Optimal Spectral Channel Selection for Cloud retrieval from IASI data using advanced machine learning techniques

IASI 2013

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Outline

- → iAVISA data set
- → Neural Network paradigm Learn-O-Matic Framework
- → IASI channel selection
- → Preliminary results
- → TOP & IOT from SEVIRI

iAVISA Data Set

Principcal data categories:

- the surface type (20 types)
- the climate zone
  - (Köppen classification over land, geographical bands over sea)
- season and
- day and night discrimination

iAVISA Data Set

Cloudiness data classification: derived from AVHRR cloud data

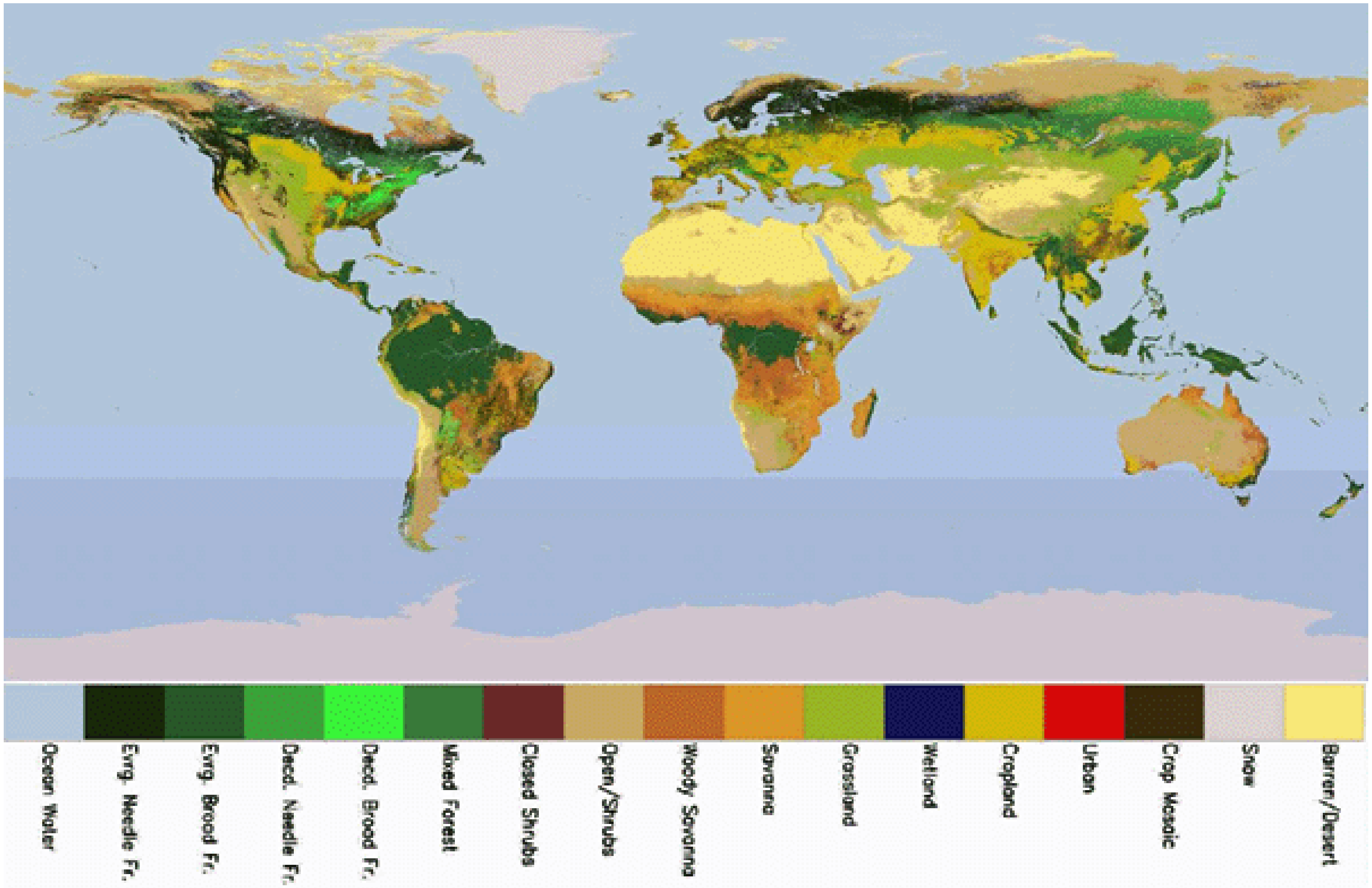
- **clear** - if the shape of the IASI footprint contains exclusively AVHHR pixels which are unambiguously cloud free, 28% of all cloudy samples

- **partly cloudy low** - if the shape of the IASI footprint contains both cloudy and cloud free AVHRR pixels, less than ~ 20% cloudy pixels, 26% of all cloudy samples

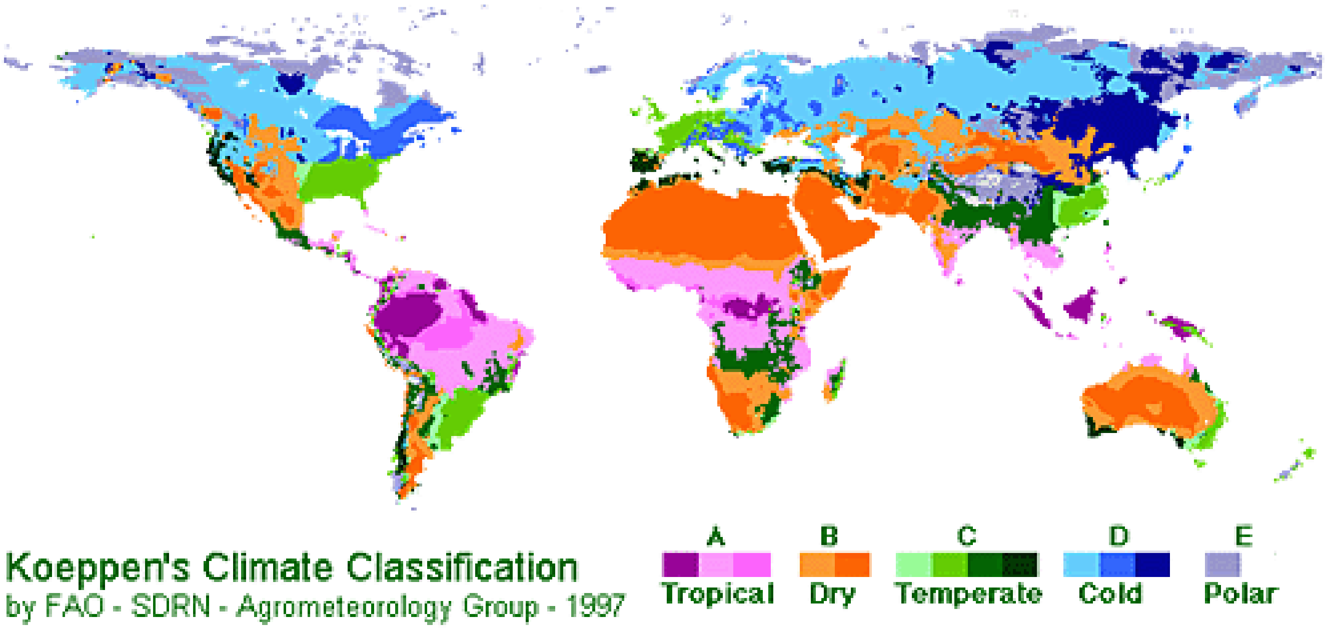
- **partly cloudy high** - if the shape of the IASI footprint contains both cloudy and cloud free AVHRR pixels, more than ~ 20% cloudy pixels, 26% of all cloudy samples

