ATMOSPHERIC BOUNDARY LAYER, STAGNATION EVENTS AND PARTICULAR MATTER CONNECTIONS OVER THE ATACAMA DESERT

Damián Oyarzún

Chris Brierley

Environmental Change Research Centre (ECRC), Department of Geography

University College London (UCL)

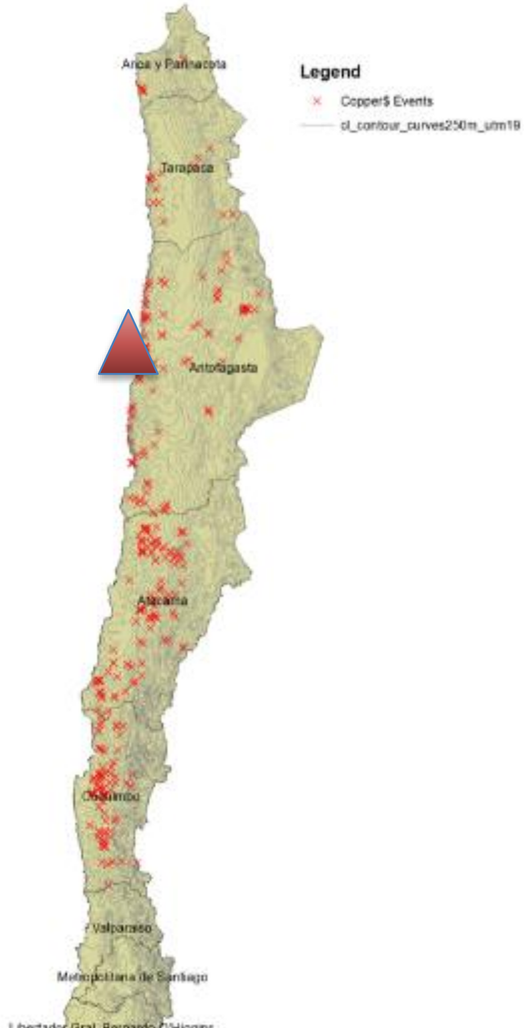
d.oyarzun@ucl.ac.uk

2nd July 2019

Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

Radiosonde
Antofagasta (30 Lat S)
1973-2018
12 UTM – 8:00 local time



(Oyarzun et al, 2019. In prep)

Motivation

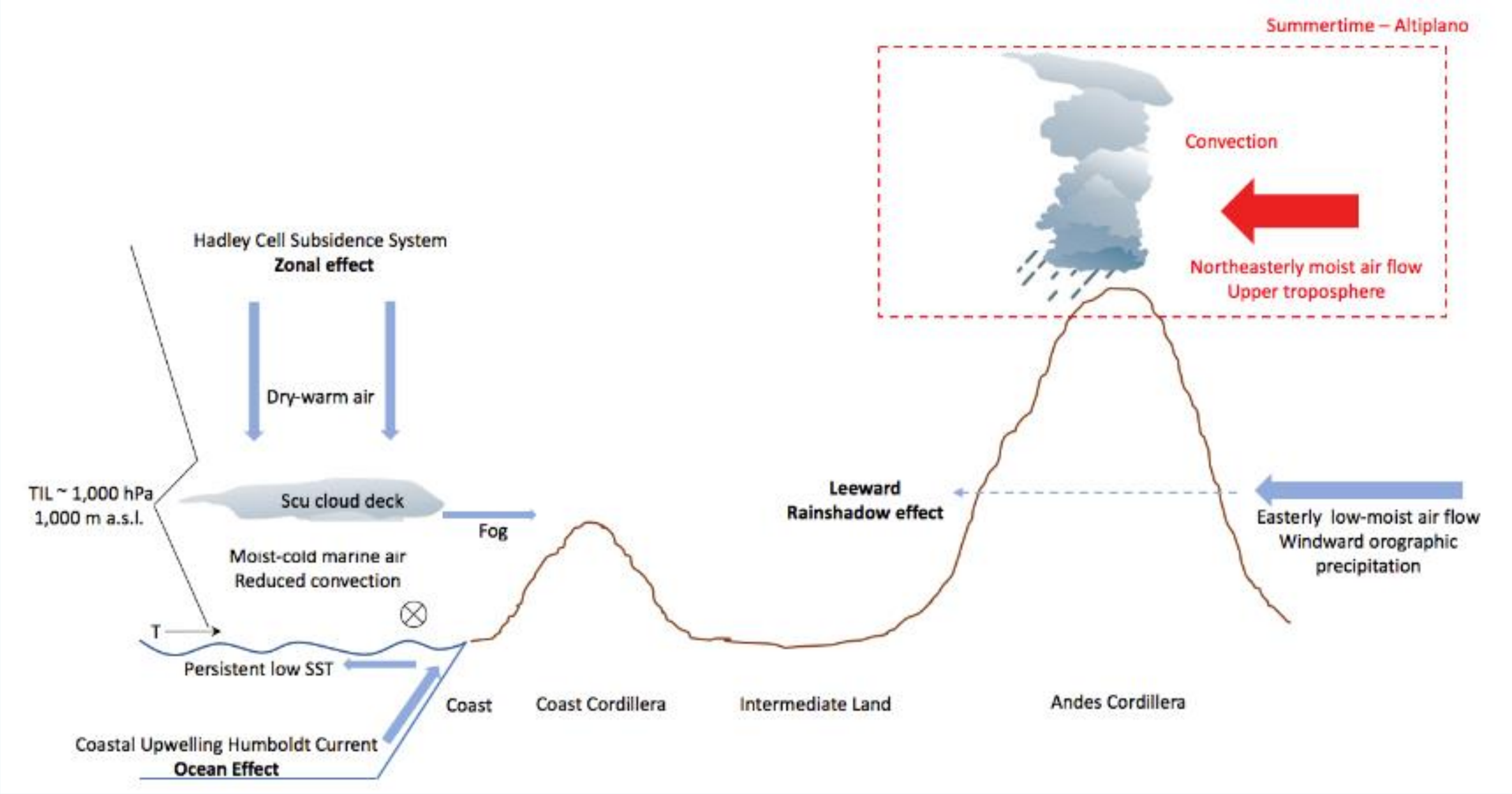
The Atacama Desert is the driest desert in the world. It's characterised by extremely arid conditions partially governed by a persistent Temperature Inversion Layer (TIL), the Humboldt coastal upwelling and the Andes Cordillera rainshadow effect. The Antofagasta Region presents high levels of PM10-2.5 which have been associated with natural sources (e.g. mineral dust), and significant anthropogenic emissions from the mining and power generation industries.

