented by a range of equally likely greenhouse gases scenarios (SRES scenarios used IPCC AR4, RCP scenarios developed for IPCC AR5) is also addressed, because the climate change in the 2nd half of the 21st century may develop quite differently, and hence climate change effects on the ozone layer remain uncertain. The proposal of climate engineering, for example by injection of sulfur gases into the stratosphere to curb climate warming in a world of increasing CO_2 emissions is discussed, with respect to the potential effects on stratospheric ozone. Coupled three-dimensional chemistry-climate models are used to make ozone projections and elucidate the mechanisms and processes, sampling the uncertainty related to the GHG scenarios. Two primary issues regarding the future ozone layer are (i) the detection and attribution of ozone recovery, and (ii) the projections of future ozone through the 21st century. There is a separate look at the impact of climate change on polar springtime ozone depletion, as well as a discussion of when the ozone hole might cease to occur. Feedbacks in the system are discussed (e.g., changes in tropospheric composition [greenhouse gases, ODS concentrations] and UV). The chapter also addresses the variability of ozone abundances and the challenge of making statistically reliable statements, conditional on the assumed GHG scenario. Model projections include a discussion of uncertainties and potential for future surprises. In coordination with Chapter 4 (below), additional topics of discussion include progress since the 2006 assessment in understanding dynamical factors such as stratosphere-troposphere exchange, the Brewer-Dobson circulation, tropical upwelling/tropical pipe, and others. Predictions of future UV are based on ozone predictions from Climate Chemistry Models, and links with the recovery of the ozone layer are topics included in the UV discussion in this chapter.

Because this is an ozone assessment and not an ozone and UV assessment, discussion of factors that influence UV other than ozone are brief.

CHAPTER 4: STRATOSPHERIC CHANGES AND CLIMATE

Piers Forster and David W. J. Thompson, Coordinating Lead Authors

Lead Authors: M.P. Baldwin, M.P. Chipperfield, M. Dameris, J.D. Haigh, D.J. Karoly, P.J. Kushner, W.J. Randel, K.H. Rosenlof, D.J. Seidel, S. Solomon
Coauthors: G. Beig, P. Braesicke, N. Butchart, N.P. Gillett, K.M. Grise, D.R. Marsh, C. McLandress, T.N. Rao, S.-W. Son, G.L. Stenchikov, S. Yoden
Contributors: E.C. Cordero, A. Jonsson, J. Logan, D. Stevenson

Focus: The impact of changes in the stratosphere (ozone changes, temperature, circulation, etc.) on climate, with a special focus on surface climate. The chapter updates the work of Chapter 5 of the 2006 assessment in describing connections between the stratosphere and climate. The major foci of the chapter are: 1) observed stratospheric trends and 2) linkages between observed stratospheric trends and tropospheric climate. The discussion of trends considers changes in stratospheric ozone, temperature, dynamics, water vapor, aerosols and source gases (including methane). It also includes a discussion of feedbacks between temperature, water vapor and ozone trends at stratospheric levels. The discussion of the effects of stratospheric changes on climate focuses on the radiative, chemical and dynamical coupling between statospheric trends and tropospheric climate. The text covers the effects of stratospheric ozone depletion not only on tropospheric dynamics but also on tropospheric chemistry (including, for example, the impacts of UV changes on chemistry, stratosphere-troposphere exchange, etc.). The change in radiative forcing due to ozone layer depletion are evaluated such that the contribution of the ODSs to climate forcing (by their action as greenhouse gases and their contribution to ozone depletion) can be calculated. The contributions of the ODSs and HFCs to climate forcing are addressed. A succinct summary of the effect of the ozone depletion on climate change is provided.

CHAPTER 5: A FOCUS ON INFORMATION AND OPTIONS FOR POLICYMAKERS

John Daniel and Guus Velders, Coordinating Lead Authors

Lead Authors: O. Morgenstern, D. Toohey, T.J. Wallington, D. Wuebbles
Coauthors: H. Akiyoshi, A.F. Bais, E. Fleming, C. Jackman, L. Kuijpers, M. McFarland, S. Montzka, M. Ross, S. Tilmes, M. Tully
Contributors: S.O. Andersen, U. Langematz, P. Midgley

Focus: Implications of ozone-relevant processes and potential policy options on ozone and climate. This includes projecting future behavior/scenarios of equivalent effective stratospheric chlorine (EESC); issues related to climate mitigation (e.g., geoengineering, etc.); future aviation; Cl_y from future launch vehicles and missiles; ODS replacements such as HFCs and their contributions to climate change; harmful unintended byproducts of the atmospheric degradation of substitutes; and other issues that relate to decision-making. Future scenarios are developed (via interaction with the Technology and Economic Assessment Panel) for emissions of controlled substances under the Protocol and other assumptions. The major characteristics of the future abundances (e.g., change of behavior once methyl chloroform is gone) are explored, and the differences among the scenarios are quantified with respect to the estimated anthropogenic impact of ODSs on stratospheric ozone depletion. Attempts are made to compare the importance of remaining ODS policy options to other anthropogenic impacts on stratospheric ozone depletion. Updated (where needed) ODPs, GWPs, and lifetimes are in an appendix to the chapter. As done in previous assessments, this chapter examines how the Montreal Protocol and its Amendments altered the projected future course of EESC and thereby the ozone layer (i.e., the "worlds avoided").

TWENTY QUESTIONS AND ANSWERS ABOUT THE OZONE LAYER: 2010 UPDATE

David Fahey and Michaela Hegglin, Coordinating Lead Authors

This popular section will be updated as appropriate.

B. REQUEST FROM THE PARTIES TO THE MONTREAL PROTOCOL

The following are the Terms of Reference for the Scientific Assessment Panel, from Decision XIX/20 of the Parties to the Montreal Protocol:

" *...for the 2010 report the Scientific Assessment Panel should consider issues including:*

(a) Assessment of the state of the ozone layer and its future evolution;

(b) Evaluation of the Antarctic ozone hole and Arctic ozone depletion and the predicted changes in these phenomena;

(c) Evaluation of the trends in the concentration of ozone-depleting substances in the atmosphere and their consistency with reported production and consumption of ozone-depleting substances and the likely implications for the state of the ozone layer;

(d) Assessment of the interaction between climate change and changes on the ozone layer;

(e) Assessment of the interaction between tropospheric and stratospheric ozone;

(f) Description and interpretation of the observed changes in global and polar ozone and in ultraviolet radiation, as well as future projections and scenarios for those variables, taking into account among other things the expected impacts of climate change;

(g) Assessment of consistent approaches to evaluating the impact of very short-lived substances, including potential replacements, on the ozone layer;

(h) Identification and reporting, as appropriate, on any other threats to the ozone layer… "

C. TIMELINE FOR THE ASSESSMENT

The timetable given below is based on the experience of previous assessments and deadlines of the current (2010) assessment.

Draft outline completed, circulated for comment	February **2009**
Coordinating Lead Authors of the chapters established	March
Chapter outlines drafted, early preparation steps begin	April/May
CLAs Planning Meeting, London	June 24-25
First drafts of chapters completed & circulated for internal review	mid-October
Internal First-Draft Review Meeting, Washington DC	17-19 November
Second draft of chapters completed and mail peer review starts	February 19, **2010**
Mail peer-review comments due	March 26
Third draft of chapters completed; circulated to Panel Reviewers	May 26
Panel Review Meeting, Les Diablerets	June 28-July 2
Final chapters completed; chapter editing and layout commences	July 30
Preprint volume to UNEP for distribution to governments	30 December 2010