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RESEARCH LETTER
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Key Points:
- Negative greenhouse effect occurs only over central Antarctica on yearly average
- Rising CO_2 can induce slightly negative instantaneous radiative forcing in central Antarctica

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How increasing CO_2 leads to an increased negative greenhouse effect in Antarctica

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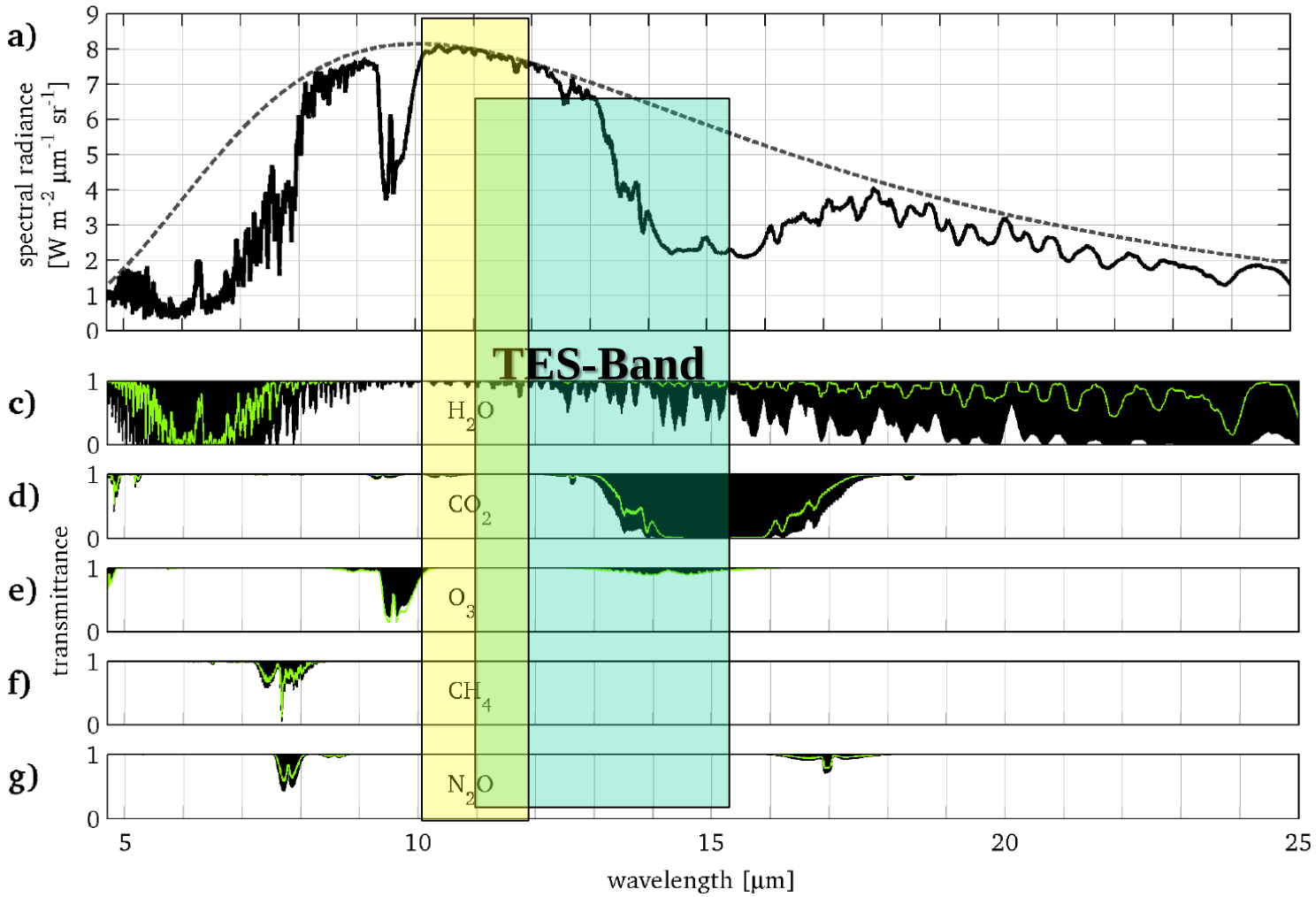
Abstract CO_2 is the strongest anthropogenic forcing agent for climate change since preindustrial times. Like other greenhouse gases, CO_2 absorbs terrestrial surface radiation and causes emission from the atmosphere to space. As the surface is generally warmer than the atmosphere, the total long-wave emission to space is commonly less than the surface emission. However, this does not hold true for the high elevated areas of central Antarctica. For this region, the emission to space is higher than the surface emission; and the greenhouse effect of CO_2 is around zero or even negative, which has not been discussed so far. We investigated this in detail and show that for central Antarctica an increase in CO_2 concentration leads to an increased long-wave energy loss to space, which cools the Earth-atmosphere system. These findings for central Antarctica are in contrast to the general warming effect of increasing CO_2.

