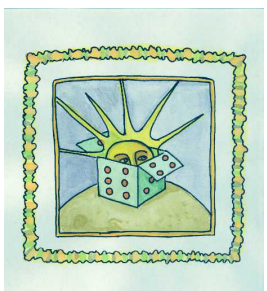
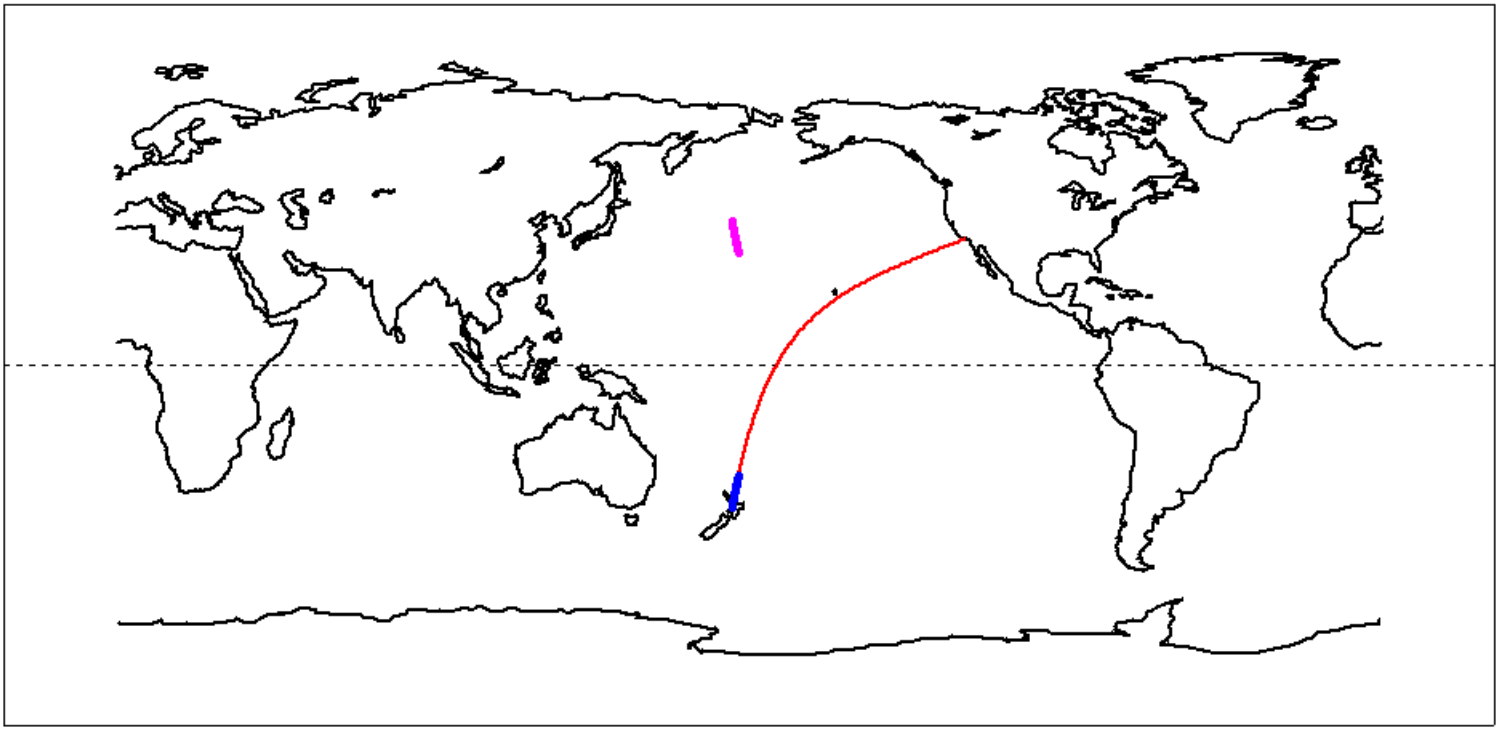
Robust Data Assimilation

Douglas Nychka, Jeff Anderson, Chris Snyder
The Data Assimilation Initiative
National Center for Atmospheric Research



Supported by the National Science Foundation DMS

What this project is about.



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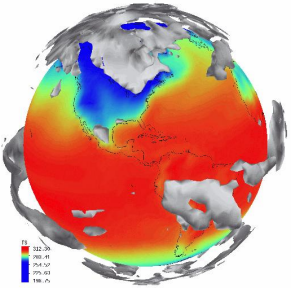
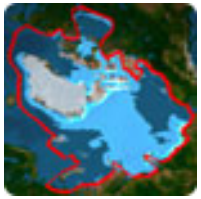
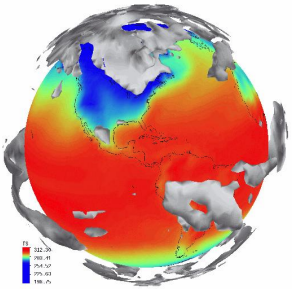
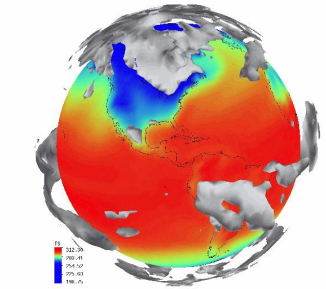
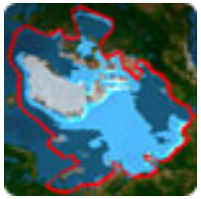
Climate,   

Climate,   

 Weather,

Climate,   

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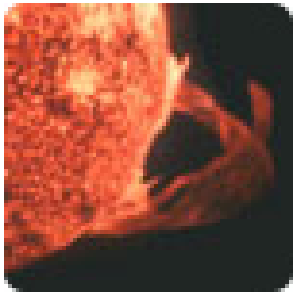
the Sun, 

Ocean-atmosphere interactions,

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Ecosystems, Economic impacts,

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Air quality,

Instrumentation, Scientific computing

and ...

