Using EOF analysis to qualitatively analyze, and identify inhomogeneities in, data from ground-based aerosol monitoring instruments

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What are EOF’s?

- Empirical orthogonal functions
- Method of simplifying data analysis
- Multidimensional data set can be expressed as small number of significant eigenvectors

Examples of EOF analysis on atmospheric data

- *Chelliah and Arkin* [1992]: found artifacts in satellite data
- *Box et al.* [1996]: Used EOF's to determine the limits of retrievable aerosol information given limits in the measurements
- *Rabbette and Pilewskie* [2001]
  - Looked at incoming solar radiation at high spectral resolution
  - Could separate different influences on incoming radiation
  - Also found data artifacts

Mathematics of EOF's

- Let **F** be an MxN matrix
  - M=number of mornings or afternoon for which optical depth data exists
  - N=number of wavelengths in device
- Covariance matrix: $\mathbf{R}=(\mathbf{F}*\mathbf{F}^T)/N$
- Vector that explains largest fraction of total variance in a data set is the eigenvector of **R** with the largest eigenvalue

Mathematics of EOF's (ctd.)

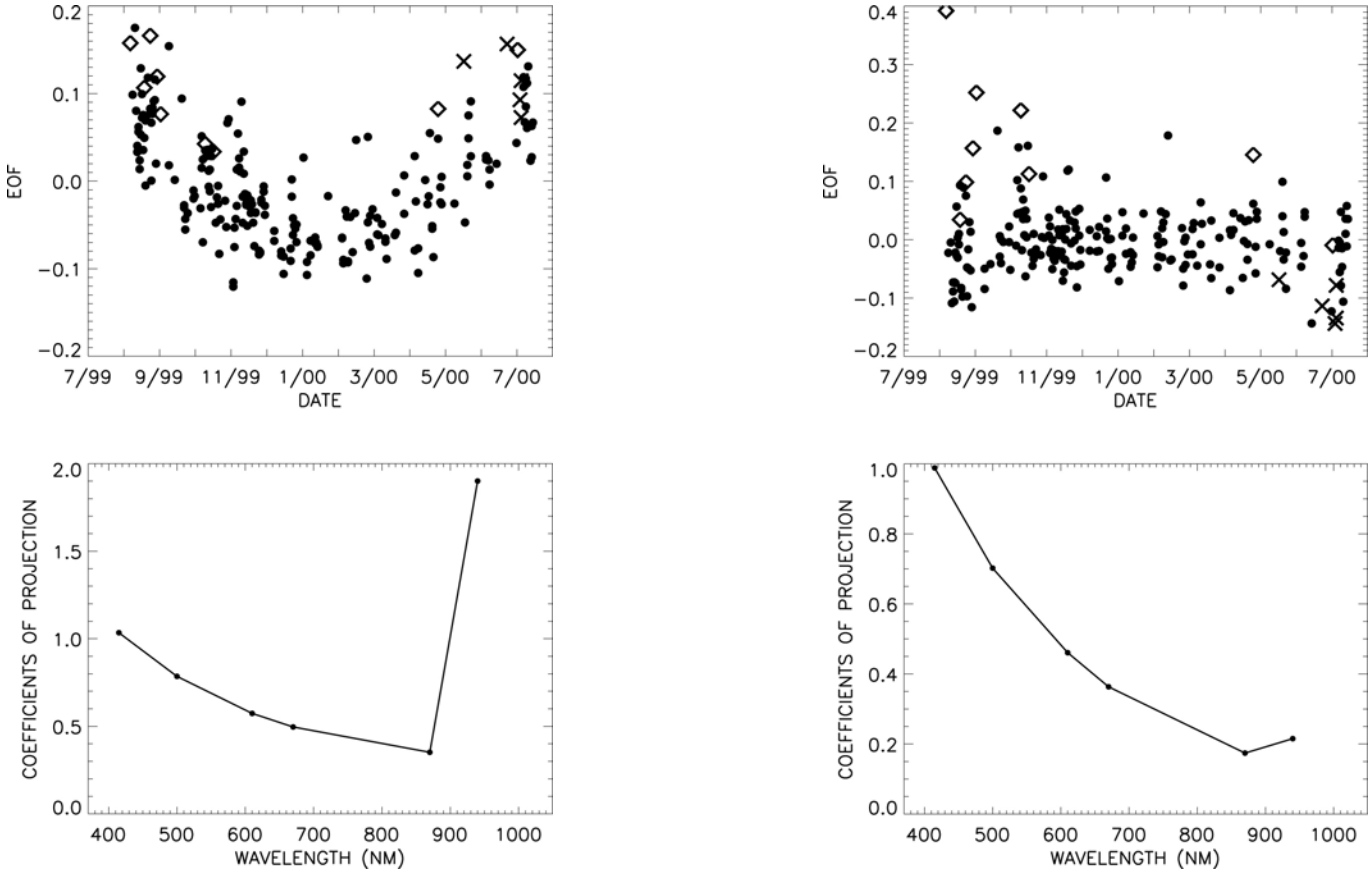
- Eigenvectors in this example are functions of day
- Eigenvector matrix **E**: first column is first eigenvector, etc.
- Coefficients of projection
  - $\mathbf{C} = \mathbf{E}^T * \mathbf{F}$
  - Coefficients are functions of wavelength

