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# Cumulus Convection Scheme for Gray Zone

Masato Sugi

MRI

# Background

- Grid size of some operational global NWP models is now in gray zone (2km ~20km).

  JMA: 20km
  ECMWF: 15km
  NCEP: 13km

- Even when CRMs are available for short range forecasts, we need gray zone models for longer range forecasts or ensemble forecasts.

- We need a good convection scheme for gray zone.

Cumulus parameterization scheme calculates Q1 and Q2.

$$Q_1 \equiv \frac{\partial \bar{s}}{\partial t} + \bar{\mathbf{v}} \cdot \nabla \bar{s} + \bar{w} \frac{\partial \bar{s}}{\partial z} = Q_R + \frac{1}{\rho} L(\bar{c} - \bar{e}) - \nabla \cdot \overline{s'\mathbf{v}'} - \frac{\partial \overline{s'w'}}{\partial z}$$

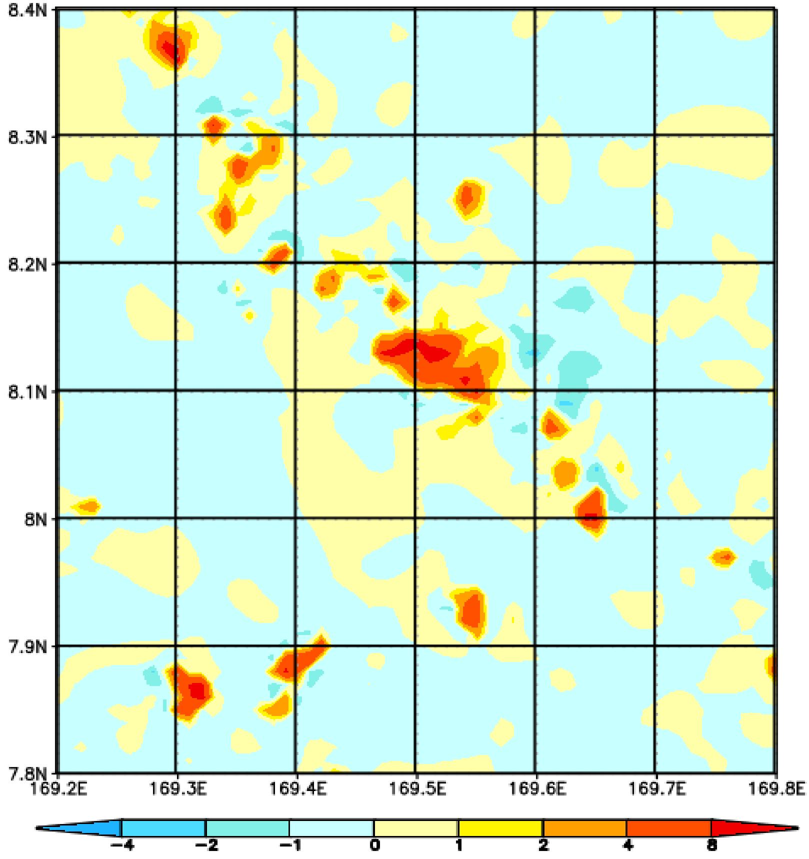
$$-Q_2 \equiv L\left( \frac{\partial \bar{q}}{\partial t} + \bar{\mathbf{v}} \cdot \nabla \bar{q} + \bar{w} \frac{\partial \bar{q}}{\partial z} \right) = \quad -\frac{1}{\rho} L(\bar{c} - \bar{e}) \; - L \nabla \cdot \overline{q'\mathbf{v}'} - L \frac{\partial \overline{q'w'}}{\partial z}$$

tend hadv vadv source hedt vedt

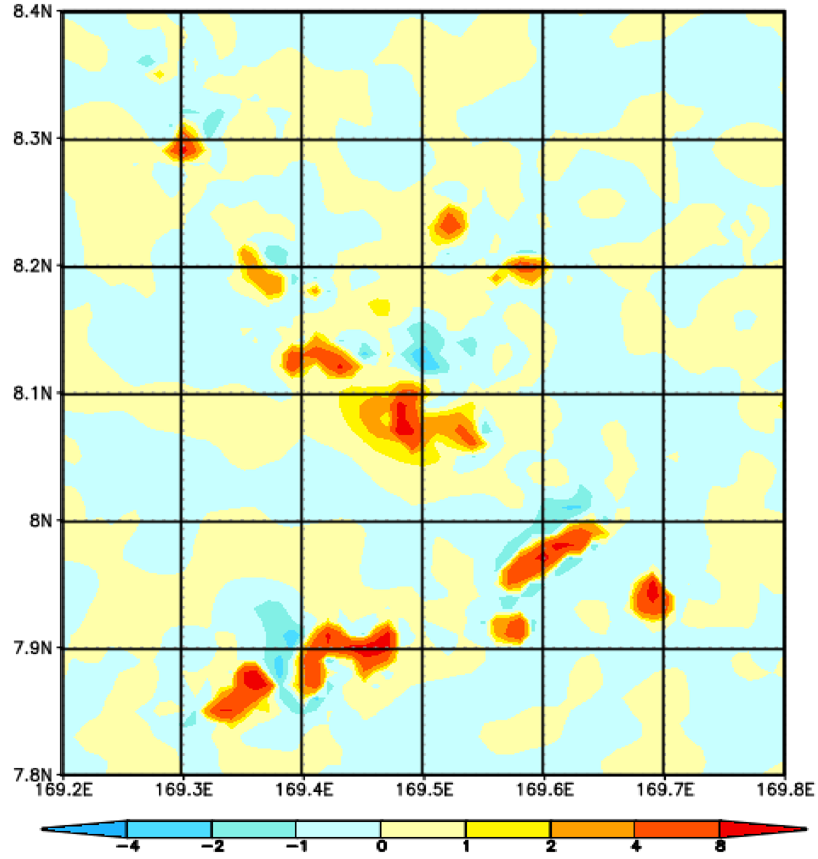
$$Q_1 - Q_2 = Q_F + Q_R - \nabla \cdot \overline{h'\mathbf{v}'} - \frac{\partial \overline{h'w'}}{\partial z} \qquad h = s + Lq$$

