TWO STAGE ARTIFICIAL INTELLIGENCE ALGORITHM FOR CALCULATING MOISTURE-TRACKING ATMOSPHERIC MOTION VECTORS

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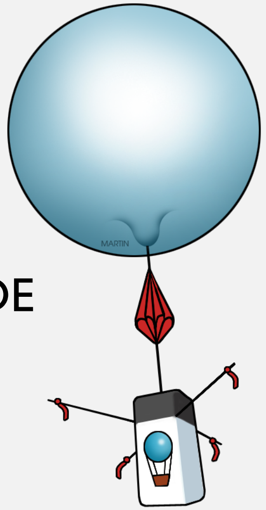
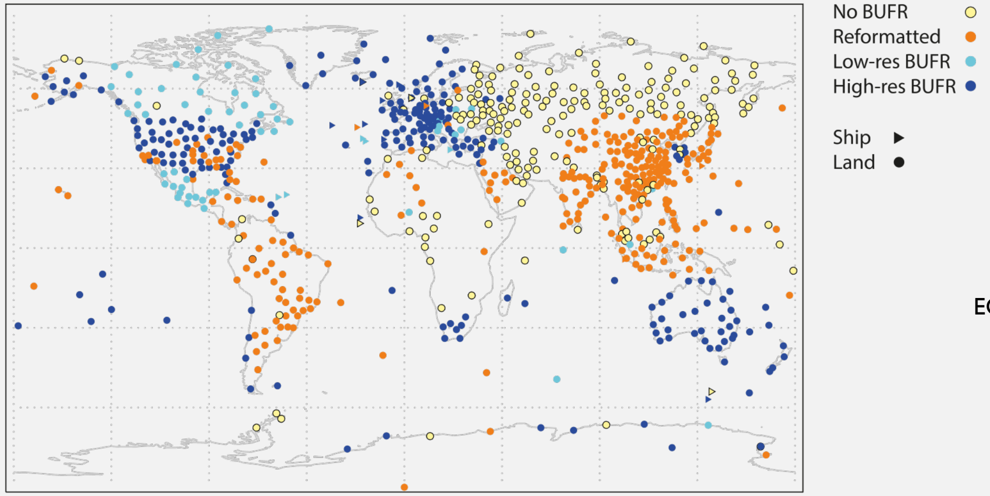
Extracting wind velocities from satellite imaging: Wind velocity measurements are important for weather and climate forecasting. Feature tracking + satellite imaging give great coverage. However feature tracking is still noisy and sparse.

