Another LES model applied to BLLAST data

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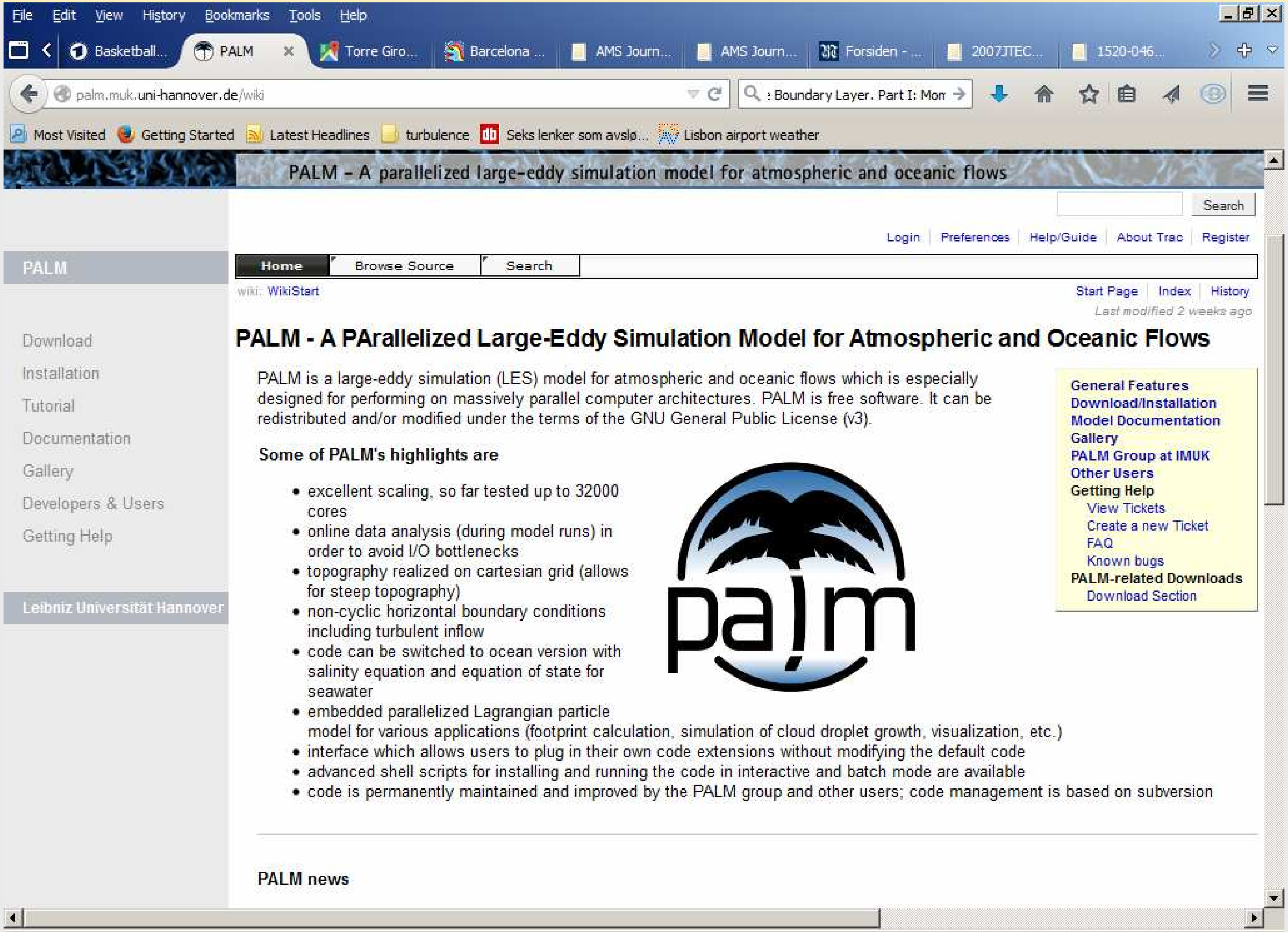
Background/motivation

- start-up and establish LES competence at GFI
- first idea was to look at the effects of surface heterogeneity on site 2 (hypothesis: differential heating/cooling over different surfaces could induce secondary circulations across the boundaries)
- (we found soon out that is not a topic for LES newbeginners)
- Using the LES model (PALM) as analytic and diagnostic tool to investigate the CBL from maximum surface heat flux to the evening transition phase
- perform LES simulations with different measurement based initializations to optimize the representation of the temporal evolution of potential temperature profiles and wind profiles in the LES simulations
- use the LES data to investigate the relevance of the convective velocity scale, together with the time scale imposed by the surface heat flux decrease.

LES model used - PALM



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PALM – A parallelized large-eddy simulation model for atmospheric and oceanic flows

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PALM - A PArallelized Large-Eddy Simulation Model for Atmospheric and Oceanic Flows

PALM is a large-eddy simulation (LES) model for atmospheric and oceanic flows which is especially designed for performing on massively parallel computer architectures. PALM is free software. It can be redistributed and/or modified under the terms of the GNU General Public License (v3).

Some of PALM's highlights are

- excellent scaling, so far tested up to 32000 cores
- online data analysis (during model runs) in order to avoid I/O bottlenecks
- topography realized on cartesian grid (allows for steep topography)
- non-cyclic horizontal boundary conditions including turbulent inflow
- code can be switched to ocean version with salinity equation and equation of state for seawater
- embedded parallelized Lagrangian particle model for various applications (footprint calculation, simulation of cloud droplet growth, visualization, etc.)
- interface which allows users to plug in their own code extensions without modifying the default code
- advanced shell scripts for installing and running the code in interactive and batch mode are available
- code is permanently maintained and improved by the PALM group and other users; code management is based on subversion

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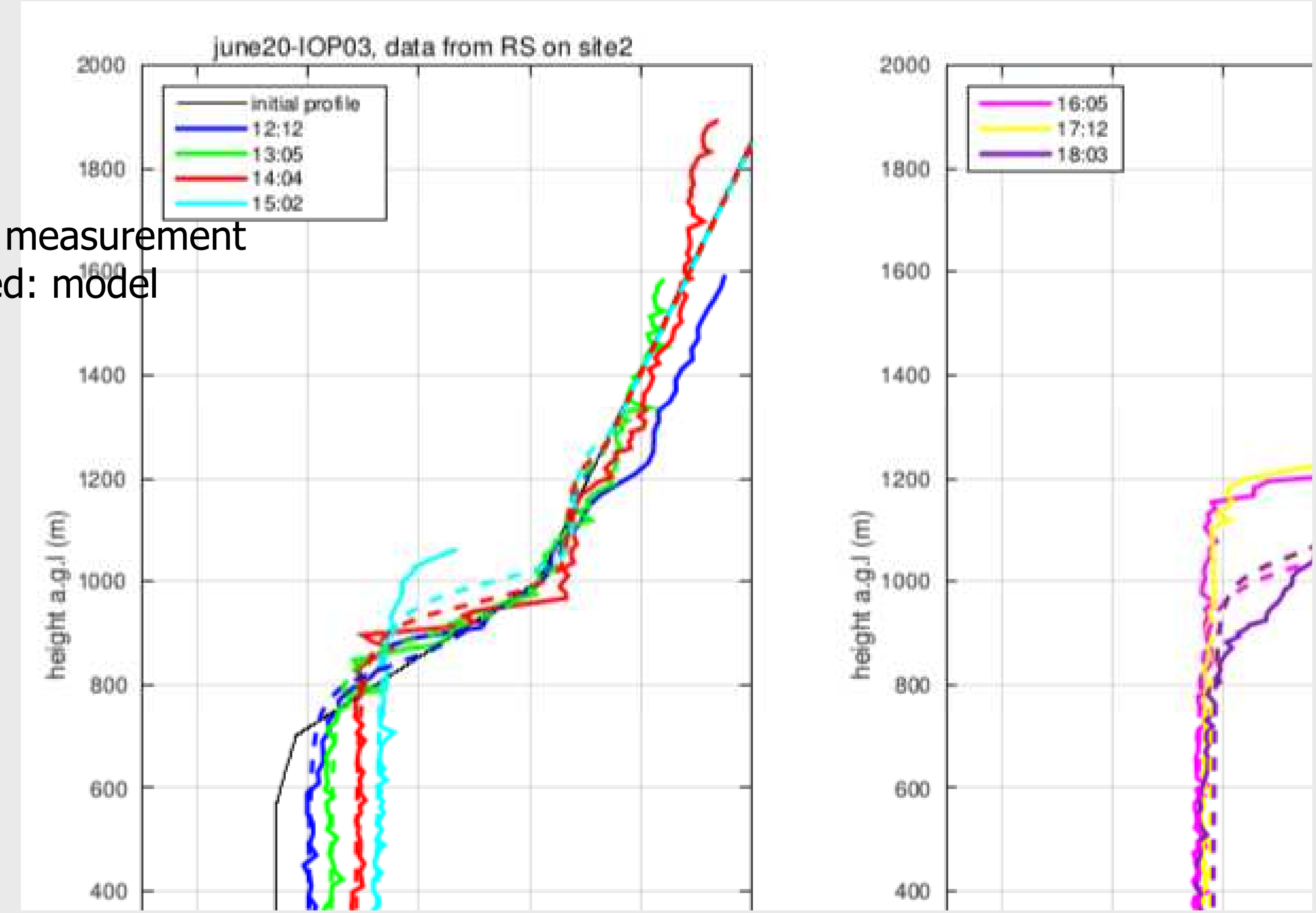
LES settings