# W at Z=4920m 60kmx60km area in NHM-1km experiment

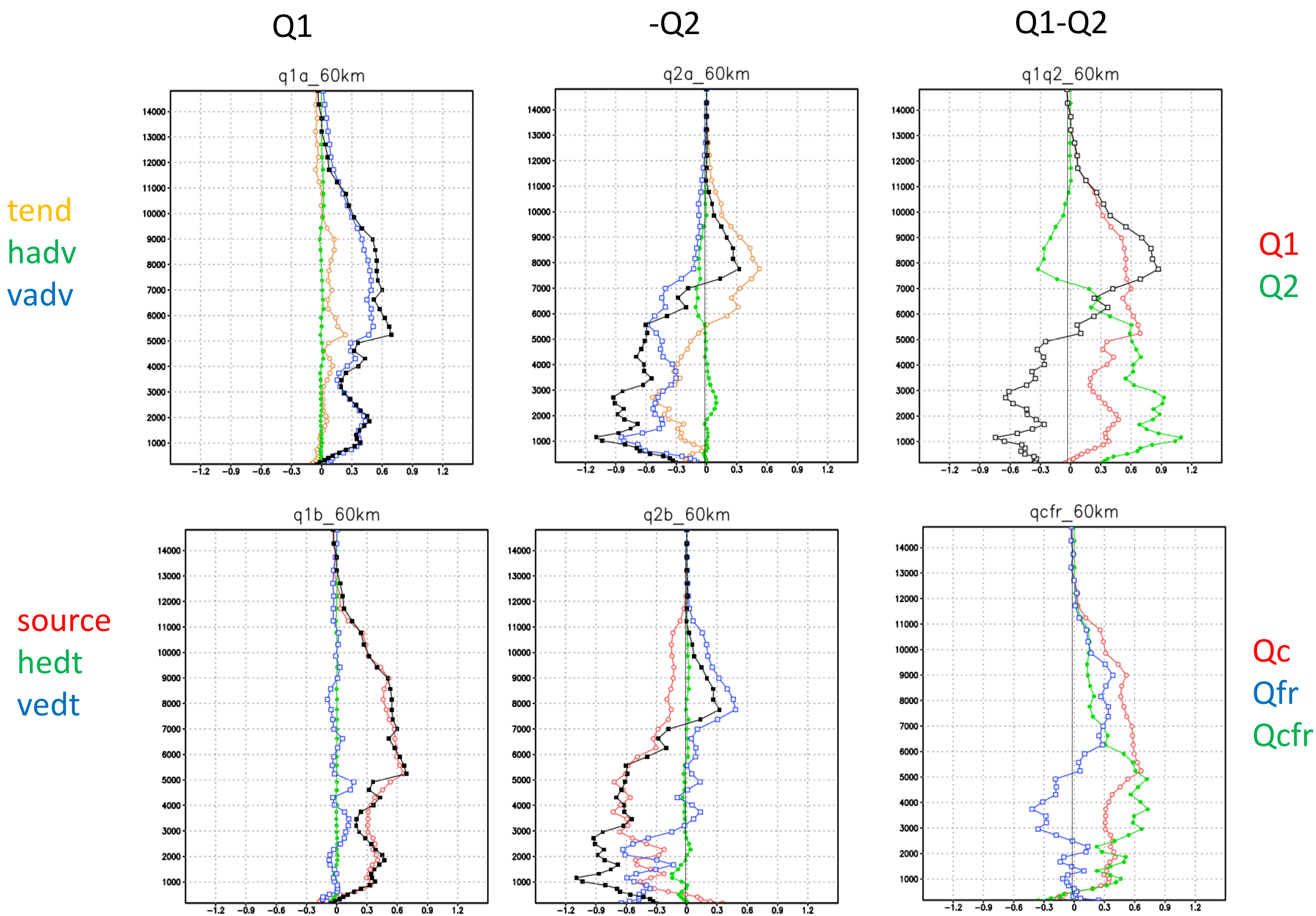
11UTC 28 AUG 2004




11UTC 28 AUG 2004 + 20min



