Forecasting Cloud Index with an Advection Model and Data Assimilation

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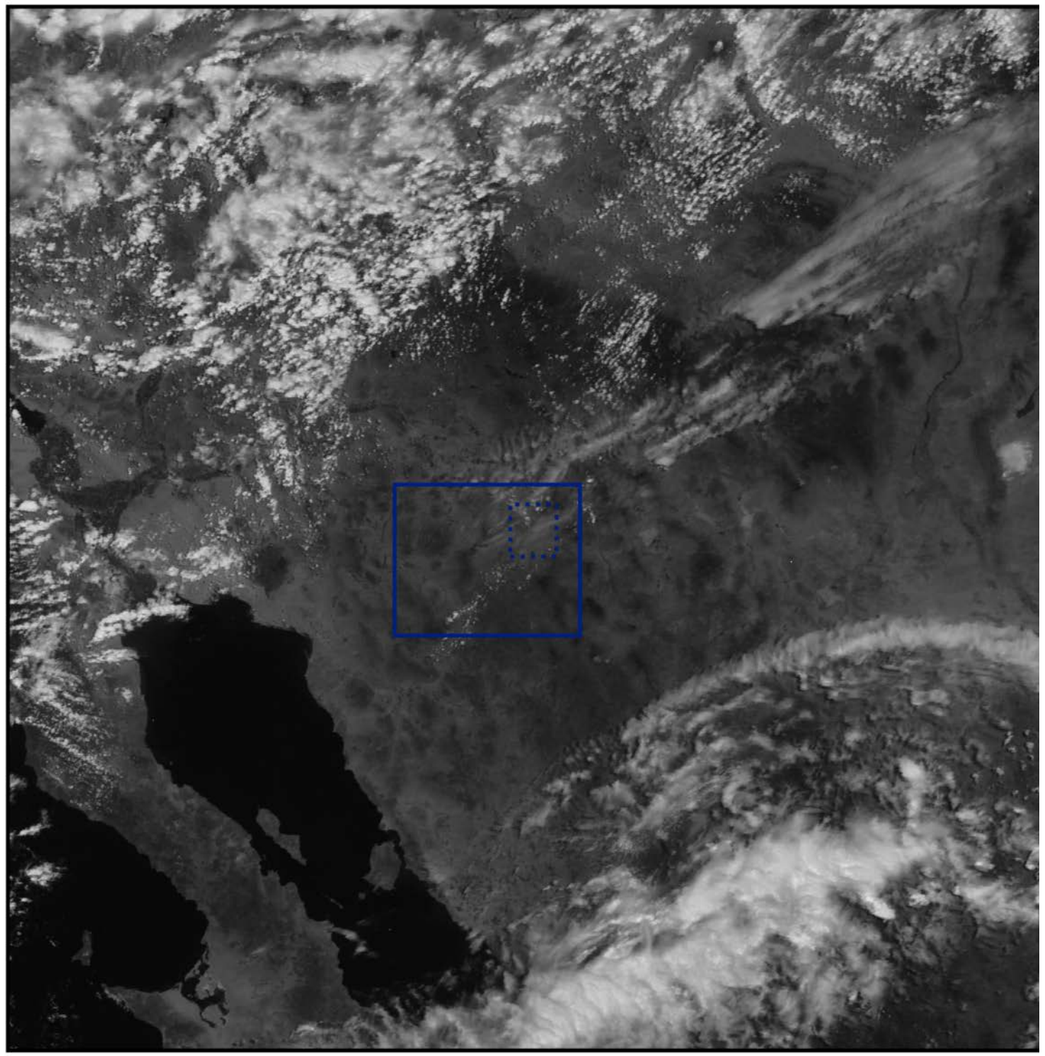
Introduction

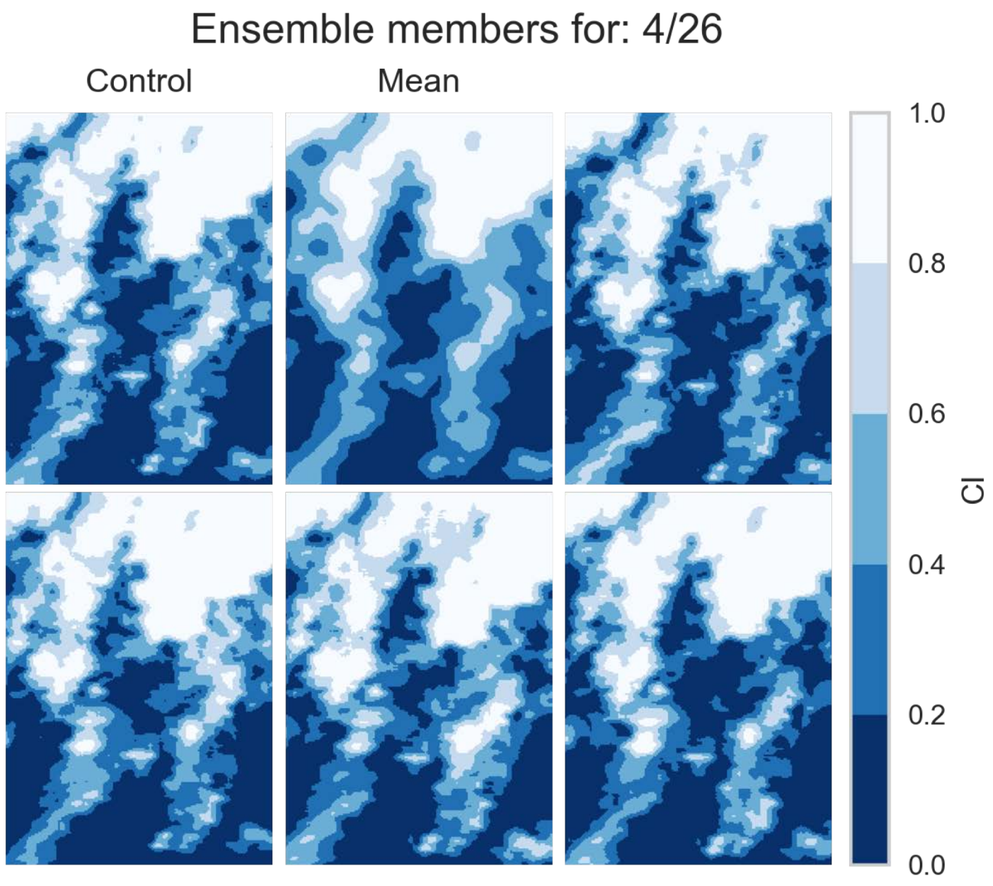
- Intra-hour cloud index forecasts over a city-sized area
- Previous work:
  - Forecasts based on advection of cloud properties using NWP winds (e.g. Miller et al., 2017).
  - Advection using CMV info from successive satellite images (e.g. Nonnenmacher and Coimbra, 2014).
- We combine the two using data assimilation.

