# A Modeling Study of PBL height

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Meteorology 605

# Motivation

- PBL parameterization schemes in NWP models need to know the depth through which to mix heat, momentum, moisture, wind etc.

- Many different definitions of PBL height
  - Which is correct?

# Experimental setup

- WRF-ARW version 3.1.1
- 16 total simulations
  - Four real-data cases
    - Summer (14 – 16 July 2010)
    - Winter (04 – 06 January 2010)
    - Spring (23 – 25 April 2010)
    - Autumn (19 – 21 October 2010)
  - Four PBL schemes (surface layer scheme)
    - Yonsei University (YSU)
      - Monin-Obukhov
    - Mellor-Yamada-Janjic (MYJ)
      - Monin-Obukhov (Janjic)
    - Quasi Normal Elimination Scale (QNSE)
      - QNSE
    - Medium Range Forecast (MRF)
      - Monin-Obukhov
- Rapid Update Cycle (RUC) hourly analyses used as "observations"

# PBL definitions

- PBL top when the following are exceeded:
- YSU
  - Critical Bulk Richardson number (Ri): 0.0
- MRF
  - Critical Ri: 0.5

$$Ri = \frac{\Delta\theta_v * \left( g / \theta_{vs} \right) * \Delta z}{\max\left\{U^2 + V^2, 1\right\}}$$

- MYJ
  - Minimum of 2*TKE parameter: 0.20
- QNSE
  - Minimum of 2*TKE parameter: 0.01
- RUC
  - $T_v > T_{v,sfc} + 0.5$ K

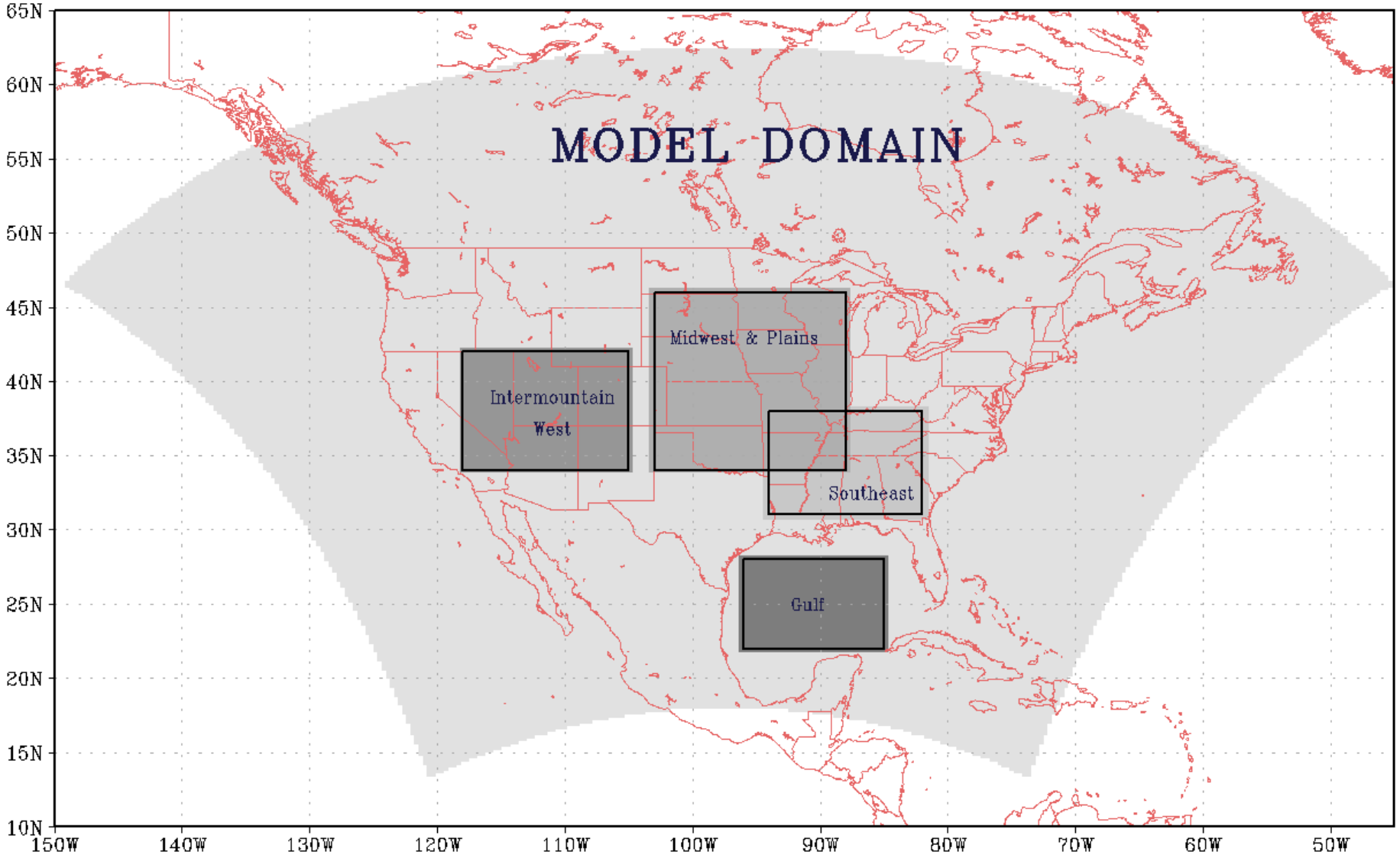
# Experimental setup

- Initialized at 0000 UTC
- Run for 60 hours
- GFS ICs/LBCs

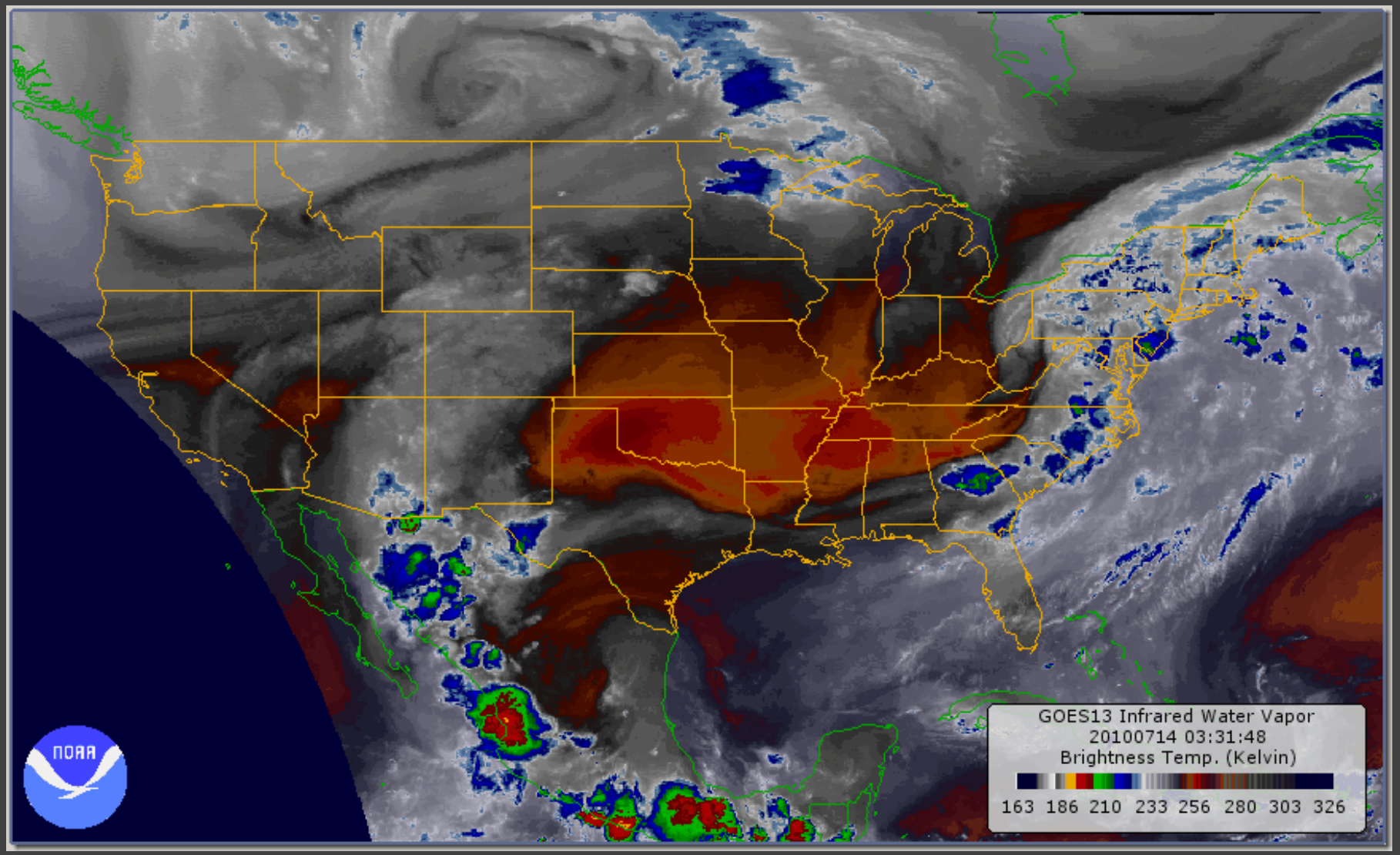
- 325 x 249 x 27 grid points
- dx = dy = 20 km
- dt = 100 s
- Ferrier microphysics
- Kain-Fritsch convection
  - cudt = 5 min

