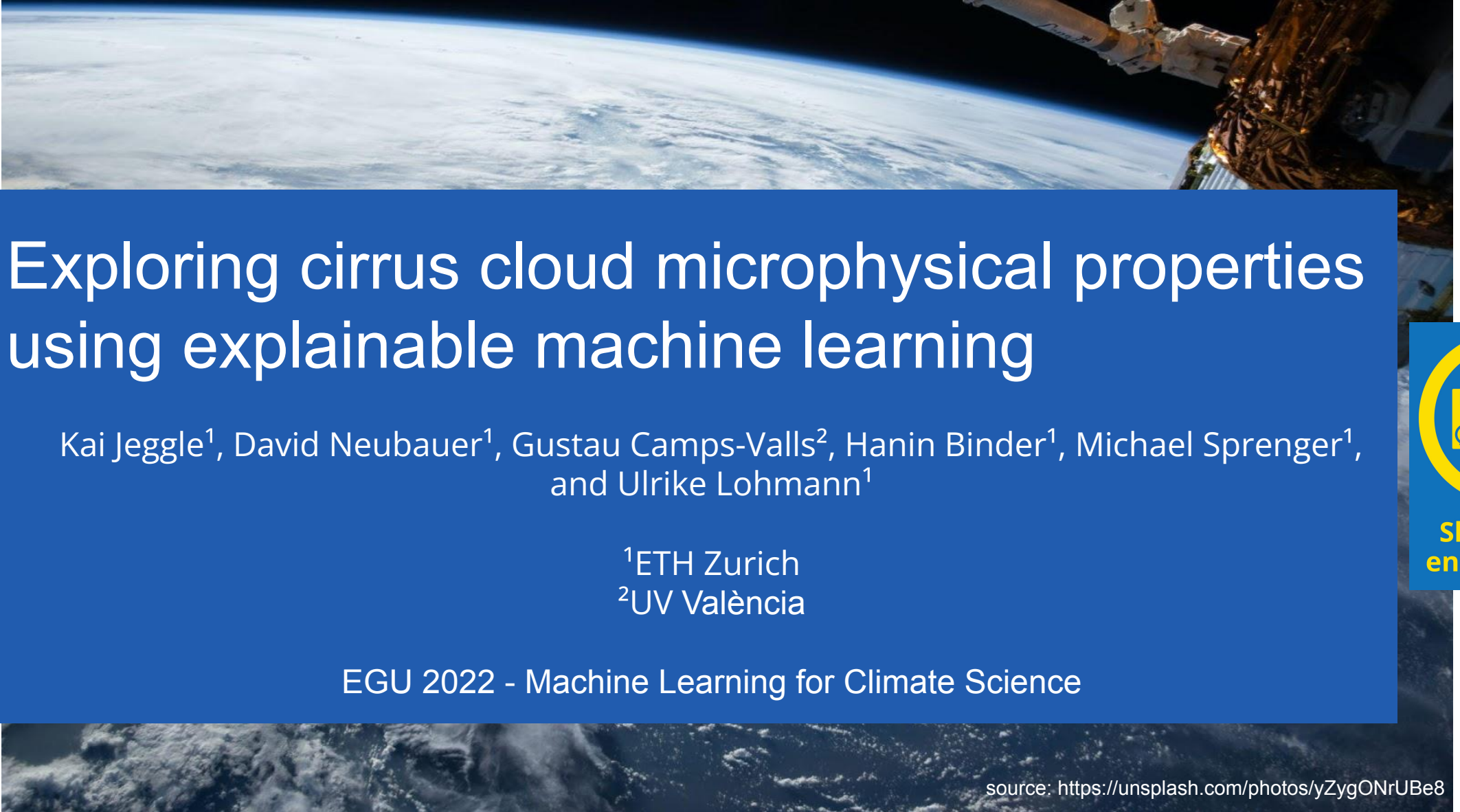




Exploring cirrus cloud microphysical properties using explainable machine learning

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EGU 2022 - Machine Learning for Climate Science



