Investigating the effects of External Forcings with the CLASS model

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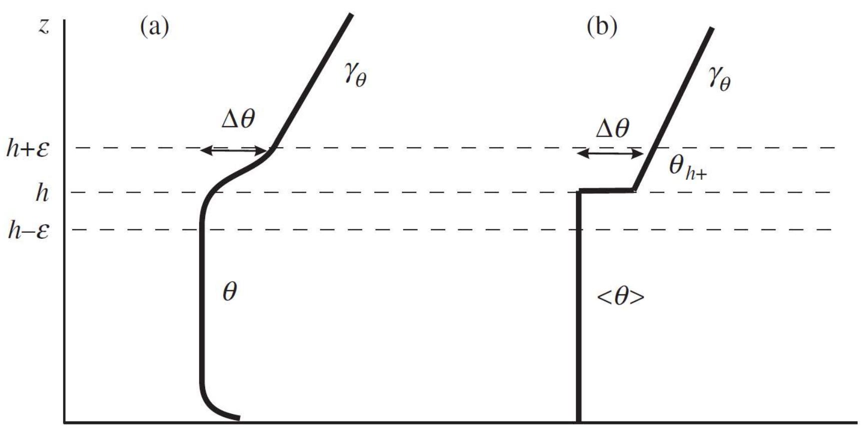
Introduction

- Introduction
- Theory
- The BLLAST Campaign
- Numerical Experiments
  - Experiment 1: Large-Scale Forcings Influence
  - Experiment 2: Initial Condition Sensitivity
  - Experiment 3: Areal Averaging Effects
- Conclusions

Motivation

- To categorise individual study days of the BLLAST campaign, according to the influence of large-scale forcings, to facilitate future research
  - The sensitivity of each day to initialisation conditions will also be assessed
- This influence will be assessed with the Chemistry Land-surface Atmosphere Soil Slab (CLASS) model, which is based on Mixed Layer Theory
- As well, a concept of surface heat flux averaging will be introduced to deal with surface heterogeneity in the Mixed Layer equations

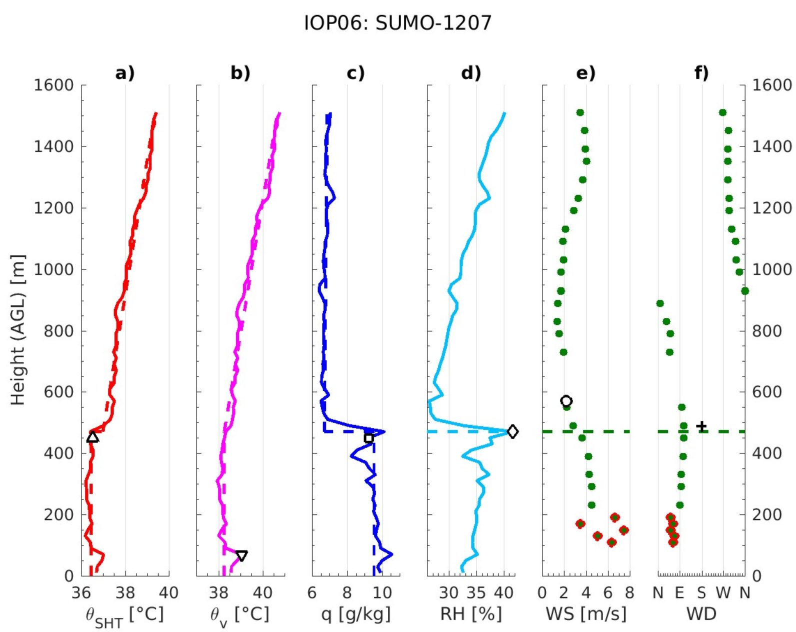
Mixed Layer Theory



(Source: Vilà-Guerau de Arellano et al. 2015)

- Single value for all of Mixed Layer (ML)
  - Average of all points below BL height
- Infinitesimally thin ML/Free Atmosphere (FA) interface, aka. zeroth-order-jump (ZOJ)
- FA lapse rate is linear trend of all data points above Boundary Layer (BL)
- ZOJ is the difference between ML value and the intersection of FA trend with BL height

