Mesoscale Convective Systems in a YOTC MJO Event

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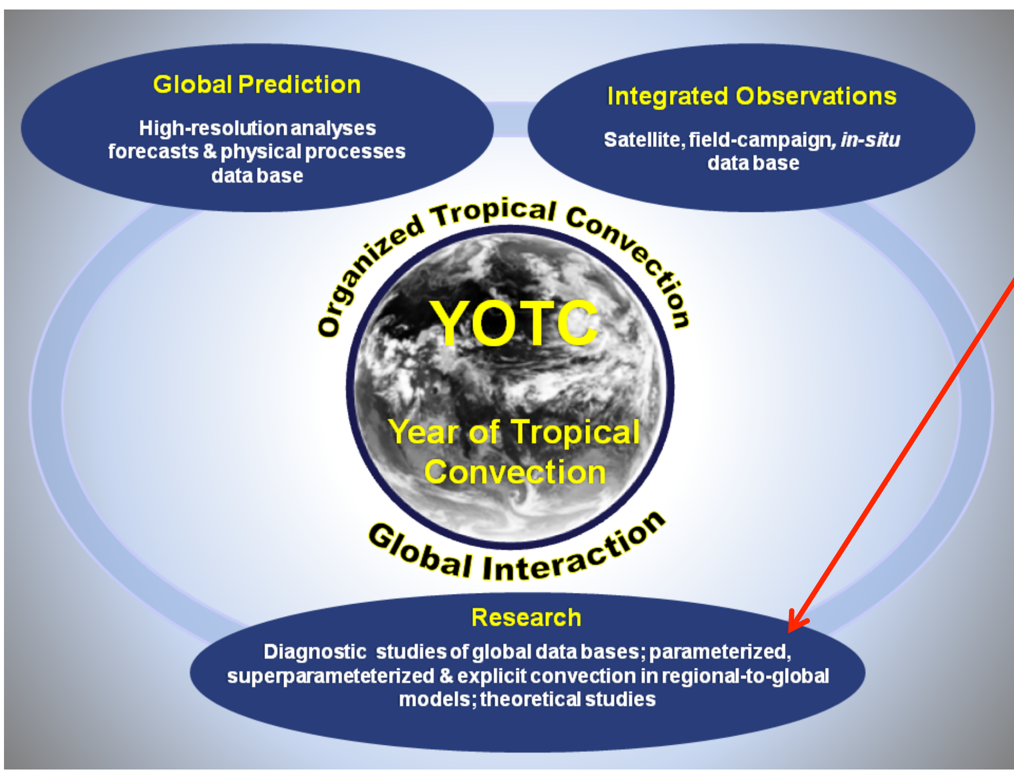


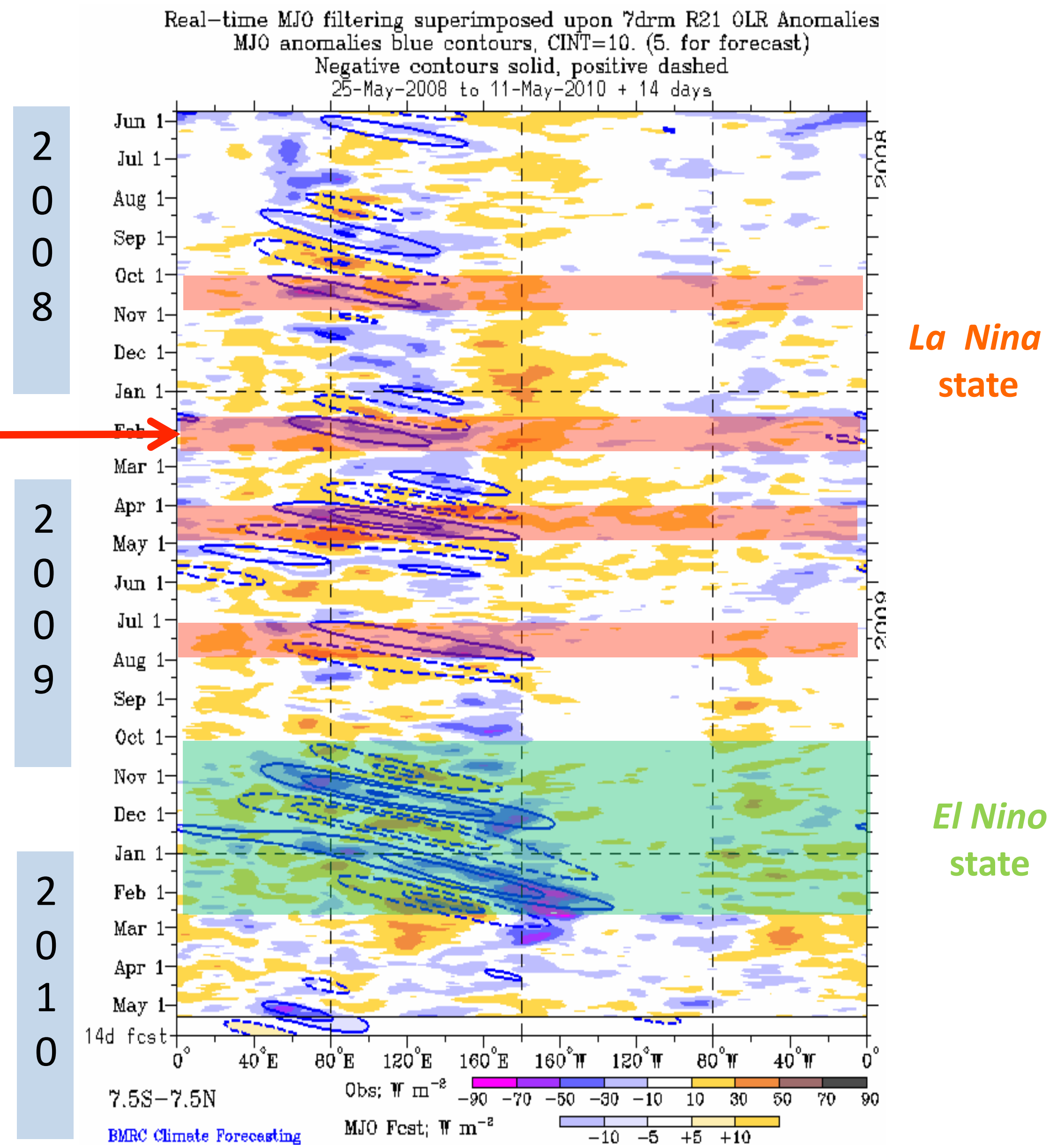
Our research focus:
- *MJO & Convectively-coupled waves*
- *Tropical-Extratropical Interaction*
- *Parameterized and explicit convection in global models*

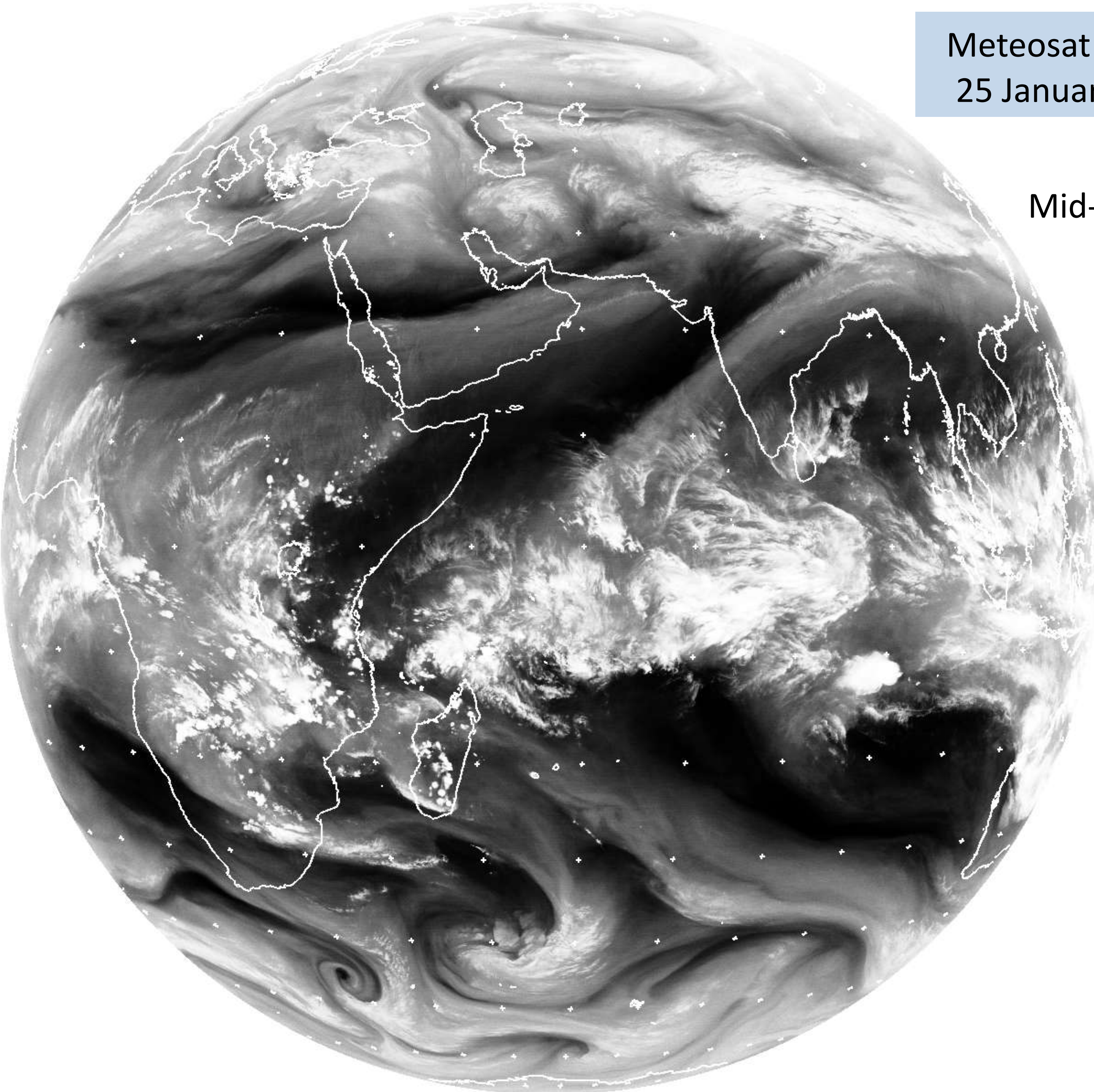
YOTC MJO event:
15 January – 4 February 2009.