Institute for Mathematics Applied to the Geosciences

- **Geophysical Turbulence Program**
- **Geophysical Statistics Project**
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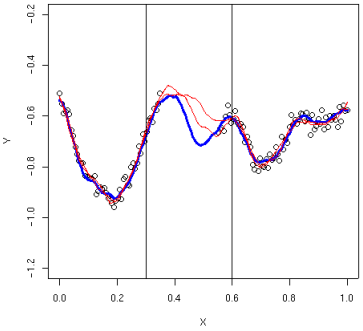

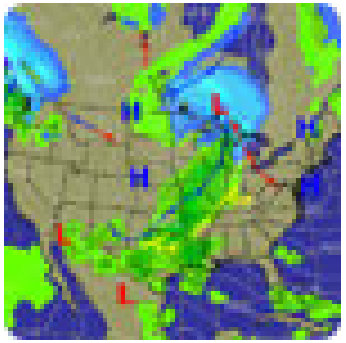

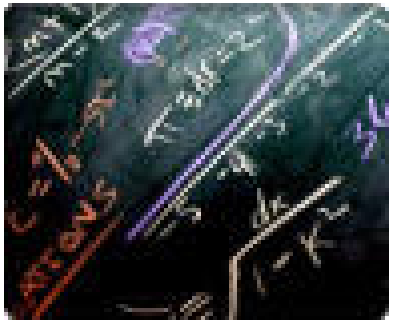

Some grand challenge problems:

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Combine complex numerical models with a variety of observations

Data/Model Fusion

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Combine predictions made by a numerical model with observed data to estimate the state of a system, x. This is also called a *filter*.

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Standard approach is the Kalman Filter ...
but it fails for large, nonlinear problems!

Ensemble Kalman Filter

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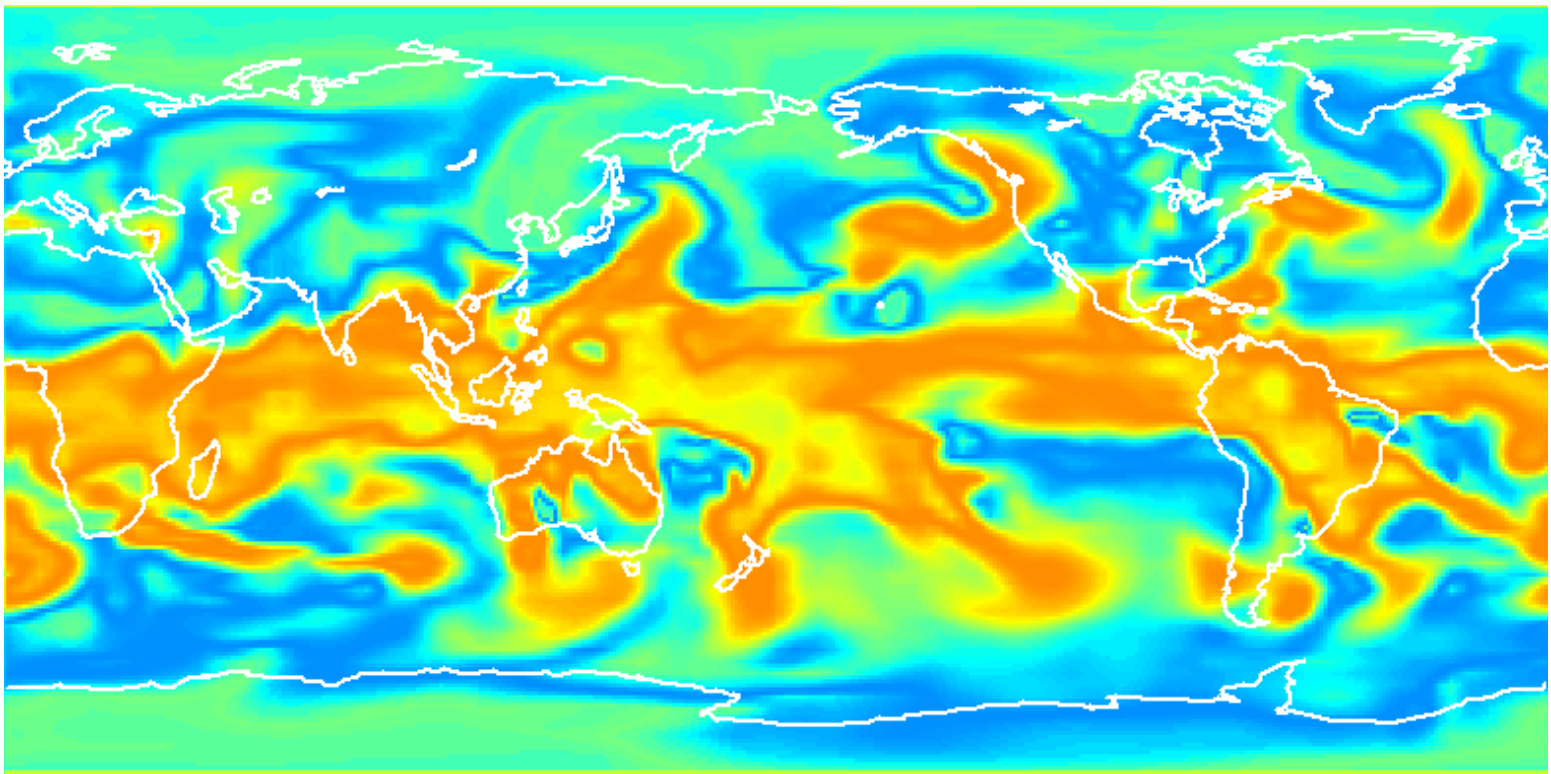
Means, variances and other statistics are found directly from the ensemble:
e.g.

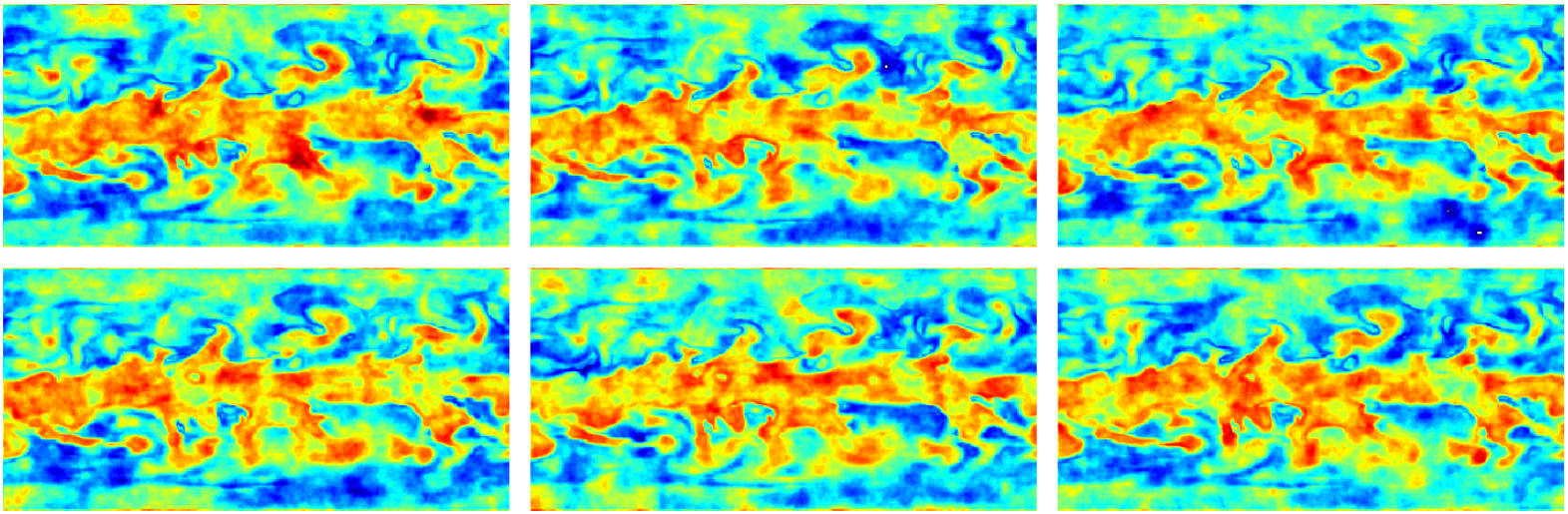
$$\textbf{Mean field} = (\boldsymbol{x}_1 + \boldsymbol{x}_2 + ... + \boldsymbol{x}_m)/m$$

