Predictability of tropical multi-scale convective systems during an MJO active phase

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Overview

To investigate the practical and intrinsic predictability of tropical weather,

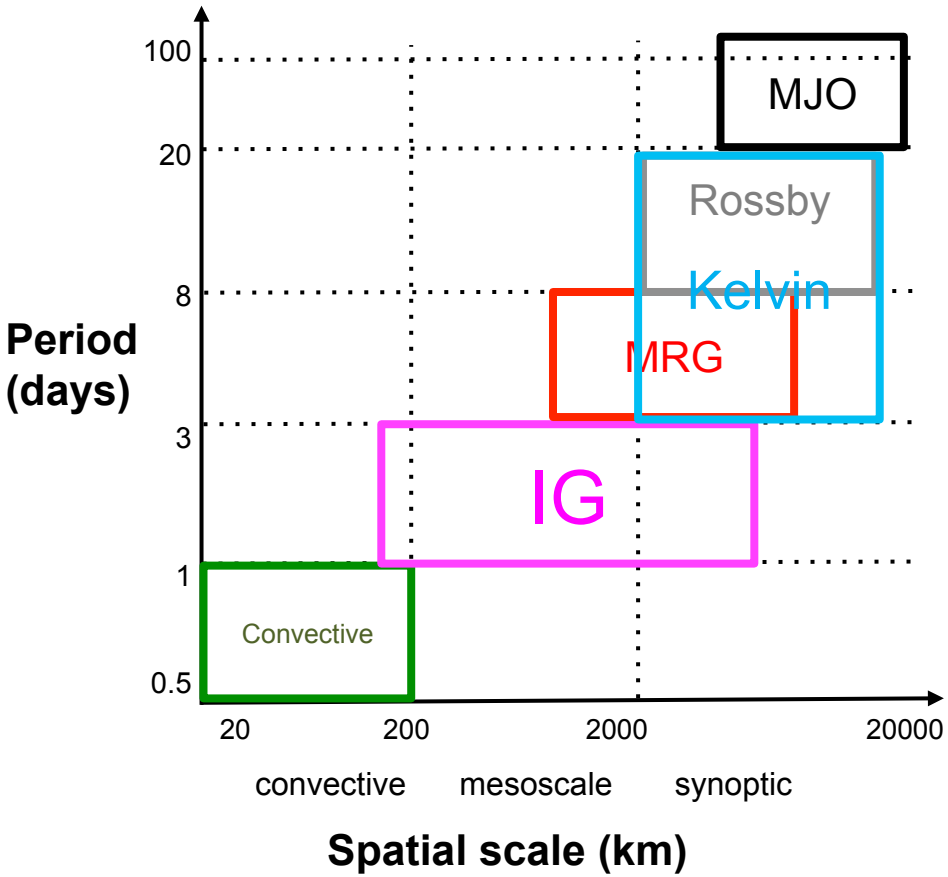
We use ERA-Interim-initialized WRF simulation as control run
and perturb its initial and boundary conditions with TIGGE global 15-day ensemble forecasts

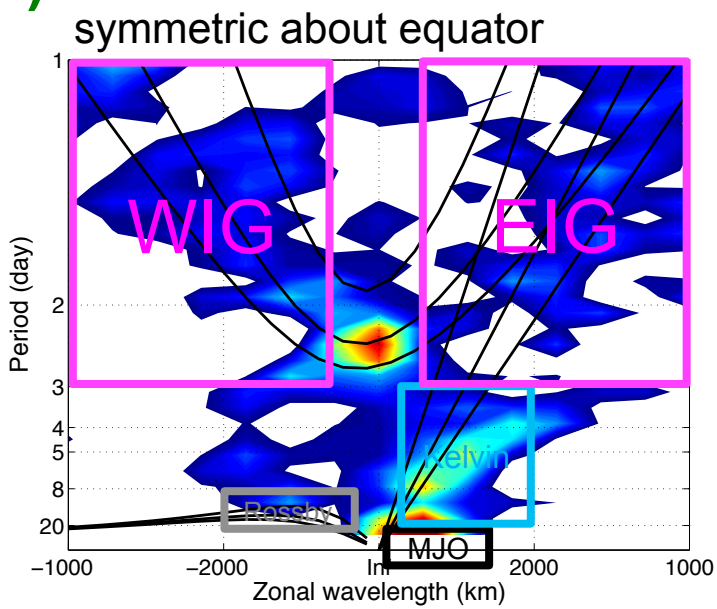
Objectives:
1. Characterize error growth from the resulting 20 perturbed runs
2. Identify limitations in practical/intrinsic predictability

