Convectively coupled gravity waves in global models vs observations

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NOAA/ESRL Physical Sciences Division

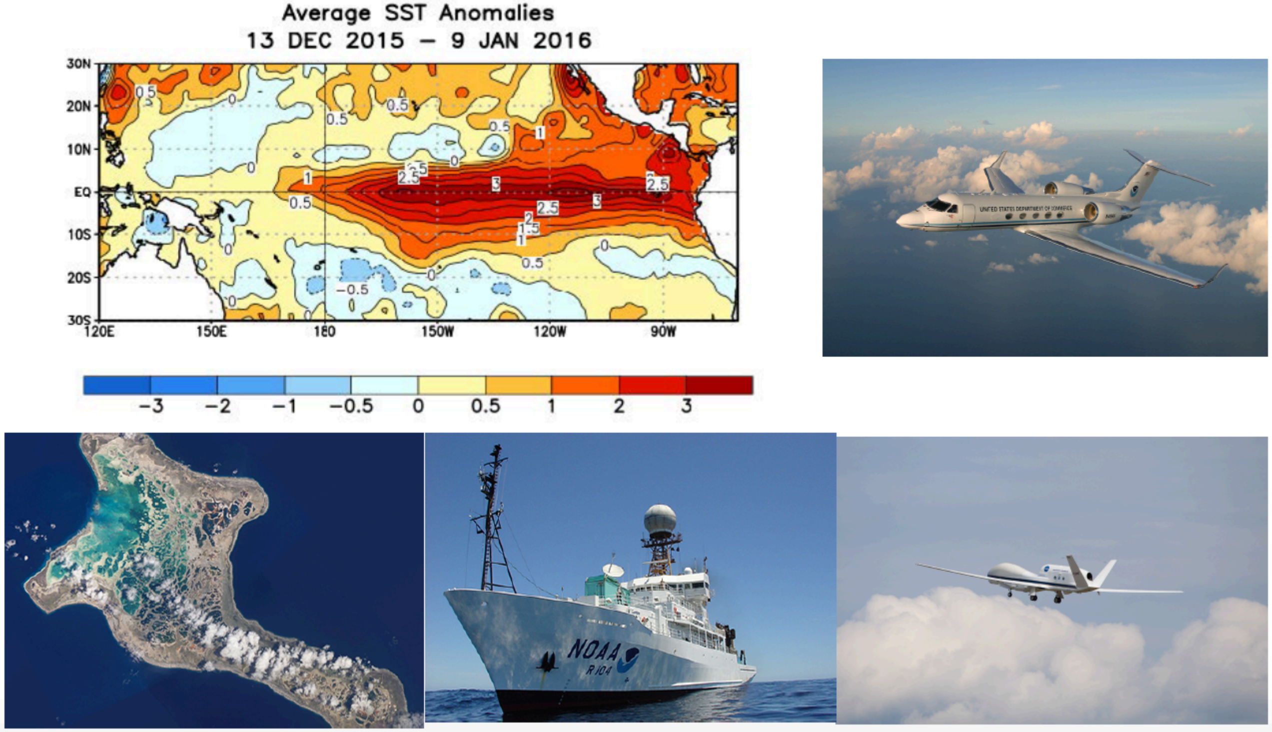
SPARC Gravity Wave Symposium
Penn State University, May 16 2016

Motivation comes partly from a recent NOAA-led field campaign

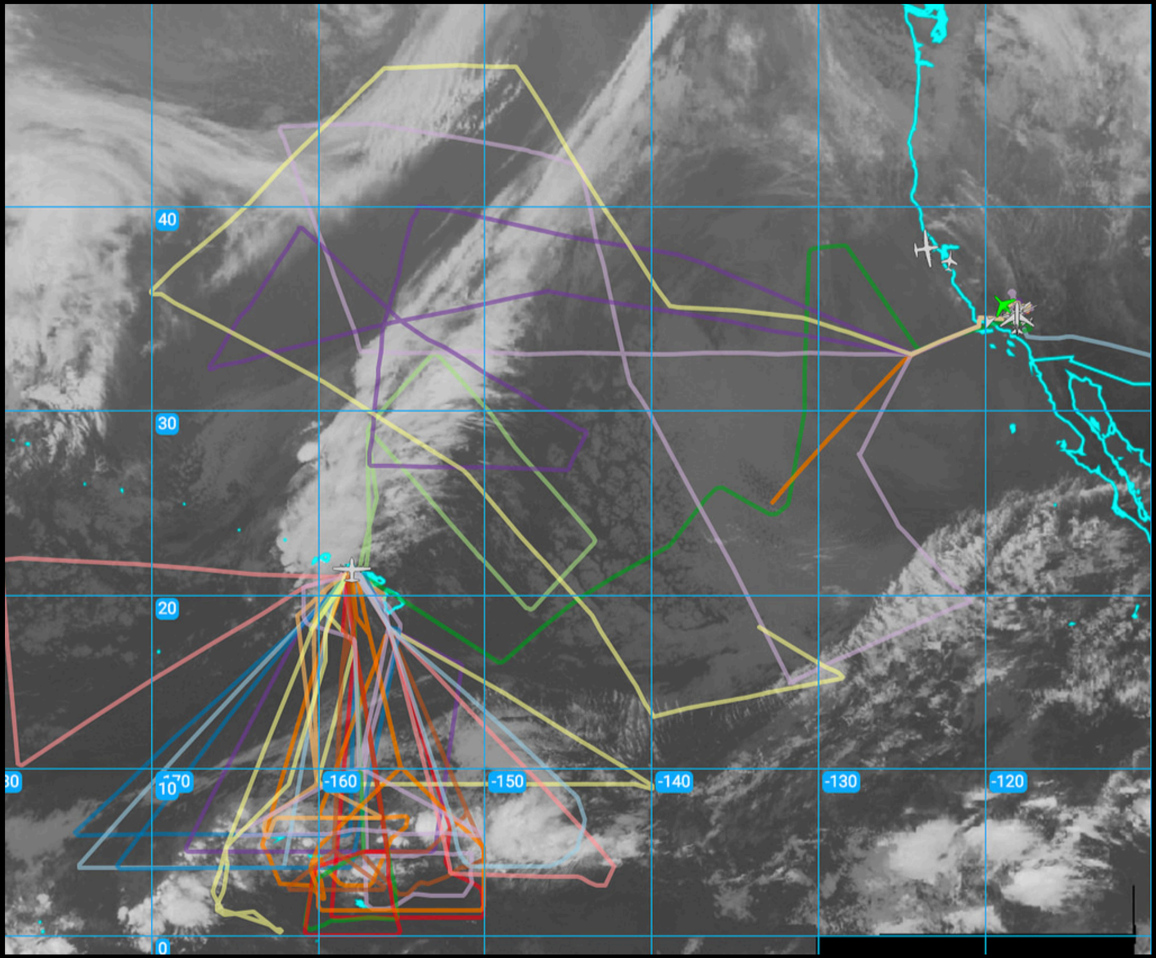
2016 NOAA El Nino Rapid Response Field Campaign

Science Overview

Randall Dole

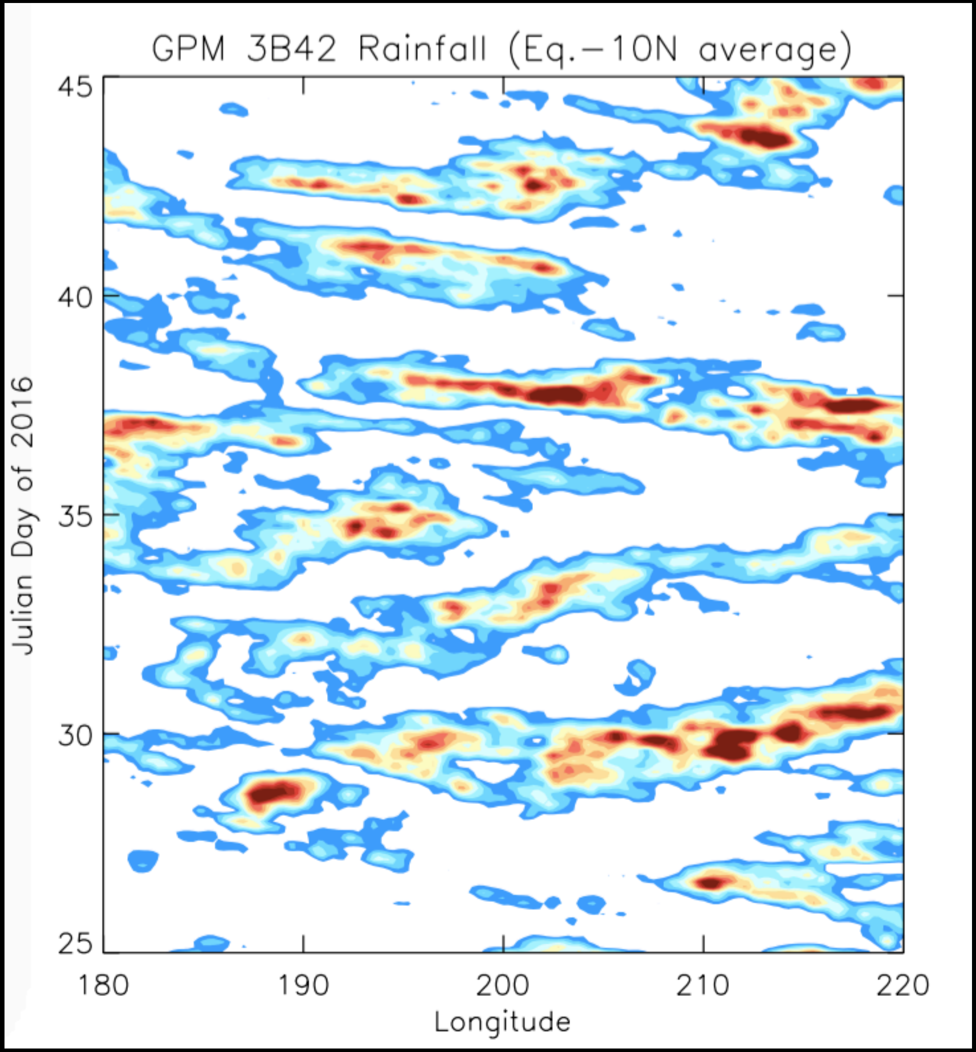


Key objective was to sample El-Nino ITCZ convection using the NOAA G4 out of Hawaii



NOAA/ESRL staff were tasked with providing guidance for 6 hr to extended range lead-times

Evolution of satellite-based rainfall indicates some potential for predictability



