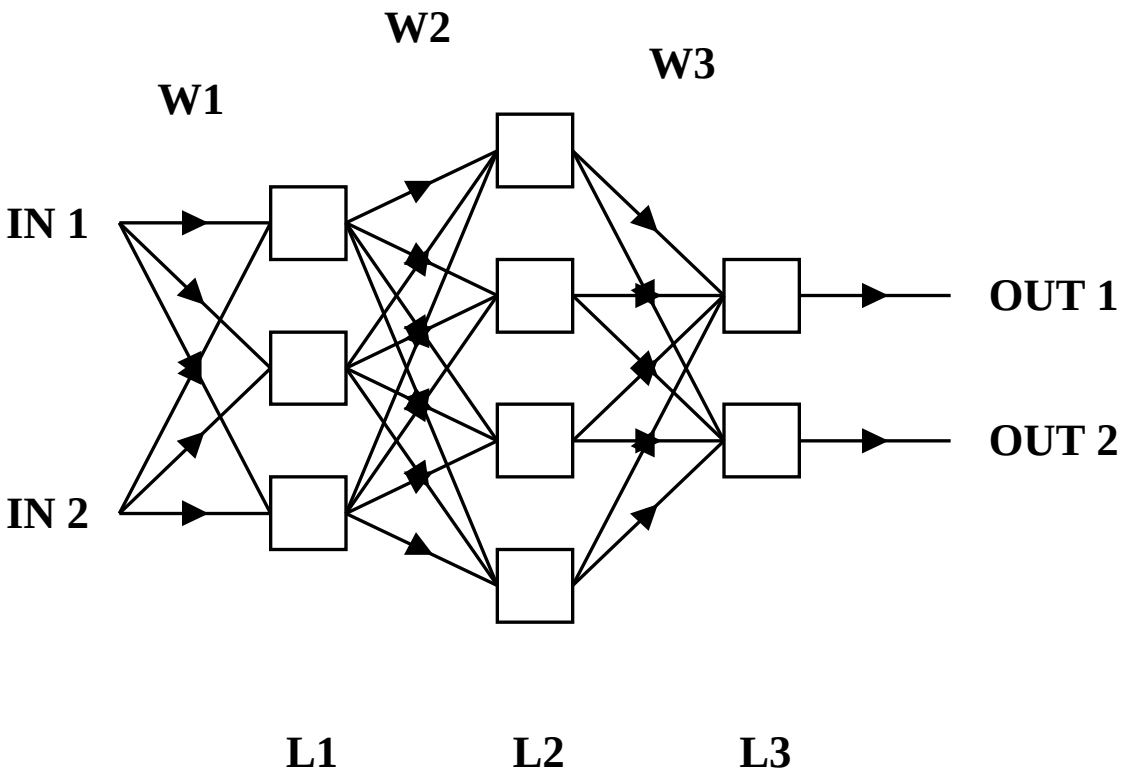
ARTIFICIAL NEURAL NETWORK SIMULATION AND ITS POSSIBLE APPLICATIONS

K. Loukachine

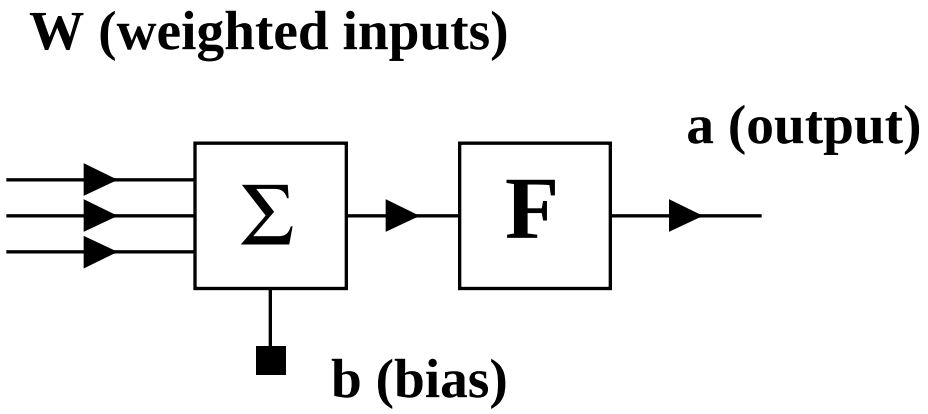
SAIC, Hampton, Virginia, USA

CERES STM, Princeton, NJ

Error Backpropaqation Feedforward ANN



Artificial Neuron Structure



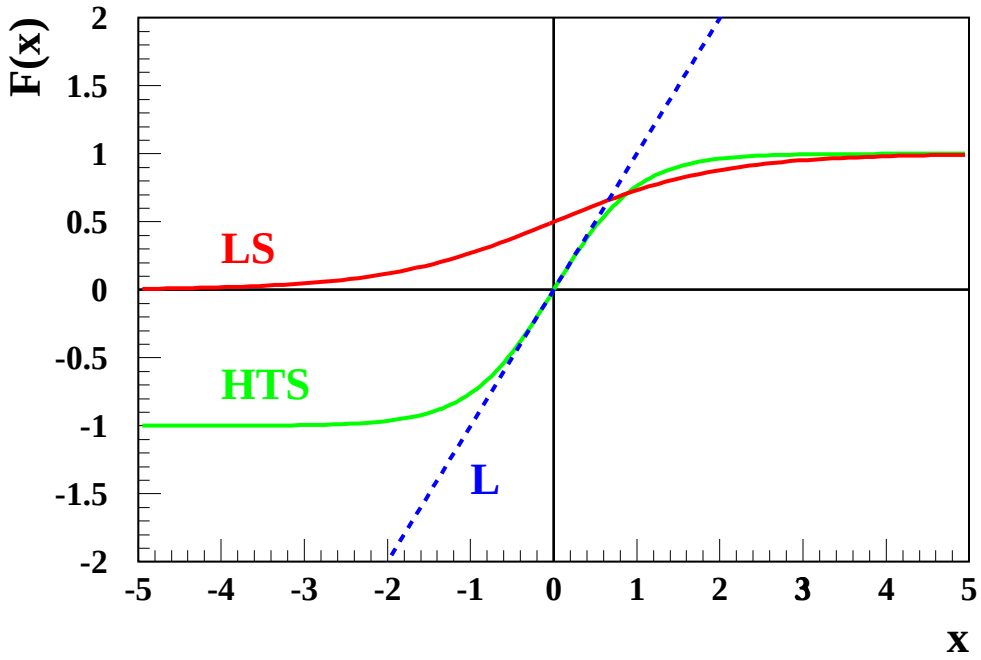
FUNCTIONS:

Linear

Log. Sigmoid

H-Tan. Sigmoid

ANN NEURON FUNCTIONS



Linear: $F(x) = x$

LogSigmoid: $F(x) = \dfrac{1}{1 + e^{-x}}$

Hyp. Tan. Sigmoid: $F(x) = \dfrac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$

TRAINING METHOD: GENERALIZED DELTA RULE

Forward Propagation

$$a^n = F^n(W^n a^{n-1} + b^n)$$