Questions:
(1) Do global 3 km and 15 km simulations capture large-scale MJO signal and convective systems?
(2) Do simulations offer any insight to scale-interactions?

MJOs during YOTC

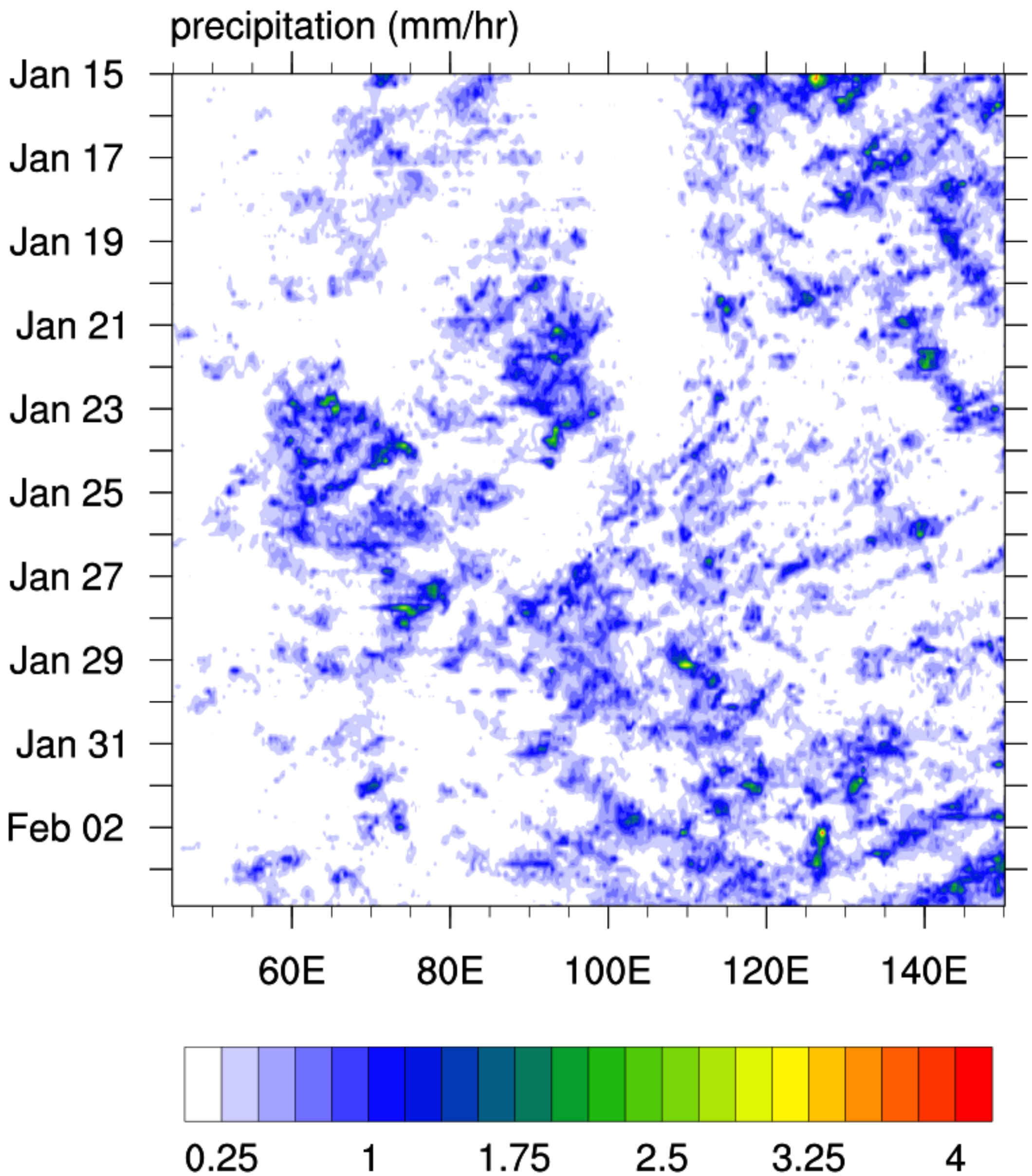
Simulation period 15 January – 4 February



