Radiative Heating Profiles for Tropical Cloud Classes

Radiative Properties Working Group,
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Procedure for obtaining Radiative Heating Rate Profiles from ARM Measurements

Radiosonde profiles of temperature and humidity +
Microwave radiometer precipitable water +
High temporal resolution surface air temperature

→ **Constrained profiles of temperature and humidity**

Radar profiles of reflected power +
Radiosonde temperature profiles +
Field observations of cloud particle distributions

→ **Profiles of liquid and ice water content and effective particle size**

Derived profiles of temperature and humidity +
Derived profiles of cloud water content and particle size
4-stream radiative transfer model (Fu and Liou, 1992)

→ **Radiative Fluxes and heating rates**

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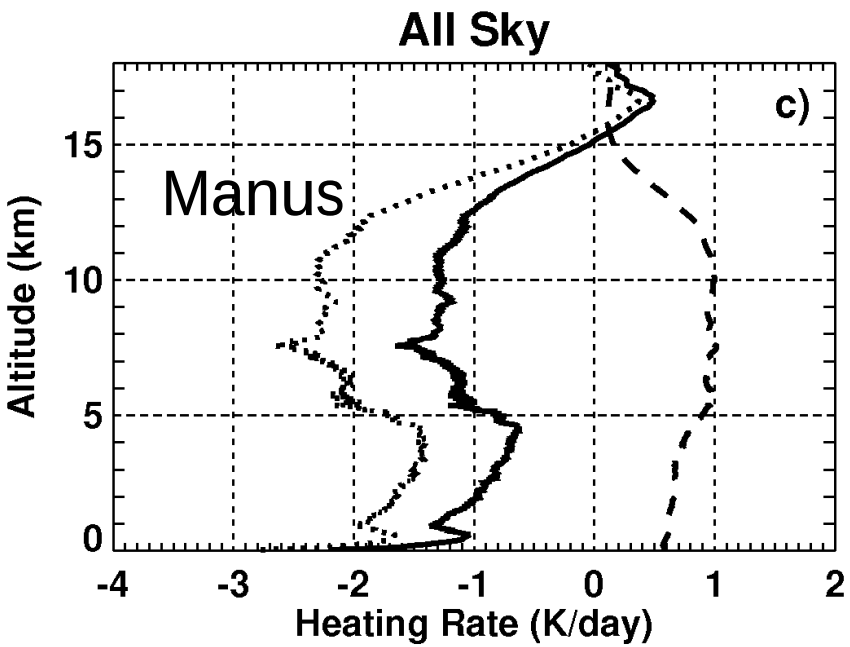
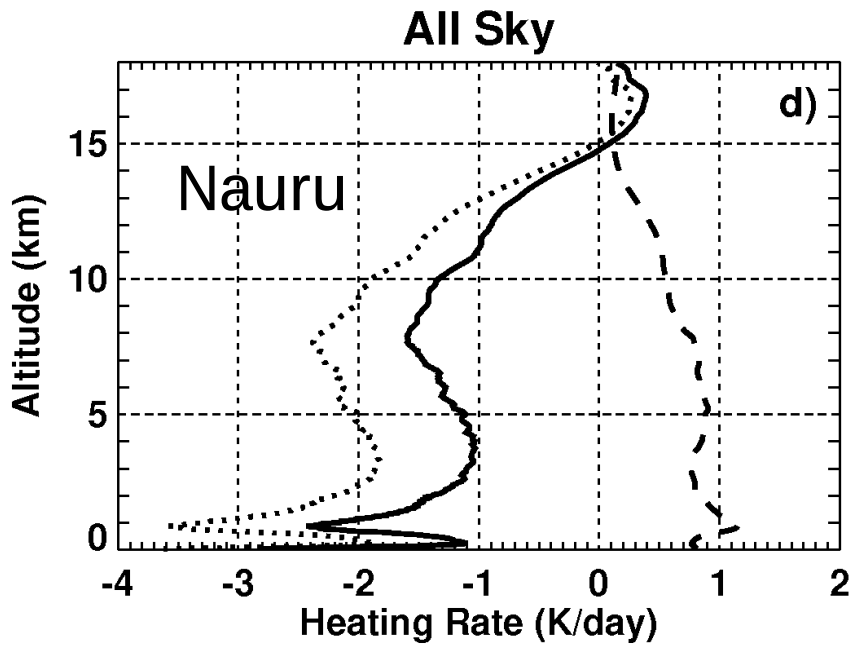
Average Heating Profiles at Manus and Nauru





