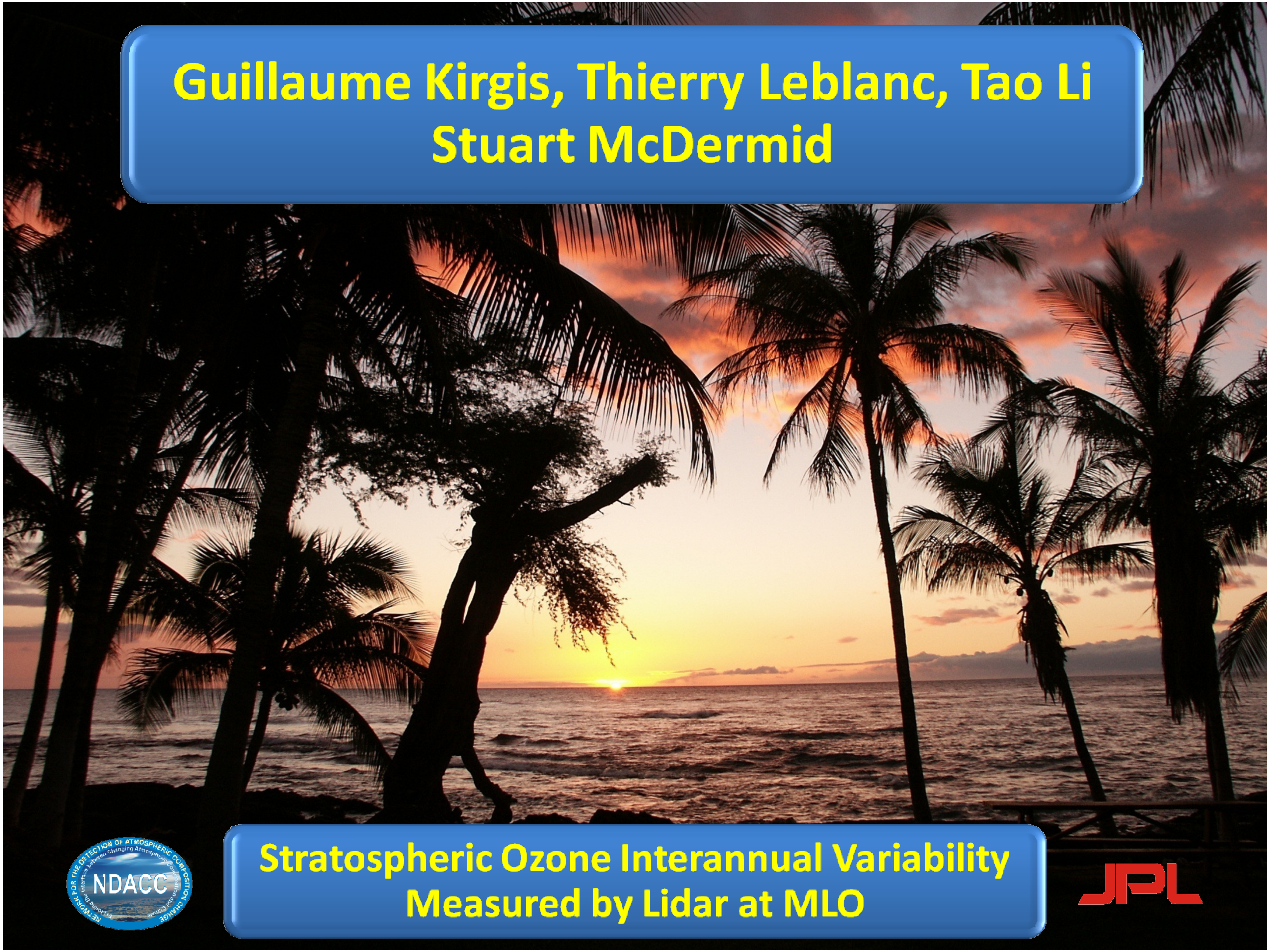
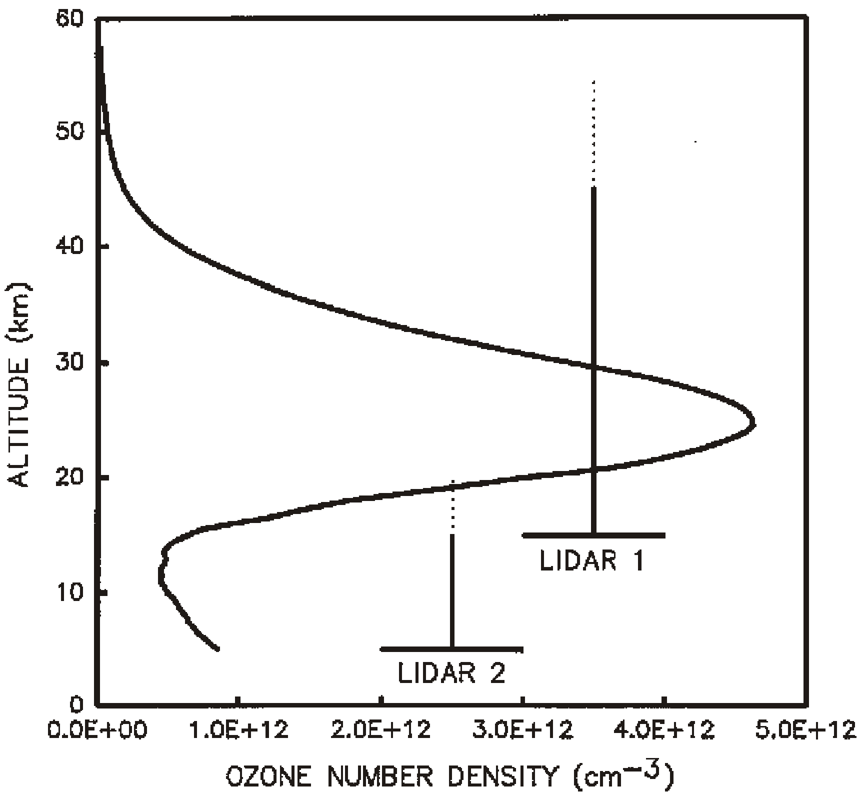
Guillaume Kirgis, Thierry Leblanc, Tao Li
Stuart McDermid



Stratospheric Ozone Interannual Variability Measured by Lidar at MLO

Ozone Differential Absorption Lidar (DIAL)

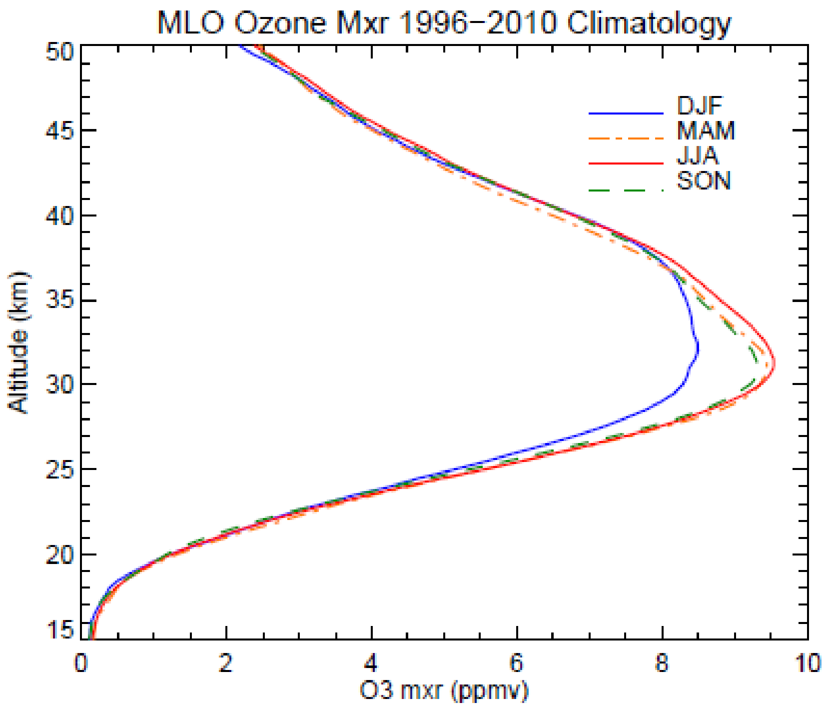


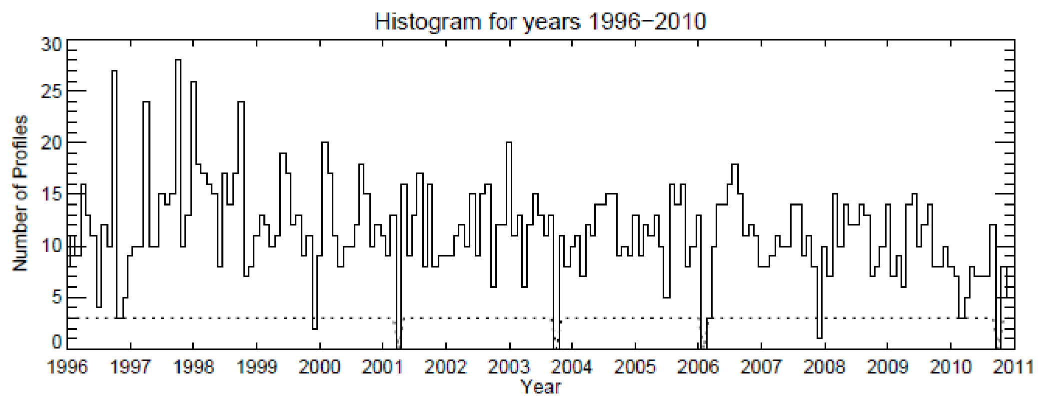
- Troposphere, <20 km
  - Wavelengths <300 nm
  - Typically 289/299 nm
- Stratosphere, 15 – 55 km
  - Wavelengths >300nm
  - Typically 308/355 nm
  - Raman returns 332/387 nm

