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Poster sessions

DNS of Intermittent Turbulence in a Stable PBL

Cedrick Ansorge[1] , Thorsten Mauritsen, Juan-Pedro Mellado

Max-Planck-Institut f¨ur Meteorologie,
Bundesstraße 53, 20146 Hamburg, Germany

In the recent decades considerable progress has been made in the modelling of convective boundary layers as part of planetary boundary layer (PBL) schemes. Concerning stable boundary layers (SBLs), however, many problems known remain to be solved. Physically based approaches have been shown to perform poorly in operational forecasts and in the lack of better, PBL schemes are tuned using observations. From observations it is well known that turbulence has regimes that depend on the magnitude of stratification. The understanding of turbulence dynamics under intermediately strong stratification is still limited, and we address some of these issues in this work.

In particular, we study the turbulent Ekman layer with stable stratification using direct numerical simulation (DNS; Ansorge, 2011). The idea is to reduce the physics of the problem to its fundamental aspects (Moin and Mahesh, 1998) in order to gain an understanding of the underlying turbulent dynamics. For the simulation, we employ a Boussinesq approximation to the Navier-Stokes Equations on the f-plane. A regular grid with a size of $130D \times 130D$ in the horizontal and about $43D$ in the vertical is used, where $D = \sqrt{2\upsilon / f}$ is the vertical scale height of a laminar Ekman layer with ν the kinematic viscosity and $f = 2|\overline{\Omega}|\sin\varphi_0$ the coriolis parameter. A Reynolds number **Re** = GD/v and a Froude number **Fr** = $G^2/B_0 0$ describe the problem exhaustively, where G is the geostrophic wind velocity and B0 the buoyancy at the surface. We perform six simulations at **Re** = 500 varying **Fr** from a neutral setup, i.e. **Fr** $\rightarrow \infty$, to very stable stratification, that is **Fr** = 25.

In observations, one usually discerns between three regimes of turbulence: a weakly, an intermediately and a very stable regime (Mahrt, Sun, Blumen et al., 1998; Mauritsen, Svensson, Zilitinkevich et al., 2007). In the latter two, wave activity and global intermittency have been observed (Mahrt, 1999), and it is problematic to represent such complex processes quantitatively exact in a simple PBLclosure. With the setup chosen the three turbulence regimes known from observations are simulated varying **Fr**, that is B_0. From the results obtained here, the intermediately stable parameter range is identified as 25 ≤ **Fr** ≤ 500. A stability-dependent **Re** can be defined as $L_M^+ = L_M u_* / \upsilon$ (Flores and Riley, 2011) with L_M the Obukhov length. Our findings indicate existence of turbulence at lower L_M^+ than in the case of channel flows. For the weakly stratified regime, i.e. **Fr** ≥ 500, self-similarity of TKEand velocity profiles is encountered when **Fr** is varied and Monin-Obukhov theory seems applicable. In the intermediately and very stable regime this self-similarity breaks. In the very stable case, turbulence initially breaks down and slowly recovers afterwards. Here, we focus on the intermediately stable regime and compare it to that under neutral stratification.

[1] cedrick.ansorge@zmaw.de thorsten.mauritsen@zmaw.de juan-pedro.mellado@zmaw.de

In the intermediately stable regime we observe global intermittency of turbulence. Close to the wall it is found using spectral analysis that within the turbulent patterns the flow behaves very similar to that under neutral stratification: Near-wall streaks dominate as observed in turbulent channel flows at similar Reynolds numbers (Jiménez, del Álamo and Flores, 2004). In the outer layer, the flow reorganizes completely and waves dominate. The turbulent eddies in this layer align with the waves, but it remains unclear whether some wave breaking mechanism or local shear initiates turbulence. In the inner layer, the turbulent patches are aligned with the direction of those wavy structures. Analyzing the temporal evolution of the flow we find internal waves appearing and disappearing periodically. This oscillation coincides with an oscillation in the horizontal mean buoyancy flux around the middle of the SBL. If the internal waves have a large amplitude, the horizontally averaged buoyancy flux at certain levels is oriented counter-gradient.

