Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Akkermans, T., Clerbaux, N.

32nd CERES Science Team Meeting

Berkeley, CA, October 29-31, 2019

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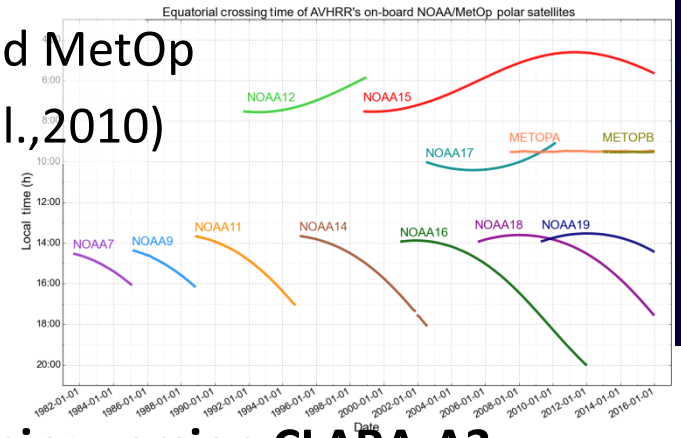
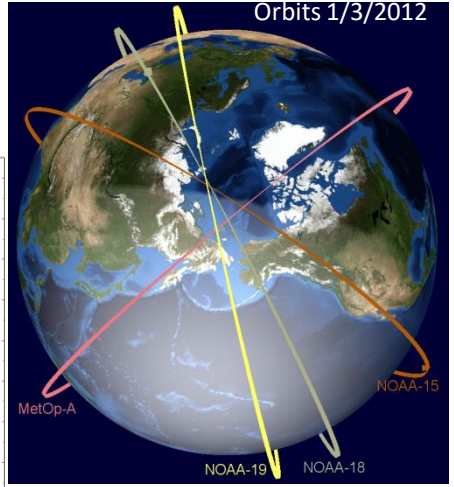
Introduction

What is CLARA? "CM SAF cLoud, Albedo and RAdiation dataset from AVHRR data" (=*Similar to Patmos-X)*

- Polar orbiting satellites NOAA and MetOp
- FCDR from NOAA (Heidinger et al.,2010)
- Currently released versions:
  - CLARA-A1 (1982-2009)
  - CLARA-A2 (1982-2015)





Some of the modifications in upcoming version CLARA-A3:

- Inclusion of AVHRR-1 sensor (TIROS-N, NOAA-6, -8, -10): extension of time range to 1978-2019 i.e. 42yr
- Updated FCDR: new calibration for visible channels (latest PATMOS-x coefficients)
- Updated cloud treatment algorithms (NWCSAF/PPS v.2018; Karlsson et al.) SMHI
- Addition of new product "TOA radiative fluxes" -> this presentation

1. Outgoing Longwave Radiation

Part1

Part2

Level-2 processing: instantaneous observations

Ougtoing Longwave Radiation (OLR)

CM-11342
Outgoing Longwave
Radiation (OLR)

Reflected Solar Flux (RSF)

CM-11312
Reflected Solar
Flux (RSF)

Part3

Level-3 processing: daily mean

OLR

Outgoing Longwave
Radiation (OLR)

RSF

Reflected Solar
Flux (RSF)

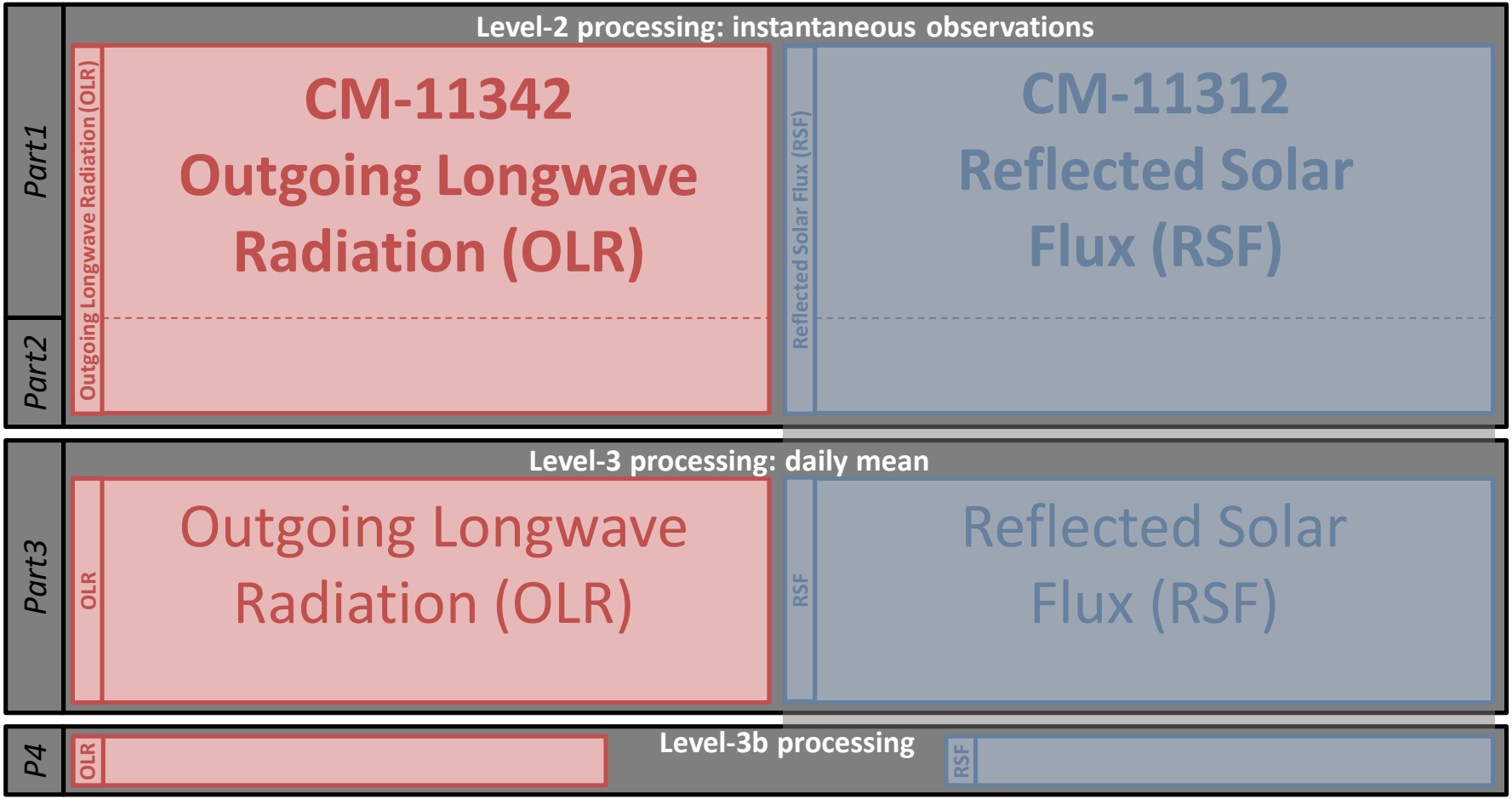
P4

OLR

Level-3b processing

RSF

1. Outgoing Longwave Radiation



1. Outgoing Longwave Radiation

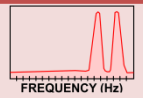
Part1 / Part2

Level-2 processing: instantaneous observations

Outgoing Longwave Radiation (OLR)

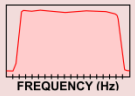
AVHRR ch4: 11µ

AVHRR ch5: 12µ



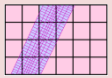
"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

OLR *[W/m²]*



Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

remapped OLR (0.25°)



Reflected Solar Flux (RSF)

CM-11312 Reflected Solar Flux (RSF)

Part3

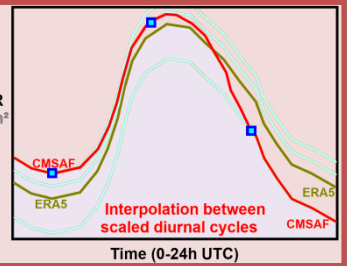
Level-3 processing: daily mean

OLR

ERA5 diurnal cycle OLR

ERA5 diurnal cycle scaled to Level-2 observations, then interpolate :

Daily mean



RSF

Reflected Solar Flux (RSF)

P4

Level-3b processing

OLR

Monthly mean

RSF

1. Outgoing Longwave Radiation

Part1

Level-2 processing: instantaneous observations

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FREQUENCY (Hz)

all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

OLR *[W/m²]*

FREQUENCY (Hz)

Part2

Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

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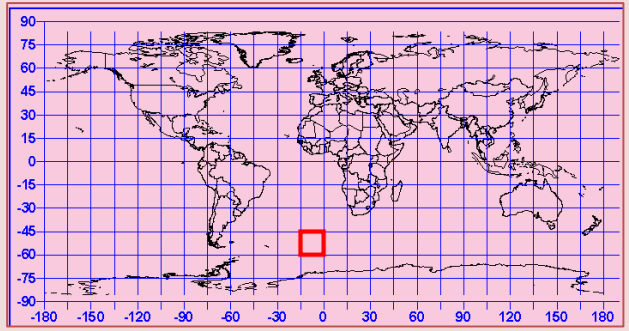

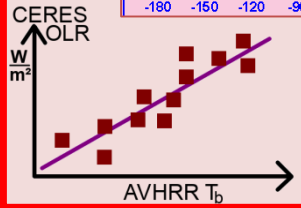

For each 10°x10° gridbox:
fit monthly regression to predict CERES OLR; predictors: AVHRR T_b *(ch4,ch5*)*, T_{sur} , VZA, column IWV

Part3

Level-3 proces

OLR

ERA5 diurnal cycle OLR

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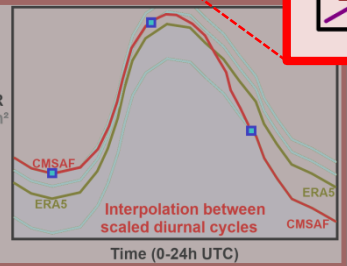

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Level-3b processing

OLR

Monthly mean

RSF

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Part1 / Part2

Level-2 processing: instantaneous observations

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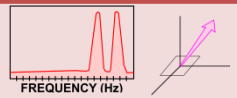

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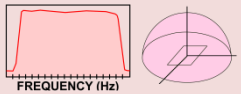
OLR *[W/m²]*



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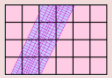
remapped OLR (0.25°)



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CM-11312 Reflected Solar Flux (RSF)

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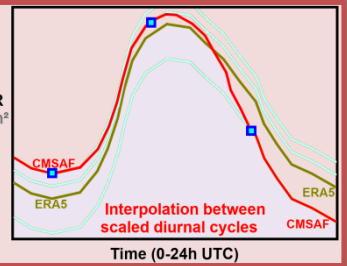

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P4

Level-3b processing

OLR

Monthly mean

RSF

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OLR *[W/m²]*

FREQUENCY (Hz)

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Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

remapped OLR (0.25°)

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Level-3 process

OLR

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Daily mean

OLR W/m²

CMSAF

ERA5

Interpolation between scaled diurnal cycles

Time (0-24h UTC)

P4

OLR

Monthly mean

Level

OLR W/m²

NOAA17

NOAA16

NOAA15

ERA5 diurnal cycle

AVHRR L2 observations

Time (0-24h UTC)

1. Outgoing Longwave Radiation

Part1

Level-2 processing: instantaneous observations

Outgoing Longwave Radiation (OLR)

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OLR *[W/m²]*

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OLR

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NOAA15

Scale cycle to obs.

ERA5 diurnal cycle

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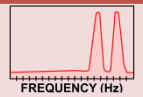

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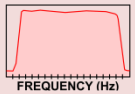
OLR [W/m²]



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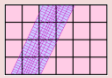

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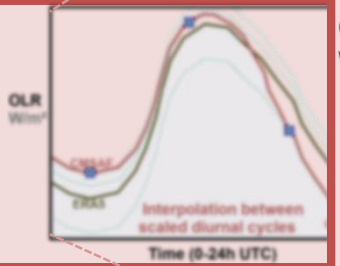

Daily mean

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OLR

Monthly mean

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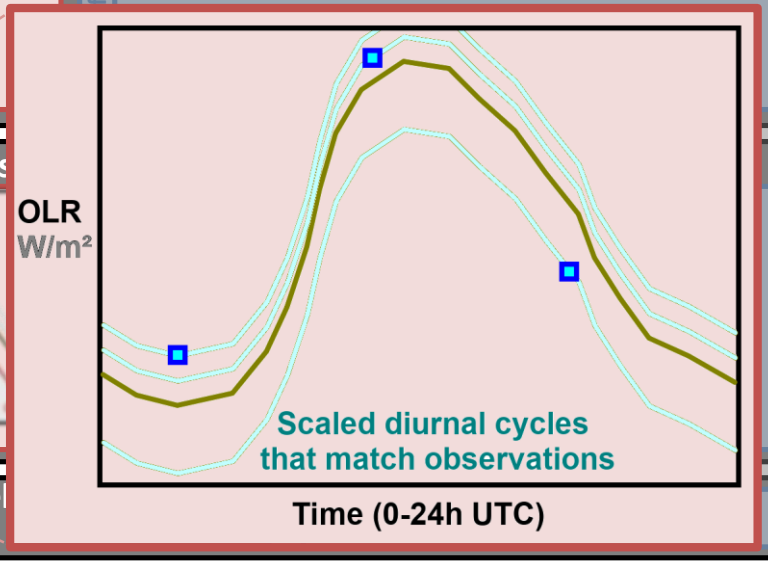

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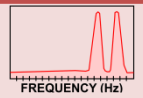

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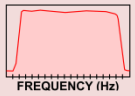

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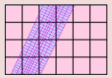

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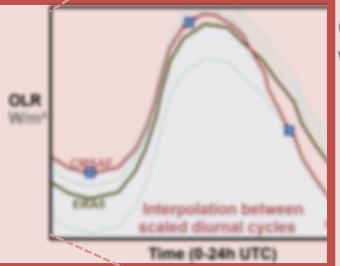
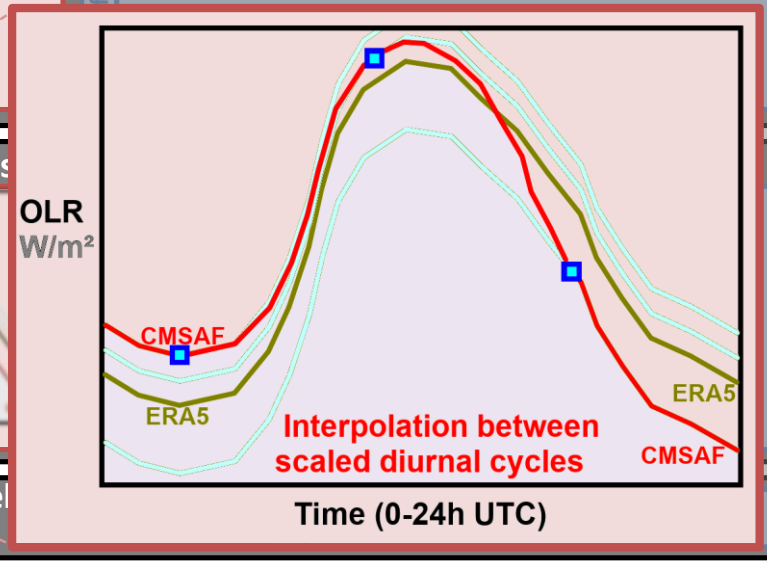


