WCO5 – 5th Workshop on Convective Organization

A new ground-based IR Dataset for Convection-Resolving Model Evaluation in the Amazon

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Institutions:

UNIFESP
UNIVERSIDADE FEDERAL DE SÃO PAULO

UEA
UNIVERSIDADE DO ESTADO DO AMAZONAS

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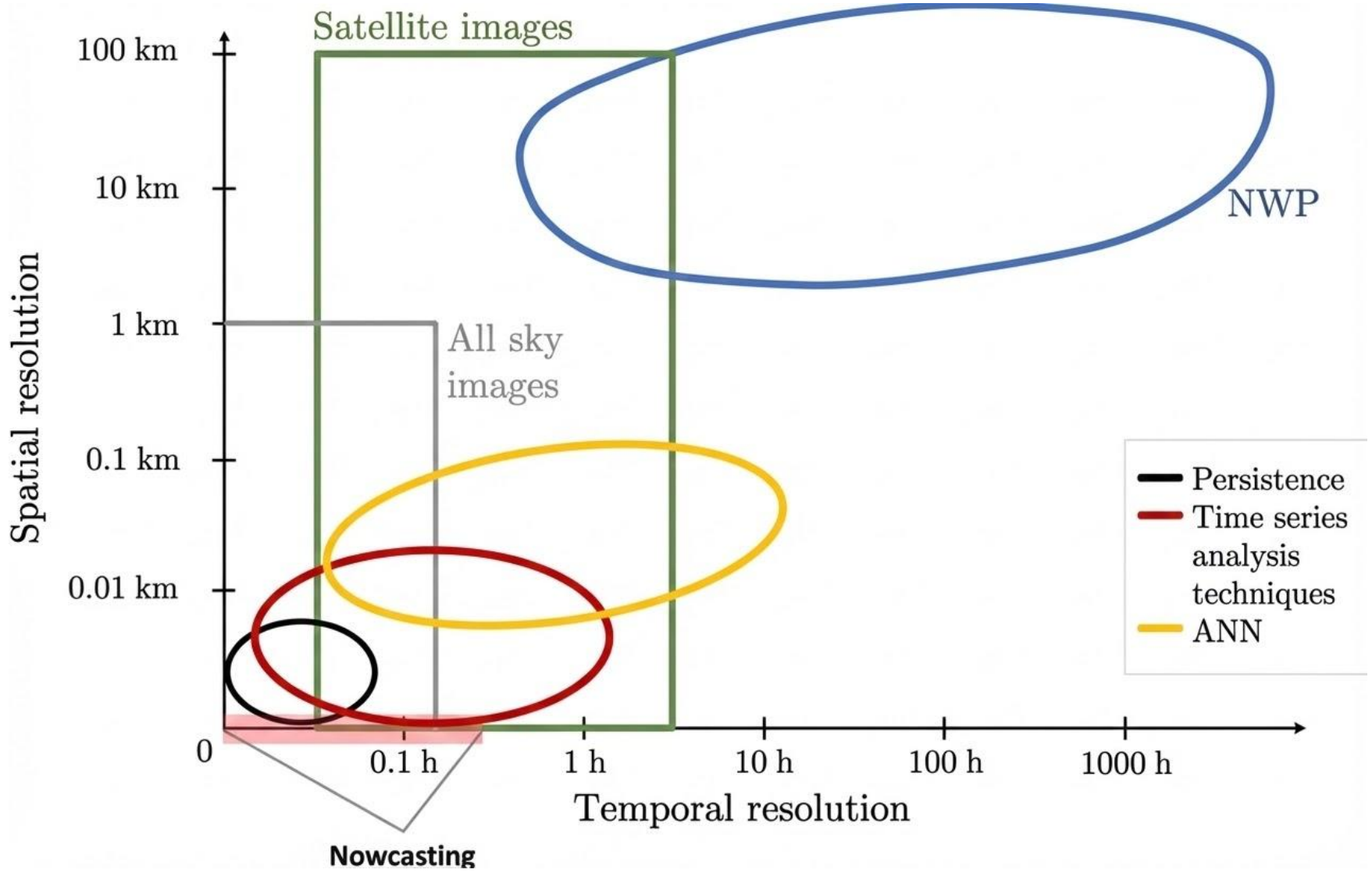
FAPEAM
Fundação de Amparo à Pesquisa do Estado do Amazonas

CNPq

Different approaches to cloud imagery

Cameras are considered:
- Low computational and time cost;
- Effective and accurate for very short-term forecasting



Ogliari et al., 2024

Different approachs to cloud imagery

Feature	Polar	Geostationary	Ground imagery
Spatial resolution	250 m – 1 km	0,5–2 km VIS; 2–4 km IR	~10-50 m
Time resolution	1 or 2 per day	5–10 min;	1 min
Spatial Coverage	Global	Hemispherical	Local (whole sky)
Advantages	Low orbit allows retrieval of microphysical parameters	Diurnal Cycle Convection Nowcasting	Extremely high resolution (both space and time)

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VISIBLE	INFRARED
Day time only	Night and day
Difficulties with sun bright	Sun is fine

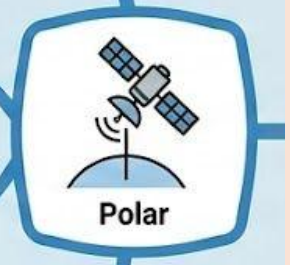
Polar

Spatial Resolution
250 m – 1 km

Time Resolution
1 or 2 per day

Spatial Coverage
Global

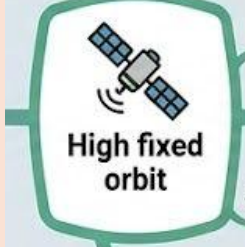
Advantages
Low orbit allows retrieval of microphysical parameters



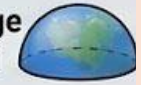
Geostationary

Spatial Resolution
0.5–2 km VIS;
2–4 km IR

Time Resolution
5–10 min;



Spatial Coverage
Hemispherical



Advantages
Diurnal Cycle
Convection
Nowcasting

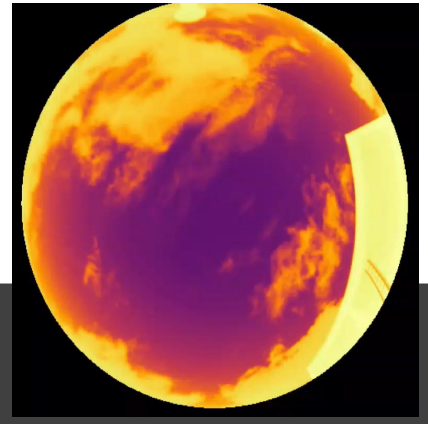
Ground imagery

Spatial Resolution
~10-50 m

Time Resolution
1 min

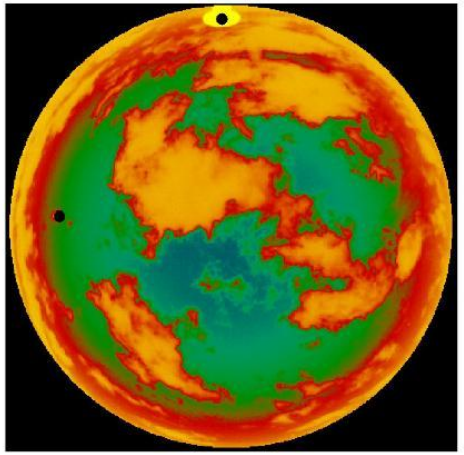
Spatial Coverage
Local (whole sky)

Advantages
Extremely high resolution (both space and time)
Rapid

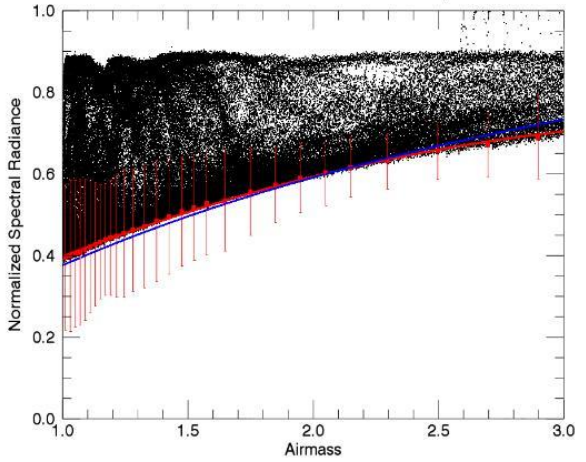


Imagery of clouds from the ground:

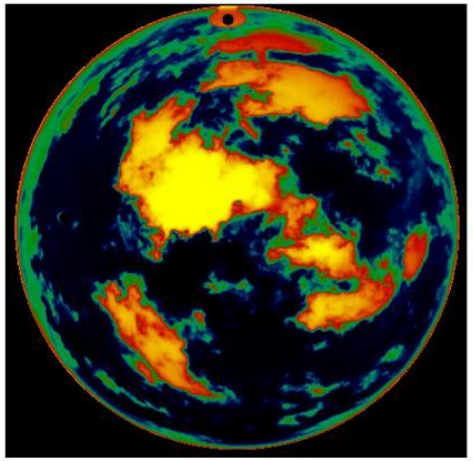
10-12 μm Normalized Image



Normalized Radiance vs. Airmass 10-12 μm

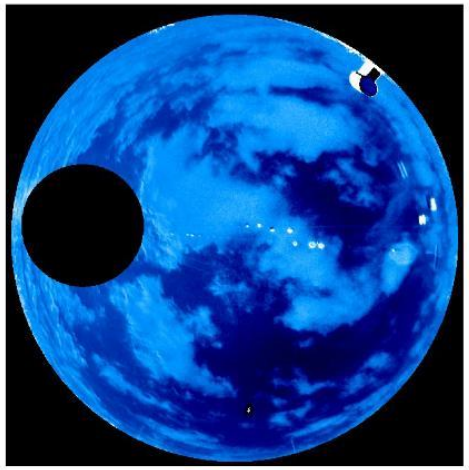


Clear Sky Subtracted Image

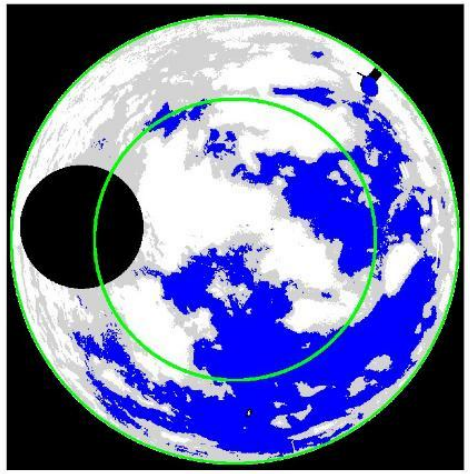


Visible Color Image

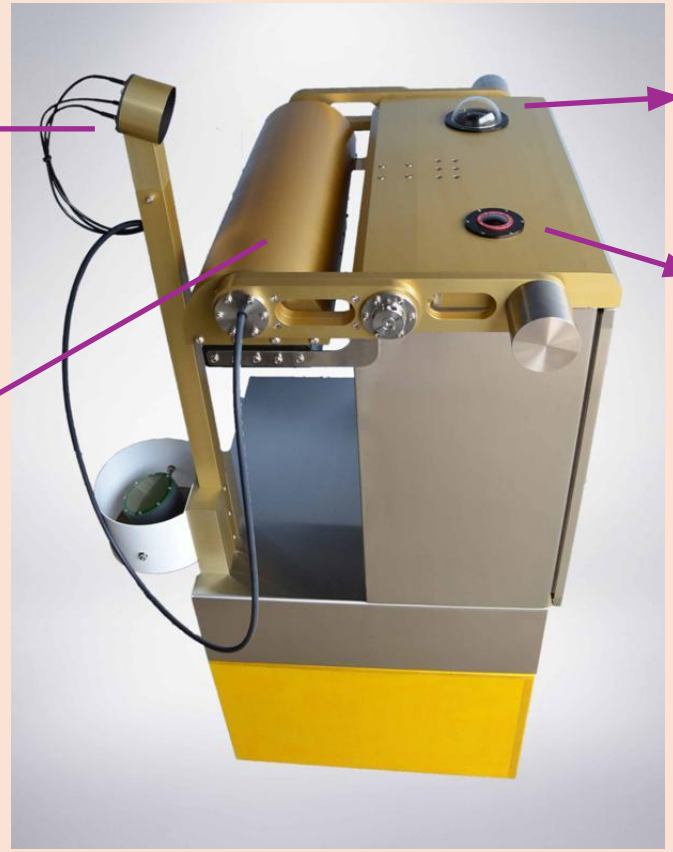
R/B Ratio Image



R/B Ratio Mask



Our measurements (methods):



