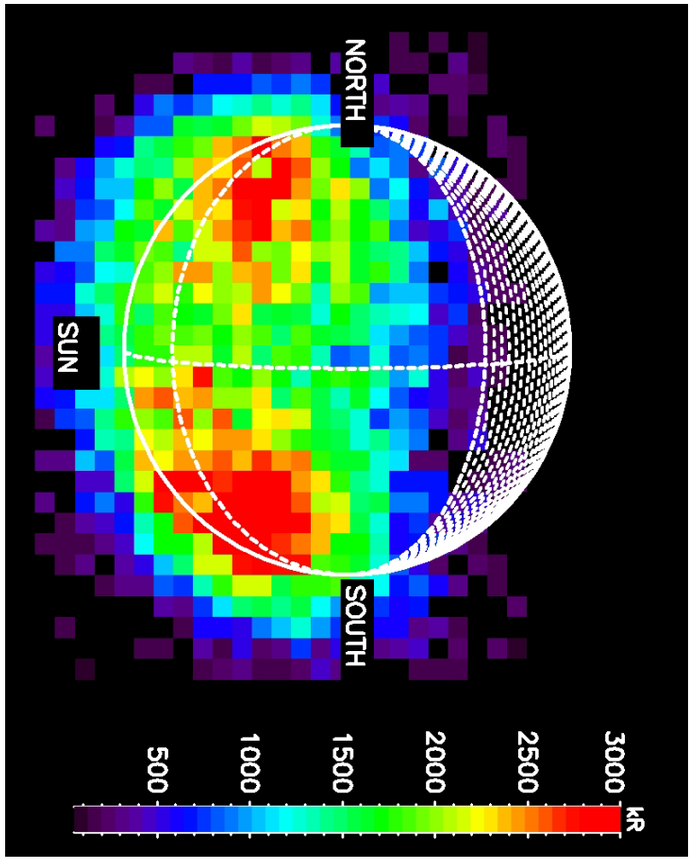
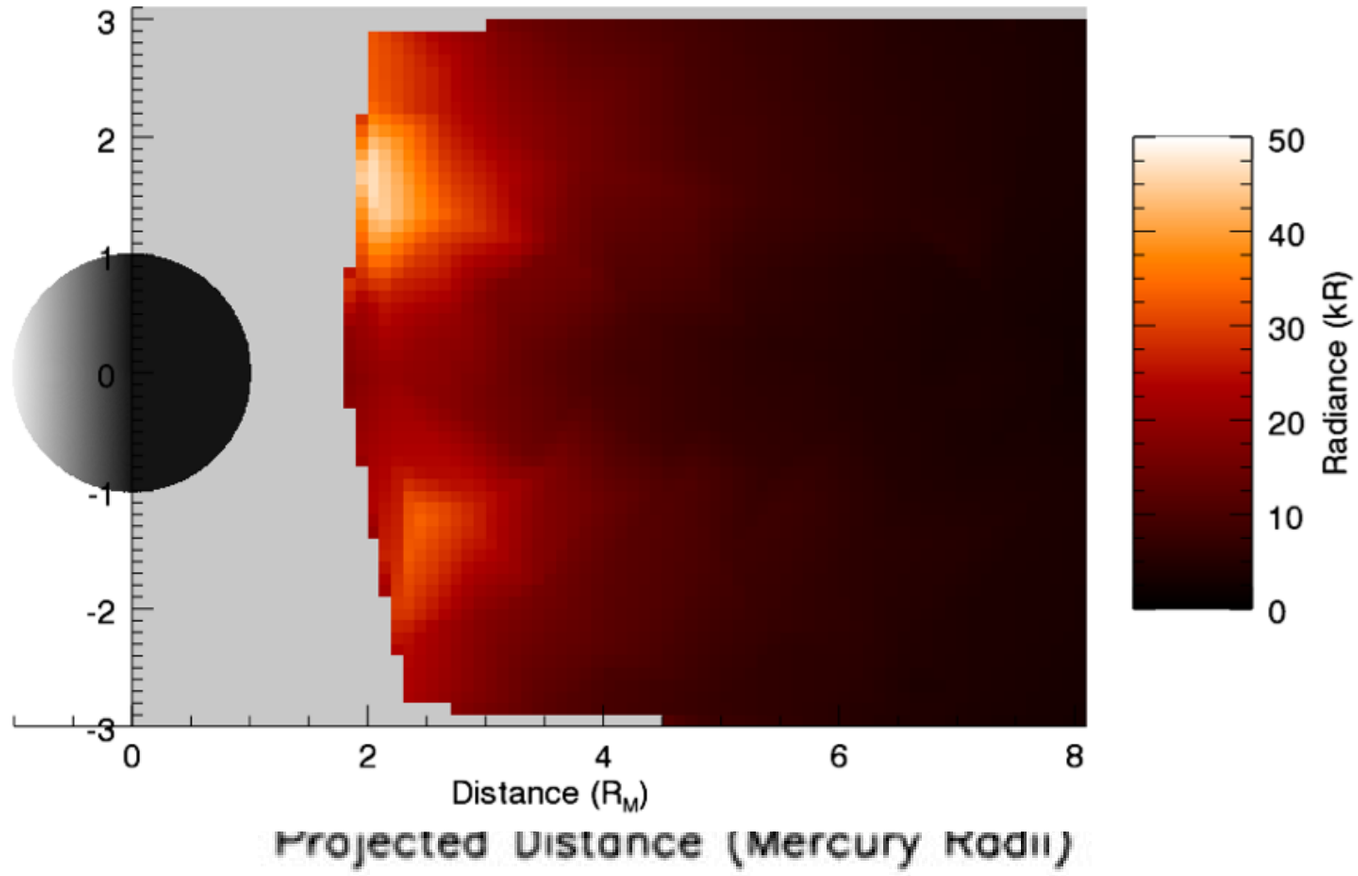
