

Effects of momentum and energy conservation in a high-lid general circulation model

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CGD

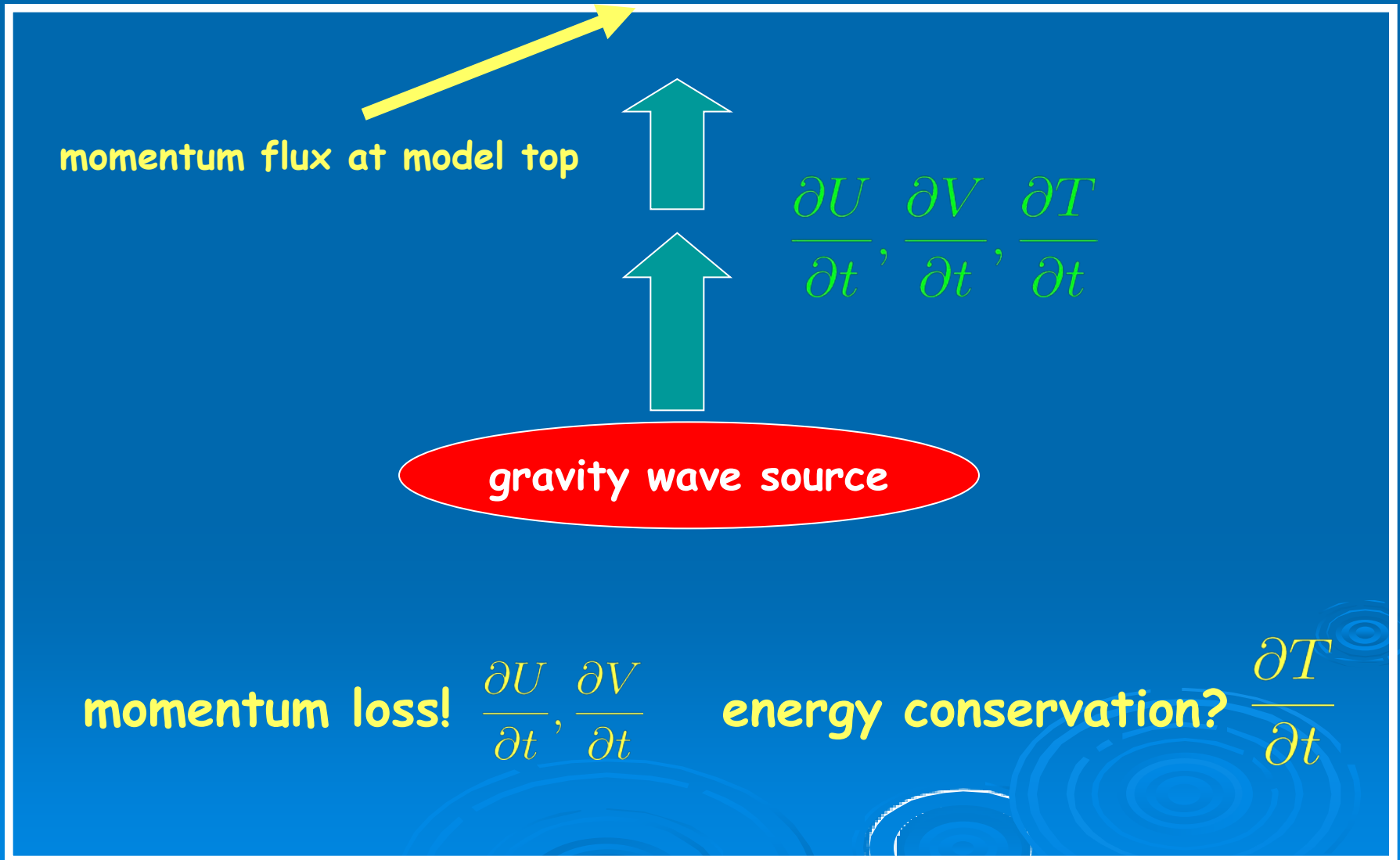
Rolando Garcia and Anne Smith
ACD

Feb 22, 2010

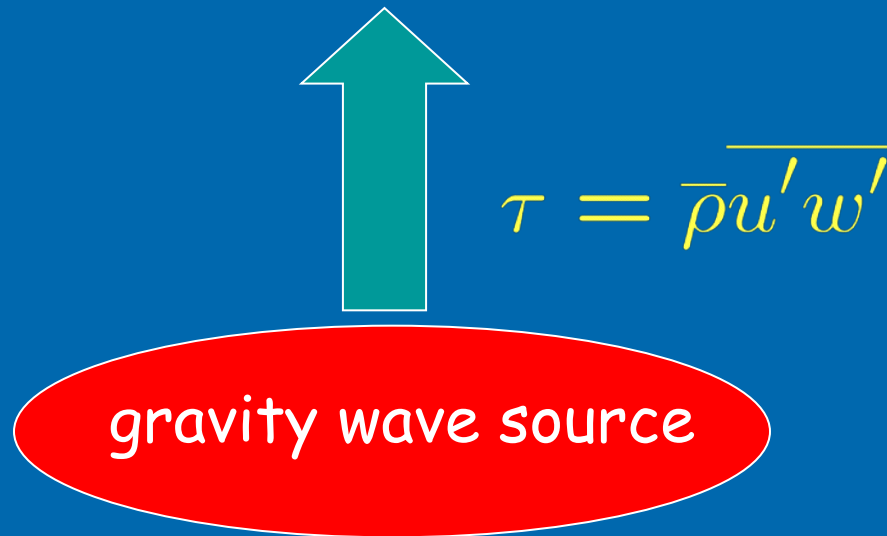
Gravity Wave Sources in WACCM

- **convection**
launch level at 100 mb → top of heating
- **fronts**
launch at 600 mb
- **orography**
launch at Earth's surface

GWD parameterization



momentum tendency below source level



$$\int \bar{\rho} \frac{\partial U}{\partial t} dz = -\tau$$

momentum tendency distribution below source

- uniform momentum tendency

$$\bar{\rho} \frac{\partial U}{\partial t} = \text{constant}$$
$$\frac{\partial U}{\partial t} \propto \frac{1}{\bar{\rho}}$$

- uniform velocity tendency

$$\frac{\partial U}{\partial t} = \text{constant}$$

total energy conservation

$$E = \rho \left(c_p T + \phi + \frac{U^2 + V^2}{2} \right)$$
$$= S + KE$$



$$\frac{\partial U}{\partial t}, \frac{\partial V}{\partial t}, \frac{\partial S}{\partial t}$$

