

Convective Initiation Using LAPS/WRF System

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RITT Forum, 19 January 2011

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LAPS Niche

High Resolution (500m – 20km), Rapid Update (10-60min), Local to Global:

- ★ 1km analysis, 15min frequency, 25-30 minute latency
- ★ Versus 60min frequency / ~60-90min latency for other hi-res analysis systems (e.g. RTMA)

Highly Portable System, Easy to Use – Many Collaborators/users World Wide

- Federal/State Gov't, International, Academia, Private Sector
- NWS/AWIPS, GTAS, FAA/COSPA, RSA, PADS, CWB Taiwan

Wide variety of data sources:

```
graph TD
    subgraph Data_Sources [Data sources]
        CloudDrift[Cloud Drift Winds]
        LocalData[Local Data (LDAD)]
        BackgroundModel[Background Model]
        SatelliteSounding[Satellite Sounding]
        NOWRAD[NOWRAD Radar]
        BoundaryLayerRASS[Boundary Layer RASS]
        GPS[GPS]
        METARs[METARs]
        Satellite[Satellite]
        ACARs[ACARs]
        LocalNEXRAD[Local NEXRAD Radar(s)]
        RASS[RASS]
        VAD[VAD]
        Profiler[Profiler]
        Buoy[Buoy]
        RAOB[RAOB]
        PIREPs[PIREPs]
        DistantNEXRAD[Distant NEXRAD Radar(s)]
    end

    subgraph Ingestion [Ingestion]
        ingest_clouddrift[ingest_clouddrift]
        ingest_pro[ingest_pro]