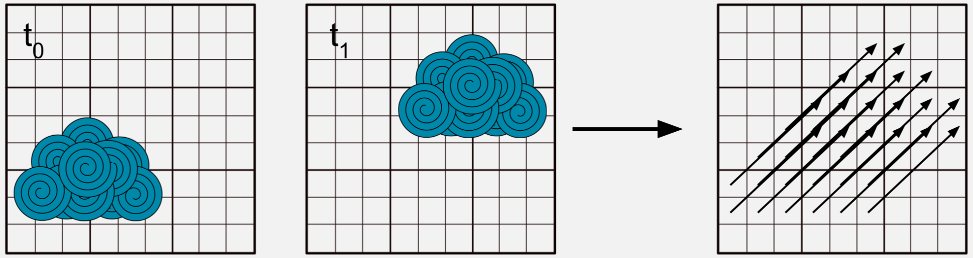
RADIOSONDE

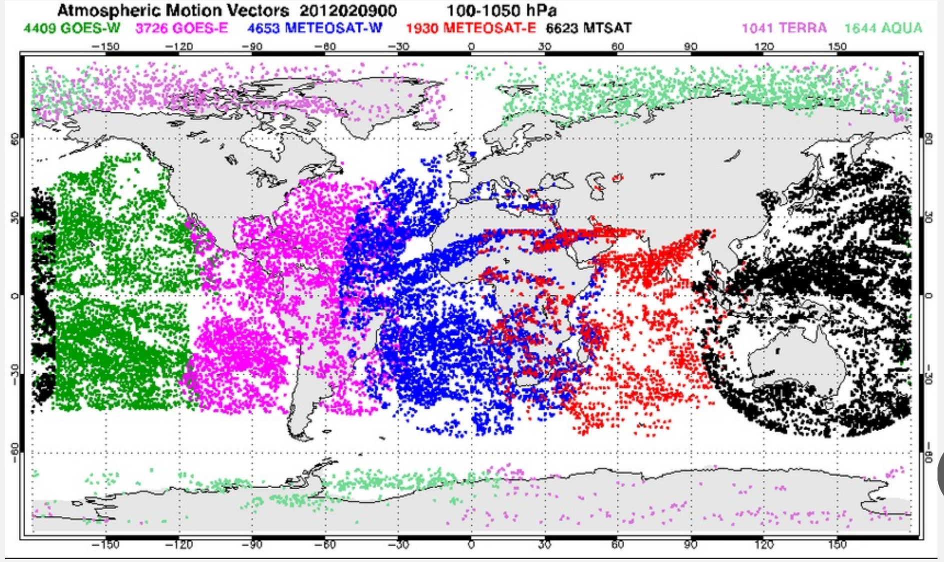




ECMWF

FEATURE TRACKING + SATELLITE IMAGING



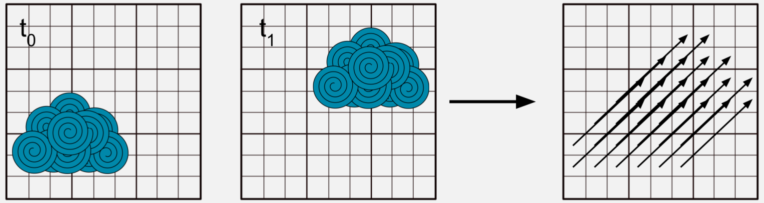


Warning: sparse vertically!

Garand, Louis, et al. "OSSE to infer the impact of Arctic AMVs extracted from highly elliptical orbit imagery."

Method: Reduce noise of **moisture tracking** by combining it with a machine learning algorithm that "learns" from short-term forecasting:

Moisture Tracking



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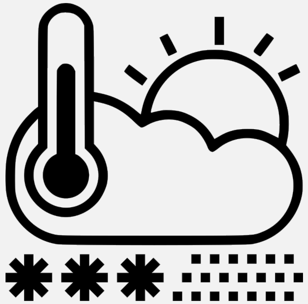
Numerical Weather Prediction



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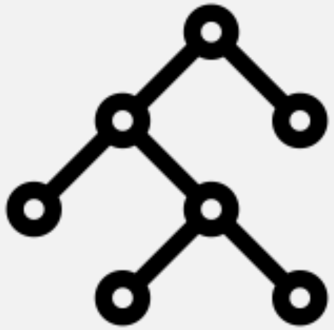
Machine Learning (Random Forest)



Two stage algorithm: Process satellite images with feature tracking and correct it with short-term forecast data at same timestep.

fsUA $$\mathbf{V}^*(t) = f_{\text{variational}}(\mathbf{q}(t-\Delta t), \mathbf{q}(t), \mathbf{q}(t+\Delta t))$$

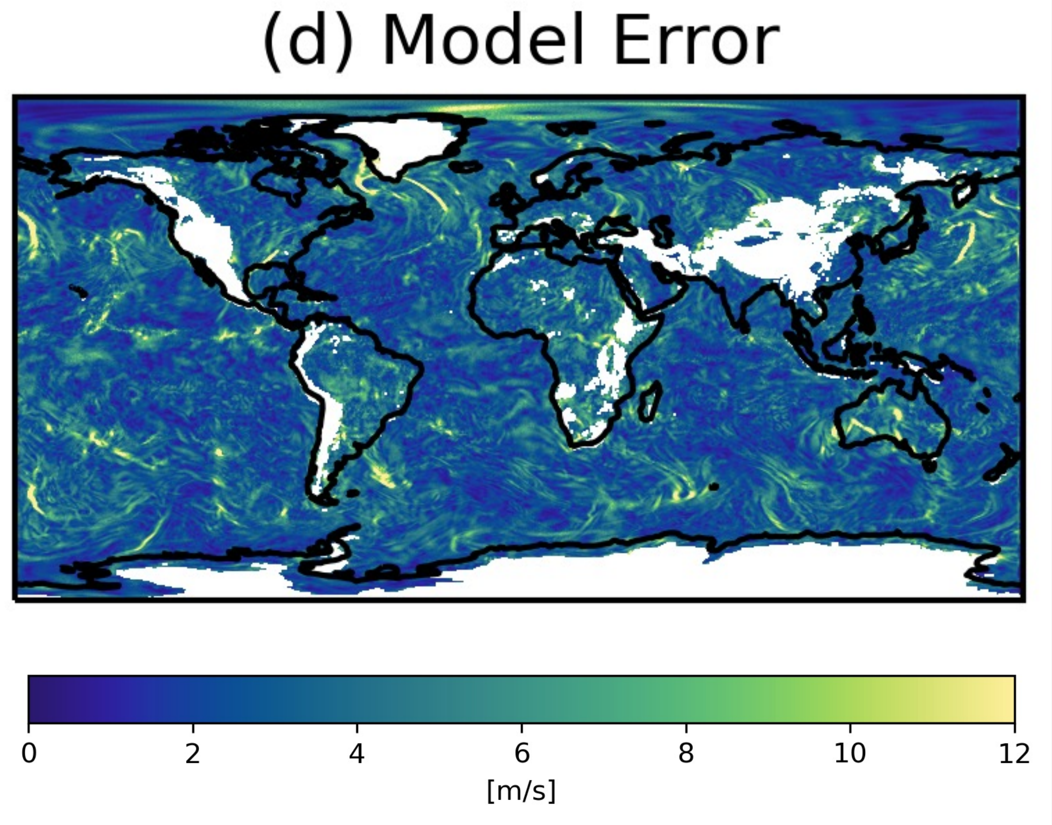
UA $$\mathbf{V}(t) = f_{\text{RF}}(\mathbf{V}^*(t), \mathbf{V}_{\text{NWP}}(t))$$

