Earth – Evolution
at the dry limit

"A new network of meteo stations in the Atacama,

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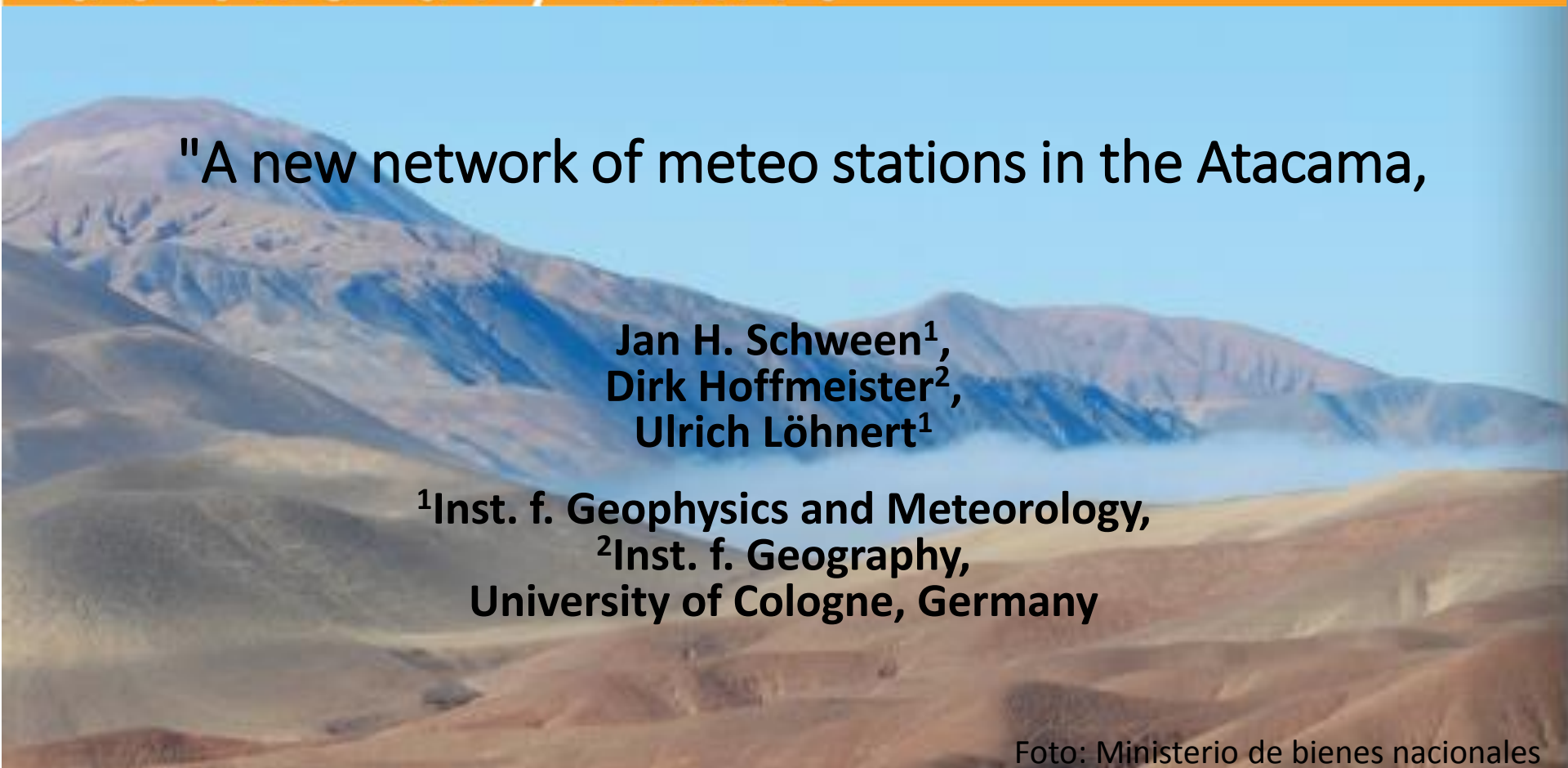
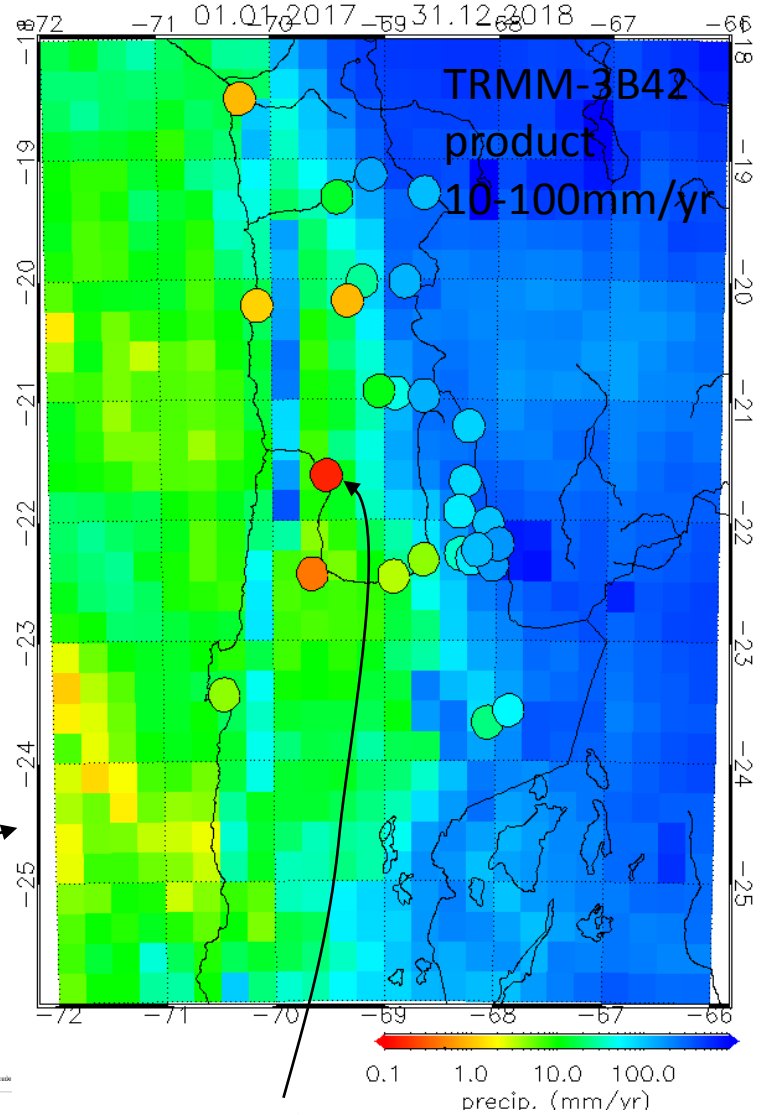
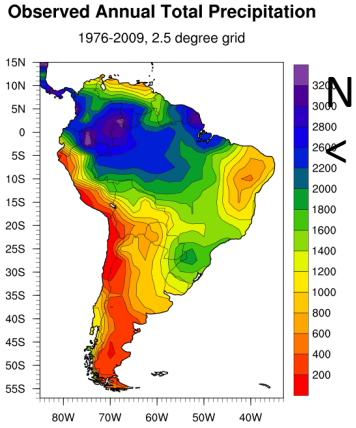


