Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

AAS03-01 Room:301A Time:May 26 11:00-11:15

Short-term Climate Simulations of African Easterly Waves with a Global Mesoscale Model.

SHEN, Bo-wen[1*]

[1]San Diego State University

Recent high-resolution global model simulations (Shen et al., 2010a, 2010b, 2012; 2013), which were conducted to examine the role of multiscale processes associated with tropical waves in the predictability of mesoscale tropical cyclones (TCs), suggested that a large-scale system (e.g., tropical waves) can provide determinism on the prediction of TC genesis, making it possible to extend the lead time of genesis predictions. Selected cases include the relationship between (i) TC Nargis (2008) and an Equatorial Rossby wave; (ii) Hurricane Helene (2006) and an intensifying African Easterly Wave (AEW); (iii) Twin TCs (2002) and a mixed Rossby-gravity wave (e.g., Silva-Dias et al. 1983) during an active phase of the Madden Julian Oscillation (MJO; Madden and Julian, 1971); (iv) Hurricane Sandy (2012) and tropical waves during an active phase of the MJO. In this talk, thirty-day simulations with different model configurations are presented to examine the model's ability to simulate AEWs and MJOs and their association with tropical cyclogenesis.

I will first discuss the simulations of the initiation and propagation of 6 consecutive AEWs in late August 2006 and the mean state of the African easterly jet (AEJ) over both Africa and downstream in the tropical Atlantic. By comparing our simulations with NCEP analysis and NASA satellite data (e.g., TRMM), it is shown that the statistical characteristics of individual AEWs are realistically simulated with larger errors in the 5th and 6th AEWs. Remarkable simulations of a mean African Easterly Jet (AEJ) are also obtained. Results from the sensitivity experiments suggest the following: 1) accurate representations of non-linear interactions between the atmosphere and land processes are crucial for improving the simulations of the AEWs and the AEJ; 2) improved simulations of an individual AEW and its interaction with local environments (e.g., the Guinea Highlands) could provide determinism for hurricane formation downstream. Of interest is the potential to extend the lead time for predicting hurricane formation (e.g., a lead time of up to 22 days) as the 4th AEW is realistically simulated; 3) however, the dependence of AEW simulations on accurate dynamic and surface initial conditions and boundary conditions (such as different sea surface temperatures, SSTs) poses a challenge in simulating their modulation on hurricane activity. In addition to the simulations of AEWs, I will also present the 30-day simulations of selected MJO cases, which were performed in support of the Year of Tropical Convection (YOTC) project, to examine the excitation of MRG waves.

It has been suggested that accurate simulations of moist processes are crucial for improving tropical weather systems (e.g., MJOs and TCs). Compared to coarse-resolution simulations, high-resolution simulations may produce excessive precipitations, leading more chaotic responses. The role of resolved heating-induced small-scale processes in system's stability (or predictability) is discussed with higher-order Lorenz models (LMs) as well as the original LM with a parameterized dissipation term (Shen 2014a,b). I will then compare the thermodynamic feedback in the nonlinear LMs with that in the column-based cumulus parameterization. In addition to the results from the global model and LMs, I will briefly discuss the performance of multiscale analysis tools (i.e., the parallel ensemble mode decomposition method) in revealing the multiscale processes during the TC formation associated with tropical waves.

Keywords: Global Mesoscale Model, Multiscale Interaction, Tropical Cyclogenesis, African Easterly Wave, Madden Julian Oscillation, Predictability

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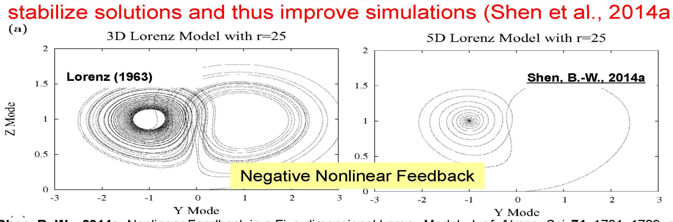
Are the Simulations of TC genesis Consistent with Chaos Theory?

- The butterfly effect of first kind: *sensitive dependence on initial conditions*.
- The butterfly effect of second kind: *a metaphor (or symbol) for indicating that small perturbations can alter large-scale structure*.
- Lorenz's studies suggested finite predictability and nonlinearity as the source of chaos.
- Increased degree of nonlinearity (e.g., multiscale interactions) can stabilize solutions and thus improve simulations (Shen et al., 2014a,b).



Shen, B.-W., 2014a: Nonlinear Feedback in a Five-dimensional Lorenz Model. *J. of Atmos. Sci.* **71**, 1701–1723. doi: http://dx.doi.org/10.1175/JAS-D-13-0223.1

AAS03-02 Room:301A Time:May 26 11:15-11:30

Assimilation experiment by using localizations considering horizontal scale of error correlation in rainfall area

OIGAWA, Masanori[1*] ; TSUDA, Toshitaka[1] ; SEKO, Hiromu[2] ; SHOJI, Yoshinori[2] ; SATO, Kazutoshi[3] ; REALINI, Eugenio[4]

[1]Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Japan, [2]Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA), Japan, [3]Japan Aerospace Exploration Agency (JAXA), Japan, [4]Geomatics Research & Development (GReD), Italy

In ensemble Kalman filter, localization is used to remove spurious error correlations between distant locations which are derived from limited ensemble size. We should use optimum localization radii by considering spatial scales of error correlations which differ depending on phenomena. Aonashi (2011) reported that horizontal scale of error correlations in precipitating region is smaller than that in non-precipitating region and dual scale sampling error damping by spectral localization is useful. However, effects of using smaller localization radius for precipitating regions have not been studied yet in a method of observation localization. The objective of this study is to investigate its effect on a simulation of rainfall distribution by using LETKF (Local Ensemble Transform Kalman Filter).