**Sharing is
encouraged**



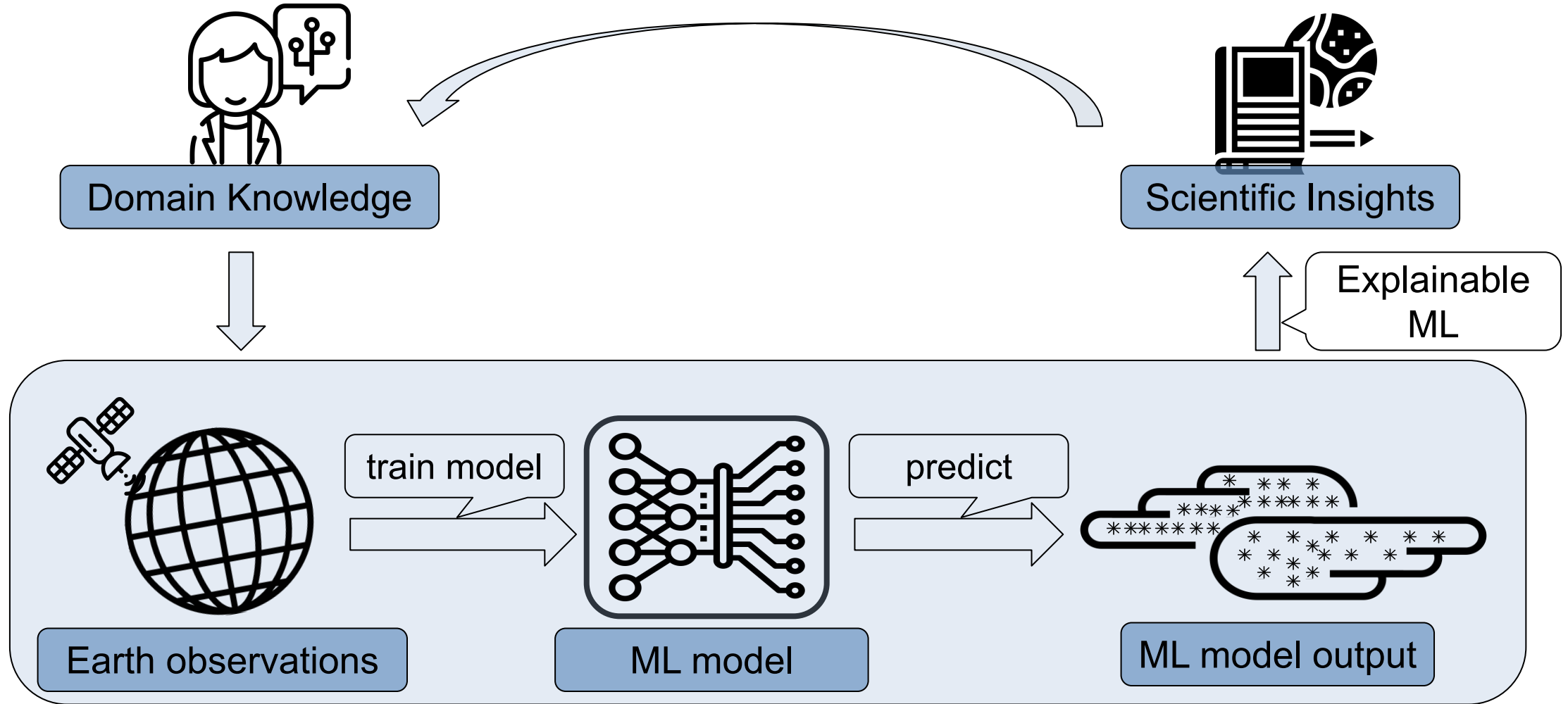
source: <https://cloudatlas.wmo.int/en/home.html>



