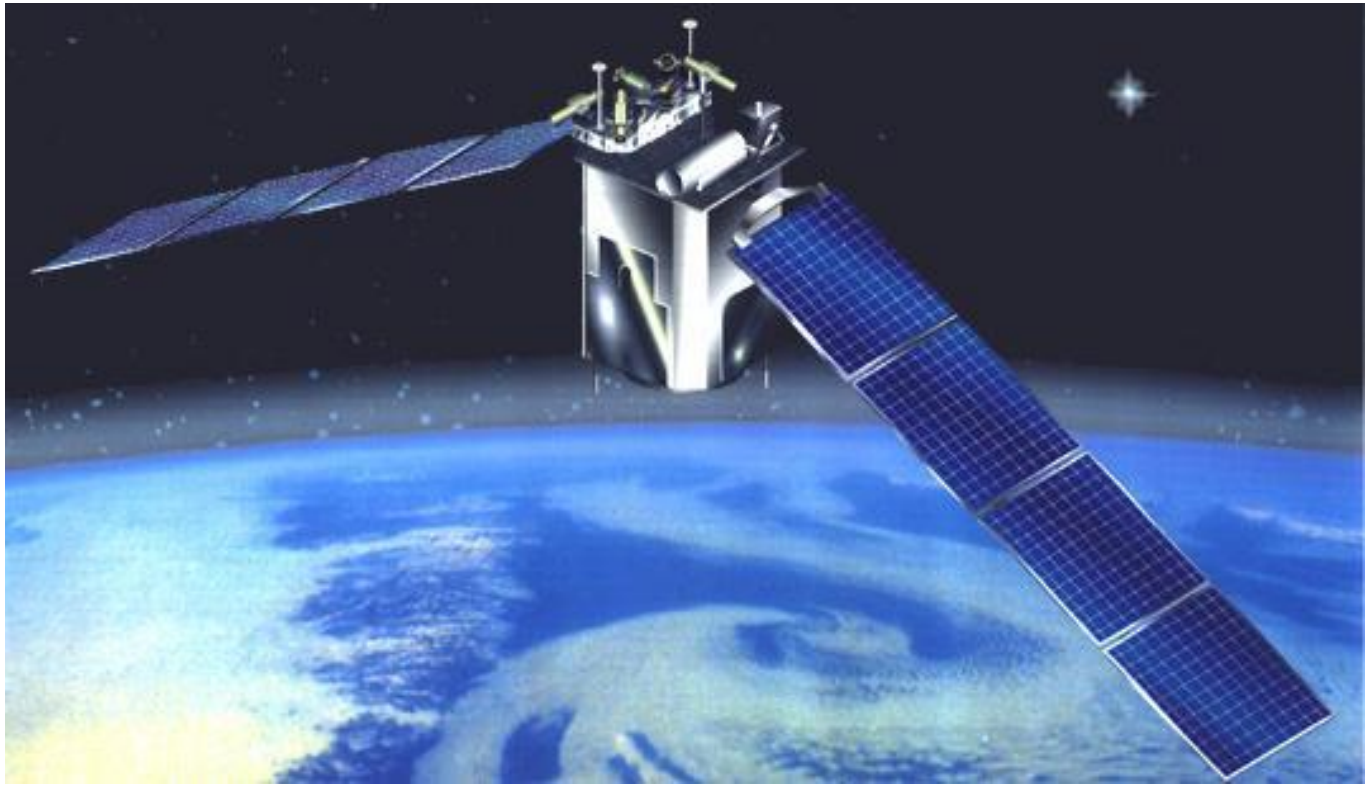
CROSS COMPARISON OF TIDI WINDS WITH METEOR RADAR WINDS AND ASSESSMENT OF THE ACCURACIES DEPENDING ON LOCAL TIME AND GEOGRAPHICAL LATITUDE

Arthur Gauthier[1,2], Claudia Borries[1], Gunter Stober[2]

[1]German Aerospace Center DLR, Insitute for Solar-Terrestrial Physics, Neustrelitz, Germany
[2]University of Bern, Bern, Switzerland

