Heating Rates and Radiative Forcing

SSFR and CG-4 during ATTREX

Peter Pilewskie, Warren Gore, Sebastian Schmidt

Radiation Objectives and Suggested Flight Patterns

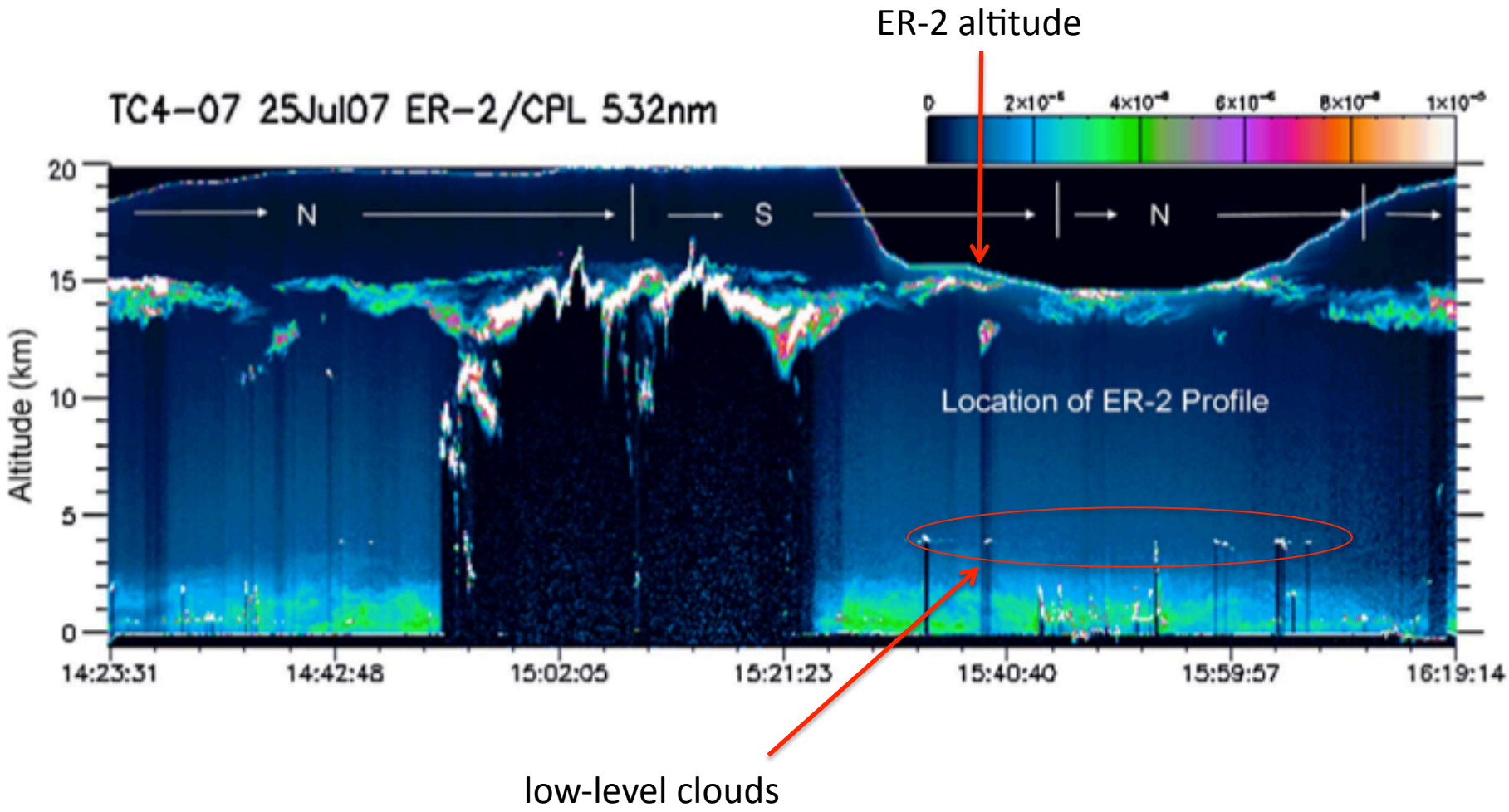
In situ and lidar observations of tropopause subvisible cirrus clouds during TC4

Sean Davis[1,2], Dennis Hlavka[3], Eric Jensen[4], Karen Rosenlof[1], Qiong Yang[5], Sebastian Schmidt[6], Stephan Borrmann[7,8], Wiebke Frey[7], Paul Lawson[9], Holger Voemel[10], T.P. Bui[4]

