

Idealized weak temperature gradient simulations: focusing on the horizontal advection of environmental moisture

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WEAK TEMPERATURE GRADIENT VERTICAL VELOCITY, w_{wtg}

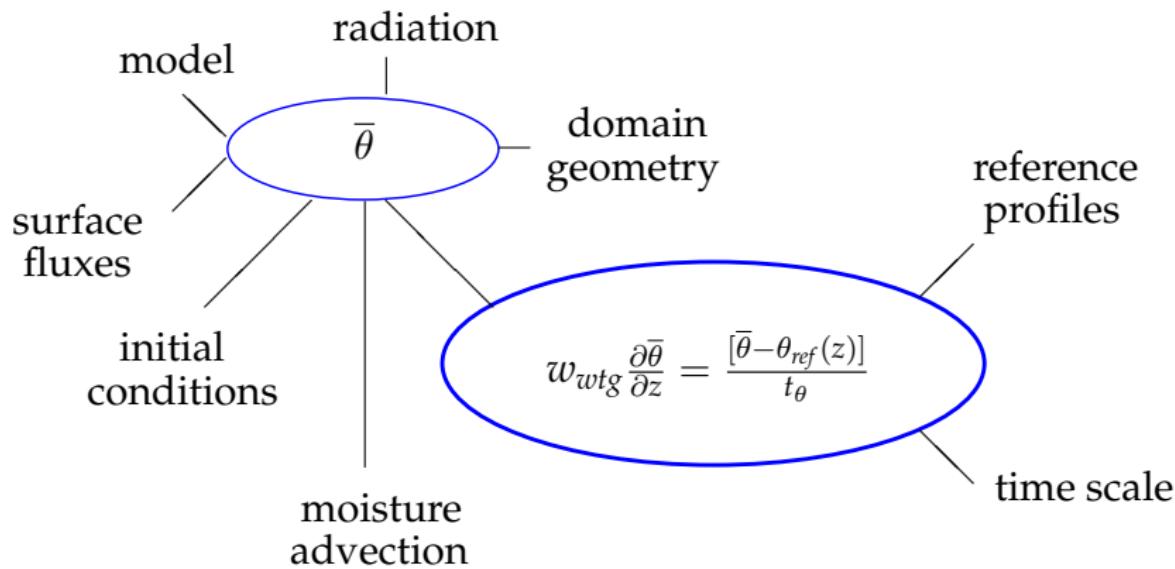
$$w_{wtg} \frac{\partial \bar{\theta}}{\partial z} = \frac{[\bar{\theta} - \theta_{ref}(z)]}{t_\theta}$$

WEAK TEMPERATURE GRADIENT VERTICAL VELOCITY, w_{wtg}

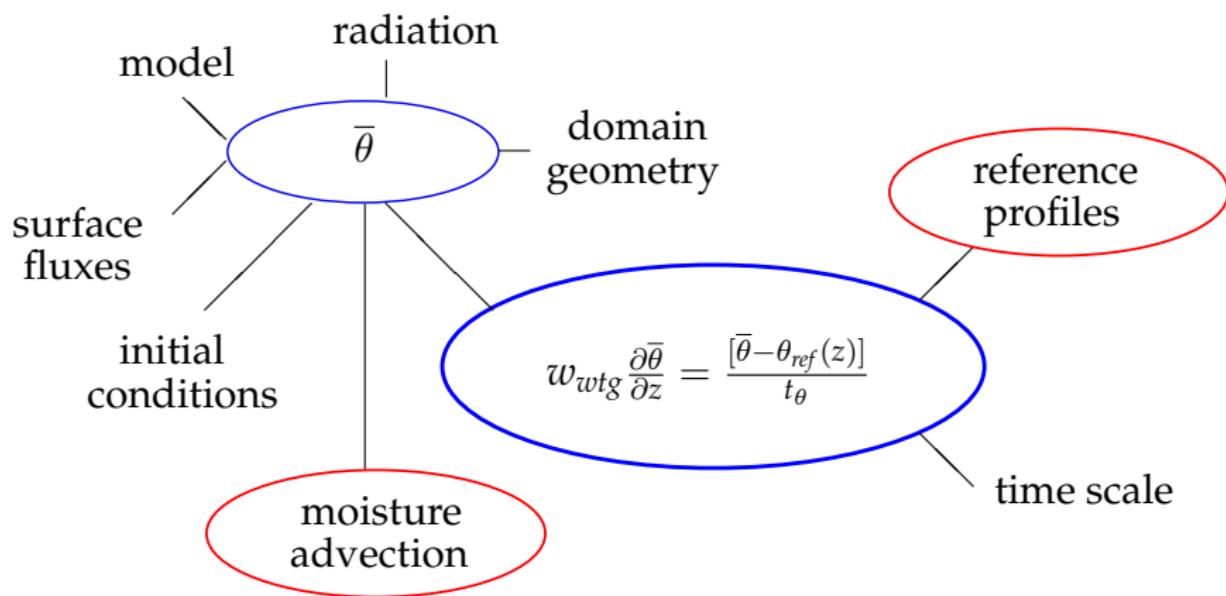
The diagram illustrates the formula for weak temperature gradient vertical velocity, w_{wtg} . It features two blue-outlined ovals. The top oval contains the symbol $\bar{\theta}$. A line connects this symbol to the bottom oval. The bottom oval contains the equation $w_{wtg} \frac{\partial \bar{\theta}}{\partial z} = \frac{[\bar{\theta} - \theta_{ref}(z)]}{t_\theta}$. Two lines extend from the right side of the bottom oval to text labels: "reference profiles" above it and "time scale" below it.

$$w_{wtg} \frac{\partial \bar{\theta}}{\partial z} = \frac{[\bar{\theta} - \theta_{ref}(z)]}{t_\theta}$$

