1st presentation

Meteorology/modelling subgroup

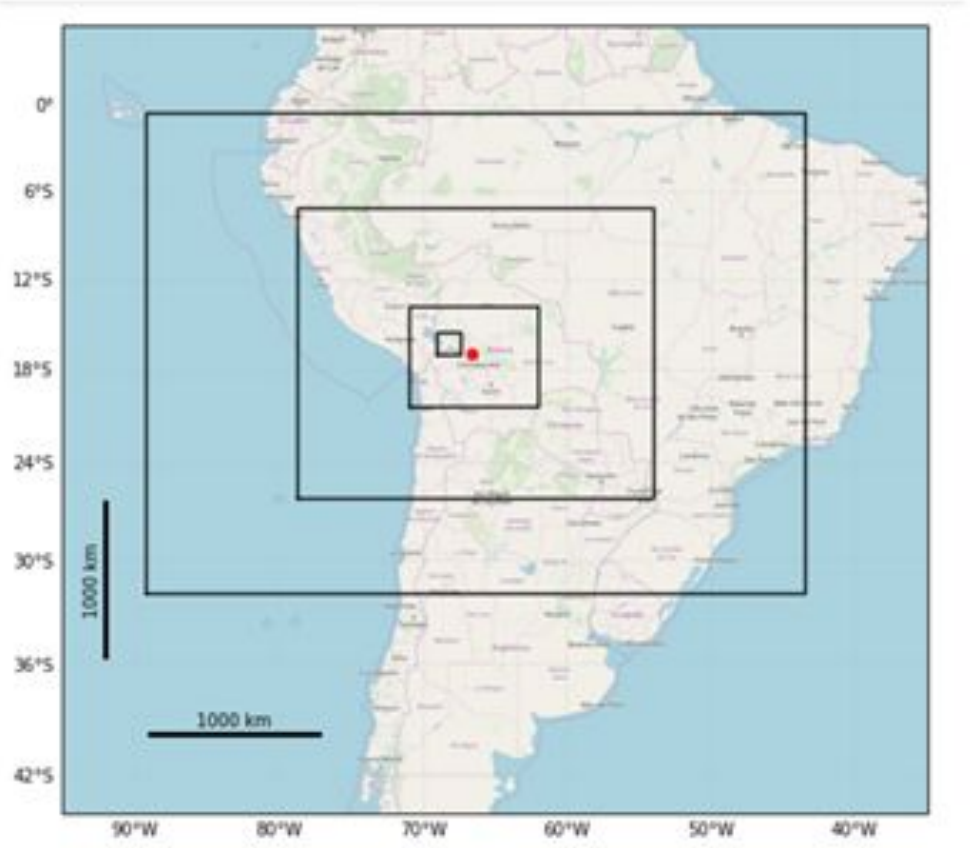
Weather modelling error quantification

- Chacaltaya measurement site close to Lake Titicaca to North and other lakes to South
- Aims:
  - To verify how accurate the forecasts are, to identify any problems, and to fix them
  - To quantify the structure of the boundary layer
  - Eventually use WRF simulation as input to FLEXPART
- Readily made WRF (Weather Research and Forecasting model) simulations, maybe new simulations later

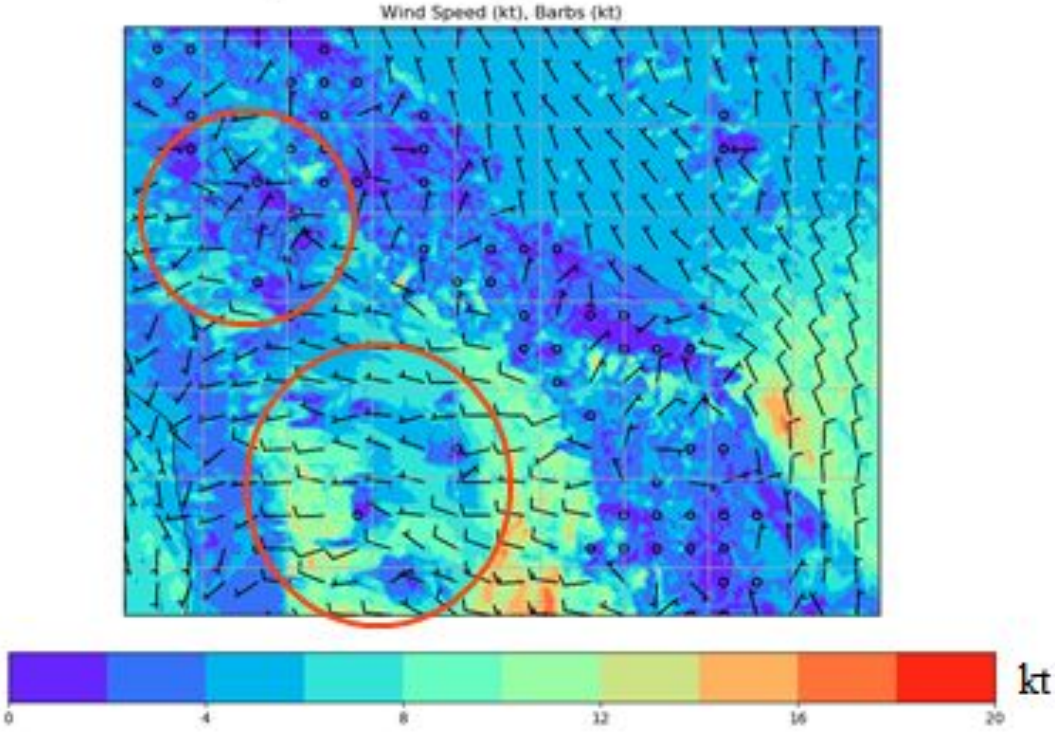
Resolutions:

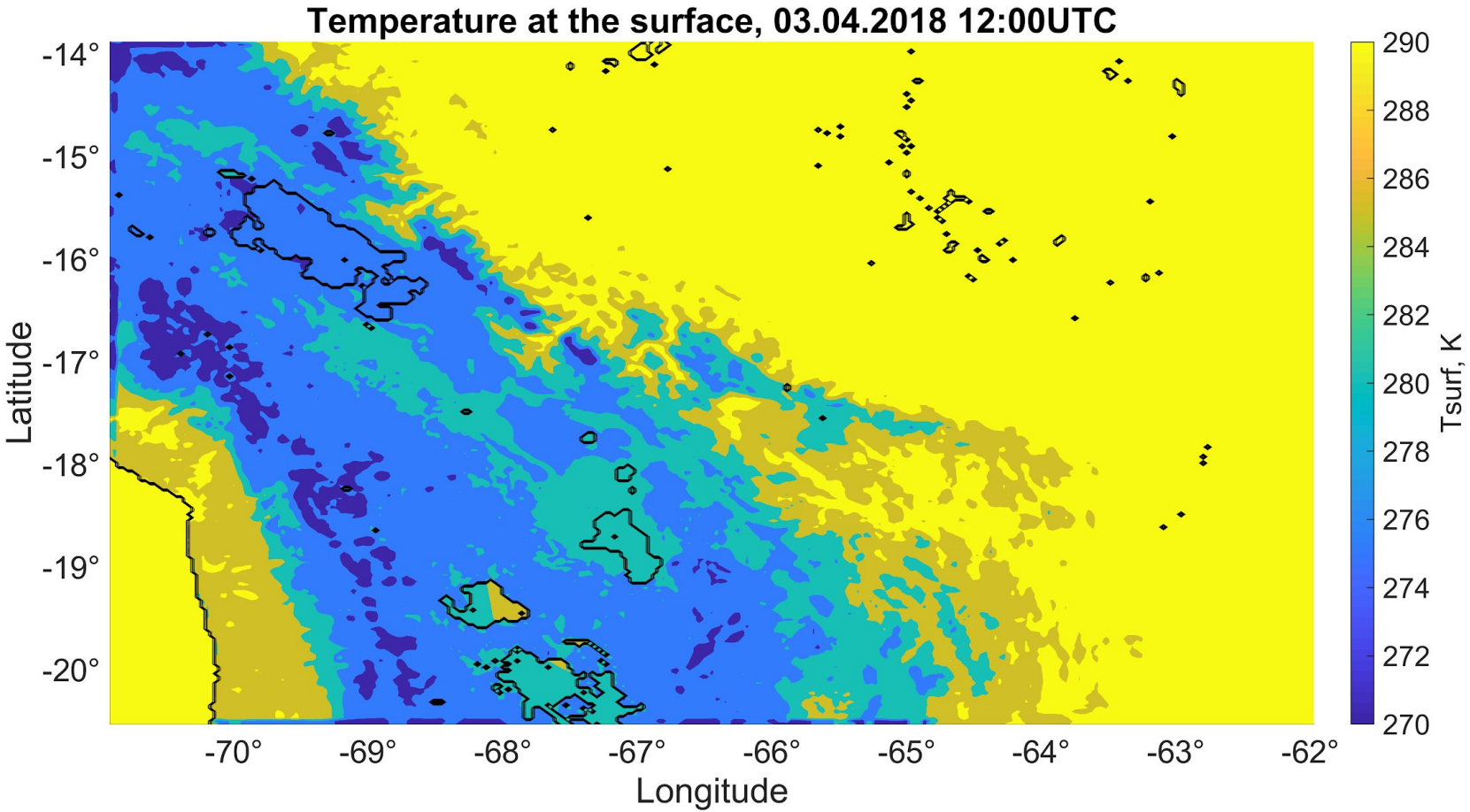
1 km
3 km
9 km
36 km

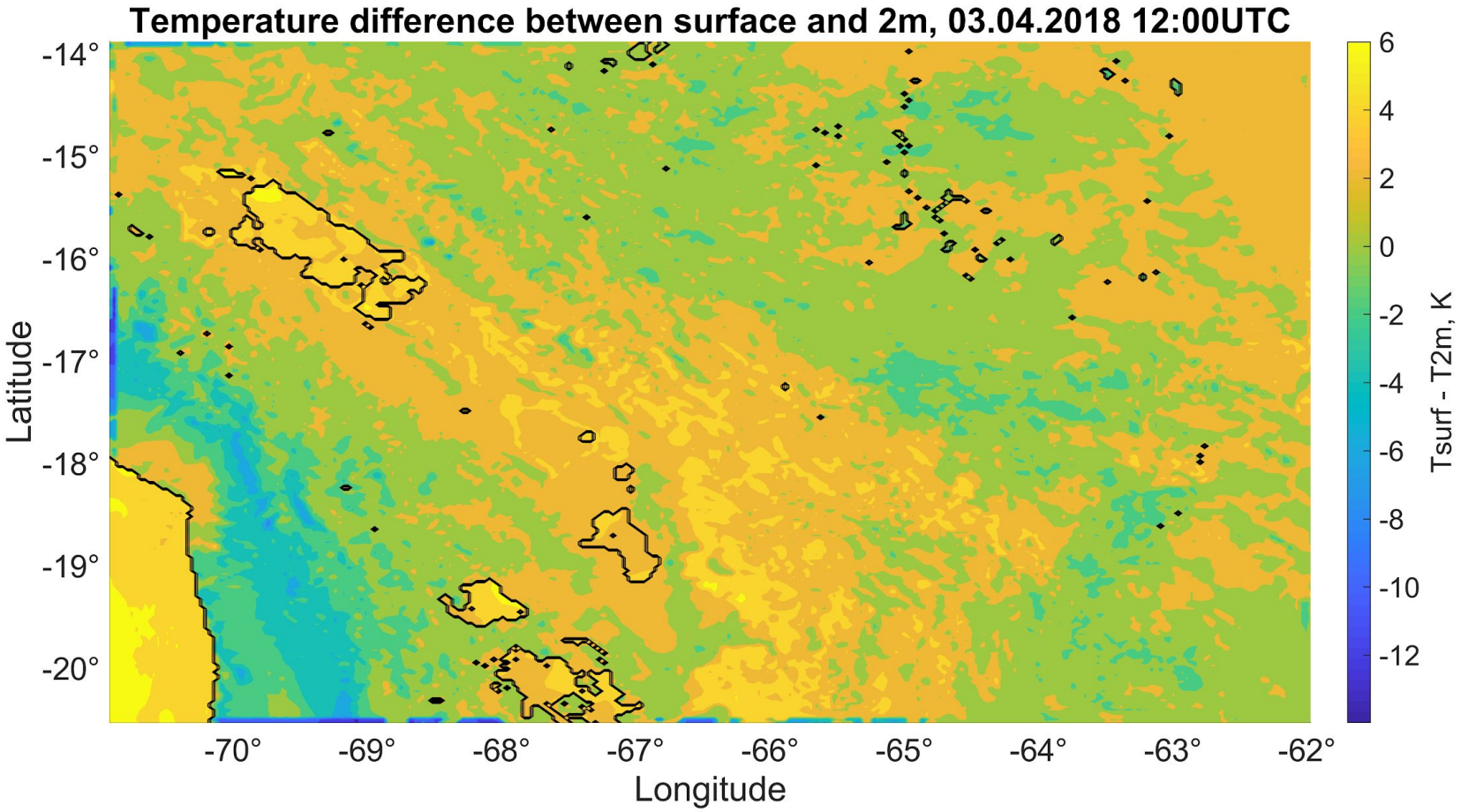
The WRF domains

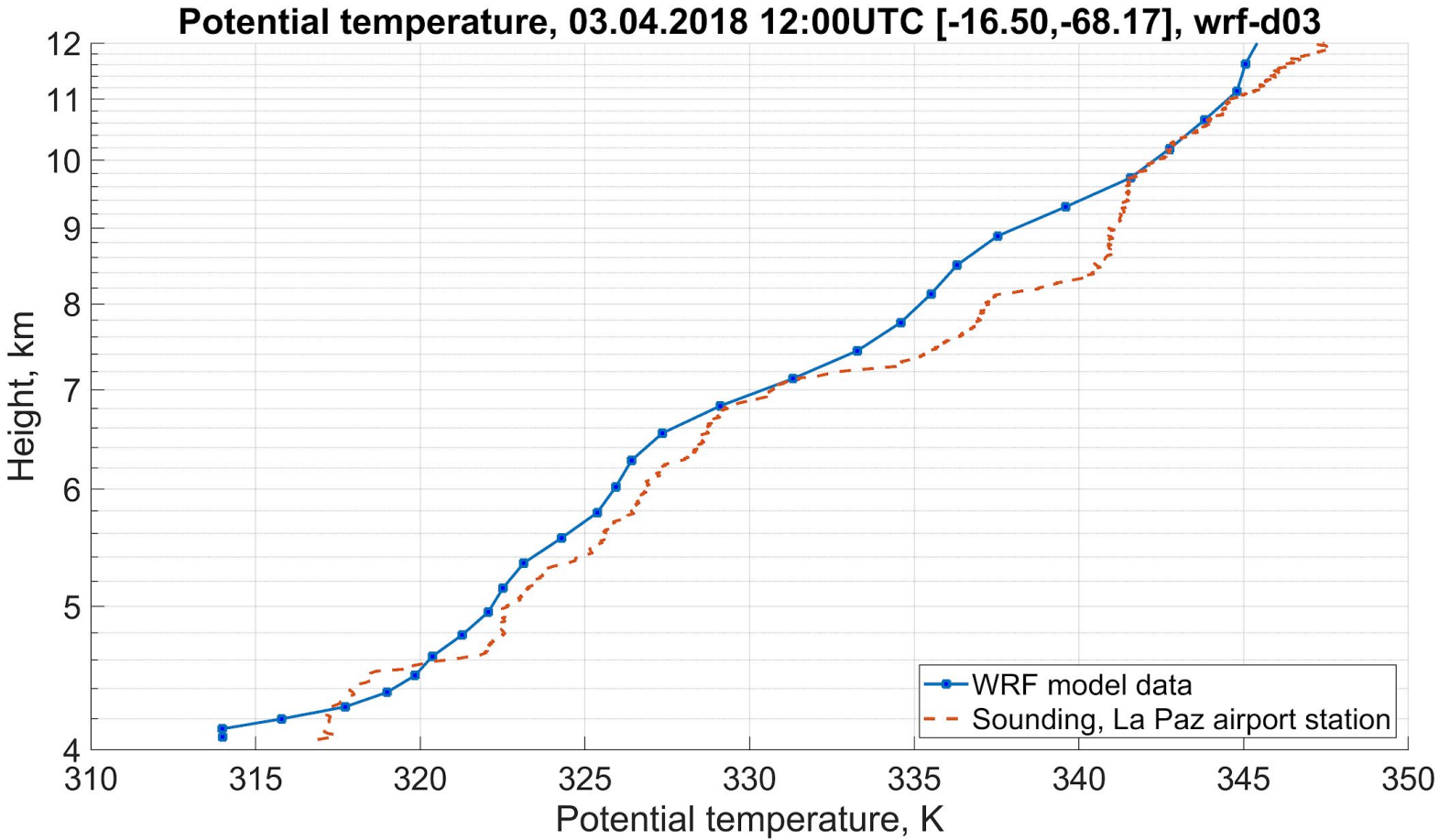


Wind at 10 May 2018 00UTC, WRF model level 1






Temperature difference between surface and 2m, 03.04.2018 12:00UTC
Latitude
-14°
-15°
-16°
-17°
-18°
-19°
-20°
Longitude
-70°
-69°
-68°
-67°
-66°
-65°
-64°
-63°
-62°
Tsurf - T2m, K
6
4
2
0
-2
-4
-6
-8
-10
-12


Potential temperature, 03.04.2018 12:00UTC [-16.50,-68.17], wrf-d03
Height, km
Potential temperature, K
12
11
10
9
8
7
6
5
4
310
315
320
325
330
335
340
345
350
WRF model data
Sounding, La Paz airport station

Observations

- Boundary layer dynamics using radio sounding data
- Will compare observations to the results from the WRF model
- Position, T, P, RH, wind speeds

18 ascents in April 2018

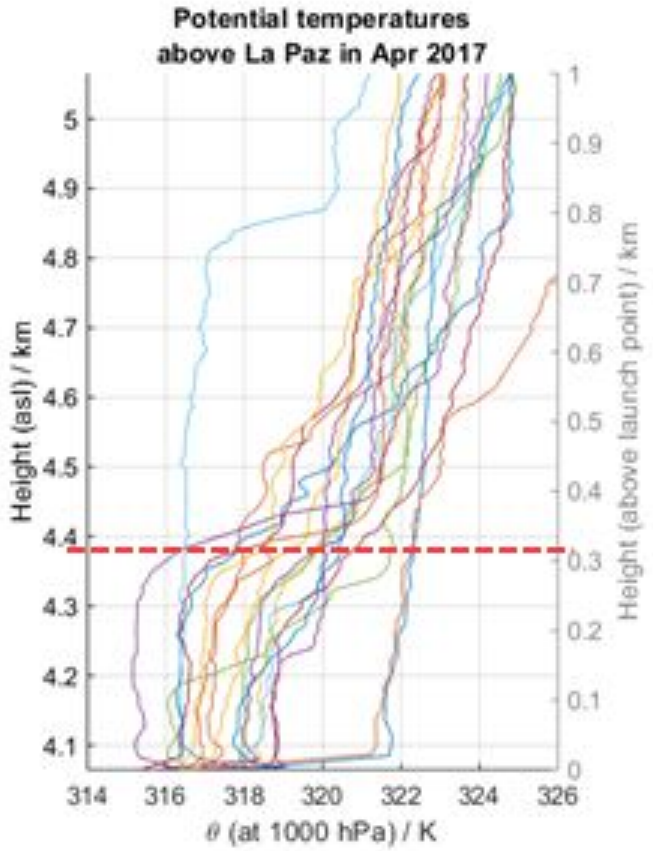
8 AM local time

~ 1 hour, ~ 20 km vertical range

Observations

Next steps:

- Look at other parameters: RH, wind speed & direction
- Will compare observations to the results from the WRF model



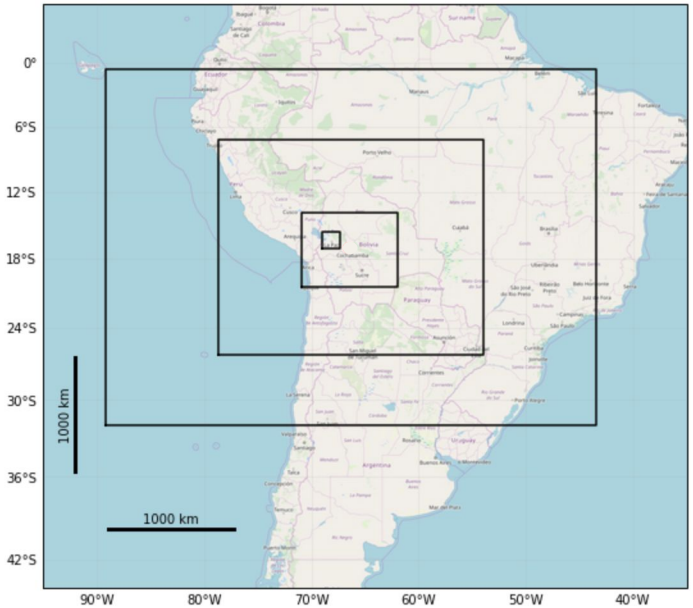
2nd presentation

Meteorology and modelling subgroup

Dan Thomas, Evgeny Kadantsev, Lauri Tuppi

Recap

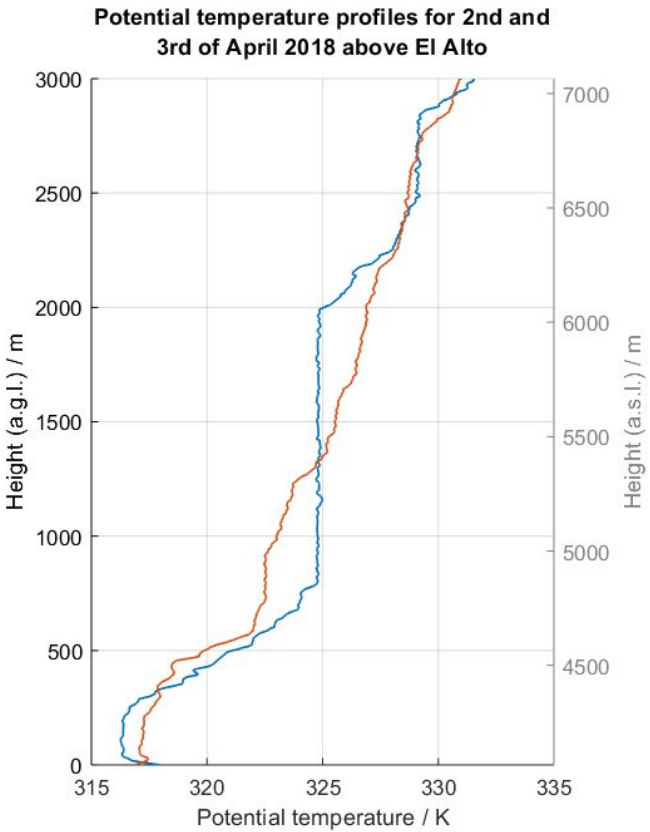
- Using WRF (Weather Research and Forecasting model) to simulate atmospheric conditions around La Paz and Chacaltaya
- Comparing to observational data
- Aim to use its output in FLEXPART (dispersion model) which will simulate particle flow



Meteorological data

- Data from observations which will test the WRF model
  - Radio sounding (untethered), *El Alto airport*
  - Radio sounding (tethered) and ceilometer, *La Paz*