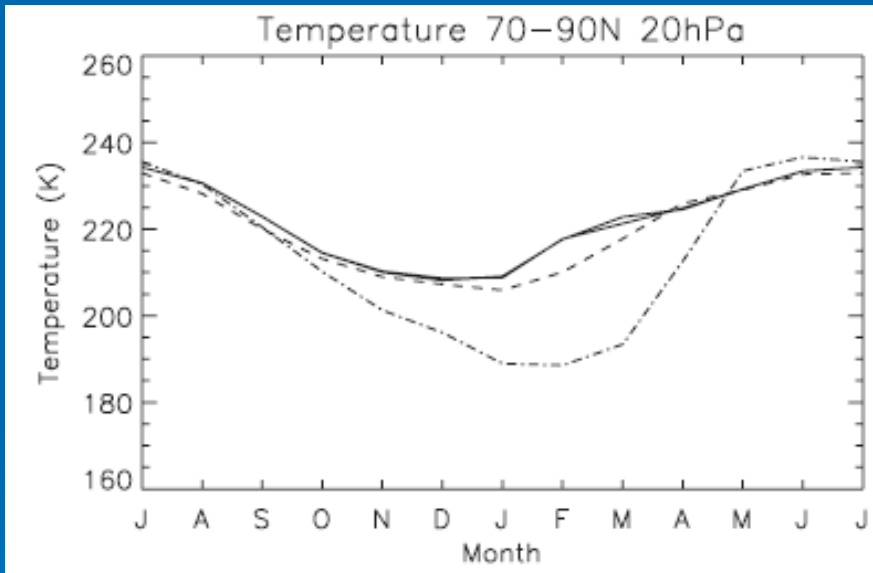
gravity wave source

$$\frac{\partial U}{\partial t}, \frac{\partial V}{\partial t}$$
$$\frac{\partial S}{\partial t} = ?$$

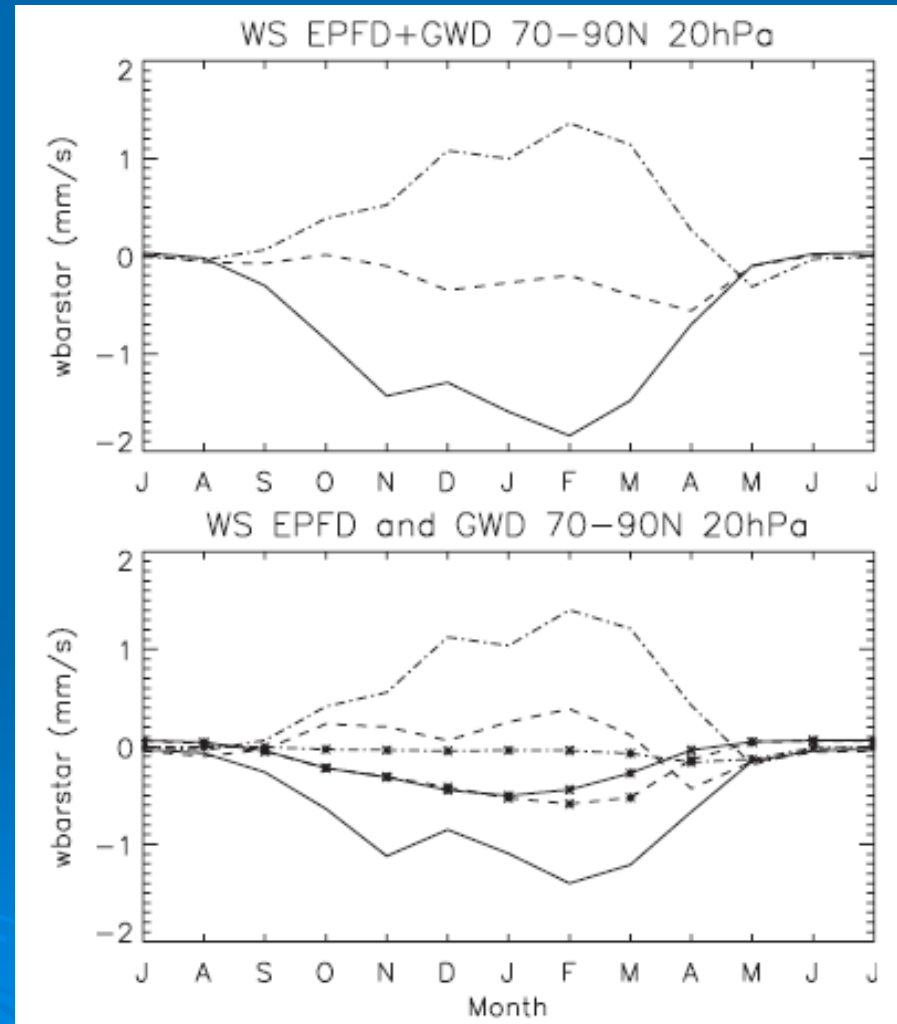
momentum conservation

no momentum leaking through model top

➤ Shaw et al, 2009



high lid (0.001 mb), conservative
low lid (10 mb), conservative
low lid (10 mb), non-conservative



experiment design

➤ EXP1:

uniform momentum tendency below source
energy conservation

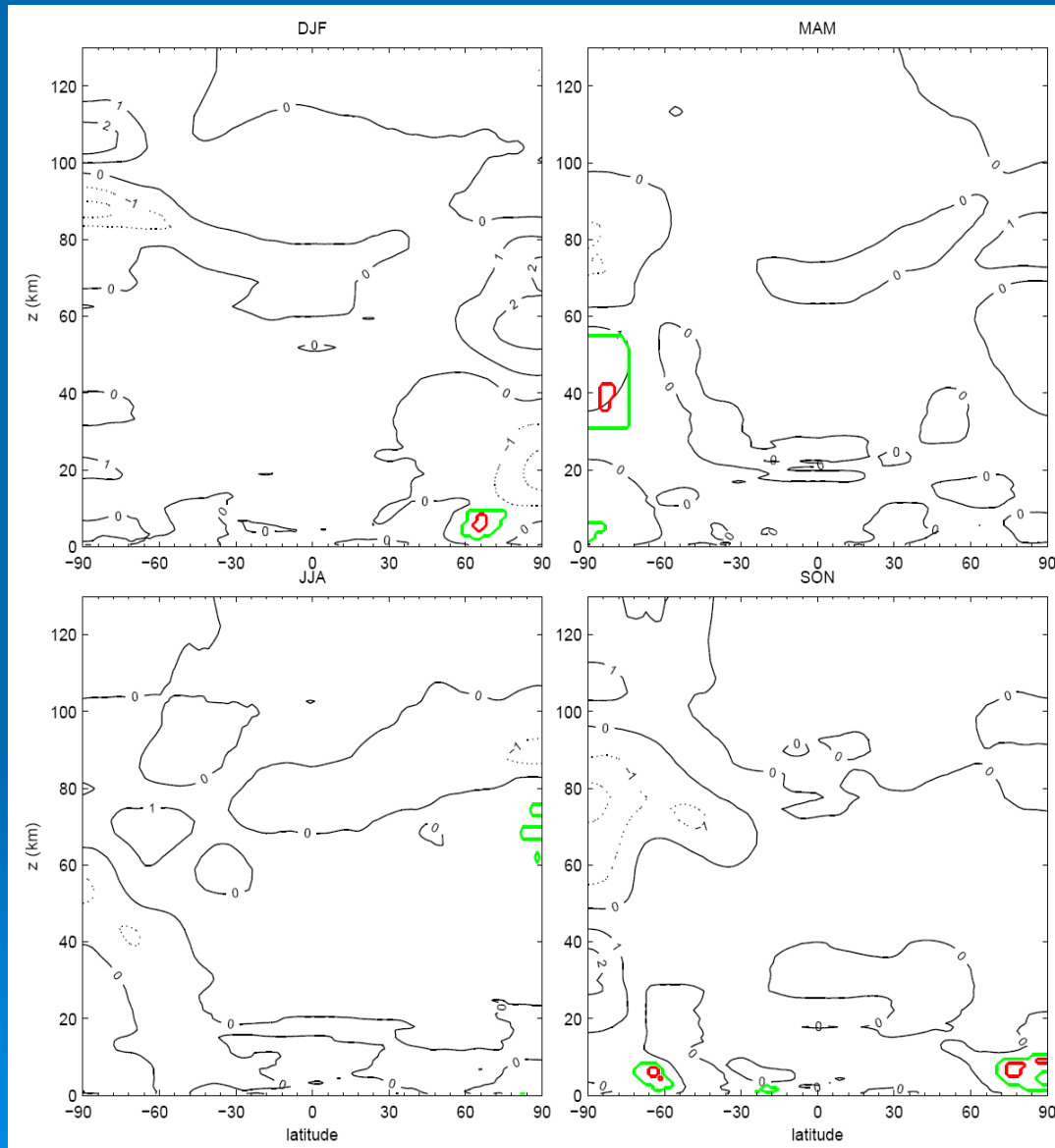
➤ EXP2:

uniform velocity tendency below source
energy conservation

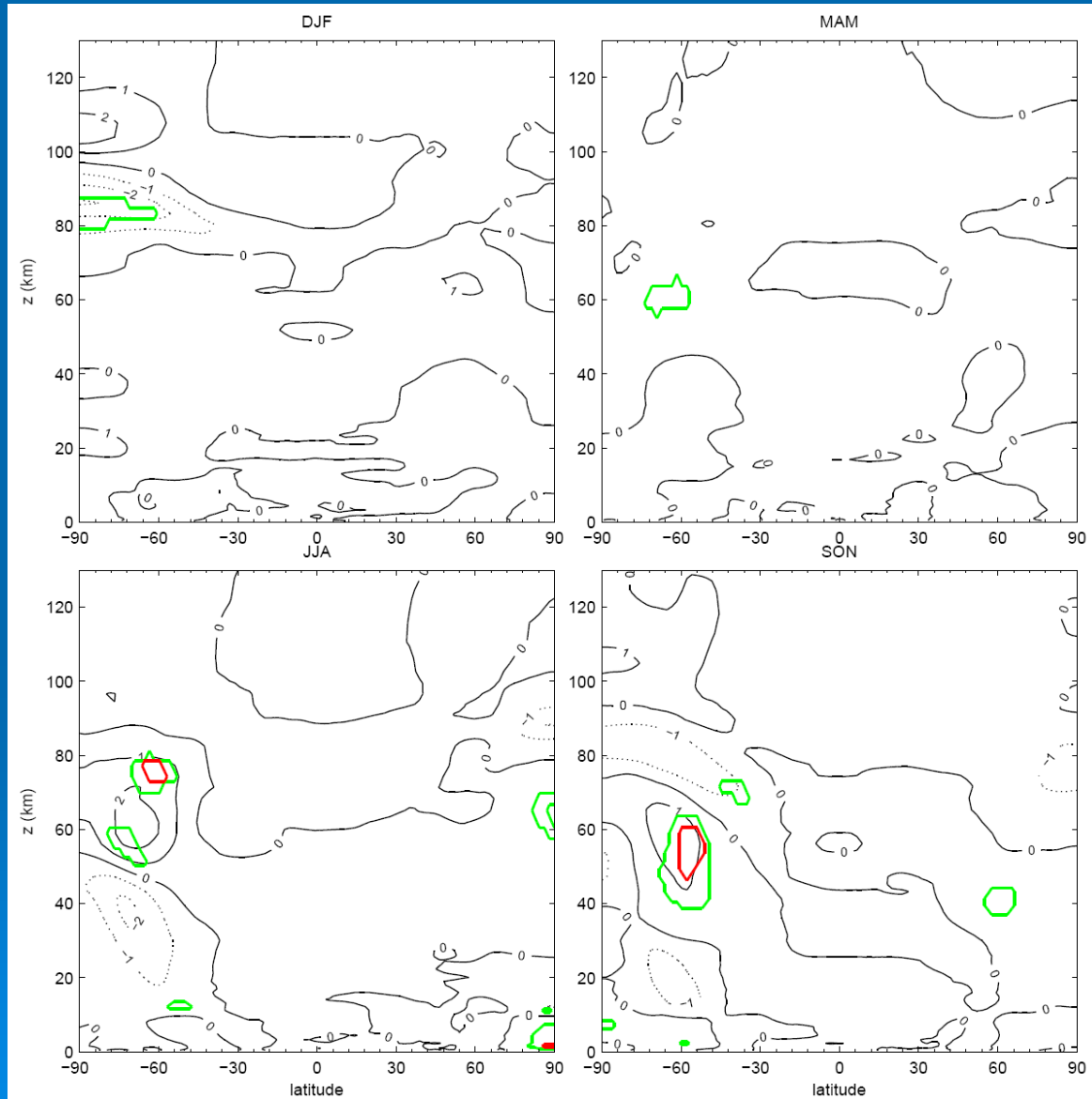
➤ EXP3:

same as exp2, plus momentum conservation

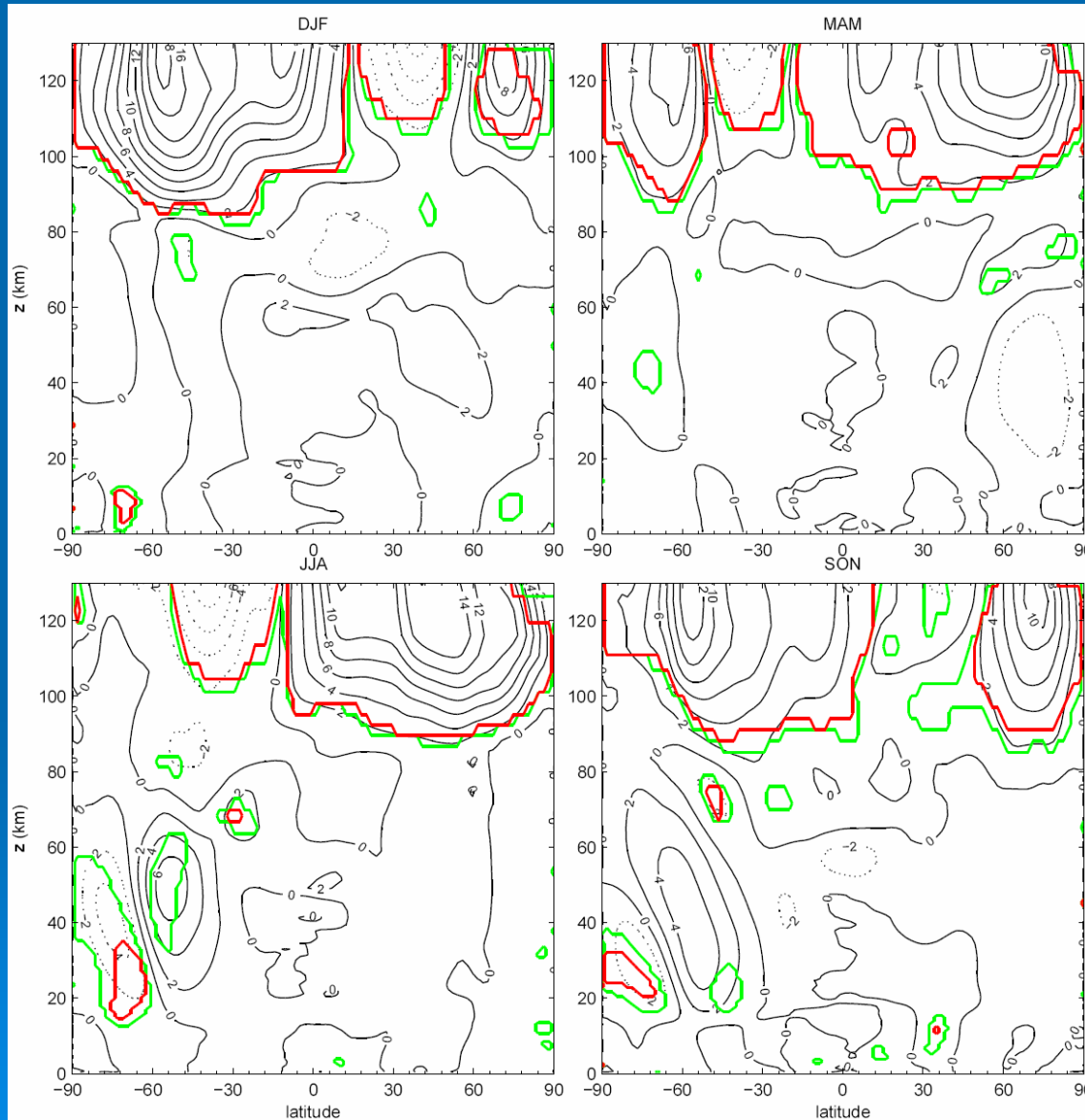
EXP1: T difference



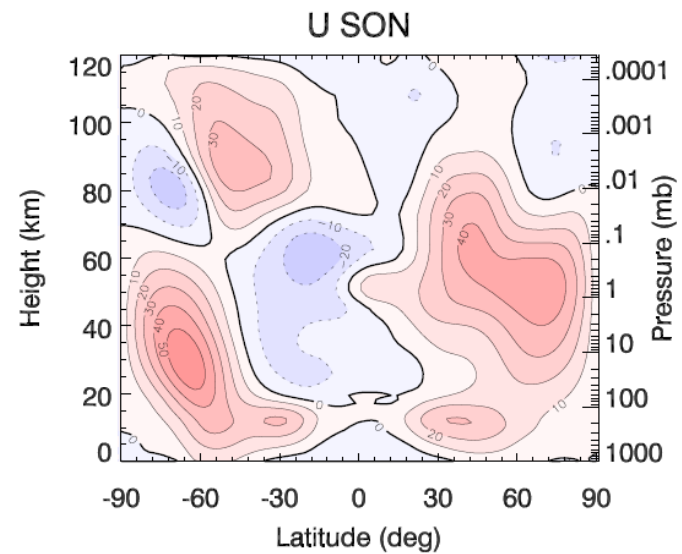
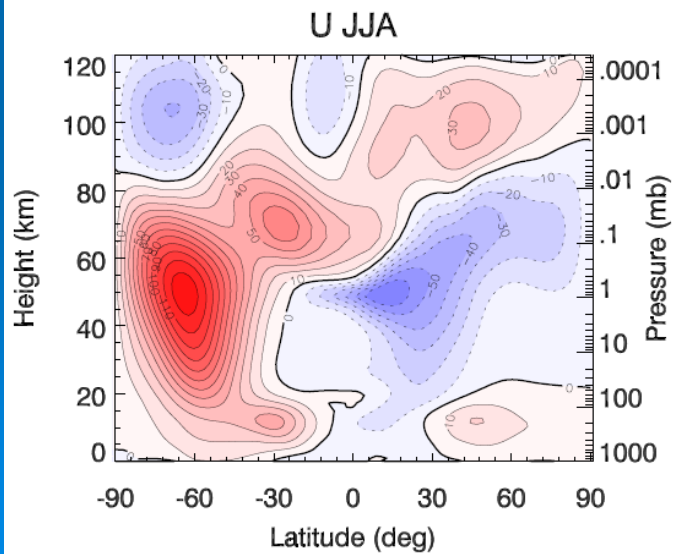
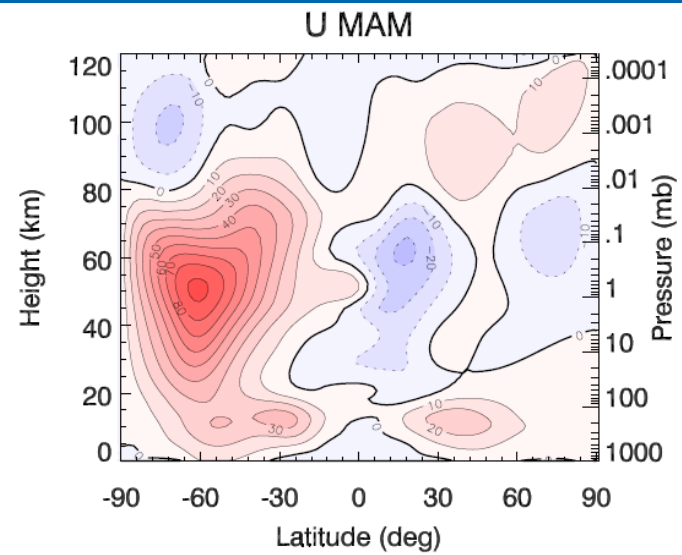
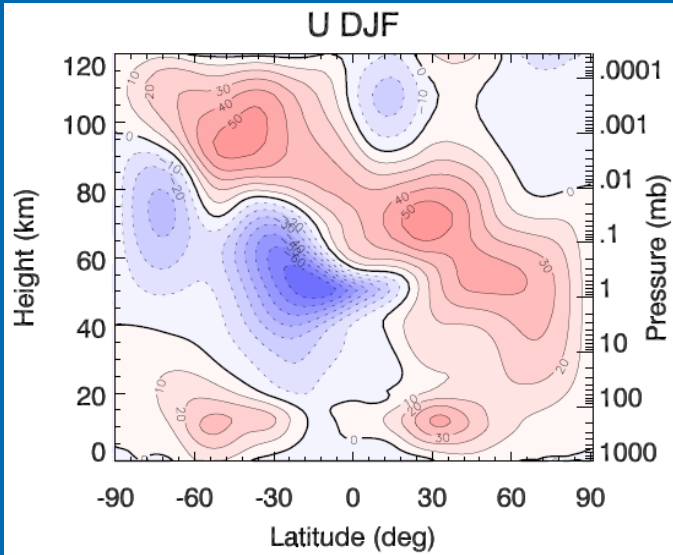
EXP2: T difference