Instrumentation

- SGP MFRSR network (C1 and extended facilities)
- RSS 102 and 105
- “MFRSR equivalent”: isolate RSS wavelengths that correspond to MFRSR wavelengths
- CIMEL at SGP

Qualitative Bimodal Aerosol Information in EOF’s

First two EOF's of "MFRSR equivalent" set

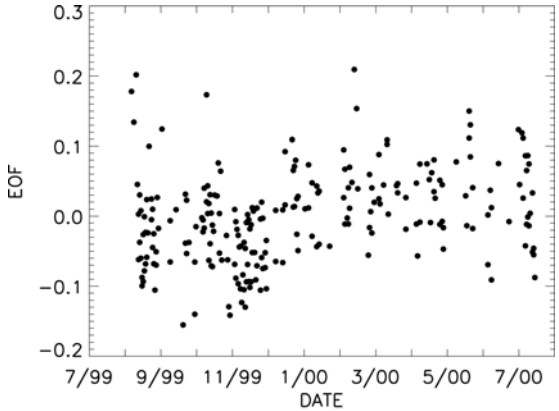


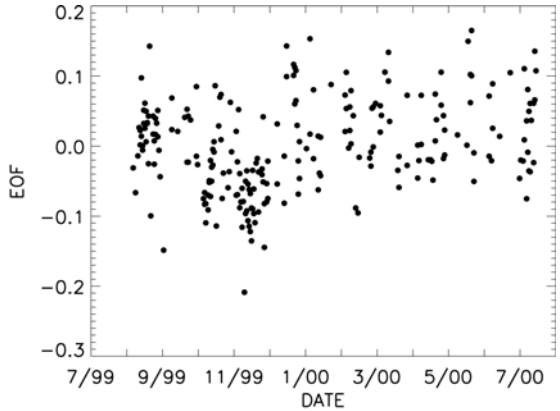
Comparing results from “MFRSR equivalent” with co-located MFRSR’s

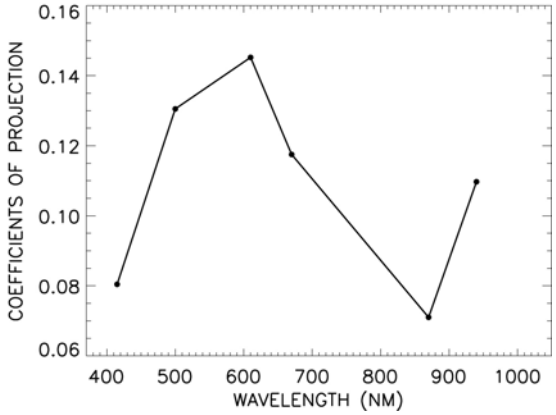
	RSS 102	USDA MFRSR	ARM MFRSR
high fine mode days:	10/6/99, 7/2/00	10/6/99, 4/18/00, 7/2/00	10/6/99, 4/18/00, 7/2/00
high coarse mode days:	6/23/00, 7/5/00	2/25/00, 6/23/00, 7/5/00	2/25/00, 6/23/00, 7/5/00