MLO Lidar Dataset - Questions

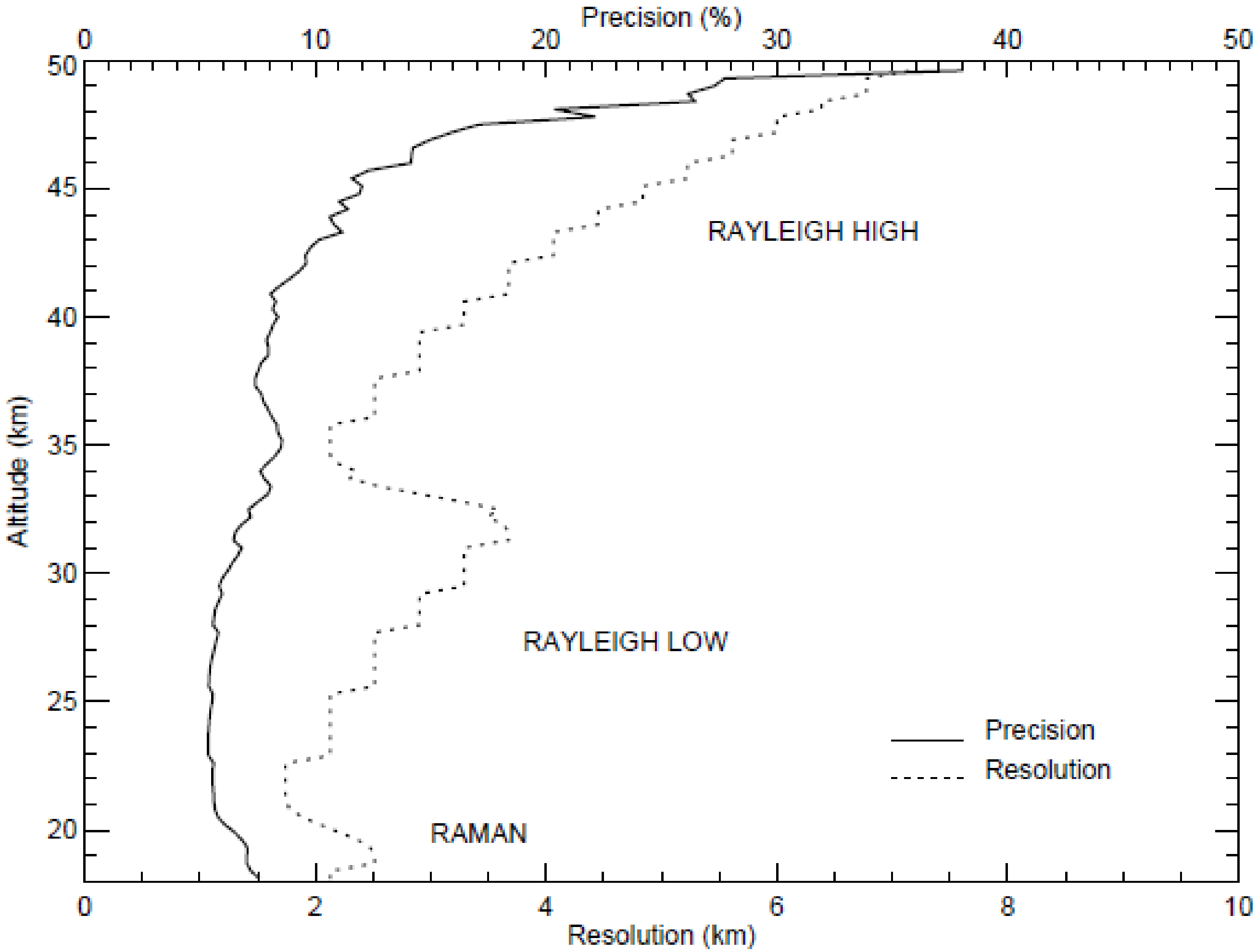
- Lidar data are spatially (vertically) high resolution data for all z<35 km, and most often integrated over several hours
- Is your data set suitable for assessing long-term changes ?
  - Yes, for z = [~20 km - ~40 km]
- How internally consistent is it ?
  - Experimental level - Reasonably consistent
    - DIAL is self calibrating
    - Measurements are made at the same solar time (beginning at the end of astronomical twilight)
  - Retrieval level - Very consistent
- What is the evidence that it is internally consistent ?
- Only one significantly different instrumental configuration (change in 2001)
- Results were produced with the same family of analysis versions (LidAna v5.4 to v6.2)
- Magnitude of annual cycle remains consistent from one year to another (consider at least 150 pts/year)
- How can it be used to evaluate other data sets ?
  - Night-by-night coincidences as well as climatological comparisons are possible
  - Special care must be taken to compare with low resolution and/or instantaneous data (e.g., satellite)
- Can it be used in conjunction with other data sets to provide a long (20-30 year) record ?
  - Yes, as far as sufficient overlap exists (at least a two-years?)

MLO Lidar – Ozone Climatology





MLO Lidar – Precision & Resolution



NDACC - Quality Control

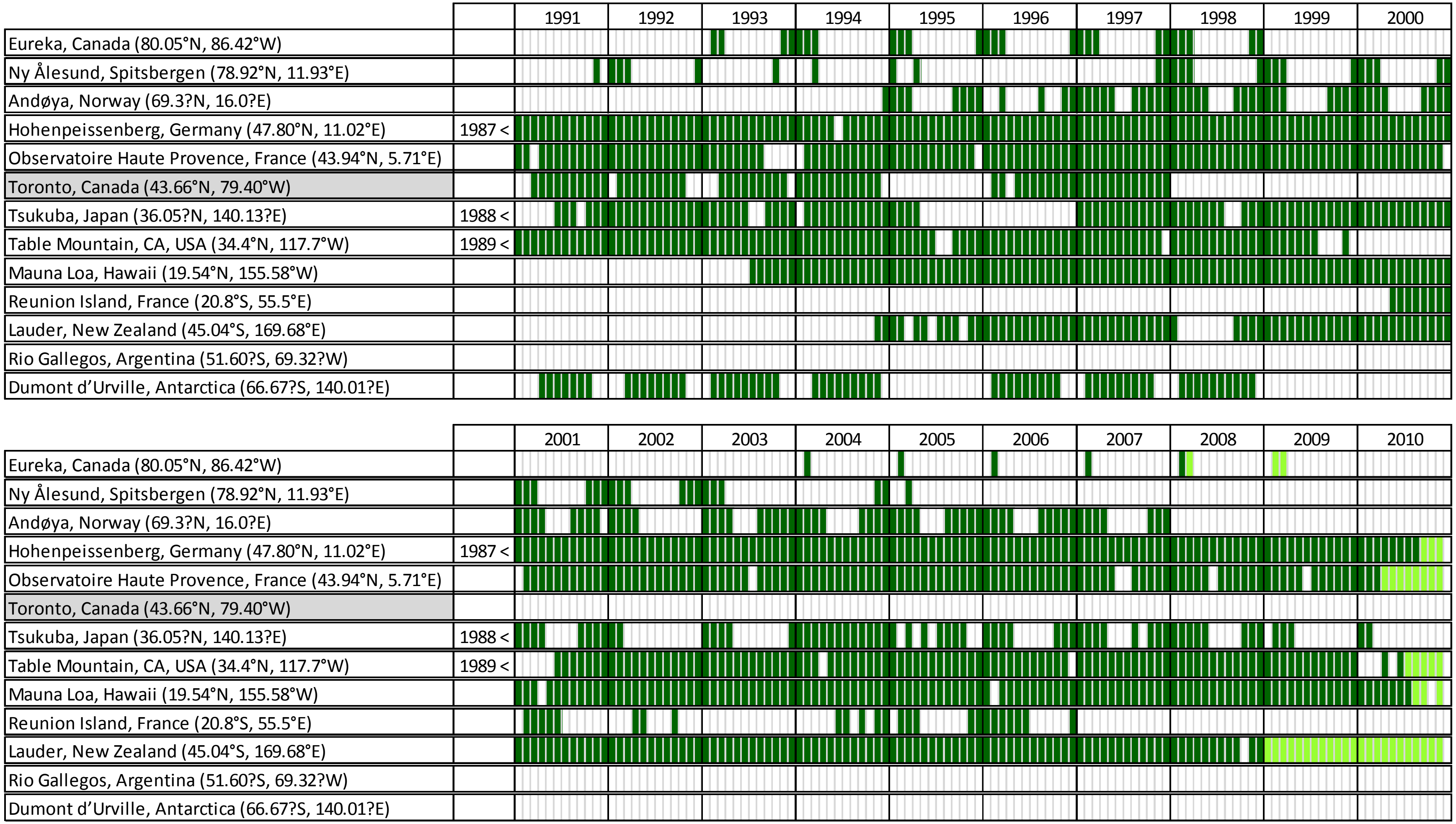
A Commitment to Data Quality

- Investigators subscribe to a protocol designed to ensure that archived data are of as high a quality as possible within the constraints of measurement technology and retrieval theory
- Validation is a continuing process
  - Instruments and data analysis methods are evaluated prior to NDACC acceptance and are continuously monitored throughout their use.
  - Formal intercomparisons are used to evaluate algorithms and instruments

