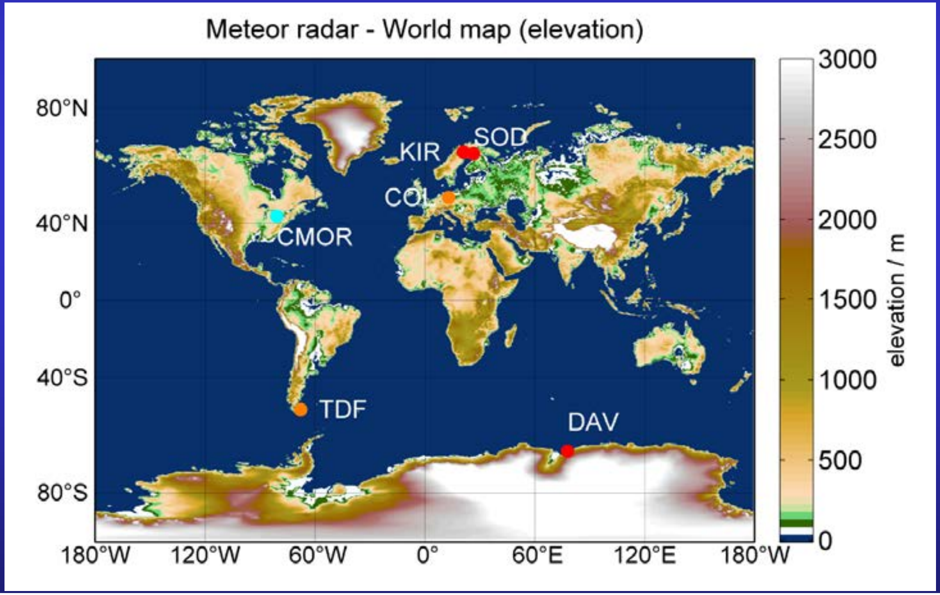
Interhemispheric differences of mesosphere/lower thermosphere winds and tides investigated from three whole atmosphere models and meteor radar observations



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https://acp.copernicus.org/preprints/acp-2021-142/

Data – Observations and Model ouputs

Three GCM models:

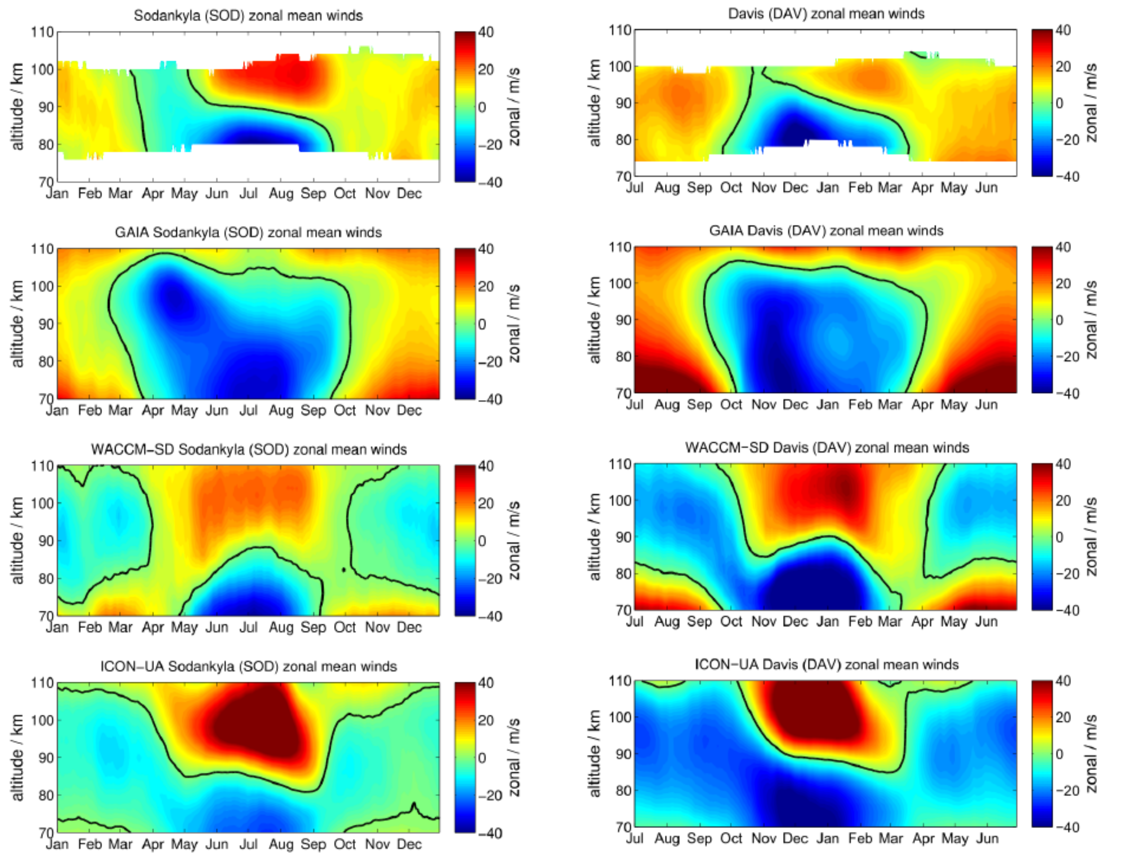
- Ground-to-Topside Model of Atmosphere and Ionosphere for Aeronomy (GAIA)
- Whole Atmosphere Community Climate Model Extension - Specified Dynamics (WACCM-X(SD))
- Upper Atmosphere - ICOsahedral Non-hydrostatic (UA-ICON)
- 6 meteor radars with long climatological data (Collm, Davis, Tierra del Fuego, Sodankyla, Esrange and CMOR)