Sensitivity (Error Backpropagation)

Gradient matrix: $\dot{F}^n = \frac{\delta F^n(a)}{\delta a}$, $a = a_k$

$$S^n = -2 \cdot \dot{F}^n \cdot (t - a^n)$$

$$S^{n-1} = \dot{F}^{n-1} \cdot {W^n}^T \cdot S^n$$

Weights & Biases Update

$$\Delta W^n(k+1) = \gamma \cdot \Delta W^n(k) - (1-\gamma) \cdot \alpha \cdot S^n \cdot (a^{n-1})^T$$

$$\Delta b^n(k+1) = \gamma \cdot \Delta b^n(k) - (1-\gamma) \cdot \alpha \cdot S^n$$

$\alpha(\Delta E)$ - Learning Rate

$\gamma(\Delta E)$ - Learning Momentum

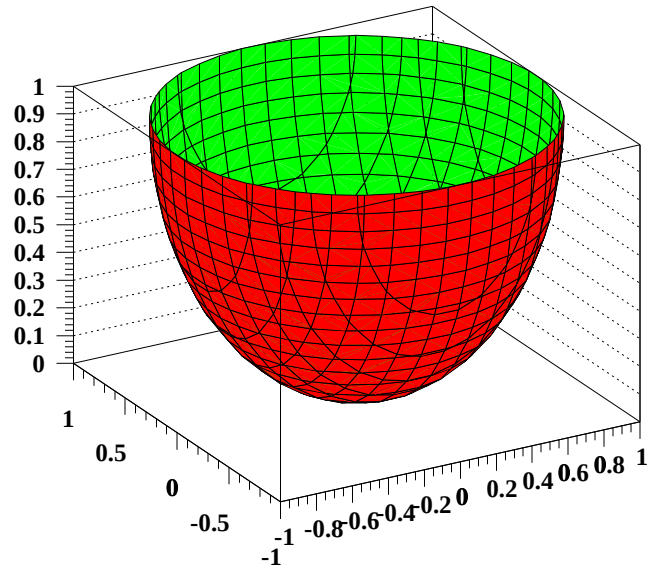
Error Index

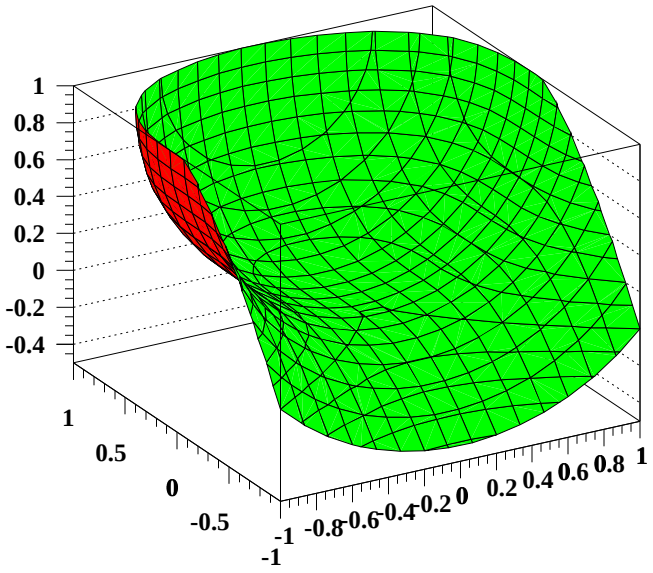
$$E(k) = \sum_{i=1}^{N} [\, t - a^n(k) \,]^2$$, N - number of training points

