Real-time Mesoscale Data Assimilation and Prediction for the Los Angeles Basin

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Outline

- Project objectives
- Modeling system description
- Results
- Future Plans

Study Objectives

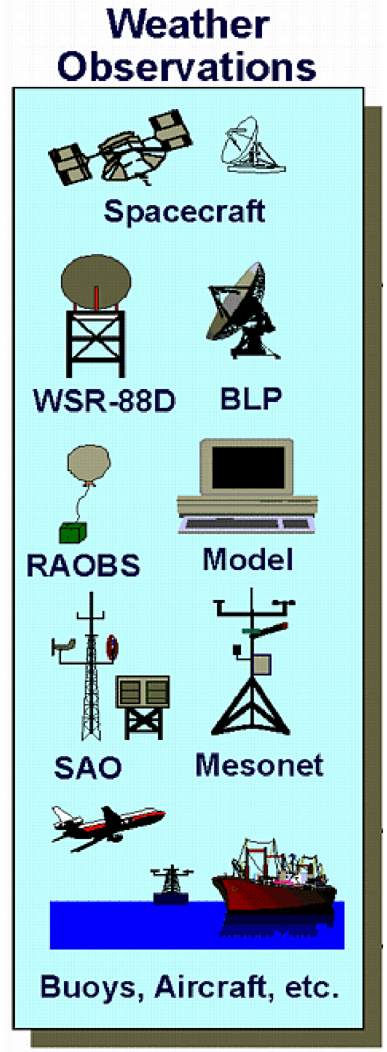
- **Improve the high-resolution capability of MM5 numerical weather prediction model through optimal assimilation of space based and local data sources**
- **Demonstrate automated daily 36 hour forecasts over the LA basin forecasts at 3km resolution**
  - **AQ predictions**
  - **Terrorist threat emergency response**
- **Access accuracy of model forecasts through quantitative and qualitative verification**

Modeling System Description

- Initialization Data
- Software
  - 3-Dimensional Variational Analysis System (3DVAR)
  - Penn State/National Center for Atmospheric Research Mesoscale Model Version 5 (MM5)
  - Post-processing and verification
- Hardware
  - Cray SV1
  - SGI Onyx

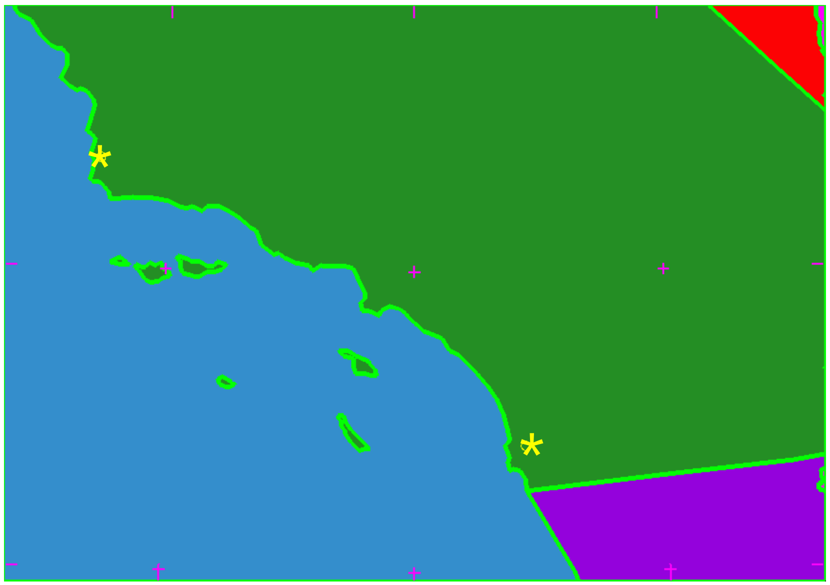
Initialization Data

- **Observations**
  - **Surface Data**
    - ➢ Conventional NWS and DoD surface reports (including ships,buoys)
    - ➢ SCAQMD Meteorological observations
    - ➢ Bureau of Land Mgmt Remote Automated Weather Obs (RAWS)
    - ➢ Additional buoys from the NBDC
  - **Profile Data**
    - ➢ Boundary Layer Profilers (Wind)
    - ➢ RASS Profiles (Temp)
    - ➢ Aircraft Reports (Aireps)
    - ➢ Radiosondes
  - **Satellite Data**
    - ➢ GOES Cloud Drift Winds
    - ➢ DMSP SSMI winds and Total Precipitable Water
    - ➢ GPSMet Total Precipitable Water

