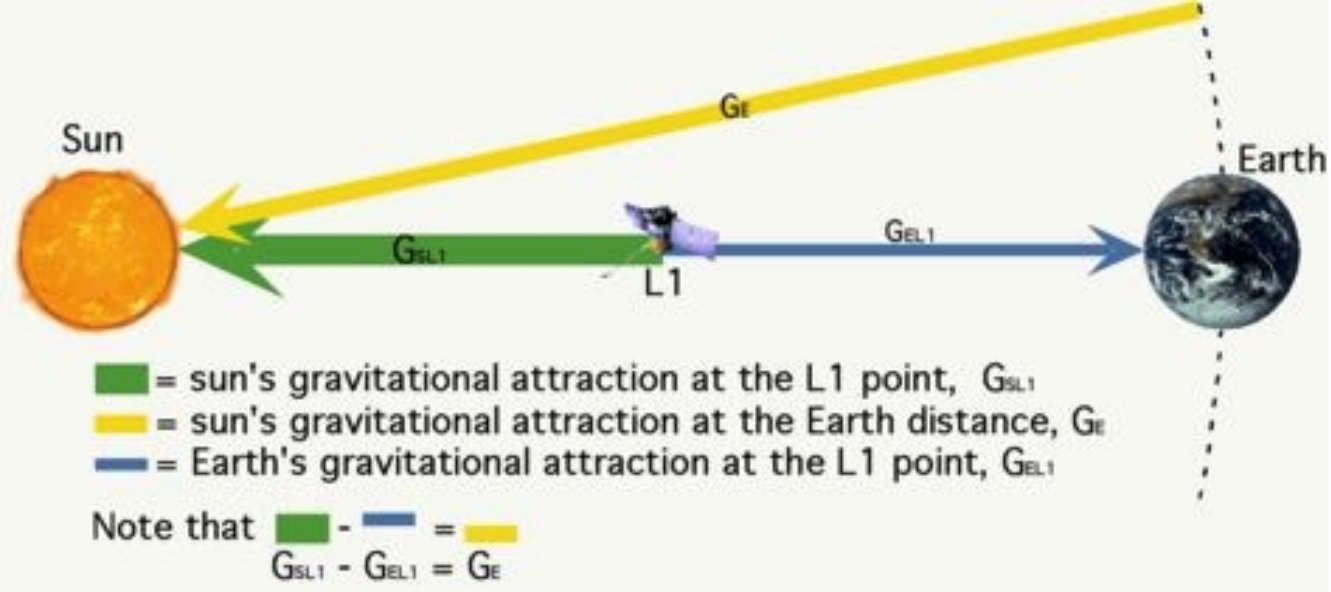
SIMULATION AND CORRECTION OF TRIANA VIEWED EARTH RADIATION BUDGET WITH ERBE DATA

- TRIANA MISSION
- OBJECTIVE
- SIMULATION OF TRIANA VIEWED EARTH RADIATION BUDGET
- DEVELOPMENT OF CORRECTION MODELS
- CONCLUSION AND FUTURE WORK

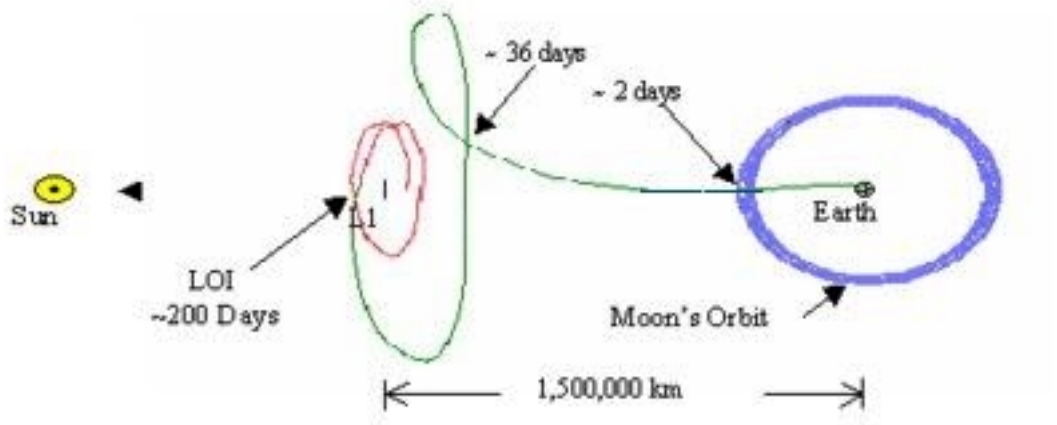
P. Minnis, J. Huang, D. R. Doelling
NASA Langley Research Center, Hampton, VA 23666
F. P. Valero
Scripps Institute of Oceanography

TRIANA MISSION



Triana is designed to continually measure the sunlit side of the earth and promises to offer new insights into how our planet's climate works as an integrated system. Triana measure broadband radiance from the entire Earth as viewed from around L1.

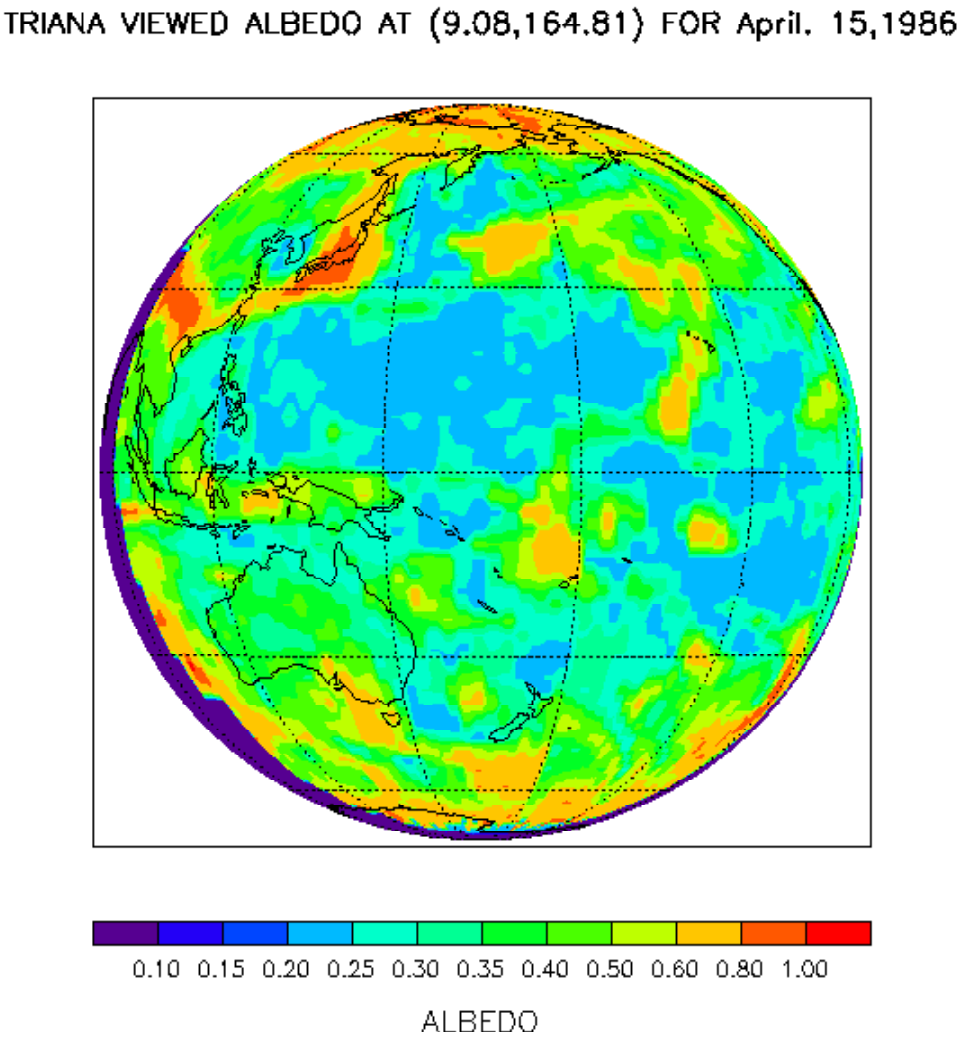
The L1 point is the location where the Earth's gravitational field equally counters that of the sun. Since the strength of the gravitational attraction determines the orbital period, Triana will orbit the sun at the same rate as the Earth. Triana will be placed in an elliptical Lissajous orbit about L1 and will vary from 4° to 15° about the Earth-sun line.



