

# Surface solar irradiance variability under shallow cumulus clouds at SGP: Insights from observations and LES

**Jake Gristey<sup>1,2</sup>**

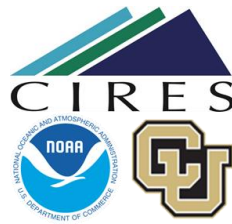
Graham Feingold<sup>2</sup>, Ian Glenn<sup>1,2</sup>, Sebastian Schmidt<sup>3</sup>, Hong Chen<sup>3</sup>

<sup>1</sup>Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, USA

<sup>2</sup>Chemical Sciences Division, NOAA Earth System Research Laboratory, Boulder, CO, USA

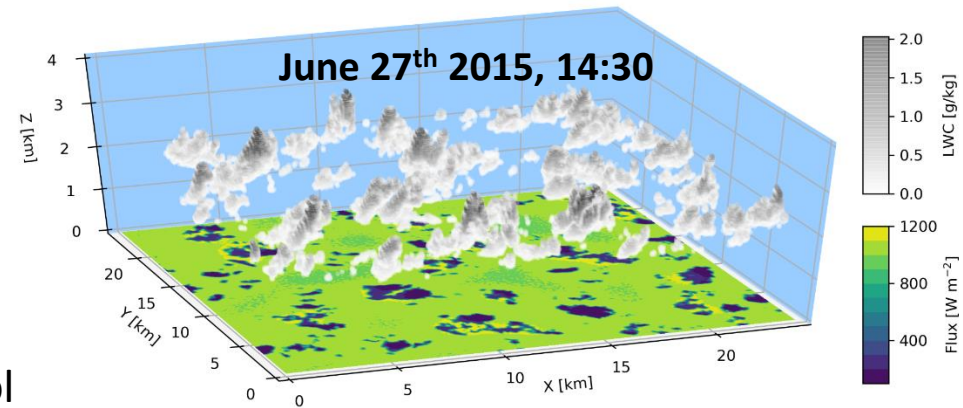
<sup>3</sup>Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA



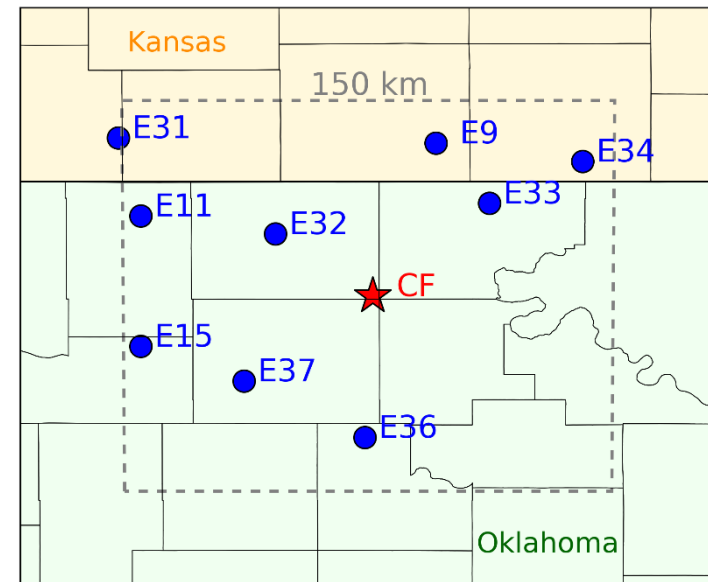
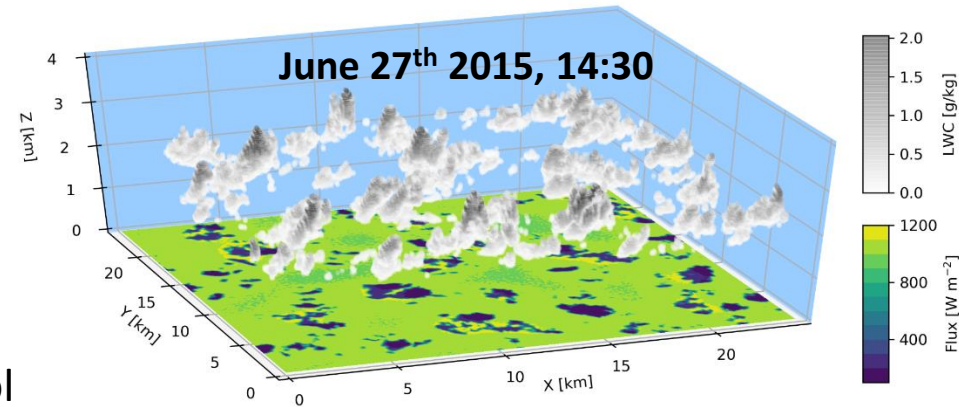


- The LASSO project is bringing together observations at the ARM SGP site with high resolution modeling [Gustafson et al. 2018]

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  - 24 km domain
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  - ~20 m vertical resolution (< 5km)

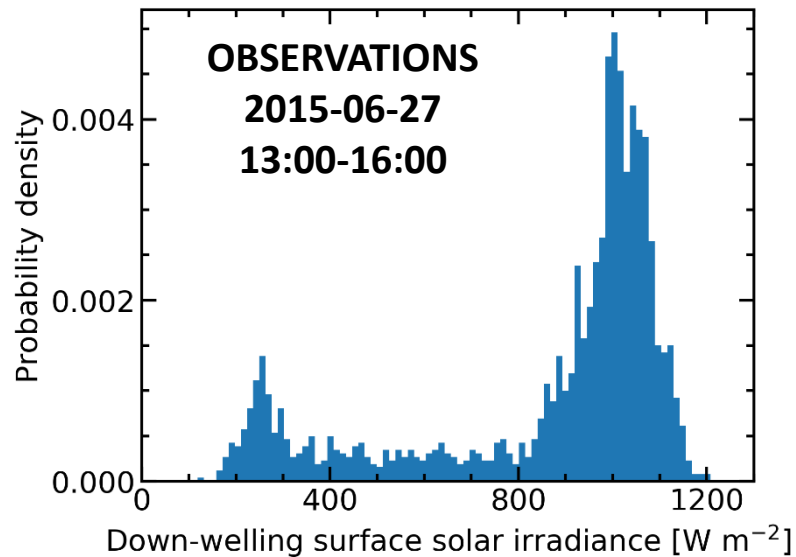


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- Observations from Radiative Flux Analysis [Long and Ackerman 2000]
  - Broad-band surface solar irradiance