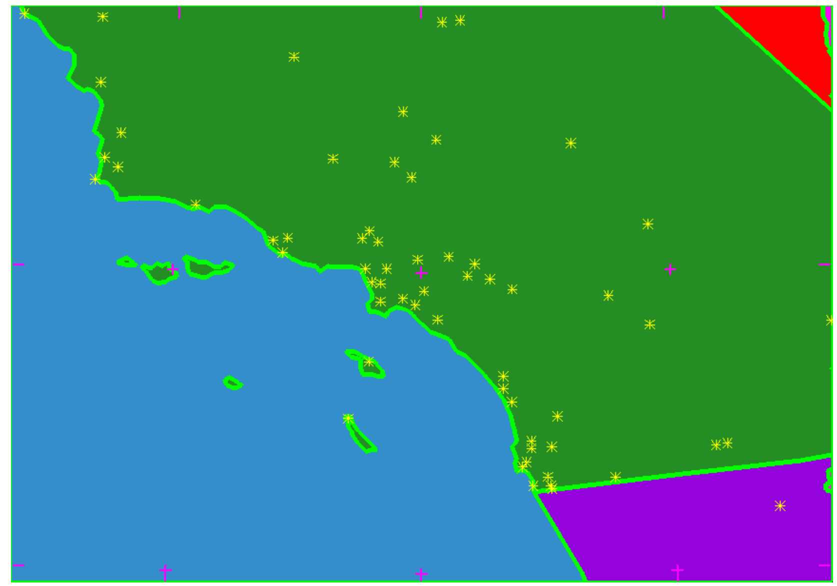


- Boundary/Background Field Sources
  - ETA Initial conditions (40 Km grid spacing)
  - MM5 6-h forecasts (15 & 5 km grid spacing)
  - NAVY Sea Surface Temperatures

Nationally Available Observations



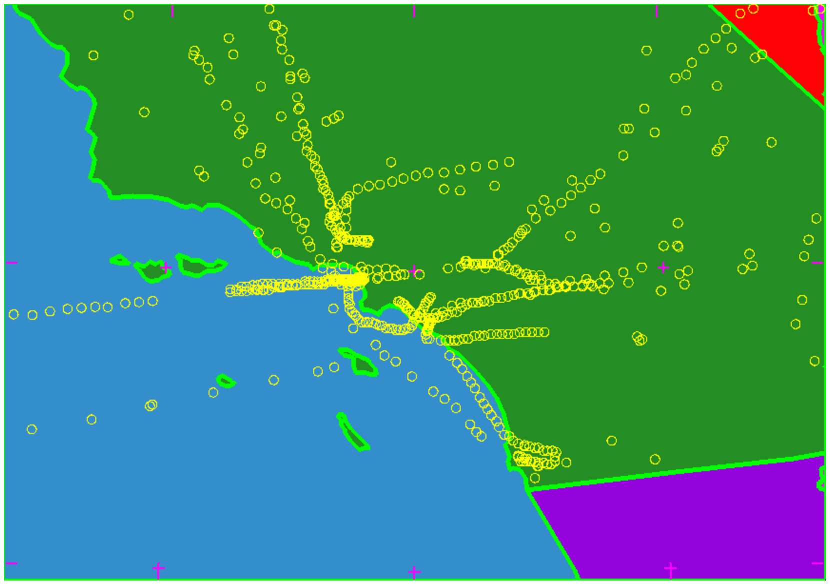
Nationally Upper Air (Profiles) Observations



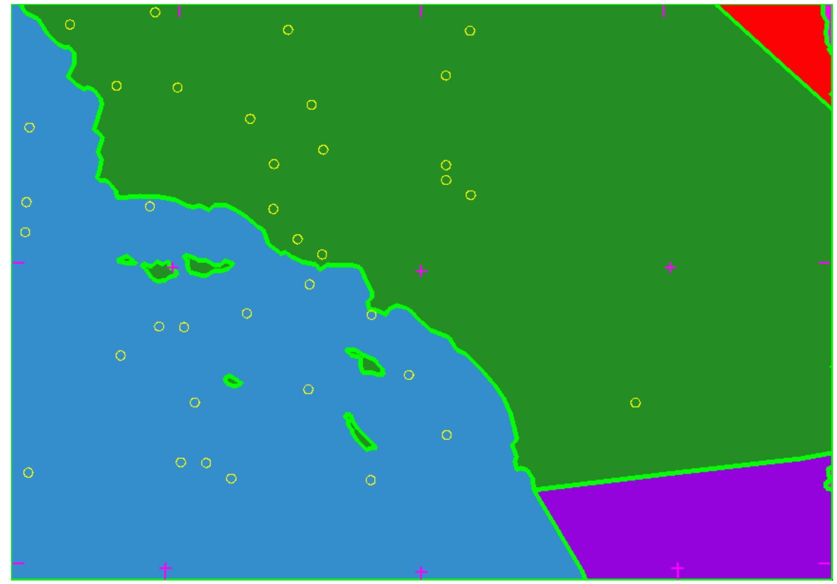
Nationally Available Surface Observations

