Atmospheric Composition Measured by Solar Occultation Spectrometry

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Purpose of the MkIV balloon instrument:
- Validate satellite measurements.
- Validate atmospheric models.
- Trend Detection.
- Evaluate adequacy of laboratory spectroscopy.
- Evaluate technology improvements.

The JPL MkIV Interferometer

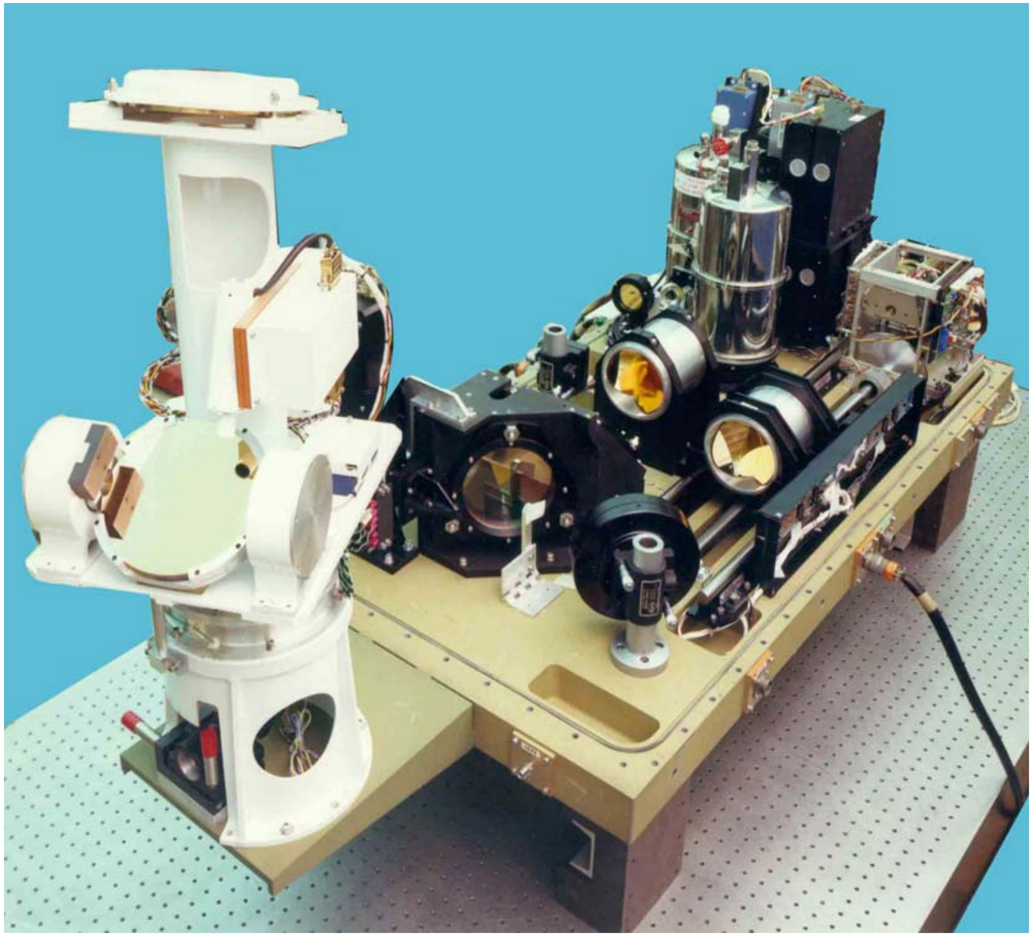
Built at JPL in 1984, following the ATMOS optical design.

Mass=200 kg, Size =1.5x1.0x0.8 m.

Parallel HgCdTe & InSb detectors simultaneously cover 650-5650 cm^{-1} with 0.008 cm^{-1} spectral resolution.

Over this wide mid-infrared interval over 30 different gases have spectral signatures, including H_2O, CO_2, O_3, N_2O, CO, CH_4, N_2, NO, NO_2, HNO_3, HO_2NO_2, N_2O_5, $ClNO_3$, H_2O_2, H_2CO, HOCl, HCl, HF, SF_6, COF_2, CF_4, CH_3Cl, $CHFCl_2$, $CFCl_3$, CF_2Cl_2, CCl_4, OCS, HCN, C_2H_2, C_2H_6 and many isotopic variants (e.g. HDO, CH_3D).

