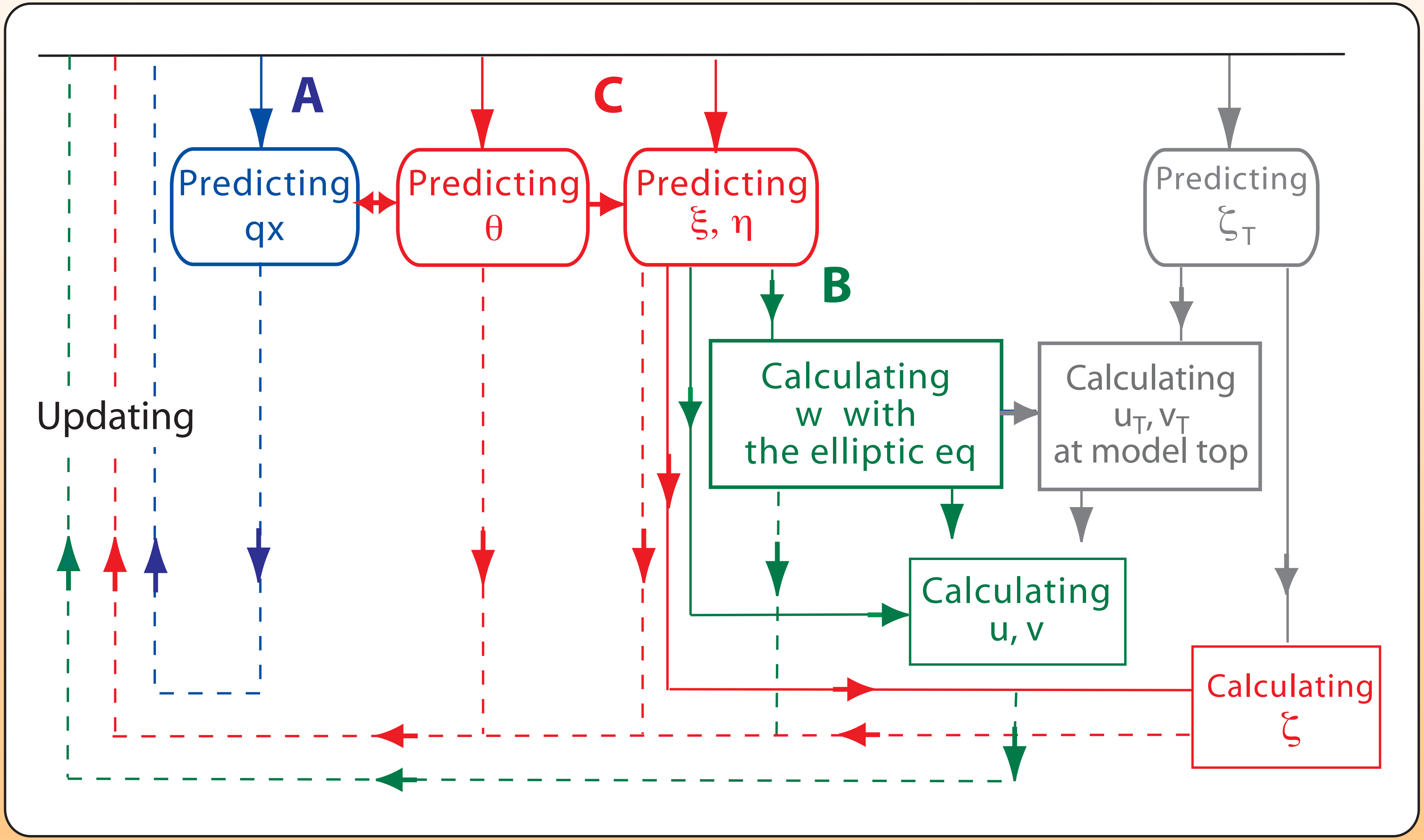
EXPERIMENTAL STRATEGY

- Break up the algorithm to pieces, and test one piece at a time.
- Always quantitatively compare with the results of 3D control run.
- Comparison is mainly through the time sequences of spatial variances (and covariances) rather than through spatial/temporal means only.

Three types of experiments being performed



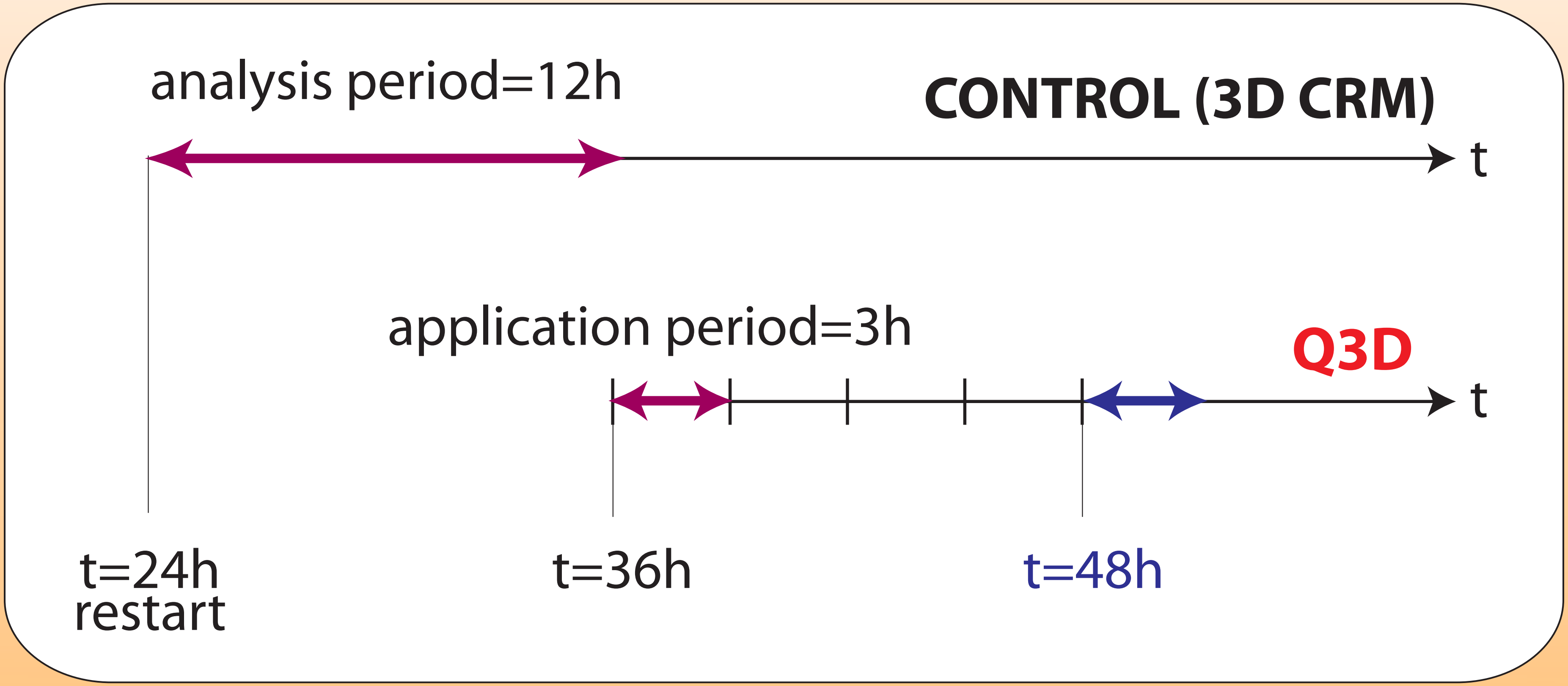
Experiment 1: **A** u, v , w & θ prescribed from control

Experiment 2: **B** + **A** ξ, η & θ prescribed from control

Experiment 3: **C** + **B** Heating rate prescribed from control

TESTING PERFORMED

for an idealized, very small domain first



3D CRM

A three-dimensional anelastic model based on the vector vorticity equation

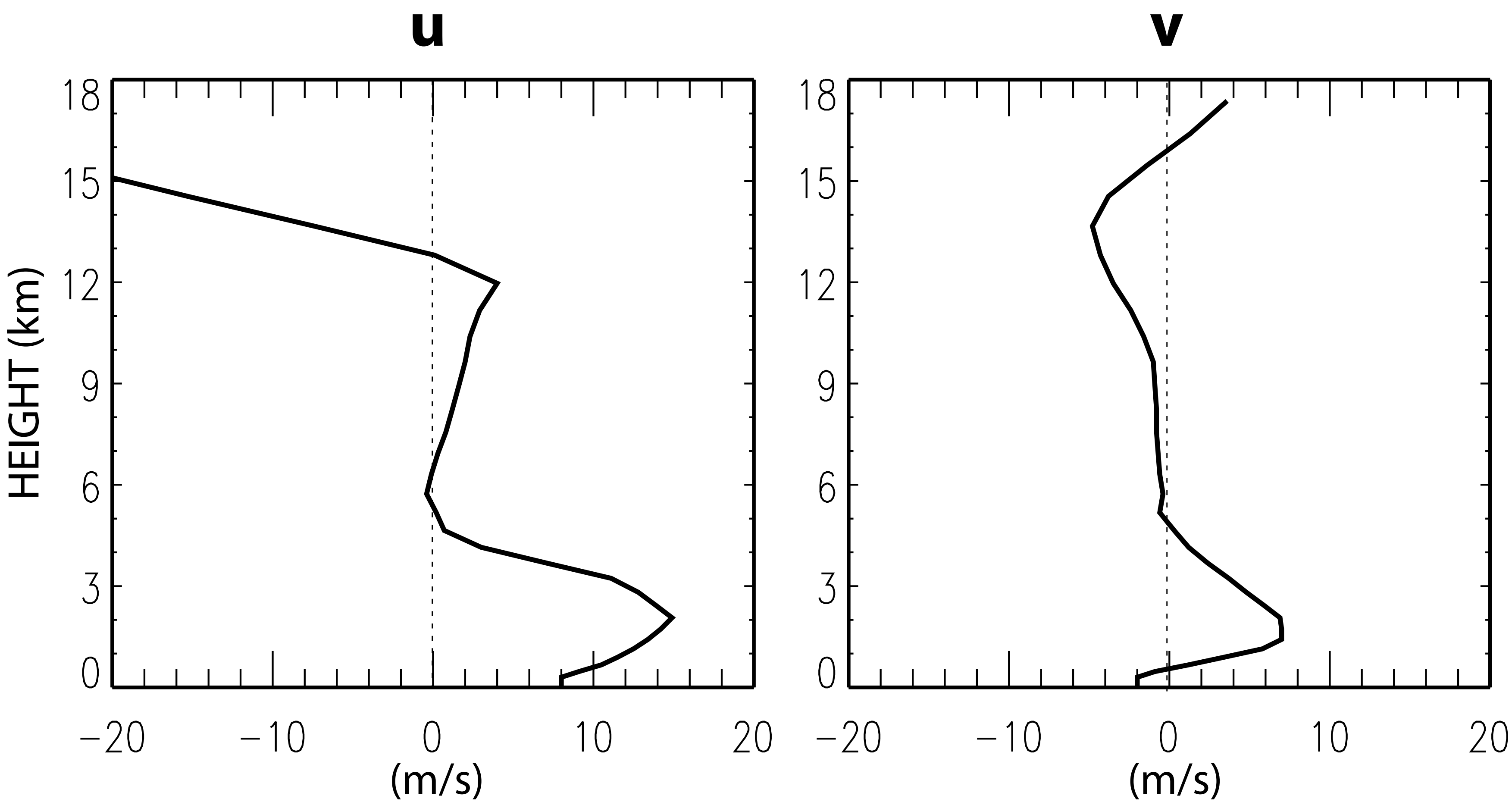
by Joon-Hee Jung and Akio Arakawa (2006), Submitted to MWR

Control Run

- **Domain size:** 126 km x 126 km x 18 km (height)
- **Horizontal resolution:** 3 km
- **Vertical resolution:** 34 layers with a stretched vertical grid
- **Lower-boundary:** ocean surface with a fixed temperature
- **Idealized tropical condition:** based on the GATE Phase-III mean sounding and wind profile during TOGA COARE
- **Large-scale forcing:** prescribed advective tendency
- **Perturbation:** small, random temperature perturbations into the lowest model layer