MSS Meteorological Satellite Systems

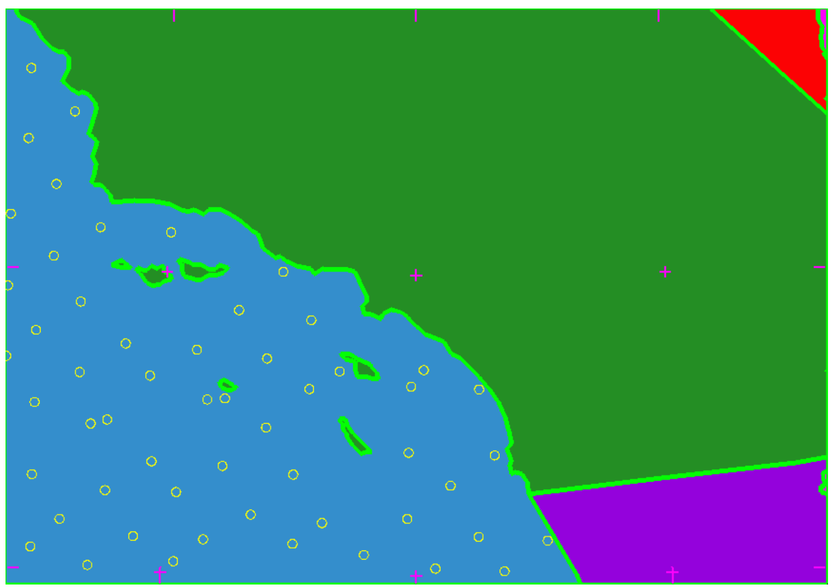
Unconventional Observations



Temperature and Wind Reports from Aircraft

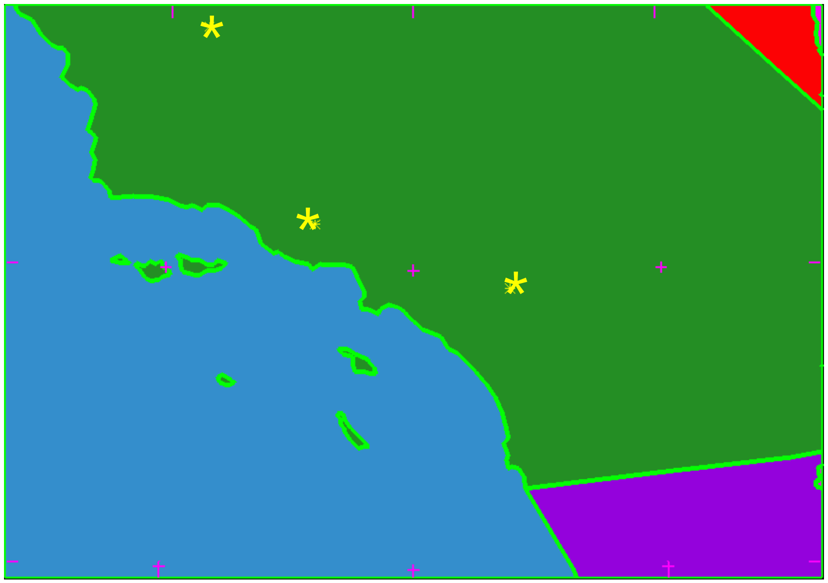


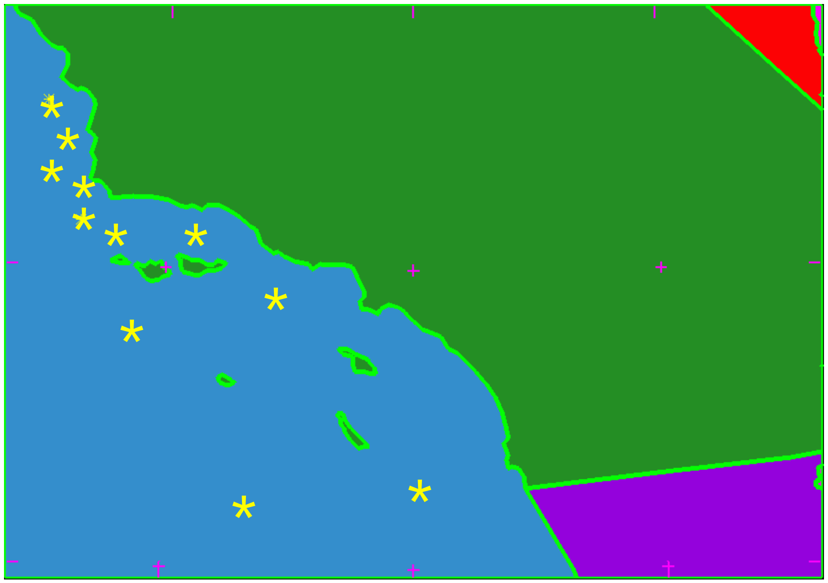
Wind Reports Derived from Cloud Motion Detected by Geostationary Weather Satellites



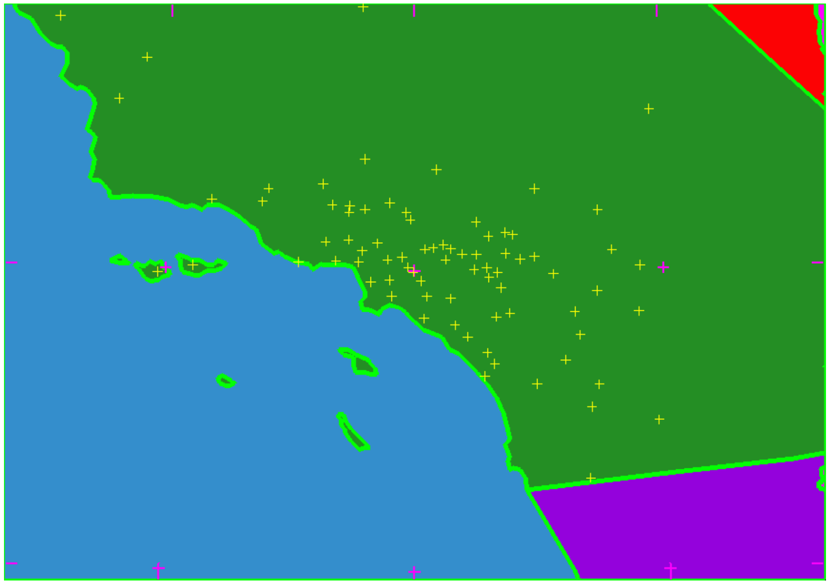
Remotely Sensed Ocean Surface Wind Speed and Total Columnar Water Vapor from SSMI

Locally Available Profiles, Surface and Buoys Observations





Boundary Layer Winds and Temperature Measurements from Wind Profilers and Radio Acoustic Sounding Systems



