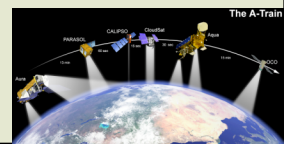
Boundary Layer Lapse Rate used in CERES Edition 3

Sunny Sun-Mack[1], Patrick Minnis[2], Yan Chen[1], Sharon Gibson[1], Yuhong Yi[1], Dave Winker[2]

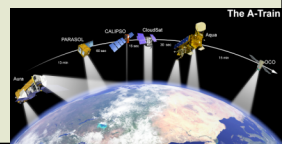
(1) SSAI, Hampton, VA, USA
(2) NASA Langley Research Center, Hampton, VA, USA

CERES STM April 27-29, 2010



Objective

To develop the best boundary layer lapse rate for CERES Edition 3



DATA

Aqua - MODIS:

L1B --- MAC02 (radiance)
L1B --- MAC03 (geolocation)
L2 --- MAC04 (aerosol)

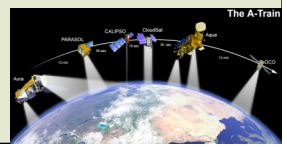
Full resolution (1 km) with 22 channel MODIS subset: 201 km MODIS swath centered at the CloudSat nadir track. Only middle 101 pixels in the scan are processed.

CALIPSO:

L2 --- Vertical Feature Mask (VFM)
L2 --- 5 km Cloud Profile (05kmCPro)
L2 --- 5 km Aerosol Layer (05kmALay)
L2 --- 5 km Cloud Layer (05kmALay)

CloudSat:

L2 --- Cloud Scenario Classification (CLDCLASS)
L2 --- Cloud Water Content (2B-CWC-RO)



Lapse Rate Calculation

For Merged CALIPSO and CERES Clouds

CALIPSO

(1) Single Layer

(2) Transparent Clouds

(3) Cloud Top Height: Z_{top}

CERES-MODIS

(1) Water Clouds

(2) Cloud Top Temp: T_{top}

(3) T_{skin} , for Ocean

(4) $T_{sfc\text{-}24h\text{-}mean}$ for Land

(5) $Z_{sfc,}$ Surface Height

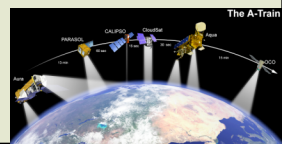
$Z_{top} - Z_{sfc} < 5$ km

$$\text{Lapse Rate} = (T_{top} - T_{skin}) / (Z_{top} - Z_{sfc}) \quad \text{<------ For Ocean}$$

$$\text{Lapse Rate} = (T_{top} - T_{sfc\text{-}24h\text{-}mean}) / (Z_{top} - Z_{sfc}) \quad \text{<------ For Land}$$

Notes of Lapse Rate Calculation

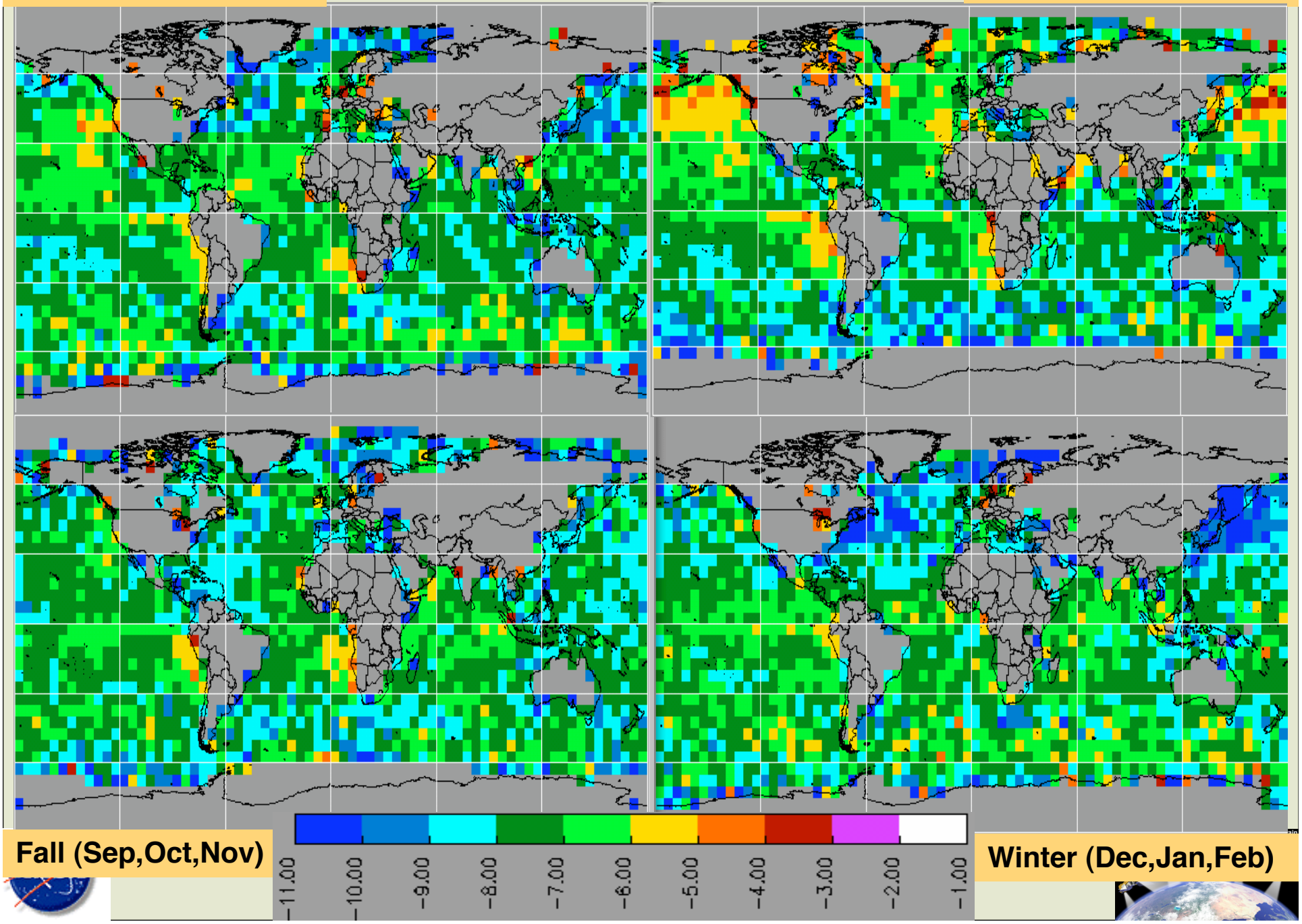
- One year of CALIPSO / CloudSat / MODIS merged fusion data: July 2006 --- June 2007
- Global maps
- Grid Box: 5 x 5 degree
- Day and night separately
- Ocean (snow free), land (snow free), and snow separately



Spring (Mar,Apr,May)

Lapse Rate,Ocean (Snow Free),Day Time

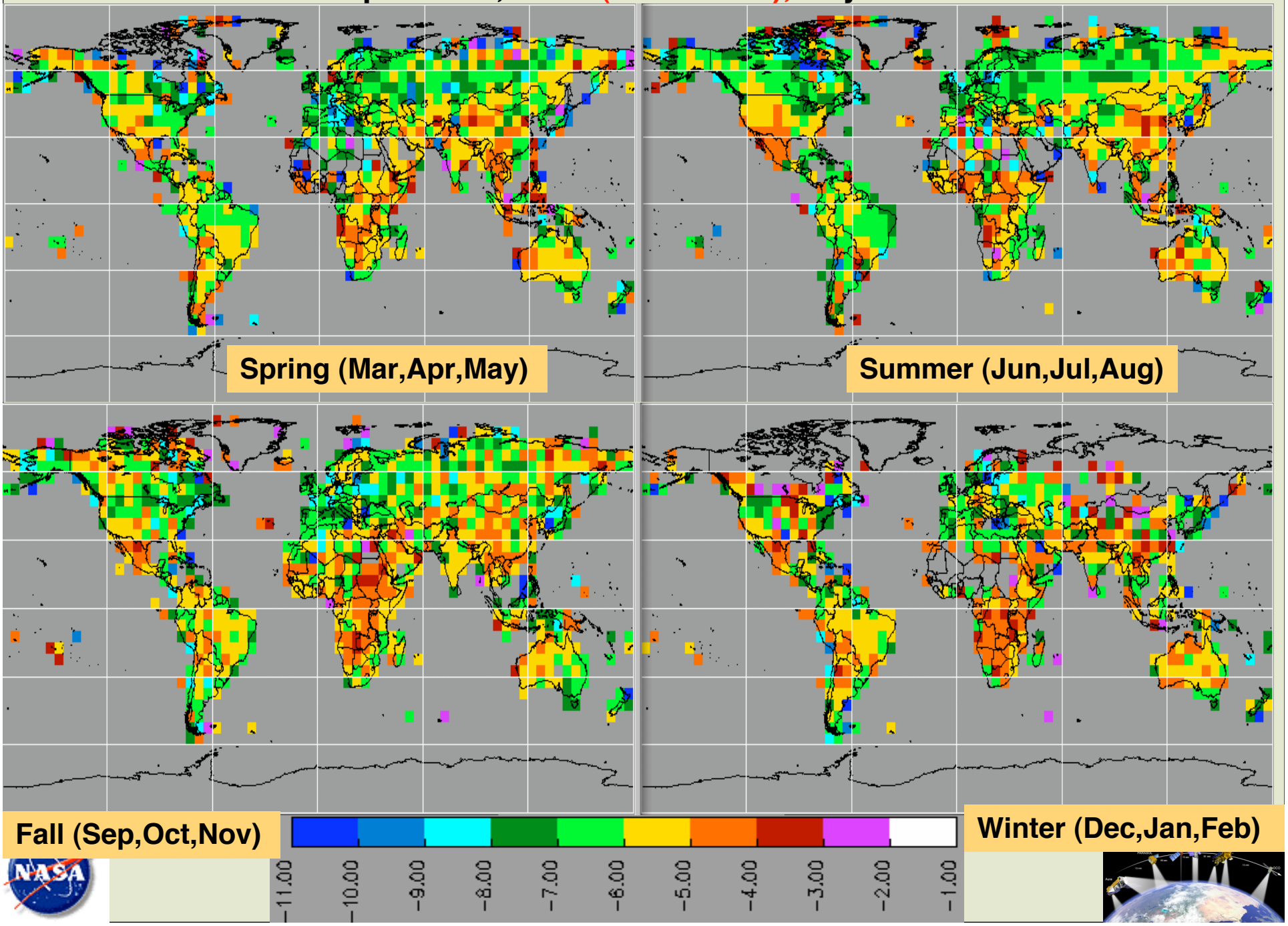
Summer (Jun,Jul,Aug)



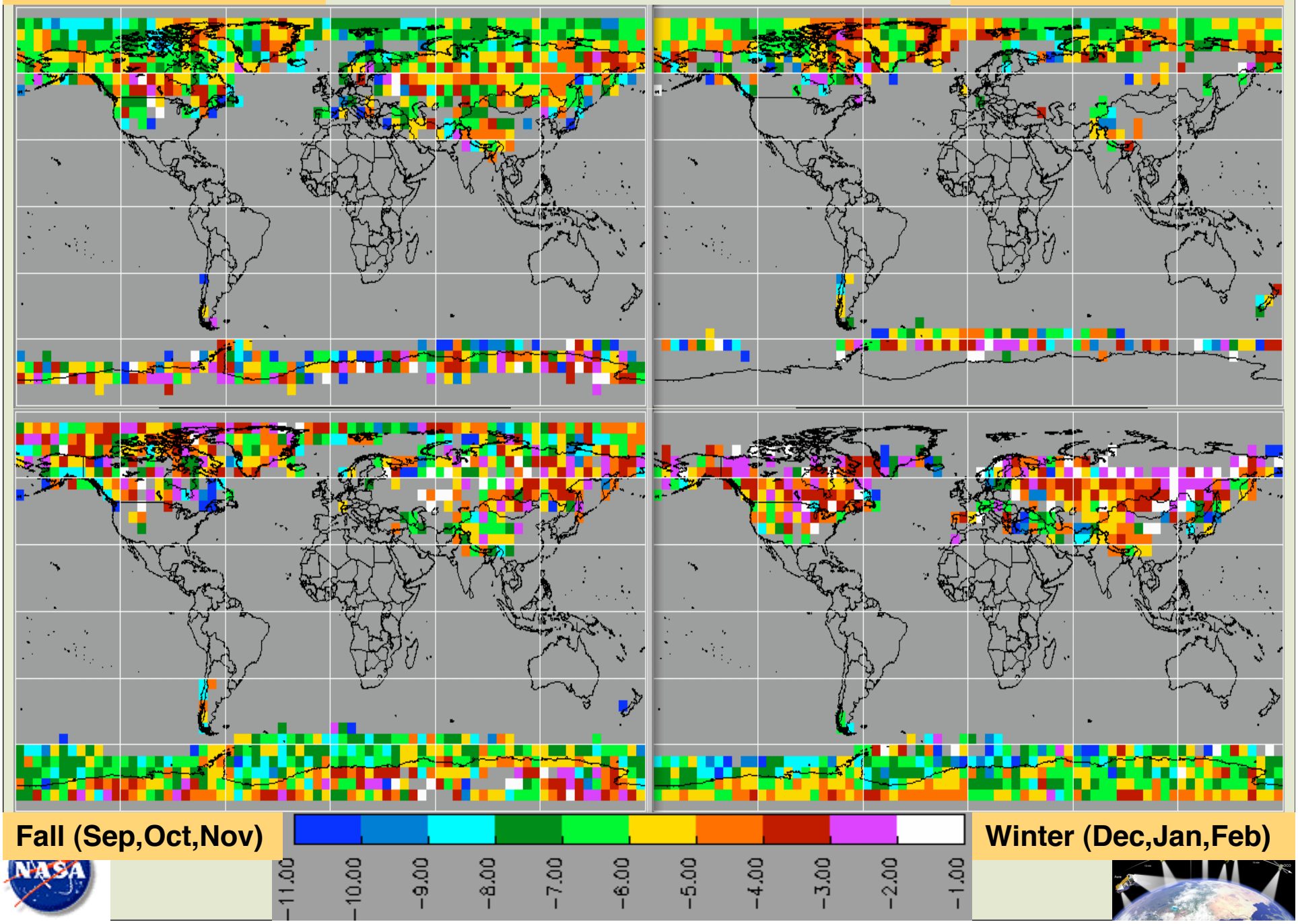
Fall (Sep,Oct,Nov)