- **cloudy** - if the shape of the IASI footprint contains exclusively AVHHR pixels which are unambiguously cloudy, 20% of all cloudy samples

iAVISA Surface Types



iAVISA Climate Zones



iAVISA Surface Types

ID	Surface Type	Pixels	Selected Samples
1	Evergreen Needle Forrest	33170	603
2	Evergreen Broad Forrest	35114	876
3	Decid. Needle Forrest	10500	89
4	Decid. Broad Forrest	11366	324
5	Mixed Forest	35405	602
6	Closed Shrubs	10817	329
7	Open Shrubs	78789	1484
8	Woody Savannas	46660	768
9	Savannas	28638	656
10	Grassland	42696	886
11	Wetlands	5789	147
12	Crops	58910	1294
13	Urban	275	44
14	Crop/Mosaic	60314	1436
15	Snow/Ice	272144	1443
16	Barren/Desert	57968	1379
17	Water	1517554	12150
18	Tundra	26691	413

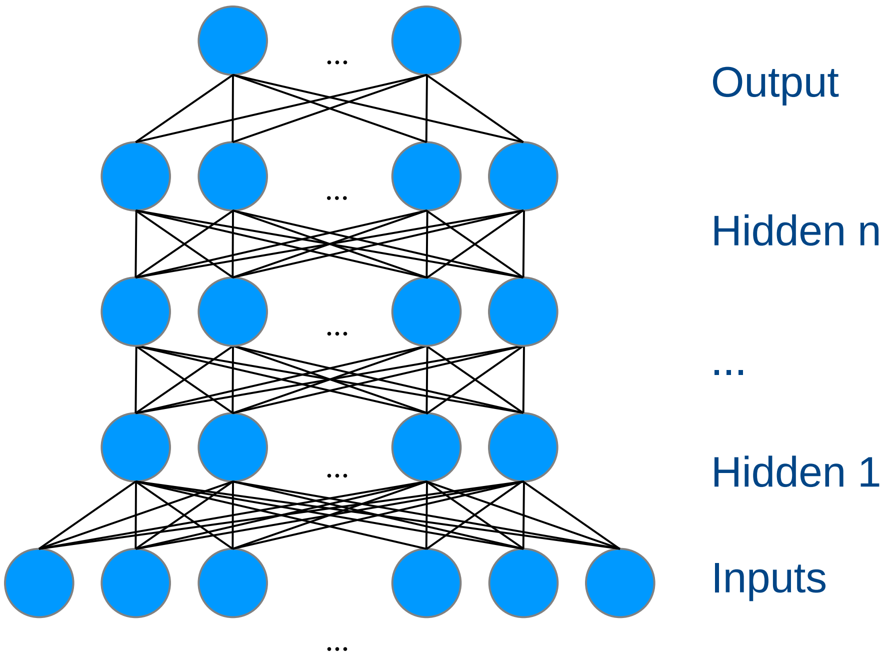
iAVISA Data Samples

Total number of data sets: 25 923

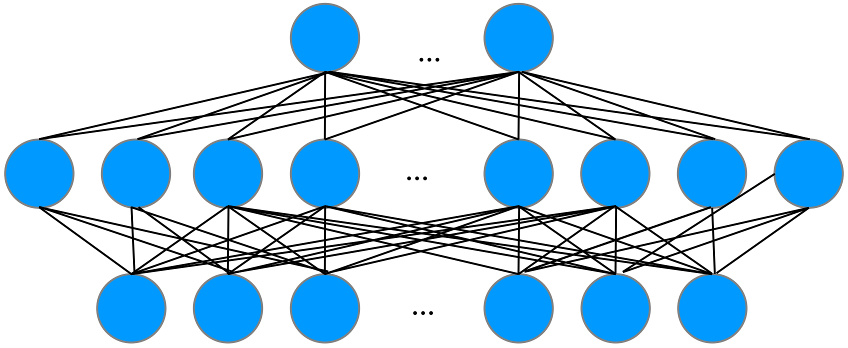
Season	Selected Samples
Spring	5862
Summer	6930
Autumn	6662
Winter	5469

Daytime	Selected Samples
Day	13455
Night	11468

New Paradigm in Neural Network Science
Deep vs Shallow



Sketch of a deep artificial Neural Network (DNN).



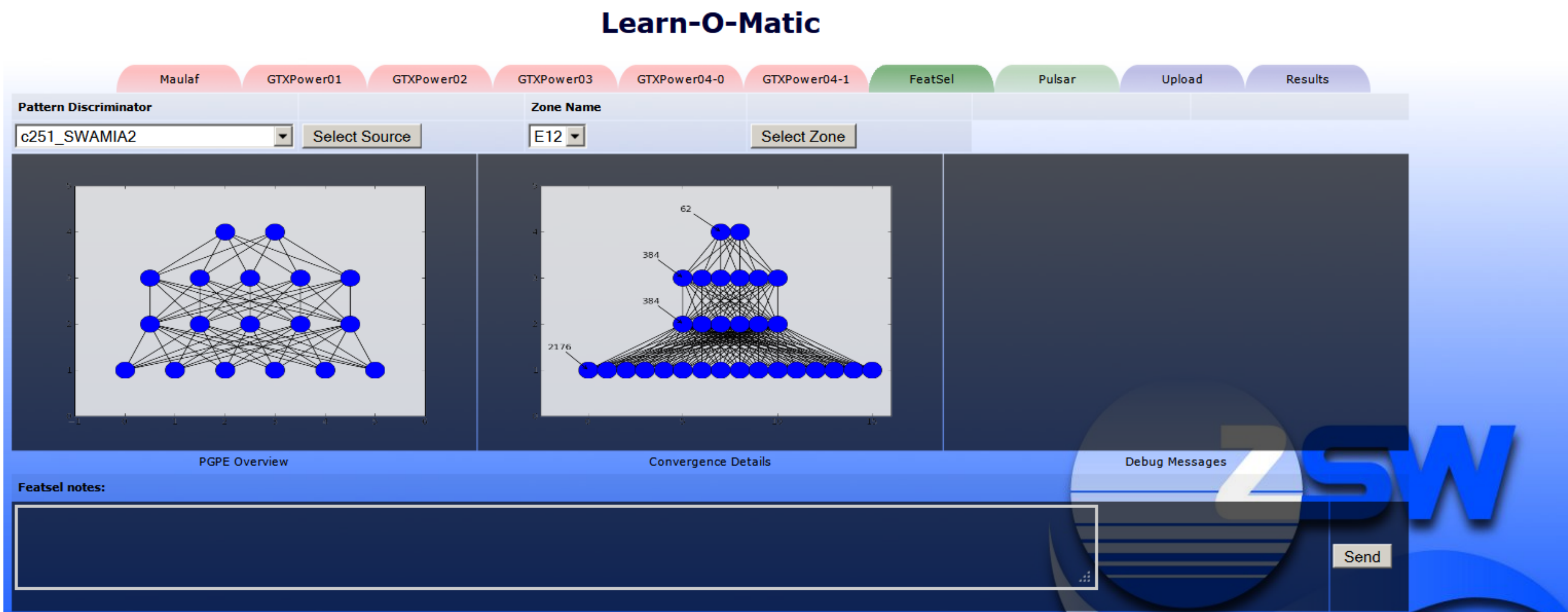
Sketch of a shallow artificial Neural Network.