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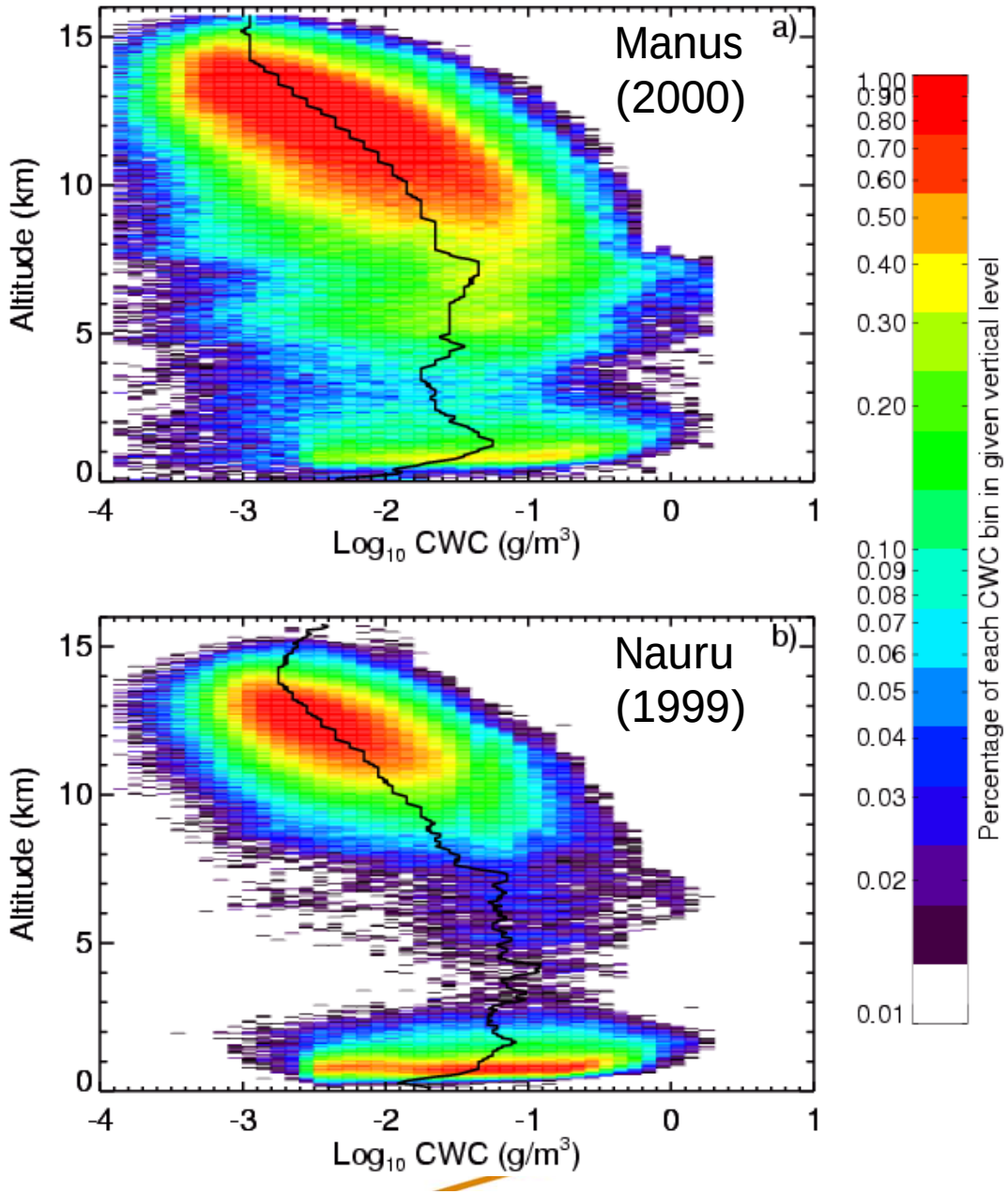
Condensed Water Frequency Distributions at Manus and Nauru



Cirrus and boundary layer features similar at Manus and Nauru.