WEAK TEMPERATURE GRADIENT VERTICAL VELOCITY, w_{wtg}

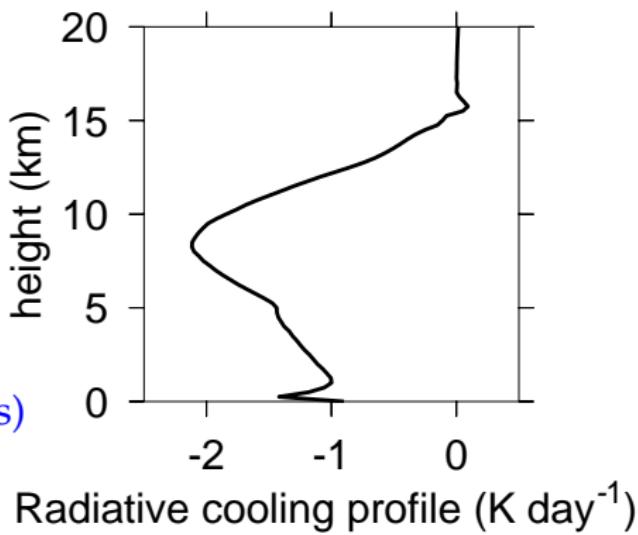


WEAK TEMPERATURE GRADIENT VERTICAL VELOCITY, w_{wtg}

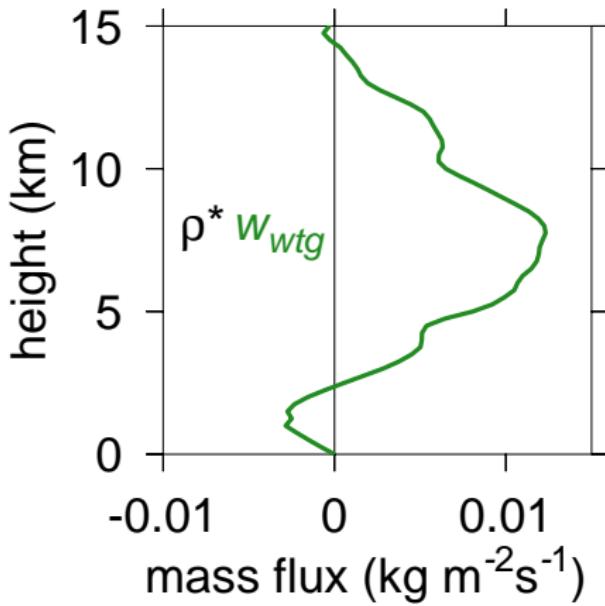


WTG EXPERIMENT PARAMETERS

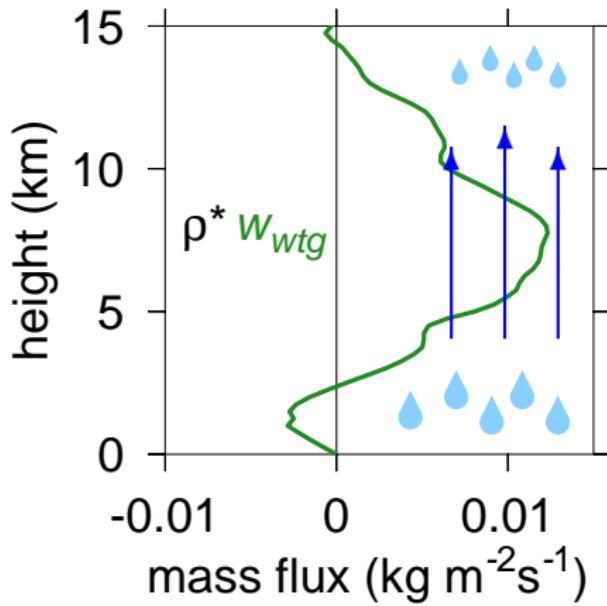
- ▶ 2D CRM
- ▶ 200 km
- ▶ 1 km res.
- ▶ SST 303 K
- ▶ wind 7 m/s (RCE @ 5 m/s)
- ▶ static radiative cooling
- ▶ $t_\theta = 11$ min.



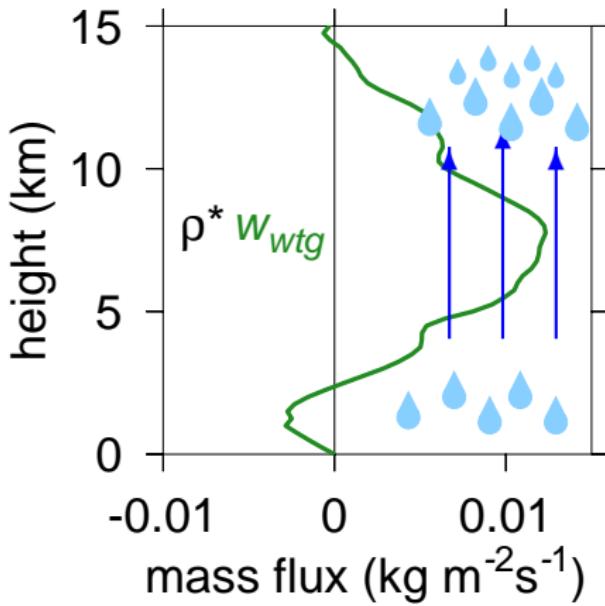
ALL RUNS ADVECT MOISTURE VERTICALLY



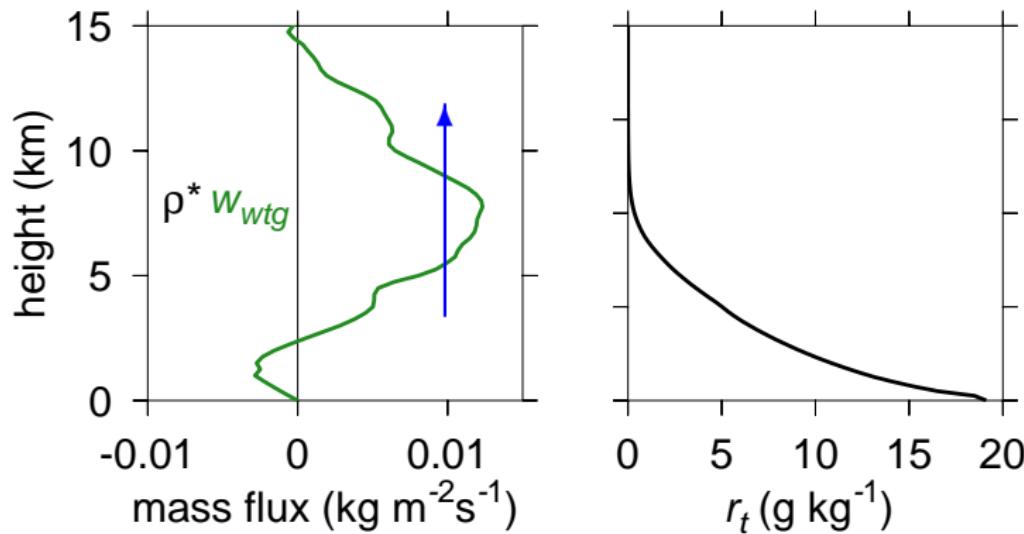
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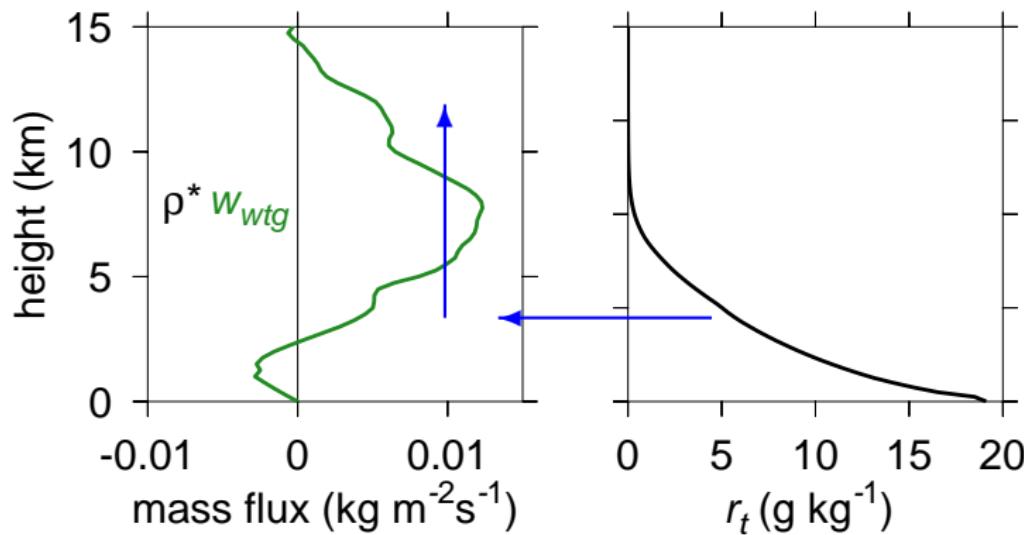
ALL RUNS ADVECT MOISTURE VERTICALLY



