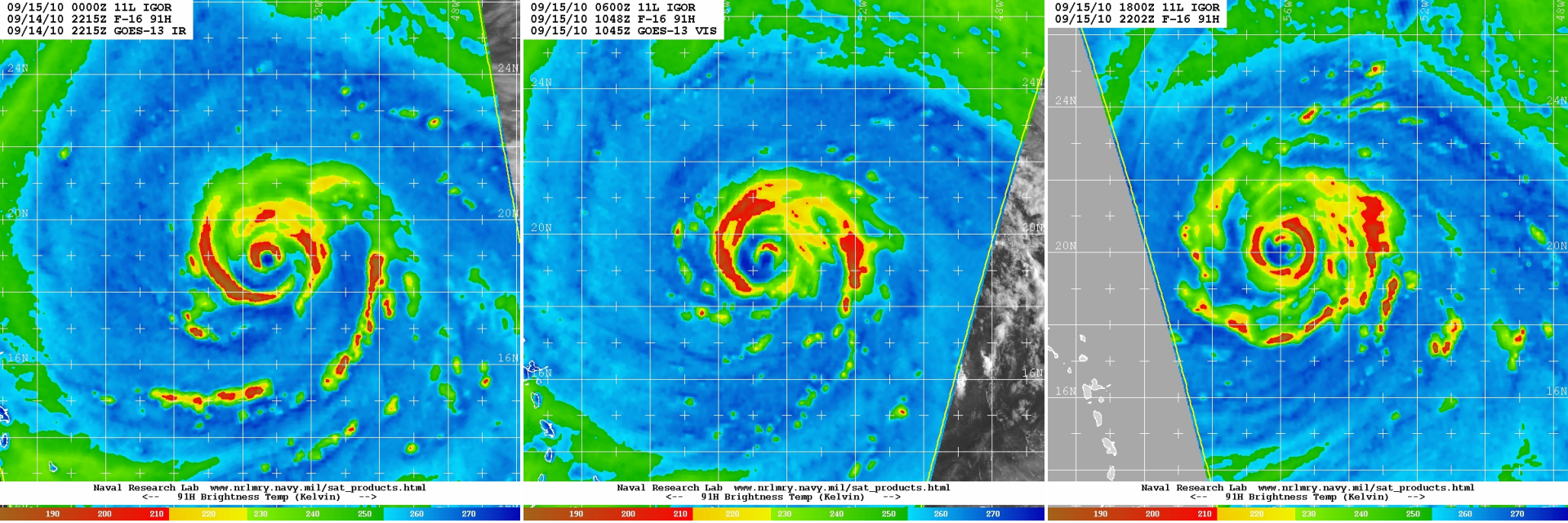
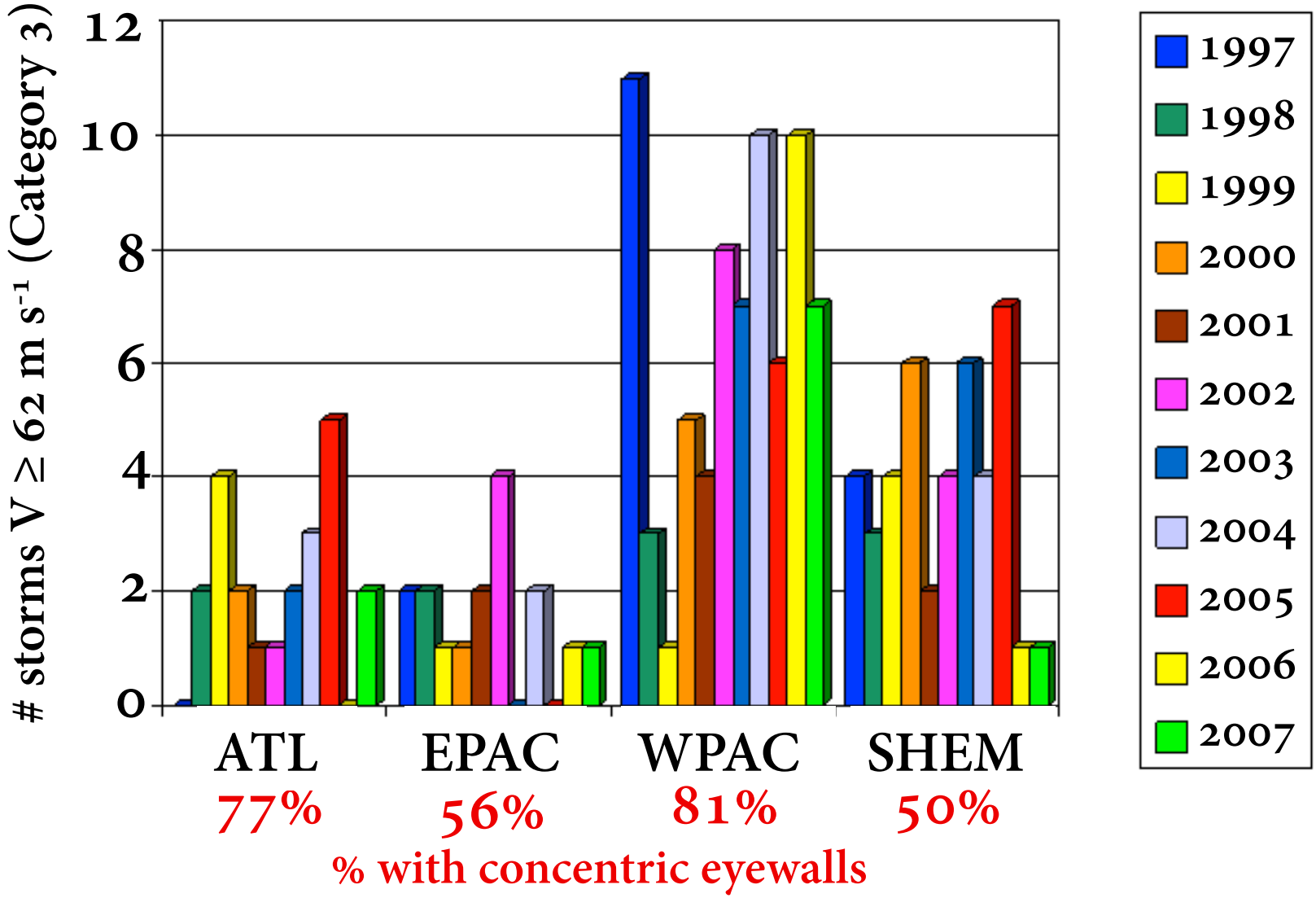


Investigating the factors responsible for secondary eyewall formation in an ensemble of high-resolution hurricane simulations

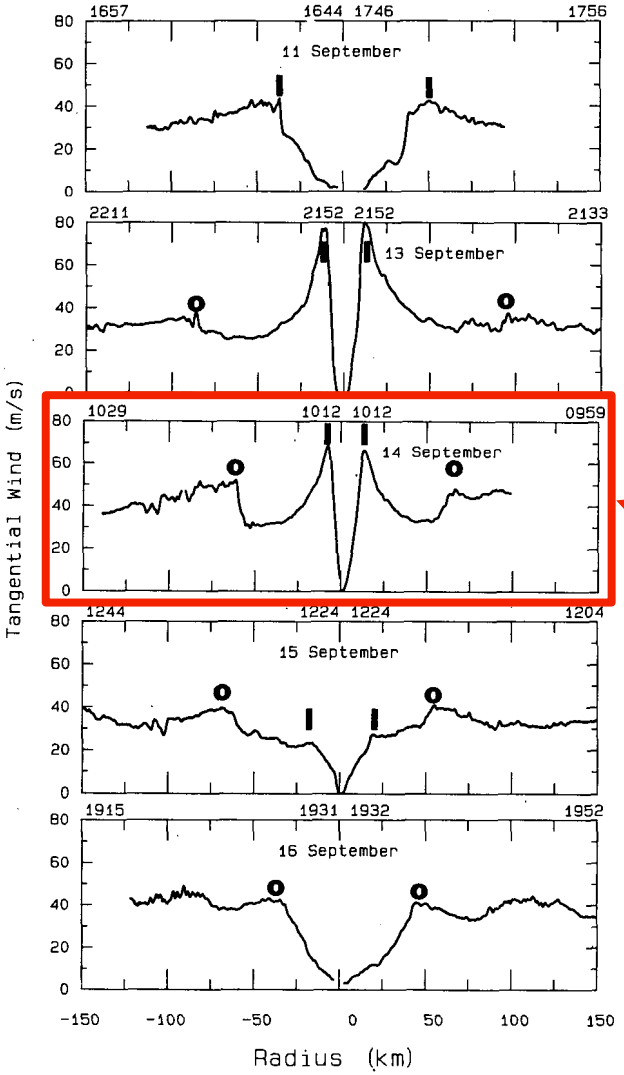
Kristen L. Corbosiero and Ryan D. Torn
University at Albany

Motivation:
Secondary eyewalls are common in strong hurricanes

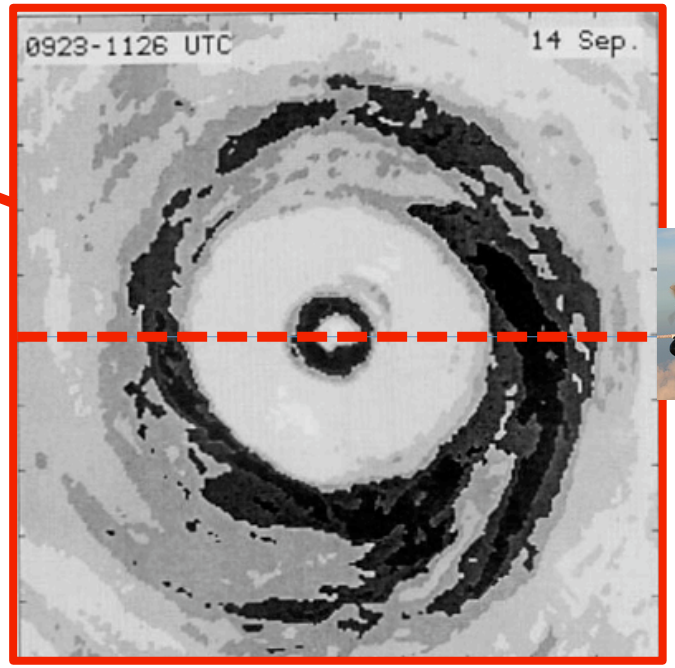


Hawkins and Helveston (2008)