P4

Level

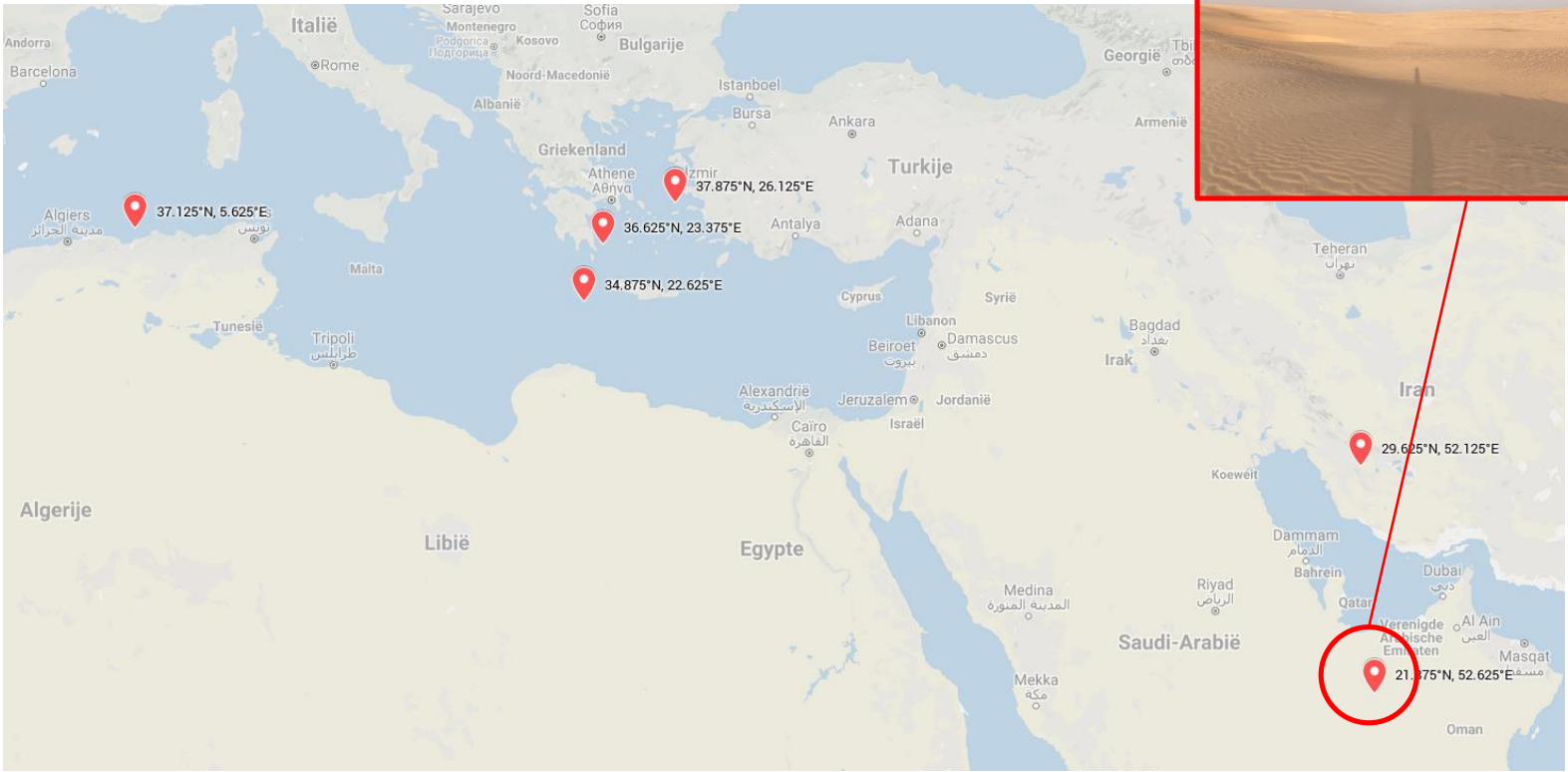
OLR

Monthly mean



1. Outgoing Longwave Radiation

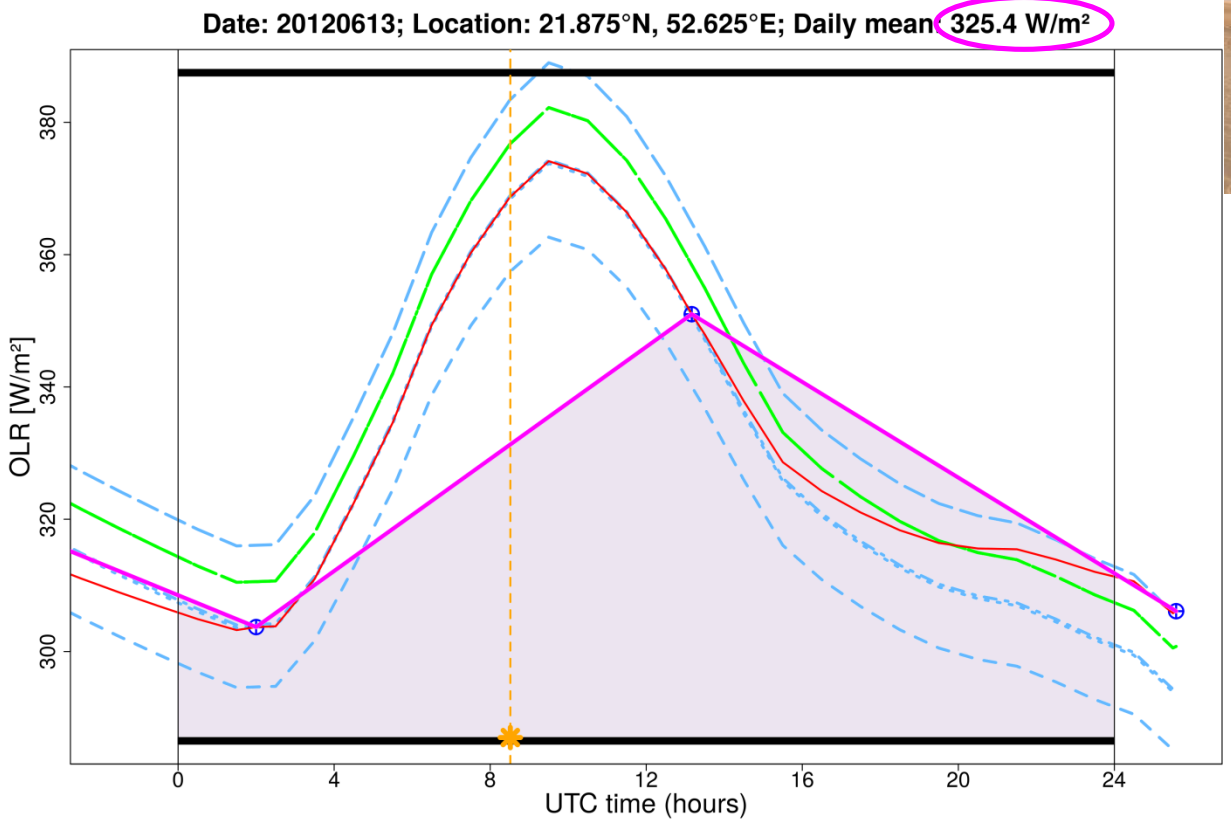
Example 1: OLR in clearsky desert scene: impact of including ERA5 diurnal cycle:



1. Outgoing Longwave Radiation

Example 1: OLR in clearsky desert scene: impact of ERA5.

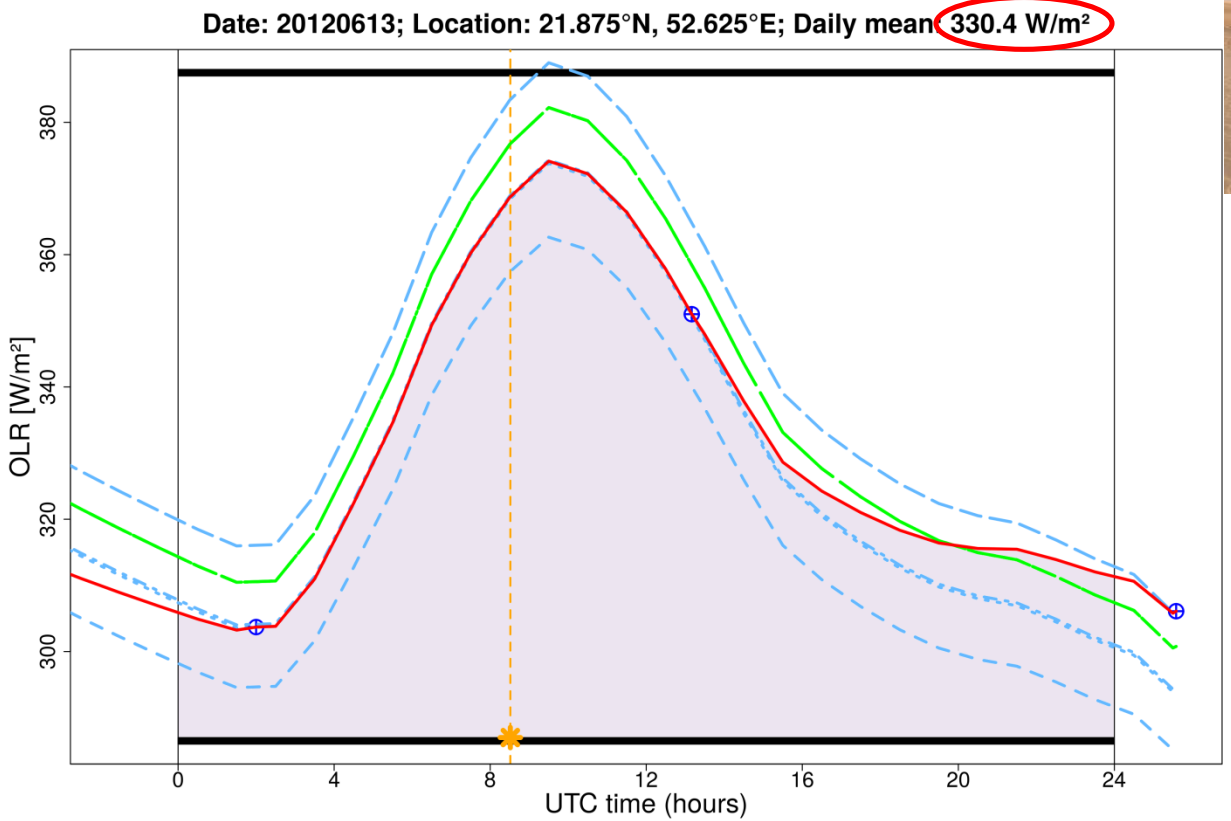
Single satellite (NOAA15) with simple linear interpolation:



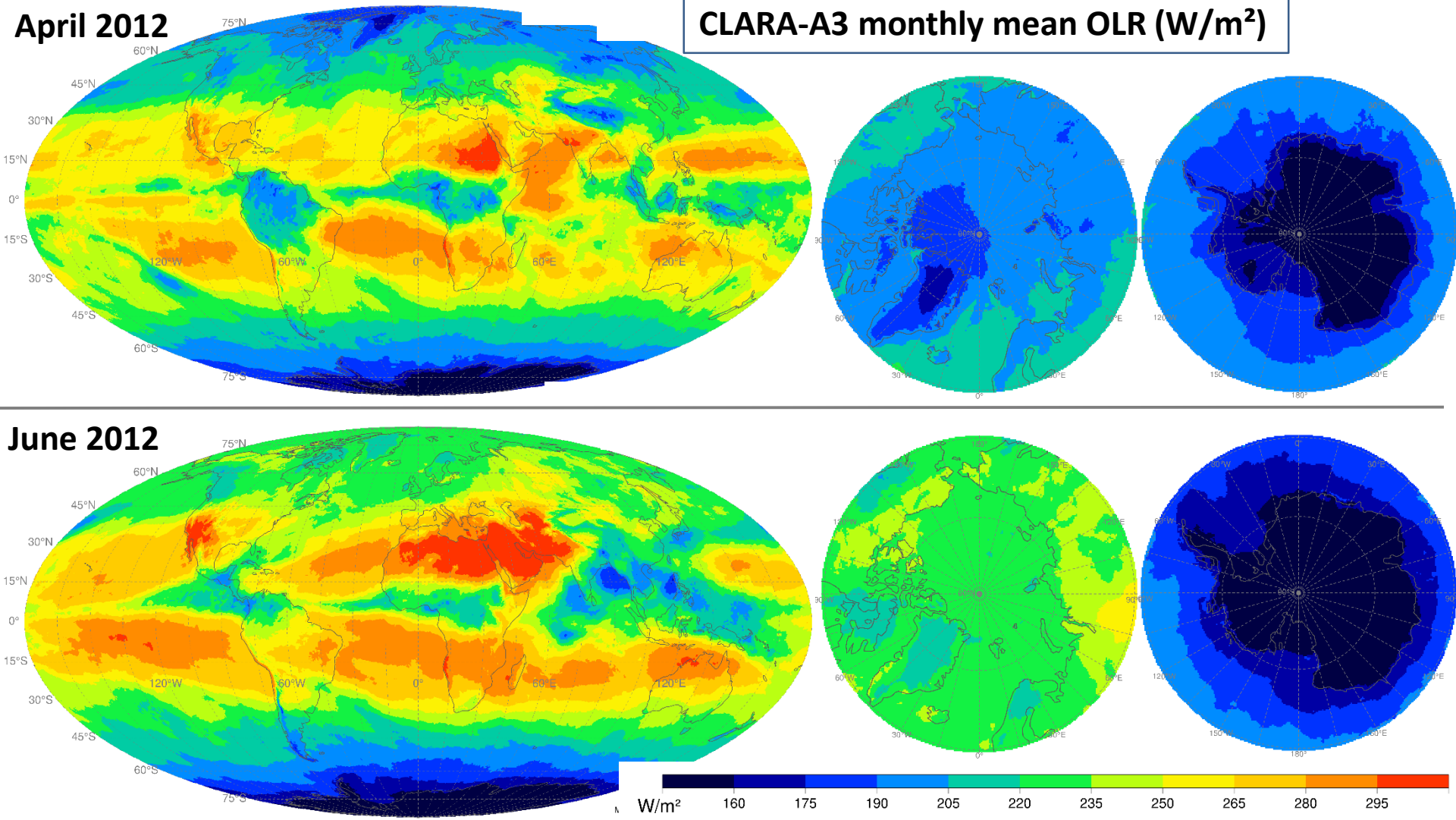
1. Outgoing Longwave Radiation

Example 1: OLR in clearsky desert scene: impact of ERA5.

Single satellite (N15) interpolated with ERA5 diurnal cycle:

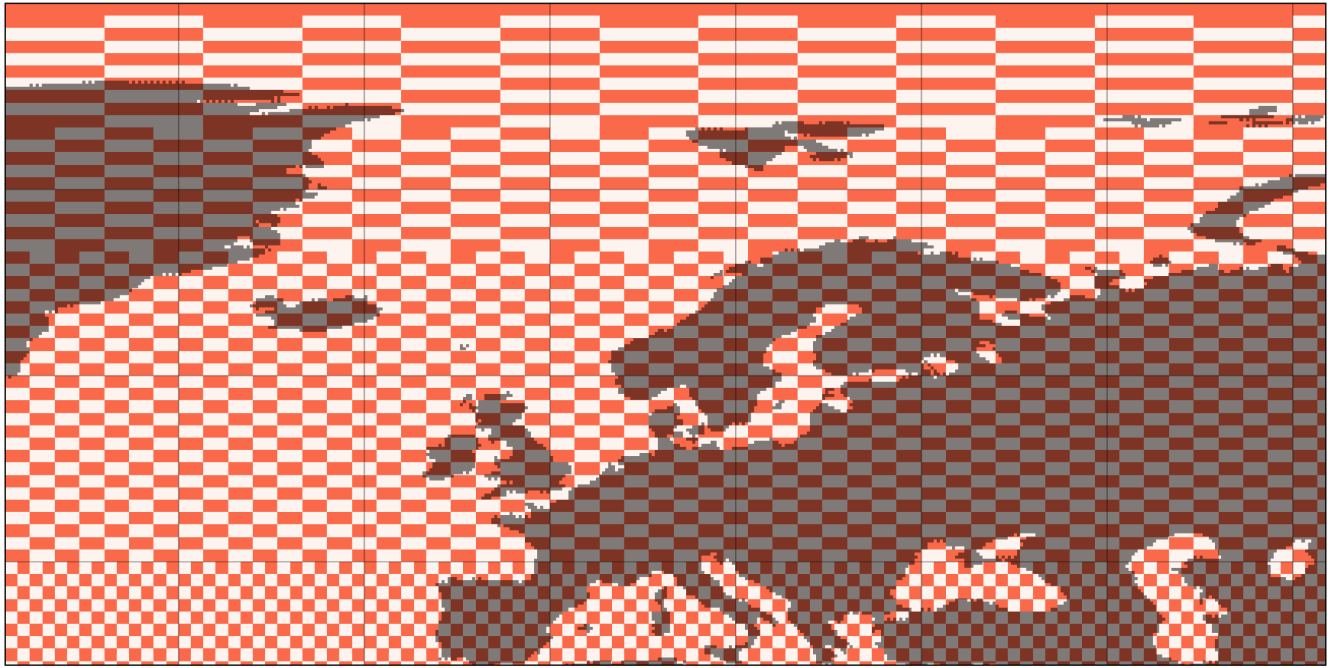


CLARA-A3 monthly mean OLR (W/m²)



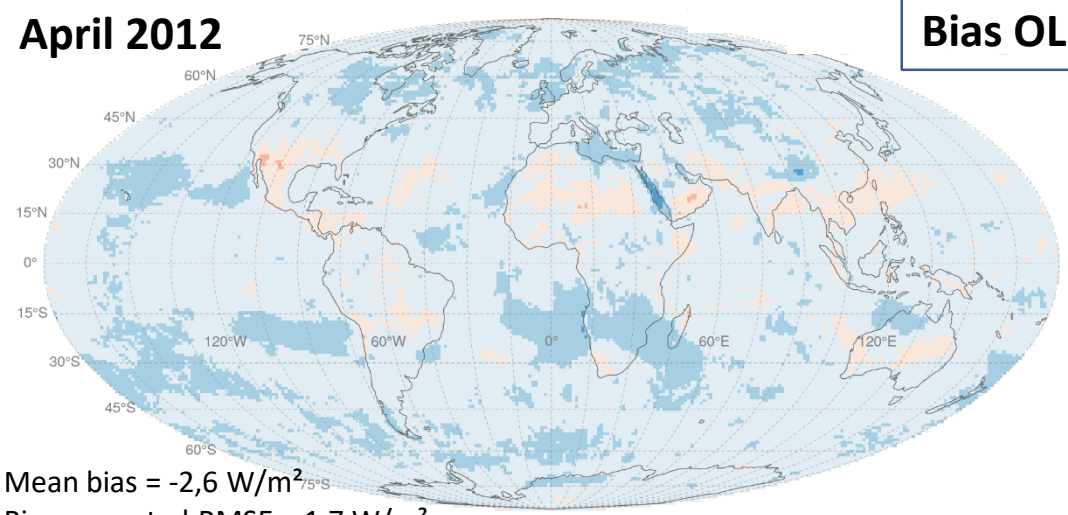
1. Outgoing Longwave Radiation

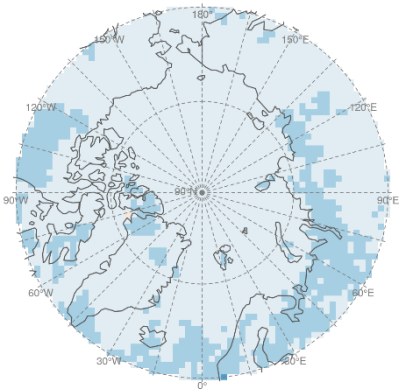
- Validation of result: calculate bias with CERES-EBAF (Ed4.1)
- First, re-grid CMSAF monthly mean to CERES nested grid:

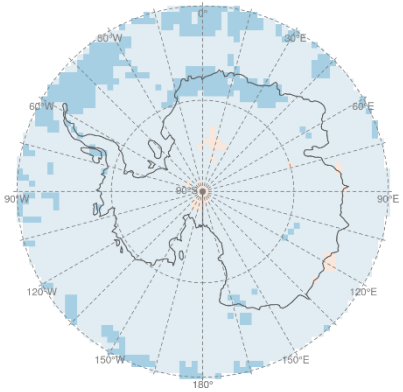


Bias OLR w.r.t. CERES-EBAF (W/m²)

April 2012

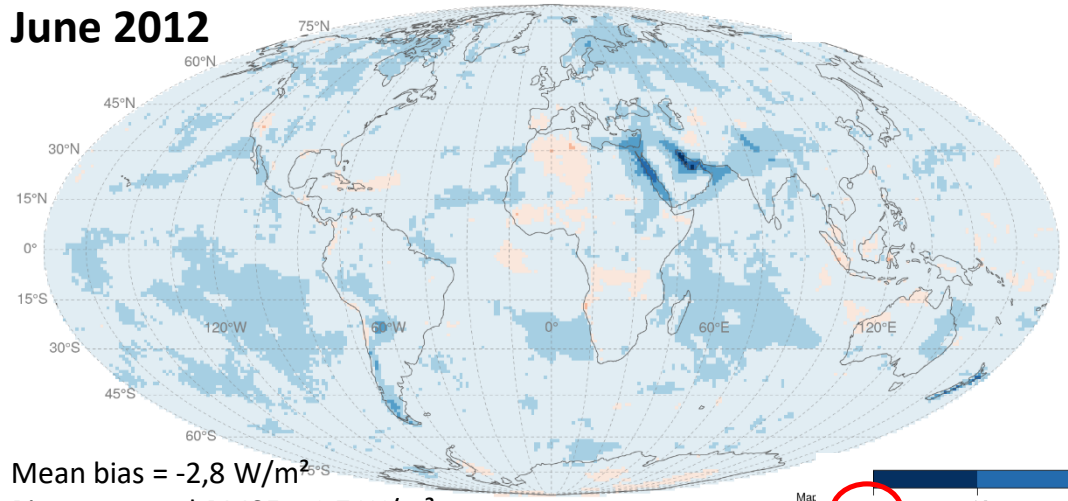


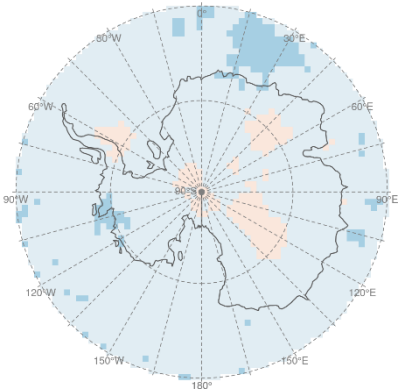




Mean bias = -2,6 W/m²
Bias-corrected RMSE = 1.7 W/m²

June 2012

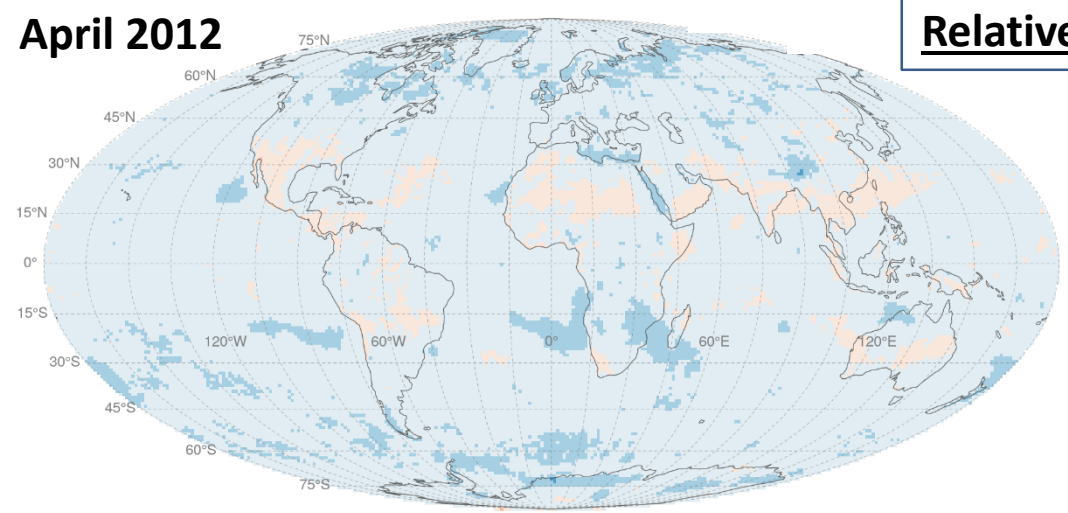


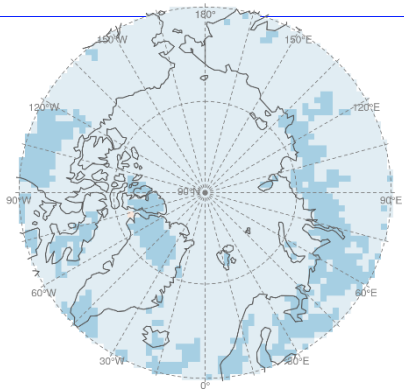


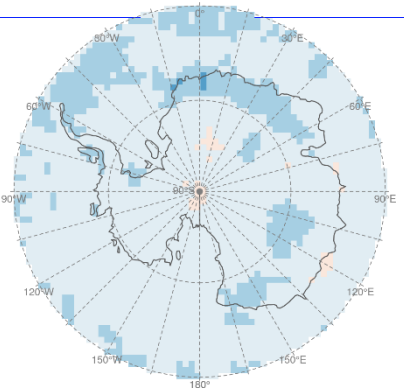
Mean bias = -2,8 W/m²
Bias-corrected RMSE = 1.7 W/m²

Relative Bias OLR w.r.t. CERES-EBAF (%)

April 2012







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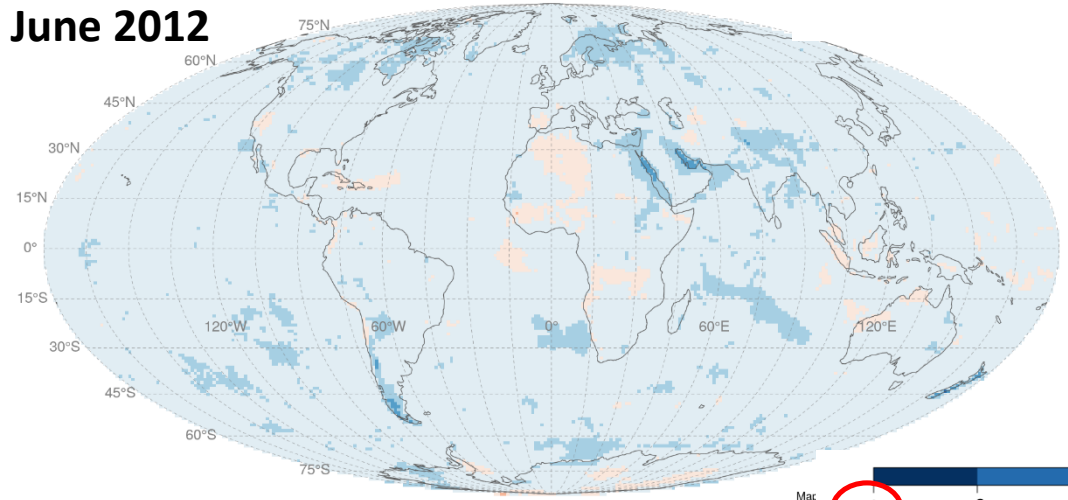

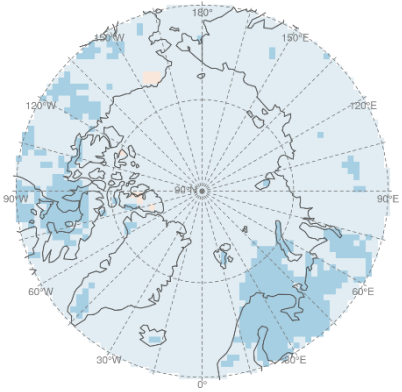

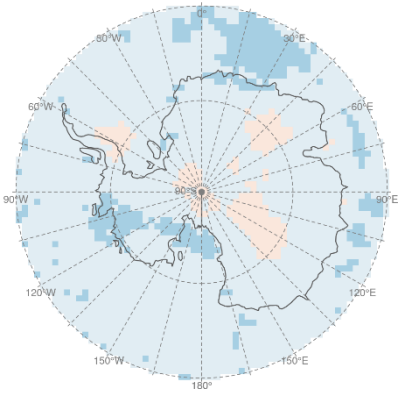

Relative Bias OLR w.r.t. CERES-EBAF (%)

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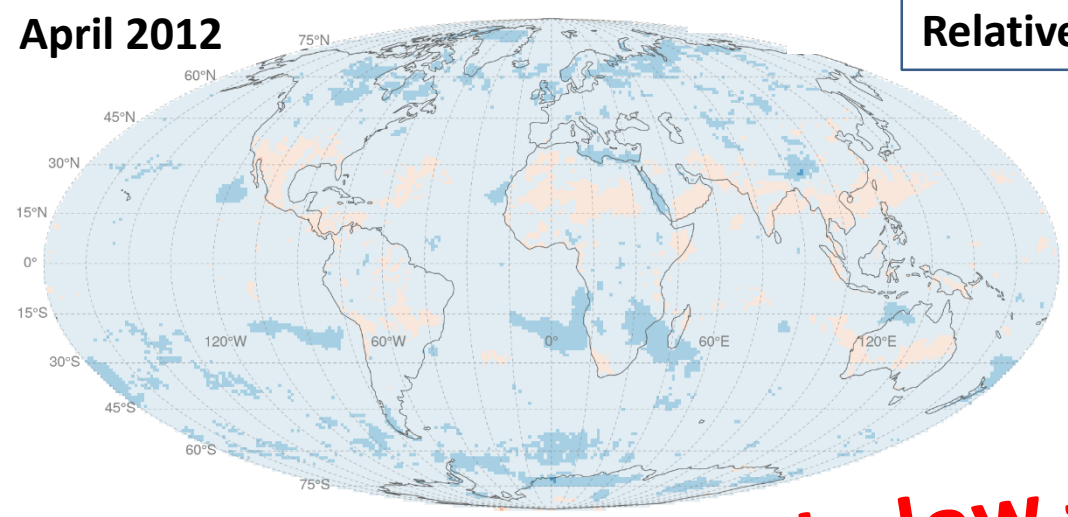
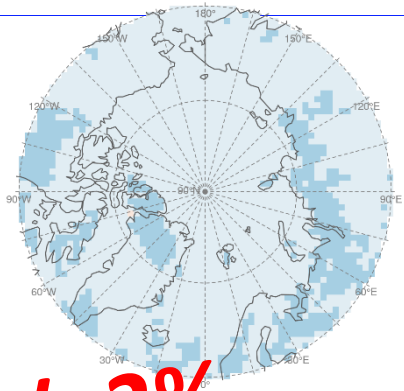
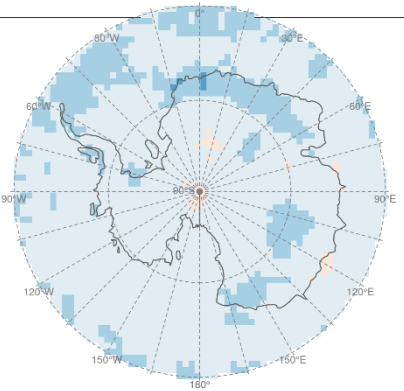
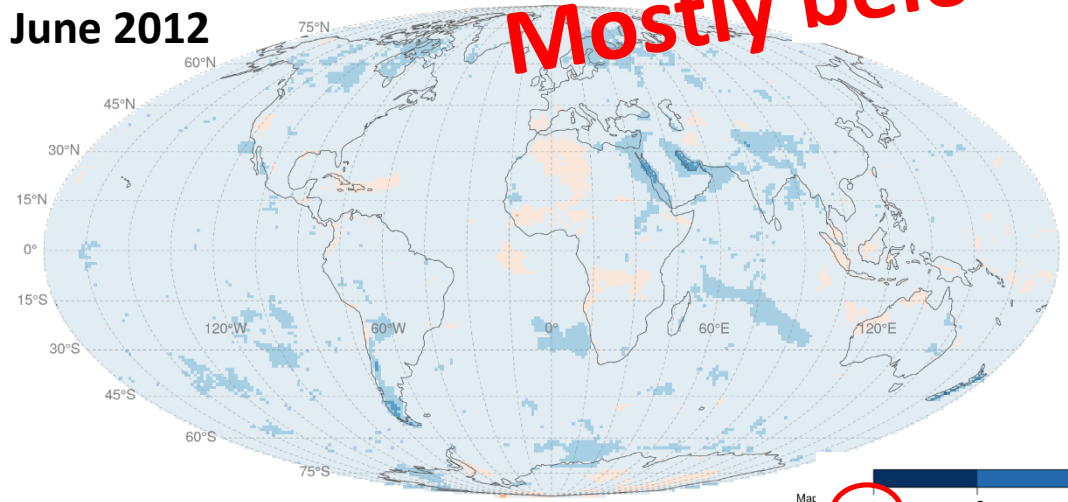


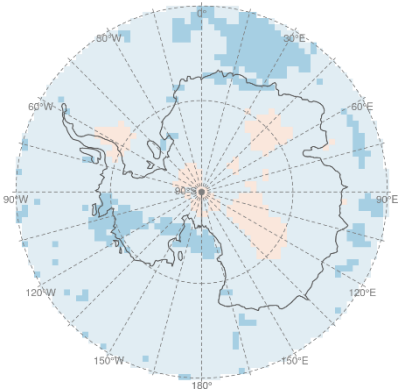




Mostly below +/- 2%

June 2012





1. Outgoing Longwave Radiation

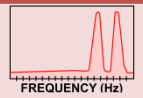
Part1 / Part2

Level-2 processing: instantaneous observations

Outgoing Longwave Radiation (OLR)

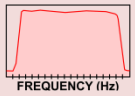
AVHRR ch4: 11µ

AVHRR ch5: 12µ



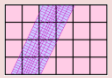
"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

OLR *[W/m²]*



Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

remapped OLR (0.25°)



Reflected Solar Flux (RSF)

CM-11312 Reflected Solar Flux (RSF)

Part3

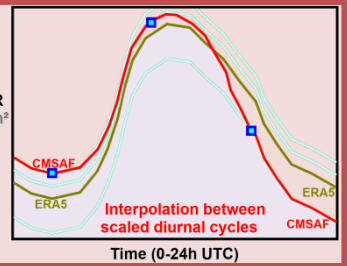
Level-3 processing: daily mean

OLR

ERA5 diurnal cycle OLR

ERA5 diurnal cycle scaled to Level-2 observations, then interpolate :

Daily mean



RSF

Reflected Solar Flux (RSF)