# Experimental setup

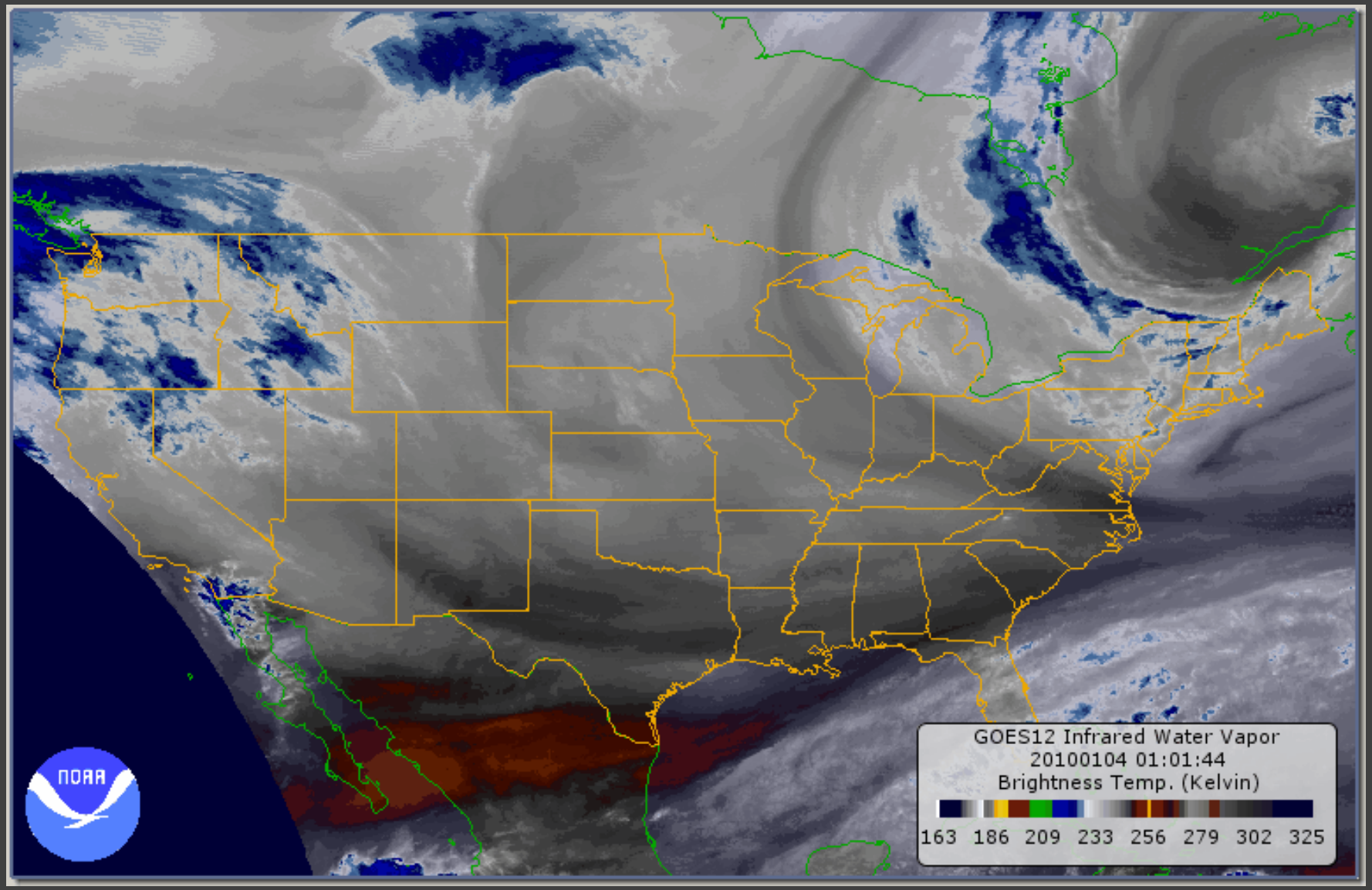
- Four analysis regions
  - "Southeast"
    - 94°-82° W lon., 31°-38° N lat.
  - "Midwest and Plains"
    - 103°-88° W lon., 34°-46° N lat.
  - "Intermountain West"
    - 118°-105° W lon., 34°-42° N lat.
  - "Gulf"
    - 96°-85° W lon., 22°-28° N lat.


MODEL DOMAIN
Midwest & Plains
Intermountain West
Southeast
Gulf
65N
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
150W
140W
130W
120W
110W
100W
90W
80W
70W
60W
50W