Motivation:
Eyewall replacement cycles are well understood

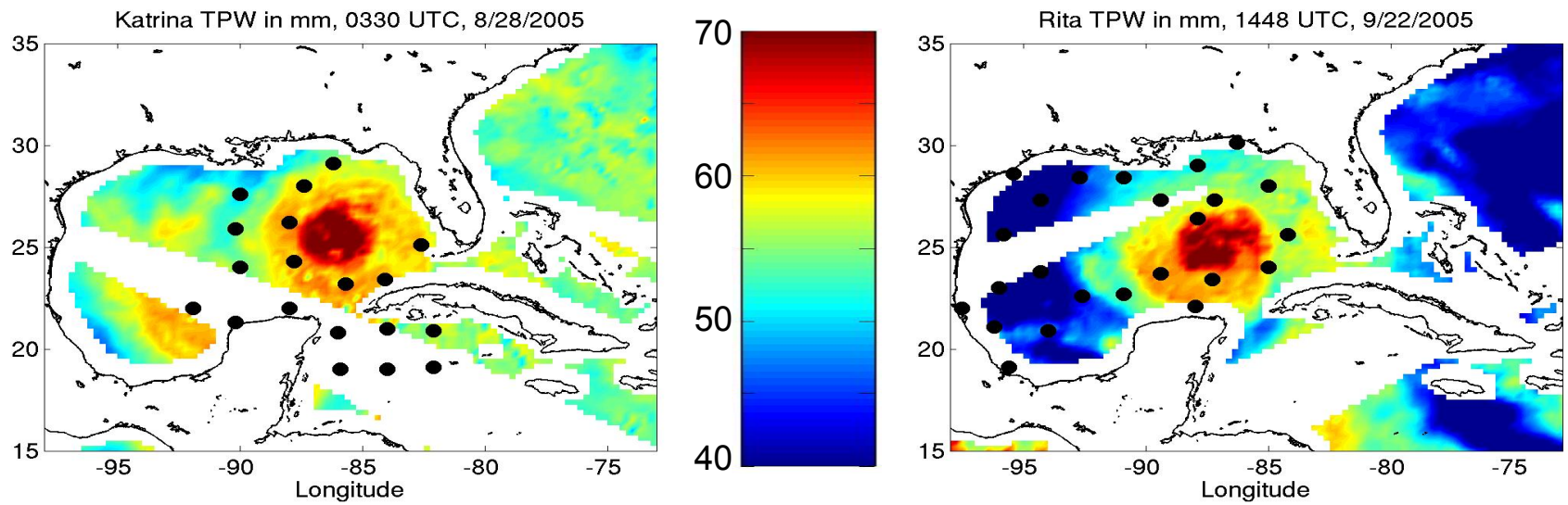


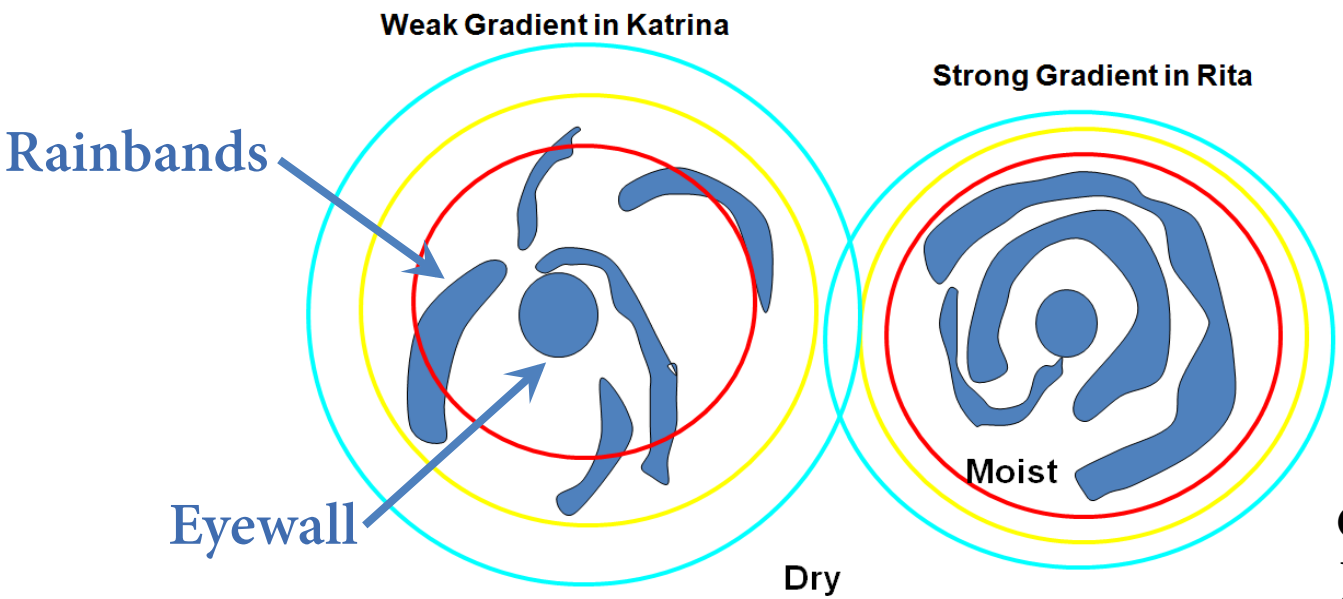
The formation of a secondary eyewall (SE) is followed by a known series of structural and intensity changes called an eyewall replacement cycle (ERC).



Black and Willoughby (1992)

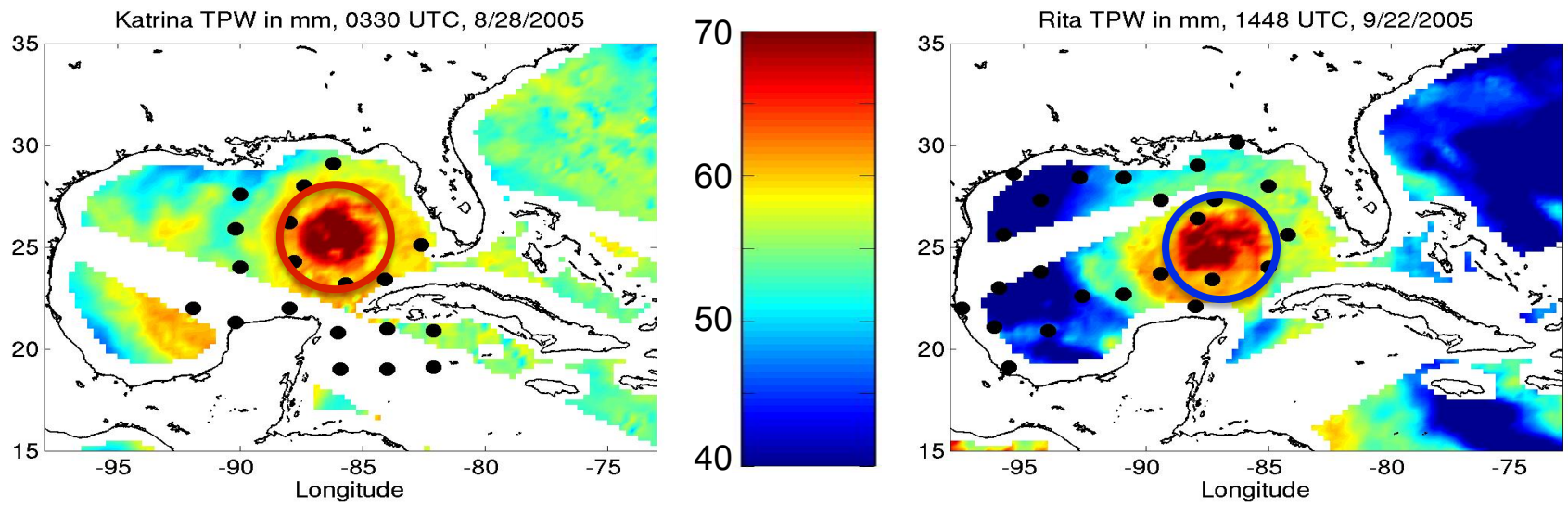
Motivation:
SE formation (SEF): Environmental moisture



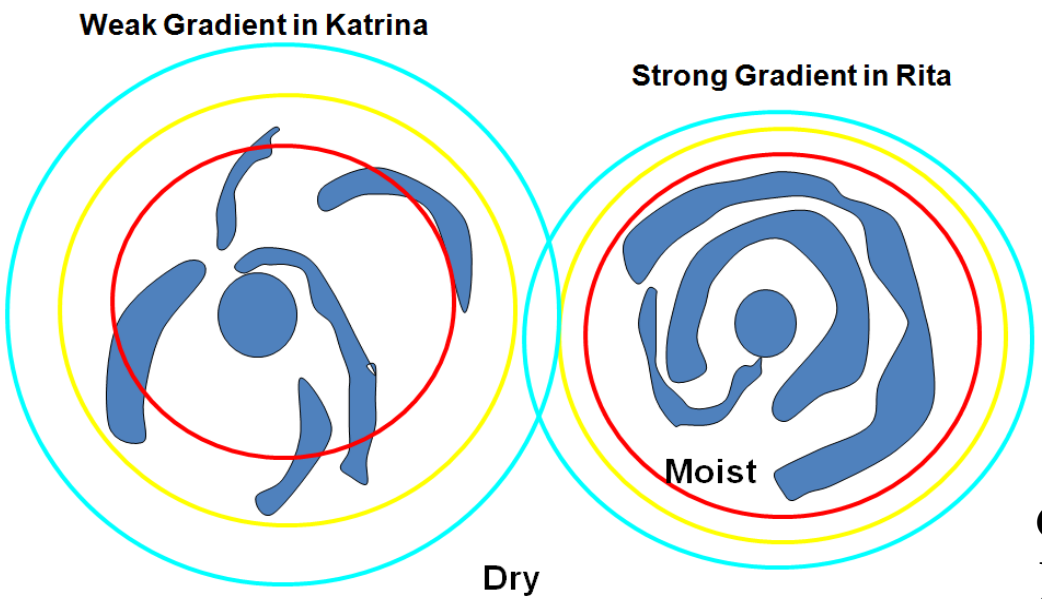


Ortt and Chen (2007)
Judt and Chen (2010)

Motivation:
SE formation (SEF): Environmental moisture



Rainbands spiraling into the center from 100s of km away

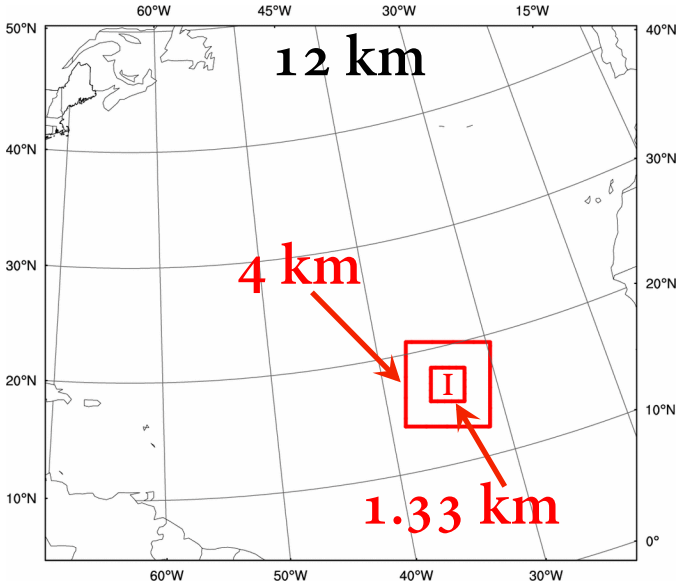


Circular rainbands surrounding the center

Ortt and Chen (2007)
Judt and Chen (2010)

Model design:
Advanced Hurricane WRF (AHW)

~ Run in **real time** at NCAR since 2004

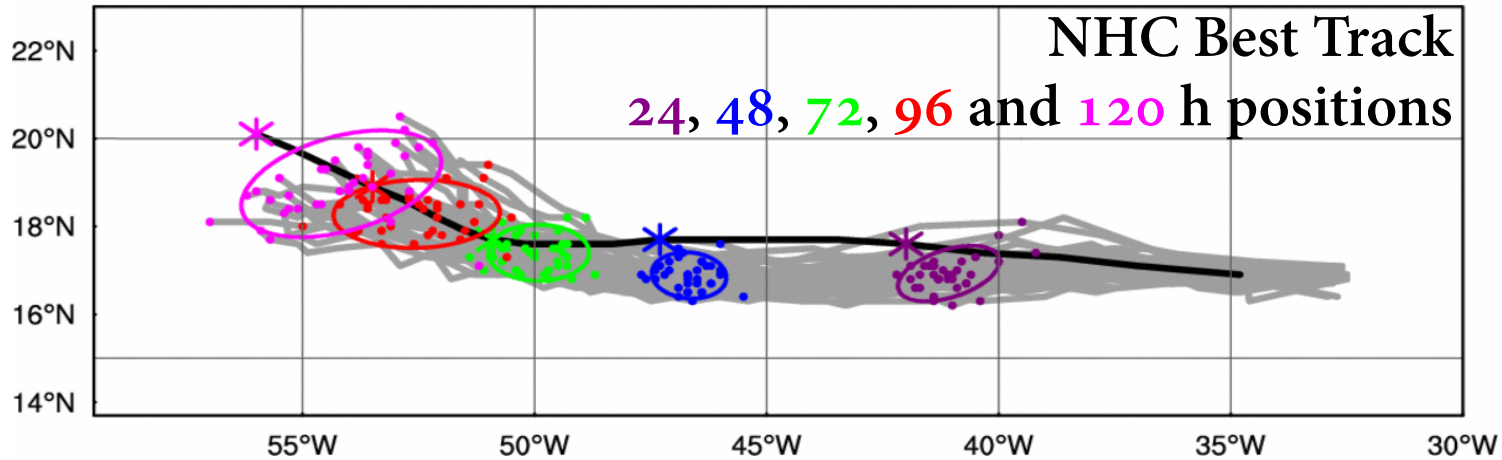


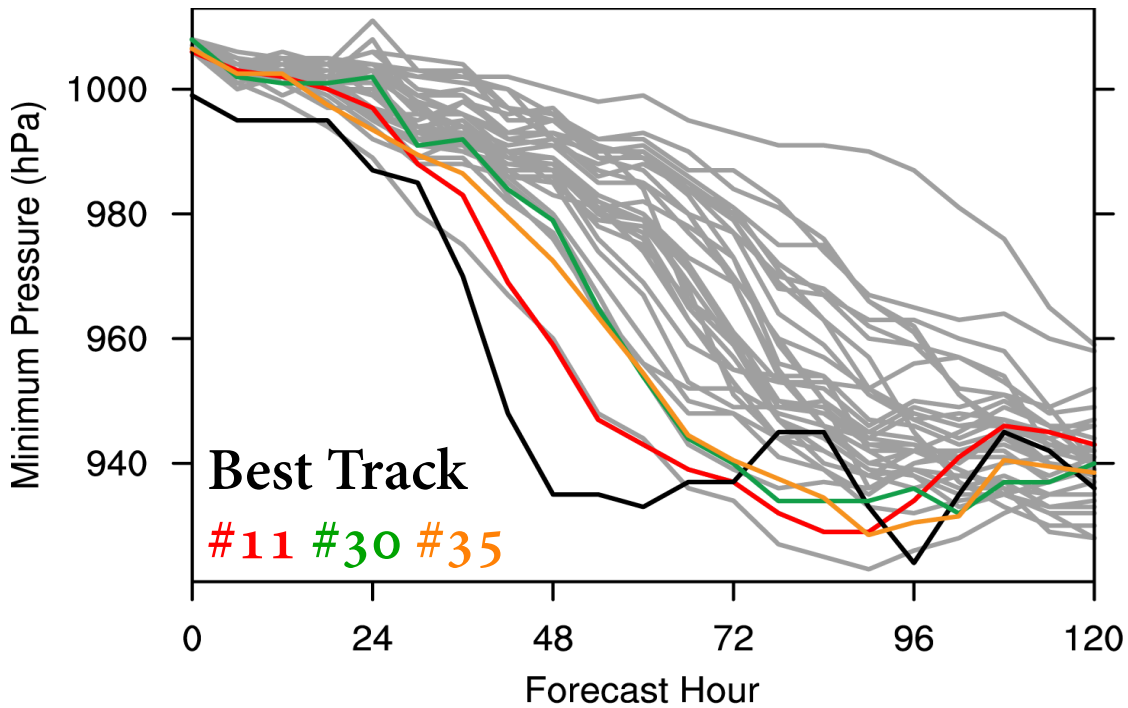
~ **Three domains** with **two-way moveable nests** that follow the hurricane center