This study aims to identify the relationship between atmospheric stagnation-ventilation and PM10-2.5 levels recorded in the Atacama Desert.

Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

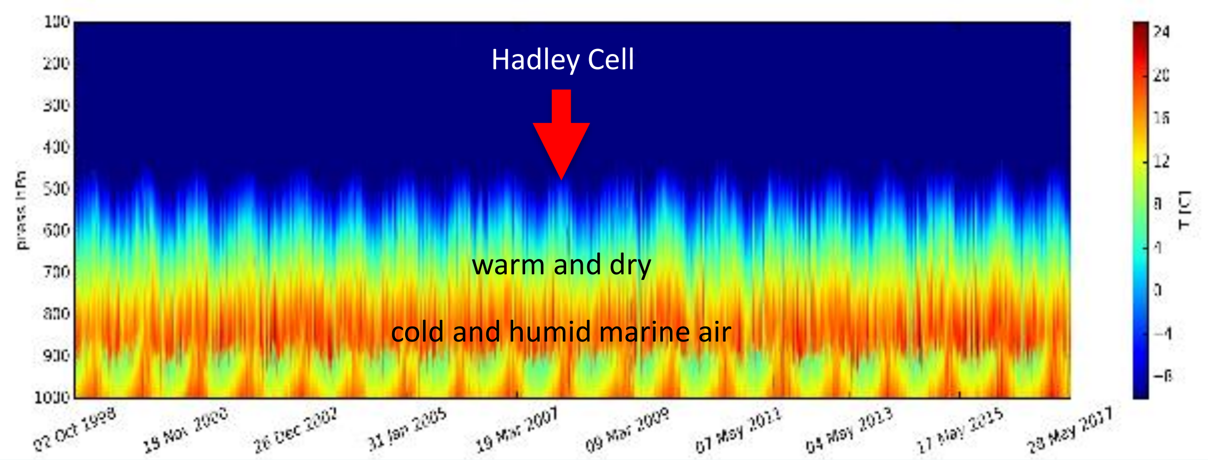
Climate Dynamics – Atacama Desert

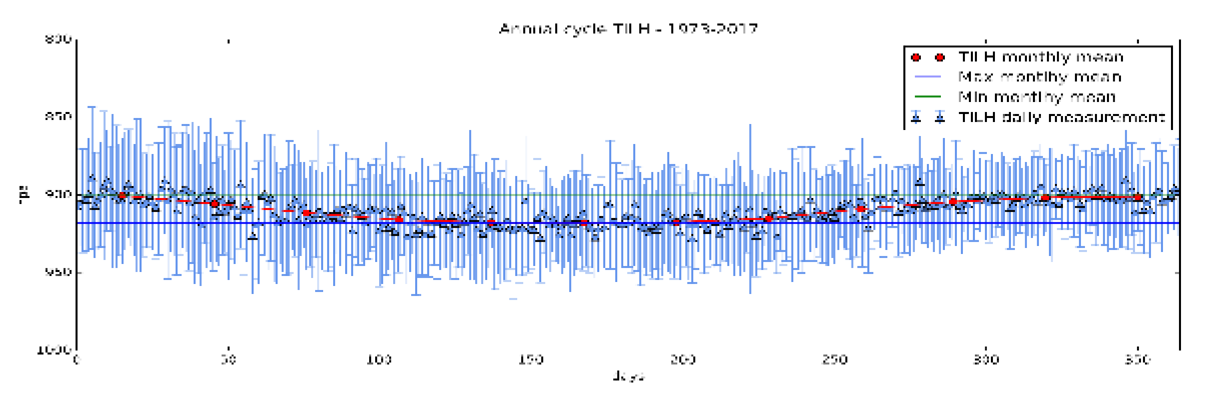


(Oyarzun et al, 2019. In prep)

