3.3 Impact of Targeted Dropsonde Observations on the Predictability of Extratropical Cyclones in a Global Model using an Observing System Simulation Experiment framework

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Global Observing Systems Analysis (GOSA) Group: http://www.esrl.noaa.gov/gsd/gosa/

21st Conference on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land

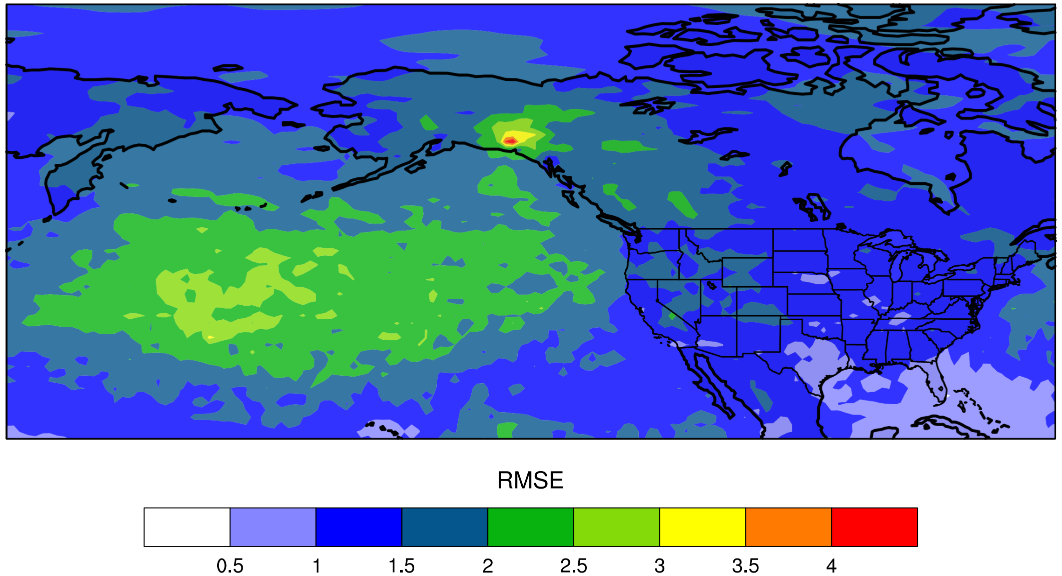
Global Observing System Simulation Experiments (OSSEs)

Motivation

High Impact Weather Events

http://www.weathernationtv.com/app/uploads/deadly-weather.jpg

Large Analysis Error over Northern Pacific Ocean



SHOUT Project

https://www.nasa.gov/sites/default/files/ed13-0399-06a.jpg
https://uas.noaa.gov/shout/img/shout-logo.png