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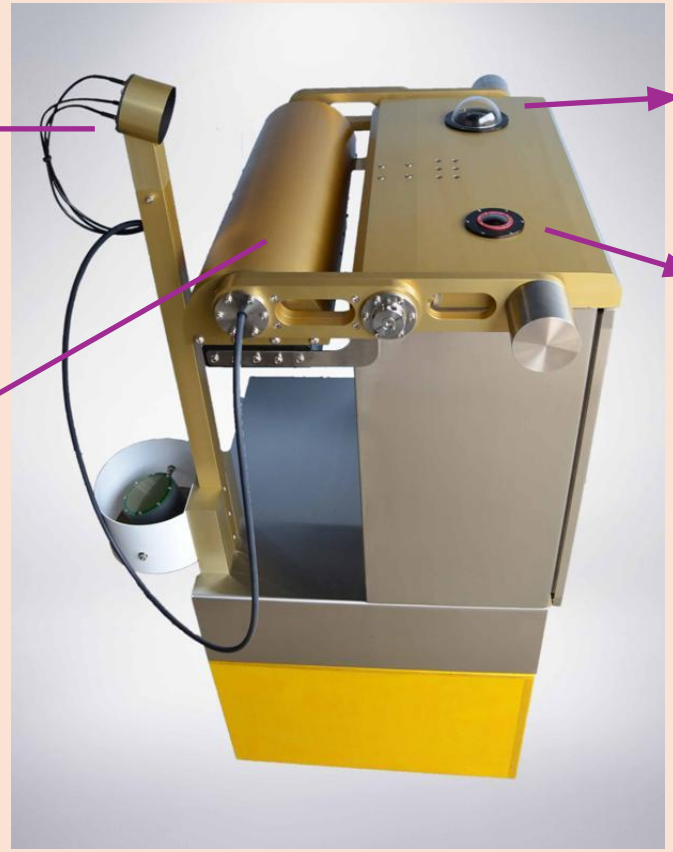
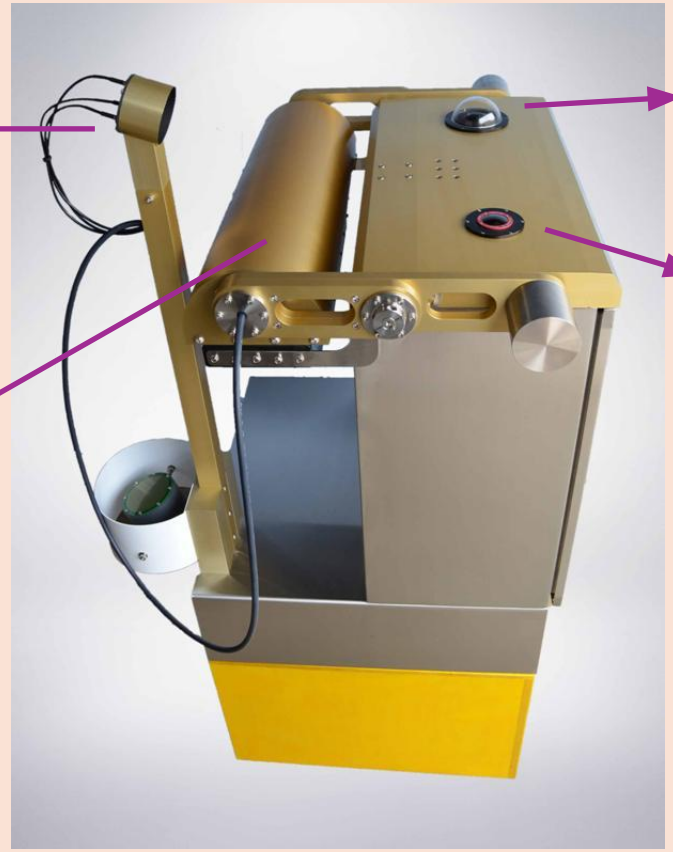


- Camera is (previously) absolutely calibrated with a reference Black Body;
- Coordinates in the image (zenithal angles, altitude and azimuth) are calibrated with astronomical procedure.

Our measurements (methods):

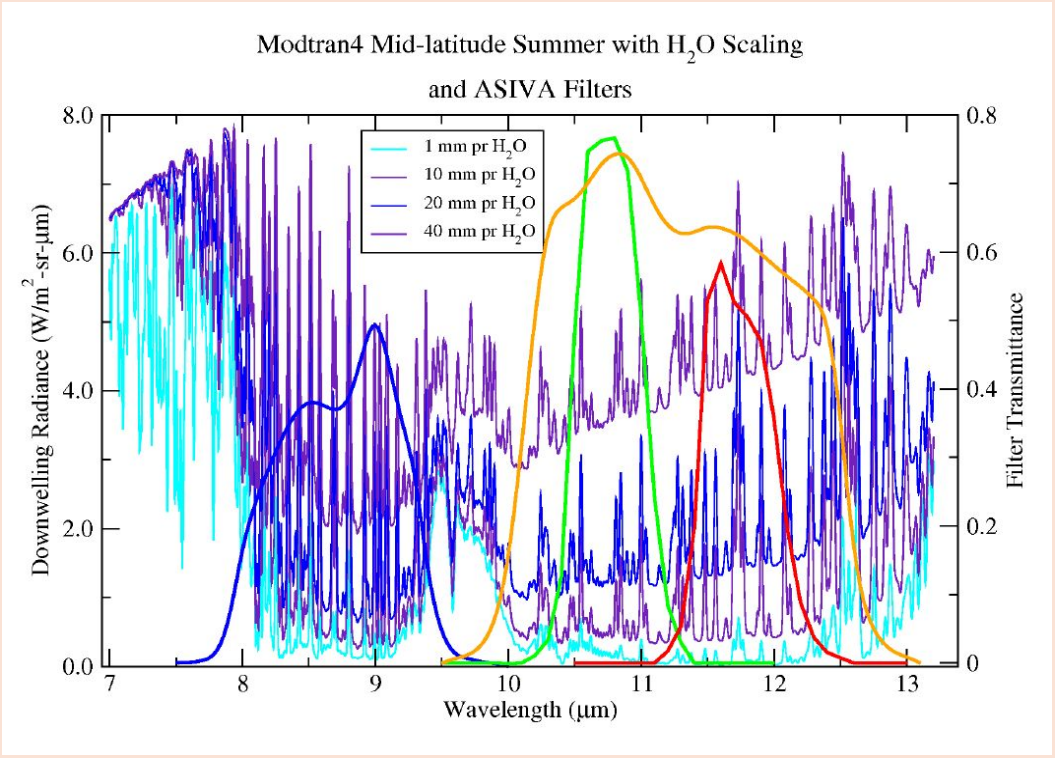
External BB

Reference BB

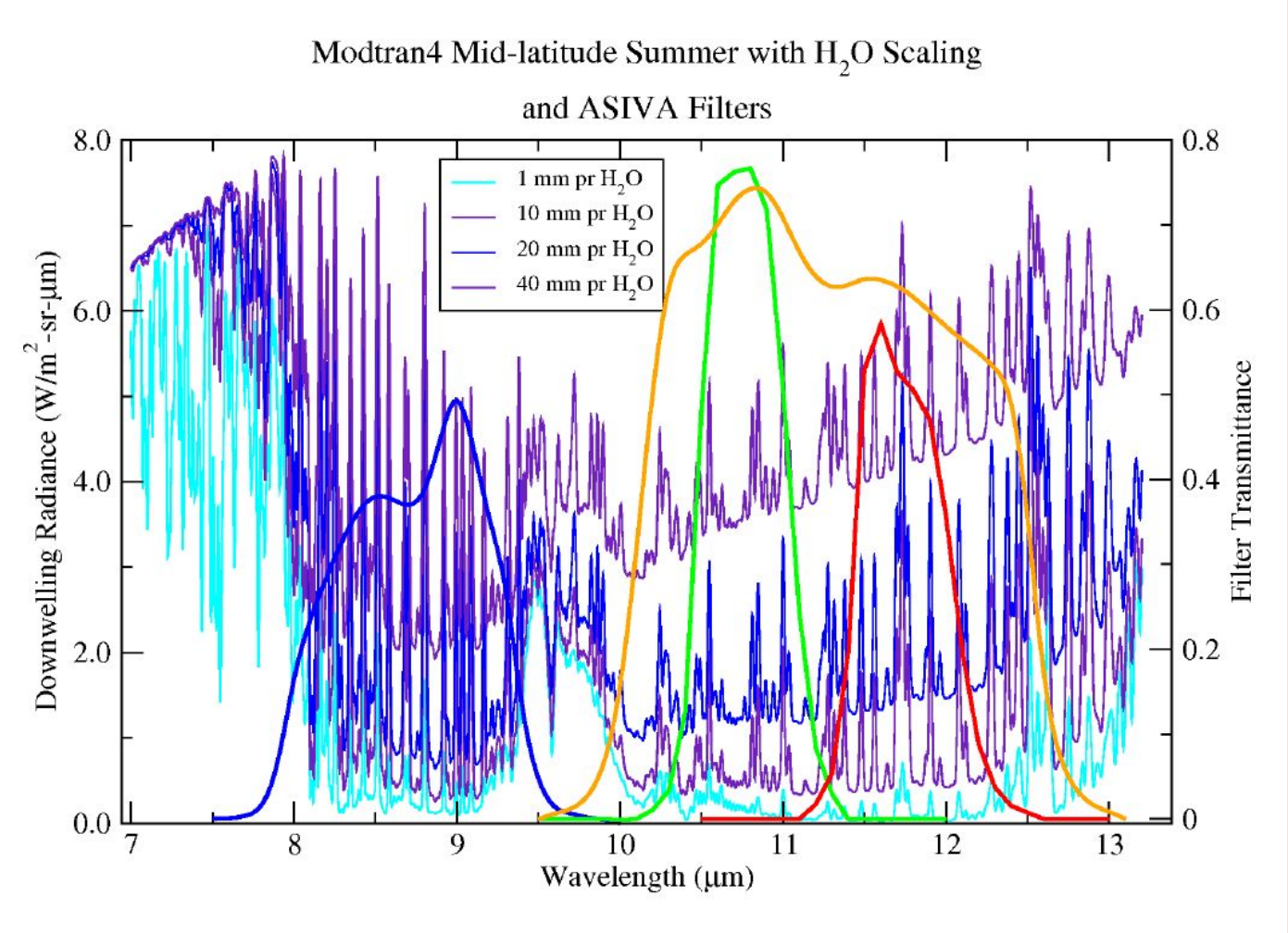


VIS Camera
(not used)

IR Camera
8-12um

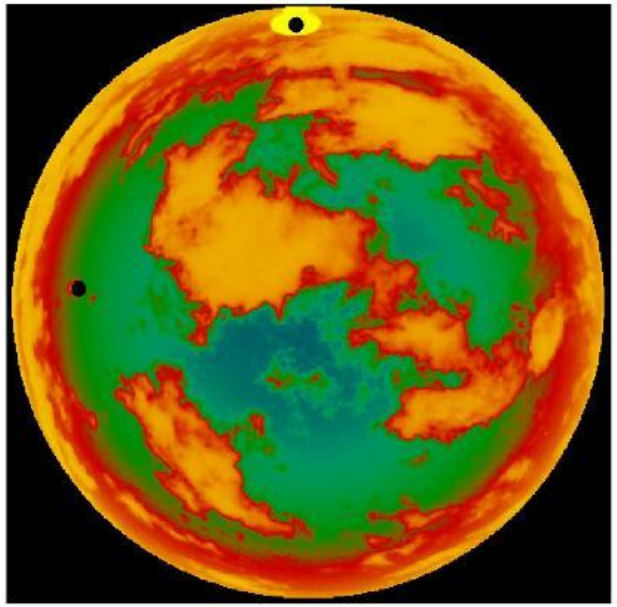


Spectral region:



- Two basic channels:
  - 8-9um (CH1)
  - 10-12 um (CH4)
- Background: water vapor (should be removed!)

