# Upward spreading of surface observations: implementation in LM nudging scheme

Davide Cesari, numerical modeling group,
ARPA-SMR, Bologna

# Background

Current assimilation scheme: the surface observations give a nudging increment only at the lowest model level.

Purpose of the work: compute an increment from surface observations on multiple model levels within the PBL.

This can be done consistently using the vertical diffusion equation system for a turbulent flow:

$$\left\{\begin{array}{l}
\frac{\partial\theta'(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(k_t\left(z,t\right)\frac{\partial\theta'(z,t)}{\partial z}\right)\\
\frac{\partial q'(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(k_t\left(z,t\right)\frac{\partial q'(z,t)}{\partial z}\right)\\
\frac{\partial u'(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(k_t\left(z,t\right)\frac{\partial u'(z,t)}{\partial z}\right)\\
\frac{\partial v'(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(k_t\left(z,t\right)\frac{\partial v'(z,t)}{\partial z}\right)
\end{array}\right. ,$$

$\theta'$, $q'$, $u'$, $v'$, are deviations from background values and $k_t$ and $k_m$ are turbulent diffusion coefficients.

# The method

- The increments above the lowest model level are computed by integrating the previous equations at every observation point for a specified time interval.

- The lower boundary condition is the observation increment at the lowest model level, computed like in the current assimilation scheme, the upper boundary condition is zero increment at top of PBL.

- The number of vertical levels on which the equations are integrated and the amount of diffusion are determined by the depth and stability of PBL as seen by the model.

- The set of equations is solved with an implicit Crank-Nicolson scheme.

# Implementation in LM

- The procedure can be switched on by a namelist parameter and, in this case, it replaces the current treatment of surface observations

- The integration of the equation system is performed every time the nudging increments have to be recalculated (by default every 10 minutes of integration)

- The increments are then spread horizontally in the way selected for surface observation increments - likely along model levels.

- They are however treated like multi-level (e.g. radiosounding) increments, due to their nature.

## Current status

- The scheme is already inserted in LM code but still doesn't run properly
- The modifications will have to be merged with the latest LM version

## Open issues

- The PBL depth should be computed in the same way used in other LM applications, likely using $TKE$ variable
- The increments computed above lowest model level have to be quality-weighted in order to properly interact with other neighbouring observations
- The length of the time interval for integrating the diffusion equation should be defined, possibly from turbulence related parameters