NaFoLiCA: Synoptic-scale controls of fog and low cloud variability in the Namib Desert

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Motivation: Fog relevant to local ecosystems but poorly understood

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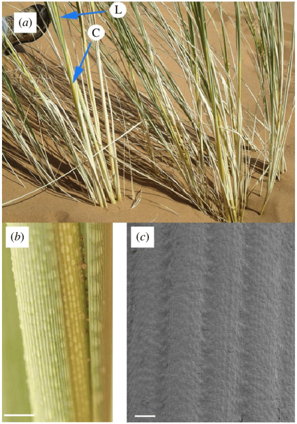
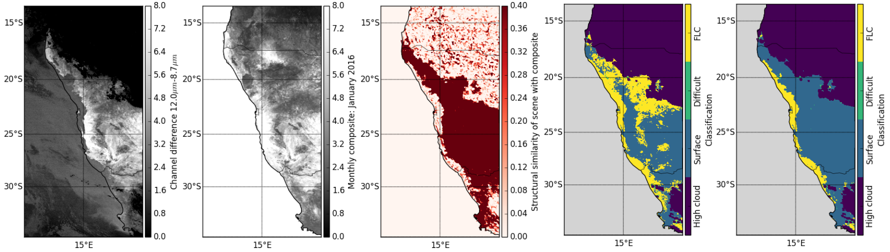


L: *Stipagrostis sabulicola:* Roth-Nebelsick et al. (2013),
R: *Onymacris unguicularis:* Anderson (2008) [modified]

Previous work I:
Satellite detection of Fog and Low Clouds (FLC)

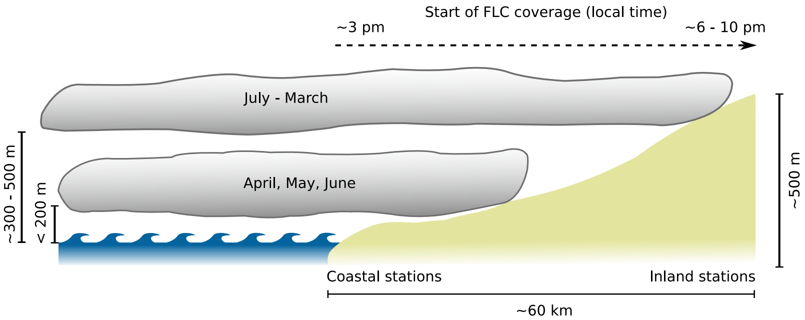
- SEVIRI-based FLC detection at native resolution (15 min, 3x3 km)
- Validation with station measurements shows good skill



Andersen and Cermak 2018, AMT

→ Continuous observations since 2004, collaborations welcome!

Previous work II: Mapping of spatiotemporal FLC patterns



Andersen et al. 2019, ACP

- Vertical position of low-cloud layer varies by season.
- Timing of FLC occurrence tightly related to the distance to the coast.
- But: Knowledge gaps concerning drivers of FLC variability

Scientific goal and approach

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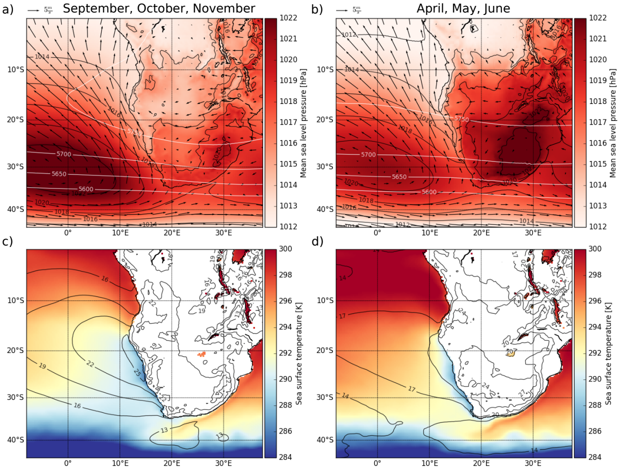
- Improve scientific understanding of the drivers of day-to-day variability of fog and low clouds in the Namib Desert.
- Analysis is done for two distinct FLC seasons: April, May, June (low-lying FLCs), and September, October, November (higher-level FLCs)
- Data basis: Satellite observations of FLCs from Andersen and Cermak (2018) and ERA5 reanalysis.