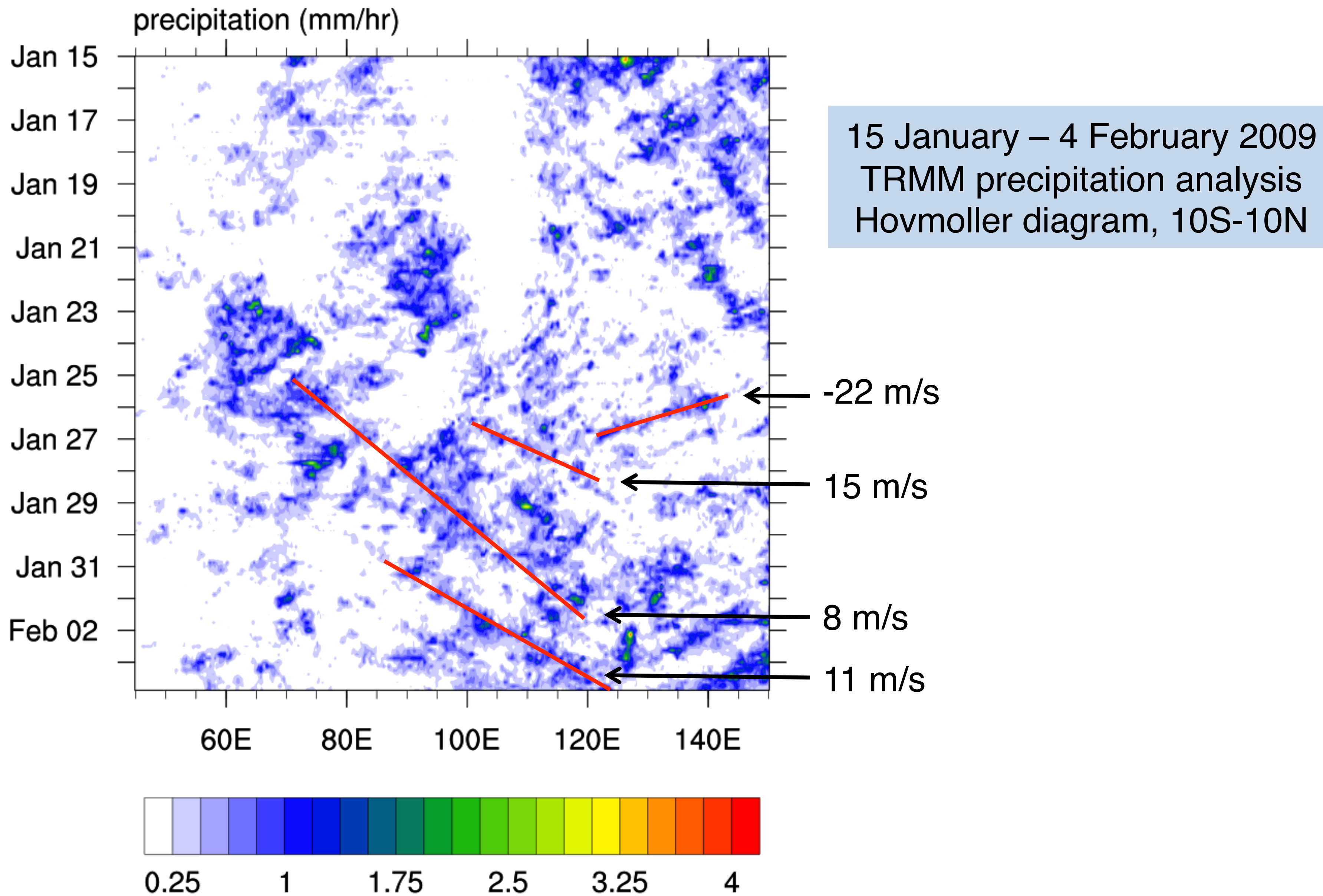


Meteosat VISSR (IODC) 057.0E
25 January 2009 at 1200 UTC

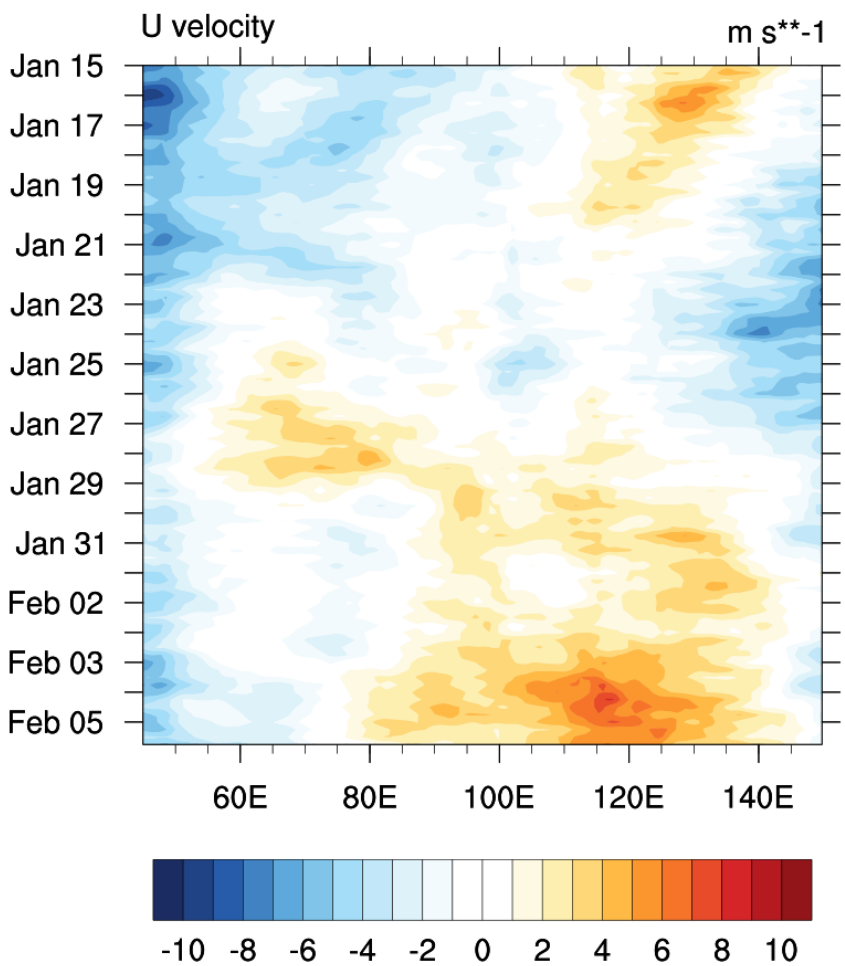
5.7 - 7.1 µm
Mid-IR / Water Vapour



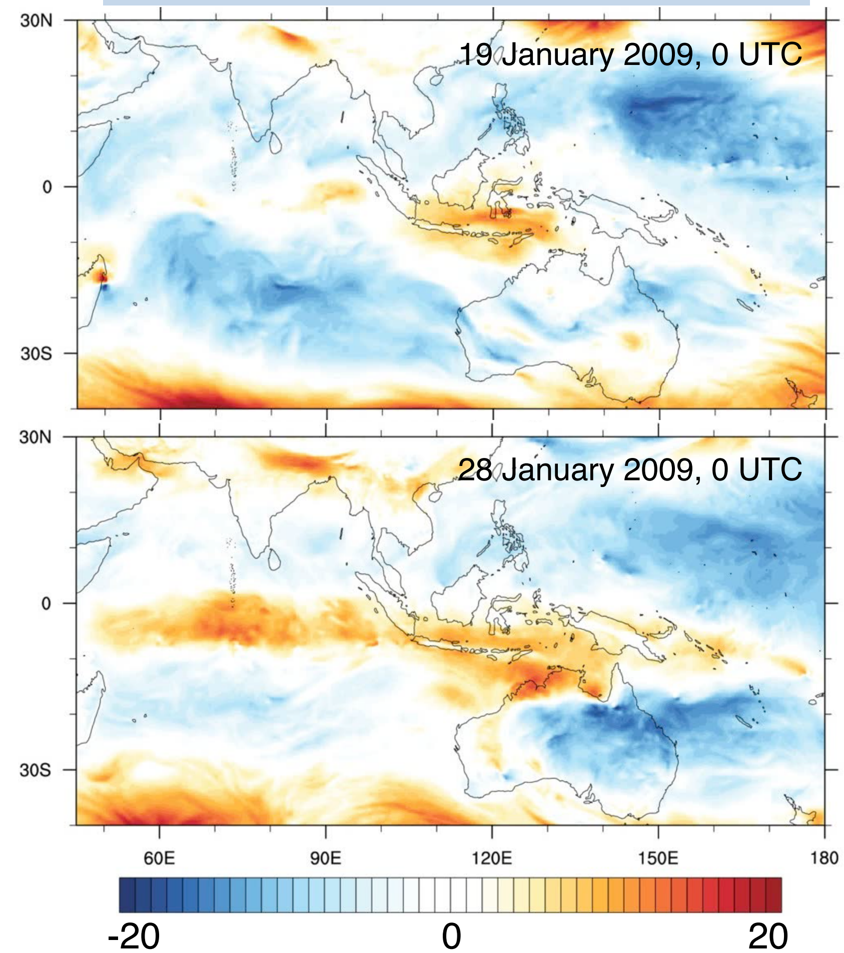
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N


precipitation (mm/hr)
Jan 15
Jan 17
Jan 19
Jan 21
Jan 23
Jan 25
Jan 27
Jan 29
Jan 31
Feb 02
60E
80E
100E
120E
140E
-22 m/s
15 m/s
8 m/s
11 m/s
0.25
1
1.75
2.5
3.25
4
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N

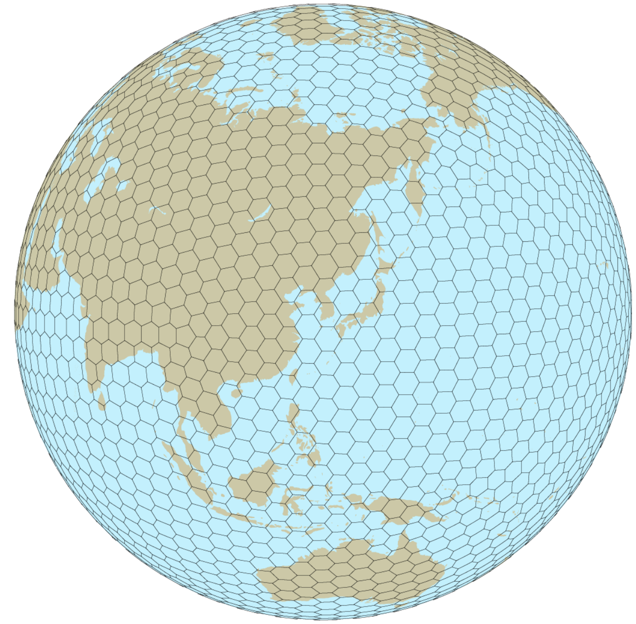
15 January – 6 February 2009
ERA-I analysis, zonal velocity
Hovmoller diagram, 10S-10N



ERA-I analysis, zonal velocity (m/s)



MPAS
Model for Prediction Across Scales

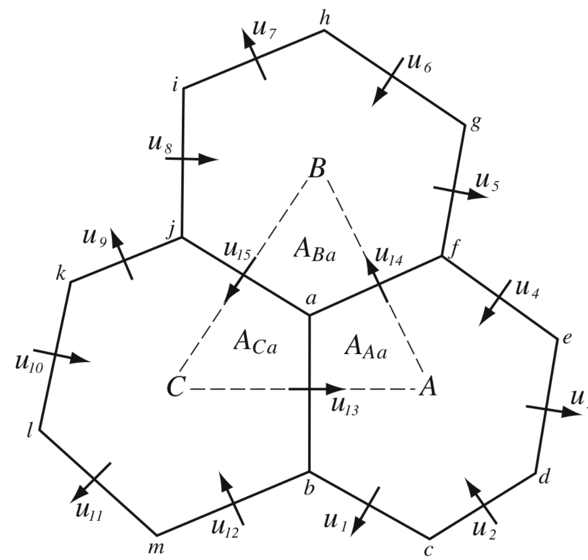


Global nonhydrostatic simulations using MPAS
0 UTC 15 January – 0 UTC 4 February 2009

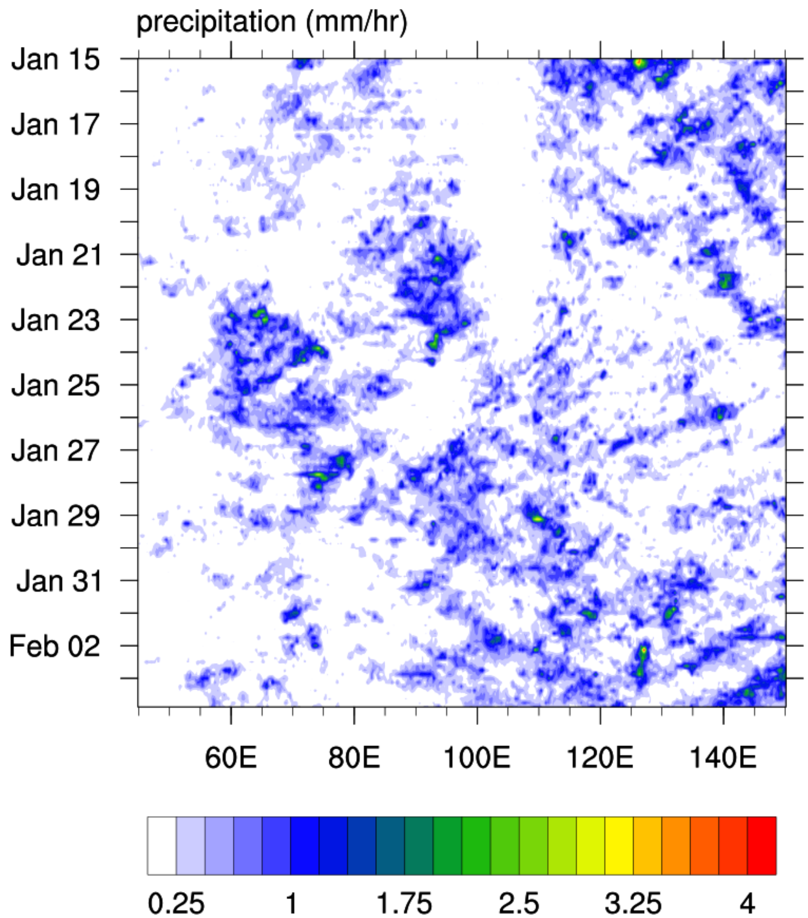
CFSR initialization.
Complete suite of NWP physics
(6 category microphysics)

3 km (cell-spacing) global uniform mesh
No convective parameterization

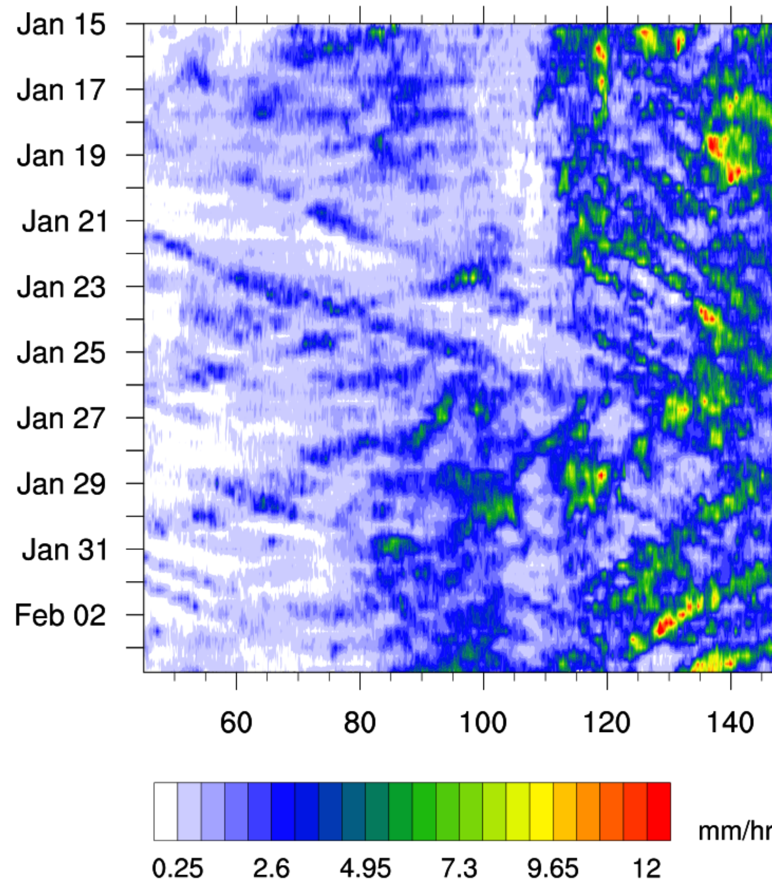
15 km (cell-spacing) global uniform mesh
(1) No convective parameterization
(2) Tiedtke convective parameterization