10-12 μm Normalized Image



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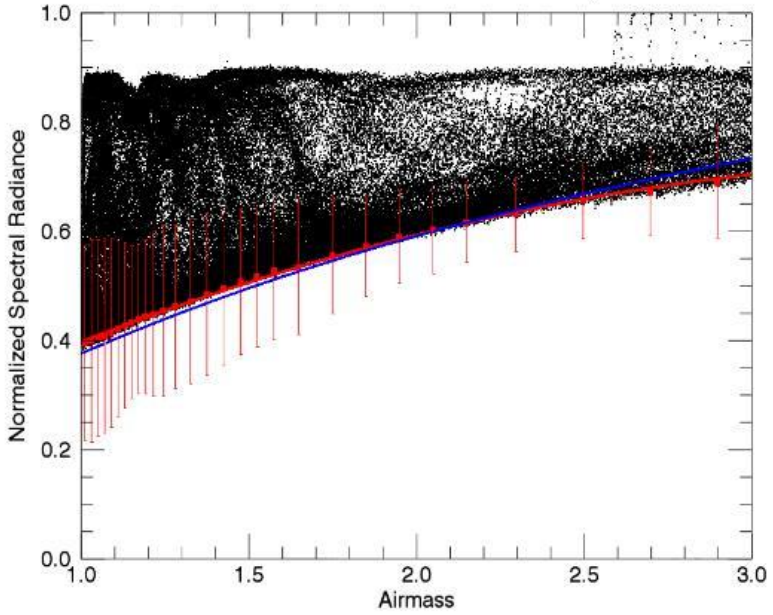
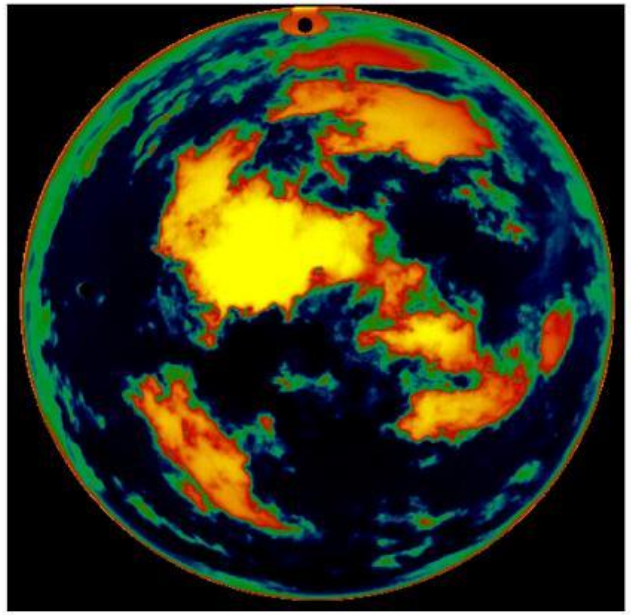
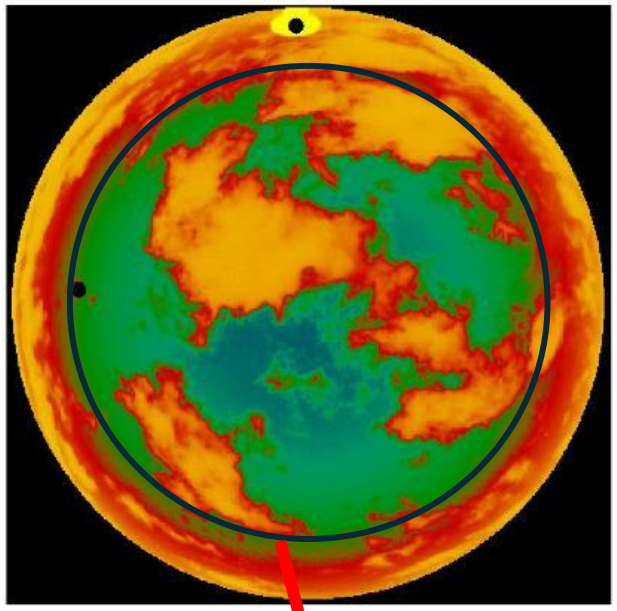
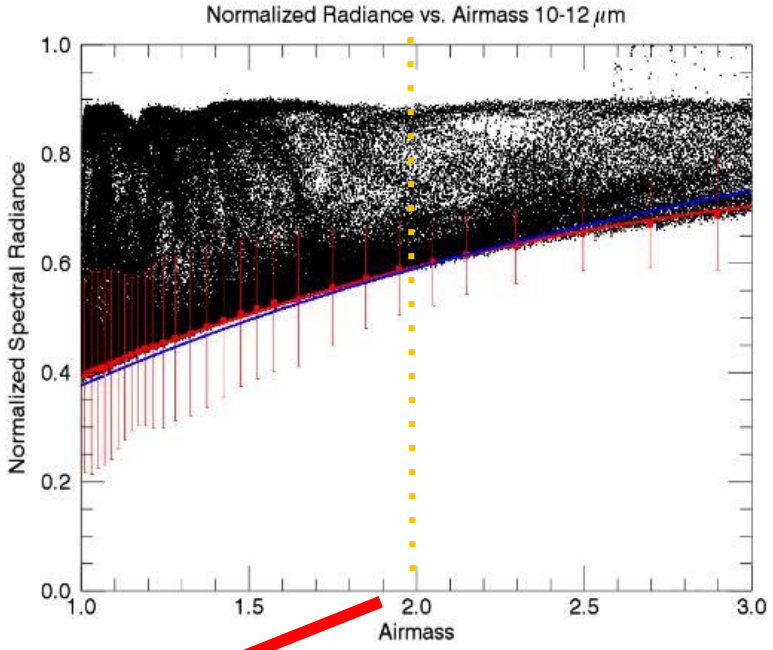
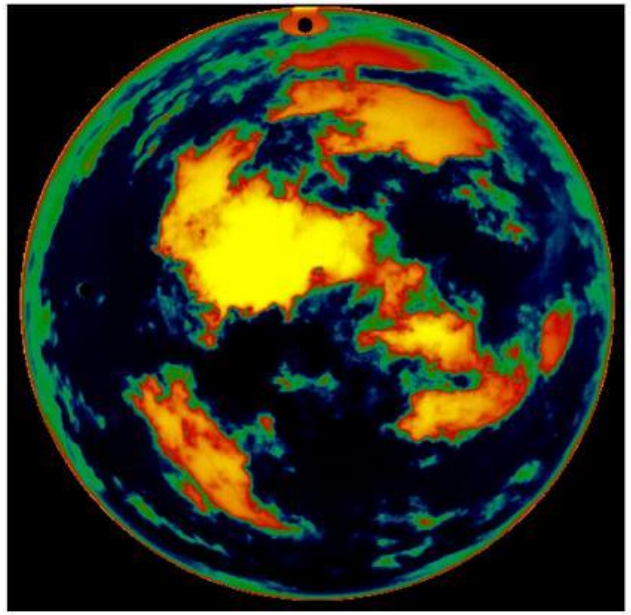


Clear Sky Subtracted Image









2 airmasses

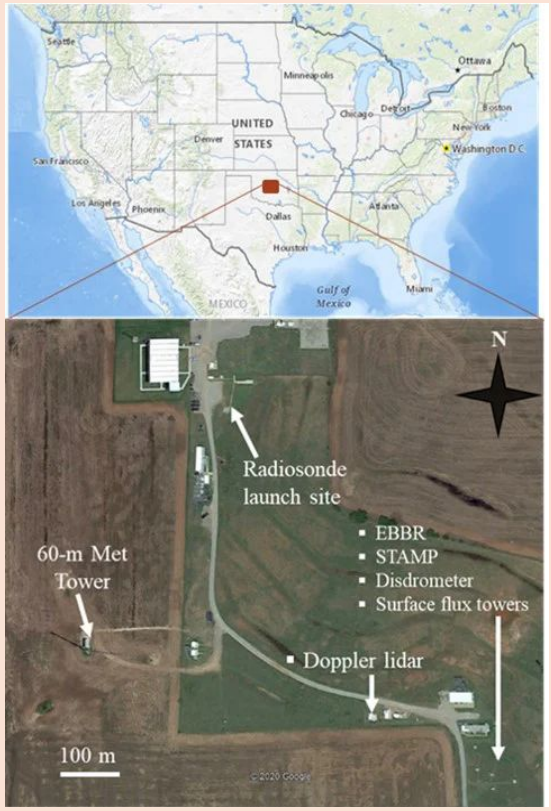
The main challenge: to fit the clear sky emission.

Possible approaches:

- Fit bottom envelope (when extra data absent);
- Atmospheric sounding (when available) >>> LibRadTran;
- Reanalysis profile >>> LibRadTran.

Where we measure?