Motivation

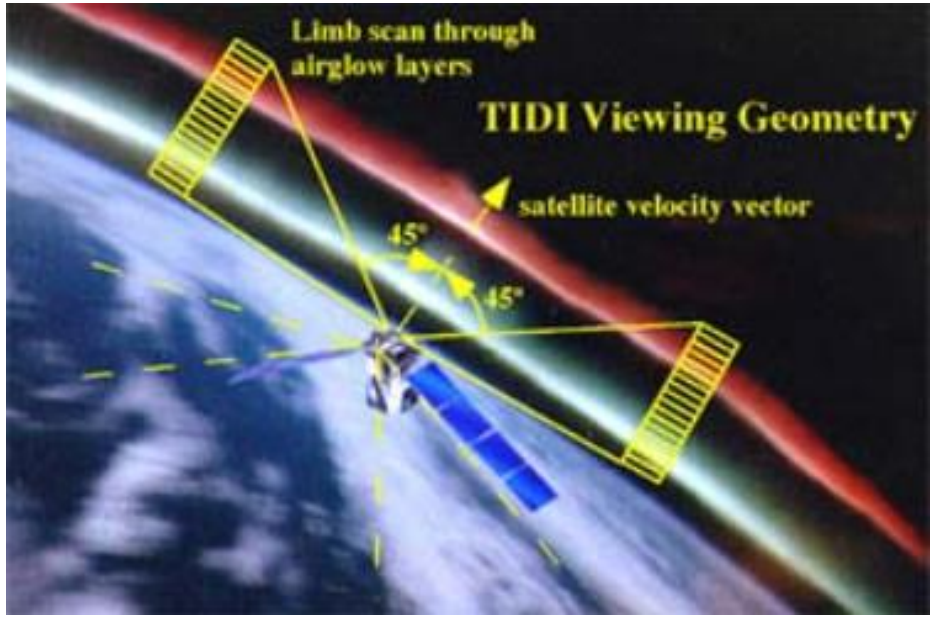
- Atmospheric waves and tides as they provide a substantial source of variability at the lower boundary of the upper atmosphere.
- Establishing a climatology of winds with TIDI and comparison to existing climatologies derived from local meteor radar(MR).