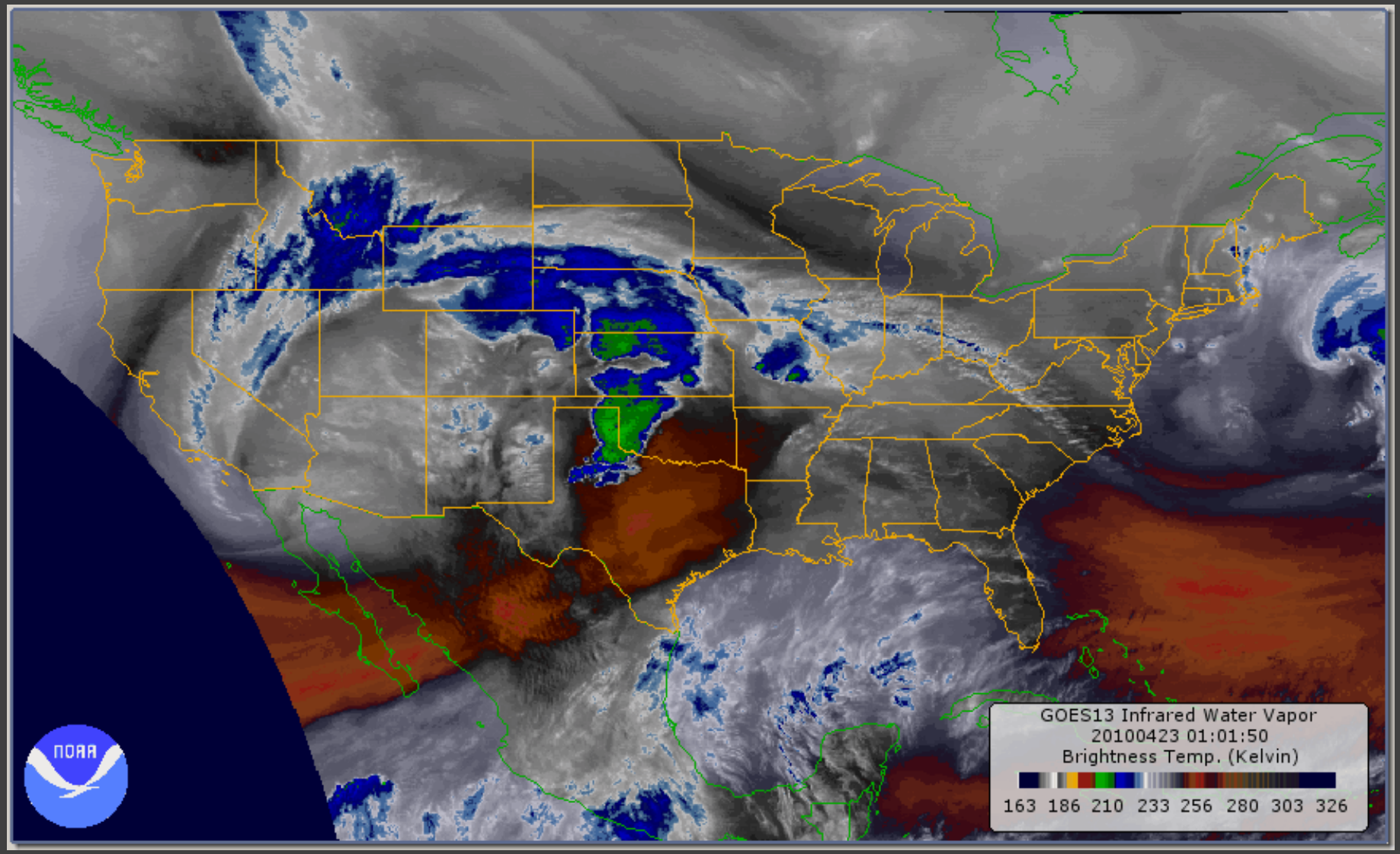
# Summer case – water vapor



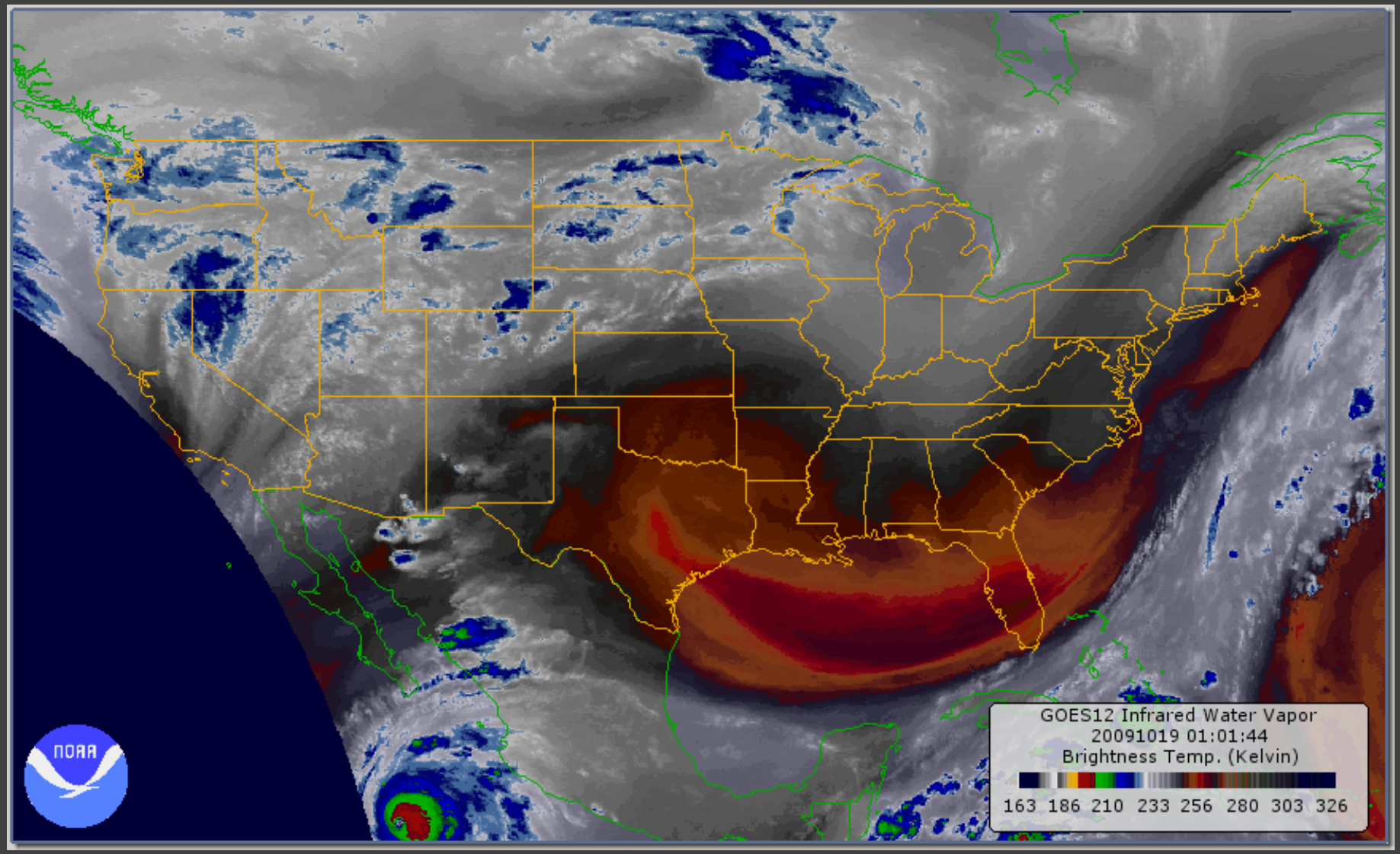
# Winter case – water vapor



# Spring case – water vapor



# Autumn case – water vapor



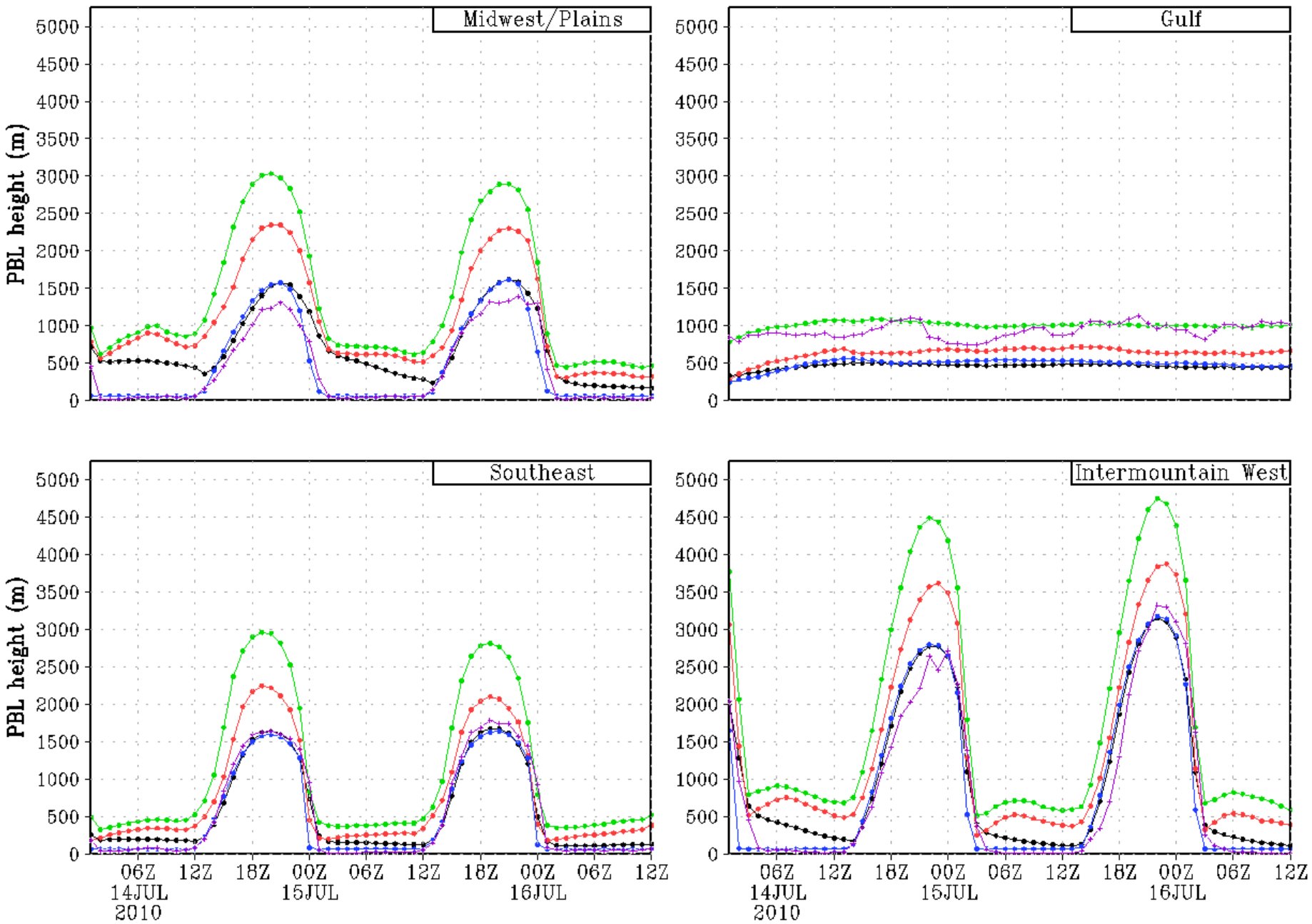
# Results

-Case

-Region

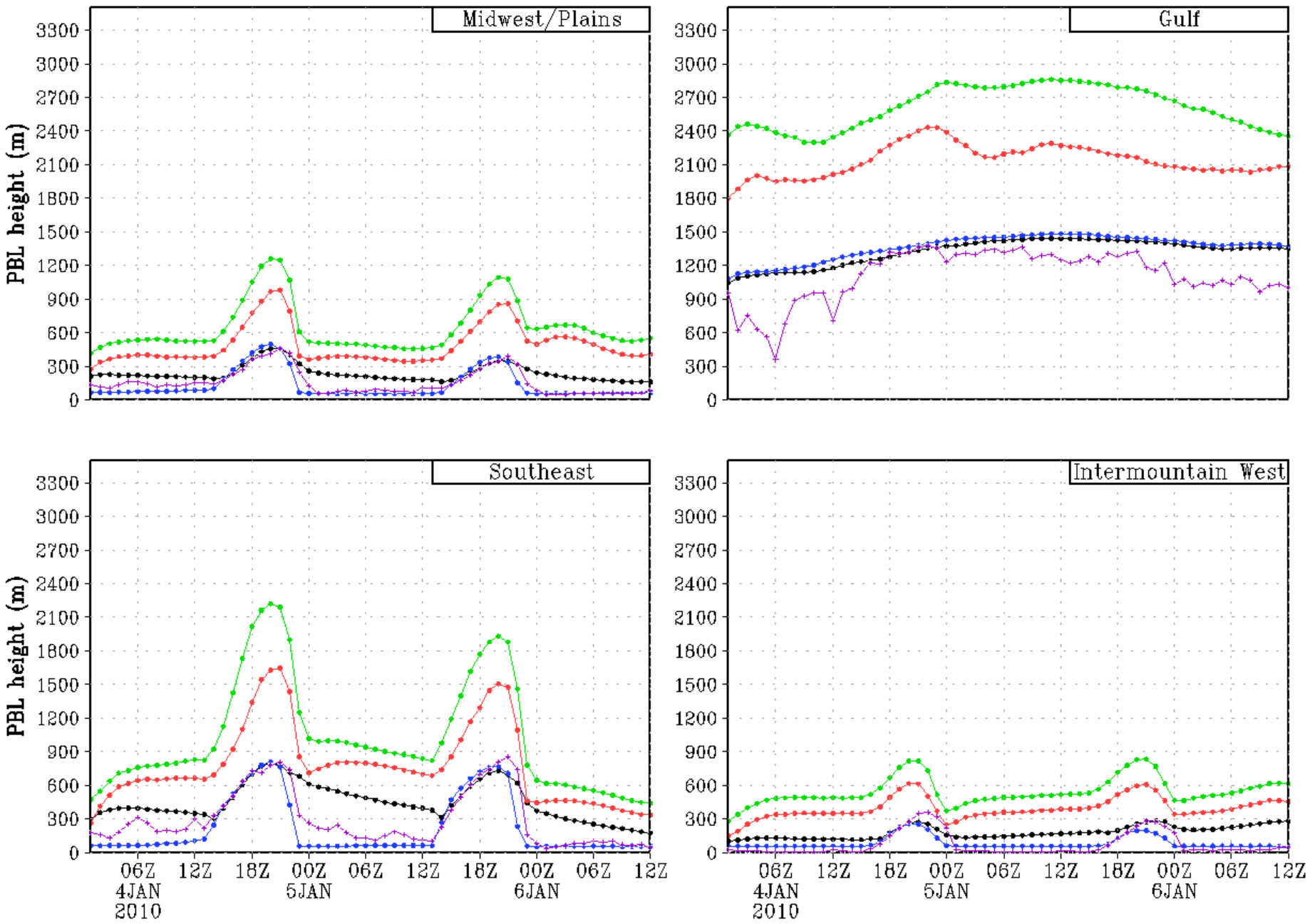
