A consistency check of AIRS and CERES radiances on Aqua

Xianglei Huang (University of Michigan)
Norman Loeb (NASA Langley)

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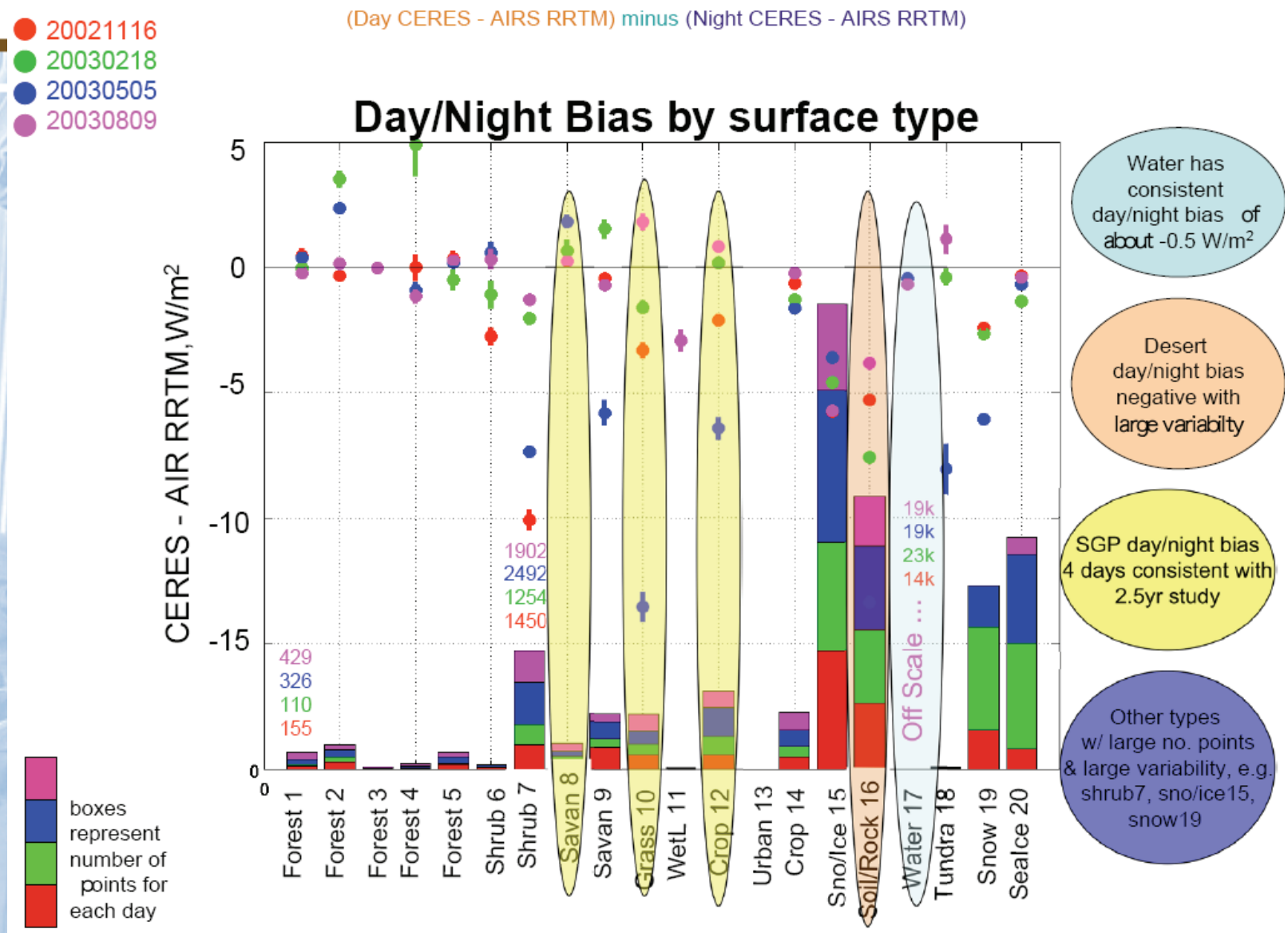
MichiganEngineering

Roadmap

- Motivations
- Datasets and approaches
- Three case studies
  - Bright desert (sid 105)
  - Clear-sky ocean (sid 1)
  - Cloudy ocean (sid 50)
  - Synthesis
- Conclusions and perspectives

Motivation (I)

- On 2008 spring STM, One presentation showed
  - OLR computed from AIRS retrieval products
    - apply 10% artificial adjustment to UTH, that's a lot to far-IR flux (should be at least 5-10Wm^{-2}, not 0.5Wm^{-2} as claimed in their slide)
    - Systematic negative bias (-5Wm^{-2} or larger) for day-night double differences over desert
      - $(\text{CERES-AIR OLR})_{day}$- $(\text{CERES-AIRS OLR})_{night}$ ~ -5Wm^{-2}
- Reasoning
  - If this day-night diff. has been real, such difference would have be seen from comparisons of CERES unfiltered/filtered radiance and integrated AIRS radiance
    - Note: CERES unfiltered LW radiance (day vs. night)
  - If we cannot see such difference directly from radiance, then something else counts for it.



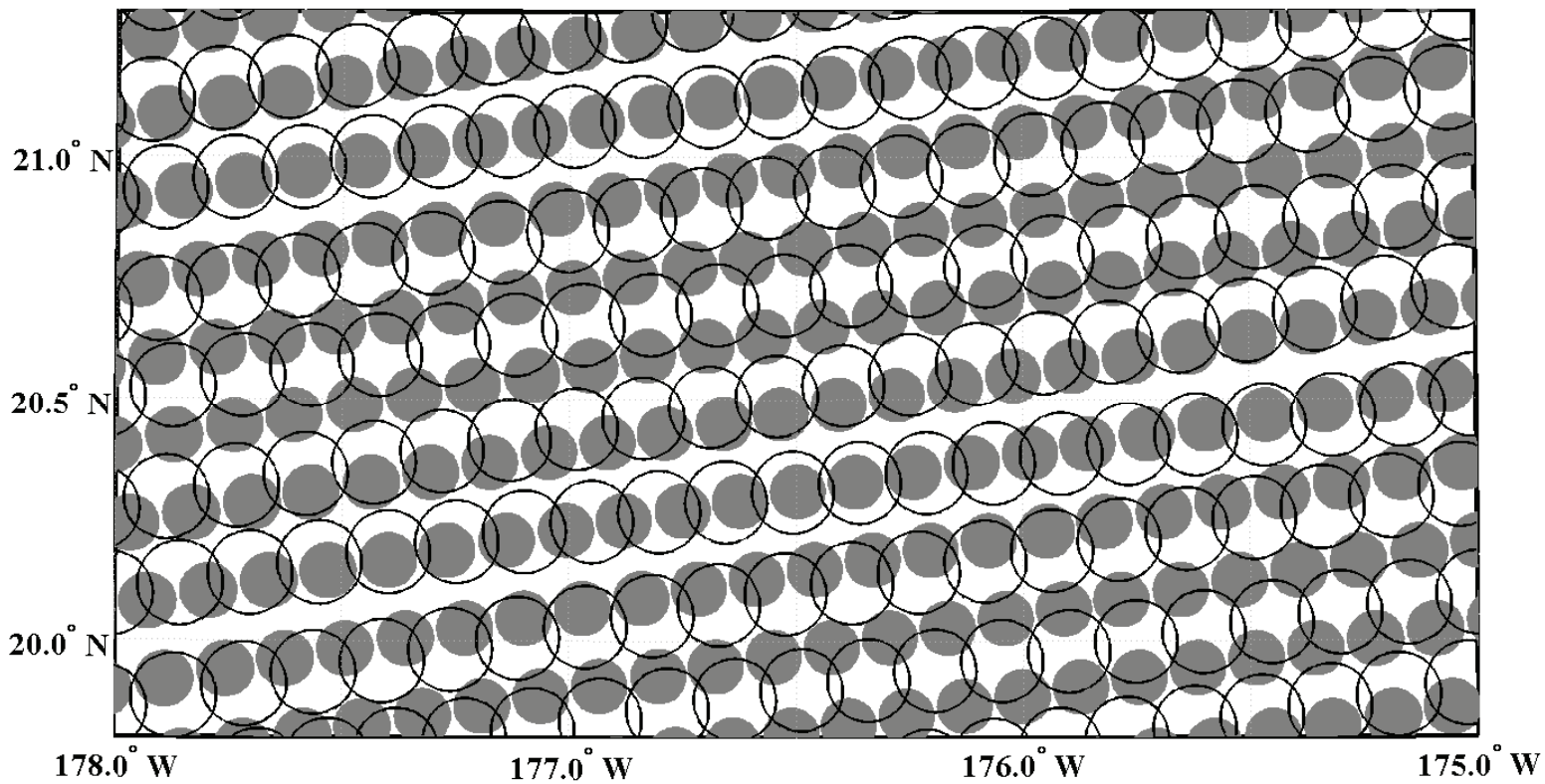
(from *Moy et al.*, 2008 CERES STM)

