



### What is light pollution?



### Effects of light pollution



### CONTENTS

- What is light pollution?
- Effects of light pollution
- The study of light pollution
- Measuring light pollution
- Light pollution simulator
- Summary
- Analysis of skyglow
- Theoretical simulation of skyglow

### The modelling of skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences

### THE STUDY OF SKYGLOW

Measuring skyglow is challenging given the different conditions, environmental and metrics to describe it are in constant development.

### Modelling skyglow

Modelling the skyglow in a reverse Fourier atmosphere is a complex system that is computationally expensive and requires the use of both the complexity of radiative transfer methods and modelling devices.

## The modelling of Skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences

2016 SSL TECHNOLOGY DEVELOPMENT WORKSHOP

### DIFFERENT TESTS

### OPTIMIZATIONS



### Skyglow simulator

### Skyglow simulator

### Light pollution simulator

# The modelling of skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences

2016 SSL TECHNOLOGY DEVELOPMENT WORKSHOP

Solano Lamphar HA, Kocifaj M

ICA, Slovak academy of sciences

National Council of Science and Technology CONACYT

Department of experimental physics, Faculty of Mathematics Physics and Informatics, Comenius University in Bratislava

hsolano@institutomora.edu.mx



 <p>Faculty of Mathematics Physics and Informatics, Comenius University in Bratislava</p>	 <p>ICA, Slovak Academy of Sciences</p>	 <p>C E N T R O M E T</p> <p>CENTRO INTERDISCIPLINARIO DE ESTUDIOS METROPOLITANOS</p>	 <p>CONACYT</p> <p>CONACYT CONSEJO NACIONAL DE CIENCIA Y TECNOLOGIA MEXICO</p>
--	--	--	---



**What is light pollution?**



**Effects of light pollution**



**CONTENTS**

- What is light pollution?
- Effects of light pollution
- The study of light pollution
- Measuring light pollution
- Light pollution simulator
- Summary
- Analysis of skyglow
- Theoretical simulation of skyglow

**The modelling of skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences**

**THE STUDY OF SKYGLOW**

Measuring skyglow is challenging given the different conditions, environmental and metrics to describe it are in constant development.

**Modelling skyglow**

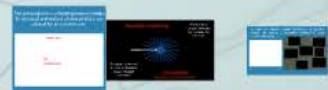
Modelling the skyglow in a reverse Fourier atmosphere is a complex system that is computationally and experimentally difficult to solve. It is both the complexity of radiative transfer methods and the lighting devices.

**The modelling of Skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences**

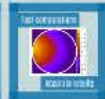
2016 SSL TECHNOLOGY DEVELOPMENT WORKSHOP

**DIFFERENT TESTS**

**OPTIMIZATIONS**



**Skyglow simulator**



# CONTENTS

What is light pollution?

