1. Introduction

- The 2009 El Niño event has ranked as one of the driest years in the past century for South and Southeast Asia (NCDC 2010). For the first time in the history of drought management, electricity and diesel fuel were supplied by the Indian government to increase irrigation (NRAA 2010) and China declared the worst drought in 60 years in the northern provinces (NCDC 2010).
- Accurate rainfall predictions are essential for efficient food production in these regions, which are strongly dependent on agriculture for consumption and export, especially during dry El Niño years such as 2002 and 2009 (NDMD 2004, Pai et al. 2009). The rapidly developing El Niños were accompanied by weakened and eastward shifted MJO activity.
- Previous results with the ECHAMS AGCM suggest a MJO related forecast skill for intraseasonal rainfall over India and Southeast Asia of more than 25 days (Liess et al. 2005).

3. ECHAMS and WRF: Model Hierarchy

- Two atmospheric models, ECHAMS and WRF/NOAH-LSM are included in this model hierarchy.
- ECHAMS is used in standard global configuration with T63 (1.9° x 1.9°) horizontal resolution and 31 vertical levels.
- WRF is run over the tropics between 20°S and 30°N with a 30 km (~0.25° x 0.25°) horizontal resolution and 38 vertical levels. It is coupled to the 5-surface-level Noah-LSM (Land Surface Model). This standard configuration is also used for daily, real-time weather forecasts.
- WRF modifications include the Grell three-dimensional ensemble cumulus scheme (Grell and Devenyi 2002) and a two-moment cloud microphysics scheme (Morrison et al. 2009).

4. WRF: Higher Resolution

- Figure 3: The July 1996 MJO also affected the monsoon trough, which produced typhoons Frank and Gloria, and super typhoon Herb, all of which made landfall over East and Southeast Asia.
- These typhoons can be simulated in the regional WRF model at 30km horizontal resolution, although the tropical variation (20°S-30°N) of the atmosphere-only WRF model simulates the location of typhoon centers 3-4 days earlier than observations, when forced with NCEP reanalysis data. This shows the importance of air-sea interaction.

5. Future Work

- Further improvements of MJO predictions, namely the representation of super cloud clusters over the Indian Ocean, the maritime continent and the western Pacific:
- Forcing high-resolution WRF forecasts with global ECHAMS predictions by nesting WRF into ECHAMS.
- Coupling to ocean models: ECHAMS/MIPI-OM and WRF/ROMS.
- Using a 1DVAR assimilation scheme in ECHAM5 to adjust simulated precipitation rates to observations during the spin-up period without violating constraints by the nudged prognostic variables and the model physics. This will be ensured by keeping temperature differences small with respect to the nudged background state.
- The 1DVAR scheme adjusts specific humidity to modify the simulated precipitation amounts.
- Observed rainfall will also be assimilated into WRF with an existing 3DVAR assimilation scheme.
- A multimodel ensemble forecast will be generated from the above model configurations.
- The breeding method (Liess et al. 2005) will be used to increase the number of ensemble members.

References