# PDFs of surface solar irradiance

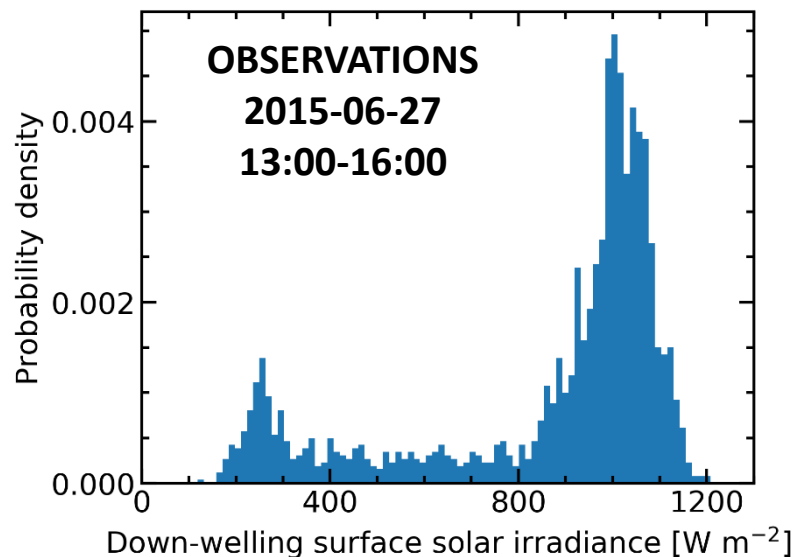
3



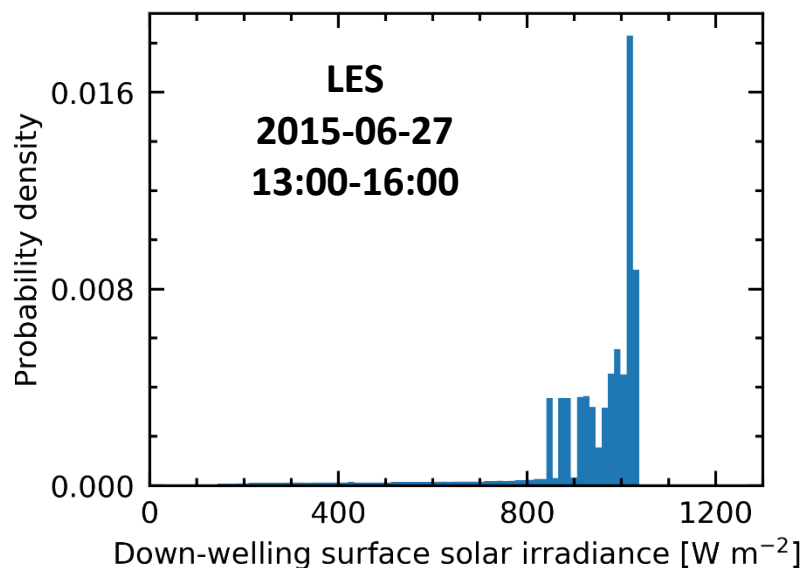
- Bi-modal distribution in observed down-welling surface solar irradiance [Schmidt et al. 2009]
  - 1<sup>st</sup> mode: sun obscured
  - 2<sup>nd</sup> mode: clear sky
- Likely influenced by cloud fraction, cloud LWP, cloud size, variability in LWP...

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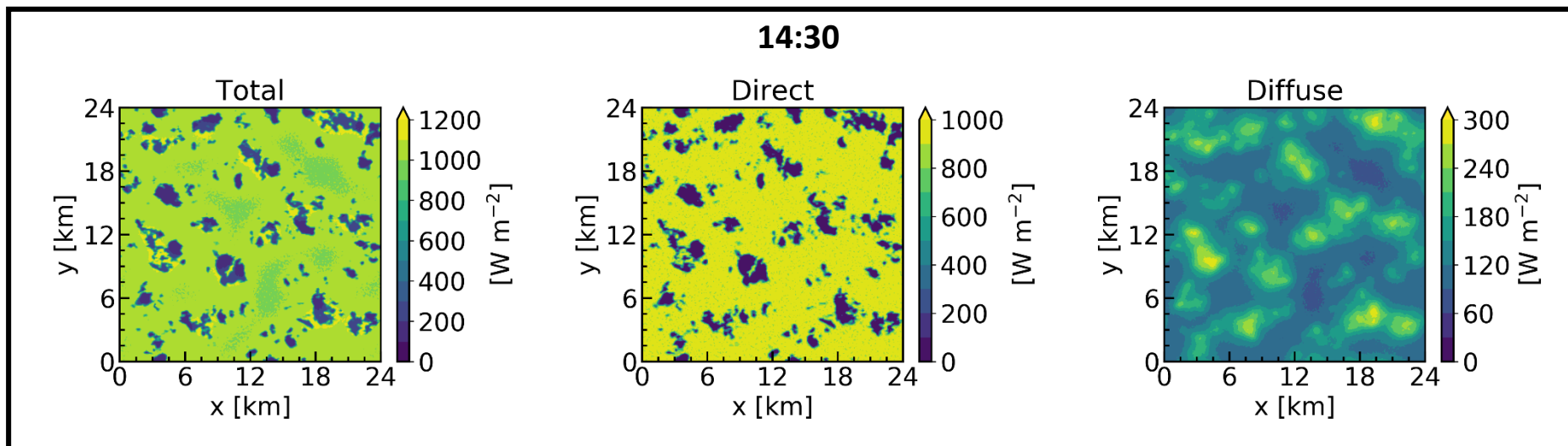
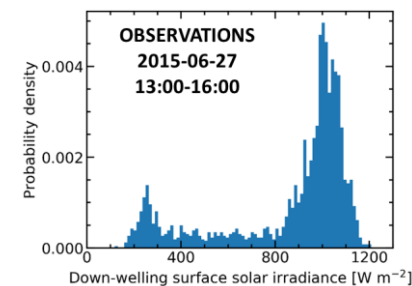
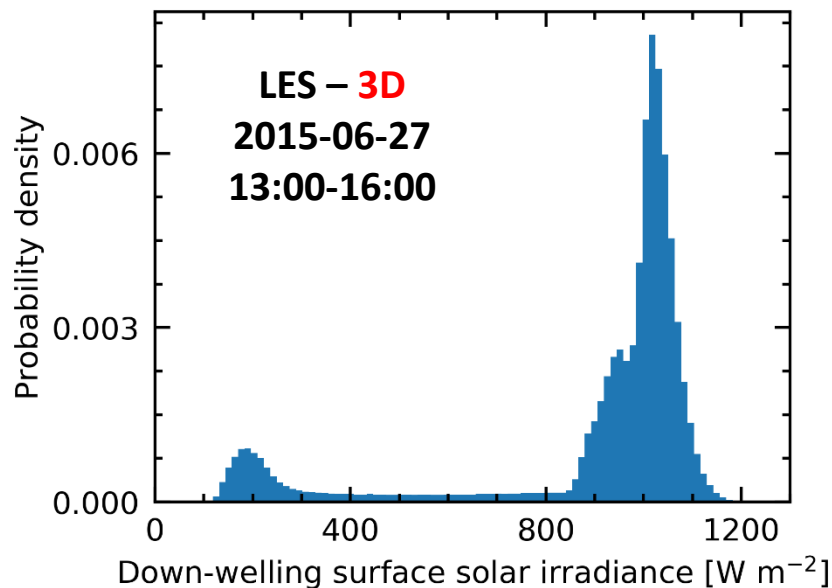


