IMPLEMENTATION OF A QUASI-3D MULTISCALE MODELING FRAMEWORK IN ACME

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Objective:

Our objective is to construct a version of ACME that uses a Quasi-3D Multiscale Modeling Framework (Q3D MMF) for a physics option, which can bridge the gap between much more expensive global cloud-resolving models and conventional superparameterized (SP) models.

Original MMF (or SP) vs. Q3D MMF:

In contrast to the original MMF, the Q3D MMF connects Cloud-Resolving Model (CRM) seamlessly, and uses two sets of perpedicular CRM channels. The domains of the CRM channels are three-dimensional although the width of channel is narrow.

Vector-Vorticity Model:

The Vector-Vorticity Model (VVM) is designed for the Q3D-type applications; the pressure gradient force is eliminated; the vertical velocity is diagnostic and this makes the formulation of lower boundary condition over topography easy with the block-mountain approach.

The prognostic variables of the VVM are horizontal component of vorticity, vertical component of vorticity (at the model top), the potential temperature, and mixing ratios of various phases of water.

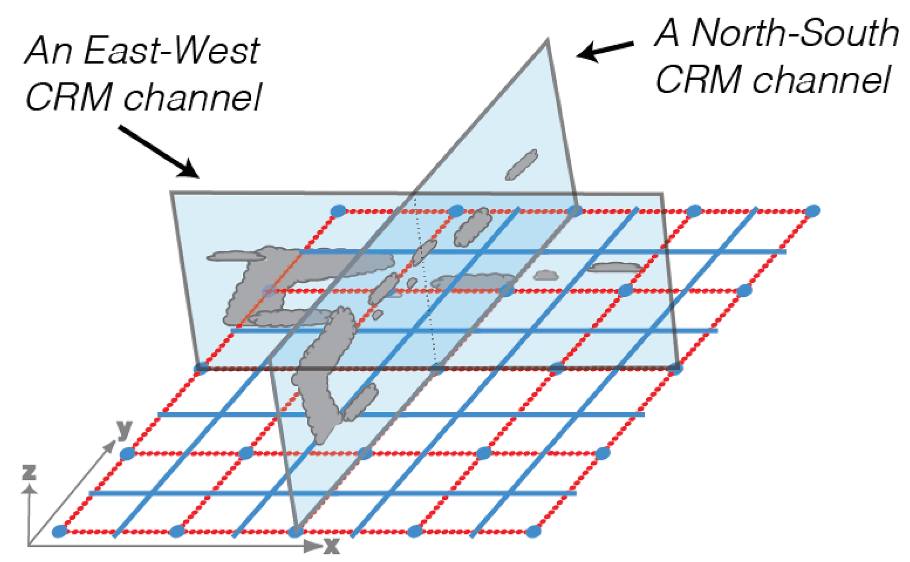
A 3D-elliptic equation is used to diagnose the vertical velocity.

The new physics package, which will be implemented soon, includes a double-moment microphysics, aerosols, 1.5-order Mellor-Yamada turbulence, RRTMG radiation, and Monin-Obukov surface flux parameterizations.

Global VVM on a cubed-sphere grid:

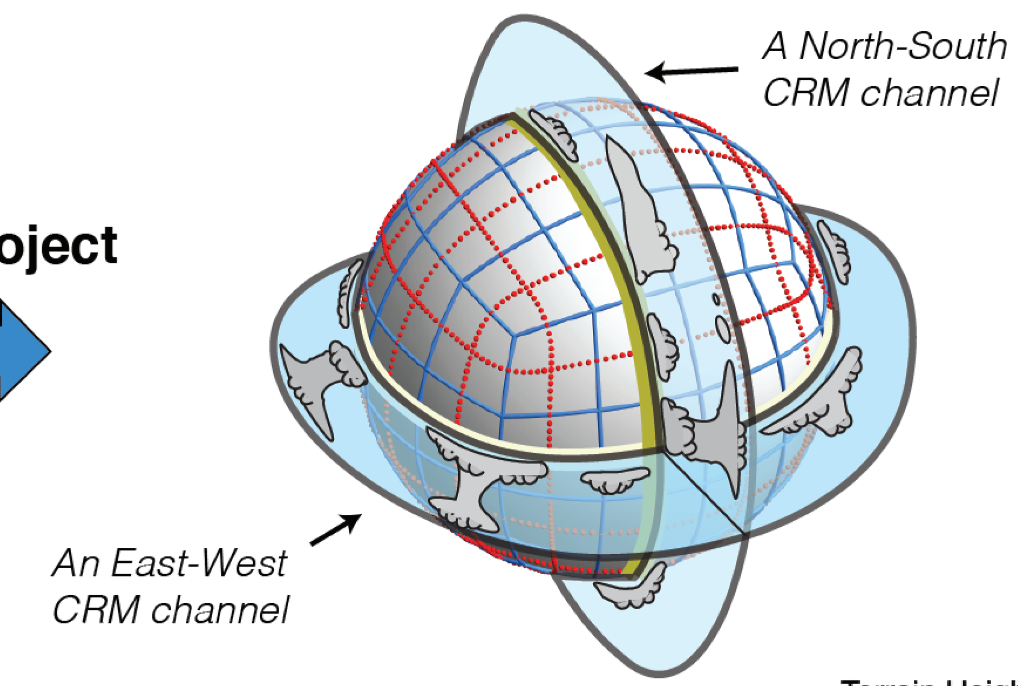
A global version of the VVM in the horizontal curvilinear coordinates is developed to run on a cubed-sphere grid that mimics the ACME grid.