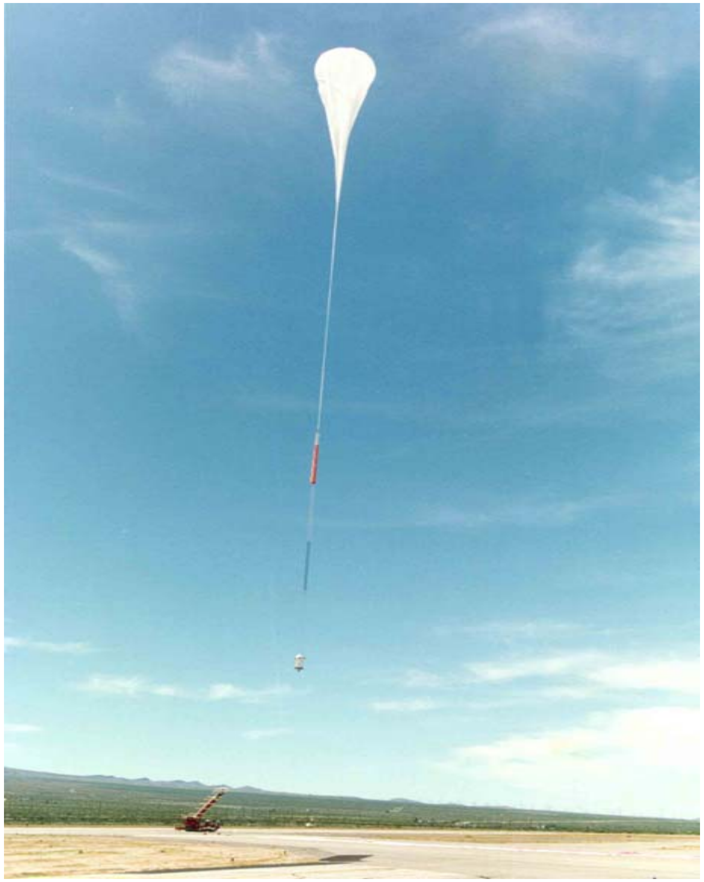
Has performed 13 balloon flights, 3 aircraft campaigns, and 878 days of ground-based observations.



MkIV Balloon Flight History

Date	Tangent Latitude (degrees)	Tangent Longitude (degrees)	Minimum Altitude (km)	Balloon Altitude (km)	Launch Site	Event
05-Oct-89	34.6	-105.7	13	37	New Mexico	Sunset
27-Sep-90	34.2	-106.0	10	36	New Mexico	Sunset
05-May-91	37.5	-111.8	15	37	New Mexico	Sunset
06-May-91	36.5	-103.0	15	32		Sunrise
14-Sep-92	35.2	-110.2	23	38	New Mexico	Sunset
15-Sep-92	35.3	-103.9	22	40		Sunrise
3-Apr-93	34.8	-115.5	17	37	California	Sunset
25-Sep-93	34.0	-109.4	4	37	New Mexico	Sunset
26-Sep-93	33.2	-100.4	11	38		Sunrise
22-May-94	36.6	-109.7	15	36	New Mexico	Sunset
23-May-94	36.3	-100.8	11	37		Sunrise
24-Jul-96	56.8	-101.0	11	24	Manitoba	Ascent
28-Sep-96	32.7	-113.0	6	38	New Mexico	Sunset
08-May-97	68.0	-147.0	8	37	Alaska	Sunrise
08-Jul-97	67.0	-148.0	8	32	Alaska	Ascent
09-Jul-97	65.0	-150.0	9	32	Alaska	Descent
03-Dec-99	64.0	19.0	6	34	Sweden	Sunset
15-Mar-00	69.0	27.0	12	30	Sweden	Sunrise

Balloon Launch of the JPL MkIV Interferometer



Advantages of High Resolution Solar Occultation Technique

Broad Spectral coverage (typically 650-5650 cm^{-1}):

Allows determination of aerosol composition and size distribution.
30+ different gases measured simultaneously in the same airmass, providing tight constraints on models.
A range of different strength bands are available for retrieval (strong for high altitude; weak for low).