Only Manus exhibits mid-level feature.

Nauru region was convectively suppressed during much of 1999.

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Partitioning Data by Cloud Type

Motivated by Heating Profile Meeting in La Jolla, set out to partition data to be more useful for model validation.

Identify common modes of cloud and heating profiles. Compare characteristics and frequency of modes to models rather than characteristics of aggregate.

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Radar-based cloud profile classification

***Vertical Layers**:* Instantaneous cloud profiles observed by the MMCR are sorted according to the cloud optical depth in three vertical layers:

Low cloud: 0-3 km
Middle cloud: 3-7 km
High cloud: 7-16 km

Optical Thickness: Within each of these layers, clouds are binned into ranges of optical depth:

Tau = 0 - 0.001 (clear)
Tau = 0.001 – 3
Tau = 3 – 20
Tau = 20 – 1000

Four optical depth ranges in 3 layers results in 64 cloud profile combinations

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Most common cloud classes are combinations of low optical depth in low and high layers.

Four optical depth ranges in 3 layers results in 64 cloud profile combinations

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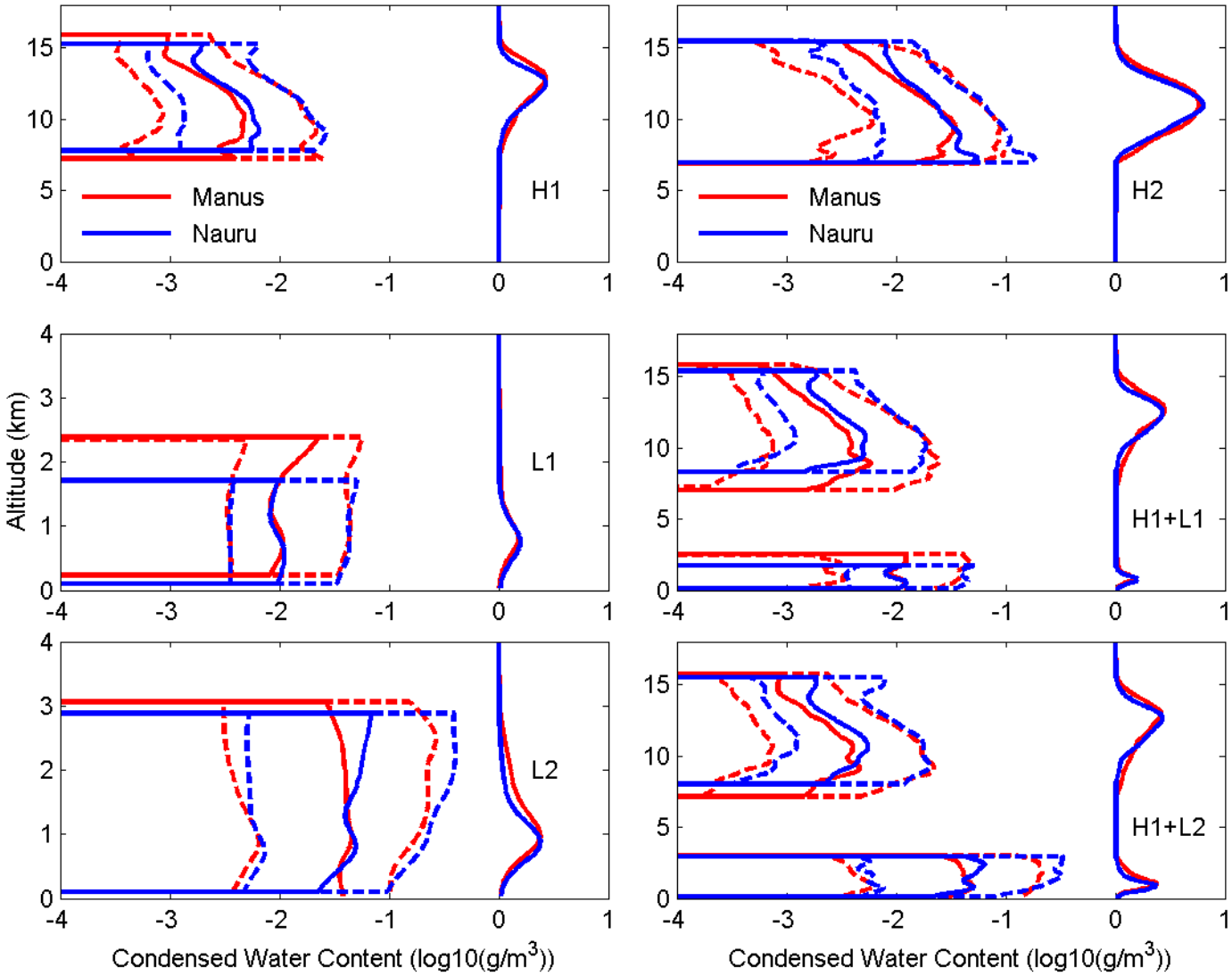
Condensed Water at Manus and Nauru