Foto: Ministerio de bienes nacionales

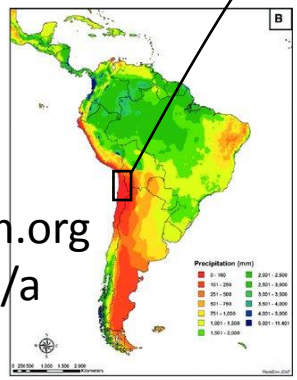
Motivation

- The *Atacama is the driest place on earth* with in some places no precipitation for years
- Observations are sparse
- Models and databases disagree on precipitation
- Satellite products overestimate precipitation by 1-2 orders of Magnitude
- Fog is in many places the main water source

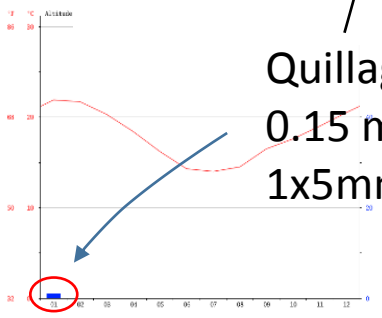




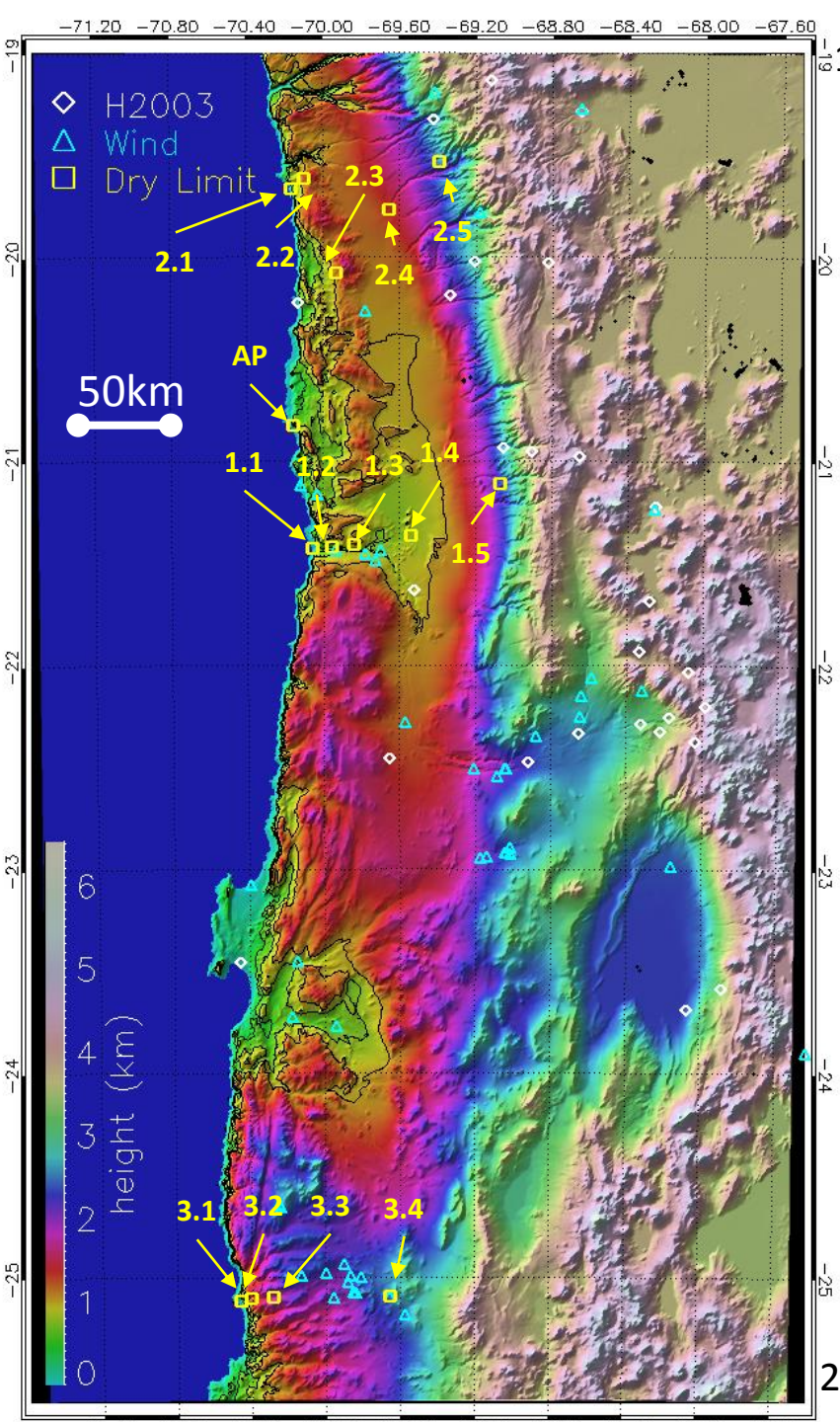
NOAA PSD
< 200mm/a



Worldclim.org
< 100mm/a



Quillagua
0.15 mm/a
1x5mm/37a



19°S

25.5°S

The network

Three transects with 5(4) stations:

- one station close to the coast
- one station at around 2300m AMSL
- stations are numbered from W to E.
- one ‚Master' per transect.

Transect 1 (21.5°S)

- along lower Rio Loa:
  corridor for humid air from the pacific
  (Cereceda et al 2008).

Transect 2 (19.7°S)

- gypsum desert in the northern coastal range and the alluvial fan along Quebrada Aroma.

Transect 3 (25°S)

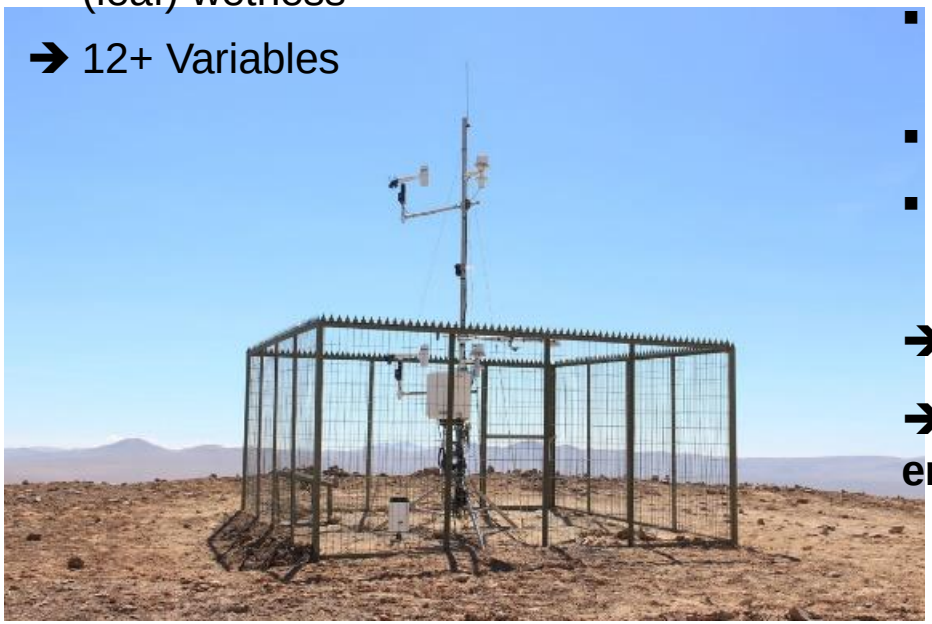
- Gradient from ‚humid' Paposo to inland

Instrumentation

Every station

- wind speed (v) and direction (dir) (2.5m)
- air temperature (Ta) and relative humidity (rH)
- pressure (P), precipitation (prec),
- solar radiation (SW dn+up)
- surface temperature (Ts)
- soil temperature (Tg, 5cm)
- soil water content (SWC, 5cm)
- (leaf) wetness

➔ 12+ Variables



Master stations *additionally* measure

- second level (4m) of v, dir, Ta and rH
- four components of radiation budget (SW dn+up, LW dn+up)
- ground heat flux (G, 5cm)
- 4 additional levels of Tg and SWC (10-40cm)