NDACC Stratospheric Ozone Data Available

LIDAR Stratospheric Ozone

Last update: October 1, 2010

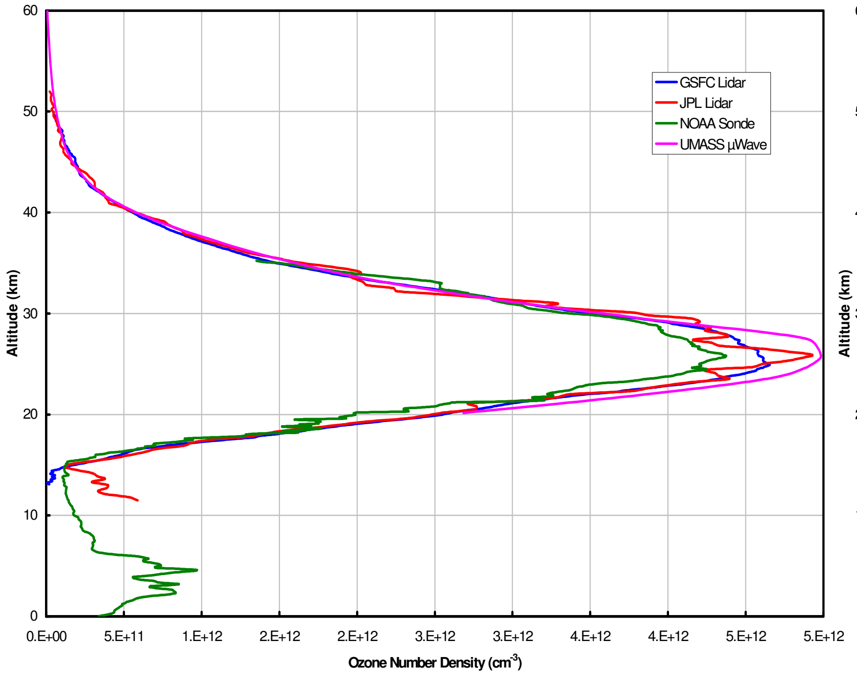


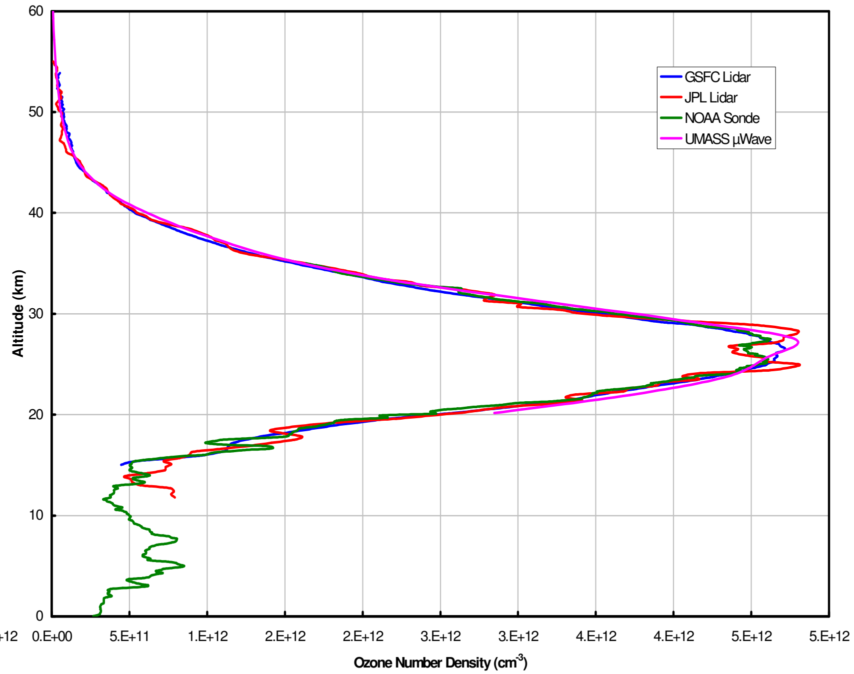
Mobile Lidars for Intercomparisons

- McGee (GSFC)
- “Ozone Trailer”
  - O_3, T, Aerosol, H_2O
- “AT Trailer”
  - T, Aerosol, H_2O
- Sites visited
  - TMF (Many)
  - MLO (2)
  - Lauder (2)
  - OHP
  - Ny Alesund
  - Hohenpeissenberg

NDACC-MLO Validation Campaign 2002

Worst and Best Intercomparisons





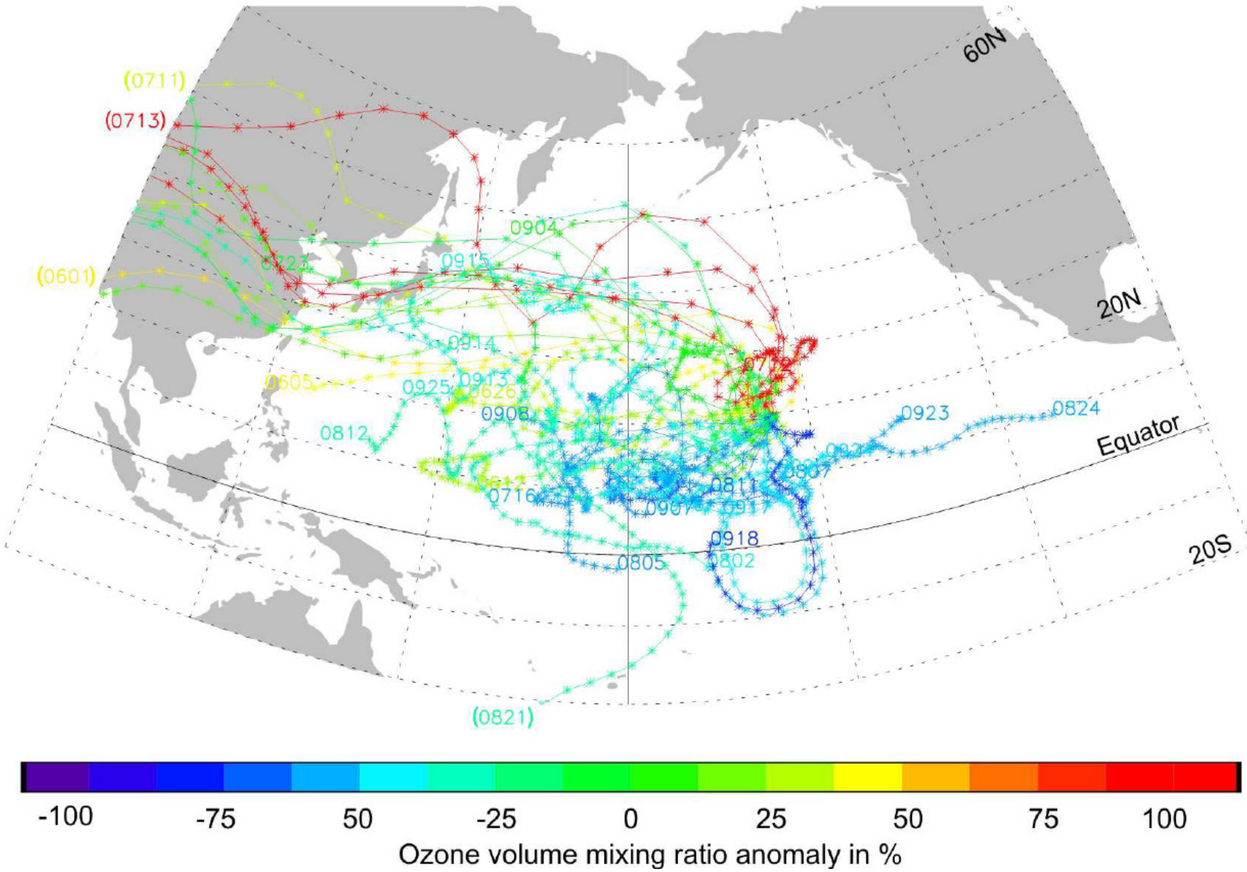
JPL Lidar – Satellite Validation

Satellite	Instrument	References		Satellite	Instrument	References
ERBS	SAGE II	McDermid et al, 1990 (2) Tsou et al, 1995		TIMED	SABER	Garcia-Comas et al, 2003
UARS	MLS	Fishbein et al, 1996 Froidevaux et al, 1996 Wu et al, 2003		ENVISAT	GOMOS	Meijer et al, 2004, 2006, 2007 Stebel et al, 2006
	CLAES	Gille et al, 1996 Bailey et al, 1996			MIPAS	Fricke et al, 2004 Cortesi et al, 2007 Meijer et al, 2006, 2007
	HALOE	Bruhl et al, 1996 Hervig et al, 1996			SCHIAMACHY	Von Savigny et al, 2005 Brinksma et al, 2004, 2006 Rosanov et al, 2007 Meijer et al 2007
	HRDI	Leblanc et al, 1999 (2)		DMSP-F16	SSMIS	Swadley et al, 2008
NOAA	SBUV-2	Planet et al, 1995		SCISAT-1	ACE	Sica et al, 2008 Depuy et al, 2008
CHAMP	GPS	Beyerle et al, 2003		AURA	MLS	Leblanc et al, 2006 Jiang et al 2007
ERS-2	GOME	Meijer et al, 2006 Iapolo et al, 2007			HRDLS	Nardi et al, 2008
ODIN	SMR	De la Noë, 2002 Jégou et al, 2008			TES	

