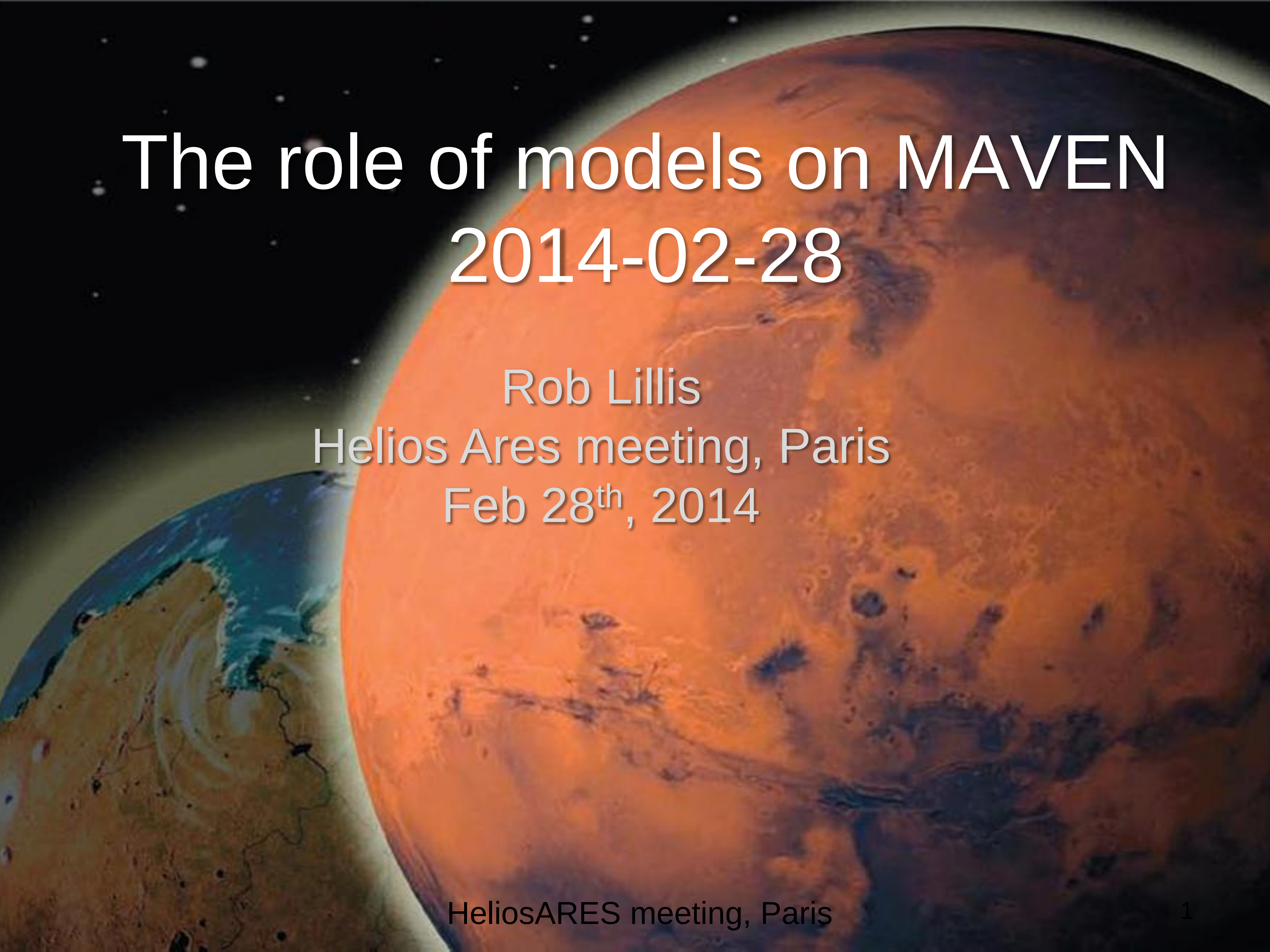


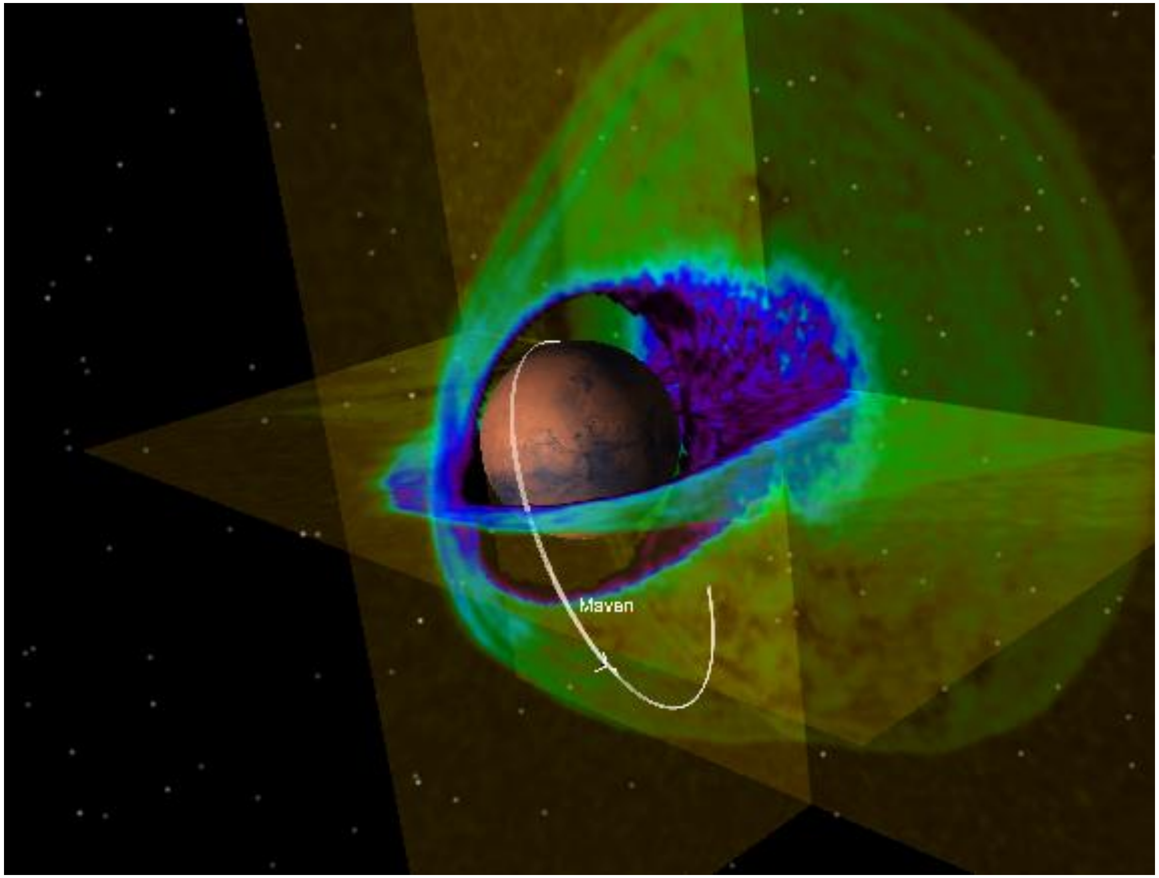
The role of models on MAVEN 2014-02-28

Rob Lillis

Helios Ares meeting, Paris

Feb 28th, 2014

Global Modeling support for MAVEN

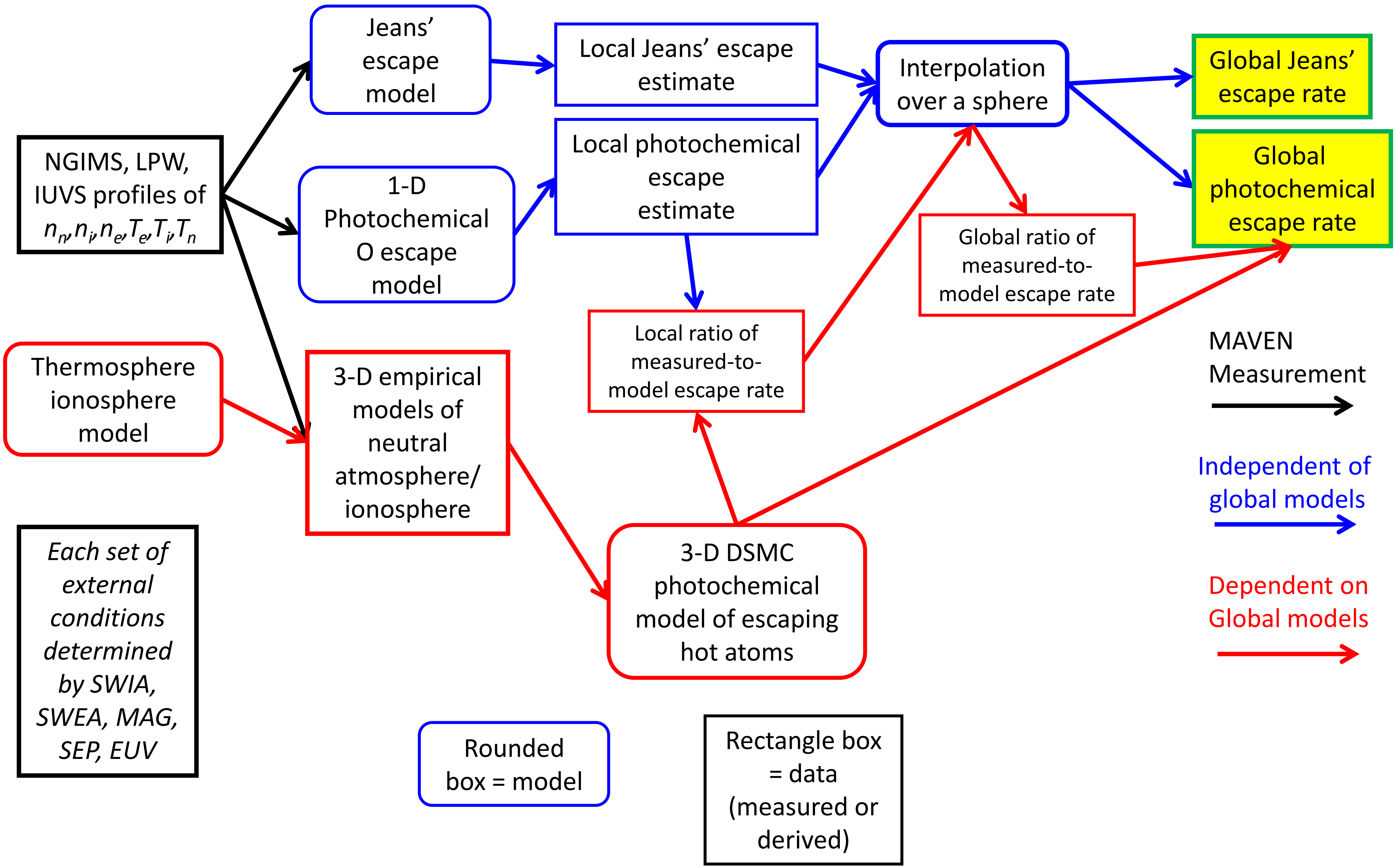


MAVEN can't be everywhere at the same time to monitor such a dynamic system, so we will employ a suite of models to 'fill in the gaps', both spatially, temporally and with respect to the external parameters that control atmospheric escape.