In this work, we have shown the ability of DNS to contribute to an understanding of turbulence in SBLs. Although there are indications of Reynolds number similarity, some of the results obtained here might depend on the Re, which is smaller than typical atmospheric values. An investigation of these issues is deferred to future work.

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Experiments with the parameterization of stable boundary layers in ACCESS NWP

Vaughan Barras[*1], Ashok Luhar[1], Peter Hurley[1], Adrian Lock[2], and John Edwards[2]

[1] Centre for Australian Weather and Climate Research, Melbourne, Australia
[2] UK Met Office, Exeter, UK

An investigation into alternate forms of the momentum scaling function was performed using the Single Column Model (SCM) and 3d NWP versions of the Australian Community Climate and Earth System Simulator (ACCESS). We used GABLS 2 as a platform to investigate the effect of applying various forms of the Luhar et al. (2009) momentum scaling function recently tested in the Coupled Atmosphere-Biosphere Land Exchange (CABLE) land surface scheme. The momentum function was devised to fit the scatter of dimensionless wind speed observations at high stabilities from the CASES-99, Cardington and Cabauw tower sites. The new parameterization switched over from the Beljaars and Holtslag (1991) scaling function to Luhar et al. (2009) at a threshold stability ($\xi = 0.4$). A tunable blending function was required to smooth this transition and the parameterization was then fit to observations. The result from SCM tests was a decrease in nocturnal 10m wind speeds, increasing the diurnal range. When applied to ACCESS NWP an overall decrease in 10m wind speeds occurred, however the greatest difference was over the Antarctic. Decreases in wind speed there were accompanied by slight increases in the westerlies over the Southern Ocean and a weak effect was observed on the depth of mid-latitude cyclones. From these tests it appears that such adjustments to the surface layer result in substantial feedbacks into the general circulation requiring further assessment whilst CABLE is being coupled to the atmospheric model.

TOUCANS - A compact parametrization of turbulence for GCM to meso-scale models valid for whole range of Richardson numbers

Ivan Bašták Ďurán[1], Jean-François Geleyn[2], Filip Váňa[3]

[1] FMFI UK KAFZM Bratislava, [2] CNRM/Météo-France, [3] ONPP/CHMI Praha
bastak@fmph.uniba.sk, ,jean-francois.geleyn@meteo.fr, lip.vana@chmi.cz

TOUCANS is a compact turbulence parametrisation for GCM to meso-scale models. TOUCANS integrates several ideas in turbulence parametrization: no existence of critical Richardson number Ricr, anisotropy of turbulence, prognostic treatment of Turbulence Kinetic Energy (TKE), Third Order Moments (TOMs) parametrisation, parametrisation of shallow convection inside turbulence scheme and 3D turbulence parametrisation (TOMs, 3D turbulence and shallow convection parametrisation are out of scope for this particular poster, about dry and highly stable turbulence).

No existence of Ri_{cr} and anisotropy of turbulence is ensured by usage of stability functions φ_3, χ_3 from two turbulent schemes: CCH02 [1] (with modications) and Quasi-Normal Scale Elimination (QNSE) [3] (with fit 'extended' for $Ri < 0$).

Prognostic treatment of TKE is adapted from p-TKE [2] turbulent parametrisation and consists of two parts: static ($\frac{dE}{dt} = 0$) and prognostic. Usage of TKE as prognostic variable enables computation of TKE dependent mixing lengths L. In TOUCANS are available five different settings for mixing length computation.

Single column model (60s time step and 64 vertical levels) experiment, with TOUCANS implemented in ALADIN/ARPEGE model (cycle CY36), for GABLS-1 settings shows that TOUCANS predict realistic vertical profiles of wind and potential temperature in stable stratification. The better prediction of the boundary layer depth and elevation of the inversion is achieved with emulation of QNSE scheme.