- Every problem solvable with a NN can be solved with one hidden layer.
- But the number of hidden units grows very fast (exponentially).
- Complex problems tend to have an intrinsic hierarchical structure.
- This is very obvious for vision problems – so in all vision benchmarks
  - DNNs fill the Top5 – Top10 of machine learninig benchmark list
- This is also obvious in atmospheric science (ozone profile retrieval, clouds)

Learn-O-Matic

Machine Learning and Optimization Tool including Deep Learning and Automatic Feature Selection *

➔ Multi-tier **GPU** based machine learning system with user friendly web frontend
➔ ~ 200 - 250 times faster compared to **CPU** core



* [Sehnke2012]

Learn-O-Matic: Implemented Features

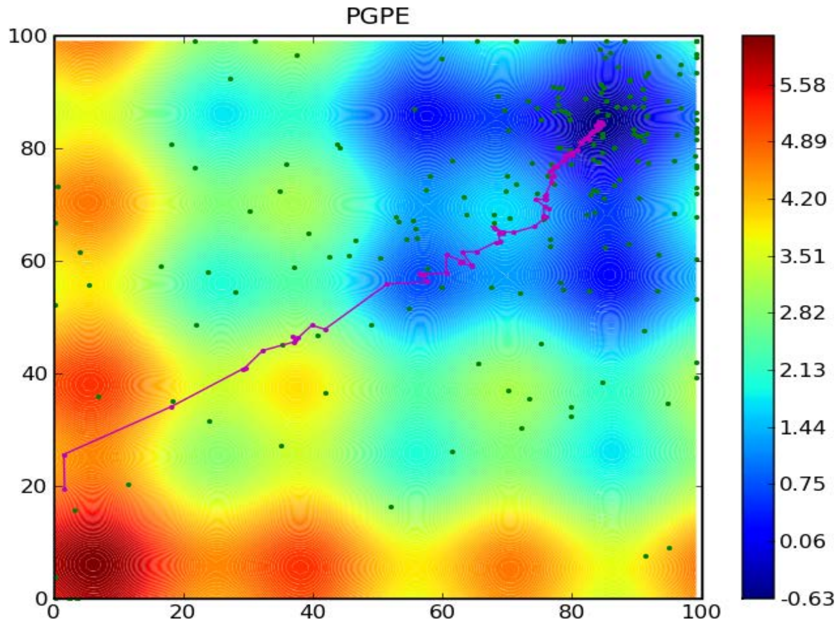
➔ Deep neural networks (DNN)

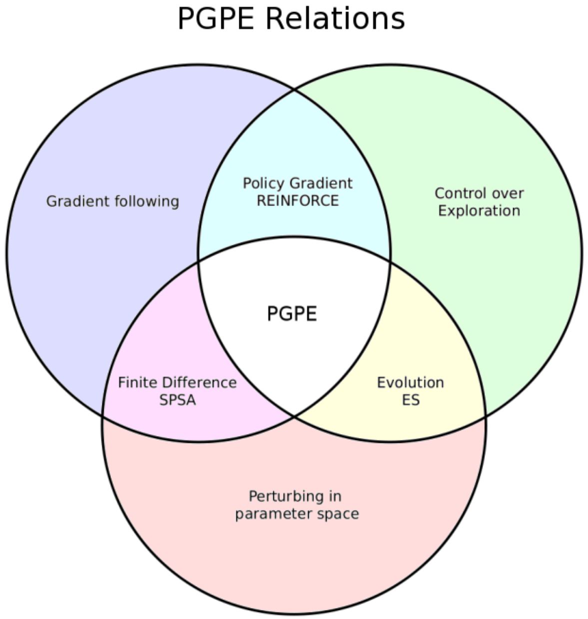
➔ Reduced Boltzmann machines [Hinton2006]

➔ Support vector machines/regression (soon)

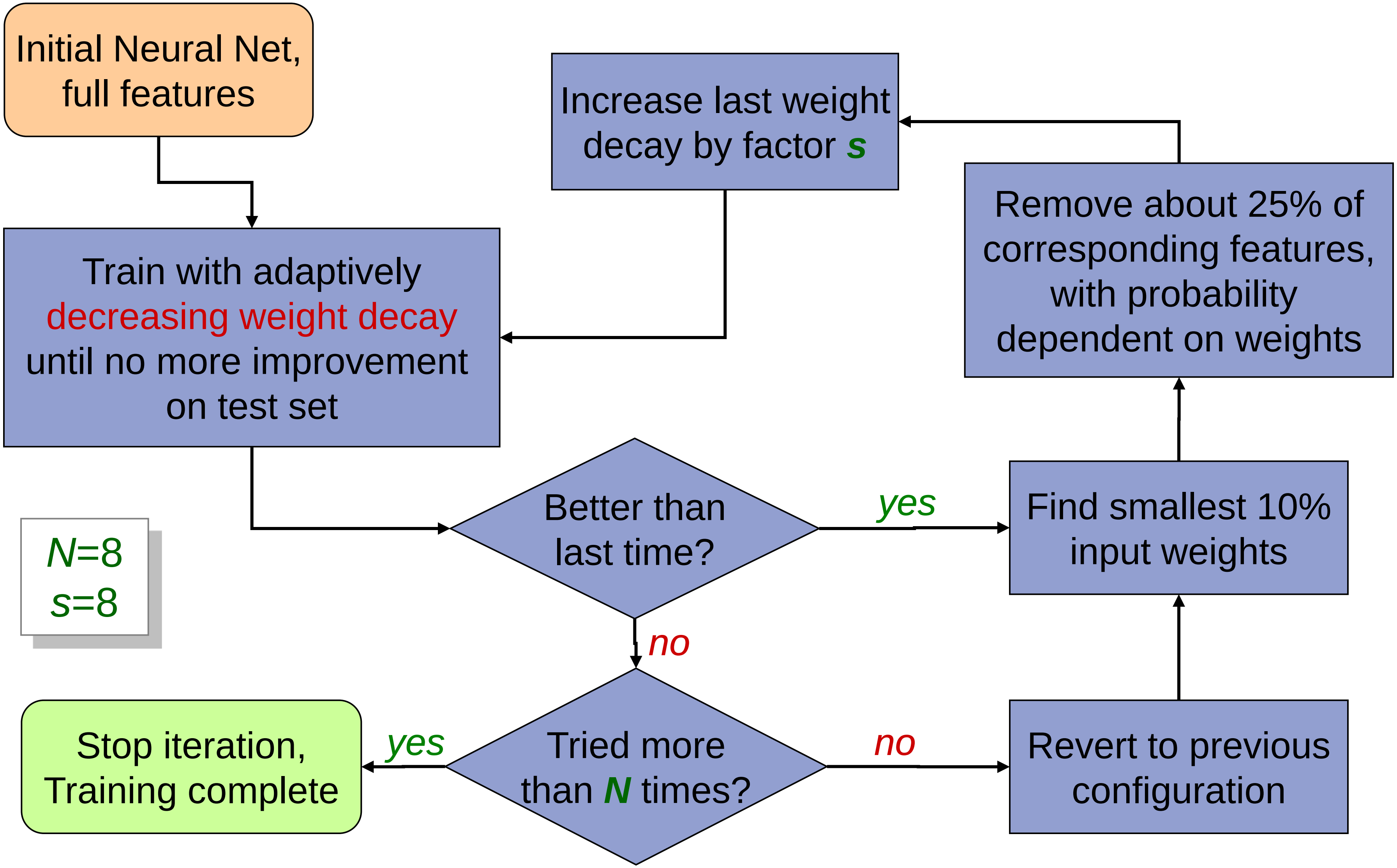
➔ Gaussian Processes (sparse approximation/regression scheme)