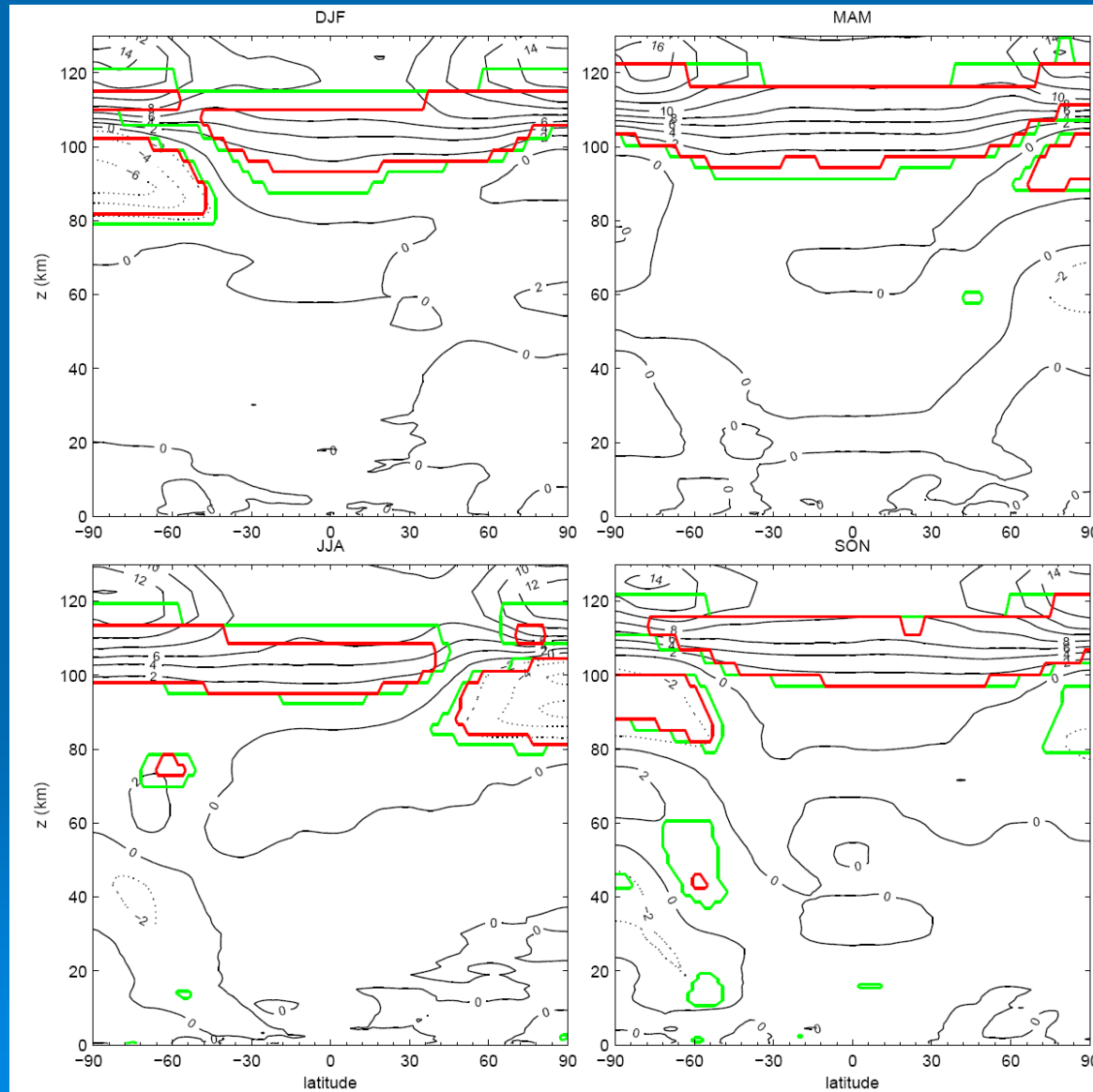
EXP3: U difference



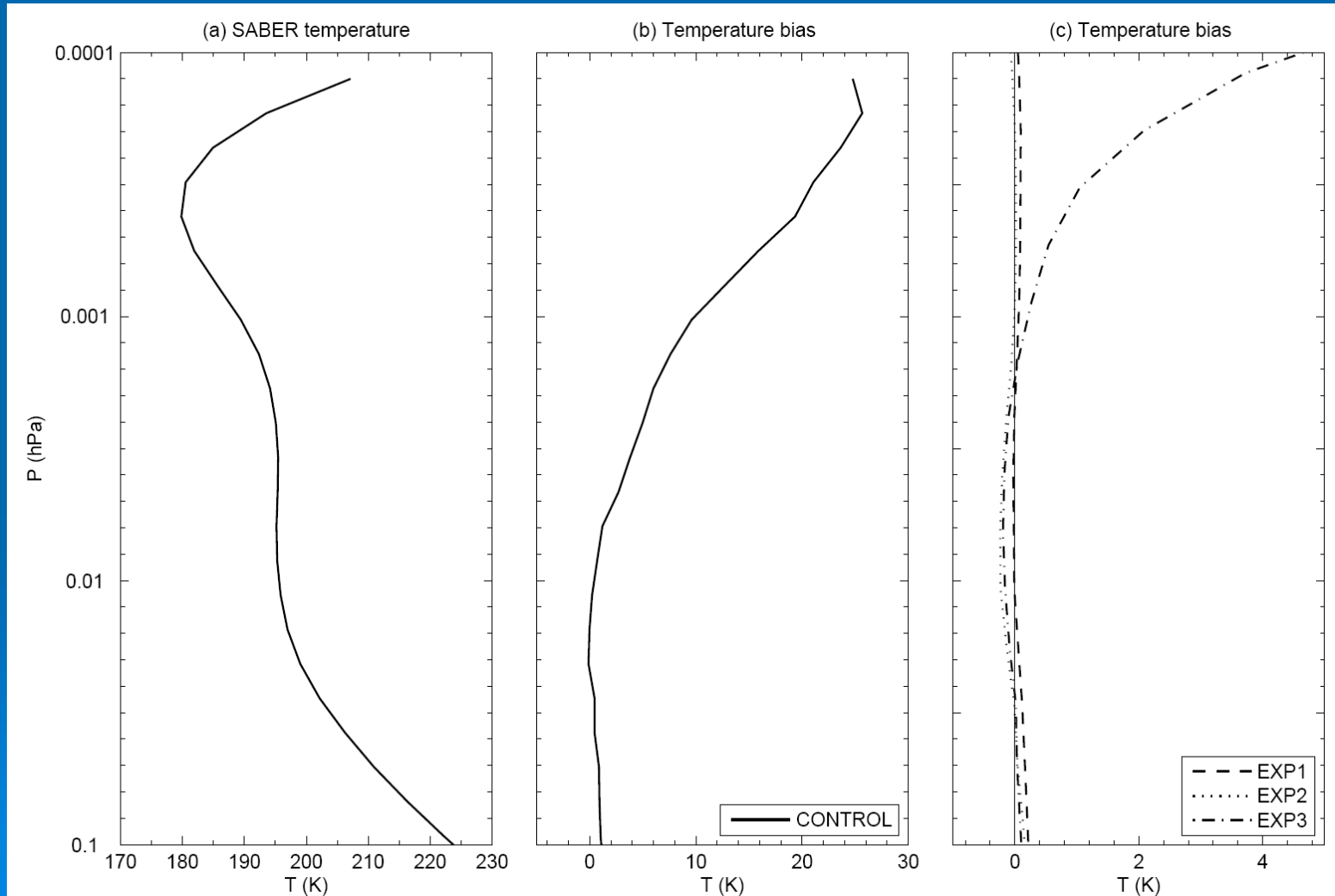