~ **AHW EnKF data assimilation** system generates a **96 member** analysis **ensemble every 6 h** for a basin scale 36 km domain, and a 12 km TC-following nested domain

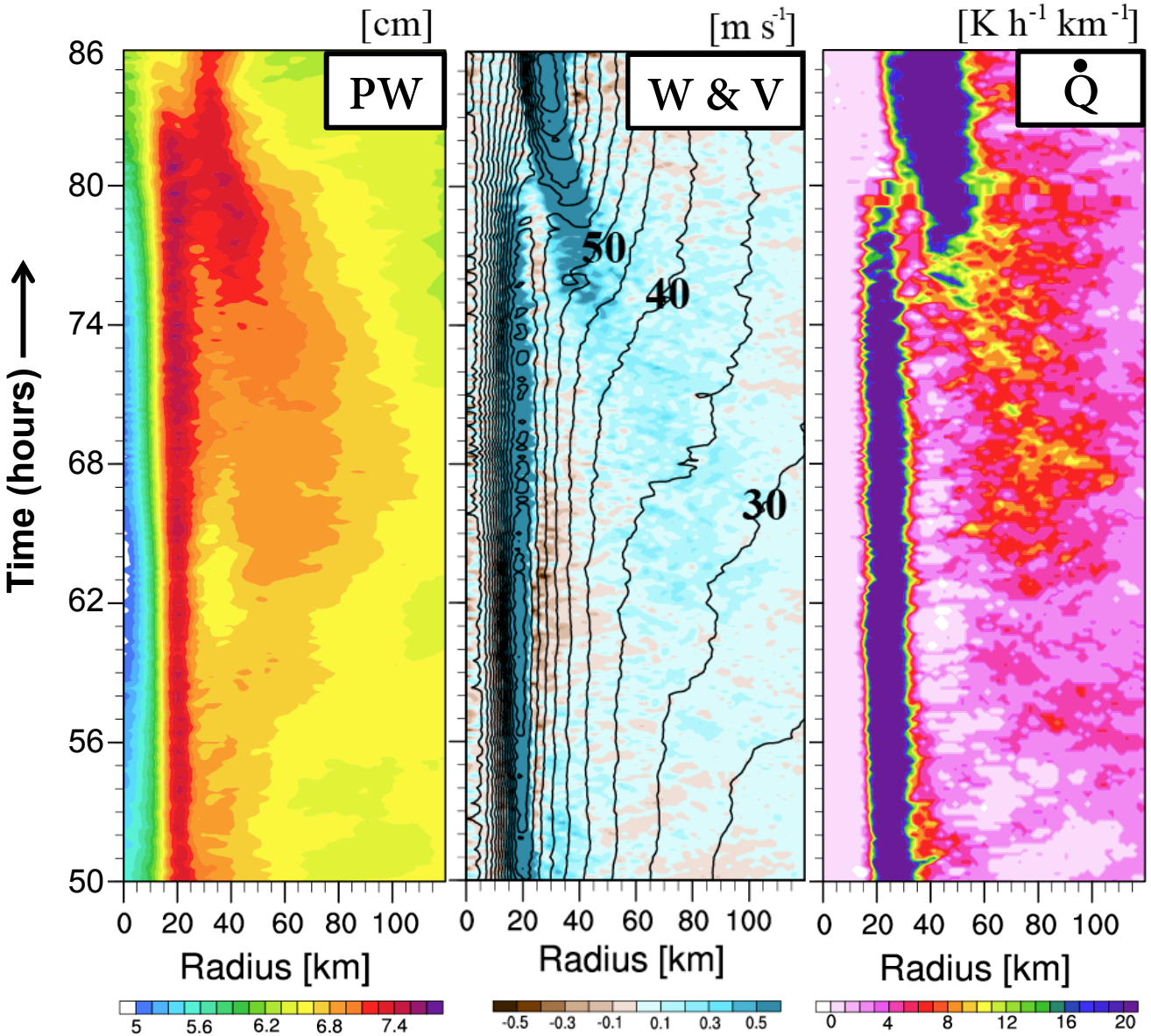
~ Analyses from **48 members** were used to initialize **forecasts** of **Igor** from 00 UTC 11 September out to 120 h

Results:
Track and intensity





Results:
SEF and ERC: Member #11



Abarca (2011)

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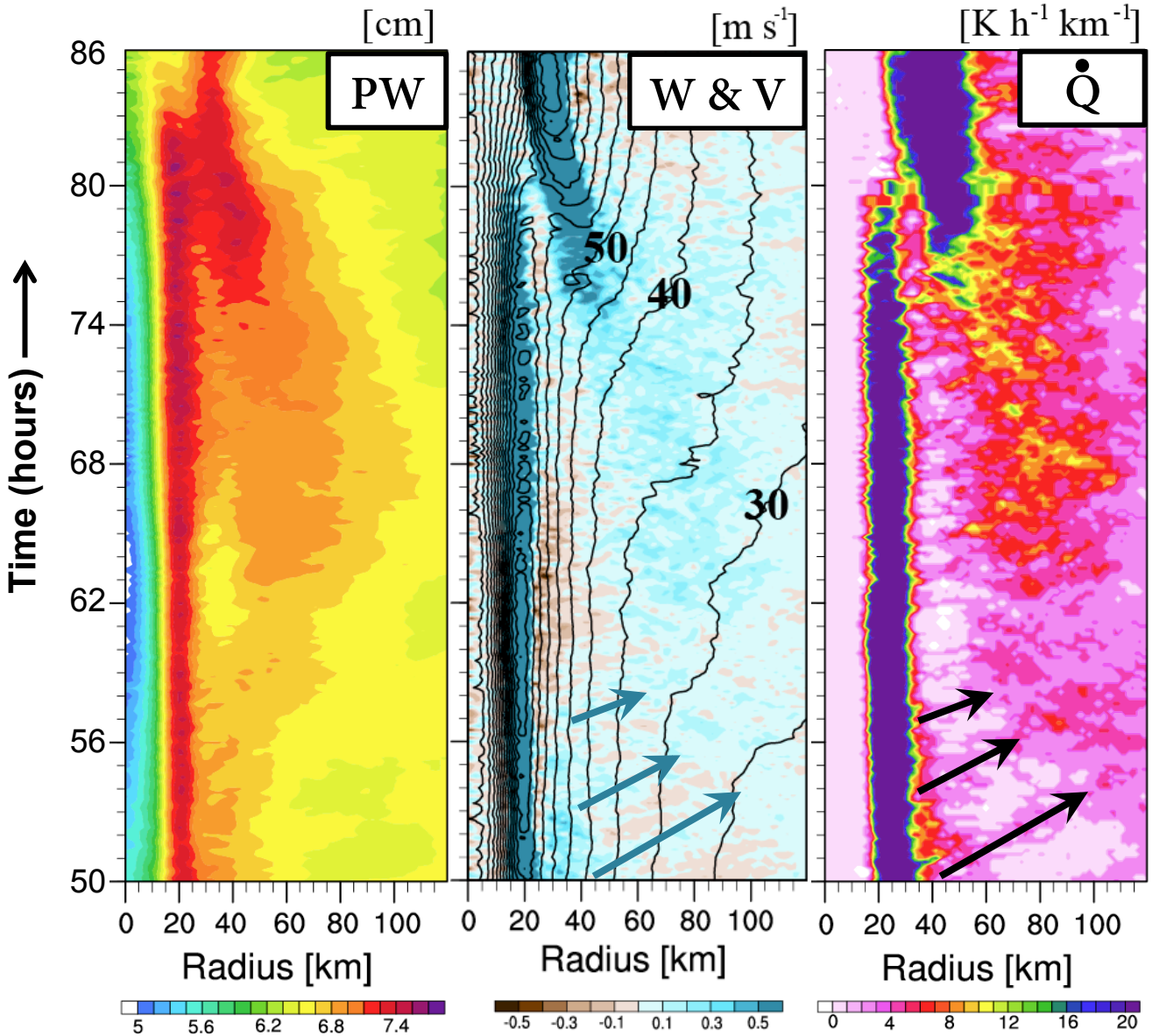
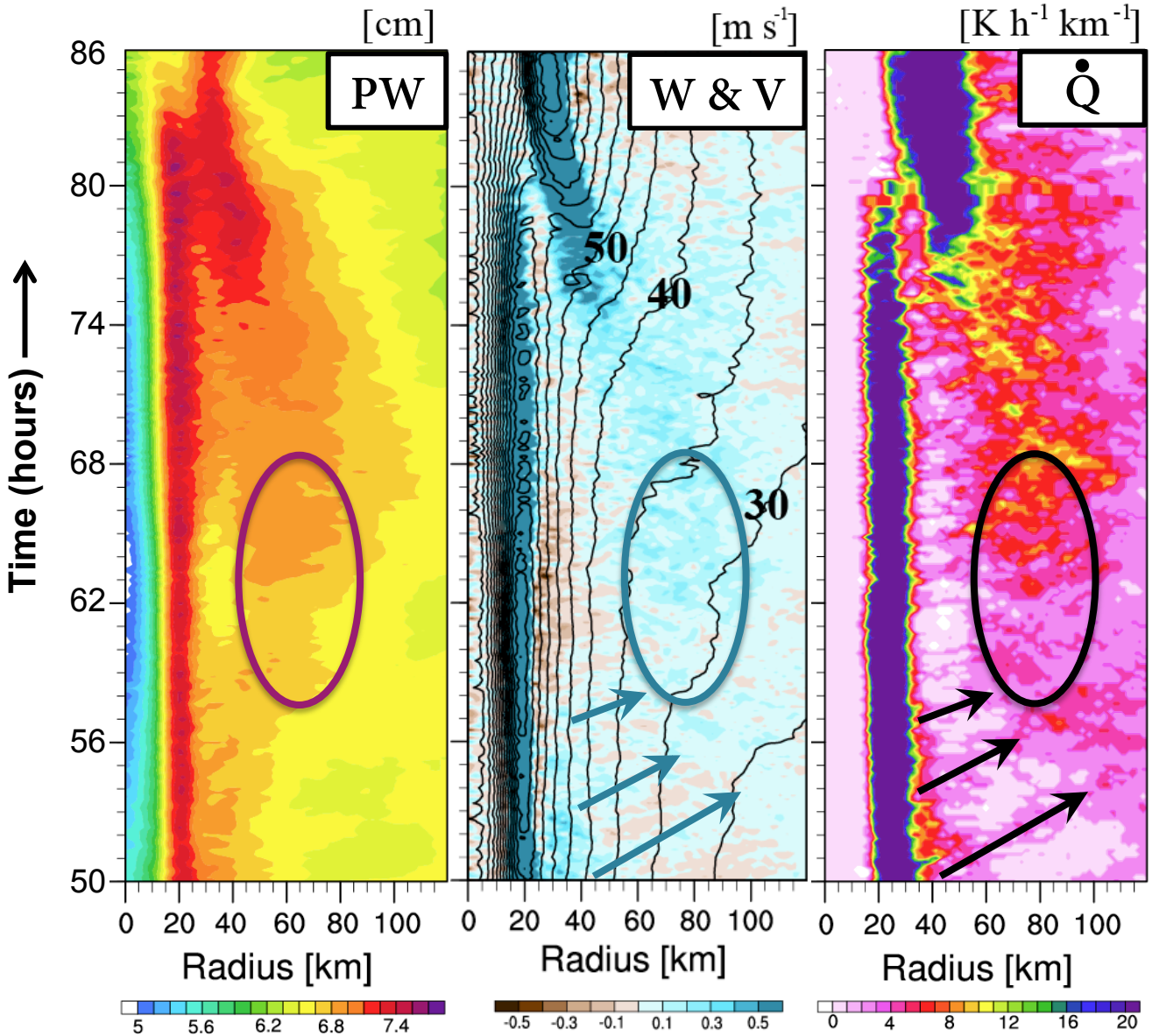
SEF and ERC: Member #11



Outward propagating features from the eyewall

Abarca (2011)

