Analysis of Ozone Trends at the Cape Point GAW Station, South Africa (34 °S)

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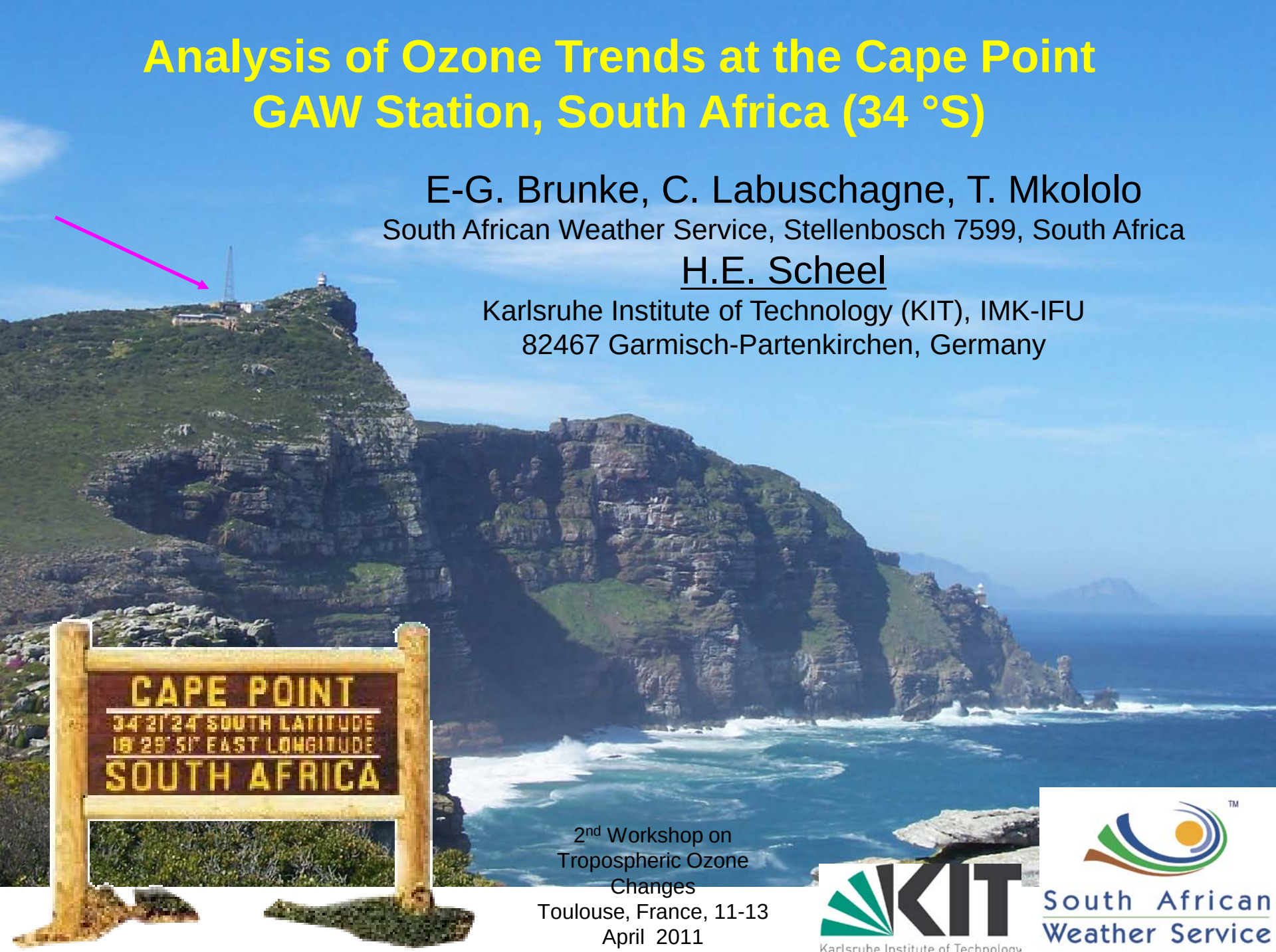

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South African Weather Service

Site description:

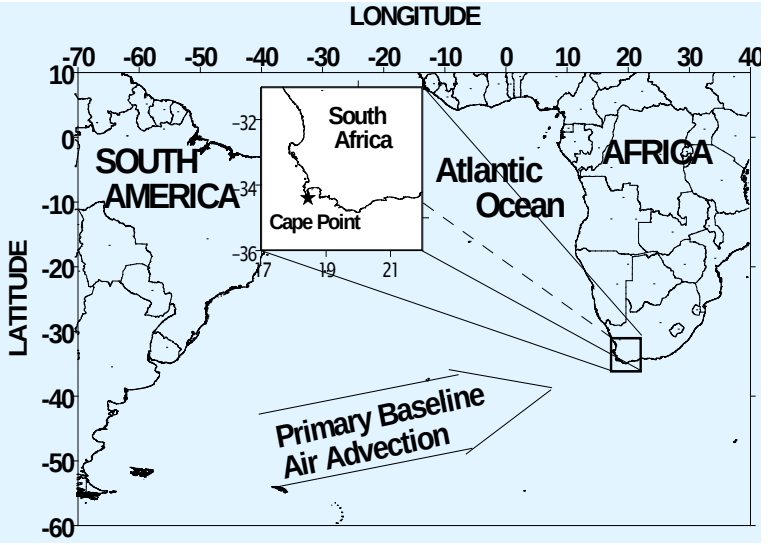
Cape Point (GAW) station: 34^0 S; 18^0 E; 230 m asl.

