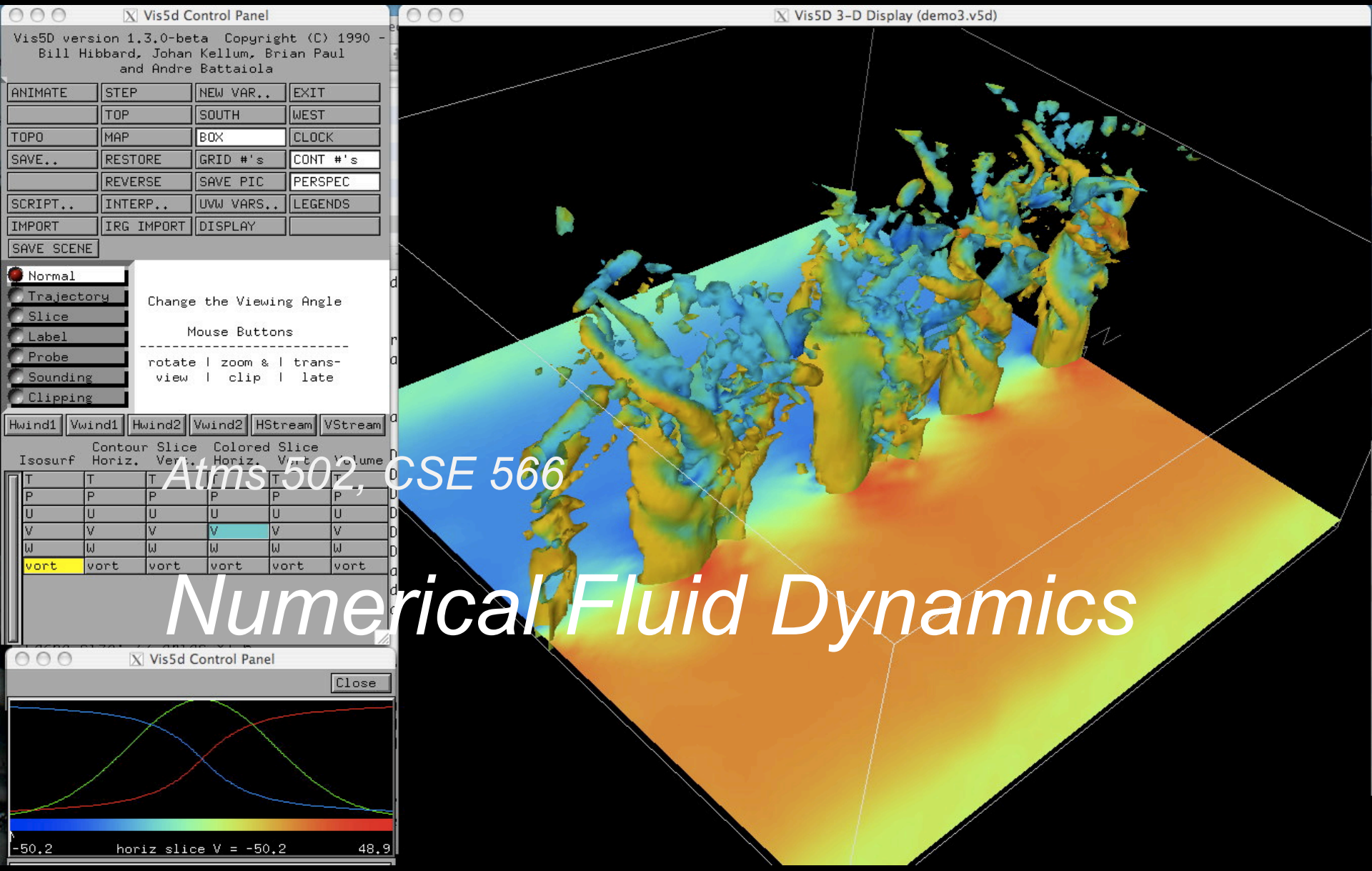


Atms 502, CSE 566

Numerical Fluid Dynamics

Tue., Apr. 23, 2019

ATMS 502
CSE 566

Tuesday,
23 April 2019

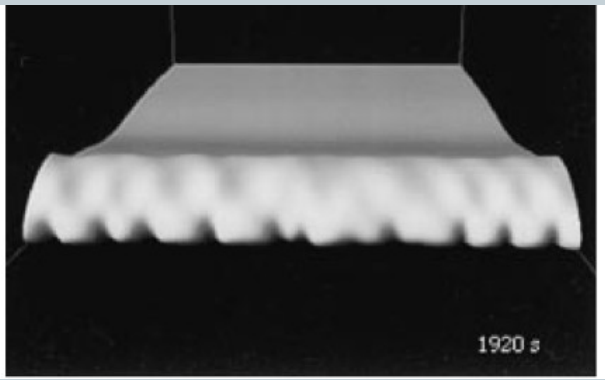
Class #25

Plan for Today

- 1) Review from last class
  - Lee and Wilhelmson paper
- 2) Program 6
  - Web pages
  - Saving data for visualization
  - Visualization-1
- 3) Fluid flow equations