➔ Policy Gradient with Parameter-based Exploration (PGPE): reinforcement learning scheme for all kind of optimization tasks [Sehnke2010] → here for optimisation of meta parameters of NN





Automatic Feature Selection

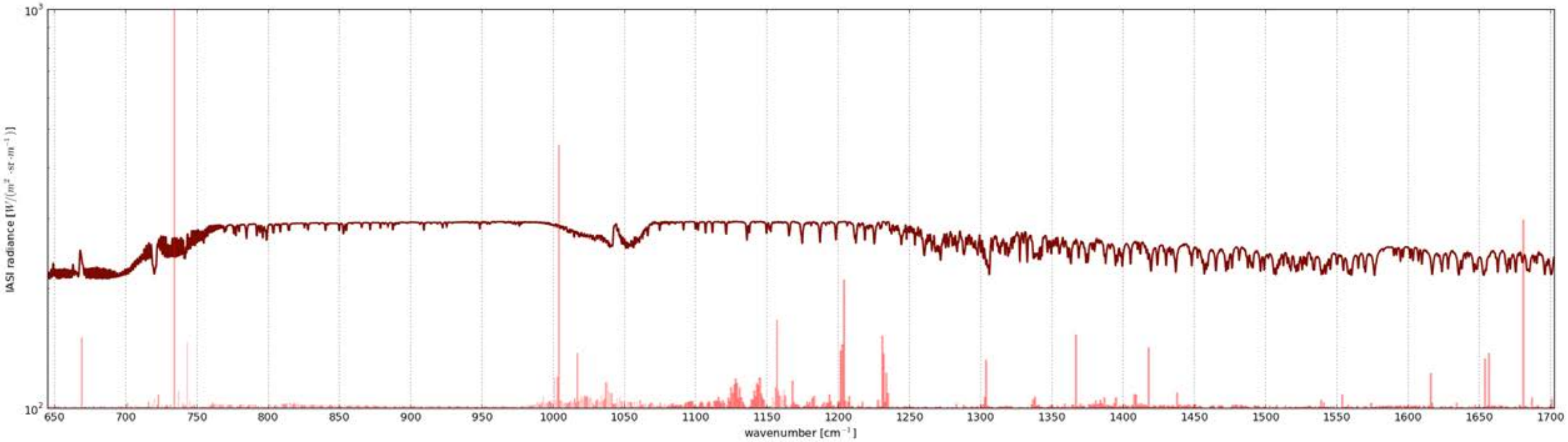


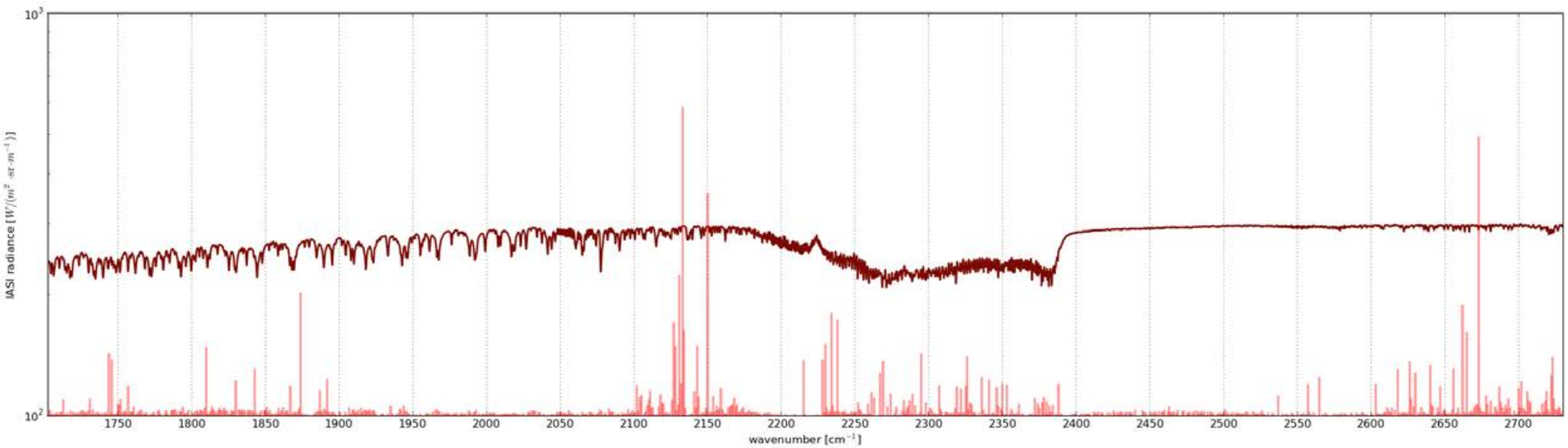
Approach

Linear NN output vs. classification and ECMWF input data

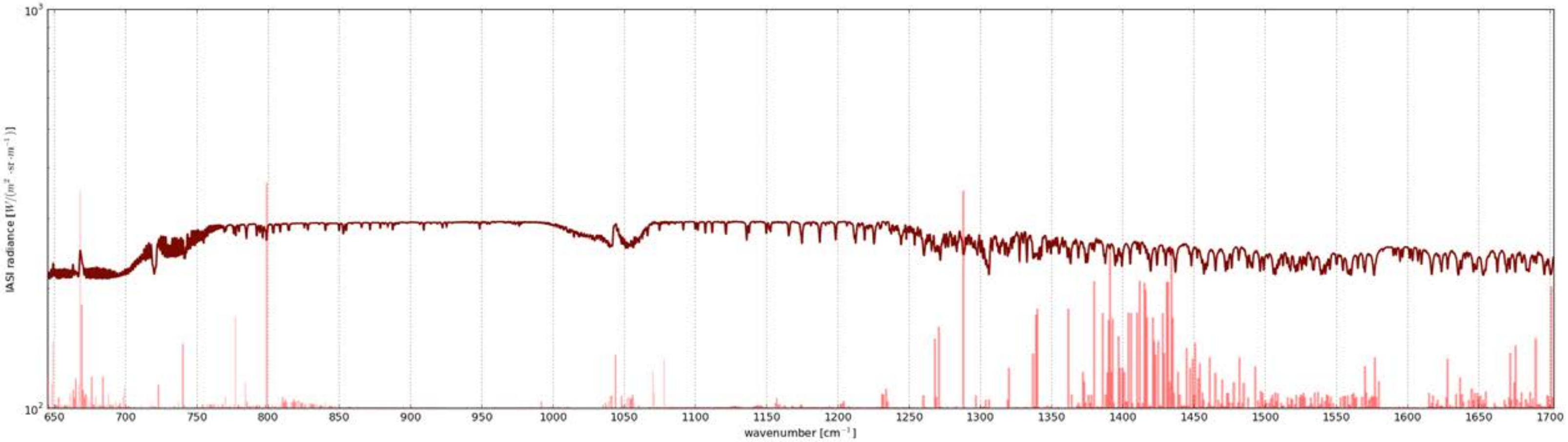
- Linear output of NN
- Classification NN
  - One NN output flagged for each cloud cover class
- Each NN training with/without ECMWF input data

