Development and Validation of a Fine Numerical model for Urban Road Surface Parameters Prediction

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Outline

- Introduction
- Model development
- Summer RST forecast
- Winter snow simulation
- Conclusion
- next
Introduction

• Research method
  – Statistical method
  – GIS based model
  – Physically based model
    • METRo
    • RWFS

• Road forecast model
  – Road surface energy balance model
  – Vehicle traffic effect
  – Coupled with BJ-RUC
  – RST, Snow/Ice, Water
Model development

- Road surface characteristics
- Road surface energy balance and water balance
- Anthropogenic Heat
- Urban Boundary Layer

Vaisala Observation Data (RST and Snow Depth) → CoLM Land Surface Model → Fine Numerical Forecast Model (Urban-RSF) → Meteorological Forcing Data → Beijing Rapid Update Cycle Model (BJ-RUC)
Road surface energy & water model

- **Energy balance model**

\[
C \frac{\partial T}{\partial t} = F_1 - \frac{\partial}{\partial z} \left( t_k \frac{\partial T}{\partial z} \right)
\]

\[
F_1 = R_{n,g} - H_g - L_f I + A
\]

- **Water balance model**

\[
\frac{\partial \theta}{\partial t} = 0
\]

Traffic effect
Traffic effect
Urban boundary layer

• Wind profile

\[ \frac{\sigma_u}{u_*} = 1.73 \left( 1 - 1.0 \frac{z'}{L} \right)^{\frac{1}{3}} \]

• Temperature profile

\[ \frac{\sigma_T}{T_*} = 0.88 \left( - \frac{z'}{L} \right)^{\frac{1}{3}} \]
RST Assimilation

\[ J(T_g, CH, \lambda) = \frac{C_1}{2} \left( T_g(t_1) - T_{obs}(t_1) \right)^2 + \frac{C_T}{2} \int_{t_0}^{t_1} \left( T_g - T_{obs} \right)^2 dt \]

\[ + \frac{C_{CH}}{2} \int_{t_0}^{t_1} \left( CH - CH' \right)^2 dt \]

\[ + \int_{t_0}^{t_1} \lambda \left[ c\Delta z \frac{\partial T_g}{\partial t} - \frac{t_k}{\Delta z} (T_2 - T_g) - R_{n,g} + H_g + L_f I - A \right] dt \]
Verification in summer

- **Time span**
  - 2009 08 10 - 2009 08 20

- **Site chosen**
Result & Discussion

• Precipitation
Verification in summer

- Mean value
Result & Discussion

- No precipitation, Around noon

\[
\begin{align*}
\text{ME} &= 14.65992 \\
\text{RMSE} &= 15.26584 \\
\text{ME} &= 10.05388 \\
\text{RMSE} &= 10.83127 \\
\text{ME} &= 3.680145 \\
\text{RMSE} &= 4.804262
\end{align*}
\]
Result & Discussion

- No precipitation, At night

```
ME=6.704623  
RMSE=7.196558
```
```
ME=2.383754  
RMSE=2.847639
```
```
ME=14.26594  
RMSE=15.64789
```
Winter snow simulation

• **Time span**
  – 2010-01-02 to 2010-01-04

• **Site chosen**
  – Wenyuhe (Airport express)
  – Xiguan （Badaling express）
  – Xihongmen （Jingkai express）
  – Lugouqiao （Jingshi express）
Winter snow simulation

Wenyuhe
Winter snow simulation

Xiguan
Winter snow simulation

Xihongmen
Winter snow simulation

Lugouqiao
Conclusion

• **Summer RST**
  – Around noon
  – At night
  – Traffic effect

• **Winter snow**
  – Variation & depth
  – Traffic effect
  – RST
The next

• **Traffic effect**
  – Anthropogenic heat
  – Spatial variation
  – Seasonal variation

• **UBL**

• **Resolution**

• **Snow depth assimilation**

• **Water depth (dry/wet condition) forecast**
Thanks!
Welcome for your suggestions and questions!