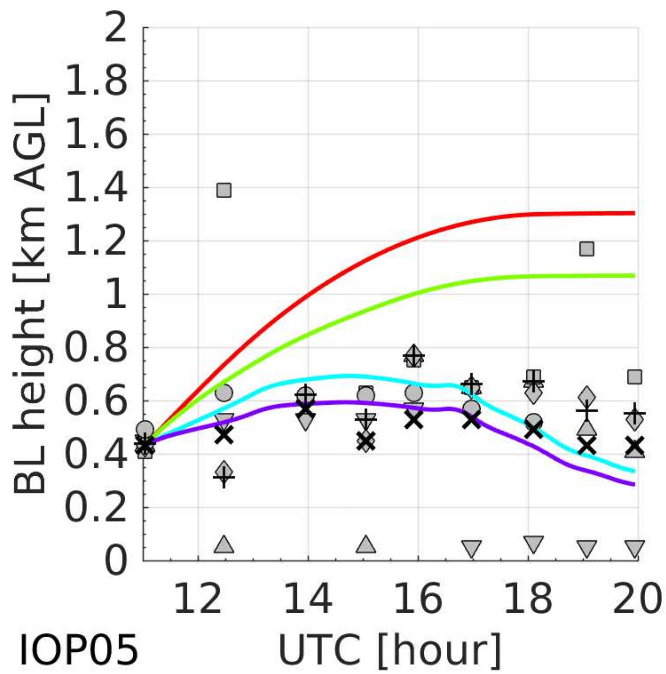
Datasets



- MesoNH modelled large-scale forcings (*Jiménez 2016*)
- Surface Heat Flux Maps (*Hartogensis 2015*)
- Small Unmanned Meteorological Observer (SUMO) profiles
  - Automatic criteria used to help guide BL height estimates

Experiment 1: Large-Scale Forcings Influence

- Using data from MesoNH, the influence of advection and subsidence was compared to large-scale forcing free runs
- Forcing influence was decomposed into advection and subsidence components, in order to properly analyse the roles played by each
- MesoNH unavailable for IOPs 02, 04, 07, & 08, therefore these IOPs were only analysed with large-scale forcing free runs
- Surface heat fluxes were averaged over a 10 x 10 km area, centered on daily launch site



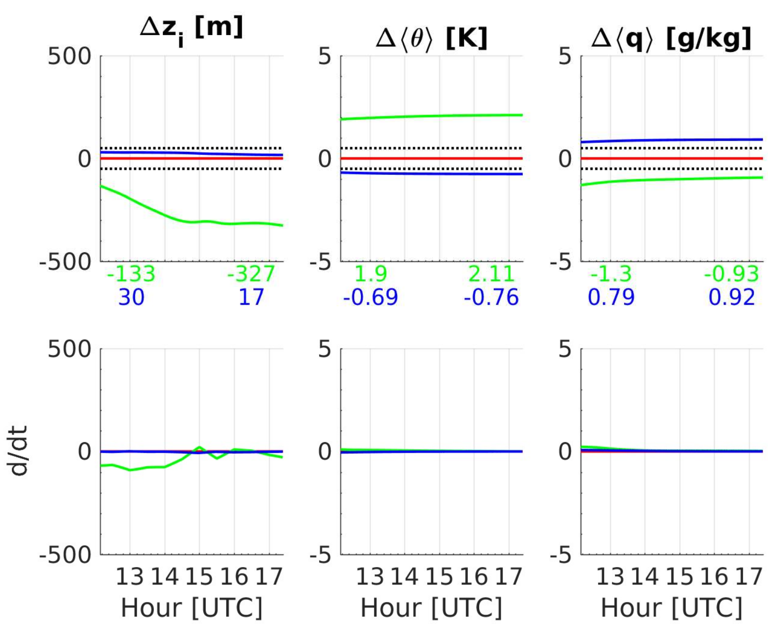
Experiment 1: Summary

- IOPs 03 & 11 were subject to FA uplifting, a situation specifically not targeted by BLLAST and a trend not present in observed BL heights
- IOPs 09 & 10 had poorly represented ML mean potential temperature, $\langle\theta\rangle$
  - This discrepancy also impacted the buoyancy flux ($\overline{w'\theta'_v}$), and in turn BL height
- IOPs 05 & 06 had poorly represented ML mean specific humidity, $\langle q\rangle$
  - Also affects the buoyancy flux, but effects are limited compared to those of $\langle\theta\rangle$

$$\overline{w'\theta'_v} = \overline{w'\theta'} + 0.61\left(\langle\theta\rangle\overline{w'q'} + \langle q\rangle\overline{w'\theta'} + \overline{w'\theta'q'}\right)$$

