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Forecasting meteotsunamis with Neural Networks

M.Vich and R. Romero

MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD
AGENCIA ESTATAL DE INVESTIGACIÓN
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
"A way to make Europe"

Grup de Meteorologia
UIB Universitat de les Illes Balears
#SOM UIB

COASTEPS meeting – Palma, May 2019

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Motivation

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Motivation

SOCIB / Balearic RIssaga Forecasting System (BRIFS)

SOCIB Balearic Islands Coastal Observing and Forecasting System

http://www.socib.eu/?seccion=modelling&facility=rissagaforecast

Predicció Probabilística del Risc de RISSAGA al Port de Ciutadella

Grup de Meteorologia

UIB Universitat de les Illes Balears

https://meteo.uib.es/rissaga/

Computational Cost

+

-

Can we go further?

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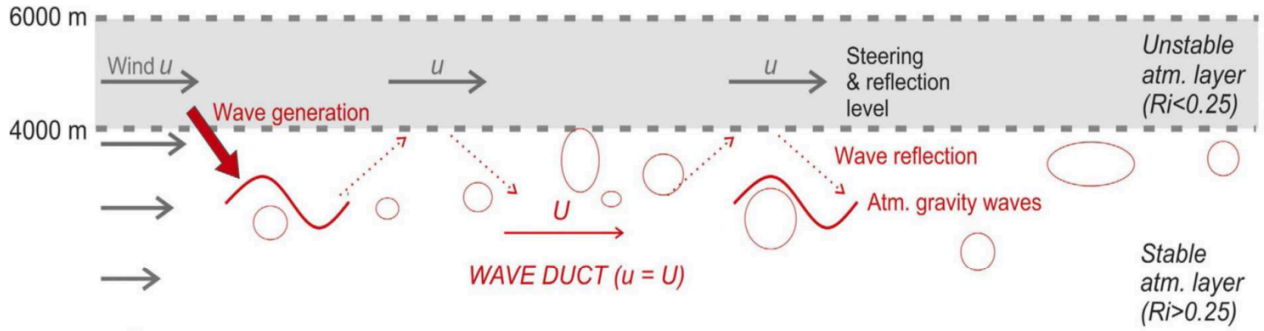
Background

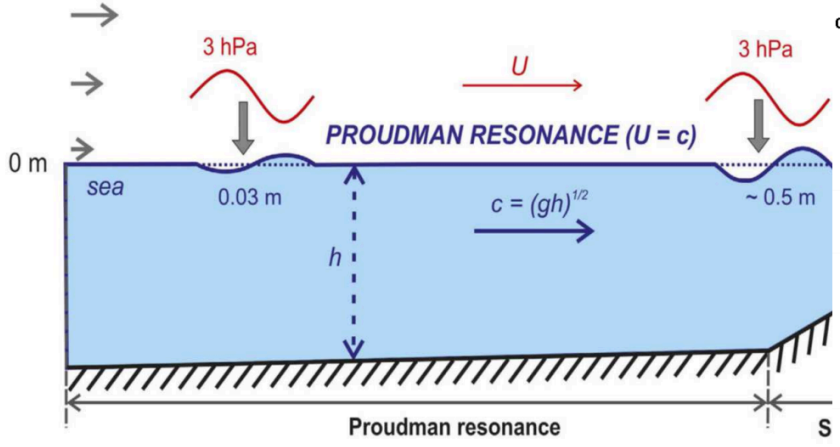
*TRAM_**non_hydro_set1_2D_oroSTRETCH_implicit***

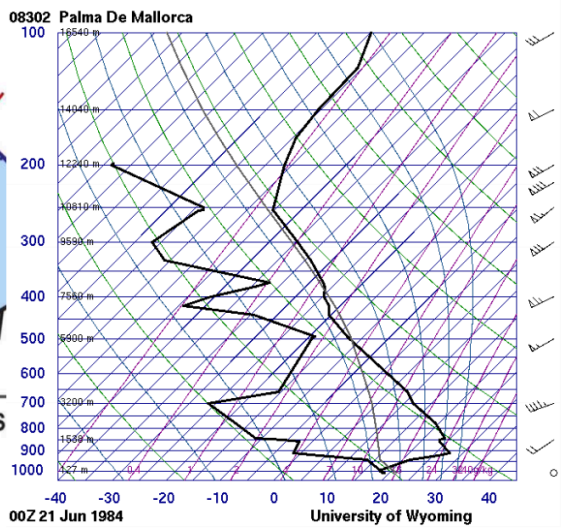
> **"Rissaga" Study**

(dx=250m,dzm=250m,stretch=5,dt=0.75s,Nstep=10,24h)



Run





Šepić et al. (2015)

https://meteo.uib.es/rissaga/

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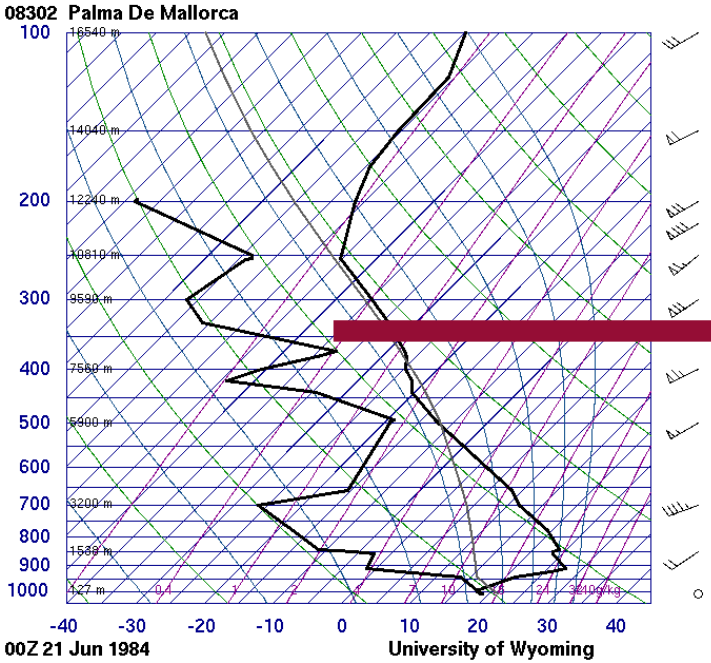
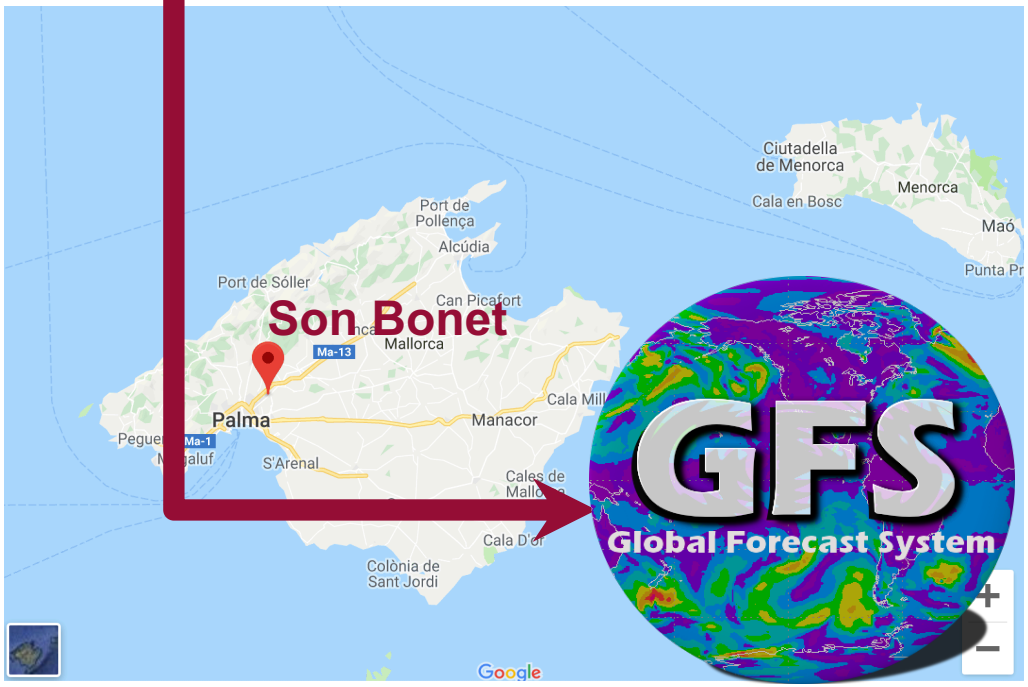
Background



