

# Variability of the West African Monsoon: an integrated view of the SHL and the AEW processes

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Contexte

AEW synoptic pattern

The Mass field organization during events

Associated rainfall Activity

Diagnostic of Diabatism Processes

Formalism

Climatology of  $Q_1$  and  $Q_2$

Synoptic scale modulation of  $Q_1^*$  and  $Q_2^*$

The Mass and Dynamics Fields Loop

The SHL construction at synoptic scale

Mass Feedback: The Q Vectors Approach  
Notations and Equations

Q Vector Divergence

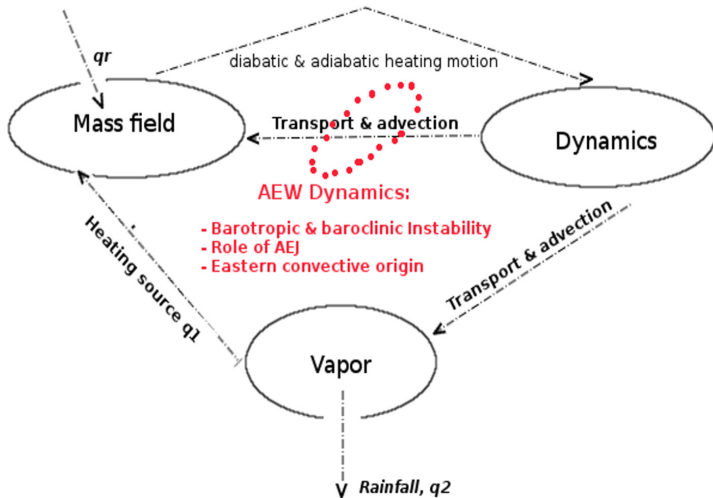
Lat-Lag

Q Vector Divergence:

Lev-Lag

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# 3-Dimensionnal Approach



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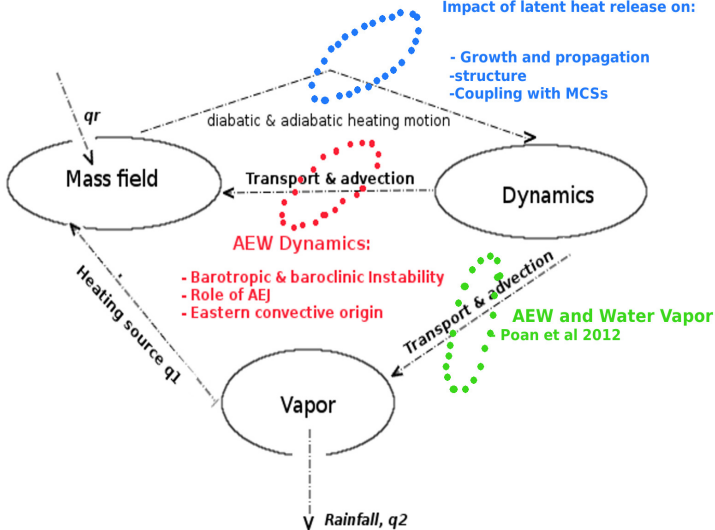
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# 3-Dimensionnal Approach

Impact of latent heat release on:

- Growth and propagation
- structure
- Coupling with MCSs



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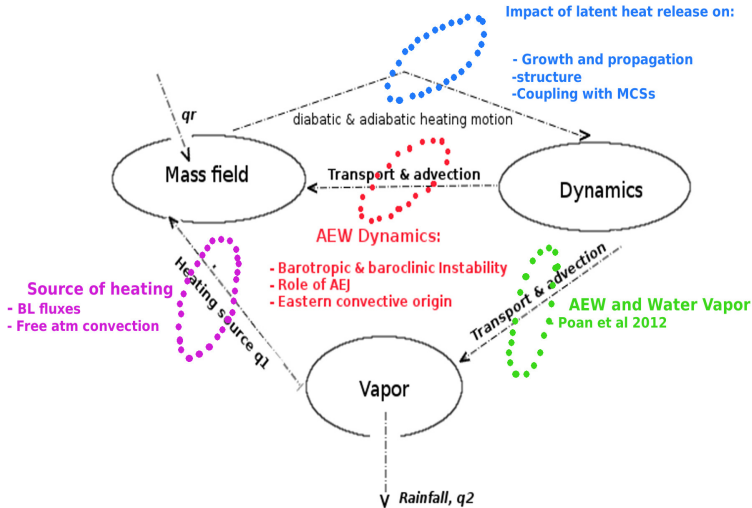
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- ▶ The mechanisms inside each box