Winter (Dec,Jan,Feb)

Lapse Rate, Land (Snow Free), Day Time



Lapse Rate, Snow, Day Time



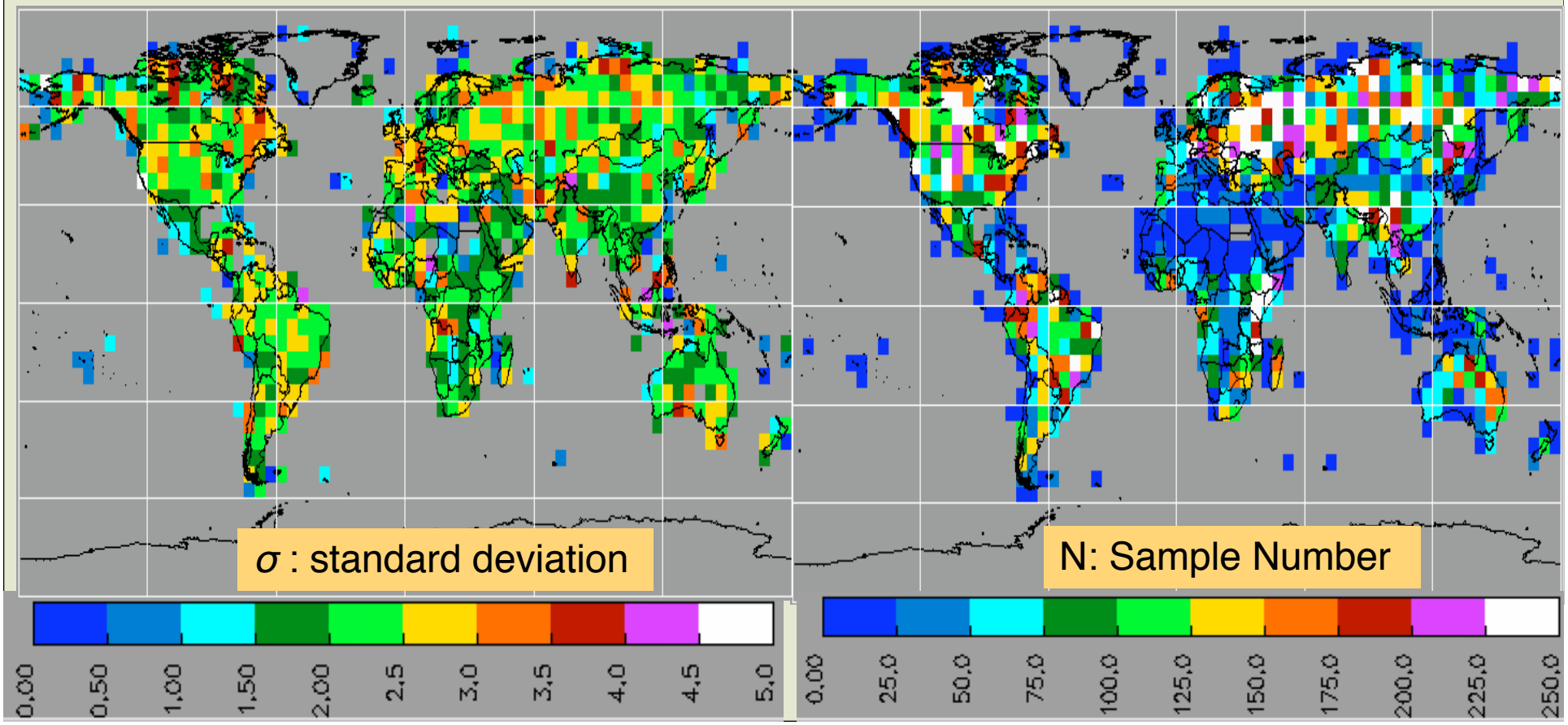
The residual error (standard error) = *σ / sqrt (N)*

where

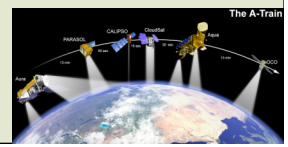
σ : standard deviation

N: sample number or number of observations

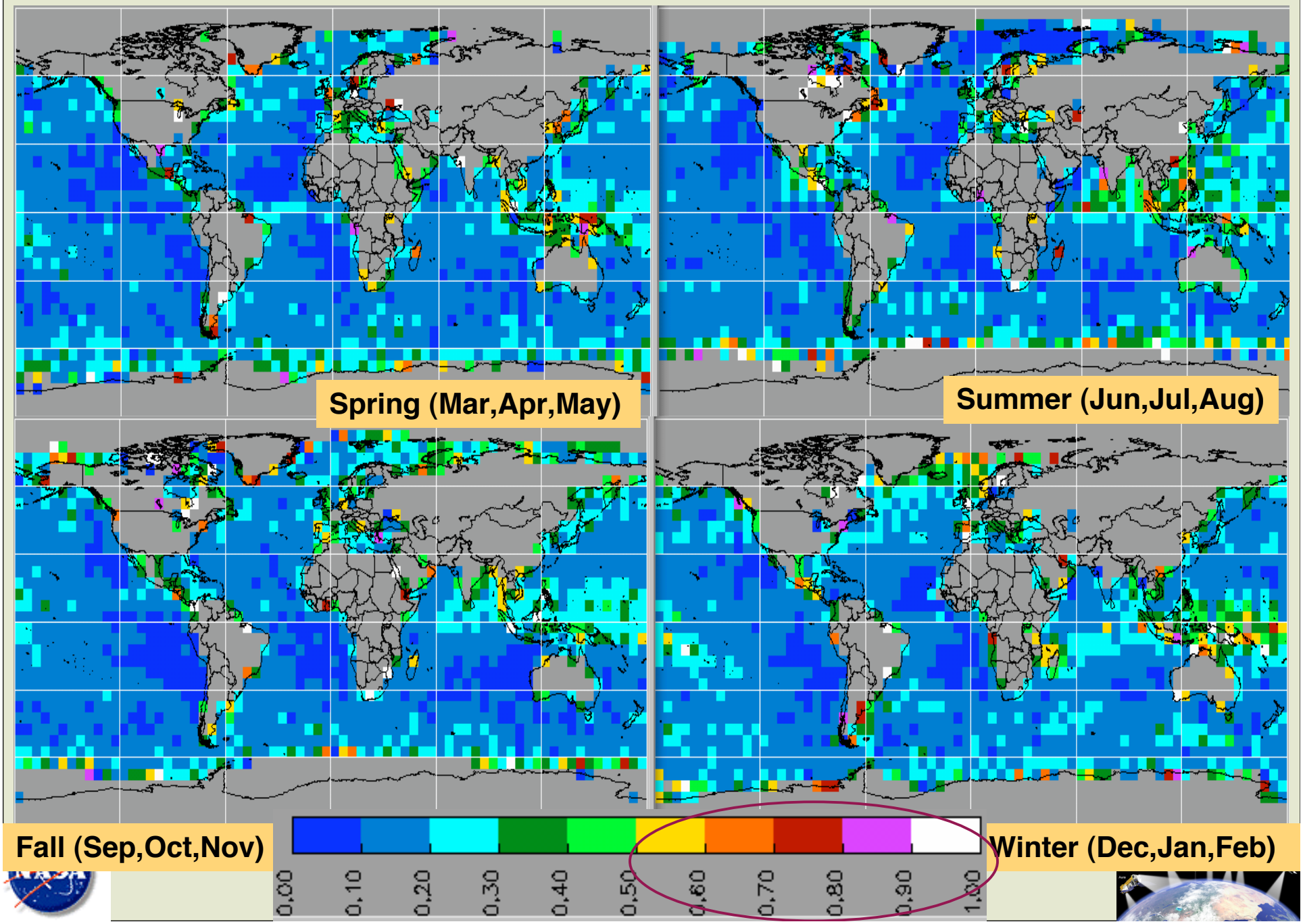
Fall (Sept. Oct. Nov), Land (Snow Free), Day Time