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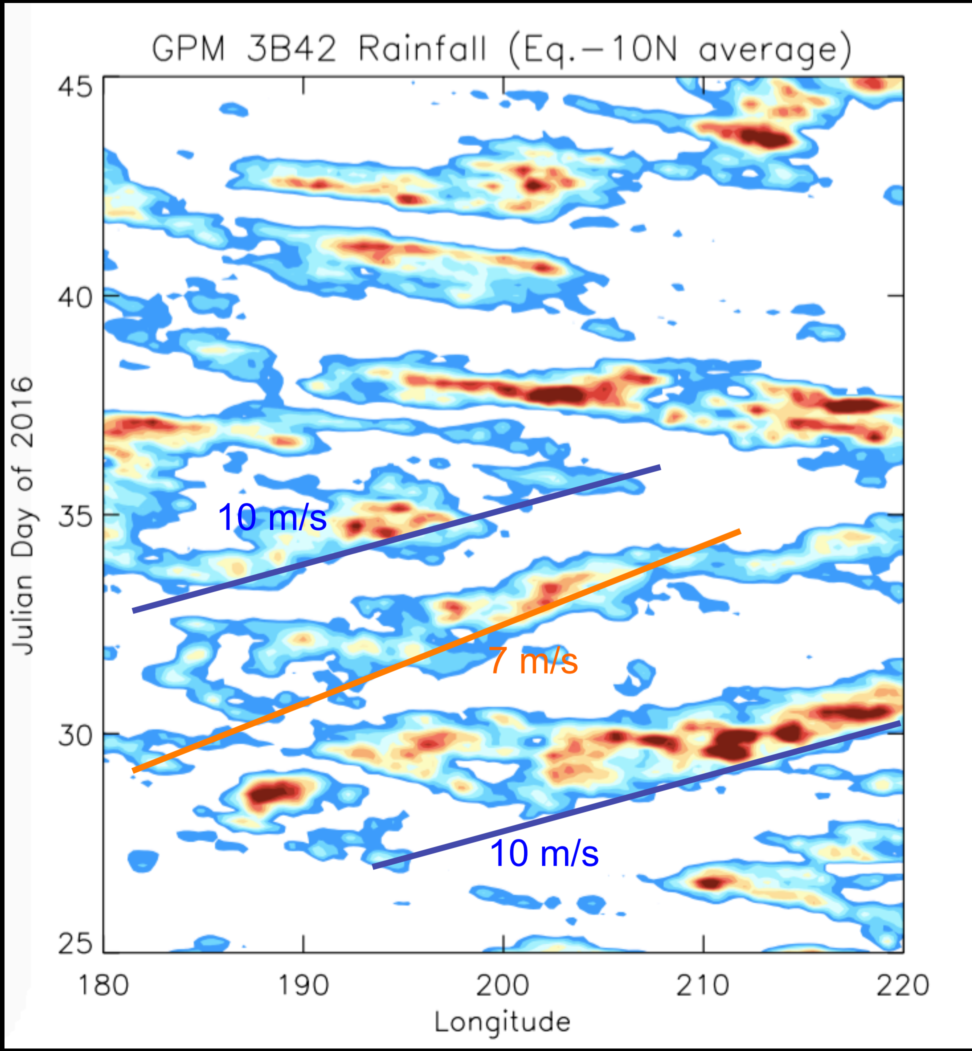
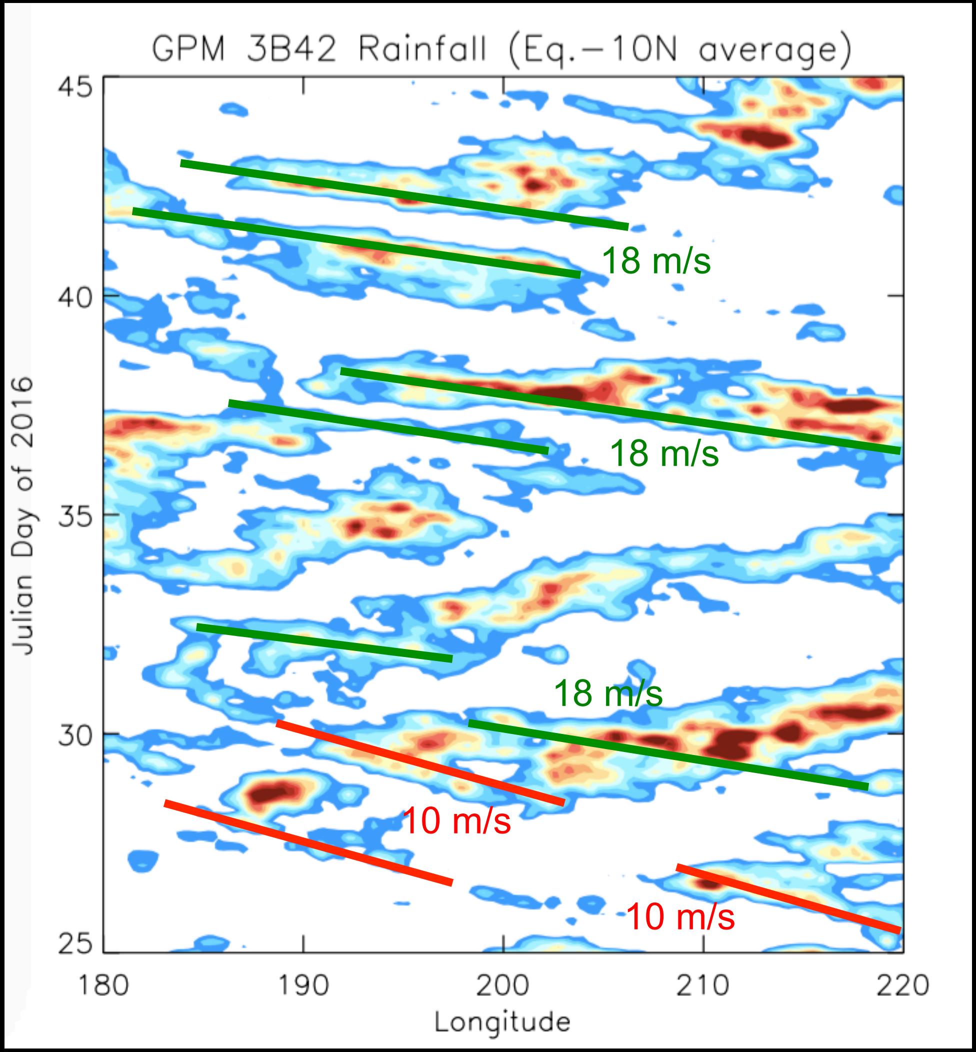
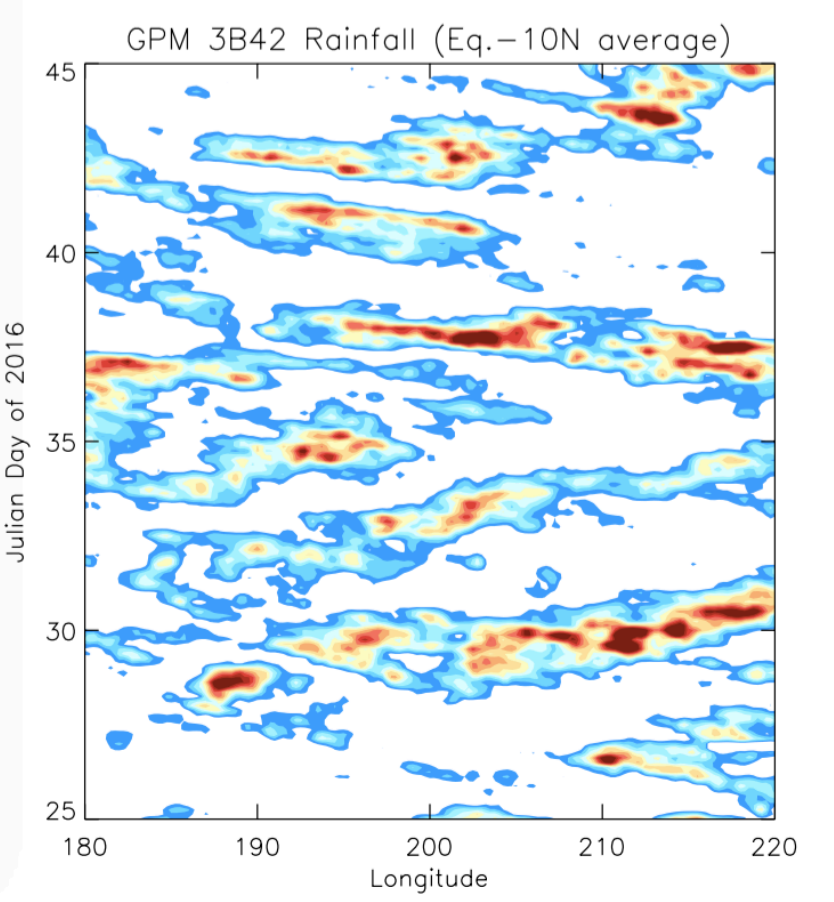
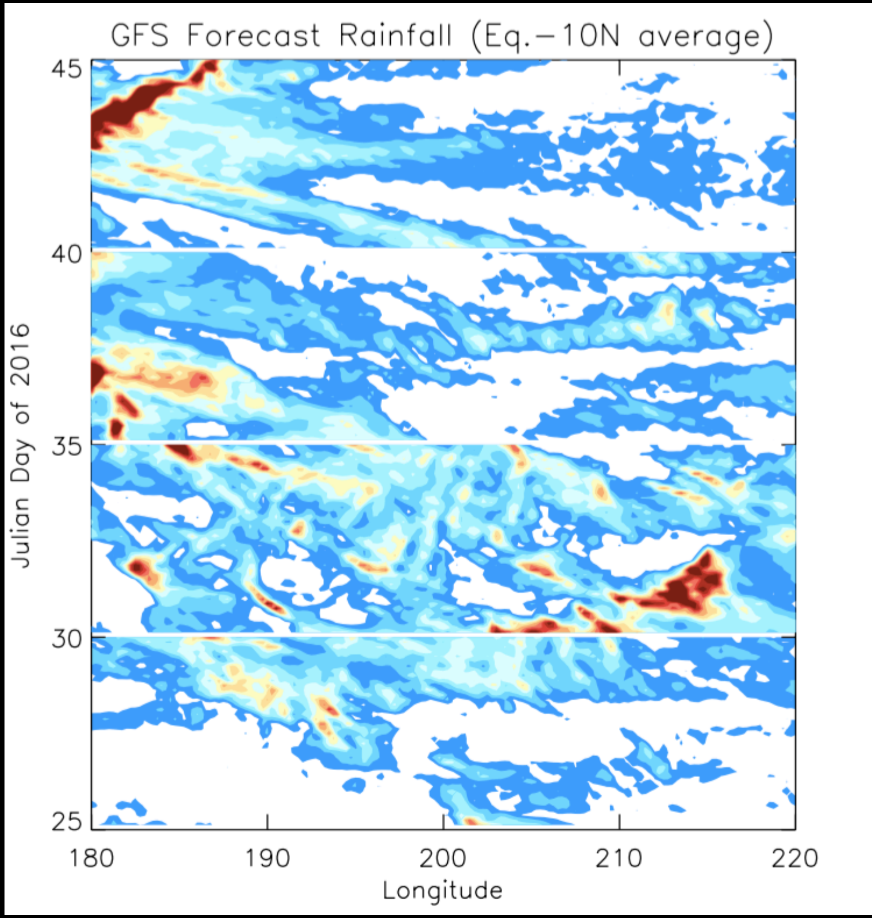


Evolution of satellite-based rainfall indicates some potential for predictability

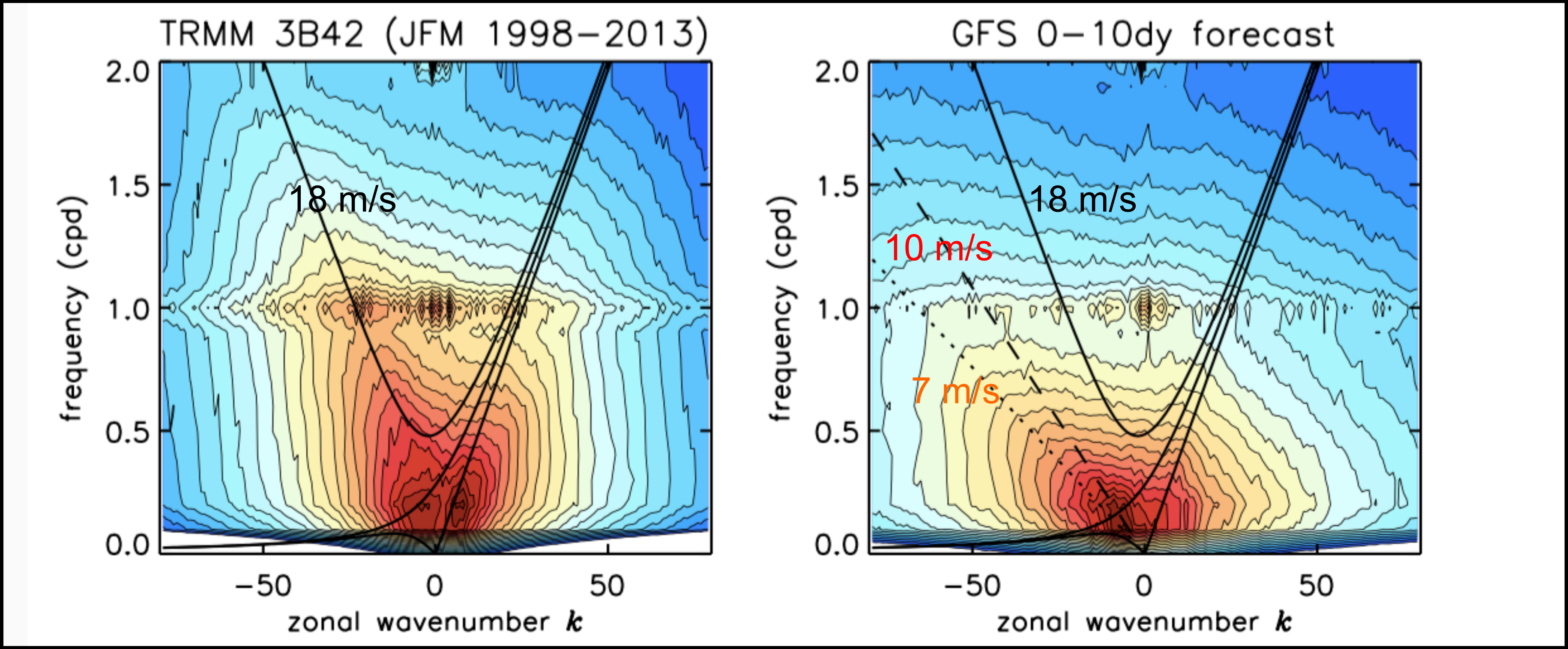


However, 13-km GFS forecasts were found to provide little guidance





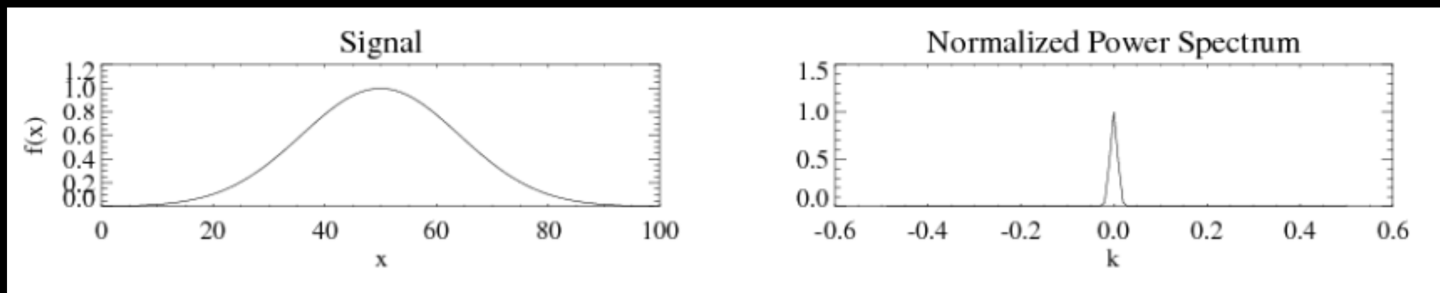
Space-time spectrum of rain confirms the GFS is missing 18-m/s IGWs

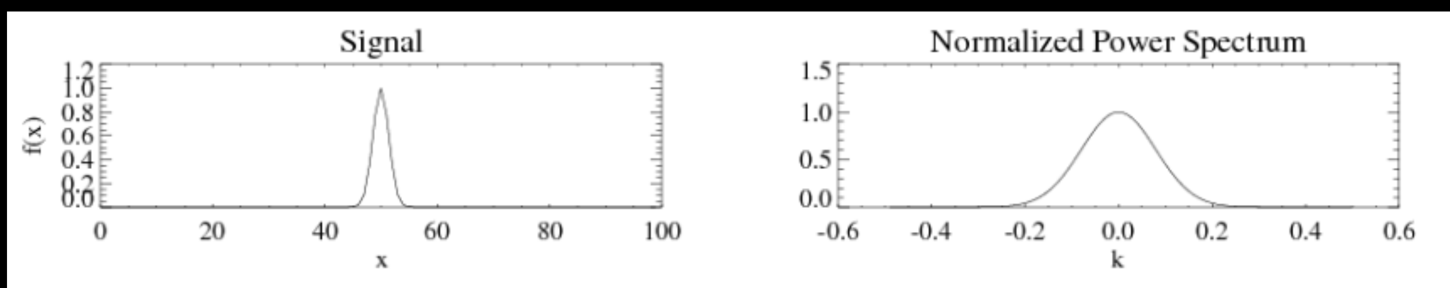


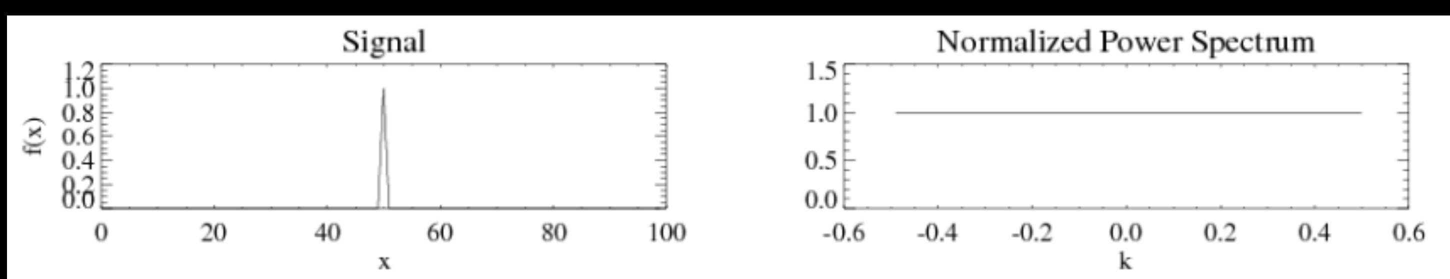
However, spectral decomposition is limited in that:

Physical Space

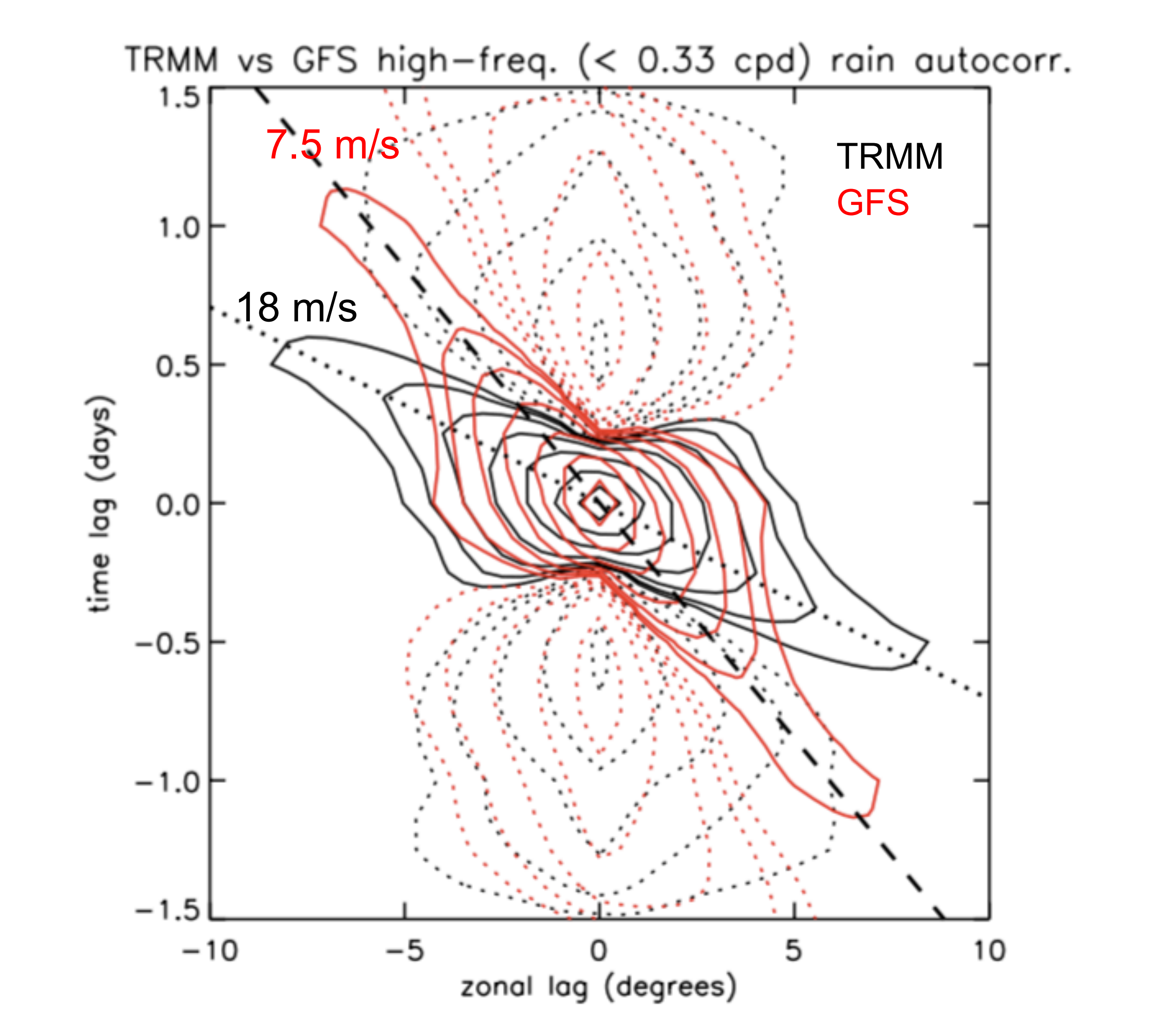
Spectral Space



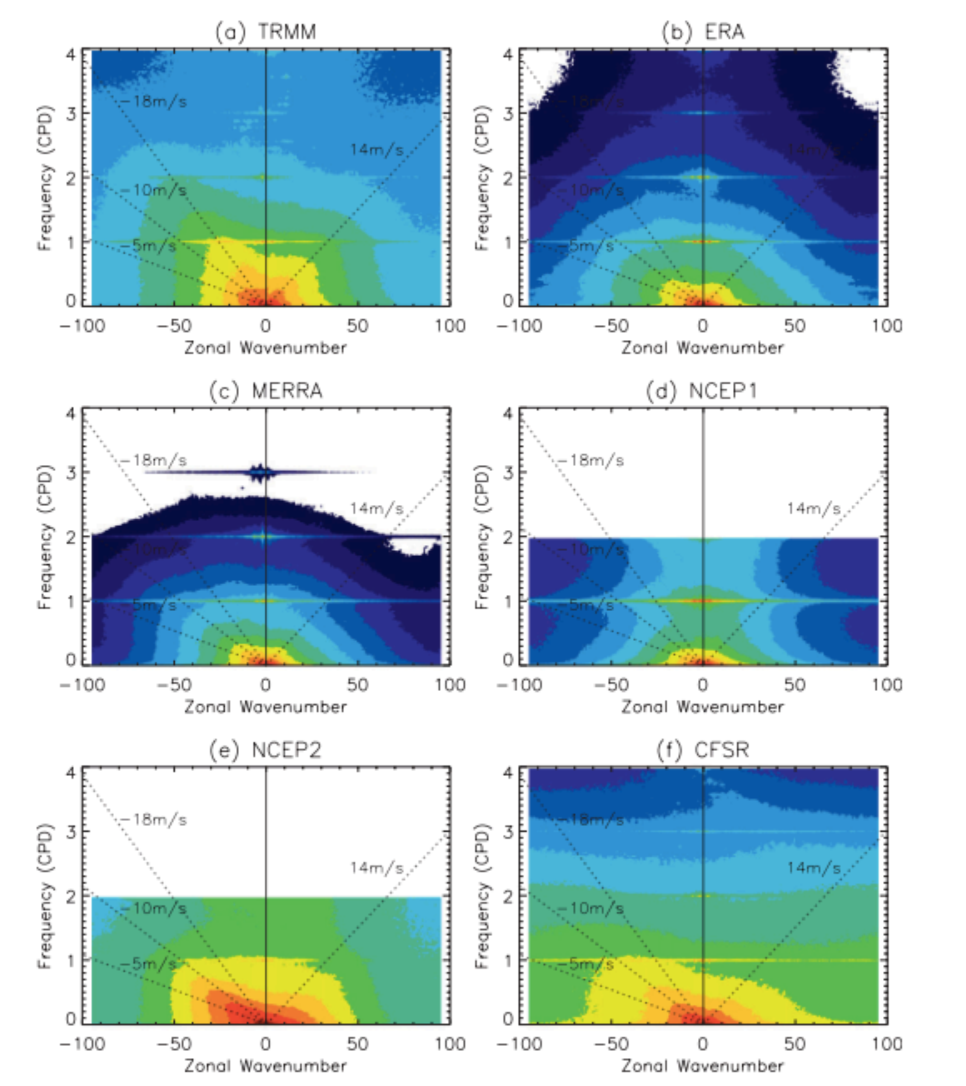




So consider the FFT of the power spectrum → autocorrelation

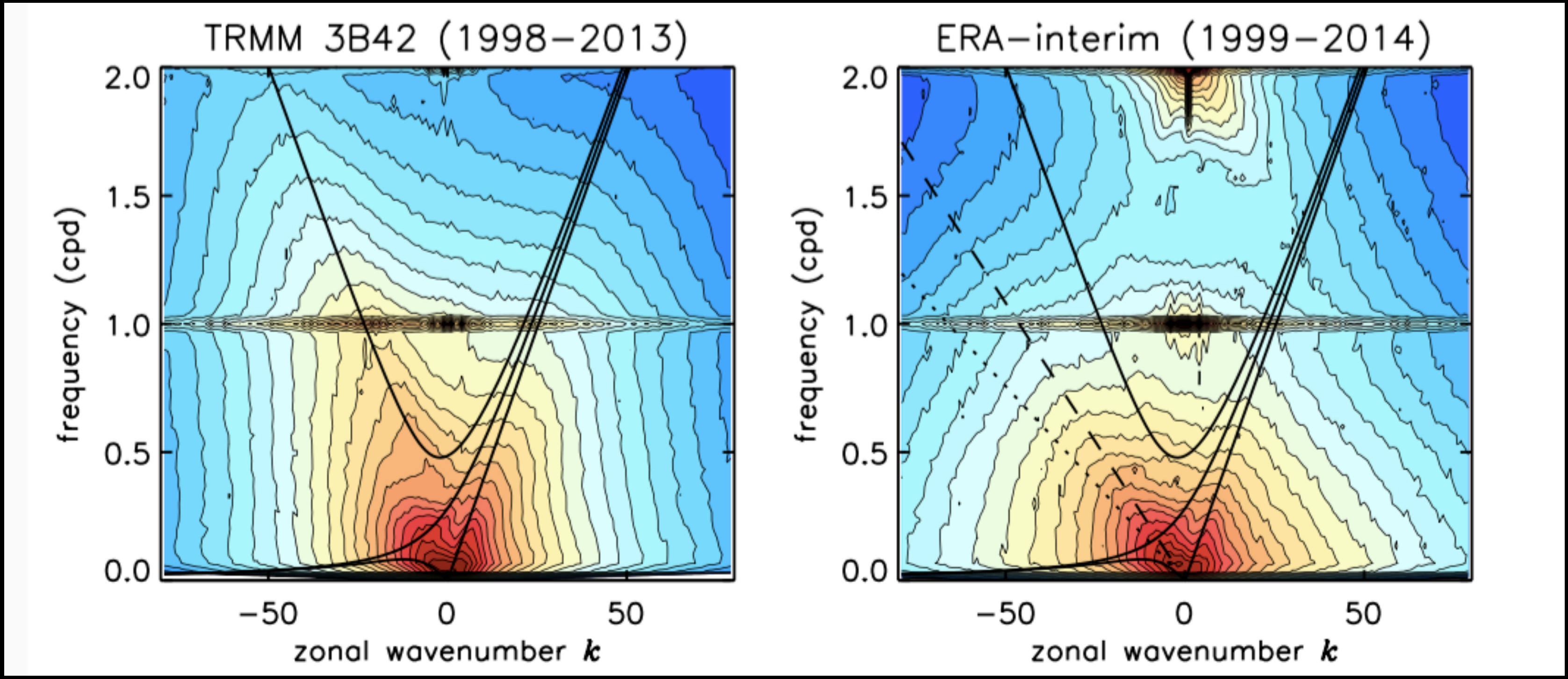


Similar results seen in most re-analysis products*



*taken from Kim and Alexander (2013; J. of Climate)

And also the gold standard, ERA-interim



Focus thus far has been on conventional global models – what about “superparameterized” models?