P4

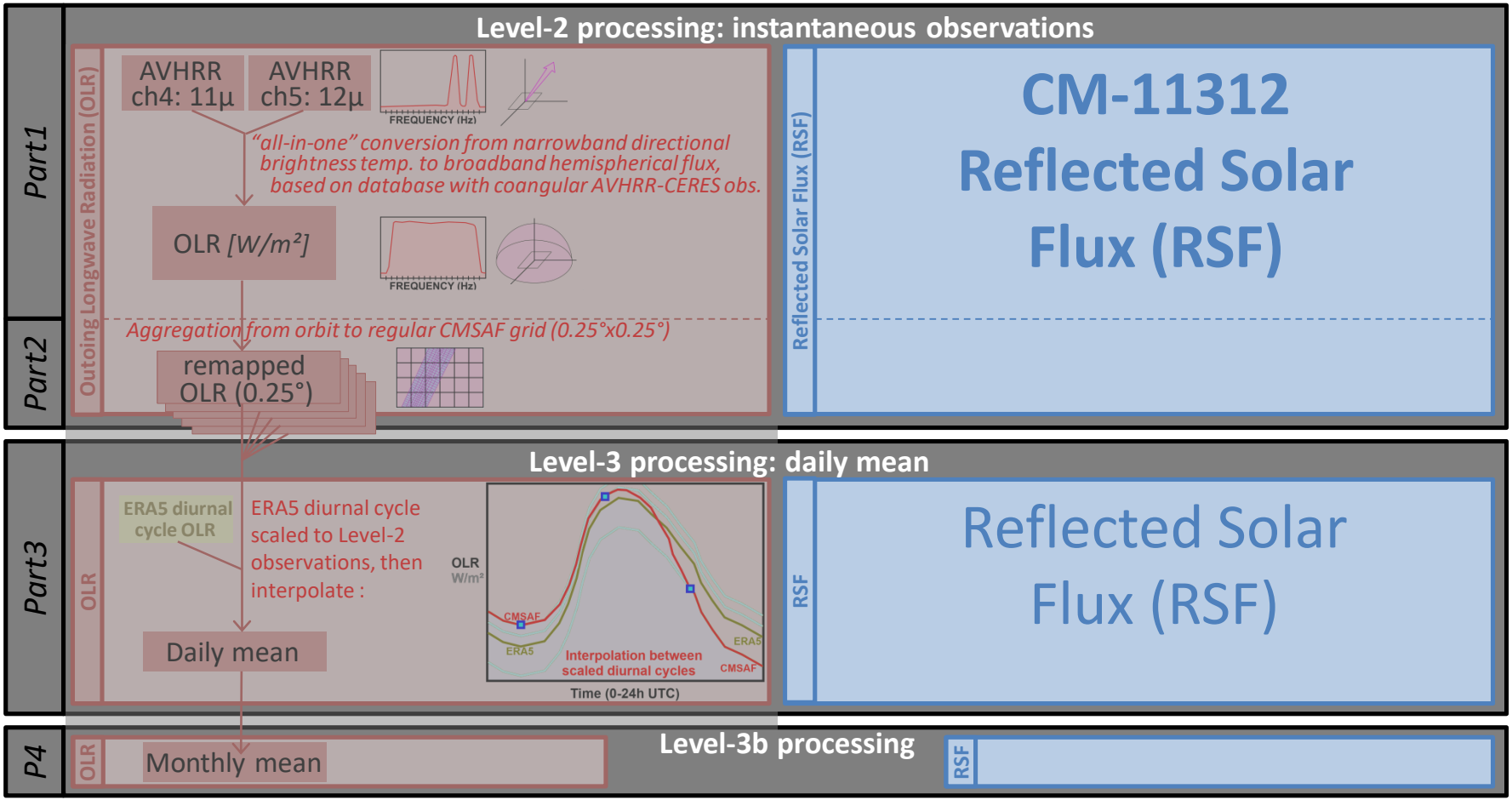
Level-3b processing

OLR

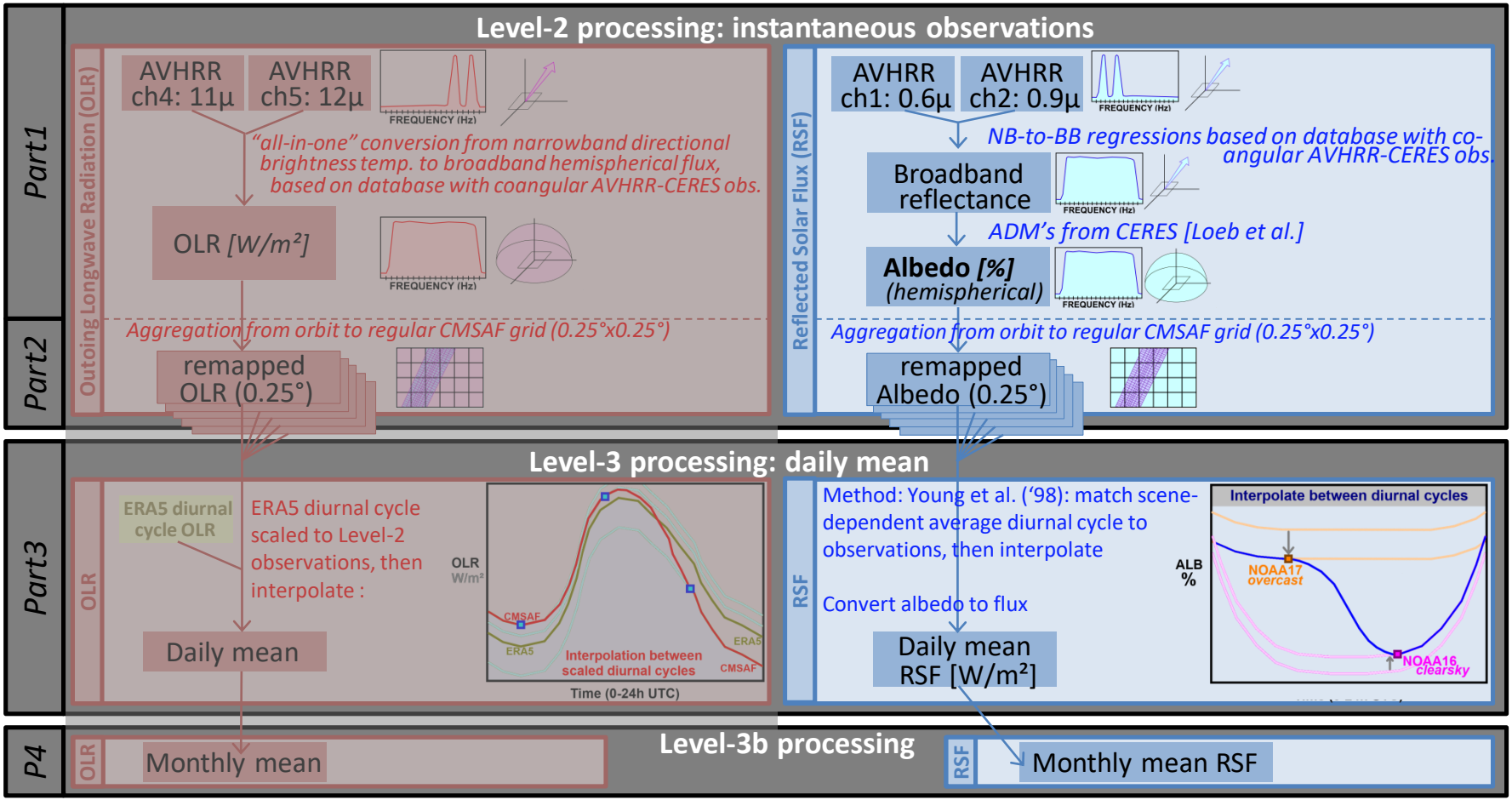
Monthly mean

RSF

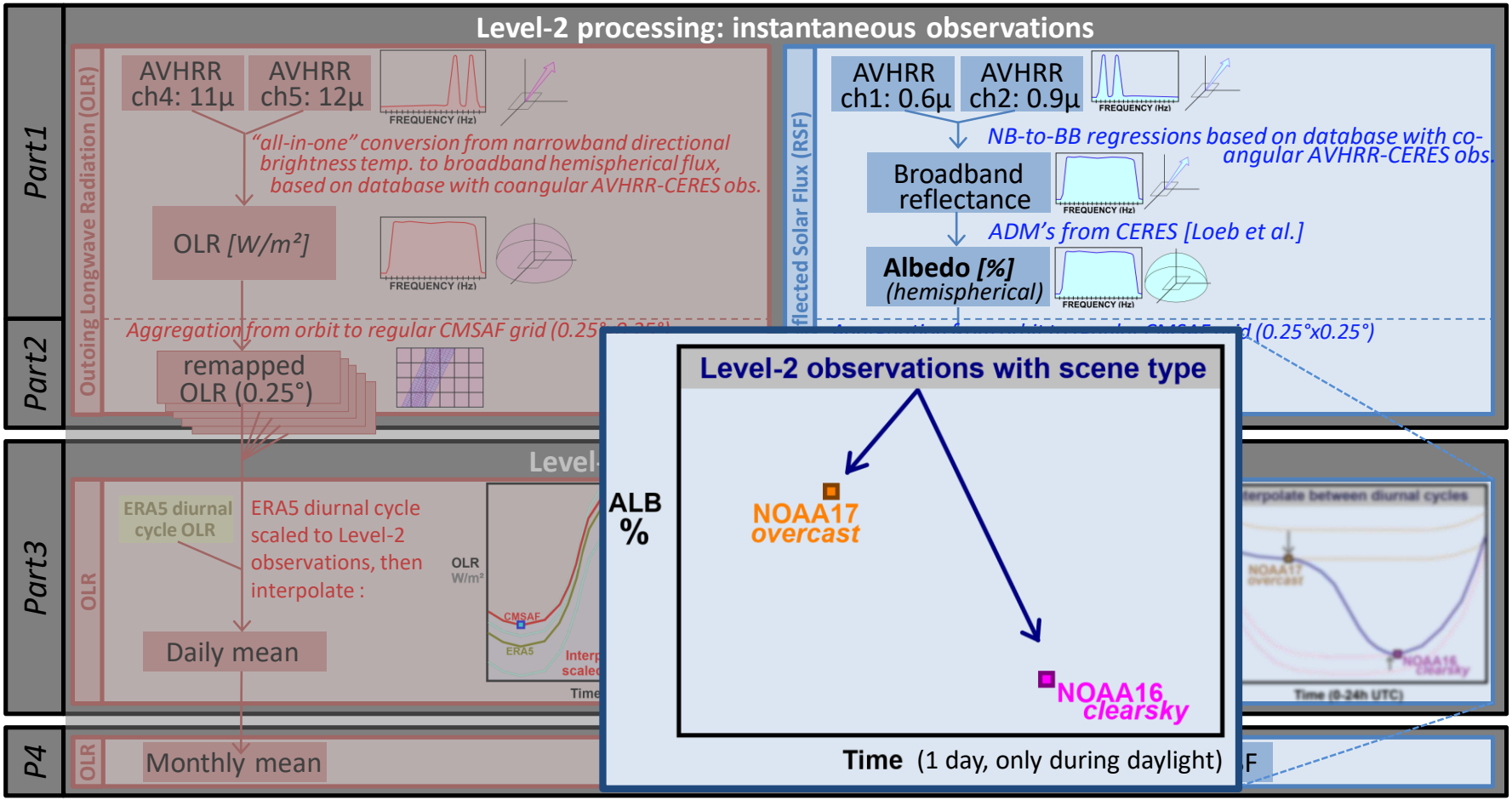
2. Reflected Solar Flux (RSF)



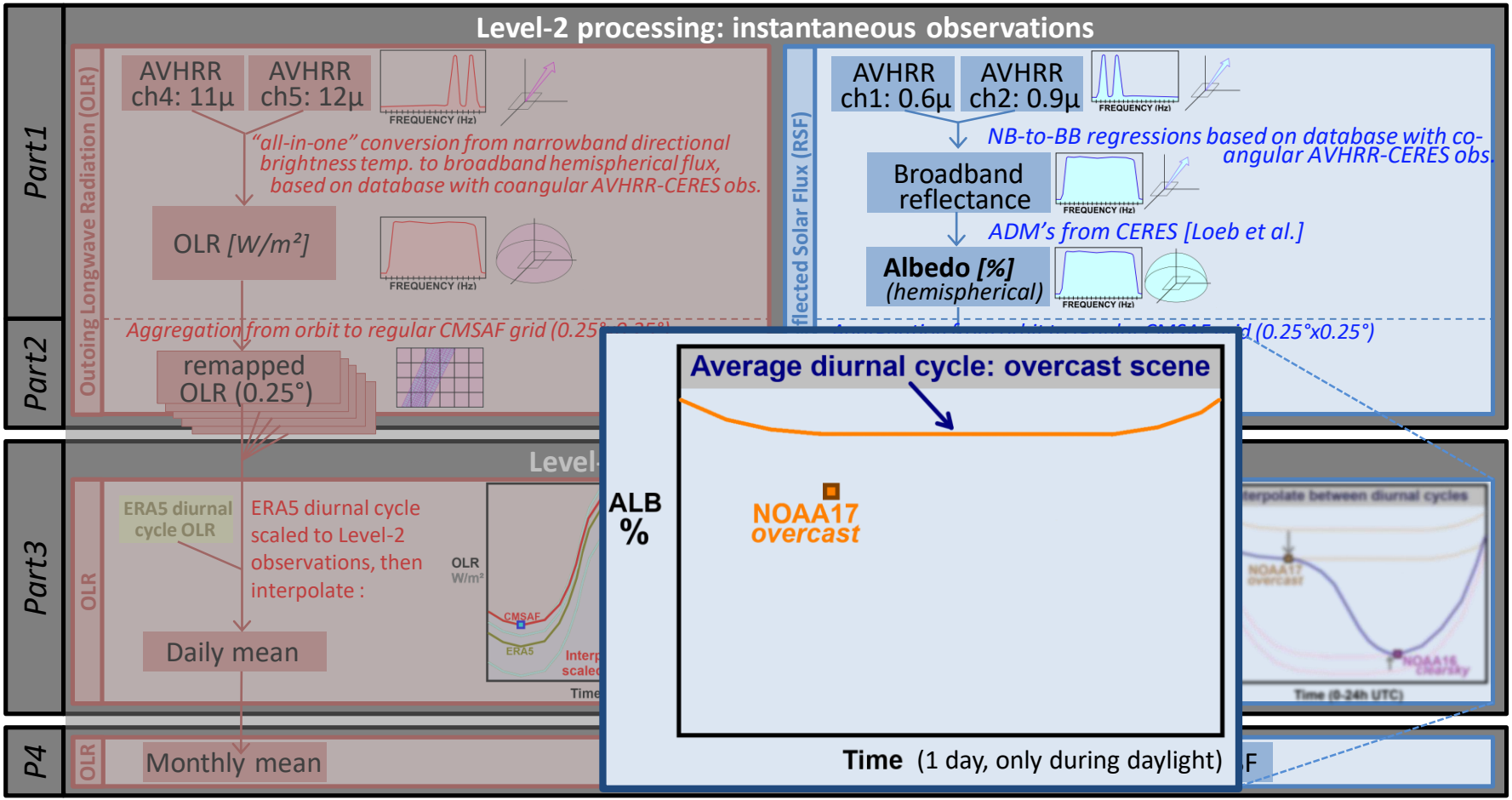
2. Reflected Solar Flux (RSF)



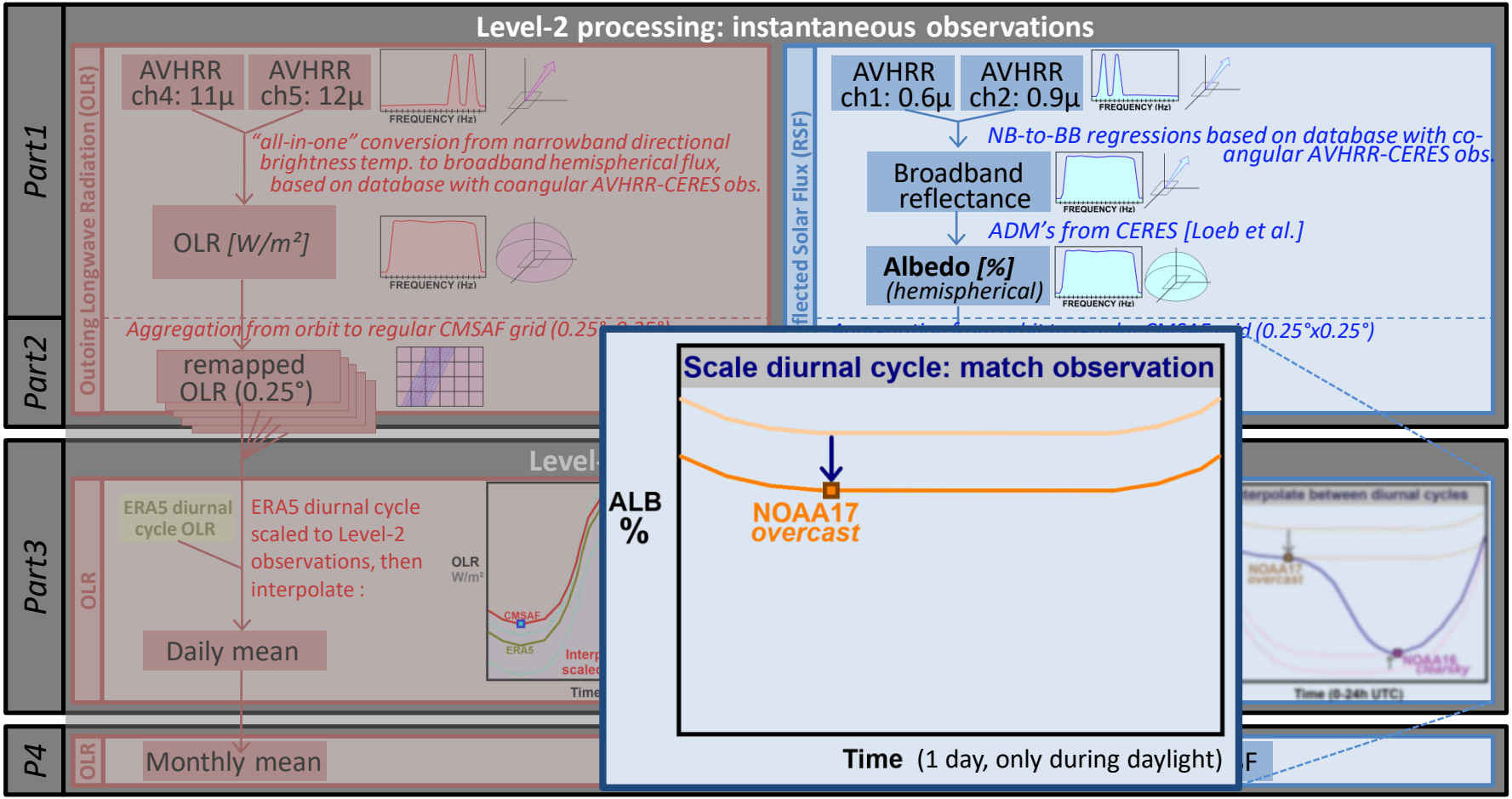
2. Reflected Solar Flux (RSF)



