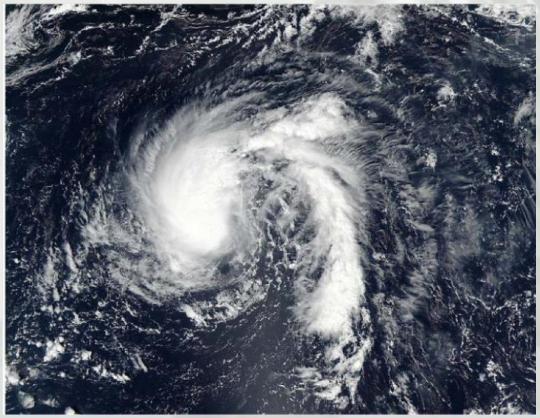
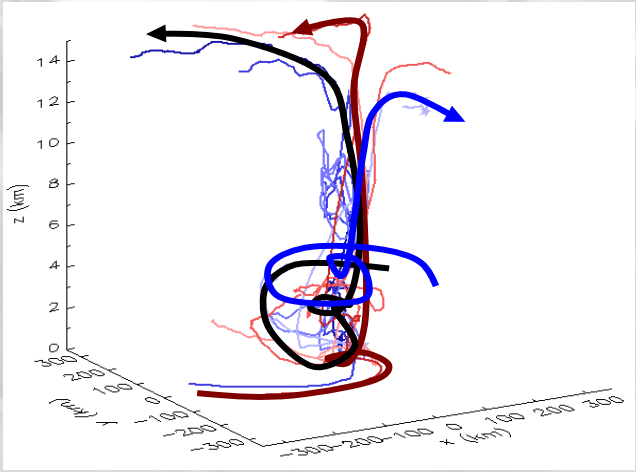
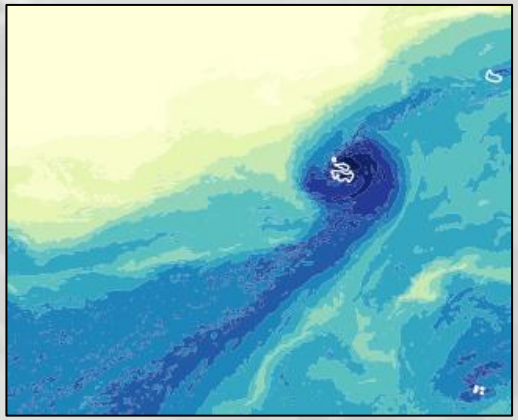
Lagrangian Description of Air Masses Associated with Latent Heat Release in Karl during Extratropical Transition

Christian Euler, Michael Riemer, Tobias Kremer, and Elmar Schömer
Johannes Gutenberg-Universität Mainz

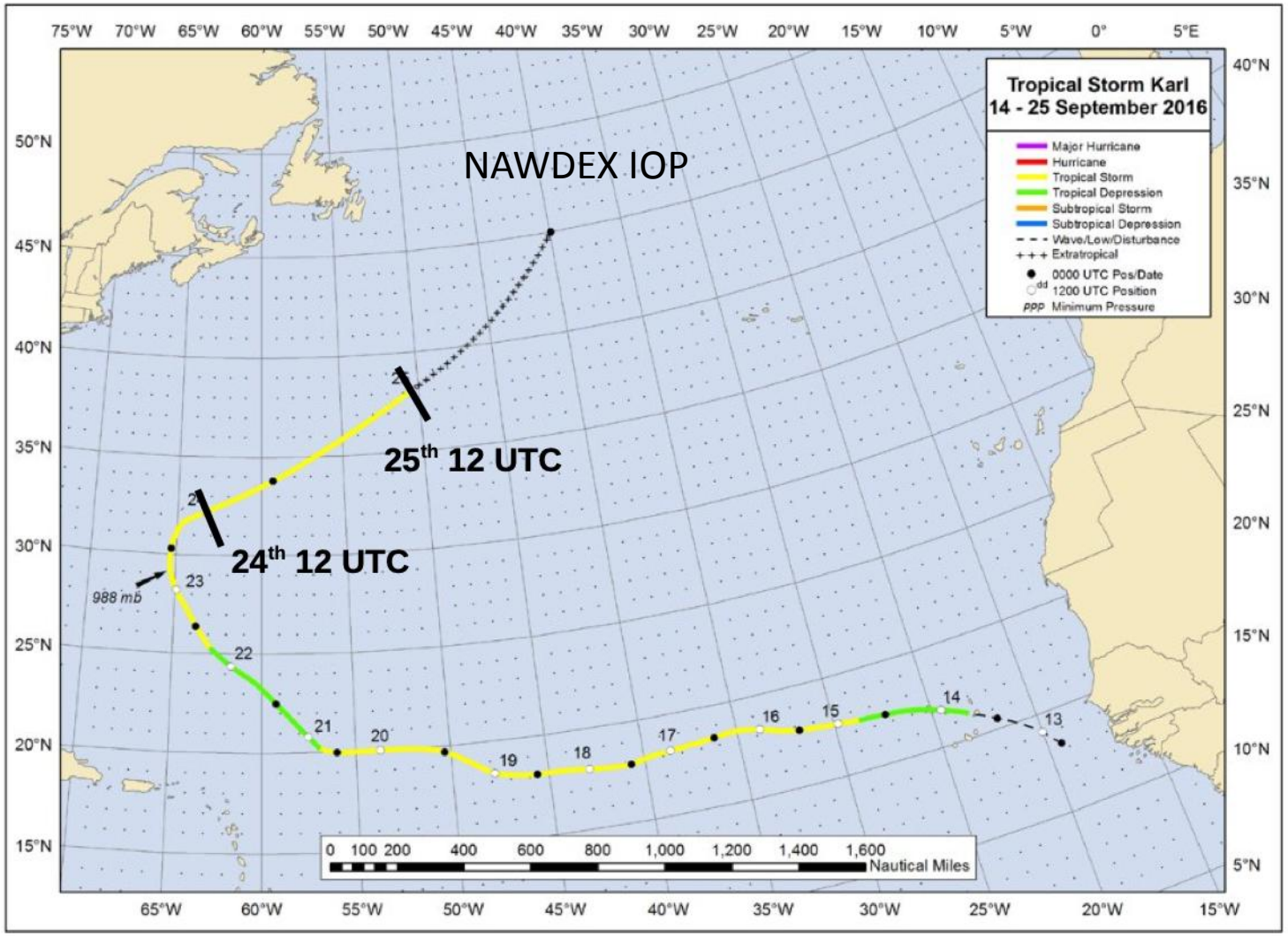


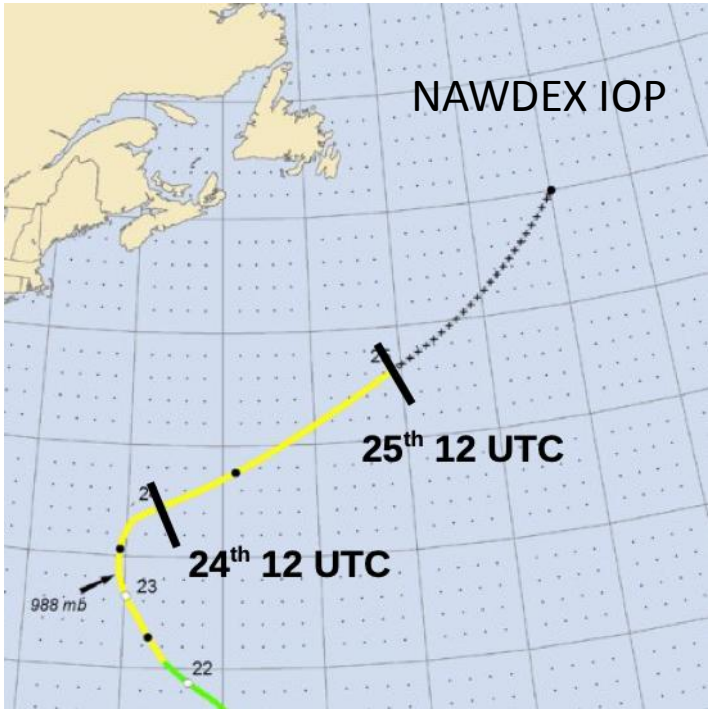




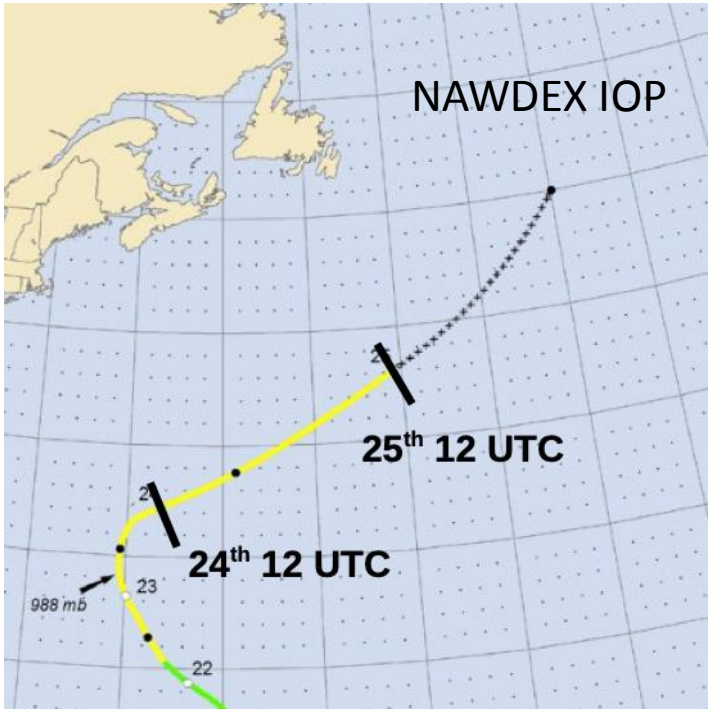
Lagrangian Description of Air Masses Associated with Latent Heat Release in Tropical Storm Karl (2016) during Extratropical Transition, Mon. Wea. Rev., in revision

TS Karl (2016)

