The CWB Monthly and Seasonal Climate Forecast Systems

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CWB NWP GFS modeling team:
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• Taiwan population (23 M) ~ 2/3 of California area (36,188 km²) ~ 1/12 of California

• Taiwan is an area at high risk for natural disaster in the world. 99% of land and population is exposed to two or more natural hazards. – Global Risk Analysis (World Bank)

• The most happening natural disasters: typhoon, flood, land slide, drought, earthquake
Monthly and Seasonal Climate Forecast – extended development from NWP

1983
Beginning of the NWP era at CWB

1988
First generation GFS Grid-point & L9 operational <Gird-point 2.5 x 2.5>

1994
Second generation GFS T79L18 operational <Spectral T79 (~1.5°)>

1998
Second generation GFS T119L18 operational <T119 (~1°)>

2002
Beginning of the development of multi-model multi-member ensemble Climate Forecast System at CWB  <2-tier, T42L18, AGCM: ECHAM5 & CWBGFS, SST: CWB-OPGSST & NCEP-CFSv1>

2003
Second generation GFS T179L30 operational <T179 (<1°)>

2007
Second generation GFS T239L30 operational <T249 (~0.5°)>

2009
First generation CWB 2-tier CFSv1 operational <40 members, fcst: 0-7 mo>

2010
Developing the Second generation 2-tier CFS and First generation 1-tier CFS  <2-tier, T119L40, AGCM: ECHAM5 & CWBGFS & NCEP-CFSv2, SST: CWB-OPGSST & NCEP-CFSv2>

2015
Second generation 2-tier CFS operational, CWB 1-tier CFSv1 quasi-operational
CWB OPGSST

Statistical Model (SVD)

Damping Persistent

Multi-model Ensemble Prediction System

Simplified Dynamical Coupled Air-Sea Models (ICM2a, ICM2b)

SST Forecast 60°S-60°N

NINO 3.4

SLP

OHC
AGCM: CWBGFS and ECHAM5

**CWBGFS: T42L18** (Hwu et al., 2002)
- Radiation: Harshvardhan et al. (1987)
- Cumulus: relax Arakawa-Schubert scheme (Moothi and Suarez 1992)
- Large scale precipitation: RH=100%
- Shallow convection: Li (1994)
- Vertical turbulence mixing: TKE-ε scheme (Detering and Etling 1985)
- Surface flux: similarity theory (Businger 1971)
- Soil model: two layer soil model (Mahrt and Pan 1984)
- Gravity wave drag: Palmer et al. (1986)

**ECHAM5: T42L19** (Roeckner et al., 2003)
- Radiation: Shortwave Fouquart and Bonnel (1980); Longwave Mlawer et al. (1997)
- Cumulus: Tiedtke (1989) with modifications of Nordeng (1994) for penetrative convection
- Grid-scale precipitation: Tmopkins (2002)
- Vertical turbulence mixing and surface flux: similarity theory
- Subgrid scale orography parameterization: Lott and Miller (1997) and Lott (1997)
- Gravity wave drag: Hines (1991a, b, c, 1993)
Dynamical Downscaling

IRI-ECHAM4.5 (T42) forecasts with forecast SST (15)

CWB-RSM (60km) (15)

NCEP-RSM (60km) (15)

Ensemble mean forecast (30)

Anomaly forecast (30)

Probability forecast (30)

PCP/MSLP/W850 200804 RCMs MAY

PCP_anomaly 200804 to MAY

PCP

N37% N40% N60%

A57% A40% A60%
<table>
<thead>
<tr>
<th>Data Used</th>
<th>Link</th>
<th>Variables</th>
<th>Frequency (/ month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAWCR Ocean</td>
<td><a href="">ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/MT.cfs_MR.fcst</a></td>
<td>14 layer ocean temperature data</td>
<td>1</td>
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<tr>
<td>NCEP CFSv1 SST</td>
<td><a href="">ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/MT.cfs_MR.fcst</a></td>
<td>Sea surface temperature</td>
<td>once a day</td>
</tr>
</tbody>
</table>
Operational Forecast Schedule