Situated on a rock face within a nature reserve at the southern point of the Cape Peninsula.

Station 60 km south of Cape Town.

Shrub (fynbos) vegetation. Winter rainfall.

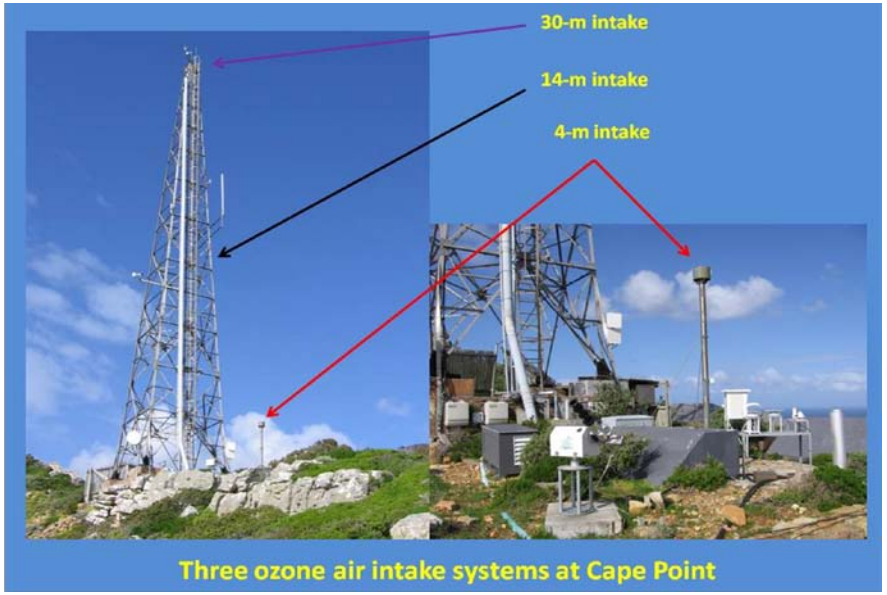
Prevailing winds from SE; however, main large-scale advection from SW.



Instrumentation:

3 analysers Thermo Electron TE 49. Air intakes at 4 m; 14 m and 30 m.

Calibration tied to the WMO/GAW scale.



Three ozone air intake systems at Cape Point

Data sets for surface ozone:

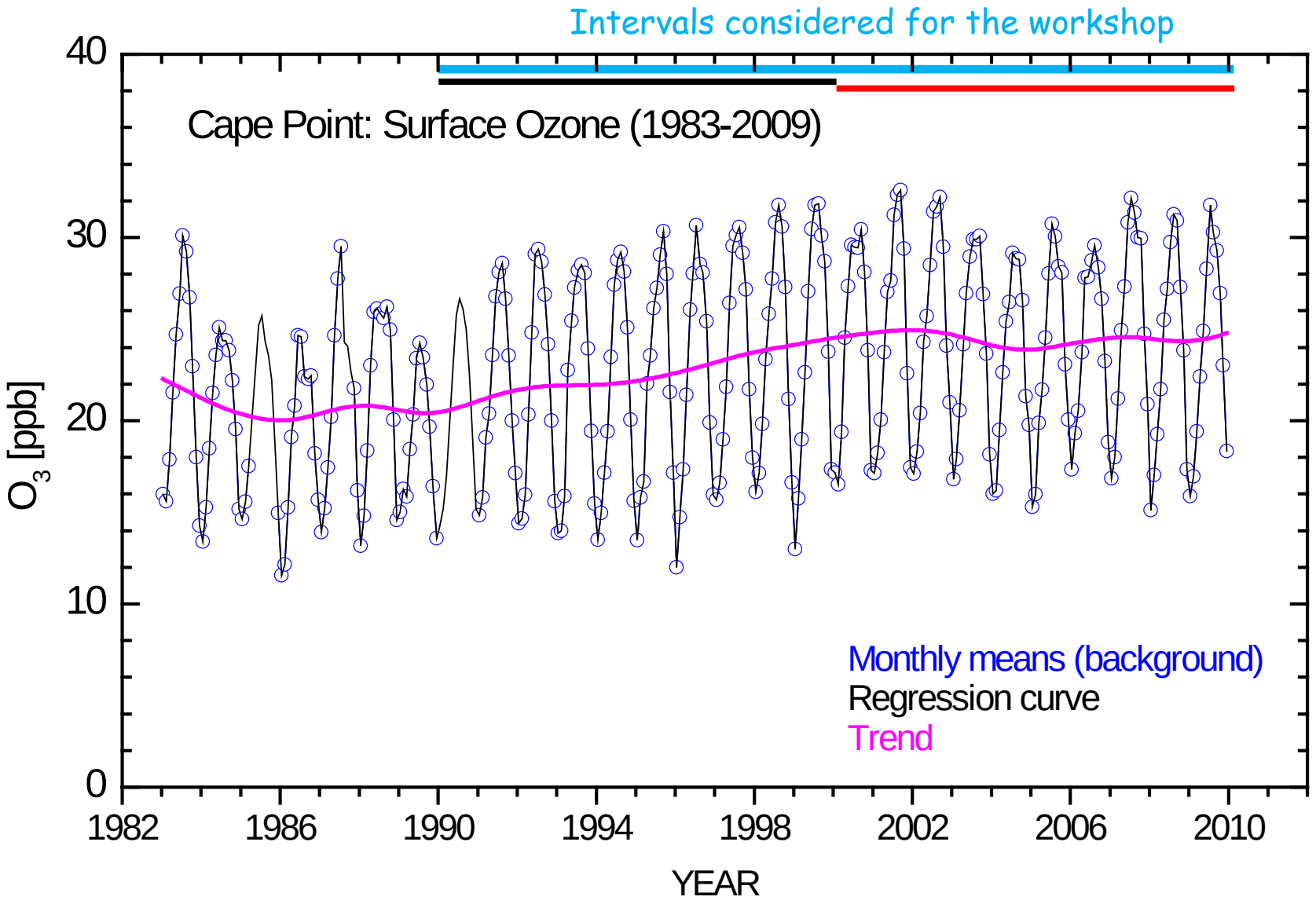
30 m: 1983 – 2009 with major gap in 1990;