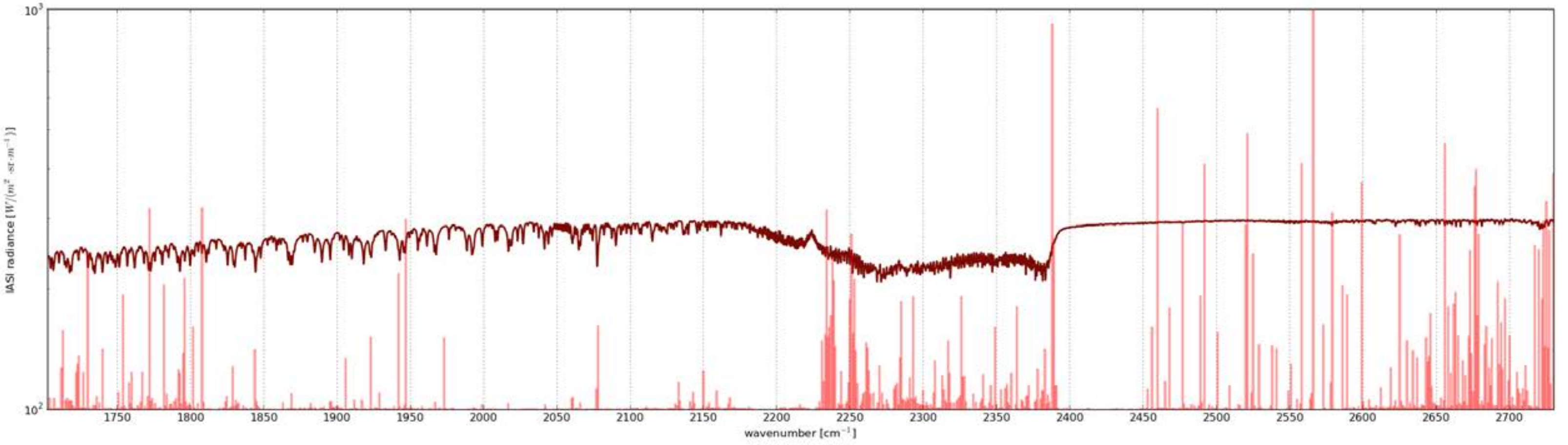
Selected Channels: Linear Output with ECMWF (T, q, O_3, ..) and emissivity (IASI)



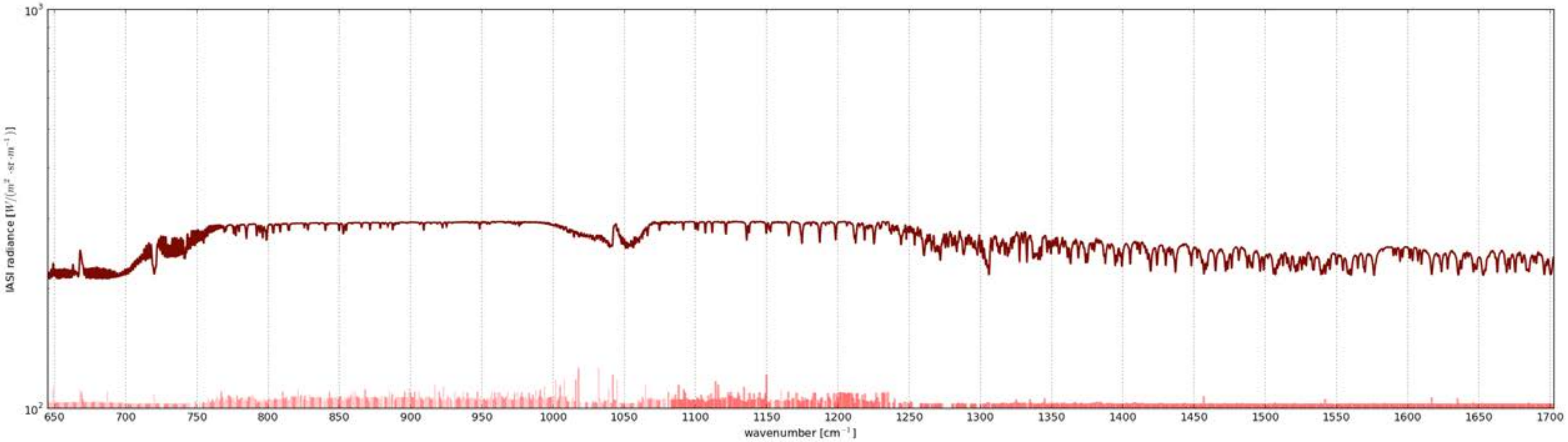


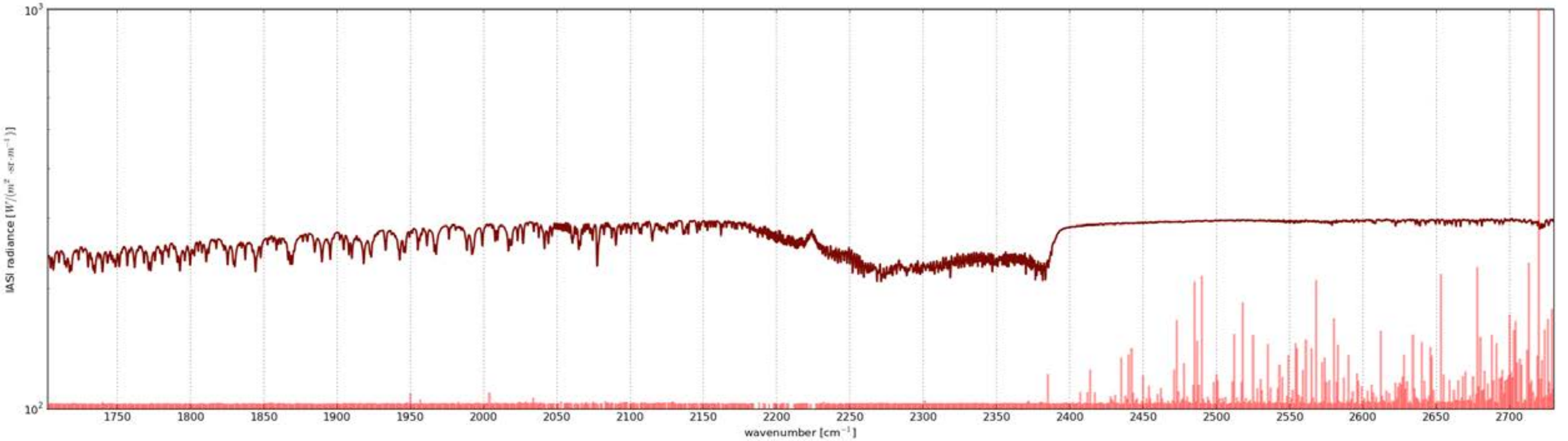
Selected Channels: Linear Output without ECMWF and emissivity (IASI)