        obs_driver[obs_driver]
        lga_exe[lga.exe]
        ingest_sounding[ingest_sounding]
        vrc_driver[vrc_driver]
        ingest_lrs[ingest_lrs]
        lsr_driver[lsr_driver]
        lvd_sat_ingest[lvd_sat_ingest]
        ingest_aircraft[ingest_aircraft]
        remap_polar[remap_polar]
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    subgraph Processing [LAPS data pre-processing]
        mosaic_radar[mosaic_radar]
    end

    subgraph Intermediate [LAPS intermediate files]
        odw[odw]
        pro[pro]
        lso[lso]
        lsr[lsr]
        lga[lga]
        lgb[lgb]
        lvd[lvd]
        snd[snd]
        pin[pin]
        vrc[vrc]
        vrz[vrz]
        vxx[vxx]
        lrs[lrs]
    end

    subgraph Analysis [LAPS Analysis]
        LAPS_Analysis[LAPS Analysis]
    end

    CloudDrift --> ingest_clouddrift
    LocalData --> ingest_pro
    BackgroundModel --> lga_exe
    SatelliteSounding --> ingest_sounding
    NOWRAD --> vrc_driver
    BoundaryLayerRASS --> ingest_lrs
    GPS --> obs_driver
    METARs --> obs_driver
    Satellite --> lsr_driver
    ACARs --> ingest_aircraft
    LocalNEXRAD --> mosaic_radar
    RASS --> remap_polar
    DistantNEXRAD --> mosaic_radar
    VAD --> ingest_pro
    Profiler --> ingest_pro
    Buoy --> obs_driver
    RAOB --> ingest_sounding