Issues and Concerns

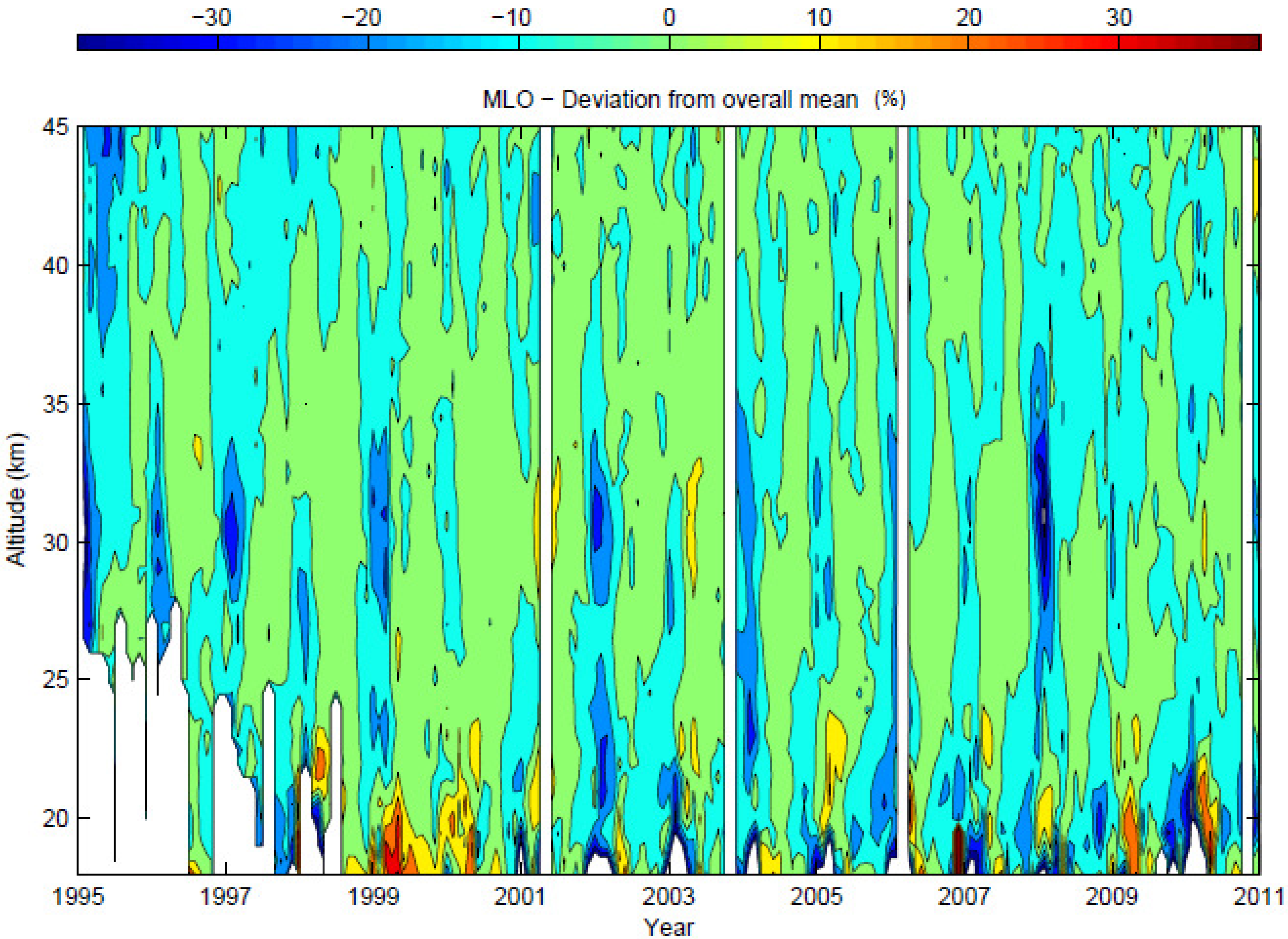
- Cross sections – ACSO WMO/IO3C Initiative
  - How accurately are they known, especially temperature dependence?
  - Are we using the best values?
  - How do we achieve uniformity between techniques?
- Resolution – Leblanc ISSI Project
  - How to define?
  - How do we achieve uniformity between techniques?
- Intercomparisons – how to reconcile?
  - Number density vs geometric altitude (lidar)
  - Partial pressure vs pressure (high resolution ozonesonde)
  - Mixing ratio vs pressure (low resolution satellite)

Ozone Relationship to Airmass Origin



10-day backward trajectories at 350 K for 51 air parcels sampled by the MLO lidar between 1 June and 30 September 2002. Each trajectory is color-coded by the deseasonalized ozone mixing ratio measured by the lidar.