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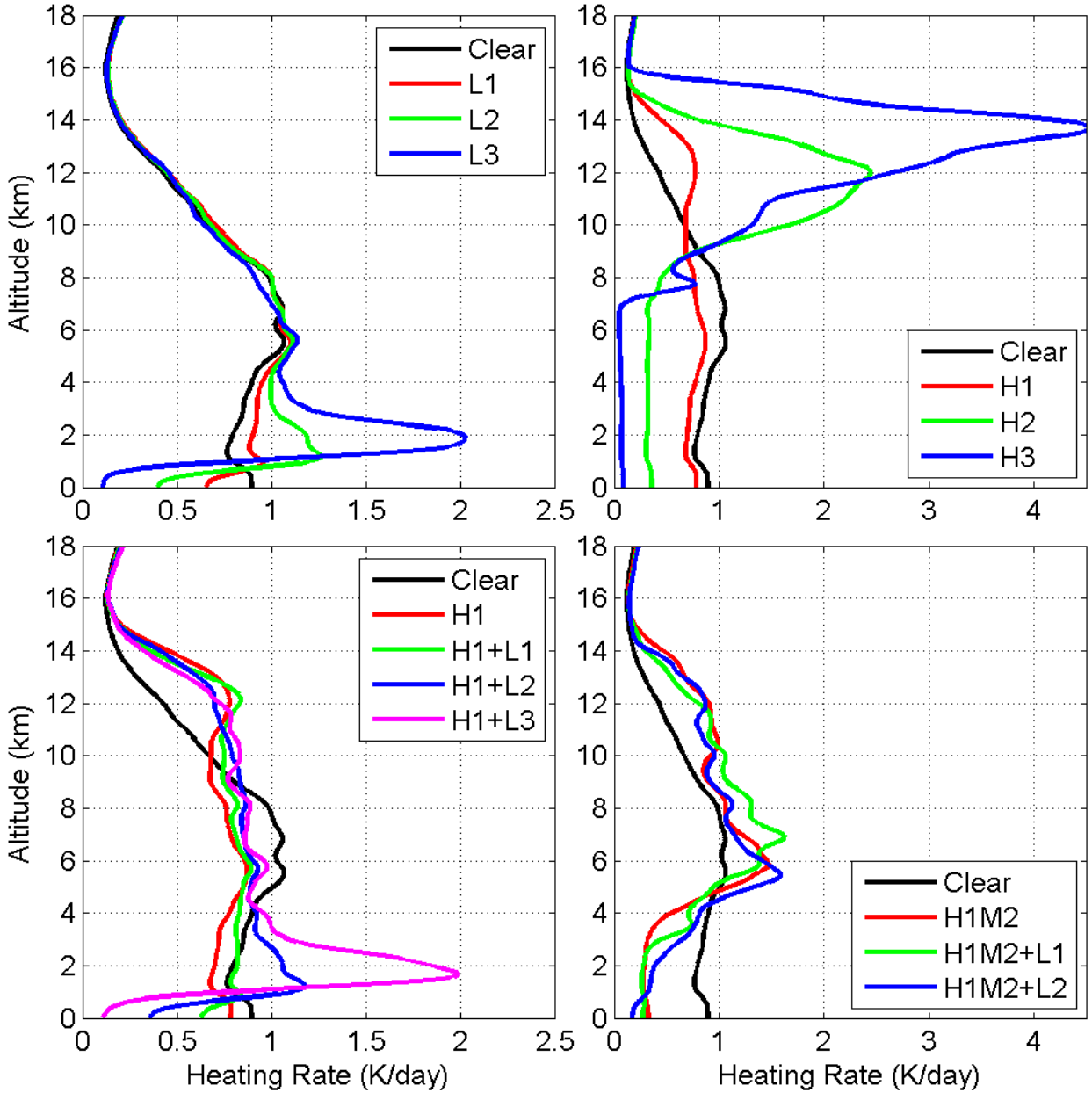
Shortwave Heating Profiles at Manus as a Function of Cloud Class



