The development of Semi-Lagrangian Semi-Implicit Global Forecast model of the Taiwan Central Weather Bureau

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CWB have been developed NWP system since 1984. The second generation global forecast model was a spectrum model and operational in 1994. Base on this model, we are developing the third generation operational model which the dynamic core is semi-Lagrangian.

1. Brief description of the current CWBGFS.
2. New HPC in CWB.
3. Plan and on going development of CWBGFS.
4. The performance of current CWBGFS.
5. The equations and numerical scheme used in SLSI model.
6. The result of Solid body rotation test: Crosse north and south pole.
7. Example of primitive equation model.
8. PI chart of spectrum and SLSI model.
Brief description of numerical scheme in SLSI

- Departure point (traditional iteration method)
  \[
  \alpha^{(k+1)} = \Delta t V \left[ x - \alpha^{(k)}, t \right]
  \]
  Linear interpolation are used to find the trajectory


Welcome to see my poster
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Abstract

The current Taiwan Central Weather Bureau operational Global Forecast System (CWBGFS) is T319L40 spectral model in which the horizontal resolution is about 37 km and the vertical 40 layers in sigma coordinate. From 2012 to 2014, the Central Weather Bureau installs a new Peta-Scale high performance computer, the Fujitsu PFX10. Based on this new high performance computer, the CWBGFS is going to increase the horizontal and vertical resolution from current T319L40 to T511L60. Moreover, the vertical coordinate will use sigma-pressure hybrid coordinate instead of sigma coordinate, and the model top layer will be raised from 1 hPa to 0.1 hPa.

For the accommodation the computation of the increasing resolution, we are developing the Semi-Lagrangian Semi-Implicit (SLSI) Scheme in CWBGFS. The characteristics of this SLSI model are: (1) the virtual potential temperature is conserved in thermodynamic equation; (2) using the cascade method (Purser and Leslie, 1992) as the interpolation scheme in variables. The idealized test, the solid body rotation experiment, shows that the shape and amplitude of the mass field passing the North/South pole will be kept well.

Current Global Forecast System (GFS) of CWB

- Data assimilation module: 3-D Var. GSI (Gridpoint Statistical Interpolation scheme)
- Model dynamic:
  1. T319L40 (24km) - sigma - model top: 1 hPa (2011)
  2. T511L60 (25km) - sigma-pressure hybrid - model top: 1 hPa
- Fujiren typhoon (typhoon relocation)

Physical Parameterization:
2. Surface flux Parm.: Miyakoda and Satutis (1986)
4. Orographic Gravity wave parm. : Palmer et al. (1986)
5. Canopy Parm. : KAS (Pan and Wu (1997))
7. Large scale precipitation Parm.: Zhao and Frederick (1997)
9. Rayleigh-friction on UV in stratosphere

SLSI equations and interpolation scheme

<table>
<thead>
<tr>
<th>Level</th>
<th>Variable</th>
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<tbody>
<tr>
<td>1/2</td>
<td>( \Delta \theta ), etc.</td>
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<tr>
<td>( \Delta \theta )</td>
<td>( \frac{1}{2} \sum \frac{\partial \Delta \theta}{\partial t} - \frac{\partial u}{\partial x} \Delta \theta - \frac{\partial v}{\partial y} \Delta \theta</td>
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Level 1/2:
- Finding the departure point:
  \( \Delta \theta = \frac{1}{2} \left[ \Delta \theta \right] + \Delta \theta \Delta \theta 
- Linear interpolation are used to find the trajectory.
- Variables Interpolation: apply Casside method/Purser and Leslie (1994) on sphere with online interpolation scheme.

Solid Body Rotation Test- Crossing South Pole

Solid Body Rotation Test- Crossing North Pole

Performance of current operational CWBGFS

- Day 5, 600hPa H AC - N Hemisphere

Example of Semi-Lagrangian model TL768L60

FIG 1. Anomaly Correction of 500hPa on day 5 forecast of operational CWBGFS in North Hemisphere from 1999 to 2013.

FIG 2. The example 5 day forecast of the sea level pressure with Semi-Lagrangian Semi-Implicit model TL768L60. The initial time is 2012-06-18 00Z with 24 hour interval forecast output (left and middle penal). The right penal is the verification of 24, 48 and 72 hours forecast.

Plan & On-Going Development of CWBGFS

1. Data assimilation
   - Develop a new hybrid data assimilation system (2013-2015)
2. Forecast model
   - Upgrade to T511L60 (25km, 2014)
   - Improve physical parameterization
     - Fresh Leaf Surface model (Kotw 2005), NOAA (Pan and Wu, 2015)
     - RTM
     - GCM
     - Surface Physics
     - Atmosphere gravity wave drag (Diazomir, 2012)
4. Developing a typhoon model for track prediction (autumn 2013-2015)
5. Developing a global marine forecast system (2015-2020)
7. Develop a semi-implicit model base on CWBGFS (2015-2020)

Performance of current operational CWBGFS

- Day 5, 600hPa H AC - N Hemisphere

Pi Chart of spectrum & semi-Lagrangian model

CWB SLSI TL768L60 120 hours/fut
24 nodes; 12 MPI task + 16 OpenMP threads

CWB SLSI TL768L60 120 hours/fut/24 nodes; 24 MPI tasks + 16 OpenMP threads

FIG 1. 5 days sea level pressure with Semi-Lagrangian Semi-Implicit model TL768L60. The initial time is 2012-06-18 00Z with 24 hour interval forecast output (left and middle penal). The right penal is the verification of 24, 48 and 72 hours forecast.