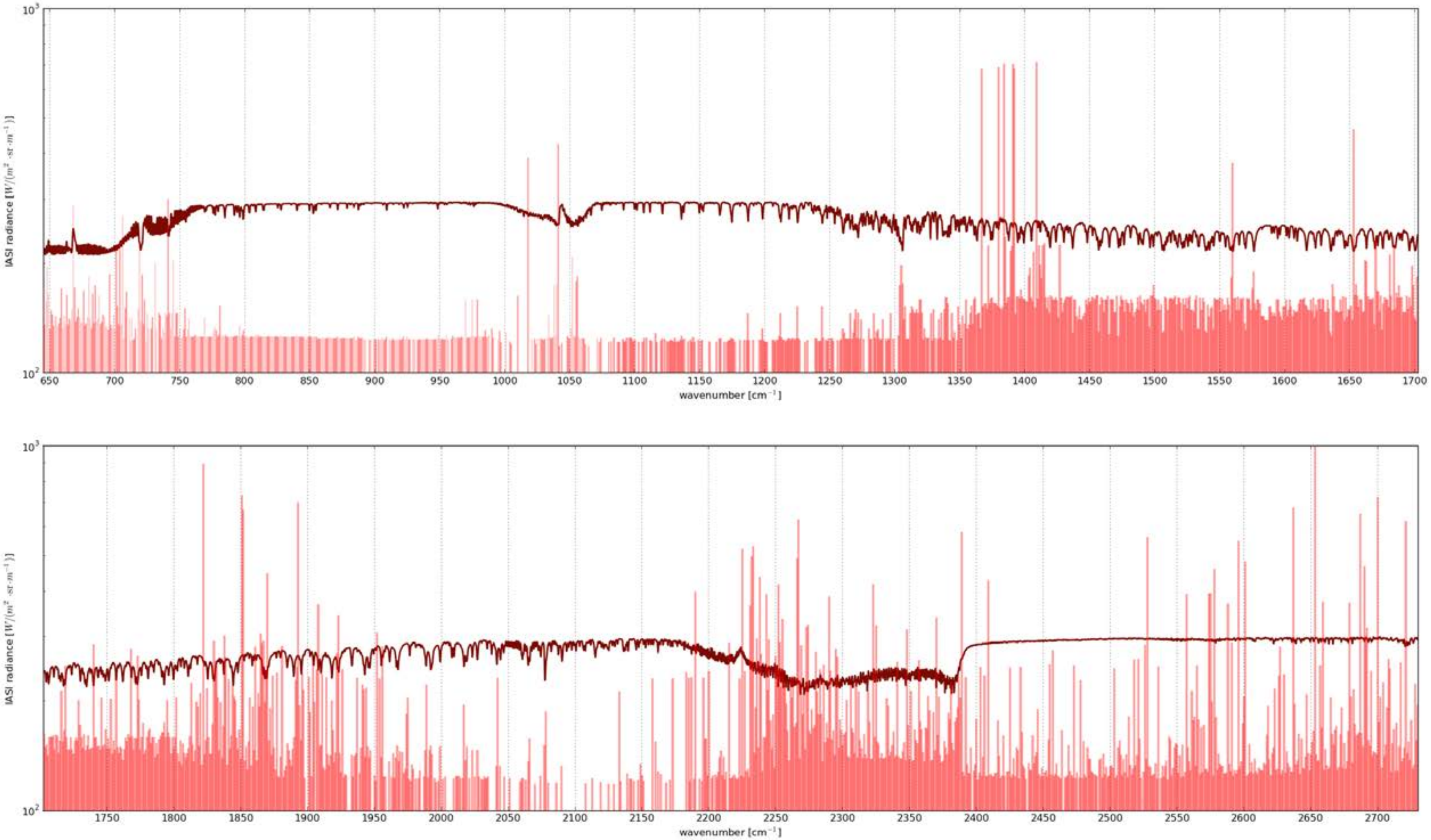


Selected Channels: Classification with ECMWF (T, q, O_3, ..) and emissivity (IASI)

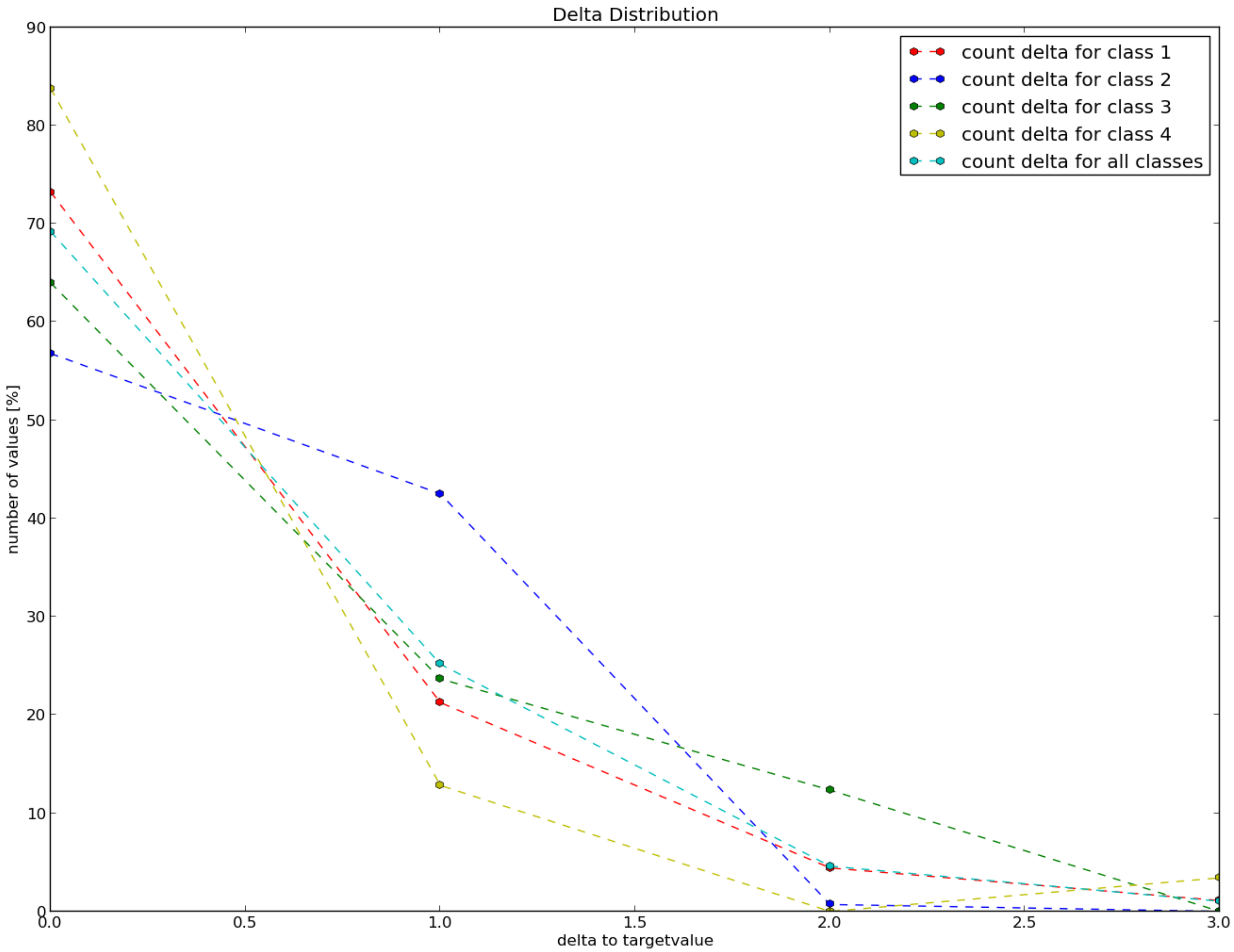




Selected Channels: Classification without ECMWF and emissivity (IASI)