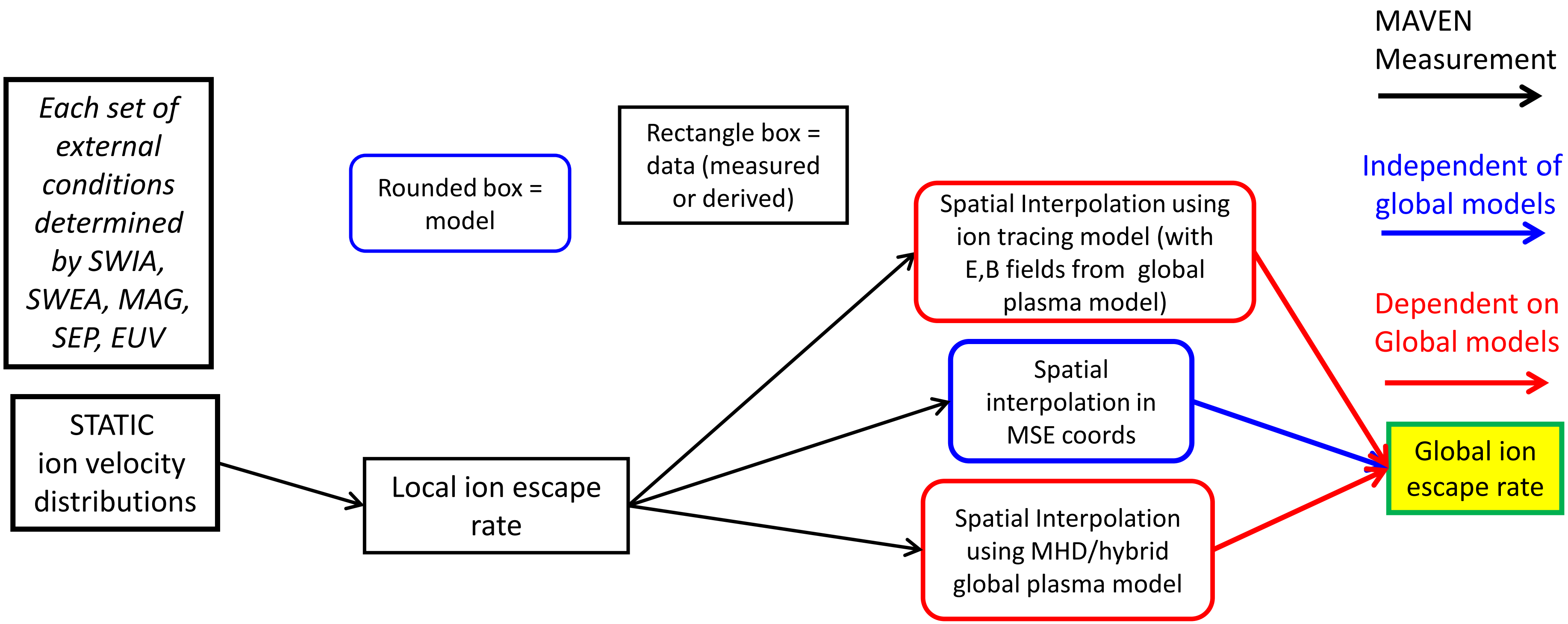
How will global models be used?

- For direct comparison with data to elucidate physical processes:
  - Thermosphere/ionospheric structure.
  - Ion/electron acceleration mechanisms & magnetic reconnection.
  - Distinguishing ion escape processes.
  - Distinguishing sputtering from photochemical escape of neutrals.
- To enable ‘smart’ interpolation of escape-relevant quantities between measurement locations:
  - A scaling function representing the ratio of measurements two modeled quantities, can be interpolated over a sphere.
  - Multiplying this function by the modeled quantity enables global escape rates to be calculated.
- Input conditions will be determined 2 different ways:
  - MAVEN model library, stored at the Science Data Center.
  - Individual runs, responding to interesting events and/or solar conditions.

