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# The VenSpec suite on the ESA Envision mission – a holistic investigation of the coupled surface atmosphere system of Venus

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# VenSpec Consortium

Coordinator: Jörn Helbert

consists of three sub-instruments with a joint science team

**VenSpec – H**
High spectral resolution IR Synthetic

**VenSpec – M**
Multi-spectral IR imager

**VenSpec – U**
UV Spectrometer

PHU – Power Handling Unit (IAA Spain)

CCU - Central Control Unit (DLR)

DHU – Data Handling Unit (MPI, IDA Germany)

BELSPO
PI: Ann Carine Vandaele

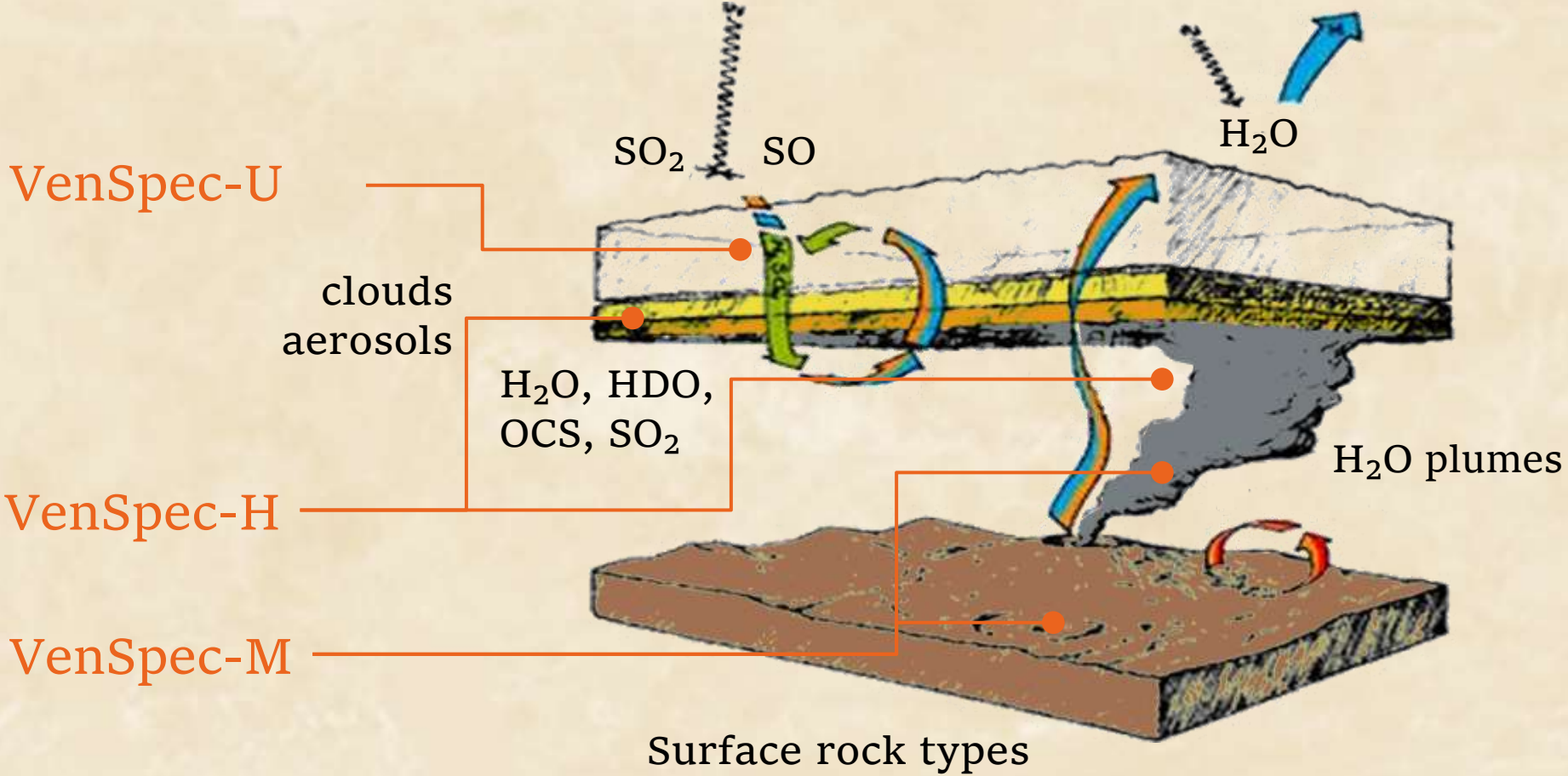
DLR
PI: Jörn Helbert

CNES
PI: Emmanuel Marcq

# VenSpec team

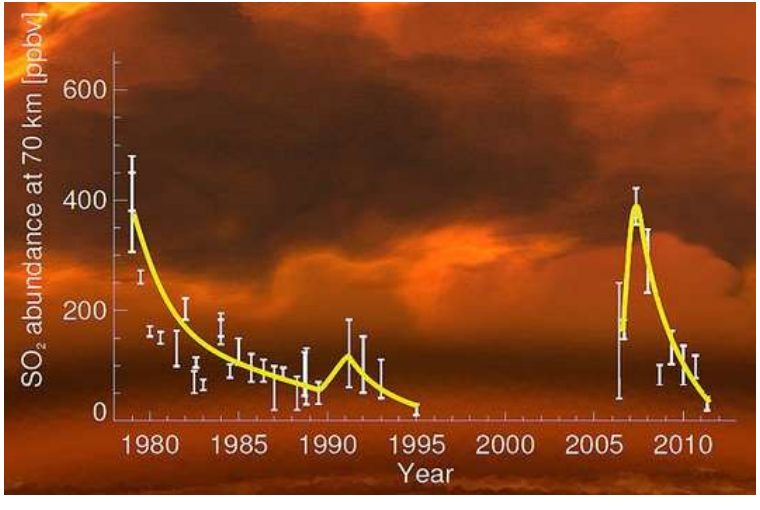
# EnVision Science Observations: VenSpec Suite