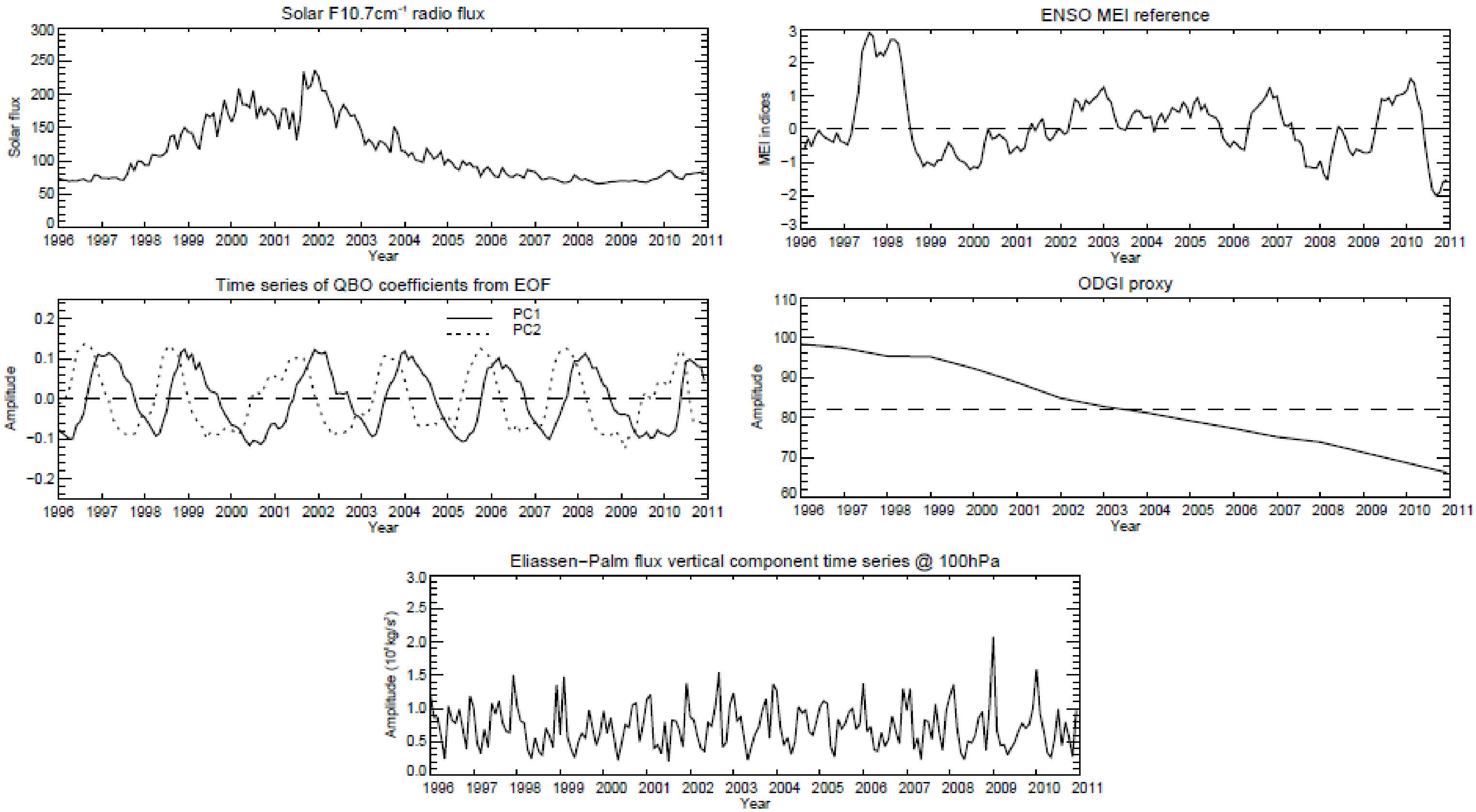
MLO Ozone Time Series



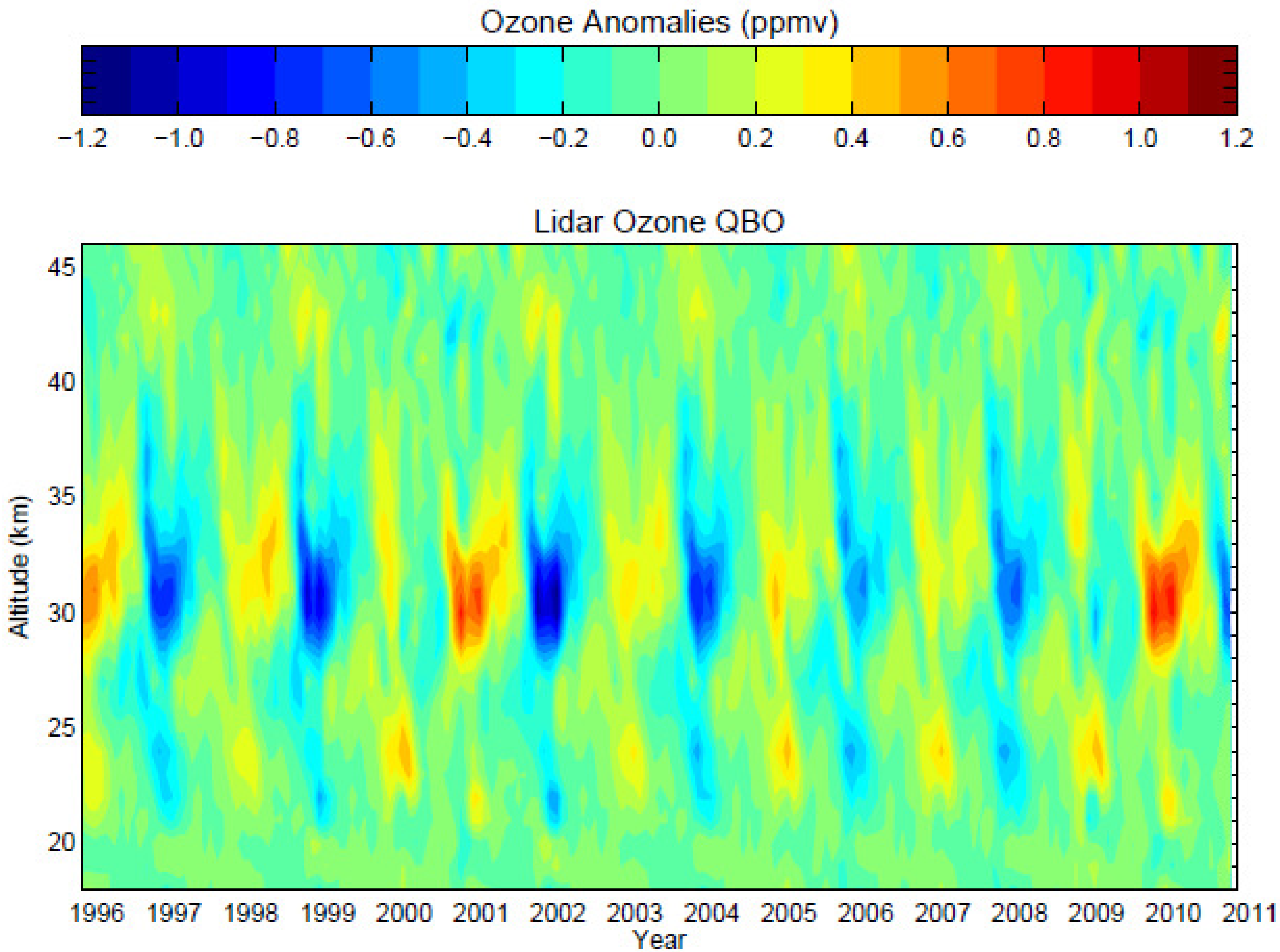
Ozone Time Series Regression Analysis

$$\mathrm{O3(t)} = (\mathrm{O3mxr})_{\mathrm{mth}} - \mathrm{mean}_{1996\text{-}2010}[(\mathrm{O3mxr})_{\mathrm{mth}}]$$

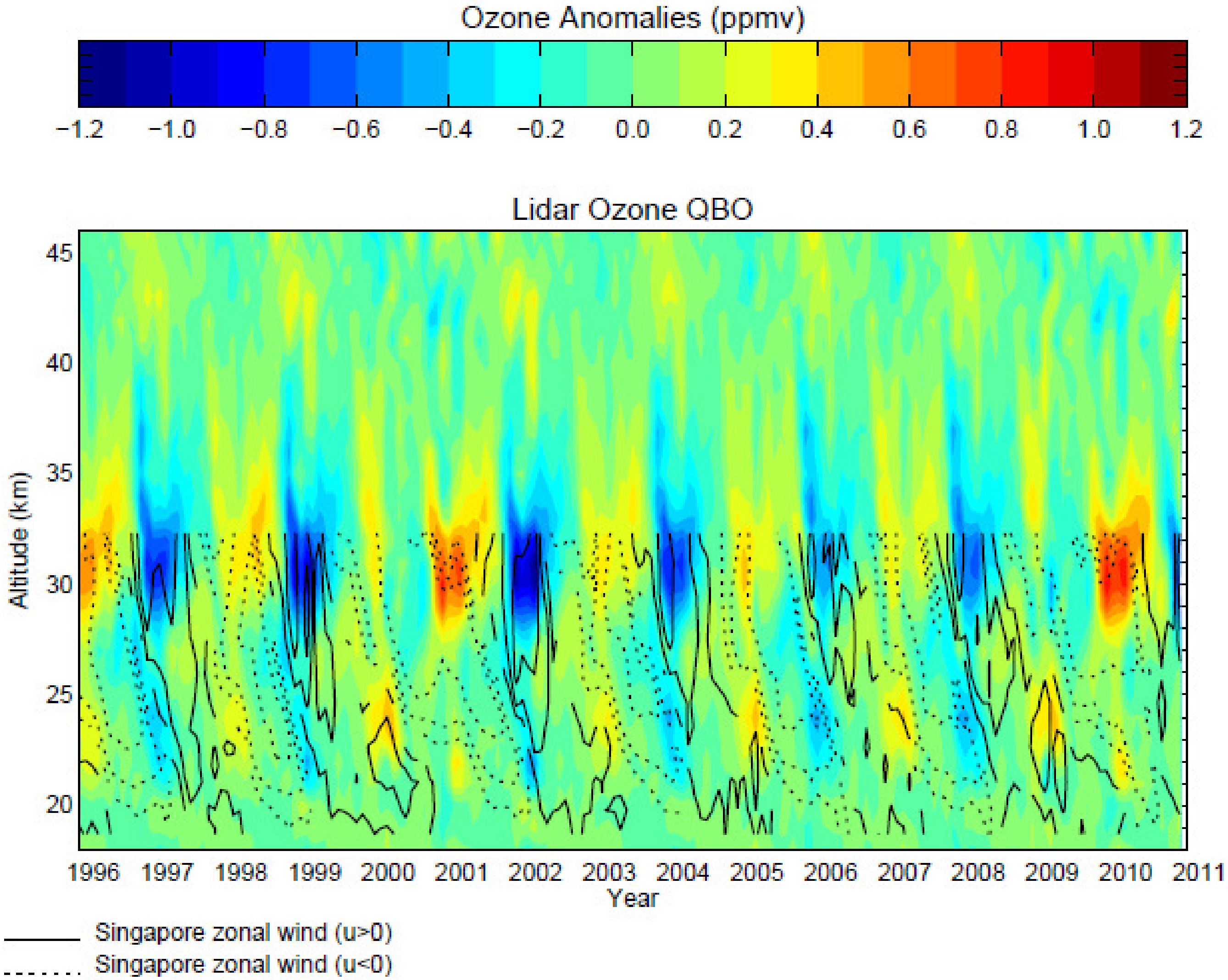
$$\mathrm{O3(t)} = \alpha \bullet \mathrm{trend} + \beta \bullet \mathrm{solar} + \gamma_1 \bullet QBO_1 + \gamma_2 \bullet QBO_2 + \varepsilon \bullet ENSO + \mu \bullet ODGI + \psi \bullet EPflux + residual$$