As an example: the global water vapor field



Middle layer of the atmosphere, $\approx$ 200km resolution.
(WET, DRY)

Some ensemble members ...



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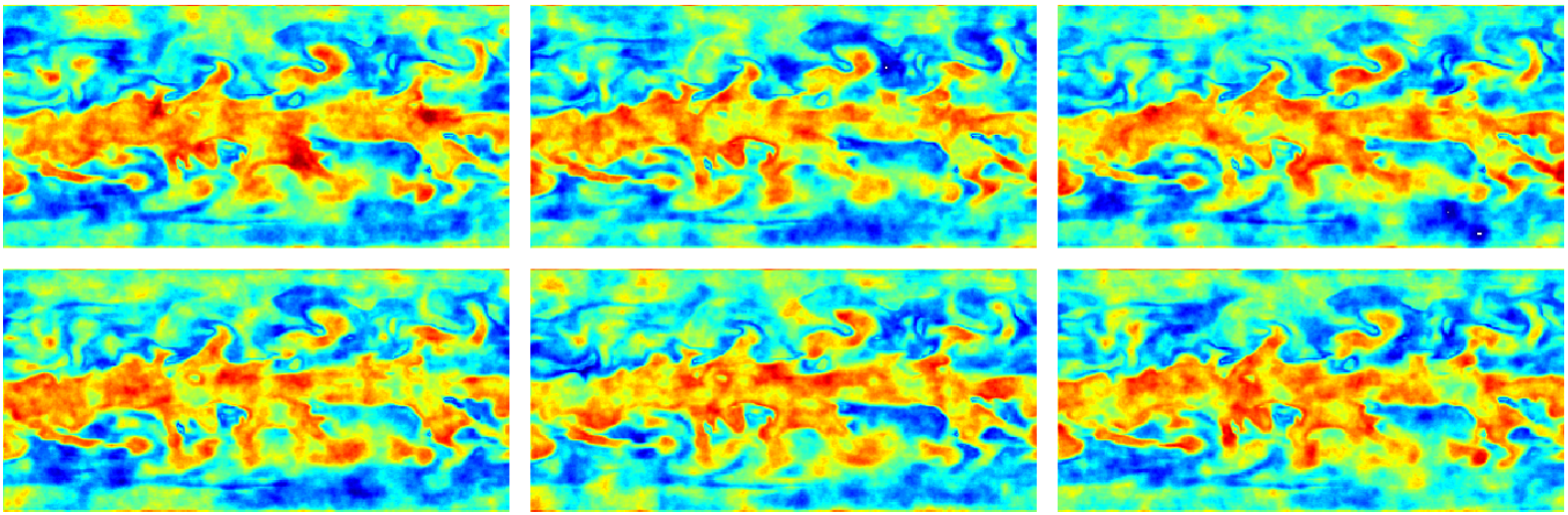
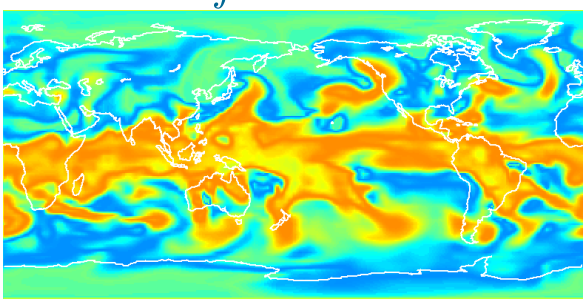
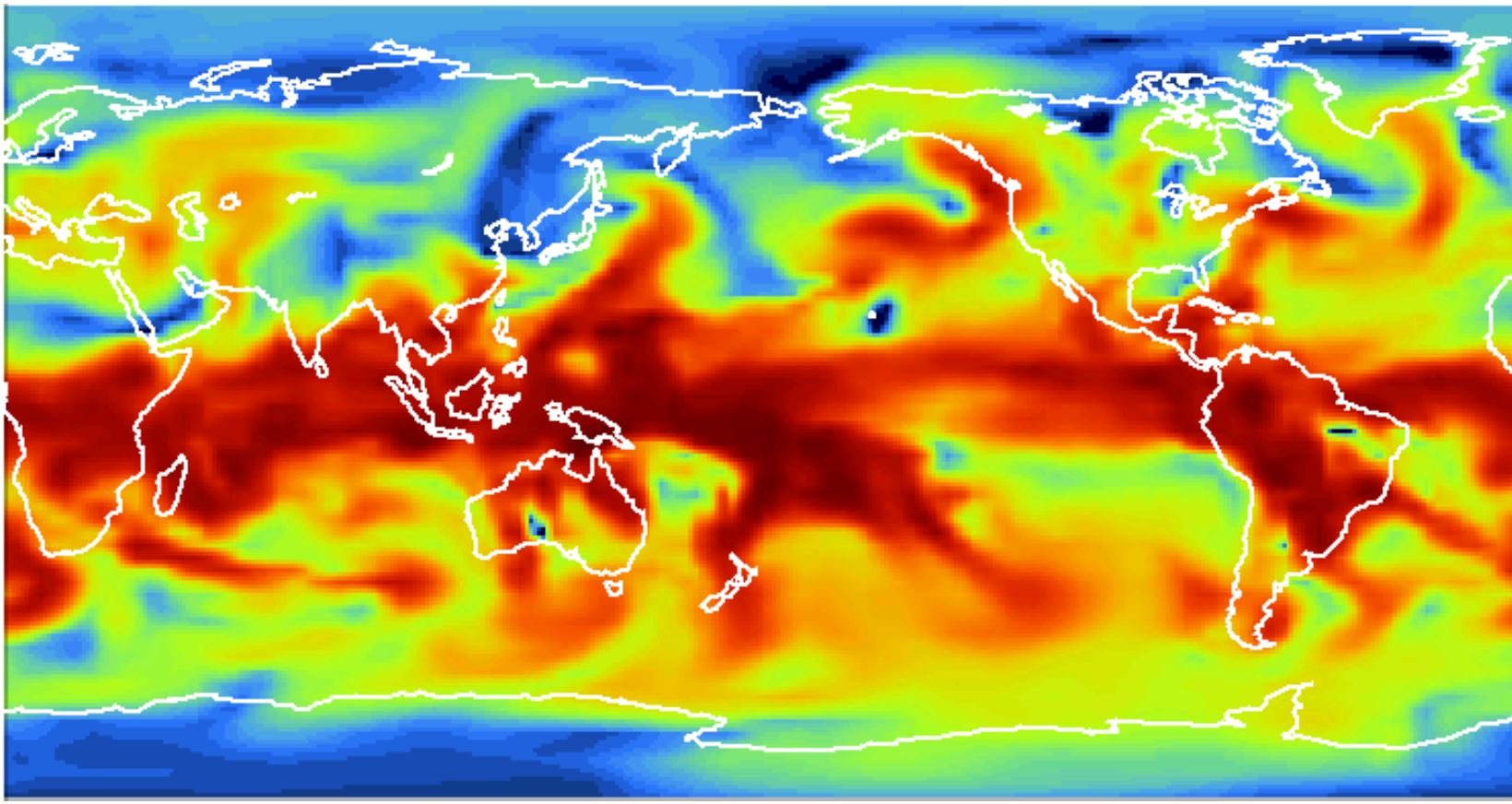


