



Diurnally Varying Hydrogen Volatiles or Regolith Temperature?

Mare and Highlands Studies of the Moon's Diurnally
Modulating Epithermal Neutron Flux Using LRO's LEND,
Diviner and LOLA Instruments

Lunar Exploration Analysis Group Meeting
Columbia MD, USA

October 20-22, 2015

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Equatorial Diurnal Neutron Flux Modulation: Diurnal Surface Hydration or Regolith Temperature?

H1: Diurnal Surface Hydration

Livengood 2014, 2015

LEND: CSETN and SETN

Dawn H, NIR observations

If correct: ~190 ml/m², *Livengood 2015b*

H2: Regolith Temperature Variation

Teodoro 2014, 2015

LPNS: Temp Corrected

Diviner Temps / Modeling

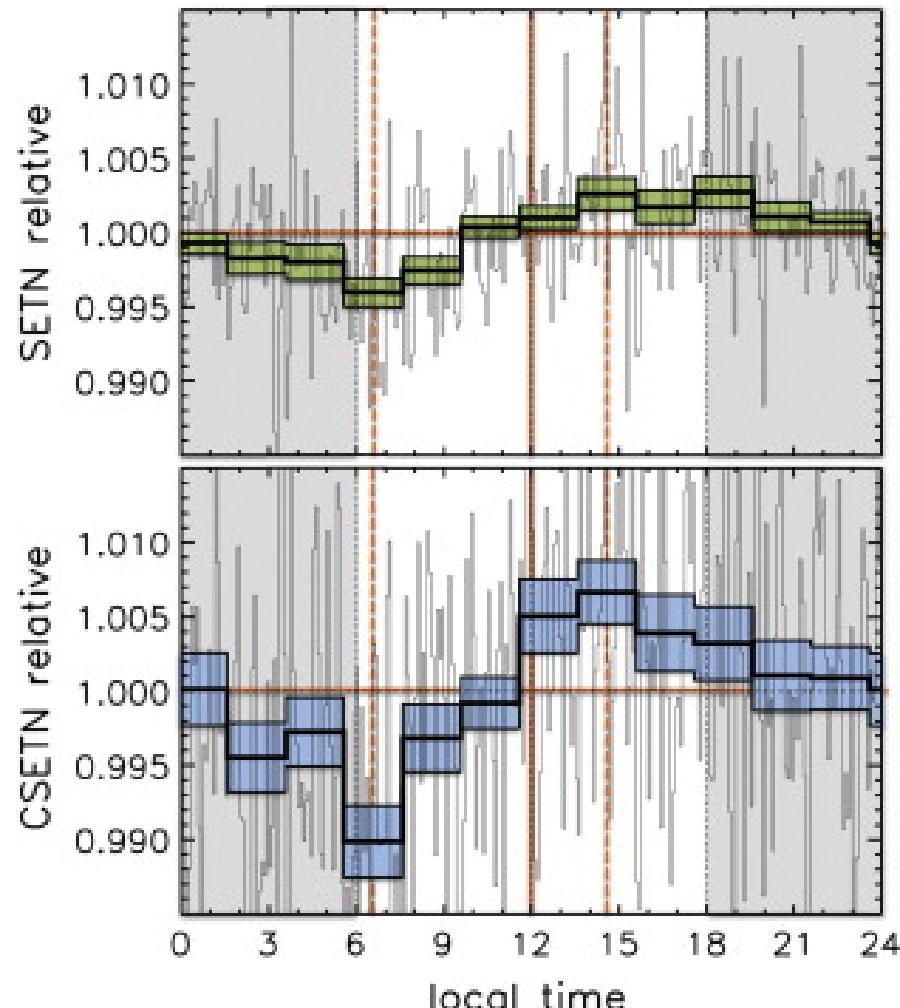
Neutron Modeling

Lawrence 2006, Little 2003

if correct: Not hydrogen

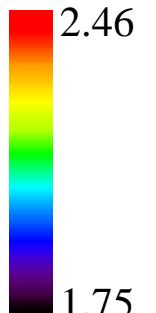
Possibly both

LEND Normalized Flux
CSETN and SETN: ±30°

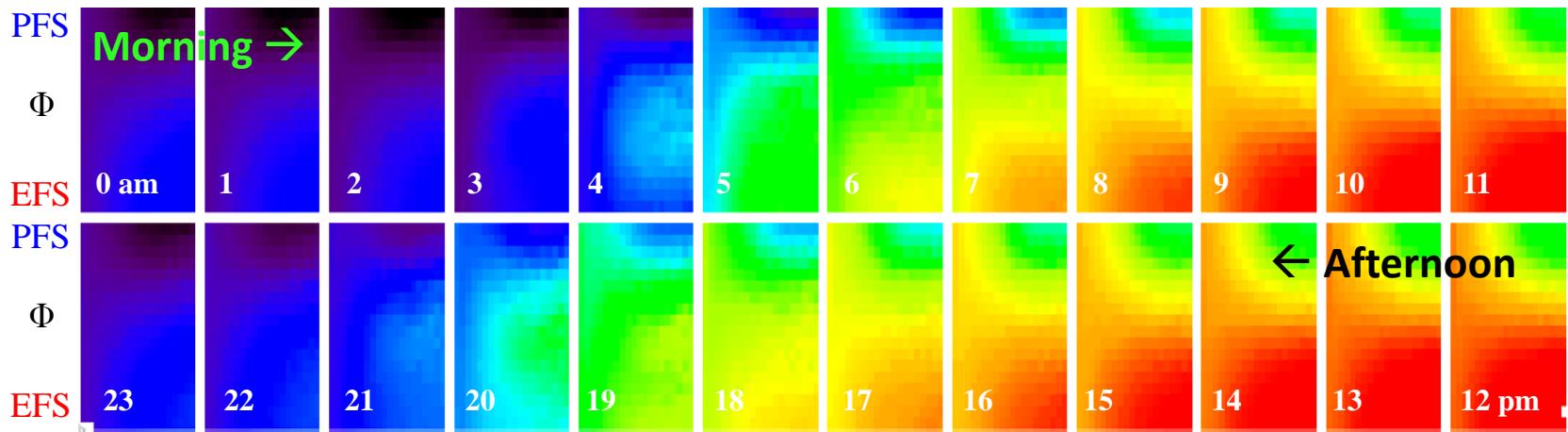


Diurnal Variation: Surface Temp vs Neutron Flux, >-75°

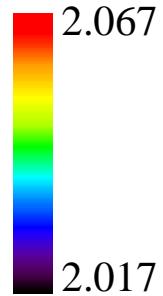
Log10((K))



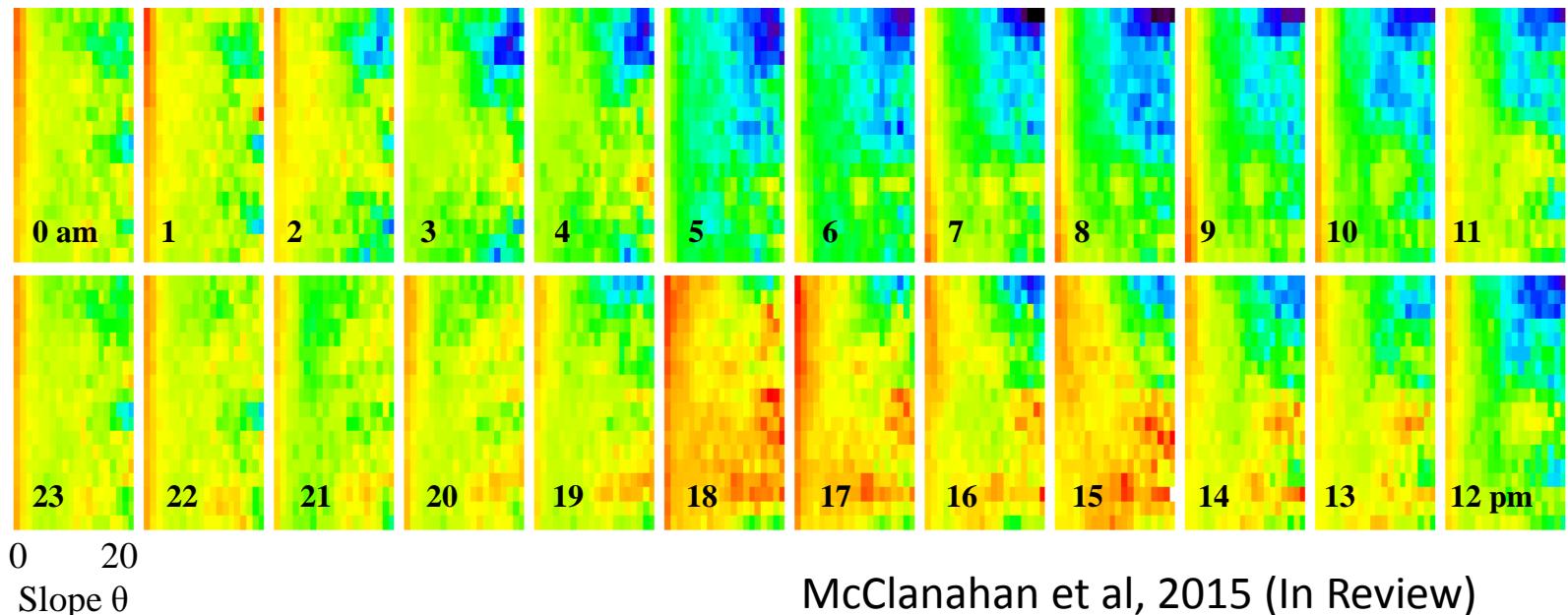
Diviner [K]



[cps]