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Diurnal cycles simulated in a Multiscale Modeling Framework (MMF) with a third-order turbulence closure

Anning Cheng[1,2] and Kuan-Man Xu[2]

[1.] *Science Systems and Applications, Inc., Hampton, VA*

[2.] *Climate Science Branch, NASA Langley Research Center, Hampton, VA*

Representation of diurnal cycle in global atmospheric models is a challenging in the prediction of climate variability and sensitivity. A promising approach to climate modeling is the Multi-scale Modeling Framework model (MMF). This approach replaces all cloud parameterizations of a conventional general circulation model (GCM) with a cloud-system resolving model (CRM) at every GCM grid. CRMs explicitly simulate the circulations associated with deep convective cloud systems. In this study, an upgraded MMF is developed by implementing an advanced higher-order turbulence in the embedded CRM to improve the representation of the boundary-layer clouds. A ten-year climate simulation is performed using the upgraded MMF with finite-volume (fv-) 1.9°X2.5° dynamic core. The vertical levels are 12 below 700 hPa in order to well resolve boundary-layer clouds. The output interval for the last year is 1 hour for a realistic analysis of the diurnal cycle. The large amount of turbulent mixing associated with the boundary-layer clouds slows down the increase of the convective available potential energy and inhibits the early transition to deep convective clouds. So a more reasonable diurnal cycle can be seen in the upgraded MMF.

Long Study of the afternoon-evening transition: the BLLAST (Boundary Layer Late Afternoon Sunset Turbulence) field campaign

F. Couvreux, M. Lothon, F. Lohou, E. Bazile, Y. Seity, B. Szintai, F. Guichard, D. Legain and the BLLAST team

Poster presented by Fleur Couvreux
Meteo-France, CNRM-GAME, 42 av G. Coriolis, 31057 Toulouse, France,
fleur.couvreux@meteo.fr

The objective of the BLLAST group is to study the transition phase that occurs in late afternoon as the atmospheric low levels evolve from a mixed convective boundary layer to a stably-stratified surface layer. The main issues are organised along three core questions: (1) the role of surface heterogeneity, and (2) the synoptic-scale processes during the transition, and (3) the evolution and complexity of the vertical structure of the boundary layer during this phase.

A field campaign designed to study this time period is first presented. It occurred between the 14 June and 8 July 2011 in southern France. It provides a new dataset combining measurements from instrumented aircraft, Unmanned Aerial Systems (UAS), remote sensing instruments, radiosoundings, tethered balloons as well as several eddy correlation stations and instrumented masts such as a 60 m tower. The instrumentation was deployed over different surfaces in the surrounding area. This allows to simultaneously document the time and spatial evolution of the PBL during this transition.

A preliminary evaluation of three numerical weather prediction models (AROME, ARPEGE and ECMWF models) during this transition is shown focusing on the representation of the thermodynamical vertical profiles and the time evolution of near surface atmospheric variables as well as the radiative and turbulent fluxes.

More information on http://bllast.sedoo.fr

A simple model to predict nocturnal wind and temperature profiles near the surface

Judith Donda

Technical University of Eindhoven (TU/e)
j.m.m.donda@tue.nl

In the field of global weather prediction models, complex physical processes like turbulence and radiative transport are usually heavily parameterized. Here we study turbulent exchange processes in the nocturnal boundary layer and link those processes to large scale forcing parameters. By combining analytical analysis with numerical simulation it is shown that near surface fluxes, wind and temperature profiles can be predicted with limited knowledge on the large scale weather conditions such as synoptic pressure gradients and cloud cover.

Surface Flux Formulations Over Land in NCEP Models

Michael Ek[1], Helin Wei[1], Vince Wong[1], Zavisa Janjič[1], Jongil Han[1], Xubin Zeng[2] and Fei Chen[3]

[1] *National Centers for Environmental Prediction/Environmental Modeling Center, Suitland, MD, USA*

[2] *University of Arizona/Department of Atmospheric Sciences, Tucson, Arizona, USA*

[3] *National Center for Atmospheric Research/Research Applications Laboratory, Boulder, CO, USA*