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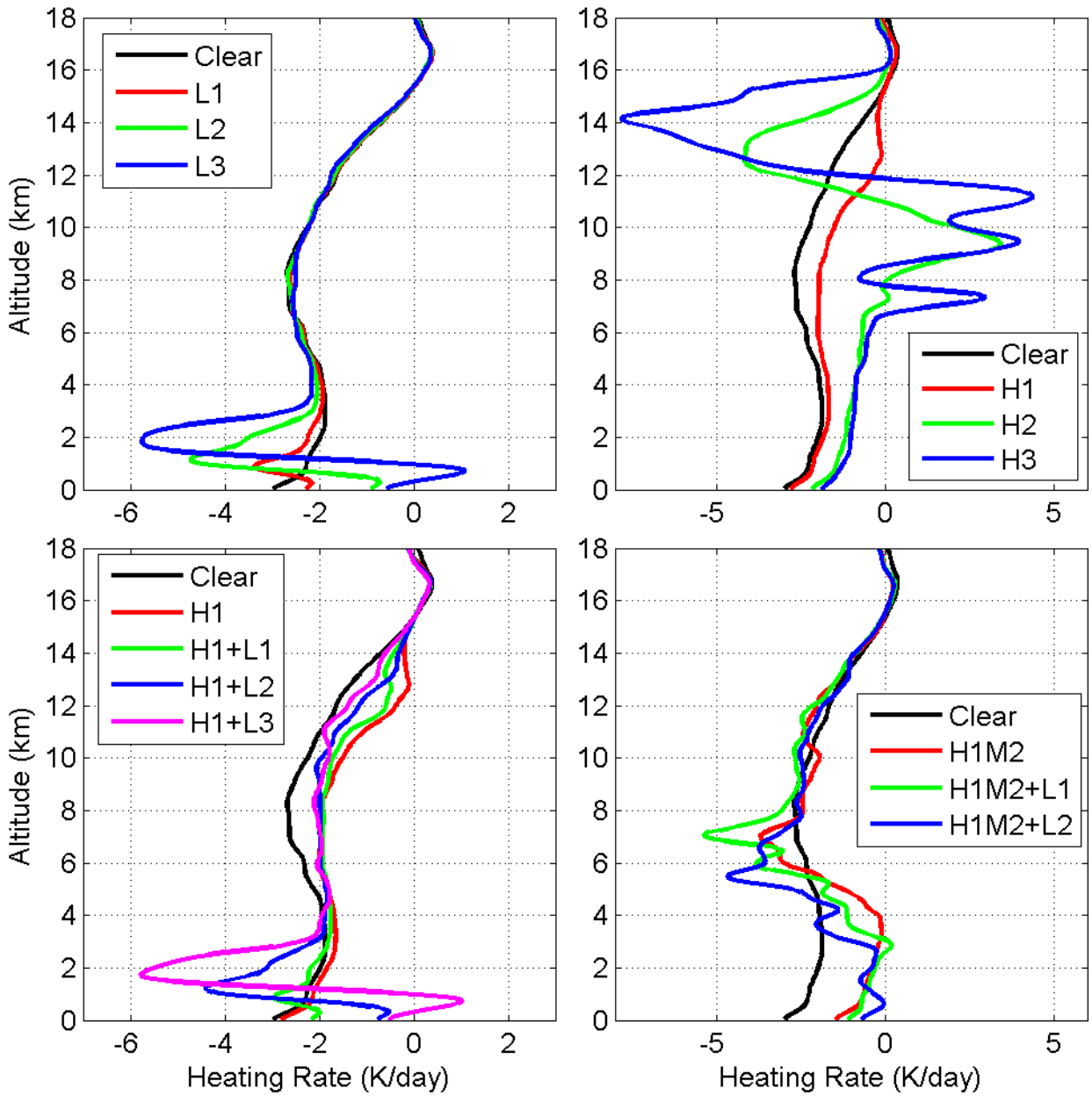
Longwave Heating Profiles at Manus as a Function of Cloud Class



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Uniformity of Heating Profiles

Given the similarity of cloud water content at Manus and Nauru, the heating profiles should also be similar.

