Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY
AT UC SAN DIEGO

A Proposed Method: Using the Height Tendency Equation to Study the Pre-Cold Frontal LLJ

Reuben Demirdjian, Joel Norris, Marty Ralph

6/27/2018

Study Goals

- Study the forcing mechanisms of the pre-cold frontal low-level jet (LLJ) within ARs
- New to this study is the analysis of the time varying forcing mechanisms of the LLJ
- A more complete understanding of the physical processes associated with the LLJ may lead to improved AR predictability

Methods

- A diagnostic analysis on an idealized WRF simulation of a developing AR and baroclinic wave using the height tendency equation to quantify wind forcing terms

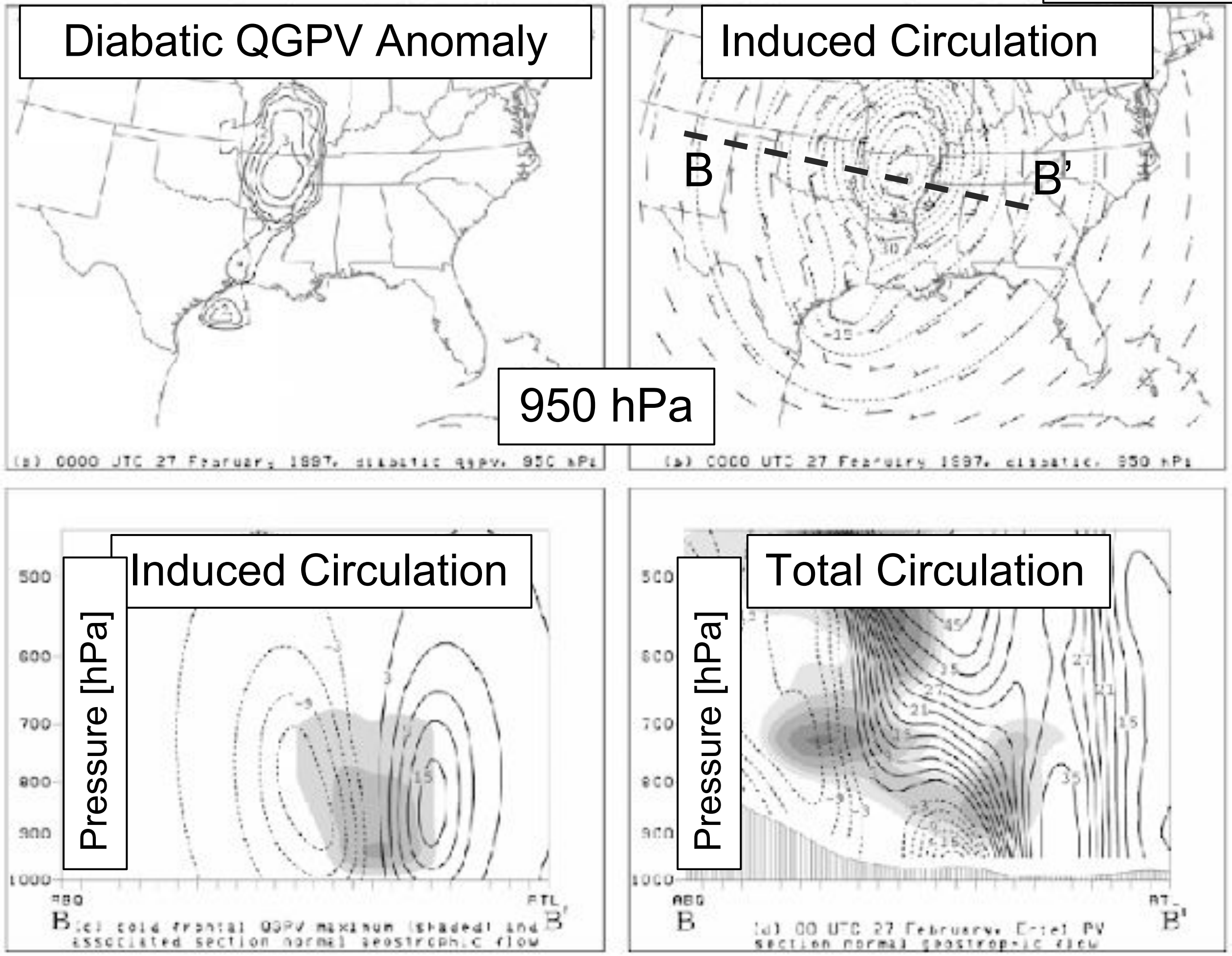
Cold-Frontal Potential Vorticity Maxima, the Low-Level Jet, and Moisture Transport in Extratropical Cyclones

GARY M. LACKMANN

Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina

(Manuscript received 5 January 2001, in final form 23 June 2001)

(Lackmann 2002)



__Methods__
Utilize the non-conservation property of PV from diabatics to calculate induced circulation from latent heating

__Some Conclusions__
LLJ situated on eastern side of low-level PV maximum

QGPV inversion indicates that the PV max contributed between 15% to 40% of the strength of the LLJ