High Signal-to-Noise Ratio and Resolving Power:

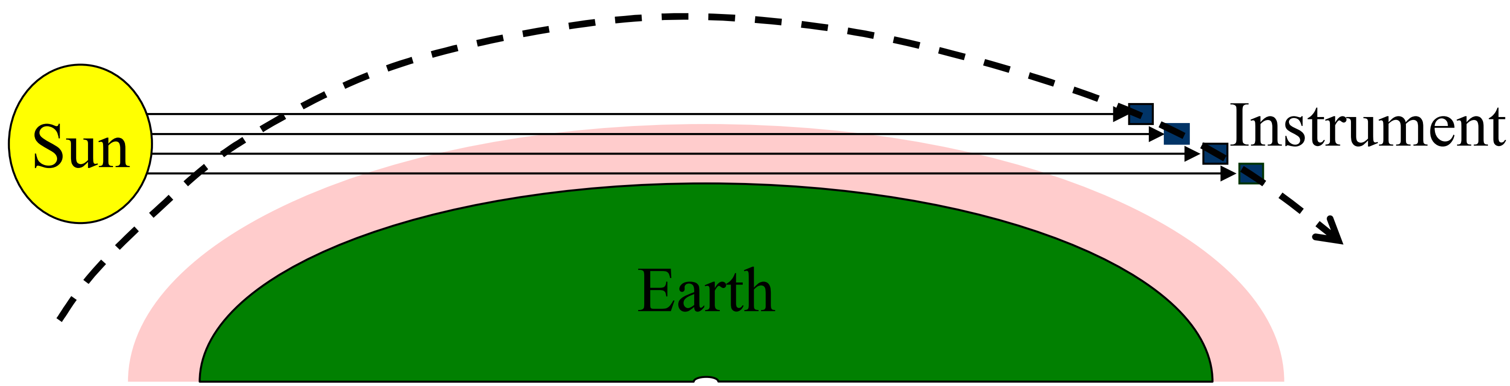
Able to measure weak absorptions of traces gases that lie close to much stronger lines.
Broad absorptions due to aerosol easily distinguished from narrow gaseous absorptions.

High Radiometric Calibration Accuracy:

Radiation thermally emitted by the instrument or atmosphere is negligible compared to Sun.
Ratioing limb spectra against exo-atmospheric spectrum removes solar & instrumental features.

Unambiguous photon path history:

All measured photons come from Sun and traverse the full limb path.