Motivation (II)

- AIRS vs. CERES
- Good collocation
- Integrand vs. integrated

$$I_{unfiltered\_CERES} = \int_{v_1}^{v_2} I(v)dv \approx \int_{v_{a1}}^{v_{a2}} I_{AIRS}(v)dv + \varepsilon$$

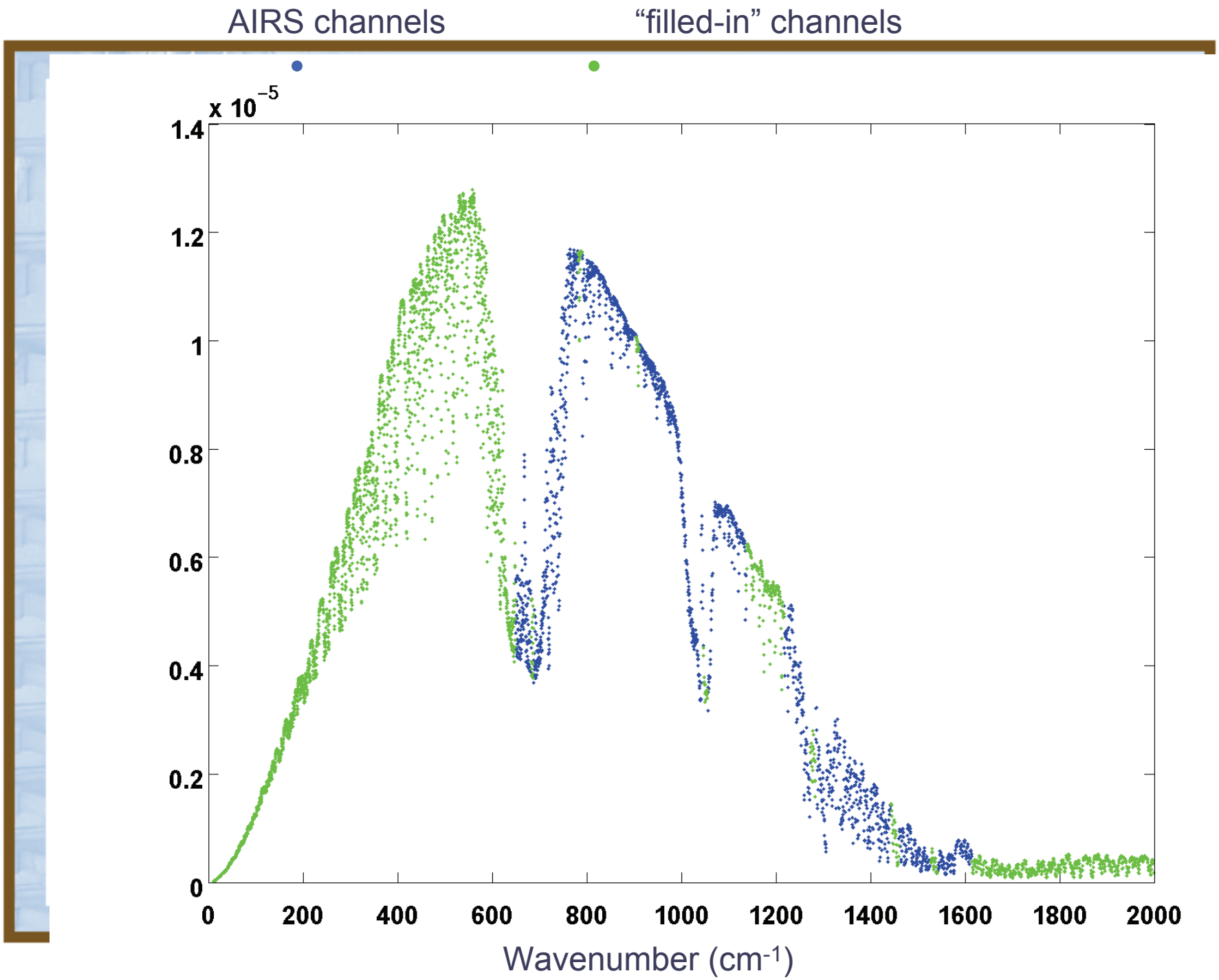
AIRS and CERES footprints



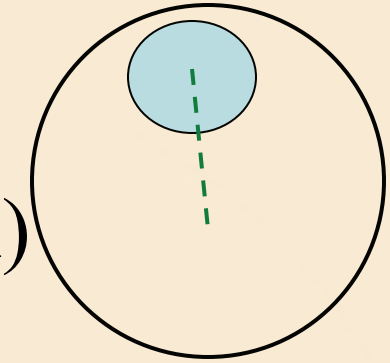
01:06:15 to 01:06:45 UTC on January 1, 2005

