Presentations

• Xin Li. Key Eco-Hydrological Parameters Retrieval and Land Data Assimilation System Development in a Typical Inland River Basin of China's Arid Region.

• Massimo Menenti. Multi-annual data products on turbulent heat fluxes at the local and continental scale using AATSR and FY-2 data,

• Li Jia. Improving the accuracy of land surface heat and water fluxes by multi-parameterizations and multi-source satellite observations.
Posters

• Xiaoduo Pan, Xin Li, Kun Yang, Jie He, Xujun Han, Yanlin Zhang, Evaluation of multi precipitation products over the Heihe River Basin.

• Shuguo Wang. Impact of soil moisture dynamics on ASAR observed backscatters and its spatial variability over the upstream of the Heihe River Basin, China

• Jing Wang, Xin Li, Ling Lu, Regional corn yield estimation by the integration of multi-source observations with a crop growth model.
Key Eco-Hydrological Parameters Retrieval and Land Data Assimilation System Development in a Typical Inland River Basin of China’s Arid Region (ID. 5322)

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Chinese Investigators

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- Zeyong Hu (CAREERI)
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- Mingguo Ma (CAREERI)
- Weizhen Wang (CAREERI)
- Tao Che (CAREERI)
- Rui Jin (CAREERI)
- Qiang Liu (IRSA)

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- Massimo Menenti (F, IT, NL)
- Jerome Colin (F)
- Robin Faivre (F)
- Zhongbo Su (NL)
- Li Jia (NL)
- Frank Veroustraete (B)
- Roderik Lindenbergh (NL)
- Vu Phan Hien (NL)
- Zhaoliang Li (F)
- Run Wang (G)
- Xin Tian (NL)
• Objectives and background
• Acquired ESA, TPM & Chinese EO data
• Other data collected
• Projects' achievements & final results
  • Retrieval of eco-hydrological parameter
  • Land data assimilation system of the HRB
• Publications
• Young scientists training
• Academic exchange
• Conclusions
1.1 Objective

- Improve the monitoring, understanding, and predictability of hydrological and ecological processes at catchment scale.
- Promote the applicability of quantitative remote sensing in watershed science.
- Some key hydrological and ecological variables will be retrieved in virtue of ESA and other satellite data and will be merged into hydrological modeling for a more coherent and precise representation of water cycle at catchment scale.
1.2 Background

Heihe Dragon project (5322)

- Satellite data
- Air-borne missions & ground truth
- Retrieval method

WATER

- Expanding research scopes
- Training of young scientist

CEOP-AEGIS
Study area: Heihe River Basin
## 2. Satellite data

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Total Scenes</th>
<th>Data Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>AATSR</td>
<td>125 scenes</td>
<td>~30G</td>
<td>LST and energy balance</td>
</tr>
<tr>
<td>MERIS</td>
<td>102 scenes</td>
<td>~4G</td>
<td>Energy balance and water cycle</td>
</tr>
<tr>
<td>ASAR</td>
<td>~300 scenes</td>
<td>~60G</td>
<td>Soil moisture</td>
</tr>
<tr>
<td>CHRIS</td>
<td>23 scenes</td>
<td>~2G</td>
<td>LAI and other biogeophysical parameters</td>
</tr>
<tr>
<td>BJ-1</td>
<td>11 scenes</td>
<td>4.7G</td>
<td>Mapping of land cover</td>
</tr>
<tr>
<td>ALOS-PALSAR</td>
<td>33 scenes</td>
<td>~4G</td>
<td>Biomass, soil moisture, archaeology</td>
</tr>
</tbody>
</table>
3. Other data collected
3.1 Airborne missions

25 missions, 8 in the cold region, 4 in the forest region, and 13 for arid region. Flying time 110 hours. During the overpass of satellite sensors.

Li, et al., JGR, 2009
<table>
<thead>
<tr>
<th>Remote sensing instrument</th>
<th>Resolution &amp; major purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L-band non-imaging microwave radiometer</strong></td>
<td>120~600 m, soil moisture</td>
</tr>
<tr>
<td><strong>K-band non-imaging microwave radiometer</strong></td>
<td>100~400 m</td>
</tr>
<tr>
<td><strong>Ka-band microwave imaging radiometer</strong></td>
<td>39 m, SWE and soil freeze/thaw</td>
</tr>
<tr>
<td><strong>VNIR push broom imaging spectrometer: PHI-II</strong></td>
<td>1.05 m</td>
</tr>
<tr>
<td><strong>Shortwave infrared push broom imaging spectrometer: SWPHI</strong></td>
<td>1.95 m, biogeophysical and biogeochemical parameters, albedo...</td>
</tr>
<tr>
<td><strong>Imaging spectrometer: OMIS-II+PHI-SWIR</strong></td>
<td>4.5 m</td>
</tr>
<tr>
<td><strong>Wide-angle infrared Dual-mode line/area Array Scanner (WiDAS), seven viewing angles</strong></td>
<td>7.86 m for <strong>thermal imager</strong>, 1.2 m for <strong>CCD camera</strong>, LST</td>
</tr>
<tr>
<td><strong>LIDAR system: LiteMapper 5600</strong></td>
<td>Point cloud density: &gt;3 point m⁻², 0.2 m for <strong>CCD</strong>, canopy structure</td>
</tr>
</tbody>
</table>