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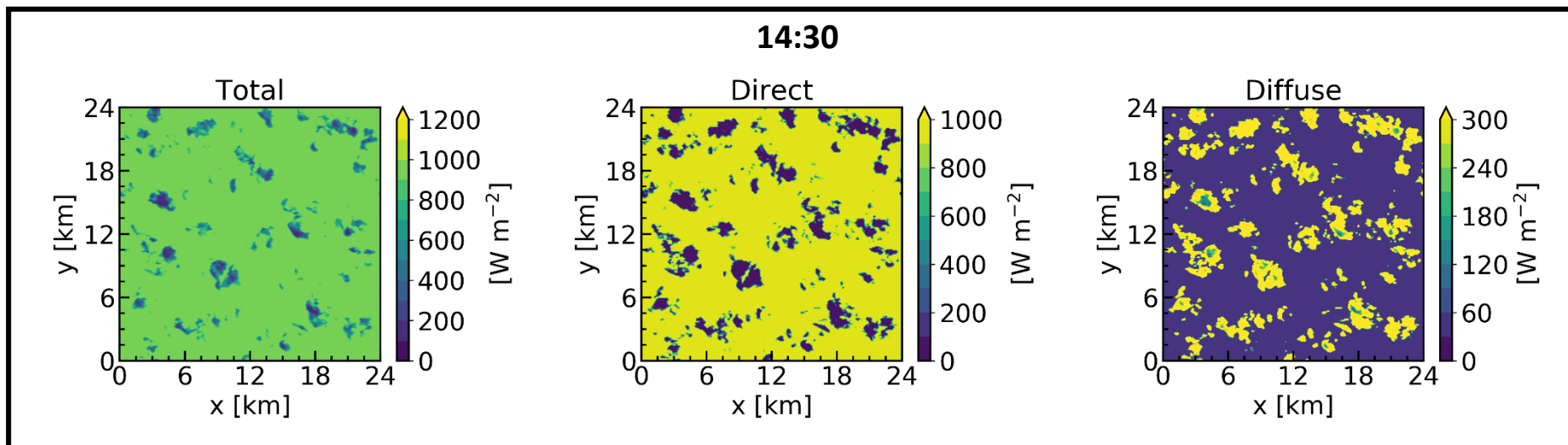
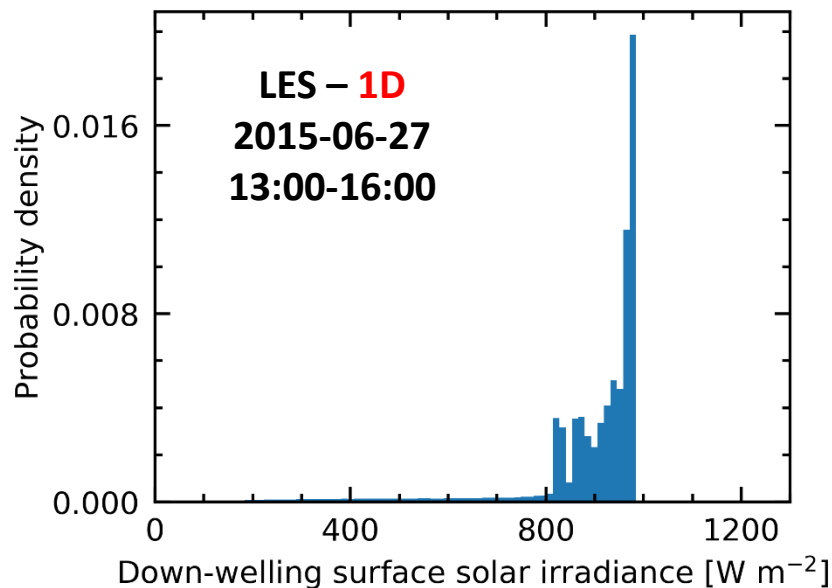


- LES output does not resemble observed PDF
- Sharp cut off at larger values, and no peak at lower values

# 3D calculations using LES output

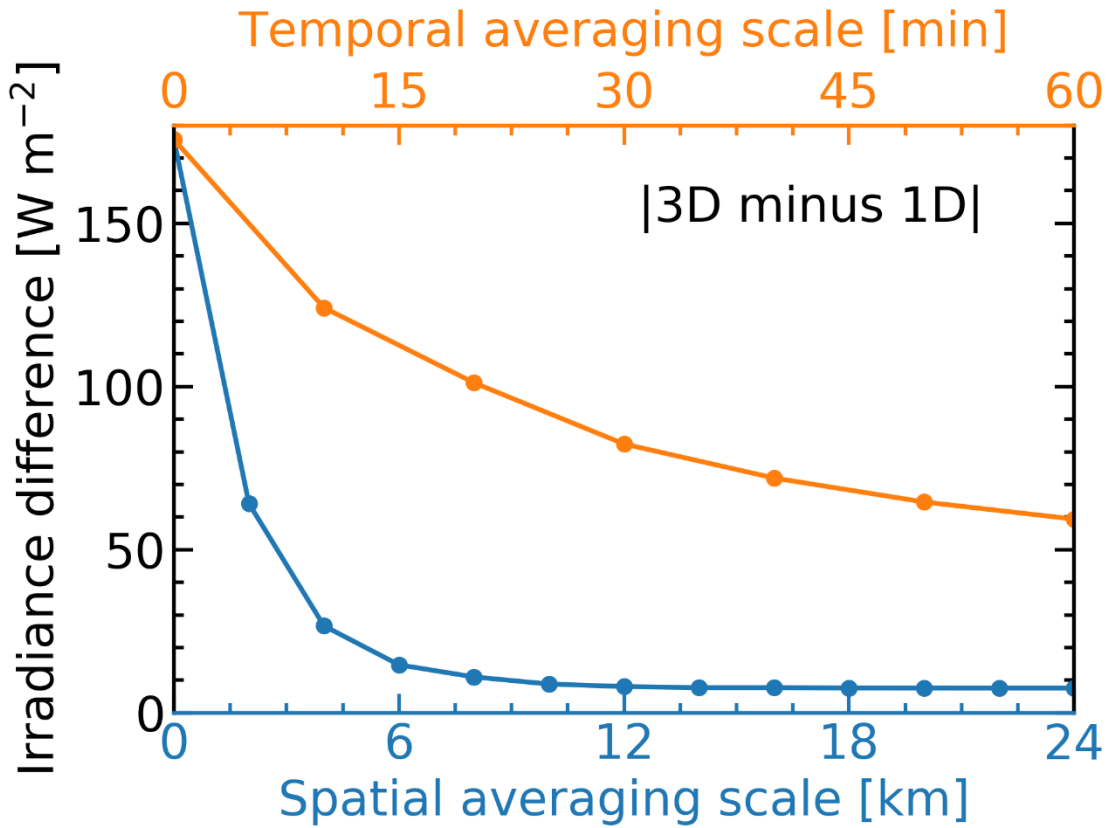
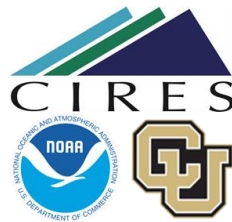