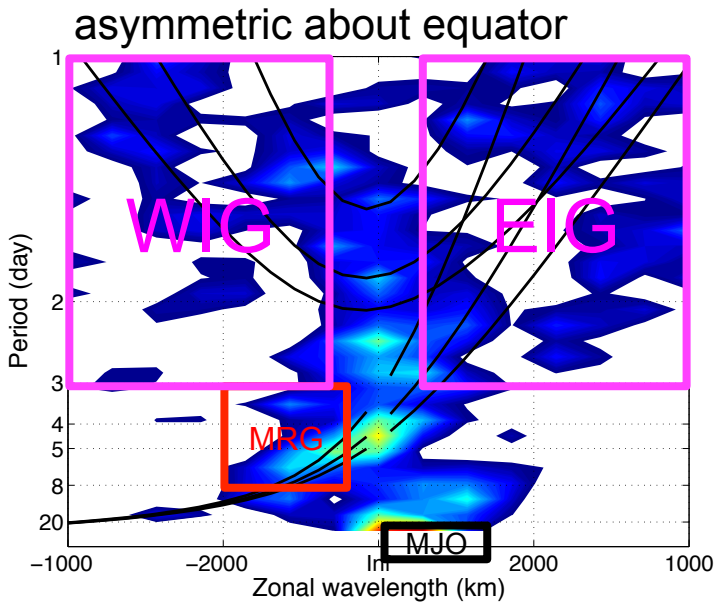
The WRF is setup with 9km grid spacing and covers 20S~20N, 50E~120E
capable of resolving horizontal scales: 70~7000 km
temporal scales: 3 hours ~ 15 days

Space-time filtering (Wheeler-Kiladis) of multi-scale convective systems

convectively coupled equatorial waves (CCEW)