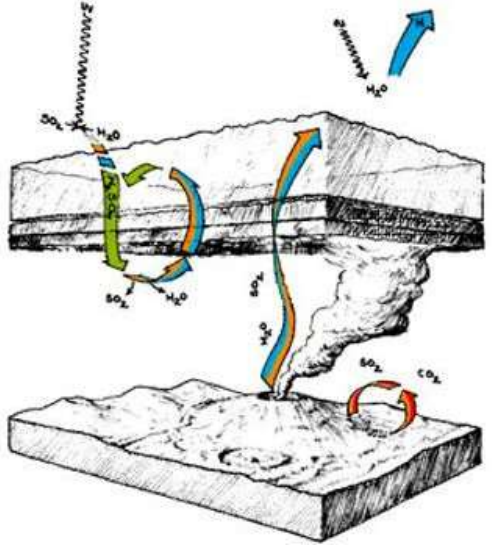


# Goal #1: mapping cloud top $SO_2$

- Strong variability, yet poorly understood
  - Source: mixing with deep atmospheric reservoir
  - Sink: photochemistry
- Is $SO_2$ variability linked with surface (volcanism, orography) or of purely atmospheric origin?

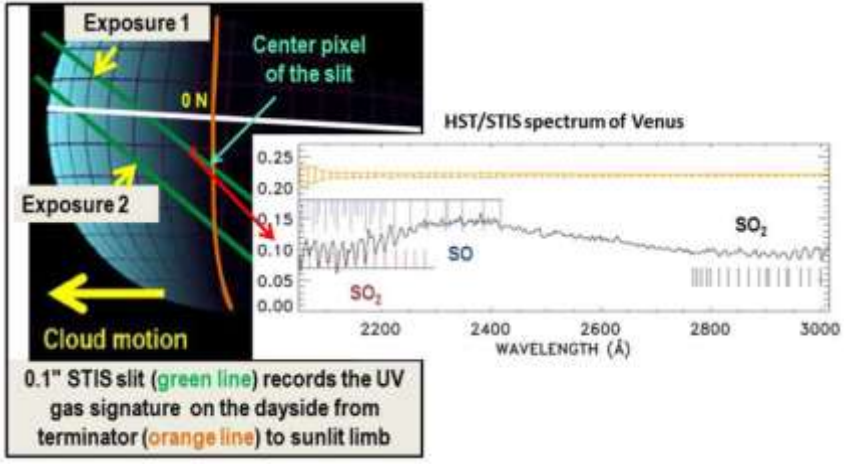



*Marcq+ (2013)*

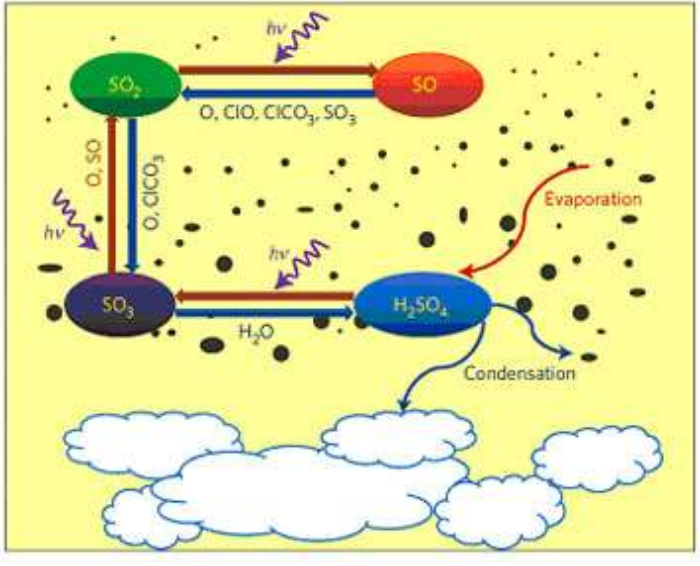


# Goal #2: mapping SO:$SO_2$ ratio

- Poorly constrained yet (as of 2023)
- Important to characterize $SO_2$ photochemical sink