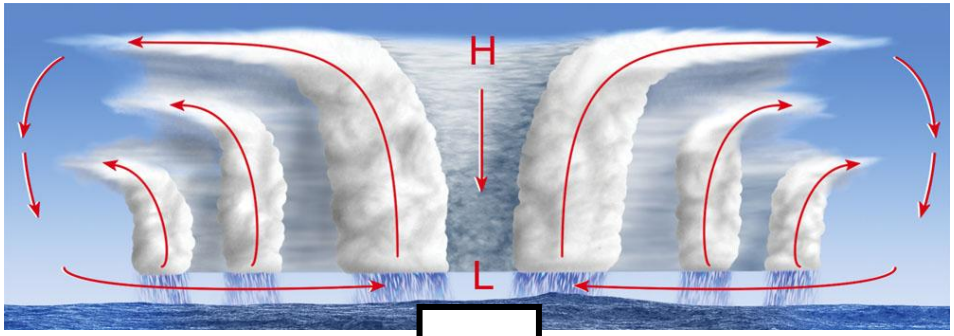

Tropical Storm Karl
14 - 25 September 2016
Major Hurricane
Hurricane
Tropical Storm
Tropical Depression
Subtropical Storm
Subtropical Depression
Wave/Low/Disturbance
Extratropical
0000 UTC Pos/Date
1200 UTC Position
Minimum Pressure
NAWDEX IOP
25th 12 UTC
24th 12 UTC
988 mb
13
14
15
16
17
18
19
20
21
22
23
0 100 200 400 600 800 1,000 1,200 1,400 1,600
Nautical Miles
75°W 70°W 65°W 60°W 55°W 50°W 45°W 40°W 35°W 30°W 25°W 20°W 15°W 10°W 5°W 0° 5°E
50°N 45°N 40°N 35°N 30°N 25°N 20°N 15°N
40°N 35°N 30°N 25°N 20°N 15°N 10°N 5°N
65°W 60°W 55°W 50°W 45°W 40°W 35°W 30°W 25°W 20°W 15°W

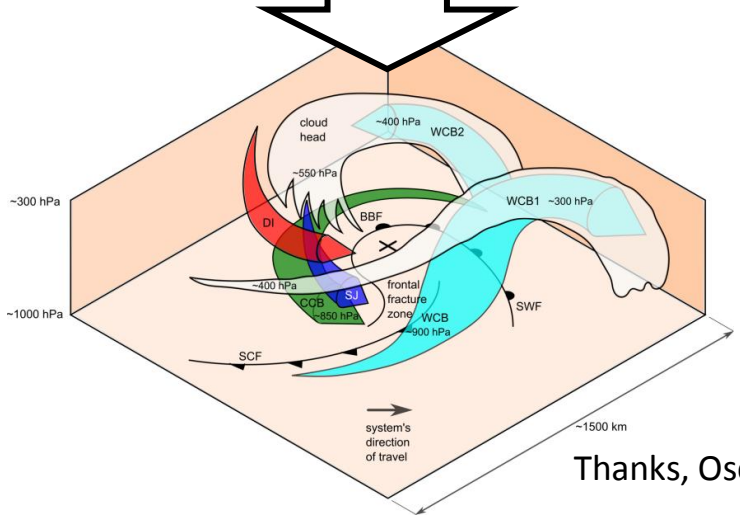


1) How does structure of Tropical Storm Karl change …

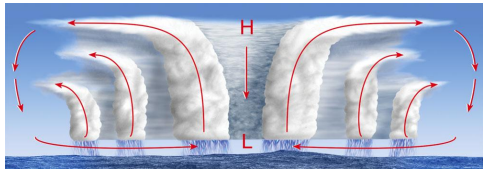


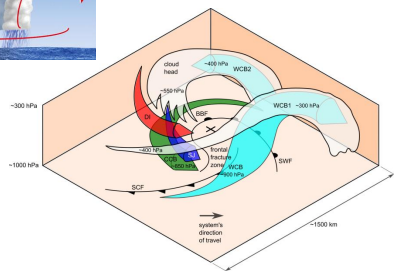
1) How does structure of Tropical Storm Karl change … in terms of the main governing airstreams?





Thanks, Oscar! ☺





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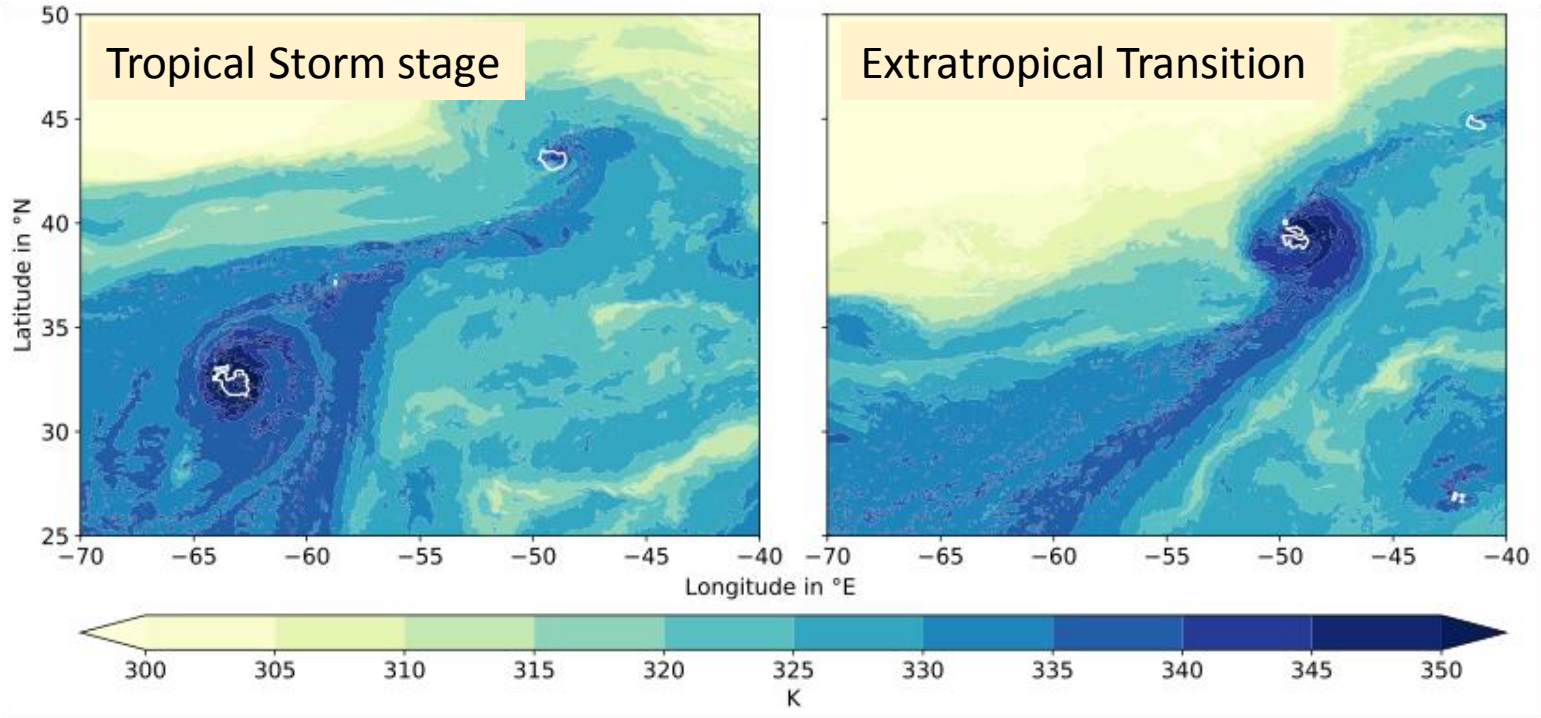
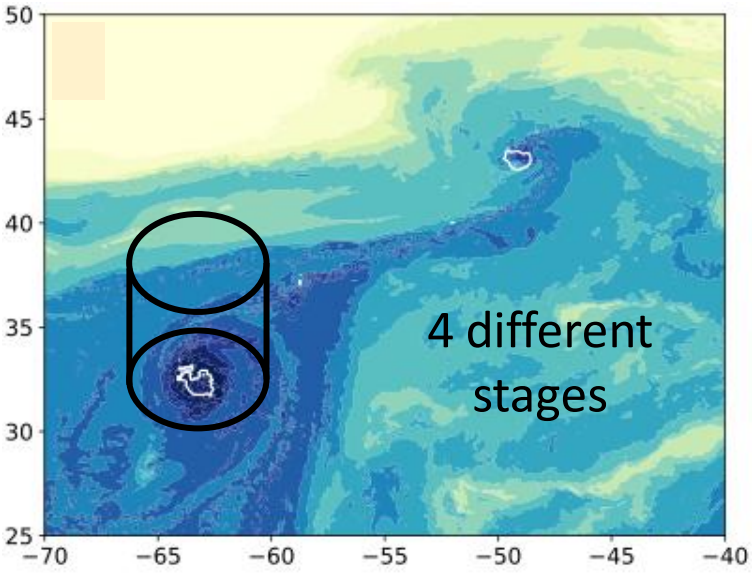


2) How does Karl interact with environmental airmasses?