HOW DOES DOMAIN FEEL r_{ref} ?

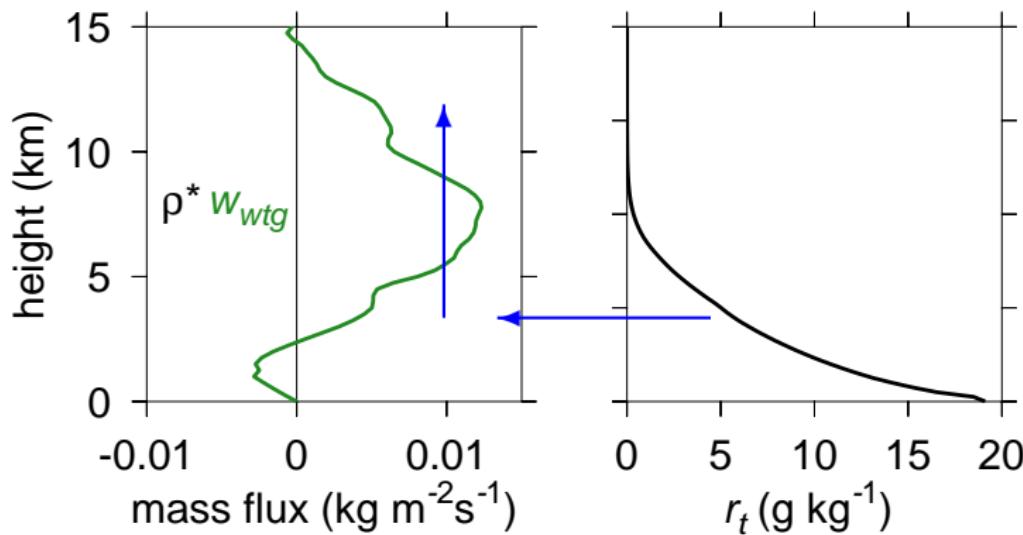


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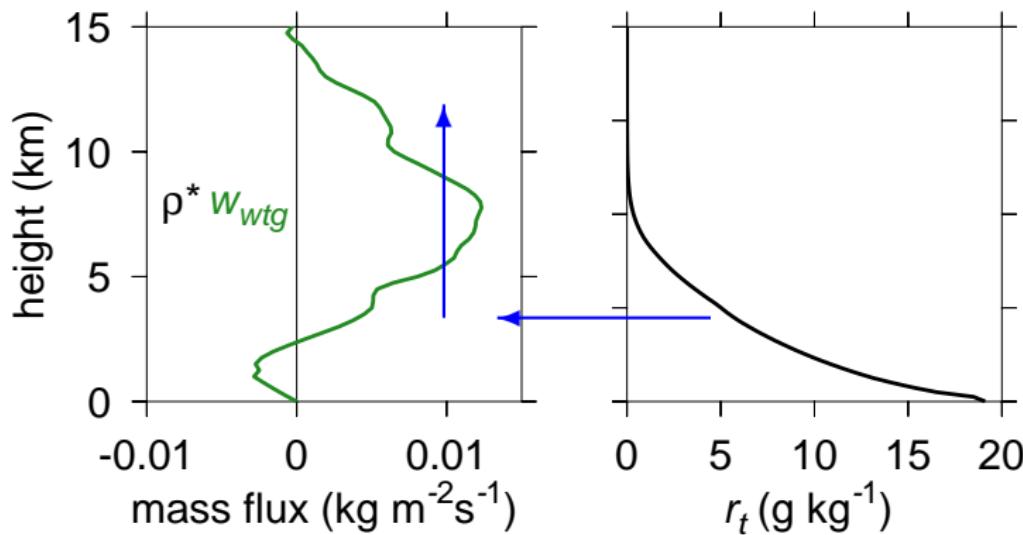
► lateral entrainment

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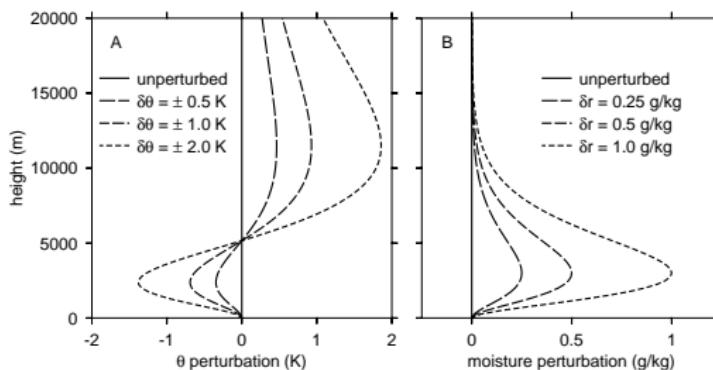
- ▶ lateral entrainment
- ▶ relax to r_{ref} : $(\bar{r} - r_{ref}) / t_{moist}$