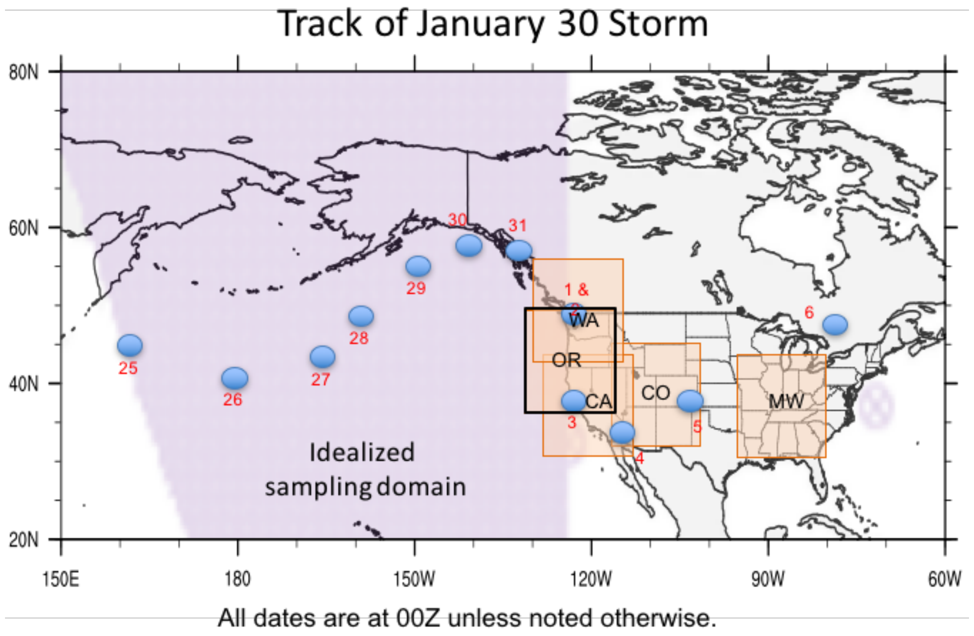
Experiment Design

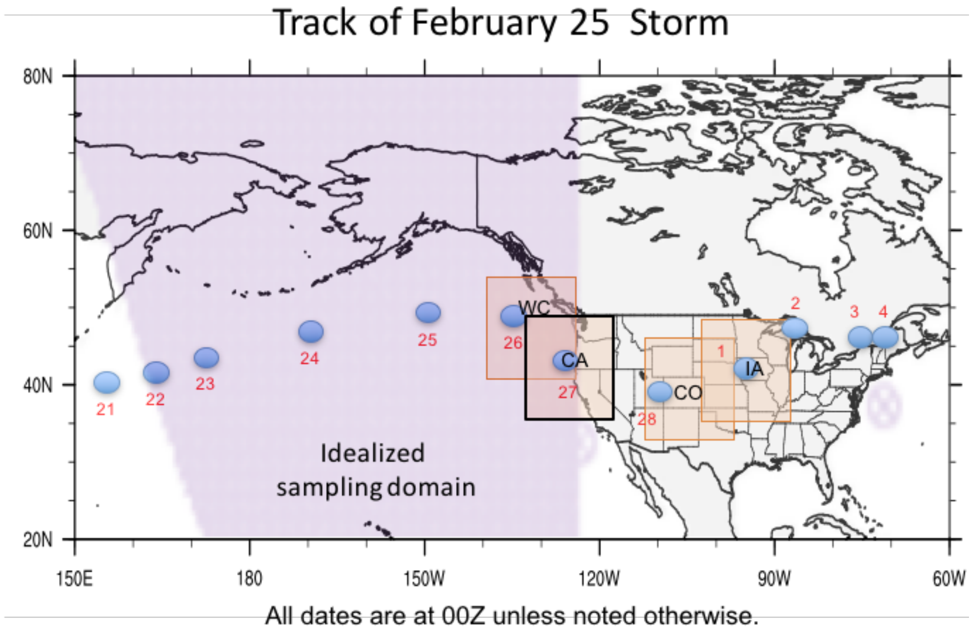
Experiment	Name	Dropsonde Obs.	Description
Control	CTL	None	simulated conventional and satellite observations
Idealized	Ideal_tquv	temp, humidity, wind	CTL + simulated dropsonde observations over a large domain
	Ideal_t	temperature	
	Ideal_uv	wind	
	Ideal_q	humidity	
Sensitivity	Sensit_(region)_tquv	temp, humidity, wind	CTL + simulated dropsonde observations over a smaller ETS domain
Flight	Flight_(region)_tquv	temp, humidity, wind	CTL + simulated dropsonde observations over a flight path

Additional Experiment Info:

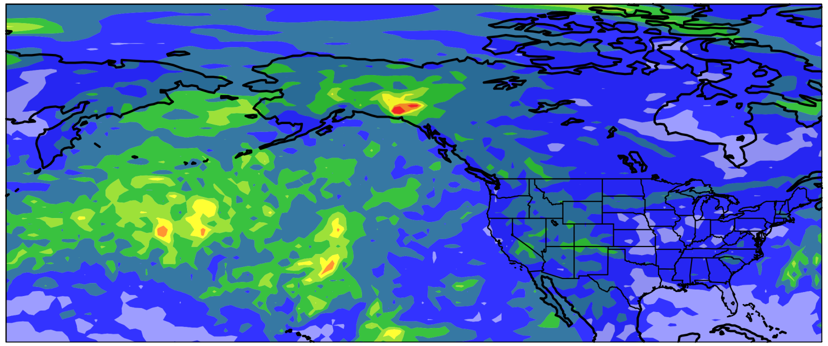
- Nature Run -> T511 ECMWF
- NCEP GFS System Q1FY15 -> T382 3D-Var EnKF
- January – February 2006
- All sampling domains over Northern Pacific Ocean