# Q1 and Q2 60km



# Q1 and Q2 60km vs 5km (1)

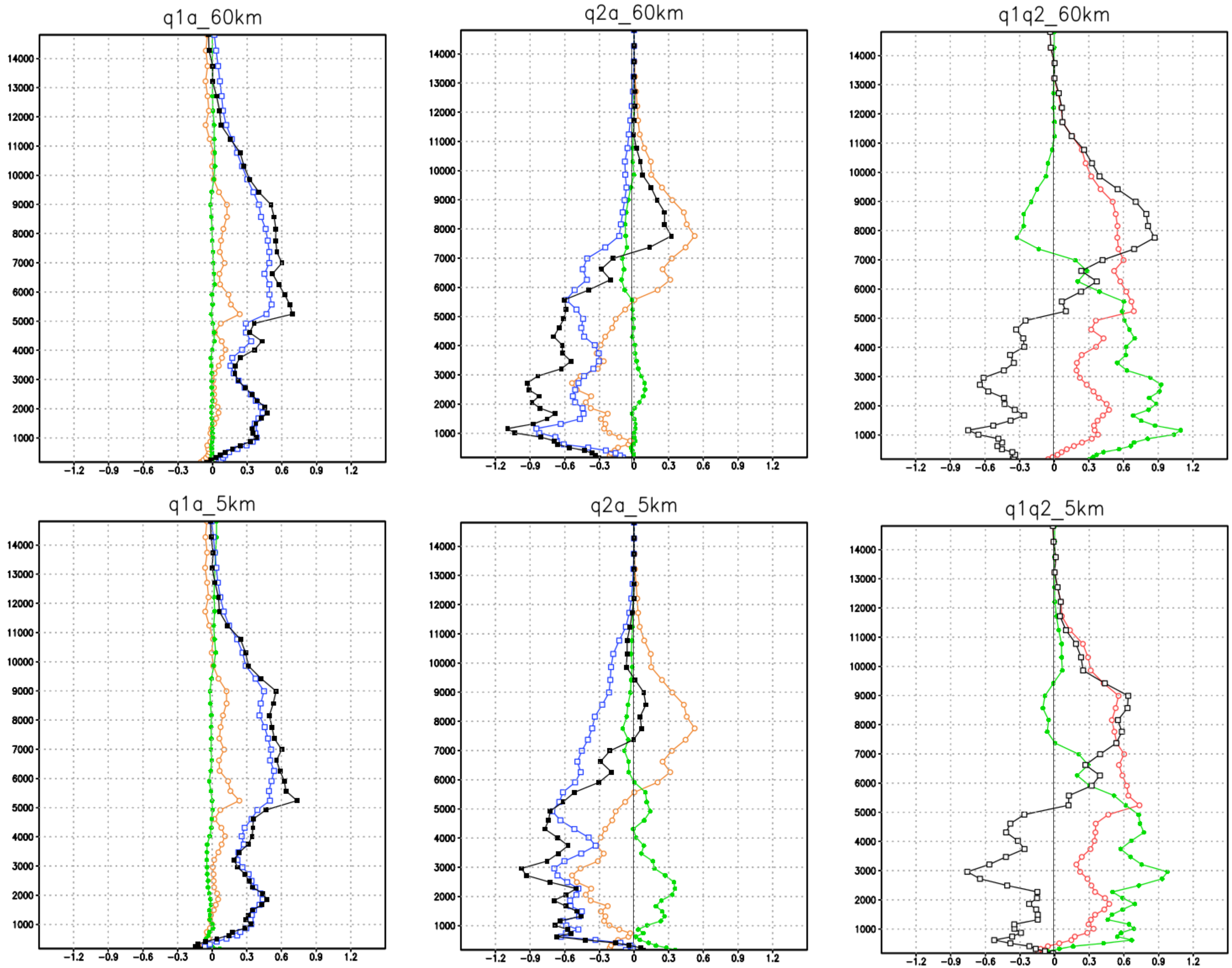
Q1 tend hadv vadv

-Q2 tend hadv vadv

Q1 Q2 Q1-Q2

60km mean

5km mean