- IOPs 02, 04, & 07 were not well represented, but IOP08 was

Experiment 2: Initial Condition Sensitivity

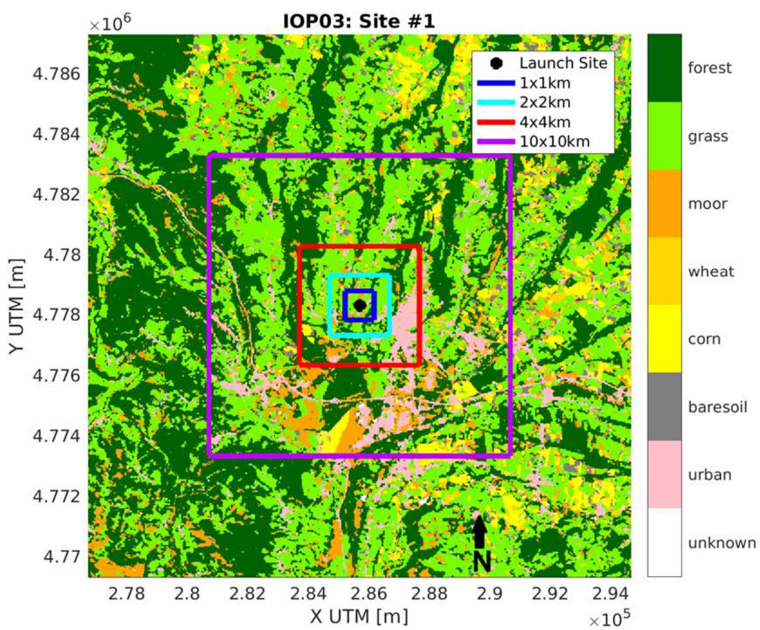


- CLASS is initialised at a moment in time
  - The sensitivity of the MesoNH IOPs to initial ML profiles required checking
- Two other initialisation times were compared to the “A-Vary/S-Vary” run of Experiment 1
- Surface heat fluxes were averaged over a 10 x 10 km area, centered on daily launch site
- BL height, potential temperature, and specific humidity differences were categorized as *Convergent*, *Paralleling* or *Divergent*

Experiment 2: Summary

- Most IOPs had parameters that paralleled one another
  - IOP05 paralleled non-linear evolutions
- Only IOP03 had mostly convergent parameters
  - Also one of the days with uplifting
- IOP06 displayed higher sensitivity to initialisation than the other IOPs studied
  - Unstable regime of initialising ML profiles and strong large-scale forcings