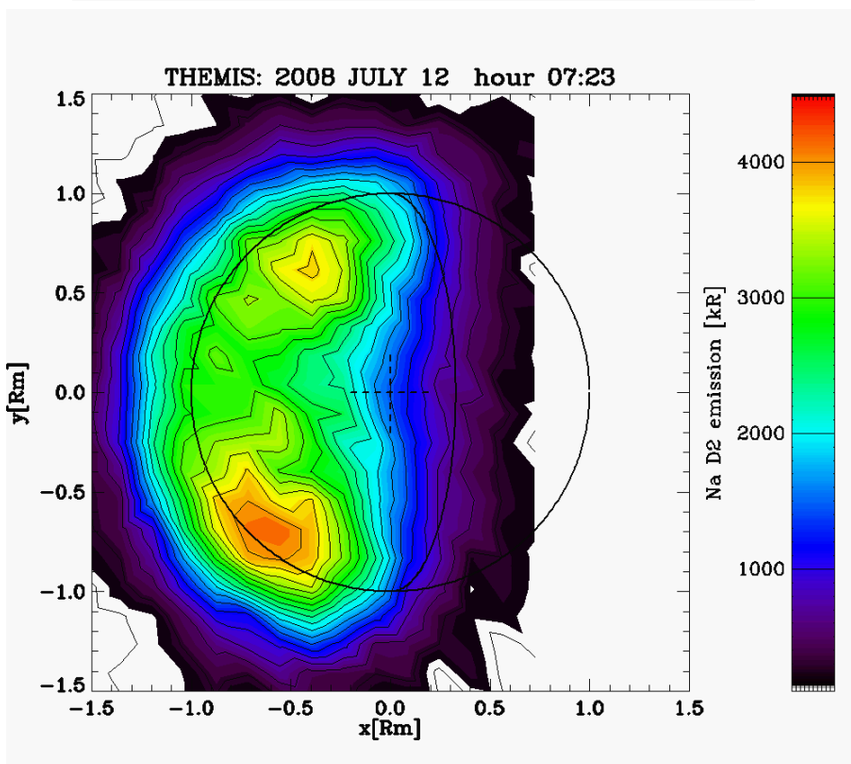
Mercury’s Exosphere: Review

