# ZONDA WIND SEVERE EVENT OF 21 JULY, 2023

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# ZONDA WIND SEVERE EVENT OF 21 JULY, 2023

**Zonda wind is a typical downslope windstorm (foehn type) over the eastern slopes of the Central Andes in Argentina. Most studies in this phenomena are concentrated in the provinces of Mendoza and San Juan.**

- **SEVERE EVENT IN MENDOZA CITY WITH**
  - **WIND GUST : > 100 KM/H**
  - **TEMPERATURE JUMP : 10°C IN 1 HOUR**
  - **RELATIVE HUMIDITY : < 5% DURING 9 HOUR**
  - **LONG DURATION : 11 HOURS**
  - **2 DECEASES**

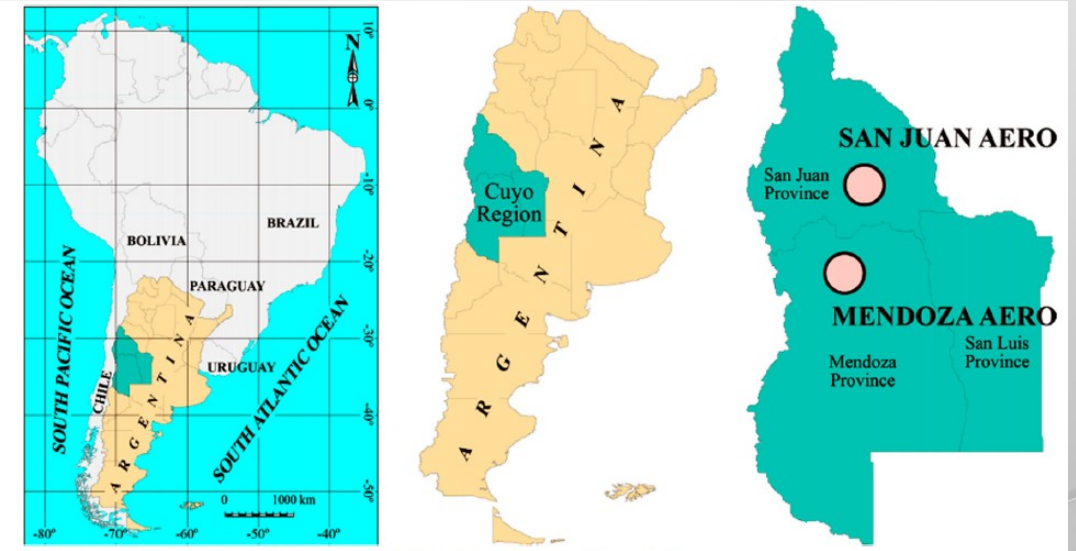
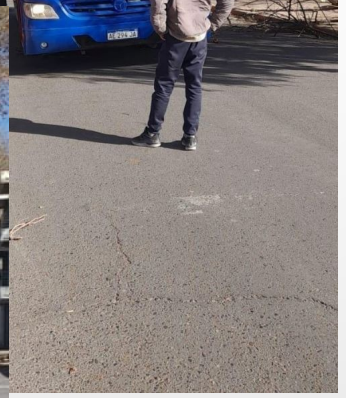


Fig. 1 Location of Argentina and Cuyo region in South America (extracted from Norte, 2015)



***Luján:***

Trees down: 90
Cables cut or poles down: 41
Roof blown off: 4
Water tanks down: 1
Danger of collapse: 1
Publicity Sign down: 1
Total: 138

**Godoy Cruz:**

Trees down : 104
Cables cut or poles down : 30
Roof blown off : 13
Danger of collapse : 2
Publicity Sign down : 1
Total: 150

**Las Heras:**

Trees down : 31
Cables cut or poles down : 28
Roof blown off : 1
Blasting of a sheet metal structure (window display of newspapers and magazines) causes 1 male fatality.
Danger of collapse : 1
Total: 61

**Ciudad:**

Trees down : 27
Cables cut or poles down : 10
Roof blown off : 1
Publicity Sign down : 2
Total: 40

**Guaymallén:**

Trees down : 12
Cables cut or poles down : 7
Roof blown off : 5
Total: 24

**Maipú:**

Cables cut or poles down : 5
Roof blown off : 1
Total: 6

**San Martín:**

Road accident causes one fatality and several injuries.

