**Brief Notes from the ARC-IONS Data Workshop Agenda, 7-8 January 2009**
**Wycliffe College, University of Toronto**

Jack Dibb: Overview of ARCTAS. ARCTAS workshop 27-30th January in Virginia Beach. We should compare ARCTAS with TOPSE (2003)!

Anne Thompson: Also noted connections to other work. Is the boundary layer unconnected to the free troposphere? (cf. *Tang et al.,* 2008). Is this true or are the models missing mixing into the PBL ? ARC-IONS profiles and trajectory plots are available at: http://croc.gsfc.nasa.gov/arcions/

David Tarasick: Spring 2008 showed lower than average frequency of depletion events. Backtrajectories show some correlation (less than expected) with satellite BrO hotspots.

Brian Stocks: Intense surface fires and intermittent crown fires were common during ARCTAS, resulting in plumes reaching 5-7 km in altitude. Also major east Siberian fires – smoke detected in NA. Peak aerosol index July 1. Noted that fire data base goes back to 1959; good fit with long-term sonde data set (back to 1966); also older NASA GTE campaign data.

Luzik/Gallagher: Detailed budget of tropospheric ozone from ARC-IONS sondes via laminar identification (LID) method, including boreal fire enhancement. Typical fire contribution 4-12% (similar to STE contribution). Problems with source attribution? Further work: How well can various sources of $O_3$ be identified in profiles? Under what conditions is the LID analysis valid?

Bernard Firanski: New tropospheric ozone DIAL at Egbert (north of Toronto). Dual wavelength single transmitter uses $CO_2$ Raman scattering of 266 nm. Operational April 10, data April 15-21. Summer data collection June 28-July 10. Altitude limit 8-10km. Defective laser crystals hampered efforts; analysis ongoing.

Sam Oltmans.: Arctic sites showed modest ozone depletion in the boundary layer through the spring campaign. Transport very important at high latitudes. Some success with source attribution via Hysplit.

Jack Dibb: Surface sink at Summit for ozone; BrO-related? Yes! Higher $Br^-$ in firn air. Snow chemistry is very complicated and interesting. Ice core measurement of trace gases oversimplified – there is a lot of exchange.

Kelly Chance: BrO measurements from space pretty robust; different satellites agree to ~30%. If we subtract a constant amount ($5x10^{13}$) for stratosphere, get good agreement with surface measurements. Or do we — unless it's in the PBL; then AMFs indicate should be double. New BrO columns available (last month).

Ross Salawitch: $5x10^{13}$ too much BrO in stratosphere. Could be 2 ppt everywhere in trop. Several flights in satellite BrO "hospots" showed low BrO and no $O_3$ depletion. 080405, 080404. On 080408 found major ODE, high $Br_2$ (in sun!), very low BrO. Flight reports make interesting reading, e.g. 080416. Noted correlation of BrO column with total $O_3$ variations. Model suggests much variability is in stratosphere. Could it be tropopause height changes?

Kaley Walker: ACE validation: lots of data in the pre-ARCTAS period from Eureka, including daily ozonesondes during intensive phase (February 19 – March 10). Almost 50 species from ACE on SCISAT-1. ACE data are available to IPY projects like ARCTAS.

Bryan Johnson: Barrow ozonesondes, practical details (explained how to get false ODEs). Some depletion most of the time; also some very high ozone.

Kim Strong: Described CANDAC work at Eureka. Quite a large suite of instruments, lots of species, variety of data, all publicly available.

Kristen Adams: Ground-based BrO retrievals from Eureka. Dependent on ozone assumed, quite noisy. Most information from stratosphere, 1.5 DOF in trop.

Laura Pan: START-08: studies of the behaviour of the extratropical tropopause; gradients & dependence on met conditions. 18 flights, complex payload. STE flight: large mixed area where thermal & PV tropopause separated. Tropospheric intrusions can create rapid transport pathway for chemicals.

Wayne Hocking: Described O-QNet radar network in Canada. Winds, tropopause height, turbulence measurements. Jumps in tropopause height precede stratospheric intrusions; FLEXPART modeling seems to show good correspondence with apparent intrusions. Turbulence is much more complex than is usually expressed in models; thin layers, $K_{zz}$ not appropriate. Exchange at tropopause could be small-scale, GW-generated?

Mohammed Osman: High ozone in upper trop at Eureka during spring ARC-IONS period. STE or transport from lower latitudes. Could be STE from somewhere else.

Huixia He: Beginning work on a continental-scale view of STE events, using FLEXPART, IONS soundings, TES, radar, lidar and Brewer observations.

John Merrill: Outline of new approaches to finding layers in sonde profiles and analyzing their occurrence. UTLS region highly variable, independent of tropopause height.

Greg Osterman: TES overview. regular measurements 180 km; Step and Stare measurements 45 km, transect measurements 12 km (possible on request; 3 weeks). Foot print 5x8 km. Version 4 data available soon. "C-curve" profiles (erroneous high surface values) 50% less in v.4; data flag added. Some cases of high CO (smoke, low $O_3$).

Chris Boxe: Actual random (noise + temperature and interfering species) error consistent with observed error from ozonesonde comparisons. Bias is consistent with prior sonde comparisons. At high latitudes TES is primarily sensitive to ozone in the middle and upper troposphere. Sensitivity to lower troposphere depends on thermal contrast.