CERES AIRS

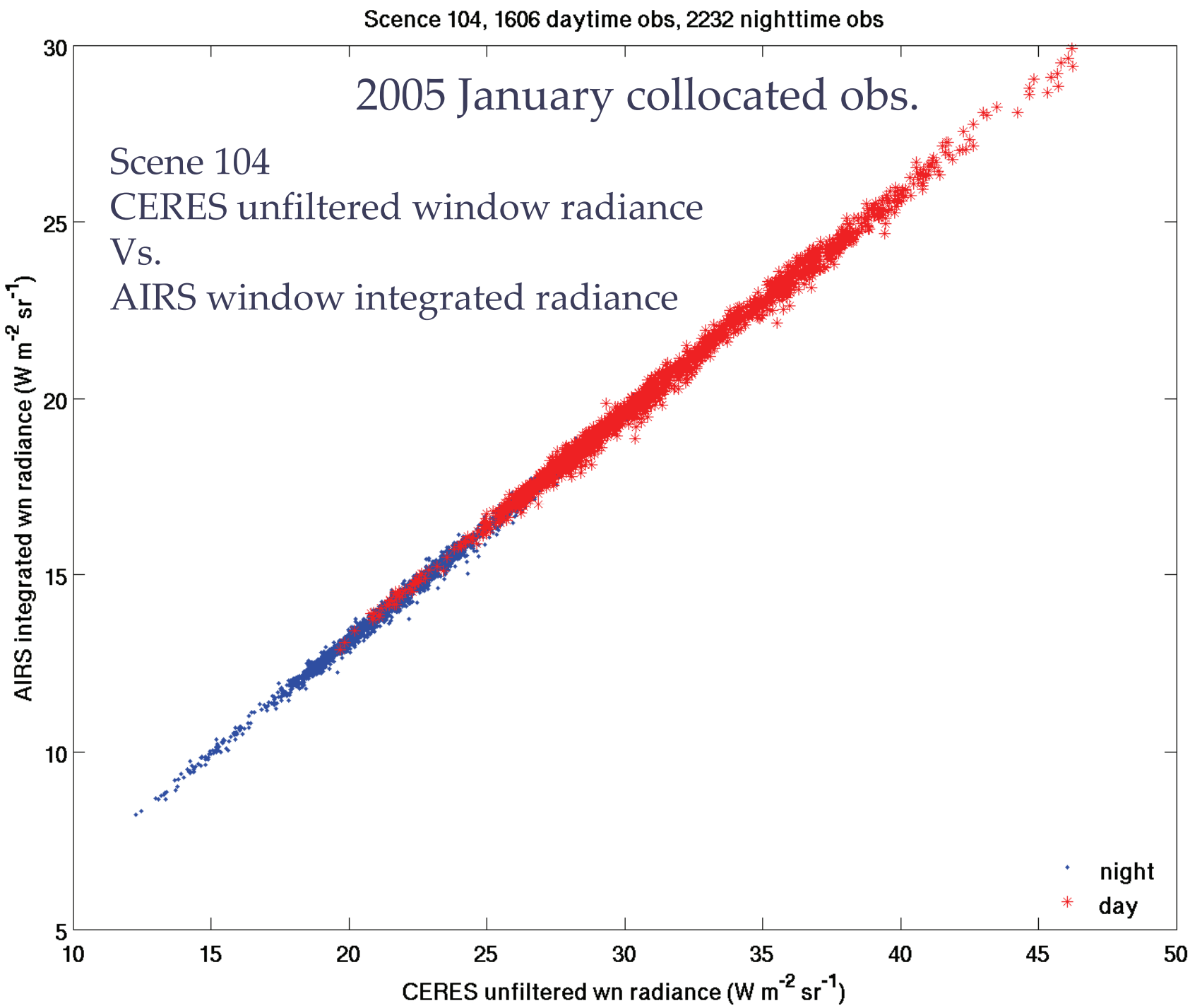
(Huang et al., JGR, 2008)

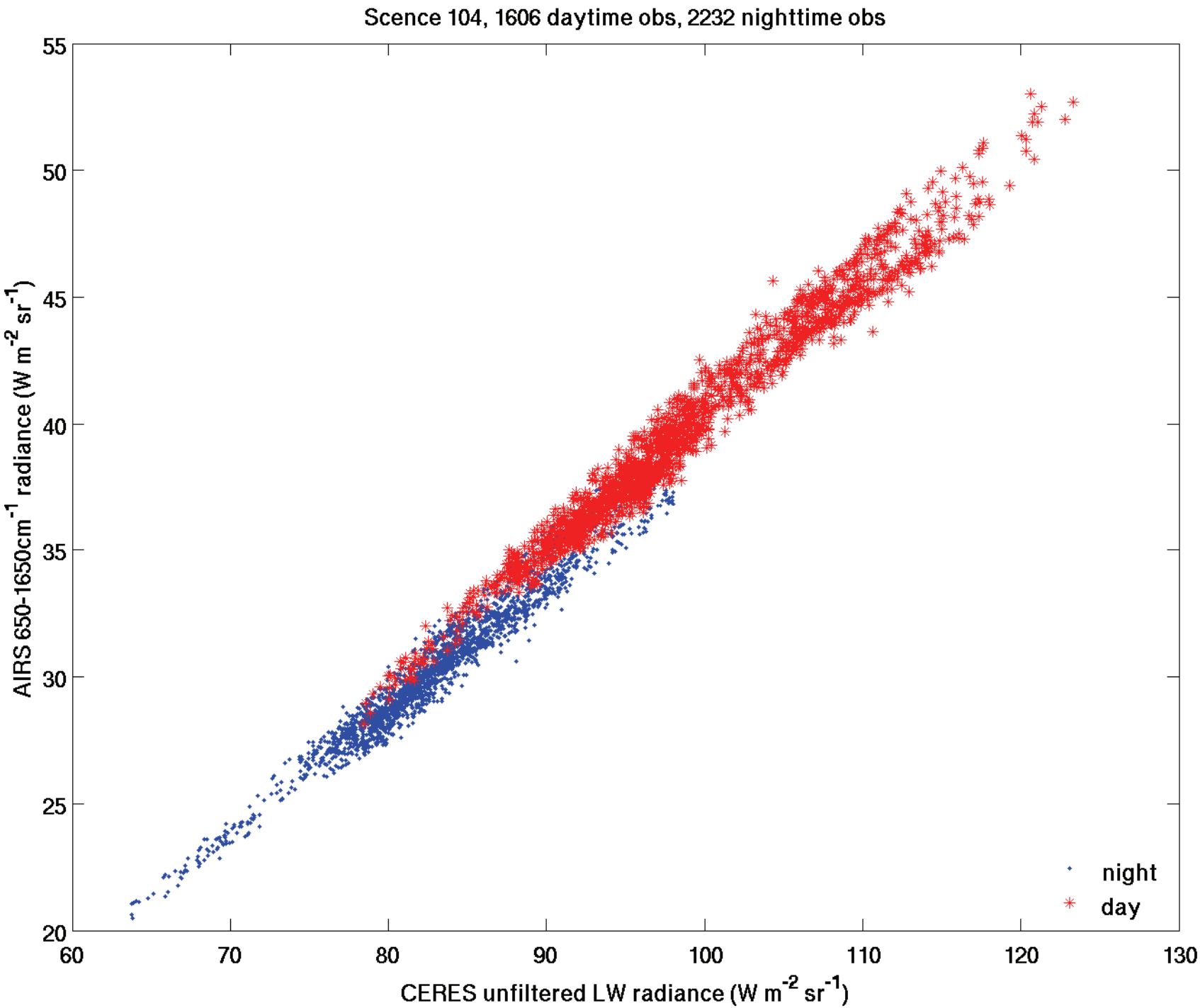

AIRS channels
"filled-in" channels
x 10^-5
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Wavenumber (cm-1)

Datasets



- CERES SSF data product (edition 2A)
  - Cross-scanning mode only
  - CERES scene types and ADMs
- AIRS (L1B version 5)
  - 3.74-4.61μm (2169-2673 cm^{-1}) excluded
  - Quality control: filtering out bad channels
- Collocation criteria
  - Time separation ⩽ 8 seconds
  - Spatial separation ⩽ 3km
- Jan 2005, 40S-40N


Scence 104, 1606 daytime obs, 2232 nighttime obs
2005 January collocated obs.
Scene 104
CERES unfiltered window radiance
Vs.
AIRS window integrated radiance
AIRS integrated wn radiance (W m-2 sr-1)
CERES unfiltered wn radiance (W m-2 sr-1)
night
day
30
25
20
15
10
5
10
15
20
25
30
35
40
45
50


Scence 104, 1606 daytime obs, 2232 nighttime obs
AIRS 650-1650cm^{-1} radiance (W m^{-2} sr^{-1})
CERES unfiltered LW radiance (W m^{-2} sr^{-1})
55
50
45
40
35
30
25
20
60
70
80
90
100
110
120
130
night
day

Approach (I): assessing the day-night difference

- Derive linear regression coefficients from nighttime AIRS and CERES observations
- Apply this set of coefficients to daytime AIRS observation→ $I_{predict}$
- Compare with CERES observation
  - Define **relative difference**

$$\boldsymbol{rel\ diff} = \frac{(I_{Ceres} - I_{predict})}{I_{predict}}$$

  - Contrast statistics of day vs. night
    - Premise: if consistent, then day & night statistics shall be very similar.

