Mesoscale Analysis for Typhoon Sinlaku (2008) and Morakot(2009) by using the three-dimensional Space-Time Mesoscale Analysis System (STMAS3D)

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Abstract

This paper presents the current result of the three-dimensional Space-Time Mesoscale Analysis System (STMAS) that developed at NOAA/GSD/FSL. The development of STMAS began in the spring of 2004 and it is not yet complete. Currently, not only the conventional observations such as surface observations (SYNOP, METAR, SHIP, BUOY, CUM, AGR, MSO), sounding and ACAR are assimilated into the system, but also adding the radial velocity of radar observation operator in the system.

Two typhoon cases are selected for the studies, Typhoon Sinlaku (2008) and Morakot (2009). The result shows that the STMAS are able to capture the mesoscale features and adjust the background field from the benefit of observations. That provides a fine gridded analysis of observations and re-constructs the initial condition for model simulations.

Key word: STMAS3D, data assimilation

1. Introduction

A sequential variational analysis system was implemented at Forecast Systems Laboratory (FSL) of ESRL/GSD which utilizing spatial and temporal information called Space and Time Mesoscale Analysis System (STMAS). The STMAS is one of the analysis component under the framework LAPS (The Local Analysis and Prediction System) Figure 1 which is a 3DVAR analysis scheme ($\min \frac{1}{2}(x-x^b)^T B^{-1}(x-x^b) + \frac{1}{2}(Hx-y)^T O^{-1}(Hx-y)$), where x^b is the background field, y is observation, B is the background covariance, O is the observation error covariance, and H is the operator mapping grid values to observations) with the capability of assimilating non-conventional observations such as radar and satellite.

Different from other single 3DVAR, STMAS uses a sequence of 3DVAR to derive its final analysis. The basic idea is to iterate through different scales from large to small that it can control the analysis scales at each of its iterations. This approach allow the ability to handle the non-linearity of analyzed field which cannot be done by one single 3DVAR and sustain features with typical mesoscale structure. It can effectively retrieve the deterministic information from observations at its initial sequence of variational analyses. After obtaining the resolvable information, it naturally reduces to a standard statistical variational analysis, such as 3DVAR or 4DVAR.

The full three-dimensional space analysis of STMAS is implemented using a multigrid technique. The multigrid implementation uses the number of grid points to control the analysis scales. For a given number of grid points over a given domain, only limited wave scales can be resolved. The more grid points there are, the smaller the scales that can be resolved. Therefore, a multigrid implementation of STMAS initially uses a smaller number of grid points in each spatial and temporal direction. This allows resolution of only the long waves in its analysis. In each following sequence of analyses, the number of grid points is doubled uniformly until the grid distance reaches a minimum that the observations provide no further information at smaller scales. Adding all of the sequence of analyses together derives the STMAS final analysis. Moreover, it is a sequential variational analysis that it can use proper balance and physical constraints at different analysis sequences, for example, applying geostrophic balance at large scale analyses and use a mesoscale numerical prediction model as constraints at relatively small scale analyses like a 4DVAR.

The 9km horizontal and 50mb vertical resolution of STMAS 3D analysis of Two Typhoon cases Sinlaku (2008) and Morakot (2009) are presented at here. Current configuration of CWB domain on NOAA/GSD/FSL is: 153*141*21 gird, 3hrs time window; 15km NFS background field and ingest surface, sounding, aircraft, radar observations. The analysis variables are U, V wind component, temperature and specific humidity.

2. STMAS 3D Analysis

(a) Typhoon Sinlaku (2008)

The impact of dropwindsondes and QSCAT observations on wind analysis are examined. With the benefit of the high observations density, a fine gridded wind analysis is conducted and the results show a great impact on the analysis variable U and V. A large wind increment (difference of background and analysis) is show at Figure 2 that a great adjustment on the background wind field. The result also indicated the asymmetric wind structure of the typhoon and outer circulation.

(b) Typhoon Morakot (2009)

Figure 3 show the 1000mb background wind field and STMAS 3D wind analysis for Typhoon Morakot at 07 AUG 1800UTC. A large and persistent (about 18 hours) low level convergence region is existed at the southwest of Taiwan on the STMAS 3D analysis while the background fields are not able to capture the phenomenon. This convergence line help to understand the exceptionally high rainfall on the central and southern part of Taiwan during the landfall period.are trying to make an example of papers' format in English mode.

3. Summary

Two typhoon cases are examined at this studies Typhoon Sinalku (2008) and Morakot(2009). The wind analysis shows that STMAS 3D are able to capture the mesoscale features and adjust the coarse background field from the benefit of different kind of observations (surface, radar, sounding, satellite etc…). The results help to understanding the structure of typhoon and the interaction with terrain.

Reference

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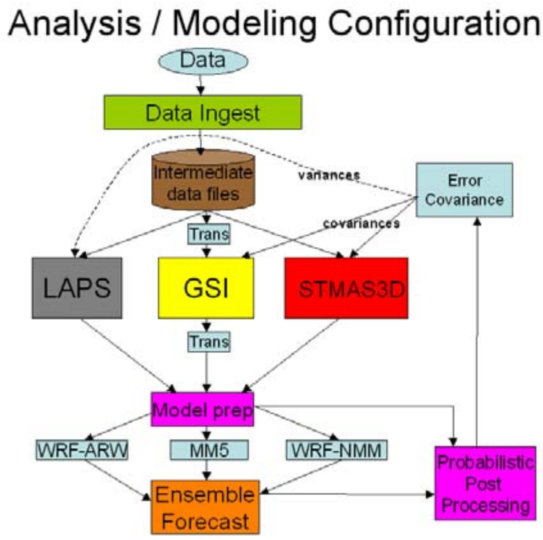


Figure 1. The frameworks of analysis and forecast systems at ESRL/GSD/FSL.