GFS “soundings”

for daily running



https://meteo.uib.es/rissaga/

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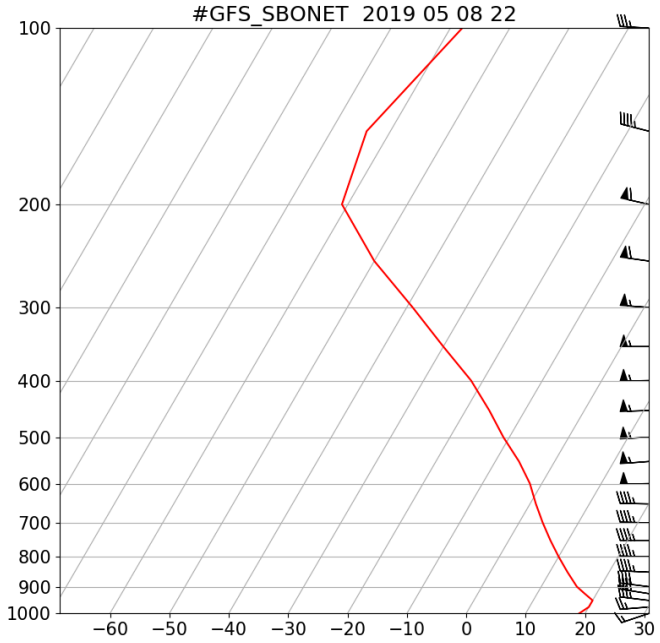
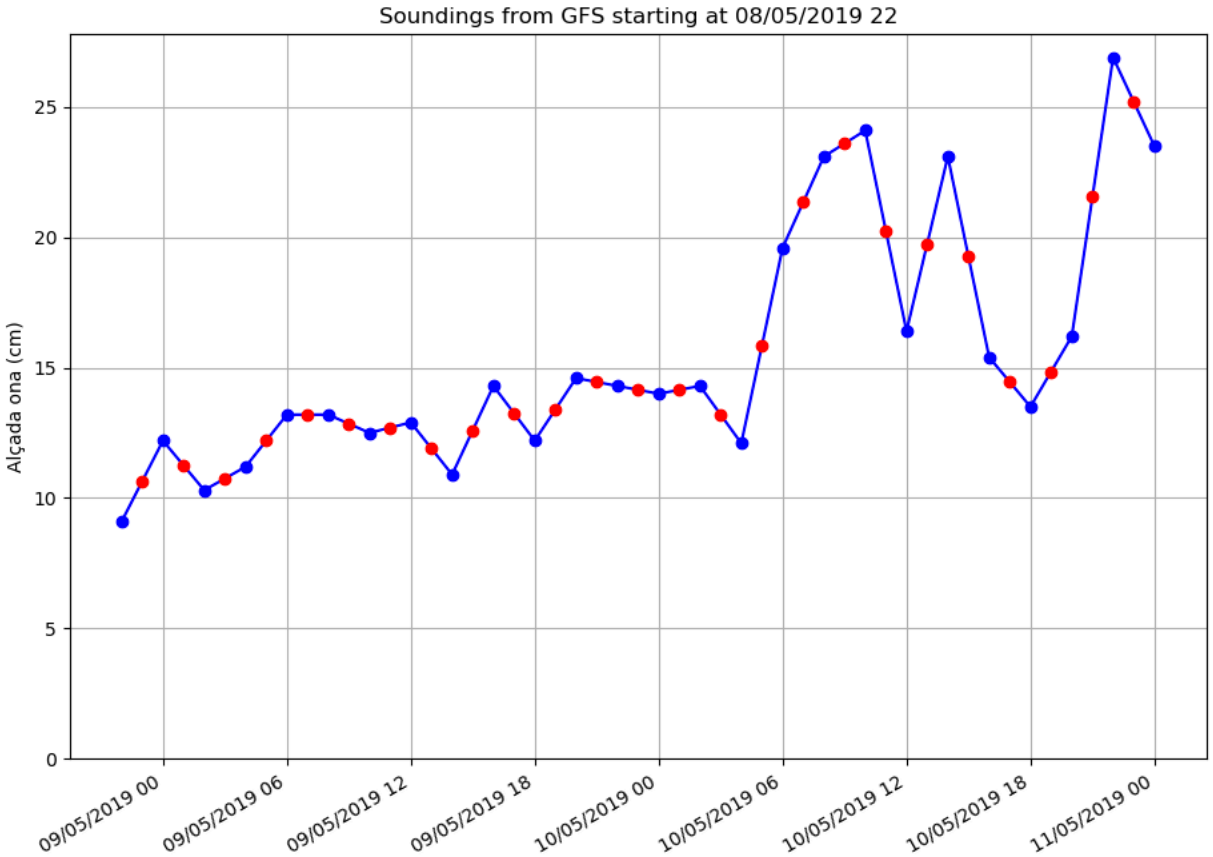
Background



26 simulations!!
6 h a regular day



https://meteo.uib.es/rissaga/

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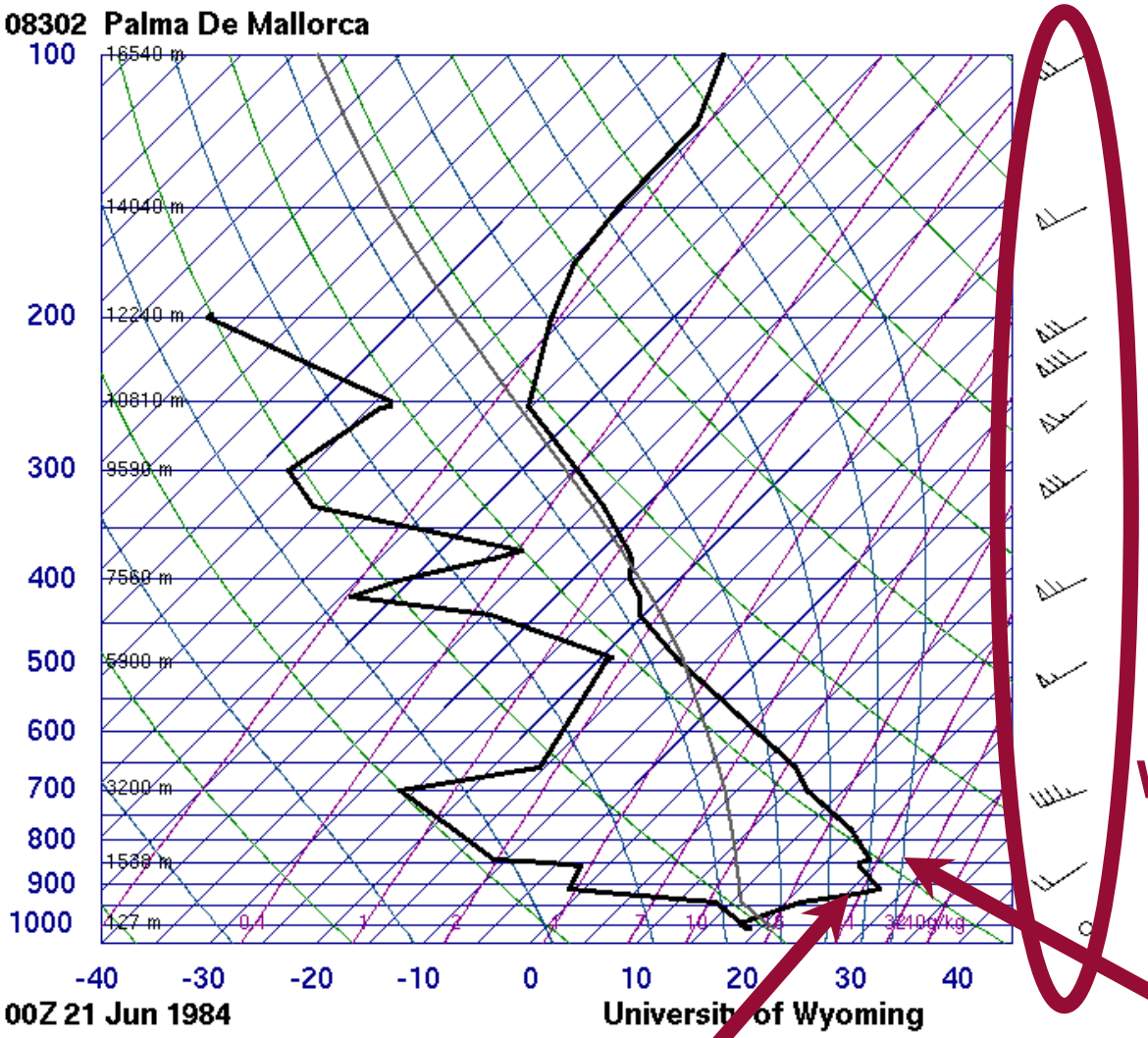
Background