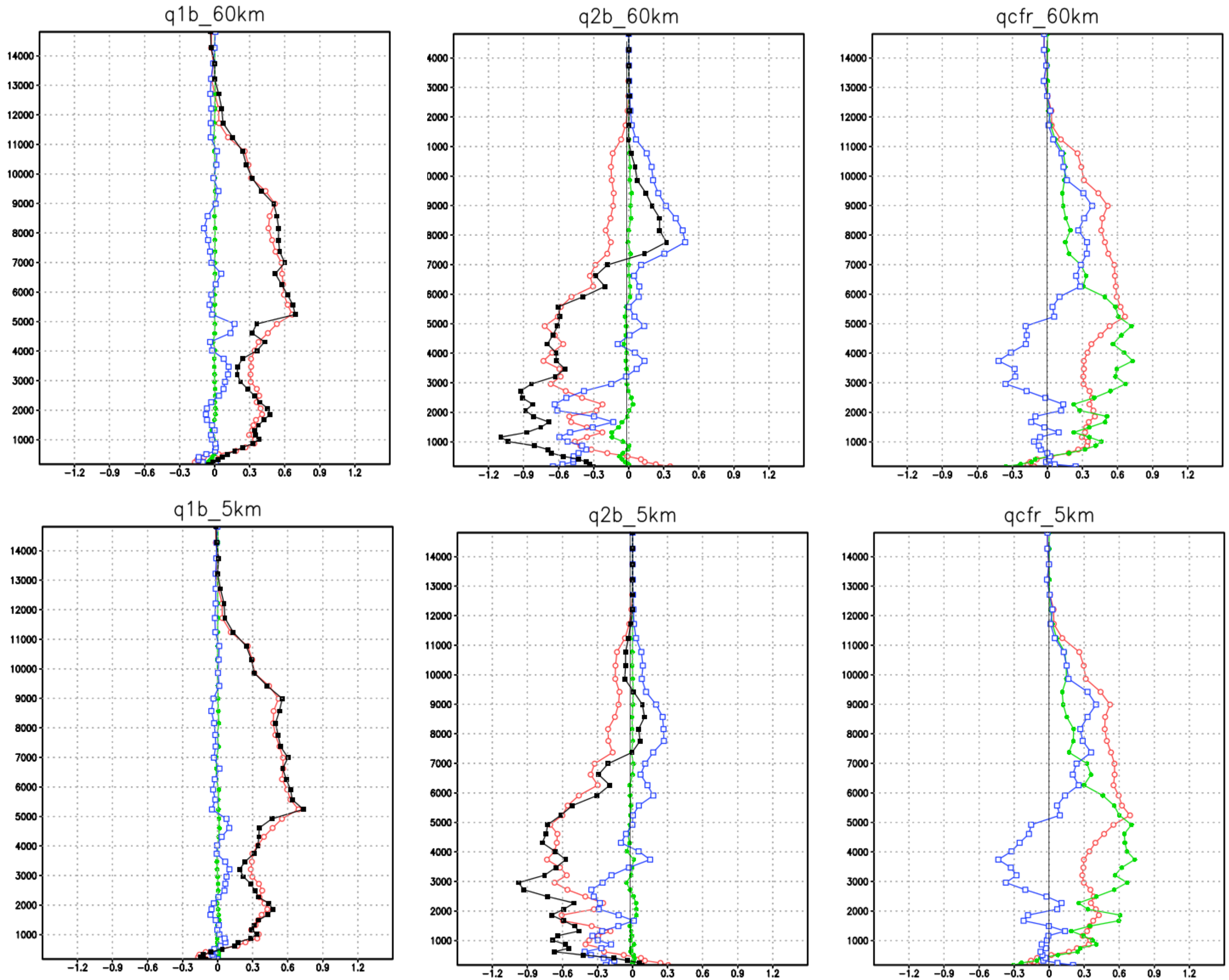


# Q1 and Q2     60km vs 5km (2)

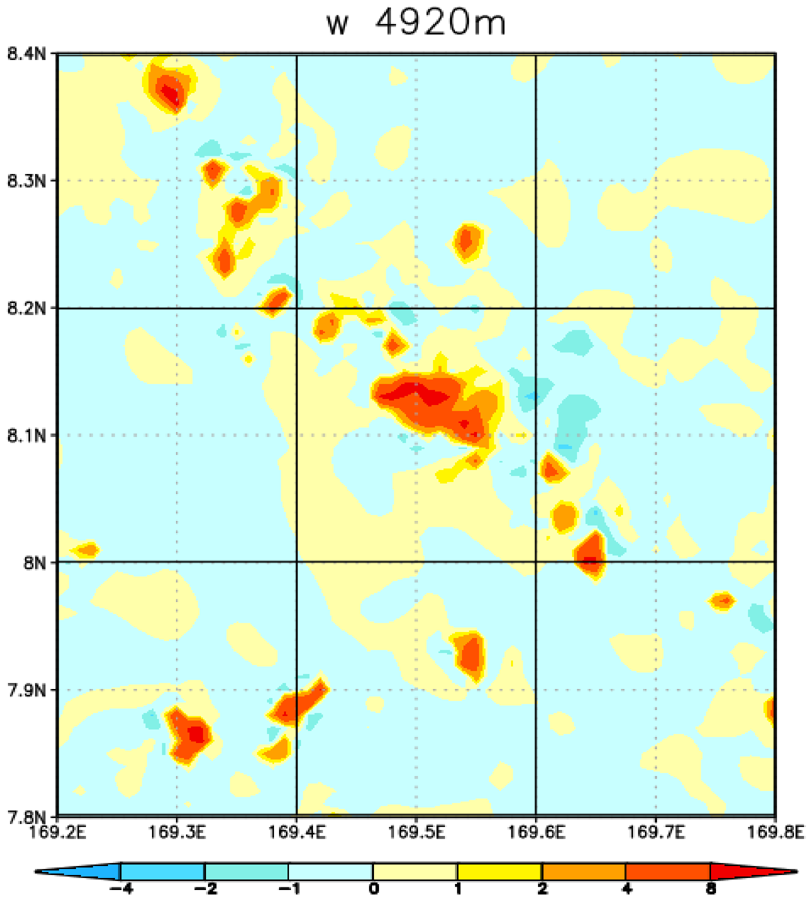
Q1 source hedt vedt     -Q2 source hedt vedt     Qcfr Qc Qfr