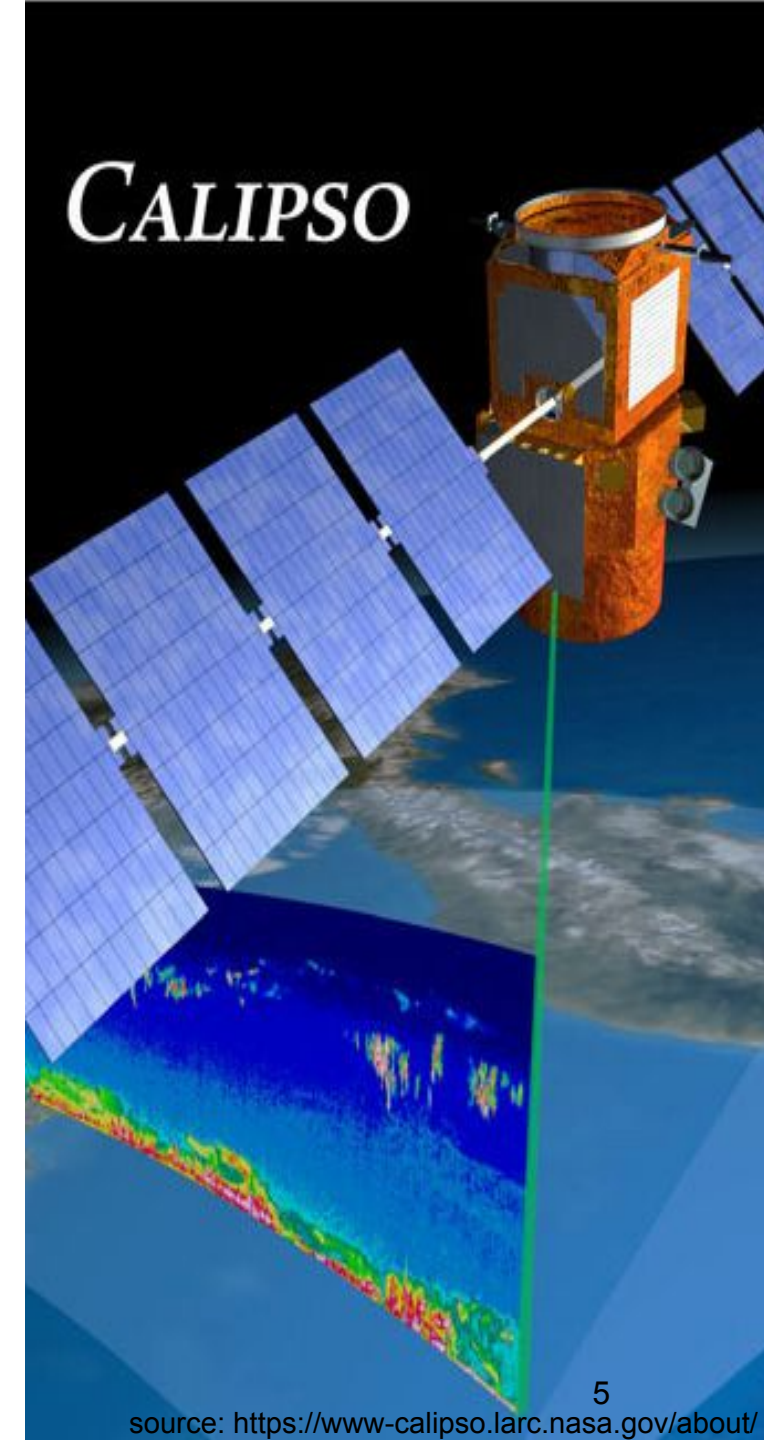
source: <https://cloudatlas.wmo.int/en/home.html>