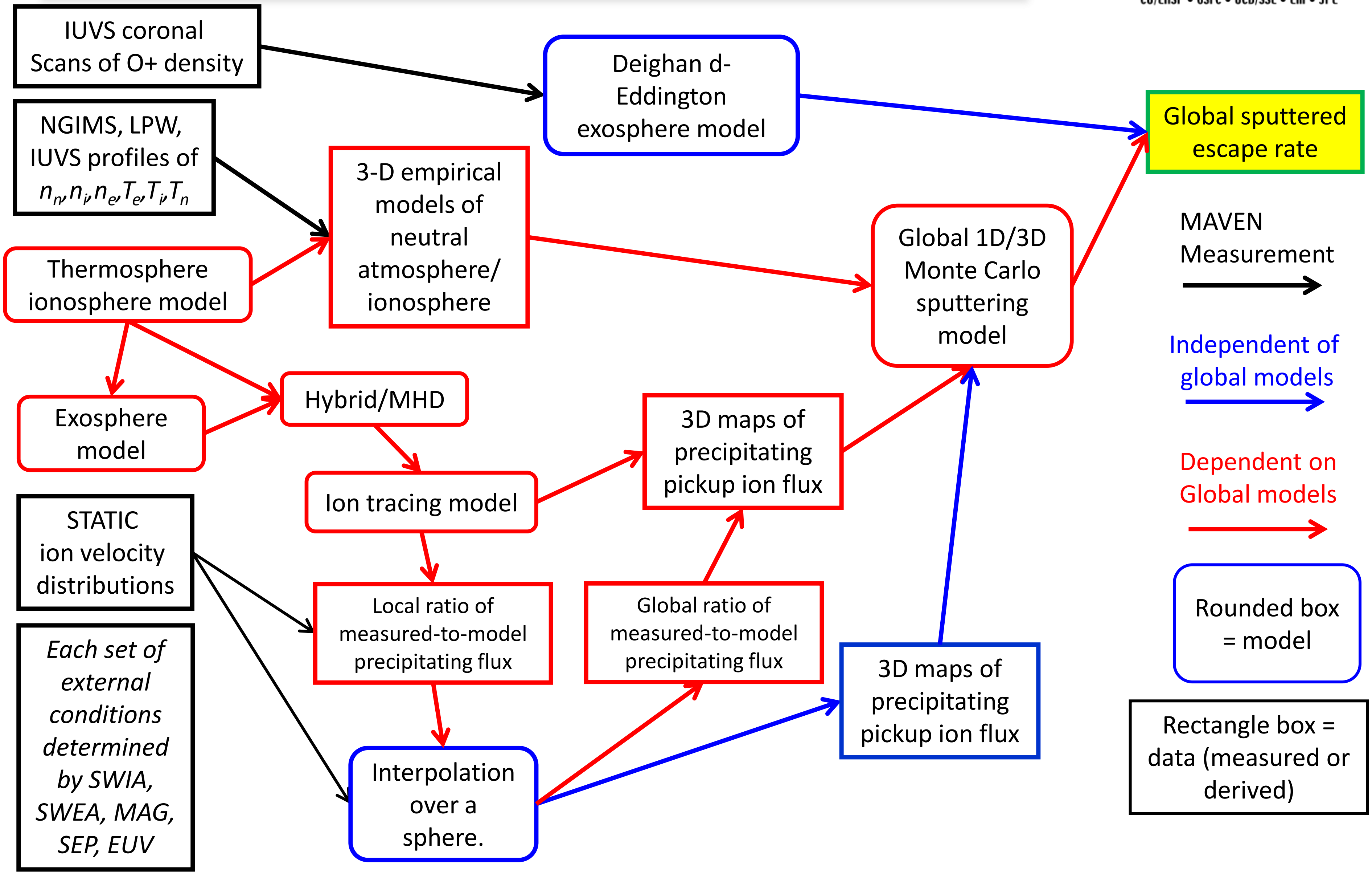
Jeans and photochemical escape pathway



Ion escape pathway



Sputtering escape pathway

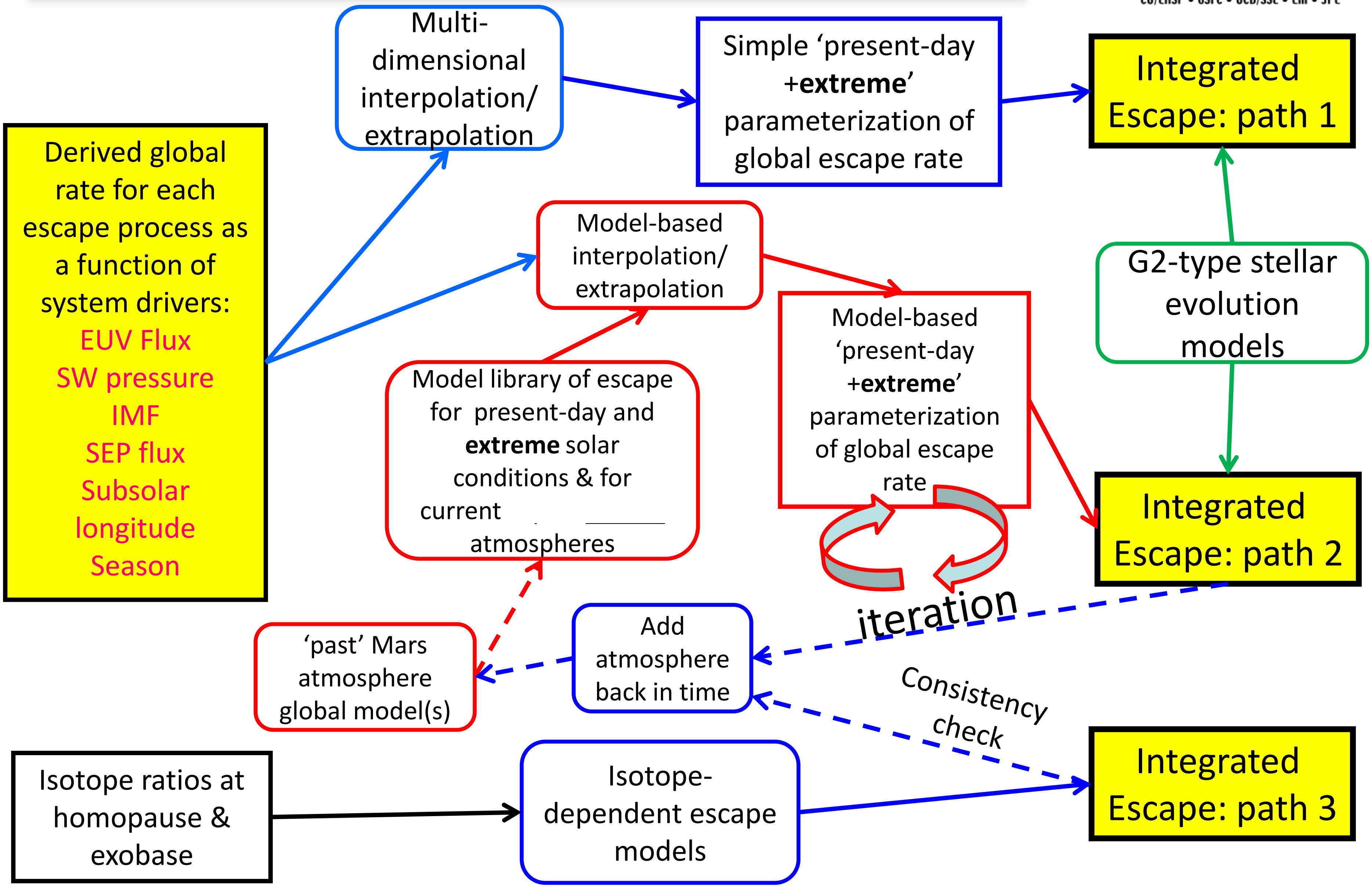


Global models & integrated escape

- Quiet-time plus ‘extreme’ global model runs required
  - Enables interpolation of global escape rates across multidimensional parameter space of inputs.
- Models with both current and ‘past’, higher surface pressures will eventually be required.
  - This will enable an iterative approach to historical atmospheric loss.

