Recent Developments in Airborne Radiometric Measurements from NSF/NCAR Aircraft

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I. Introduction

Measurements of the solar and terrestrial radiation spectra from aircraft have numerous applications to climate-related studies. Recent developments of various passive radiation sensors for use on the NCAR/NSF C-130 and Gulfstream V (GV) aircraft offer new capabilities for radiation budget studies, investigation of photochemical processes, and interpretation of trace gas, hydrometeor, and aerosol measurements.

Energy transfer through horizontal layers is characterized by two spectrometers which provide visible to near-IR irradiance measurements from the GV. In addition to these spectrally resolved measurements of irradiance, a set of (broadband) pyrgeometers extends the observations into the IR portion of the spectrum. Pyrgeometers are also available on the C-130. New pyranometers have been acquired for making broadband irradiance measurements from the C-130 in the visible wavelengths as well. Work is underway to develop stabilized platforms for these sensors to compensate for aircraft attitude changes.

In addition to irradiance measurements, spectrally resolved actinic flux measurements from the GV provide spherical radiances used to determine photolysis rates.

Finally, measurements of emitted radiation on oxygen absorption lines are acquired by the Microwave Temperature Profiler. Temperature profiles from above and below the GV are retrieved from these observations, providing meteorological context for a variety of measurements made by other instruments.

Gulfstream V

- *Visible irradiance (spectrally resolved, stabilized platform)*
- *IR irradiance (broadband)*
- *Actinic Flux*
- *Remote temperature profiles*

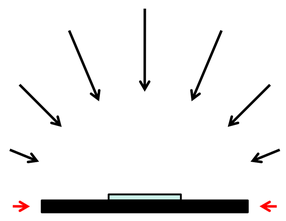
C-130

- *Visible irradiance (broadband, stabilized platform)*
- *IR irradiance (broadband)*

II. Irradiance

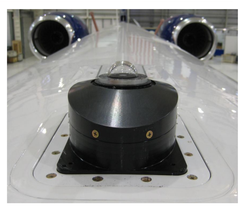
Flat Plate or **Integrating Sphere**

Measures Energy Flux through a plane



Cosine response (i.e., insensitive to photons from 90 deg)

Many uses in radiative transfer including **Net Irradiance** (difference between downwelling and upwelling)



Zeiss Spectrometers
- Zenith & nadir cosine-weighted integrating spheres
- VIS-NIR 260-1090 nm (1024 detectors)
  - ~0.8 nm sampling
  - ~3.0 FWHM
- NIR 903-2217 nm (256 detectors)
  - ~5.0 nm sampling
  - ~12 nm FWHM
- 90% Solar Spectrum

Kipp & Zonen Pyrgeometers
- Zenith & nadir cosine-weighted integrating spheres
- IR 4500-42000 nm

III. Actinic Flux

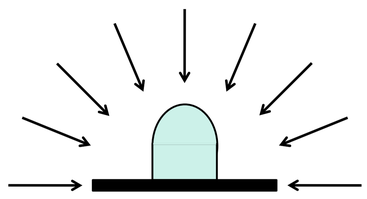
Frosted Dome

Measures Energy Flux through a sphere

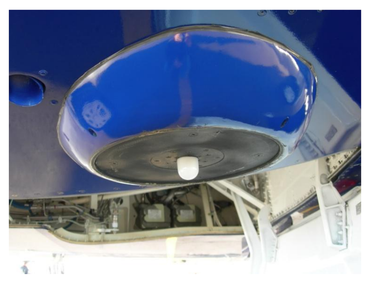
Equally responsive to photons from all directions

Total Actinic Flux (sum of downwelling and upwelling) also known as spherical radiance

Molecules (and people) are 3-D and can absorb photons from any direction



- Concentric domes
- UV-VIS 280-680 nm
  - ~0.8 nm sampling
  - ~FWHM 1.7 @ 297 nm, 2.4 @ 400 nm



IV. Remote Temperature Profiles

Microwave Temperature Profiler (MTP)

- Measures emission in oxygen absorption bands
- Scans through 10 elevation angles between nadir and zenith
- Calibration system uses heated blackbody target and ambient air temperature

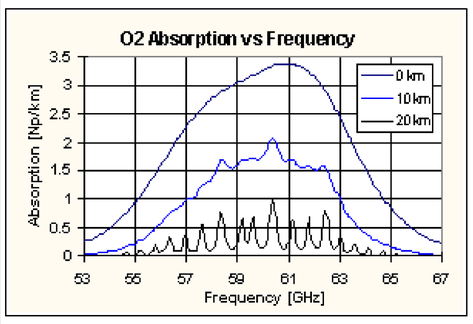
Specifications

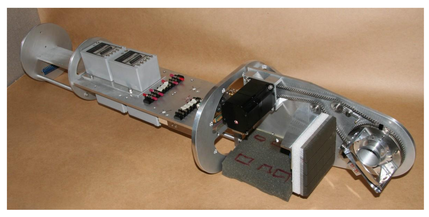
- Profile available every 17 seconds
- 100 m vertical resolution near aircraft
- Measurement uncertainty ~0.5 to 1.5 K within +/- 6km of flight level

Scientific Applications

- Meteorological context for measurements made by other instruments
- Interpretation of trace gas, hydrometeor, and aerosol measurements
- Validation of satellite temperature field measurements
- Real-time flight planning (e.g., tropopause location)

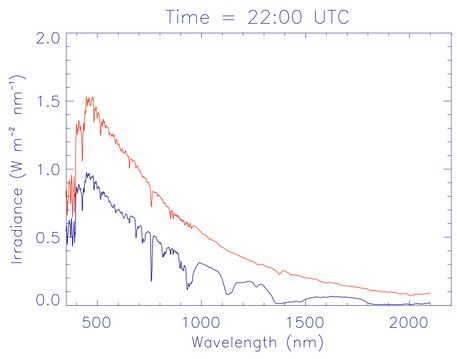
MTP fairing with high-density polyethylene window. The Ultra High Sensitivity Aerosol Spectrometer (UHSAS) is mounted next to MTP.