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- ▶ The interactions between the different boxes

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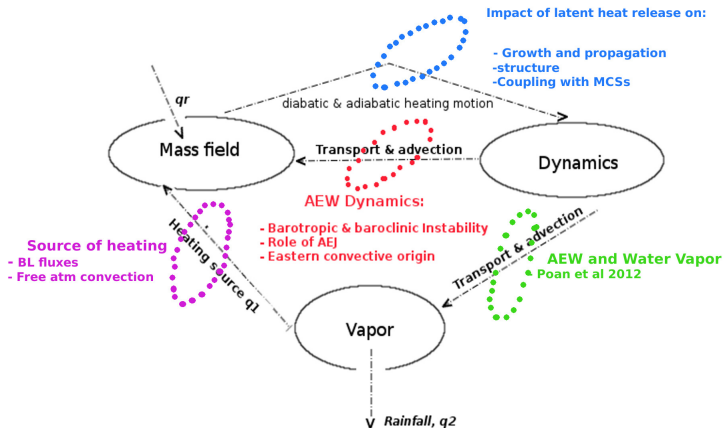
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# Main goals

- ▶ The mechanisms inside each box
- ▶ The interactions between the different boxes
- ▶ A consistent scheme of the global physics



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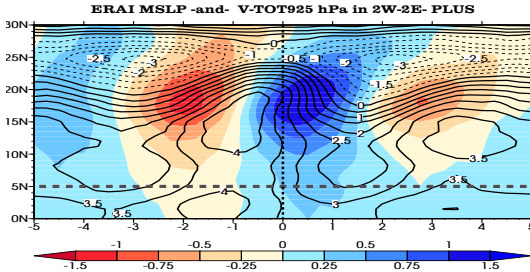
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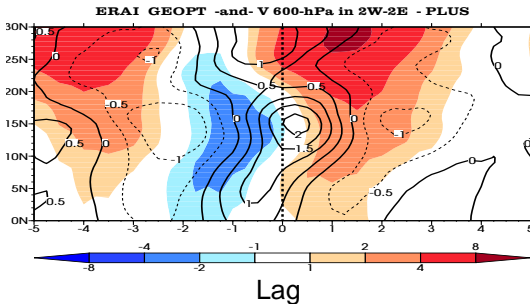
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# Latitude-Time Evolution of Mass Field

Lat



Pmer



600 hPa  
Geopt

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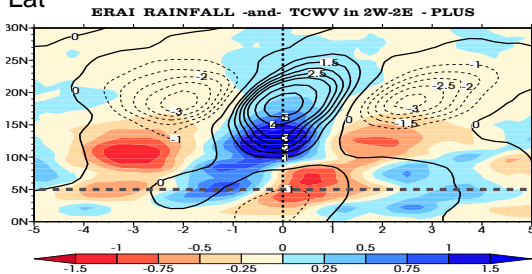
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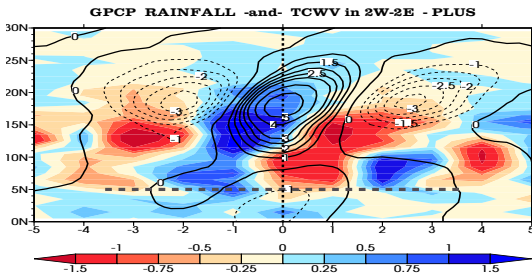