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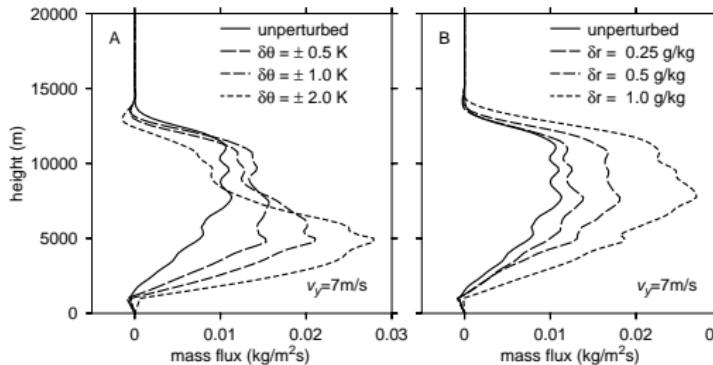
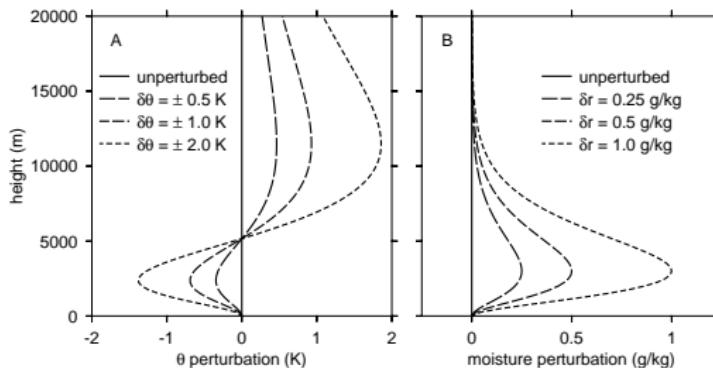


- ▶ lateral entrainment
- ▶ relax to r_{ref} : $(\bar{r}_t - r_{ref})/t_{moist}$
- ▶ both
- ▶ none

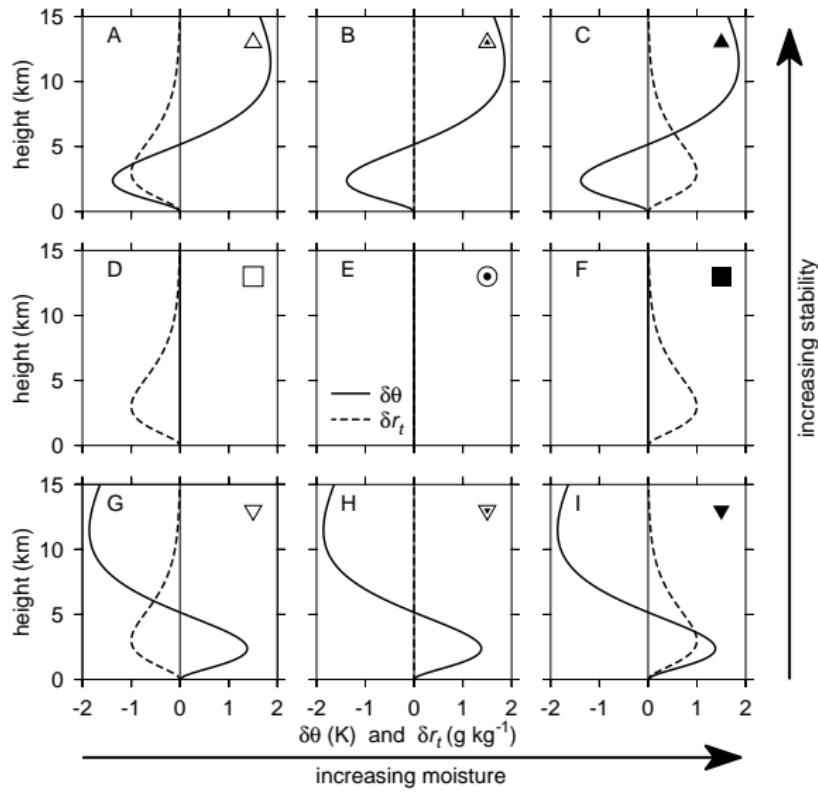
EFFECT OF θ_{ref} , r_{ref} ON MASS FLUX