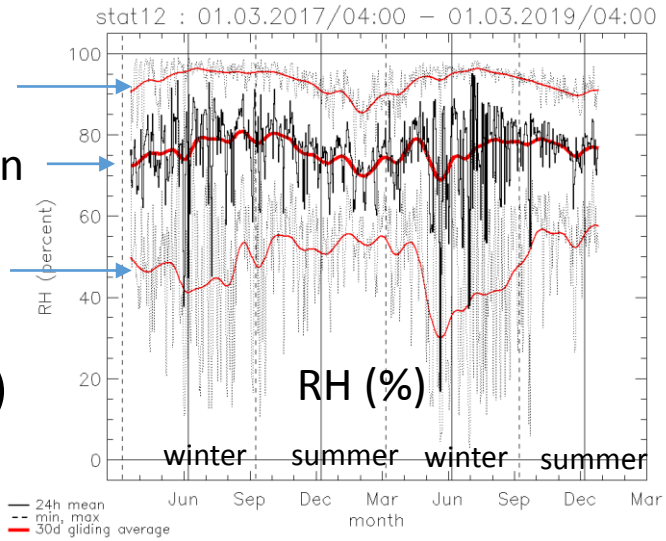
➔ 29+ Variables

➔ Parameters allow calculation of **energy budget** and **turbulent fluxes**

Seasonal course of humidity

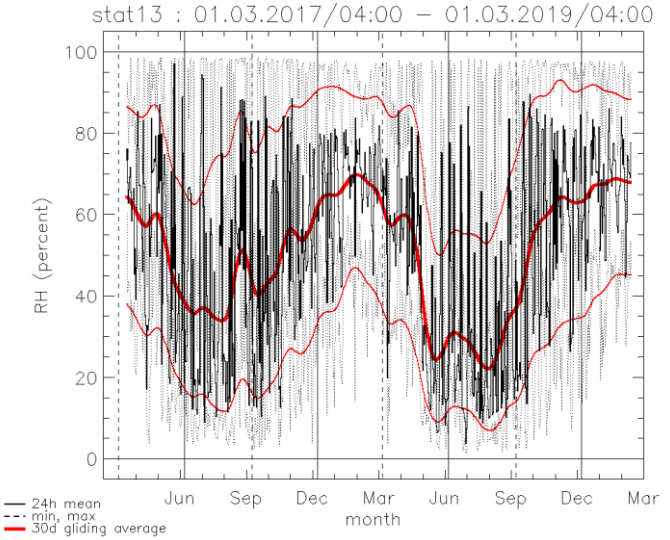
Stat.12

10km from coast, 771mASL

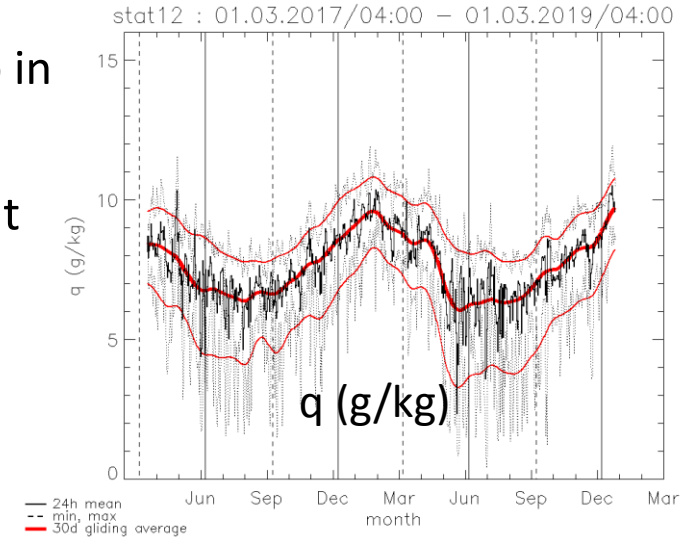


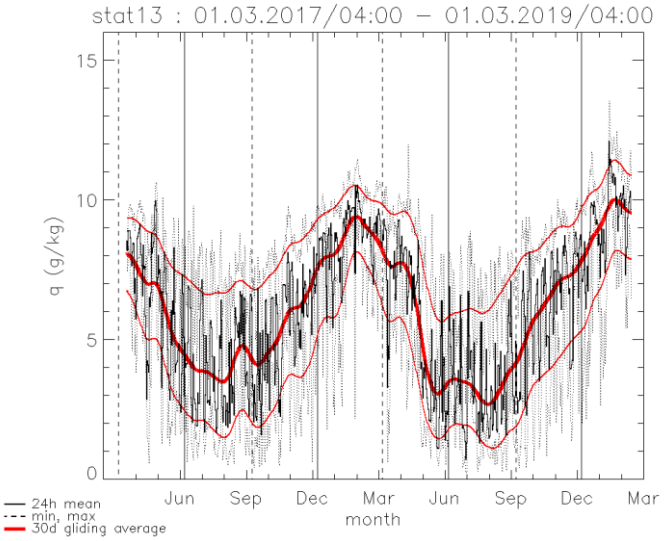