Buoys via the NBDC

SCAQMD Surface Meteorological Observations and BLM RAWs

3-Dimensional Variational Analysis System (3DVAR)

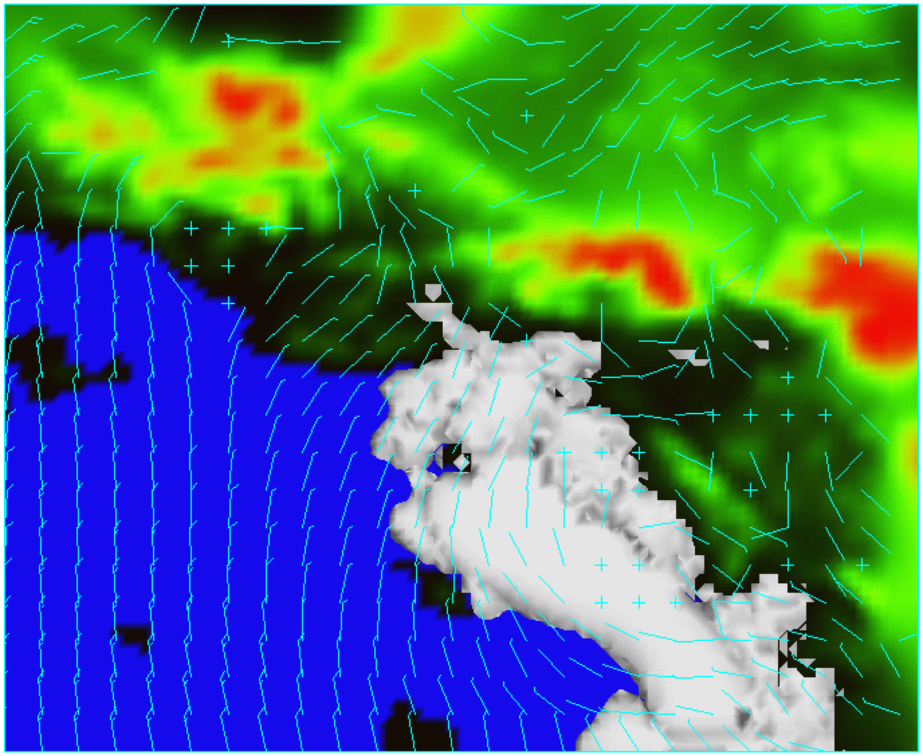
- Analysis is a “weighted fit” of all sources of info
- “Optimal” analysis $\boldsymbol{x^a}$ is that $\boldsymbol{x}$ which minimizes the cost-function:

$$J(\boldsymbol{x}) = \frac{1}{2}(\boldsymbol{x}-\boldsymbol{x}^b)^T \boldsymbol{B}^{-1}(\boldsymbol{x}-\boldsymbol{x}^b) + \frac{1}{2}(\boldsymbol{y}-\boldsymbol{y}^o)^T(\boldsymbol{O}+\boldsymbol{F})^{-1}(\boldsymbol{y}-\boldsymbol{y}^o)$$

- ***x** = a vector of the model variables at a given time over the 3-D grid*
- ***y*** = ***Hx*** where ***H*** is the “observation operator”
- ***O*** = Observation (instrumental) error
- ***F*** = Representivity (observation operator) error
- **B** = Background (previous forecast) error

MM5 Configuration

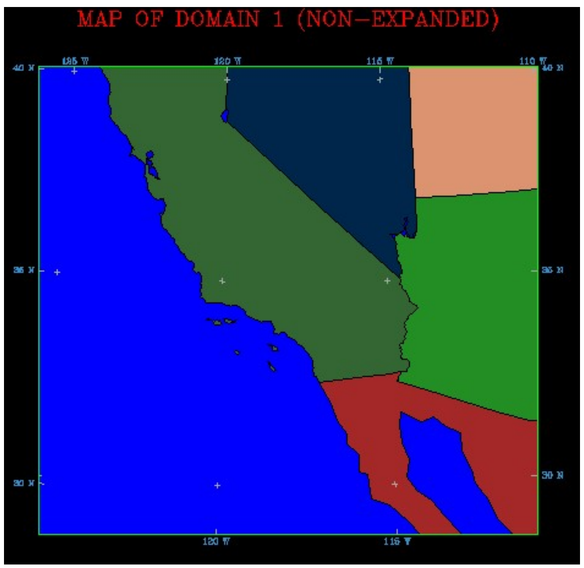
- 30 sec (0.9 km) terrain
- Cumulus parameterization (Grell) in just the outer domain
- Long and short wave radiation scheme with cloud radiative cooling
- Mixed phase cloud micro-physics
- Multilayer soil temperature model
- MRF planetary boundary layer (PBL) scheme
- 37 vertical (half-sigma) levels with the top of the model at 100 hPa



Example of MM5 Output for Southern California Area

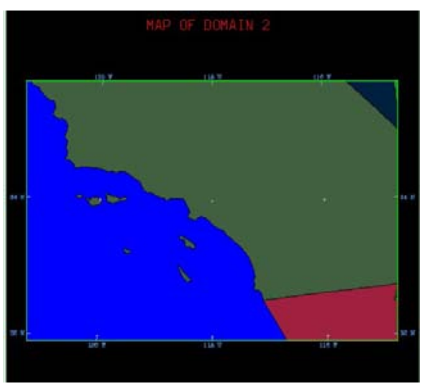
Model Domains and Terrain

Domain	Grid (km)	LatMin – LatMax LonMin - LongMax
1	15	28.64 to 40.10 -126.11 to -109.71
2	5	31.91 to 35.74 -121.37 to –114.58