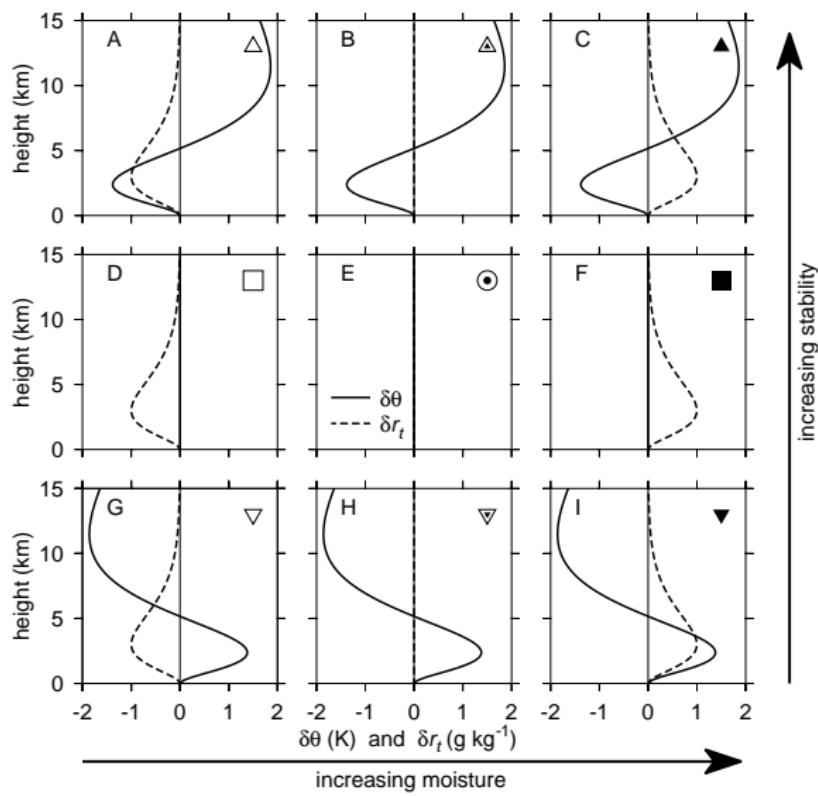
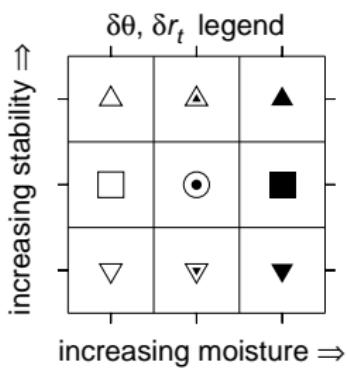
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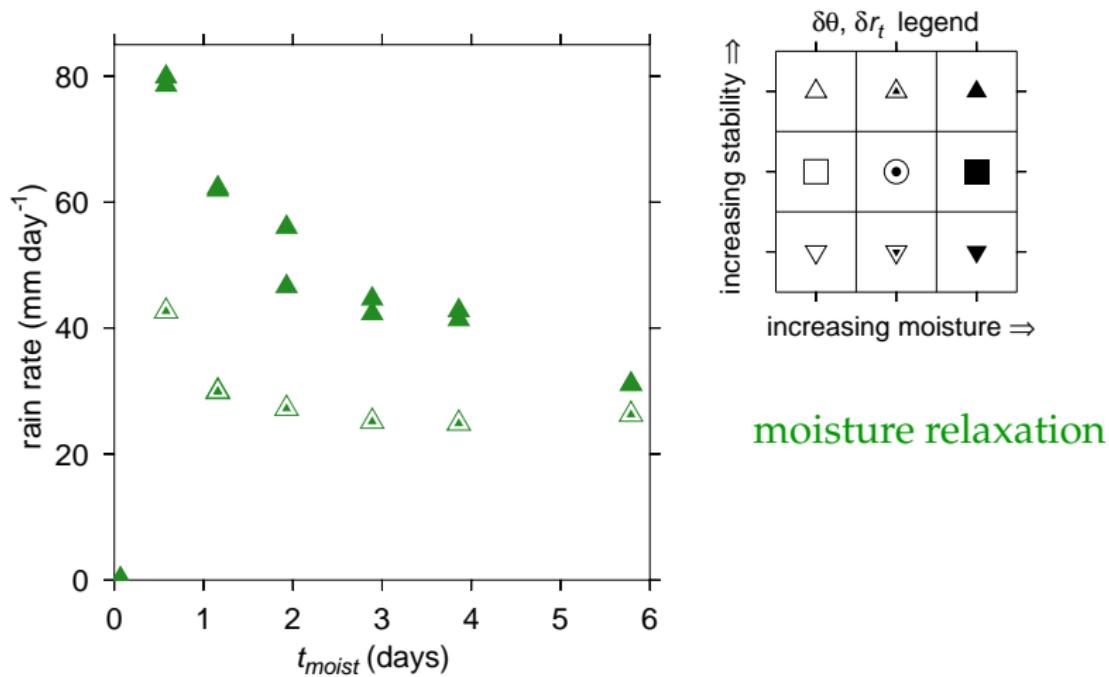
$$\delta\theta, \delta r_t$$



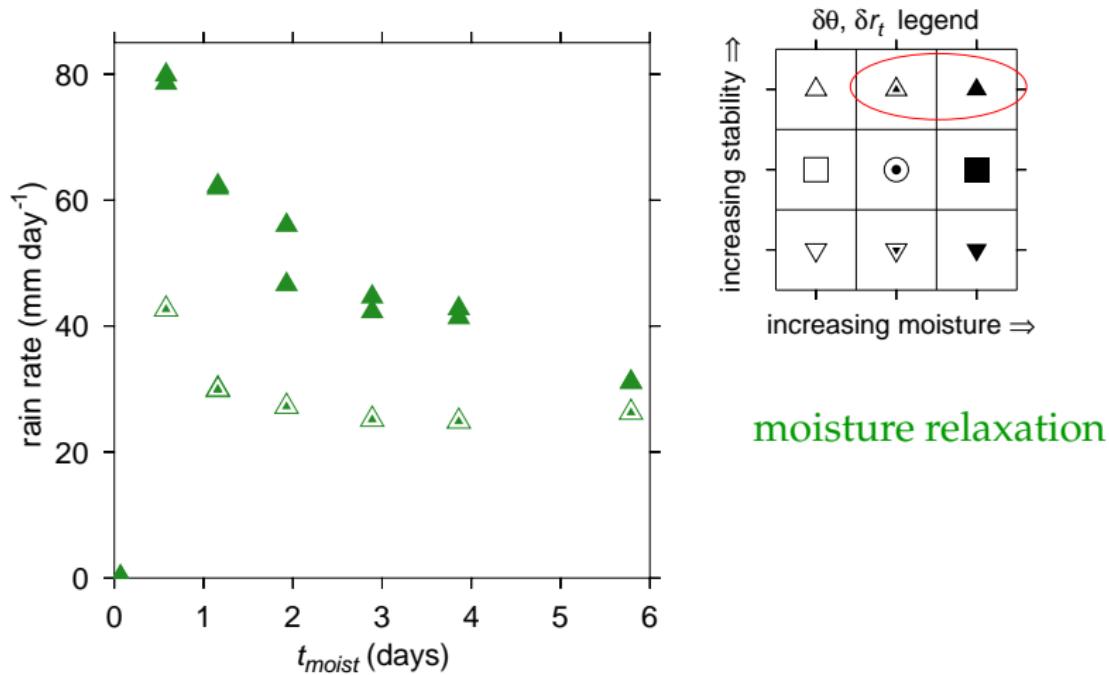
$$\delta\theta, \delta r_t$$



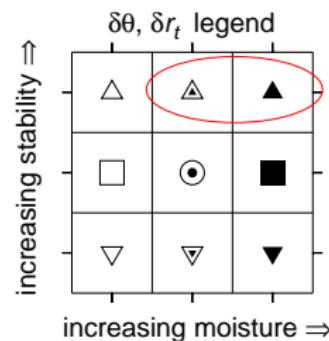
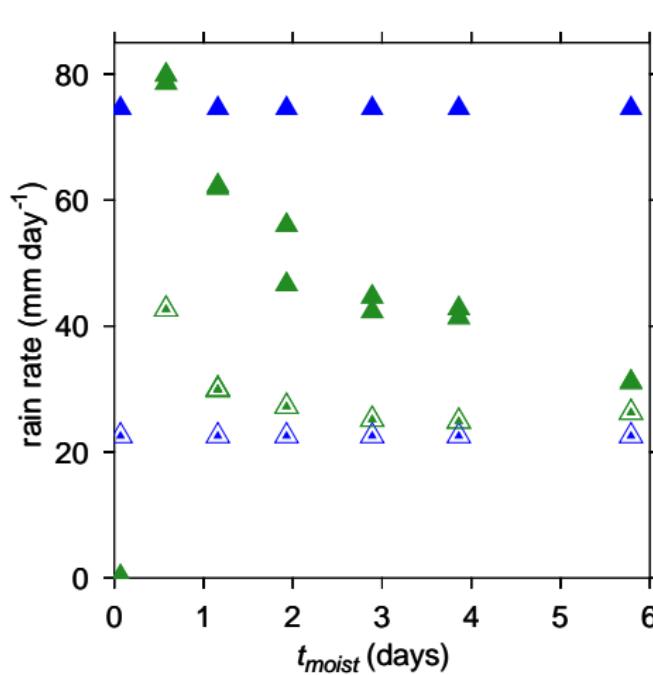
MOISTURE RELAXATION TIME SCALE, t_{moist}



