Future lander observation by Japanese Mars EDL mission

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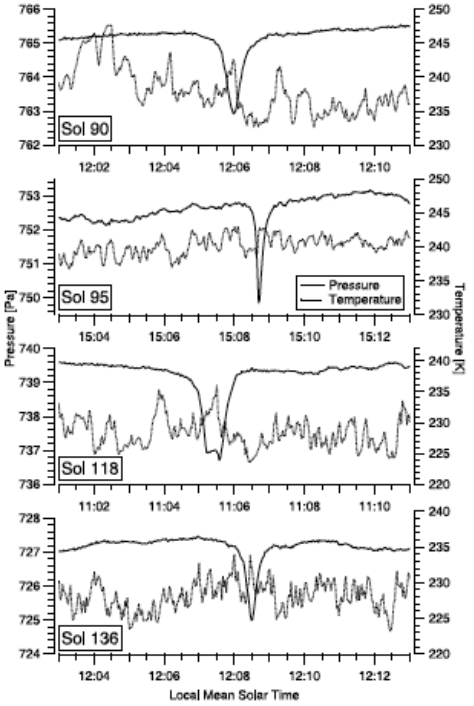
Meteorological Interest on Martian Surface

- Source of Physical components
  - (Dust, Water Vapor,..)
- Boundary Layer
  - (Source / Sink of Momentum)
  - Transport Physical Components
- Others
  - in-situ (e.g. Heat Inertia, Roughness, …)

Meteorological Observation:

1. Environmental Monitor and meteorological observation (10 minutes mean)
    1. Temperature
    2. Wind Velocity, Wind Direction
    3. Pressure
    4. Short / Long wave radiation
    5. Thermal Inertia of soil
        (1 hour mean of surface temperature)
2. Dust devil Structure
    1. Pressure drop (2Pa) of Dust devil
    2. Wind velocity / direction
    3. Numbers or Amount of dust
        (require Dust particle counter or LIDAR)
    4. Opacity (Navigation Camera)
3. Power spectrum of wind (Extra)
    1. Wind velocity / Pressure at 2s period (up to 60sol)



Observed Pressure while Dust devil Event

Instruments

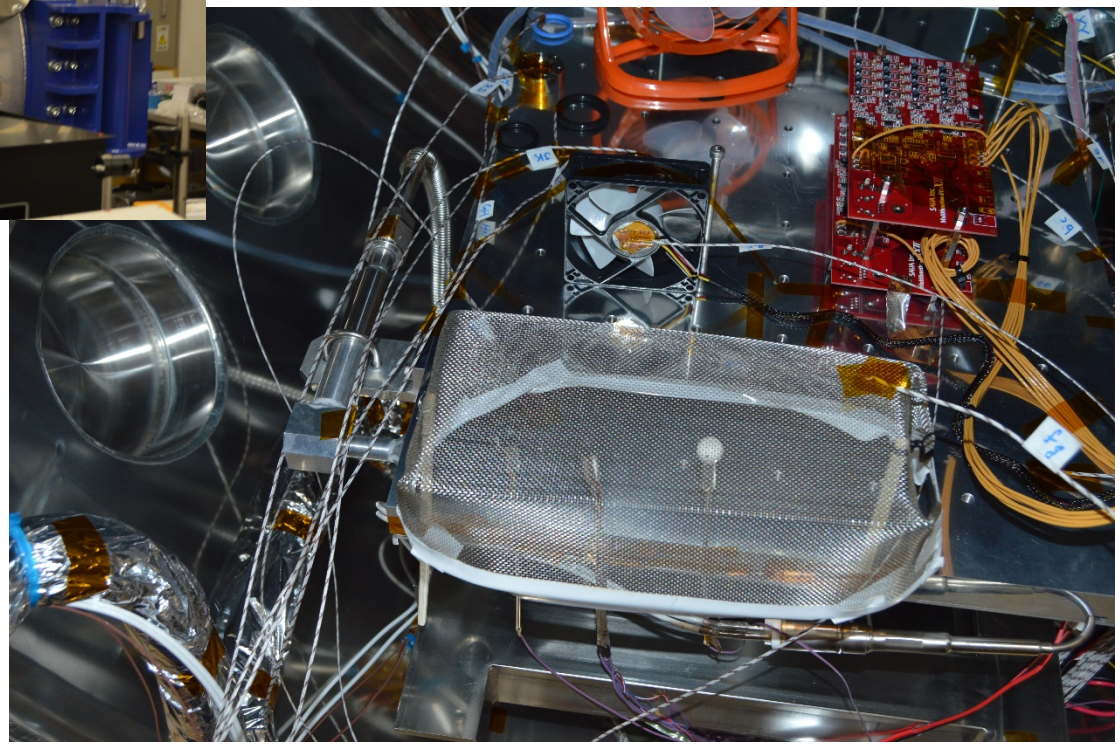
- BASIC Components
  - Thermometer
  - Barometer
  - Anemometer
  - (CAMERA)
- Dust Measurements
  - Particle Counter
  - LIDAR