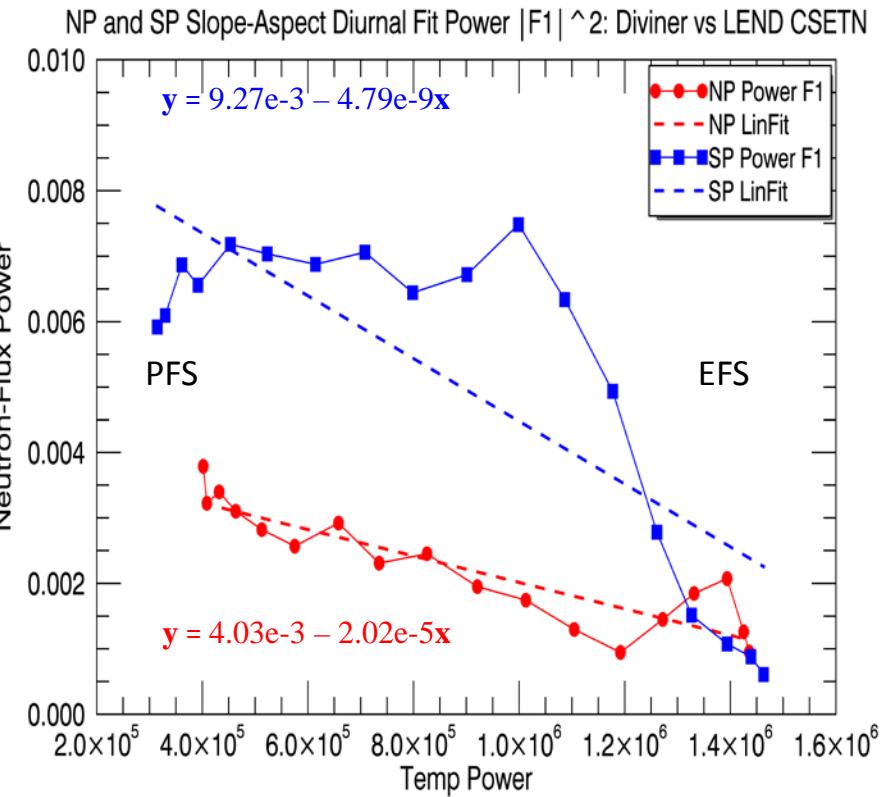
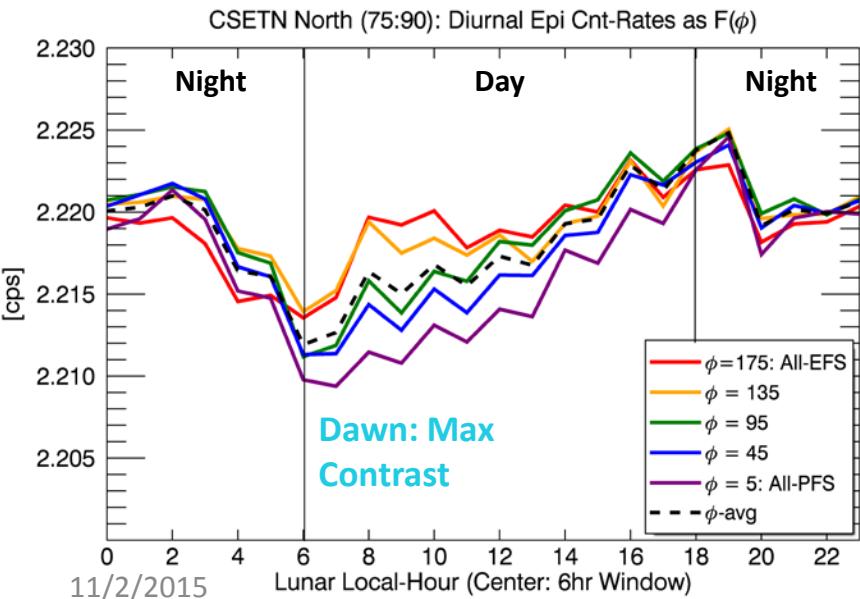
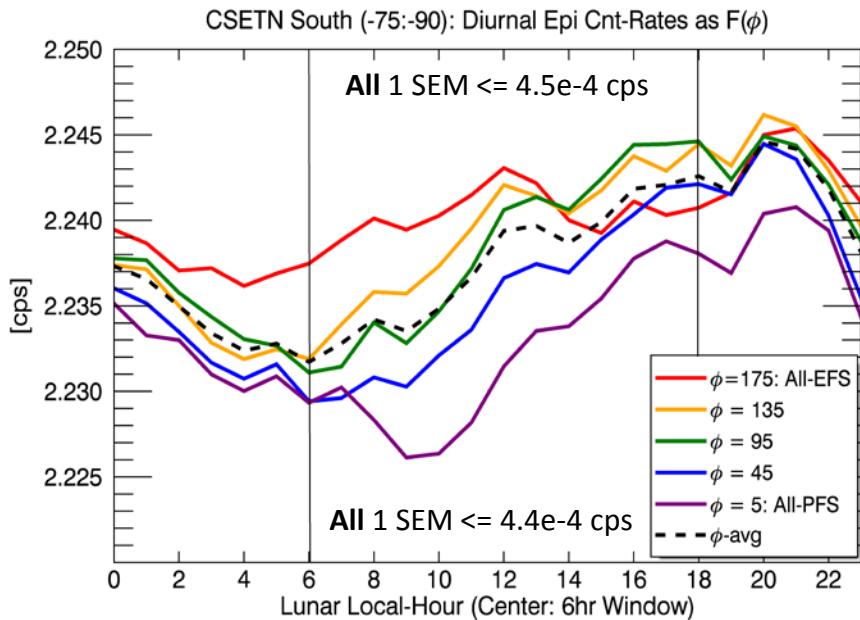
LEND CSETN [cps]



