Tropical Convective-scale Numerical Weather Prediction

SINGV – A Tropical Convective-scale NWP system
Resolution and convection modelling
Tropical model error covariance and model balancing
Data assimilation

Hans Huang
Senior Principal Research Scientist

YMC workshop

27-30 Jan 2015

SINGV – A Tropical Convective-Scale NWP/Nowcasting system:

Overall goals

- To equip the MSS with a state-of-the-art tropical, convective-scale NWP/nowcasting system, also suitable for high-resolution climate simulations.
- To make use of the wide range of global expertise in the use of operational UM.
- To transition to a full operational NWP service for the provision of forecasts and hazard warnings.
- To provide a framework for training and R&D collaborations between MSS scientists and operational users of UM worldwide.
- To establish the MSS as a leading centre of expertise and capability in tropical, high-resolution NWP.

SINGV Project

UKMO :

Dale Barker
Stu Webster
Douglas Boyd
Kalli Furtado
Jonathan Wilkinson
Adrian Lock
Martin McMillan
Laura Stewart
Graeme Kelly

MSS:

Hans Huang
Jeff Lo
Sijin Zhang
Xiangming Sun
Mai Nguyen
IT STAFF
SR/SCIENTIST
UKMO long-term visitor 1
UKMO long-term visitor 2

SINGV: Milestones

- Establish NWP R&D test-bed at MSS April 2014
- Transition the downscaler to real-time May 2015
- Start probabilistic NWP April 2017
- Upgrade to ensemble DA system April 2018

Project kick-off: 1 May 2013

Year 1-2: A real-time, single forecast experimental test-bed

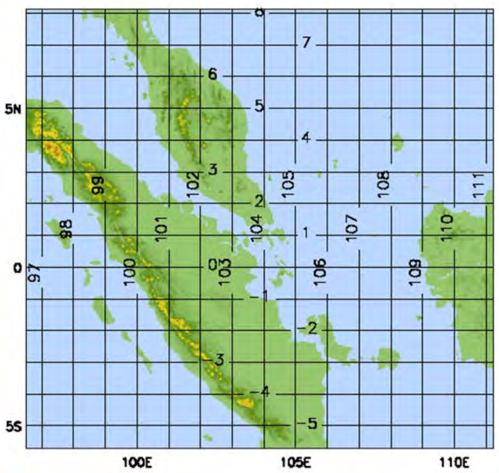
Year 3: Real time application and data assimilation upgrade

Year 4-5: Probabilistic forecasting, transit to operational

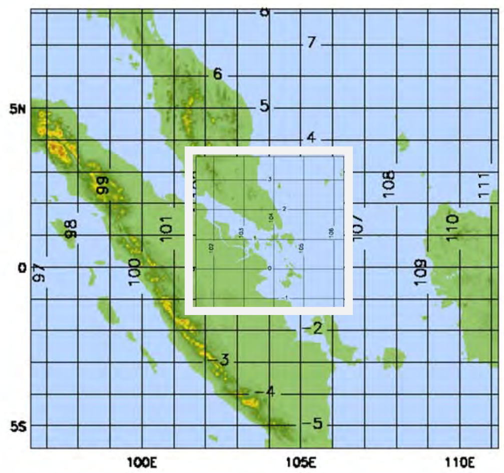
SINGV can be used during YMC field experiments?!

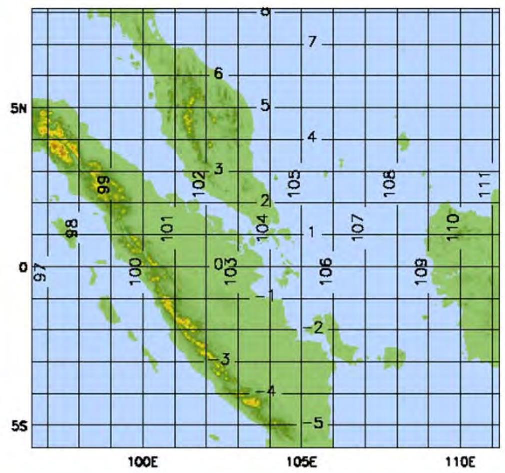
Layout of various SINGV configurations

|← 1500km →|



→| 500km |←





Global ► 4.5 km (large domain)