Turbulent surface fluxes of heat, moisture and momentum affect surface energy and water budgets, and as such are an important part of the connection between land and atmosphere; therefore it is crucial that these fluxes be well-represented in weather and climate models. Surface-layer formations are included in NCEP operational models, and are in implicit form (in the mesoscale NAM) and quasi-explicit (in the global/seasonal climate GFS and CFS). Recent modifications to the surface-layer scheme in the NAM address temperature and humidity biases directly attributable to stable boundary layer processes. An upgrade to the GFS includes the addition of a thermal roughness length (as a function vegetation fraction), and helps reduce low-level temperature biases. Future work will re-examine stability profile functions and associated numerics in surface-layer formulations, possibly incorporate vegetation height into these formulations, account for the snow effect on momentum roughness, and finally address the need to unify surface-layer formulations in NCEP models.

Performance of boundary layer schemes in the JMA NWP Models

Tabito Hara

Numerical Prediction Division
Japan Meteorological Agency
E-mail: tabito.hara@met.kishou.go.jp

The Japan Meteorological Agency has been operating two NWP models: a global spectral model (GSM) and a meso-scale mode model (MSM). The two models have different dynamical frames and physical processes, and have been developed almost independently. Therefore, comparison of boundary layer schemes between two models has never been conducted so far. As the first step to collaborate each other among developers of the two models, we compare boundary layer schemes on GSM and MSM from the view of diurnal changes of cloud-free boundary layer and representation of stratocumulus capped boundary layer to investigate their basic features and differences.

Both boundary layer schemes are based on the Mellor-Yamada second order turbulent closure model (MY). Turbulent fluxes or diffusion coefficients are determined with predicted / diagnosed TKE and a mixing length. However, we have recognized that some modifications to make stable layer more diffusive (including the top of boundary layers) in GSM lead to significantly different performances, especially in stable layer and stratocumulus capped layer. The more diffusive boundary layer top was intended to represent the entrainment across the BL top in coarser vertical resolution with the classical local closure model. At the same time, however, it is difficult for the models to generate inversion layer because that could be destroyed by the diffusive mixing at the top. Therefore, GSM employs a special parameterization for stratocumulus, in which less diffusive layer is assumed and cloud fraction and condensed water contents are diagnosed using gap across inversion if the inversion is strong enough. The scheme works well in the targeted areas like California and Peru, but it sometimes forms false lower clouds. On the other hand, MSM, with higher vertical resolution, no artificial limiters, and TKE and covariant of heat and moisture fluctuation predicted, provides good predictions of the inversion height (i.e. entrainment rate) in a SCM experiment for stratocumulus, and reproduces inversion layer relatively well in some fog events.

In our presentation, we will show some results of the comparison, and comparisons with meso-scale models might be helpful for large scale models to improve BL schemes especially when we consider parameterizations in higher vertical resolution.

Long term objective observational diagnosis of boundary layer type

Natalie Harvey

Department of Meteorology, University of Reading, UK
n.j.harvey@pgr.reading.ac.uk

Boundary layer mixing is highly turbulent and complex and is therefore parameterised in weather forecast and climate models. In particular, it is often necessary to classify the boundary layer in these models in order to determine which mixing scheme (local or non-local) to apply, or whether to apply a cloud-top entrainment parameterisation. But are the parameterisations implemented in these models representative of the real world?

For the first time, Doppler lidar and sonic anemometer data have been used to objectively classify the observed boundary layer into eight different types. The types are based on those in the Met Office "Lock" scheme, but with two of them split into two depending on whether cloud is present. Examples of these types are decoupled stratocumulus, cumulus –capped and stable with no turbulent cloud. This method has been applied to 2 years of data from Chilbolton Observatory and a climatology of boundary layer type has been created. The frequency of occurrence of each boundary layer type is analysed as a function of season and part of the diurnal cycle. Initial comparisons between the 12km resolution version of The Met Office Unified Model and observations show that the model over predicts the amount of decoupled stratocumulus boundary layers in all seasons. The skill of the model in predicting boundary-layer class at the right time has also been assessed.

