Simulation of the TWP-ICE Case with the Vector Vorticity Cloud Model

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Vector Vorticity Cloud Model

• A three-dimensional non-hydrostatic anelastic cloud model based on the vorticity equation

•This is the first three dimensional model of its kind

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

• 3-D elliptic (or parabolic) equation is now solved for vertical velocity

•Prognostic variables:

- •Horizontal components of vorticity
- •Vertical component of vorticity (at the model's top)
- •Horizontally uniform part of horizontal vorticity (at the model's top)
- •Potential Temperature
- •Mixing ratio of various phases of water

• Physics:

- •Bulk ice-phase microphysical parameterization
- •Radiation parameterization (RRTMG)
- •Turbulence parameterization (1st-order closure)

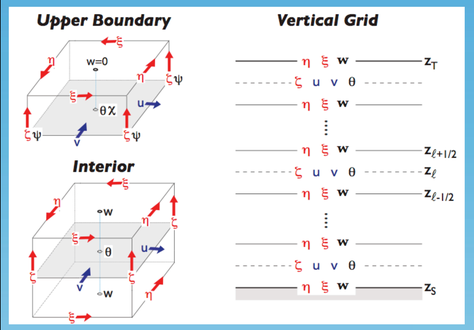


FIG 1. The model grid set up.

Model Results

• The model's spin-up time is 36 hrs. After this threshold the model produced simulated results.

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 minimums of mean precipitation as shown in FIG 10.

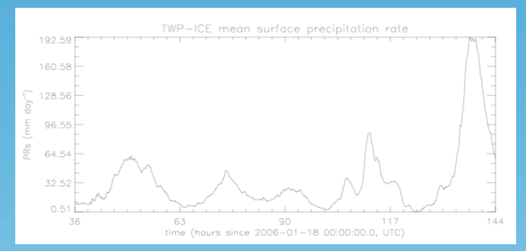


FIG 10. Mean precipitation over the entire domain in mm/day

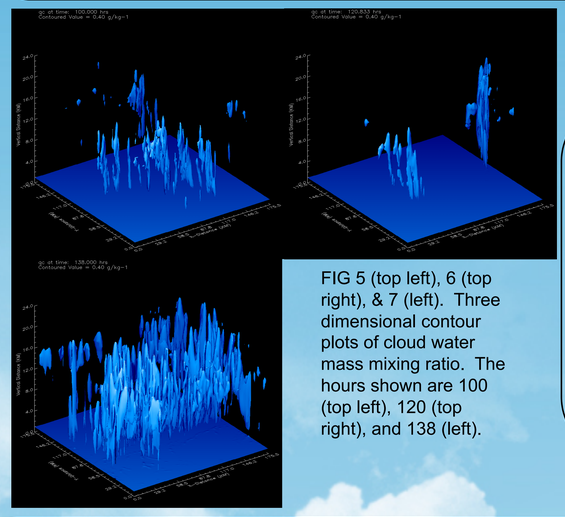


FIG 5 (top left), 6 (top right), & 7 (left). Three dimensional contour plots of cloud water mass mixing ratio. The hours shown are 100 (top left), 120 (top right), and 138 (left).

3-D Visualization

• 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.

• 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 may not completely represent a true cloud so further analysis must take place.

• A time lapse animation of our entire 10 minute output was created to see the cloud progressing and advecting over the domain.

FIG 2. The domain of the TWP-ICE experiment with locations of measurement apparatuses

Tropical Warm Pool – International Cloud Experiment

• A field program focusing on the tropical convection

• The purpose of the experiment is to provide a testbed through which representation of convection in models can be evaluated an improved

• This was an experiment that took place in and around Darwin, Australia (FIG. 2), from January 20 trhough February 13, 2006.

• The observations 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. FIG. 2 shows the observation network.

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.

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.

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 lateral boundary conditions

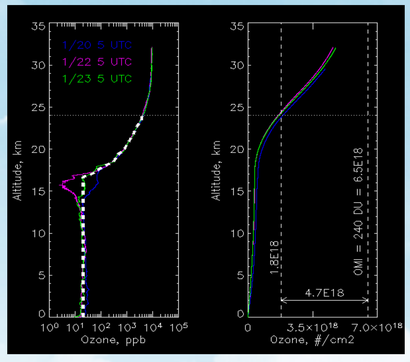
• Sea surface temperature must be 29 C with an albedo of .07

•Fully interactive fluxes

• Domain-mean large scale forcings, ozone and aerosol profiles are prescribed are from observations

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

• Nudging to observations every 6 hours



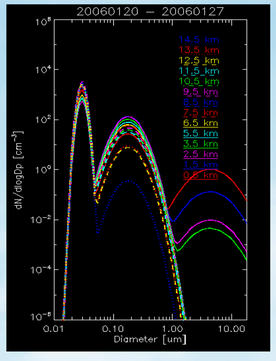


FIG 3 (left) : Ozone sounding profiles for the TWP-ICE domain
FIG 4 (right) : Aerosol profile for the TWP-ICE domain

Cloud Top Temperatures

• In another effort to identify the location of clouds in the entire domain, we utilized cloud water mixing ratio and cloud ice mixing ratio to derive cloud top temperatures. These values represent the approximate locations on cloud tops.

• 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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