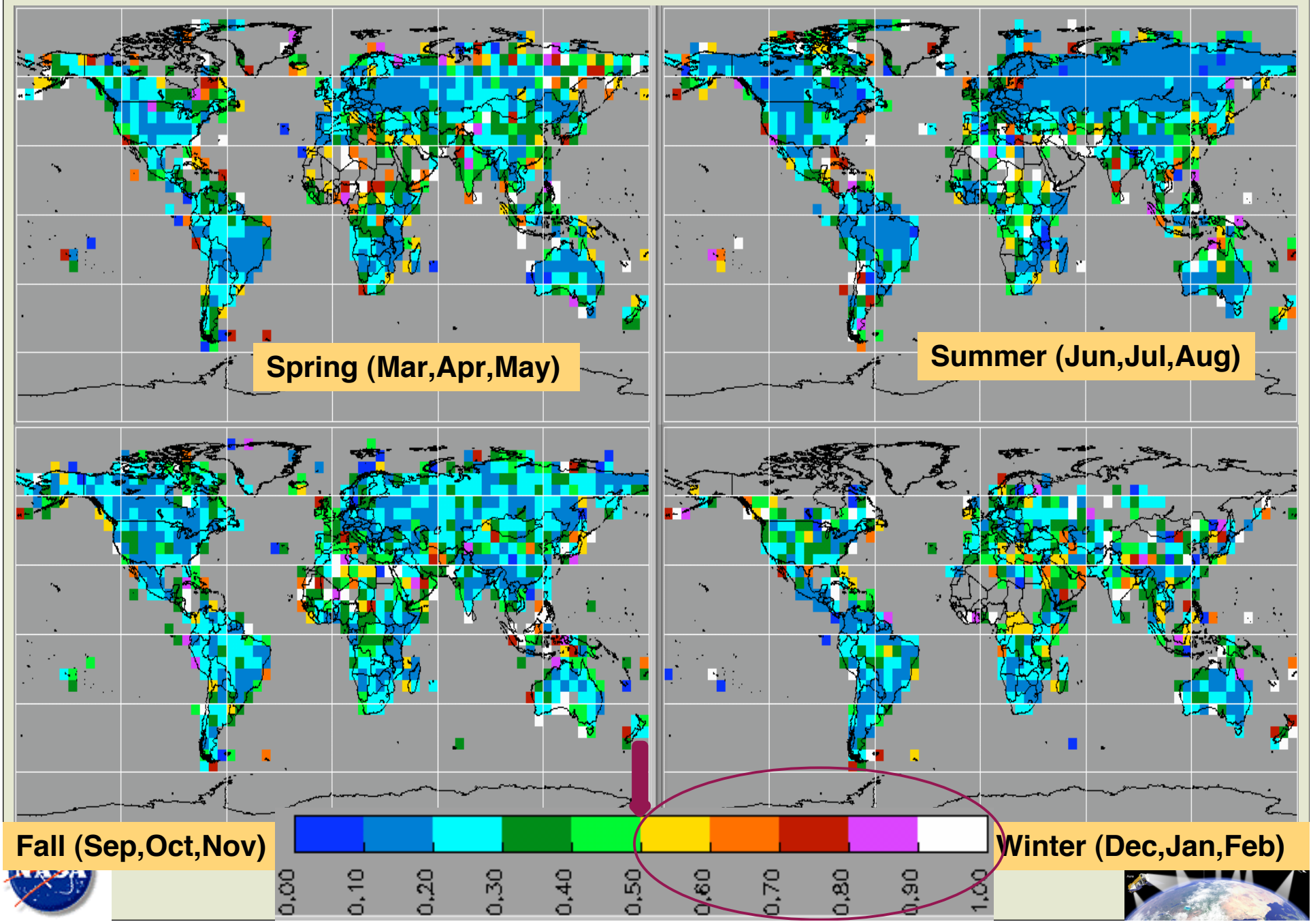
Residual Error Maps



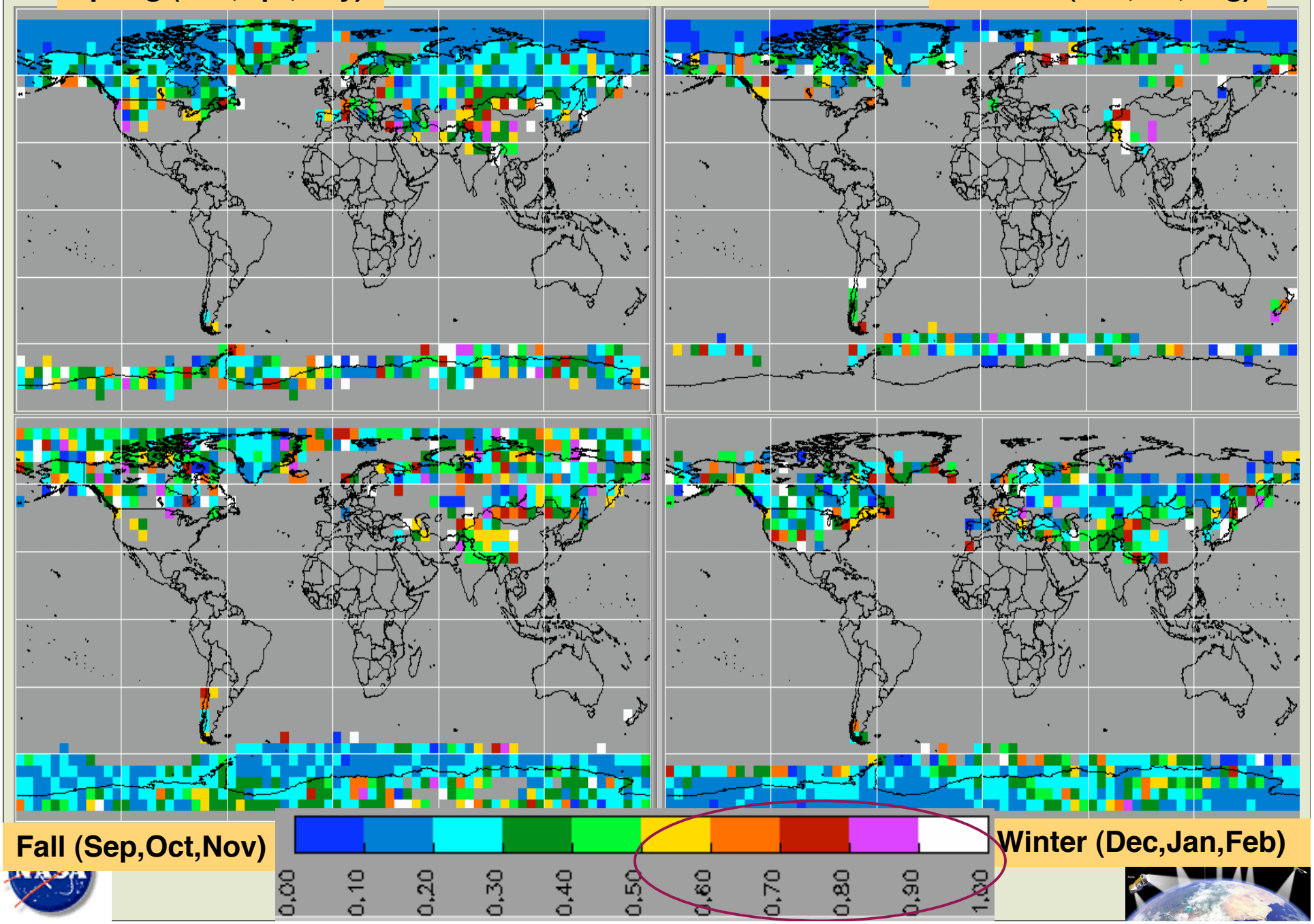
Residual Error, Ocean (Snow Free), Day Time



Residual Error, Land (Snow Free), Day Time



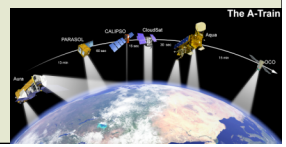
Residual Error, Snow, Day Time

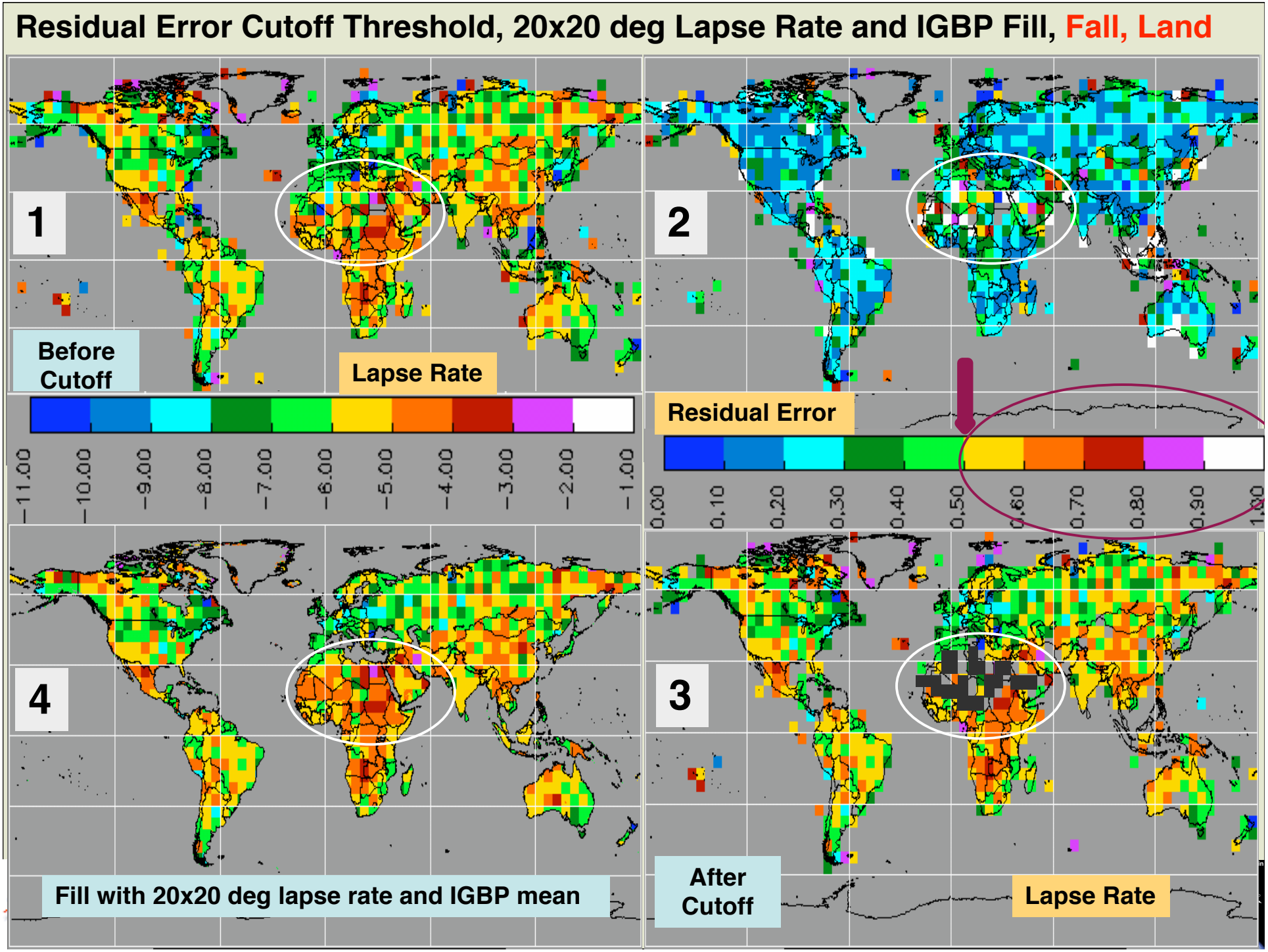


Residual Error Cutoff = 0.5

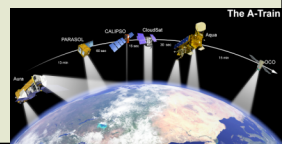
20 degree Lapse Rate Fill

IGBP Mean Fill

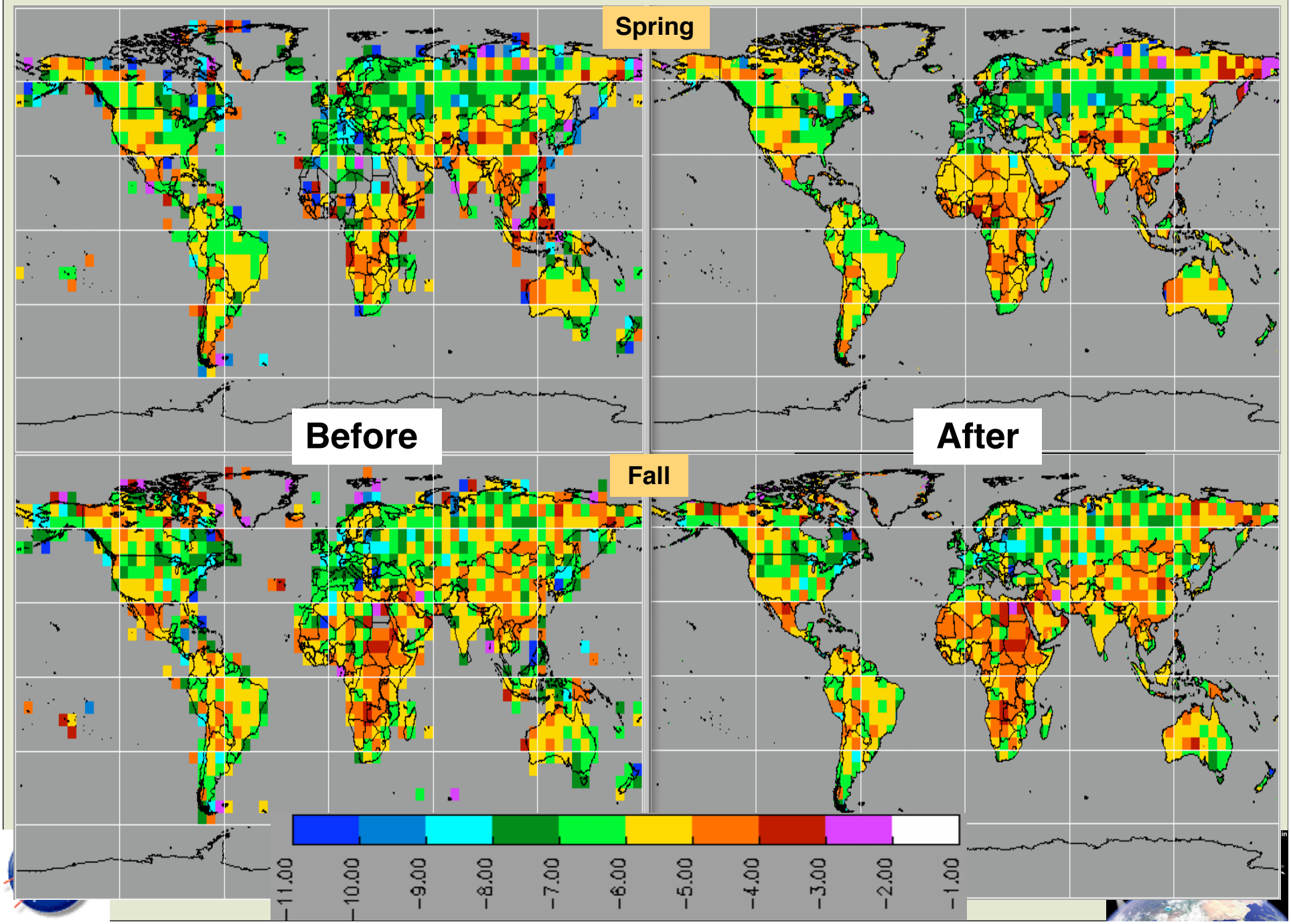



Residual Error Cutoff Threshold, 20x20 deg Lapse Rate and IGBP Fill, Fall, Land
1
Before Cutoff
Lapse Rate
2
Residual Error
−11.00
−10.00
−9.00
−8.00
−7.00
−6.00
−5.00
−4.00
−3.00
−2.00
−1.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
4
Fill with 20x20 deg lapse rate and IGBP mean
3
After Cutoff
Lapse Rate