The mean field



Assimilation of water vapor



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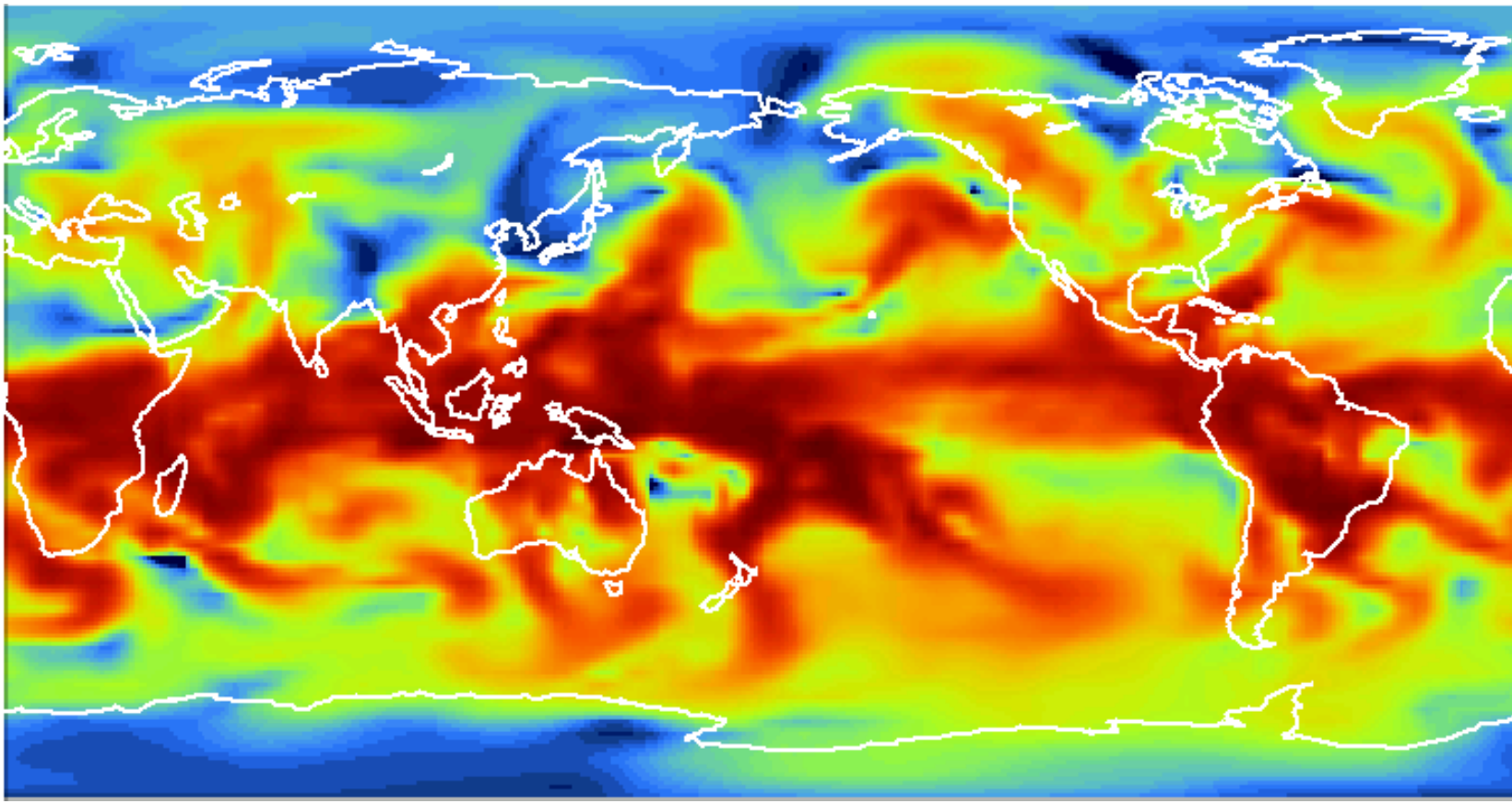

