Installation and initial testing of the Weather Research and Forecasting (WRF) Model on the California State University (CSU), Chico Department of Physics server

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Department of Physics Server:

- U1 Mac XServe
- 64-bit Darwin Mac 10 OS
- Dual quad-core processor
- 24 GB of RAM

WRF Model Details:

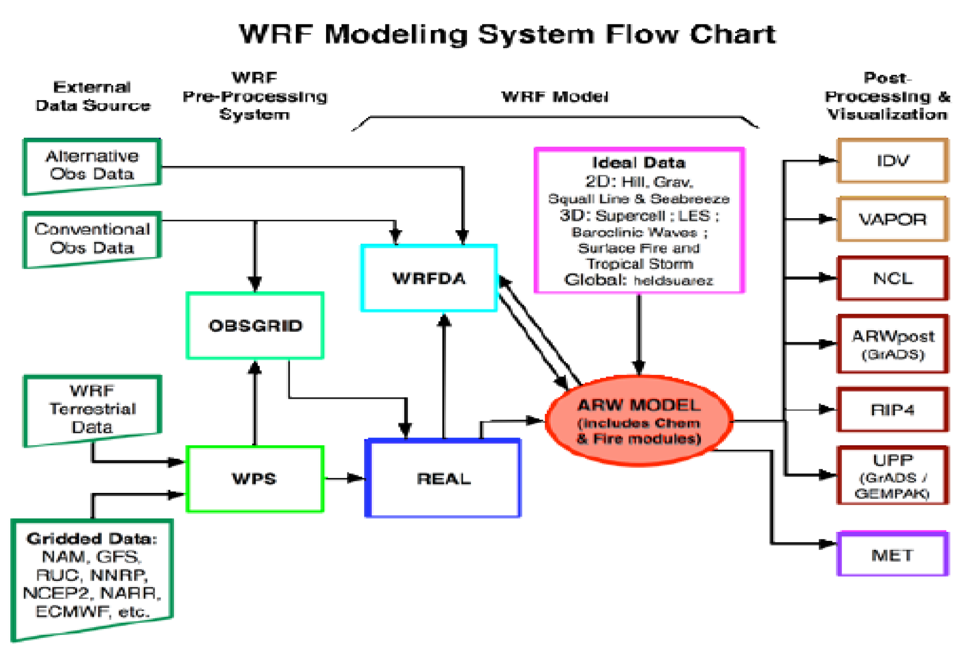


Figure provided by the WRF User's Manual (1)

The WRF model package is a sophisticated system of software components that pre-process, solve, post-process, and visualize one's modeling case of interest. The WRF was designed to model both idealized and real data cases.

Highlights of the WRF:
- Solved by finite-differencing
- Fully compressible and optionally hydrostatic
- Regional and global applications
- Complete Coriolis and curvature terms
- Multiple nesting options
- Adaptive time-stepping capabilities
- Single column ocean mixed layer model
- Grid and spectral analysis nudging

Physics Options:
- Microphysics
- Shortwave and Longwave Radiation
- Surface Layer
- Land Surface
- Urban Surface
- Planetary Boundary Layer
- Cumulus Parameterization
- Shallow Convection

Diffusion and Damping Options:
- Diffusion
- K Option
- 6th Order Horizontal Diffusion
- Nonlinear Backscatter Anisotropic

Advection Options:
- Horizontal, Vertical, and Monotonic Transport

Abstract:

