Actuación 7.2

Space instrumentation for Mars exploration

Francisco González-Galindo, **Sergio Jurado-Fortuna**, Luisa Lara, Denis Shulyak

IAA-CSIC

+ AIRBUS Spain MAWI team (J. Closas, A. Zurita, M. Martínez, B. Giménez, D. Toledano)

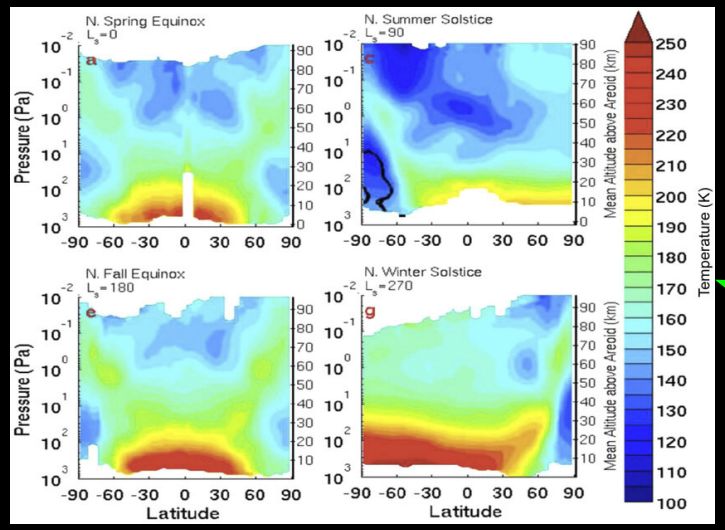
The authors acknowledge financial support from Unión Europea - NextGenerationEU, el Ministerio de Ciencia, Innovación y Universidades y la Consejería de Universidad, Investigación e Innovación. Ref. AST22 00001 23

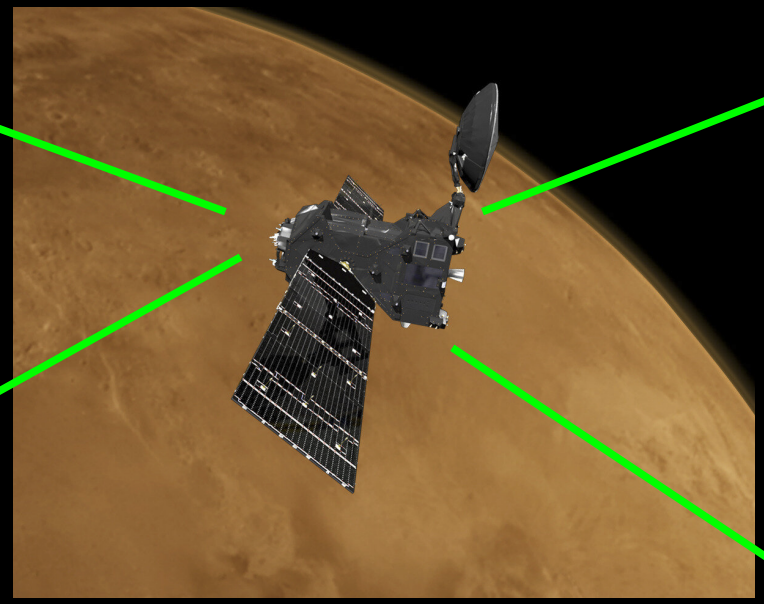
IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