Stat.13

20km from coast, 1152mASL



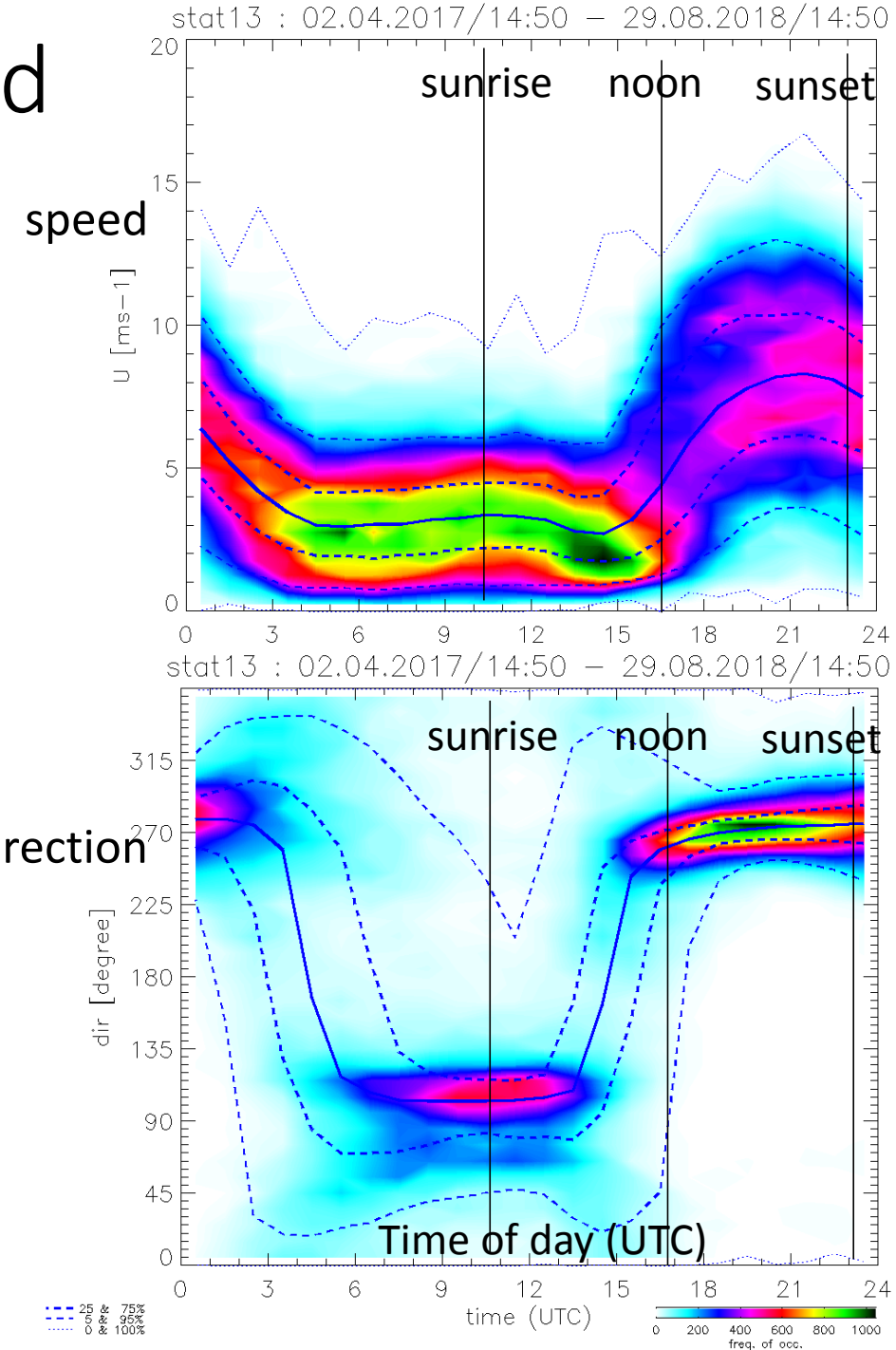
- Relative humidity (RH) higher close to coast (height of BL)
- Variability higher in Winter (more fog)
- RH more variable at Stat13 (mountain top in cloud)
- Specific humidity (q) higher at Stat 12 – but only in winter