Effects of light pollution

The study of light pollution

Modelling light pollution

Skyglow simulator

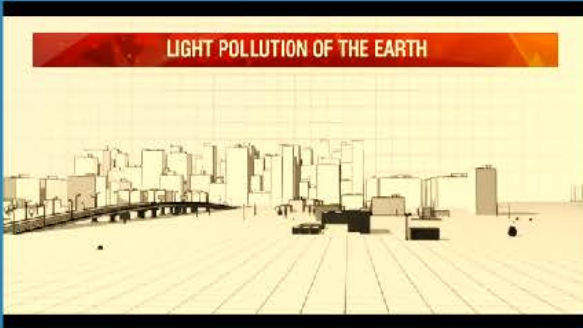
Summary

Analysis of skyglow

Theoretical simulation of skyglow

# What is light pollution?

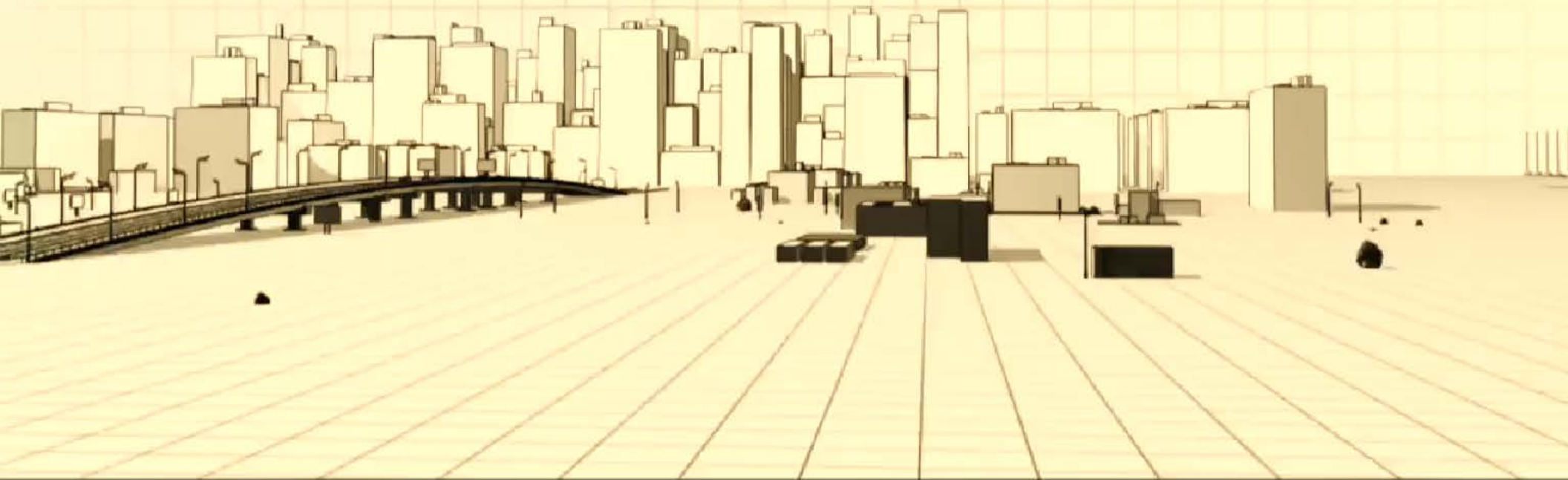
LIGHT POLLUTION OF THE EARTH



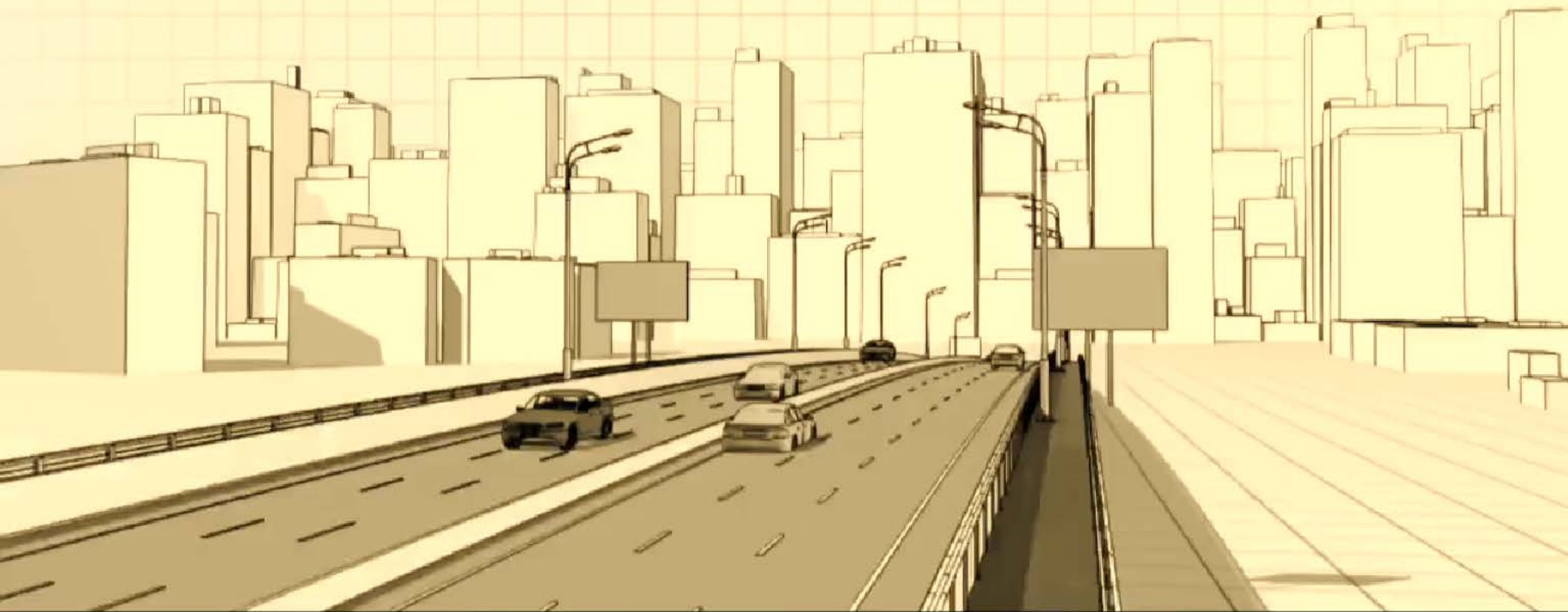
LIGHT POLLUTION OF THE EARTH



# LIGHT POLLUTION OF THE EARTH

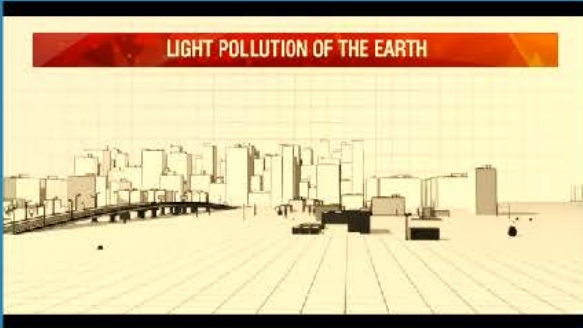


# LIGHT POLLUTION OF THE EARTH



# What is light pollution?

LIGHT POLLUTION OF THE EARTH



LIGHT POLLUTION OF THE EARTH





# Effects of light pollution

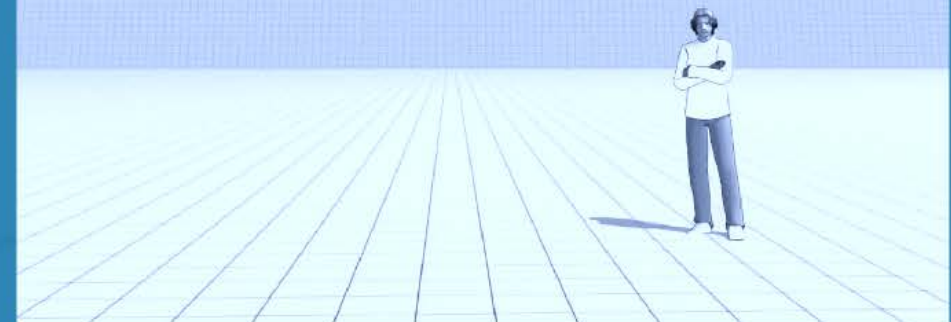
## LIGHT POLLUTION OF THE EARTH

Why is light pollution dangerous?



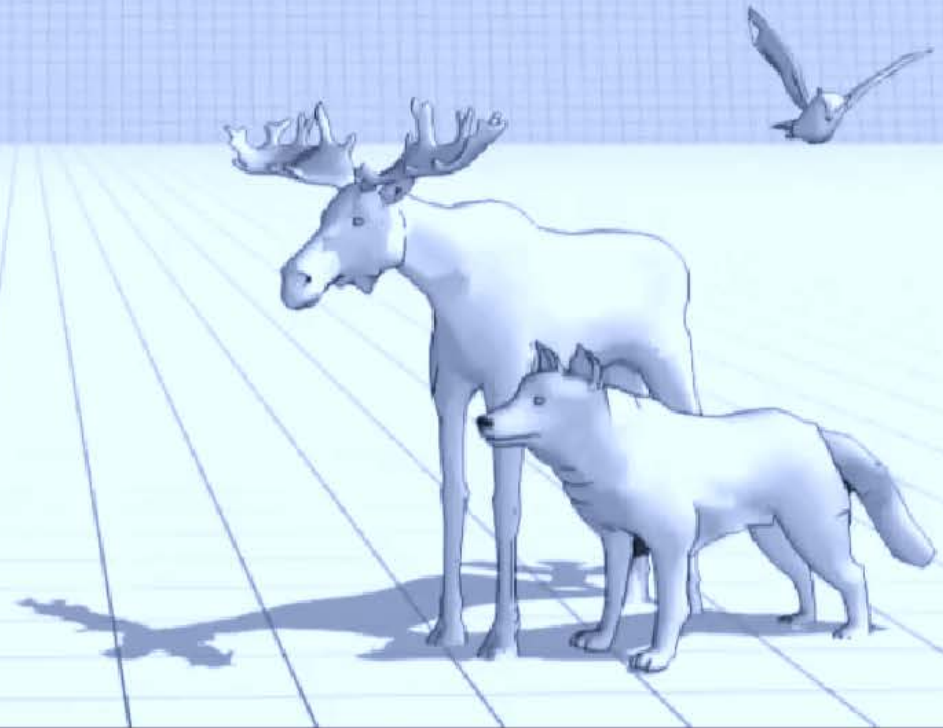
## LIGHT POLLUTION OF THE EARTH

Why is light pollution dangerous?



## LIGHT POLLUTION OF THE EARTH

Why is light pollution dangerous?



# LIGHT POLLUTION OF THE EARTH

Why is light pollution dangerous?