v_{NWP} (t): forecasted horizontal wind field at time t from operational model.

For current experiments, we mimic short term forecasting as GEOS-5 nature run (G5NR) wind fields with random noise calculated from reanalysis data (ERA-5 and CFS) and add collocation error. We calculate RMSE using the “denoised” wind fields as ground truth.

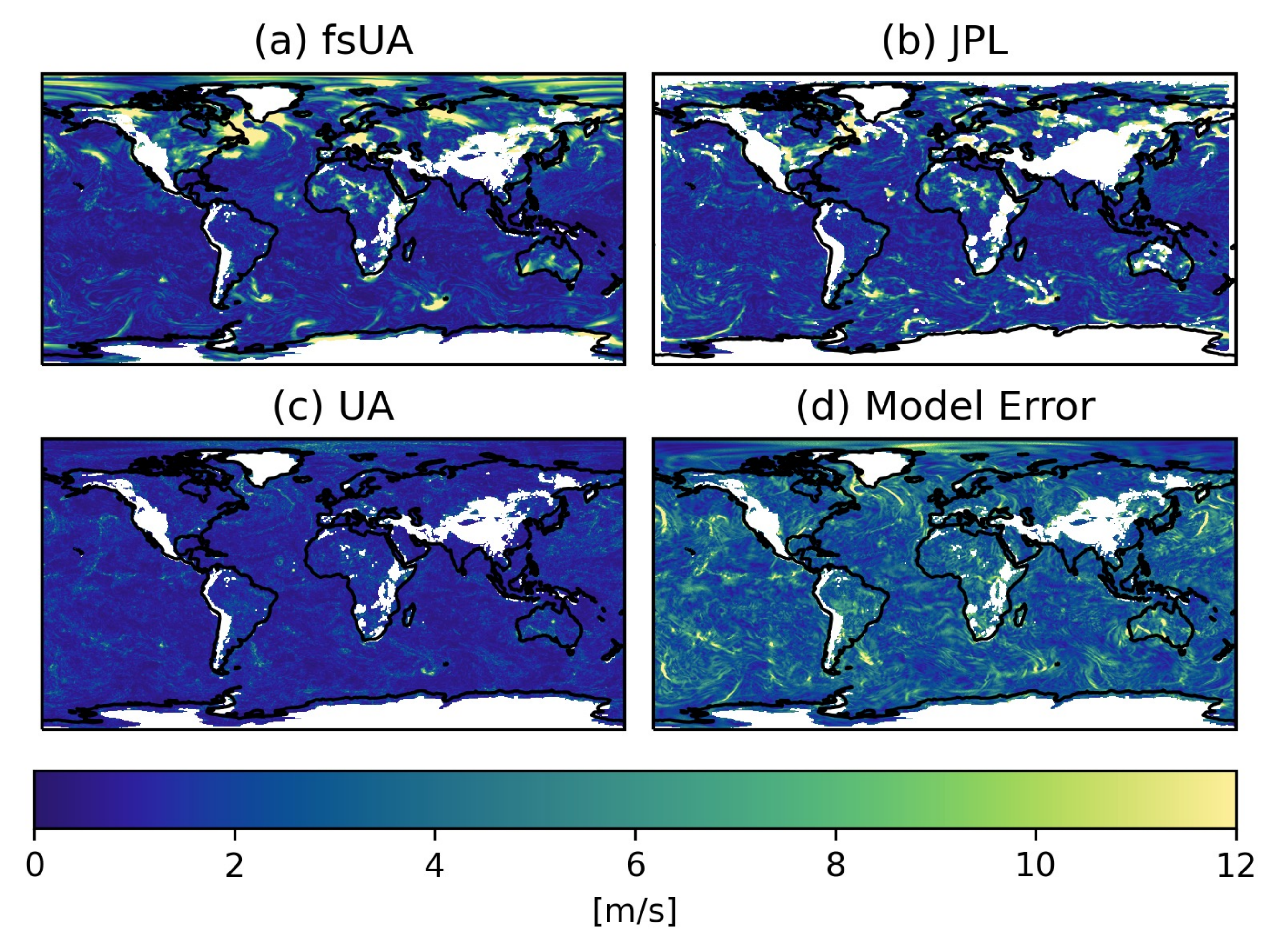
$$v_{NWP}(t) = v_{G5NR}(t) + \varepsilon_{Model}$$
$$v_{ground\ truth}(t) = v_{G5NR}(t)$$