TIMED

Instrumentation: TIMED mission and TIDI instrument

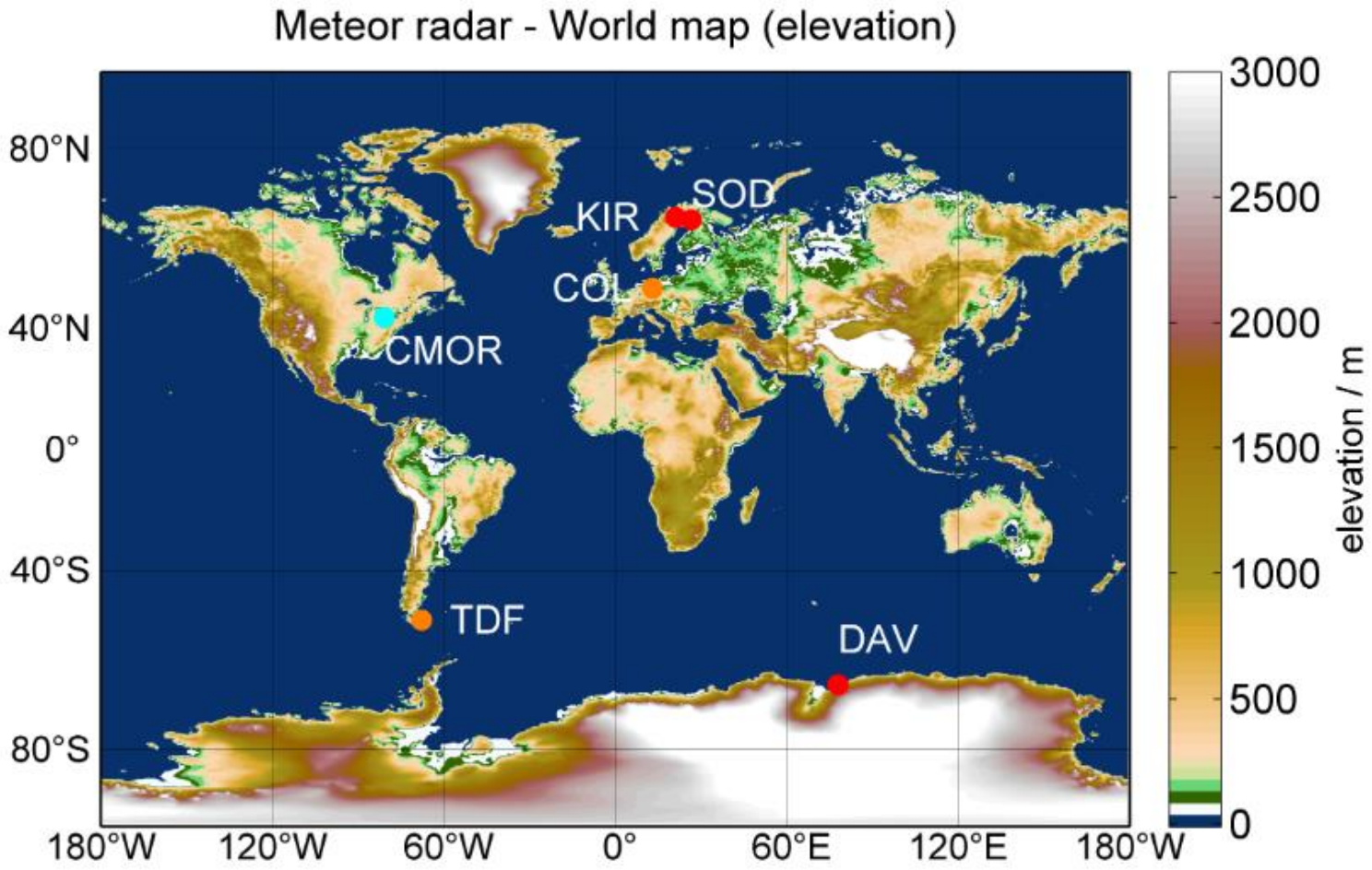
TIMED Mission



TIDI interferometer

- TIDI sampling track covers 24 hours in local time every 60 days
- Day and night coverage of neutral wind and temperature measurements
- Construction of horizontally resolved vector winds(zonal and meridional winds) as a function of altitude
- Accuracy: 3 m/s and 3 K
- Vertical altitude resolution: 2.5 km between 70 and 120 km

Instrumentation: Meteor radar stations



Meteor radar stations at different latitudes

- Local observations at different latitudes
- Comparison with TIDI for stations with 10 years of observation
- MR winds provide zonal and meridional winds
- Vertical altitude resolution: 2 km between 70 and 120 km
- Temporal resolution: 1h

Dataset for TIDI-MR comparison

TIDI data :