1. Introduction

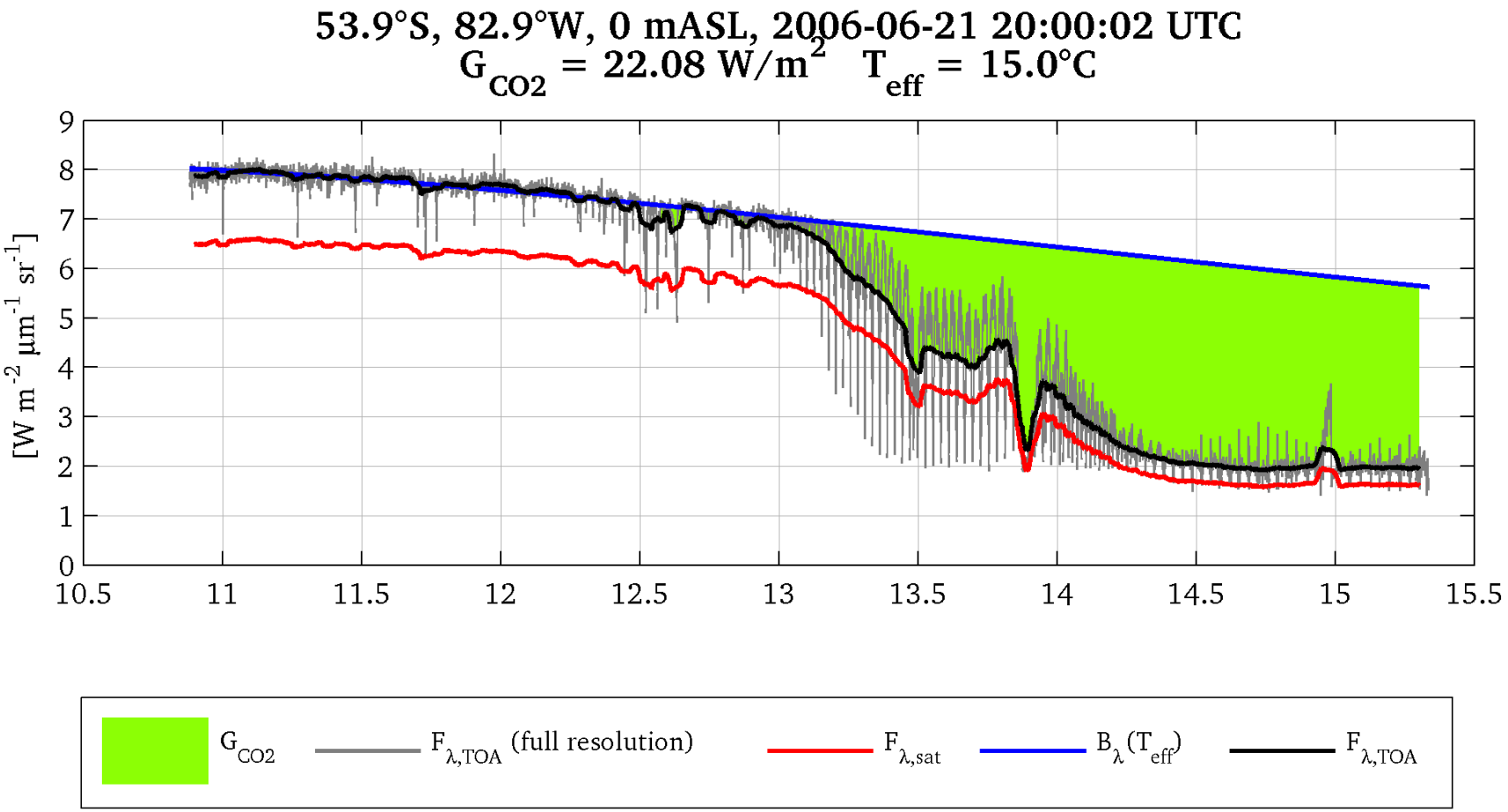
Throughout the last years, several ideas have been discussed describing the lack of warming of central Antarctica [*Chapman and Walsh*, 2007; *Steig et al.*, 2009; *Thompson et al.*, 2011; *Langematz et al.*, 2003; *Shindell and Schmidt*, 2004; *Shine and Forster*, 1999]. The global warming observed is to a large extent caused by anthropogenic emission of greenhouse gases [*Intergovernmental Panel on Climate Change (IPCC)*, 2013]. Greenhouse gases (GHGs) act on the climate by absorbing terrestrial surface radiation and provoking long-wave (LW) emission from the

Typical TOA Long-Wave Emission



Typical Spectra from Satellite

(Tropospheric Emission Spectrometer)



