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

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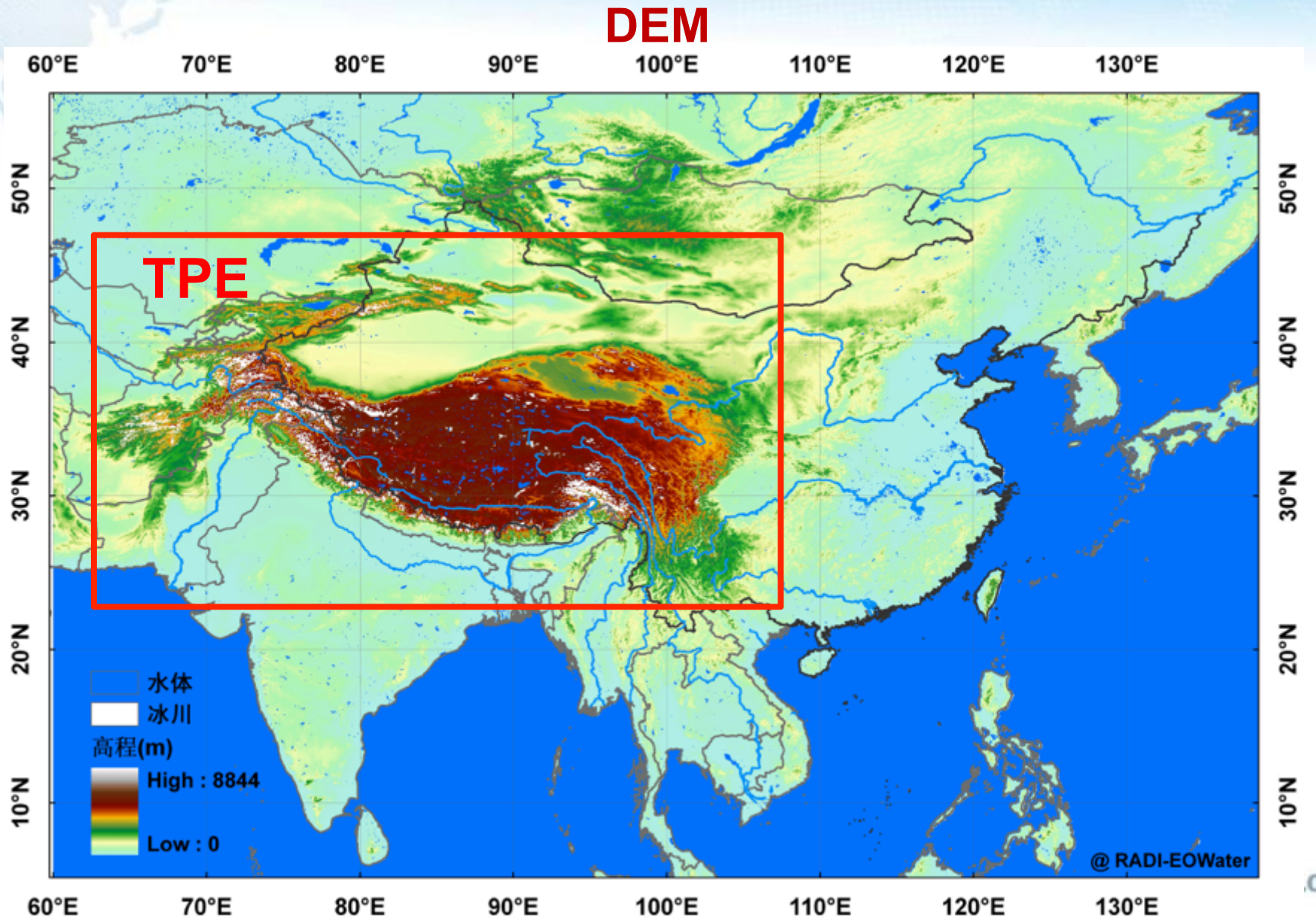
HMA Region Background



Key Issues

High Mountain Asia (HMA) Glaciers

- **What & How**: Location, status and changes
- **Why**: Forcing factors
- **Which**: Impacts & Feedbacks

Issues

- Area
- Volume
- Mass balance

- Climate (T & P)
- Radiative Forcing
- Human Activities

- Local & Plateau & Regional & Global Hydro/Climate/Eco conditions
- Local & downstr. Hazards

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

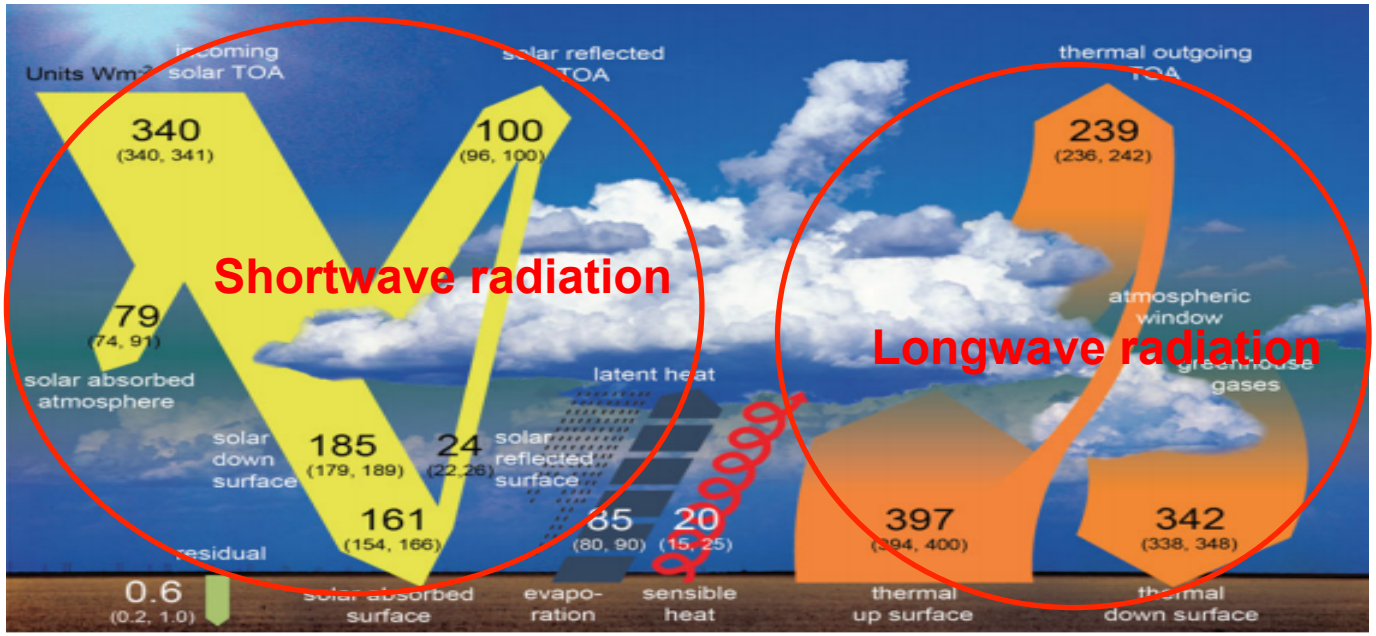
Radiation Budget

Surface Radiation Balance Eq.:

$$R\downarrow n = R\downarrow n\uparrow s + R\downarrow n\uparrow l = R\downarrow d\uparrow s\,(1-\alpha) + \varepsilon R\downarrow d\uparrow l - \sigma\varepsilon T\uparrow 4$$