Results:
SEF and ERC: Member #11

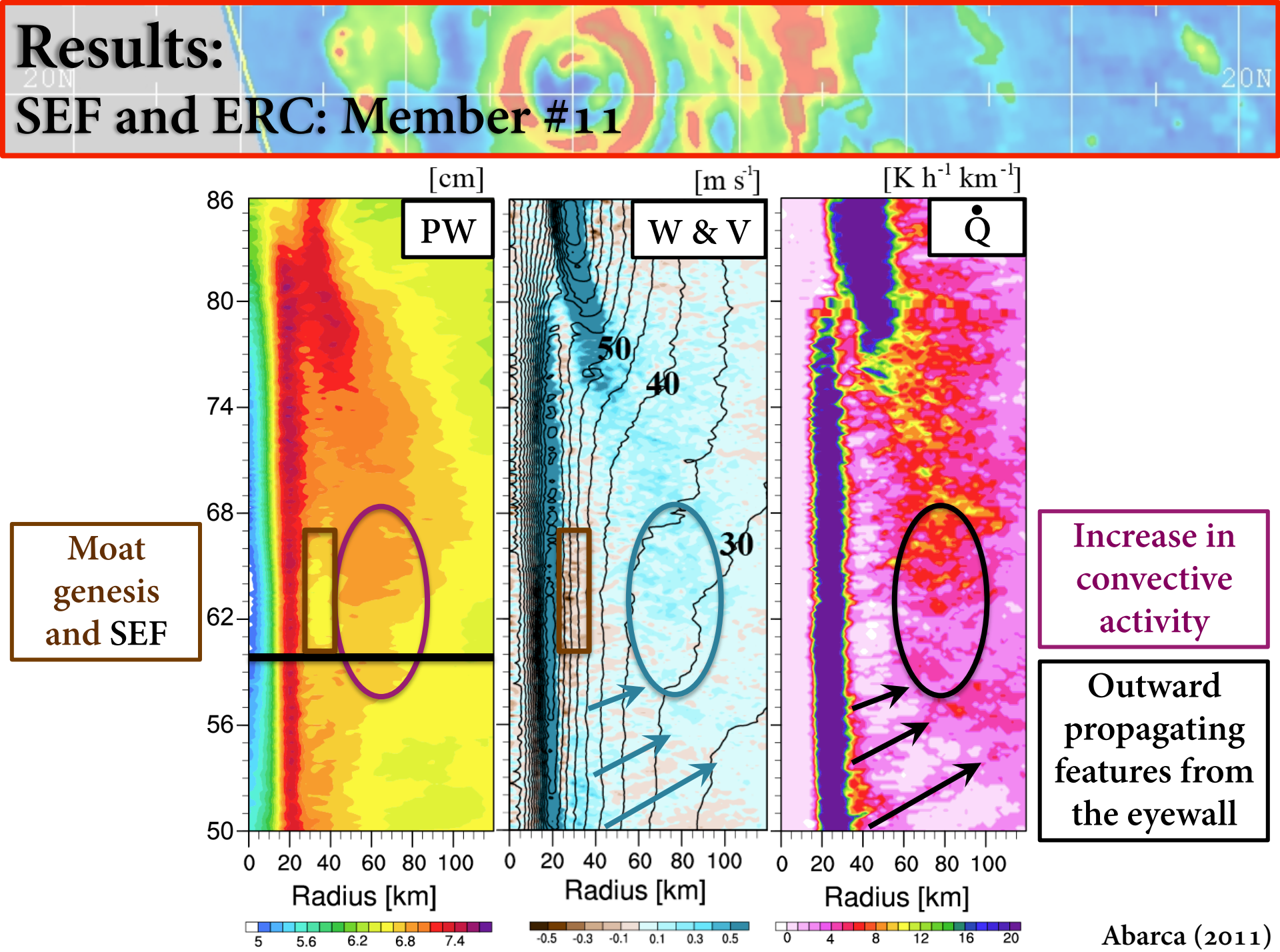


Increase in convective activity

Outward propagating features from the eyewall

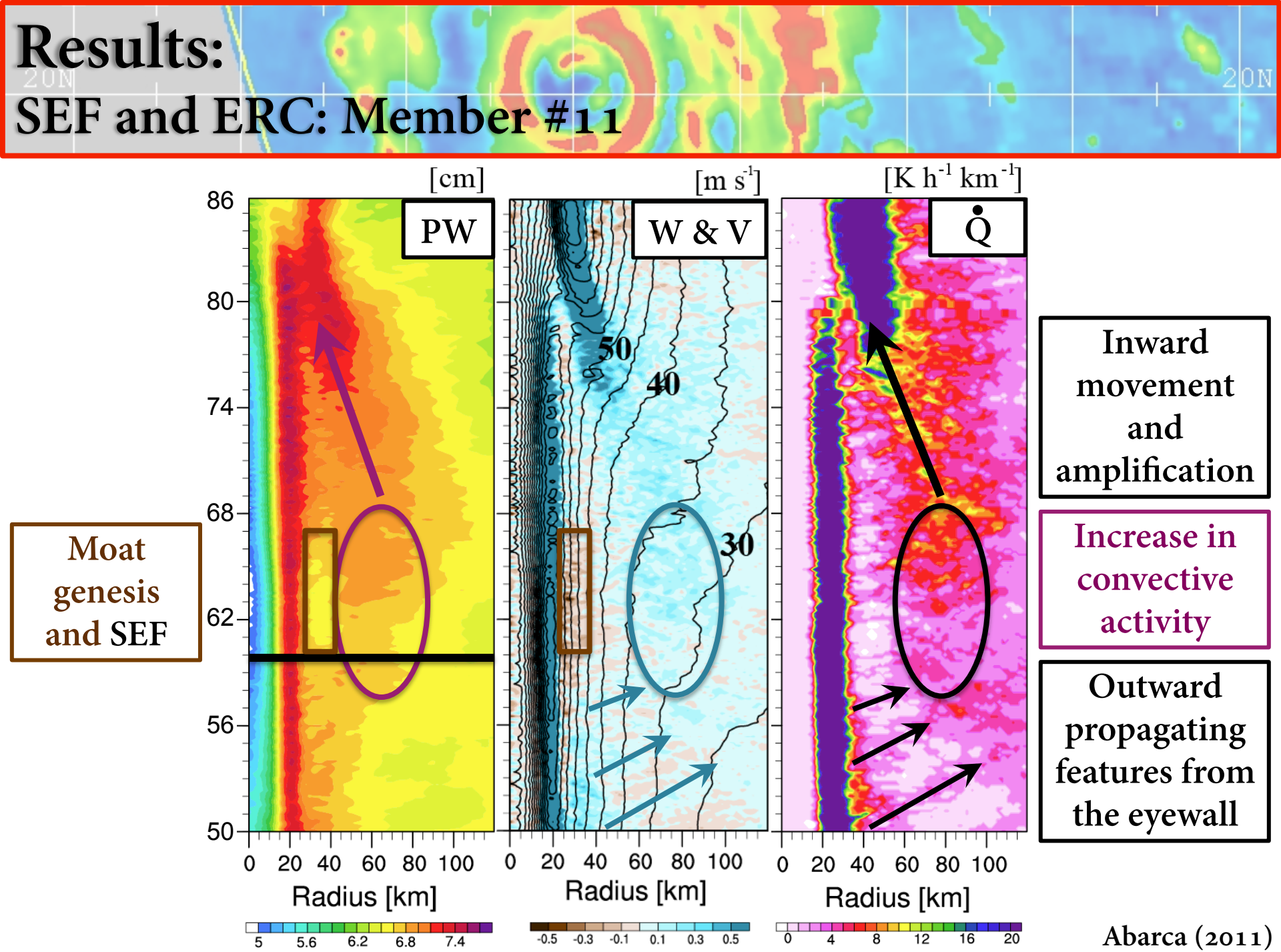
Abarca (2011)

Results:
SEF and ERC: Member #11



Abarca (2011)

Results:
SEF and ERC: Member #11

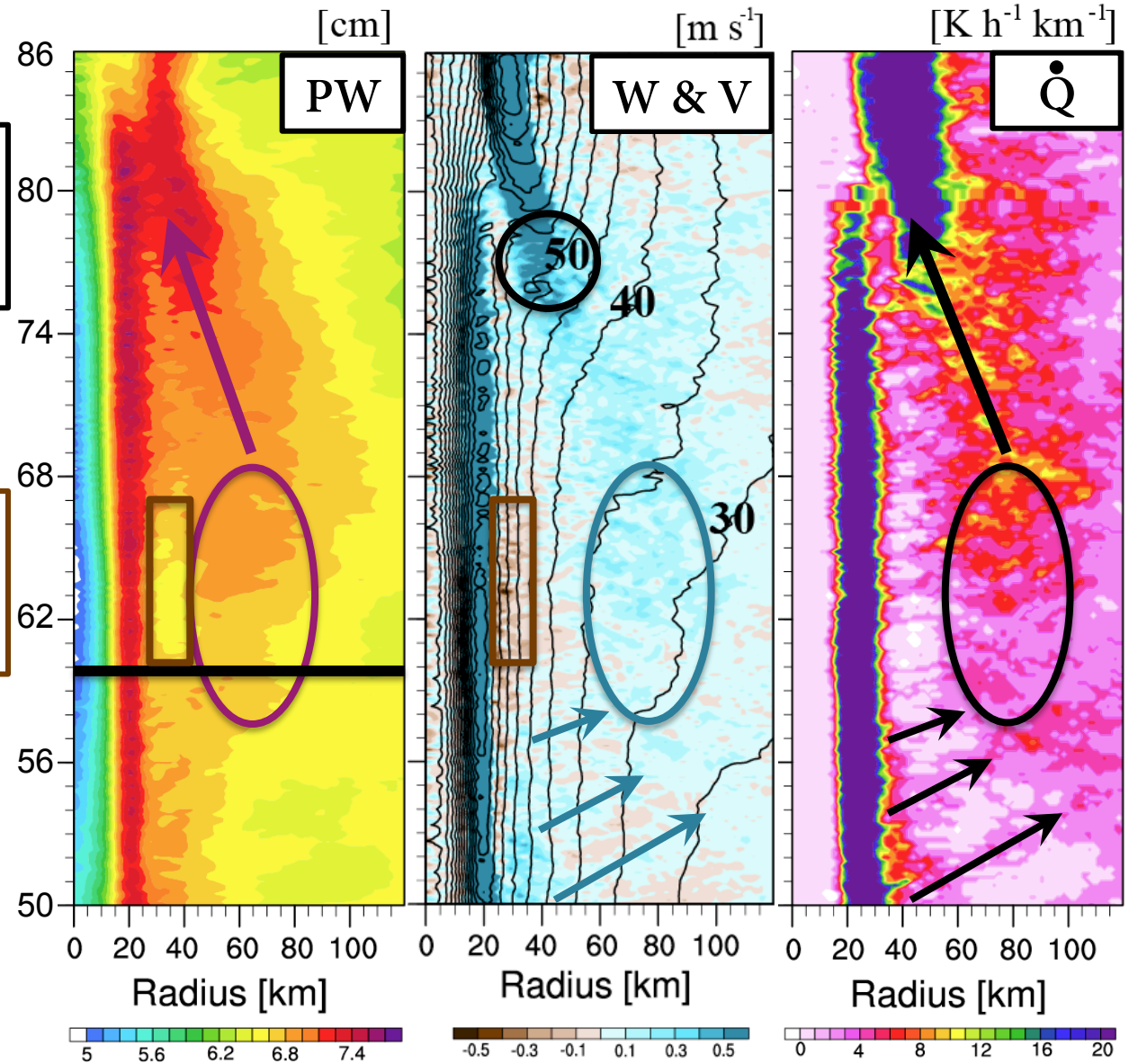


Abarca (2011)