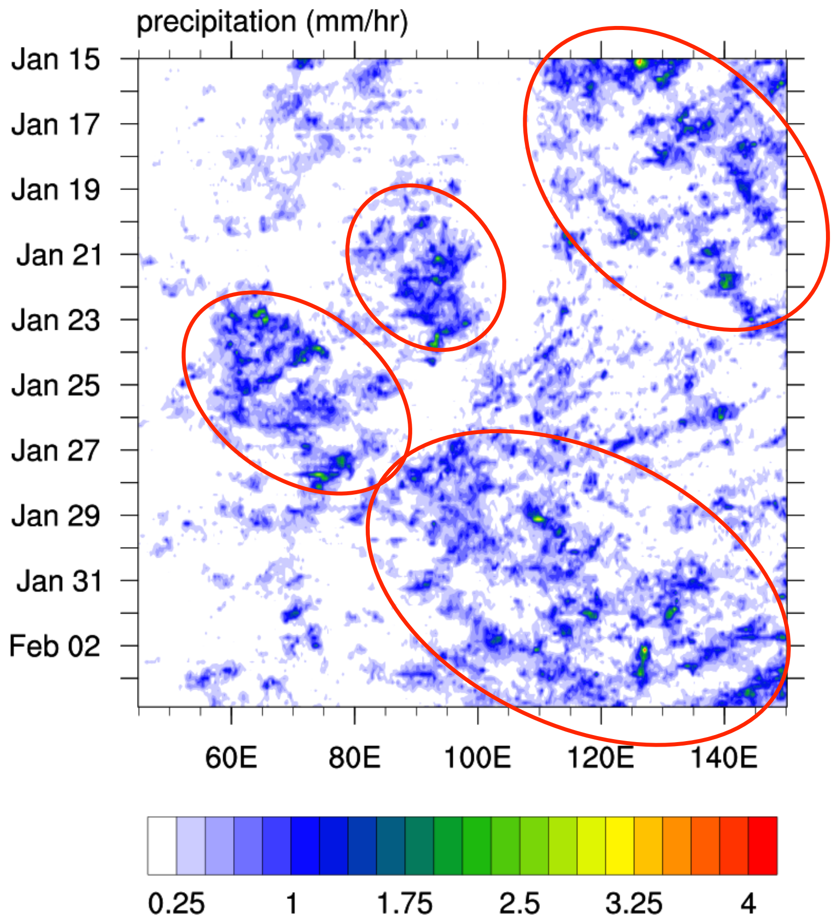
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N



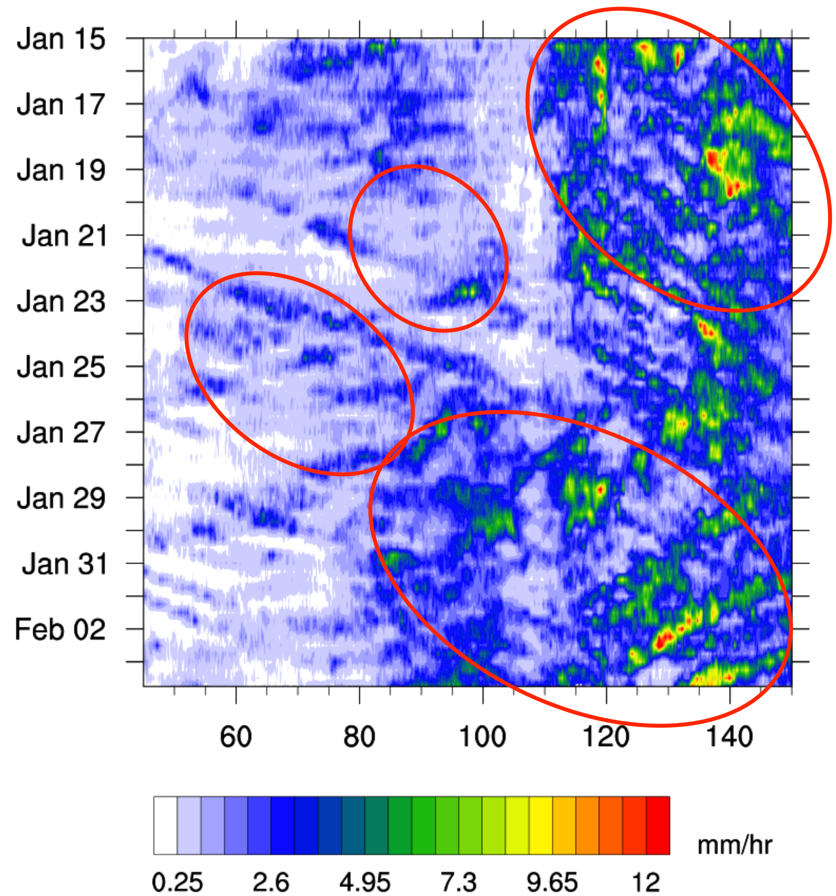
15 January – 4 February 2009
3 km MPAS, precipitation
Hovmoller diagram, 10S-10N



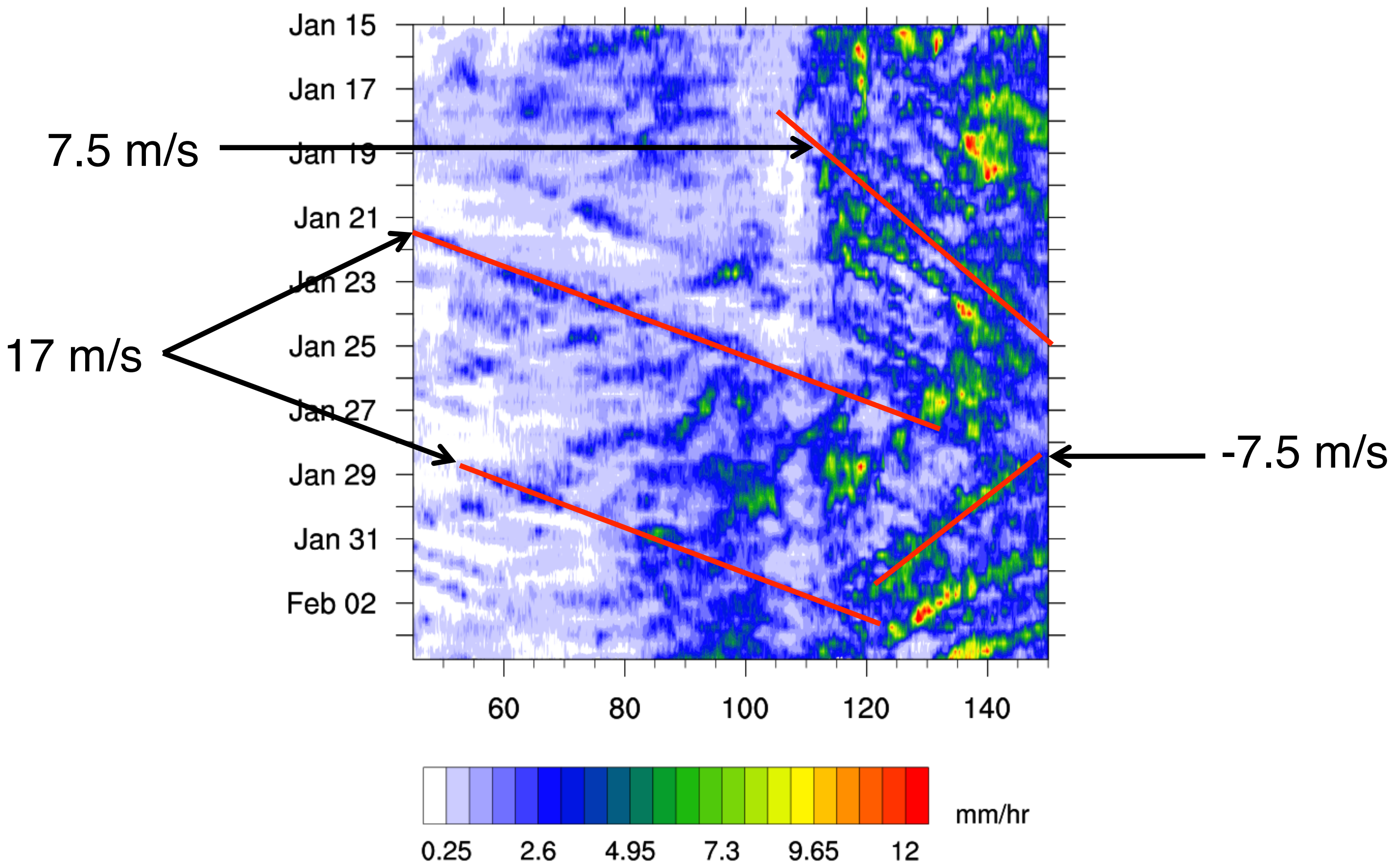
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N