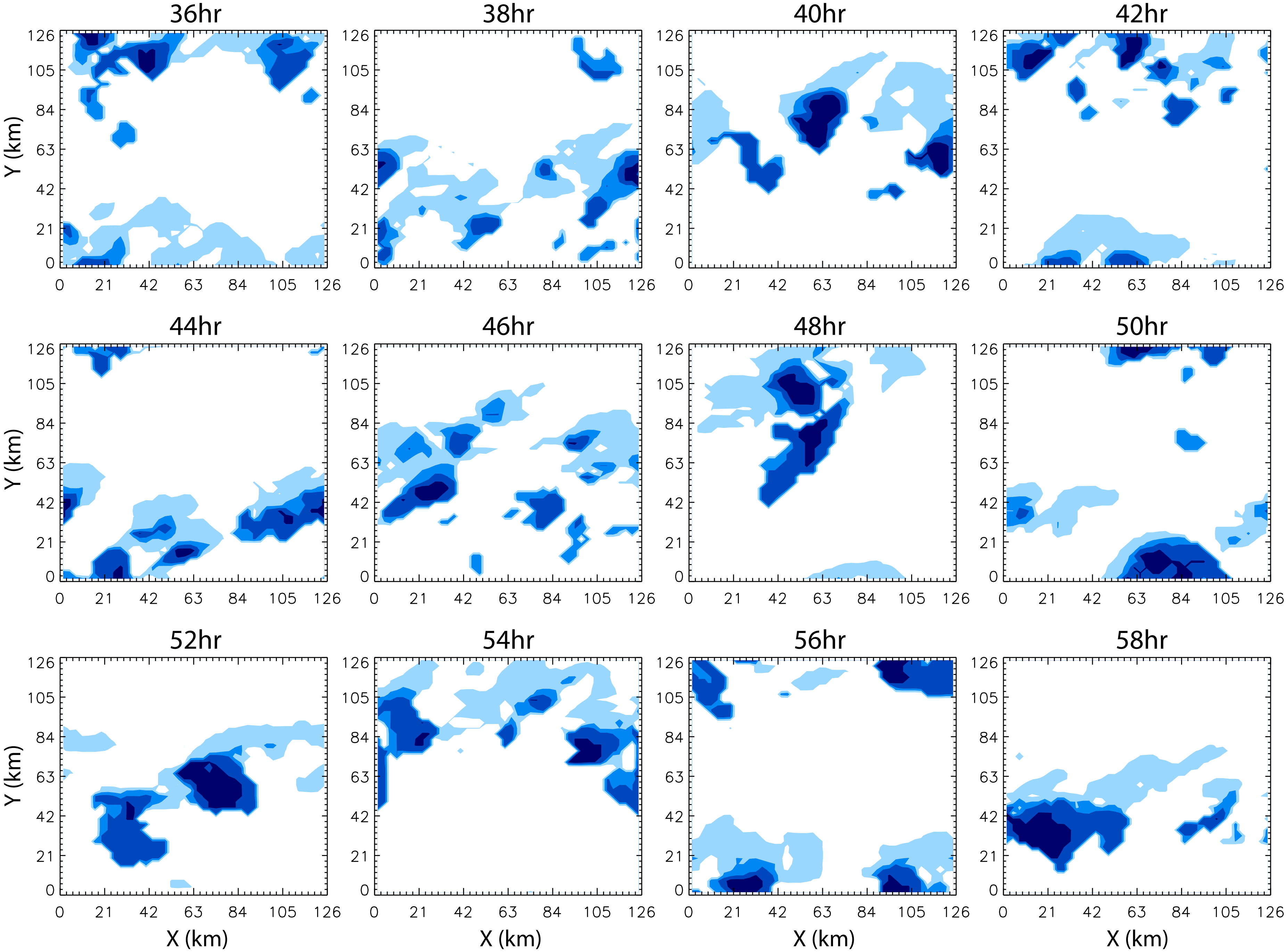
CONTROL

Domain Average



CONTROL

Cloud Top Temperature



Q3D RUN

All experiments are made with the same Q3D model.

Experiment 1:
Test for scalar advection (with cloud physics)

θ and all velocity components are prescribed.

Scalar variables on the network are predicted and those at the ghost points are obtained with the Q3D algorithm.

$$q = \overline{q} + q' + q''$$

$\overline{q}$: synoptic-scale (background field)