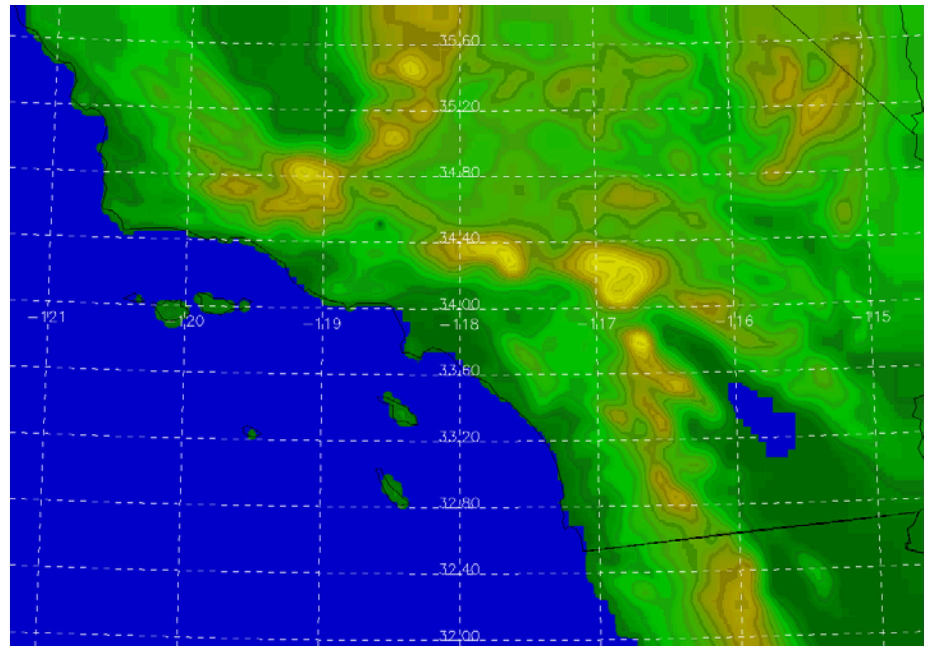


Outer Domain 1

Inner Domain 2



Terrain of Inner Domain



Mounts Pinos, San Jacinto, and San Gorgonio remain prominent, as do the Palos Verdes peninsula, and Catalina and other islands

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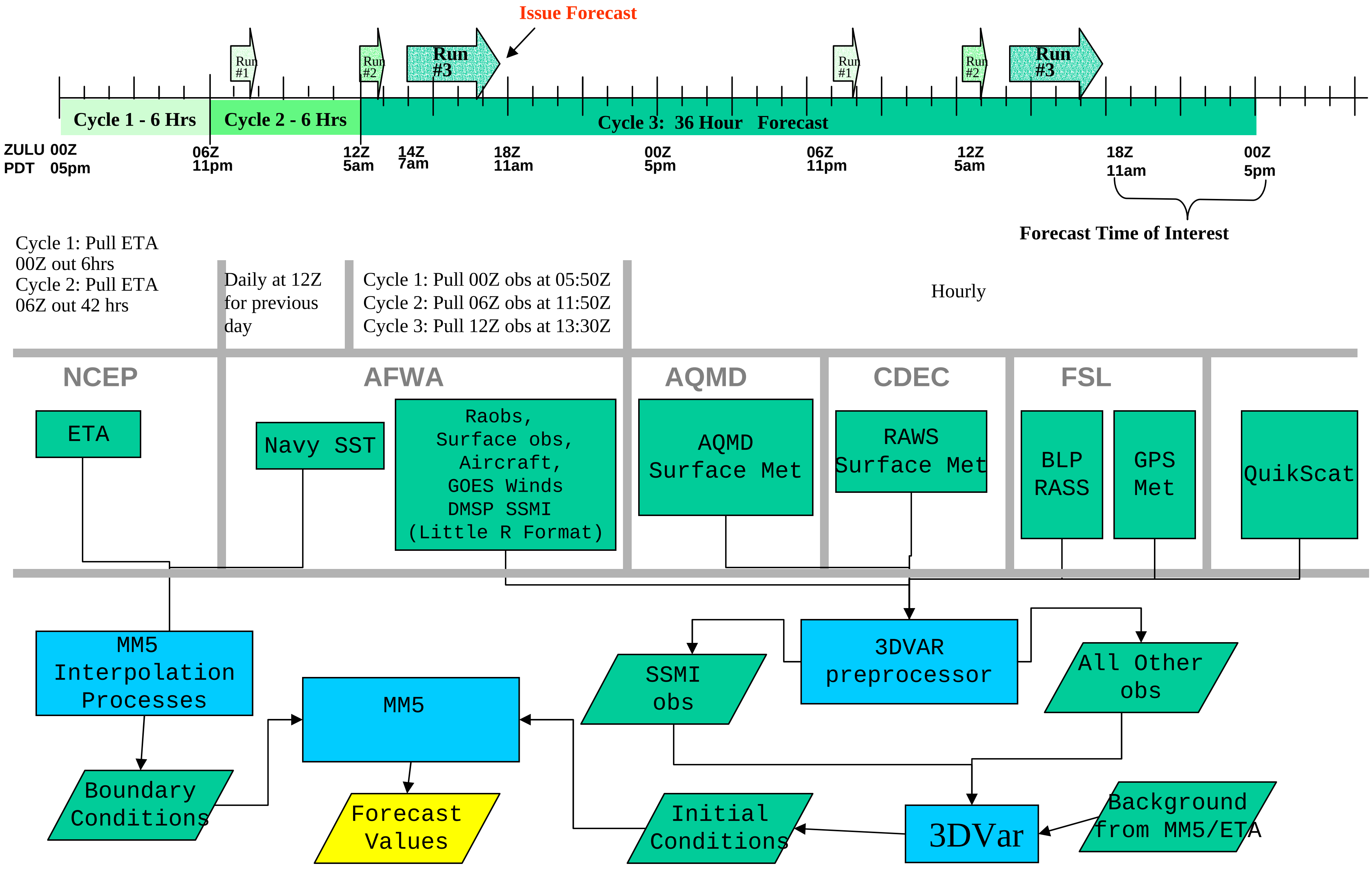
Modeling Hardware