2014-04-02 20:15 UTC



ANOC forecasting

- ANOC: Assimilation of NWP and Optical flow CMVs.
- Ensemble data assimilation (EnKF).
- Conceptually intuitive and computationally inexpensive 2D advection model.
- Assimilate cloud motion vector (CMV) data from optical flow and wind fields from Numerical Weather Prediction (NWP).
- Data assimilation takes the uncertainty of each source of data into account.



Ensemble perturbations

- 2D advection does not capture complex cloud dynamics.
- Must perturb initial cloud index and cloud motion fields to generate ensemble.

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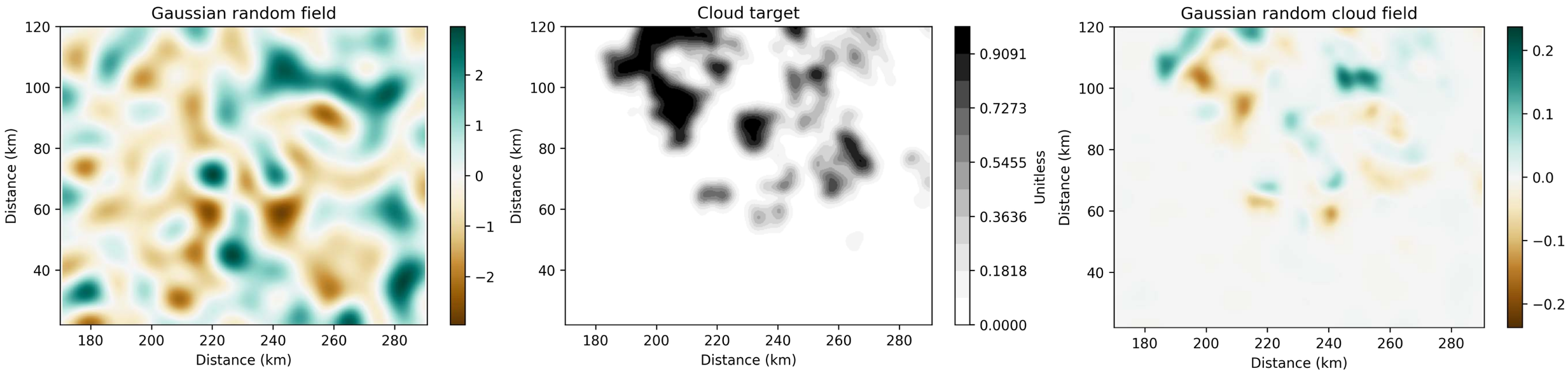
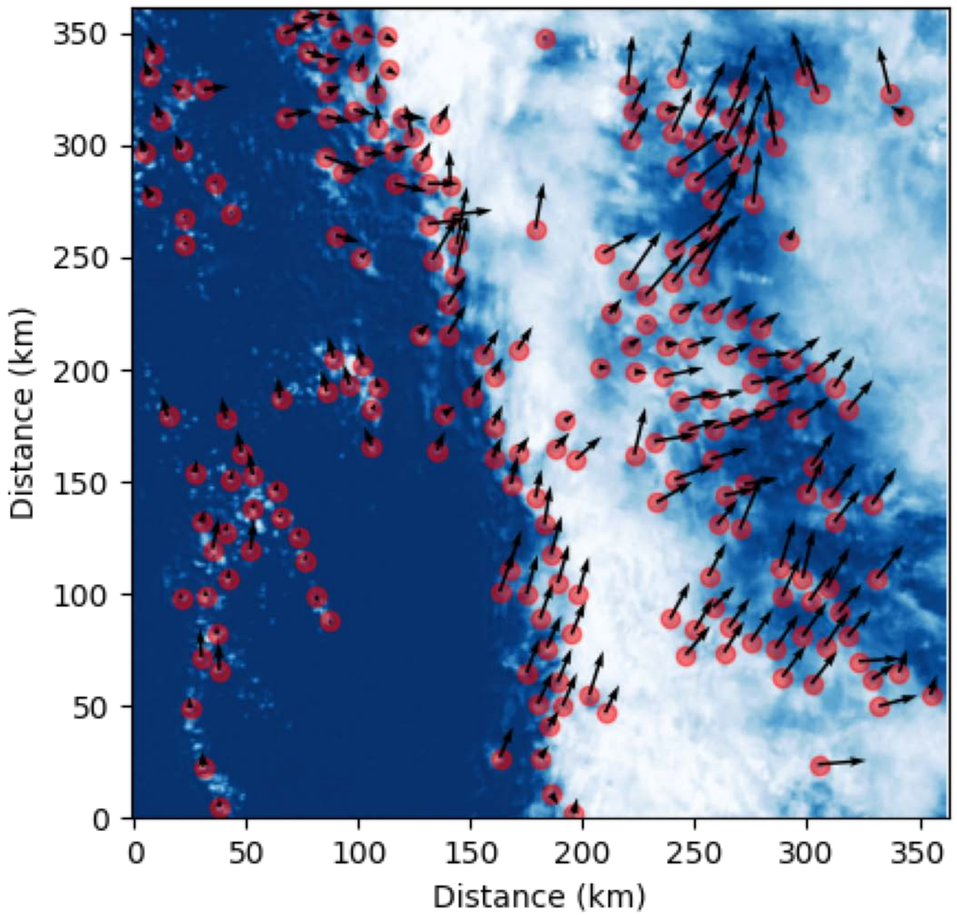
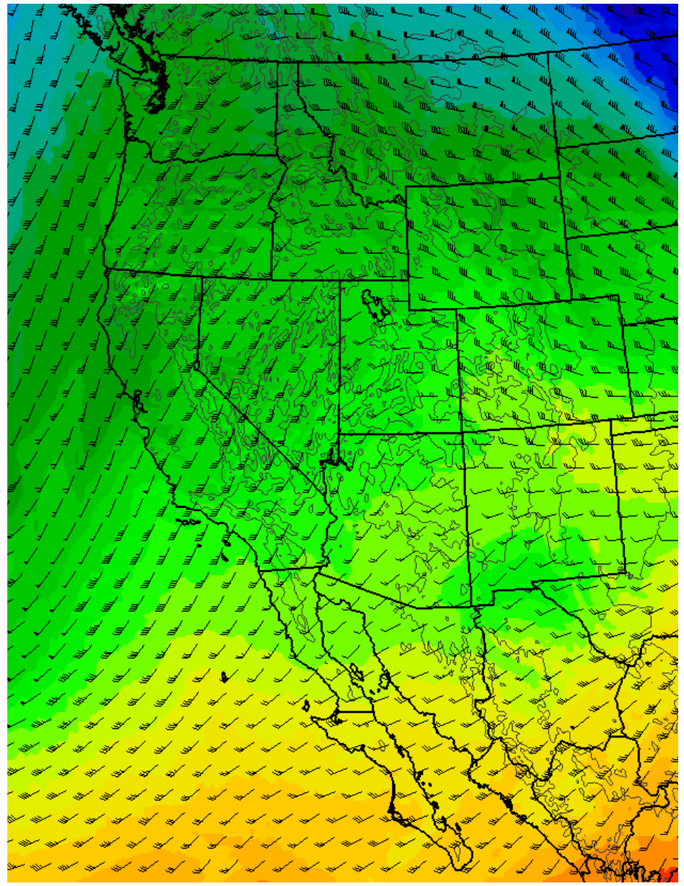


- Perturb cloud index field and cloud motion vector field using a Gaussian random field.