- To investigate boundary layer dynamics



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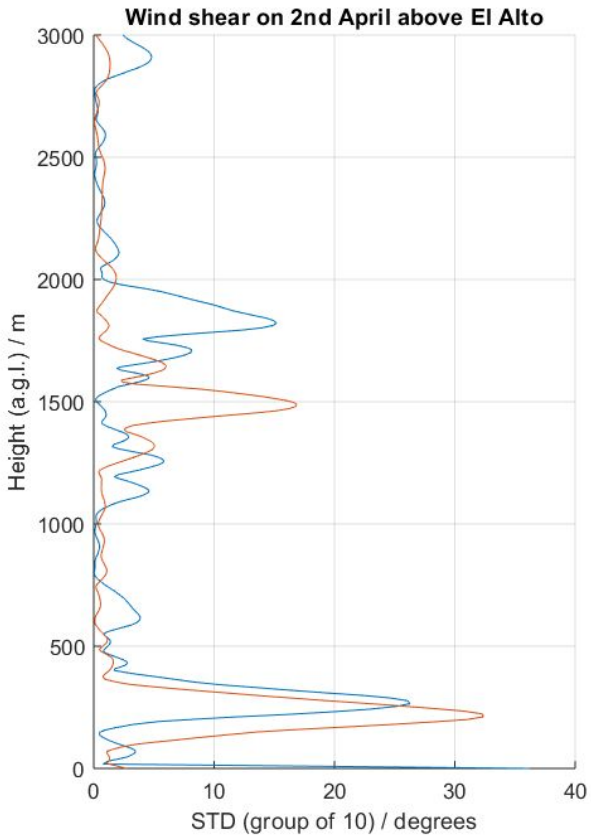
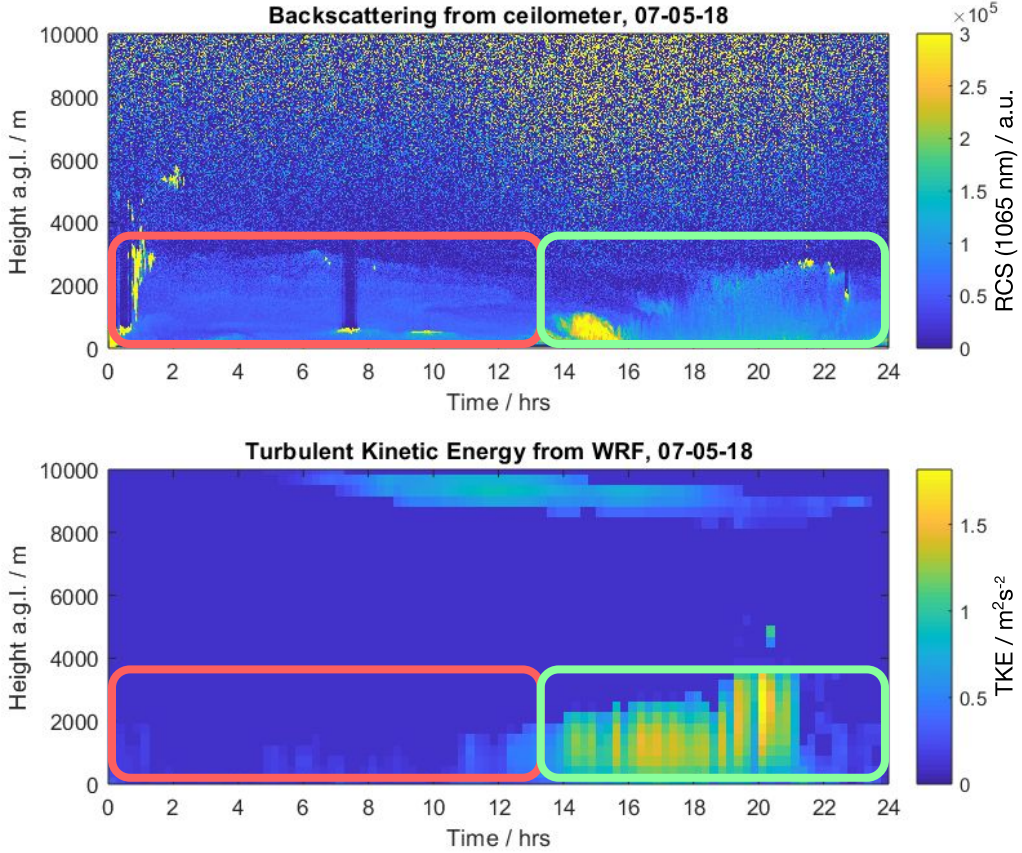


Boundary layers

Backscattering data from ceilometer compared to Turbulent Kinetic Energy

Reproduces **convective boundary layer** but not the **residual boundary layer**



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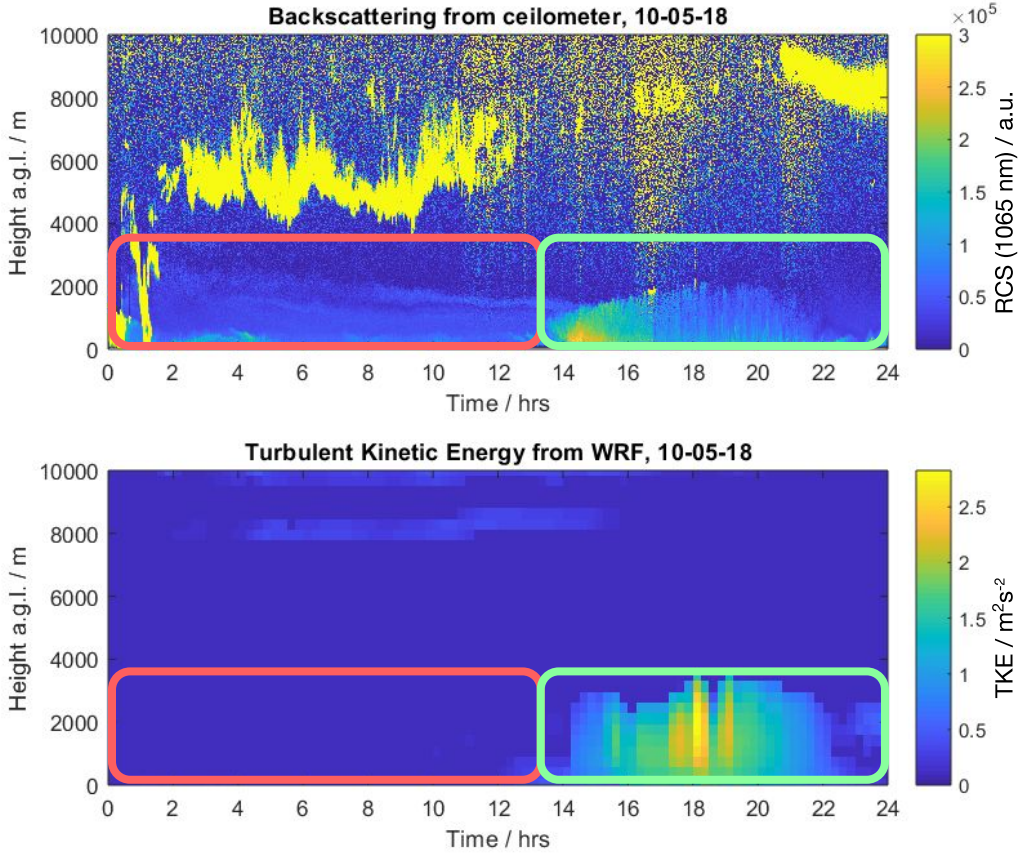
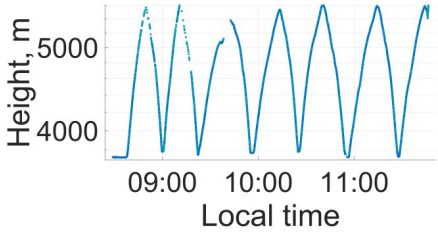
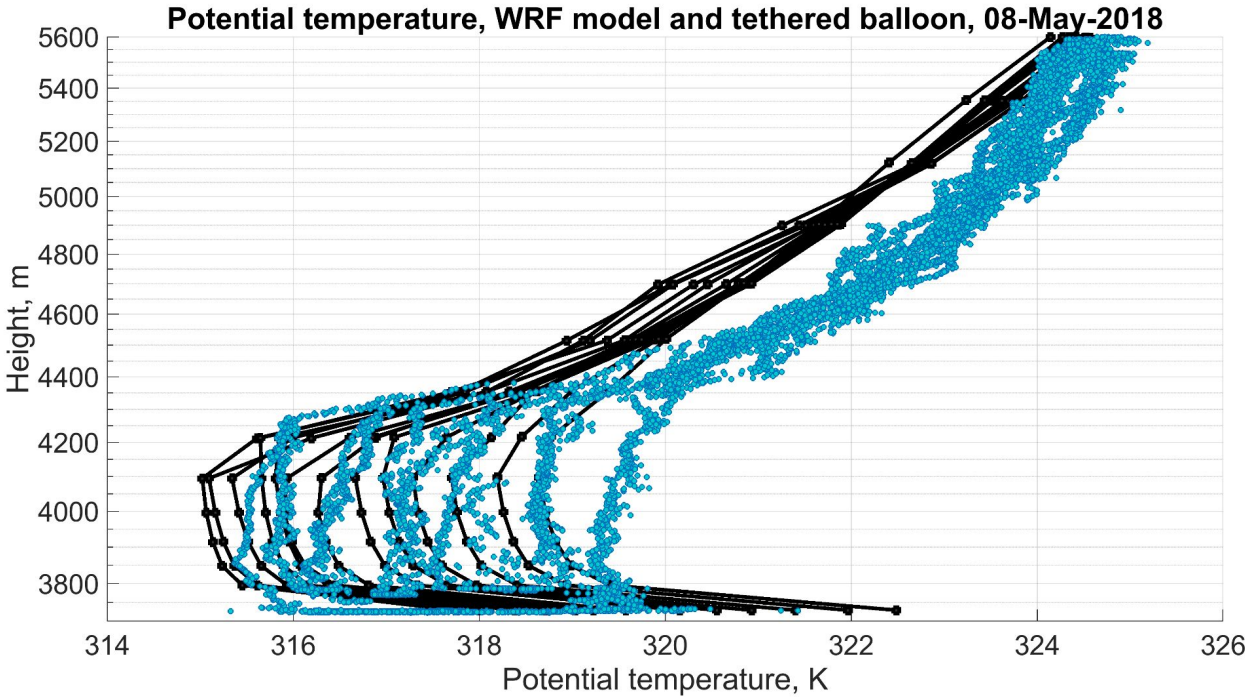


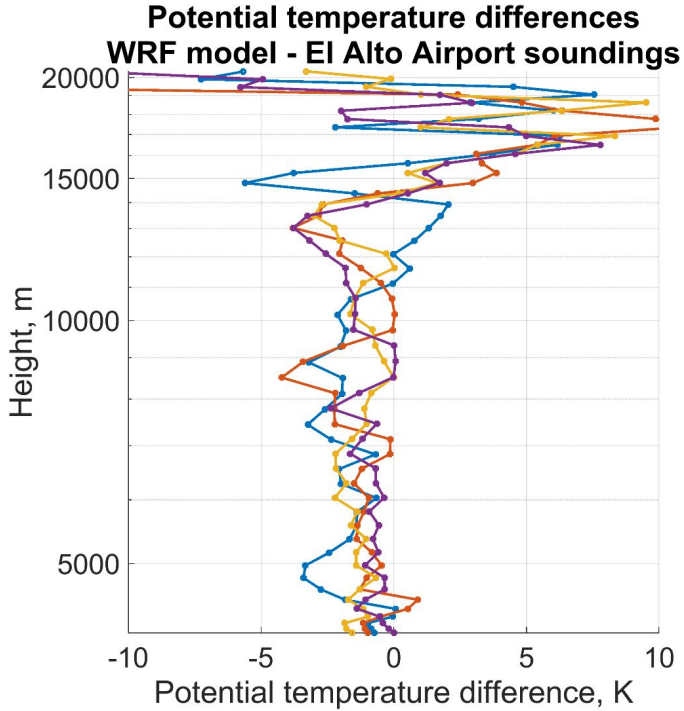
WRF model vs Tethered balloon soundings

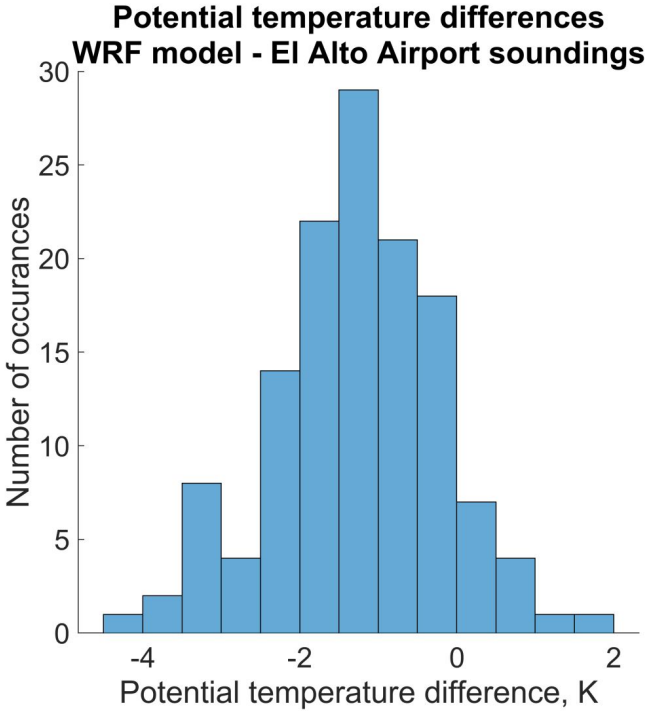
Time evolution of Boundary layer is well captured
Boundary layer height is also reproduced
Some underestimation of Potential temperature