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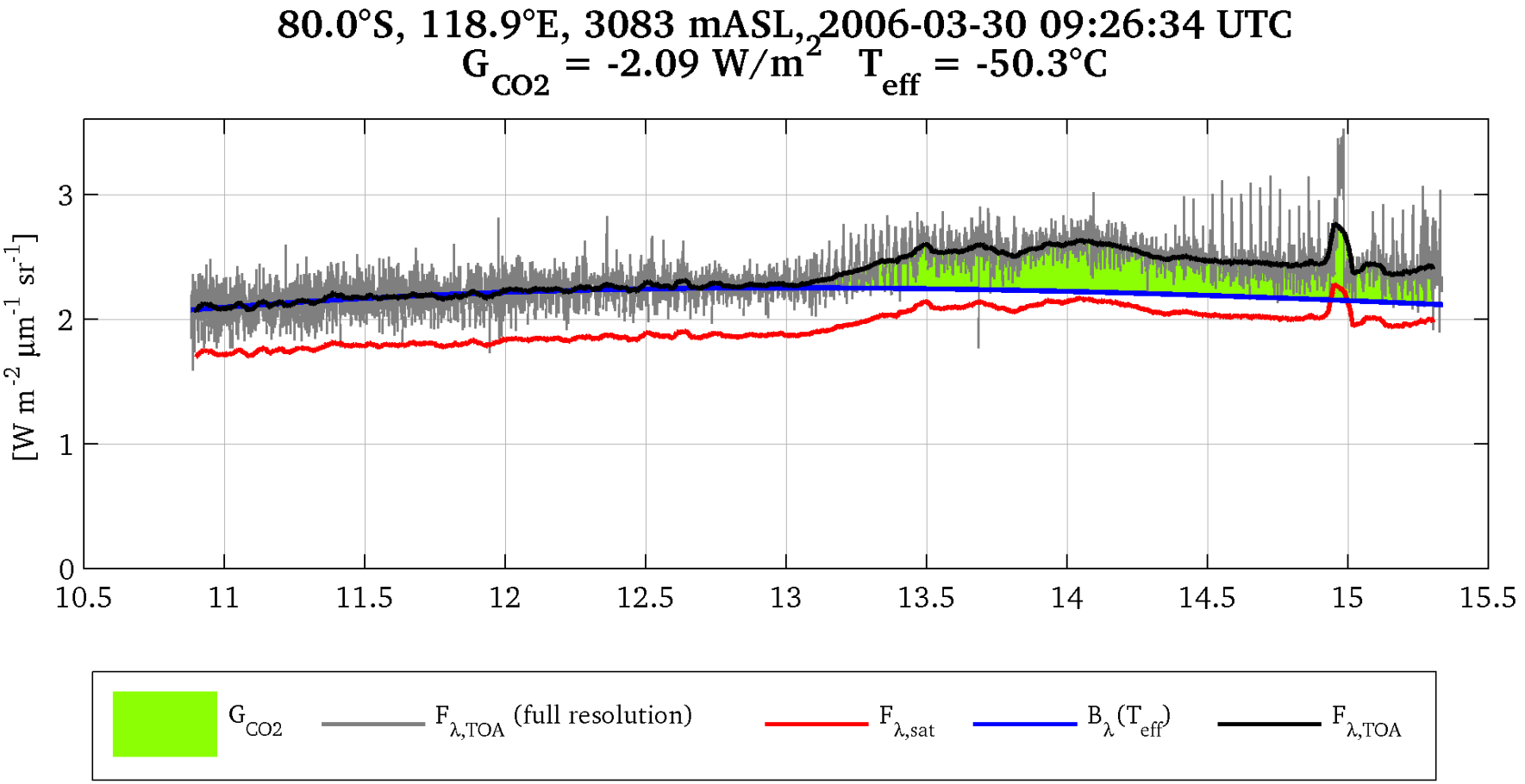
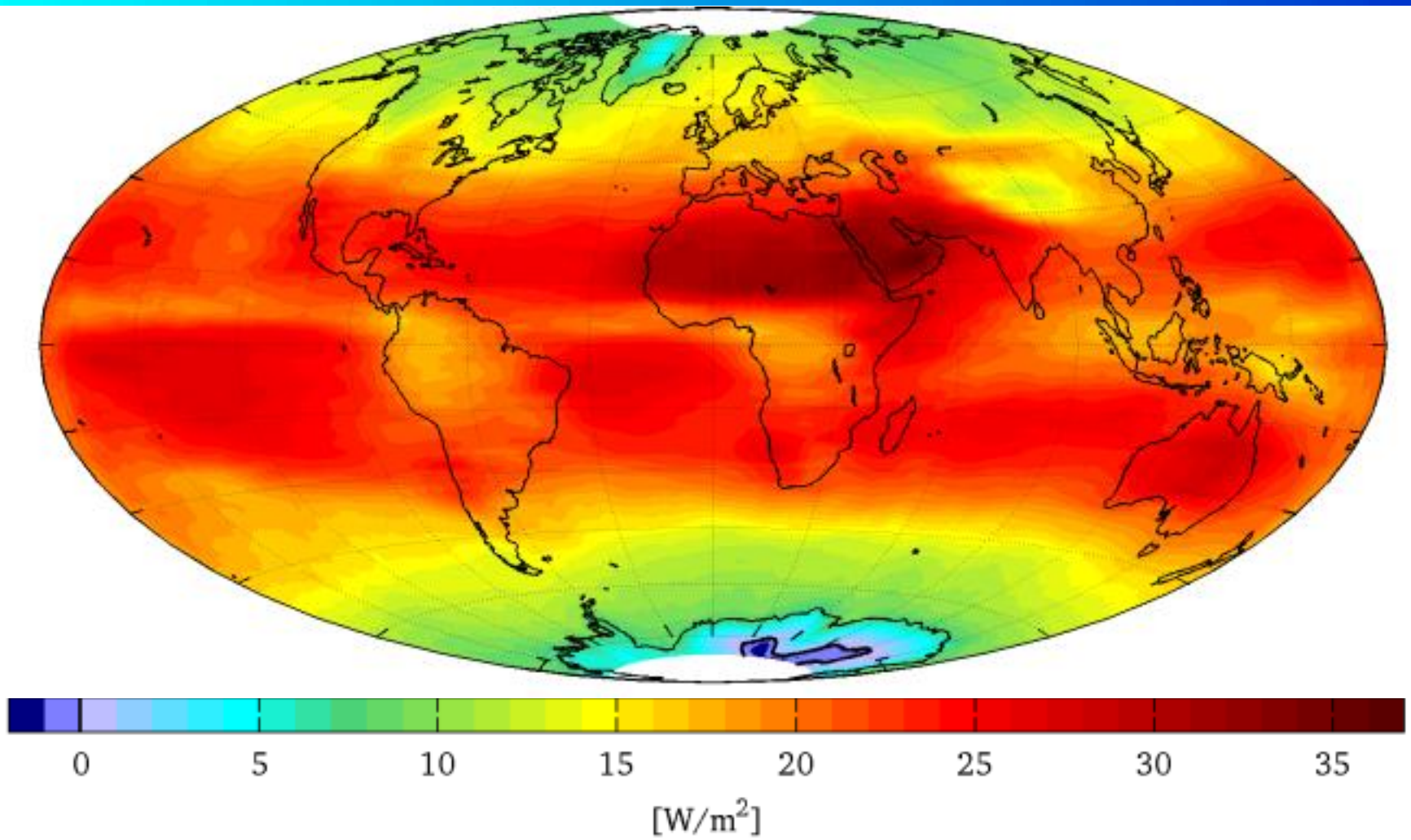
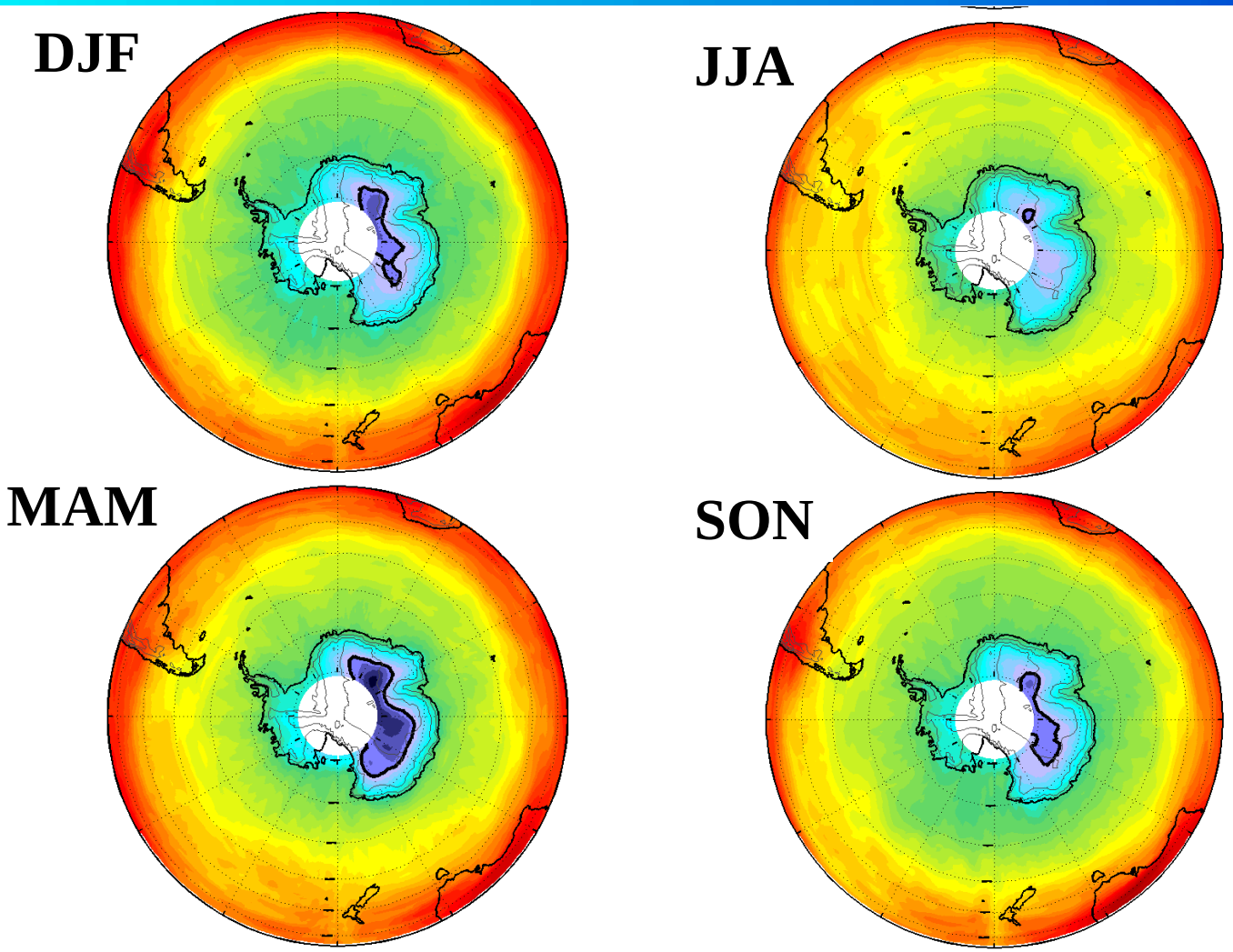


