Ultra-High Resolution AgMet Information from Seeding to Harvesting

- seamless data for prospect estimation of crop yields -

Feb. 13, 2017

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850hPa Temperature Prediction for MAM 2017

Anomaly Prediction

- MAR 2017
- APR 2017
- MAY 2017
- MAM 2017

Probability Prediction

- MAR 2017
- APR 2017
- MAY 2017
- MAM 2017

Legend:
-1.0σ - 0.5σ - 0.25σ  0.5σ  1.0σ

0 60 80
Precipitation Prediction for MAM 2017

Anomaly Prediction
Total Precipitation of ICON(40 km) for Korea

Probability Prediction
Total Precipitation of ICON(40 km) for Korea
1. Agrometeorology Federation in Korea

- High Resolution Weather & Climate Data
- Prevention of Harmful Insects
- Prophylaxis for Urban Flooding
- Agricultural Ecology
- Water Resource Management
- Crop Modeling
- Super-high Speed Network Infrastructure
Introduction

- **Seamless** AgMet data from past to future
- **Nano-scale** AgMet data from past to future
Nano-Weather System

PKNU ICON Global Model
10 days forecasting & nowcasting
20/10 km

Observations

QTM, QPM, QWM
< 1.0 km

Temperature, Precipitation (~ 10 m)

Surface Wind field (~ 10 m)

Urban Flooding Model

Storm Surge Model

Ocean Model
(Air-Sea interaction)

Nano-Weather
Earth Surface
= \(2\pi R^2\)
= \(2 \times 3.14 \times 6350 \times 6350\)
= \(2.53 \times 10^8\) km²

1 km² = 4 x 10⁻⁹ Earth’s Surface

- Objectives for Disaster Prevention
  - 10 day forecast (every week)
  - Typhoon prediction
  - Quantitative Precipitation Forecast
  - Yellow sand prediction

- Climate Prediction Objectives
  1. Seasonal prediction with Ensemble experiments
  2. AMIP
  3. Global Warming Scenario production
Seamless Full-spectrum Weather & Climate Information

- Past, present and future

**Major Components**

- **Nano-scale (∼10m)** Recover Temp., Prec., & Wind for Ungauged Sites
- **Ultra-High Resolution Global Prediction System (∼20 km)**
- **Nano-scale (∼10 m)** Prediction for Limited Target Area

**한글 정보**

- 미관측 지점의 기온, 강수, 바람 자료 복원
  Nano-scale (∼10m) Recover Temp., Prec., & Wind for Ungauged Sites
- 高해상도 (20 km) 전지구 모델
  Ultra-High Resolution Global Prediction System (∼20 km)
- 초고해상도 (∼10 m) 예측 모델
  Nano-scale (∼10m) Prediction for Limited Target Area
Landslide at Mt. Woomyen in Seoul (2011.7.27)
4. Syn. Prec. data

- **CASE 3**: moderate rainfall (Ty. Meari) : max. R 38 mm/h (2011.6.29-30)

  **Observation**: 41 point
  **Synthetic Precipitation Data**: 35112 point (231x152)

  < evaluation points (7 sites): score

<table>
<thead>
<tr>
<th>Synthetic Data</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>157</td>
<td>42</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>138</td>
</tr>
</tbody>
</table>

  **Bias**
  
  \[
  \text{Bias} = \frac{\text{Hit} + F_i}{\text{Hit} + M}
  \]

  - **Yes**: Hit 157, False 42
  - **No**: Miss 6, Correct 138

  **Bias**: 1.22

  < Difference analysis for Hit cases >

  **CC**: 0.93
  **80%**: -3.5 ~ 3.5 mm/h

  ![Graph showing frequency of difference (mm/h) with CC: 0.93 and 80% range: -3.5 to 3.5 mm/h]
Seamless Full-spectrum Weather & Climate Information

Major Components

- Nanoscale (∼10m) Recover Temp., Prec., & Wind for Ungauged Sites
- Ultra-High Resolution Global Prediction System (∼20 km)
- Nanoscale (∼10m) Prediction for Limited Target Area
ICOsahedral Non-hydrostatic (ICON) model