Typical rissaga sounding



SLAT 39.61
SLON 2.71
SELV 41.00
SHOW 4.17
LIFT -0.33
LFTV -0.55
SWET 136.9
KINX -8.10
CTOT 6.50
VTOT 35.50
TOTL 42.00
CAPE 83.27
CAPV 101.5
CINS -1322
CINV -1164
EQLV 384.5
EQTV 382.5
LFCT 506.7
LFCV 510.9
BRCH 0.74
BRCV 0.90
LCLT 289.2
LCLP 947.9
MLTH 293.7
MLMR 12.36
THCK 5773.
PWAT 19.13

Wind shear

Unstable layer

Stable layer

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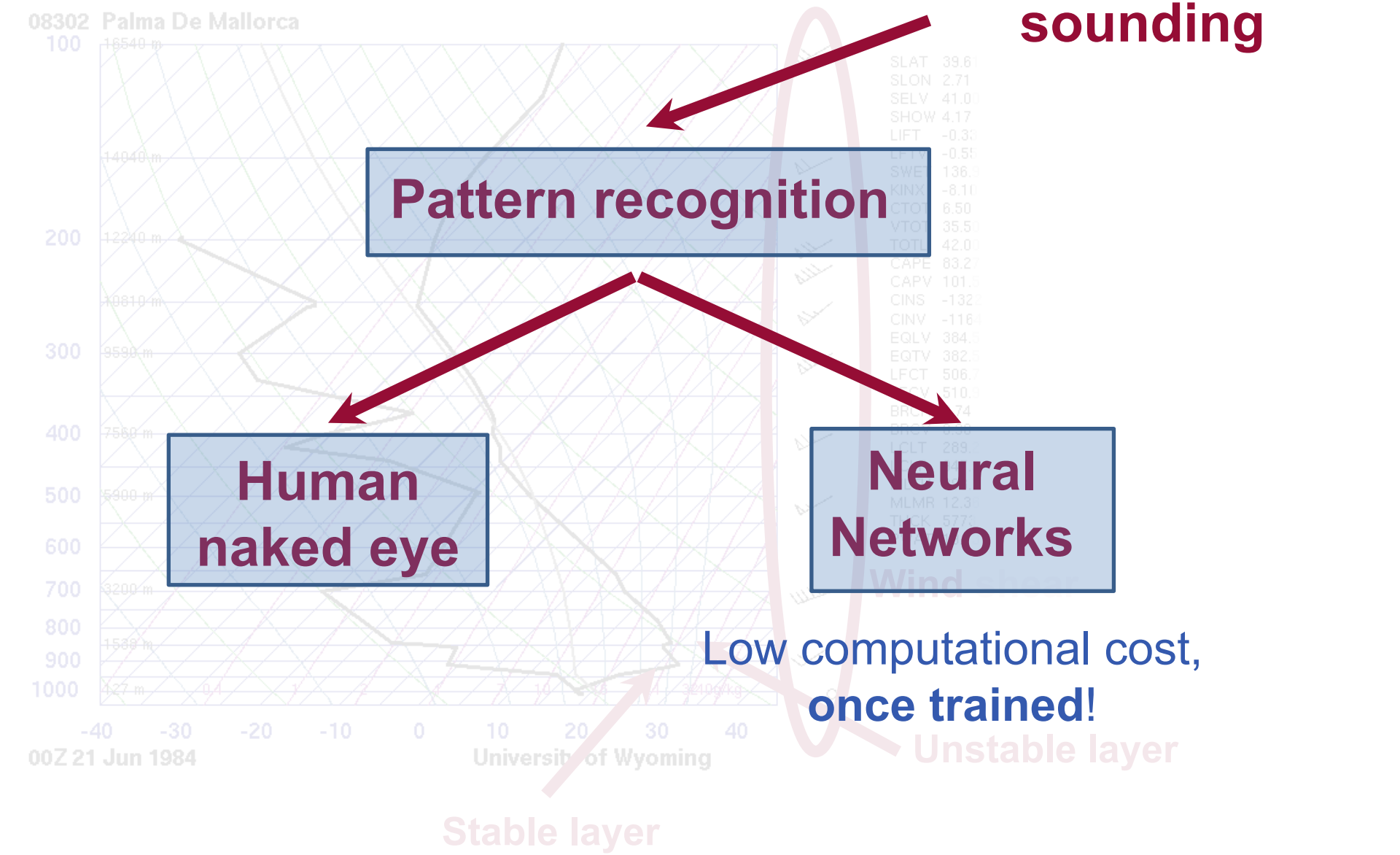

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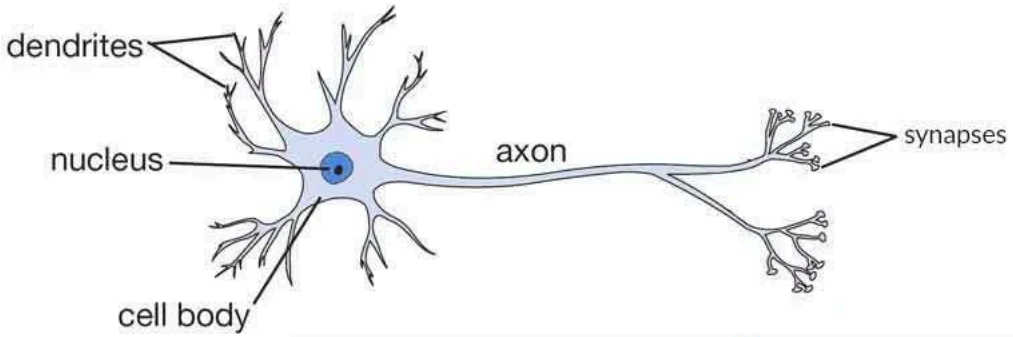
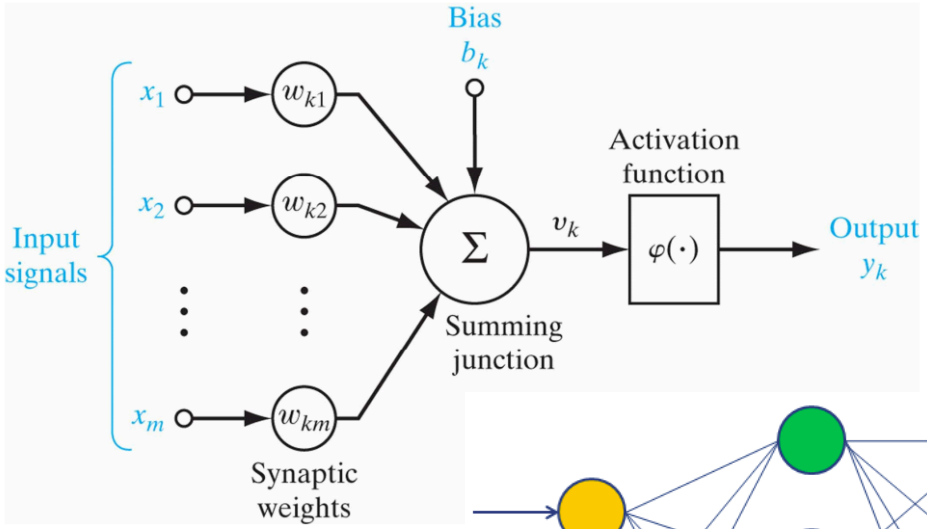
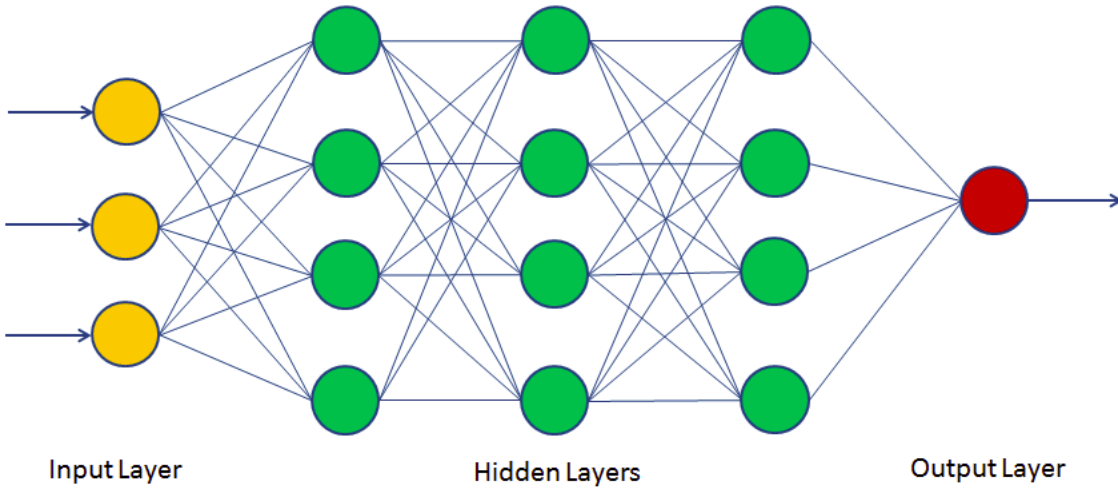
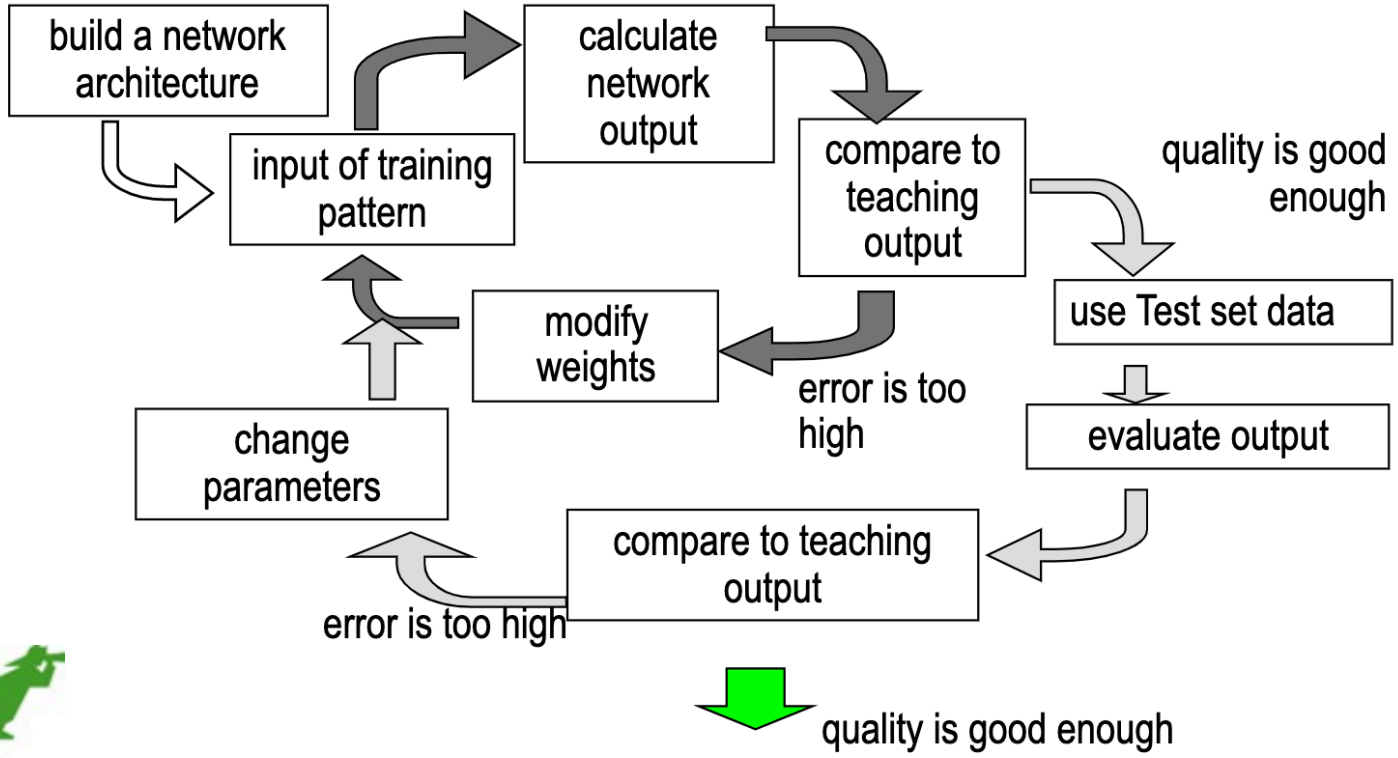
Neural networks