Limited-Area Q3D MMF

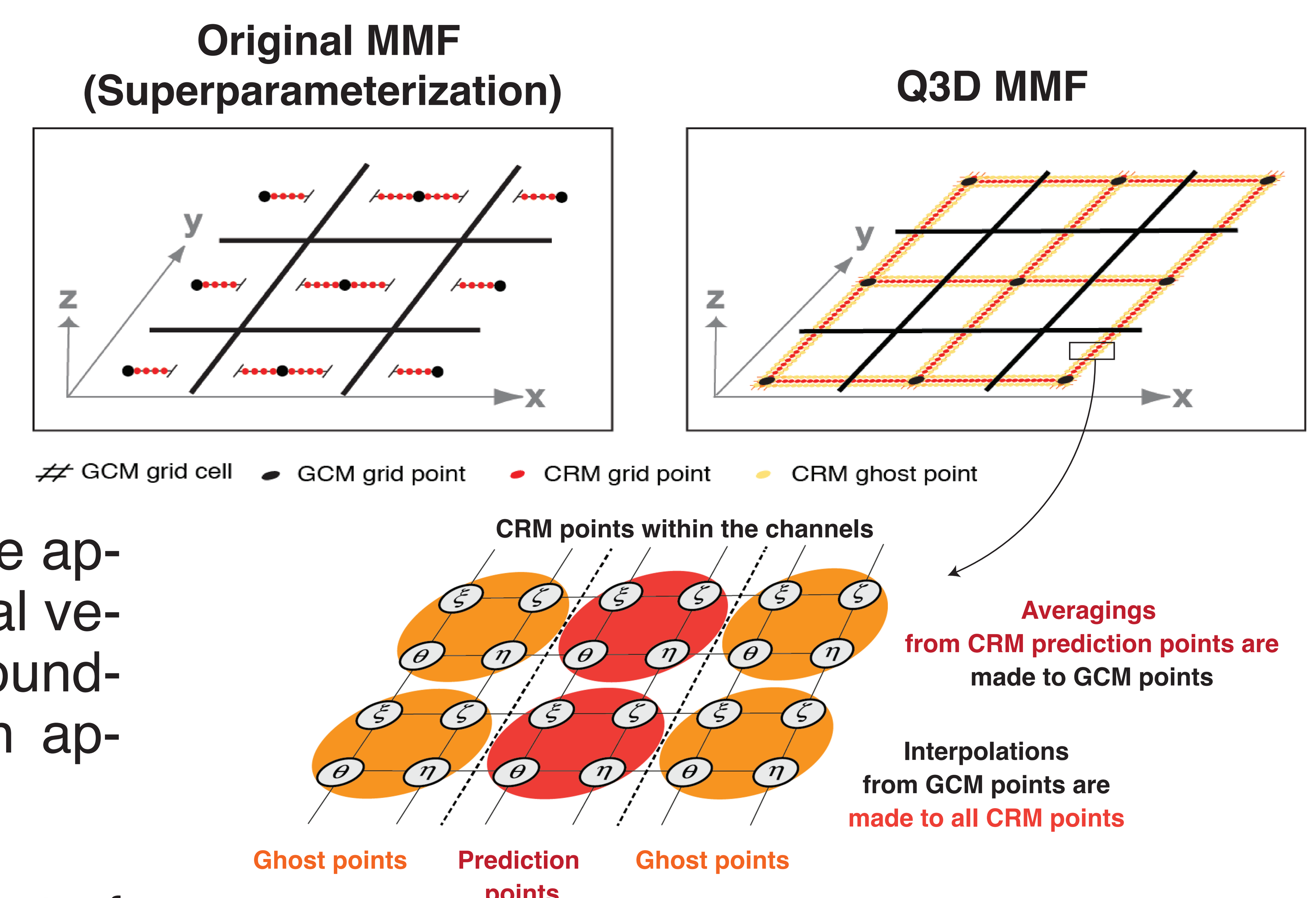


Our project

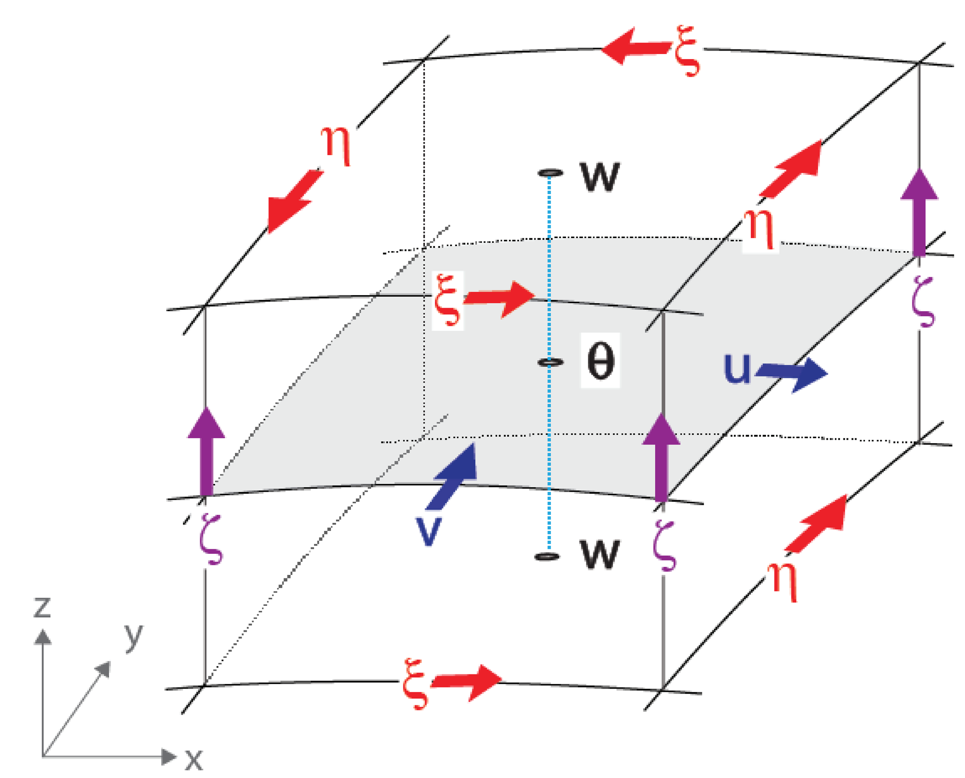
ACME with Q3D MMF



Original MMF (Superparameterization) / Q3D MMF

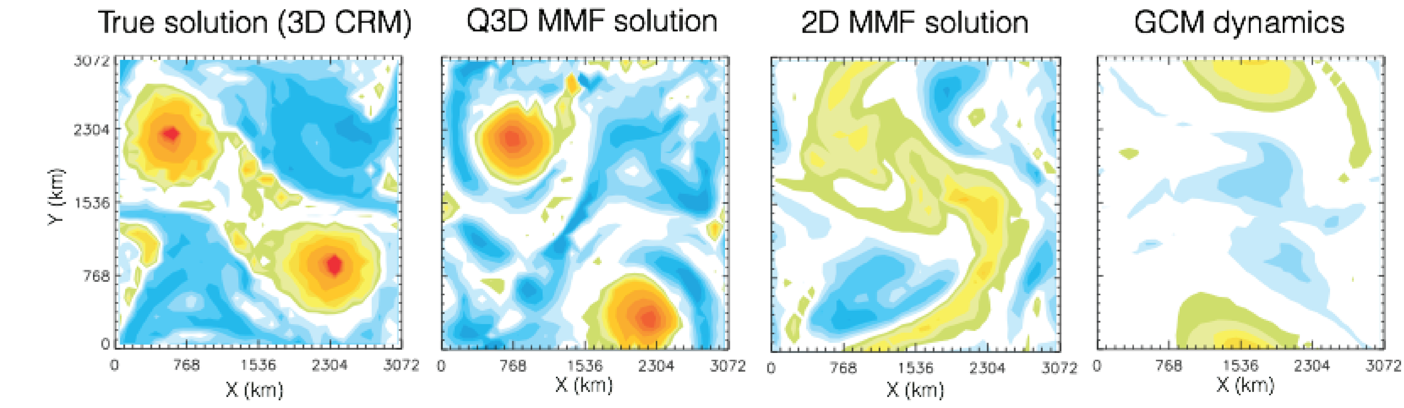