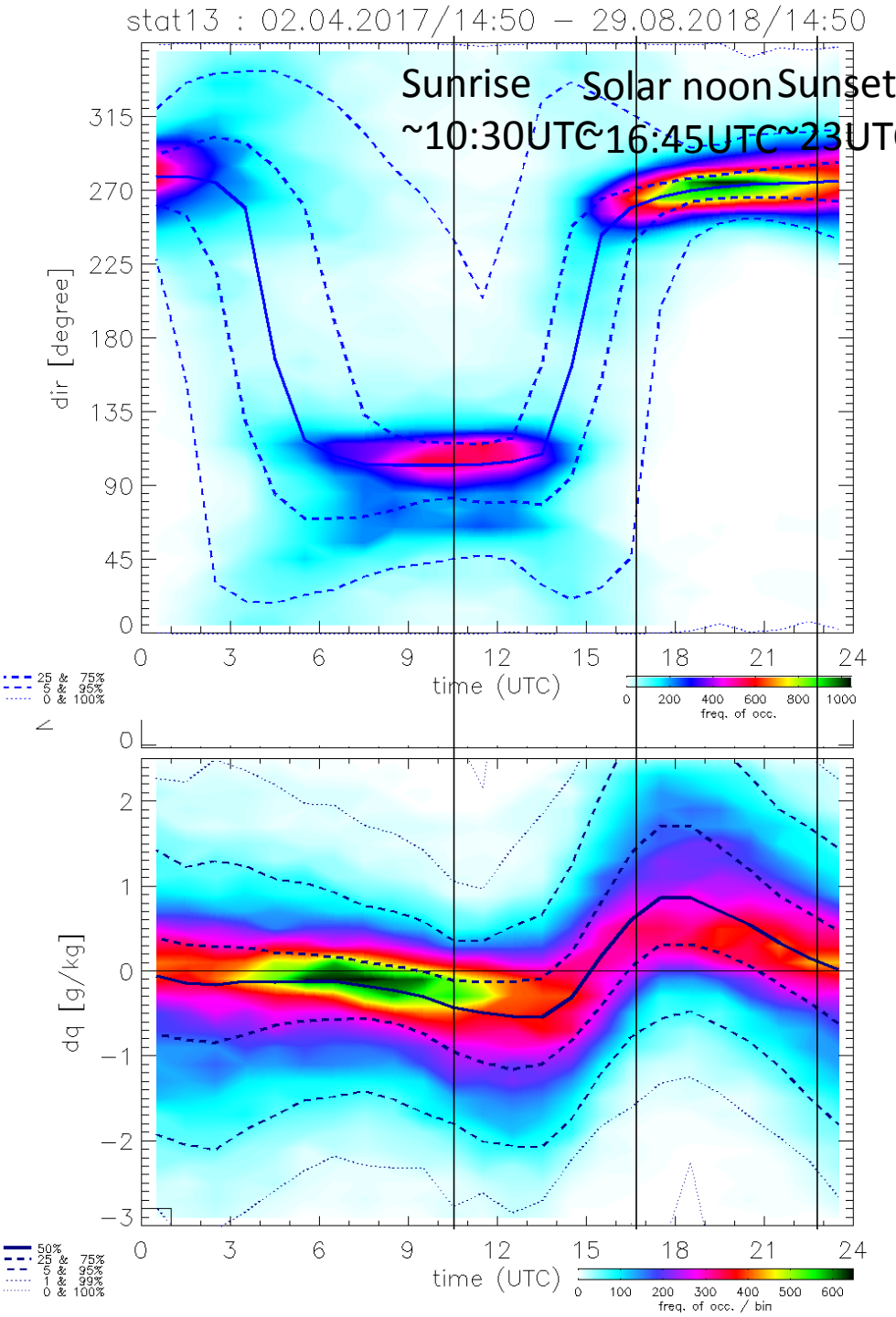
Diurnal course of wind

- Very regular pattern
- Similar at all inland stations
- Night - noon: low speeds from east (Andes)
- Noon - evening: high speeds from west (sea)



Wind and Humidity over the day

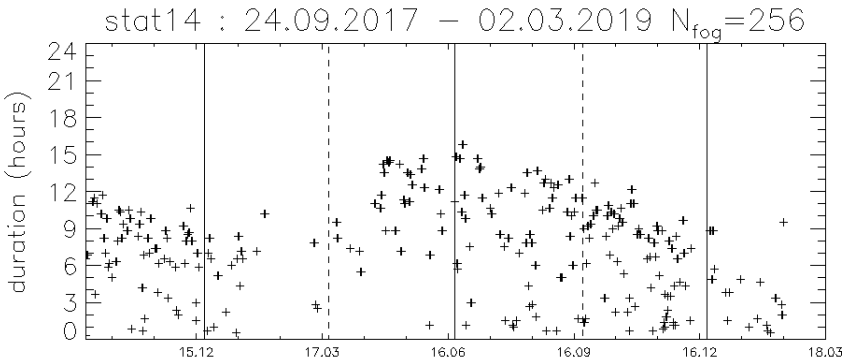
- => dry air from the desert to the ocean
- => moist air from the ocean into the desert
- Similar at all inland stations, except 15, 25, 34 (Andes slope)
- Where does the moisture go ?
- 3 options:
  1. Into desert as fog or dew
  2. To the Altiplano
  3. To middle troposphere
- Estimate of option 1 gives
  0.2mm/day
  as average over the year
  in central valley
- Compare to 0.15mm/year at Quillagua !



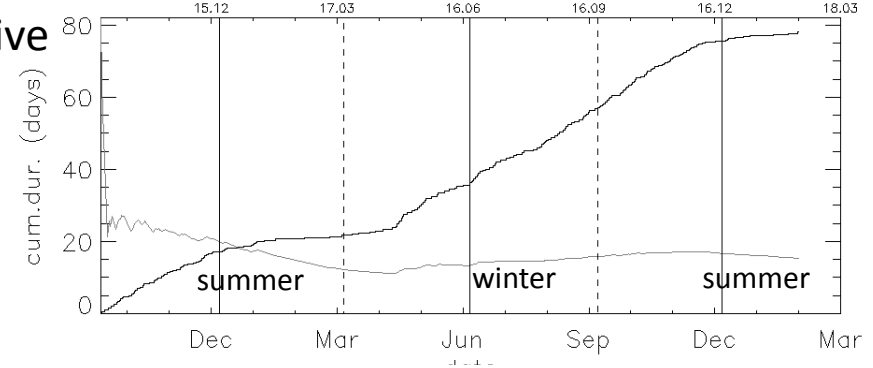
Fog

- Fog mostly in winter not in summer
- Always beginning in the night
- Beginning with west wind (from the ocean)
- Then Turning to easterly (from the desert)
- Sometimes lasting till noon
- 256 cases/524 days = 1/2days
- Fog during 15% of the time