# 1D calculations using LES output





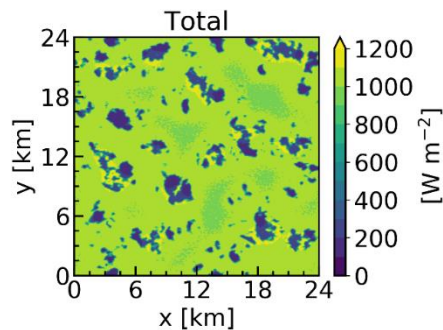
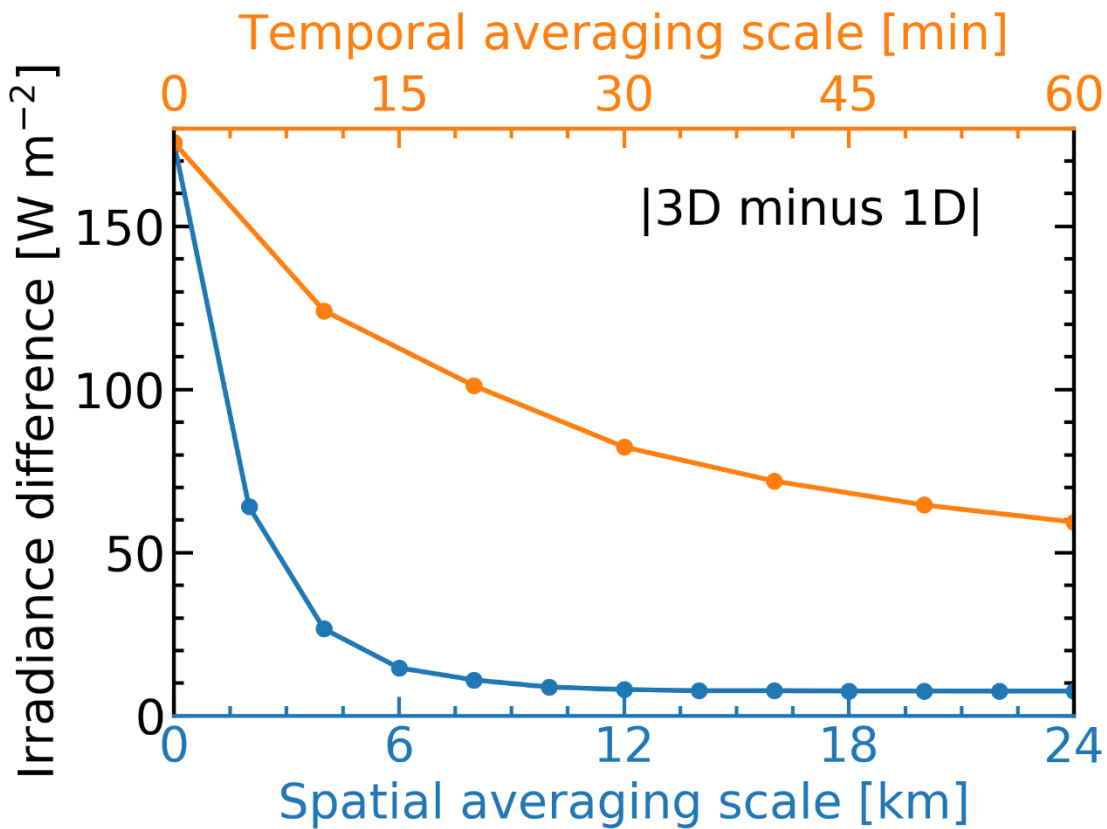
# Scale sensitivity



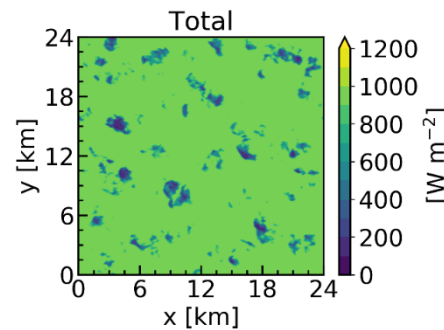
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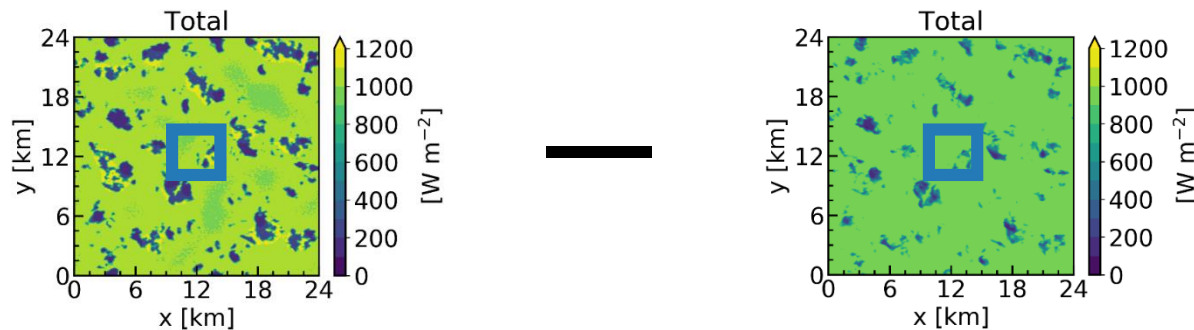
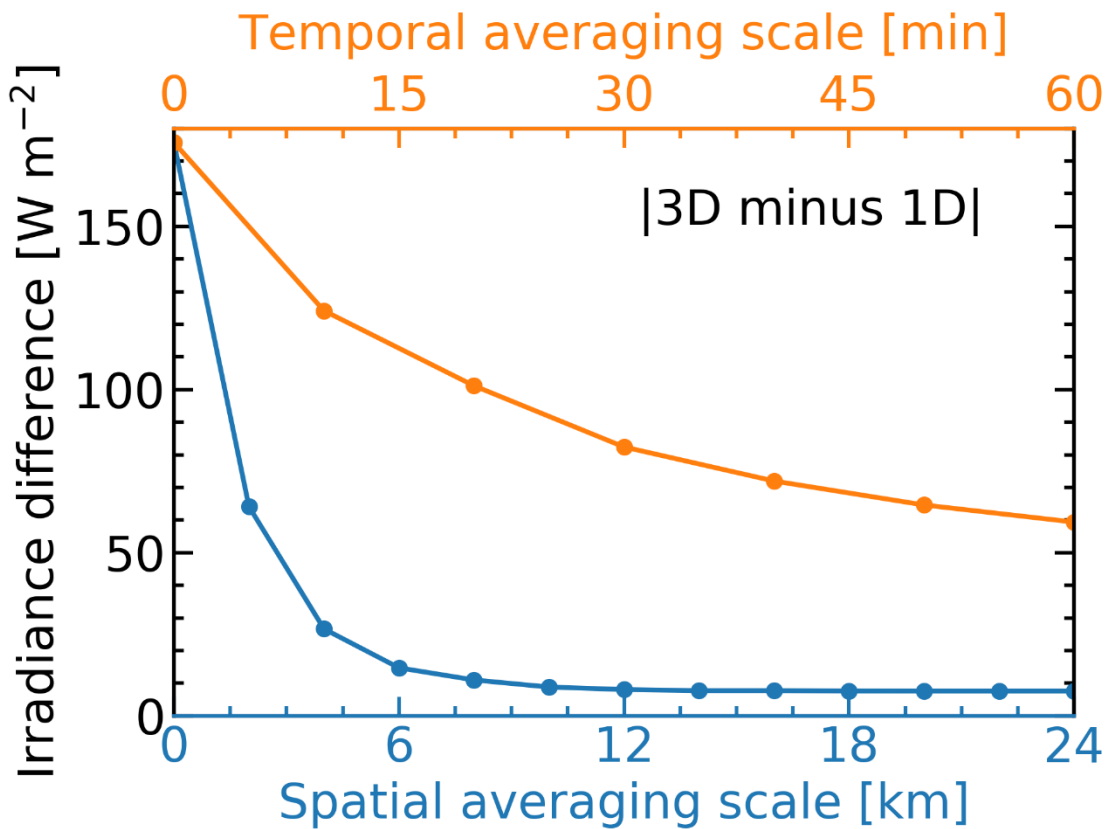