11/2/2015

McClanahan et al, 2015 (In Review)

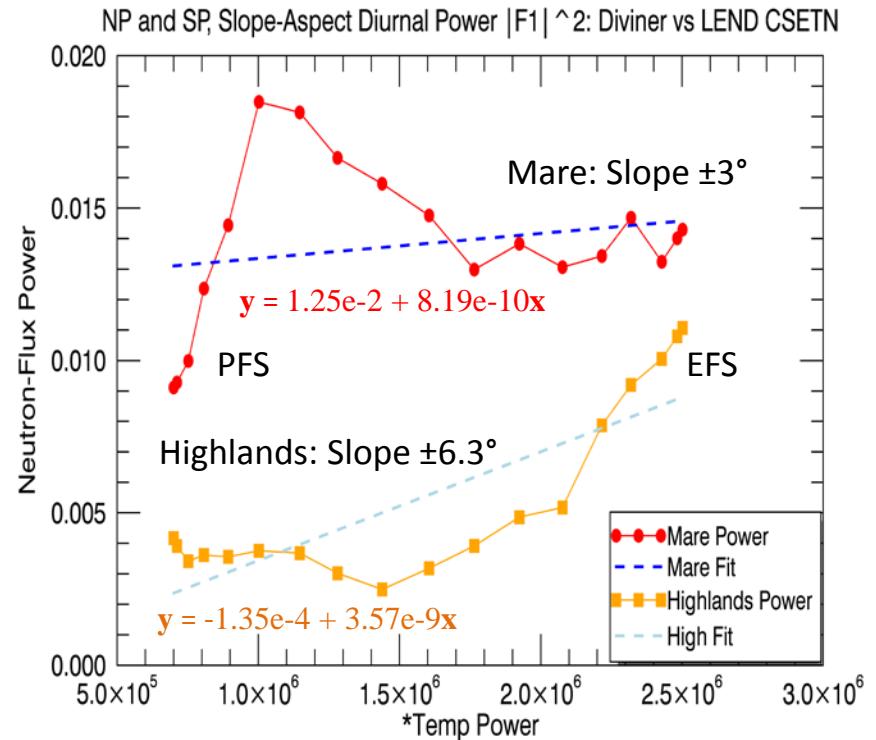
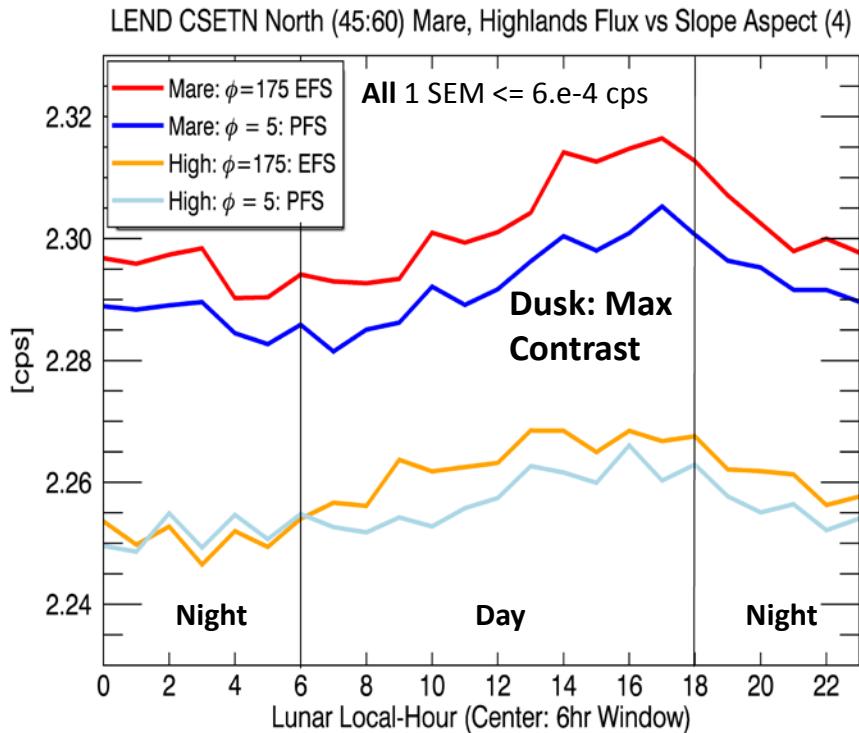
North and South: Diurnal Power Temps vs Neutrons, $\pm(75$ to $90)^\circ$