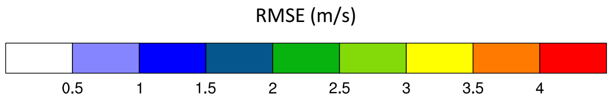
Chose two storms in Nature Run to study



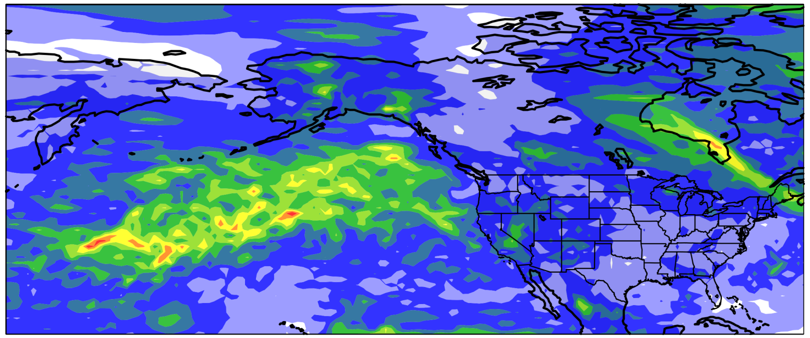


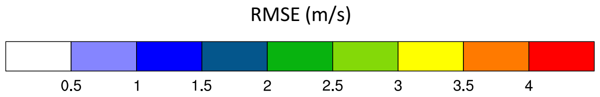
January 30th Storm: RMSE U, 500 hPa



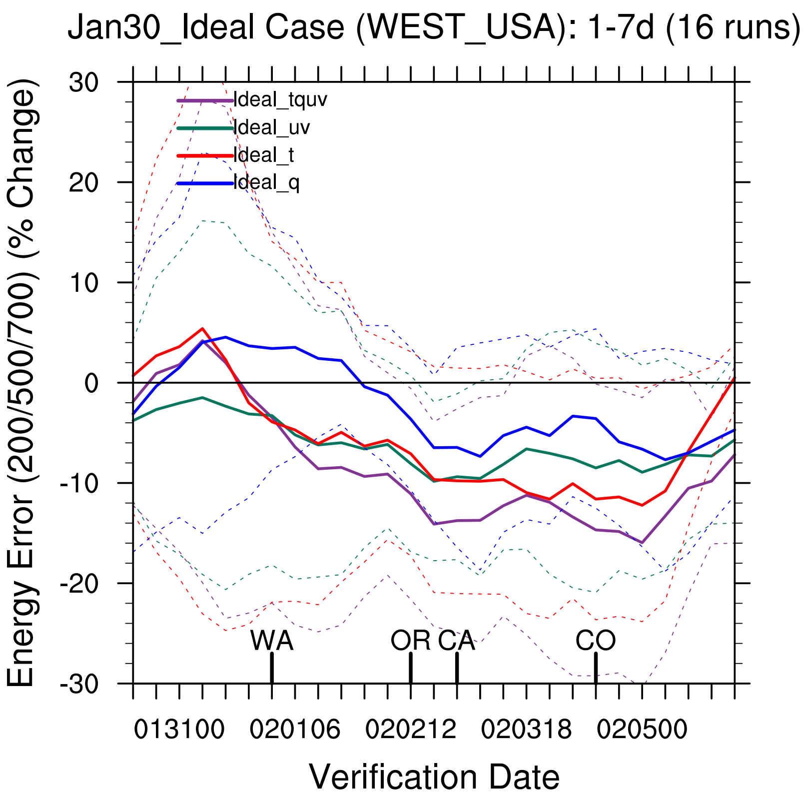


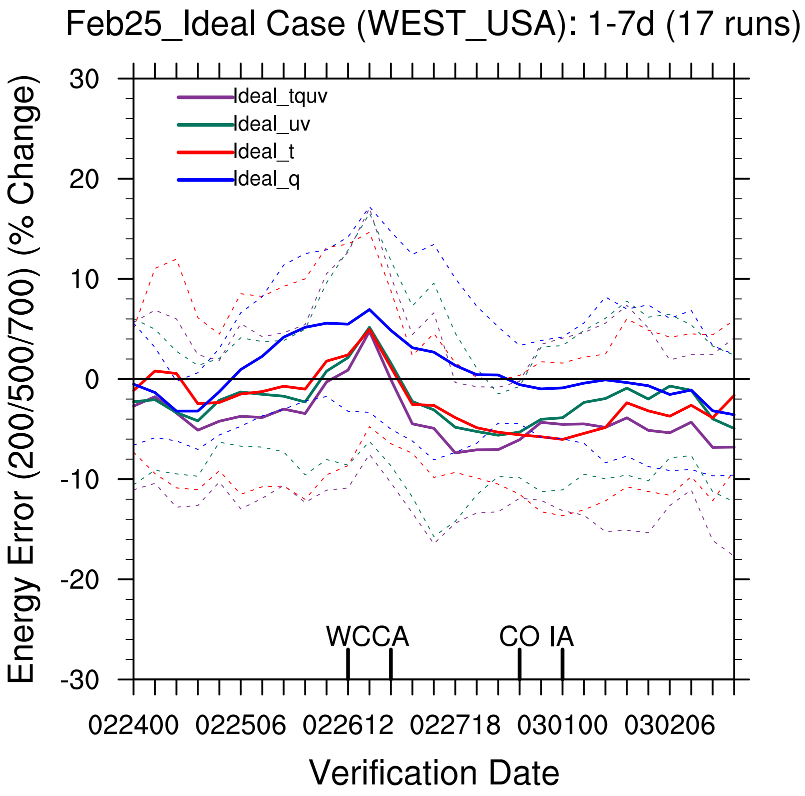
February 25th Storm: RMSE U, 500 hPa





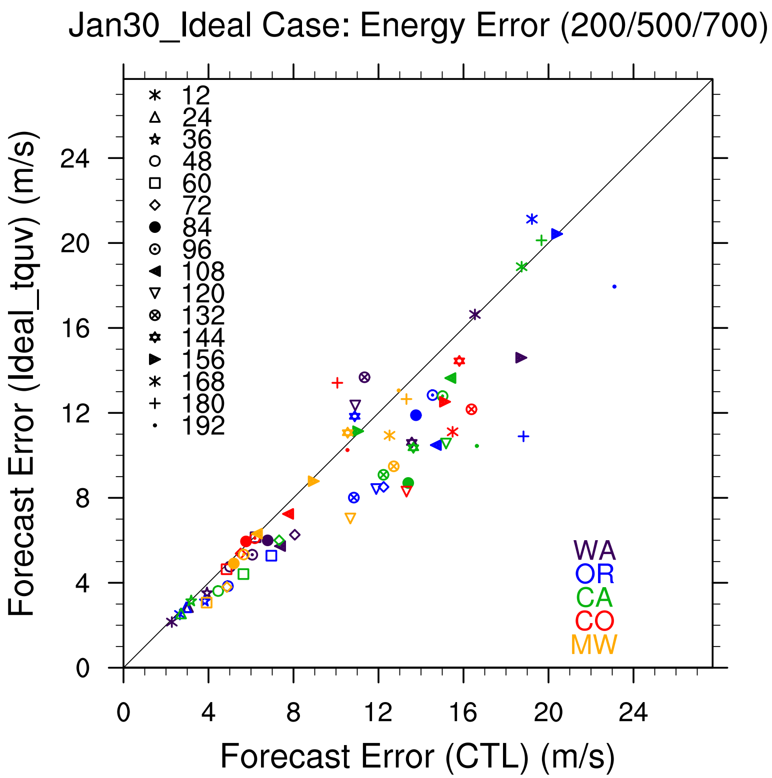
Results: Idealized Experiments

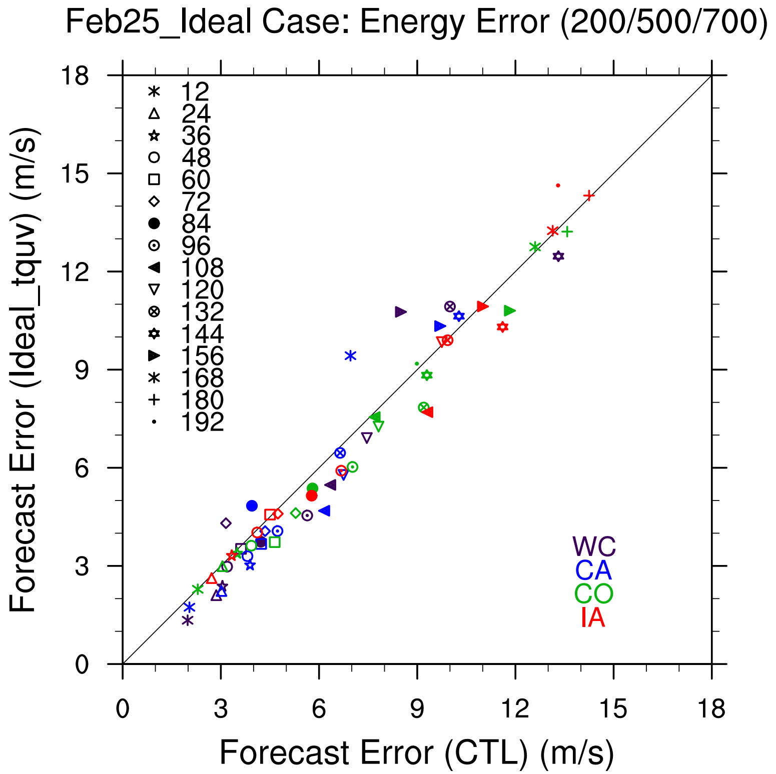




