Unlocking the Scientific Potential of EarthCARE's CPR Doppler Velocity Observations

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3. Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Torino, Italy
4. Department of Physics and Astronomy, University of Leicester, Leicester, UK

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Overview

The EarthCARE Cloud Profiling Radar is the first-ever space-borne radar with Doppler capabilities, providing an unprecedented global record of Doppler velocity observations collected from space

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Reduce the uncertainty

Unlock the scientific potential

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C-CD: Doppler velocity Quality Control

Antenna Pointing correction

Non-uniform beam filling correction

Along-track averaging to reduce uncertainty

Unfolding

Sedimentation velocity estimation

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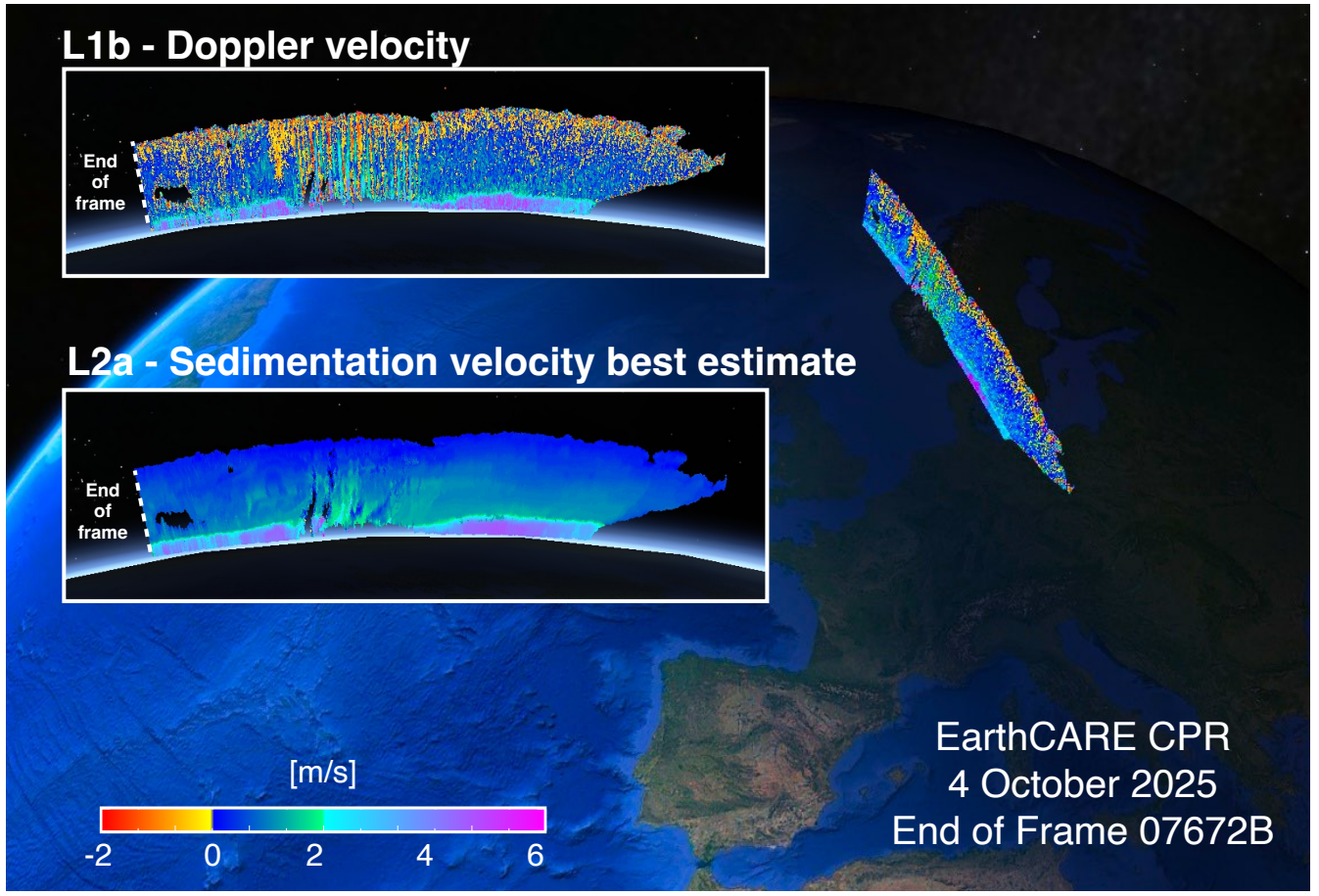
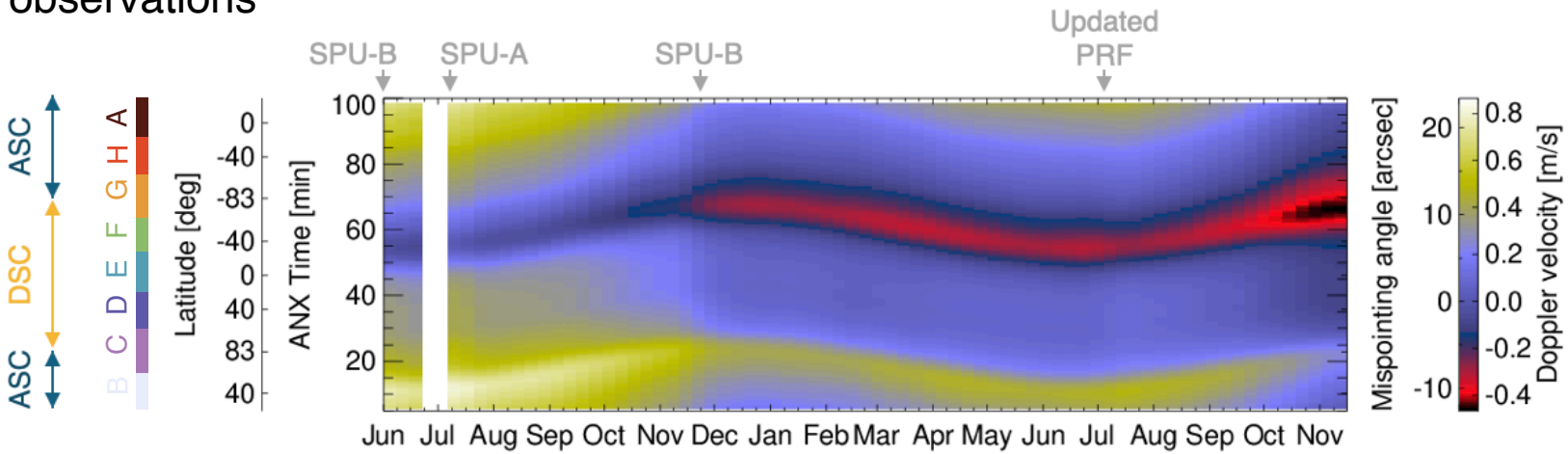


Antenna Pointing Correction

Surface reference technique

CPR antenna mispointing estimated from ocean (free of ice), Antarctica and Greenland land surface Doppler observations



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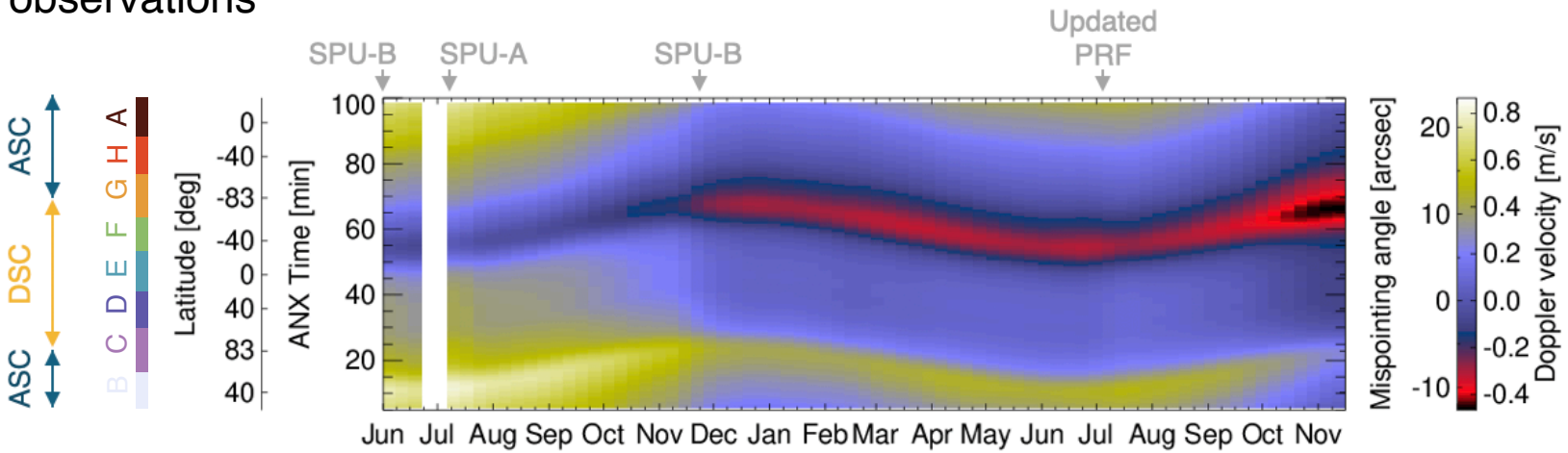

Lessons learned

Receiver saturation and high $|R_1|$ amplitudes bias the surface Doppler observations

The surface signal captures all sources of Doppler bias, including internal calibration issues or attitude anomalies

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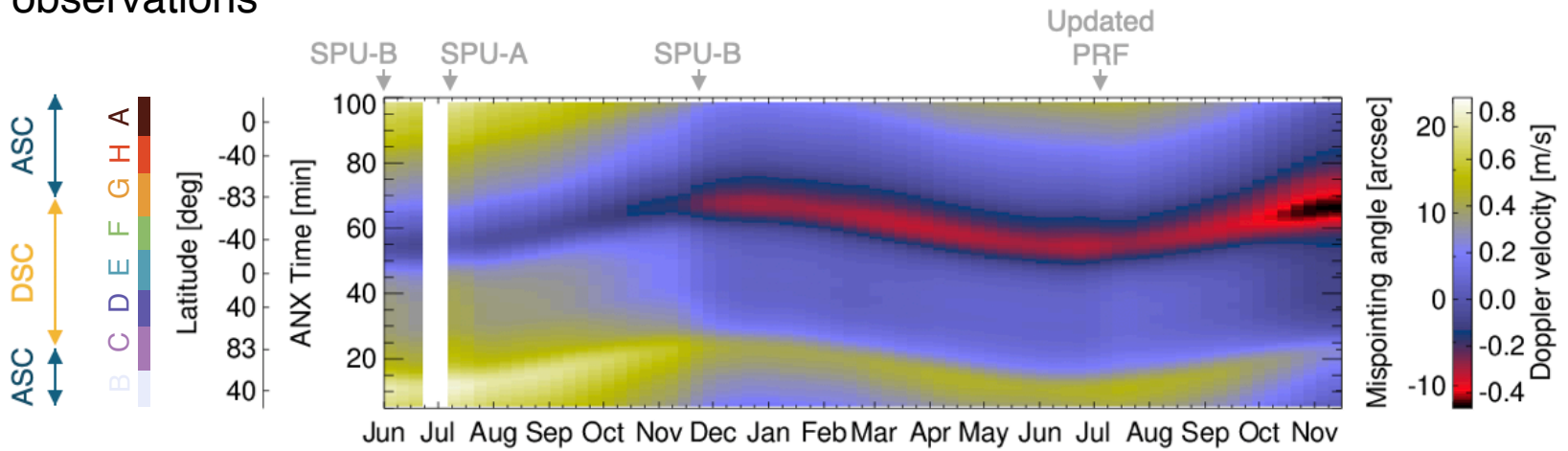

