Instrumental and Methodological Developments in UV Research

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• Instrumental Developments
• Intercomparisons
• Correction Methods
• Methods for Interpreting UV Data
Single-Channel Broadband Radiometers

From: COST/LAP/WMO intercomparison, Thessaloniki, Greece, in 1999
Single-Channel Broadband Radiometers

Multichannel Filter Instruments

FARIN intercomparison, Oslo, Norway, 2005

Biospherical Instruments Inc.  www.biospherical.com/nsf
Multichannel Filter Instruments

From: G. Bernhard, C.R. Booth, and J.C. Ehramjian, Real-time UV and column ozone from multi-channel UV radiometers deployed in the National Science Foundation’s UV monitoring network, Optical Engineering, 44(4), 041011-1 - 041011-12, 2005.
**Calibrations methods:**

1. **Raw data** → 1st guess Erythemal Irradiance → Erythemal Irradiance
   - Comparison with Spectroradiometer → Correction for SZA, Ozone

2. **Raw data** → Spectral Irradiance → Erythemal Irradiance
   - Comparison with Spectroradiometer → Inversion

3. **Raw data** → “Response weighted irradiance” → Erythemal Irradiance
   - Spectral Response Functions → Inversion

4. **Raw data** → Direct irradiance → Global irradiance → Erythemal Irradiance
   - Langley Plots → Inversion

5. **Raw data** → Reconstructed Spectrum → Erythemal Irradiance
   - Inversion → Weighting
Multichannel Filter Instruments

New developments

• Miniaturization
• New geometries
• Larger dynamic range
• High sampling rates (>15 Hz)
• Improved data reduction procedures
Spectroradiometers

SUB-150 Spectroradiometer at Summit, Greenland
Stray Light Correction


Correction is done by “subtracting the mean apparent irradiance measured between 290 and 292.5 nm from the whole spectrum.”

Correction based on information gained from scanning the 325 nm line of the helium cadmium laser.

**Figure 3.** Example of stray light correction for a spectrum measured by Brewer instrument 14. The relative contribution of stray light as a function of wavelength is also shown.
UV-Rotating Shadowband Spectroradiometer (UV-RSS)

Published Applications:
Global, direct and diffuse irradiance, aerosol retrievals, determination of extraterrestrial solar spectrum, column water vapor, photon pathlength, cloud optical depth

From: Yankee Environmental Systems Inc., product description
UV-Rotating Shadowband Spectroradiometer (UV-RSS)

Figure 17: Slit scattering function.

PAN-1 CMOS spectrometer

CCD-based Spectrograph

New “front ends”

- Development of input optics with small cosine error
- Actinic flux
- Radiation on inclined surfaces
- Sky scanners (also including polarization)
- “Variable Sky Platform”

Results of 21 Intercomparisons

A. Number of Participants

B. Maximum Overestimation

C. Maximum Underestimation

D. Fraction within ±15% of Core Group

E. 2\sigma (Standard Deviation of Difference)

F. 2\sigma-Uncertainty
Deterioration of Calibration Standards

**Figure 2a.** Normal evenly spaced coiled-coil filament

**Figure 2b.** Abnormal warped tungsten filament

Need for lower uncertainty

• Calculation of extraterrestrial spectrum via Langley plots
• Satellite validation
• Model validation
• Process studies
• Simultaneous retrieval of albedo and cloud optical depth
Simultaneous Retrieval of Albedo and Cloud OD

“This high sensitivity of optical thickness to calibration error is rather disturbing, considering the fact that it is extremely difficult to calibrate instruments to better than ±5%.”


**Figure 2.** DISORT model calculations of downwelling surface irradiance of the 630-nm (solid) and 410-nm (dashed) bands for a solar zenith angle of 65°.
<table>
<thead>
<tr>
<th>Correction</th>
<th>SHICrivm</th>
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<tr>
<td>Cosine error correction</td>
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<td>Model spectra for clear skies</td>
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<tr>
<td>Model spectra for cloudy skies</td>
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<td>Normalization to standard bandpass</td>
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<tr>
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<tr>
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</table>
Comparison of Wavelength-Shift Programs

From: NSF Version 2 Network Data, Volume 15, Summit
SHICrvm Flagging

From: http://www.muk.uni-hannover.de/~martin/database.html
Detection of distorted spectra

From: NSF Version 2 Network Data, Volume 15, Summit
Detection of Distorted Spectra

From: NSF Version 2 Network Data, Volume 10, Barrow
Determination start wavelength

From: NSF Version 2 Network Data, Volume 16, McMurdo
Methods for Interpreting UV Data

• Statistical methods
  ➔ Climatological information, geographical differences, trends

• Process studies
  ➔ Correlation with factors affecting UV
  ➔ Reconstruction / forecast

• Process studies based on radiative transfer modeling
  ➔ Model provides reference spectra
  ➔ Parameters not accessible by measurements

• Retrieval of data products
  ➔ Total ozone, aerosol OD, effective albedo, actinic flux, effective ozone temperature
UV Climatology at McMurdo, Antarctica

From: NSF Version 2 Network Data, McMurdo

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Process Studies with Models

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Retrieval of Effective Ozone Temperature from Brewer

Conclusions

- **UV instruments** have matured over the last 20 years
- Current developments focus on “front end” geometries, spectrographs, and improved accuracy
- Need for reducing uncertainties further
- Methods for assessing and improving the quality of measurements are now operational
- Methods for data interpretation are continuously advanced (reconstruction, forecasting, model integration, retrievals of secondary data products)
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