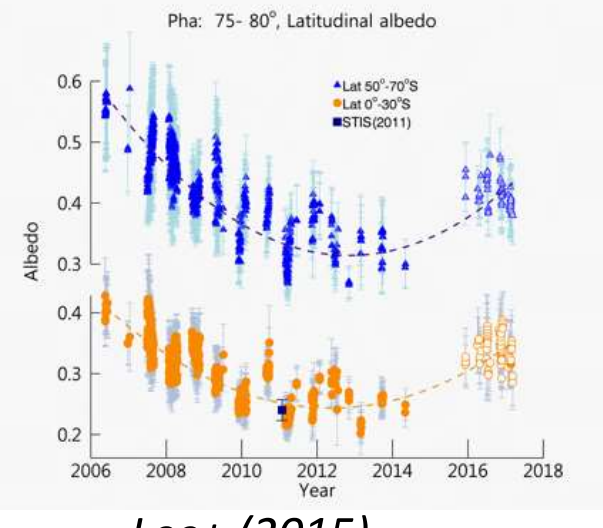



*Jessup+ (2015)*



# Goal #3: monitoring and mapping UV absorber

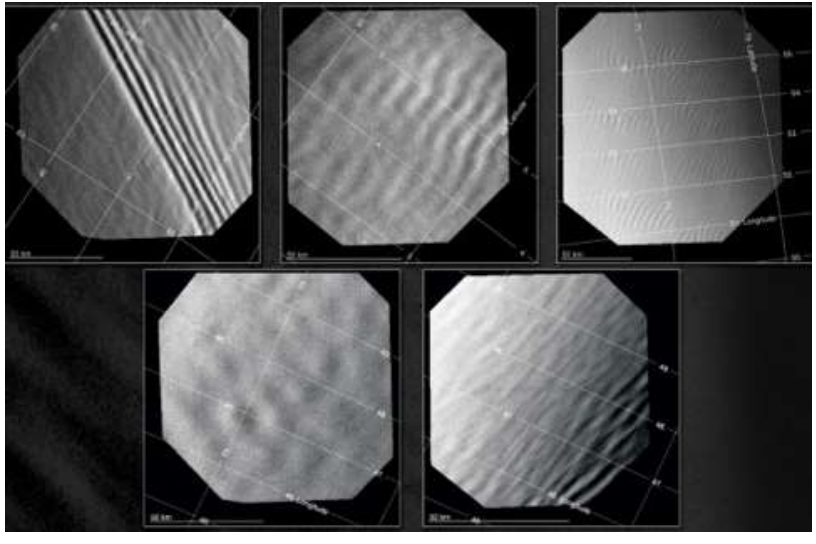
- Likely linked to sulfur cycle, yet still unidentified!
- Good tracer of atmospheric activity
- Comparison with existing 365 nm datasets (VMC/VEx, UVI/VCO)



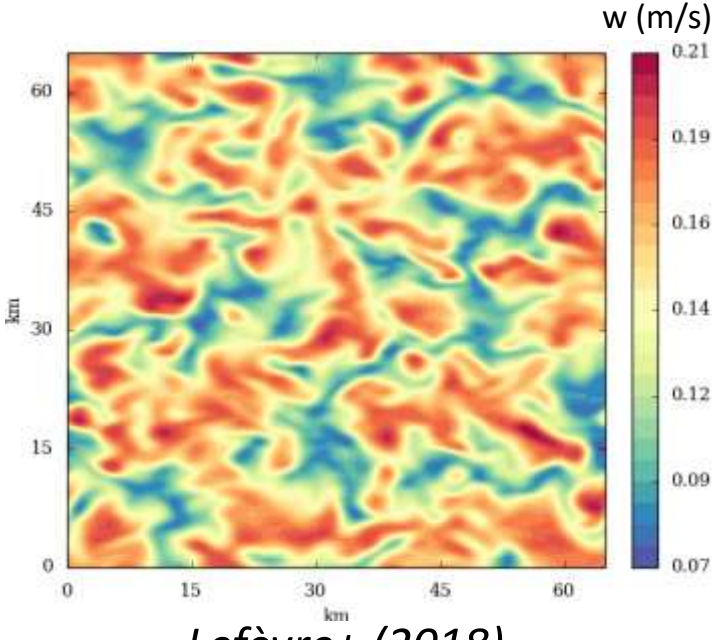

*Lee+ (2015)*

# Goal #4: high spatial resolution

- UV contrasts down to <10 km: what about $SO_2$?
- Cloud top convection cells, atmospheric waves
- Constrain mesoscale/LES coupled chemistry/dynamics models



*Piccialli+ (2013)*

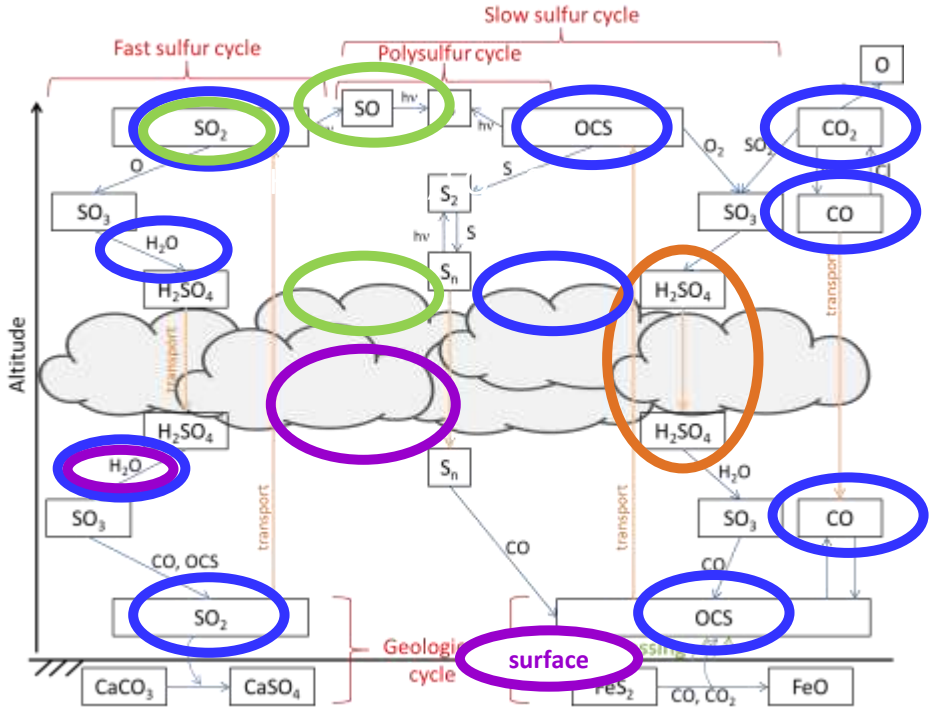



*Lefèvre+ (2018)*

# Obj #1: Better characterize the water and sulfur cycles

Need to measure key species of the water and sulfur cycles below and above the clouds