NAFOLICA

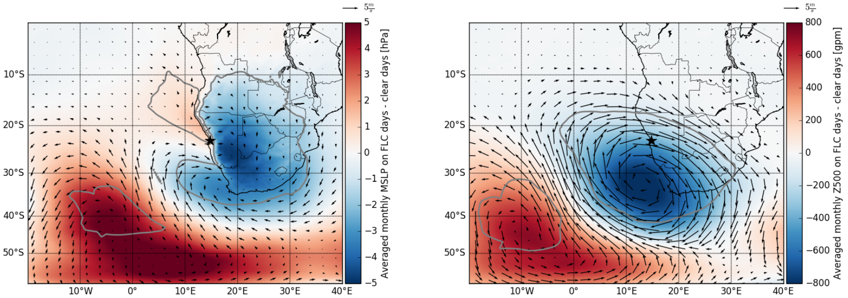
Image credits: Julia Fuchs

The seasonal large-scale setting



Top: 14-year average mean sea level surface pressure and 10m winds, bottom: SST and LTS. Andersen et al. 2020, ACP

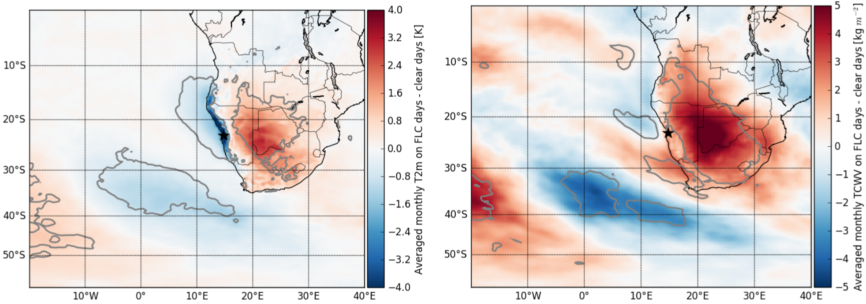
AMJ: comparison of meteo. FLC vs. clear days



Left: MSLP and 10m wind differences, right: Z500 and 500hPa wind differences; Andersen et al. 2020, ACP)

- Significant differences of atmospheric dynamics on FLC vs. clear days at synoptic scales
- Combination of synoptic-scale forcing (Z500) and heat low (MSLP) on FLC days

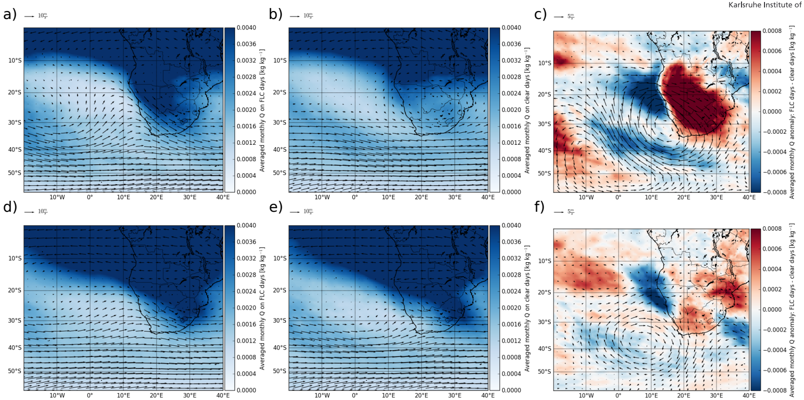
AMJ: comparison of meteo. FLC vs. clear days



Left: T2m differences, right: TCWV differences; Andersen et al. 2020, ACP

- Higher continental temperatures on FLC days
- T2m anomalies related to increased TCWV from large-scale moisture transport on FLC days (correlation of anomalies over land: 0.75)

Comparison: meteo. FLC vs. clear days



Winds, Q at 700hPa during AMJ (top) and SON (bottom) during FLC days (left), clear days (center) and differences (right); Andersen et al. 2020, ACP)

- Synoptic-scale disturbance → moisture transport during AMJ
- Dry anomaly in free-troposphere where FLCs form in both seasons