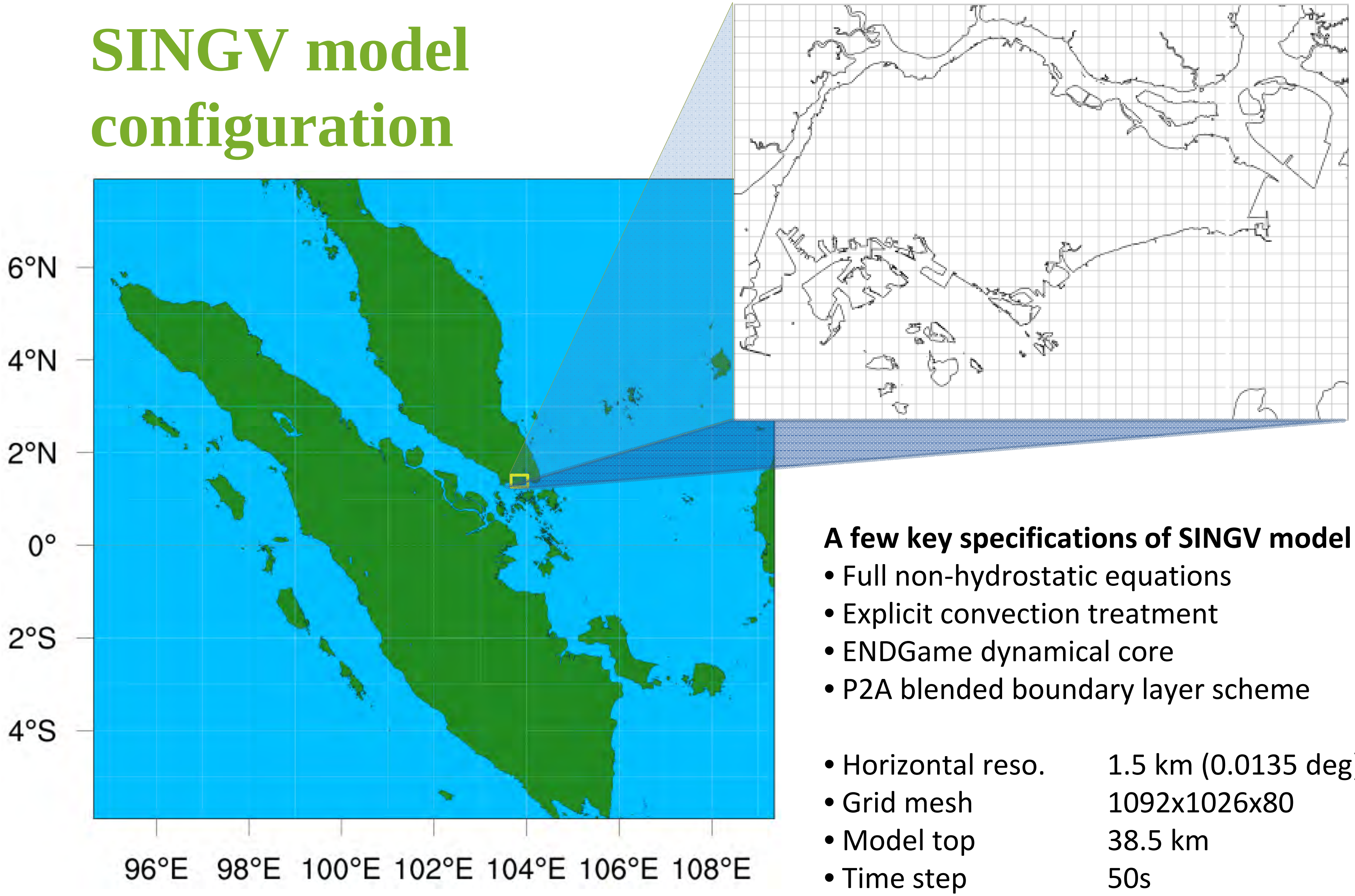
Global ► 1.5 km (small domain)

Global ► 4.5 km ► 1.5 km

Global ► 1.5 km (large domain)

Credit: Stuart Webster

SINGV model configuration



A few key specifications of SINGV model

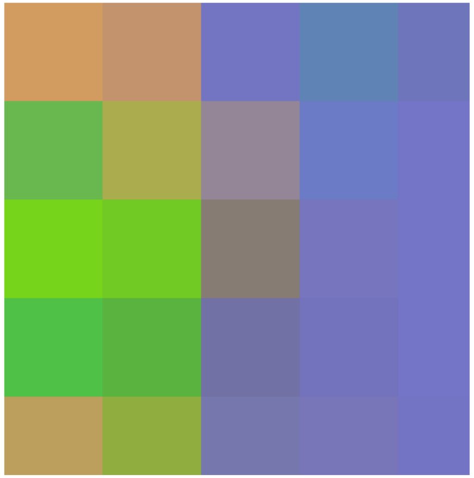
- Full non-hydrostatic equations
- Explicit convection treatment
- ENDGame dynamical core
- P2A blended boundary layer scheme

• Horizontal reso.	1.5 km (0.0135 deg)
• Grid mesh	1092x1026x80
• Model top	38.5 km
• Time step	50s

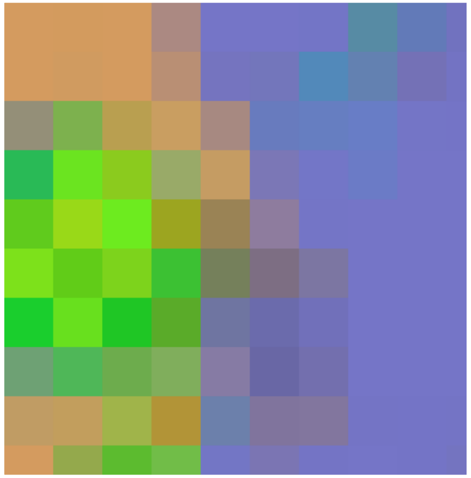
Need High Resolution to:

- Resolve localized convective weather systems
- Resolve land-sea contrasts and orography
- Explicitly model convection (avoid convection parameterization) – improve precipitation simulation
- … etc.