➔ $H_2O$ (and HDO), CO, SO2, OCS




VenSpec-H

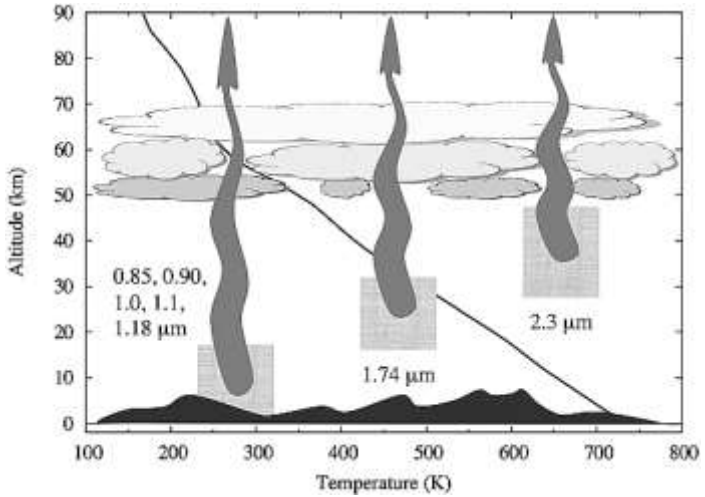
VenSpec-M

VenSpec-U

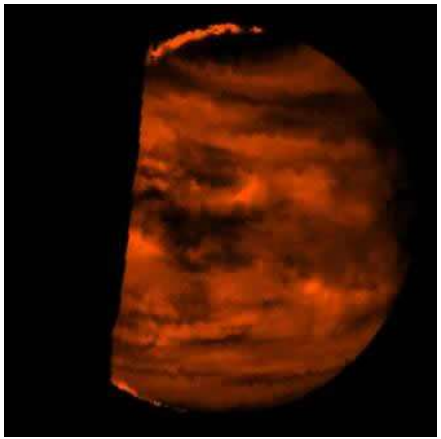
Radio Science

# Obj #2: Search for volcanism and surface changes

- Volcanic gases close to the surface
- Need to look through the clouds down to the surface
  - Infrared spectral bands in the 'Atmospheric transparent windows'
  - Only during the night



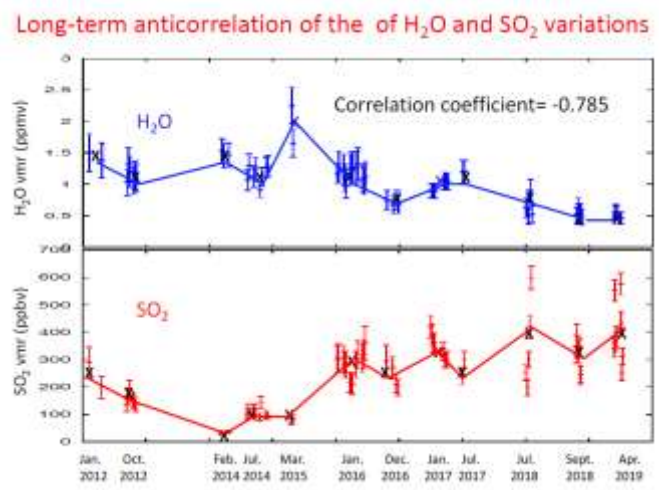

(Bézard and De Bergh, JGR 2007)