Decision is based on $\Delta E = E(k) - E(k-1)$

ERROR INDEX SURFACE

Global and Local minima cases



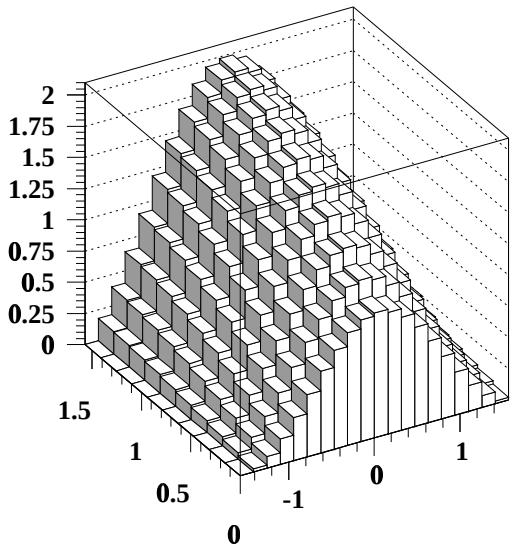


x2 + y**2 + (z-1)**2 = 1**

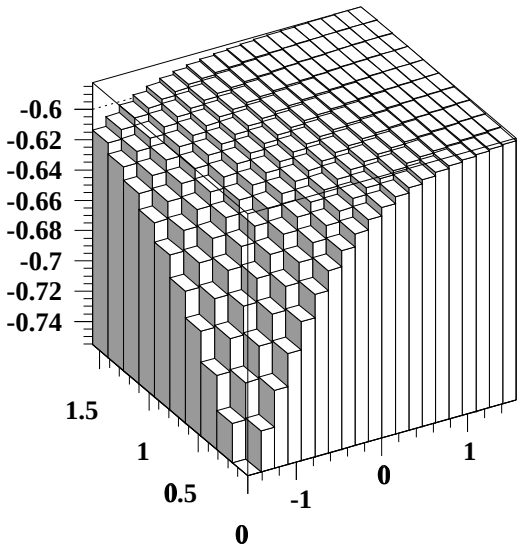
2D EXAMPLE

Target Function $G(x, y) = (\cos x)^2 + abs(\sin y \cdot \cos x)$

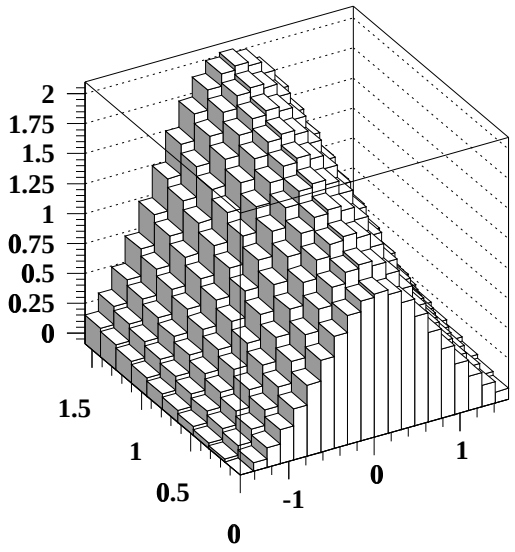
ANN: 2TS-9TS-1L, $\alpha = 0.1$, $\gamma = 0.15$



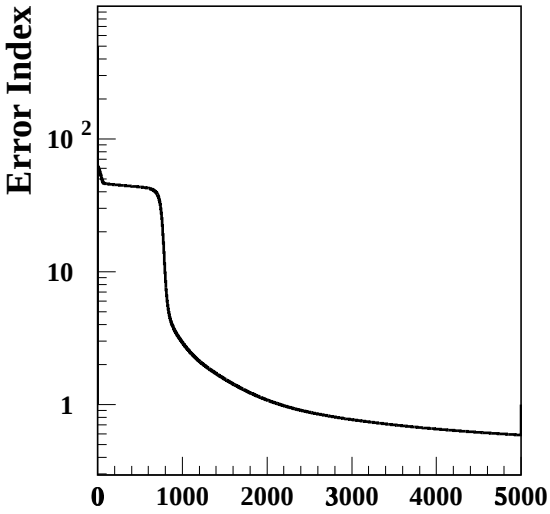
Exact Function



ANN Starting Function



ANN Function



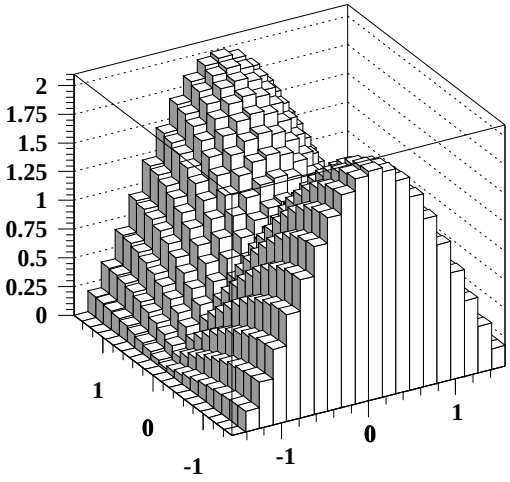
Iteration N

2D EXAMPLE

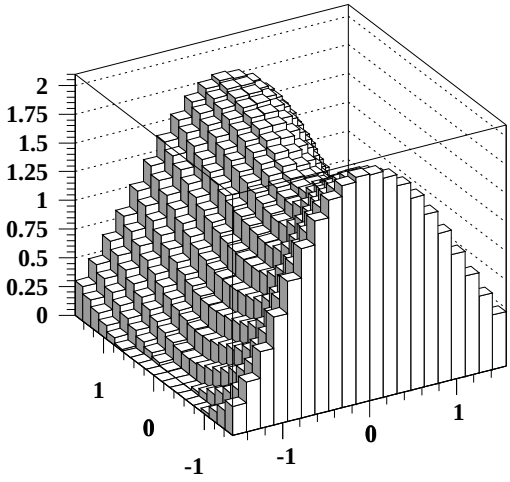
Target Function $G(x, y) = (\cos x)^2 + abs(\sin y \cdot \cos x)$