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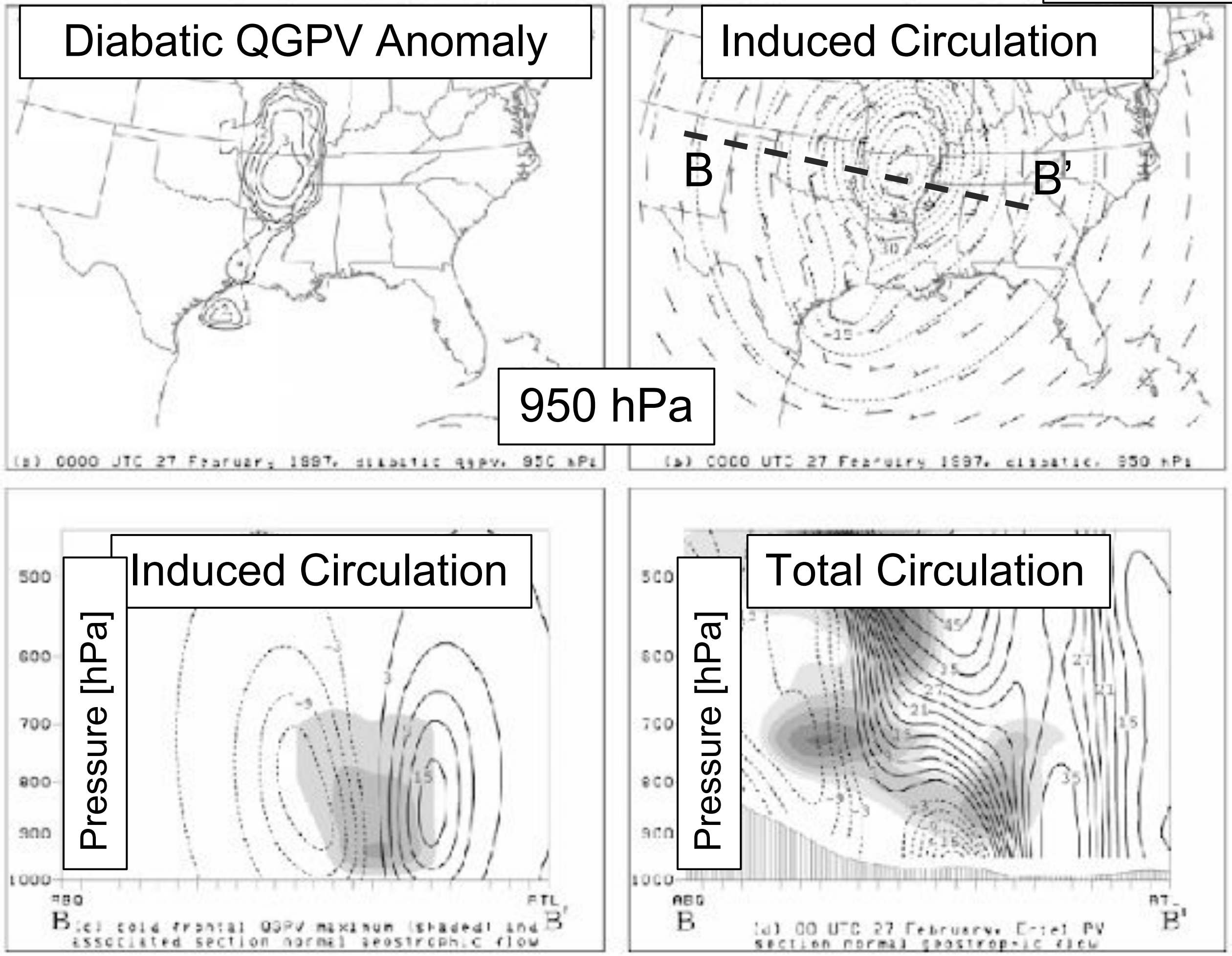


Connection to The Present Study

We would like to extend this work by

i. Extending to a full framework from the QG one

ii. Looking at the time varying contribution to the wind speed

iii. Analyzing the wind speed contributions from more terms

Simulation Details

- WRF idealized simulation of a moist baroclinic wave in a periodic channel
- Resolution: dx=dy=25km on cartesian grid with 65 σ-levels
- 10 day run with 30 min output
- Parameterizations include convection, a PBL, radiative forcings, and microphysics schemes