AIRBUS

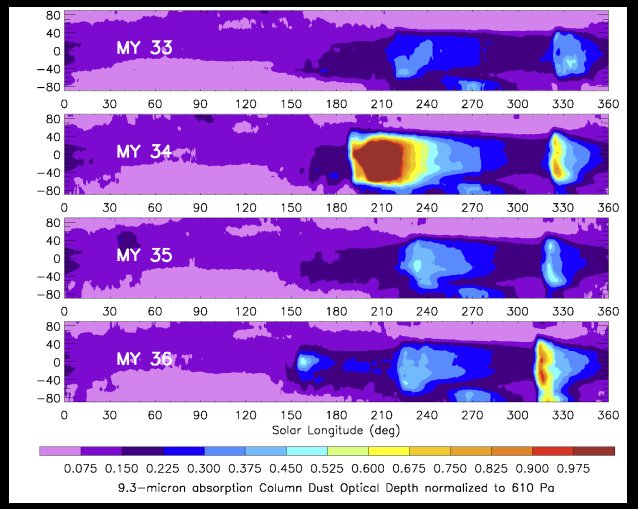
Motivation

Temperature

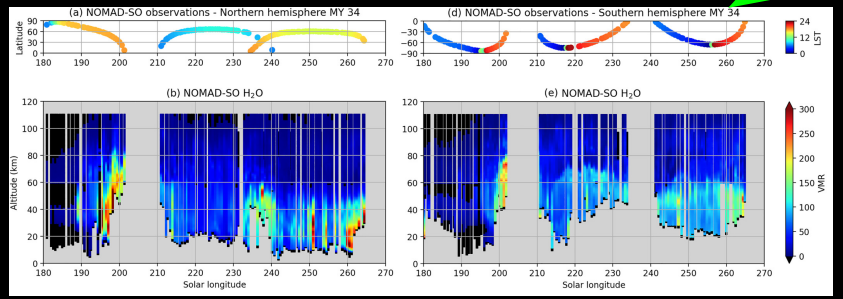




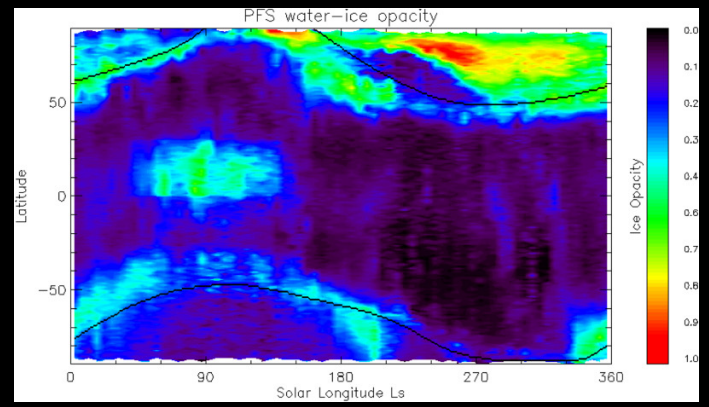
Dust abundance



Composition



Clouds



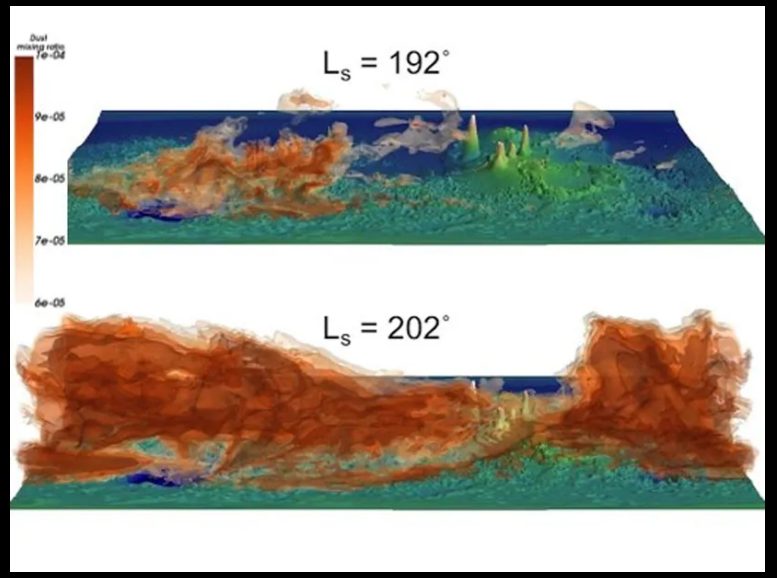
Winds??