Optical flow & NWP

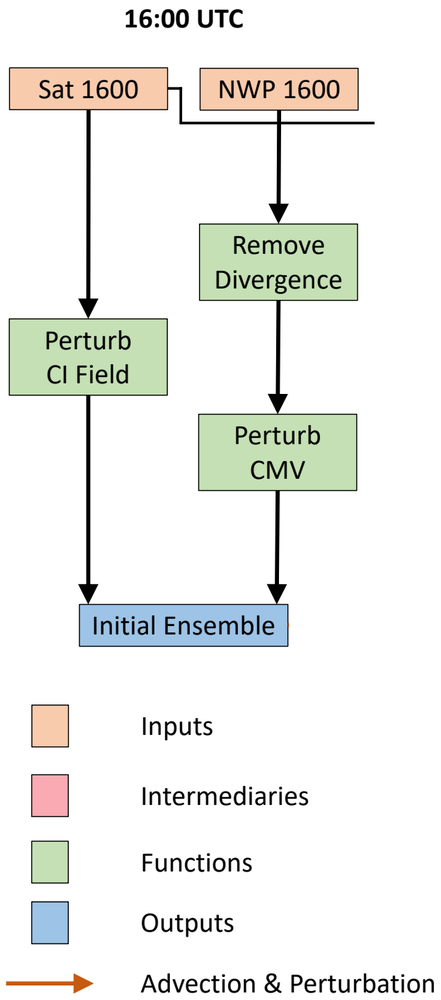




- Choose features on the satellite image based on the gradient of the image and the image's windowed variance.
- Track features to estimate the cloud motion field.
- Use NWP winds from vertical level with highest relative humidity

(Lucas and Kanade,1981; Horn and Schunck, 1981; Lave and Kleissl, 2013)

Schematic of forecast



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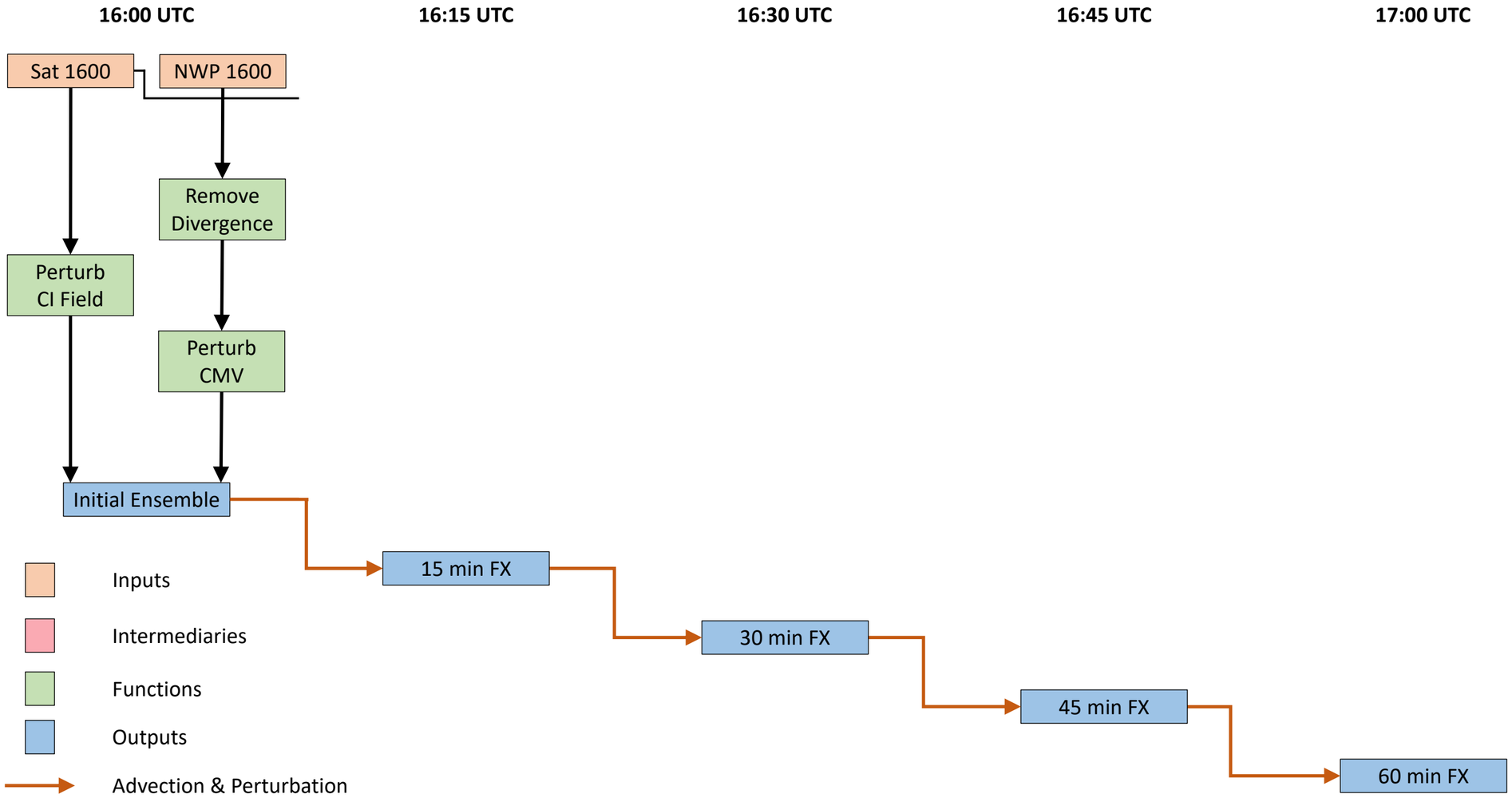