    PIREPs --> ingest_sounding

    ingest_clouddrift --> odw
    ingest_pro --> pro
    obs_driver --> lso
    lga_exe --> lsr
    ingest_sounding --> lga
    vrc_driver --> lgb
    ingest_lrs --> lvd
    lsr_driver --> snd
    ingest_aircraft --> pin
    remap_polar --> vrc
    mosaic_radar --> vrz
    remap_polar --> vxx
    ingest_lrs --> lrs

    odw --> LAPS_Analysis
    pro --> LAPS_Analysis
    lso --> LAPS_Analysis
    lsr --> LAPS_Analysis
    lga --> LAPS_Analysis
    lgb --> LAPS_Analysis
    lvd --> LAPS_Analysis
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    vrz --> LAPS_Analysis
    vxx --> LAPS_Analysis
    lrs --> LAPS_Analysis
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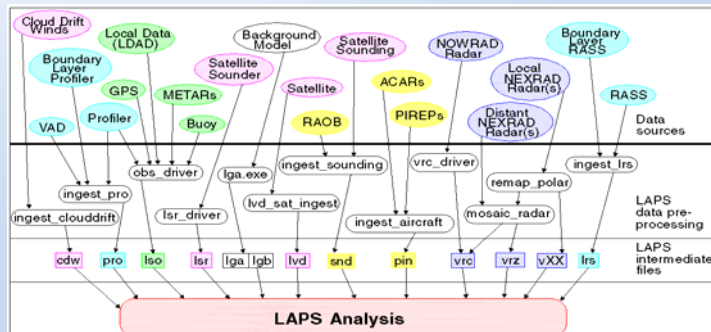
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Wide variety
of data sources:



LAPS TEAM

Data assimilation

Steve Albers, Yuanfu Xie

Satellite and other observations

Dan Birkenheuer, Seth Gutman, Kirk Holub, Tomoko Koyama

Physical processes

Paul Schultz

Ensemble forecasting

Isidora Jankov

Evaluation and verification

Ed Tollerud, Ed Szoke

Software engineering

Linda Wharton, Paula McCaslin

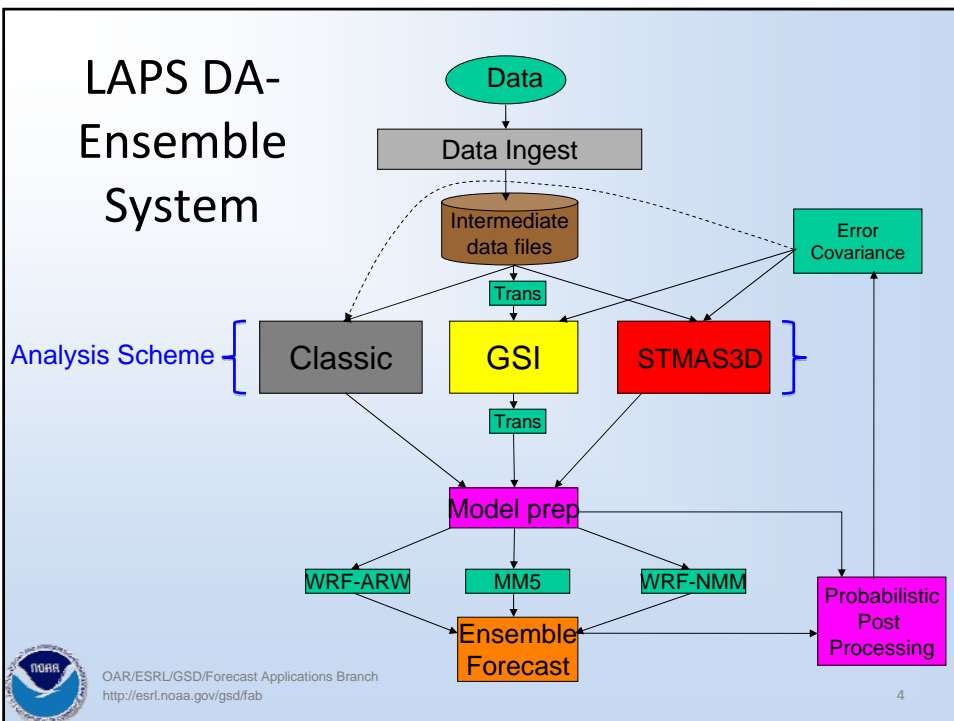
Technical support

Adrienne Rose, Joanne Krumel, Stanislav Stoichev

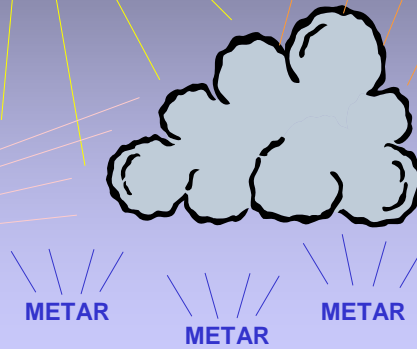
Former colleagues

