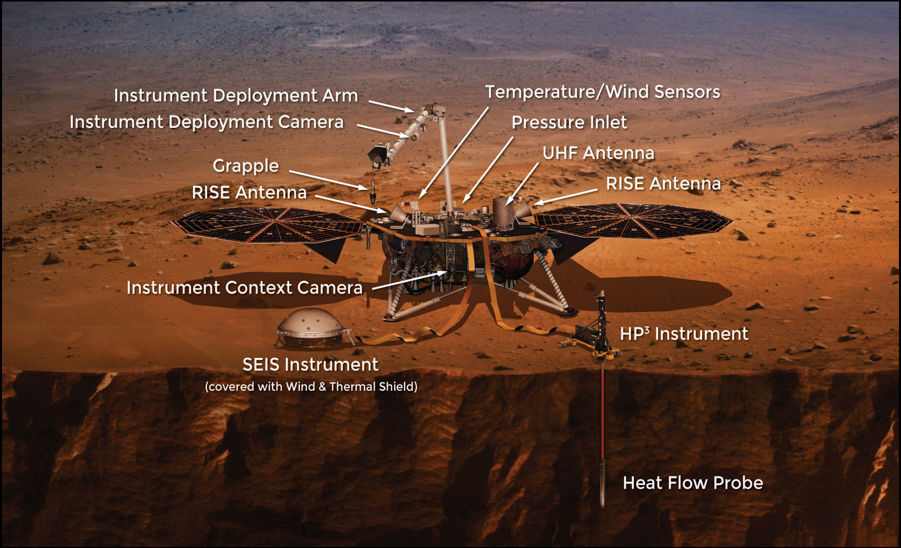
Atmospheric science with InSight

Aymeric Spiga et al.

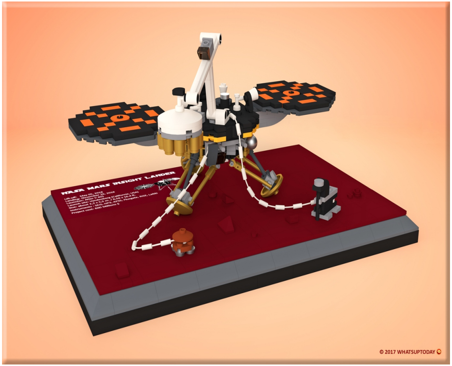
February 28, 2018

InSight 2018 mission to Mars



[NASA InSight website: artist's Concept of InSight Lander on Mars]

Vote for InSight lander replica at LEGO Ideas



WTS deployment test

[Project submitted by Philippe Labrot and Valérie Roche]

InSight instruments for atmospheric science

Temperature and wind (speed & direction)

- ✎ APSS/TWINS: 2 booms repackaged from MSL / REMS
- ✎ sampling at 1 Hz, accuracy of about 5 K and $1 - 3$ m s^{-1}
- ✎ one boom operating windward (boom swapping $> 2\times$ a sol)

Pressure sensor

- ✎ APSS/PS: highly-sensitive, low noise (RMS $\sim$ 10 mPa)
- ✎ would enable pressure decorrelation of seismic signal
- ✎ sampling at 20 Hz, response time of at least several Hz

Other instruments

- ✎ HP^3 / RAD measurements of surface brightness temperature
- ✎ cameras IDC / ICC for dust opacity; monitoring ice clouds
- ✎ RISE to detect rotational variations of Mars

InSight original observing strategy

Limited bandwidth + Focus on rare seimic events

- ✎ sampling full rates *continuously* (SEIS & PS 20-100 Hz, 1 Hz TWINS)
- ✎ Stored on board in circular buffer (6 weeks long, 7 priority buffers)
- ✎ Down-sampled data ($0.1 - 0.2$ Hz) & high-frequency diagnostics (variance sampled $1 - 0.25$ Hz) downlinked for ALL times
- ✎ Ground processing will then select specific events for full data-rate playback
- ✎ Remaining bandwidth will be used following the recommendation of the science team.