60km mean

5km mean



60km → 20km


w 4920m
8.4N
8.3N
8.2N
8.1N
8N
7.9N
7.8N
169.2E
169.3E
169.4E
169.5E
169.6E
169.7E
169.8E
-4
-2
-1
0
1
2
4
8

# Q1 and Q2 20km mean vs active (1)

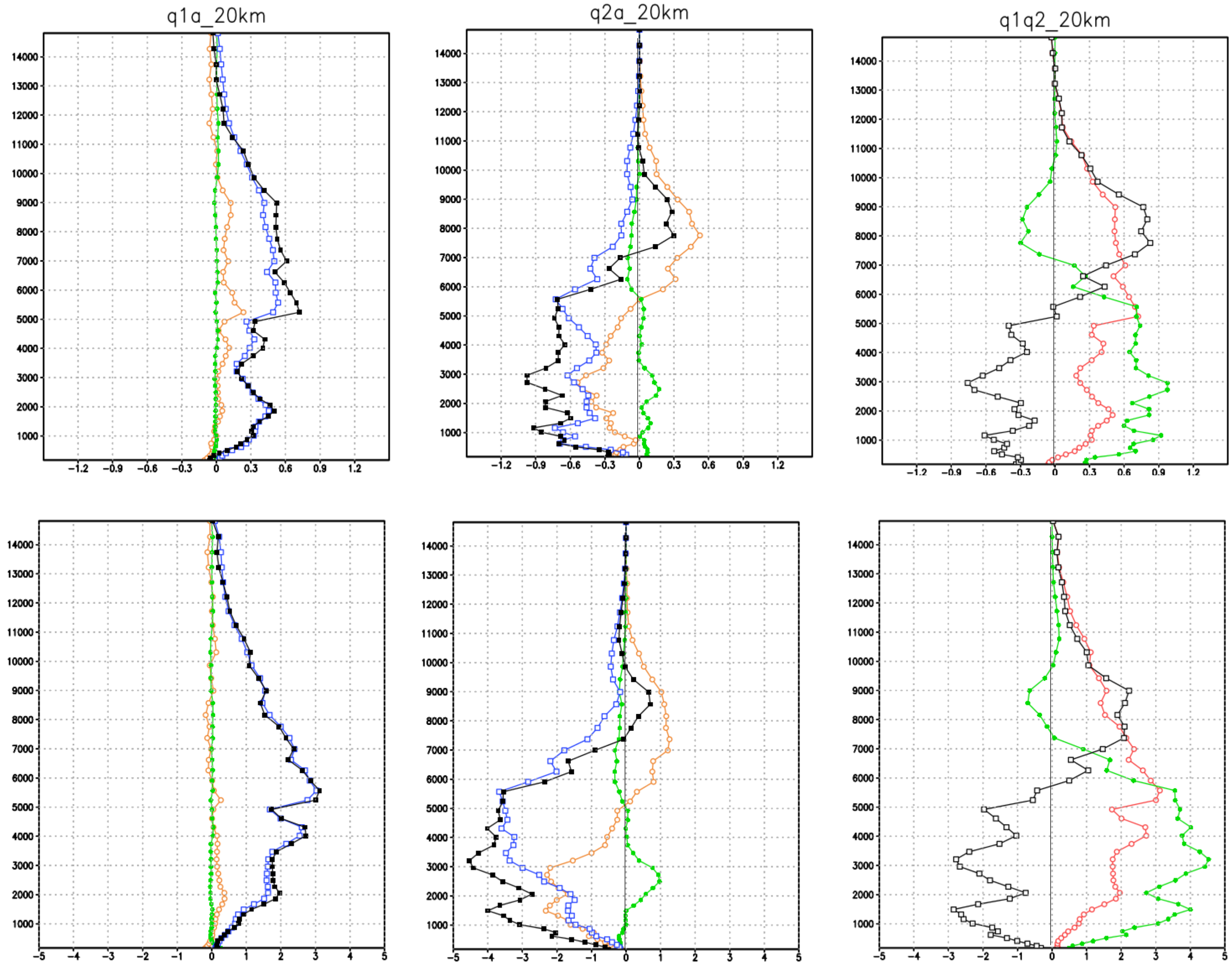
Q1 tend hadv vadv

-Q2 tend hadv vadv

Q1 Q2 Q1-Q2

20km mean

20km active



# Q1 and Q2 20km mean vs active (2)

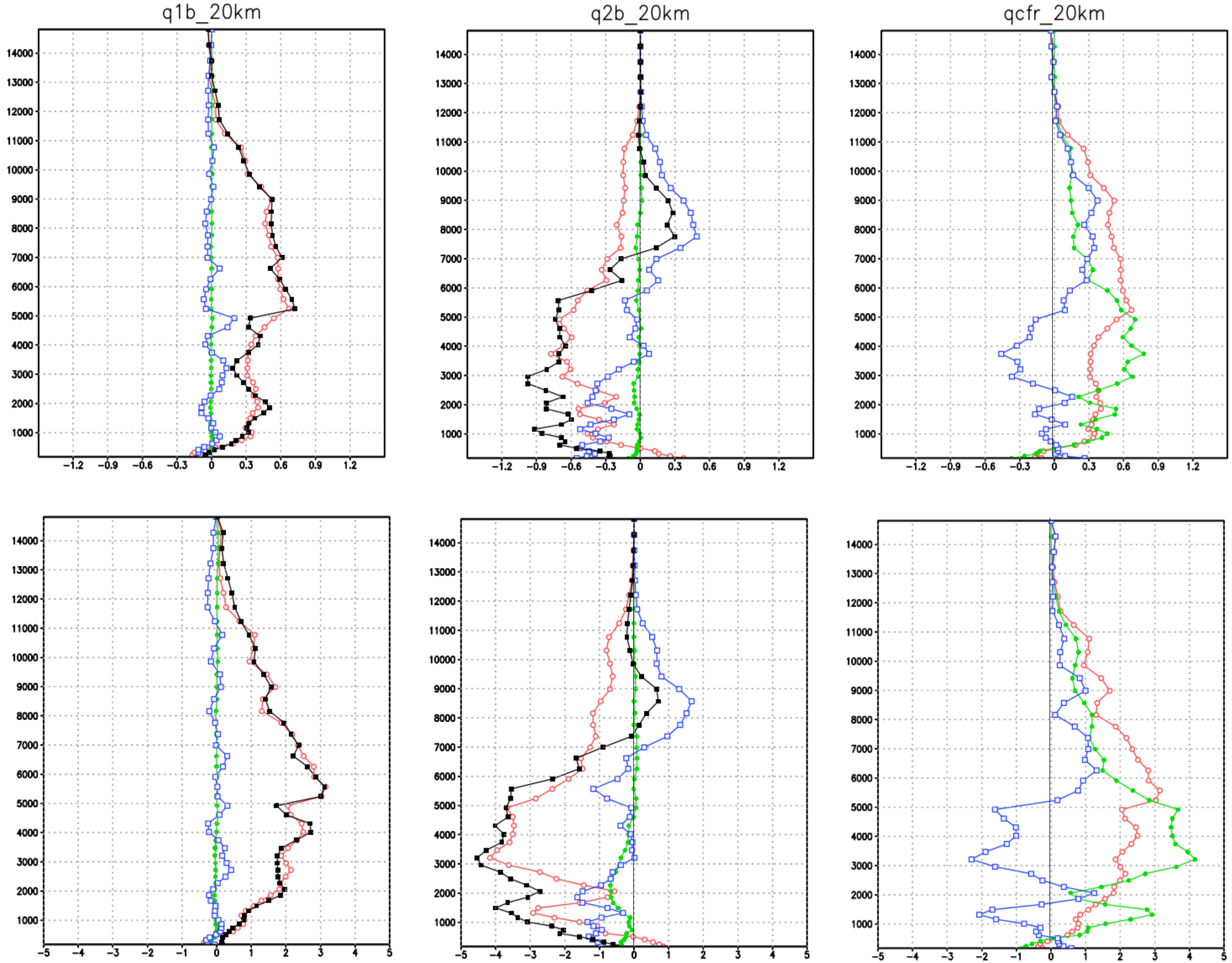
Q1 source hedt vedt

-Q2 source hedt vedt