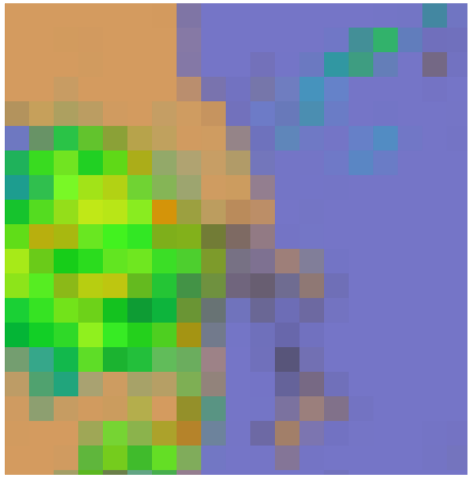
50km



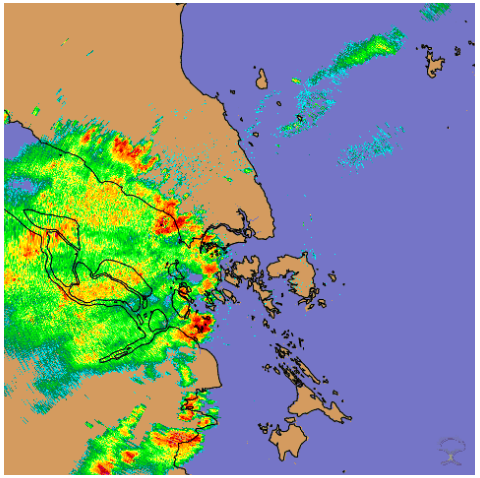
25km



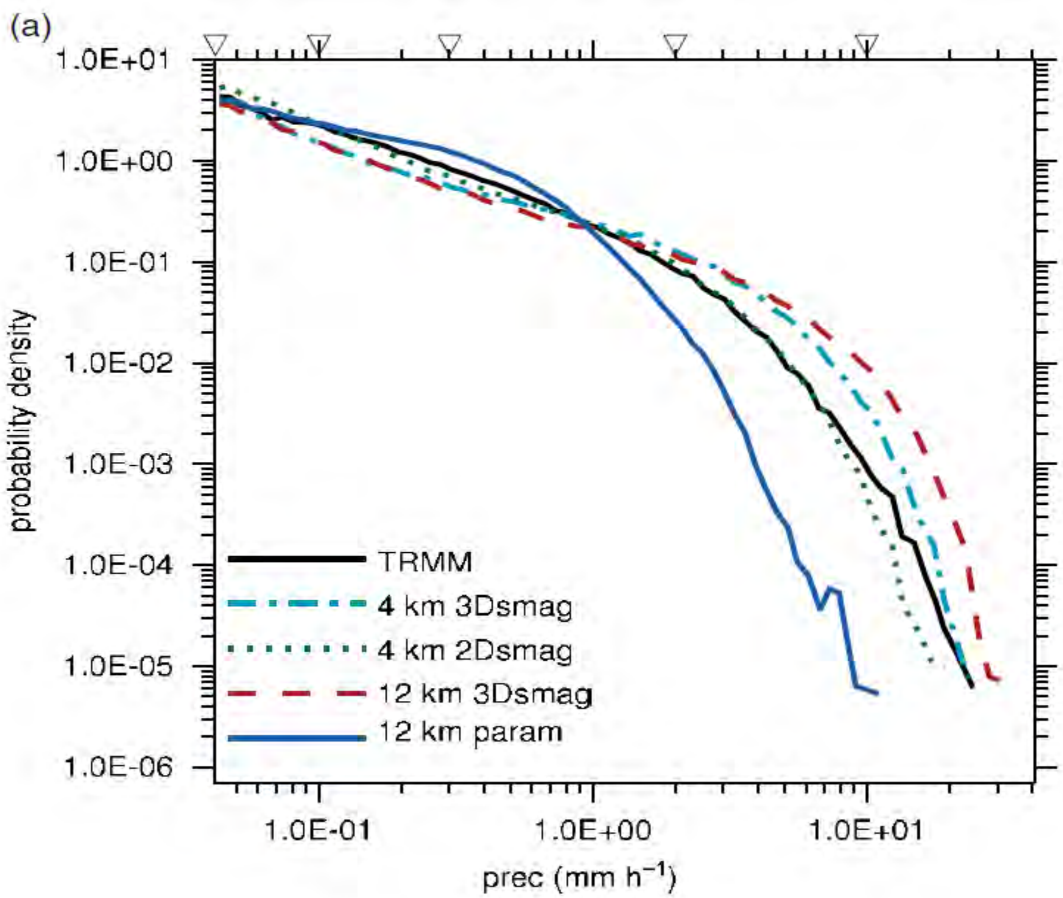
5km



1km



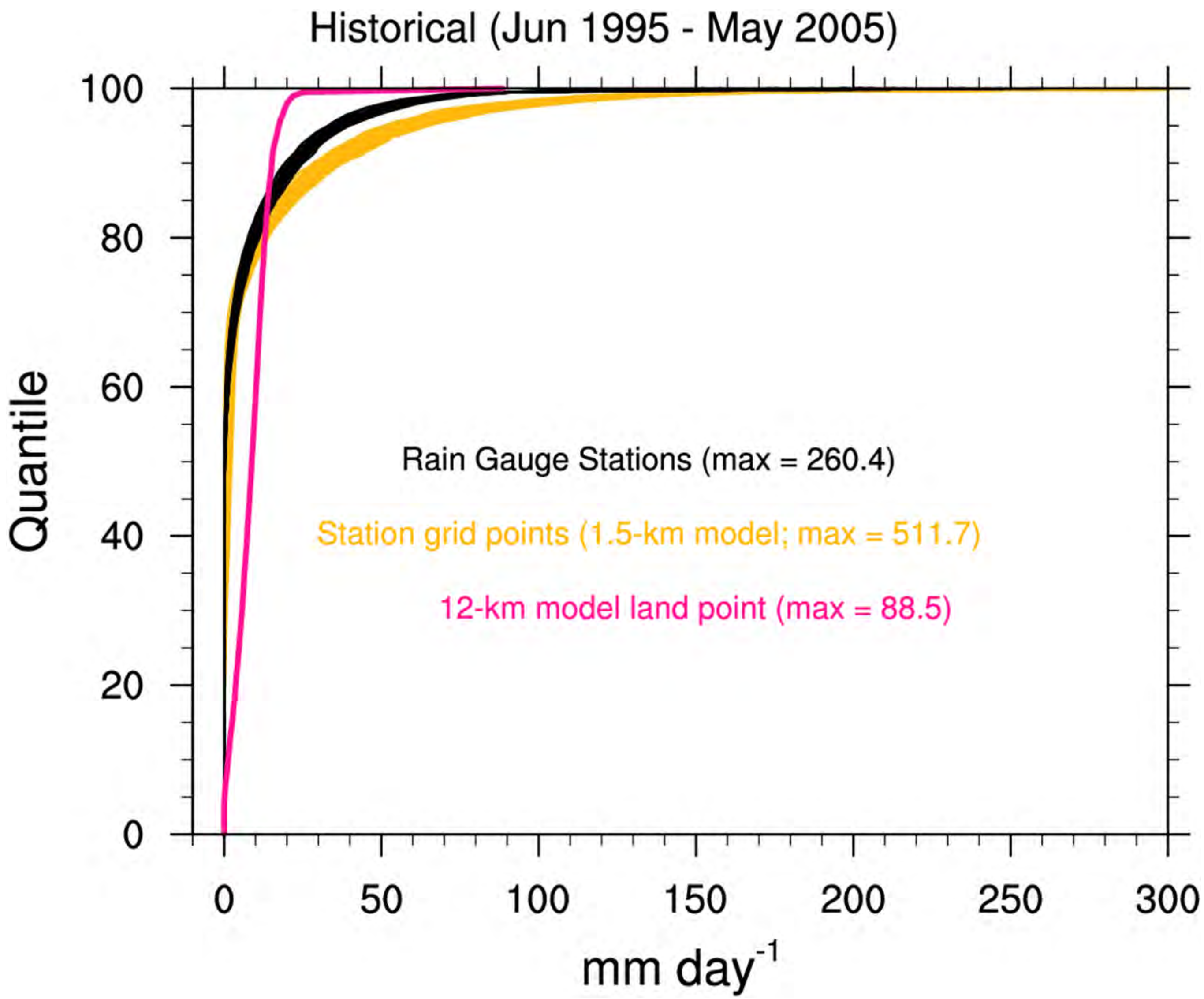
Convection modelling



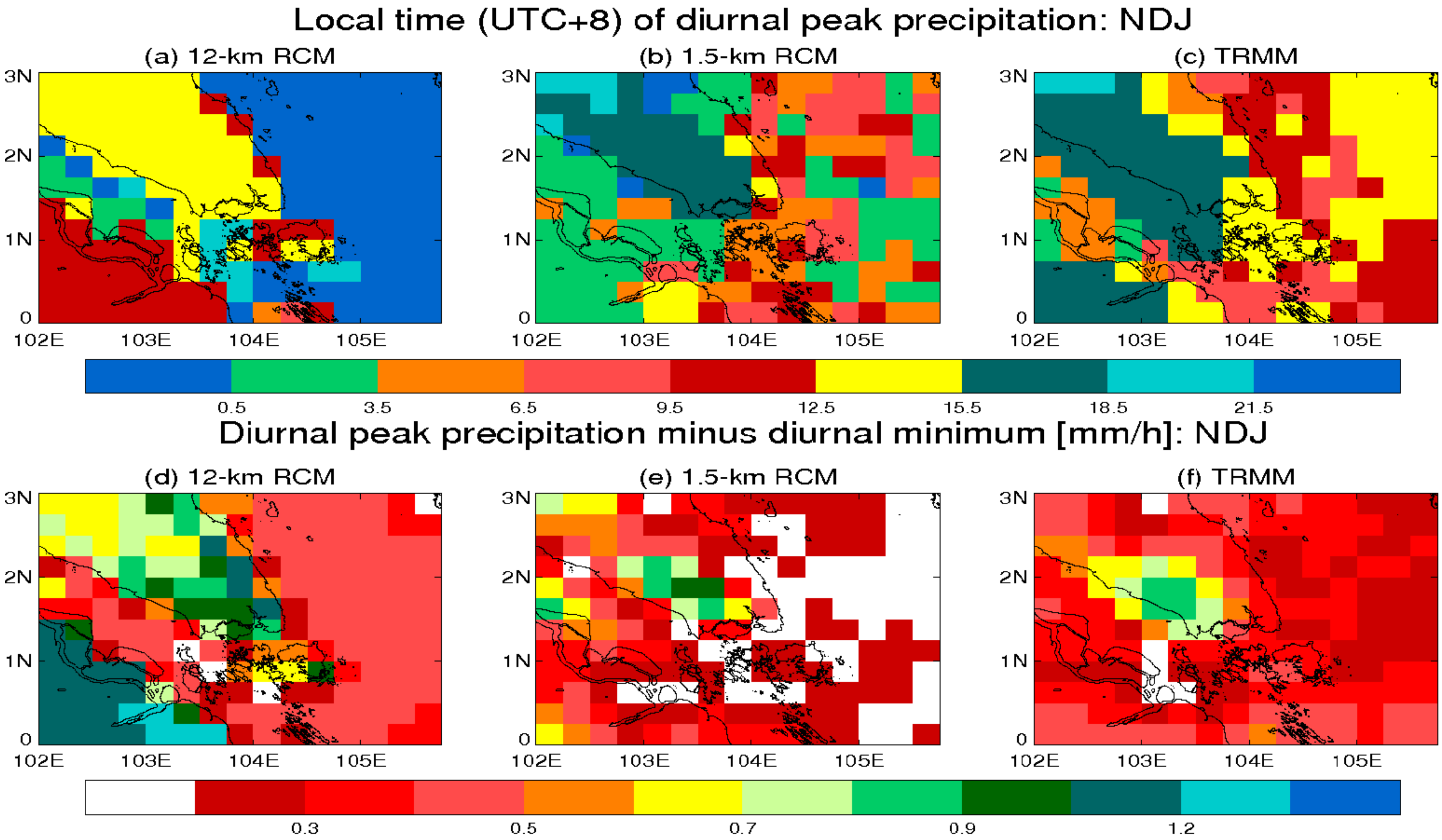
Probability densities of precipitation from MetUM limited-area model simulations at 12km horizontal resolution with parameterised convection (12km param) and at 4 and 12km with the convection scheme switched off (4 km 3Dsmag and 12km 3Dsmag). 4km was run with both 2D and 3D subgrid Smagorinski mixing schemes (taken from Holloway et al. 2012).