- Although most of the Earth is seen from the Triana orbit, a small (2% to 8%) but variable sliver of sunlight is always out of view.

- Most of darkside of Earth is never seen.

- To derive the Earth radiation budget, a set of correction factors must be used to convert to the radiance to flux and to account for the areas that are not viewed.



Objective

- DEVELOPMENT OF TRIANA VIEWED SIMULATION DATASET BASED ON ERBE.
- DEVELOPMENT OF AN EMPIRICAL SET OF CORRECTION FACTORS SPECIFIC TO TRIANA VIEWS.
- ANALYSIS OF THE VARIABILITY OF THE CORRECTION FACTORS WITH RESPECT TO THE SATELLITE'S POSITION FROM L1.
- DEVELOPMENT OF A SET OF CORRECTION MODEL FOR PRODUCING A HIGHLY ACCURATE GLOBAL ERB FROM TRIANA.

ERBE DATA

ERBE was a multi-satellite system designed to measure the ERB. ERBE data were collected from three satellites (ERBS, NOAA-9, and NOAA-10).

Each satellite measured broadband SW and LW radiances from cross-track scanners and wide-field-of-view radiometers.

This combination of multiple satellite is used to produce a Triana-viewed ERB. In this study, we use 4 years (Jan. 1985 to Dec. 1988) of ERBE S-9 data to develop a simulated Triana dataset.

- **TRIANA GLOBAL BIDIRECTIONAL FACTOR**

$$\chi_{triana}(\mathbf{gmt}) = \mathbf{REF}_{triana}(\mathbf{gmt}) / \alpha_{triana}(\mathbf{gmt})$$

- **TRIANA GLOBAL MISSING LIGHT ALBEDO CORRECTION FACTOR**

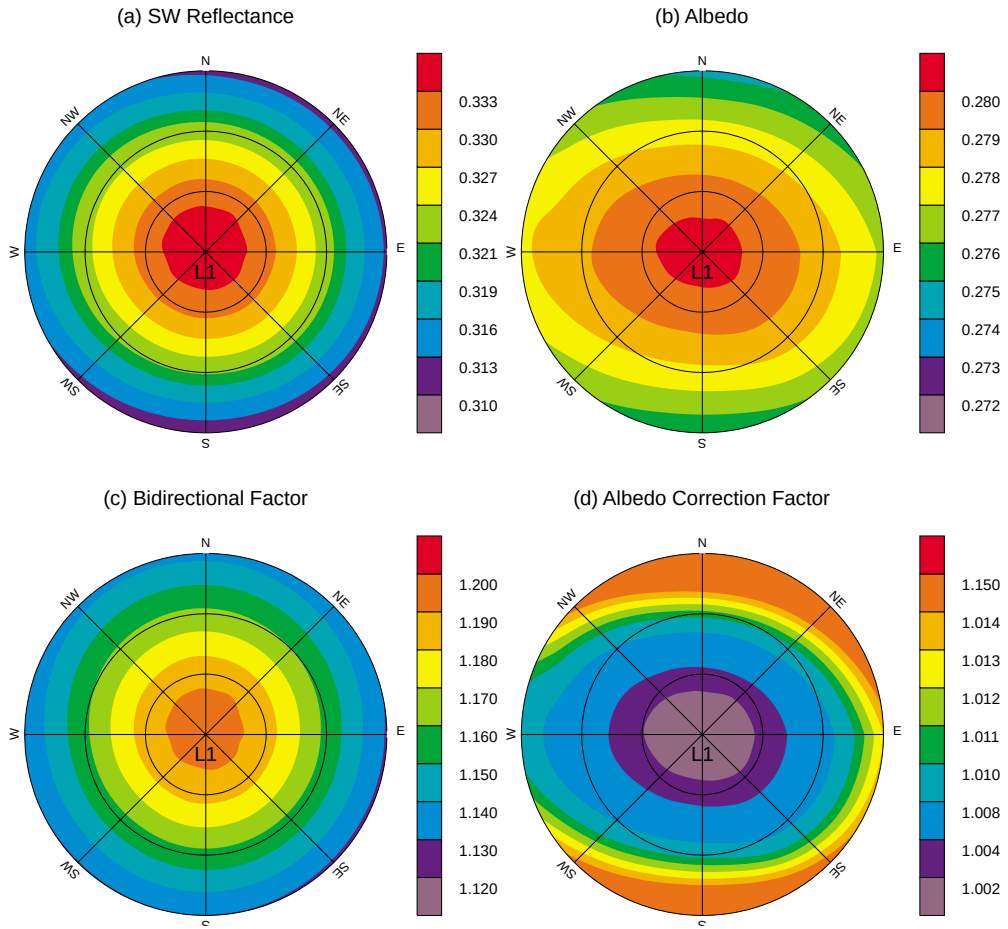
$$\alpha_{FACTOR}(\mathbf{gmt}) = \left[\sum_{earth} \alpha_{erbe}(\mu_i)\, \mu_i \cos(\mathbf{lat}_i) / \sum_{earth} \mu_i \cos(\mathbf{lat}_i) \right] / \left[\alpha_{triana}(\mathbf{gmt}) \right]$$