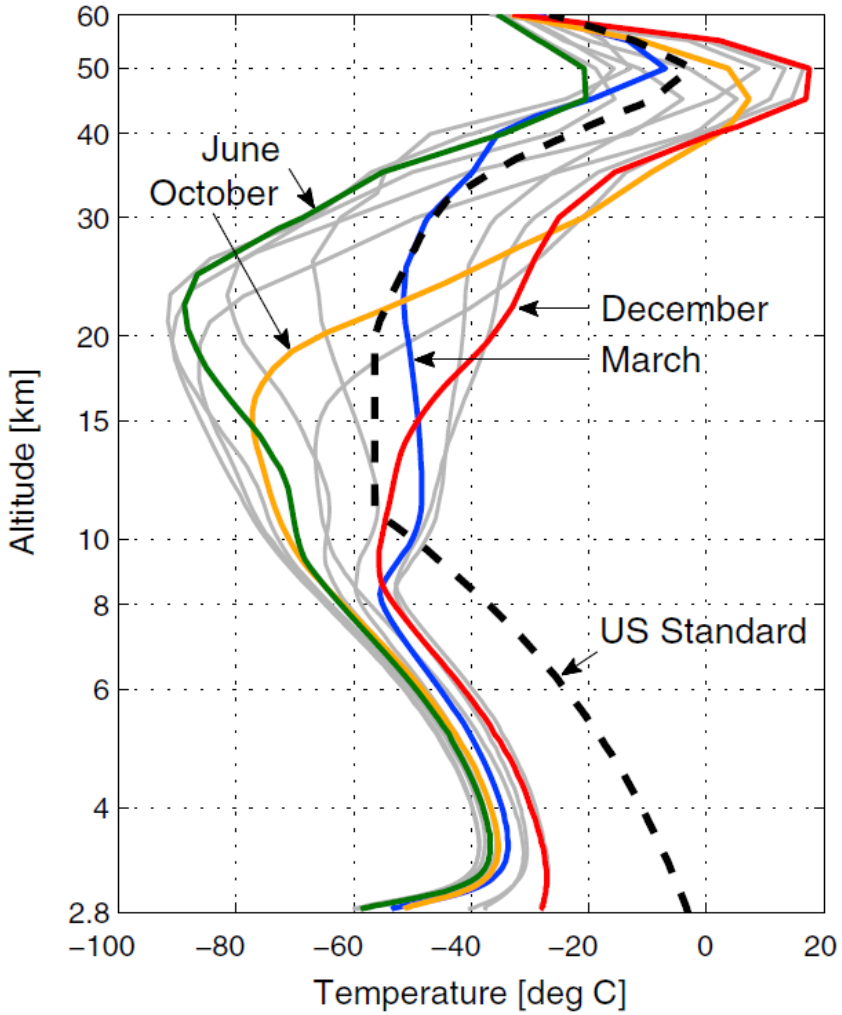
Yearly averaged greenhouse effect of CO2 in 2006 calculated from TES