ANN: 2TS-15TS-1L, $\alpha = 0.05$, $\gamma = 0.2$

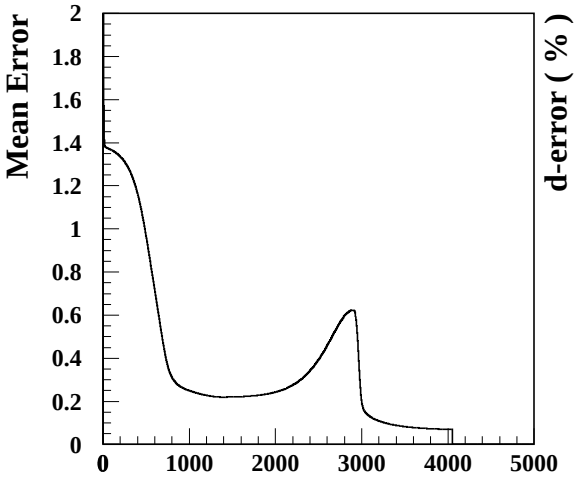
Both variable positive and negative



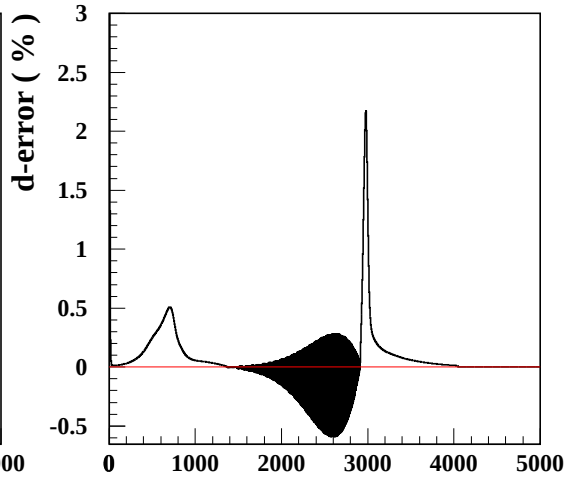
Exact Function



ANN Function



Iteration N



Iteration N

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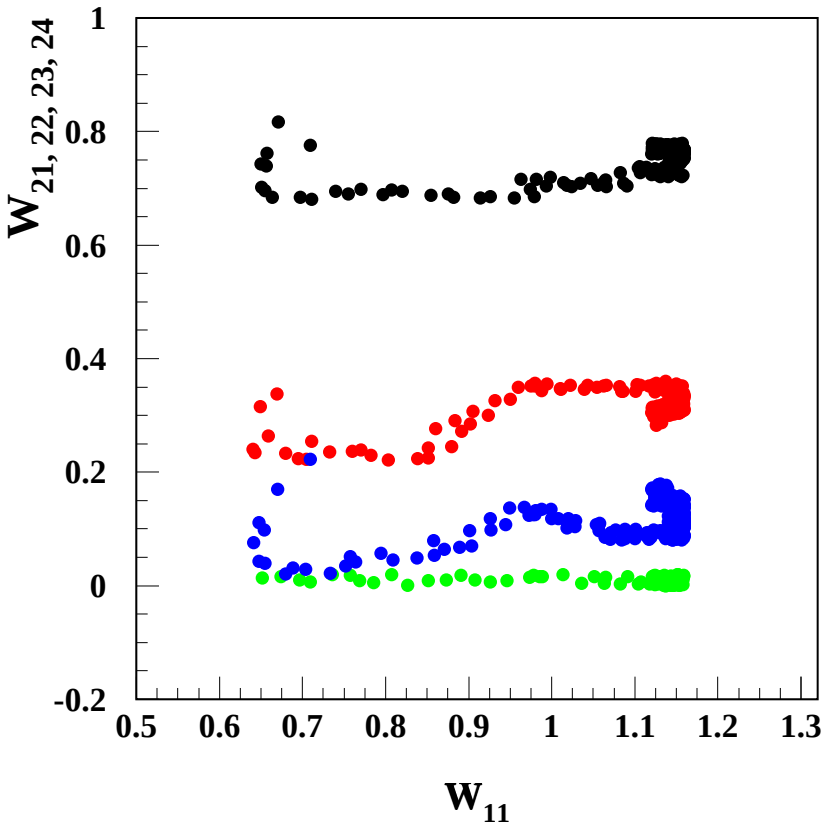


CERES/TRMM RAPS DATA, SW FLUX

ANN CONFIGURATION: 5TS - 12TS - 1L

Supervised Training for the $\bar{R}_{SSF}$

SSF EDITION-2B TRAINING SETS

Variable	N bins	Bin Width	Normalization
VZA	7	10°	90°
SZA	9	10°	90°
RAZ	9	20°	180°
LWR	15	10 $\mathrm{Wm^{-2}\ sr^{-1}}$	150 $\mathrm{Wm^{-2}\ sr^{-1}}$
SWR	30	10 $\mathrm{Wm^{-2}\ sr^{-1}}$	300 $\mathrm{Wm^{-2}\ sr^{-1}}$