Qcfr Qc Qfr

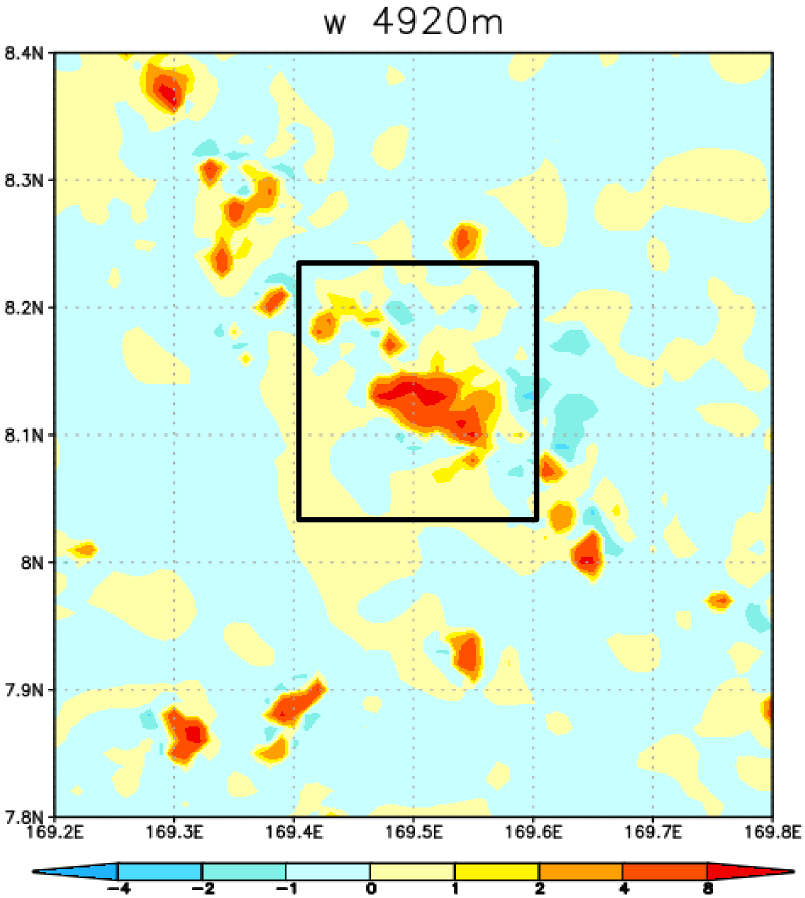
20km mean

20km active

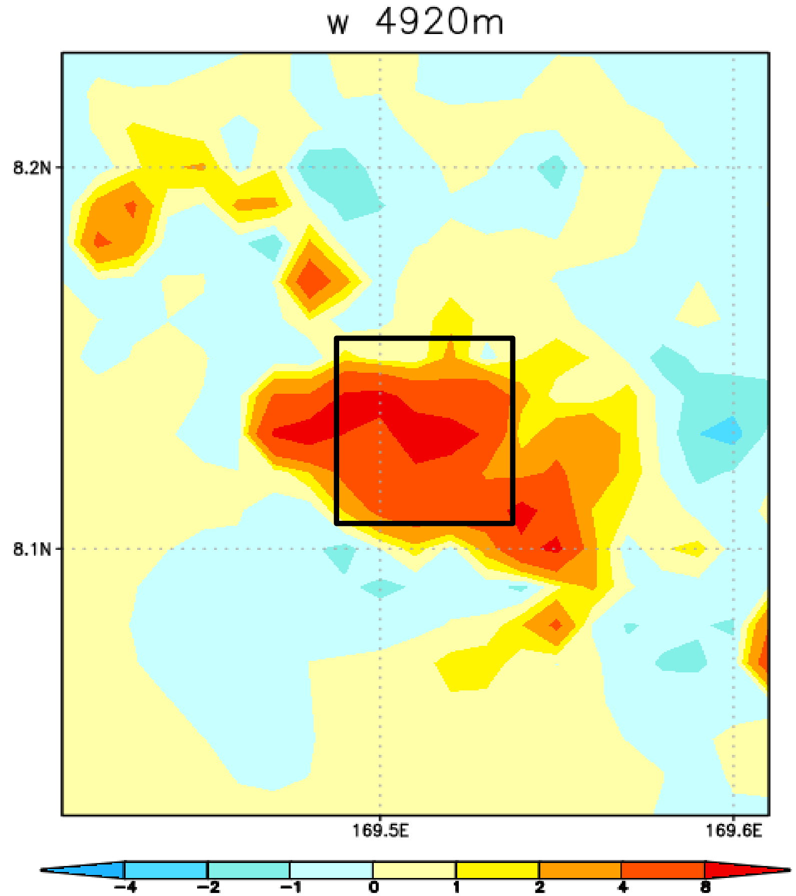


# Q1 and Q2 for most active regions

60km → 20km




20km → 5km



# Q1 and Q2 20km vs 5km (1)

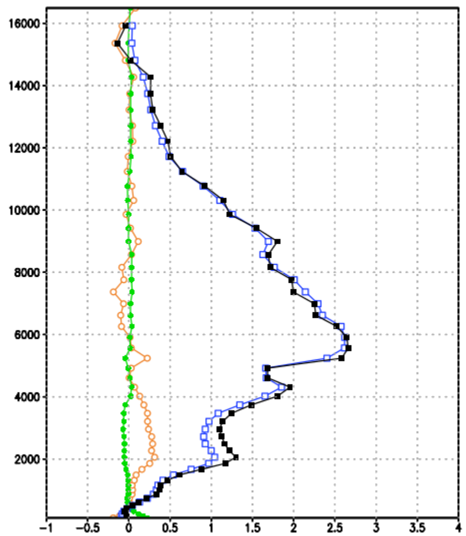
Q1 tend hadv vadv

-Q2 tend hadv vadv

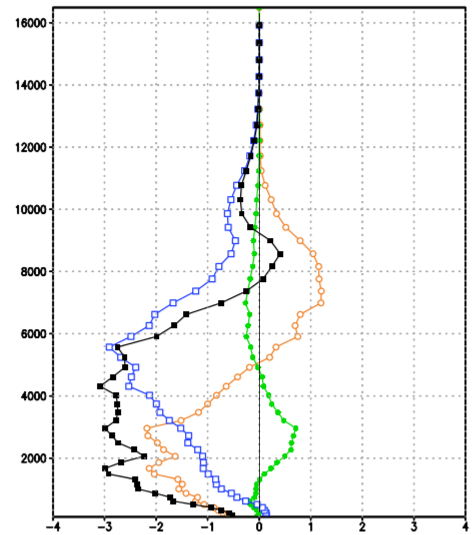
Q1 Q2 Q1-Q2

20km active

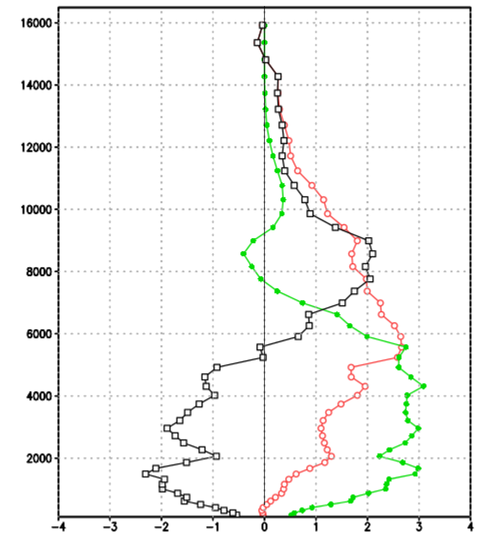