ARM SGP (2017-2024)



Central Amazon (2025/26) Urban and Rural sites

Sao Paulo Metropolitan Area (2016; 2025)

What we get in the very end:

Manaus (central Amazon, urban site, DRY SEASON)

- Spectrally calibrated radiance

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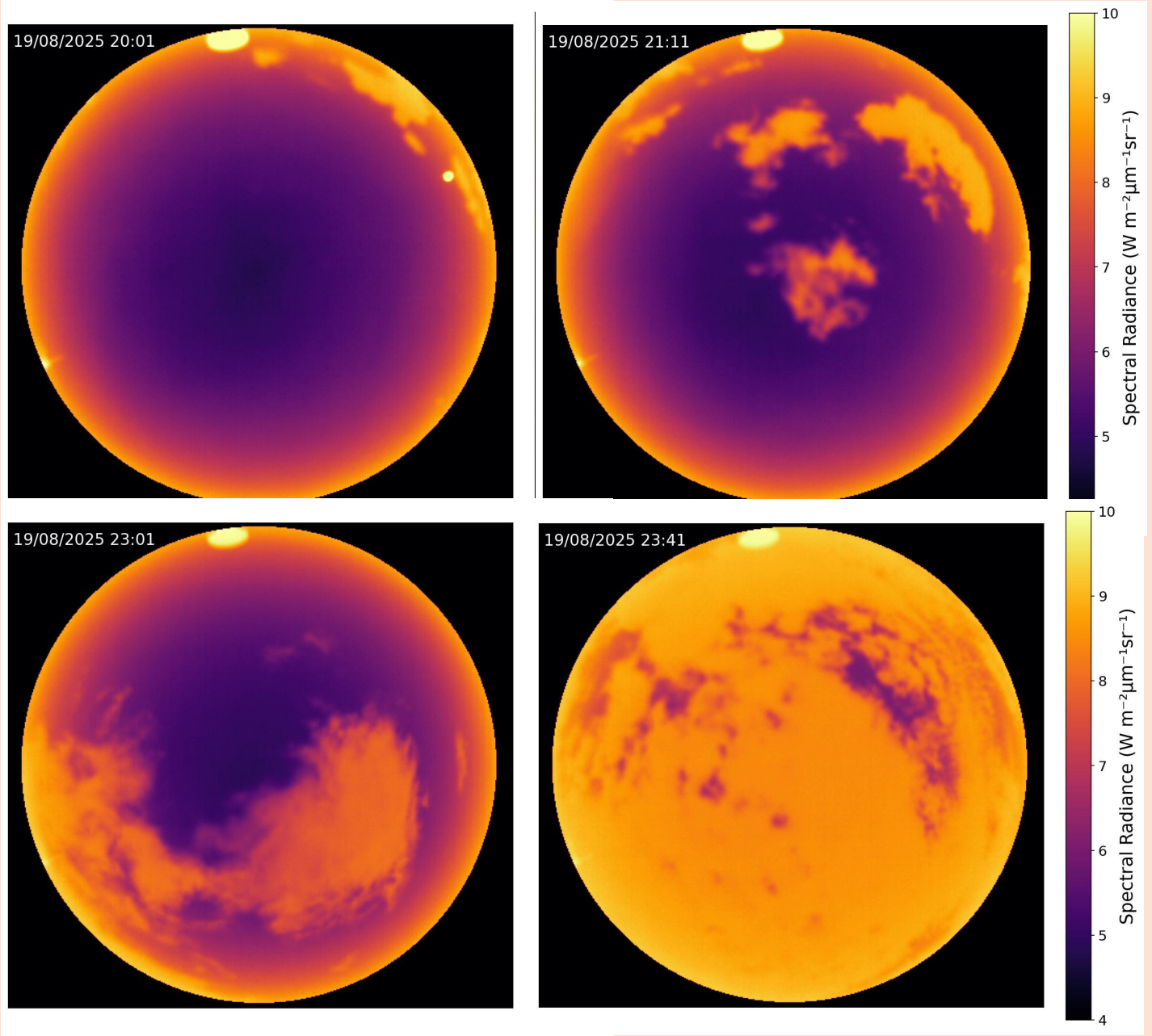
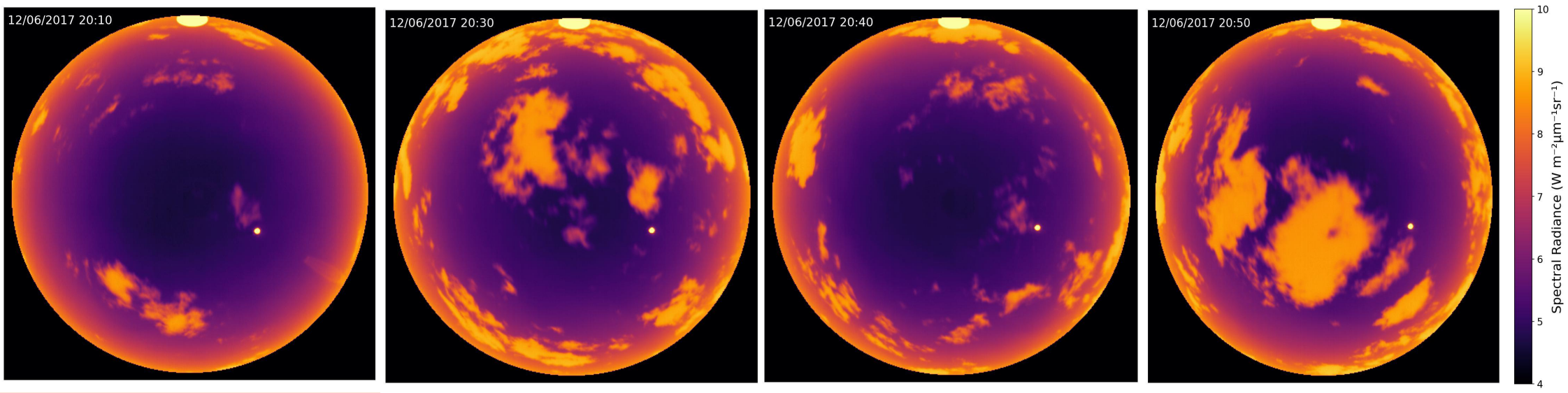


ARM-SGP (June 2017)

Actual Radiance field (as function of zenithal angle)



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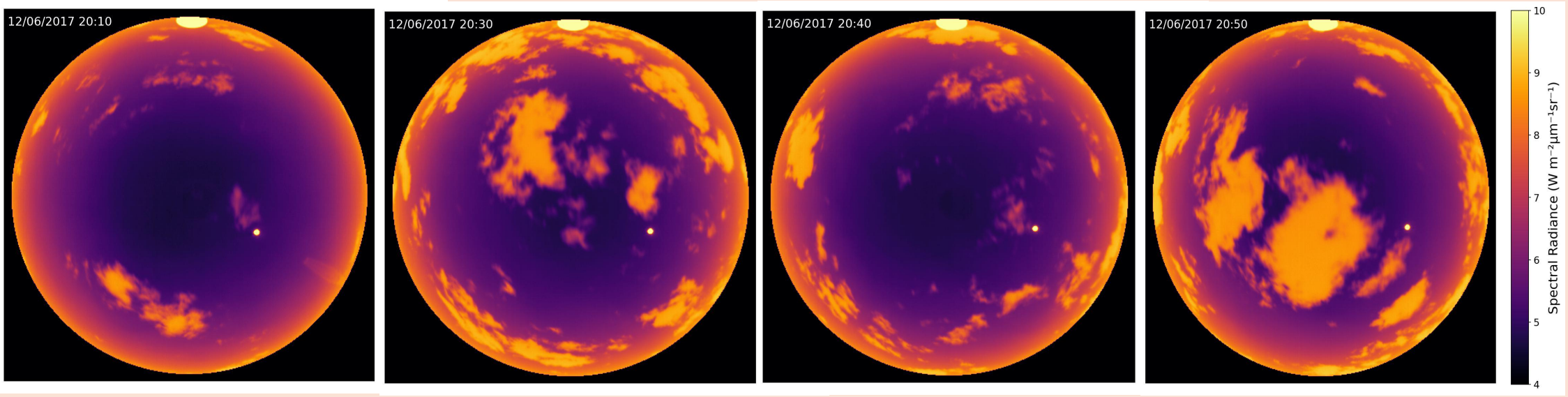
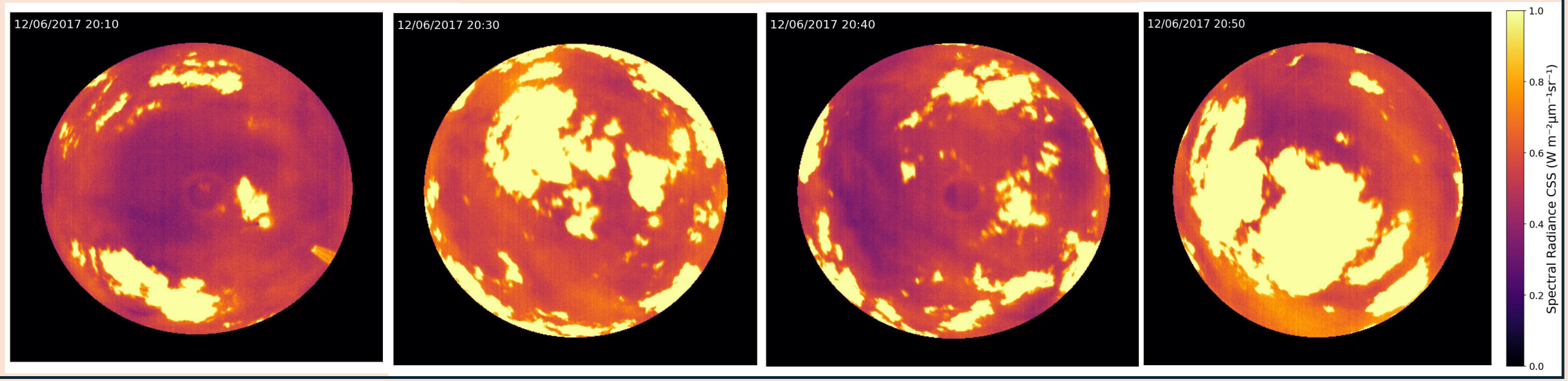
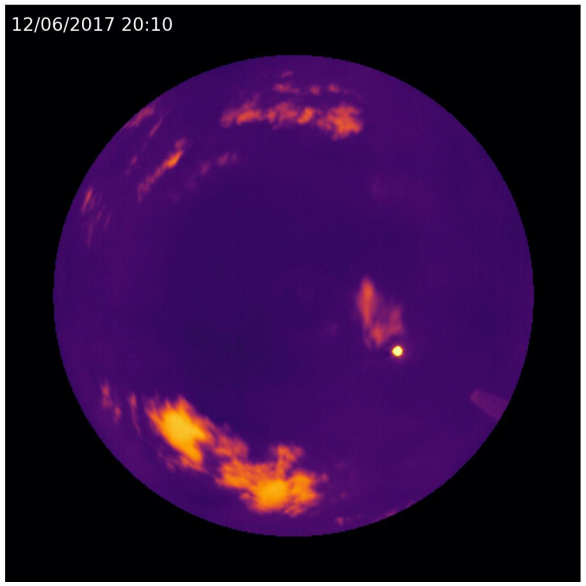
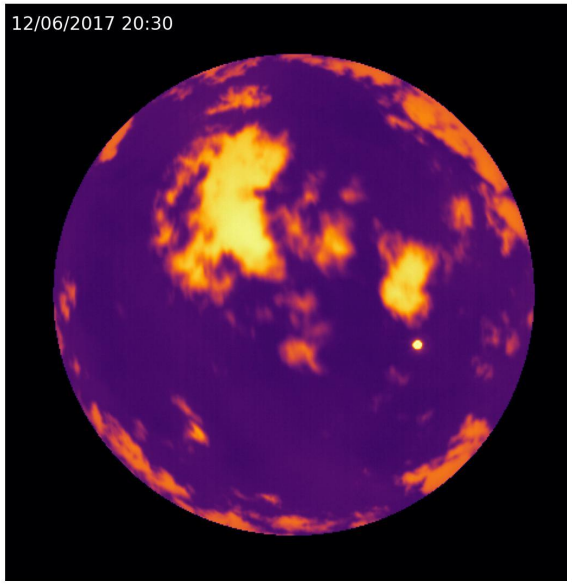