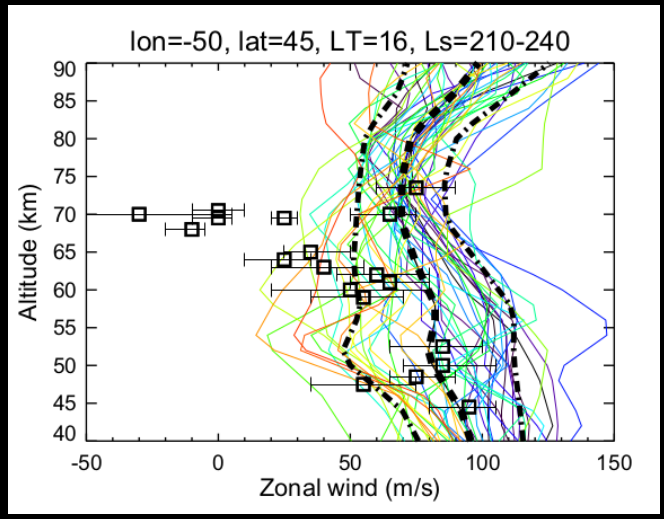
INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

AIRBUS

Motivation

- Wind strongly affects geological and atmospheric processes on current Mars
- Winds impact entry-descent landing maneouvers
- Wind measurements scarce, most knowledge comes from unvalidated models





IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

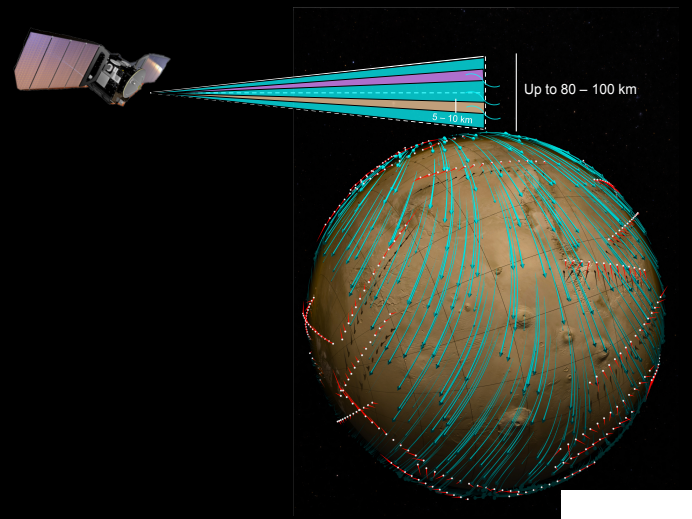
AIRBUS

Motivation

- Wind strongly affects geological and atmospheric processes on current Mars
- Winds impact entry-descent landing maneouvers
- Wind measurements scarce, most knowledge comes from unvalidated models

Dedicated instrument on Mars orbit for wind measurements needed to fill this gap

MAWI



IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

AIRBUS

MAWI

- MArs WInd limb microwave spectrometer (MAWI): Airbus Spain + IAA, PRODEX ESA programme
- Main scientific case: determination of wind velocity from Doppler shift of microwave emission lines by limb observations from Martian orbiter:

$$\Delta\nu = \frac{v_{\mathrm{LOS}}}{c}\nu_0$$

- CO emission lines: well mixed gas, little seasonal and geographical variations
- Two isotopes (different line intensities) to maximize altitude range
- Secondary scientific objectives: CO abundances + temperature profiles

IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

AIRBUS

MAWI requirements and characteristics

- Wind measured between 20 and 100 km altitude, with:
  - Error < 10 m/s between 40 y 100 km
  - Resolution: horizontal < 300 km; vertical < 10km
  - Ideally 2 wind components (E-W + N+S)
- Temperature @ alt <100 km, accuracy < 5 K
- [CO] @ alt <60 km, accuracy < 100 ppm

- Baseline: orbiter @ 450 km circular orbit
- Observation of CO (576.268 GHz) and ^{13}CO (550.926 GHz) lines
- Spectral resolution: 100 kHZ in 40 MHz band @ line center + 2 MHz in 2 GHz band for line wings
- Antenna vertical footprint < 10 km (5 km goal)
- Mechanical vertical scanning
- Integration time <1 to 10 s
- Two orthogonal views (goal)
- Current estimation: ~20 kg, 35 W, 65x55x39 cm