Talk about :

developing / testing status some instruments

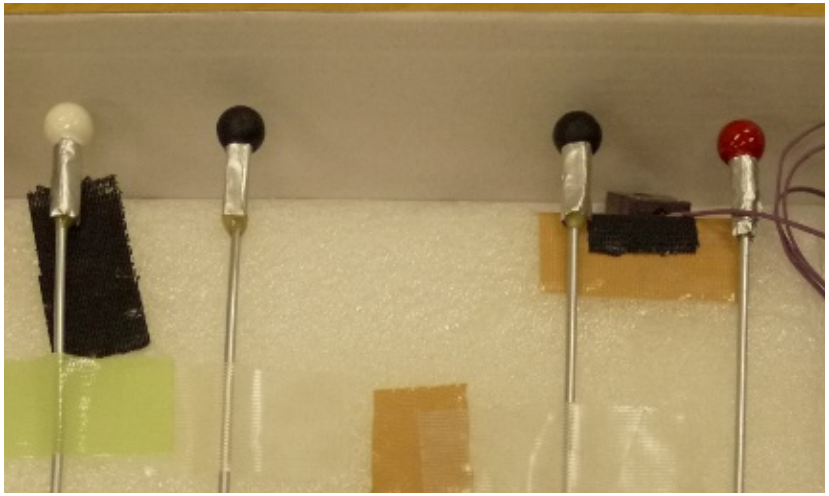
TESTING ENVIRONMENT

Mars Environmental Simulation Chamber / PERC



5-10hPa (1000 – 0 hPa)
0 : -120℃ (40 : -120℃)
CO_2 or Ar (Lower -80℃)

Globe Thermo-Radiative-Anemometer



using on Earth with Bio-sensors
for human health meteorology
(Heatstroke)

（Nakayoshi /Tokyo Univ. of Sci.）

- 2 globes of different colors + 1 more black globe (ϕ12)
- different absorption rates of radiation
  (Shortwave (Solar radiation) and Longwave(mainly Ground Radiation)).
- measurement of each temperature of globes (by thermocouple).
- 1 more black globe is heated.

Tested in Mars Environment Chamber

Globe Sensors Temperature determination factor

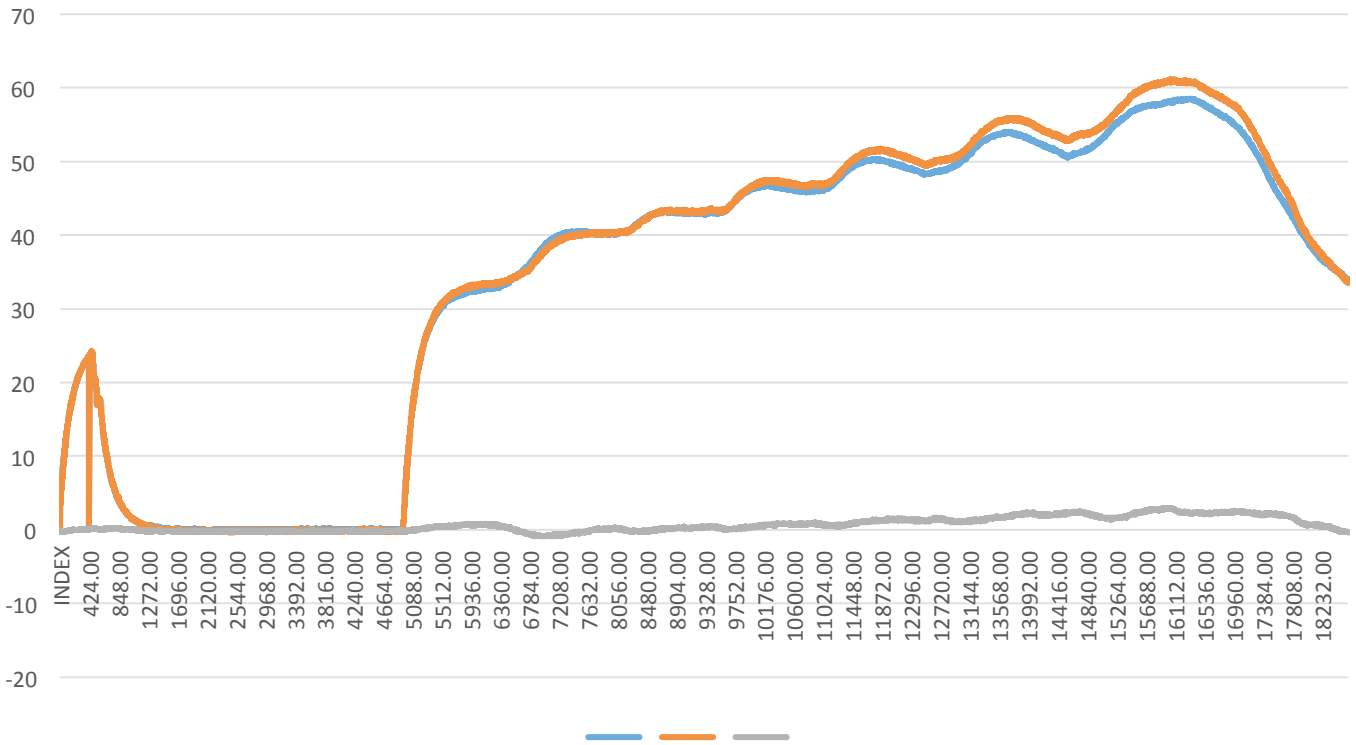
$$C\downarrow gbh\ /A\ (dT\downarrow gbh\ /dt\ )=(1-\alpha\downarrow b\ )\mathrm{S}+\varepsilon\downarrow b\ L-\varepsilon\downarrow b\ \sigma\ T\downarrow gbh\uparrow 4\ -h(T\downarrow gbh-T\downarrow a\ )+H\downarrow input$$

