monthly dust outlooks

early results from a lightweight CNN

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Challenges in producing monthly dust outlooks

early results from a lightweight CNN

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26 million tonnes of dust
+ 500 million tonnes every year
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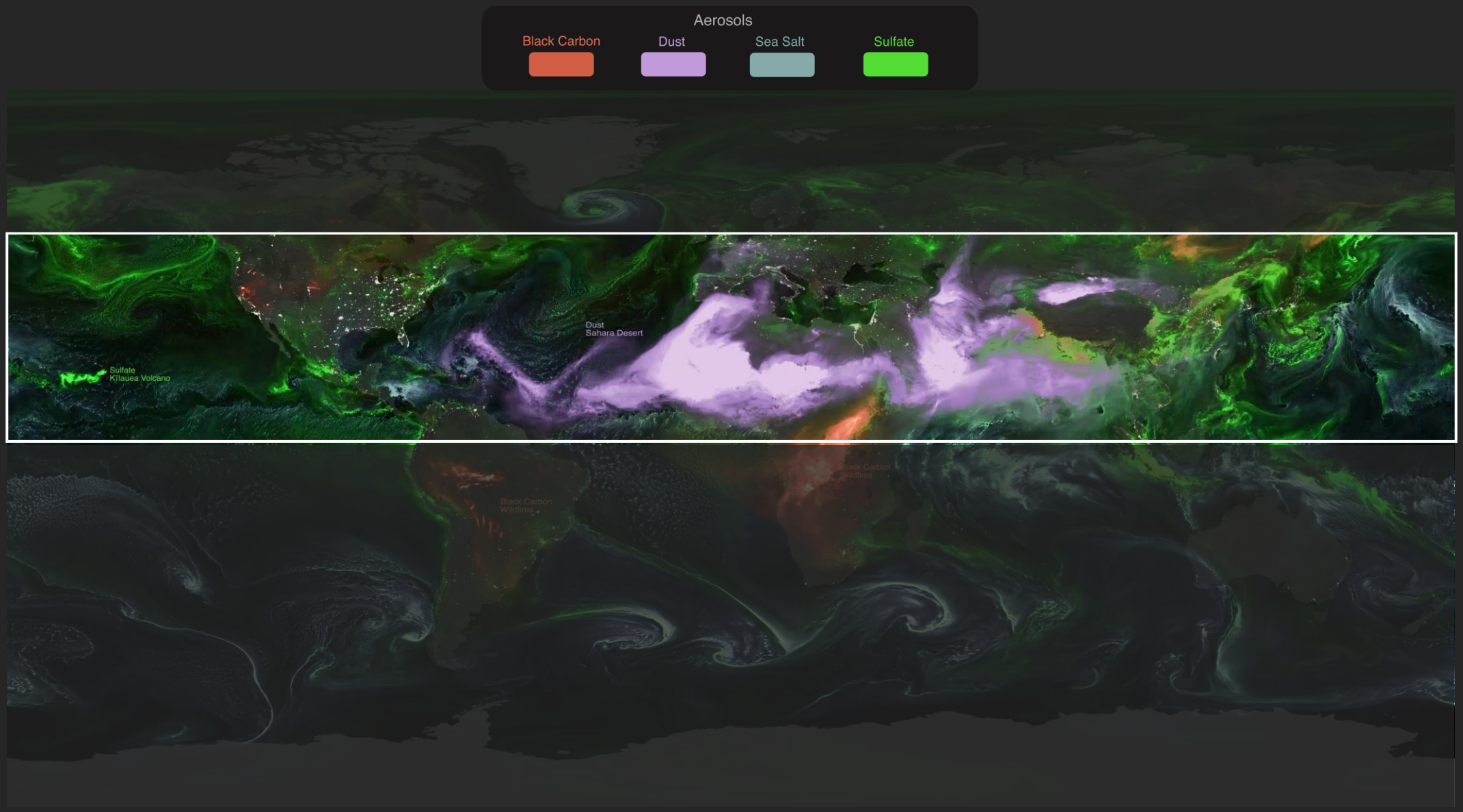
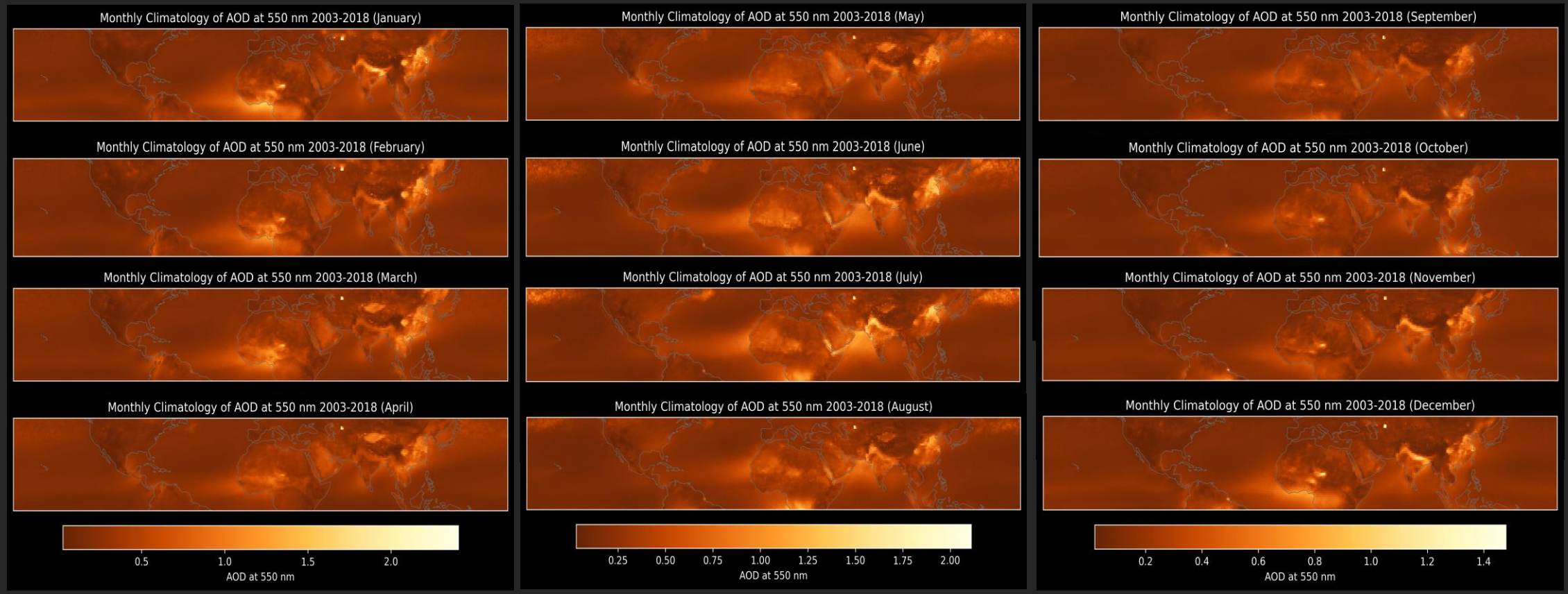
Aerosols (AOD) and the Global Dust Belt



Current monthly AOD forecasts

Current monthly AOD “forecasts”