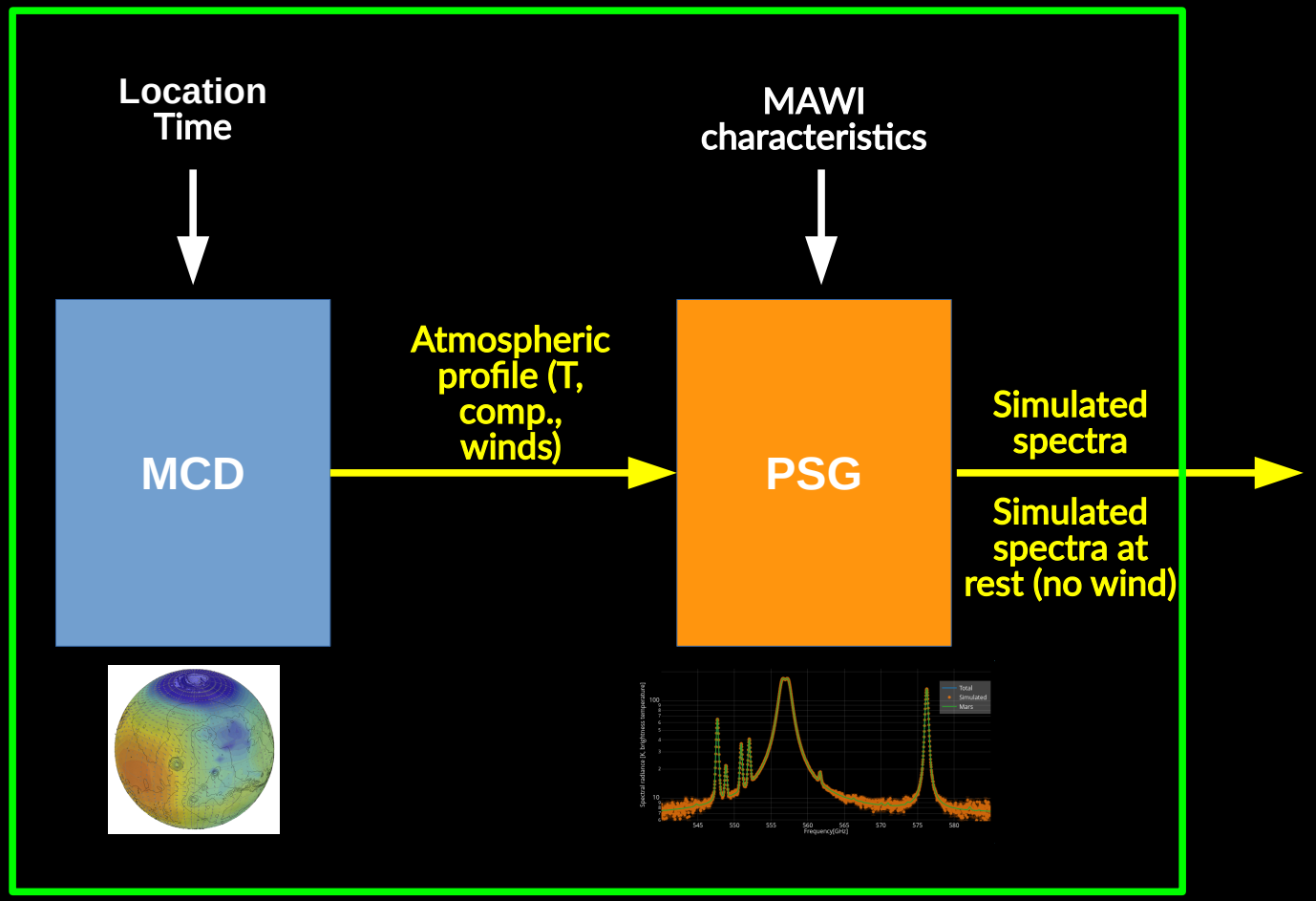
IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA · EXCELENCIA SEVERO OCHOA · CSIC

AIRBUS

MAWI and PPCC

- Programatic goal: propose a **Spanish-led instrument** for future mission opportunities
- Main scientific/technological goal: develop tools to
  - **Simulate MAWI measurements**
  - **Derive physical information from MAWI measurements**
- Scientific support to the technological instrument design
- Main science output: Characterize the **expected precision of the retrieved winds** (+ T , [CO]) as a function of altitude, Local Time, season, and latitude