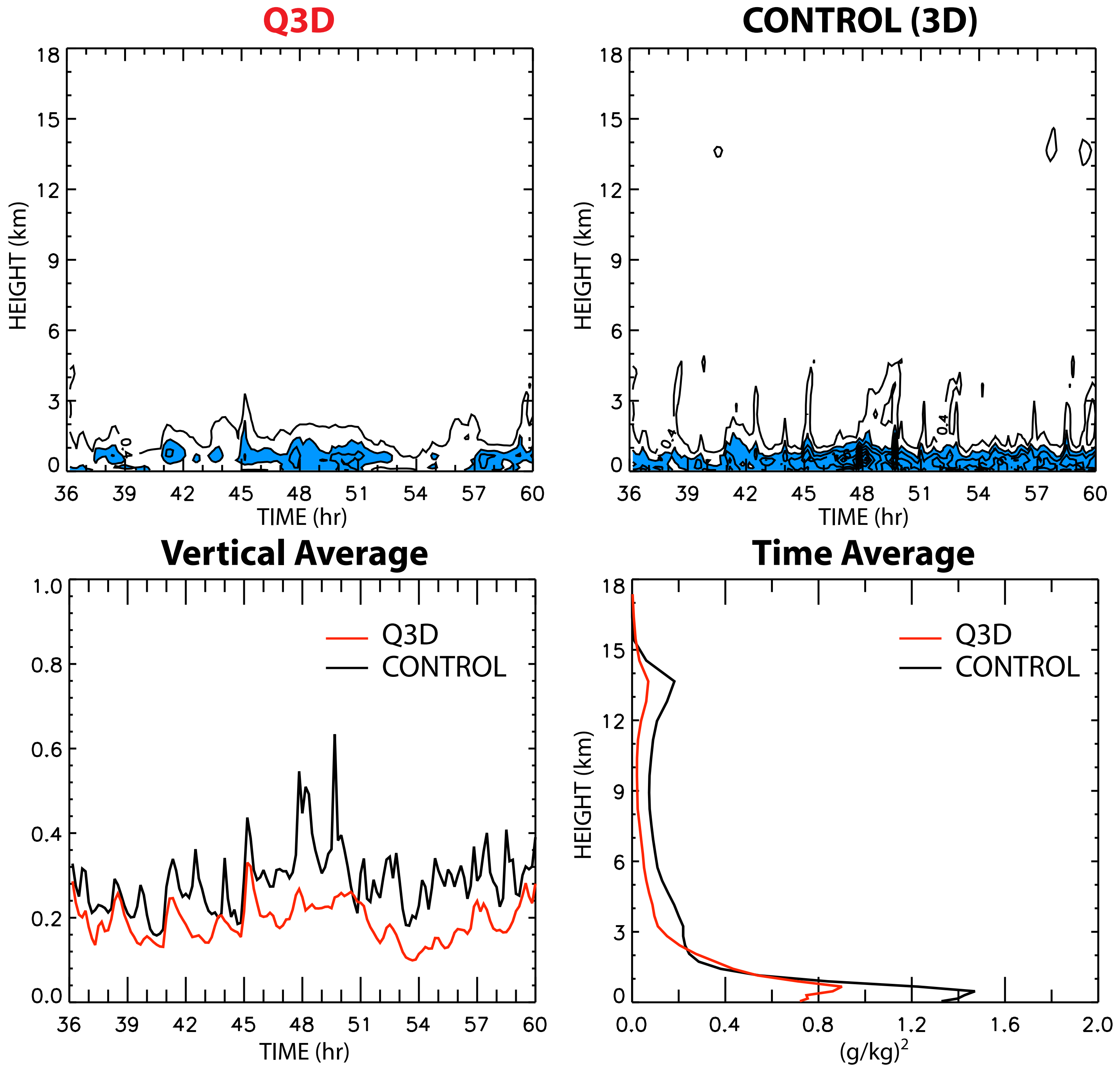
q': cloud-system scale

q'': cloud scale

q^* = $q' + q''$

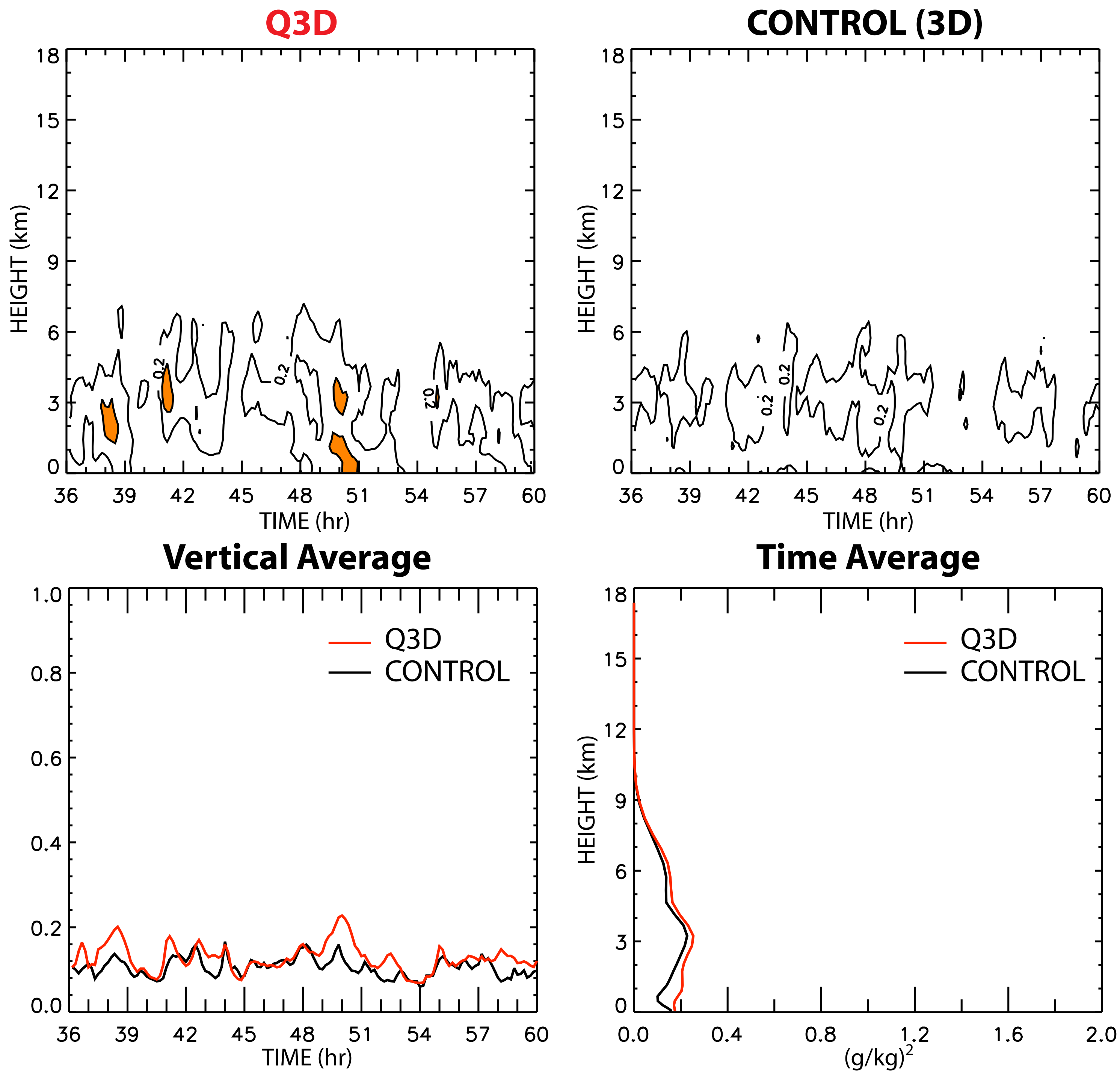
Experiment 1

q_t^{*2} : Network ***variance*** of tracer mixing ratio



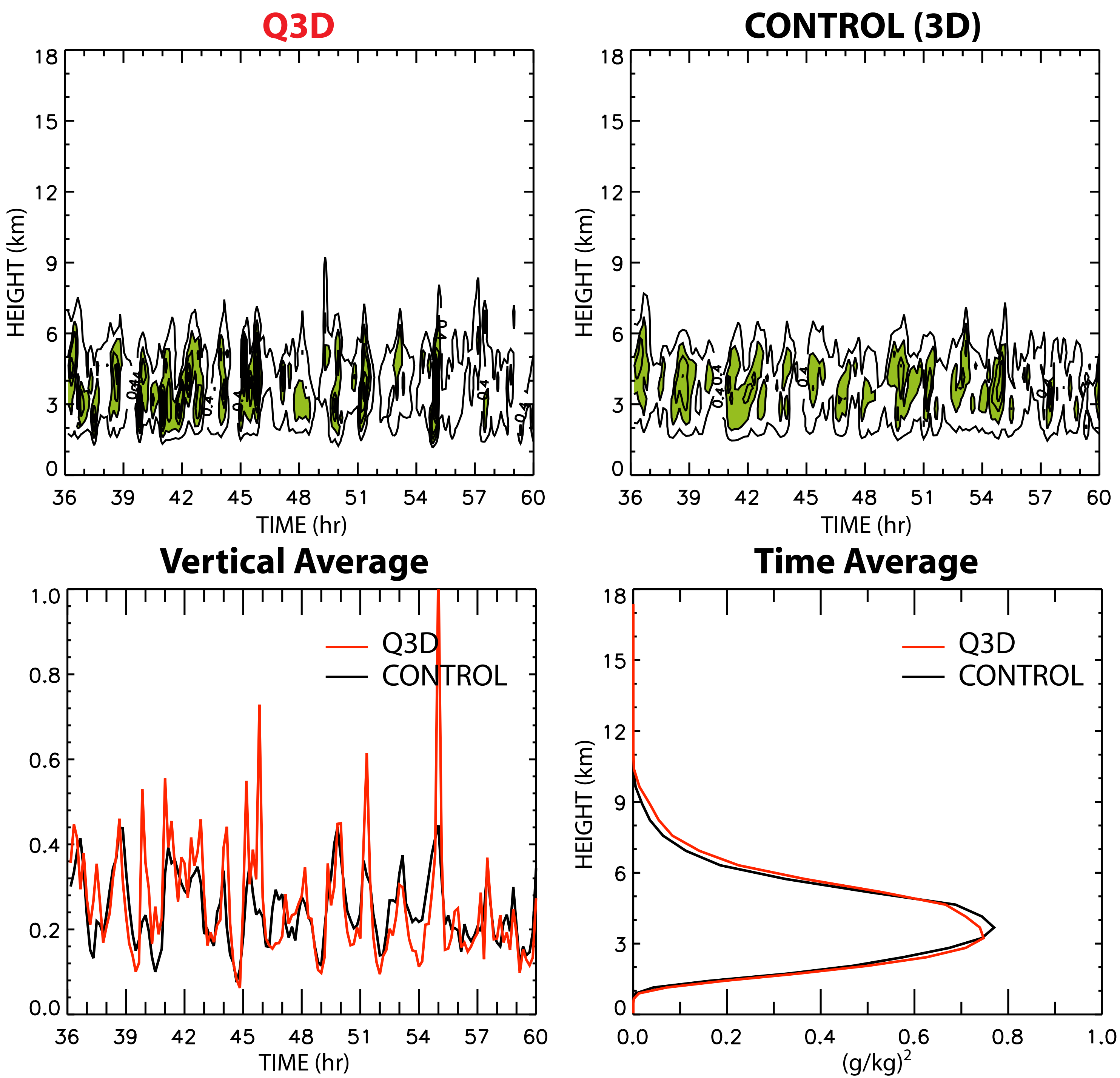
Experiment 1

q_v^{*2} : Network ***variance*** of water vapor mixing ratio



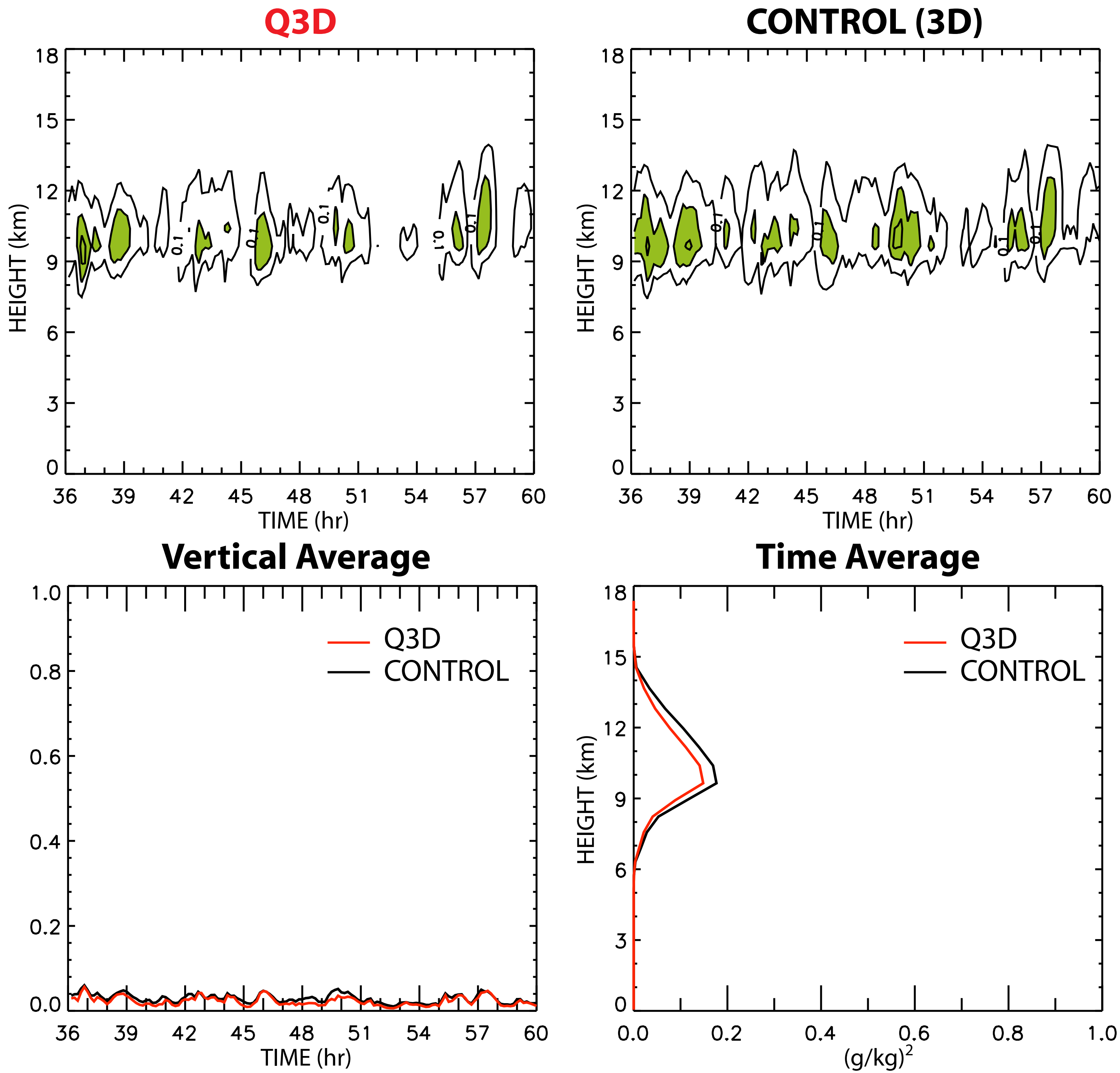
Experiment 1

q_c^{*2} **:** Network ***variance*** of liquid water mixing ratio (10^{-1})



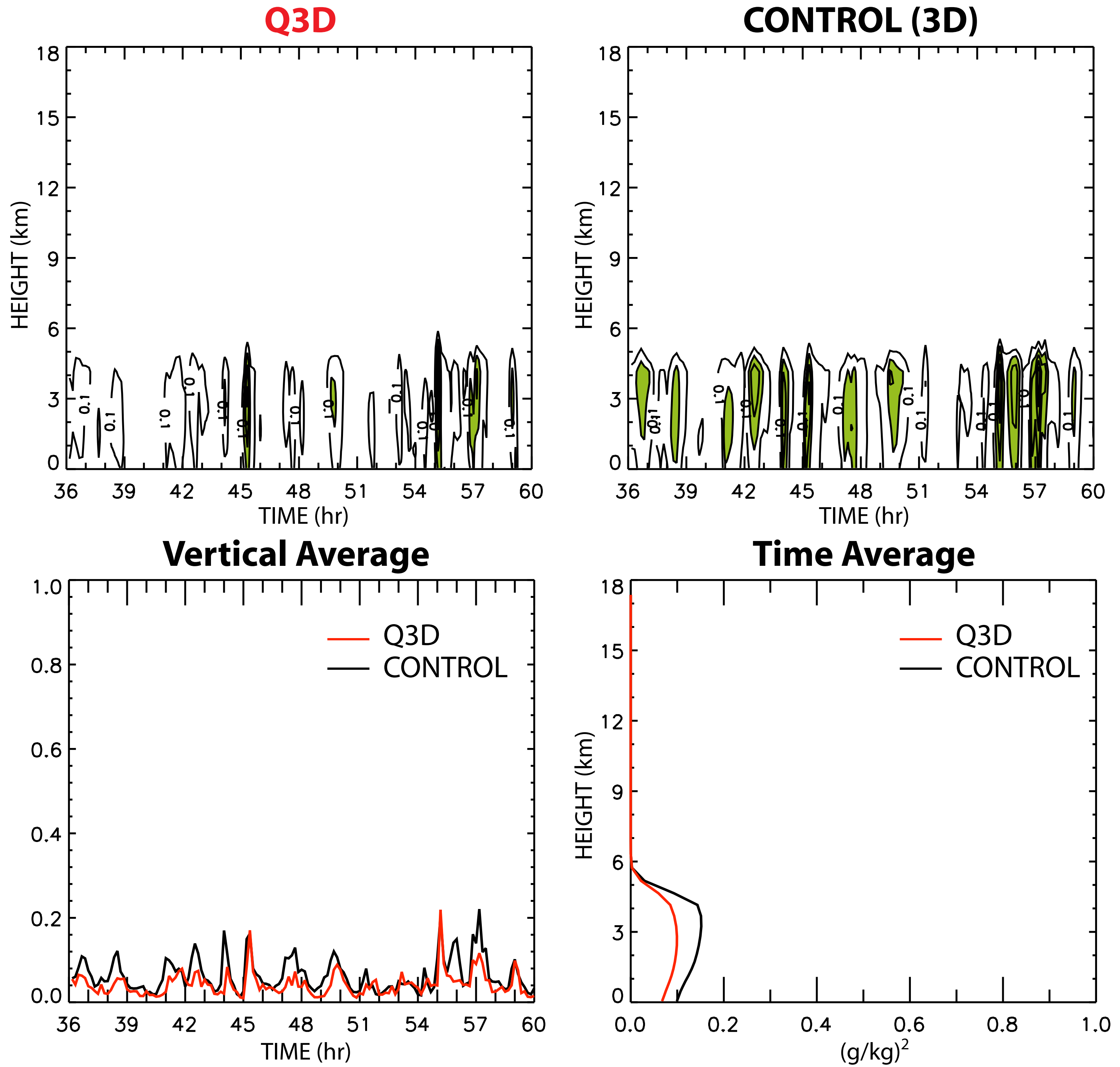
Experiment 1

q_i^{*2}: Network ***variance*** of ice water mixing ratio (10^{-1})



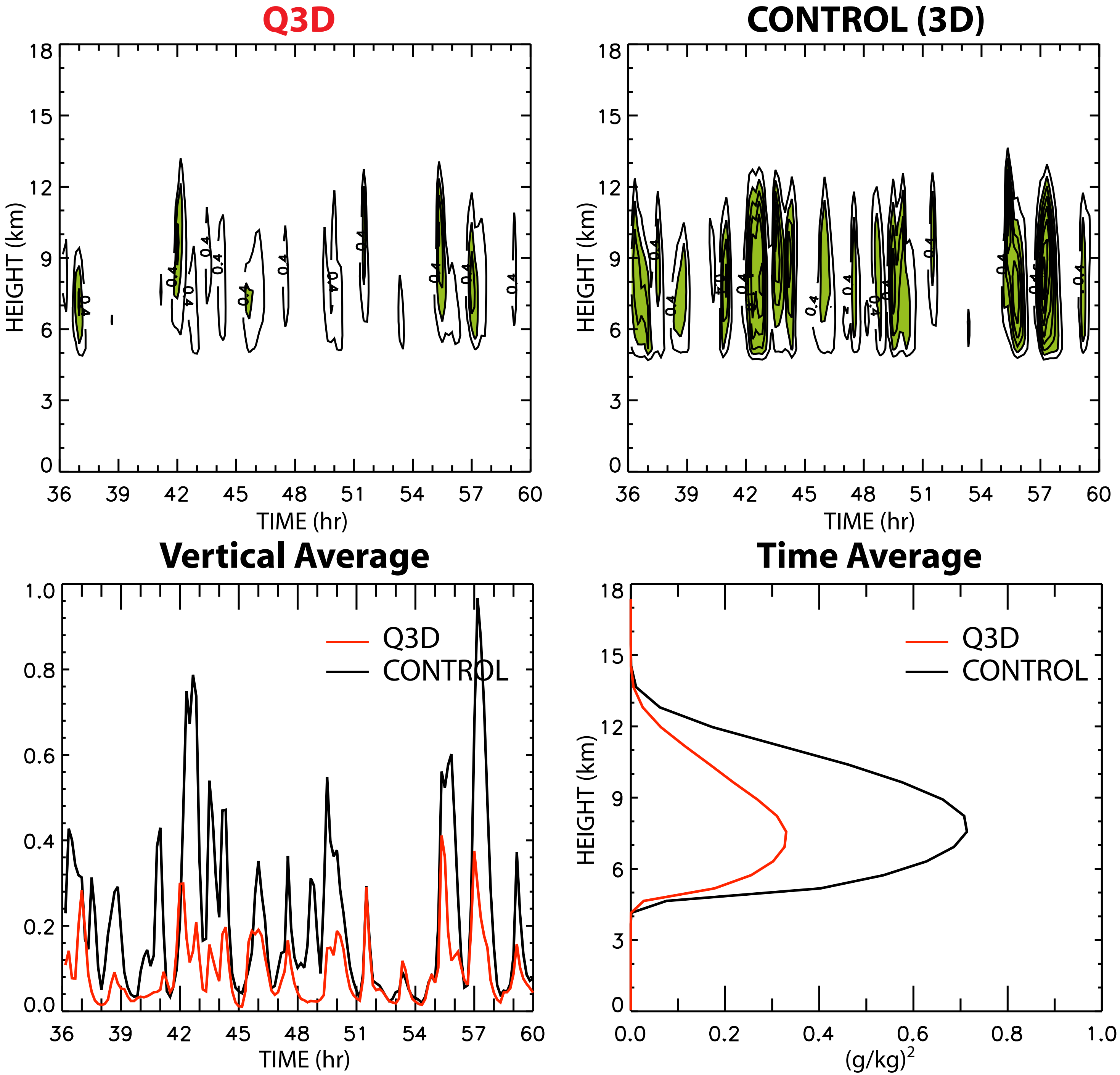
Experiment 1

q_r^{*2} **:** Network ***variance*** of rain mixing ratio



Experiment 1

q^{*2}_{s+g} **:** Network ***variance*** of (snow+graupel) mixing ratio



Experiment 1:
Test for scalar advection (with cloud physics)

- Q3D algorithm of scalar advection works reasonably well.

Experiment 2: Test for dynamics I

EXP2A

θ and all vorticity components are prescribed everywhere.

All velocity components are obtained from the Q3D algorithm.