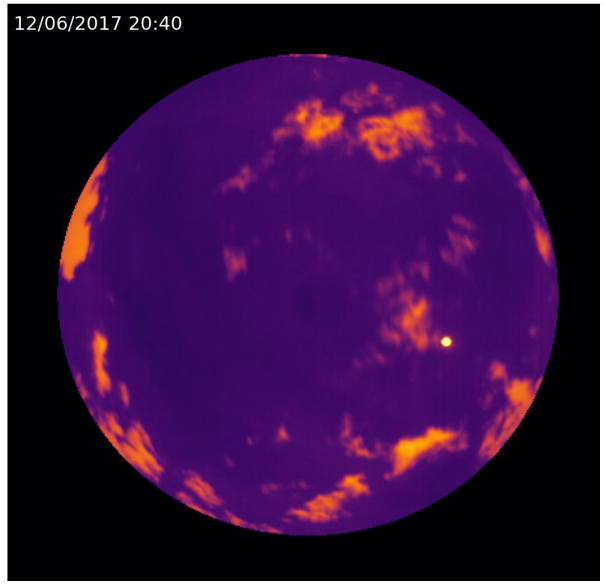
Clear Sky Subtracted Radiance: *proxy for cloud mask*

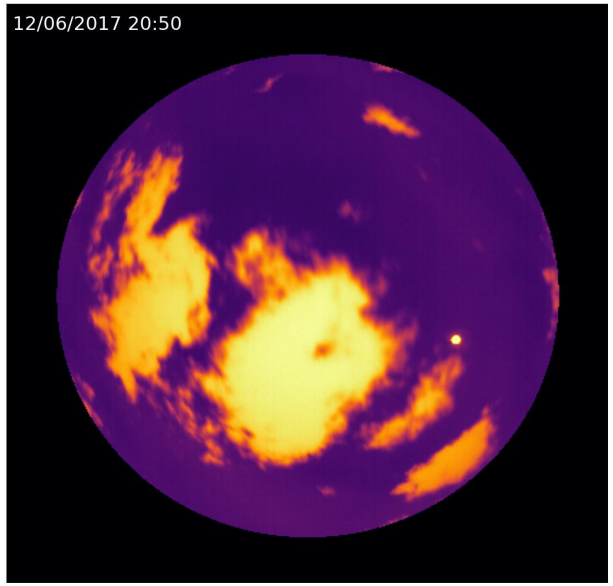


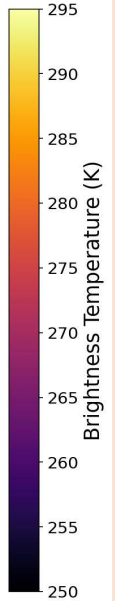
•Brightness Temperature: *Proxy for cloud base height*

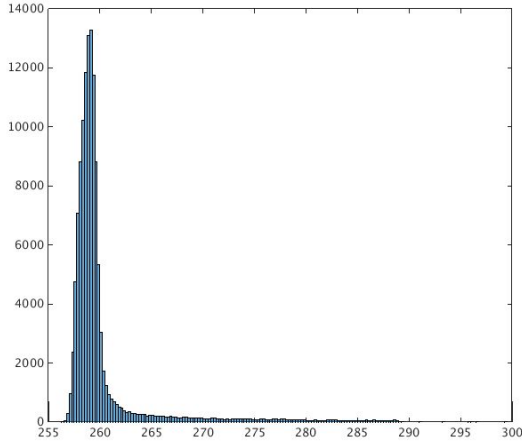


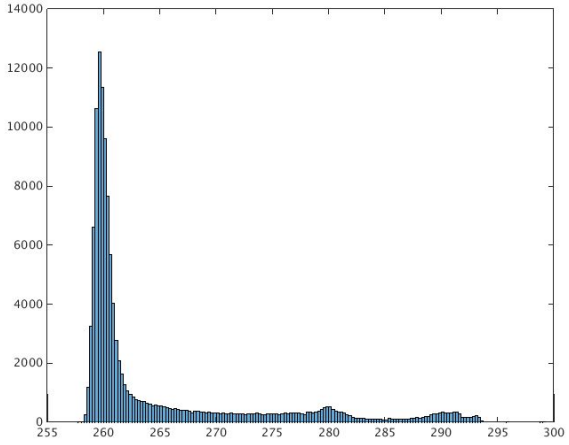


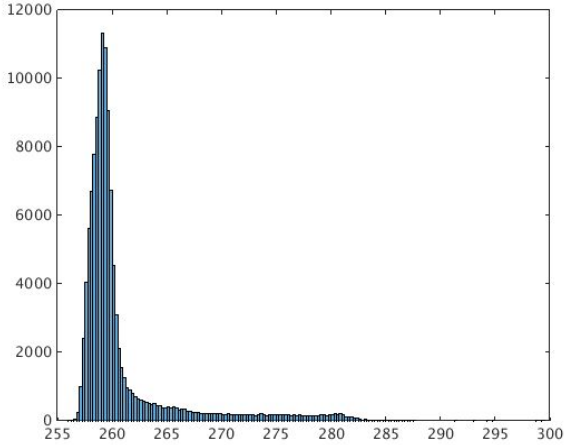


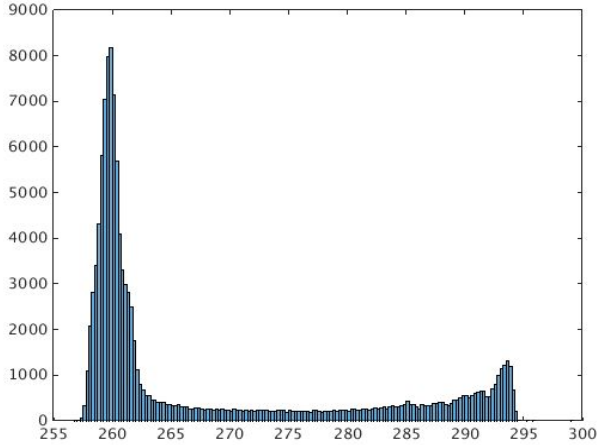




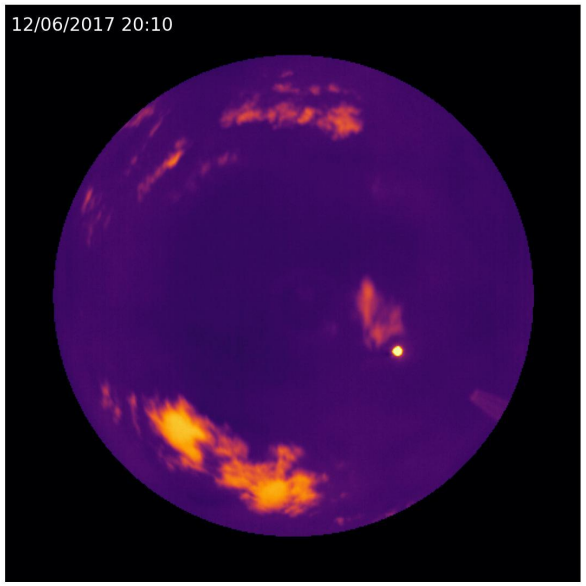


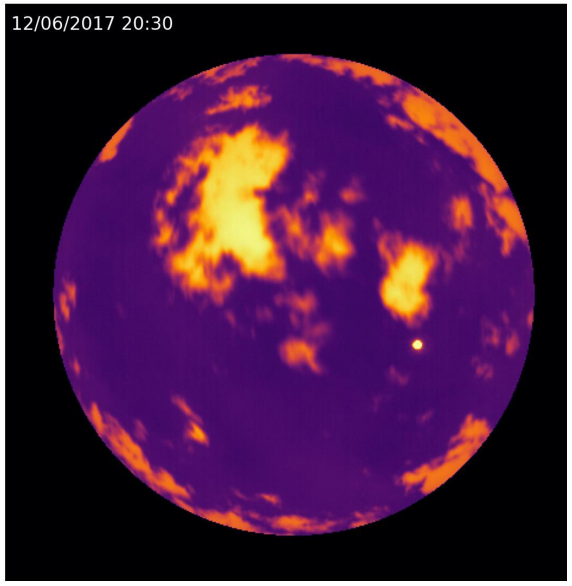


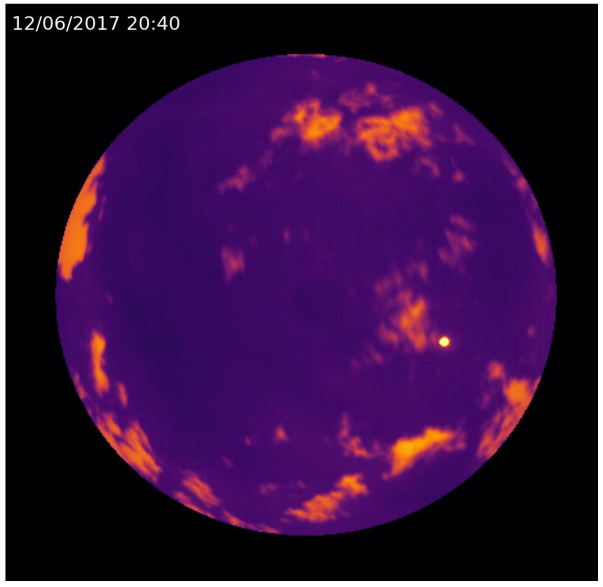


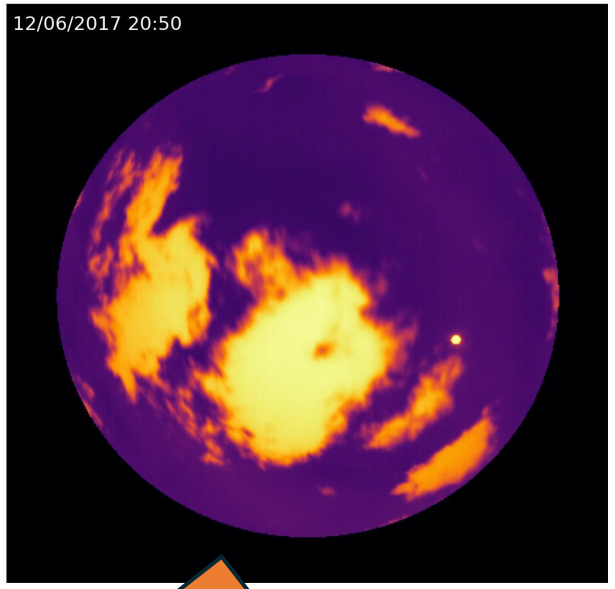


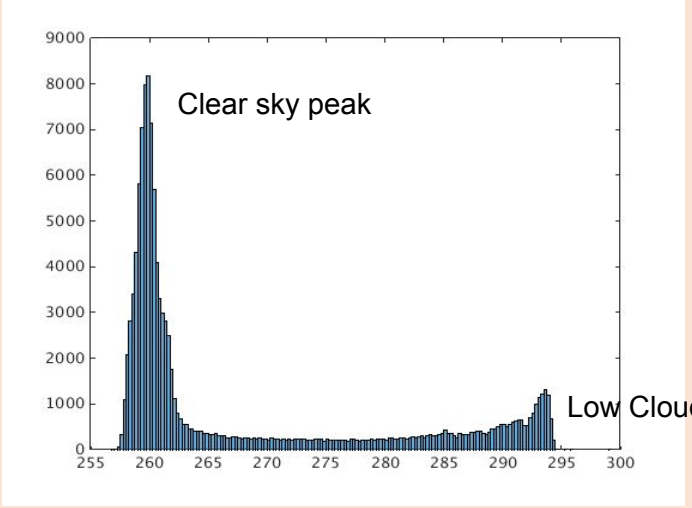
•Brightness Temperature: *Proxy for cloud base height*











