SWIR SKY GLOW AND CLOUD COMPARISON BETWEEN URBAN AND RURAL MEASUREMENTS

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Technical Paper

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ATA

Introduction

- Low Light Passive SWIR Imaging
  - Natural Night Time Sources
  - SWIR Sky Glow
    - High Altitude Chemical Luminescence
  - Cloud Reflection
  - Moon

- Sensors Unlimited SWIR Camera
  - 50 e- Noise per Pixel
  - F/1.4 Lens
SWIR Sky Glow

- Vibration and Rotation States of Hydroxyl OH
- Complex Chemical Interactions Involving Ozone
  - UV Radiation Charges During the Day
  - Reverse Process Produces SWIR photons at Night
Natural Night Sky Irradiance Sources

- Full Moon
- 295K Blackbody
- Airglow
- Integrated Starlight
- 273K Blackbody
- Zodiacal Light
SUI 320KTX Camera

- 320x240x40μm pixels
- 50 e- Read Noise
- 2.3x10-10 NEI
- Rolling Shutter
- Spectral Response
  - 0.9 – 1.7 μm
Measurements

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- Collected Between 11 Pm and 1 Am
- No Moon
- Partly Cloudy Conditions
  - City Lights Reflected from Cloud Bottoms
  - Mie Scattering varies with Scatter Angle
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Bar Chart 100 Yds
5” Separation


Rng= 2000 Alt= 0 SNR= 52.5189 SUI a= 0.9 b= 0
Comparison with Intensified CCD Camera

Note: Excess Noise (Scintillations) in ICCD Camera

ICCD Camera

SWIR Camera

Irradiance $\sim 1.2 \times 10^{-8} \text{ W/cm}^2$
Image Comparison Near Horizon
Looking Away from City
(~ 20 Deg)

ICCD Camera

SWIR Camera
Sky Glow Radiance ~ 2.9x10^-8 W/cm²
Cloud Radiance ~ 3.5x10^-9 W/cm²
Image Comparison
Bright Clouds
Looking Towards Albuquerque
(≈ 40 Deg)

City Reflection off Clouds

City Reflection off Clouds + Sky Glow

ICCD Camera

SWIR Camera

Sky Glow Irradiance ≈ 2.1x10^{-8} W/cm²
Cloud Irradiance ≈ 2.1x10^{-8} W/cm²
Image Comparison Near Zenith (~ 80 Deg)

ICCD Camera

SWIR Camera

Sky Glow Radiance ~ 4.2x10^-9 W/cm²
Cloud Radiance ~ 7.6x10^-9 W/cm²
Image Comparison Near Zenith (~ 90 Deg)

ICCD Camera

SWIR Camera

Sky Glow Radiance ~ -3.0x10^-9 W/cm^2

4.24x10^-9 W/cm^2
Traveling Waves
<table>
<thead>
<tr>
<th>Zenith Angle</th>
<th>SWIR SKY Glow Radiance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2.9x10-8 W/cm²</td>
</tr>
<tr>
<td>40</td>
<td>2.1x10-8 W/cm²</td>
</tr>
<tr>
<td>80</td>
<td>4.2x10-9 W/cm²</td>
</tr>
<tr>
<td>90</td>
<td>3.0x10-9 W/cm²</td>
</tr>
</tbody>
</table>

Integrated Measurement Over Sensor Bandwidth
Measured Data
Vs
Models

![Graph showing measured data and models for different types of light sources and blackbodies.](graph_image)
Conclusions

- SWIR Sky Glow
  - Chemical Luminescence
  - Illumination for Passive Night Imaging
  - Competes Favorably with Intensified Visible
  - Measurements Compare Well to Published Models
  - Order of Magnitude Variation with Zenith Angle
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