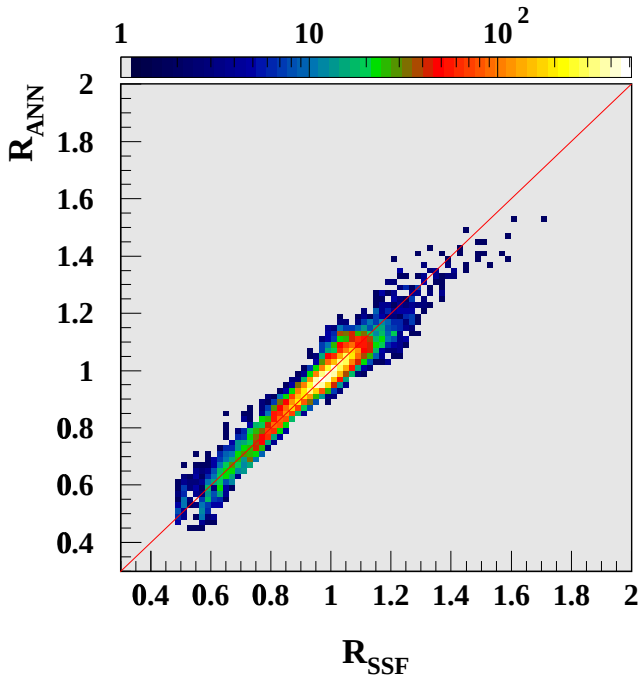
Total Number of Bins = 255,150

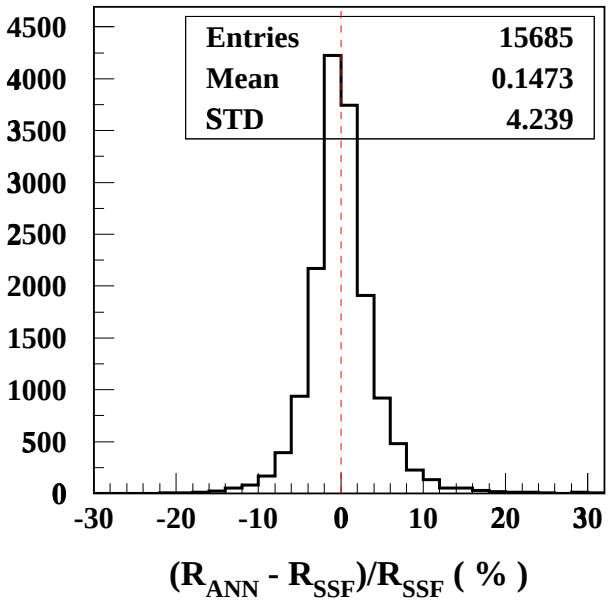
CERES/TRMM SSF, RAPS DATA, SW FLUX

EDITION-2B TRAINING SETS

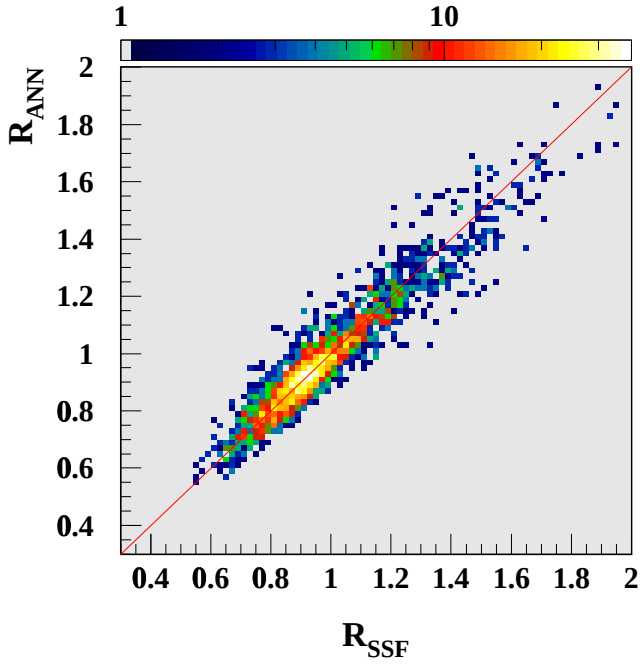
SCENE (All-Sky)	**Threshold** (FOV/bin)	**N bins**	**Iterations**	**E / N Bins**
No-Glint-Ocean	**250**	**16255**	**5000**	$\mathbf{2.51 \cdot 10^{-3}}$
Glint-Ocean	**50**	**4180**	**25000**	$\mathbf{1.02 \cdot 10^{-2}}$
MH/TS	**50**	**17013**	**5000**	$\mathbf{2.58 \cdot 10^{-3}}$
LM/TS	**75**	**18012**	**5000**	$\mathbf{2.59 \cdot 10^{-3}}$
DD	**30**	**16761**	**5000**	$\mathbf{3.31 \cdot 10^{-3}}$
BD	**15**	**15685**	**5000**	$\mathbf{1.50 \cdot 10^{-3}}$

