# Visualization and Model Intercomparisons of the Vector Vorticity Model

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## Vector Vorticity Model

•A three-dimensional anelastic cloud model based on the vorticity equation
- •The anelastic set of equations maintain a good approximation for cloud dynamics and with the coupling of the vorticity equation allows data to be more straightforward.

•This is the first three dimensional model of its kind, as far as we know.

•Utilizing vorticity simplifies the problem of boundary conditions at the surface of complex terrains.

•Key nonlinear dynamical processes can be more directly implemented and thus lowers the computational requirements.

•Prognostic variables: horizontal components of vorticity, potential temperature, mixing ratios of various water phases, and the vertical component of vorticity at the model top.

•Previous Tests
- • Bubble-type test which simulates a warm plume of air
- •GATE Phase-III: A test of simulating ensemble clouds with full model physics in a large domain.

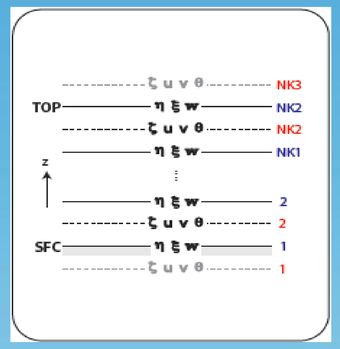



FIG 1. Vertical grid used for discretization

## Tropical Warm Pool – International Cloud Experiment

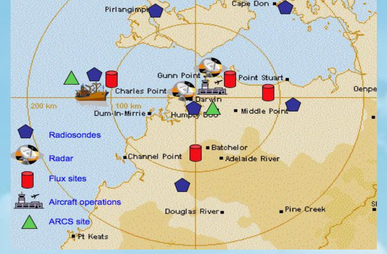



FIG 2. The Domain of the TWP-ICE experiment with locations of measurement apparatuses (Courtesy of Shaocheng Xie, LLNL)

•This was an experiment that took place in and around Darwin, Australia from January 20 through February 13, 2006.

• Noted as the first field program in the tropics that attempted to describe the evolution of tropical convection.

•The real measurements were taken by the US Department of Energy's Atmospheric Radiation Measurement Program, also known as ARM, and a polarmetric weather radar operated by the Australian Bureau of Meteorology.

•The purpose of taking the TWP-ICE data was to improve the climate forecasting skills of general circulation models.

## TWP-ICE Model Set-Up

In order to reproduce results with the VVM, we had to set the model up in exactly the following manner:

• Model runs of 16 days (January 18- February 3, 2006)

• Horizontal domain size = 176 km X 176 km

• Vertical domain size must be greater than 24 km

•Periodic boundary conditions

• Sea surface temperature must be 29 C with an albedo of .07

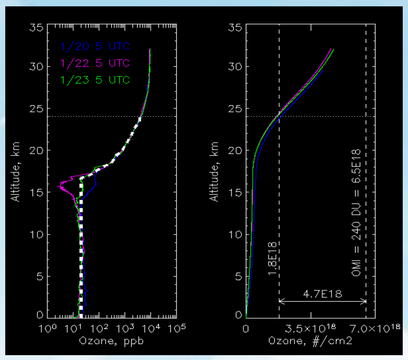
•Fully interactive fluxes

•Idealized ozone and aerosol profiles from measured observations

•Domain-mean large scale forcings are derived from observations

•Apply the forcings at full strength below 15 km and zero above 15 km

• Nudge observations every 6 hours



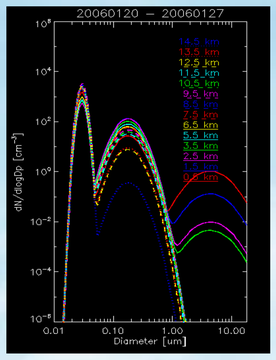




FIG 3 (left) : Ozone sounding profiles for the TWP-ICE domain
FIG 4 (right) : Aerosol profile for the TWP-ICE domain

## Model Results

• The model produced results beginning at 36 hours after the simulation. This initial 36 hours is regarded as the VVM's spin up time and all data within the spin-up time may be disregarded.

### Precipitation

• The initial 10 minute run ran from hours 36 to 144 which results in a 6 day run of the entire timeframe.