Results:
SEF and ERC: Member #11

Formation of outer V_{max}

Moat genesis and SEF



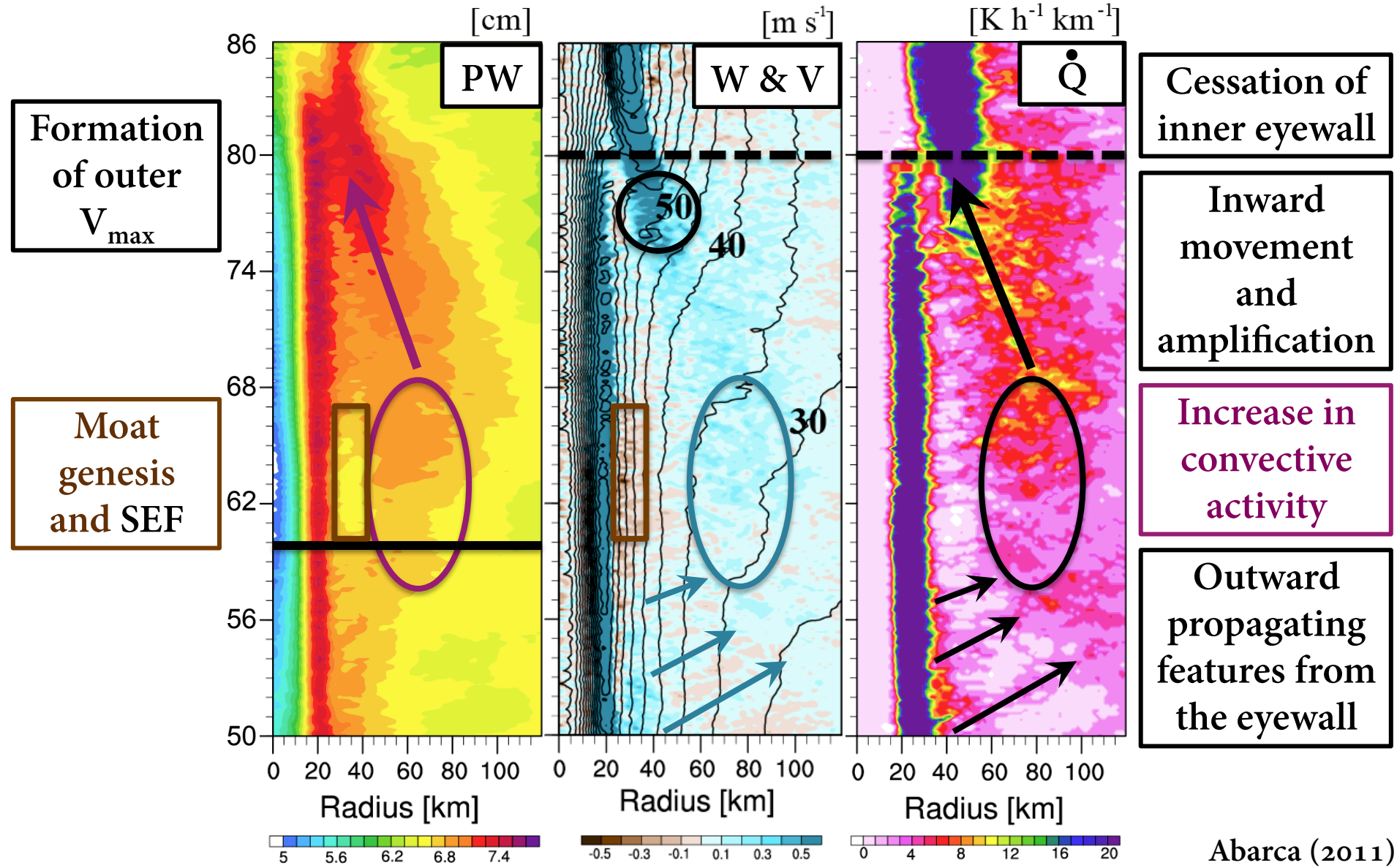
Inward movement and amplification

Increase in convective activity

Outward propagating features from the eyewall

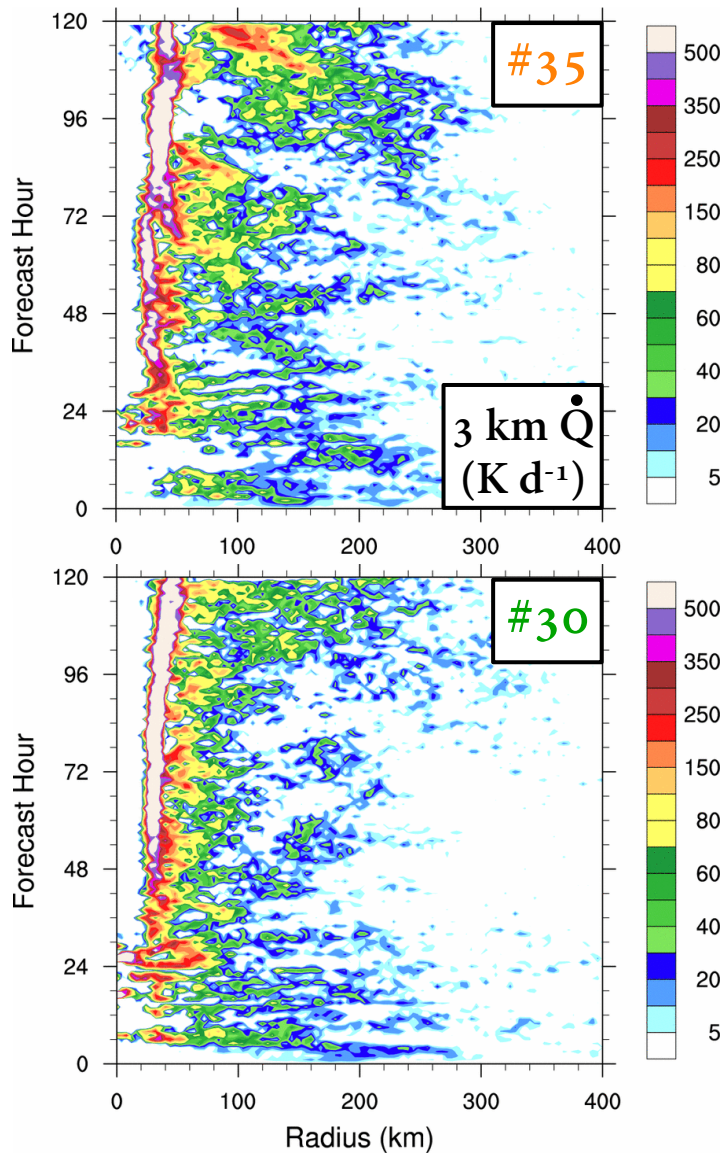
Abarca (2011)

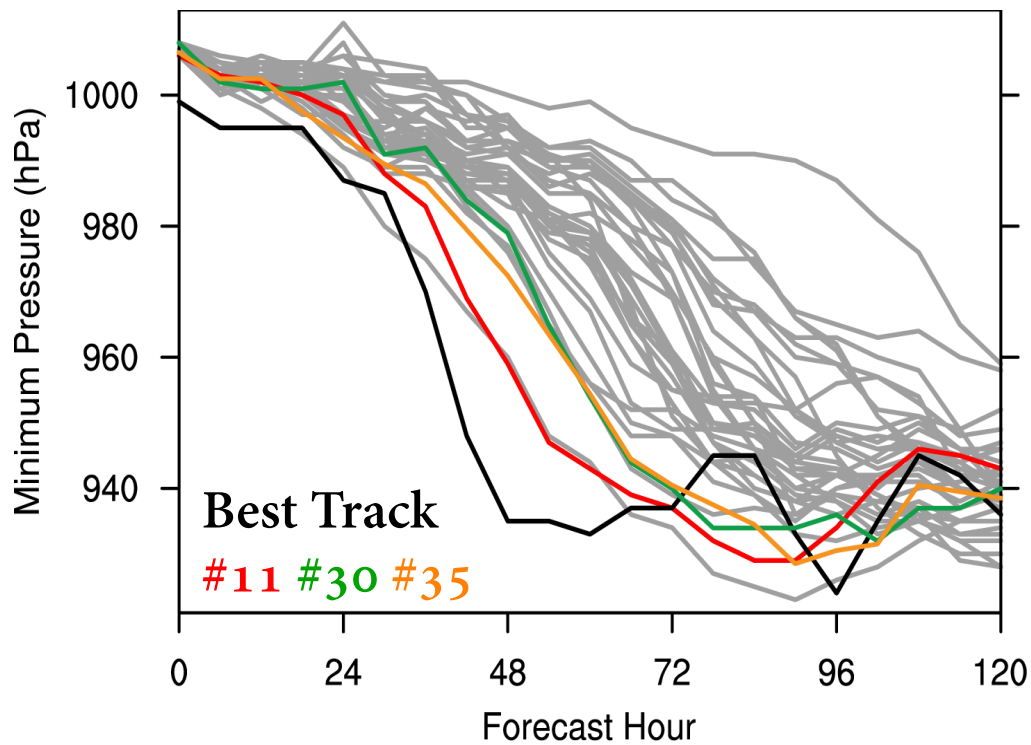
Results:
SEF and ERC: Member #11



Abarca (2011)

Results:
Comparison of two strong members





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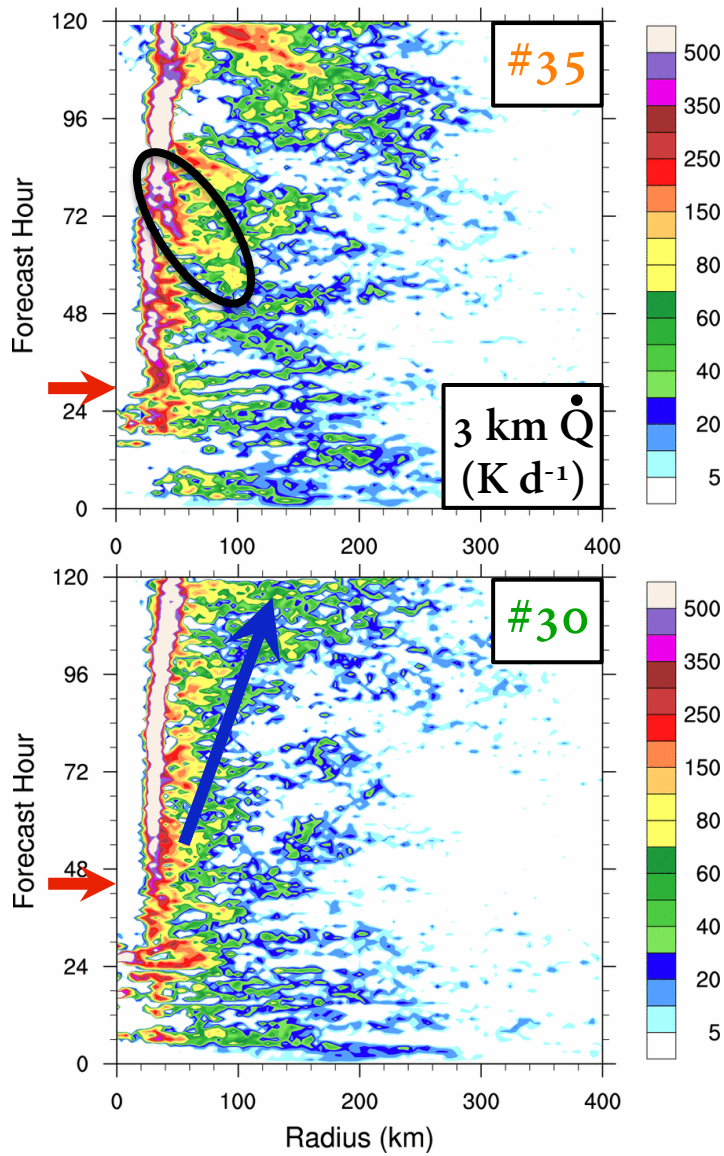
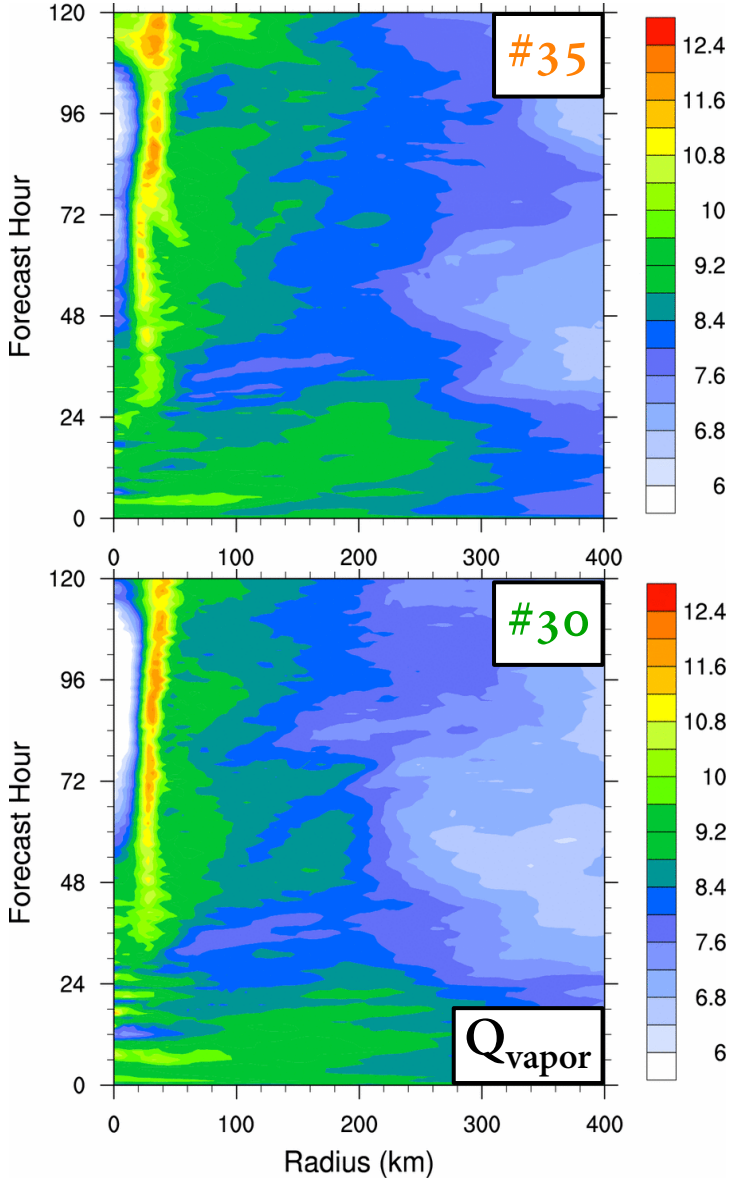
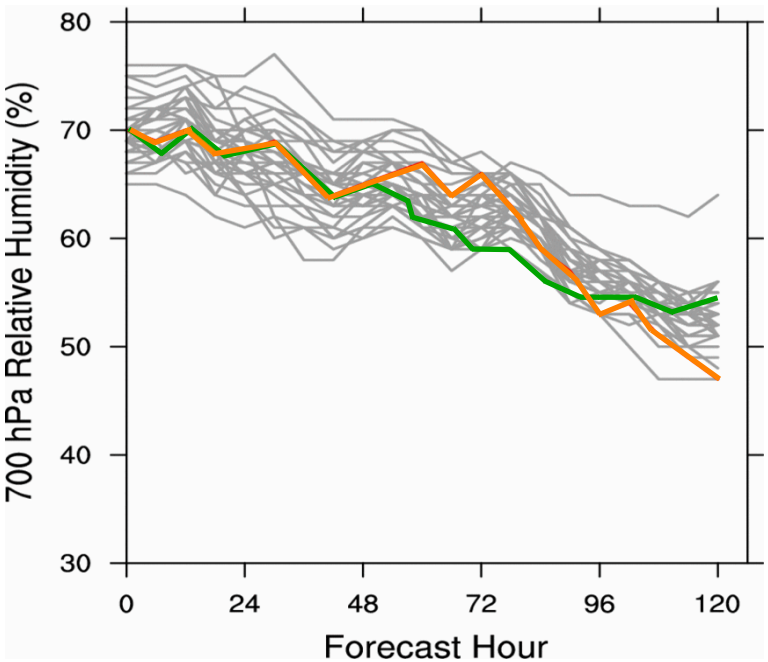