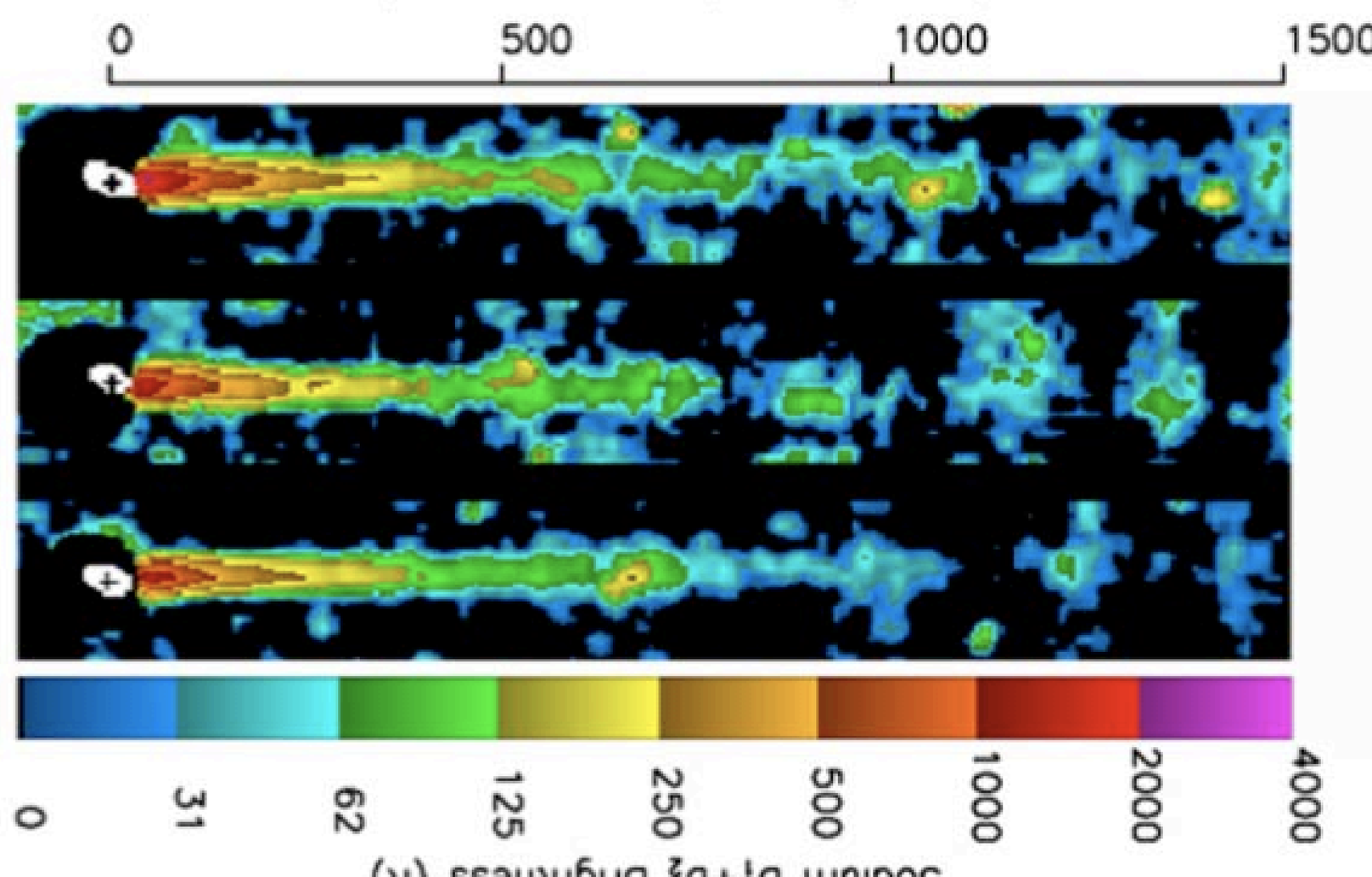
Observations

- Observed species: H, He, Na, K, Ca, Mg, Al
- Multiple spatial scales