Lessons learned
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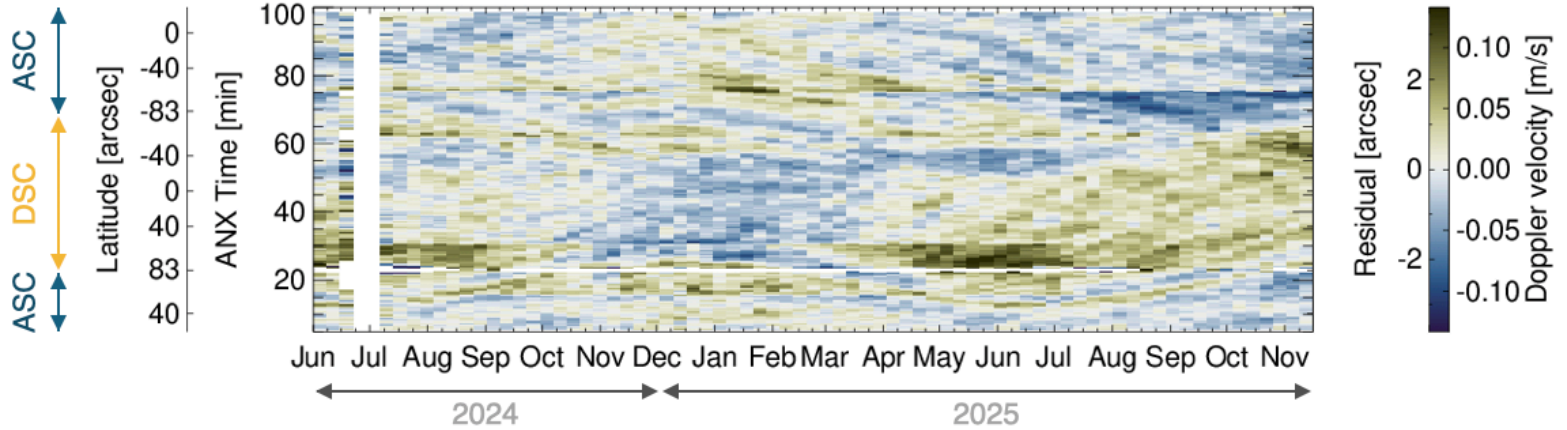
The surface signal captures all sources of Doppler bias, including internal calibration issues or attitude anomalies

C-CD L2a — Residual Antenna Pointing Error relative to the CPR mispointing climatology



Seasonal and Orbit-Phase Variability in Antenna Pointing Residuals —
DSC winter vs summer
ASC vs DSC autumn
etc.

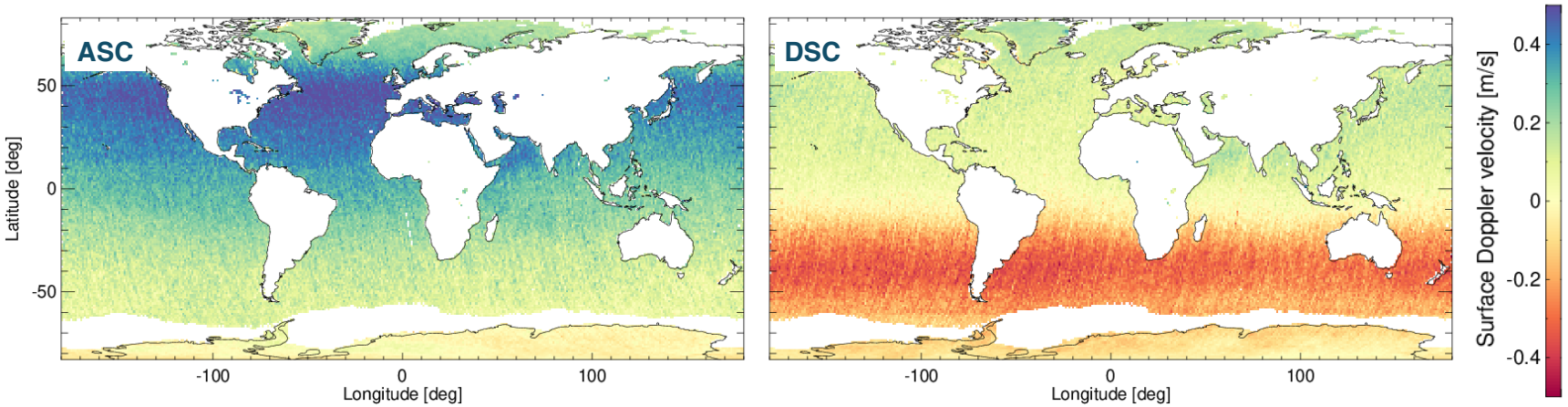
CPR Surface Doppler velocity

Summer 2025 / averaged 100 km / corrected for NUBF

Ocean (free of ice), Antarctica and Greenland

Pronounced surface Doppler velocity biases induced by **antenna mispointing**

Without antenna pointing correction



CPR Surface Doppler velocity

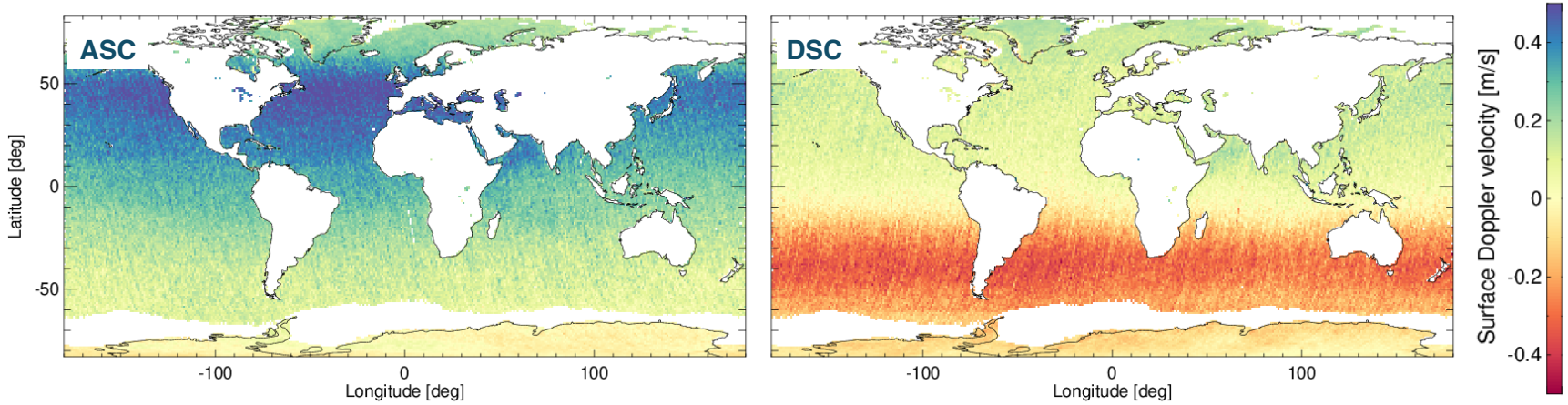
Summer 2025 / averaged 100 km / corrected for NUBF

Ocean (free of ice), Antarctica and Greenland

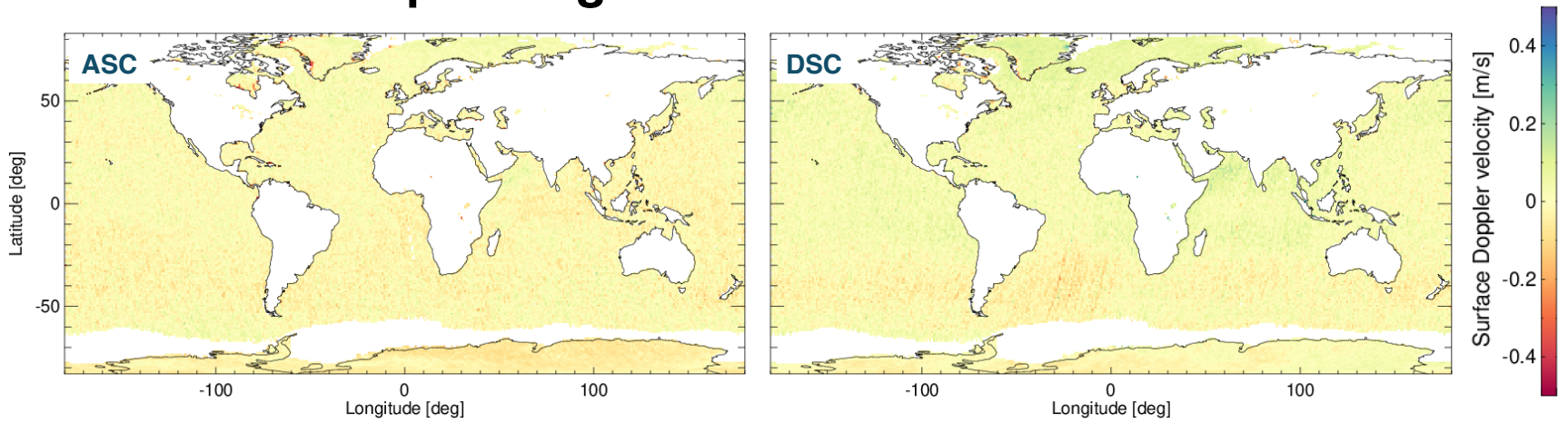
Pronounced surface Doppler velocity biases induced by **antenna mispointing**

After correction, the **near-zero surface Doppler velocity** highlights the good health of the Doppler signal