EXP2B

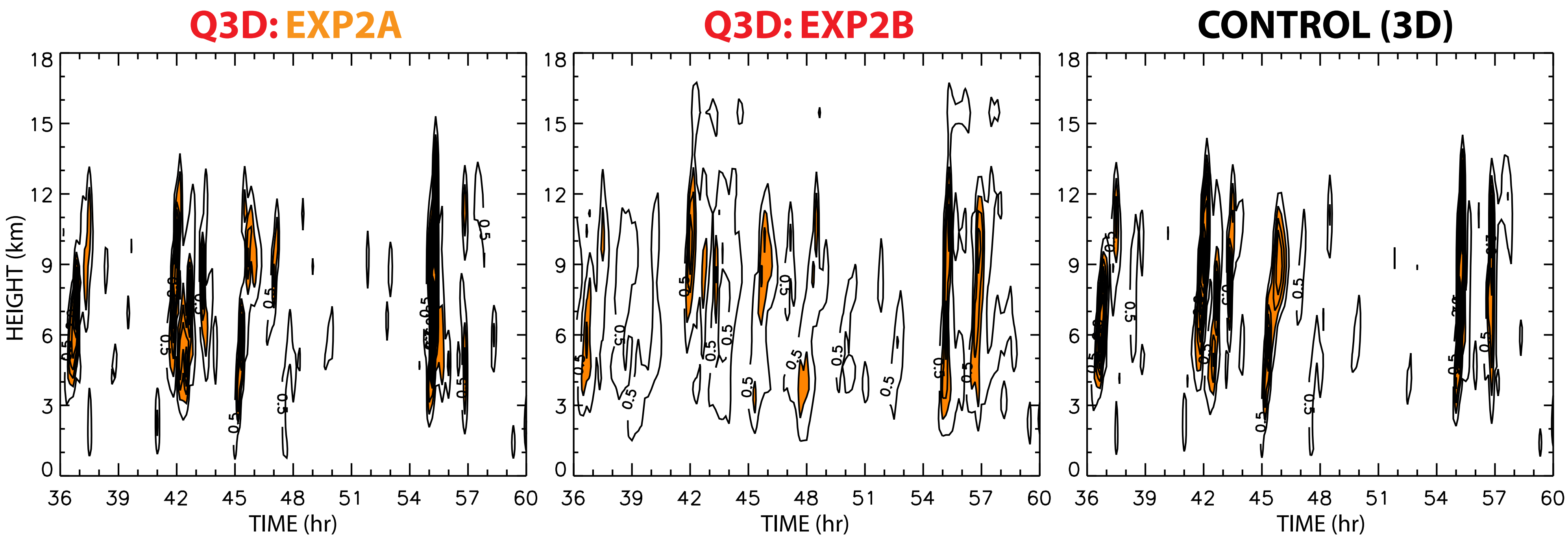
θ is prescribed everywhere and vorticity components on the network are prescribed.

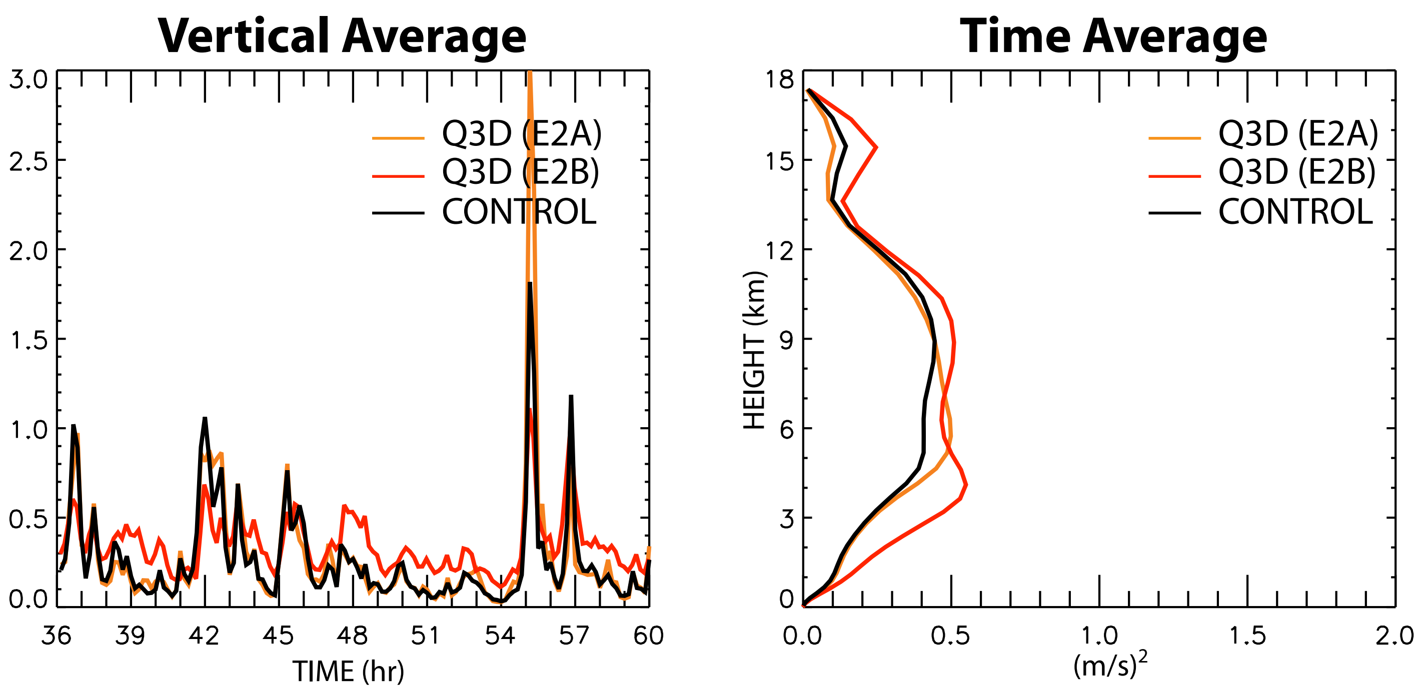
All velocity components and vorticity components at ghost points are obtained from the Q3D algorithm.

The vorticity gradient in the right hand side of the w-equation is obtained from the Q3D algorithm.

Experiment 2

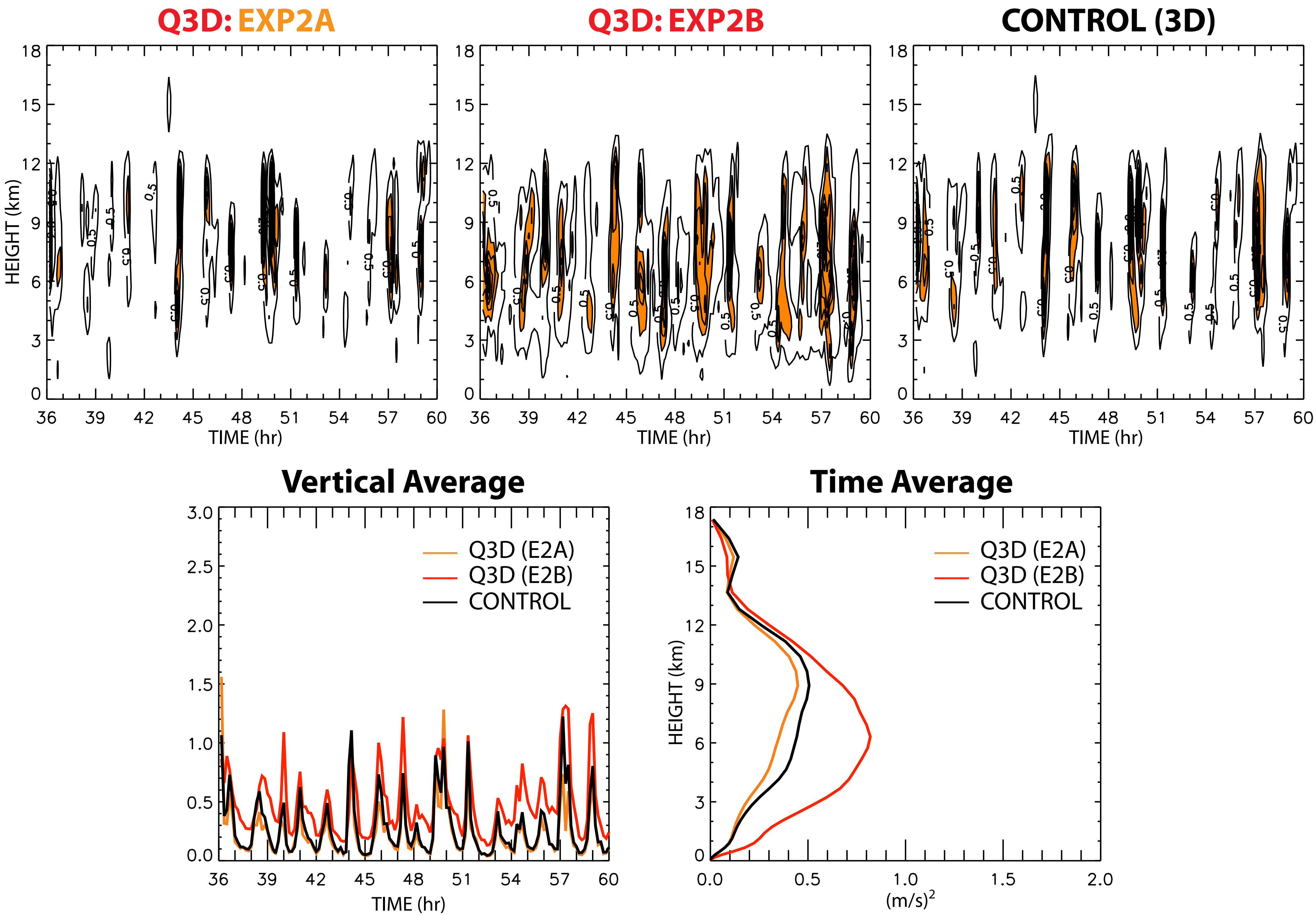
w^{*2} **:** x-array ***variance*** of vertical velocity





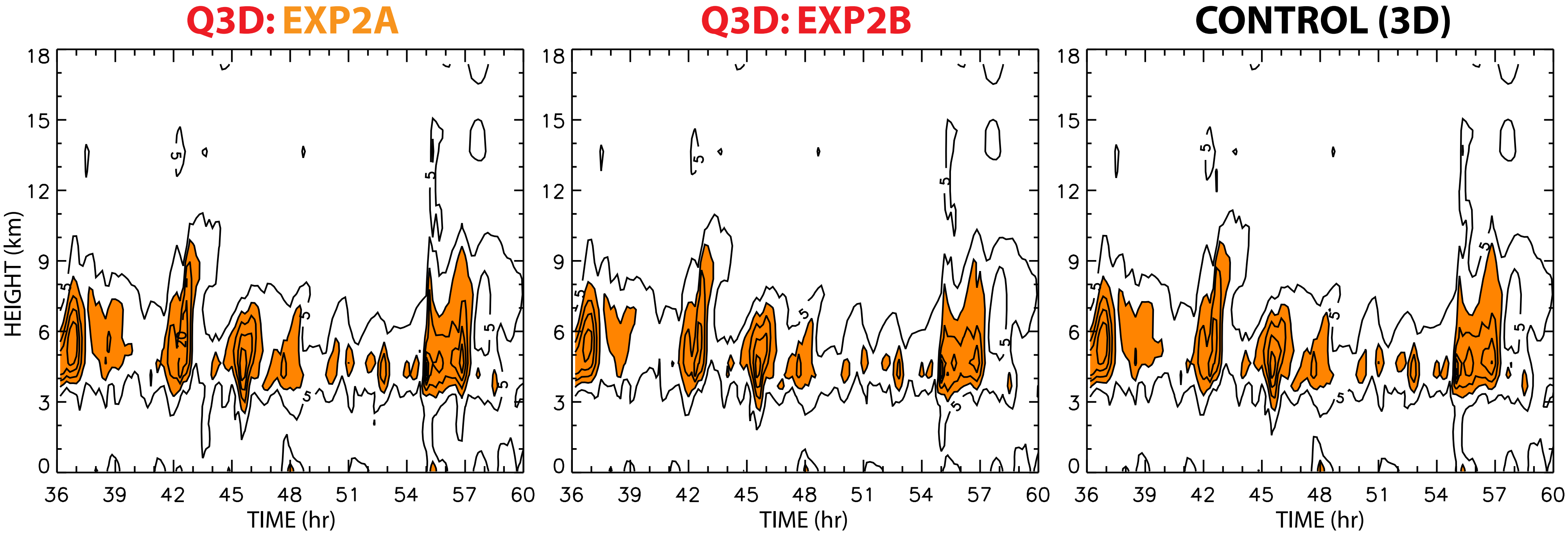
Experiment 2

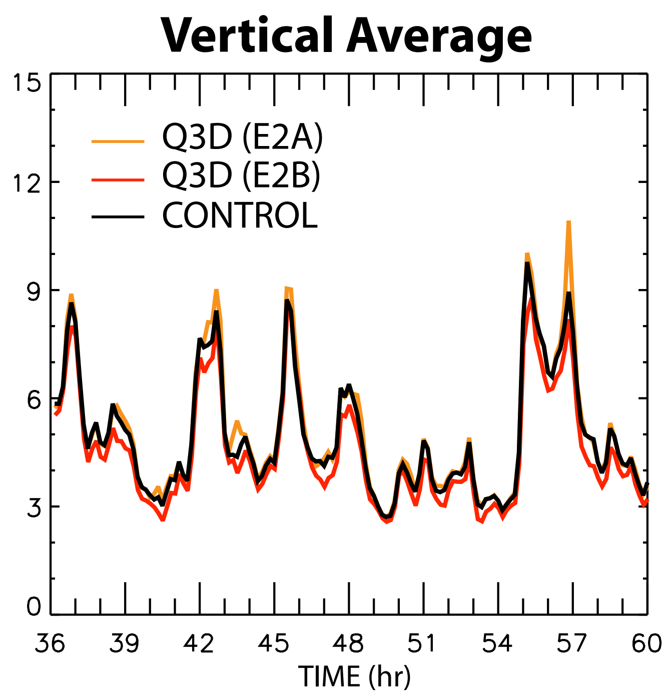
w^{*2} : y-array ***variance*** of vertical velocity