NORTH
SUN
SOUTH
500
1000
1500
2000
2500
3000
kR

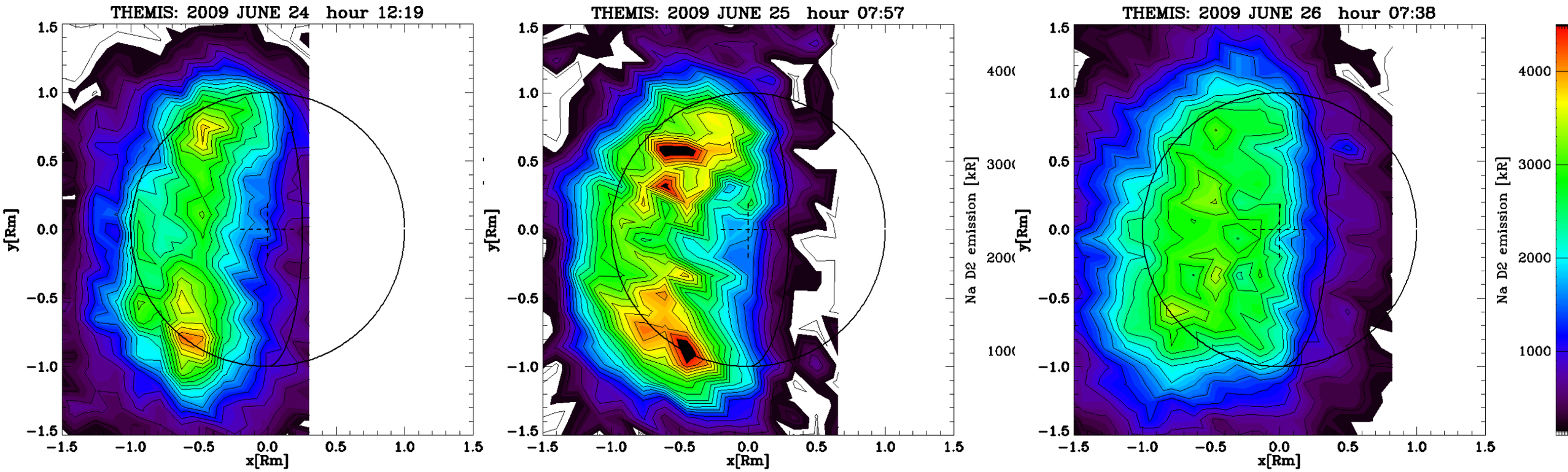

Distance (R_M)
Radiance (kR)