Quantile distributions of daily mean rainfall amounts

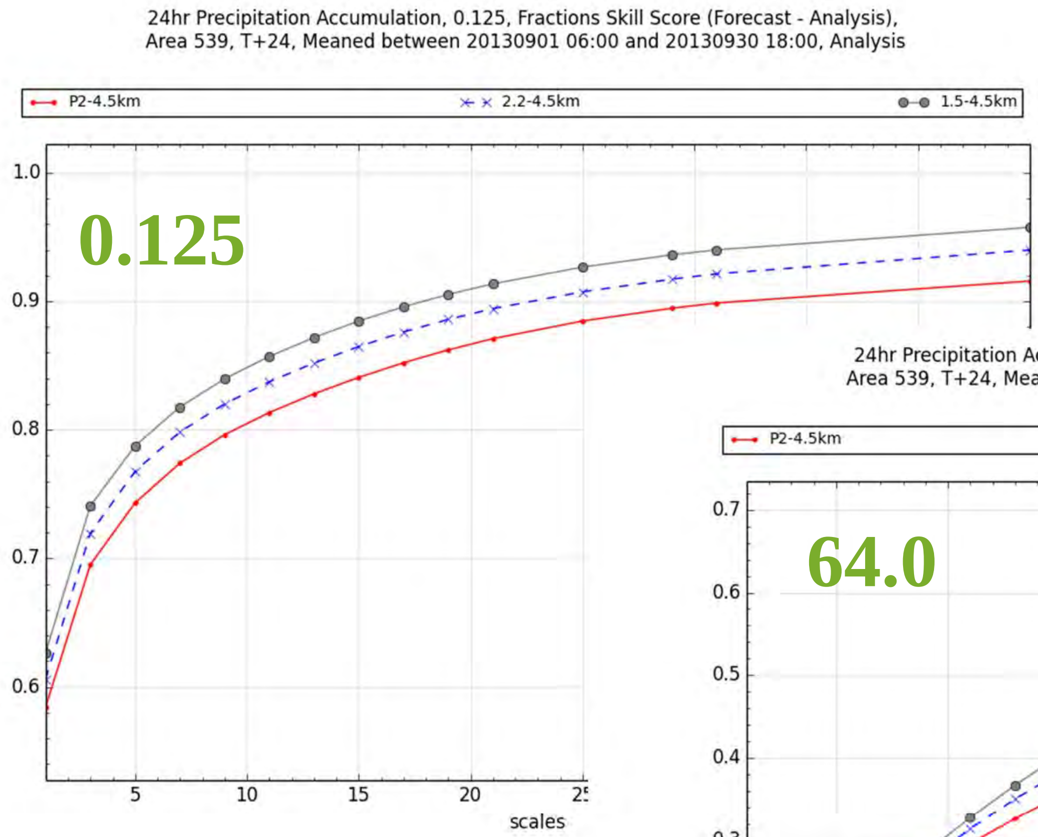
(CDFs – Cumulative Distribution Functions)

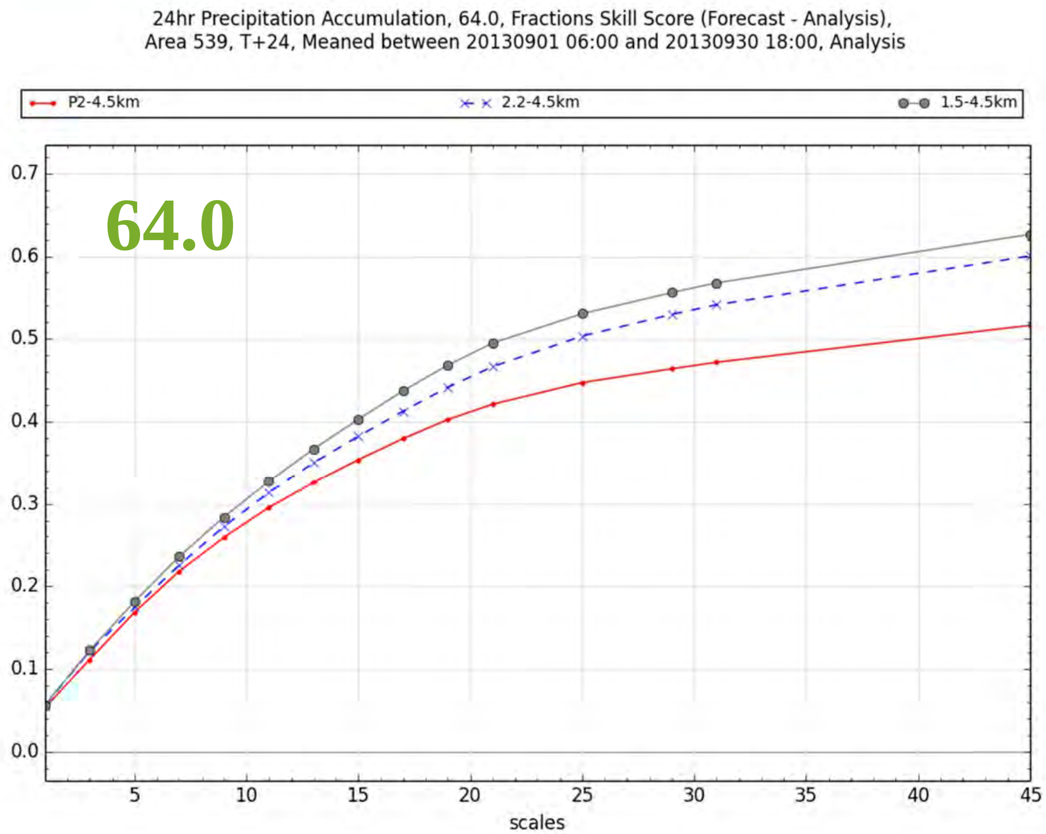


Diurnal peak precipitation and the amplitude of diurnal cycle



24hr Precipitation Accumulation Fraction Skill Score (FSS)