Temperature Inversion Layer

Antofagasta (30S) radiosonde1973-2018 – 12 UTM – 8:00 LT



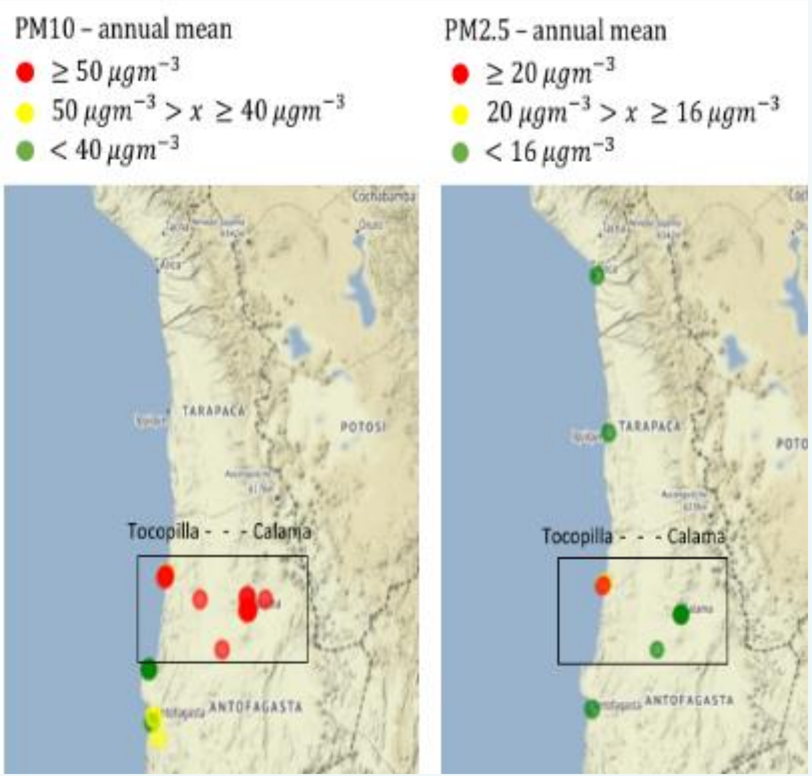


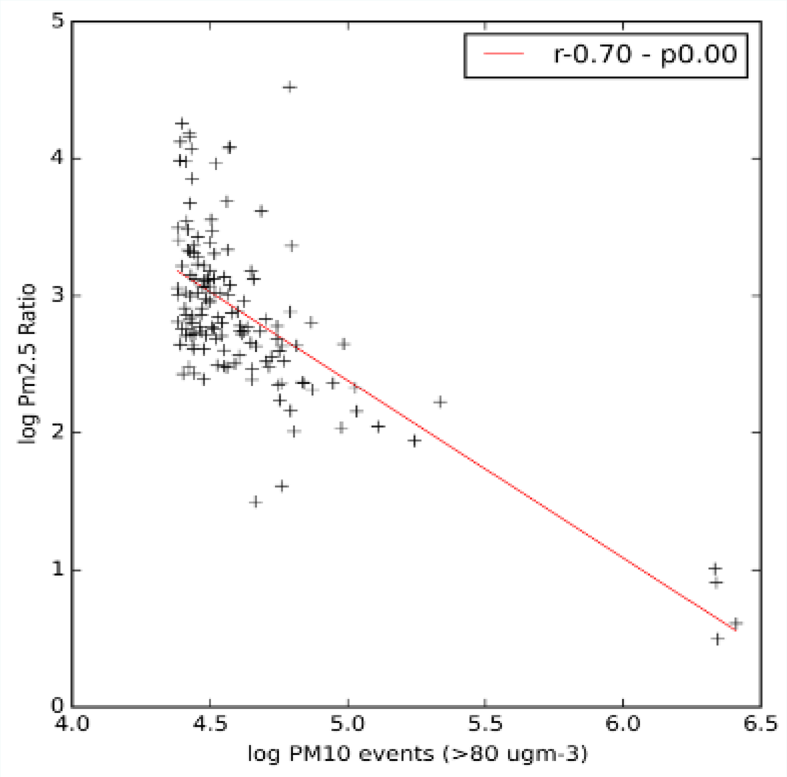
(Oyarzun et al, 2019. In prep)

Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

Air Quality _ SINCA Network





In both coastal and desert (inland) sites, PM10 events are consistently dominated by the coarse fraction.

(Oyarzun et al, 2019. In prep)

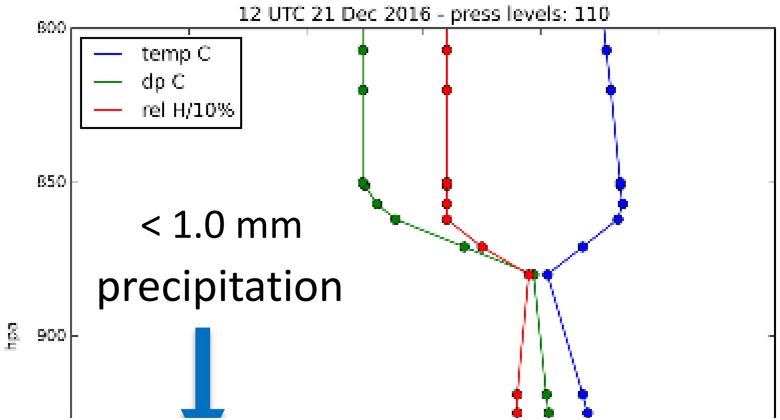
Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

Air Stagnation Index (ASI)