- ***Adding dropsondes significantly reduces forecast error.***
- All experiments reduce forecast error, but temperature and wind individually have more impact than humidity
- Ideal_tquv experiment has the largest positive impact on forecast skill.

Results: Idealized Experiments (Cont'd)

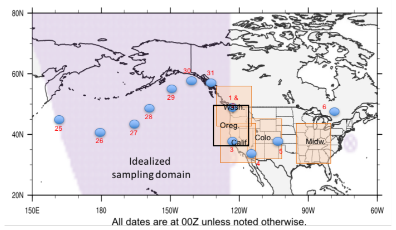




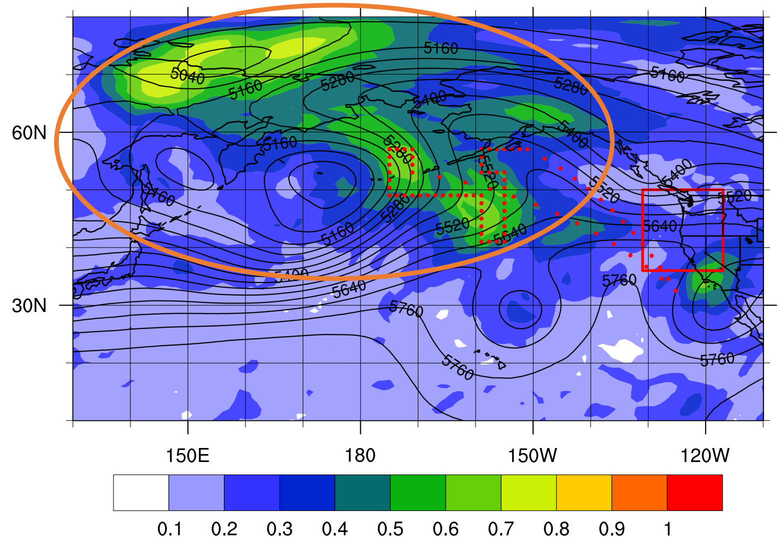
- ***Adding dropsondes significantly reduces forecast error at most locations and lead-times (but not all)***