- Joint development project of DWD and Max-Plank-Institute for Meteorology for the next-generation global NWP and climate modeling system
- Non-hydrostatic dynamical core on an icosahedral-triangular Arakawa C-grid
- Coupled with almost full set of physics parameterizations
- Two-way nesting with capability for multiple nests per nesting levels in order to replace extra process for downscaling
- Full hybrid (MPI/OpenMP) parallelization

Vertical grid in ICON and GME
Results1: Verification of precipitation across the AMIP simulations

※ GME: Precipitation minimizes too much at the EQ
  : SPCZ too zonal (not tilted)
  : Overestimated precipitation over eastern tropical Pacific

※ ICON: Overestimated precipitation over Micronesia
Results1: Verification of precipitation across the AMIP simulations

High resolution \( \leq 1.125^\circ \)

Low resolution \( > 1.125^\circ \)
Results: Verification of precipitation across the AMIP simulations

※ GME: weak low-level divergence over east African Ocean (5°S-5°N, 40-70°E)
ICON: strong convergence over Indian Ocean and western Pacific Ocean
Results 2: Analysis for Tropical Cyclones (TCs) Activities

Global distribution of tropical cyclone (TC) tracks during all season from 1979 to 2009

(a) OBS: IBTrACS-All (1979-2012)  GL = 84.3

(b) CFSR 50 km (1979-2009)  GL = 88.2

(c) GME 40km (1979-2009)  GL = 51.6

(d) ICON 40km (1979-2009)  GL = 84.4

The numbers for each basin show the annual mean number of TCs. TC tracks are color coded according to the intensities of TCs as categorized by the Saffir-Simpson Hurricane Wind Scale (e.g., tropical depression (TD), tropical storms (TS), and the categories 1–5 (C1–C5)).
Results 2: Analysis for Tropical Cyclones (TCs) Activities

A number of TC genesis: Monthly Climatology over western North Pacific

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSMC</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.6</td>
<td>1.1</td>
<td>1.6</td>
<td>3.2</td>
<td>5</td>
<td>4.6</td>
<td>3.1</td>
<td>1.6</td>
<td>0</td>
<td>21.5</td>
</tr>
<tr>
<td>CFSR</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>0.6</td>
<td>1.4</td>
<td>1.7</td>
<td>4.1</td>
<td>6.0</td>
<td>5.5</td>
<td>3.8</td>
<td>2.4</td>
<td>1.3</td>
<td>27.3</td>
</tr>
<tr>
<td>ERA</td>
<td>0.4</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.3</td>
<td>2.1</td>
<td>3.0</td>
<td>3.2</td>
<td>3.4</td>
<td>2.6</td>
<td>1.6</td>
<td>19.8</td>
</tr>
<tr>
<td>GME</td>
<td>0.7</td>
<td>0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>0.4</td>
<td>1.2</td>
<td>1.5</td>
<td>1.1</td>
<td>1.4</td>
<td>1.5</td>
<td>1.1</td>
<td>0.6</td>
<td>11.4</td>
</tr>
<tr>
<td>ICON</td>
<td>0.7</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>1.7</td>
<td>1.6</td>
<td>3.9</td>
<td>4.3</td>
<td>4.8</td>
<td>4.7</td>
<td>3.6</td>
<td>1.9</td>
<td>29.3</td>
</tr>
</tbody>
</table>
Seasonal Prediction for India
Simulated with ICON model

Issued on 07 Feb. 2017
**Preparation of Seasonal Prediction for Spring, 2017**

<table>
<thead>
<tr>
<th><strong>Initial Condition</strong></th>
<th>ECMWF Operational Analysis data (2017.1.21.-1.30.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boundary Condition</strong></td>
<td>NOAA OI Monthly Global SST data (2017.1.15.-1.21.)</td>
</tr>
<tr>
<td></td>
<td>ECMWF Operational Analysis data for Sea ice (2017.1.18.)</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>ICOsahedral Non-hydrostatic (ICON) MODEL</td>
</tr>
<tr>
<td><strong>Vertical &amp; Horizontal Resolution</strong></td>
<td>40 km/90 layers</td>
</tr>
<tr>
<td><strong>Integration period</strong></td>
<td>From 2017.01.21 to 2017.05.31</td>
</tr>
<tr>
<td><strong>Method for Seasonal Prediction</strong></td>
<td>Time-lag Method</td>
</tr>
<tr>
<td></td>
<td>- Prediction run with daily SST forcing (10 Ensemble members)</td>
</tr>
<tr>
<td></td>
<td>AMIP-type Present-day run</td>
</tr>
<tr>
<td></td>
<td>- Climatology run during 1979-2008 (30years)</td>
</tr>
<tr>
<td><strong>Presented Variables</strong></td>
<td>850hPa Temperature, Precipitation</td>
</tr>
</tbody>
</table>
**Boundary Condition**