# summer case – PBL height by region

black: YSU | blue: MRF | green: QNSE | red: MYJ | purple: RUC



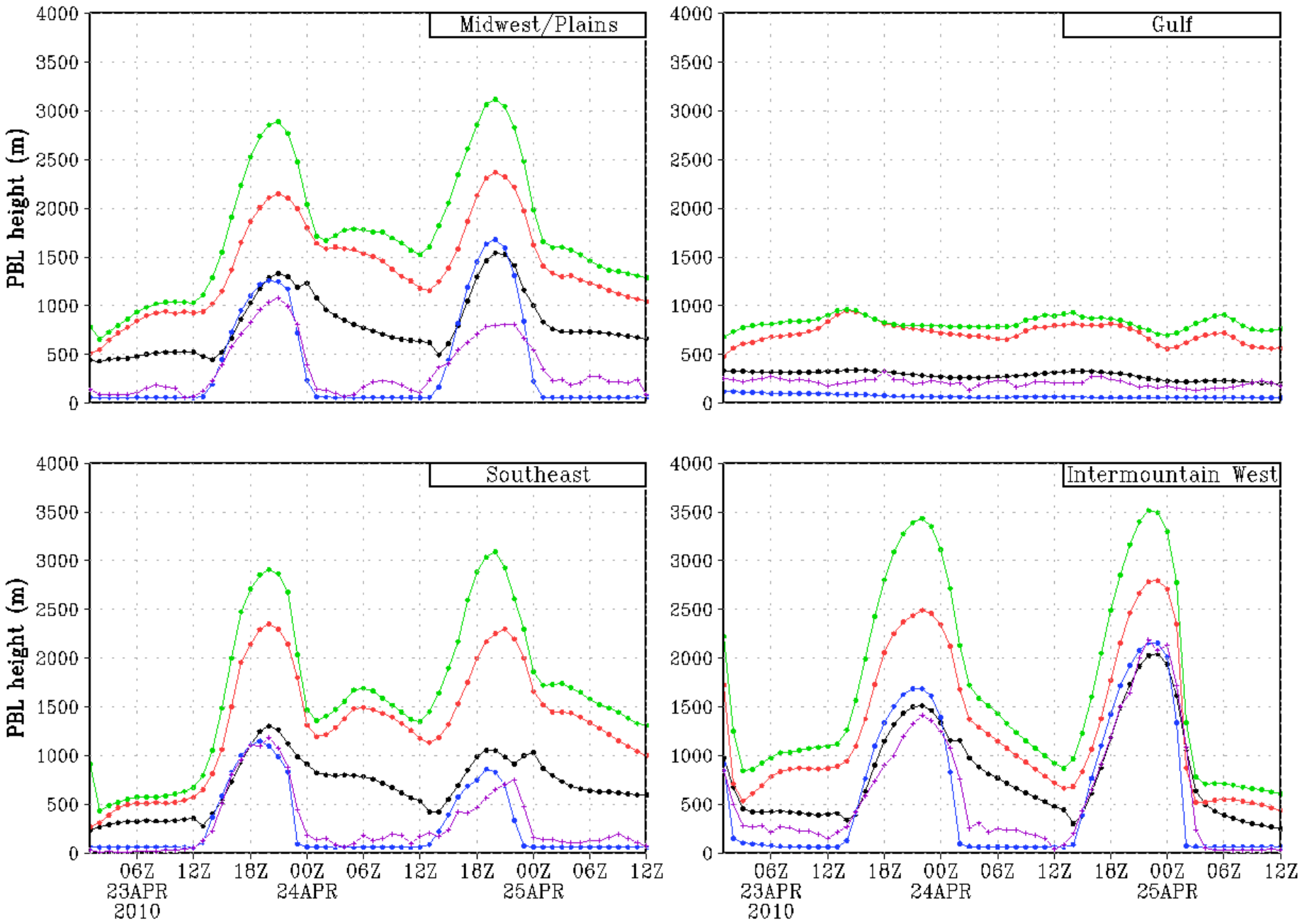
# winter case – PBL height by region

black: YSU | blue: MRF | green: QNSE | red: MYJ | purple: RUC



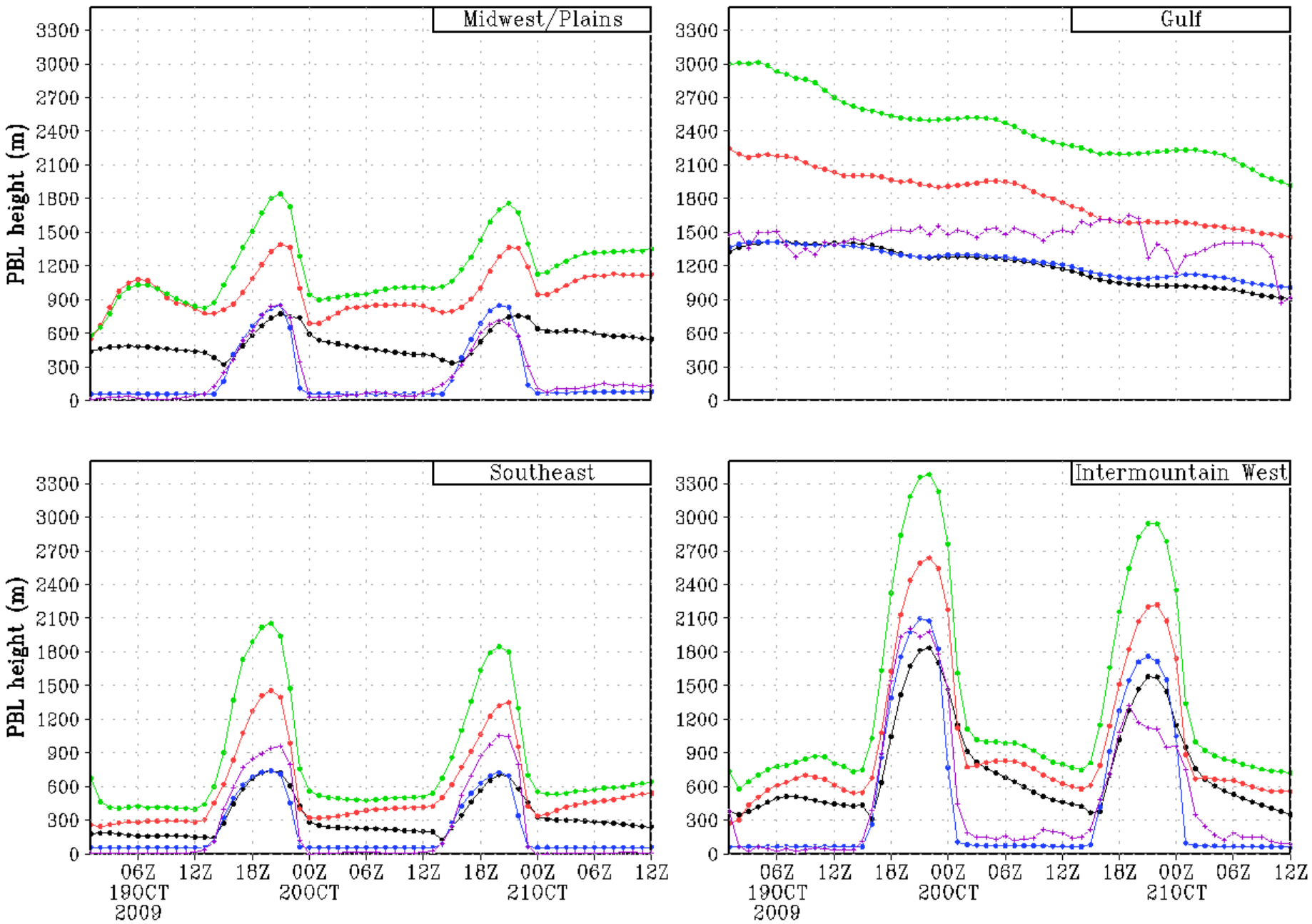
# spring case – PBL height by region

black: YSU | blue: MRF | green: QNSE | red: MYJ | purple: RUC