Net radiation | Incident solar radiation | Albedo | Emissivity | LST

Downward longwave radiation



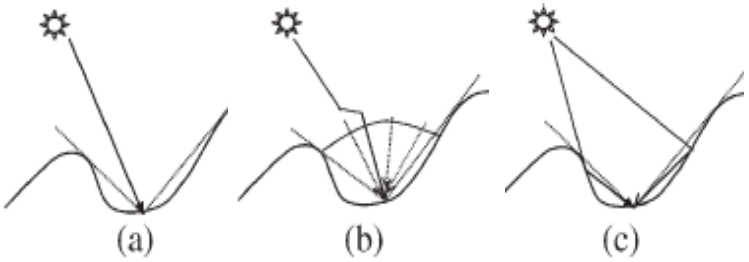
Wild et al. (2013)

Surface Albedo: Terrain Impact

How topography influence surface radiation balance ?

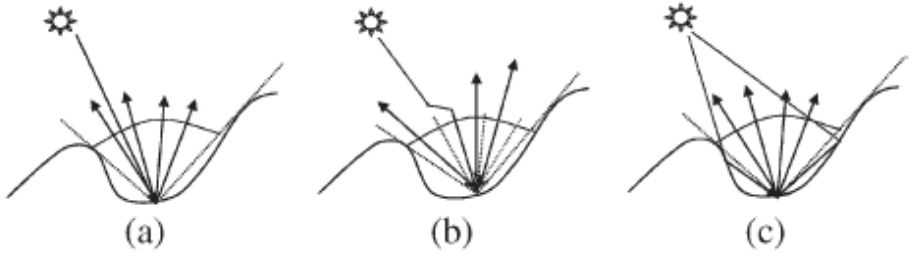
$$R\downarrow n = R\downarrow n\uparrow s + R\downarrow n\uparrow l = R\downarrow d\uparrow s\,(1-\alpha) + \varepsilon R\downarrow d\uparrow l - \sigma\varepsilon T\uparrow 4$$

Incident shortwave radiation



(a) direct solar irradiance
(b) diffused solar irradiance
(c) terrain-scattering irradiance from the adjacent terrain

Surface albedo



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

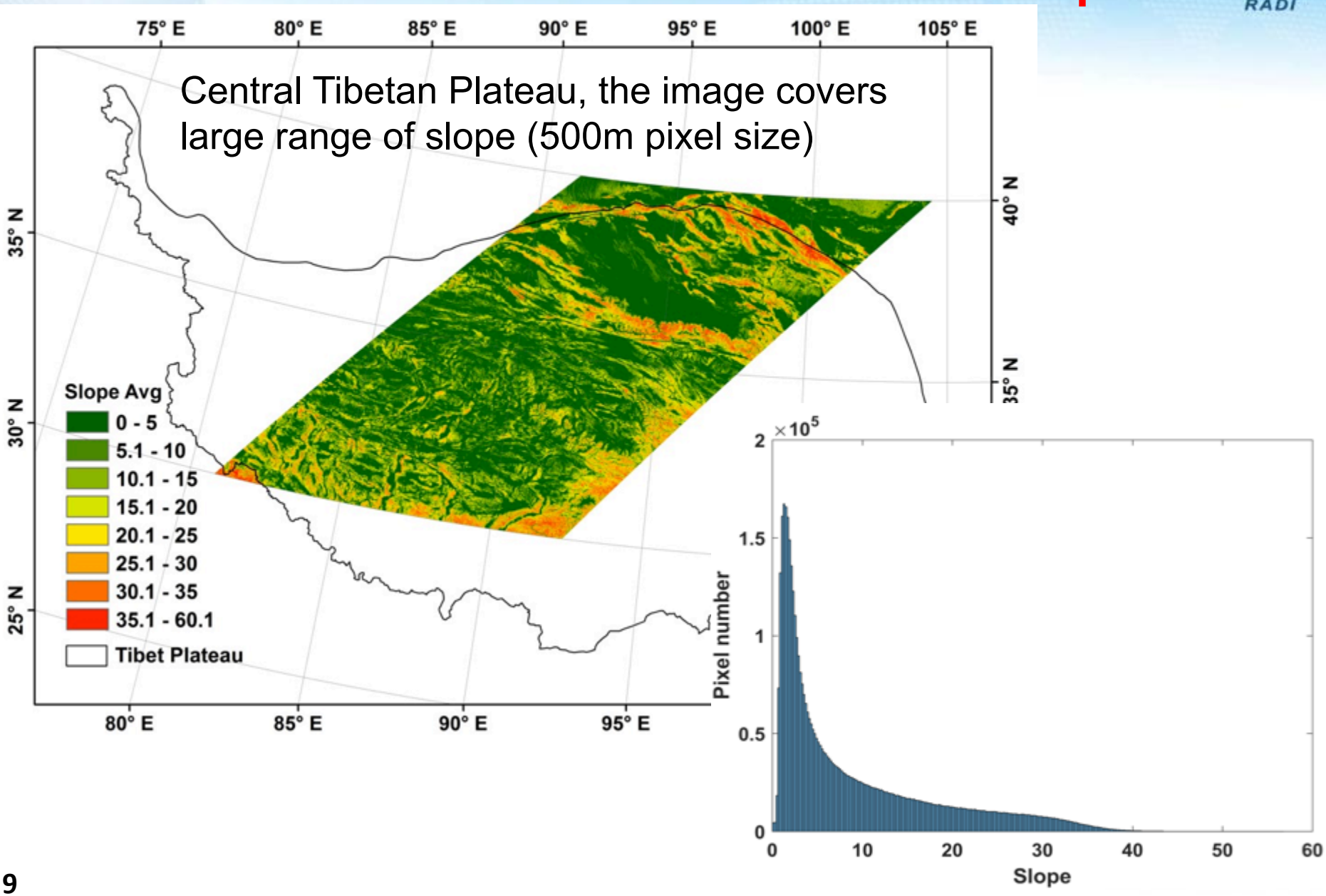
(Gao, Jia et al;, 2014)