We've only compared the sites for six of the most common classes. The all-sky heating profile integrates the effect of all classes.

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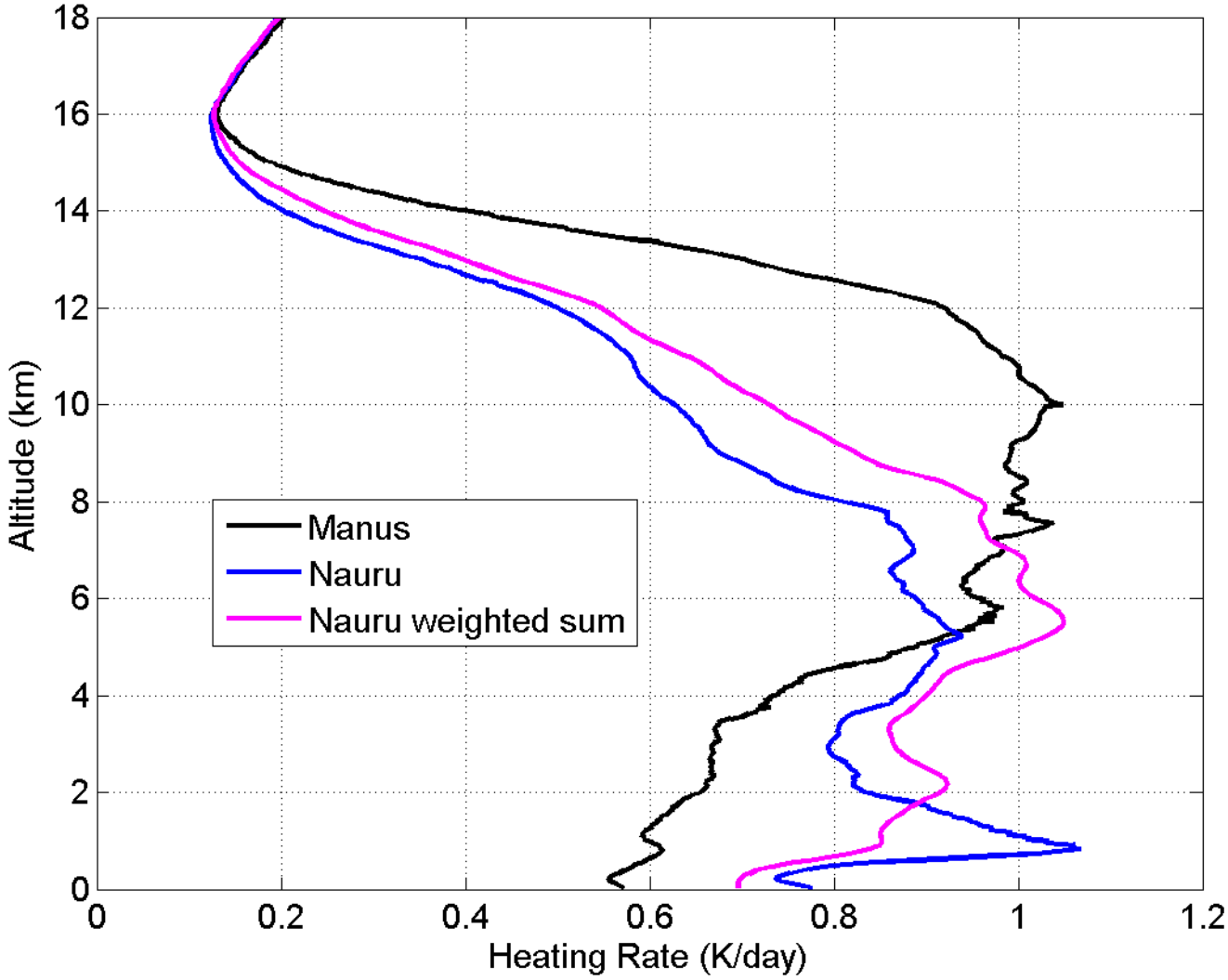
Applying Manus heating classes to Nauru