Without antenna pointing correction



With antenna pointing correction



CPR Surface Doppler velocity

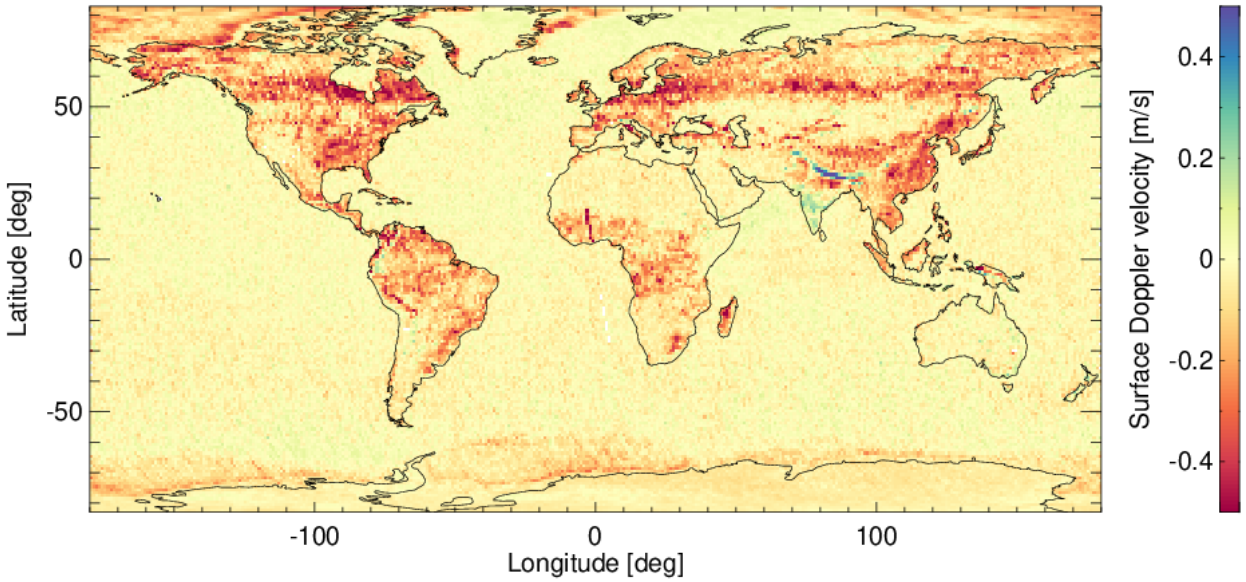
Summer 2025 / averaged 100 km / corrected for NUBF

Land-type and orbit-phase dependencies over land

Land-surface observations are currently excluded from the antenna pointing correction because can induce biases

We are evaluating land surfaces as a possible way to extend the mispointing reference observations

Ascending



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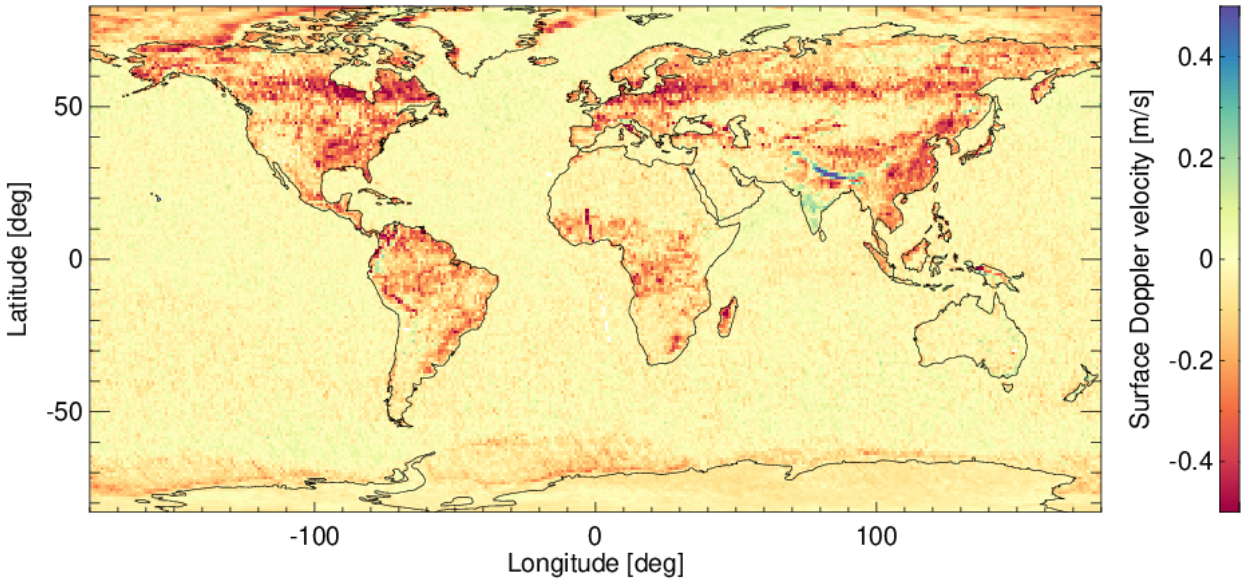
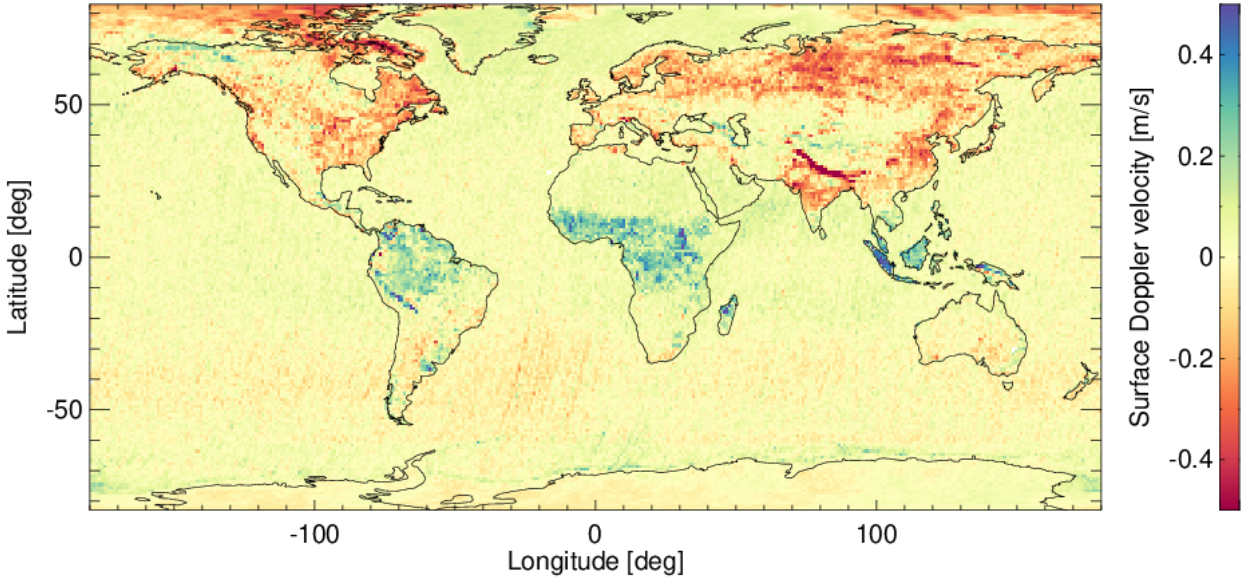


Descending



CPR Surface Doppler velocity

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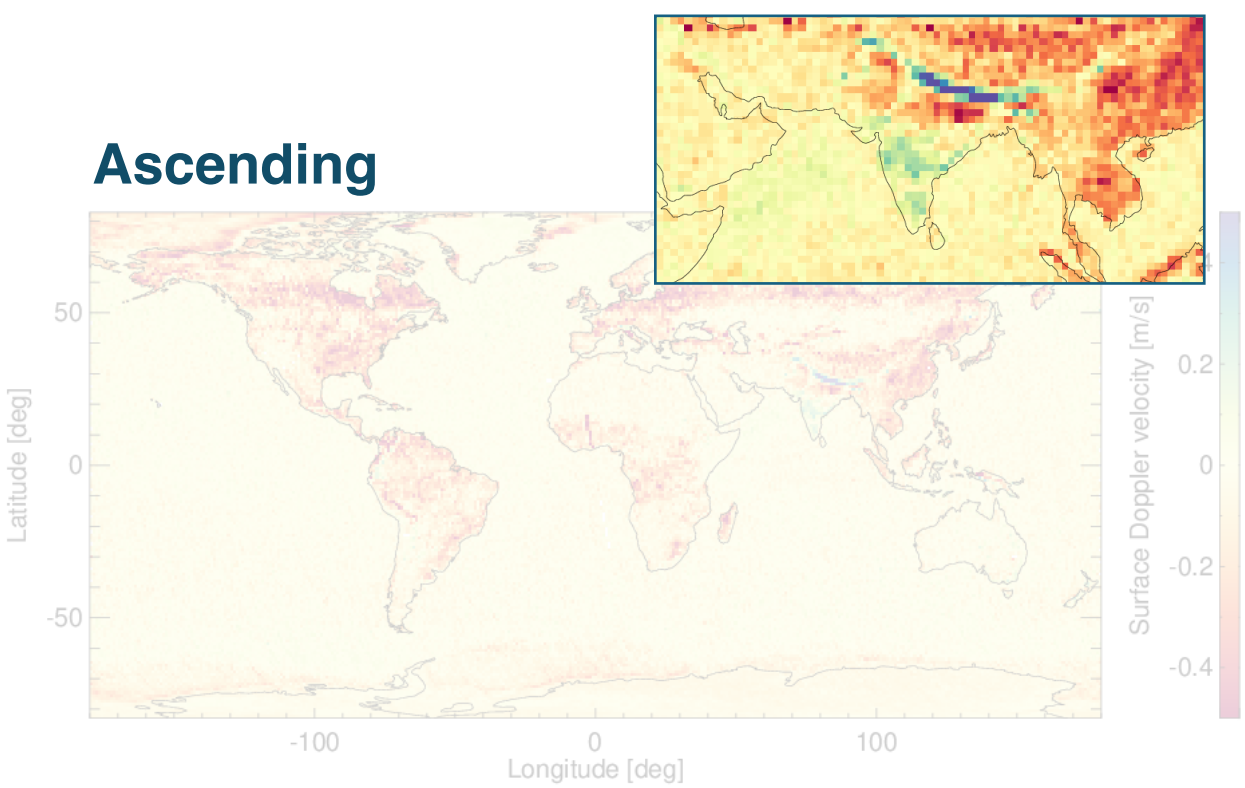
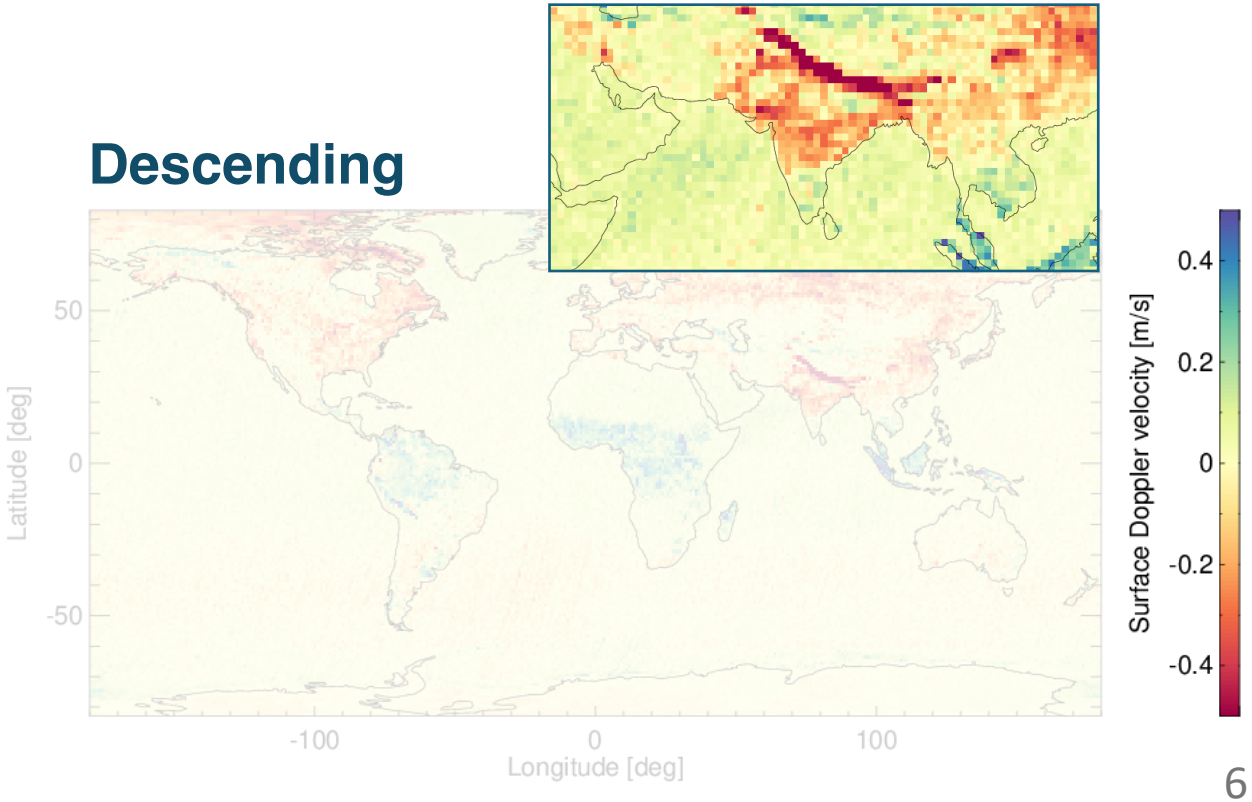
Land-type and orbit-phase dependencies over land