Directly measured heating rates of a tropical subvisible cirrus cloud

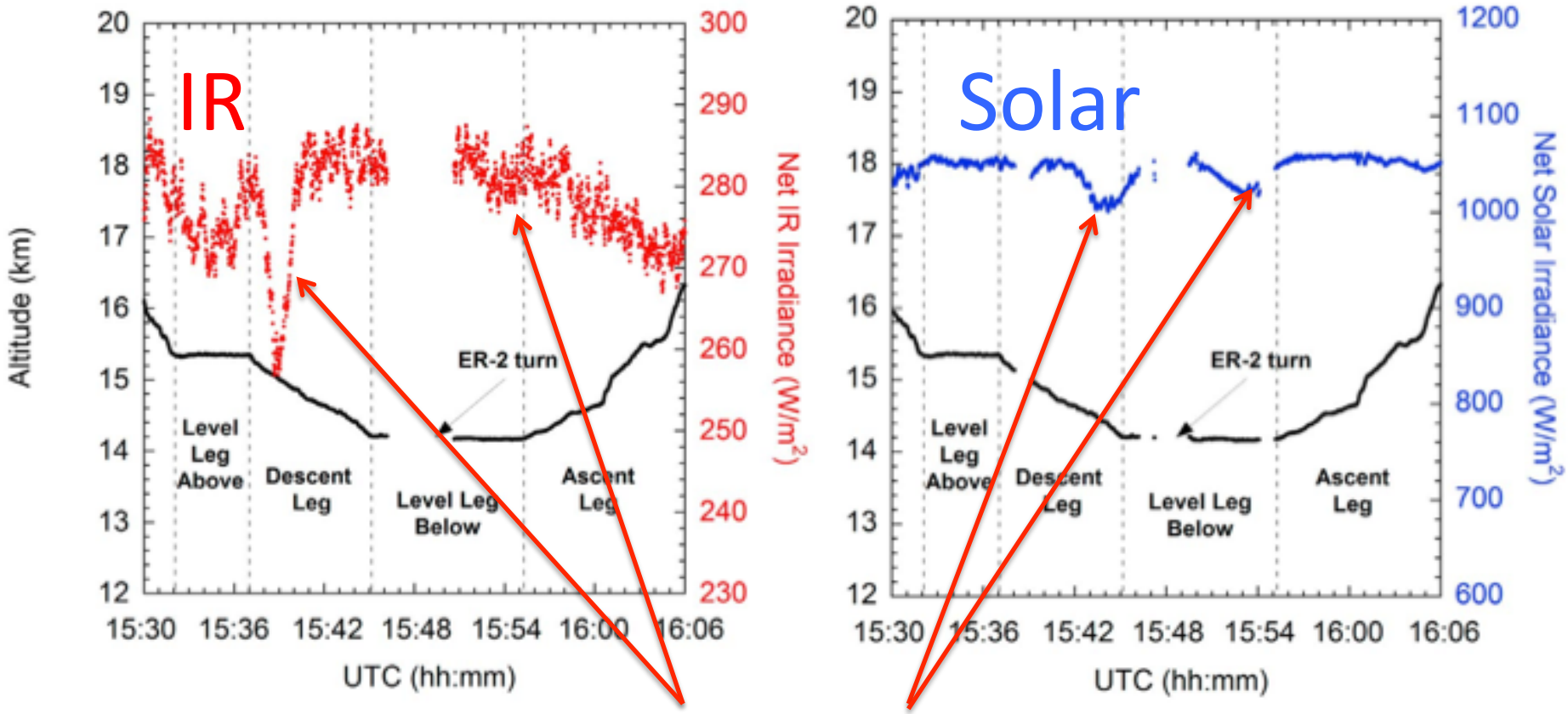
Anthony Bucholtz,[1] Dennis L. Hlavka,[2] Matthew J. McGill,[3] K. Sebastian Schmidt,[4] Peter Pilewskie,[4] Sean M. Davis,[5] Elizabeth A. Reid,[1] and Annette L. Walker[1]