**Microwave Radiometer**

![OMIS-II PHI-SWIR](image1)

**Airborne Multi-angle TIR/VNIR Imaging System**

![PHI-SWIR OMIS-II LIDAR](image2)
3.2 Hydrometeorology observation network

Network of AMS and flux tower

Dadongshu Station  Binggou Station  A’ rou Station

Li, et al., JGR, 2009
3.3 Ground measurement

Ground: snow cover extent, depth, SWE, albedo reflectance, temperature, grain size, density, moisture, and ground-based radiometer and scatterometer.
4. Project’s achievements and final results on key eco-hydrological parameters retrieval
3D rendering of the Yingke area obtained by combination of the LIDAR Digital Surface Model and the high resolution image simultaneously acquired by the CCD camera

Colin et al., 2010, HESS
Link high resolution Lidar data with roughness length models → 2D 2m wind speed for Surface Energy Balance calculations

Roughness length maps derived from the LIDAR data over the Yingke area for wind flows from N-E, W-NW, and W

Colin et al., 2010, HESS

25m resolution wind speed field at 2m
Leaf and soil BT separation results in the YK-wheat field on July 7th, 2008.


Using multi-angular airborne TIR observations
Heat fluxes estimation using directional thermal-infrared (TIR) data and the two-layer model

A new assumption

Winter wheat

Angle information of TIR data was considered

Maize

Xin et al., 2010, HESS
A revised surface resistance parameterisation for estimating evapotranspiration from remotely sensed data

Four factors (radiation, soil water content, saturated vapour pressure deficit (VPD) and air temperature) that affect the ET are taken into the algorithm.

4.2 Biomass

A new hybrid canopy reflectance model was developed and applied it to estimate LAI from CHRIS/PROBA.

LAI derived from CHRIS

CHRIS data of the study area after geometric correction

LAI map retrieval based on the empirical relationship between LAI and NDVI (left) and using DSD (directional second derivative) method (right)

Fan et al., 2010, HESS
4.4 soil moisture

Microwave radiometer

ASAR images (multi-angular data in sequential days)

Ground-based measurements

Estimated soil moisture from microwave radiometer and PALSAR data

Estimated roughness and soil moisture from ASAR

Validations

Klenk et al., 2009; Zhao et al., 2009; Wang et al., 2011, HESS
5. Progress on the Heihe data assimilation system (HDAS)
Heihe Data Assimilation System - HDAS

Integrated Watershed Model

1. Data Assimilation
2. Forcing Data
3. Parameters
4. Re-Initialization
5. Observation Operator
6. Output

HeiHe Data Assimilation System - HDAS

CLM
NOAH
RAPID
Lorenz63

Microwave
Infrared
Visible

Active MW
Passive MW
Visible/Near-Infrared
Thermal Infrared
Ground

Watershed Observation System
Multi-sources observations

- **Remote sensing**
  - **MODIS**: Leaf area index, Land surface temperature, Snow cover
  - **AMSR-E, SMOS**: Brightness temperature
  - **ASAR, PALSAR**: Back-scattering coefficients
  - **GRACE**: Ground water variations

- **Ground based**
  - **Wireless sensor network**: Moisture, temperature
  - **Other sensors**: COsmic-ray (Soil moisture and snow), water table
Case 1 – Impacts of Soil Moisture and Snow Water Equivalent Assimilation on Streamflow
Case 1 – Impacts of Soil Moisture and Snow Water Equivalent Assimilation on Streamflow

- The Nash-Sutcliffe efficiencies of streamflow in **spring** was increased from 0.154 to 0.416, (26% ↑)
- The Nash-Sutcliffe efficiencies of streamflow in **summer** was increased from 0.317 to 0.712, (40% ↑)
- The **yearly** Nash-Sutcliffe efficiencies of streamflow was increased from 0.191 to 0.679, (49% ↑)
Case 2 – Combining Soil Moisture Assimilation and Weather Forecast in Irrigation Optimization