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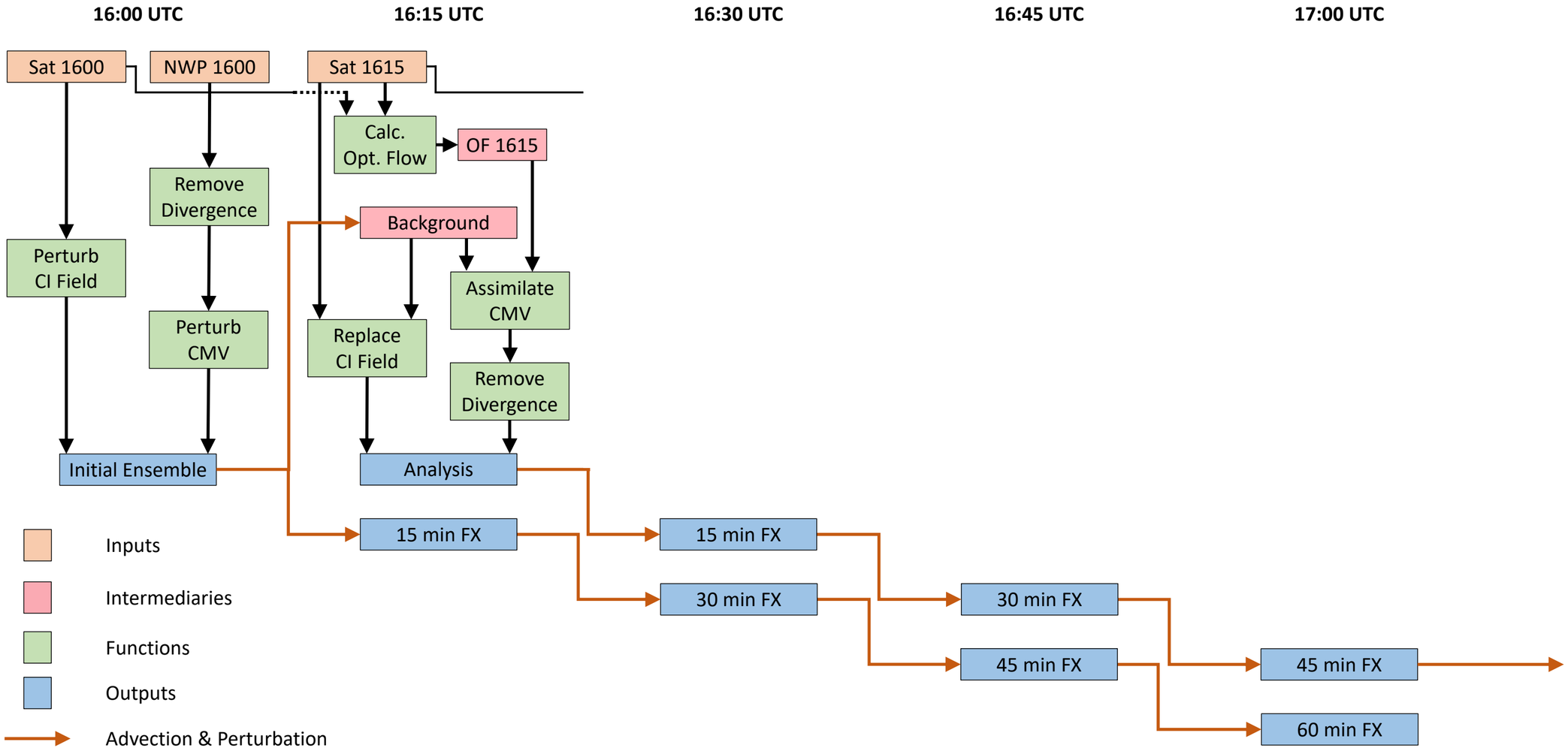
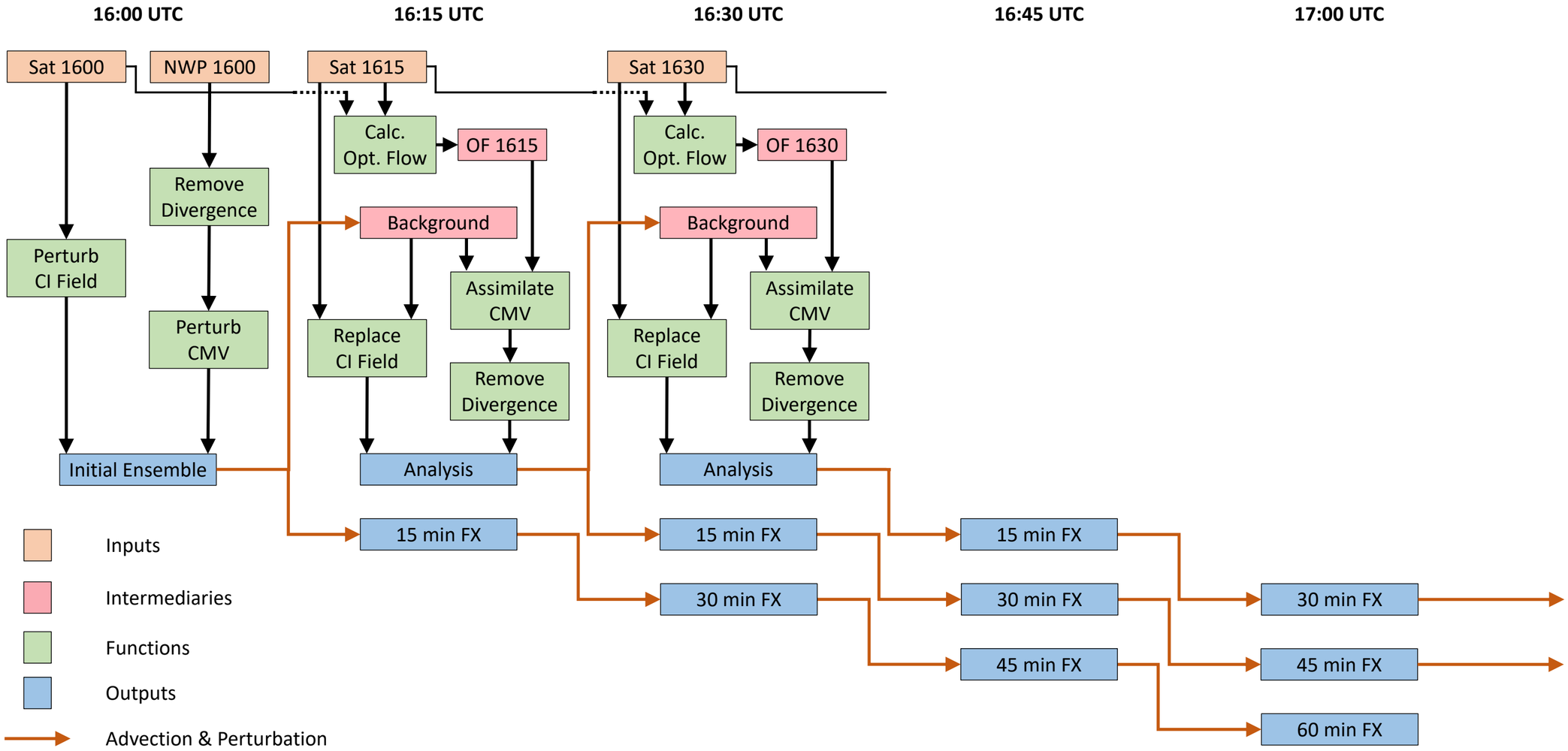