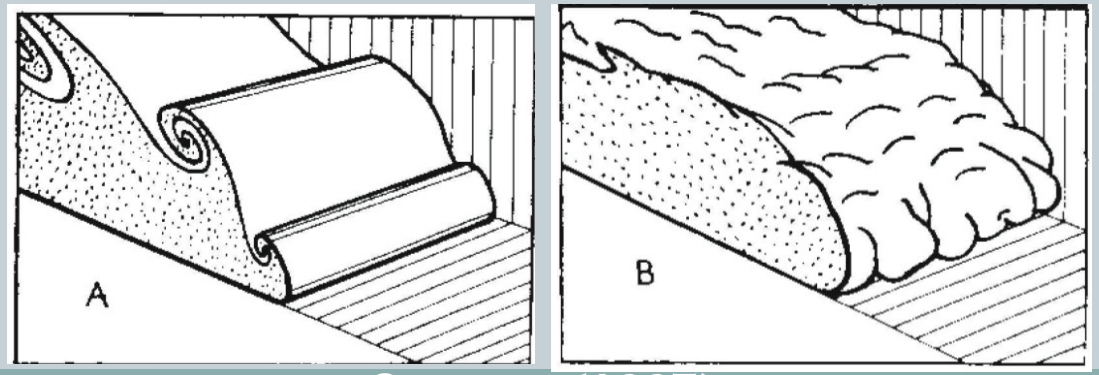
Lee and Wilhelmson (1997)

- **Evolution**, step 1:
  - *Random temp. perturbations + semi-slip surface produces **lobe and cleft** instability along leading edge of density current*



Lee/Wilhelmson Fig. 5: density current leading edge: lobe and cleft instability

Program 6: uses $\Delta U'_{T=0}$



KELVIN-HELMHOLTZ

LOBE & CLEFT

SIMPSON (1997)

Lee and Wilhelmson (1997)