Himalayas

Southern slope descending gradually into the Indo-Gangetic plain
Northern boundary where the Tibetan Plateau is high and flat





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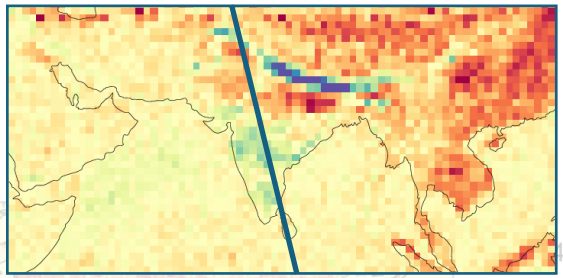

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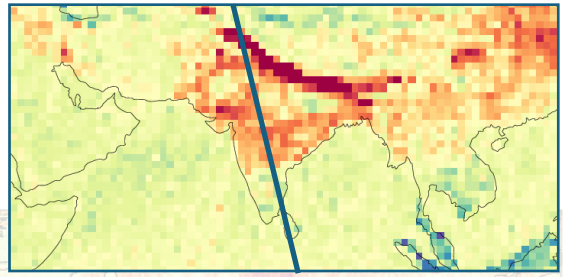
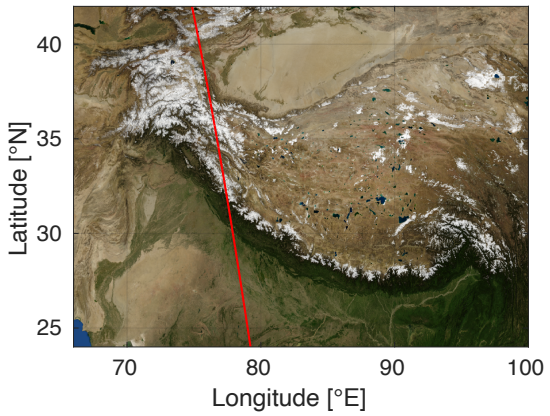
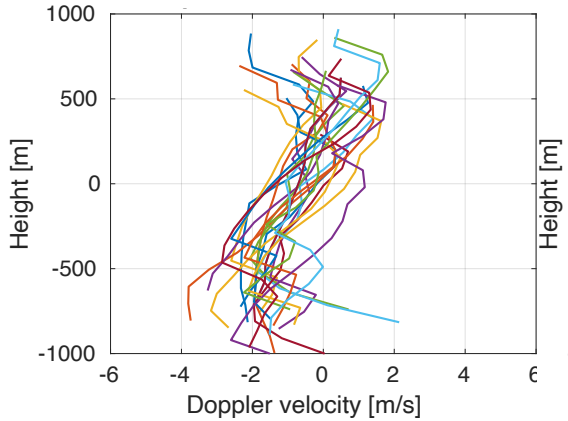


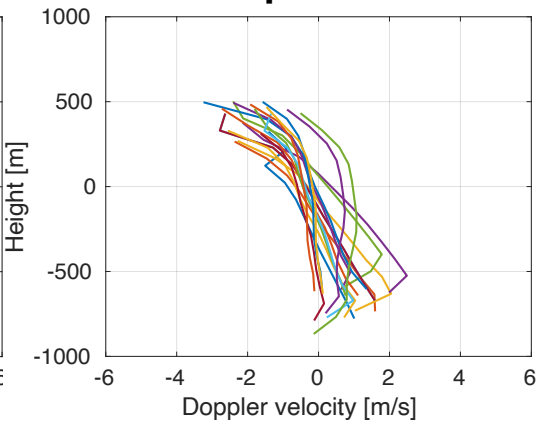
Frame: 08074B
Ascending

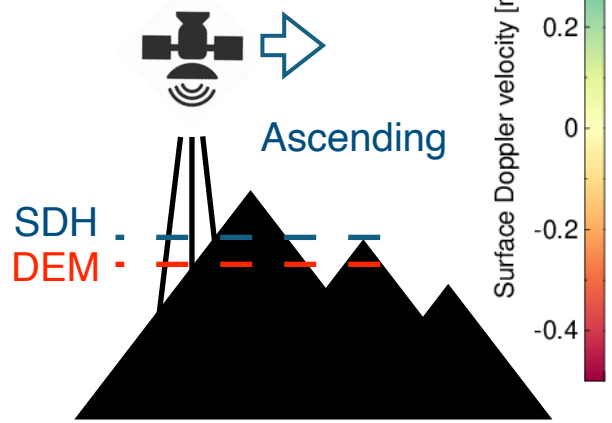


Slope Up



Slope Down





CPR Surface Doppler velocity

Summer 2025 / averaged 100 km /
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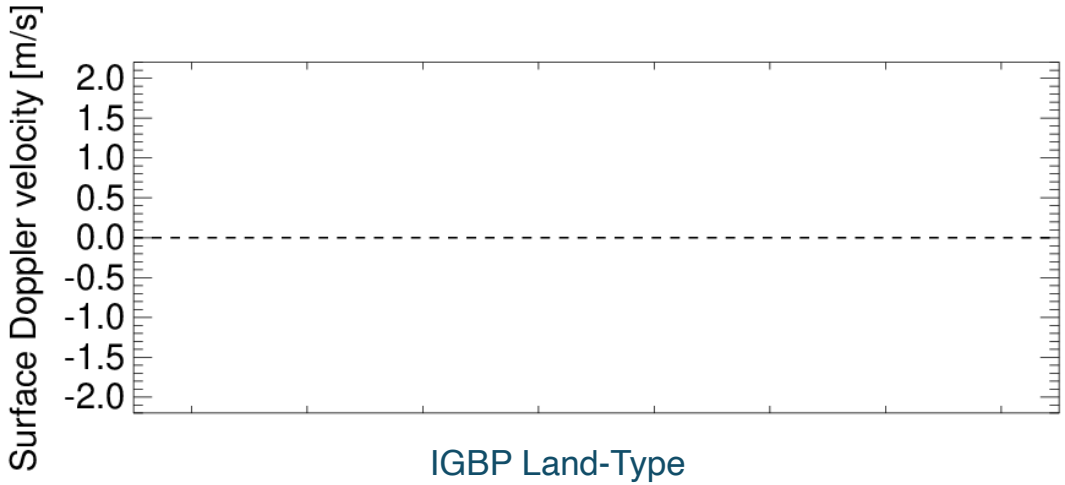
Land-type dependencies

Surface Doppler variability by Land Type, based on the International Geosphere-Biosphere Programme (IGBP) classification system



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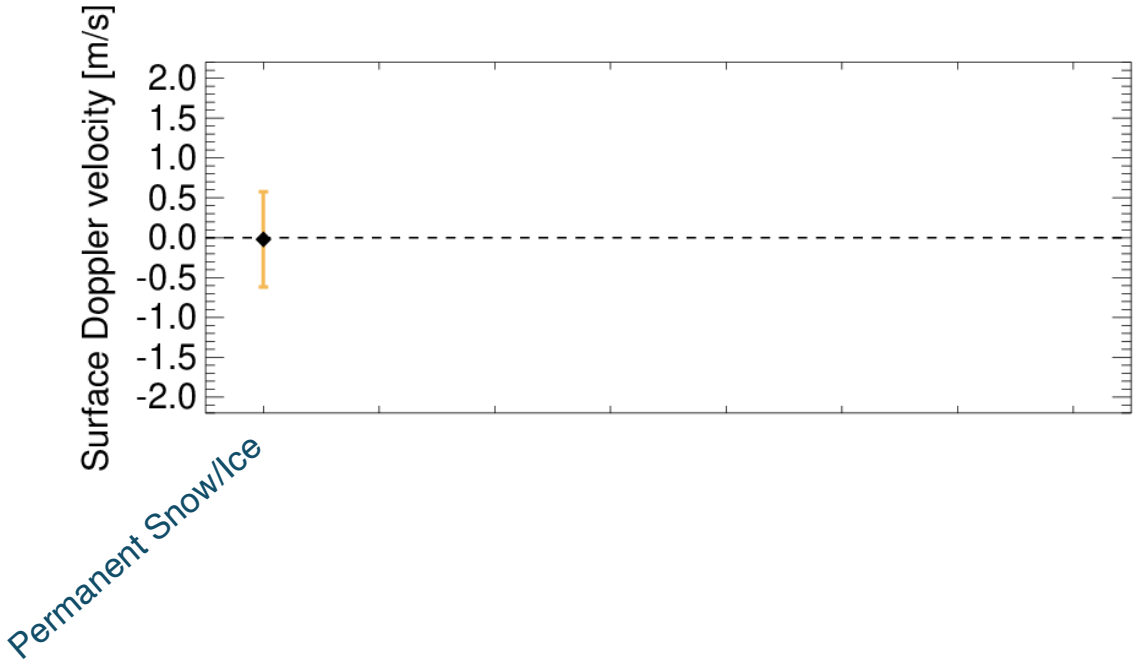
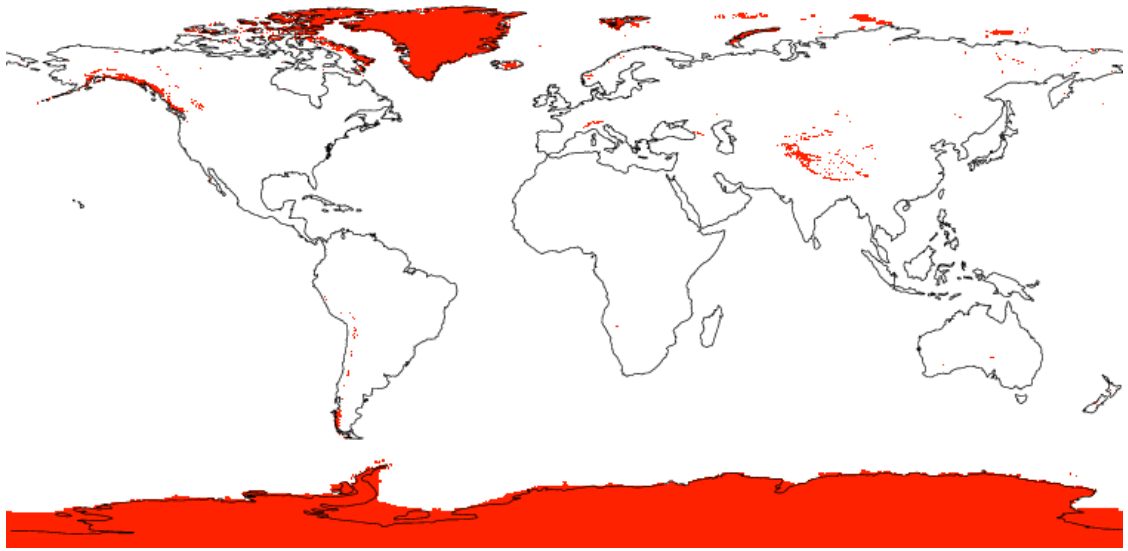