- **TRIANA GLOBAL LIMB DARKENING FACTOR**

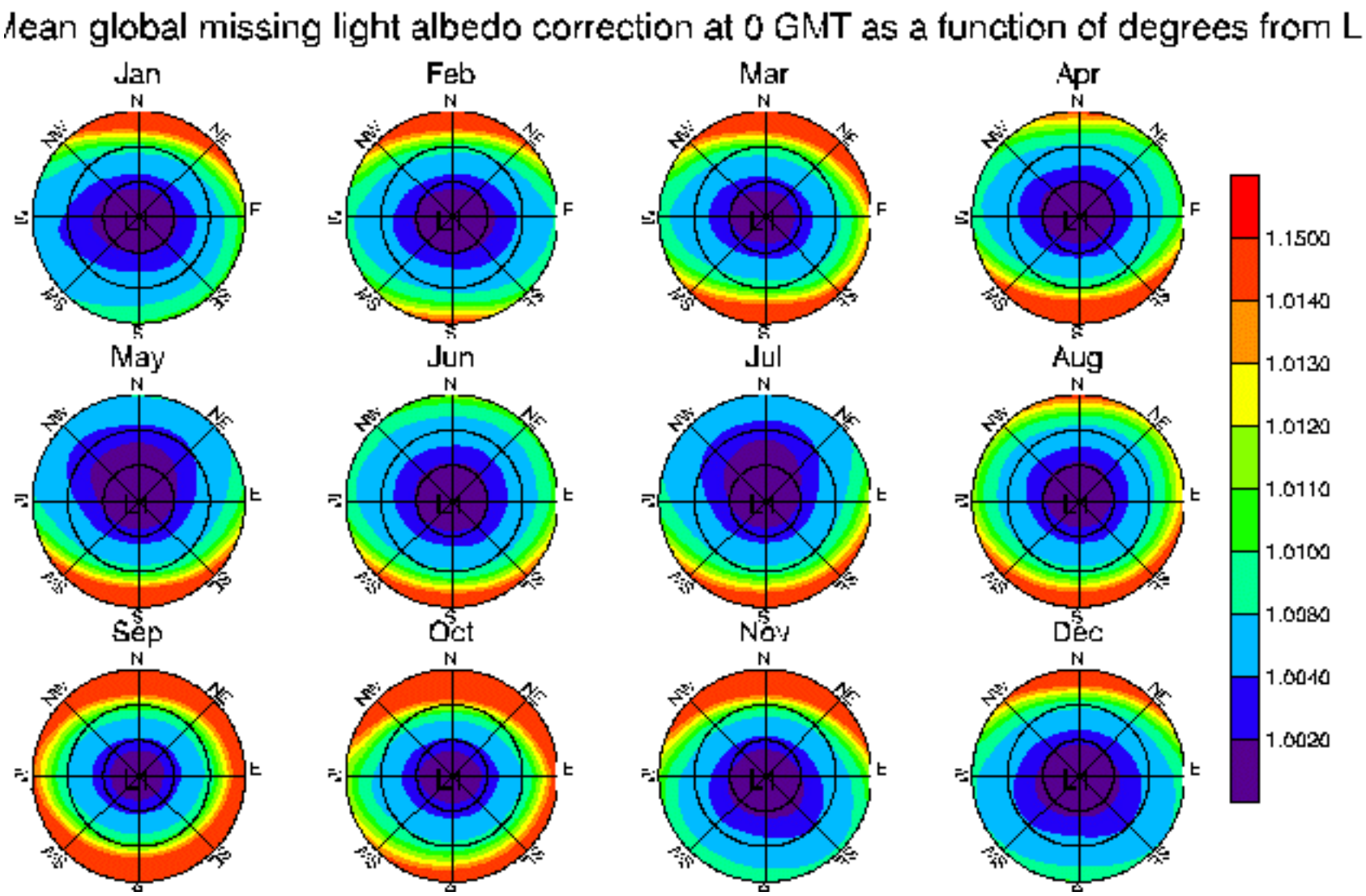
$$\gamma_{triana}(\mathbf{gmt}) = \mathbf{RAD}_{triana}(\mathbf{gmt}) / \mathbf{OLR}_{triana}(\mathbf{gmt})$$

- **TRIANA GLOBAL NIGHT OLR CORRECTION FACTOR**

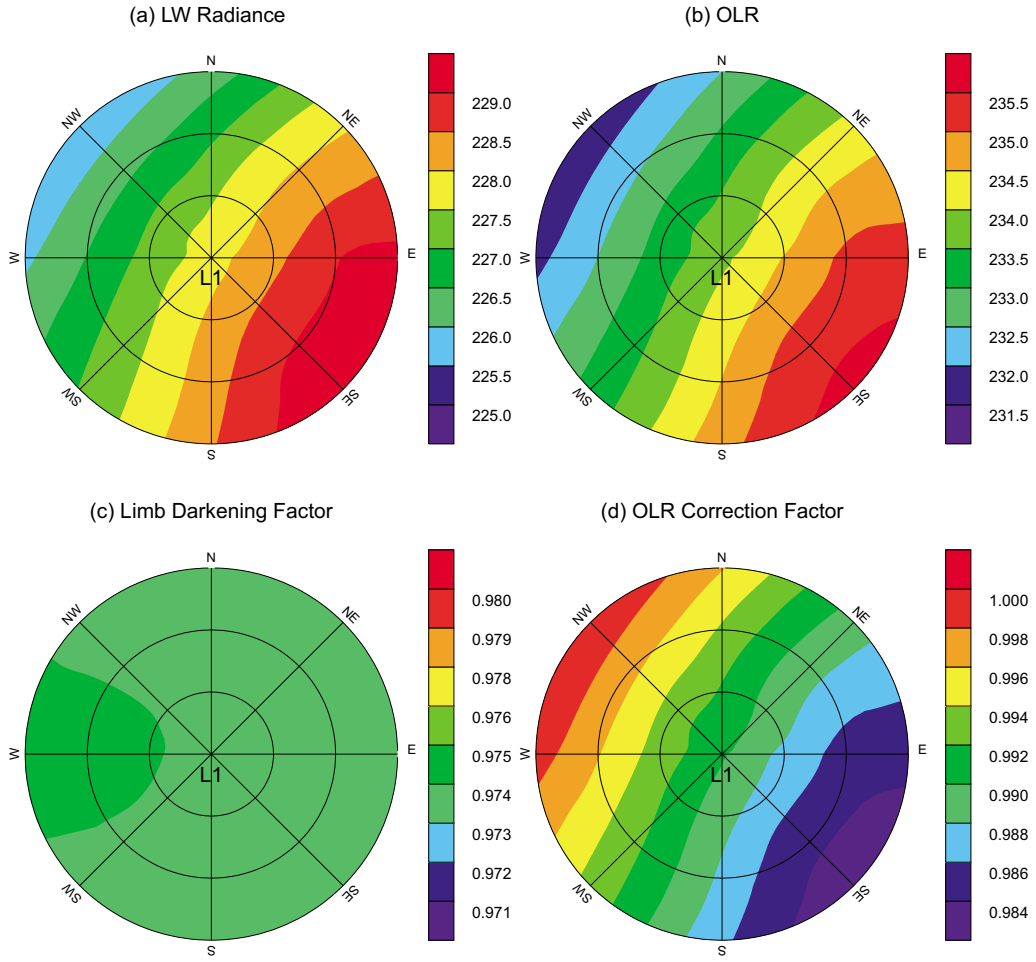
$$\mathbf{OLR}_{FACTOR}(\mathbf{gmt}) = \left[\sum_{earth} \mathbf{OLR}_{erbe}(t_T) \cos(\mathbf{lat}_i) / \sum_{earth} \cos(\mathbf{lat}_i) \right] / \left[\mathbf{OLR}_{triana}(\mathbf{gmt}) \right]$$



