POLAR HEAT FLOW ON IO. G. J. Veeder, D. L. Matson, T. V. Johnson, A. G. Davies and D. L. Blaney. Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109. (gveeder@scn1.jpl.nasa.gov).

Introduction: Recently, Galileo spacecraft data have revealed Io's polar regions to be much warmer than previously expected. This unexpected development came from Photo-Polarimeter Radiometer (PPR) data which show that the minimum night temperatures are in the range of 90-95 K virtually everywhere on Io [1-4]. The minimum night temperatures show no dependence upon latitude and, when away from the sunset terminator, they show no dependence upon time of night. This is indeed bizarre behavior for surface units which generally had been assumed to be passive with respect to Io's pervasive volcanism.

Night temperatures of 90-95 K at high, polar latitudes are particularly hard to explain. Even assuming infinite thermal inertia, at these latitudes there is insufficient sunlight to support these warm night temperatures. Thus, through the process of elimination of other possibilities, we come to the conclusion that these surfaces are volcanically heated [5-8].

Taking previously passive units and turning them into new sources of heat flow is a radical departure from previous thermophysical model paradigms [9-11]. However, the geological interpretation is straight forward. We are simply seeing the effect of 'old', cool lava flows which cover most of the surface of Io but yet have some heat to radiate [12-14].

Under these new constraints, we have taken on the challenge of formulating a physical model which quantitatively reproduces all of the observations of Io's thermal emission. In the following we introduce a new parametric model which suffices to identify a previously unrecognized polar component of Io's heat flow.

Model: We use a 'Three Component' background model for Io to address this polar conundrum as summarized in the Table. This model has the following general characteristics. The predicted infrared radiation is consistent with available data for Io at multiple wavelengths both day and night [15]. The background has both relatively high and low albedo components. The background has both very high and very low thermal inertia components. The very high thermal inertia component provides cooling of the day side as well as infrared radiation at night. We now include a warm volcanic unit in the polar regions which also contributes significant infrared radiation at night.

Table: *'Three Component' Model for Io*

Unit	Albedo	Inertia	Latitude	Longitude
	A	γ	φ	λ
Infinite γ	high	∞	0-60	day & night
Zero γ	low	0.0	0-90	day
Polar	high	n/a	60-90	day & night

The 'Infinite γ' unit is the largest and has a very high thermal inertia and relatively high albedo. It is a passive regional unit confined to the non-polar surface of Io. The 'Infinite γ' unit provides for a warm equatorial zone and re-radiates absorbed solar insolation both day and night. The 'Zero γ' unit has a very low thermal inertia and relatively low albedo. This passive unit occurs globally on Io. In particular the 'Zero γ' unit provides for an even warmer subsolar region. The 'Zero γ' unit re-radiates all absorbed solar insolation during the day and drops to zero temperature with no radiation beyond the terminator. The new 'Polar' unit is the key to our 'Three Component' model. This is an active regional unit with relatively high albedo. The 'Polar' unit re-radiates all absorbed solar insolation during the day but continues to be supported at a modest constant temperature through the night by widespread low level volcanic activity.

At non-polar latitudes (below 60°), this particular model is similar to that of our previous work [15]. The 'Infinite γ' unit has an albedo of ~0.585 and covers ~75% of the surface. The 'Zero γ' unit has an albedo of ~0.3 and covers the remaining ~25% of the surface. At polar latitudes (above 60°), this model includes a new active volcanic unit with an albedo of ~0.585 and filling factor of ~75%. The 'Polar' unit has a night temperature (T_P) of 100 K. The remaining ~25% of the polar region is also covered by the 'Zero γ' unit. Thus, the 'Zero γ' unit uniformly covers ~25% of the entire surface of Io.

Heat Flow: A widespread warm volcanic region is required to support the observed elevated night polar temperatures on Io. The 'Three Component' model presented is one example of a class consisting of a mosaic of low and high albedo, zero and infinite thermal inertia, and active volcanic units. All models in this class produce a similar amount of additional heat flow due to (polar) volcanic activity while retaining both day and night temperatures at high and low latitudes which are reasonable. The nominal active component has a temperature (T_P) of 100 K with a filling factor of 75% within polar latitudes (above 60°). Thus, the effective temperature at the poles and night caps is ~93 K. The caps cover ~16% of Io's surface and therefore the polar active component covers ~12%. This results in an additional heat flow of ~0.6 W m^{-2} which increases our estimate of Io's total heat flow from 2.5 [15] to ~3 W m^{-2}. The uncertainty of this value remains on the order of ±1 W m^{-2}.

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