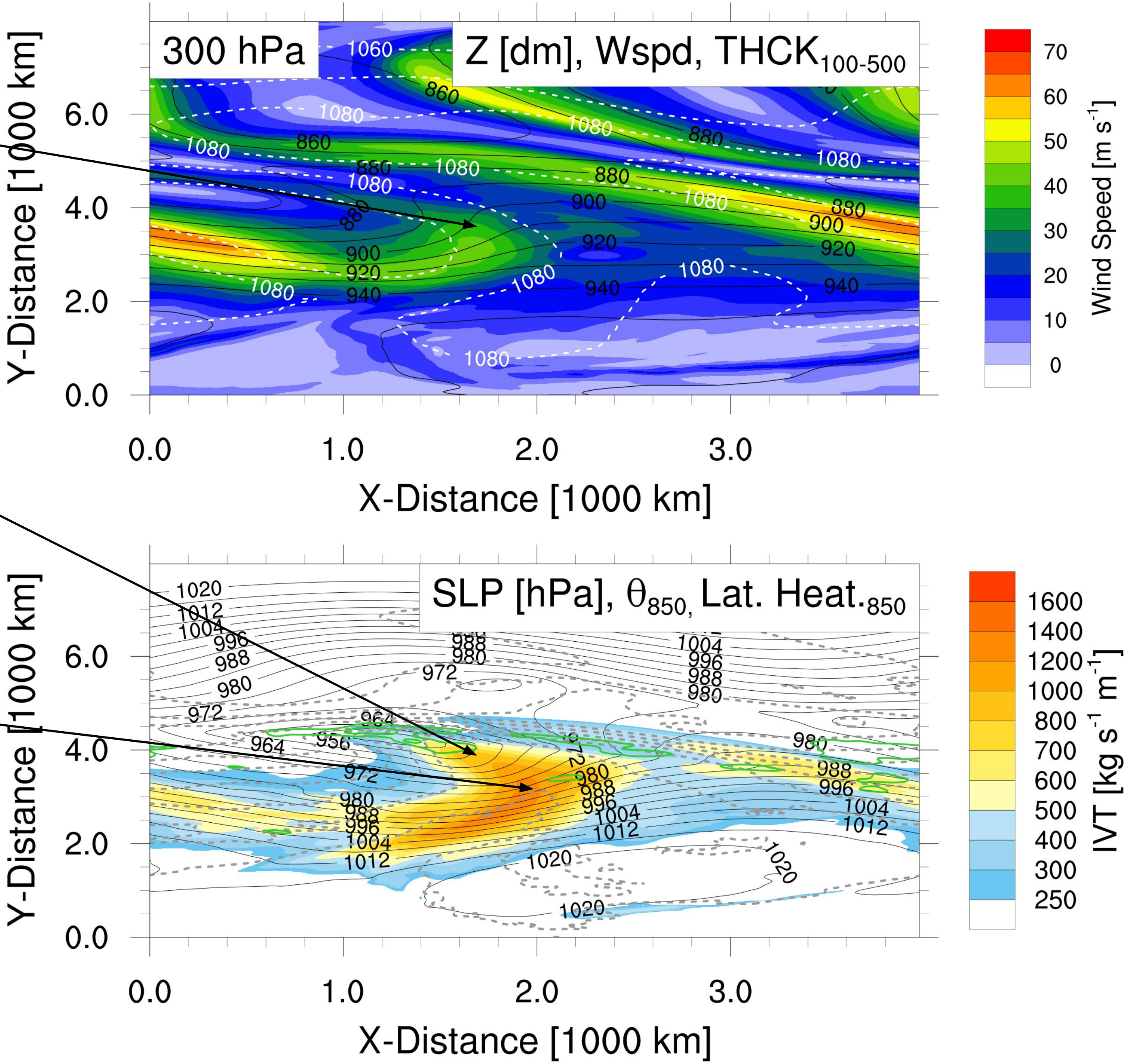
Simulation: Synoptic Scale

Simulation Time 237 hr

Instability Begins

Modest IVT

Well Developed AR



SLP
Θ
Lat. Heating

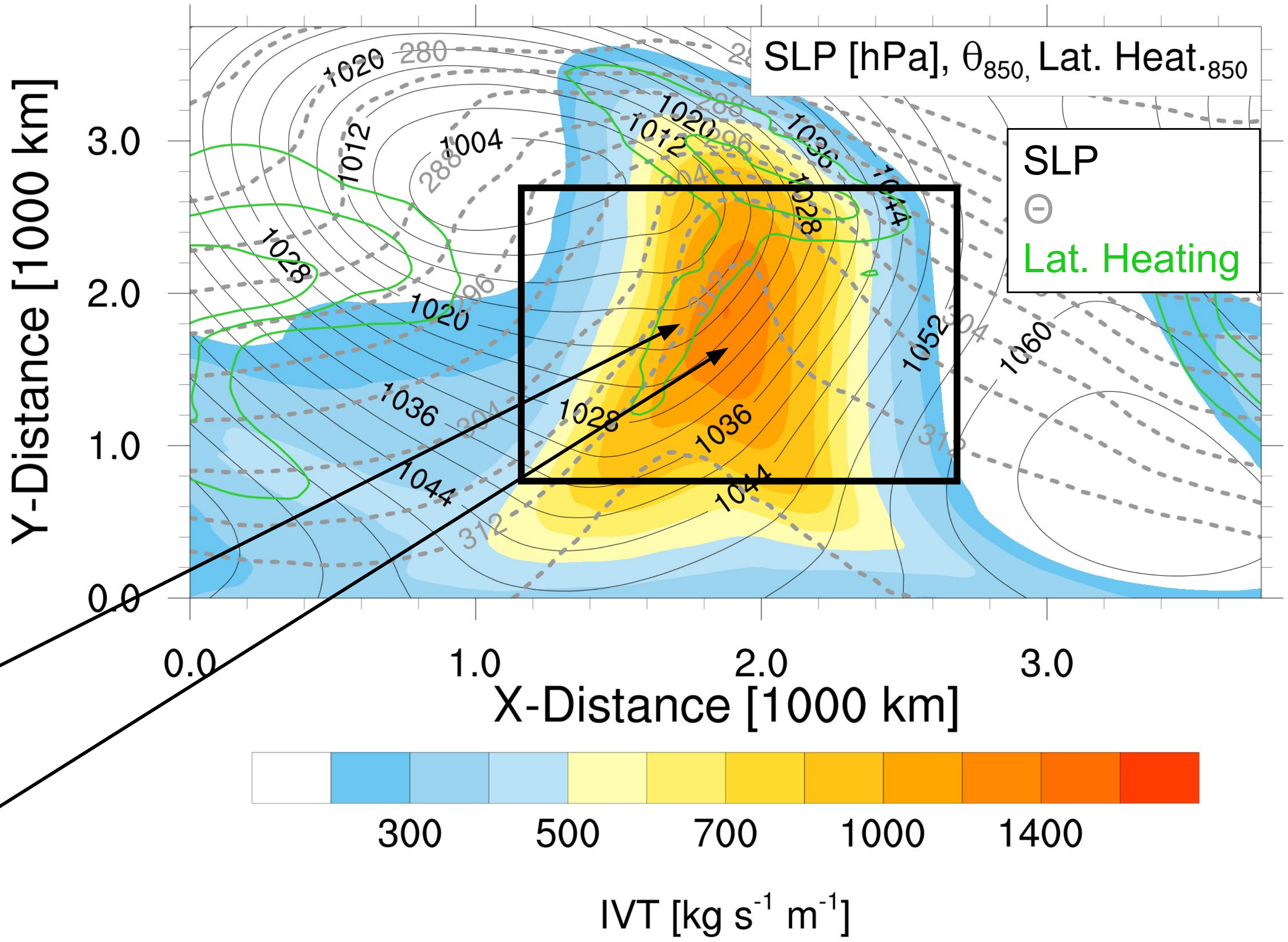
CW3E

Simulation: Mesoscale

Plan View Composite

Methods

- 60 hour composite during strong AR conditions from 120 through 180 hours
- Composite centered on IVT max



Features

- Diabatic heating strongest along the cold front and occlusion zones
- IVT max located ahead of the diabatic heating