# Effects of light pollution



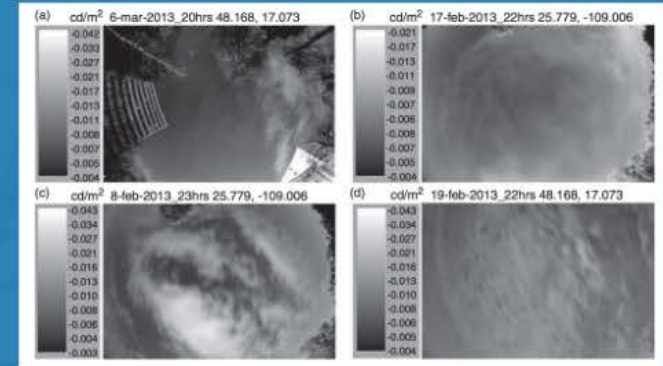


# The study of SKYGLOW

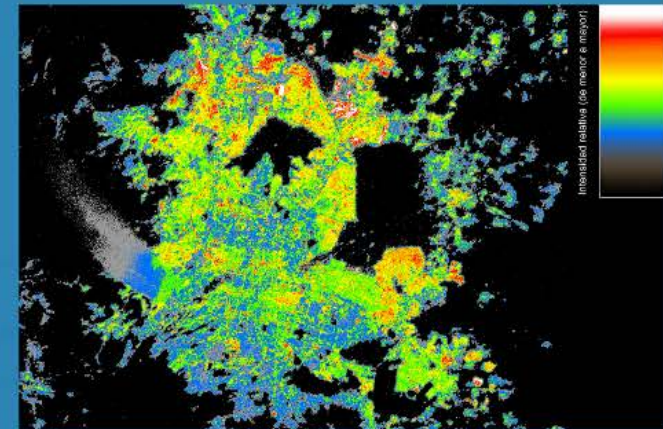


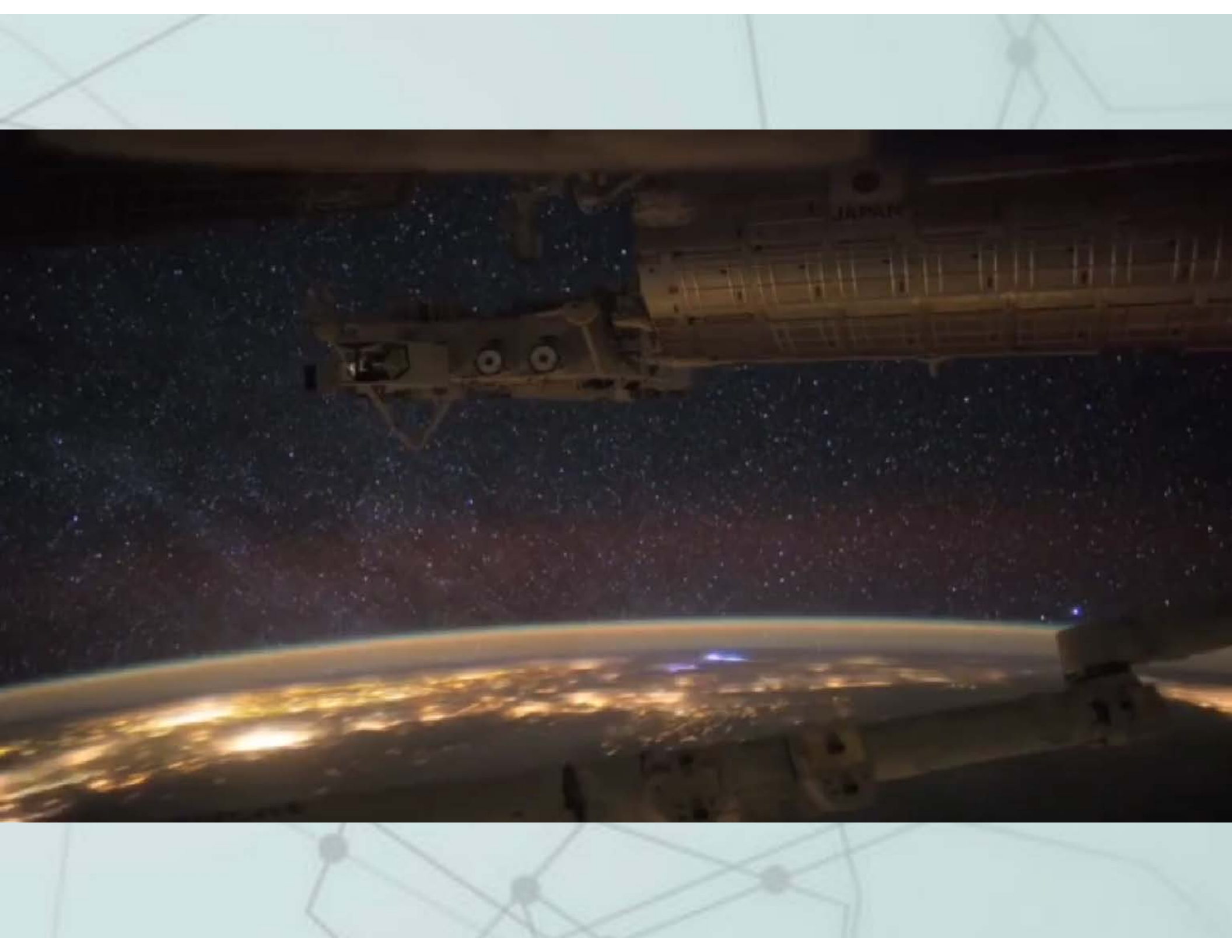
Measuring skyglow is challenging given the different complex environments and metrics to describe it are in constant development.

Innovative techniques such as all-sky imaging and aerial photography



International Space Station and satellite imagery



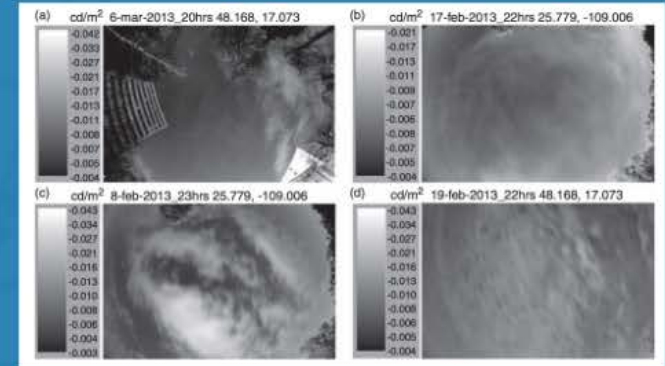


# The study of SKYGLOW

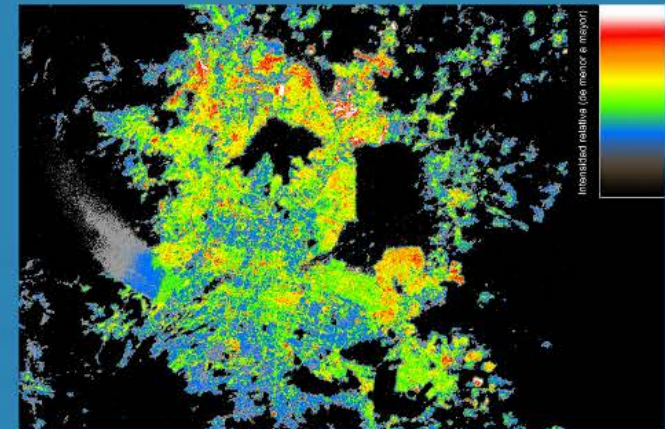


Measuring skyglow is challenging given the different complex environments and metrics to describe it are in constant development.

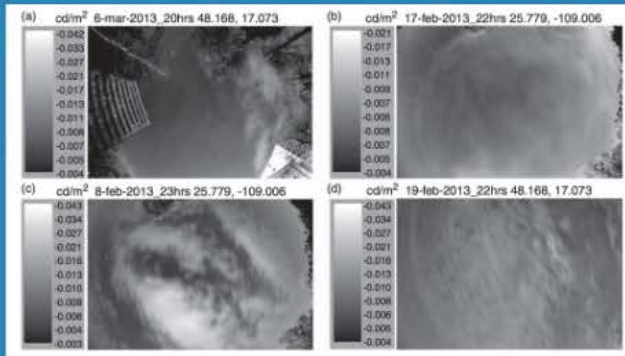
Innovative techniques such as all-sky imaging and aerial photography



