FogNet: 3D CNN for Coastal Fog Prediction

Evan Krell, Hamid Kamangir, Waylon Collins, Scott A. King, Philippe Tissot

https://gridftp.tamucc.edu/fognet/

- Fog substantially affects transportation, including air and sea
- Accurate fog prediction → actionable insights for safety & efficiency

Image: Bumble Bee Productions (https://youtu.be/5Z_Hx0nvR9w)

Image: zzathras777 (https://www.flickr.com/photos/zzathras777/)

- Developed a fog prediction model for the Texas Coastal Bend (6, 12, & 24-hour)
- Currently analyzing model → want longer lead times, extension to coastal CONUS

Related publications

Kamangir, Hamid, et al. "FogNet: A multiscale 3D CNN with double-branch dense block and attention mechanism for fog prediction." Machine Learning with Applications 5 (2021): 100038.

Kamangir, Hamid, et al. "Importance of 3D convolution and physics on a deep learning coastal fog model." Environmental Modelling & Software (2022): 105424.

Krell, Evan, et al. "Explainable artificial intelligence for geoscience models with highly correlated, high-dimensional inputs: a case study with FogNet, a 3D CNN for predicting coastal fog." In-progress.

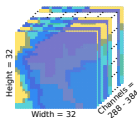# FogNet: 3D CNN for Coastal Fog Prediction

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FogNet

- 3D CNN with attention, dense block, & dilated convolution
- Imbalanced dataset: very few fog cases
- Input data: fusion of NWP output & satellite imagery

Architecture overview
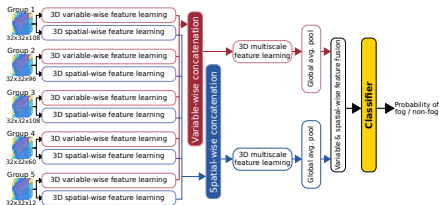
Physics-based channel groups

G1	G2	G3	G4	G5
108	96	108	68	12
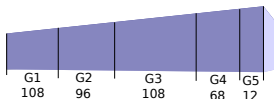
G1 wind
G2 turbulence kinetic energy & humidity
G3 lower atmosphere thermodynamic profile
G4 surface atmospheric moisture & microphysics
G5 sea surface temperature

Performance

Explainable Artificial Intelligence (XAI): what strategies has FogNet learned?

- **Which spatio-temporal features are most influential for FogNet's decisions?**
  Do these strategies match forecaster knowledge?

- **Model performs better for Advection fog (A) than the other types**
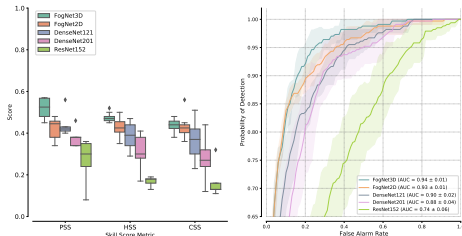 How do strategies differ between fog types?

- **We customize & apply Shapley-based XAI techniques to investigate the model**

XAI results

- **Channel-wise superpixels**   →
  Spatial features: where is FogNet looking?

- **Top channels**   ↓
  Which features are most influential?

Top 3 channels:

1. Vertical velocity, 950 mb, 6 hours
2. Surface T minus dew point temperature, 12 hours
3. Vertical velocity, 875mb, at initialization

Hits (R, A-R)   Hits (A)   False alarms   Misses (R, A-R)   Misses (A)   Correct rejects

(a) G5 TMP-DPT   (b) G5 DPT-SST   (c) G5 DPT-SST   (d) G5 TMP-SST   (e) G5 TMP-SST   (f) G5 TMP-SST

(g) G5 TMP-SST   (h) G5 TMP-SST   (i) G5 TMP-SST   (j) G5 TMP-DPT   (k) G5 TMP-DPT   (l) G5 TMP-DPT

(m) G4 VVel 950mb   (n) G5 TMP-DPT   (o) G5 TMP-DPT   (p) G3 RH 750mb   (q) G4 VVel 825mb   (r) G5 DPT-SST

(s) G4 VVel 875mb   (t) G4 VVel 825mb   (u) G4 VVel 850mb   (v) G4 VVel 700mb   (w) G2 TKE 975mb   (x) G3 RH 750mb

(y) G4 VVel 925mb   (z) G4 VVel 850mb   (aa) G4 VVel 825mb   (ab) G4 VVel 925mb   (ac) G4 8VVel 50mb   (ad) G4 VVel 950mb

(ae) G5 DPT-SST   (af) G4 VVel 925mb   (ag) G4 VVel 925mb   (ah) G2 TKE 825mb   (ai) G4 VVel 925mb   (aj) G4 VVel 925mb

(ak) G4 VVel 800mb   (al) G4 VVel 975mb   (am) G4 VVel 975mb   (an) G2 TKE 975mb   (ao) G2 TKE 825mb   (ap) G4 VVel 825mb