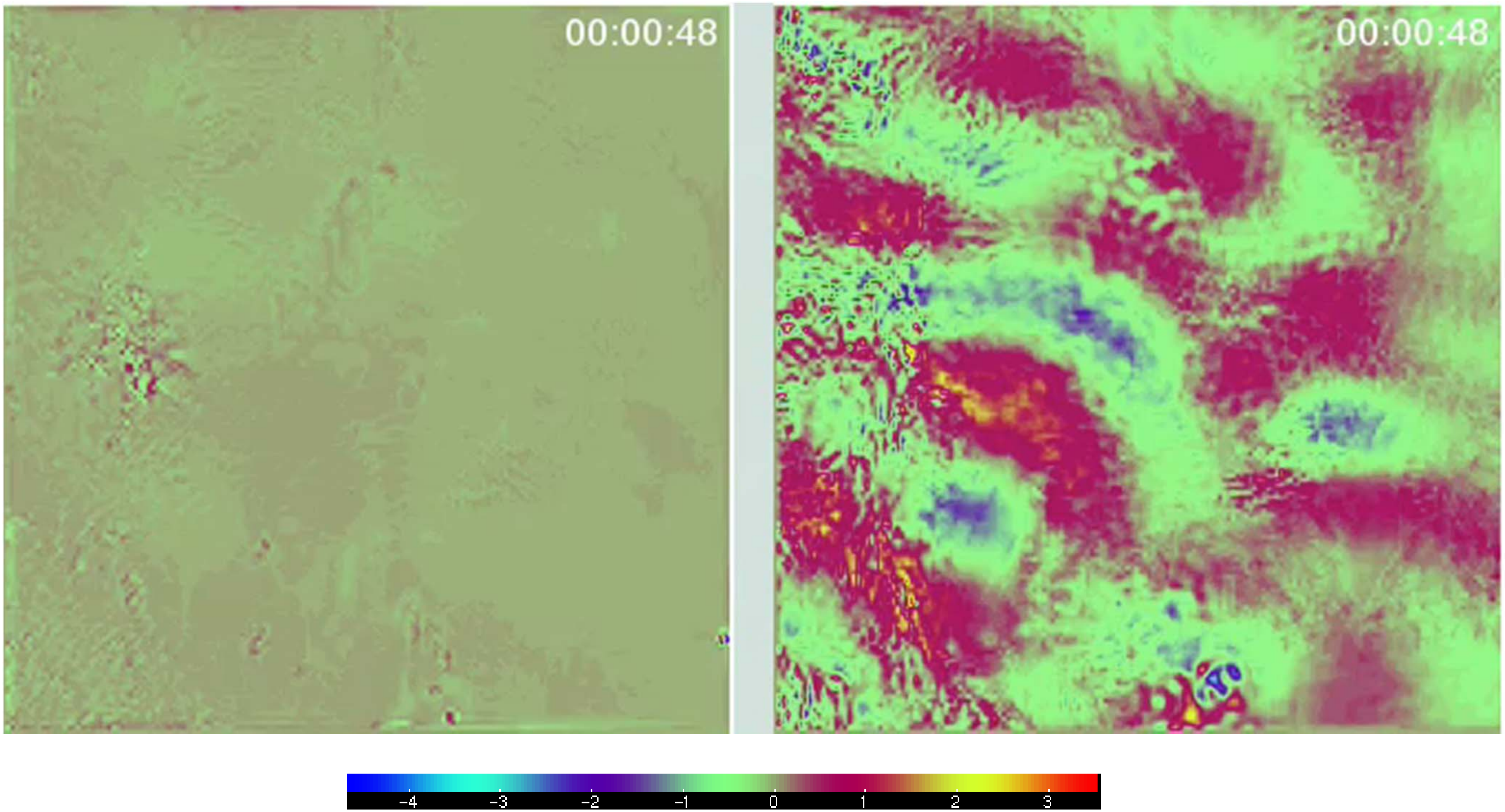




Balance in Tropical Convective-Scale Models?