Wang and Angell (1999) thresholds – daily basis – 4 consecutive days

500 hPa ws → < 13.0 m/s

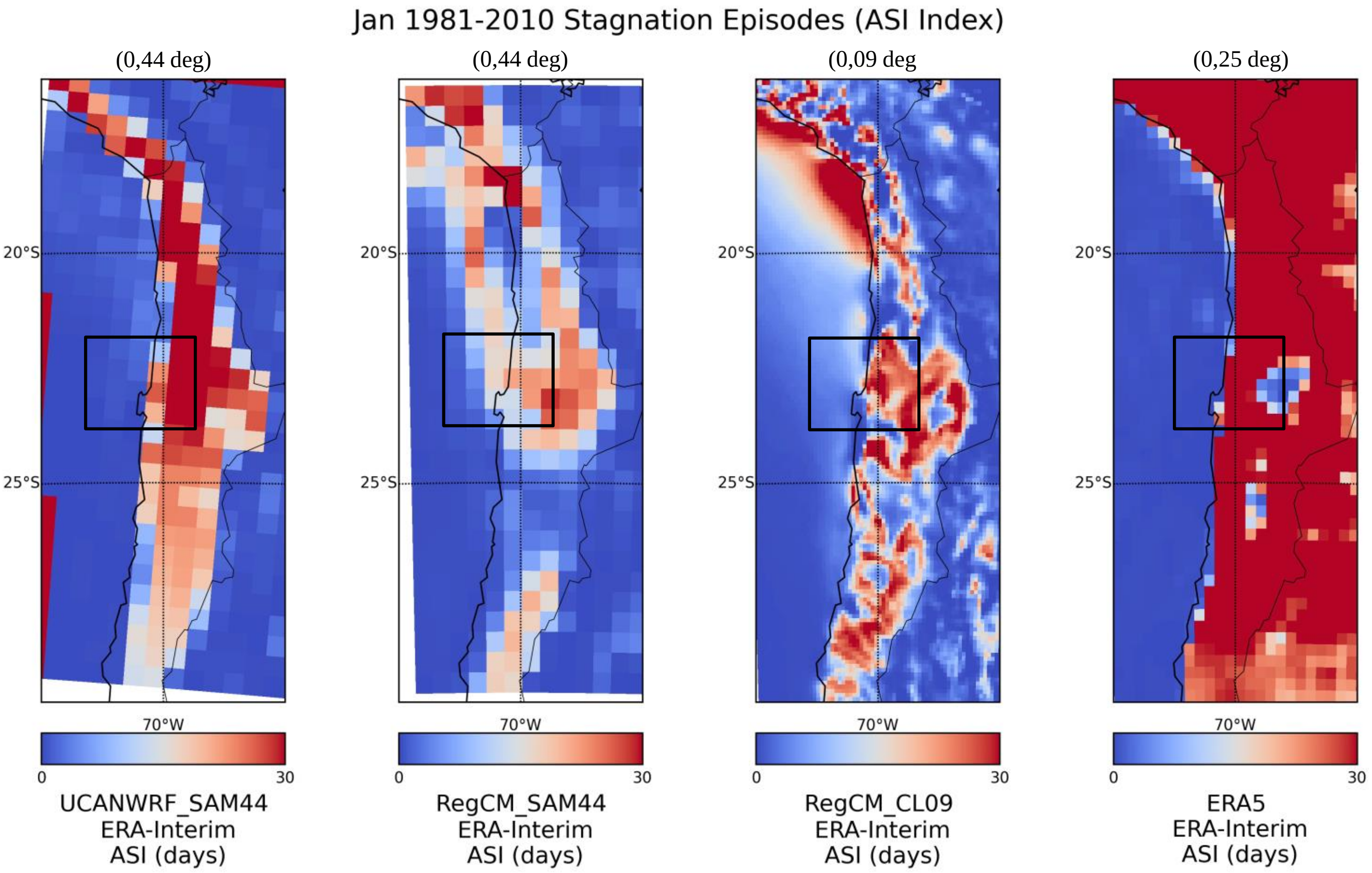


< 1.0 mm precipitation

Dataset	Horizontal Res	Ref
UCANWRF 341I SAM44 ERA-Interim	0.44	CORDEX - Manzanas et al., 2018
RegCM4 SAM44 ERA-Interim	0.44	CR2 - Bozkurt, 2018
RegCM4 09CL ERA-Interim	0.09	CR2 - Bozkurt, 2018
ERA5 reanalysis	0.25	Copernicus Climate Change Service (C3S) (2017)

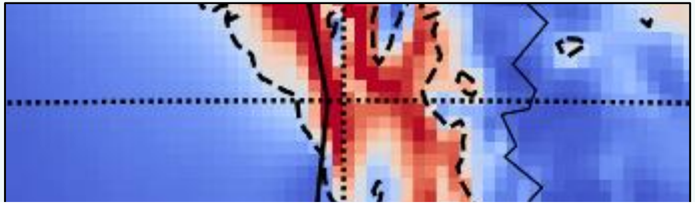
(Oyarzun et al, 2019. In prep)

ASI Index (1981-2011)

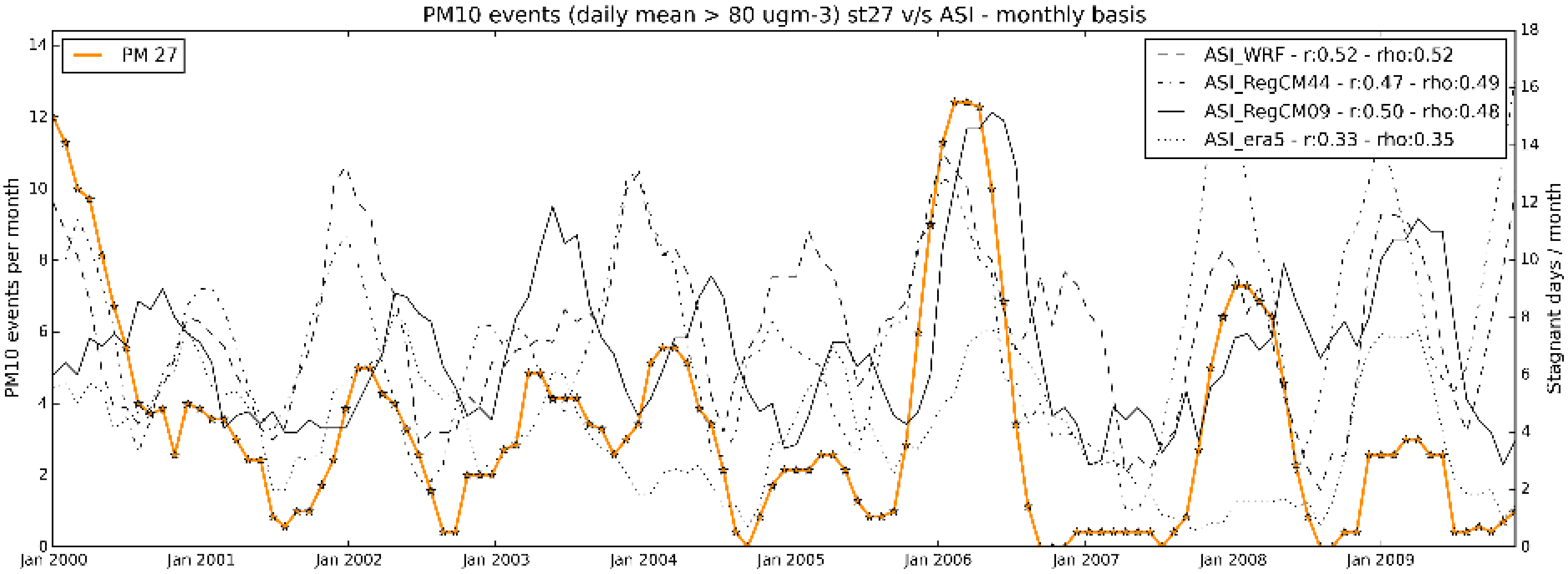


(Oyarzun et al, 2019. In prep)

ASI Index (1981-2011 – ERA-Interim reanalysis)



- Binary index
- Time scale
- Mixing layer not considered
- Focused on pollution events