General approach: extensive trajectory analysis

- Convection-permitting simulation with COSMO
- Horizontal resolution of 0.025° (~2.8 km)
- Off-line trajectory calculation
  - 5-minute output
  - seeded every grid point in 2°-radius cylinder around Karl



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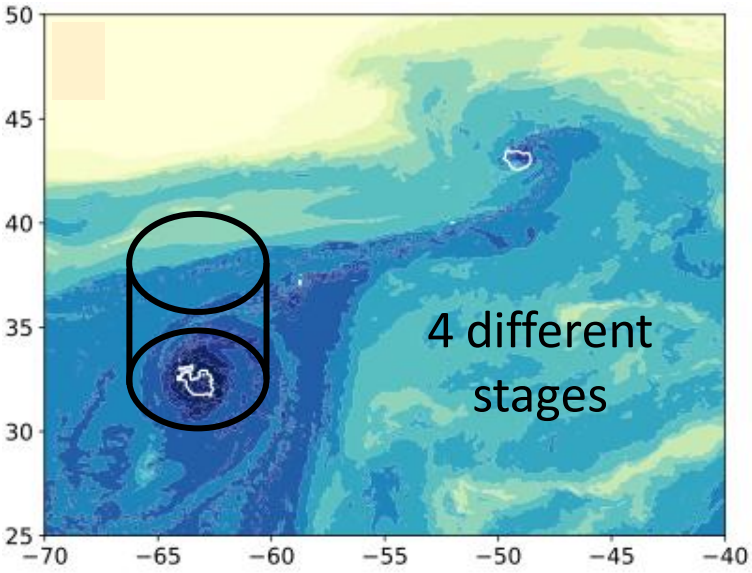

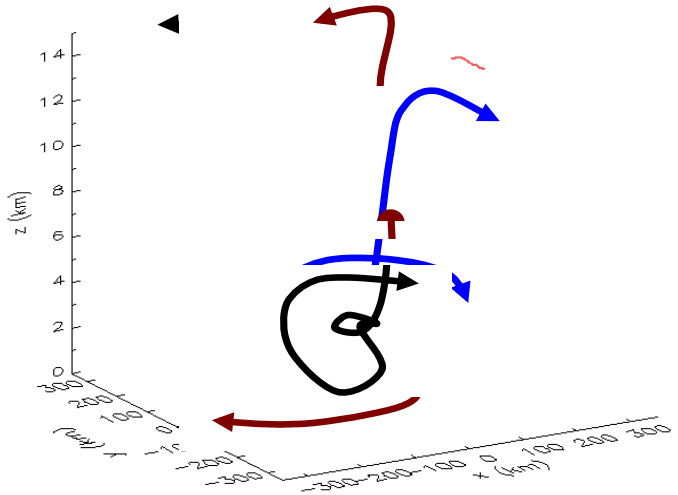

6 h fwd + back trajectories

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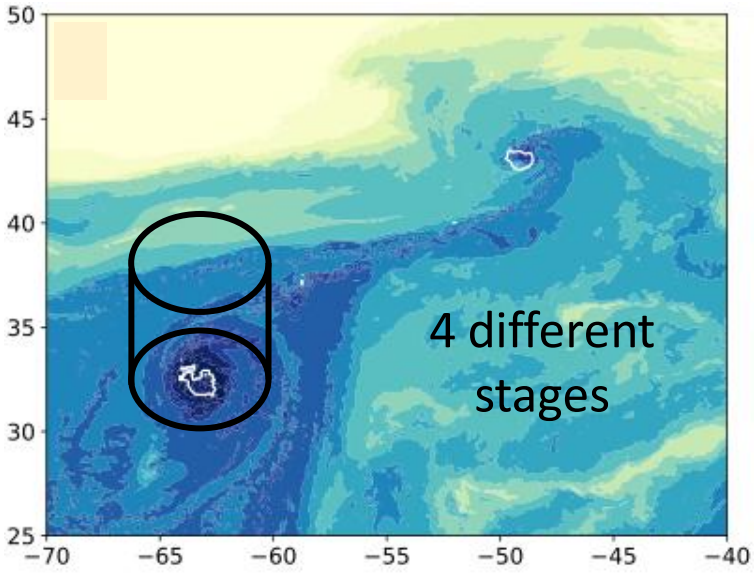
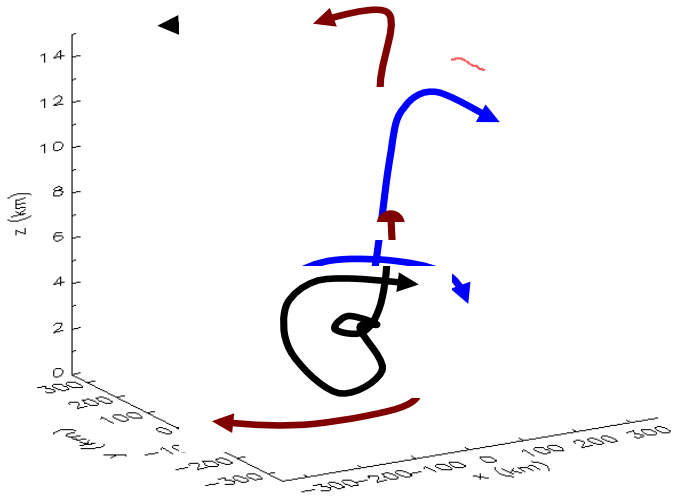
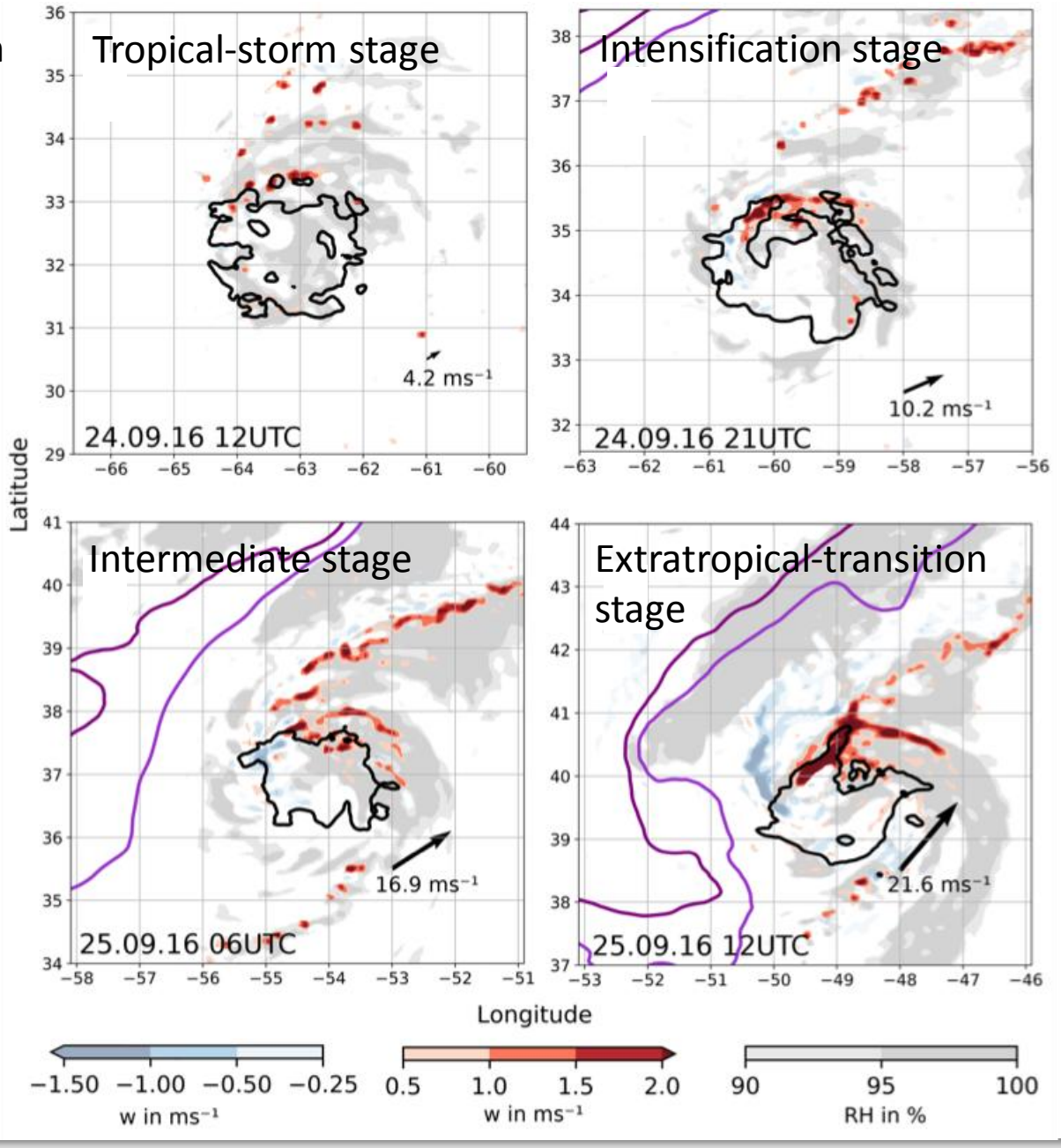