4 m: 1997 - 2009

Data filtered for background conditions stored separately.

Years of general tendency change: 1989 – 1991, when an overall O_3 increase began.

O_3 monthly mean values (1983 – 2009) together with regression curve and long-term trend component



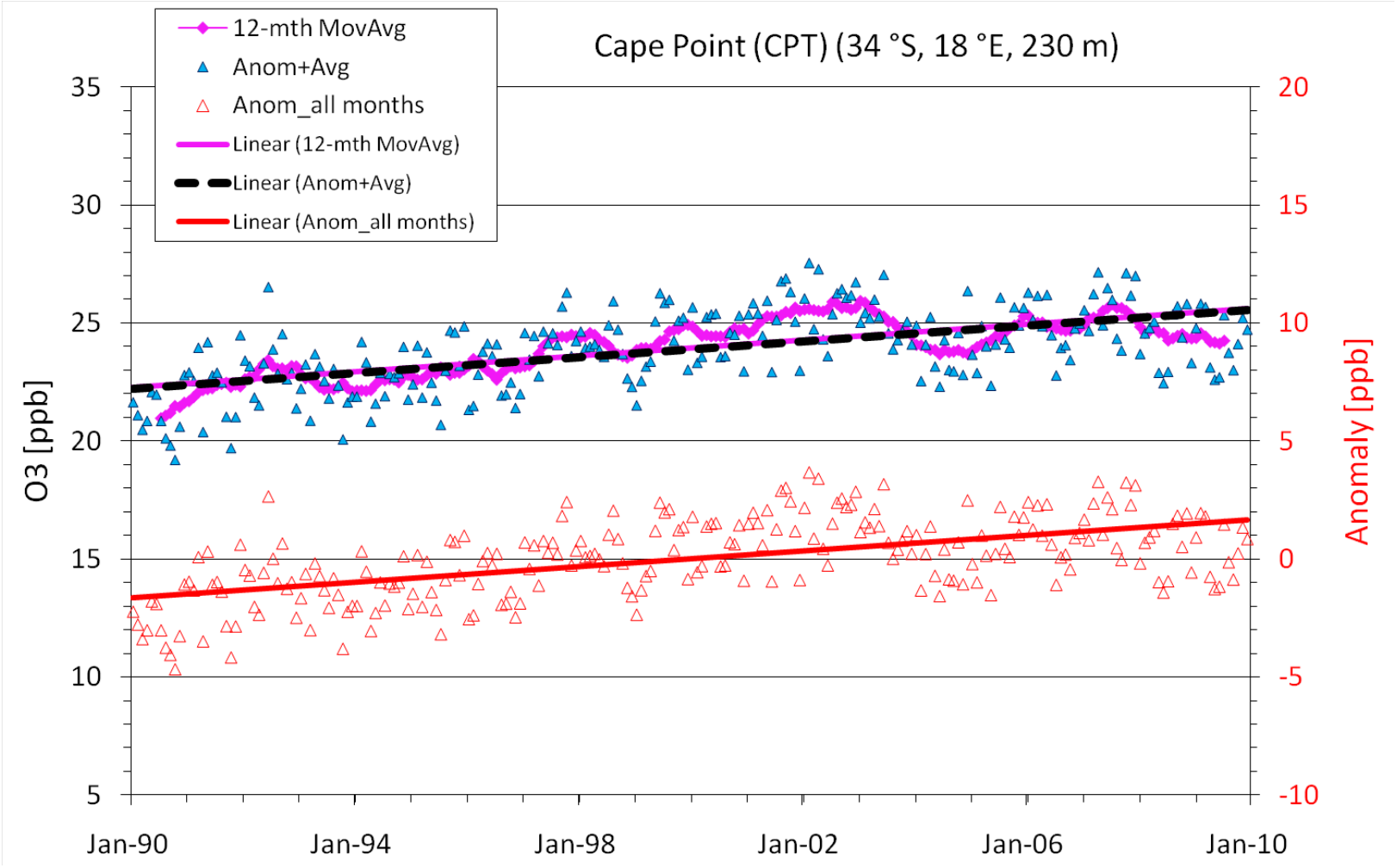
Time series for 30-m air intake, statistical background filter