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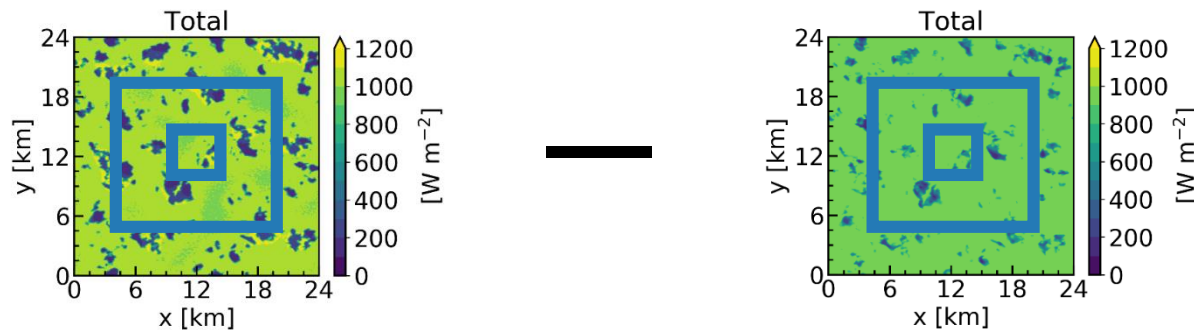
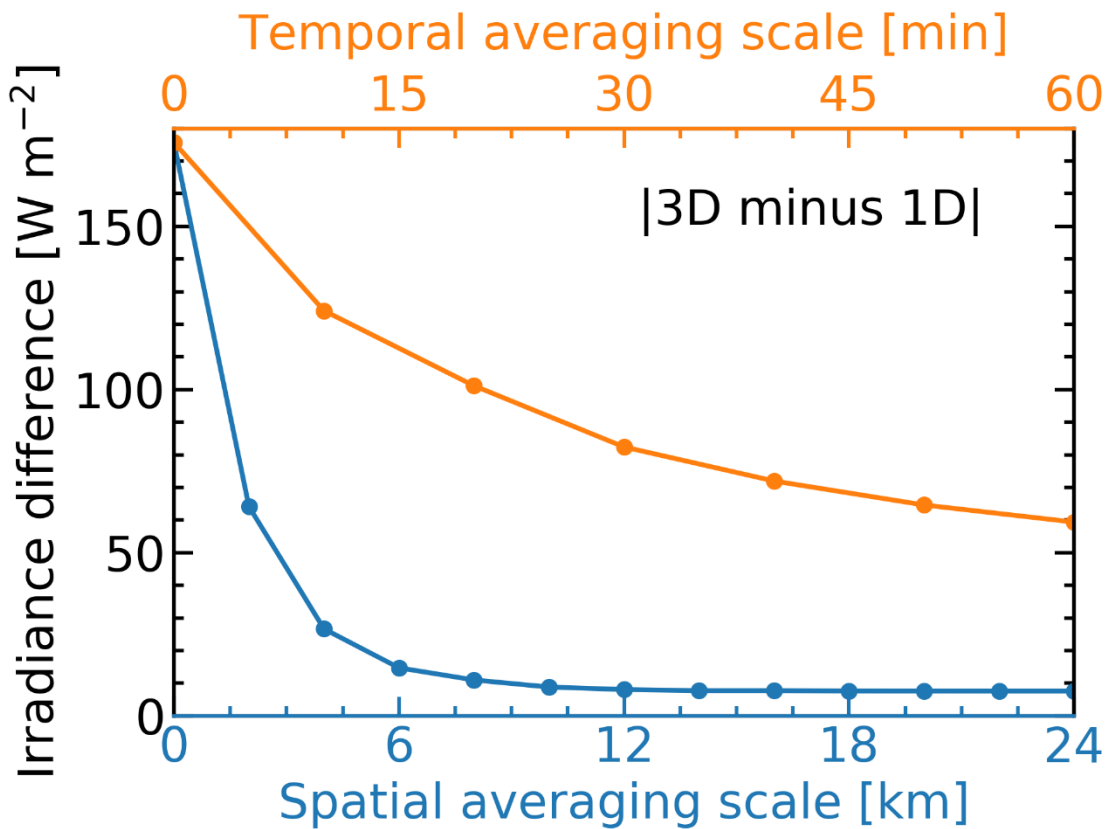
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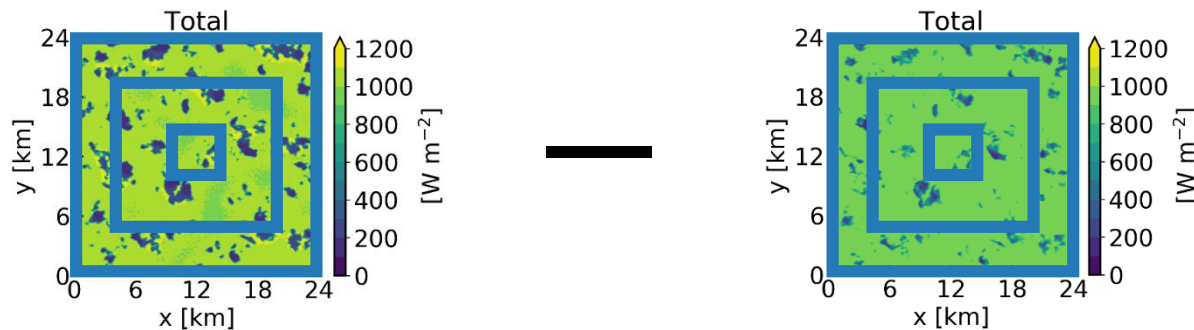
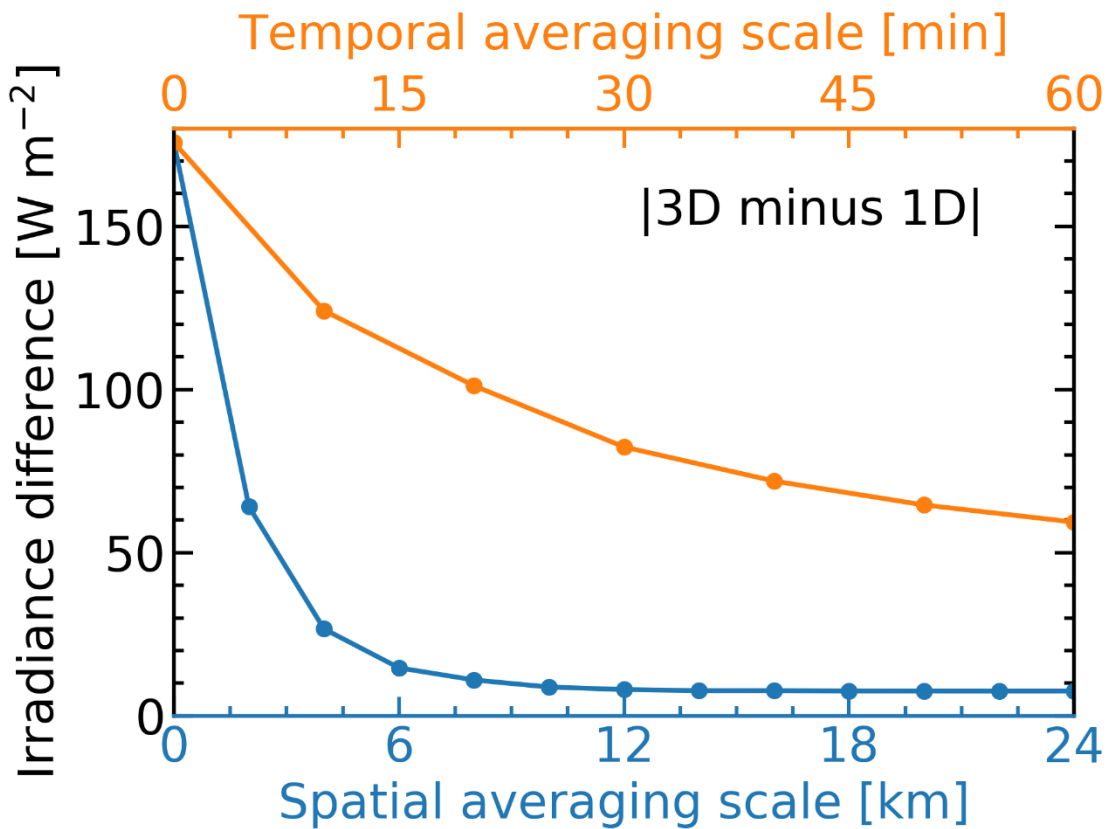
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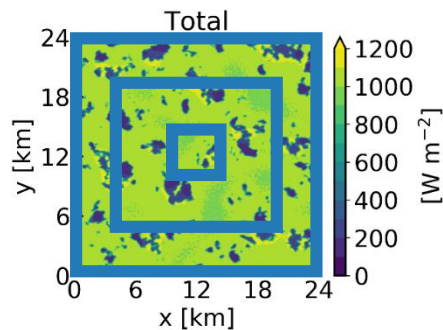
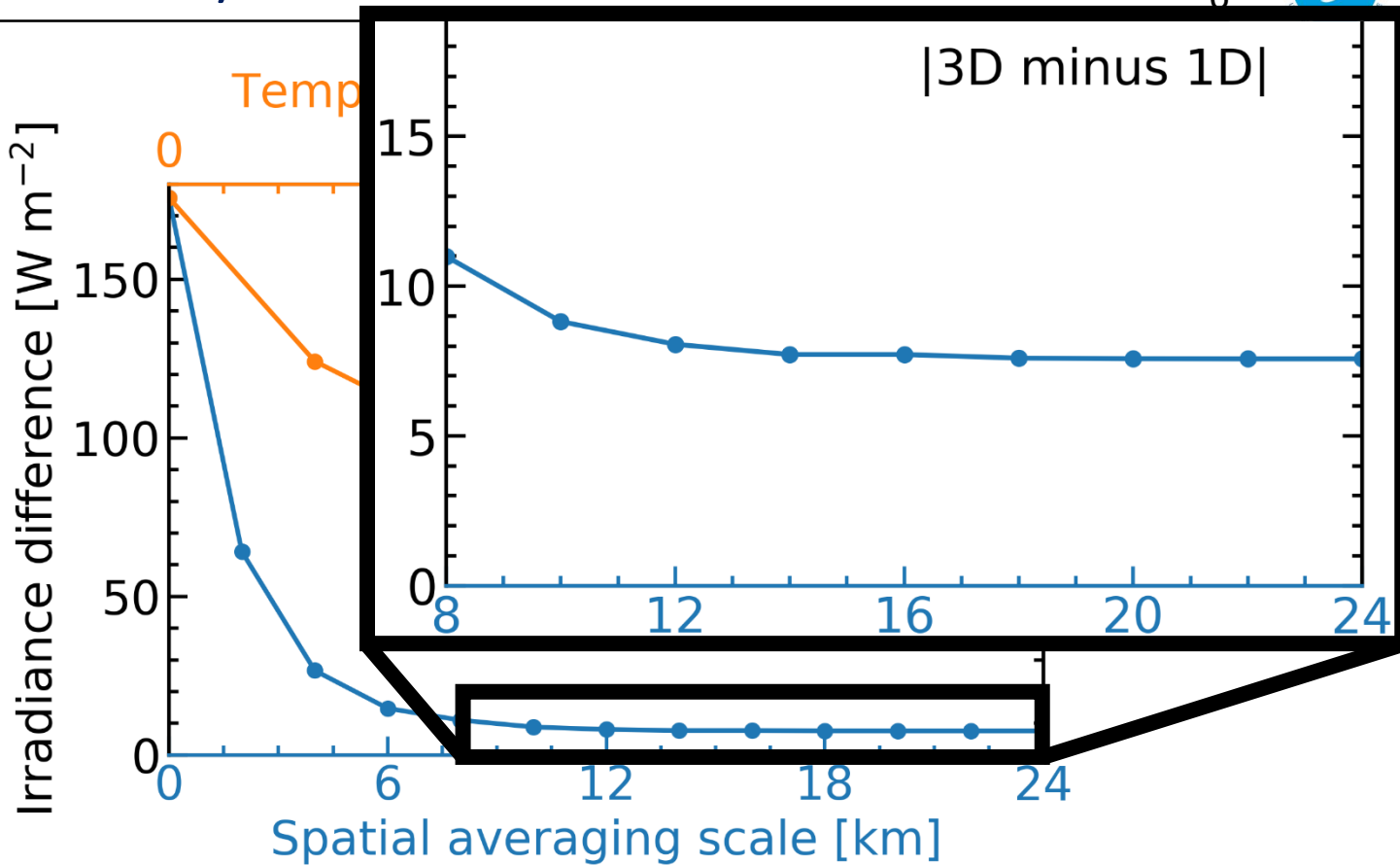
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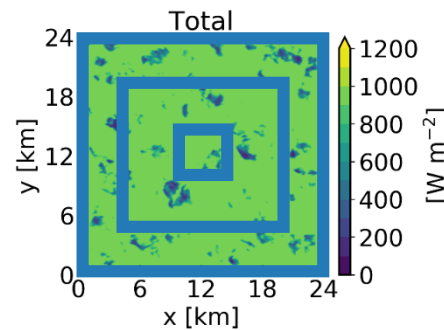