CONTROL : U



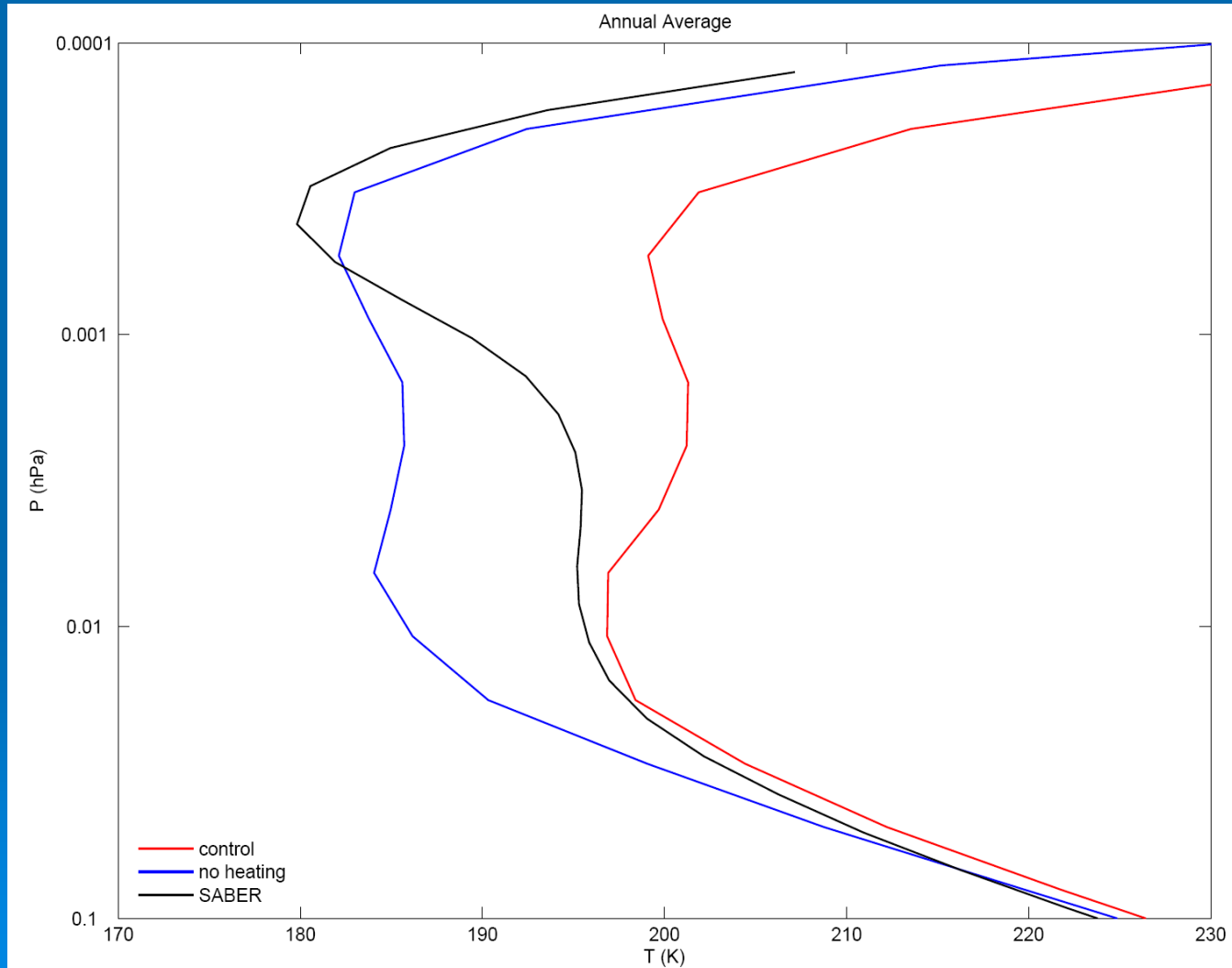
EXP3: T difference



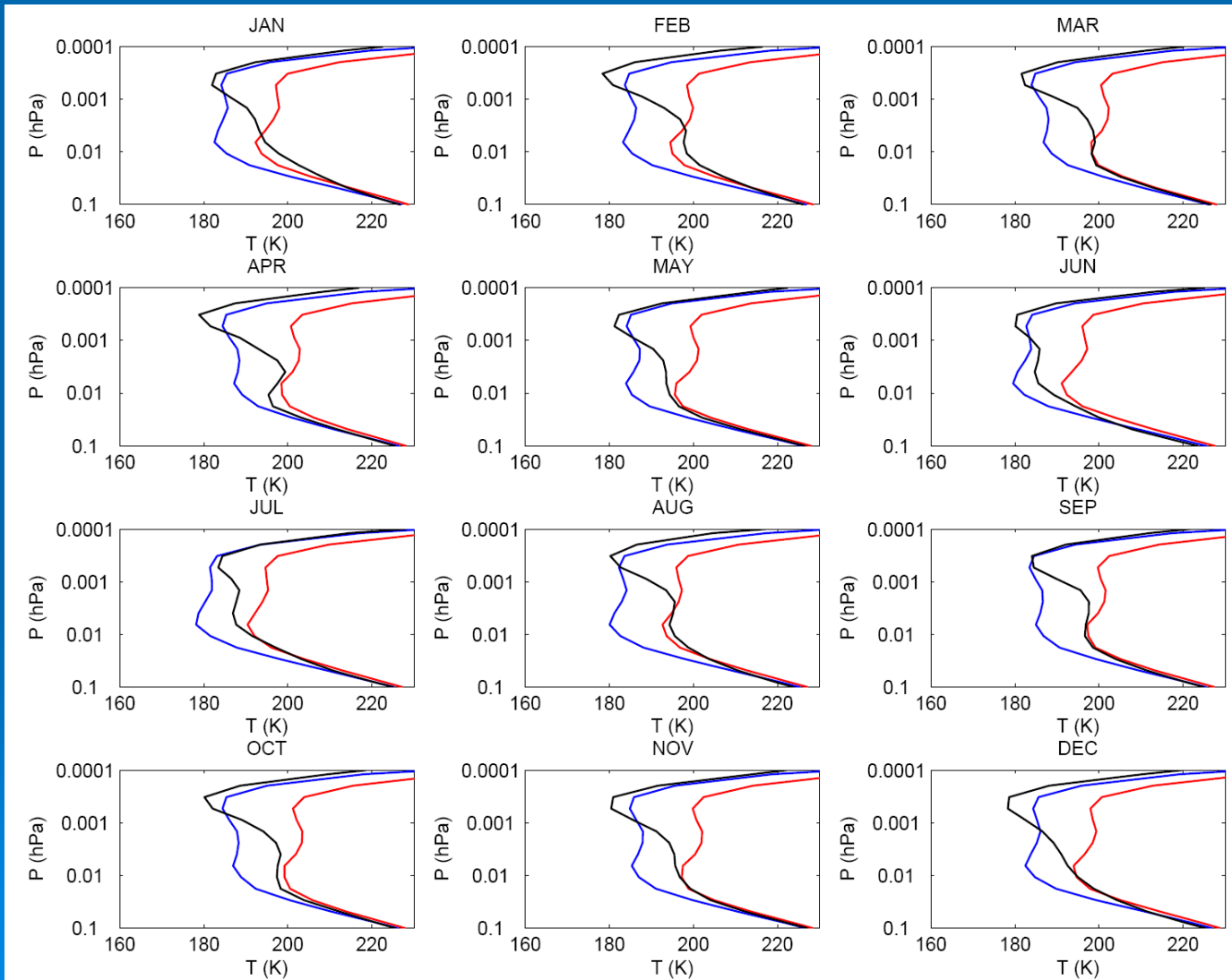
Temperature profile vs SABER



turning off heating in GWD parameterization (blue curve)