Example for τ ~ 0.1



Bucholtz et al., *JGR*, 2010

Example for τ ~ 0.1



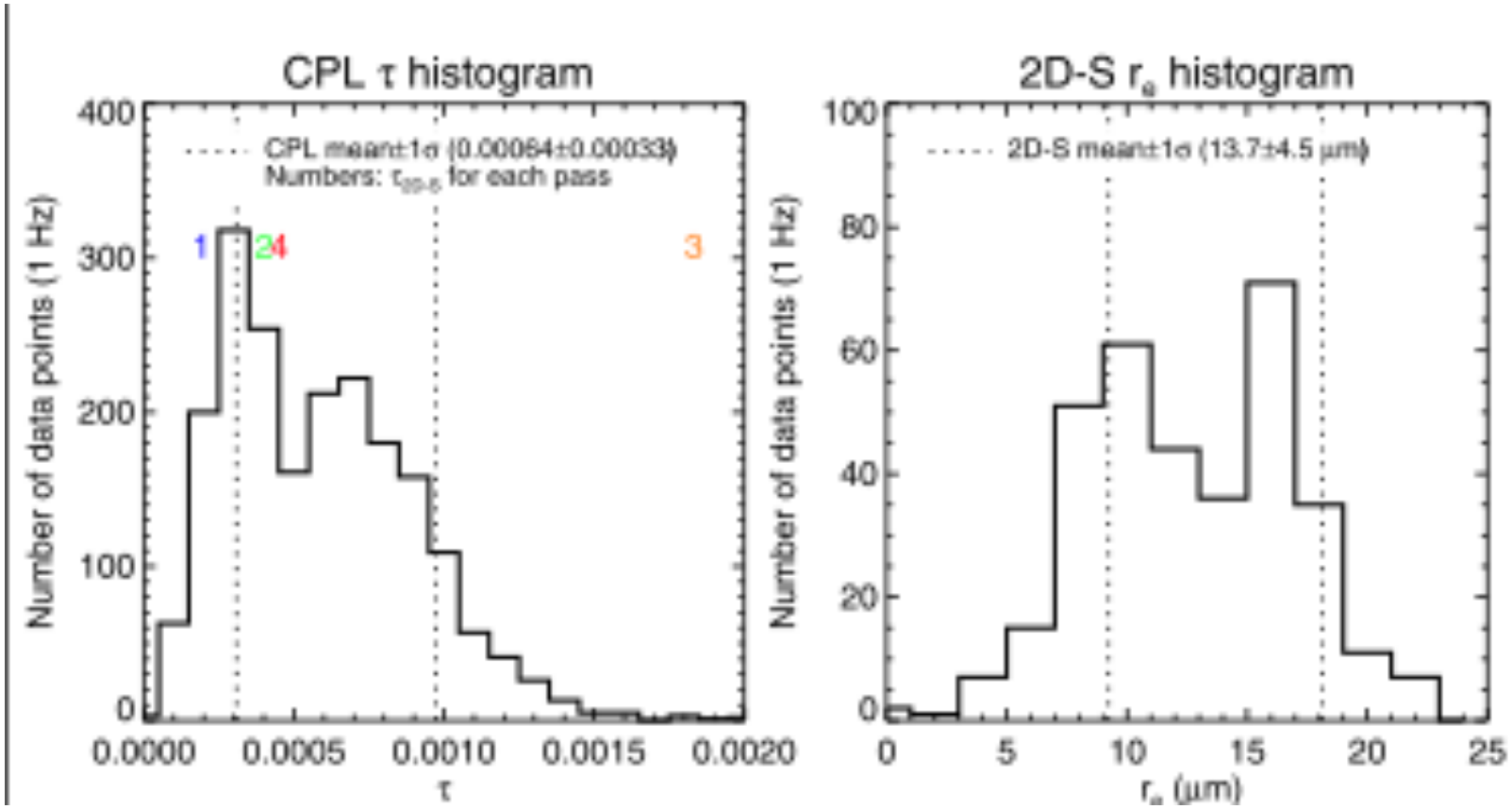
CPL-τ ≈ 0.1

$HR_{IR} \approx 3 \pm 1.5$ K day^{-1}

$HR_{SOLAR} \approx 0$ K day^{-1}

Bucholtz et al., *JGR*, 2010