Approach (II): Two regression technique

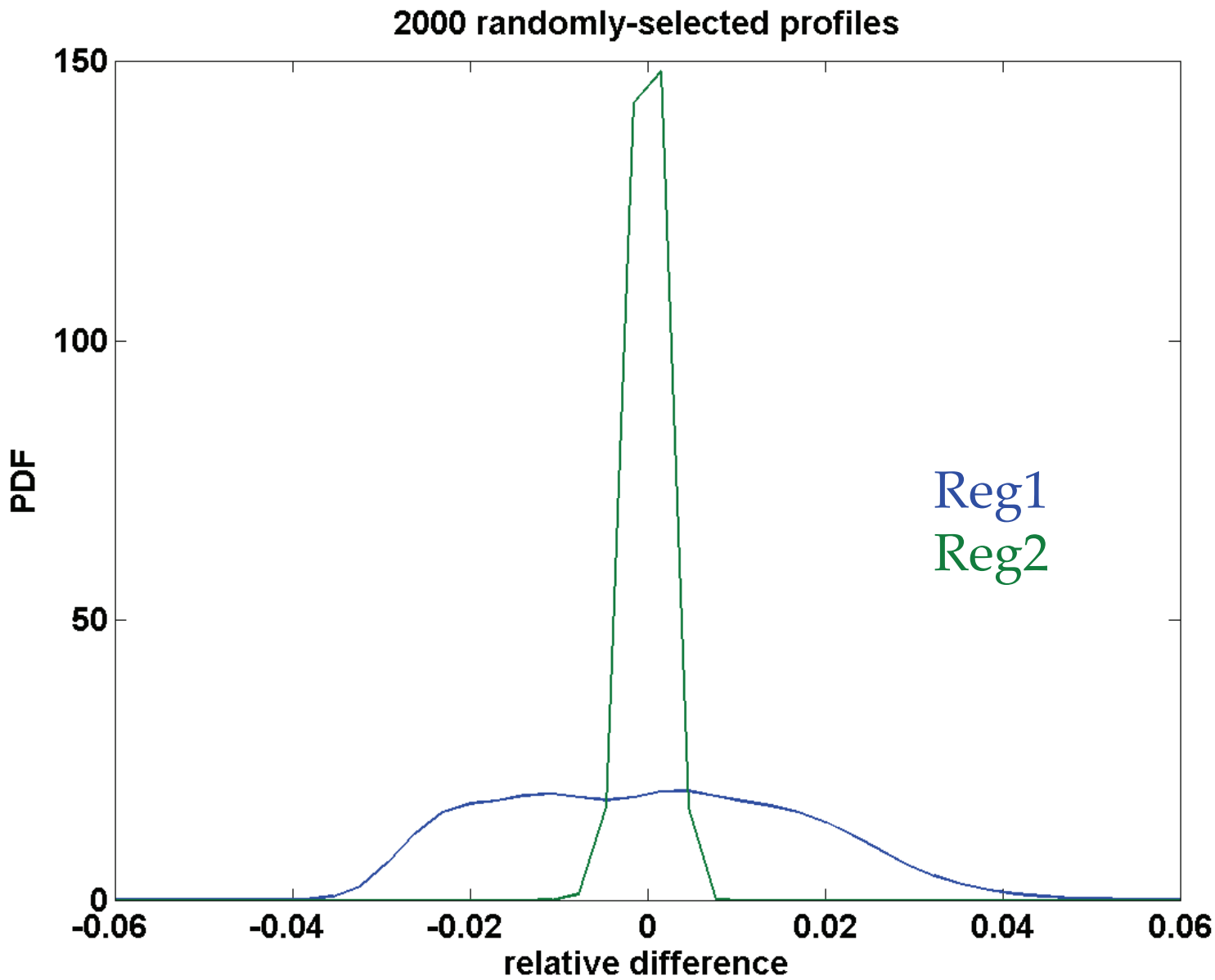
- To cop with gaps in AIRS radiance

$$I_C = aI_A + b, \text{ where } I_A = \sum_{v_i} I_{AIRS}(v_i)dv_i$$

$$I_C = \sum_{j=1}^{6} I_{A_j} a_j + b, \text{ where } I_{A_j} = \sum_{v_i \in V_j} I_{AIRS}(v_i)dv_i$$

$V_{1...6}$ [640 - 800], [800, 900] & [1070 - 1200],
[900 - 990], [990 - 1070],
[1200 - 1400]
[1400 and beyond]

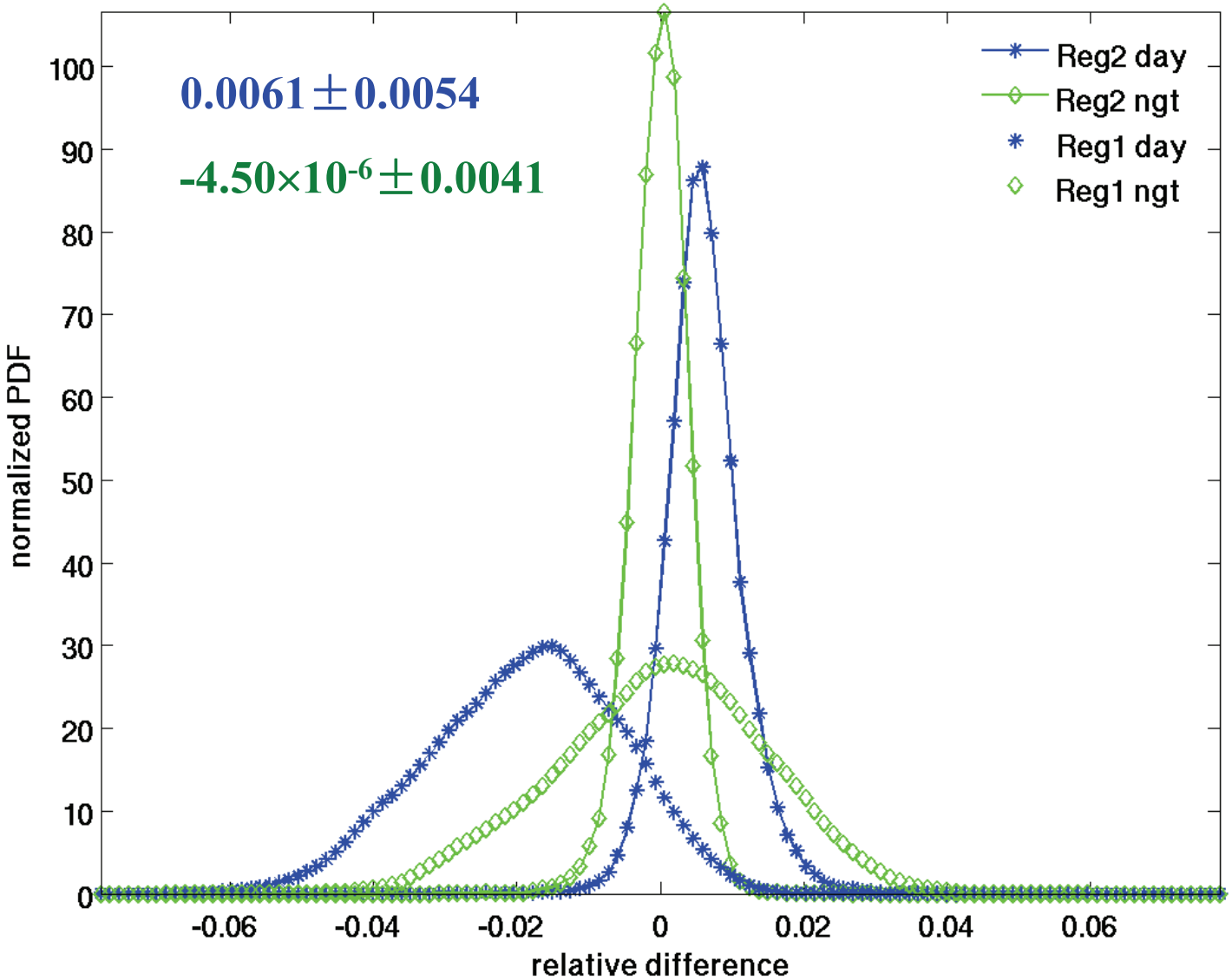
A simulation to check regression methods