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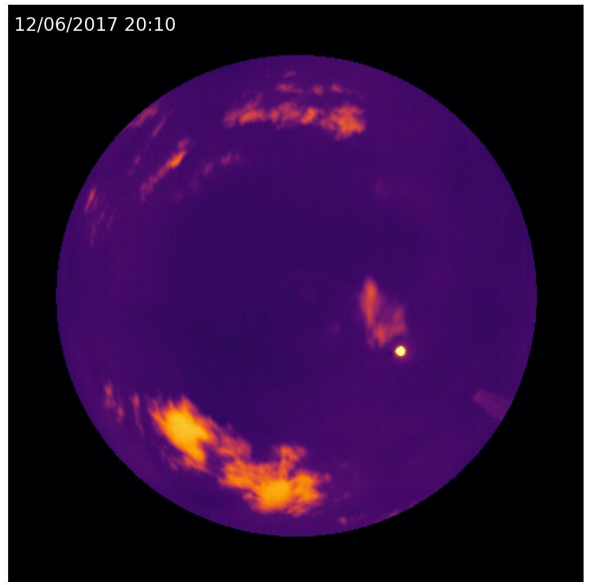
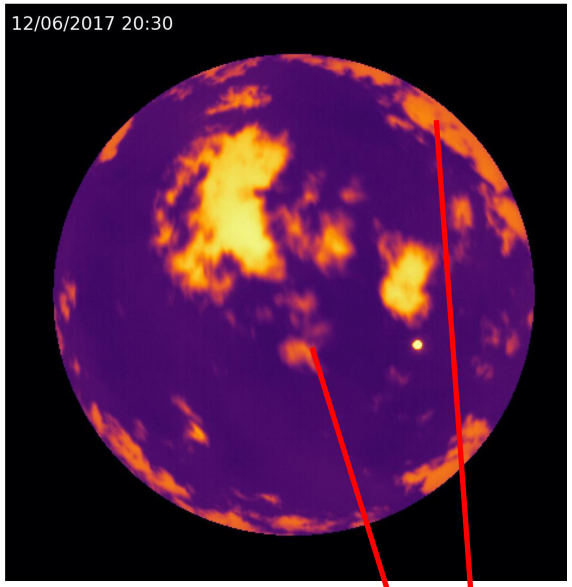
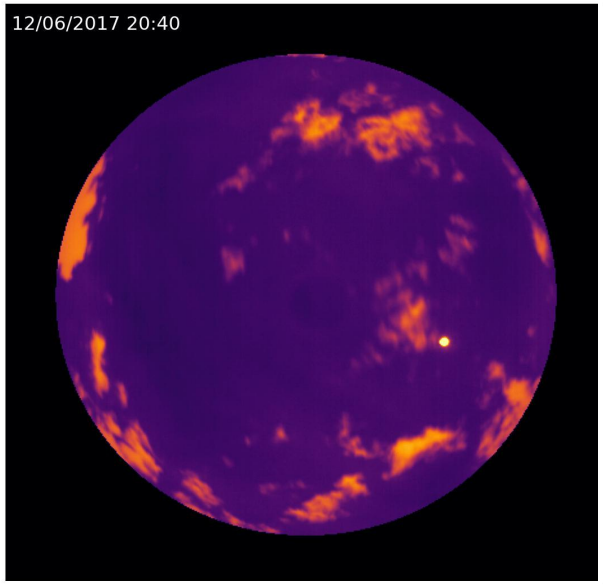
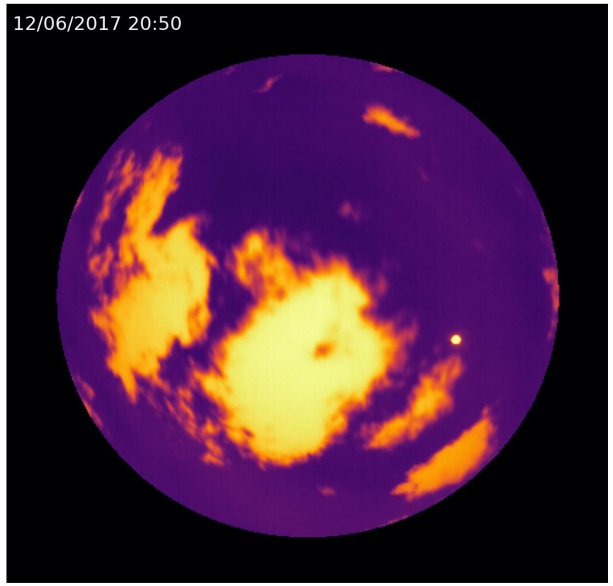
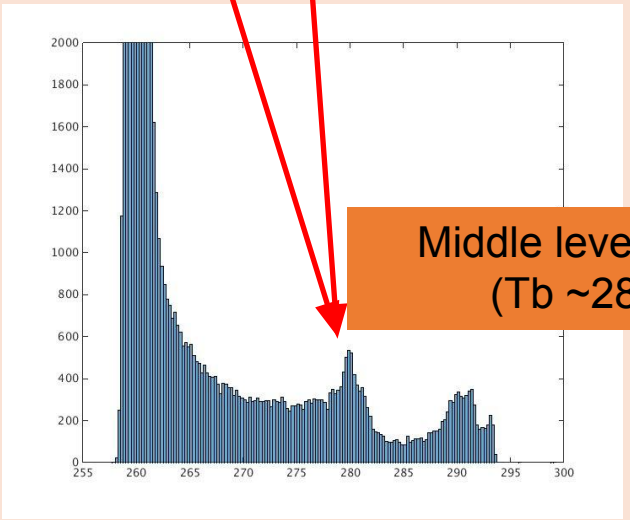








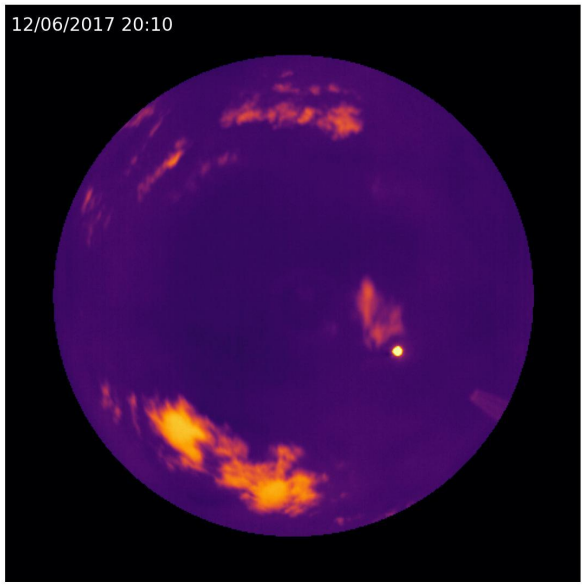


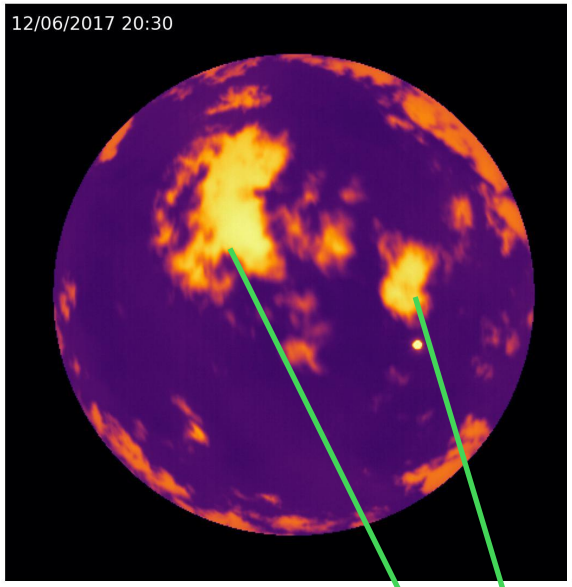
Middle level clouds
(Tb ~280K)

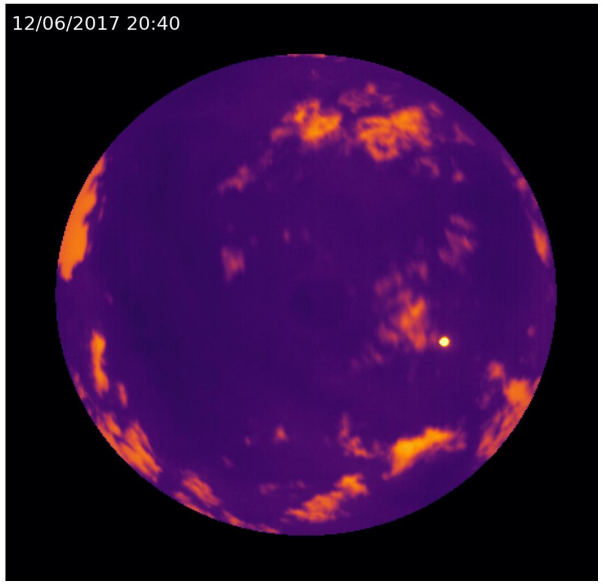
Temp Ambient **~309K!**

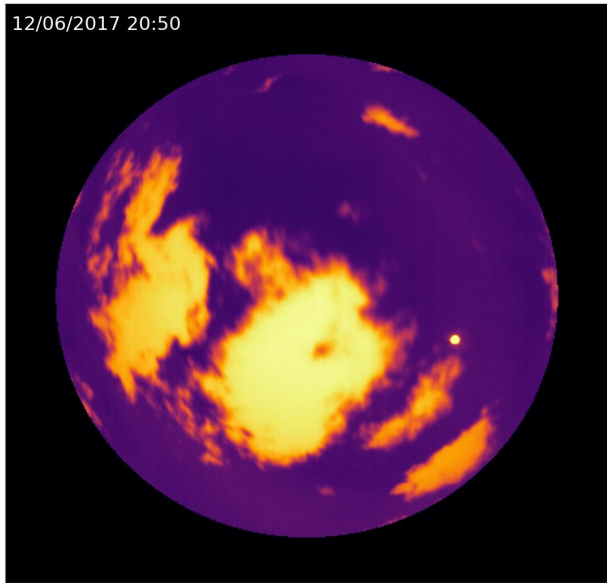
Zoomed Histogram

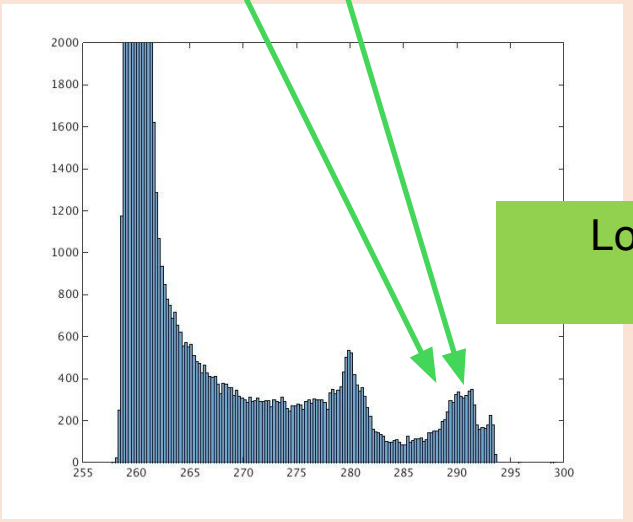
•Brightness Temperature: *Proxy for cloud base height*











Low level clouds
(Tb ~292K)

Temp Ambient **~309K!**

Zoomed Histogram

Potential applications in modelling:

- Validation of Cloud Resolving simulations:
  - 1 minute gridded fields of:
    - Cloud radiance; Clear Sky Radiance.
    - Cloud mask;
    - Cloud Base downward IR radiance
  - Horizontal domain: ~40 km

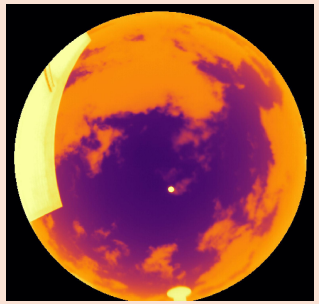
Other applications for this technique:

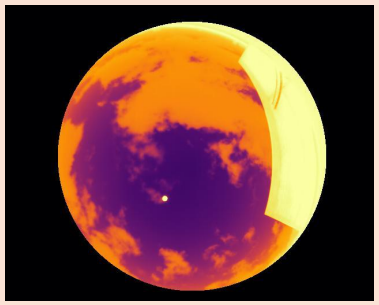
- Cloud effect of Solar Power Plants;
- Laser communication;
- Astronomy;
- Military.