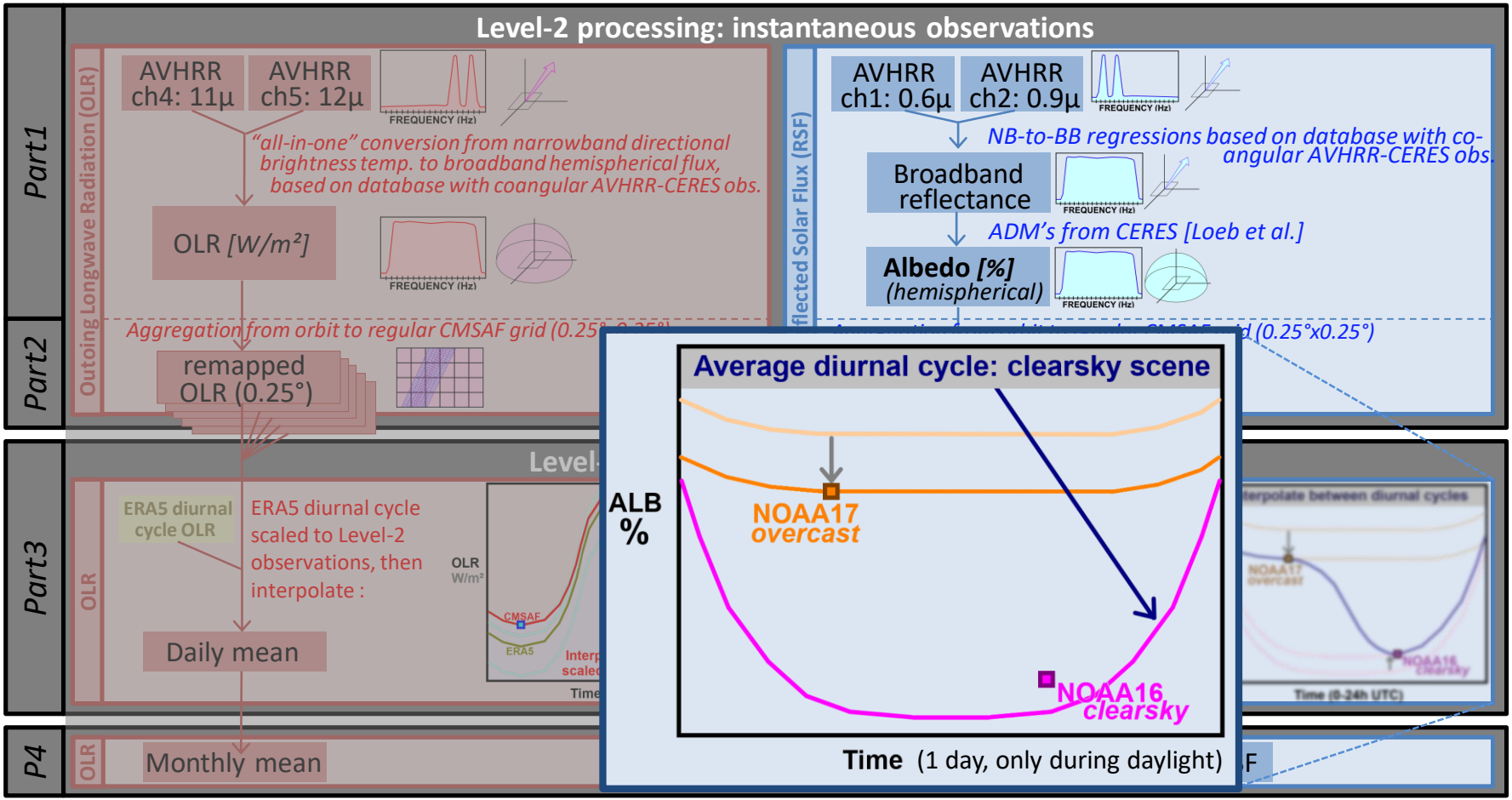
2. Reflected Solar Flux (RSF)



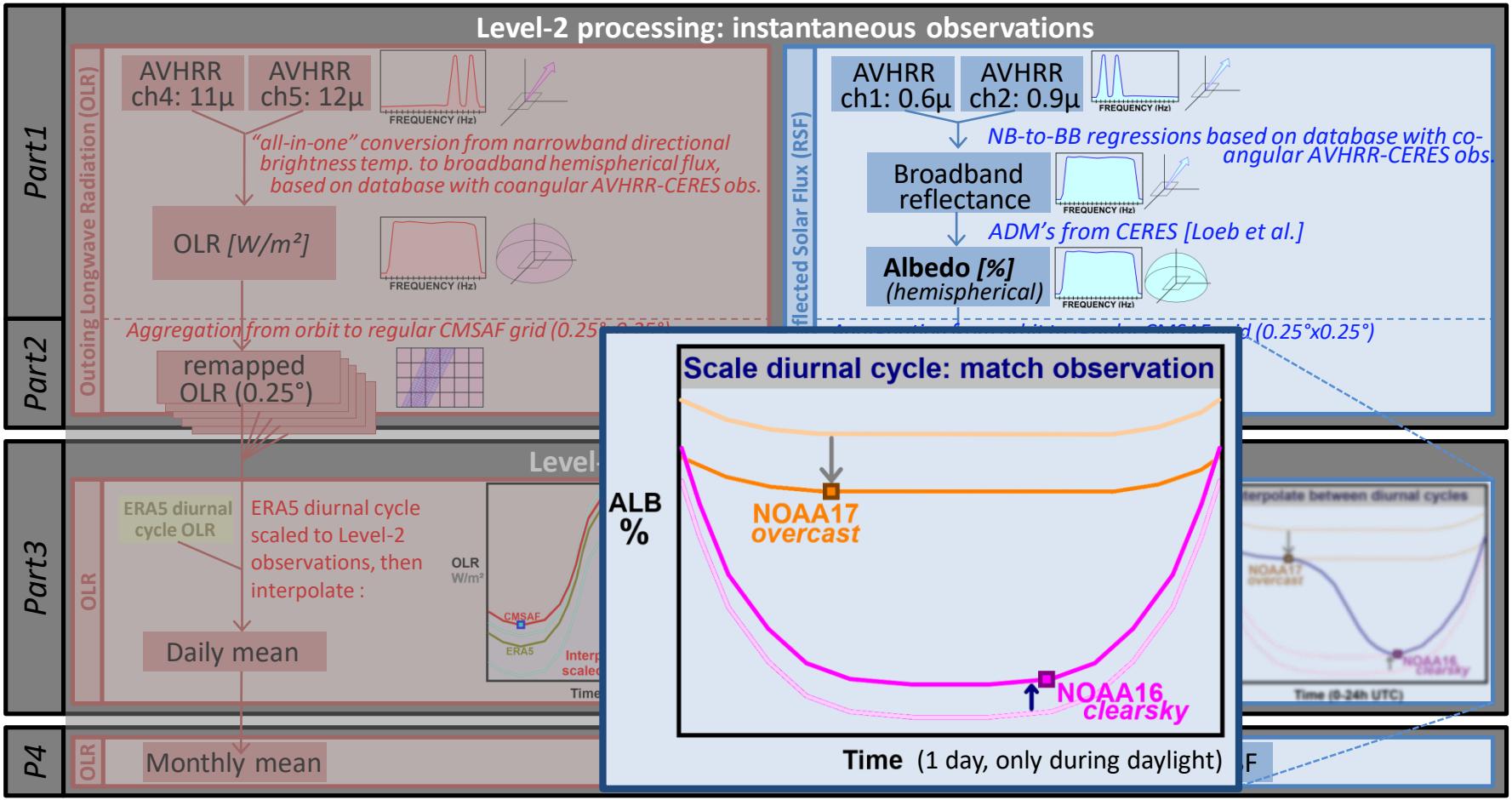
2. Reflected Solar Flux (RSF)



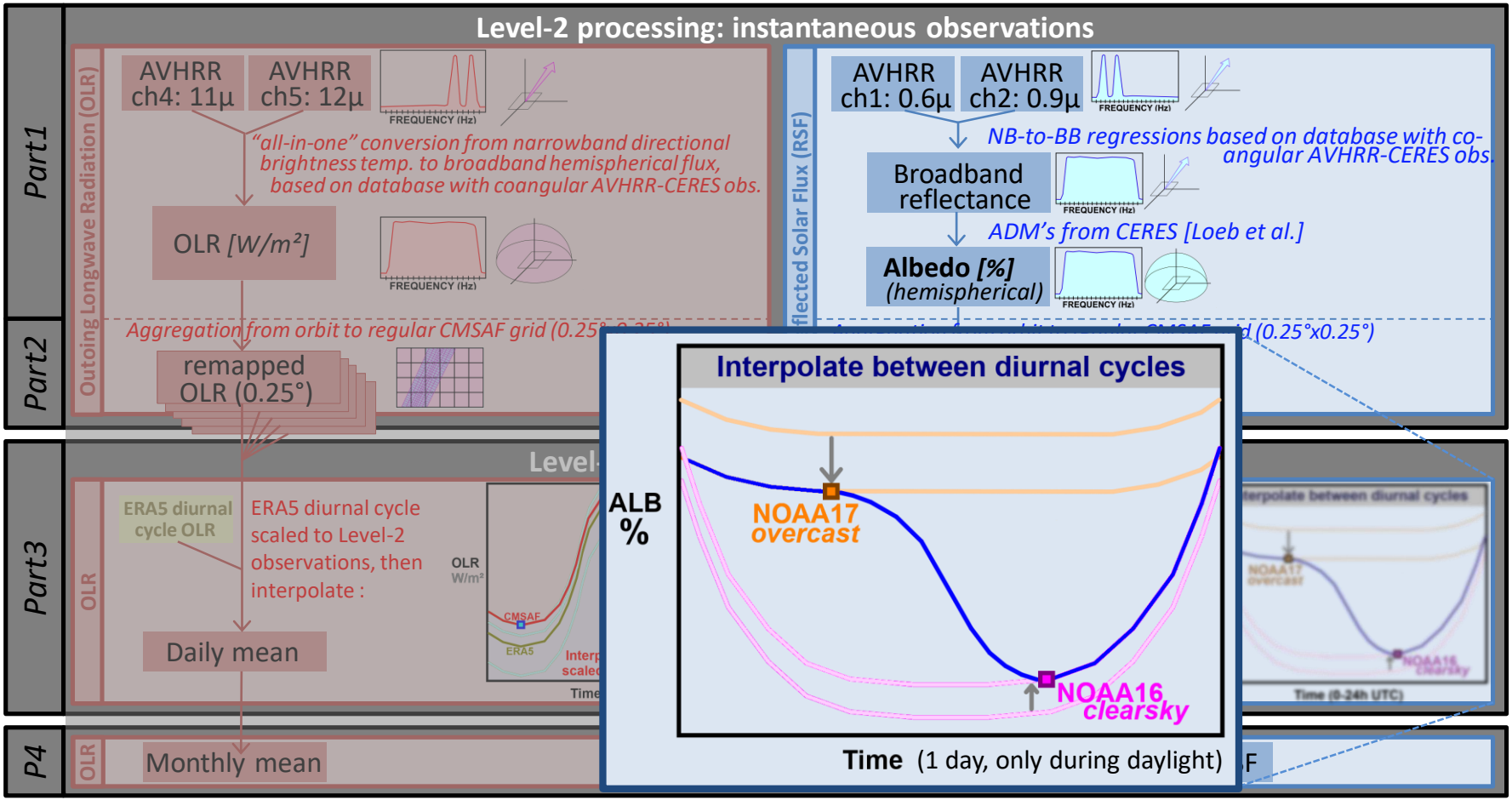
2. Reflected Solar Flux (RSF)



2. Reflected Solar Flux (RSF)

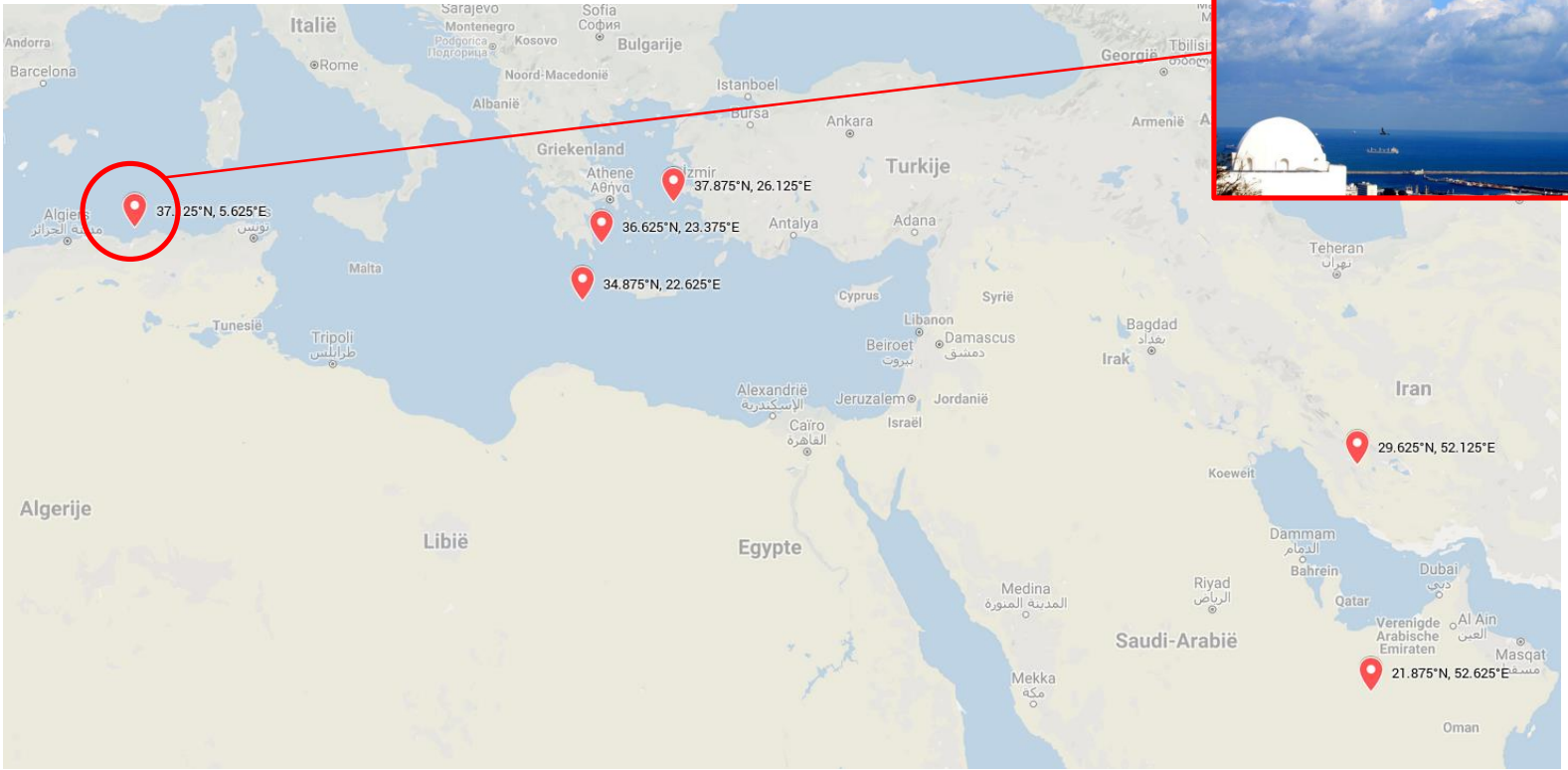


2. Reflected Solar Flux (RSF)



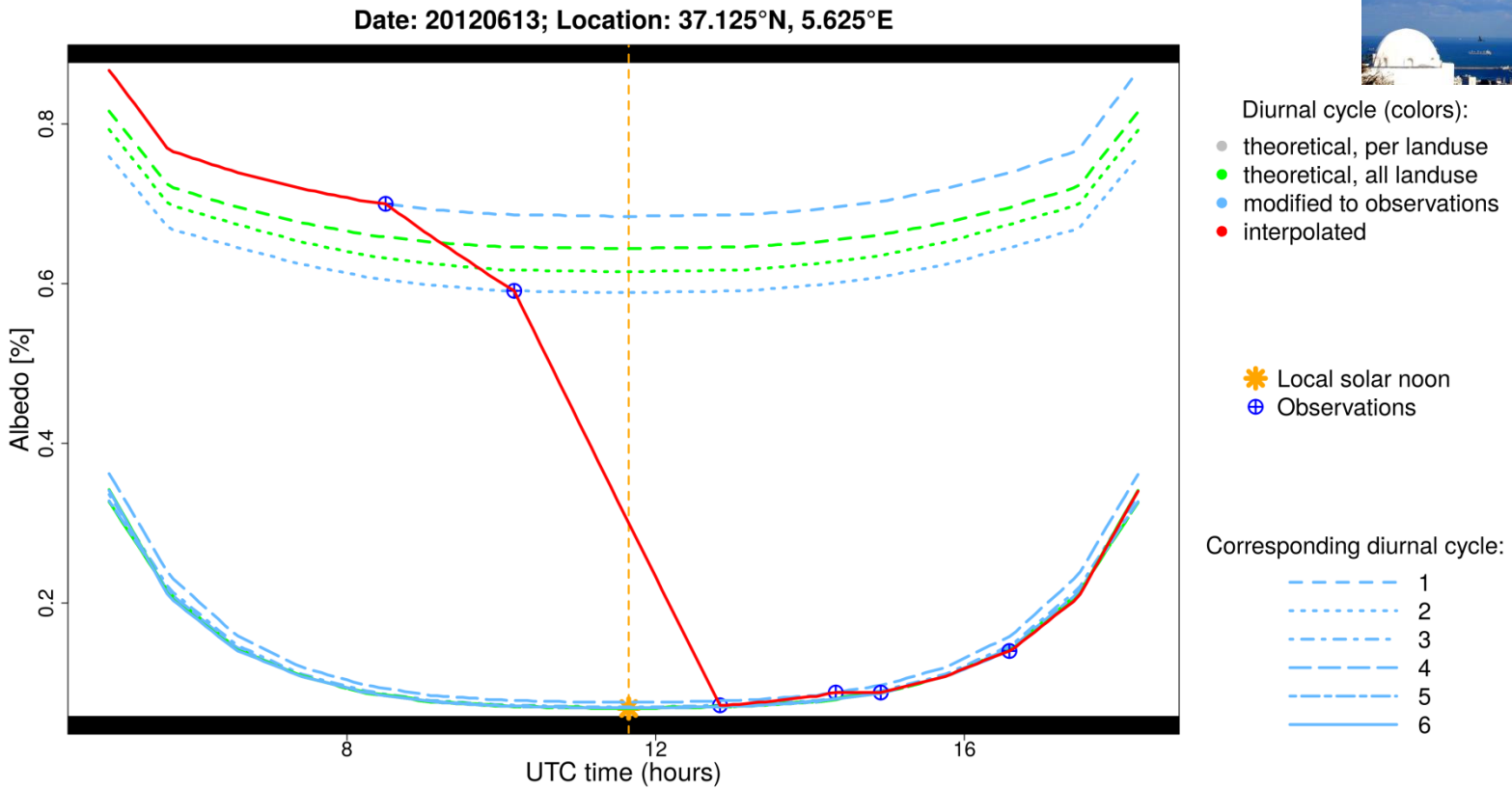
2. Reflected Solar Flux (RSF)