(a) (b) (c)

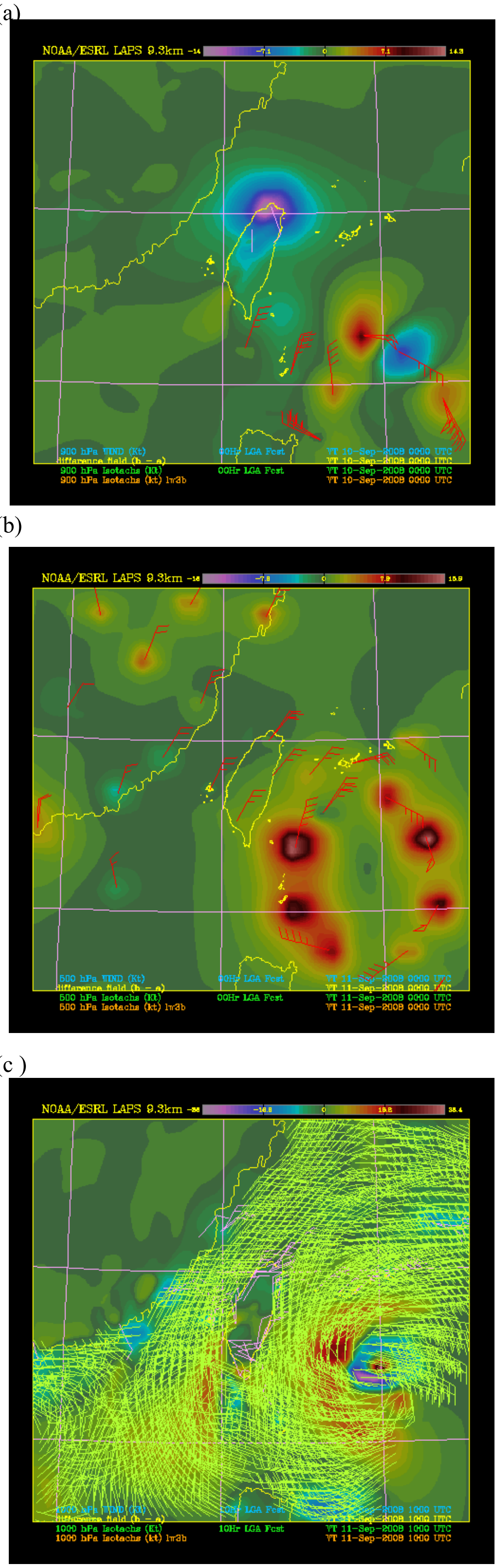
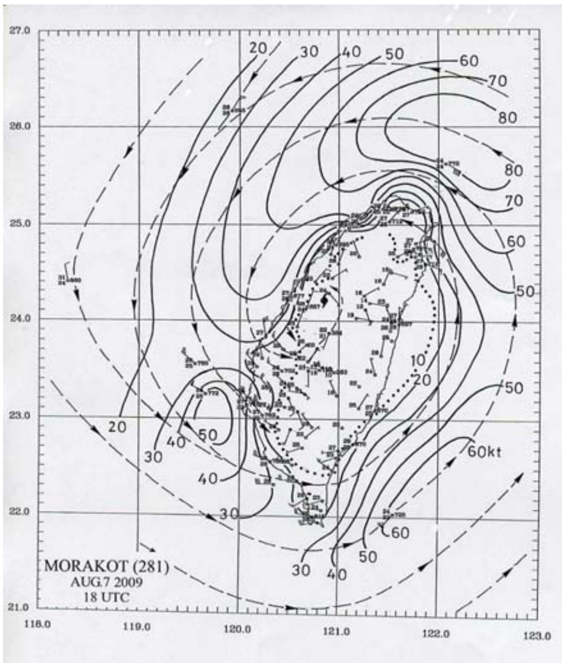


Figure 2 The STMAS3D wind analysis with superimpose (a) and (b) dropwindsnode and (c) QSCAT observation.

(a)



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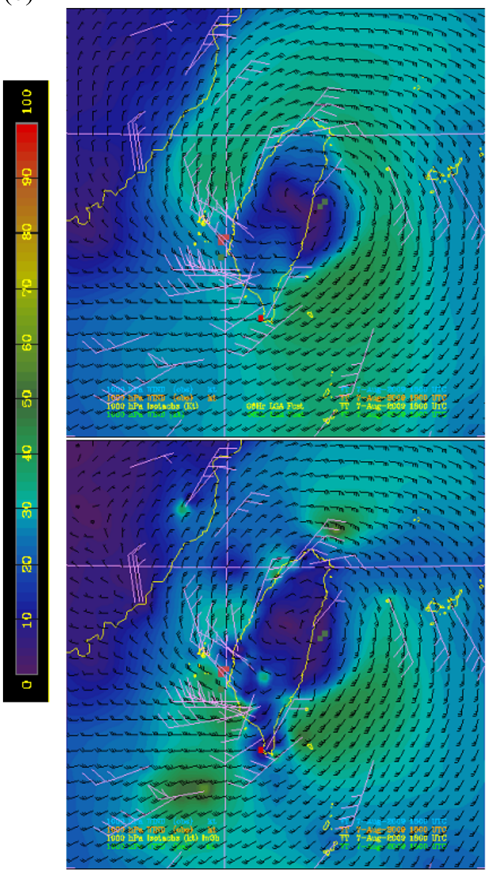

Figure 3. Surface wind field analysis (a) from CWB (b) background and (c) STMA3D .