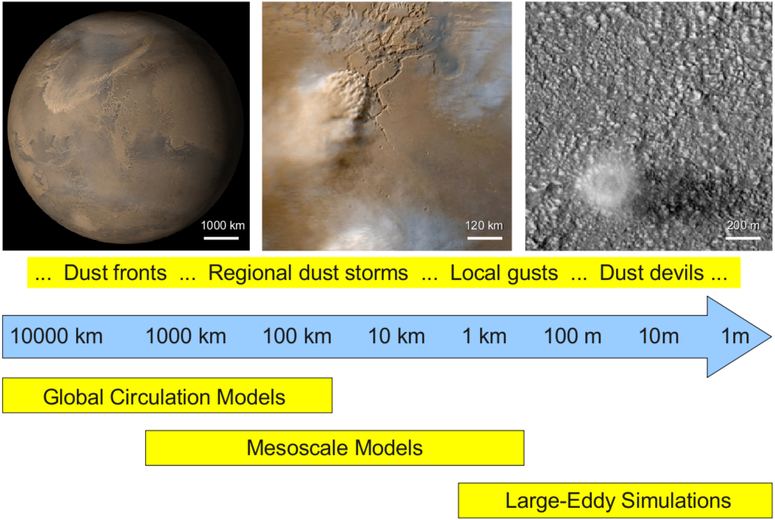
Not all meteorological occurrences are events

- ✎ ✔ convective vortices, gravity waves
- ✎ ✗ dust fronts, regional dust storms, diurnal cycle

Pressure: THE meteorological variable

Variability	Associated phenomena
Secular	CO_2 cap mass budget
Interannual	global dust storms
Seasonal	CO_2 cycle, atmospheric dynamics
Day-to-day	baroclinic waves
Diurnal	thermal tides, slope winds
Hour-to-hour	gravity waves, slope winds
Minute-to-minute	boundary layer convection
Second-to-second	convective vortices & cells
Below second	inertial / dissipation turbulence

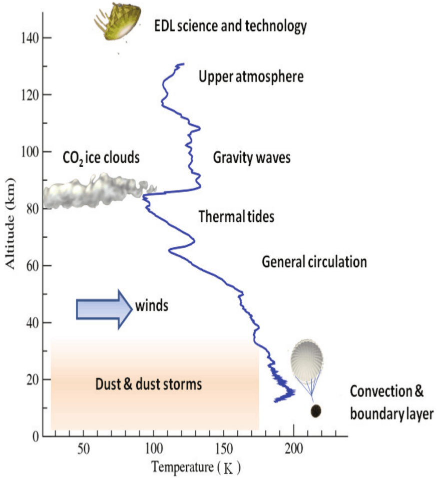
Scales and Models

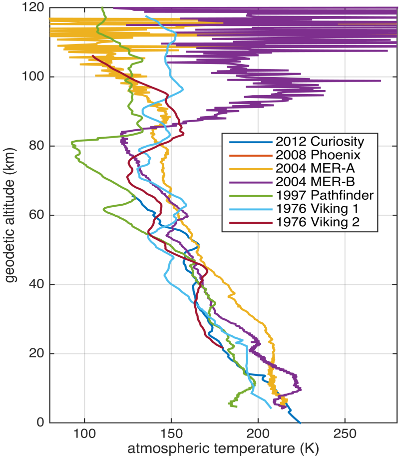


[Spiga and Lewis, Mars Journal 2010]