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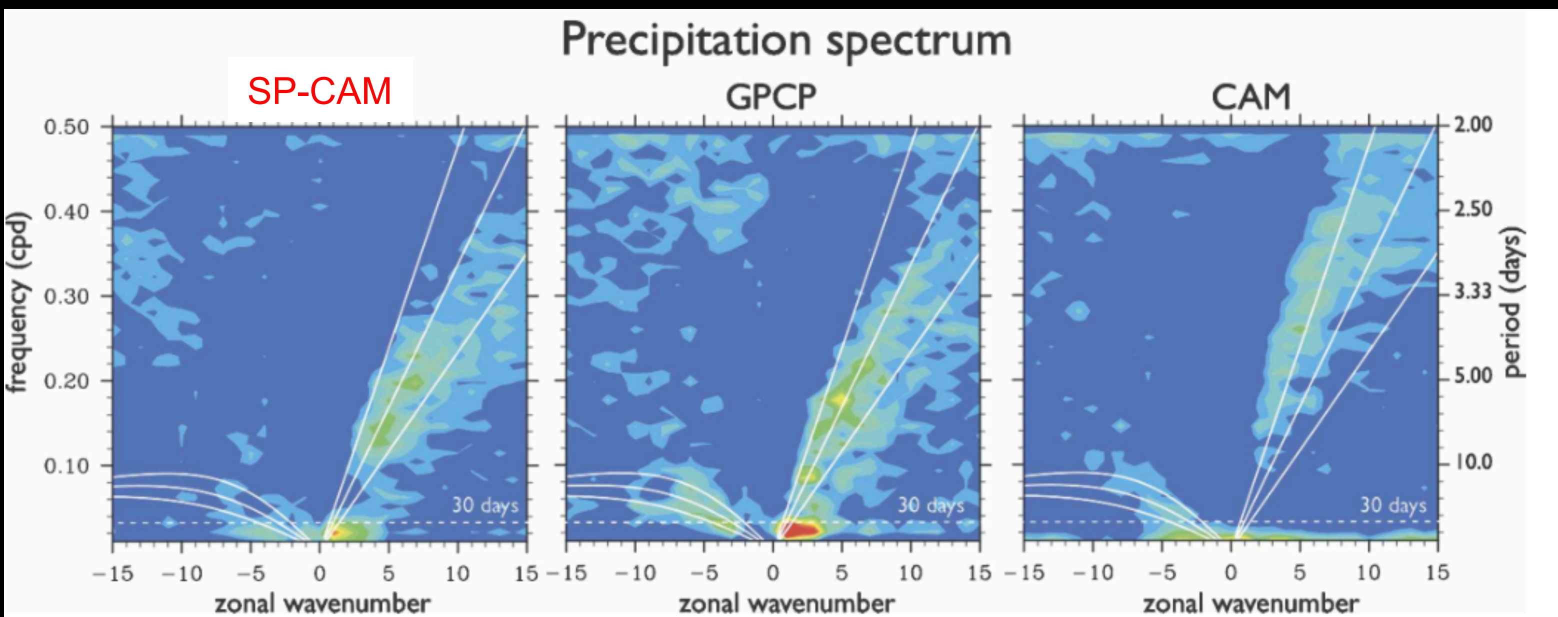
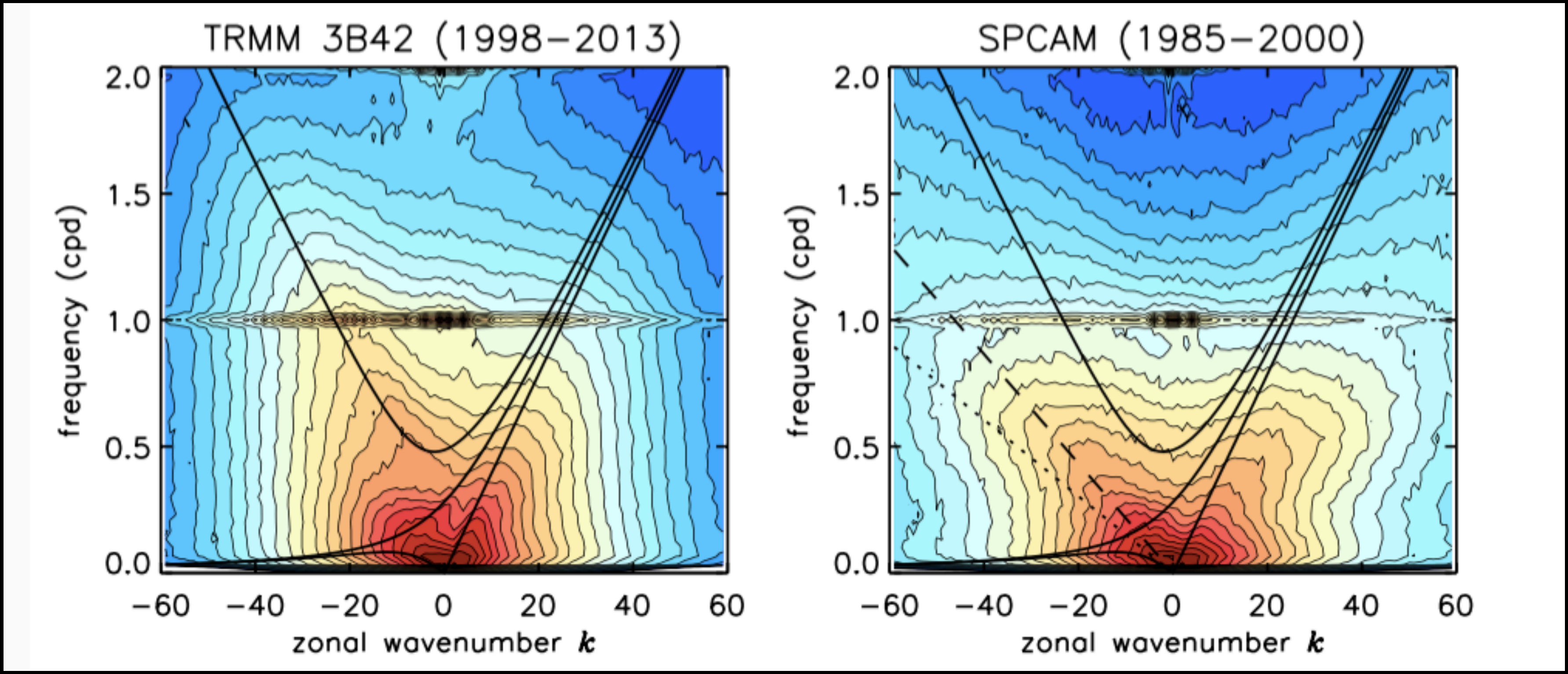
Evaluation of the Simulated Interannual and Subseasonal Variability in an AMIP-Style Simulation Using the CSU Multiscale Modeling Framework

MARAT KHAIROUTDINOV,* CHARLOTTE DEMOTT, AND DAVID RANDALL



Looking at smaller scales in the SP-CAM shows both eastward and westward IGW signals



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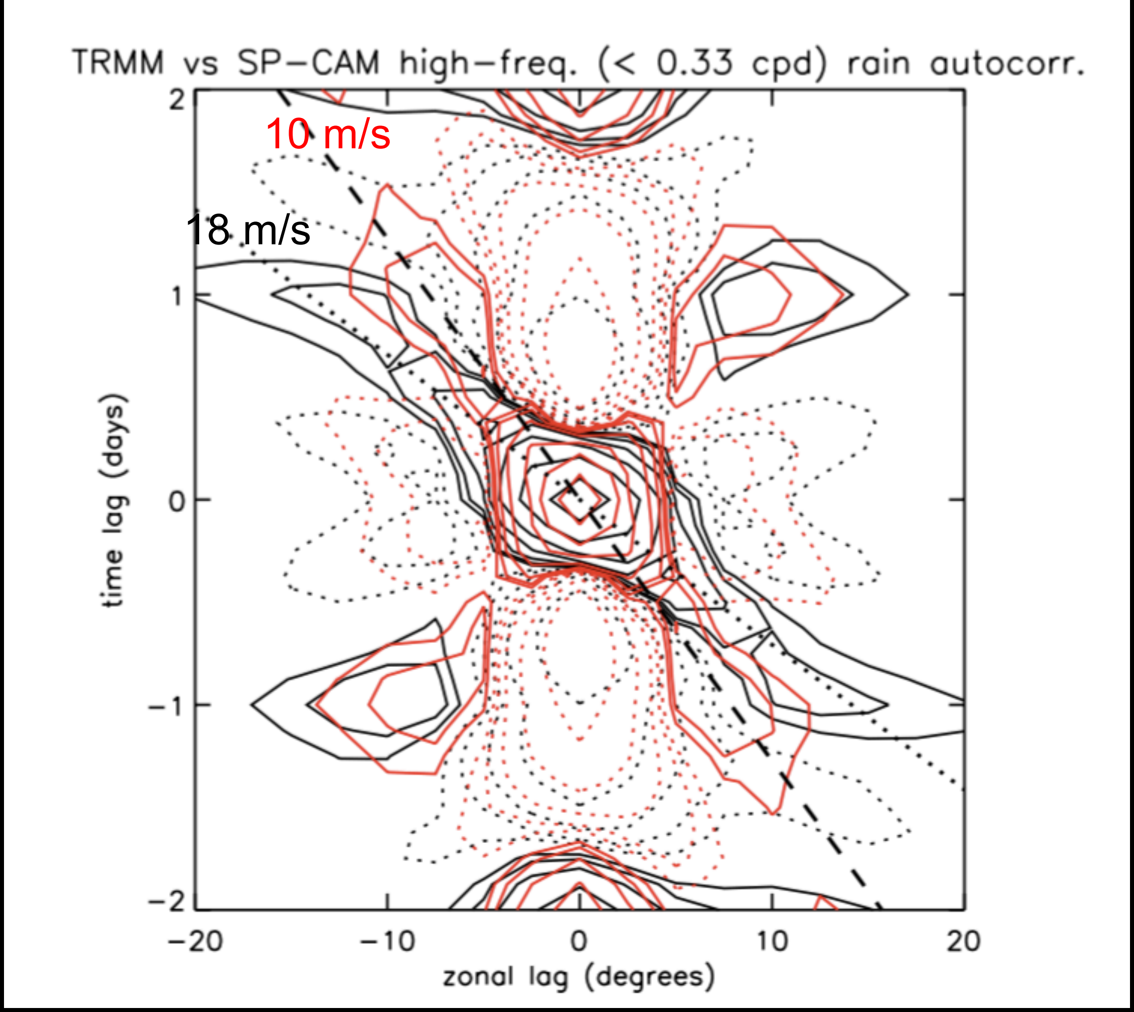
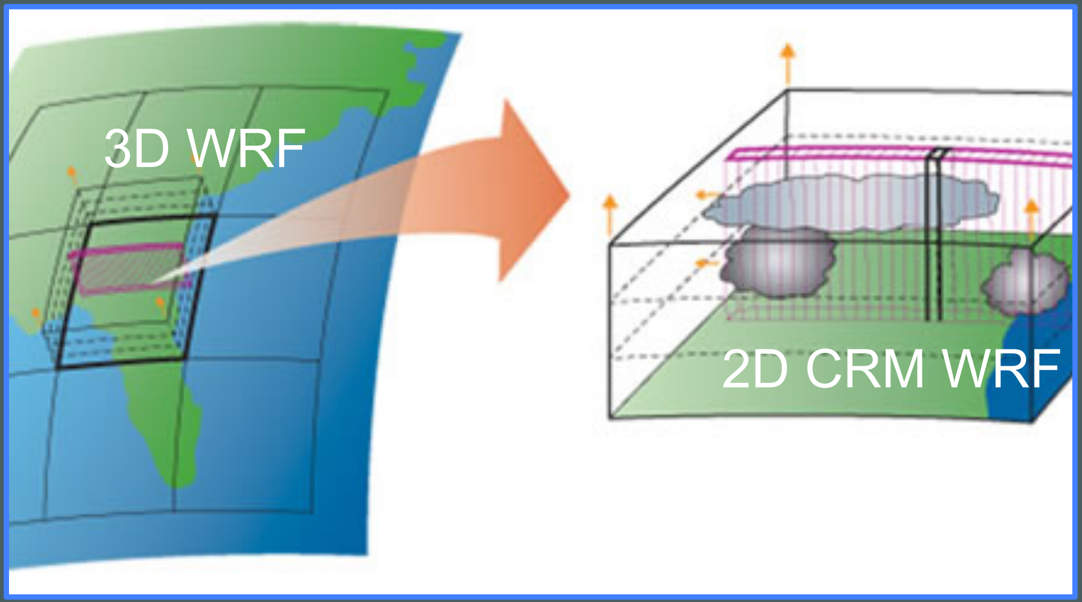


Remainder of this talk will focus on a new superparameterized WRF model*



Unique capabilities:

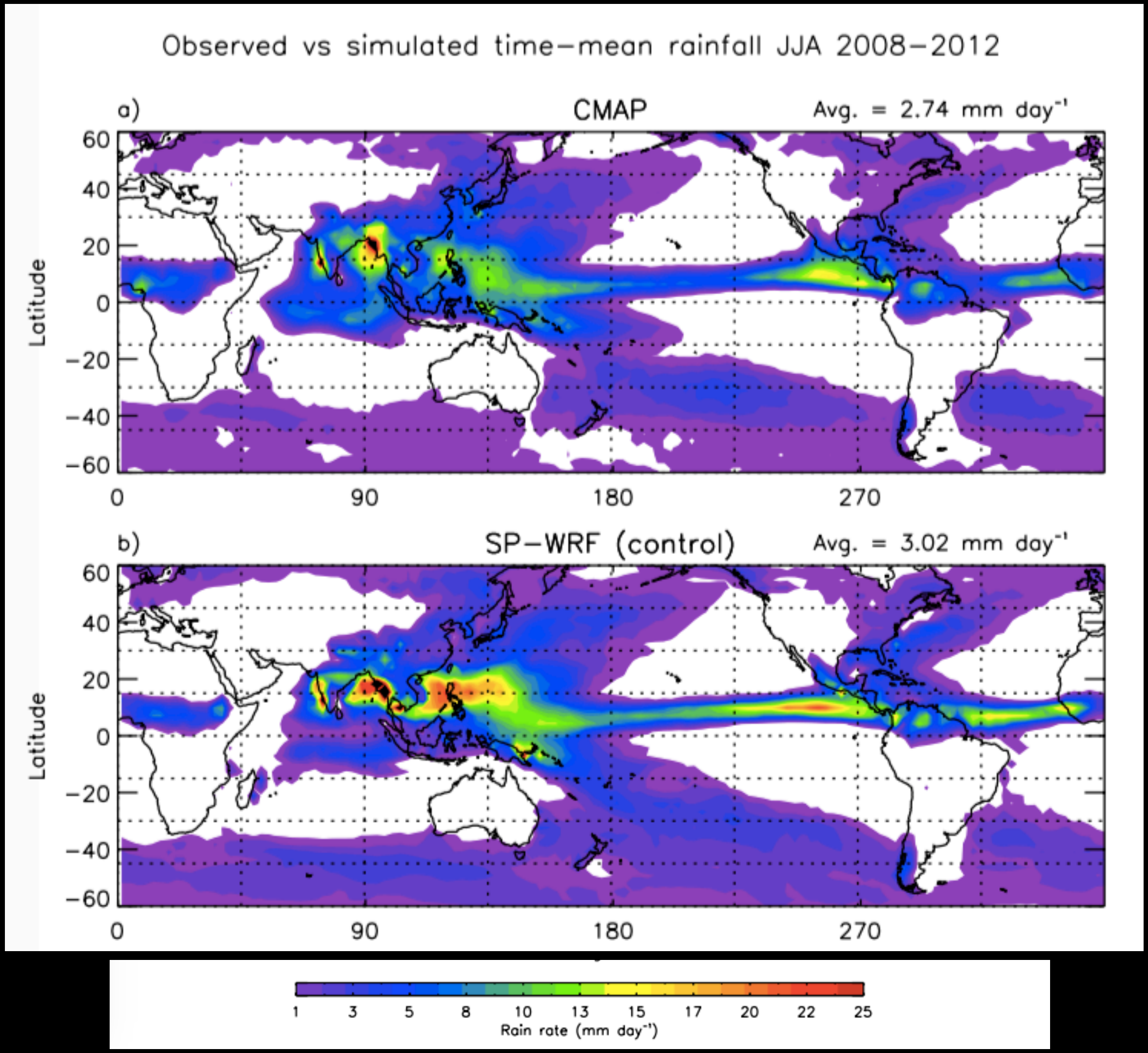
- » Can be run either regionally or globally
- » Seamless GCM-CRM coupling (WRF inside WRF)
- » Wide variety of bulk physics options
- » Novel treatment of convective momentum transport (CMT)