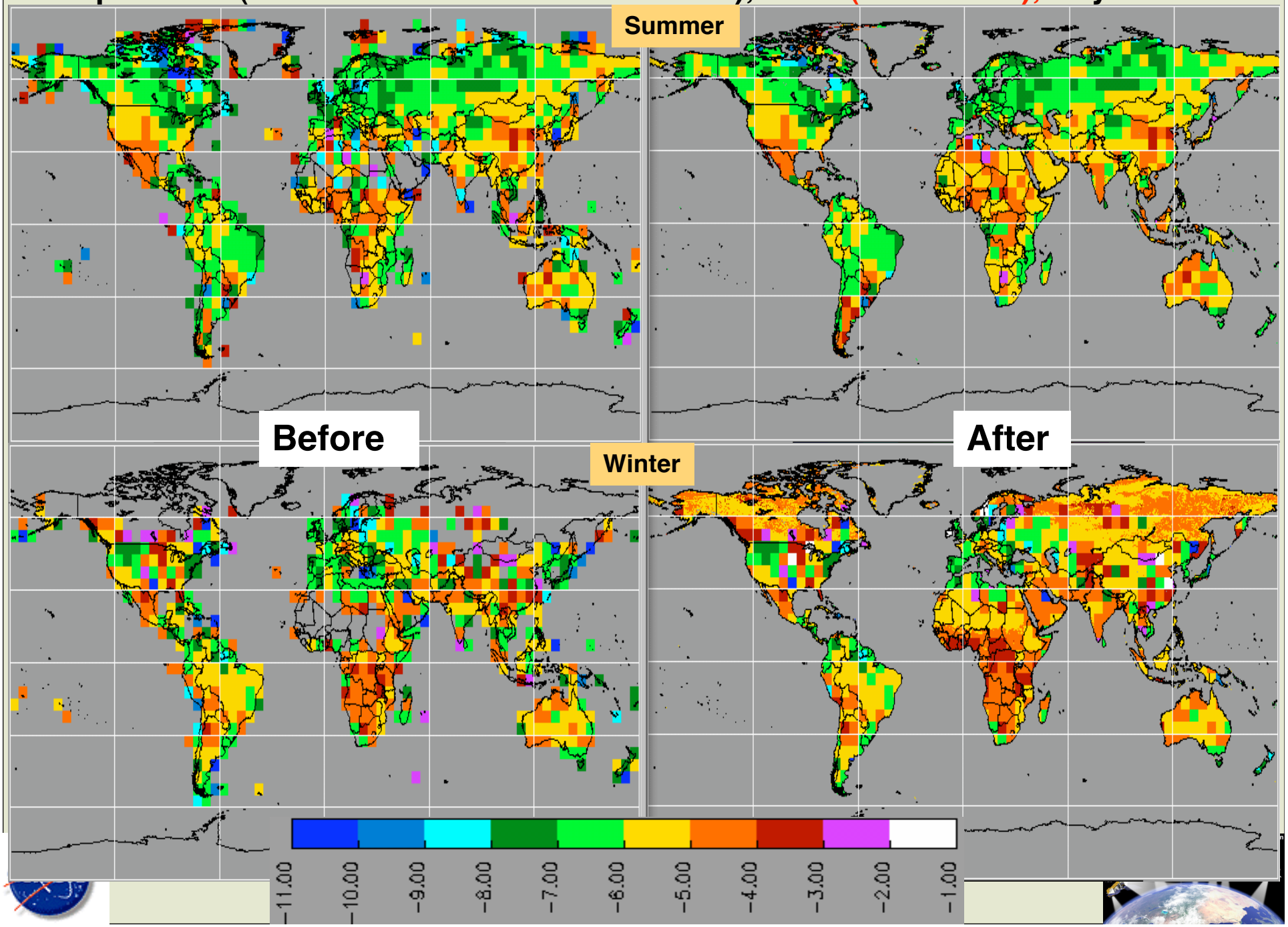
Examples of Before and After Lapse Rate Removal and Fill



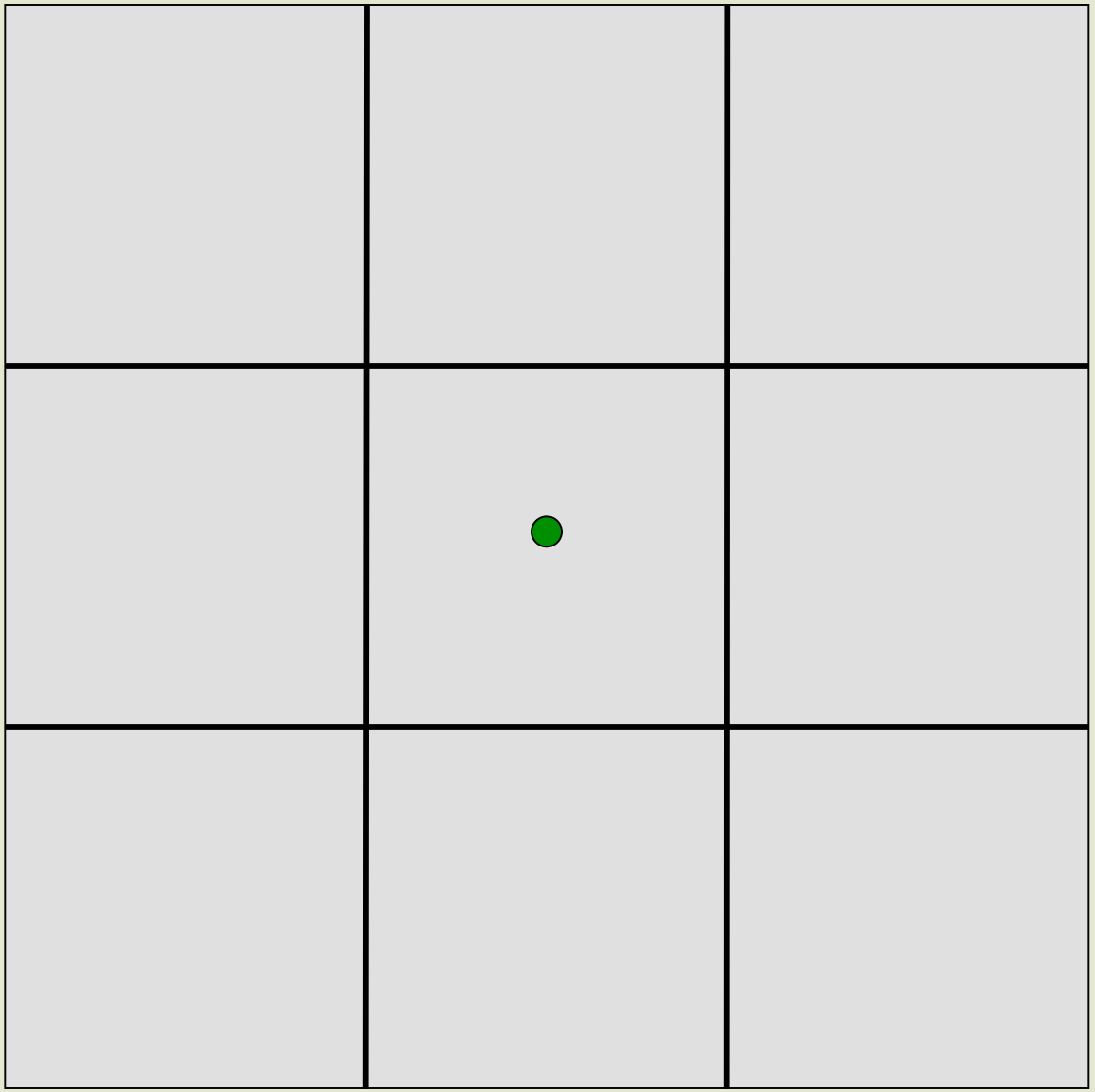
Lapse Rate (before and after removal and fill), Land (Snow Free), Day Time



Lapse Rate (before and after removal and fill), Land (Snow Free), Day Time

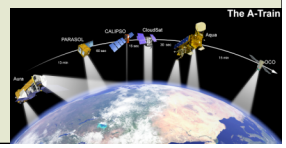


9 Points Smoothing

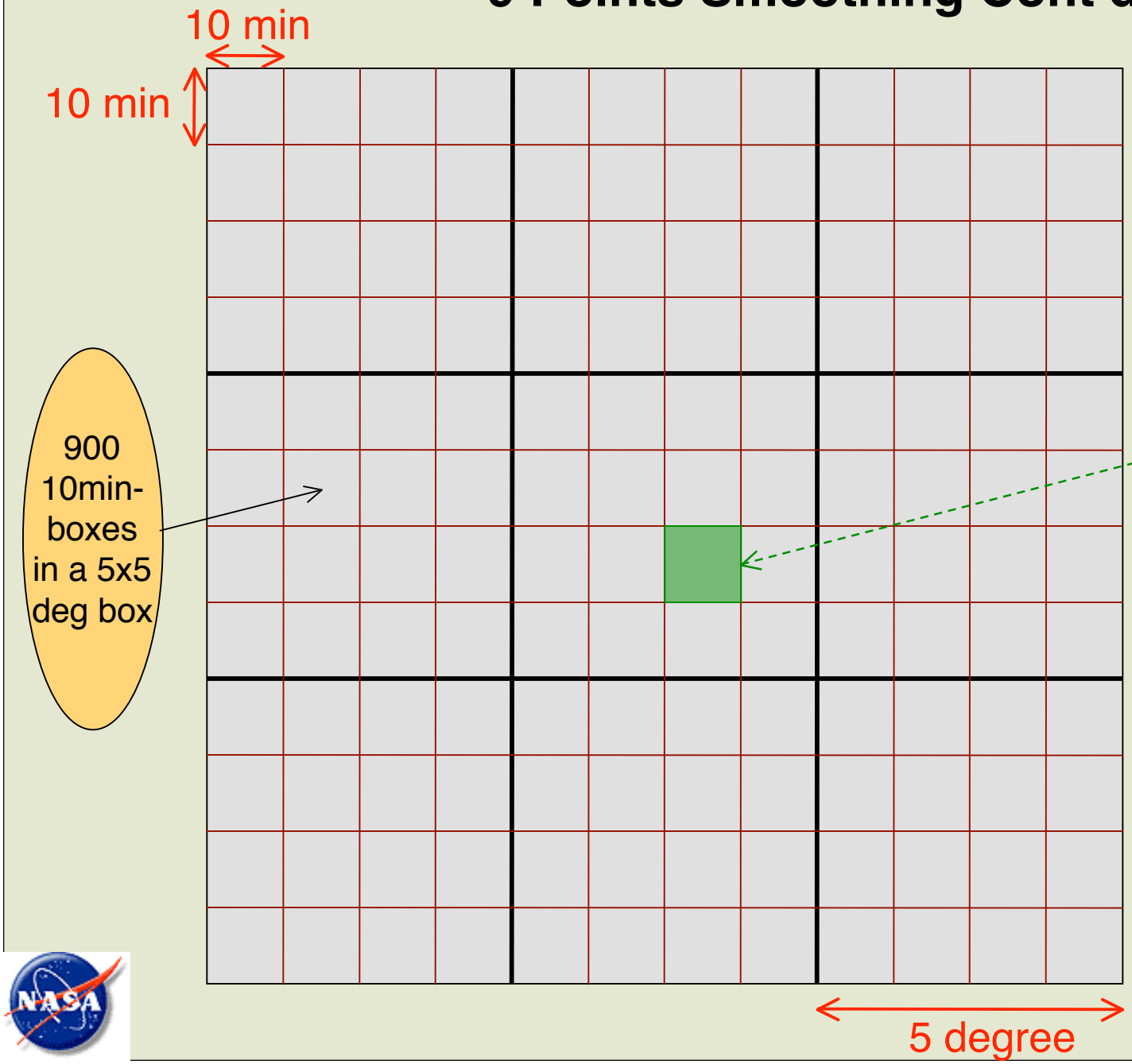


5 degree

5 degree



9 Points Smoothing Cont'd



- Average Lapse Rate

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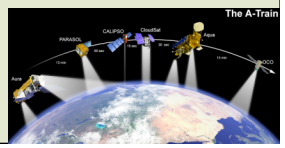
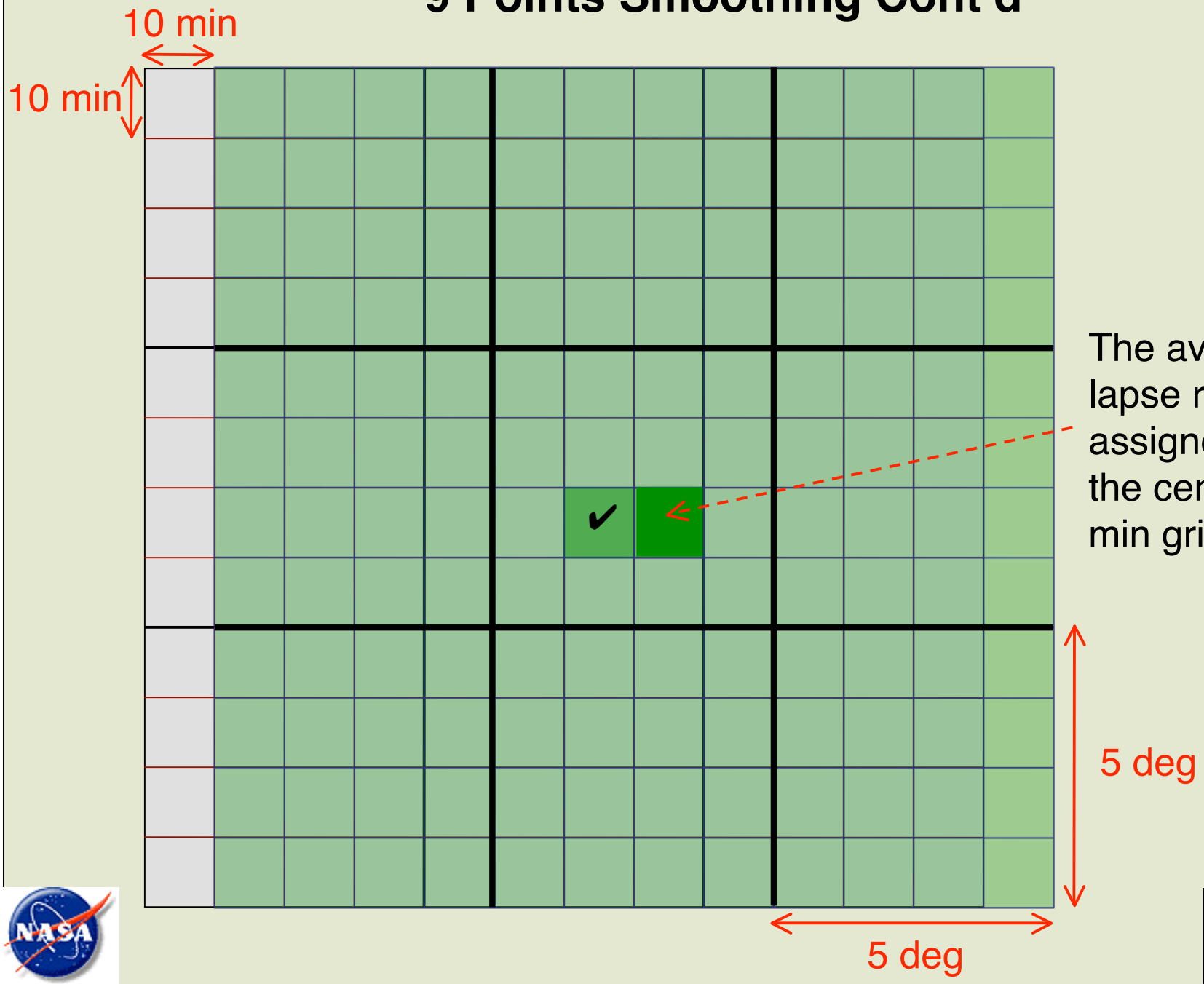
  Avg. of 9 lapse rate within 5 x 5 degree neighboring boxes

- The average lapse rate is then assigned to the center 10 min grid box.