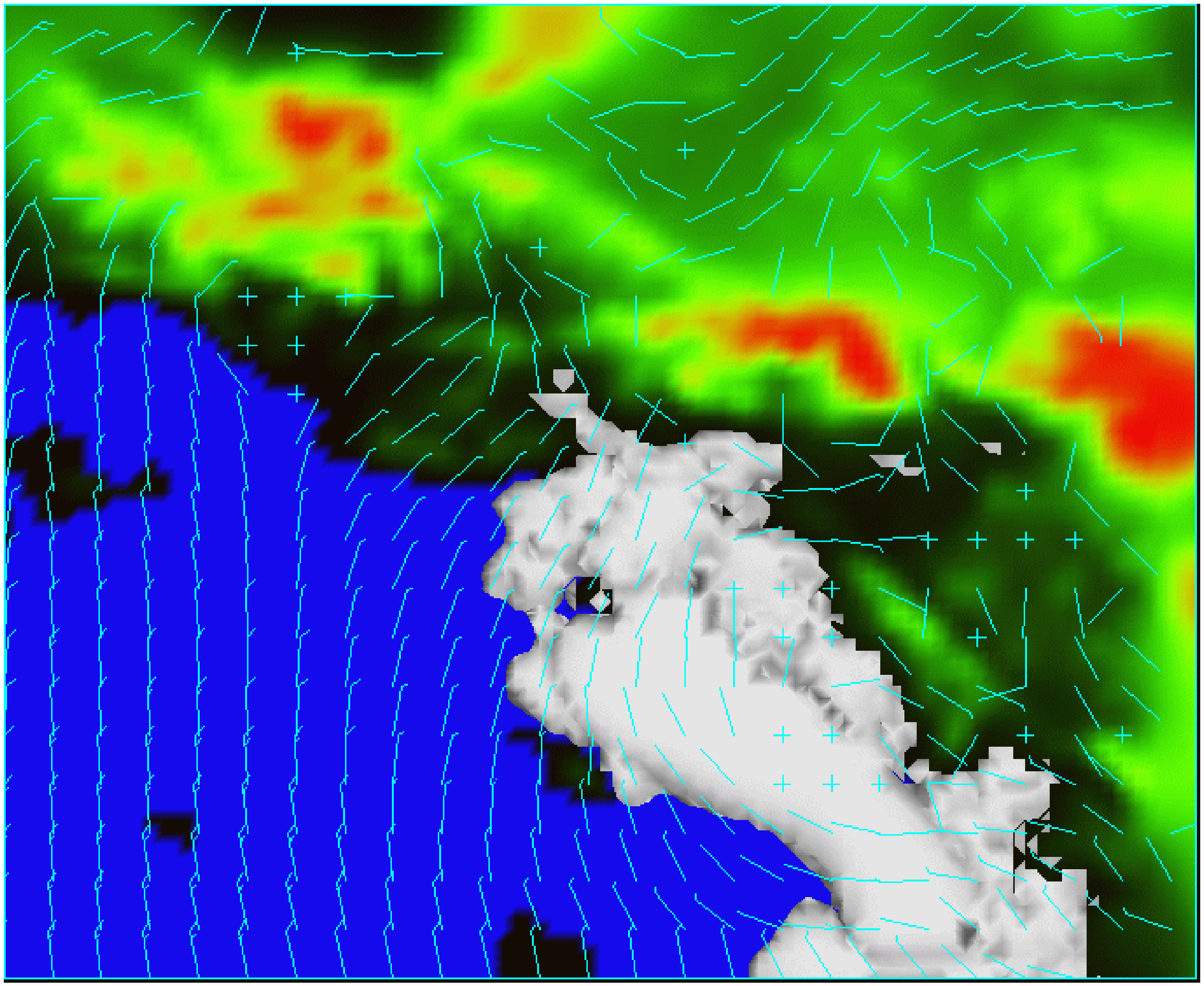
- Multiprocessor Cray Research SV1
  - 16 SV1 vector processors
  - 4 Gbytes of Memory

- Multiprocessor SGI Onyx 2
  - 16 processor @ 500 MHz (R14000)
  - 4.5 Gbytes of Memory