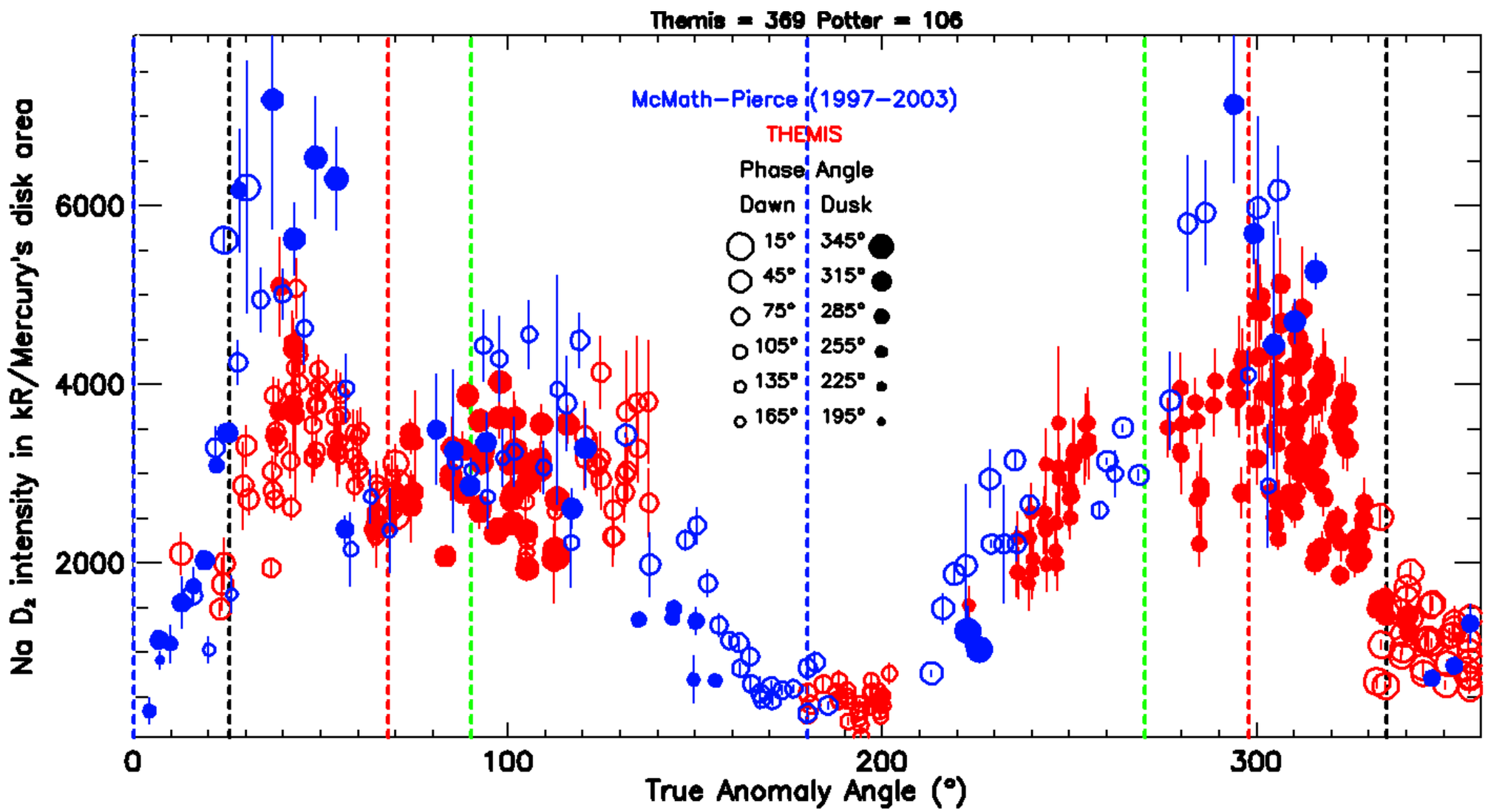

THEMIS: 2008 JULY 12 hour 07:23
y[Rm]
x[Rm]
Na D2 emission [kR]


Projected Distance (Mercury Radii)
Sodium D2 Brightness (R)

Observations

- Observed species: H, He, Na, K, Ca, Mg, Al
- Multiple spatial scales
- Variability on multiple time scales


THEMIS: 2009 JUNE 24 hour 12:19
THEMIS: 2009 JUNE 25 hour 07:57
THEMIS: 2009 JUNE 26 hour 07:38
y[Rm]
x[Rm]
Na D2 emission [kR]


Themis = 369 Potter = 106
McMath−Pierce (1997−2003)
THEMIS
Phase Angle
Dawn Dusk
15° 345°
45° 315°
75° 285°
105° 255°
135° 225°
165° 195°
Na D2 intensity in kR/Mercury's disk area
True Anomaly Angle (°)

Observations

- Observed species: H, He, Na, K, Ca, Mg, Al
- Multiple spatial scales
- Variability on multiple time scales
- Distinct spatial distributions for the species observed by MASCS -> distinct source processes and source distribution
- Need for simultaneous ground-based and MESSENGER observations
  - Ground-based observations can provide the global context for the localized s/c measurements
  - see Mouawad et al., Icarus, in press

Physics

- Source processes:
  - impact vaporization: global and ~isotropic
  - PSD and thermal vaporization: dayside processes
  - ion sputtering and ESD: magnetospheric processes
- Atomic physics
  - atomic vs. molecular production processes
  - photo-ionization and dissociation
  - radiation pressure
  - emission by resonant scattering

Physics

- Surface physics
  - diffusion of volatiles outward in grains
  - ion induced chemistry and diffusion (OH, H_2O, Na production)
  - adsorption, desorption, and energy transfer
  - surface charging
  - space weathering processes