Numerical simulation of weather and climate is an important tool in weather forecasting, climate prediction, air quality forecasts, wind energy assessments, and atmospheric research. Several state-of-the-art models exist and are freely available for use by the scientific community. For this study, we chose the Weather Research and Forecasting (WRF) model (version 3.3) for its versatility, integrity, and user-friendliness. We used the CSU Chico Department of Physics server as the computational platform. It has 8 cores and 24 GB of RAM. In order to compile and install the model, several additional software requirements had to be satisfied. These included: a UNIX based Operating System (OS); compilers (e.g, Fortran 90/95 and C/C++); scripting languages (e.g., perl, Cshell and Bourne shell); library software (e.g., netCDF); and a post-processing utility (NCAR Command Language (NCL)). After the software packages and the WRF model were compiled, we ran an idealized test case provided in the WRF installation. The idealized test case selected was a baroclinic atmospheric wave. This is a mid-latitude cyclonic circulation. The simulation begins from a horizontally homogeneous initial condition with a baroclinically unstable jet u(y,z) on an f-plane. The simulation has symmetrical boundary conditions in the north/south and periodic boundary conditions in the east/west; 100-km grid point spacing over a domain of 41 x 81 points in the horizontal; 64 layers over a 16 km depth; and a 4-km damping layer in the top. The simulation created one output file containing five days of model output. The data file was then visualized using the open source NCL post-processing visualizer.

WRF Baroclinic Wave Idealized Test Case:

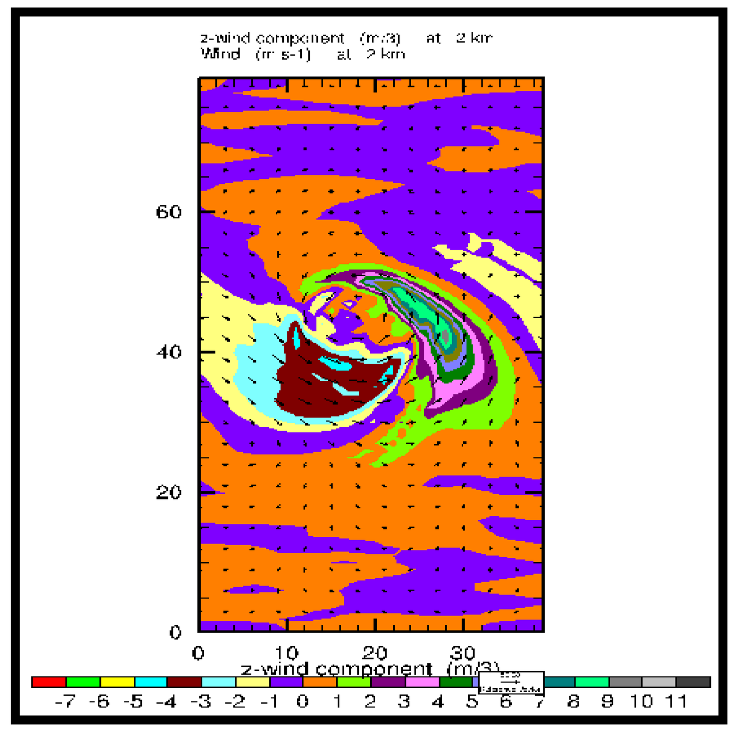


Figure 1: z-wind component (m/s) vector field of a baroclinic wave at two kilometers altitude over a five day simulation period with a grid-spacing of 41x81.