Jacek Kaminski: GEM forecast skill similar to the best models; not quite as good as ECMWF. GEM-AQ doing a good job of reproducing climatology of a large suite of species. Model shows some skill with daily ozone forecasts, also able to simulate fire plumes and their time evolution.

Mike Moran: GEM-MACH15 and ARC-IONS: GEM-MACH15 domain encompasses full ARC-IONS network (past North Pole); horizontal grid spacing 15 km. 58 vertical levels from surface to 10 hPa, will be expanded to 80 vertical levels with top at 0.1 hPa. Summer 2008 is one evaluation period being used; ARC-IONS data will be used to evaluate vertical $O_3$ structure. Horizontal and vertical resolution sufficient to resolve STE. Plan to include real-time estimates of boreal wildfire emissions in operational GEM-MACH15; will permit studies of impact of boreal forest fires in both remote and populated areas. Plan to use satellite chemical measurements (e.g., $O_3$, $NO_2$, CO) to assess GEM-MACH15 performance.

Mark Parrington: Assimilated tropospheric ozone data from TES with GEOS-Chem, compared with IONS-06 (August) ozonesondes. Assimilation reduces bias in free tropospheric $O_3$ from -35% to < 5% (300 - 800 hPa). Reduction of bias in the model $O_3$ enhances flux of $O_3$ into the boundary layer. Assimilation exacerbates bias in surface $O_3$, suggesting model bias in ozonesources and sinks or in downward transport of $O_3$ into the boundary layer.

Thomas Walker: The improvement at midlatitudes as a result of TES assimilation increases transport of ozone into the Arctic, in UTLS; bias relative to ozonesondes decreases from +9.2 to -0.1 ppbv between 400-500 hPa.

Discussion I: Biomass Burning

1) Incorporation of long-term sonde data set into analyses (back to 1966). Synthesize sonde data with fire data base (back to 1959); Focus on major events each year. Use Hysplit to identify layers affected. Inclusion of older NASA GTE data into analyses.

2) Sort out effect of fire plumes on $O_3$ during ARCTAS: Evidence for $O_3$ suppression (as seen by TES). If so, why (compare with DC-8 measurements of $HO_x$, $NO_x$)? If not, why is TES seeing something different than sondes?

3) Evaluation of trajectory models, including FLEXPART. How good are they in the troposphere?

4) Incorporation of CALIPSO, MISR, and MODIS data into analyses.

5) Ultimate science driver: impact of climate change on future boreal fires and their effect on AQ. How can ARCTAS data improve fire assessments?

6) How to incorporate high spatial/temporal resolution data in coarse resolution models?

Discussion II: Bromine & Ozone Depletion Events

1) Characterize ODEs in 2008 versus other years; Relation to frost flowers and leads Why was 2008 a moderate year for ODEs, given the presumable large amount of first year sea ice?

2) Summit BrO: what is the source of the elevated levels of BrO observed at this site? Sea salt source appears to be much too small. Not near open ice.

3) What levels of the atmosphere are leading to the satellite BrO hotspots? Availability of COBRA data? MAXDOAS data from Summit? Effect of clouds on satellite retrievals?

4) Relate regions of stratospheric "thickness" (presences of air at high pressure with, for example, $O_3$ > ~100 ppb) to satellite BrO hotspots. If a relation can be developed, then it can be used to help define the relation between BrO in the PBL and satellite BrO hotspots.

5) Long standing challenge: if ODEs are really confined to lowest few 100 m, and presumably highly elevated BrO is similarly confined to these altitudes, then how are the satellite BrO "hotspots" affected by clouds?

Discussion III: Strat-trop exchange

1. Turbulence layering - impact on K.
2. Meaning of K – different things to different scientists (small scale vs large scale vs modeling).
3. Hotspots in Eps/K – "pre-tuned" by background shears (e.g. jet stream shears)
4. GW sources in the jet stream – are the edges more important for GW generation?
5. BL/Free Troposphere coupling an issue?
6. Impact of BL processes up into the free troposphere – can convection be important to several km?
7. Double tropopause
8. Is STE more important at short or longer term scales – presumably longer? Is there an "optimum" time scale at which STE has biggest impact?
9. Coupling between small and large scales? Also how far down can STE dynamics have an impact.
10. Gravity waves – does breaking occur above the tropopause? Distinguish spectrum vs monochromatic waves.

11. Night vs Day differences?  Esp. re transport. Sun-rise studies?
12. Disappearance of stratospheric ozone 2-3 km above ground?
13. Two-way STE movement? up and down? How much upward movement from the troposphere to the stratosphere takes place at midlatitudes, relative to "equatorial boilerbox". Longitudinal/regional differences (Siberian conveyer belt vs Canadian processes).
14. Mechanism of vertical lifting of smoke.
15. Cross pacific transport – tropospheric transport at low level vs. lofting into stratosphere and then stratospheric transport. 2004 c.f. 2008? Impact of synoptic "pre-conditioning" on response of fires and thence process of lifting into stratosphere – impact of pre-conditioning (synoptic, fuel dryness etc) can impact level of lofting.
16. Community cross-fertilization.
17. Russian Ozonesonde networks? Collaborate? Siberian fies impact in Canada? Important to look from Arctic regions.
18. Rossby Wave breaking and impact on ozone transport and climatology.