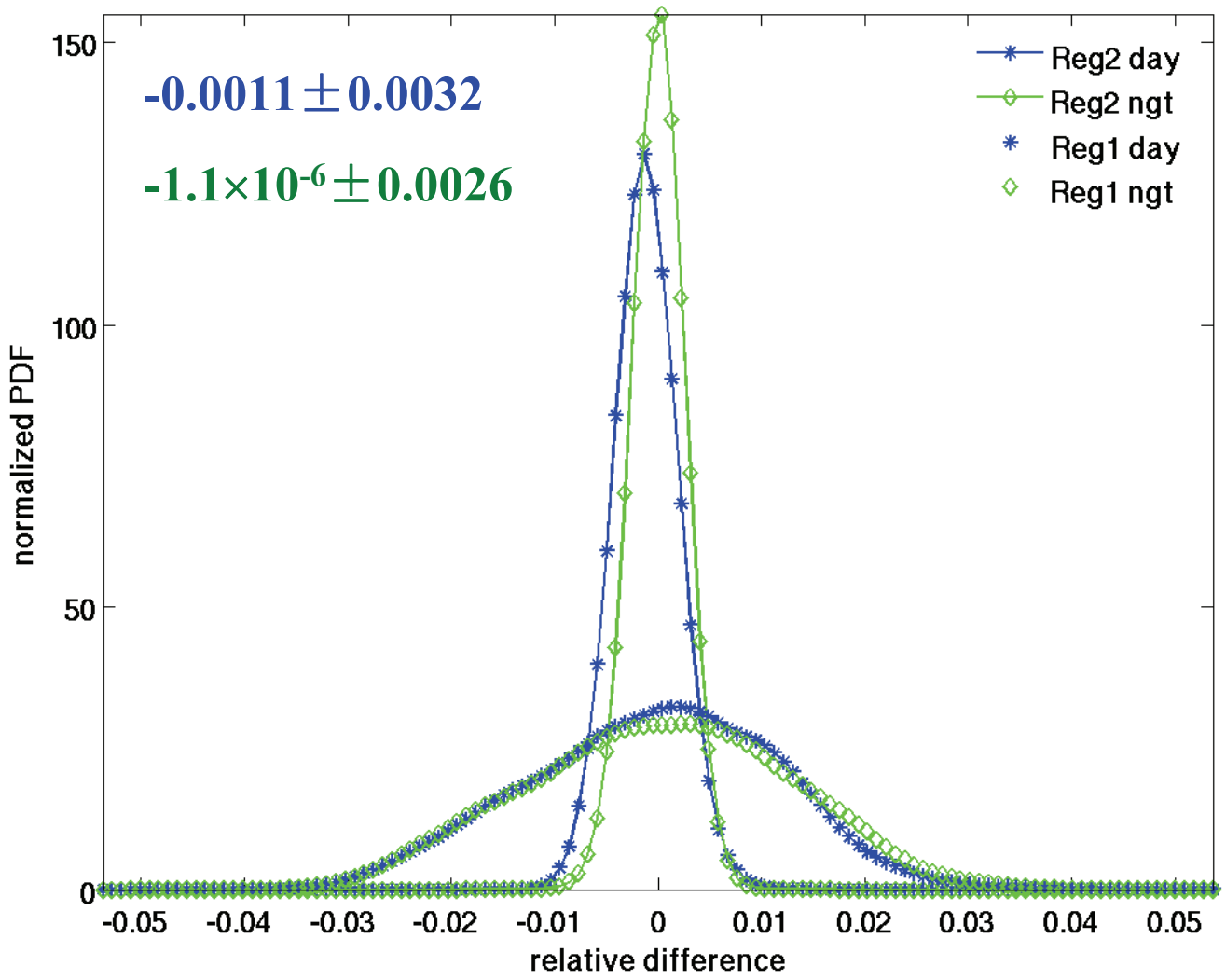
Cast studies

- Bright desert
  - Huge diurnal cycle
- Clear-sky ocean
  - Small diurnal cycle, but
  - SW contribution is also small
- Overcast ocean
  - Single-layer
  - Cloud fraction > 99.9%
  - Strong SW contribution in daytime

