Iso-Contour Tracing for Parameter Space Analysis of an Atmospheric Convection Model

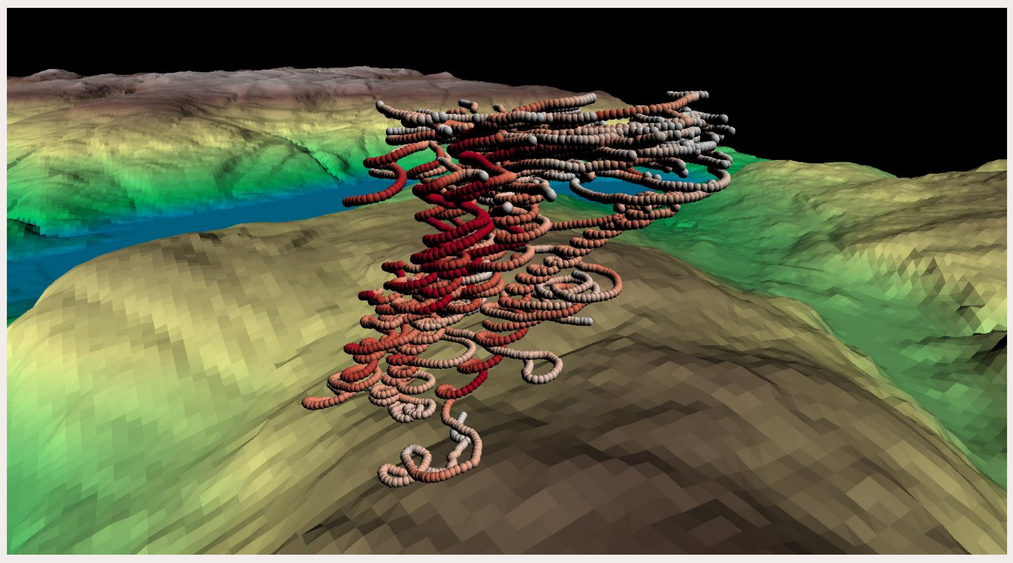
Juraj Pálenik, Thomas Spengler, and Helwig Hauser

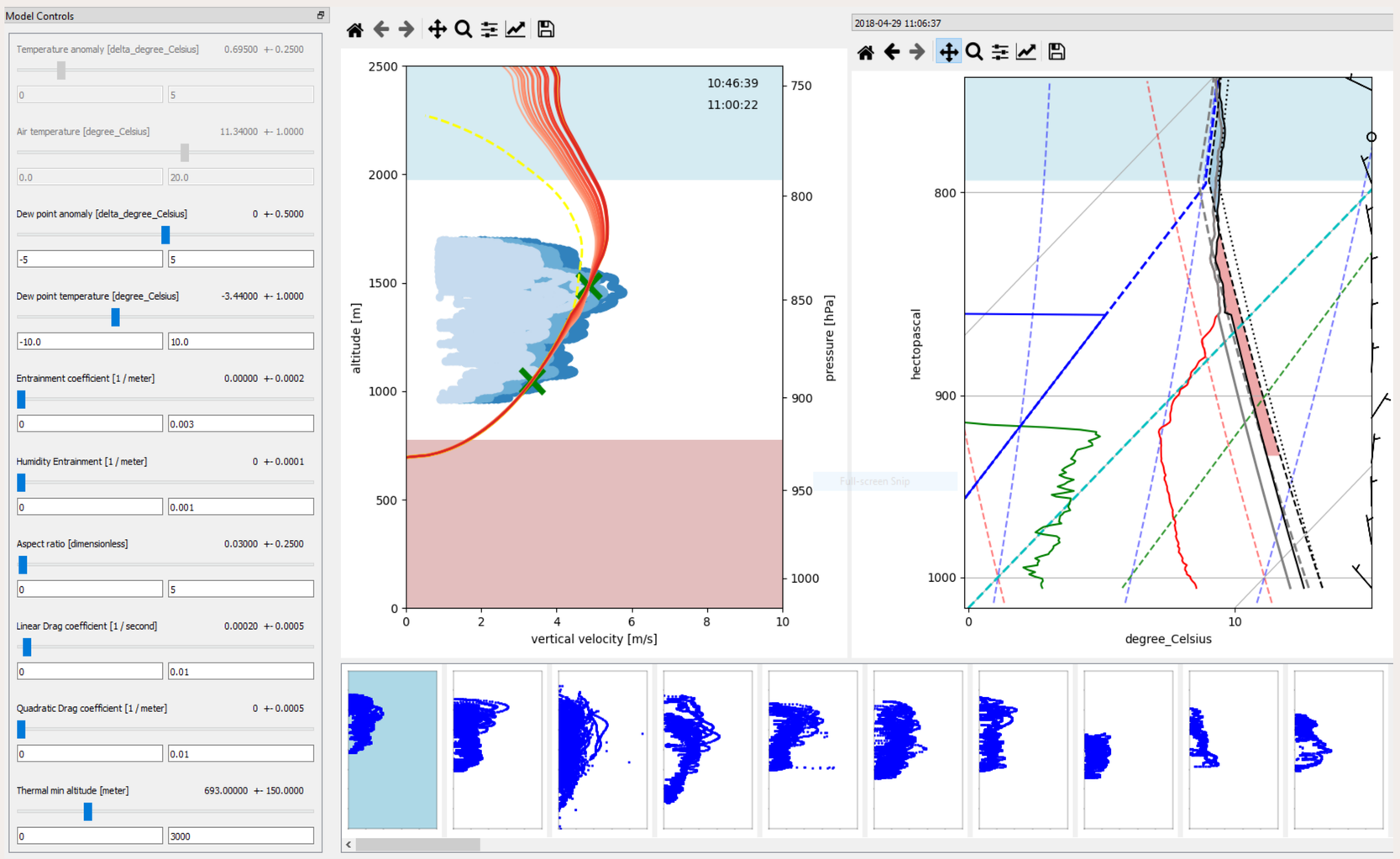
We enhance the understanding of an atmospheric convection model by revealing dependencies between model parameters through user-guided exploration of the model.