- horizontal resolution : 12.5m, vertical resolution : 25m
- The domain size depends on the simulated IOP ; for each simulation, the horizontal dimension is taken equal to at least $4z_i$, the vertical one is at least $2z_i$.
- The surface sensible and latent heat fluxes are prescribed to the model as boundary conditions (sinus fit). The resulting buyoancy flux at the surface gives the time scale for the buyoancy flux decrease.
- all the simulations are driven with the surface fluxes from the moor field.
- the surface momentum flux is calculated using Monin Obukhov similarity.
- Initial profiles of temperature, humidity and wind are given by the observations.
- The spin-up time is one hour for all the simulations. End time of spin-up is the initial time, when the surface buyoancy flux is maximum. Simulations go from this initial time, until the time when buyoancy flux reaches 0.

LES settings

- investigated IOPs so far 02, 03, 05, and 06 (it is also planned to do it for the rest)
- larger scale synoptic forcings (geostrophic wind and subsidence) are not taken from the meso-scale models, but estimated and tuned by analyzing the observed temperature and wind profiles.

IOP3 20.06.2011 – potential temperature profiles



solid: measurement
dashed: model

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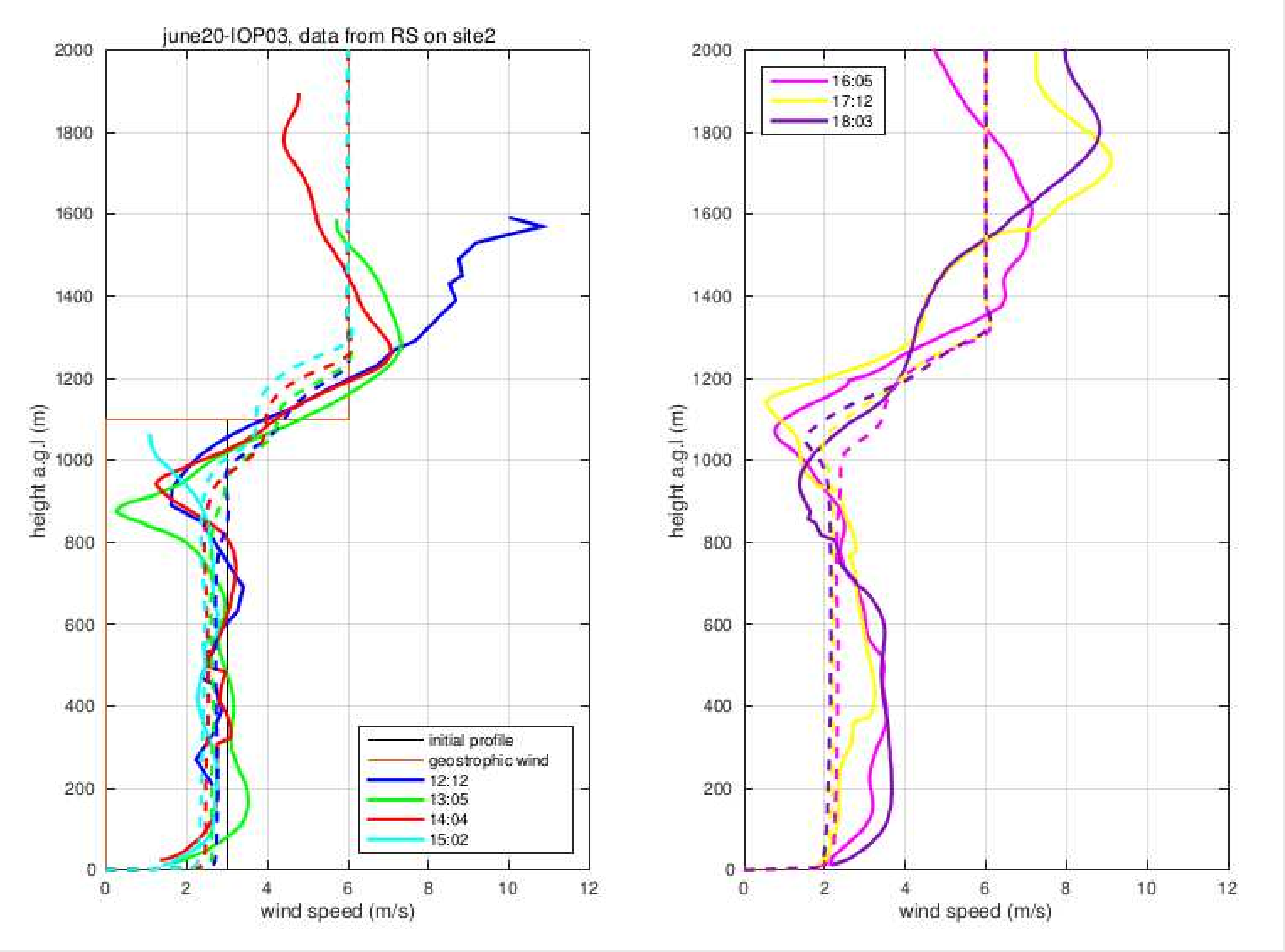
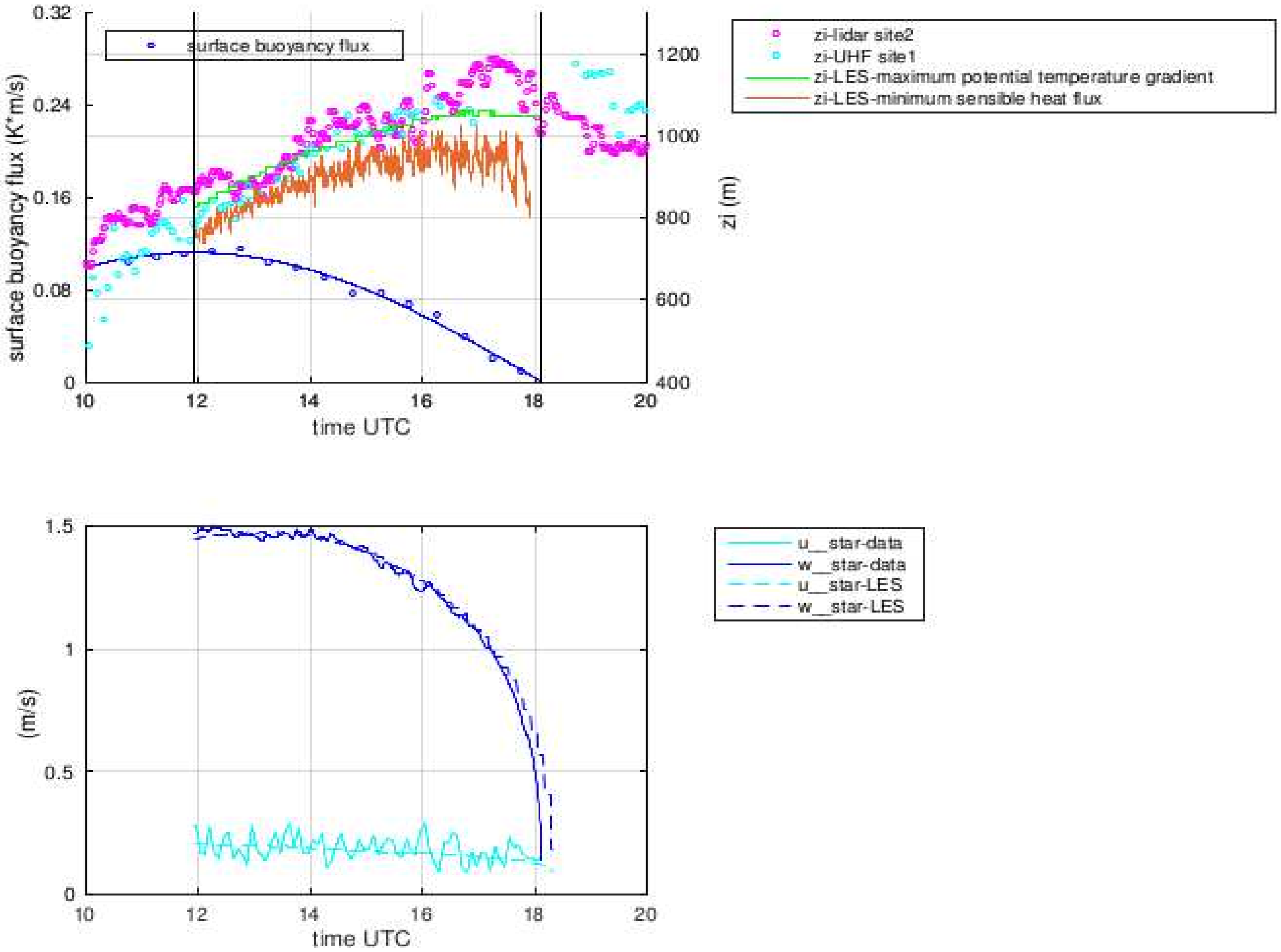
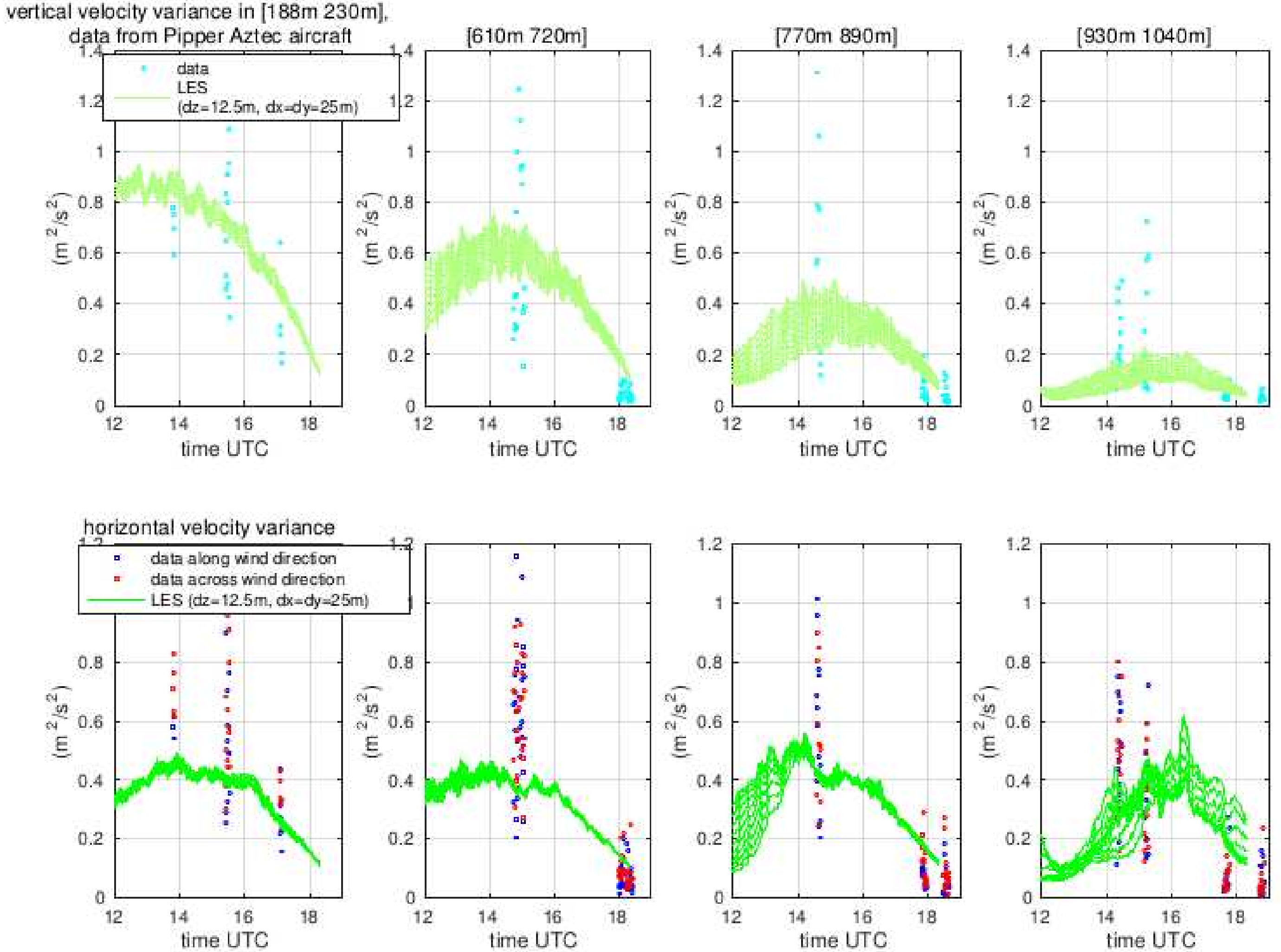
IOP3 20.06.2011 – initial profiles