Data analysis:

- model geopotential heights converted to geometric altitude using the WGS84 reference ellipsoid
- common diagnostic with the adaptive spectral filter to decompose time series in daily mean wind, atmospheric tides and gravity waves (with full non-linear error propagation)
- harmonized data analysis for radars and models
- ICON-UA free running 15 years
- GAIA and WACCM-X(SD) nudged to reanalysis
- all three models use a GW parameterization

	TDF	COL	SOD	KIR	DAV	CMO
Freq. (MHz)	32.55	36.2	36.9	32.55	33.2	17.45, 29.85,38.15
Power (kW)	64	6/15	7.5/15	6	7	6/15/6
PRF (Hz)	625	2144/625	2144	2144	430	532
coherent integration	1	4/1	4	4	4	1
pulse code	7-bit Barker	mono/7-bit Barker	mono	mono	4-bit complementary	mono
sampling (km)	1.5	2/1.5	2	2	1.8	3
location (lat,lon)	53.7°S, 67.7°W	51.3°N, 13.0°E	67.4°N, 26.6 °E	67.9°N, 21.1°E	68.6°S, 78.0°E	43.3°N, 80.8°W
observations	02/2008-2020	08/2004-2020	12/2008-2020	12/1999-2020	02/2005-2020	01/2002-2020

Conjugate latitude zonal wind comparison (polar)



Sodankyla vs. Davis (69° N and S)

- zonal winds are stronger eastward during hemispheric winter in the SH
- summer wind reversal occurs at higher altitudes in the SH
- eastward summer jet is stronger on NH
- GAIA shows better agreement for the winter and a too high summer wind reversal
- WACCM-X(SD) and ICON-UA show weatward winds during hemispheric winter and too strong summer jets
- ICON-UA and GAIA capture the seasonal asymmetry of the summer wind reversal