Neural networks



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Our neural network setup

Package 'neuralnet'

February 7, 2019

Type Package

Title Training of Neural Networks

Version 1.44.2

Date 2019-02-07

Depends R (>= 2.9.0)

Imports grid, MASS, grDevices, stats, utils, Deriv

Description Training of neural networks using backpropagation, resilient backpropagation with (Riedmiller, 1994) or without weight backtracking (Riedmiller and Braun, 1993) or the modified globally convergent version by Anastasiadis et al. (2005). The package allows flexible settings through custom-choice of error and activation function. Furthermore, the calculation of generalized weights (Intrator O & Intrator N, 1993) is implemented.

License GPL (>= 2)

Suggests testthat

URL https://github.com/bips-hb/neuralnet

BugReports https://github.com/bips-hb/neuralnet/issues

RoxygenNote 6.1.0

NeedsCompilation no

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Repository CRAN

Date/Publication 2019-02-07 22:20:07 UTC

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Our neural network setup

Algorithm type to calculate the neural network (NN)

Rprop+

Resilient backpropagation with weight backtracking

- First order minimizing algorithms - a general method for **gradient based optimization**.
- Particularly used for the optimization the weights of Artificial Neural Networks due to its **faster convergence**.
- Takes into account only the **sign of the partial derivative over all patterns (not the magnitude)** to indicate the direction of the weight update, and acts independently on each "weight".
- Weight backtracking means **retracting a previous weight update** for some or all weights. Whether to take back a step or not is decided by means of a heuristic.

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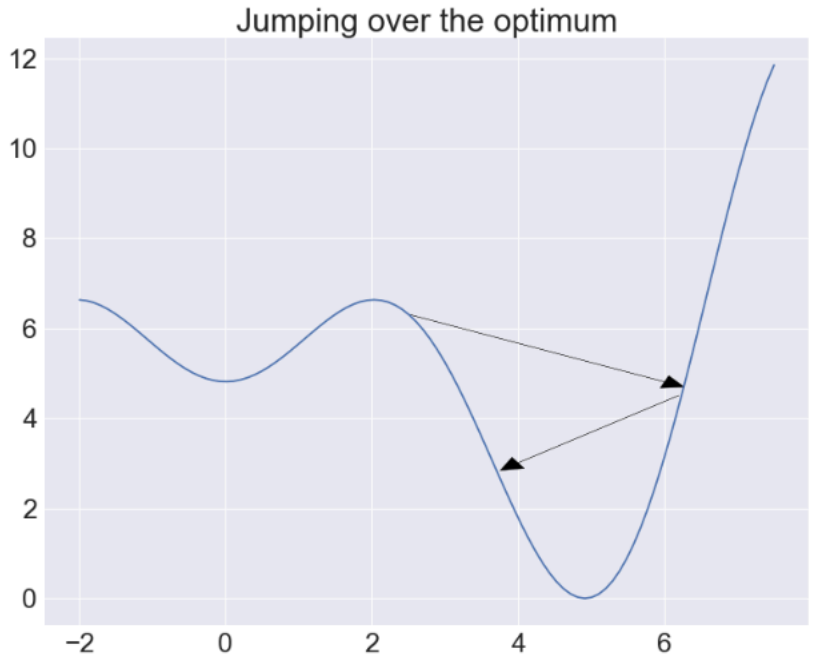