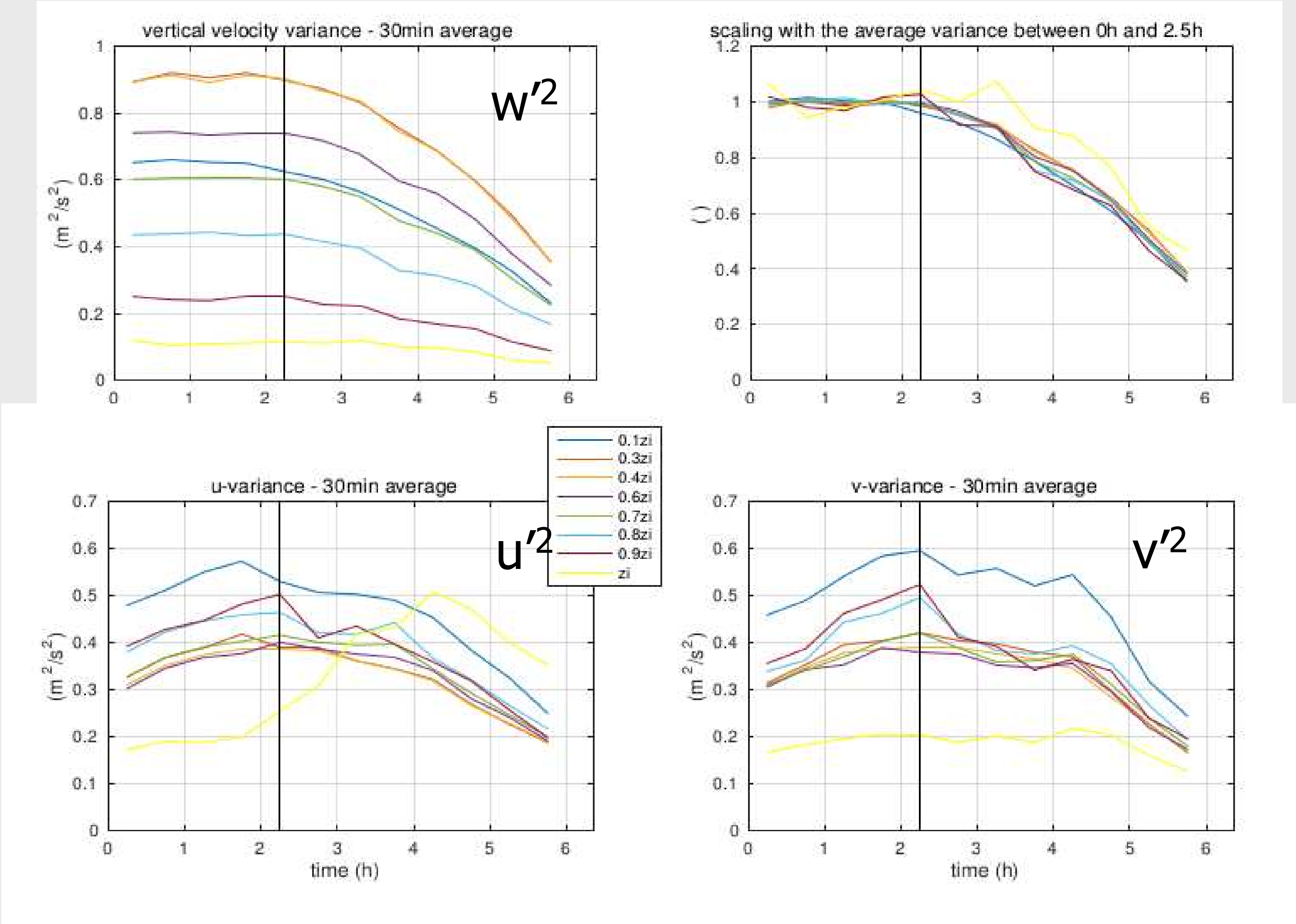
IOP3 20.06.2011 – comparison



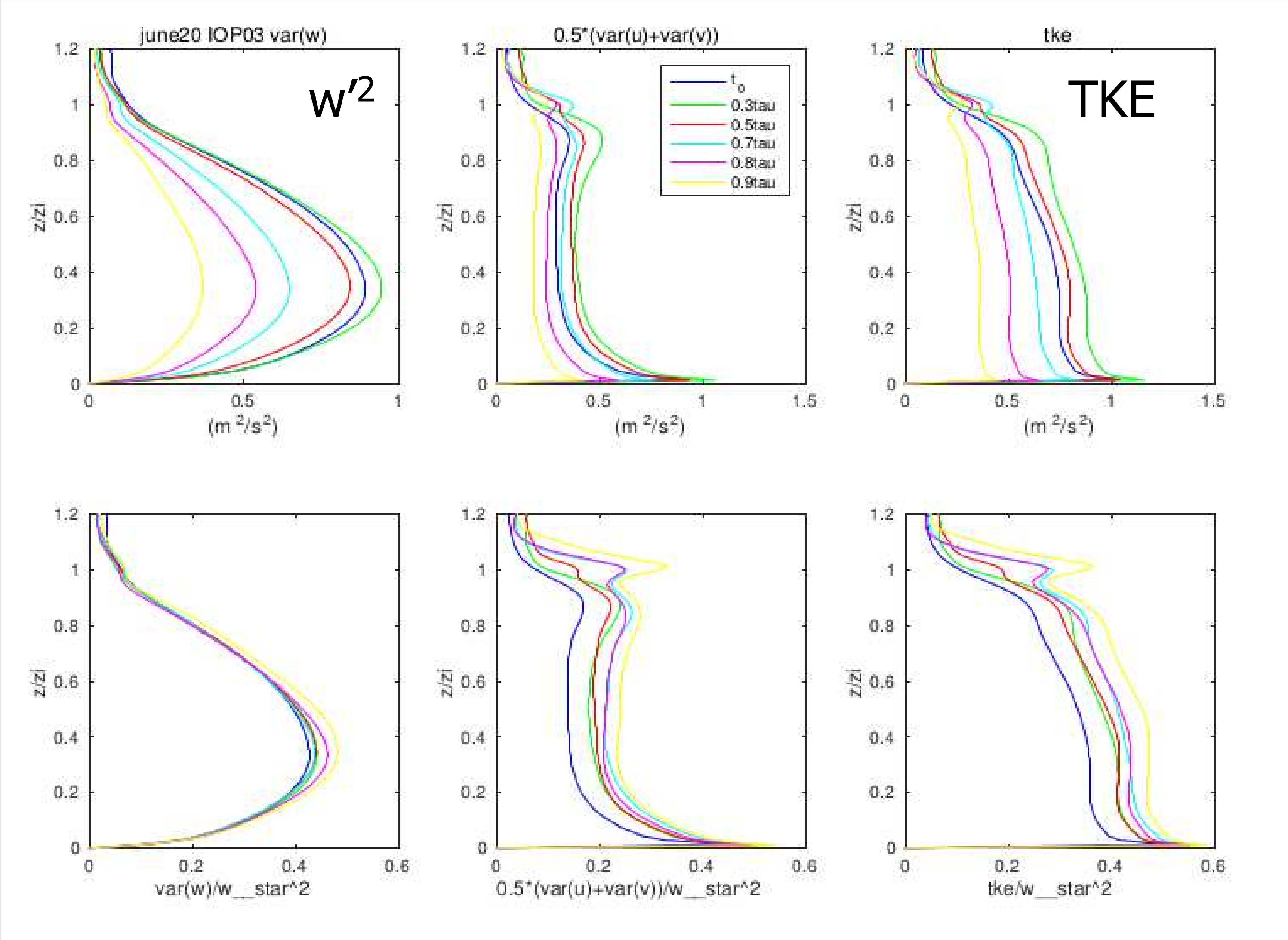
IOP3 20.06.2011 – comparison



IOP3 20.06.2011 – LES results velocity variances

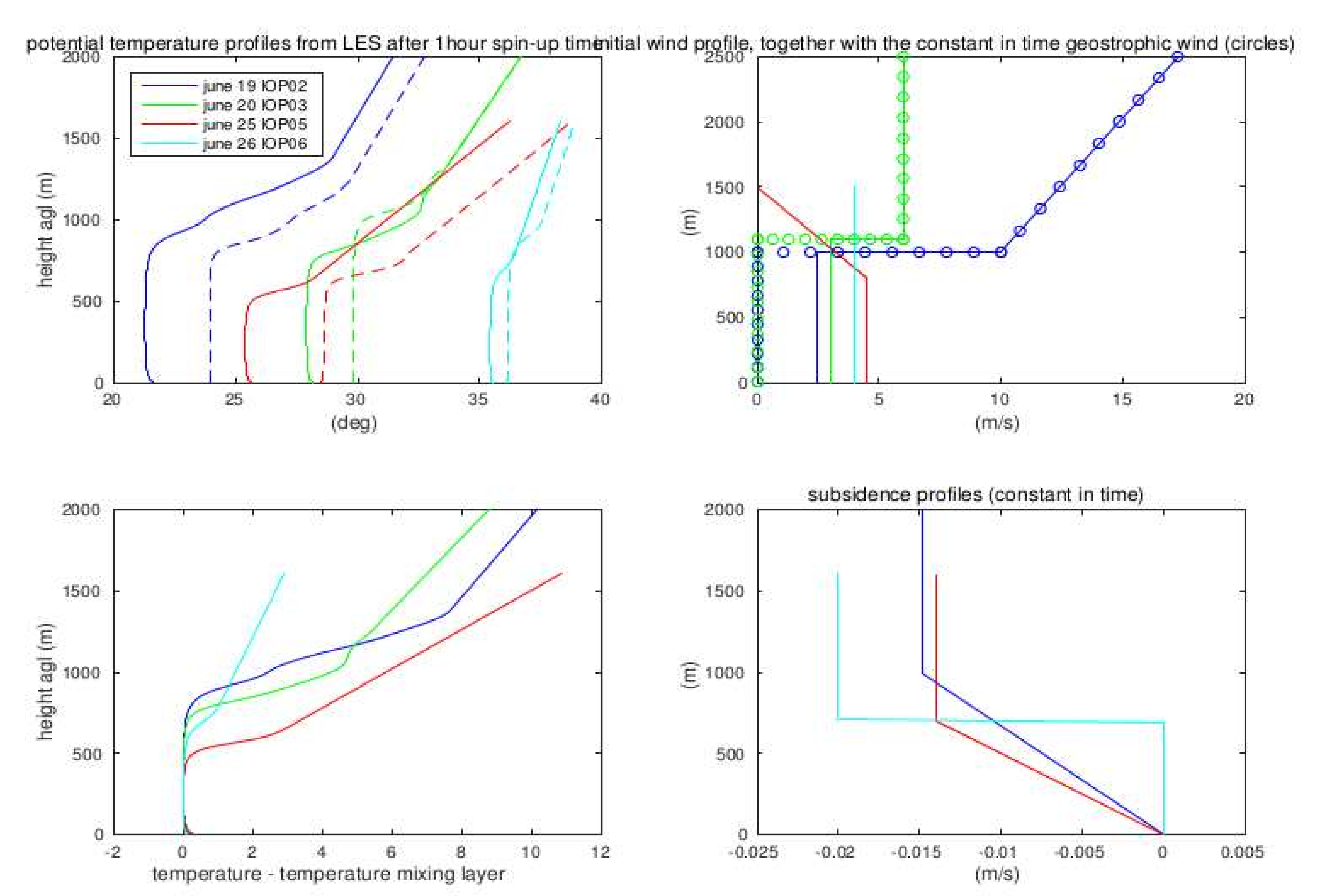


IOP3 20.06.2011 – LES 30 min averaged profiles