Tools adaptation and development



INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA
EXCELENCIA SEVERO OCHOA
CSIC
AIRBUS

Tools adaptation and development

Location
Time

MAWI
characteristics

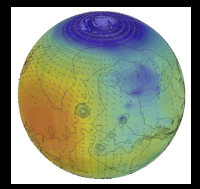
MCD

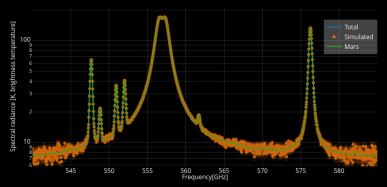
Atmospheric profile (T, comp., winds)

PSG

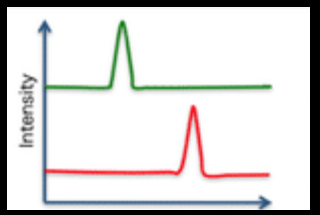
Simulated spectra

Simulated spectra at rest (no wind)





MAWI simulator

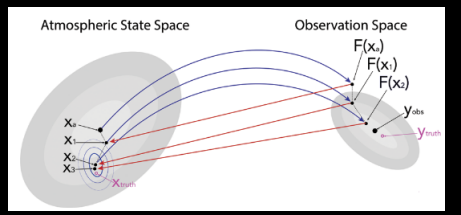


Cross-correlation

Derived wind

Retrieval scheme

Derived Wind, T, [CO]