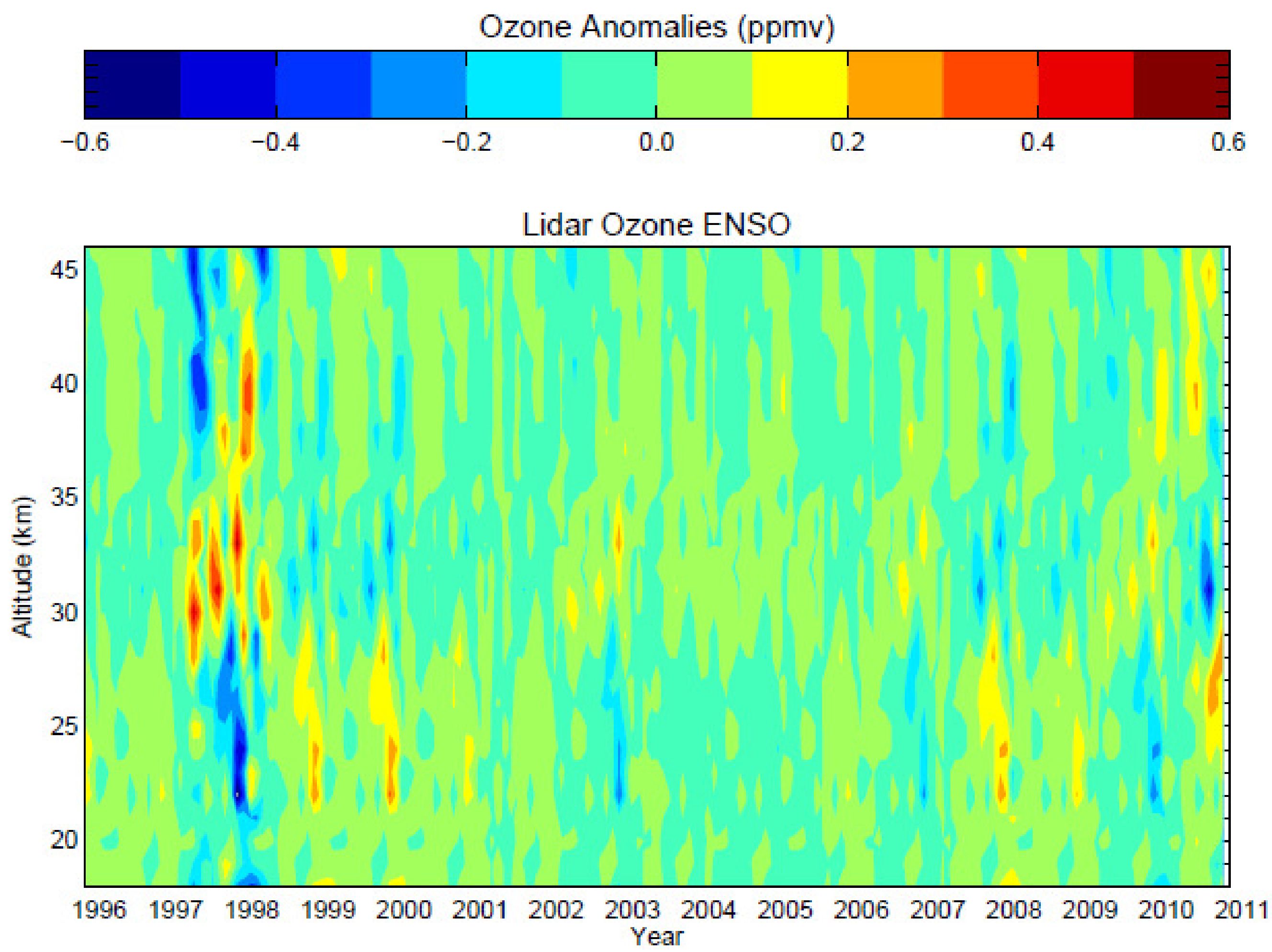
Ozone Variations Response to the QBO



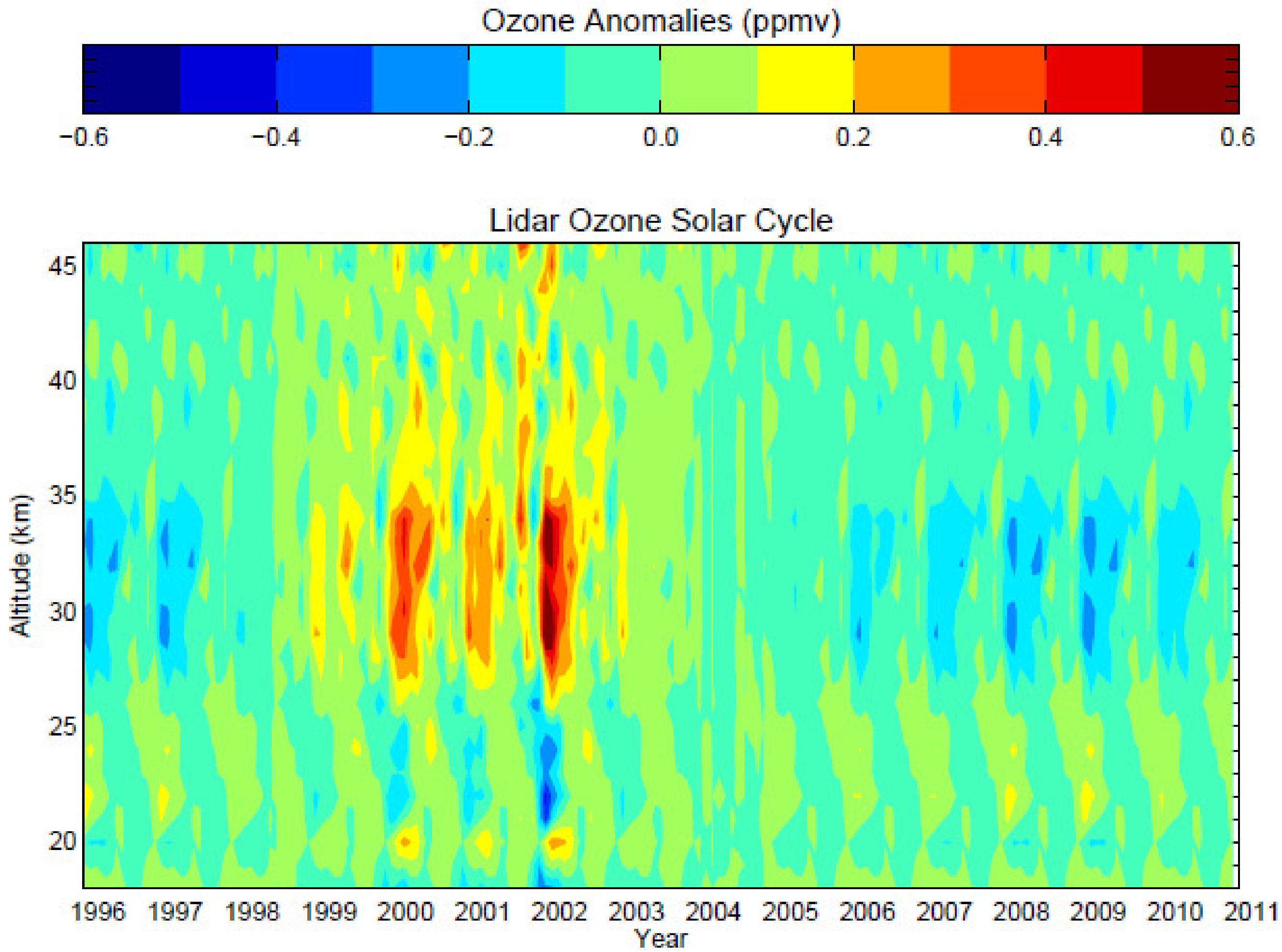
Ozone Variations Response to the QBO



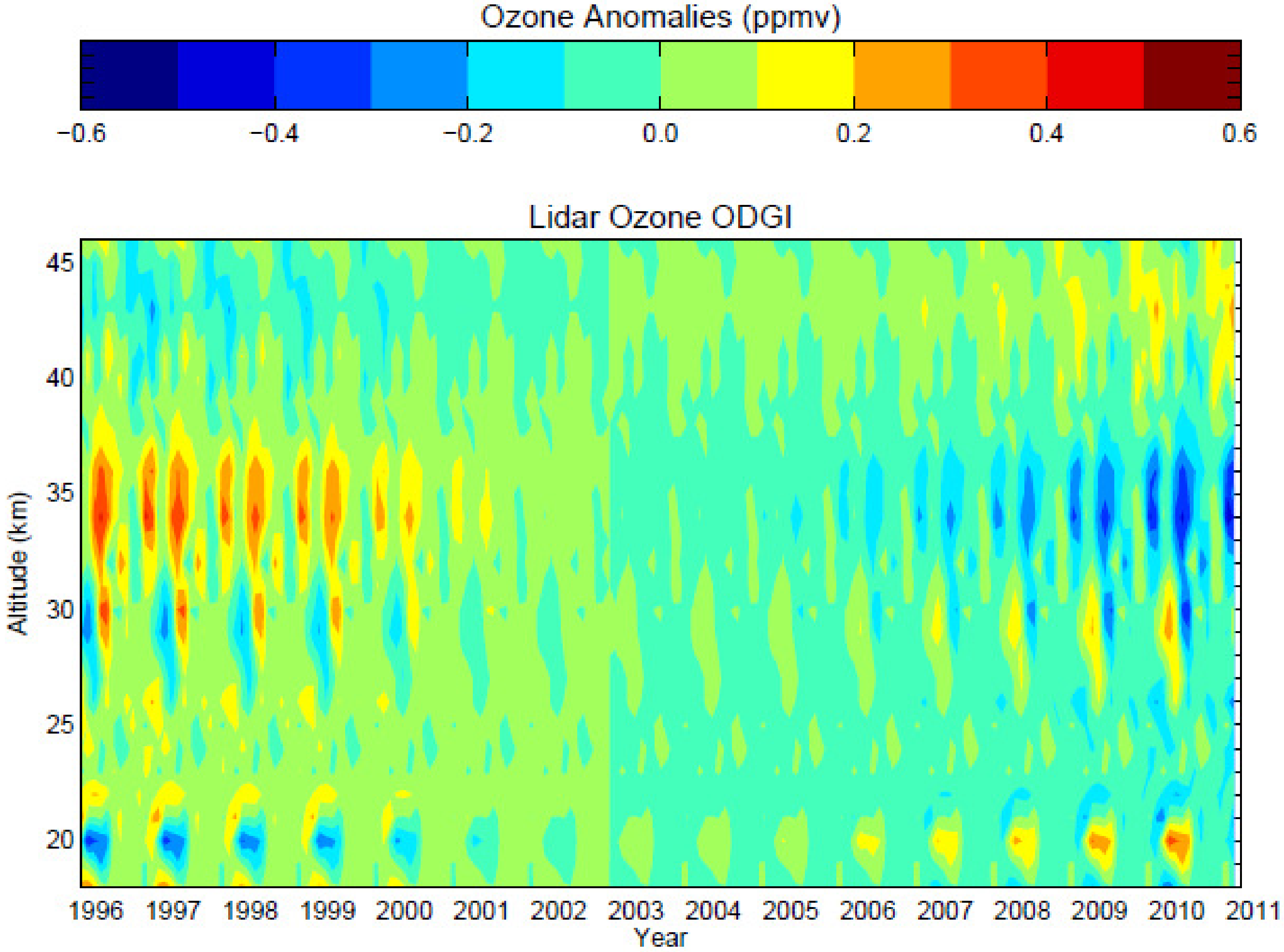