Radiative effects of thin Cirrus are typically small, particularly in the shortwave (hence, “sub-visible”) and hard to measure



Davis et al., *JGR*, 2010

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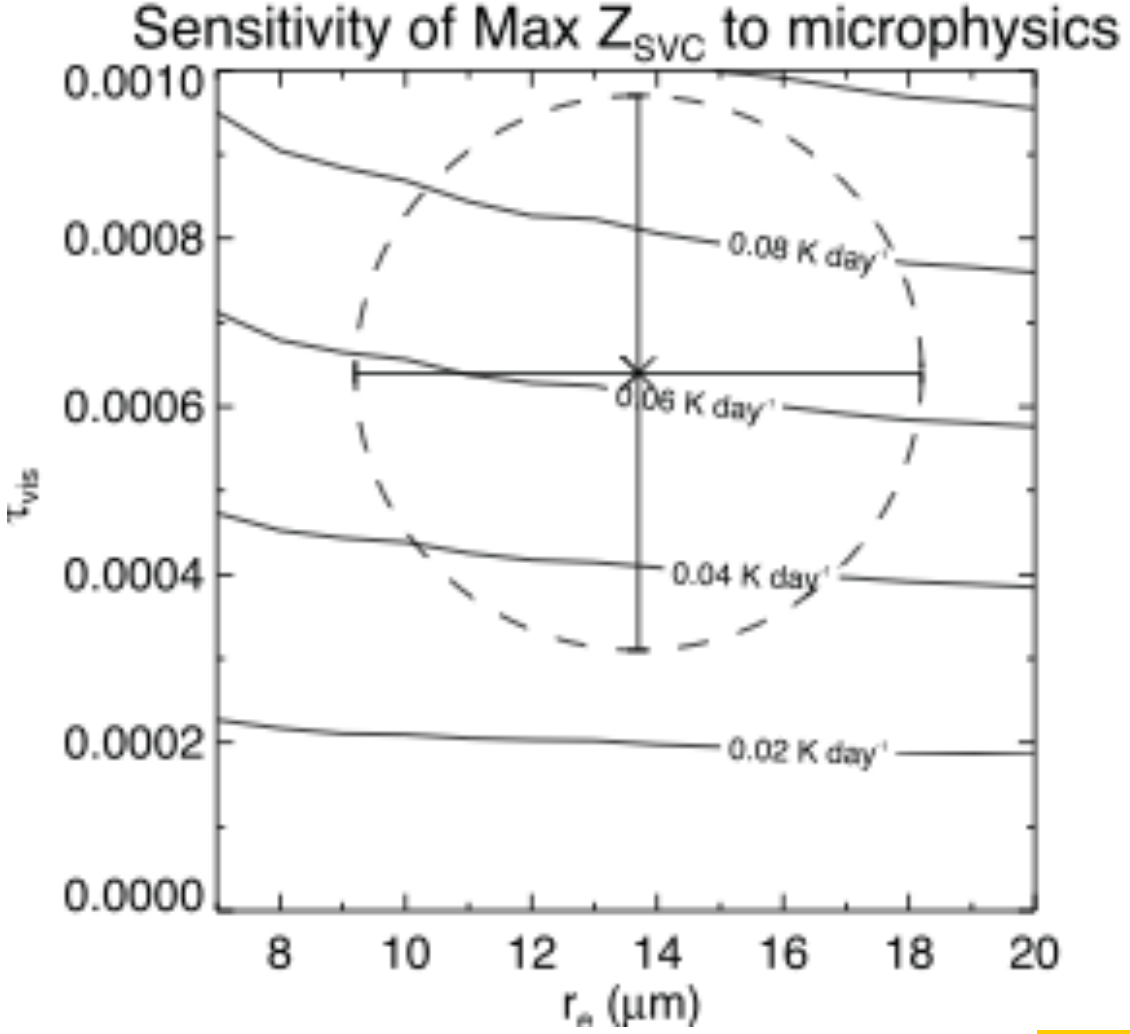
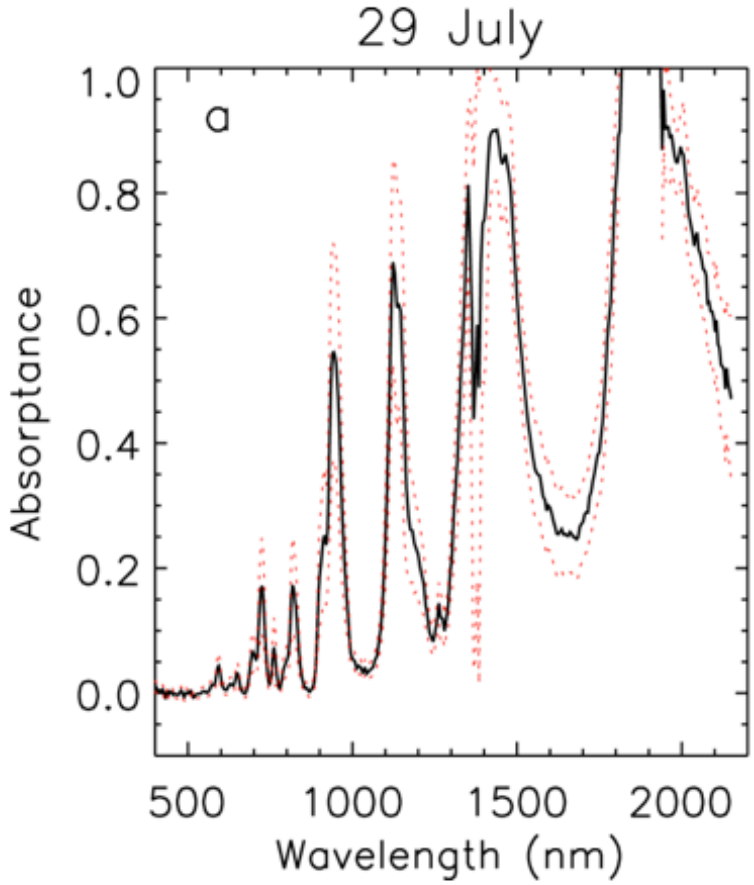