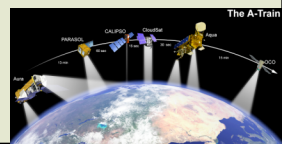


9 Points Smoothing Cont'd



The average lapse rate is assigned to the center 10 min grid box.

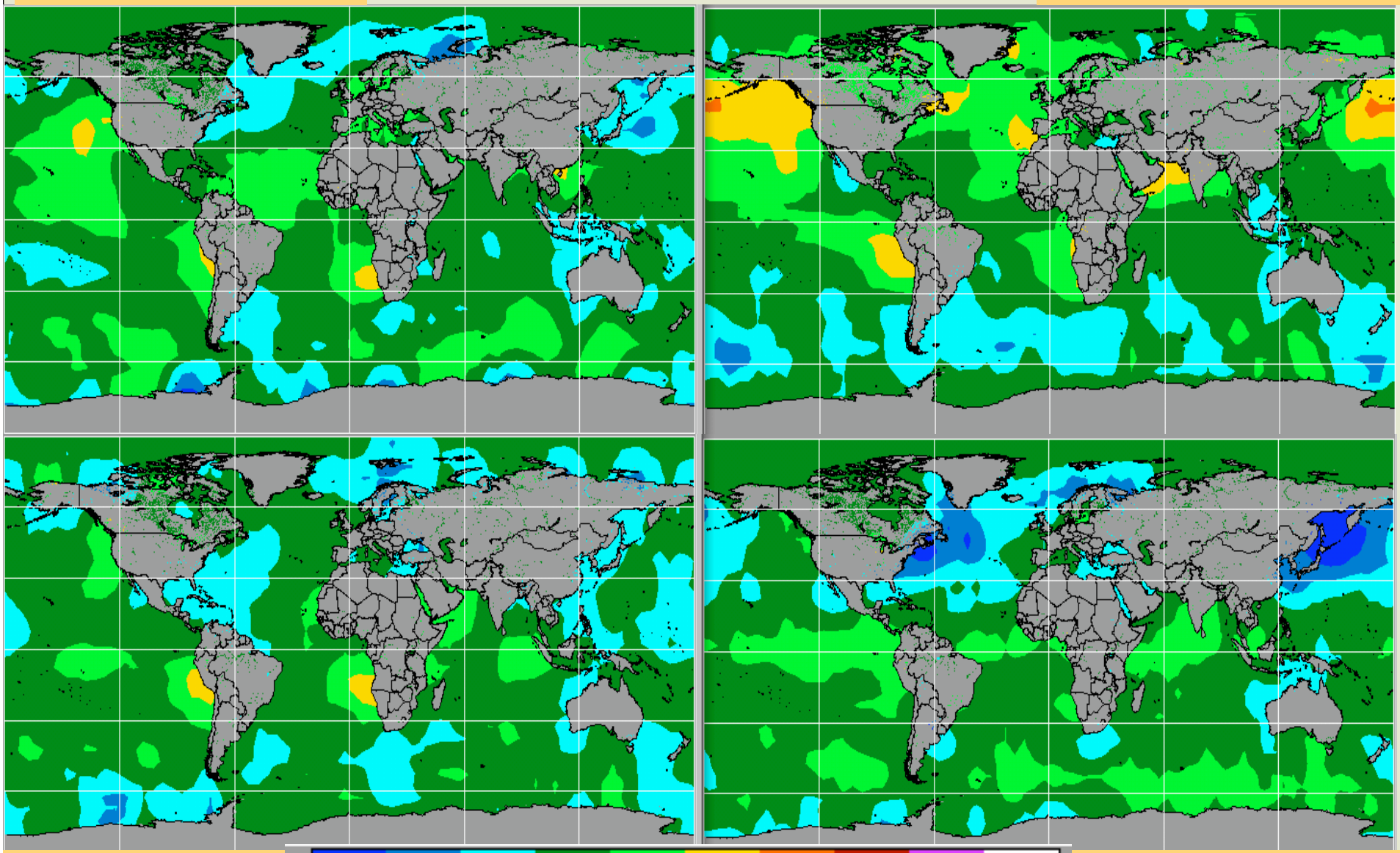
Final Lapse Rate



Spring (Mar,Apr,May)

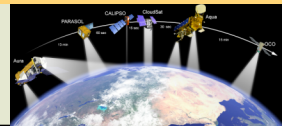
Lapse Rate, Ocean (Snow Free), Day Time

Summer (Jun,Jul,Aug)

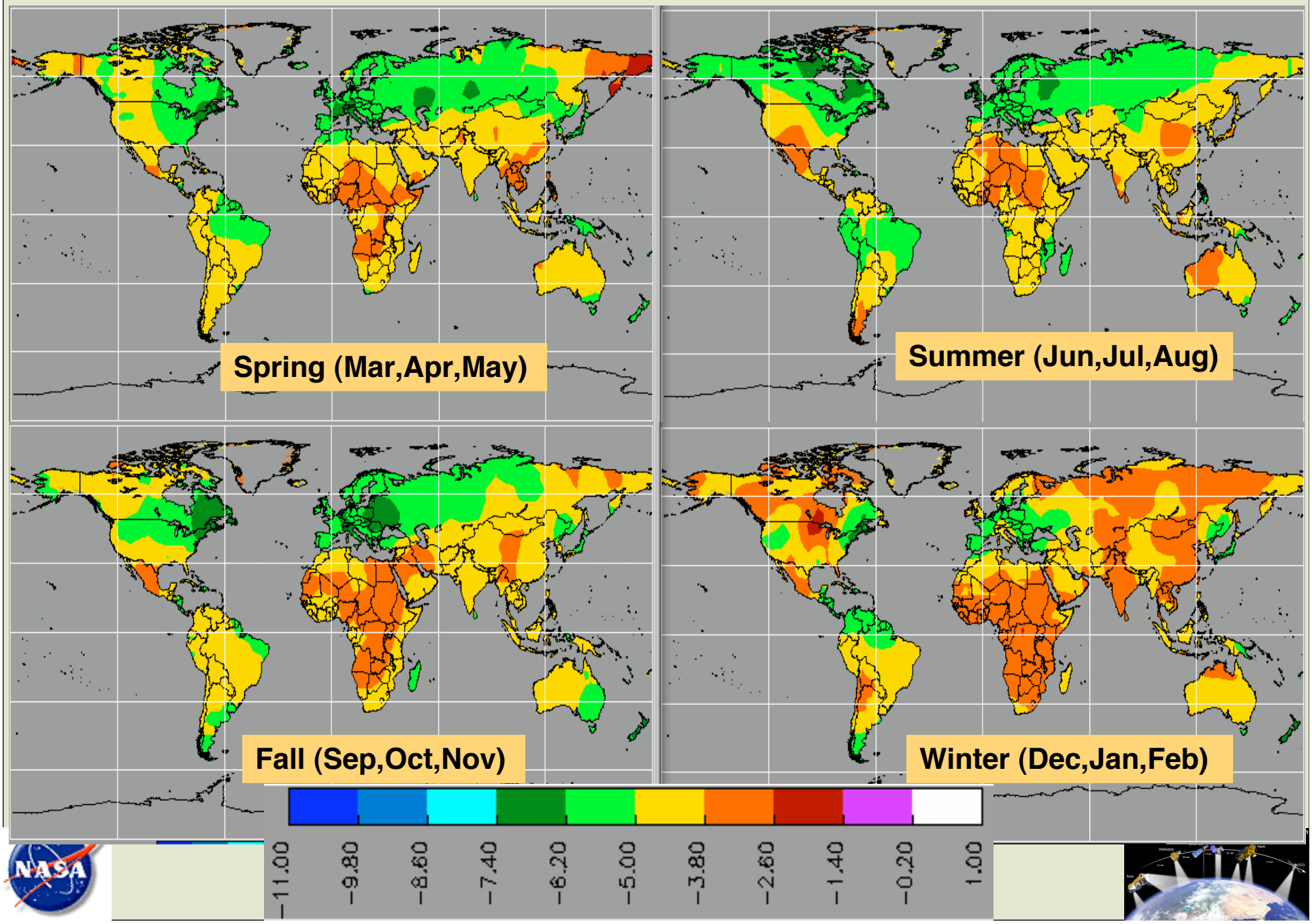


Fall (Sep,Oct,Nov)

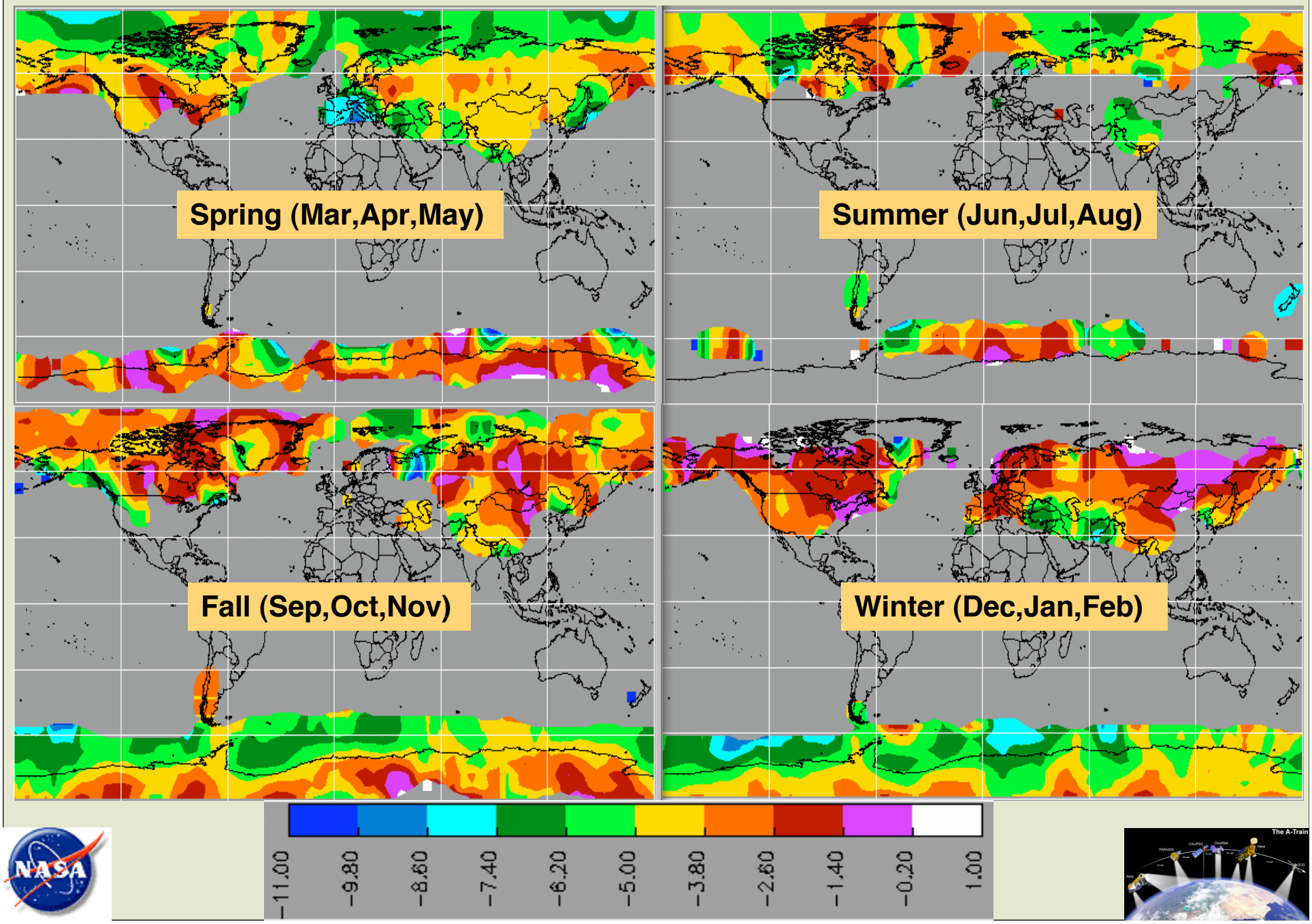
Winter (Dec,Jan,Feb)