Example 2: coastal cloud passage near Algiers



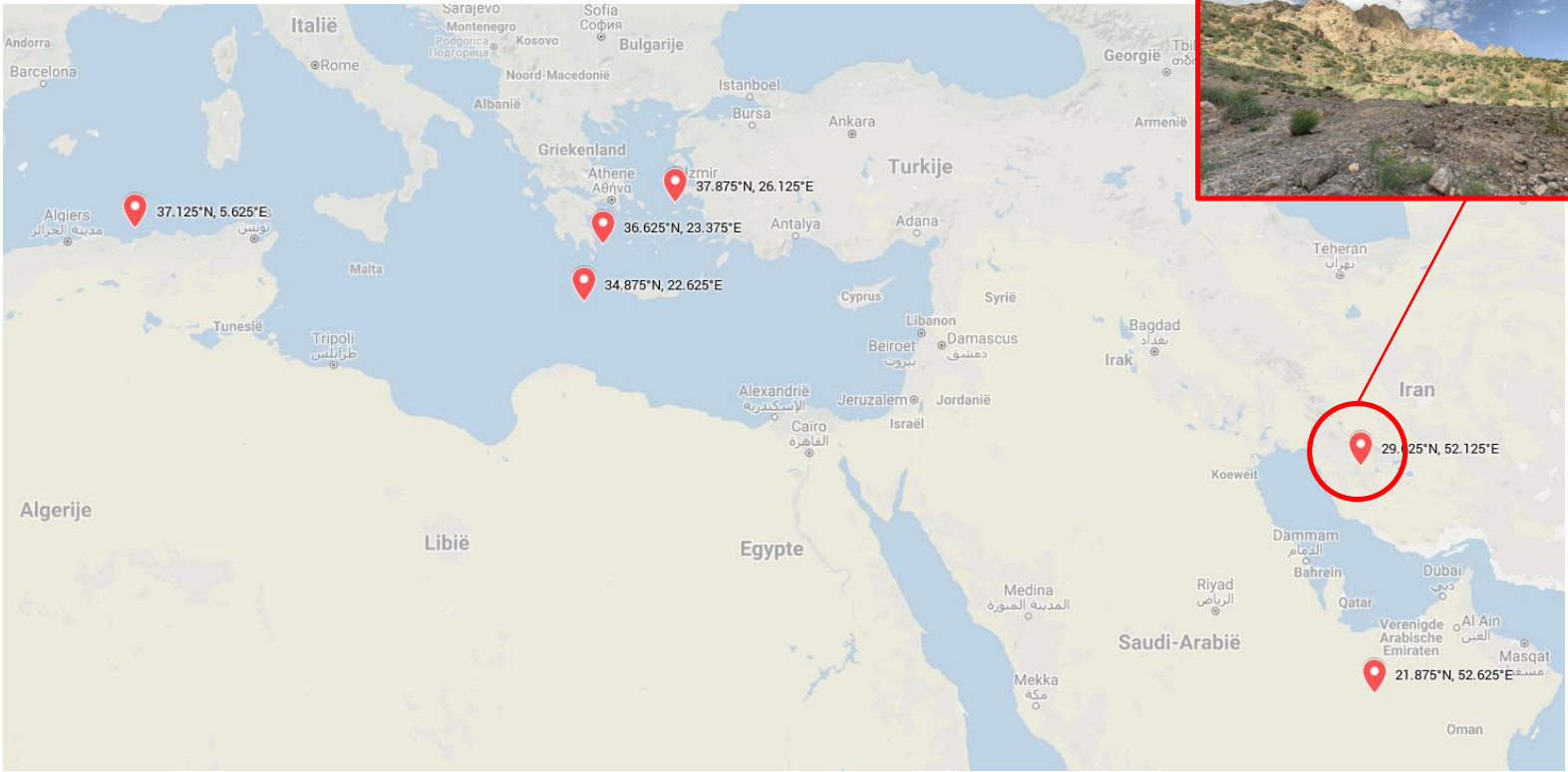
2. Reflected Solar Flux (RSF)

Example 2: coastal cloud passage near Algiers



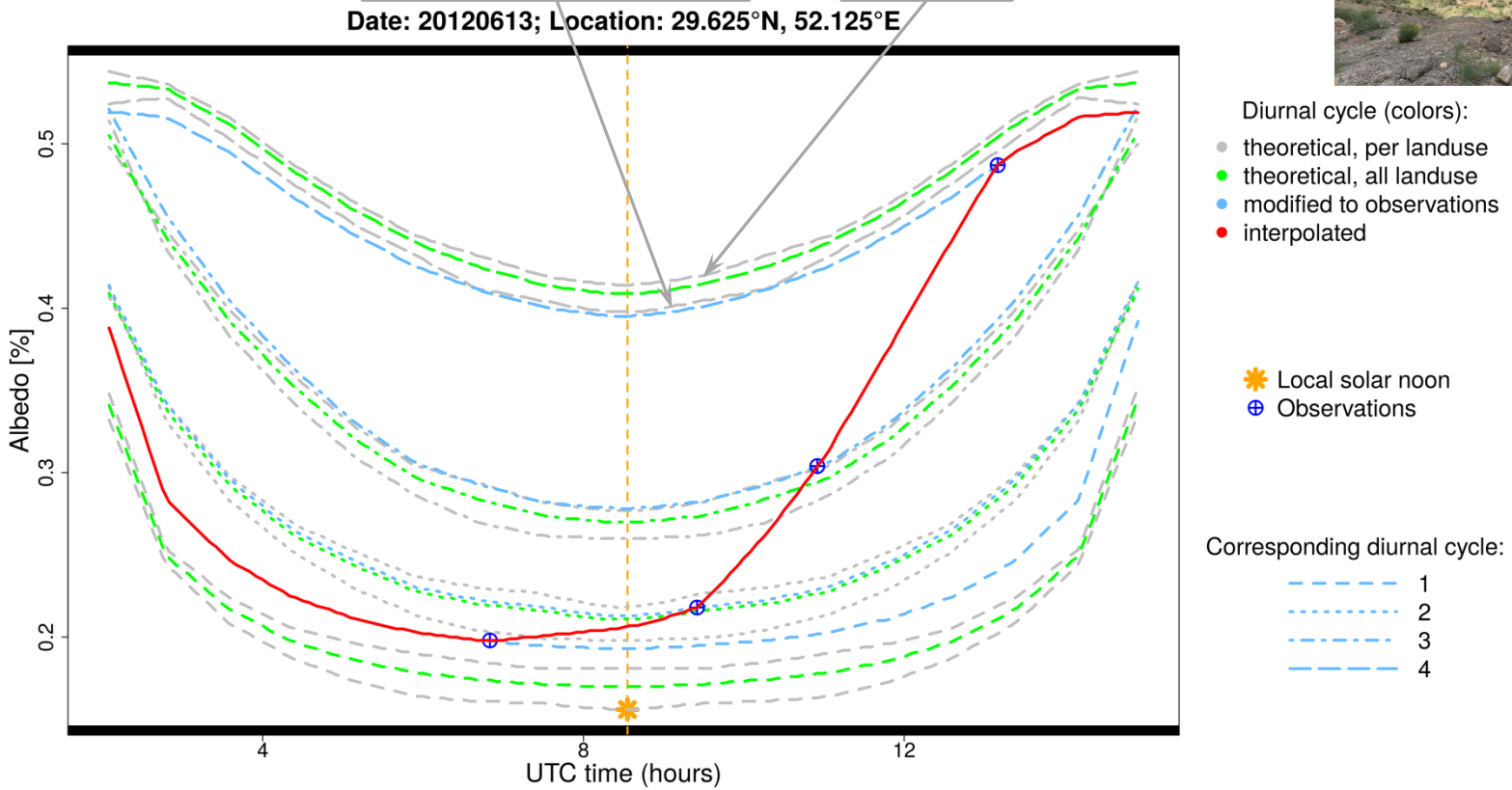
2. Reflected Solar Flux (RSF)

Example 3: cloud formation on Zagros mountain range



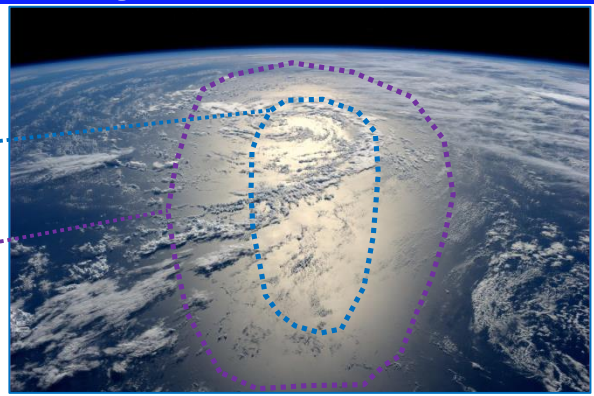
2. Reflected Solar Flux (RSF)

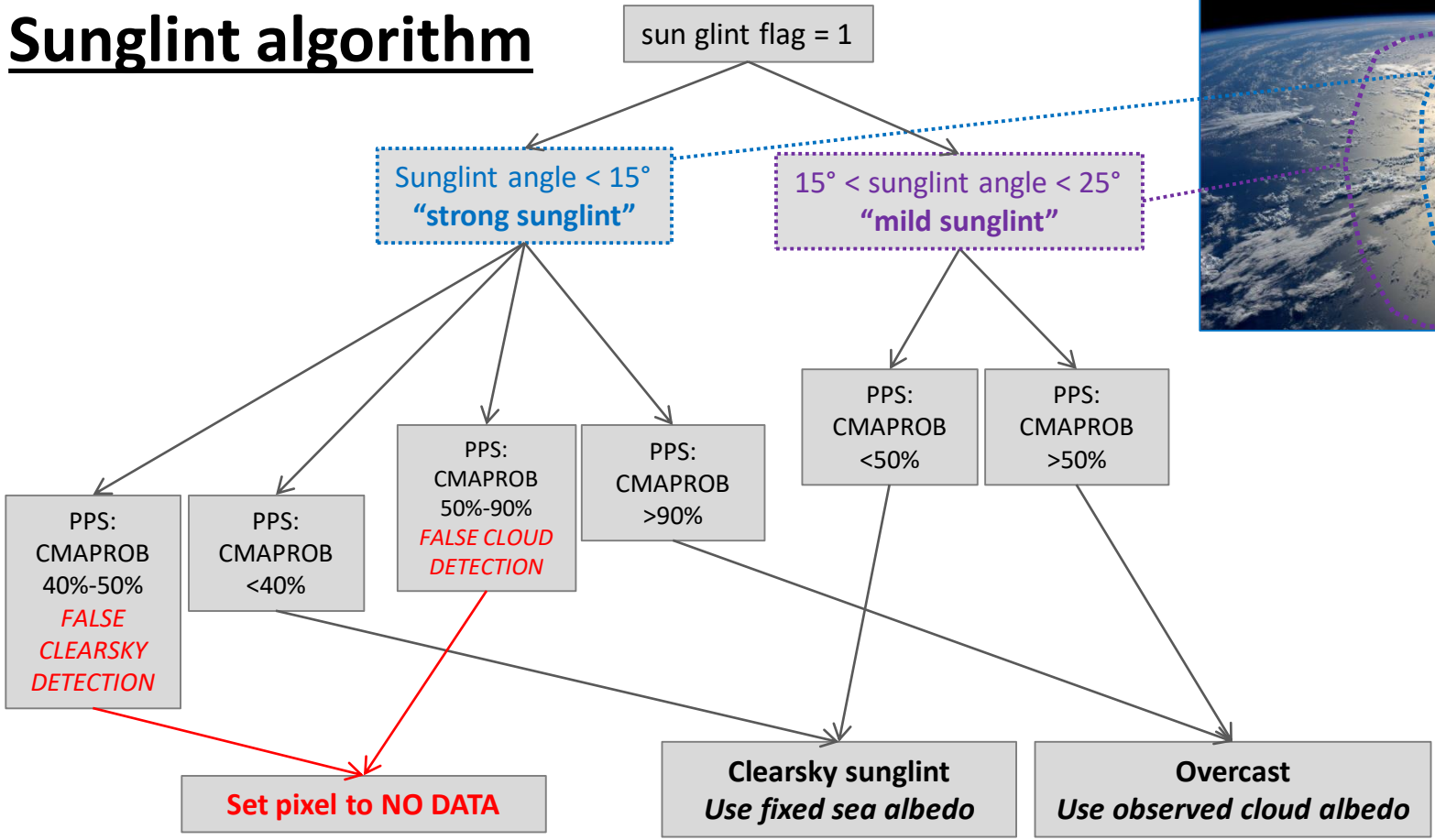
Example 3: cloud formation on Zagros mountain range;
Landuse is mixture of bright vegetation and desert.



2. Reflected Solar Flux (RSF)

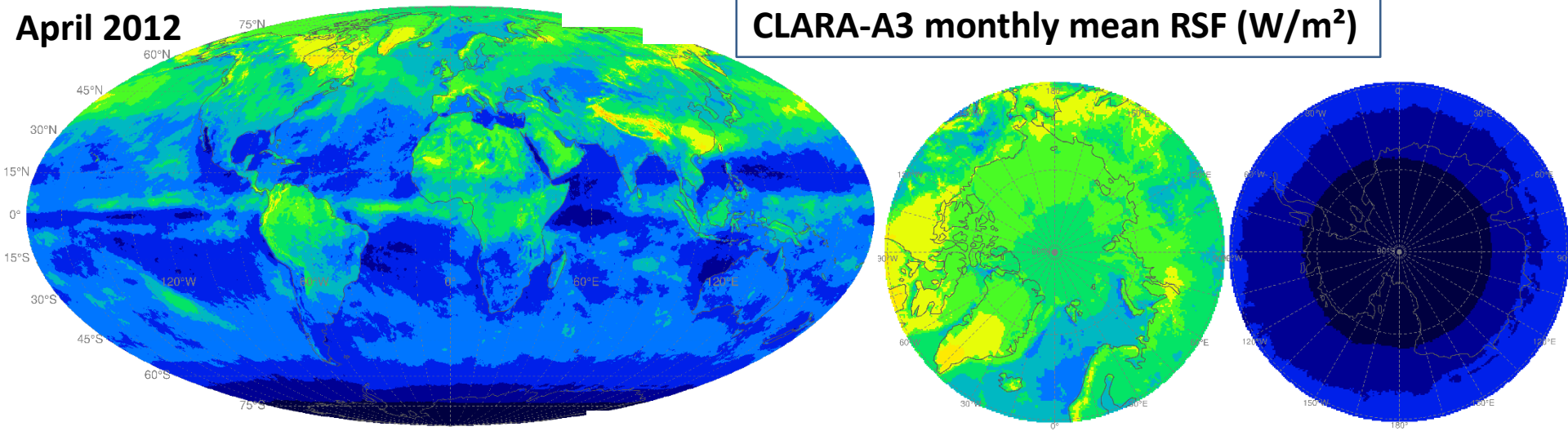
Sunglint algorithm



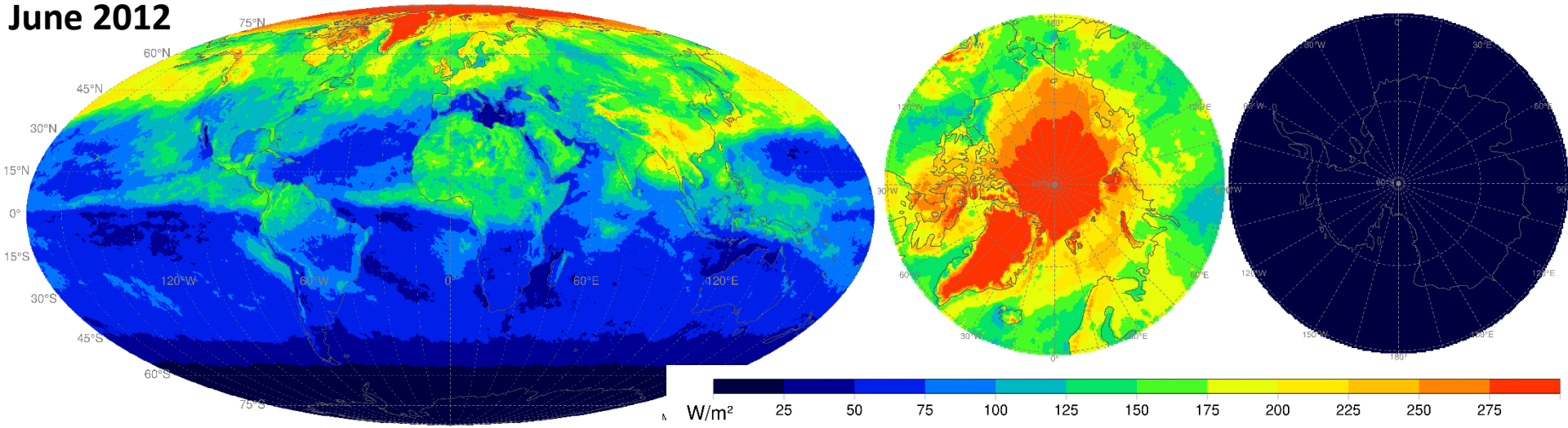


CLARA-A3 monthly mean RSF (W/m²)