3 paths to integrated escape

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL



MAVEN Model Library Basics

- Coupling objective: To realistically coordinate global 3-D thermosphere-ionosphere-exosphere (TIE) model inputs to the plasma codes in order to fully capture the state (and variability) of the TIE system that serves as the reservoir for both neutral and ion escape.
- Coupling methodology: Sequential 1-way coupling between models (e.g. thermosphere-ionosphere -> exosphere -> plasma code exchange of fields)
- Parameters driving variability of neutral and ion escape to address:

-- Solar factors: (a) solar EUV fluxes, (b) SW dynamic pressure (e.g. density, speed), (c) IMF direction and magnitude.

-- Planetary Factors: (a) Mars season (heliocentric distance, sub-solar latitude), (b) Mars dust activity, (c) Mars crustal field orientation.

Thermosphere/Ionosphere-Exosphere-Plasma Model Simulations Planned (Michigan)

MAVEN
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Parameters	M-GITM (13)	DSMC (13)	MHD-MF (28)
Ls (season)	0, 90, 180, 270	0, 90, 180, 270	90, 180, 270
F10.7-cm (solar cycle)	70, 130, 200	70, 130, 200	70, 130, 200
Solar Wind N (#/cm^3), V(km/s) B(nT), IMF Orientation			**Nominal** 4.0, 400. 3.0, Normal
Sub-solar B-crustal orientation (180W is max field loc)			180W (noon) 0W (midnight) 90W (dawn)
Ancient Mars Parameters (2.5 BYA)	F10.7 = 3x Modern Ls = 180 (Equinox)	F10.7 = 3x Modern Ls = 180 (Equinox)	F10.7 = 3x Modern Ls = 180 (Equinox) N=4, V=400, B=3 180W (noon) IMF (Nominal)
	Bougher, Pawlowski	**Combi Group**	**Dong, Ma, Nagy**

Thermosphere/Ionosphere-Exosphere-Plasma Model Simulations Planned (HeliosAres)

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Parameters	LMD-MGCM (12)	Exosphere (12)	Hybrid global plasma model (6)
Ls (season)	0, 90, 180, 270	0, 90, 180, 270	90, 180, 270
F10.7-cm (solar cycle)	74, 120, 224	74, 120, 224	124
Solar Wind N (#/cm^3) V(km/s) B(nT) IMF Orientation			**Nominal** 4.0 400. 3.0 Normal, Cone angle 90°, near 0°
Sub-solar B-crustal orientation (180W is maximum field location)			180W 90W

Possible Cases to Extend the Library for various SW Conditions

Case Name	SW (density): #/cm³	SW (Velocity): Km/s	B(IMF): nT	B(crustal) Orient. wrt Sub-solar
High Speed Stream	4.0	1000.0	3.0 nT (Nominal sign)	0W (midnight)
SW Compression	20.0	400.0	3.0 nT (Nominal sign)	0W (midnight)
High SW Dynamic Pressure	20.0	1000.0	3.0 nT (Nominal sign)	0W (midnight)
Fast ICME Sheath	20.0	1000.0	*B*(IMF) Increased (Nominal sign) T_{ion} (increased)	0W (midnight)
ICME Driver	4.0	1000.0	*B*(IMF) Increased (Nominal sign) T_{ion} (nominal)	0W (midnight)
Rarefaction	0.5	400.0	*B*(IMF) nominal 3 nT magn & sign but more radial	0W (midnight)
IMF Opposite-1 (Ls = 90; F10.7 = 70)	4.0	400.0	3.0 nT IMF (opposite sign)	180W (noontime)
IMF Opposite-2 (Ls = 270; F10.7 = 200)	4.0	400.0	3.0 nT IMF (opposite sign)	0W (midnight)