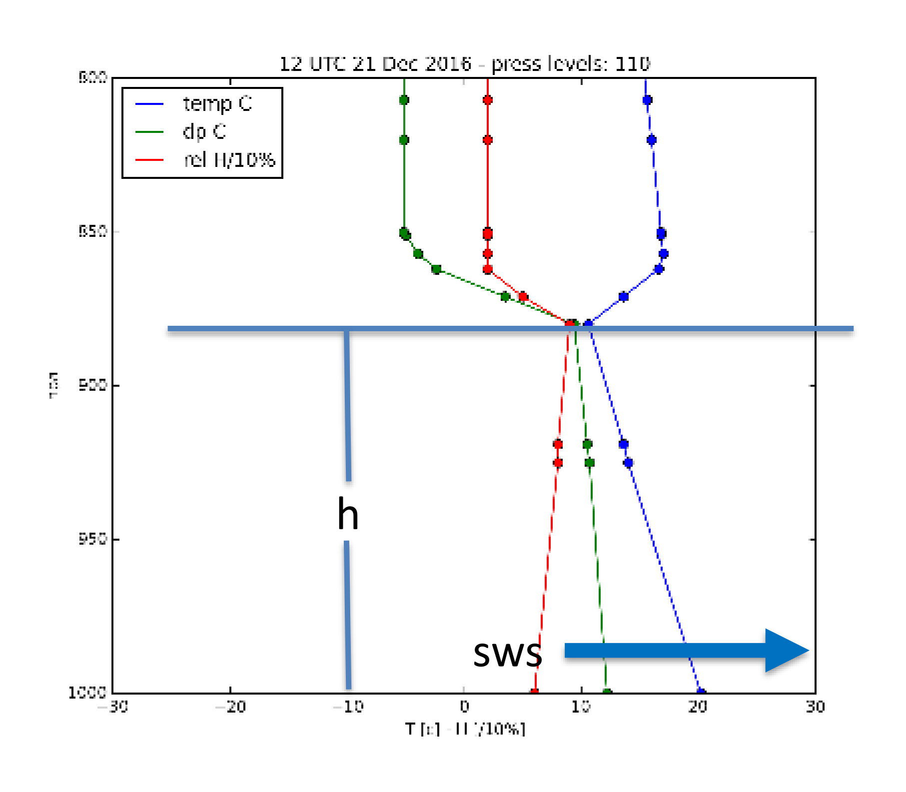
(Oyarzun et al, 2019. In prep)

Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

Ventilation Coefficient

Kassomenos et al. (1995) - daily basis

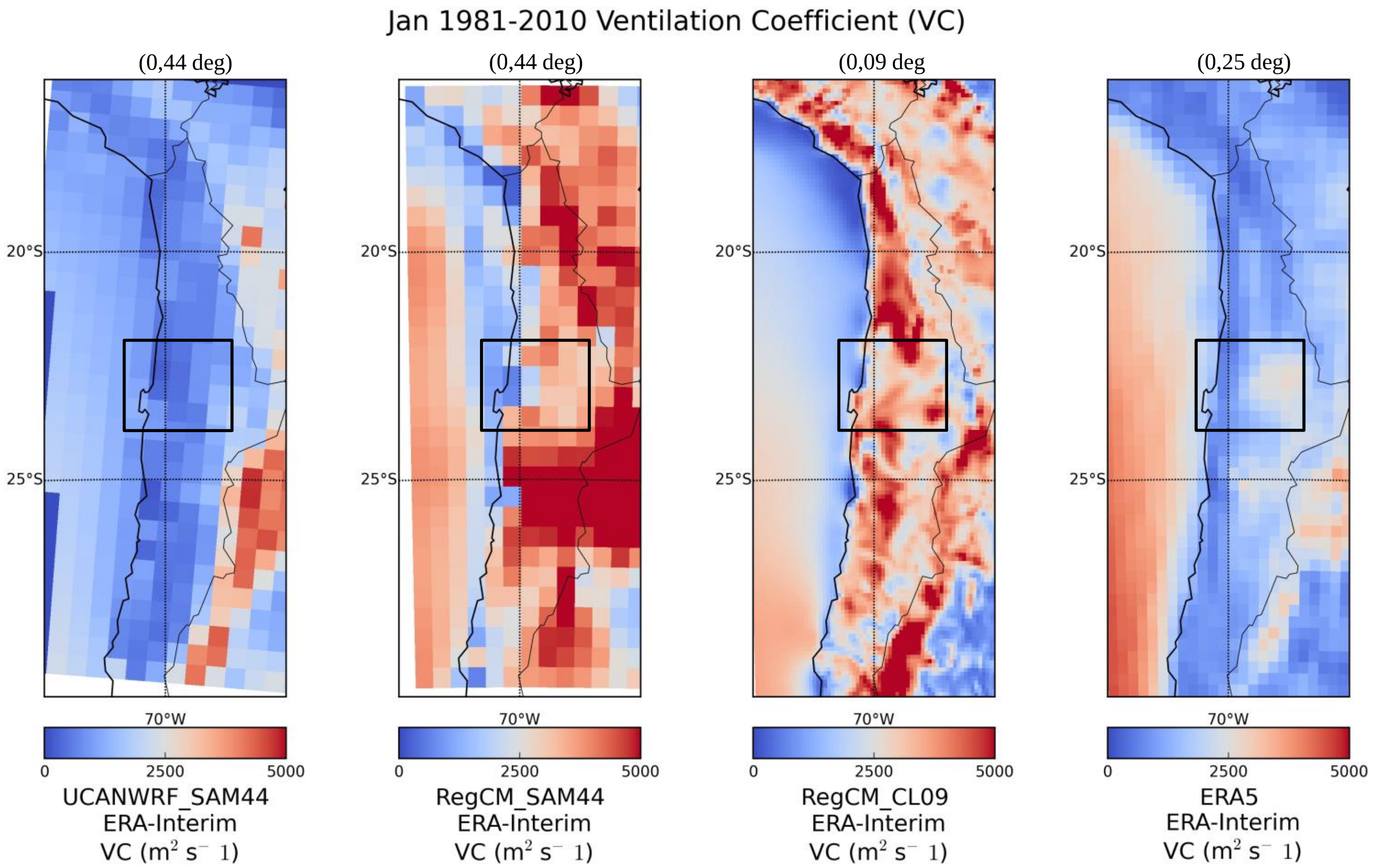


T inversion

VC = BLH x sws

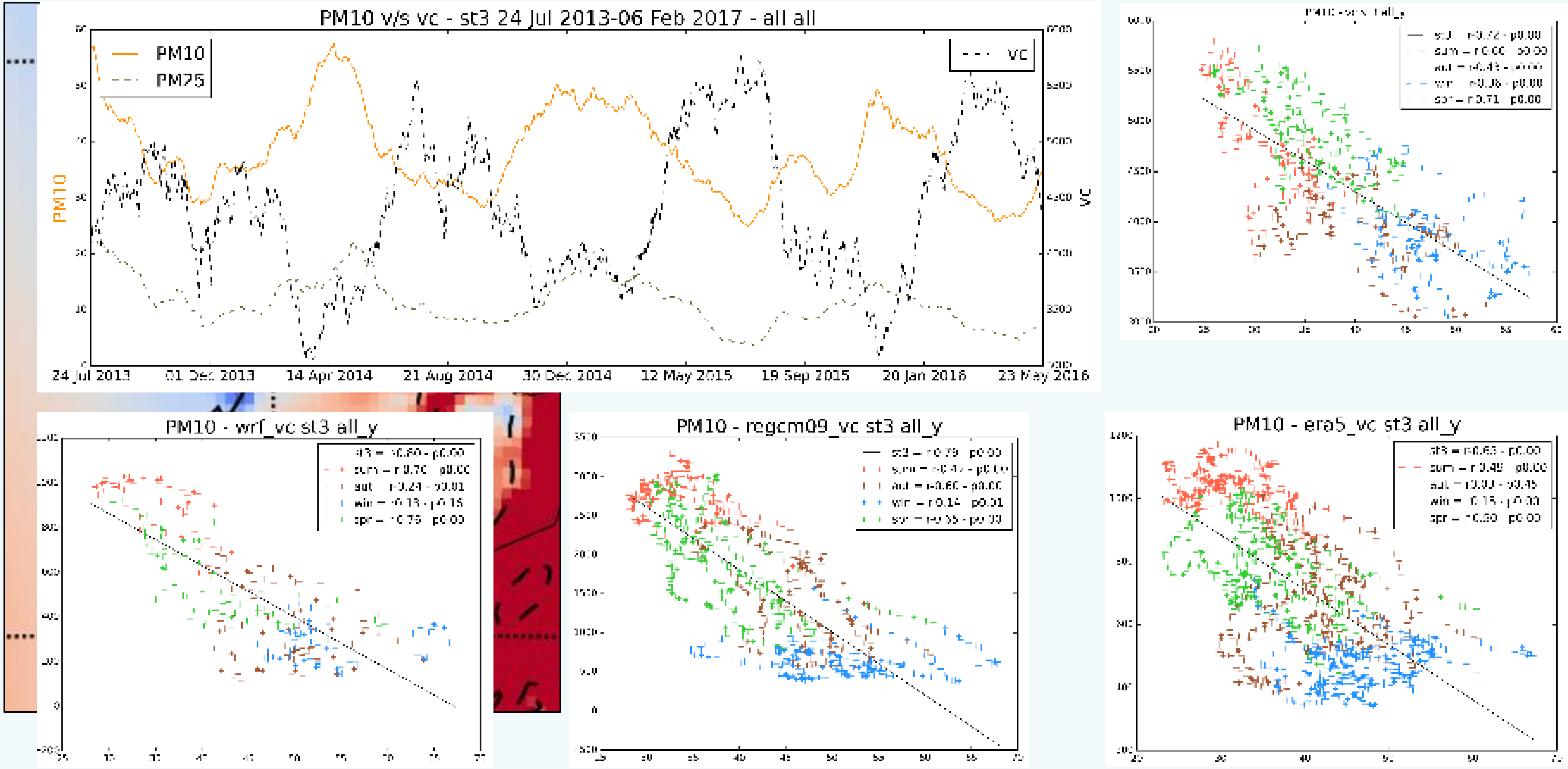
(Oyarzun et al, 2019. In prep)

Ventilation Coefficient



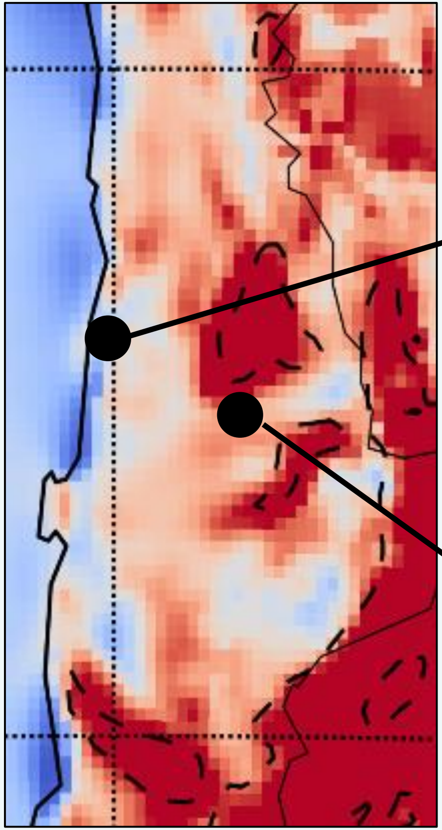
(Oyarzun et al, 2019. In prep)