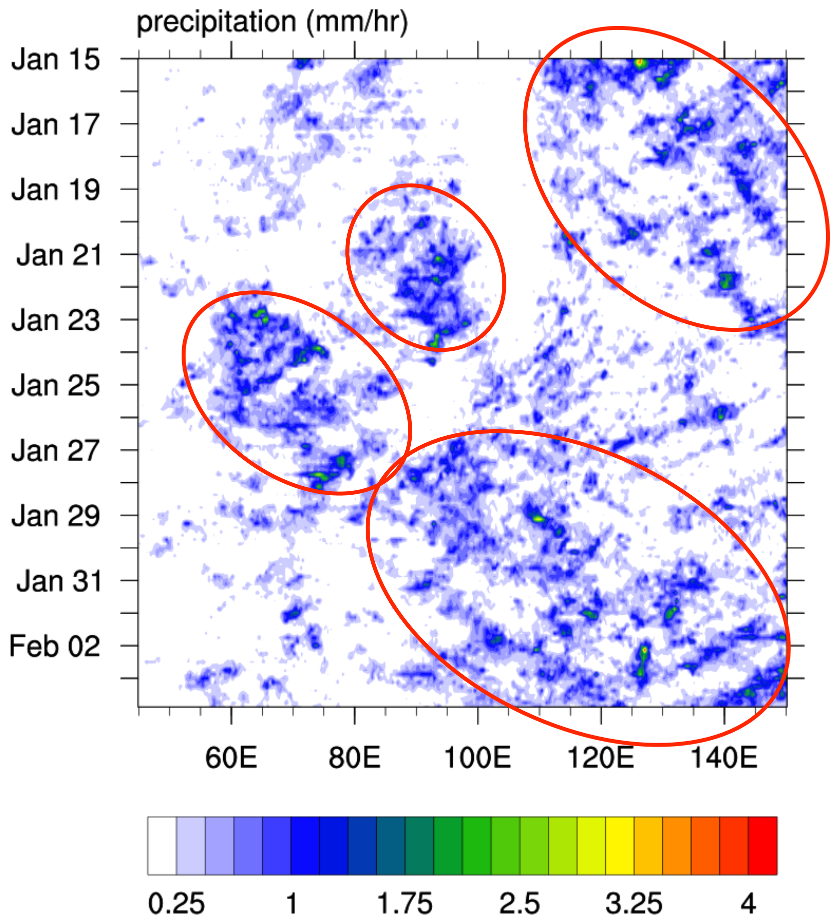
15 January – 4 February 2009
3 km MPAS, precipitation
Hovmoller diagram, 10S-10N



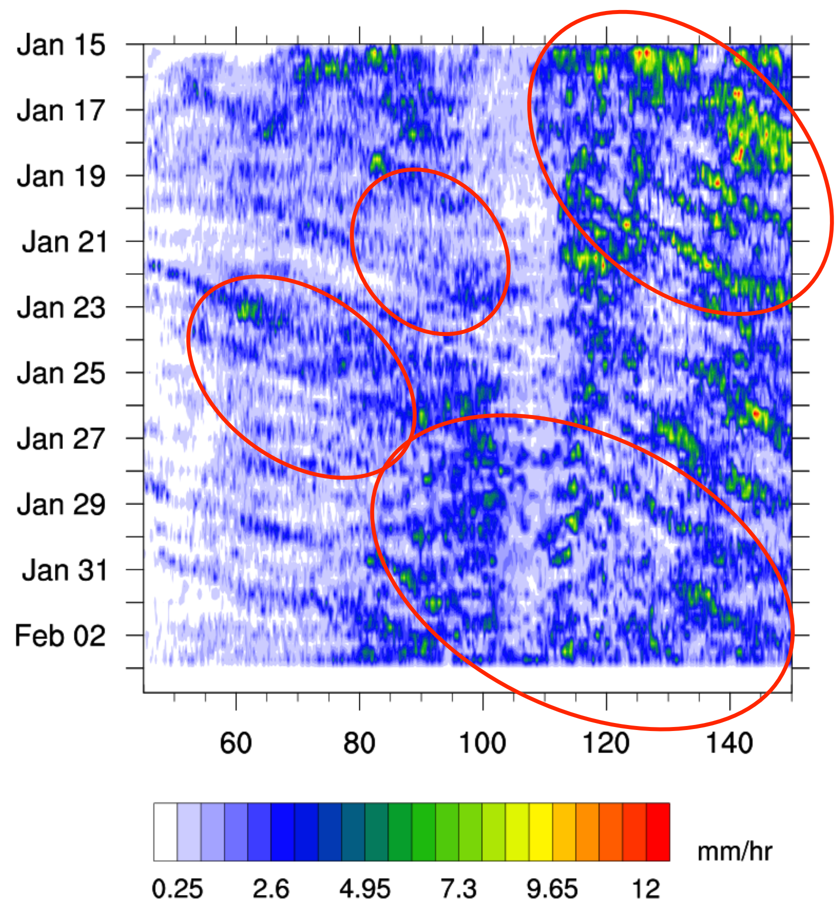
15 January – 4 February 2009
3 km MPAS, precipitation
Hovmoller diagram, 10S-10N



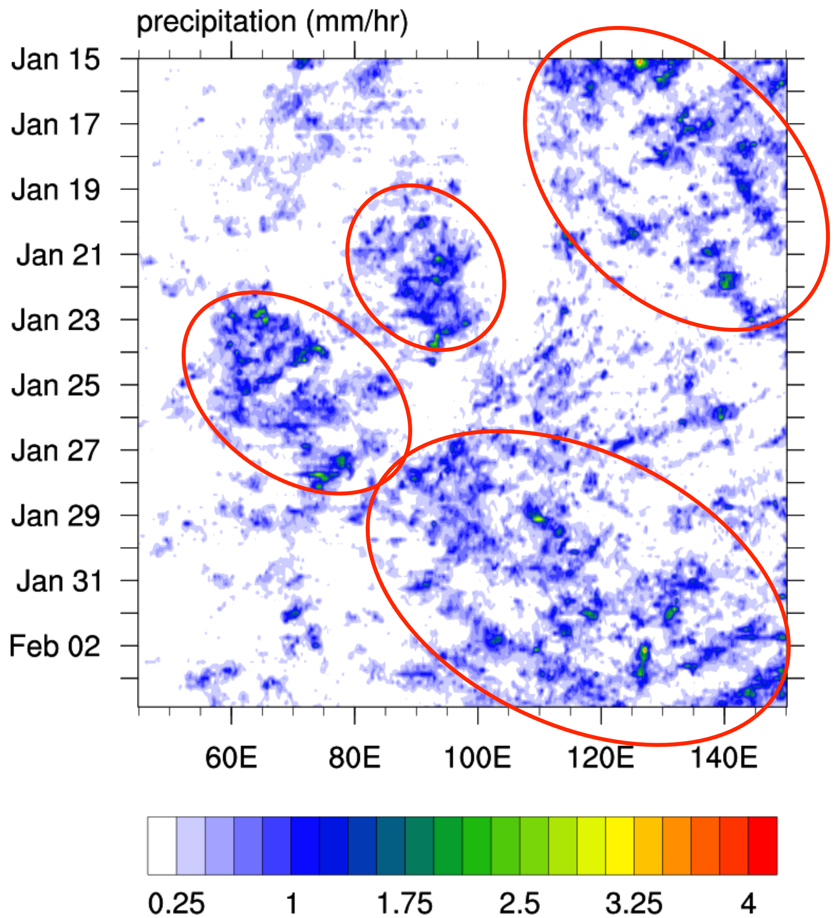
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N



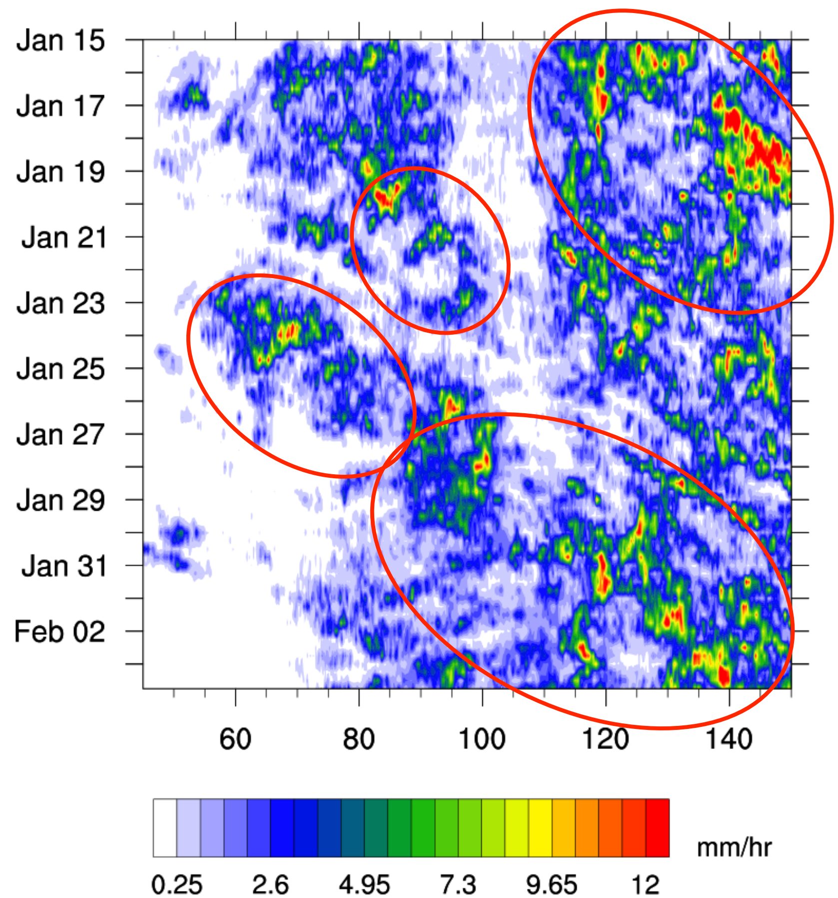
15 January – 4 February 2009
15 km MPAS, precipitation
Hovmoller diagram, 10S-10N
no convective param.