- **Evolution of leading edge vorticity**

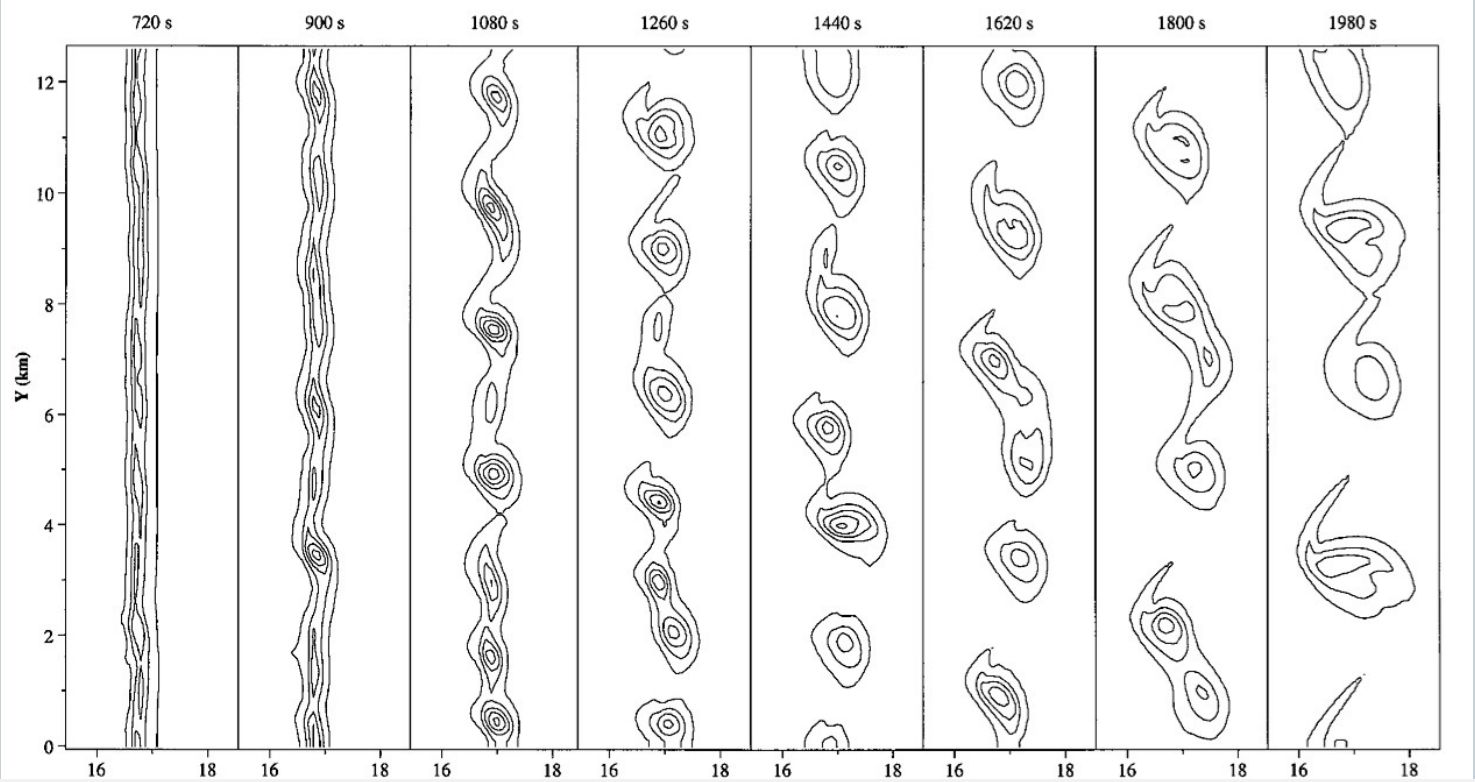
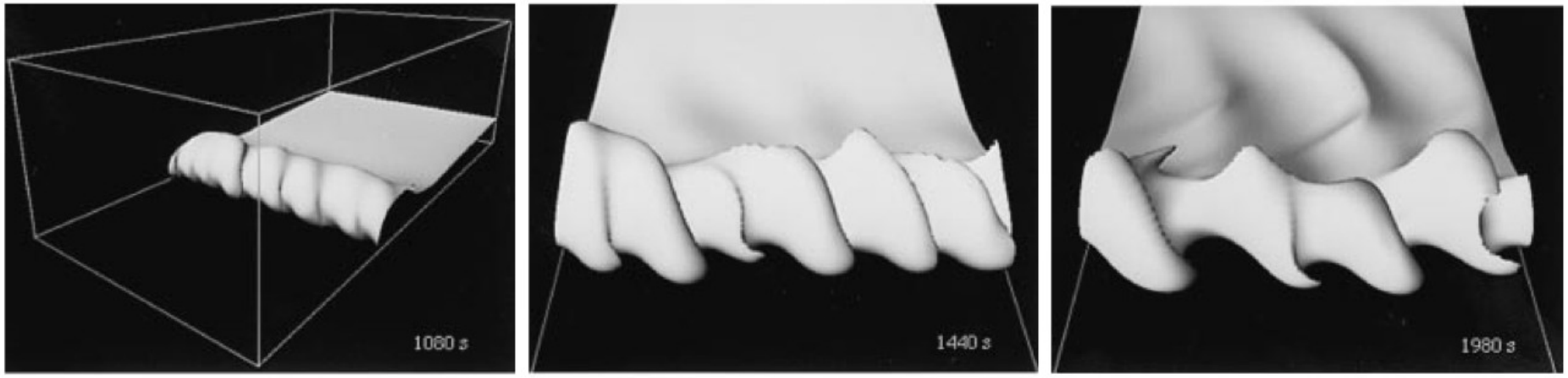


Figure 9: x-y plot of vertical vorticity at leading edge of the density current

Lee and Wilhelmson (1997)

- **Evolution:**
  - *Circulations with HSI evolve:*
    - *vortex sheet roll up*
    - *subharmonic interaction*
    - *consolidation, dissipation*

Figure 4: Evolution of leading edge of density current.