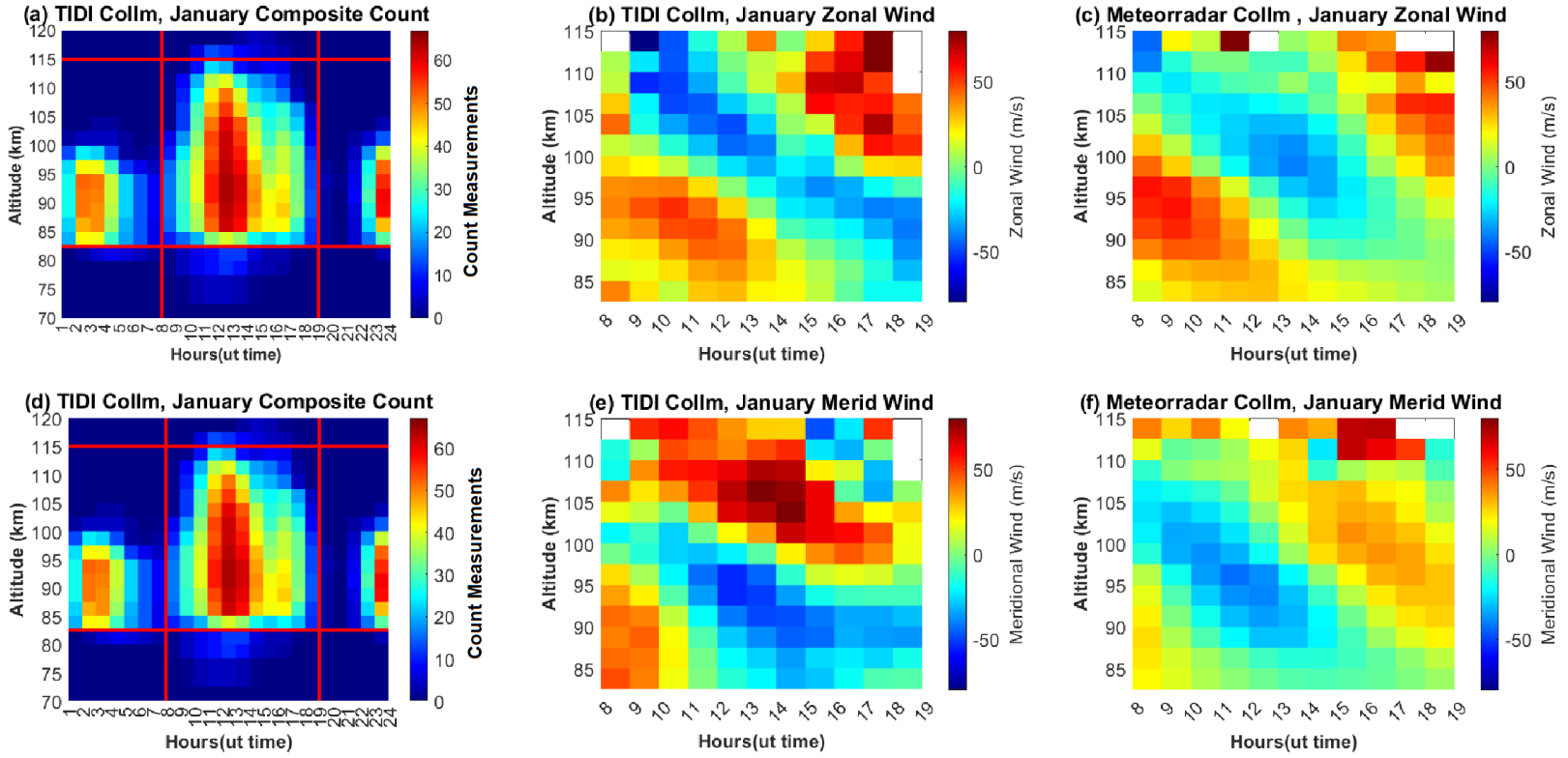
- **Binning of the TIDI data** in longitude, latitude and time and preparation of a spatial grid with 30° longitude bins and 10°latitude bins.
- **Averaging of all measurements** that fall within each longitude and latitude bins for each hour using all orbits within 30 days to ensure the sampling of all local times for each spatial and temporal bin.

MR data :

- **Matching the sampling of the TIDI instrument to hourly MR resolution:** MR winds are averaged +/- 30 days for every hour of the day around a certain day to obtain composites with a temporal resolution of 1 hour.

TIDI winds and MR winds comparison

- **Method:** Choosing of the longitude/latitude bin of the TIDI winds where the MR is located.
- For TIDI we determine the number of accepted observations for each bin as a quality control criteria.



Collm MR and TIDI for january, for zonal and meridional components

- Remarkable agreement between both datasets.
- Zonal winds show semidiurnal tide typical for winter months at midlatitudes.
- More observations in local daytime than in nighttime.

Arthur Gauthier, DLR, 05.06.2024

TIDI winds and MR winds comparison

Correlations between TIDI and MR stations for summer and winter months:

	Zonal (summer)	Merid (summer)	Zonal (winter)	Merid (winter)
DAV (Davis)	0.62	0.78	0.69	0.49
CMO (CMOR)	0.44	0.82	0.52	
TRO (Nordic)	0.71	0.61	0.52	0.69
COL (Collm)	0.67	0.56	0.87	0.67
TDF (Tierra del Fuego)	0.70		0.67	0.37

Correlation values TIDI – MR stations at different latitudes

Criteria: TIDI zonal and meridional winds with a measurement statistics of 30 and more TIDI observations for each time, altitude, and latitude-longitude bin.

