

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

Jake Gristey^{1,2}

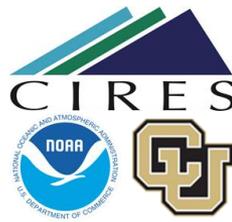
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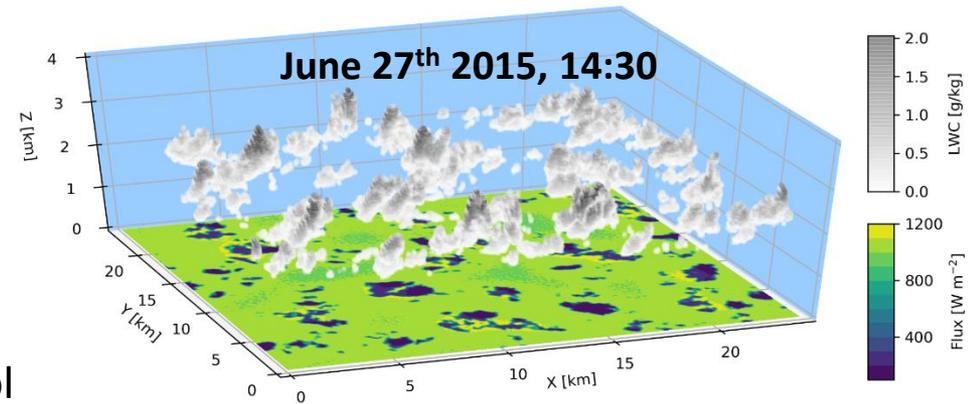
³Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA



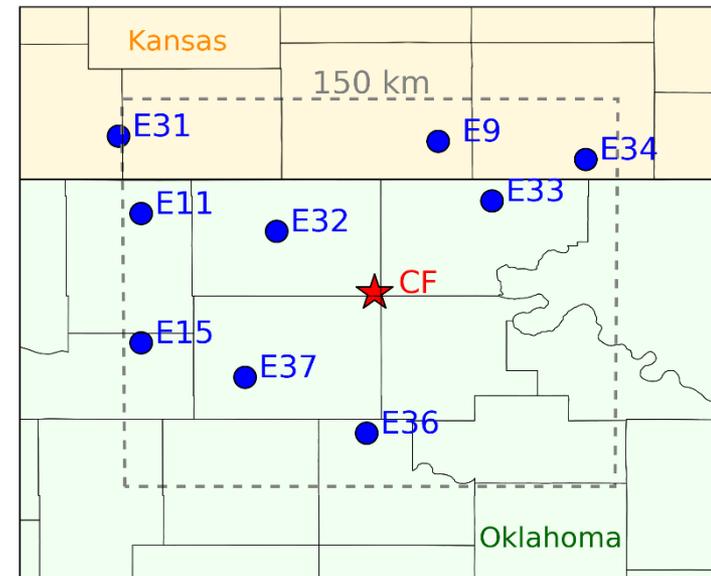
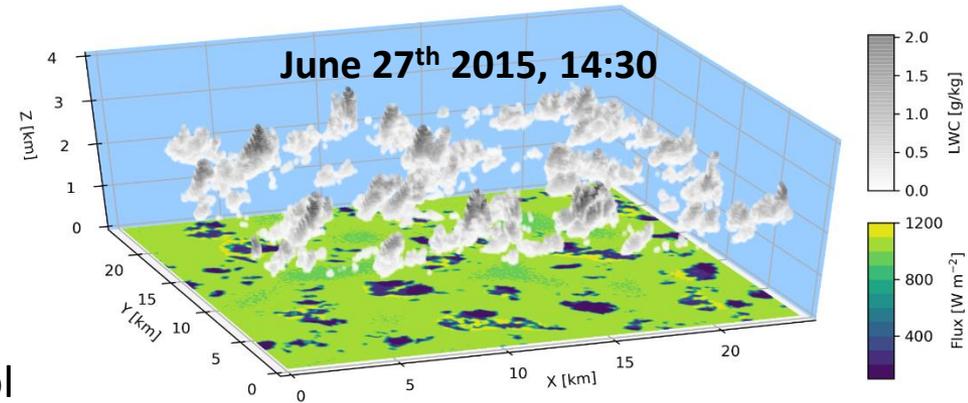


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 - 24 km domain
 - 100 m horizontal resolution
 - ~20 m vertical resolution (< 5km)

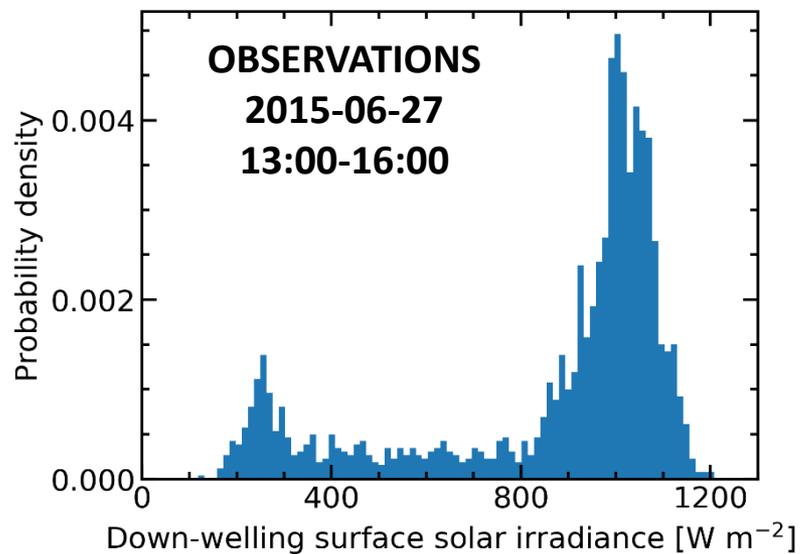


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- Observations from Radiative Flux Analysis [Long and Ackerman 2000]
 - Broad-band surface solar irradiance