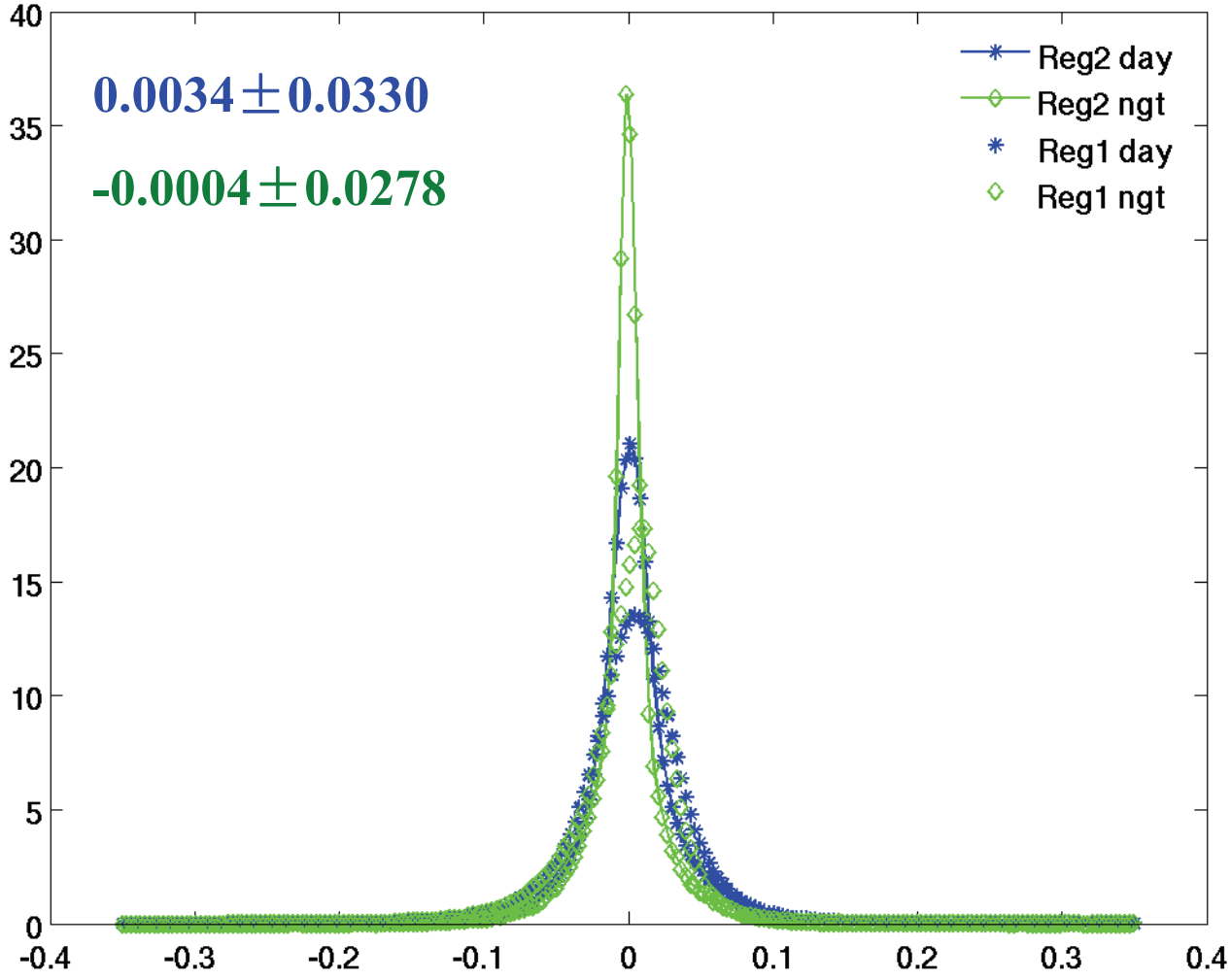
Desert (20662d 19668n obs)



Clear-sky ocean (66023d 50993n obs)

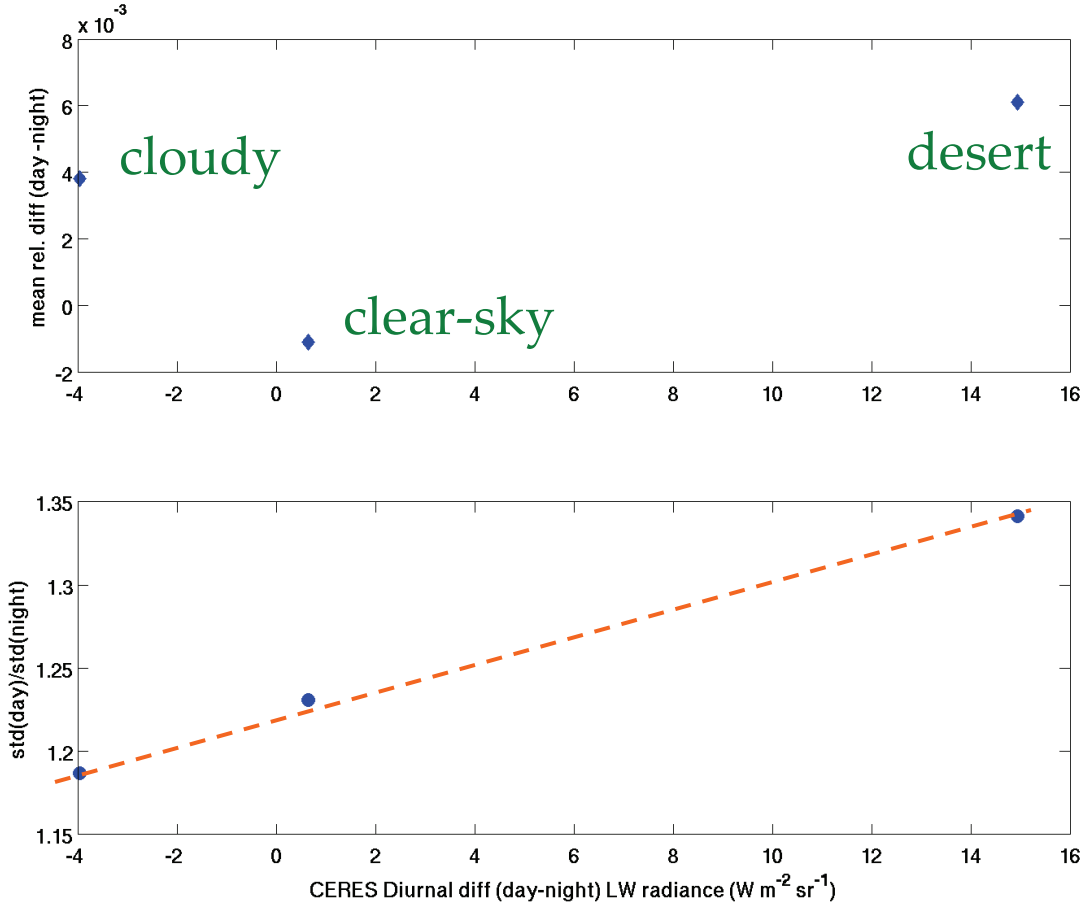


Cloudy-sky ocean (116177d 134378n obs)



Synthesis

- $(\text{Mean\_rel\_diff})_{day}$-$(\text{Mean\_rel\_diff})_{night}$
  - Desert and cloudy ocean, between 1σ and 2σ
  - Clear-sky ocean, <1σ
- Vs. Diurnal difference of LW flux



?

Back to desert double difference

- Derive regression coefficients from data of 2005 Jan
- Apply it to AIRS 2005 Feb data
- Compare with CERES 2005 Feb data
- What's the day –night double difference then?