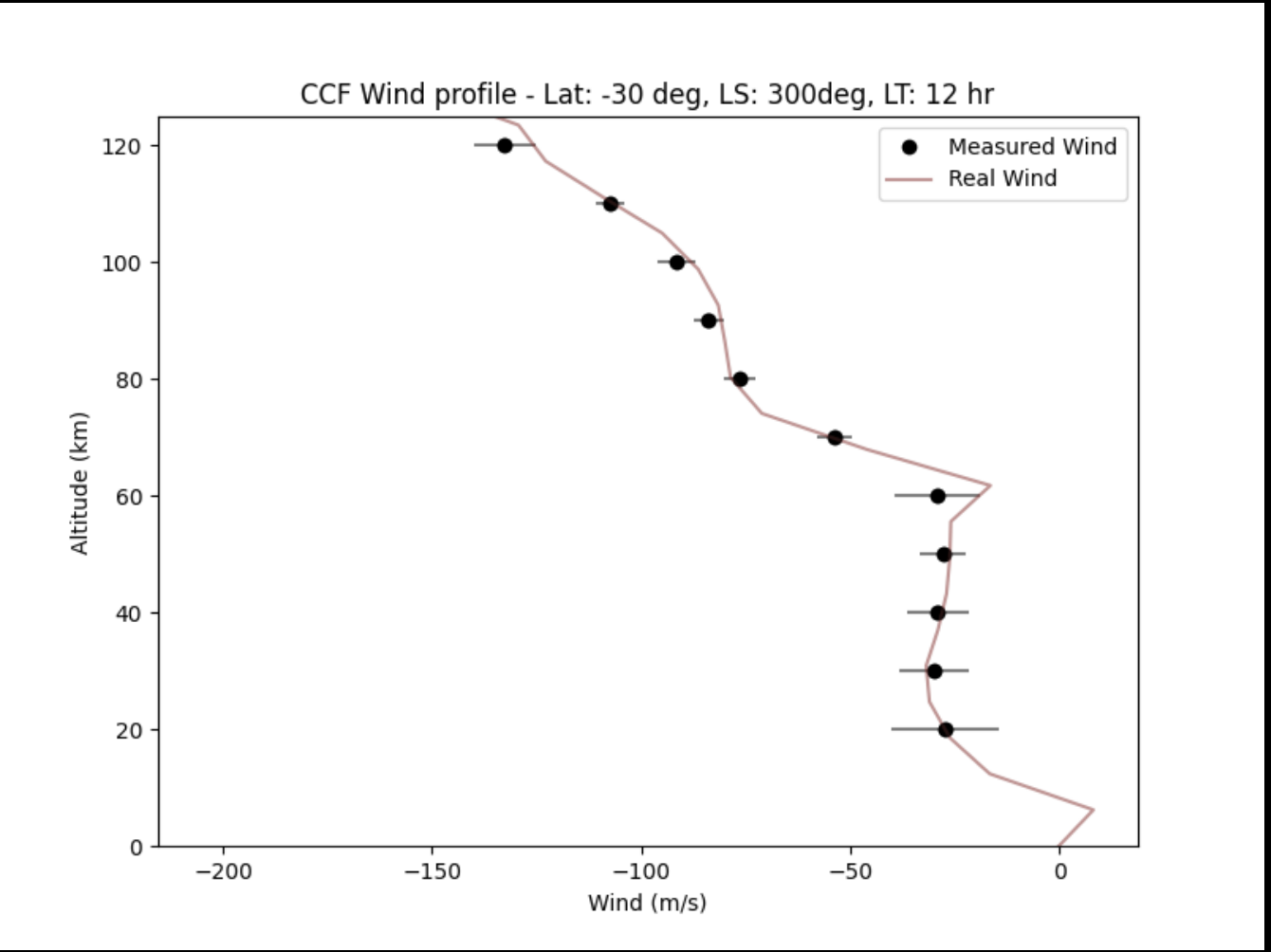


MAWI analyzer

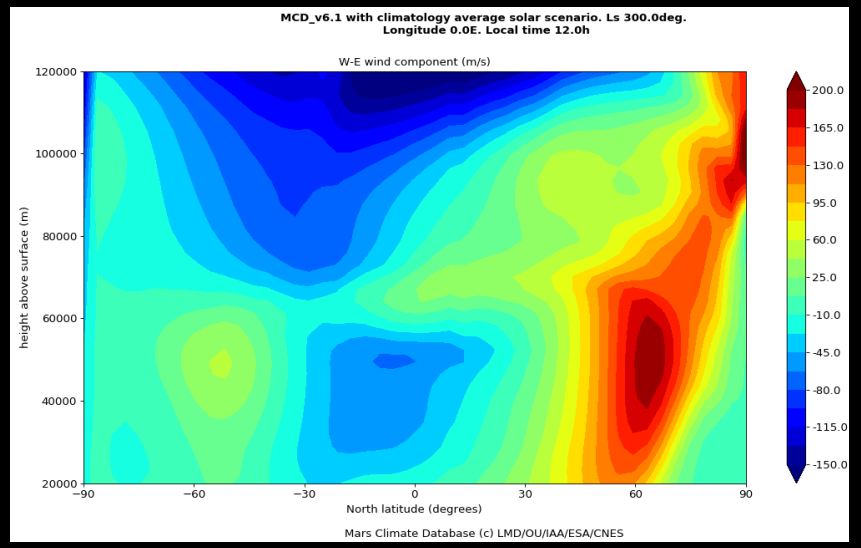
IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA
EXCELENCIA SEVERO OCHOA
CSIC