Goal: Detect & quantify cirrus cloud drivers

Method



Data



Data

Predictands

Cirrus Proxies	Source
ICNC (small, large)	DARDAR NICE ¹
IWC	

Predictors

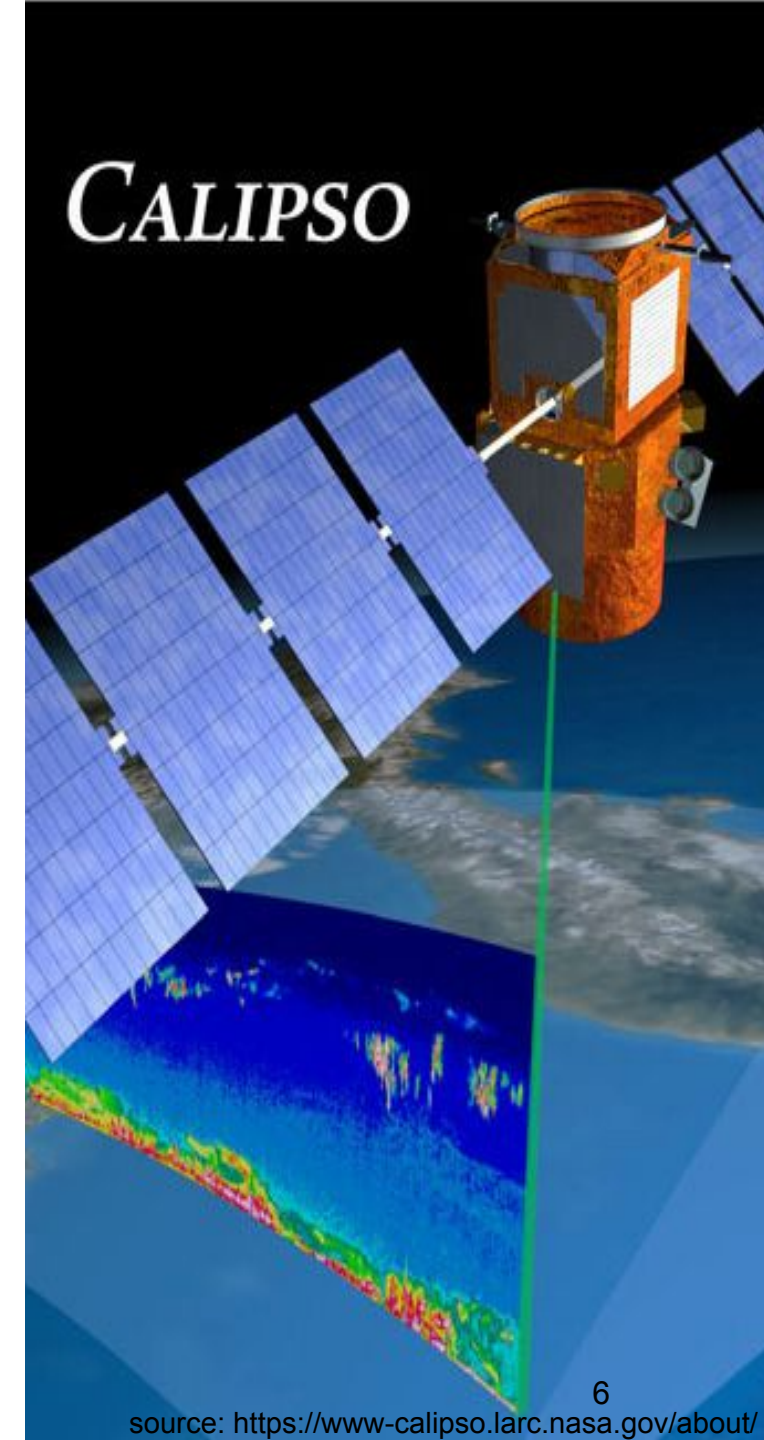
Meteorological Variables	Source
Temperature	ERA5
Relative humidity	
Vertical velocity	
Horizontal winds	