PDFs of surface solar irradiance

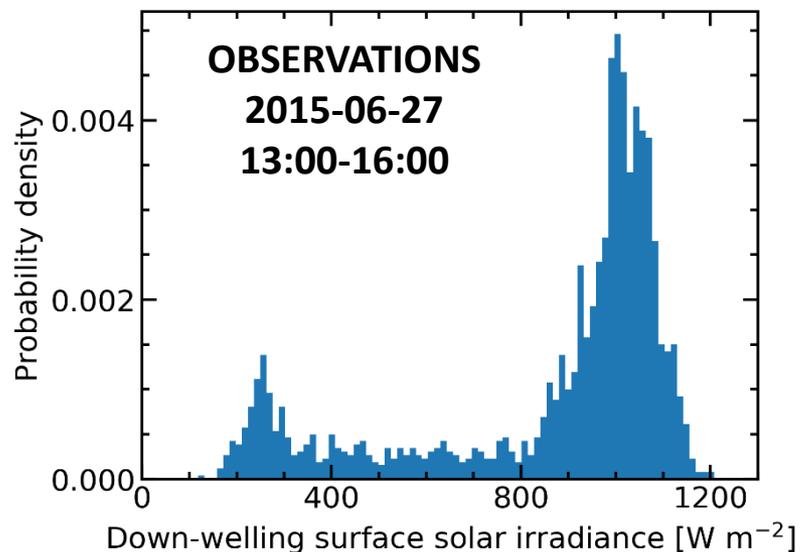
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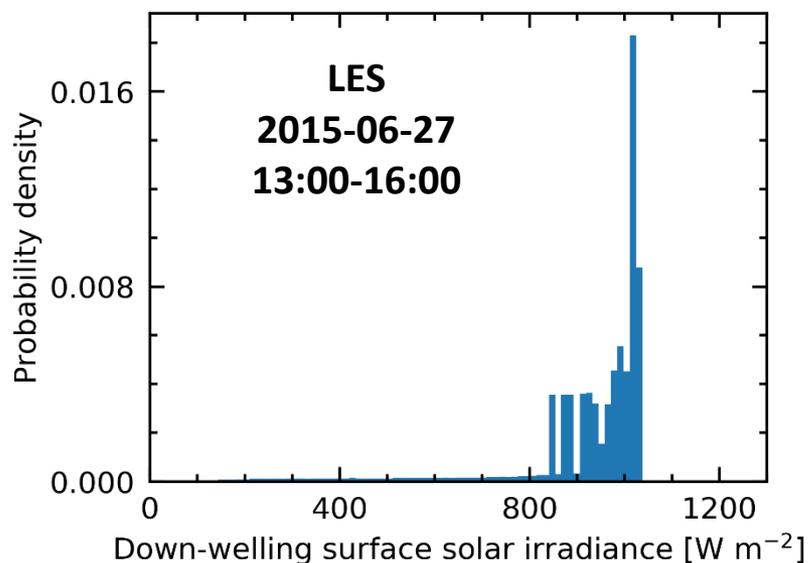
- Bi-modal distribution in observed down-welling surface solar irradiance [Schmidt et al. 2009]
 - 1st mode: sun obscured
 - 2nd mode: clear sky
- Likely influenced by cloud fraction, cloud LWP, cloud size, variability in LWP...

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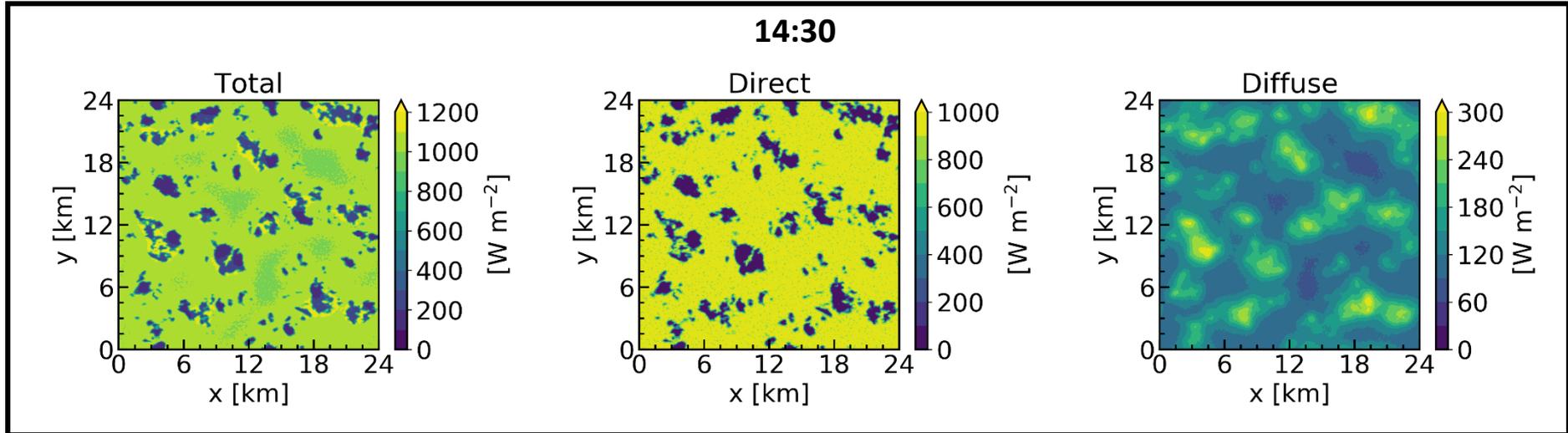
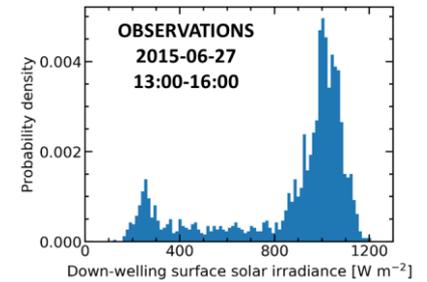
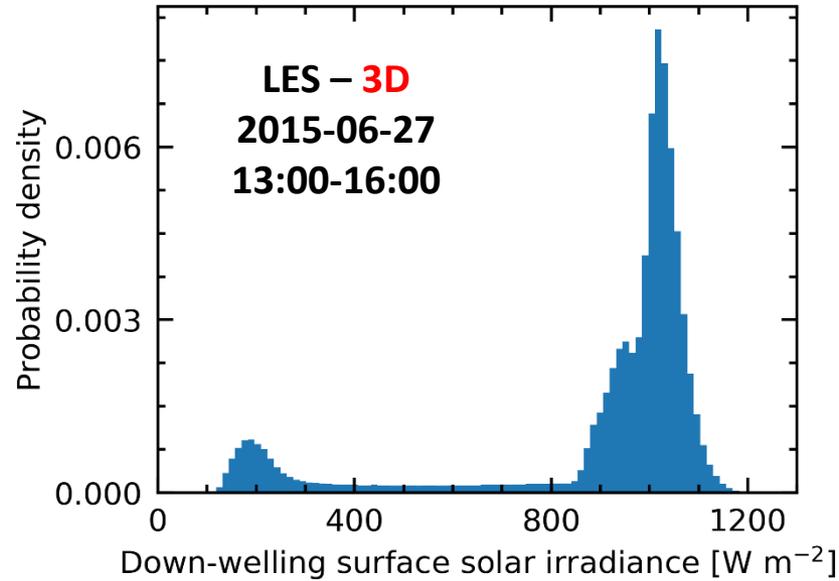