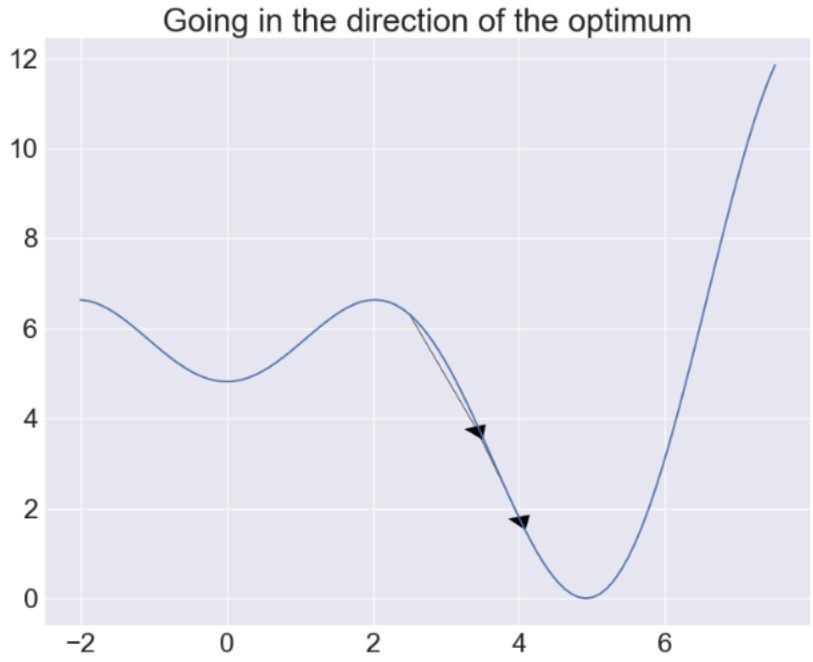

The gradient direction changes when jumping over optima

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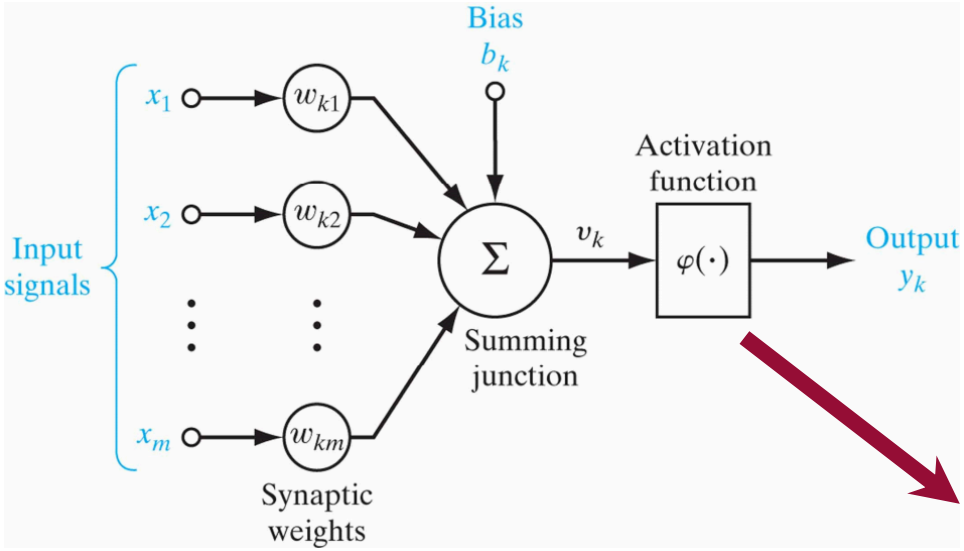
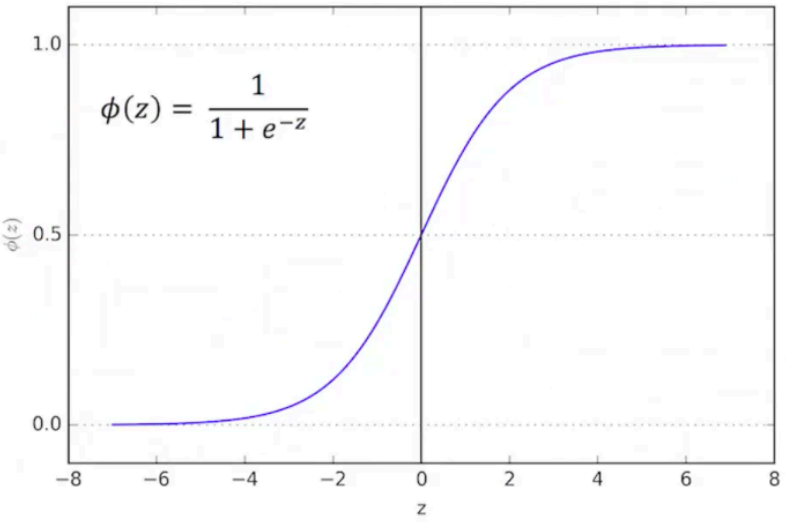


Activation function: Logistic function



Activation functions

- Determine the output of a neural network and each individual neuron.
- Help normalize the output of each neuron to a range between 1 and 0 or between -1 and 1.

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Our neural network setup

Database

Training (75%) – Test (25%)

- **126 rissaga days**
  Extending heterogeneously from July 1981 to July 2018 (plus one old case from September 1975).

- **549 non-rissaga days**
  Quasi-continuous record from December 2016 to July 2018. After filtering out a dozen of rissaga days happened in period and discarding those days without thermodynamic soundings available.

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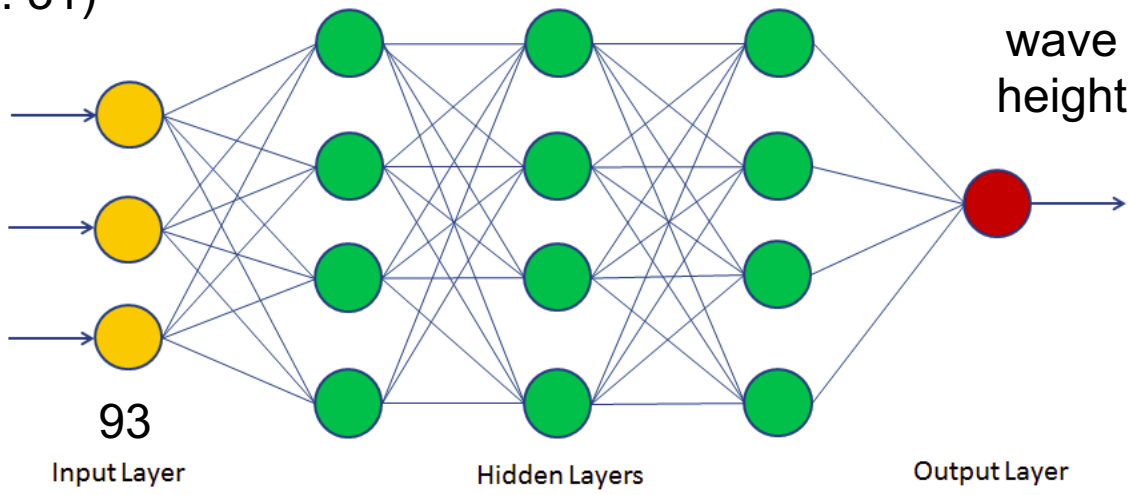
Our neural network setup

Design

"GFS soundings"
(same pressure levels: 31)

- Temperature
- u-wind component
- v-wind component



stopping criteria (threshold) role?

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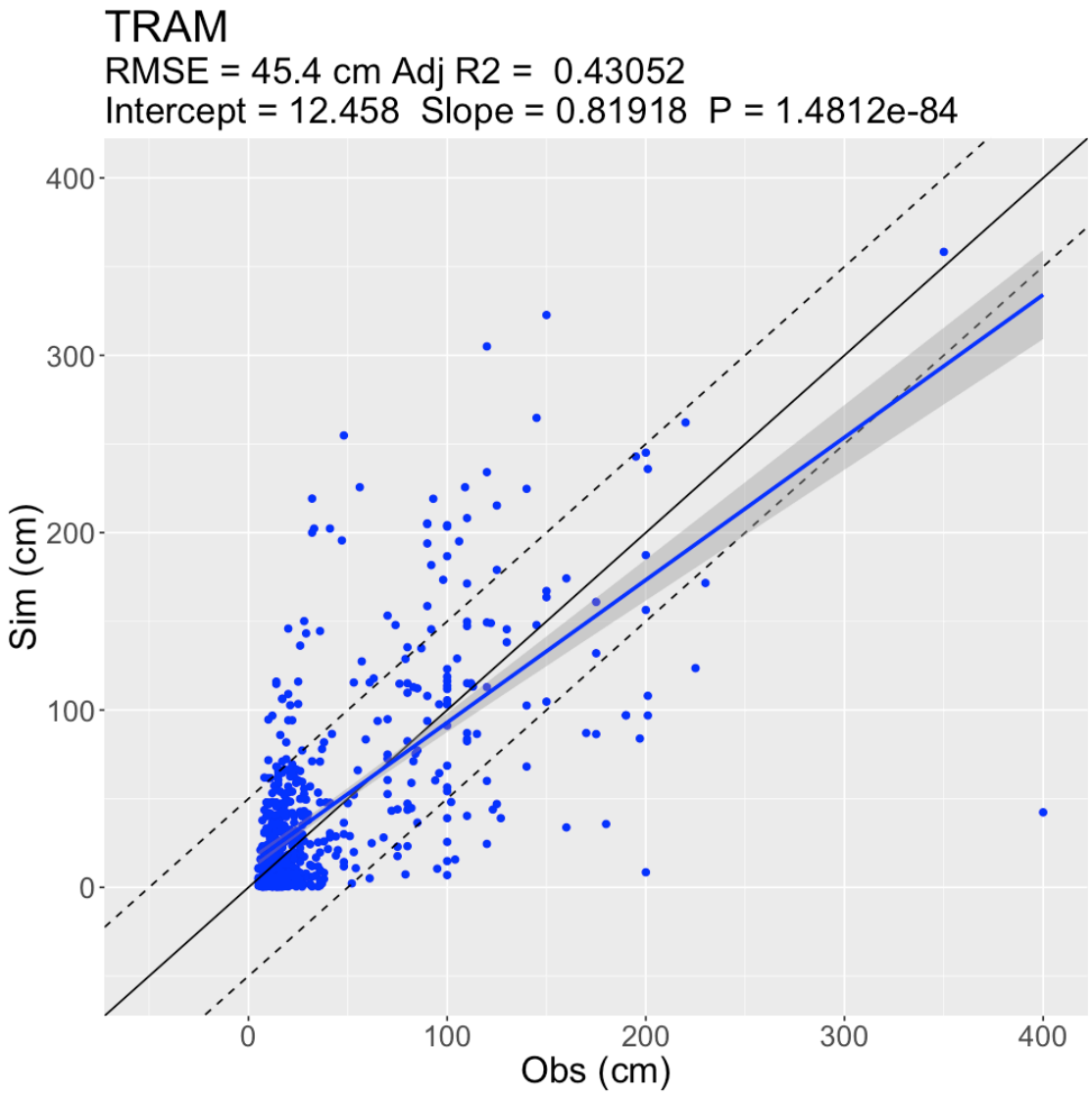
Results