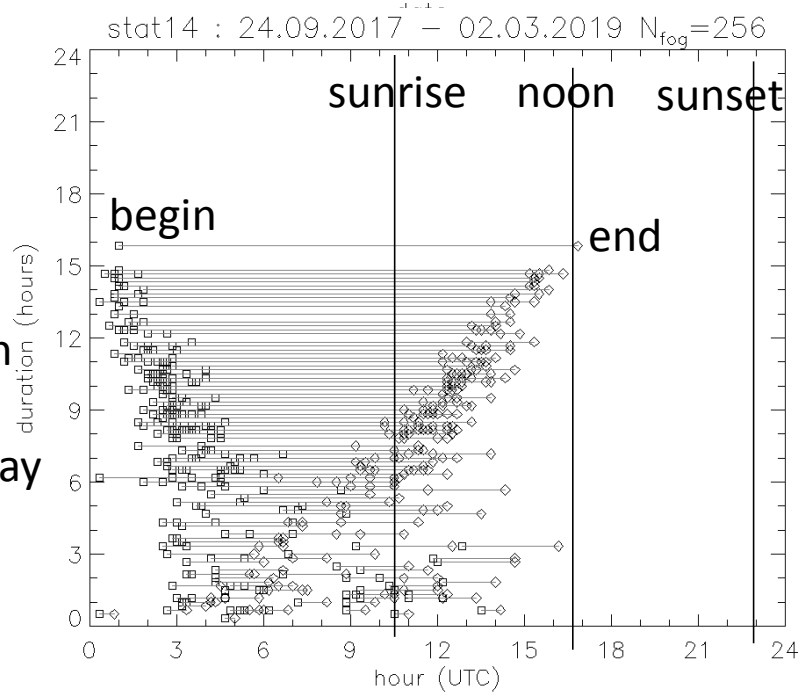
Duration (hours)



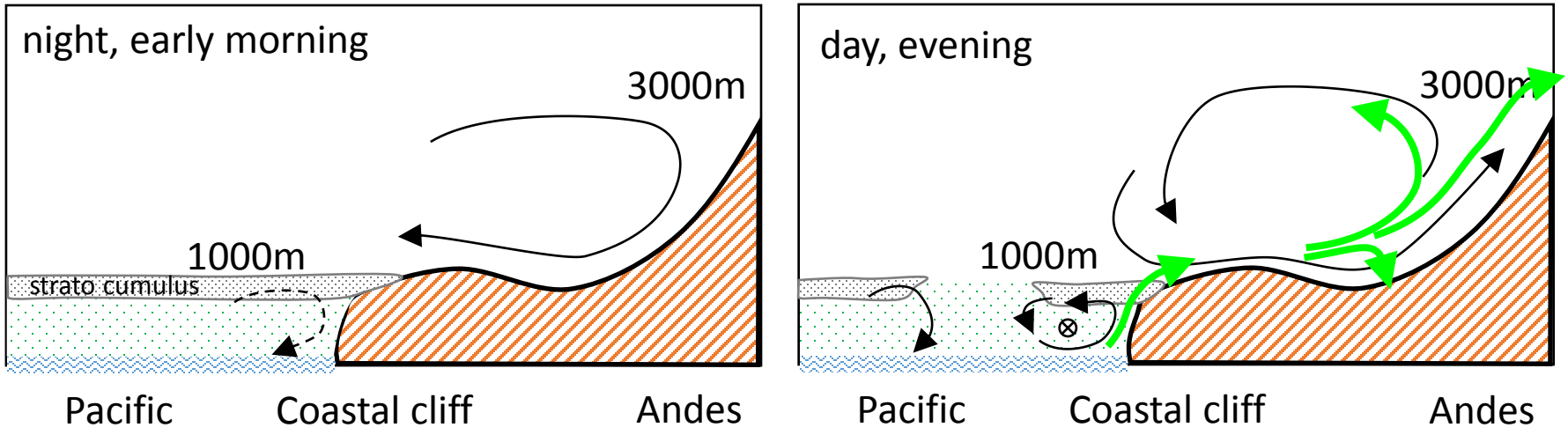
Cumulative Duration (days)



Duration Vs Hour of day



General circulation



- Night, early morning:
  - Down slope winds at the Andes and at the coast
- Day, evening:
  - Upslope winds
  - Injection of moist, aerosol rich air from pacific into desert and further transport to
    - Desert (fog or dew deposition)
    - Middle troposphere
    - or Altiplano
- Derived from data of Meteo stations and remote sensing of wind profile at the coast at Iquique in agreement with Rutlland et al 2003 (JGR 108/D17)

Summary

- We installed a network of 15 climate stations in the Atacama desert
- Organized in 3 transects from the coast to ~2400m AMSL
- Equipped with standard meteorology (wind, Temp. humidity) but also radiation sensors, soil temp and moisture
- Master station equipped for flux estimation
- First results:
  - Wind system dominated by Andes: from noon to evening to the mountains, from night to noon from the mountains
  - Wind transports moisture towards (in ?) the desert
  - During half of the nights fog in the coastal range
  - Fog during 15% of the time and 1/2days

Data available via data base website of SFB:
https://www.crc1211db.uni-koeln.de
(CSV-ASCII)
Netcdf in preparation

Weather Data

...ma desert, which were installed by the
...e Andes each consisting of four to five

...cama desert, Chile. CRC1211 Database

Weather Stations

ID	Type	Name	Startdate	Transect
11	basis	Caleta Loa	2017-10-01	center
12	basis	Rio Loa	2017-09-10	center
13	master	Cerros de Calate	2017-03-01	center
14	basis	Salar de Llamara	2017-09-22	center
15	basis	Quebrada de Mani	2017-09-25	center
20	basis	Alto Patache	2018-03-05	north
21	basis	Caleta Junin	2018-03-06	north
22	basis	Cerro San Antonio	2018-03-09	north
23	master	Cerro Constancia	2018-03-09	north
24	basis	Quebrada de Aroma	2018-03-10	north

Details of the selected weather station

Lat: -21.4029°
Lon: -69.8402°
UTM-N: 7632230m
UTM-E: 412286m
Elevation: 1148m
DOI: 10.5880/CRC1211DB.4