Schematic of forecast



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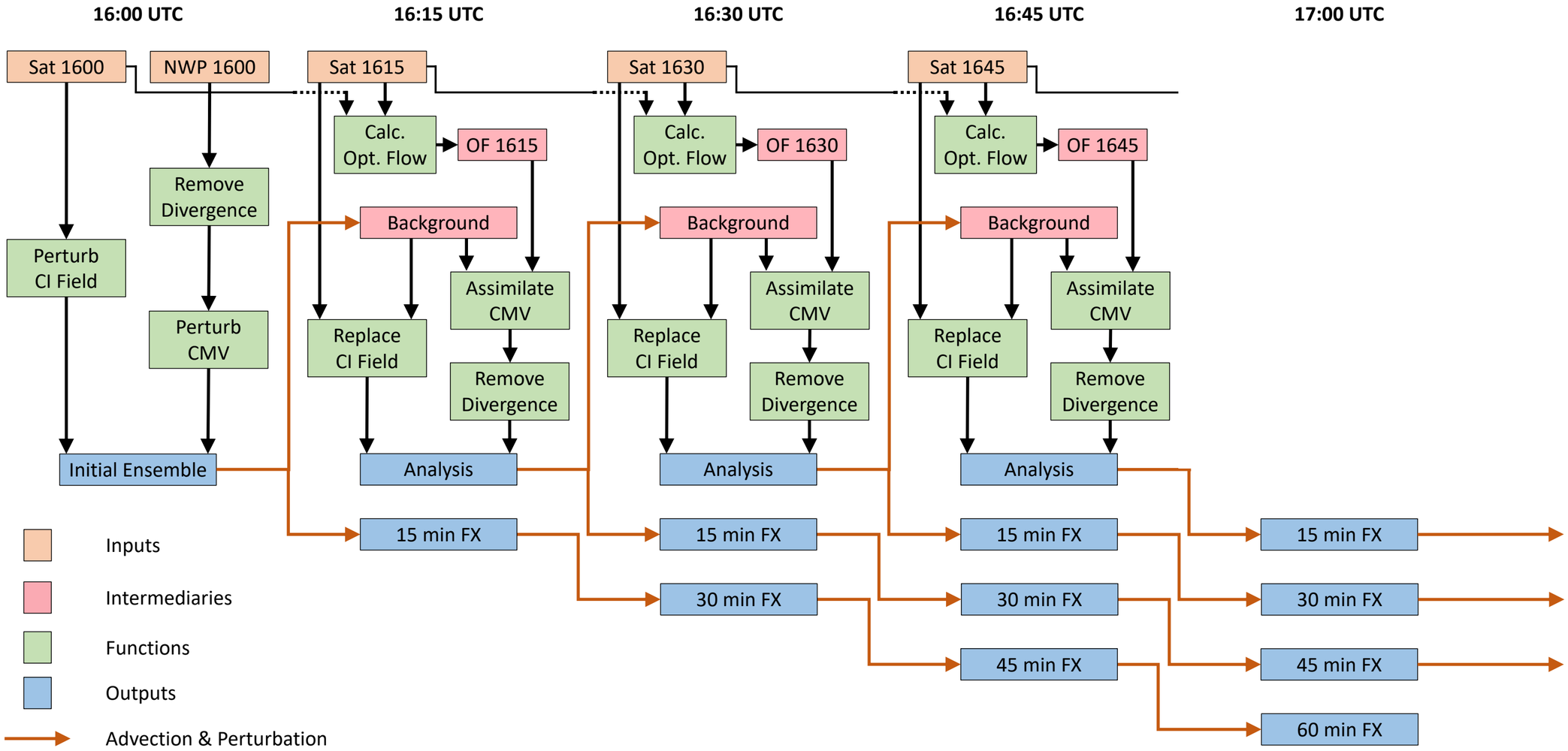