Aerosol Environment	Source
Dust aerosols	MERRA2
Sulfate aerosols	

Meta Information	Source
Topography	ERA5
Season	
Region	

¹Sourdeval et al. 2018

IWC – Ice Water Content | ICNC – Ice crystal number concentration



Data

Predictands

Cirrus Proxies	Source
ICNC (small, large)	DARDAR
IWC	NICE

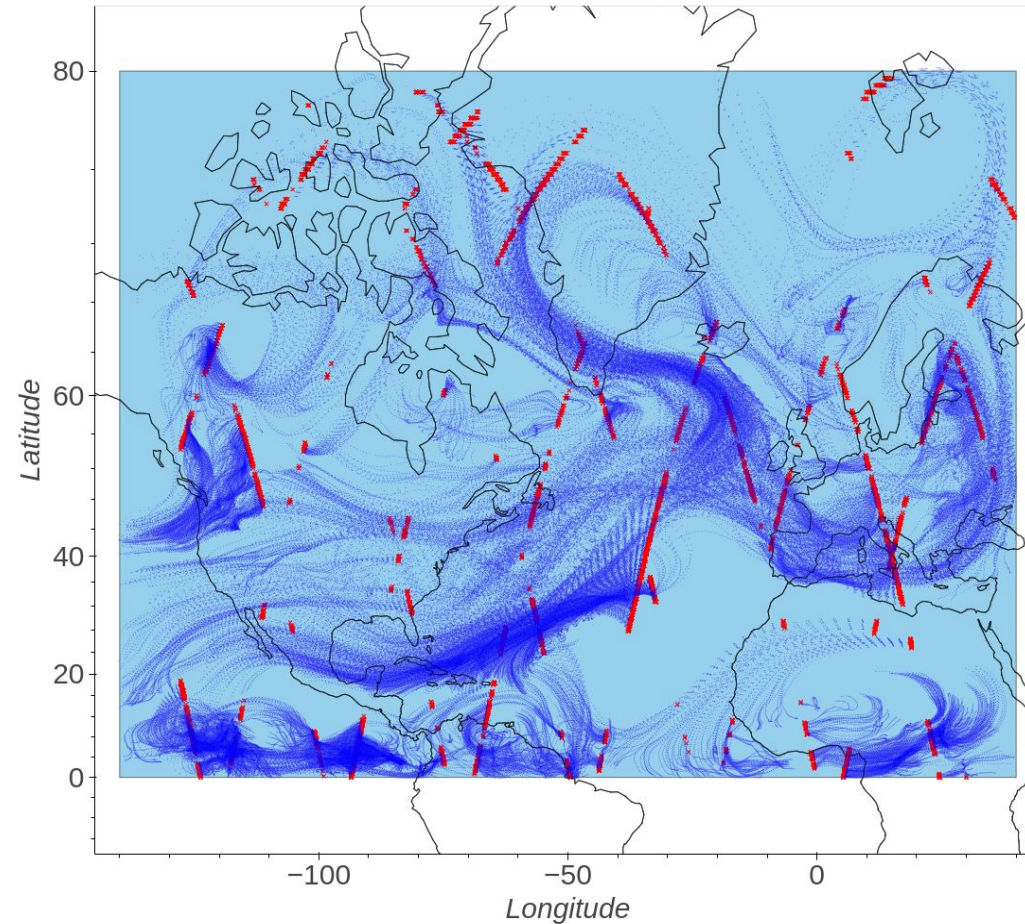
Predictors

Meteorological Variables	Source
Temperature	ERA5
Relative humidity	
Vertical velocity	
Horizontal winds	

Aerosol Environment	Source
Dust aerosols	MERRA2
Sulfate aerosols	

Meta Information	Source
Topography	ERA5
Season	
Region	

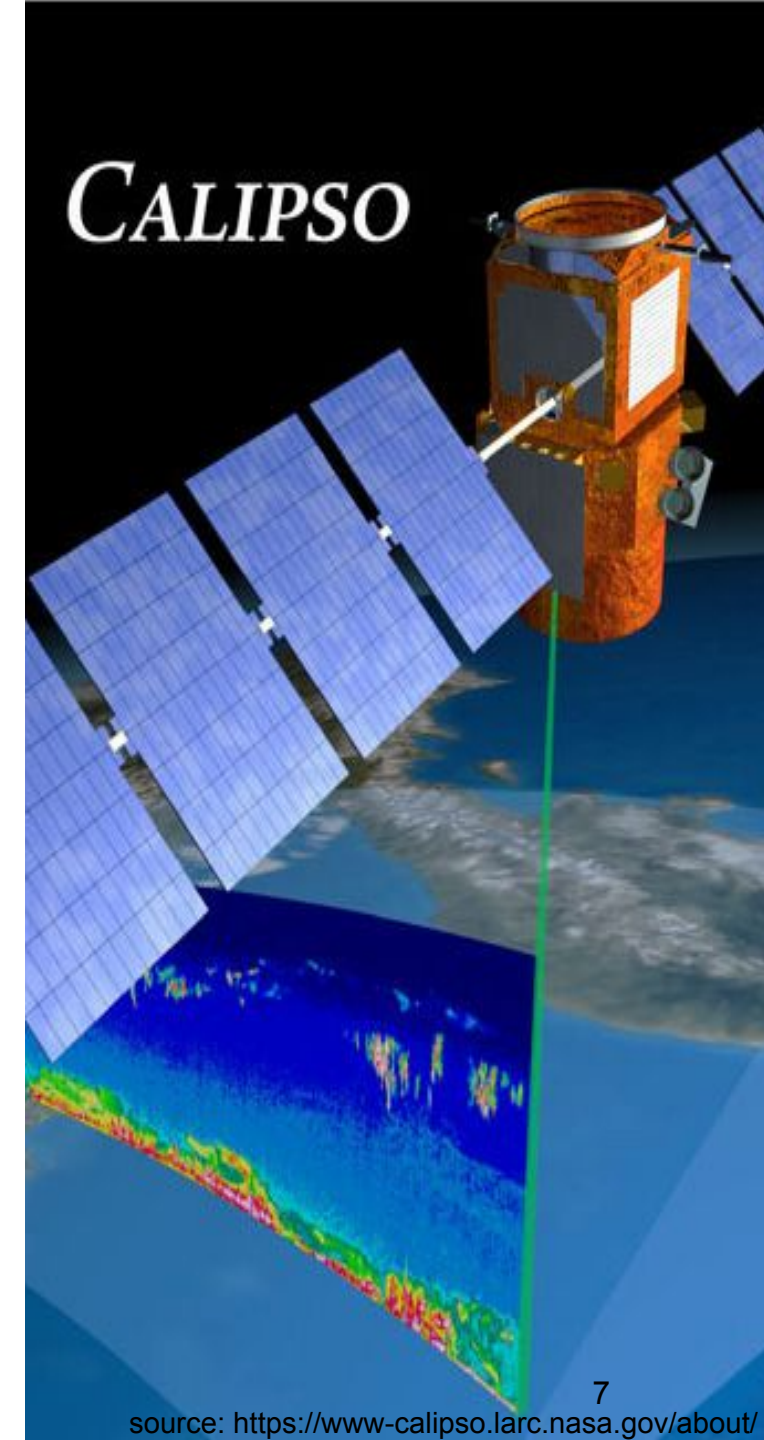
Augment with Lagrangian backtrajectories