LEAD MONTH

DATE 14

LEAD-0

22 23 24 25 26 27 28 29 30 31

12 13 14

LEAD-1

01 02 03 04 05

OPGSST FORECAST

CFS SST ENSEMBLE

4 member run for 22th 12Z

4 member run for 23th 12Z

40-member ensemble

forecast result

• IC: last 10 days of lead0 from NCEP/GDAS.
• 4 members run in all IC+2 days (GFS/OPGSST, GFS/CFS, ECHAM/OPGSST, ECHAM/CFS) with 7 months forecasting.
• Each member need about 40 minutes for model running and another 30 minutes for post process.
Retrospective Forecast Data Base

- Background Statistics -

- 25 years: 1981-2005
- 40 forecasts per calendar month
- Each forecast predicts 9 months

Forecast Skill Evaluation

- Pattern Anomaly Correlation
- Temporal Correlation
- Mean Square Skill Score
- Gerrity Skill Score
- ROC
- Relative Diagram
CWB 2-T CFSv1 FORECAST PRODUCTS

• Global SST (60°S~ 60°N)
  issuing frequency: 1 time/month
  lead time: 0-7 months
  product format: monthly, seasonal

• Global Temperature, Precipitation
  issuing frequency: 1 time/month
  lead time: 0-7 months
  product format: monthly, seasonal

• Taiwan Temperature, Precipitation
  (downscaled to 9 stations)
  issuing frequency: 1 time/month
  lead time: 0-7 months
  product format: monthly, seasonal
  (dynamical downscaling – downscaled to 4 regions)
  issuing frequency: 1 time/month
  lead time: 0-4 months
  product format: monthly, seasonal

Calibration Basis ~
CWB 2-tier CFS Hindcast/Forecast Data Base:
1981-present daily outputs at standard pressure levels
Observation: Jul 2011 (lead 0)

Forecast~ Sep 2011

Forecast~ Oct 2011

Forecast~ Nov 2011
Precip Rate: Jul 2011 (lead 0)

Rainfall Anomaly

Forecast~ Sep 2011

Forecast~ Oct 2011

Forecast~ Nov 2011
Statistically Downscaled
Taiwan Rainfall Anomaly

Above — red
Normal — yellow
Below — blue
Statistically Downscaled Taiwan Temperature Anomaly

Above — red
Normal — yellow
Below — blue

201108Sep Station Temperature

201108Oct Station Temperature

201108Nov Station Temperature
The Monthly-to-Seasonal Climate Forecast System Development (II)

2010~2015
• **CWB CFS Improvement/Development**

- **Move toward a seamless forecast system** – use a lower-resolution version of NWP operational AGCM for monthly-to-seasonal forecast
  
  NWP: T319L40
  CWB 2-T CFSv2: T119L40

- **Update forecast initial condition** – use CFSR

- **Improve MME strategy** – include NCEP CFSv2 forecasts in CWB 2-tire CFSv2 (feasibility?)

- **Develop a one-tier climate forecast system** – replace the AGCM in NCEP CFSv1 by CWB’s AGCM (collaborator - NCU)
  
  CWB 1-T CFSv1: T119L40+MOM3
<table>
<thead>
<tr>
<th>Attribute</th>
<th>T119L40</th>
<th>T42L18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulus Convection Parameterization</td>
<td>Simplified Arakawa-Schubert (Pan and Wu 1995)</td>
<td>Relax Arakawa-Schubert scheme (Moothi and Suarez 1992)</td>
</tr>
<tr>
<td>Grid-scale Precipitation</td>
<td>Predict could water scheme (Zhao and Frederick 1997)</td>
<td>Diagnostic method (RH value)</td>
</tr>
<tr>
<td>Shallow Cumulus Convection</td>
<td>Li and Young (1993)</td>
<td>Li (1994)</td>
</tr>
<tr>
<td>Boundary-layer Parameterization</td>
<td>First-order nonlocal scheme (Troen and Mahrt 1986)</td>
<td>TKE-(\varepsilon) scheme (Detering and Etling 1985)</td>
</tr>
<tr>
<td>Land Model</td>
<td>NOAH (Ek et. al. 2003)</td>
<td>Bucket method (Manebe 1969)</td>
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<tr>
<td>Surface-layer Parameterization</td>
<td>Similarity theory (Businger 1971)</td>
<td>Similarity theory (Businger 1971)</td>
</tr>
<tr>
<td>Gravity wave drag</td>
<td>Palmer et al. (1986)</td>
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</table>
CWB 2-T CFSv2 Development & Data Requirements