Simulation: Mesoscale

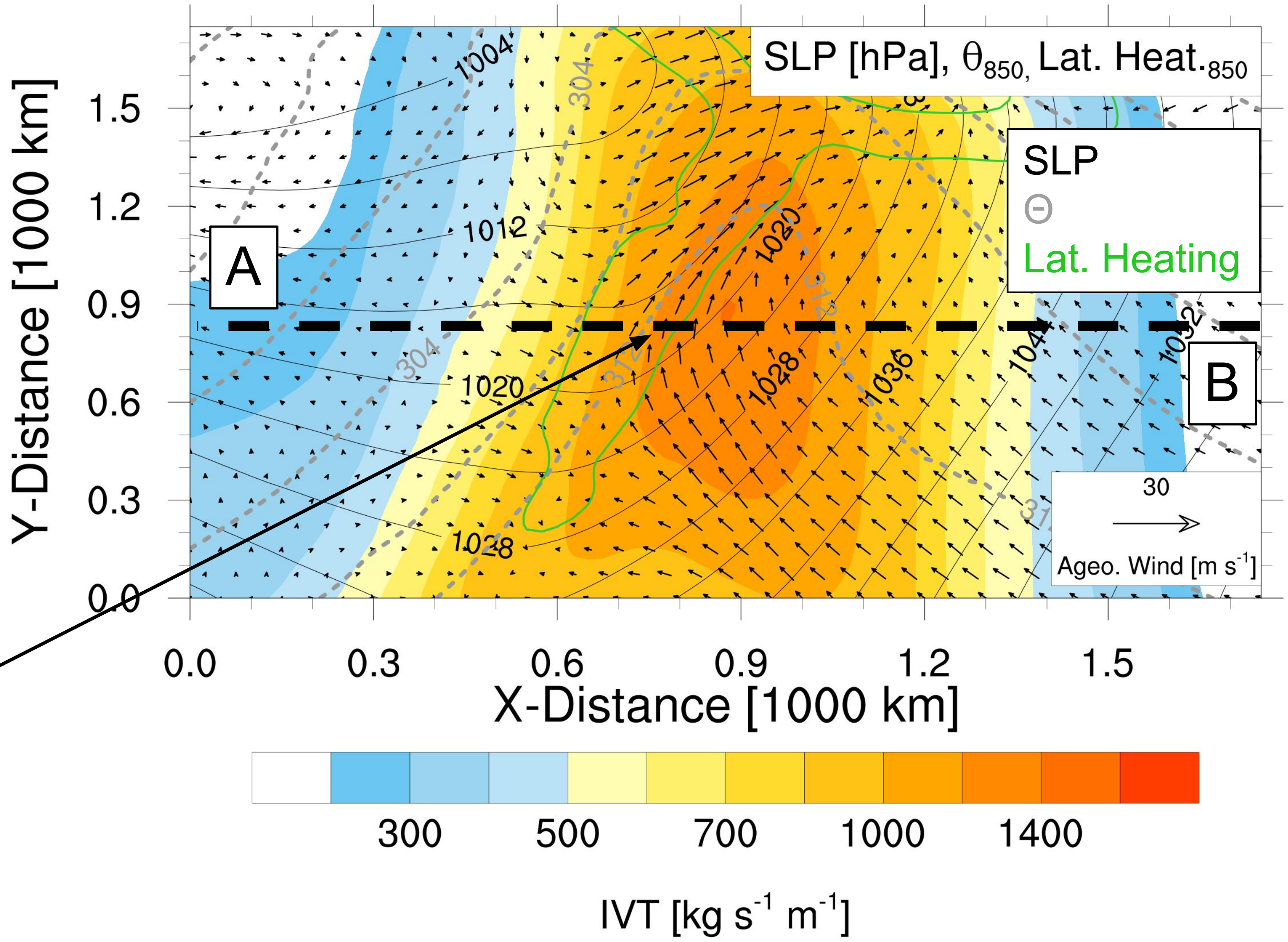
Plan View Composite

Methods

- 60 hour composite during strong AR conditions from 120 through 180 hours
- Composite centered on IVT max

Features

- Ageostrophic circulation in the along cold-front direction within the region of strongest IVT
- The along-front unbalanced flow indicates that some interesting dynamics may be at play