A proposed acronym: IDEAS

InSight Descent and Entry: Atmospheric Science

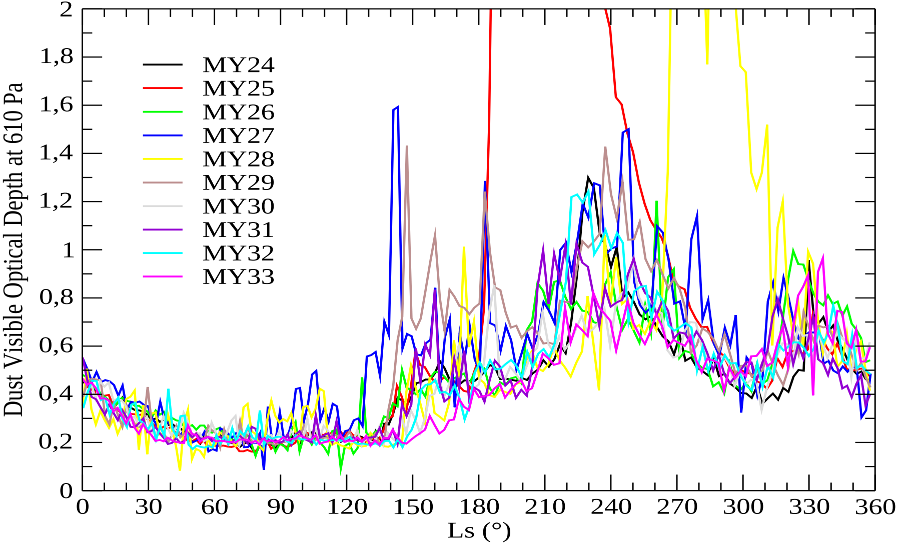




[Left: F. Forget; Right: B. Van Hove, included in Spiga et al. SSR submitted]

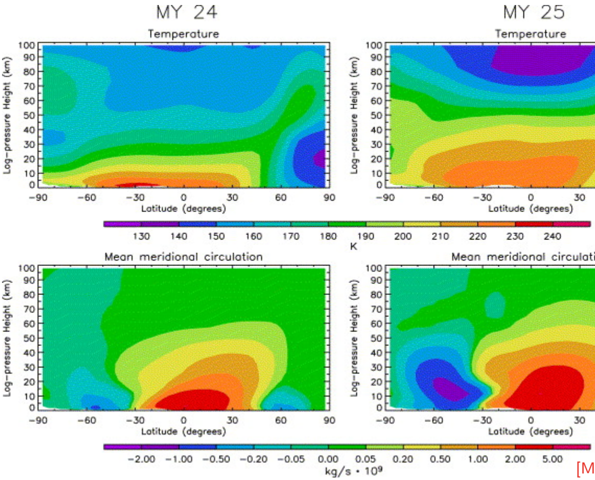
Interannual variability in dust opacity

orbital+in-situ datasets interpolated with kriging by Montabone et al. Icarus 2015



Suspended dust and Global circulation

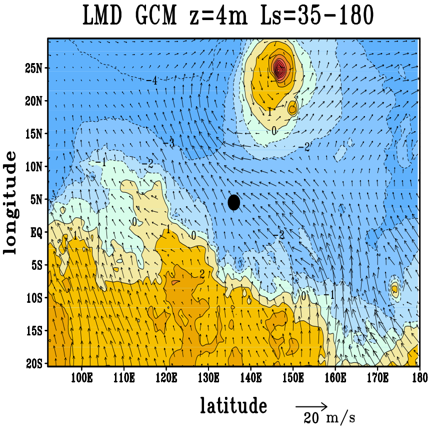
Question : how does the Hadley cell evolve when the Martian atmosphere is very dusty on a global scale



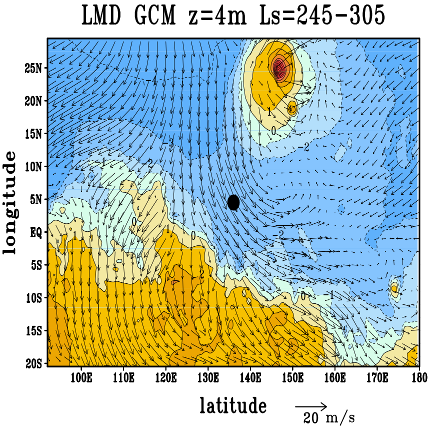
[Montabone et al. AdSR 2005]

