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#### Indexing of exoplanets in search for potential habitability: application to Mars-like worlds

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ESLAB/ESA 2017

# **Data and Analysis**

**Data Source**: For 3500+ exoplanets

- 1. Habitable Exoplanet Catalog-University of Puerto Rico (www.phl.upr.edu)
- 2. Solar system dynamics database-JPL, CalTech (<u>www.ssd.jpl.nasa.gov</u>)
- 3. Exoplanet.org/eu.



### **Calibration of Surface Temperature**



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J. M. Kashyap et al. (2017), Astrophys Space Sci

# **Earth Similarity Index (ESI)**

ESI is a scale to measure the similar parameters as that of Earth.

$$ESI_x = \left(1 - \left|\frac{x - x_0}{x + x_0}\right|^m\right)^{w_x}$$

Where, **x** is the property of the planet- in this case, either **radius**, **density**, **escape velocity** or **temperature**.

 $\mathbf{x_0}$  is the value of this property for Earth,

**m** is the input variable

 $\mathbf{w}_{\mathbf{x}}$  is the weight exponent of a property.



## **Calculated weight exponents**

Planetary Property	Ref. Value	Ref. Value	Weight Exponents	Weight Exponents
	for ESI	for MSI	for ESI	for MSI
Mean Radius	1EU	1MU	0.57	0.77
Bulk Density	1EU	1MU	1.07	2.09
Escape Velocity	1EU	1MU	0.70	1.04
Surface Temperature	288K	240K	5.58	3.08



# Interior, Surface ESI & Global ESI

 $ESI_I = (ESI_r \times ESI_\rho)^{1/2}$ 

$$ESI_S = (ESI_e \times ESI_T)^{1/2}$$

#### $ESI = (ESI_I \times ESI_S)^{1/2}$





## **Comparison of ESI<sub>s</sub>and ESI<sub>I</sub>**



### **Scattered ESI Plot results**





# **Mars Similarity Index (MSI)**

MSI is a scale to measure the similar parameters as that of Mars.

$$MSI_{x} = \left( \left[ 1 - \left( \frac{x - x_{0}}{x + x_{0}} \right)^{n} \right]^{W_{x}} \right)$$

Where, **x** is the property of the planet- in this case, either **radius**, **density**, **escape velocity** or **temperature**.

 $\mathbf{x_0}$  is the value of this property for Earth,

**m** is the input variable

 $\mathbf{w}_{\mathbf{x}}$  is the weight exponent of a property



# Interior, Surface MSI & Global MSI

$$MSI_I = (MSI_R \times MSI_\rho)^{1/2}$$

 $MSI_{S} = (MSI_{T} \times MSI_{v_{e}})^{1/2}$ 

 $MSI = (MSI_I \times MSI_S)^{1/2}$ 



#### **Comparison of interior and surface MSI**



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#### **Scattered MSI plot result**





#### Mass v/s Radius Plot in (EU)



#### Conclusions

- Using the known data for the Solar System objects, we established the calibration relation between surface and equilibrium temperatures to devise an effective way to estimate the value of the surface temperature of exoplanets.
- From our study, we found that 20 Earth-like exoplanets with ESI value above 0.8 are potentially habitable planets.
- ▶ 12 Mars-like planets with MSI, to search methane specific extremophiles.

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# References

Schulze-Makuch D., et al."A two-tiered approach to assess the habitability of exoplanets," *Astrobiology*, **11**, 1041 (2011).

Kashyap J. M., Safonova M. and Gudennavar S. B., "ESI and MSI data sets2", *Mendeley*, 2017. http://dx.doi.org/10.17632/c37bvvxp3z.6.

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