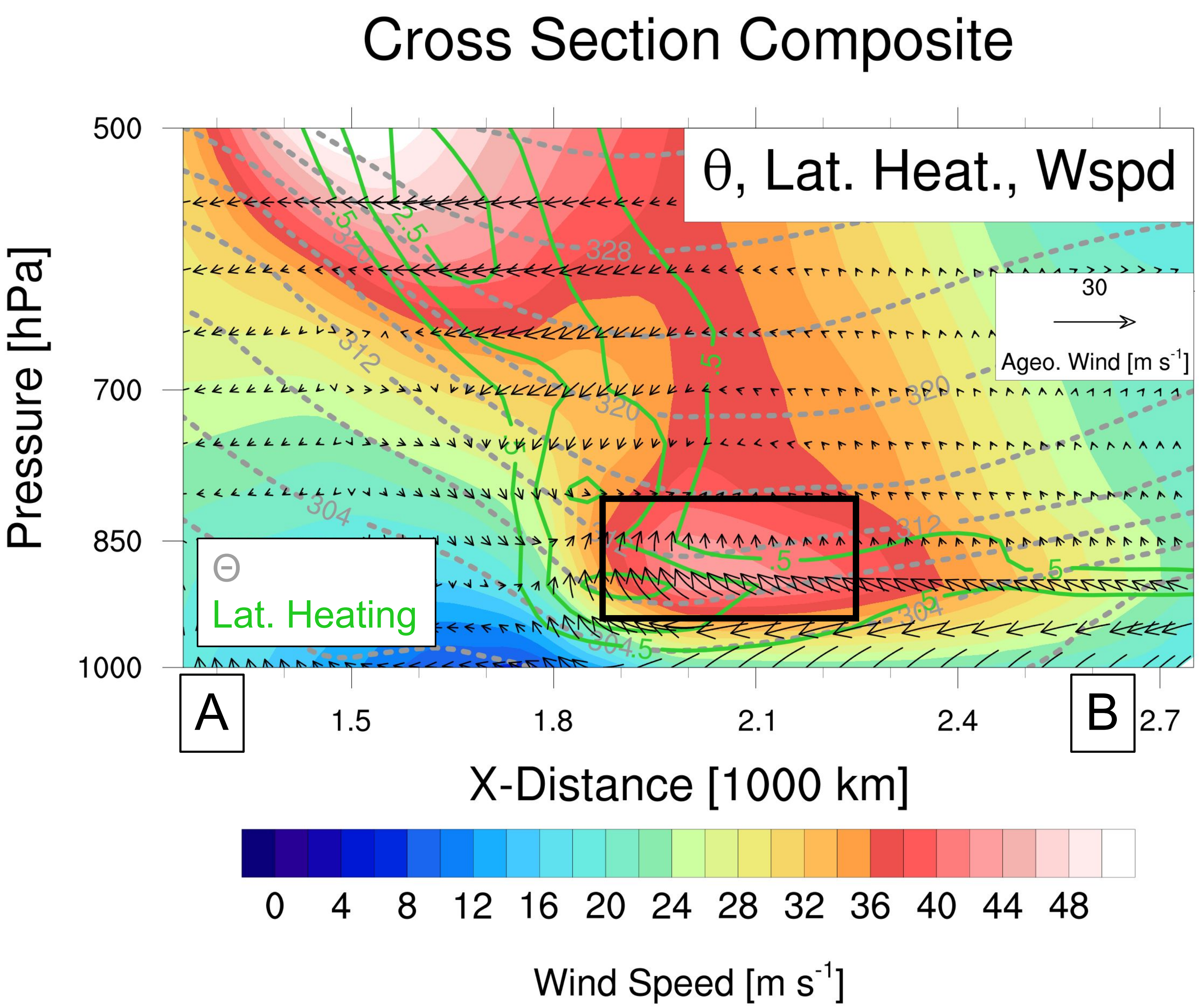
Simulation: Mesoscale

Methods

- 60 hour composite during strong AR conditions from 120 through 180 hours
- Composite centered on IVT max

Features

- Ageostrophic wind in the along cold frontal axis is located at the LLJ max