Juraj Palenik
University of Bergen
Juraj.Palenik@uib.no

Background

Atmospheric convection is associated with rising and sinking air in the lower atmosphere. It is responsible for vertical mixing of the atmosphere and cloud formation. Unfortunately, due to its scale and turbulent behavior, it is impossible for numerical weather prediction models to fully resolve convective processes. Therefore, empirical parametrizations are commonly employed. These depend on many parameters, making them challenging to verify, as an exhaustive parameter space sampling would be beyond reasonable computational capacities. We tackle this complexity by extracting interdependencies between model parameters.





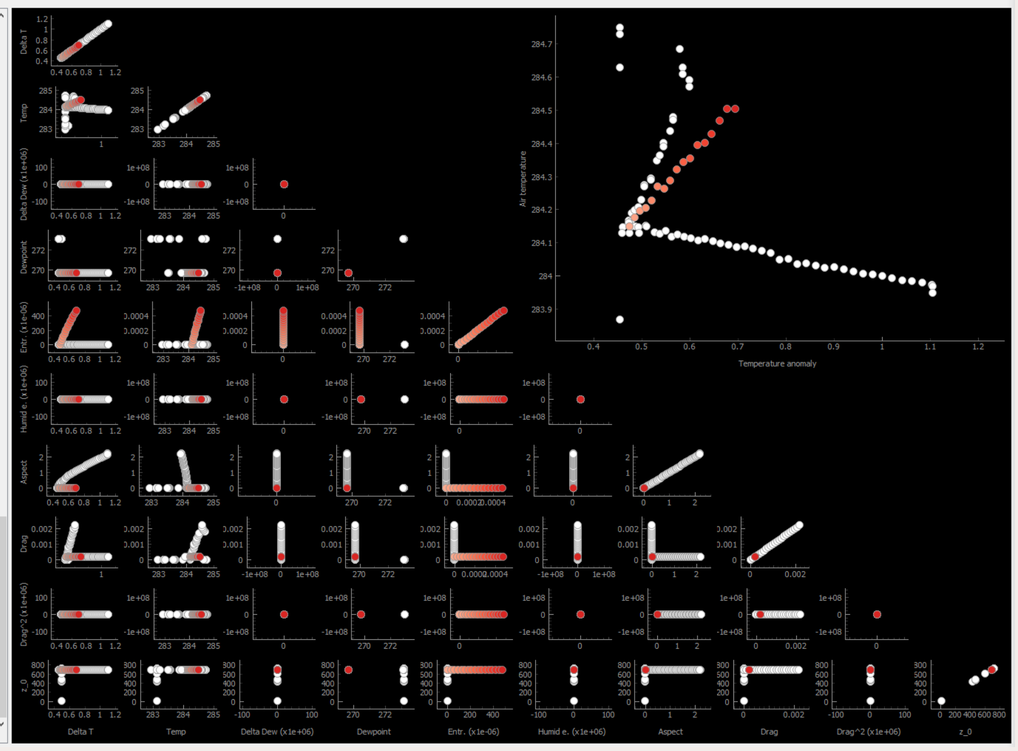
Atmospheric convection model

The analysis tool (left) enables a multiparameter investigation of the atmospheric convection model. The model can be manually constrained using anchor points based on measurement data extracted from paragliding flights (top). The interdependencies between parameters are discovered by constraining the model and sampling along parameter-space iso-contours.

Parameter space tracing

Traces of the parameter values are shown in a scatterplot view. This enables the user to better navigate the parameter space, go back to previous results, and compare different model runs. It explicitly shows the sampled iso-contours of the model, which represent the interdependencies between parameters.

	mperature anom	Air temperature	ew point anomal	v point temperat	ainment coeffic
76	8.815e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
77	9.011e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
78	9.209e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
79	9.408e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
80	9.608e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
81	9.810e-01	2.840e+02	0.000e+00	2.697e+02	0.000e+00
82	1.001e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
83	1.022e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
84	1.042e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