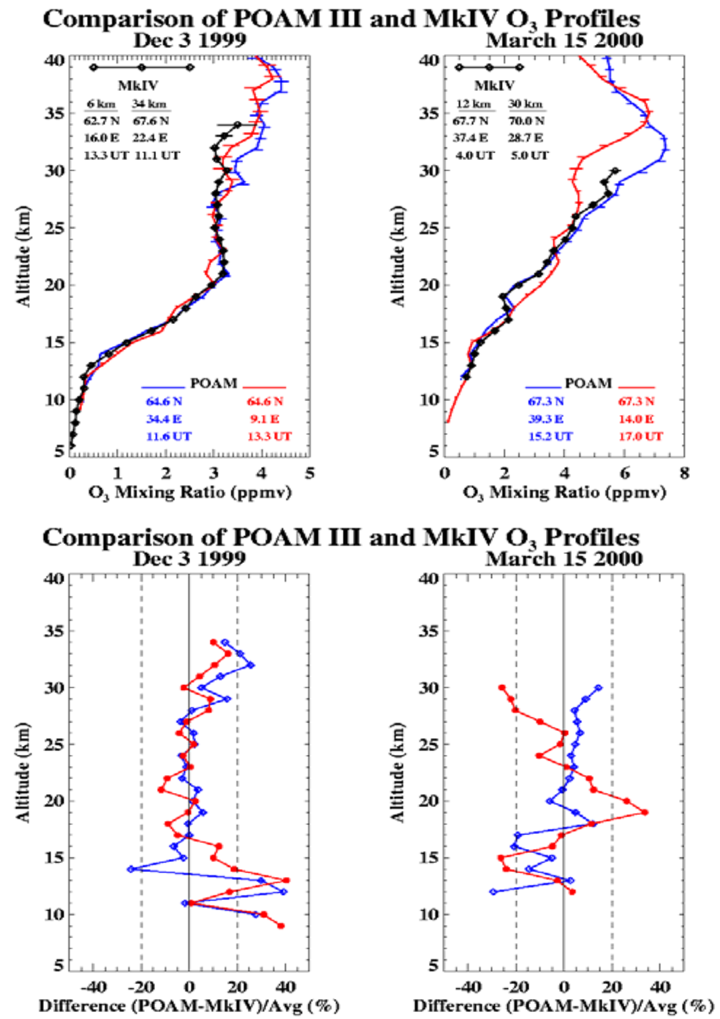


Validation of POAM III Ozone Measurements - MkIV

The MkIV payload made two flights during SOLVE. On the first flight, Dec 3, 1999, MkIV measured a sunset occultation, whereas the second flight on Mar 15, 2000 was a sunrise occultation.

POAM ozone profiles on Dec 3 show excellent overall agreement, within 10%, with the MkIV profile, deviating only at the very top of the profile and below 15 km.

POAM ozone profile at 39 N measured on Mar 15, sampling coincident air masses with the balloon, reproduces the detailed vertical structure in the MkIV profile almost exactly and are within 5 – 10 % at almost all altitudes, whereas the other POAM profile shows a very different vertical structure, consistent with fact that it is sampling very different air.



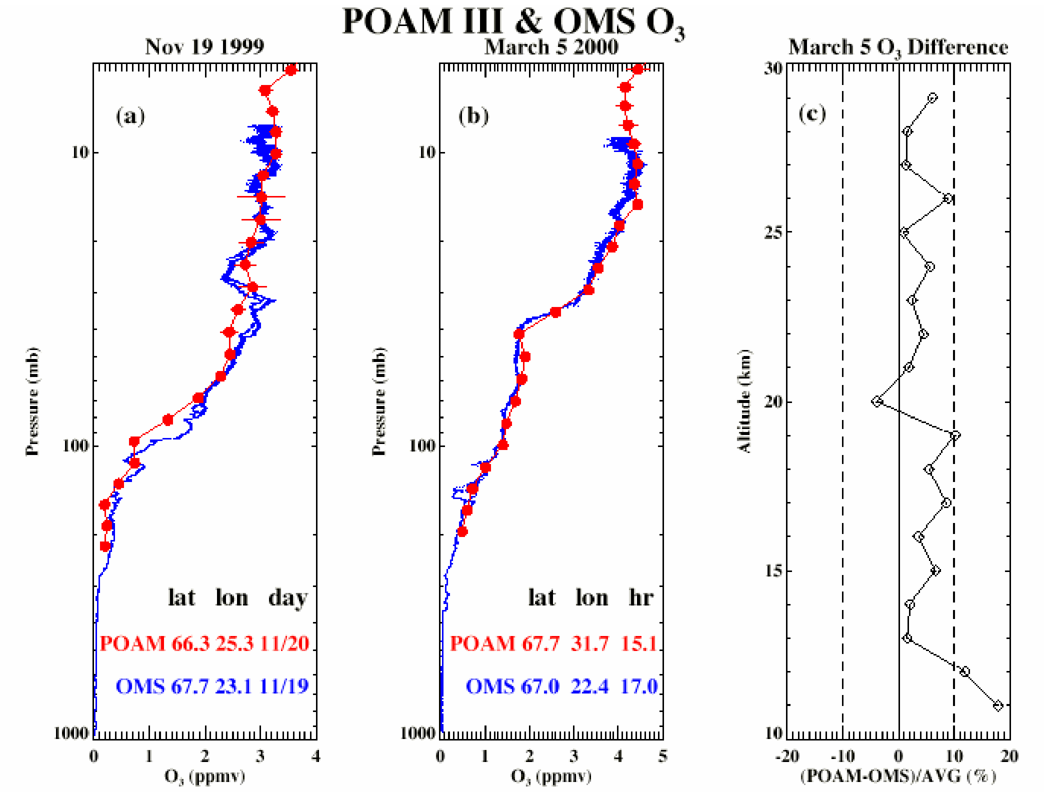
Lumpe *et al.*, *JGR*, *in press*, 2002.