Davis et al., *JGR*, 2010

New results from TC4

VIS/NIR: There are some ways to get rid of cloud heterogeneity effects (conditional sampling).

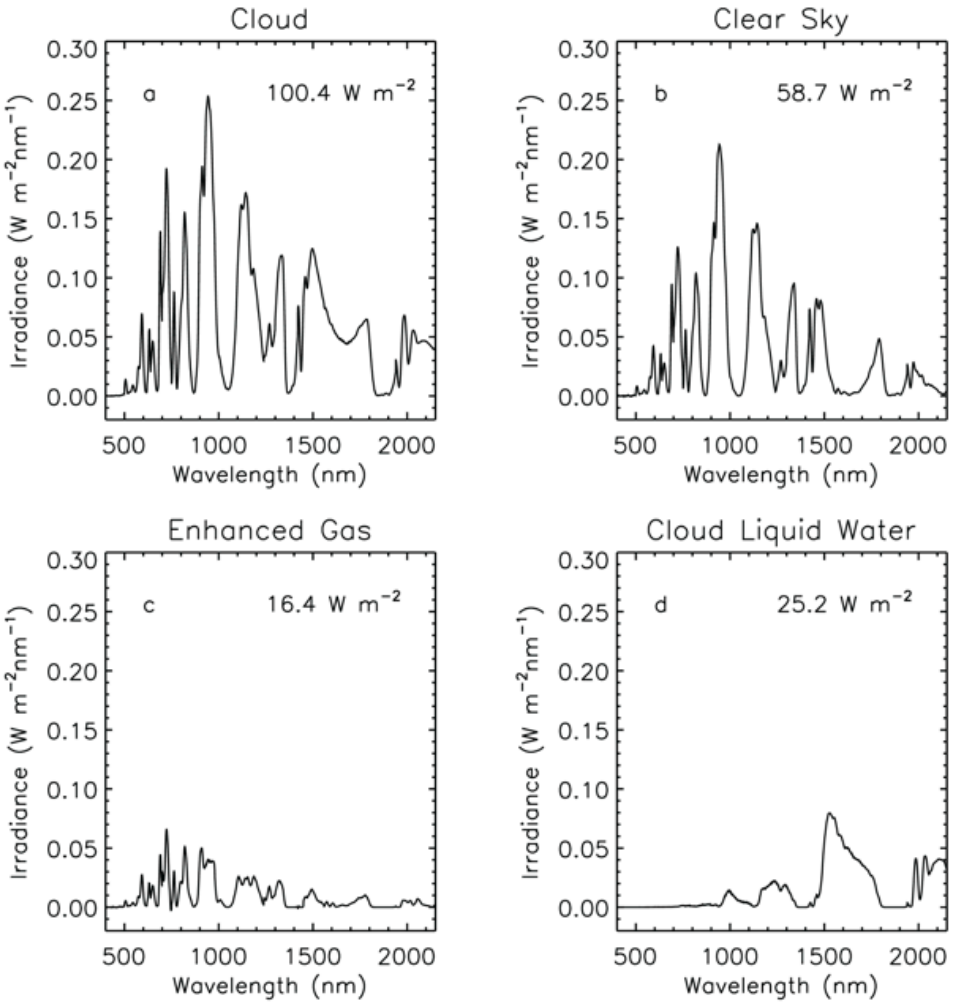
Match those net irradiance spectra (below/above) that have *no absorption* at 500 nm.