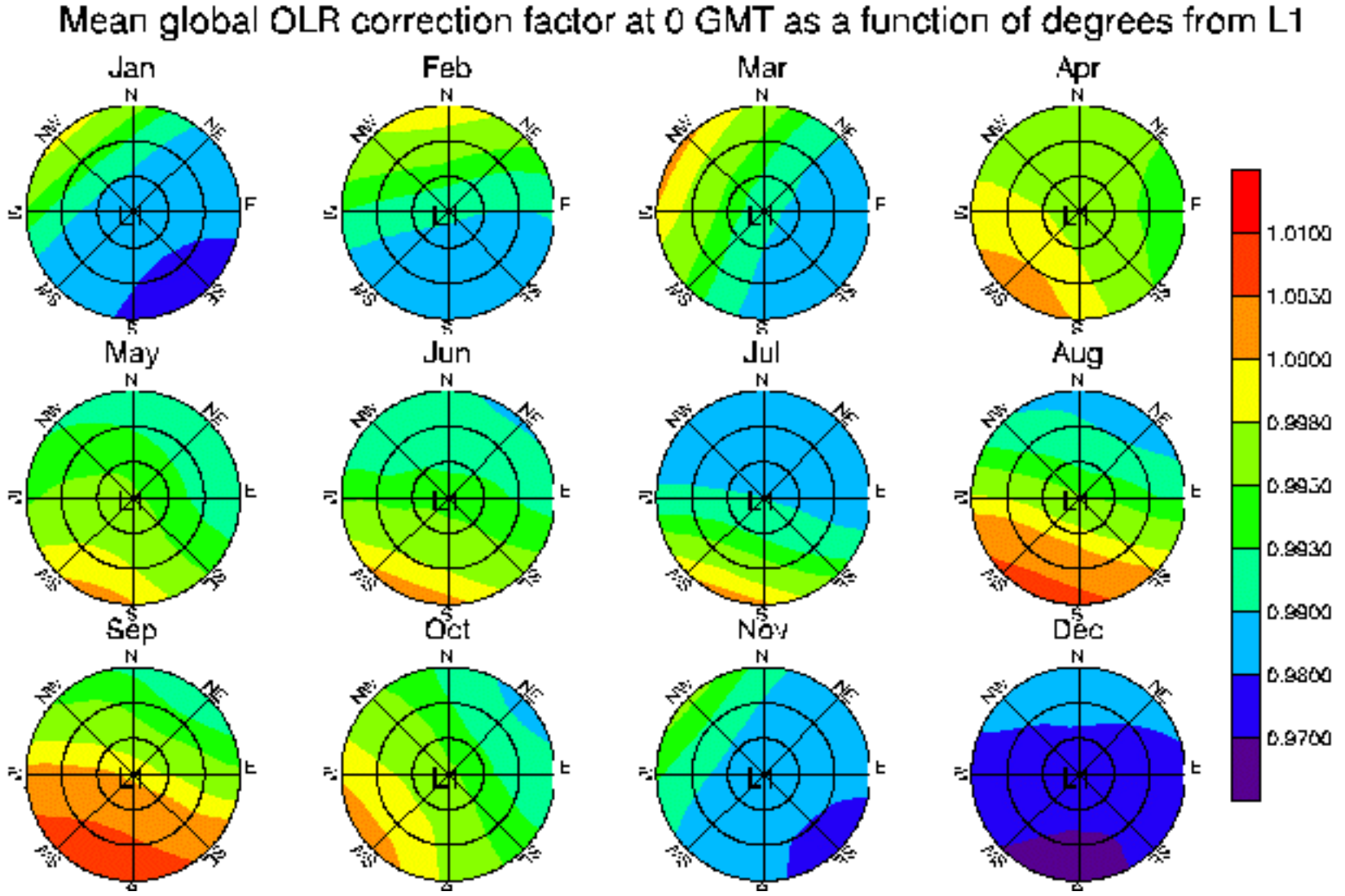
Simulated monthly mean global Triana short-wave parameters as a function of degree from L1 at 0 GMT for March 1986.


Mean global missing light albedo correction at 0 GMT as a function of degrees from L
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1.1500
1.0140
1.0130
1.0120
1.0110
1.0100
1.0080
1.0040
1.0020