- January 30th Storm shows consistent reduction in forecast error for all verification regions and the majority of forecast hours.
- February 25th Storm shows a reduction in forecast error for all verification regions and for earlier forecast (~ ≤ 108). Later forecast hours show neutral impact.

Set-up: Sensitivity and Flight Experiments

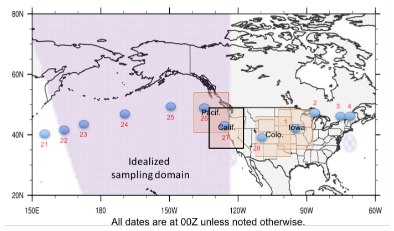
Track of January 30th Storm



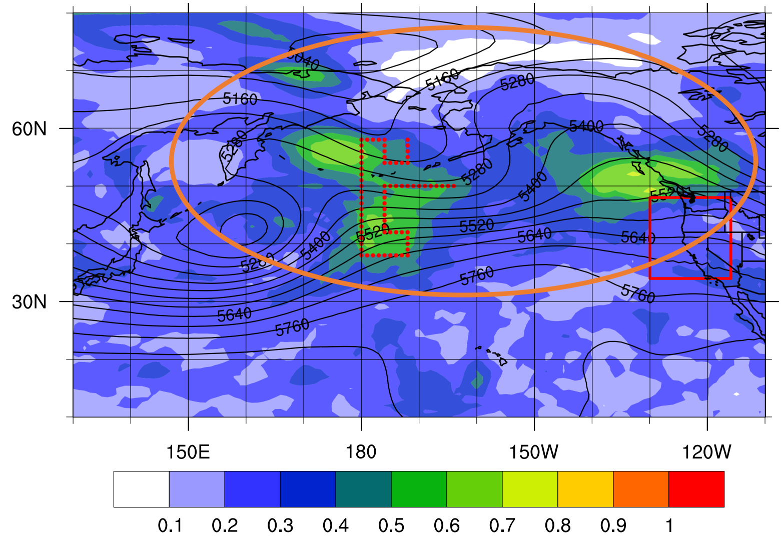
Jan. 30 Storm: Dropsondes (80, 22.8 hrs) and ETS