Validation of POAM III Ozone Measurements - in situ O_3

The JPL in situ Ozone Photometer (Margitan/PI and Sen/co-I) is flying as a piggy-back instrument with the MkIV for the SOLVE-II flights.

The Ozone Photometer made two flights during SOLVE as part of the OMS in situ payload.

Both flights show very good agreement with POAM III, although there was a 1-day difference for the November flight. For the close coincidence March flight, agreement is around 3-5% over mos tof the profile.

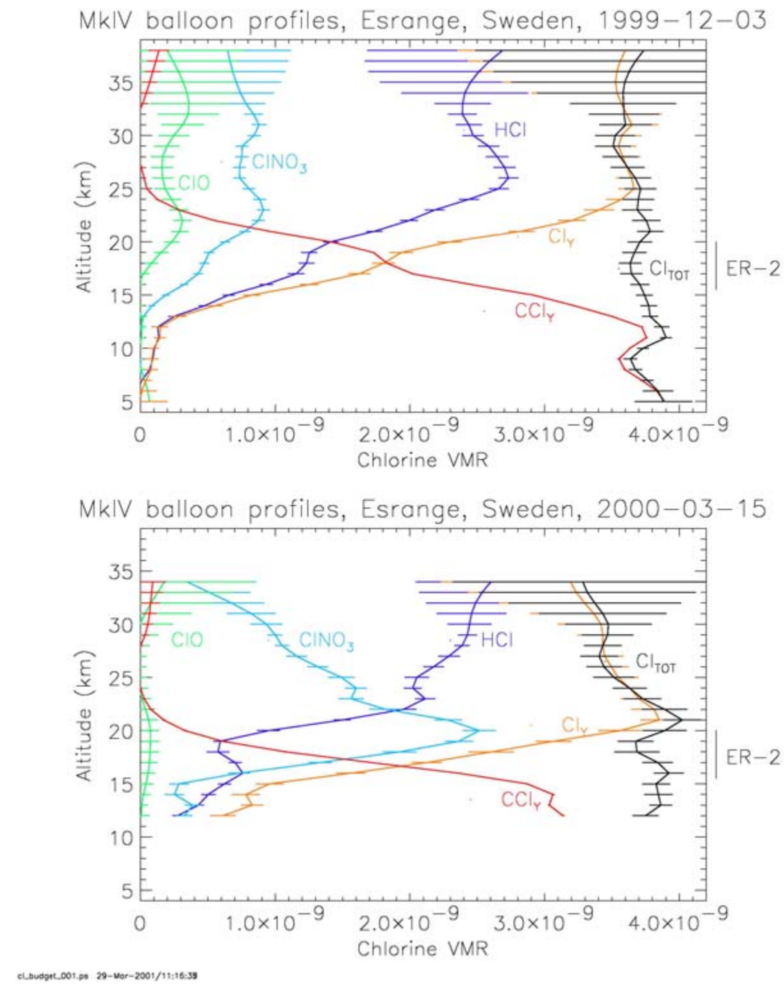


Lumpe *et al.*, *JGR*, *in press*, 2002.

Measurements of Inorganic Chlorine During SOLVE

The upper panel shows that the total Cly was mainly HCl in Dec 1999.

The lower panel shows that chlorine partitioning was highly disturbed for the Mar 2000 flight. The HCl/Cly ratio decreased from 0.7 in Dec 1999 to 0.2 in Mar 2000. $ClNO_3$ was the predominant form of chlorine by mid-Mar 2000 (over 75% at 19 km altitude).