6 h fwd + back trajectories

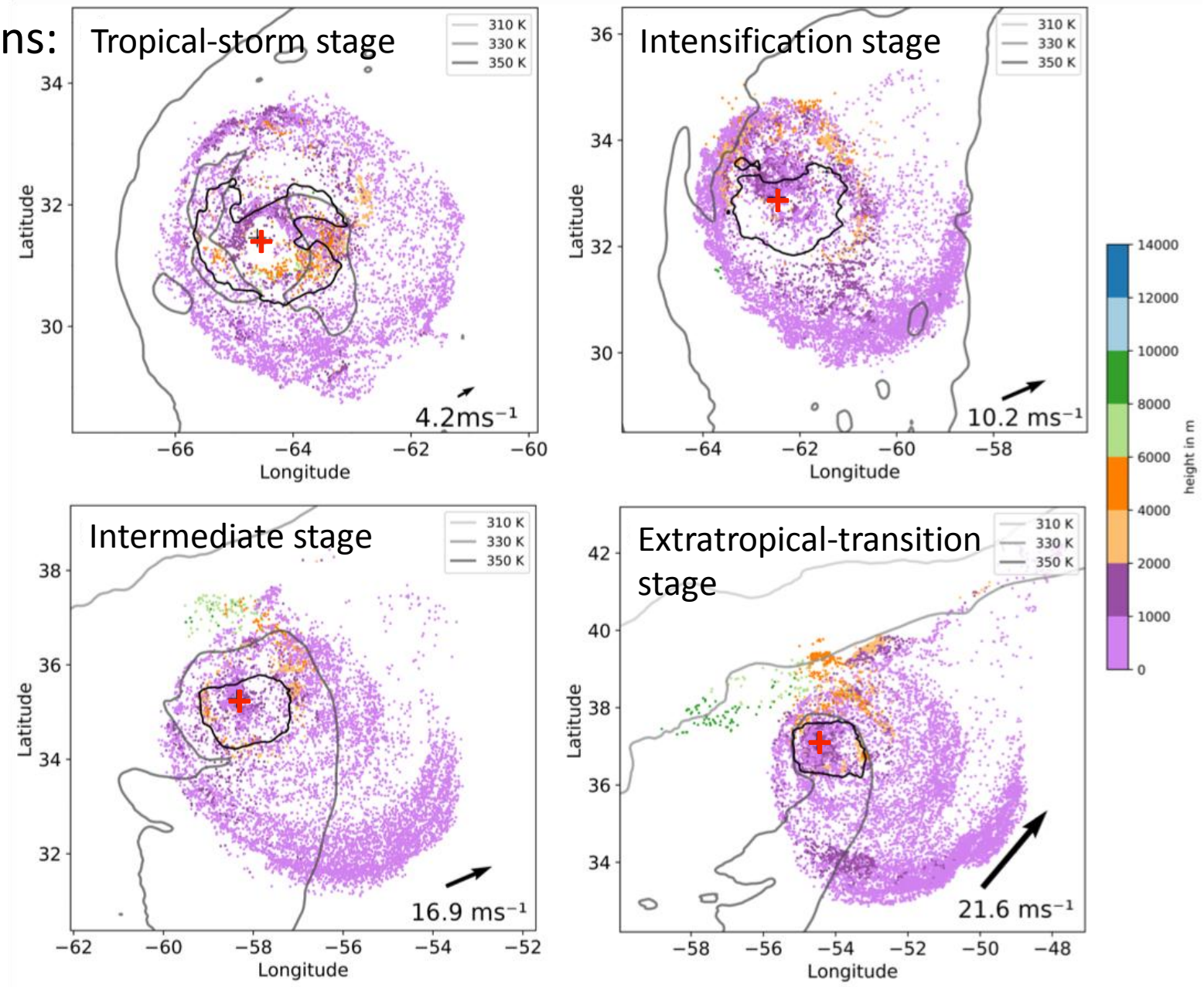
Origin and fate of airstream: i) inner-core convection, ii) convection outside the core [and iii) inner-core descent]

at 3000m



Inertial-stability threshold

Initial positions: „inner-core convection“ air parcels



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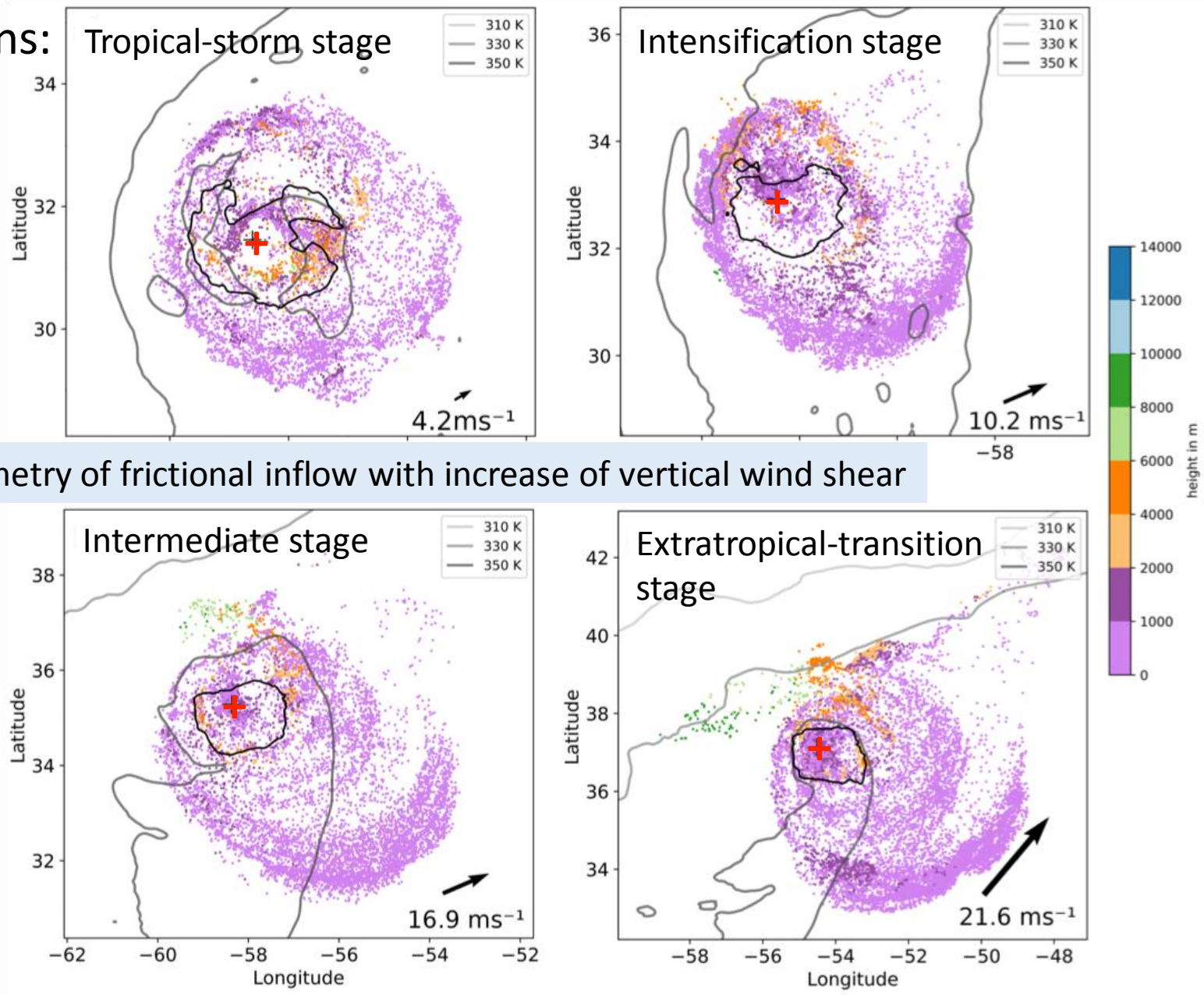
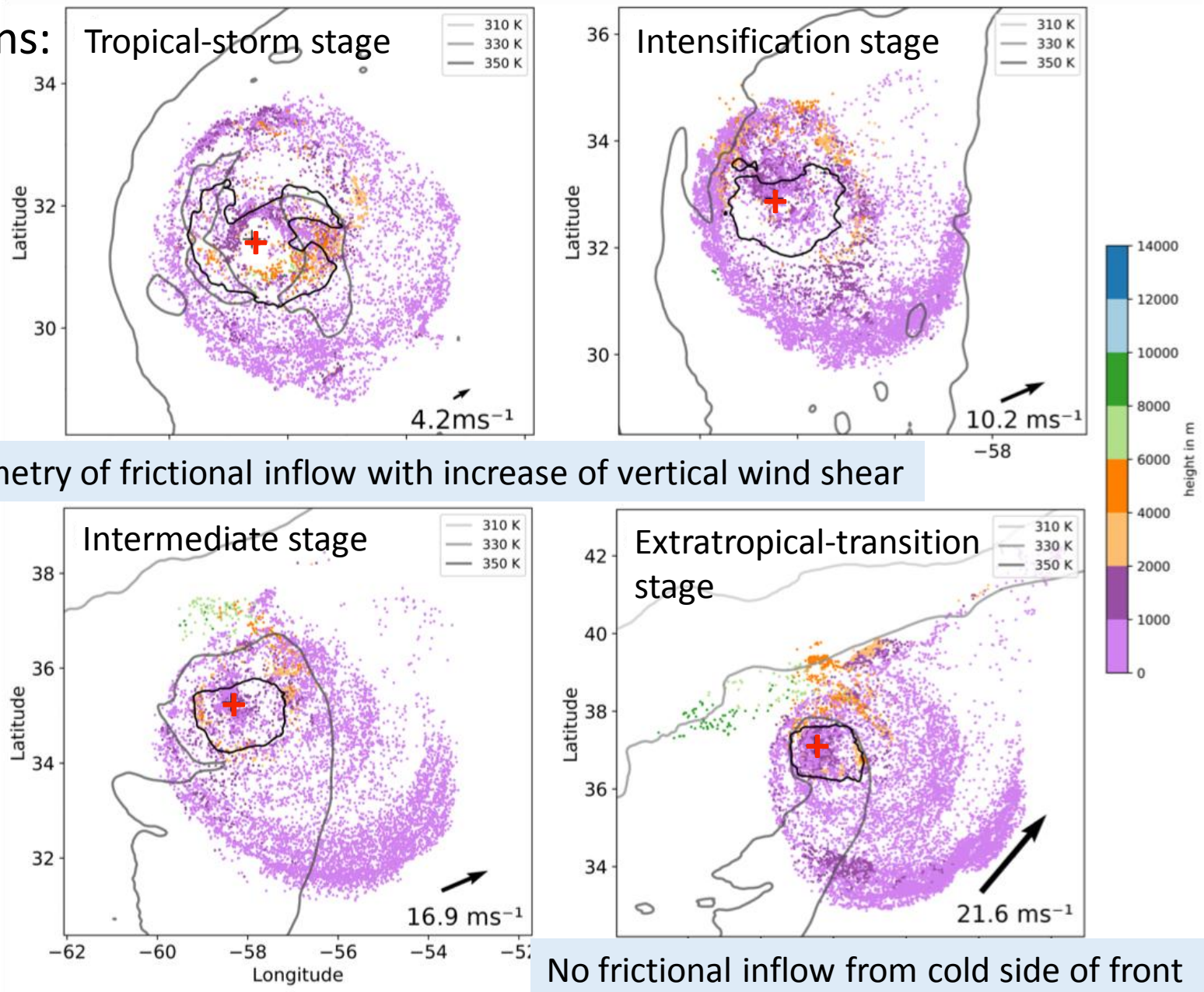