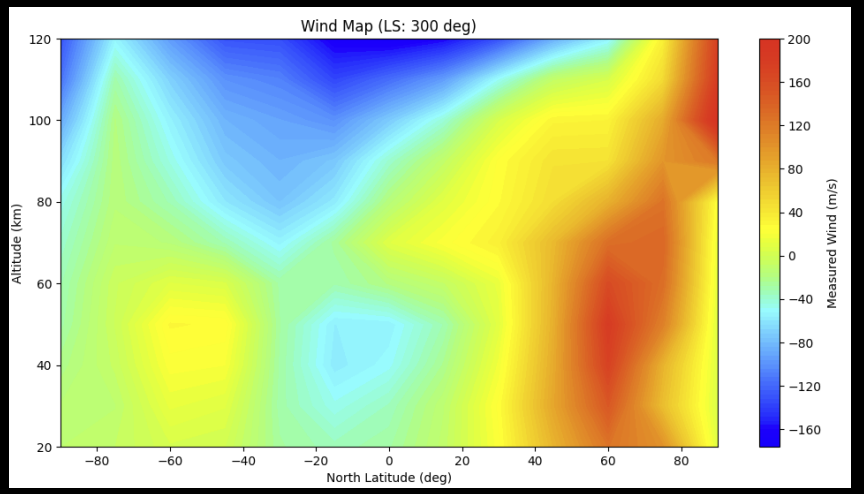
AIRBUS

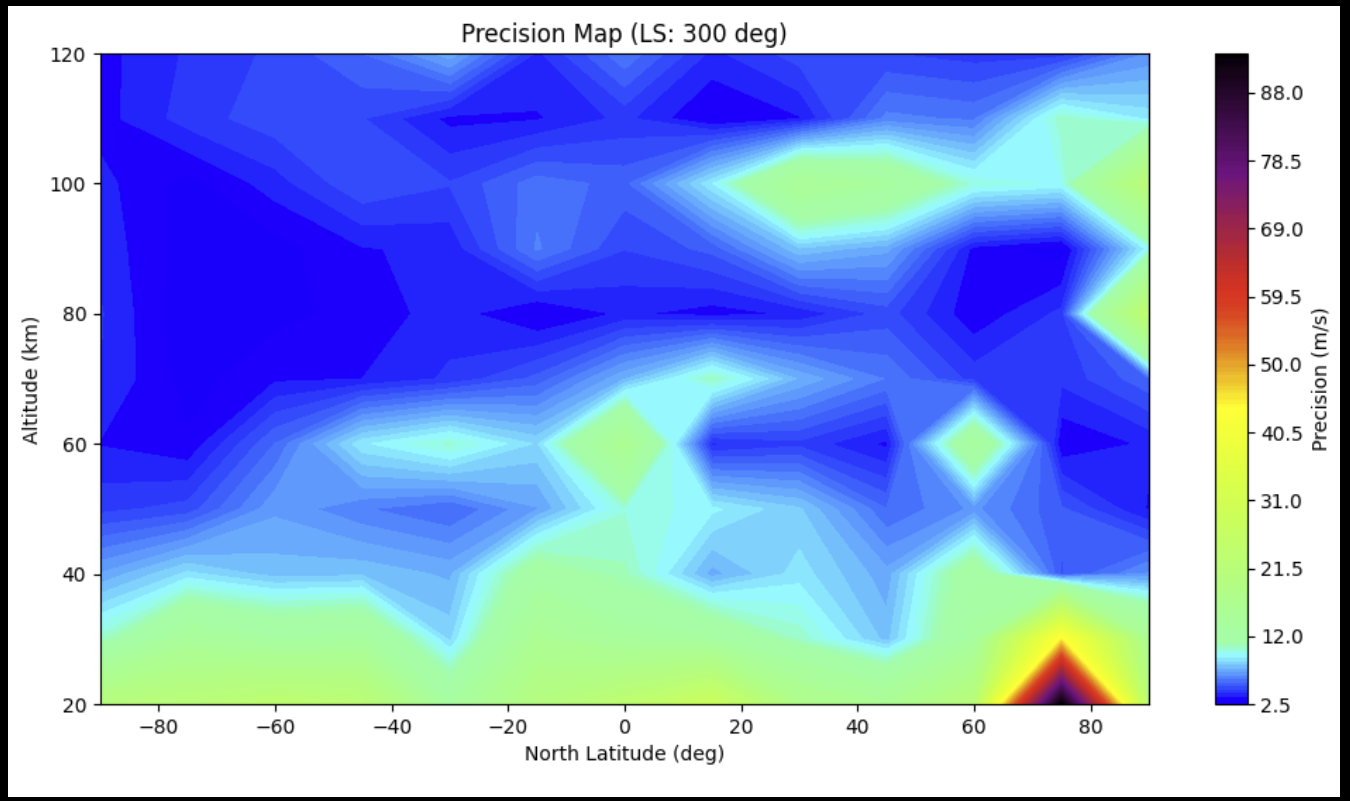
Some preliminary results



Some preliminary results







INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA
EXCELENCIA SEVERO OCHOA
CSIC
AIRBUS

Current status and perspectives

- **MAWI submitted in response to ESA's RFI** on Mars orbital observational payloads (March 2024) for a potential future Mars mission
- Continue **collaboration with Airbus Spain**: scientific implications of potential instrument modifications
- Potential future opportunities:
  - ESA's M8 and F3 calls
- Adaptation to Venus feasible