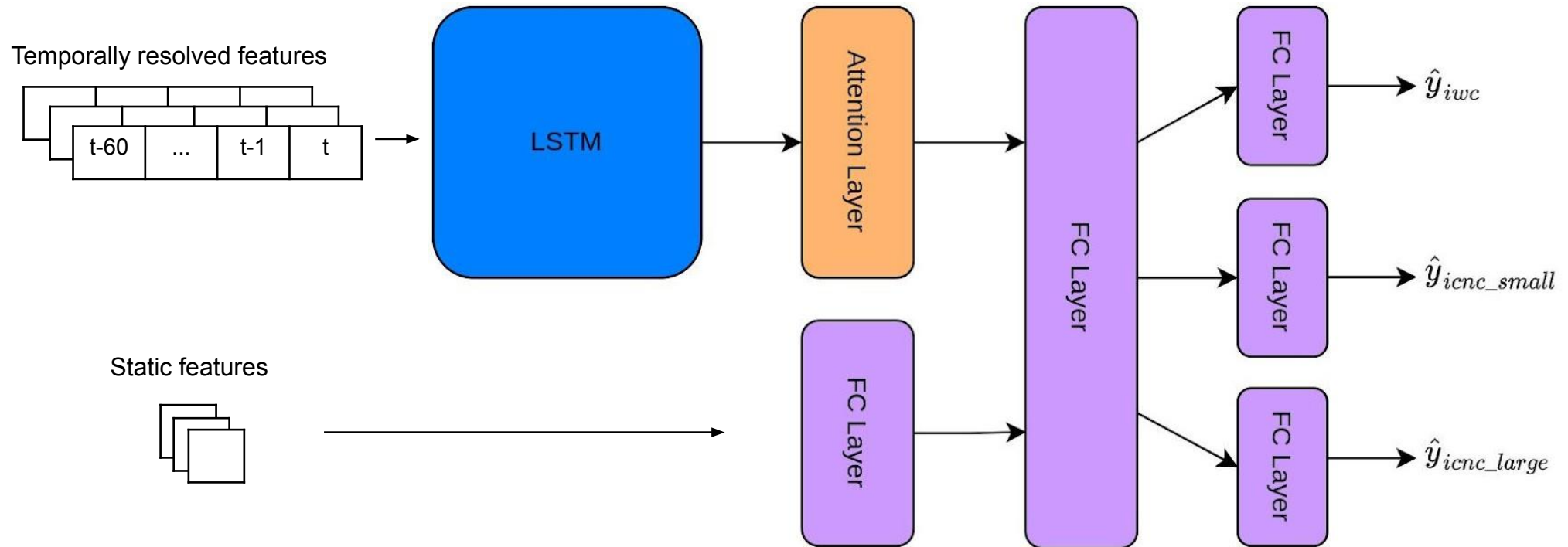
¹Sourdeval et al. 2018

IWC – Ice Water Content | ICNC – Ice crystal number concentration

CALIPSO



Machine Learning Architecture

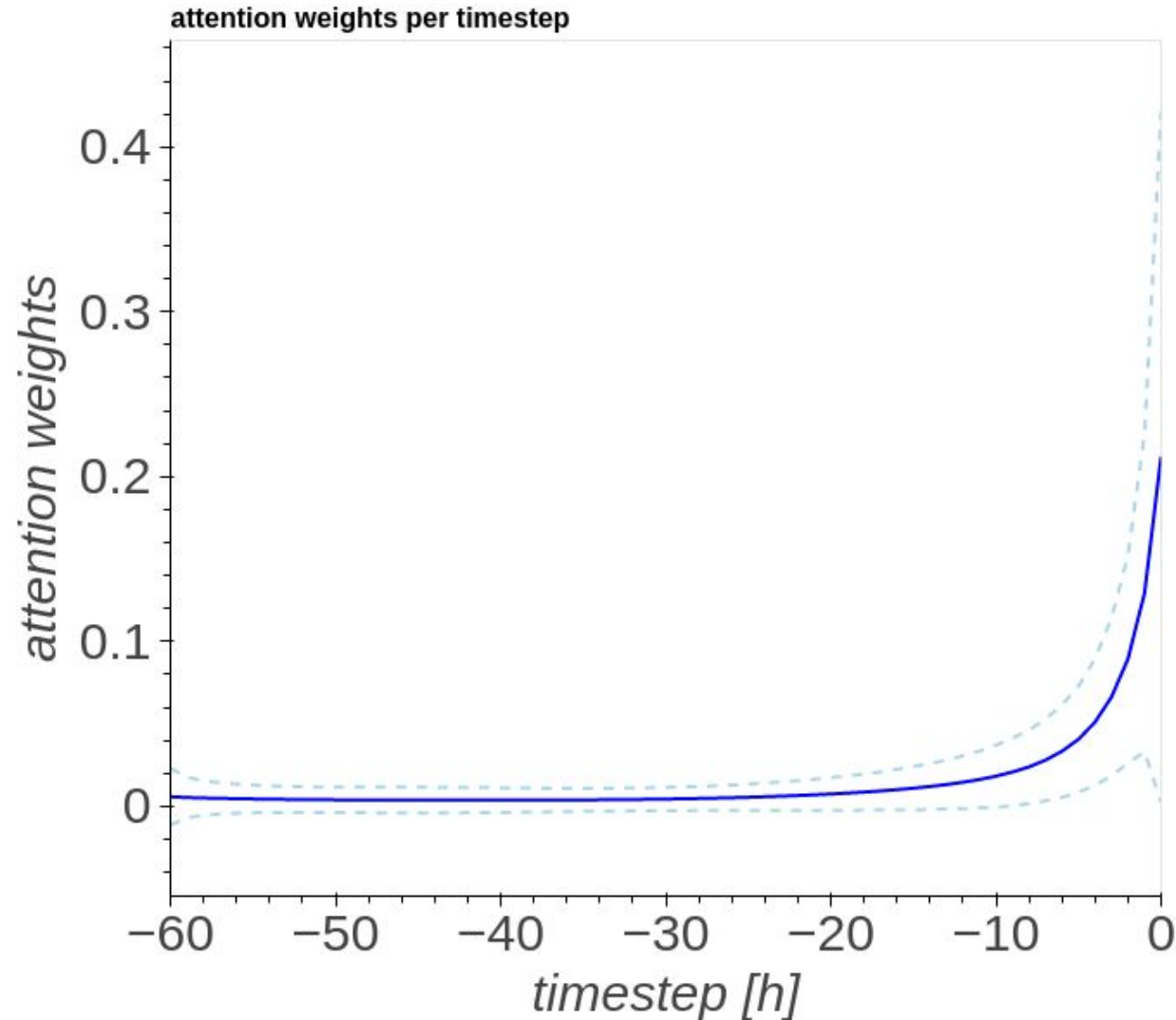


Results

Model	IWC [kg m ⁻³]		ICNC 5um [m ⁻³]		ICNC 100um [m ⁻³]	
	rmse	R ²	rmse	R ²	rmse	R ²
Vanilla LSTM	0.3	0.32	0.39	0.28	0.41	0.31
LSTM + Attention	0.29	0.45	0.37	0.31	0.36	0.34
LSTM + Attention + cost sensitive reweighting	0.27	0.49	0.33	0.40	0.35	0.39
Multitask LSTM + Attention + cost sensitive reweighting	0.27	0.53	0.27	0.48	0.3	0.51
XGBoost	0.42	0.37	0.37	0.35	0.41	0.31
Linear	0.47	0.19	0.51	0.17	0.44	0.21