Monthly climatological means only



3-months ahead AOD model

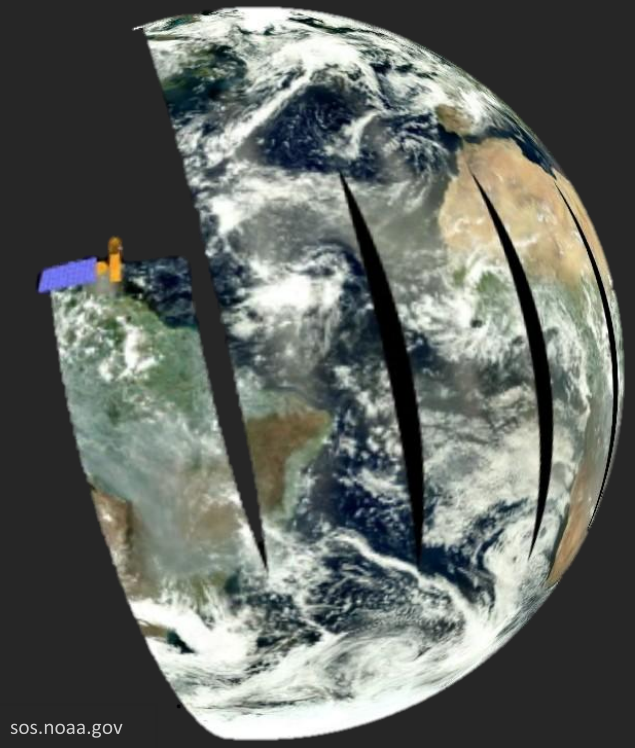
DustTempoNet

Data

Model

Results

Aerosol Optical Depth Data (**AOD**) 2003–2025

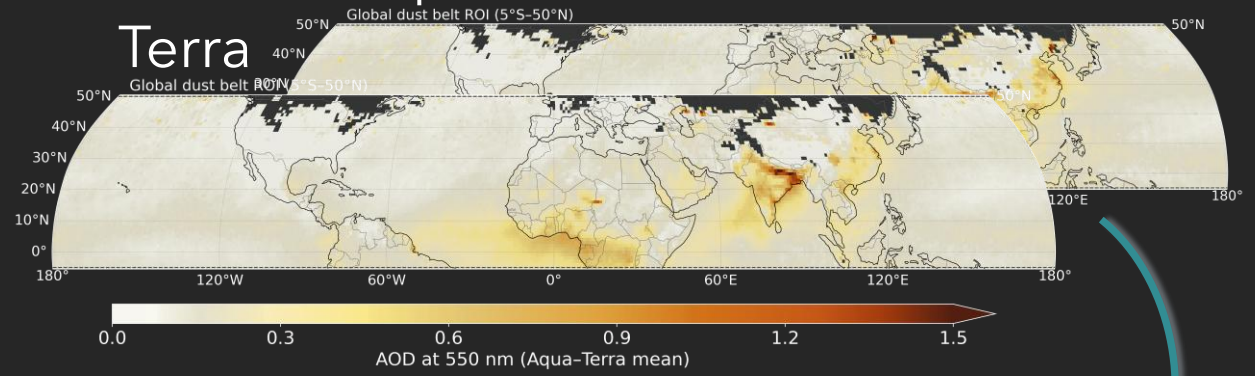


22 years
276 monthly means

MODIS

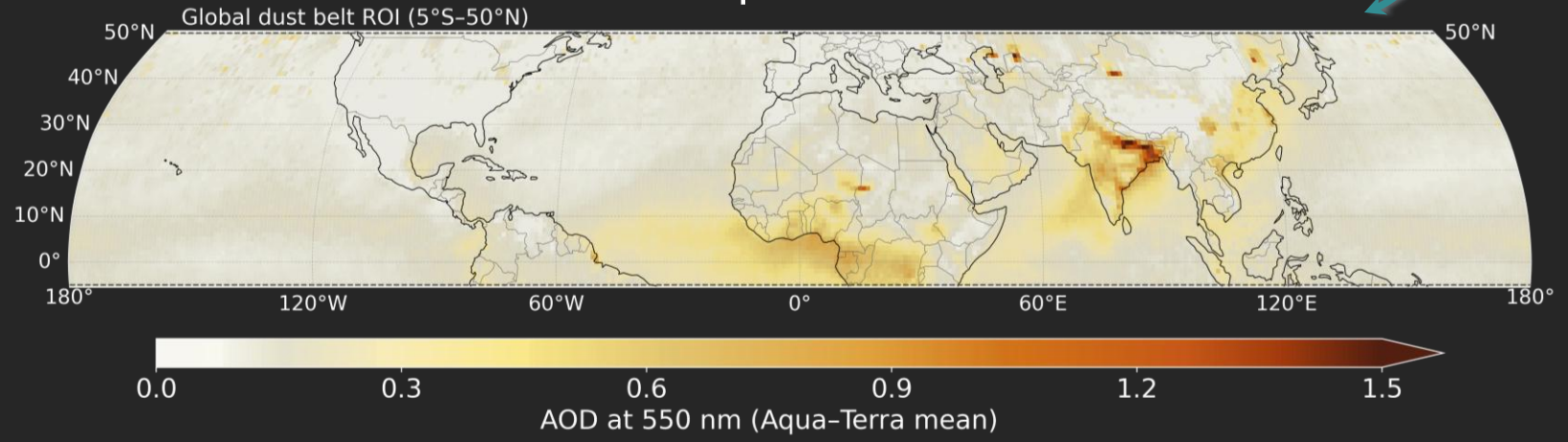
Aqua

Terra



Target:

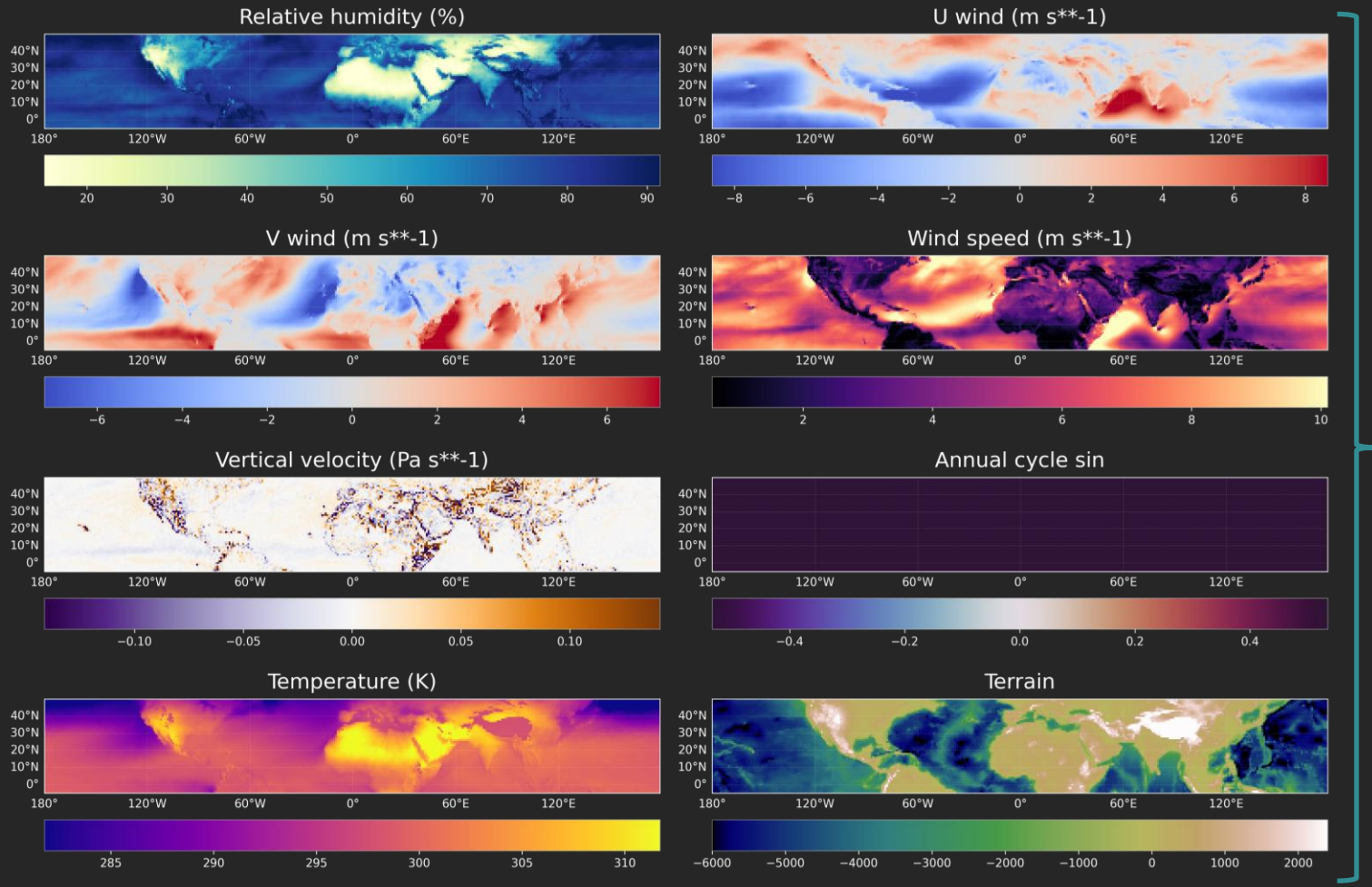
Imputed



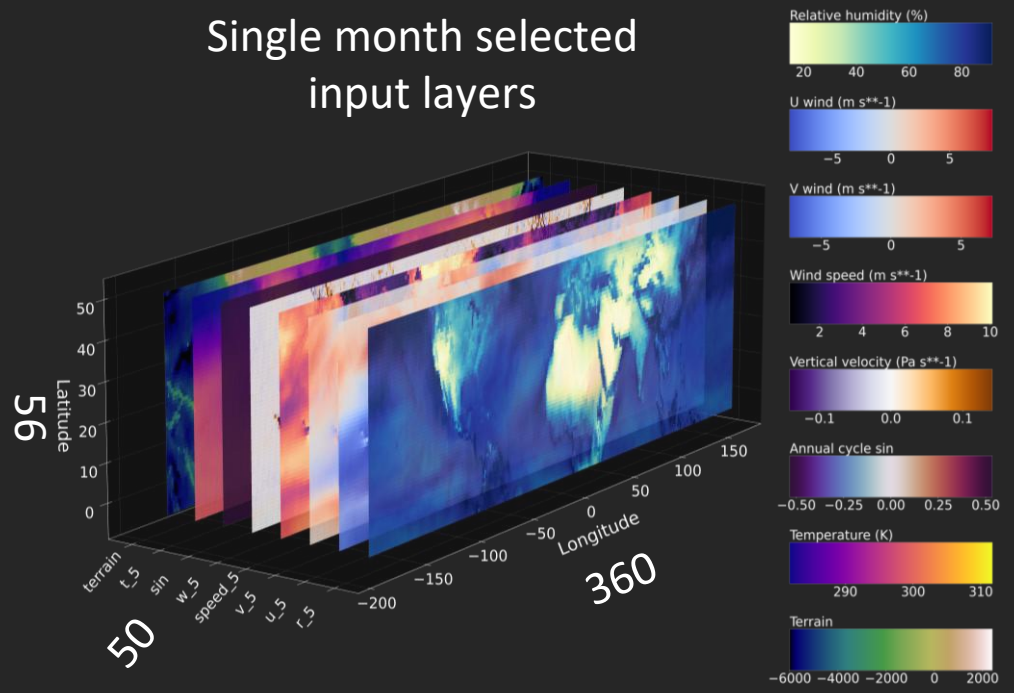
Input features (channels)

ERA5 on 5 pressure levels: 1000hPa to 550hPa

Lagged by 1 month (t-1)



Single month selected input layers

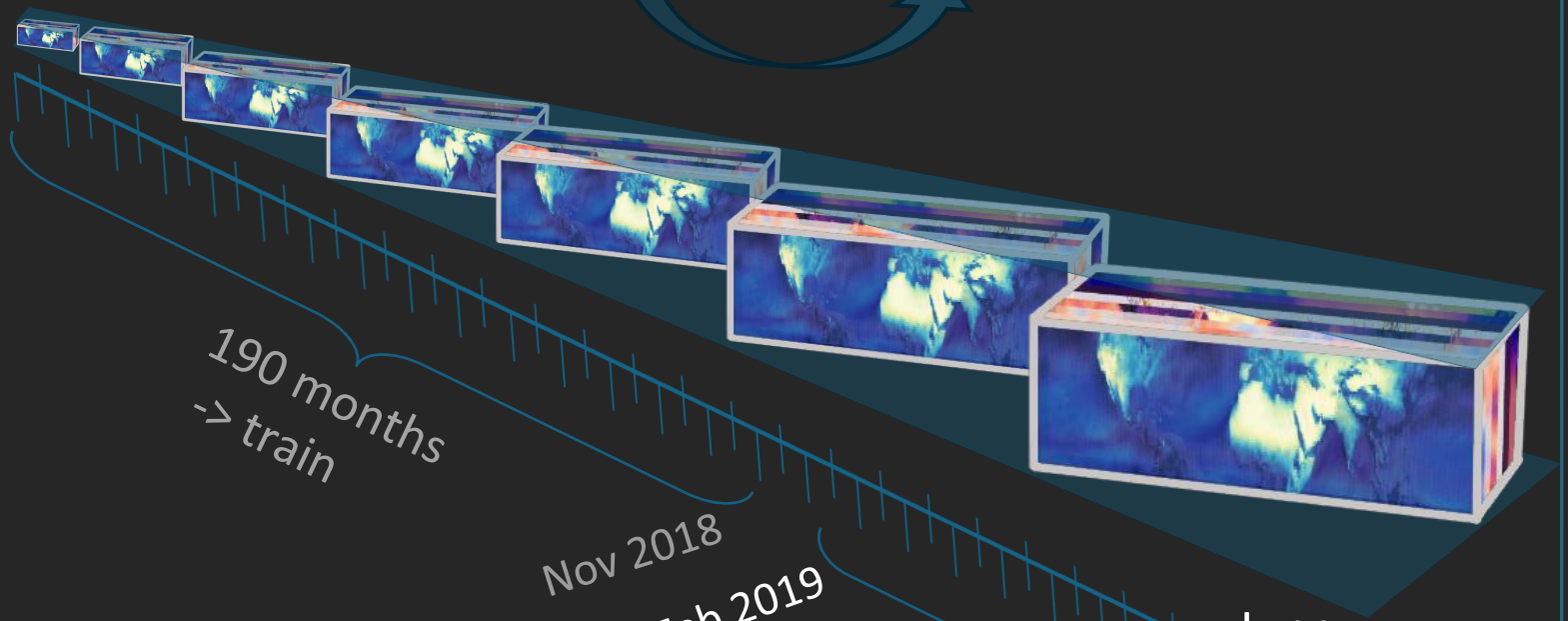


Final array shape:
(276, 56, 360, **50**)

