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Using Antarctic observations to improve gravity wave parameterization in climate models

Damian Murphy[1], Simon Alexander[1], Andrew Klekociuk[1], John French[1], Stephen Eckermann[2] , Adrian McDonald[3], Mike Taylor[4], Robert Vincent[5] and Iain Reid[5]

1: Australian Antarctic Division, Kingston, Tasmania, Australia.
2 Space Science Division, Naval Research Laboratory, Washington, DC, USA.
3:University of Canterbury, Christchurch, New Zealand.
4:Utah State University, Logan, Utah, USA.
5:University of Adelaide, Adelaide Australia.

Presenting Author contact details:
Damian.murphy@aad.gov.au
Climate Processes and Change, Australian Antarctic Division,
Department of Sustainability, Environment, Water, Population and Communities,
203 Channel Highway, Kingston, Tas. 7004, Australia.

WHY? - A project aimed at supporting improvements to gravity wave drag parameterization in numerical models of the atmosphere is under development within the Climate Processes and Change group (CPC) at the Australian Antarctic Division. A key element of this project is the linkage between proposed observations and the needs of the modelling community. This project seeks to optimize the design of our observations relative to the requirements of the climate modelling community and to ensure effective exchange of observations and insights through strong linkages to that community.

How can we ensure the utility of our observations in model development?

What will the next generation of GWD parameterization schemes be like? (Vertical columns? Ray-tracing?)

Interfacing with (influencing?) model development

Observations and analysis will focus on the parameters of most interest to the current GW drag parameterization schemes. These are described below with some comments on potential contributions.

The seasonal and spatial distribution of gravity-wave source strength and variability:

Å Statistical studies using ground-based instruments provide seasonal variations of gravity wave activity;
Å Extension of Antarctic radiosonde analysis to the present day;
Å Case studies to relate observations to local meteorological parameters
Å Ray tracing studies extend MLT GW observations to lower altitudes.

Observed gravity-wave momentum fluxes (and the instrumental filtering influencing them):

Å Momentum flux measurements in the MLT using dual beam Doppler and meteor radar techniques;
Å Comparisons between ground- and space-based momentum flux measurements.

Are variances in zonal and meridional wind useful for comparison with models?

Motivation – The goals of the 'Atmospheric Processes and Change' Stream within the strategic plan for Australian Antarctic Science for 2011-2021 include:
Å To understand the connections between ozone concentrations and characteristics of the polar vortex that will enable improved projections of the climate system response to ozone recovery, and particularly of changes to winds and storm frequencies at high southern latitudes.
Å To improve representation in numerical models of radiative, dynamical and chemical coupling processes throughout the atmosphere, focusing on energy and momentum transfer, chemical transport and links between regions and hemispheres.

The propagation of gravity waves from their source to deposition region:

Å Case studies of waves of known wavelength and phase speed;
Å Statistical studies through a modelled (and assimilated) atmosphere extending from the ground to the mesosphere.

In order to maximize the utility of the outcomes of this project, we seek to balance the capabilities of the observations with the difficulties of tuning and running a climate model. Please come and talk to us about your model and the challenges associated with changing its GW drag parameterization.

Making relevant observations

Davis (69°S, 78°E) has been at the centre of Antarctic middle atmosphere research for some years. It also has a long history of meteorological soundings. The instruments currently running at Davis provide a backbone for gravity wave observations. Proposed instruments and global data sets (assimilations, satellite observations) will add to our capabilities (see the table below).

Observational challenges – bridging the gap between what we would like and what we can get.

Å Relating gravity wave observations in the upper middle atmosphere back to the model domain: The development of a gravity wave ray tracing capability will help to bridge this gap. Assimilation of observations into models will provide an excellent background atmosphere through which to trace;
Å Linking observations made at Davis to global observations: A global perspective is needed for modelling studies. Our observations can be used to truth space-based measurements. Structures observed near Davis can be explained with the aid of our observations.

Advantages of the Davis site:

Å It is well instrumented (see table);
Å Davis is either inside the stratospheric polar vortex or near its edge;
Å The general absence of convective sources allows a focus on non-convective source mechanisms;
Å Its distance from the strong Antarctic Peninsula source region provides another perspective on southern polar sources.

Instrument	Height range	Relevant parameters	Operational?	Notes
MF Radar	~70-96 km	u, v	Yes	Data set extends back to 1993
VHF Radar	~80-92 km (summer only) ~2-12 km (all year)	u, v, w, <uôwô>, <vôwô>	Yes (Technical issues with antenna array need to be addressed)	Doppler mode operation swapping between E-W-N-S-V beams
33MHz Meteor Radar	~81-97 km	u, v, velocity variance	Yes	Velocities are for large scale motions, variance is for small scale motions [Mitchell and Beldon, 2009]
33MHz Meteor Radar (High power)	~81-97 km	u, v, velocity variance <uôwô>, <vôwô>	No	Proposed upgrade to above system. Time scale over which momentum flux measurements will be possible is not yet known.
Rayleigh LIDAR	~30-70 km (verify)	T	Yes	Upper height depends on season and integration time
UWOSCR	Hydroxyl layer (~87 km)	8x8 raster map of Radiance	Yes	Dark times only: no summer data. Historical data extends back to 1999
Airglow Imager	Hydroxyl layer (~87 km)	High resolution maps of T	No	In collaboration with Utah State University ANGWIN project.
Radio Sondes	0-~30 km	u, v, T, humidity	Yes	Upper height limit varies. Data extends back many years. Ozone sondes flown over last decade.

Studies of instrumental filtering associated with each measurement are planned to facilitate meaningful comparisons with other observations and with models.

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