Explainability

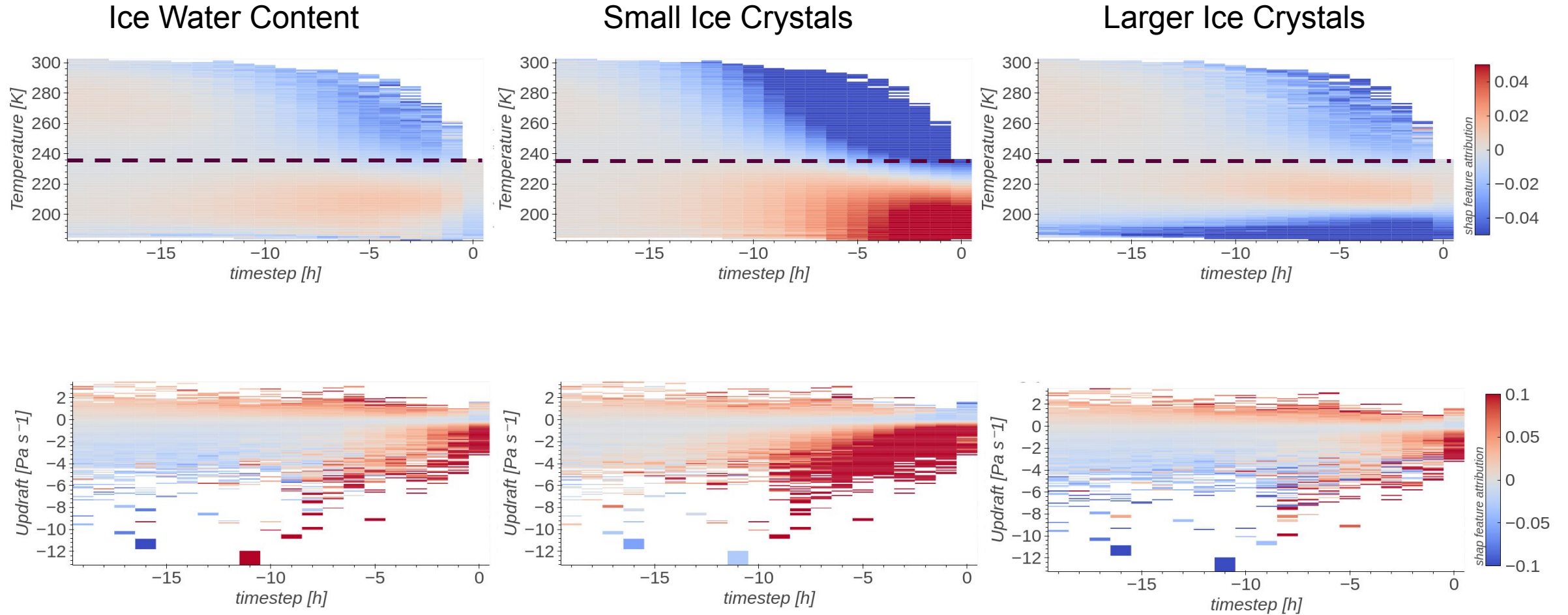
Attention Layer Interpretation



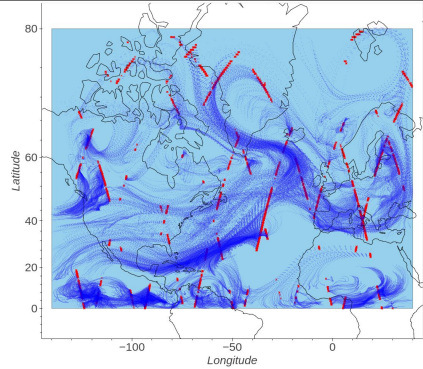
- Information more than 20 hours before observation is not used in model
- Last 5-10 hours before observation are most important

Explainability – Gradient SHAP

Feature attribution of temperature and updraft velocities

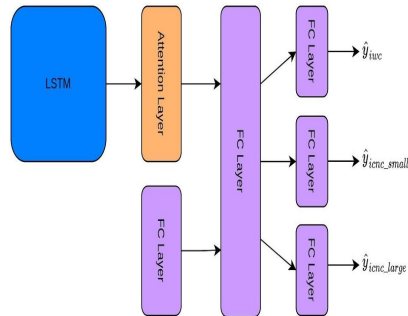


Summary



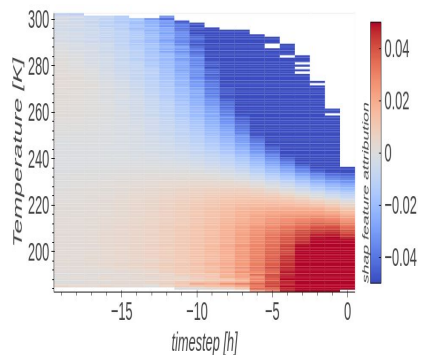
Data

- DARDAR NICE (Calipso + Cloudsat) colocated with ERA5 & MERRA2 reanalysis data
- Augmented with reanalysis backtrajectories



ML Model

LSTM + Attention based multi-task model



XAI

- Attention layer inherently provides temporal interpretation
- In depth feature attributions via SHAP values

Thank you :)

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