30-m air intake, unfiltered data

Annual Trends

Comparison of anomalies (relative and absolute) with 12-month moving averages (1990 – 2009)

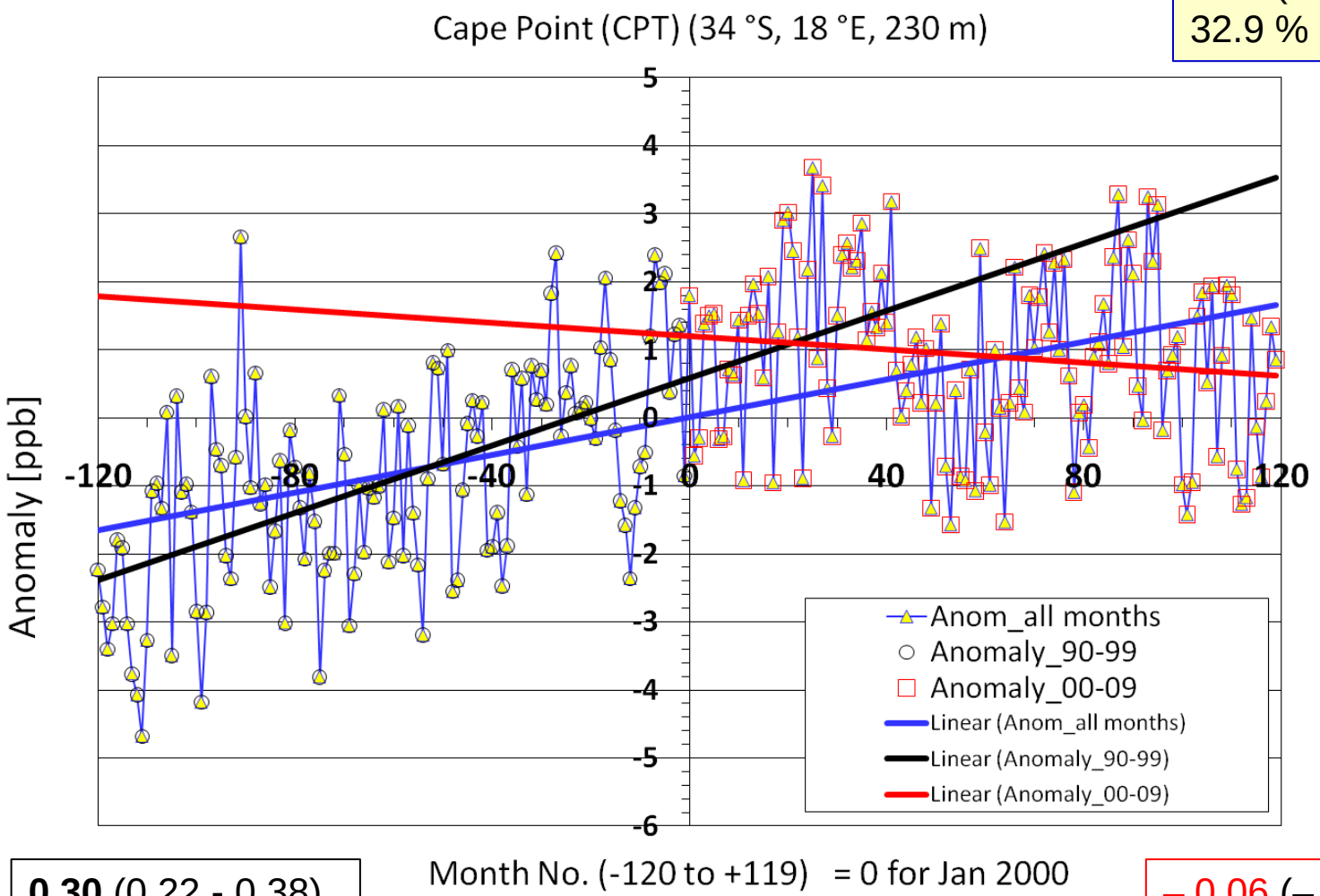
ppb / yr *(95%-conf. interval)*	**0.17** (0.14 - 0.20)
Intercept Jan 2000 (C.I.)	23.9 (23.7 - 24.1)
r² [%]	32.9 %



absolute anomaly = calculated anomaly + average O_3. Ref. = January 2000

Average ozone changes according to anomalies of the periods **1990 – 2009**, **1990 – 1999**, **2000 - 2009**