Large-scale wind regimes at InSight landing site

spring-summer

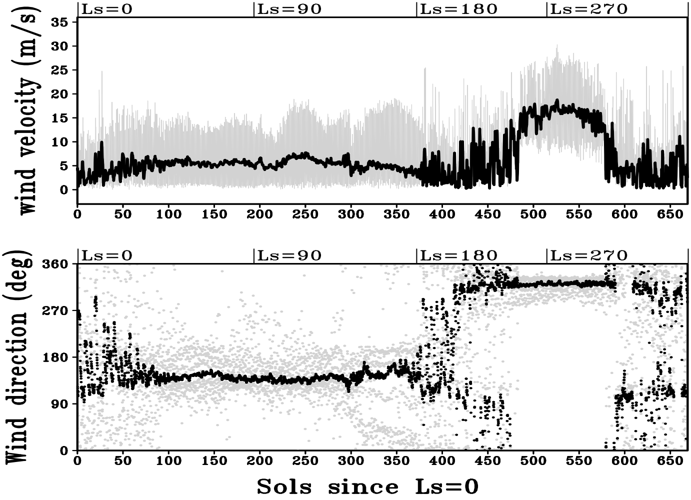


fall-winter



[Spiga et al. SSR submitted; from Pottier et al. Icarus 2017 GCM simulations]

Large-scale wind regimes at InSight landing site



[Spiga et al. SSR submitted; from Pottier et al. Icarus 2017 GCM simulations]

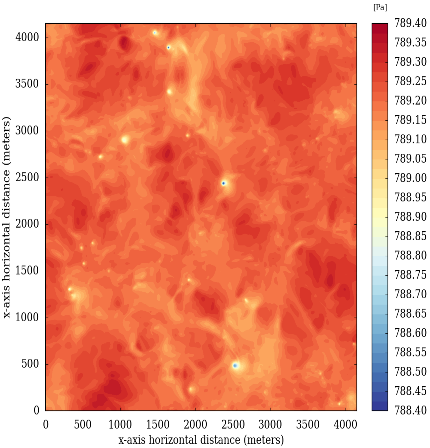
InSight plongée dans la couche limite

[Extrait d'un dessin original de Manchu]

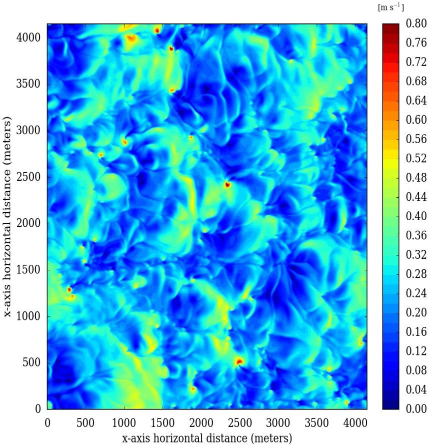
Large-Eddy Simulations for Insight

horizontal resolution 10 m, results at local time 9AM

Surface pressure



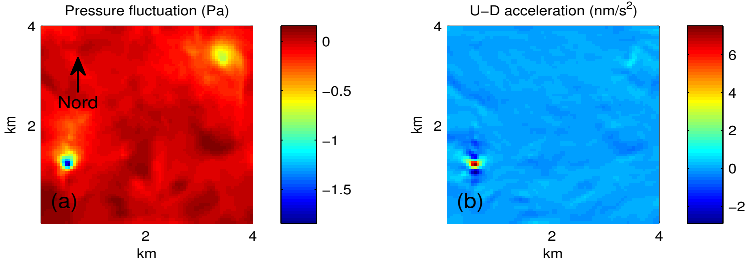
Friction velocity

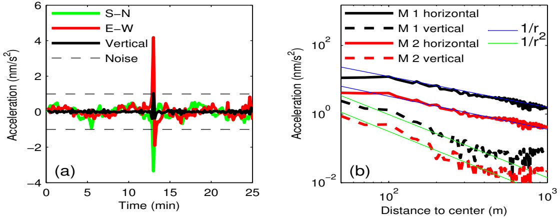


[Spiga et al. SSR submitted]