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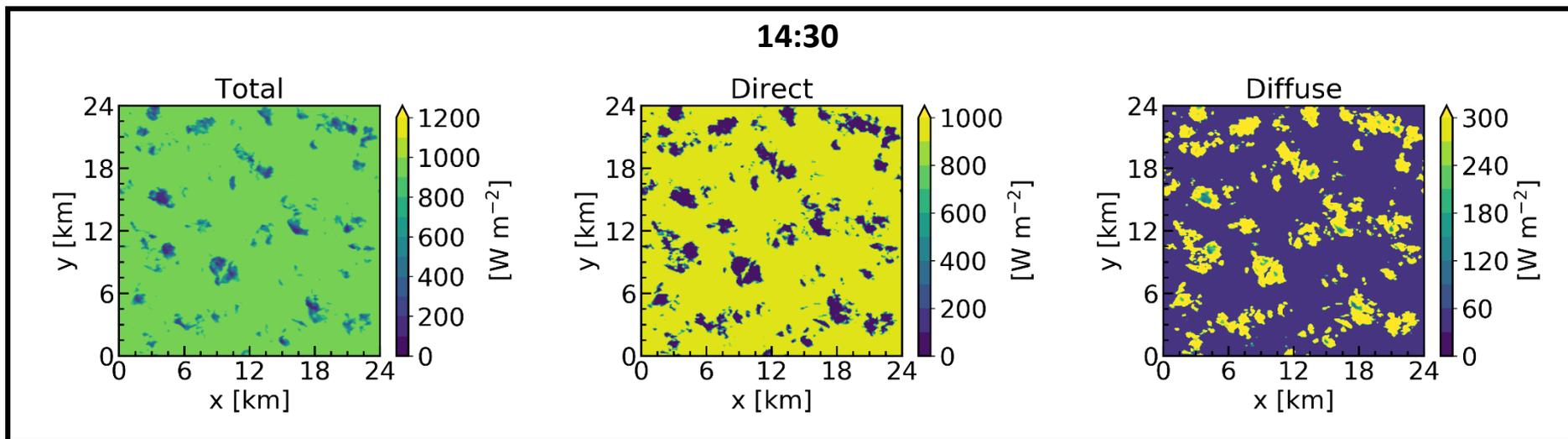
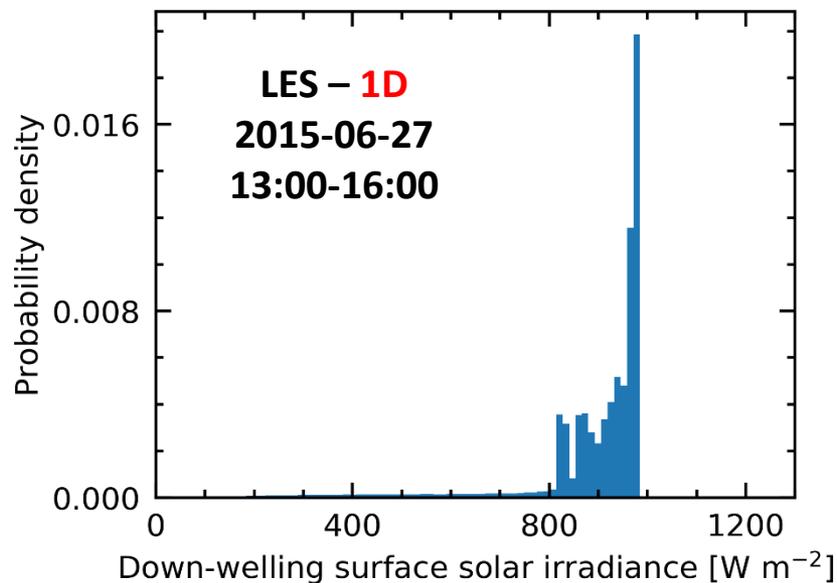


- LES output does not resemble observed PDF
- Sharp cut off at larger values, and no peak at lower values

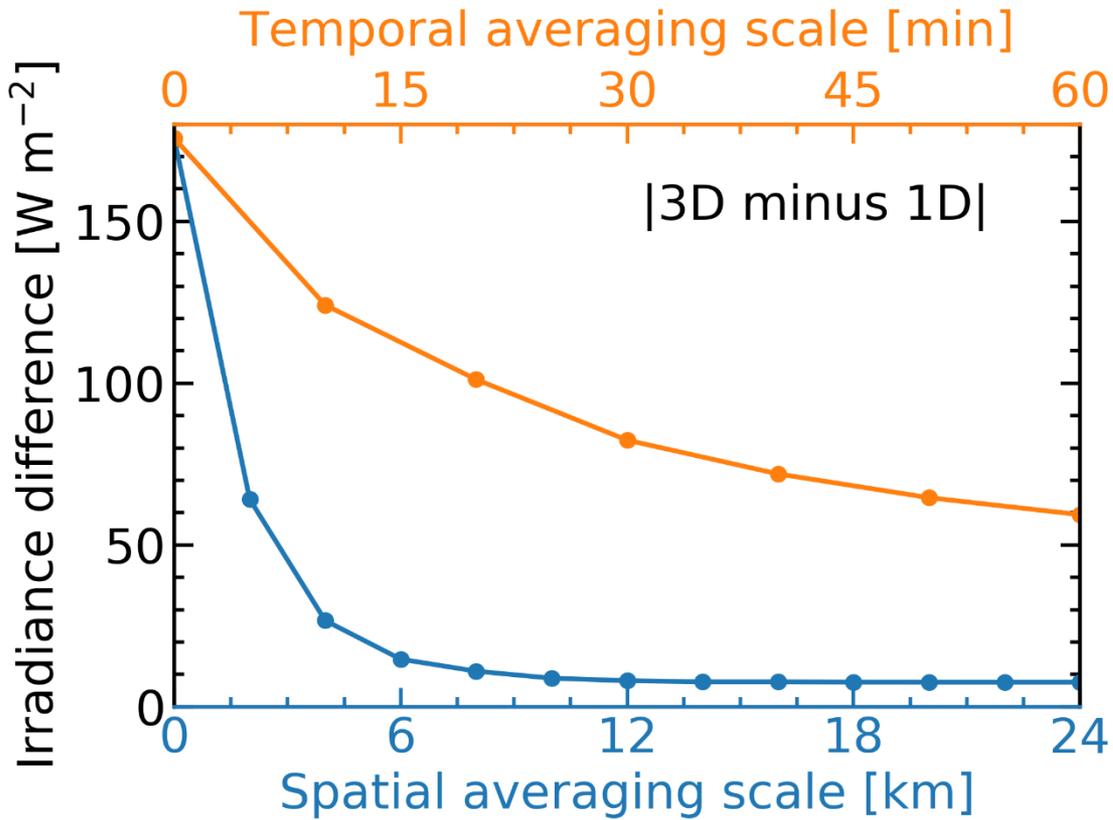
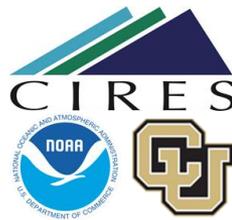
3D calculations using LES output