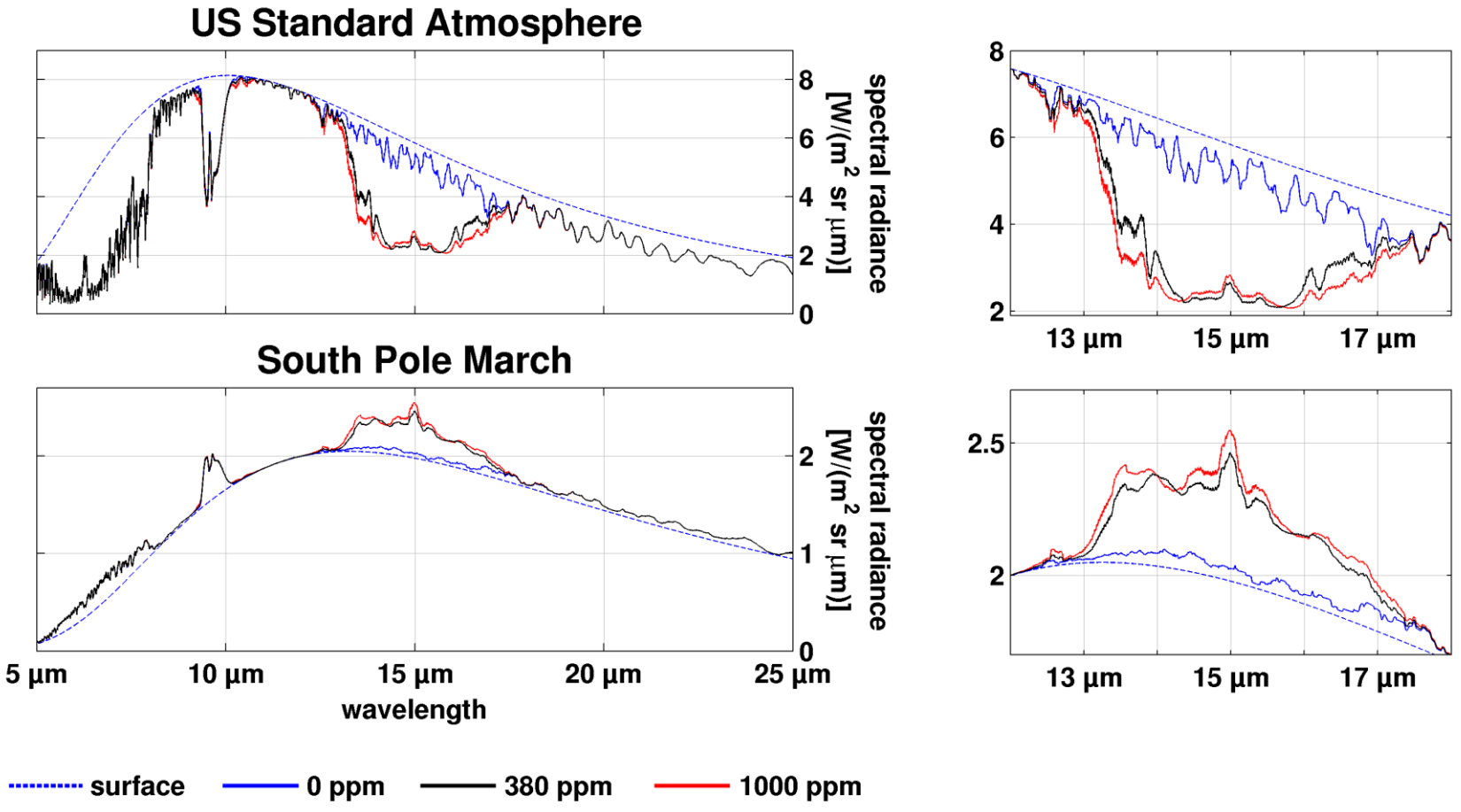
Seasonally averaged greenhouse effect of CO2 in 2006, calculated from TES spectra