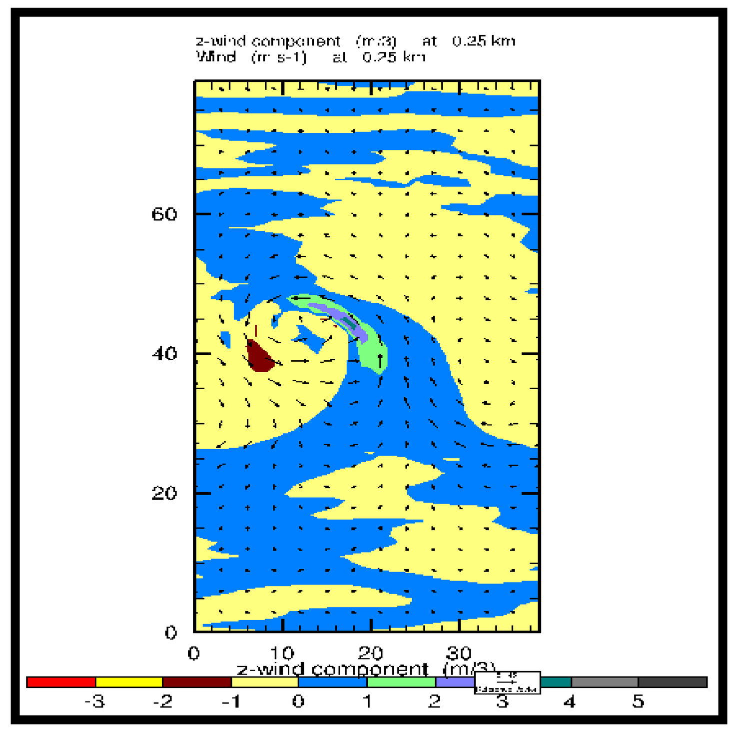


Figure 3: z-wind component (m/s) vector field of a baroclinic wave at 0.25 kilometers altitude over a 4.5 day simulation period with a grid-spacing of 41x81.

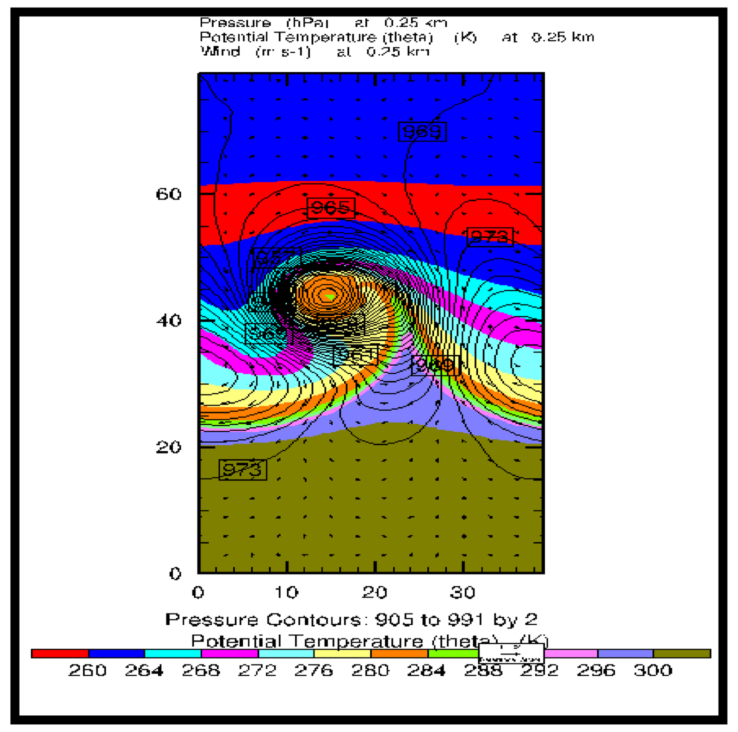


Figure 5: Pressure Contours (hPa) and Potential Temperature (K) of a baroclinic wave at 0.25 km altitude over a 4.75 day simulation period with a grid-spacing of 41x81.