# Latitude-Time Evolution of Rainfall

Lat



ERA-I



GPCP

Lag

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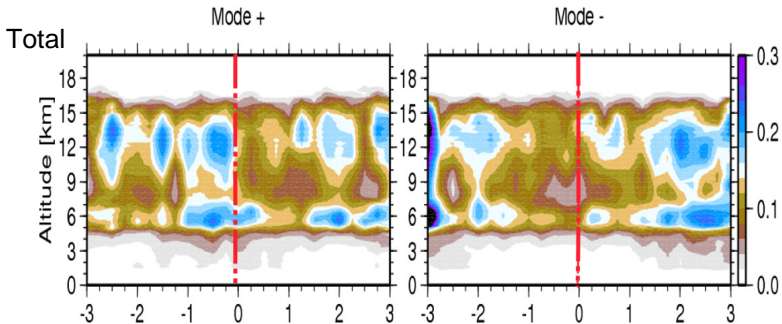
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## Cloud Fraction



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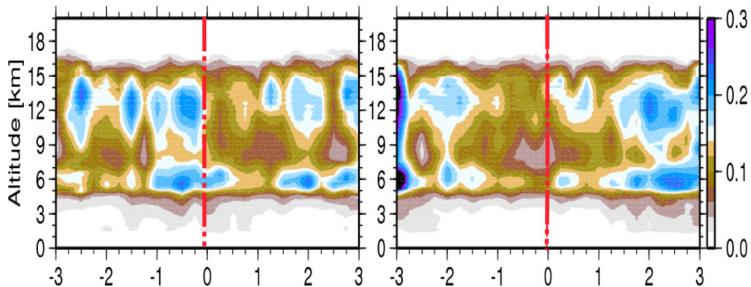
# From cloud observations

## Cloud Fraction

Total

Mode +

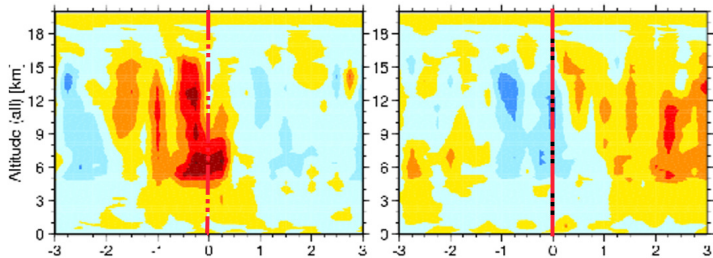
Mode -



Anom

Mode +

Mode -



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# Diabatic Processes: Equations and Notations

Following Yanai et al 1973:

$$Q_1 = \frac{d\theta}{dt} = Q_R + L(c - e) - \frac{\partial s'\omega'}{\partial p}$$

$$Q_2 = -L\frac{dq}{dt} = L(c - e) + L\frac{\partial q'\omega'}{\partial p}$$

Two ways to diagnose  $Q_1$  and  $Q_2$ :

- ▶ Using The Tendency terms due to Physics in ERAinterim Reanalysis
- ▶ Computing  $Q_1$  and  $Q_2$  as Residuals from the equations

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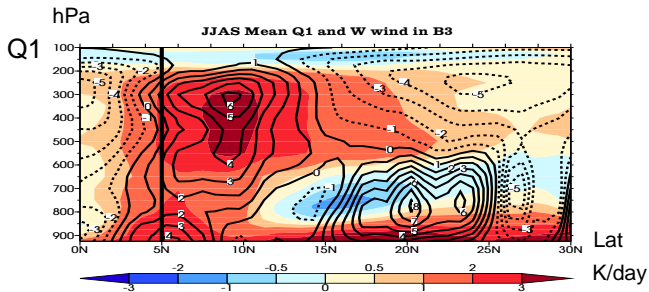
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# The JJAS mean Structure