Seismic noise of dust devils (for InSight / SEIS)

Large-Eddy Simulations + Sorrell theory

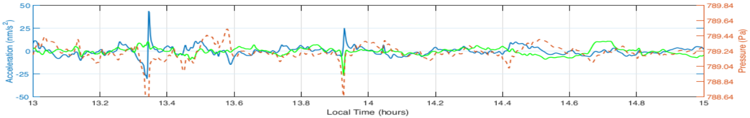


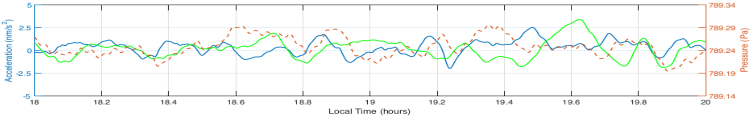


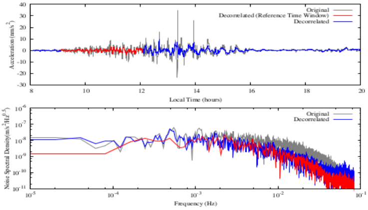
[Kenda et al. Space Science Reviews 2017]

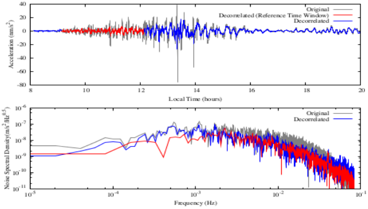
InSight decorrelation strategy tested

with the synthetic “noise” from LES pressure field (in windy & calm conditions)







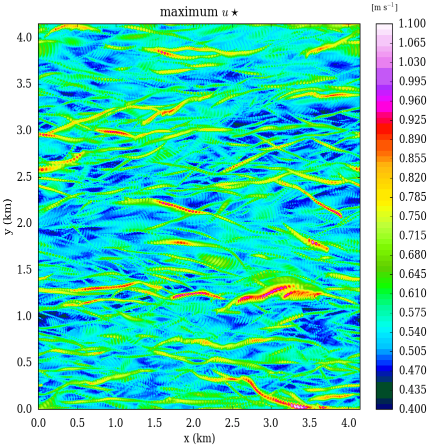


[Murdoch et al. Space Science Reviews 2017]

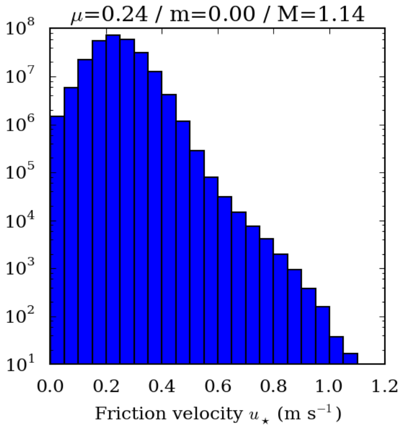
Friction velocity predicted by LES computations

Background wind is 5 m s^{-1}

Maximum map

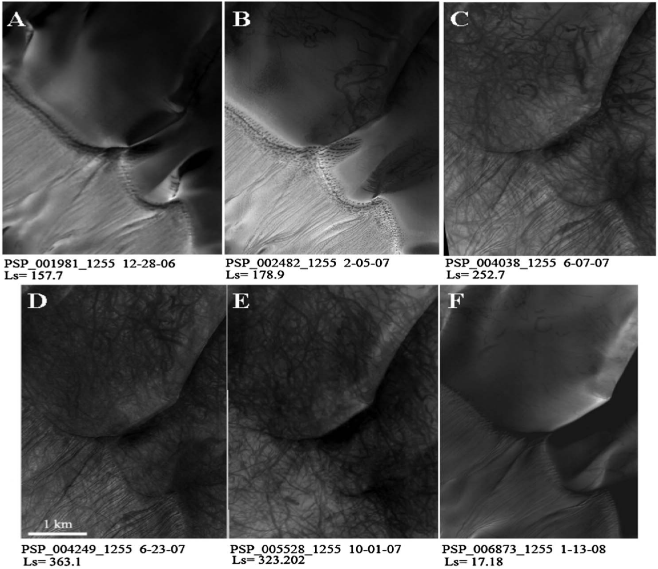


Histogram



[Spiga et al. SSR in preparation; method in Mulholland et al. Icarus 2015]