Increasing asymmetry of frictional inflow with increase of vertical wind shear

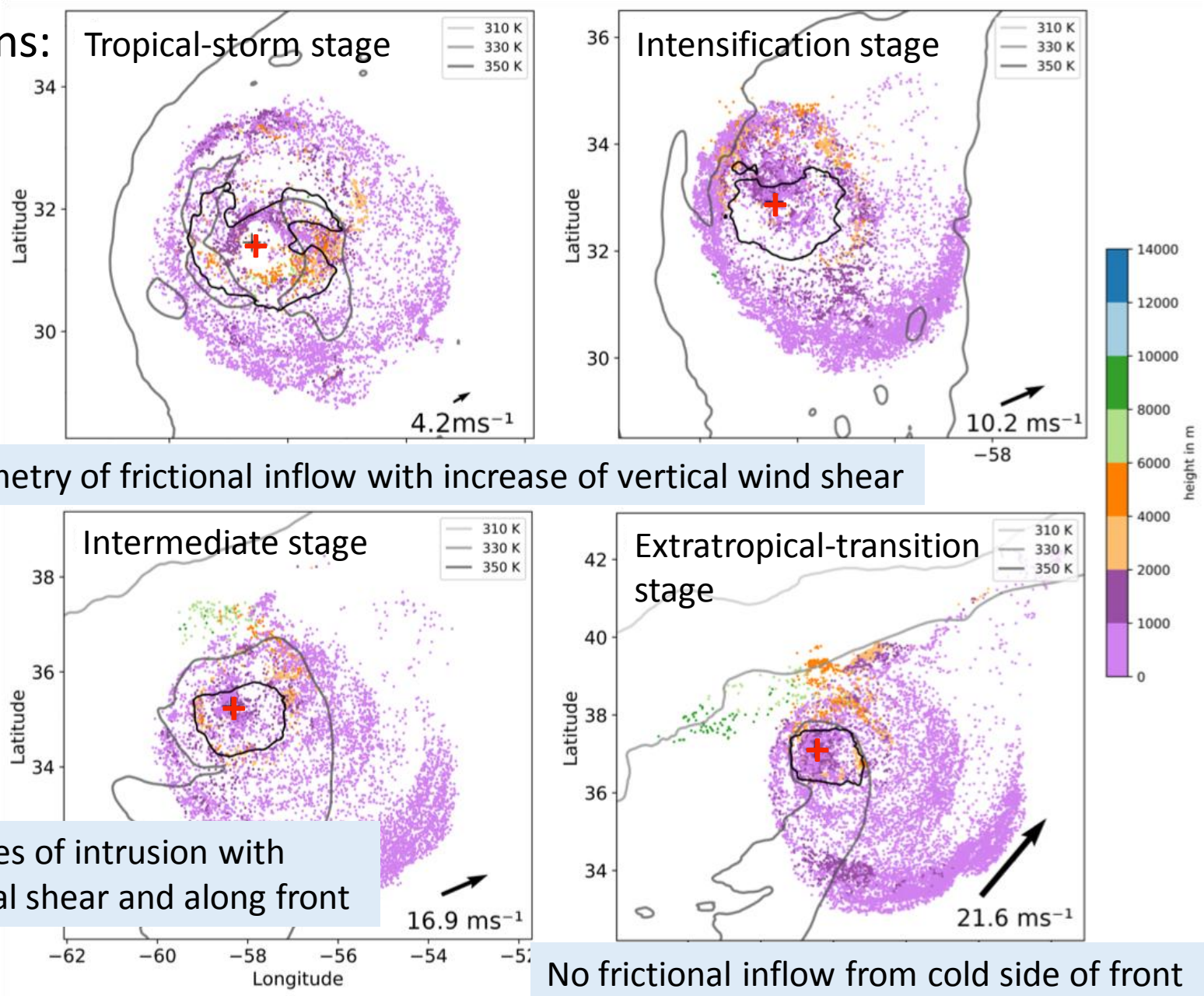
Initial positions: „inner-core convection“ air parcels



Increasing asymmetry of frictional inflow with increase of vertical wind shear

No frictional inflow from cold side of front

Initial positions: „inner-core convection“ air parcels

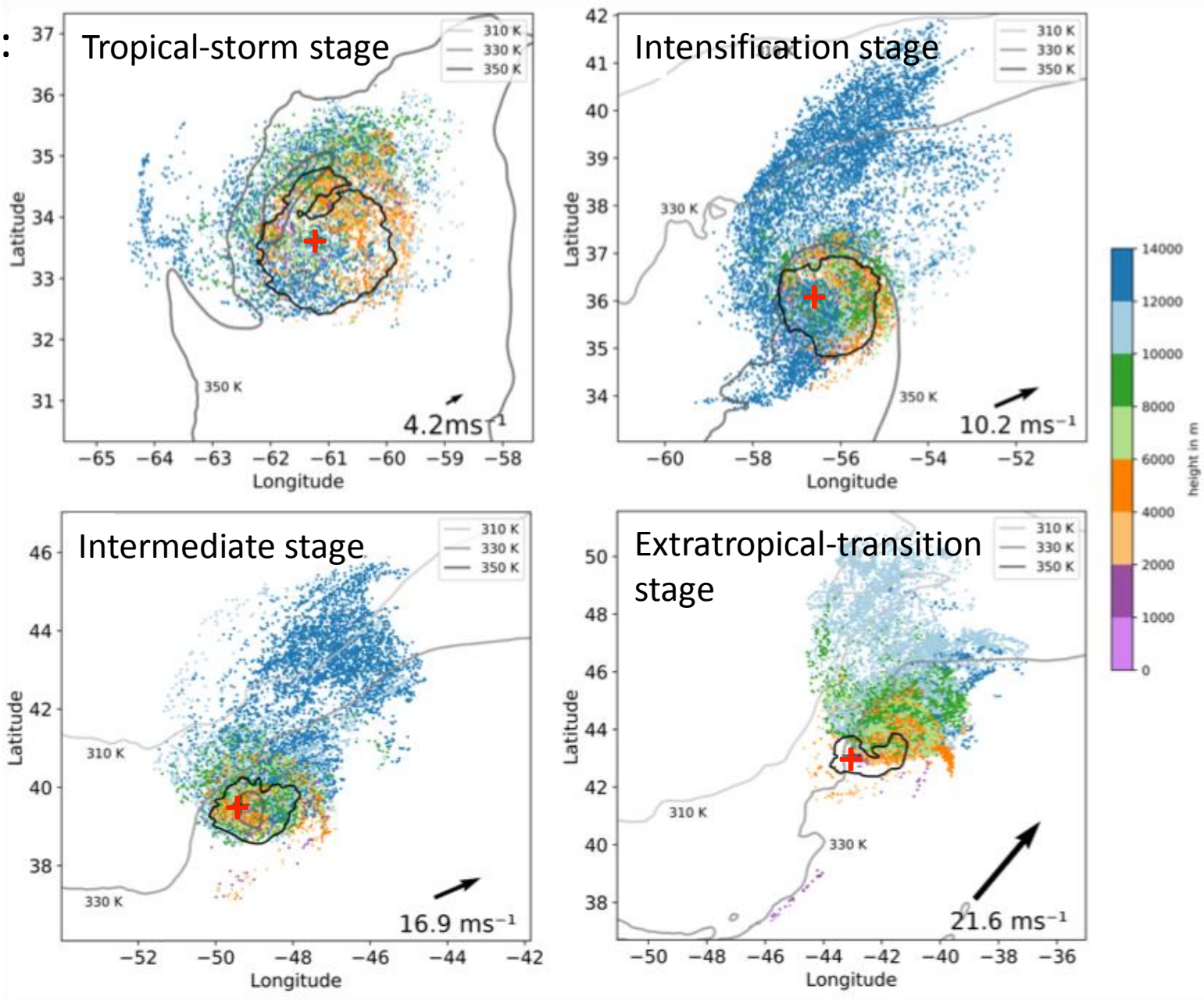


Increasing asymmetry of frictional inflow with increase of vertical wind shear

Systematic changes of intrusion with increase of vertical shear and along front

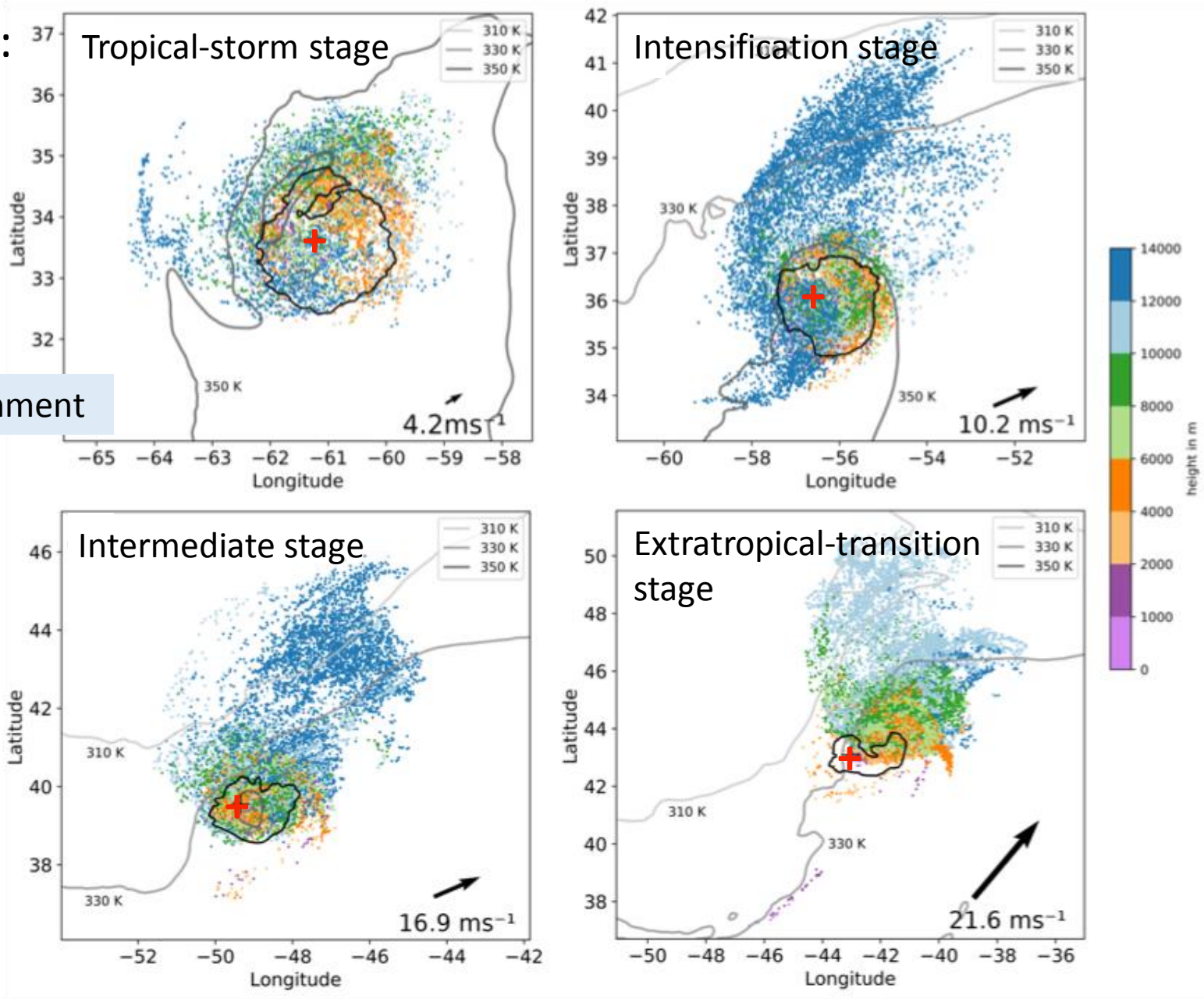
No frictional inflow from cold side of front