The amplitude of the diurnal neutron leakage flux is inversely correlated to surface temperature amplitude ($>\pm 75^\circ$).
 → Not consistent with regolith temp

N 45 to 65° (Mare vs Highlands): Diurnal Power Temp vs Neutrons,

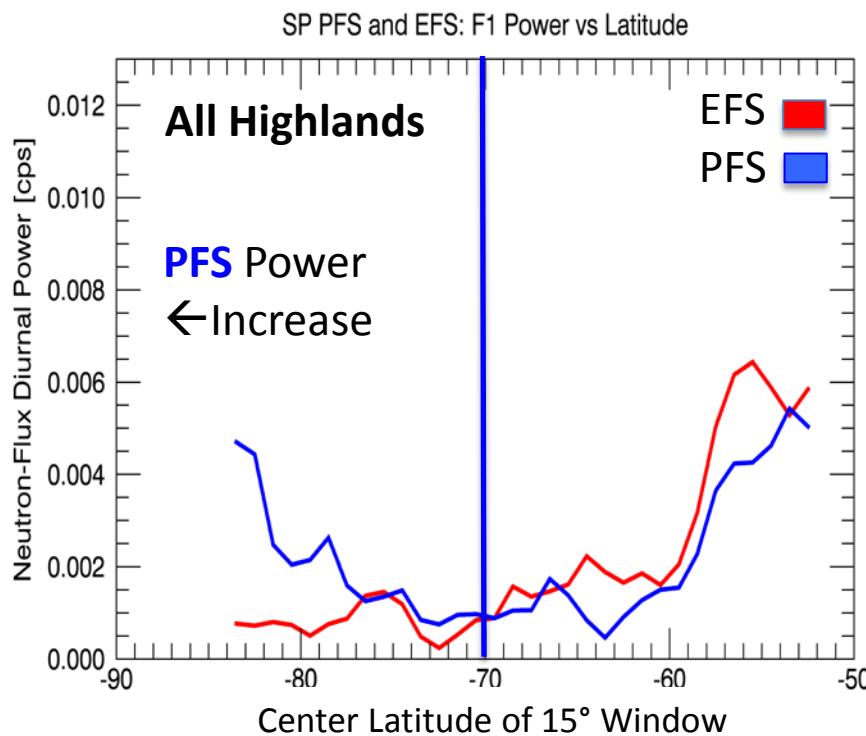
- Temps scaled from North High Lats*
- Mare = (0 to 90E Lon, 270 to 0E Lon), Highlands = (90E to 270E)



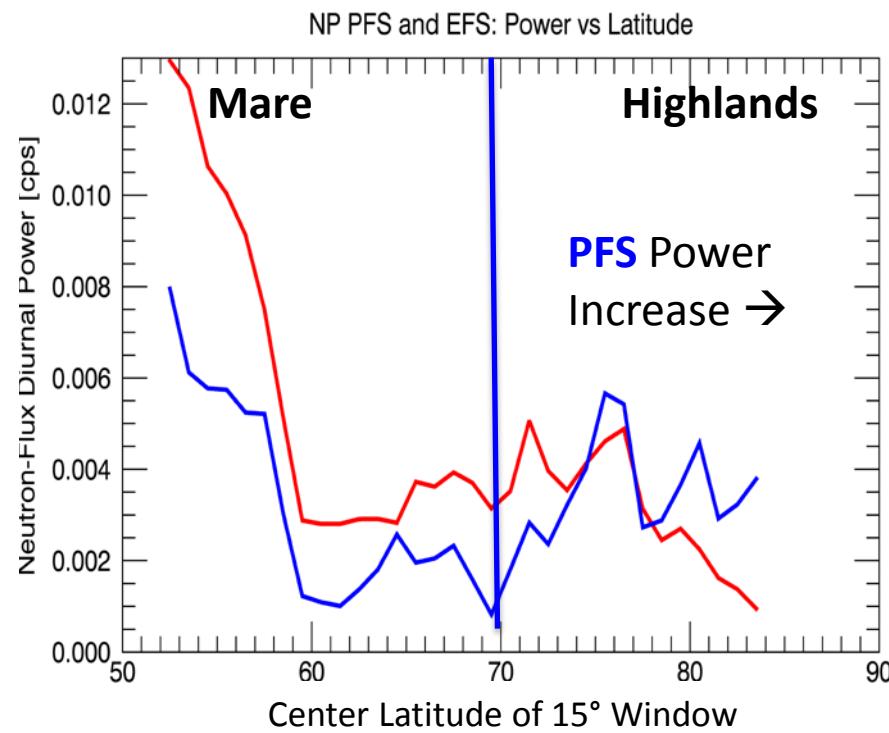
Diurnal neutron leakage flux power is positively correlated to surface temperature power (45:60°N).
 → Consistent with regolith temperature