0.17 (0.14 - 0.20)
23.9 (23.7 - 24.1)
32.9 %

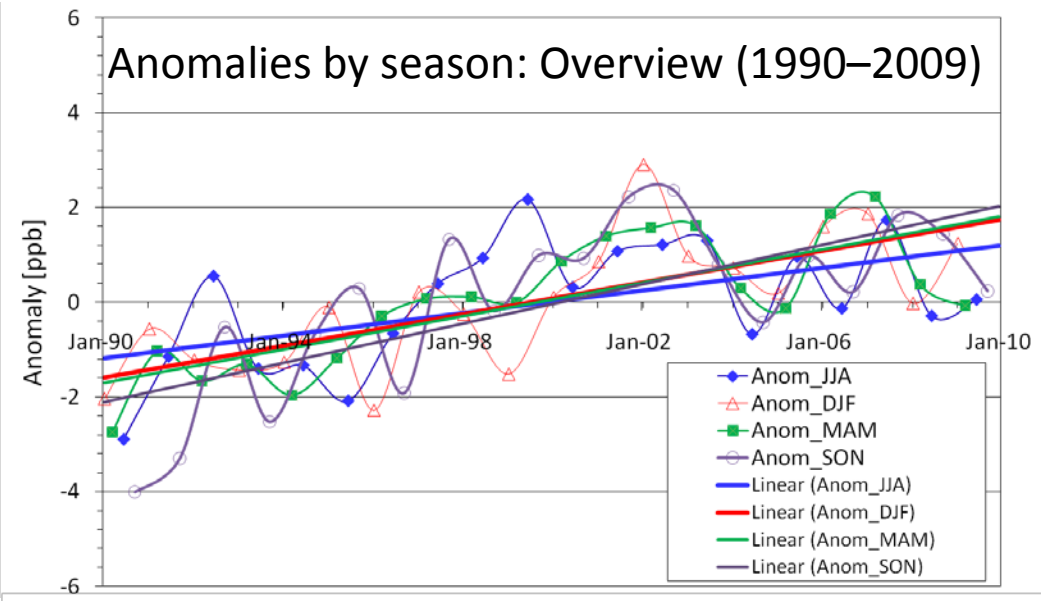


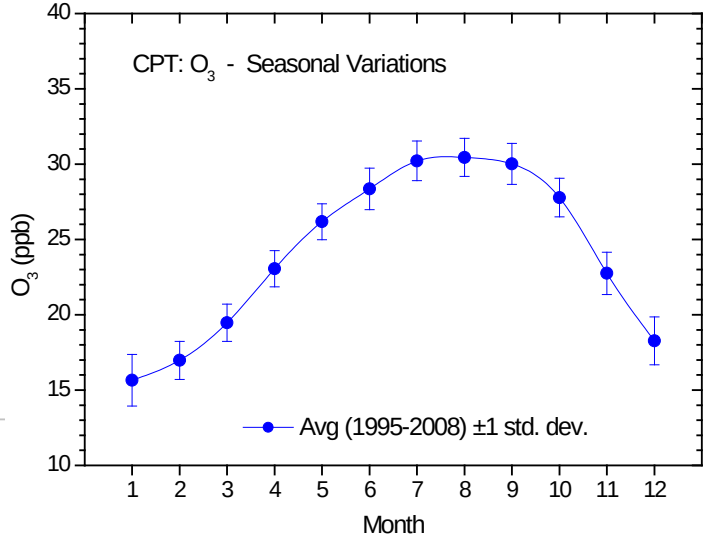
0.30 (0.22 - 0.38)
24.5 (24.0 - 24.9)
31.1 %