TRAIN

70%
TRAIN

15%
SELF
VALIDATE



Feb
2003

190 months
-> train

Nov 2018

Feb 2019

40 months
-> validate

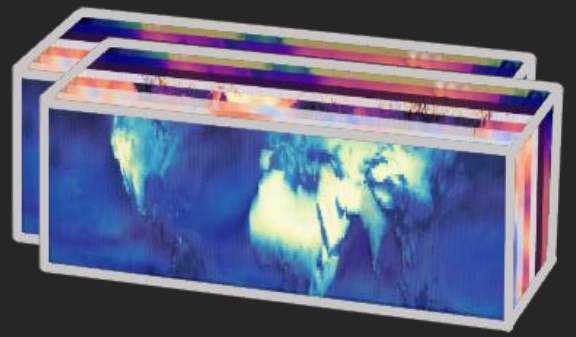
June
2022

TEST

15%

SET ASIDE

LEAD 1: July 2022 – Oct 2025
LEAD 2: Aug 2022 – Nov 2025
LEAD 3: Sept 2022 – Dec 2025



40 months

July
2022

Dec
2025

DustNet (v1)

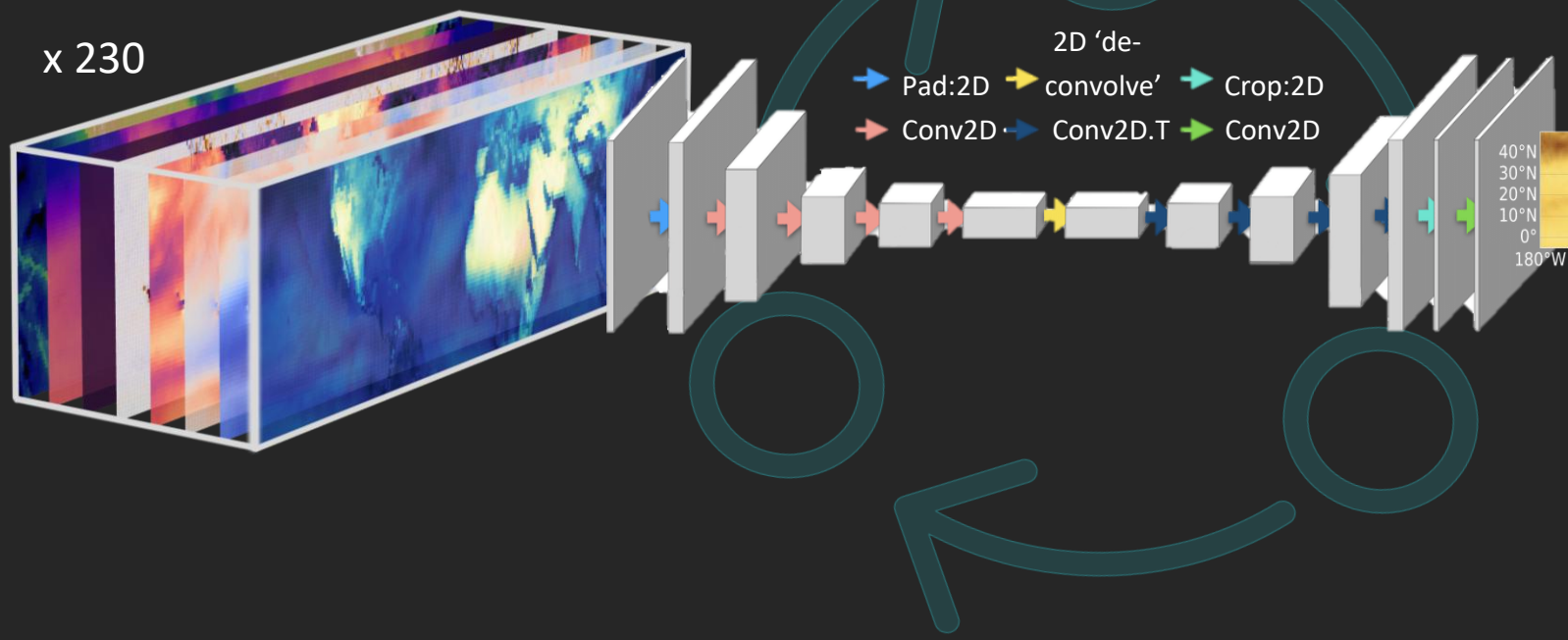
DustTempoNet Model

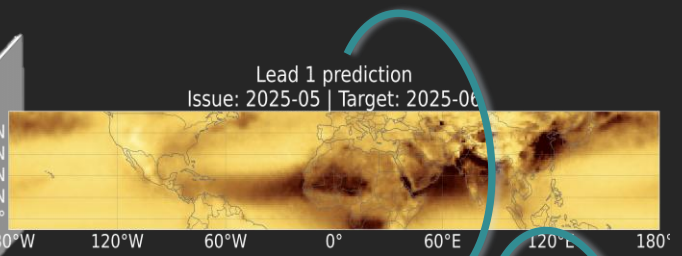