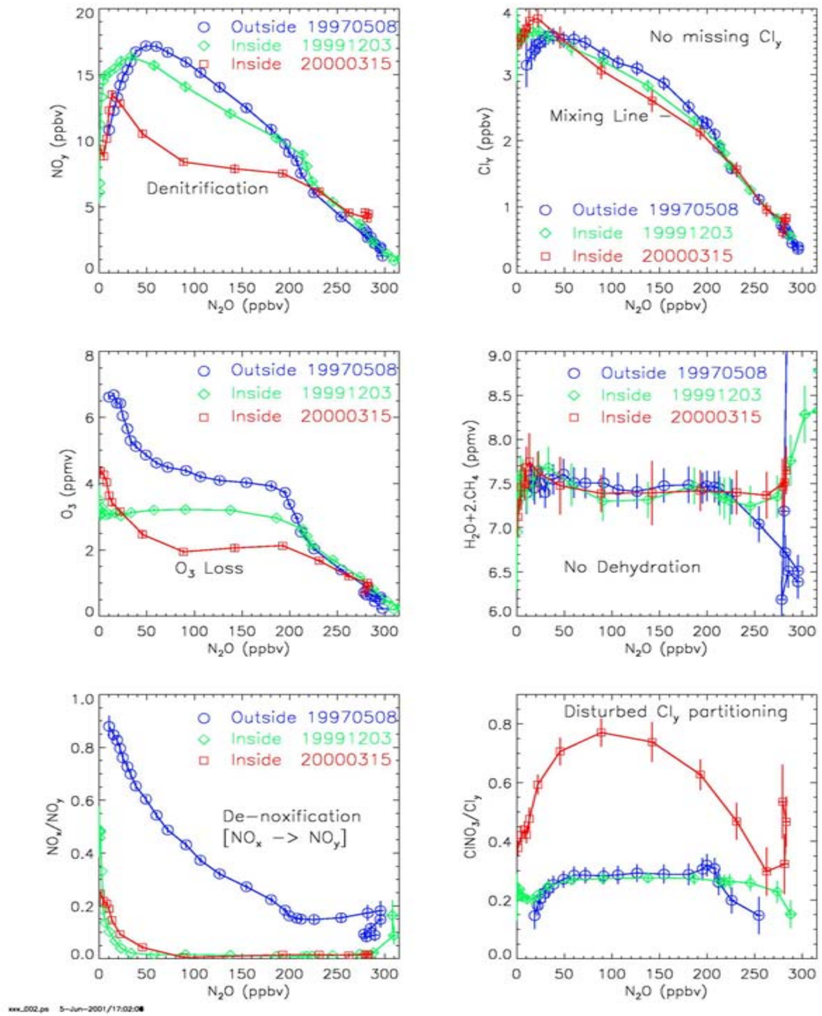


Summary of MkIV Measurements During SOLVE

The panels exhibit the relationship versus N_2O of NO_y, Cl_y, O_3, $H_2O + 2CH_4$, NO_x/NO_y, and $ClNO_3/Cl_y$ observed by MkIV during balloon flights in May 1997, Dec 1999, and Mar 2000.

They illustrate substantial loss of NO_y and O_3 in the 17 - 21 km altitude range in Mar 2000 (red). The NO_x/NO_y ratio is suppressed throughout the polar stratosphere as compared with the non-vortex balloon flight (blue).

Chlorine partitioning was highly perturbed for the Mar 2000 balloon flight with $ClNO_3$ the predominant form of chlorine.



Status of the MkIV Gondola During SOLVE II

MkIV payload weight has been reduced from 1900 lbs to 1300 lbs since the SOLVE campaign.

MkIV gondola is flight ready and awaiting launch by CNES from Esrange.

Last possible flight date is Dec 19, 2002.

Ground-based measurements are planned for Jan – Mar, 2003, under remote control from JPL.

Additional balloon flights are being planned for Mar and Apr, 2003, for SAGE III and ILAS II validation, respectively.

Conclusions

Solar occultation spectrometry has the high SNR and spectral resolving power necessary to:

Identify weak absorptions due to numerous trace gases and minor isotopomers.

Identify inadequacies in the spectroscopic database and pinpoint their cause.

Validate solar absorption spectrometric measurements of the Earth's atmospherere from space.

Characterize the airmasses that would experience chemical perturbations due to wintertime processing (e.g., ozone loss, denitrification, etc.) and explore the vertical extent of these chemical perturbations.