Satellite Based Water Monitoring and Flow Forecasting System in the Yellow River Basin

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Contents of the presentation

- Introduction to the EWBMS
- Derivation and examples of data products
- Validation of EWBMS data
- Drought monitoring
- Flow simulation and forecasting
- Conclusions
The Energy and Water Balance

- Radiation
- Heat
- Evaporation
- Precipitation
- Run-off
Geostationary Meteorological Satellites

- GOES E (USA) 98°W
- GOES W (USA) 131°W
- 140°E
- METEOSAT MSG
- MTSat (Japan)
- FY2c
- INSAT (India)
- 94°E
- METEOSAT 5
Energy and Water Balance Monitoring System (EWBMS)

- FY2 Meteosat
- WMO-GTS precipitation

**Cloud duration**

**Rainfall**

**Temperature Albedo**

**Evaporation**

**Energy balance processing**

**Radiation**

- Water Monitoring System
- Drought Monitoring System
- Yield Monitoring System

- Water Resources, Flow forecast
- Soil moisture & Drought Products
- Crop & Pasture Yield Products

Hourly VIS, TIR

EARS

Satellite Data for Water and Food
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Data products
September 2005, 1st dekad

1.5 m Air temperature (°C)
Global radiation (W/m²)
Surface albedo (%)
Relative evapotranspiration (%)

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Air temperature mapping

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Satellite Data for Water and Food
Observation height air temperature map

Boundary layer temperature: based on regression between noon and midnight surface temperatures

1.5 m Temperature: based on mixing surface and boundary layer temperature

China, Bayan Mud (40.75N 104.5E), clear days 2000

\[ y = 1.0173x + 0.7584 \]

\[ R^2 = 0.9629 \]
Precipitation monitoring
Precipitation processing

- Based on cloud detection, height classification
- Regression between cloud frequencies and GTS rainfall

- Rainfall
- Snow storage (if T<0)
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Precipitation

1st quarter 2000

2nd quarter 2000

3rd quarter 2000

4th quarter 2000
Evapotranspiration Monitoring
Energy balance processing

Global and net radiation

Sensible heat flux

Latent energy flux

↓

Actual evaporation

Snowmelt

\[ I_n = (1-A) \left( I_{sol} - I_{ter} \right) \]
\[ H = \alpha \left( T_0 - T_a \right) \]
\[ LE = I_n - H \]
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Actual evapotranspiration

1st quarter 2000

2nd quarter 2000

3rd quarter 2000

4th quarter 2000

EARS
Satellite Data for Water and Food
Validation in Yellow River basin
1.5 m air temperature validation
Net radiation validation

Net radiometer

EARS
Satellite Data for Water and Food
EWBMS and ground measured net radiation

Scattergram 4 NR-Lite stations
Sensible heat flux validation
Ears Satellite Data for water and food

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EWBMS and LAS sensible heat flux

Jingchuan - 2006

Xinghai - 2007

EWBMS

LAS
Rainfall and water budget validation
Comparison reported and estimated rainfall

Daily Rainfall Scatter Plot, Average of 5 northern and western UYRB stations

Daily Rainfall Scatter Plot, Average of 5 southeastern UYRB stations
Water budget & discharge

Net precipitation 5 days-floating average

River discharge at Tangnaihai

Cumulative evapotranspiration
Cumulative net precipitation
Cumulative precipitation
Cumulative river discharge

Net precipitation and river discharge graphs over a period from July 2005 to July 2008.
Drought monitoring
Meteorological drought

2008年全国降水量距平图（单位 %）

Rainfall deviation from average (SFA-CNDMC)
Agricultural drought (1)

- 2 monthly relative evapotranspiration (EDI)
- Proportional to crop growth
- Proportional to plant available water (PAW)

\[ PAW \approx 0.35 \text{ RE} \]
Agricultural drought during 2008

RE May-June

RE July - August
Hydrological drought

CWR = Precipitation – Actual evapotranspiration

Subcatchment water resources in 2007-2008 hydrologic year
Flow forecasting

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Yellow River sub-catchments

Upper Yellow River

Second largest river basin of China

Wei River

EARS Satellite Centre for Weather and Floods
Large Scale Hydrological Model (LSHM)

**Land component:**
2-dimensional diffusion process

**River flow component:**
Muskingum-Cunge routing

EWBMS Rainfall  Actual Evaporation
Flow simulation
Upper Yellow River
## Flow forecast performance UYRB

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Hydrological station</th>
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<tbody>
<tr>
<td></td>
<td>Jimai</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.8</td>
</tr>
<tr>
<td>RMSE (m$^3$/s)</td>
<td>55.5</td>
</tr>
<tr>
<td>RRMSE</td>
<td>0.45</td>
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<tr>
<td>BIAS (m$^3$/s)</td>
<td>21.9</td>
</tr>
<tr>
<td>% volume error</td>
<td>17.9</td>
</tr>
<tr>
<td>Drainage area (km$^2$)</td>
<td>45,800</td>
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</tbody>
</table>
One day forecast at Tangnaihai (basin outlet)

RMSE = 161 m³/s  RRMSE = 0.17
COE = 0.84  R² = 0.93
Conclusions

- EWBMS is an abundant climate data source
- Water resources monitoring
- Meteorological, agricultural and hydrological drought monitoring
  - Including: Plant available soil water content
- Flow forecasting through LSHM
- Good performance and validation results
- EWBMS and LSHM are fully operational
- Need: High res. Geostationary Hydrological Satellite (HGHS: 0.5 km)
Thank you for your attention

More: www.ears.nl