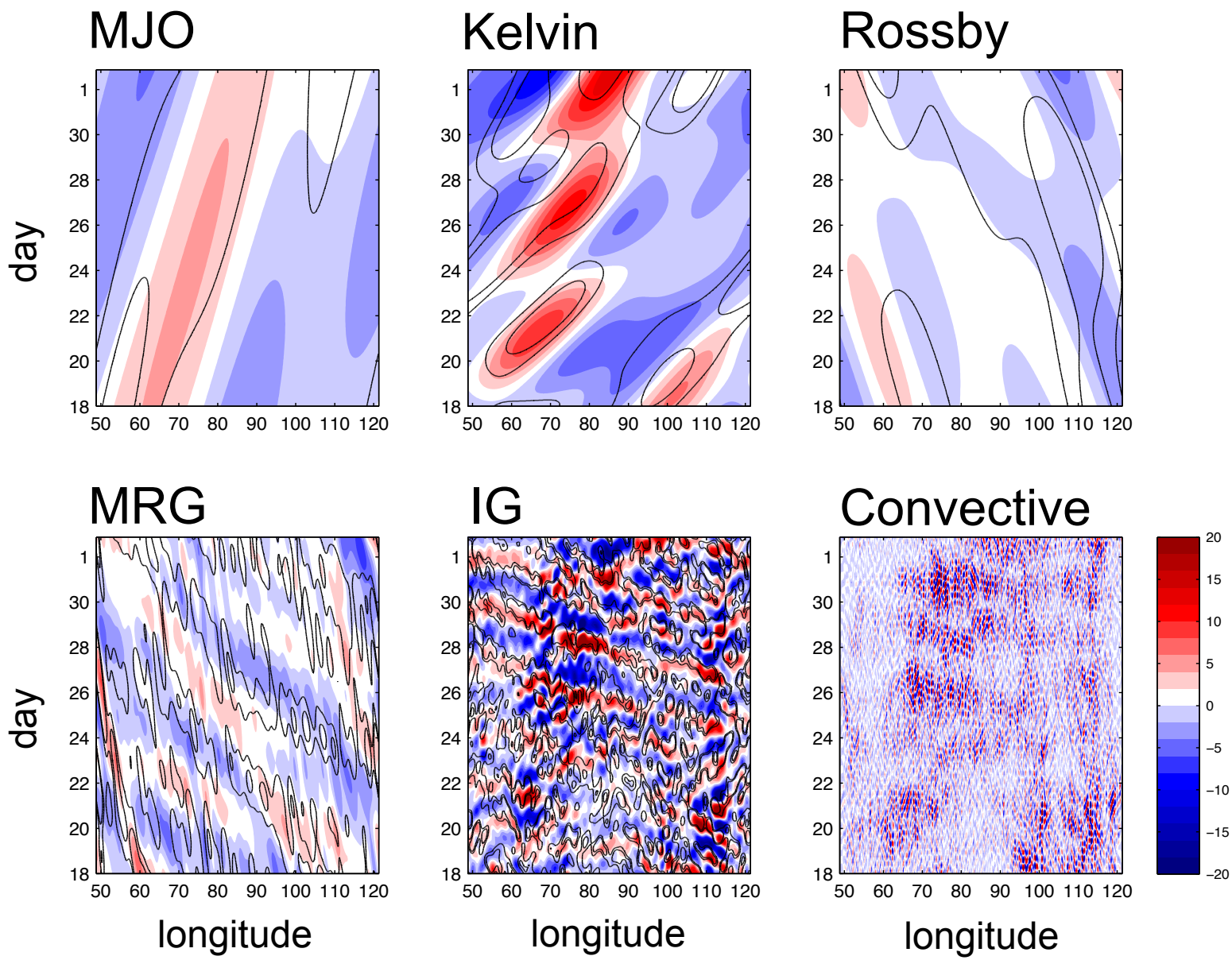






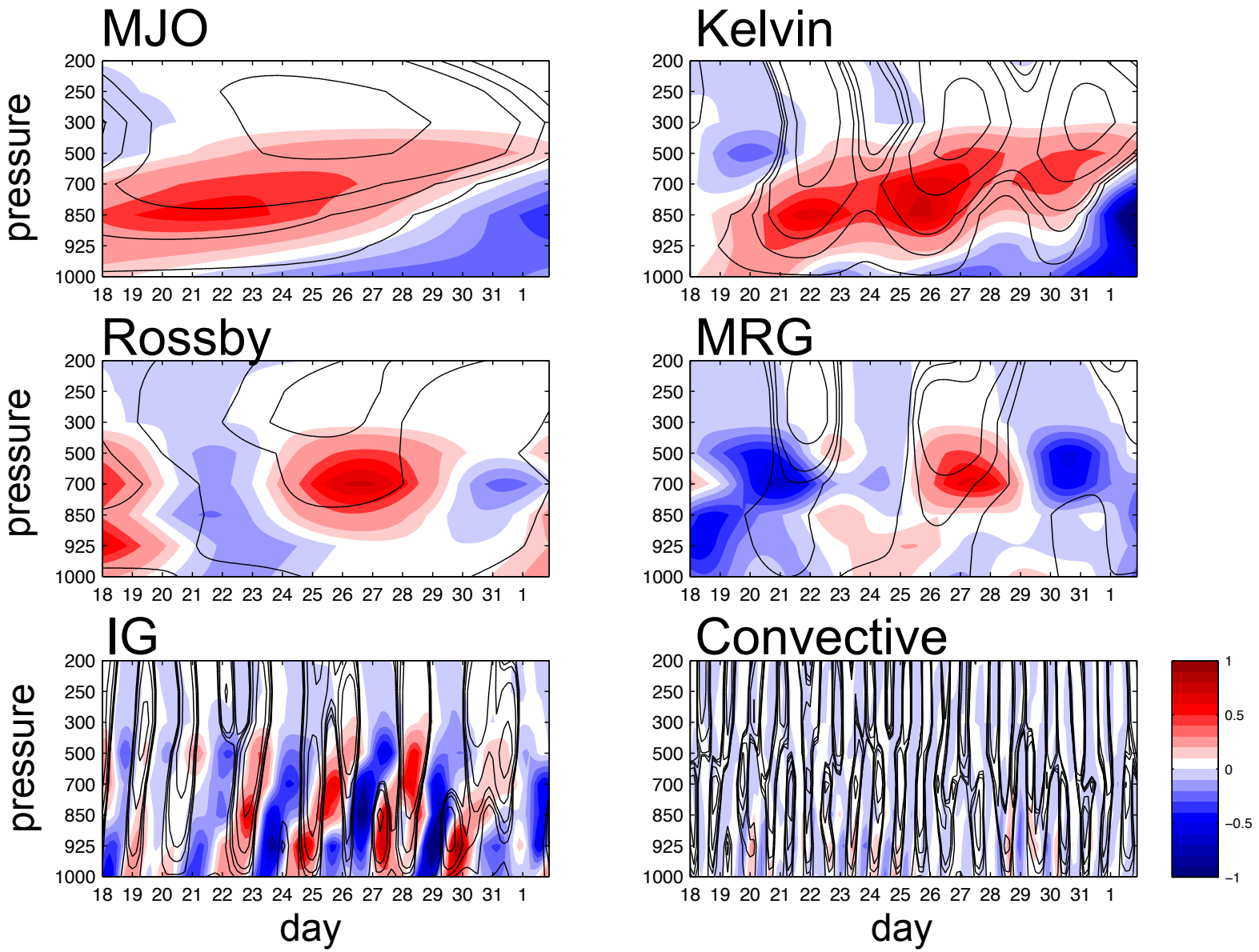
Synopsis of Oct 2011 MJO active phase

time-longitude plots of precipitation (color) and 200-mb zonal wind divergence (contours)