John McGinley, Huiling Yuan, Brad Beechler, Brent Shaw, etc

Long list of collaborators, visitors, etc



LAPS Cloud analysis

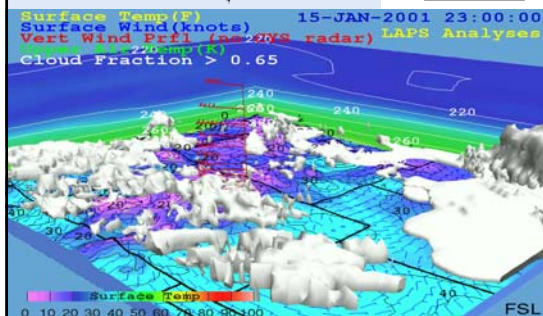


OAR/ESRL/GSD/Forecast Applications Branch

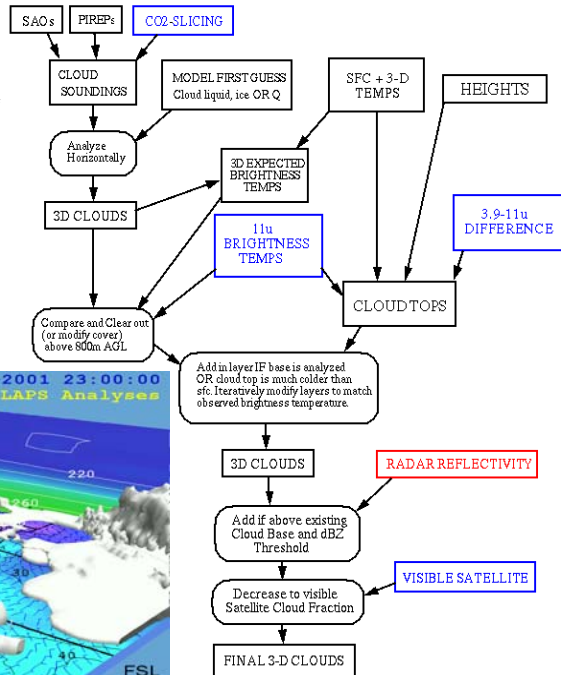
5

Cloud Analysis Flow Chart

Cloud Fraction 3-D Isosurface

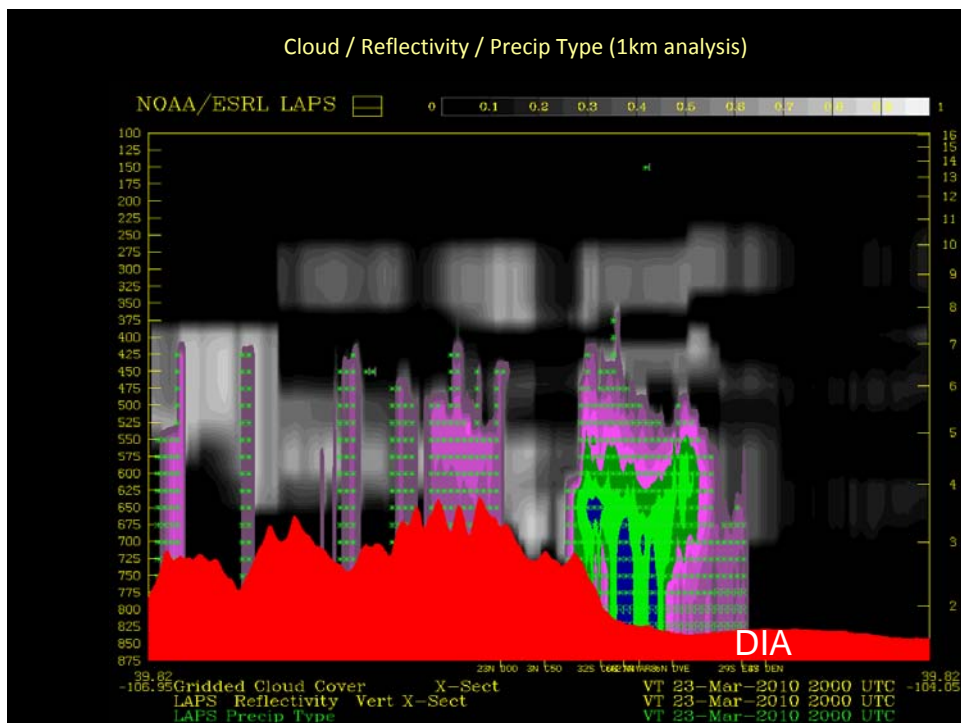
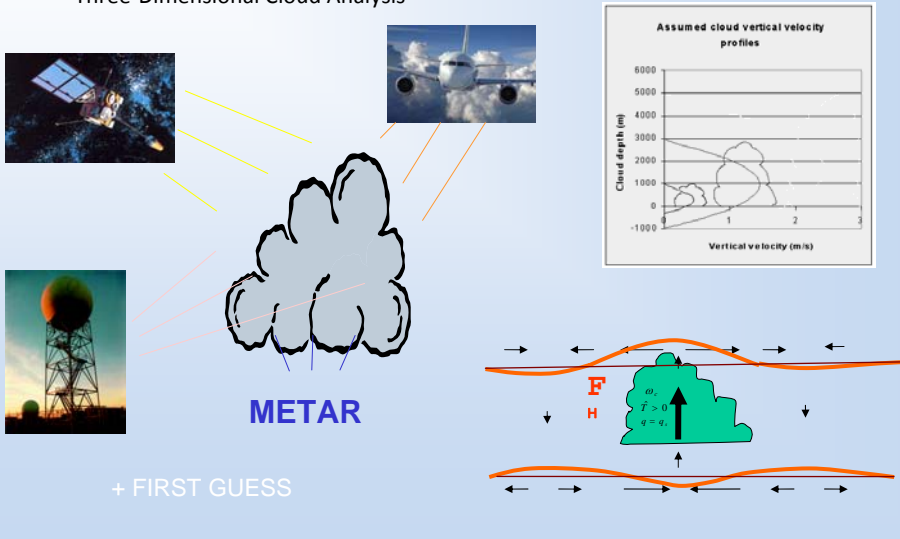


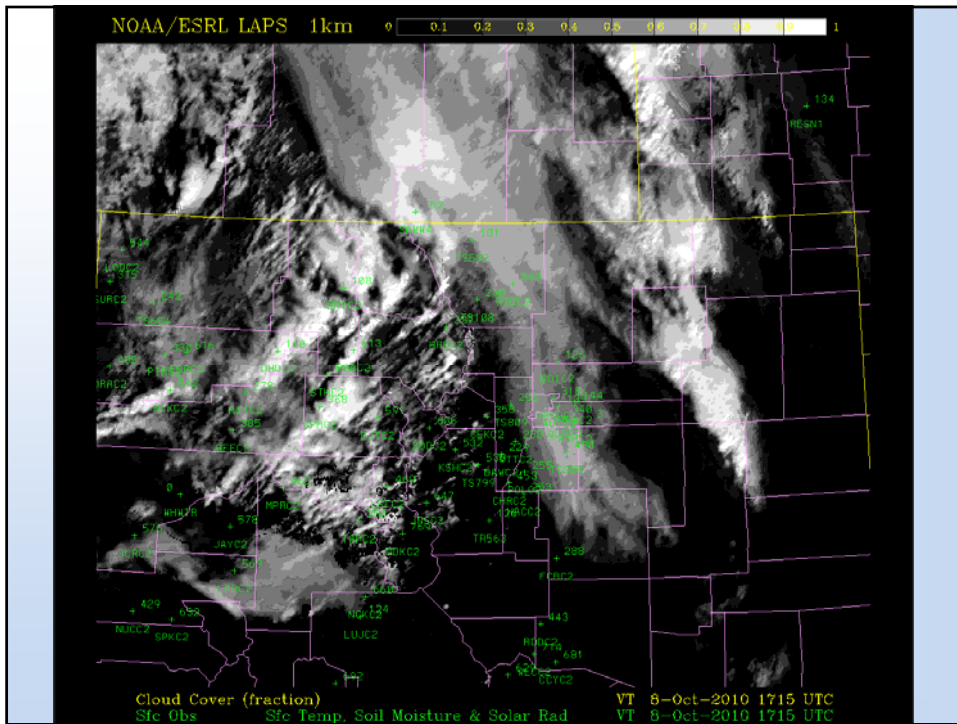
LAPS CLOUD ANALYSIS



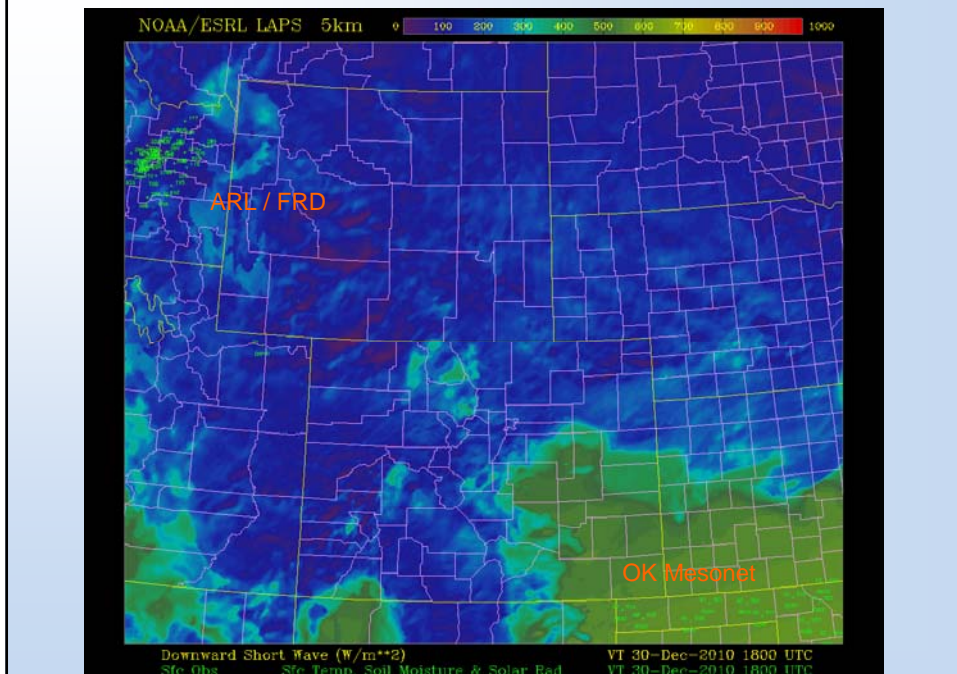
LAPS HOT START INITIALIZATION

Three-Dimensional Cloud Analysis



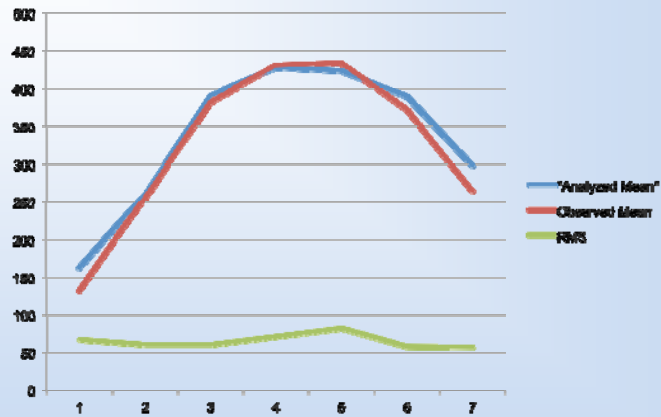


Global Solar Radiation Analysis + Observations



"Global" Solar Radiation Analysis Verification Stats (Colorado Region)

SWI W/m² with time (16-22 UTC) 31 December 2010

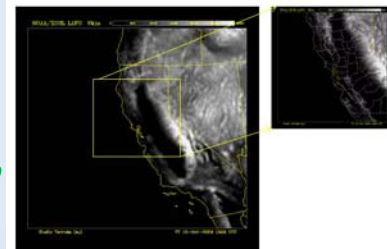


Convective Initiation of WRF Model

QPF related activities

- HMT ensemble precipitation forecasting
 - mixed model/mixed physics /mixed LBCs ensemble
 - 9 members
 - nested domain
 - LAPS analysis

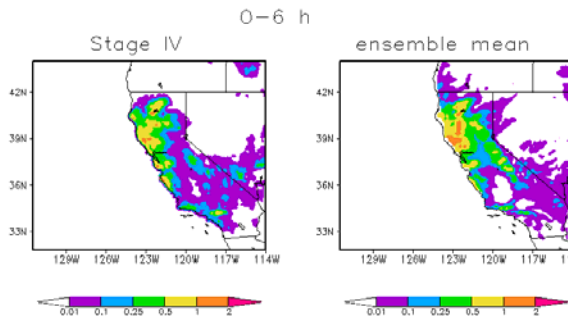
Yuan et al. 2008, Jankov et al. 2007, Jankov et al. 2009



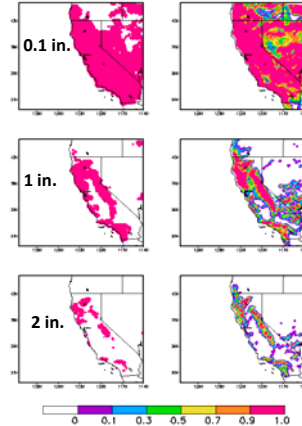
- Convective Precipitation forecasting
 - high resolution diabatical initialization (LAPS/STMAS)
 - *Etherton and Santos 2006, Jankov 2007 a,b*
 - high spatial/temporal resolution numerical model runs
