Chapter 3. Observational Evidence & Capabilities Related to Hemispheric or Intercontinental Transport (Hajime Akimoto, David Parrish)
(Surface networks**:** Kjetil Torseth, Joe Prospero Shiro Hatakeyama, Rich Sheffe; Field Campaigns: Dan Jaffe, Stuart Penkett, Mat Evans, Russ Dickerson; Satellite Observations: David Edwards & Randall Martin, Lorraine Remer, Tony Hollingsworth, Ulrich Platt, John Burrows)

> The chapter should focus on carefully selected observational evidence that clearly illustrates the impact of long-range transport on local pollutant levels. The bulk of the chapter should be a clear but concise presentation of the best illustrative examples that we can find to present a balanced, reasonably comprehensive picture of the experimental evidence.

3.1 Introduction *Very brief motivation and description of this chapter* (This section will be drafted by Hajime Akimoto and David Parrish with input form all when other sections are available)

- Very brief motivation and description of capabilities, limitations and needs for the various types of data (surface monitoring, intensive campaigns and satellite)
- Introduction to the "nature" of surface sites:
  1) What is meant by regional and global representative sites,
  2) Brief historic perspective of how monitoring strategies have evolved,
  3) Introduce the difficulties in identifying HTAP events in the boundary layer,
  4) Geographic locations which are more suited,
  5) Many surface sites lack measurement parameters which makes data interpretation more difficult.
  6) Linking boundary layer observations with FT,
  7) Need for vertically resolved data in combination with surface sites.
- It would be useful if we could state the usefulness of each data source for specific issues related to the scope of the CLRTAP (e.g. while surface observations of precipitation chemistry are difficult to use to identify the relative contribution originating from intercontinental transport (specific transport events etc), it is probable the longest dataset of consistent data we have for assessing trends, the geographical coverage is good, further these data are the only data representing a flux-term (transboundary fluxes and deposition amounts are key in the Gothenburg protocol revisions), wet scavenging is the major sink term and must treated properly in the models, they are important as they get the monitoring agency involved in the technical work, etc.) The variability of rainfall events in terms of frequency and quantity coupled with the variability of transport results in a very high statistical variability and consequently great difficulty in resolving trends.

3.2 Long-range Transport of Ozone and its Precursors
Evidence and illustrative examples from surface measurements, field campaigns and satellites. We should highlight those observations that have most contributed to current knowledge of LRT

- In-situ surface monitoring of photochemical oxidants and precursors (O3, NOy, VOCs), in addition vertical profiles from soundings. Data from Convention based monitoring programmes,
- Specific focus on data from "inflow/outflow" sites and sites at high elevations (several recent European projects TROTREP and TOR2 have assessed European ozone trends).

- Asian surface sites including Cape Hedo in Okinawa

(The above three bullets should be covered by
Coordinating Lead Authors: Kjetil Torseth Joe Prospero
Lead Authors: Shiro Hatakeyama, Rich Scheffe)

- Long-term aircraft programmes (e.g. IAGOS/MOSAIC)
- Asian aircraft missions (PEM-West, Ace-Asia, TRACE-P, APEX, and PEACE; campaigns over China)
- Evidence for hemispheric/intercontinental transport of ozone and precursors from intensive campaigns:
  -- across the Pacific (PHOBEA, TRACE-P, ITCT, INTEX, others?).
  -- across the Atlantic (NARE, ICARTT, ITOP, others?).
  -- across the Eurasian continents (APARE, TRACE-P, ACE-Asia, PEACAMPOT, others?).

(The above three bullets should be covered by
Coordinating Lead Authors: Dan Jaffe, Stuart Penkett
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- Evidence for hemispheric/intercontinental transport of ozone and precursors from satellite data sets
  -- O_3? (TOMS, GOME, SCIAMACHY?, OMI?....)
  -- CO (MOPITT, AIRS…)
  -- NO_2? (GOME, SCIAMACHY?, OMI?...)
- The role of satellite data in intensive field campaigns
  -- TRACE-P and INTEX experience, others?

(The above two bullets should be covered by
Coordinating Lead Authors: David Edwards, Randall Martin
Lead Authors: Lorraine Remer, Tony Hollingsworth, Ulrich Platt, John Burrows)

Capabilities, limitations and future needs (All work together to contribute here after the above bullets are drafted)

- NOy and VOCs data are sparse.
- organic tracers? Several recent studies have demonstrated LRT of Levoglucosan (eg. Stohl et al 2006)
- Representativeness or adequacy of existing satellite data for characterizing intercontinental transport across the Northern Hemisphere
- Issues of vertical sensitivity and measurement frequency in satellite data sets.
- Challenges in validation of satellite measurements
- Future satellite needs: What are the missing observations and what would be the ideal observing requirements of a future satellite mission(s) to track LRT?
  -- Orbits, spatial and temporal measurement resolutions etc.
  -- Should we develop a set of standard observational platforms and measurements to enhance data consistency globally and examine trends?
  -- Tie-in with work of EMEP CCC, WMO GAW, and the IGACO strategy
  -- Outreach to regions beyond the LRTAP Convention.

3.3 Long-range Transport of Aerosols and its Precursors

Evidence and illustrative examples from surface measurements, field campaigns and satellites.