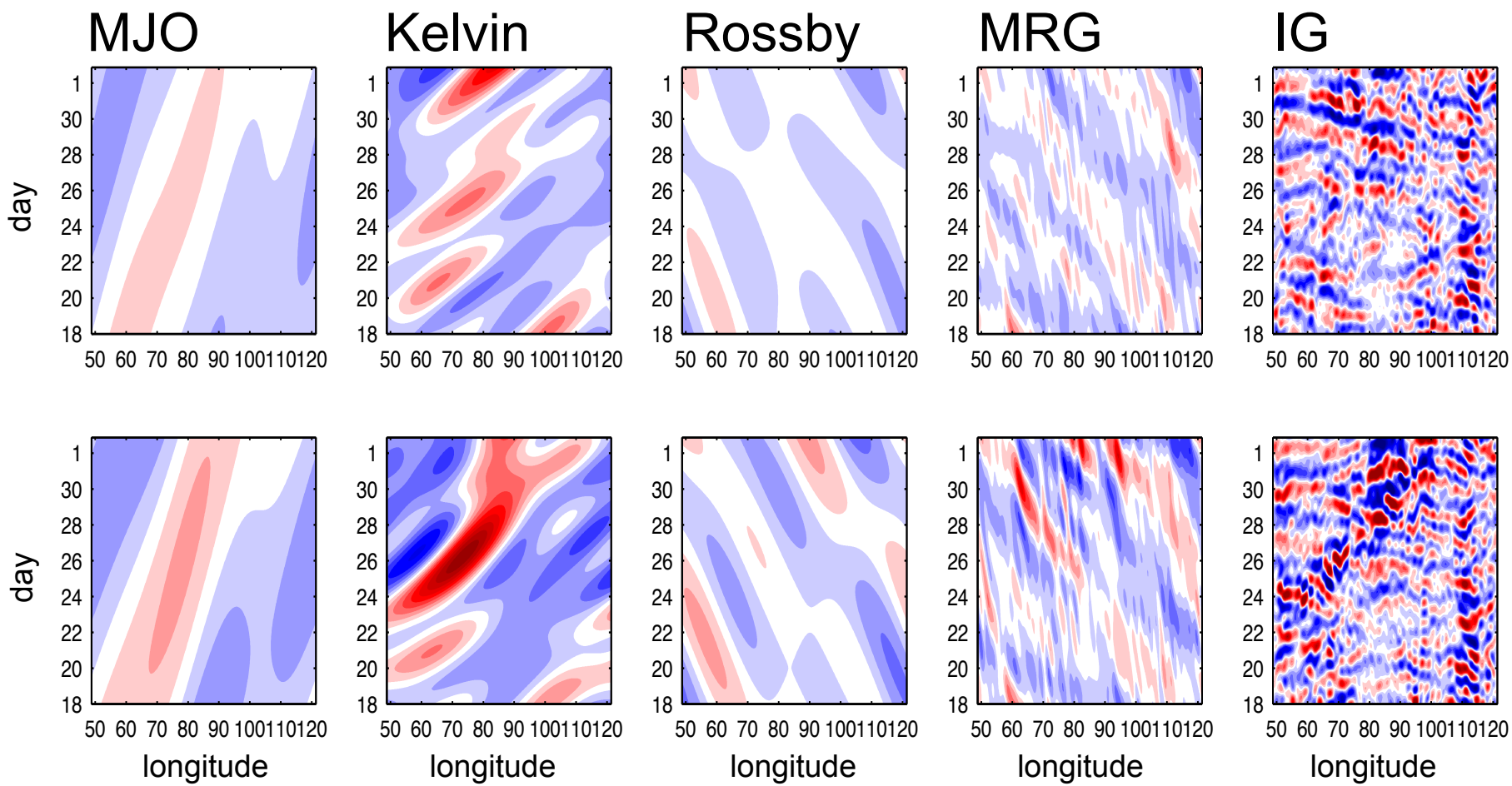
Synopsis of Oct 2011 MJO active phase

time-height plots of specific humidity (color) and vertical motion (contours)



Perturbed runs: precipitation time-longitude plots

comparing member 14 (top row) and member 19 (bottom row)