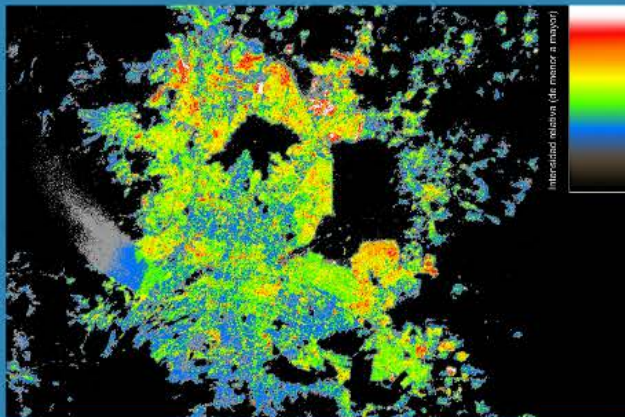
International Space Station and satellite imagery



Innovative techniques  
such as all-sky imaging and aerial photography



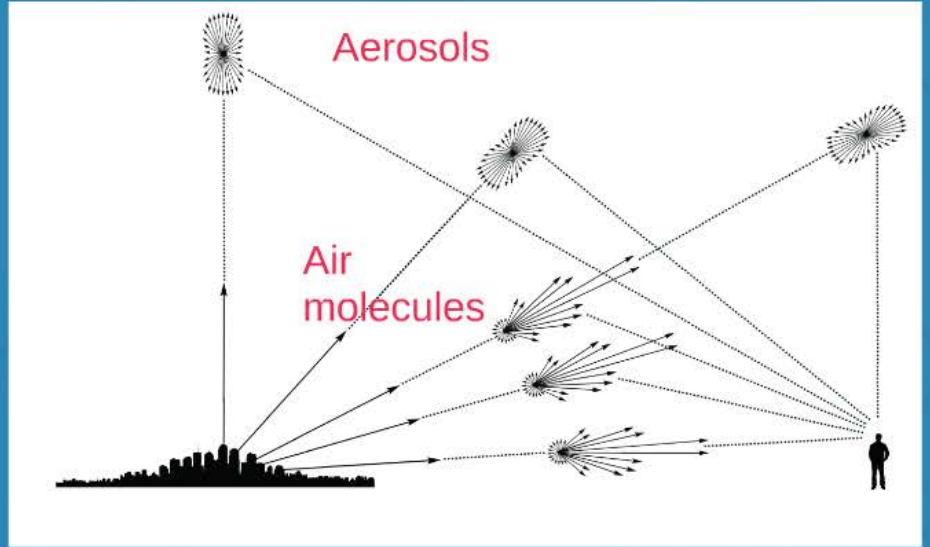
International Space Station  
and satellite imagery



# Modelling skyglow

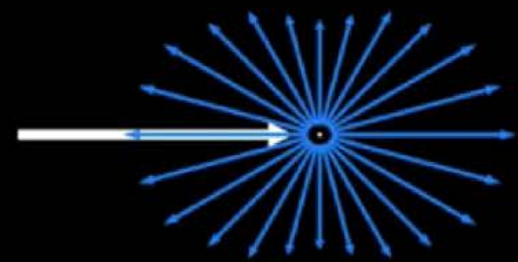
Modelling the skyglow in a diverse nocturnal atmosphere is a non-trivial problem that is theoretically and experimentally difficult to solve, due to both the complexity of radiative transfer methods and measuring devices.

The atmosphere is a heterogeneous media; its physical and optical characteristics are altered by its constituents.



### Rayleigh scattering

Mie theory is used to simulate light scatter by aerosols.

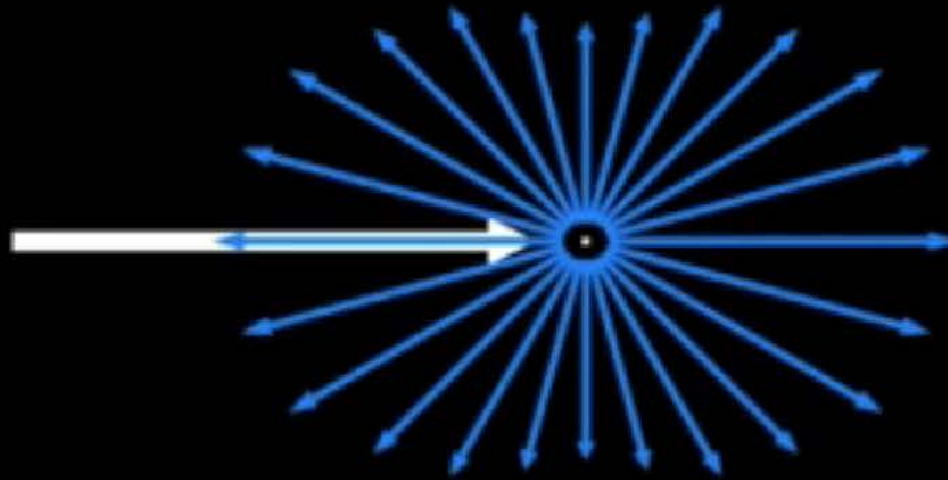


Rayleigh scattering is used to simulate scatter through molecules.

**tiny particle**  
less than 1/10 of wavelength

## Rayleigh scattering

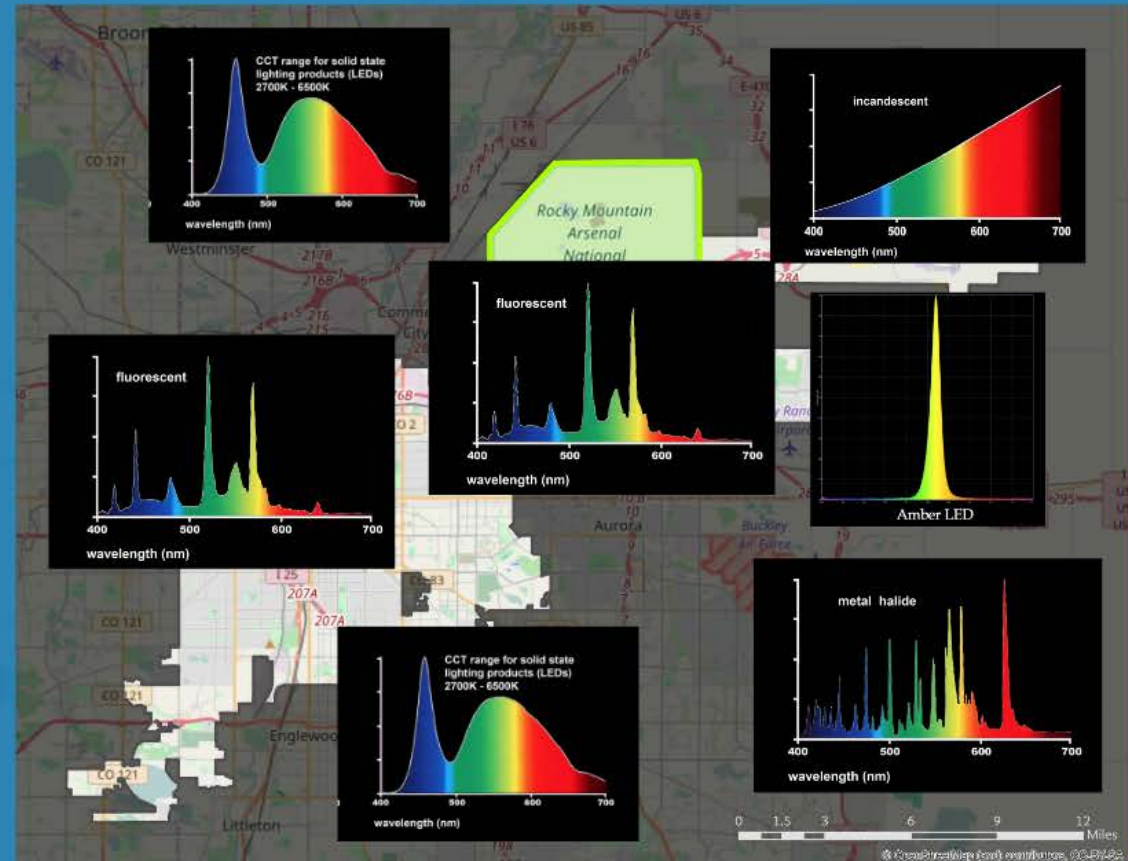
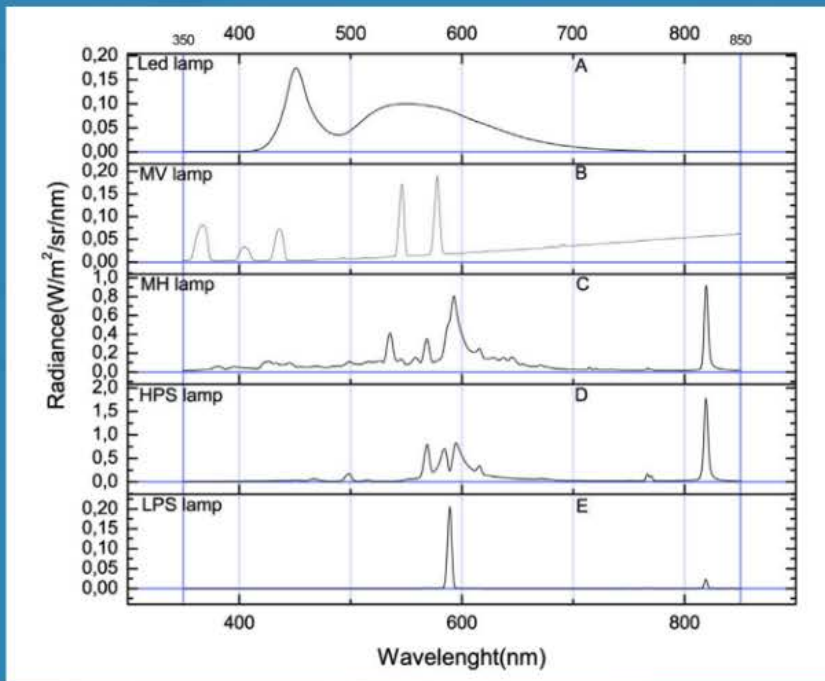
Mie theory is used to simulate light scatter by aerosols.