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

Surface Albedo

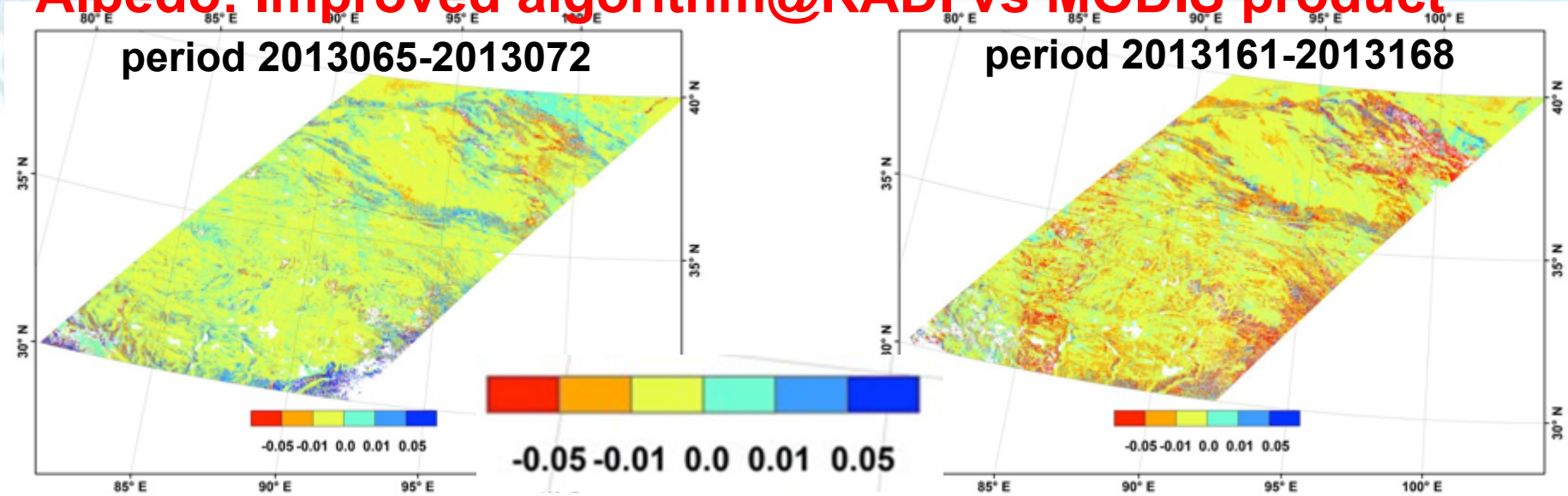
- Terrain Impact
- Snow cover impact
- Glacier albedo

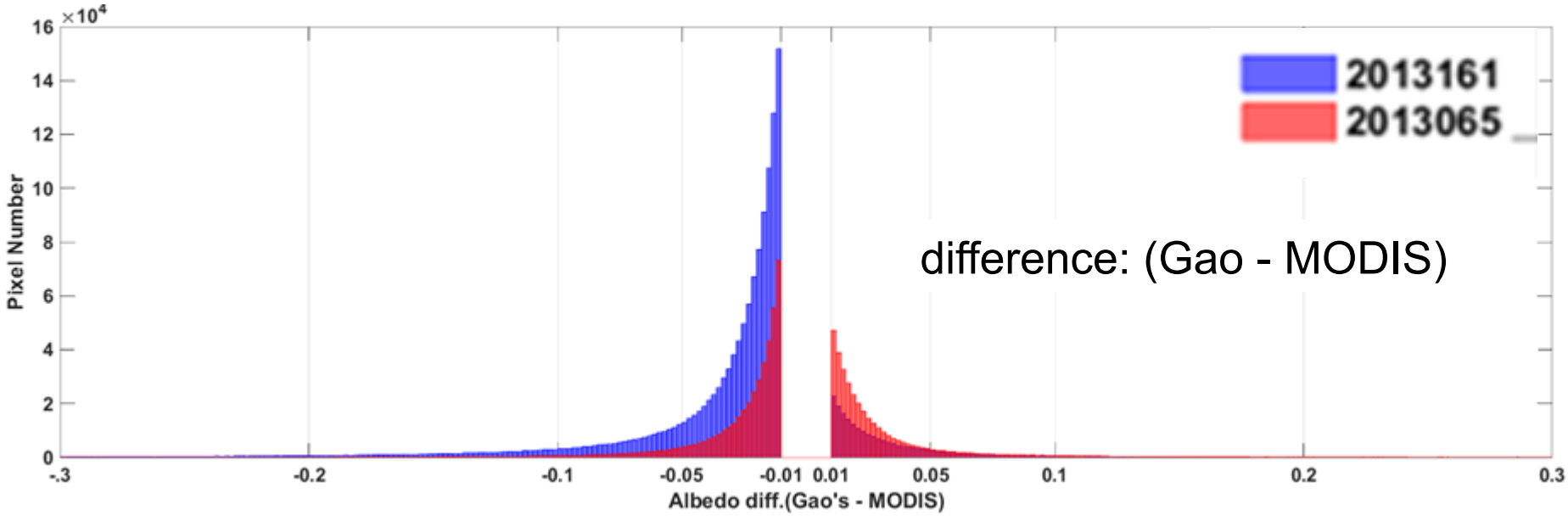
Surface Albedo: Terrain Impact



Surface Albedo: Terrain Impact

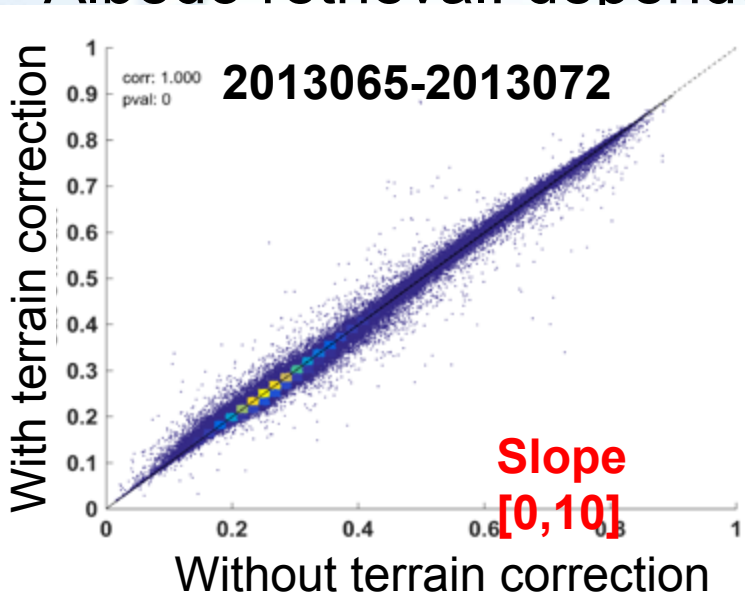
Albedo: Improved algorithm@RADI vs MODIS product

