Concerted Earth Observation and Prediction of Water and Energy Cycles in the Third Pole Environment (CEOP-TPE) (ID. 10603)

Yaoming Ma (马耀明)\textsuperscript{1}, Bob Su (苏中波)\textsuperscript{2}, Weiqiang Ma (马伟强)\textsuperscript{1}, Lei Zhong (仲雷)\textsuperscript{3}, Maoshan Li (李茂善)\textsuperscript{4}, Cunbo Han (韩存博)\textsuperscript{1}, Binbin Wang (王宾宾)\textsuperscript{1,2} on behalf of the Chinese Dragon CEOP-TPE Team

\textsuperscript{1}Key Laboratory of Tibetan Environment Changes and Land Surface Processes, Institute of Tibetan Plateau Research, the Chinese Academy of Sciences, Beijing 100085  Email: ymma@itpcas.ac.cn
\textsuperscript{2}Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, Enschede 7500 AA, Netherlands
\textsuperscript{3}School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026
\textsuperscript{4}Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000

22–26 June 2015 | Interlaken | Switzerland
Outline

- EO data acquisition and ground data collection campaigns
- Progresses
  - Parameterization of soil heat flux
  - Parameterization of effective roughness length
  - Plateau-scale land surface parameters from satellite data and WRF model
- The role of young scientists
- Publications
- Plans for next years
<table>
<thead>
<tr>
<th>Location</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haibei</td>
<td></td>
</tr>
<tr>
<td>Lhasa</td>
<td>Sino-Tajikistan joint station</td>
</tr>
<tr>
<td>Mutztag Ata</td>
<td>Sino-Pakistan joint station</td>
</tr>
<tr>
<td>Yazhog Yumco</td>
<td>Sino-Pakistan joint expedition to Karakorum</td>
</tr>
<tr>
<td>Mt Tangglha</td>
<td>China-India-Nepal joint expedition to Gangrenboqi</td>
</tr>
<tr>
<td>Northern Plateau</td>
<td></td>
</tr>
<tr>
<td>NAMORS</td>
<td></td>
</tr>
<tr>
<td>NAWORS</td>
<td></td>
</tr>
<tr>
<td>Yulong Glacier</td>
<td></td>
</tr>
<tr>
<td>Qangtang Plateau</td>
<td></td>
</tr>
<tr>
<td>Mt Gongga</td>
<td></td>
</tr>
<tr>
<td>SETS</td>
<td></td>
</tr>
<tr>
<td>Beiluhe</td>
<td></td>
</tr>
<tr>
<td>Metog</td>
<td></td>
</tr>
<tr>
<td>Tianshuihai</td>
<td></td>
</tr>
<tr>
<td>Nyinchi</td>
<td></td>
</tr>
<tr>
<td>QOMS</td>
<td></td>
</tr>
<tr>
<td>Maqin</td>
<td></td>
</tr>
<tr>
<td>Naqu</td>
<td></td>
</tr>
<tr>
<td>Mt Qilian</td>
<td></td>
</tr>
<tr>
<td>Waliguan</td>
<td></td>
</tr>
</tbody>
</table>

- **TPE implementation plan**
- **Sino-Tajikistan joint expedition to Pamir**
- **Sino-Pakistan joint expedition to Karakorum**
- **China-India-Nepal joint expedition to Gangrenboqi**
- **Sino-Nepal joint expedition to Everest**
- **Sino-Nepal joint expedition to Xixabangma**
青藏所的10个多圈层综合观测研究站、9个地气相互作用过程站点分布
Five comprehensive observation and research platforms have been set up.
Optical and Microwave Remote Sensing Data

ASTER
SPOT
LANDSAT
MODIS
AVHRR
Optical and Microwave Remote Sensing Data

FY

ENVISAT

ERS

TRMM

SMOS

GOCE
Results—soil heat flux

Comparisons between TDEC results and in-situ values measured by soil heat flux plate
(a) ANNI, (b) BJ, (c) D105

Time series of soil heat flux derived by different methods at ANNI station
(a) 10 cm, (b) 20 cm
Daily variations of soil heat flux at ANNI station under different weather conditions
(a) Sunny, (b) cloudy, (c) rainy
Daily variations of soil heat flux at three stations
(a) 0 cm, (b) 30 cm, (c) 50 cm

<table>
<thead>
<tr>
<th>站名</th>
<th>ANNI</th>
<th>BJ</th>
<th>D105</th>
</tr>
</thead>
<tbody>
<tr>
<td>净辐射通量日均值</td>
<td>266.7</td>
<td>158.4</td>
<td>146.9</td>
</tr>
<tr>
<td>$G_{TDE0}$ 日最大值/日最小值/日均值</td>
<td>363.6 / -177.1 / 39.3</td>
<td>306.8 / -184.0 / 21.7</td>
<td>264.3 / -119.2 / 12.0</td>
</tr>
<tr>
<td>$G_{TDE50}$ 日最大值/日最小值/日均值</td>
<td>96.3 / -32.0 / 17.9</td>
<td>36.4 / -14.2 / 8.5</td>
<td>40.4 / -6.0 / 10.9</td>
</tr>
<tr>
<td>$G_{TDE50}$ 日最大值/日最小值/日均值</td>
<td>19.1 / -3.1 / 5.3</td>
<td>14.2 / -1.9 / 4.8</td>
<td>14.2 / 7.4 / 10.4</td>
</tr>
</tbody>
</table>