*SP-WRF (Tulich, JAMES 2015)

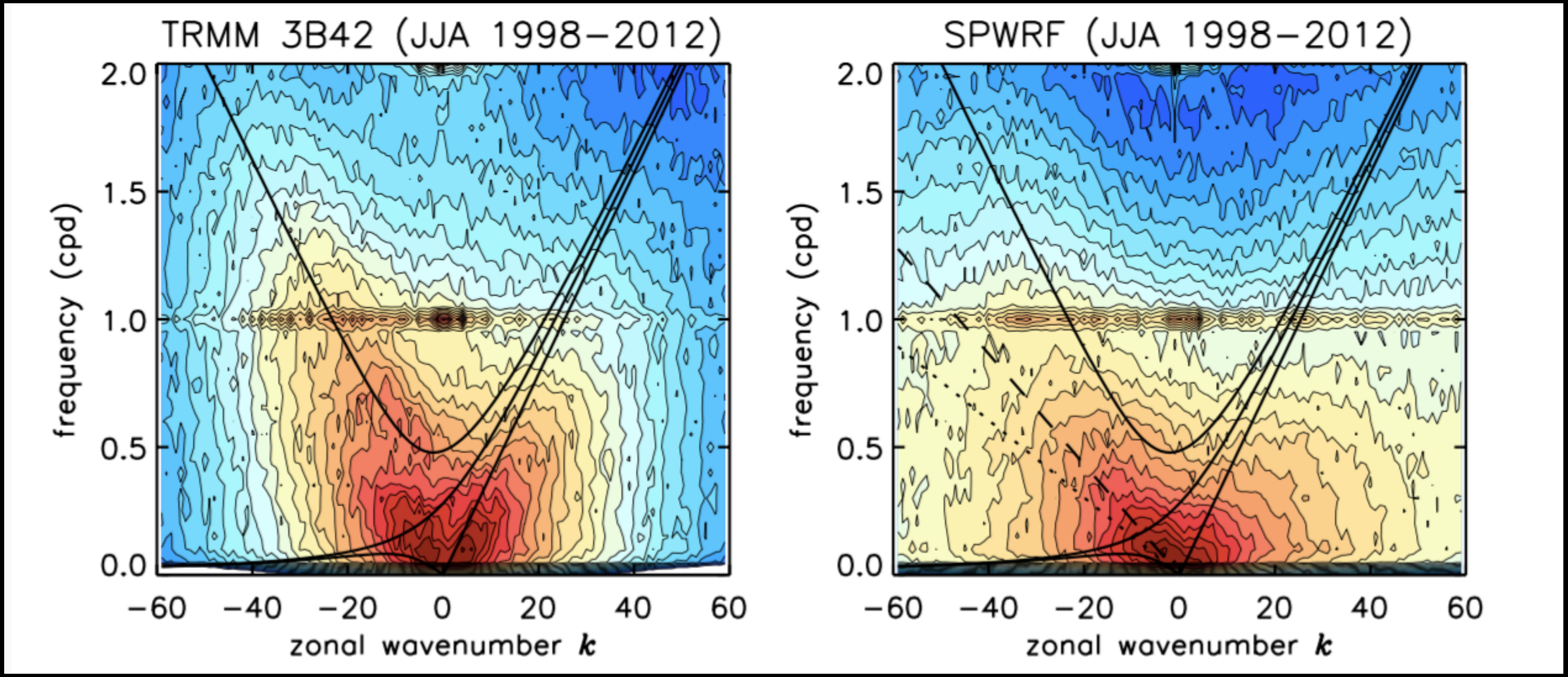
Model Setup

- Series of June-August simulations for 5 consecutive years (2008-2012)
- Global 2.8 deg x 2.8 deg with 51 levels and 32 x 4-km CRMs
- Model initialized from ERA-interim data using four-dimensional data assimilation
- Microphysics and radiation based on Goddard schemes

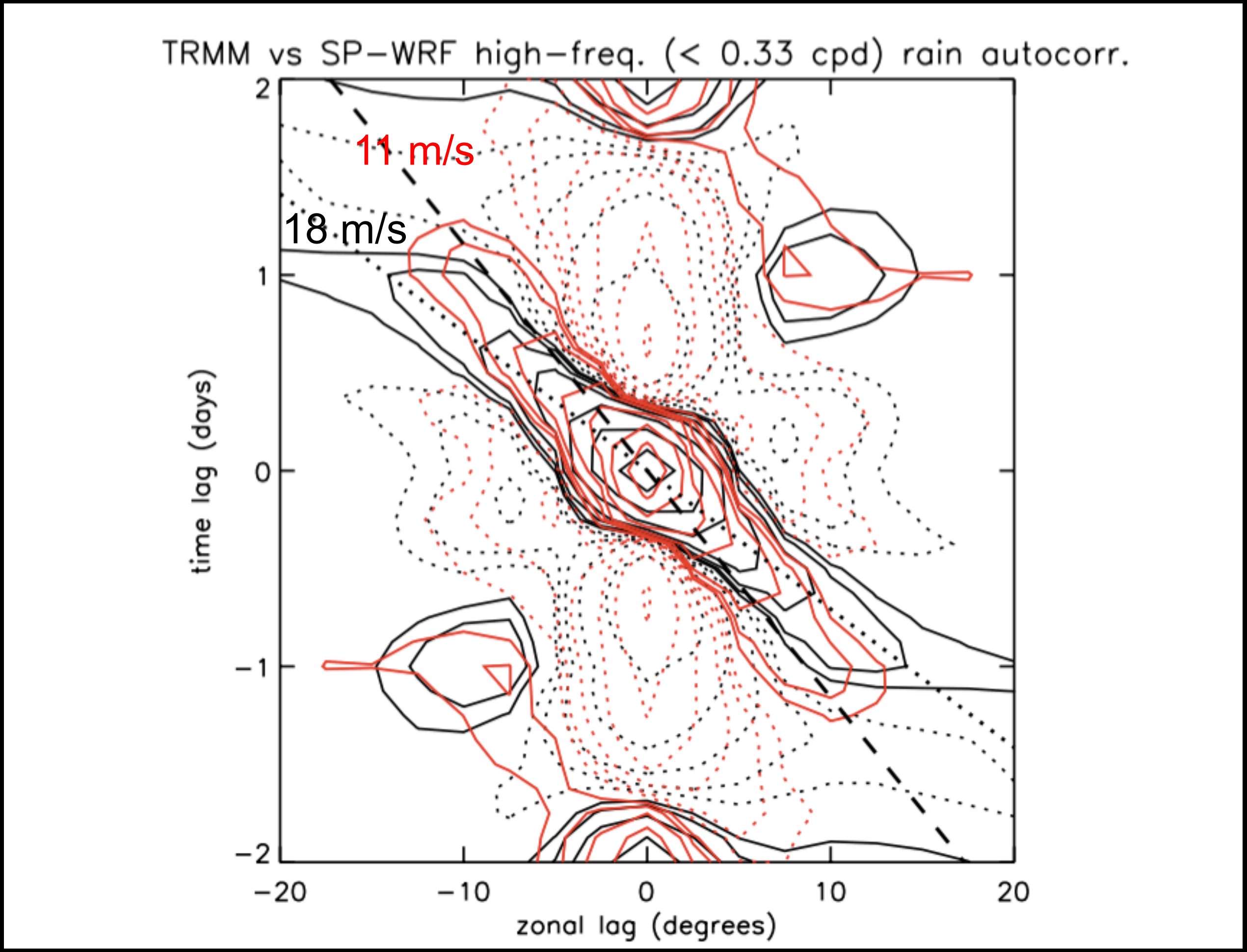
Simulated time-mean precipitation looks reasonable



