On the spatial and temporal discretization of vertical diffusion in the turbulent planetary boundary layer

Florian Lemarié

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1 - Spatial discretization

Context: advection-diffusion operator to parameterize unresolved scales in PBLs (and beyond) The resulting turbulent viscosity/diffusivity $K$ strongly varies spatially, i.e. large values of $K$ depend nonlinearly on model variables $u$, induces stiffness, i.e. large $\mu^2 / K$. $K$.

Usual approach: use of (semi-)implicit temporal schemes with 2nd-order FD discretization

What could be wrong with 2nd-order in space?
- With $\Delta x^2 / \mu^2 \ll 1$, $n \geq 2$
- With $\Delta x^2 / \mu^2 > 1$, $n \geq 4$

$\alpha(x,x+\Delta x) = \alpha(x+\Delta x,x) = \alpha(x,0) = \alpha(0,x) = \alpha(x)$

$\alpha(x) = \alpha(x) = \alpha(x)$

Single column exp. 0%-4$\alpha$ and 4$\alpha$-8$\alpha$

2 - Treatment of the boundary condition (Monin-Obukhov consistency)

no-slip boundary condition is never applied in practice replaced by a flux condition consistent with wall laws

Current practice:

- $\phi(x) = \phi(x) = \phi(x)$
- $\phi(x) = \phi(x) = \phi(x)$

IVP approach with $\phi_0 = \phi_1$:

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