How Library Outputs will be Made Available to MAVEN team

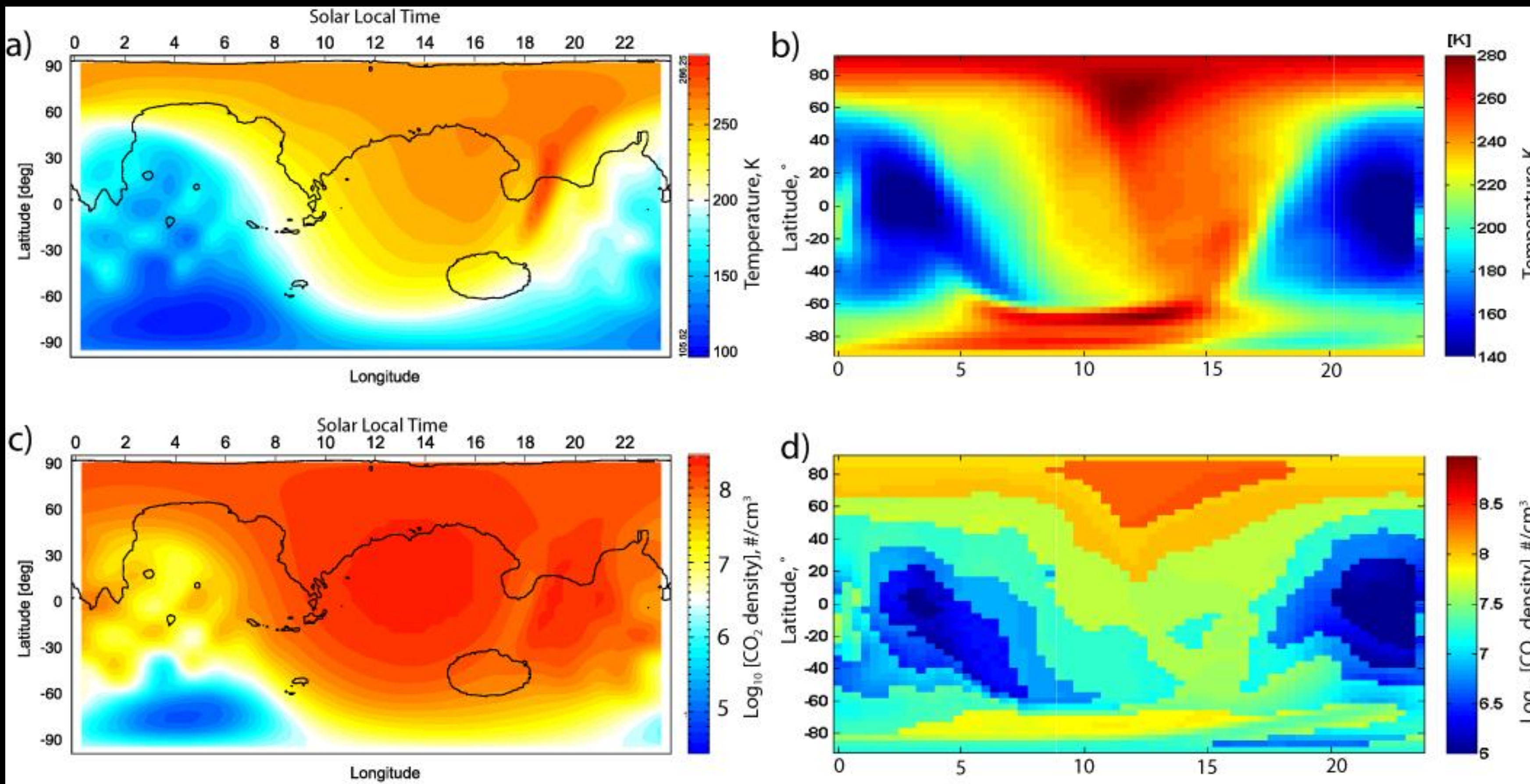
- Data cubes and associated documentation:
  - -- Neutral outputs (both cold and hot species: [n], Tn, winds)
  - -- Plasma outputs (both ionosphere & SW plasma: [i, e], Vi, B, Te, Ti)
  - -- Both MSO and GEO gridded tables
  - -- Formats (e.g. ascii files, idl save files)
  - -- Repository will be housed at the SDC.
- Flythrough routines:
  - -- Modeled KP files suffer from subsolar longitude errors: crustal fields will almost always be wrong…..
  - -- Existing project code can be used to fly-through model KP datasets
  - -- Model KPs may be made for special events where global model runs are appropriate
- Data visualization on MAVEN webpage (dynamic plots):
  - -- Global models only (Michigan, HelioSares, Japan, others?)
  - -- Multiple teams, with few varied input parameters chosen:
    (a) solar EUV (Lo-Hi), (b) SW dynamic pressure, (c) crustal fields?
  - -- Model tabs on webpage.

Global models: some questions

- Should the Michigan and HeliosAres models be used completely separately?
- Are there any plans to use the same lower atmosphere inputs to the two model sets?
- How will MAVEN NGIMS data be used to determine the basic inputs to the LMD-MGCM?

Modeling support for MAVEN

Thermosphere-Ionosphere models (Ls = 90, SMOD)

