The Dynamics of Atmospheric Bores

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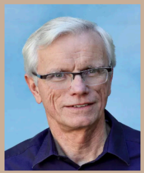


Introduction

Atmospheric bores are disturbances whose passage is accompanied by a pressure rise and a semi-permanent upward displacement of the isentropic surfaces.

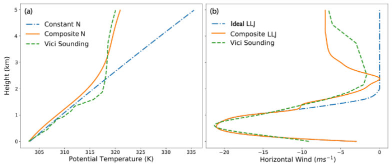
- A series of waves often trails behind the bore's leading edge
- In contrast to density currents, the near-surface temperature remains relatively unchanged, or even warms, after the bore passes.
- In the US Great Plains nocturnal bores can propagate hundreds of kilometers and trigger new convection through low-level lifting.

Bore dynanmics have modeled using

- Shallow-water theory
- Linear trapped internal gravity waves

Methodology

We test these theories using two-dimensional numerical simulations and a prototypical bore sounding composited from observations collected on 0900 UTC 4 June 2002 during the IHOP experiment.



Enivronmental θ(z), U(z) profiles. LLJ opposes the bore's motion: audio caption.

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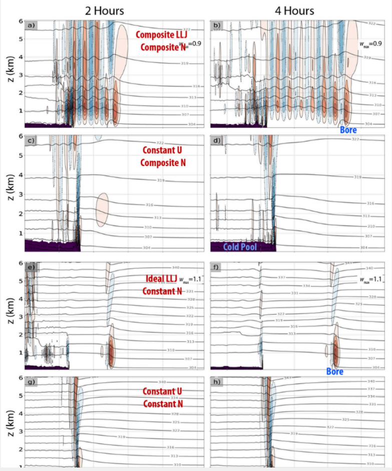
Sensitivity to N(z) and U(z)

Four Environments

Disturbances are triggered by an expanding cold pool (black densely packed isentropes at lower left in each plot).

Bore develops well ahead of the cold pool in cases with low-level jet, even when *N(z)* is constant

No bores develop in the cases where *U(z)* is a constant 10 m/s, even in the case with a layer of high *N* at the surface.



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Inherently Finite-Amplitude

Bore is not a trapped internal wave

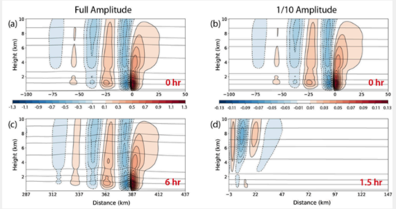
There are no eigenvalue-eigenfunction solutions to the vertical structure equation

$$\hat{w}_{zz} + \left(\frac{N^2}{(U-c)^2} - \frac{U_{zz}}{U-c} - k^2 \right) \hat{w} = 0$$

corresponding to linear trapped waves moving at a speed *c* even roughly similar to the speed of the bore.

Testing sensitivity to amplitude

- The isolated full-amplitude bore propagates with almost constant form for 6 hrs.
- The reduced-amplitude isolated bore dissipates within 1.5 hrs



Evolution of full- and 1/10-amplitude isolated bores: audio caption

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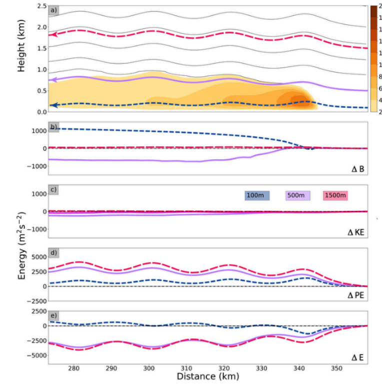
Air-mass transformation

Bore-relative Bernoulli function analysis

$$B = c_p T + gz + \frac{1}{2}\left[(u-c)^2 + w^2\right]$$

Perturbations satisfy

$$\Delta B = \Delta E + \Delta PE + \Delta KE$$



Changes in ΔB and its components along bore-relative streamlines: audio caption

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