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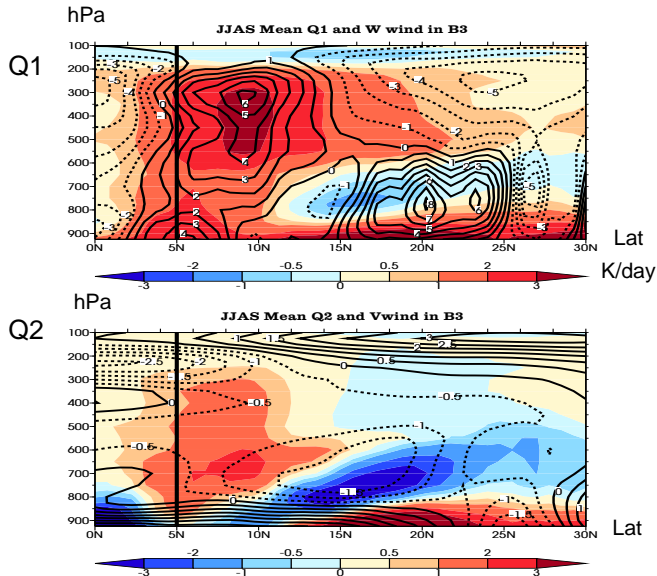
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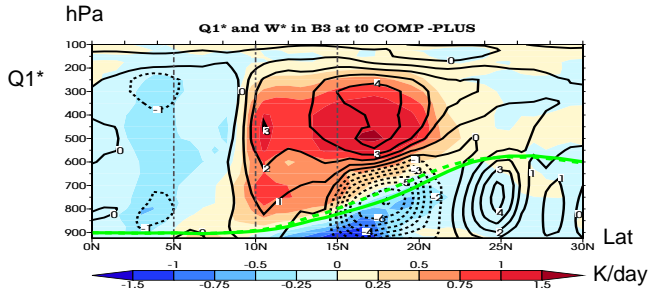
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# Composite of $Q_1^*$ and $Q_2^*$ at $t_0$ : "Wet Event"



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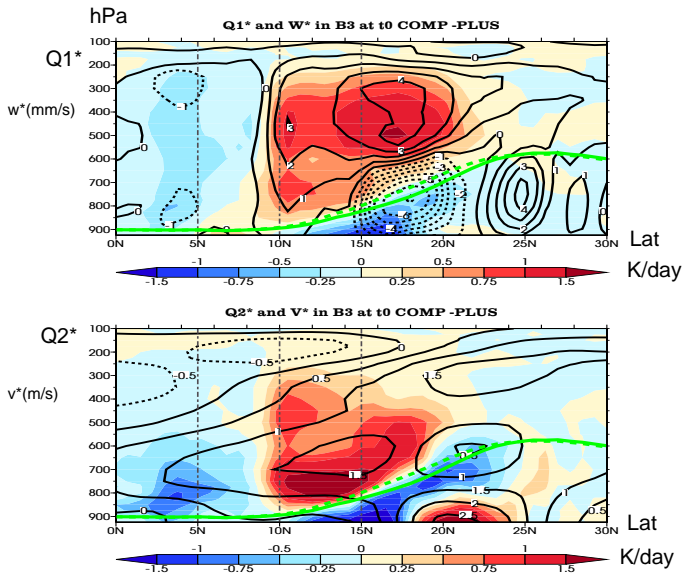
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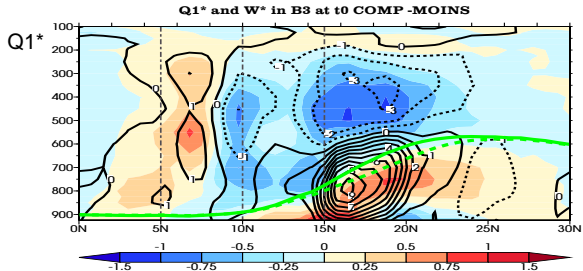
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# Composite of $Q_1^*$ and $Q_2^*$ at $t_0$ : "Dry Event"