However, gravity wave signals are once again too slow

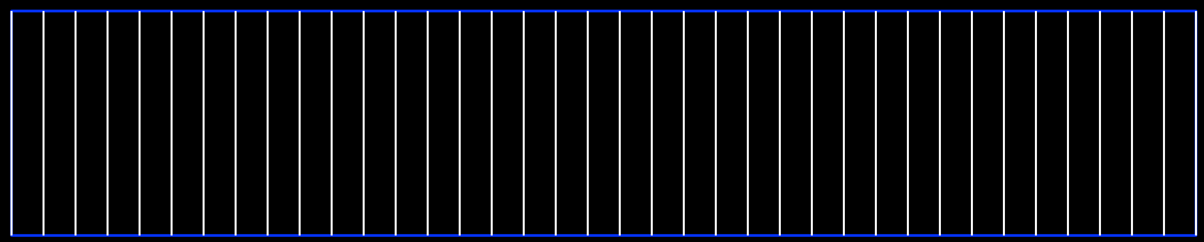


…but better than the previous models



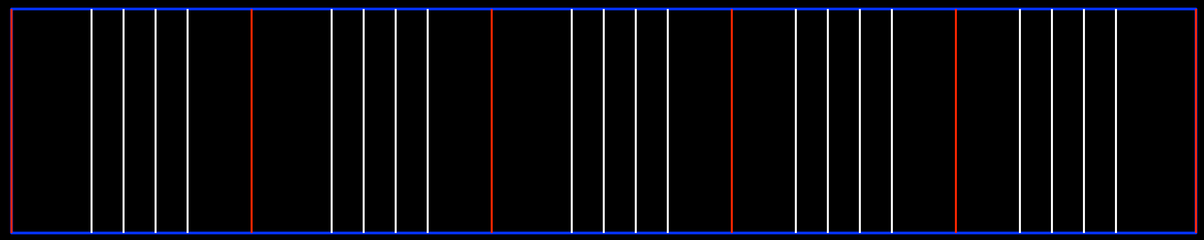
An idealized benchmark to gain insight

Standard WRF as large 2D CRM

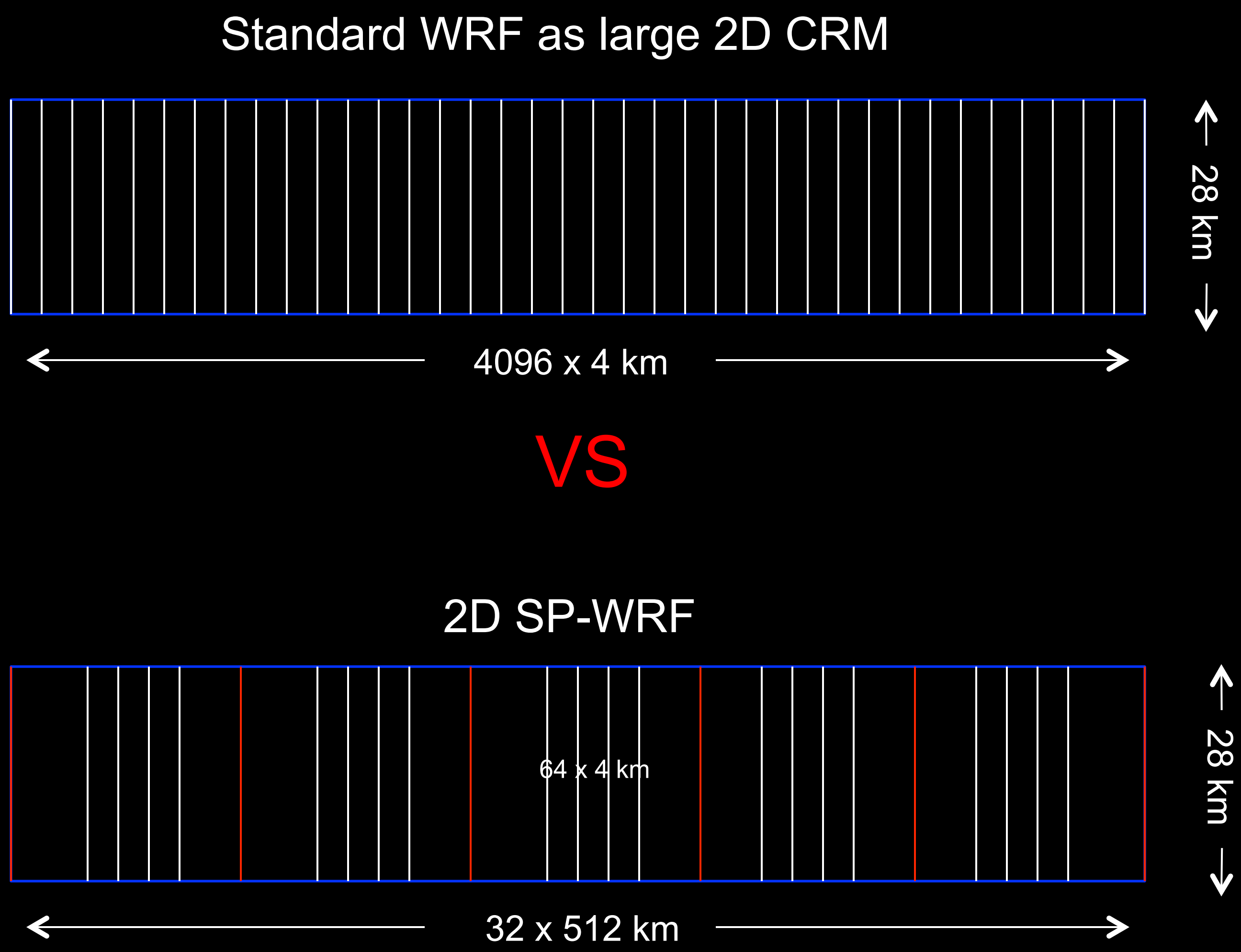


VS

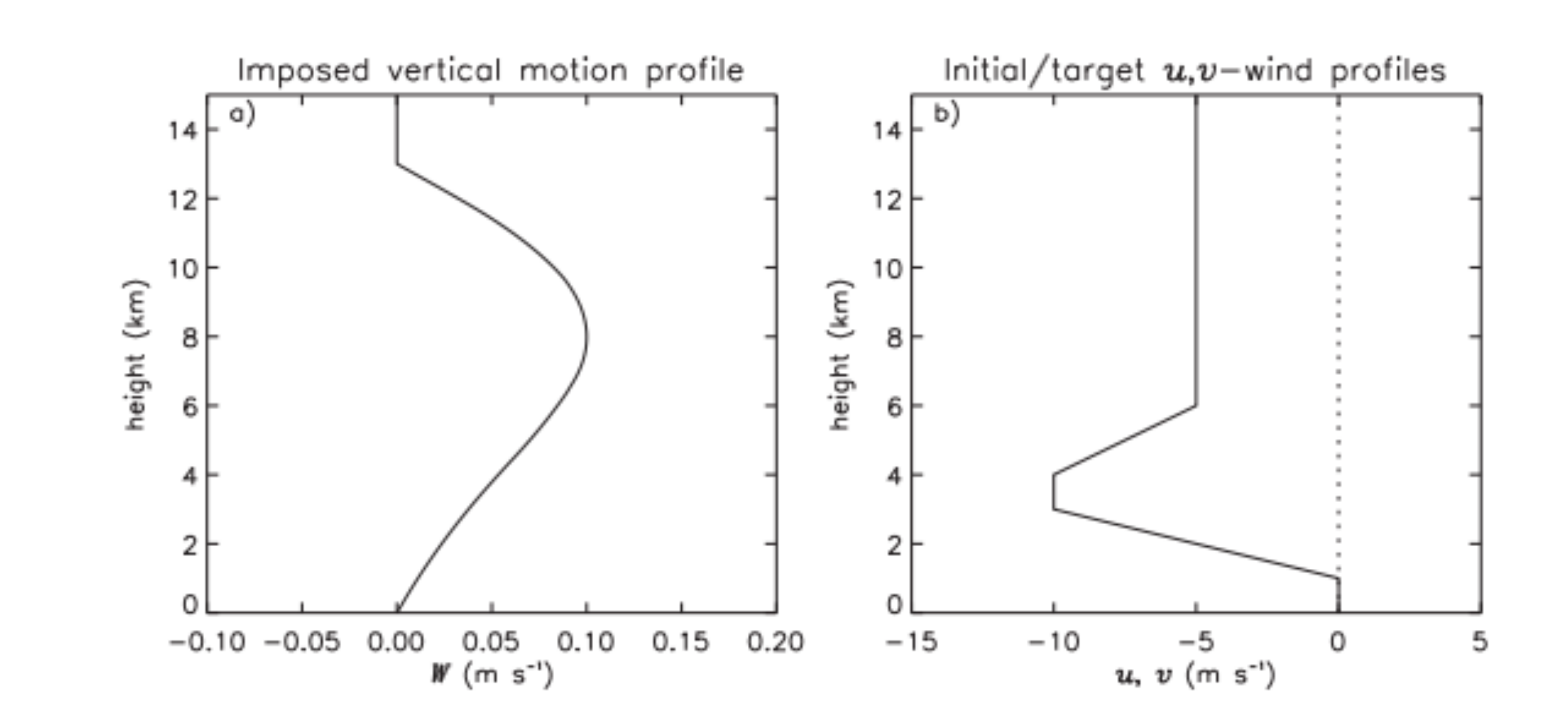
2D SP-WRF



An idealized benchmark to gain insight

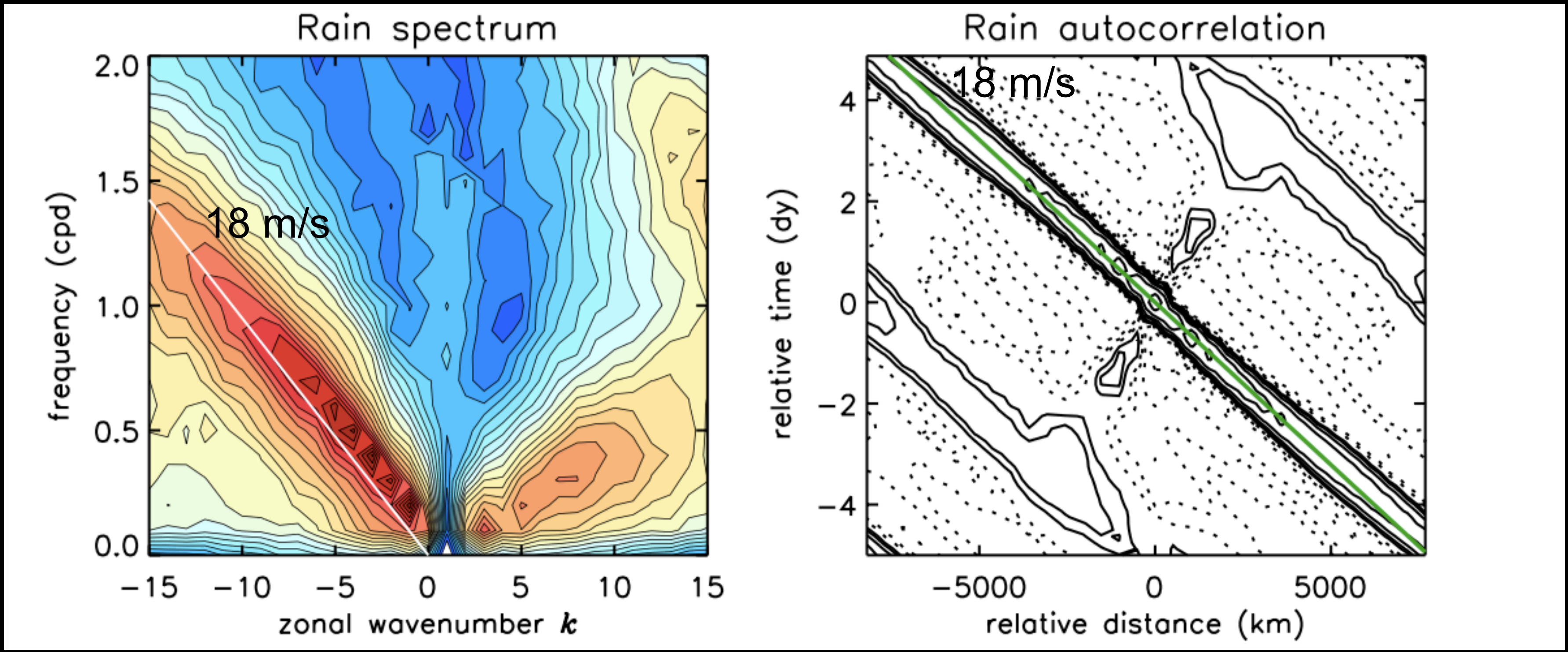


Model forcing is given by:

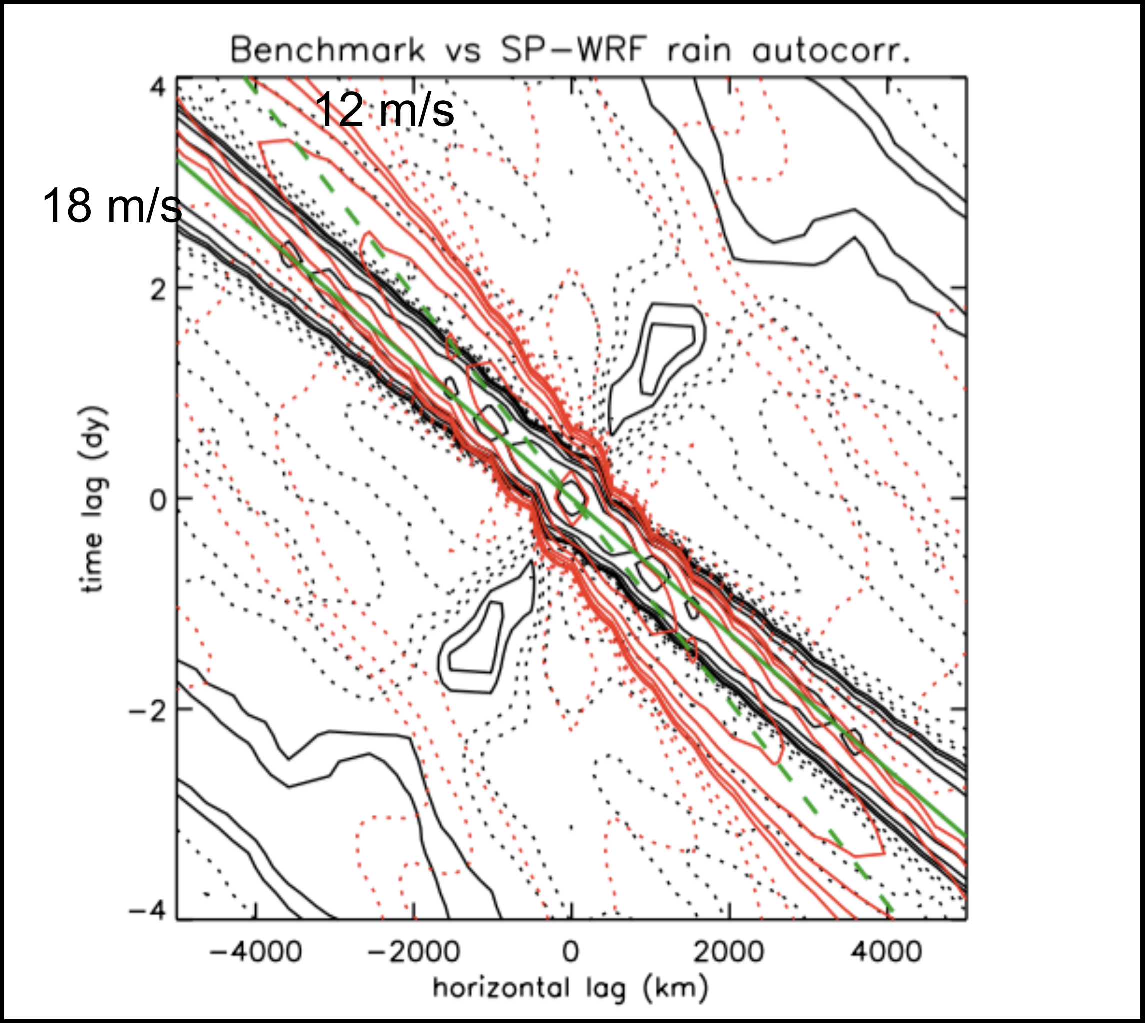


Also, SST is uniform at 302.5 K and radiative-like cooling of 1.5K/day is prescribed in the troposphere