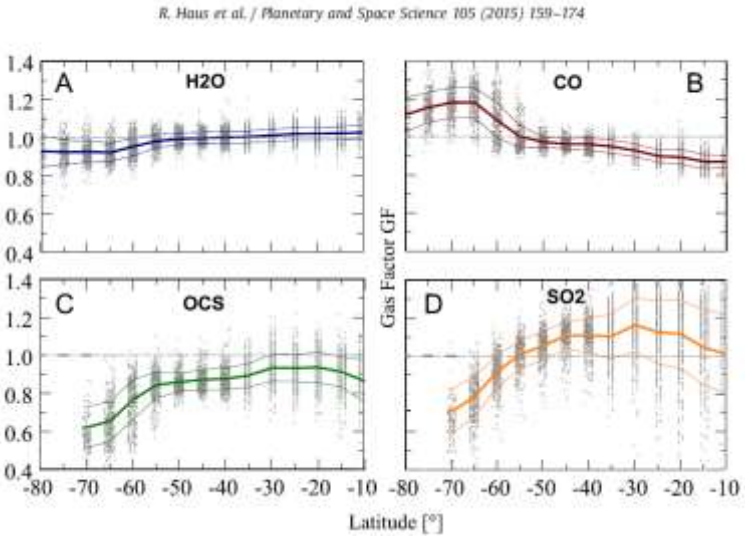
# Obj #3: Impact on climate

Observation of

- Short- and long-term trends
- Spatial and temporal variability

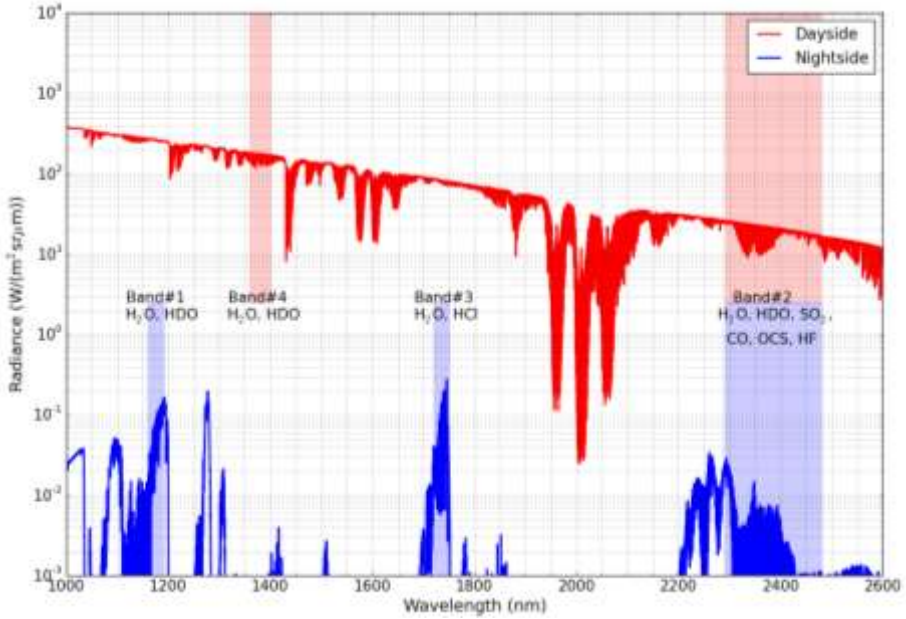



Encrenaz et al (2020)




Analysis from the *whole* VEx mission: Haus et al PSS 2015

# Summary




- **Water and sulfur cycle**

➔ **$H_2O$/HDO, $SO_2$, OCS, other trace gases**

- **Linked to volcanism – other geological processes**

➔ **Below the clouds, down to the surface**

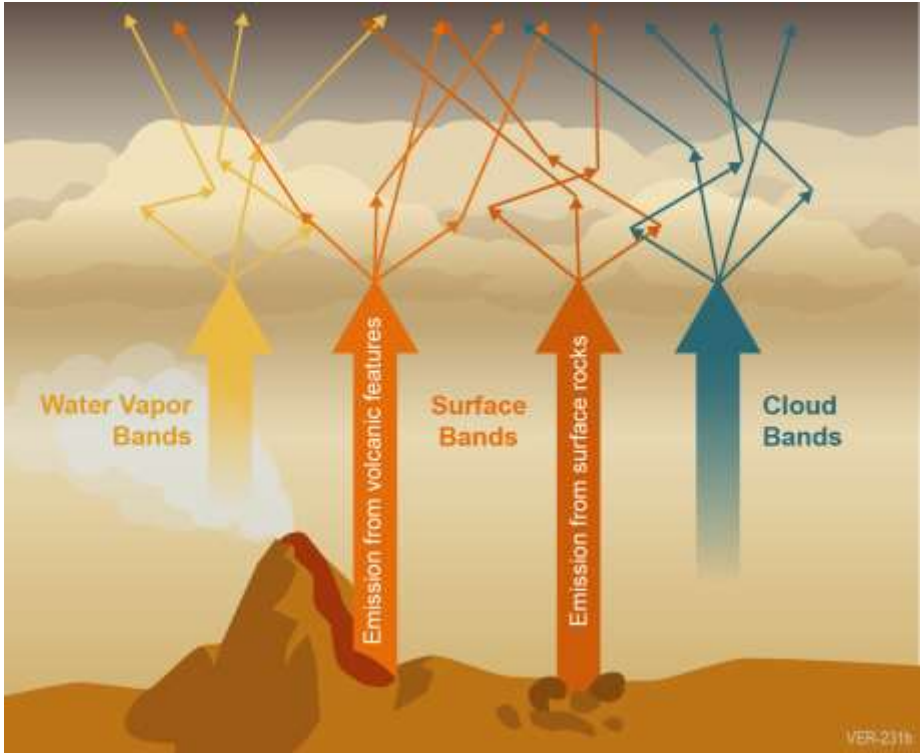
- **Impact on climate**

➔ **from the surface to above the clouds, variability**

| | | | | | |
|---|---|---|---|---|---|
| NIGHTSIDE | Band#1 | 1.17 µm | $H_2O$, HDO | 0-15km | Near-surface water contents |
| | Band#2ab | 2.4 µm | $H_2O$, HDO, CO, OCS, $SO_2$ | 30-40km | Minor species in the troposphere |
| | Band#3 | 1.7 µm | $H_2O$, HCl | 15-30km | Water contents in the middle of the troposphere |
| DAYSIDE | Band#2ab | 2.4 µm | $H_2O$, HDO, CO, OCS, $SO_2$ | 65-80km | Minor species in the mesosphere |
| | Band#4 | 1.38 µm | $H_2O$, HDO | 65-80km | Water contents in the mesosphere |