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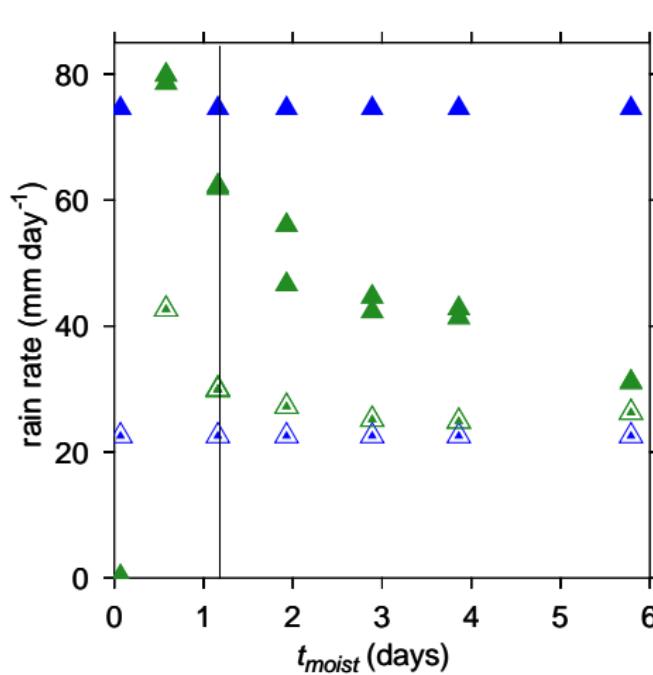
MOISTURE RELAXATION TIME SCALE, t_{moist}



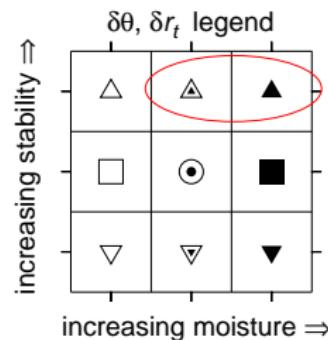
moisture relaxation

lateral entrainment

MOISTURE RELAXATION TIME SCALE, t_{moist}



Choose $t_{moist} = 1.2$ days

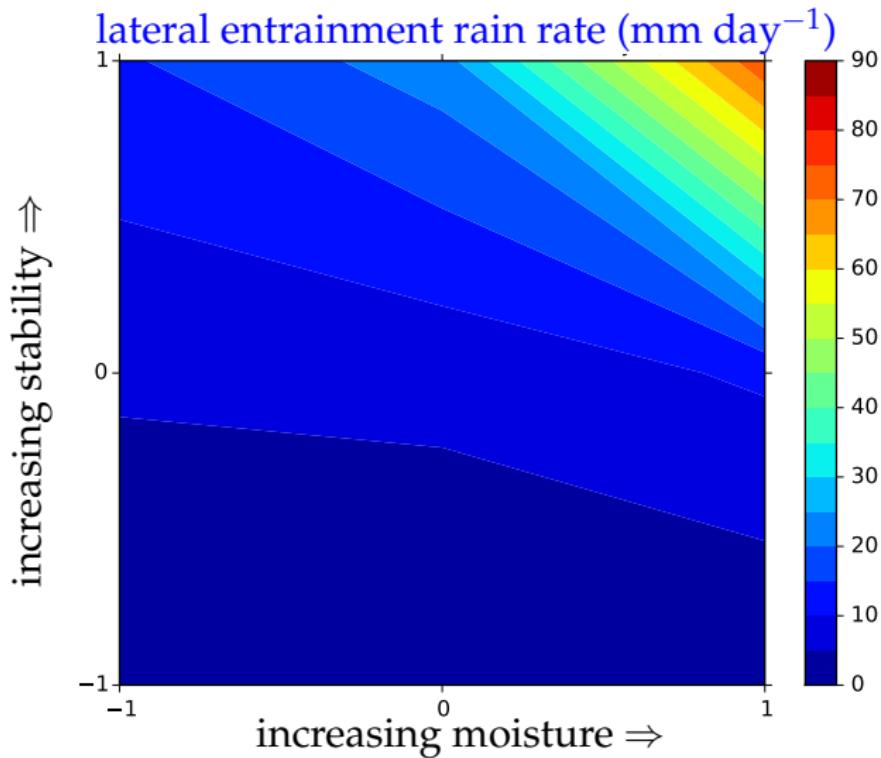


increasing stability \Rightarrow
moisture relaxation

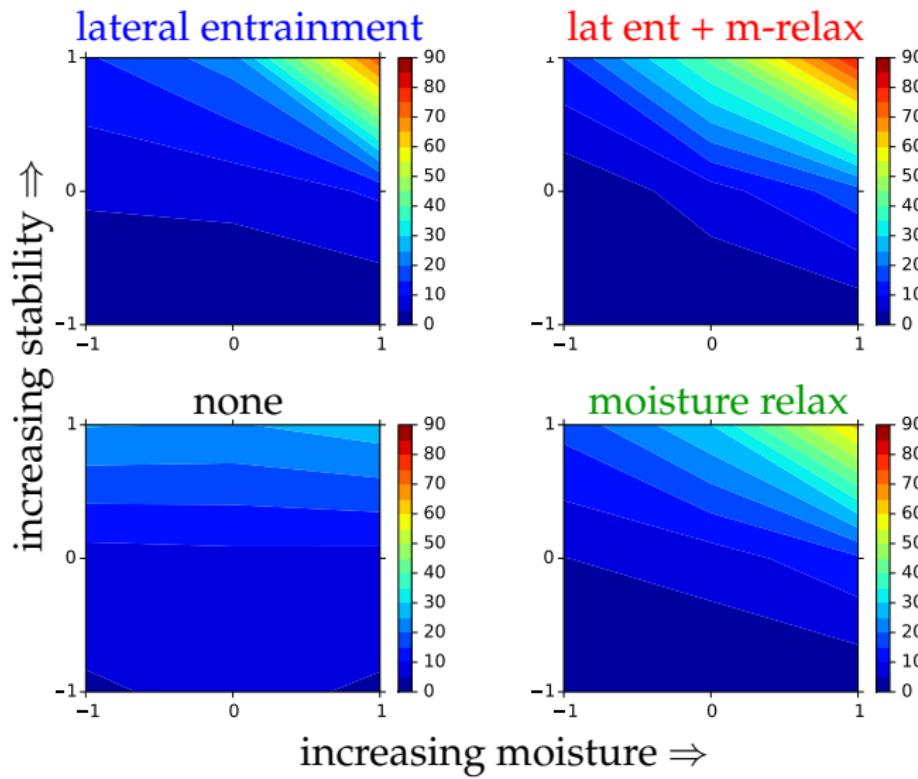
increasing moisture \Rightarrow
lateral entrainment