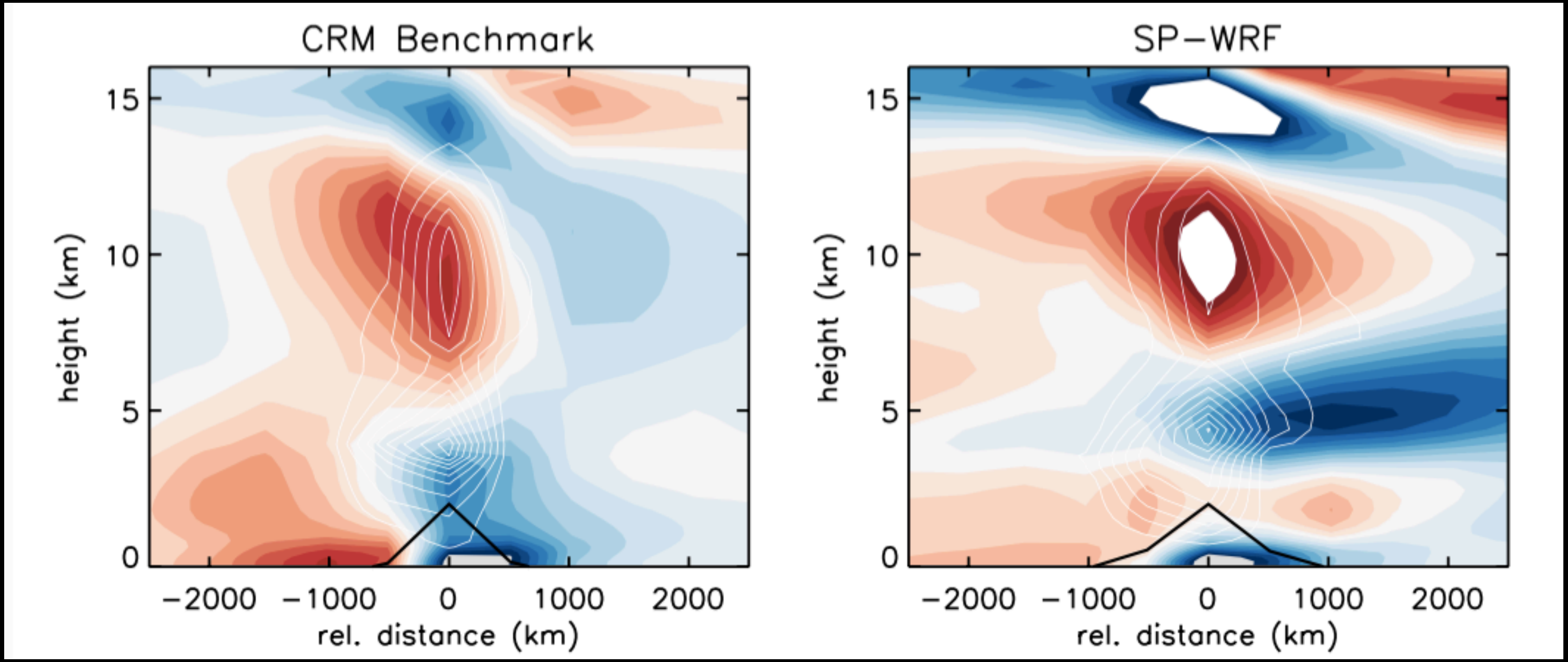
Results of the benchmark calculation



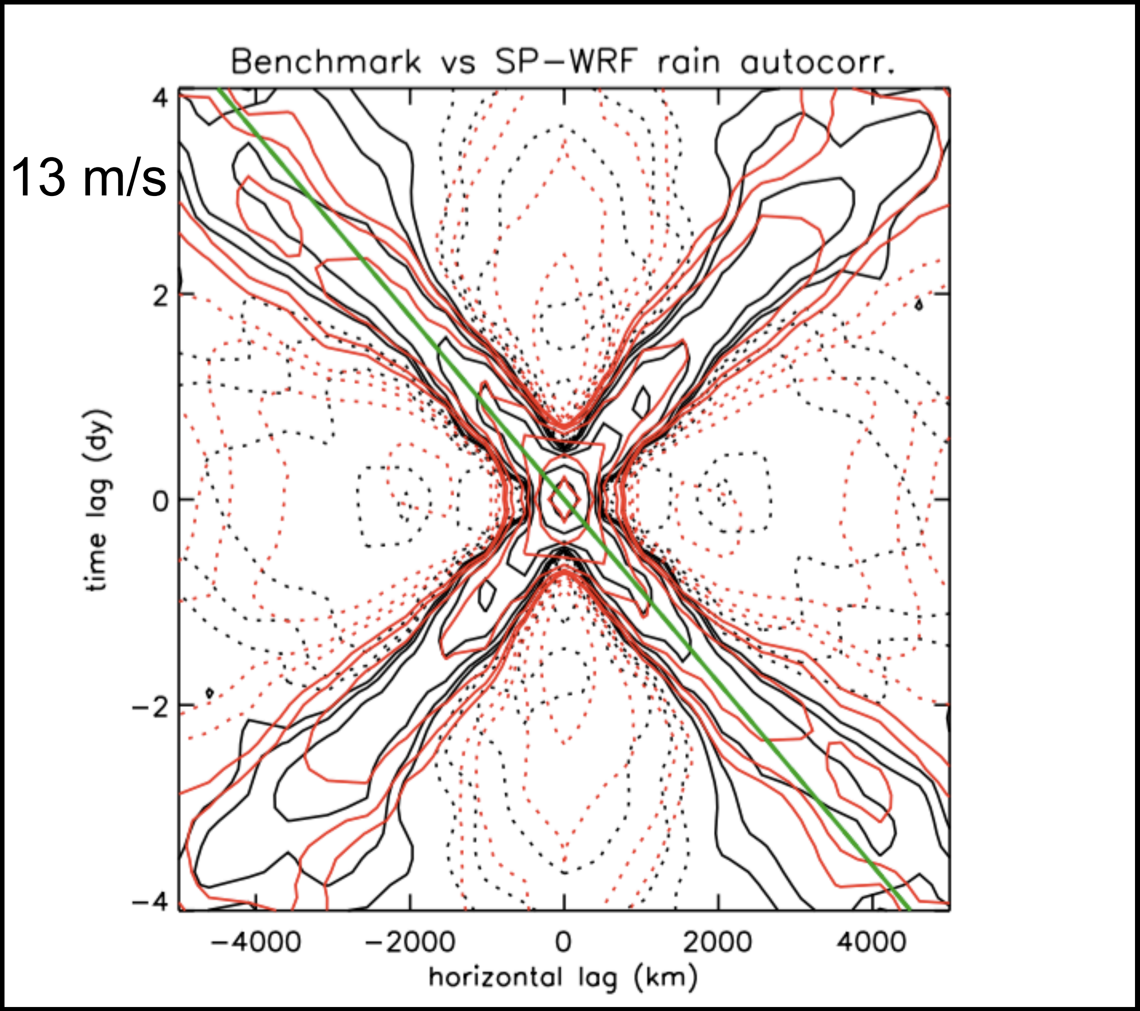
However, SP-WRF produces slower and less-coherent waves



Likely due to very different temperature structures



These differences appear to be due to the presence of a background flow



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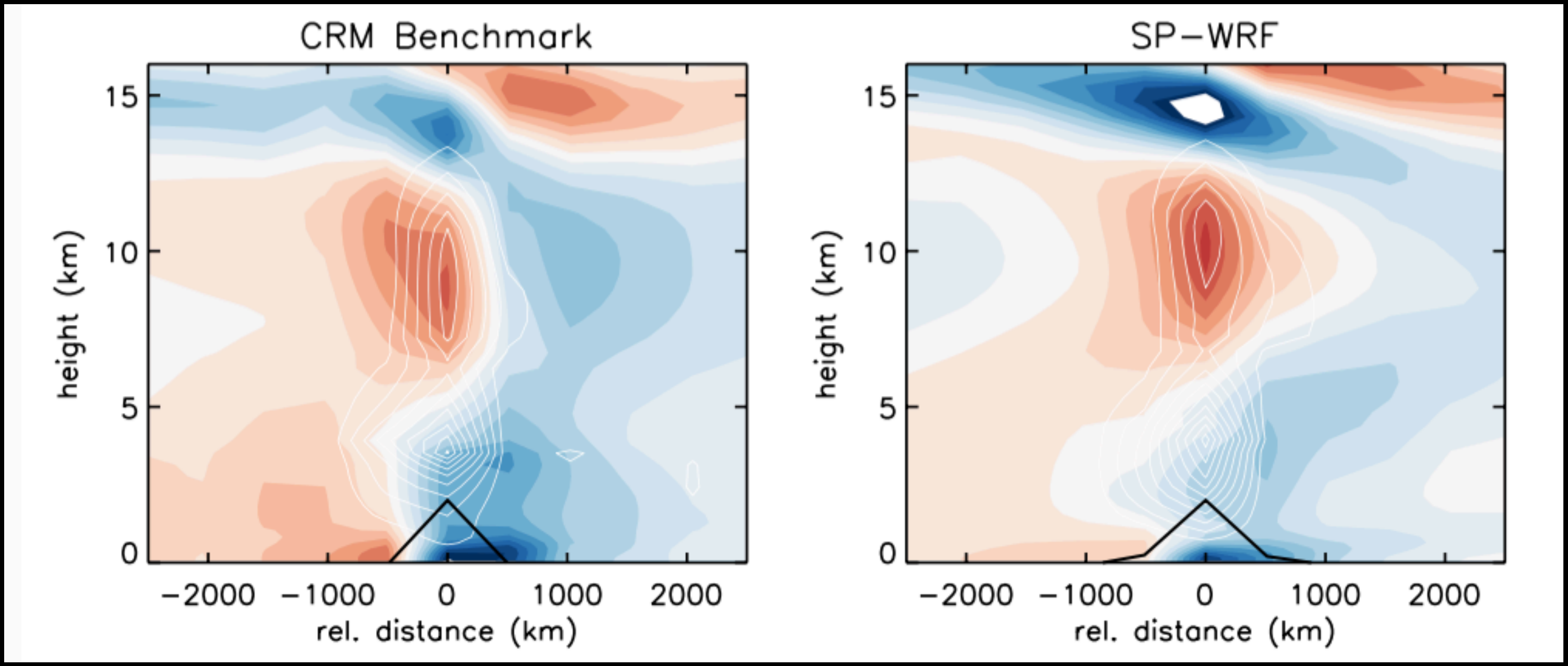
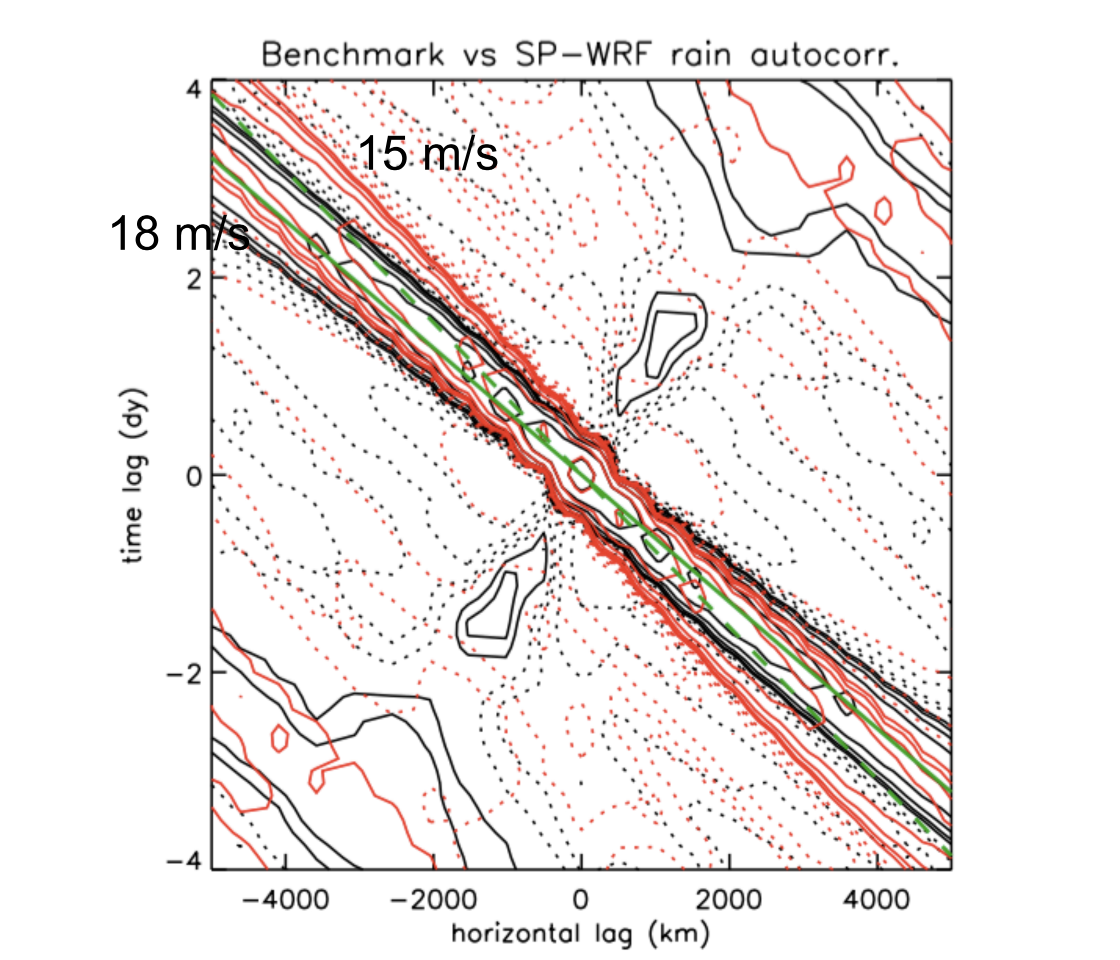


Better agreement is also obtained with shear at higher outer-model resolution (64 km)