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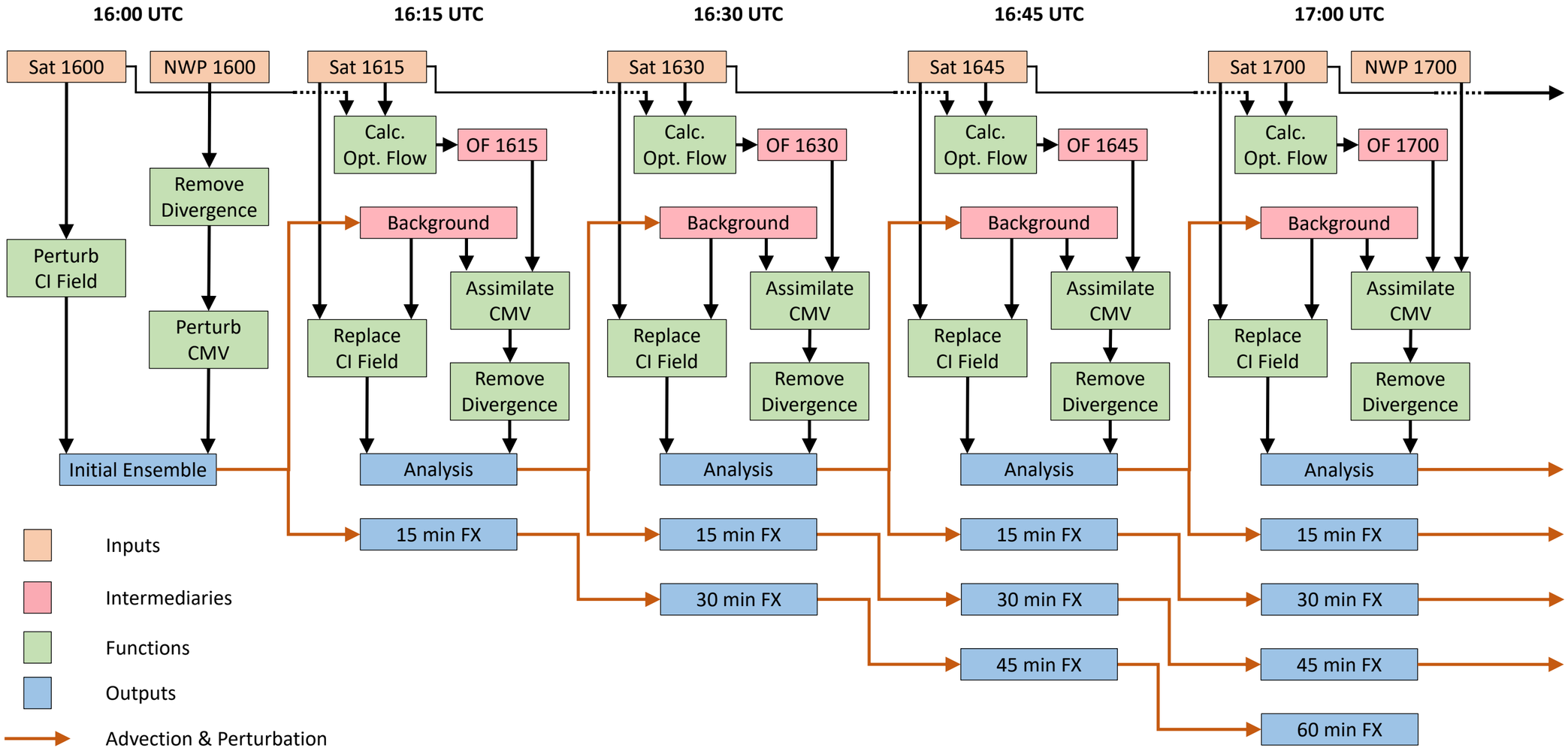
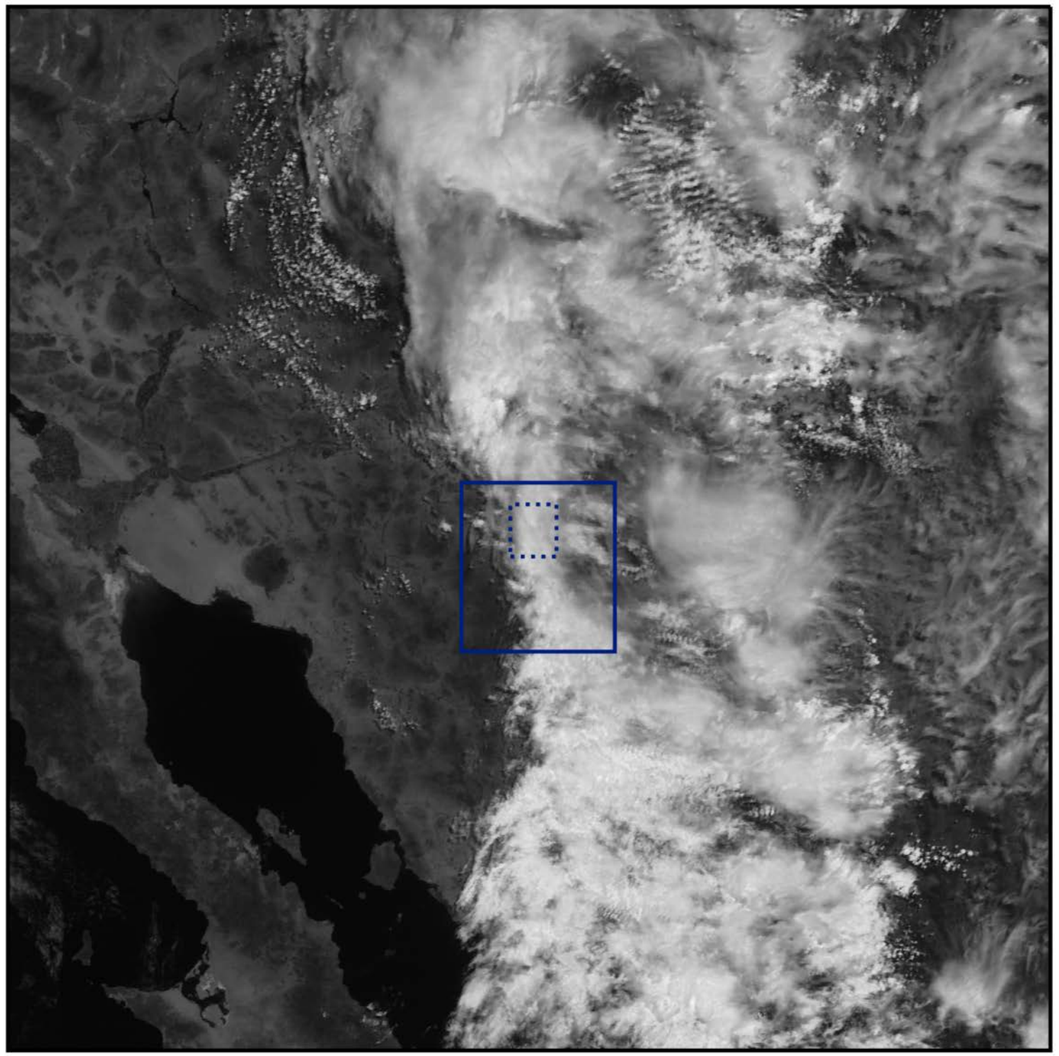