**San Rafael:**

Trees down : 1
fallen branches : 10
Total: 11

**Trees down = 264**

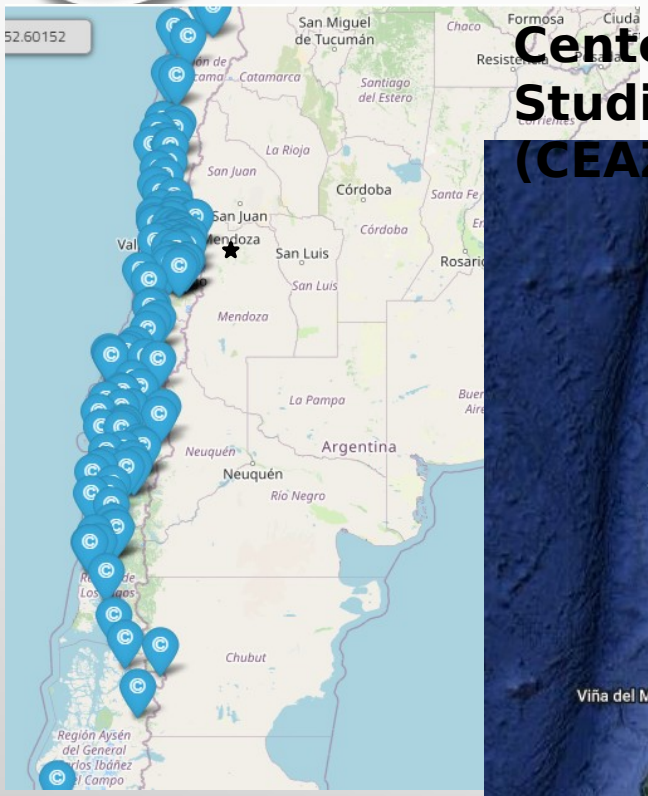
**Cables cut or poles down = 138**

**Fatalities = 2**

**Roof blown off = 25**

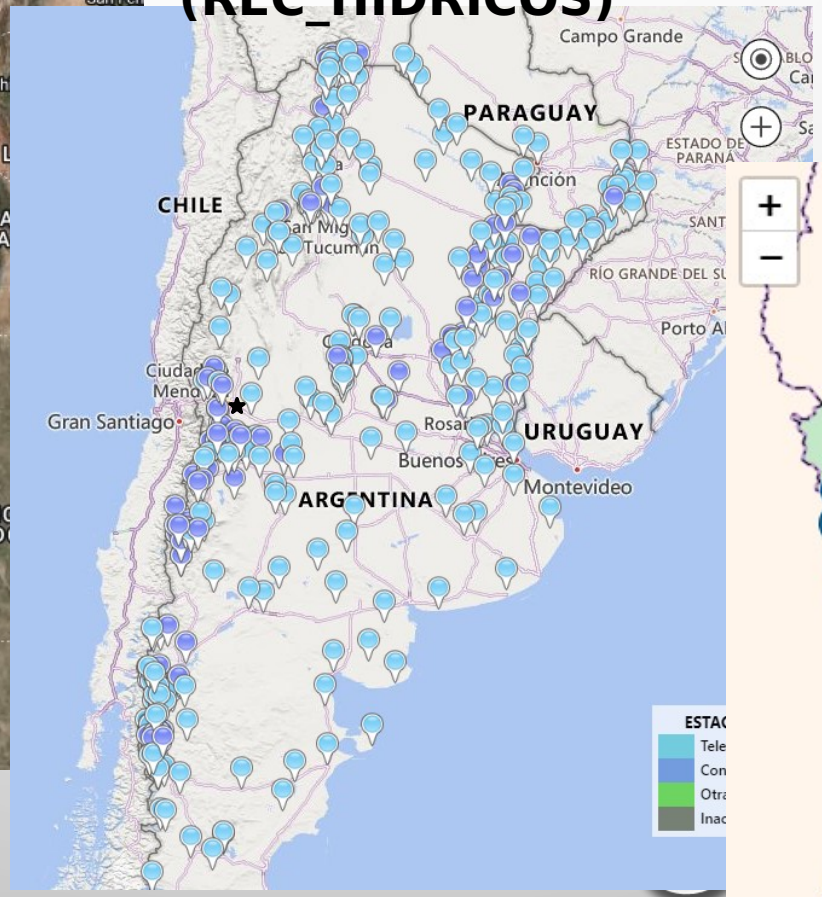
# Available data

**nal Weather service Chile (METEOCHILE)**

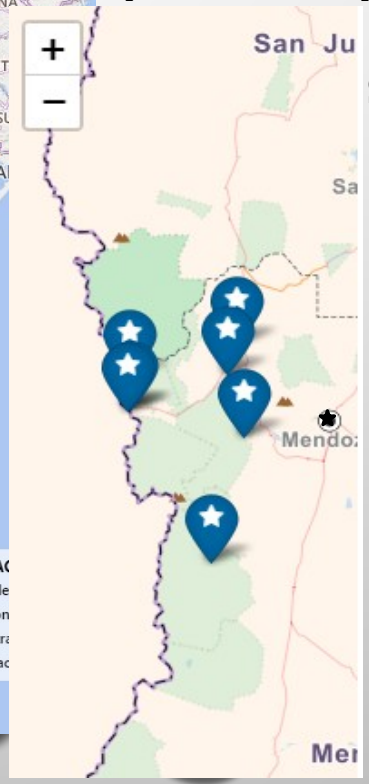



**Center for Advanced Studies in Arid Zones (CEAZA)**

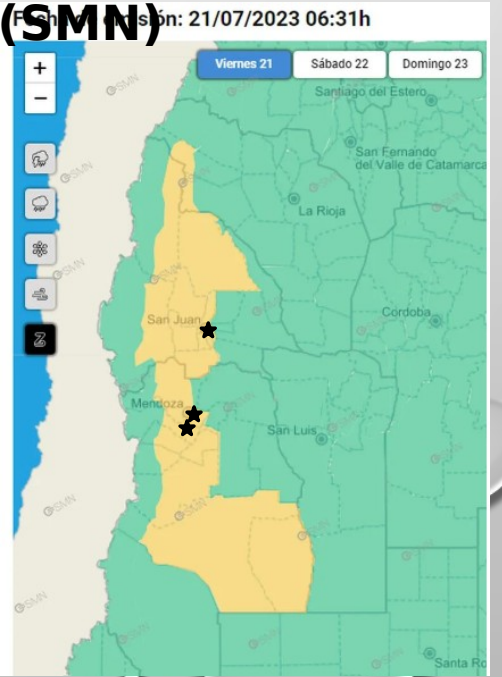

**National water information system (REC_HIDRICOS)**




**Andean observatory (IANIGLA)**




**National Weather service Argentina (SMN)**



# Data characteristic

**tional Weather service of Chile (METEOC**

Minute and hourly data. (wide range and spatial distribution)
Quite Good network but need quality control

**Center for Advanced Studies in Arid Zones (CEAZA)**

Hourly data. (wide time range, but short spatial distribution)
Wind speed usually at 5m not at 10m, so intepolation is needed
need quality control

**National water information system (REC_HIDRICOS)**

4 daily data 0, 4, 12 and 16 LT. (not always). Need quality control
Almost all station are in valleys (model terrain height might not be correct

**Andean observatory (IANIGLA)**

Hourly data. (short range, 2018-2023/4)
Need quality control
Lot of missing data

**National Weather service Argentina (SMN)**

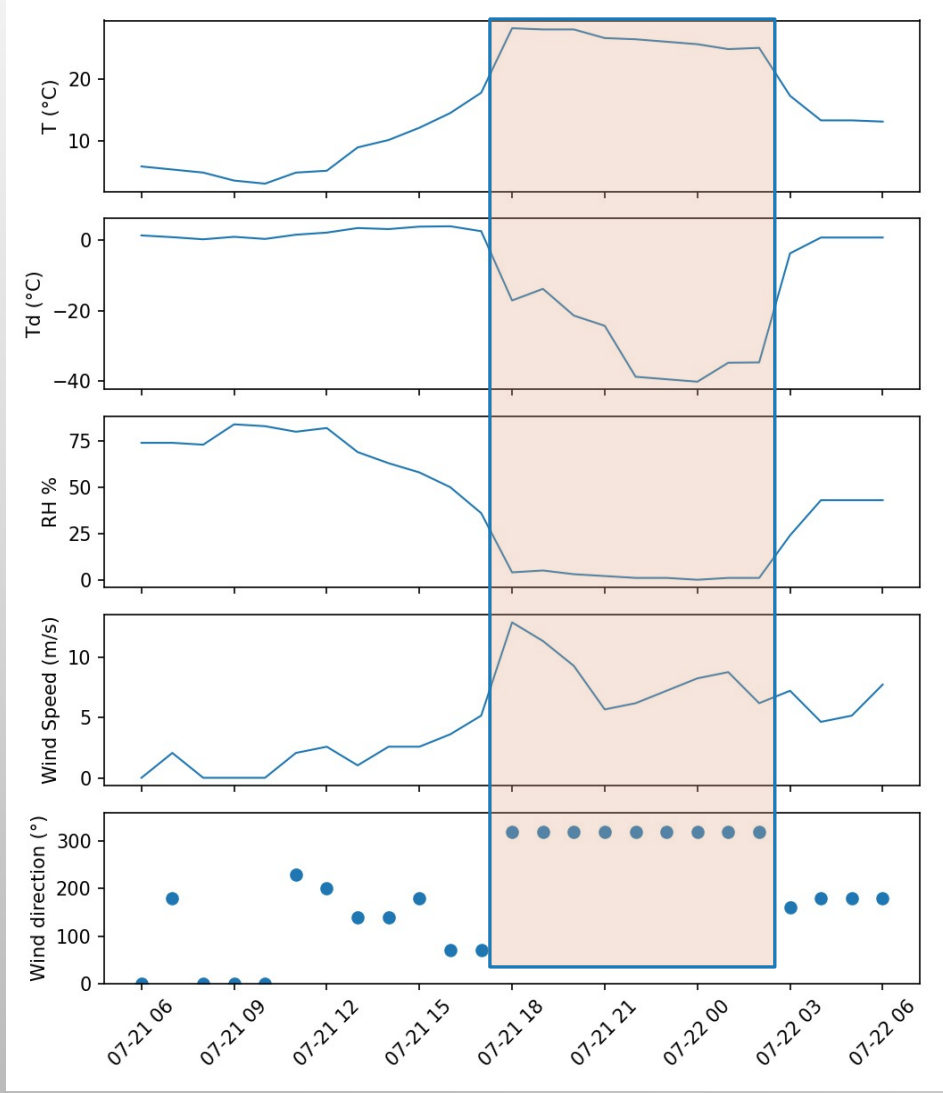
Hourly data and vertical soundings. (wide time range, but scarse station distribution). No need quality control