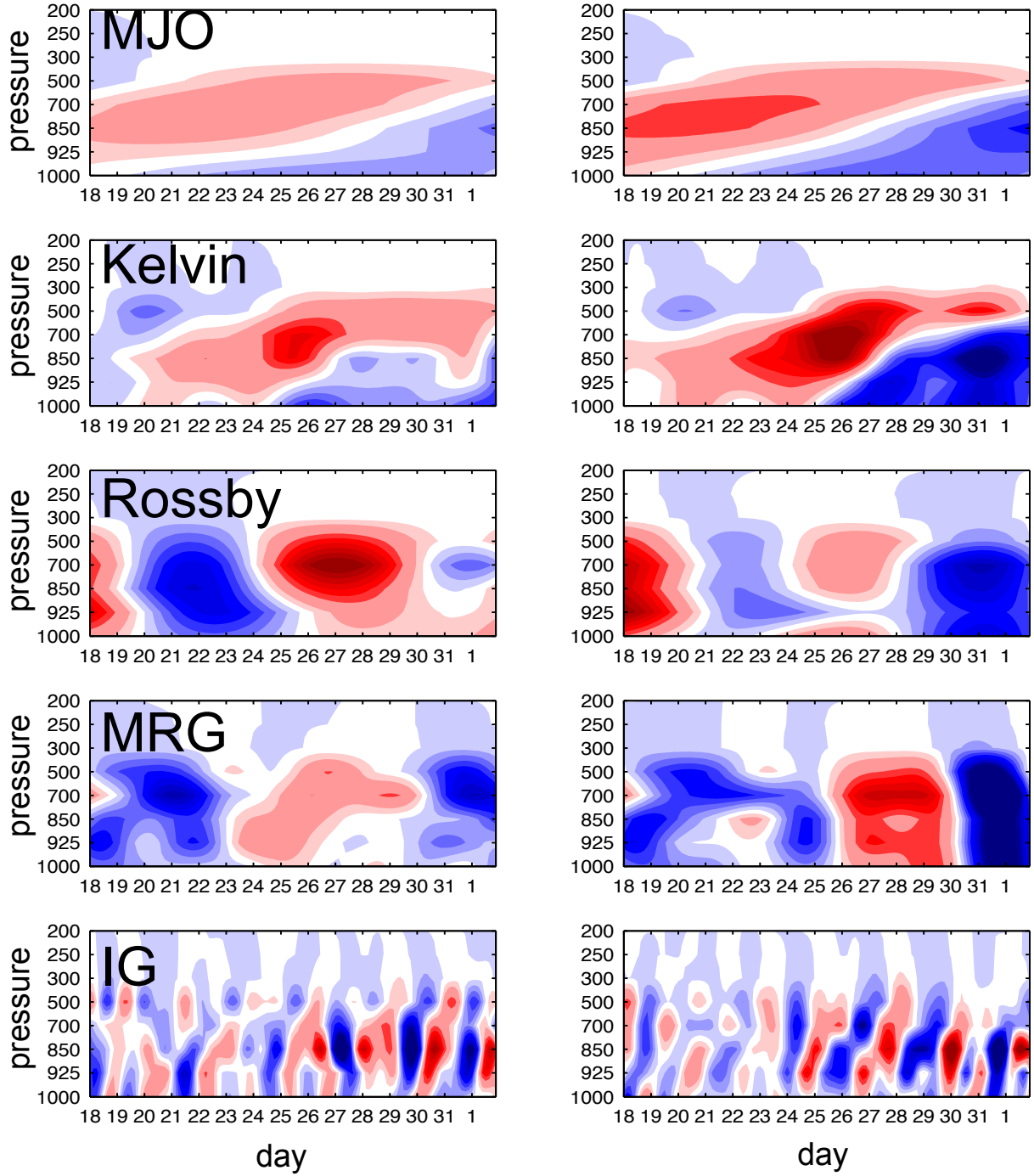


Perturbed runs: specific humidity time-height plots

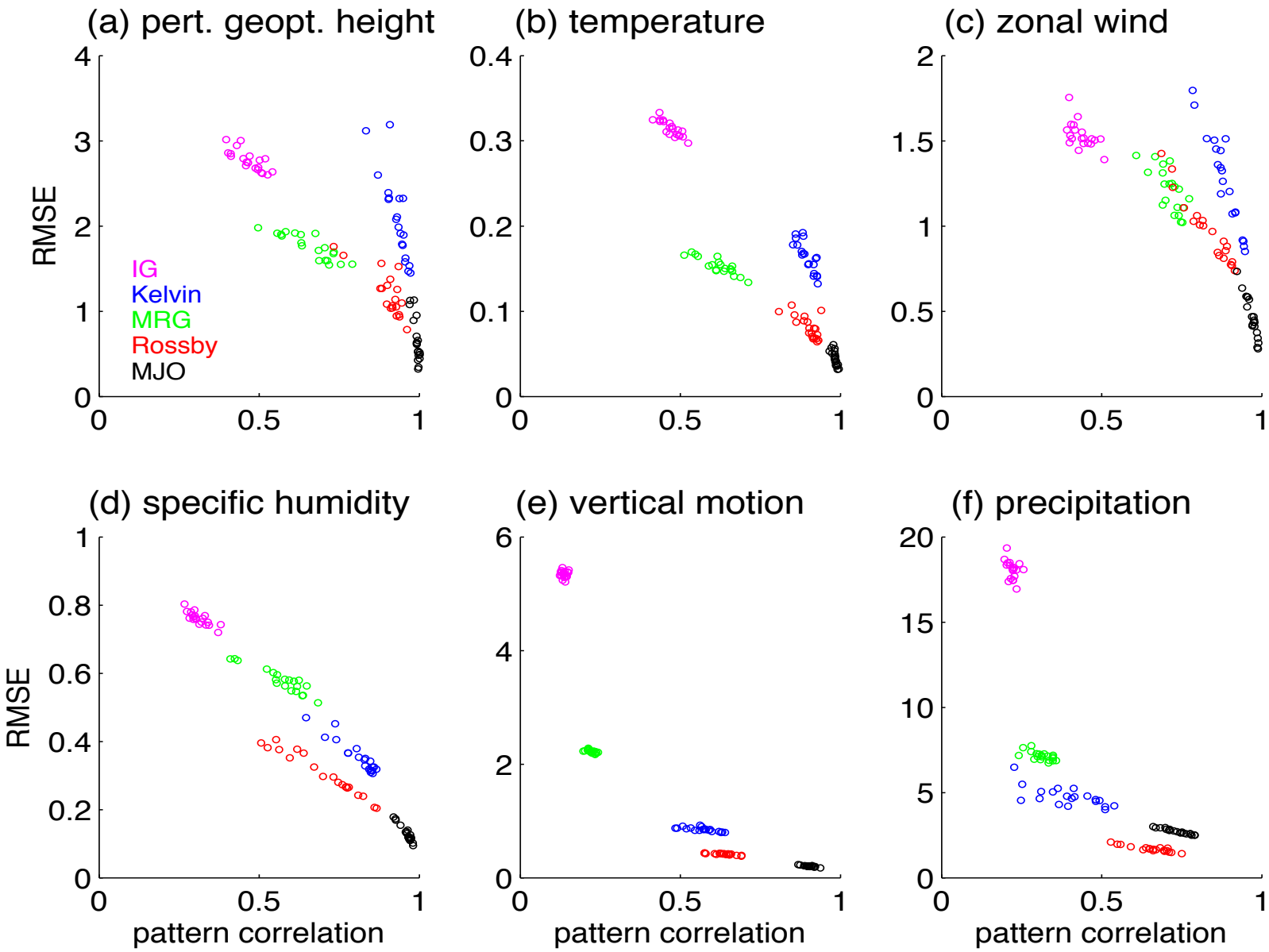
comparing member 14 (left) and member 19 (right)