$$H^{nau} = \Sigma\, a_i^{nau}\, H_i^{man}$$

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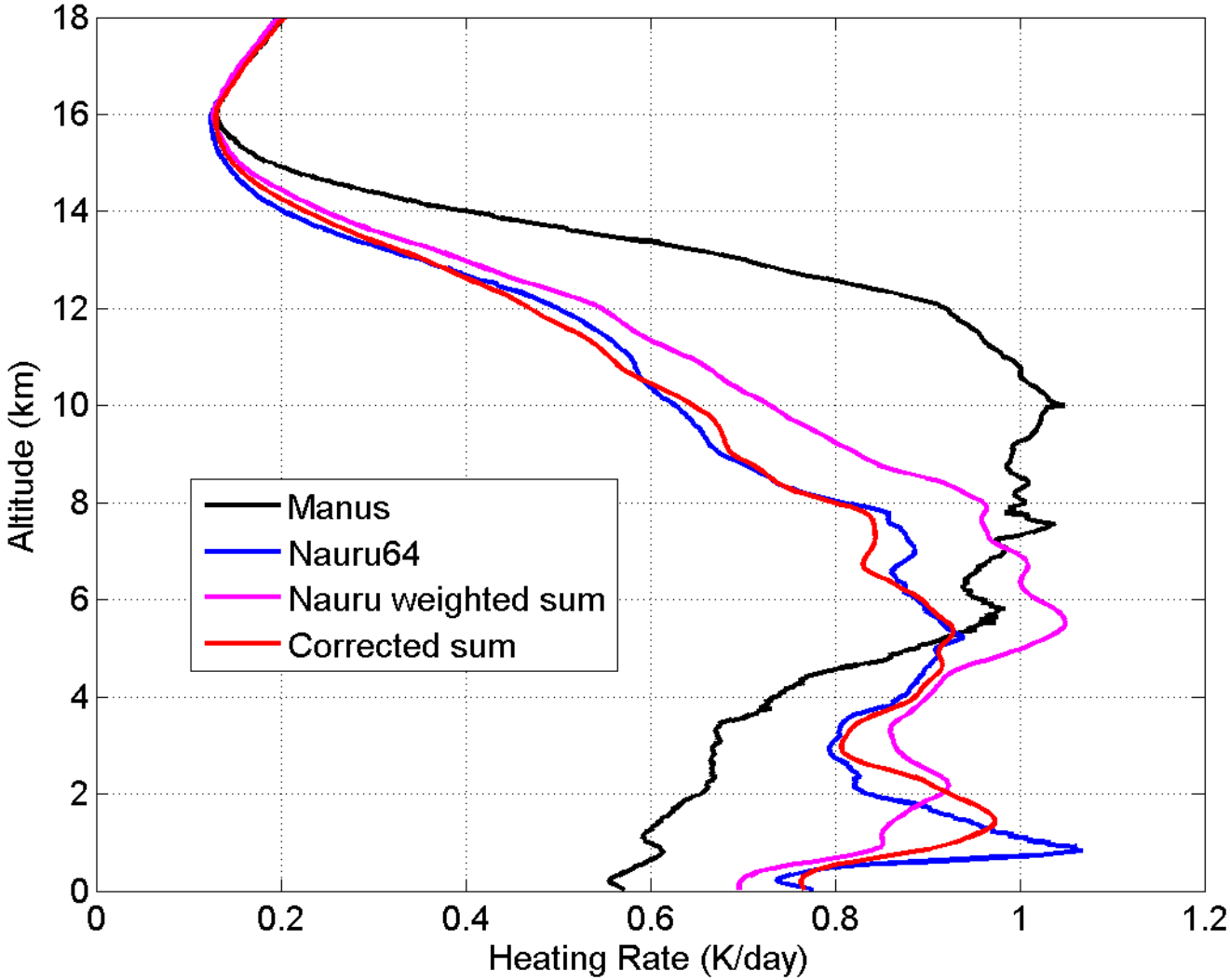
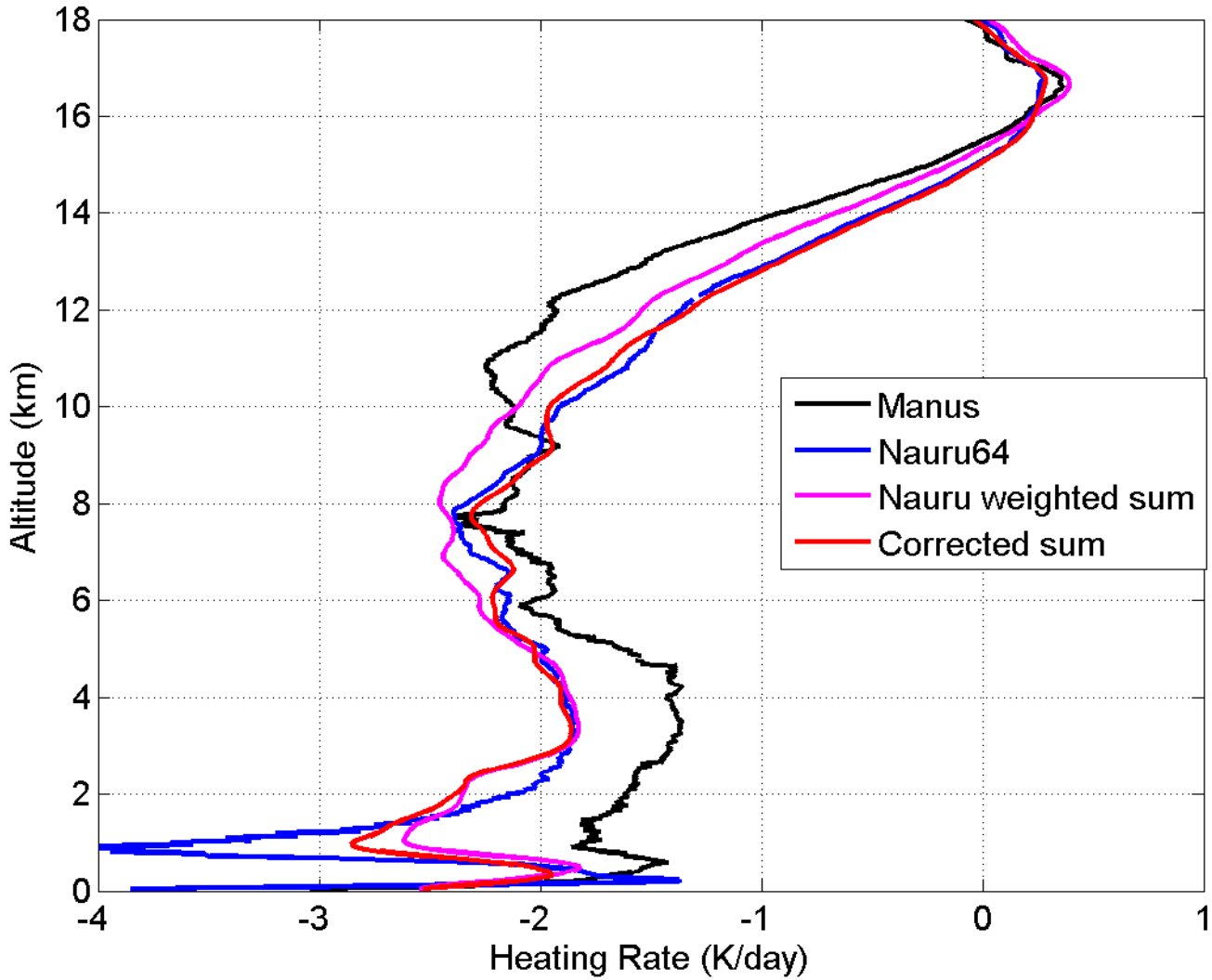
Correcting heating profile for clear sky background



$$H^{nau} = HC^{nau} - HC^{man} + \Sigma\, a_i^{nau}\, H_i^{man}$$

Longwave heating for Manus and Nauru



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Conclusions and Applications

- Analysis of cloud properties and heating profiles for Manus and Nauru indicate a strong similarity between the sites for a given cloud class.

- Differences between Manus and Nauru clouds have more to do with meteorology than cloud properties.

- Cloud classes provide a more stringent tool (than aggregate profiles) for testing model simulations.

- Determining the distribution of cloud classes as a function of meteorological regime will provide a mechanism to tie ARM data to satellite retrievals.

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