Ozone Variations Response to the ENSO



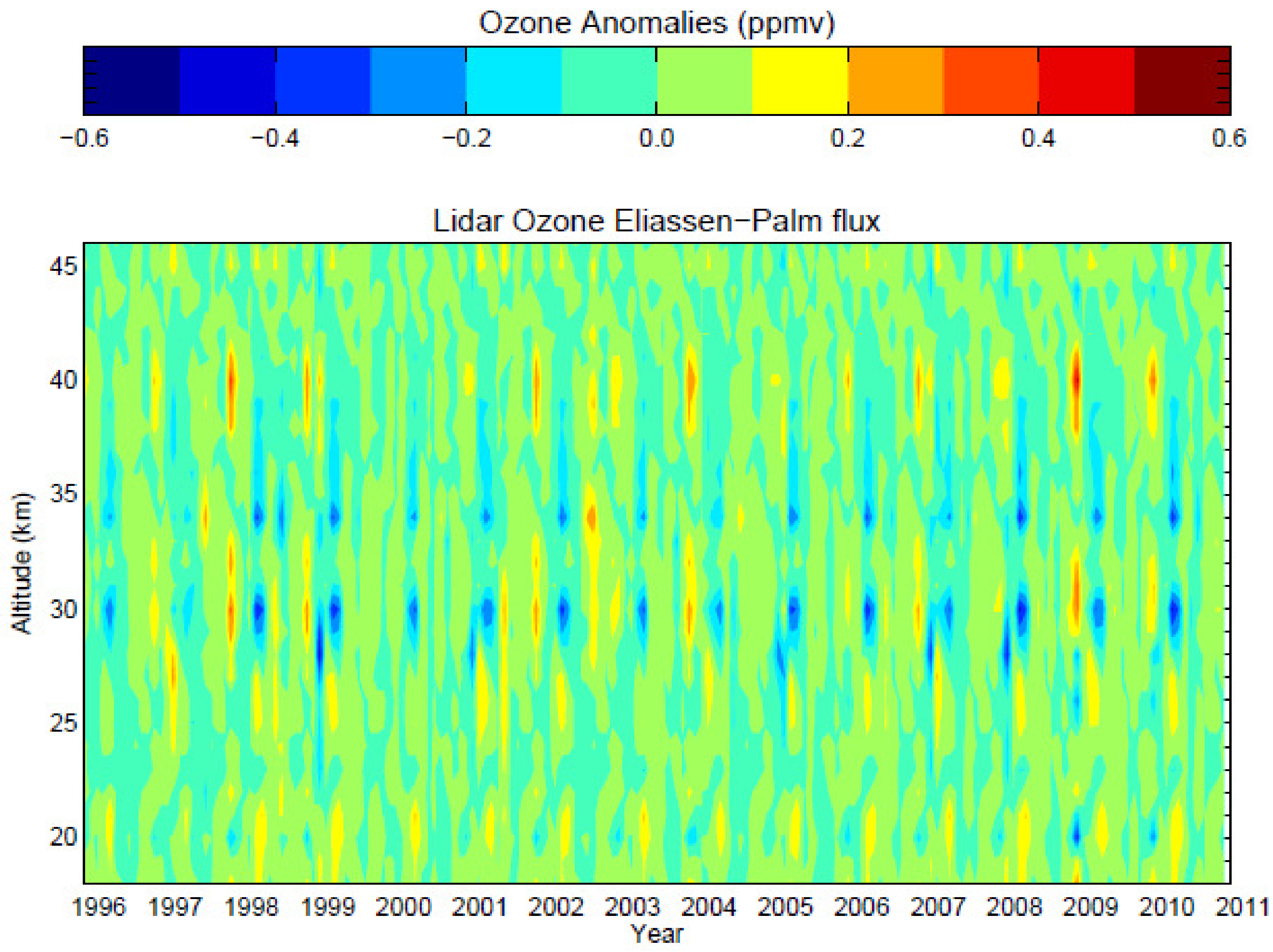
Ozone Variations Response to the Solar Cycle



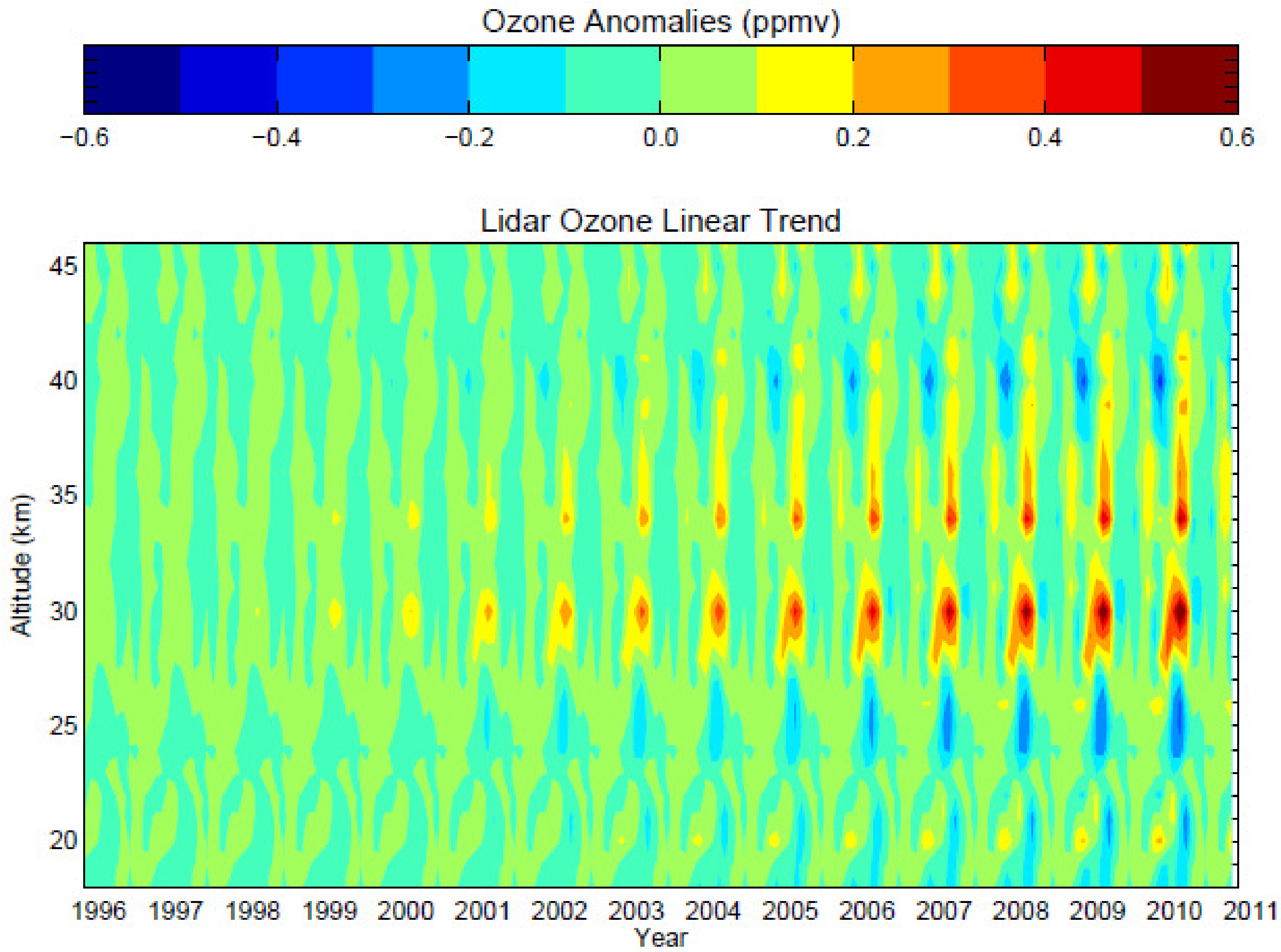
Ozone Variations Response to the Depleting Gas Index