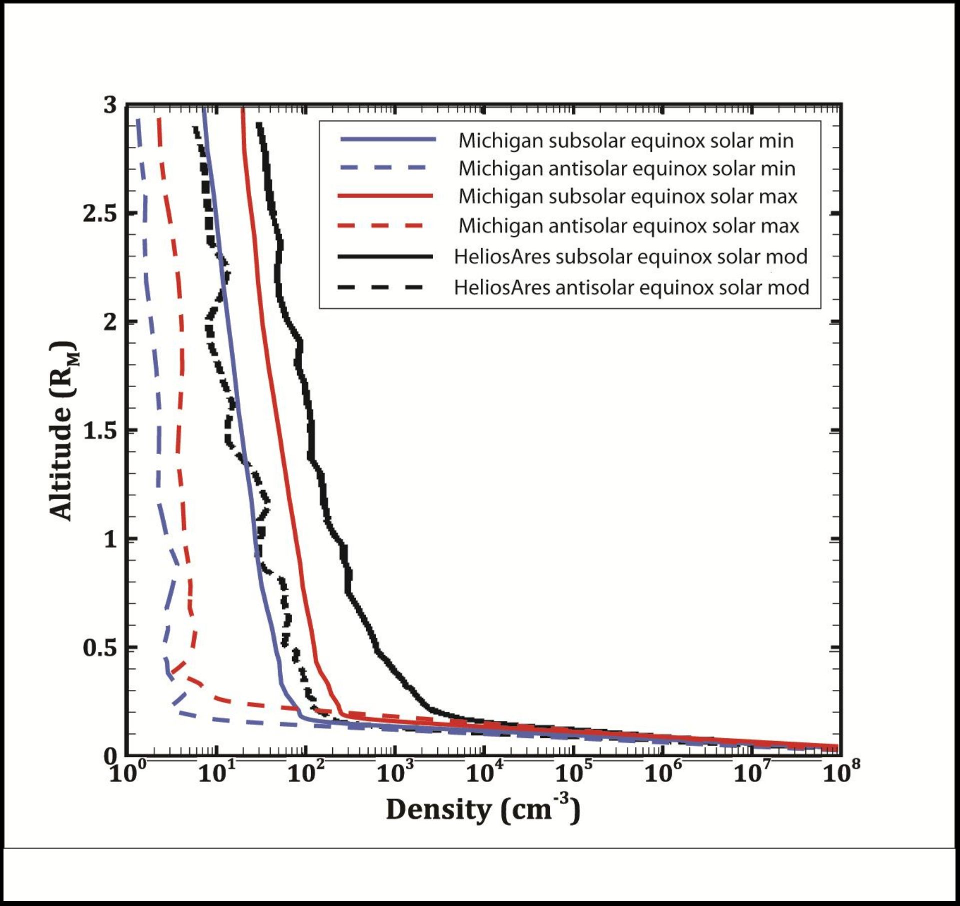


M-GITM (U. Michigan)

MGCM (LMD)

Modeling support for MAVEN

Kinetic neutral thermosphere-exosphere models



DSMC (U. Michigan)

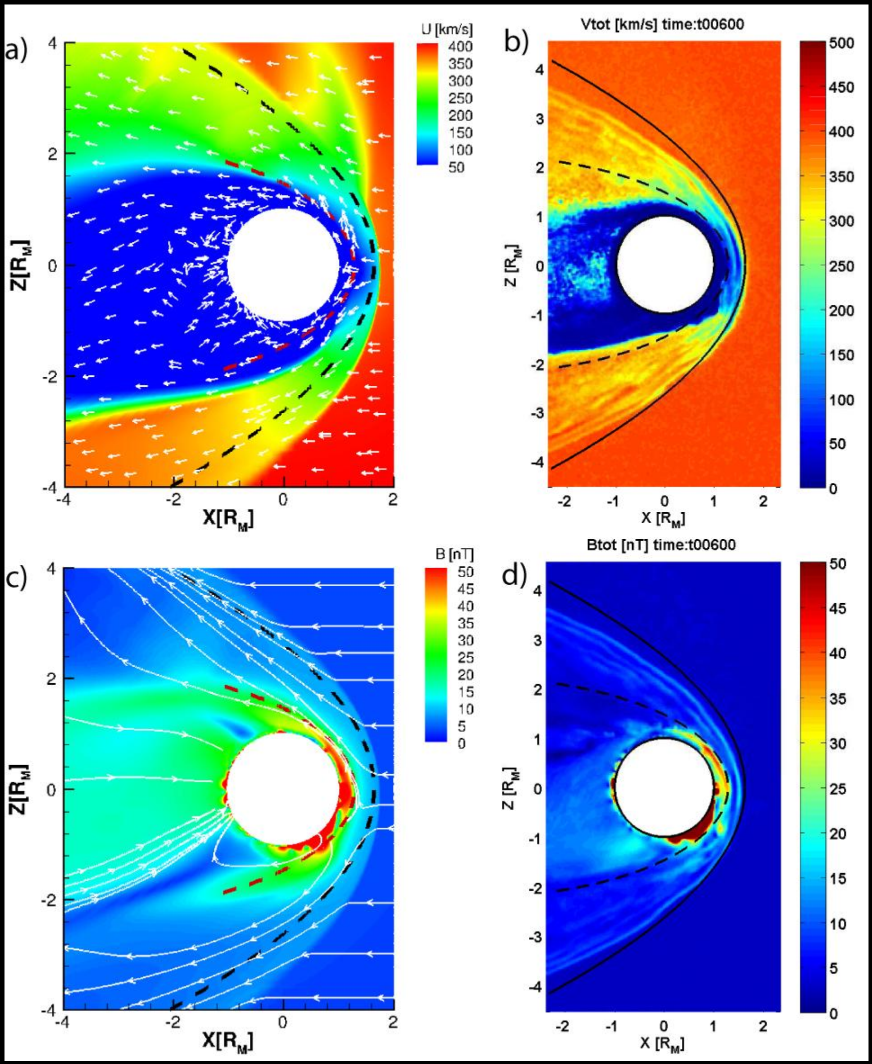
DSMC (Chaufray, LeBlanc)