- Ageostrophic wind adds about 5 – 10 m s^{-1} in the along frontal direction at the LLJ



CW3E

Simulation: Mesoscale

Cross Section Composite

Methods

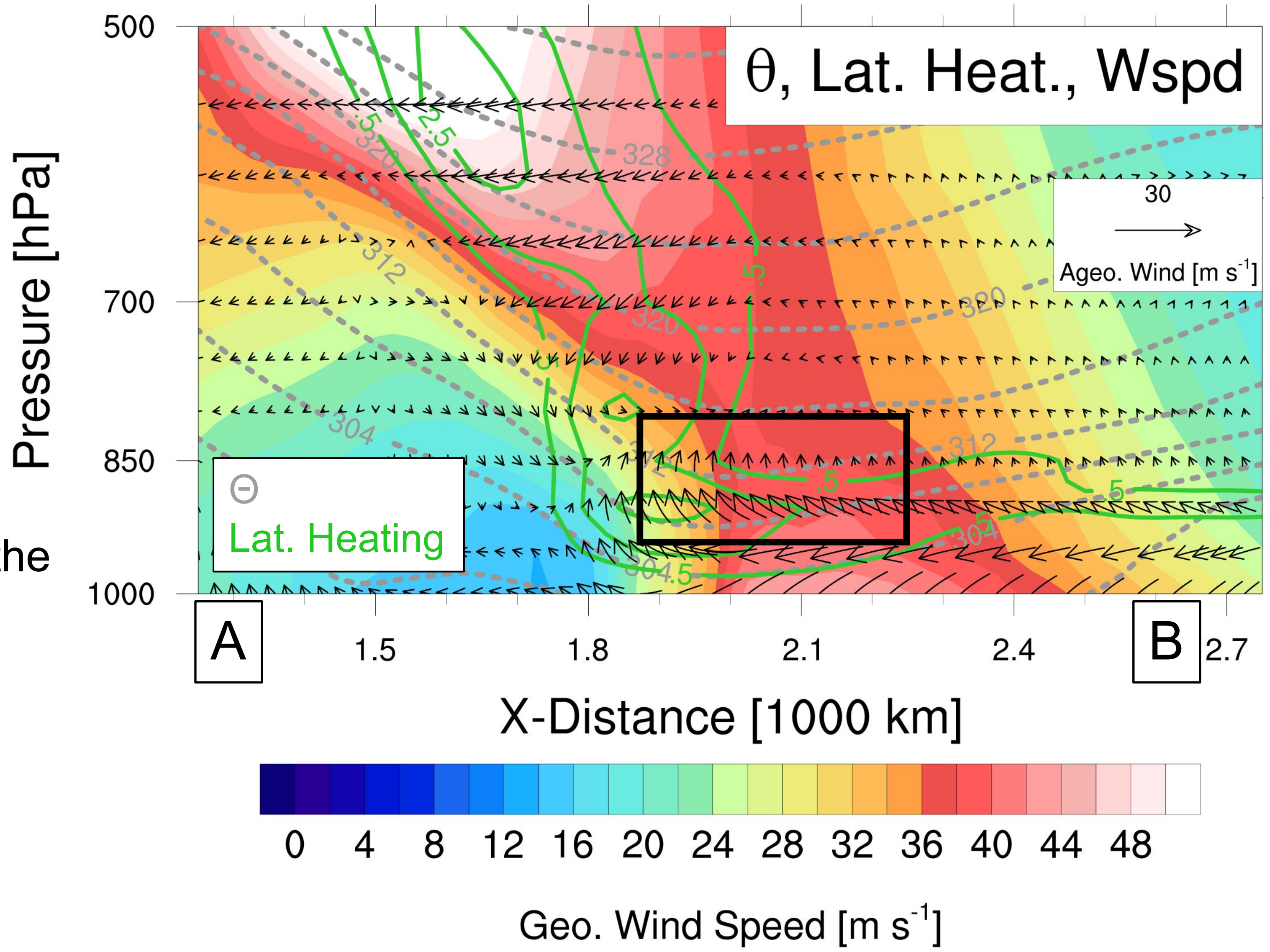
- 60 hour composite during strong AR conditions from 120 through 180 hours
- Composite centered on IVT max