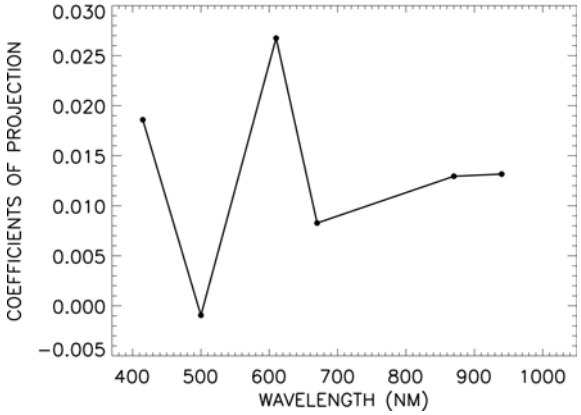
Anomalous Optical Depth Measurements in MFRSR Filters

Third and fourth EOF's of "MFRSR equivalent" set

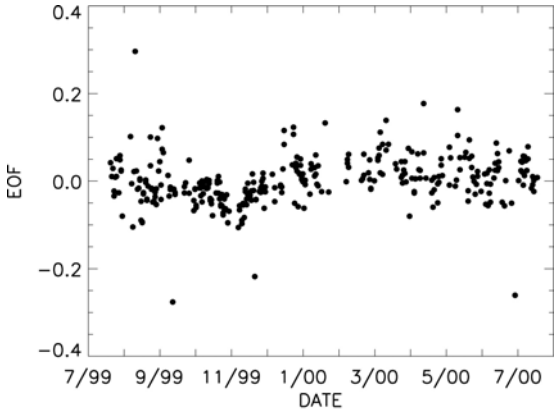


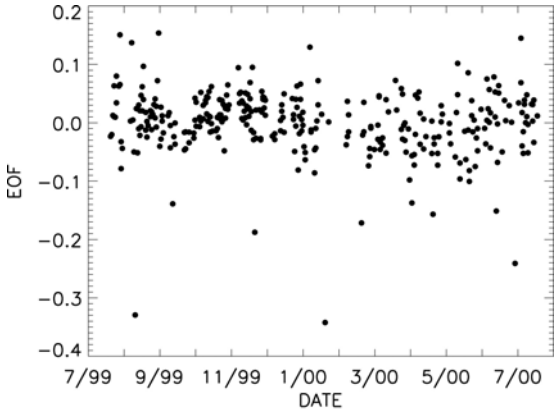


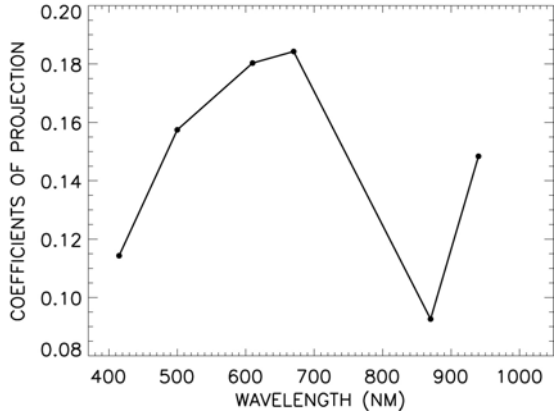