RAIN RATE AS A FUNCTION OF θ_{ref}, r_{ref}

LATERAL ENTRAINMENT



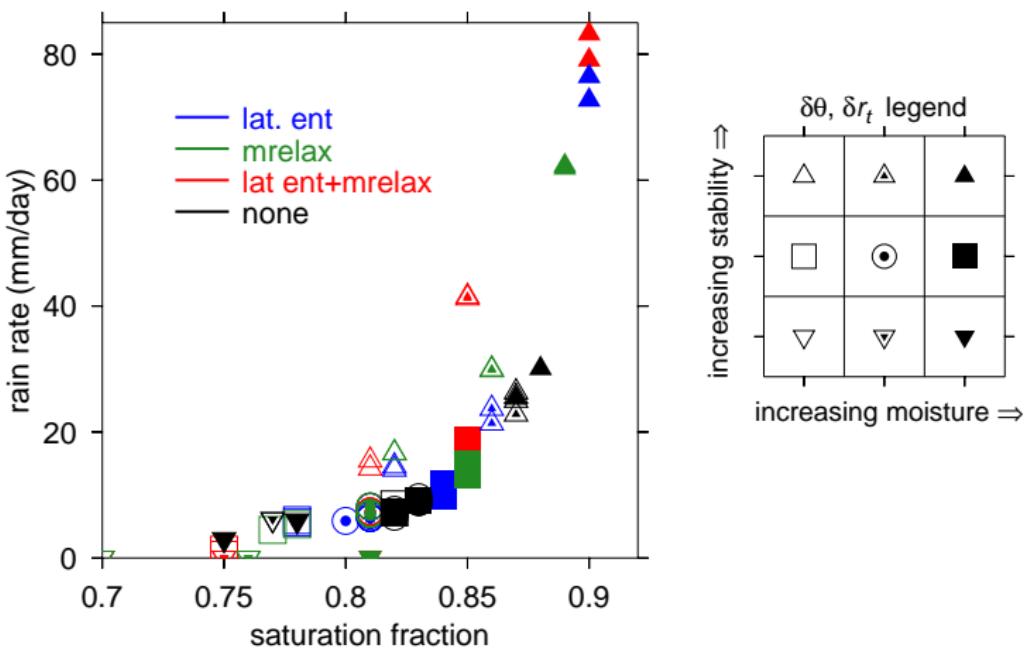
RAIN RATE AS A FUNCTION OF θ_{ref}, r_{ref}



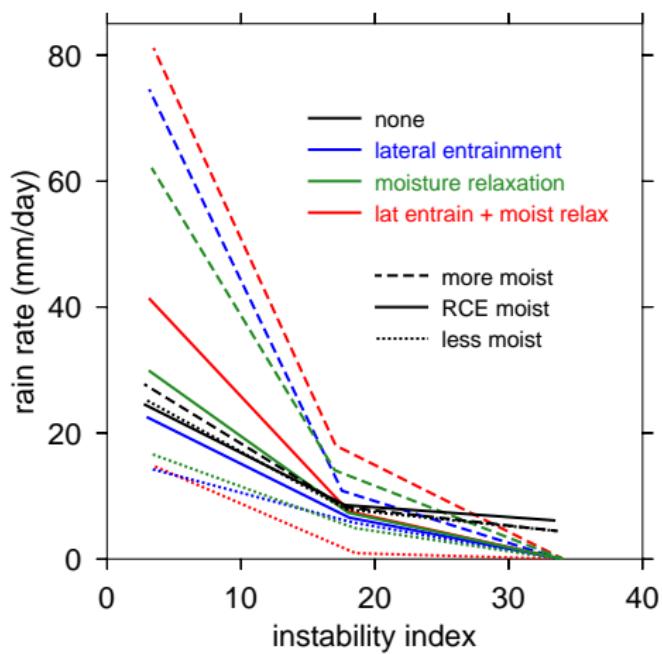
DIAGNOSTIC VARIABLES

- ▶ saturation fraction = $\frac{\text{precipitable water}}{\text{sat'd precipitable water}}$
- ▶ instability index, $\Delta s^* = s_{1-3km}^* - s_{5-7km}^*$
- ▶ $NGMS = \frac{\text{moist entropy export}}{\text{moisture import}}$