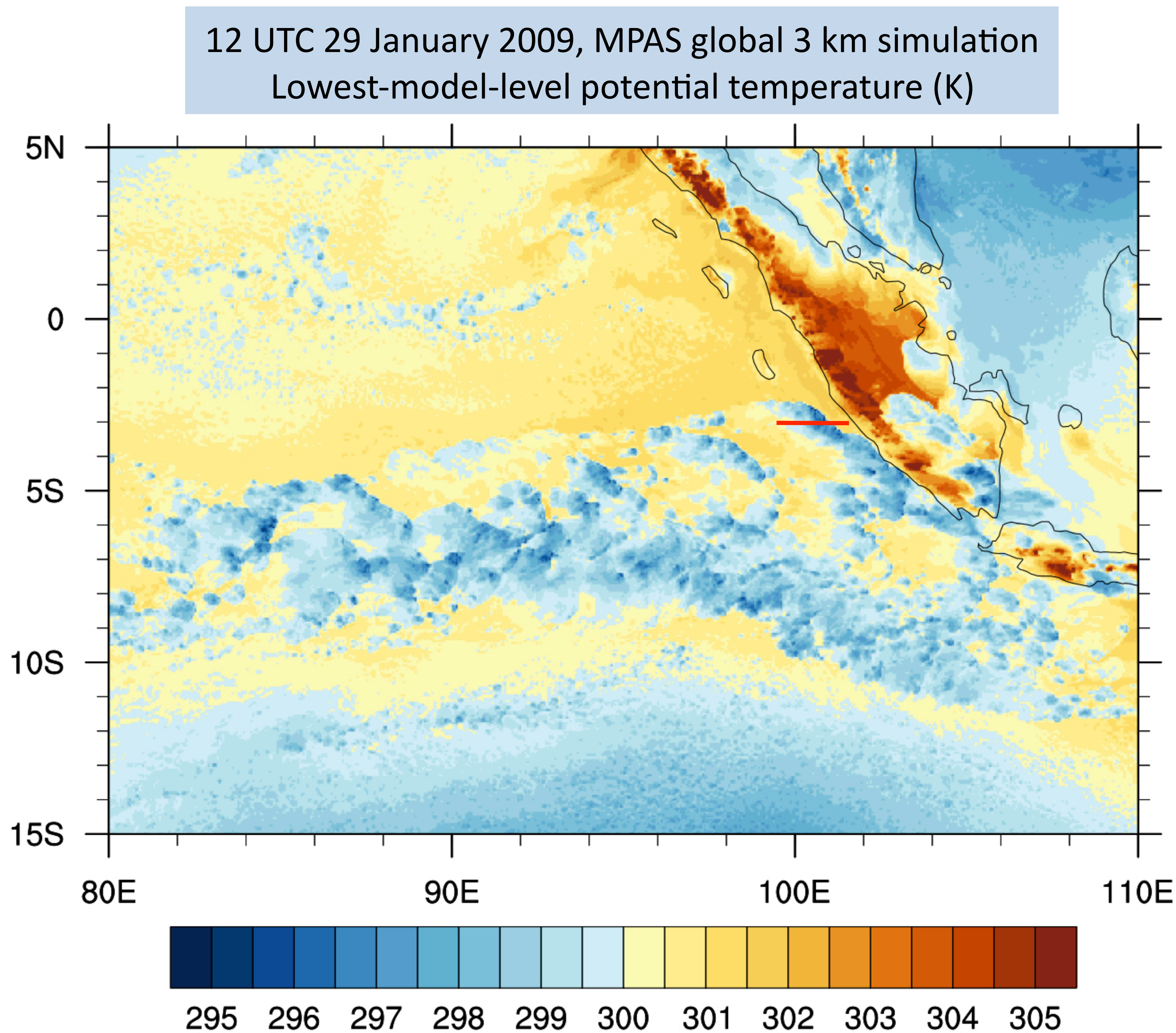


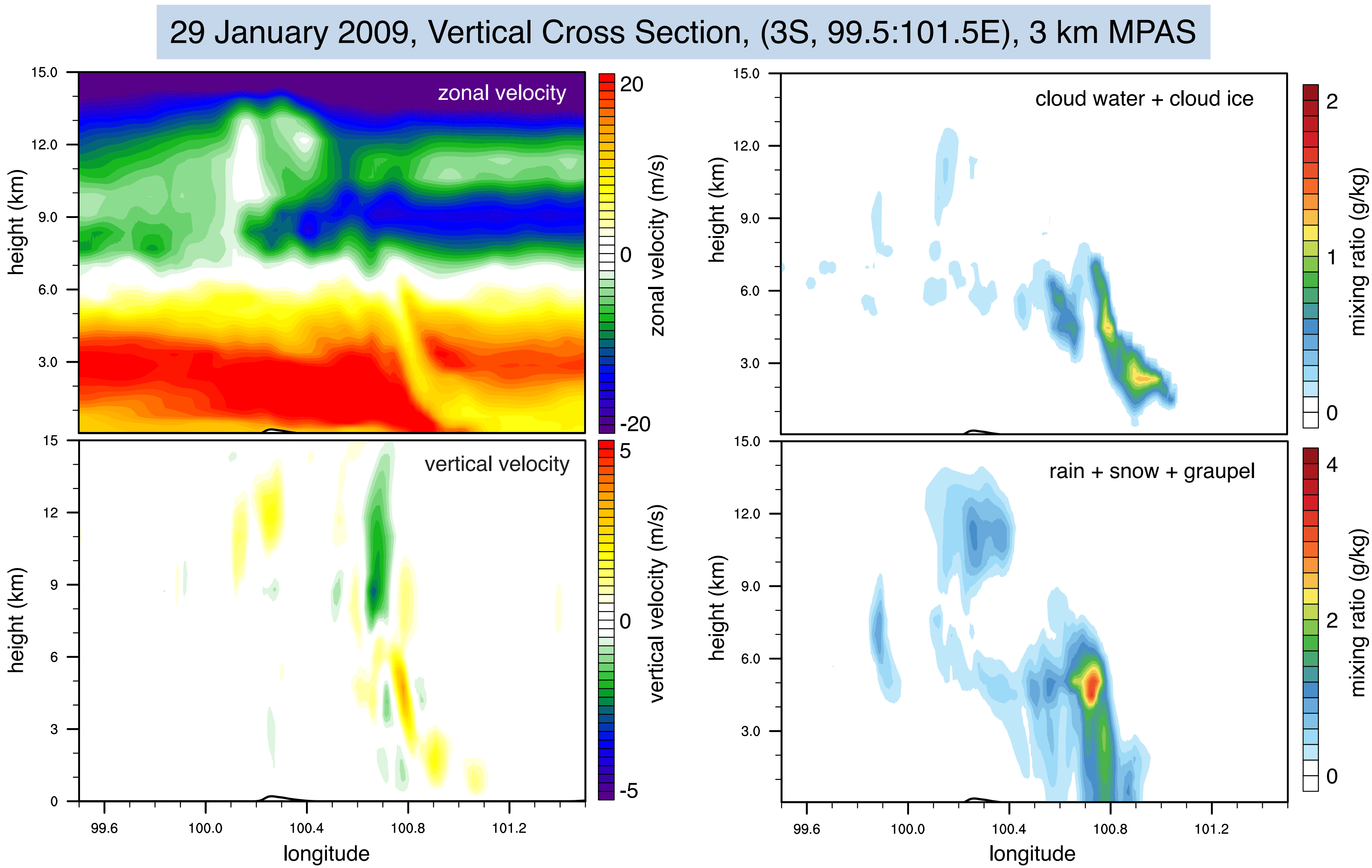
15 January – 4 February 2009
TRMM precipitation analysis
Hovmoller diagram, 10S-10N