 - frequent update

HMT QPF and PQPF

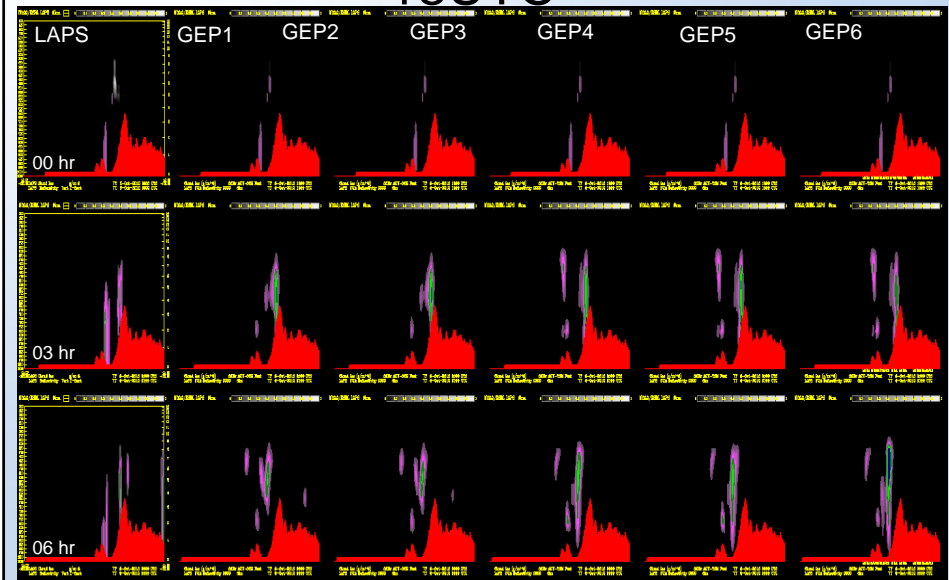
48-hr forecast starting at 12 UTC, 18 January 2010



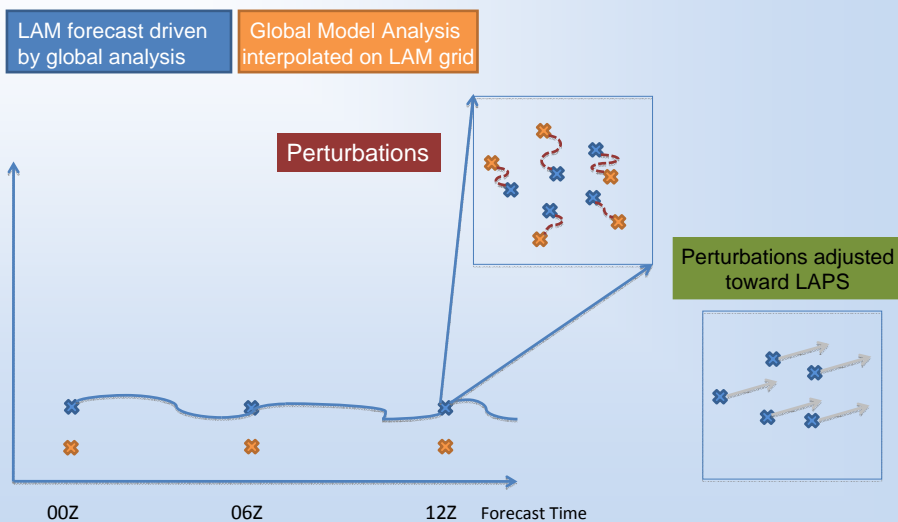
24-hr PQPF

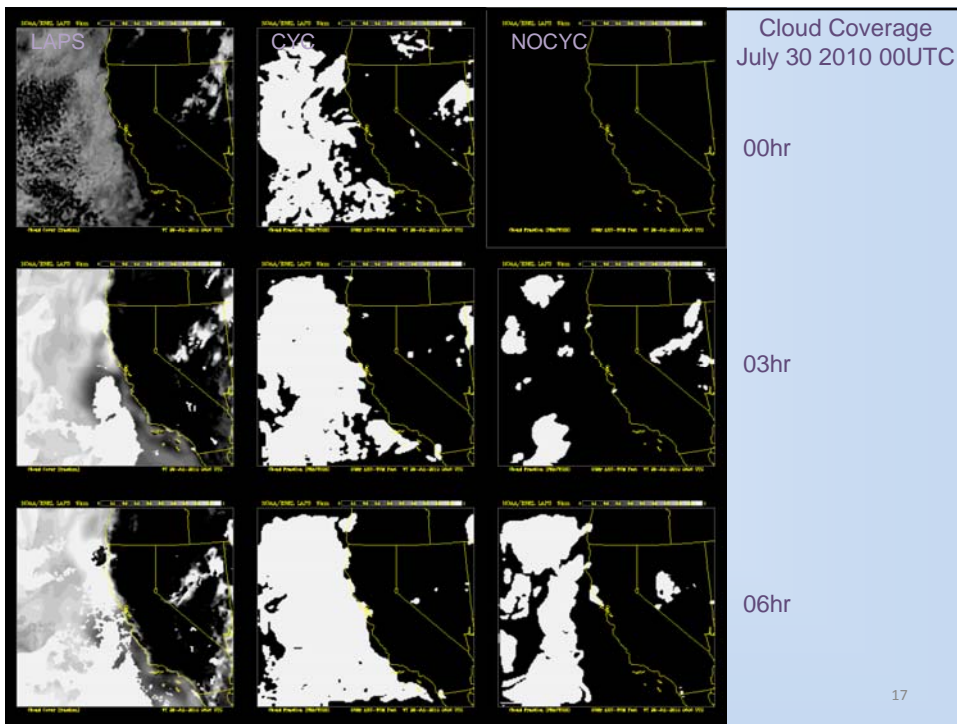


Xsect Reflectivity 06 Oct. 2010 18UTC



Initial Perturbations for HMT-10/11 “Cycling” perturbations

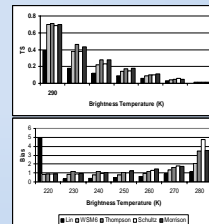
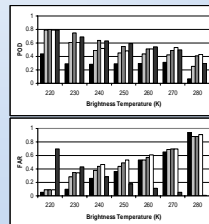
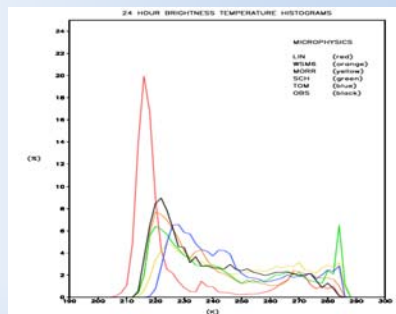
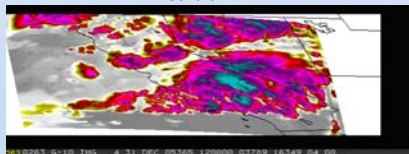
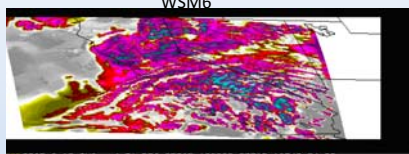
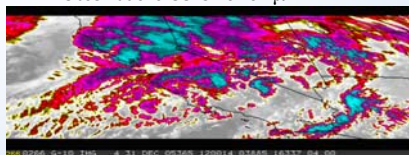




Possible use of synthetic satellite imagery, as an additional way to indirectly evaluate the performance of various microphysical schemes, was evaluated.

24-hr forecast valid at 31 Dec. 2005 at 12 UTC

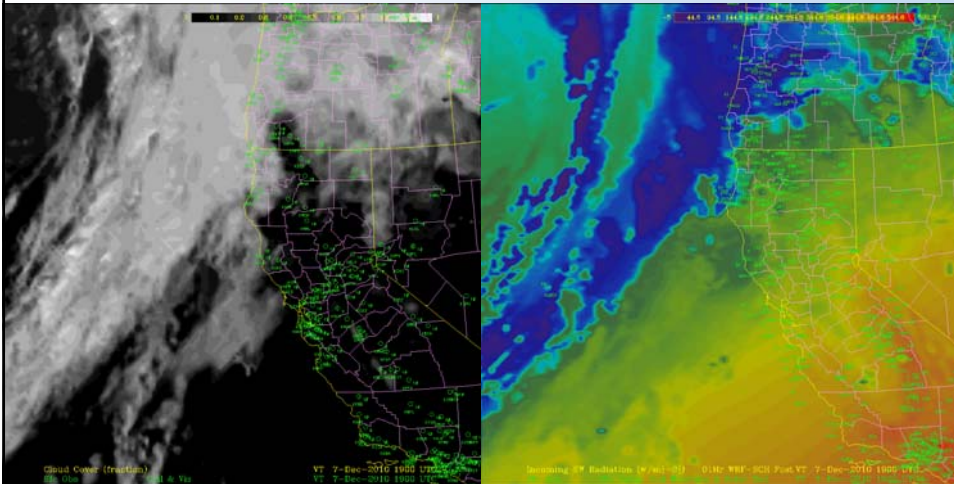
Observations-GOES-10 10.7 μ m



Jankov, I. L. D. Grasso, M. Sengupta, P. J. Neiman, D. Zupanski, M. Zupanski, D. Lindsey, D. W. Hillger, D. L. Birkenheuer, R. Brummer and H. Yuan, 2010: An Evaluation of Five WRF-ARW Microphysics Schemes Using Synthetic GOES Imagery for an Atmospheric River Event Affecting the California Coast. In press JHM.

Cloud Cover Analysis

Matching 1-3 hour Solar Radiation Forecast

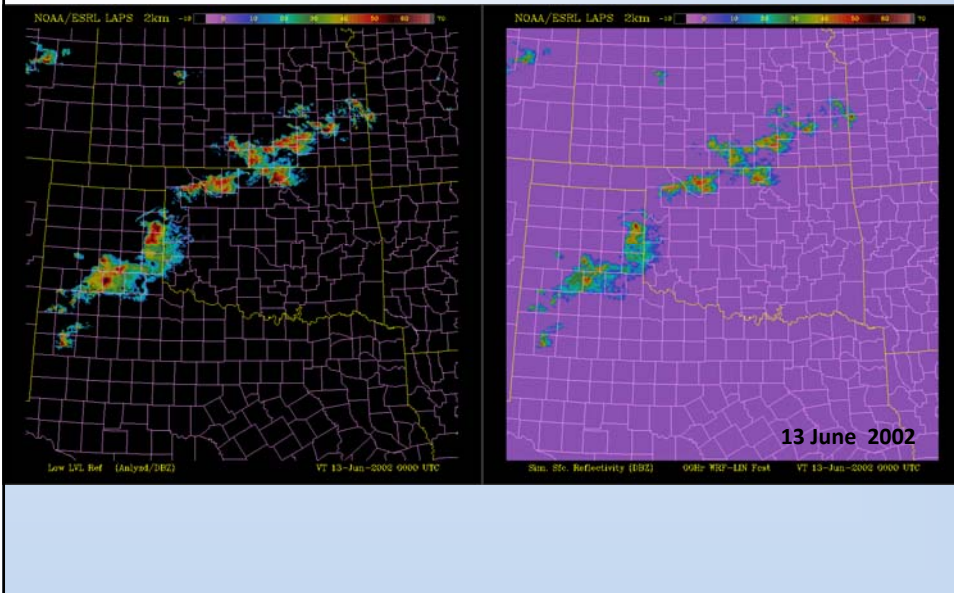


Solar Radiation comparison between 3hr WRF model forecast valid