**Models Used**

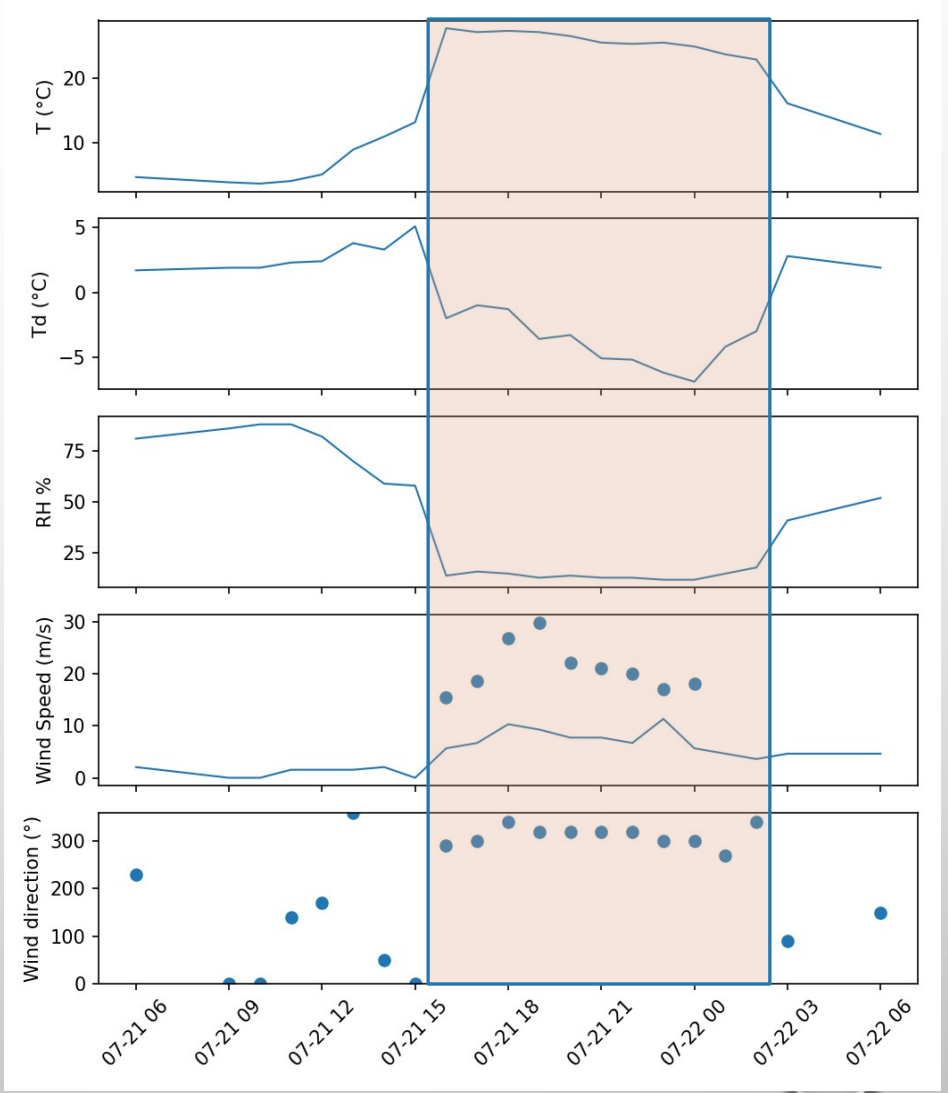
**ERA5 single levels (0.25°)** **ERA5 land (0.125°)**
**WRF (2km)**