Installation date: 2017-03-01
Communication: GOES
Last Visit: 0000-00-00 00:00:00
Documents:
Protocols & malfunctions:

Gallery

Parameters of the selected weather station

Type	Manufacturer	Modell	Measuring Parameter	Measuring Unit	Abbre- viation	Measuring Height	PDF
Battery	Campbell		datalogger battery voltage	V	BattV	1.200	
Humidity	Campbell	Leaf wetness sensor	leaf wetness	mV	LWmV	0.200	

Thank you

Remote sensing of clouds in Iquique

Cloud radar 35Ghz

- Sensitve for cloud droplets
- Cloud base and top (~)
- Radar reflectivity
- Doppler velocity

FogHat microwave radiometer

- Temperature and humidity as function of height
- Water vapor column (IWV)
- Liquid water column (LWP)

Doppler Windlidar

- Backscatter (-> cloud base)
- vertical wind speed
- Horizontal wind speed (scans)

Typical day in summer

Top of Aerosol Layer at ~1km

Wind at surface

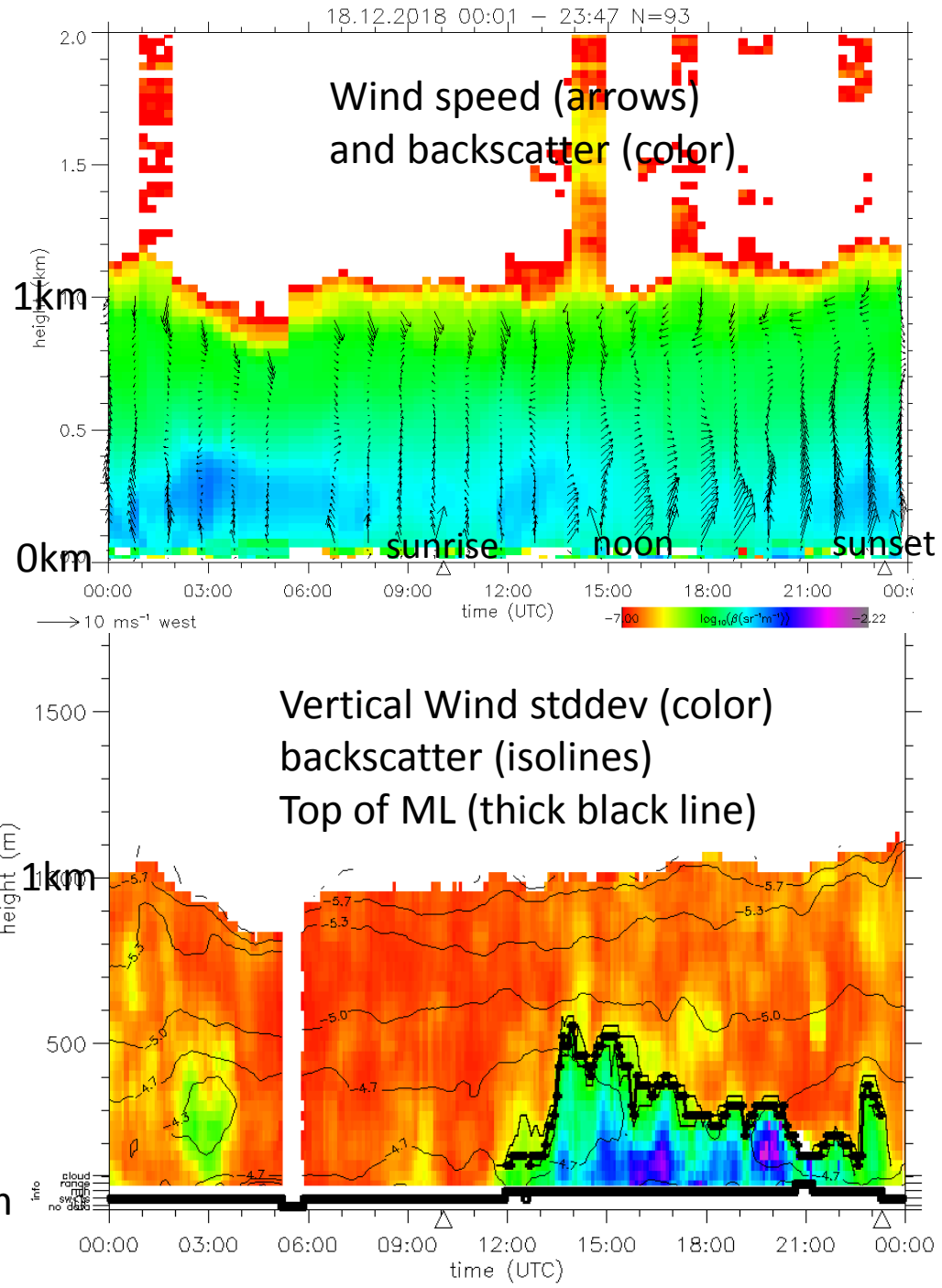
- from south
- during daytime stronger and inland component

Wind at 1km

- during daytime from east
- during night from north west

Mixed Layer

- Max height at 500m



Typical day winter

Cloud top at ~0.9km
=> 400m thick
Cloud is drizzling
but does not reach surface –but maybe at cliff (?)
LWP of drizzling cloud ~150 g/m2
End of drizzle => thin cloud with very low LWP