#35: Quick to develop; classic SEF & ERC between 60 h and 78 h

#30: Slow, outward movement of the eyewall and expansion of the convective field

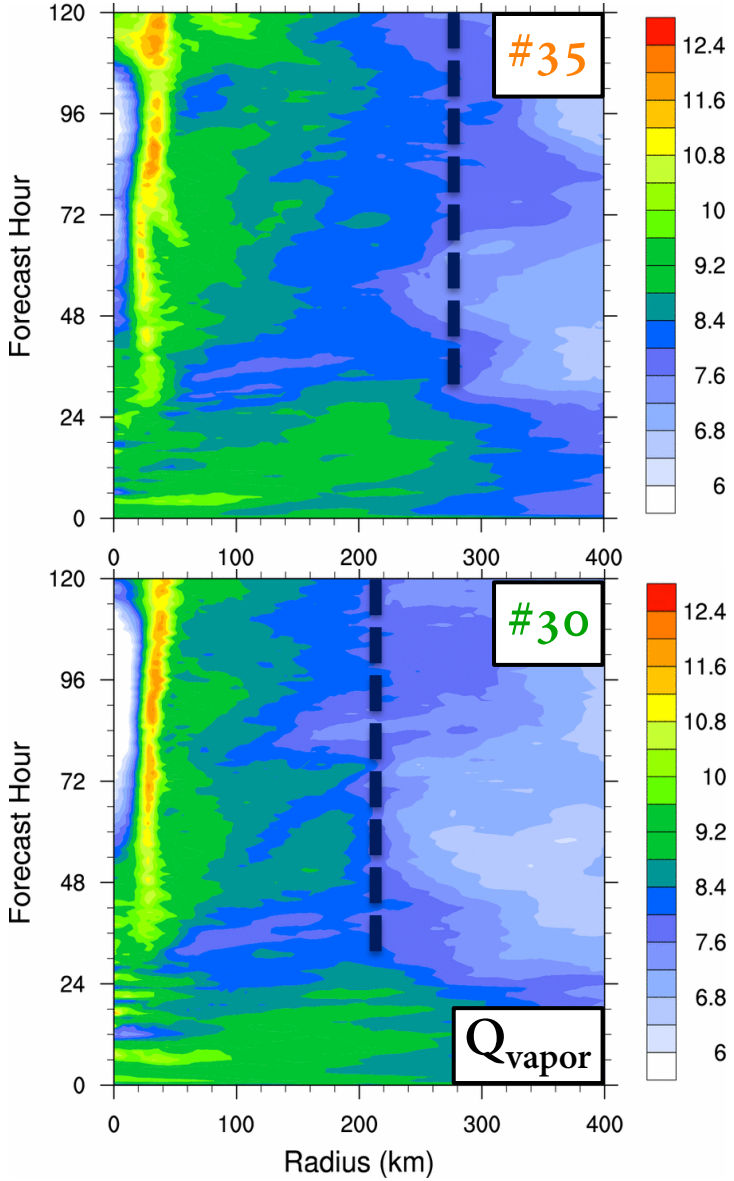
Results:
Comparison of two strong members

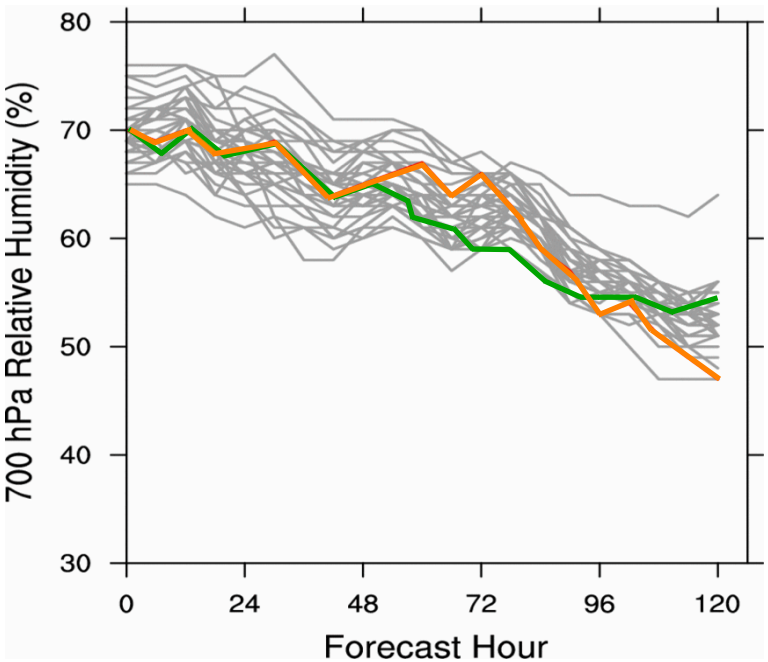




#30 is **drier** and exhibits a **stronger moisture gradient** between the core and environment

Results:
Comparison of two strong members





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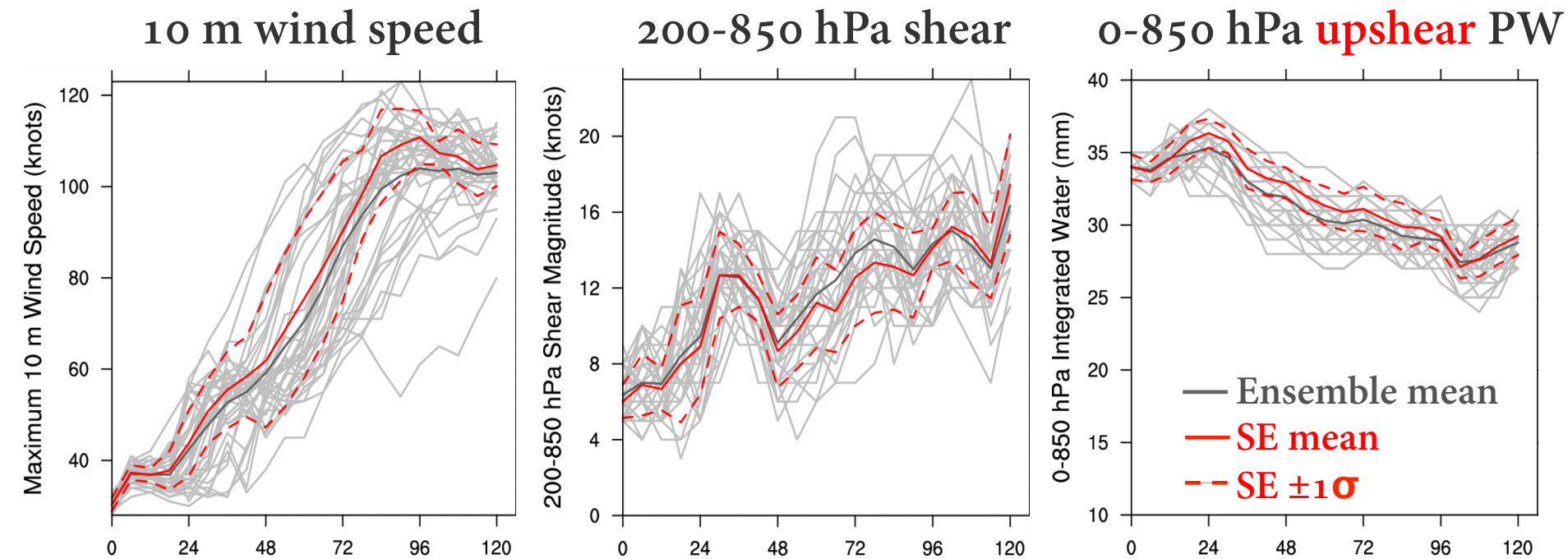
Results:
Composite evolution



The **members** exhibiting SEs are **more intense**, especially in the time period **after** the ERCs are complete (78-102 h).

The **time period** of SEF featured **below** ensemble **mean** wind **shear** and **significantly higher upshear PW**.

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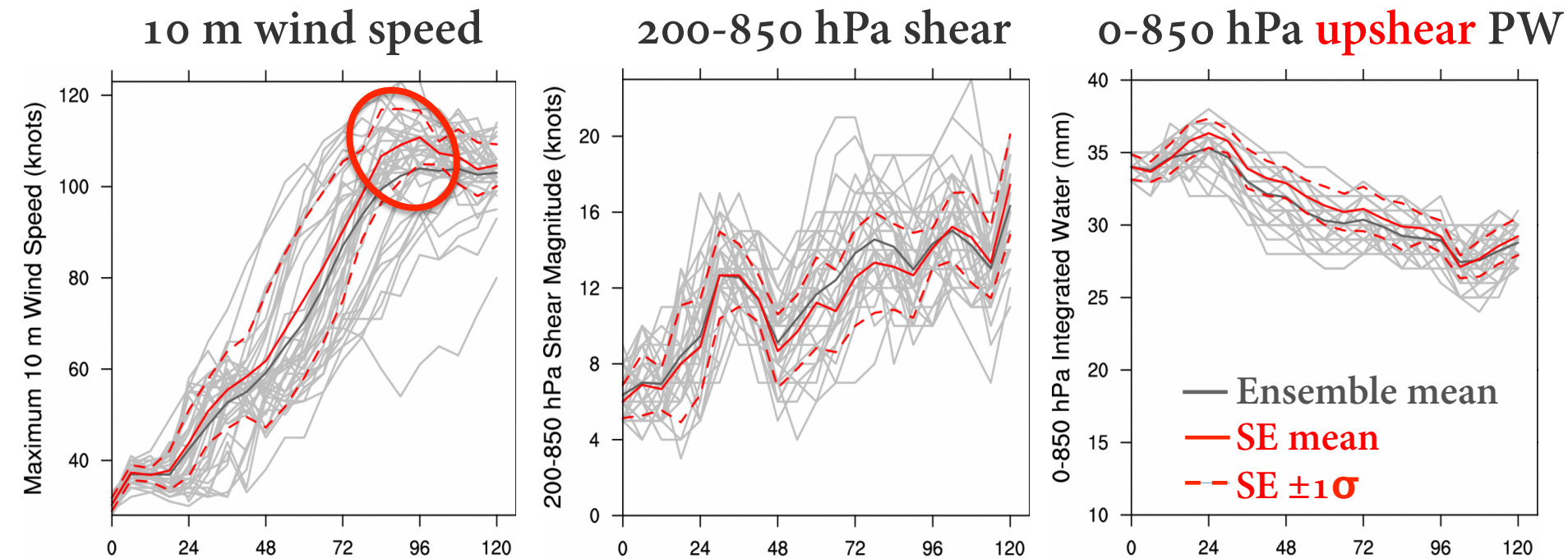
Composite evolution



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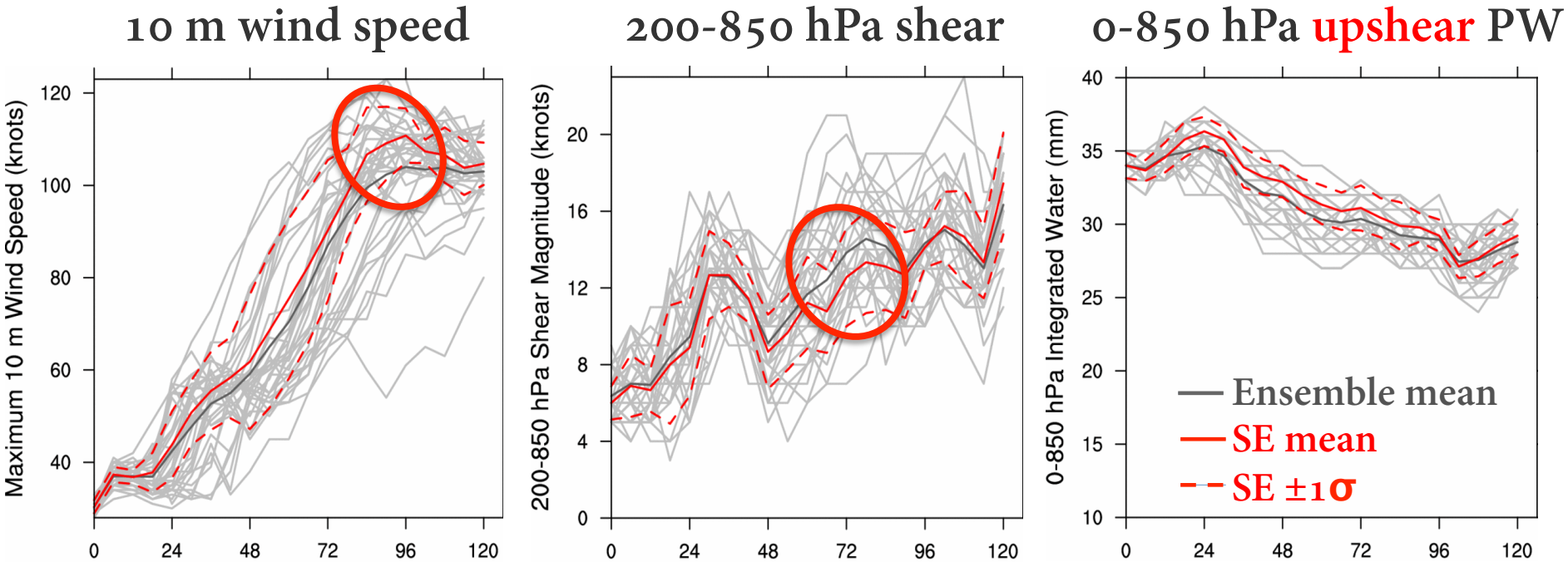