Evgeny Kadantsev



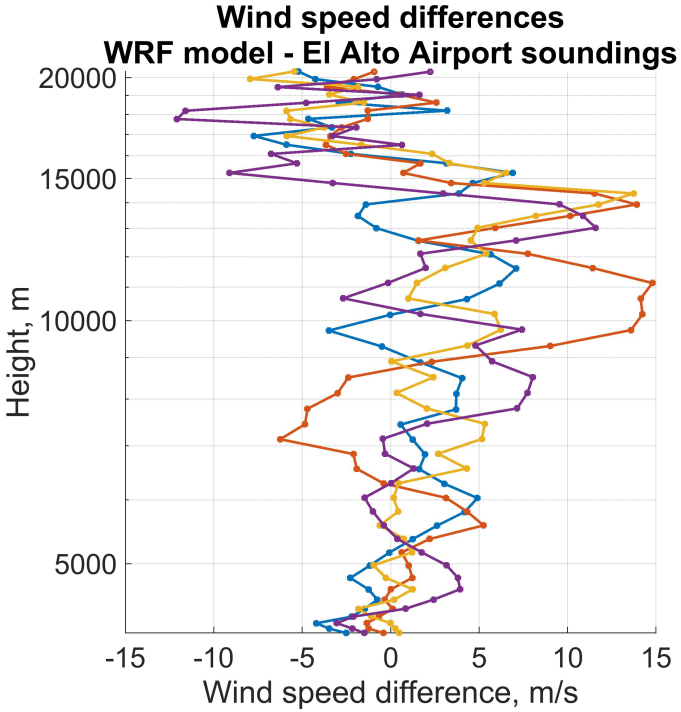


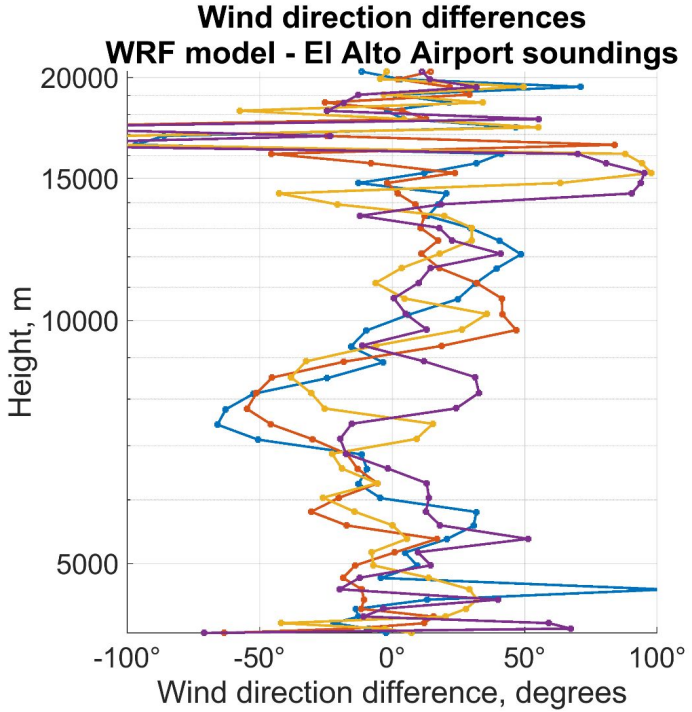
Vertical structure of Potential temperature is reproduced very well

Consistent negative bias of 1 K up to 15km

Standard deviation is ~1.06K

Evgeny Kadantsev



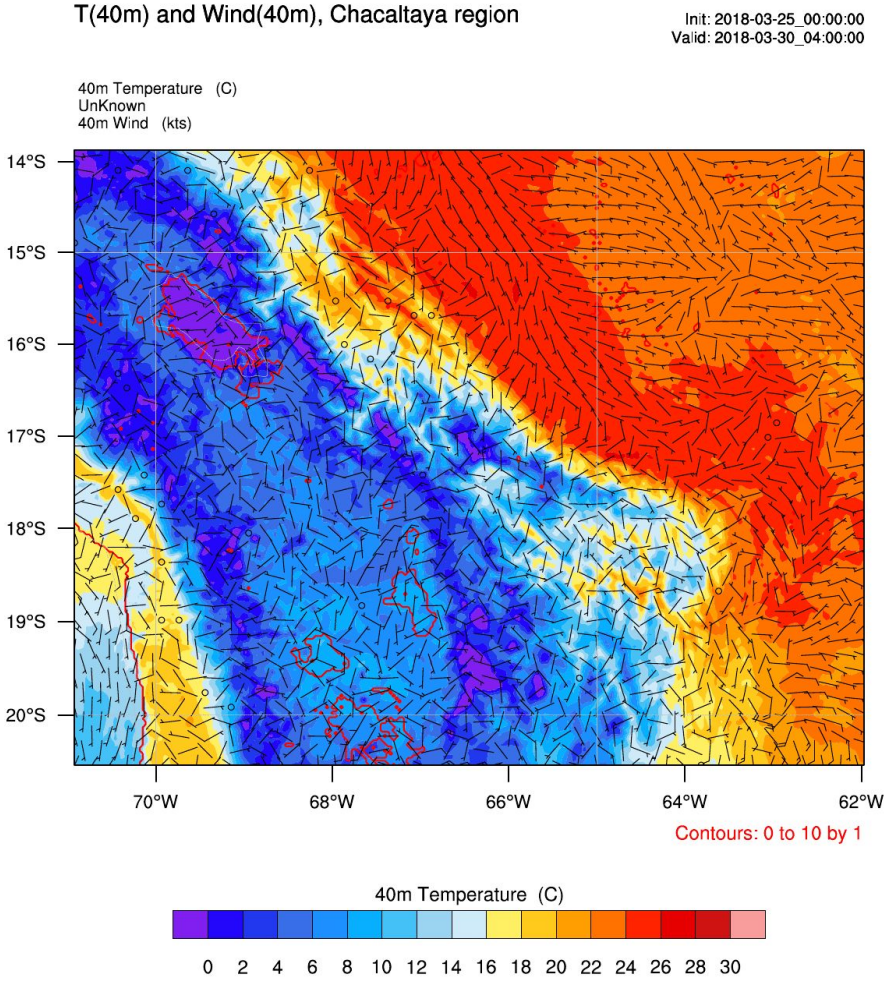


Wind field is poorly reproduced
Could be due to wrong turbulent momentum flux for the surface
Could be improved with different turbulent and surface-layer schemes

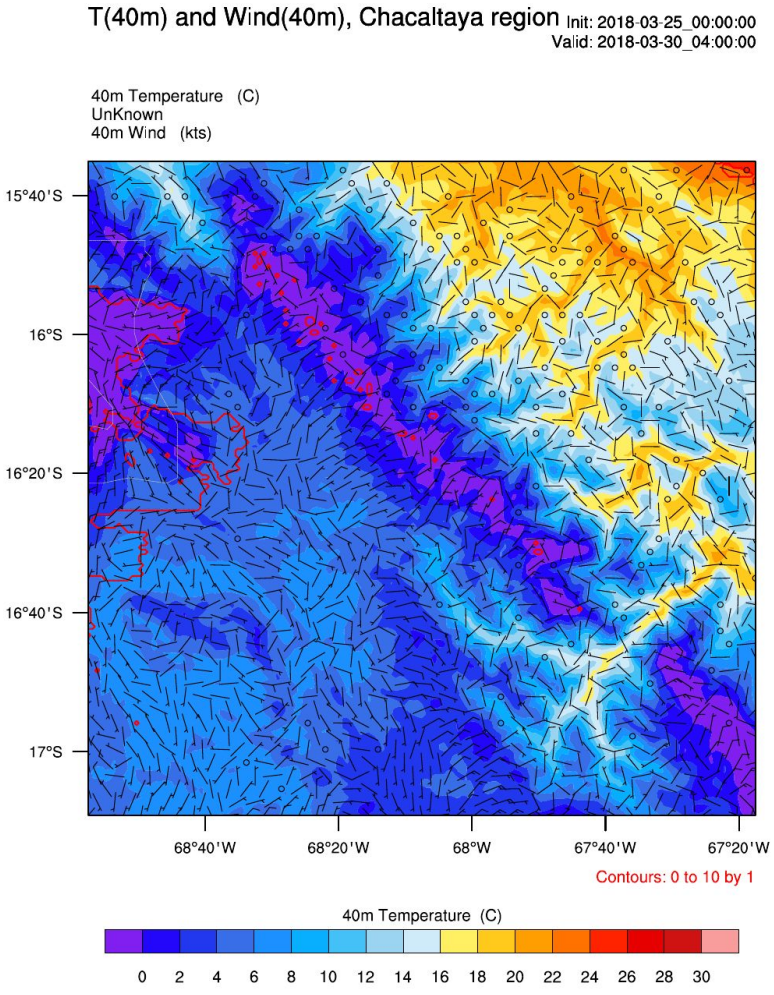
Evgeny Kadantsev

General behaviour of WRF

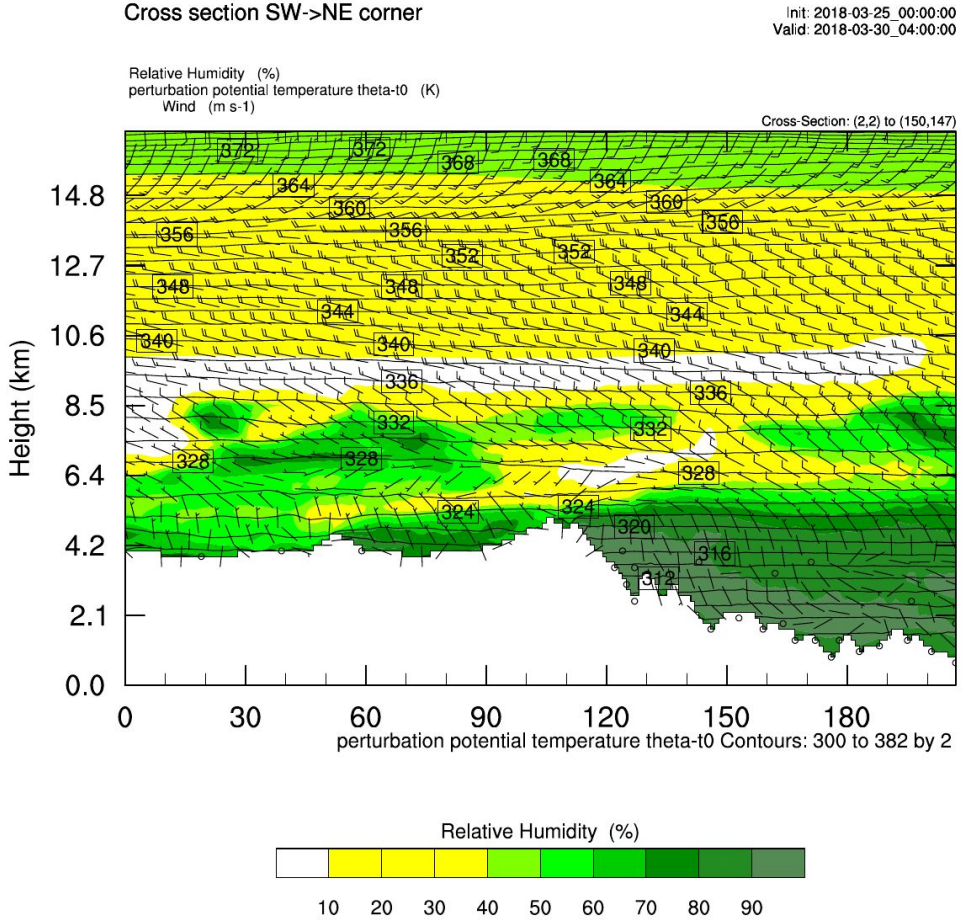
- Target: to find all errors and unphysical features in WRF simulations
- Visual inspection (animations in next slides):
  - no clearly unphysical features visible except for the too cold lakes
  - cold air spreading from the lakes, stabilization of boundary layer in Altiplano
  - otherwise reasonable looking boundary layer and convection