$$C/A\ (dT\downarrow gb\ /dt\ )=(1-\alpha\downarrow b\ )\mathrm{S}+\varepsilon\downarrow b\ L-\varepsilon\downarrow b\ \sigma T\downarrow gb\uparrow 4\ -h(T\downarrow gb-T\downarrow a\ )$$

$$C/A\ (dT\downarrow gw\ /dt\ )=(1-\alpha\downarrow w\ )\mathrm{S}+\varepsilon\downarrow w\ L-\varepsilon\downarrow w\ \sigma\ T\downarrow gw\uparrow 4\ -h(T\downarrow gw-T\downarrow a\ )$$

C: Thermal Capacity A:Surface Area S,L:Short,Long wave radiative flux
α:Albedo ε:emissivity σ : Stefan-Boltzmann constant Hinput:Heater's Heat input

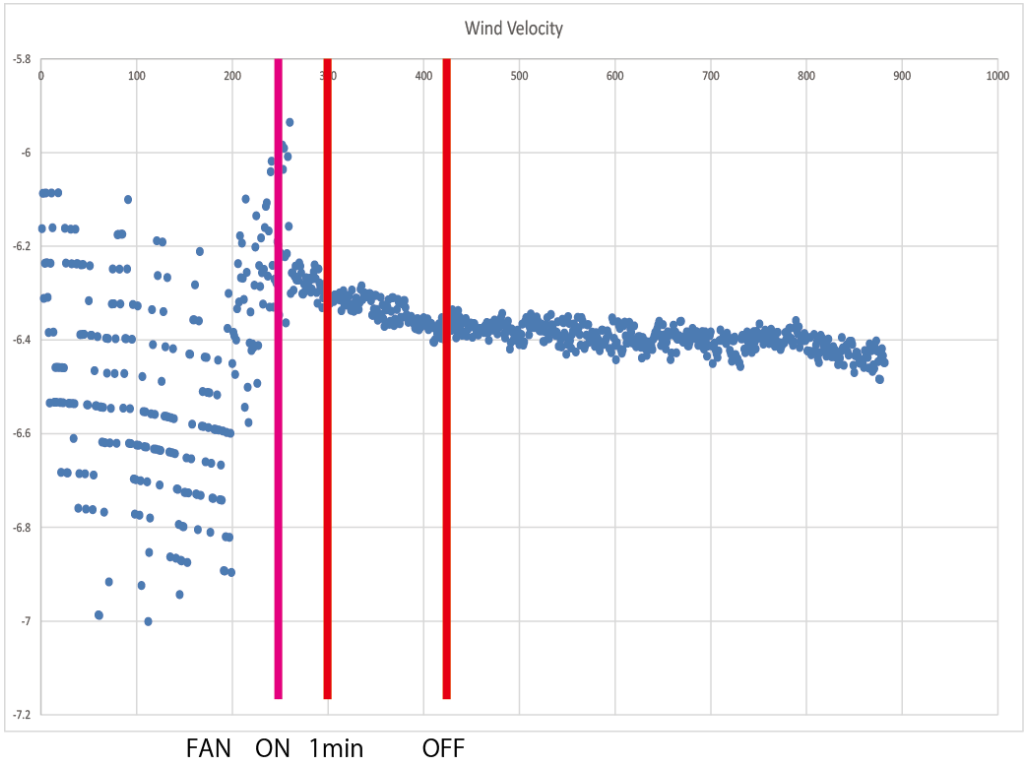
Radiation



difference between globes:

gray line : feel Long wave (due to difference of emissivity)

Anemometer



Calculated Wind velocity
(1 min Running mean)

Left side of vertical FAN ON line :
very turbulently air condition.
(because of injection CO2)

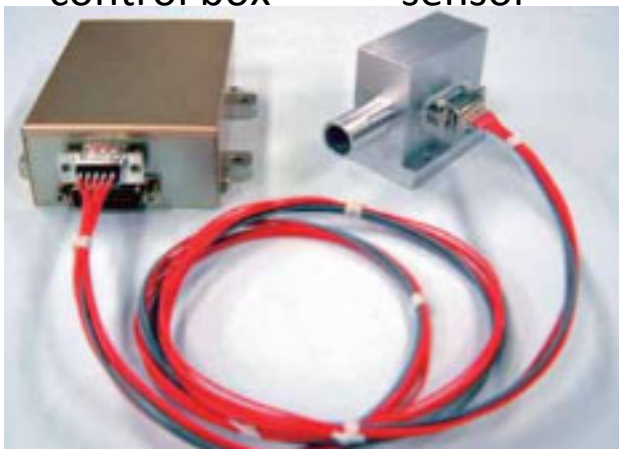
NOTE: using Heat Capacity value at 1000hPa Air
So Calculated value is not meaningless.