Permanent Snow and Ice



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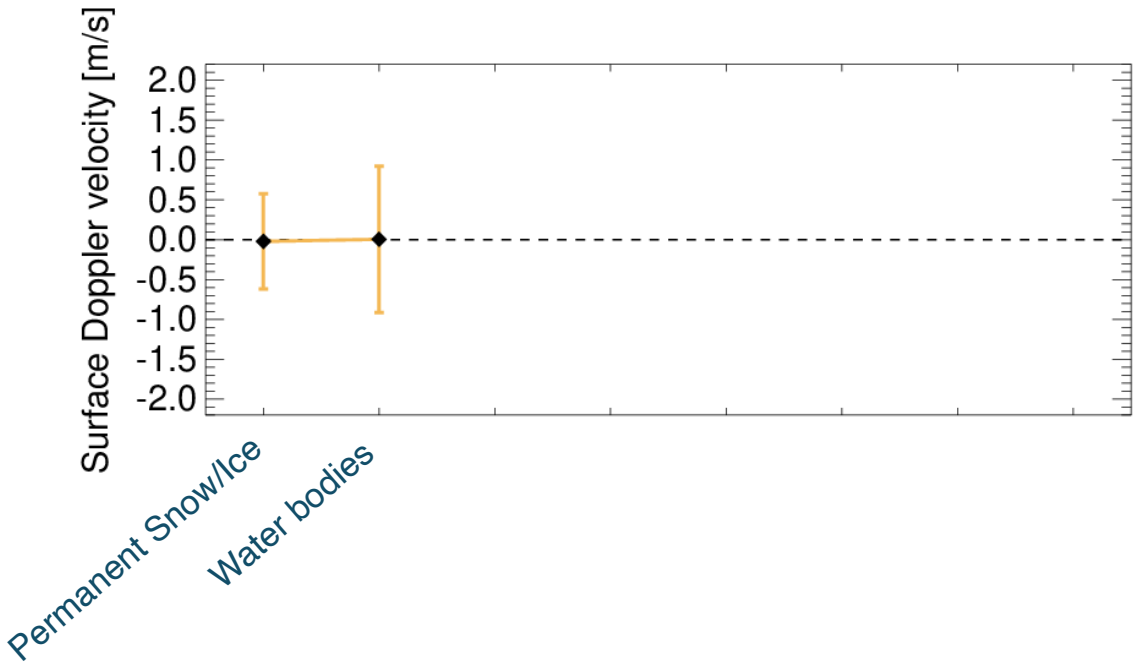
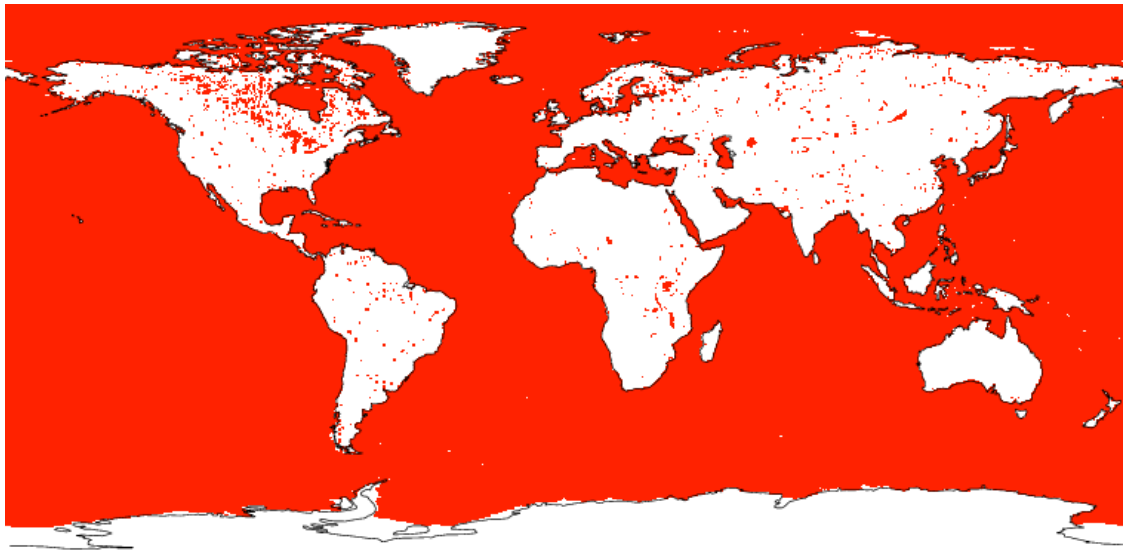


Water bodies



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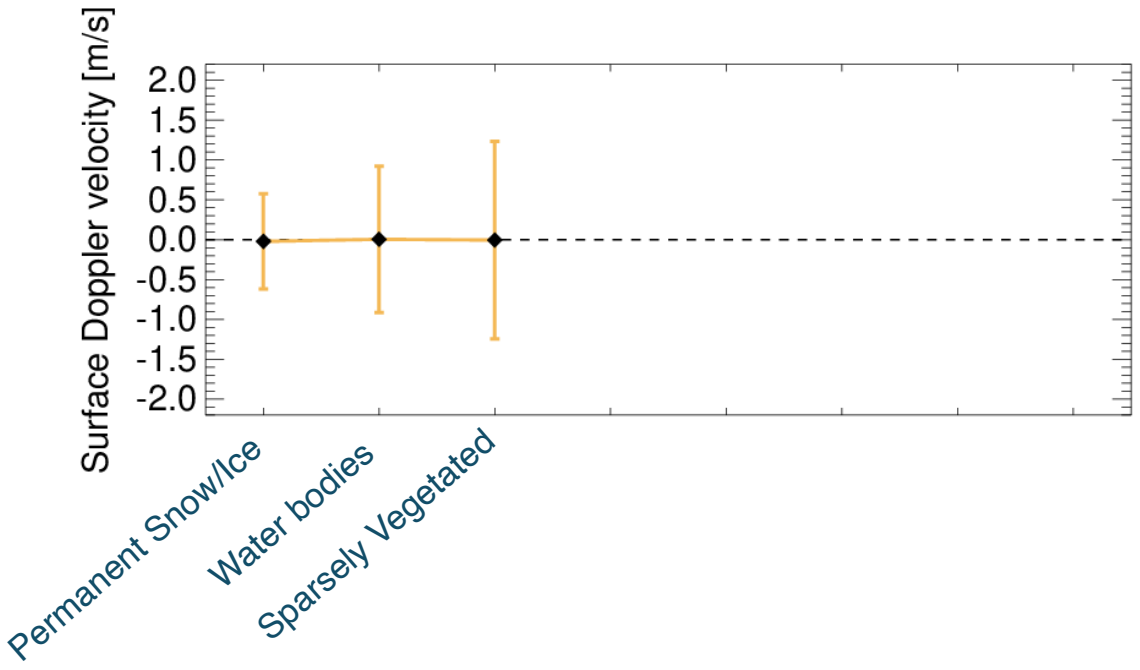
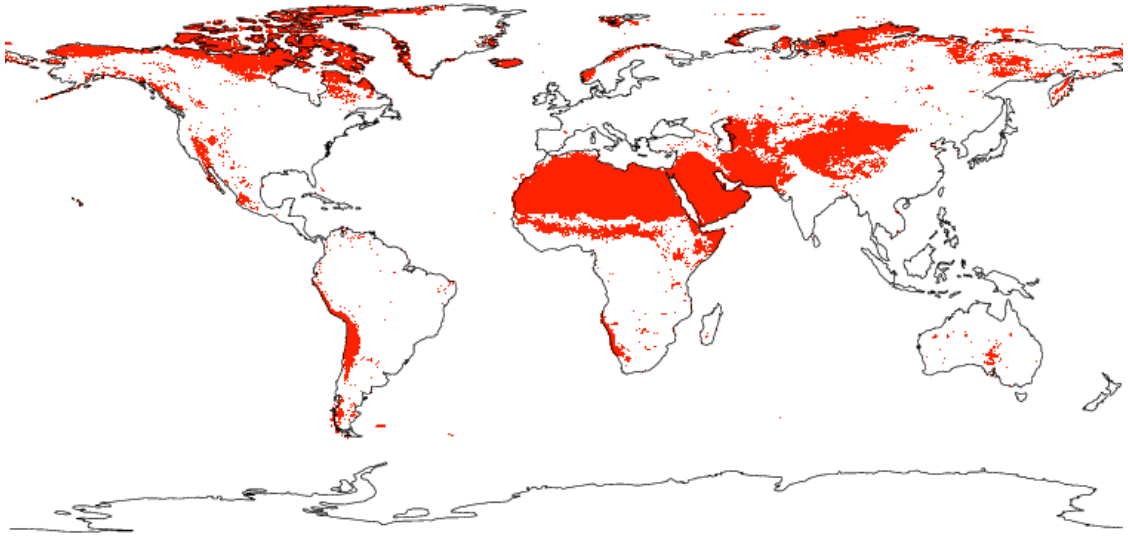