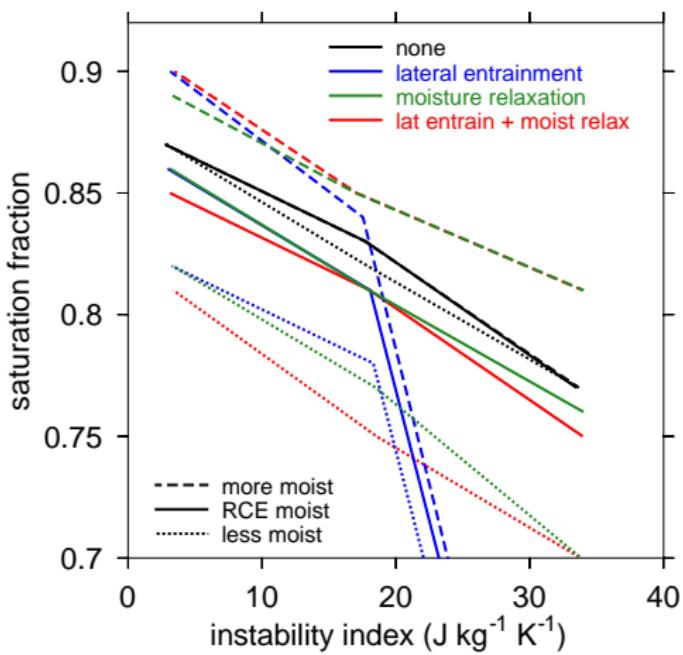
RAIN VS. SATURATION FRACTION



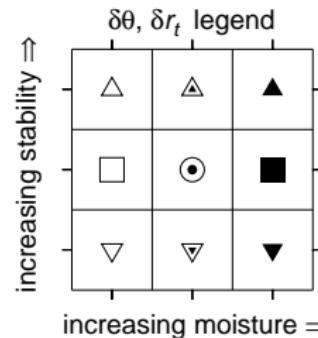
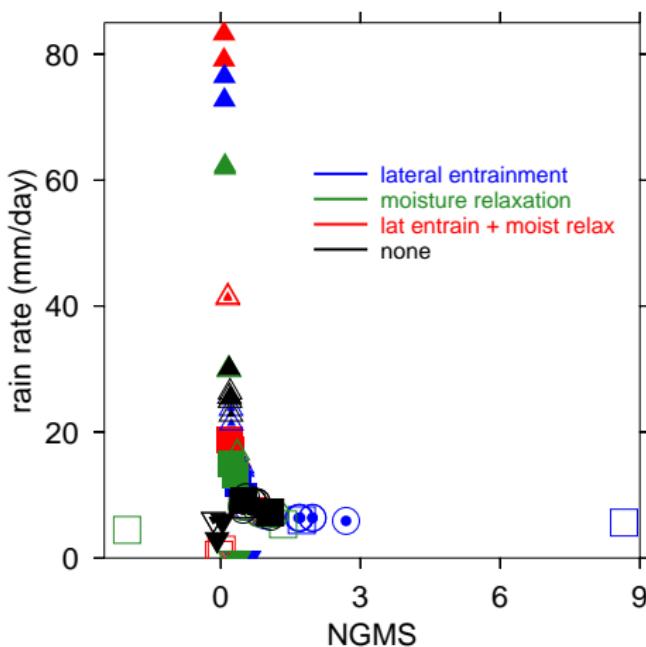
RAIN VS. INSTABILITY INDEX



SATURATION FRACTION VS. INSTABILITY INDEX

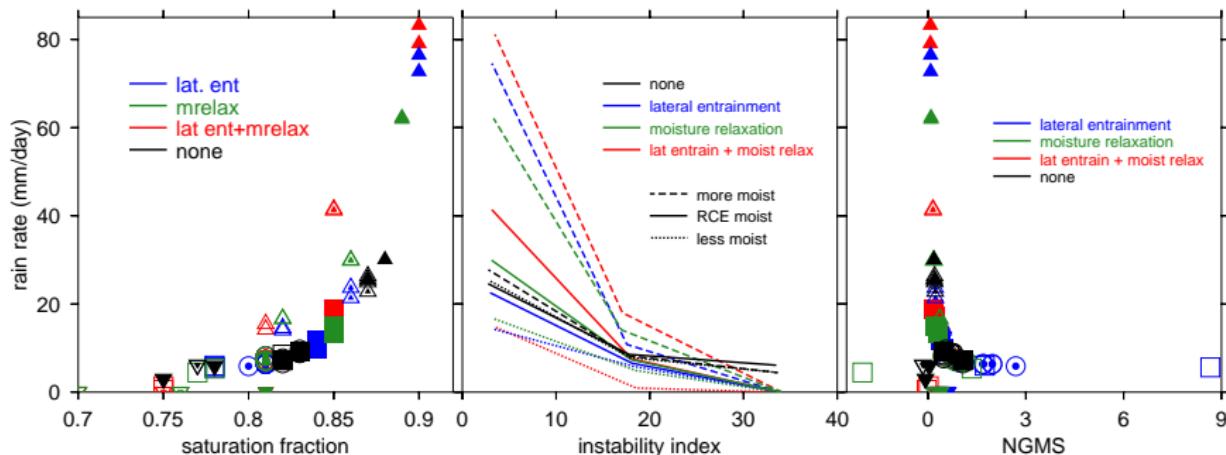


RAIN VS. NGMS

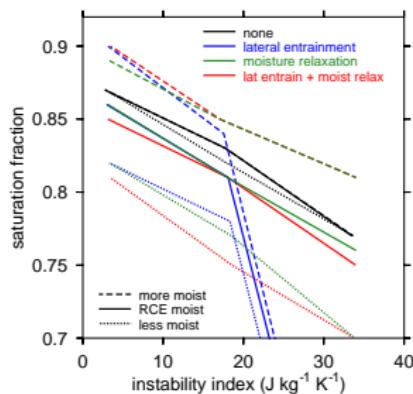
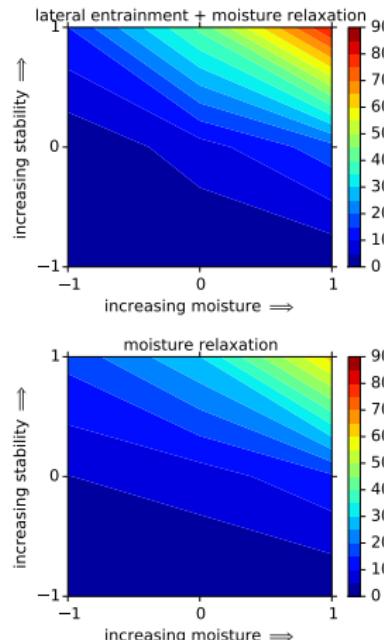
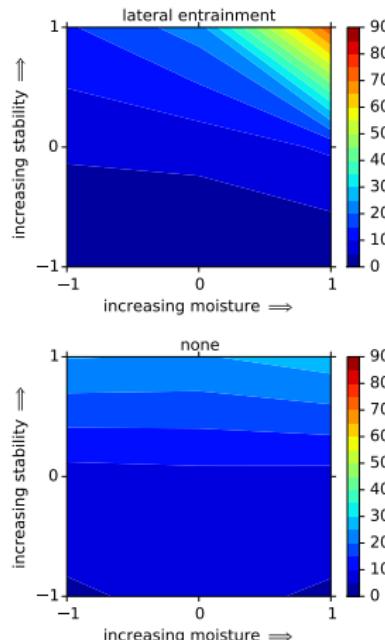


$$NGMS \propto \frac{\text{entropy forcing}}{\text{net precip}}$$

MOISTURE CHOICES ARE SIMILAR IN SOME RESPECTS...



...BUT ALSO HAVE SIGNIFICANT DIFFERENCES



Dependence of rain on θ_{ref}, r_{ref}