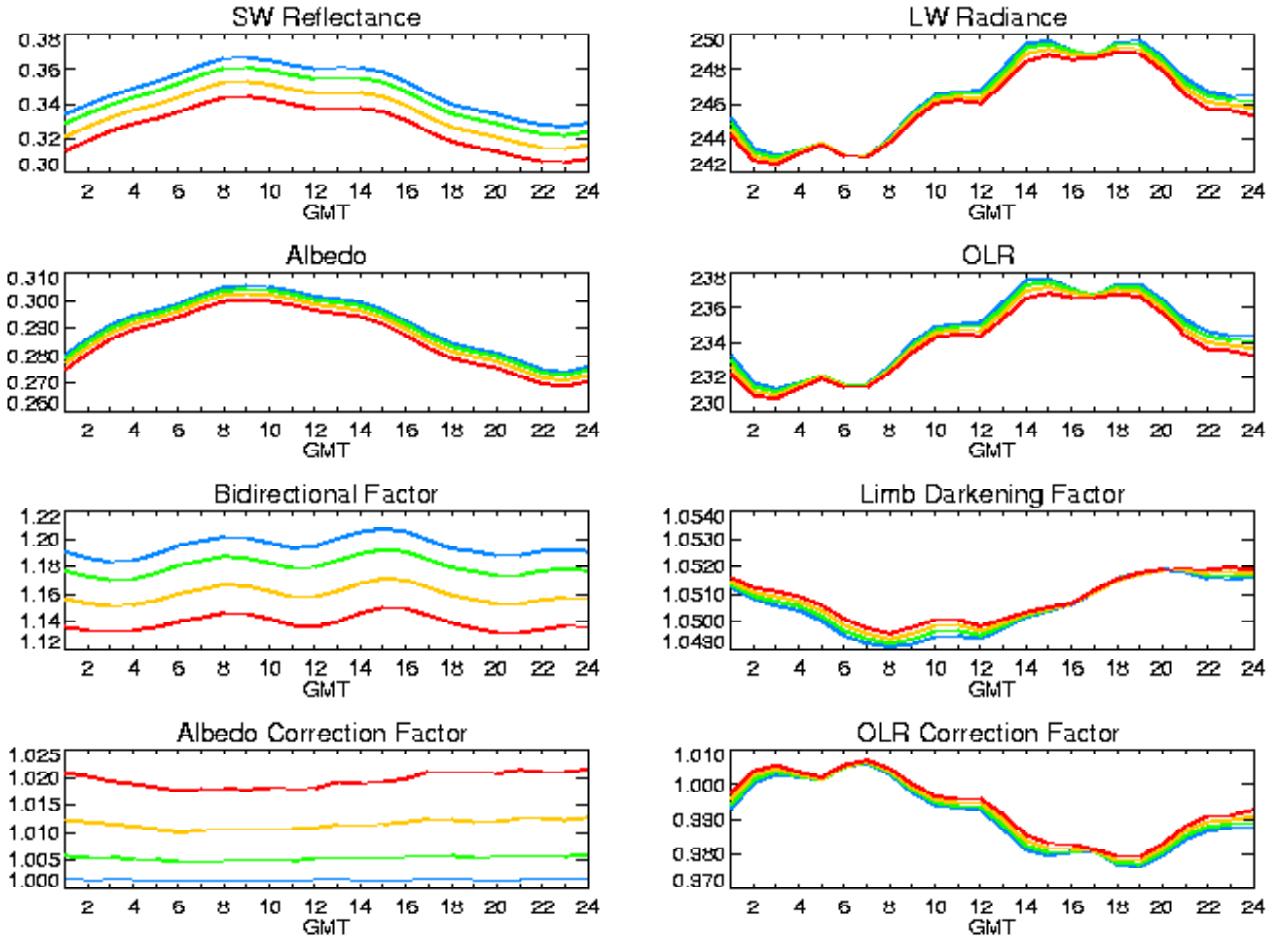
Triana Project



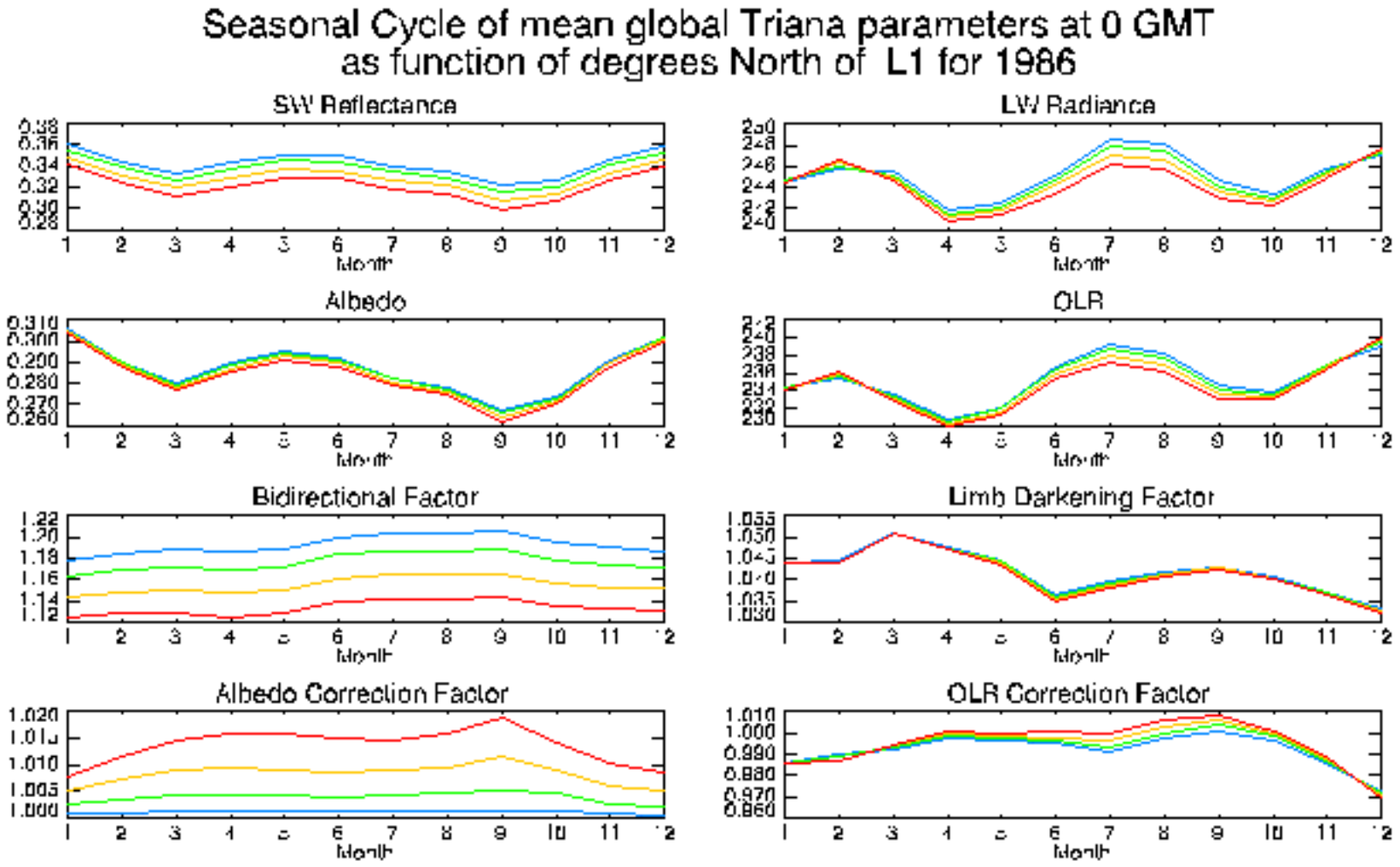
Simulated monthly mean global Triana long-wave parameters as a function of degree from L1 at 0 GMT for March 1986.


Mean global OLR correction factor at 0 GMT as a function of degrees from L1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1.0100
1.0050
1.0000
0.9950
0.9900
0.9850
0.9800
0.9750

Diurnal variation of mean global Triana parameters as function of degrees North of L1 for March 1986



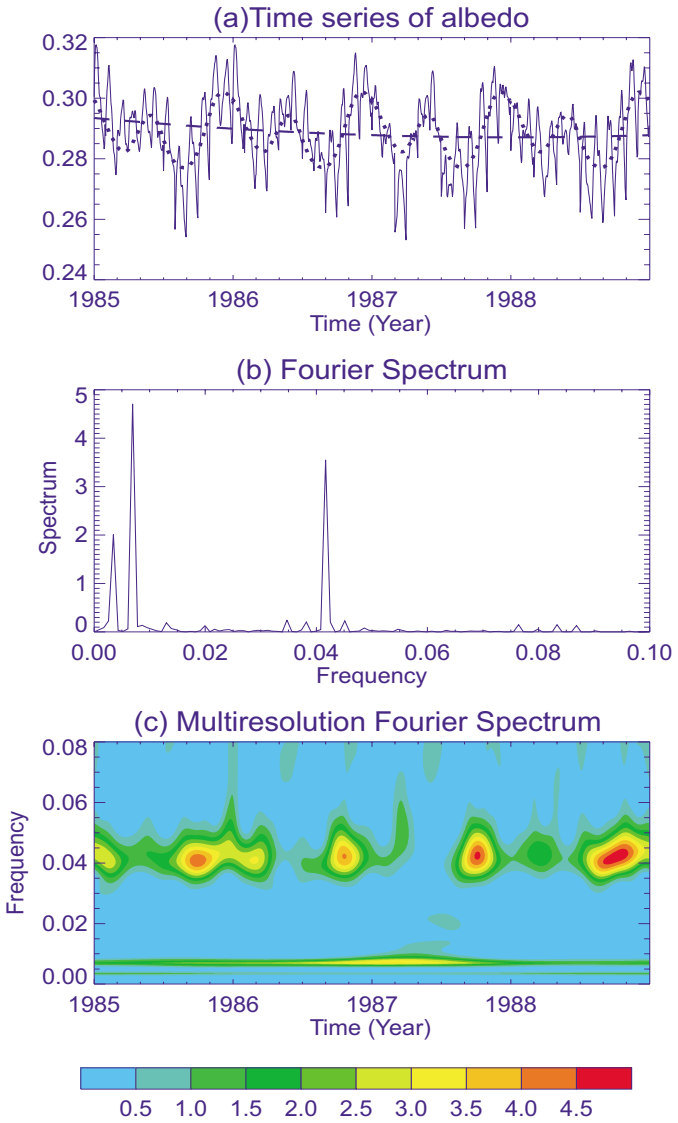
Red line =15.0, Yellow line =11.0, Green line =7.0 and Blue line =3.0