Barren or Sparsely Vegetated



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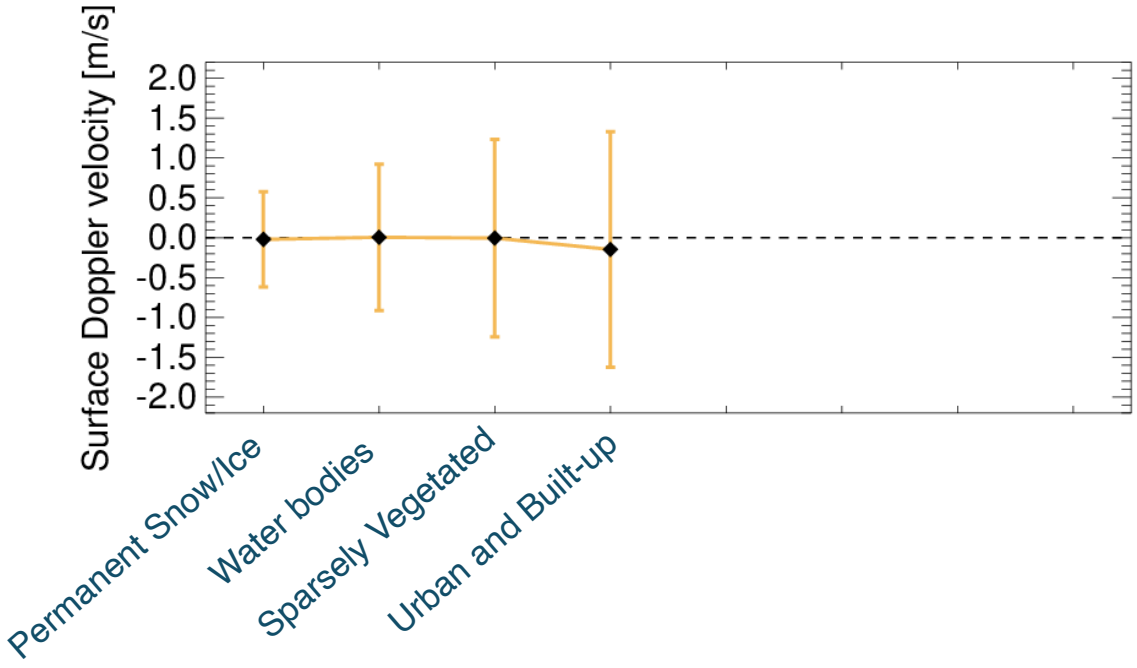
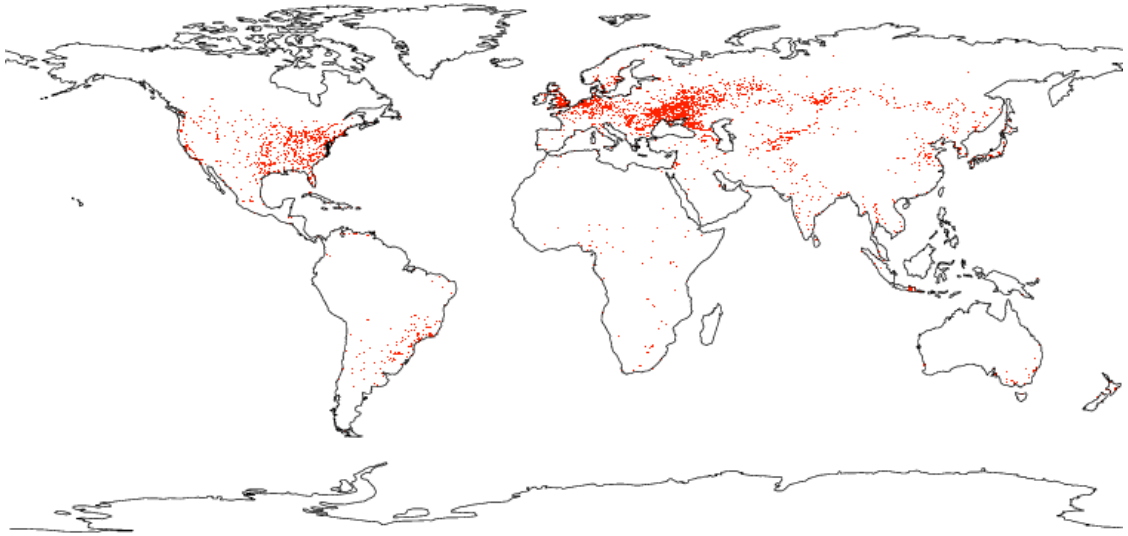


Urban and Built—up



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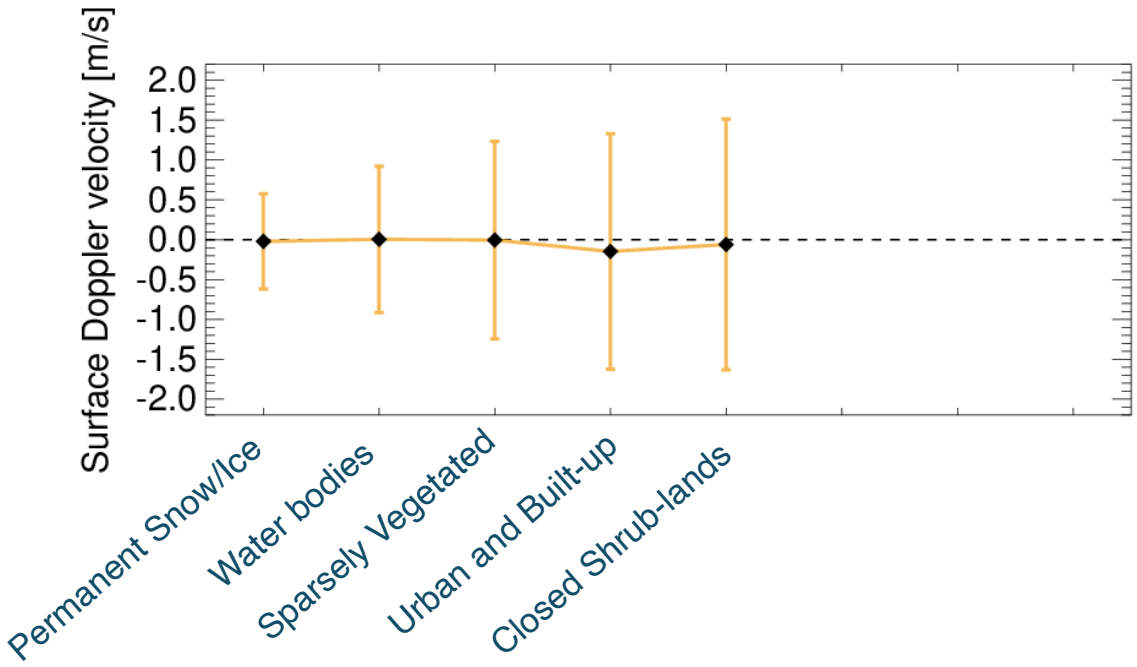
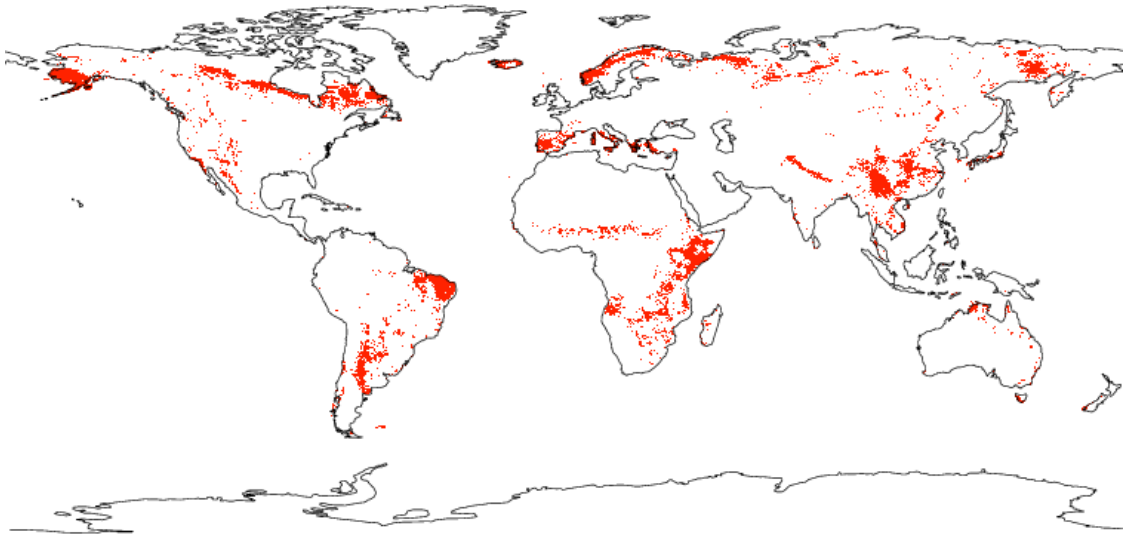