On 14 January 2011 at 15 UTC and Observations

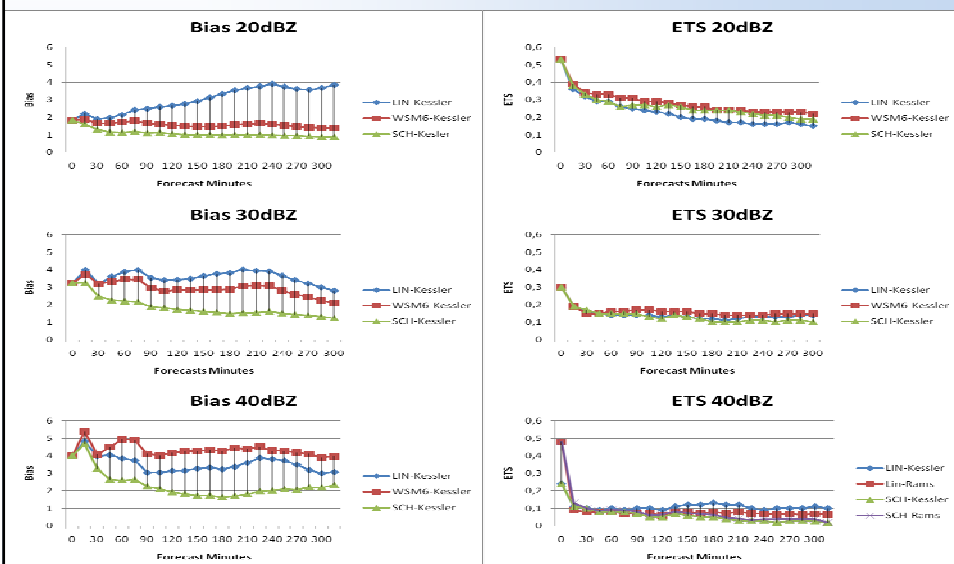
Station	3hr Forecasts	Observations	Stats
ARC	251	236	Bias=13
BIG	225	187	RMS=43
CRA	177	237	R=0.73
DEA	237	229	
MIN	268	347	
RIC	344	344	

Analysis

6-hr Diabatically (LAPS) initialized
WRF-ARW forecast

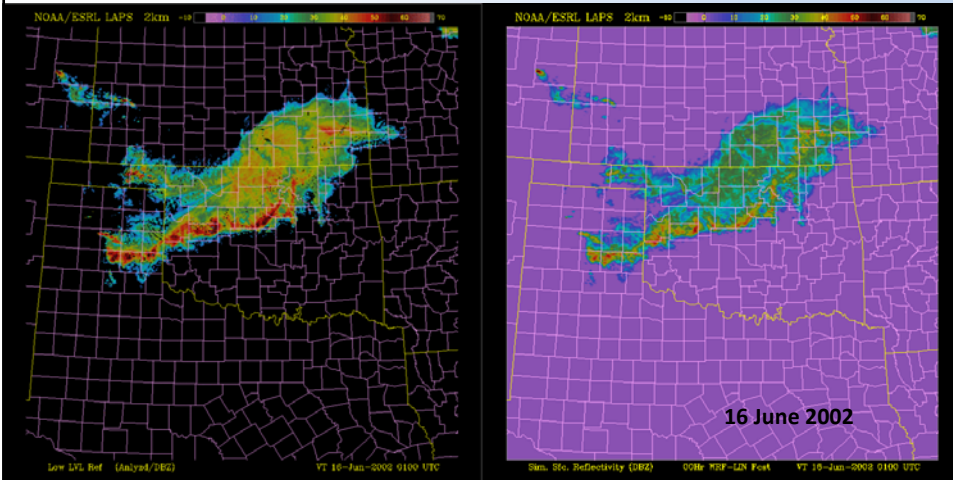


Bias & ETS June 13 2002



Analysis

3-hr Forecast, Lin μ Phys



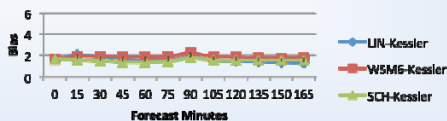
Well-Developed Squall Line at Initial time

Bias & ETS June 16 2002

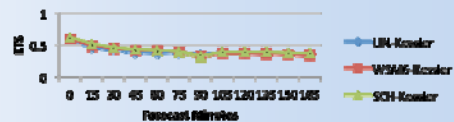
Low Sensitivity in Bias to Variations in Microphysics (developed squall line case)

ETS values are highest at early times due to hot-start

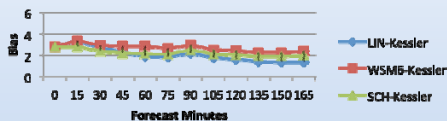
Bias 20dBZ



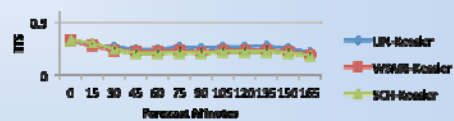
ETS 20dBZ



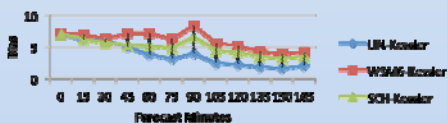
Bias 30dBZ



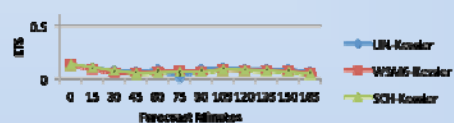
ETS 30dBZ



Bias 40dBZ



ETS 40dBZ

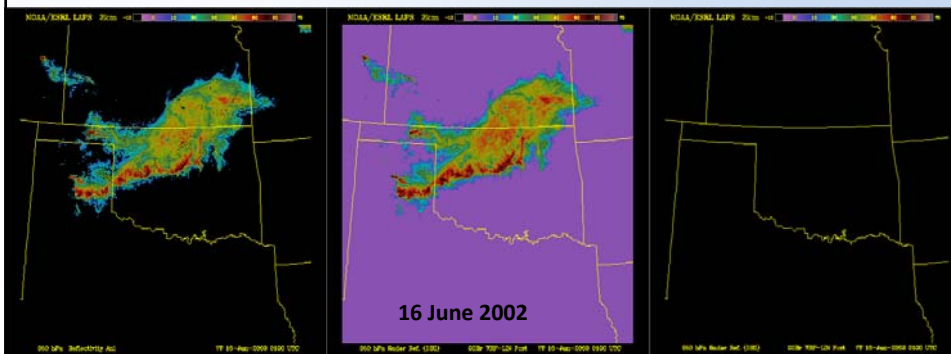


850 mb Analyzed and Simulated Reflectivity

Analysis

2hr HOT Fcst

2hr NO-HOT Fcst



Future Modeling Plans

HMT

- Continue to improve winter season QPF and PQPF
- Microphysics related research
- Ensemble stream flow

Convective weather (HWT)

- Increased resolution diabatic NWP initialization (LAPS/STMAS)
- Increased spatial/temporal resolution forecasts