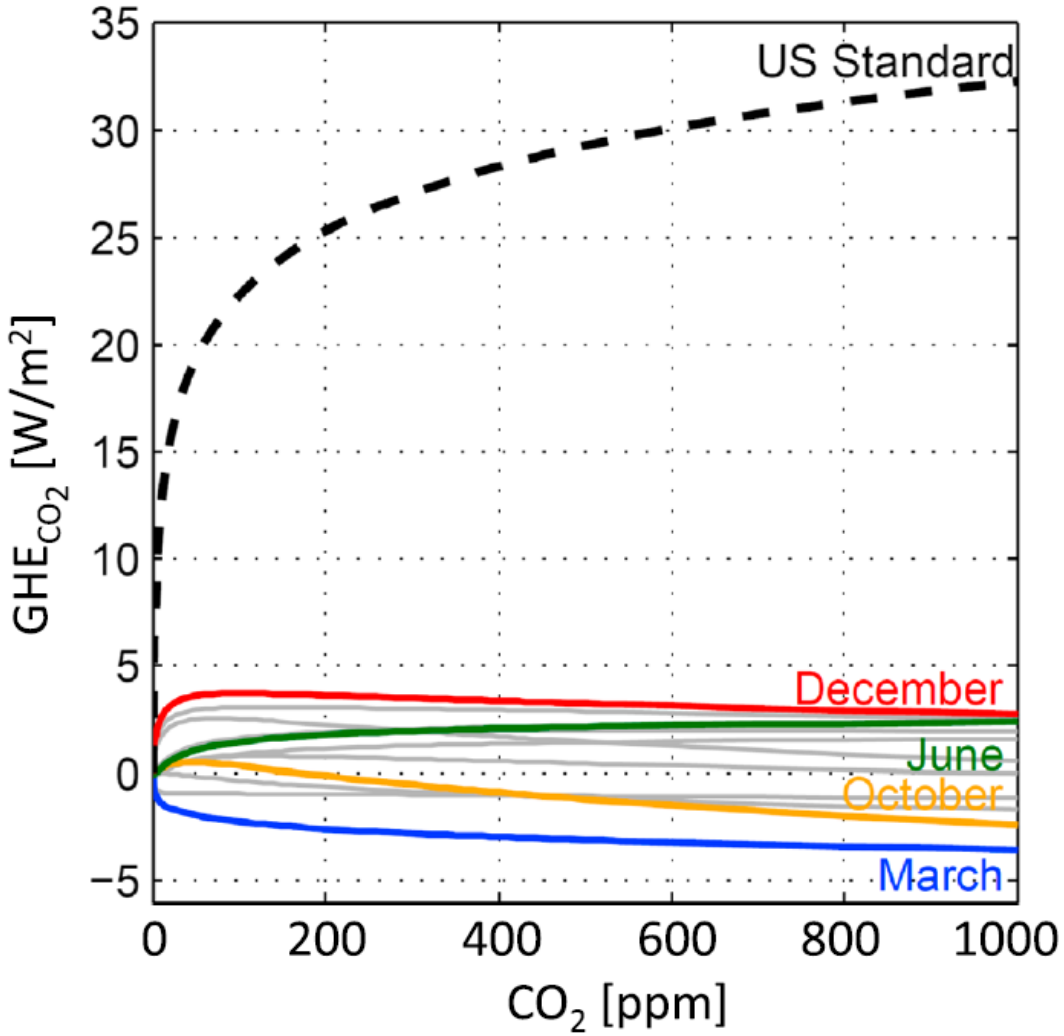
Monthly averaged temperature profiles from South Pole