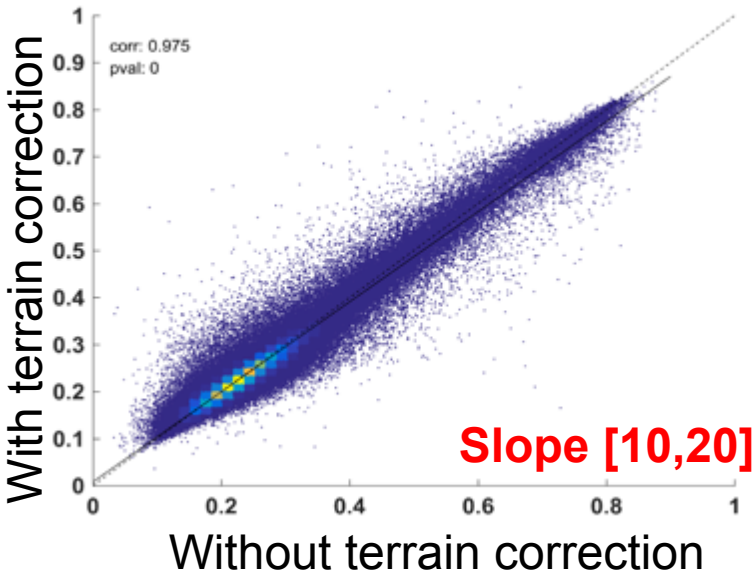


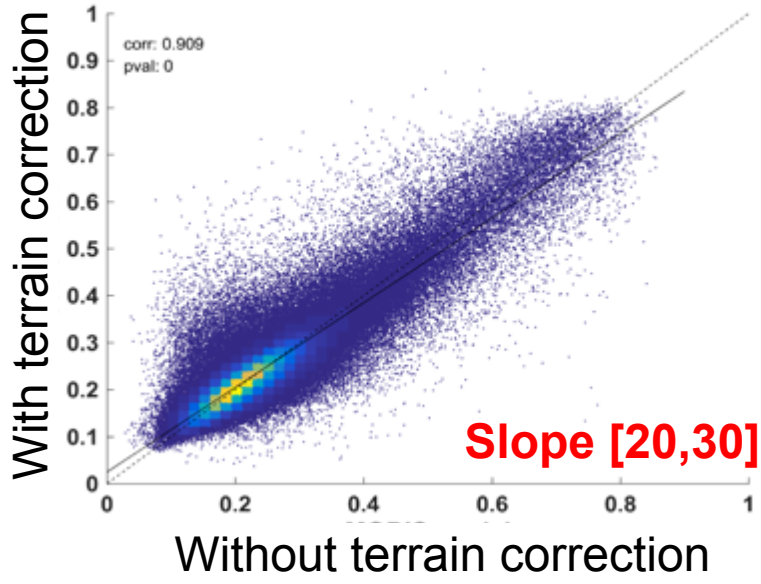


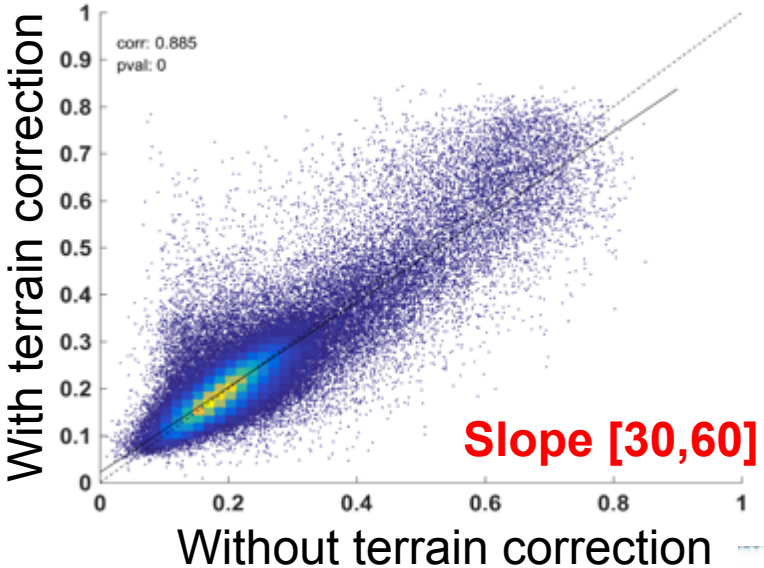
Surface Albedo: Terrain Impact

Albedo retrieval: dependence of terrain correction on slope





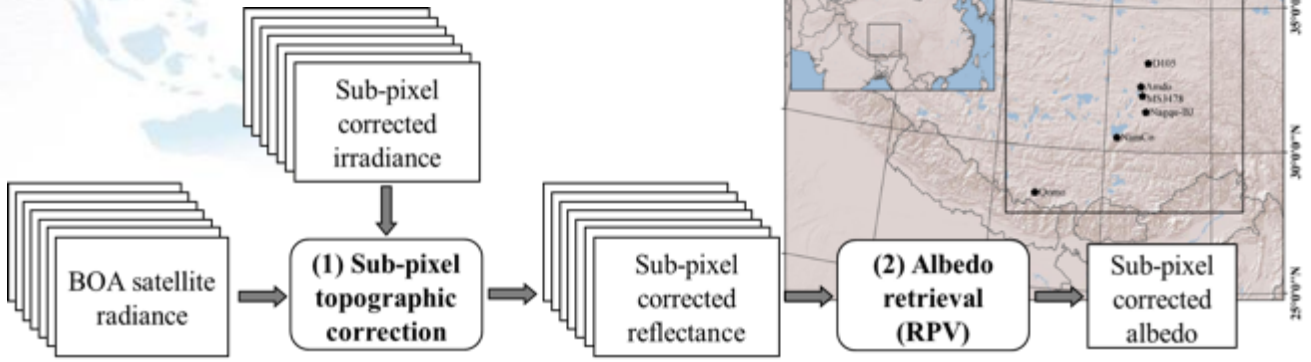


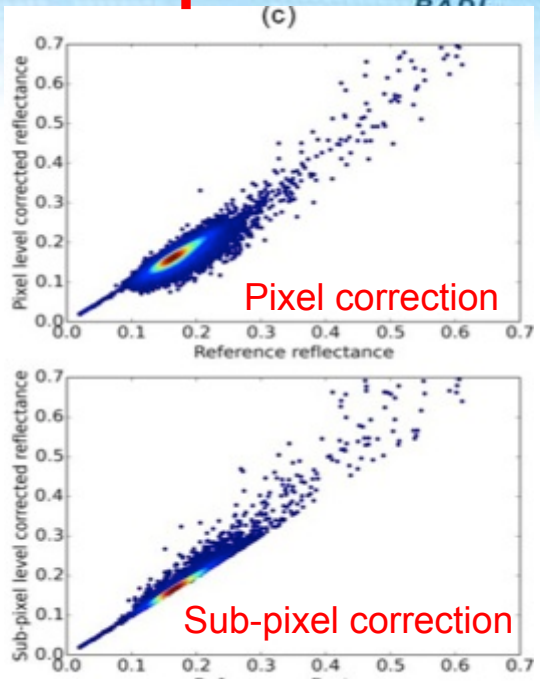


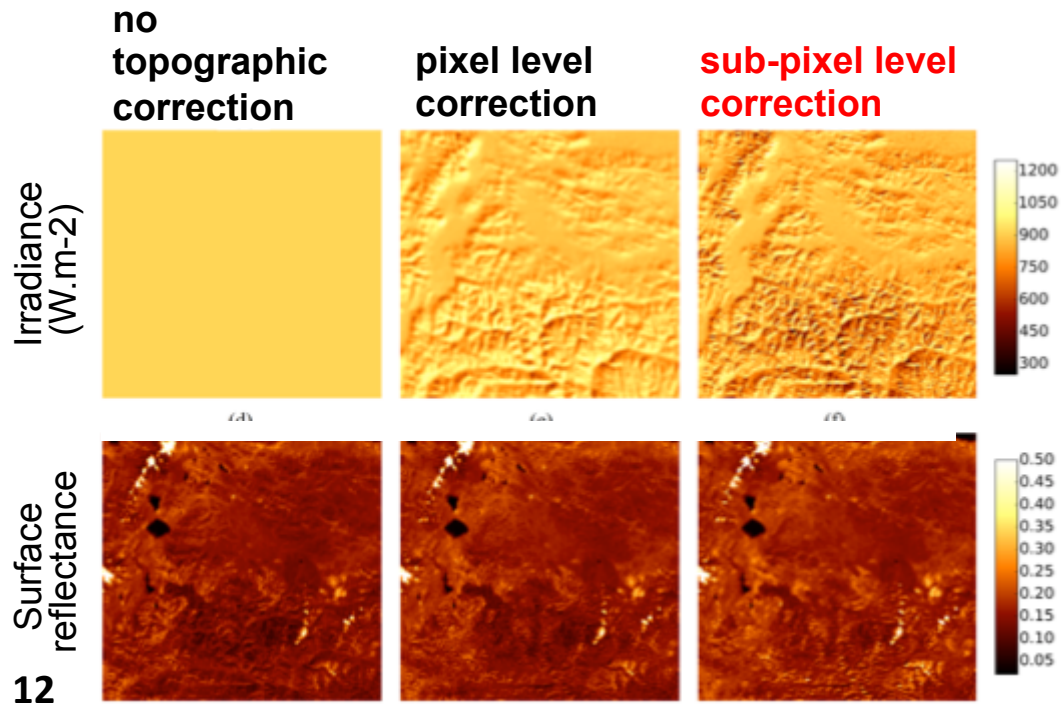
Surface Albedo: Terrain Impact