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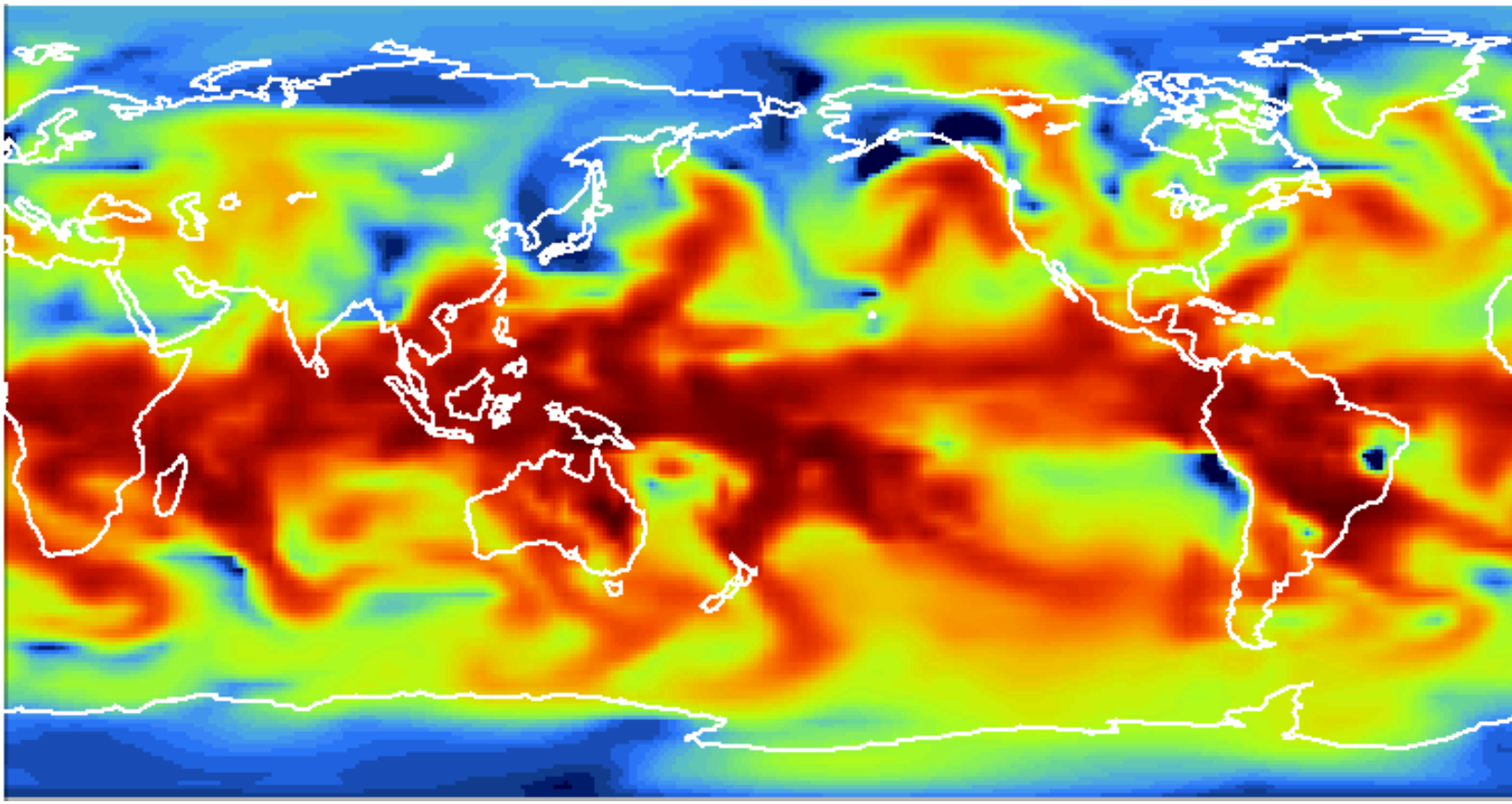

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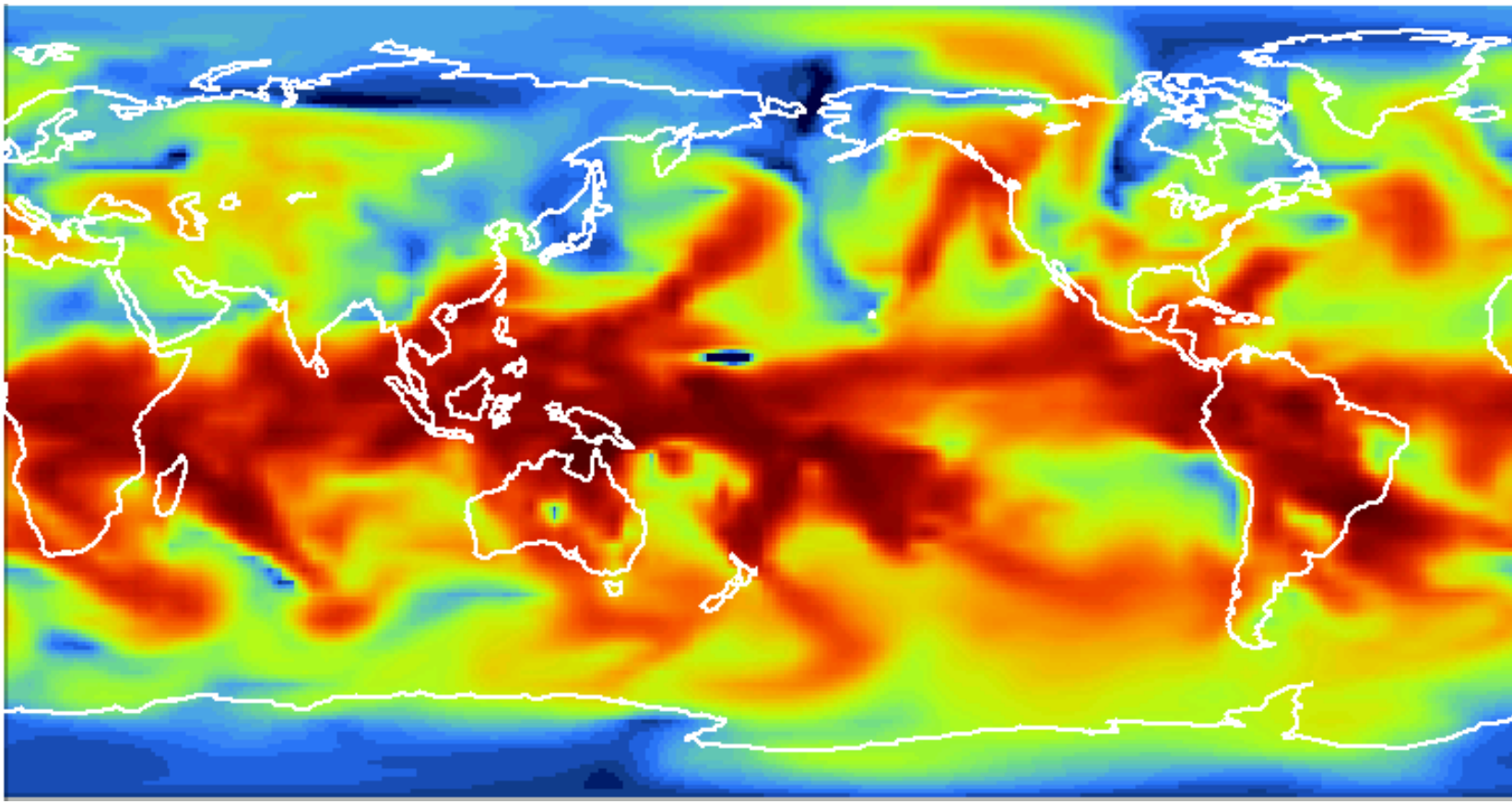