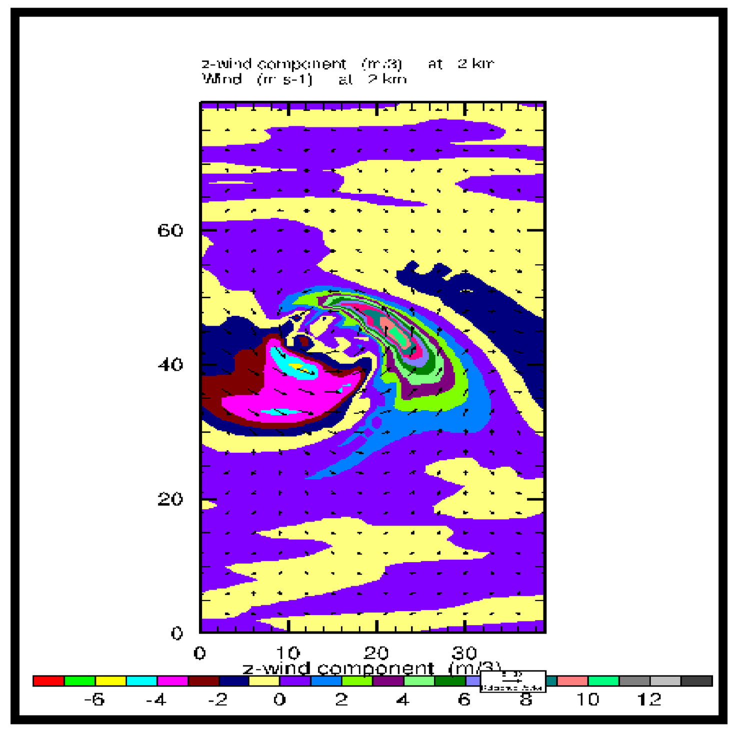


Figure 2: z-wind component (m/s) vector field of a baroclinic wave at two kilometers altitude over a 4.75 day simulation period with a grid-spacing of 41x81.

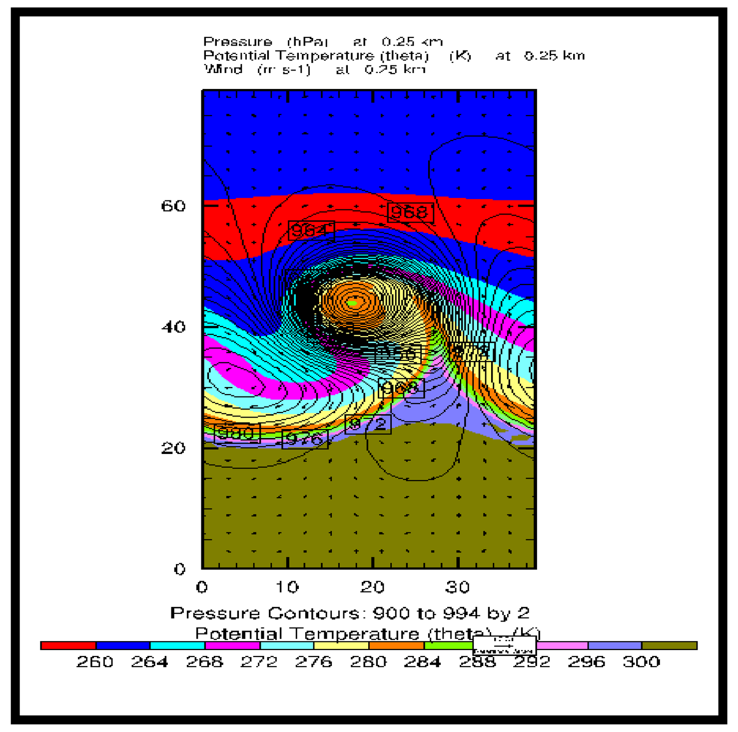


Figure 4: Pressure Contours (hPa) and Potential Temperature (K) of a baroclinic wave at 0.25 km altitude over a five day simulation period with a grid-spacing of 41x81.