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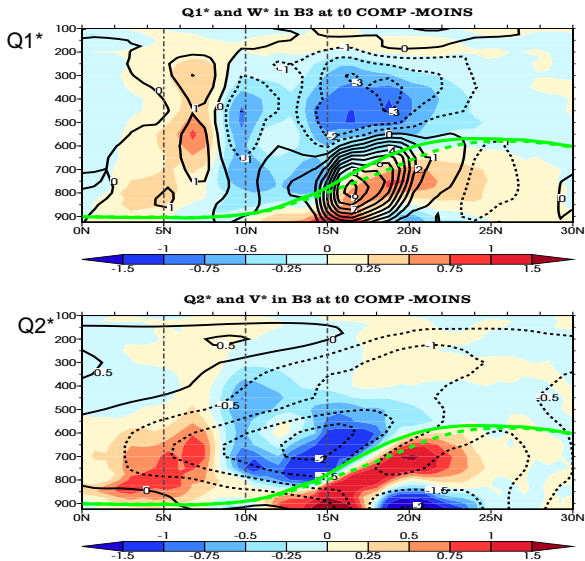
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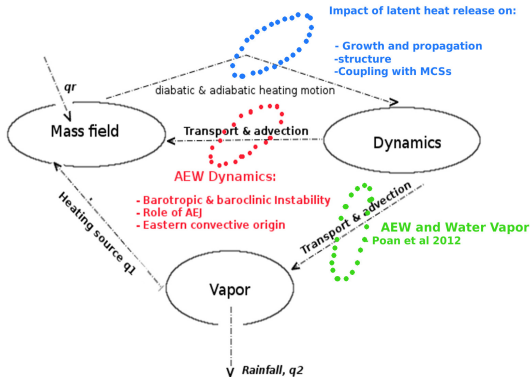
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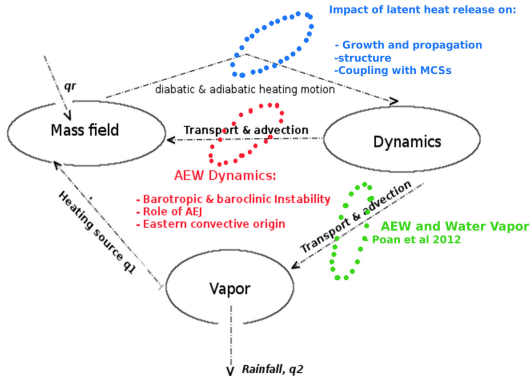
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## 1. Transport of Mass Field: Key Role of the Saharan Heat Low

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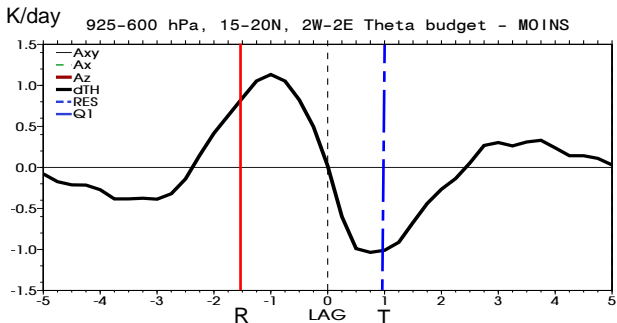
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1. Transport of Mass Field: Key Role of the Saharan Heat Low
2. Mass feedback on circulation: Importance of Latent Heat Release