Units: W·m⁻²

soil texture

<table>
<thead>
<tr>
<th>站名</th>
<th>ANNI</th>
<th>BJ</th>
<th>D105</th>
</tr>
</thead>
<tbody>
<tr>
<td>土壤深度/cm</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>ANNI</td>
<td>砂质壤土</td>
<td>砂质壤土</td>
<td>砂质壤土</td>
</tr>
<tr>
<td>BJ</td>
<td>砂土</td>
<td>砂土</td>
<td>砂土</td>
</tr>
<tr>
<td>D105</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>
Results—effective roughness length

- **QOMS**: GPS Radiosonde, Wind Profiler and EC
- **Shiquanhe**: GPS Radiosonde
- **Litang**: GPS Radiosonde and EC
Estimation of $z_{0m}$ and $d_0$ from wind profiles

\[
U = \frac{u_\ast}{\kappa} \ln \left( \frac{z - d_0}{z_{0m}} \right)
\]

\[
u_\ast = 0.4(U_2 - U_1) / \ln \left( \frac{z_2 - C_0z_{0m}}{z_1 - C_0z_{0m}} \right)
\]

\[
z_{0m} = z_1 \left[ \exp(0.4U_1 / u_\ast) + C_0 \right]^{-1}
\]

\[
d_0 = C_0z_{0m}
\]

\[
\lambda = \frac{A}{S} = \frac{h}{L}
\]

\[
C_0 = a\lambda^{-b}
\]

(Kustas and Brutsaert, 1986)
Semi-log plot of near-neutral wind profiles at QOMS(a), Shiquanhe(b) and Litang station(c).

The selected wind profiles coincide with the logarithmic law of neutral condition.

\[ |Ri_B| < 0.01 \]
Average and standard deviation of $z_{0m}$ and $d_0$ for QOMS station, Shiquanhe station, and Litang station calculated using wind profile data.

\[ z_{0m}^{\text{eff}} \quad \text{&} \quad d_0 \]

<table>
<thead>
<tr>
<th>Station (Samples)</th>
<th>Average $d_0$ (m)</th>
<th>Average $z_{0m}^{\text{eff}}$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QOMS (24)</td>
<td>$551.7 \pm 39.0$</td>
<td>$68.9 \pm 5.0$</td>
</tr>
<tr>
<td>Shiquanhe (12)</td>
<td>$81.9 \pm 34.5$</td>
<td>$10.2 \pm 4.3$</td>
</tr>
<tr>
<td>Litang (9)</td>
<td>$60.7 \pm 11.1$</td>
<td>$6.0 \pm 1.1$</td>
</tr>
</tbody>
</table>
Relation between roughness parameter and terrain characteristics

\[ \ln^2\left(\frac{h}{2z_{0m}^{\text{eff}}}\right) = \frac{k^2}{0.5DA/S + k^2/\ln^2\left(\frac{h}{2z_{0m}}\right)} \]

(Grant and Mason, 1990)

\[ F_f = 0.5 \rho DU^2 \left(\frac{h}{2}\right)A \] (Form drag term)

\[ F_s = \frac{k^2}{\ln^2\left(\frac{h}{2z_{0m}}\right)} \rho U^2 \left(\frac{h}{2}\right)S \] (Shear stress term)

\[ F_t = \frac{k^2}{\ln^2\left(\frac{h}{2z_{0m}^{\text{eff}}}\right)} \rho U^2 \left(\frac{h}{2}\right)S \] (Total drag)
Comparison of different parameterization schemes

The curve with $D=0.5$ produces the best agreement. So 0.5 is a more appropriate value of form drag coefficient in mountainous areas especially in mountainous areas like the Tibetan Plateau.
**Comparison of different parameterization schemes**

<table>
<thead>
<tr>
<th>Station</th>
<th>height $h$ (m)</th>
<th>density $\lambda$</th>
<th>$z_{0m}^{\text{GM90B}}$ (m)</th>
<th>$z_{0m}^{\text{ERA-Interim}}$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QOMS</td>
<td>527.6</td>
<td>0.1988</td>
<td>61.2</td>
<td>47.4</td>
</tr>
<tr>
<td>Shiquanhe</td>
<td>303.3</td>
<td>0.0930</td>
<td>15.4</td>
<td>7.4</td>
</tr>
<tr>
<td>Litang</td>
<td>359.7</td>
<td>0.1292</td>
<td>24.4</td>
<td>19.5</td>
</tr>
</tbody>
</table>