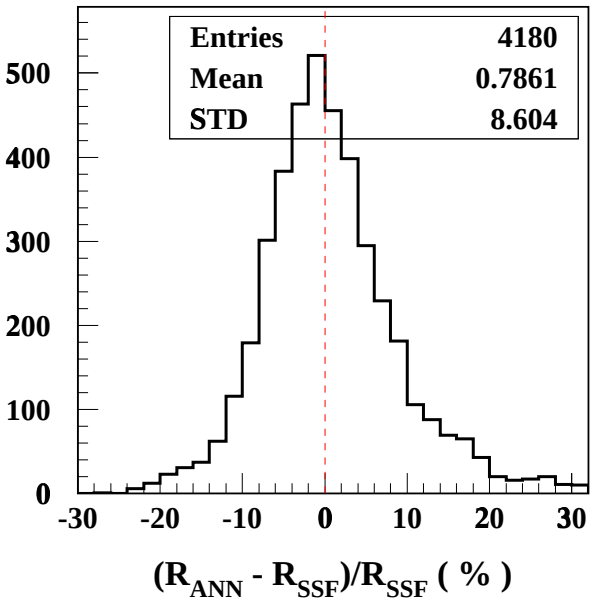
BD SCENE TYPE TRAINING, R_{SW}

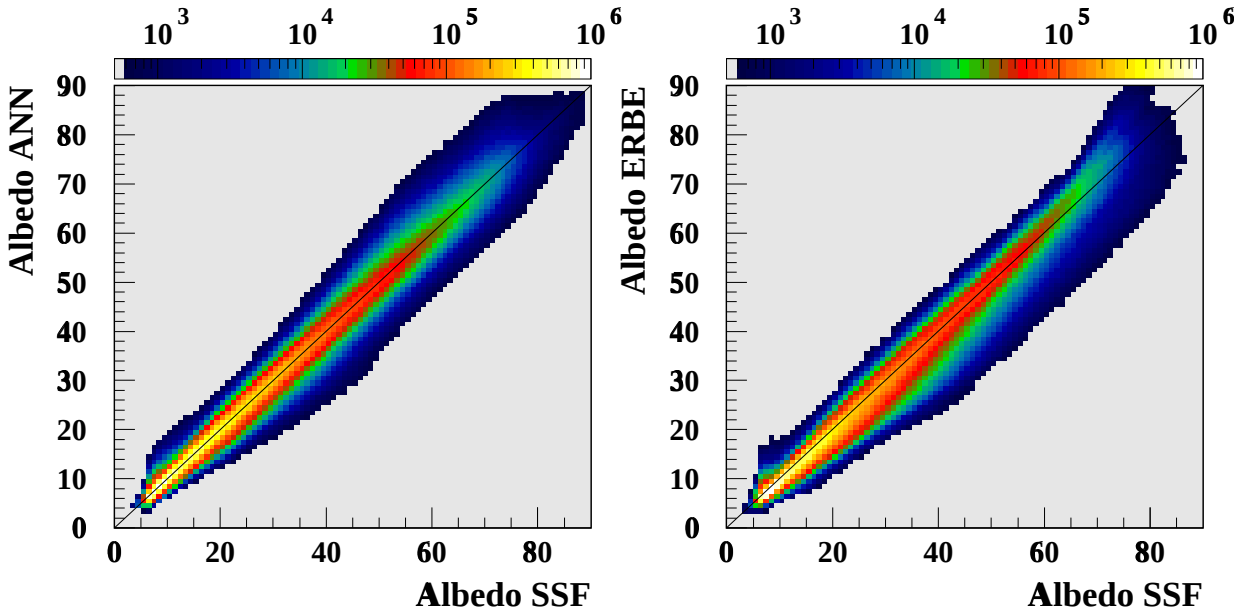




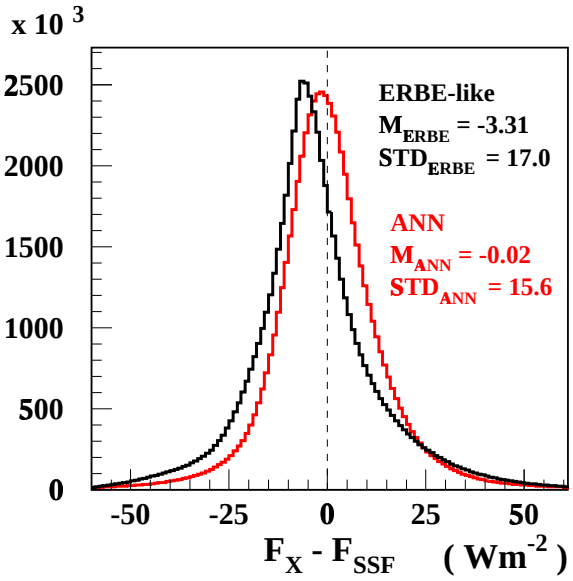
GLINT OCEAN SCENE TYPE TRAINING, R_{SW}

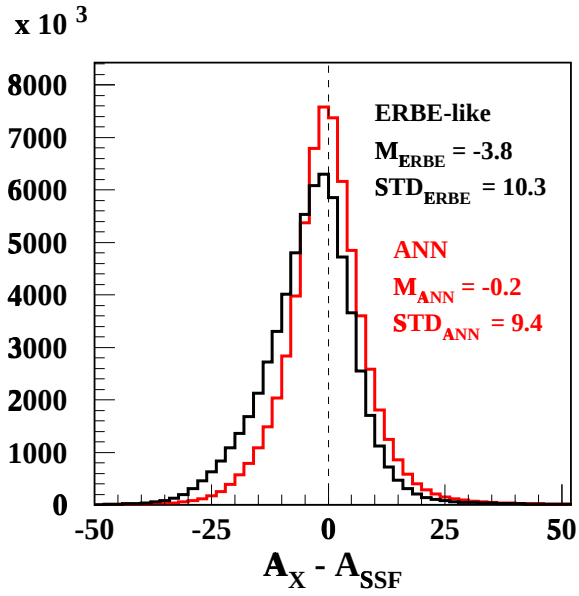