Comparison: meteo. on FLC and clear days

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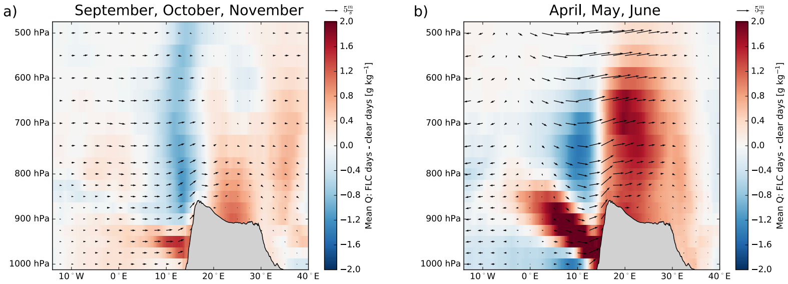
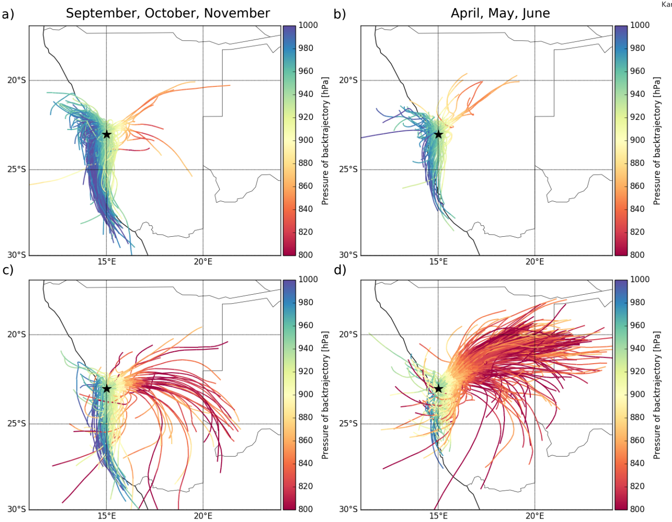


Differences on fog vs. clear days: winds, specific humidity (Q) at different levels; Andersen et al. 2020, ACP

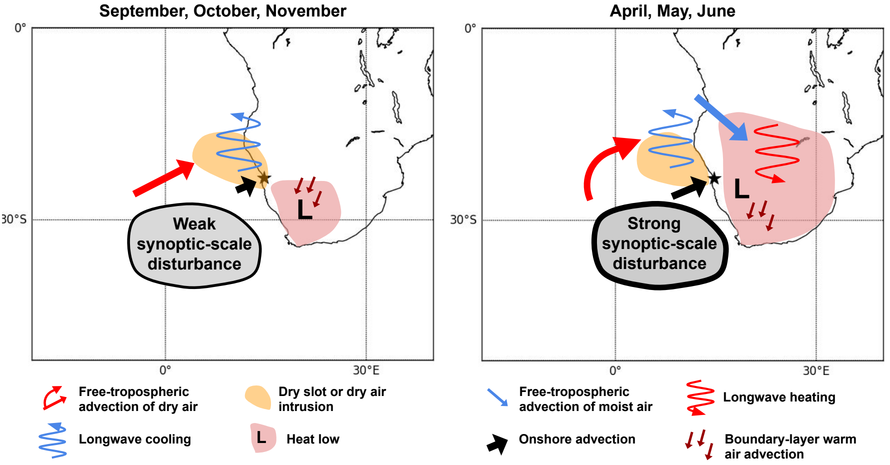
- Dry anomaly in free-troposphere overlies moist anomaly in marine boundary layer on FLC days
- Enhanced radiative cooling at cloud-top helps maintain FLCs
- Higher SSTs upwind suggest increased MBL moisture fluxes

Comparison of backtrajectories



Top: FLC days, bottom: clear days; Andersen et al. 2020, ACP

Concept: Seasonal synoptic-scale controls



Andersen et al. 2020, ACP

What have we learned... and what is next?

Conclusions

- FLCs are associated with advection of marine boundary-layer air.
- Synoptic-scale disturbances drive moisture transport, long wave radiative cooling(ocean)/warming(land) and control FLC variability.

Outlook

- Predict FLC occurrence and future changes with statistical models.
- Detailed-case studies based on field campaign.
- Link synoptic to local scales and models.

NaFoLiCA resources

- Satellite FLC-detection paper: `10.5194/amt-11-5461-2018`
- Spatiotemporal patterns paper: `10.5194/acp-19-4383-2019`
- Synoptic-scale controls paper: `10.5194/acp-20-3415-2020`
- IOP paper: `10.1175/bams-d-18-0142.1`