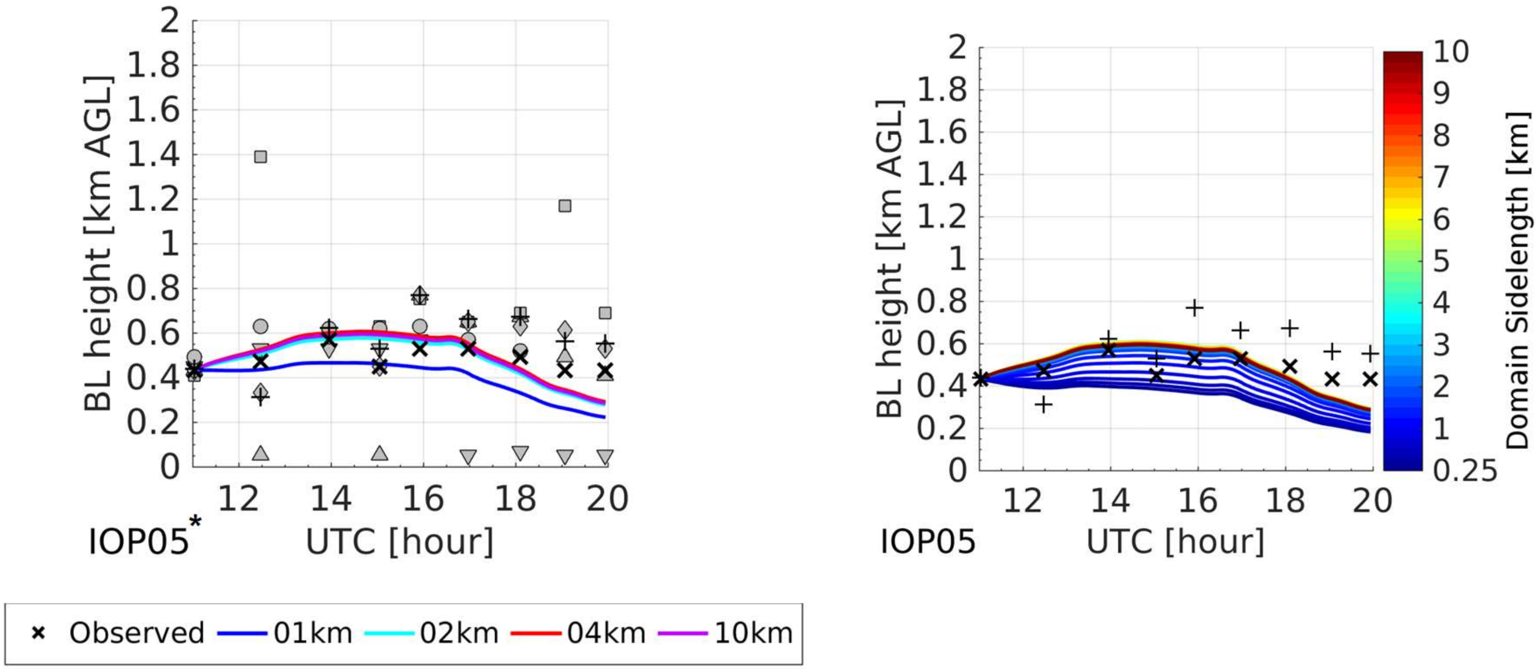
Experiment 3: Areal Averaging Effects



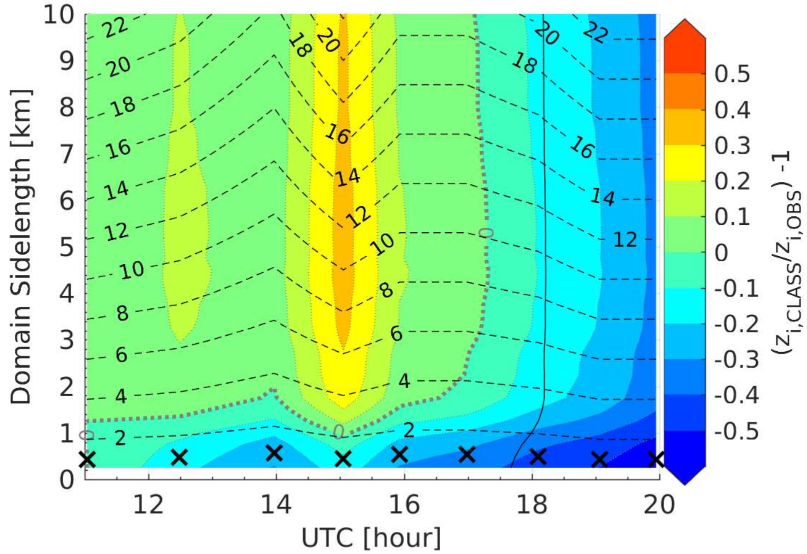
(Modified from: Hartogensis 2015)

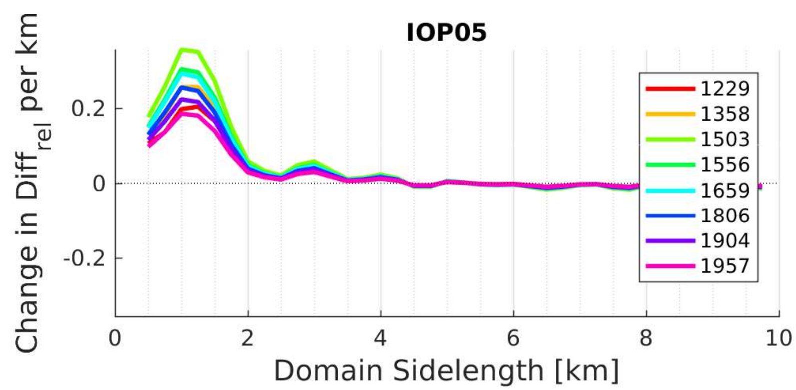
- ML theory assumes no horizontal gradients
  - Difficulty dealing with surface heterogeneity and associated heat fluxes
- Tested averaging "box" over surface heat fluxes using heat flux maps
  - This essentially imposes limitations to the extent of homogeneous mixing and integrates the different surface types
  - 1 km, 2 km, and 4 km box sizes compared to 10 km box from Experiments 1 & 2