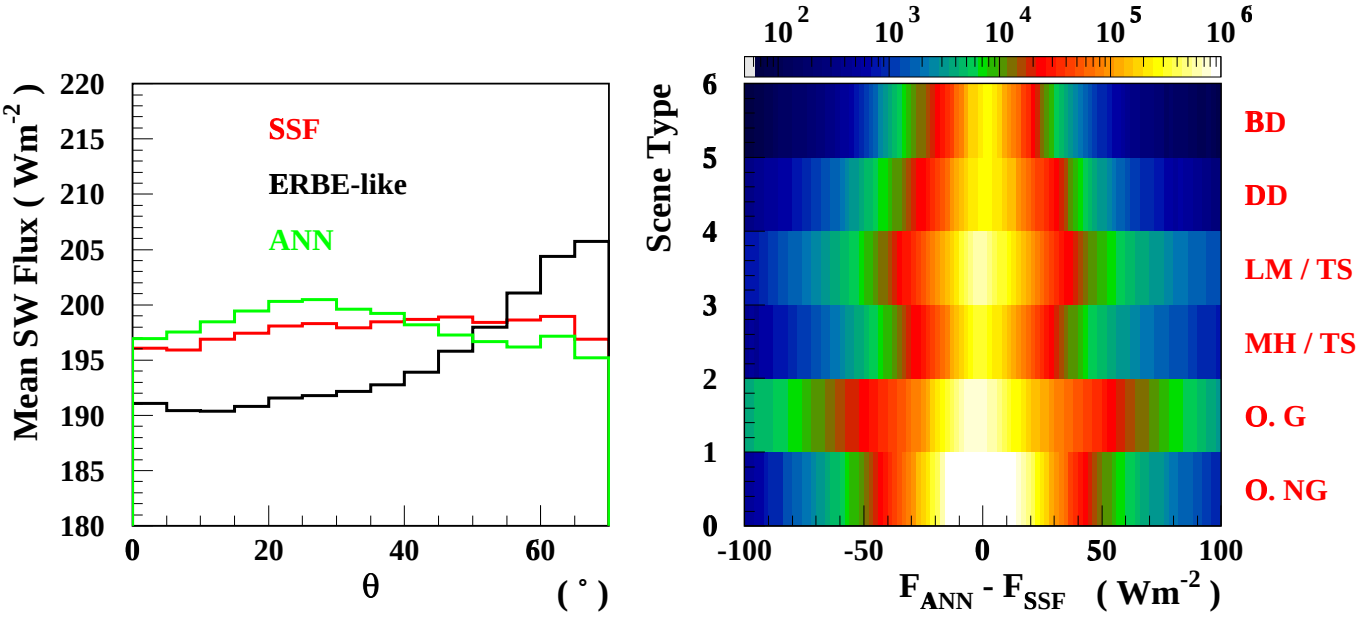

CERES/TRMM SSF, RAPS, All-Sky, All SZA
10^3
10^4
10^5
10^6
Albedo ANN
Albedo SSF
Albedo ERBE
Albedo SSF
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80