Can we do better?

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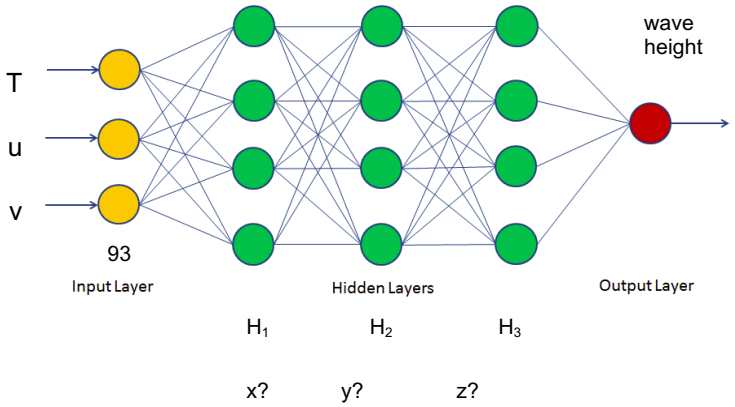
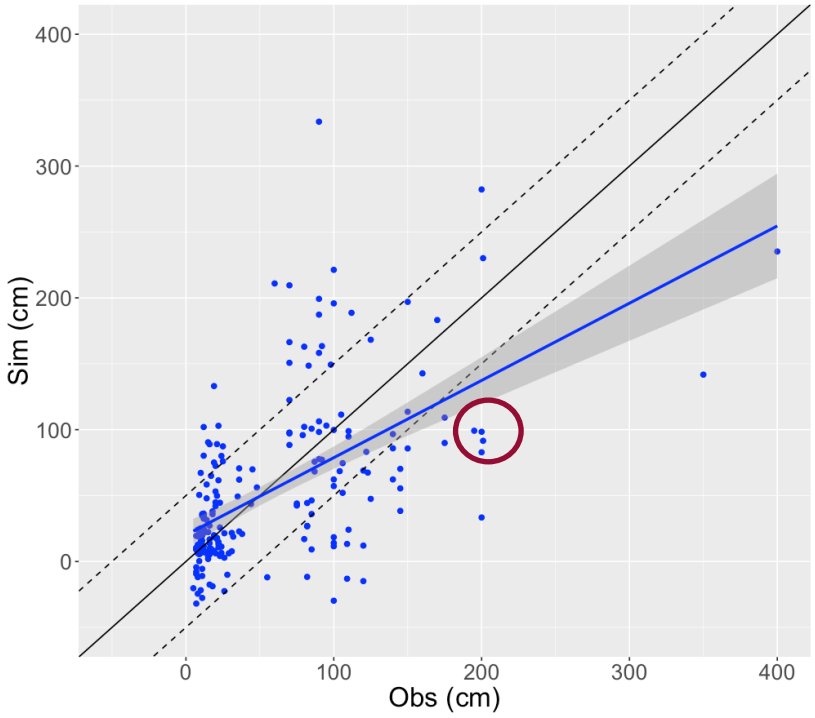
Results



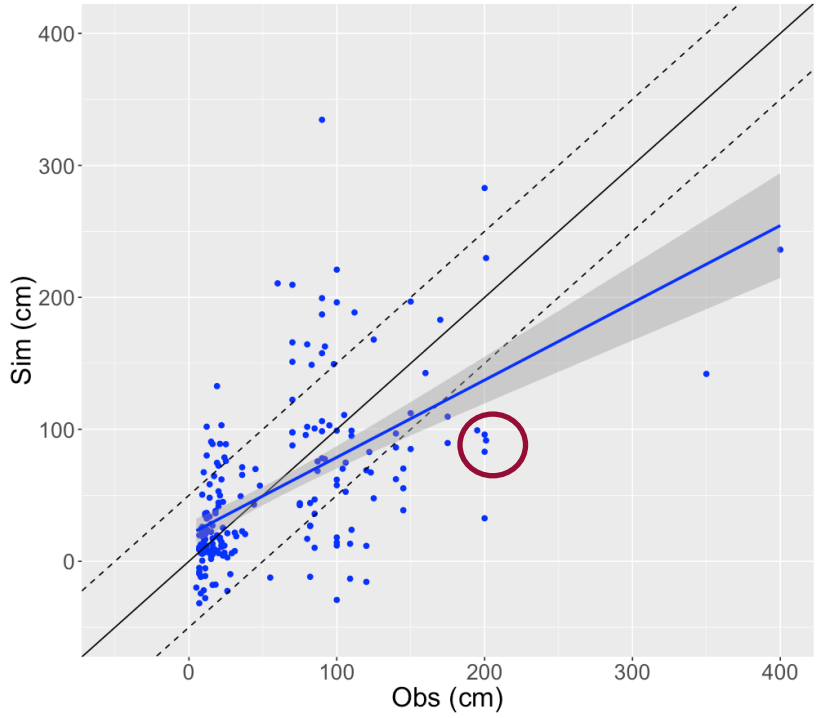
Threshold: **0.1**

H1: 70 , H2: 45 , H3: 25 - Threshold: 0.1
RMSE = 56.9 cm Adj R2 = 0.32954
Intercept = 19.461 Slope = 0.59063 P = 5.0548e-20



Threshold: **0.05**

H1: 70 , H2: 45 , H3: 25 - Threshold: 0.05
RMSE = 56.9 cm Adj R2 = 0.32882
Intercept = 19.54 Slope = 0.59003 P = 5.65e-20