JMA-NHM (Japan Meteorological Agency Non-Hydrostatic Model) (Saito et al., 2007) and a nested NHM-LETKF system (Seko et al., 2013) which consists of outer (15 km grid) and inner (1.875 km grid) LETKFs were used. We targeted to reproduce rain bands which caused Uji heavy rainfall on 13-14 August 2012. GPS derived PWV (precipitable water vapor) data observed by our hyper-dense network installed in Uji with 1 km resolution (Sato et al., 2013) and GPS receivers of GEONET (GPS Earth Observation NETwork) were assimilated. Intense precipitating areas where rain rates are more than 10 mm/h were detected from radar data. We adopted 1 grid scale of localization radius for intense precipitating region and 5 grid scale for the other regions in inner LETKF. RMSEs of 1 hour rainfall of first guess averaged around rain band were calculated for 8 cycles of inner LETKF.

As a result of using smaller localization radius for intense precipitating area, RMSE became smaller in 5 cycles and became large only in 1 cycle. In 8th cycle when intensity of the rain band was at its peak, RMSE was improved about 10%.

Keywords: GPS derived PWV, Data assimilation, LETKF, Localization

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High resolution WRF downscaling of the SINTEX-F1 CGCM seasonal forecasts over the Kanto region

JAYANTHI, Venkata ratnam[1*] ; BEHERA, Swadhin kumar[1] ; DOI, Takeshi[1] ; OETLLI, Pascal[1] ; YAMAGATA, Toshio[1]

[1]Application Laboratory, JAMSTEC, Japan

The Weather Research and Forecasting (WRF) regional model is used to downscale an ensemble of the SINTEX-F1 generated seasonal forecasts over the Kanto region. WRF model with three two-way interacting domains at horizontal resolutions of 27km, 9km and 3 km and 30 vertical levels is used for the downscaling. The cloud resolving WRF models ability to reproduce the climate of the Kanto region was initially tested by making the model simulation with ERA-Interim reanalysis data as the boundary conditions. Comparing the WRF model simulated precipitation and temperature with the AMeDAS observed precipitation and temperature data showed that the model could realistically capture the variations of the parameters from seasonal to diurnal time scales.

Comparing the SINTEX-F1 downscaled forecasts of the last few years with the AMeDAS observed data shows that the WRF model improves the spatial and temporal distribution of the precipitation and temperature over the Kanto region with respect to the SINTEX-F1 forecasts. The improvements in the WRF forecasts are seen to be due to better representation of the orography over the Kanto region.

Keywords: WRF, SINTEX-F1, Seasonal Forecast

AAS03-04 Room:301A Time:May 26 11:45-12:00

Stochastic analysis of spatio-temporal variations of high-resolution GNSS wet delays for meteorological applications

REGUZZONI, Ivan[1] ; FERMI, Alessandro[1] ; REALINI, Eugenio[2*] ; VENUTI, Giovanna[1] ; OIGAWA, Masanori[3] ; TSUDA, Toshitaka[3]

[1]Geomatics and Earth Observations laboratory, Politecnico di Milano, Italy, [2]Geomatics Research & Development (GReD) srl, Italy, [3]Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Japan

Although designed for positioning purposes, the Global Navigation Satellite System (GNSS) can be also exploited for atmospheric sounding and in particular for troposphere water vapor content monitoring. The water vapor content in fact reflects in a GNSS signal delay, which can be evaluated in terms of Zenith Wet Delay (ZWD). This is an average parameter accounting for delays affecting the signals arriving to a GNSS receiver from all satellites in view.

The modeling of water vapor variations in space and time is still a challenging research topic: since it is difficult to characterize it in a deterministic way, stochastic approaches are often preferred; moreover, the turbulent behavior demands a high-resolution sampling both in time and space.

ZWDs derived from regional permanent GNSS networks result in high-rate time series, but the space resolution is still too loose for reconstructing the turbulent component of the water vapor content. Possible solutions can be envisaged from the coupling of GNSS with radar or SAR products or by the possibility to densify existing networks by exploiting low-cost GNSS receivers designed in view of meteorological applications.

With the aim of assessing the potential use of GNSS observations for this purpose, a network of 17 dual-frequency receivers, installed near the Uji campus of Kyoto University, Japan, was used. The network covers an area of about 10×6 km^2 and inter-station distances range between 1 and 2 km. All receivers are identical and observe GPS, GLONASS and QZSS at 1 Hz. Weather stations are installed within the network, measuring ground pressure and temperature for accurate ZWD and precipitable water vapor (PWV) retrieval.

In this work we exploit ZWDs derived by Precise Point Positioning (PPP) on observations of this network, which were extensively validated in previous studies by comparison with independent measurements by radiosondes and microwave radiometers.

The delay at a given epoch is modeled as a homogeneous random field. The estimated values, properly reduced to account for the height-dependent component, are used epoch-by-epoch to determine isotropic and anisotropic variograms, describing the spatial correlation of the ZWDs themselves.

In order to investigate the relationship between these second order statistics, rain-gauge observations and radar-derived precipitation values, an ad-hoc software tool was developed, able to compare all these data types.

From this comparison it results that meteorological atmospheric instabilities, associated to precipitation, reflect in specific behaviours of the ZWD variograms.

Directional variograms enhance a clear azimuth-dependent signature, consistent with the main direction of movement of precipitation clouds detected by radar.

Encouraged by these results, we start exploring the joint temporal and spatial variability of the ZWD field. On-going research activities on this subject, and specifically on the estimation of average wind velocities based on the frozen flow hypothesis will also be presented.

Keywords: GNSS, troposphere, zenith wet delay, covariance