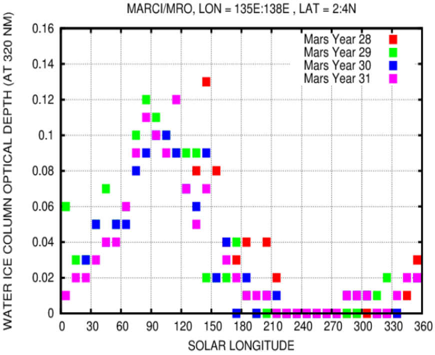
Seasons and dust devils' tracks Russell Crater SH

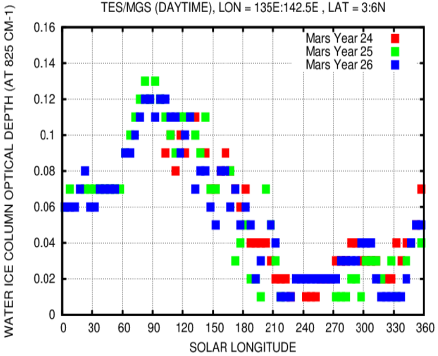


[Verba et al. JGR 2010]

Mars' dust storms

Water-ice clouds at InSight landing site





[Spiga et al. SSR submitted; data courtesy of M. Wolff and M. Smith]

Coordinated observations: landers & orbiters

A prototype of meteorological network

- ✎ Comparisons TWINS on Elysium vs. REMS on Curiosity
- ✎ Comparisons tau measurements: InSight vs. Curiosity

Orbital spacecraft vs. InSight

- ✎ dust storms, clouds, etc... MRO/HiRISE+MARCI, TGO/CaSSIS
- ✎ TGO/ACS measurements of temperature, dust (+ MRO/MCS)
- ✎ ...assimilation in LMD GCM: winds
- ✎ MEx continuing monitoring (OMEGA, PFS, MaRS)

References

Kenda, B., Lognonné, P., Spiga, A., Kawamura, T., Kedar, S., Banerdt, W. B., Lorenz, R., Banfield, D., and Golombek, M. (2017).
Modeling of ground deformation and shallow surface waves generated by martian dust devils and perspectives for near-surface structure inversion.
Space Science Reviews.

Murdoch, N., Kenda, B., Kawamura, T., Spiga, A., Lognonné, P., Mimoun, D., and Banerdt, W. B. (2017).
Estimations of the seismic pressure noise on mars determined from large eddy simulations and demonstration of pressure decorrelation techniques for the insight mission.
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Spiga, A., Teanby, N., Forget, F., Lucas, A., Kenda, B., Banfield, D., Widmer-Schnidrig, R., Murdoch, N., Lemmon, M., Garcia, R., Martire, L., Karatekin, O., Le Maistre, S., Van Hove, B., Dehant, V., Lognonné, L., Lorenz, R., Mimoun, D., Rodriguez, S., Beucler, E., Daubar, I., Golombek, M., Bertrand, T., Nishikawa, Y., Millour, E., Rolland, L., Brissaud, Q., Rodriguez Manfredi, J., Kawamura, T., Mocquet, A., Mueller, N., Martin, R., Clinton, J., Stutzmann, E., Spohn, T., Smrekar, S., and Banerdt, W. (2018).
Atmospheric Science with InSight.
Space Science Reviews (submitted).

One intriguing question whose answer I would like to know

What chain of physical and dynamical processes makes one given dust grain to be lucky enough to be part of a global dust event, while so many fellow dust grains would only participate to local storms?

Short version

Hi. I am a dust grain on Mars. How can I get a free worldwide tour?