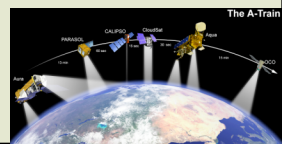
Lapse Rate, Land (Snow Free), Day Time



LapseRate, Snow, Day Time

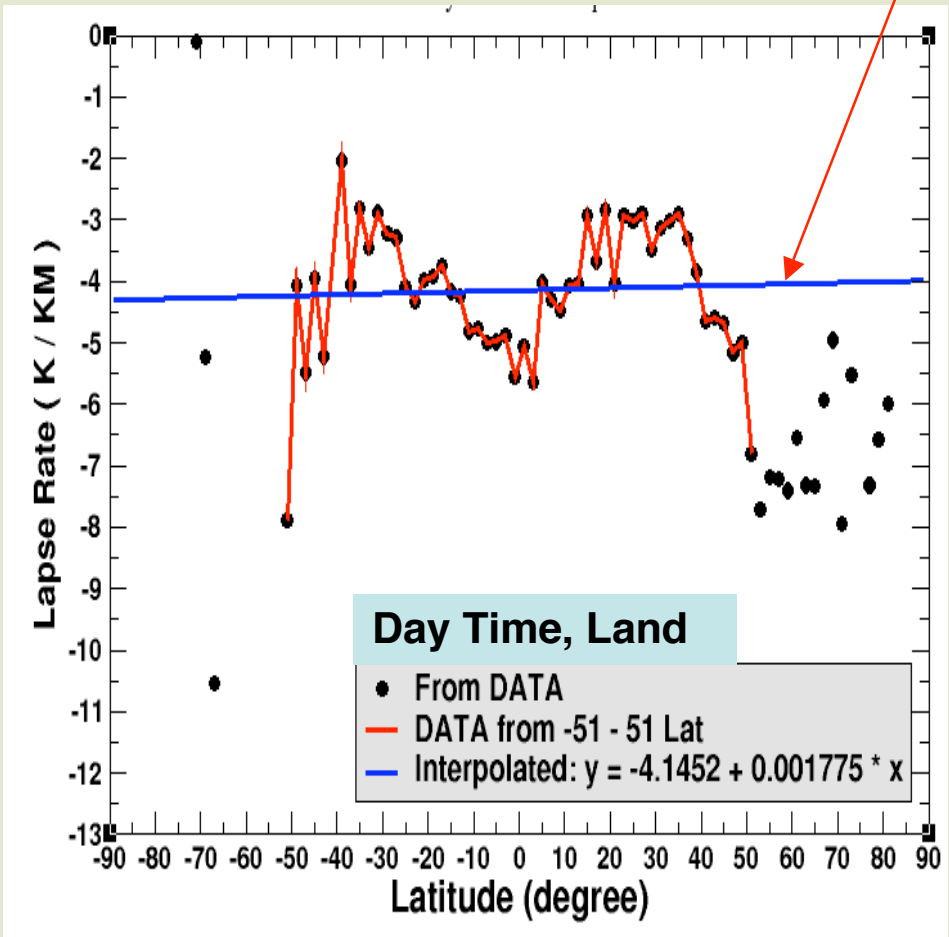


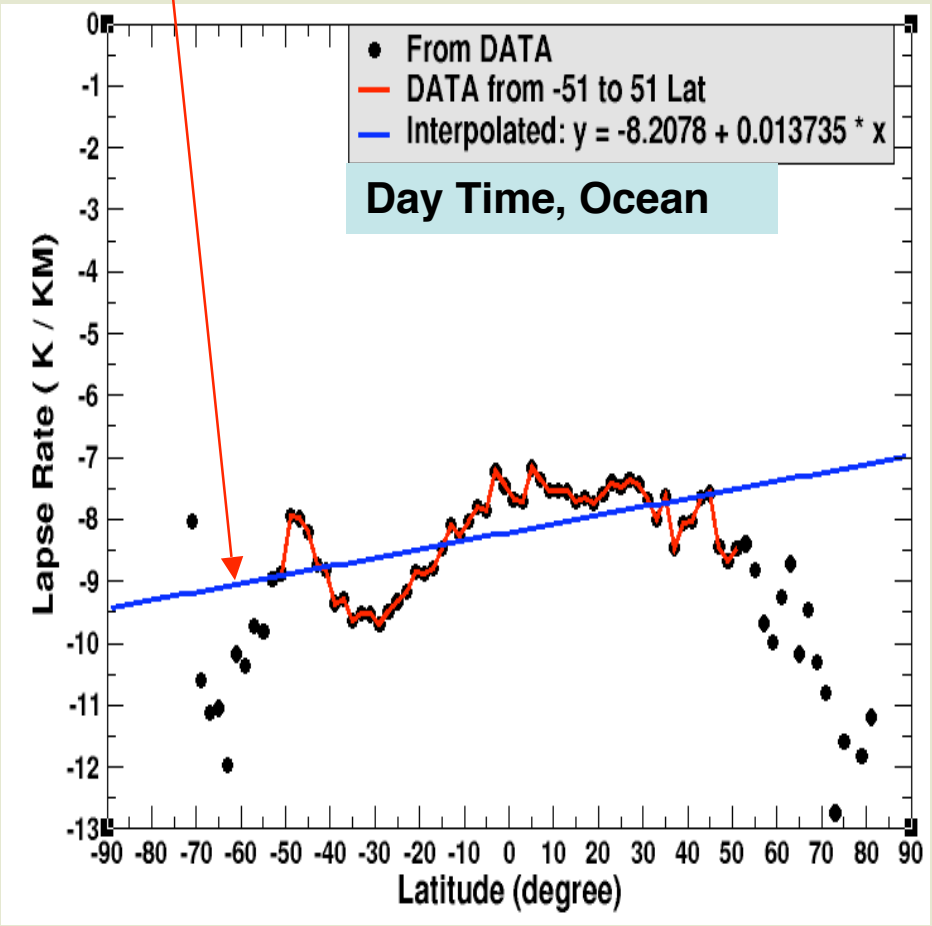
Comparisons with CALIPSO using Ed3 lapse rate and Ed3-Beta2 lapse rate respectively

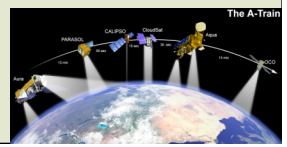


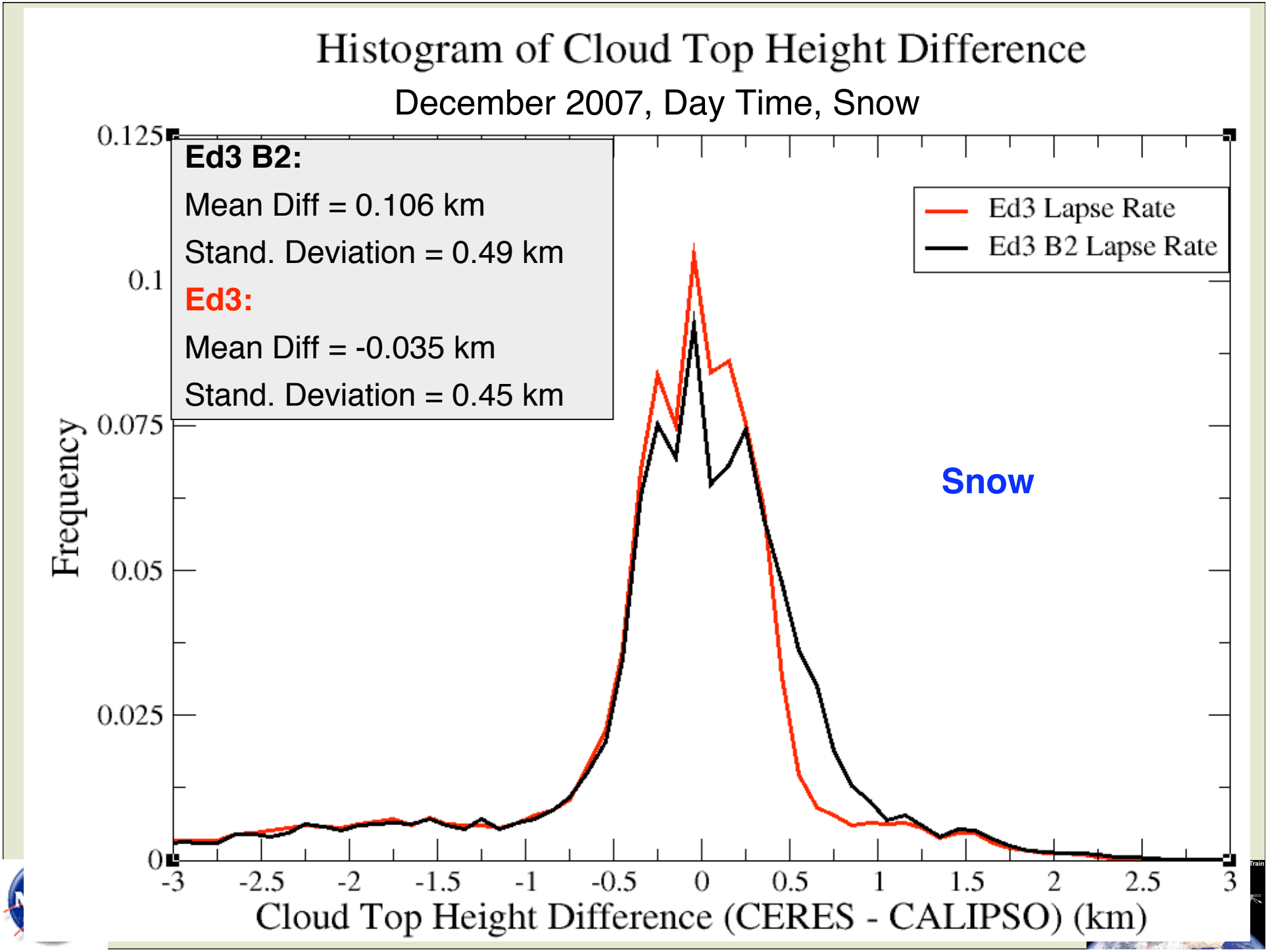
Zonal Lapse Rate (Derived from April 2007 Merged Data)