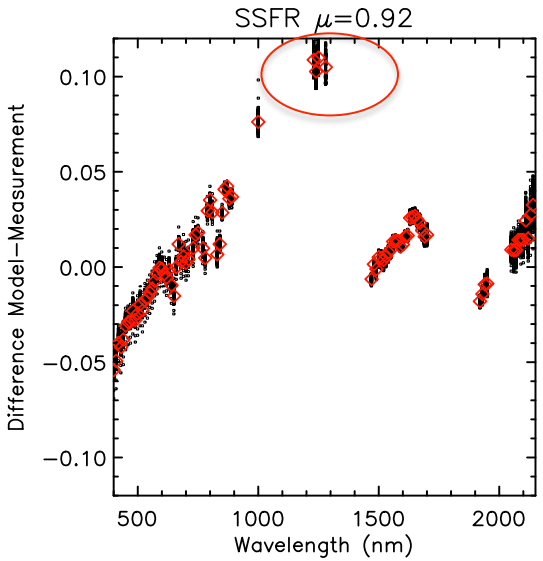
Kindel et al., *JGR*, 2010

More results from TC4

Partition “cloud” absorption into contributions (COD=26)

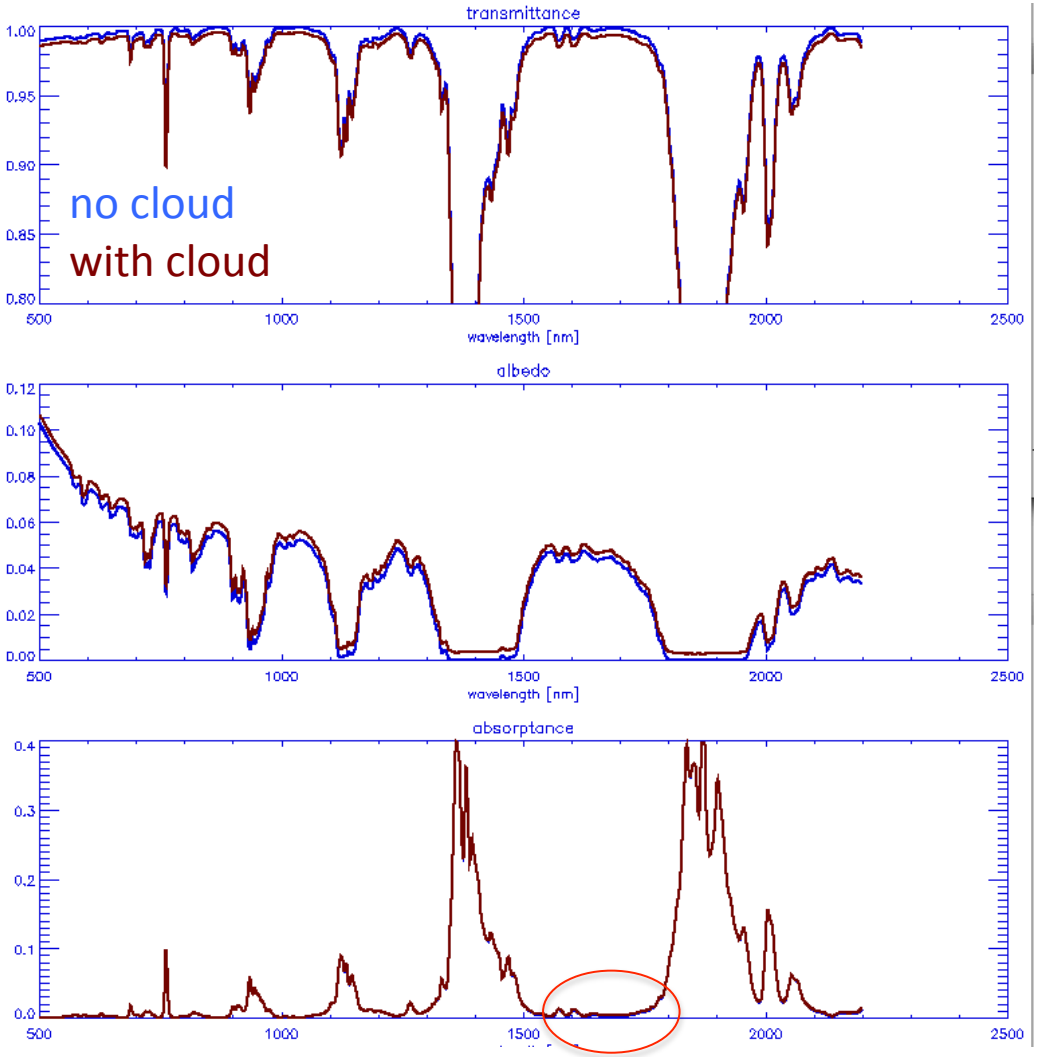


Identify spectral inconsistencies in ice single scattering properties



Kindel et al., *JGR*, 2010

Magnitude of Effect τ=0.1 in VIS/NIR



Transmittance

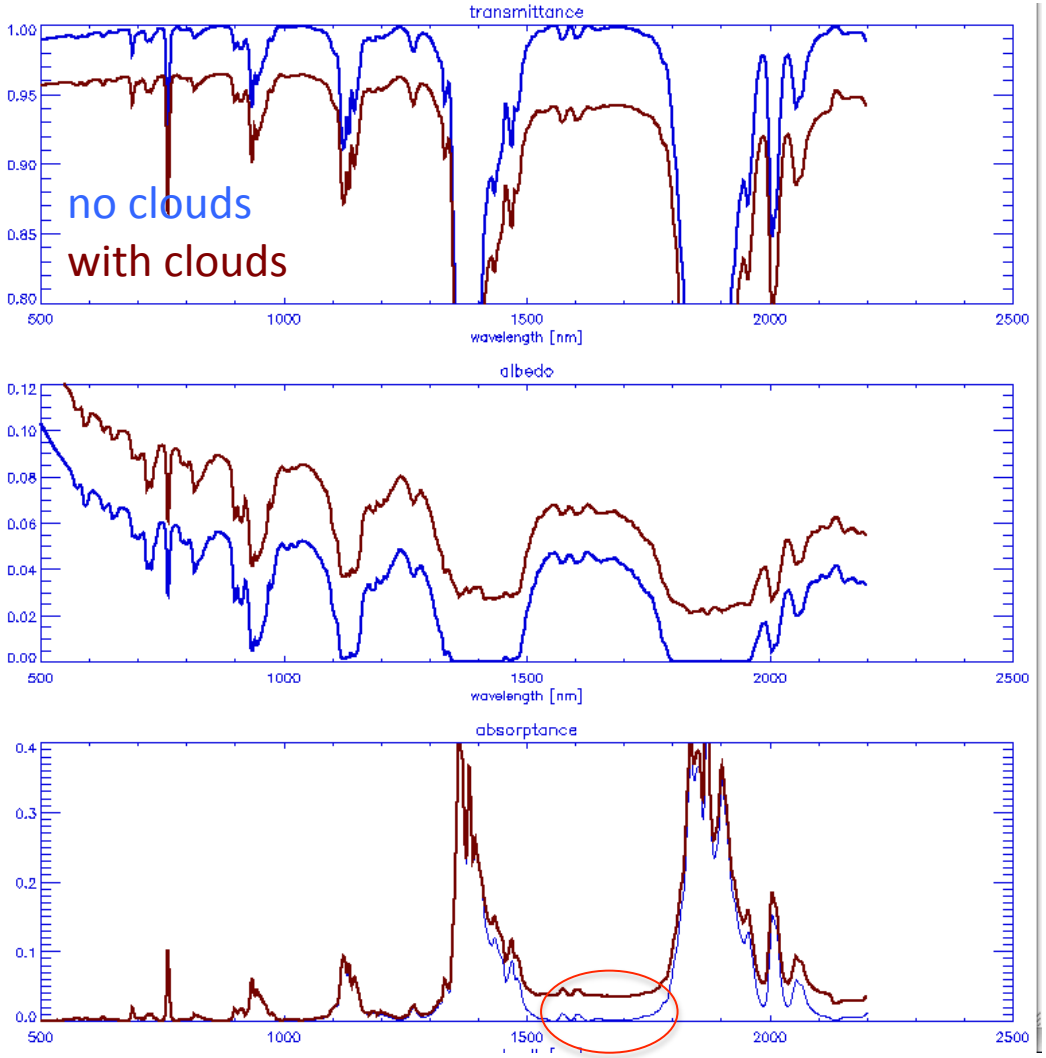
Albedo

Absorbed: 20 W/m^2

Extra due to clouds: 0.4 W/m^2