**SST Anomaly of MAM, 2017 [Present SST – Climatology SST]**

- Present SST: NOAA OI Weekly SST centered on Wednesday (Jan. 15~21, 2017)
- Climatology SST: NOAA OI Average year SST (1971~2000)
Boundary Condition

Sea-ice Anomaly of MAM, 2017 [Present SST – Climatology SST]

Present Sea Ice: ECMWF Sea Ice (Jan. 18, 2017)
Climatology Sea Ice: ERA-40 Average year Sea Ice (1971~2000)
MAM 2017 outlook – MSLP/500hPa GPH Anomaly

Mean Sea Level Pressure [hPa] Anomaly

MAR 2017

APR 2017

MAY 2017

MAM 2017

500hPa Geopotential Height Anomaly

MAR 2017

APR 2017

MAY 2017

MAM 2017
MAM 2017 outlook for the globe (850hPa Temp.)

Anomaly Prediction

Probability Prediction
MAM 2017 outlook for South Asia (850hPa Temp.)

Anomaly Prediction

- March 2017
- April 2017
- May 2017
- Major 2017

Probability Prediction

- March 2017
- April 2017
- May 2017
- Major 2017

Legend:
- Below Normal
- Normal
- Above Normal
MAM 2017 outlook for India (850hPa Temp.)

Anomaly Prediction

- Below Normal
- Normal
- Above Normal

Probability Prediction

Below Normal  | Normal  | Above Normal
60  | 80  | 60  | 80  | 60  | 80
MAM 2017 outlook for the globe (Precipitation)

Anomaly Prediction

Probability Prediction

MAR 2017

APR 2017

MAY 2017

MAM 2017

MAR 2017

APR 2017

MAY 2017

MAM 2017

-1.0σ -0.5σ -0.25σ 0.5σ 1.0σ

Below Normal  Normal  Above Normal
MAM 2017 outlook for South Asia (Precipitation)

Anomaly Prediction

Probability Prediction

MAR 2017

APR 2017

MAY 2017

MAM 2017

MAR 2017

APR 2017

MAY 2017

MAM 2017

Below Normal

Normal

Above Normal
MAM 2017 outlook for South Asia (Precipitation)

**Anomaly Prediction**

- **MAR 2017**
- **APR 2017**
- **MAY 2017**
- **MAM 2017**

**Probability Prediction**

- **MAR 2017**
- **APR 2017**
- **MAY 2017**
- **MAM 2017**

Legend:
- Below Normal
- Normal
- Above Normal
Method

Synthesis of Observation

- **QPM** (Quantitative Precipitation Model)
- **QTM** (Quantitative Temperature Model)

**Observation Data**
- South Korea: AWS/ASOS & MERRA
- North Korea: MERRA

Prediction

- **Model**: ICON
- **Horizontal & Vertical Resolution**: 40 km/90 layers
- **Method for Seasonal Prediction**
  - Time-lag Method
    - Prediction run with daily SST & sea ice forcing (10 Ensemble)
- **I. C.**: ECMWF Operational Analysis data
- **B. C.**: NOAA OI Monthly Global SST data
  ECMWF Operational Analysis sea ice data
Synthesis of Observation

Data

- North Korea

<table>
<thead>
<tr>
<th>Data</th>
<th>Time Interval</th>
<th>Horizontal Resolution</th>
<th>Vertical Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERRA (NASA)</td>
<td>vertical: 3hrs</td>
<td>1.25°×1.25°</td>
<td>72 Levels</td>
</tr>
<tr>
<td></td>
<td>horizontal: 1hr</td>
<td>0.667°×0.5°</td>
<td></td>
</tr>
</tbody>
</table>

- South Korea

<table>
<thead>
<tr>
<th>Data</th>
<th>Time Interval</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS &amp; ASOS (KMA)</td>
<td>1hr, daily</td>
<td>494 / 93</td>
</tr>
</tbody>
</table>