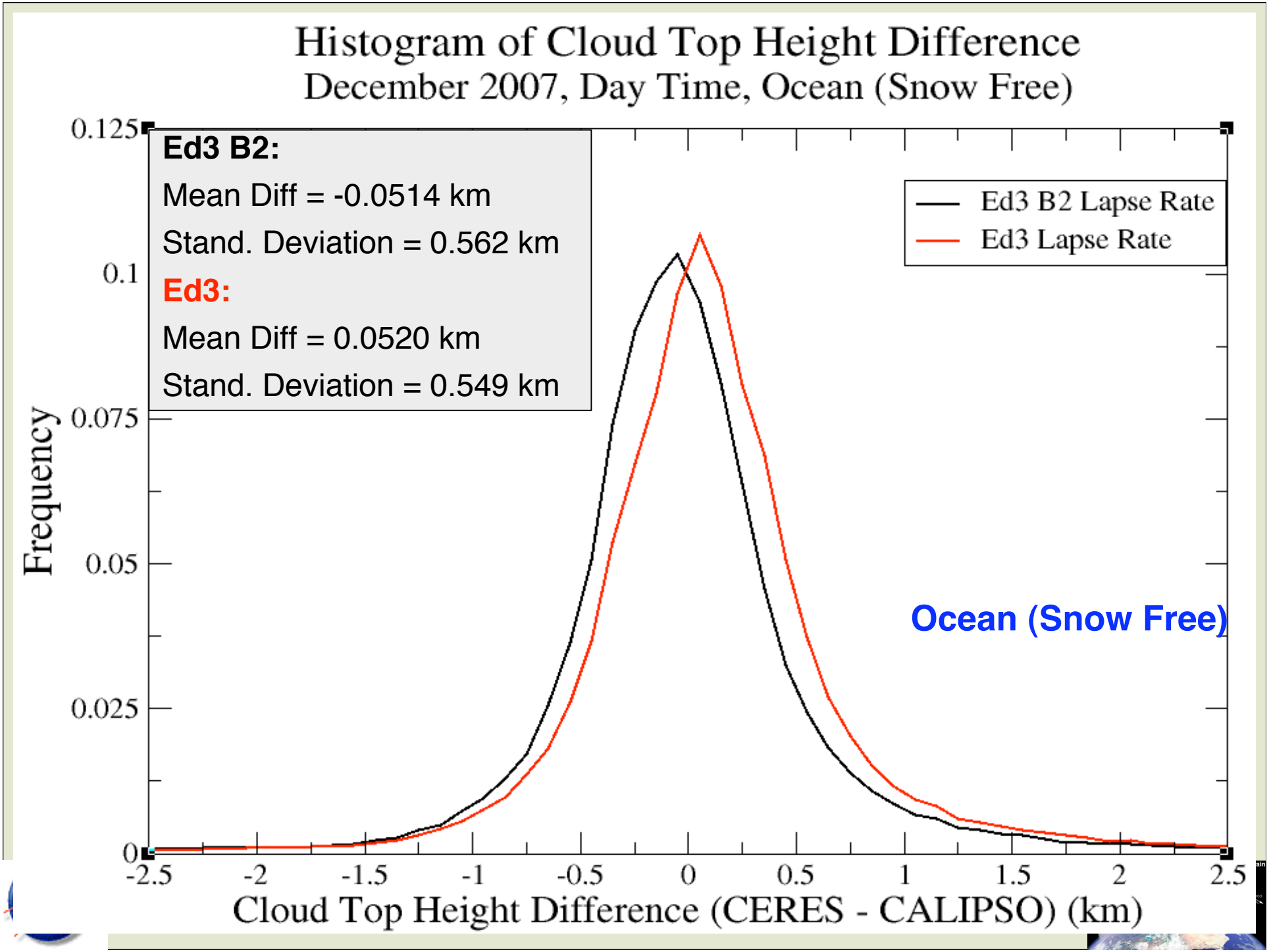
Ed3 Beta2 Lapse Rate

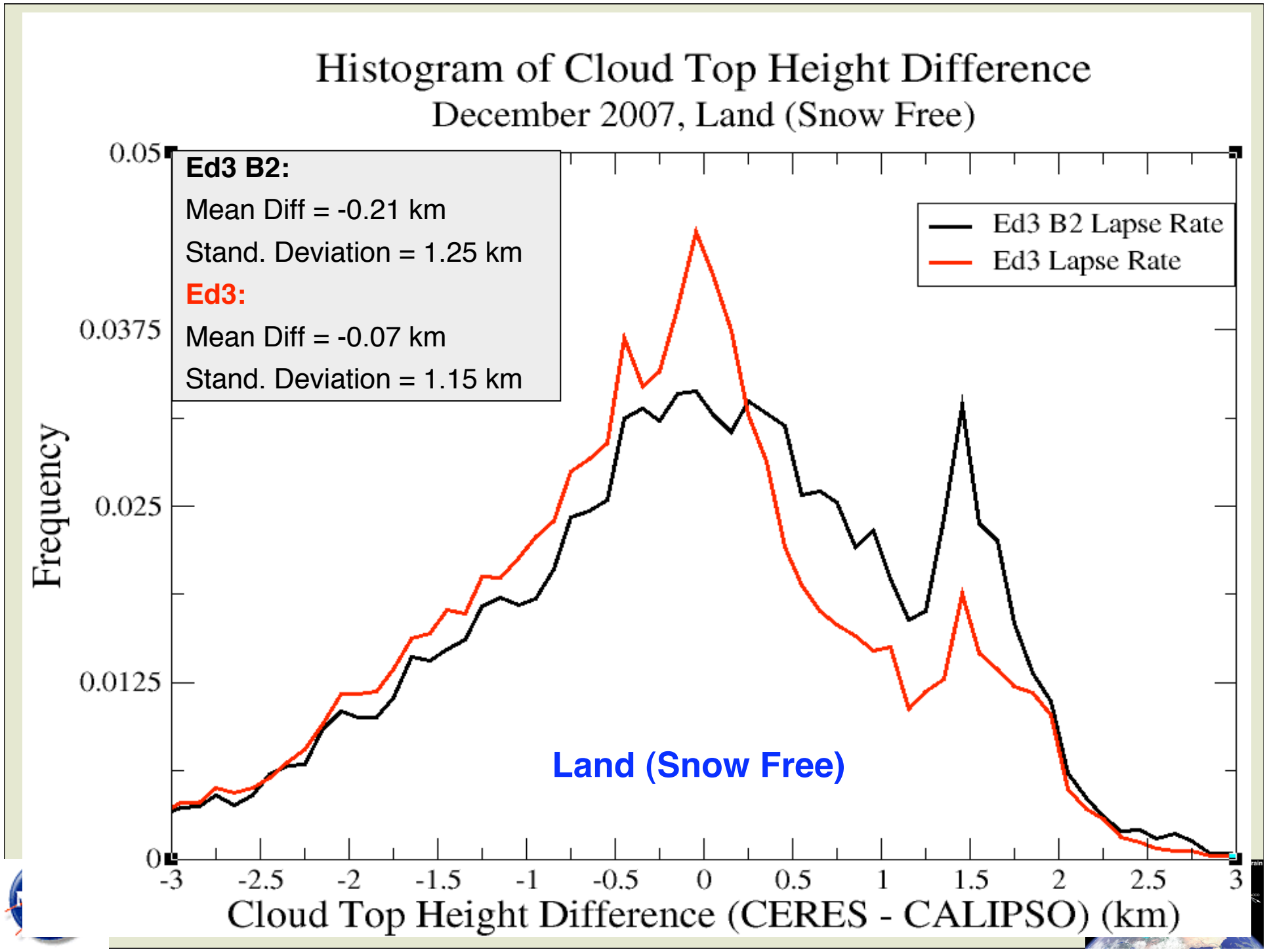







Histogram of Cloud Top Height Difference
December 2007, Day Time, Snow
Ed3 B2:
Mean Diff = 0.106 km
Stand. Deviation = 0.49 km
Ed3:
Mean Diff = -0.035 km
Stand. Deviation = 0.45 km
Ed3 Lapse Rate
Ed3 B2 Lapse Rate
Snow
Frequency
0.125
0.1
0.075
0.05
0.025
0
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
Cloud Top Height Difference (CERES - CALIPSO) (km)

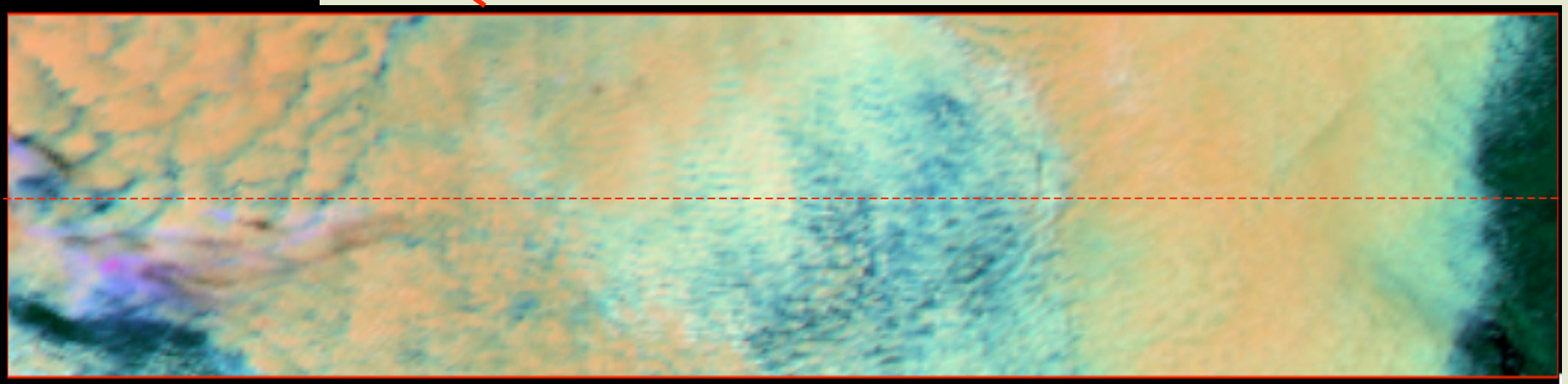

Histogram of Cloud Top Height Difference
December 2007, Day Time, Ocean (Snow Free)
Ed3 B2:
Mean Diff = -0.0514 km
Stand. Deviation = 0.562 km
Ed3:
Mean Diff = 0.0520 km
Stand. Deviation = 0.549 km
Ed3 B2 Lapse Rate
Ed3 Lapse Rate
Ocean (Snow Free)
Frequency
0.125
0.1
0.075
0.05
0.025
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Cloud Top Height Difference (CERES - CALIPSO) (km)

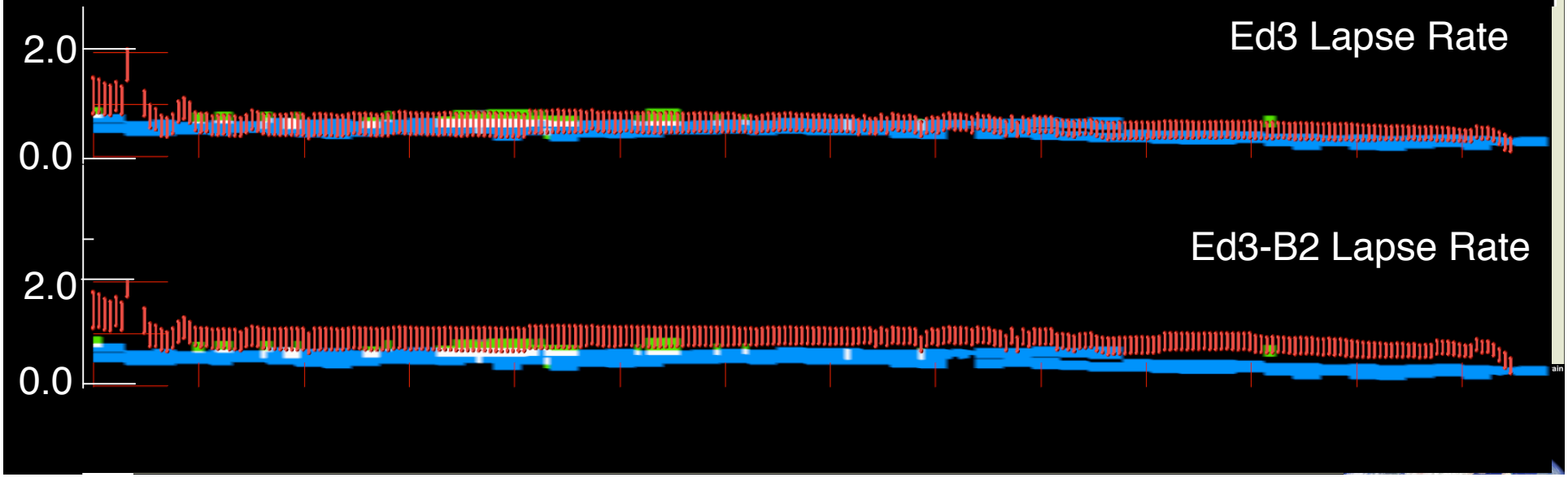

Histogram of Cloud Top Height Difference
December 2007, Land (Snow Free)
Ed3 B2:
Mean Diff = -0.21 km
Stand. Deviation = 1.25 km
Ed3:
Mean Diff = -0.07 km
Stand. Deviation = 1.15 km
Ed3 B2 Lapse Rate
Ed3 Lapse Rate
Land (Snow Free)
Frequency
0.05
0.0375
0.025
0.0125
0
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
Cloud Top Height Difference (CERES - CALIPSO) (km)

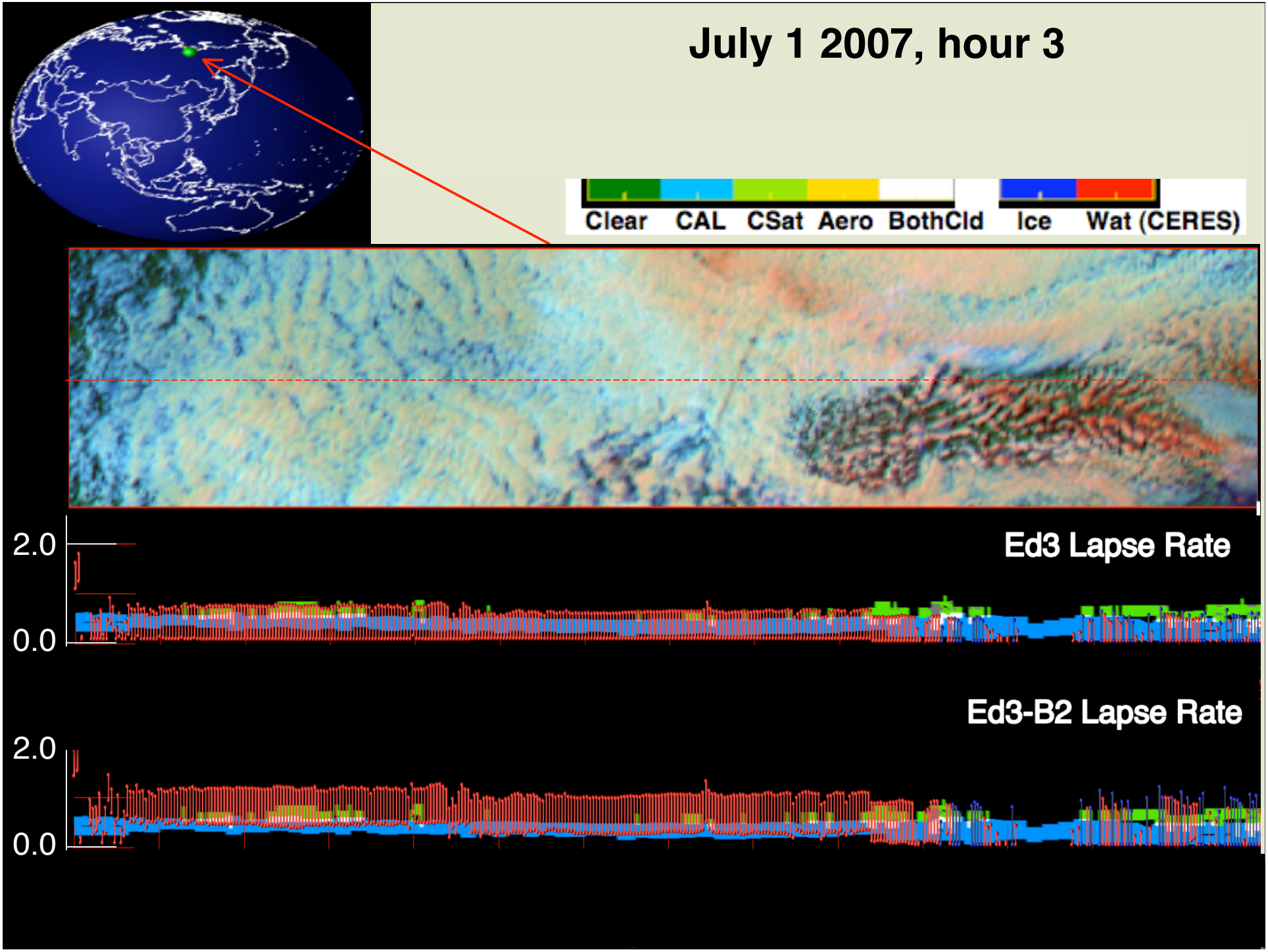
Over Siberia

July 31 2007, hour 4

Clear CAL CSat Aero BothCld Ice Wat (CERES)