# The event

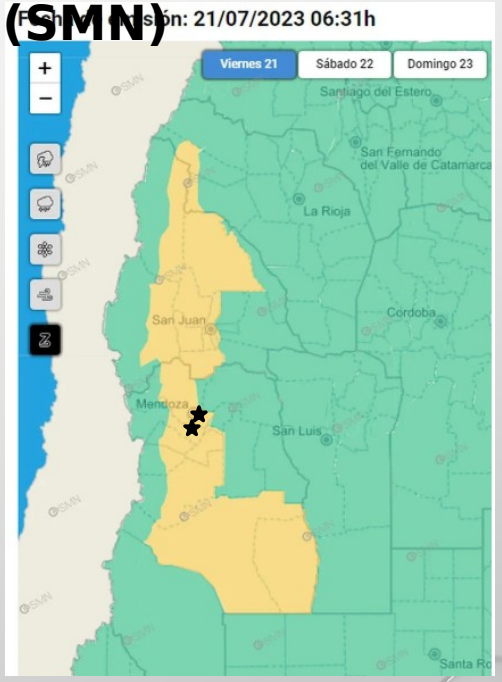
Mendoza Airport




Mendoza Observatory



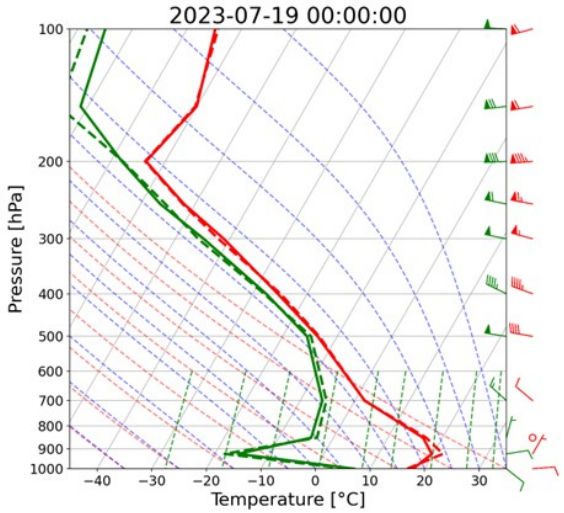

**National Weather service Argentina (SMN)**

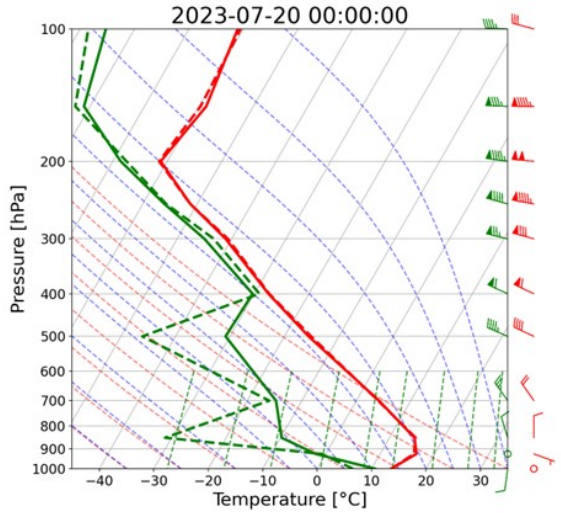


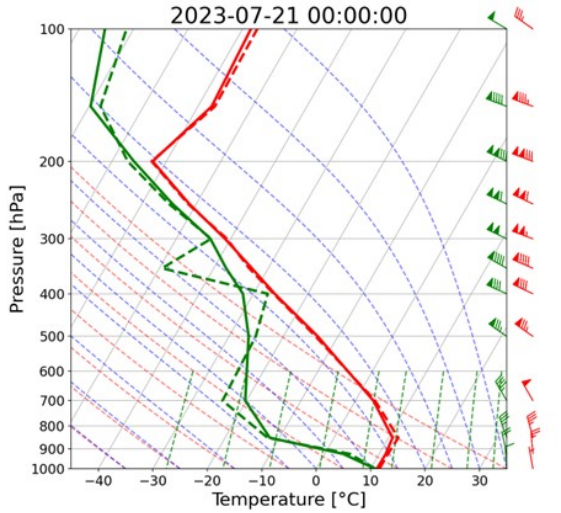
ERA5 Reanalysis pressure levels

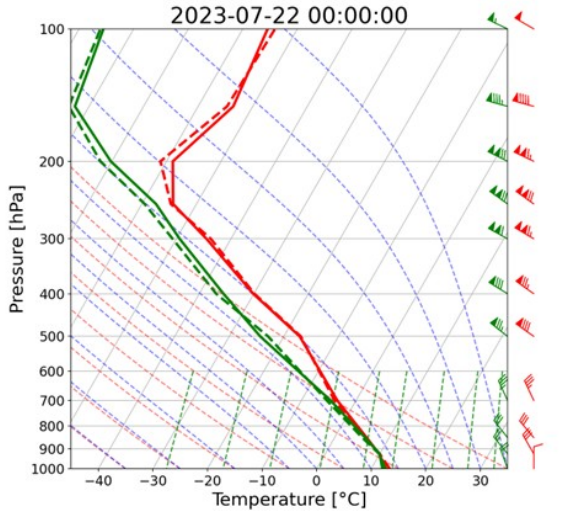
# Validation

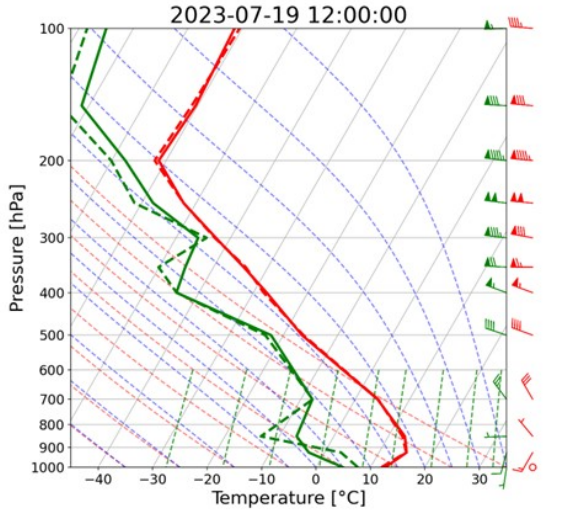
## Very good agreement

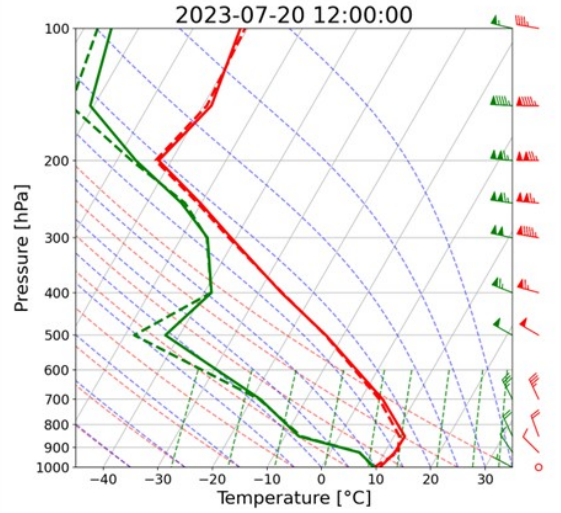


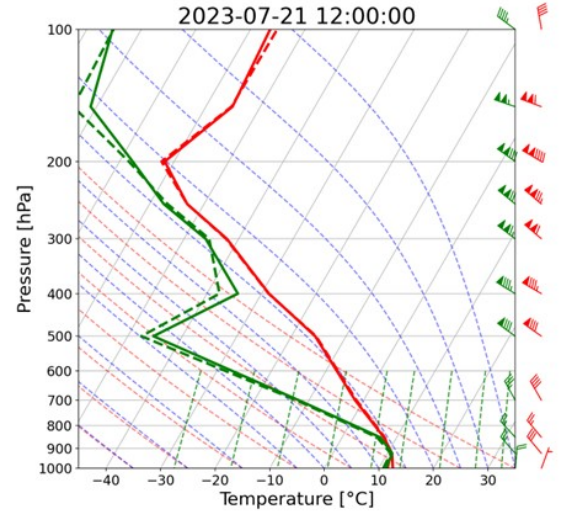