April 2012

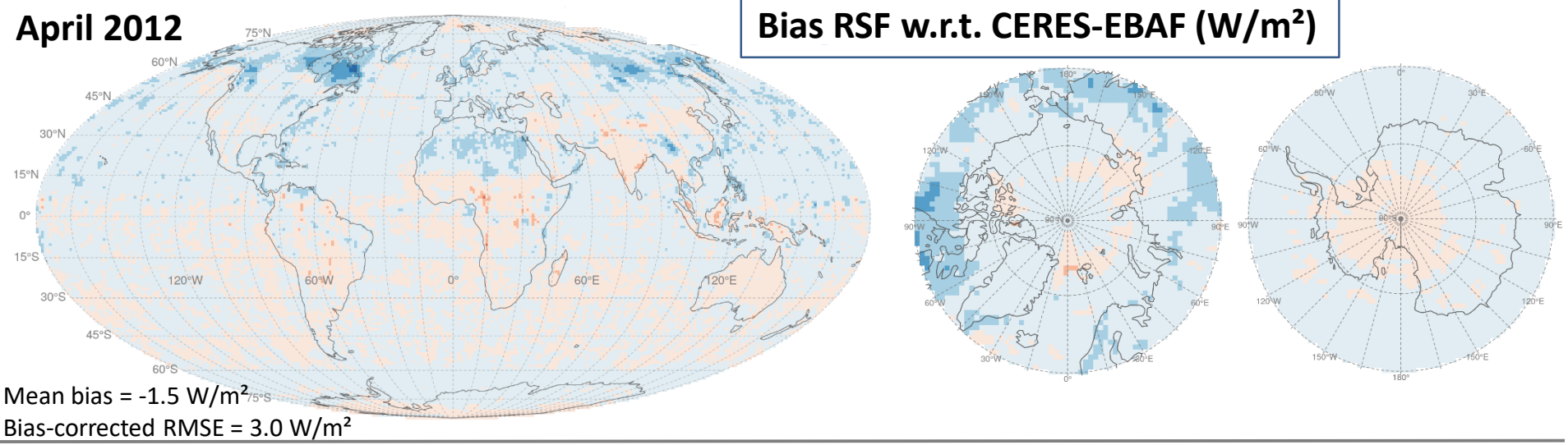


June 2012



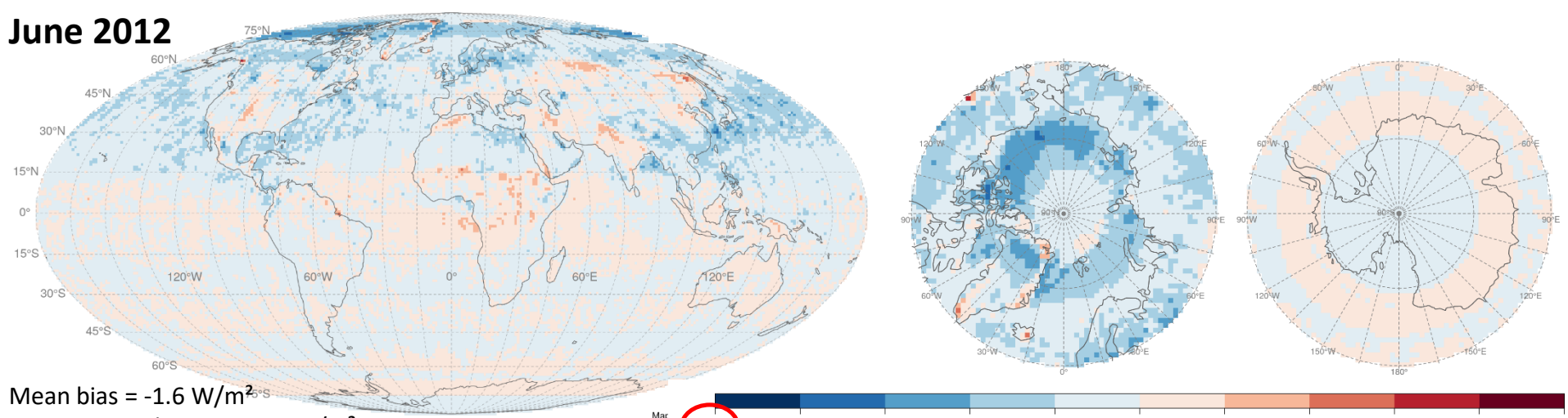
Bias RSF w.r.t. CERES-EBAF (W/m²)

April 2012



Mean bias = -1.5 W/m²
Bias-corrected RMSE = 3.0 W/m²

June 2012

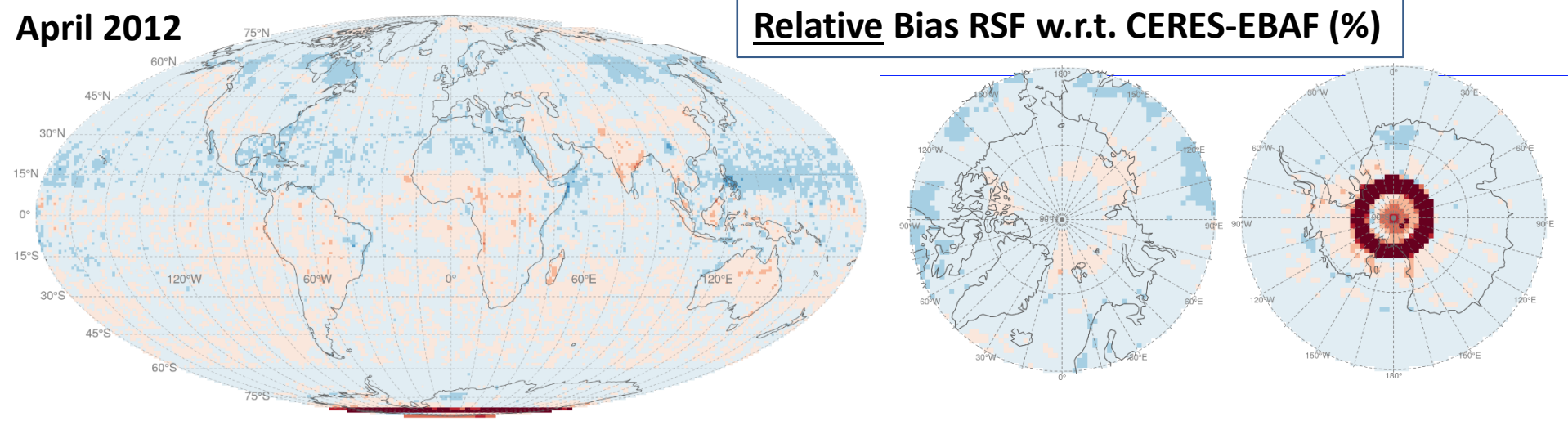


Mean bias = -1.6 W/m²
Bias-corrected RMSE = 3.5 W/m²

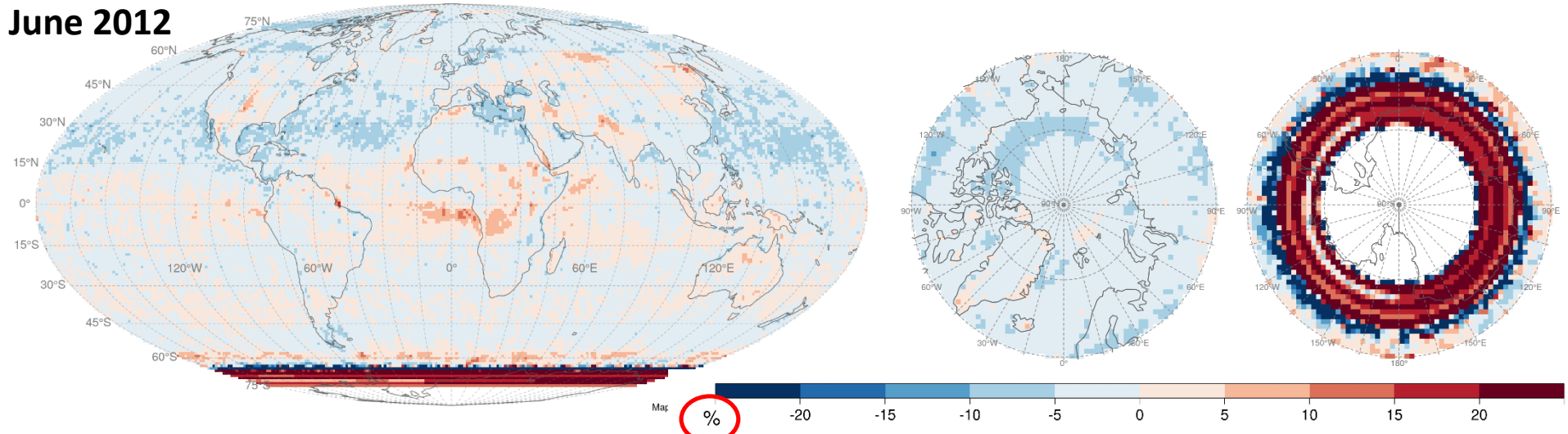
Map W/m² -16 -12 -8 -4 0 4 8 12 16

Relative Bias RSF w.r.t. CERES-EBAF (%)

April 2012

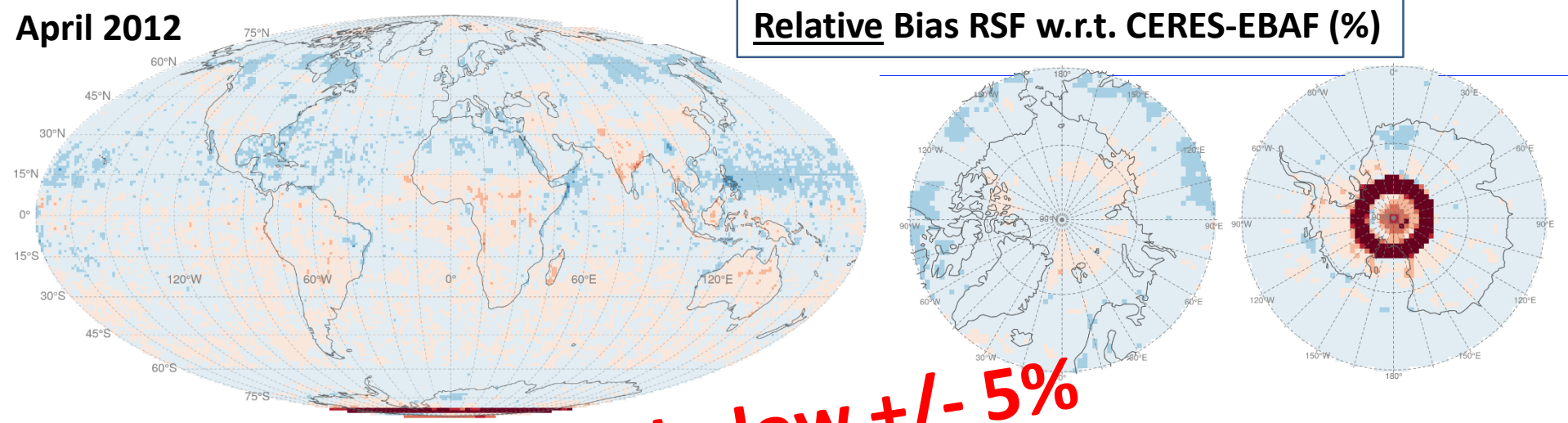


June 2012

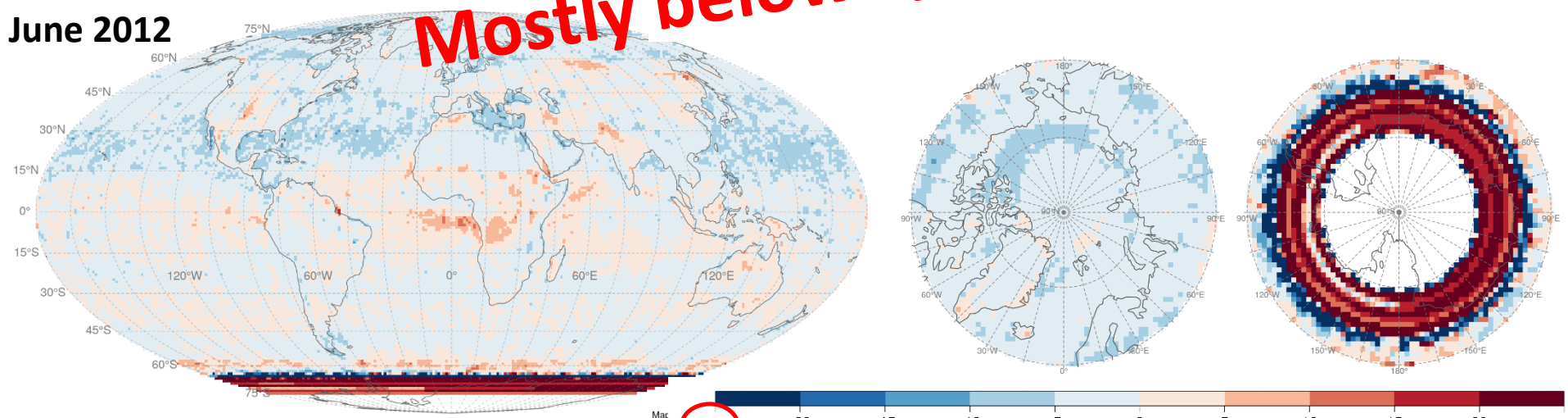


Relative Bias RSF w.r.t. CERES-EBAF (%)

April 2012



June 2012

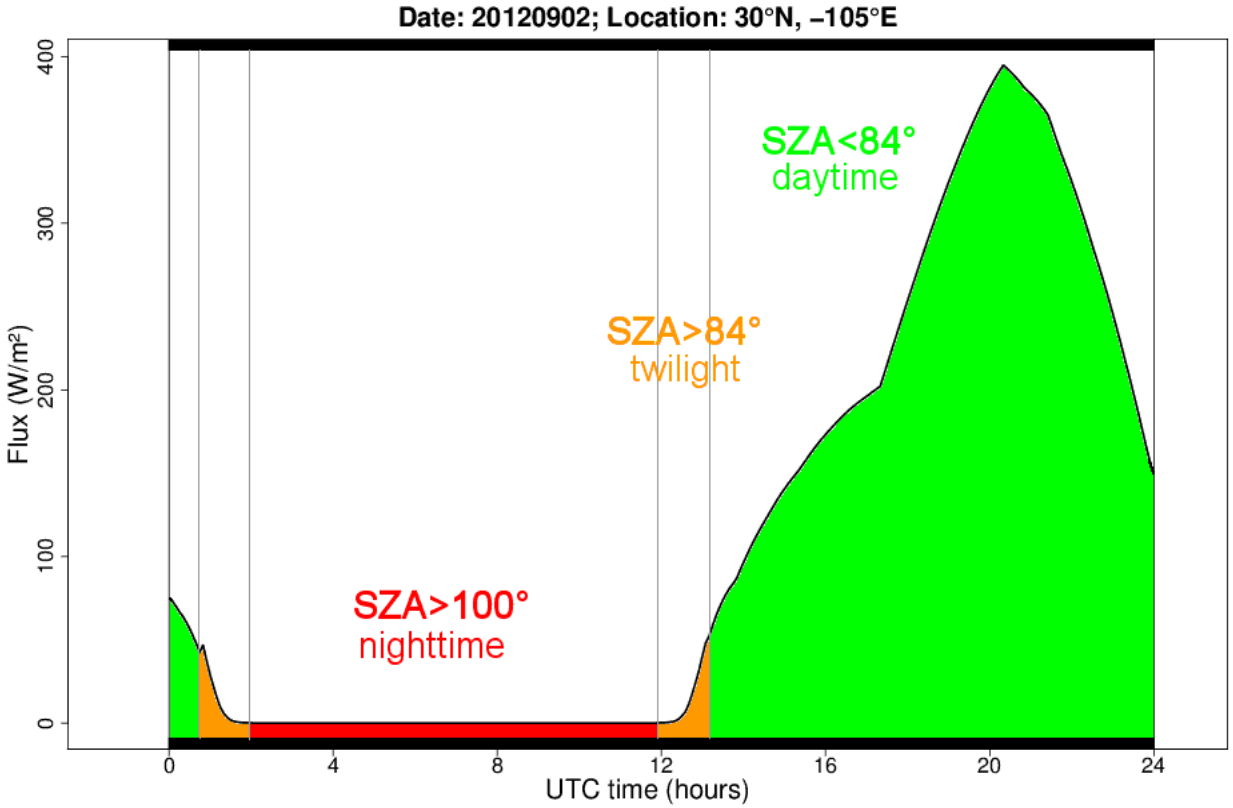


Mostly below +/- 5%

%

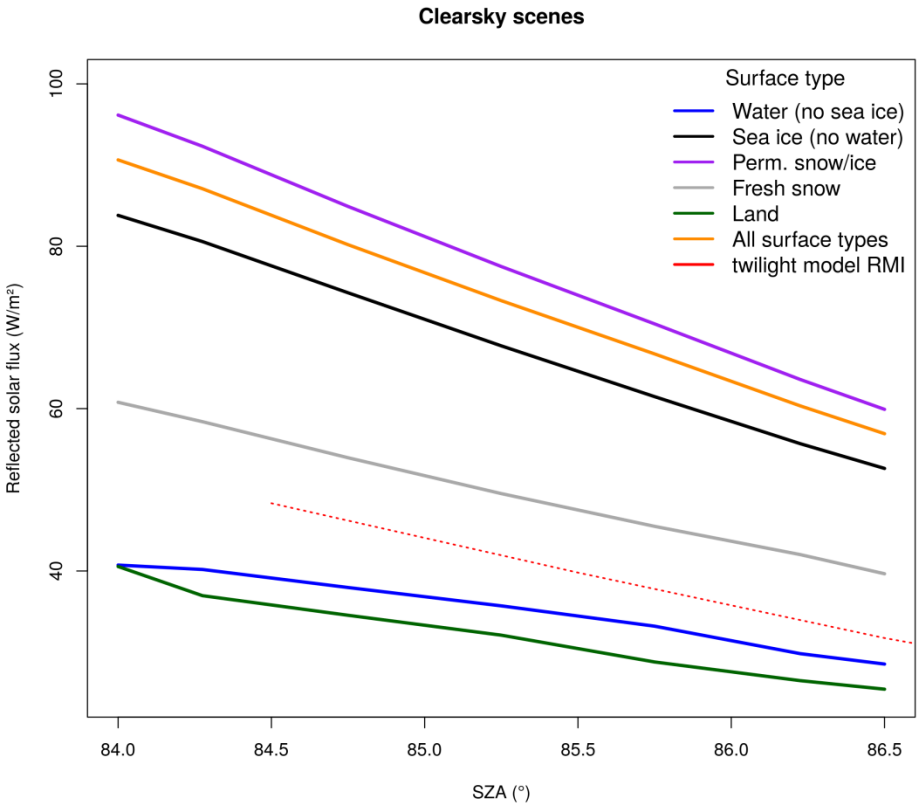
2. Reflected Solar Flux (RSF)