Results for Cloud Classification



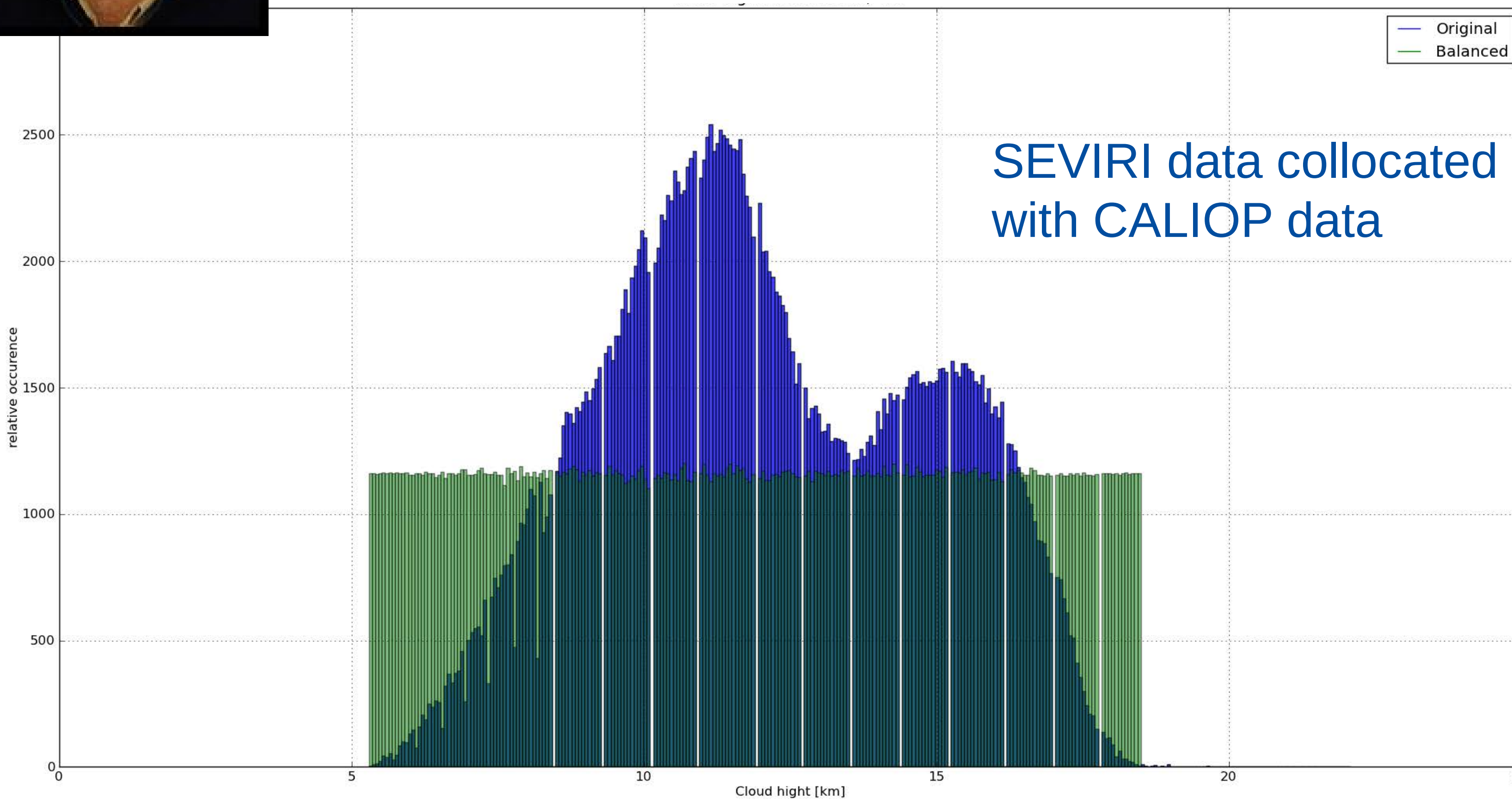
Summary

- → iAVASA data set is a good source data source for cloud detection training but
  - → The discrete cloud cover classes are not optimal
    - → Better more continous cloud cover classes
  - → For full IASI channel selection, the number of samples is too small
    - → pre-selection of spectral ranges
    - → do not use full spectral resolution
- → Automatic channel selection can give new insight to IASI channel selection for cloud detection.
- → Missing ECMWF data are compensated by use of more IASI channels.
- → More work necessary to fully exploit the informaiton content of iAVISA data set.