T(40m) and Wind(40m), Chacaltaya region
Init: 2018-03-25_00:00:00
Valid: 2018-03-30_04:00:00
40m Temperature (C)
UnKnown
40m Wind (kts)
14°S
15°S
16°S
17°S
18°S
19°S
20°S
70°W
68°W
66°W
64°W
62°W
Contours: 0 to 10 by 1
40m Temperature (C)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

Lauri Tuppi


T(40m) and Wind(40m), Chacaltaya region Init: 2018-03-25_00:00:00
Valid: 2018-03-30_04:00:00
40m Temperature (C)
UnKnown
40m Wind (kts)
15°40'S
16°S
16°20'S
16°40'S
17°S
68°40'W
68°20'W
68°W
67°40'W
67°20'W
Contours: 0 to 10 by 1
40m Temperature (C)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

Lauri Tuppi


Cross section SW->NE corner
Init: 2018-03-25_00:00:00
Valid: 2018-03-30_04:00:00
Relative Humidity (%)
perturbation potential temperature theta-t0 (K)
Wind (m s-1)
Cross-Section: (2,2) to (150,147)
Height (km)
14.8
12.7
10.6
8.5
6.4
4.2
2.1
0.0
0
30
60
90
120
150
180
perturbation potential temperature theta-t0 Contours: 300 to 382 by 2
Relative Humidity (%)
10 20 30 40 50 60 70 80 90

Lauri Tuppi

Next

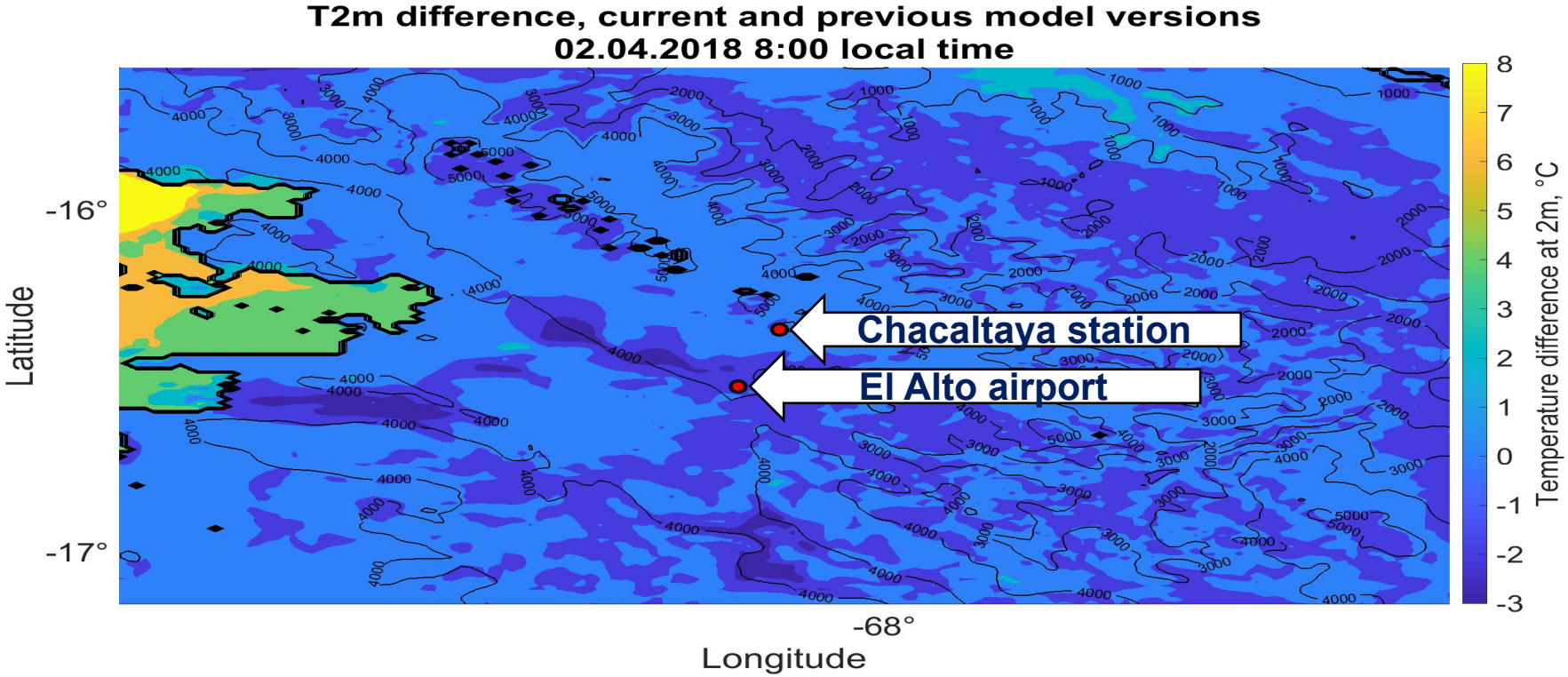
- Verification statistics (RMSE, bias) against surface observations
- Perhaps new WRF model run with manually set proper surface conditions (lake temperature), different boundary layer scheme
- + verification

3d Presentation

Meteorology and Modelling

Evgeny Kadantsev, Dan Thomas, Lauri Tuppi

Modified WRF run: 25.03 – 05.04.2018, 64 CPUs on csc.fi
~46 real time hours, ready by 22:00 today



Evgeny Kadantsev

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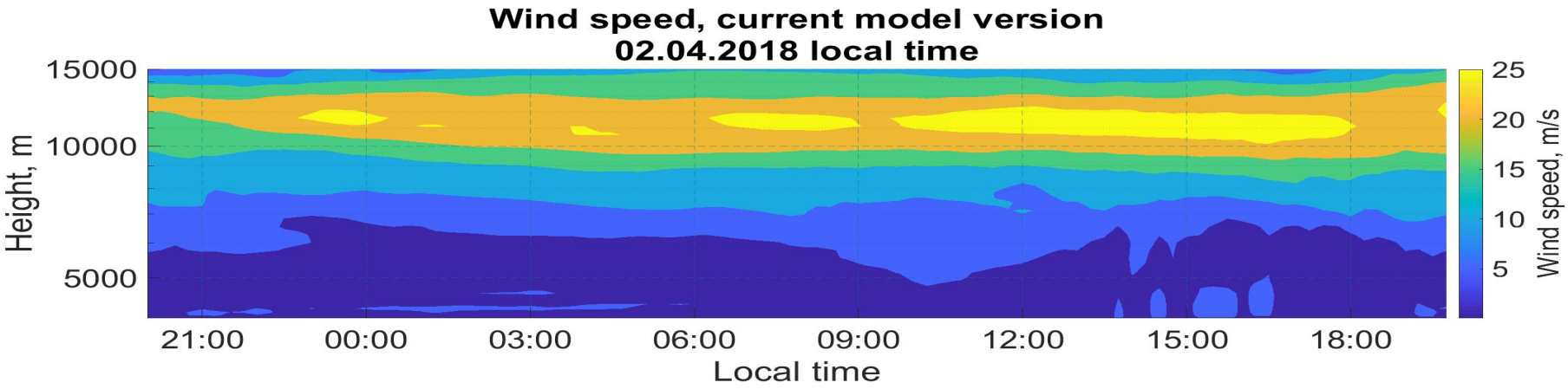

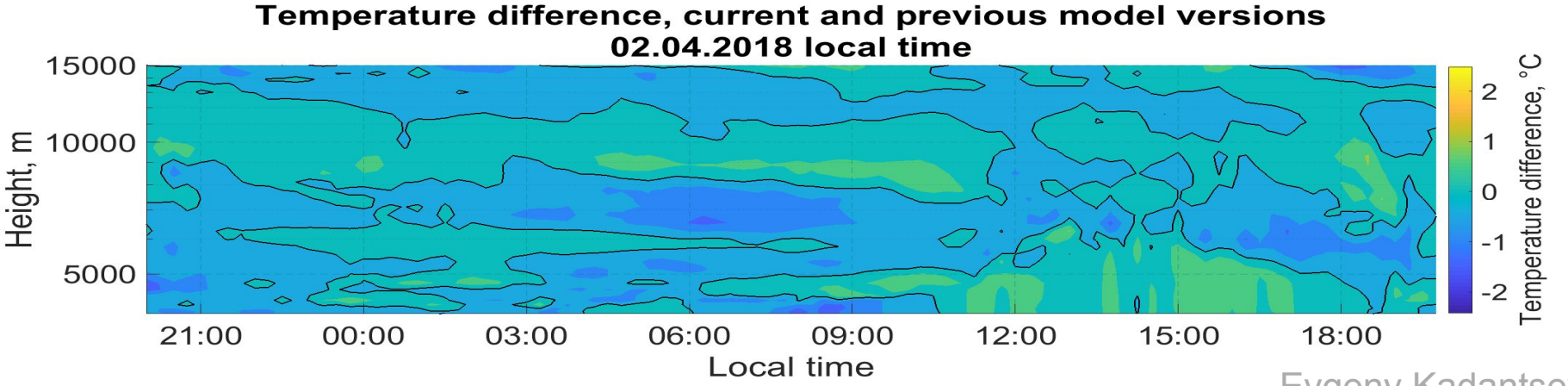

Evgeny Kadantsev

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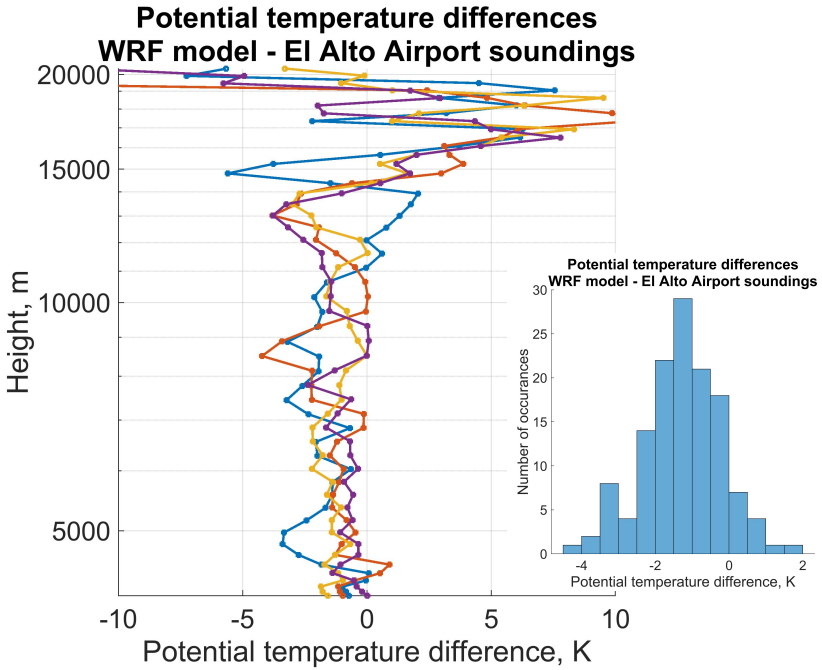