scaling with the actual w_*

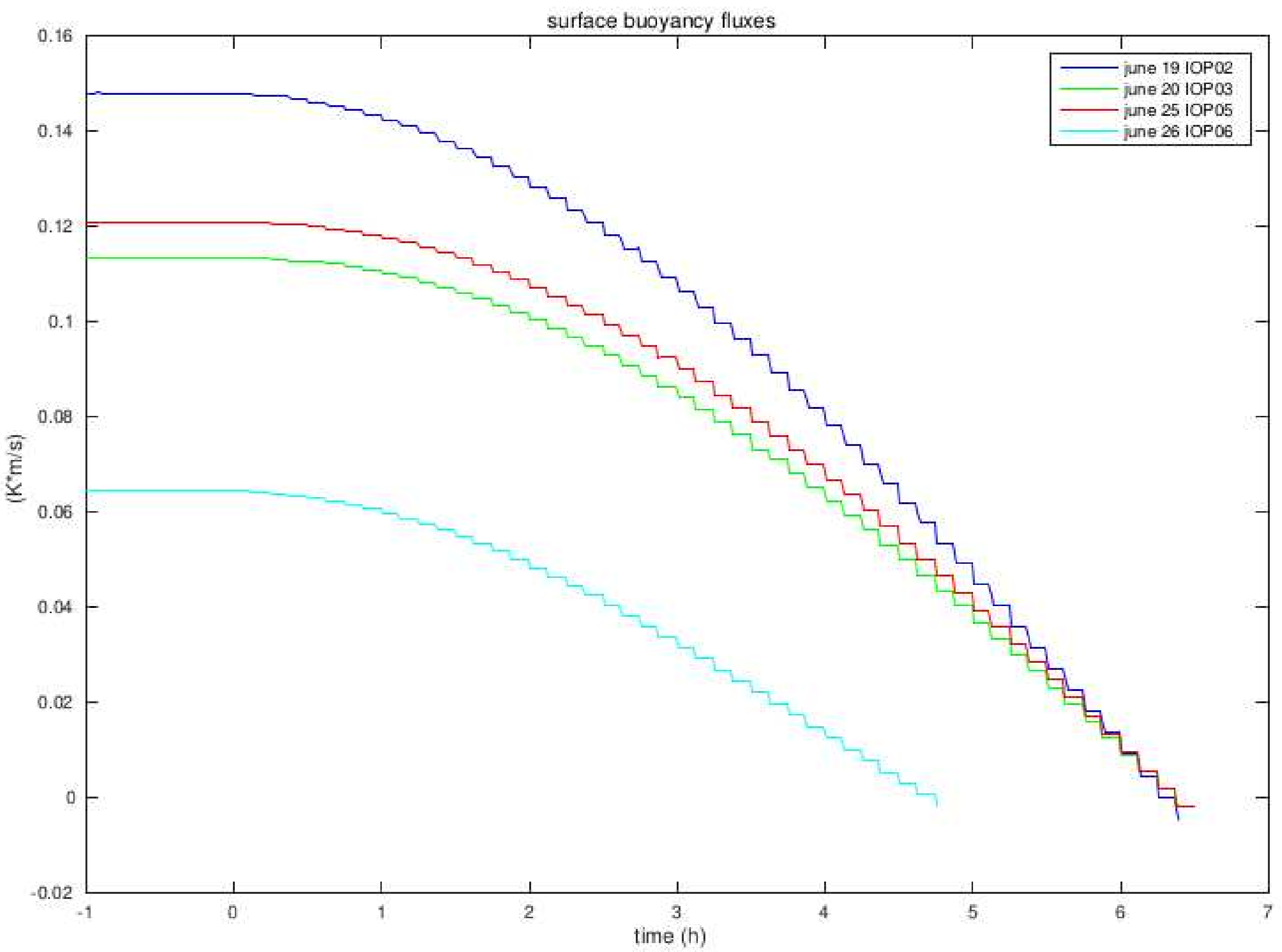
Initial profiles for the simulations of IOPs 2, 3, 5 and 6



Solid: at the initial time (end of spin-up)

Dashed: at the end of the simulation (surface heat flux reches 0)