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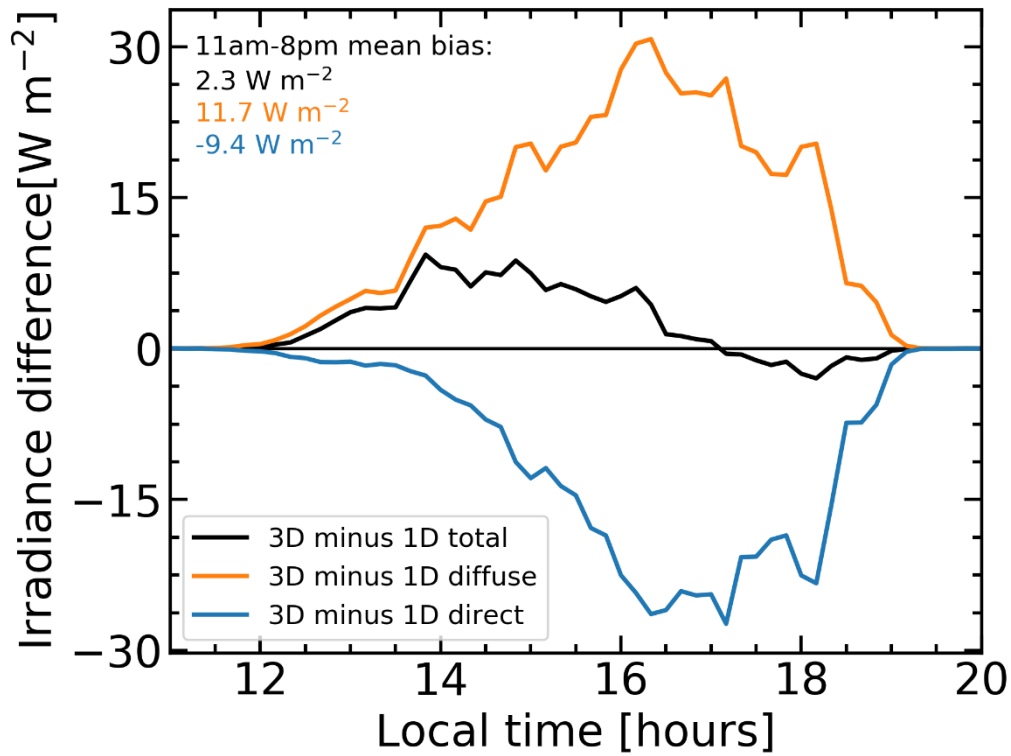
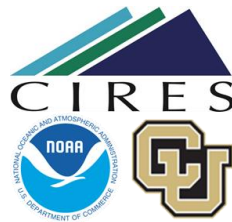
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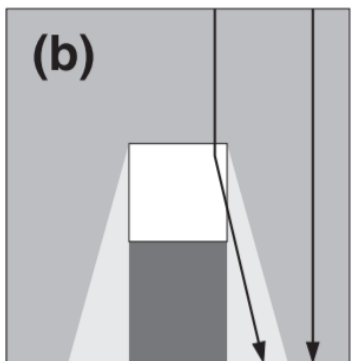
# 1D vs. 3D domain-mean diurnal cycle