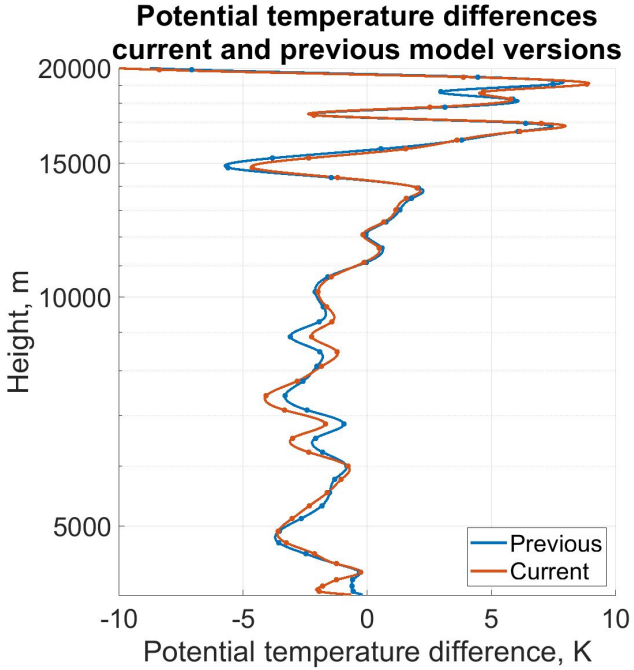

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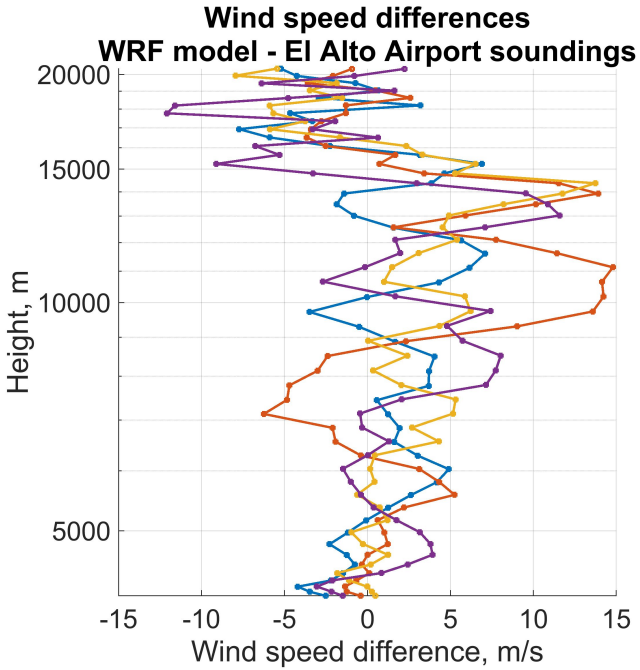

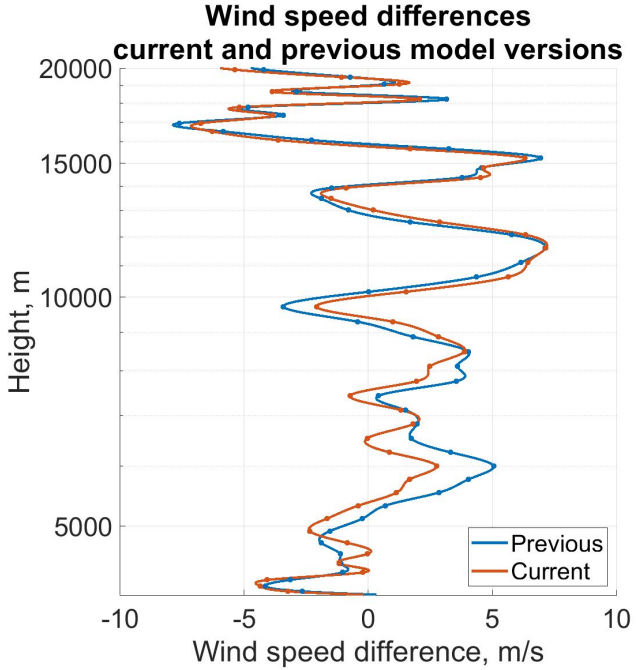

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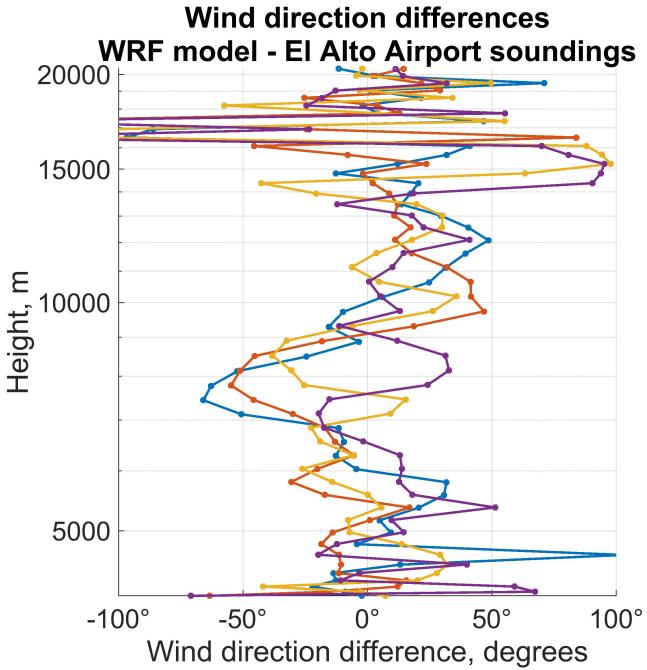
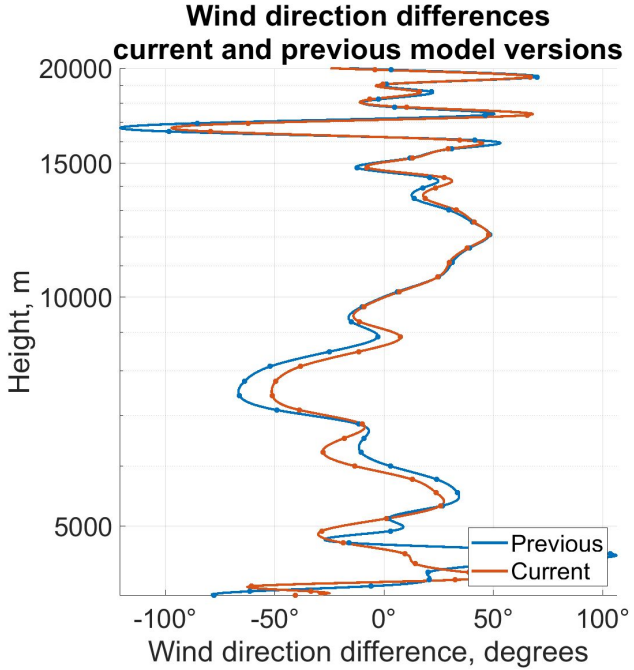
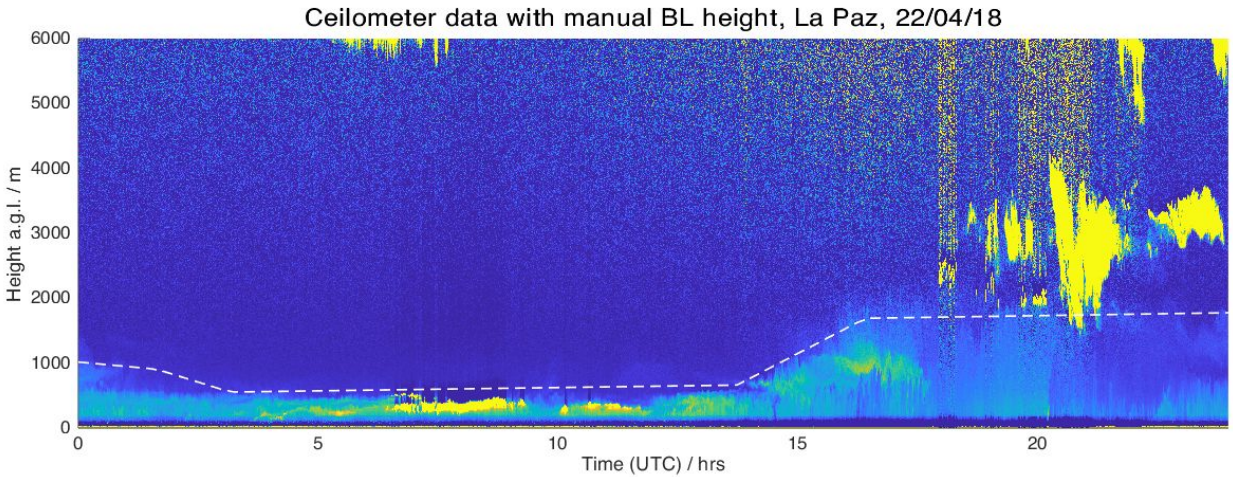




Meteorology

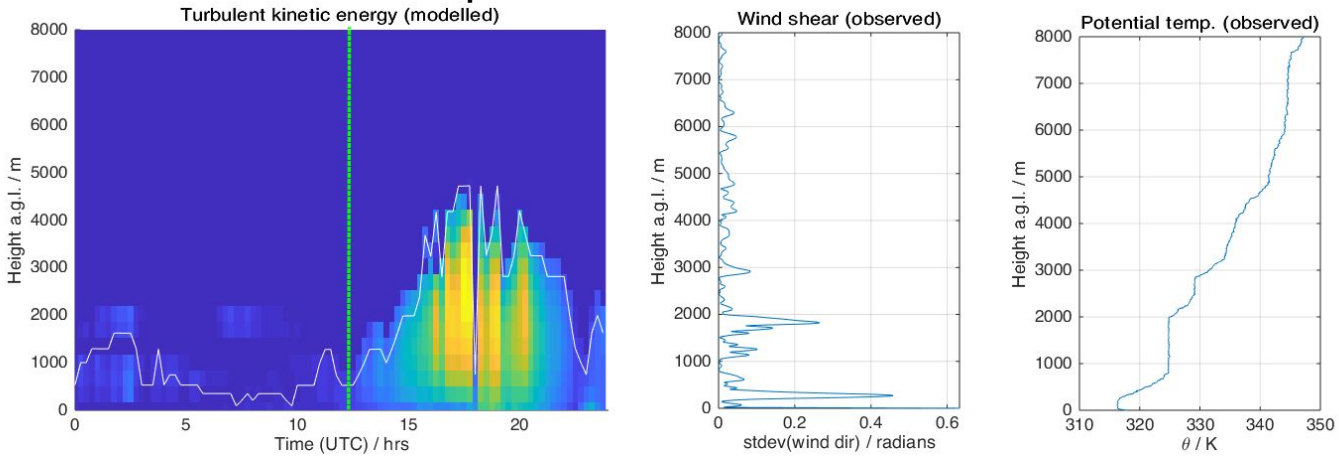
- Boundary layer info from ceilometer data + qualitative information



Comparison to model

- Comparing **modelled TKE** (Turbulent Kinetic Energy) to **observed wind shear** and **observed potential temperature**

02/04/18, La Paz, previous model. Observations at 12:00 UTC (08:00 local time)