→ extra solar heating rate due to clouds ~ 0.1 K day^{-1}

Magnitude of Effect τ=1.0 in VIS/NIR



Transmittance

Albedo

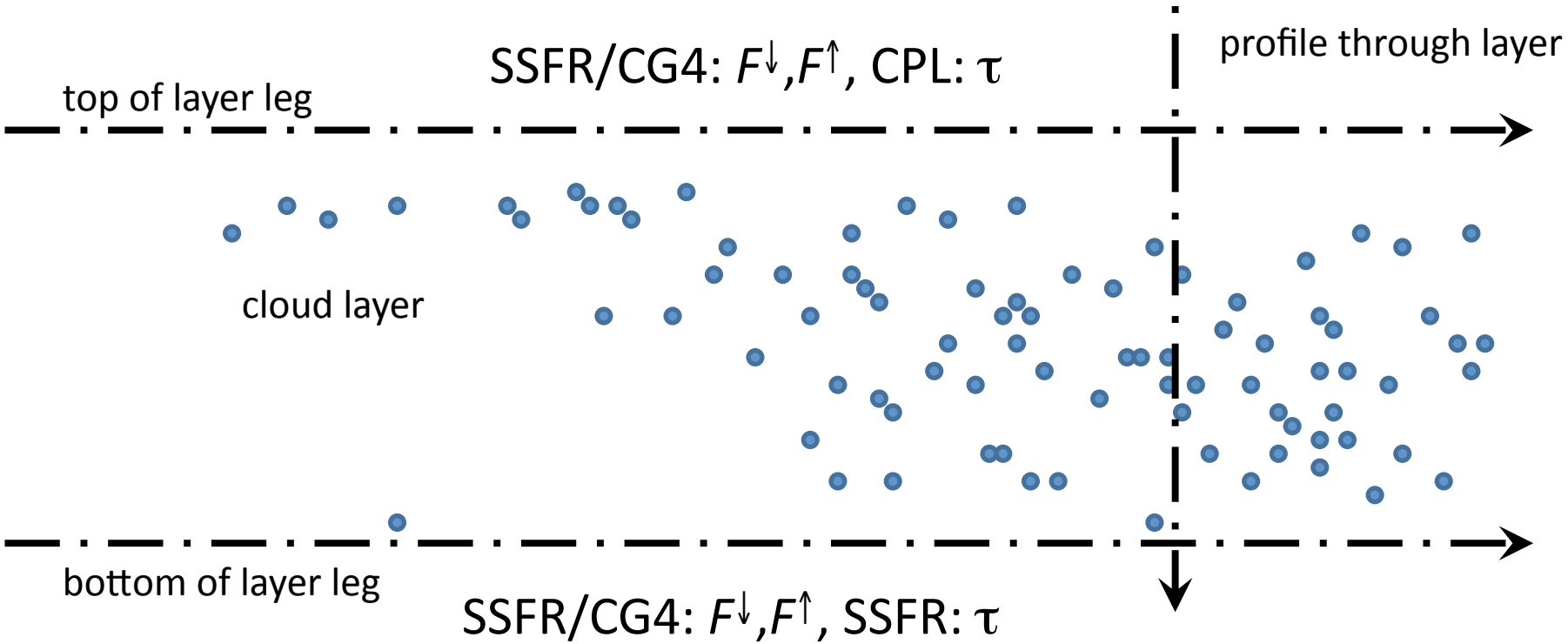
Absorbed: 25 W/m^2

Extra due to clouds: 5 W/m^2

Approach (1) – Level legs

VIS: Ideal if $\tau > 1$ (signal-to-noise; noise=heterogeneous background of clouds below)

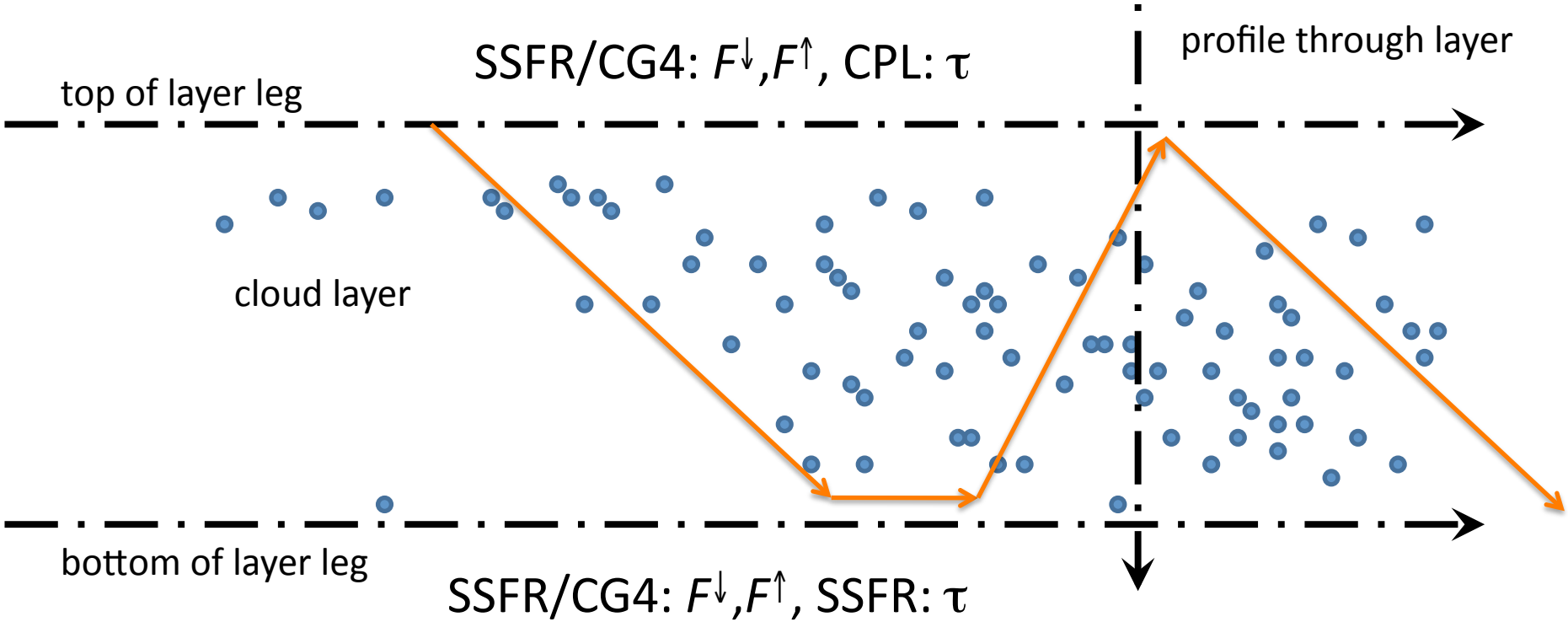
IR: Works if clouds underneath don't change