Transition from wavenumber 8, to 6, to 4

Program 6

6

WEB PAGES
VISUALIZATION-1
BATCH SYSTEM

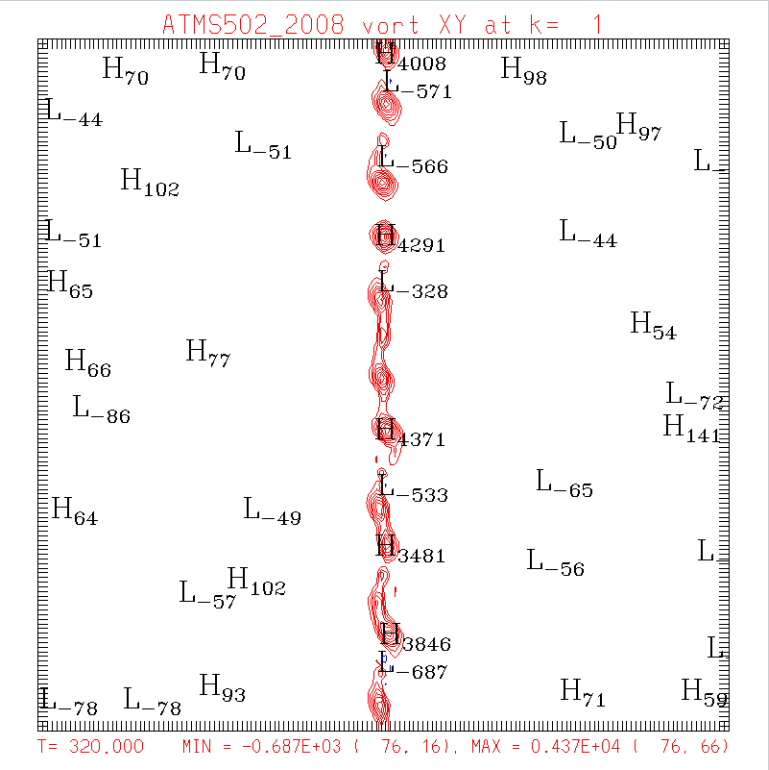
Computer problem #6

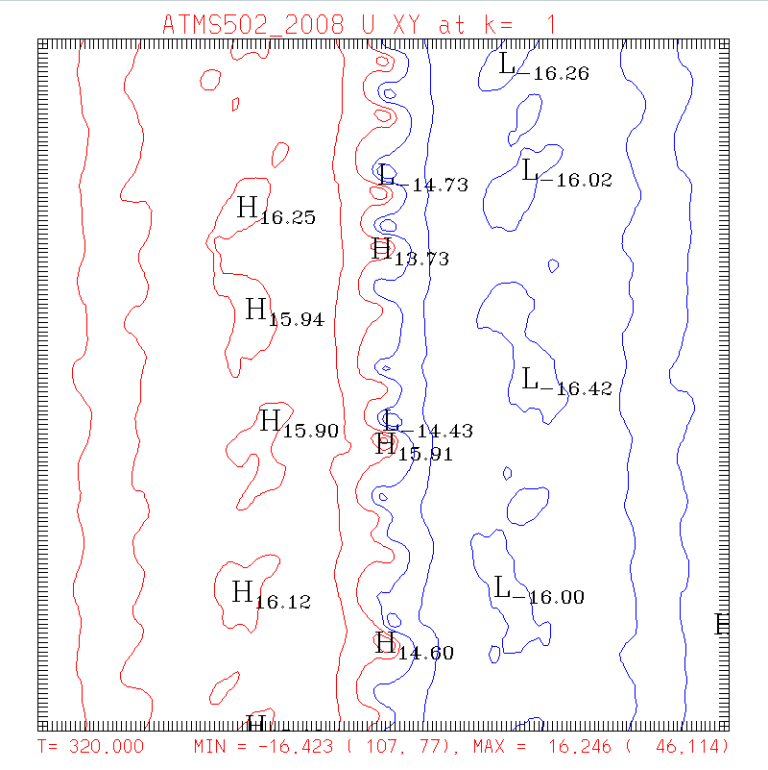
- **Problem: colliding density currents**
  - In 3-D
  - With shearing instability
  - With vortex interaction
  - Preferred wavelengths emerge during integration