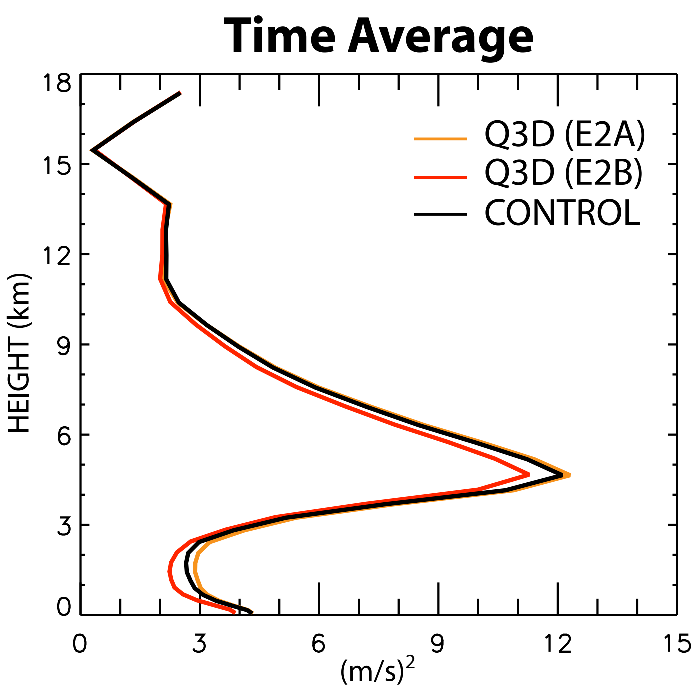


Experiment 2

u^{*2} **:** x-array ***variance*** of horizontal velocity

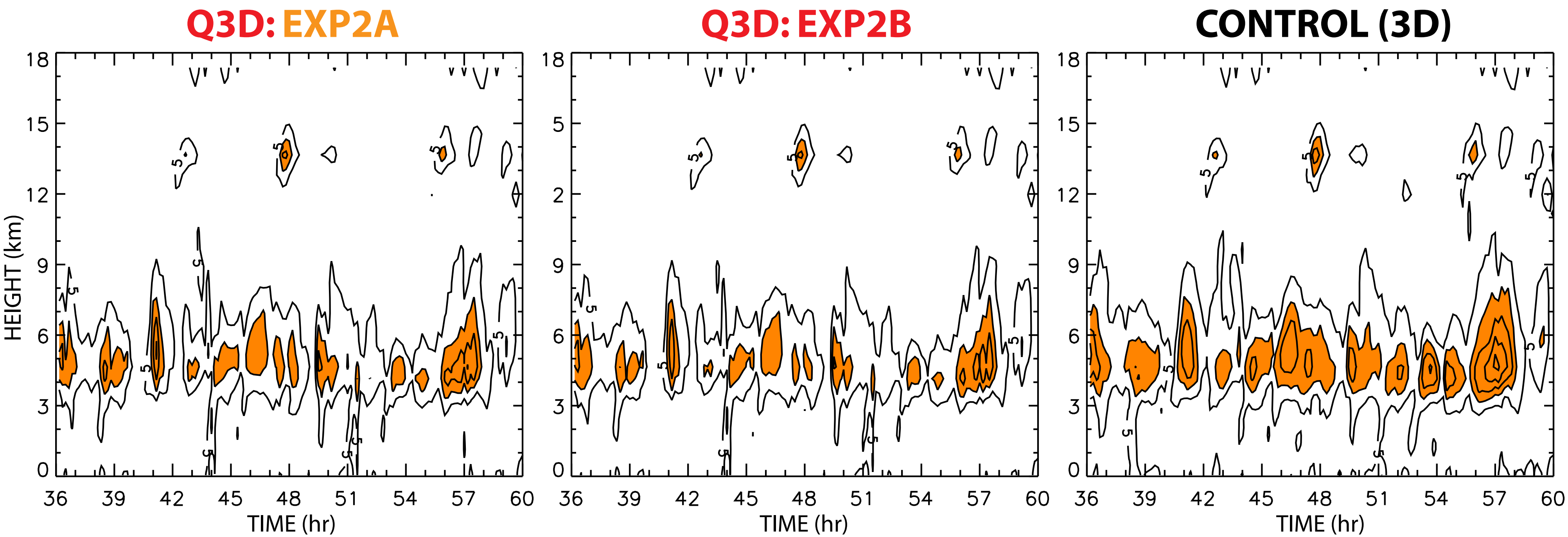


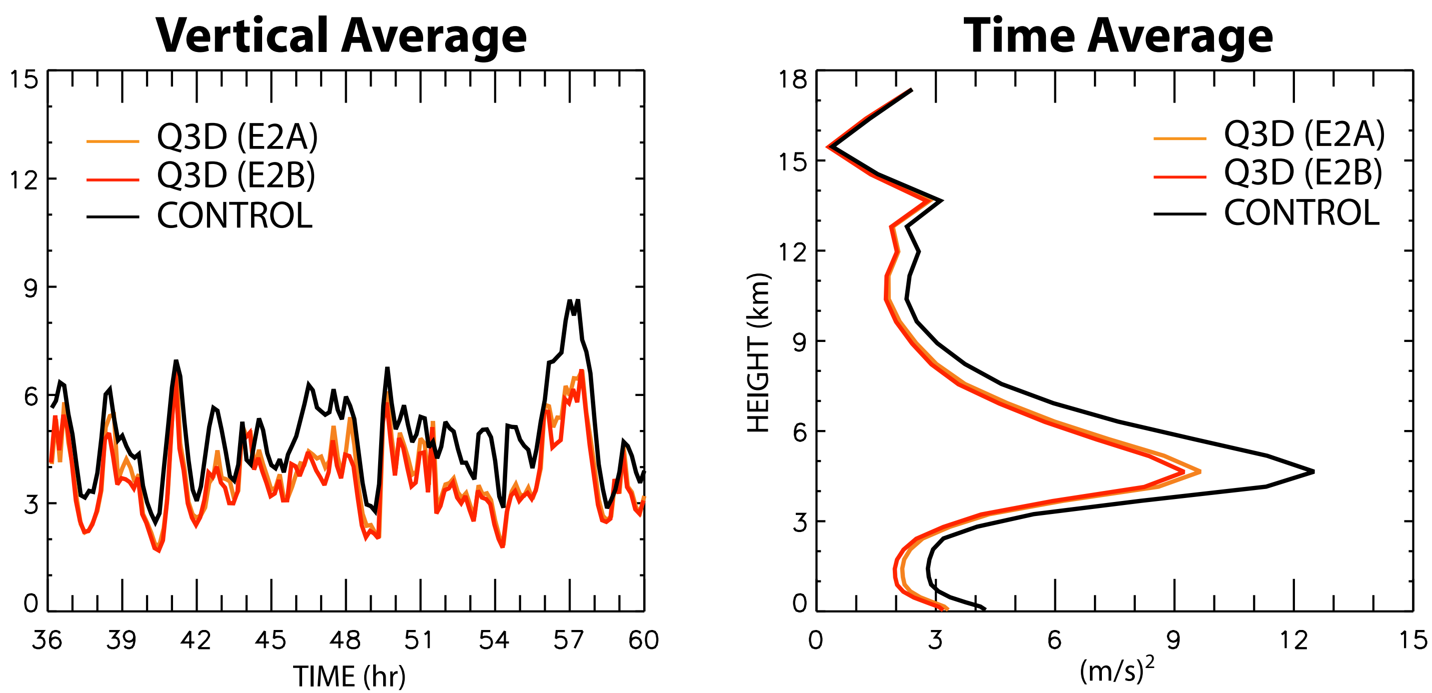




Experiment 2

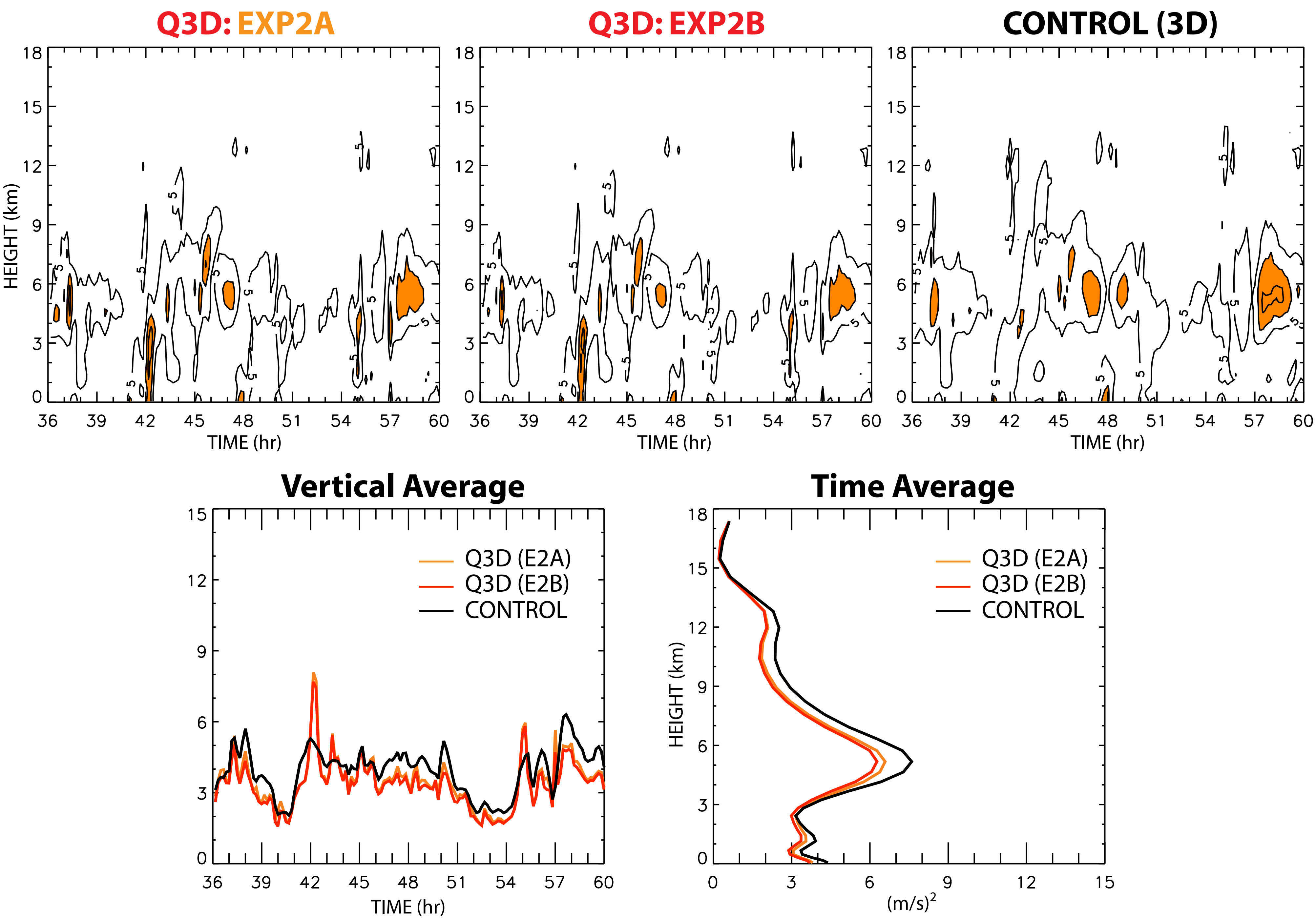
u^{*2} **:** y-array ***variance*** of horizontal velocity