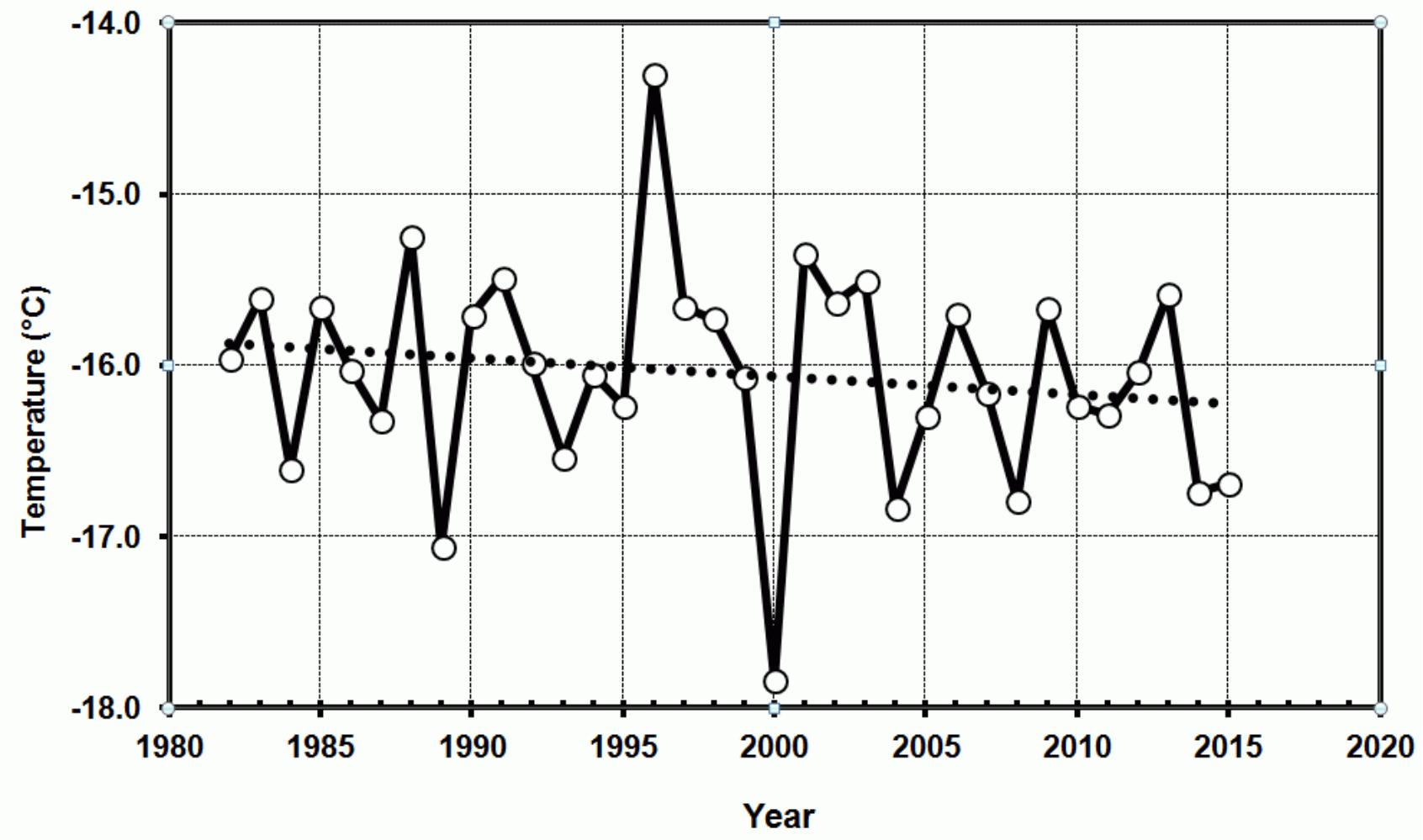
Effect of increasing CO_2 on F_{TOA} using the line-by-line modell ALFIP



Greenhouse effect of CO2 as a function of CO2 concentration for temperature profiles from South Pole

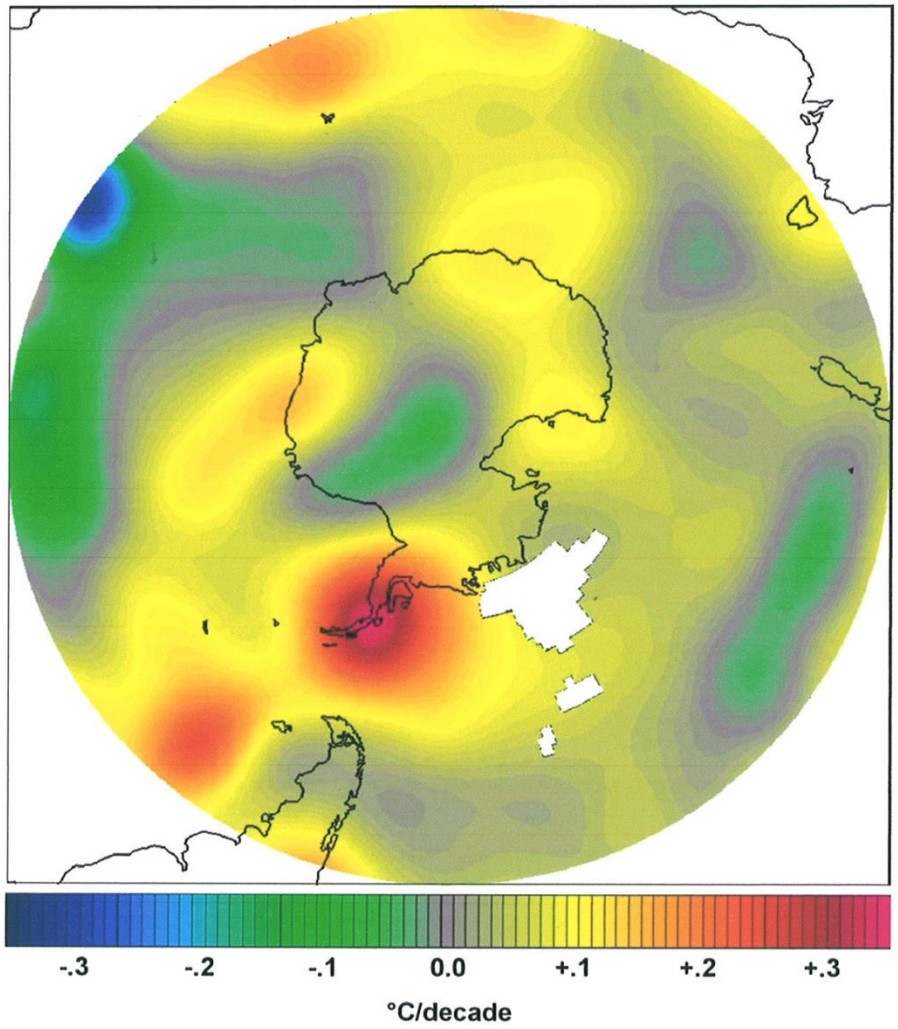


Yearly averaged air temperature at Neumayer



Temperature trends from observations

A Synthesis of Antarctic Temperatures (CHAPMAN et al., 2006)