– 0.06 (– 0.14 - 0.02)
25.1 (24.6 - 25.5)
1.8 %

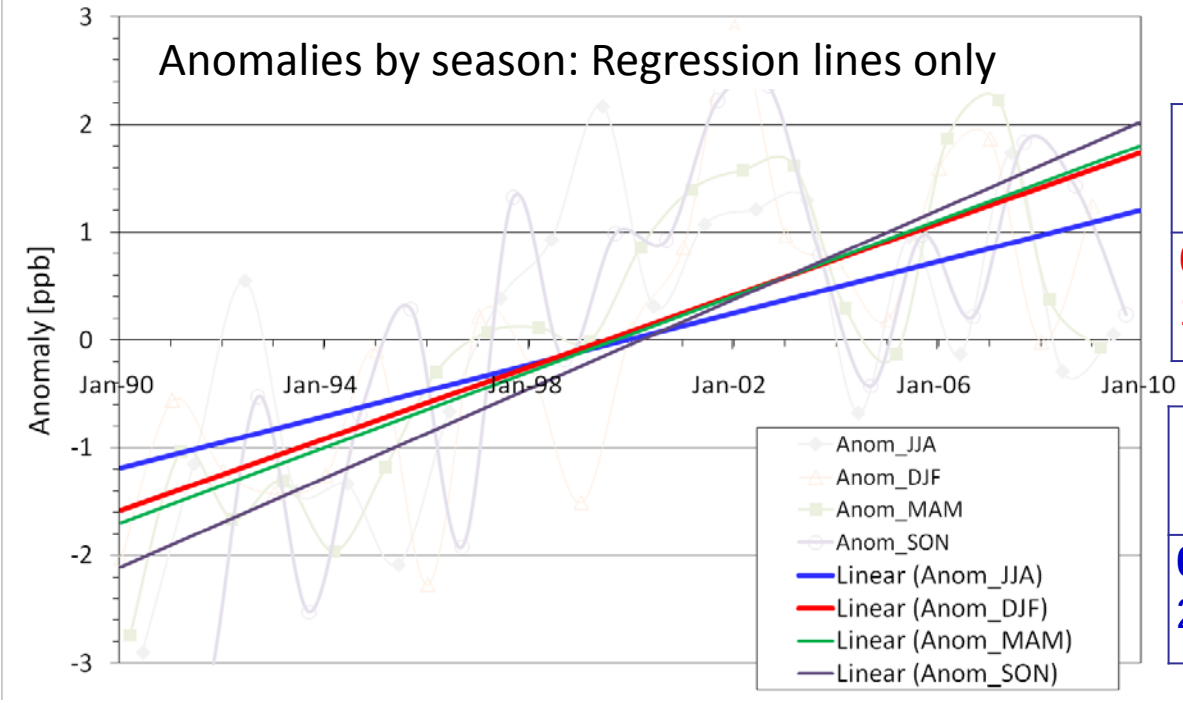
Seasonal Trends: Max. SON, Min. JJA

Cape Point surface ozone:
Average seasonal variations (1995 – 2008) with flat July-September maximum and minimum in January.





Cape Point (CPT) (34 °S, 18 °E, 230 m)



DJF SH summer	**MAM** SH autumn
0.17 (0.09 - 0.25) 17.0	**0.18** (0.10 - 0.25) 23.0

JJA SH winter	**SON** SH spring
0.12 (0.03 - 0.21) 29.2	**0.21** (0.10 - 0.31) 26.5

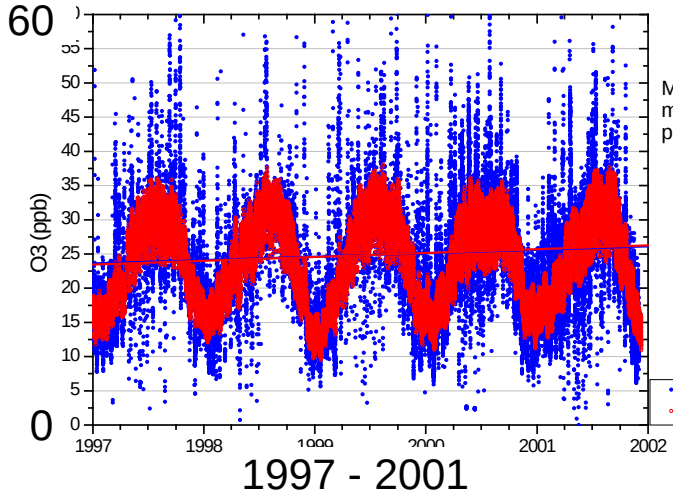
Site: **CPT** **Annual trends**	Statist. param. of Lin. Regr.. Intercept (abso-lute) for Jan 2000	From monthly mean anomalies (all available data) 30-m air intake	Statistical background filtering	4-m air intake (all data) 2000 - 2009
1990 – 2009	Slope [ppb/yr] Intercept [ppb] r^2	**0.17** (0.14 - 0.20) 23.9 (23.7 - 24.1) 32.9 %	**0.17** (0.15 - 0.20) 23.5 (23.4 - 23.7) 39.3 %	----------
1990 - 1999	Slope [ppb/yr] Intercept [ppb] r^2	**0.30** (0.22 - 0.38) 24.5 (24.0 - 24.9) 31.1 %	**0.34** (0.27 - 0.40) 24.3 (23.9 - 24.7) 44.8 %	----------
2000 - 2009	Slope [ppb/yr] Intercept [ppb] r^2	– 0.06 (–0.14 - 0.02) 25.1 (24.6 - 25.5) 1.8 %	– 0.06 (–0.13 - 0.01) 24.7 (24.3 - 25.1) 2.3 %	– 0.07 (–0.24 - 0.10) 25.0 (24.0 - 26.0) 0.6 %

Significant positive rates in **bold** No significant negative rates

Seasonal trends (30 m all)	DJF SH summer	MAM SH autumn	JJA SH winter	SON SH spring
1990 – 2009	**0.17** (0.09 - 0.25) 17.0 (16.5 - 17.4) 52.1 %	**0.18** (0.10 - 0.25) 23.0 (22.5 - 23.4) 58.7 %	**0.12** (0.03 - 0.21) 29.2 (28.7 - 29.7) 28.8 %	**0.21** (0.10 - 0.31) 26.5 (25.9 - 27.1) 48.1 %
1990 - 1999	0.08 (–0.14 - 0.29) 16.3 (14.9 - 17.6) 7.8 %	**0.27** (0.14 - 0.41) 23.3 (22.5 - 24.2) 73.4 %	**0.37** (0.08 - 0.65) 30.5 (28.9 - 32.2) 52.7 %	**0.48** (0.18 - 0.77) 27.8 (26.1 - 29.4) 63.9 %
2000 - 2009	0.00 (–0.24 - 0.24) 17.9 (16.6 - 19.2) 0.0 %	– 0.07 (–0.29 - 0.15) 24.2 (23.0 – 25.4) 6.7 %	– 0.07 (–0.28 - 0.14) 30.1 (28.9 - 31.3) 7.4 %	– 0.09 (–0.32 - 0.15) 28.0 (26.7 - 29.4) 8.7 %

Discussion Points

Regression lines for "**all**" and "statistically selected" data coincide.