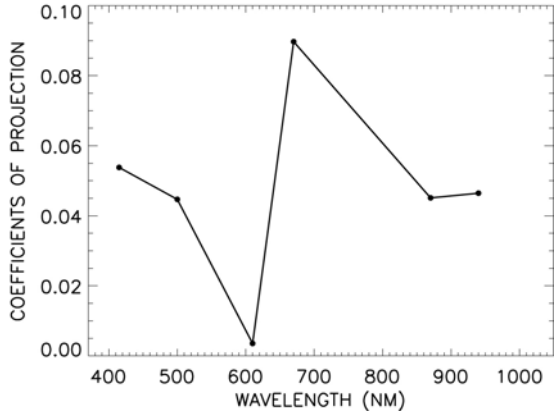


Third and fourth EOF's at E5

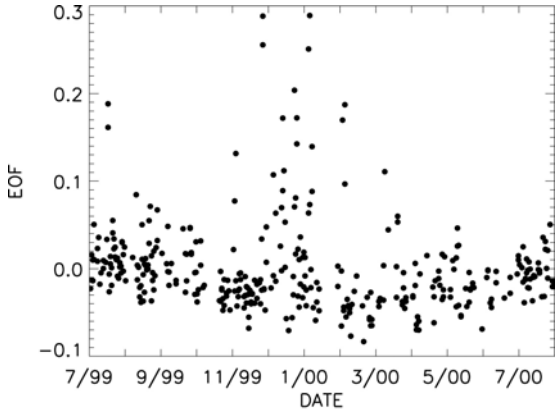


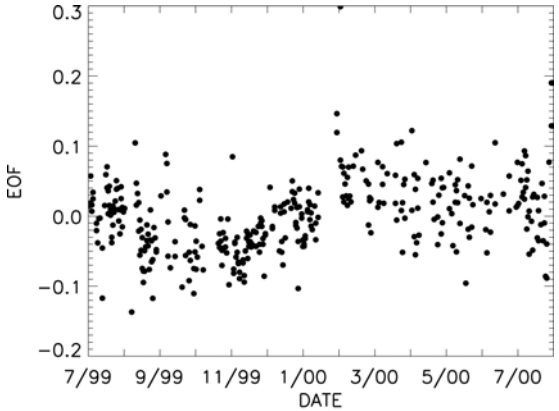


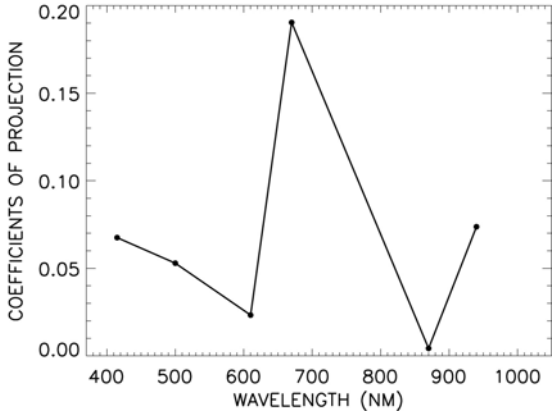


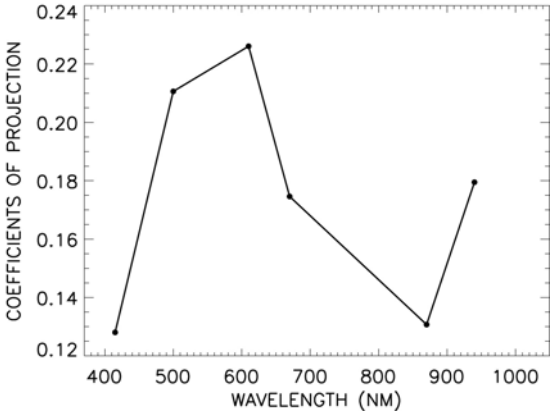