North, South: EFS vs PFS, Diurnal Power (F1), 45° to 90°

South Power F1: EFS, PFS vs Latitude



North Power F1: EFS, PFS vs Latitude

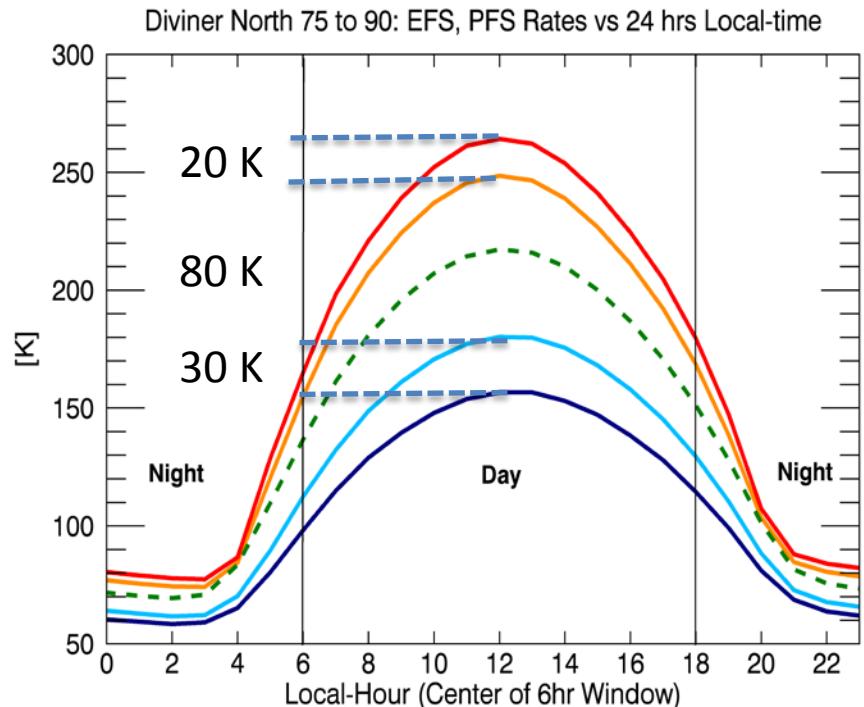


1. **EFS power** decreases towards poles --> Regolith temp.
2. $>\pm 75^\circ$: **PFS power < EFS power**: Not Regolith Temp \rightarrow possibly Hydration
3. $>\pm 65^\circ$ to 70° : Power relationships invert, transitional
 $<\pm 65^\circ$, **EFS power > PFS power**: Regolith temperature dominates

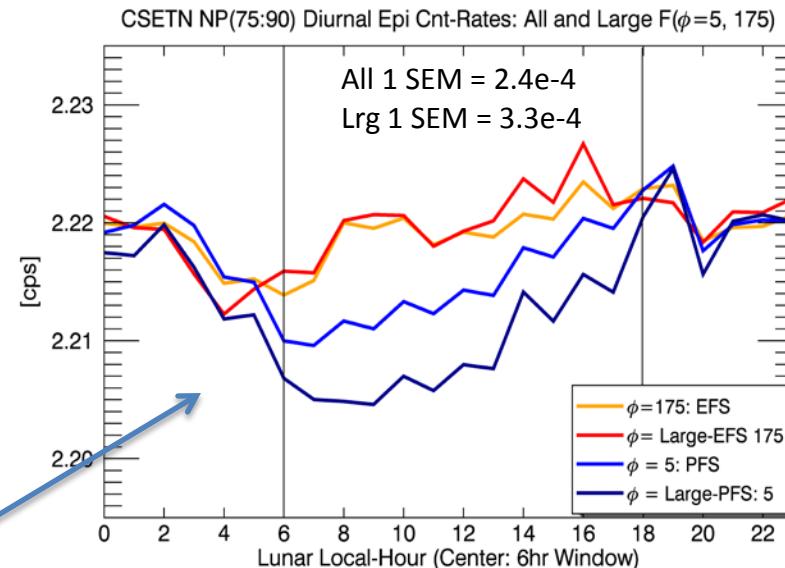
CSET Neutron Suppression Scale Dependence