- The unit is mm/s
- The irrigation happens for 2 hours every 2 days
Case 2 – Combining Soil Moisture Assimilation and Weather Forecast in Irrigation Scheduling

• Both soil moisture and weather forecast could contribute to the real time irrigation scheduling, but soil moisture plays a key role

• The assimilation soil moisture can offset the uncertainties in the weather data and model parameters

<table>
<thead>
<tr>
<th>Case Name</th>
<th>Irrigation Requirement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>406.59</td>
</tr>
<tr>
<td>No_Weather_No_DA</td>
<td>211.76</td>
</tr>
<tr>
<td>Only_DA_SM</td>
<td>356.36</td>
</tr>
<tr>
<td>Only_Weather</td>
<td>221.11</td>
</tr>
<tr>
<td>Both_Weather_DA_SM</td>
<td>369.32</td>
</tr>
</tbody>
</table>
HDAS output (1km & 1hr data products)

MODIS LAI 2008-08-04

CLM

MODIS LAI 2008-09-05

CLM

MODIS
HDAS output (1km & 1hr data products)

MODIS LAI 2008-08-04 - CLM

MODIS LAI 2008-08-04 - Assim
HDAS Products

- Soil States
  - Moisture Profile
  - Temperature Profile
  - Irrigation

- Surface States
  - Snow
  - Ground Temperature
  - Leaf Area Index

- Surface Fluxes
  - Latent Heat
  - Sensible Heat
  - Soil Heat

- Water Balance
  - Runoff
  - Infiltration
  - Recharge
  - Ground Water
6. Publications


Conference papers:


JAE special issue on retrieval of key eco-hydrological parameters for cold and arid regions
Guest editors: X Li, ZB Su and BF Wu

HESS special issue on observing and modeling the catchment scale water cycle
Http://www.hydrol-earth-syst-sci.net/special_issue116.html
Guest editors: X Li, XW Li, K Roth, M Menenti, W Wagner
• Young scientists play a very important role in our team and they have made considerable efforts.
• They are actively involved in Dragon symposiums, 17 posters during the course of Dragon 2.
• e.g., Three Ph. D. students attend the Barcelona workshop and present their post presentations

1. A method for forest height inversion by polarimetric SAR interferometry

2. Estimation of land surface energy flux based on satellite remote sensing

3. Mapping surface soil moisture in Heihe river basin using combined active and passive microwave remote sensed data
Prof. Xin Li visited ESRIN in Nov. 2011

Dr. Shuguo Wang visited ESRIN from Nov. 2011 to Apr. 2012
Multi-channel GPR with geostatistical analysis:
simultaneous mapping of small-scale spatial variability in soil
moisture content and reflector depth on field scales.

- 40 m × 30 m measurement area
- 7 parallel lines
- 10 cm spacing for traces
- 2500 data points

<table>
<thead>
<tr>
<th></th>
<th>(d)</th>
<th>(\theta) [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>1.14 m</td>
<td>0.27</td>
</tr>
<tr>
<td>(\sigma^2)</td>
<td>0.03 m²</td>
<td>0.001</td>
</tr>
<tr>
<td>range</td>
<td>0.61 - 1.8 m</td>
<td>0.1 - 0.4</td>
</tr>
</tbody>
</table>

\(d\): reflector depth
Dr. Muhammad Jahanzeb Malik visited CAREERI in Nov. 2008

- Discussed the research of snow properties retrieval by the utilization of SAR observations
- Conducted field work in Binggou watershed
- Planning to come to CAREERI again next year
9. Conclusions

• The retrieval methods of some key hydrological and ecological variables/parameters are developed, modified or reparameterized in virtue of the satellite-borne remote sensing data, most from Dragon II project, as well as the airborne and ground data obtained during the WATER.

• Ground truths collected in WATER field campaigns are tested to be very useful in validation of the models/algorithms for retrieval of hydrological and ecological parameters.
Conclusions

- A multi-source remote sensing data assimilation system has developed, which can produce a spatiotemporally and physically consistent data sets by merging earth observing data and remote sensing models. Data products are being produced but this needs further validation and more efforts.

- International cooperation, in terms of joint field campaigns, data collection, data analysis, coauthorship, coordination of related projects, and young scientist training benefits both sides. It can be concluded as a great success.
Conclusions

- Dragon III hydrology project will be a continuity of dragon II hydrology project. In the project, a long-term, high resolution, and reliable data set of water cycle is proposed to be developed. Field campaigns (HiWATER) will be conducted in association with this project. The work introduced here lay the foundation of the successfulness of the new project.
Thank you!