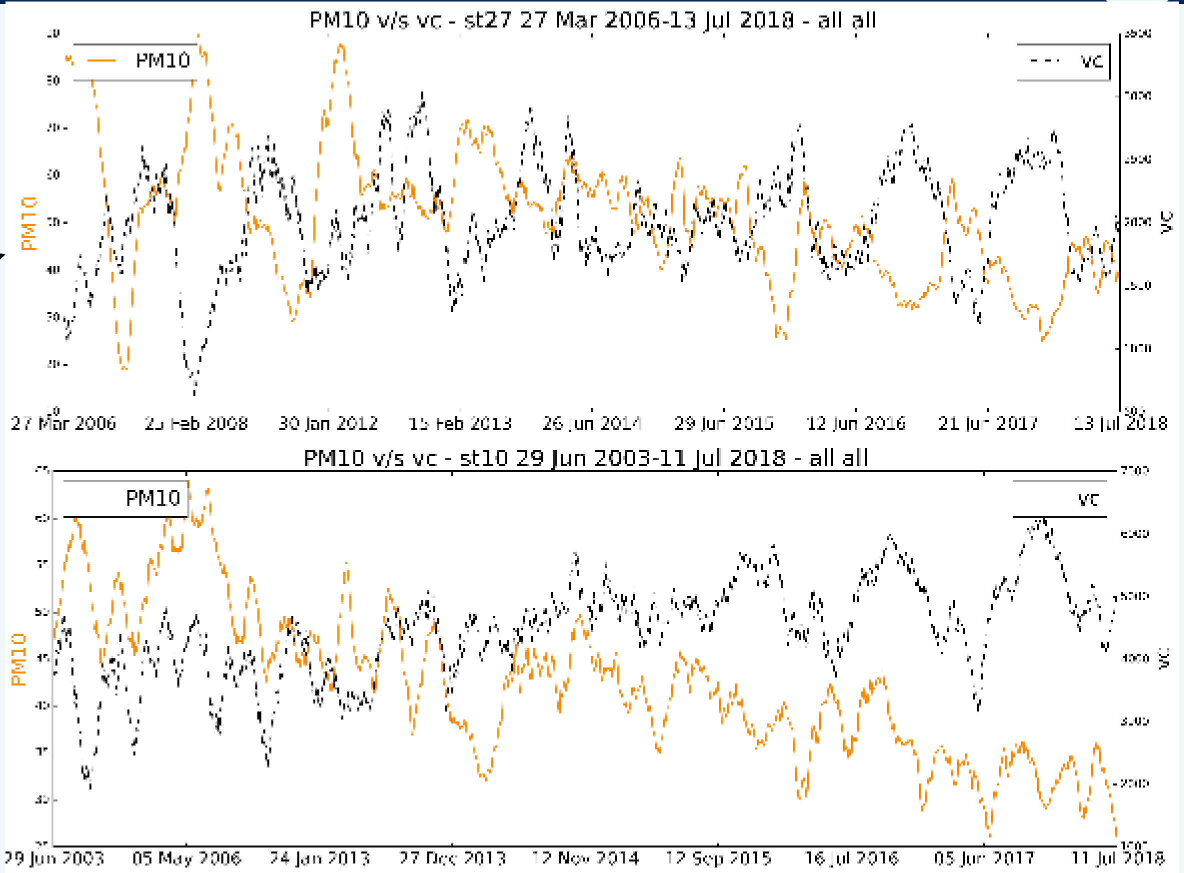
Ventilation Coefficient



(Oyarzun et al, 2019. In prep)

Ventilation Coefficient





- In both coastal and inland sites observed and simulated VC contribute to PM10 variability
- Short PM timeseries

(Oyarzun et al, 2019. In prep)

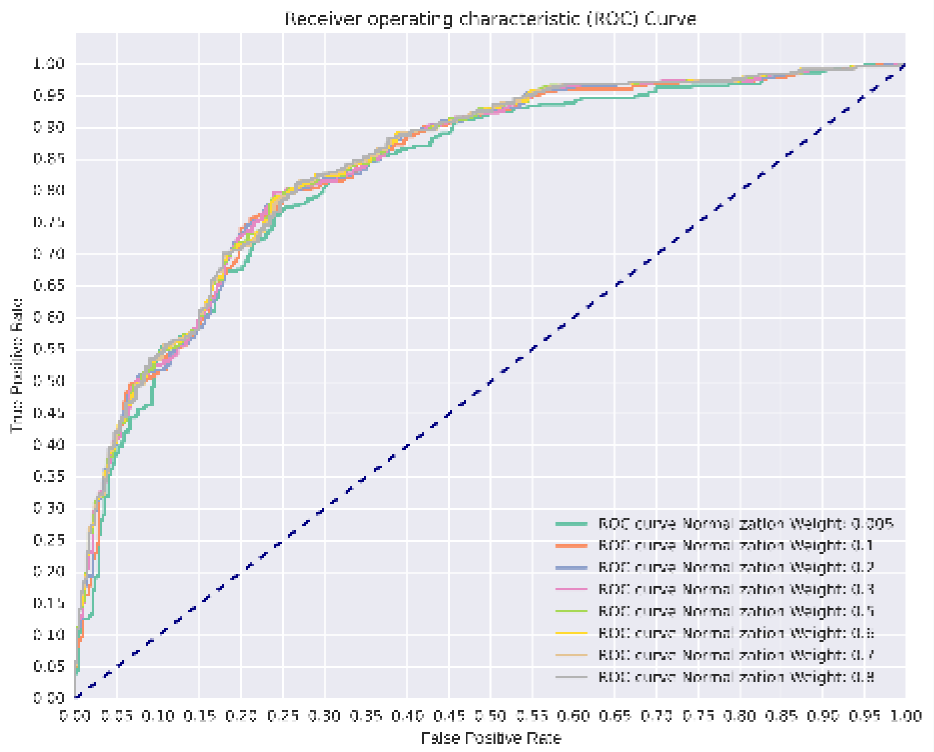
Logistic Model – PM Events

VC was identified as a significant parameter (-) associated to PM10 events in logistic models (ROC curve computed from test datasets).