July 1 2007, hour 3
Clear
CAL
CSat
Aero
BothCld
Ice
Wat (CERES)
2.0
0.0
Ed3 Lapse Rate
2.0
0.0
Ed3-B2 Lapse Rate

Monthly Lapse Rate

Spring -----> April

Summer -----> July

Fall -----> October

Winter ----> January

Interpolate the lapse rate for the months In between

6 lapse rate maps per month

Day Time

Night Time

Land (Snow Free)

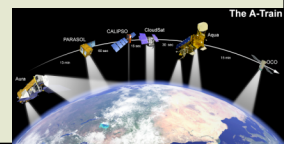
Ocean (Snow Free)

Snow

Land (Snow Free)

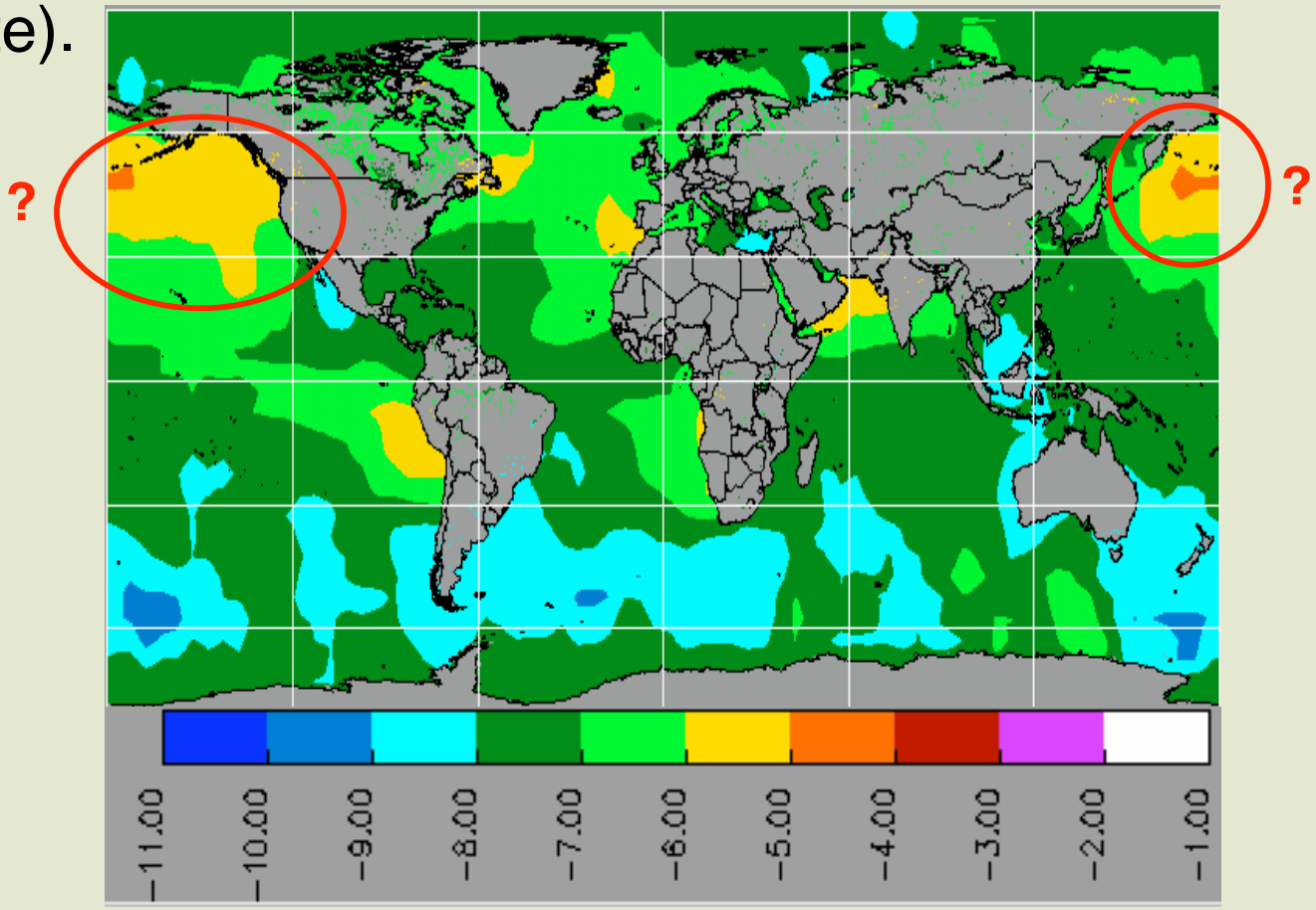
Ocean (Snow Free)

Snow

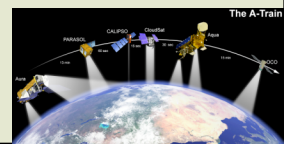


Future Plan

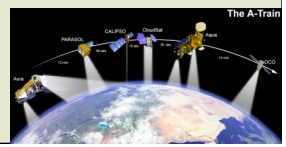
• Need close examination of ocean cloud temperature for lapse rate in summer over northern hemisphere (small lapse rate).

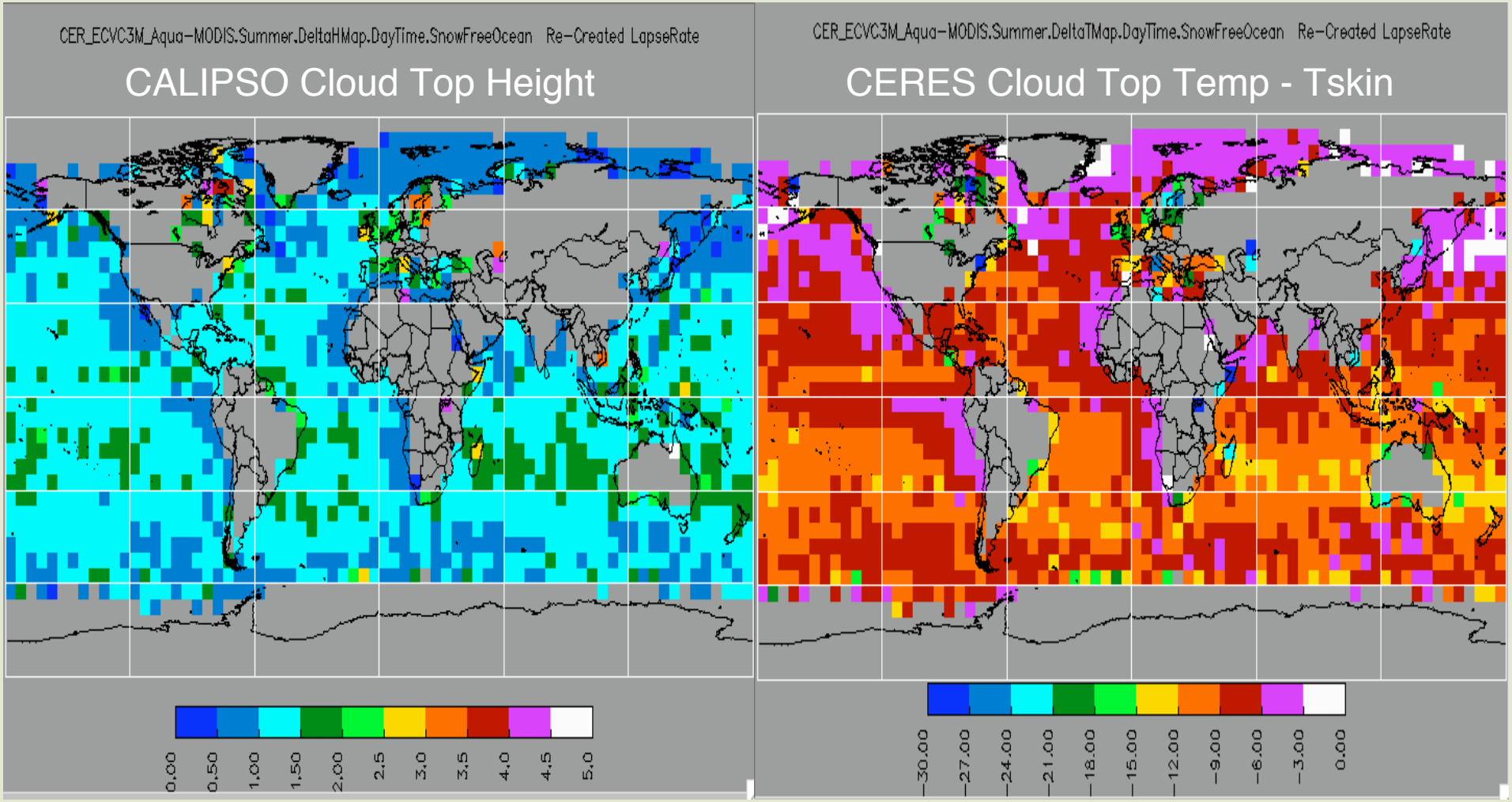


• Need to derive lapse rate for night time.

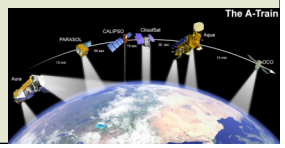
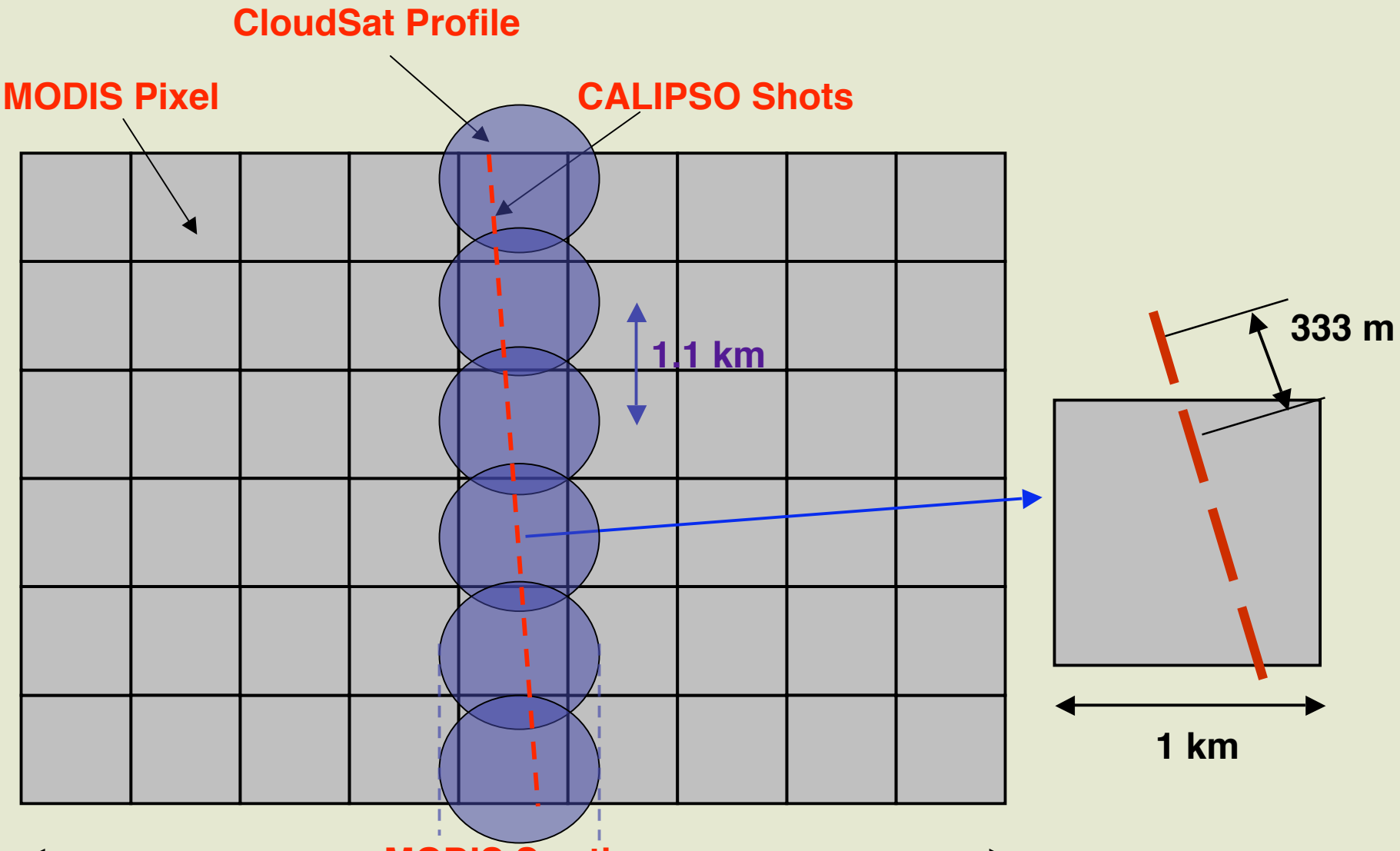


Back Slides




CER_ECVC3M_Aqua-MODIS.Summer.DeltaHMap.DayTime.SnowFreeOcean Re-Created LapseRate
CALIPSO Cloud Top Height
0.00
0.50
1.00
1.50
2.00
2.5
3.0
3.5
4.0
4.5
5.0
CER_ECVC3M_Aqua-MODIS.Summer.DeltaTMap.DayTime.SnowFreeOcean Re-Created LapseRate
CERES Cloud Top Temp - Tskin
-30.00
-27.00
-24.00
-21.00
-18.00
-15.00
-12.00
-9.00
-6.00
-3.00
0.00

Summer


The A-Train

MODIS, CALIPSO and CloudSat Collocation