- In-situ monitoring of major inorganic ions in air (SOx, HNO3/NO3, NHx, precipitation chemistry, sea-salts, base cations/mineral dust, data sources
- Convention based monitoring programmes. (IMPROVE, CREATE, EARLINET, AERONET, others).
- SKYNET data from sites located mainly in the Eastern Asia from Mongolia to Thailand as well as in Japan
- Lidar network in the East Asia.
- Oceanic aerosol sampling stations (Prospers et al.) operated from early 1980s and extending to the late 1990s.
- Asian surface sites including Cape Hedo in Okinawa

(The above six bullets should be covered by

Coordinating Lead Authors: Kjetil Torseth Joe Prospero

Lead Authors: Shiro Hatakeyama, Rich Scheffe)

- Asian aircraft missions (PEM-West, Ace-Asia, TRACE-P, APEX, and PEACE; campaigns over China)
- Evidence for hemispheric/intercontinental transport of aerosols and precursors from intensive campaigns:
  - -- across the Pacific (PHOBEA, TRACE-P, ITCT, INTEX, others?).
  - -- across the Atlantic (NARE, ICARTT, ITOP, others?).
  - -- across the Eurasian continents (APARE, TRACE-P, ACE-Asia, PEACAMPOT, others?).

(The above two bullets should be covered by

Coordinating Lead Authors: Dan Jaffe, Stuart Penkett

Lead Authors: Russ Dickerson, Mat Evans)

- Evidence for hemispheric/intercontinental transport of aerosols and precursors from satellite data sets
  - -- Aerosol (MODIS, TOMS AI?, ...)

(The above bullet should be covered by

Coordinating Lead Authors: David Edwards, Randall Martin

Lead Authors: Lorraine Remer, Tony Hollingsworth, Ulrich Platt, John Burrows)

Capabilities, limitations and future needs (All work together to contribute here after the above bullets are drafted)

- In-situ monitoring of aerosol mass/aerosol chemical composition (size segregated), The latter is available mainly on an occasional basis. What can we learn from size resolved information (making these types of measurements is difficult, tedious, and expensive). From the standpoint of radiative/optical/remote sensing, a size cut at about 1 um diameter would be needed. Is there any reason to do PM2.5/PM10?
- aerosol optical properties/aerosol optical depth, Aerosol integrated light scatter would provide important optical/size information on a continuous basis. This would be good for high time resolution data for modeling of events. An AERONET type device is essential for optical depth and as a measure of vertically-integrated aerosol loading.

- aerosol vertical distribution, LIDAR would be ideal but expensive and troublesome. But maybe over time this will improve.
- BC and OC (These (or some other measure of carbon/organics) is essential BC and OC can be relatively easily obtained by filter combustion/reflectance techniques although here too there are problems of interpretation.
- Given the variability of aerosol (and precipitation) concentrations, if one is to characterize trends, one needs to make measurements over extended time periods.
- From the standpoint of modeling events and linking to remote sensing, you need daily measurements. This can be a huge job if you attempt to do everything on this time scale. The strategy should be to pick a critical subset of measurements that you can do on a daily schedule.

3.4 Maximum concentrations seen at downwind receptor locations and implications for surface air quality in those regions.
This section will discuss episodic events that have lead to high concentrations at the surface of ozone, PM or other key pollutants at inter-continental scale. We will want to emphasize that these large episodes are relatively rare, but can bring high concentrations to the surface.
(This section should be covered by
Coordinating Lead Authors: Kjetil Torseth Joe Prospero
Lead Authors: Shiro Hatakeyama, Rich Scheffe)

3.5 Observational evidence for attribution of source regions.
This section will discuss methods that have been used to do source attribution, including meteorological methods (trajectories and their derivatives) and chemical methods (e.g. chemical ratios). We will not discuss Global modeling, since this is covered in a separate section, but I think we should discuss "hybrid" methods, for example Flexpart, or other approaches.

- Inverse modeling of emissions from satellite data sets

(This bullet should be covered by
Coordinating Lead Authors: David Edwards, Randall Martin
Lead Authors: Lorraine Remer, Tony Hollingsworth, Ulrich Platt, John Burrows)

- Discussion of the important distinction between episodes vs. increases in background concentrations and the implications for surface air quality?

(This bullet should be covered by
Coordinating Lead Authors: Kjetil Torseth Joe Prospero
Lead Authors: Shiro Hatakeyama, Rich Scheffe)

Capabilities, limitations and future needs (All work together to contribute here after the above bullets are drafted. Major contributions will have to come from
Coordinating Lead Authors: David Edwards, Randall Martin
Lead Authors: Lorraine Remer, Tony Hollingsworth, Ulrich Platt, John Burrows)

- Does a sufficient satellite database exist to evaluate the predictions of current models?
- Satellite data are limited in vertical sensitivity, ability to observe diurnal variation in emissions
- Challenges in validation of satellite measurements

3.6 Can we track long-term trends in hemispheric transport from existing surface observations?

This section will describe what evidence exists to assess trends and whether the existing data are adequate to do this.

(This section should be covered by

Coordinating Lead Authors: Kjetil Torseth Joe Prospero

Lead Authors: Shiro Hatakeyama, Rich Scheffe)

3.7 Concluding Remarks future needs for observations to understand HTAP (This section will be drafted by Hajime Akimoto and David Parrish with input form all when other sections are available)