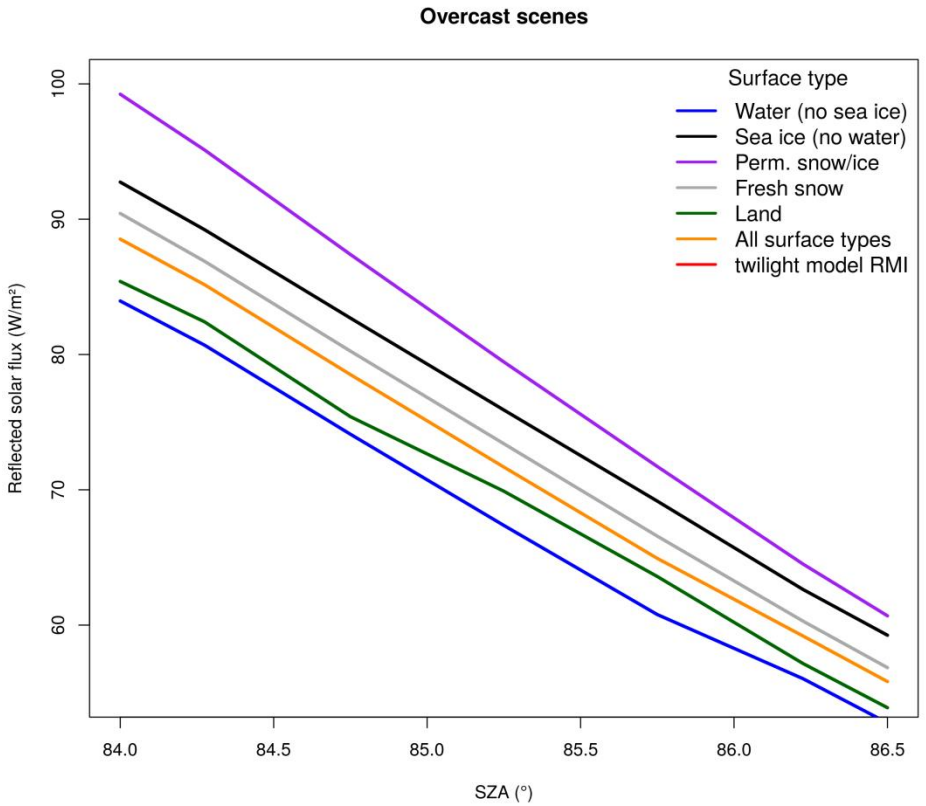
Twilight conditions when SZA is between 84°-100°



2. Reflected Solar Flux (RSF)

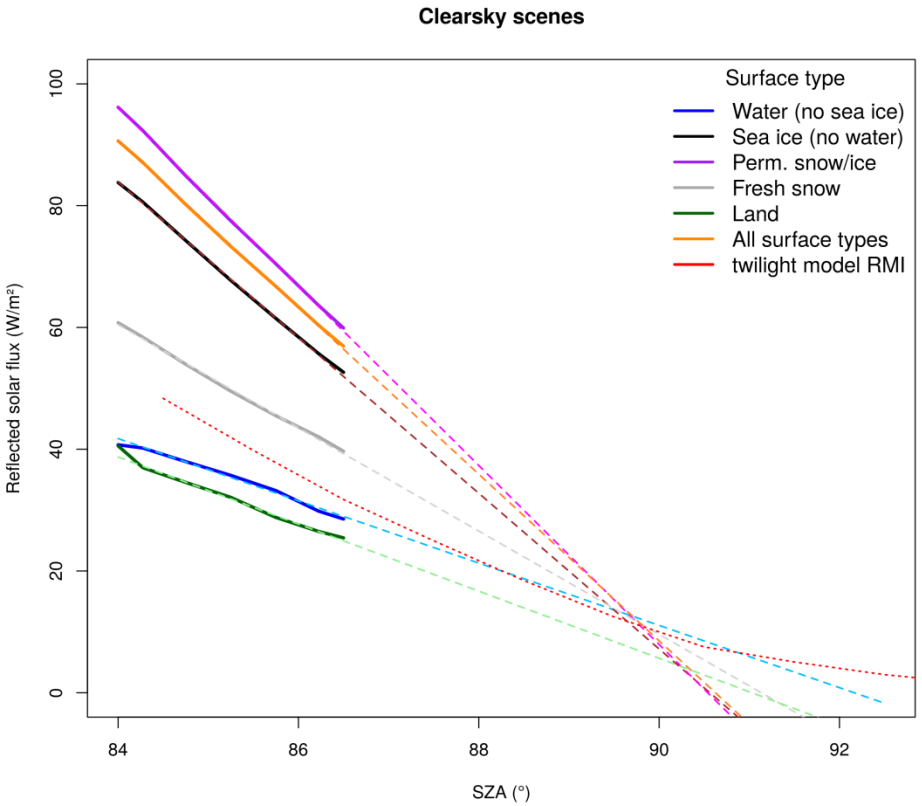
Twilight: plot SSF Aqua/Terra CERES SW TOA flux (W/m²) as function of SZA (limited at 86.5°)

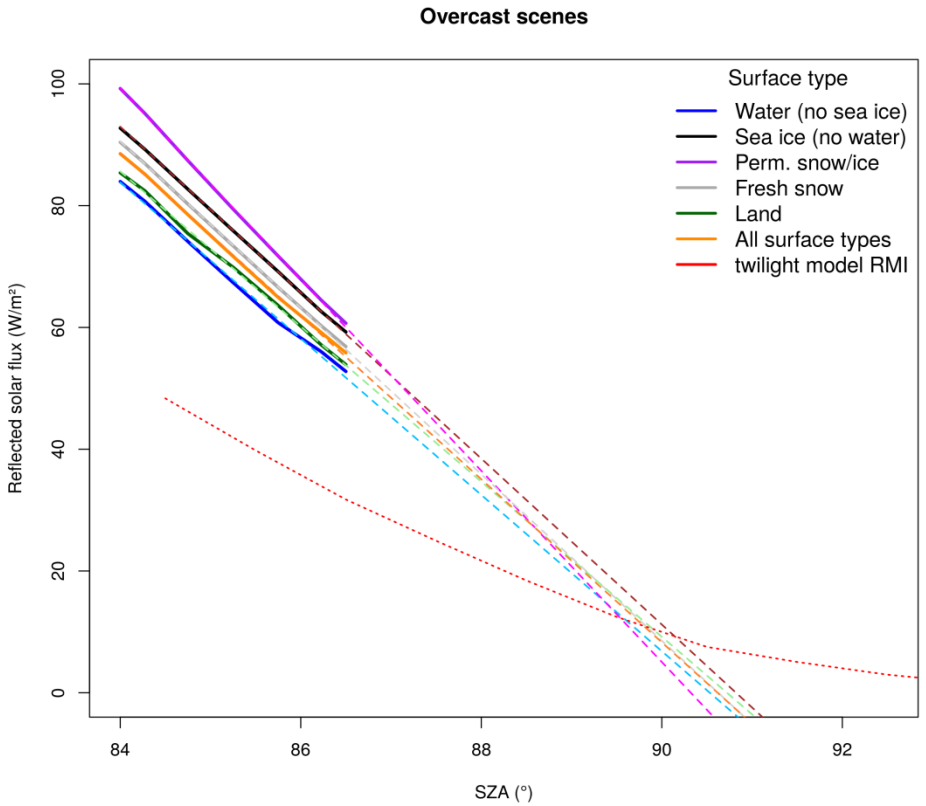




2. Reflected Solar Flux (RSF)

Twilight: derive linear regression on known data (84°<SZA<86.5°) and extrapolate regression line

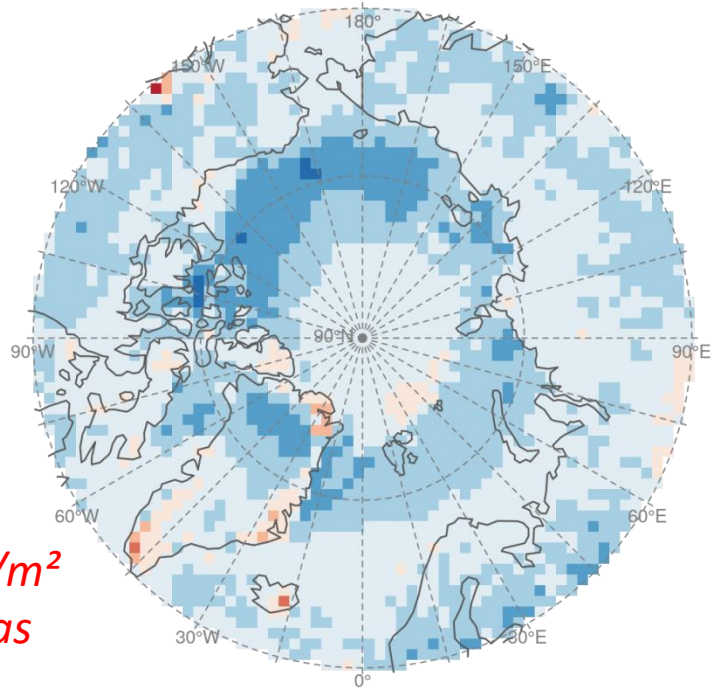


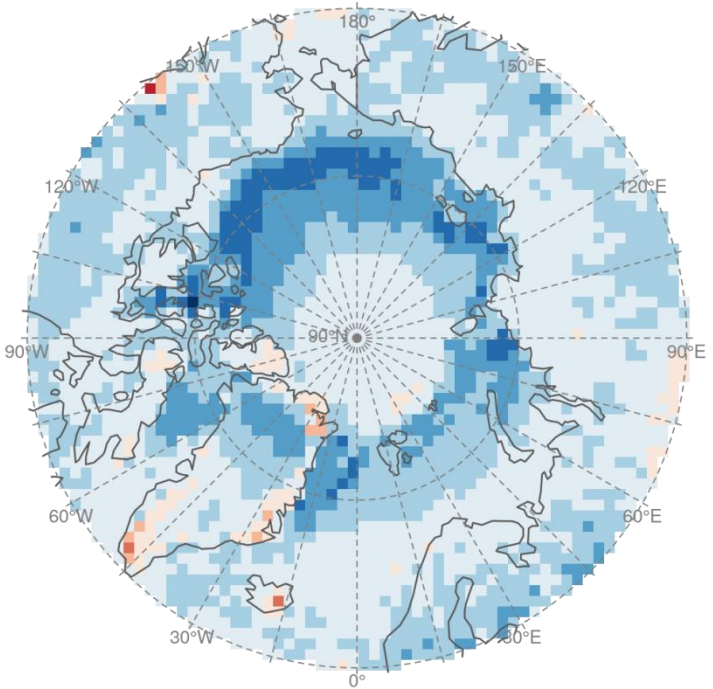


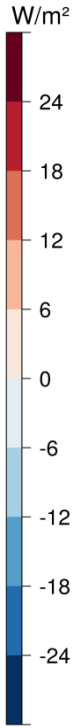
2. Reflected Solar Flux (RSF)

Impact of using new CERES ADMs (Ed.4): example for <u>overcast sea-ice</u>:

Bias of CLARA-A3 TOA RSF w.r.t. CERES EBAF (201206)







2-6 W/m² less bias

New Ed4 ADMs (Su et al, 2015)

Old Ed2.8 ADMs (Loeb et al, 2005)

EUMETSAT CM SAF

CCLRC - DFBO - DIFA - GKSS - Hadley Centre GERB Imperial College - RMIB - University of Leicester

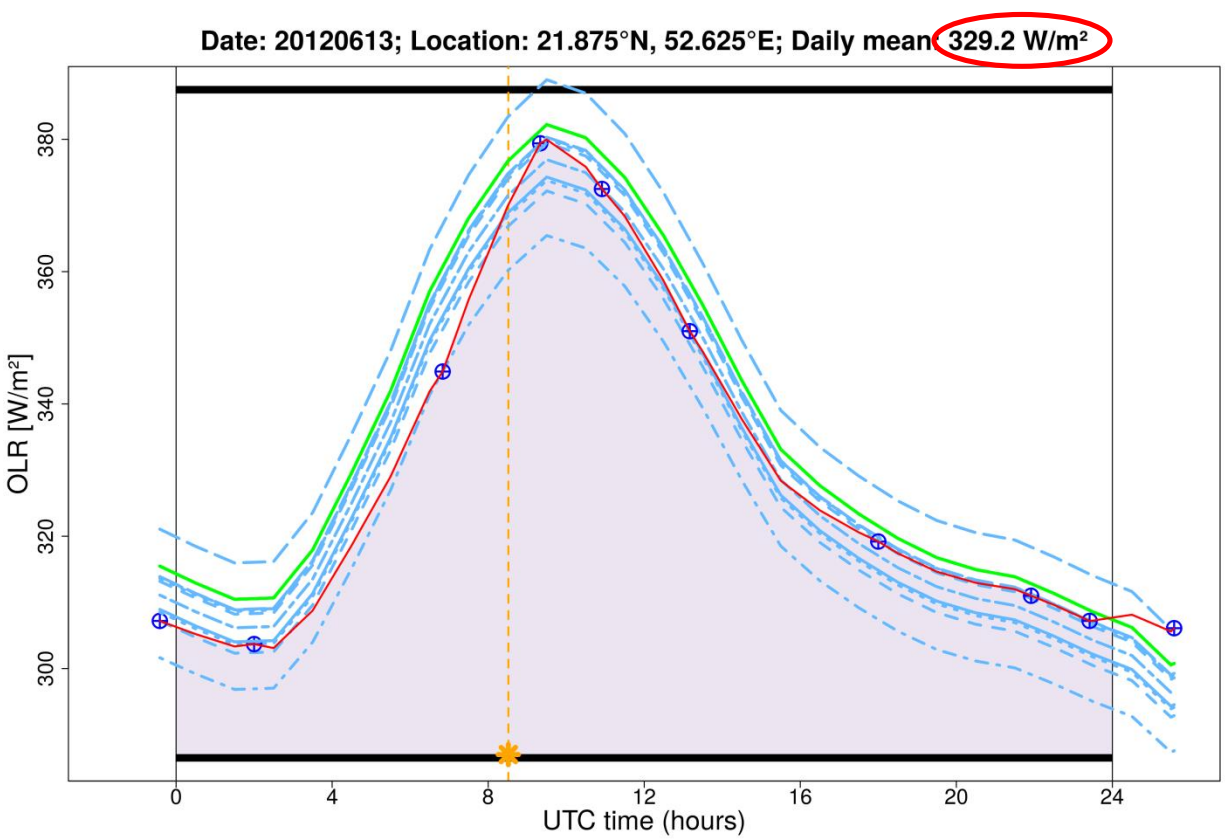
Royal Meteorological Institute Belgium RMI

Thanks for your attention!

<tom.akkermans@meteo.be>

2. Improvements/additions

- **All** satellites (N15-18-19/MetA) :



Local solar noon
Observations

Corresponding diurnal cycle:
1
2
3
4
5
6
7
8