Seasonal Cycle of mean global Triana parameters at 0 GMT
as function of degrees North of L1 for 1986
SW Reflectance
LW Radiance
Albedo
OLR
Bidirectional Factor
Limb Darkening Factor
Albedo Correction Factor
OLR Correction Factor
Month
Red line 15.0; Yellow line 11.0; Green line 7.0 and Blue line 3.0

SUMMARY

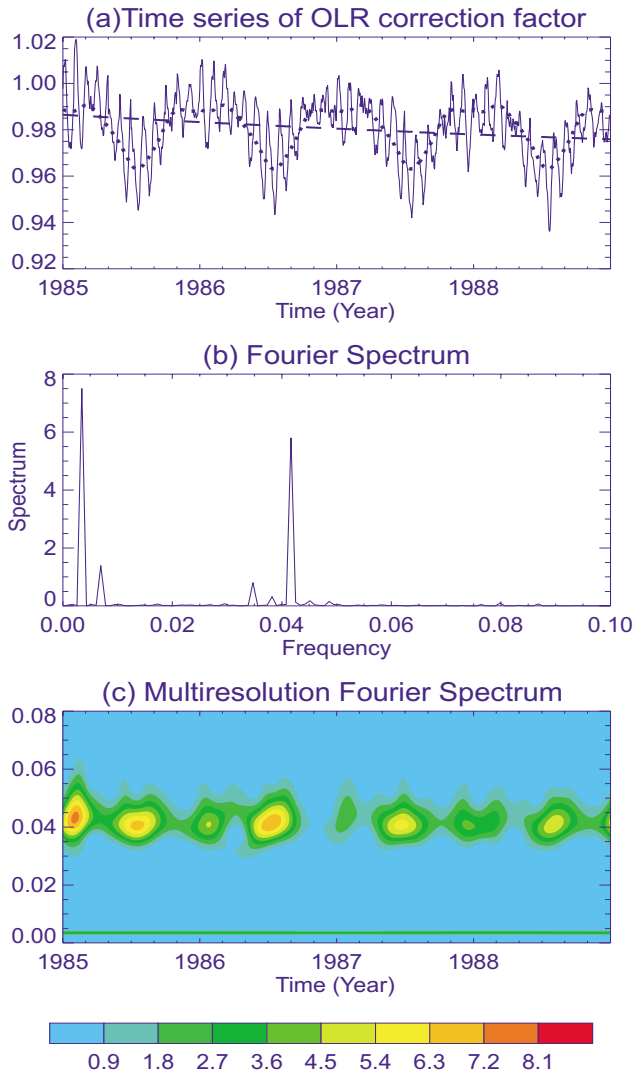
- Both diurnal and seasonal variability are significant for all Triana correction parameters.
- The variability are also sensitive to the Triana offset phase angle (away from L1).
- One year correction factors computed:
  - BRF 1.1216 -- 1.1616 SD 0.0018 -- 0.0176
  - ACF 1.0063 -- 1.0259 SD 0.0008 -- 0.0048
  - LDC 1.0354 -- 1.0519 SD 0.0002 -- 0.0012
  - OCF 0.9448 -- 1.0083 SD 0.0021 -- 0.0106

- Time series analysis of simulated monthly-hourly albedo at 15º North from L1
- (a) the original simulated time series (solid line), seasonal cycle (thick solid line) and its long-term trend calculated by a 2-degree polynomial (dash line),
- (b) Fourier spectrum of albedo;
- (c) multi-resolution Fourier spectrum.



- Time series analysis of simulated monthly-hourly nighttime OLR correction factor at 15º North from L1

- (a) the original simulated time series (solid line), seasonal cycle (thick solid line) and its long-term trend calculated by a 2-degree polynomial (dash line),
- (b) Fourier spectrum of albedo;
- (c) multi-resolution Fourier spectrum.