# autumn case – PBL height by region

black: YSU | blue: MRF | green: QNSE | red: MYJ | purple: RUC

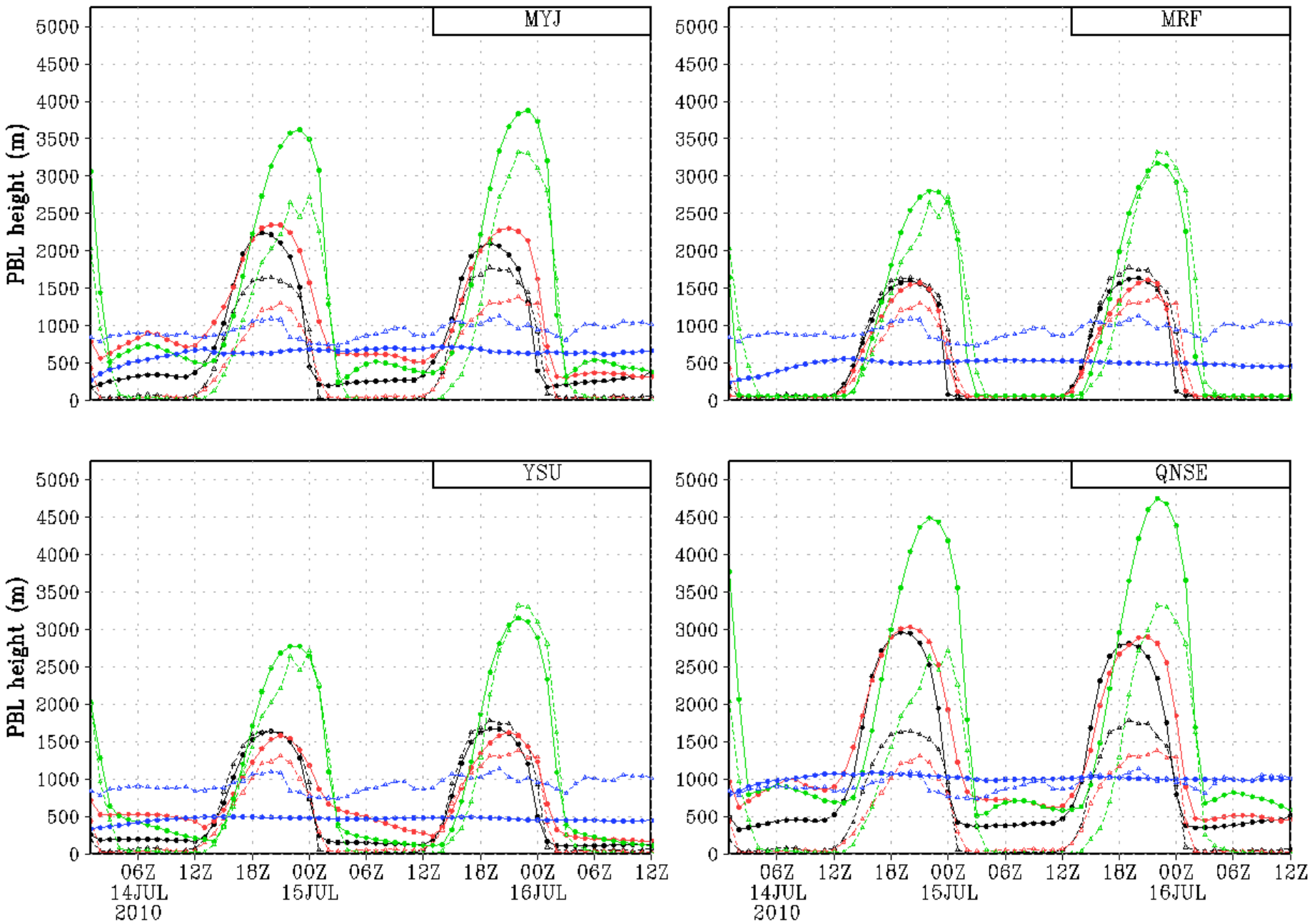


# Results

- Region
  - Case

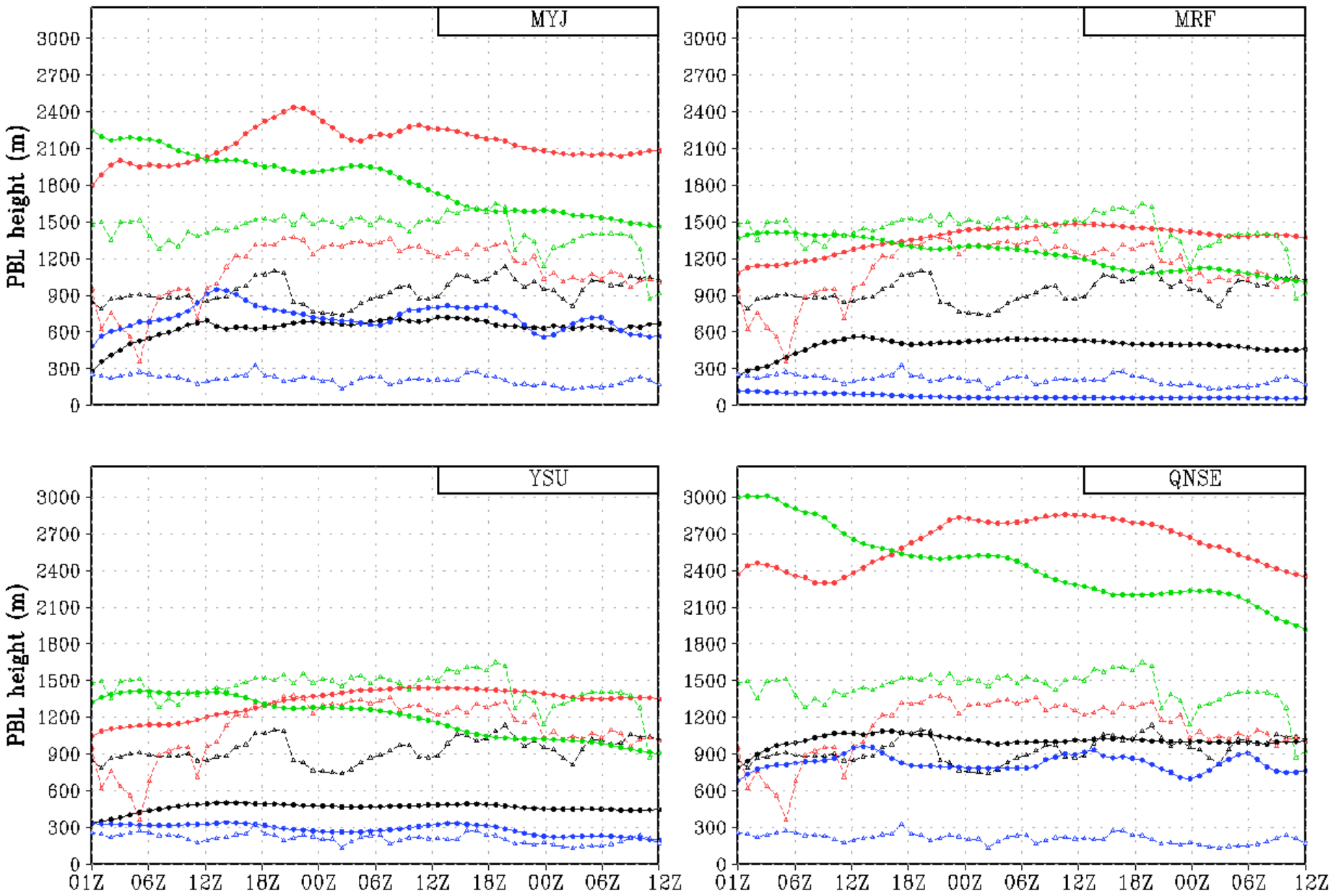
# summer case – PBL height by scheme

black: Southeast | blue: Gulf | green: Intermountain West | red: Midwest & Plains