large-scale remains more or less in phase with amplitude errors

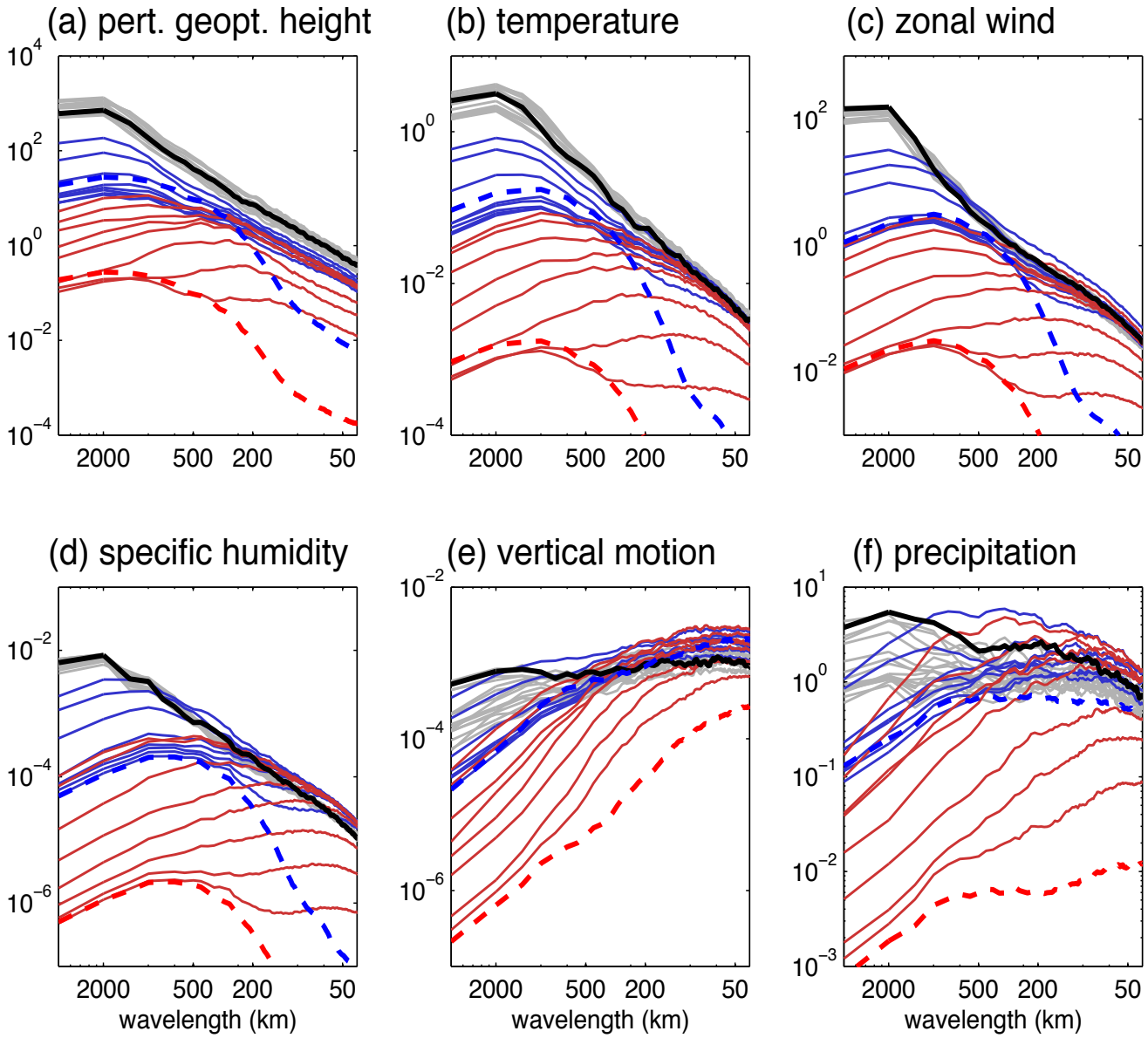
smaller scales become less predictable due to the modulation from larger scales