1D calculations using LES output



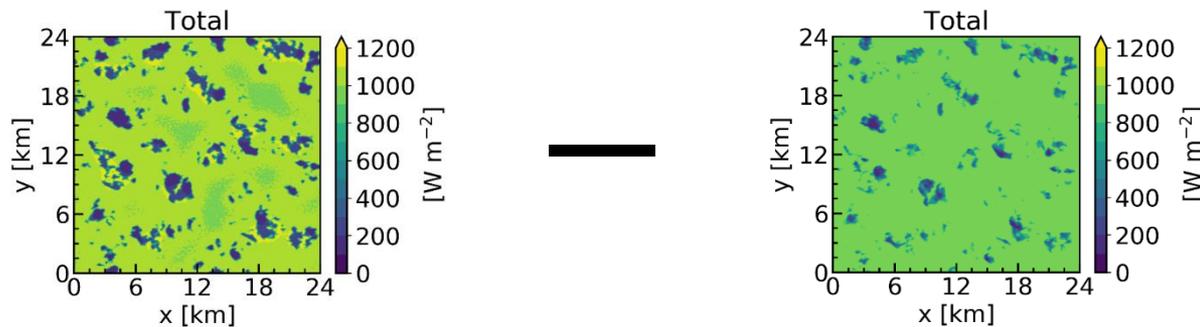
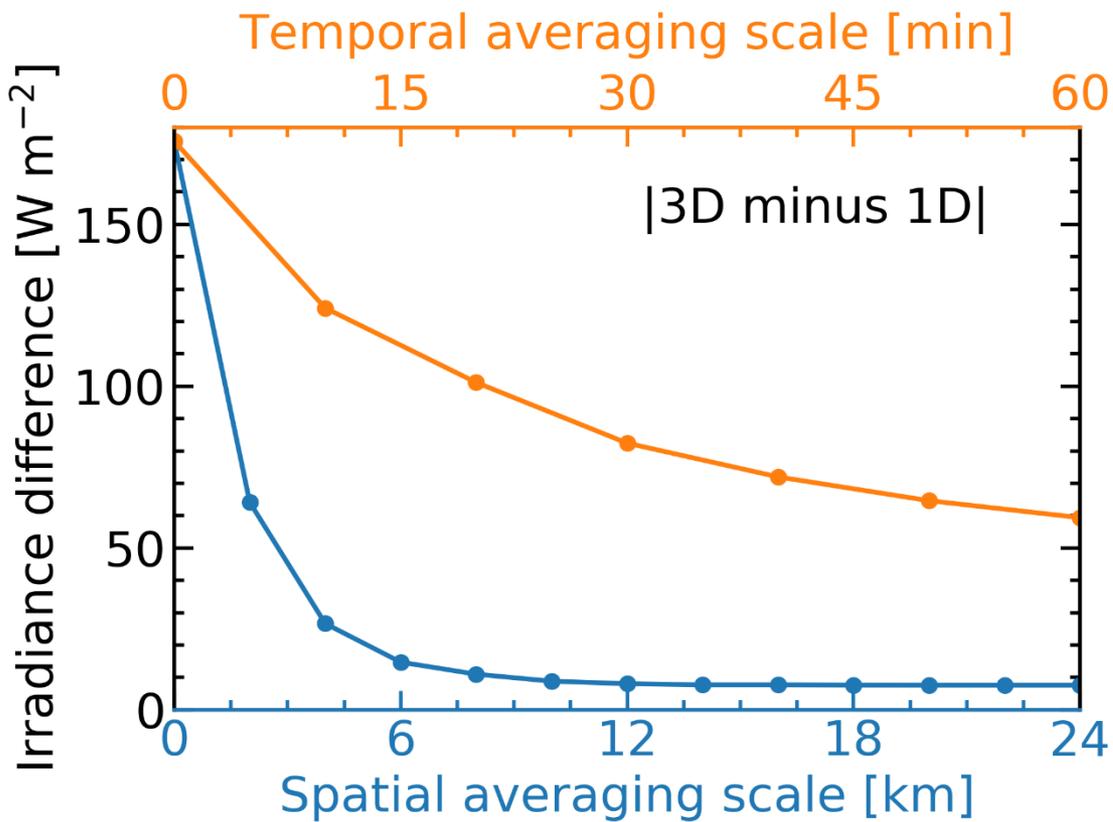
Scale sensitivity