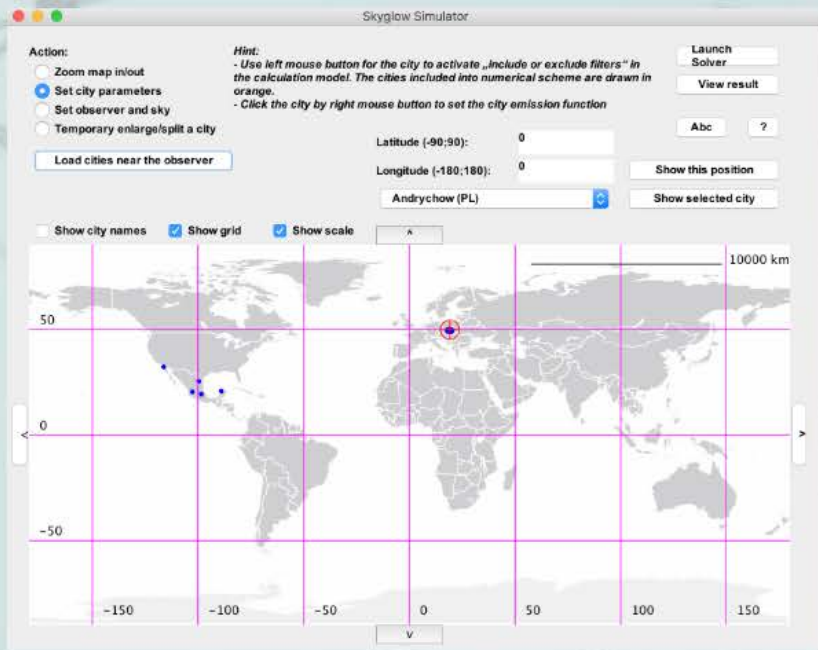


Rayleigh scattering is used to simulate scatter through molecules.

**tiny particle**  
less than 1/10 of wavelength

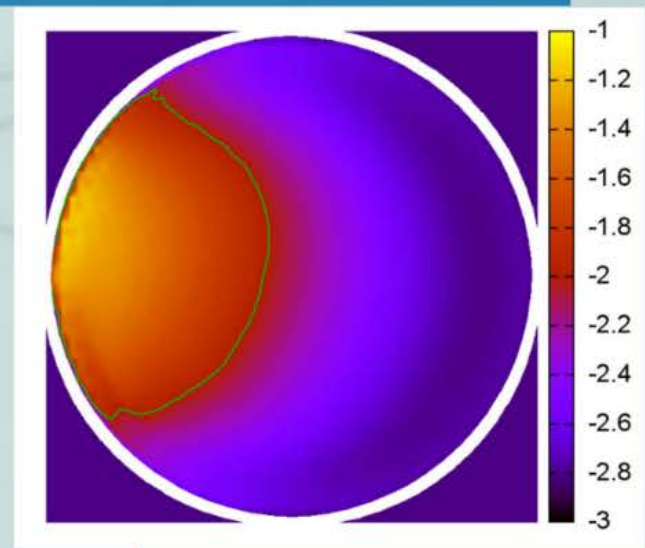
As well, the spectral power distribution of ground-based light sources is dissimilar, making the issue more challenging.





Skyglow simulator

Fast computations



Accurate results

# Main folders



# Type of font

Skyglow Simulator

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Use left mouse button for the city to activate „include or exclude filters“ in the calculation model. The cities included into numerical scheme are drawn in orange.
- Click the city by right mouse button to set the city emission function

Latitude (-90;90):

Longitude (-180;180):

Show city names     Show grid     Show scale   

10000 km

50

0

-50

-150    -100    -50    0    50    100    150

# Zooming

Skyglow Simulator

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Use left mouse button for the city to activate „include or exclude filters“ in the calculation model. The cities included into numerical scheme are drawn in orange.
- Click the city by right mouse button to set the city emission function

Latitude (-90;90):

Longitude (-180;180):

Show city names  Show grid  Show scale

50

0

-50

-150 -100 -50 0 50 100 150

10000 km

# Setting the city parameters

Skyglow Simulator

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Use mouse wheel or click left mouse button to zoom in
- Use mouse wheel or click right mouse button to zoom out
- Use 'Show this position' or 'Show selected city' tool to change the view

Latitude (-90;90):

Longitude (-180;180):

Show city names    Show grid    Show scale

40.0

39.8

39.6

39.4

-105.8 -105.6 -105.4 -105.2 -105.0 -104.8 -104.6 -104.4 -104.2 -104.0

10 km

Denver (USA)

# Setting the atmospheric parameters and the observer

**Skyglow Simulator**

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Use left mouse button for the city to activate „include or exclude filters“ in the calculation model. The cities included into numerical scheme are drawn in orange.
- Click the city by right mouse button to set the city emission function

Latitude (-90;90):   

Longitude (-180;180):

Show city names  Show grid  Show scale

40.0  
39.8  
39.6  
39.4

105.8 -105.6 -105.4 -105.2 -105.0 -104.8 -104.6 -104.4 -104.2 -104.0

10 km

Denver (USA)

# Dividing a city

Skyglow Simulator

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Click left mouse button to choose the observer's position
- Use 'Set observer's position' tool to change the actual position
- Click right mouse button to set the locality-specific parameters

Latitude (-90;90):

Longitude (-180;180):

Show city names     Show grid     Show scale

39.9  
39.8  
39.7  
39.6

-105.4   -105.3   -105.2   -105.1   -105.0   -104.9   -104.8   -104.7   -104.6   -104.5   -104

10 km

Denver (USA)

### Skyglow Simulator

**Action:**

- Zoom map in/out
- Set city parameters
- Set observer and sky
- Temporary enlarge/split a city

**Hint:**

- Use left mouse button for the city to activate „include or exclude filters“ in the calculation model. The cities included into numerical scheme are drawn in orange.
- Click the city by right mouse button to set the city emission function

Latitude (-90;90):

Longitude (-180;180):

Show city names  
  Show grid  
  Show scale



# Publications in different journals

### Light-pollution model for cloudy and cloudless night skies with ground-based light sources

Uroskić, K. et al.