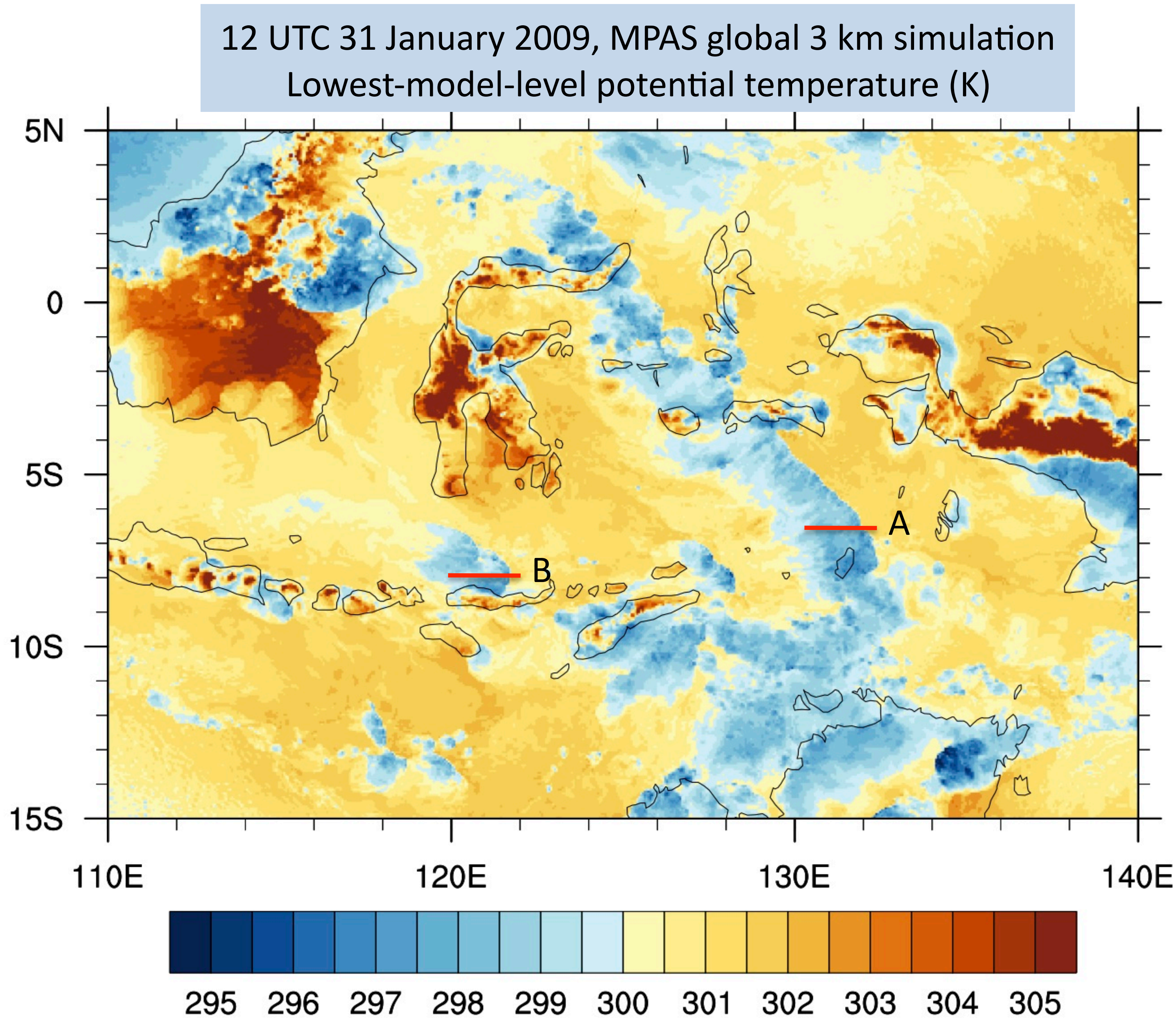


15 January – 4 February 2009
15 km MPAS, precipitation
Hovmoller diagram, 10S-10N
Tiedtke convective param.

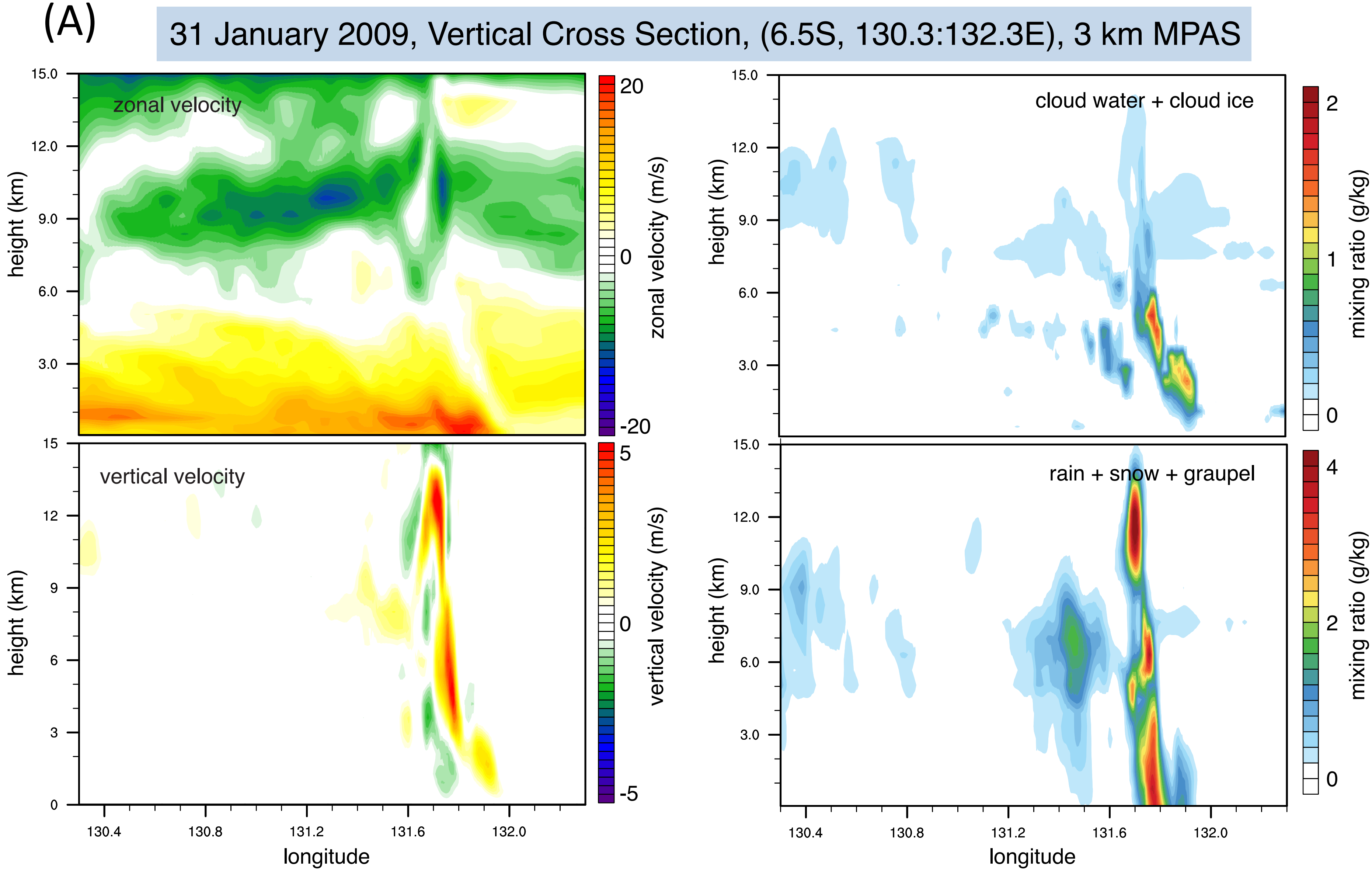



12 UTC 29 January 2009, MPAS global 3 km simulation
Lowest-model-level potential temperature (K)
5N
0
5S
10S
15S
80E
90E
100E
110E
295
296
297
298
299
300
301
302
303
304
305


29 January 2009, Vertical Cross Section, (3S, 99.5:101.5E), 3 km MPAS
zonal velocity
zonal velocity (m/s)
20
0
-20
cloud water + cloud ice
mixing ratio (g/kg)
2
1
0
vertical velocity
vertical velocity (m/s)
5
0
-5
rain + snow + graupel
mixing ratio (g/kg)
4
2
0
height (km)
15.0
12.0
9.0
6.0
3.0
15
12
9
6
3
0
99.6
100.0
100.4
100.8
101.2
longitude

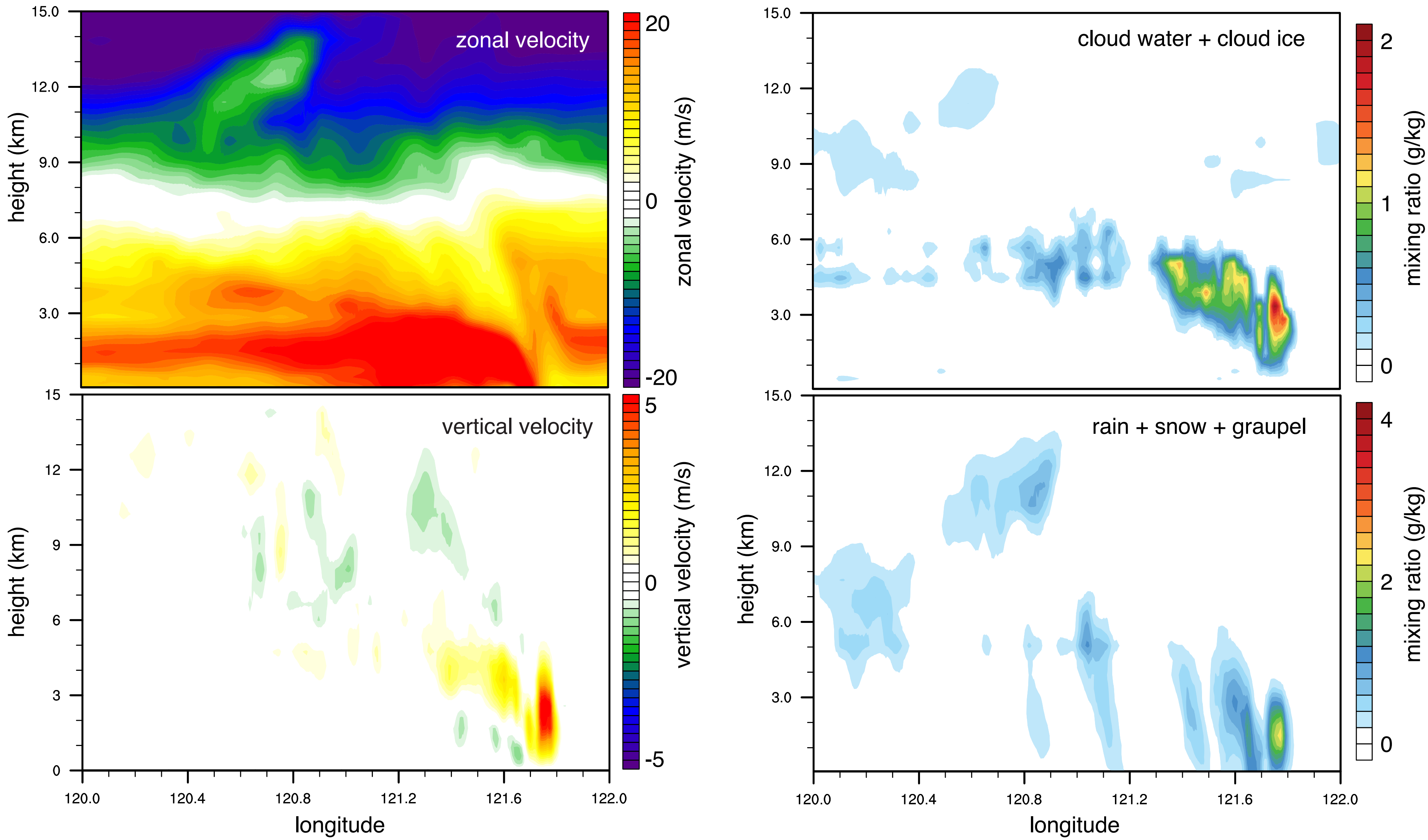

12 UTC 31 January 2009, MPAS global 3 km simulation
Lowest-model-level potential temperature (K)
5N
0
5S
10S
15S
110E
120E
130E
140E
A
B
295
296
297
298
299
300
301
302
303
304
305