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<td></td>
<td>horizontal: 1hr</td>
<td>0.667°×0.5°</td>
<td></td>
</tr>
</tbody>
</table>
Time traveling climate information

Ex) 2m Temperature

Observation-based Synthetic data (1km × 1km)

the same as above
### Variables Data for Crop Model

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Level</th>
<th>Long name (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>albdo</td>
<td>surface</td>
<td>(solar) shortwave albedo at the surface (%)</td>
</tr>
<tr>
<td>ssr</td>
<td>surface</td>
<td>surface solar radiation balance (W/m**2)</td>
</tr>
<tr>
<td>pres</td>
<td>surface</td>
<td>surface pressure on model orography (Pa)</td>
</tr>
<tr>
<td>tmp</td>
<td>850hPa</td>
<td>temperature at 850hPa (K)</td>
</tr>
<tr>
<td>tmax</td>
<td>2m</td>
<td>maximum temperature at (K)</td>
</tr>
<tr>
<td>tmin</td>
<td>2m</td>
<td>minimum temperature at (K)</td>
</tr>
<tr>
<td>pr</td>
<td>surface</td>
<td>precipitation (kg/m**2)</td>
</tr>
<tr>
<td>uwind</td>
<td>10m</td>
<td>zonal wind at 10m above ground (m/s)</td>
</tr>
<tr>
<td>vwind</td>
<td>10m</td>
<td>meridional wind at 10m above ground (m/s)</td>
</tr>
<tr>
<td>shum</td>
<td>surface</td>
<td>specific humidity (kg/kg)</td>
</tr>
</tbody>
</table>

*Data set is depending on the user.*
Seasonal Prediction

2016 MAR.-OCT. Prediction

850hPa Temperature [K]
Seasonal Prediction

2016 MAR.-OCT. Prediction

Precipitation [kg/m**2]
Application for Africa

ования Data in African 3 Regions for Crop Model

- 2m Maximum Temperature [K] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- 2m Minimum Temperature [K] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Precipitation [kg/m²] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- 850 hPa Temperature [K] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Solar Radiation Balance at the Surface [W/m²] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Solar Shortwave Albedo at the Surface [%] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Specific Humidity [kg/kg] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Climatology in Western Africa
- Climatology in Eastern Africa
- Climatology in Southern Africa

- Surface Pressure [Pa] 2016/3/1
  - Prediction in Western Africa
  - Prediction in Eastern Africa
  - Prediction in Southern Africa

- Climatology in Western Africa
- Climatology in Eastern Africa
- Climatology in Southern Africa
Seamless Full-spectrum Weather & Climate Information

Major Components

- Nano-scale (∼10 m) Recover Temp., Prec., & Wind for Ungauged Sites
- Ultra-High Resolution Global Prediction System (∼20 km)
- Nano-scale (∼10m) Prediction for Limited Target Area
1km Resolution Future change of 2m temperature

2m Temperature Anomaly

RCP8.5
Anomaly = 0.12°C
2006 Year

Data points = 672,661

Suyoung-gu
Anomaly = 0.21°C
2006 Year

Data points = 19

Busan
Anomaly = 0.17°C
2006 Year

Data points = 2,001

50.0°

7.5°

0.55°

0.05°

0.4°
1km Resolution Future change of precipitation

Precipitation Anomaly

RCP8.5
Anomaly=0.00mm/day 2006 Year

Data points = 672,661

RCP8.5
Anomaly=0.03mm/day 2006 Year

Data points = 2,001

Suyoung-gu
Anomaly=0.61mm/day 2006 Year

Data points = 19

Busan
Anomaly=-0.75mm/day 2006 Year

Data points = 19
Future change of 2m temperature – Global, Asia, India region

Area-averaged Time series
Future change of precipitation – Global, Asia, India region

Area-averaged Time series
Conclusions

- Ultra-high resolution prediction system provides useful data to agricultural community in detail.

- This system has the following advantage:
  
  1. Providing *daily essential variables* for crop model for not only rich observational data area but poor data area.
  
  2. Providing timely updated *nano-scale seamless AgMet data* in combination of the past, present and future data

- Ultra-high resolution prediction system provides a climate service to not only agricultural community but also to hydrological community to predicting flesh floods.
Thank you for your attention!

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