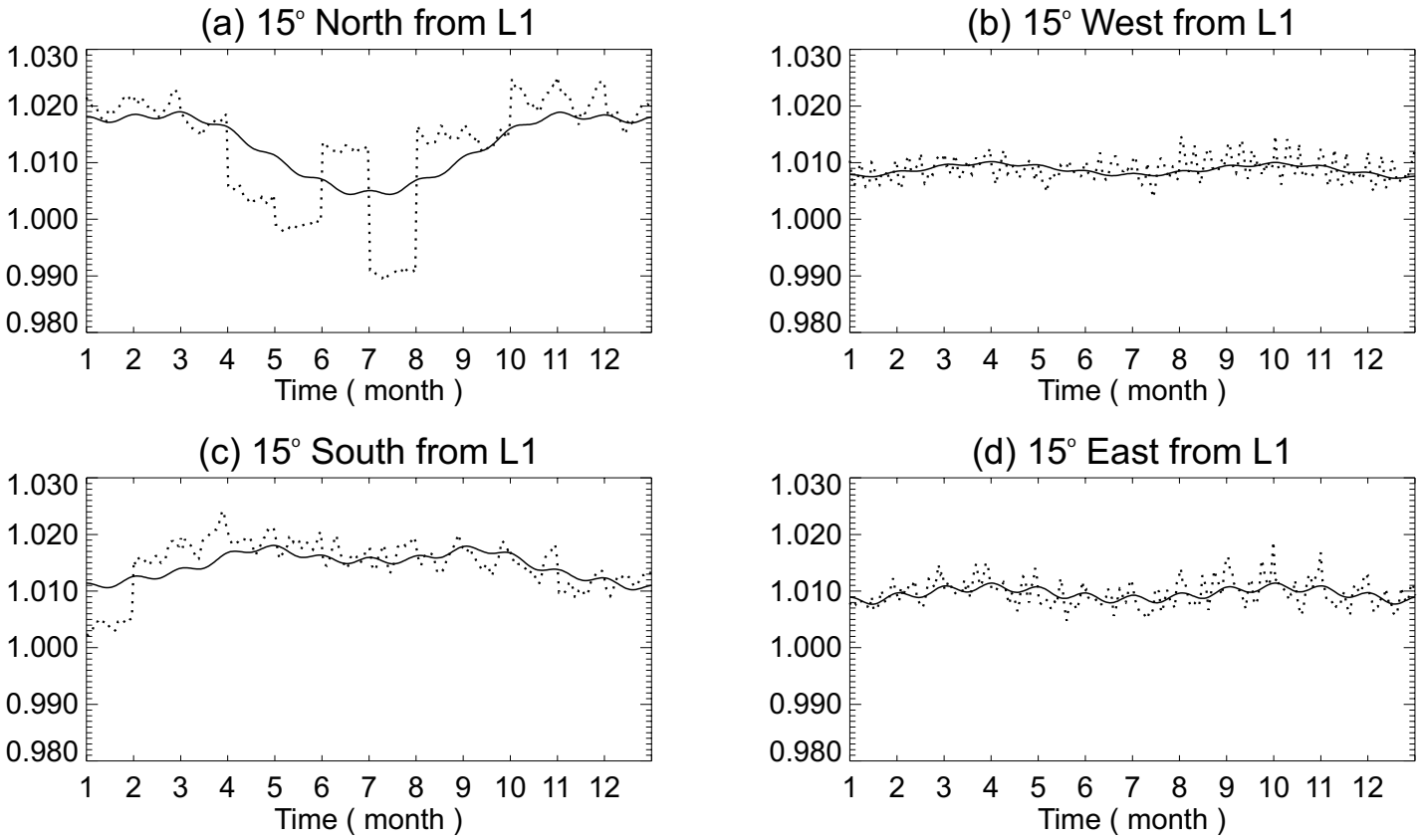


Correction Model Development

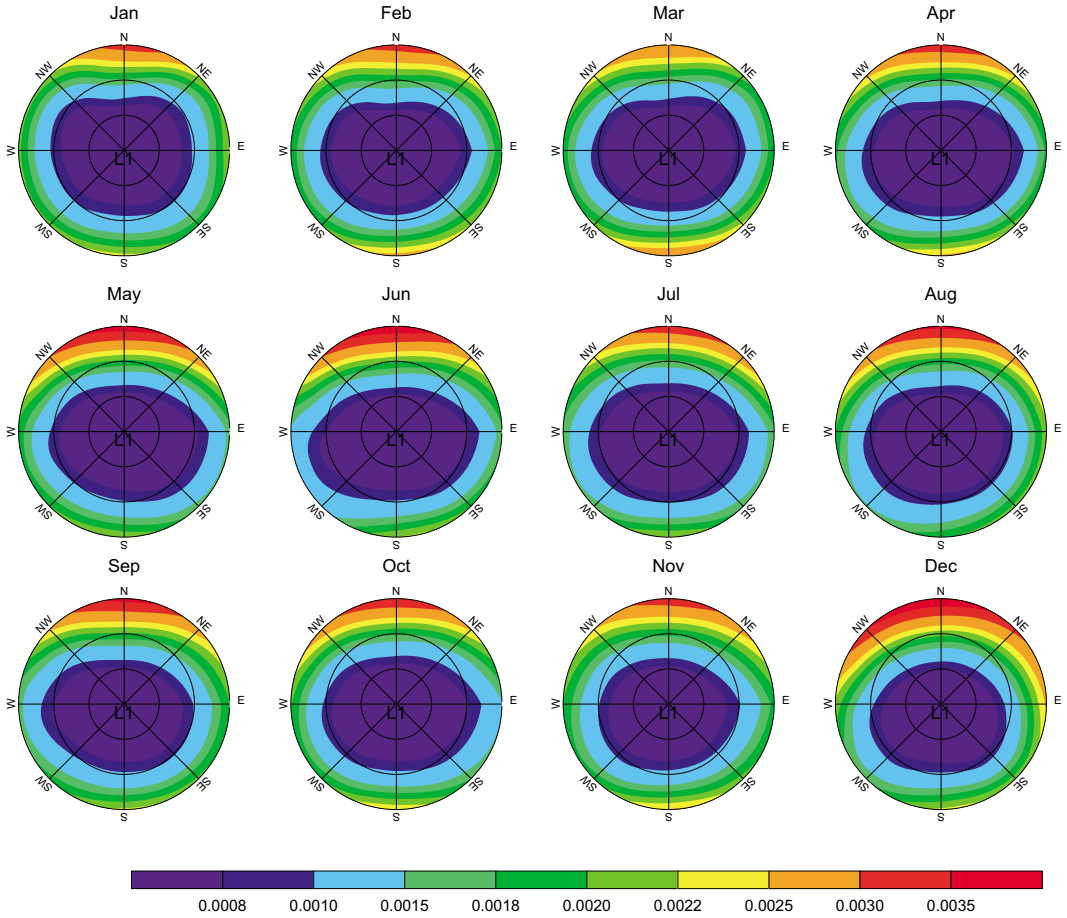
Based on the time series analysis results, the correction model should include the long-term trend, the annual cycle, and the seasonally modulated diurnal cycle.

$$Y^{\alpha}_{p}(T_d,\ T_g,\ \phi,\theta) = C_0(\phi,\theta) + C_1(\phi,\theta)*T_d + C_2(\phi,\theta)*T_d^{\,2} + C_3(\phi,\theta)*\cos(2\pi f_d T_d)$$
$$+ C_4(\phi,\theta)*\cos(2\pi f_b T_d) + C_5(\phi,\theta)*\cos(2\pi f_g T_g) + C_6(\phi,\theta)*\cos(2\pi f_d T_d)*\cos(2\pi f_g T_g)$$

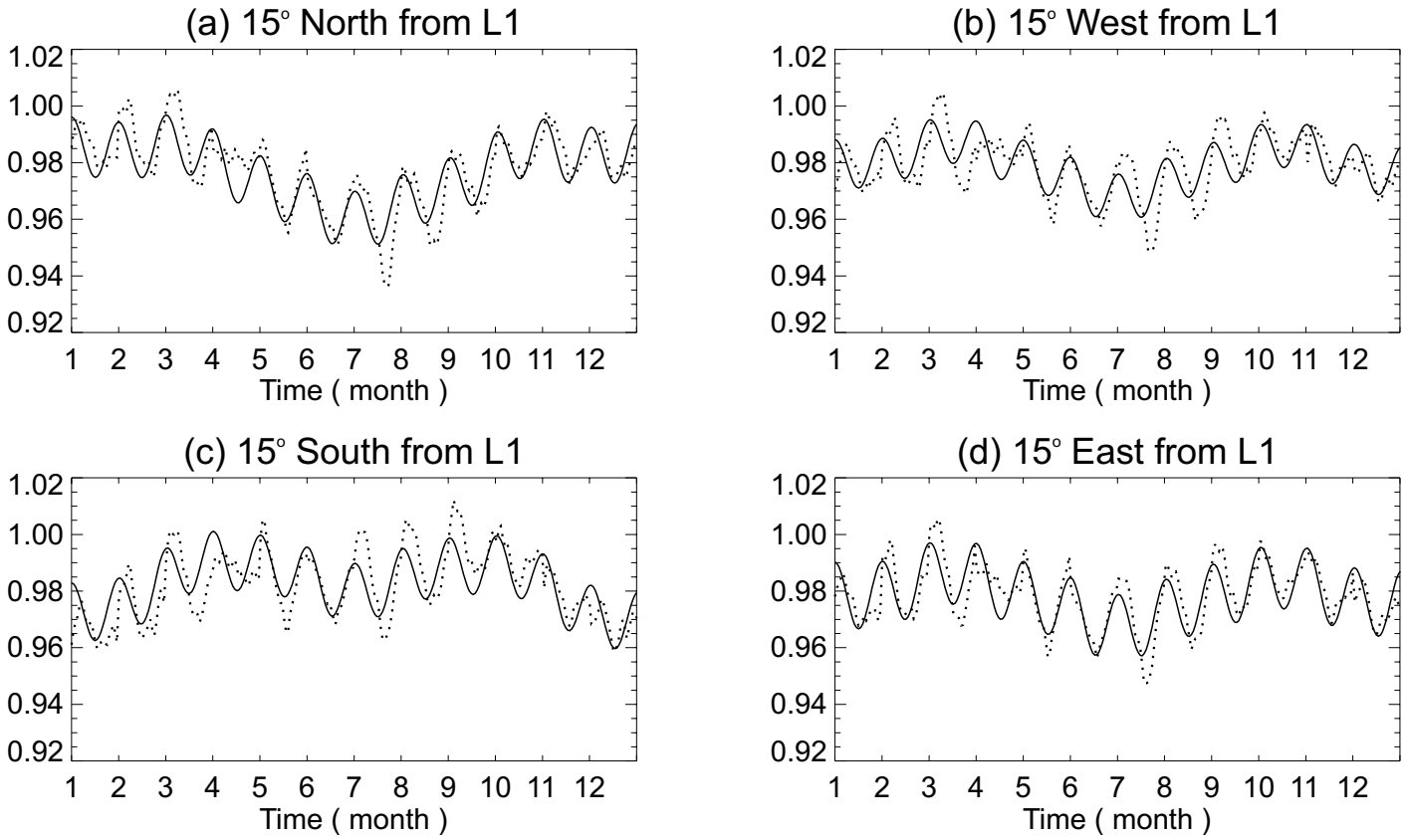
were ϕ is the angle from North (in degrees), θ is the distance from L1 (in degrees), and f_d, f_b and f_g are the frequencies of the annual, bi-annual and diurnal cycles, respectively.