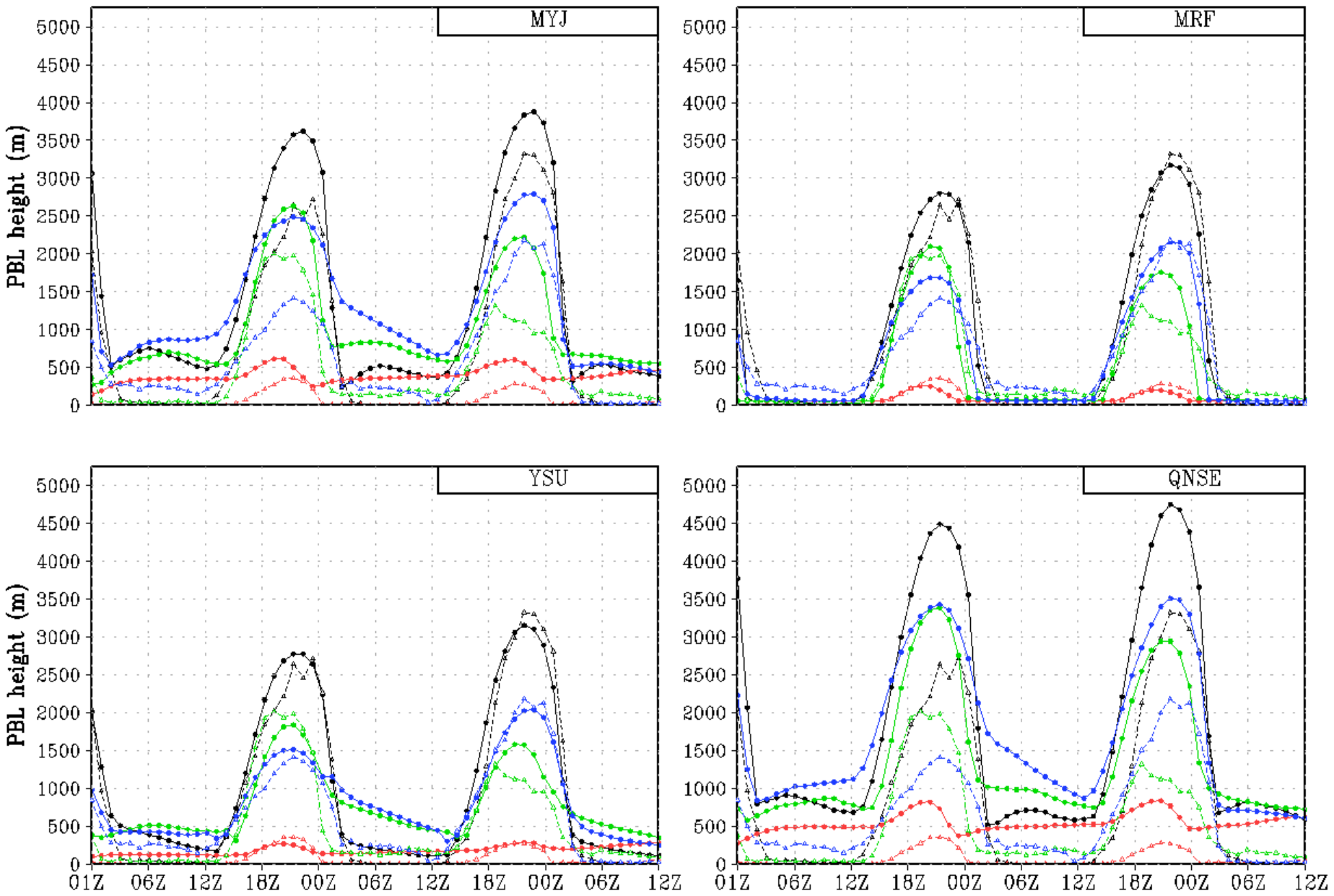
# Gulf – PBL height by scheme

black: summer | blue: spring | green: autumn | red: winter



# Intermountain West – PBL height by scheme

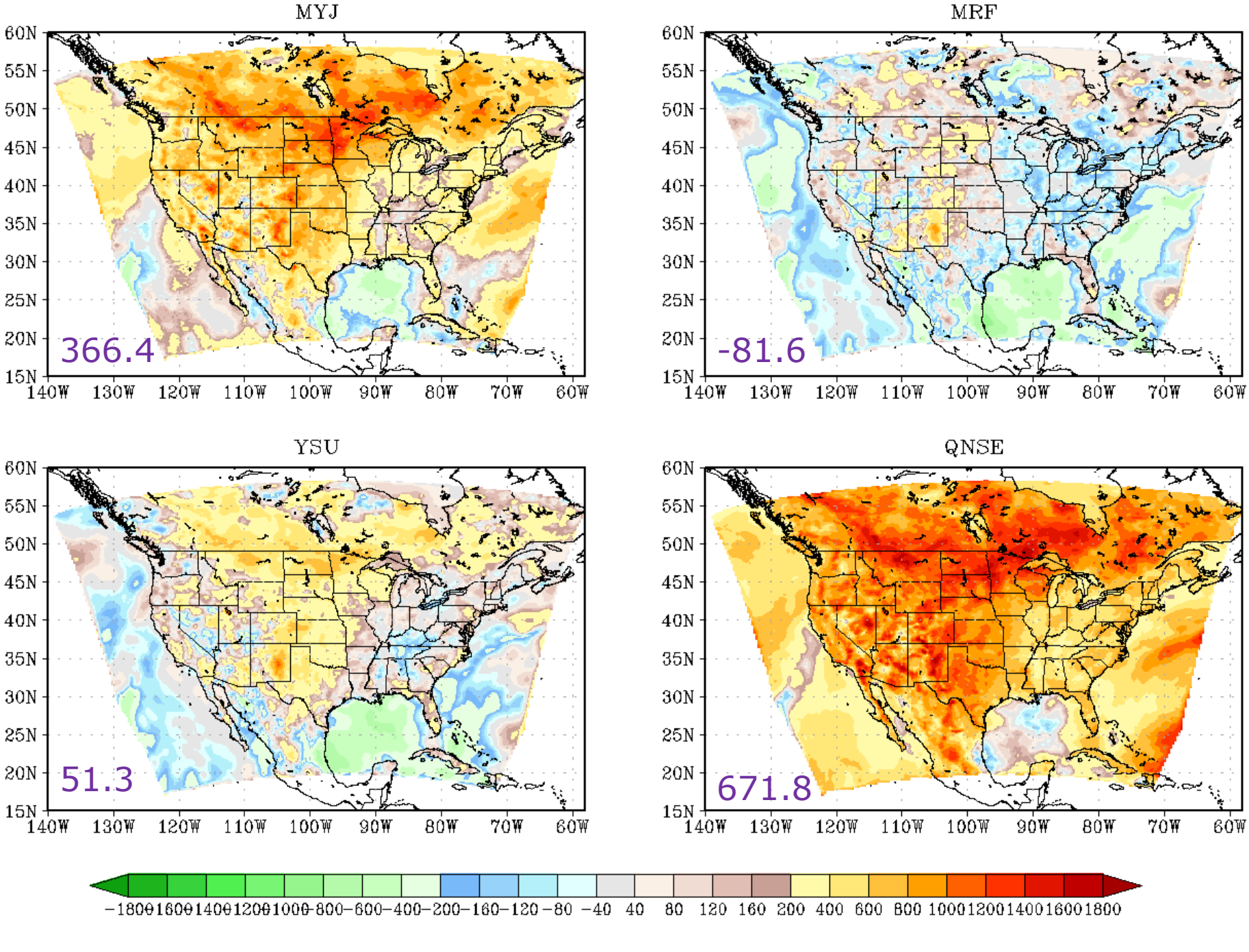
black: summer | blue: spring | green: autumn | red: winter



