Land Surface Energy and Water Balance in High Elevation Asia by Remote Sensing

Li Jia
(jiali@radi.ac.cn)
Institute of Remote Sensing and Digital Earth (RADI), CAS

TPE-GHP/GEWEX Joint Workshop
17-19 October 2017, Kathmandu, Nepal
HMA Region Background

DEM

TPE
Key Issues

High Mountain Asia (HMA) Glaciers

• **What & How**: Location, status and changes
  - Area
  - Volume
  - Mass balance

• **Why**: Forcing factors
  - Climate (T & P)
  - Radiative Forcing
  - Human Activities

• **Which**: Impacts & Feedbacks
  - Local & Plateau & Regional & Global Hydro/Climate/Eco conditions
  - Local & downstr. Hazards

Issues

Determinant Processes

- Energy balance and Heat exchanges
- Water / Mass balance

Data/Tools/Methods

- Satellite / Airborne Observations
- Meteo / Climate Data
- Modelling
- Field Survey / Measurements

Know Enough?

Understand Clearly?

Quantity / Quality Sufficient?
Variables/Parameters relevant to Energy and Water Balance from Remote Sensing

• Forcing:
  – Net Radiation
  – Precipitation

• Surface status and processes:
  – Albedo (energy)
  – Land surface Temperature (LST)
  – Soil Moisture
  – Snow Cover
  – Freeze/Thaw
  – Lake area
  – Glacier thickness change
  – Evapotranspiration

Objective: Towards more accurate and higher resolution data products over HMA and its surrounding regions.
Outline

• Radiation Budget – Surface Albedo
• Evapotranspiration
Surface Radiation Balance Eq.:

\[ R_{\downarrow n} = R_{\downarrow n}^{\uparrow s} + R_{\downarrow n}^{\uparrow l} = R_{\downarrow d}^{\uparrow s} (1 - \alpha) + \varepsilon R_{\downarrow d}^{\uparrow l} - \sigma \varepsilon T_{\uparrow 4} \]
Surface Albedo: Terrain Impact

How topography influence surface radiation balance?

\[ R_{\text{down}} = R_{\text{down},s} + R_{\text{down},l} = R_{\text{down},s}(1 - \alpha) + \varepsilon R_{\text{down},l} - \sigma \varepsilon T^4 \]

- Incident shortwave radiation
- Surface albedo

(a) Direct solar irradiance
(b) Diffused solar irradiance
(c) Terrain-scattering irradiance from the adjacent terrain

(a) Directional hemispheric albedo
(b) Sky-diffused albedo
(c) Terrain-scattering albedo

(Gao, Jia et al., 2014)

- Topography
  - (shadow, sunlit aspects)
- Surface properties
  - (veg., soil, snow, glacier, water, …)
Surface Albedo

- Terrain Impact
- Snow cover impact
- Glacier albedo
Surface Albedo: Terrain Impact

Central Tibetan Plateau, the image covers large range of slope (500m pixel size)
Surface Albedo: Terrain Impact

Albedo: Improved algorithm@RADI vs MODIS product

period 2013065-2013072

period 2013161-2013168

difference: (Gao - MODIS)
Surface Albedo: Terrain Impact

Albedo retrieval: dependence of terrain correction on slope

2013065-2013072

Slope [0,10]

Without terrain correction

Slope [10,20]

Without terrain correction

Slope [20,30]

Without terrain correction

Slope [30,60]

Without terrain correction
Surface Albedo: Terrain Impact

Albedo: Sub-pixel Topographic Correction

FY-2D geostationary data

- BOA satellite radiance → (1) Sub-pixel topographic correction → Sub-pixel corrected irradiance → Sub-pixel corrected reflectance → (2) Albedo retrieval (RPV) → Sub-pixel corrected albedo

- no topographic correction
- pixel level correction
- sub-pixel level correction

Irradiance (W.m\(^{-2}\))

Surface reflectance

(Roupioz, Jia et al., 2014, ISRSE35)
Surface Albedo: **Snow cover impact**

GLASS 8-day albedo (MODIS based): 1 image every 8 days:

- 2013097 (097 – 104)
- 201305 (105 – 111)
The 8-day albedo cannot capture the fast snow process.
Improved SCF product @ RADI & BNU, 1 image /1-day

MOD10A1 Albedo
Surface Albedo: Snow cover impact + Glacier albedo

Selected 3 pixels for time series analysis:

Point 1: higher part of glacier
Point 2: lower part of glacier
Point 3: apart from glacier
Surface Albedo: Snow cover impact

Point 1: higher part of glacier

Point 2: lower part of glacier

Point 3: apart from glacier

RADI&BNU SCF daily
Outline

• Radiation Budget – Surface Albedo
• Evapotranspiration
Evapotranspiration

Global energy cycle (Wild et al. 2013)

Global water cycle (From Oki and Kanae, 2006)

Connecting Energy and Water Balance