Modeling support for MAVEN

Global plasma models of the Mars-solar wind interaction

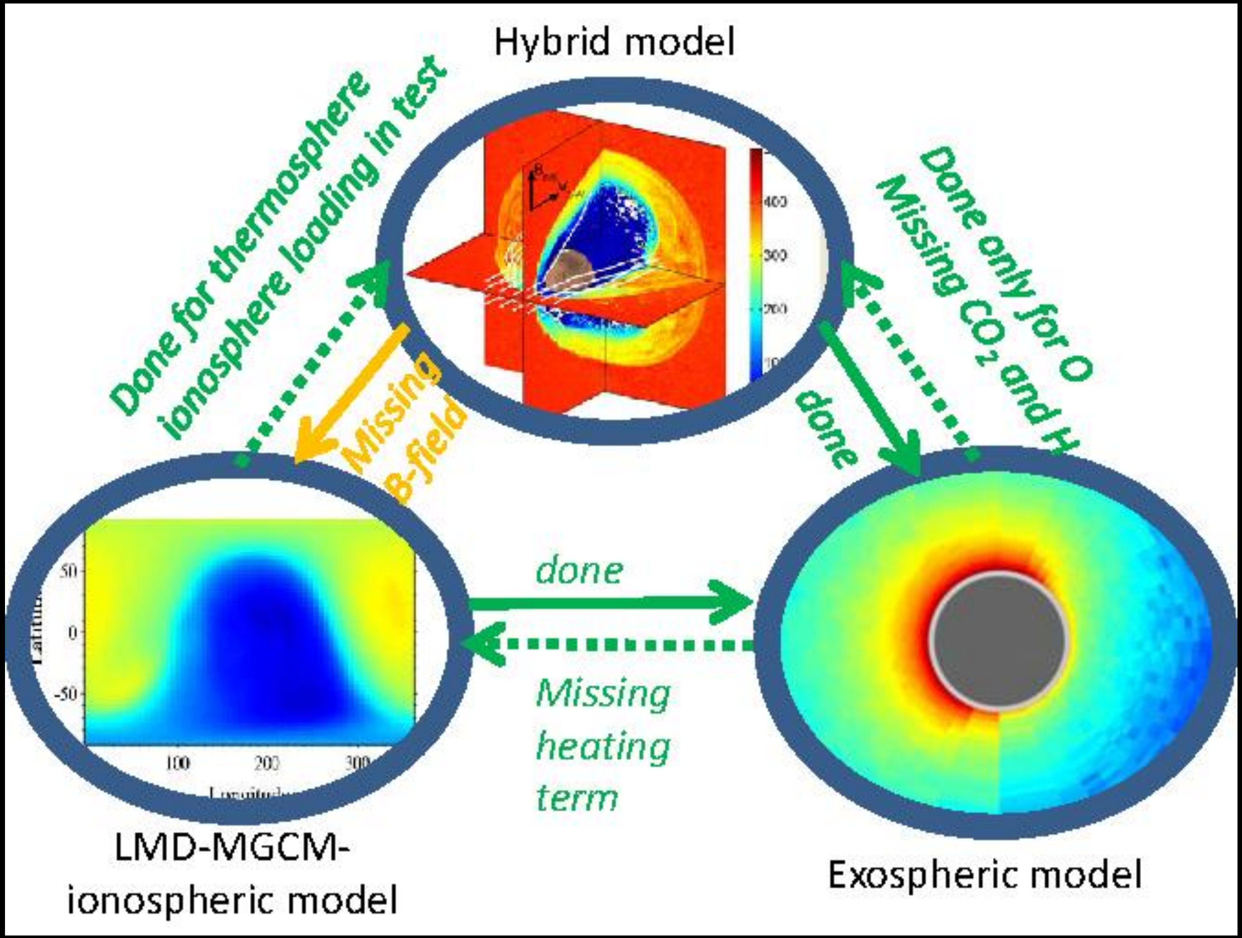
Ls = 180, SMAX

MHD multi-fluid
(U. Michigan)



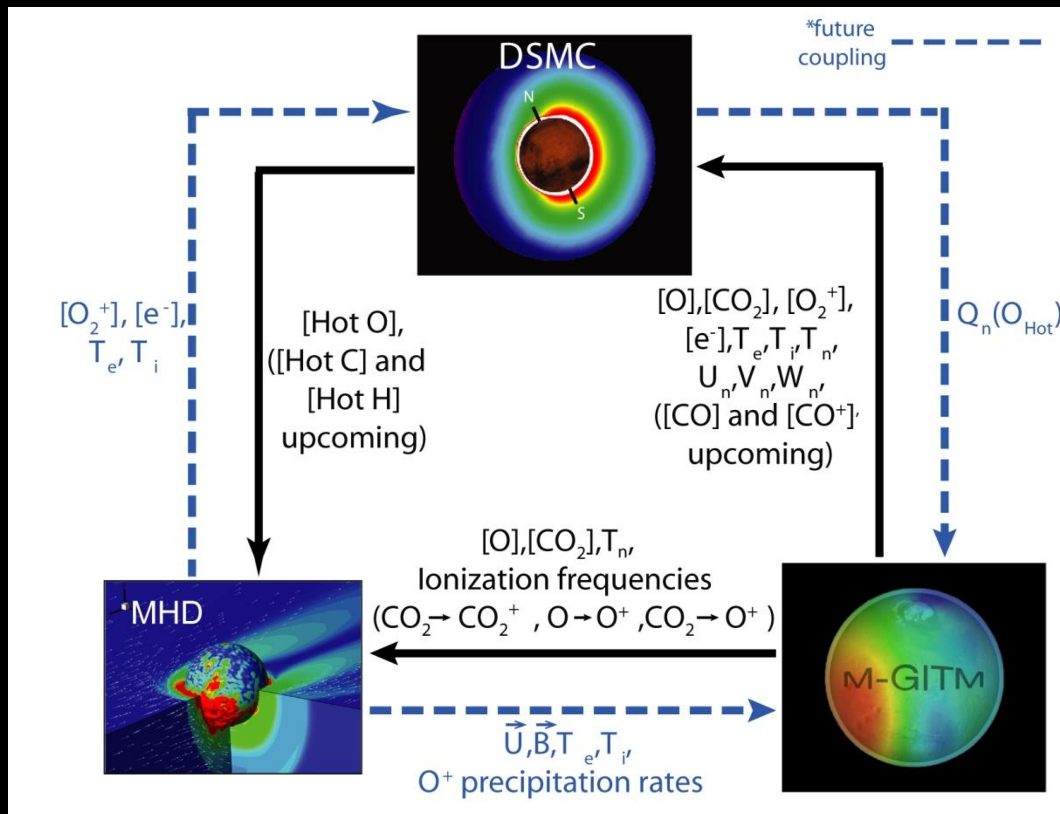
Hybrid model
(LMD)

Modeling support for MAVEN



HeliosAres Mars model framework

Modeling support for MAVEN



U. Michigan Mars model framework