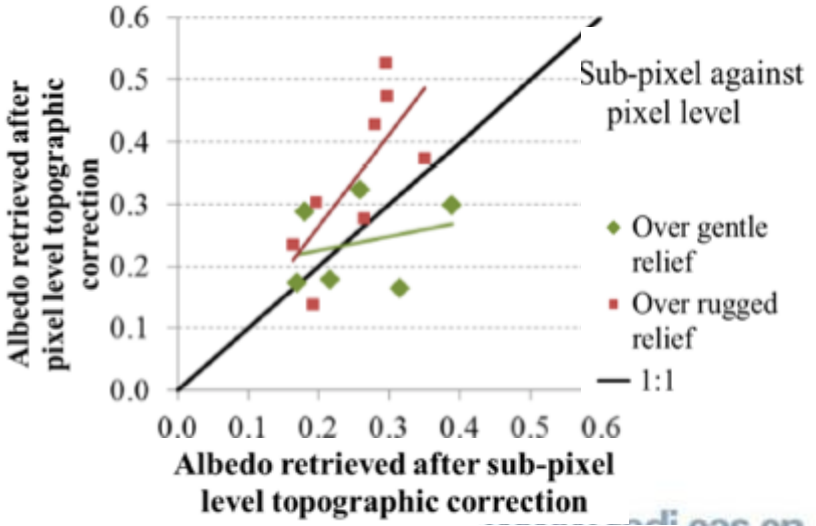
Albedo: Sub-pixel Topographic Correction

FY-2D geostationary data



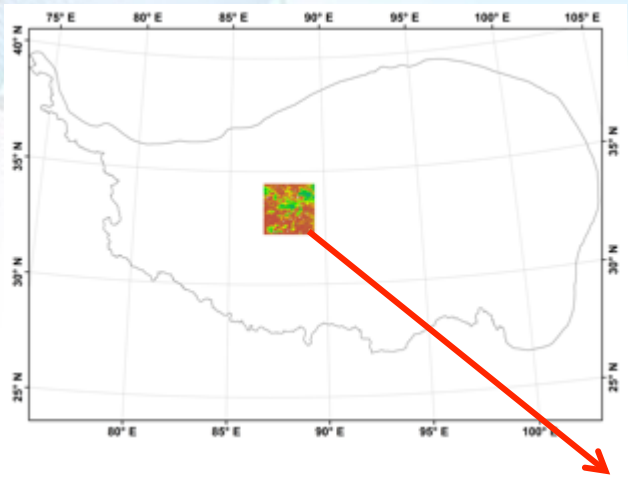






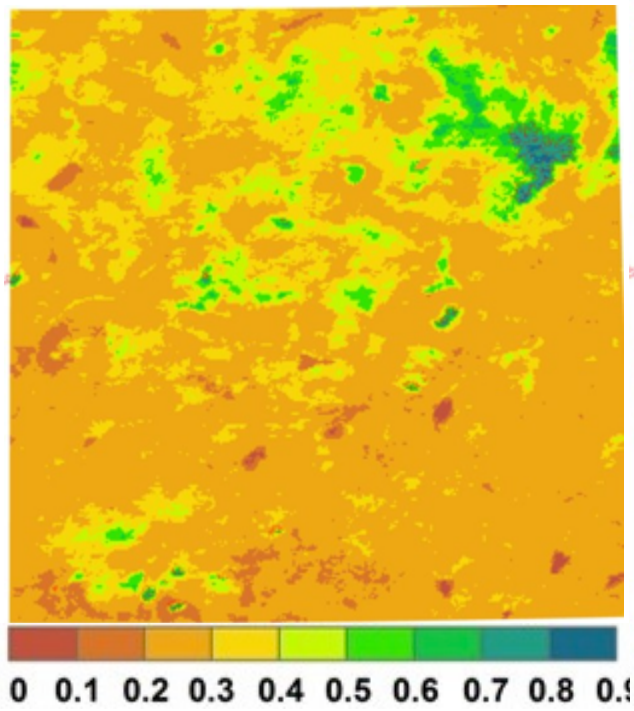
(Roupioz, Jia et al., 2014, ISRSE35)

Surface Albedo: Snow cover impact

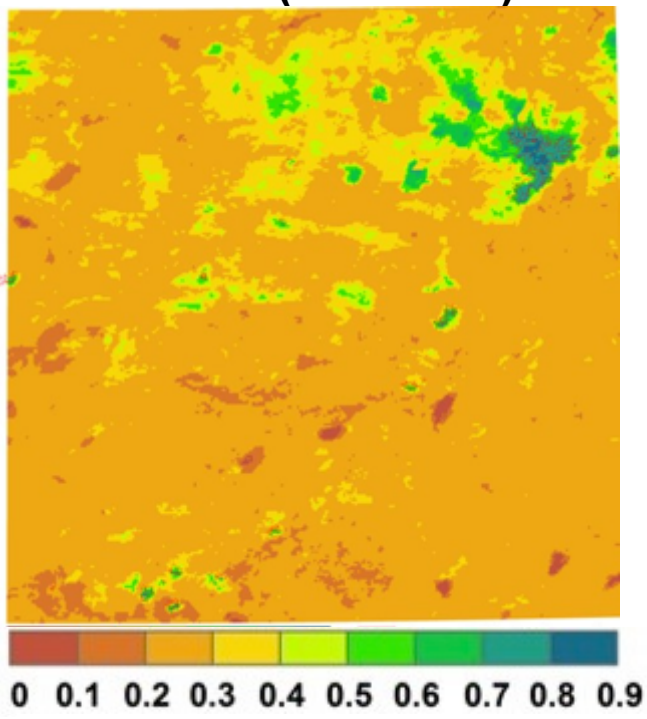


GLASS 8-day albedo (MODIS based):
1 image every 8 days:

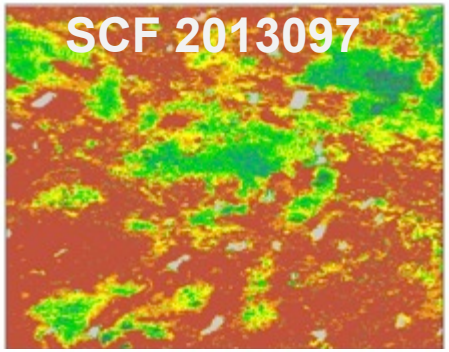
2013097 (097 – 104)

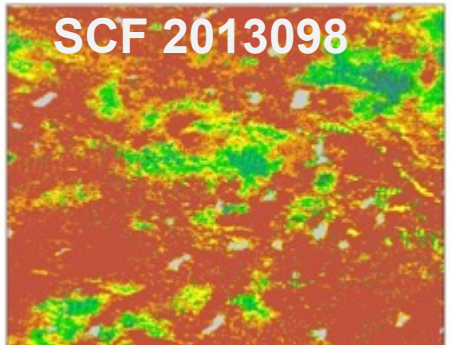


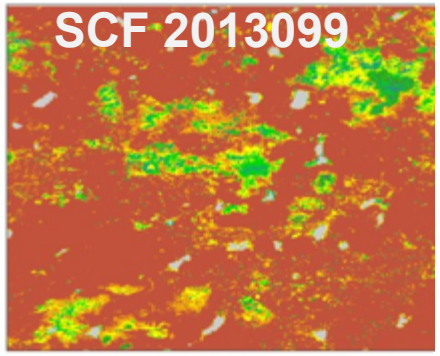
2013105 (105 – 111)

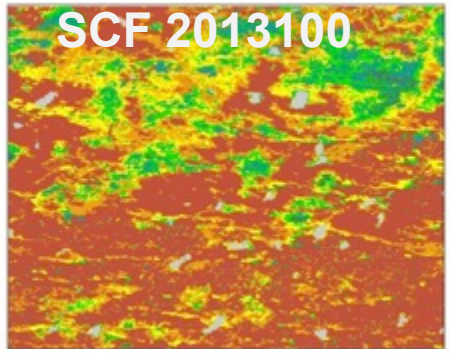


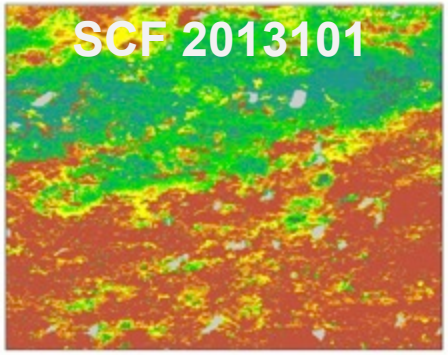
Improved SCF product @ RADI & BNU, 1 image /1-day