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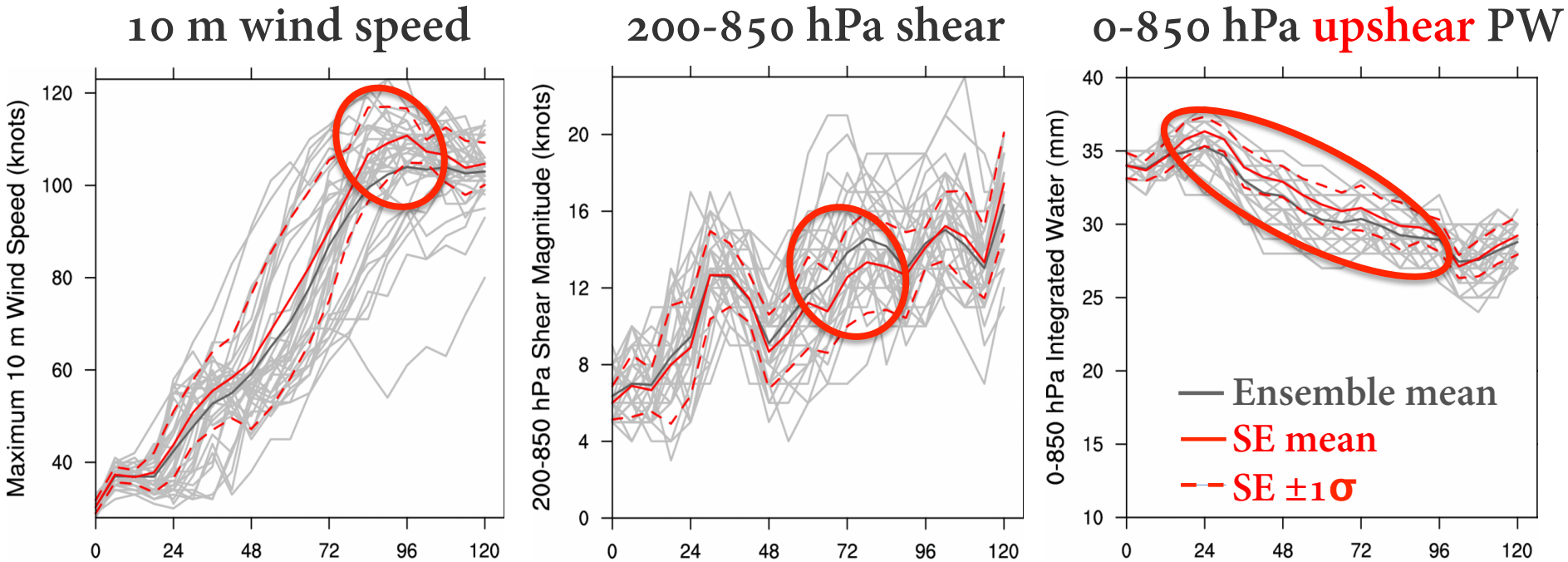

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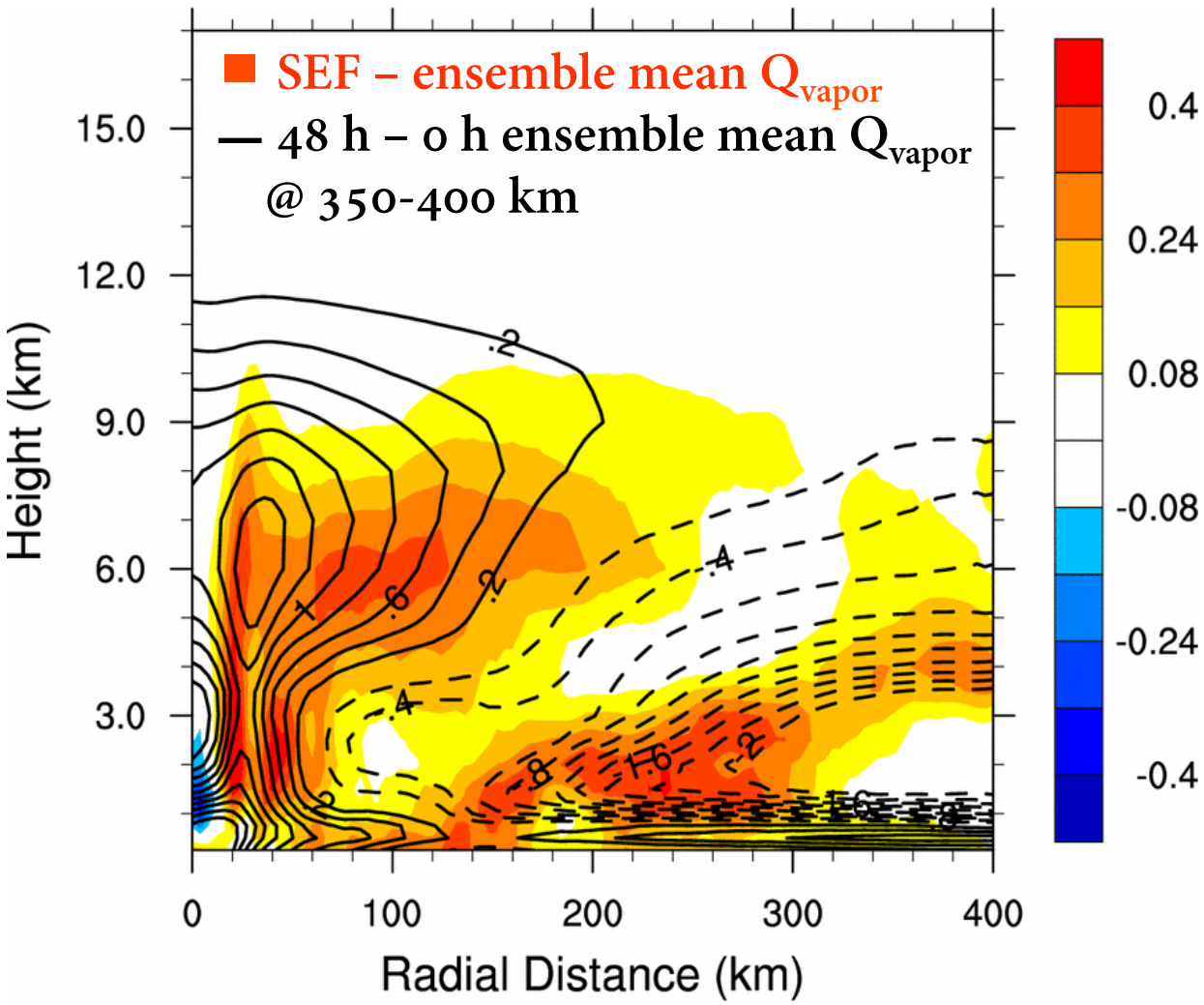
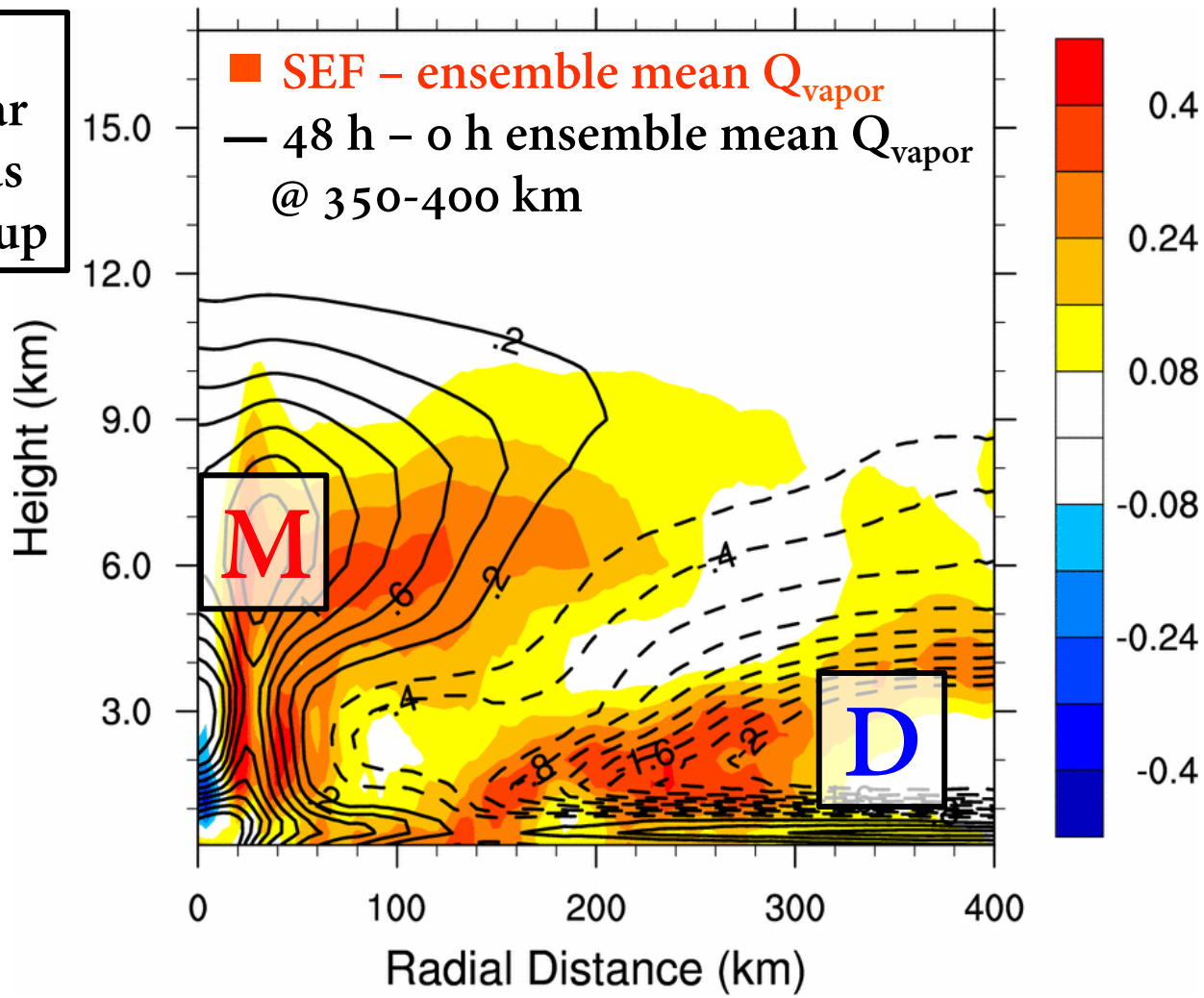
Results:
Qvapor distribution: SEF members vs. ensemble mean



Results:
Qvapor distribution: SEF members vs. ensemble mean

Inner core **moistens**, far field **dries** as storm spins up



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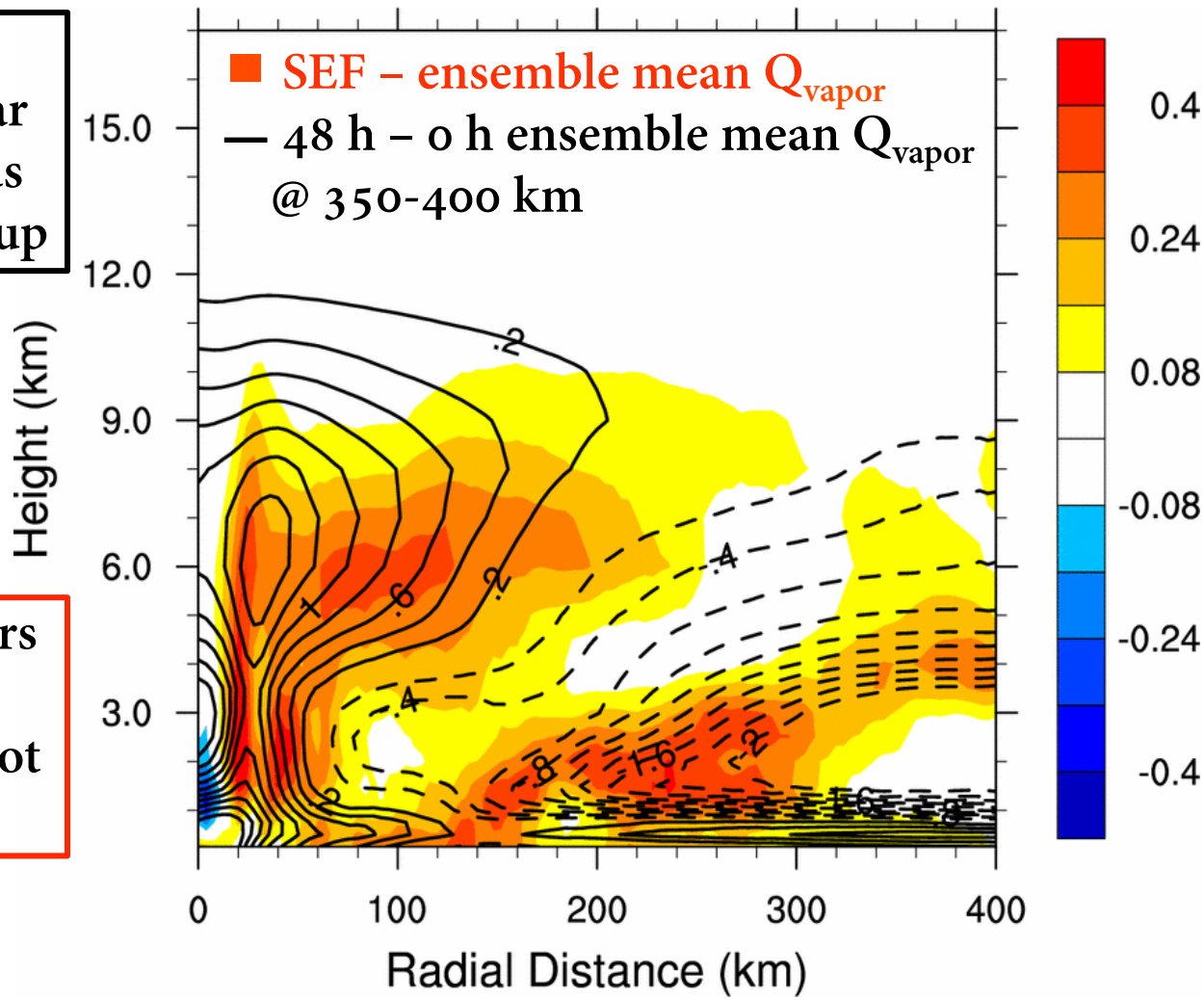
Inner core **moistens**, far field **dries** as storm spins up