Features

- Geostrophic wind has a max only at the surface
- The ageo. wind modifies the LLJ by:

i) Reducing the surface geostrophic maxima though friction,

ii) Creating an elevated max through other processes



CW3E

The full height tendency eq. is given by,

LHS

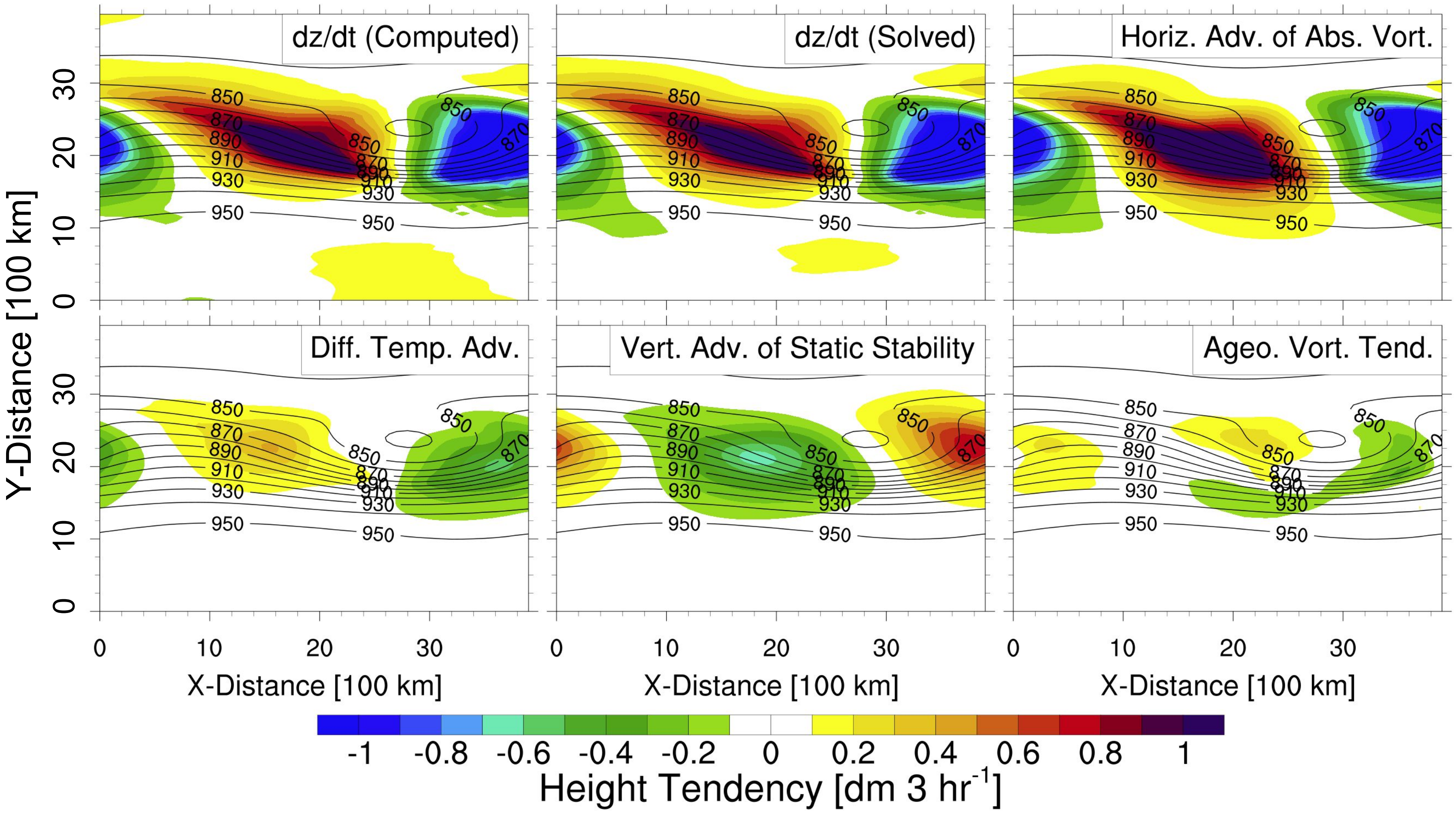
$$\underbrace{\left[\nabla^2 + \frac{(\zeta+f)f}{\sigma}\frac{\partial^2}{\partial p^2}\right]\frac{\partial\phi}{\partial t}}_{\text{(A)}} - \underbrace{\frac{1}{f}\nabla f\cdot\nabla\frac{\partial\phi}{\partial t}}_{\text{(A')}}$$

Tsou et al. (1987)

Methods

- PDE Solver: successive over-relaxation method
- Periodic domain along the x-axis
- dx=dy=100 km dry simulation