The article presents a model of light pollution for ground-based light sources. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### The spectral energy distribution of clouds in the night sky

Uroskić, K. et al.

This paper discusses the spectral energy distribution of clouds in the night sky. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Light Pollution in Ultraviolet and Visible Spectrum Effect on Different Visual Perceptions

Uroskić, K. et al.

This paper discusses the effect of light pollution on different visual perceptions. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Skynote a method of the approximate reduced intensity function of ground-based light sources

Uroskić, K. et al.

This paper discusses a method for approximating the reduced intensity function of ground-based light sources. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### On the relation between zenith sky brightness and horizontal illuminance

Uroskić, K. et al.

This paper discusses the relation between zenith sky brightness and horizontal illuminance. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### How well light pollution function fits observed experimental night sky data

Uroskić, K. et al.

This paper discusses how well the light pollution function fits observed experimental night sky data. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Urban night-sky luminance due to different cloud types: A numerical experiment

Uroskić, K. et al.

This paper discusses urban night-sky luminance due to different cloud types. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Quantitative analysis of night sky brightness under cloudy conditions

Uroskić, K. et al.

This paper discusses a quantitative analysis of night sky brightness under cloudy conditions. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Revised of Gershwin's zenith function from all-sky camera images

Uroskić, K. et al.

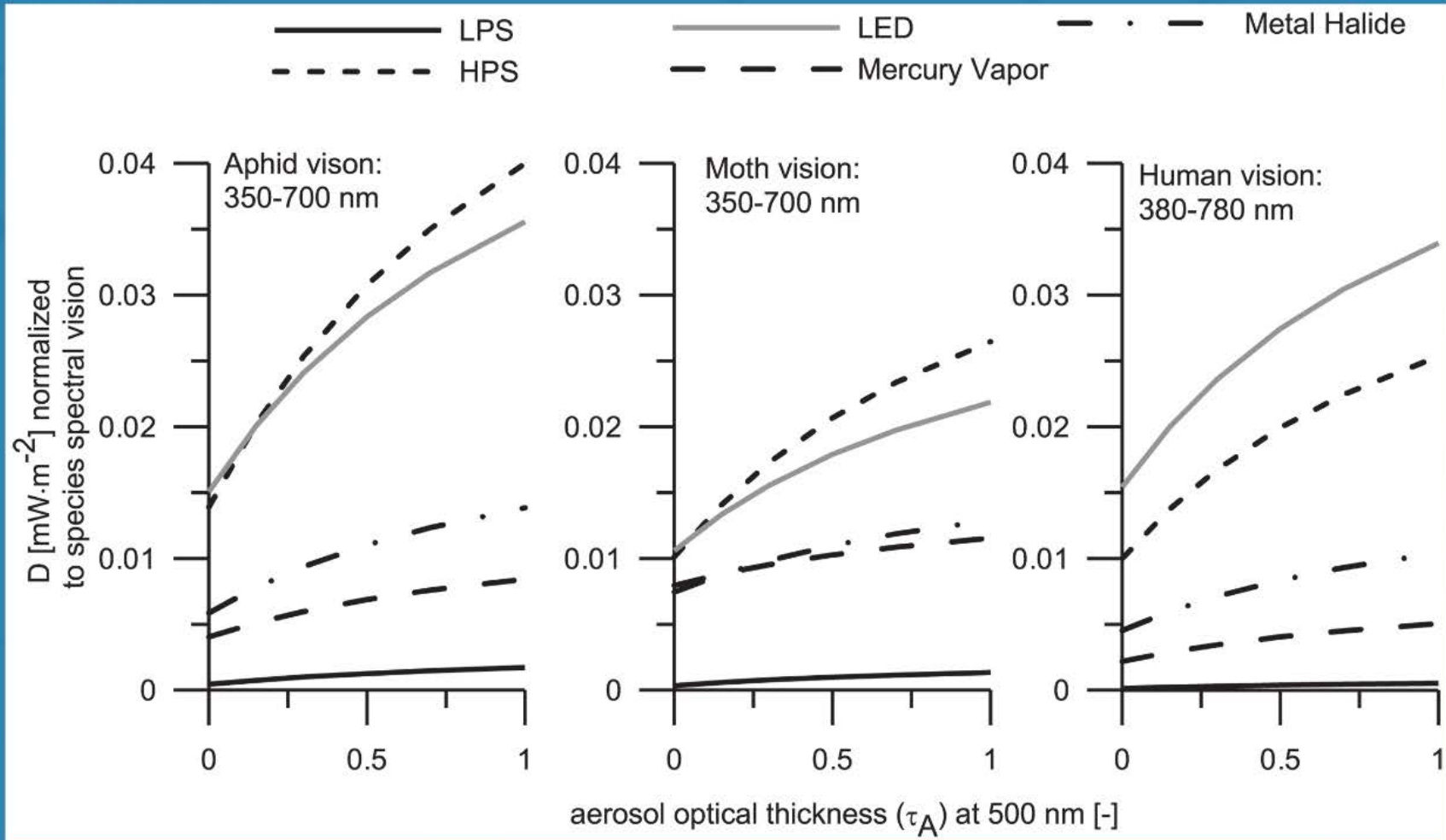
This paper discusses a revised version of Gershwin's zenith function from all-sky camera images. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

### Skynote effects in UV and visible spectra radiance flux

Uroskić, K. et al.

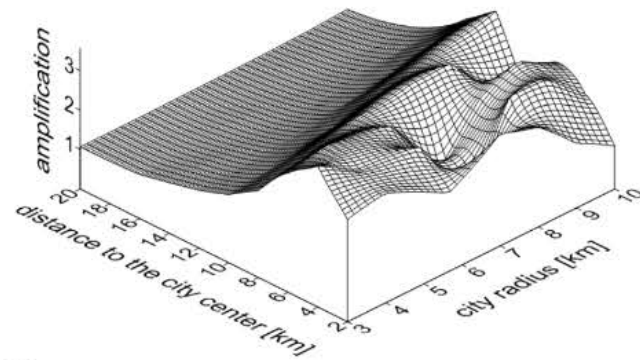
This paper discusses skynote effects in UV and visible spectra radiance flux. It is based on the assumption that the sky is a uniform plane of light sources. The model is applied to real data obtained on various nights with different cloud coverages. The results show that the model is able to describe the observed data well. The model is also used to estimate the contribution of different light sources to the total light pollution.