Track of February 25th Storm

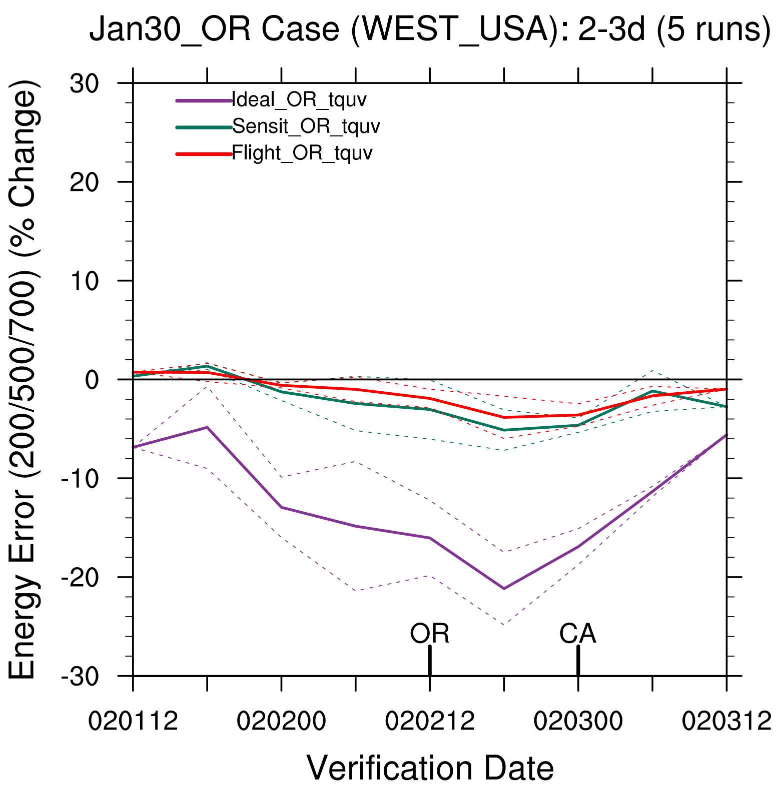


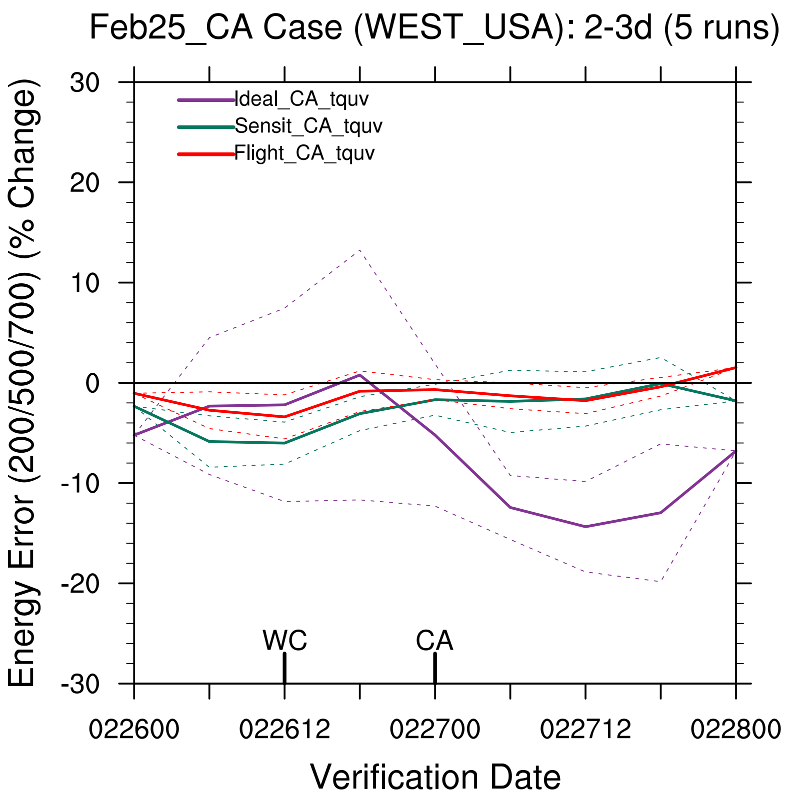
Feb. 25 Storm: Dropsondes (73, 24.2 hrs) and ETS