Random Forest parameters		
Input	Output	Training set size
V^*(t), position, land cover	V_{NWP}(t)	5 %



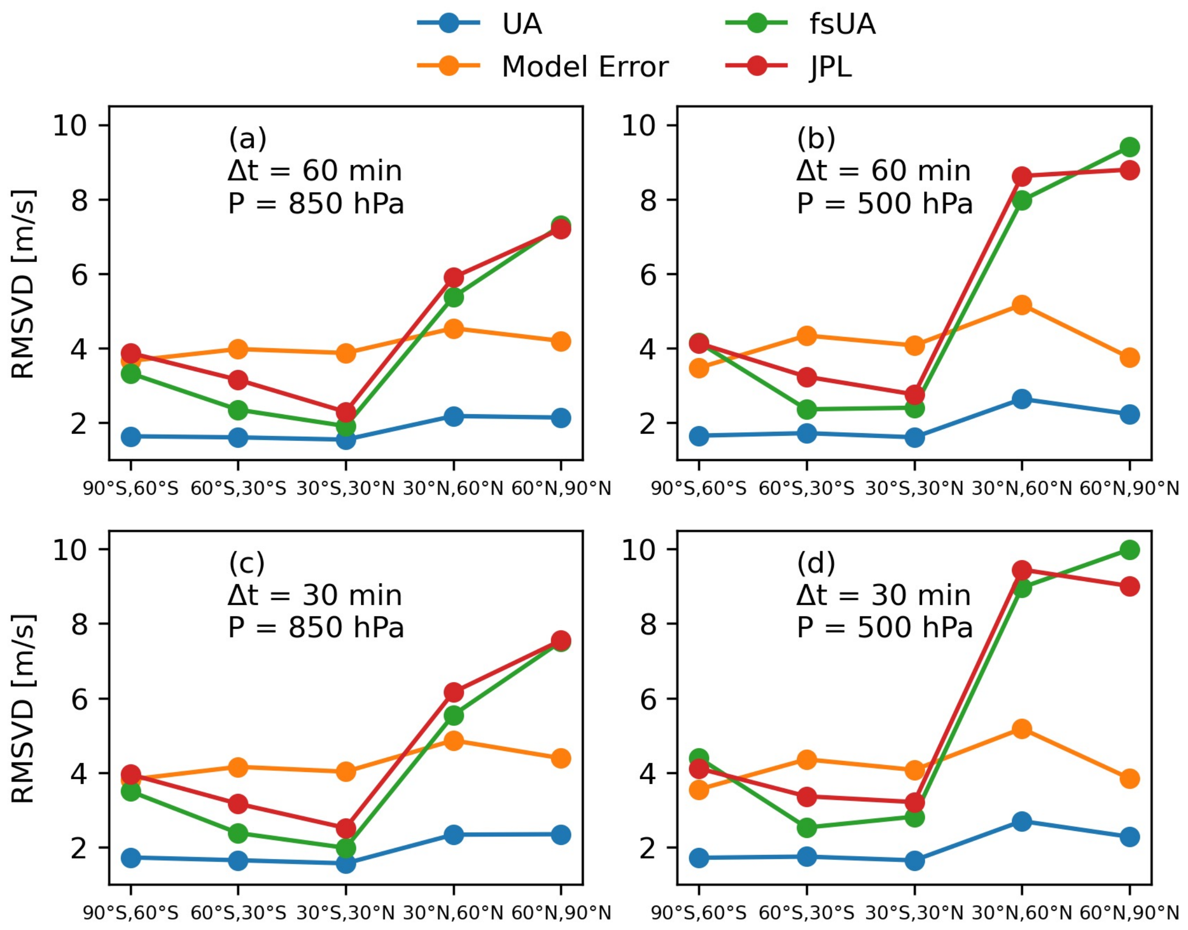
January 1, 2006, 0:00 (UT)

UA algorithm effectively filters the noise (850 hPa, dt=1 hour, January 1, 2006, 0:00 (UT)). JPL stands for Jet Propulsion Laboratory.