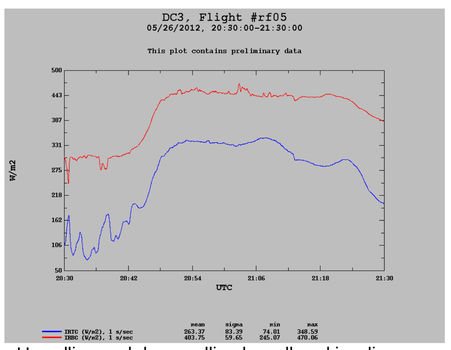


VI. Measurement Examples

Irradiance



Spectrally-resolved upwelling and downwelling irradiance from HARP.



Upwelling and downwelling broadband irradiance from the GV pyrgeometers during the DC3 project.

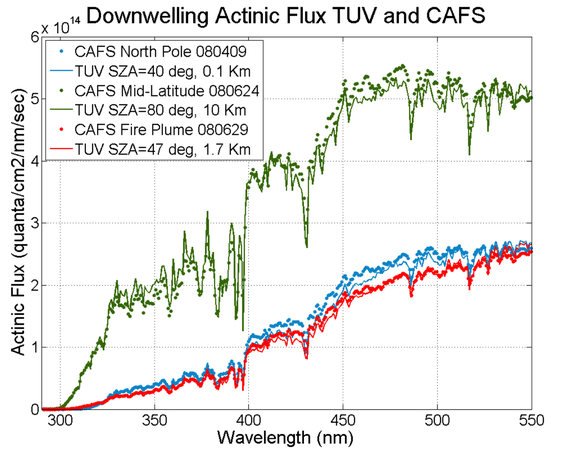
Actinic Flux measurements combined with ancillary information allow determination of **photolysis rates** for a variety of chemical reactions such as

***j* [O3->O2+O(1D)]**

***j* [NO2->NO+O(3P)]**

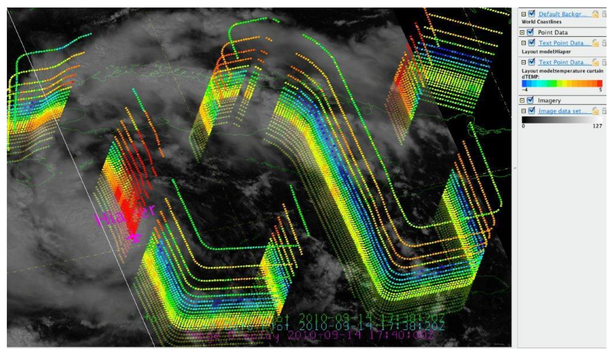
***j* [H2O2->2OH]**

… and many more.

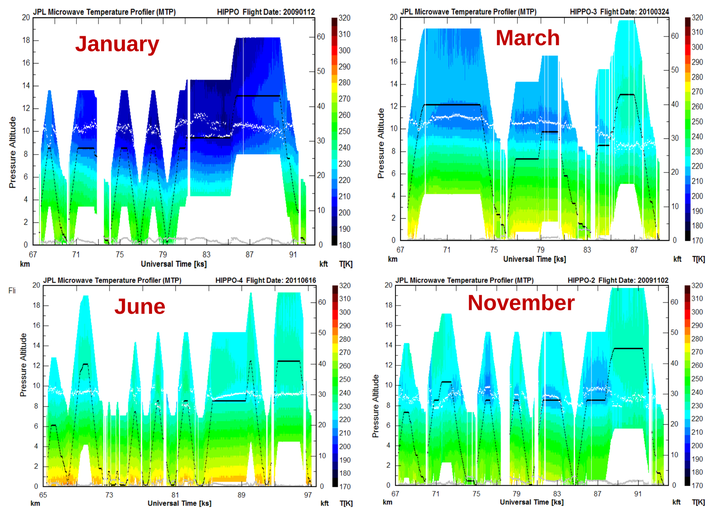


Actinic flux as measured by the CCD Actinic Flux Spectroradiometer (CAFS) compared to values obtained from the Tropospheric Ultraviolet and Visible (TUV) radiative transfer model.

Remote Temperature Profiles



Temperature anomaly in Tropical Storm Karl on 14 Sept 2010 as derived from MTP temperature profiles vs. GFS temperature analysis. A warm anomaly (orange) is evident in the center of Karl. Image provided by Chris Davis and David Ahijevych.



Temperature curtain plots from a series of arctic flights during HIPPO. Tropopause height (white trace) and aircraft altitude (black trace) are indicated.

References

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Acknowledgments

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