75°N to 90°N

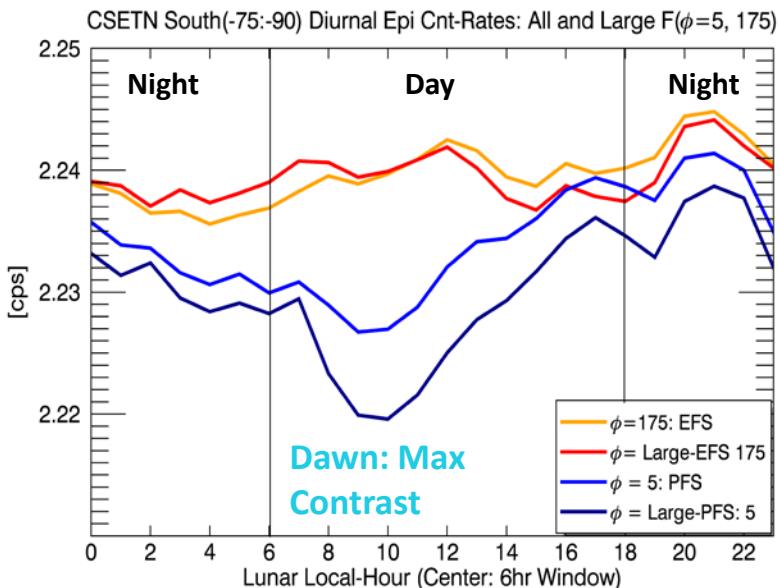
Diviner NP



North	
<u>dT</u>	% Supp
20 K	= 0%
80 K	= 55%
30 K	= 45%



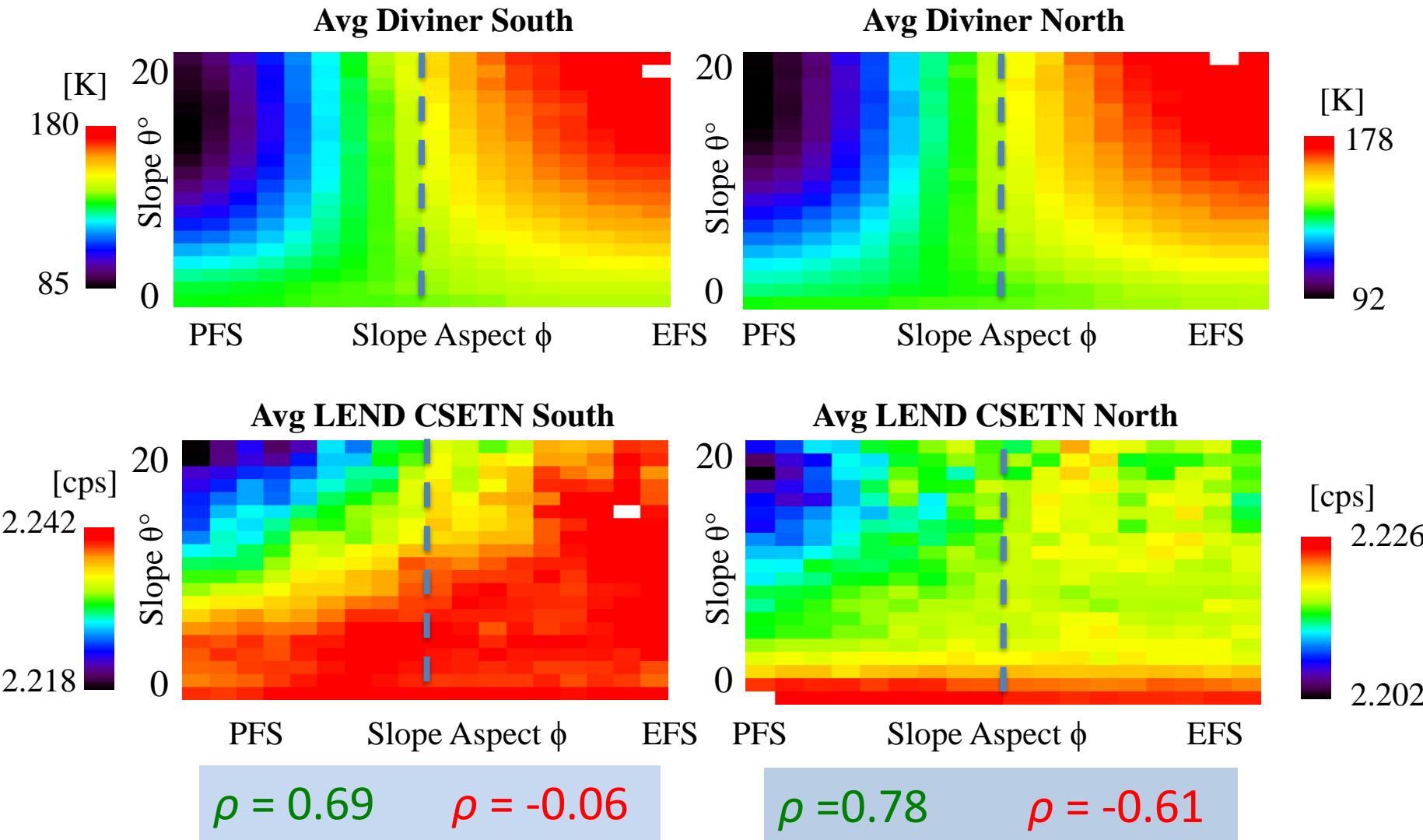
75°S to 90°S



Conclusions

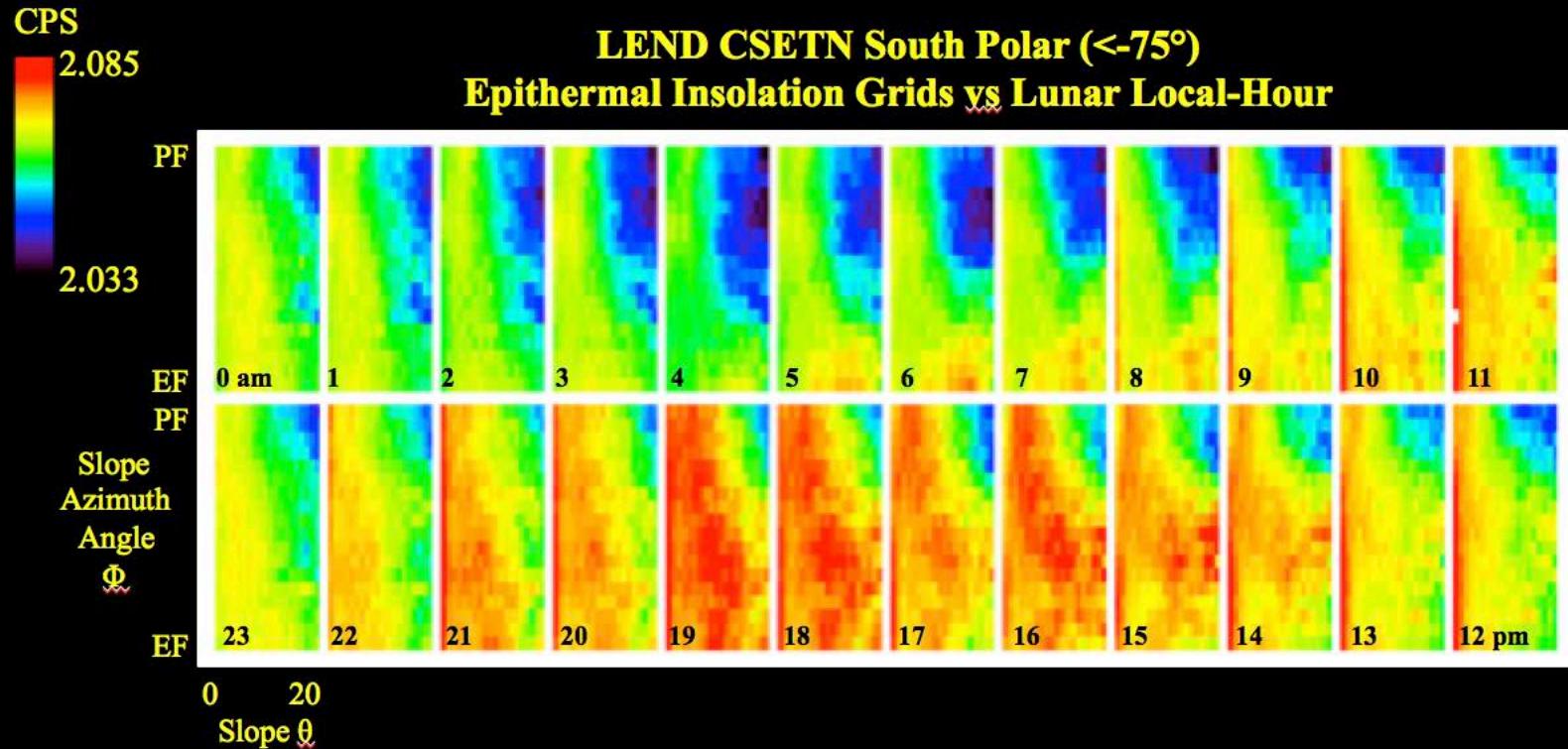
1. **Polar Latitudes, $>\pm 75^\circ$:** LRO's LEND, LOLA and Diviner instruments –
 - No evidence of regolith temperature, **PFS power > EFS power**
 - Non-linear with temperature for large scale PFS slopes.
 - Possibly hydrogen being diurnally cycled at/within the surface.
If so: [0.012% WEH, 12 ppm] at dawn towards PFS [7 to 9am]
H pumping, (Schorghofer, Aharonson 2014), 110-130 K, Lats, H
 - **Not supported by exosphere observations, ~4 orders of magnitude too large!!**
2. **Mid Latitudes, $\pm(45^\circ < 60^\circ)$:** Consistent with **regolith temperature dominating** the neutron flux modulation, **EFSpower > PFSpower**
 - Mare power > Highlands, 2x
 - Livengood et al., Cycled H concentrations likely overestimated
 - CSETN Fast Neutrons → Shallow depth (top several cm)
3. **Alternative:** High Lats – **Regolith temperature** can't be excluded. **EFS, PFS** diurnal power may be dependent on regolith composition → Thermal waves differ?

Correlation: LEND CSETN to Diviner Temperature, >75°



→ No evidence – CSETN n flux not + correlated to regolith temp → EFS

South -75:-90, CSETN Insolation Grids vs Local-Time



- Morning PFS epithermal suppression towards PFS
- Negligible daytime epithermal response towards EFS