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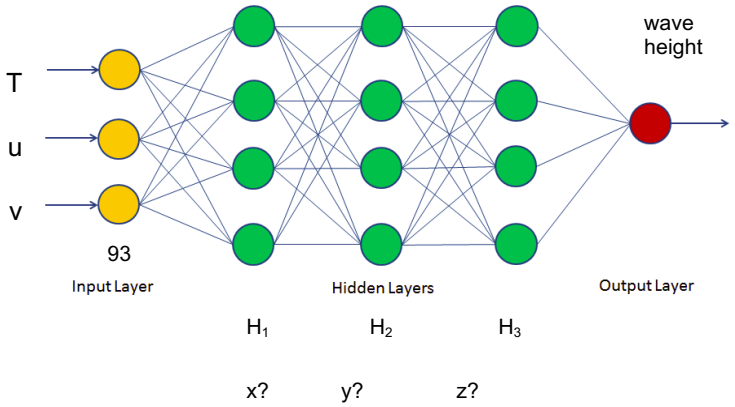
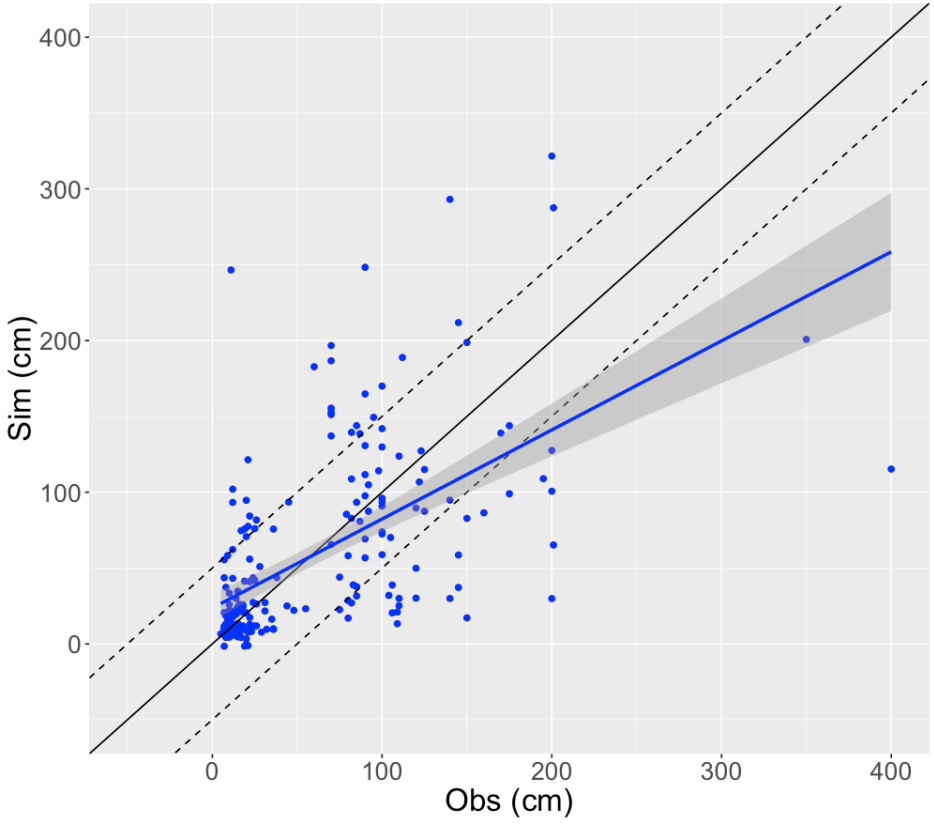
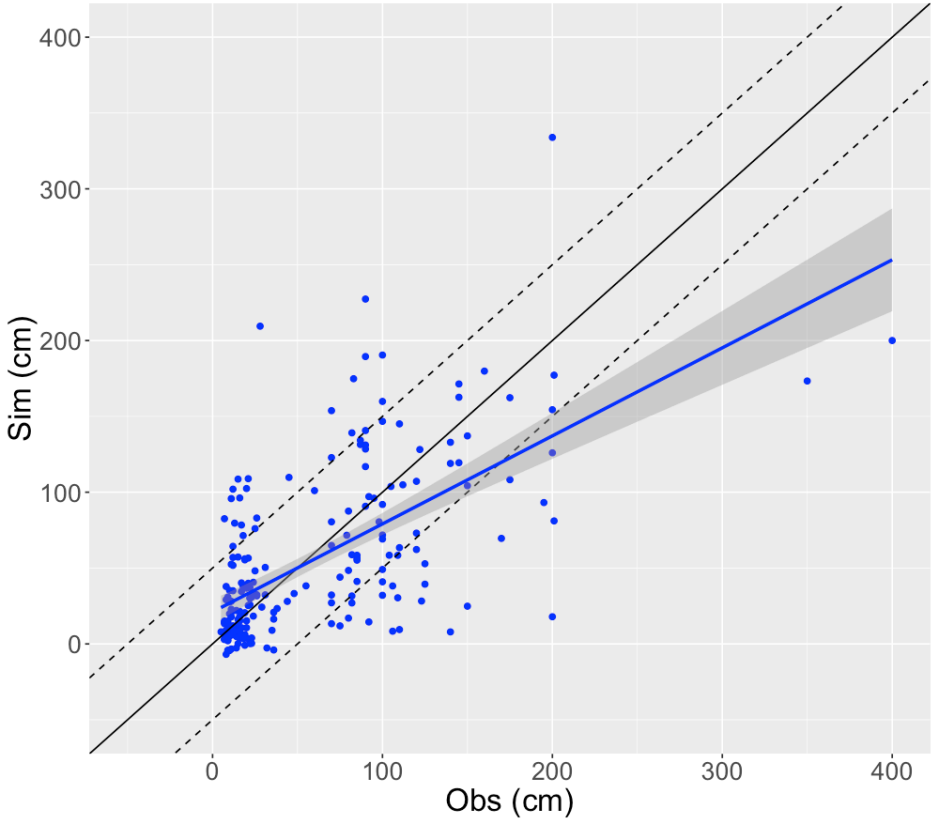
Results



H1: 150, H2: 90 , H3: 30 - Threshold: 0.1
RMSE = 55.7 cm Adj R2 = 0.33765
Intercept = 23.629 Slope = 0.58713 P = 1.4077e-20



H1: 170, H2: 90 , H3: 30 - Threshold: 0.1
RMSE = 50.4 cm Adj R2 = 0.39686
Intercept = 21.061 Slope = 0.58038 P = 7.6762e-25



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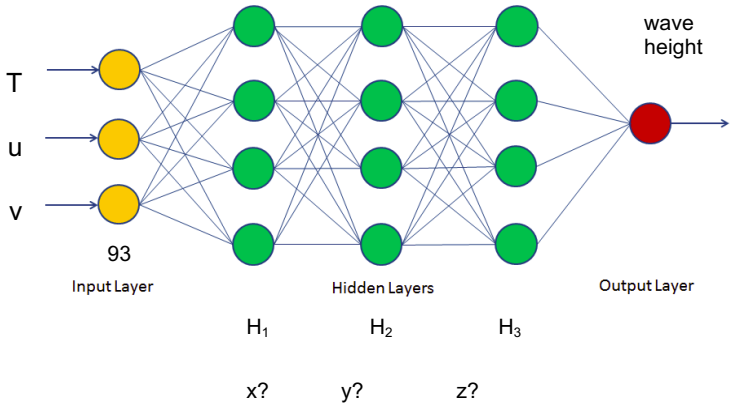
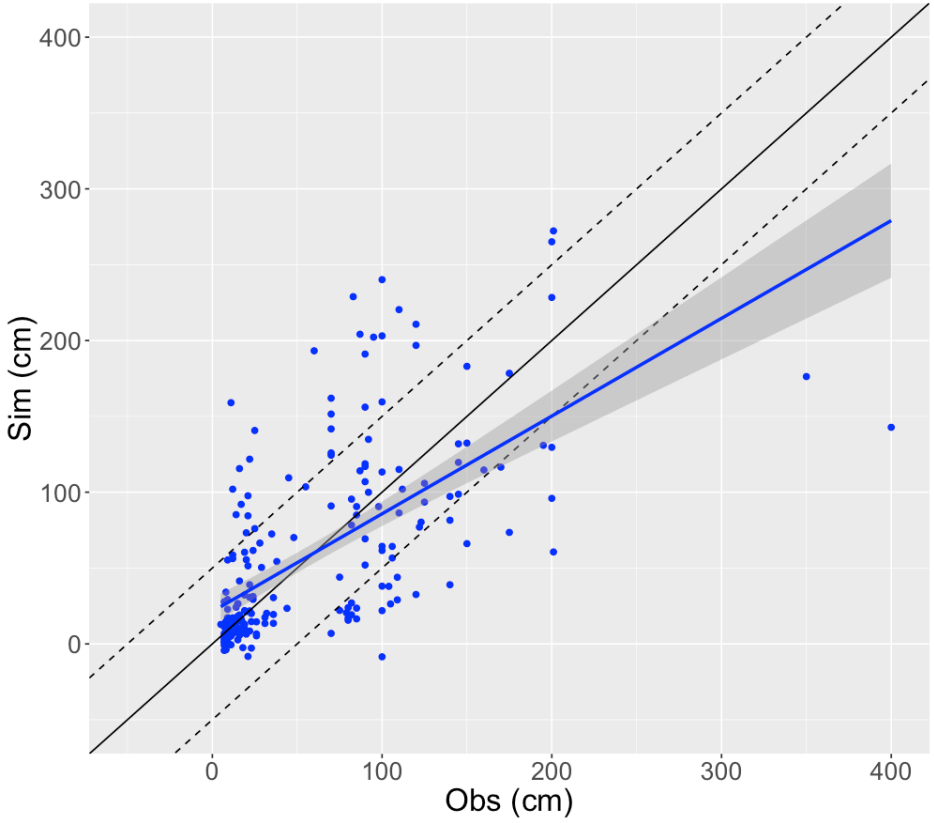
Results



H1: 180 , H2: 120 , H3: 90 , H4: 30 - Threshold: 0.1
RMSE = 52.8 cm Adj R2 = 0.39673
Intercept = 21.326 Slope = 0.64435 P = 7.8535e-25