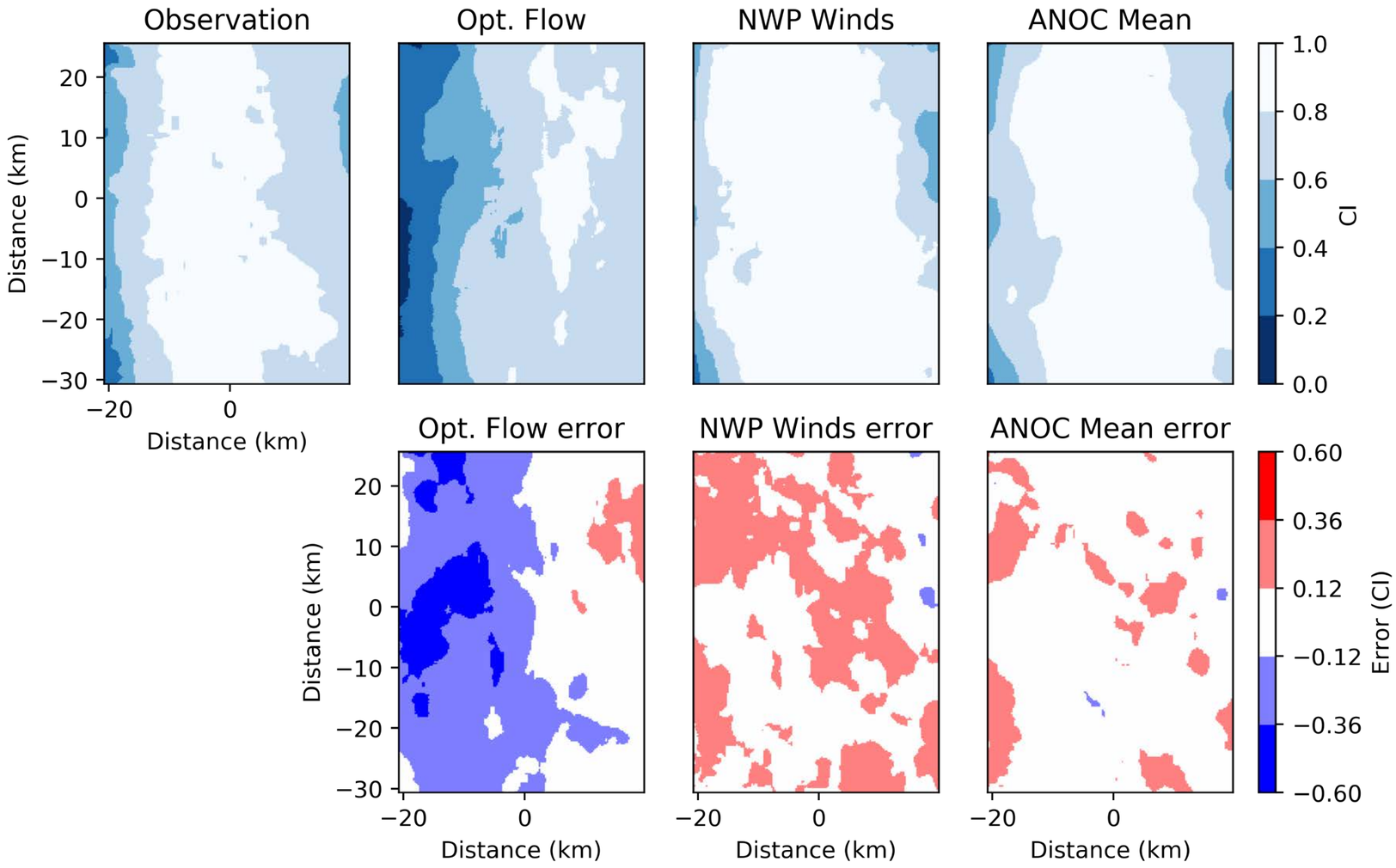
An example day: May 29th 2014

- Shortwave trough.
- Mixed variety of mid-altitude clouds.
- 12Z radiosonde has a single relative humidity peak near 5.5 km.