# Light Pollution in Ultraviolet and Visible Spectrum: Effect on Different Visual Perceptions

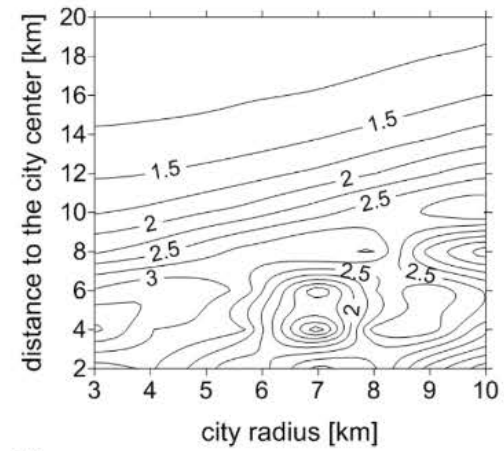


## Quantitative analysis of night skyglow amplification under cloudy conditions

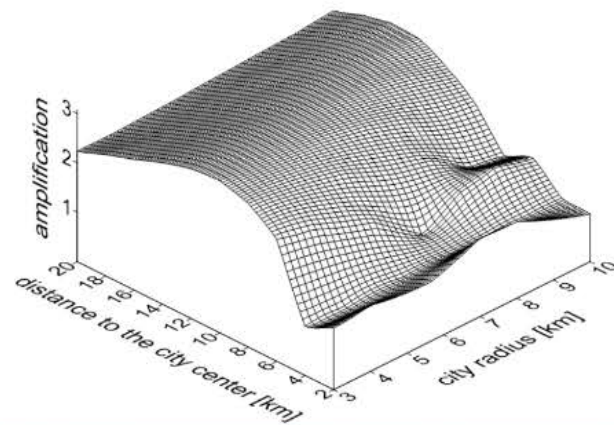
A



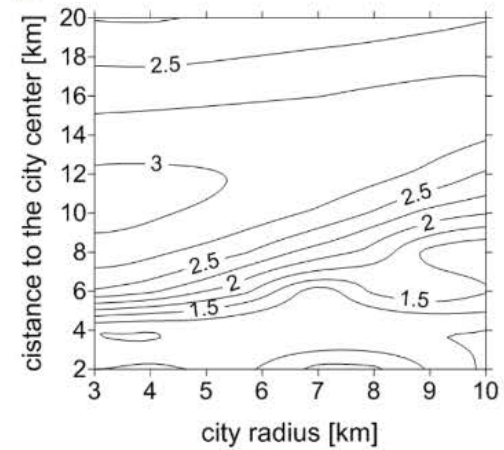
B



C

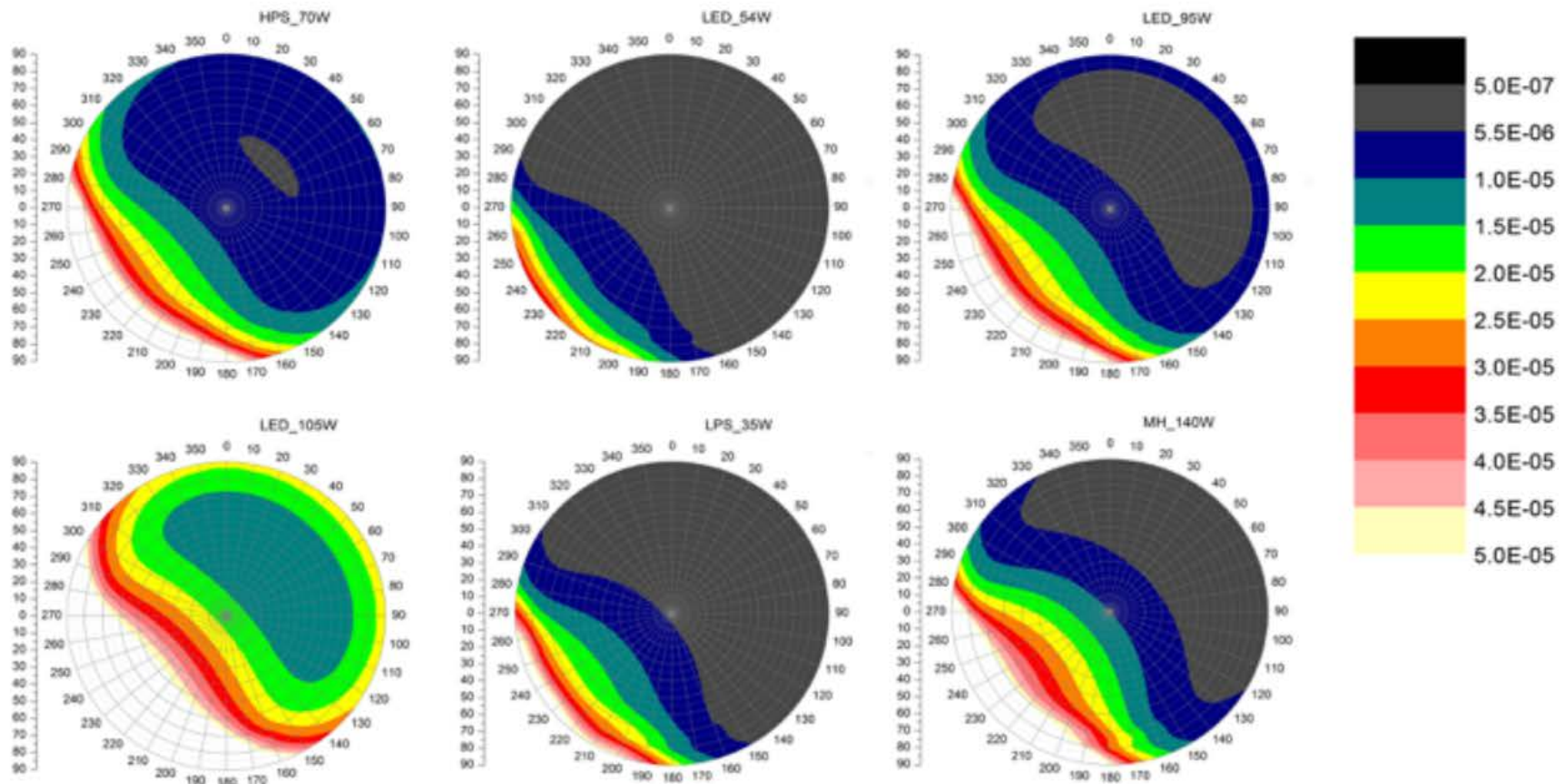


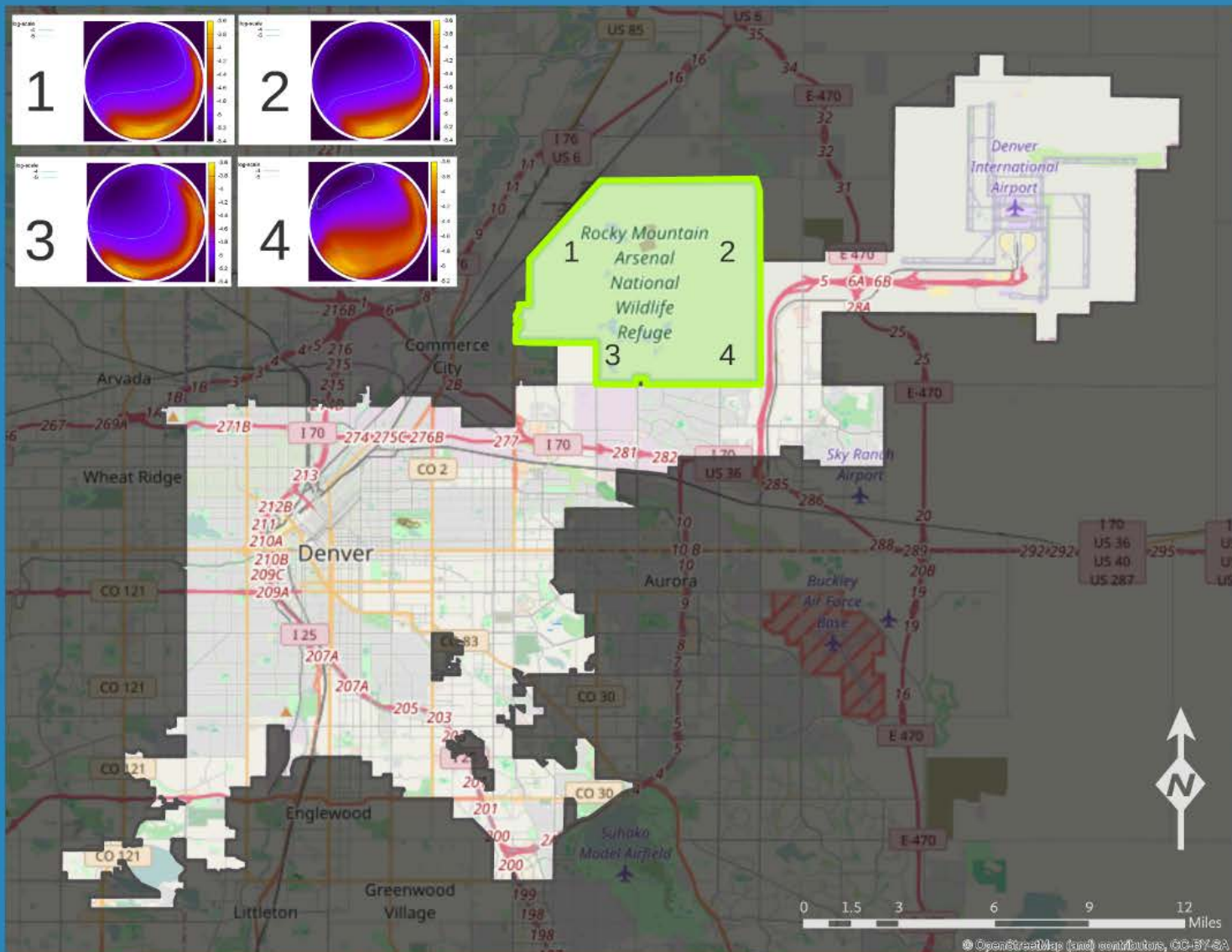
D



# Infrared, visible and UV features of light pollution near urbanized, industrial and natural regions: effect on plants

Overcast - Sensor PFR



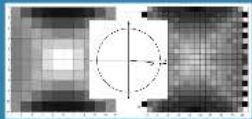


© OpenStreetMap (and) contributors, CC-BY-SA

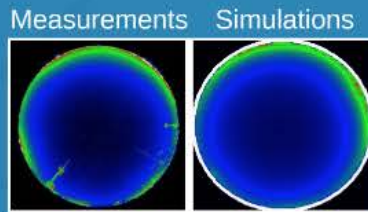
# OPTIMIZATIONS

## Optimization

- Discretization
- Comparisons to other models
- Comparisons to reality



The effect of cutting intervals  
Altitude, scattering angle, and  
atmospheric characteristics.

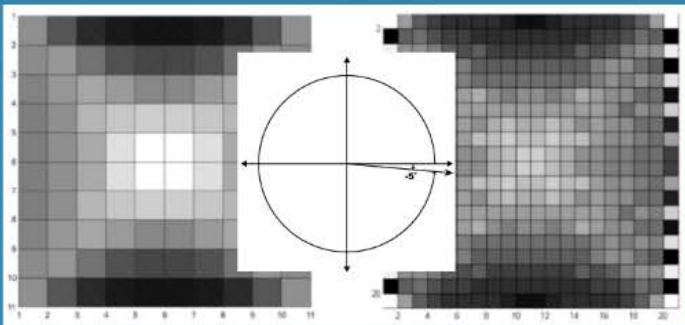


## Future scopes

- Different emission functions for other kinds of fixtures.
- The methodology to retrieve the emission function has been developed.
- Merge the data with VIIRS database.
- Non spherical particles.

# Optimization

- Discretization
- Comparisons to other models
- Comparisons to reality

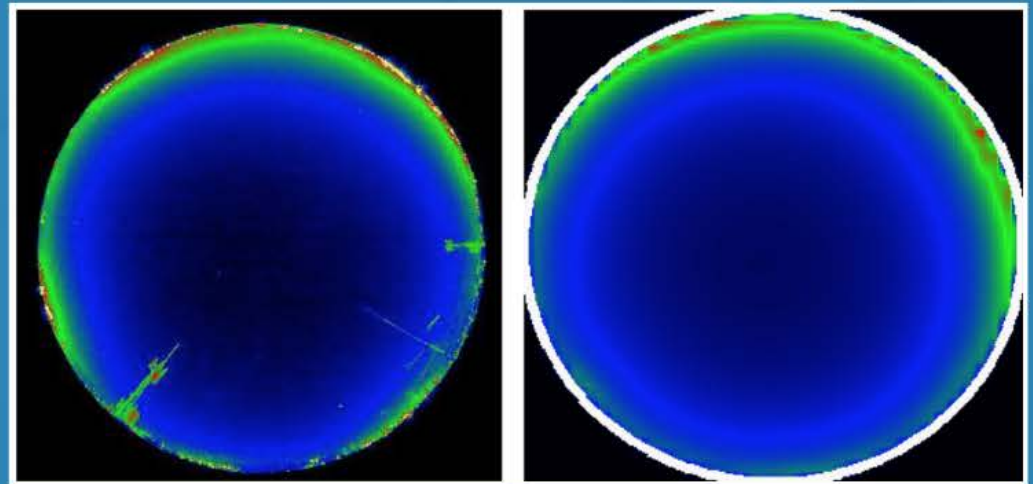


The effect of cutting intervals

Altitude, scattering angle, and atmospheric characteristics.

Measurements

Simulations



# Future scopes

Different emission functions for other kinds of fixtures.