# VenSpec-M maps the surface at the resolution limit

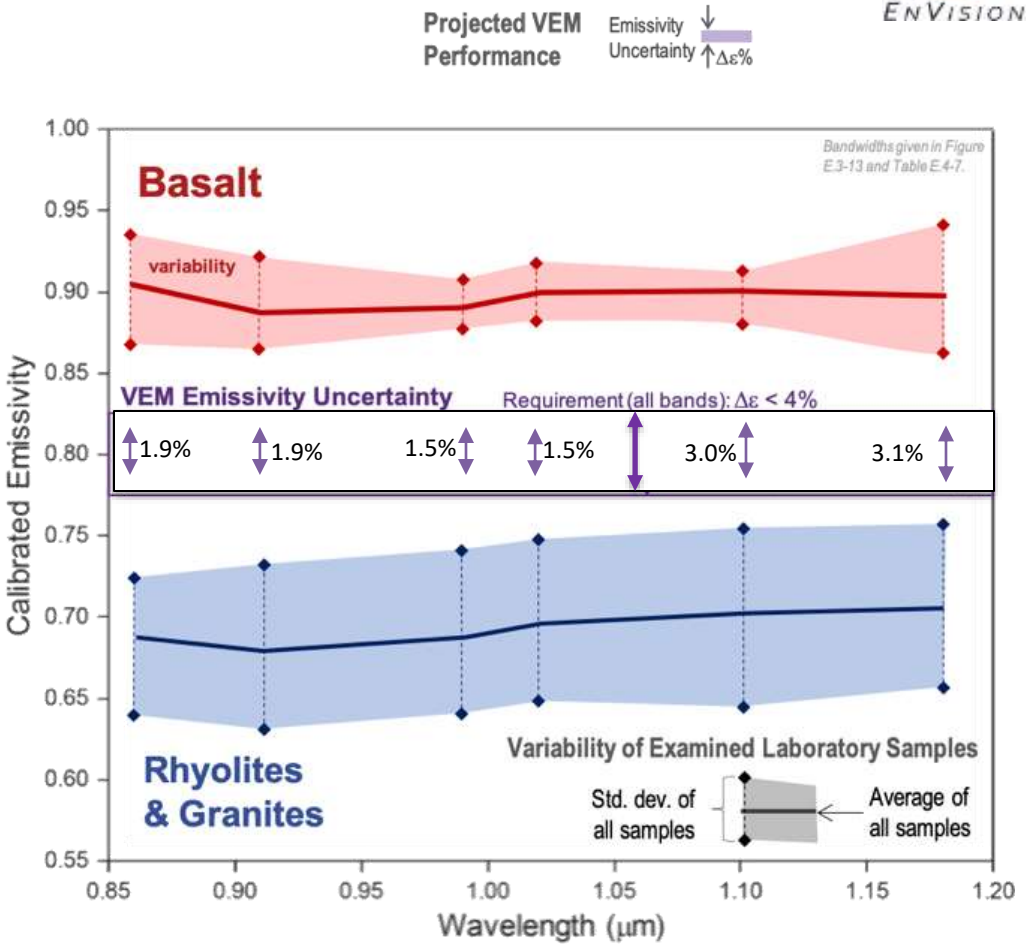
- VenSpec-M is a 14 band multi-spectral imager
- VenSpec-M will provide
  - a global map of rock types on the surface
  - monitor for active volcanism by its heat signature and by the enhancement of water vapor in a volcanic plume
  - study change within the mission and in comparison to VERITAS and VenusExpress




# VenSpec-M and VEM will create the first „global“ rock type map of Venus

- Already now we are (most likely) capable to identify intermediate compositions like dacites, etc
- The smaller our uncertainty gets the better our rock type mapping gets
- So in combining the datasets between VERITAS and Envision we can derive more details in the surface composition

***But what if the surface changes between VERITAS and Envision??***

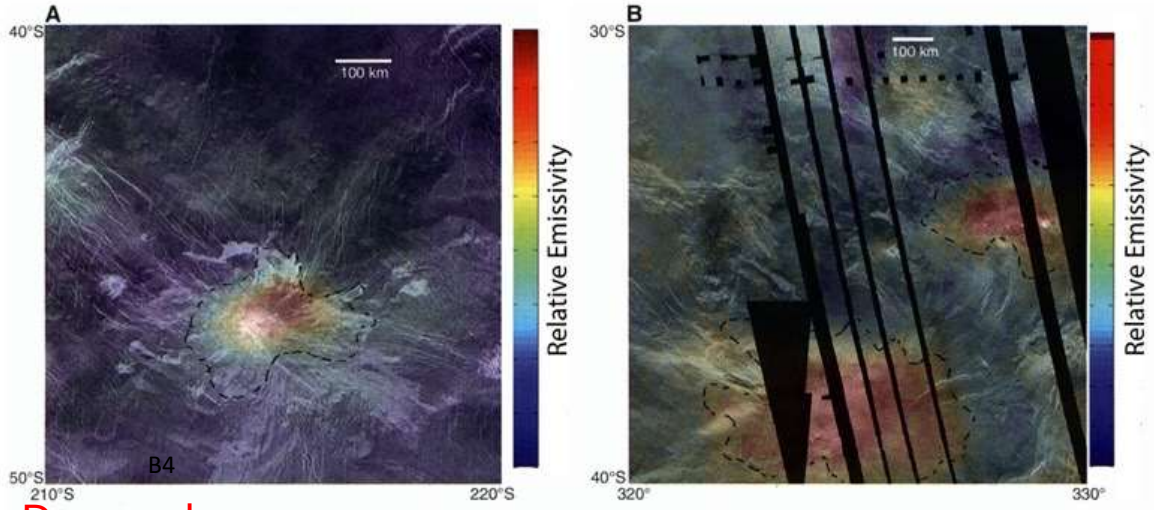



See presentations by Maturilli, Dyar and Alemanno tomorrow!

# Subtle changes in the emissivity signatures were seen by the ESA VIRTIS instrument and will be even more visible to VERITAS and EnVision

**VIRTIS observed relative emissivity variations interpreted to imply the presence of very young volcanism.** Surface weathering was identified on the basis of a reduction in emissivity signature at 1.02 μm by Smrekar et al. (2010), D'Incecco et al. (2017), and Mueller et al. (2008, 2020).

**With 6 bands and better topographic constraints, VEM will detect these with improved accuracy.** VEM will use spectral slopes and ratios (30 spectral parameters along with the six band intensities) to develop discriminators for assessing relative surface weathering.