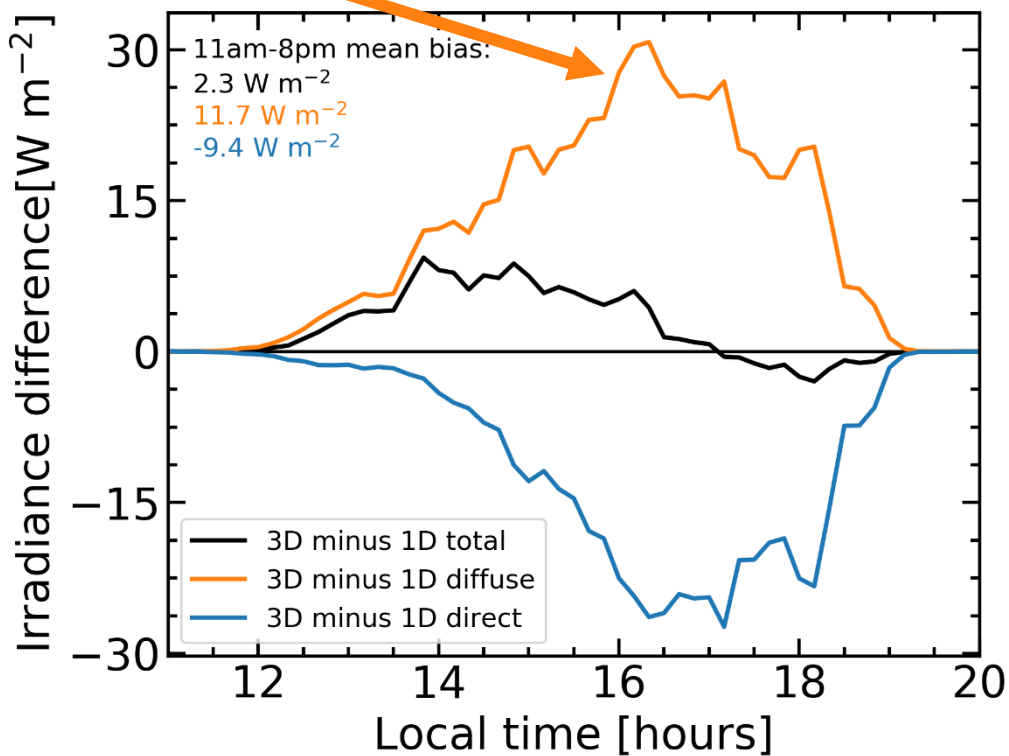
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**“side escape”**

When the sun is high in the sky, this effect dominates.



[Hogan and Shonk 2012]

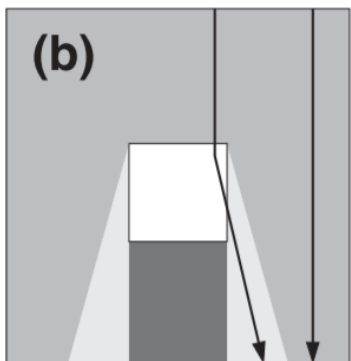




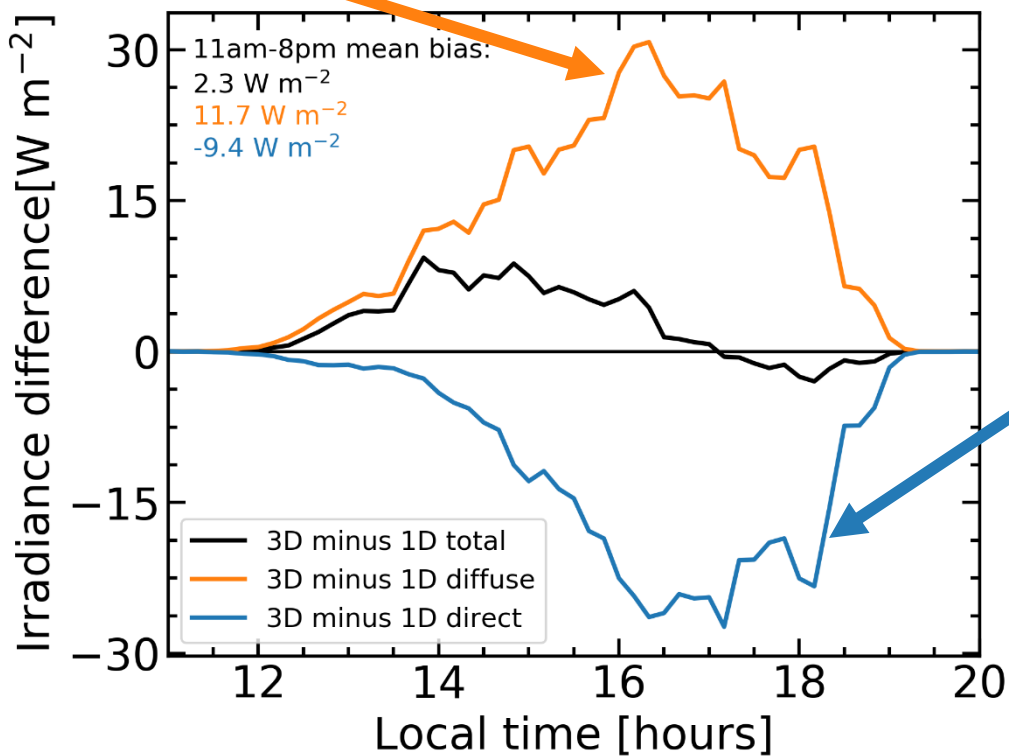
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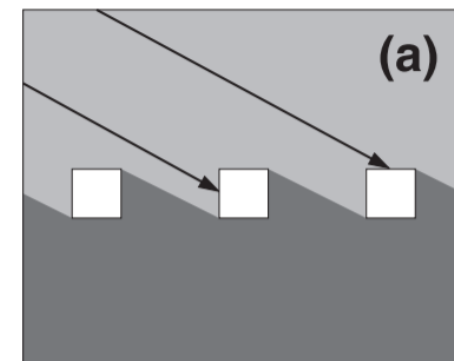


[Hogan and Shonk 2012]



**“side illumination”**

When the sun is low in the sky, this effect dominates.