2014-05-29 19:45 UTC



May 29th: 30 minute forecast

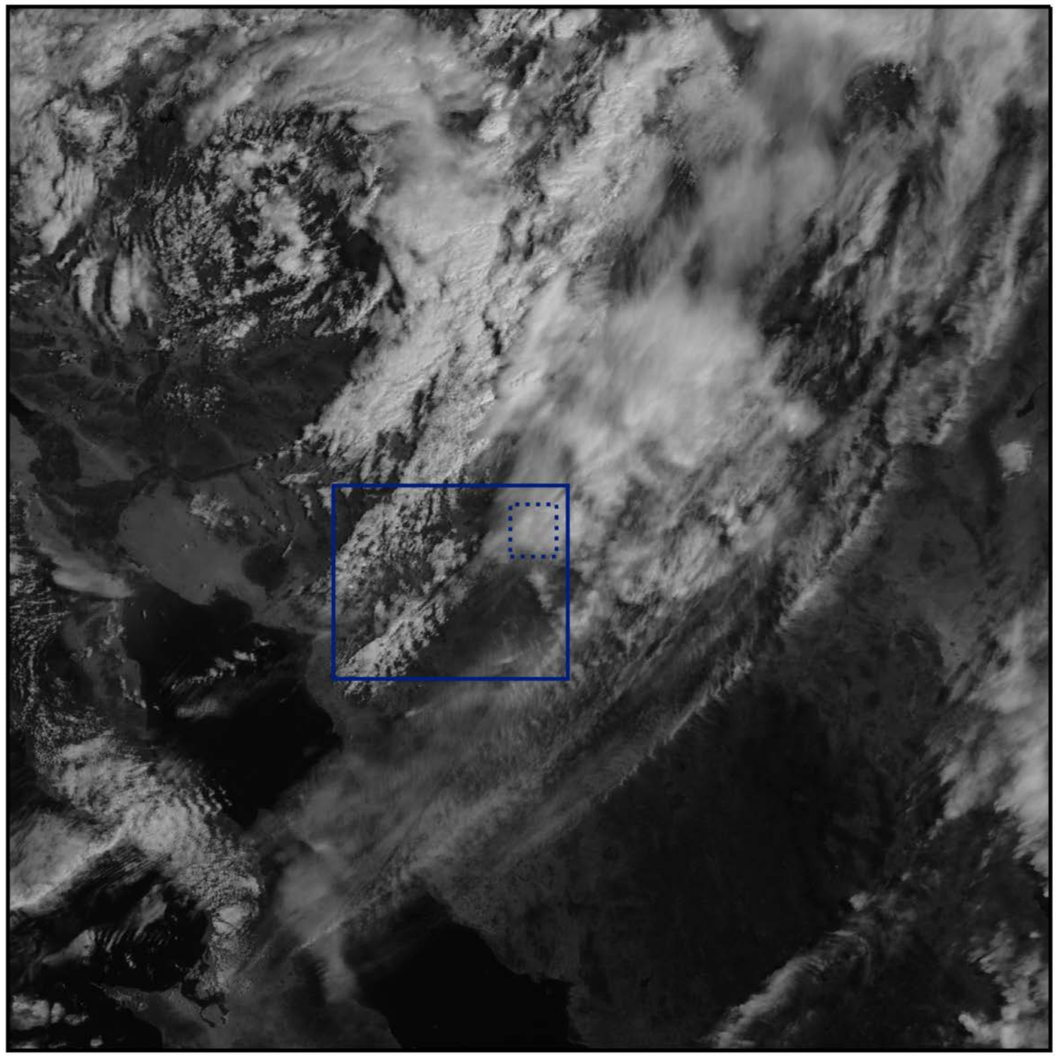


Daily RMSE: ANOC < NWP winds < optical flow

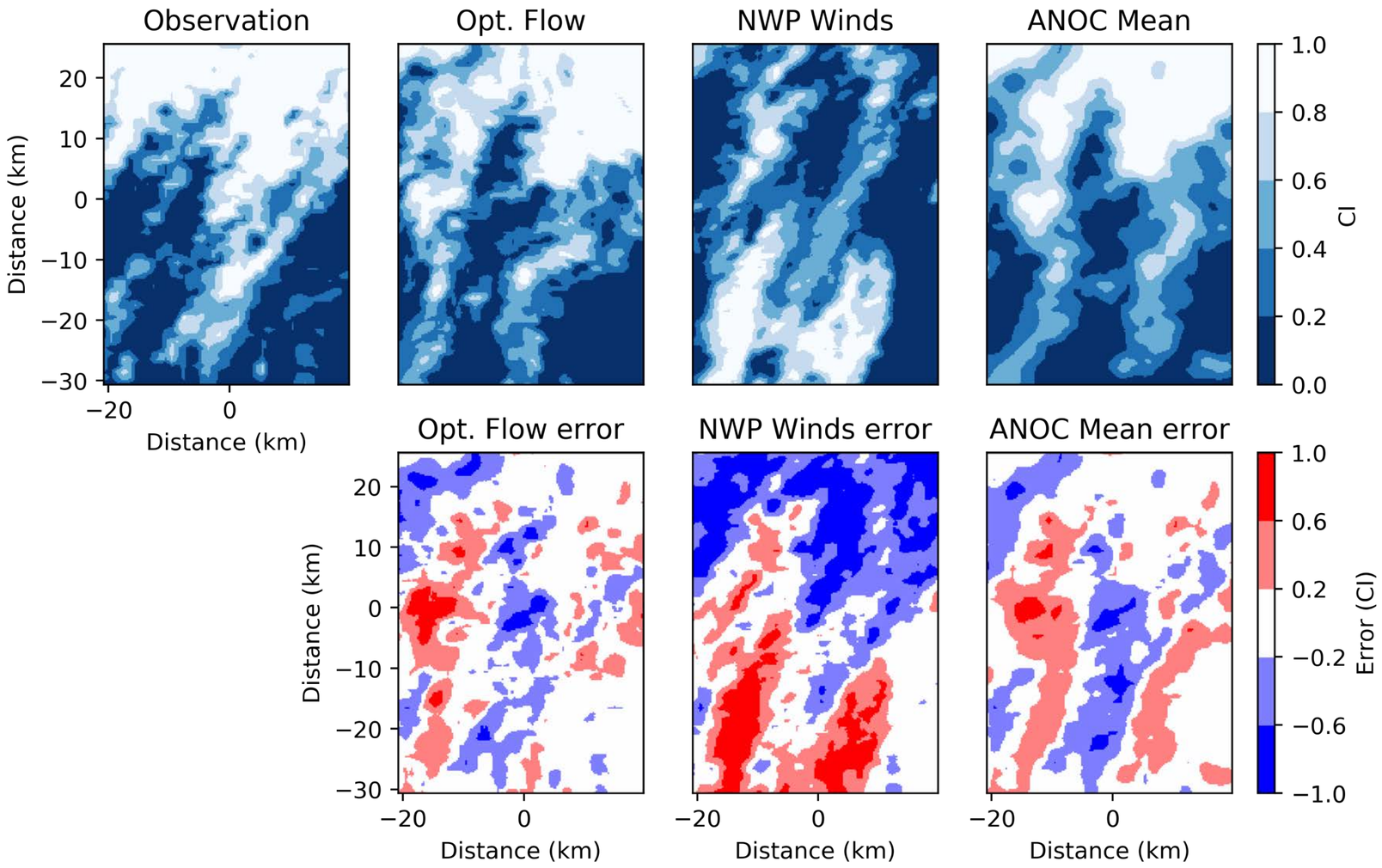
An example day: April 26th 2014

- Strong mid-latitude trough.
- Two cloud levels: Mixed variety of mid-altitude clouds and high-altitude cirrus.
- 12Z radiosonde has relative humidity peaks near 4 km and 10 km.

2014-04-26 17:15 UTC



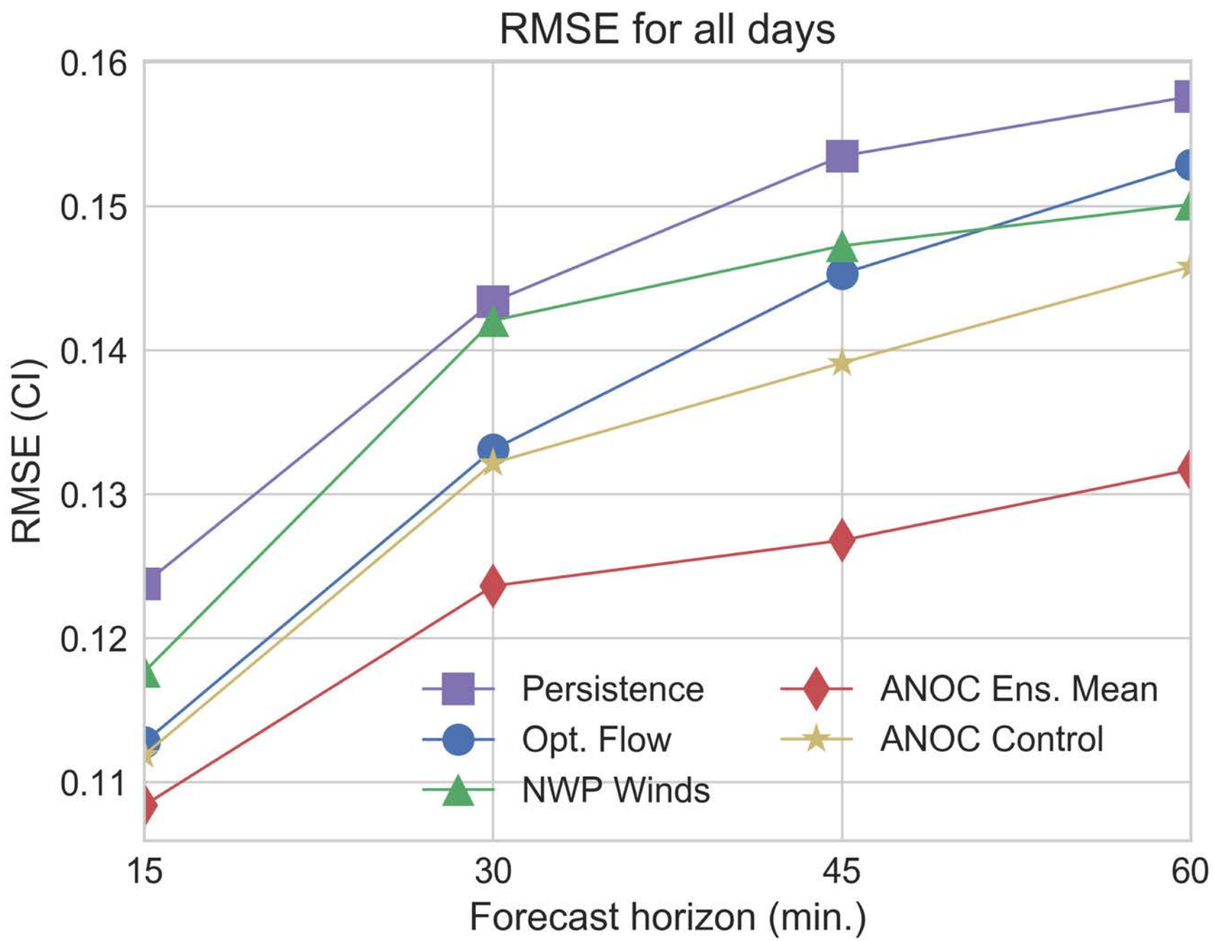
April 26th: 30 minute forecast



Daily RMSE: ANOC < optical flow < NWP winds

Error over 29 cloudy days

- Error over 29 cloudy days from April, May, and June 2014.
- All methods show skill over persistence.
- Both ANOC forecasts (ensemble mean and control) have lowest RMSE for all forecast horizons.
- Ensemble mean is smoother than control accounting for some difference in RMSE.



Summary

- ANOC forecasts have similar or lower RMSE when compared to forecasts based on only NWP winds or dense optical flow.
- Data assimilation to combine sparse optical flow and NWP winds can avoid potential pitfalls of each technique.
- The use of a conceptually intuitive and computationally inexpensive 2D advection with ensemble data assimilation shows promise as an intra-hour forecasting method.
- Paper under review: 10.5281/zenodo.2533068

Thank you!

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