Neutral Exosphere Models

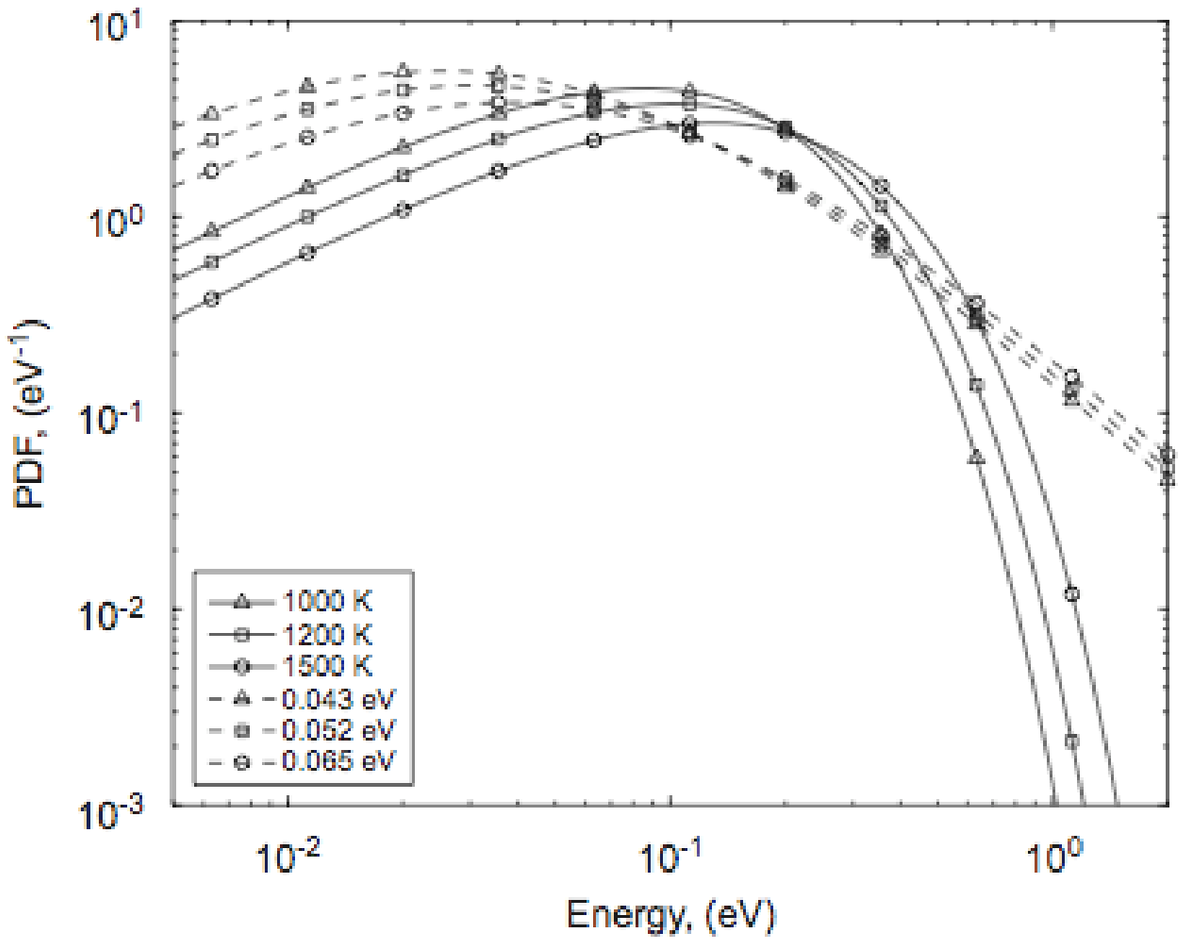
- Mura (Na)
  - sodium supplied to the surface through diffusion and ion-induced chemistry (chemical sputtering)
- Leblanc (Na)
  - Modeling variability over the course of a Mercury year
  - Importance of global transport of Na
- Kameda (Na)
  - Influence of interplanetary dust cloud or solar tides on the exosphere
- Sarantos (Mg)
  - evidence for multiple source processes
- Burger (Na,Ca)
  - Constraints on impact vaporization
  - Evidence for a localized, high temperature Ca source

Open Questions and Needs

- Observations:
  - Continued ground-based observing in conjunction with MESSENGER orbital phase
  - MMO BepiColumbo will have instruments devoted to observing the dust environment and sodium exosphere
- Models:
  - Need to unite the models of the near-surface and escaping components
  - Understand periodic vs. stochastic variability

Open Questions and Needs

- Impact vaporization
  - What is the micrometeorite flux?
  - How well is the physics of vapor production understood?
- PSD
  - What is the energy distribution of desorbed atoms?
  - What species can be ejected by PSD?



Yakshinskiy & Madey (1999)

$$f(E) = \frac{E}{(k_B T)^2} e^{(-E/k_B T)}$$

Johnson et al. (2002)

$$f(E) = x(1+x)\frac{EU^x}{(E+U)^{2+x}},$$

Open Questions and Needs

- Ion sputtering and ESD
  - What are the yields?
  - neutral/ion ejection ratio?
  - Species fractionation?
  - Energy distributions of ejected atoms?
- Gas-surface interaction
  - Sticking coefficients vs. species, temperature, surface composition, etc.
  - Thermal accommodation coefficients
- Surface composition
- Ion and electron precipitation fluxes and energies
  - Rates of chemical sputtering and ion enhanced diffusion are uncertain/unknown
- Photoionization and dissociation rates are unknown or uncertain for potential exospheric species