# The SHL Construction: Temperature Budget



Budget in the SHL layer: 925-600 hPa in 2W-2E, 15-20N, During a DRY EVENT

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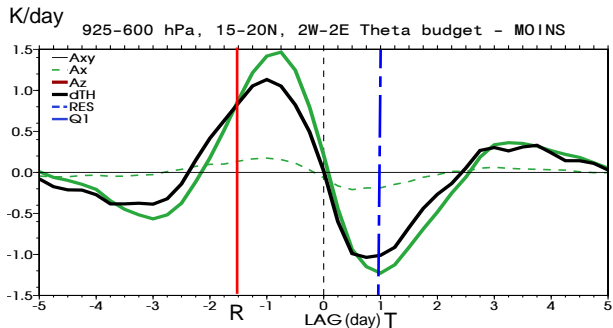
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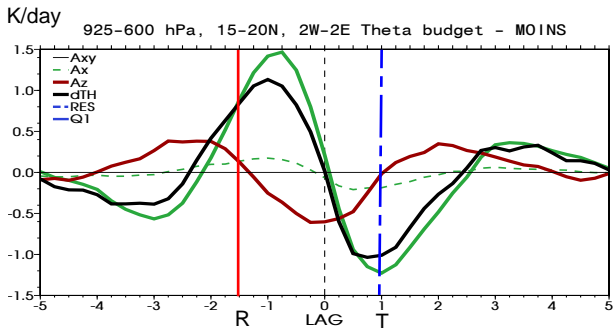
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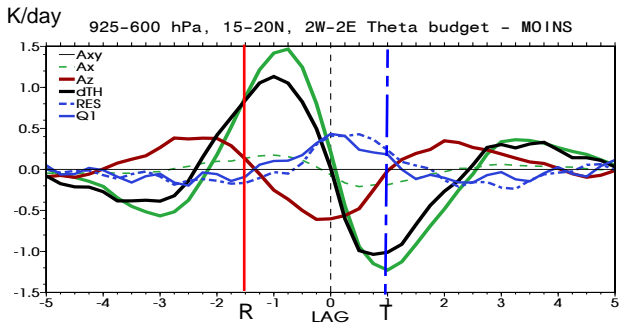
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## Mass Feedback: The Q vector Approach, Equations

The adiabatic Q vector is given by the equation (Kiladis et al 2006.)

$$Q_{adiab} = (Q_{x0}, Q_{y0}) = \frac{R_a}{p} \left( \frac{\partial v^*}{\partial x} \cdot \frac{\partial T_m}{\partial y}, \frac{\partial v^*}{\partial y} \cdot \frac{\partial T_m}{\partial y} \right)$$

The diabatic  $Q_{diab}$  vector is given by the equation:

$$Q_{diab} = (Q_{x1}, Q_{y1}) = \frac{R_a}{p} \left( \frac{\partial Q_{1ERA}}{\partial x}, \frac{\partial Q_{1ERA}}{\partial y} \right)$$

where  $Q_{1ERA}$  is the latent heat source provided in ERAI Reanalysis.

Following Hoskins et al. 1978, the Divergence of  $Q_{adiab}$  is proportional to the vertical velocity.

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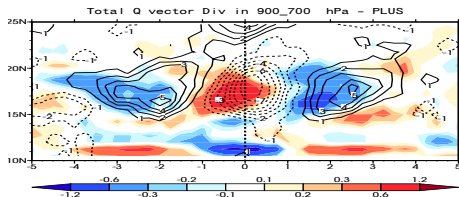
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Total Q vector  
Divergence



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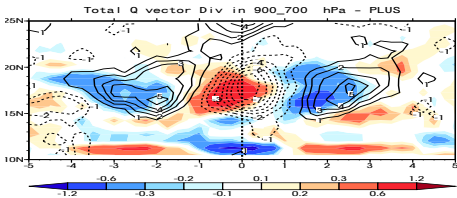
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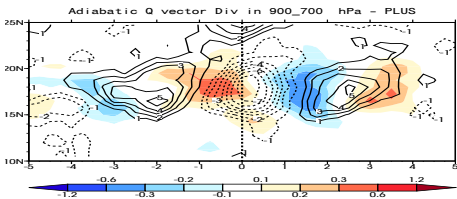
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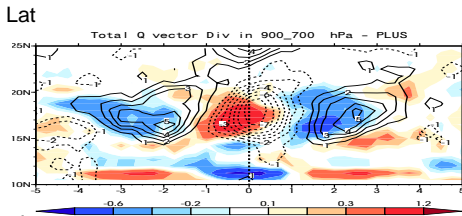
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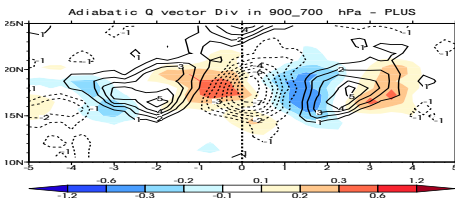
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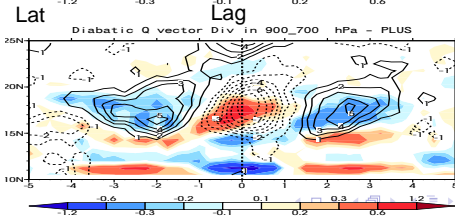
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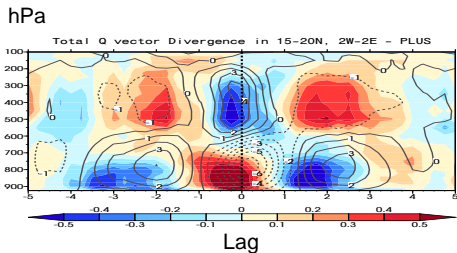
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# Height-Time Profiles: Box 15-20N, 2W-2E