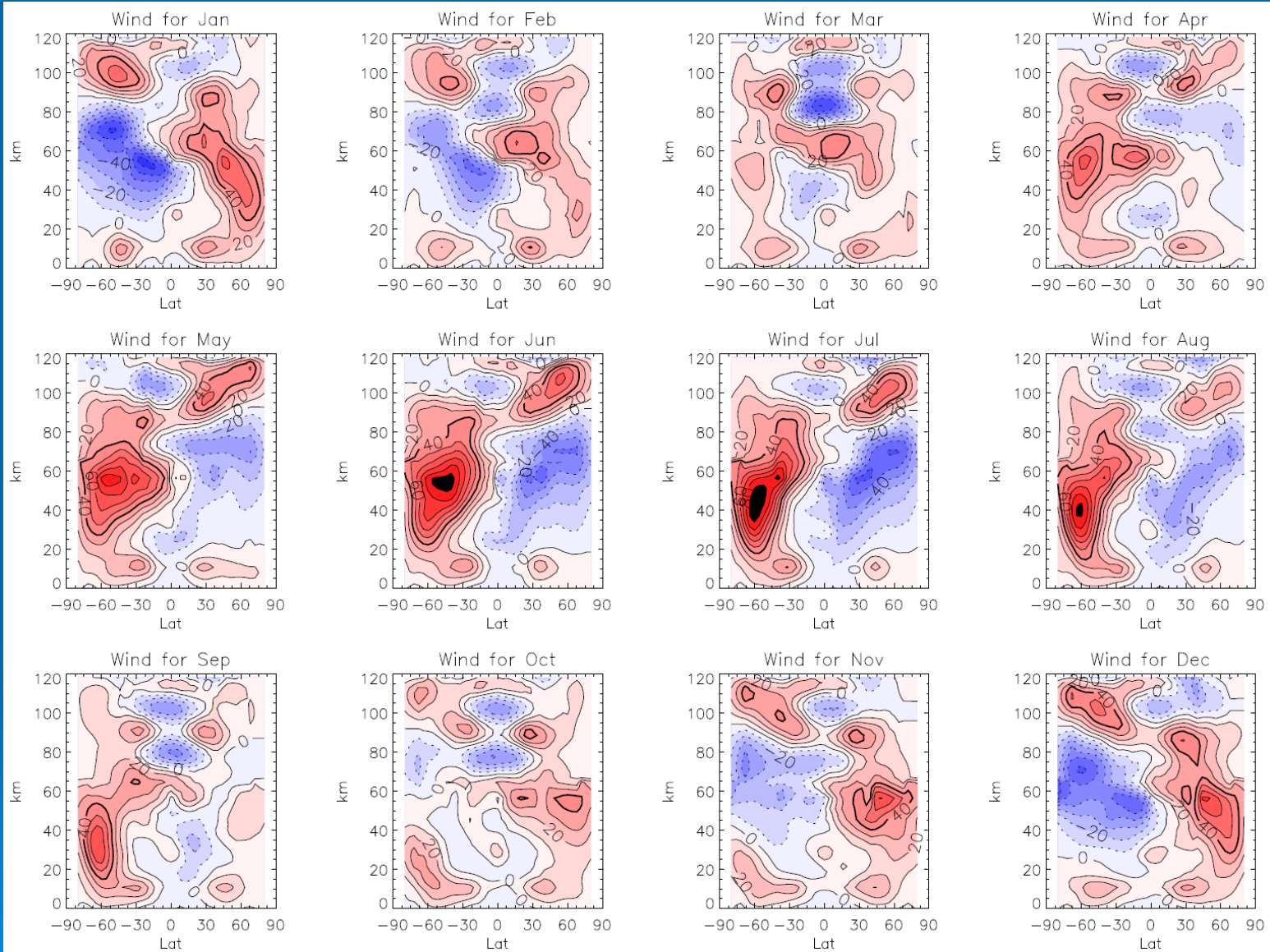
turning off heating in GWD parameterization (blue curve)



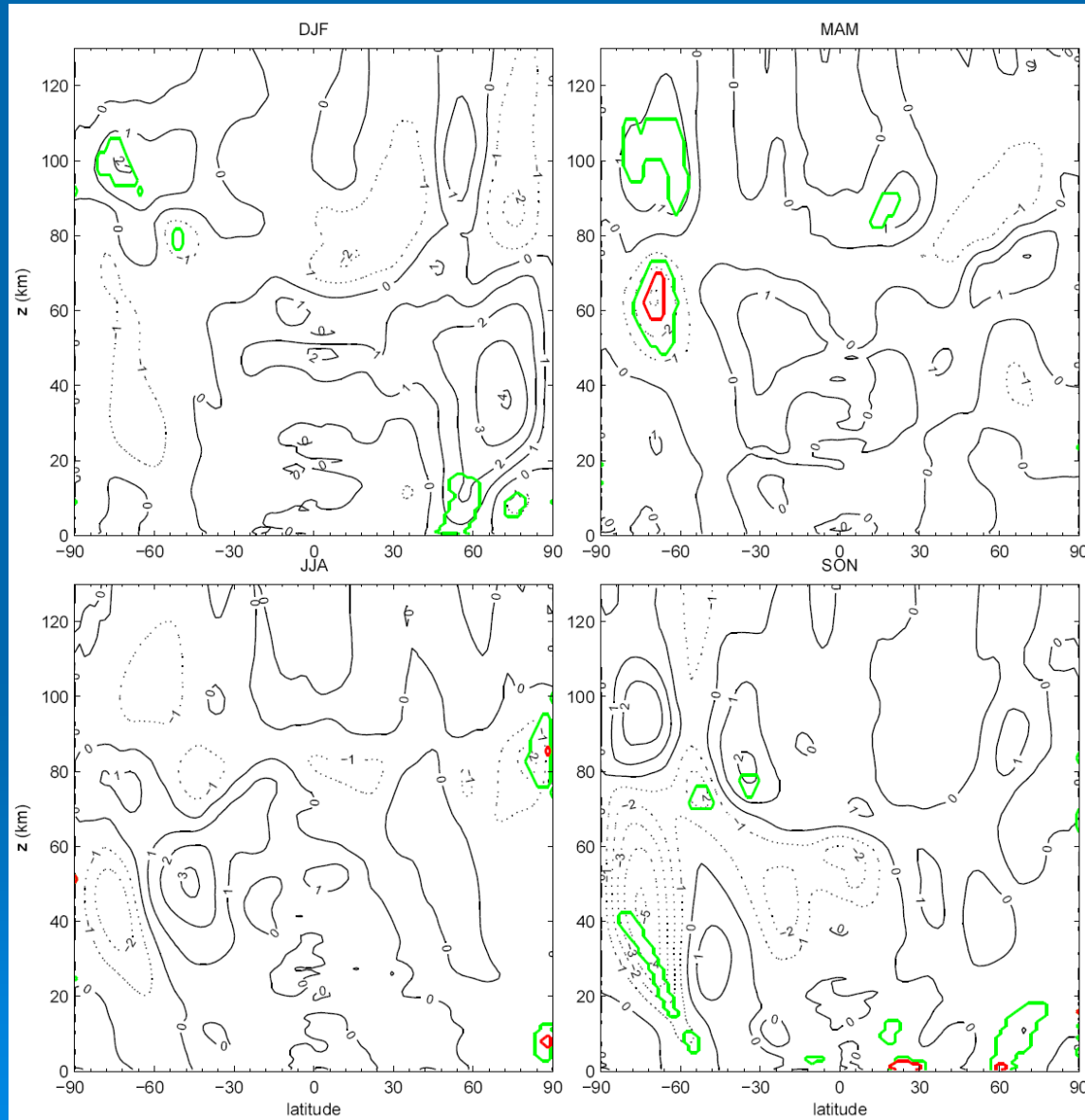
Summary

- Momentum and heating tendencies added below the source level do not produce significant changes in the simulated circulation.
- Setting momentum flux to zero at the model top creates dramatic changes in the simulation. This implies that there is substantial gravity wave action near the model top.
- Momentum conservation for WACCM further intensifies warm biases above the mesopause.
- Turning off gravity wave heating reduces warm biases, implying GW heating may be overestimated in the parameterization.

obs: U



exp1: U difference



exp2: U difference

