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Fog and low stratus life cycle processes in the Po valley, Italy

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MOTIVATION

- Fog and low stratus (FLS) life cycle processes important for traffic security and solar power prediction
- No satellite-based analysis of the impact of synoptic and local drivers on the FLS life cycle in the Po valley exists
- **Aim of the study:** Systematically analyze the large-scale and local conditions associated with different FLS formation mechanisms in the Po valley, Italy

DATA & METHODS

Data

- Study area: Po valley, Italy, time period: 2006-2015
- Satellite-based FLS formation and dissipation time data set [1] & FLS life cycle regimes [2]
- era5 reanalysis data on pressure and single levels

Methods

1) Selection of FLS formation events with a large spatial extent (>30 pixels with 0.25°x0.25° pixel size) and start after 12pm → 70 events (Fig. 1)
2) K-means clustering on the latitudinal relative humidity profile at 12pm over the Po valley with 4 clusters

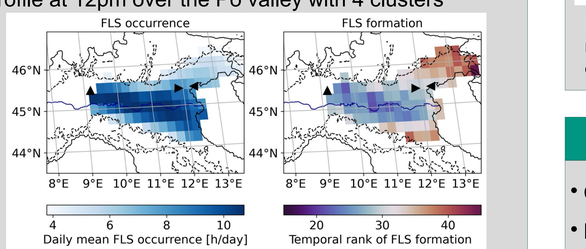

Fig. 1: Average FLS occurrence and temporal rank of FLS formation of all selected FLS events. The temporal rank of FLS formation is assigned for each pixel based on its position in time.

RESULTS I: IMPACT OF LOCAL COOLING

- FLS forms earlier at the river and persists longer at the river and near the coast (Fig. 2)
- High pressure field and reduced wind speeds over the Po valley region (Fig. 3)
- Radiative cooling and a stable boundary layer drive FLS formation (Fig. 4)

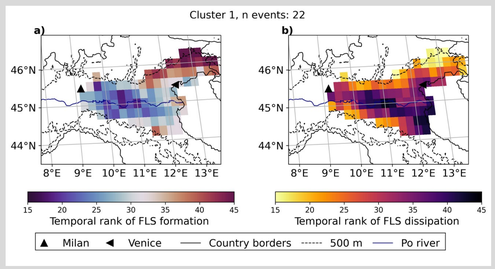

Fig. 2: Average temporal rank of FLS formation and dissipation for all events in cluster 1. The temporal rank is assigned for each pixel for each formation/dissipation event based on its position in time.

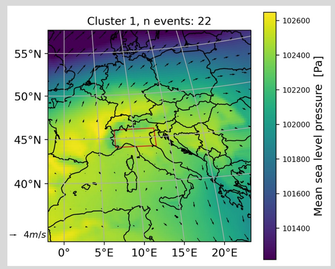

Fig. 3: Average mean sea level pressure and 10m winds at 12pm for all events in cluster 1. The red rectangle indicates the location of the Po valley.

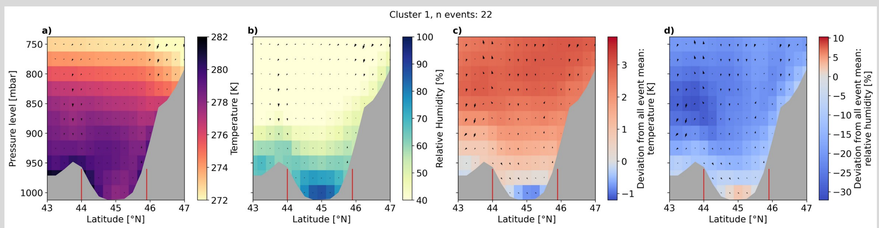

Fig. 4: Latitudinal profiles averaged along 11.25-12.25°E at 12pm showing mean temperature (a) and relative humidity (b) for all events in cluster 1, and the deviation of the cluster specific mean from the all event mean for temperature (c) and relative humidity (d). The vertical red lines mark the Po valley.

RESULTS II: IMPACT OF ADVECTIVE PROCESSES

- FLS formation from west to east, FLS fields most persistent in southwestern part of the study area (Fig. 5)
- Low pressure field and reduced wind speeds over the Po valley region (Fig. 6)
- Moisture advection over Appennines dominating driver of FLS formation (Fig. 7)

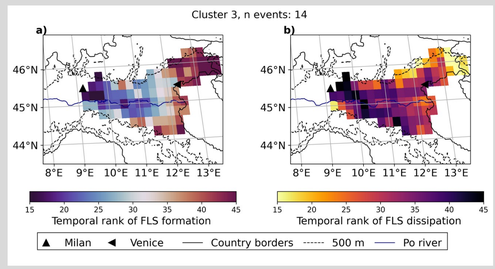

Fig. 5: Average temporal rank of FLS formation and dissipation for all events in cluster 3. The temporal rank is assigned for each pixel for each formation/dissipation event based on its position in time.

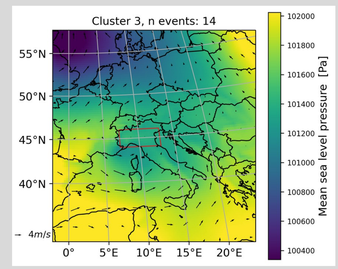

Fig. 6: Average mean sea level pressure and 10m winds at 12pm for all events in cluster 3. The red rectangle indicates the location of the Po valley.

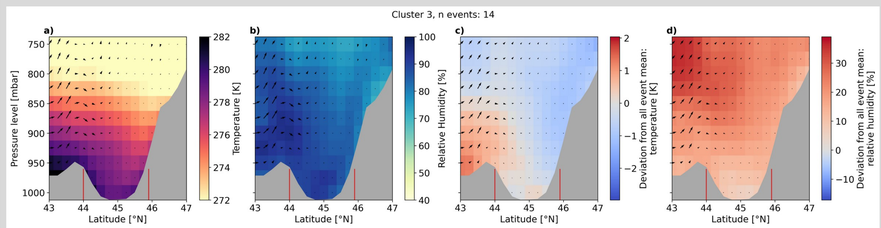

Fig. 7: Latitudinal profiles averaged along 11.25-12.25°E at 12pm showing mean temperature (a) and relative humidity (b) for all events in cluster 3, and the deviation of the cluster specific mean from the all event mean for temperature (c) and relative humidity (d). The vertical red lines mark the Po valley.

CONCLUSIONS

- Clustering approach reveals different FLS formation mechanisms over the Po valley
- Depending on the synoptic setting, local cooling, moisture and temperature advection drive FLS formation in the Po valley

→ different temporal and spatial patterns of FLS formation and dissipation

OUTLOOK

- Investigation of the role of aerosols on the timing of FLS formation and dissipation
- Process-oriented sensitivity studies using explainable machine learning

References

[1] Pauli, E., Cermak, J., & Andersen, H. (2022). A satellite-based climatology of fog and low stratus formation and dissipation times in central Europe. Quarterly Journal of the Royal Meteorological Society, 148 (744), 1439–1454.doi: 10.1002/qj.4272

[2] Pauli, E., Cermak, J., Andersen, H., Fuchs, J., (2024). An analysis of fog and low stratus life cycle regimes over central Europe. Quarterly Journal of the Royal Meteorological Society, doi: 10.1002/qj.4714