Update on the IRGASON project: results from the spring field campaign in Northwest China

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YNCenter Video Conference
Nanjing, August 15, 2014
Outline

- Background & Motivation
- Site & Instrumentation
- Preliminary results
  - Evaluation of air flow distortion
  - Evaluation of fluxes measurement
  - Implication for WPL correction
1. Background

LI-7500A + Gill (Li-Cor Inc.)

Physical separation and self-heating.

IRGASON (Campbell Scientific Inc.)

IRGASON’s advantages in geometry (colocation, synchronicity and aerodynamics) and low power consumption.
Motivation

- Does the colocation of CSAT3 and EC150 in IRGASON minimize the air flow distortion?

- How are about the performance of IRGASON in a dry and cold environment as compared to separated open-path EC system (LI-7500A+Gill)?

- Has IRGASON addressed the self-heating by co-locating the measurement volumes for wind and gas samples?
2. Site

(By Lichen Deng)

<table>
<thead>
<tr>
<th>Geography</th>
<th>Climatology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>Air temperature 12 °C</td>
</tr>
<tr>
<td>Longitude</td>
<td>Annual precipitation 37.2 mm</td>
</tr>
<tr>
<td>Elevation</td>
<td>Wind speed 2.4 m s⁻¹</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Prevailing wind NE, NW</td>
</tr>
<tr>
<td>Canopy height</td>
<td>Sunshine percentage 68%</td>
</tr>
</tbody>
</table>

- Latitude: 40°26'02.27" N
- Longitude: 88°01'36.20" E
- Elevation: 843 m
- Vegetation: *populus euphratica*
- Canopy height: 10 m
- Sunshine percentage: 68%
## Instrumentation

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Sensors</th>
<th>Height/Depth (m)</th>
<th>Variables</th>
<th>Operation period</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>EC150+CSAT3</td>
<td>15</td>
<td>$H, \lambda E, F_c, u^*$, $\text{CO}_2$, $\text{H}_2\text{O}$, $U$, wind direction</td>
<td>Jun.2013-Dec.2013</td>
</tr>
<tr>
<td></td>
<td>PAR LITE</td>
<td>14</td>
<td>PAR</td>
<td></td>
</tr>
<tr>
<td>MET</td>
<td>HMP155A</td>
<td>11, 14</td>
<td>$T_a, \text{RH}$</td>
<td>Jun.2013-Apr.4,2014</td>
</tr>
<tr>
<td></td>
<td>SI111</td>
<td>11</td>
<td>$T_{\text{skin}}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TE525MM</td>
<td>11</td>
<td>Precipitation</td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>Hukseflux</td>
<td>0.08, 0.2, 0.5</td>
<td>Soil heat flux</td>
<td>Jun.2013-Apr.4,2014</td>
</tr>
<tr>
<td></td>
<td>HFP01</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>


**Mar.12, 2014—Apr.13, 2014 (Spring)**
Buds appear on some trees

(By Jian Cui)
Monin-Obukhov scaling

\[ \sigma_W / u^* \]

- **Observation**
- \( 1.25(1-3\zeta^{1/3})(\zeta<0) \)
- \( 1.25(1+0.2\zeta)(\zeta>0) \)
- \( 1.8(-\zeta)^{1/3}(\zeta<0), 1.25(\zeta>0) \)

(a) LI-7500A+Gill

(b) IRGASON

*(Garratt, 1992; Kaimal and Finnigan 1994)*
Tilt as a function of wind direction

(a) LI-7500A+Gill

(b) IRGASON

Wind direction (°)
Time series of temperature
Time series of H$_2$O concentration
Time series of CO$_2$ concentration
Comparison of friction velocity

![Graphs showing comparison of friction velocity](image)

- (a) Time series of friction velocity ($u^*$) for LI-7500A+Gill and IRGASON.
- (b) Scatter plot showing the relationship between $u^*$ and $u^*$-IRGASON.

Regression line:

$$y = 1.08(\pm 0.01)x - 0.01(\pm 0.004)$$

$R = 0.97$, $P < 0.001$
Comparison of sensible heat flux

(a) LI-7500A+Gill
IRGASON

(b) $y=1.09(\pm 0.01)x-3.93(\pm 0.8)$
$R=0.99, P<0.001$
Comparison of latent heat flux

(a) Comparison of latent heat flux between LI-7500A+Gill and IRGASON.

(b) Scatter plot showing the correlation between latent heat flux (λE) and LI-7500A+Gill compared to IRGASON. The equation of the linear fit is $y = 1.34(±0.07)x + 0.23(±0.23)$ with $R = 0.77$, $P < 0.001$. 

Graph (a) shows that the LI-7500A+Gill values are consistently higher than the IRGASON values throughout the day.

Graph (b) indicates a strong positive correlation between the two methods, with most data points clustering around the diagonal line.

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Comparison of CO$_2$ flux

(a) Comparison of $F_c$ (µmol m$^{-2}$ s$^{-1}$) over different times.

(b) Scatter plot showing the relationship between $F_c$ - LI-7500A + Gill (µmol m$^{-2}$ s$^{-1}$) and $F_c$ - IRGASON (µmol m$^{-2}$ s$^{-1}$). The linear regression equation is $y=0.25(\pm0.02)x+0.06(\pm0.01)$ with $R=0.26$, $P<0.001$.
WPL correction and development

\[ \lambda E = \lambda \cdot w' \rho'_v + \lambda \cdot \mu \sigma \cdot w' \rho'_v + \lambda \cdot (1 + \mu \sigma) \cdot \frac{\rho_v}{T_a} \cdot \frac{H}{\rho_a \cdot C_p} \]

\[ F_c = w' \rho'_c + \mu \cdot \frac{\rho_c}{\rho_d} \cdot w' \rho'_v + (1 + \mu \sigma) \cdot \frac{\rho_c}{T_a} \cdot \frac{H}{\rho_a \cdot C_p} \]

\[ F_{c_M} = F_{c_{raw}} + WPL_M \]

\[ F_{c_T} = F_{c_{raw}} + WPL_T \]

\[ WPL_T = WPL_M \times \frac{\chi_T}{\chi_{M\_moist}} \]

\[ F_{c_T} = F_{c_{raw}} + WPL_M \times \frac{\chi_T}{\chi_{M\_moist}} = F_{c_M} + WPL_M \times \left( \frac{\chi_T}{\chi_{M\_moist}} - 1 \right) \]

(Webb et al., 1980; Lee, 2012)
WPL correction for CO$_2$ flux in winter field campaign

(Xu et al., 2014)
WPL correction for latent heat flux
WPL correction for CO$_2$ flux
WPL correction for latent heat flux by exchanging the H$_2$O concentration

(a) IRGASON

(b) LI-7500A+Gill
WPL correction for CO$_2$ flux by exchanging the CO$_2$ concentration
Thank you!

<table>
<thead>
<tr>
<th>Date</th>
<th>Note</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.12, 2014</td>
<td>Replaced by a new IRGASON</td>
<td>Cheng Liu, Cheng Hu</td>
</tr>
<tr>
<td>Apr.13, 2014</td>
<td>Finished the IRGASON project in Xinjiang</td>
<td>Jian Cui, Jing Shen</td>
</tr>
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