Questions for Discussion from AQ Managers

1. **Evaluation of Model Performance**

   How well can current global and regional models quantify:

   a. Spatial patterns and temporal trends in
      i. Surface ozone concentrations
      ii. Fine particle concentrations
      iii. Nitrogen deposition
   b. Elevated levels of ozone in urban and rural locations, including high elevation sites.

Questions for Discussion from AQ Managers

1. Evaluation of Model Performance

HTAP 2010 Conclusions:

O_3: Current global models reproduce the observed regional and seasonal variability in surface ozone at most locations, demonstrating our ability to represent the key large-scale processes controlling the formation, transport and removal of ozone and its precursors.

However, significant discrepancies exist on shorter spatial and temporal scales indicating weaknesses in our representation of local- and urban-scale processes in current models.

Observed increases at remote locations are generally underestimated in model simulations, indicating that precursor emissions and/or atmospheric processes are not represented well in current models.

$PM_{2.5}$: Models calculate a wide range of surface aerosol concentrations and relative annual intercontinental responses to emission perturbations, reflecting large uncertainties in emissions, atmospheric processes and analysis methods.

Questions for Discussion from AQ Managers

2. Evaluation of Source Attribution

How well can current global and regional models quantify:

c. Contributions of local and regional anthropogenic sources as distinguished from

   i. Anthropogenic sources outside the region (e.g. North America or the United States)

   ii. Stratospheric intrusion

   iii. Biogenic, wildfires, wind-blown dust, and other uncontrollable emissions

Questions for Discussion from AQ Managers

2. Evaluation of Source Attribution

HTAP 2010 Conclusions (ozone):

Annual average surface O3 levels averaged over the 4 HTAP regions = 37±4 ppbv
~25% anthropogenic sources in the region, ~25% anthropogenic transported from outside the region, 20-25% stratospheric, 20-25% natural emissions

The impact of 20% changes in anthropogenic emissions in one region on annual regional-mean surface ozone in the other regions lies between 0.07 and 0.37 ppbv, based on the ensemble mean from the HTAP simulations. These values are significant in comparison to the response of surface O_3 to 20% decreases of emissions within the region itself, which vary from 0.8 to 1.3 ppbv. These annual average, region-wide values mask large temporal and geographic variability.

The relative annual intercontinental response for annual mean surface O3 is found to vary from 43% for Europe, to 40% for EA, to 32% for NA and SA in the HTAP simulations. These results indicate that in all four regions, emissions changes in the other three source regions are about half as important as the same domestic emissions change.

Questions for Discussion from AQ Managers

2. Evaluation of Source Attribution

HTAP 2010 Conclusions (ozone):

The maximum influence of intercontinental transport on ground-level ozone generally occurs on mid-range pollution days (i.e., near the middle of the ozone probability distribution, typically 50-70 ppbv).

The O3 response to anthropogenic emissions of CH4 from distant source regions is nearly as large as that to emissions of the traditional O3 precursors in these regions. The O3 response to changes in CH4 emissions requires several decades to be fully realized, given the relatively long atmospheric lifetime of CH4.

Substantial O3 transport takes place above the boundary layer in the free troposphere, where it can be brought to lower altitudes over distant receptors during subsidence, and mix with local emissions. The relative annual intercontinental responses are larger for O3 column than for surface O3, and exceed 50% over EU and EA.

Questions for Discussion from AQ Managers

2. Evaluation of Source Attribution

HTAP 2010 Conclusions (aerosols):

Multi-model experiments show that, over the four HTAP source regions, the surface concentrations of sulphate and BC are mostly (60-90%) from pollution sources within the region. However, contributions from outside the source region are increasingly large at higher altitudes.

Over the surface in the Arctic, European pollution is the most significant source of sulphate while Eurasian biomass burning is the major contributor to BC and POM. More than 80% of surface dust is from Asia and Africa.

An increase in regional and hemispheric background of photo-oxidant levels can change S/R relationships involving secondary aerosol components significantly and may increase domestic formation of secondary aerosol. The relative annual intercontinental responses for PM may depend as much on emissions of NOx and CO as on hemispheric transport of PM.

Questions for Discussion from AQ Managers

3. **Standards for Model Evaluation**

   Are robust and generally acceptable model performance standards established and routinely applied in the global and regional modeling communities?

Questions for Discussion from AQ Managers

3. Standards for Model Evaluation

Is there a *de facto* standard for global models?

GAW

AERONET

EMEP

CASTNET

IMPROVE

EANET

AERONET

Questions for Discussion from AQ Managers

4. **Establishing Regional Boundary Conditions**
   a. In a nested system, how does global model performance affect regional model performance?
   b. How should future year regional boundary conditions (e.g. for western U.S. regional modeling) be determined or evaluated?

Questions for Discussion from AQ Managers

4. Establishing Regional Boundary Conditions

HTAP 2010 Conclusions:

Regional emission changes in coming decades are not sufficiently large to cause substantial non-linear responses, so changes in S/R relationships can be estimated from current conditions. The importance of foreign emission changes compared to domestic changes is likely to increase substantially, and for North America is expected to double before 2050 under all four RCP emission scenarios as domestic emissions fall and emissions from South and East Asia continue to grow. The sensitivity to changes in geographical distribution of emissions within a particular region has not been adequately assessed yet.

CH4 is of major importance as a contributor to surface ozone. Roughly 40% of the annual mean O3 increase since the preindustrial is believed to be due to anthropogenic CH4 and future changes in atmospheric CH4 concentrations have a large influence on surface O3 changes following the RCP scenarios.