Closed Shrub-lands



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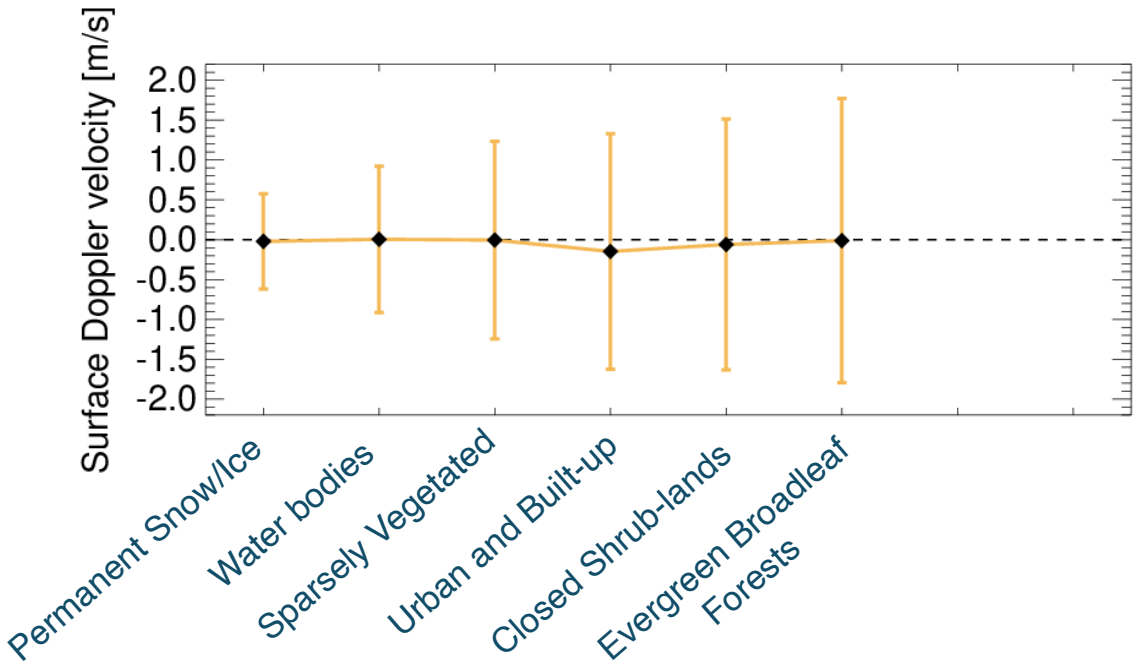
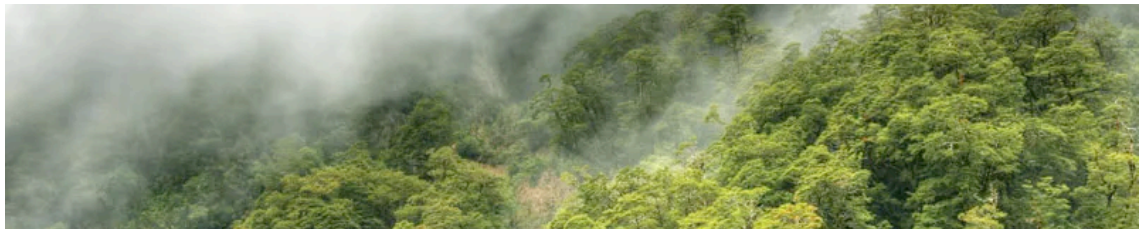
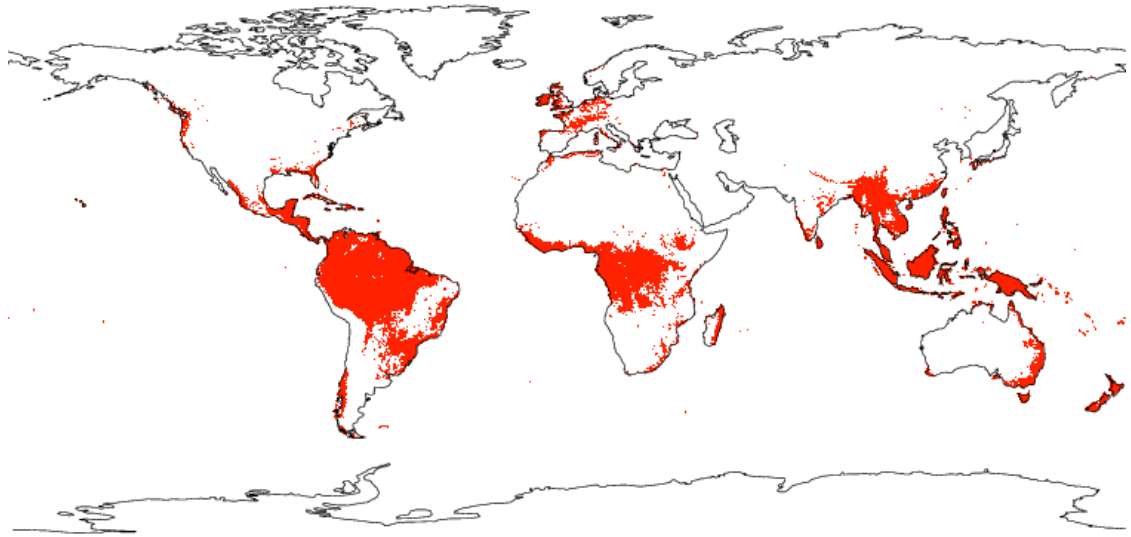


Evergreen Broadleaf Forests





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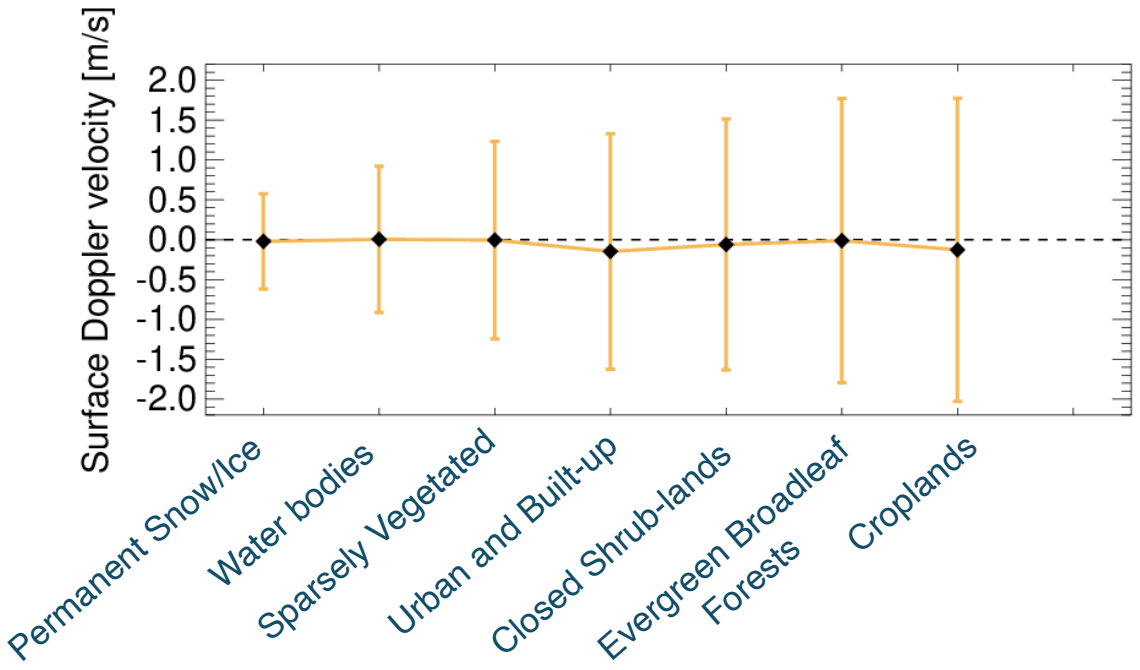
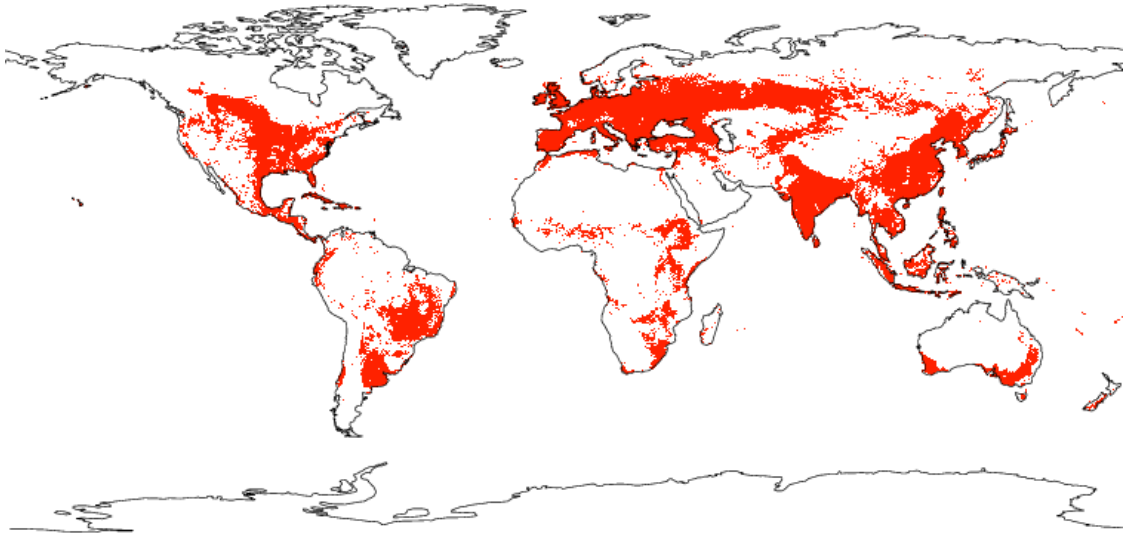


Croplands



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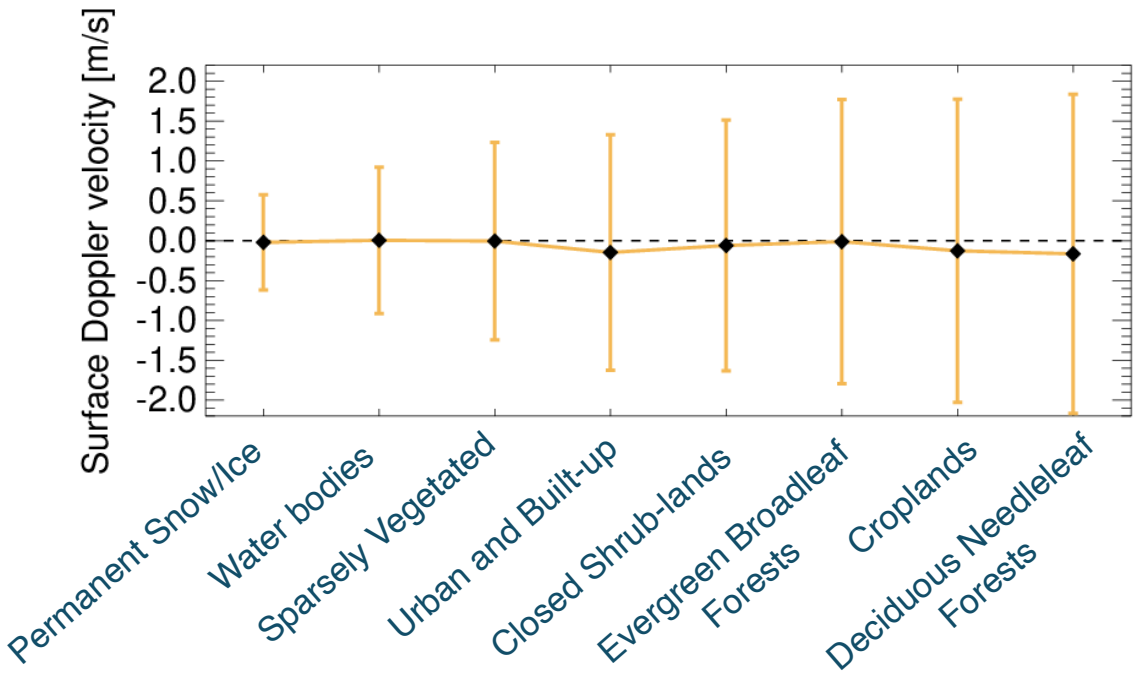
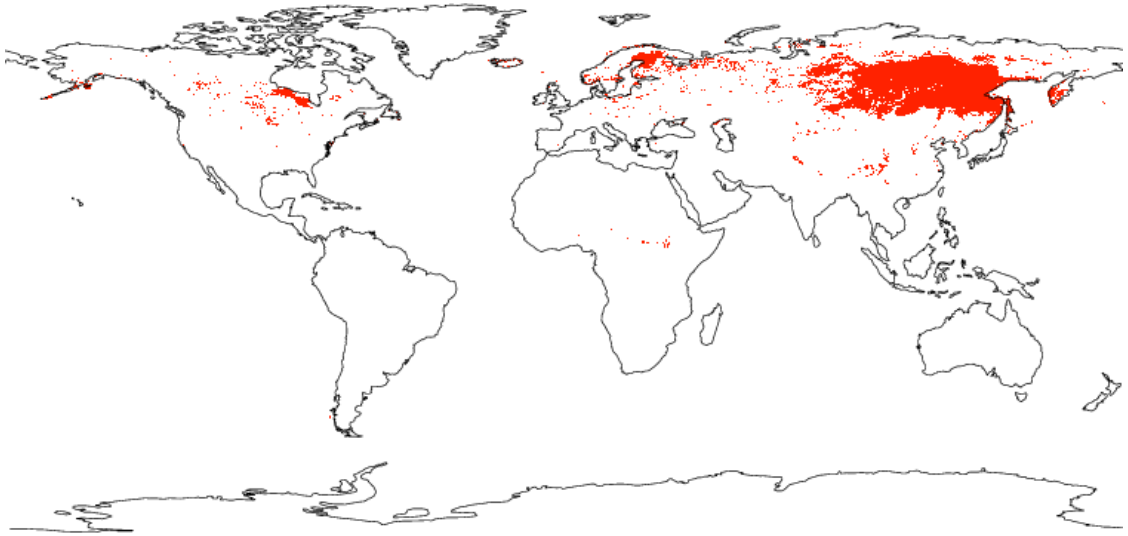