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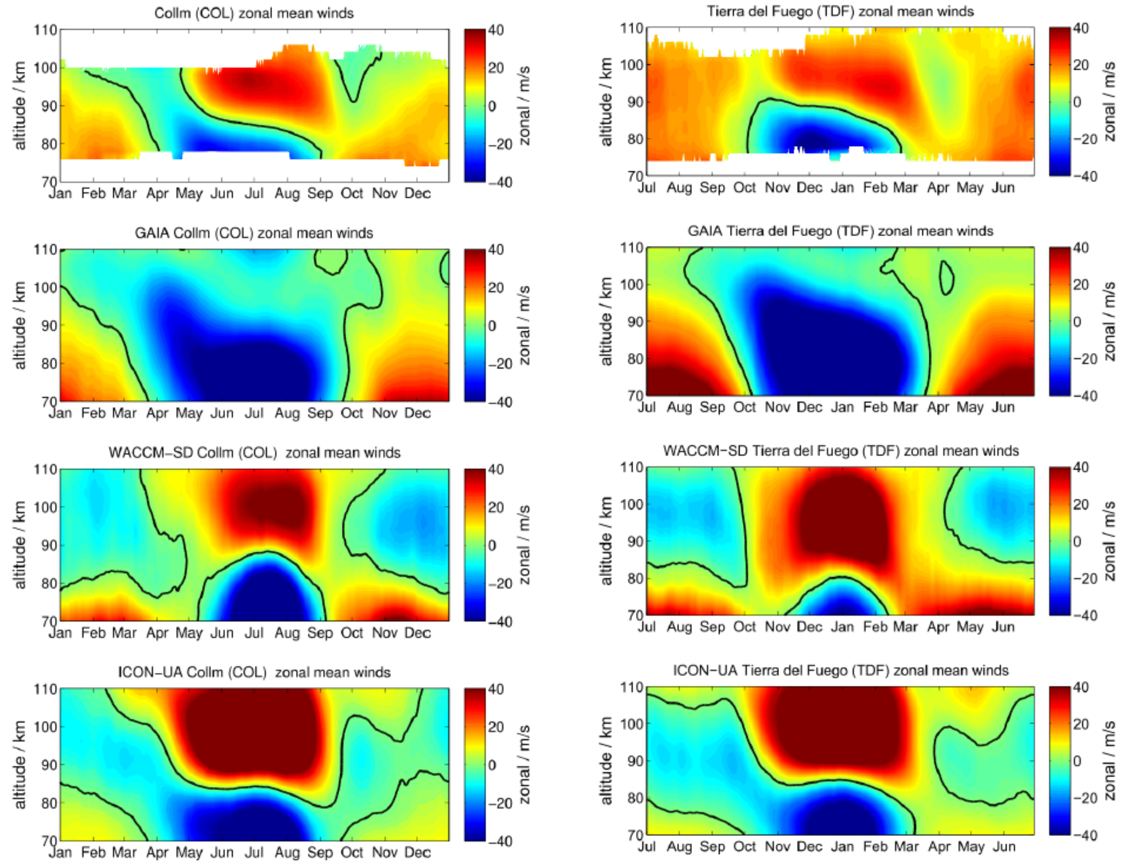
Conjugate latitude zonal wind comparison (mid-latitude)



Collm vs. TDF (51° N and S)

- zonal winds are stronger eastward during hemispheric winter in the SH
- summer wind reversal occurs at higher altitudes in the SH
- secondary waves affecting the winter above TDF enhancing the eastward zonal winds
- models show similar agreements and disagreements than for polar latitudes

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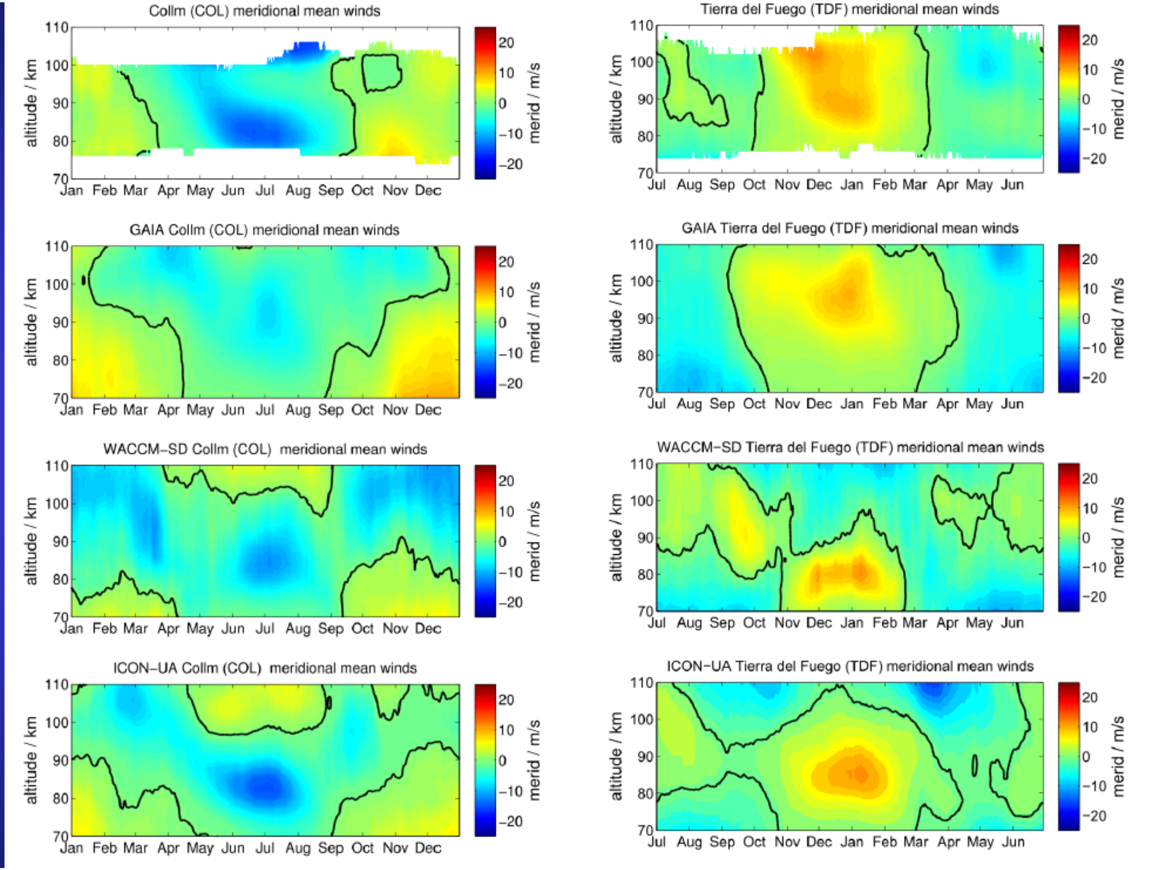
Conjugate latitude meridional wind comparison (mid-latitude)