Third and fourth EOF's at E16

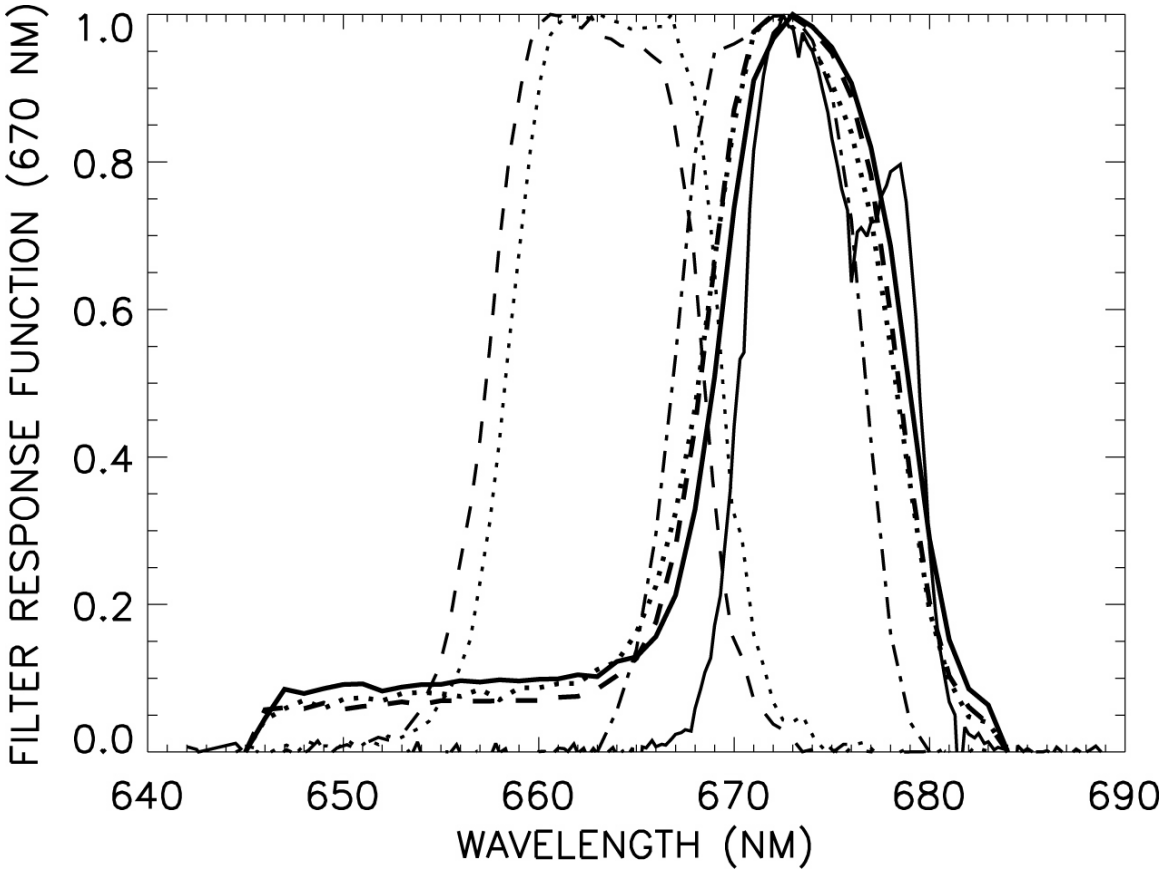






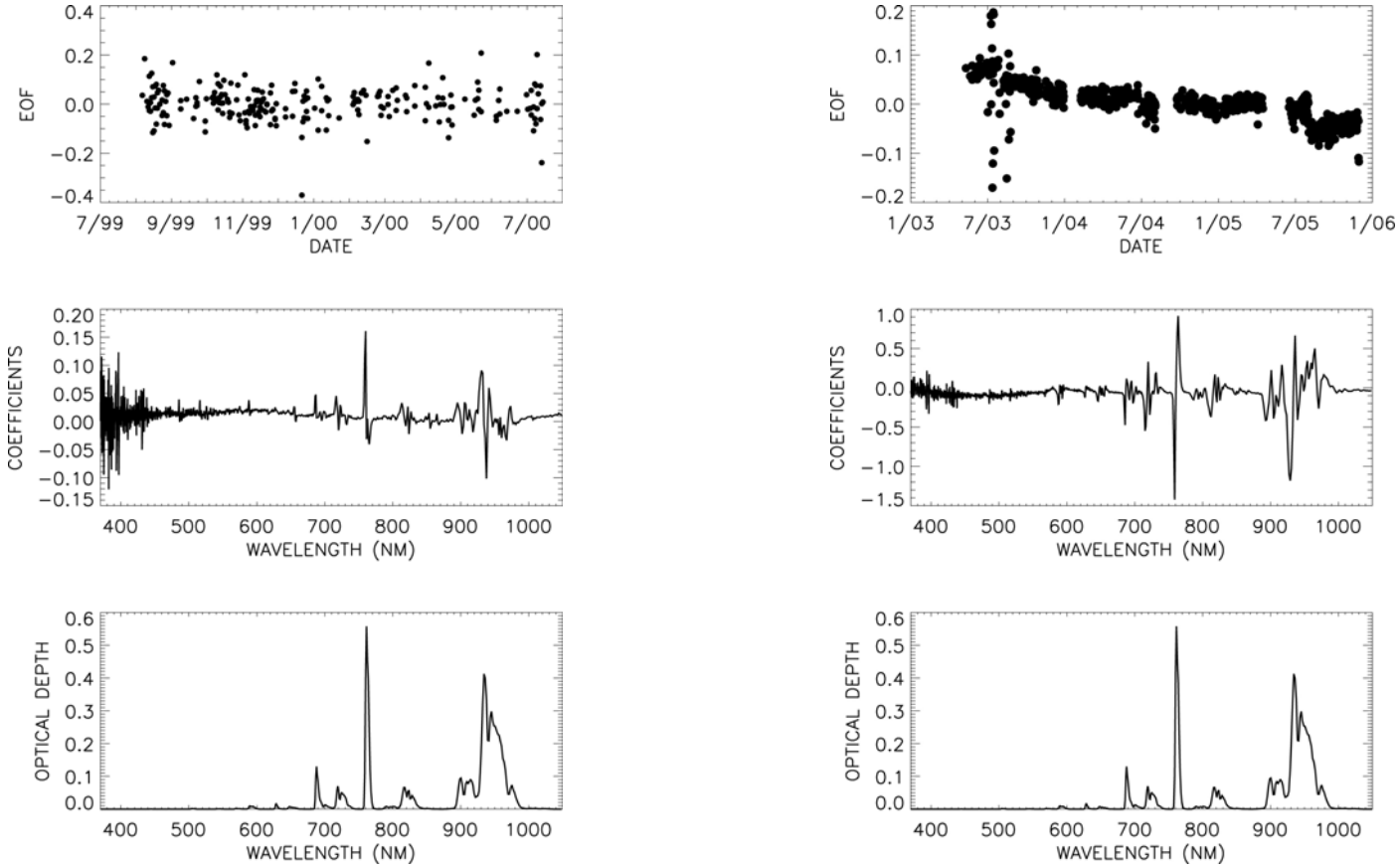


Filter functions for fourth MFRSR channels in extended network



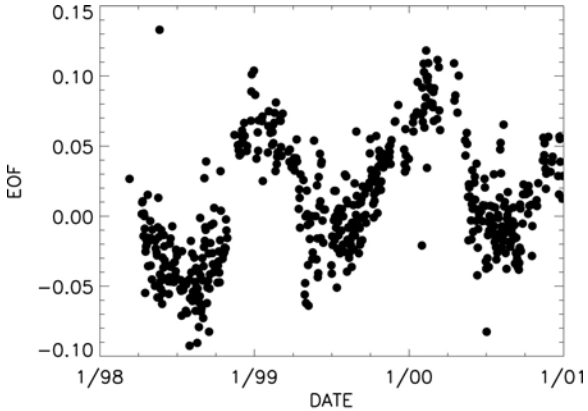
Wavelength Shifts in RSS Data