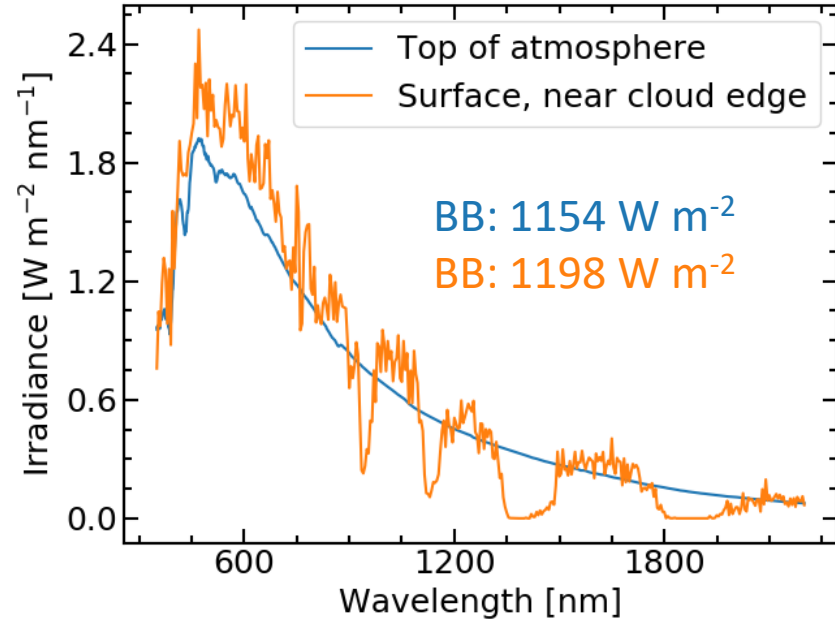
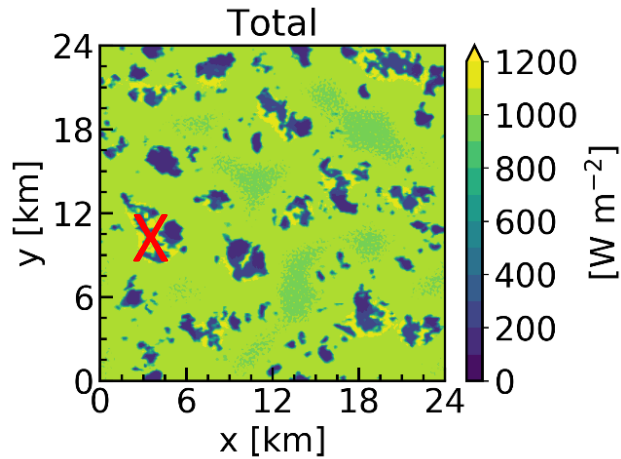


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# Possibilities for extending to spectral

8

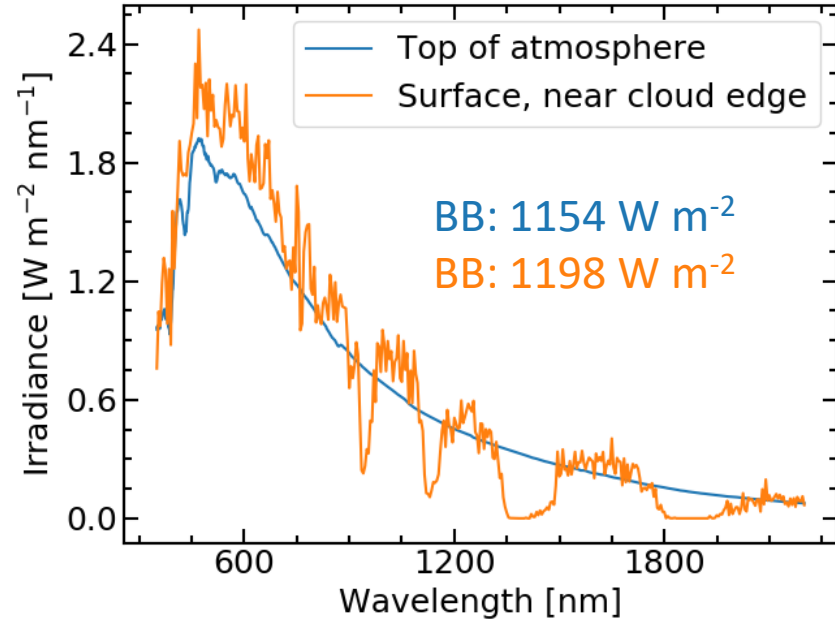
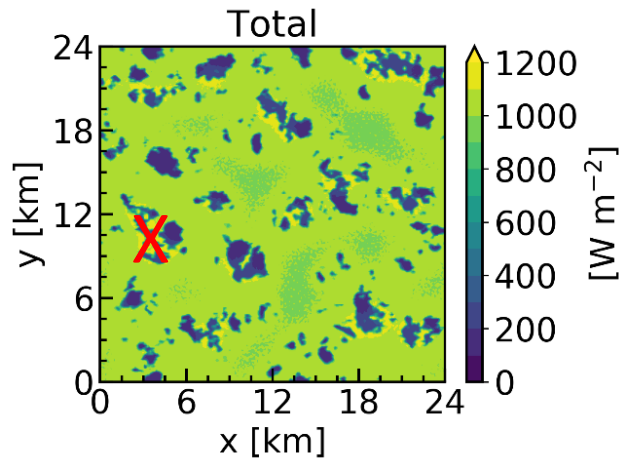
- All 3D and 1D offline calculations are spectral!



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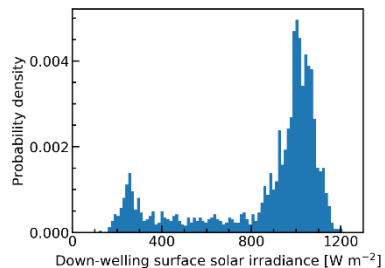
- Applications:

- Renewable energy potential: PV cell efficiency depends strongly on wavelength [Gouvêa et al. 2017]
- Human health: Enhanced UV exposure due to 3D effects
- Atmospheric chemistry

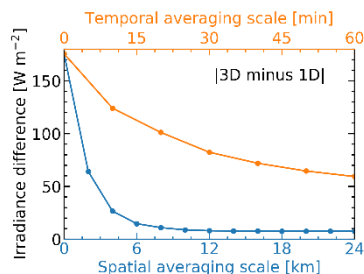
- Separate cloud, aerosol and surface influences [Schmidt et al. 2009]

# Preliminary conclusions and next steps

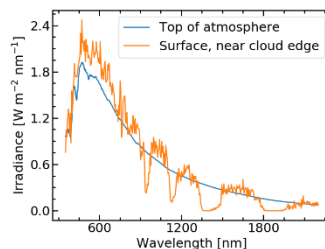
9



- 3D radiative effects are responsible for the observed bi-modal PDF of down-welling surface solar irradiance.



- The difference between 3D and 1D calculations is a strong function of spatial/temporal scale.



- Spectrally resolved data offers potential for further investigation.

Results presented have focused on one day: 27<sup>th</sup> June 2015. Analysis for multiple days is underway. Early results for other days support the findings, and suggest the importance of 3D radiative effects can actually be much larger!