Characterization of PBL structure and $PM_{2.5}$ in Taiwan: T-POMDA field campaign and modeling

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— Introduction —

- T-POMDA stands for PBL Observation, Modeling, and Data Assimilation. This comprehensive experiment investigates boundary layer structures and their impact on air pollution dispersion.
- During the field campaign, various PBL profiling techniques were deployed over central western Taiwan to observe PBL structures. Three IOPs were conducted during the spring season from 2021 to 2023. This presentation focused on findings from the 3rd IOP.

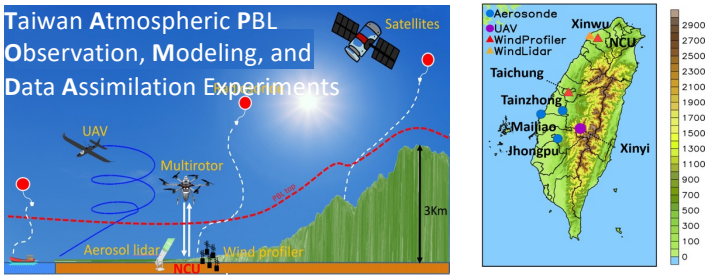


Fig. 1. T-POMDA experiment and observation sites

— Model Experiments and Observations —

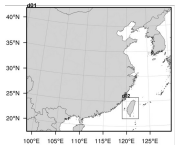


Fig. 2. Simulation domain.

WRFv3.8.1/CMAQv5.2		
Resolution	d01: 15km	d02: 3km and 600m
PBL scheme	YSU	YSU/MYNN2.5/ACM2

- Chemical mechanism: CB06r3 – AE6
- Emissions: MIX 2010/TEDS11.1/MEGANv2.04

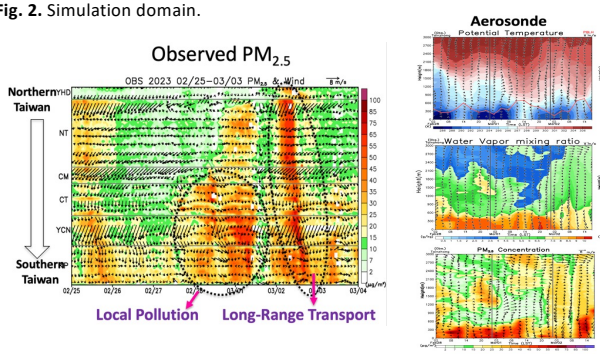
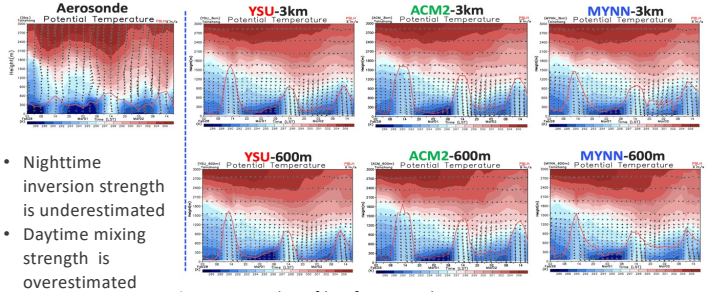


Fig. 3. Surface $PM_{2.5}$ observation (left) and aerosonde observation (right)

— Vertical Profiles —

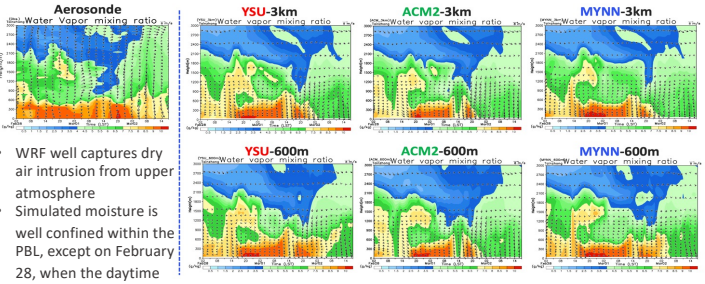
Theta Profile



- Nighttime inversion strength is underestimated
- Daytime mixing strength is overestimated

Fig. 4. Vertical profile of potential temperature

Water Vapor Profile



- WRF well captures dry air intrusion from upper atmosphere
- Simulated moisture is well confined within the PBL, except on February 28, when the daytime mixing is too strong.

Fig. 5. Vertical profile of wind field

PM2.5 Profile

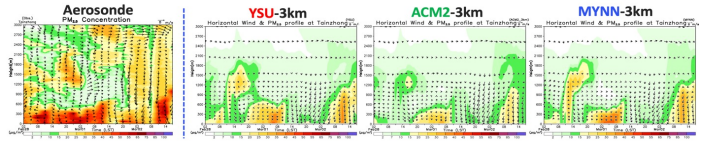
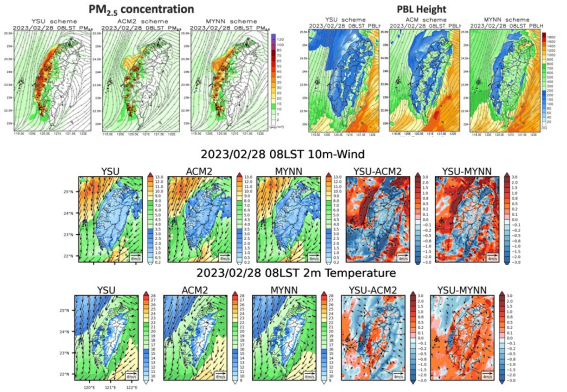


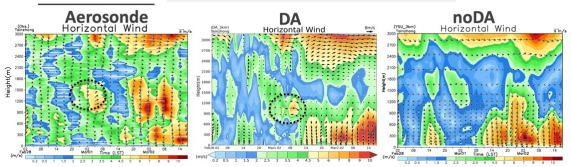
Fig. 6. Vertical profile of $PM_{2.5}$

— $PM_{2.5}$, wind, PBL ht, Leeside Vortex —

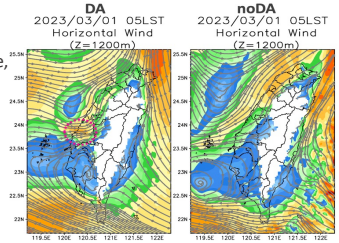


— Data Assimilation —

Wind Profile



- **No Data Assimilation (noDA):** Simulated leeside vortex is positioned offshore, southwest of Taiwan.
- **With Data Assimilation (DA):** Vortex shifts inland, strengthening the westerly wind flow.
- Assimilation of PBL profiles leads to changes in vortex location.



— Conclusions —

- **T-POMDA** Experiment: investigate PBL structures and air quality
- **Aerosonde Observation**: Nighttime surface inversion layer and daytime shallow ML limits $PM_{2.5}$ dispersions
- **Model Performance**: Model underestimates strength of nighttime surface cooling and overestimates daytime mixing strength
- **PBL Simulations**: (1) Subtle differences are seen in temperature and moisture fields among different PBL simulations, (2) Wind fields reveal differences among different PBL schemes due to presence of a leeside vortex
- **Leeside vortex**: (1) Plays a major role in redistributing moisture and air pollutants, (2) Environmental wind and local wind flow, such as land-sea breeze, influence formation of a leeside vortex.