1997 - 2001

- Long-term trends for "all" and "statistically filtered" data coincide.
- High and low O_3 deviations level each other out.
- "Statistical filter" and "CO background filter" yield similar results (not shown here).
- For the current study, the major data gap of 1990 was closed using interpoled data from the dynamic harmonic regression fit.

- Significant growth rates for the periods 1990 – 2009, and part 1, 1990 – 1999
- Average ozone levels nearly constant during 2000 – 2009
- Seasonal trends significant for 1990 – 2009

For part 1, 1990 – 1999, only with the exception of DJF (SH summer). Explained by pronounced interannual variability.

- O_3 increase shows only little seasonal dependency. → **?** Supposition of hemispheric processes rather than regional effects **?**

→ Concurrent declining CO trend in recent years.

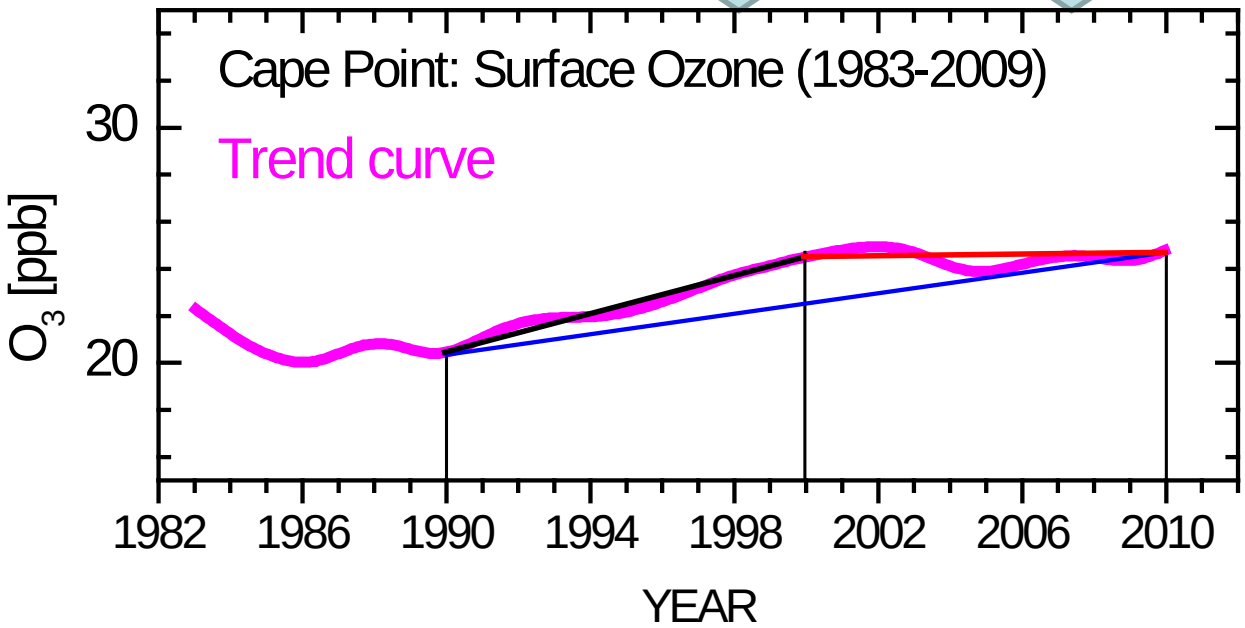
? No larger O_3 production related to biomass burning **?**

? Increasing stratospheric influence **?**

Comparison with alternative statistical approaches

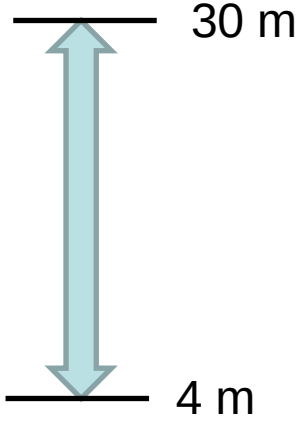
Different calculations of growth rates [ppb/yr]
CPT, 30-m air intake, all data

	Anomalies as ref.	Lin. regr. on monthly means (not deseas.)	Lin. regr. on trend curve	Average rates derived from trend curve	From differ. Trend_(max - min)
1990 - 2009	0.17 (0.14 - 0.20)	0.19	0.18	0.22	0.22
1990 - 1999	0.30 (0.22 - 0.38)	0.37	0.33	0.39	0.38
2000 - 2009	-0.06 (-0.14 - 0.02)	0.02	-0.03	0.05	-0.05