End positions: „inner-core convection“ air parcels



End positions: „inner-core convection“ air parcels

Excessive detrainment



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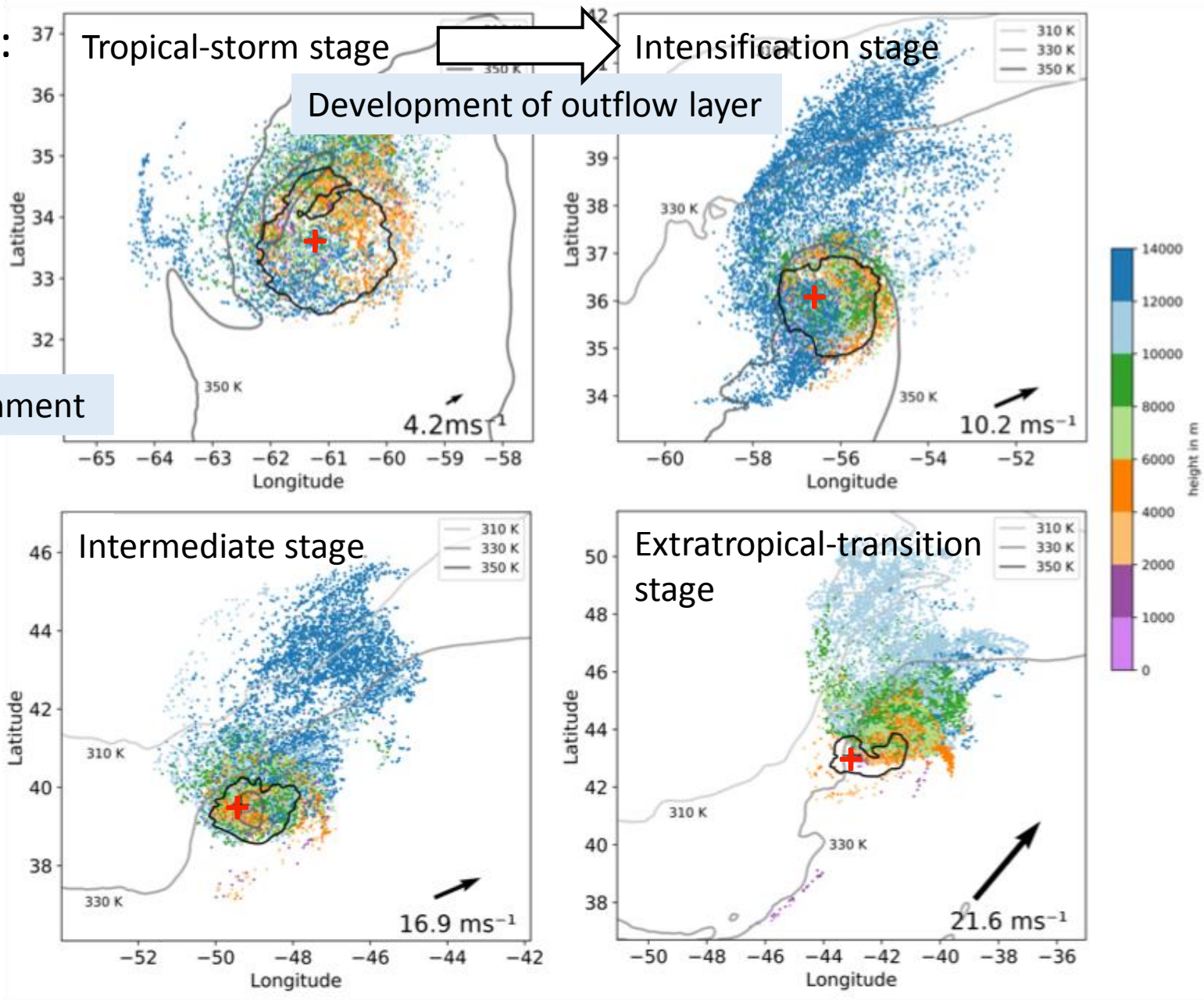
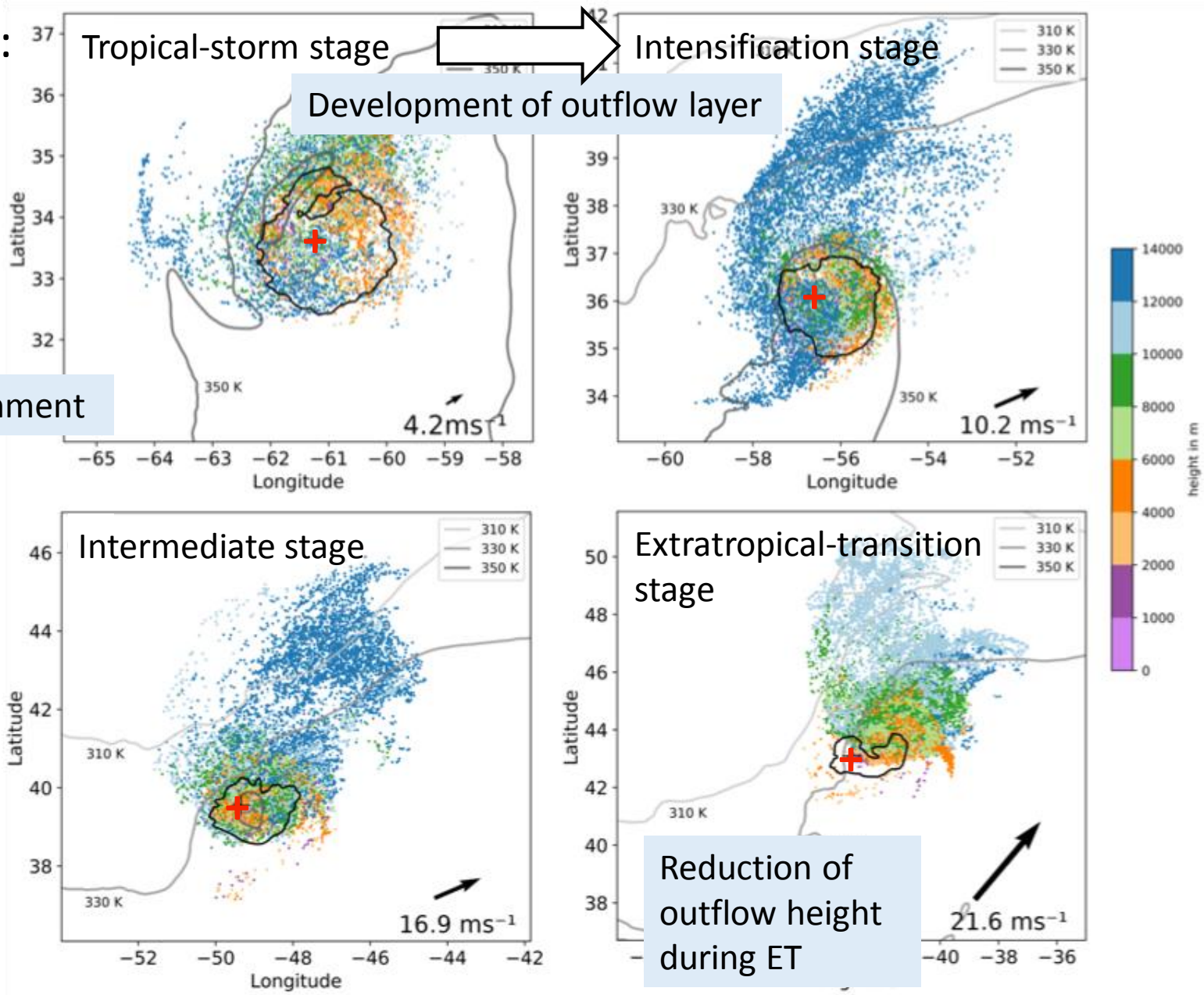