TIDI winds and MR winds comparison: seasonal comparison

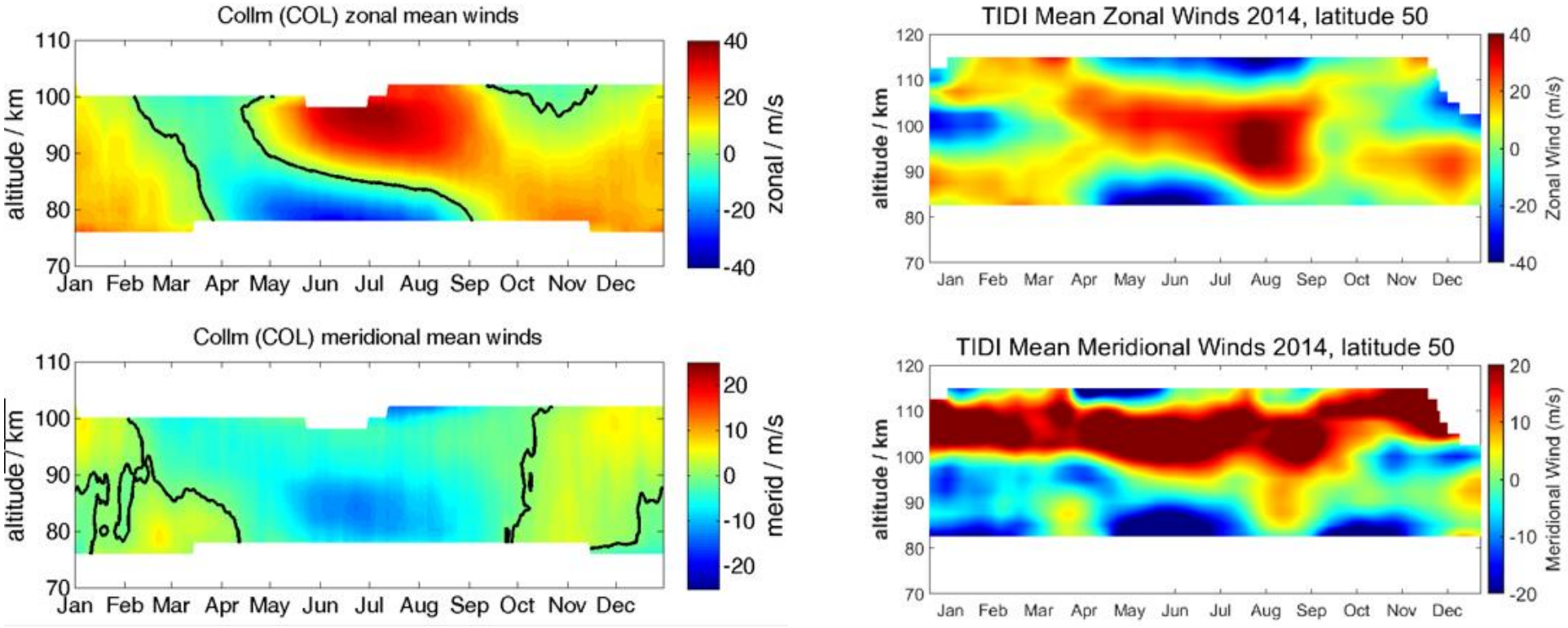
Method:

1. Building of an adapted composite to account for different day and nighttime coverage.
2. Data is taken from every longitude for each latitude but longitudinal difference was converted in a time offset around the Greenwich meridian.
3. These composite days are decomposed applying a classical tidal fit including mean zonal and meridional winds, and the diurnal, semidiurnal and terdiurnal component.

$$u, v = u_0, v_0 + \sum_{n=1}^{3} A_n \sin(2\pi \cdot t/T_n) + B_n \cos(2\pi \cdot t/T_n)$$

4. Comparing of these mean zonal and mean meridional winds to the MR climatologies applying the same averaging window of 60 days.