Accuracy

- On Earth
  - Wind Velocity(0.24 m/s)
  - Short Wave flux (19.1W/m^2)
  - Long Wave flux (14.8W/m^2)
- On Mars
  - Wind Velocity -> detectable?
  - Short Wave (maybe same: twice larger relatively)
  - Long Wave (maybe same: 10times larger relatively)

Barometer

control box sensor



Crystal Oscillator:

- Impedance is a Fuction of Friction (and temperature)
- Dependency can control with cutting angle
  (this sensor mainly Impedance - friction(pressure)
  Frequency - Temperature)
- total 200g , 10cm x 10cm x 5cm

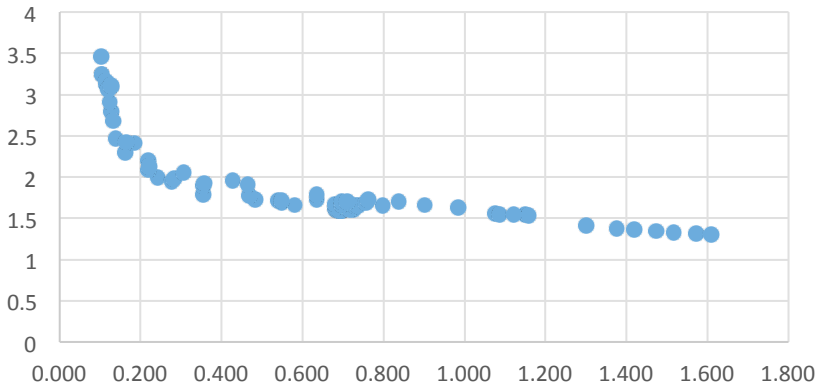
Kurihara(Hokkaido Univ.)

Using on Rocket observation troposphere to mesosphere:

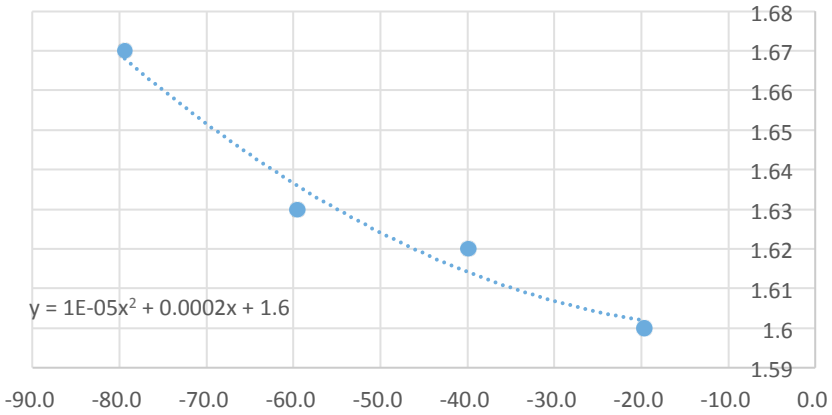
- wide dynamic range
- robust for vibration at launch time

Pressure

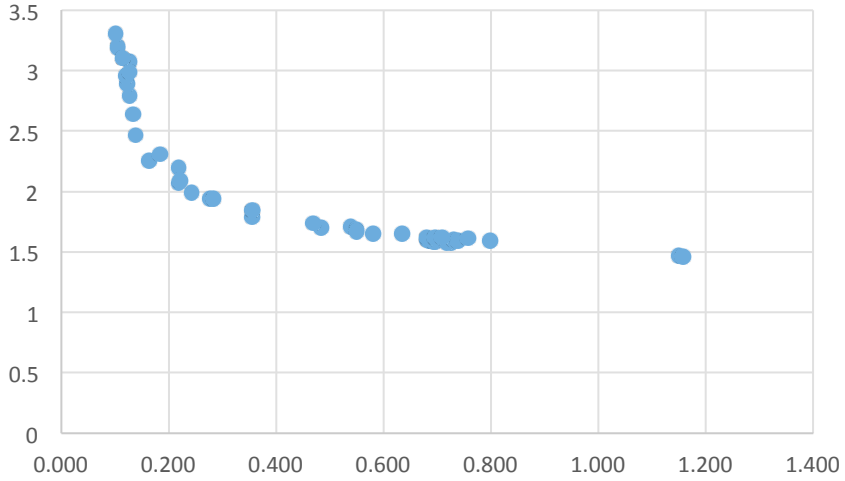
Barometer（y：Barometer　x：ControlPanel/ pressure gauge）