Experiment 3: Example Results

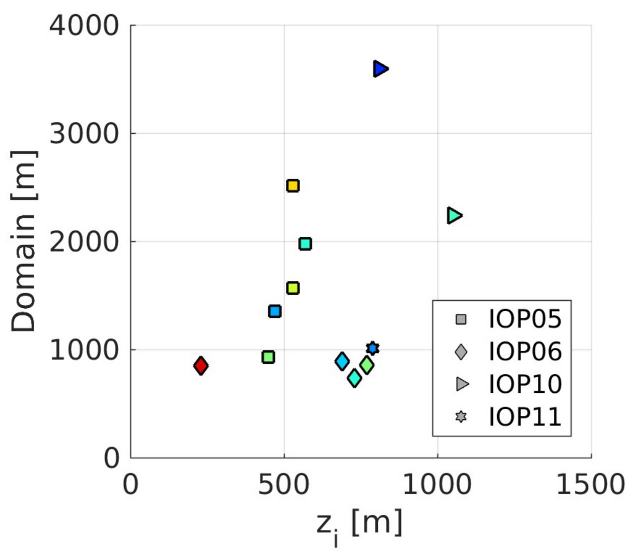


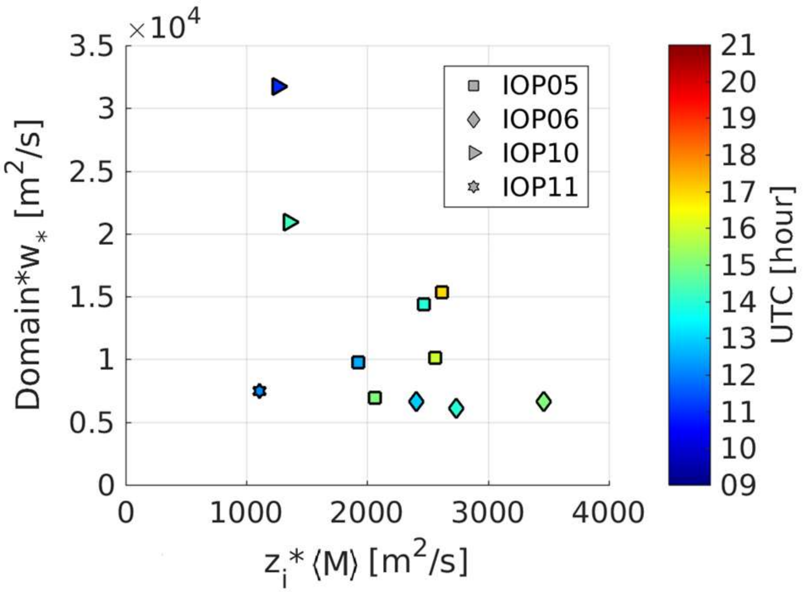
Experiment 3b: IOP05





Experiment 3b:





Experiment 3: Summary

- ML model horizontal blending length-scale for the BLLAST campaign area of approximately 5 km

- No definitive relation between BL height and optimal domain size
  - Introduction of wind speed and convective velocity scale helped to better organise the data
  - Best case of IOP05 maintained an optimal domain size (horizontal) to BL height (vertical) ratio of approximately 3:1

Conclusions

- Continue looking for a robust criteria for BL height identification, to add objectivity to ML profile determination

- BLLAST campaign area has a ML model horizontal blending length-scale of approximately 5 km

- IOPs 05, 06, & 08 are prime candidates for further ML model research
  - IOP06 requires careful treatment due to higher sensitivity
  - Other IOPs still can be subject to future research

Outlook & Further work

- Reassess with better BL height definition

- Use the MesoNH data (θ, q, u, and v profiles) to initialise CLASS

- Test different setups for Experiment 3
  - Shape of averaging area
  - Distance weighted influence

Sources

Hartogensis, O. (2015), `Surface flux maps'. **URL**: *http://bllast.sedoo.fr/database/source/displayDataset.php?repertoire=../data/AUTH/Area-averaged_surface_flux_maps/&fichier=Surfacefluxmaps.xml*

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Thank you for your attention!

Questions?