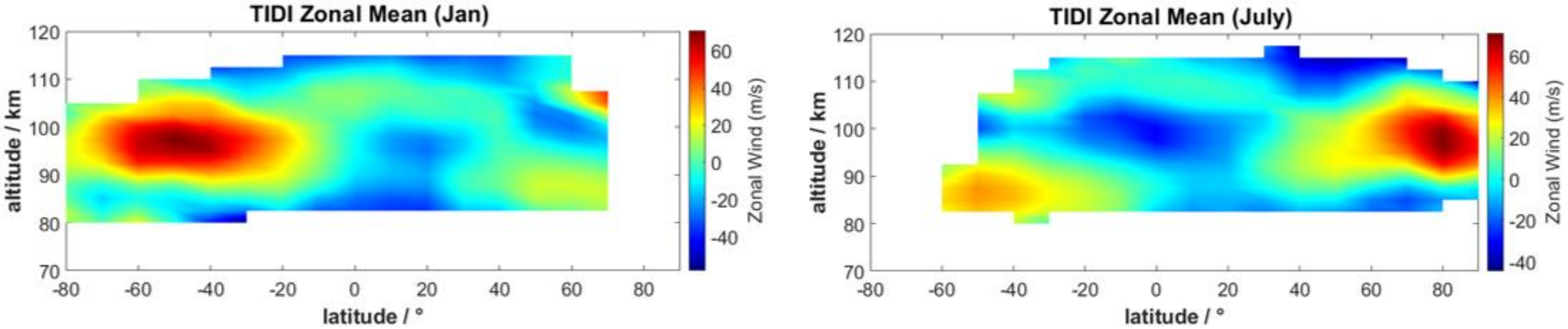
TIDI winds and MR winds comparison: seasonal comparison



Collm zonal and meridional TIDI – MR comparison

- Summer wind reversal is well reproduced concerning the reversal altitude and magnitude.
- Weak eastward zonal winds during winter season up to 90 km.
- Above 90km: rapid wind reversal to westward which is not observed in MR data.
- Observed TIDI meridional winds are very different to the seasonal behavior from MR winds.

TIDI winds and MR winds comparison: latitudinal cross section of mean zonal winds

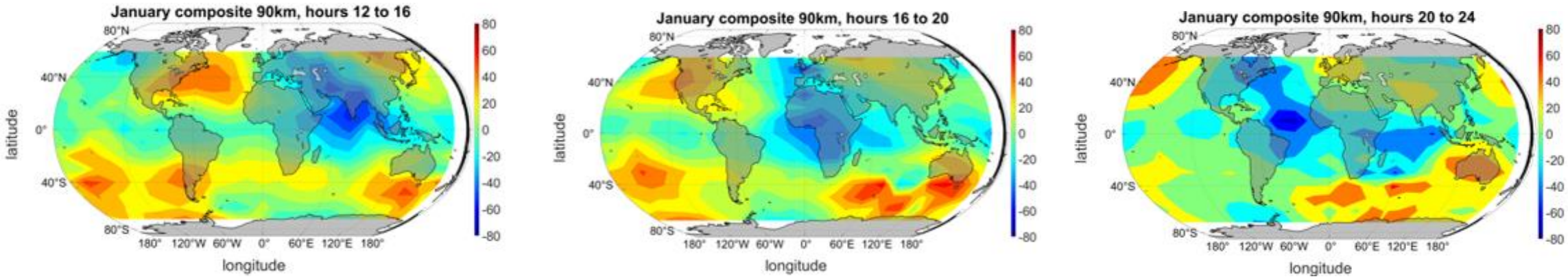


Latitudinal cross section of mean zonal winds for winter and summer period

- TIDI zonal winds indicate summer hemispheric wind reversal and latitudinal dependency of the reversal altitude.
- Those winds are in good agreement with the MRs: *McCormack et al., 2017; Stober et al.,2020; Liu et al., 2022.*
- This study supports the presence of a hemispheric asymmetry between the summer and winter hemispheres, which can also be found in MR data: *Stober et al., 2021b.*

TIDI Global Map observations

Determination of 4-hourly-TIDI winds shows the semidiurnal westward propagating tide due to the solar heating of the atmosphere.



TIDI: Semidiurnal westward propagating tide on a global map

Arthur Gauthier, DLR, 05.06.2024

Conclusion:

TIDI and MR winds comparison :

- Filtering of TIDI data through a count measurement quality filter and calculation of subsequent correlation values show good correlation between TIDI and MR data.
- Performing of seasonal TIDI-MR comparison shows that TIDI captures most seasonal characteristics at mid and polar latitudes for zonal winds, but not for meridional winds.
- Latitudinal cross section for TIDI zonal winds shows hemispheric wind reversal. Also it suggests the presence of a hemispheric asymetry between the summer and winter hemispheres, which agree with MR data.