COSMO stable boundary layers validated with Falkenberg measurements

C. Heret, G.Vogel and F. Beyrich

German Meteorological Service (DWD), Meteorological Observatory Lindenberg
Claudia.Heret@dwd.de

The accurate prediction of atmospheric boundary-layer (ABL) parameters is an essential requirement to any numerical weather forecast, since most of the commercial and societal activities of mankind are concentrated in the ABL. Our validation studies focus on ABL processes assessing the model behaviour for different meteorological conditions to reveal possible deficiencies. Due to the great variety of quantities measured at boundary layer field site Falkenberg more processes can be studied in detail than normally considered with areal verification techniques using standard SYNOP data. Our validation studies cover different aspects: quasi operational monthly validation studies, long time studies and case studies. They consider the three operational DWD models GME, COSMO-EU, COSMO-DE and the IFS (ECMWF). We present a few examples, focussing on the COSMO-EU, which is most comparable with IFS from the spatial resolution point of view.

Evaluation of a 3D mesoscale model in the GABLS3 case

M. Kleczek, G.J. Steeneveld, and A.A.M. Holtslag

Meteorology & Air Qaulity Section, Wageningen University,
Wageningen, Netherlands
michal.kleczek@wur.nl

Correct forecasting of the diurnal cycle of the atmospheric boundary layer (ABL) is of key importance for many applications in wind energy engineering, weather forecasting, agriculture, and air quality prediction. Previous research has shown models are very sensitive to the selected boundary-layer parameterization. Each model has a different method for ABL height estimation and turbulent diffusion. In this contribution we extend the GABLS3 column model intercomparison (Bosveld et al., 2011; http://www.knmi.nl/samenw/gabls/), by evaluating the WRF three dimensional model (version 3.2.1) for the same case. Preliminary results show satisfactory model behaviour for net radiation with comparison to Cabauw observations (Netherlands). It is worth mentioning that a 20 [W/m-2] positive bias in long wave downward radiation as in earlier studies has been confirmed. Two meter temperatures are slightly underestimated during daytime, and substantially underestimated at night. Concerning, vertical profiles, the YSU ABL scheme in WRF overestimates the ABL depth and low level jet (LLJ) altitude. The modelled LLJ speed also is too low according to the validating radio-sounding measurements in de Bilt (Netherlands, KNMI measurement site) and at Cabauw. To circumvent the relatively poor skill of the YSU scheme for the LLJ, the YSU scheme has been modified by implementation of the ABL height definition in Vogelezang and Holtslag (1996). The latter accounts for the fact that the ABL depth is related to both boundary layer wind shear and near surface mechanical shear production. The modification results in an improvement of LLJ shape, i.e. the LLJ speed increases and the LLJ altitude is lowered and both become in closer agreement with the observations.

Boundary layer dynamics in the Grenoble valley during strongly stable episodes

Yann Largeron, Jean-Pierre Chollet and Chantal Staquet

Laboratoire des Ecoulements Géophysiques et Industriels, Grenoble, France
Correspondence: chantal.staquet@legi.grenoble-inp.fr

In a valley environment, serious air pollution episodes develop mostly when the boundary-layer flow is not subject to any strong synoptic forcing. Such a decoupling occurs when the boundary layer is capped by an inversion layer and the atmosphere is stably stratified. In this case, pollutants are confined into a shallow layer, increasing dramatically near-surface concentrations. Surprisingly, there has been no detailed study of such situations in the Grenoble valley, though this valley is one of the most populated areas in the Alps. The dynamics of the atmospheric boundary layer in the Grenoble valley under strongly stable and polluted conditions is the focus of the present study. Numerical modelling is used for this purpose, along with the available ground temperature measurements.

We analysed indeed ground temperature data within the valley, provided by Meteo-France, at altitudes ranging between 220 m (valley bottom) and 1730 m during 5 months of winter 2006-2007. Our purpose was to detect strongly stable episodes, these being defined by the episode-averaged vertical gradient of the absolute temperature being larger than the winter average during at least three days. Five episodes were selected from this criterion. We also analyzed air quality data recorded by the Grenoble air quality agency to detect strongly polluted events for PM10 and found that the five episodes were also strongly polluted episodes.