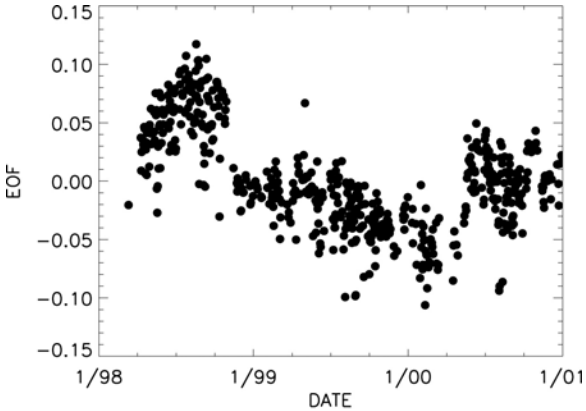
Left: Fifth eigenvector of RSS 102
Right: Fourth eigenvector of RSS 105

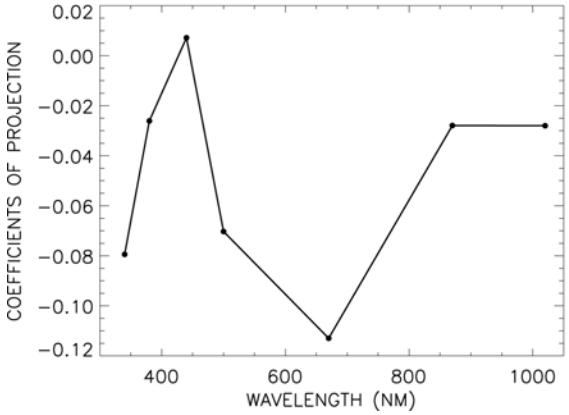


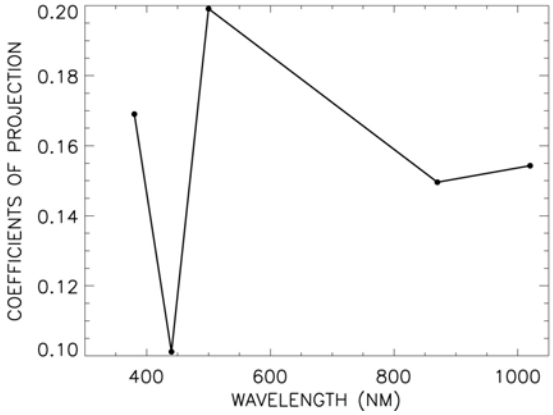
Problems with the Data Transmitter of the CIMEL at SGP