There is a systematic underestimation of ERA-Interim which also use GM 90 method but with $D$ of 0.4
Parameterization Scheme

(Ma et al., 2012, AAS; Ma et al., 2013, TAAC; Ma et al., 2014, ACP)
Land surface heating field (net radiation)

\[
R_{nd} = (1 - \alpha)R_{sd} + R_{ld} - \varepsilon\sigma T_{savg}^4
\]

\[
R_{ld} = \sum_{i=1}^{8} \varepsilon_{ai} \sigma T_{ai}^4
\]

\[
\varepsilon_{ai} = clf + (1 - clf)[1.24(\frac{e}{T_{ai}})]
\]

\[
clf = 1 - \frac{R_{sw}}{R_{ctr,sw}}
\]

(Brutsaert 1975)

(Crawford and Duchon 1999)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Source</th>
<th>Spatial resolution</th>
<th>Time resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albedo</td>
<td>MODIS reflectance</td>
<td>0.01 degree</td>
<td>8 d</td>
</tr>
<tr>
<td>SWD</td>
<td>ITPCAS Reanalysis</td>
<td>0.1 degree</td>
<td>3 h</td>
</tr>
<tr>
<td>Specific humidity</td>
<td>ITPCAS Reanalysis</td>
<td>0.1 degree</td>
<td>3 h</td>
</tr>
<tr>
<td>Air temperature</td>
<td>ITPCAS Reanalysis</td>
<td>0.1 degree</td>
<td>3 h</td>
</tr>
<tr>
<td>Air pressure</td>
<td>ITPCAS Reanalysis</td>
<td>0.1 degree</td>
<td>3 h</td>
</tr>
<tr>
<td>LST (Terra, Aqua)</td>
<td>MODIS products</td>
<td>0.01 degree</td>
<td>1 d 4 data</td>
</tr>
<tr>
<td>Emissivity (Terra, Aqua)</td>
<td>MODIS Products</td>
<td>0.01 degree</td>
<td>1 d 4 data</td>
</tr>
<tr>
<td>DEM</td>
<td>ASTER</td>
<td>0.01 degree (30m)</td>
<td>------</td>
</tr>
</tbody>
</table>

The ITPCAS reanalysis data (SWD, air temperature, air pressure) is downscaled from 0.1 degree to 0.01 degree.
Validation of ITPCAS forcing data

The daily sum of SWD radiation is validated and show acceptable result between ITPCAS forcing data and observations in BJ, Nam Co, Qomo and Linzh station.
ITPCAS reanalysis data correction

The corrections is performed using DEM with the following methods:

1) The air temperature is corrected using the lapse rate;

2) The air pressure is corrected using the air pressure estimation equation;

\[ P = 1000 \times (2.406 - 0.0000534 \times h)^{5.26} \]

3) The short wave radiation is corrected with the radiation simulation model for slope and aspect.

\[ y = 0.7278 + 0.2514 \cos(\text{slop}) + 1.1134 \sin(\text{slop}) \cos(\text{asp}) + 0.0021 \sin(\text{slop}) \sin(\text{asp}) \]
10-year averaged land surface heating field

West Middle East
Hourly variations of air temperature

Air Temperature (K) 00:00 UTC 01 Aug 2007
Hourly variations of sensible heat flux

Sensible Heat Flux (W/m$^2$) 00:00 UTC 01 AUG 2007
Hourly variations of soil heat flux

Soil Heat Flux (W/m$^2$) 00:00UTC01AUG2007
The modeling results and observations from 2 Aug 2007. 
Note: a) net radiation; b) sensible heat flux; c) latent heat flux; d) soil heat flux
Young scientists

- **Weiqiang Ma** (Prof.) (land surface processes, remote sensing and numerical model)
- **Lei Zhong** (A. Prof.) (land surface processes, monsoon climate)
- **Maoshan Li** (A. Prof.) (land surface processes, Land surface modeling)
- **Binbin Wang** (PhD student) (land surface processes, remote sensing)
- **Cunbo Han** (PhD student) (Land-atmosphere interactions)
- **Junping Du** (PhD student) (remote sensing)
Academic Exchange Programmes

- Four PhD students have been sent to European partner for joint training
- Lei Zhong and Xuelong Chen have got their PhD degree from University of Twente under the supervision of Prof. Yaoming Ma and Prof. Z. (Bob) Su
- Several European students from our partner also come to China regularly for joint field visiting and academic exchange
Publications


What we will do in next years?

- Intensive field observations for the TP
- Continuous cal/val of EO data products
- Validation & improvements of model parameterization
- Generation of basin scale water and energy cycle data to close water and energy balance on basin scale
  - For Nagqu River basin, Namco Lake basin
- Academic exchange programmes
Thank You!