CERES/TRMM SSF, RAPS, All-Sky, All SZA

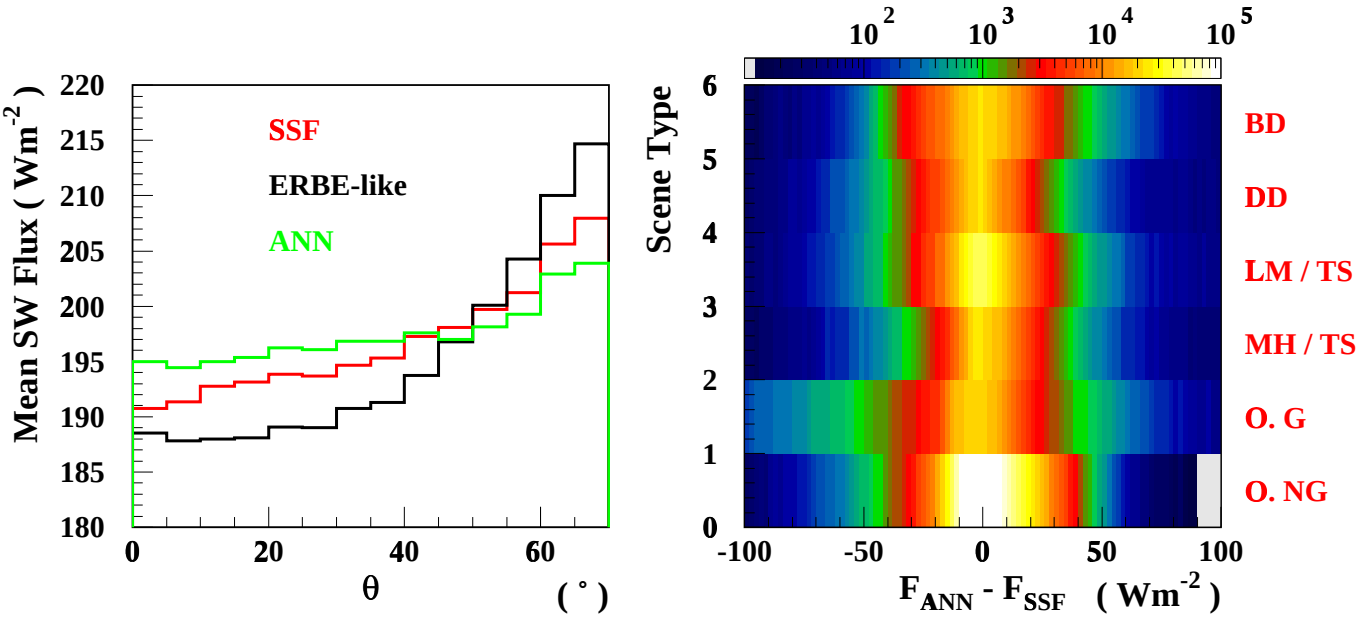


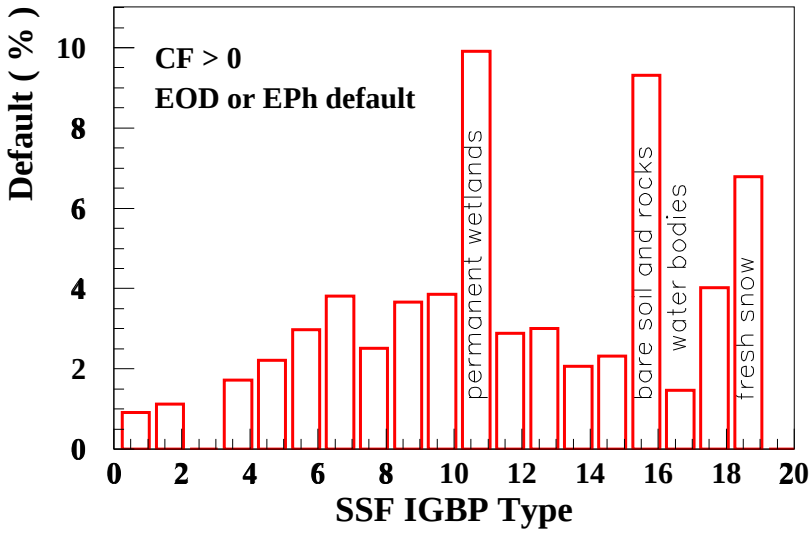


CERES/TRMM SSF, RAPS, All-Sky, All SZA



CERES/TRMM SSF, RAPS, UNKNOWN, All SZA





RAPS DATA, LW FLUX, ALL-SKY OCEAN

ANN CONFIGURATION: 4TS - 13TS - 1L

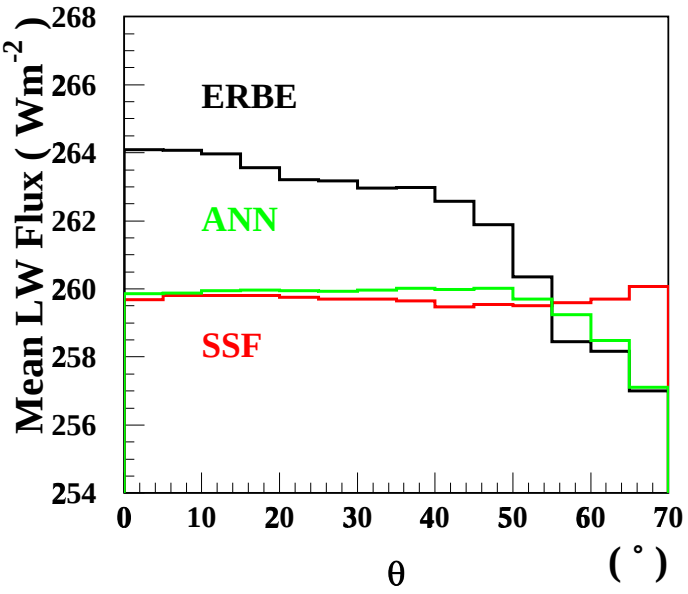
Variable	N bins	Bin Width	Normalization
VZA	28	2.5°	90°
T-skin	12	2.5°K	310°K
LWR	24	5 Wm^{-2} sr^{-1}	120°
SWR	20	15 Wm^{-2} sr^{-1}	300 Wm^{-2} sr^{-1}

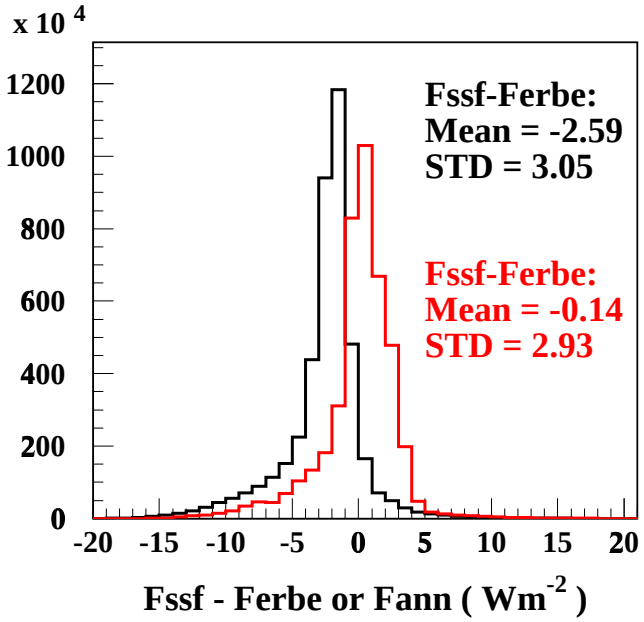
Threshold = 30 FOV/bin

Non-zero N bins = 38,198

After 1,000 iterations E / N bins = $2.25 \cdot 10^{-4}$

RAPS DATA, LW FLUX, ALL-SKY OCEAN





SUMMARY

- **ANN simulation algorithms DO work.**
- **Application of ANN simulation algorithms as *Unknown* ADM type for Terra products (no imager information).**
- **Possibility of reducing ERBE-like data flux errors by applying ANN-based ADMs.**
- **Application of ANN simulation algorithms to satellites without imager instrument.**