

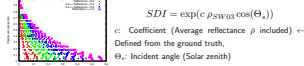
Shadow index estimation algorithm development and improvement

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19 Jan. 2022

Definition (cont.)

Relationship between the shadow content and $\sum_{i=1}^N \cos(\theta_{si}) \rho_i$

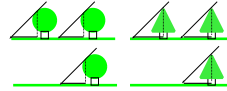
ρ_i	Uniform random number within the range of 0.05 - 0.1, 0.15 - 0.3, 0.25 - 0.5, 0.35 - 0.7, 0.45 - 0.9
w_i	Uniform random number within the range of $1.0 \times 10^{-10} - 1.0 \times 10^{-6}$
$1 - \cos(\theta_{si})$	Log-normal distribution with the average of 0.1 - 0.9 and the standard deviation of 0.2, 0.4, 0.6
Cast shadow	Uniform random number within the range of 0 - 0.01, 0 - 0.05, 0 - 0.1



Contents

- Shadow index definition and estimation algorithm
- Validation results
- Application: Broadleaf/Needleleaf forest discrimination

Canopy and Shadow



⇒ Shadow area reflects the leaf and canopy type.

Definition

Land leaving radiance from a pixel
 $I_s = (F_s \cos(\theta_s) + F_d) \frac{1}{2}$ (if $\theta_s > \pi/2$, $\cos(\theta_s) = 0$)
 F_s : direct solar irradiance, θ_s : average incident angle, F_d : diffuse solar irradiance, ρ : average surface reflectance ← Direct reflection contains the shadow

Reflectance scale up
 $I_s = \sum_{i=1}^N (w_i (F_s \cos(\theta_{si}) + F_d) \frac{1}{2}) = (F_s \cos(\theta_s) + F_d) \frac{1}{2}$
(w_i : area proportion of the i th subsurface)

Assumptions

- Each subsurface within a pixel has the same reflectance ρ_i and incident angle θ_{si} .
 - F_d is negligible (SWIR: SGLI/SW03: 1.6 μ m)
 - $\sum_{i=1}^N w_i F_s \cos(\theta_{si}) \frac{1}{2} = F_s \cos(\theta_s) \frac{1}{2}$, $\sum_{i=1}^N w_i F_s \frac{1}{2} = F_s \frac{1}{2}$
- Definition of the average surface reflectance: $\rho = \sum w_i \rho_i$
Definition of the average incident angle: $\cos(\theta_s) \rho = \sum w_i \cos(\theta_{si}) \rho_i$

SGLI Shadow Index product (SDI)

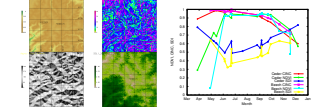
- Assumption 1: Neglect the diffuse solar irradiance → 1.6 μ m (SW03) and not hazy aerosol condition.
- Assumption 2: For the vegetation area. In the case of NDVI < 0.75, On the QA field, Non-vegetation flag is assigned.
- Coeff. definition and validation: From LPC (USGS/3DEP) and the solar geometry at the observation, the shaded area within a pixel is computed.



Examples



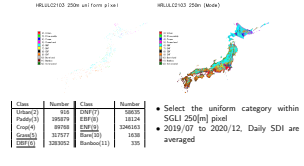
SDI and forest type: Shirakami beech forest



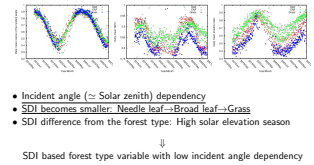
Solar incident angle $\cos(SZA) \cos(Slope) + \sin(SZA) \sin(Slope) \cos(Azimuth - SZA)$
dependency

Comparison between JAXA/HRULC

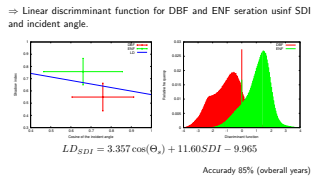
JAXA/HRULC(High Resolution Land Use Land Cover): 10[m] resolution land use land cover dataset



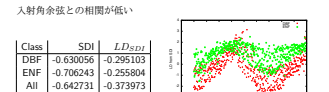
Comparison between JAXA/HRULC (cont.)