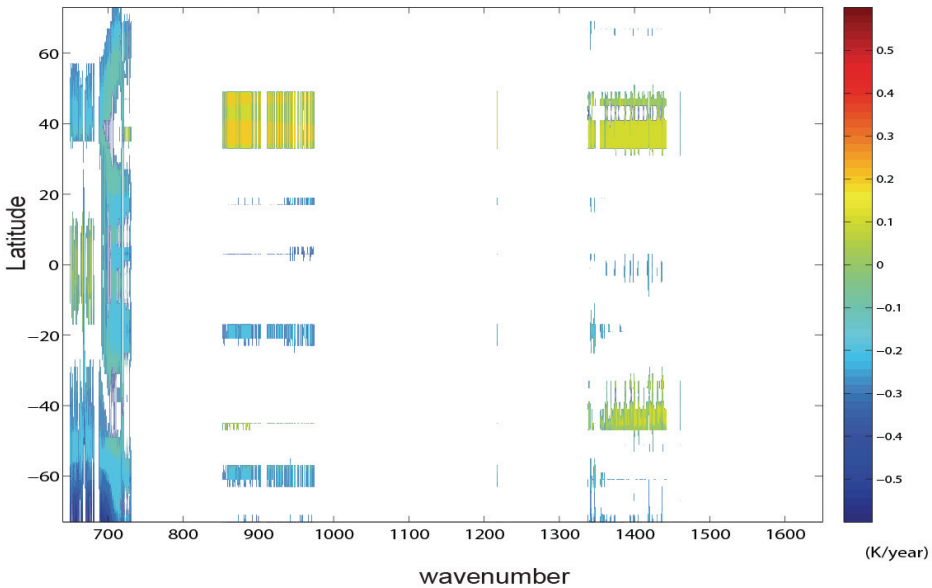
  $\sim\pi\times(-0.0216+0.0114)= -0.03 Wm^{-2}$

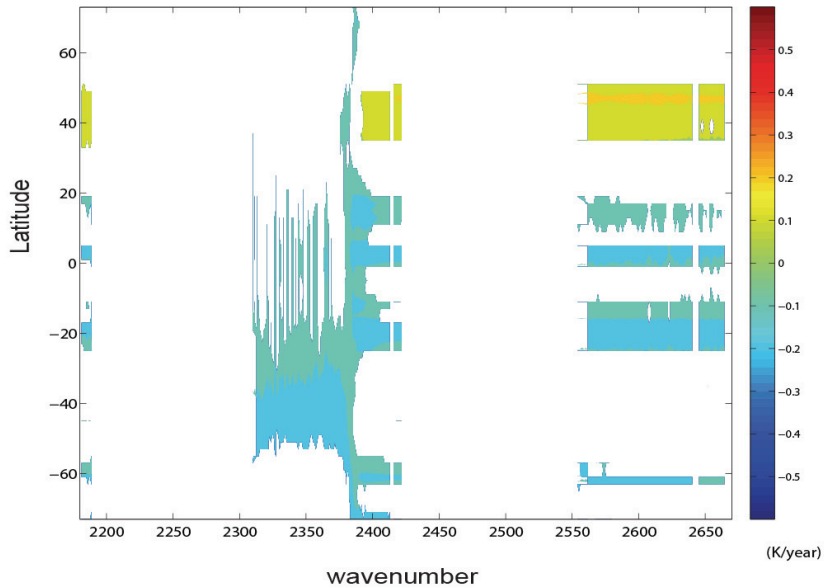
Conclusion

- The AIRS-CERES consistency check is feasible
- For the month we examined, no statistically significant day-night differences in CERES LW radiance are detected using this approach.
- If any real difference, it shall be (much) smaller than regression error here ($\leq$~1.4Wm^{-2})
- Perspectives
  - Compile statistics over extended period (2002-2008)
  - Other metrics?
  - Window radiances
  - More refined regression schemes to cope with nuisance AIRS "popcorn" noises

Supporting slides

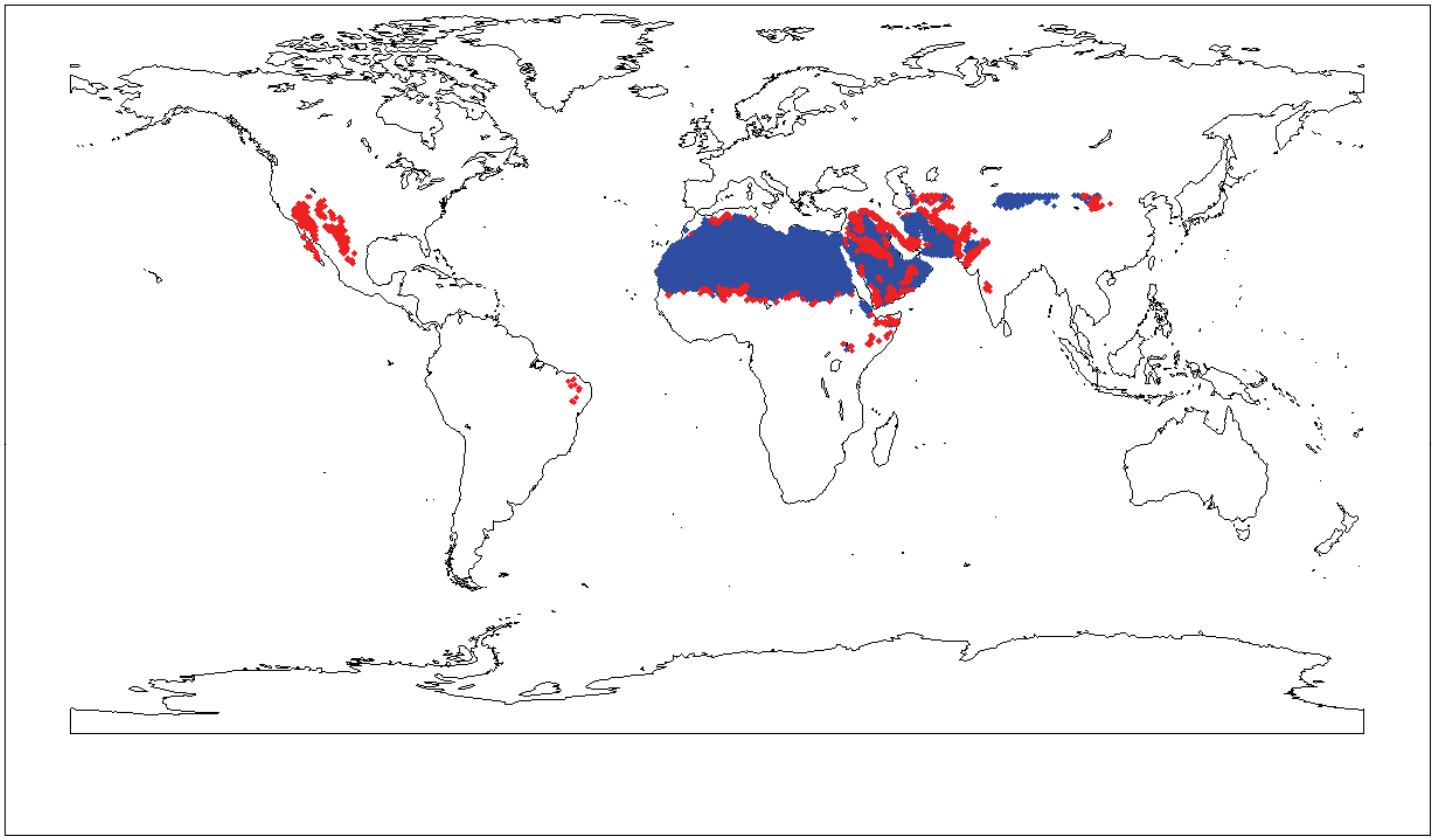
Zonal Trends of AIRS 6-years of radiance