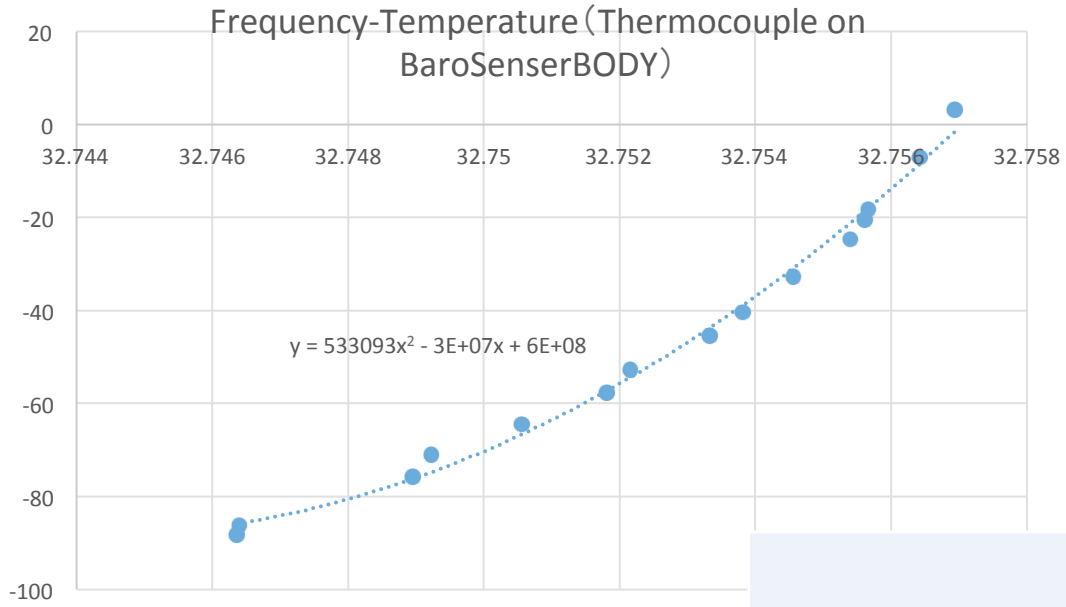
Dependency on Temperature(6.8hPa)



Corrected with Temperature



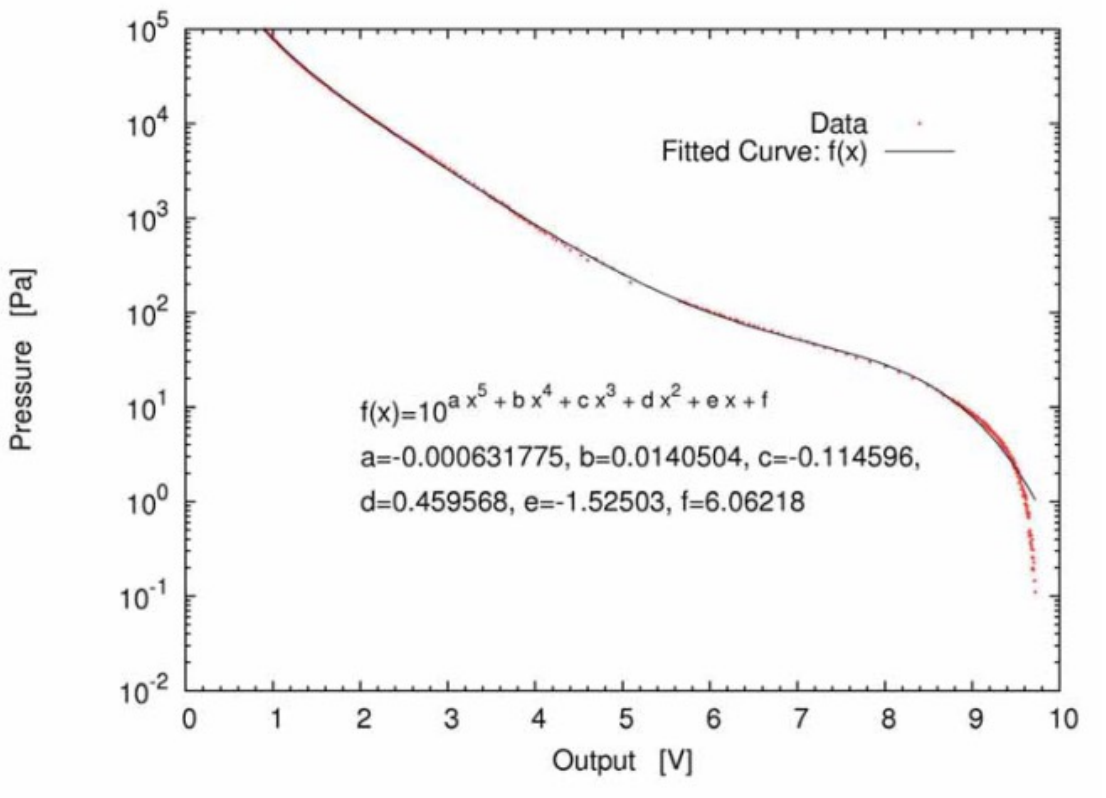
Thermocouple vs Temperature from frequency



	Outside Thermocouple	Inner Thermocouple	Temperature Frequency
22:56:30	-71.94	-94.4	-83.2389
23:00:32	-54.13	-74.7	-68.7101
23:02:20	-46.35	-58.7	-60.2459
23:03:32	-39.58	-53.8	-54.0083
23:04:26	-37.44	-46.3	-49.5689
23:06:06	-29.47	-36.1	-41.0071
23:09:26	-12.48	-17.0	-24.3147