DFI

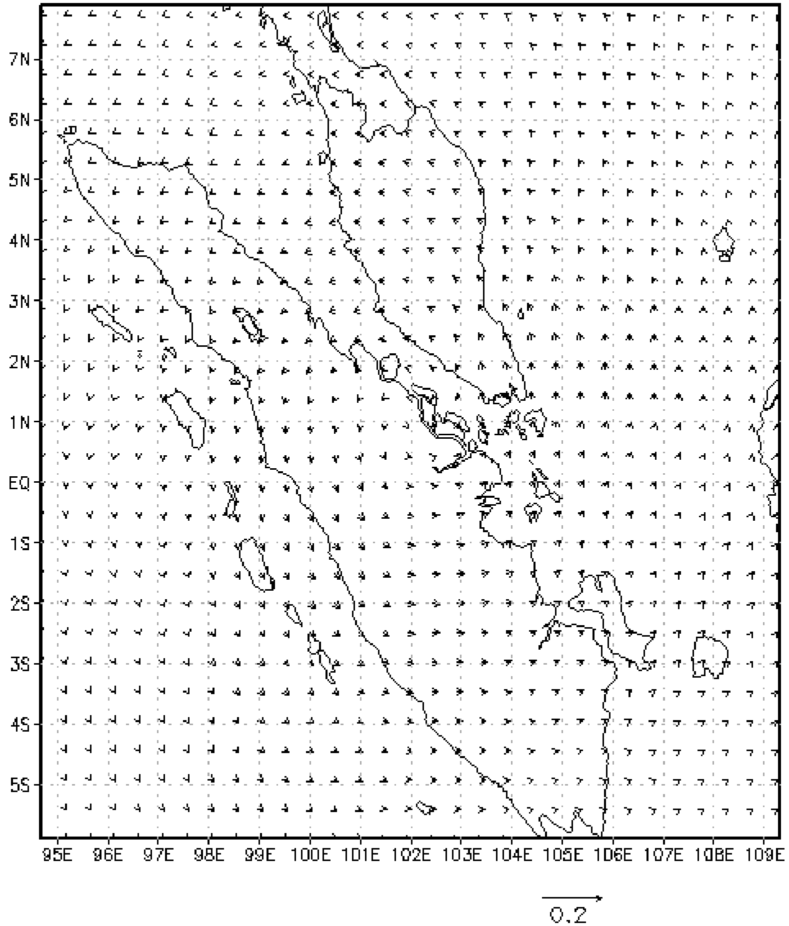
No DFI



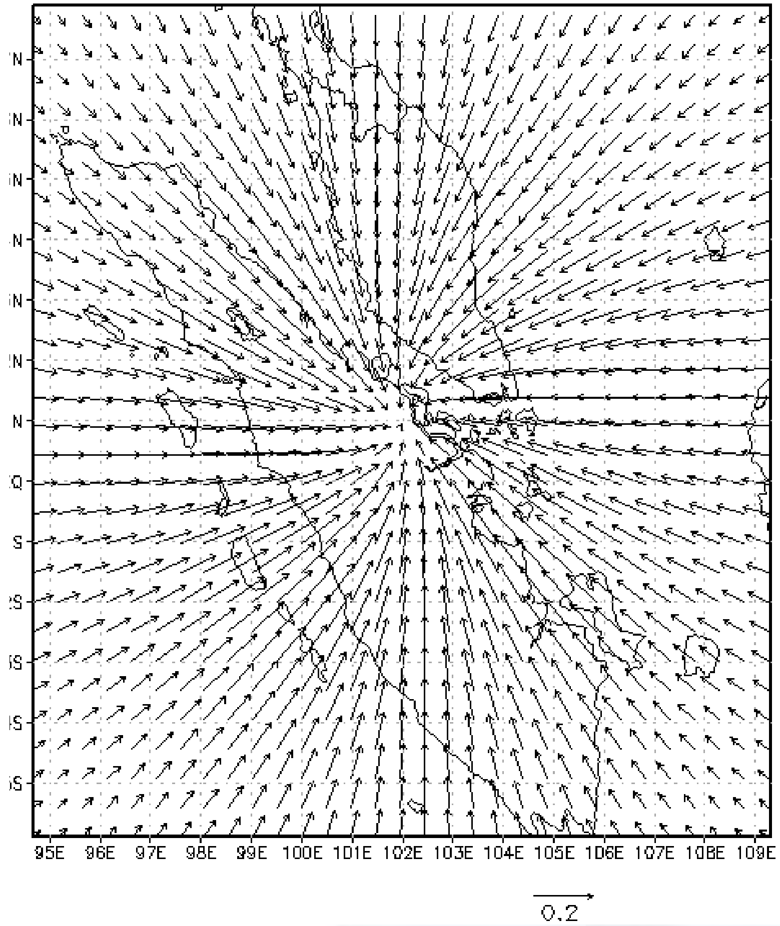
(Dry) Surface Pressure Tendency

BE: Covariance Modeling

CV5



CV6



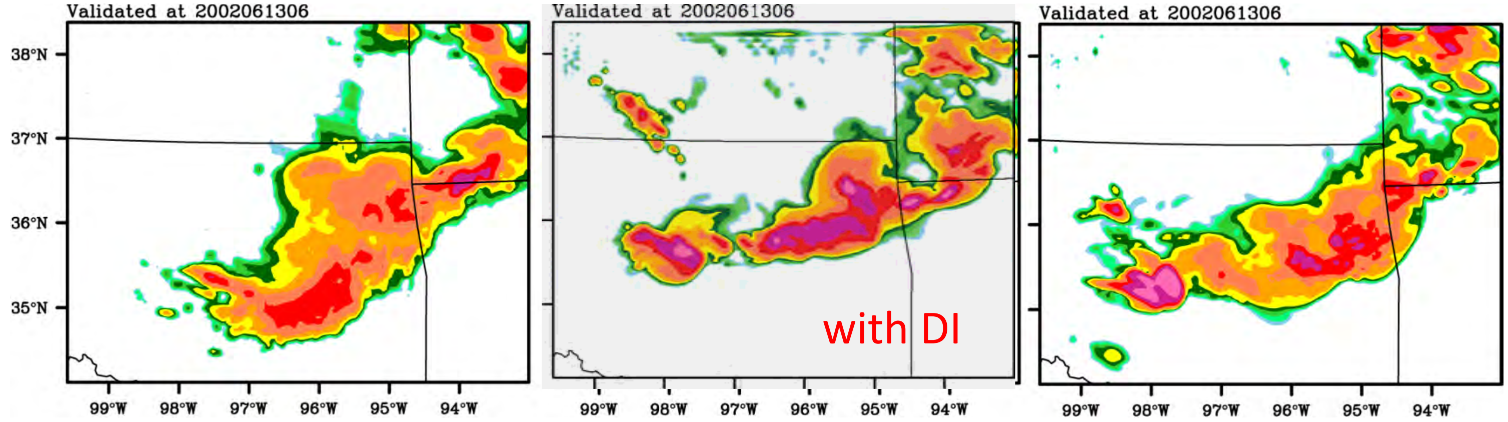
Wind increments (m/s) after assimilating a single T observation at model level 5

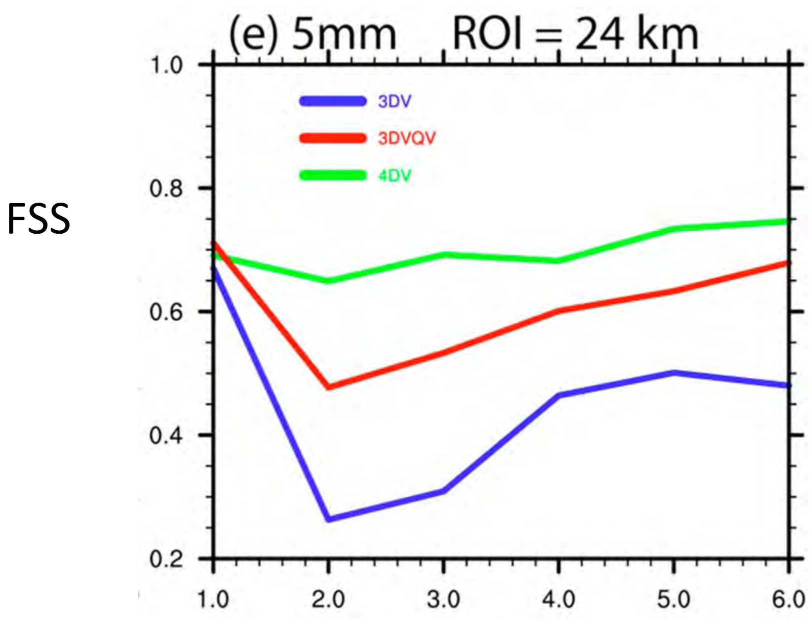
Case study of WRF 4D-Var radar DA for a US squall line