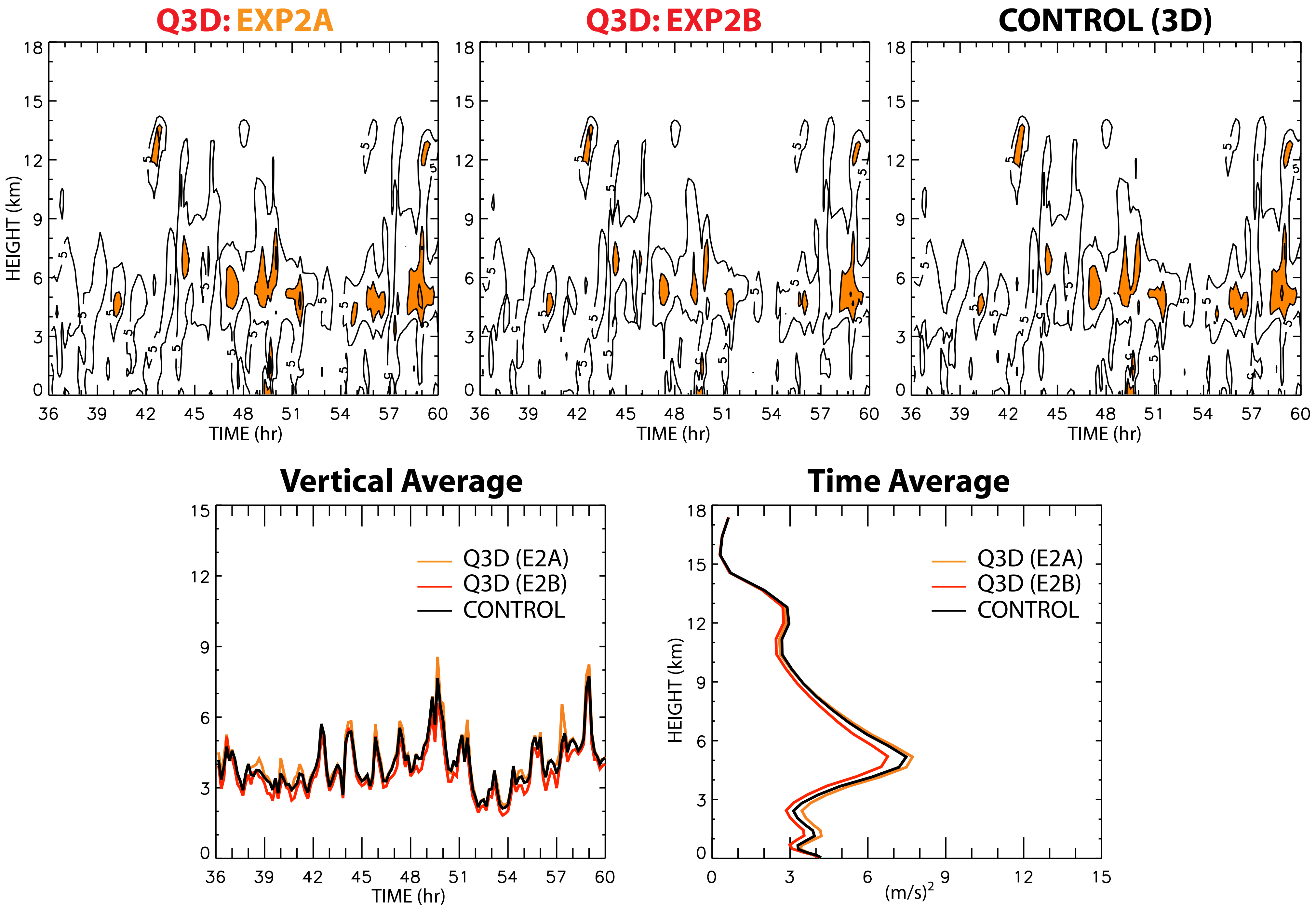
Experiment 2

v^{*2} : x-array ***variance*** of horizontal velocity



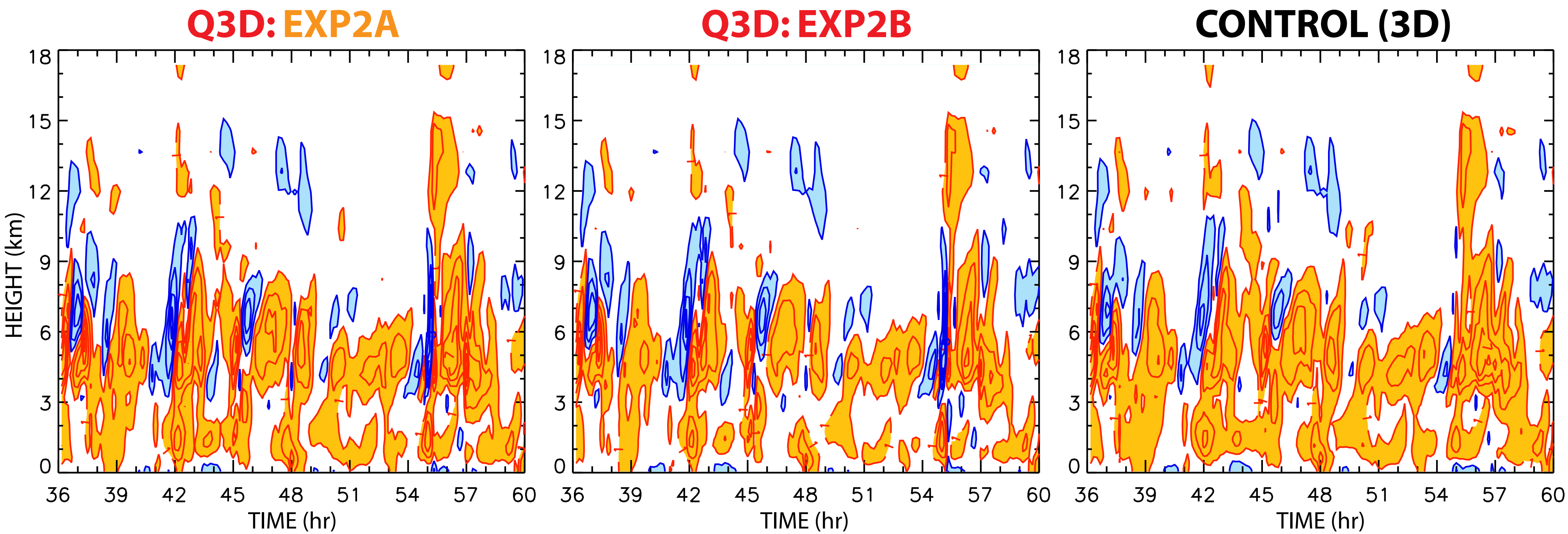
Experiment 2

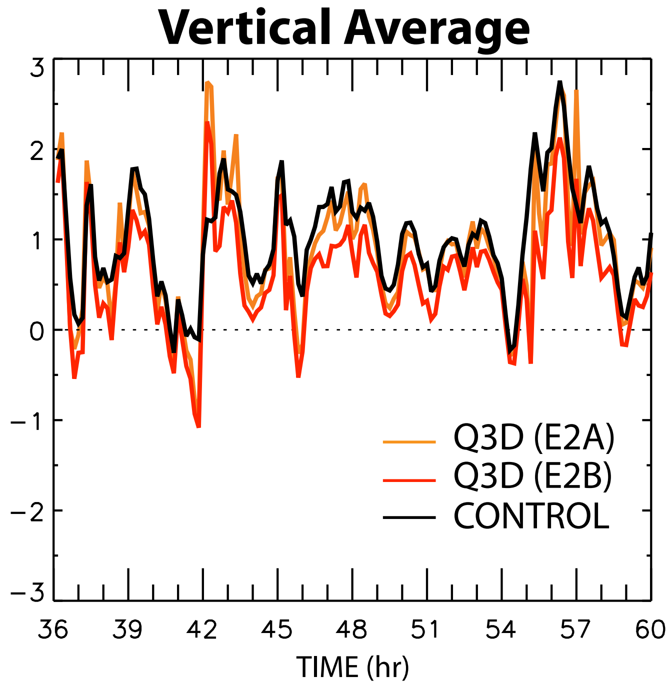
v^{*2} : y-array ***variance*** of horizontal velocity