Approach (2) – Profiles

Use horizontal or vertical gradients in optical thickness
(works only if we have homogeneous conditions *below*)

Problem: CPL will be unable to deliver τ – need to rely on in-situ?



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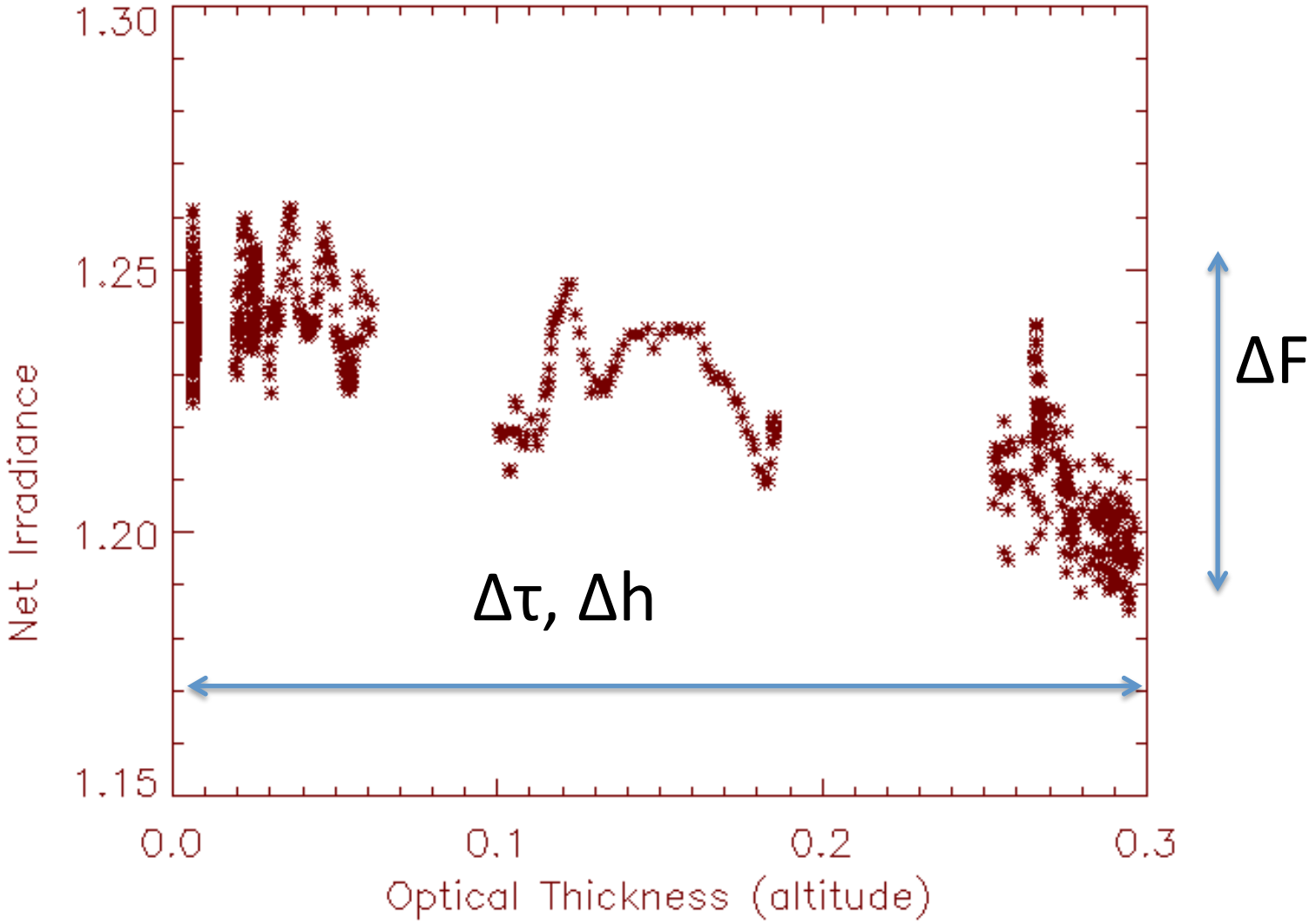

Summary

- Measuring heating rates for clouds this tenuous ($\tau<0.05$) is a challenge.
  - Shortwave particularly difficult; capitalize on gradient methods applied to aerosol layers from previous studies.
  - Longwave is at the limit of measurement sensitivity; requires stable (homogenous layers).
  - For both long- and shortwave, requires homogeneous scene beneath flight altitude.
- **Measuring TTL shirt- and long-wave radiative fields will be valuable in spite of the challenges in measuring thin cirrus hearting.**