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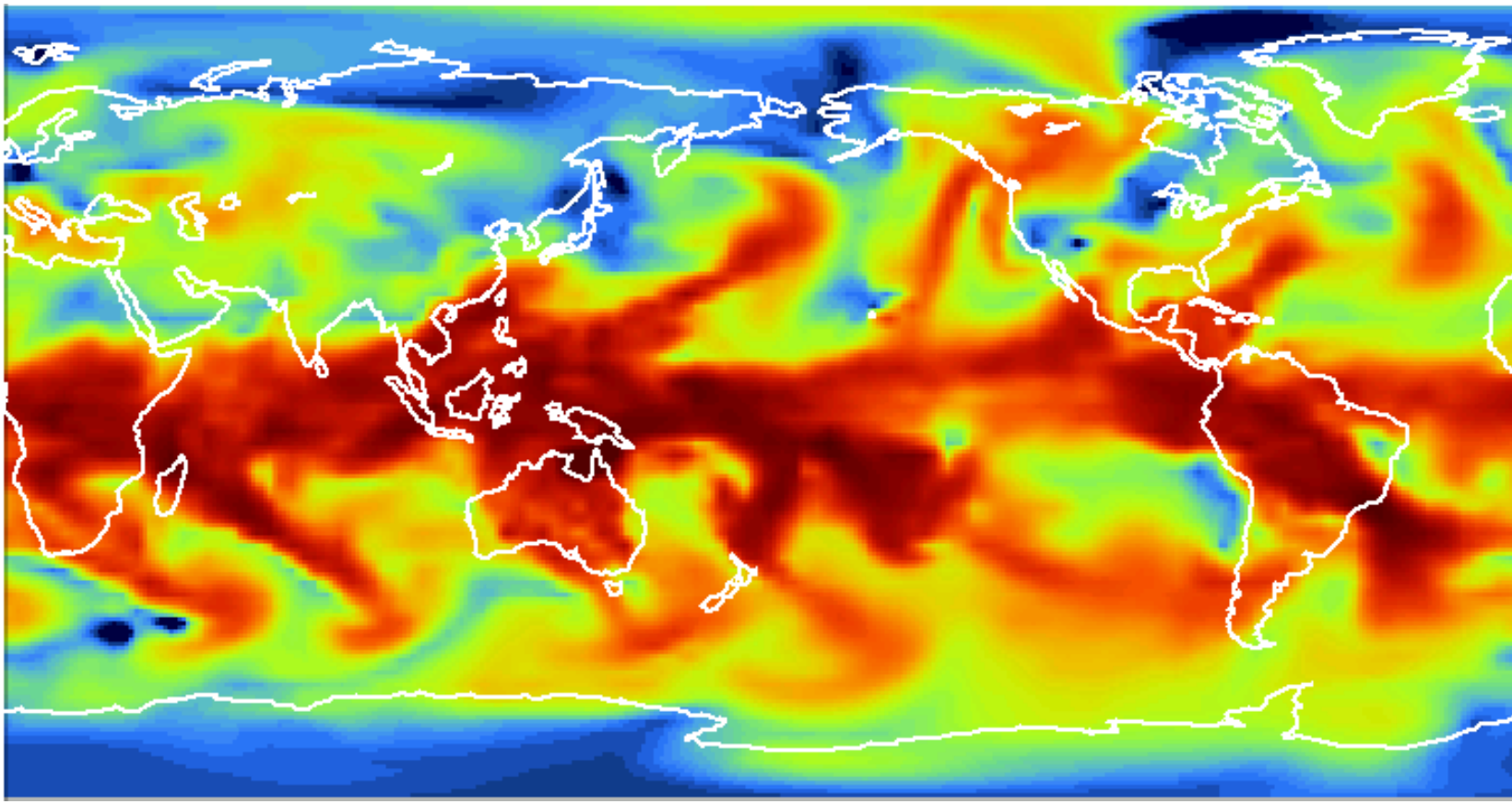

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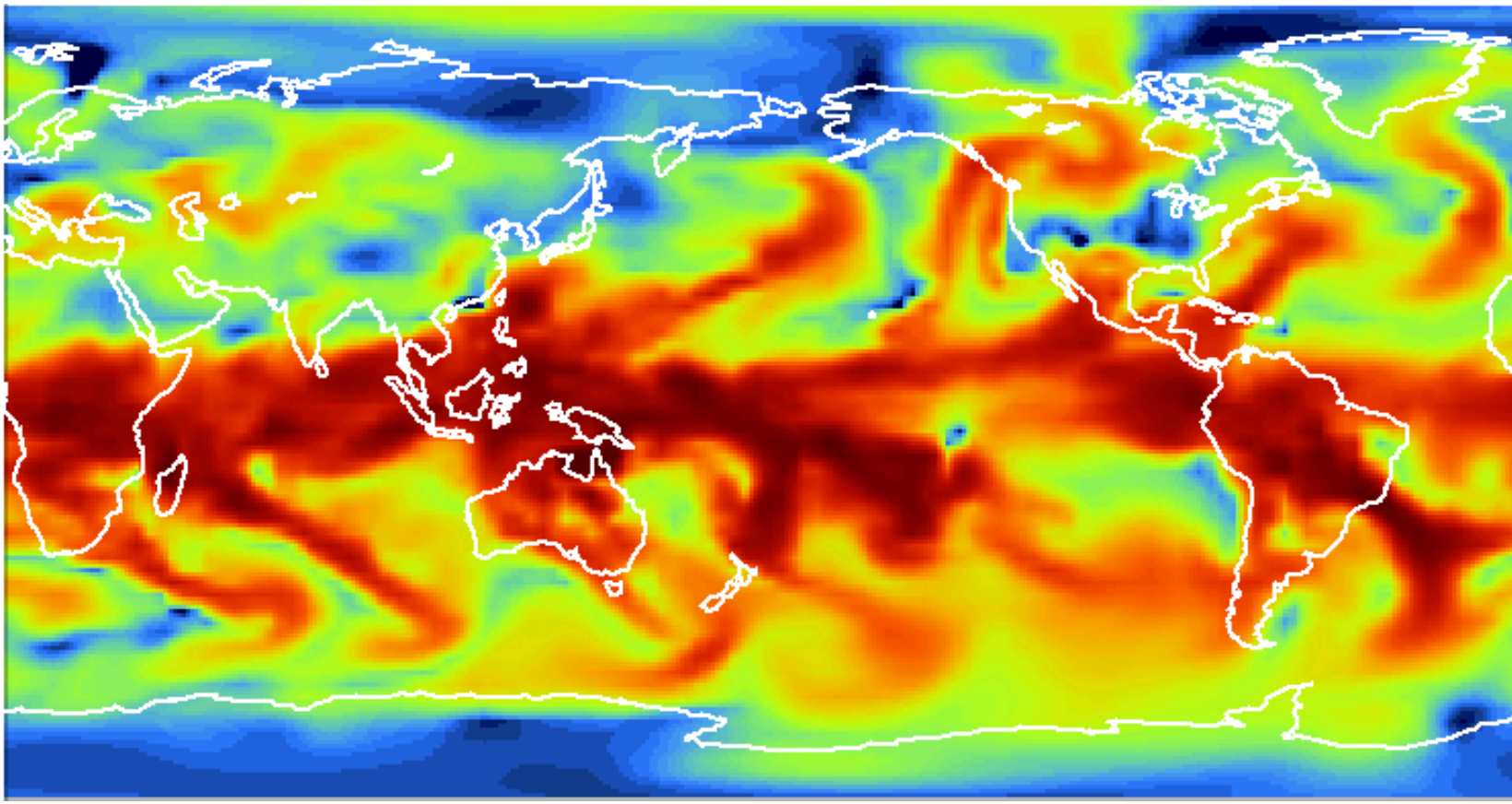