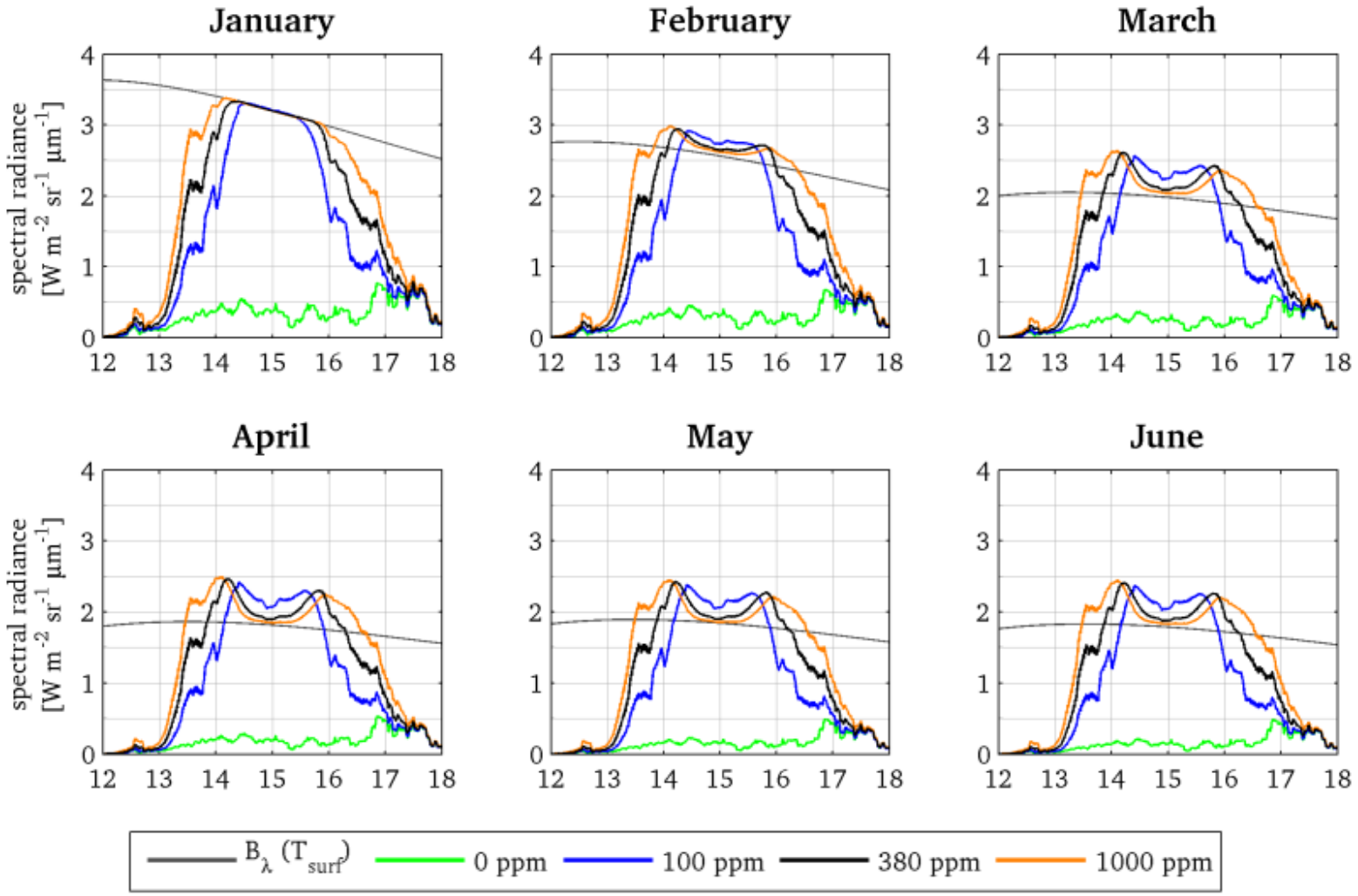


Summary

- **„Global warming“ does not take place in central Antarctica**
- **The greenhouse effekt (GEH) is extremely week and even negative in central Antarctica**
- **Increasing CO2 leads to increasing LW-TOA fluxes over central Antarctica**
- **The main reason: The surface in central Antarctica is frequently colder than the stratosphere**

Open Question: Where does the CO_2-cooling takes place???

LWD modelled using ALFIP
(T-profiles from South Pole, no clouds)



Summary LWD

Long Wave Downwelling radiation (F_{surf})

- For increasing CO_2 the emission height decreases
- For a temperature inversion increasing CO_2 leads to a decrease of F_{surf} for the center of the CO_2 band
- Overall, an increase in CO_2 leads to an increase in F_{surf}