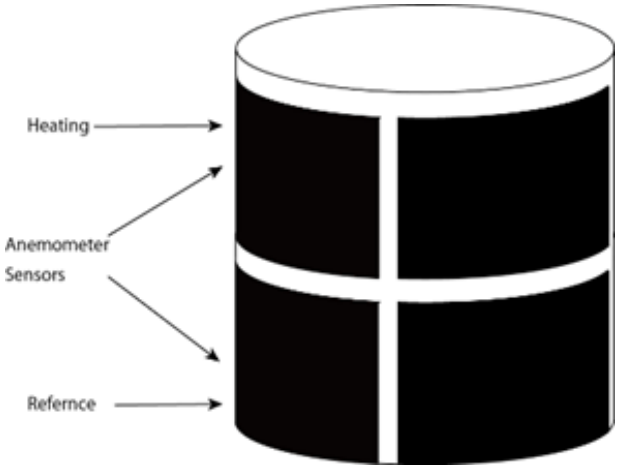
Accuracy of Barometer

- 0.1Pa on Martian Surface (Tunable)



Calibration in air

Anemometer



- Concept
  - Split Film around cylinder
  - Top film is heated
  - Pt heater
  - Wind direction is calculated difference of sensor pair

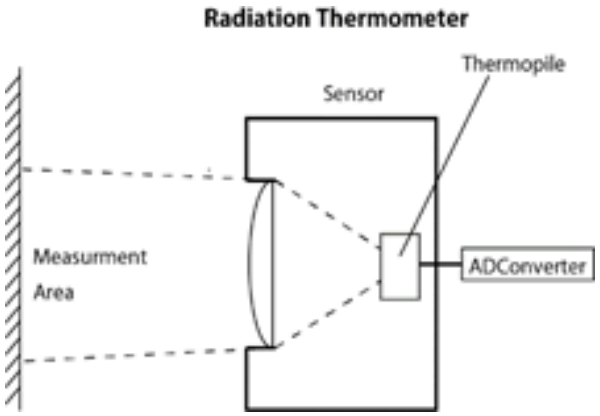
Radiation Thermometer

$$C/A\,(dT\downarrow gb\,/dt\,)=(1-\alpha\downarrow b\,)\mathrm{S}+\varepsilon\downarrow b\,L-\varepsilon\downarrow b\,\sigma T\downarrow gb\uparrow 4 -h(T\downarrow gb-T\downarrow a\,)$$

Cut by Ge Lens

No Wind

HORIBA Ltd.