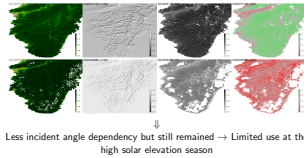
SDI based forest type variable: LDSDI



LDSDI



LDSDI



Less incident angle dependency but still remained → Limited use at the high solar elevation season

Summary and the future plan

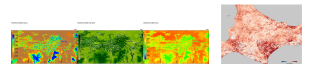
- SDI version 3 is developed and validated.
- For the forest type discrimination, SDI and solar incident angle based variable is defined and shows the probability of the forest type discrimination in the high solar elevation season.
- LPC based validation will be continued. (Not only 3DEP, but Japanese local government provided LPC)
- LANDSAT SDI will be developed for the indirect validation.
- LDSDI will be refined for the VRI → AGB coefficient definition.

LST estimation algorithm development and improvement

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19 Jan. 2022

Contents

- GCOM-C/SGLI LST product error analysis
- Effect of the time difference between the observation and the numerical forecasting data.
- Summary and future



SGLI/LST estimation algorithm

Inputs: Brightness temp. T_1, T_2
Radiation parameters from the numerical forecasting data τ, I_{at}, F
Unknowns: $\epsilon_1, \epsilon_2, T_s$
 $f_1 = B_1^{-1}(\tau_1(\theta) \epsilon_1 B_1(T_1) + (1 - \epsilon_1) \frac{F}{2}) + I_{at}(\theta) - T_1 = 0$
 $f_2 = B_2^{-1}(\tau_2(\theta) \epsilon_2 B_2(T_2) + (1 - \epsilon_2) \frac{F}{2}) + I_{at}(\theta) - T_2 = 0$
 $f_3 = C_3 + (C_1 + \tau_1 C_2) T_1 + C_3 \tau_1 + (C_1 + \tau_2 C_2) T_2 + C_3 \tau_2 - T_s = 0, (\tau_1 = 1 - \epsilon_1)$
Third formula: Split window
Newtonian iteration
 $J = \sqrt{f_1^2 + f_2^2 + f_3^2} \rightarrow \min., T_s, \epsilon_1, \epsilon_2 \Rightarrow$ solution
 $J \leq 1[K]$: Converged, $1 < J \leq 2[K]$: Semi-converged, $J > 2[K]$: Non-converged
→ QA