Left: Third eigenvector of CIMEL
Right: without 340 and 670 nm

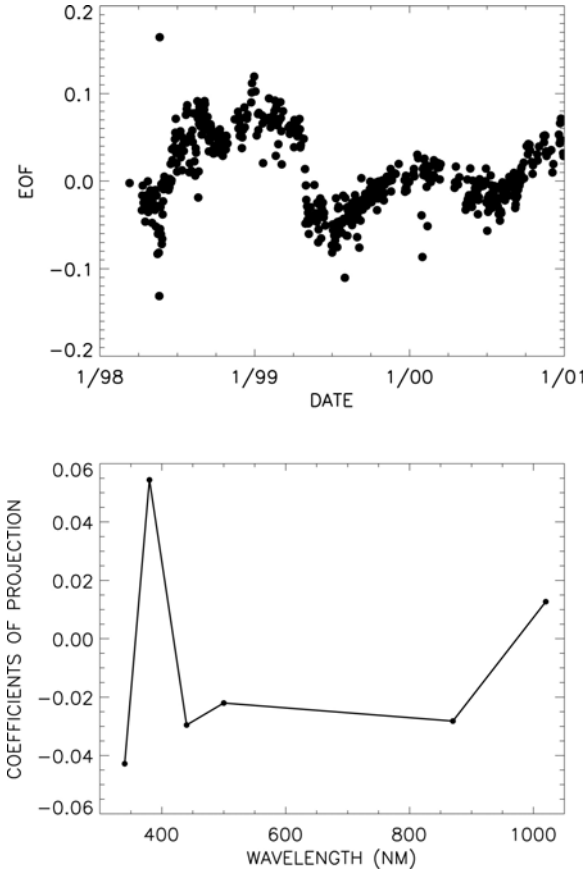


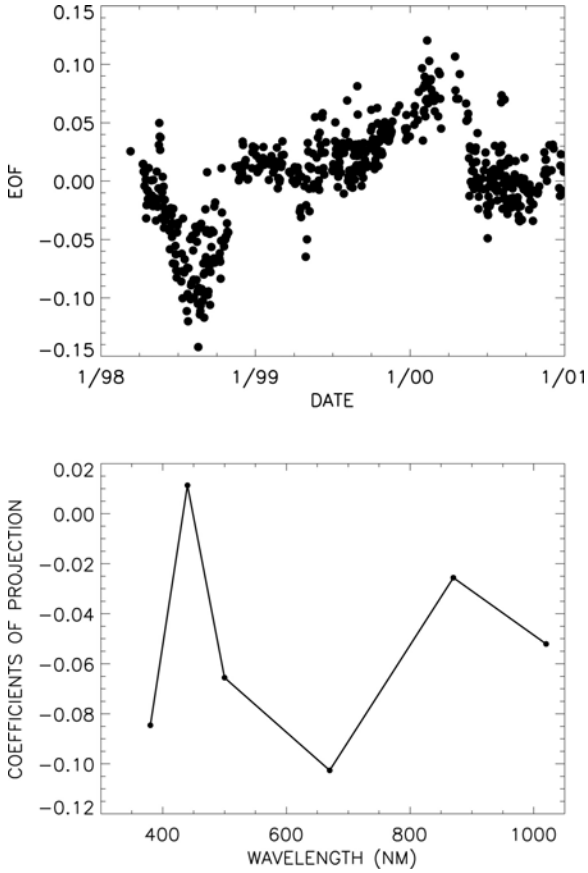






Left: with 340 nm, without 670 nm
Right: with 670 nm, without 340 nm





Conclusions

- EOF’s provide rapid analysis of full, multi-dimensional data sets
- Qualitative information on contributors to atmospheric extinction
- Can determine if device is behaving properly
- Can isolate specific days where specific channels didn’t perform properly