Deciduous Needleleaf Forests



CPR Surface Doppler velocity

Heterogenic and rough topography can generate diffuse backscattering and significant terrain-induced Doppler effects (slopes and NUBF)

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Sedimentation velocity

C-CD: Doppler velocity Quality Control

Antenna Pointing correction
Non-uniform beam filling correction
Along-track averaging to reduce uncertainty
Unfolding
Sedimentation velocity estimation

$$V = V_{sed} + W + \epsilon$$

Measured Doppler velocity

Sedimentation velocity

Vertical air motion

Sedimentation velocity

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Measured Doppler velocity — Sedimentation velocity — Vertical air motion

Algorithm overview

- Estimates the terminal fall speed by statistically averaging Doppler observations from neighbouring samples with similar reflectivity and temperature
- Assumes that small-scale microphysical variability is weaker than the variability introduced by vertical air motion
- **Not meant to work in convection**

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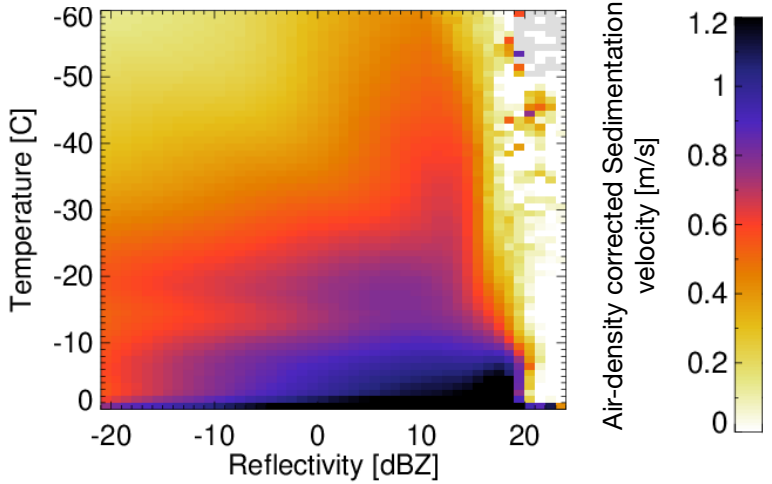
Measured Doppler velocity | Sedimentation velocity | Vertical air motion

L2a



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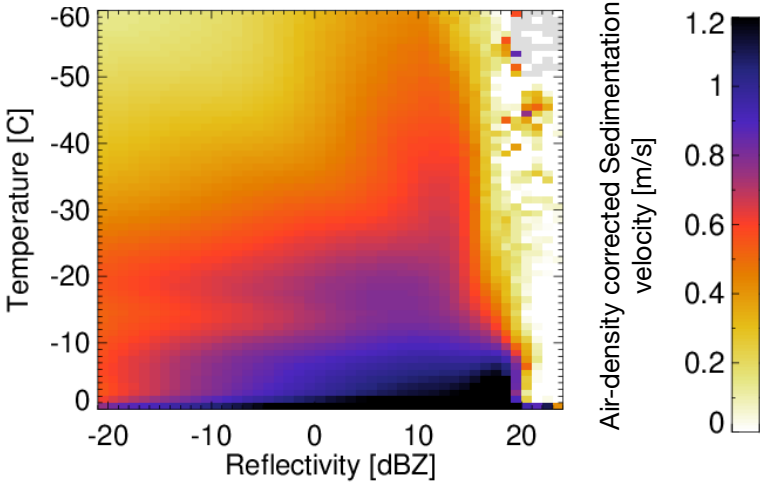

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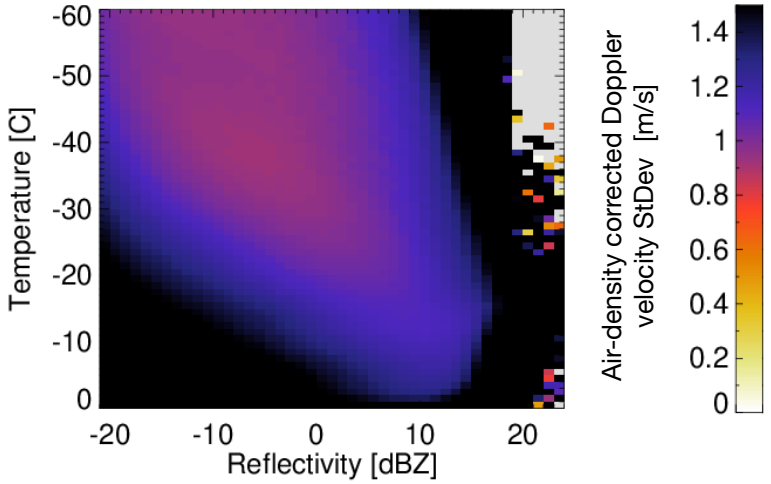
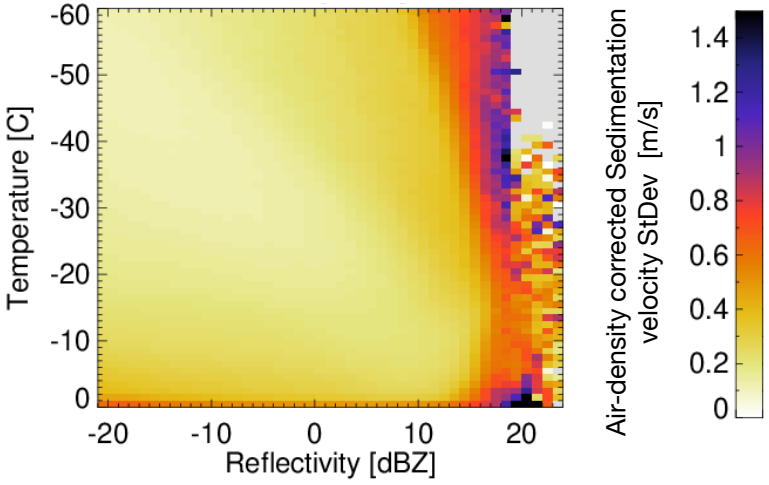
L1b



L2a



Thank you!

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McGill University

Stony Brook University

Politecnico di Torino

EarthCARE Science and Validation Workshop 2025
1-5 December 2025 | The University of Tokyo | Tokyo, Japan

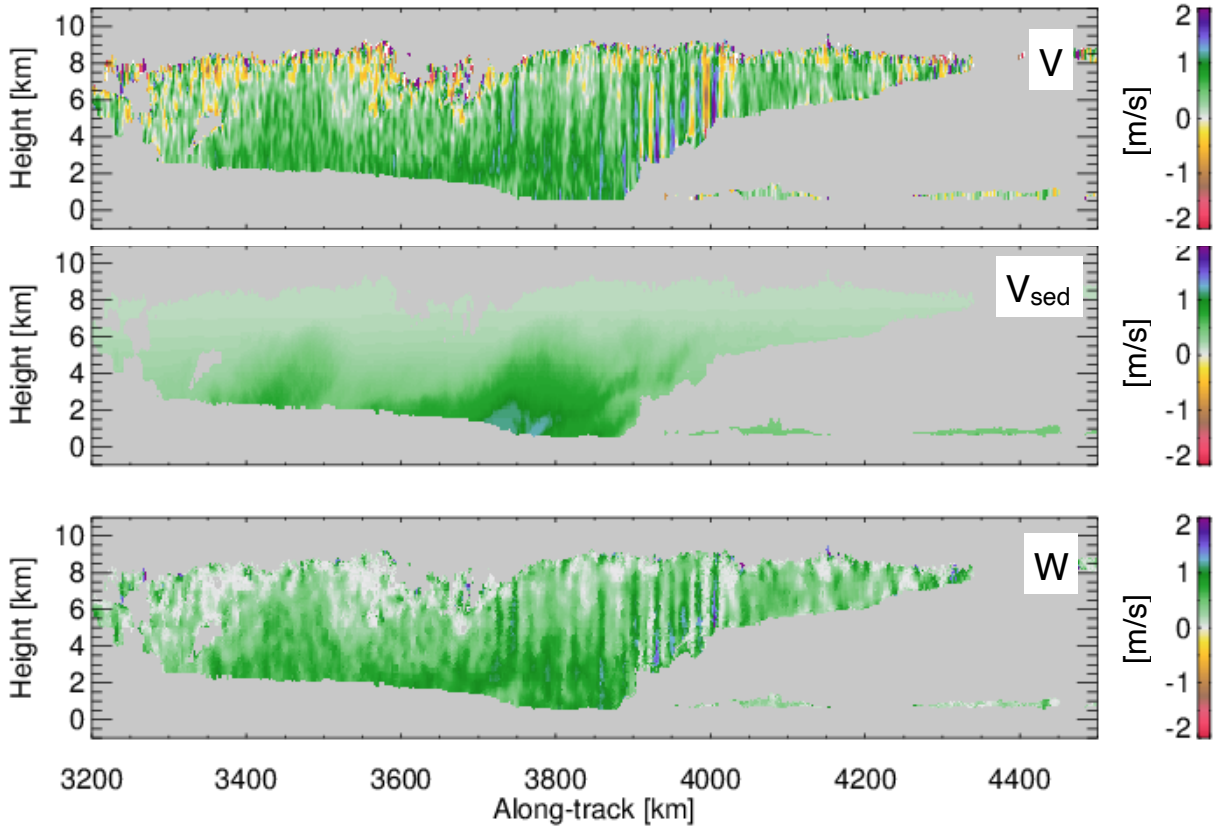
JAXA

esa

Gravity Waves

Identification using Continuous Wavelet Transform

CWT's provides sharp time–frequency localization, showing when specific periods appear, disappear, and drift.



$$V = V_{sed} + W + \epsilon$$