RTC. Split window

Simplified radiative transfer code
Precipitable water, Surface air temperature: Inputs ϵ : Optical thickness($\tau(\theta) = \exp(-\epsilon / \cos(\theta))$), $I_{at}(\theta)$: Path radiance F : Downward irradiance at the surface.
Split window
3 coeff. sets.
Profile: ECMWF 2000 Monthly mean Profile (averaged over 10 deg latitude interval)
Surface temperature: Air temperature at the surface = 0, 5, 10, 15, 20, 25, 30, 35, 40 deg
Observation error: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20.0, 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5, 30.0, 30.5, 31.0, 31.5, 32.0, 32.5, 33.0, 33.5, 34.0, 34.5, 35.0, 35.5, 36.0, 36.5, 37.0, 37.5, 38.0, 38.5, 39.0, 39.5, 40.0, 40.5, 41.0, 41.5, 42.0, 42.5, 43.0, 43.5, 44.0, 44.5, 45.0, 45.5, 46.0, 46.5, 47.0, 47.5, 48.0, 48.5, 49.0, 49.5, 50.0, 50.5, 51.0, 51.5, 52.0, 52.5, 53.0, 53.5, 54.0, 54.5, 55.0, 55.5, 56.0, 56.5, 57.0, 57.5, 58.0, 58.5, 59.0, 59.5, 60.0, 60.5, 61.0, 61.5, 62.0, 62.5, 63.0, 63.5, 64.0, 64.5, 65.0, 65.5, 66.0, 66.5, 67.0, 67.5, 68.0, 68.5, 69.0, 69.5, 70.0, 70.5, 71.0, 71.5, 72.0, 72.5, 73.0, 73.5, 74.0, 74.5, 75.0, 75.5, 76.0, 76.5, 77.0, 77.5, 78.0, 78.5, 79.0, 79.5, 80.0, 80.5, 81.0, 81.5, 82.0, 82.5, 83.0, 83.5, 84.0, 84.5, 85.0, 85.5, 86.0, 86.5, 87.0, 87.5, 88.0, 88.5, 89.0, 89.5, 90.0, 90.5, 91.0, 91.5, 92.0, 92.5, 93.0, 93.5, 94.0, 94.5, 95.0, 95.5, 96.0, 96.5, 97.0, 97.5, 98.0, 98.5, 99.0, 99.5, 100.0, 100.5, 101.0, 101.5, 102.0, 102.5, 103.0, 103.5, 104.0, 104.5, 105.0, 105.5, 106.0, 106.5, 107.0, 107.5, 108.0, 108.5, 109.0, 109.5, 110.0, 110.5, 111.0, 111.5, 112.0, 112.5, 113.0, 113.5, 114.0, 114.5, 115.0, 115.5, 116.0, 116.5, 117.0, 117.5, 118.0, 118.5, 119.0, 119.5, 120.0, 120.5, 121.0, 121.5, 122.0, 122.5, 123.0, 123.5, 124.0, 124.5, 125.0, 125.5, 126.0, 126.5, 127.0, 127.5, 128.0, 128.5, 129.0, 129.5, 130.0, 130.5, 131.0, 131.5, 132.0, 132.5, 133.0, 133.5, 134.0, 134.5, 135.0, 135.5, 136.0, 136.5, 137.0, 137.5, 138.0, 138.5, 139.0, 139.5, 140.0, 140.5, 141.0, 141.5, 142.0, 142.5, 143.0, 143.5, 144.0, 144.5, 145.0, 145.5, 146.0, 146.5, 147.0, 147.5, 148.0, 148.5, 149.0, 149.5, 150.0, 150.5, 151.0, 151.5, 152.0, 152.5, 153.0, 153.5, 154.0, 154.5, 155.0, 155.5, 156.0, 156.5, 157.0, 157.5, 158.0, 158.5, 159.0, 159.5, 160.0, 160.5, 161.0, 161.5, 162.0, 162.5, 163.0, 163.5, 164.0, 164.5, 165.0, 165.5, 166.0, 166.5, 167.0, 167.5, 168.0, 168.5, 169.0, 169.5, 170.0, 170.5, 171.0, 171.5, 172.0, 172.5, 173.0, 173.5, 174.0, 174.5, 175.0, 175.5, 176.0, 176.5, 177.0, 177.5, 178.0, 178.5, 179.0, 179.5, 180.0, 180.5, 181.0, 181.5, 182.0, 182.5, 183.0, 183.5, 184.0, 184.5, 185.0, 