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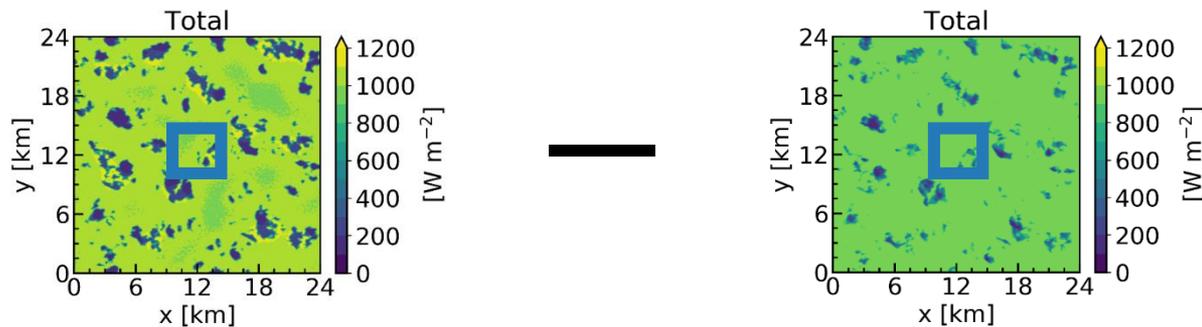
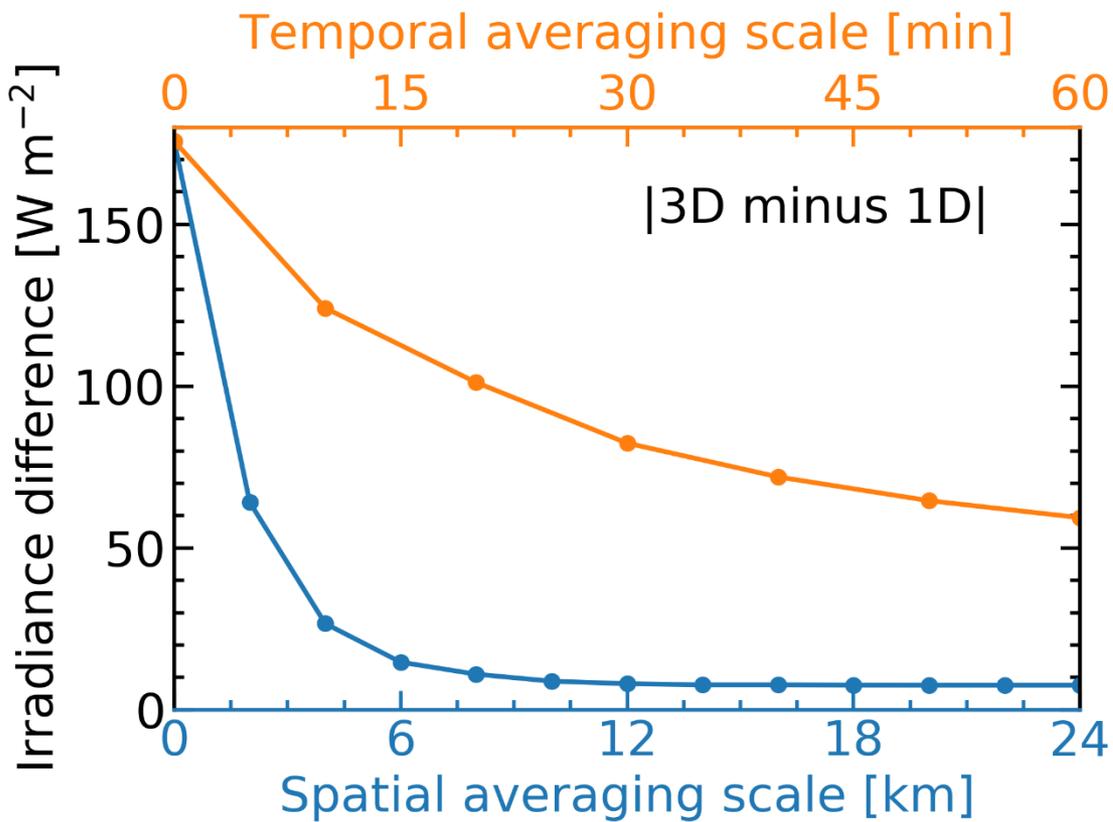
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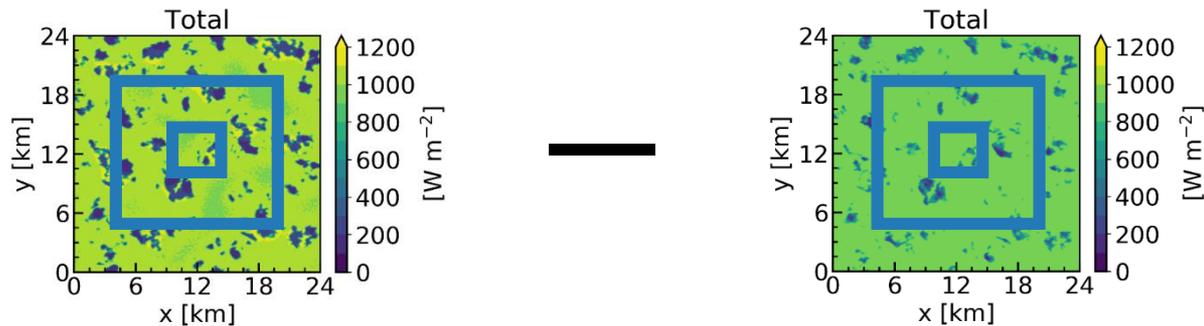
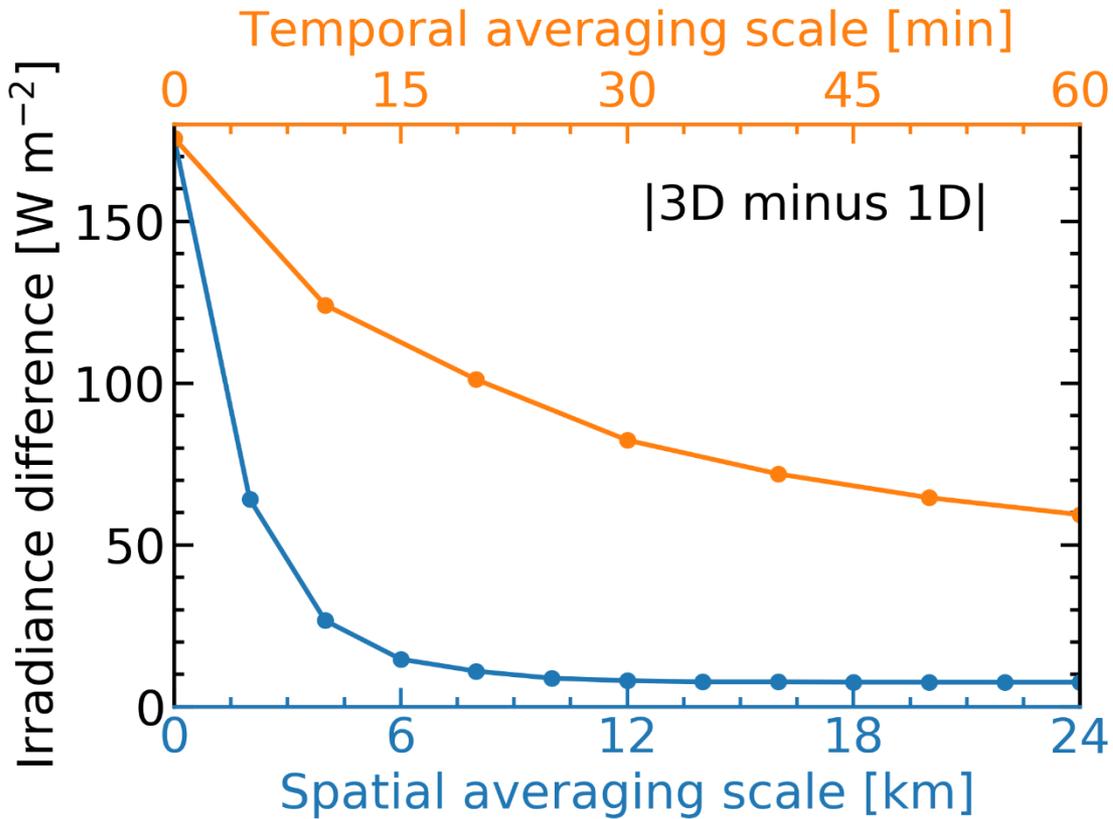
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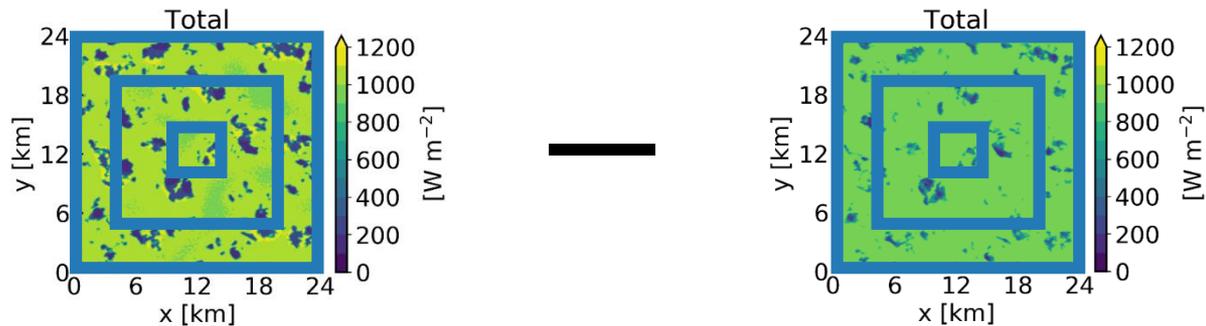
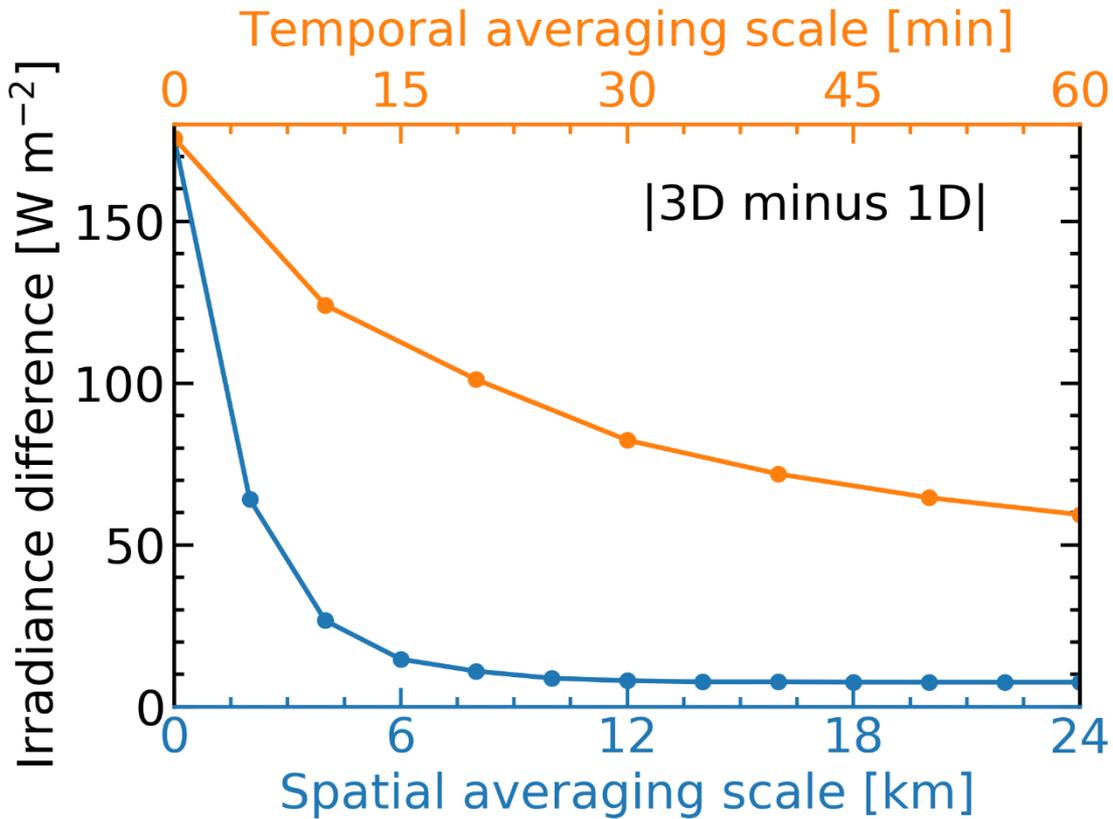
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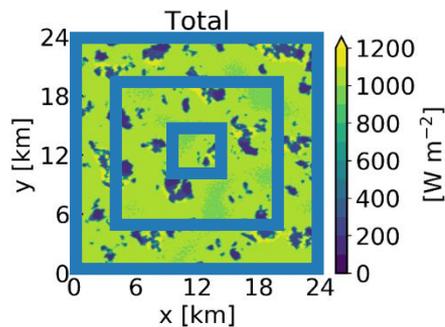
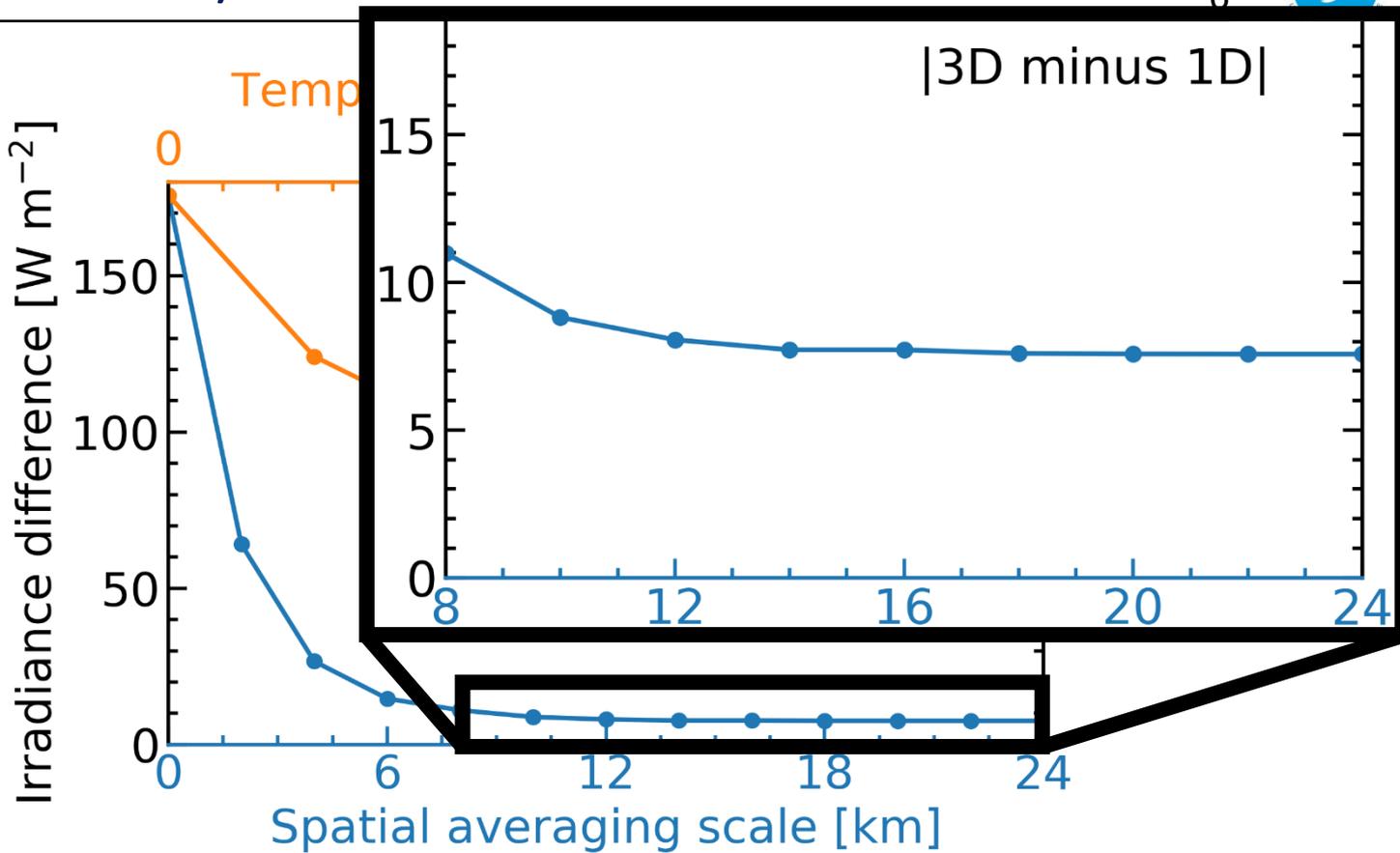
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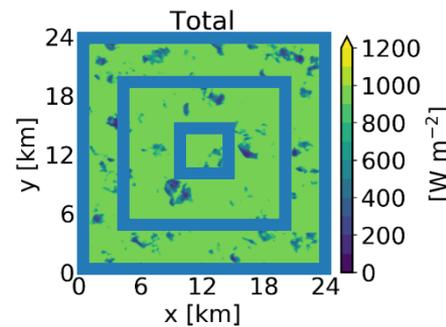