To perform a more detailed analysis of these five episodes, we reproduced their dynamics with the numerical code Meso-NH. Four nested domains were used, the horizontal resolution being 333 m; from comparison with ground temperature data, we found that the vertical resolution above ground level in the innermost domain (containing the Grenoble valley) had to be as low as 4 meters.

The boundary layer dynamics in the numerical simulations for each episode was found to be decoupled from the (anticyclonic, weak) synoptic flow, consistent with the value of the Froude number associated with the inversion layer. These dynamics result from thermal winds flowing from the higher altitude valleys which surround Grenoble. Remarkably, the same flow pattern was found in the valley during the five episodes, both horizontally and vertically, implying that this pattern solely depends upon the geometry of the topography once a strong enough thermal inversion has formed. A detailed analysis of one such episode was next conducted. We found that the wind displays a strong vertical veering shear as a result of the superposition of the katabatic winds flowing from the different valleys. This may result in vertical ventilation if turbulence occurs in maximum shear locations. In the horizontal direction, the relative importance of ventilation and stagnation regions close to valley bottom was quantified through the computation of indices as defined by Allwine and Whiteman (1994), providing in particular a clear view of the stagnation regions which are critical for air quality.

Erosion of the nocturnal boundary layer in Amazonia

T. Neves[1], G. Fisch[2], R. M. N. Santos[3]

[1] *National Institute for Space Research – INPE, São José dos Campos, Brazil (neves.theomar@gmail.com)*

[2] *Department of Aerospace Science and Technology - DCTA, São José dos Campos, Brazil (fisch.gilberto@gmail.com)*

[3] *State University of Amazonas - UEA, Av. Darcy Vargas, 1200, Parque 10, Manaus, Brazil (rmsantos@uea.edu.br, rosa.maria.sto@gmail.com)*

This work aims to contribute to better understanding of the atmospheric characteristics of the morning transition, which are much less known, and to analyze the observational morning transition is important, more when related with the Amazonian region. The measurements dataset was carried out from 3 different LBA campaigns (seasons): RBLE (dry), RaCCI (dry-to-wet) and WetAMC (wet), collected with tethered balloon and eddy correlation method in a pasture site FNS in Rondônia-RO, western Amazonian region.

It was observed that the Amazon region has its start of Nocturnal Boundary Layer (NBL) erosion in a period of approximately 1 hour after the sunrise (5:47 LT), an advance from the results of median latitudes. The CLN warming during the erosion, the surface heat flux totalize in median 79,2 m K, resulting in only 30% of the total heat. However, the difference between the boundary layer warm to the heat flux estimate presented differences much smaller than between the dry and wet seasons, or else, a best balance. The heat in time function agree with values of the dry and wet tide, featuring the existence of advection.

Key Words: NBL erosion, surface heat flux, Amazonia.

The role of stably stratified turbulence in climate

Felix Pithan and Thorsten Mauritsen

Max Planck Institute for Meteorology, Hamburg, Germany
felix.pithan@zmaw.de

While stable boundary-layer (SBL) diffusivity is known to be crucial in enhancing the forecast skill for NWP models, little is known about the impact of SBL diffusivity on simulated climate and climate change in GCMs. Perturbing SBL diffusivity in ECHAM6, we can not confirm a substantial impact on Arctic amplification but find a beneficial effect of reduced diffusivity on subtropical cloud fields.

A strong correlation between the strength of the simulated arctic inversion in present-day climate and the Arctic amplification of climate change has been found in CMIP3 model results. Since the strength of the Arctic temperature inversion depends directly on the diffusivity of SBLs, this points to one potential impact of SBL diffusivity in GCMs.

In order to investigate this and other potential impacts of SBL diffusivity, we perturbed the stability function for stable boundary-layers within the TKE-scheme of ECHAM6. Arctic amplification – defined here as the ratio of surface air temperature change north of 70N to the global mean temperature change – was unaffected by this perturbation when computing a control and 2xCO2 climate using a mixed-layer ocean setup.