85	1.063e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
86	1.084e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
87	1.104e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
88	1.105e+00	2.840e+02	0.000e+00	2.697e+02	0.000e+00
89	1.105e+00	2.839e+02	0.000e+00	2.697e+02	0.000e+00
90	4.737e-01	2.842e+02	0.000e+00	2.697e+02	0.000e+00
91	4.750e-01	2.841e+02	0.000e+00	2.697e+02	0.000e+00
92	4.852e-01	2.842e+02	0.000e+00	2.697e+02	3.000e-05
93	4.970e-01	2.842e+02	0.000e+00	2.697e+02	6.000e-05
94	5.090e-01	2.842e+02	0.000e+00	2.697e+02	9.000e-05
95	5.213e-01	2.842e+02	0.000e+00	2.697e+02	1.200e-04
96	5.339e-01	2.843e+02	0.000e+00	2.697e+02	1.500e-04
97	5.468e-01	2.843e+02	0.000e+00	2.697e+02	1.800e-04
98	5.600e-01	2.843e+02	0.000e+00	2.697e+02	2.100e-04
99	5.736e-01	2.843e+02	0.000e+00	2.697e+02	2.400e-04
100	5.874e-01	2.843e+02	0.000e+00	2.697e+02	2.700e-04
101	6.017e-01	2.844e+02	0.000e+00	2.697e+02	3.000e-04
102	6.162e-01	2.844e+02	0.000e+00	2.697e+02	3.300e-04
103	6.311e-01	2.844e+02	0.000e+00	2.697e+02	3.600e-04
104	6.464e-01	2.844e+02	0.000e+00	2.697e+02	3.900e-04
105	6.620e-01	2.845e+02	0.000e+00	2.697e+02	4.200e-04
106	6.781e-01	2.845e+02	0.000e+00	2.697e+02	4.500e-04
107	6.942e-01	2.845e+02	0.000e+00	2.697e+02	4.800e-04



Results

Iso-tracing is a powerful method for multi-parameter analysis of scientific models. We were able to describe the interplay between *drag*, *entrainment*, *aspect ratio,* and other parameters of the atmospheric convection model. Currently, we are obtaining high quality observations comprising a combination of Laser Direction and Ranging methods (LIDAR) and data mining from paragliding datasets to confront the model findings with real-world observations.

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REFERENCES
J. Palenik, T. Spengler and H. Hauser, "IsoTrotter: Visually Guided Empirical Modelling of Atmospheric Convection," in IEEE Transactions on Visualization and Computer Graphics, vol. 27, no. 2, pp. 775-784, Feb. 2021, doi: 10.1109/TVCG.2020.3030389.

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