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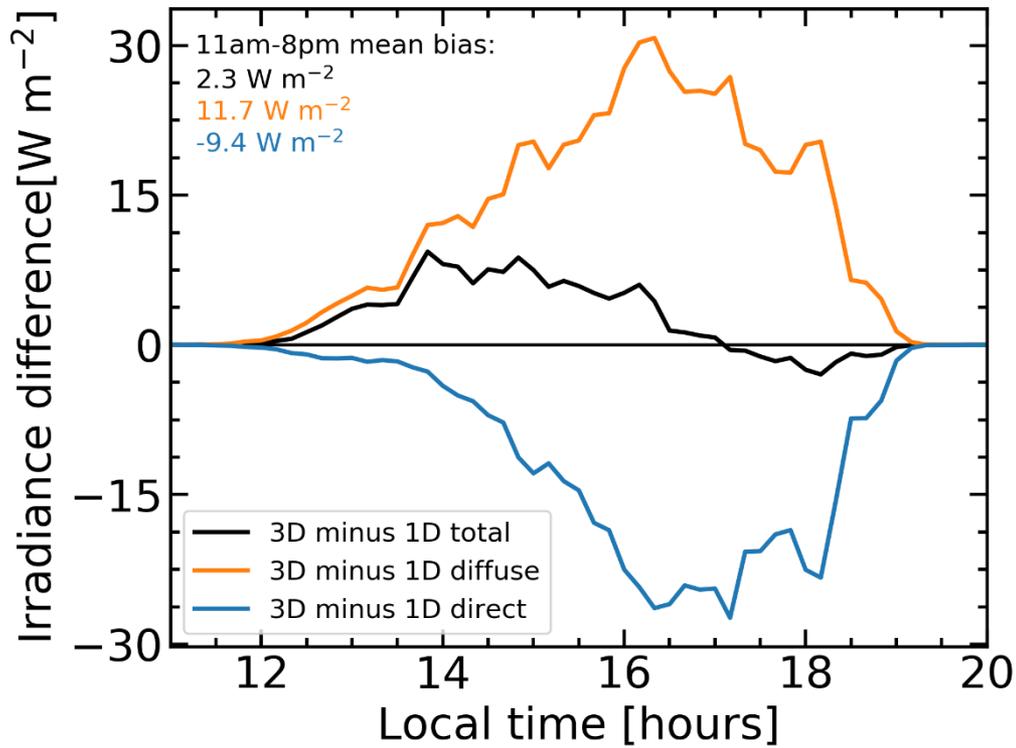
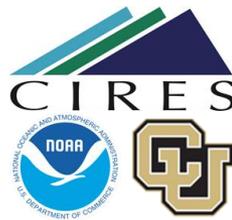
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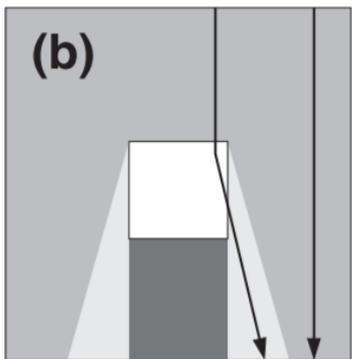
1D vs. 3D domain-mean diurnal cycle