Collm vs. TDF (51° N and S)

- meridional winds indicate similar seasonal behavior than expected for the resdiual circulation
- TDF shows wind reversal in hemisperhic winter due to secondary waves
- GAIA and MR observations exhibit a similar morphology and magnitude of the winds
- WACCM-X(SD) and ICON-UA capture some features of the seasonal morphology, but also show dissimilarities

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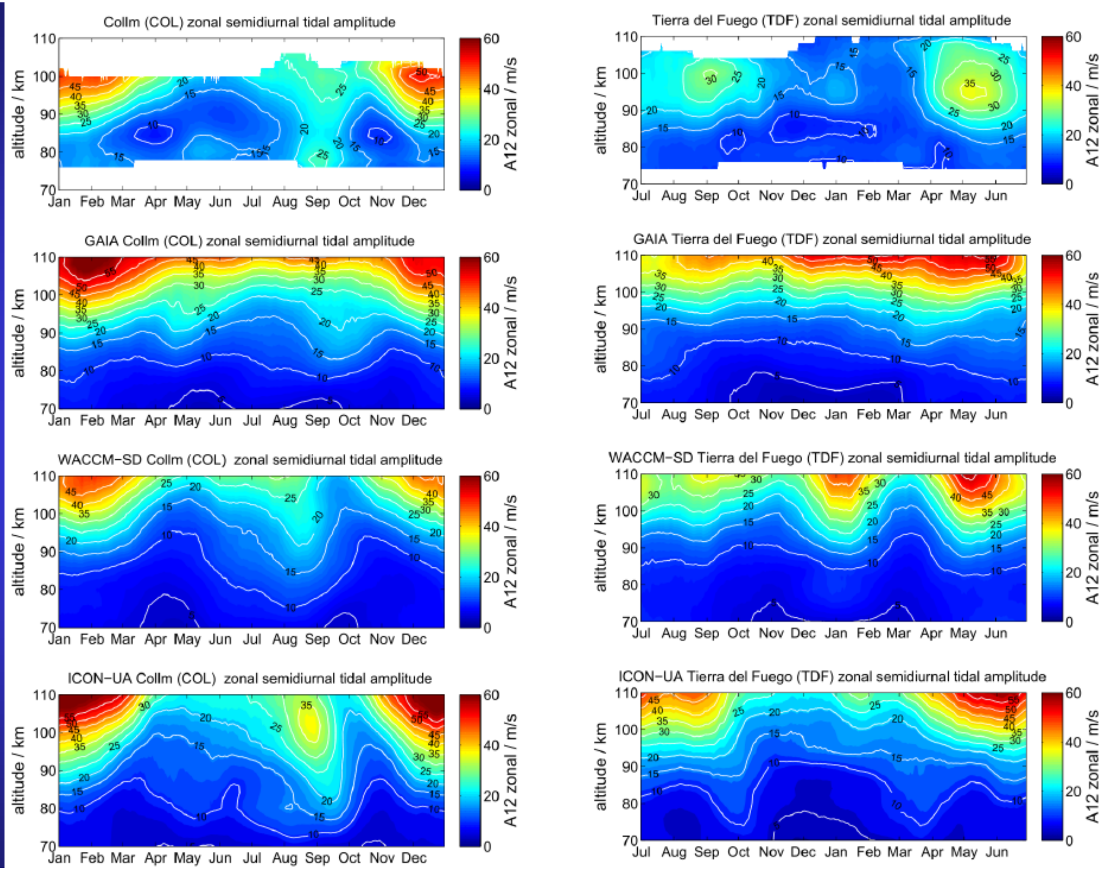
Conjugate latitude semidiurnal tide comparison (mid-latitude)



Collm vs. TDF (51° N and S)