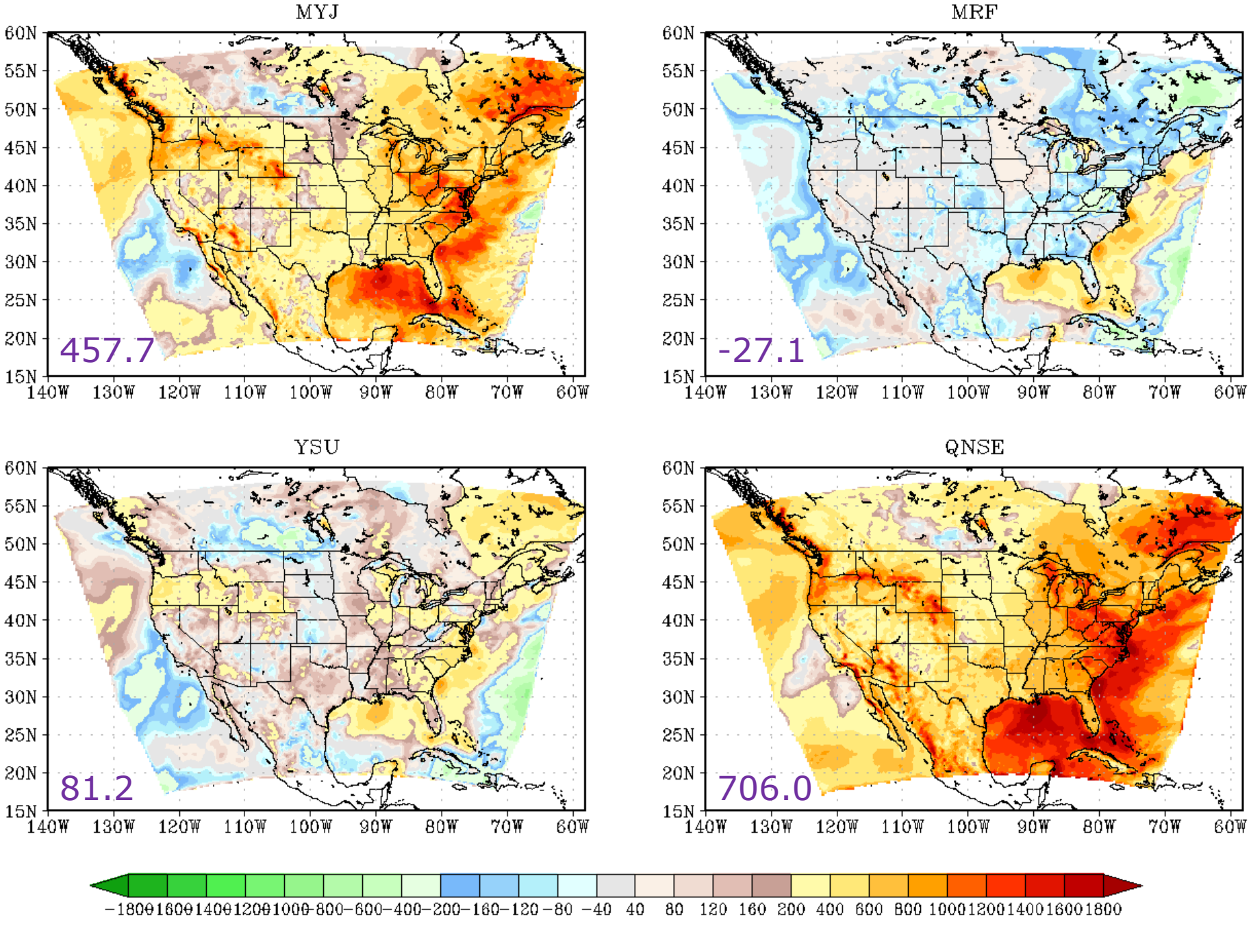
# Results

Areal, by case

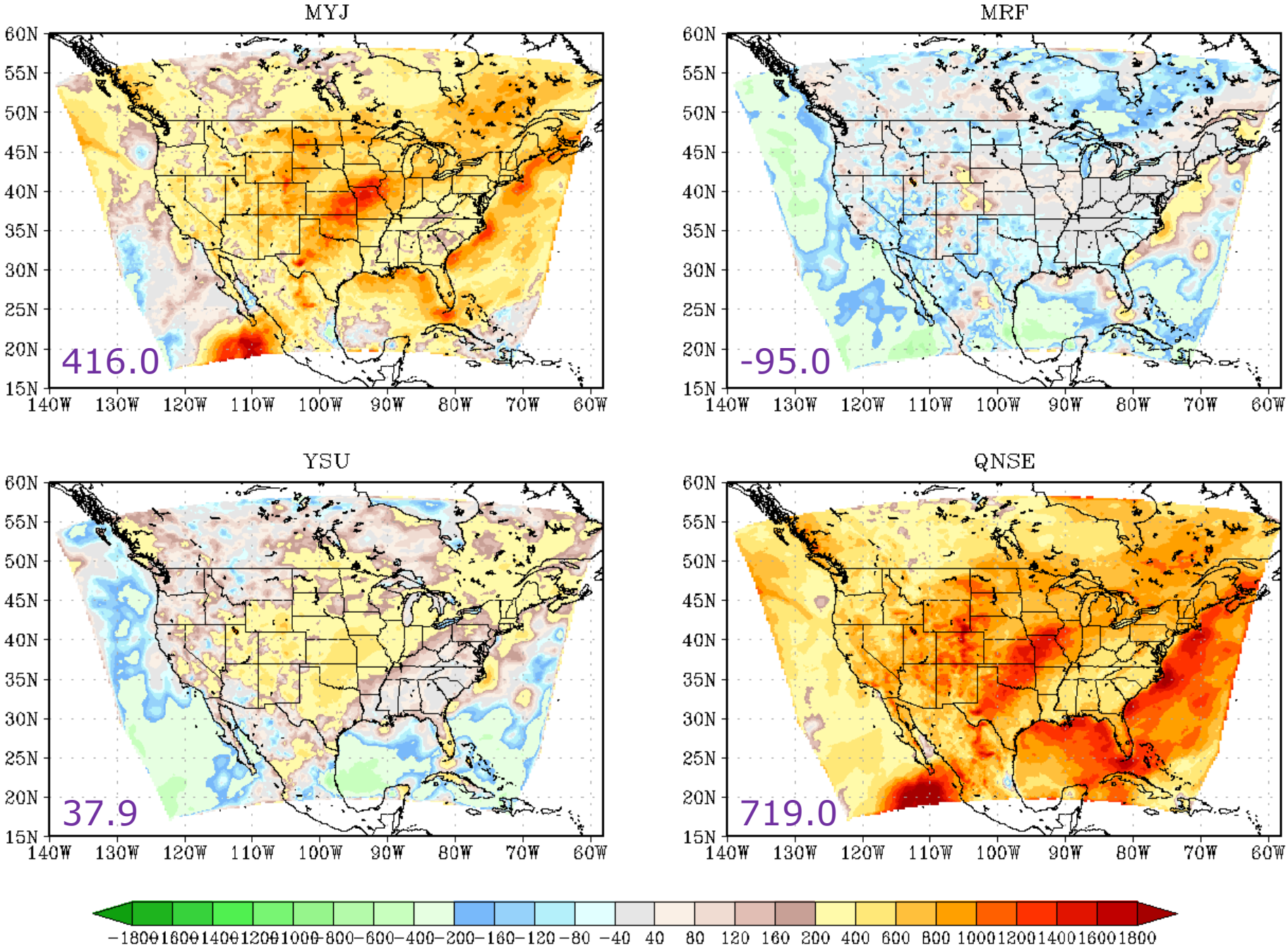
# summer PBL height errors



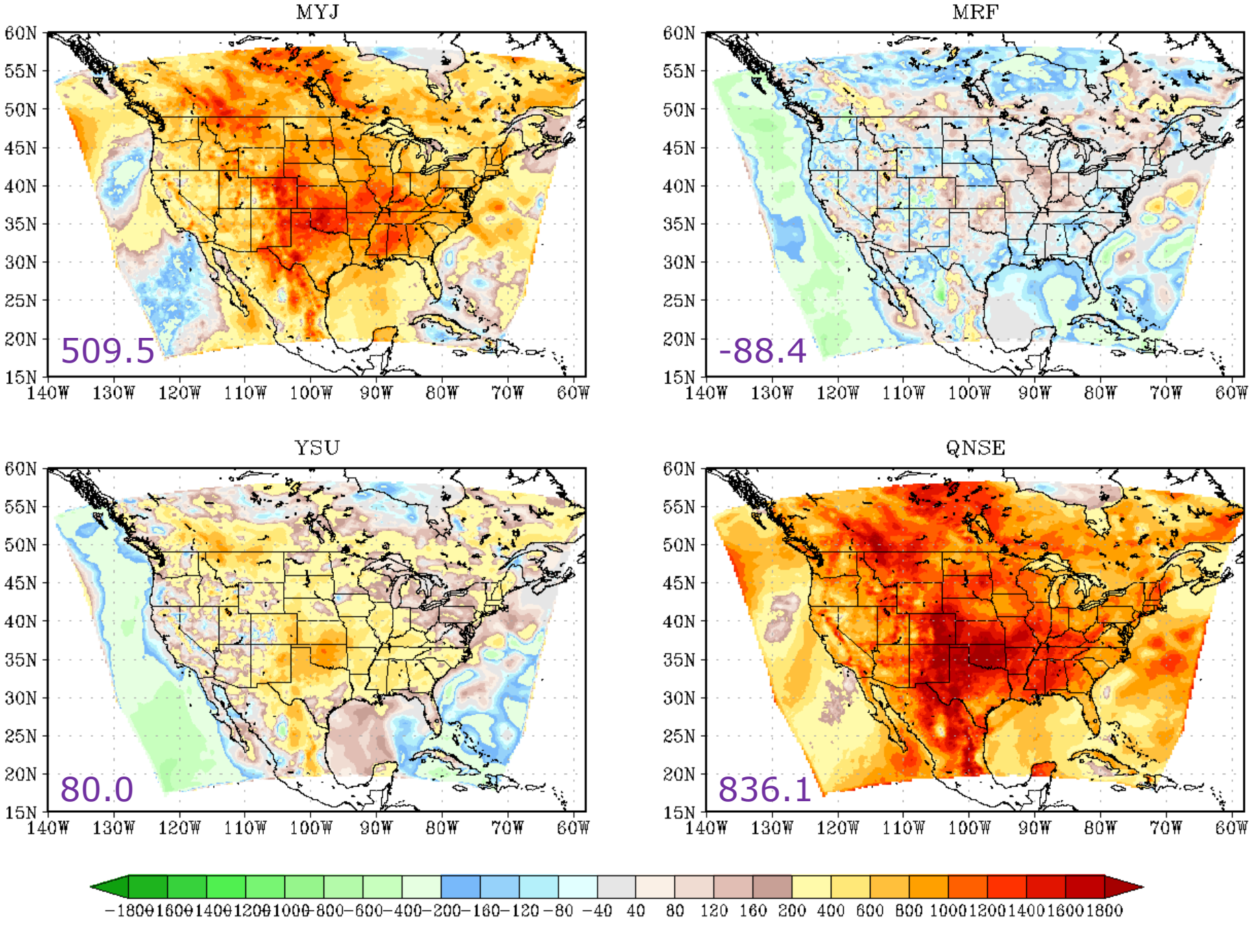
# winter PBL height errors



# autumn PBL height errors



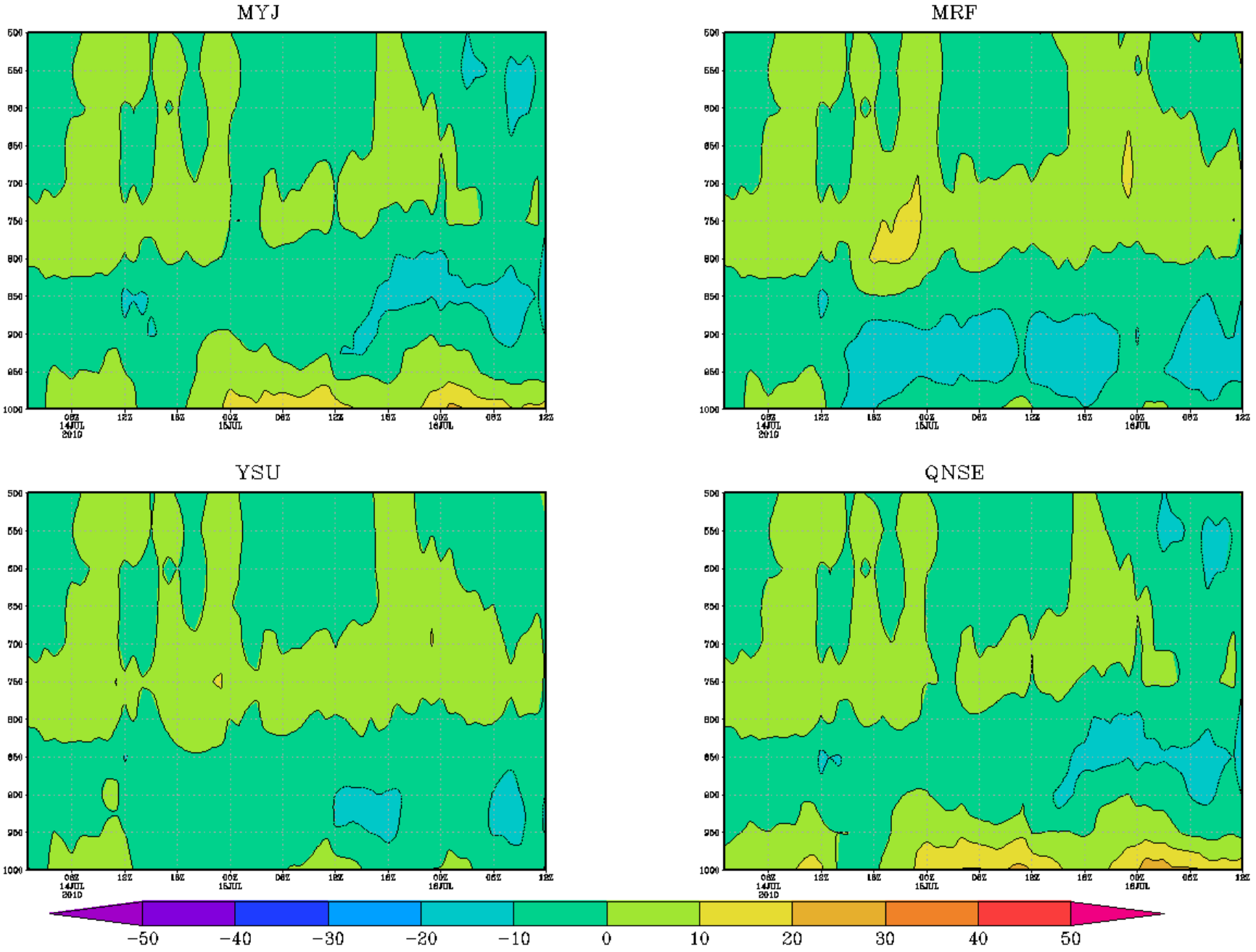
# spring PBL height errors



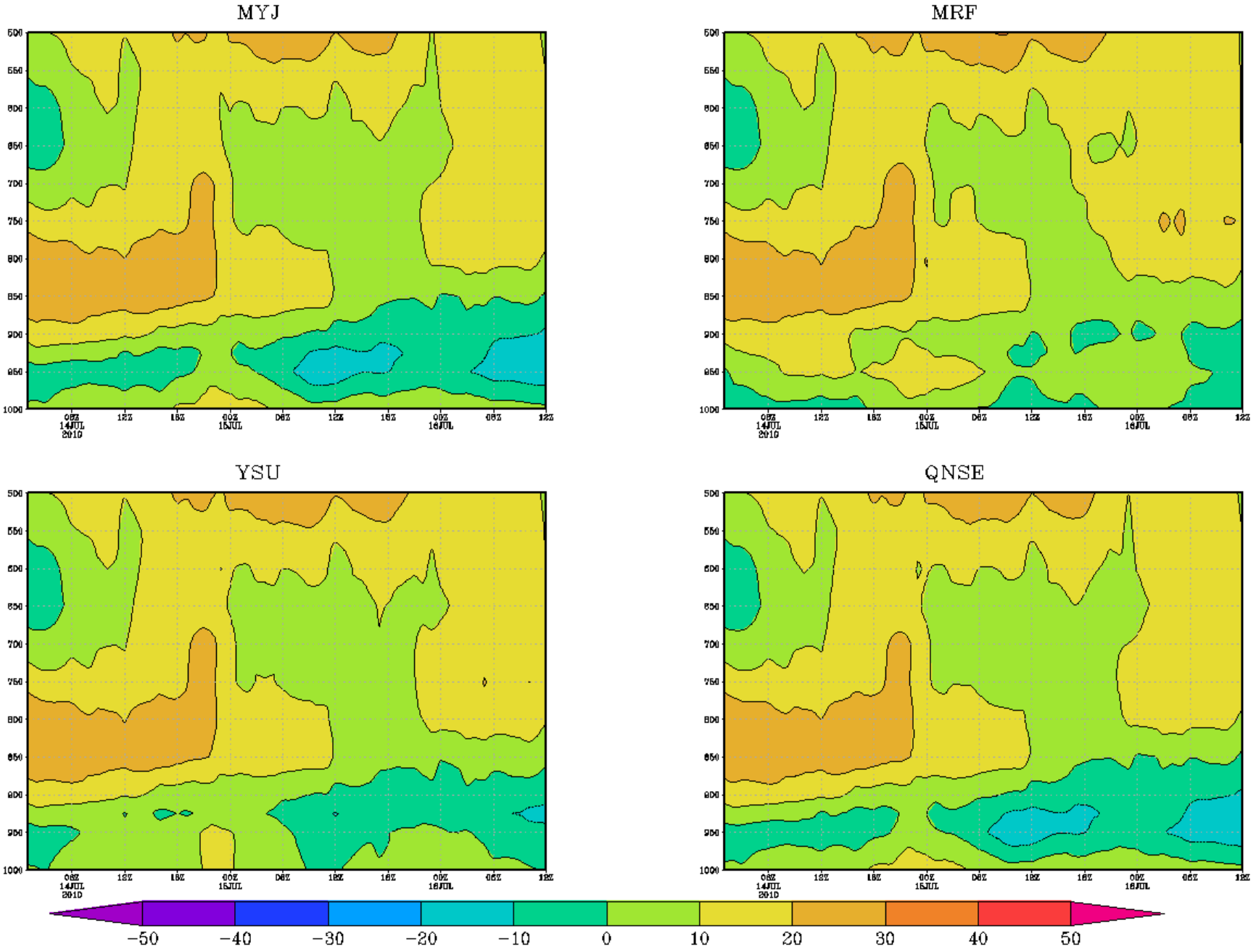
# Discussion

- MRF and YSU schemes better overall
  - Disagrees with Deng and Stauffer (2006) and Pleim (2007b): MRF – too high of PBL height
    - Not in this study
- Pleim (2007b): MRF can over mix, resulting in too deep, too dry, too warm BL
- G. Thompson (2010, personal communication): YSU scheme produces warm and dry BL, MYJ scheme produces cool and wet BL

# summer – Midwest & Plains area-averaged RH – RUC vs. PBL scheme



# summer – Gulf area–averaged RH – RUC vs. PBL scheme



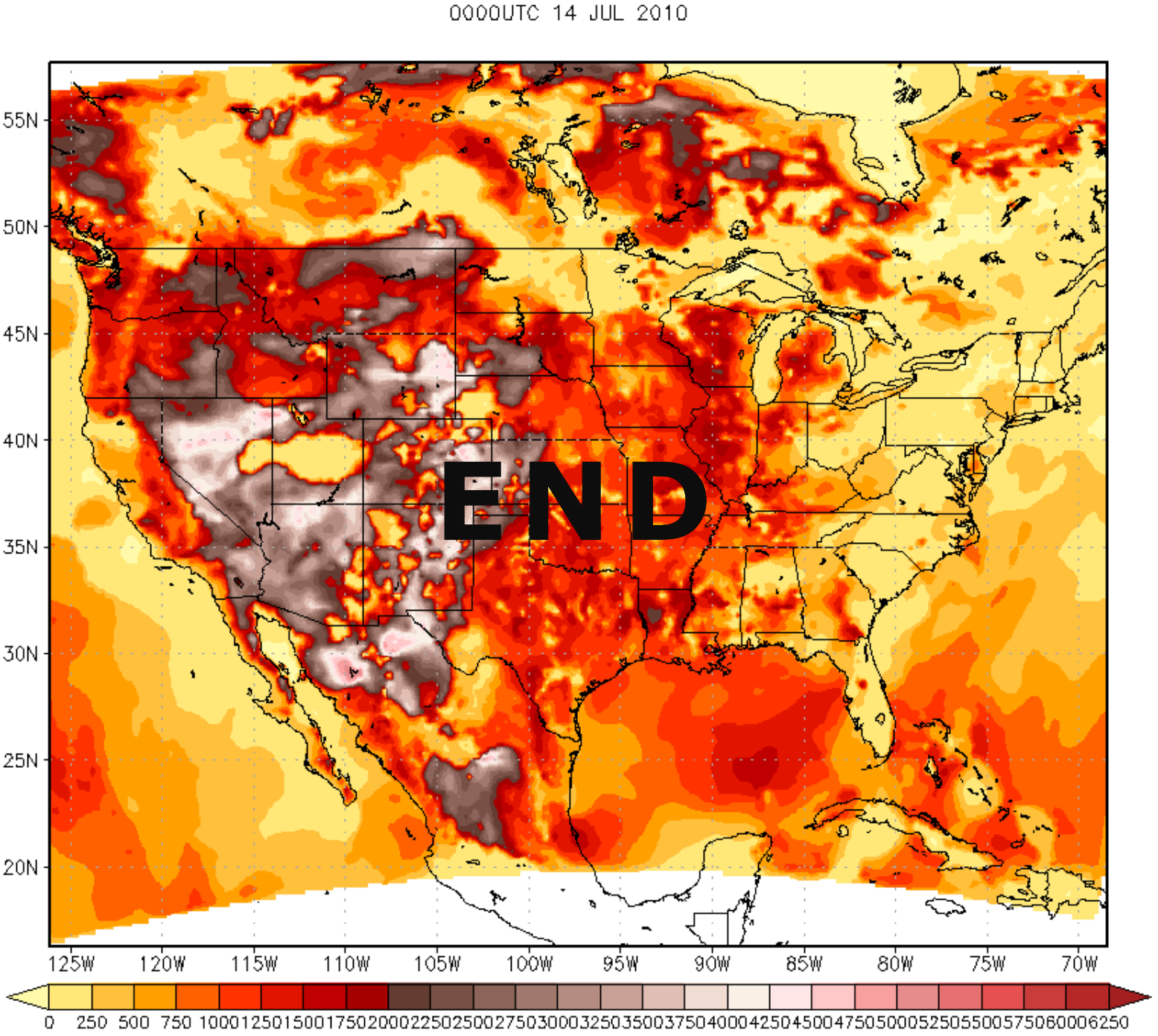
# Future work

- Computation resource limitations on:
  - Horizontal resolution (4 km?)
  - Domain size
  - Length (3, 4, diurnal cycles or more)
- Use other analysis regions
- Use other PBL schemes
- Alter code so that many different definitions of PBL height are used
  - Compare how the different definitions result in different PBL heights

# References


- Deng, A., and D. R. Stauffer, 2006: On improving 4-km mesoscale model simulations. *J. Applied Meteor. Climatology*, **45**, 361–381.

- Pleim, J., 2007b: A combined local and non-local closure model for the atmospheric boundary layer. Part II: Application and evaluation in a mesoscale meteorological model. *J. Applied Meteor. Climatology*, **46**, 1396–1409.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