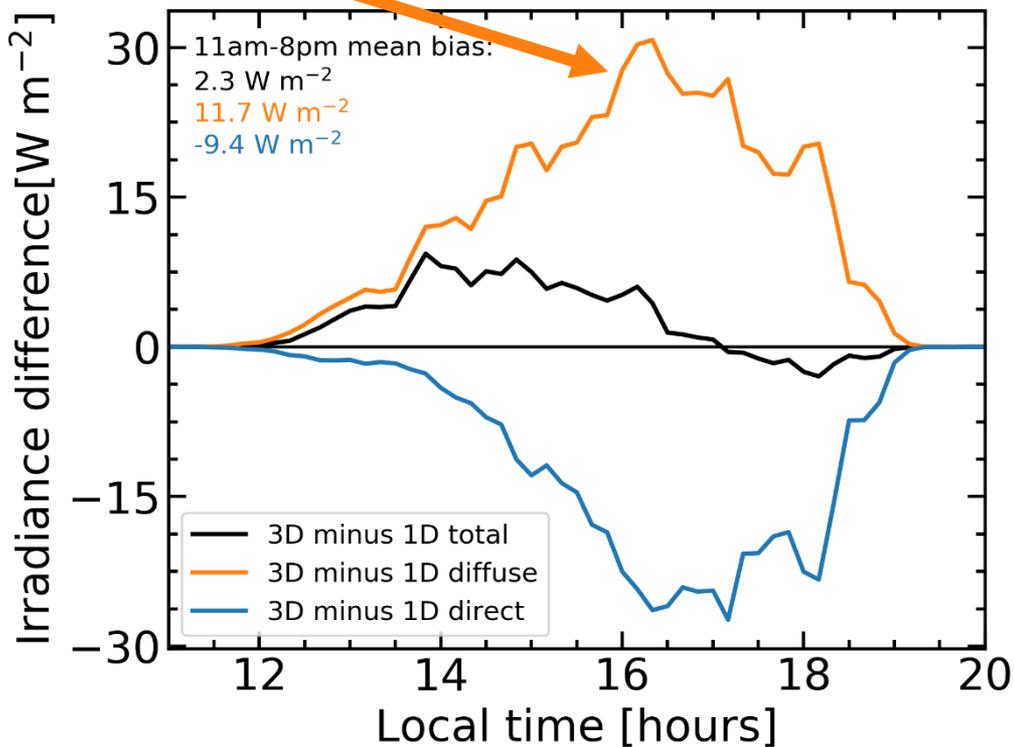
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“side escape”

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



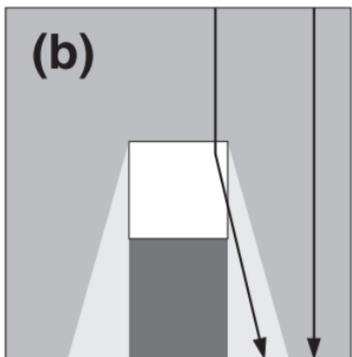
[Hogan and Shonk 2012]



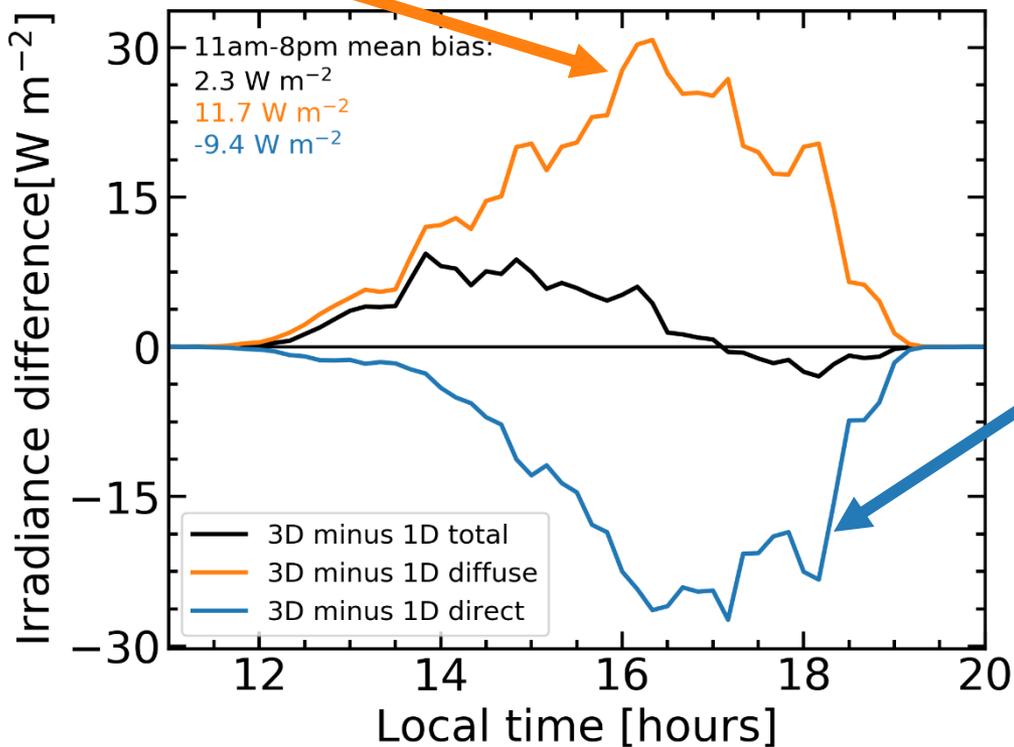
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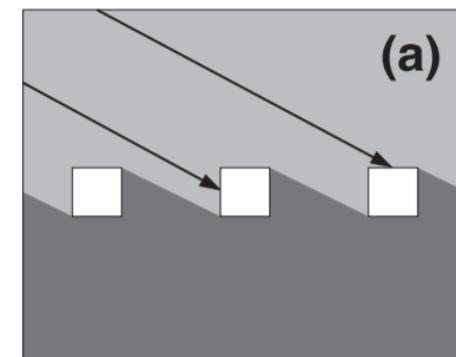