AUC-ROC = 0.82

p75: 46 ug/m3 - Data 2182 days -EVENTS: 546

Id	Feat	Coef
0	vc	-2.73383
1	stg	0.338754
2	wdir_E	0.472314
3	wdir_S	-0.21643
4	wdir_W	0.2618
5	day_w	0.436042
6	day_wend	0.081645
7	seas_djf	-1.25656
8	seas_jja	1.489253
9	seas_mam	0.453177
10	seas_son	-0.16819



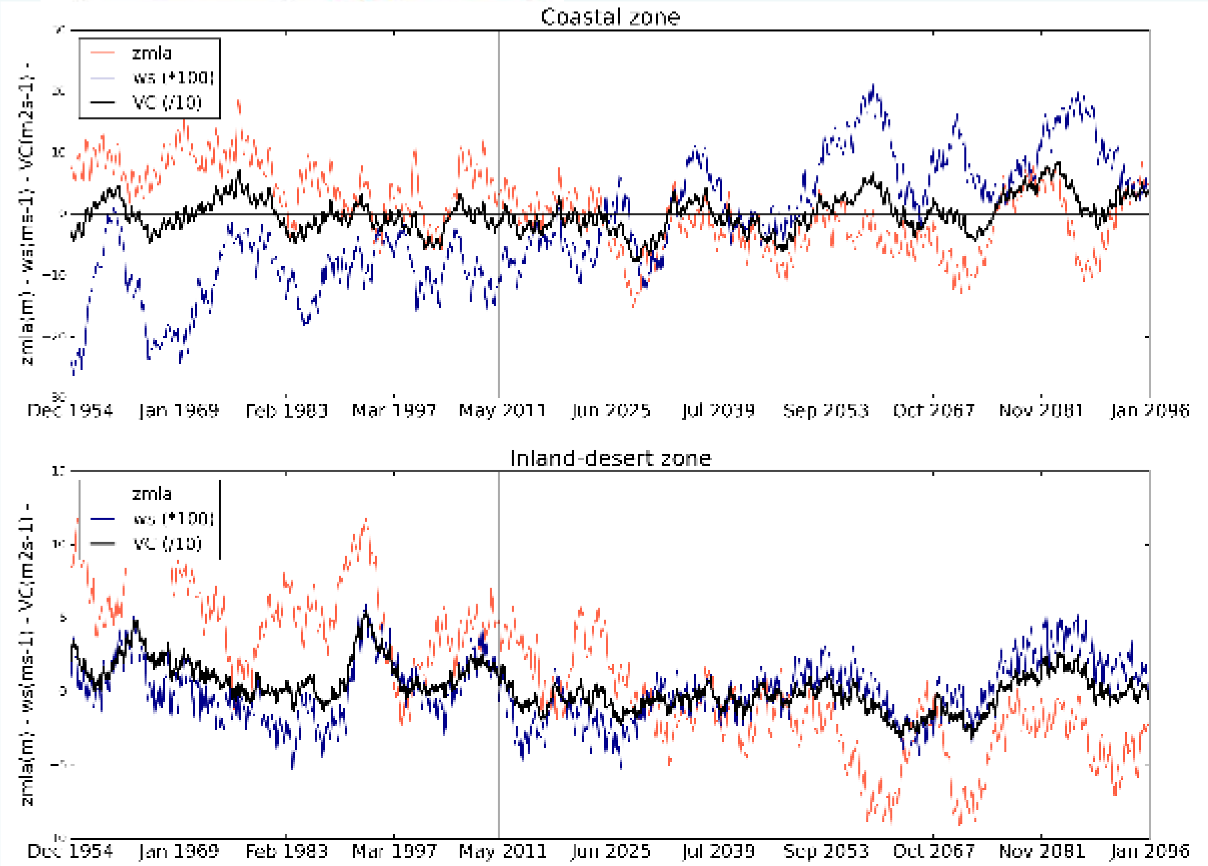
(Oyarzun et al, 2019. In prep)

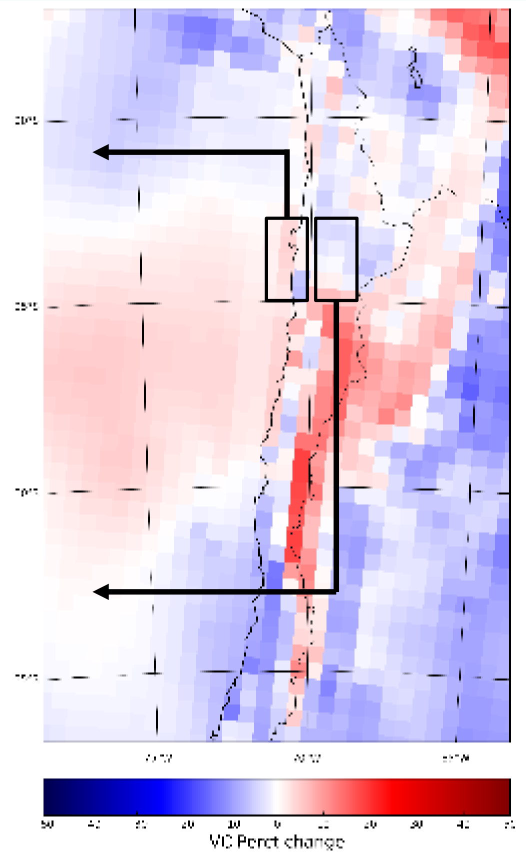
Outline

- The Atacama Desert - Motivation
- Climate dynamics in Northern Chile
- Air pollution in Northern Chile
- Atmospheric Stagnation and PM events
- Atmospheric ventilation and PM variability
- Atmospheric Ventilation: Climate change signal
- Conclusions

ASI Index (WRF - Climate Change Signal)

UCAN – WRF341I 0.4 RCP4.5 (2071-2100) - Historical (1971-2000)





(Oyarzun et al, 2019. In prep)

Conclusions

- Quasi-permanent Temperature Inversion layer. Stagnant episodes are highly frequent, especially in summer.

- Despite significant anthropogenic emissions, ventilation and TILH contributes to both PM10-2.5 levels and PM10 events at synoptic scale in both coastal and inland sites. Stronger relationships in coastal areas.

- UCANWRF simulations suggest an opposite response of surface wind speed in coastal and inland zones over the 21st Century (RCP45 scenario). Uncertain PM response and source contribution (natural-anthropogenic). Also, there are limitations regarding time-series length from SINCA monitoring records.

- The highly complex topography contribute to the uncertainty in simulations. Therefore, simulating climatologies at finer resolution is strongly suggested. A dynamical approach (RCM-CTM) is proposed to explore the contribution of ventilation to PM levels and sources contribution.

- Policy implications.

Thank you!

Any questions?

Damián Oyarzún V.
ECRC
UCL Geography
d.oyarzun@ucl.ac.uk @damianoyarzun

Acknowledgement: this work is partially supported by the National Commission for Scientific and Technological Research of Chile (CONICYT)