Reducing SBL diffusivity in ECHAM6 leads to an increase in subtropical stratocumulus cloud cover and a decrease in trade wind cumulus. These changes are beneficial since subtropical stratocumulus cloud reflectivity is usually underestimated by the model while trade wind cumulus cloud reflectivity is overestimated.

A Nocturnal Boundary Layer (NBL) modeling exercise over forest and deforested areas in Amazonia

M. N. Santos[1], G. Fisch[2], T. Neves[3]

[1] *State University of Amazonas - UEA, Av. Darcy Vargas, 1200, Parque 10, Manaus, Brazil (rmsantos@uea.edu.br, rosa.maria.sto@gmail.com)*

[2] *Department of Aerospace Science and Technology - DCTA, São José dos Campos, Brazil (fisch.gilberto@gmail.com)*

[3] *National Institute for Space Research – INPE, São José dos Campos, Brazil (neves.theomar@gmail.com)*

A modeling study using the OSU-CAPS model has been carried out in order to investigate the Nocturnal Boundary Layer (NBL) evolution during the wet season over the Amazon region to increase the existing knowledge about its dynamics under different environmental conditions. The model simulated the NBL depth (hi) and structure over 3 experimantal sites (RM, Forest and FNS) in Rondônia – RO, western Amazonian region. It was verified that the model has reasonably represented the NBL structure and evolution to the 3 sites. Simulations showed that RM (transiction forest-pasture) and the Forest sites have presented similar NBL development characteristics mainly for the period between 7 pm and 06 am. In the case of FNS (pasture) the analyses pointed out the NBL development to be similar to the one observed in urban areas – where a shallow mixing layer might be watched close to the surface, in the evening.

Key Words: numerical modeling, OSU-CAPS model, nocturnal boundary layer, Amazonia

Unravelling the role of turbulent mixing, land surface coupling and radiation in a coupled GABLS1 experiment

H.A.M. Sterk, G.J. Steeneveld, A.A.M. Holtslag

Meteorology and Air Quality Section, Wageningen University
Wageningen, The Netherlands
marina.sterk@wur.nl

The Arctic regions are very sensitive to climate change and have shown to warm the last few decades. Global climate models show a similar signal for the Arctic, but their magnitude varies substantially, and they show a large spread in temporal and spatial patterns. This uncertainty may partly be caused by differences in formulations for snow/ice physics, atmospheric mixing and radiation used in the various models. This multiplicity of processes forces us to examine which process has the relatively most impact in accurately modelling the Arctic stable boundary layer (SBL).

This study extends the case of the GABLS1 model intercomparison (Cuxart et al., 2006) to obtain more insight in the relative role of physical processes in the SBL over sea-ice. The GABLS1 case is a relatively simple shear driven case over ice. The Single Column Model (SCM) version of the Weather Research and Forecasting (WRF) mesoscale meteorological model is a coupled model and is run for different combinations of boundary-layer and radiation schemes. As such, an intercomparison of schemes within a single model is obtained.

Using a novel analysis method based on time-integrated SBL development (Bosveld et al., 2010), the variation between the different runs indicate the relative orientation of model sensitivities to variations in atmospheric mixing, radiation, and land-surface coupling. Preliminary results show that a change in mixing and coupling gives the strongest impact for the Arctic. Approximately, the sensitivities to mixing and coupling have a similar orientation, while the sensitivity to radiation is approximately perpendicular to the other processes. These relative orientations compare well with results in the GABLS3 model intercomparison (Bosveld et al., 2010). The above study is repeated for a range of geostrophic wind speeds in order to represent a large range of synoptic conditions.