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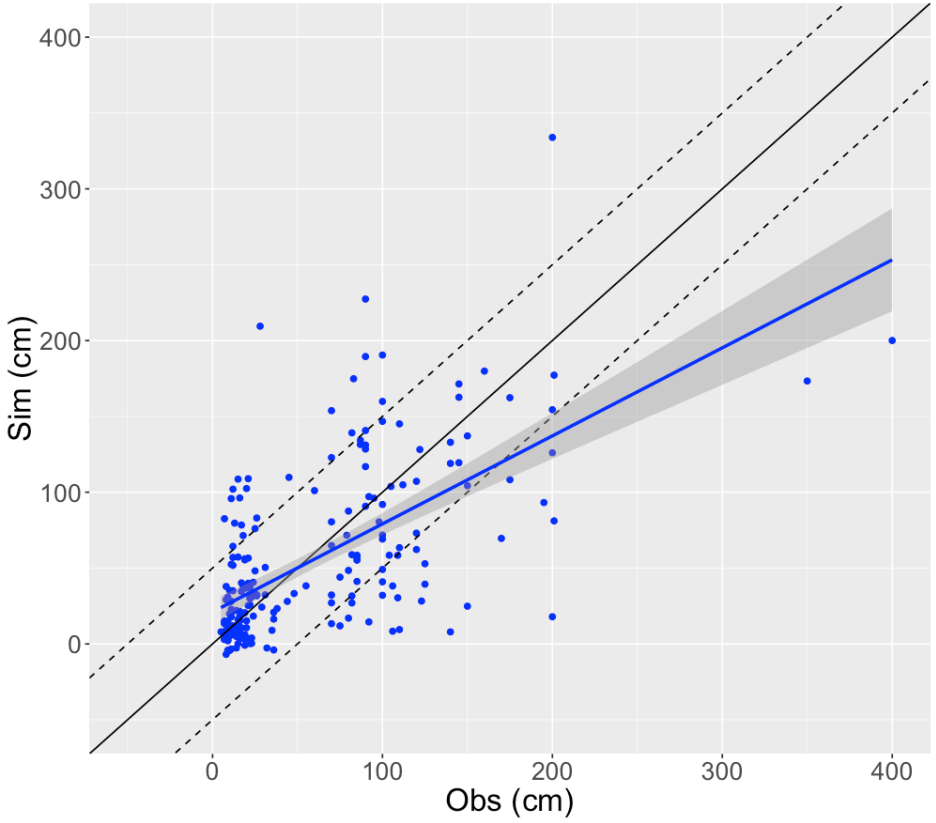

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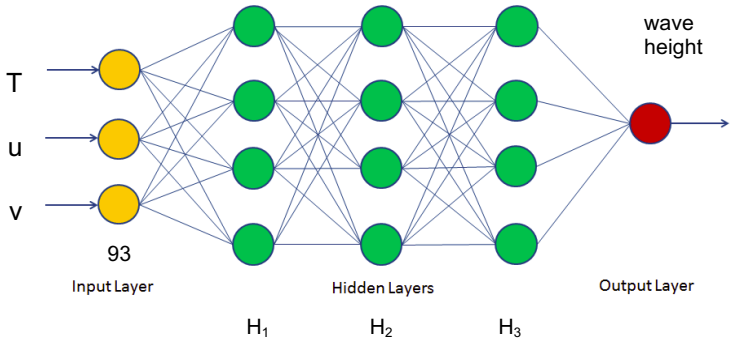
Results



NN

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RMSE = 52.8 cm Adj R2 = 0.39673
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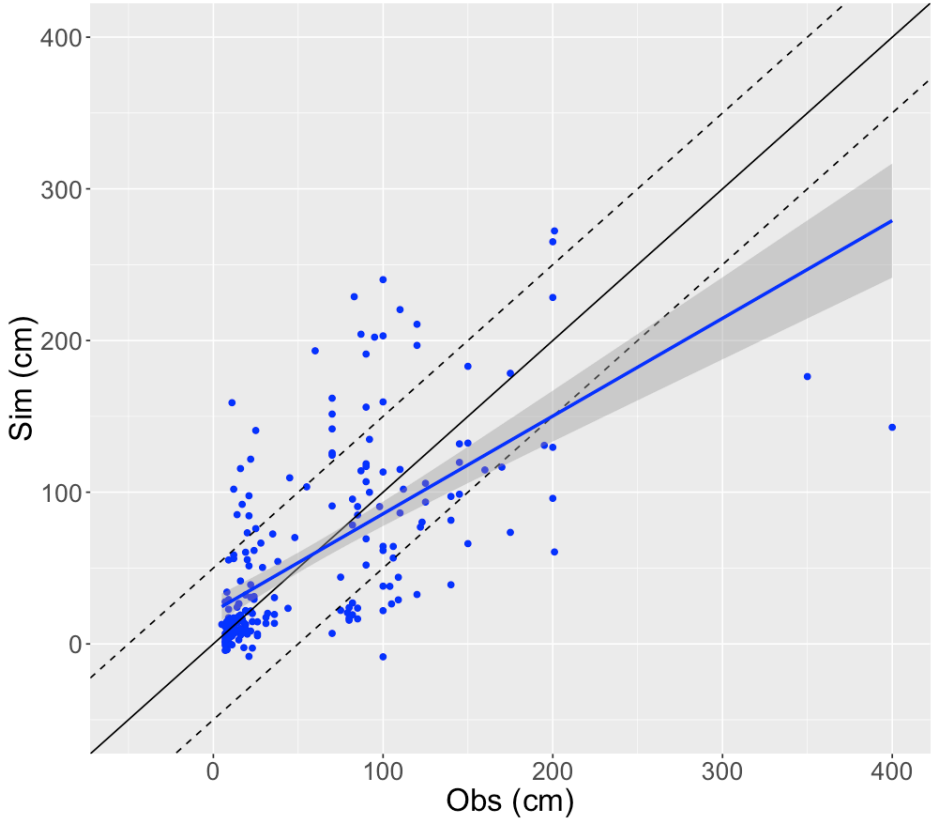
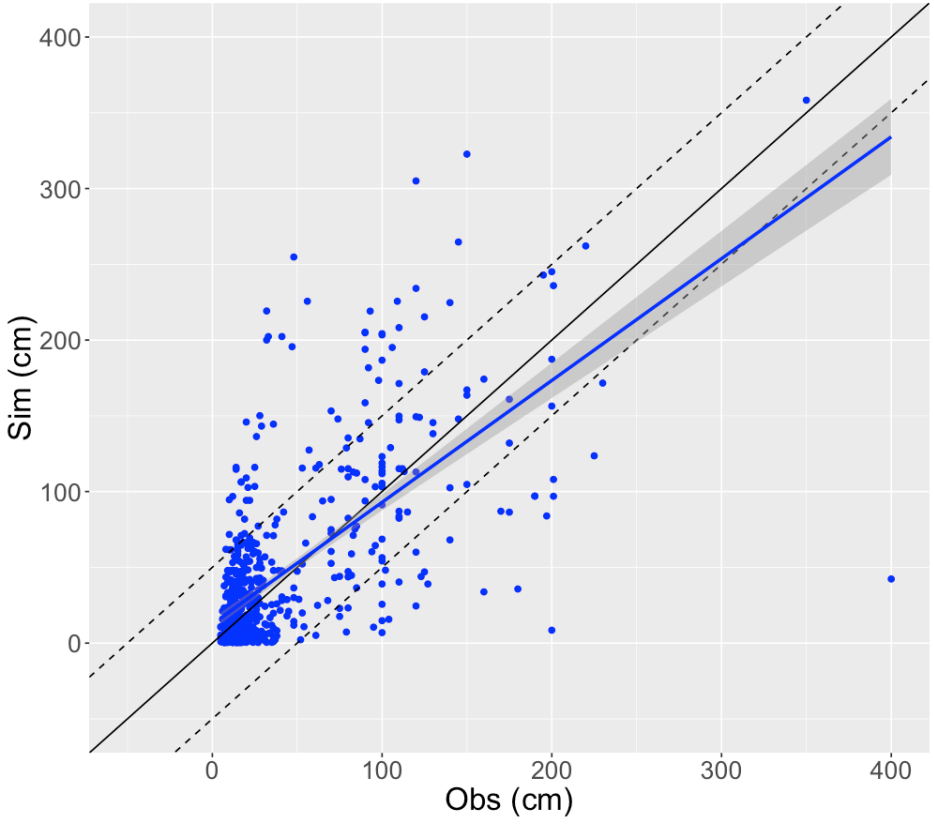


TRAM

TRAM
RMSE = 45.4 cm Adj R2 = 0.43052
Intercept = 12.458 Slope = 0.81918 P = 1.4812e-84



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Conclusions

- Our NN shows **similar** forecasting **ability** that our current forecasting system **to predict rissagues** with a **cheaper computational cost.**

- **More work** needs to be done to **properly design the NN** in order to improve the prediction.

We can do better!

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