- Normalized Ensemble Transform Sensitivity (ETS) plots for each storm
- Each plot is based on the chosen verification region for each storm
  - Jan. 30th Storm -> Oregon, 2/2 12Z
  - Feb. 25th Storm -> California, 2/27 00Z
- Dotted lines is the generated flight path for each storm
- Sensitivity Experiments
  - Domain Sample: ETS values ≥ 0.5
- Flight Experiments
  - Domain Sample: Flight Path

Results: Sensitivity and Flight Experiments





- ***The Sensitivity and Flight experiments reduce forecast error for both storms, with the impact being more significant for the Jan. 30th Storm.***
- Improvements are much smaller with the Sensitivity and Flight experiments than the Idealized experiments, as expected.

Summary

- We used OSSEs to study the impact of targeted dropsonde observations on the forecast accuracy of 2 storms over the CONUS.

- Adding dropsondes over a large idealized region of the Pacific Ocean significantly reduces forecast error over the CONUS, with temp/winds having more impact than humidity.

- Targeted observations using the ETS technique can reduce forecast error for both storms (although the impact is smaller than for the idealized domain, as expected).

Extra Slides

OSSE Configuration

- Summary of differences between CTL and Operational version in late-2012
  - CTL is a close approximation of the Q1FY15 GDAS/GFS system, ported to Theia (some changes for running on Theia)...so it's advanced beyond the late 2012 version. See the three most recent implementations listed in the "Previous Implementations" section of this page:

    http://www.emc.ncep.noaa.gov/?branch=GFS&tab=impl

  - forecast model - T574 eulerian (Ops2012) vs T1534 semi-lagrangian Q1FY15 system (CTL)
  - analysis - Q3FY12 GSI/EnKF at T254 (Ops2012) vs Q1FY15 GSI/EnKF at T574 (CTL), see #2 in January 2015 implementation description for changes made in Q1FY15 version

IR, Visible, MW Satellites	
NOAA-15	AMSU-A
NOAA-18	AMSU-A, MHS
NOAA-19	AMSU-A, MHS
Suomi NPP	CrIS, ATMS
Metop-A	HIRS4, IASI, AMSU-A, MHS
Metop-B	AMSU-A, MHS
Aqua	AIRS, AMSU-A
GEOS-15	sndrD1, sndrD2, sndrD3, sndrD4

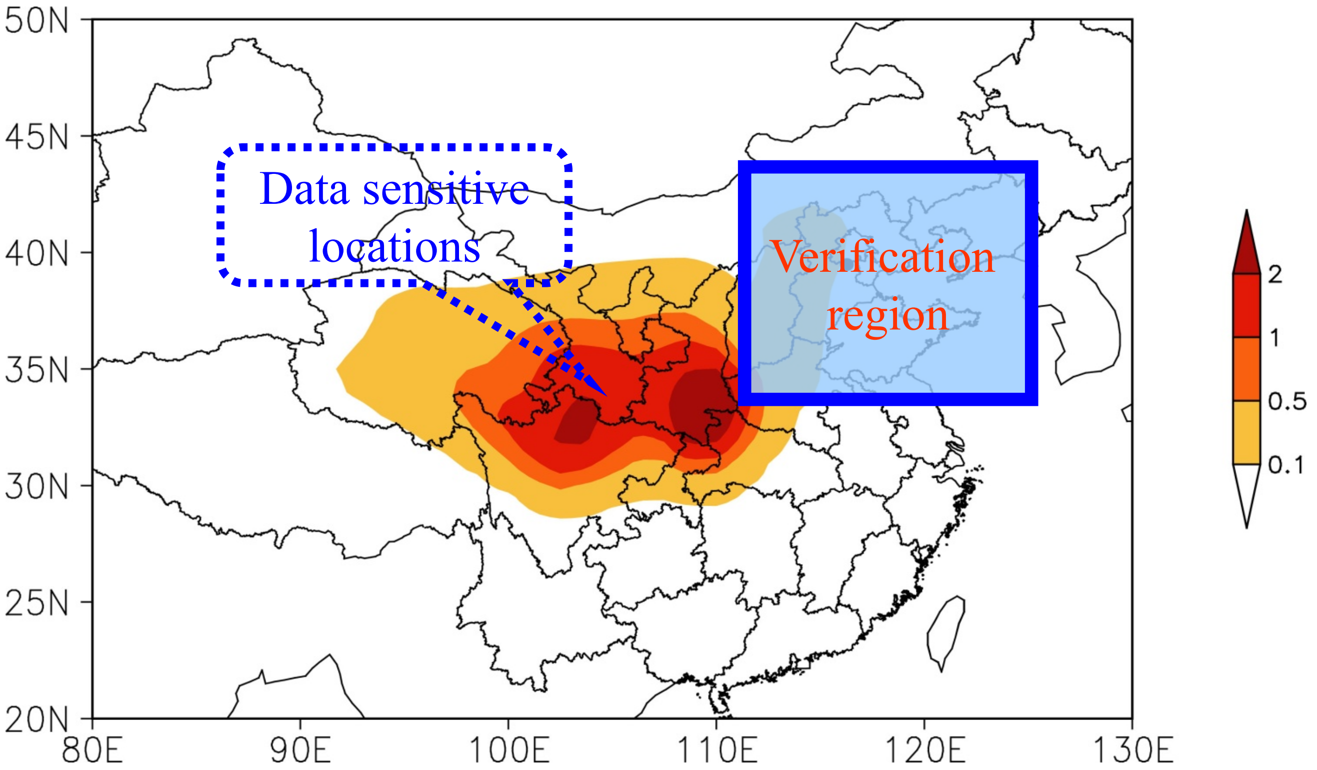
DMSP F17	SSMIS
Meteosat 10	SEVIRI
GPS-RO Satellites	
COSMIC	JPL Blackjack
TerraSAR-X	JPL Blackjack
GRACE-A	JPL Blackjack
C/NOFS	CORISS
Metop-A	GRAS
Metop-B	GRAS