CV5 4km
6 outer loops with
20 iterations for each

6h fcst of 1h accum. rainfall

Obs | WRF 3DVar | WRF 4DVar





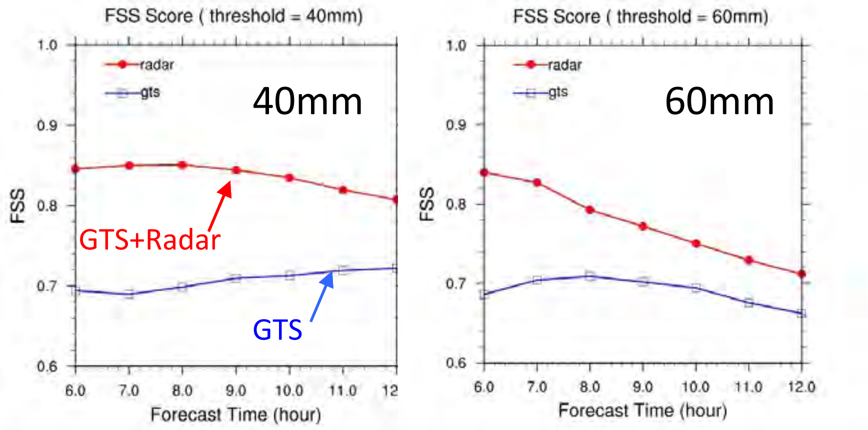
- ✦Diabatic initialization significantly improves the QPF
- ✦Compared with 4DVar, 3DVar produces a slower squall line and the precipitation amount is ove-predicted

Sun and Wang (2013)

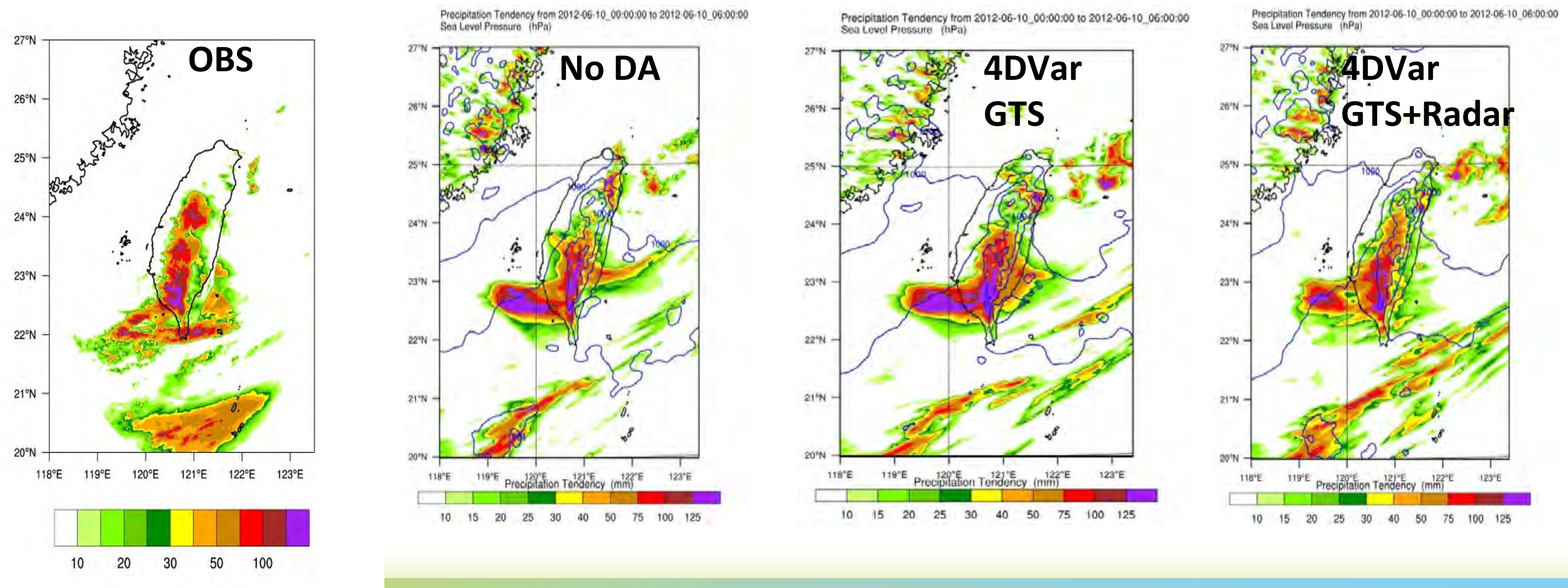
Radar data assimilation with WRFDA 4D-Var for a Meiyu case

Courtesy of Ying Zhang (NCAR)
CV7, 3KM

- 20 min assimilation window
- Assimilate radial velocity and reflectivity from 4 CWB operational radars
- 3 outer loops with 45 iterations each



6hr rainfall valid at 2012-06-10_06



METEOROLOGICAL SERVICE SINGAPORE
Centre for Climate Research Singapore

Summary

1. SINGV – A Tropical Convective-scale NWP system
2. Resolution and convection modelling
3. Tropical model error covariance and model balancing
4. Data assimilation