Total Q vector  
Divergence



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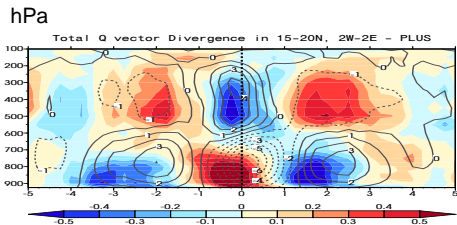
Q Vector Divergence  
Lat-Lag

**Q Vector Divergence:  
Lev-Lag**

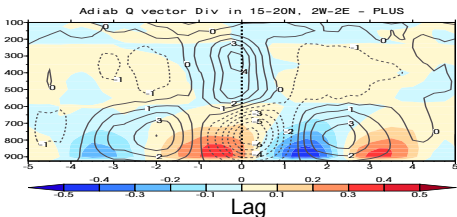
Conclusion

# Height-Time Profiles: Box 15-20N, 2W-2E

Total Q vector  
Divergence



Adiab Q vector  
Divergence



Contexte

AEW synoptic pattern

The Mass field organization during events  
Associated rainfall Activity

Diagnostic of Diabatic Processes

Formalism  
Climatology of  $Q_1$  and  $Q_2$   
Synoptic scale modulation of  $Q_1^*$  and  $Q_2^*$

The Mass and Dynamics Fields Loop

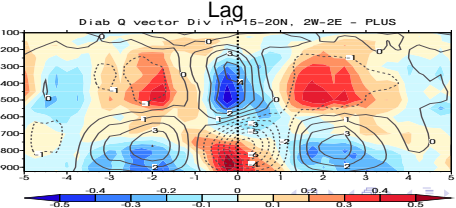
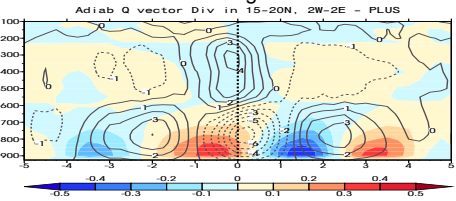
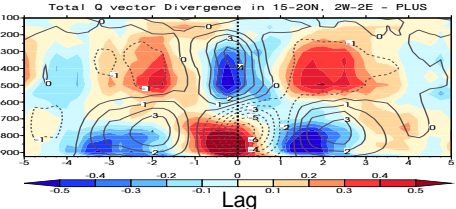
The SHL construction at synoptic scale  
Mass Feedback: The Q Vectors Approach  
Notations and Equations

Q Vector Divergence  
Lat-Lag  
Q Vector Divergence: Lev-Lag

Conclusion

# Height-Time Profiles: Box 15-20N, 2W-2E

hPa



Total Q vector Divergence

Adiab Q vector Divergence

Diab Q vector Divergence

- Contexte
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- The Mass and Dynamics Fields Loop
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- Lat-Lag
- Q Vector Divergence: Lev-Lag
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## Conclusions and Perspectives

- ▶ Many interactions to take into account: The 3-Dimensional Approach
- ▶ AEW is not only a zonal cell: There is a strong meridional activity through the SHL modulation – A Momentum Budget would help to quantify the "intrinsic" role of the HL
- ▶ We show here how mass and dynamics play together through different processes: Qualitative approach of Q Vectors
- ▶ A second step is to couple the Vapor field which is the tank of convection energy

Contexte

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