COCS Data

in memorial to Hermann Mannstein

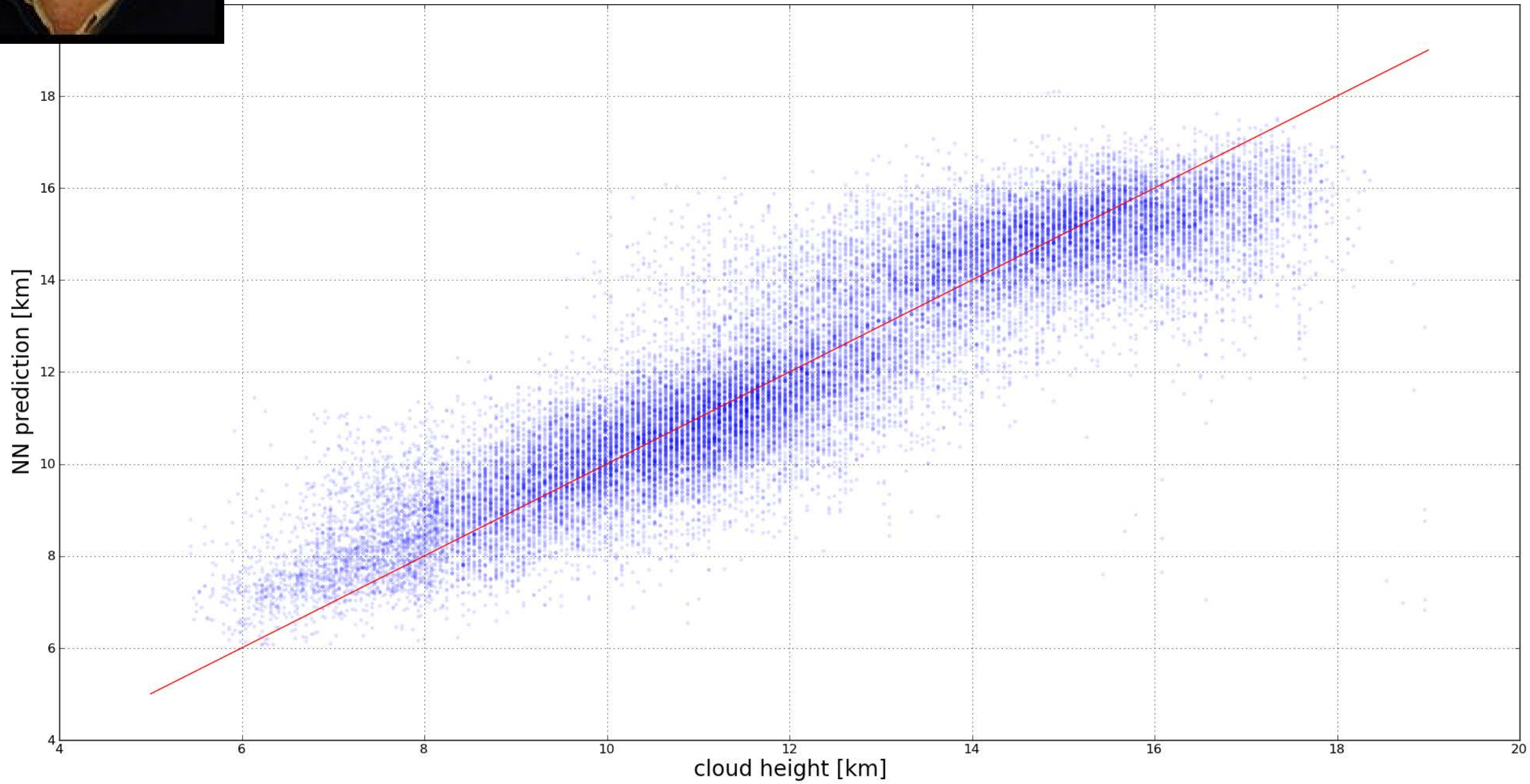
cirrus cloud top height distribution



SEVIRI data collocated with CALIOP data

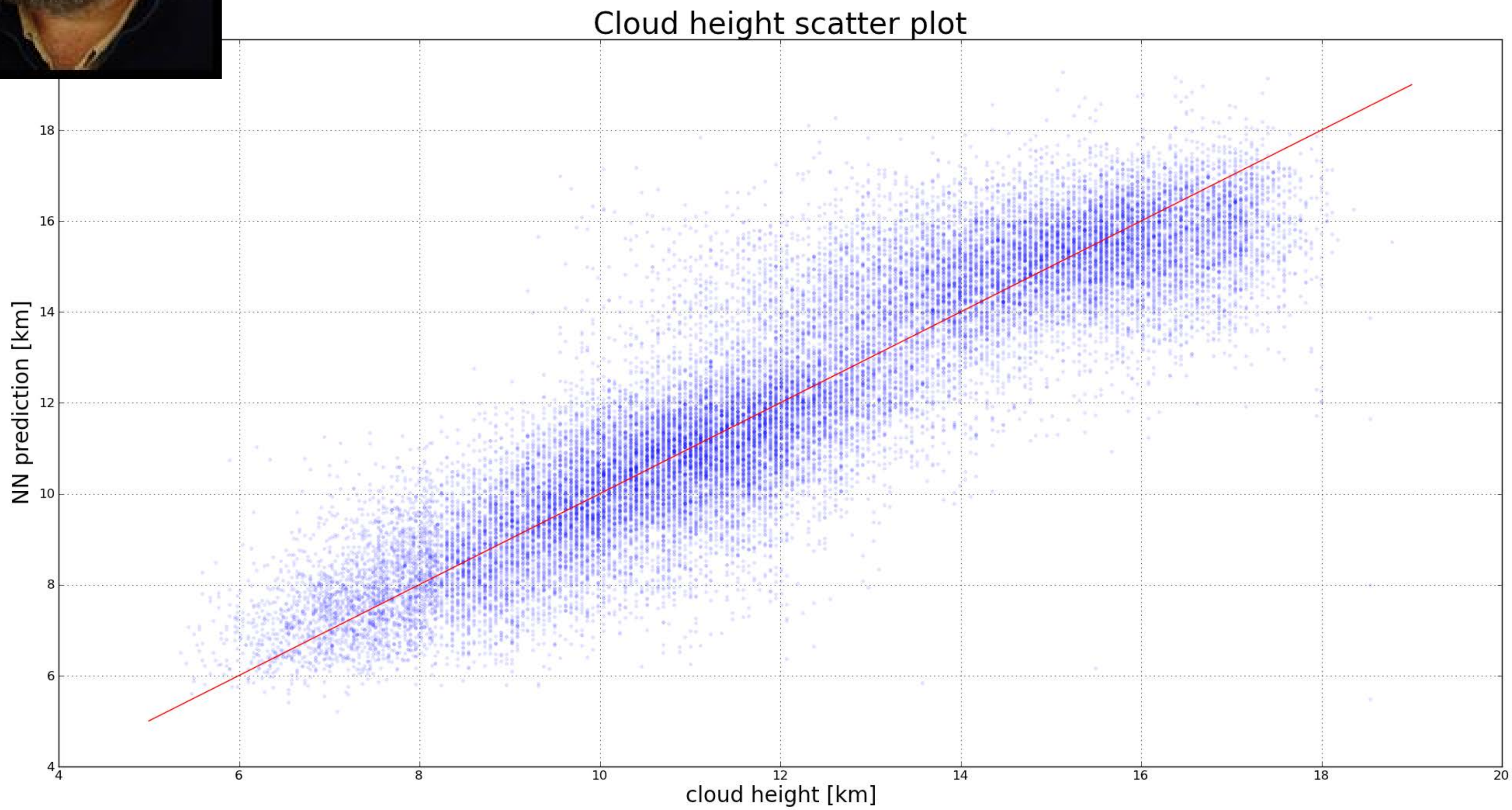
COCS Data

TOP scatter plot without blancing: → RMSE = 1.4 km



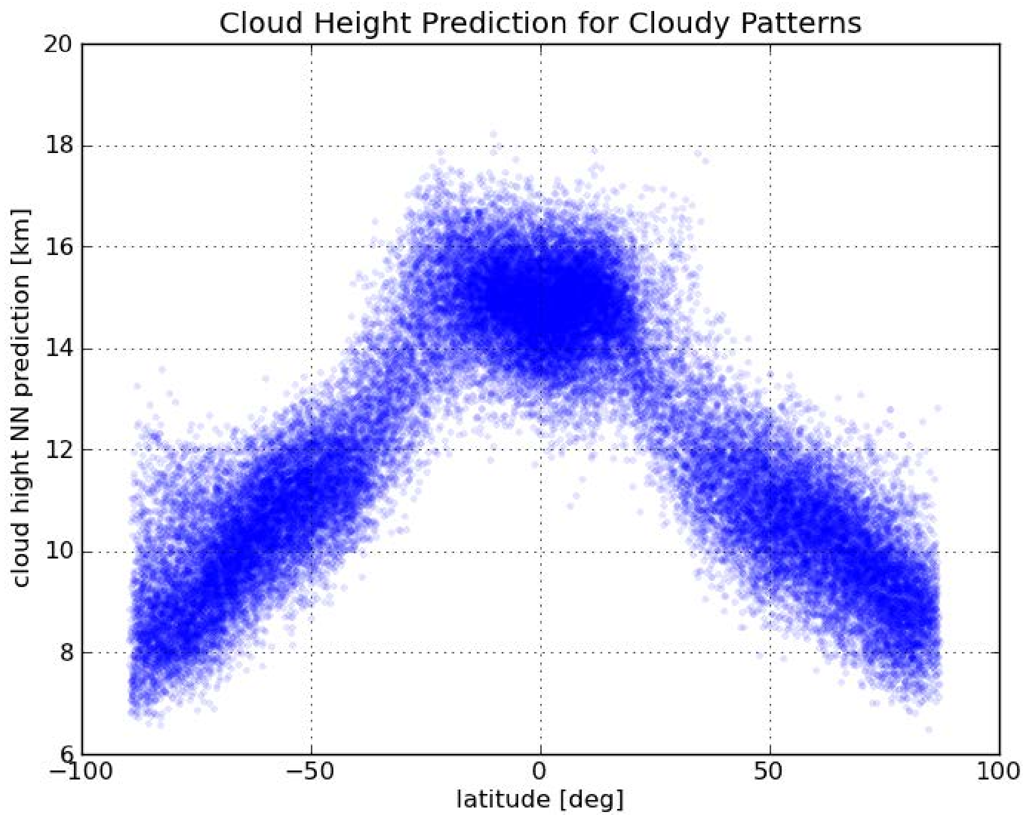
COCS Data

TOP scatter plot with blancing: → RMSE = 1.1 km



COCS Data

Cirrus cloud top over latitude: RMSE = 1.14



COCS Data

Cirrus ice optical thickness: IOT → RMSE = 0.26