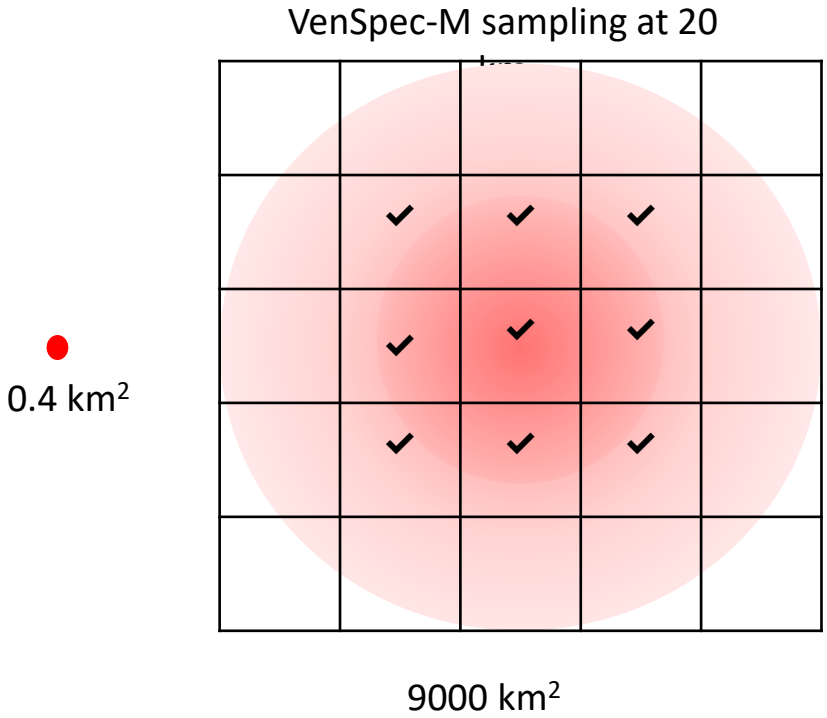



From Smrekar et al. (2010)

See presentations by Maturilli, Dyar and Alemanno tomorrow!

# Detect Active Volcanism

- VenSpec-M and VEM search for radiance anomalies to detect volcanic activities
- The scattering in the atmosphere means a small feature illuminates a large spot at the top of the atmosphere
- VenSpec-M searches for active lava flows with 20 km instrumental resolution allowing robust automatic detection



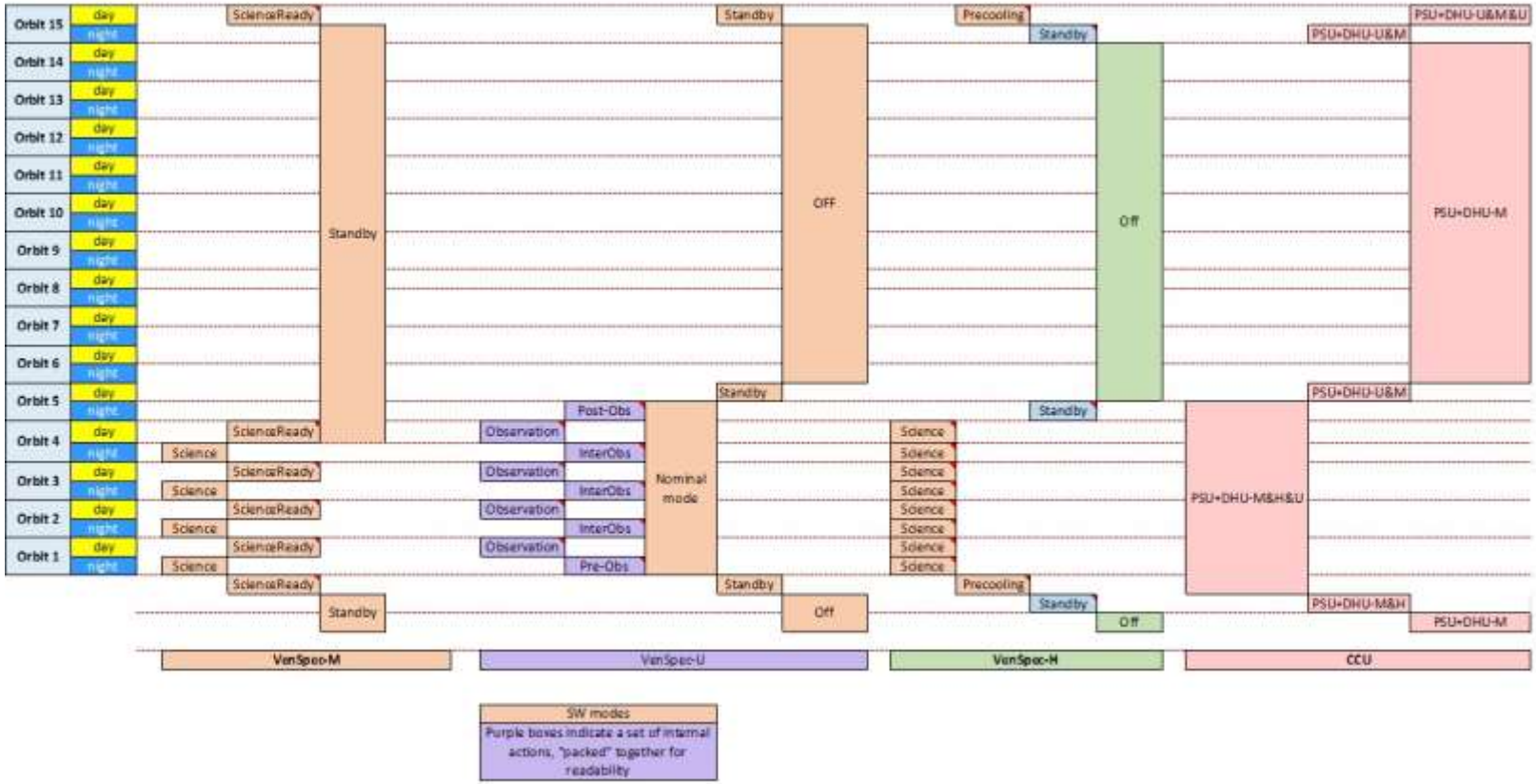

See presentation by Müller et al tomorrow!