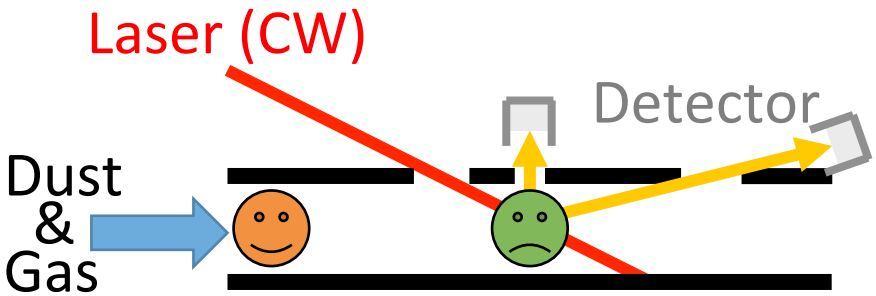


- Surface Temperature monitoring

Only qualitative test:
working but value is not validated

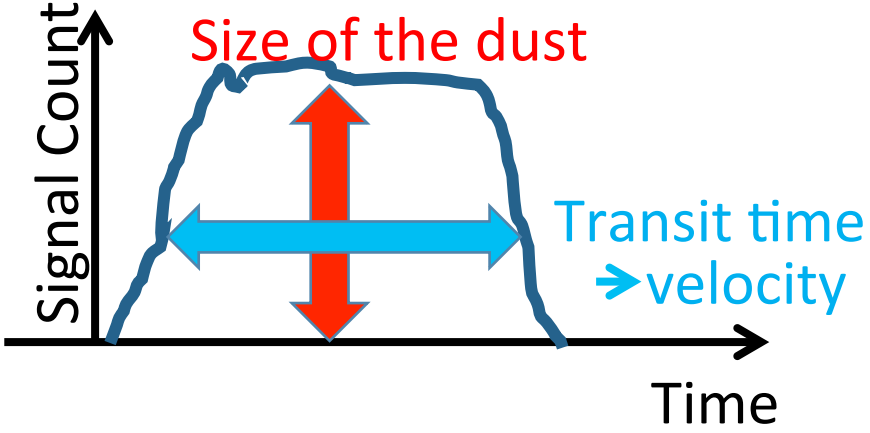
Dust Monitoring

Particle sensor



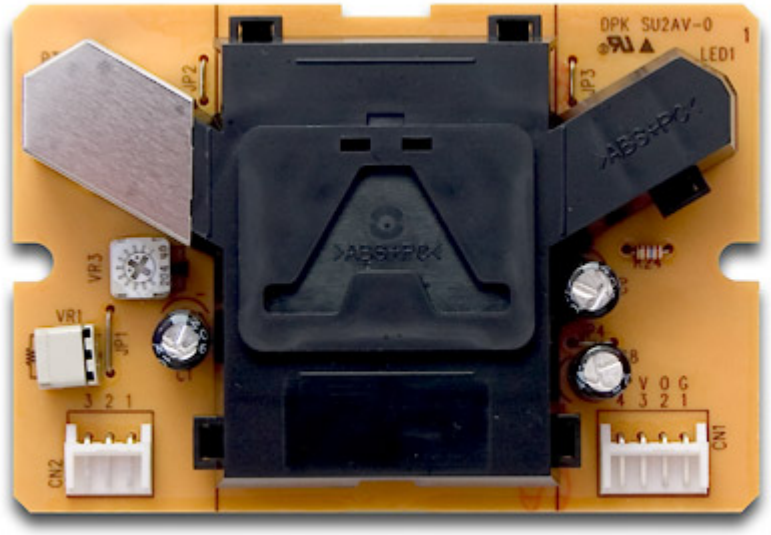
In reality, CW laser is wider (~1mm) than the size of typical dust size (~a few um).

Signal pattern from one particle



- Particle sensor monitors the frequency of signal from transiting dust
- Already used as particle counter in cirrus cloud
- Size distribution is divided into 5+ bins.
- Specifications:
  - Weight:
    - less than 200g (sensor part +electric part +cables)
  - Size:
    - 100mmX80mmX30mm (sensor part)
  - Power consumption
    - <1W (in run)

Particle Counter



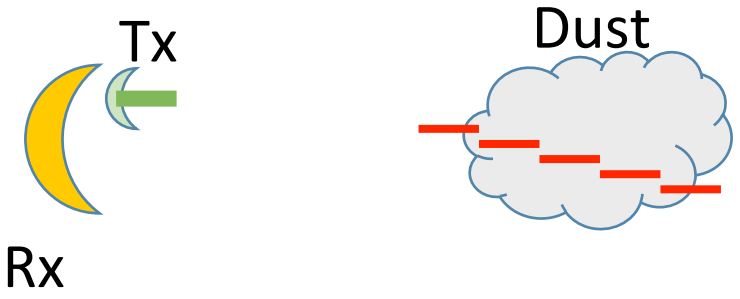
- Based Cirrus Cloud Particle Counter
- (5-6/2015 Compare with OPC)

(Fujiwara / Hokkaido Univ.)

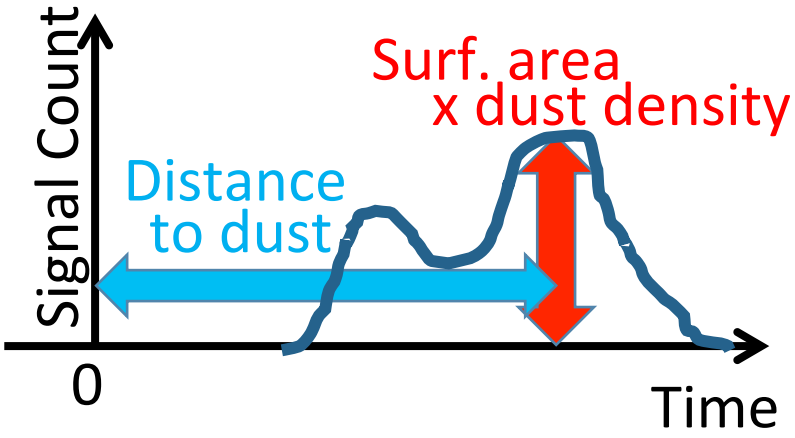
Visual Field 10mm^3 (=0.01cc)
1μm particle 0.5 – 2particle (0.01 cc)
100μm particle is much fewer

Dust Monitoring

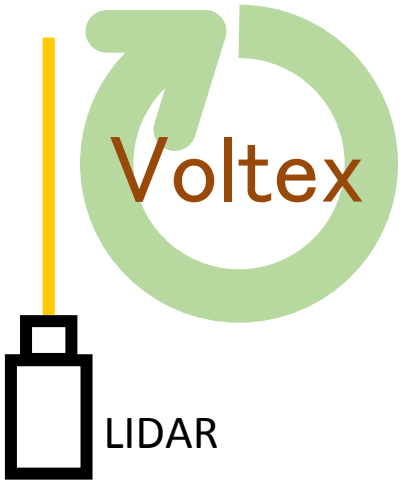
Short range LIDAR (LIght Detection and Ranging)

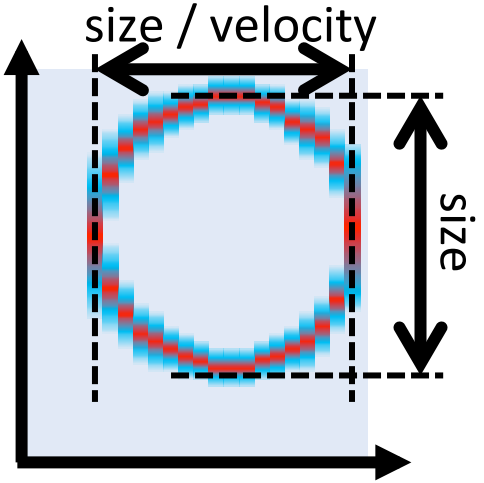


- LIDAR transmits a pulse laser and measure the profile of returned light.