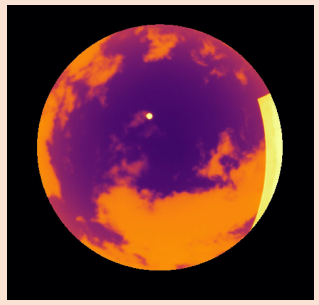
Acknowledgements

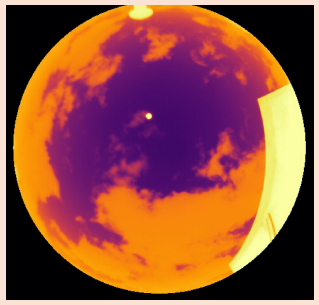
- FAPEAM;
- CNPq;
- Embrapa Amazônia Ocidental;
- UEA staff.

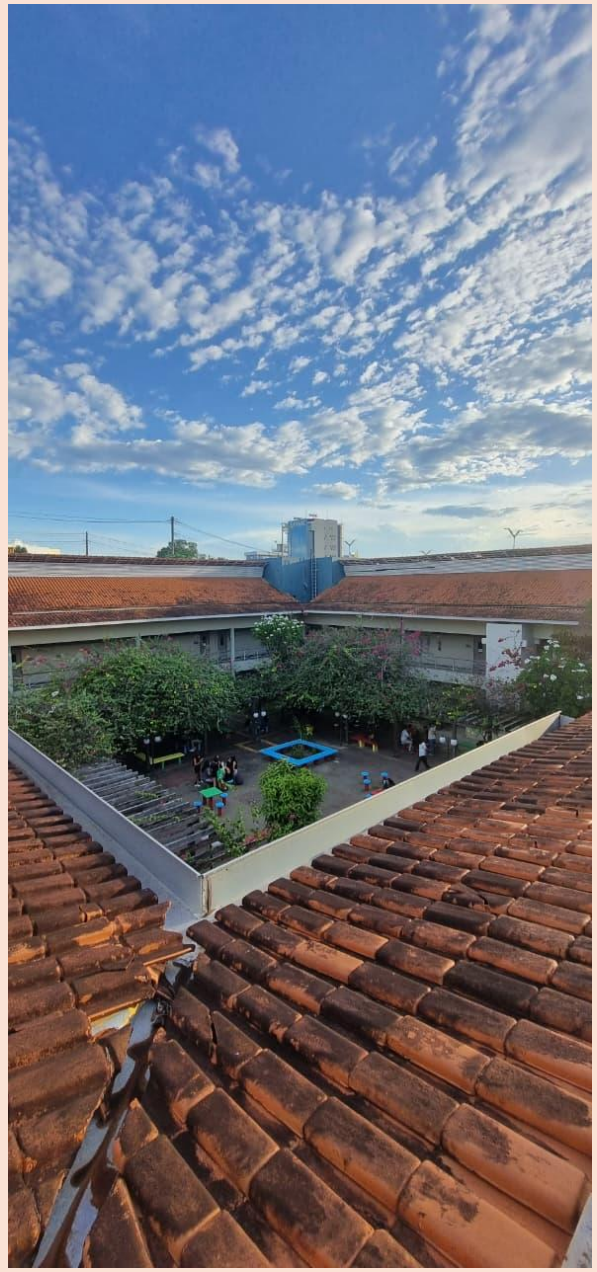
Thank you!











The whole process

RAW data:
SKY image;
Ref Image;

$$F_{\lambda_{Sky}} = \frac{I_{\lambda_{Sky}} - I_{\lambda_{Ref}}}{G_\lambda} + BB_\lambda(T_{Ref}) \left\{ Watts/m^2/\mu m/sr \right\},$$

Spectral Radiance

Polynomial Fitting of envelope

OR

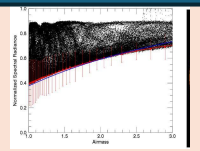
Sounding + libRadtran

OR

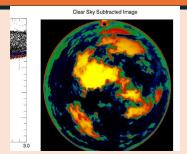
Reanalysis Profile + libRadtran

"Site dependent"

Clear Sky envelope



Clear Sky Subtracted



PRODUCTS:

- Cloud field
- High/low emission clouds;
- Cloud Base Brightness Temperature
- Subvisible clouds;
- Water Vapor anisotropy.

The whole process

RAW data:
- SKY image
- Ref Image

Spectral Radiance

↓

Clear Sky envelope

↓

Clear Sky Subtracted

↕

Polynomial Fitting of envelope
OR
Sounding + libRadtran
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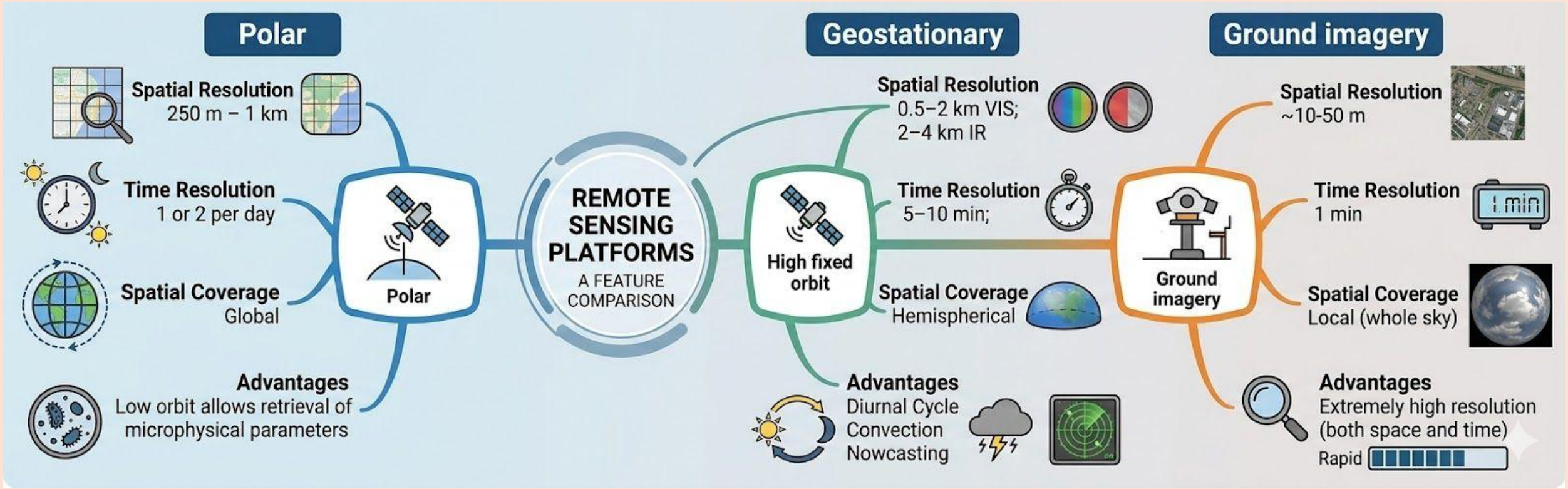
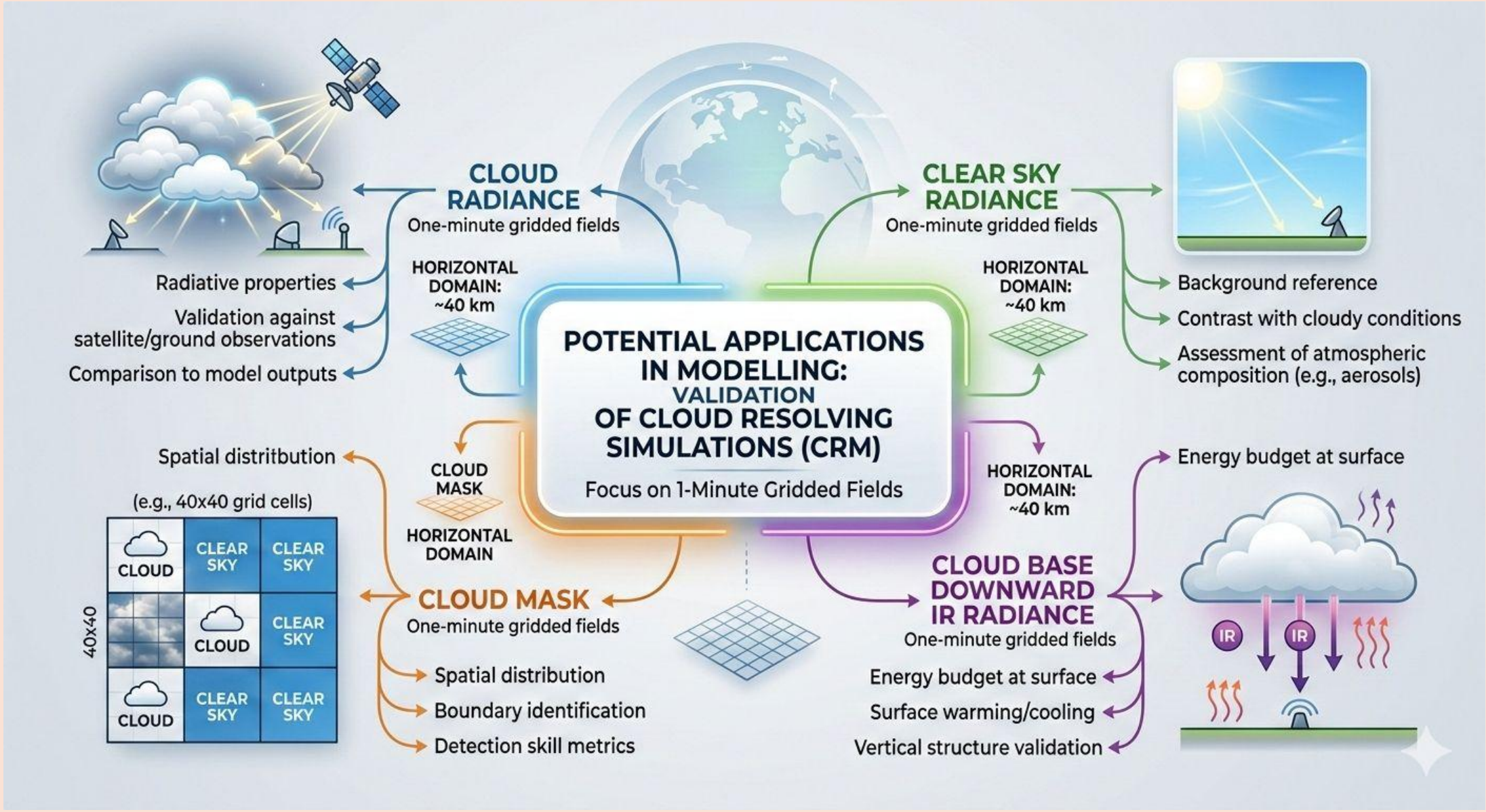
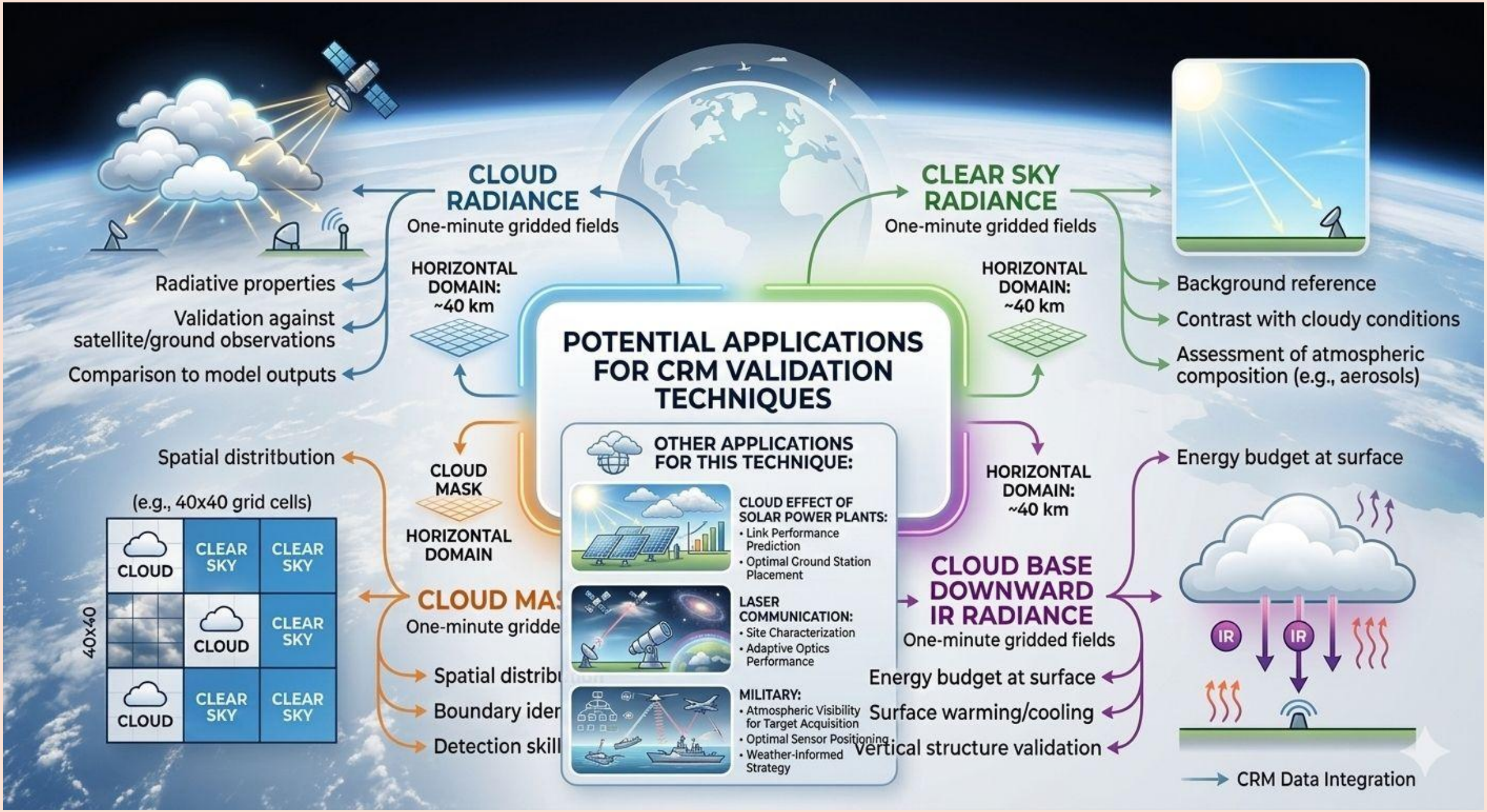