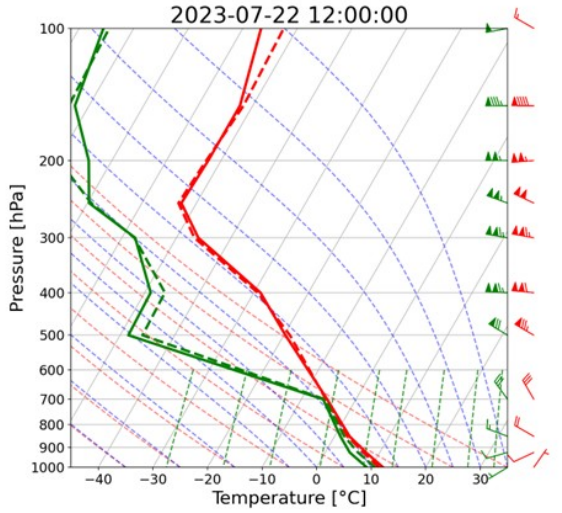




Reanalysis Temp

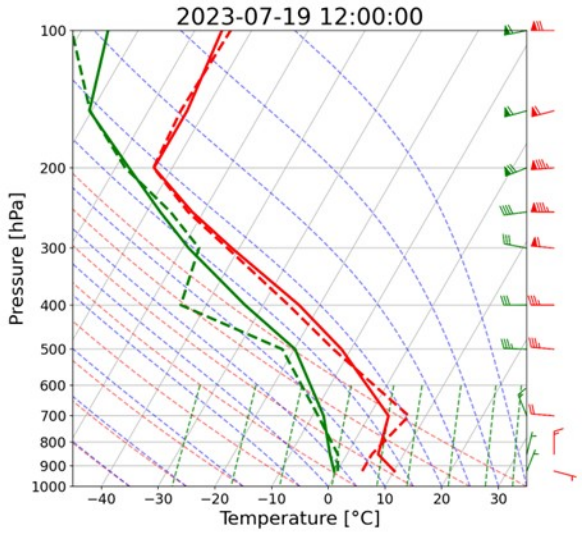
Sounding Temp

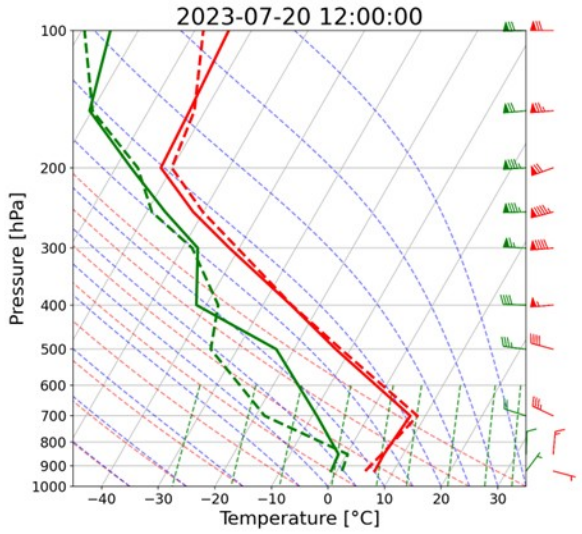
Reanalysis Td

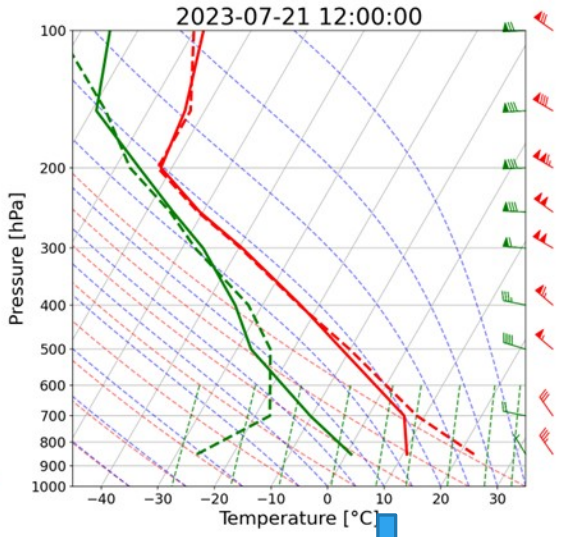
Sounding Td

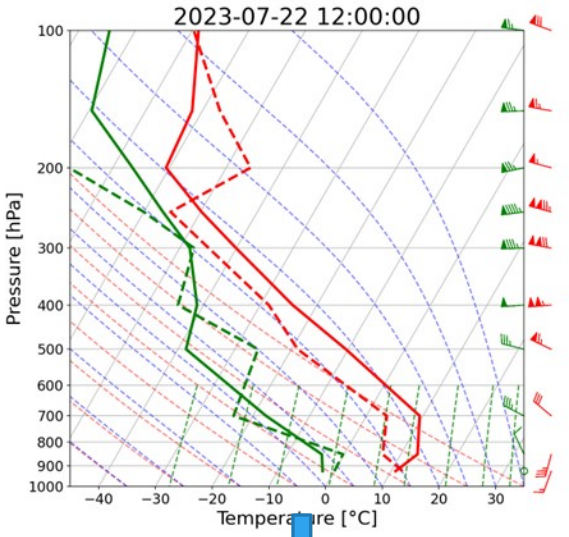
# Validation

## Not so good agreement leward!

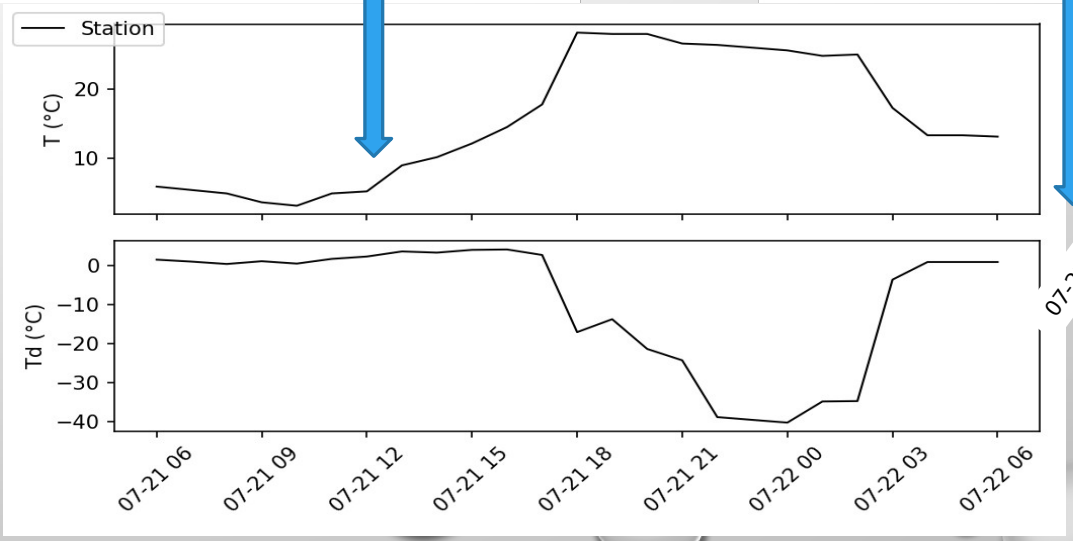



- **No high Zonda wind before the event**
- **Lower wind speed at almost all levels**
- **Zonda event persist in ERA5 Reanalysis**