Model Concept of Operations



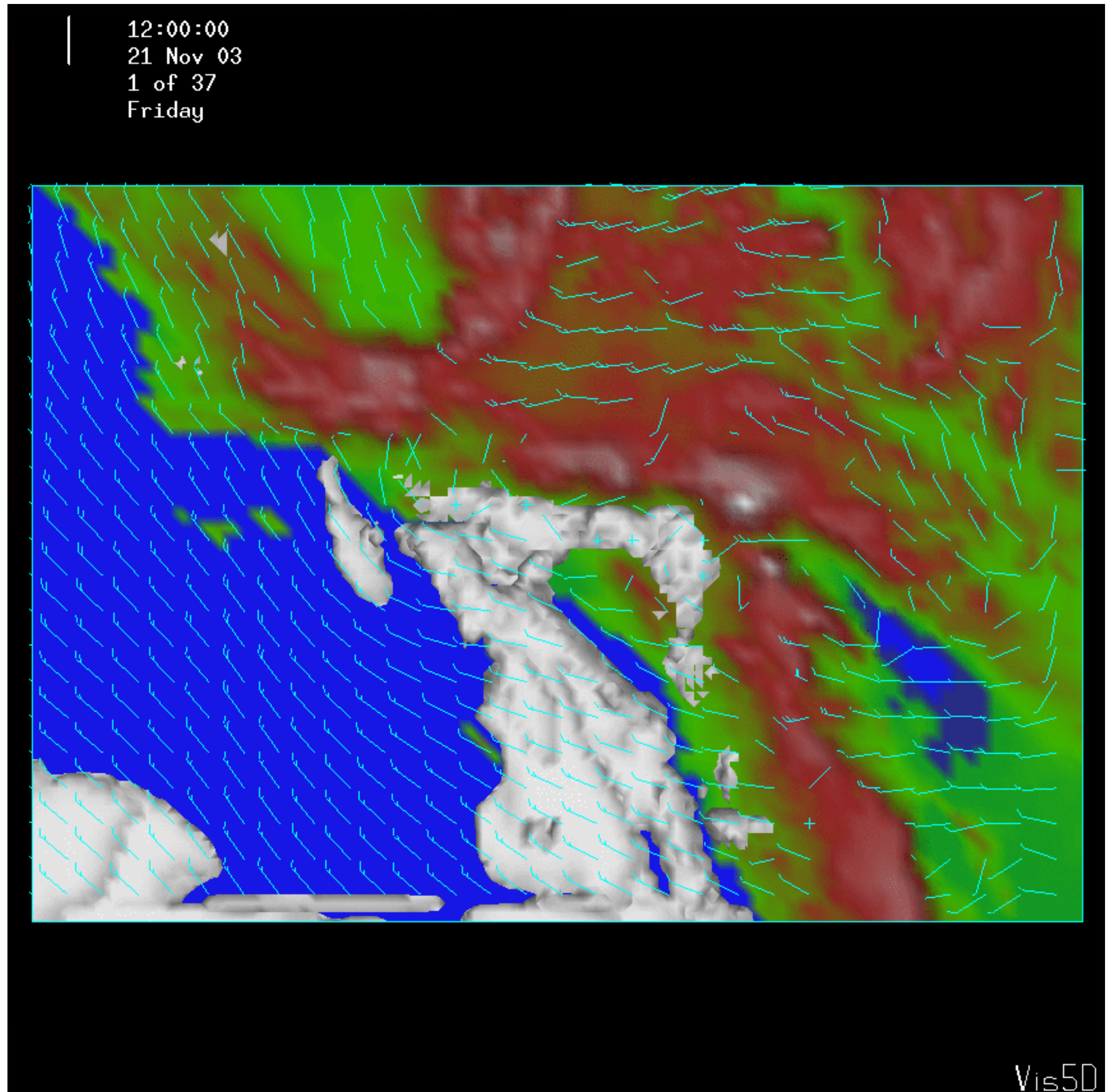
Weak Forcing
16 Jun 03 Test Case



- Forecast initialized on 16 June 2003 at 12Z (05L)
- Forecast runs through to 18 June 2003 at 00Z (17 June, 17L) with hourly output
- Winds displayed at the height of 1km
- Cloud field is an isosurface of the model predicted cloud liquid water
- Forecast seems to realistically capture the “Catalina Eddy” a local small-scale feature
- Forecast also captures some low-level cloud fields and their diurnal fluctuation

Santa Ana Winds
21 Nov 03

- Forecast started at 12Z, 21 Nov
- 36 hr forecast to 00Z, 23 Nov
- 1 km winds
- Five km grid
- Isosurfaces of cloud liquid water