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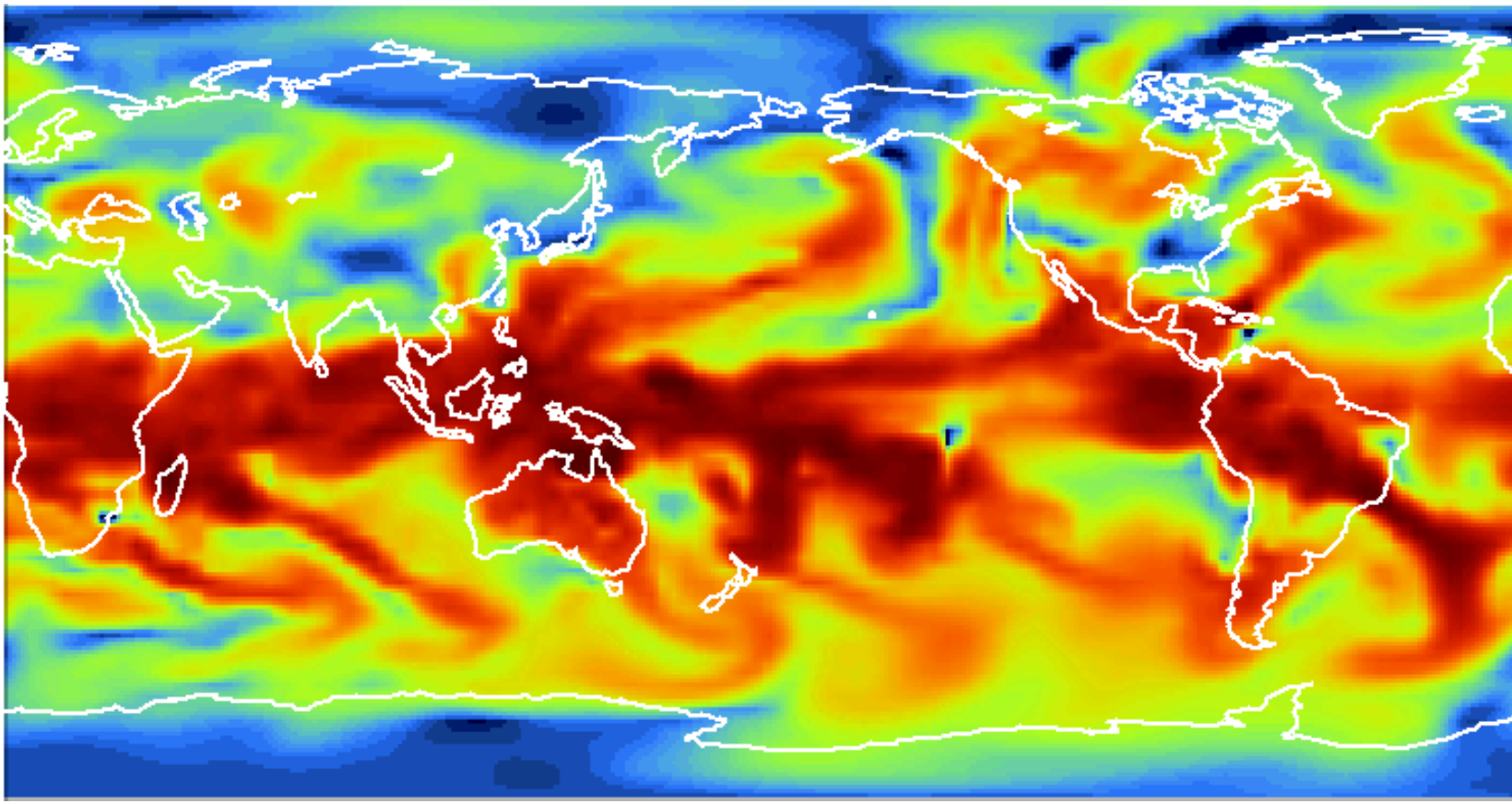