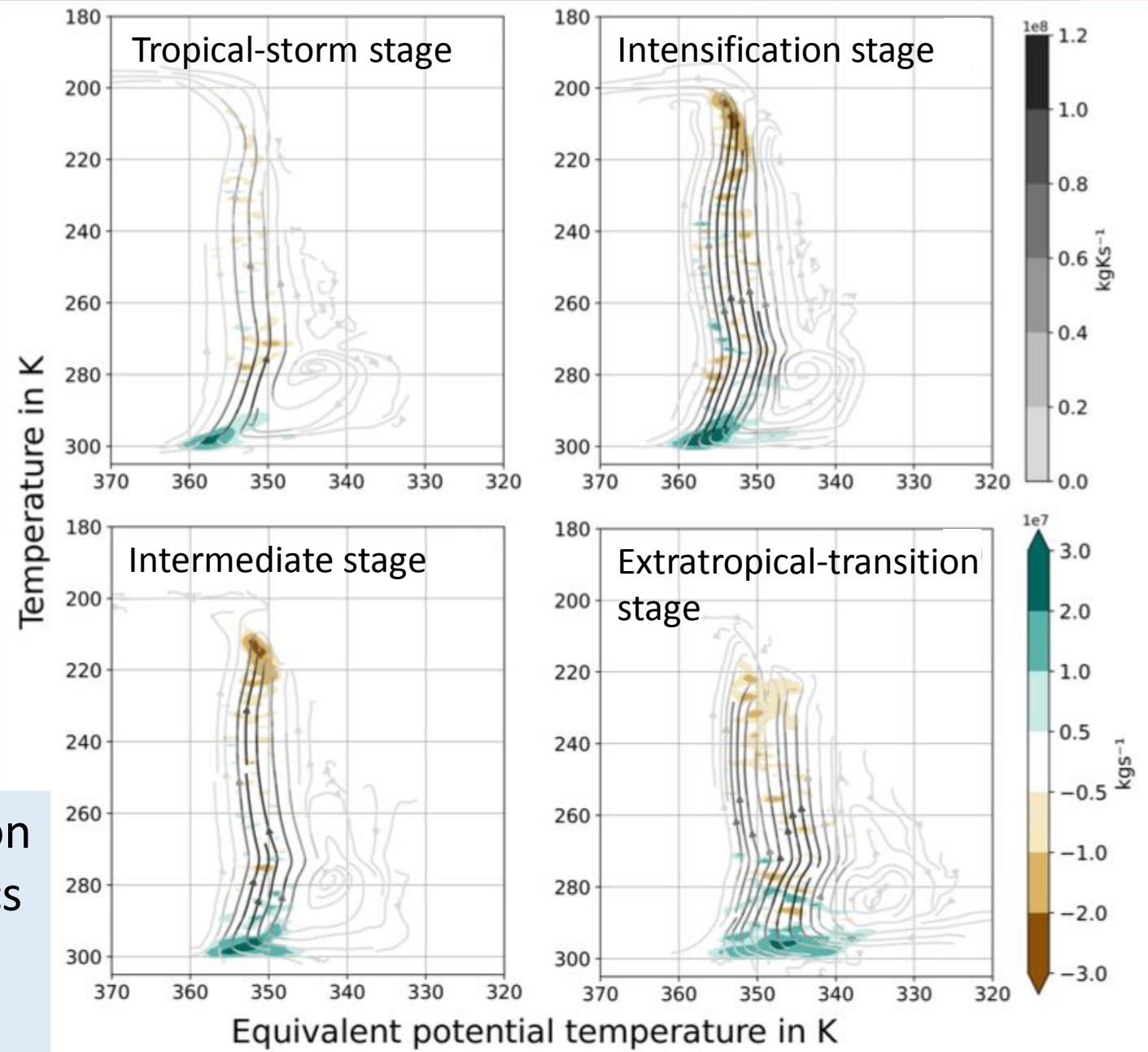
End positions: „inner-core convection“ air parcels



Excessive detrainment

Reduction of outflow height during ET

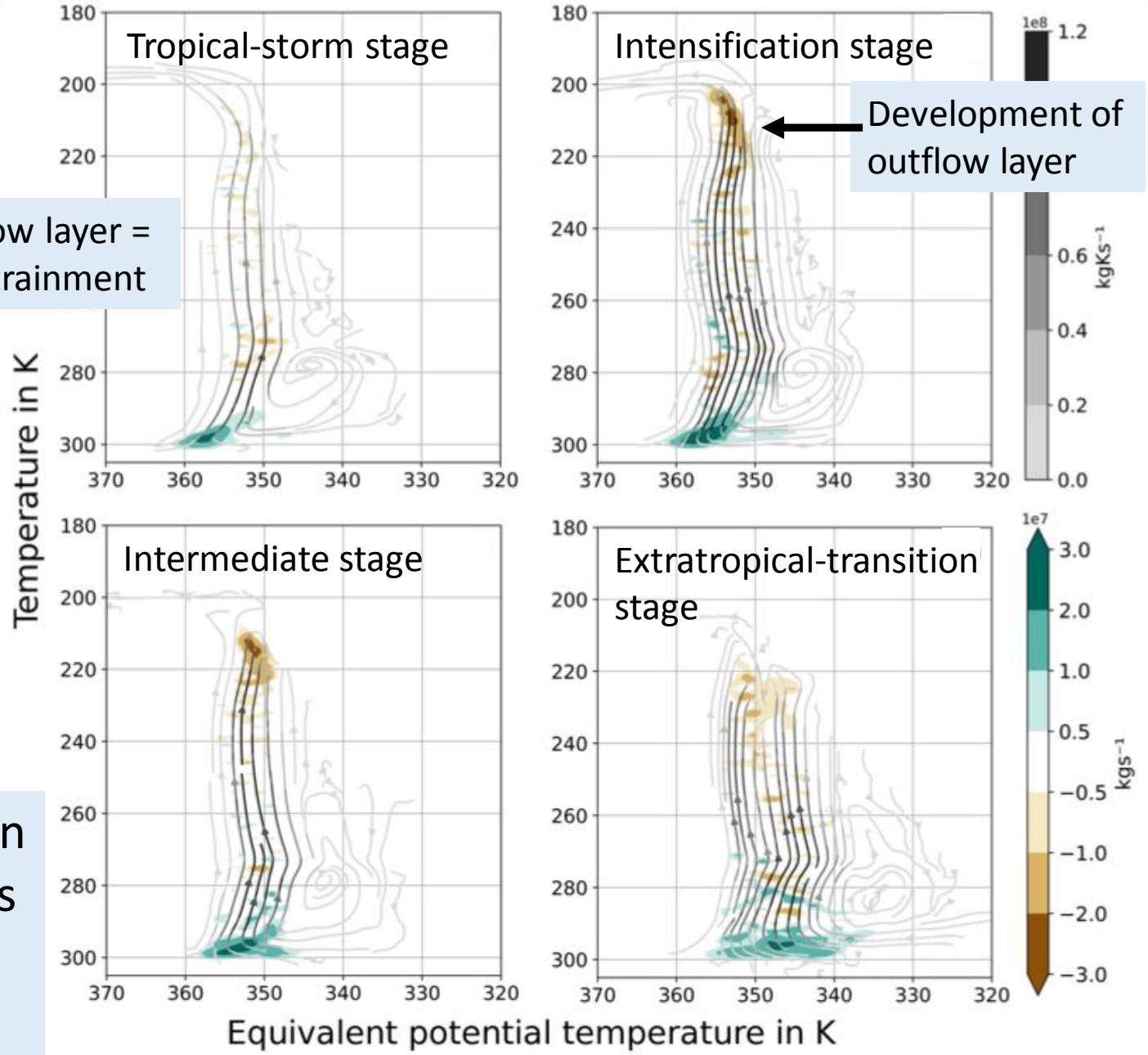
Mass flux in thermodynamic space



Succinct description of thermodynamics from Langrangian perspective

Mass flux in thermodynamic space

Lack of outflow layer = Excessive detrainment



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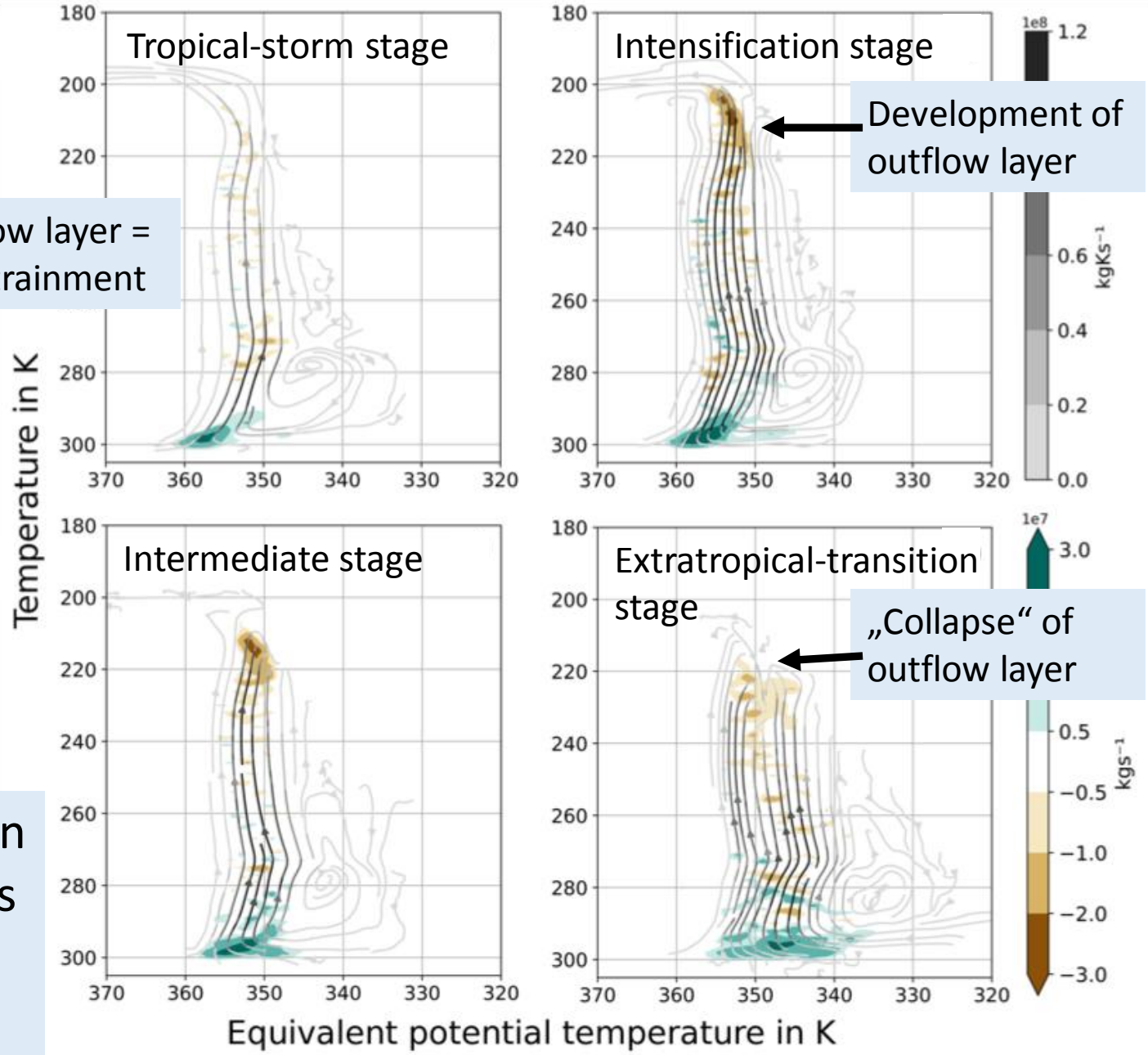