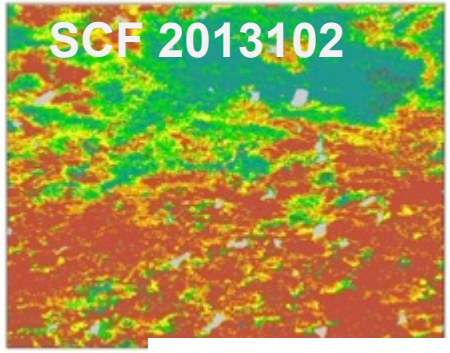


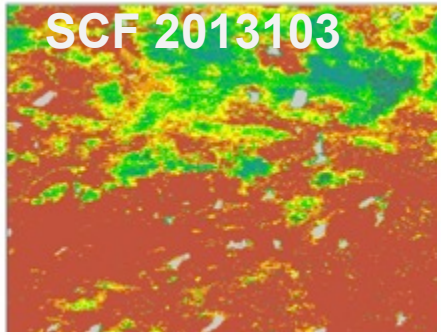


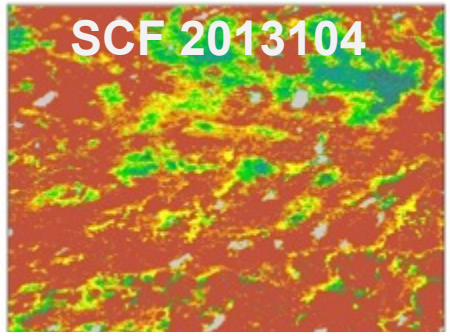


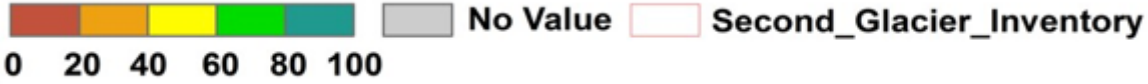




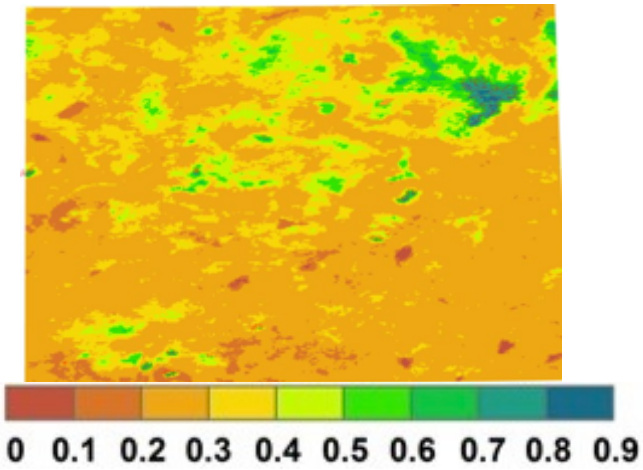






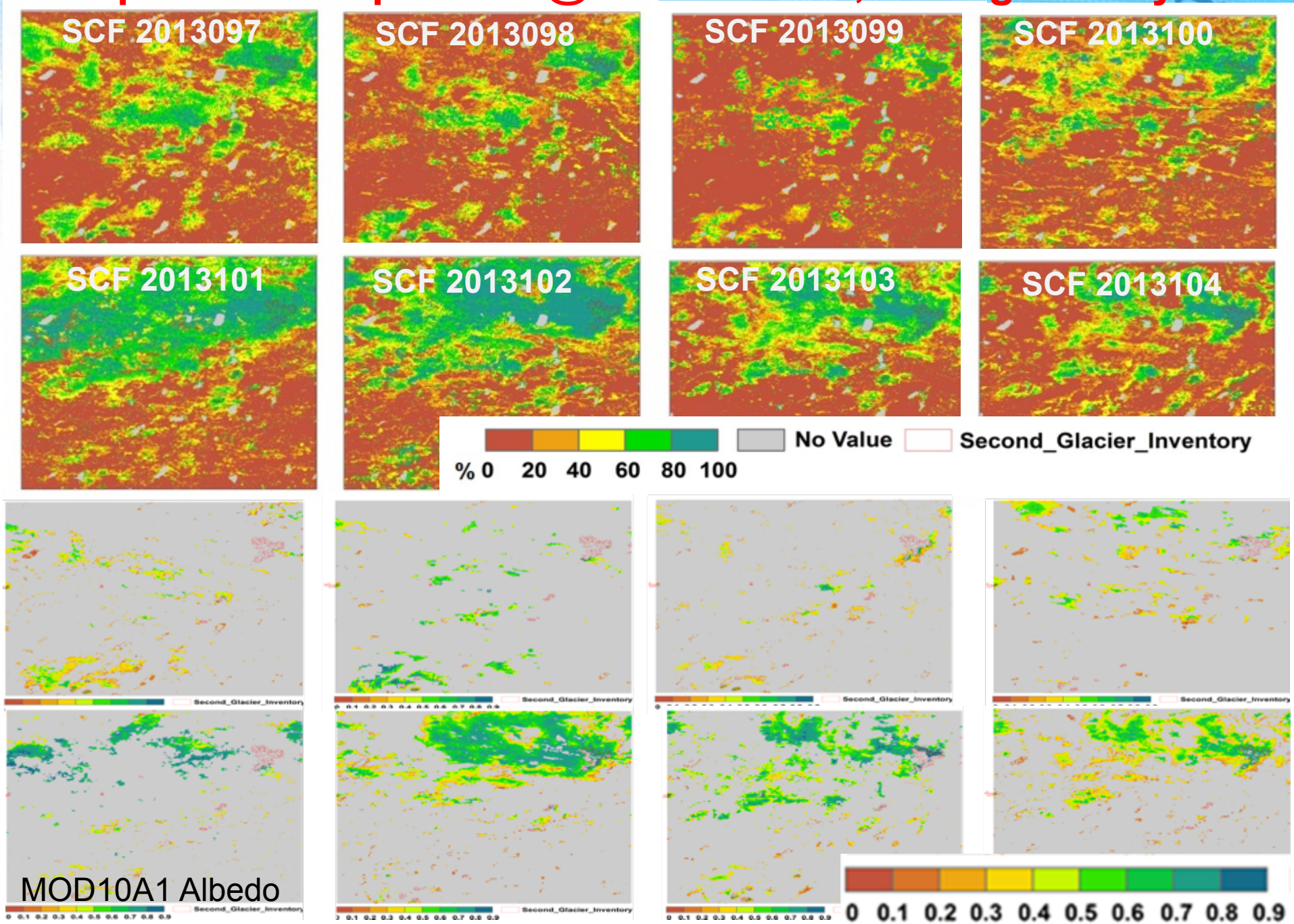


GLASS 8-day Albedo product
2013097 - 2013104

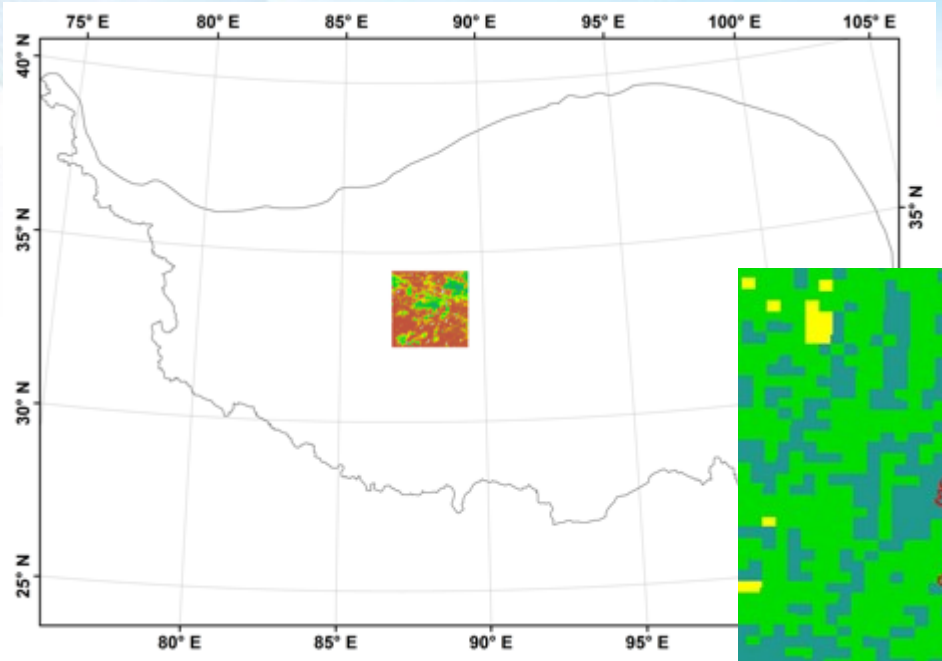


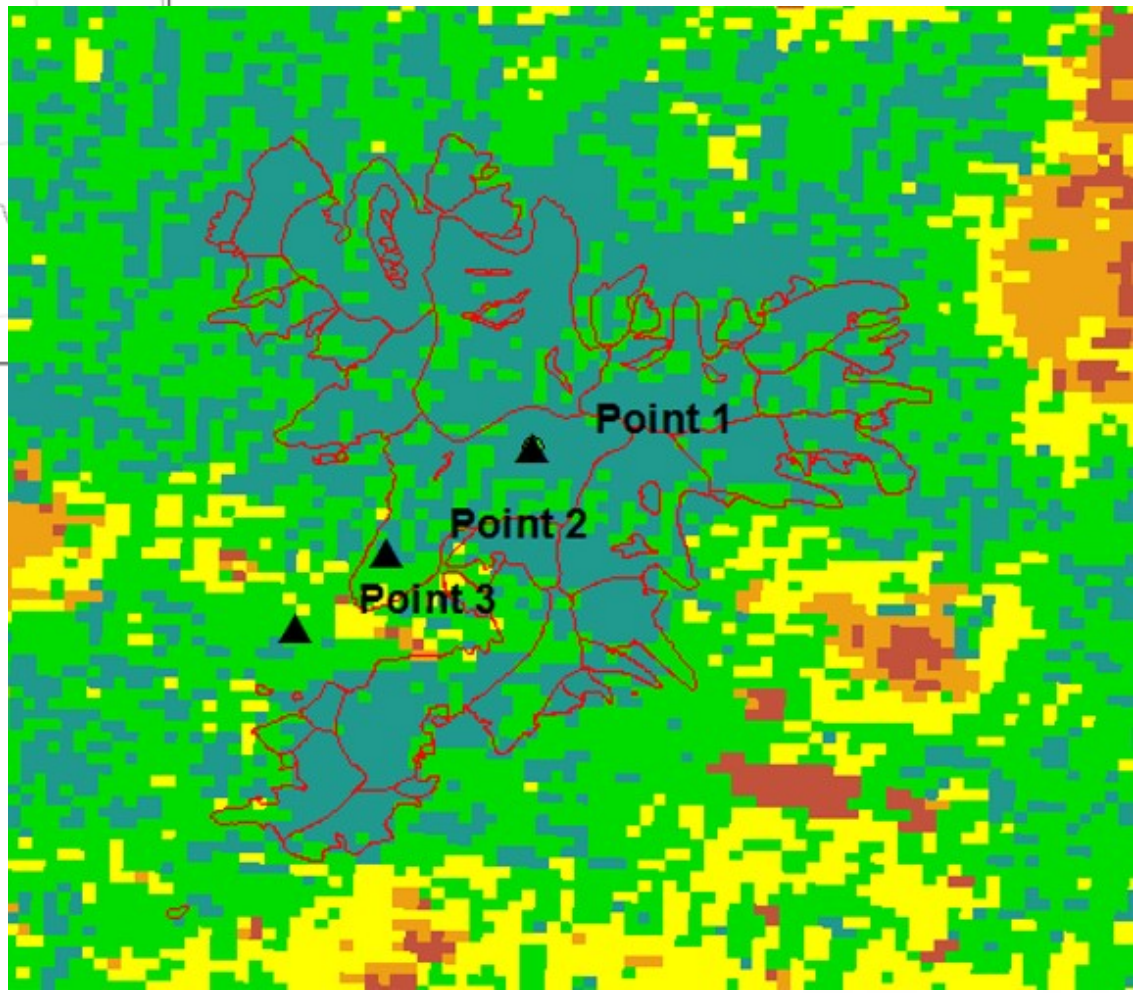
The 8-day albedo cannot capture the fast snow process