•To continue our analysis, we focused on the greatest maximums and lowest minimums of mean precipitation as shown in FIG 10.

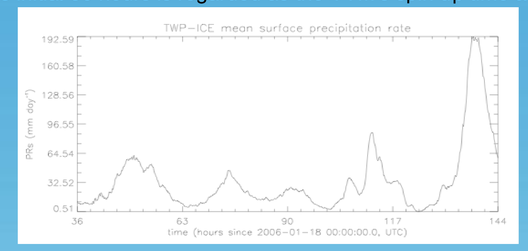



FIG 10. Mean precipitation over the entire domain in mm/day

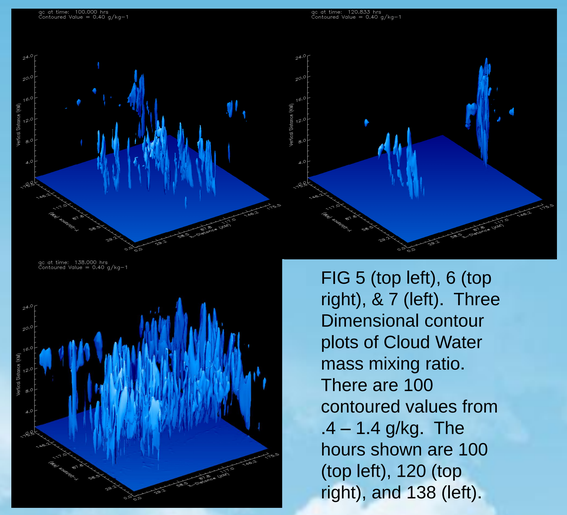


FIG 5 (top left), 6 (top right), & 7 (left). Three Dimensional contour plots of Cloud Water mass mixing ratio. There are 100 contoured values from .4 – 1.4 g/kg. The hours shown are 100 (top left), 120 (top right), and 138 (left).

### Mixing Ratios and Vertical Velocity

•Utilizing both X-Y slices of vertical velocity and cloud water mass mixing ratio, one can infer the location of updrafts with warm most air.

•This is like a proxy for cloud locations. The evidence displayed in FIG 8 & 9 suggests the location of clouds in FIG 7 do make sense.

### 3-D Visualization

• Perhaps one of the most important items to submit to the intercomparison was a 3-D output of what clouds look like after the model simulation at 10 minute intervals.

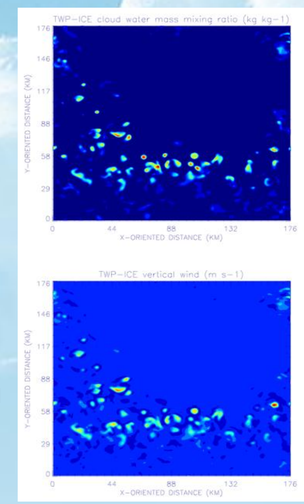
•Utilizing IDL, contour plots of cloud water mass mixing ratio were used to simulate the shapes and locations of clouds over the entire domain. (FIG 5, 6, & 7)

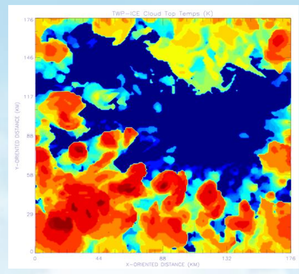
• The contour blobs created are stringy and thus may not completely represent a true cloud so further analysis must take place.

• In addition, a time lapse animation of our 10 minute output was created to see how the clouds were progressing and advected over the domain during entire run time.

FIG 8 (right) & 9 (right middle). Cloud Water mass mixing ratio (top) and Vertical velocity (bottom) as measured from Z= 6 km at 138 hours

FIG 11 (right bottom). An example of cloud top temperatures in X-Y domain at hour 138. Warmer colors indicate colder clouds.




### Cloud Top Temperatures

• In another effort to identify the location of clouds in the entire domain, we utilized a calculation that found an approximate location of cloud tops via their temperatures according to the cloud water mass mixing ratio and cloud ice mixing ratio.

•This better represented the size and coverage of the clouds.

### Future Work

• Continue work with the VVM over new land based and land/ocean cases.

• Currently the next test for the VVM is in its planning stages and is the ARM July 1997 study based over Oklahoma, USA.

### References

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