The methodology to retrieve the emission function has been developed.

Merge the data with VIIRS database.  
Non spherical particles.



**What is light pollution?**



**Effects of light pollution**

**CONTENTS**

What is light pollution?	Analysis of skyglow
Effects of light pollution	Theoretical simulation of skyglow
The study of light pollution	
Measuring light pollution	
Skyglow simulator	
Summary	

**The modelling of skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences**

**THE STUDY OF SKYGLOW**

Measuring skyglow is challenging given the different conditions, environments and metrics to describe it are in constant development.

**Modelling skyglow**

Modelling the skyglow in a reverse Fourier atmosphere is a complex system that is computationally expensive and requires the use of both the complexity of radiative transfer methods and modelling devices.

**The modelling of Skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences**

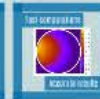
2016 SSL TECHNOLOGY DEVELOPMENT WORKSHOP

**DIFFERENT TESTS**

**OPTIMIZATIONS**



**Skyglow simulator**



# The modelling of skyglow: the experiences of the light pollution research group from the Slovak Academy of Sciences

2016 SSL TECHNOLOGY DEVELOPMENT WORKSHOP

Solano Lamphar HA, Kocifaj M

ICA, Slovak academy of sciences

National Council of Science and Technology CONACYT

Department of experimental physics, Faculty of Mathematics Physics and Informatics, Comenius University in Bratislava

hsolano@institutomora.edu.mx