Improved SCF product @ RADI & BNU, 1 image /1-day



Surface Albedo: Snow cover impact
+ Glacier albedo

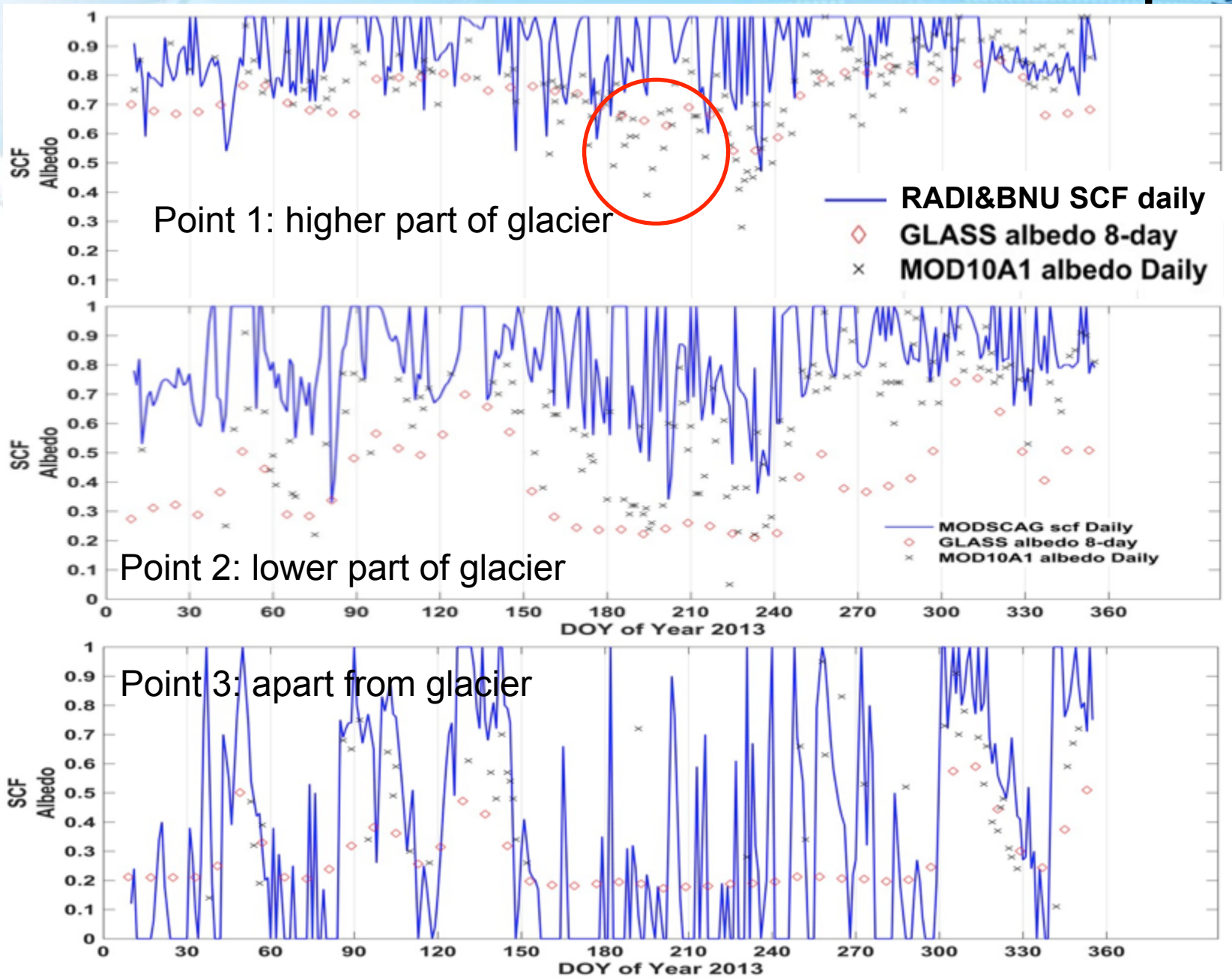




Selected 3 pixels for time series analysis:

Point 1: higher part of glacier
Point 2: lower part of glacier
Point 3: apart from glacier

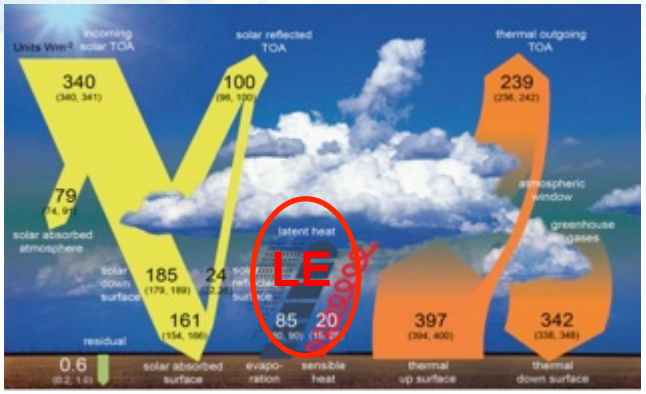
Surface Albedo: Snow cover impact



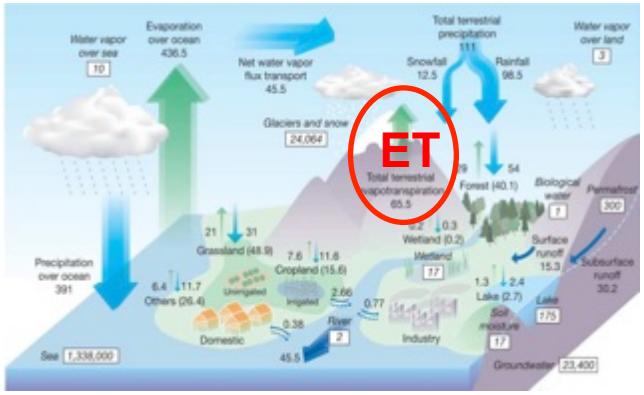
Outline

- Radiation Budget – Surface Albedo
- **Evapotranspiration**

Evapotranspiration



Global energy cycle (Wild et al. 2013)



Global water cycle (From Oki and Kanae, 2006)

Energy Balance and Heat Exchanges

$$R_n = H + LE + G$$

Net radiation | Sensible heat flux | Latent heat flux | Soil heat flux

Water/Mass Balance

$$R = P - ET - \Delta S - \Delta W + \Delta M$$

Runoff | Precipitation | Evapotranspiration | Soil Moisture | Groundwater | Glacier meltwater

Connecting Energy and Water Balance