- Ensemble approach (DET)
- Ongoing verification for both analyses and forecasts for various fields including solar radiation

Future DA Development - 1

- Higher Resolution Space / Time
 - 2km – 5 to 15min national analysis for FAA/COSPA
 - 1km or less for AWIPS-II WFO domain
 - 20-50 meter analysis for fire weather
 - Initialize WRF at high resolution for WFO domain
- Develop forward models for all data sources being used to more fully implement a 4DVAR approach
- Incorporate clouds/precipitation variationally into STMAS
 - subsequently feed into GSI
- Dynamical Downscaling
 - consider hi-res terrain dependent flow in variational cost function
- Use ensemble covariances in STMAS
- Share methodologies between LAPS / STMAS / HRRR

Future DA Development - 2

- Implement LAPS in AWIPS-II, transitioning to STMAS
- Consider new data sources (e.g. GPS, radiometer, Level-II radar)
 - Some are available in “full” LAPS, so can be included for AWIPS as well
 - Acquire global geostationary & polar orbiter satellite radiances / imager data
- Improve quality control (in LAPS/STMAS and upstream in MADIS)
- More efficient net enabled data access (e.g. NNEW)
- Full dynamic constraints in STMAS toward a multigrid 4DVAR analysis system with WRF adjoint system.

Thanks!

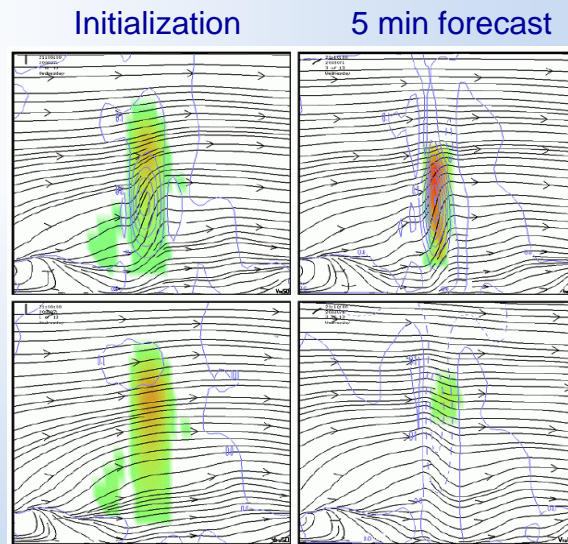
- More info at:
<http://laps.noaa.gov>
- Questions / Comments?



OAR/ESRL/GSD/Forecast Applications Branch
<http://esrl.noaa.gov/gsd/fab>

Hot Start Clouds
+ vertical motion

Cloud Insertion
only



Cloud liquid (shaded), vertical velocity (contours) and cross-section streamlines for analyses (right) and 5-min forecasts (left). The top pair shows LAPS hot-start DI with upward vertical motions where clouds are diagnosed and properly sustained cloud and vertical motions in the forecast; the bottom pair demonstrates the artificial downdraft that usually results from simply injecting cloud liquid into a model initialization without supporting updrafts or saturation. Note that cloud liquid at the top of the updraft shown in the hot-started forecast (above right) has converted to cloud ice.

ATMOSPHERIC RIVERS

o During the winter season significant precipitation events in California are often caused by land-falling “atmospheric rivers” associated with extra tropical cyclones in the Pacific.

o Atmospheric rivers are elongated regions of high values of vertically integrated water vapor over the Pacific and Atlantic oceans that extend from the tropics and subtropics into the extratropics and are readily identifiable using SSM/I.

o Due to the terrain steepness and soil characteristics in the area, a high risk of flooding and landslides is often associated with these events.