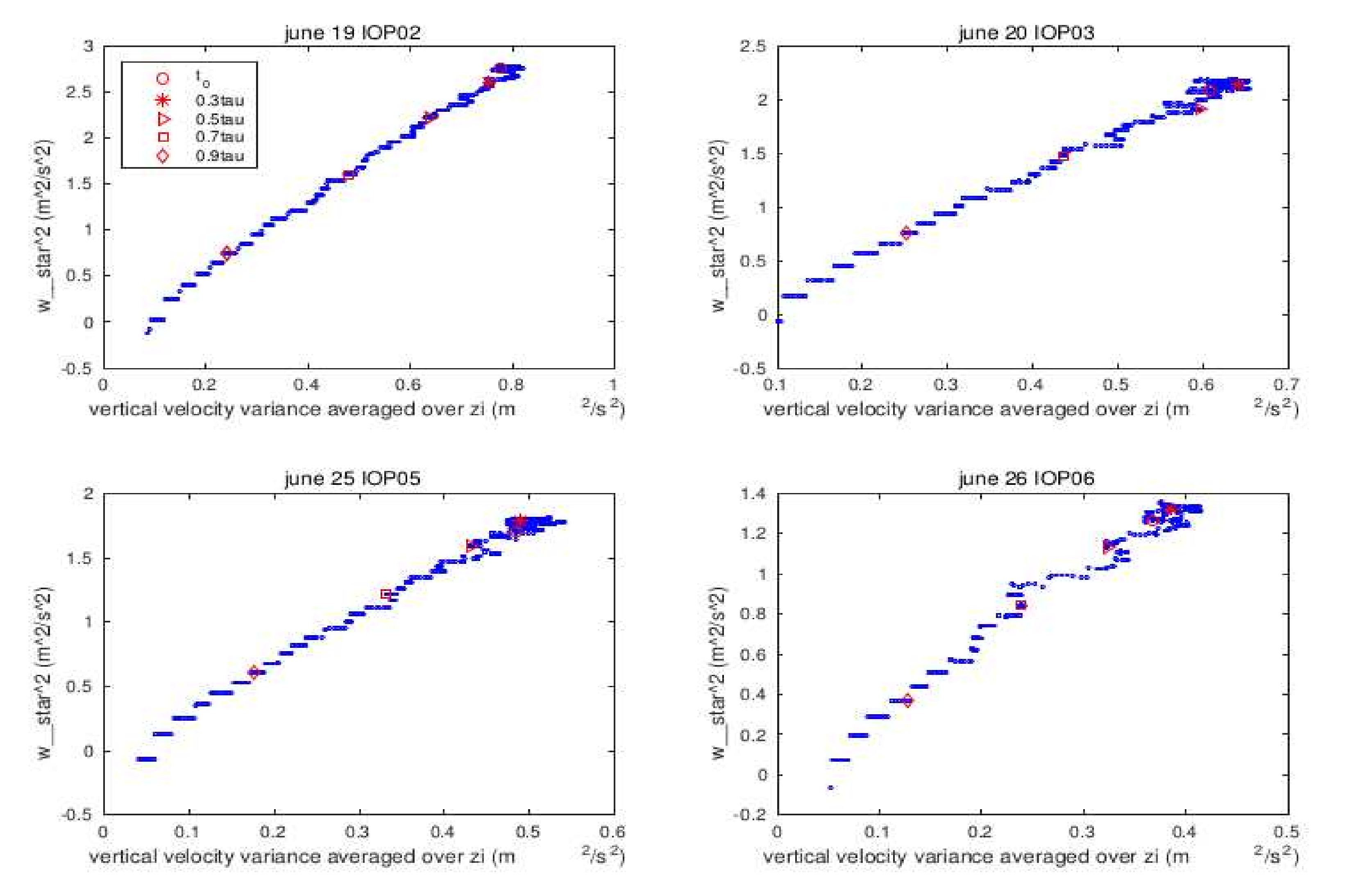
Surface buoyancy fluxes for IOPs 2, 3, 5 and 6



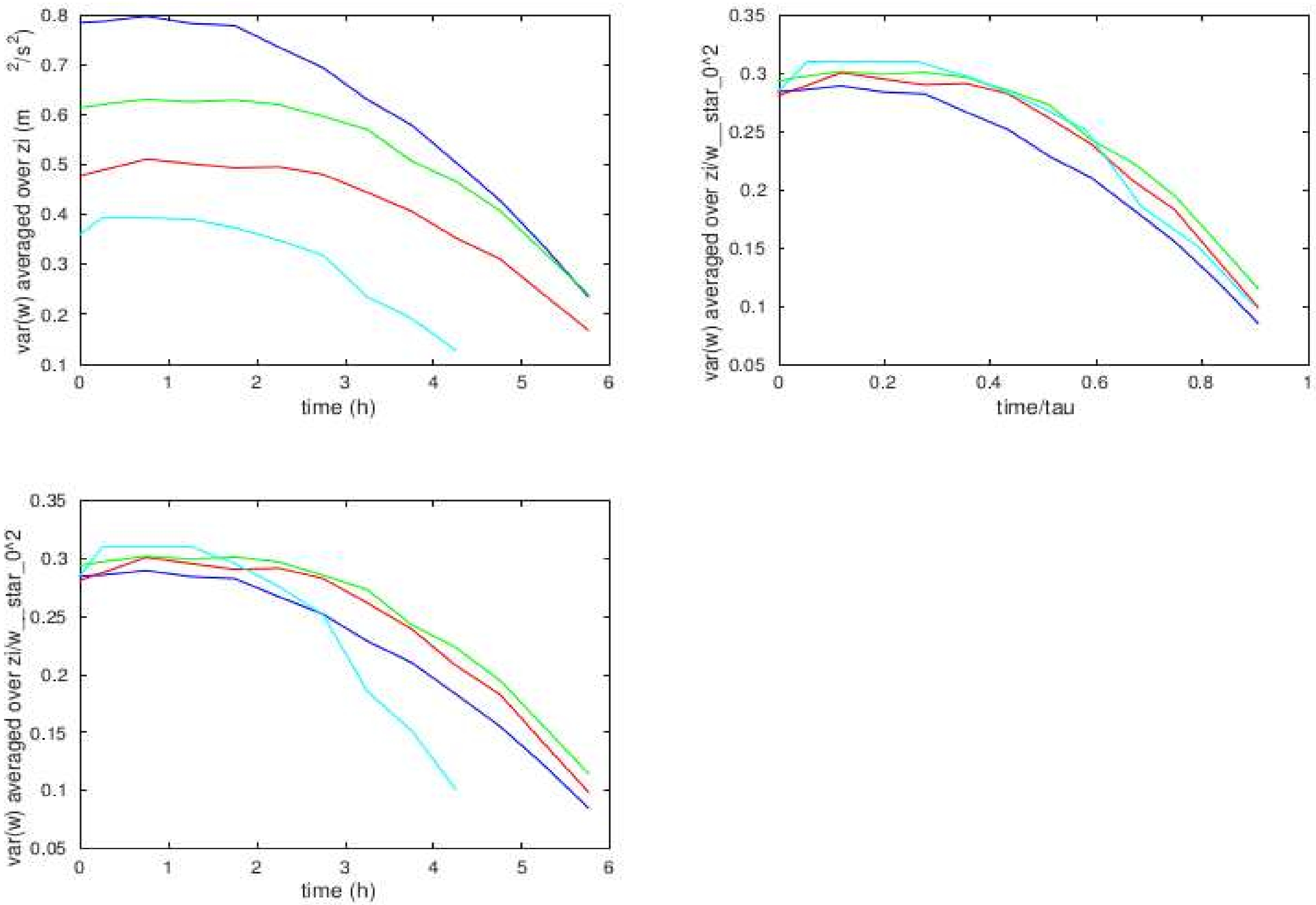
Characteristic scales IOPs 2, 3, 5, 6

	IOP02	IOP03	IOP05	IOP06
Surface kinematic heat flux (K*m/s)	0,148	0,113	0,121	0,064
Tau (h)	6,4	6,4	6,4	4,8
zi(t=0) (m)	930	825	575	700
w*(t=0) (m/s)	1,66	1,45	1,31	1,12
t*(t=0) (min)	9,3	9,5	7,3	10,4