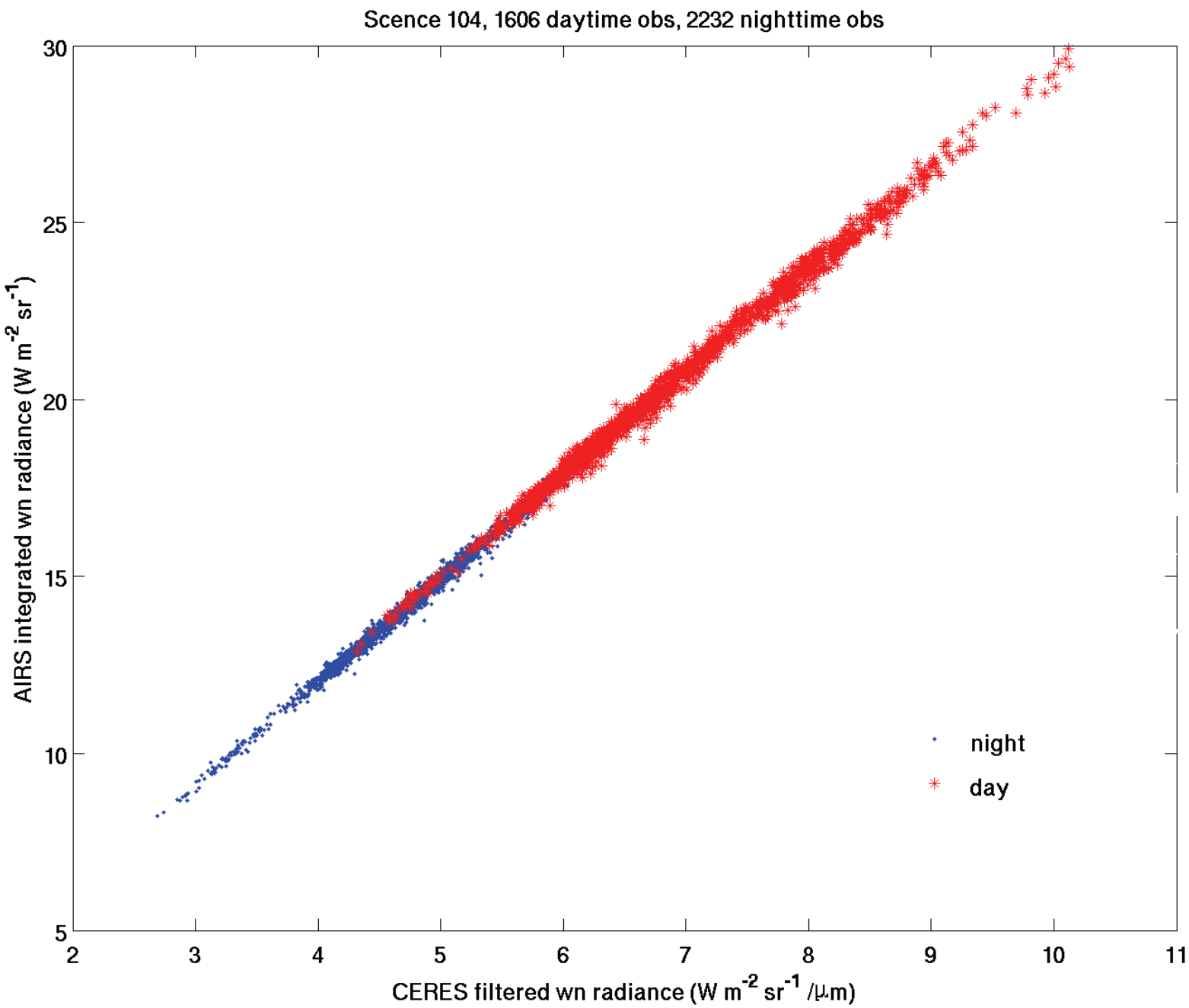


Stability: < 0.01K/year

Locations of observations used in this analysis



- LW ADM Scence 105
- LW ADM Scence 104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AIRS integrated wn radiance (W m-2 sr-1)
CERES filtered wn radiance (W m-2 sr-1 /μm)
night
day
30
25
20
15
10
5
2
3
4
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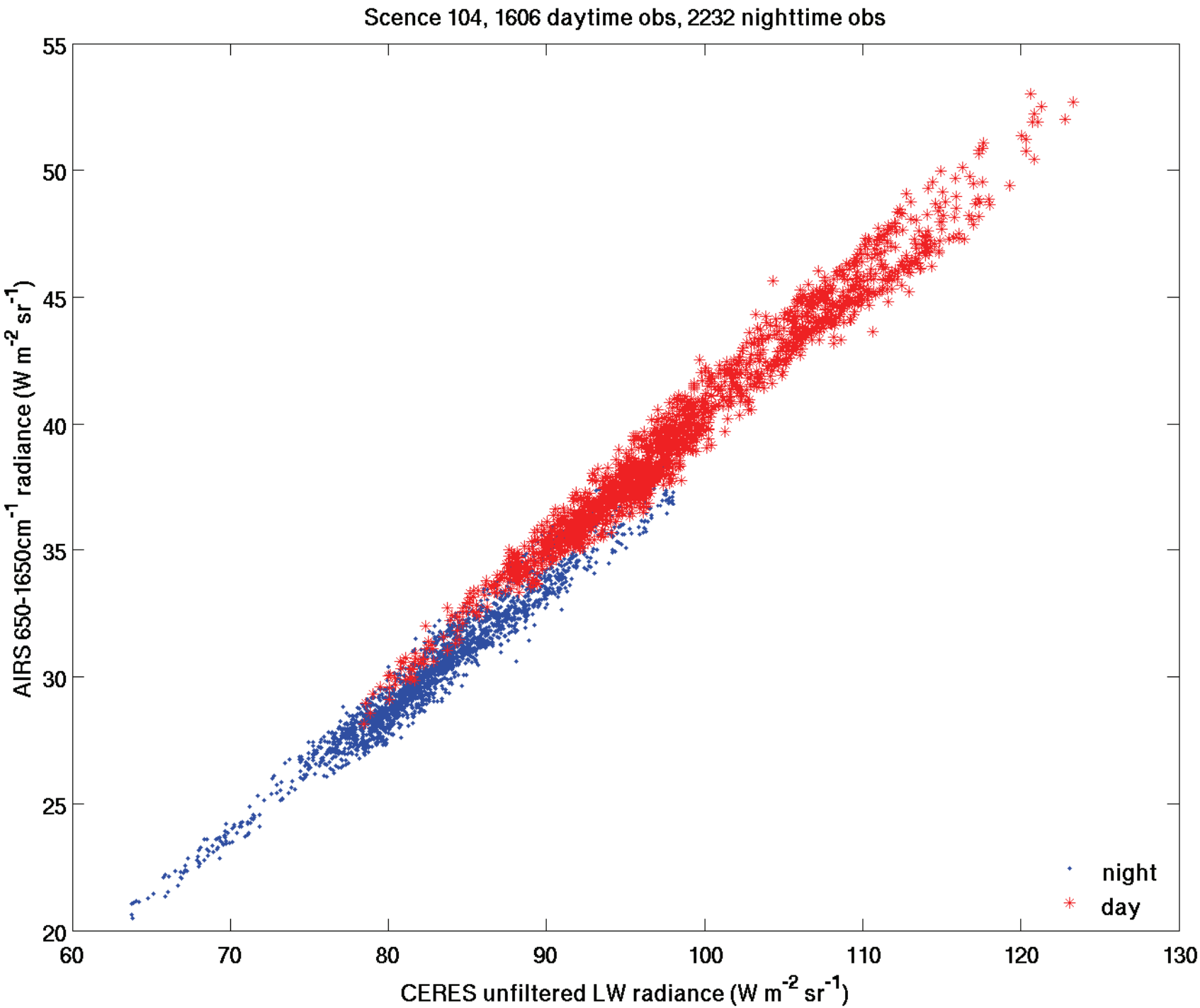
6
7
8
9
10
11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