Height Tendency Solution F+139 hr, 300 hPa



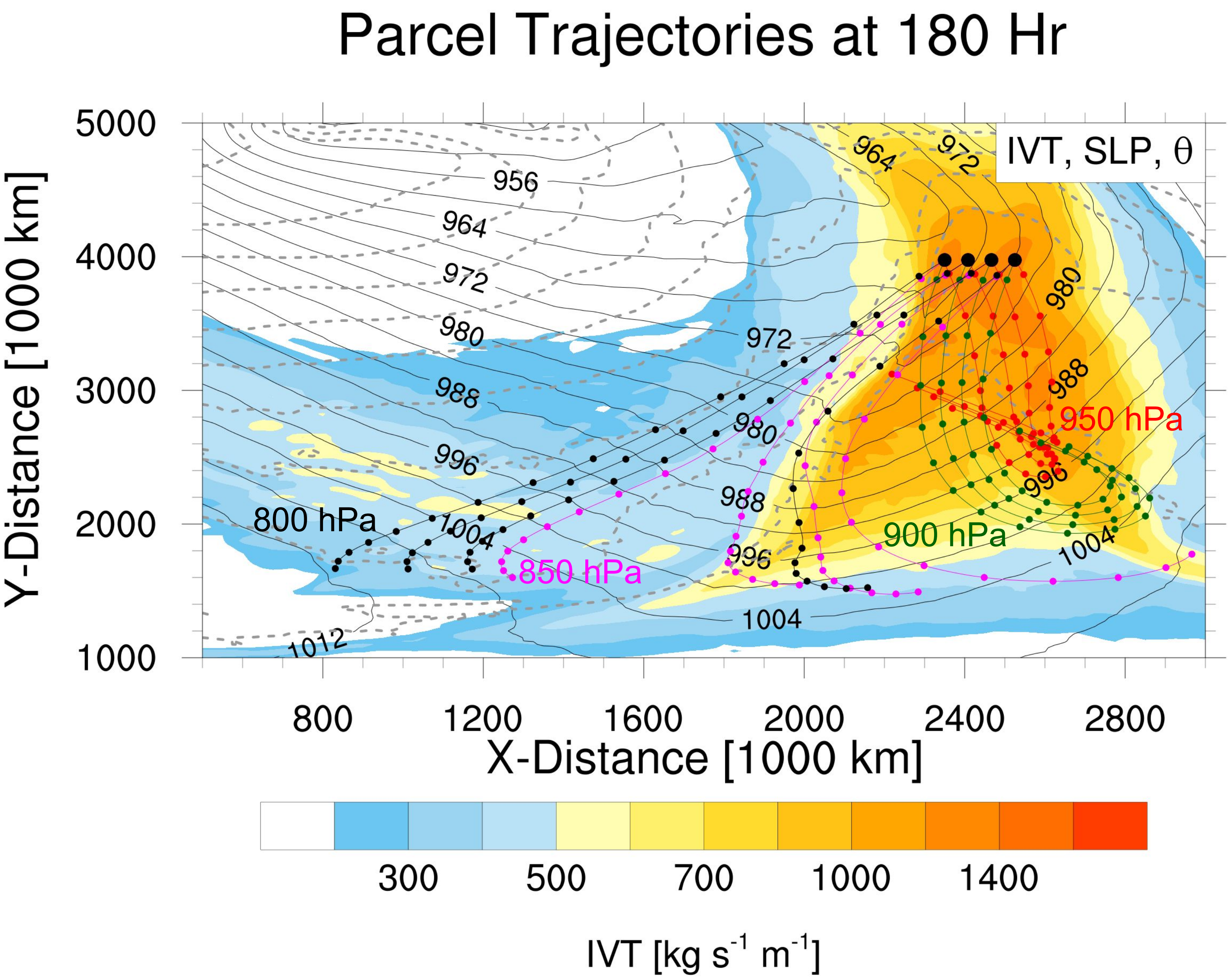
Goal and Methods

- Quantify each component of the velocity using the height tendency method

- At each parcel location, plot vectors for the various contributions to the velocity from each of the height tendency forcing terms

$$\vec{v}^{i}{}_{ag} = -f^{-2}\nabla\frac{\partial \phi^{i}}{\partial t}$$

Where i = each forcing term



- The height tendency equation may be used to study the interplay of forcing terms as an air parcel moves within the LLJ and to quantify their contribution to the wind speed in time
- Some more work must be done to flush out current bugs in the current iteration of the height tendency solver
- Once the application of the height tendency solver package is successful for the idealized simulation, then we will apply it to real AR cases

Thank you for Listening!

A very special thank you to the following people for helpful discussions and assistance on this project: Caroline Papadopoulos, Leah Campbell, Meredith Fish, Rachel Weiss, Chad Hecht, Brian Kawzenuk, Jay Cordeira, Rich Rotunno, Gary Lackmann, Lance Bossart, Daniel Keyser, and Jim Steenbergh

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Tsou, C., P.J. Smith, and P.M. Pauley, 1987: A Comparison of Adiabatic and Diabatic Forcing in an Intense Extratropical Cyclone System. *Mon. Wea. Rev.*, **115**, 763–786,https://doi.org/10.1175/1520-0493(1987)115<0763:ACOAAD>2.0.CO;2