REMOTE SENSING PLATFORMS
A FEATURE COMPARISON
Polar
Spatial Resolution
250 m – 1 km
Time Resolution
1 or 2 per day
Spatial Coverage
Global
Advantages
Low orbit allows retrieval of microphysical parameters
Polar
Geostationary
Spatial Resolution
0.5–2 km VIS;
2–4 km IR
Time Resolution
5–10 min;
Spatial Coverage
Hemispherical
Advantages
Diurnal Cycle
Convection
Nowcasting
High fixed orbit
Ground imagery
Spatial Resolution
~10-50 m
Time Resolution
1 min
1 min
Spatial Coverage
Local (whole sky)
Advantages
Extremely high resolution (both space and time)
Rapid
Ground imagery


POTENTIAL APPLICATIONS IN MODELLING:
VALIDATION
OF CLOUD RESOLVING SIMULATIONS (CRM)
Focus on 1-Minute Gridded Fields
CLOUD RADIANCE
One-minute gridded fields
Radiative properties
Validation against satellite/ground observations
Comparison to model outputs
HORIZONTAL DOMAIN: ~40 km
CLEAR SKY RADIANCE
One-minute gridded fields
Background reference
Contrast with cloudy conditions
Assessment of atmospheric composition (e.g., aerosols)
HORIZONTAL DOMAIN: ~40 km
CLOUD MASK
HORIZONTAL DOMAIN
Spatial distribution
(e.g., 40x40 grid cells)
40x40
CLOUD
CLEAR SKY
CLOUD MASK
One-minute gridded fields
Spatial distribution
Boundary identification
Detection skill metrics
HORIZONTAL DOMAIN: ~40 km
CLOUD BASE DOWNWARD IR RADIANCE
One-minute gridded fields
Energy budget at surface
Surface warming/cooling
Vertical structure validation
Energy budget at surface
IR


CLOUD RADIANCE
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CLEAR SKY RADIANCE
One-minute gridded fields
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Background reference
Contrast with cloudy conditions
Assessment of atmospheric composition (e.g., aerosols)
POTENTIAL APPLICATIONS FOR CRM VALIDATION TECHNIQUES
OTHER APPLICATIONS FOR THIS TECHNIQUE:
CLOUD EFFECT OF SOLAR POWER PLANTS:
• Link Performance Prediction
• Optimal Ground Station Placement
LASER COMMUNICATION:
• Site Characterization
• Adaptive Optics Performance
MILITARY:
• Atmospheric Visibility for Target Acquisition
• Optimal Sensor Positioning
• Weather-Informed Strategy
Spatial distribution
(e.g., 40x40 grid cells)
CLOUD
CLEAR SKY
CLEAR SKY
CLOUD
CLEAR SKY
CLOUD
CLEAR SKY
CLEAR SKY
40x40
CLOUD MASK
HORIZONTAL DOMAIN
CLOUD MA
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CLOUD BASE DOWNWARD IR RADIANCE
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Surface warming/cooling
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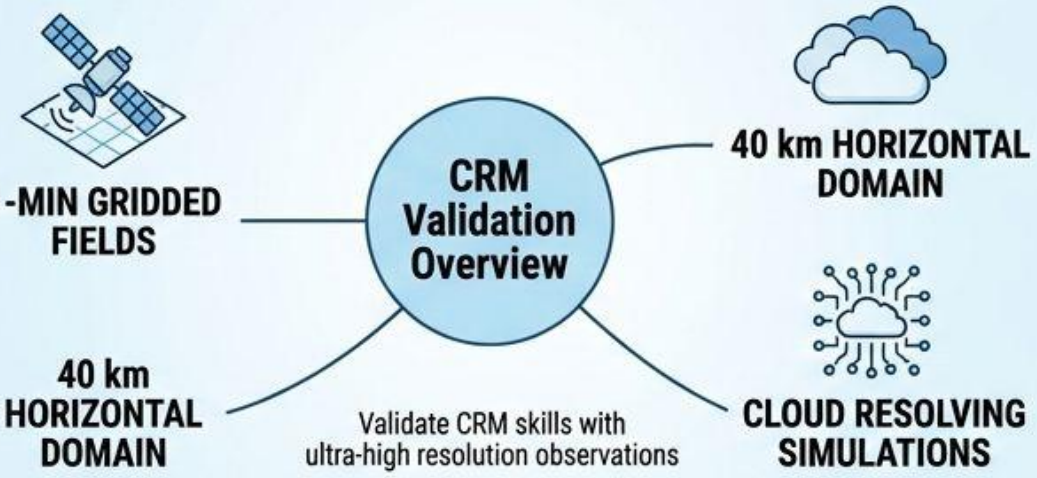
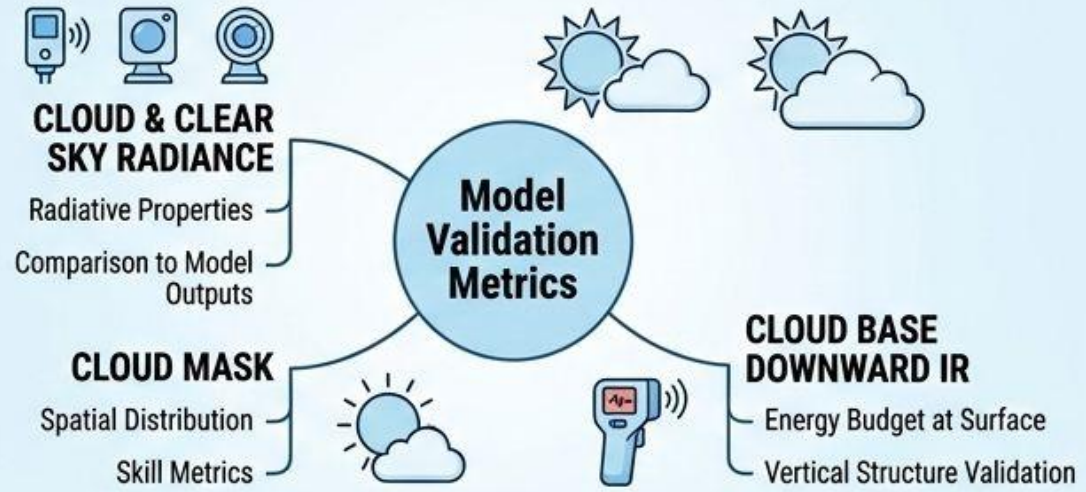
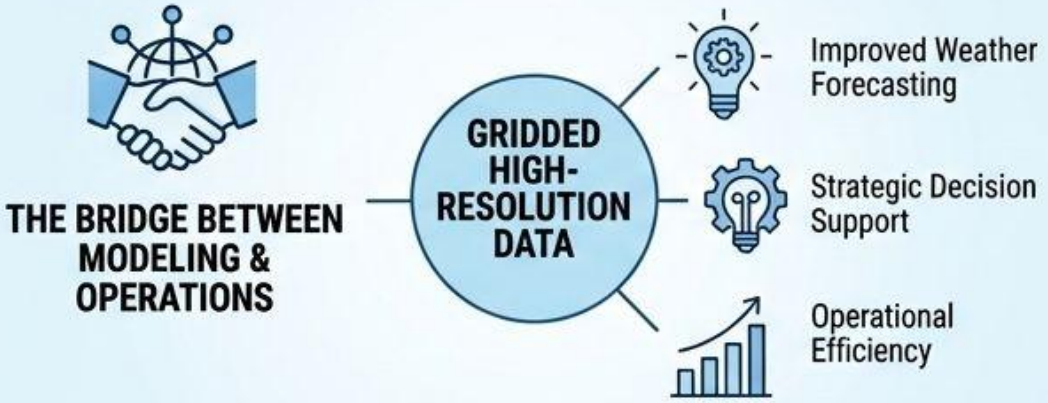
Energy budget at surface
IR
IR
CRM Data Integration

ATMOSPHERIC MODELLING APPLICATIONS: OVERVIEW



CORE VALIDATION PARAMETERS



CROSS-INDUSTRY APPLICATIONS

CONCLUSION & SUMMARY