3D grid of the VVM in horizontal curvilinear coordinates

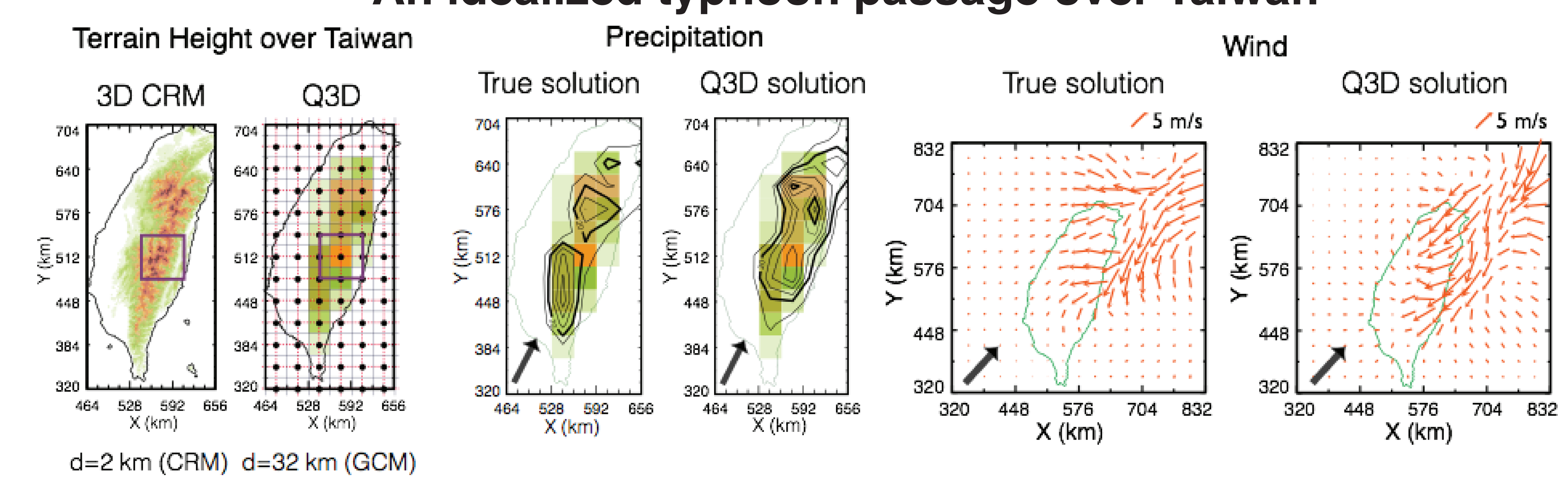


Simulations with the limited-area version of the Q3D MMF

An idealized tropical cyclogenesis

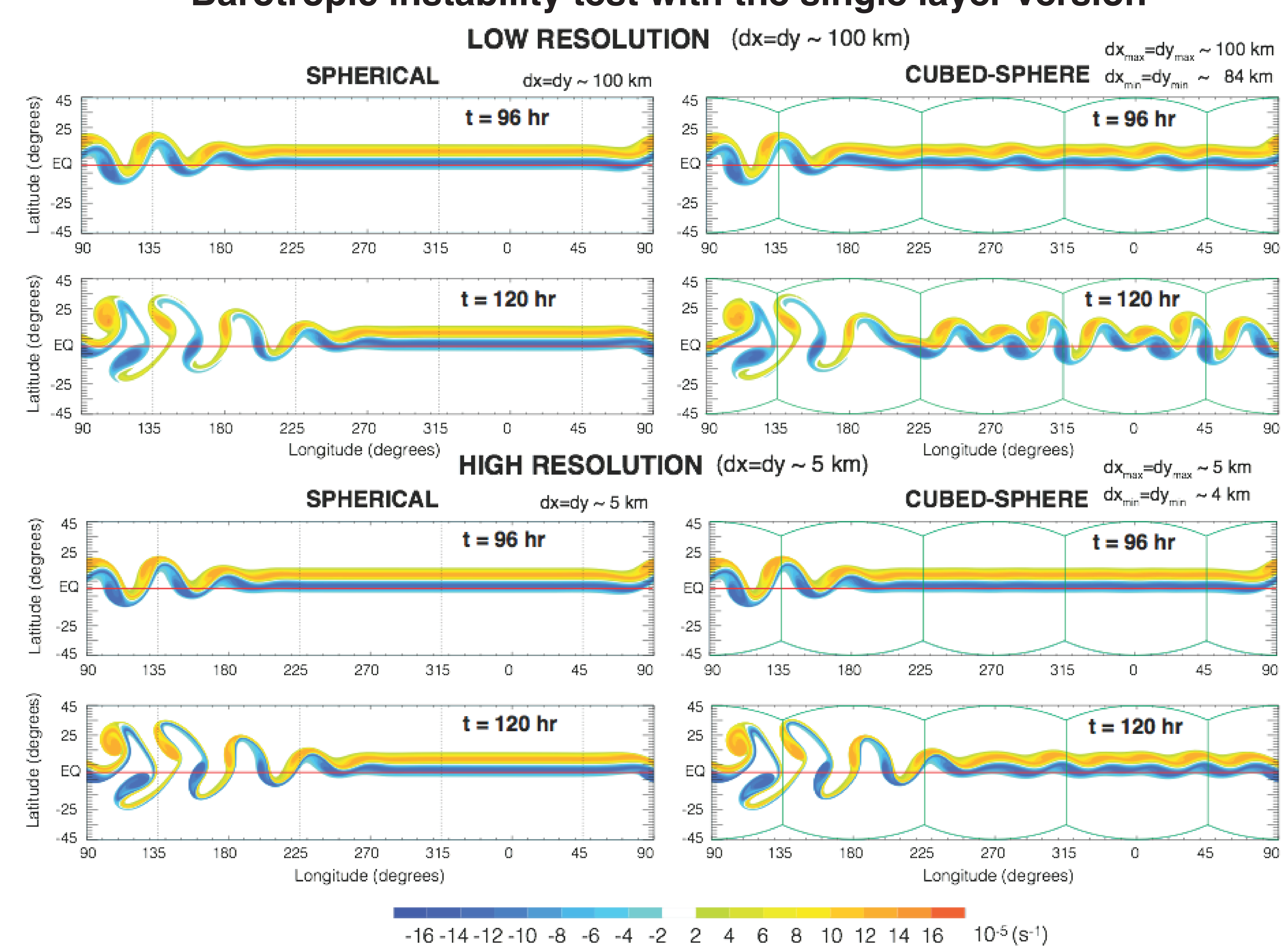


An idealized typhoon passage over Taiwan



Simulations with the global version of the VVM

Barotropic instability test with the single layer version



Next: Baroclinic instability test with the multi-layer version.

Next year: Implementation of the Q3D MMF in ACME dycore.