- Semidiurnal tide dominant tidal mode at mid-latitudes
- shows significant interhemispheric differences between COL and TDF
- hemispheric winter amplitudes are stronger at the NH
- NH autumn enhancement is not existing at southern hemisphere above TDF
- ICON-UA exhibits the interhemispheric differences and shows reasonable agreement to observations
- WACCM-X(SD) captures the semidiurnal todal morphology only at the NH
- GAIA shows only partly the seasonal morphology

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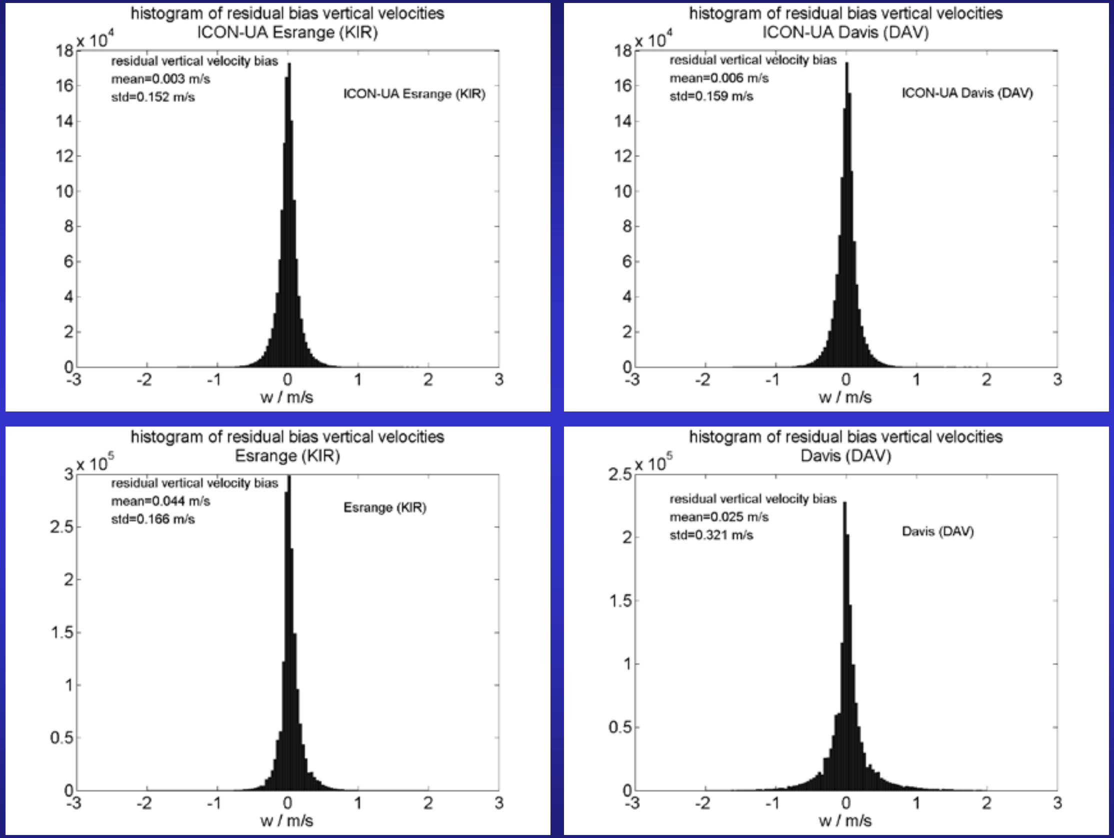
Statistical comparison of vertical winds (MR vs. ICON-UA)



- Meteor radar vertical velocities obtained with ASGARD software (Stober et al., 2021 prep.)
- vertical velocities are most challenging to be retrieved
- seasonal morphology of vertical velocities correlates with meridional wind – only statistical comparison meaningful
- mean velocities are in the range from mm/s to cm/s and consistent with trace gas observations (Straub et al., 2012)
- vertical velocity variances are between 15-35 cm/s considering the sampling volume
- values above +/-1 or 2 m/s are extreme outliers and often associated with poor measurement statistics

Conclusions

- Meteor radar observations indicate interhemispheric differences in the seosnal morphology of the zonal and meridional mean winds
- GAIA, WACCM-X(SD) and ICON-UA capture only partly the mean wind climatology at mid- and polar latitudes and underestimate interhemispheric differences
- Semidiurnal tidal climatologies are challenging to be reproduced in the models
- WACCM-X(SD) and ICON-UA capture the sesonal pattern of the SDT on the Northern hemisphere
- only ICON-UA reproduces most of the interhemispheric differences
- vertical velocities between meteor radars and ICON-UA show good statistical agreements, providing confidence in the wind retrievals

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