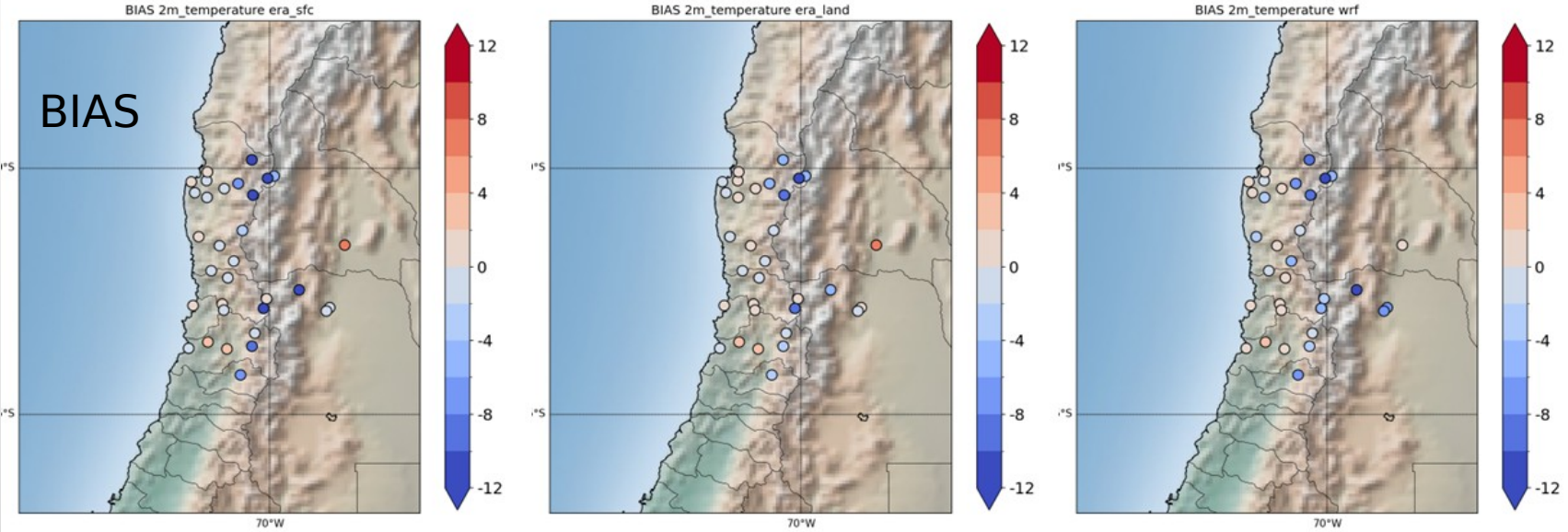

Reanalysis Temp

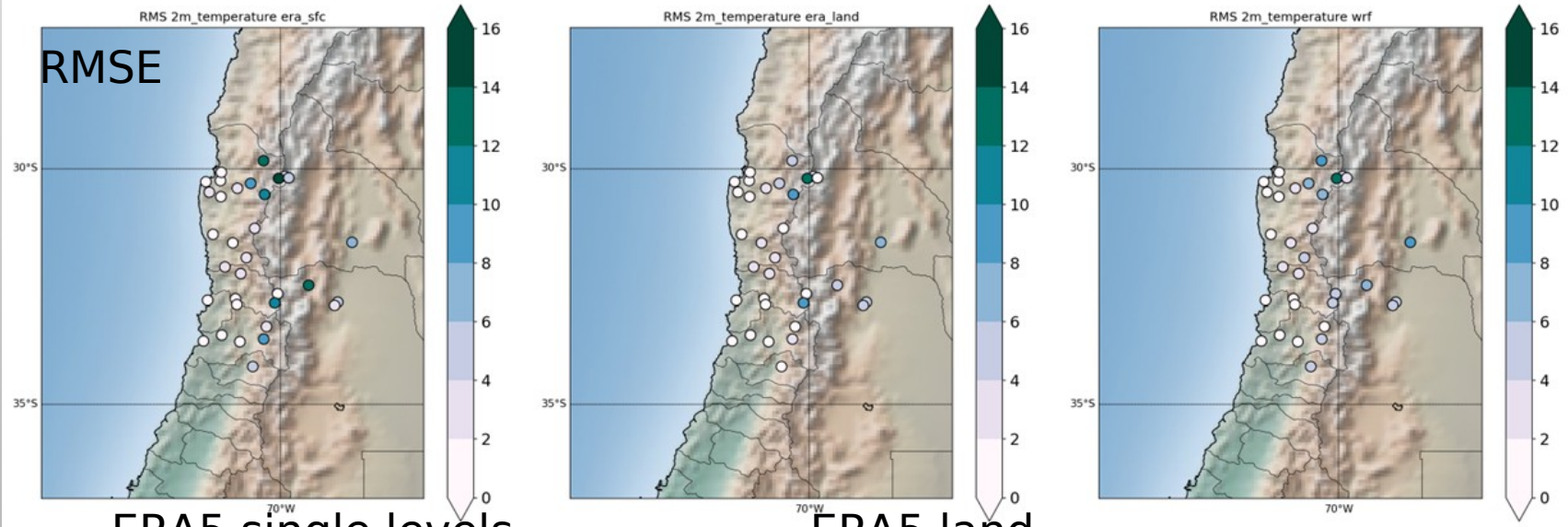
Sounding

Reanalysis Td

Sounding

# 2m Temperature Validation



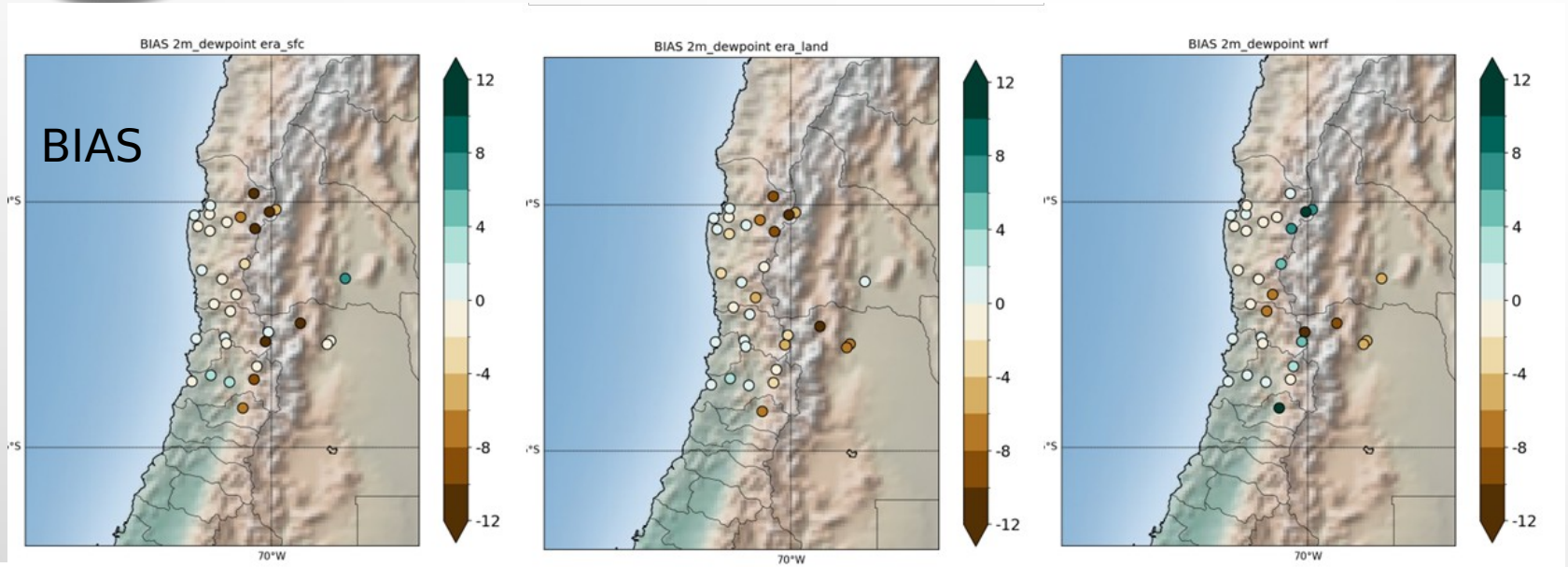

ERA5 single levels

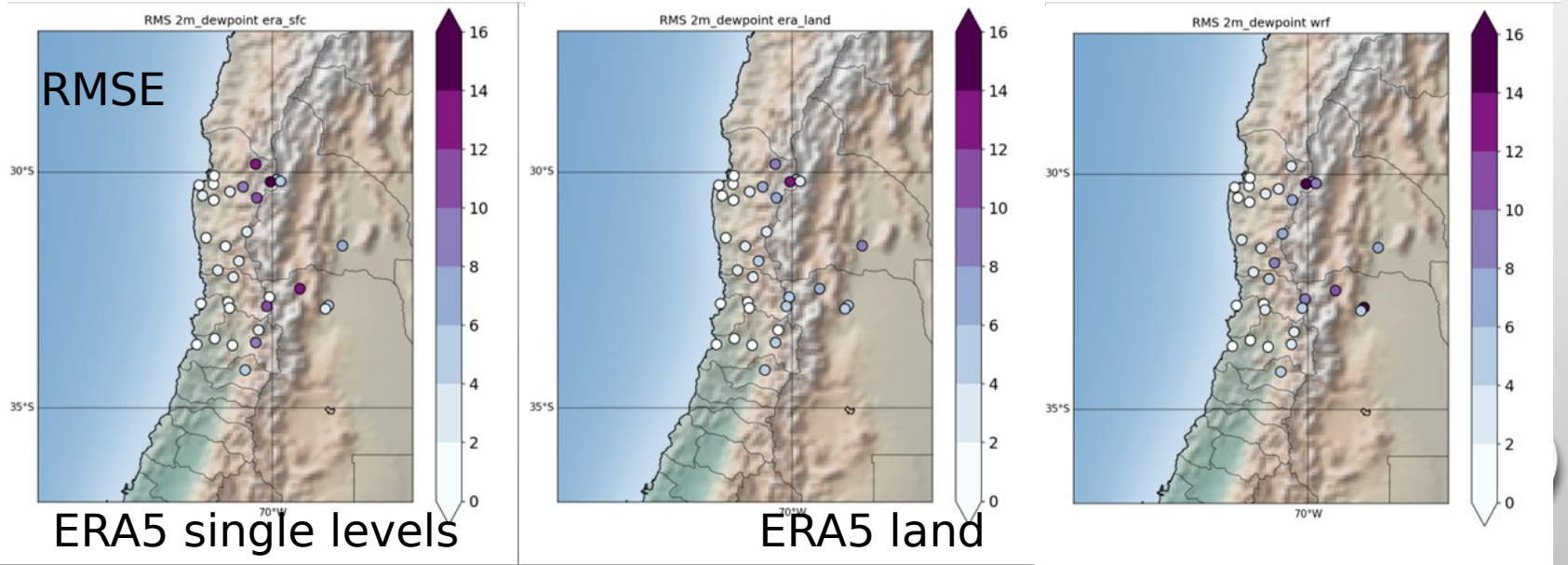
ERA5 land

Warmer bias at low altitude stations and colder bias at high altitudes stations.

Lower RMSE at low altitude station and higher RMSE at high altitudes.