SEF members are more **moist**, but not uniformly



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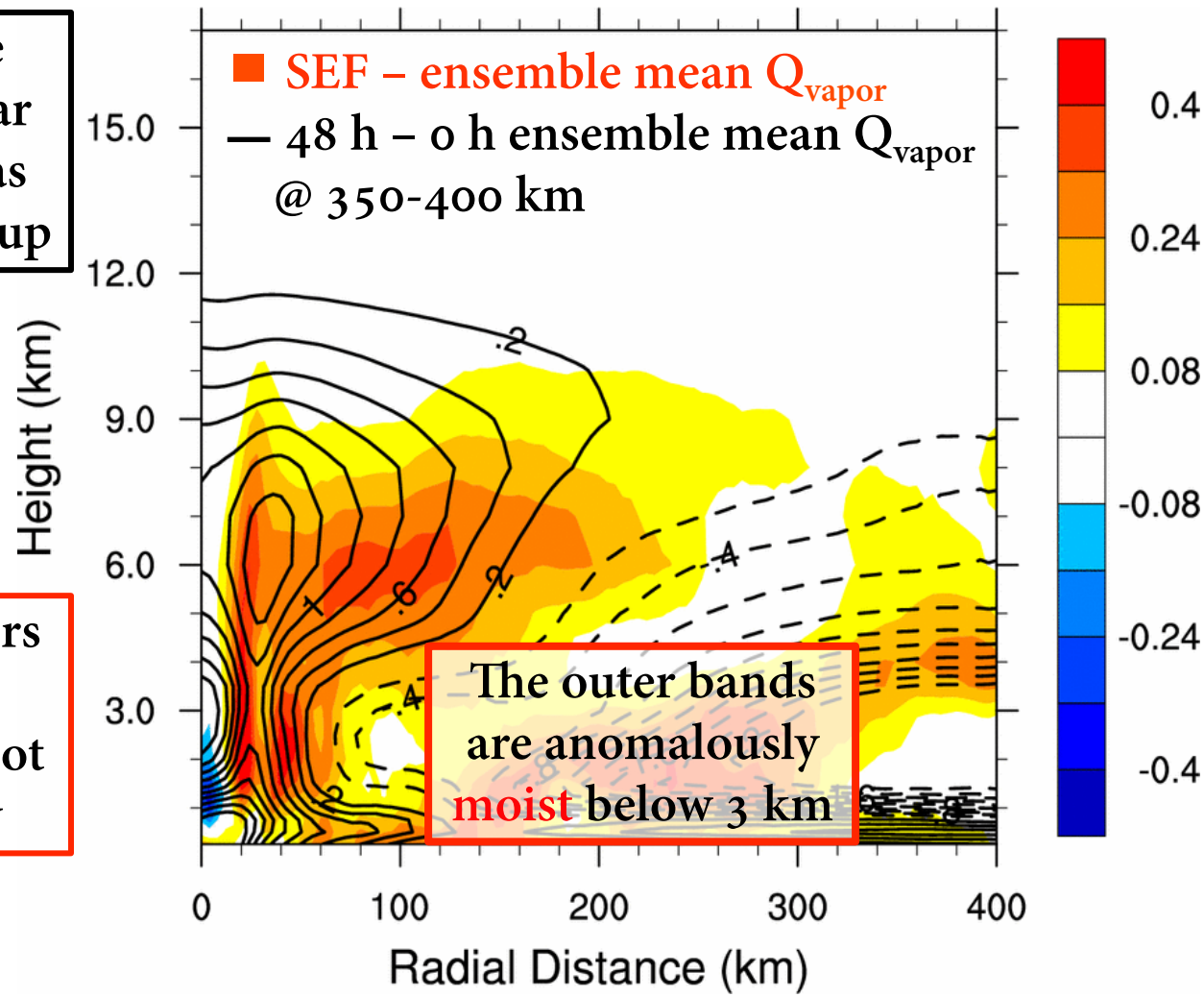

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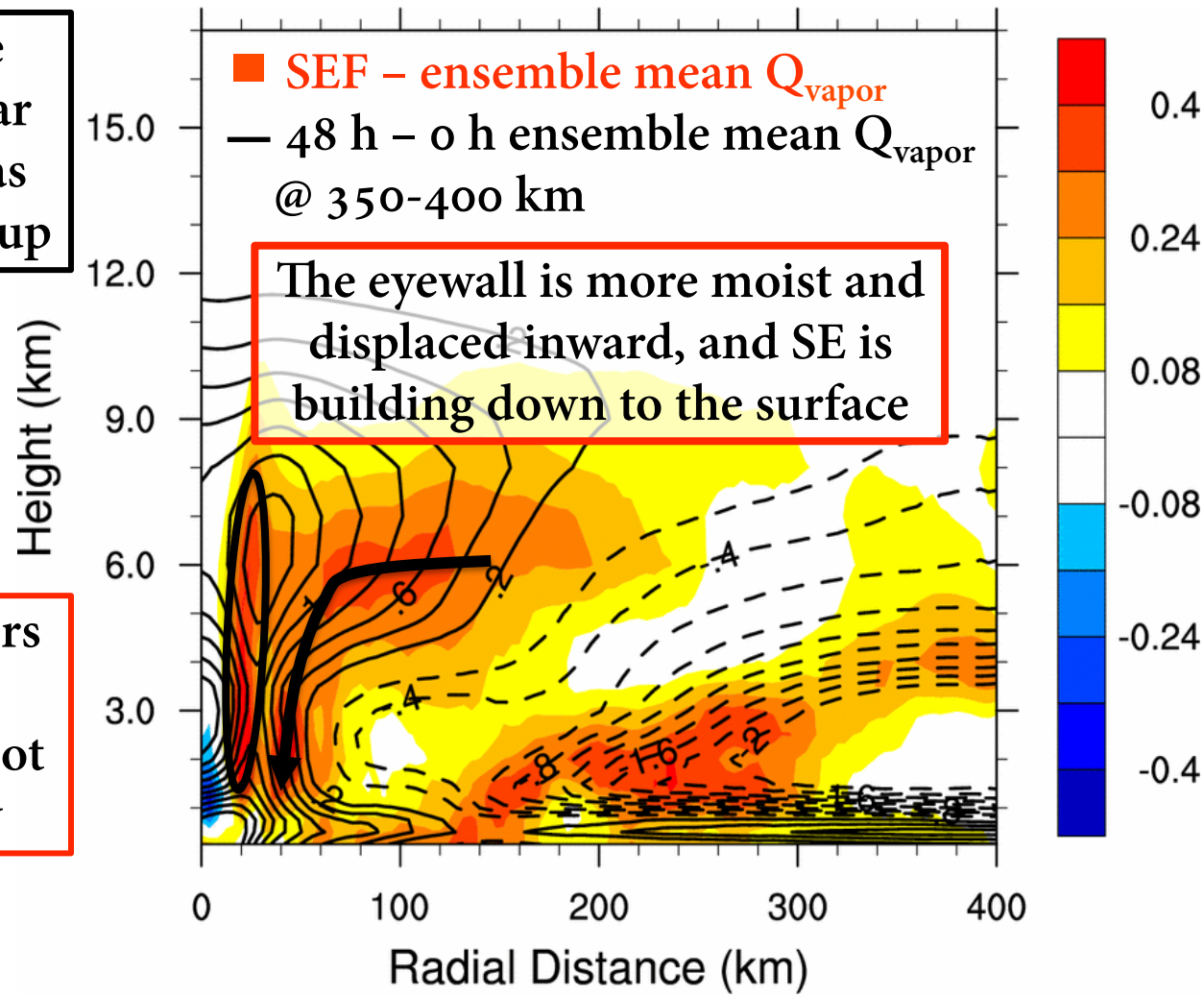

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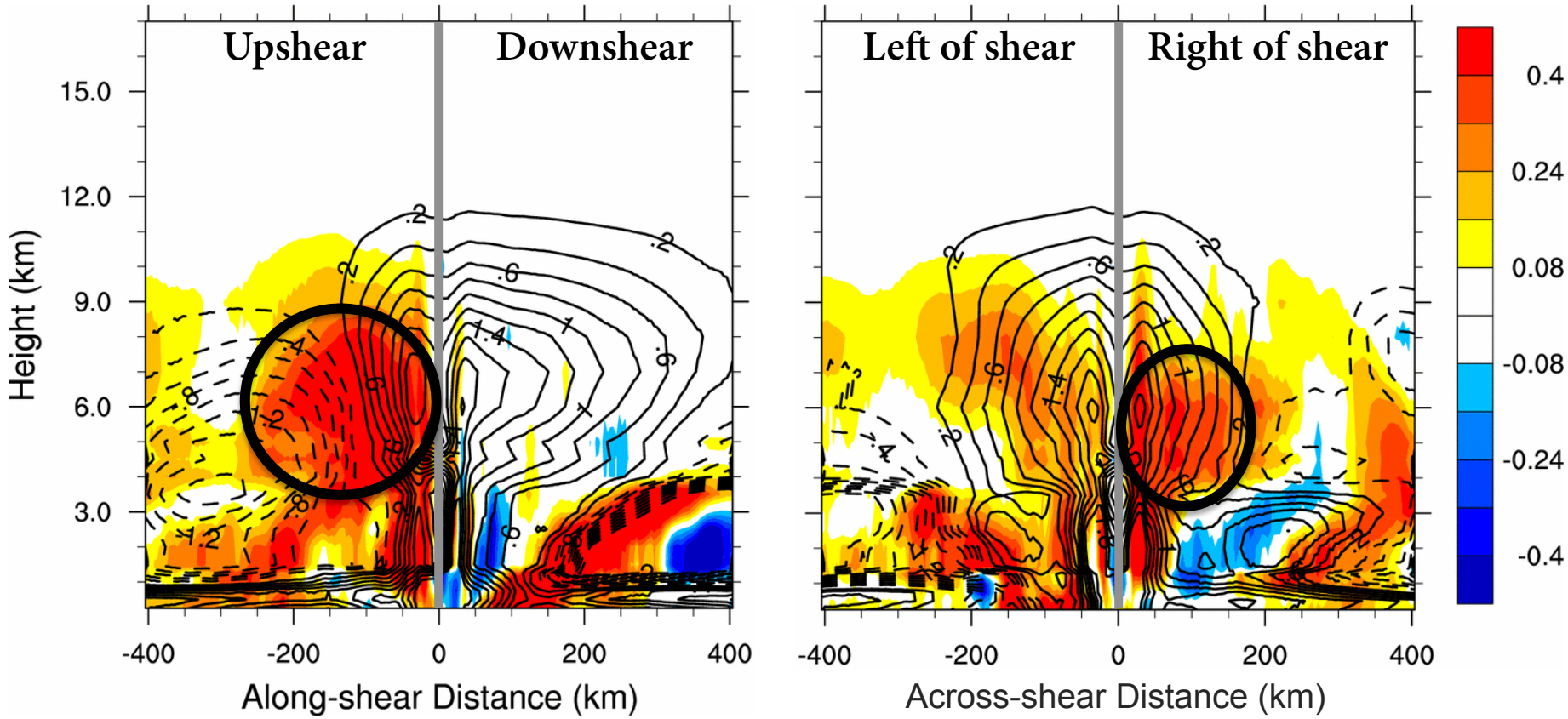
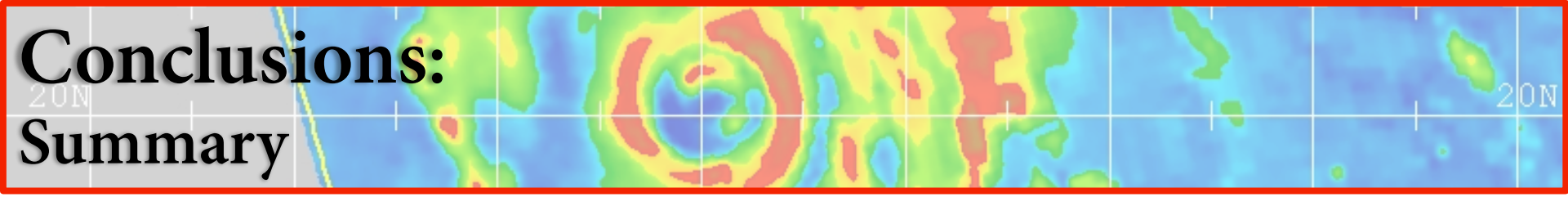


The **largest** Q_{vapor} **anomalies** at **mid-levels** are **upshear** and **right** of **shear**, while the outer **rainband** region is **uniformly moist.**

Conclusions: Summary



~ The **AHW EnKF system** is able to **realistically simulate** the **secondary eyewall formation** and **eyewall replacement cycle** of Hurricane Igor (2010)

~ The **SEF members** are **more intense**, are embedded in environments with **weaker shear**, and are **more moist**

~ The **outer rainband region** is **uniformly**, anomalously **moist**, while **enhanced moisture** is predominantly **upshear** and **right of shear** in the core