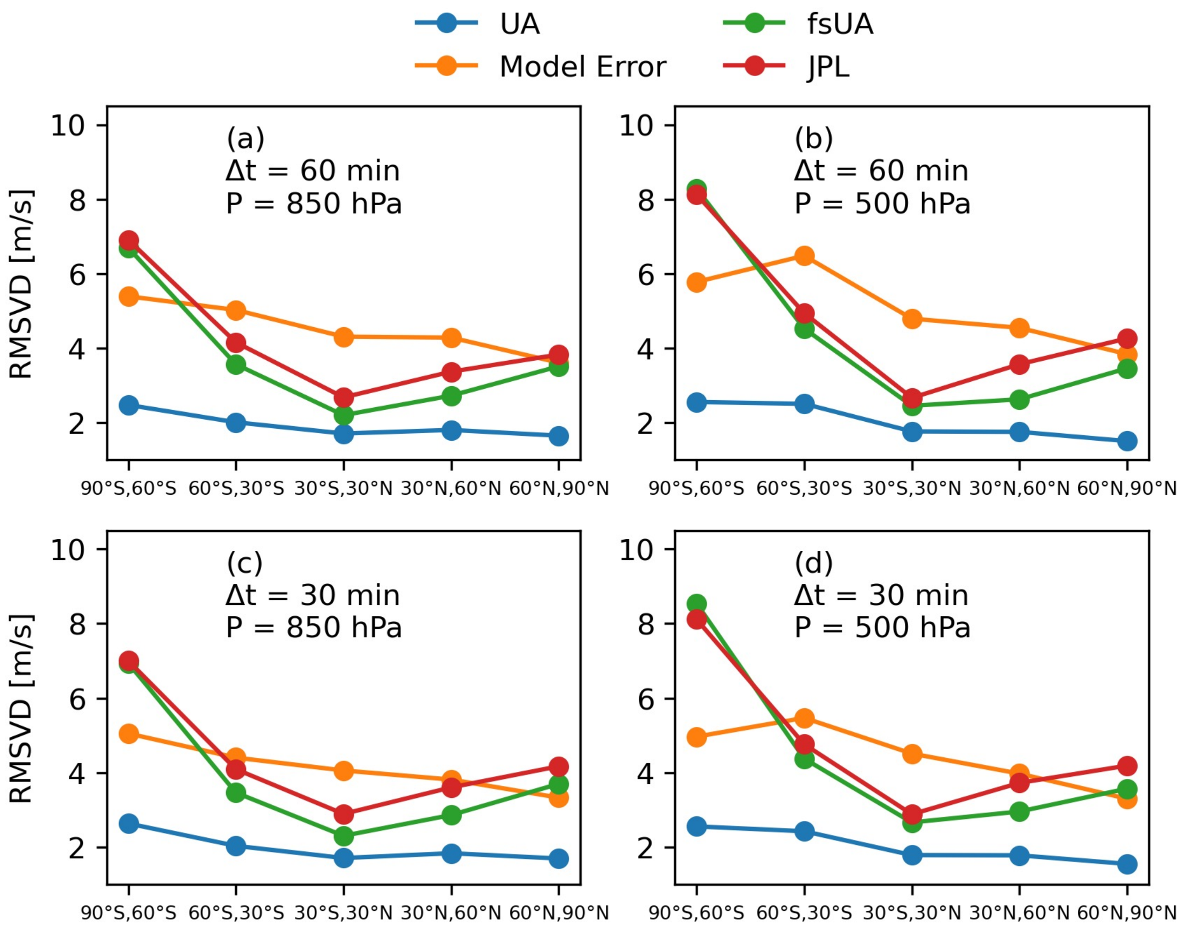


Results: UA algorithm (blue line) effectively filters the noise (yellow line). Error for UA is as much as 75 percent lower than for JPL.

January 1-3, 2006



July 1-3, 2006



Conclusion

- UA performs much better than the JPL algorithm.
- UA also filters the error inherent to NWP fields, implying that it doesn't overfit the NWP signal.
- The low error implies that UA potentially could produce more AMVs than traditional algorithms that break through quality thresholds.
- This results act as a lower bound of error for UA, since they are based on model data, rather than satellite imaging.
- For future work we will apply UA to 3D water vapor fields derived from hyper-spectral satellite data.