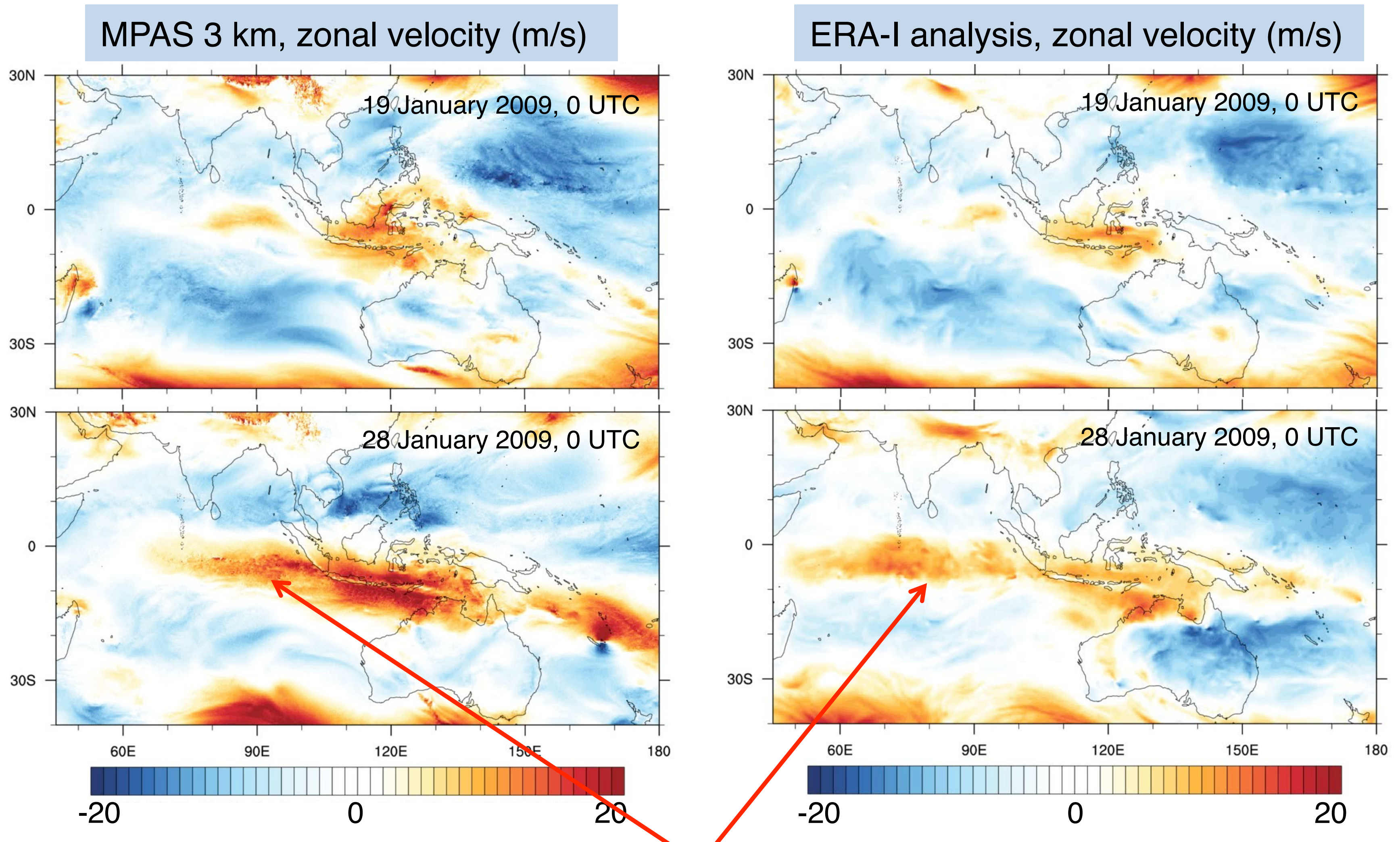
(A)


31 January 2009, Vertical Cross Section, (6.5S, 130.3:132.3E), 3 km MPAS
zonal velocity
zonal velocity (m/s)
20
0
-20
vertical velocity
vertical velocity (m/s)
5
0
-5
cloud water + cloud ice
mixing ratio (g/kg)
2
1
0
rain + snow + graupel
mixing ratio (g/kg)
4
2
0
height (km)
15.0
12.0
9.0
6.0
3.0
15
12
9
6
3
0
130.4
130.8
131.2
131.6
132.0
longitude

(B)

31 January 2009, Vertical Cross Section, (7.9S, 120:122E), 3 km MPAS

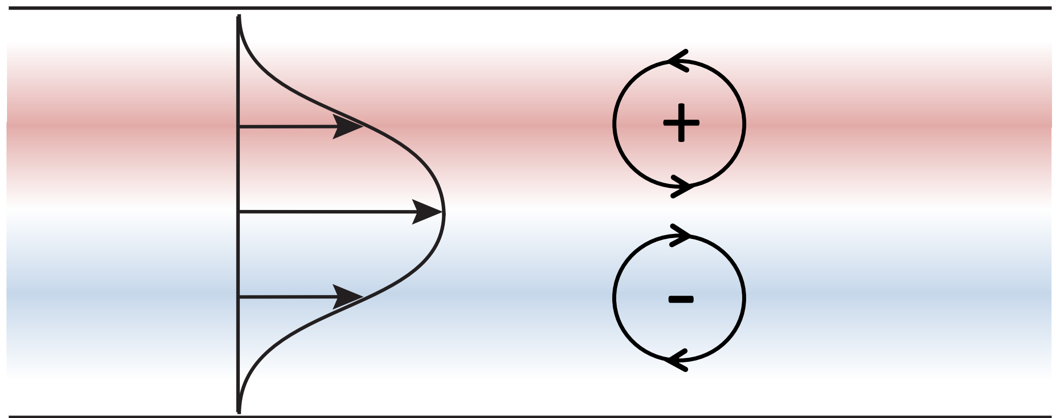




How is the westerly wind burst (jet) produced in this MJO event?

How is the westerly wind burst (jet) produced in this MJO event?

jet ⟶ vertical vorticity

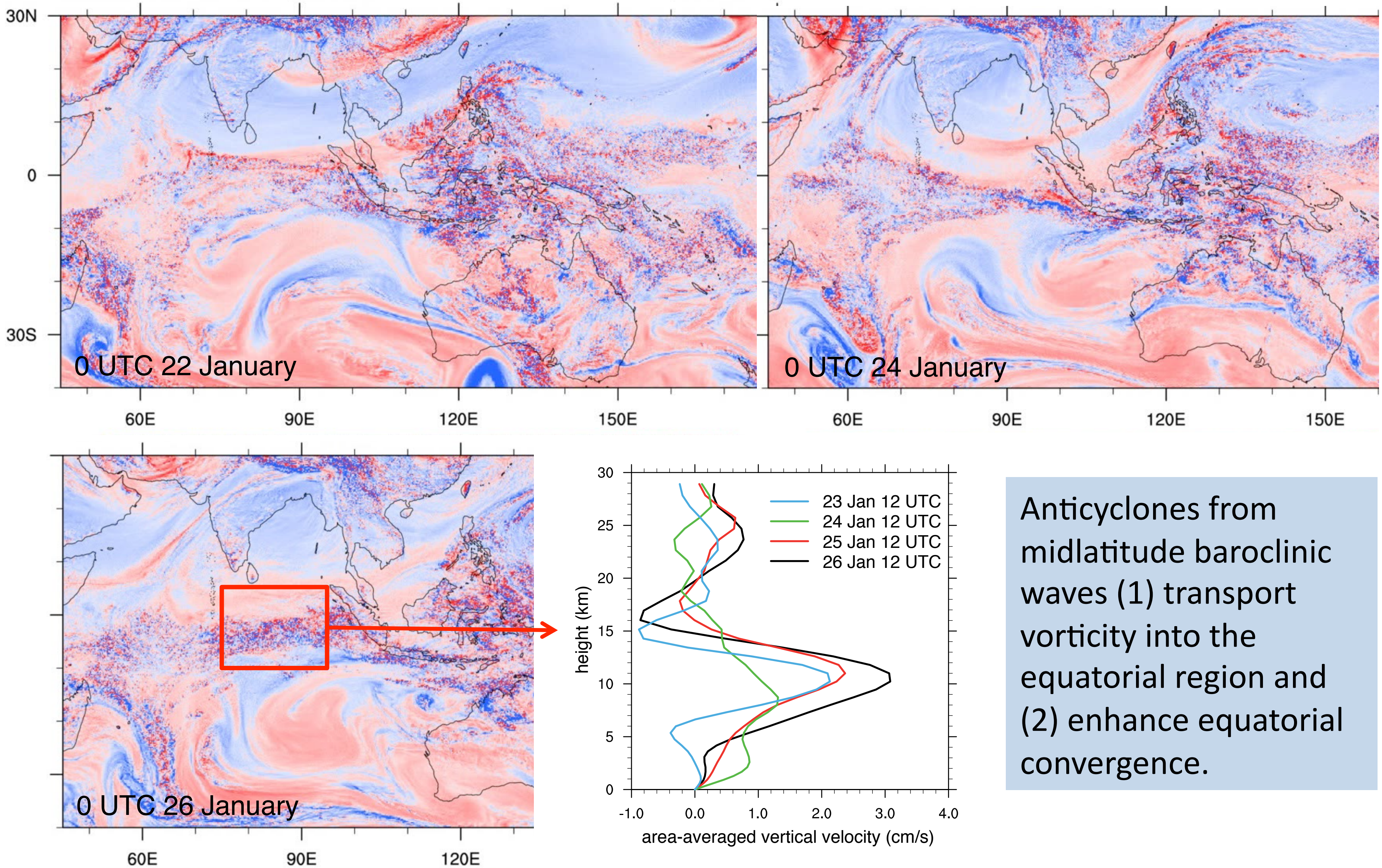


Possible mechanisms for producing the jet:

(1) In situ production of the vertical vorticity (tilting, baroclinic effects)

(2) Transport into the equatorial region and subsequent amplification (stretching)

MPAS 3 km, relative (vertical) vorticity



Anticyclones from midlatitude baroclinic waves (1) transport vorticity into the equatorial region and (2) enhance equatorial convergence.

Summary

Simulations capture some aspects of Jan-Feb 2009 MJO event

- Westerly wind burst
- Propagating convective systems

There are some significant errors

- Delayed onset of convective enhancement in early period (no convective parameterization simulations).
- Simulated MCS propagation speeds greater than observed.

Midlatitude baroclinic waves and associated anticyclone evolution contribute to the development of the westerly wind burst in this case.

Next: model improvements, other YOTC and DYNAMO cases.