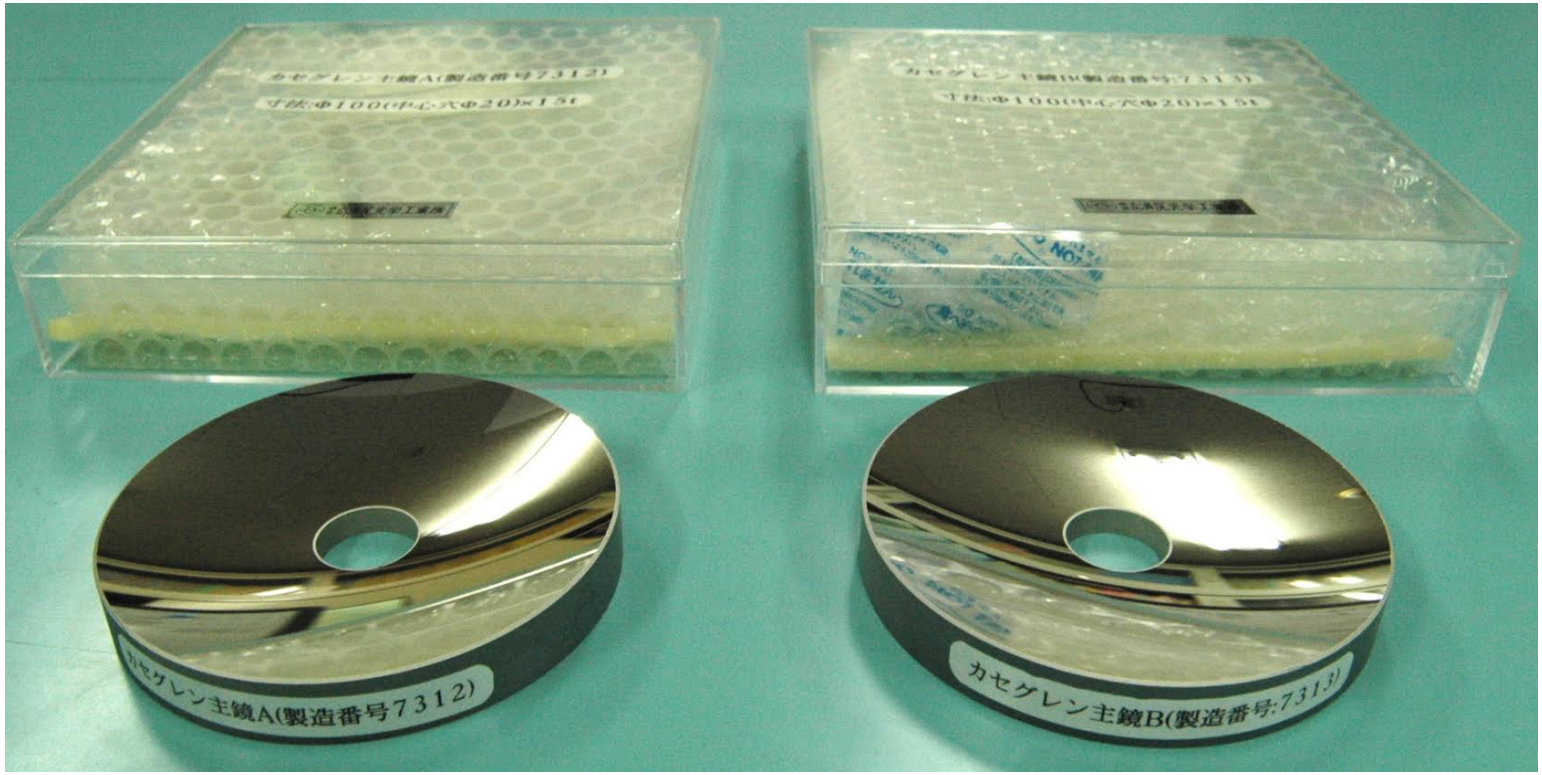


- LIDAR measures the distribution of dust grains on the line of sight.
- Comm. base instrument has been developed.
- Observe 100m dividing into 1m bins
- ϕ100mm, 900g in total





LIDAR (mirror)



(Shiina / Chiba Univ.)

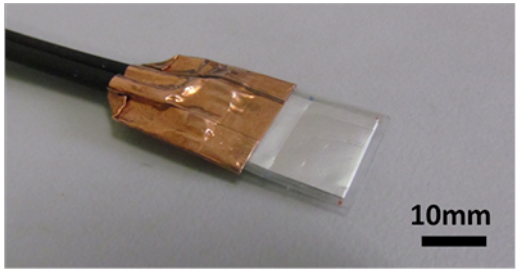
2014/Apr Test each component
2015/May Assemble Sensor / Main Board -> Calibration
2015/Summer Field test

UV or Violet LED / transmitting mirror size

Sonic Anemometer Status

- Transducer's sound Impedance very different from Martian Air's

Piezoelectric Polymer Film
TORAY Engineering Co.



Electlet Condenser Film
(Kageyama/ Saitama Univ.)