# 2m Dewpoint Validation




ERA5 single levels

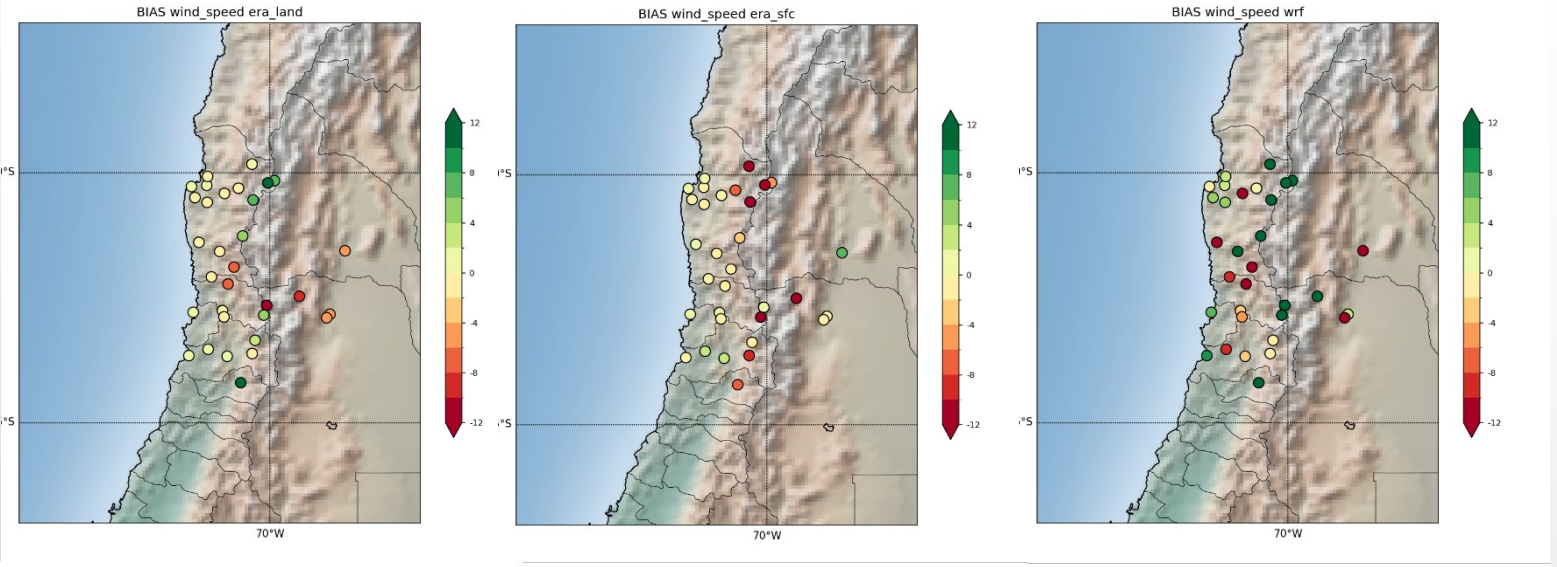
ERA5 land

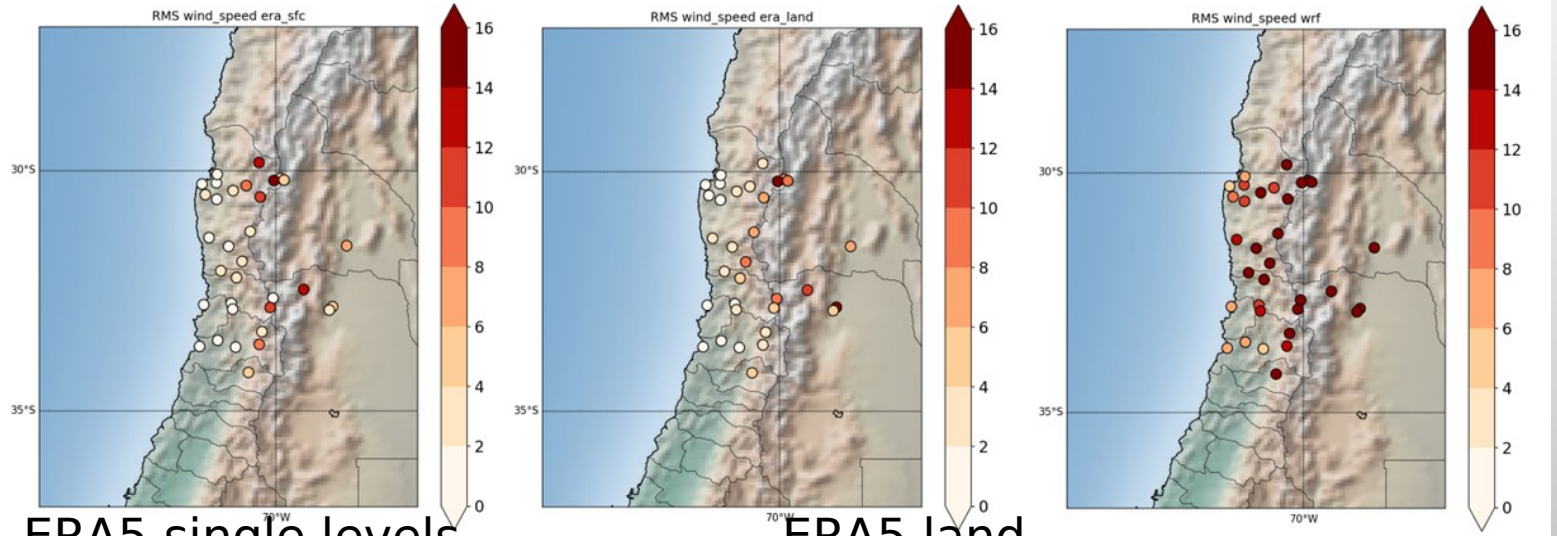
Good correlation for lower altitudes in Chilean side

High altitude stations with dry bias for ERA5 and wet for WRF model. Dry bias where the Zonda blows with better agreement for ERA5 land model.

Lower RMSE at low altitude station and higher RMSE at high altitudes and Zonda stations.

# 10m windspeed Validation




ERA5 single levels

ERA5 land

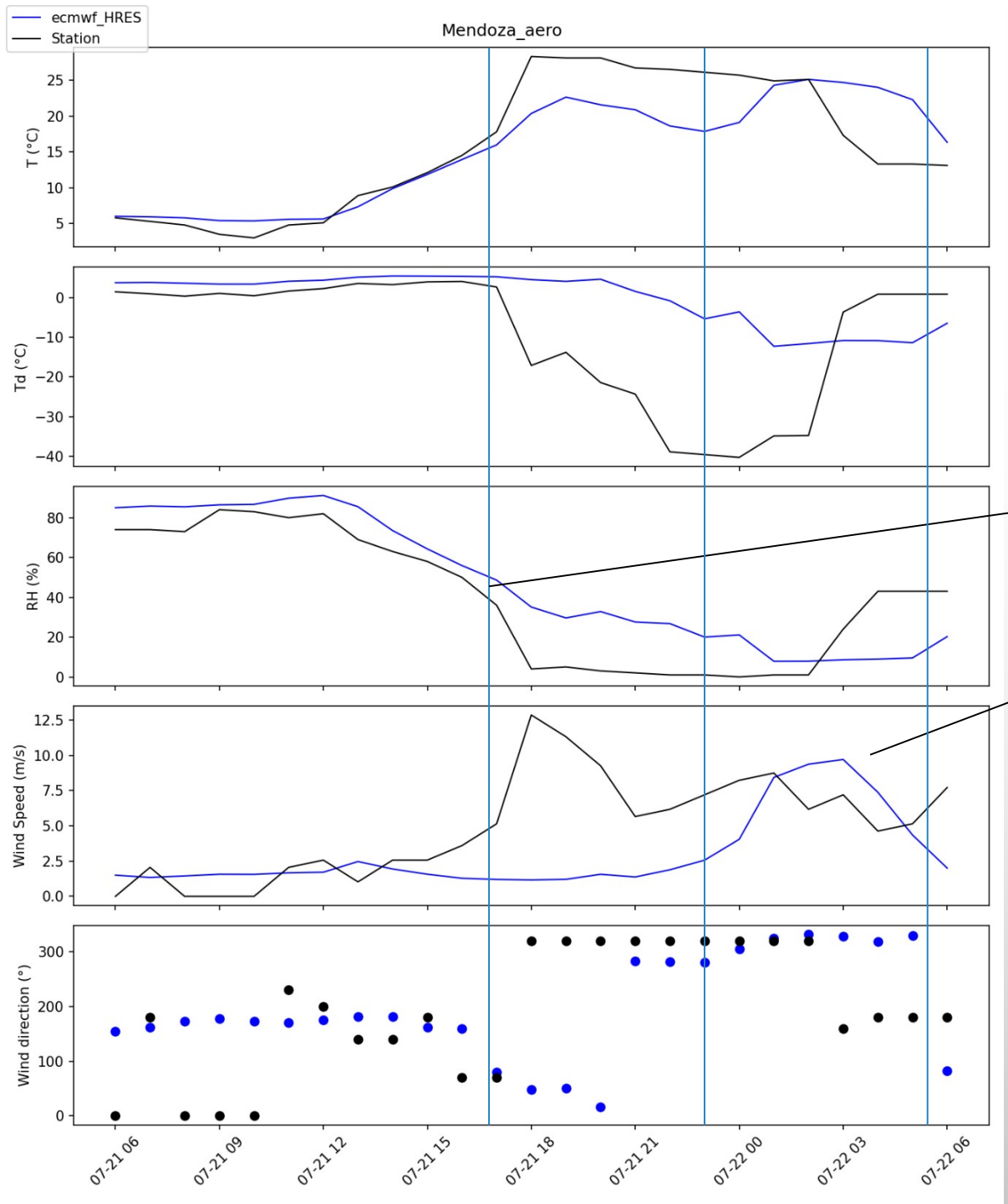
Good correlation for lower altitudes in Chilean side

Larger differences in beetwen ERA5 land, with lower wind speed and ERA5 single levels, with higher wind speed at high altitudes

WRF pressent higher winds speed and no so good representation of wind speed in general (BIAS and RMSE)

ERA reanalysis present negative bias in Zonda stations

Lower RMSE at low altitude station and higher RMSE at high altitudes




# ECMWF HIRES Forecast Validation

2023-07-19 12 UTC ecmwf_HIRES forecast for Mendoza Aero

Good agreement leeward before the event
Not so good during and after the event.