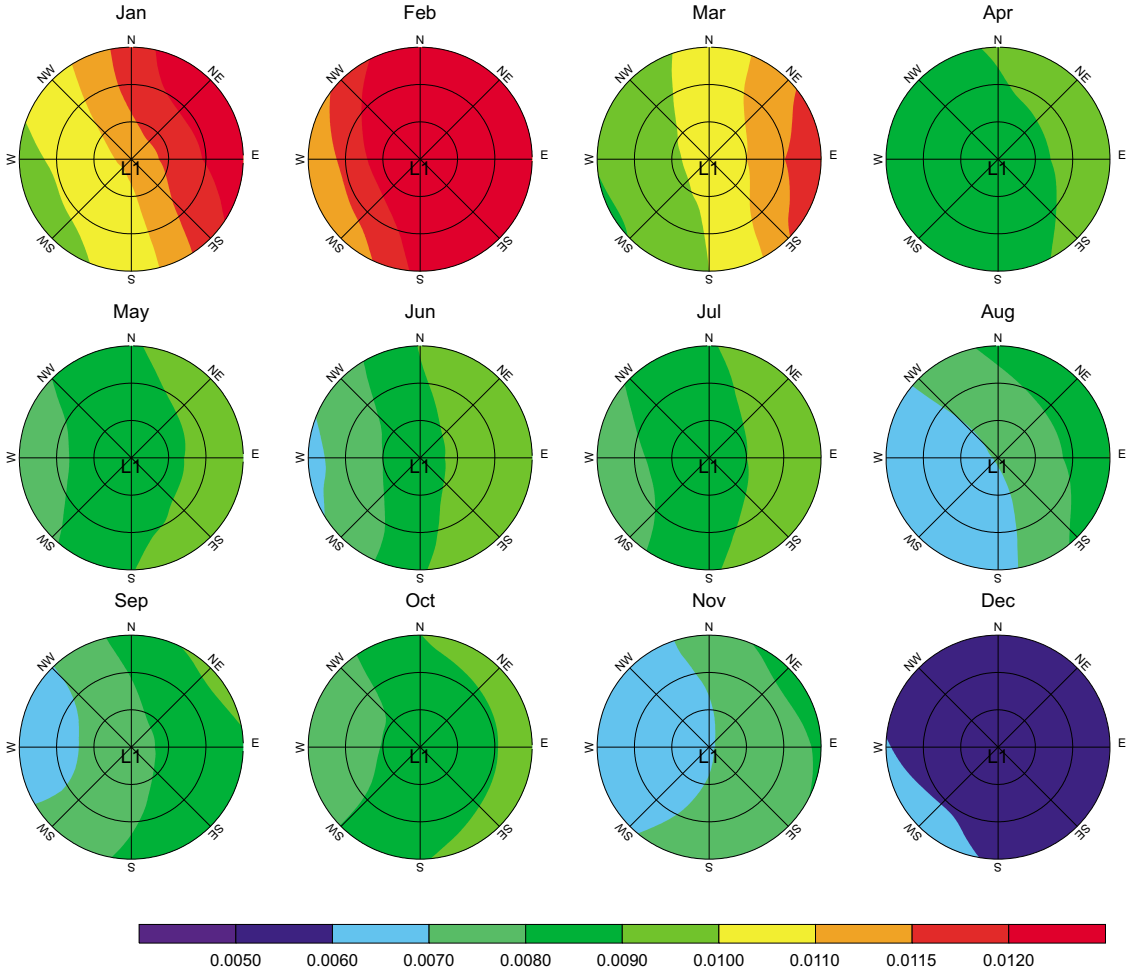
Predicted (solid line) and simulated 1988 missing light albedo correction factors (dashed line) for : (a) 15° north from L1; (b) 15° west from L1; (c) 15° east from L1; (d) 15° South from L1.



Seasonal variation of RMS of nighttime OLR correction factors as a function of degree from L1 at 0 GMT for 1988.



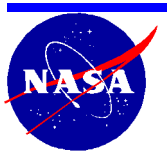
Predicted (solid line) and simulated 1988 night OLR correction factors (dashed line) for : (a) 15° north from L1; (b) 15° west from L1; (c) 15° east from L1; (d) 15° South from L1.



Seasonal variation of RMS of nighttime OLR correction factors as a function of degree from L1 at 0 GMT for 1988.

CONCLUSIONS AND DISCUSSIONS

- To derive the Earth radiation budget (ERB) from the Traian measurement, it is necessary to account for the radiation field in unsampled areas.
- The operational correction models have to be developed for producing a highly accurate global ERB from Triana.
- Both diurnal and seasonal variability are significant for all Triana correction parameters.
- The variability are also sensitive to the Triana L1 offset position (away from L1).
- The preliminary prediction results indicate that these correction models can be used to produce the most accurate global ERB to date.



Future Work

- The correction models are purely statistical and it is not possible to distinguish between physical and random relationships in the data. Also, the models may be biased by the sampling patterns of the ERBE satellites.

- To improve on the ERBE sampling, 3 hourly geostationary data will be used to fill the gaps between the ERBE measurements. Further studies will use combinations of ERBS and ISCCP (International Satellite Cloud Climatology Project) datasets to simulate the ERB as measured by Triana.