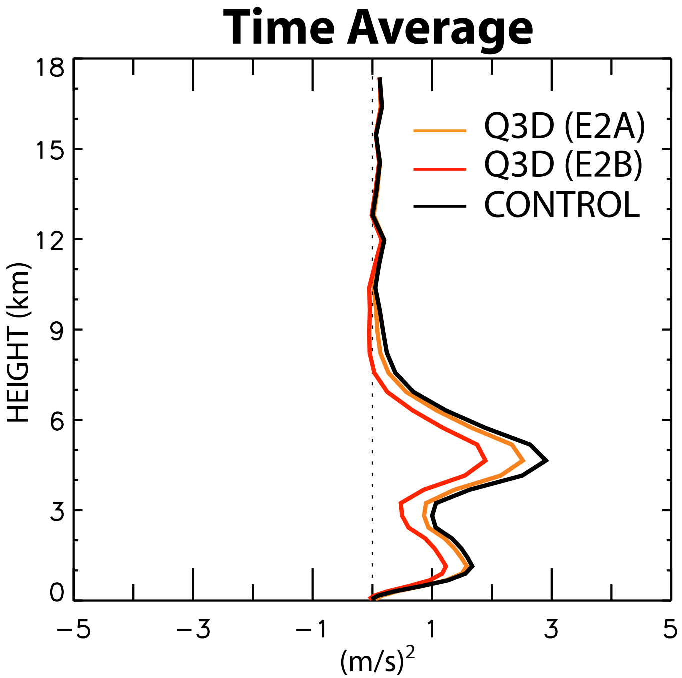


Experiment 2

u^*v^* : x-array ***covariance*** of horizontal velocity

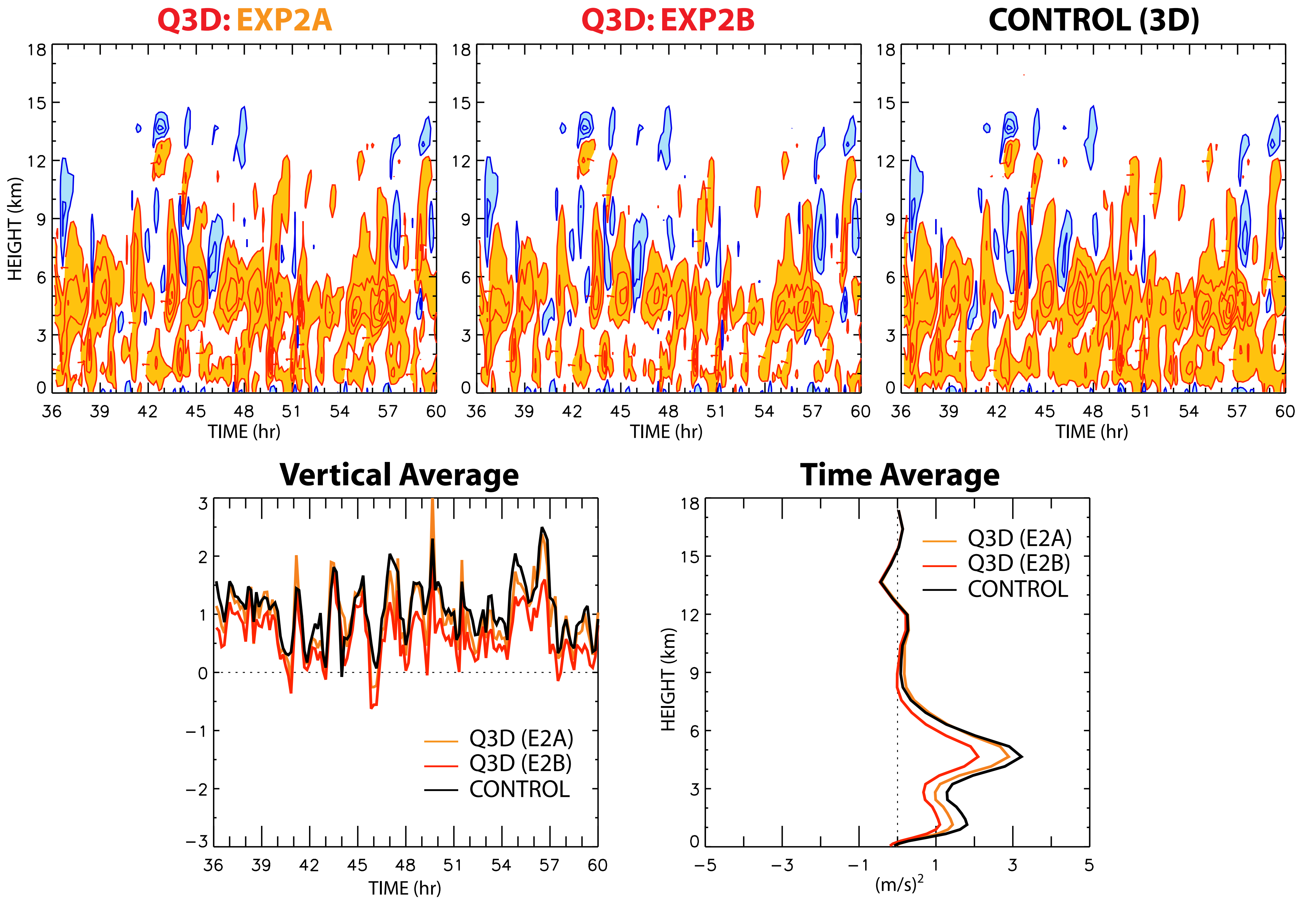






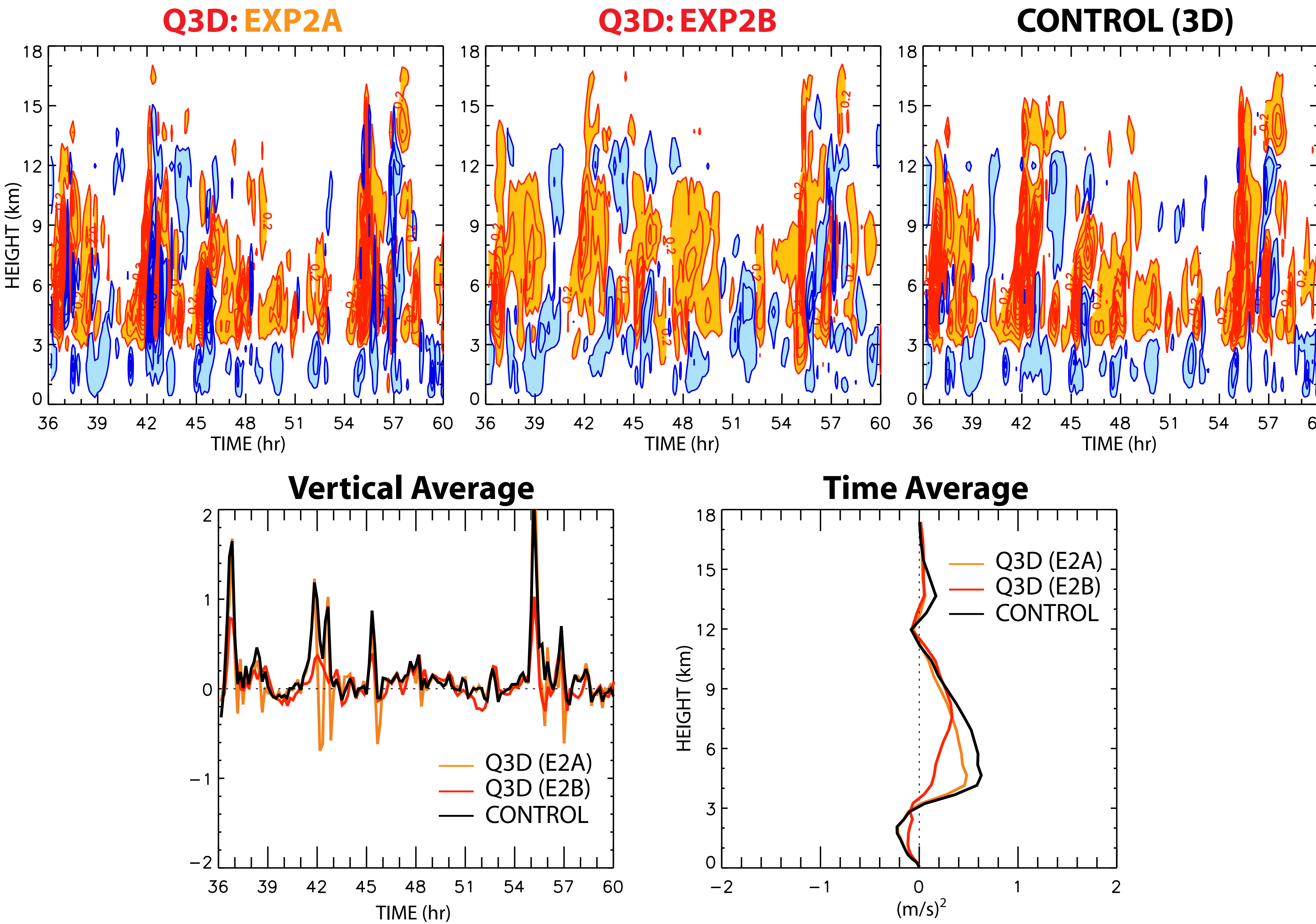
Experiment 2

$u^* v^*$: y-array ***covariance*** of horizontal velocity



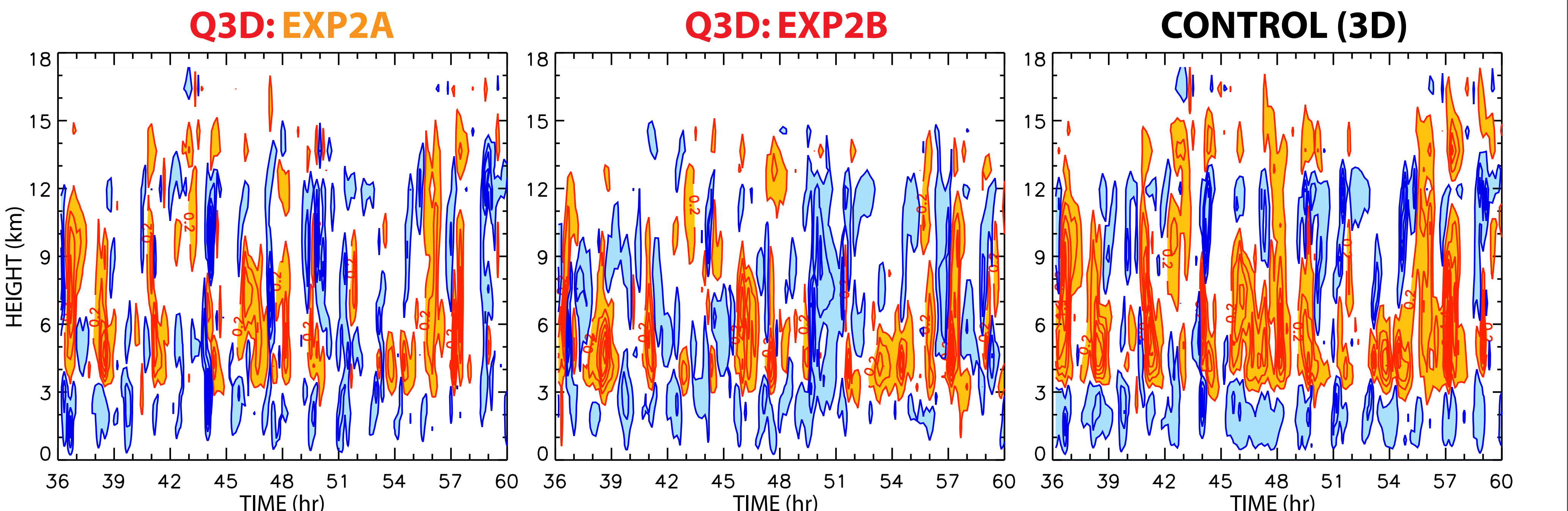
Experiment 2

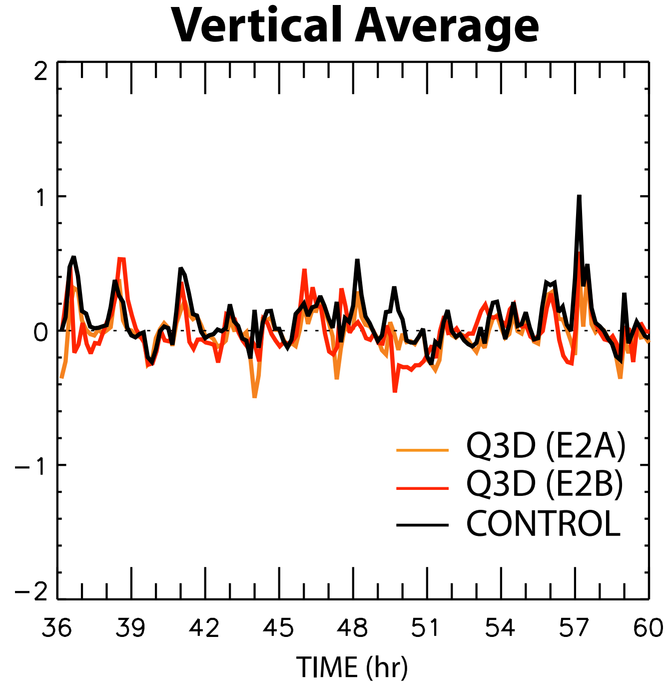
$u^* w^*$: x-array ***covariance*** of velocity