20km Q1




20km -Q2

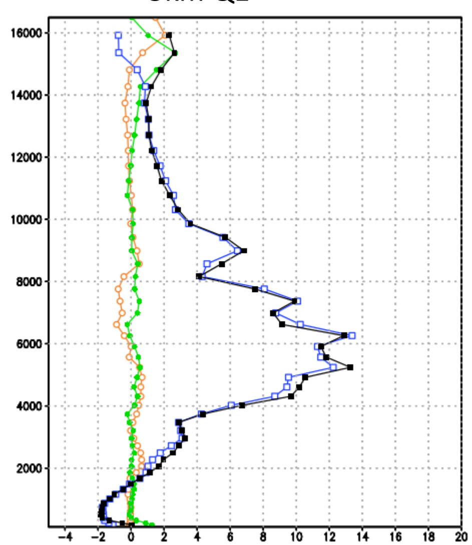



20km Q1-Q2

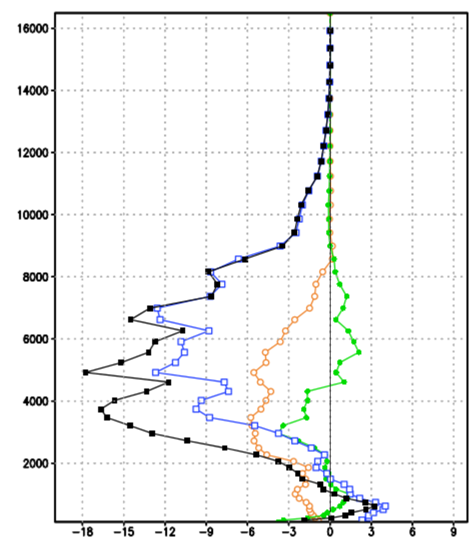



5km active

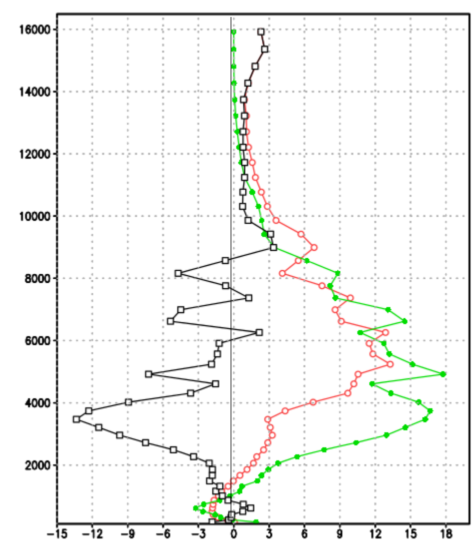
5km Q1




5km -Q2




5km Q1-Q2

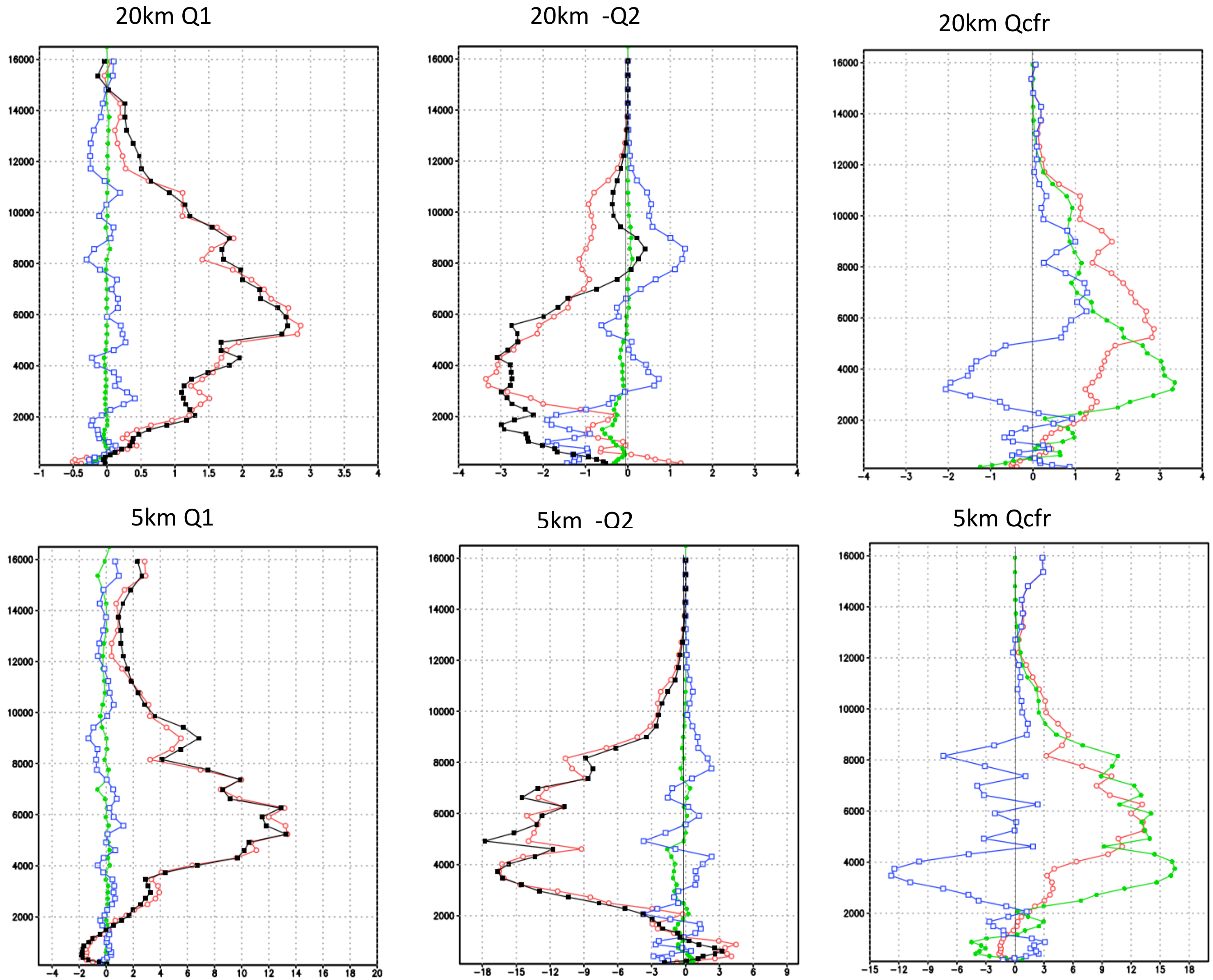


# Q1 and Q2 20km vs 5km (2)

Q1 source hedt vedt -Q2 source hedt vedt Qcfr Qc Qfr

20km active

5km active



# Summary

- Temperature tendency term in Q1 is small, but moisture tendency in Q2 is not small. Cumulus convections substantially change moisture field.

- Major part of Q1-Q2 is EDT of moisture, but contribution from Qfr (freezing-melting) is also significant.

- In active convection regions, relative contribution of EDT terms to the Q1 and Q2 decreases as the resolution increases. However, even at 5km resolution EDT is not negligible, and a parameterization is needed.