[Hogan and Shonk 2012]



“side illumination”

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

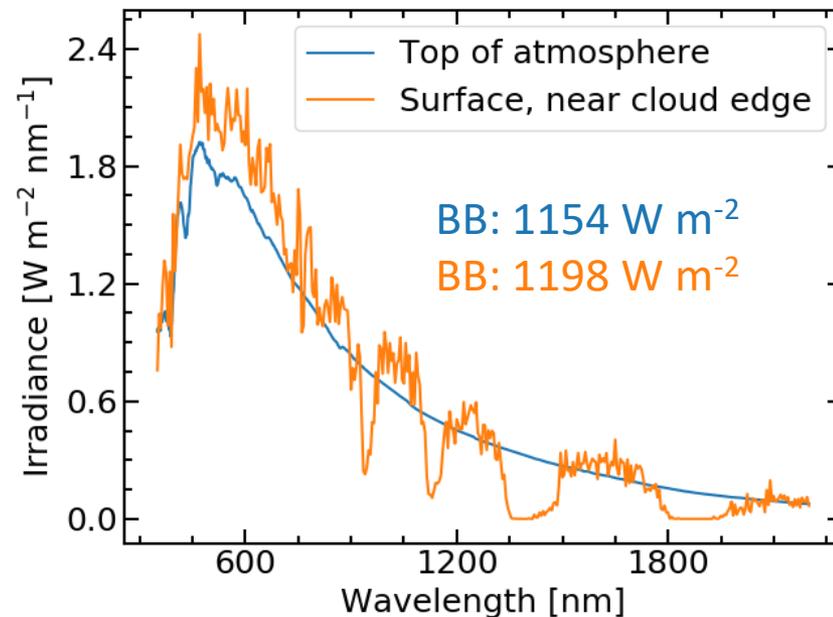
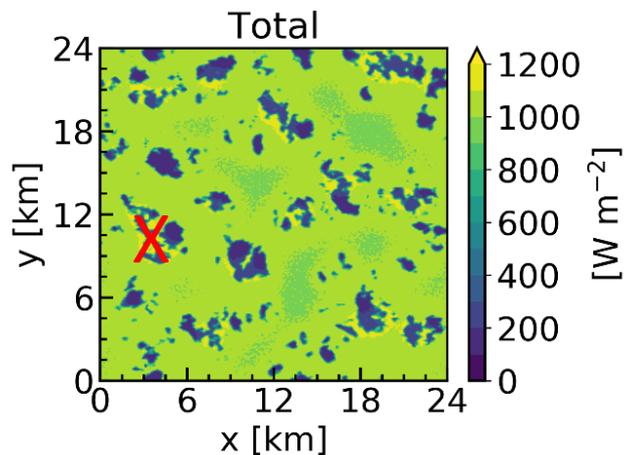


[Hogan and Shonk 2012]

Possibilities for extending to spectral

8

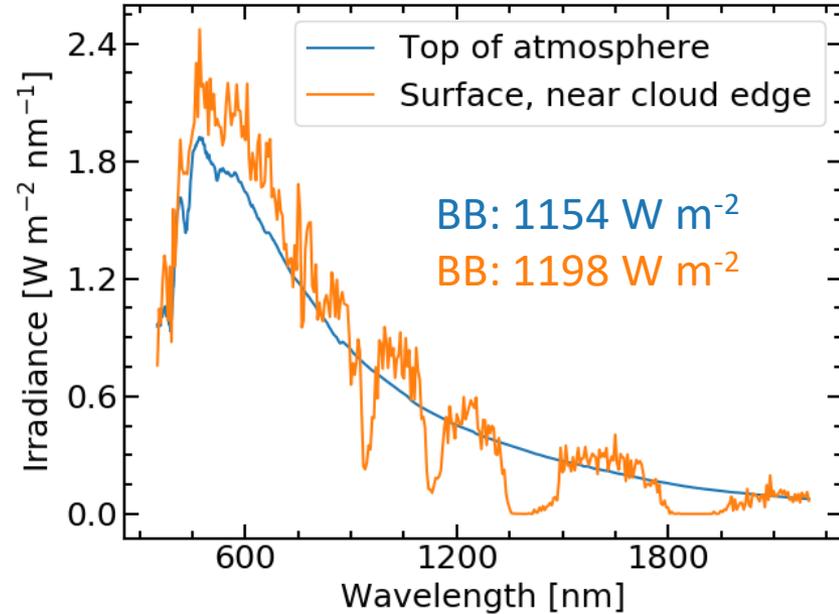
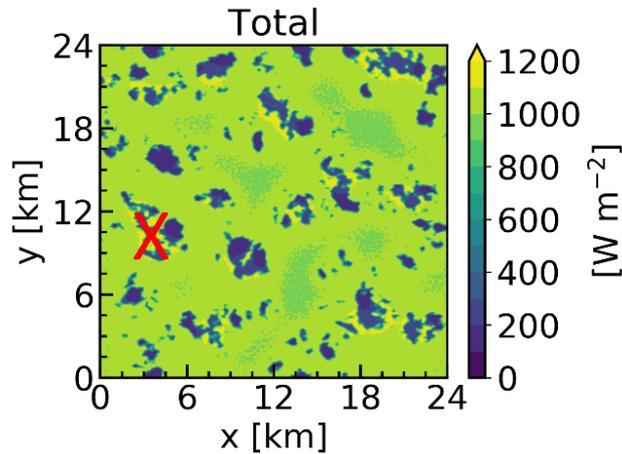
- All 3D and 1D offline calculations are spectral!



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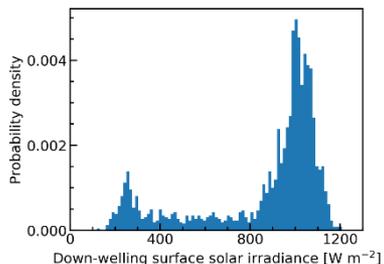
- Applications:

- 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

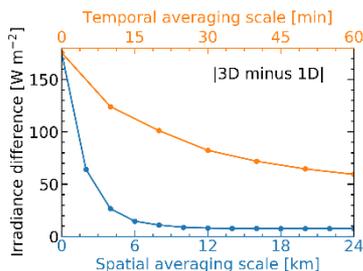
- Separate cloud, aerosol and surface influences [Schmidt et al. 2009]

Preliminary conclusions and next steps

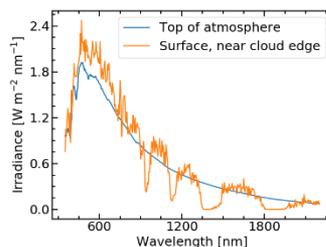
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- 3D radiative effects are responsible for the observed bi-modal PDF of down-welling surface solar irradiance.



- 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: 27th 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!