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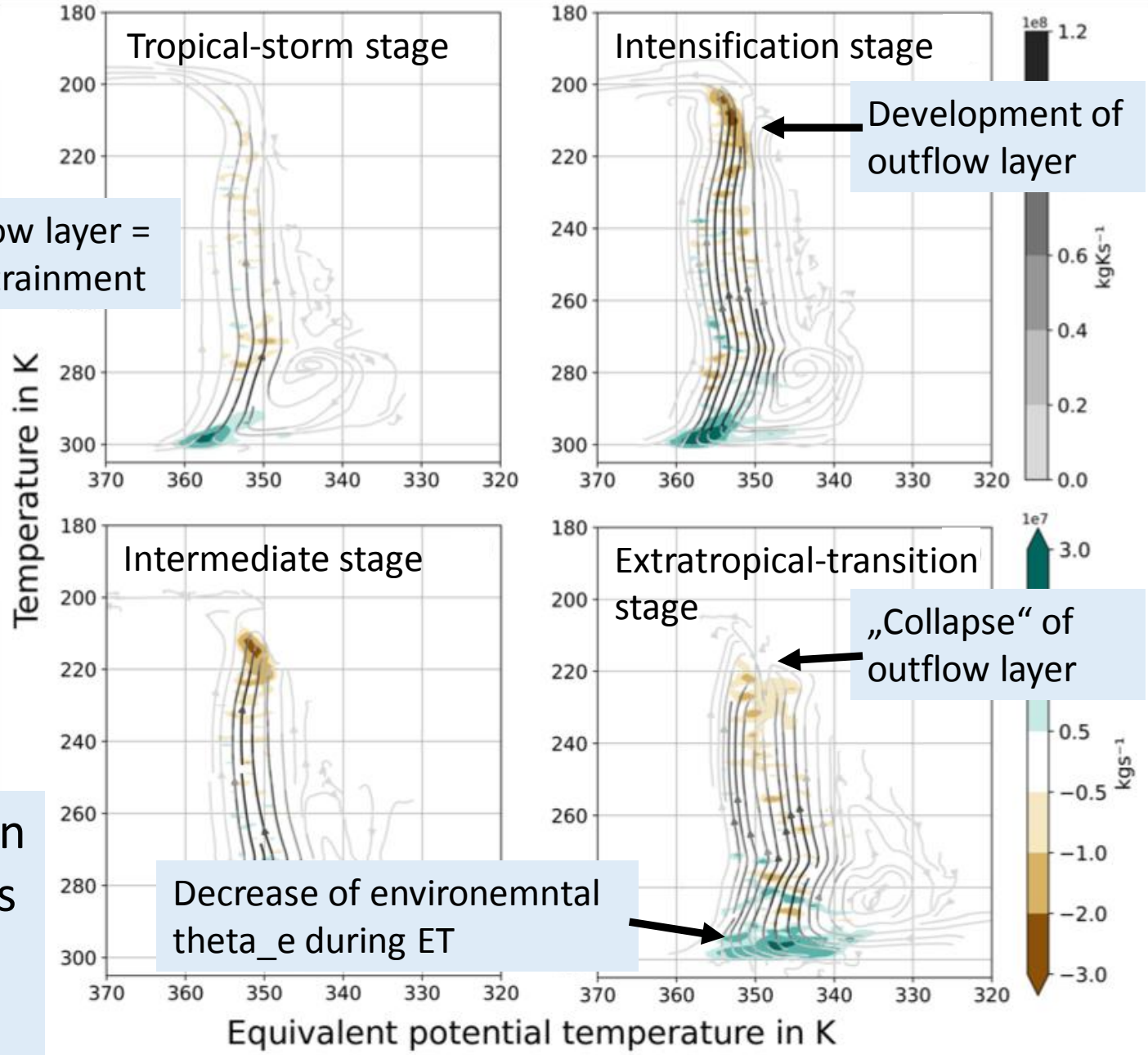
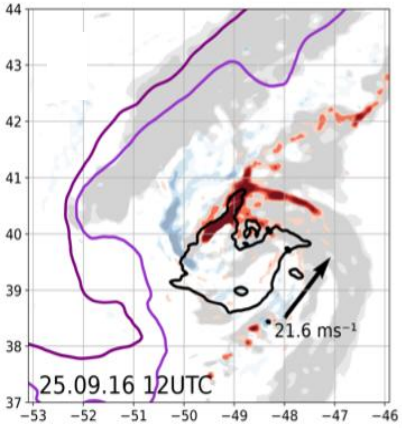
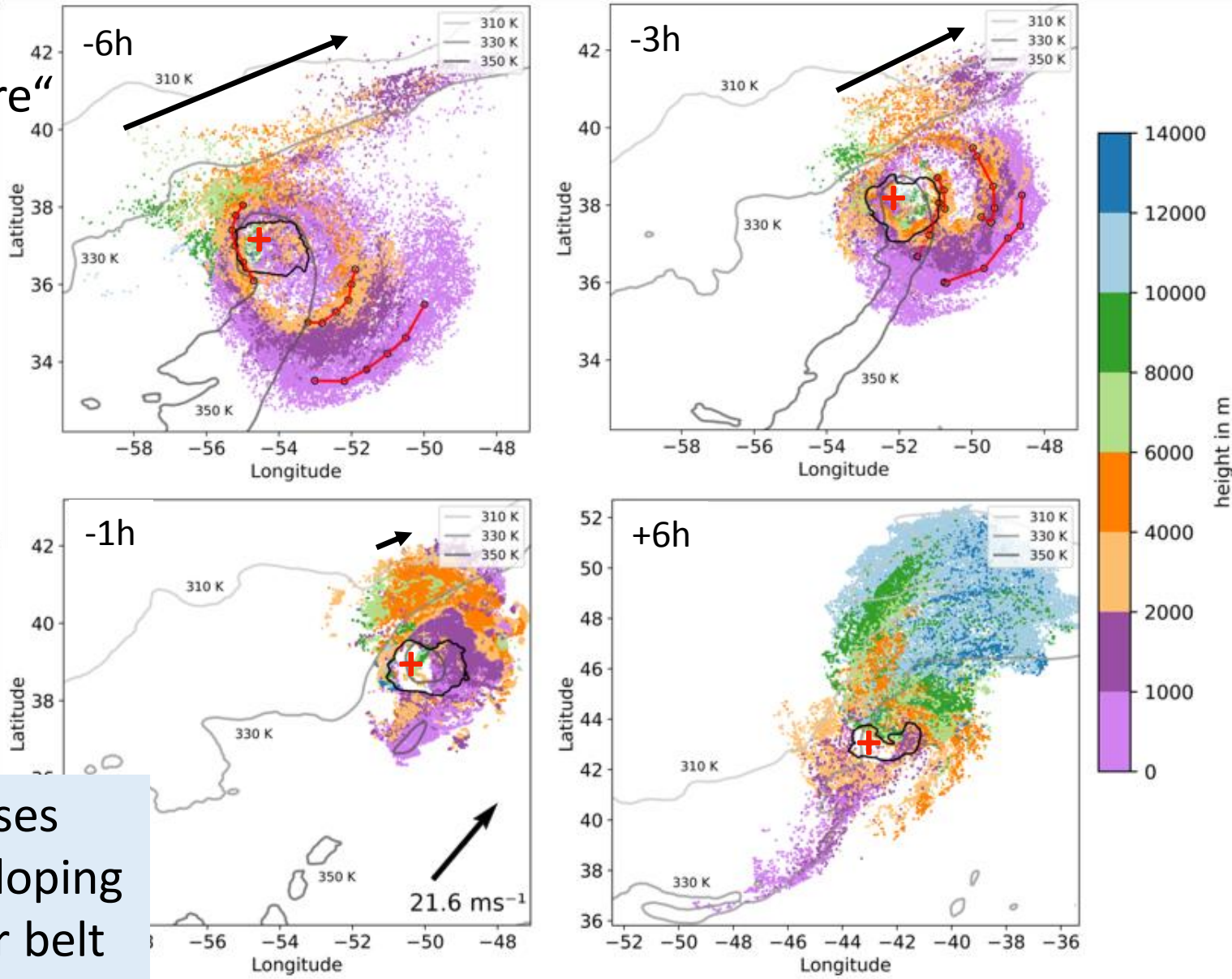


Succinct description of thermodynamics from Langrangian perspective

Initial positions: „convection outside the core“ air parcels



Extratropical-transition stage



Several airmasses comprise developing warm conveyor belt

Summary

- Excessive detrainment hinders intensity
- Intensification in increasing shear associated with development of well-defined outflow layer
- Increasing asymmetry of frictional inflow with increasing vertical wind shear
- No frictional inflow from cold side of baroclinic zone
- Changing environment impacts predominantly through lower-theta_e air in inflow layer
- Developing WCB comprises different airmasses

Cyclone Workshop

Kloster Seeon (near Munich)

29 September – 4 October