No GPU's

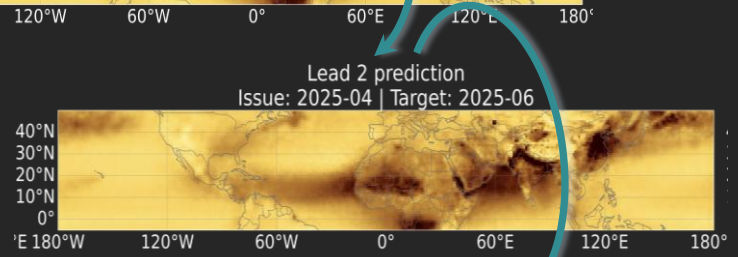
Trains < 48 min

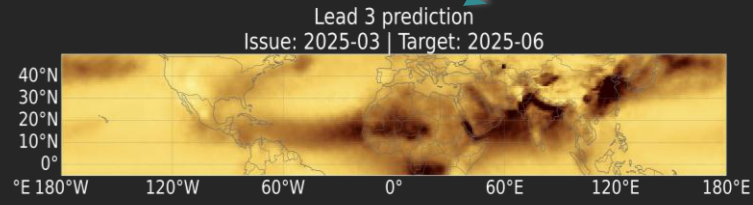
Predicts < 1s

x 230









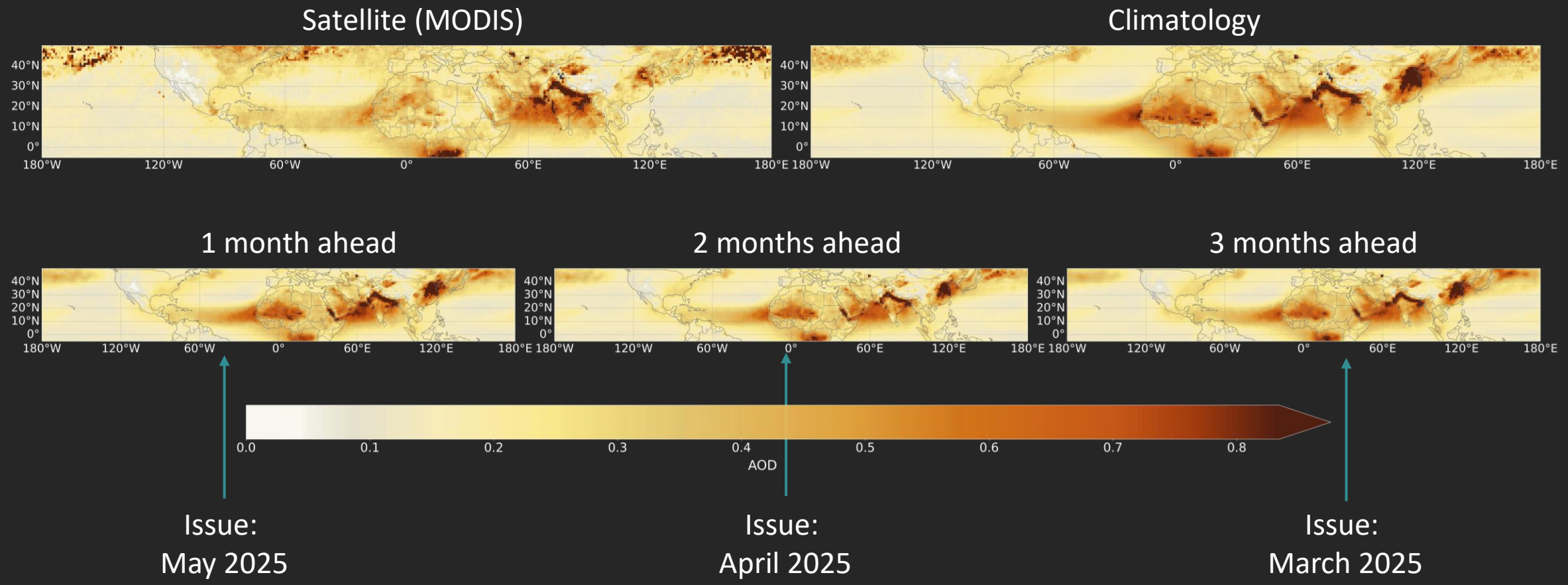
based on Nowak et al., 2025: DustNet (v1)

Results

Test set: 38 months

Sept 2022 – November 2025

Example target month results: June 2025



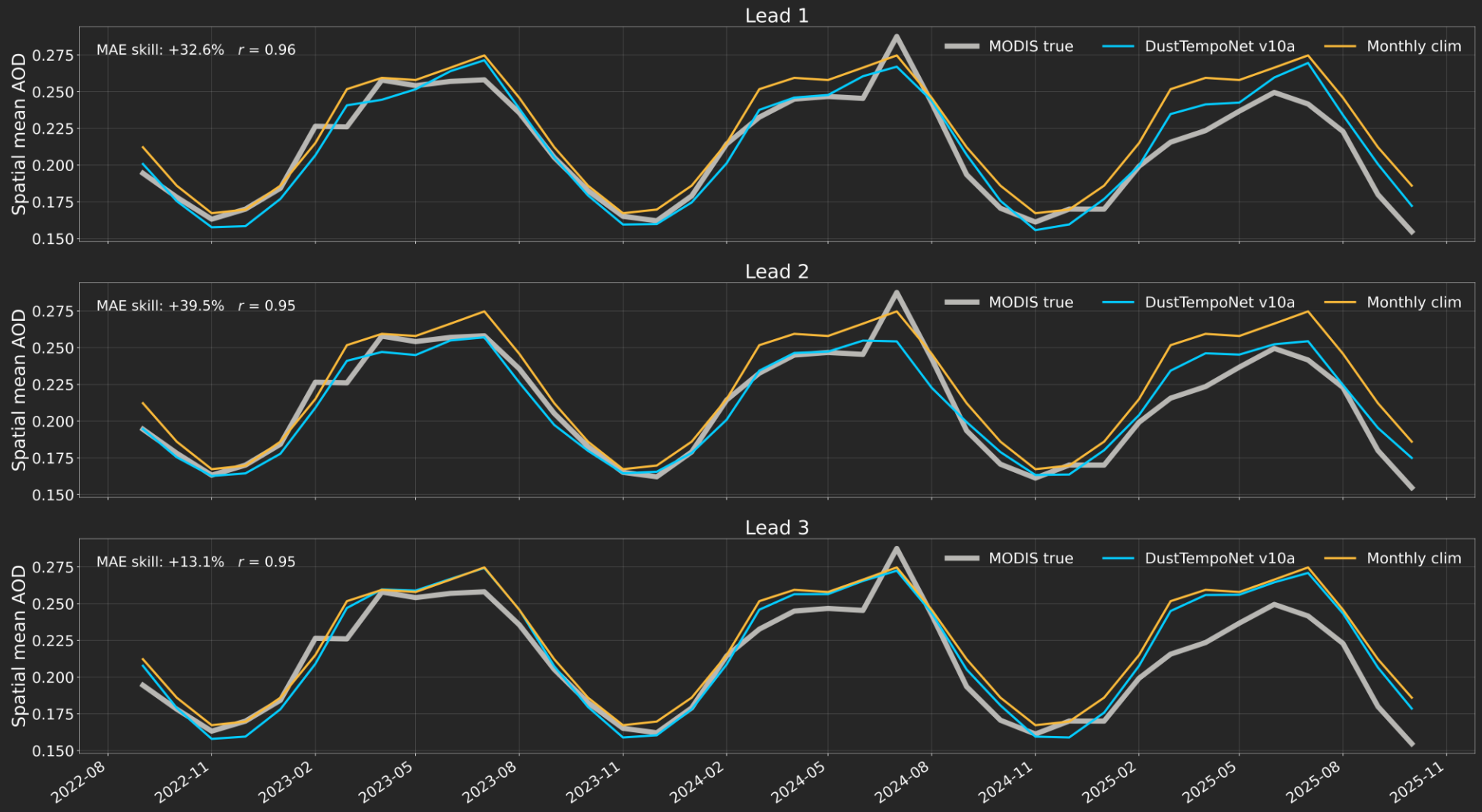
Temporal MAE comparison: DustTempoNet •MODIS•Climatology

MAE skill:

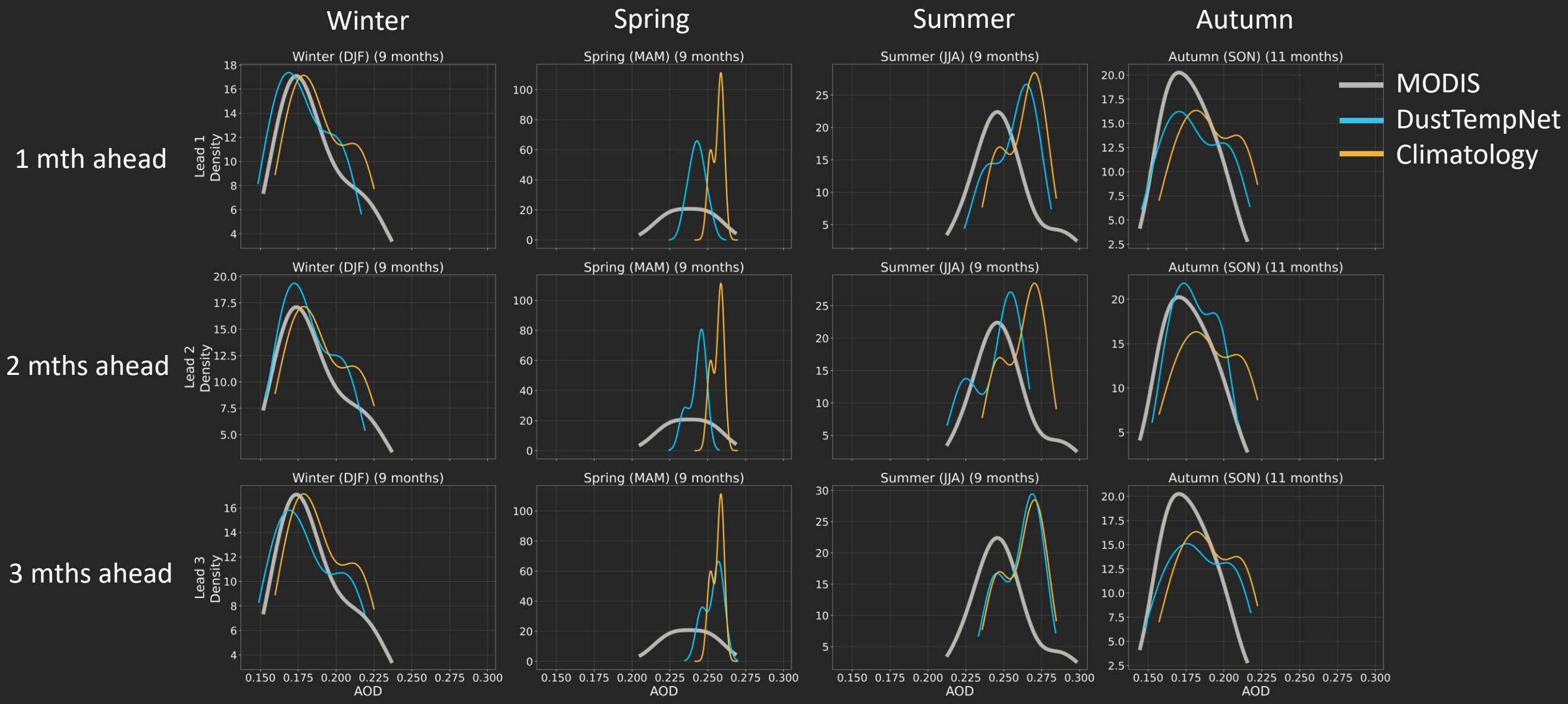
+ 32.6%

+ 39.5%

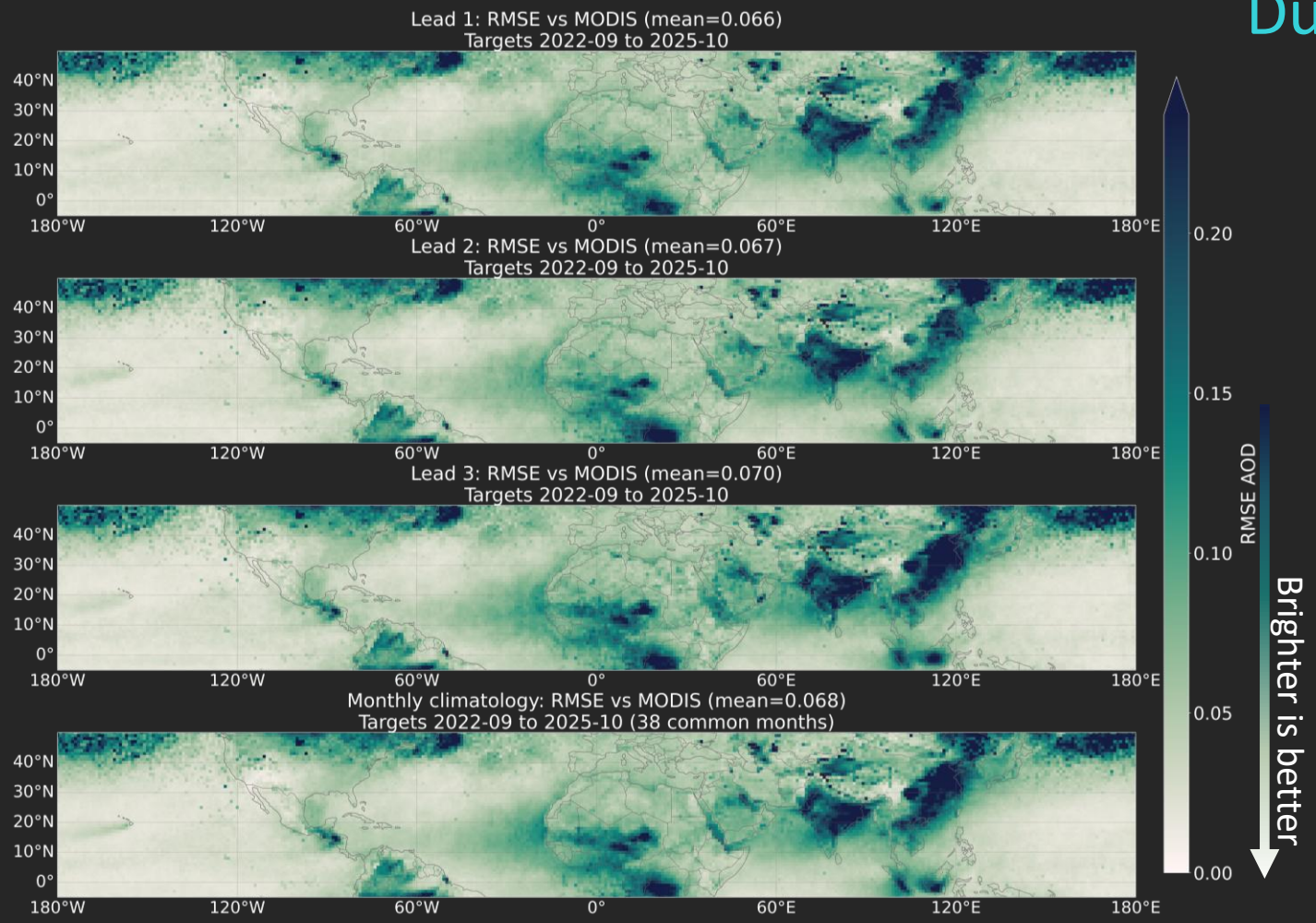
+ 13.1%



Seasonal density curves per lead head



RMSE vs monthly MODIS fields (**RMSE ≤ 0.07**)



DustTempoNet:

1-month ahead mean = 0.066

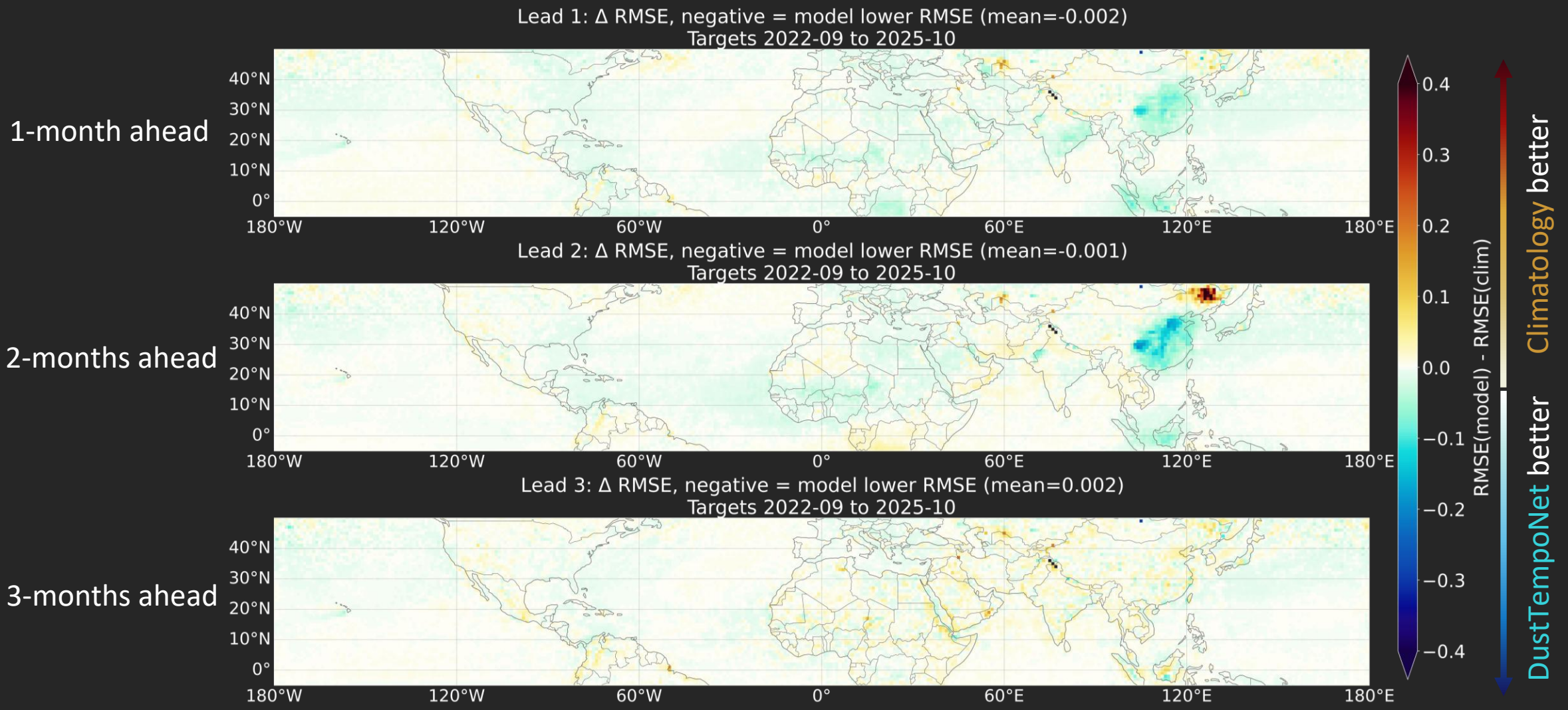
2-months ahead mean = 0.067

3-months ahead mean = 0.070

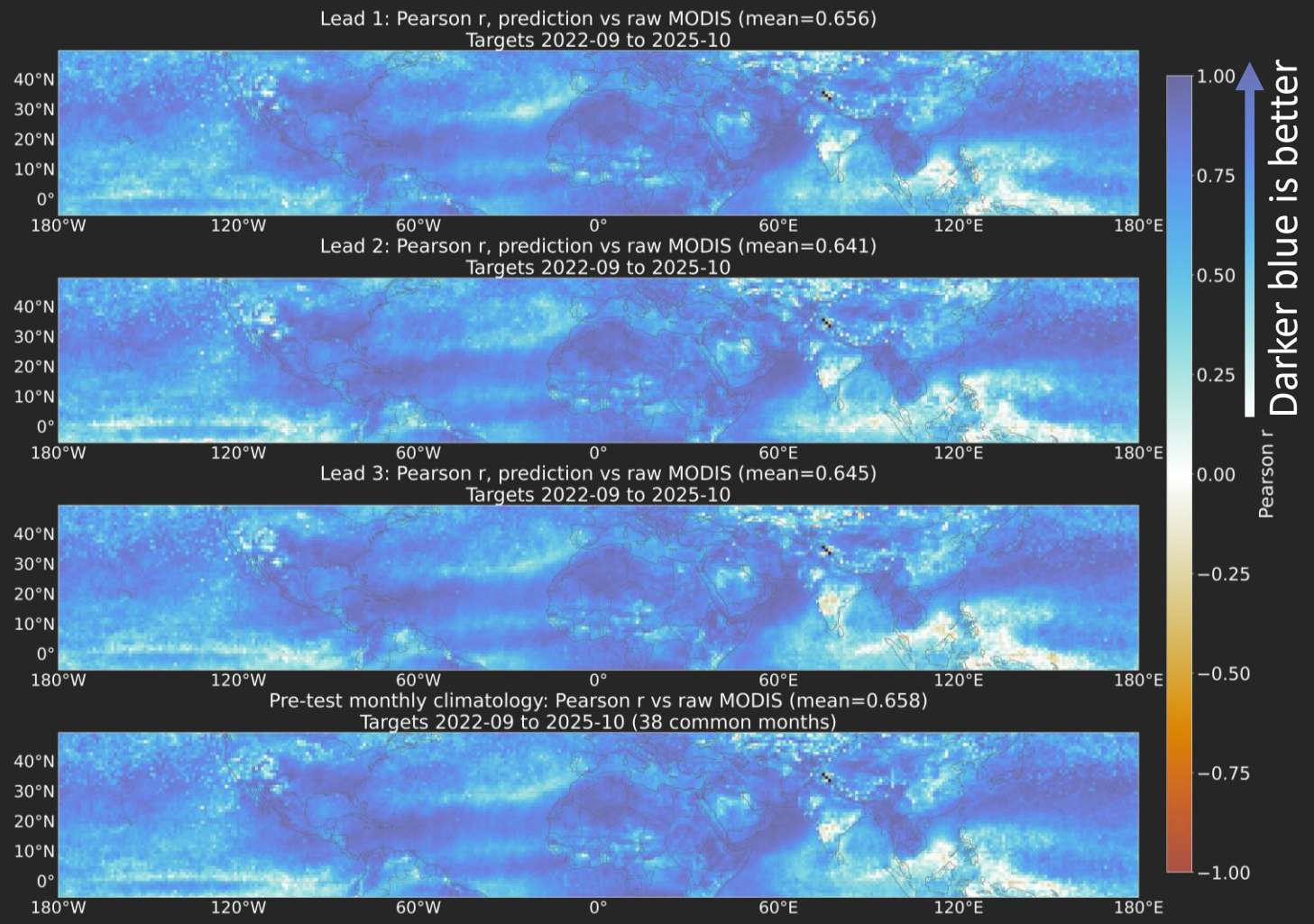
Climatology mean = 0.068

AOD: < 0.1 = clear sky > 0.5 = dimmed sun > 1.0 = severe haze/obscured sun

DustTempoNet and Climatology Δ errors vs MODIS



Pearsons $r \geqslant 0.64$



DustTempoNet:

1-month ahead mean = 0.656

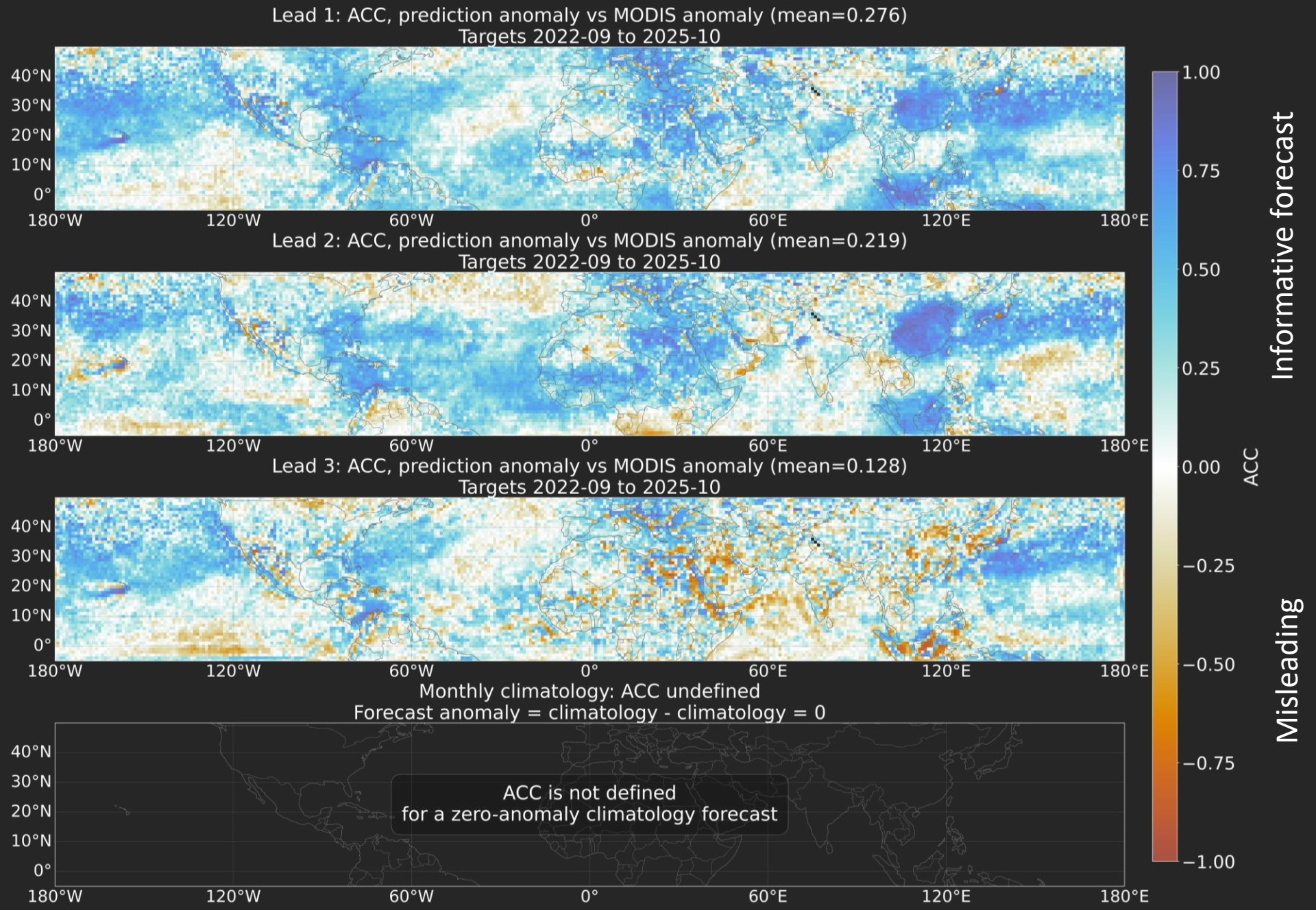
2-months ahead mean = 0.641

3-months ahead mean = 0.645

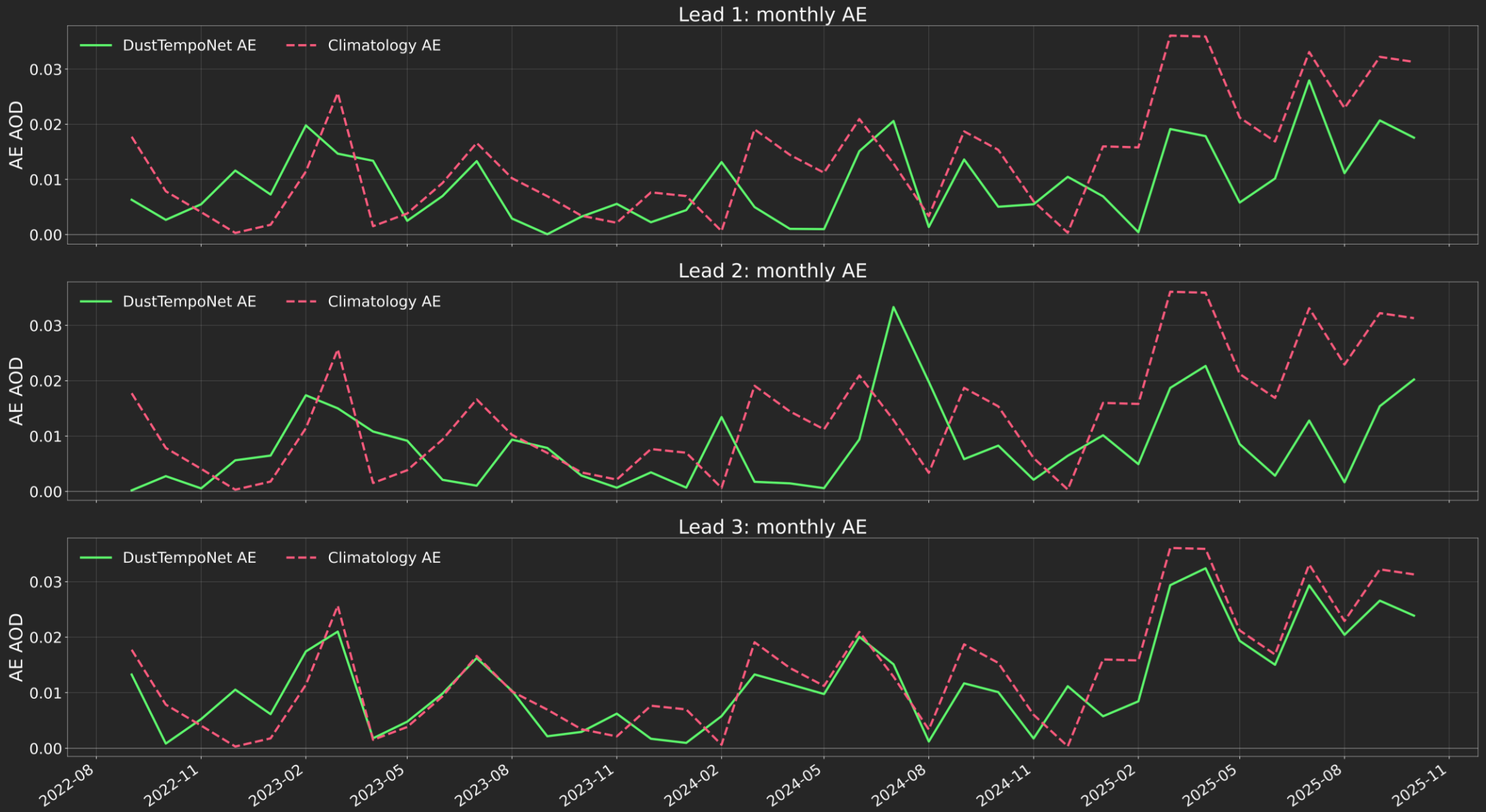
Climatology mean = 0.658


ANY QUESTIONS
WELCOME

Anomaly correlation coefficient



Temporal Absolute Error



Example: picked month skill June 2025