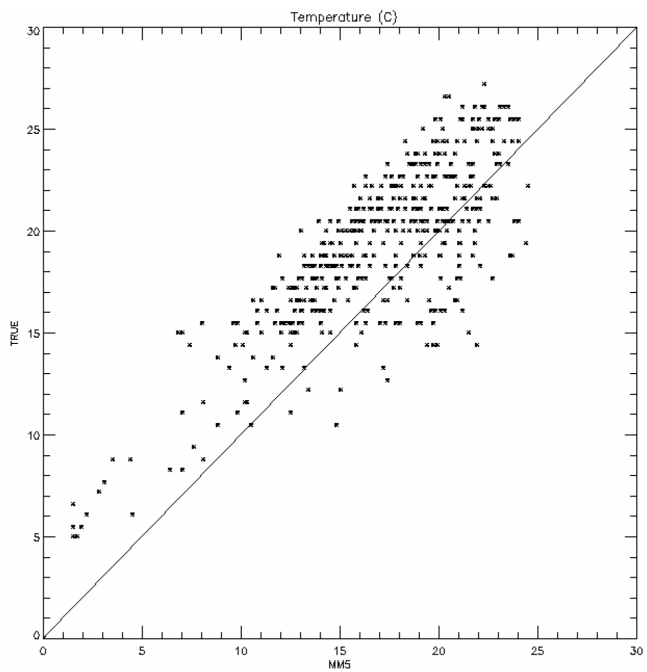
MODEL VERIFICATION

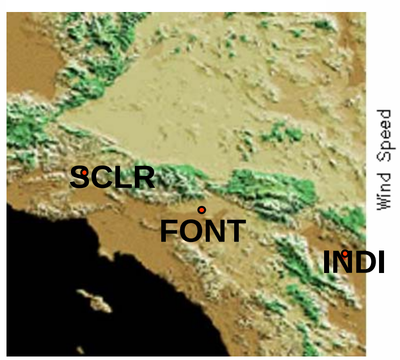
Surface Plots

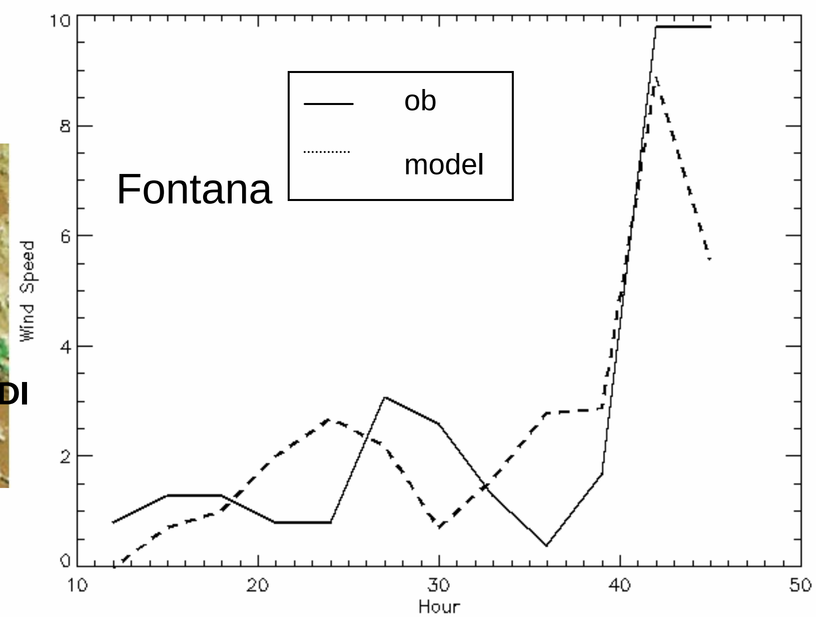
AFWA Surface Obs Scatter Plots
AQMD Surface Obs Scatter Plots
CDEC Surface Obs Scatter Plots
Fontana AQMD Station Time Series Plots
Indio AQMD Station Time Series Plots
Santa Clarita AQMD Station Time Series Plots

Profile Plots

RAAS Temperature Scatter Plots
BLP Wind Direction Scatter Plots
BLP Wind Speed Scatter Plots
LAX Station Profiles
MOVCA Station Profiles
PTLCA Station Profiles
SIMCA Station Profiles







Automated Distribution of Products

- Model Forecast plots available daily ~ 1pm at www.aerospaceweather.com
- Verification plots posted as the data catches up with forecast period (~ 2 days after the run)
- Binary data shipped to an external FTP site daily (aerospace.aero.org)

Future Work

- Establish a continual data assimilation cycle
- Complete Background Error Statistics for the LA Basin
- Assimilate additional data sources
  - NEXRAD
  - AMSR
- Couple the MM5 with a more sophisticated Land Surface Model (LSM)
- Use JPL High Resolution SST
- Optimize model configuration based on feedback from verification efforts and collaborators
- Determine impact of data assimilation on model forecast quality

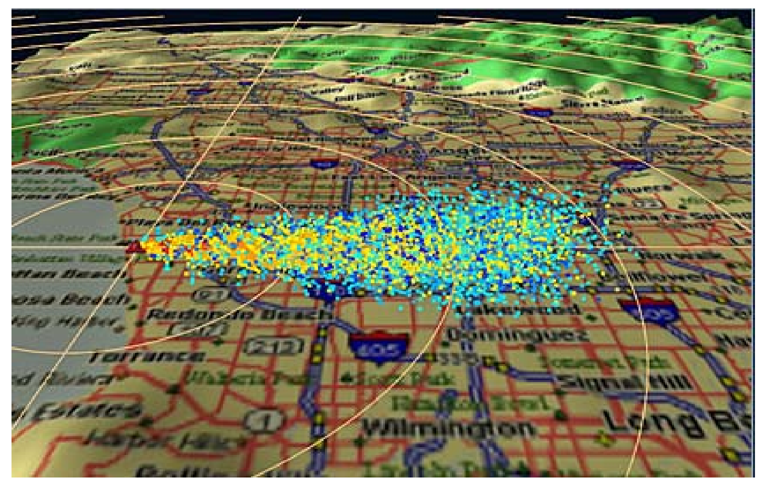
MSS Meteorological Satellite Systems

Future Work

- Deploy Aerospace Transportable Lidar System (ATLS) to locations in the LA Basin to verify MM5 model forecasts

- Use MM5 wind forecasts as input to a Aerospace developed Multi-Particle Dispersion Model (MPDM)

ATLS Deployed in Kauai, Hawaii



Plume Dispersion Simulation of NO Release in LA Basin using MPDM

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