- CWB OPGSSTv2 ready
- SDS strategy decided
- I.D.C. (MJJ) - ready for Summer hindcast
- T119L40 50-yr AMIP evaluation
- Initial data collection (I.D.C.) (DJF) - ready for Spring hindcast 1981-2010

- CFSv2 Reforecast (initial: DJF) data collection 1979-2009
- I.D.C. (ASO) - ready for Fall&Winter hindcast 1981-2010

- Summer (I.C.-MJJ) hindcast & SDS 1981-2010 evaluation
- MME strategy decided
- Spring (I.C.-DJF) hindcast & SDS 1981-2010 evaluation
- Fall&Winter (I.C.-ASO) hindcast & SDS 1981-2010 evaluation

- CFSv2 Reforecast (initial: MJJ, ASO, MA, N) data collection 1979-2009
- MME Forecast Spring (I.C.-DJF) hindcast evaluation

CWB 2-T CFSv2 Ready for Operational

- Initial Data Collection Complete
- MME Forecast Spring (I.C.-DJF) hindcast evaluation

- CWB 2-T CFSv2 Ready for Operational

- CFSv2 Reforecast Data Collection Complete
CWB would like to use the Archived Reanalysis (CFSR) data (1981-2010) for building the reforecast data base of CWB 2-Tier CFSv2.

CWB plans to start the reforecast runs in 2012 and to complete the 30-year reforecast in early 2014.

CWB would like to get NCEP CFSv2 Reforecast (CFSRR) data for forecast comparison and MME forecast system development for both monthly-to-seasonal and 2nd week forecasts.

The Reforecast data of interest are 36 members per month with selective fields. The 36 members consist of 12 members of 9 month runs and 24 members of 45 days runs.
Archive (Real time) Requirement:

- CWB would like to use the Real Time analysis data, consistent with CFSR, as the initial condition for the operational runs of CWB 2-Tier CFSv2.
- CWB would like to use the Real Time forecast data, consistent with CFSRR, as members of CWB MME forecast system.

NOMADS Requirement:
For the aforementioned purposes, CWB will need the following help from NOMADS.
1) The ftp option and inventory files for “Climate Forecast System Initial Conditions” at http://nomads.ncdc.noaa.gov/data.php?name=access#cfsr
2) The ftp option and inventory files for “Hourly, Pressure, Fluxes, and Ocean Data” under “Climate Forecast System Reanalysis” at http://nomads.ncdc.noaa.gov/data.php?name=access#cfsr
THANK YOU
<table>
<thead>
<tr>
<th>Process</th>
<th>CWB 2-tier CFSv1</th>
<th>CWB DDFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Obs. Data</td>
<td>NCEP Analysis - ① GDAS ② R1; ③ OI SST</td>
<td>IRI Global Forecast (15 members)</td>
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<tr>
<td>Sfc. &amp; Atmosphere</td>
<td></td>
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<tr>
<td>SST Forcing</td>
<td>① NCEP CFSv1 SST</td>
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<tr>
<td></td>
<td>② CWB OPGSST</td>
<td></td>
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<tr>
<td>Input Data Pre-process</td>
<td>data interpolation &amp; initialization (hydrostatic adjustment ECHAM)</td>
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<tr>
<td>Global Forecast</td>
<td>① CWB-GFS/NCEP-SST ② CWB-GFS/OPGSST ③ ECHAM5/NCEP-SST ④ ECHAM5/OPGSST 10x4=40 members</td>
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<tr>
<td>Regional Downscaling</td>
<td>SVD-based downscaling to 9 Taiwan stations</td>
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<tr>
<td>Forecast Result</td>
<td>• ensemble mean • anomalies • tercile category</td>
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<td>Post-process</td>
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<td>Final Forecast</td>
<td>• ensemble mean • anomalies • tercile category</td>
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<td>Products</td>
<td>③ T, Prcip. - • ensemble mean • anomalies • tercile category</td>
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<tr>
<td></td>
<td>④ Large-scale SLP, U,V,T,Z - • ensemble mean • anomalies</td>
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