- **Colliding density currents …**
  - With opposite ***V***, and random ***U*** perturbations at T=0
  - Evolving vorticity structures for each, *prior* to collision

Computer problem #6

- Example of 50m solution, T=320s





Program #6: plotting

- Unlike earlier programs: do not call plot routines directly. Instead call *putfield* routine to store raw simulation output to disk as a binary file.
  - Details will be on program #6 page online.
- Then run program *plotp6* to create plots of desired fields. This allows you to:
  - Generate plots with a script, if desired
  - Decide later what plots you want - there are many possibilities with 3-D data
  - Handle large data sets quickly. My code created >4 GB of data for the test case shown today.

Program #6: batch system

- Run parallel jobs on Stampede2 batch system
- Requires a batch script ("deck") that contains
  - Commands to run your program
  - Directives requesting compute resources --
    - ✓ Number of processors
    - ✓ Batch queue ("development" or "normal"); development = 1 job, 2 hours, 256 cores
- Examples on Stampede2 and program #6 page

Analysis and visualization: 1

MODEL OUTPUT

CONTOUR TOOLS

WEB PAGE GENERATION

NETCDF OUTPUT

Analysis and visualization 1: *putfield()*

- **Saving data during your simulation**
  - *putfield()*
    - Fortran and C routines in ~502/Pgm6 on Maverick
    - demo-write(.c, .f90) demonstration code, calls putfield
    - putfield(.c, .f90) saves data to disk
    - makefile for compiling
    - RunHistory.dat default output file name *(unformatted binary)*
- **Calls from C**
  - prototype statement
  - putfield("T", dt*(float)step, nx, ny, nz, array_name);
- **Calls from Fortran**
  - call putfield('T', dt*real(step), array_name, nx, ny, nz)

Analysis and visualization: *plot3d*

- **plot3d program**
  - Purpose: save all the data - to be plotted as needed, later
  - Script and executable at: ~tg457444/502/Tools
    - **Requires**: X-windows (Win: Xming/VcXsrv; Mac: Xquartz)
    - Written in: Fortran-90 & C
- **Starting**
  - plot3d (no arguments) *Reads: RunHistory.dat*
  - plot3d datafile *Reads: datafile*
- **Questions**
  - Should this program call IDT directly? (hit return: default=yes)
  - Enter title for all plots? (hit return: no title is required)
  - Enter dx (meters): (For vorticity…hit return: default=500 m)

Analysis and visualization: *plot3d (2)*

- **plot3d - starting up**
  - Reads entire file, lists fields and times.
- **Normal use**
  - Enter name of a field, e.g. *T* *[or **?** for help]*
  - Enter the type of plot: *xy xz yz 3d*
  - Enter the slice value:
    - for X-Y plots, enter the 3rd index "k"; default=1 [ground]
    - for X-Z plots, enter the 3rd index "j", default = center
    - for Y-Z plots, enter the 3rd index "i", default = center
    - for 3-D plots, enter: (1) eye position, (2) isosurface value

  and then contour interval
- **When you plot**
  - idt window appears; click > to plot • close window when done
  - you can enter a file name [other than gmeta] to "save" plots.

Analysis and visualization: *plot3d (3)*

- **plot3d - other options**
  - www - generate web pages (xy,xz,yz,3d)
    - a list of all fields are shown
    - you pick slices (xy, xz, yz) or isosurface (3d) or hit return for defaults
    - you pick contour intervals for all (or use *auto*)
  - set max (list max value, along with making plots)
  - set HL (add or remove H/L labels)
  - set times (specify time range)
  - set color (image cell fill)
  - set window (plot subregion)
  - netcdf (create netcdf file)
    - you are prompted for a time range *and* interval; enter 3 numbers

Computer problem #6

- Initial condition, 50m: potential temperature