Characterisation of the air between 4 m and 30 m

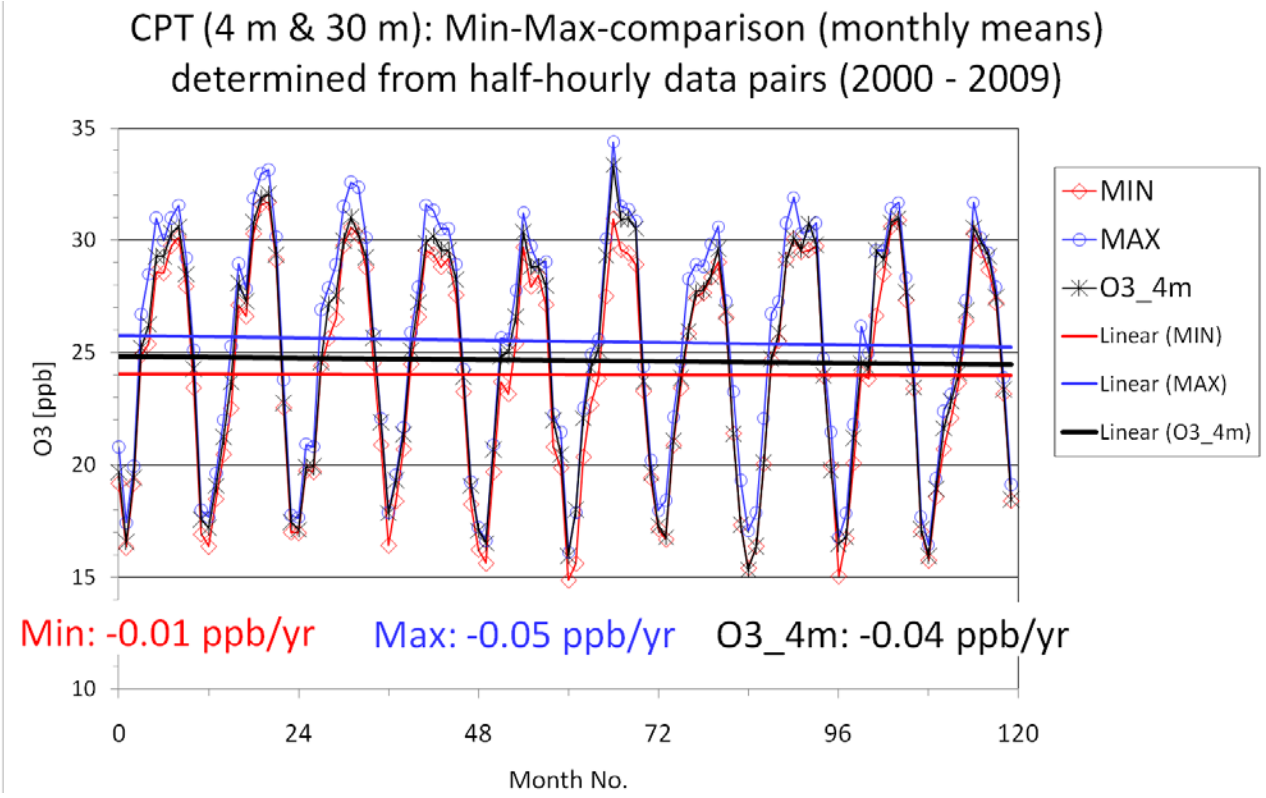
CPT, air intake heights



Data since 1997

During pollution episodes (especially regional fire plumes) differences > 60 ppb between the intakes can occur.

Goal: Estimate of representativeness of the air at the 2 intake heights.
Approach: 1/2-h means for the 2 heights, sorted as maximum and minimum. → Calculation of monthly means. → Visualisation of both time series together with linear regression.
***Result**:* Between 4 and 30 m the O_3 maxima and minima within the 1/2-h periods differ only by 1.5 ppb on average. No indication of different trend behaviour.
The 2000-2009 O_3 averages over the monthly means for 4 m and 30 m agree within ≈ 0.2 ppb.



Surface Ozone at Cape Point (1983 – 2009)
Summary

- The time series can roughly be divided into 3 parts:

1983 – 1989/90: No clear trend behaviour, 2 major gaps.
1990 – 2002: Ozone increase statistically significant.
2003 onwards: Stabilization.

- The present study with its periods 1990 – 1999 and 2000 – 2009 partially merges the Cape Point trend observations.
Nonetheless, statistically significant growth rates for 1990 – 2009 and 1990 – 1999. Maximum annual rate about 0.3 ppb/yr.

- Different statistical techniques yield compatible growth rate estimates.

- Long-term trend of surface ozone at Cape Point not critically dependent on air intake height between 4 m and 30 m.

- Calculated O_3 reference mixing ratio for January 2000:
23.9 ppb (all data), 23.5 ppb (background).

Outlook:
Trend estimates based on different monthly percentiles (notably 10^{th}, 25^{th}, 75^{th} and 90^{th})

South African Weather Service

Karlsruhe Institute of Technology

Thank you!

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