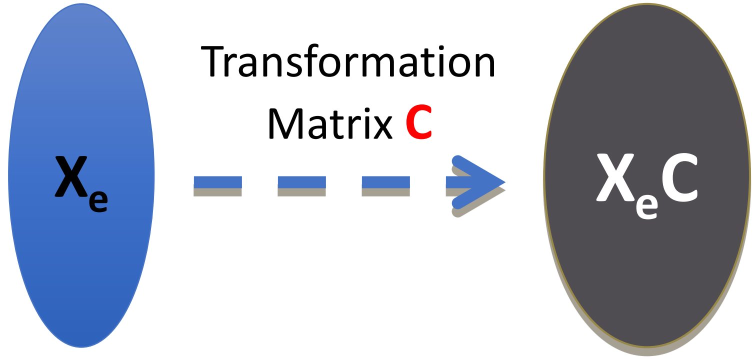
OSSE vs. Operational Configuration

- What is new/updated in the Model Configuration used for the OSE
  - Forecast Model
    - Updated SST and Sea Ice Concentration Climatology (1982-2001 → 1982-2012)
    - 5 minute Ice Analysis Data replaced 30 minute data for large bodies of water
    - Divergence Damping used in Stratosphere to reduce noise
    - Uses Monte-Carlo Independent Column Approximation (McICA) for Rapid Radiation Transfer Model (RRTM) Radiation
    - Reduced Drag Coefficient at High Wind Speeds
    - Updated Scheme for Mass-Flux at the Planetary Boundary Layer
    - Retuned orographic gravity-wave forcing and mountain blocking
    - Reduced the sharp decrease in the cloud water in the first model time step
    - Corrected bug in condensation calculation
  - Analysis
    - Updated Radiance Assimilation and Enhanced Radiance Bias Correction Scheme
    - Updated to Version 2.1.3 of the Community Radiative Transfer Model (improved the analysis of near-surface temperature over water)
    - Uses Stochastic Physics in ENKF Ensemble Forecasts
    - Dump window for GOES Satellite Wind changed from 1 hour to 6 hours.

Ensemble Transform Sensitivity technique

(a) Calculate Ensemble transform matrix
(b) Predict forecast error covariance (analysis and forecast error)
(c) Estimate prediction error variance reduction





Ensemble perturbations 80 GEFS members

Perturbations transformed to represent effect of adaptive observations

specify regions for possible adaptive observations

ETS based on Total Energy Norm
Temp, wind at 200, 500, 700 hPa

The locations of sensitive regions is dependent on the area in which a forecast improvement is wanted, the verification area, but also the forecast length and the atmospheric flow between the targeting and verification times.

Zhang et al. (2016)