Phase error vs. amplitude error



Error power spectrum and its evolution in time



reference spectra

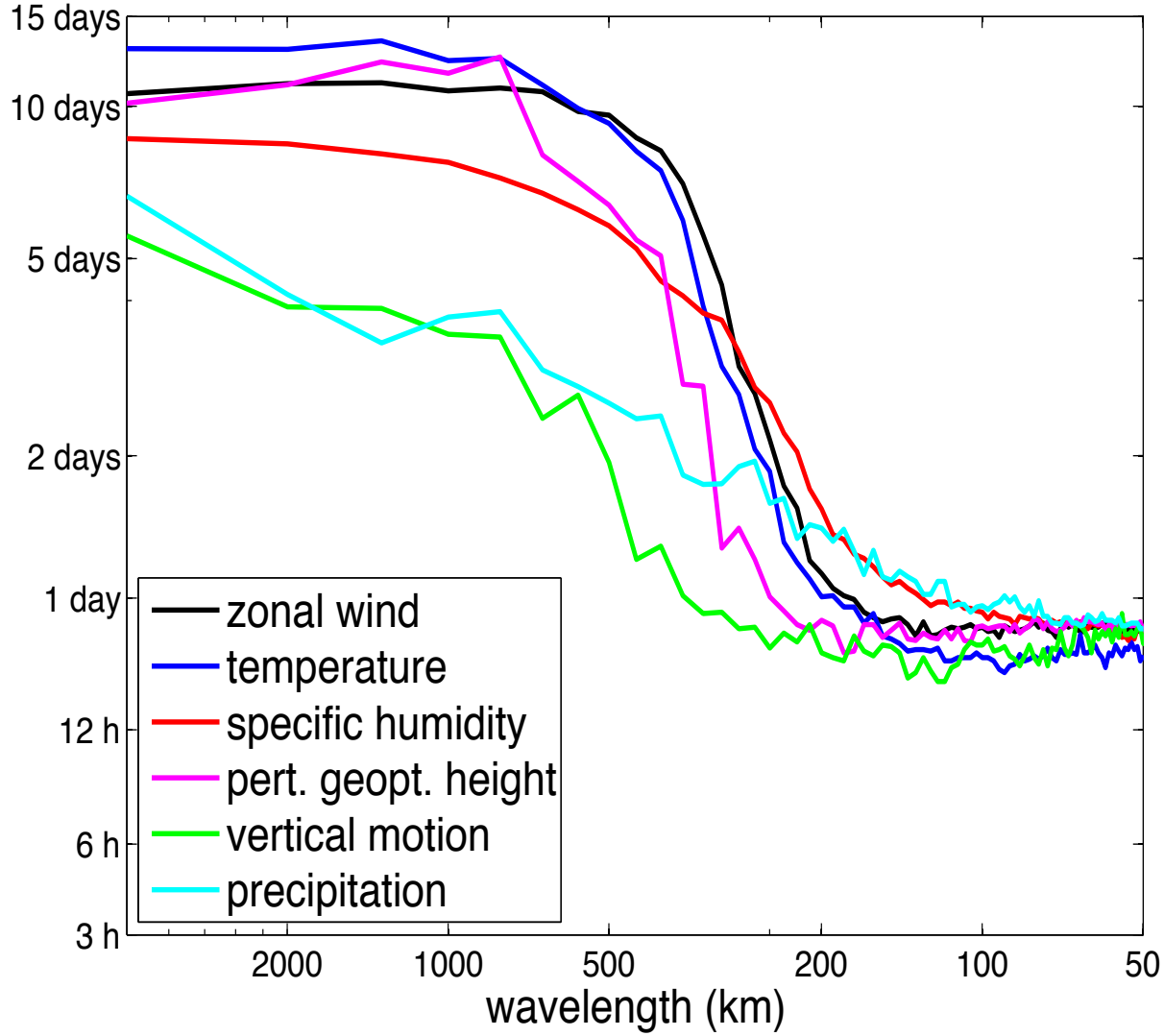
error spectra w/ full perturbation

error spectra w/ 10% perturbation

initial perturbation

Error growth time scale

the time it takes for 10% initial perturbation to grow and reach 100%



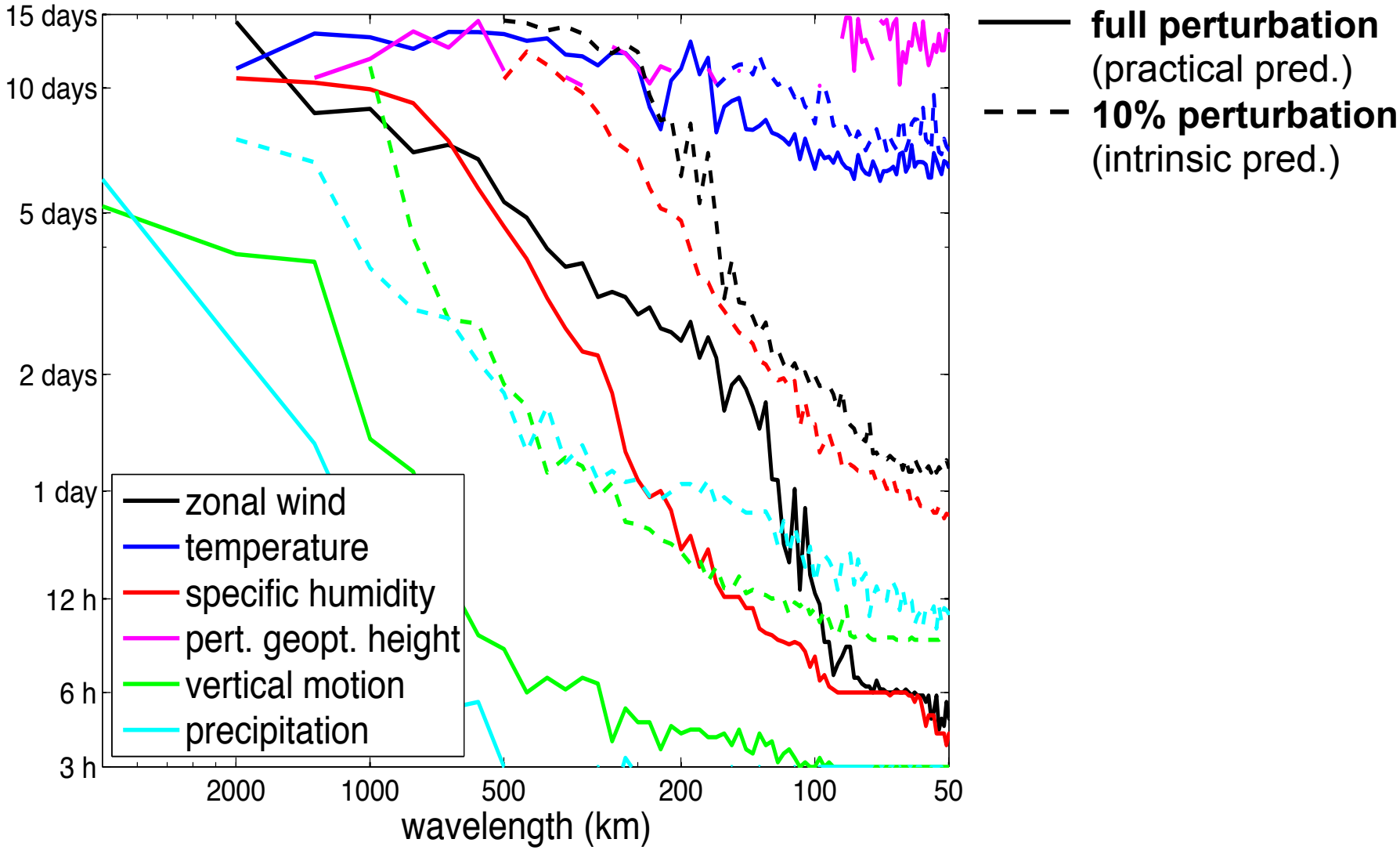
error grow 10 times in less than 1 day for smallest scales

different variables have varying time scale for large-scale error growth: precipitation/vertical motion faster than others

200~500 km is where the error growth rate drastically change

Scale- and variable-dependent predictability

the time it takes for error power to reach reference power (loss of predictability)



Concluding remarks

Multi-scale convective systems in the tropics features a hierarchy of motion with larger scale modulating the smaller ones. With perturbed larger scale motion, the smaller scale becomes out of phase, therefore also larger in error.

Errors at convective scale grow rapidly (10x within 1 day), the rate of growth drastically decrease across meso- to synoptic scales (10~15 days for wind/ mass/humidity, but only ~5 days for precipitation and vertical motion).

The limit of predictability also depends on variables and scales.