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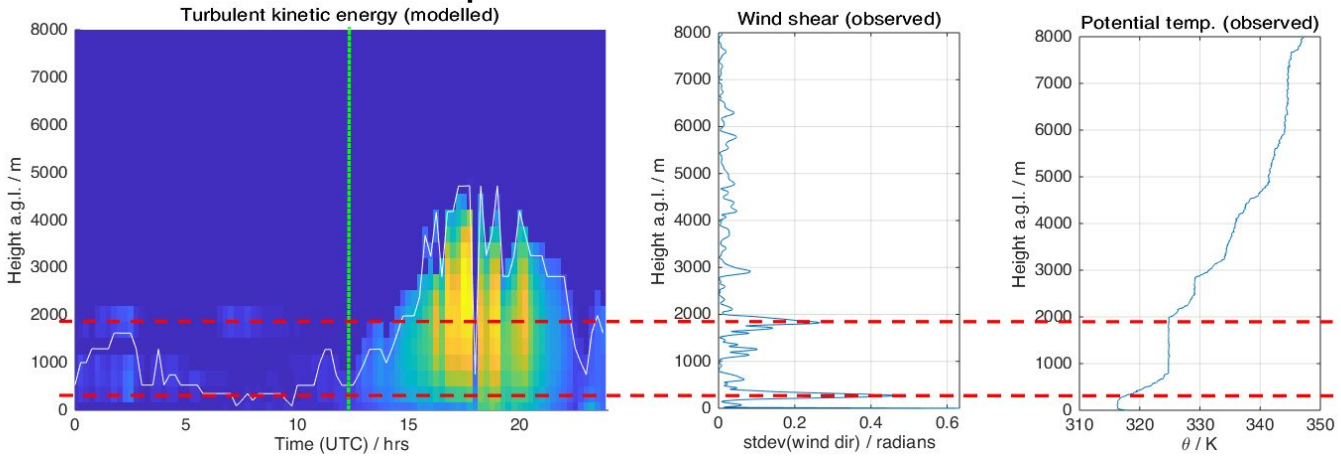

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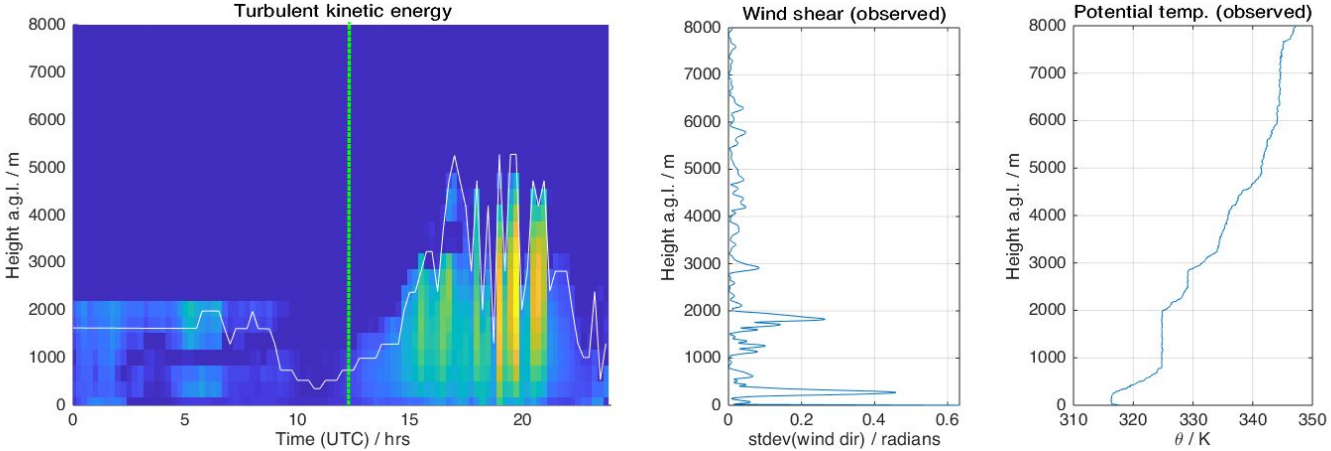

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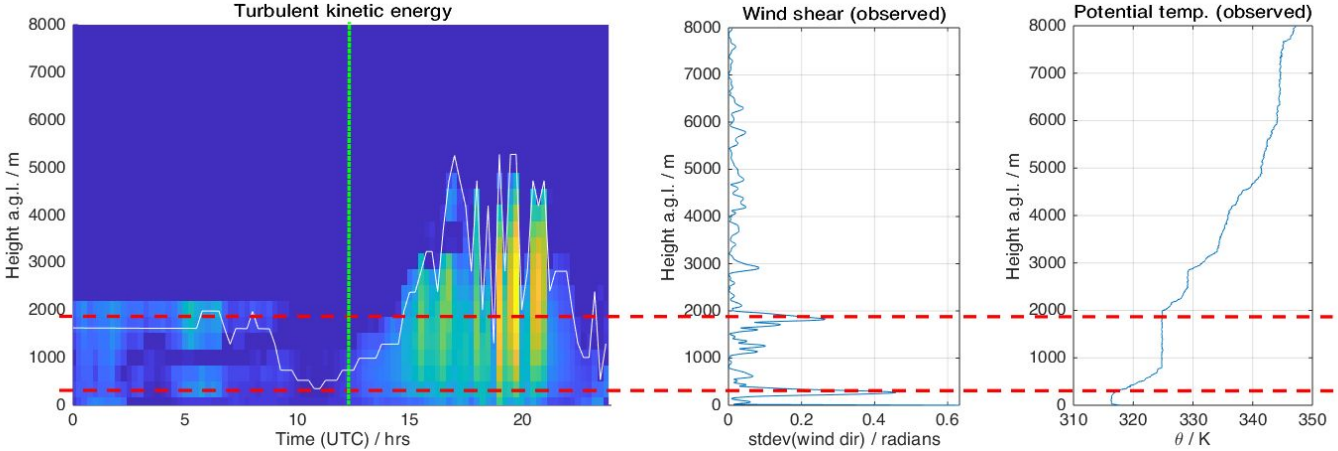
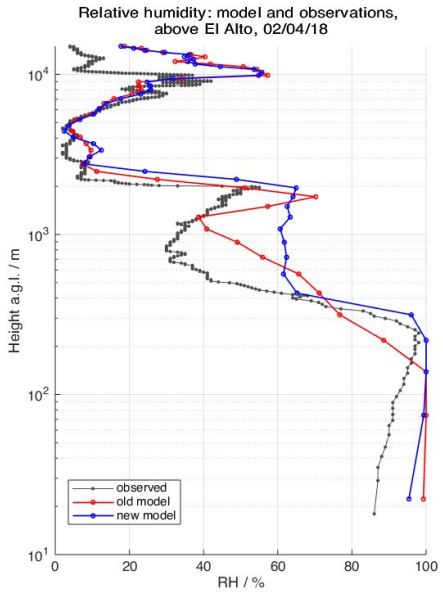
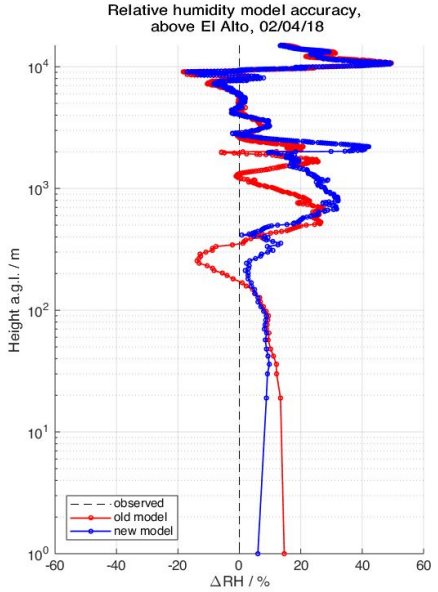


Comparison to model

- Relative humidity reproduced better in first 500 m a.g.l.
- Need to test for more days

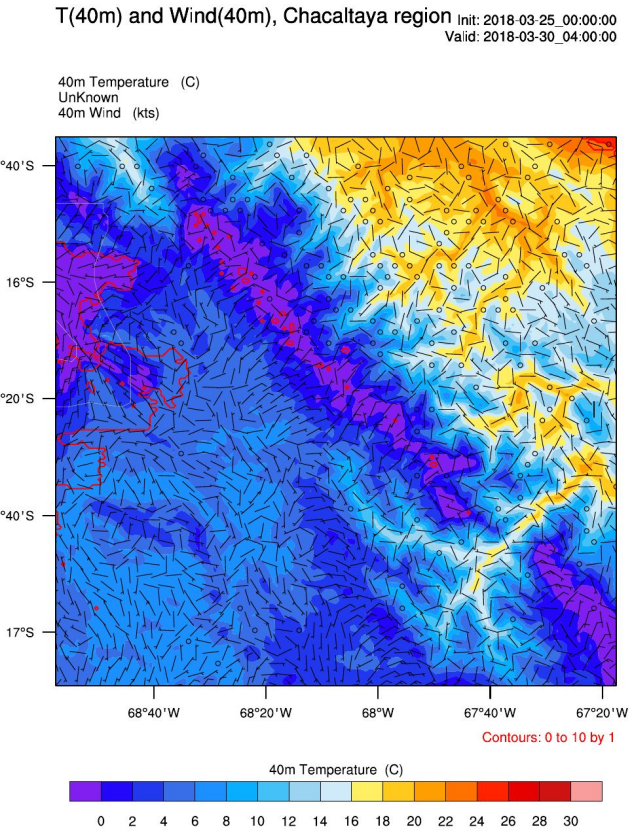




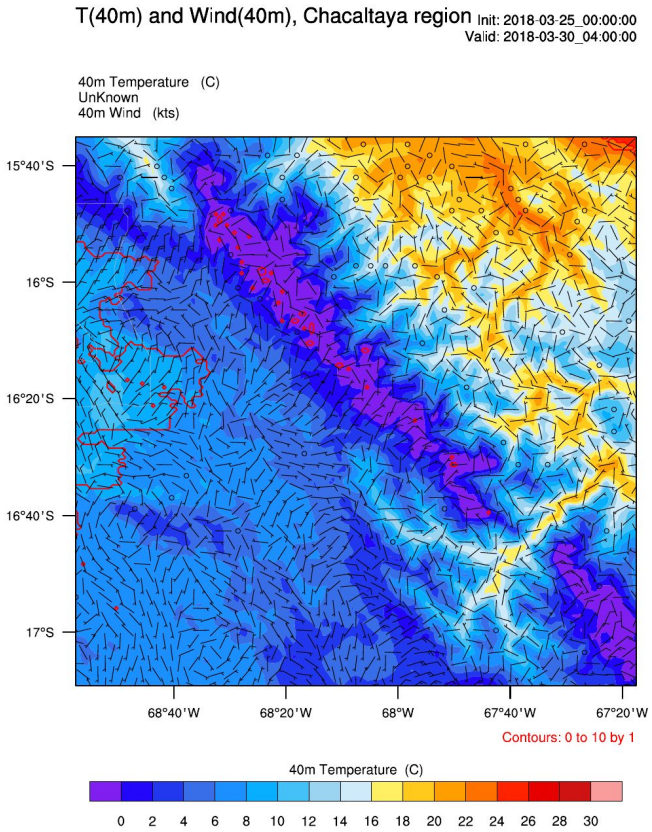
New WRF simulation

- We increased the surface temperature of Lake Titicaca to +17ºC
- Generally slightly warmer model
- No more unrealistically cold low level temperatures, and wind blowing from the lake
- Slightly more convection near the lake (not visible in these animations)