185.5, 186.0, 186.5, 187.0, 187.5, 188.0, 188.5, 189.0, 189.5, 190.0, 190.5, 191.0, 191.5, 192.0, 192.5, 193.0, 193.5, 194.0, 194.5, 195.0, 195.5, 196.0, 196.5, 197.0, 197.5, 198.0, 198.5, 199.0, 199.5, 200.0, 200.5, 201.0, 201.5, 202.0, 202.5, 203.0, 203.5, 204.0, 204.5, 205.0, 205.5, 206.0, 206.5, 207.0, 207.5, 208.0, 208.5, 209.0, 209.5, 210.0, 210.5, 211.0, 211.5, 212.0, 212.5, 213.0, 213.5, 214.0, 214.5, 215.0, 215.5, 216.0, 216.5, 217.0, 217.5, 218.0, 218.5, 219.0, 219.5, 220.0, 220.5, 221.0, 221.5, 222.0, 222.5, 223.0, 223.5, 224.0, 224.5, 225.0, 225.5, 226.0, 226.5, 227.0, 227.5, 228.0, 228.5, 229.0, 229.5, 230.0, 230.5, 231.0, 231.5, 232.0, 232.5, 233.0, 233.5, 234.0, 234.5, 235.0, 235.5, 236.0, 236.5, 237.0, 237.5, 238.0, 238.5, 239.0, 239.5, 240.0, 240.5, 241.0, 241.5, 242.0, 242.5, 243.0, 243.5, 244.0, 244.5, 245.0, 245.5, 246.0, 246.5, 247.0, 247.5, 248.0, 248.5, 249.0, 249.5, 250.0, 250.5, 251.0, 251.5, 252.0, 252.5, 253.0, 253.5, 254.0, 254.5, 255.0, 255.5, 256.0, 256.5, 257.0, 257.5, 258.0, 258.5, 259.0, 259.5, 260.0, 260.5, 261.0, 261.5, 262.0, 262.5, 263.0, 263.5, 264.0, 264.5, 265.0, 265.5, 266.0, 266.5, 267.0, 267.5, 268.0, 268.5, 269.0, 269.5, 270.0, 270.5, 271.0, 271.5, 272.0, 272.5, 273.0, 273.5, 274.0, 274.5, 275.0, 275.5, 276.0, 276.5, 277.0, 277.5, 278.0, 278.5, 279.0, 279.5, 280.0, 280.5, 281.0, 281.5, 282.0, 282.5, 283.0, 283.5, 284.0, 284.5, 285.0, 285.5, 286.0, 286.5, 287.0, 287.5, 288.0, 288.5, 289.0, 289.5, 290.0, 290.5, 291.0, 291.5, 292.0, 292.5, 293.0, 293.5, 294.0, 294.5, 295.0, 295.5, 296.0, 296.5, 297.0, 297.5, 298.0, 298.5, 299.0, 299.5, 300.0, 300.5, 301.0, 301.5, 302.0, 302.5, 303.0, 303.5, 304.0, 304.5, 305.0, 305.5, 306.0, 306.5, 307.0, 307.5, 308.0, 308.5, 309.0, 309.5, 310.0, 310.5, 311.0, 311.5, 312.0, 312.5, 313.0, 313.5, 314.0, 314.5, 315.0, 315.5, 316.0, 316.5, 317.0, 317.5, 318.0, 318.5, 319.0, 319.5, 320.0, 320.5, 321.0, 321.5, 322.0, 322.5, 323.0, 323.5, 324.0, 324.5, 325.0, 325.5, 326.0, 326.5, 327.0, 327.5, 328.0, 328.5, 329.0, 329.5, 330.0, 330.5, 331.0, 331.5, 332.0, 332.5, 333.0, 333.5, 334.0, 334.5, 335.0, 335.5, 336.0, 336.5, 337.0, 337.5, 338.0, 338.5, 339.0, 339.5, 340.0, 340.5, 341.0, 341.5, 342.0, 342.5, 343.0, 343.5, 344.0, 344.5, 345.0, 345.5, 346.0, 346.5, 347.0, 347.5, 348.0, 348.5, 349.0, 349.5, 350.0, 350.5, 351.0, 351.5, 352.0, 352.5, 353.0, 353.5, 354.0, 354.5, 355.0, 355.5, 356.0, 356.5, 357.0, 357.5, 358.0, 358.5, 359.0, 359.5, 360.0, 360.5, 361.0, 361.5, 362.0, 362.5, 363.0, 363.5, 364.0, 364.5, 365.0, 365.5, 366.0, 366.5, 367.0, 367.5, 368.0, 368.5, 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