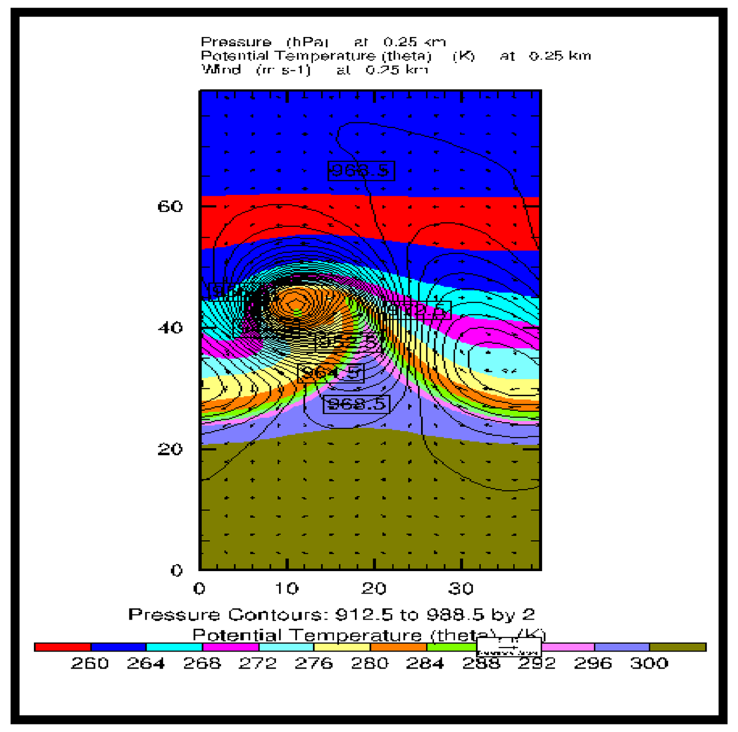
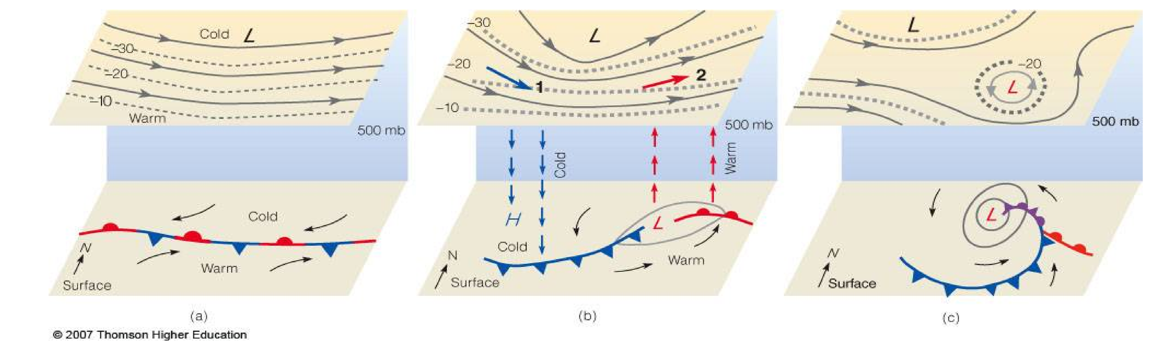


Figure 6: Pressure Contours (hPa) and Potential Temperature (K) of a baroclinic wave at 0.25 km altitude over a 4.5 day simulation period with a grid-spacing of 41x81.

Baroclinic Waves:



$$\frac{D\vec{\omega}}{Dt} \equiv \frac{\partial\vec{\omega}}{\partial t} + (\vec{V}\cdot\vec{\nabla})\vec{\omega} = (\vec{\omega}\cdot\vec{\nabla})\vec{V} - \vec{\omega}(\vec{\nabla}\cdot\vec{V}) + \underbrace{\frac{1}{\rho^2}\vec{\nabla}\rho\times\vec{\nabla}p}_{\text{baroclinic contribution}}$$

Vorticity equation

Baroclinic waves are atmospheric processes on the synoptic-scale (1000s of km) that develop in mid-latitudes (30° to 60° north and south of the equator) due to baroclinic instability. This baroclinic instability is a result of surfaces of constant pressure (isobaric) and density (isosteric) intersecting.

Future Objectives:

The goal of this project was to gain competency in the software components of the WRF model, install the WRF model and necessary software programs, and run an idealized test case to ensure proper installation. All such goals were met.

Future goals for the WRF:
- Atmospheric Boundary Layer meteorology
- Climatological research
- Educational purposes
- Large Eddy Simulations (LES)
- LIDAR and WRF coupled research
- Sea Breezes

References:

(1)Wang, W., et al., 2012: Weather Research and Forecasting User's Guide. National Center for Atmospheric Research (NCAR). Version 3, 1-371; published January 2012.

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- CSU, Chico Department of Physics