Lauri Tuppi



Old model

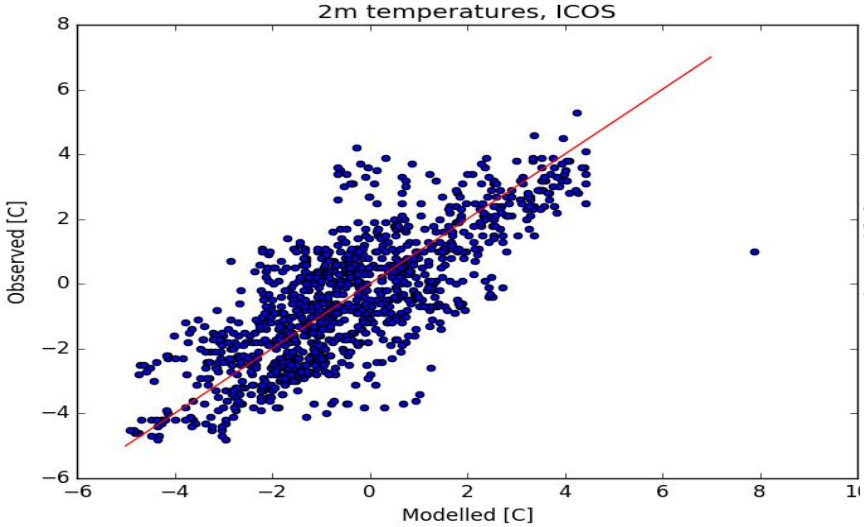


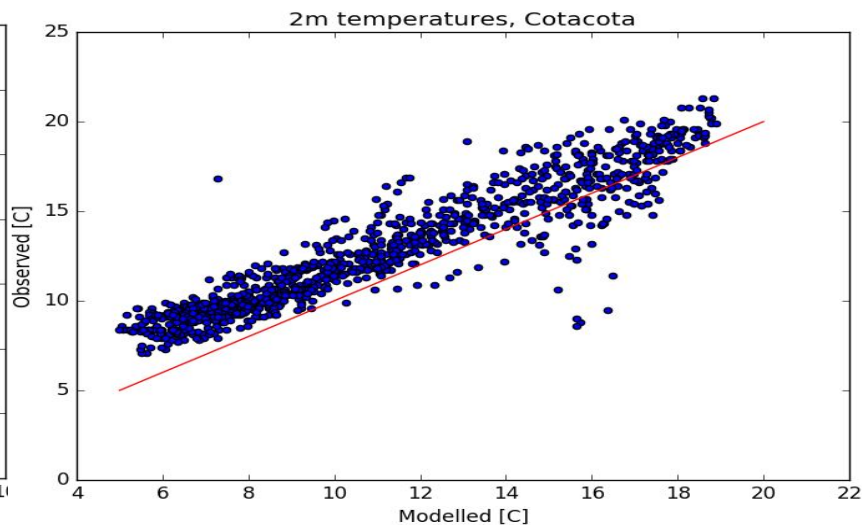
New model
- less NW wind in day time

Verification against observations

- ICOS (mountain) and CotaCota (Altiplano, foothills) stations
- 2m temperature
- Aim to reduce bias and RMSE
- - due to connections between modelled processes surprises are possible

Old model





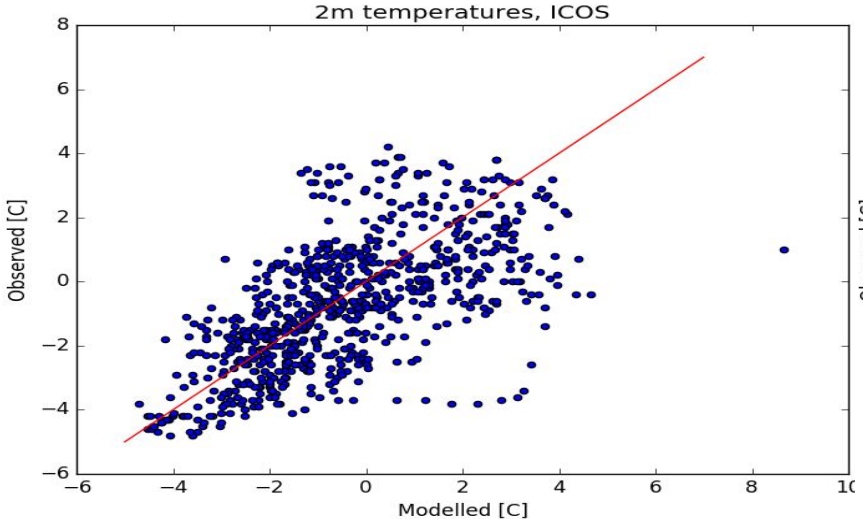
Bias = 0.0018 C
RMSE = 1.15 C
CORR = 0.72

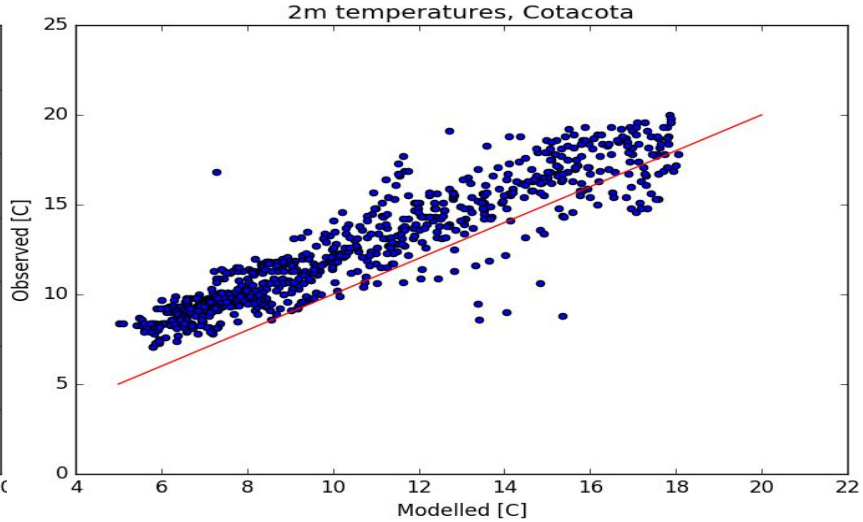
Bias = -1.83 C
RMSE = 4.25 C
CORR = -0.0094

CORR = Pearson product moment correlation between modelled and observed 2m temperature

Lauri Tuppi

New model





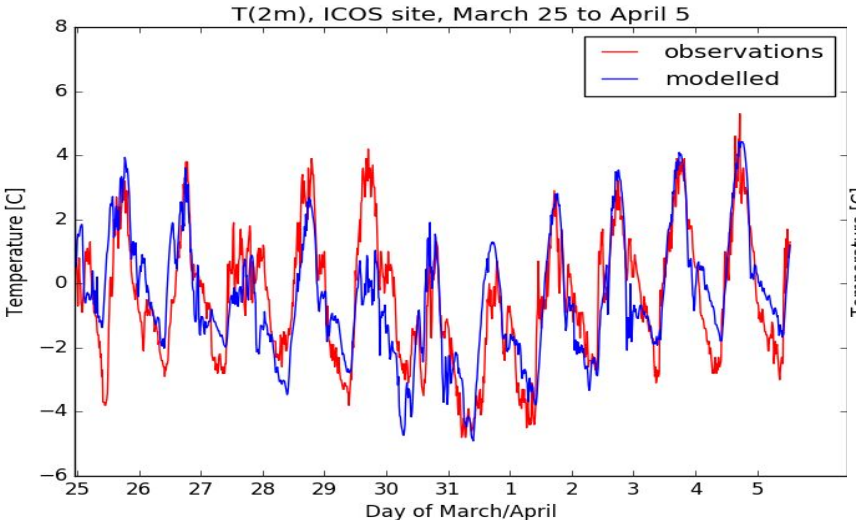
Bias = 0.26 C
RMSE = 1.31 C
CORR = 0.64

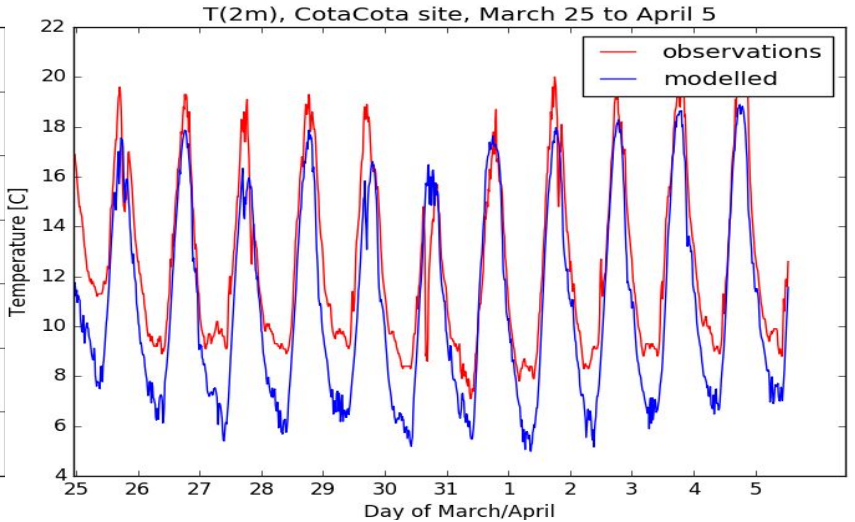
Bias = -2.22 C
RMSE = 4.25 C
CORR = -0.0021

Slight degradation of scores in these stations – not meaning degradation of Entire simulation

Lauri Tuppi

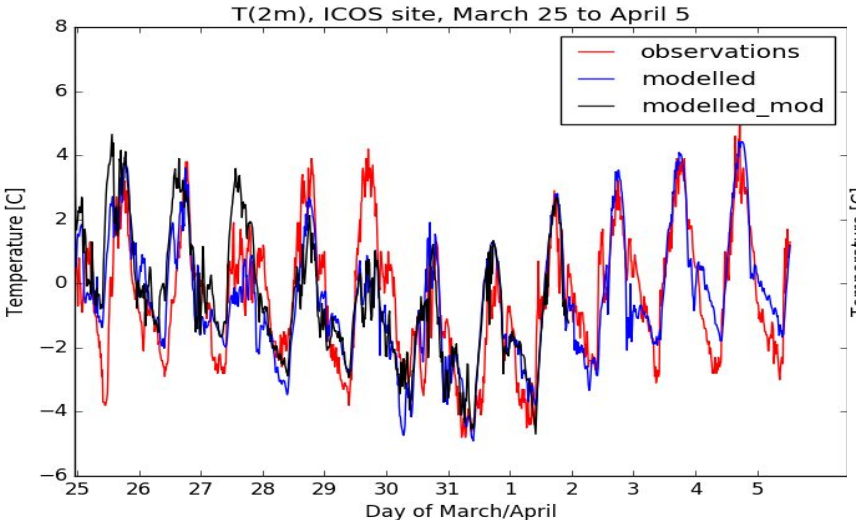
Old model

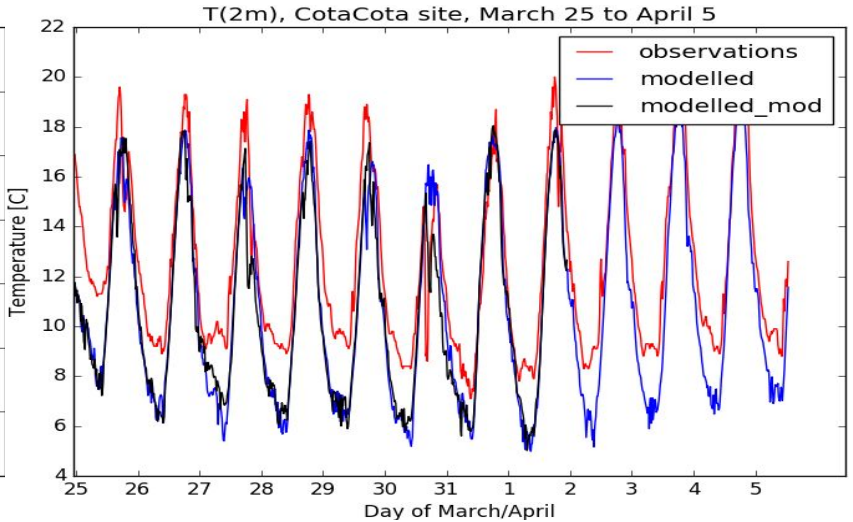




Lauri Tuppi

New model





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Conclusions

- WRF is a step closer to give reliable data for back trajectories
- Slight deterioration of scores of one variable from two stations does not mean deterioration of entire model
- We believe that WRF is now physically realistic in Chacaltaya's surroundings
- Remaining questions: the Southern lakes / salt