- Zonda event in ecmwf model starts later, at 2023-07-21 23 UTC and continues for 3 more hours.

The event was predicted by the model!!
(while reanalysis don't)

RMSE 2m TEMP = 4.98
RMSE 2m DEWPOINT = 17.4
RMSE REL. HUMIDITY = 18.9
RMSE 10m WIND SPEED = 4.3

BIAS 2m TEMP = -0.63
BIAS 2m DEWPOINT = -15.9
BIAS REL. HUMIDITY = 32.1
BIAS 10m WIND SPEED = -4.4

# Conclusions

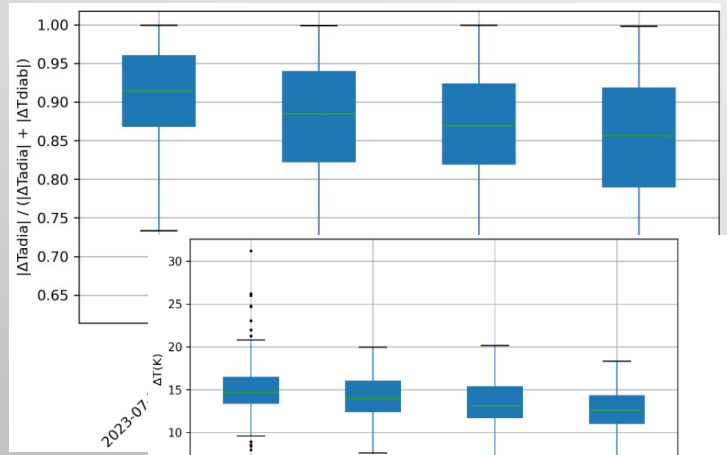
Models/reanalysis represent better:

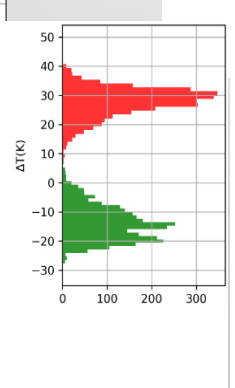
- Windward than leeward
- Lower altitudes  than high altitudes
- 2m temperature than humidity and winds

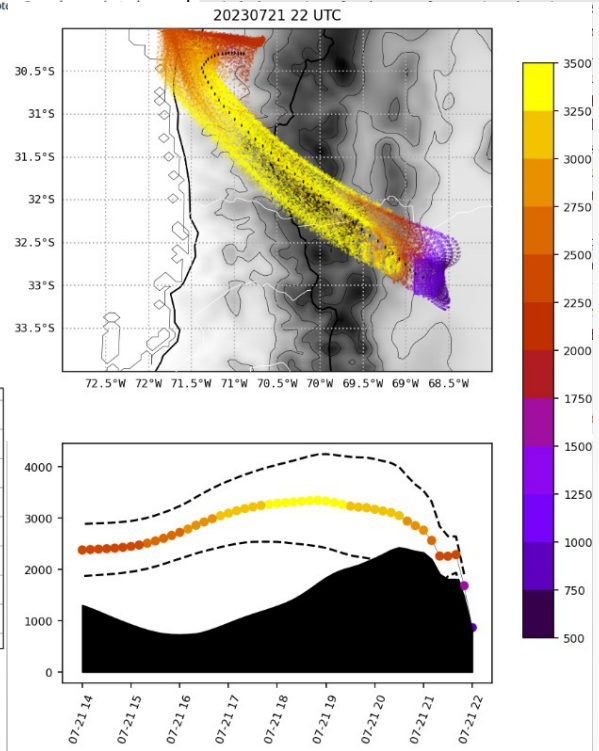
ERA5 land has better results than ERA5 single levels reanalysis
Both has problems to represent the event, but was forecasted in ecmwf HIRES

# What we do?

- Find the events
- Use of vertical soundings and synoptic fingerprints to forecast yes/no Zonda wind
- Trajectory análisis to

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RESEARCH ARTICLE

International Journal of Climatology

## Zonda wind classification using machine learning algorithms

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**Abstract**
Zonda wind is a typical downslope windstorm over the eastern slopes of
tral Andes, in Argentina, which produces extremely warm and dry condi
creating substantial socioeconomic impacts. To achieve the Zonda wind c
fication, objective methods based on supervised machine learning (ML)
rithms are used. ML training and supervision is based on the subjective Z
wind classification assessing the total hourly data that correspond to Z

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RESEARCH ARTICLE

International Journal of Climatology | RMetS

## Synoptic fingerprints of Zonda wind from a statistical prediction model

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Email: fotero@mendoza-conicet.gob.ar

**Abstract**
Zonda wind is a typical downslope windstorm over the eastern slopes of the Central Andes in Argentina, which produces extremely warm and dry conditions and has substantial socioeconomic impacts. In this study, we propose a new statistical model for Zonda prediction based on the "synoptic fingerprints" of atmospheric diagnostic variables from ERA5. The model combines principal component analysis (PCA) and logistic regression to establish a relationship between the observed occurrence and the PCA loading component of a predictor variable. This approach enables us to determine the probability of Zonda occurrence at selected stations and identify the synoptic structure features (fingerprints) associated with Zonda events. The obtained fields successfully discriminate between Zonda and non-Zonda events, suggesting that the available information in the reanalysis data is sufficient for predicting the presence of Zonda. The synoptic finger-

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• Original Paper •

## Forecasting Zonda Wind Occurrence with Vertical Sounding Data

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ABSTRACT

Zonda wind is a typical downslope windstorm over the eastern slopes of the Central Andes in Argentina, which produces extremely warm and dry conditions and creates substantial socioeconomic impacts. The aim of this work is to obtain an index for predicting the probability of Zonda wind occurrence. The Principal Component Analysis (PCA) is applied to the vertical sounding data on both sides of the Andes. Through the use of a binary logistic regression, the PCA is applied to discriminate those soundings associated with Zonda wind events from those that are not, and a probabilistic forecasting tool for Zonda occurrence is obtained. This index is able to discriminate between Zonda and non-Zonda events with an effectiveness close to 91%. The best model consists of four variables from each side of the Andes. From an event-based statistical perspective, the probability of detection of the mixed model is above 97% with a probability of false detection lower than 7% and a missing ratio below 1%. From an alarm-based perspective, models exhibit false alarm rate below 7%, a missing alarm ratio lower than 1.5% and higher than 93% for the correct alarm ratio. The zonal component of the wind on both sides of the Andes and the windward temperature are the key variables in class discrimination. The vertical structure of Zonda wind includes two wind maximums and an unstable lapse rate at midlevels on the lee side and a wind maximum at 700 hPa accompanied by a relatively stable layer near the mountain top.

**Key words:** Zonda wind, foehn, downslope windstorm, forecasting

**Citation:** Otero, F., and D. Araneo, 2022: Forecasting Zonda wind occurrence with vertical sounding data. *Adv. Atmos. Sci.*, **39**(1), 161–177, https://doi.org/10.1007/s00376-021-1007-0.

# What left to do?

**Zonda predictability?  and probability Index?** EFI and ANF (ensambles)

**Trajectory análisis? Understand better the phenomena?**

**Altitude correction method for WRF and ERA's models?**

**Other posible data to ingest?** Aircraft Meteorological Data Relay (AMDAR)