Evaluation and sensitivity analysis of the WRF model to simulate gravity waves triggered by a density current

M. Udina[1], M.R.Soler[1], S.Viana[2], C. Yagüe[3]

(1) Dept. Astronomia i Meteorologia. Universitat de Barcelona, Barcelona, Spain

(2) Agencia Estatal de Meteorología, Barcelona, Spain

(3) Dpto. Geofísica y Meteorología. Universidad Complutense de Madrid, Madrid, Spain

Gravity or density currents are usually horizontal flows created due to differences in the density of two adjacent fluids. They are important mesoscale phenomena often originated and driven by topographical features that influence the local weather. They are caused by cold air adjacent to the ground, flowing under the influence of gravity, and they can be initiated by squalls, distant cold fronts, sea-breeze fronts or other atmospheric mesoscale disturbances. In addition, on relatively flat plains adjacent to mountain slopes, gravity currents may be initiated by katabatic flows coming off the mountains at night. Several studies show that the origin of a katabatic flow at the foot of a slope can be both the local cooling and the arrival of a density current that enhances the surface inversion and produces sharp temperature falls as well as changes in wind direction. The irruption of this flow with sudden variations in the above-mentioned magnitudes may result in vertical displacement of air parcels from their equilibrium position, which is a common source of internal gravity waves (IGWs). The IGWs act as a modulator of the gravity current and may produce events of intermittent turbulence.

In this study, starting from an observational study of internal gravity waves generated at the top of a drainage flow during the SABLES2006 (Stable Atmospheric Boundary Layer Experiment in Spain-2006) field campaign, we try to reproduce this wave event through mesoscale meteorological modelling. In addition, we attempt to simulate their origin and the structure of the mesoscale flow that generated it. Simulations are performed with the Weather Research and Forecasting model (WRF-ARW), version 3.1.1, using four nested domains with 1 km horizontal resolution in the finest grid. Two different experiments corresponding to two different parameterizations of the surface layer and the Planetary Boundary Layer (PBL) were considered. The first includes the MM5 similarity for surface layer and the Yonsei University (YSU) scheme for PBL, whilst the second uses the Eta surface layer and the Mellor-Yamada-Janjic (MYJ) PBL schemes.

Results show the capability of the WRF model to detect internal gravity waves becoming a useful tool to study the origin and development of density currents. However, PBL sensitivity analysis also reveals large differences between the schemes used in this study, like their different capability to detect internal gravity waves.

Modelling and Observing the Antarctic Boundary Layer

Kieran Walesby, Bob Beare and Phil Anderson

University of Exeter
kieranw12@gmail.com

The stable boundary layer (SBL) is a key issue for weather forecasting and climate modelling, due to its crucial role in controlling heat, moisture and momentum fluxes between the surface and atmosphere.

Some of the most stably stratified boundary layers develop on the Antarctic continent. We have used a single column model (SCM) to simulate turbulence in such boundary layers. Our SCM uses first-order turbulence closure on a logarithmic, Lorenz vertical grid.

These model results have been compared against a suite of in-situ observations from the British Antarctic Survey's Halley Station and output from the Met Office's Large Eddy Simulation (LES). GABLS-1 produced many interesting insights using SCM and LES results. In this work, these SCM and LES simulations are verified and constrained using a variety of observations.

The choice of stability functions is an important decision for column based parameterizations of the SBL. Four schemes were tested, and the models were initialised using the Halley observations just after the evening transition on 29 October, 2003. Model results and observations were compared 6 hours after the transition. We found that the sharper-tailed schemes produced shallower mixing, resulting in stronger stratification. This better replicated the observed potential temperature profile.

In addition to mean profiles, we have also verified flux profiles against observations. All the stability function schemes systematically overestimated the magnitude of the surface heat flux. However, the sharper-tailed schemes (with their associated shallower mixing) performed better when compared with observations.

The results from the single column model were also compared against the output from some initial LES simulations. We found that 6 hours after the transition a deeper boundary layer formed in the LES than the single column model. Interestingly, this is not what previous work found (Cuxart et al., 2006). The reasons for this remain a topic for future work, although this result might be explained by the initial conditions used in the LES.

This work has outlined a powerful framework for verifying SCM and LES results against a range of in-situ observations. These comparisons have been used to better constrain the models tested. Further evidence has been found to support the use of sharp/cut-off stability functions. Future work will include expanding the number of case studies considered.