# VenSpec-M will monitor for active volcanism with VenSpec-H and U

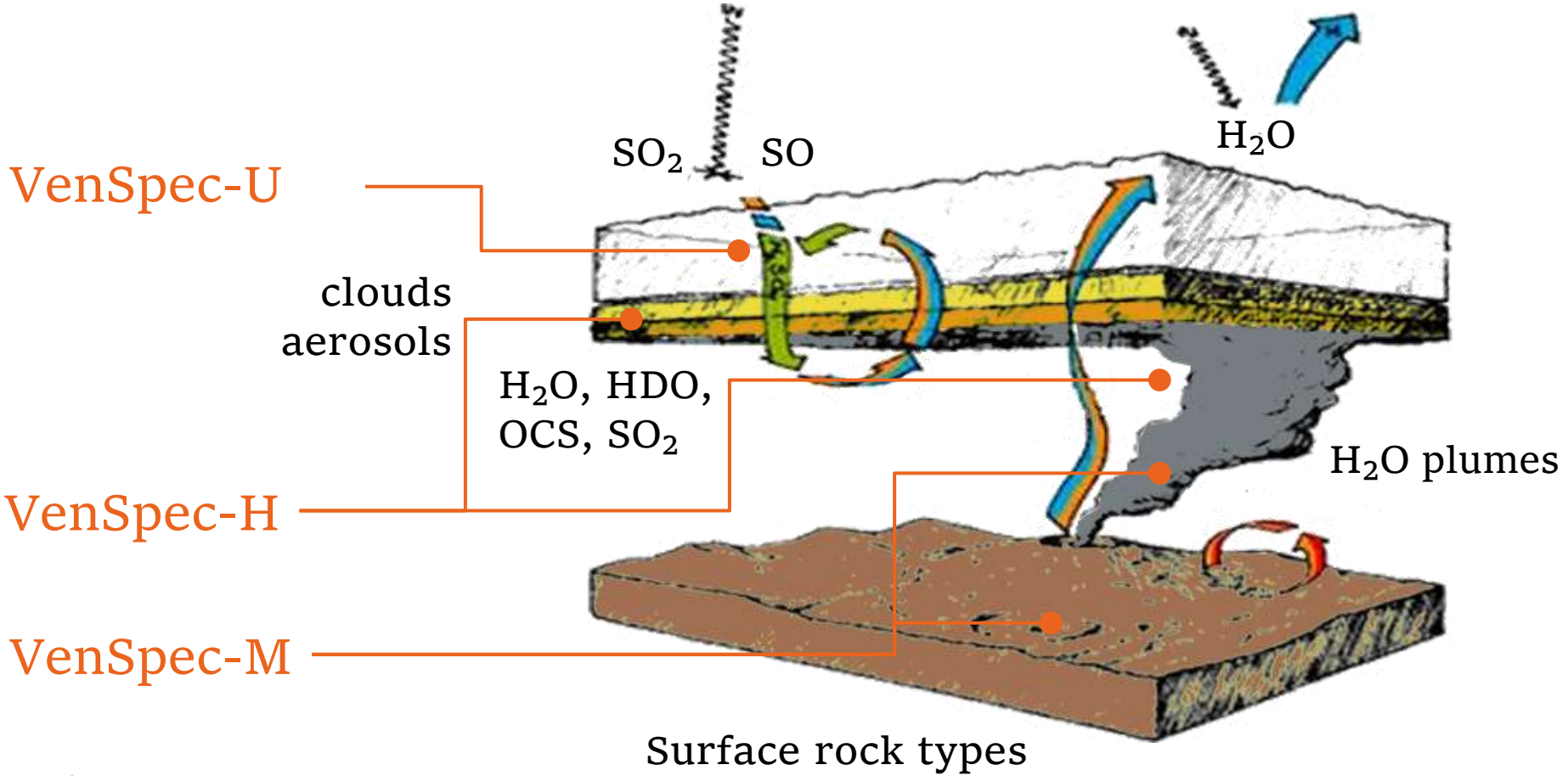
See presentation by Adeli et al tomorrow!

This is also a view of active volcanism - Envision with the VenSpec suite will be more suitable to detect this

# The VenSpec operation scenario




# VenSpec will provide a unique integrated dataset to study the coupled surface interior system of Venus




# VenSpec will study the coupled surface atmosphere system of Venus

- VenSpec is a key element in the holistic approach of the EnVision mission
- VenSpec will provide a set of complementary observations that will yield new insights in the evolution and current state of Venus
- VenSpec is uniquely suited to
  - provide a (more or less) global map of surface composition
  - study the coupling between the surface and the atmosphere
  - Search for active volcanism, both by heat signature and volcanic outgassing
- VenSpec has a joint science team to to study the coupled system as a whole with all datasets combined from the start
- The designs of all channels are consolidated in the Phase B1 phase

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