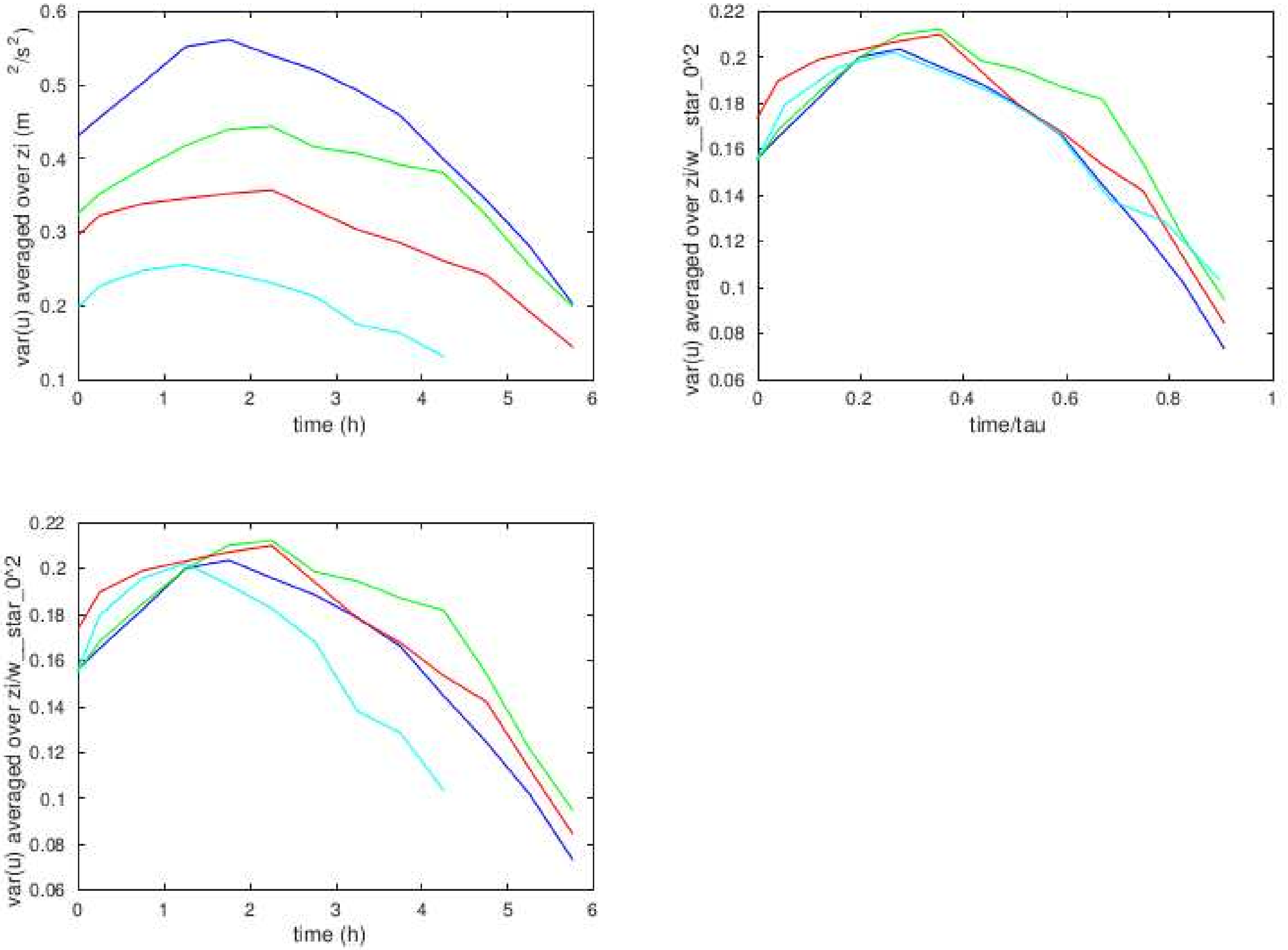
Correlation between w_* and w'^2 averaged over z_i



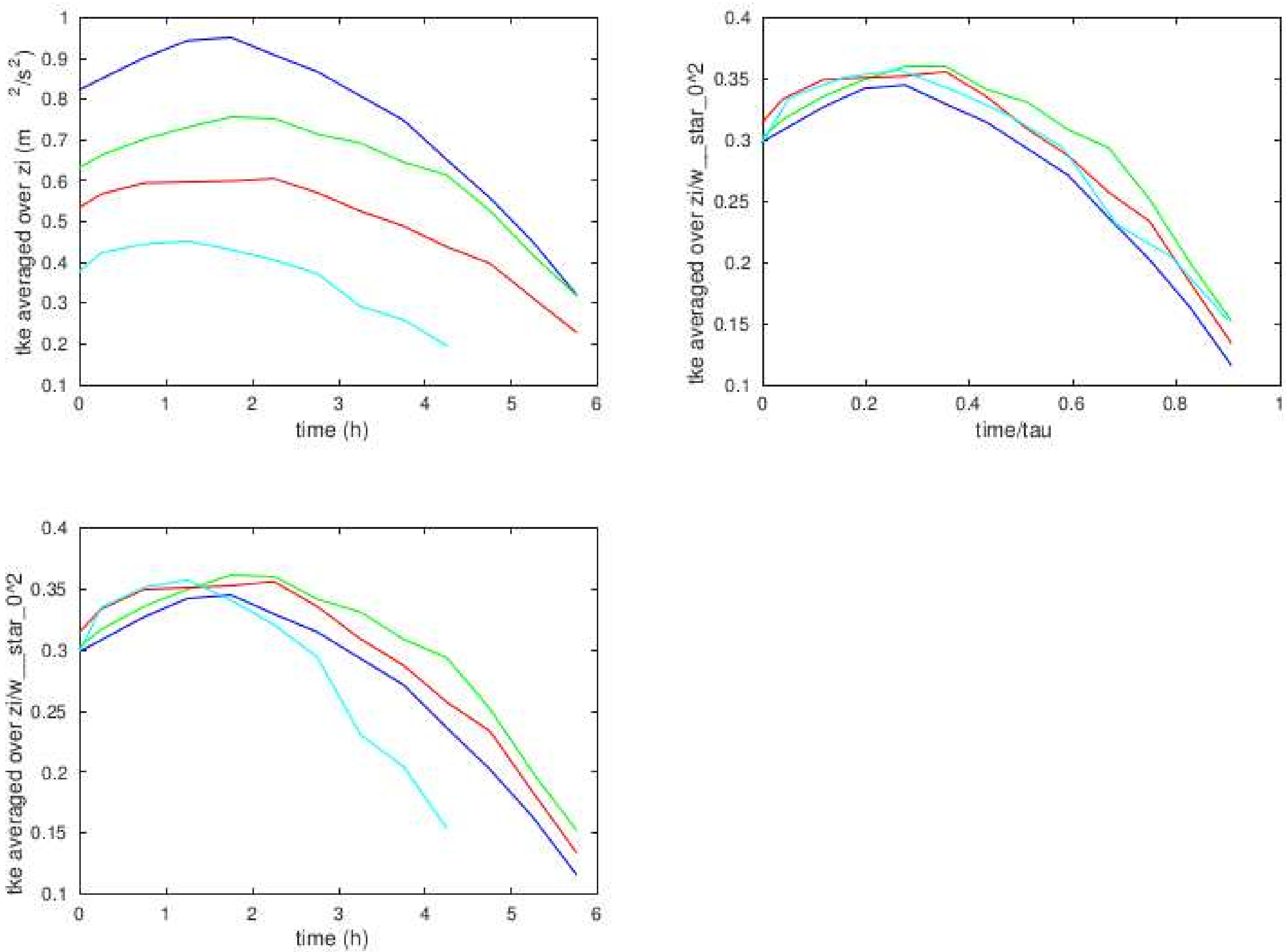
Relevane of w_* and τ for scaling – w'^2



