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On the effectiveness of surface assimilation in probabilistic nowcasts of planetary boundary layer profiles

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Surface observations comprise a wide, non-expensive and reliable source of information about the state of the near-surface planetary boundary layer (PBL). Operational data assimilation systems have encountered several difficulties in effectively assimilating them, among others due to their local-scale representativeness, the transient coupling between the surface and the atmosphere aloft and the balance constraints usually used.
A long-term goal of this work is to find an efficient system for probabilistic PBL nowcasting that can be employed wherever surface observations are present. Earlier work showed that surface observations can be an important source of information with a single column model (SCM) and an ensemble filter (EF). Here we extend that work to quantify the probabilistic skill of ensemble SCM predictions with a model including added complexity. We adopt a factor separation analysis to quantify the contribution of surface assimilation relative to that of selected model components (parameterized radiation and externally imposed horizontal advection) to the probabilistic skill of the system, and of any beneficial or detrimental interactions between them.
To assess the real utility of the flow-dependent covariances estimated with the EF and of the SCM of the PBL we compare the skill of the SCM/EF system to that of a reference one based on climatological covariances and a 30-min persistence model. It consists of a dressing technique, whereby a deterministic 3D mesoscale forecast (e.g. from WRF model) is adjusted and dressed with uncertainty using a seasonal sample of mesoscale forecasts and surface forecast errors.
Results show that assimilation of surface observations can improve deterministic and probabilistic profile predictions more significantly than major model improvements. Flow-dependent covariances estimated with the SCM/EF show clear advantage over the use of climatological covariances when the flow is characterized by wide variability, when climatological covariances do not resemble true error covariances and when 30-min persistence fails. Conversely, the climatological dressing technique may lead to enhanced results relative to the SCM/EF under convective regime if SCM PBL predictions show significant bias.
Several of our conclusions are expected to extend to 3D mesoscale model-EF systems assimilating surface observations.
The results suggest that an SCM/EF may be helpful in wind-power and pollutant dispersion applications.