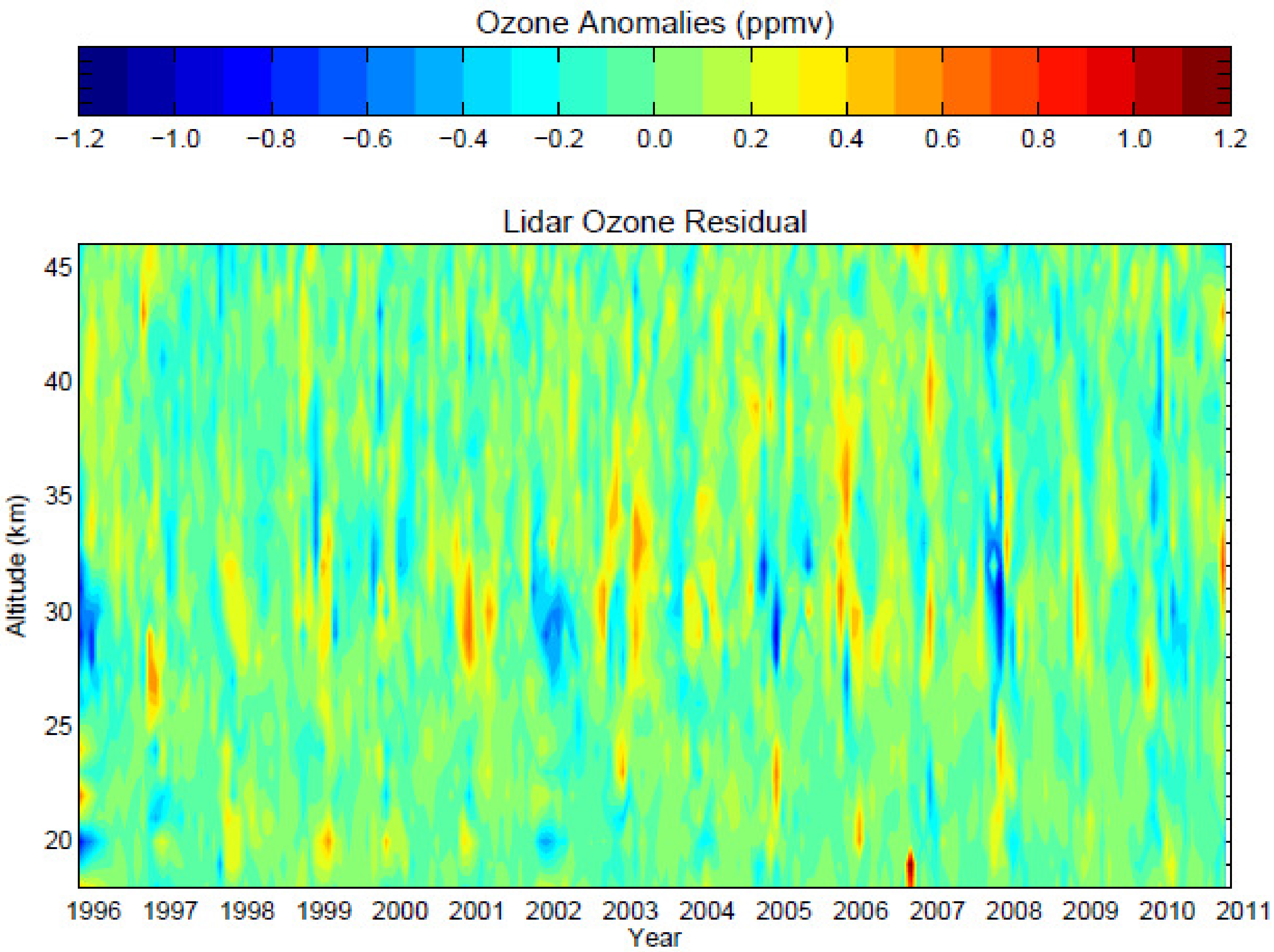
Ozone Variations Response to the EP Flux



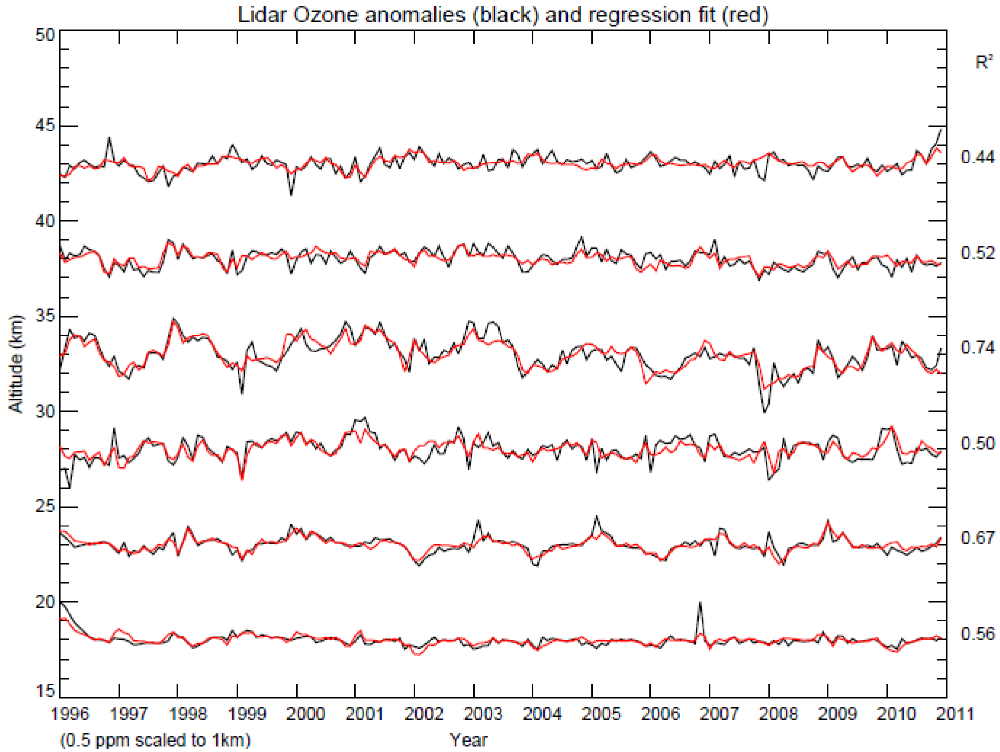
Lidar Ozone Linear Trend

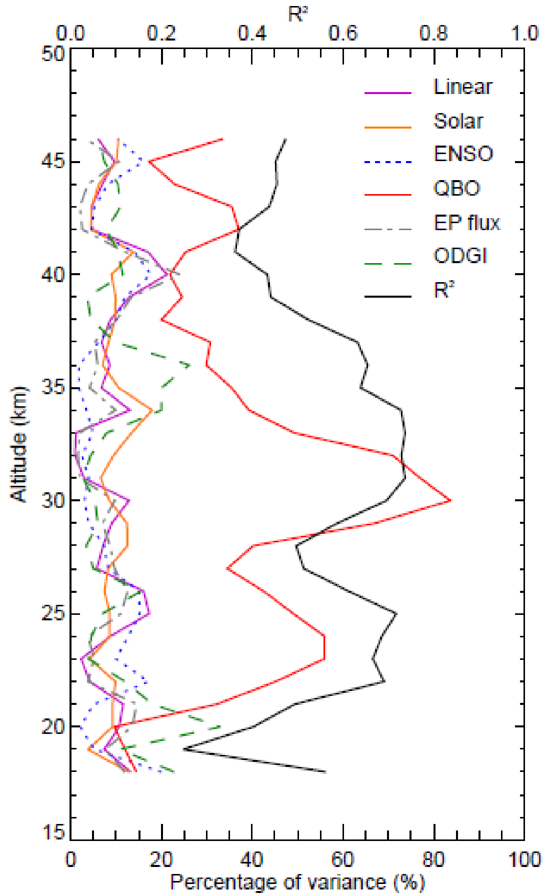


Regression Analysis Residuals

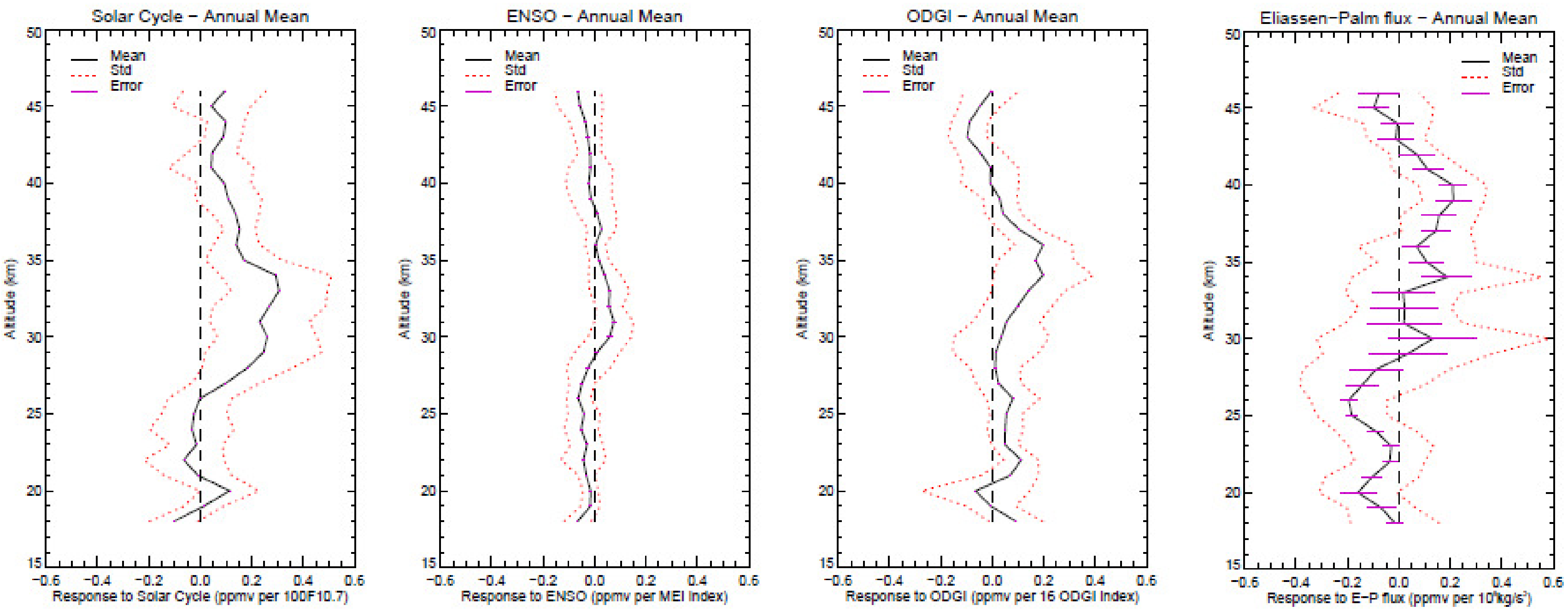


MLO Ozone Time Series Regression Analysis





Summary of Responses to the Regression Parameters



MLO Ozone Time Series Regression Analysis