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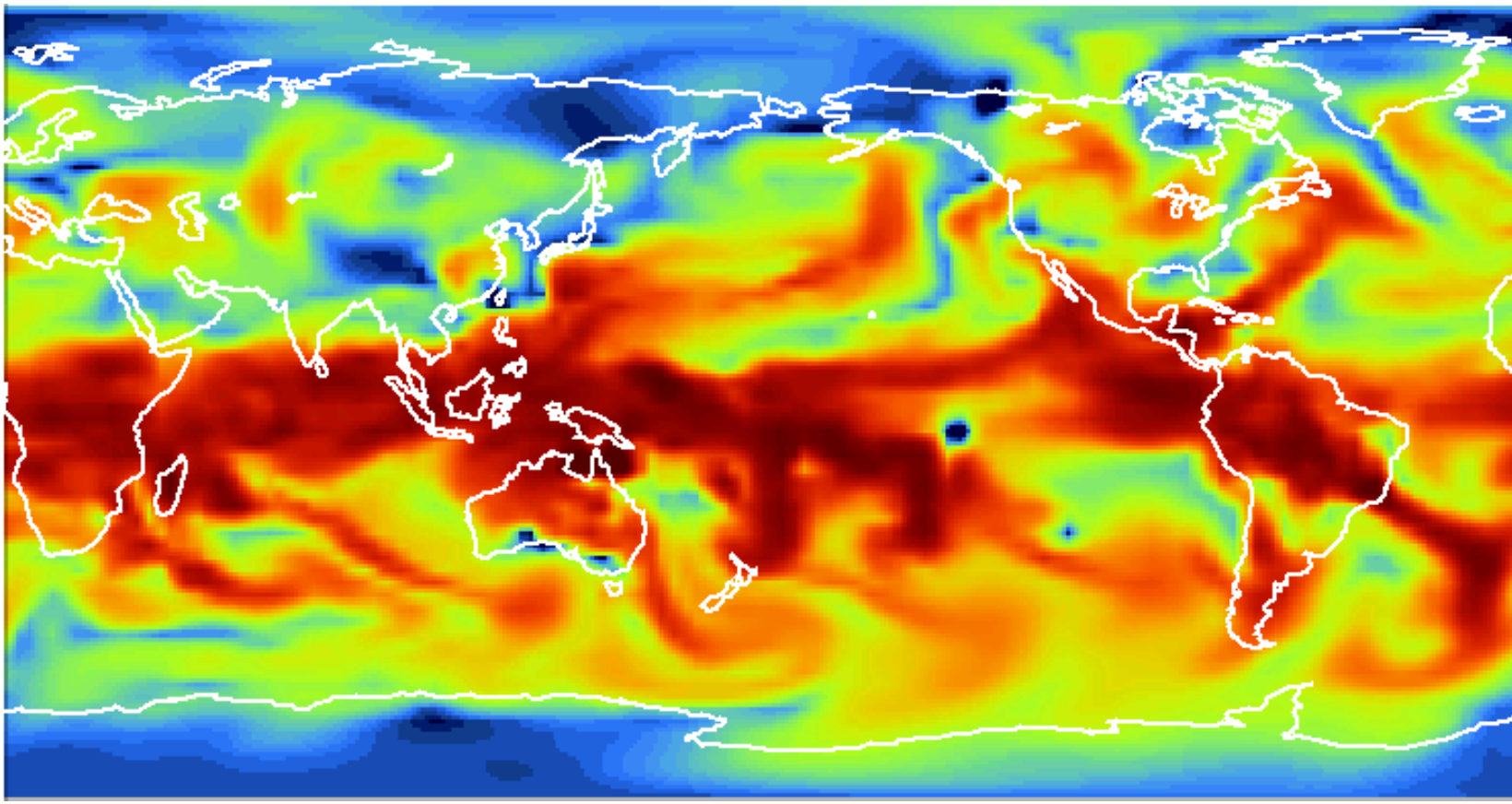
Assimilation of water vapor – final



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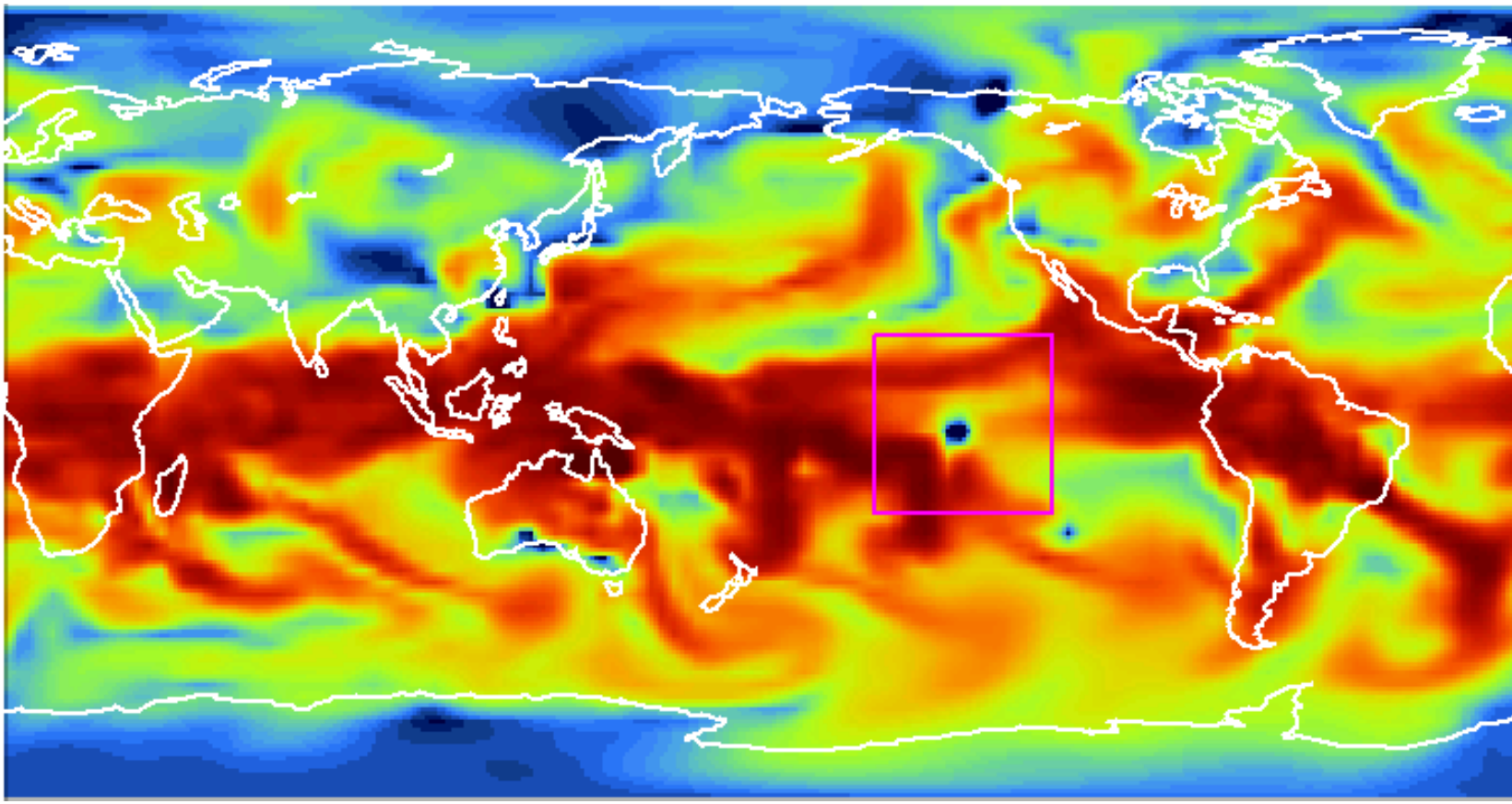
Assimilation of water vapor: Robustness



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Key:

Create a robust filter using the uncertainty from the ensemble spread to decide if a new observation is an outlier.

The RIPS Project

A robust ensemble filter for data assimilation: A forecasting system to handle outliers.

- **Adapt the Ensemble Kalman Filter to detect and handle unusual, bad observations.**

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- *Have some fun!*