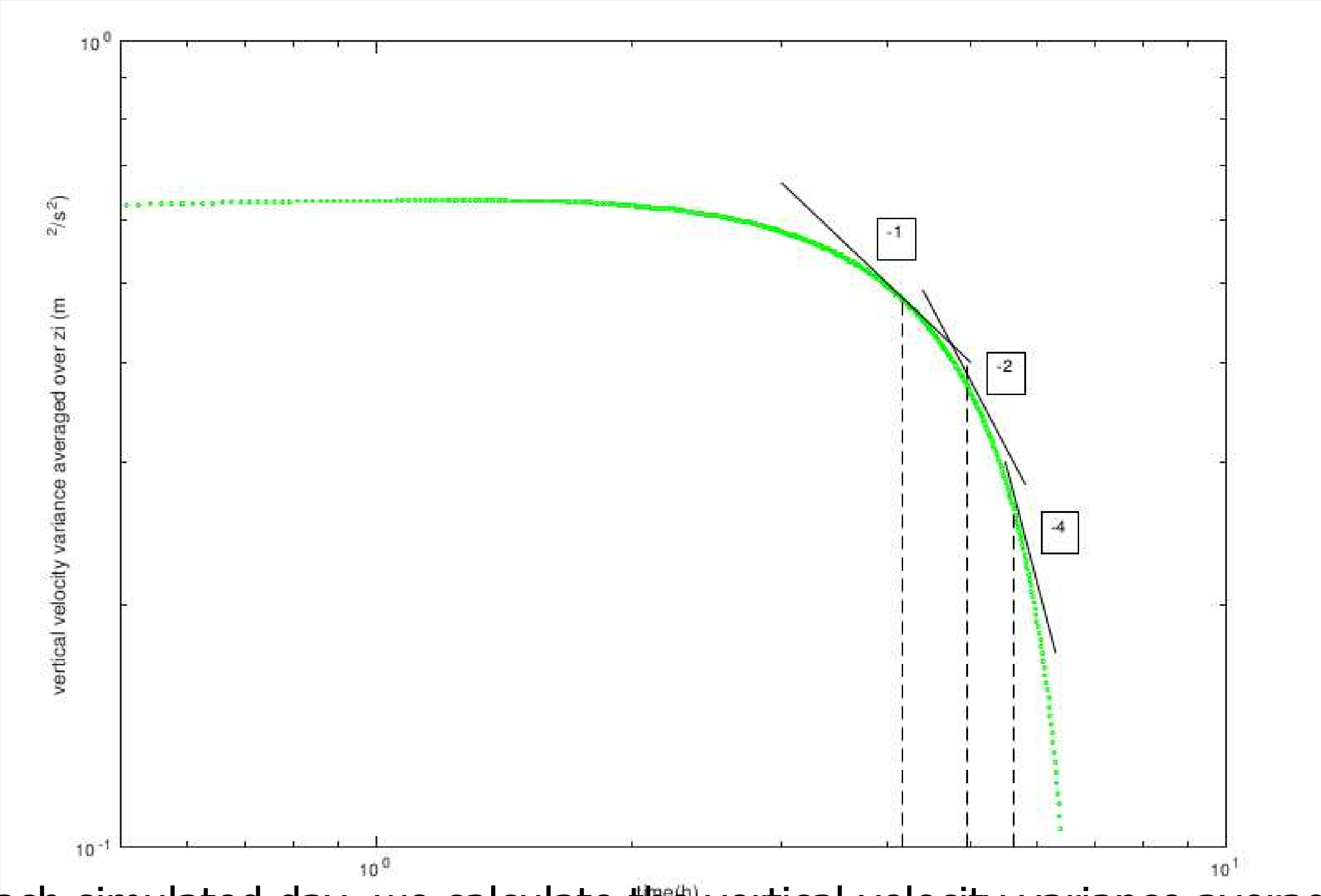
Relevane of w_* and τ for scaling – u'^2,v'^2



Relevane of w_* and τ for scaling – TKE

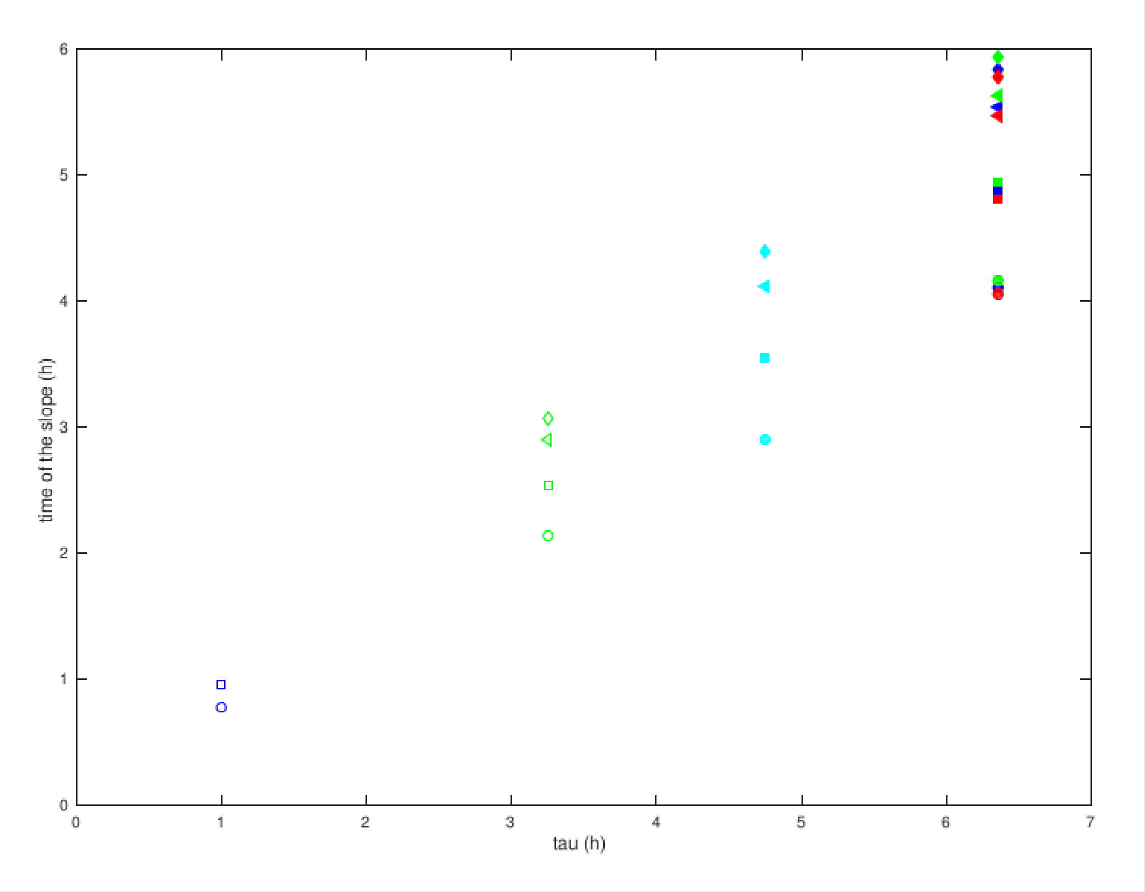


analysis of w'^2 averaged over z_i



For each simulated day, we calculate the vertical velocity variance averaged over z_i , plot log(var(w)) aginst log(t), and identify the time when the slopes -1, -2, -4 and -6 are reached

analysis of w'^2 averaged over z_i



Blue : IOP02
Green : IOP03
Red : IOP05
Cyan : IOP06

Circles : slope -1
Squares : slope -2
Triangle : slope -4
Diamond : slope -6

Filled symbols corresponds to simulations initialized with observed surface fluxes.
Open symbols corresponds to simulations having exactly the same initialization as for the filled circles but with a reduced τ in the surface fluxes