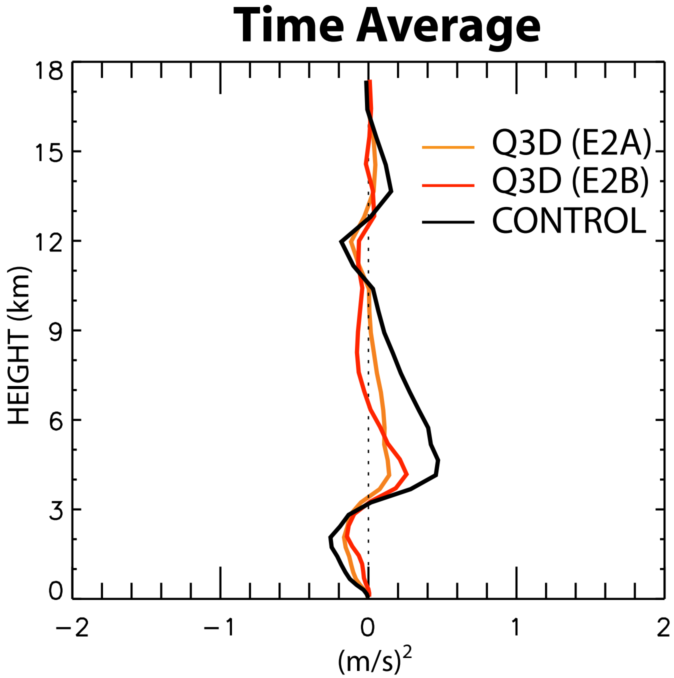


Experiment 2

$u^* w^*$: y-array ***covariance*** of velocity

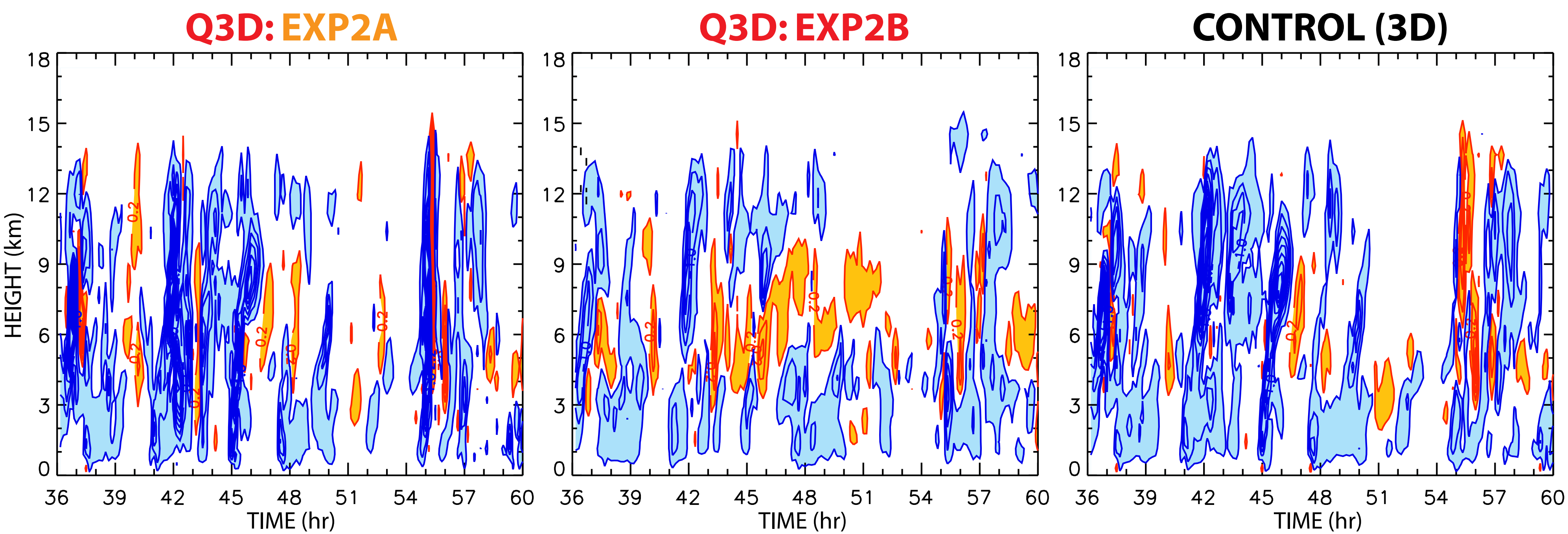


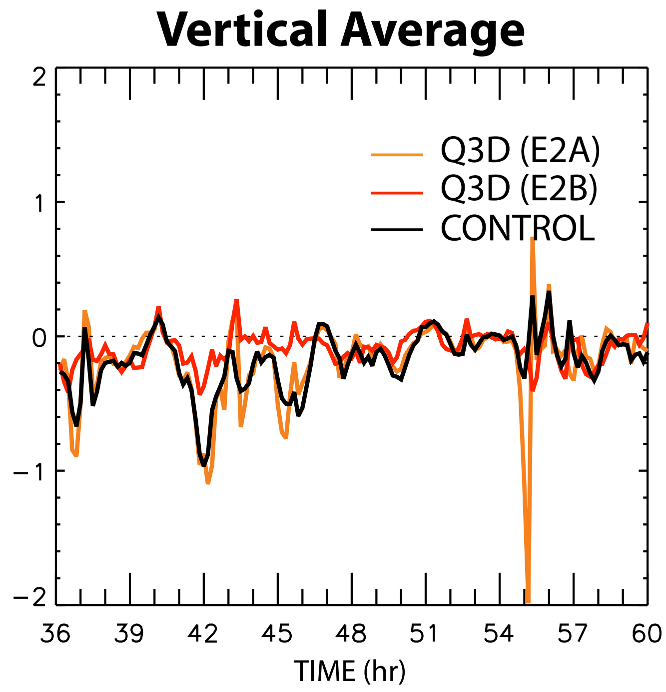


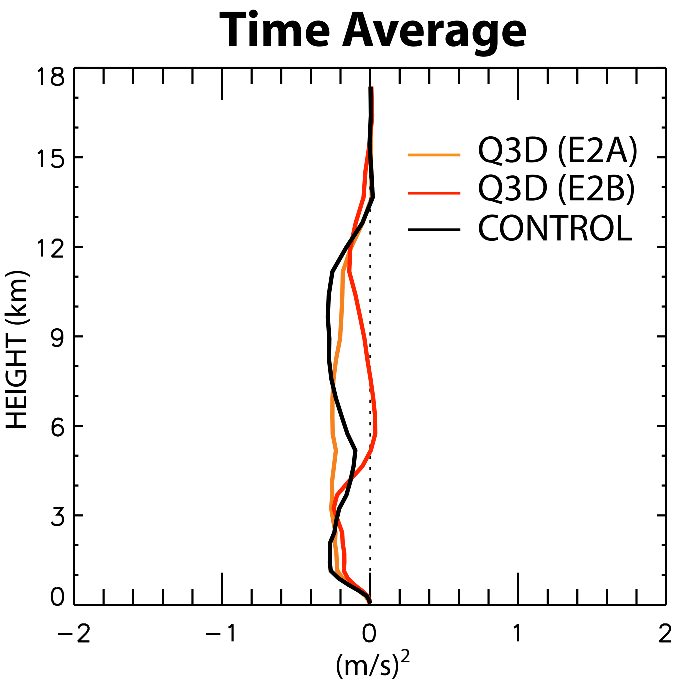


Experiment 2

$v^* w^*$: x-array ***covariance*** of velocity

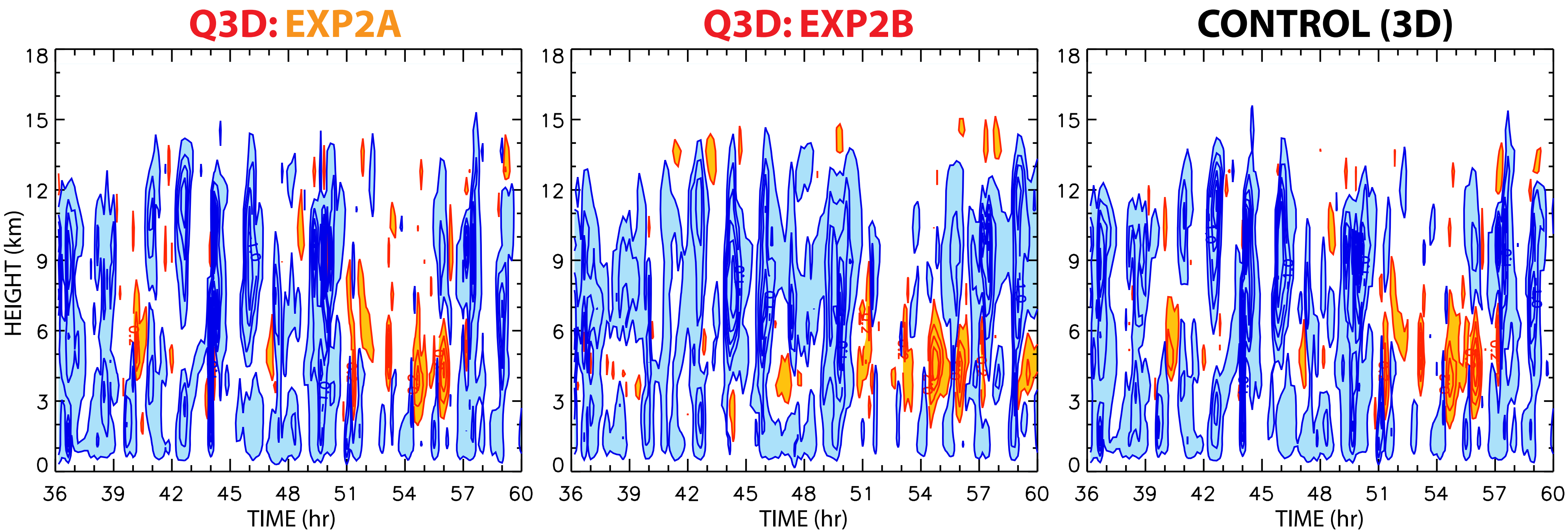


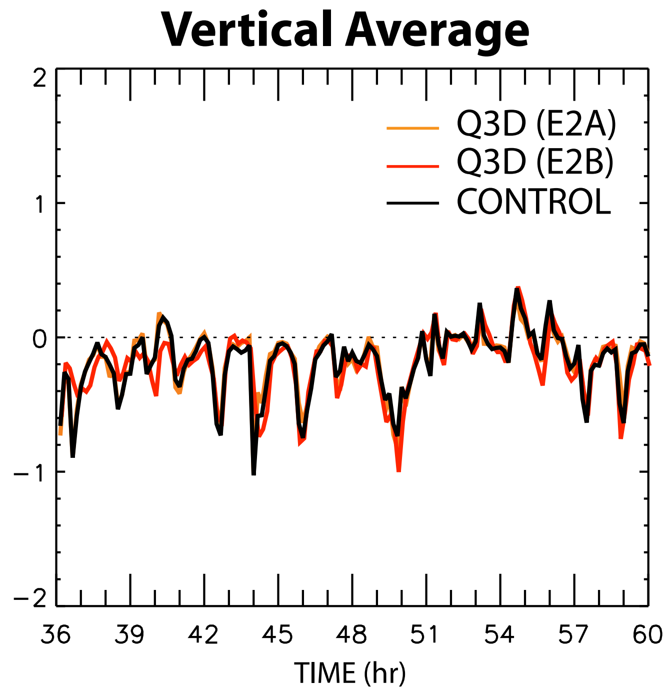


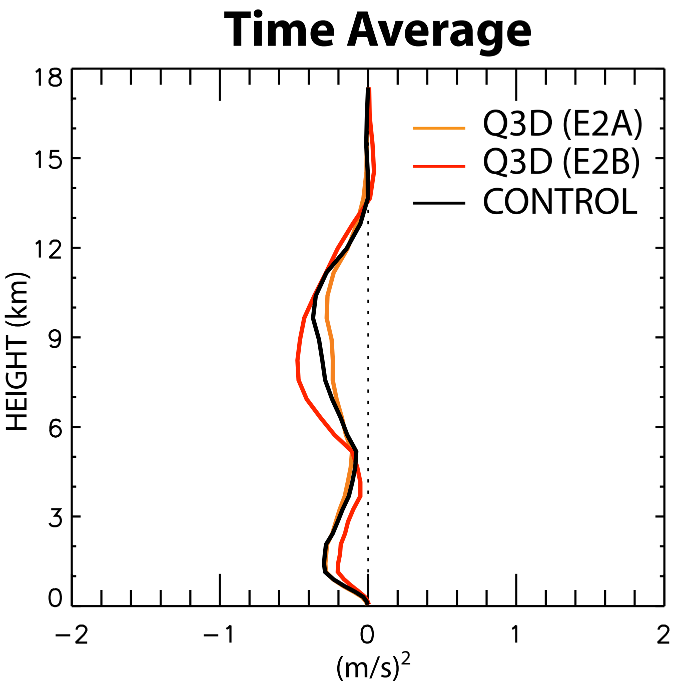


Experiment 2

$v^* w^*$: y-array ***covariance*** of velocity







Experiment 2: Test for dynamics I

EXP2A

EXP2B

- Generally, the results of EXP2B are comparable to those of EXP2A.
- This means that estimation of the vorticity components at the ghost points works well.

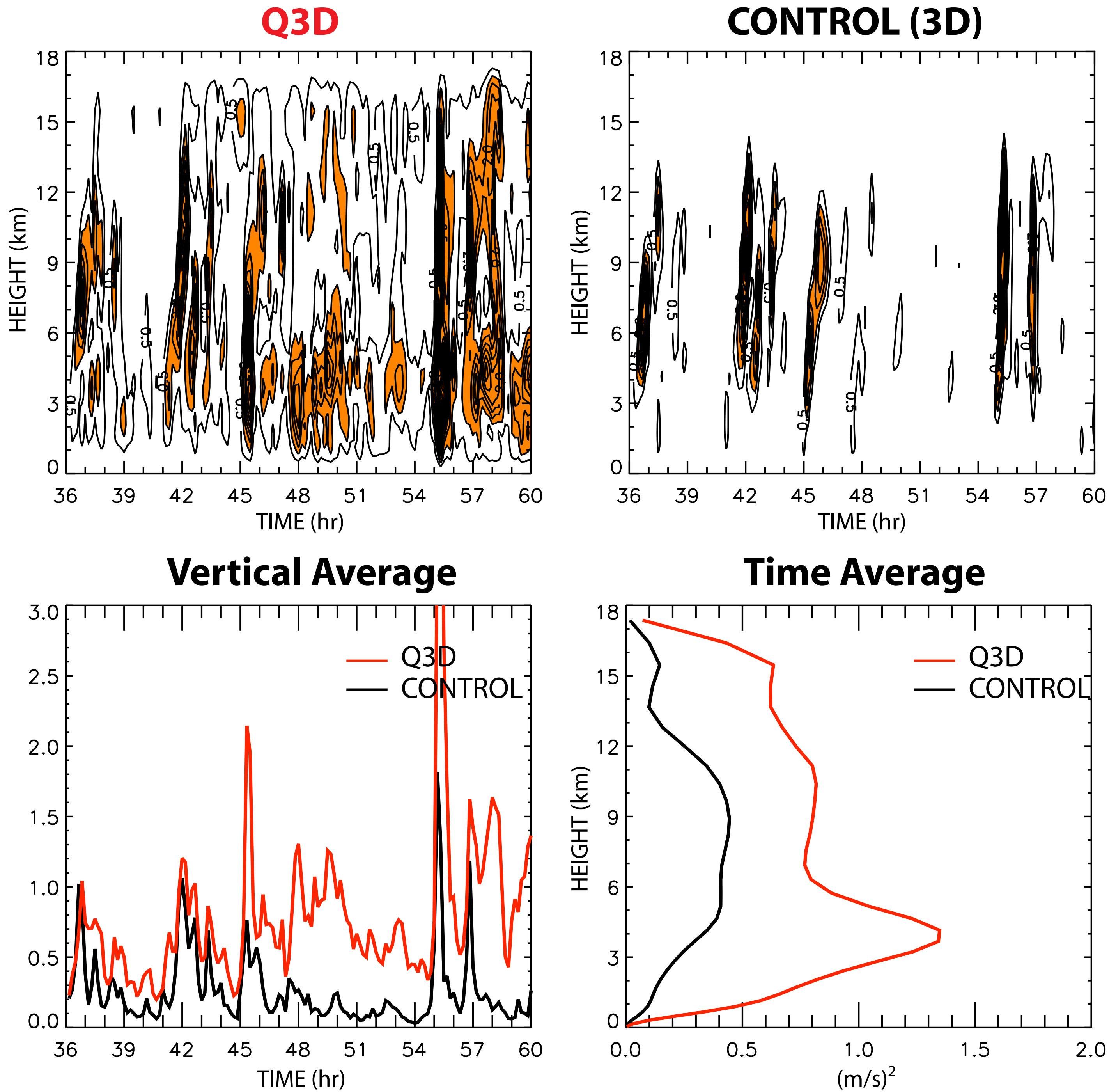
Experiment 3: Test for dynamics II

Diabatic heating rate on the network is prescribed from Control.

We are in the middle of improving the vorticity prediction, especially formulation of dissipation process.

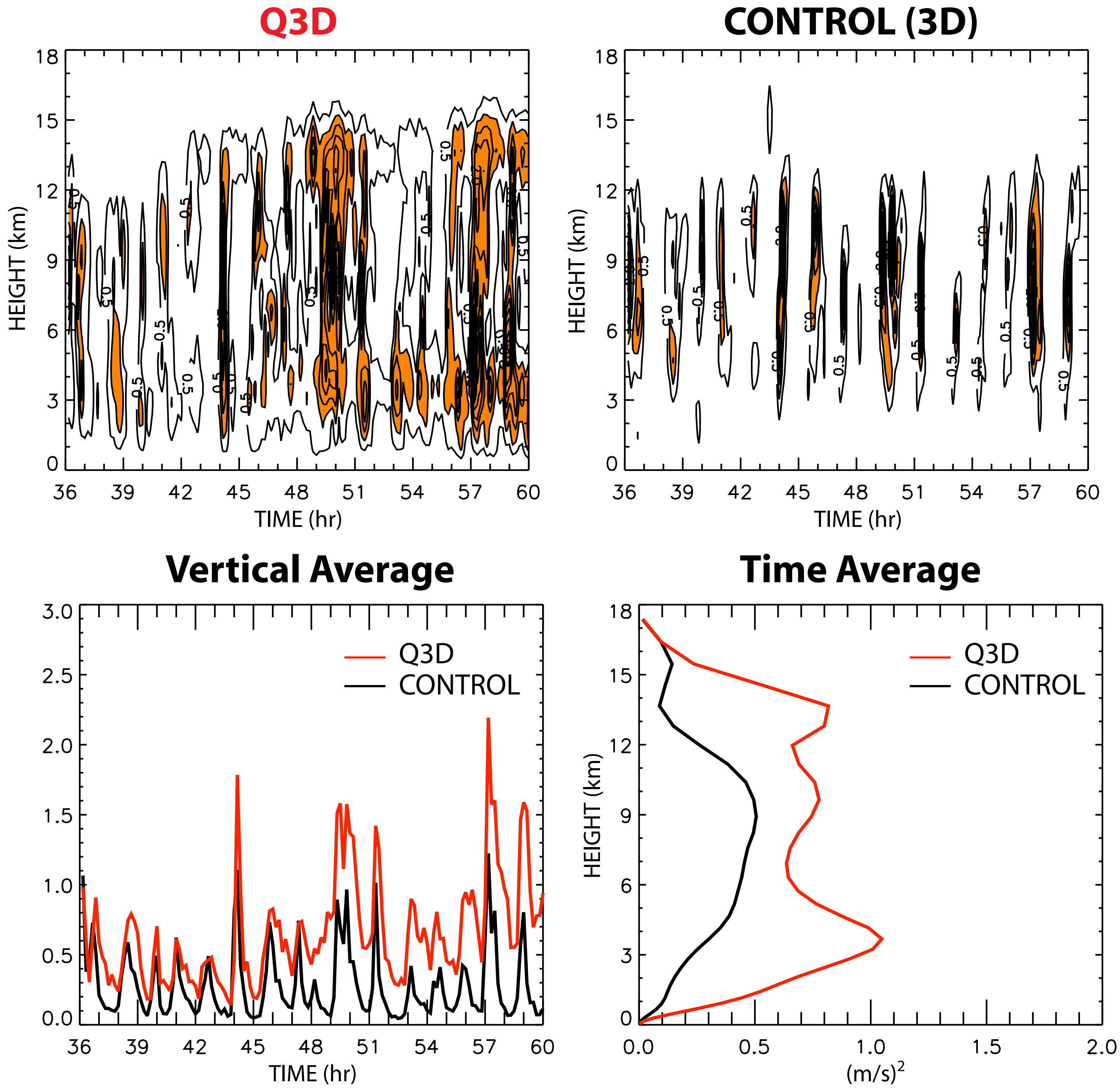
Experiment 3

w^{*2} **:** x-array ***variance*** of vertical velocity



Experiment 3

w^{*2} : y-array ***variance*** of vertical velocity



FUTURE PLAN

Completion of the three types of Experiments

- Improving quasi-3d vorticity dynamics
- Comparisons with 2D experiments

Refinement of the Algorithms

- Identifying key tuning parameters and possibly eliminating others
- Replacing the ad hoc formulations by less arbitrary formulations
- Reformulating the algorithms, if necessary, in view of convergence and parallel computing

Expansion of the Domain with More Local Statistical Analysis

Coupling with an Idealized GCM