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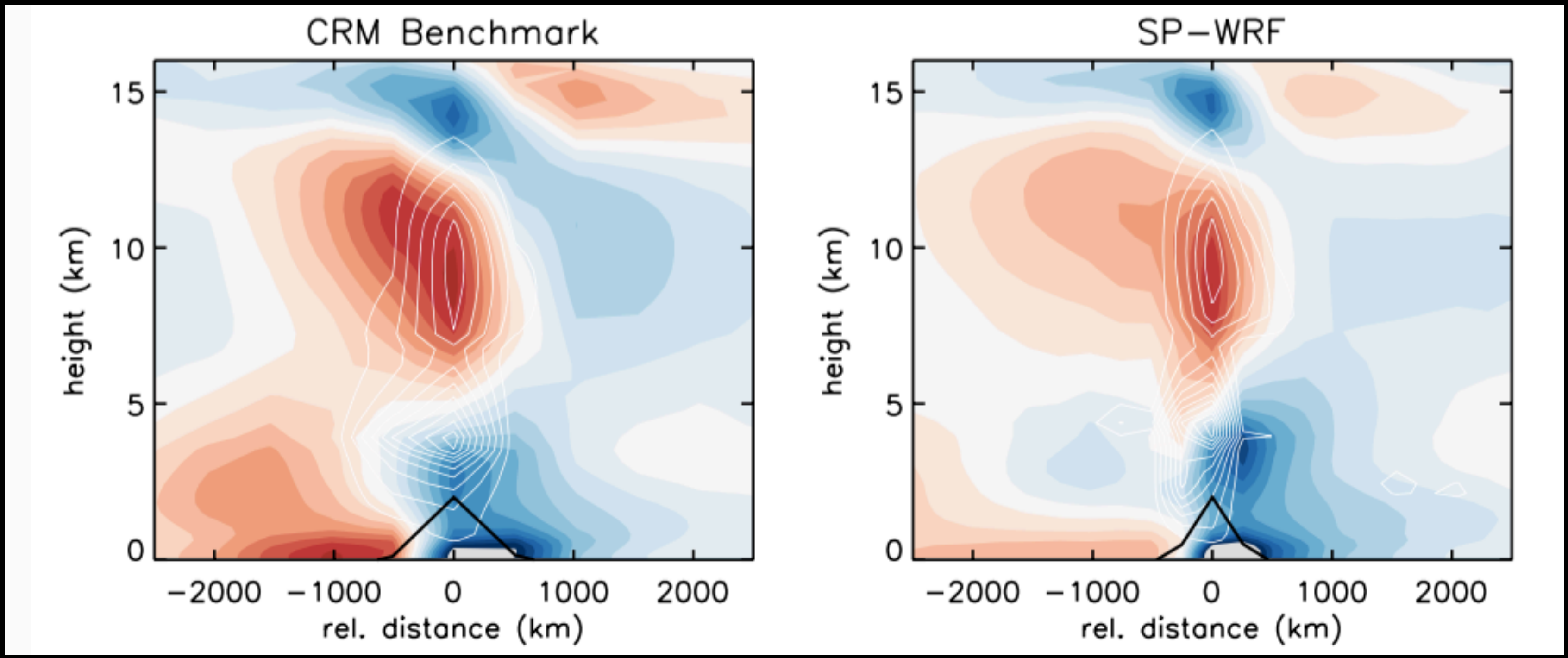
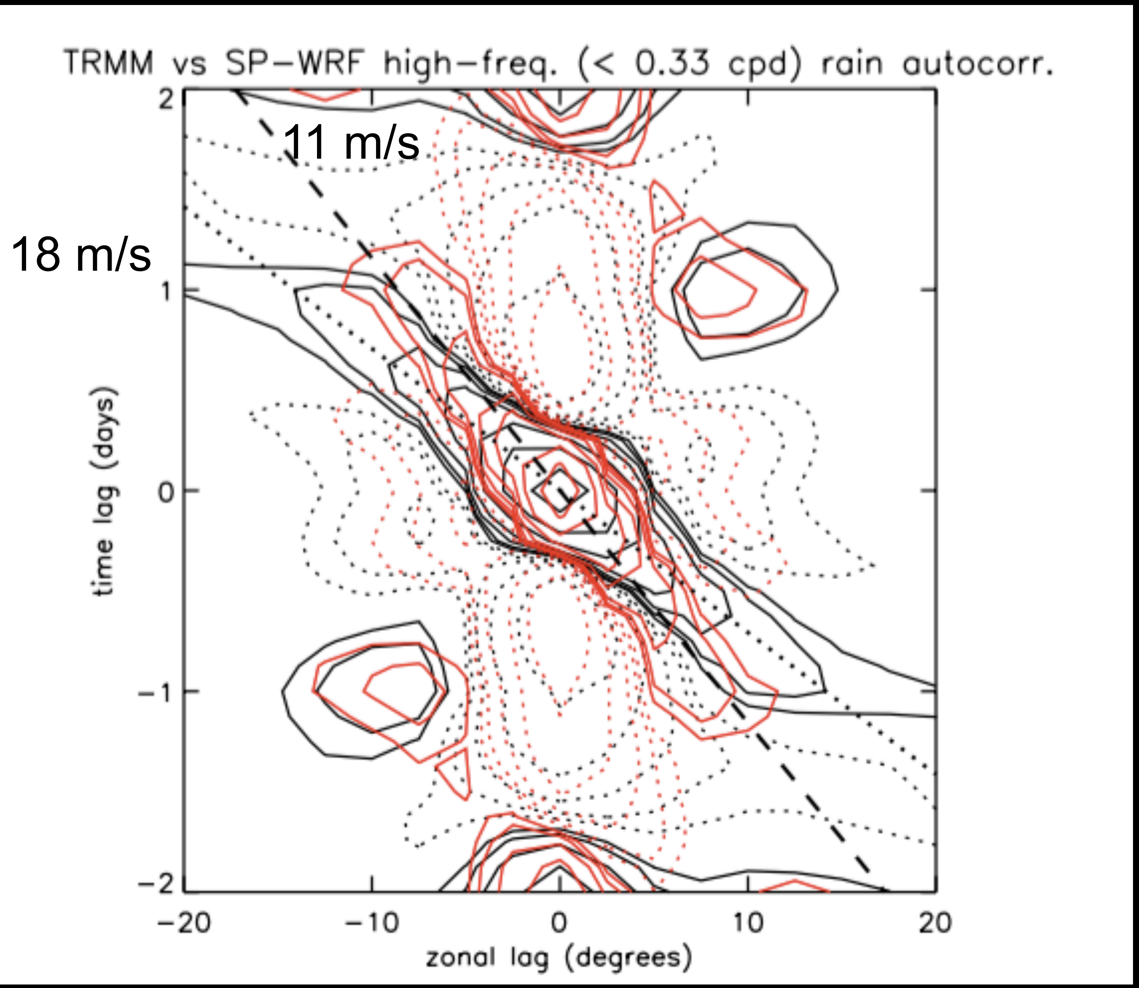
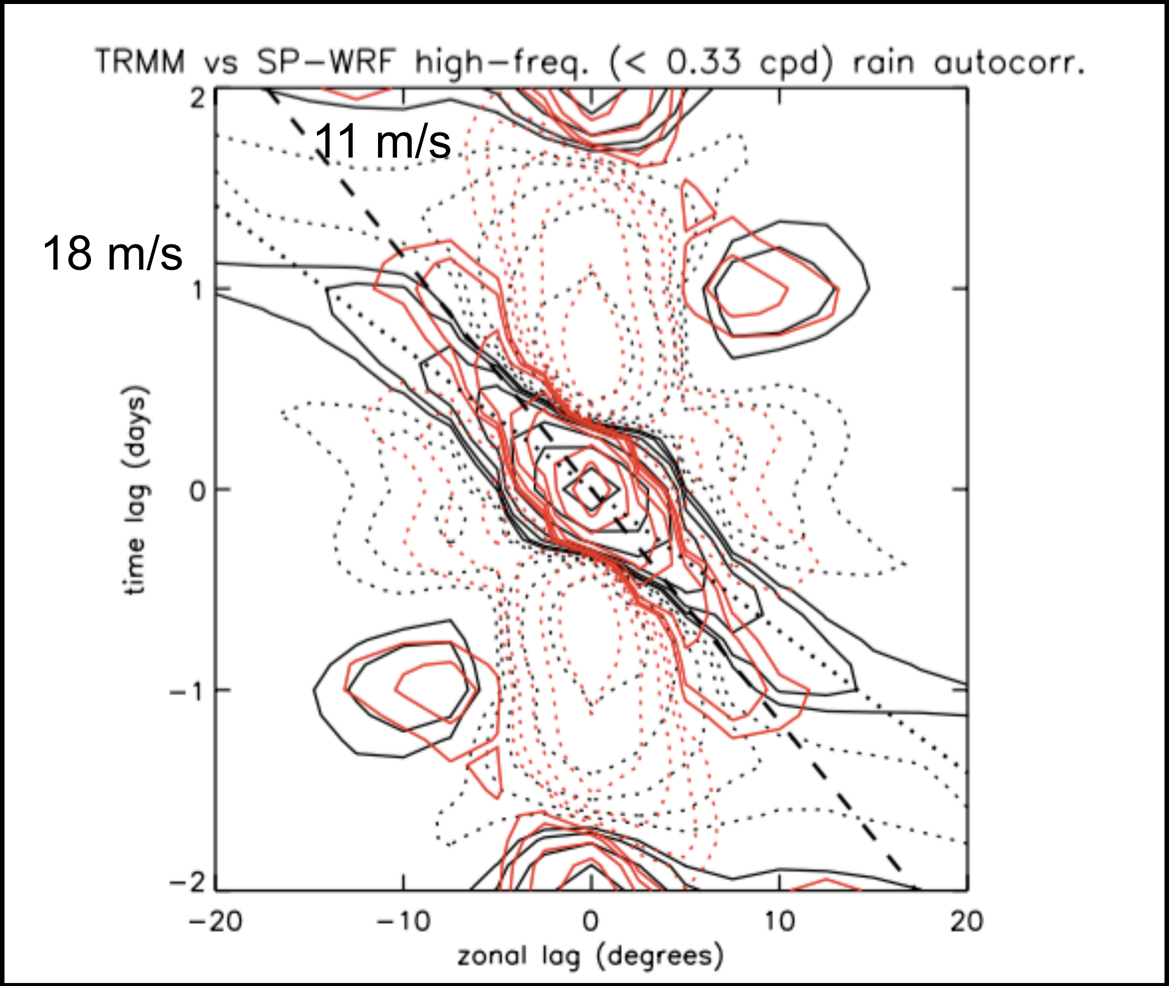


However, this result does not carry over to the global climate simulation



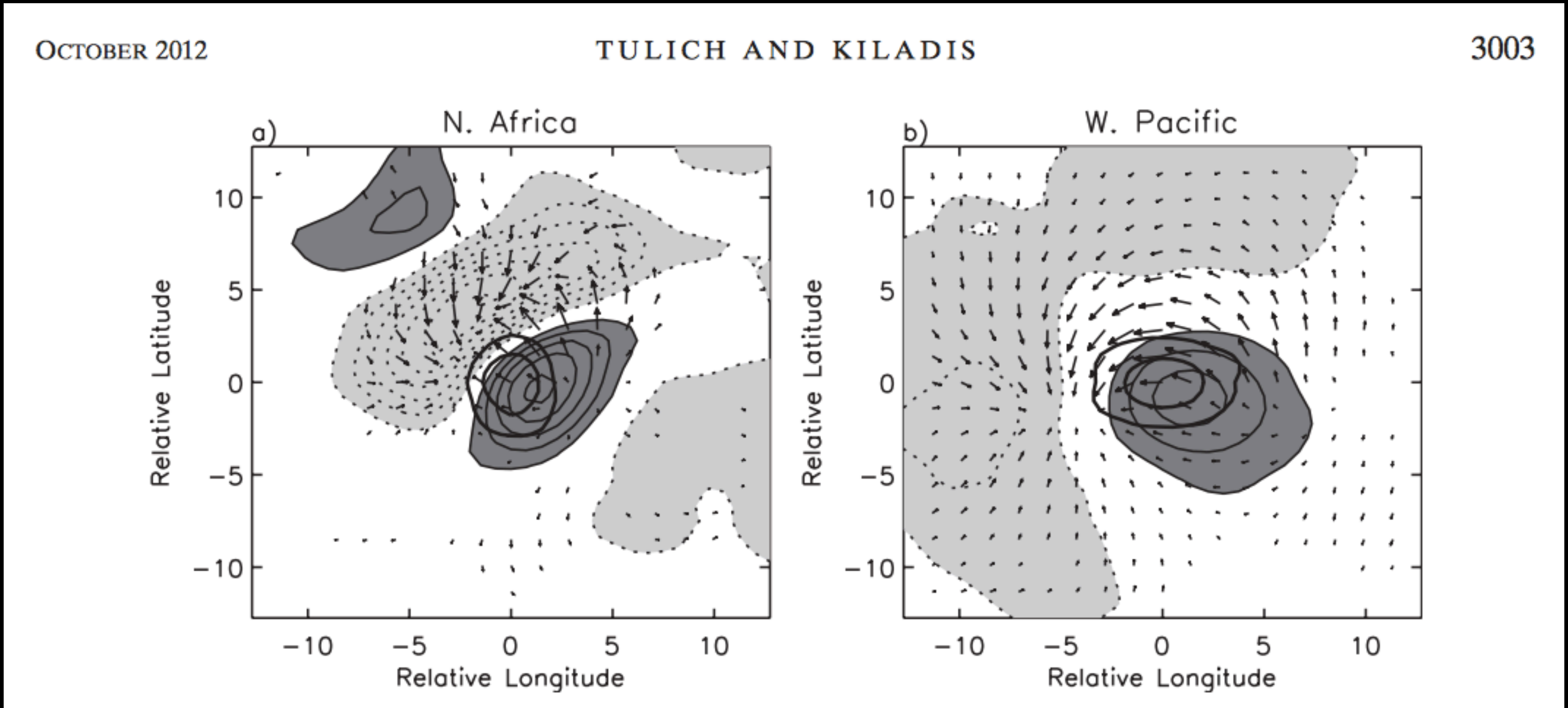
0.7x0.7 deg. with 8 x 4-km CRMs

Perhaps due to other



0.7x0.7 deg. with 8 x 4-km CRMs

Perhaps due to other complicating factors such as ambient rotation



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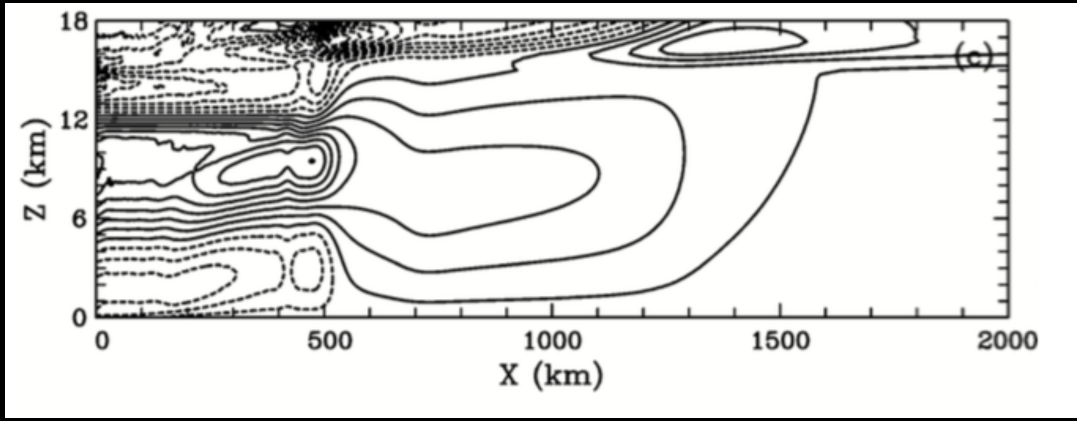
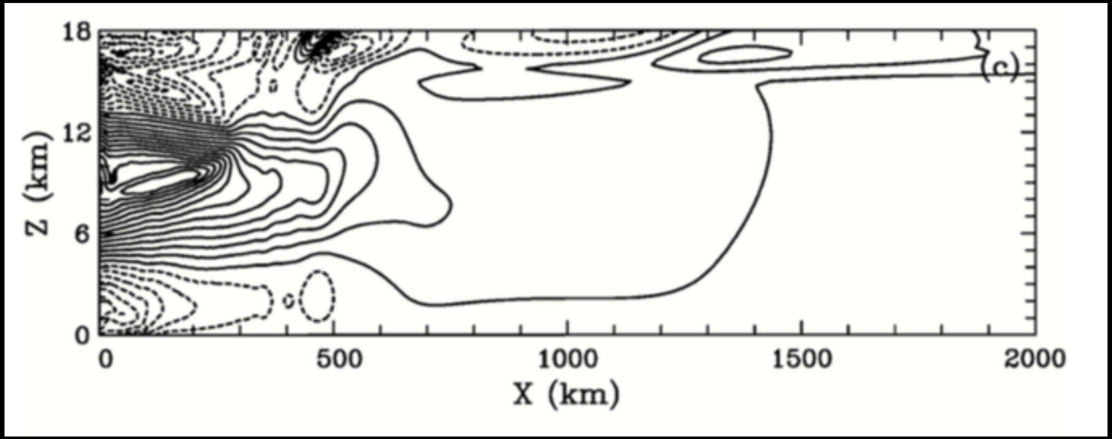


f = 0



$f = 10^{-4}\ s^{-1}$

From Liu and Moncrieff (2004; *J. Atmos. Sci.*)

Concluding remarks

- Simulation of convectively coupled IG waves is clearly challenge for numerical models even at grey-zone resolution or with superparameterized physics
- Important implications for predicting short-term weather in the tropics (and extra-tropics), as well as for simulating the QBO